



CRC

HANDBOOK OF  
**CHEMISTRY**  
*and*  
**PHYSICS**

DAVID R. LIDE  
Editor-in-Chief

**90<sup>TH</sup>**  
**EDITION**  
2009 - 2010



# **CRC Handbook of Chemistry and Physics**

**90<sup>th</sup> Edition**  
**Internet Version 2010**

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Former Director, Standard Reference Data  
National Institute of Standards and Technology

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Scientist Emeritus  
National Institute of Standards and Technology

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## FOREWORD BY THE PUBLISHER

Publishing the 90<sup>th</sup> edition of this landmark reference is a true milestone in the history of CRC Press. Since its first publication in 1913 – as a 116-page pocket-sized book priced at \$2 – the *CRC Handbook of Chemistry and Physics* has developed into a 2800 page tome that no longer fits anyone's pocket but still finds a place on every scientist's bookshelf.

Certainly, the tremendous advances in science and technology over the past 96 years have fuelled the increase in the *Handbook's* contents, but the immense task of data selection, compilation, and organization has been expertly performed by a succession of Editors, Advisory Board members, and Contributors. These people have played a significant role in shaping the *Handbook* that we see today, and it is to them that I wish to pay tribute in this Foreword.

Covering such large subject areas, the Editors have always relied on a team of subject experts from around the world to contribute articles and tables. A cursory glance over the names credited through the years provides an interesting historical roll call of renowned chemists and physicists who have given their time and scientific expertise to the *Handbook*. These contributors include leaders such as Nobel Laureate Glenn T. Seaborg, space science pioneer James Van Allen, and C. S. "Speed" Marvel, considered the father of synthetic polymer chemistry.

Originally conceived by the Ohio-based Chemical Rubber Company as an incentive to encourage sales of their laboratory supplies, the *Handbook* started life as a small booklet of useful mathematical formulae and laboratory data. By 1913, it had grown to 116 pages and was published in its own right as the *Handbook of Chemistry and Physics*. The Editor was William R. Veazey, an Associate Professor of Chemistry at the (then) Case School of Applied Science. Who could have predicted that this pocket book was to become so well known that its users came to refer to it as the 'Rubber Bible' or, simply, the 'CRC'? To paraphrase a review of the 88<sup>th</sup> edition – "if you can't find a copy in your lab, that's because someone in the next lab has stolen it."

Veazey's successor was Charles D. Hodgman, his Assistant Editor for the first edition and an Associate Professor of Physics at Case. Hodgman went on to hold the position of Editor from 1915 to 1963, overseeing 42 editions of the *Handbook*. Under his

Editorship the *Handbook* grew to over 3000 pages and the coverage expanded to include x-ray crystallography, nuclear physics, synthetic polymers, and other fields that did not exist when his first edition appeared.

Following Hodgman's retirement Robert Weast took over the Editorship and published the 45<sup>th</sup> edition in 1964. Noticeably bigger with an 8" by 10" page size, the *Handbook* continued to expand in both scope and magnitude over the next few years. In 1972, The Chemical Rubber Company first published it under the CRC Press imprint, and in the late 1970's sold off its laboratory supply business, moved to new headquarters in Florida, and began building its book publishing business.

David R. Lide became the *Handbook's* fourth Editor in 1989, and took the opportunity to radically overhaul the organization and content to reflect the needs of the modern user. He added, merged, and deleted tables, and during the period of his editorship, updated 100 percent of the content. Staying within the confines of a single volume has always meant difficult decisions on which tables to include – often at the expense of others – but with the advent of electronic media, the *Handbook* is now available electronically and space constraints are less of a problem. Modern production techniques and the move to a larger page size have given the current *Handbook* a cleaner and more user-friendly look.

Publication of the 90<sup>th</sup> edition marks David Lide's final edition as Editor-in-Chief, and the publisher wishes to take this opportunity to thank him for his tremendous expertise and enthusiasm that has helped make the *Handbook* so indispensable to today's scientists.

Starting with the 91<sup>st</sup> edition, the *Handbook* editorship transfers to W.M. "Mickey" Haynes, Editor-in-Chief of the *International Journal of Thermophysics*, Scientist Emeritus at the National Institute of Standards and Technology (NIST), and former Chief of the NIST Physical and Chemical Properties Division. We look forward to a new era in the *Handbook's* long and illustrious history.

**Fiona Macdonald**  
Publisher, CRC Press  
Boca Raton, Florida  
March 2009

## PREFACE

The 90th Edition of the *CRC Handbook of Chemistry and Physics* marks a milestone for this reference work, which first appeared in 1913. For almost a century the *Handbook* has been updated annually, except for a few wartime years, and has served several generations of R&D professionals, engineers, and students. Its aim has always been to provide broad coverage of all types of physical science data commonly encountered by scientists and engineers, with as much depth as can be accommodated in a one-volume format. The data contained in the *Handbook* have been carefully selected by experts in each field; quality control is a high priority and the sources are documented. The annual updates make it possible to add new and improved data in a timely fashion, and references to more detailed data sources have helped to establish the *Handbook* as the first place to look for physical and chemical data.

This edition also marks the retirement of the current Editor-in-Chief after 20 years in that post. The reception to the changes I have made in the book is very gratifying, and I greatly appreciate the suggestions that have come from the Editorial Board, the contributors, and many users. The new Editor will be W. M. “Mickey” Haynes, who has had long experience in providing physical and chemical data through the National Institute of Standards and Technology and through his service as Editor of the *International Journal of Thermophysics*. I am confident that he will continue the tradition of excellence the *Handbook* has achieved.

Many new tables and updates are included in the 90th Edition, especially in the following areas:

Fluid properties (Sec. 6) - new data over a wider temperature and pressure range for

- Water (including D<sub>2</sub>O) and steam
- Air
- Refrigerants and other important industrial fluids

Biochemistry (Sec. 7) – new tables on

- Enzyme catalyzed reactions
- Structure and functions of common drugs
- Chemical constituents of human blood

Analytical chemistry (Sec. 8) – new and expanded tables on

- Proton NMR shifts for solvents and other fluids
- Mass spectral peaks
- Nuclear moments and other data for NMR spectroscopy
- Aqueous solubility of organic compounds

Astronomy and geophysics (Sec. 14) – new data on

- Properties of the planets and their satellites
- Major world earthquakes, 850 AD to 2008
- Interstellar molecules

Other new and expanded tables

- International recommendations for the expression of uncertainty of measurements
- Description of the new IUPAC chemical identifier (InChI)
- Nobel prize winners in physics and chemistry
- Threshold limits for airborne contaminants

In addition to offering the full text of the print edition in searchable pdf format, this Internet Version 2010 presents the major tables of numerical data in the form of interactive tables that can

be sorted, filtered, and combined in various ways. Substances in these tables can be retrieved by searching on name, formula, CAS Registry Number, or chemical structure, and such a search can be combined with a request for a desired property. Thus one can request a specific property of a specific substance (for example, viscosity of benzene) and receive a customized table with exactly that information. In addition, the Internet version includes a section with pdf files of many older tables that have been removed from the print edition to make space for new material.

Suggestions on new topics for the *Handbook* and notification of errors are always appreciated. Input from users plays a key role in keeping the book up to date. Address all comments to Editor-in-Chief, *CRC Handbook of Chemistry and Physics*, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487.

The *Handbook of Chemistry and Physics* is dependent on the efforts of many contributors throughout the world. The list of current contributors follows this Preface. The assistance and support of Dr. Fiona Macdonald, Chemical and Biological Sciences Publisher for CRC Press/Taylor & Francis Books, is greatly appreciated. Finally, I want to thank Mimi Williams, Pam Morrell, Glen Butler, James Yanchak, and Theresa Delforn for their outstanding work in production of the book and Ronel Decius, Robert Morris, and Aviel Alkon for producing the Internet version.

**David R. Lide**  
**June 2009**

**The 90th Edition of the *Handbook of Chemistry and Physics* is dedicated to my wife,  
Bettijoyce Breen Lide, and to the members of my family  
David Alston Lide, Vanessa Lide Whitcomb and David Whitcomb, James Lide and Deborah  
Horowitz, Quentin Lide and Suzanne Romero, Neil and Lizzie Molino, and Van Molino  
and to my grandchildren  
David A. Lide, Jr., Mary Lide, Grace Lide, David A. Whitcomb, Kate Whitcomb, and  
Zoë Lide**

#### **How To Cite this Reference**

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## CURRENT CONTRIBUTORS

**Robert A. Alberty**

Department of Chemistry  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

**Lev I. Berger**

California Institute of Electronics and  
Materials Science  
2115 Flame Tree Way  
Hemet, California 92545

**A. K. Covington**

Department of Chemistry  
University of Newcastle  
Newcastle upon Tyne NE1 7RU  
England

**J. R. Fuhr**

Atomic Physics Division  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**J. Gmehling**

Universität Oldenburg  
Fakultät V, Technische Chemie  
D-26111 Oldenburg, Germany

**Robert N. Goldberg**

Biotechnology Division  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**Allan H. Harvey**

Thermophysical Properties Division  
National Institute of Standards and  
Technology  
Boulder, Colorado 80305

**Steven R. Heller**

Chemical and Biochemical Reference Data  
Division  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**Norman E. Holden**

National Nuclear Data Center  
Brookhaven National Laboratory  
Upton, New York 11973

**Henry V. Kehiaian**

7, Allée de la Caravelle  
94430 Chennevieres sur Marne  
France

**Carolyn A. Koh**

Center for Hydrate Research  
Colorado School of Mines  
1600 Illinois St.  
Golden, Colorado 80401

**Willem H. Koppenol**

Dept CHAB  
Lab. f. Anorg. Chemie, HCI H211  
Wolfgang-Pauli-Strasse 10  
ETH Hönggerberg  
CH-8093 Zürich, Switzerland

**Eric W. Lemmon**

Thermophysical Properties Division  
National Institute of Standards and  
Technology  
Boulder, Colorado 80305

**Frank J. Lovas**

8616 Melwood Rd.  
Bethesda, Maryland 20817

**Yu-Ran Luo**

School of Chemistry and Material Science  
University of Science and Technology of  
China  
Hefei 230026, China

**William C. Martin**

Atomic Physics Division  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**Alan D. McNaught**

8 Cavendish Avenue  
Cambridge CB1 7US  
England

**Thomas M. Miller**

Air Force Research Laboratory/VSBP  
29 Randolph Rd.  
Hanscom AFB, Massachusetts 01731-3010

**N. Moazzen-Ahmadi**

Department of Physics and Astronomy  
University of Calgary  
2500 University Drive NW  
Calgary, Alberta T2N 1N4, Canada

**Peter J. Mohr**

Physics Laboratory  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**I. Ozier**

Department of Physics and Astronomy  
University of British Columbia  
6224 Agricultural Road  
Vancouver, British Columbia V6T 1Z1,  
Canada

**Cedric J. Powell**

Surface and Microanalysis Science  
Division  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**Joseph Reader**

Atomic Physics Division  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**E. Dendy Sloan**

Center for Hydrate Research  
Colorado School of Mines  
1600 Illinois St.  
Golden, Colorado 80401

**Lewis E. Snyder**

Astronomy Department  
University of Illinois  
Urbana, Illinois 61801

**Barry N. Taylor**

Physics Laboratory  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**Petr Vanýsek**

Department of Chemistry  
Northern Illinois University  
DeKalb, Illinois 60115

**Wolfgang L. Wiese**

Atomic Physics Division  
National Institute of Standards and  
Technology  
Gaithersburg, Maryland 20899

**Christian Wohlfarth**

Martin Luther University  
Institute of Physical Chemistry  
Mühlpforte 1  
06108 Halle (Saale), Germany

**Daniel Zwillinger**

Mathematics Department  
Rensselaer Polytechnic Institute  
Troy, New York 12180

**Piotr Zyla**

Particle Data Group  
Lawrence Berkeley Laboratory  
Berkeley, California 94720

# CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS: 2006

Peter J. Mohr, Barry N. Taylor, and David B. Newell

These tables give the 2006 self-consistent set of values of the basic constants and conversion factors of physics and chemistry recommended by the Committee on Data for Science and Technology (CODATA) for international use. The 2006 adjustment takes into account the data considered in the 2002 adjustment as well as the data that became available between 31 December 2002, the closing date of that adjustment, and 31 December 2006, the closing date of the new adjustment. The new data has led to a significant reduction in the uncertainties of many recommended values. The 2006 set replaces the previously recommended 2002 CODATA set and may also be found on the World Wide Web at [physics.nist.gov/constants](http://physics.nist.gov/constants).

This report was prepared by the authors under the auspices of the CODATA Task Group on Fundamental Constants. The members of the task group are:

F. Cabiati, Istituto Nazionale di Ricerca Metrologica, Italy  
 K. Fujii, National Metrology Institute of Japan, Japan  
 S. G. Karshenboim, D. I. Mendeleyev All-Russian Research Institute for Metrology, Russian Federation  
 I. Lindgren, Chalmers University of Technology and Göteborg University, Sweden  
 B. A. Mamyrin (deceased), A. F. Ioffe Physical-Technical Institute, Russian Federation  
 W. Martienssen, Johann Wolfgang Goethe-Universität, Germany

P. J. Mohr, National Institute of Standards and Technology, United States of America  
 D. B. Newell, National Institute of Standards and Technology, United States of America  
 F. Nez, Laboratoire Kastler-Brossel, France  
 B. W. Petley, National Physical Laboratory, United Kingdom  
 T. J. Quinn, Bureau international des poids et mesures  
 B. N. Taylor, National Institute of Standards and Technology, United States of America  
 W. Wöger, Physikalisch-Technische Bundesanstalt, Germany  
 B. M. Wood, National Research Council, Canada  
 Z. Zhang, National Institute of Metrology, China (People's Republic of)

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2. Yao, W. M., et al., *J. Phys. G* **33**, 1, 2006.

TABLE I: An abbreviated list of the CODATA recommended values of the fundamental constants of physics and chemistry based on the 2006 adjustment.

| Quantity                                            | Symbol        | Numerical value                                               | Unit                                      | Relative std. uncert. $u_r$ |
|-----------------------------------------------------|---------------|---------------------------------------------------------------|-------------------------------------------|-----------------------------|
| speed of light in vacuum                            | $c, c_0$      | 299 792 458                                                   | $\text{m s}^{-1}$                         | (exact)                     |
| magnetic constant                                   | $\mu_0$       | $4\pi \times 10^{-7}$<br>$= 12.566 370 614... \times 10^{-7}$ | $\text{N A}^{-2}$<br>$\text{N A}^{-2}$    | (exact)                     |
| electric constant $1/\mu_0 c^2$                     | $\epsilon_0$  | $8.854 187 817... \times 10^{-12}$                            | $\text{F m}^{-1}$                         | (exact)                     |
| Newtonian constant of gravitation                   | $G$           | $6.674 28(67) \times 10^{-11}$                                | $\text{m}^3 \text{kg}^{-1} \text{s}^{-2}$ | $1.0 \times 10^{-4}$        |
| Planck constant                                     | $h$           | $6.626 068 96(33) \times 10^{-34}$                            | $\text{J s}$                              | $5.0 \times 10^{-8}$        |
| $h/2\pi$                                            | $\hbar$       | $1.054 571 628(53) \times 10^{-34}$                           | $\text{J s}$                              | $5.0 \times 10^{-8}$        |
| elementary charge                                   | $e$           | $1.602 176 487(40) \times 10^{-19}$                           | $\text{C}$                                | $2.5 \times 10^{-8}$        |
| magnetic flux quantum $h/2e$                        | $\Phi_0$      | $2.067 833 667(52) \times 10^{-15}$                           | $\text{Wb}$                               | $2.5 \times 10^{-8}$        |
| conductance quantum $2e^2/h$                        | $G_0$         | $7.748 091 7004(53) \times 10^{-5}$                           | $\text{S}$                                | $6.8 \times 10^{-10}$       |
| electron mass                                       | $m_e$         | $9.109 382 15(45) \times 10^{-31}$                            | $\text{kg}$                               | $5.0 \times 10^{-8}$        |
| proton mass                                         | $m_p$         | $1.672 621 637(83) \times 10^{-27}$                           | $\text{kg}$                               | $5.0 \times 10^{-8}$        |
| proton-electron mass ratio                          | $m_p/m_e$     | 1836.152 672 47(80)                                           |                                           | $4.3 \times 10^{-10}$       |
| fine-structure constant $e^2/4\pi\epsilon_0\hbar c$ | $\alpha$      | $7.297 352 5376(50) \times 10^{-3}$                           |                                           | $6.8 \times 10^{-10}$       |
| inverse fine-structure constant                     | $\alpha^{-1}$ | 137.035 999 679(94)                                           |                                           | $6.8 \times 10^{-10}$       |
| Rydberg constant $\alpha^2 m_e c/2\hbar$            | $R_\infty$    | 10 973 731.568 527(73)                                        | $\text{m}^{-1}$                           | $6.6 \times 10^{-12}$       |
| Avogadro constant                                   | $N_A, L$      | $6.022 141 79(30) \times 10^{23}$                             | $\text{mol}^{-1}$                         | $5.0 \times 10^{-8}$        |

TABLE I: (Continued.)

| Quantity                                                                          | Symbol   | Numerical value                       | Unit                                | Relative std. uncert. $u_r$ |
|-----------------------------------------------------------------------------------|----------|---------------------------------------|-------------------------------------|-----------------------------|
| Faraday constant $N_A e$                                                          | $F$      | 96 485.3399(24)                       | C mol <sup>-1</sup>                 | $2.5 \times 10^{-8}$        |
| molar gas constant                                                                | $R$      | 8.314 472(15)                         | J mol <sup>-1</sup> K <sup>-1</sup> | $1.7 \times 10^{-6}$        |
| Boltzmann constant $R/N_A$                                                        | $k$      | $1.380\,6504(24) \times 10^{-23}$     | J K <sup>-1</sup>                   | $1.7 \times 10^{-6}$        |
| Stefan-Boltzmann constant $(\pi^2/60)k^4/\hbar^3 c^2$                             | $\sigma$ | $5.670\,400(40) \times 10^{-8}$       | W m <sup>-2</sup> K <sup>-4</sup>   | $7.0 \times 10^{-6}$        |
| <i>Non-SI units accepted for use with the SI</i>                                  |          |                                       |                                     |                             |
| electron volt: $(e/C)$ J                                                          | eV       | $1.602\,176\,487(40) \times 10^{-19}$ | J                                   | $2.5 \times 10^{-8}$        |
| (unified) atomic mass unit                                                        |          |                                       |                                     |                             |
| 1 u = $m_u = \frac{1}{12}m(^{12}\text{C}) = 10^{-3}$ kg mol <sup>-1</sup> / $N_A$ | u        | $1.660\,538\,782(83) \times 10^{-27}$ | kg                                  | $5.0 \times 10^{-8}$        |

TABLE II: The CODATA recommended values of the fundamental constants of physics and chemistry based on the 2006 adjustment.

| Quantity                                                                  | Symbol             | Numerical value                                                               | Unit                                                                                   | Relative std. uncert. $u_r$                  |
|---------------------------------------------------------------------------|--------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------|
| UNIVERSAL                                                                 |                    |                                                                               |                                                                                        |                                              |
| speed of light in vacuum                                                  | $c, c_0$           | 299 792 458                                                                   | m s <sup>-1</sup>                                                                      | (exact)                                      |
| magnetic constant                                                         | $\mu_0$            | $4\pi \times 10^{-7}$<br>$= 12.566\,370\,614... \times 10^{-7}$               | N A <sup>-2</sup>                                                                      | (exact)                                      |
| electric constant $1/\mu_0 c^2$                                           | $\epsilon_0$       | $8.854\,187\,817... \times 10^{-12}$                                          | F m <sup>-1</sup>                                                                      | (exact)                                      |
| characteristic impedance<br>of vacuum $\sqrt{\mu_0/\epsilon_0} = \mu_0 c$ | $Z_0$              | 376.730 313 461...                                                            | $\Omega$                                                                               | (exact)                                      |
| Newtonian constant<br>of gravitation                                      | $G$<br>$G/\hbar c$ | $6.674\,28(67) \times 10^{-11}$<br>$6.708\,81(67) \times 10^{-39}$            | m <sup>3</sup> kg <sup>-1</sup> s <sup>-2</sup><br>(GeV/c <sup>2</sup> ) <sup>-2</sup> | $1.0 \times 10^{-4}$<br>$1.0 \times 10^{-4}$ |
| Planck constant                                                           | $h$                | $6.626\,068\,96(33) \times 10^{-34}$                                          | J s                                                                                    | $5.0 \times 10^{-8}$                         |
| in eV s                                                                   |                    | $4.135\,667\,33(10) \times 10^{-15}$                                          | eV s                                                                                   | $2.5 \times 10^{-8}$                         |
| $\hbar/2\pi$                                                              | $\hbar$            | $1.054\,571\,628(53) \times 10^{-34}$                                         | J s                                                                                    | $5.0 \times 10^{-8}$                         |
| in eV s                                                                   |                    | $6.582\,118\,99(16) \times 10^{-16}$                                          | eV s                                                                                   | $2.5 \times 10^{-8}$                         |
| $\hbar c$ in MeV fm                                                       |                    | 197.326 9631(49)                                                              | MeV fm                                                                                 | $2.5 \times 10^{-8}$                         |
| Planck mass $(\hbar c/G)^{1/2}$                                           | $m_P$              | $2.176\,44(11) \times 10^{-8}$                                                | kg                                                                                     | $5.0 \times 10^{-5}$                         |
| energy equivalent in GeV                                                  | $m_P c^2$          | $1.220\,892(61) \times 10^{19}$                                               | GeV                                                                                    | $5.0 \times 10^{-5}$                         |
| Planck temperature $(\hbar c^5/G)^{1/2}/k$                                | $T_P$              | $1.416\,785(71) \times 10^{32}$                                               | K                                                                                      | $5.0 \times 10^{-5}$                         |
| Planck length $\hbar/m_P c = (\hbar G/c^3)^{1/2}$                         | $l_P$              | $1.616\,252(81) \times 10^{-35}$                                              | m                                                                                      | $5.0 \times 10^{-5}$                         |
| Planck time $l_P/c = (\hbar G/c^5)^{1/2}$                                 | $t_P$              | $5.391\,24(27) \times 10^{-44}$                                               | s                                                                                      | $5.0 \times 10^{-5}$                         |
| ELECTROMAGNETIC                                                           |                    |                                                                               |                                                                                        |                                              |
| elementary charge                                                         | $e$<br>$e/h$       | $1.602\,176\,487(40) \times 10^{-19}$<br>$2.417\,989\,454(60) \times 10^{14}$ | C<br>A J <sup>-1</sup>                                                                 | $2.5 \times 10^{-8}$<br>$2.5 \times 10^{-8}$ |
| magnetic flux quantum $h/2e$                                              | $\Phi_0$           | $2.067\,833\,667(52) \times 10^{-15}$                                         | Wb                                                                                     | $2.5 \times 10^{-8}$                         |
| conductance quantum $2e^2/h$                                              | $G_0$              | $7.748\,091\,7004(53) \times 10^{-5}$                                         | S                                                                                      | $6.8 \times 10^{-10}$                        |
| inverse of conductance quantum                                            | $G_0^{-1}$         | 12 906.403 7787(88)                                                           | $\Omega$                                                                               | $6.8 \times 10^{-10}$                        |
| Josephson constant <sup>1</sup> $2e/h$                                    | $K_J$              | $483\,597.891(12) \times 10^9$                                                | Hz V <sup>-1</sup>                                                                     | $2.5 \times 10^{-8}$                         |
| von Klitzing constant <sup>2</sup><br>$h/e^2 = \mu_0 c/2\alpha$           | $R_K$              | 25 812.807 557(18)                                                            | $\Omega$                                                                               | $6.8 \times 10^{-10}$                        |
| Bohr magneton $e\hbar/2m_e$                                               | $\mu_B$            | $927.400\,915(23) \times 10^{-26}$                                            | J T <sup>-1</sup>                                                                      | $2.5 \times 10^{-8}$                         |
| in eV T <sup>-1</sup>                                                     |                    | $5.788\,381\,7555(79) \times 10^{-5}$                                         | eV T <sup>-1</sup>                                                                     | $1.4 \times 10^{-9}$                         |
|                                                                           | $\mu_B/h$          | $13.996\,246\,04(35) \times 10^9$                                             | Hz T <sup>-1</sup>                                                                     | $2.5 \times 10^{-8}$                         |

<sup>1</sup>See Table IV for the conventional value adopted internationally for realizing representations of the volt using the Josephson effect.<sup>2</sup>See Table IV for the conventional value adopted internationally for realizing representations of the ohm using the quantum Hall effect.

TABLE II: (Continued).

| Quantity                                                                                                          | Symbol              | Numerical value                           | Unit                          | Relative std. uncert. $u_r$ |
|-------------------------------------------------------------------------------------------------------------------|---------------------|-------------------------------------------|-------------------------------|-----------------------------|
|                                                                                                                   | $\mu_B/\hbar c$     | 46.686 4515(12)                           | $\text{m}^{-1} \text{T}^{-1}$ | $2.5 \times 10^{-8}$        |
|                                                                                                                   | $\mu_B/k$           | 0.671 7131(12)                            | $\text{K T}^{-1}$             | $1.7 \times 10^{-6}$        |
| nuclear magneton $e\hbar/2m_p$<br>in $\text{eV T}^{-1}$                                                           | $\mu_N$             | $5.050\,783\,24(13) \times 10^{-27}$      | $\text{J T}^{-1}$             | $2.5 \times 10^{-8}$        |
|                                                                                                                   |                     | $3.152\,451\,2326(45) \times 10^{-8}$     | $\text{eV T}^{-1}$            | $1.4 \times 10^{-9}$        |
|                                                                                                                   | $\mu_N/\hbar$       | 7.622 593 84(19)                          | $\text{MHz T}^{-1}$           | $2.5 \times 10^{-8}$        |
|                                                                                                                   | $\mu_N/\hbar c$     | $2.542\,623\,616(64) \times 10^{-2}$      | $\text{m}^{-1} \text{T}^{-1}$ | $2.5 \times 10^{-8}$        |
|                                                                                                                   | $\mu_N/k$           | $3.658\,2637(64) \times 10^{-4}$          | $\text{K T}^{-1}$             | $1.7 \times 10^{-6}$        |
| <b>ATOMIC AND NUCLEAR</b>                                                                                         |                     |                                           |                               |                             |
| <b>General</b>                                                                                                    |                     |                                           |                               |                             |
| fine-structure constant $e^2/4\pi\epsilon_0\hbar c$<br>inverse fine-structure constant                            | $\alpha$            | $7.297\,352\,5376(50) \times 10^{-3}$     |                               | $6.8 \times 10^{-10}$       |
|                                                                                                                   | $\alpha^{-1}$       | 137.035 999 679(94)                       |                               | $6.8 \times 10^{-10}$       |
| Rydberg constant $\alpha^2 m_e c/2\hbar$                                                                          | $R_\infty$          | 10 973 731.568 527(73)                    | $\text{m}^{-1}$               | $6.6 \times 10^{-12}$       |
|                                                                                                                   | $R_\infty c$        | $3.289\,841\,960\,361(22) \times 10^{15}$ | Hz                            | $6.6 \times 10^{-12}$       |
|                                                                                                                   | $R_\infty \hbar c$  | $2.179\,871\,97(11) \times 10^{-18}$      | J                             | $5.0 \times 10^{-8}$        |
| $R_\infty \hbar c$ in eV                                                                                          |                     | 13.605 691 93(34)                         | eV                            | $2.5 \times 10^{-8}$        |
| Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2$                                                | $a_0$               | $0.529\,177\,208\,59(36) \times 10^{-10}$ | m                             | $6.8 \times 10^{-10}$       |
| Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2 R_\infty \hbar c$<br>$= \alpha^2 m_e c^2$<br>in eV                     | $E_h$               | $4.359\,743\,94(22) \times 10^{-18}$      | J                             | $5.0 \times 10^{-8}$        |
|                                                                                                                   |                     | 27.211 383 86(68)                         | eV                            | $2.5 \times 10^{-8}$        |
| quantum of circulation                                                                                            | $\hbar/2m_e$        | $3.636\,947\,5199(50) \times 10^{-4}$     | $\text{m}^2 \text{s}^{-1}$    | $1.4 \times 10^{-9}$        |
|                                                                                                                   | $\hbar/m_e$         | $7.273\,895\,040(10) \times 10^{-4}$      | $\text{m}^2 \text{s}^{-1}$    | $1.4 \times 10^{-9}$        |
| <b>Electroweak</b>                                                                                                |                     |                                           |                               |                             |
| Fermi coupling constant <sup>3</sup>                                                                              | $G_F/(\hbar c)^3$   | $1.166\,37(1) \times 10^{-5}$             | $\text{GeV}^{-2}$             | $8.6 \times 10^{-6}$        |
| weak mixing angle <sup>4</sup> $\theta_W$ (on-shell scheme)<br>$\sin^2 \theta_W = s_W^2 \equiv 1 - (m_W/m_Z)^2$   | $\sin^2 \theta_W$   | 0.222 55(56)                              |                               | $2.5 \times 10^{-3}$        |
| <b>Electron, <math>e^-</math></b>                                                                                 |                     |                                           |                               |                             |
| electron mass<br>in u, $m_e = A_r(e)$ u (electron<br>relative atomic mass times u)<br>energy equivalent<br>in MeV | $m_e$               | $9.109\,382\,15(45) \times 10^{-31}$      | kg                            | $5.0 \times 10^{-8}$        |
|                                                                                                                   |                     | $5.485\,799\,0943(23) \times 10^{-4}$     | u                             | $4.2 \times 10^{-10}$       |
|                                                                                                                   | $m_e c^2$           | $8.187\,104\,38(41) \times 10^{-14}$      | J                             | $5.0 \times 10^{-8}$        |
|                                                                                                                   |                     | 0.510 998 910(13)                         | MeV                           | $2.5 \times 10^{-8}$        |
| electron-muon mass ratio                                                                                          | $m_e/m_\mu$         | $4.836\,331\,71(12) \times 10^{-3}$       |                               | $2.5 \times 10^{-8}$        |
| electron-tau mass ratio                                                                                           | $m_e/m_\tau$        | $2.875\,64(47) \times 10^{-4}$            |                               | $1.6 \times 10^{-4}$        |
| electron-proton mass ratio                                                                                        | $m_e/m_p$           | $5.446\,170\,2177(24) \times 10^{-4}$     |                               | $4.3 \times 10^{-10}$       |
| electron-neutron mass ratio                                                                                       | $m_e/m_n$           | $5.438\,673\,4459(33) \times 10^{-4}$     |                               | $6.0 \times 10^{-10}$       |
| electron-deuteron mass ratio                                                                                      | $m_e/m_d$           | $2.724\,437\,1093(12) \times 10^{-4}$     |                               | $4.3 \times 10^{-10}$       |
| electron to alpha particle mass ratio                                                                             | $m_e/m_\alpha$      | $1.370\,933\,555\,70(58) \times 10^{-4}$  |                               | $4.2 \times 10^{-10}$       |
| electron charge to mass quotient                                                                                  | $-e/m_e$            | $-1.758\,820\,150(44) \times 10^{11}$     | $\text{C kg}^{-1}$            | $2.5 \times 10^{-8}$        |
| electron molar mass $N_A m_e$                                                                                     | $M(e), M_e$         | $5.485\,799\,0943(23) \times 10^{-7}$     | $\text{kg mol}^{-1}$          | $4.2 \times 10^{-10}$       |
| Compton wavelength $\hbar/m_e c$                                                                                  | $\lambda_C$         | $2.426\,310\,2175(33) \times 10^{-12}$    | m                             | $1.4 \times 10^{-9}$        |
| $\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$                                                            | $\tilde{\lambda}_C$ | $386.159\,264\,59(53) \times 10^{-15}$    | m                             | $1.4 \times 10^{-9}$        |
| classical electron radius $\alpha^2 a_0$                                                                          | $r_e$               | $2.817\,940\,2894(58) \times 10^{-15}$    | m                             | $2.1 \times 10^{-9}$        |
| Thomson cross section $(8\pi/3)r_e^2$                                                                             | $\sigma_e$          | $0.665\,245\,8558(27) \times 10^{-28}$    | $\text{m}^2$                  | $4.1 \times 10^{-9}$        |

<sup>3</sup>Value recommended by the Particle Data Group (Yao *et al.*, 2006).<sup>4</sup>Based on the ratio of the masses of the W and Z bosons  $m_W/m_Z$  recommended by the Particle Data Group (Yao *et al.*, 2006). The value for  $\sin^2 \theta_W$  they recommend, which is based on a particular variant of the modified minimal subtraction ( $\overline{\text{MS}}$ ) scheme, is  $\sin^2 \hat{\theta}_W(M_Z) = 0.231\,22(15)$ .



TABLE II: (Continued).

| Quantity                                                                           | Symbol                    | Numerical value                          | Unit                            | Relative std. uncert. $u_r$ |
|------------------------------------------------------------------------------------|---------------------------|------------------------------------------|---------------------------------|-----------------------------|
| electron magnetic moment                                                           | $\mu_e$                   | $-928.476\,377(23) \times 10^{-26}$      | J T <sup>-1</sup>               | $2.5 \times 10^{-8}$        |
| to Bohr magneton ratio                                                             | $\mu_e/\mu_B$             | $-1.001\,159\,652\,181\,11(74)$          |                                 | $7.4 \times 10^{-13}$       |
| to nuclear magneton ratio                                                          | $\mu_e/\mu_N$             | $-1838.281\,970\,92(80)$                 |                                 | $4.3 \times 10^{-10}$       |
| electron magnetic moment anomaly $ \mu_e /\mu_B - 1$                               | $a_e$                     | $1.159\,652\,181\,11(74) \times 10^{-3}$ |                                 | $6.4 \times 10^{-10}$       |
| electron $g$ -factor $-2(1 + a_e)$                                                 | $g_e$                     | $-2.002\,319\,304\,3622(15)$             |                                 | $7.4 \times 10^{-13}$       |
| electron-muon magnetic moment ratio                                                | $\mu_e/\mu_\mu$           | $206.766\,9877(52)$                      |                                 | $2.5 \times 10^{-8}$        |
| electron-proton magnetic moment ratio                                              | $\mu_e/\mu_p$             | $-658.210\,6848(54)$                     |                                 | $8.1 \times 10^{-9}$        |
| electron to shielded proton magnetic moment ratio (H <sub>2</sub> O, sphere, 25°C) | $\mu_e/\mu'_p$            | $-658.227\,5971(72)$                     |                                 | $1.1 \times 10^{-8}$        |
| electron-neutron magnetic moment ratio                                             | $\mu_e/\mu_n$             | $960.920\,50(23)$                        |                                 | $2.4 \times 10^{-7}$        |
| electron-deuteron magnetic moment ratio                                            | $\mu_e/\mu_d$             | $-2143.923\,498(18)$                     |                                 | $8.4 \times 10^{-9}$        |
| electron to shielded helion magnetic moment ratio (gas, sphere, 25°C)              | $\mu_e/\mu'_h$            | $864.058\,257(10)$                       |                                 | $1.2 \times 10^{-8}$        |
| electron gyromagnetic ratio $2 \mu_e /\hbar$                                       | $\gamma_e$                | $1.760\,859\,770(44) \times 10^{11}$     | s <sup>-1</sup> T <sup>-1</sup> | $2.5 \times 10^{-8}$        |
|                                                                                    | $\gamma_e/2\pi$           | $28\,024.953\,64(70)$                    | MHz T <sup>-1</sup>             | $2.5 \times 10^{-8}$        |
| <b>Muon, <math>\mu^-</math></b>                                                    |                           |                                          |                                 |                             |
| muon mass                                                                          | $m_\mu$                   | $1.883\,531\,30(11) \times 10^{-28}$     | kg                              | $5.6 \times 10^{-8}$        |
| in u, $m_\mu = A_r(\mu)$ u (muon relative atomic mass times u)                     |                           | $0.113\,428\,9256(29)$                   | u                               | $2.5 \times 10^{-8}$        |
| energy equivalent                                                                  | $m_\mu c^2$               | $1.692\,833\,510(95) \times 10^{-11}$    | J                               | $5.6 \times 10^{-8}$        |
| in MeV                                                                             |                           | $105.658\,3668(38)$                      | MeV                             | $3.6 \times 10^{-8}$        |
| muon-electron mass ratio                                                           | $m_\mu/m_e$               | $206.768\,2823(52)$                      |                                 | $2.5 \times 10^{-8}$        |
| muon-tau mass ratio                                                                | $m_\mu/m_\tau$            | $5.945\,92(97) \times 10^{-2}$           |                                 | $1.6 \times 10^{-4}$        |
| muon-proton mass ratio                                                             | $m_\mu/m_p$               | $0.112\,609\,5261(29)$                   |                                 | $2.5 \times 10^{-8}$        |
| muon-neutron mass ratio                                                            | $m_\mu/m_n$               | $0.112\,454\,5167(29)$                   |                                 | $2.5 \times 10^{-8}$        |
| muon molar mass $N_A m_\mu$                                                        | $M(\mu), M_\mu$           | $0.113\,428\,9256(29) \times 10^{-3}$    | kg mol <sup>-1</sup>            | $2.5 \times 10^{-8}$        |
| muon Compton wavelength $\hbar/m_\mu c$                                            | $\lambda_{C,\mu}$         | $11.734\,441\,04(30) \times 10^{-15}$    | m                               | $2.5 \times 10^{-8}$        |
| $\lambda_{C,\mu}/2\pi$                                                             | $\tilde{\lambda}_{C,\mu}$ | $1.867\,594\,295(47) \times 10^{-15}$    | m                               | $2.5 \times 10^{-8}$        |
| muon magnetic moment                                                               | $\mu_\mu$                 | $-4.490\,447\,86(16) \times 10^{-26}$    | J T <sup>-1</sup>               | $3.6 \times 10^{-8}$        |
| to Bohr magneton ratio                                                             | $\mu_\mu/\mu_B$           | $-4.841\,970\,49(12) \times 10^{-3}$     |                                 | $2.5 \times 10^{-8}$        |
| to nuclear magneton ratio                                                          | $\mu_\mu/\mu_N$           | $-8.890\,597\,05(23)$                    |                                 | $2.5 \times 10^{-8}$        |
| muon magnetic moment anomaly $ \mu_\mu /(e\hbar/2m_\mu) - 1$                       | $a_\mu$                   | $1.165\,920\,69(60) \times 10^{-3}$      |                                 | $5.2 \times 10^{-7}$        |
| muon $g$ -factor $-2(1 + a_\mu)$                                                   | $g_\mu$                   | $-2.002\,331\,8414(12)$                  |                                 | $6.0 \times 10^{-10}$       |
| muon-proton magnetic moment ratio                                                  | $\mu_\mu/\mu_p$           | $-3.183\,345\,137(85)$                   |                                 | $2.7 \times 10^{-8}$        |
| <b>Tau, <math>\tau^-</math></b>                                                    |                           |                                          |                                 |                             |
| tau mass <sup>5</sup>                                                              | $m_\tau$                  | $3.167\,77(52) \times 10^{-27}$          | kg                              | $1.6 \times 10^{-4}$        |
| in u, $m_\tau = A_r(\tau)$ u (tau relative atomic mass times u)                    |                           | $1.907\,68(31)$                          | u                               | $1.6 \times 10^{-4}$        |

<sup>5</sup>This and all other values involving  $m_\tau$  are based on the value of  $m_\tau c^2$  in MeV recommended by the Particle Data Group (Yao *et al.*, 2006), but with a standard uncertainty of 0.29 MeV rather than the quoted uncertainty of  $-0.26$  MeV,  $+0.29$  MeV.

TABLE II: (Continued).

| Quantity                                                                                       | Symbol                     | Numerical value                                | Unit                            | Relative std. uncert. $u_r$                  |
|------------------------------------------------------------------------------------------------|----------------------------|------------------------------------------------|---------------------------------|----------------------------------------------|
| energy equivalent<br>in MeV                                                                    | $m_\tau c^2$               | $2.847\,05(46) \times 10^{-10}$<br>1776.99(29) | J<br>MeV                        | $1.6 \times 10^{-4}$<br>$1.6 \times 10^{-4}$ |
| tau-electron mass ratio                                                                        | $m_\tau/m_e$               | 3477.48(57)                                    |                                 | $1.6 \times 10^{-4}$                         |
| tau-muon mass ratio                                                                            | $m_\tau/m_\mu$             | 16.8183(27)                                    |                                 | $1.6 \times 10^{-4}$                         |
| tau-proton mass ratio                                                                          | $m_\tau/m_p$               | 1.893 90(31)                                   |                                 | $1.6 \times 10^{-4}$                         |
| tau-neutron mass ratio                                                                         | $m_\tau/m_n$               | 1.891 29(31)                                   |                                 | $1.6 \times 10^{-4}$                         |
| tau molar mass $N_A m_\tau$                                                                    | $M(\tau), M_\tau$          | $1.907\,68(31) \times 10^{-3}$                 | kg mol <sup>-1</sup>            | $1.6 \times 10^{-4}$                         |
| tau Compton wavelength $h/m_\tau c$                                                            | $\lambda_{C,\tau}$         | $0.697\,72(11) \times 10^{-15}$                | m                               | $1.6 \times 10^{-4}$                         |
| $\lambda_{C,\tau}/2\pi$                                                                        | $\tilde{\lambda}_{C,\tau}$ | $0.111\,046(18) \times 10^{-15}$               | m                               | $1.6 \times 10^{-4}$                         |
| <b>Proton, p</b>                                                                               |                            |                                                |                                 |                                              |
| proton mass                                                                                    | $m_p$                      | $1.672\,621\,637(83) \times 10^{-27}$          | kg                              | $5.0 \times 10^{-8}$                         |
| in u, $m_p = A_r(p)$ u (proton<br>relative atomic mass times u)                                |                            | 1.007 276 466 77(10)                           | u                               | $1.0 \times 10^{-10}$                        |
| energy equivalent                                                                              | $m_p c^2$                  | $1.503\,277\,359(75) \times 10^{-10}$          | J                               | $5.0 \times 10^{-8}$                         |
| in MeV                                                                                         |                            | 938.272 013(23)                                | MeV                             | $2.5 \times 10^{-8}$                         |
| proton-electron mass ratio                                                                     | $m_p/m_e$                  | 1836.152 672 47(80)                            |                                 | $4.3 \times 10^{-10}$                        |
| proton-muon mass ratio                                                                         | $m_p/m_\mu$                | 8.880 243 39(23)                               |                                 | $2.5 \times 10^{-8}$                         |
| proton-tau mass ratio                                                                          | $m_p/m_\tau$               | 0.528 012(86)                                  |                                 | $1.6 \times 10^{-4}$                         |
| proton-neutron mass ratio                                                                      | $m_p/m_n$                  | 0.998 623 478 24(46)                           |                                 | $4.6 \times 10^{-10}$                        |
| proton charge to mass quotient                                                                 | $e/m_p$                    | $9.578\,833\,92(24) \times 10^7$               | C kg <sup>-1</sup>              | $2.5 \times 10^{-8}$                         |
| proton molar mass $N_A m_p$                                                                    | $M(p), M_p$                | $1.007\,276\,466\,77(10) \times 10^{-3}$       | kg mol <sup>-1</sup>            | $1.0 \times 10^{-10}$                        |
| proton Compton wavelength $h/m_p c$                                                            | $\lambda_{C,p}$            | $1.321\,409\,8446(19) \times 10^{-15}$         | m                               | $1.4 \times 10^{-9}$                         |
| $\lambda_{C,p}/2\pi$                                                                           | $\tilde{\lambda}_{C,p}$    | $0.210\,308\,908\,61(30) \times 10^{-15}$      | m                               | $1.4 \times 10^{-9}$                         |
| proton rms charge radius                                                                       | $R_p$                      | $0.8768(69) \times 10^{-15}$                   | m                               | $7.8 \times 10^{-3}$                         |
| proton magnetic moment                                                                         | $\mu_p$                    | $1.410\,606\,662(37) \times 10^{-26}$          | J T <sup>-1</sup>               | $2.6 \times 10^{-8}$                         |
| to Bohr magneton ratio                                                                         | $\mu_p/\mu_B$              | $1.521\,032\,209(12) \times 10^{-3}$           |                                 | $8.1 \times 10^{-9}$                         |
| to nuclear magneton ratio                                                                      | $\mu_p/\mu_N$              | 2.792 847 356(23)                              |                                 | $8.2 \times 10^{-9}$                         |
| proton $g$ -factor $2\mu_p/\mu_N$                                                              | $g_p$                      | 5.585 694 713(46)                              |                                 | $8.2 \times 10^{-9}$                         |
| proton-neutron<br>magnetic moment ratio                                                        | $\mu_p/\mu_n$              | -1.459 898 06(34)                              |                                 | $2.4 \times 10^{-7}$                         |
| shielded proton magnetic moment<br>(H <sub>2</sub> O, sphere, 25°C)                            | $\mu'_p$                   | $1.410\,570\,419(38) \times 10^{-26}$          | J T <sup>-1</sup>               | $2.7 \times 10^{-8}$                         |
| to Bohr magneton ratio                                                                         | $\mu'_p/\mu_B$             | $1.520\,993\,128(17) \times 10^{-3}$           |                                 | $1.1 \times 10^{-8}$                         |
| to nuclear magneton ratio                                                                      | $\mu'_p/\mu_N$             | 2.792 775 598(30)                              |                                 | $1.1 \times 10^{-8}$                         |
| proton magnetic shielding<br>correction $1 - \mu'_p/\mu_p$<br>(H <sub>2</sub> O, sphere, 25°C) | $\sigma'_p$                | $25.694(14) \times 10^{-6}$                    |                                 | $5.3 \times 10^{-4}$                         |
| proton gyromagnetic ratio $2\mu_p/\hbar$                                                       | $\gamma_p$                 | $2.675\,222\,099(70) \times 10^8$              | s <sup>-1</sup> T <sup>-1</sup> | $2.6 \times 10^{-8}$                         |
|                                                                                                | $\gamma_p/2\pi$            | 42.577 4821(11)                                | MHz T <sup>-1</sup>             | $2.6 \times 10^{-8}$                         |
| shielded proton gyromagnetic<br>ratio $2\mu'_p/\hbar$<br>(H <sub>2</sub> O, sphere, 25°C)      | $\gamma'_p$                | $2.675\,153\,362(73) \times 10^8$              | s <sup>-1</sup> T <sup>-1</sup> | $2.7 \times 10^{-8}$                         |
|                                                                                                | $\gamma'_p/2\pi$           | 42.576 3881(12)                                | MHz T <sup>-1</sup>             | $2.7 \times 10^{-8}$                         |
| <b>Neutron, n</b>                                                                              |                            |                                                |                                 |                                              |
| neutron mass                                                                                   | $m_n$                      | $1.674\,927\,211(84) \times 10^{-27}$          | kg                              | $5.0 \times 10^{-8}$                         |
| in u, $m_n = A_r(n)$ u (neutron<br>relative atomic mass times u)                               |                            | 1.008 664 915 97(43)                           | u                               | $4.3 \times 10^{-10}$                        |
| energy equivalent                                                                              | $m_n c^2$                  | $1.505\,349\,505(75) \times 10^{-10}$          | J                               | $5.0 \times 10^{-8}$                         |
| in MeV                                                                                         |                            | 939.565 346(23)                                | MeV                             | $2.5 \times 10^{-8}$                         |
| neutron-electron mass ratio                                                                    | $m_n/m_e$                  | 1838.683 6605(11)                              |                                 | $6.0 \times 10^{-10}$                        |

TABLE II: (Continued).

| Quantity                                    | Symbol                  | Numerical value                        | Unit                            | Relative std. uncert. $u_r$ |
|---------------------------------------------|-------------------------|----------------------------------------|---------------------------------|-----------------------------|
| neutron-muon mass ratio                     | $m_n/m_\mu$             | 8.892 484 09(23)                       |                                 | $2.5 \times 10^{-8}$        |
| neutron-tau mass ratio                      | $m_n/m_\tau$            | 0.528 740(86)                          |                                 | $1.6 \times 10^{-4}$        |
| neutron-proton mass ratio                   | $m_n/m_p$               | 1.001 378 419 18(46)                   |                                 | $4.6 \times 10^{-10}$       |
| neutron molar mass $N_A m_n$                | $M(n), M_n$             | $1.008 664 915 97(43) \times 10^{-3}$  | kg mol <sup>-1</sup>            | $4.3 \times 10^{-10}$       |
| neutron Compton wavelength $h/m_n c$        | $\lambda_{C,n}$         | $1.319 590 8951(20) \times 10^{-15}$   | m                               | $1.5 \times 10^{-9}$        |
| $\lambda_{C,n}/2\pi$                        | $\tilde{\lambda}_{C,n}$ | $0.210 019 413 82(31) \times 10^{-15}$ | m                               | $1.5 \times 10^{-9}$        |
| neutron magnetic moment                     | $\mu_n$                 | $-0.966 236 41(23) \times 10^{-26}$    | J T <sup>-1</sup>               | $2.4 \times 10^{-7}$        |
| to Bohr magneton ratio                      | $\mu_n/\mu_B$           | $-1.041 875 63(25) \times 10^{-3}$     |                                 | $2.4 \times 10^{-7}$        |
| to nuclear magneton ratio                   | $\mu_n/\mu_N$           | -1.913 042 73(45)                      |                                 | $2.4 \times 10^{-7}$        |
| neutron $g$ -factor $2\mu_n/\mu_N$          | $g_n$                   | -3.826 085 45(90)                      |                                 | $2.4 \times 10^{-7}$        |
| neutron-electron                            |                         |                                        |                                 |                             |
| magnetic moment ratio                       | $\mu_n/\mu_e$           | $1.040 668 82(25) \times 10^{-3}$      |                                 | $2.4 \times 10^{-7}$        |
| neutron-proton                              |                         |                                        |                                 |                             |
| magnetic moment ratio                       | $\mu_n/\mu_p$           | -0.684 979 34(16)                      |                                 | $2.4 \times 10^{-7}$        |
| neutron to shielded proton                  |                         |                                        |                                 |                             |
| magnetic moment ratio                       | $\mu_n/\mu'_p$          | -0.684 996 94(16)                      |                                 | $2.4 \times 10^{-7}$        |
| (H <sub>2</sub> O, sphere, 25°C)            |                         |                                        |                                 |                             |
| neutron gyromagnetic ratio $2 \mu_n /\hbar$ | $\gamma_n$              | $1.832 471 85(43) \times 10^8$         | s <sup>-1</sup> T <sup>-1</sup> | $2.4 \times 10^{-7}$        |
|                                             | $\gamma_n/2\pi$         | 29.164 6954(69)                        | MHz T <sup>-1</sup>             | $2.4 \times 10^{-7}$        |
| <b>Deuteron, d</b>                          |                         |                                        |                                 |                             |
| deuteron mass                               | $m_d$                   | $3.343 583 20(17) \times 10^{-27}$     | kg                              | $5.0 \times 10^{-8}$        |
| in u, $m_d = A_r(d)$ u (deuteron            |                         |                                        |                                 |                             |
| relative atomic mass times u)               |                         | 2.013 553 212 724(78)                  | u                               | $3.9 \times 10^{-11}$       |
| energy equivalent                           | $m_d c^2$               | $3.005 062 72(15) \times 10^{-10}$     | J                               | $5.0 \times 10^{-8}$        |
| in MeV                                      |                         | 1875.612 793(47)                       | MeV                             | $2.5 \times 10^{-8}$        |
| deuteron-electron mass ratio                | $m_d/m_e$               | 3670.482 9654(16)                      |                                 | $4.3 \times 10^{-10}$       |
| deuteron-proton mass ratio                  | $m_d/m_p$               | 1.999 007 501 08(22)                   |                                 | $1.1 \times 10^{-10}$       |
| deuteron molar mass $N_A m_d$               | $M(d), M_d$             | $2.013 553 212 724(78) \times 10^{-3}$ | kg mol <sup>-1</sup>            | $3.9 \times 10^{-11}$       |
| deuteron rms charge radius                  | $R_d$                   | $2.1402(28) \times 10^{-15}$           | m                               | $1.3 \times 10^{-3}$        |
| deuteron magnetic moment                    | $\mu_d$                 | $0.433 073 465(11) \times 10^{-26}$    | J T <sup>-1</sup>               | $2.6 \times 10^{-8}$        |
| to Bohr magneton ratio                      | $\mu_d/\mu_B$           | $0.466 975 4556(39) \times 10^{-3}$    |                                 | $8.4 \times 10^{-9}$        |
| to nuclear magneton ratio                   | $\mu_d/\mu_N$           | 0.857 438 2308(72)                     |                                 | $8.4 \times 10^{-9}$        |
| deuteron $g$ -factor $\mu_d/\mu_N$          | $g_d$                   | 0.857 438 2308(72)                     |                                 | $8.4 \times 10^{-9}$        |
| deuteron-electron                           |                         |                                        |                                 |                             |
| magnetic moment ratio                       | $\mu_d/\mu_e$           | $-4.664 345 537(39) \times 10^{-4}$    |                                 | $8.4 \times 10^{-9}$        |
| deuteron-proton                             |                         |                                        |                                 |                             |
| magnetic moment ratio                       | $\mu_d/\mu_p$           | 0.307 012 2070(24)                     |                                 | $7.7 \times 10^{-9}$        |
| deuteron-neutron                            |                         |                                        |                                 |                             |
| magnetic moment ratio                       | $\mu_d/\mu_n$           | -0.448 206 52(11)                      |                                 | $2.4 \times 10^{-7}$        |
| <b>Triton, t</b>                            |                         |                                        |                                 |                             |
| triton mass                                 | $m_t$                   | $5.007 355 88(25) \times 10^{-27}$     | kg                              | $5.0 \times 10^{-8}$        |
| in u, $m_t = A_r(t)$ u (triton              |                         |                                        |                                 |                             |
| relative atomic mass times u)               |                         | 3.015 500 7134(25)                     | u                               | $8.3 \times 10^{-10}$       |
| energy equivalent                           | $m_t c^2$               | $4.500 387 03(22) \times 10^{-10}$     | J                               | $5.0 \times 10^{-8}$        |
| in MeV                                      |                         | 2808.920 906(70)                       | MeV                             | $2.5 \times 10^{-8}$        |
| triton-electron mass ratio                  | $m_t/m_e$               | 5496.921 5269(51)                      |                                 | $9.3 \times 10^{-10}$       |
| triton-proton mass ratio                    | $m_t/m_p$               | 2.993 717 0309(25)                     |                                 | $8.4 \times 10^{-10}$       |

TABLE II: (Continued).

| Quantity                                                                                       | Symbol                | Numerical value                           | Unit                            | Relative std. uncert. $u_r$ |
|------------------------------------------------------------------------------------------------|-----------------------|-------------------------------------------|---------------------------------|-----------------------------|
| triton molar mass $N_A m_t$                                                                    | $M(t), M_t$           | $3.015\,500\,7134(25) \times 10^{-3}$     | kg mol <sup>-1</sup>            | $8.3 \times 10^{-10}$       |
| triton magnetic moment                                                                         | $\mu_t$               | $1.504\,609\,361(42) \times 10^{-26}$     | J T <sup>-1</sup>               | $2.8 \times 10^{-8}$        |
| to Bohr magneton ratio                                                                         | $\mu_t/\mu_B$         | $1.622\,393\,657(21) \times 10^{-3}$      |                                 | $1.3 \times 10^{-8}$        |
| to nuclear magneton ratio                                                                      | $\mu_t/\mu_N$         | $2.978\,962\,448(38)$                     |                                 | $1.3 \times 10^{-8}$        |
| triton $g$ -factor $2\mu_t/\mu_N$                                                              | $g_t$                 | $5.957\,924\,896(76)$                     |                                 | $1.3 \times 10^{-8}$        |
| triton-electron magnetic moment ratio                                                          | $\mu_t/\mu_e$         | $-1.620\,514\,423(21) \times 10^{-3}$     |                                 | $1.3 \times 10^{-8}$        |
| triton-proton magnetic moment ratio                                                            | $\mu_t/\mu_p$         | $1.066\,639\,908(10)$                     |                                 | $9.8 \times 10^{-9}$        |
| triton-neutron magnetic moment ratio                                                           | $\mu_t/\mu_n$         | $-1.557\,185\,53(37)$                     |                                 | $2.4 \times 10^{-7}$        |
| <b>Helion, h</b>                                                                               |                       |                                           |                                 |                             |
| helion ( <sup>3</sup> He nucleus) mass                                                         | $m_h$                 | $5.006\,411\,92(25) \times 10^{-27}$      | kg                              | $5.0 \times 10^{-8}$        |
| in u, $m_h = A_r(h)$ u (helion relative atomic mass times u)                                   |                       | $3.014\,932\,2473(26)$                    | u                               | $8.6 \times 10^{-10}$       |
| energy equivalent                                                                              | $m_h c^2$             | $4.499\,538\,64(22) \times 10^{-10}$      | J                               | $5.0 \times 10^{-8}$        |
| in MeV                                                                                         |                       | $2808.391\,383(70)$                       | MeV                             | $2.5 \times 10^{-8}$        |
| helion-electron mass ratio                                                                     | $m_h/m_e$             | $5495.885\,2765(52)$                      |                                 | $9.5 \times 10^{-10}$       |
| helion-proton mass ratio                                                                       | $m_h/m_p$             | $2.993\,152\,6713(26)$                    |                                 | $8.7 \times 10^{-10}$       |
| helion molar mass $N_A m_h$                                                                    | $M(h), M_h$           | $3.014\,932\,2473(26) \times 10^{-3}$     | kg mol <sup>-1</sup>            | $8.6 \times 10^{-10}$       |
| shielded helion magnetic moment (gas, sphere, 25°C)                                            | $\mu'_h$              | $-1.074\,552\,982(30) \times 10^{-26}$    | J T <sup>-1</sup>               | $2.8 \times 10^{-8}$        |
| to Bohr magneton ratio                                                                         | $\mu'_h/\mu_B$        | $-1.158\,671\,471(14) \times 10^{-3}$     |                                 | $1.2 \times 10^{-8}$        |
| to nuclear magneton ratio                                                                      | $\mu'_h/\mu_N$        | $-2.127\,497\,718(25)$                    |                                 | $1.2 \times 10^{-8}$        |
| shielded helion to proton magnetic moment ratio (gas, sphere, 25°C)                            | $\mu'_h/\mu_p$        | $-0.761\,766\,558(11)$                    |                                 | $1.4 \times 10^{-8}$        |
| shielded helion to shielded proton magnetic moment ratio (gas/H <sub>2</sub> O, spheres, 25°C) | $\mu'_h/\mu'_p$       | $-0.761\,786\,1313(33)$                   |                                 | $4.3 \times 10^{-9}$        |
| shielded helion gyromagnetic ratio $2 \mu'_h /\hbar$ (gas, sphere, 25°C)                       | $\gamma'_h$           | $2.037\,894\,730(56) \times 10^8$         | s <sup>-1</sup> T <sup>-1</sup> | $2.8 \times 10^{-8}$        |
|                                                                                                | $\gamma'_h/2\pi$      | $32.434\,101\,98(90)$                     | MHz T <sup>-1</sup>             | $2.8 \times 10^{-8}$        |
| <b>Alpha particle, <math>\alpha</math></b>                                                     |                       |                                           |                                 |                             |
| alpha particle mass                                                                            | $m_\alpha$            | $6.644\,656\,20(33) \times 10^{-27}$      | kg                              | $5.0 \times 10^{-8}$        |
| in u, $m_\alpha = A_r(\alpha)$ u (alpha particle relative atomic mass times u)                 |                       | $4.001\,506\,179\,127(62)$                | u                               | $1.5 \times 10^{-11}$       |
| energy equivalent                                                                              | $m_\alpha c^2$        | $5.971\,919\,17(30) \times 10^{-10}$      | J                               | $5.0 \times 10^{-8}$        |
| in MeV                                                                                         |                       | $3727.379\,109(93)$                       | MeV                             | $2.5 \times 10^{-8}$        |
| alpha particle to electron mass ratio                                                          | $m_\alpha/m_e$        | $7294.299\,5365(31)$                      |                                 | $4.2 \times 10^{-10}$       |
| alpha particle to proton mass ratio                                                            | $m_\alpha/m_p$        | $3.972\,599\,689\,51(41)$                 |                                 | $1.0 \times 10^{-10}$       |
| alpha particle molar mass $N_A m_\alpha$                                                       | $M(\alpha), M_\alpha$ | $4.001\,506\,179\,127(62) \times 10^{-3}$ | kg mol <sup>-1</sup>            | $1.5 \times 10^{-11}$       |
| <b>PHYSICOCHEMICAL</b>                                                                         |                       |                                           |                                 |                             |
| Avogadro constant                                                                              | $N_A, L$              | $6.022\,141\,79(30) \times 10^{23}$       | mol <sup>-1</sup>               | $5.0 \times 10^{-8}$        |
| atomic mass constant $m_u = \frac{1}{12}m(^{12}\text{C}) = 1$ u                                | $m_u$                 | $1.660\,538\,782(83) \times 10^{-27}$     | kg                              | $5.0 \times 10^{-8}$        |

TABLE II: (Continued).

| Quantity                                                                                                                                                                                                                                   | Symbol      | Numerical value                                                     | Unit                                | Relative std. uncert. $u_r$                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------------------|-------------------------------------|----------------------------------------------|
| $= 10^{-3} \text{ kg mol}^{-1}/N_A$                                                                                                                                                                                                        |             |                                                                     |                                     |                                              |
| energy equivalent<br>in MeV                                                                                                                                                                                                                | $m_u c^2$   | $1.492\,417\,830(74) \times 10^{-10}$                               | J                                   | $5.0 \times 10^{-8}$                         |
| Faraday constant <sup>6</sup> $N_A e$                                                                                                                                                                                                      | $F$         | 931.494 028(23)                                                     | MeV                                 | $2.5 \times 10^{-8}$                         |
|                                                                                                                                                                                                                                            |             | 96 485.3399(24)                                                     | C mol <sup>-1</sup>                 | $2.5 \times 10^{-8}$                         |
| molar Planck constant                                                                                                                                                                                                                      | $N_A h$     | $3.990\,312\,6821(57) \times 10^{-10}$                              | J s mol <sup>-1</sup>               | $1.4 \times 10^{-9}$                         |
|                                                                                                                                                                                                                                            | $N_A h c$   | 0.119 626 564 72(17)                                                | J m mol <sup>-1</sup>               | $1.4 \times 10^{-9}$                         |
| molar gas constant                                                                                                                                                                                                                         | $R$         | 8.314 472(15)                                                       | J mol <sup>-1</sup> K <sup>-1</sup> | $1.7 \times 10^{-6}$                         |
| Boltzmann constant $R/N_A$<br>in eV K <sup>-1</sup>                                                                                                                                                                                        | $k$         | $1.380\,6504(24) \times 10^{-23}$                                   | J K <sup>-1</sup>                   | $1.7 \times 10^{-6}$                         |
|                                                                                                                                                                                                                                            |             | $8.617\,343(15) \times 10^{-5}$                                     | eV K <sup>-1</sup>                  | $1.7 \times 10^{-6}$                         |
|                                                                                                                                                                                                                                            | $k/h$       | $2.083\,6644(36) \times 10^{10}$                                    | Hz K <sup>-1</sup>                  | $1.7 \times 10^{-6}$                         |
|                                                                                                                                                                                                                                            | $k/hc$      | 69.503 56(12)                                                       | m <sup>-1</sup> K <sup>-1</sup>     | $1.7 \times 10^{-6}$                         |
| molar volume of ideal gas $RT/p$<br>$T = 273.15 \text{ K}$ , $p = 101.325 \text{ kPa}$                                                                                                                                                     | $V_m$       | $22.413\,996(39) \times 10^{-3}$                                    | m <sup>3</sup> mol <sup>-1</sup>    | $1.7 \times 10^{-6}$                         |
| Loschmidt constant $N_A/V_m$<br>$T = 273.15 \text{ K}$ , $p = 100 \text{ kPa}$                                                                                                                                                             | $n_0$       | $2.686\,7774(47) \times 10^{25}$                                    | m <sup>-3</sup>                     | $1.7 \times 10^{-6}$                         |
|                                                                                                                                                                                                                                            | $V_m$       | $22.710\,981(40) \times 10^{-3}$                                    | m <sup>3</sup> mol <sup>-1</sup>    | $1.7 \times 10^{-6}$                         |
| Sackur-Tetrode constant<br>(absolute entropy constant) <sup>7</sup><br>$\frac{5}{2} + \ln[(2\pi m_u k T_1 / h^2)^{3/2} k T_1 / p_0]$<br>$T_1 = 1 \text{ K}$ , $p_0 = 100 \text{ kPa}$<br>$T_1 = 1 \text{ K}$ , $p_0 = 101.325 \text{ kPa}$ | $S_0/R$     | -1.151 7047(44)<br>-1.164 8677(44)                                  |                                     | $3.8 \times 10^{-6}$<br>$3.8 \times 10^{-6}$ |
| Stefan-Boltzmann constant<br>$(\pi^2/60)k^4/\hbar^3 c^2$                                                                                                                                                                                   | $\sigma$    | $5.670\,400(40) \times 10^{-8}$                                     | W m <sup>-2</sup> K <sup>-4</sup>   | $7.0 \times 10^{-6}$                         |
| first radiation constant $2\pi\hbar c^2$                                                                                                                                                                                                   | $c_1$       | $3.741\,771\,18(19) \times 10^{-16}$                                | W m <sup>2</sup>                    | $5.0 \times 10^{-8}$                         |
| first radiation constant for spectral radiance $2hc^2$                                                                                                                                                                                     | $c_{1L}$    | $1.191\,042\,759(59) \times 10^{-16}$                               | W m <sup>2</sup> sr <sup>-1</sup>   | $5.0 \times 10^{-8}$                         |
| second radiation constant $hc/k$                                                                                                                                                                                                           | $c_2$       | $1.438\,7752(25) \times 10^{-2}$                                    | m K                                 | $1.7 \times 10^{-6}$                         |
| Wien displacement law constants<br>$b = \lambda_{\max} T = c_2/4.965\,114\,231\dots$<br>$b' = \nu_{\max}/T = 2.821\,439\,372\dots c/c_2$                                                                                                   | $b$<br>$b'$ | $2.897\,7685(51) \times 10^{-3}$<br>$5.878\,933(10) \times 10^{10}$ | m K<br>Hz K <sup>-1</sup>           | $1.7 \times 10^{-6}$<br>$1.7 \times 10^{-6}$ |

TABLE III: The variances, covariances, and correlation coefficients of the values of a selected group of constants based on the 2006 CODATA adjustment. The numbers in bold above the main diagonal are  $10^{16}$  times the numerical values of the relative covariances; the numbers in bold on the main diagonal are  $10^{16}$  times the numerical values of the relative variances; and the numbers in italics below the main diagonal are the correlation coefficients.<sup>1</sup>

|             | $\alpha$       | $h$            | $e$            | $m_e$          | $N_A$           | $m_e/m_\mu$    | $F$           |
|-------------|----------------|----------------|----------------|----------------|-----------------|----------------|---------------|
| $\alpha$    | <b>0.0047</b>  | 0.0002         | 0.0024         | -0.0092        | 0.0092          | -0.0092        | 0.0116        |
| $h$         | <i>0.0005</i>  | <b>24.8614</b> | <b>12.4308</b> | <b>24.8611</b> | <b>-24.8610</b> | -0.0003        | -12.4302      |
| $e$         | <i>0.0142</i>  | <i>0.9999</i>  | <b>6.2166</b>  | <b>12.4259</b> | <b>-12.4259</b> | -0.0048        | -6.2093       |
| $m_e$       | <i>-0.0269</i> | <i>0.9996</i>  | <i>0.9992</i>  | <b>24.8795</b> | <b>-24.8794</b> | 0.0180         | -12.4535      |
| $N_A$       | <i>0.0269</i>  | <i>-0.9996</i> | <i>-0.9991</i> | <i>-1.0000</i> | <b>24.8811</b>  | -0.0180        | 12.4552       |
| $m_e/m_\mu$ | <i>-0.0528</i> | <i>0.0000</i>  | <i>-0.0008</i> | <i>0.0014</i>  | <i>-0.0014</i>  | <b>6.4296</b>  | -0.0227       |
| $F$         | <i>0.0679</i>  | <i>-0.9975</i> | <i>-0.9965</i> | <i>-0.9990</i> | <i>0.9991</i>   | <i>-0.0036</i> | <b>6.2459</b> |

<sup>1</sup> The relative covariance is  $u_r(x_i, x_j) = u(x_i, x_j)/(x_i x_j)$ , where  $u(x_i, x_j)$  is the covariance of  $x_i$  and  $x_j$ ; the relative variance is  $u_r^2(x_i) = u_r(x_i, x_i)$ ; and the correlation coefficient is  $r(x_i, x_j) = u(x_i, x_j)/[u(x_i)u(x_j)]$ .

<sup>6</sup>The numerical value of  $F$  to be used in coulometric chemical measurements is 96 485.3401(48) [ $5.0 \times 10^{-8}$ ] when the relevant current is measured in terms of representations of the volt and ohm based on the Josephson and quantum Hall effects and the internationally adopted conventional values of the Josephson and von Klitzing constants  $K_{J-90}$  and  $R_{K-90}$  given in Table IV.

<sup>7</sup>The entropy of an ideal monoatomic gas of relative atomic mass  $A_r$  is given by  $S = S_0 + \frac{3}{2} R \ln A_r - R \ln(p/p_0) + \frac{5}{2} R \ln(T/K)$ .

TABLE IV: Internationally adopted values of various quantities.

| Quantity                                                 | Symbol               | Numerical value     | Unit                 | Relative std. uncert. $u_r$ |
|----------------------------------------------------------|----------------------|---------------------|----------------------|-----------------------------|
| relative atomic mass <sup>1</sup> of $^{12}\text{C}$     | $A_r(^{12}\text{C})$ | 12                  |                      | (exact)                     |
| molar mass constant                                      | $M_u$                | $1 \times 10^{-3}$  | kg mol <sup>-1</sup> | (exact)                     |
| molar mass of $^{12}\text{C}$                            | $M(^{12}\text{C})$   | $12 \times 10^{-3}$ | kg mol <sup>-1</sup> | (exact)                     |
| conventional value of Josephson constant <sup>2</sup>    | $K_{J-90}$           | 483 597.9           | GHz V <sup>-1</sup>  | (exact)                     |
| conventional value of von Klitzing constant <sup>3</sup> | $R_{K-90}$           | 25 812.807          | $\Omega$             | (exact)                     |
| standard atmosphere                                      |                      | 101 325             | Pa                   | (exact)                     |

<sup>1</sup> The relative atomic mass  $A_r(X)$  of particle  $X$  with mass  $m(X)$  is defined by  $A_r(X) = m(X)/m_u$ , where  $m_u = m(^{12}\text{C})/12 = M_u/N_A = 1 \text{ u}$  is the atomic mass constant,  $M_u$  is the molar mass constant,  $N_A$  is the Avogadro constant, and  $\text{u}$  is the unified atomic mass unit. Thus the mass of particle  $X$  is  $m(X) = A_r(X) \text{ u}$  and the molar mass of  $X$  is  $M(X) = A_r(X) M_u$ .

<sup>2</sup> This is the value adopted internationally for realizing representations of the volt using the Josephson effect.

<sup>3</sup> This is the value adopted internationally for realizing representations of the ohm using the quantum Hall effect.

TABLE V: Values of some x-ray-related quantities based on the 2006 CODATA adjustment of the values of the constants.

| Quantity                                                                                | Symbol                   | Numerical value                      | Unit                             | Relative std. uncert. $u_r$ |
|-----------------------------------------------------------------------------------------|--------------------------|--------------------------------------|----------------------------------|-----------------------------|
| Cu x unit: $\lambda(\text{CuK}\alpha_1)/1\,537.400$                                     | $xu(\text{CuK}\alpha_1)$ | $1.002\,076\,99(28) \times 10^{-13}$ | m                                | $2.8 \times 10^{-7}$        |
| Mo x unit: $\lambda(\text{MoK}\alpha_1)/707.831$                                        | $xu(\text{MoK}\alpha_1)$ | $1.002\,099\,55(53) \times 10^{-13}$ | m                                | $5.3 \times 10^{-7}$        |
| ångstrom star: $\lambda(\text{WK}\alpha_1)/0.209\,010\,0$                               | $\text{\AA}^*$           | $1.000\,014\,98(90) \times 10^{-10}$ | m                                | $9.0 \times 10^{-7}$        |
| lattice parameter <sup>1</sup> of Si<br>(in vacuum, 22.5°C)                             | $a$                      | $543.102\,064(14) \times 10^{-12}$   | m                                | $2.6 \times 10^{-8}$        |
| {220} lattice spacing of Si $a/\sqrt{8}$<br>(in vacuum, 22.5°C)                         | $d_{220}$                | $192.015\,5762(50) \times 10^{-12}$  | m                                | $2.6 \times 10^{-8}$        |
| molar volume of Si<br>$M(\text{Si})/\rho(\text{Si}) = N_A a^3/8$<br>(in vacuum, 22.5°C) | $V_m(\text{Si})$         | $12.058\,8349(11) \times 10^{-6}$    | m <sup>3</sup> mol <sup>-1</sup> | $9.1 \times 10^{-8}$        |

<sup>1</sup> This is the lattice parameter (unit cell edge length) of an ideal single crystal of naturally occurring Si free of impurities and imperfections, and is deduced from measurements on extremely pure and nearly perfect single crystals of Si by correcting for the effects of impurities.

TABLE VI: The values in SI units of some non-SI units based on the 2006 CODATA adjustment of the values of the constants.

| Quantity                                                                                                             | Symbol    | Numerical value                       | Unit              | Relative std. uncert. $u_r$ |
|----------------------------------------------------------------------------------------------------------------------|-----------|---------------------------------------|-------------------|-----------------------------|
| Non-SI units accepted for use with the SI                                                                            |           |                                       |                   |                             |
| electron volt: $(e/C) \text{ J}$                                                                                     | eV        | $1.602\,176\,487(40) \times 10^{-19}$ | J                 | $2.5 \times 10^{-8}$        |
| (unified) atomic mass unit:<br>$1 \text{ u} = m_u = \frac{1}{12} m(^{12}\text{C}) = 10^{-3} \text{ kg mol}^{-1}/N_A$ | u         | $1.660\,538\,782(83) \times 10^{-27}$ | kg                | $5.0 \times 10^{-8}$        |
| Natural units (n.u.)                                                                                                 |           |                                       |                   |                             |
| n.u. of velocity:<br>speed of light in vacuum                                                                        | $c, c_0$  | 299 792 458                           | m s <sup>-1</sup> | (exact)                     |
| n.u. of action:<br>reduced Planck constant $(\hbar/2\pi)$                                                            | $\hbar$   | $1.054\,571\,628(53) \times 10^{-34}$ | J s               | $5.0 \times 10^{-8}$        |
| in eV s                                                                                                              |           | $6.582\,118\,99(16) \times 10^{-16}$  | eV s              | $2.5 \times 10^{-8}$        |
| in MeV fm                                                                                                            | $\hbar c$ | 197.326 9631(49)                      | MeV fm            | $2.5 \times 10^{-8}$        |

TABLE VI: (Continued.)

| Quantity                                                                                                           | Symbol            | Numerical value                                               | Unit                                          | Relative std. uncert. $u_r$                  |
|--------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------|-----------------------------------------------|----------------------------------------------|
| n.u. of mass:<br>electron mass                                                                                     | $m_e$             | $9.109\,382\,15(45) \times 10^{-31}$                          | kg                                            | $5.0 \times 10^{-8}$                         |
| n.u. of energy<br>in MeV                                                                                           | $m_e c^2$         | $8.187\,104\,38(41) \times 10^{-14}$<br>$0.510\,998\,910(13)$ | J<br>MeV                                      | $5.0 \times 10^{-8}$<br>$2.5 \times 10^{-8}$ |
| n.u. of momentum<br>in MeV/c                                                                                       | $m_e c$           | $2.730\,924\,06(14) \times 10^{-22}$<br>$0.510\,998\,910(13)$ | kg m s <sup>-1</sup><br>MeV/c                 | $5.0 \times 10^{-8}$<br>$2.5 \times 10^{-8}$ |
| n.u. of length ( $\hbar/m_e c$ )                                                                                   | $\lambda_C$       | $386.159\,264\,59(53) \times 10^{-15}$                        | m                                             | $1.4 \times 10^{-9}$                         |
| n.u. of time                                                                                                       | $\hbar/m_e c^2$   | $1.288\,088\,6570(18) \times 10^{-21}$                        | s                                             | $1.4 \times 10^{-9}$                         |
| Atomic units (a.u.)                                                                                                |                   |                                                               |                                               |                                              |
| a.u. of charge:<br>elementary charge                                                                               | $e$               | $1.602\,176\,487(40) \times 10^{-19}$                         | C                                             | $2.5 \times 10^{-8}$                         |
| a.u. of mass:<br>electron mass                                                                                     | $m_e$             | $9.109\,382\,15(45) \times 10^{-31}$                          | kg                                            | $5.0 \times 10^{-8}$                         |
| a.u. of action:<br>reduced Planck constant ( $\hbar/2\pi$ )                                                        | $\hbar$           | $1.054\,571\,628(53) \times 10^{-34}$                         | J s                                           | $5.0 \times 10^{-8}$                         |
| a.u. of length:<br>Bohr radius (bohr) ( $\alpha/4\pi R_\infty$ )                                                   | $a_0$             | $0.529\,177\,208\,59(36) \times 10^{-10}$                     | m                                             | $6.8 \times 10^{-10}$                        |
| a.u. of energy:<br>Hartree energy (hartree)<br>( $e^2/4\pi\epsilon_0 a_0 = 2R_\infty \hbar c = \alpha^2 m_e c^2$ ) | $E_h$             | $4.359\,743\,94(22) \times 10^{-18}$                          | J                                             | $5.0 \times 10^{-8}$                         |
| a.u. of time                                                                                                       | $\hbar/E_h$       | $2.418\,884\,326\,505(16) \times 10^{-17}$                    | s                                             | $6.6 \times 10^{-12}$                        |
| a.u. of force                                                                                                      | $E_h/a_0$         | $8.238\,722\,06(41) \times 10^{-8}$                           | N                                             | $5.0 \times 10^{-8}$                         |
| a.u. of velocity ( $\alpha c$ )                                                                                    | $a_0 E_h/\hbar$   | $2.187\,691\,2541(15) \times 10^6$                            | m s <sup>-1</sup>                             | $6.8 \times 10^{-10}$                        |
| a.u. of momentum                                                                                                   | $\hbar/a_0$       | $1.992\,851\,565(99) \times 10^{-24}$                         | kg m s <sup>-1</sup>                          | $5.0 \times 10^{-8}$                         |
| a.u. of current                                                                                                    | $e E_h/\hbar$     | $6.623\,617\,63(17) \times 10^{-3}$                           | A                                             | $2.5 \times 10^{-8}$                         |
| a.u. of charge density                                                                                             | $e/a_0^3$         | $1.081\,202\,300(27) \times 10^{12}$                          | C m <sup>-3</sup>                             | $2.5 \times 10^{-8}$                         |
| a.u. of electric potential                                                                                         | $E_h/e$           | $27.211\,383\,86(68)$                                         | V                                             | $2.5 \times 10^{-8}$                         |
| a.u. of electric field                                                                                             | $E_h/ea_0$        | $5.142\,206\,32(13) \times 10^{11}$                           | V m <sup>-1</sup>                             | $2.5 \times 10^{-8}$                         |
| a.u. of electric field gradient                                                                                    | $E_h/ea_0^2$      | $9.717\,361\,66(24) \times 10^{21}$                           | V m <sup>-2</sup>                             | $2.5 \times 10^{-8}$                         |
| a.u. of electric dipole moment                                                                                     | $ea_0$            | $8.478\,352\,81(21) \times 10^{-30}$                          | C m                                           | $2.5 \times 10^{-8}$                         |
| a.u. of electric quadrupole moment                                                                                 | $ea_0^2$          | $4.486\,551\,07(11) \times 10^{-40}$                          | C m <sup>2</sup>                              | $2.5 \times 10^{-8}$                         |
| a.u. of electric polarizability                                                                                    | $e^2 a_0^2/E_h$   | $1.648\,777\,2536(34) \times 10^{-41}$                        | C <sup>2</sup> m <sup>2</sup> J <sup>-1</sup> | $2.1 \times 10^{-9}$                         |
| a.u. of 1 <sup>st</sup> hyperpolarizability                                                                        | $e^3 a_0^3/E_h^2$ | $3.206\,361\,533(81) \times 10^{-53}$                         | C <sup>3</sup> m <sup>3</sup> J <sup>-2</sup> | $2.5 \times 10^{-8}$                         |
| a.u. of 2 <sup>nd</sup> hyperpolarizability                                                                        | $e^4 a_0^4/E_h^3$ | $6.235\,380\,95(31) \times 10^{-65}$                          | C <sup>4</sup> m <sup>4</sup> J <sup>-3</sup> | $5.0 \times 10^{-8}$                         |
| a.u. of magnetic flux density                                                                                      | $\hbar/ea_0^2$    | $2.350\,517\,382(59) \times 10^5$                             | T                                             | $2.5 \times 10^{-8}$                         |
| a.u. of magnetic dipole moment ( $2\mu_B$ )                                                                        | $\hbar e/m_e$     | $1.854\,801\,830(46) \times 10^{-23}$                         | J T <sup>-1</sup>                             | $2.5 \times 10^{-8}$                         |
| a.u. of magnetizability                                                                                            | $e^2 a_0^2/m_e$   | $7.891\,036\,433(27) \times 10^{-29}$                         | J T <sup>-2</sup>                             | $3.4 \times 10^{-9}$                         |
| a.u. of permittivity ( $10^7/c^2$ )                                                                                | $e^2/a_0 E_h$     | $1.112\,650\,056 \dots \times 10^{-10}$                       | F m <sup>-1</sup>                             | (exact)                                      |

TABLE VII: The values of some energy equivalents derived from the relations  $E = mc^2 = hc/\lambda = h\nu = kT$ , and based on the 2006 CODATA adjustment of the values of the constants;  $1 \text{ eV} = (e/C) \text{ J}$ ,  $1 \text{ u} = m_{\text{u}} = \frac{1}{12}m(^{12}\text{C}) = 10^{-3} \text{ kg mol}^{-1}/N_{\text{A}}$ , and  $E_{\text{h}} = 2R_{\infty}hc = \alpha^2 m_{\text{e}}c^2$  is the Hartree energy (hartree).

| Relevant unit      |                                                                                |                                                                                 |                                                                                      |                                                                                       |
|--------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|                    | J                                                                              | kg                                                                              | $\text{m}^{-1}$                                                                      | Hz                                                                                    |
| 1 J                | (1 J) =<br>1 J                                                                 | (1 J)/ $c^2$ =<br>$1.112\,650\,056 \dots \times 10^{-17} \text{ kg}$            | (1 J)/ $hc$ =<br>$5.034\,117\,47(25) \times 10^{24} \text{ m}^{-1}$                  | (1 J)/ $h$ =<br>$1.509\,190\,450(75) \times 10^{33} \text{ Hz}$                       |
| 1 kg               | (1 kg) $c^2$ =<br>$8.987\,551\,787 \dots \times 10^{16} \text{ J}$             | (1 kg) =<br>1 kg                                                                | (1 kg) $c/h$ =<br>$4.524\,439\,15(23) \times 10^{41} \text{ m}^{-1}$                 | (1 kg) $c^2/h$ =<br>$1.356\,392\,733(68) \times 10^{50} \text{ Hz}$                   |
| $1 \text{ m}^{-1}$ | (1 $\text{m}^{-1}$ ) $hc$ =<br>$1.986\,445\,501(99) \times 10^{-25} \text{ J}$ | (1 $\text{m}^{-1}$ ) $h/c$ =<br>$2.210\,218\,70(11) \times 10^{-42} \text{ kg}$ | (1 $\text{m}^{-1}$ ) =<br>$1 \text{ m}^{-1}$                                         | (1 $\text{m}^{-1}$ ) $c$ =<br>$299\,792\,458 \text{ Hz}$                              |
| 1 Hz               | (1 Hz) $h$ =<br>$6.626\,068\,96(33) \times 10^{-34} \text{ J}$                 | (1 Hz) $h/c^2$ =<br>$7.372\,496\,00(37) \times 10^{-51} \text{ kg}$             | (1 Hz) $c$ =<br>$3.335\,640\,951 \dots \times 10^{-9} \text{ m}^{-1}$                | (1 Hz) =<br>1 Hz                                                                      |
| 1 K                | (1 K) $k$ =<br>$1.380\,6504(24) \times 10^{-23} \text{ J}$                     | (1 K) $k/c^2$ =<br>$1.536\,1807(27) \times 10^{-40} \text{ kg}$                 | (1 K) $k/hc$ =<br>$69.503\,56(12) \text{ m}^{-1}$                                    | (1 K) $k/h$ =<br>$2.083\,6644(36) \times 10^{10} \text{ Hz}$                          |
| 1 eV               | (1 eV) =<br>$1.602\,176\,487(40) \times 10^{-19} \text{ J}$                    | (1 eV)/ $c^2$ =<br>$1.782\,661\,758(44) \times 10^{-36} \text{ kg}$             | (1 eV)/ $hc$ =<br>$8.065\,544\,65(20) \times 10^5 \text{ m}^{-1}$                    | (1 eV)/ $h$ =<br>$2.417\,989\,454(60) \times 10^{14} \text{ Hz}$                      |
| 1 u                | (1 u) $c^2$ =<br>$1.492\,417\,830(74) \times 10^{-10} \text{ J}$               | (1 u) =<br>$1.660\,538\,782(83) \times 10^{-27} \text{ kg}$                     | (1 u) $c/h$ =<br>$7.513\,006\,671(11) \times 10^{14} \text{ m}^{-1}$                 | (1 u) $c^2/h$ =<br>$2.252\,342\,7369(32) \times 10^{23} \text{ Hz}$                   |
| $1 E_{\text{h}}$   | (1 $E_{\text{h}}$ ) =<br>$4.359\,743\,94(22) \times 10^{-18} \text{ J}$        | (1 $E_{\text{h}}$ )/ $c^2$ =<br>$4.850\,869\,34(24) \times 10^{-35} \text{ kg}$ | (1 $E_{\text{h}}$ )/ $hc$ =<br>$2.194\,746\,313\,705(15) \times 10^7 \text{ m}^{-1}$ | (1 $E_{\text{h}}$ )/ $h$ =<br>$6.579\,683\,920\,722(44) \times 10^{15} \text{ Hz}$    |
|                    | K                                                                              | eV                                                                              | u                                                                                    | $E_{\text{h}}$                                                                        |
| 1 J                | (1 J)/ $k$ =<br>$7.242\,963(13) \times 10^{22} \text{ K}$                      | (1 J) =<br>$6.241\,509\,65(16) \times 10^{18} \text{ eV}$                       | (1 J)/ $c^2$ =<br>$6.700\,536\,41(33) \times 10^9 \text{ u}$                         | (1 J) =<br>$2.293\,712\,69(11) \times 10^{17} E_{\text{h}}$                           |
| 1 kg               | (1 kg) $c^2/k$ =<br>$6.509\,651(11) \times 10^{39} \text{ K}$                  | (1 kg) $c^2$ =<br>$5.609\,589\,12(14) \times 10^{35} \text{ eV}$                | (1 kg) =<br>$6.022\,141\,79(30) \times 10^{26} \text{ u}$                            | (1 kg) $c^2$ =<br>$2.061\,486\,16(10) \times 10^{34} E_{\text{h}}$                    |
| $1 \text{ m}^{-1}$ | (1 $\text{m}^{-1}$ ) $hc/k$ =<br>$1.438\,7752(25) \times 10^{-2} \text{ K}$    | (1 $\text{m}^{-1}$ ) $hc$ =<br>$1.239\,841\,875(31) \times 10^{-6} \text{ eV}$  | (1 $\text{m}^{-1}$ ) $h/c$ =<br>$1.331\,025\,0394(19) \times 10^{-15} \text{ u}$     | (1 $\text{m}^{-1}$ ) $hc$ =<br>$4.556\,335\,252\,760(30) \times 10^{-8} E_{\text{h}}$ |
| 1 Hz               | (1 Hz) $h/k$ =<br>$4.799\,2374(84) \times 10^{-11} \text{ K}$                  | (1 Hz) $h$ =<br>$4.135\,667\,33(10) \times 10^{-15} \text{ eV}$                 | (1 Hz) $h/c^2$ =<br>$4.439\,821\,6294(64) \times 10^{-24} \text{ u}$                 | (1 Hz) $h$ =<br>$1.519\,829\,846\,006(10) \times 10^{-16} E_{\text{h}}$               |
| 1 K                | (1 K) =<br>1 K                                                                 | (1 K) $k$ =<br>$8.617\,343(15) \times 10^{-5} \text{ eV}$                       | (1 K) $k/c^2$ =<br>$9.251\,098(16) \times 10^{-14} \text{ u}$                        | (1 K) $k$ =<br>$3.166\,8153(55) \times 10^{-6} E_{\text{h}}$                          |
| 1 eV               | (1 eV)/ $k$ =<br>$1.160\,4505(20) \times 10^4 \text{ K}$                       | (1 eV) =<br>1 eV                                                                | (1 eV)/ $c^2$ =<br>$1.073\,544\,188(27) \times 10^{-9} \text{ u}$                    | (1 eV) =<br>$3.674\,932\,540(92) \times 10^{-2} E_{\text{h}}$                         |
| 1 u                | (1 u) $c^2/k$ =<br>$1.080\,9527(19) \times 10^{13} \text{ K}$                  | (1 u) $c^2$ =<br>$931.494\,028(23) \times 10^6 \text{ eV}$                      | (1 u) =<br>1 u                                                                       | (1 u) $c^2$ =<br>$3.423\,177\,7149(49) \times 10^7 E_{\text{h}}$                      |
| $1 E_{\text{h}}$   | (1 $E_{\text{h}}$ )/ $k$ =<br>$3.157\,7465(55) \times 10^5 \text{ K}$          | (1 $E_{\text{h}}$ ) =<br>$27.211\,383\,86(68) \text{ eV}$                       | (1 $E_{\text{h}}$ )/ $c^2$ =<br>$2.921\,262\,2986(42) \times 10^{-8} \text{ u}$      | (1 $E_{\text{h}}$ ) =<br>$1 E_{\text{h}}$                                             |



## STANDARD ATOMIC WEIGHTS (2007)

This table of atomic weights includes the changes made in 2007 by the IUPAC Commission on Isotopic Abundances and Atomic Weights. Those changes affected the following elements: Lu, Mo, Ni, Yb, and Zn.

The Standard Atomic Weights apply to the elements as they exist naturally on Earth, and the uncertainties take into account the isotopic variation found in most laboratory samples. Further comments on the variability are given in the footnotes.

The number in parentheses following the atomic weight value gives the uncertainty in the last digit. An atomic weight entry in brackets indicates that the element that has no stable isotopes; the

value given is the atomic mass in  $u$  (or the mass number, if the mass is not accurately known) for the isotope of longest half-life. Thorium, protactinium, and uranium have no stable isotopes, but the terrestrial isotopic composition is sufficiently uniform to permit a standard atomic weight to be specified.

## References

1. Weiser, M. E., "Atomic weights of the elements 2005," *Pure Appl. Chem.* 78, 2051, 2006; *J. Phys. Chem. Ref. Data* 36, 485, 2007.
2. *Chemistry International*, Vol. 29, No. 6, p. 18, 2007.

| Name         | Symbol | Atomic no. | Atomic weight  | Footnotes | Name          | Symbol | Atomic no. | Atomic weight | Footnotes |
|--------------|--------|------------|----------------|-----------|---------------|--------|------------|---------------|-----------|
| Actinium     | Ac     | 89         | [227.0277]     | a         | Iodine        | I      | 53         | 126.90447(3)  |           |
| Aluminum     | Al     | 13         | 26.9815386(8)  |           | Iridium       | Ir     | 77         | 192.227(3)    |           |
| Americium    | Am     | 95         | [243.0614]     | a         | Iron          | Fe     | 26         | 55.845(2)     |           |
| Antimony     | Sb     | 51         | 121.760(1)     | g         | Krypton       | Kr     | 36         | 83.798(2)     | g m       |
| Argon        | Ar     | 18         | 39.948(1)      | g r       | Lanthanum     | La     | 57         | 138.90547(7)  | g         |
| Arsenic      | As     | 33         | 74.92160(2)    |           | Lawrencium    | Lr     | 103        | [262.1097]    | a         |
| Astatine     | At     | 85         | [209.9871]     | a         | Lead          | Pb     | 82         | 207.2(1)      | g r       |
| Barium       | Ba     | 56         | 137.327(7)     |           | Lithium       | Li     | 3          | 6.941(2)      | b g m r   |
| Berkelium    | Bk     | 97         | [247.0703]     | a         | Lutetium      | Lu     | 71         | 174.9668(1)   | g         |
| Beryllium    | Be     | 4          | 9.012182(3)    |           | Magnesium     | Mg     | 12         | 24.3050(6)    |           |
| Bismuth      | Bi     | 83         | 208.98040(1)   |           | Manganese     | Mn     | 25         | 54.938045(5)  |           |
| Bohrium      | Bh     | 107        | [264.12]       | a         | Meitnerium    | Mt     | 109        | [268.1388]    | a         |
| Boron        | B      | 5          | 10.811(7)      | g m r     | Mendelevium   | Md     | 101        | [258.0984]    | a         |
| Bromine      | Br     | 35         | 79.904(1)      |           | Mercury       | Hg     | 80         | 200.59(2)     |           |
| Cadmium      | Cd     | 48         | 112.411(8)     | g         | Molybdenum    | Mo     | 42         | 95.96(2)      | g         |
| Calcium      | Ca     | 20         | 40.078(4)      | g         | Neodymium     | Nd     | 60         | 144.242(3)    | g         |
| Californium  | Cf     | 98         | [251.0796]     | a         | Neon          | Ne     | 10         | 20.1797(6)    | g m       |
| Carbon       | C      | 6          | 12.0107(8)     | g r       | Neptunium     | Np     | 93         | [237.0482]    | a         |
| Cerium       | Ce     | 58         | 140.116(1)     | g         | Nickel        | Ni     | 28         | 58.6934(4)    |           |
| Cesium       | Cs     | 55         | 132.9054519(2) |           | Niobium       | Nb     | 41         | 92.90638(2)   |           |
| Chlorine     | Cl     | 17         | 35.453(2)      | g m r     | Nitrogen      | N      | 7          | 14.0067(2)    | g r       |
| Chromium     | Cr     | 24         | 51.9961(6)     |           | Nobelium      | No     | 102        | [259.1010]    | a         |
| Cobalt       | Co     | 27         | 58.933195(5)   |           | Osmium        | Os     | 76         | 190.23(3)     | g         |
| Copper       | Cu     | 29         | 63.546(3)      | r         | Oxygen        | O      | 8          | 15.9994(3)    | g r       |
| Curium       | Cm     | 96         | [247.0704]     | a         | Palladium     | Pd     | 46         | 106.42(1)     | g         |
| Darmstadtium | Ds     | 110        | [271]          | a         | Phosphorus    | P      | 15         | 30.973762(2)  |           |
| Dubnium      | Db     | 105        | [262.1141]     | a         | Platinum      | Pt     | 78         | 195.084(9)    |           |
| Dysprosium   | Dy     | 66         | 162.500(1)     | g         | Plutonium     | Pu     | 94         | [244.0642]    | a         |
| Einsteinium  | Es     | 99         | [252.0830]     | a         | Polonium      | Po     | 84         | [208.9824]    | a         |
| Erbium       | Er     | 68         | 167.259(3)     | g         | Potassium     | K      | 19         | 39.0983(1)    | g         |
| Europium     | Eu     | 63         | 151.964(1)     | g         | Praseodymium  | Pr     | 59         | 140.90765(2)  |           |
| Fermium      | Fm     | 100        | [257.0951]     | a         | Promethium    | Pm     | 61         | [144.9127]    | a         |
| Fluorine     | F      | 9          | 18.9984032(5)  |           | Protactinium  | Pa     | 91         | 231.03588(2)  |           |
| Francium     | Fr     | 87         | [223.0197]     | a         | Radium        | Ra     | 88         | [226.0254]    | a         |
| Gadolinium   | Gd     | 64         | 157.25(3)      | g         | Radon         | Rn     | 86         | [222.0176]    | a         |
| Gallium      | Ga     | 31         | 69.723(1)      |           | Rhenium       | Re     | 75         | 186.207(1)    |           |
| Germanium    | Ge     | 32         | 72.64(1)       |           | Rhodium       | Rh     | 45         | 102.90550(2)  |           |
| Gold         | Au     | 79         | 196.966569(4)  |           | Roentgenium   | Rg     | 111        | [272.1535]    | a         |
| Hafnium      | Hf     | 72         | 178.49(2)      |           | Rubidium      | Rb     | 37         | 85.4678(3)    | g         |
| Hassium      | Hs     | 108        | [277]          | a         | Ruthenium     | Ru     | 44         | 101.07(2)     | g         |
| Helium       | He     | 2          | 4.002602(2)    | g r       | Rutherfordium | Rf     | 104        | [261.1088]    | a         |
| Holmium      | Ho     | 67         | 164.93032(2)   |           | Samarium      | Sm     | 62         | 150.36(2)     | g         |
| Hydrogen     | H      | 1          | 1.00794(7)     | g m r     | Scandium      | Sc     | 21         | 44.955912(6)  |           |
| Indium       | In     | 49         | 114.818(3)     |           | Seaborgium    | Sg     | 106        | [266.1219]    | a         |

| Name       | Symbol | Atomic no. | Atomic weight  | Footnotes | Name        | Symbol | Atomic no. | Atomic weight | Footnotes |
|------------|--------|------------|----------------|-----------|-------------|--------|------------|---------------|-----------|
| Selenium   | Se     | 34         | 78.96(3)       | r         | Tin         | Sn     | 50         | 118.710(7)    | g         |
| Silicon    | Si     | 14         | 28.0855(3)     | r         | Titanium    | Ti     | 22         | 47.867(1)     |           |
| Silver     | Ag     | 47         | 107.8682(2)    | g         | Tungsten    | W      | 74         | 183.84(1)     |           |
| Sodium     | Na     | 11         | 22.98976928(2) |           | Ununbium    | Uub    | 112        | [285]         | a         |
| Strontium  | Sr     | 38         | 87.62(1)       | g r       | Ununhexium  | Uuh    | 116        | [289]         | a         |
| Sulfur     | S      | 16         | 32.065(5)      | g r       | Ununquadium | Uuq    | 114        | [289]         | a         |
| Tantalum   | Ta     | 73         | 180.94788(2)   |           | Uranium     | U      | 92         | 238.02891(3)  | g m       |
| Technetium | Tc     | 43         | [97.9072]      | a         | Vanadium    | V      | 23         | 50.9415(1)    |           |
| Tellurium  | Te     | 52         | 127.60(3)      | g         | Xenon       | Xe     | 54         | 131.293(6)    | g m       |
| Terbium    | Tb     | 65         | 158.92535(2)   |           | Ytterbium   | Yb     | 70         | 173.054(5)    | g         |
| Thallium   | Tl     | 81         | 204.3833(2)    |           | Yttrium     | Y      | 39         | 88.90585(2)   |           |
| Thorium    | Th     | 90         | 232.03806(2)   | g         | Zinc        | Zn     | 30         | 65.38(2)      |           |
| Thulium    | Tm     | 69         | 168.93421(2)   |           | Zirconium   | Zr     | 40         | 91.224(2)     | g         |

<sup>a</sup> No stable isotope exists. The atomic mass in u (or the mass number, if the mass is not accurately known) is given in brackets for the isotope of longest half-life.

<sup>b</sup> Commercially available Li materials have atomic weights that range between 6.939 and 6.996; if a more accurate value is required, it must be determined for the specific material.

<sup>c</sup> Geological specimens are known in which the element has an isotopic composition outside the limits for the normal material. The difference between the atomic weight of the element in such specimens and that given in the table may exceed the stated uncertainty.

<sup>m</sup> Modified isotopic compositions may be found in commercially available material because it has been subject to an undisclosed or inadvertent isotopic fractionation. Substantial deviations in atomic weight of the element from that given in the table can occur.

<sup>r</sup> Range in isotopic composition of normal terrestrial material prevents a more precise atomic weight being given; the tabulated value should be applicable to any normal material.

# ATOMIC MASSES AND ABUNDANCES

This table lists the mass (in atomic mass units, symbol u) and the natural abundance (in percent) of the stable nuclides and a few important radioactive nuclides. A complete table of all nuclides may be found in Section 11 ("Table of the Isotopes").

The atomic masses were taken from the 2003 evaluation of Audi, Wapstra, and Thibault (References 2, 3). The number in parentheses following the mass value is the uncertainty in the last digit(s) given. An asterisk \* after an entry indicates the mass value was derived not purely from experimental data, but at least partly from systematic trends.

Natural abundance values were taken from the IUPAC Technical Report "Atomic Weight of the Elements: Review 2000" (Reference 4); these entries are also followed by uncertainties in the last digit(s) of the stated values. This uncertainty includes both the estimated measurement uncertainty and the reported range of variation in different terrestrial sources of the element (see Reference 4 for full

details and caveats regarding elements whose abundance is variable). The absence of an entry in the Abundance column indicates a radioactive nuclide not present in nature or an element whose isotopic composition varies so widely that a meaningful natural abundance cannot be defined.

## References

1. Holden, N. E., "Table of the Isotopes", in Lide, D. R., Ed., *CRC Handbook of Chemistry and Physics*, 86th Ed., CRC Press, Boca Raton FL, 2005.
2. Audi, G., Wapstra, A. H., and Thibault, *Nucl. Phys.*, A729, 336, 2003.
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4. de Laeter, J. R., Böhlke, J. K., De Bièvre, P., Hidaka, H., Peiser, H. S., Rosman, K. J. R., and Taylor, P. D. P., *Pure Appl. Chem.* 75, 683, 2003.

| Z  | Isotope          | Mass in u          | Abundance in % |
|----|------------------|--------------------|----------------|
| 1  | <sup>1</sup> H   | 1.00782503207(10)  | 99.9885(70)    |
|    | <sup>2</sup> H   | 2.0141017778(4)    | 0.0115(70)     |
|    | <sup>3</sup> H   | 3.0160492777(25)   |                |
| 2  | <sup>3</sup> He  | 3.0160293191(26)   | 0.000134(3)    |
|    | <sup>4</sup> He  | 4.00260325415(6)   | 99.999866(3)   |
| 3  | <sup>6</sup> Li  | 6.015122795(16)    | 7.59(4)        |
|    | <sup>7</sup> Li  | 7.01600455(8)      | 92.41(4)       |
| 4  | <sup>9</sup> Be  | 9.0121822(4)       | 100            |
| 5  | <sup>10</sup> B  | 10.0129370(4)      | 19.9(7)        |
|    | <sup>11</sup> B  | 11.0093054(4)      | 80.1(7)        |
| 6  | <sup>11</sup> C  | 11.0114336(10)     |                |
|    | <sup>12</sup> C  | 12.0000000(0)      | 98.93(8)       |
|    | <sup>13</sup> C  | 13.0033548378(10)  | 1.07(8)        |
|    | <sup>14</sup> C  | 14.003241989(4)    |                |
| 7  | <sup>14</sup> N  | 14.0030740048(6)   | 99.636(7)      |
|    | <sup>15</sup> N  | 15.0001088982(7)   | 0.364(7)       |
| 8  | <sup>16</sup> O  | 15.99491461956(16) | 99.757(16)     |
|    | <sup>17</sup> O  | 16.99913170(12)    | 0.038(1)       |
|    | <sup>18</sup> O  | 17.9991610(7)      | 0.205(14)      |
| 9  | <sup>18</sup> F  | 18.0009380(6)      |                |
|    | <sup>19</sup> F  | 18.99840322(7)     | 100            |
| 10 | <sup>20</sup> Ne | 19.9924401754(19)  | 90.48(3)       |
|    | <sup>21</sup> Ne | 20.99384668(4)     | 0.27(1)        |
|    | <sup>22</sup> Ne | 21.991385114(19)   | 9.25(3)        |
| 11 | <sup>22</sup> Na | 21.9944364(4)      |                |
|    | <sup>23</sup> Na | 22.9897692809(29)  | 100            |
|    | <sup>24</sup> Na | 23.99096278(8)     |                |
| 12 | <sup>24</sup> Mg | 23.985041700(14)   | 78.99(4)       |
|    | <sup>25</sup> Mg | 24.98583692(3)     | 10.00(1)       |
|    | <sup>26</sup> Mg | 25.982592929(30)   | 11.01(3)       |
| 13 | <sup>27</sup> Al | 26.98153863(12)    | 100            |
| 14 | <sup>28</sup> Si | 27.9769265325(19)  | 92.223(19)     |
|    | <sup>29</sup> Si | 28.976494700(22)   | 4.685(8)       |
|    | <sup>30</sup> Si | 29.97377017(3)     | 3.092(11)      |
| 15 | <sup>31</sup> P  | 30.97376163(20)    | 100            |
|    | <sup>32</sup> P  | 31.97390727(20)    |                |
| 16 | <sup>32</sup> S  | 31.97207100(15)    | 94.99(26)      |
|    | <sup>33</sup> S  | 32.97145876(15)    | 0.75(2)        |
|    | <sup>34</sup> S  | 33.96786690(12)    | 4.25(24)       |
|    | <sup>35</sup> S  | 34.96903216(11)    |                |
|    | <sup>36</sup> S  | 35.96708076(20)    | 0.01(1)        |

| Z  | Isotope          | Mass in u         | Abundance in % |
|----|------------------|-------------------|----------------|
| 17 | <sup>35</sup> Cl | 34.96885268(4)    | 75.76(10)      |
|    | <sup>37</sup> Cl | 36.96590259(5)    | 24.24(10)      |
| 18 | <sup>36</sup> Ar | 35.967545106(29)  | 0.3365(30)     |
|    | <sup>38</sup> Ar | 37.9627324(4)     | 0.0632(5)      |
|    | <sup>40</sup> Ar | 39.9623831225(29) | 99.6003(30)    |
| 19 | <sup>39</sup> K  | 38.96370668(20)   | 93.2581(44)    |
|    | <sup>40</sup> K  | 39.96399848(21)   | 0.0117(1)      |
|    | <sup>41</sup> K  | 40.96182576(21)   | 6.7302(44)     |
|    | <sup>42</sup> K  | 41.96240281(24)   |                |
|    | <sup>43</sup> K  | 42.960716(10)     |                |
| 20 | <sup>40</sup> Ca | 39.96259098(22)   | 96.941(156)    |
|    | <sup>42</sup> Ca | 41.95861801(27)   | 0.647(23)      |
|    | <sup>43</sup> Ca | 42.9587666(3)     | 0.135(10)      |
|    | <sup>44</sup> Ca | 43.9554818(4)     | 2.086(110)     |
|    | <sup>45</sup> Ca | 44.9561866(4)     |                |
|    | <sup>46</sup> Ca | 45.9536926(24)    | 0.004(3)       |
|    | <sup>47</sup> Ca | 46.9545460(24)    |                |
|    | <sup>48</sup> Ca | 47.952534(4)      | 0.187(21)      |
| 21 | <sup>45</sup> Sc | 44.9559119(9)     | 100            |
| 22 | <sup>46</sup> Ti | 45.9526316(9)     | 8.25(3)        |
|    | <sup>47</sup> Ti | 46.9517631(9)     | 7.44(2)        |
|    | <sup>48</sup> Ti | 47.9479463(9)     | 73.72(3)       |
|    | <sup>49</sup> Ti | 48.9478700(9)     | 5.41(2)        |
|    | <sup>50</sup> Ti | 49.9447912(9)     | 5.18(2)        |
| 23 | <sup>50</sup> V  | 49.9471585(11)    | 0.250(4)       |
|    | <sup>51</sup> V  | 50.9439595(11)    | 99.750(4)      |
| 24 | <sup>50</sup> Cr | 49.9460442(11)    | 4.345(13)      |
|    | <sup>51</sup> Cr | 50.9447674(11)    |                |
|    | <sup>52</sup> Cr | 51.9405075(8)     | 83.789(18)     |
|    | <sup>53</sup> Cr | 52.9406494(8)     | 9.501(17)      |
|    | <sup>54</sup> Cr | 53.9388804(8)     | 2.365(7)       |
| 25 | <sup>54</sup> Mn | 53.9403589(14)    |                |
|    | <sup>55</sup> Mn | 54.9380451(7)     | 100            |
| 26 | <sup>52</sup> Fe | 51.948114(7)      |                |
|    | <sup>54</sup> Fe | 53.9396105(7)     | 5.845(35)      |
|    | <sup>55</sup> Fe | 54.9382934(7)     |                |
|    | <sup>56</sup> Fe | 55.9349375(7)     | 91.754(36)     |
|    | <sup>57</sup> Fe | 56.9353940(7)     | 2.119(10)      |
|    | <sup>58</sup> Fe | 57.9332756(8)     | 0.282(4)       |
|    | <sup>59</sup> Fe | 58.9348755(8)     |                |
| 27 | <sup>57</sup> Co | 56.9362914(8)     |                |

| Z                | Isotope          | Mass in u        | Abundance in %    | Z                 | Isotope           | Mass in u         | Abundance in %    |                   |                 |          |
|------------------|------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-----------------|----------|
| 28               | <sup>58</sup> Co | 57.9357528(13)   | 100               | 41                | <sup>96</sup> Zr  | 95.9082734(30)    | 2.80(9)           |                   |                 |          |
|                  | <sup>59</sup> Co | 58.9331950(7)    |                   |                   | <sup>93</sup> Nb  | 92.9063781(26)    | 100               |                   |                 |          |
|                  | <sup>60</sup> Co | 59.9338171(7)    |                   |                   | <sup>92</sup> Mo  | 91.906811(4)      | 14.77(31)         |                   |                 |          |
|                  | <sup>58</sup> Ni | 57.9353429(7)    |                   |                   | <sup>94</sup> Mo  | 93.9050883(21)    | 9.23(10)          |                   |                 |          |
|                  | <sup>59</sup> Ni | 58.9343467(7)    |                   |                   | <sup>95</sup> Mo  | 94.9058421(21)    | 15.90(9)          |                   |                 |          |
|                  | <sup>60</sup> Ni | 59.9307864(7)    |                   |                   | <sup>96</sup> Mo  | 95.9046795(21)    | 16.68(1)          |                   |                 |          |
|                  | <sup>61</sup> Ni | 60.9310560(7)    |                   |                   | <sup>97</sup> Mo  | 96.9060215(21)    | 9.56(5)           |                   |                 |          |
|                  | <sup>62</sup> Ni | 61.9283451(6)    |                   |                   | <sup>98</sup> Mo  | 97.9054082(21)    | 24.19(26)         |                   |                 |          |
|                  | <sup>63</sup> Ni | 62.9296694(6)    |                   |                   | <sup>99</sup> Mo  | 98.9077119(21)    | 9.67(20)          |                   |                 |          |
|                  | <sup>64</sup> Ni | 63.9279660(7)    |                   |                   | <sup>100</sup> Mo | 99.907477(6)      |                   |                   |                 |          |
| 29               | <sup>63</sup> Cu | 62.9295975(6)    | 69.15(3)          | 43                | <sup>97</sup> Tc  | 96.906365(5)      | 5.54(14)          |                   |                 |          |
|                  | <sup>64</sup> Cu | 63.9297642(6)    |                   |                   | <sup>98</sup> Tc  | 97.907216(4)      |                   |                   |                 |          |
|                  | <sup>65</sup> Cu | 64.9277895(7)    |                   |                   | <sup>99</sup> Tc  | 98.9062547(21)    |                   |                   |                 |          |
| 30               | <sup>64</sup> Zn | 63.9291422(7)    | 48.268(321)       |                   | 44                | <sup>96</sup> Ru  |                   | 95.907598(8)      | 1.87(3)         |          |
|                  | <sup>65</sup> Zn | 64.9292410(7)    |                   | <sup>98</sup> Ru  |                   | 97.905287(7)      | 12.76(14)         |                   |                 |          |
| 31               | <sup>66</sup> Zn | 65.9260334(10)   | 27.975(77)        | <sup>99</sup> Ru  |                   | 98.9059393(22)    | 12.60(7)          |                   |                 |          |
|                  | <sup>67</sup> Zn | 66.9271273(10)   | 4.102(21)         | <sup>100</sup> Ru |                   | 99.9042195(22)    | 17.06(2)          |                   |                 |          |
|                  | <sup>68</sup> Zn | 67.9248442(10)   | 19.024(123)       | <sup>101</sup> Ru |                   | 100.9055821(22)   | 31.55(14)         |                   |                 |          |
|                  | <sup>70</sup> Zn | 69.9253193(21)   | 0.631(9)          | <sup>102</sup> Ru |                   | 101.9043493(22)   | 18.62(27)         |                   |                 |          |
|                  | <sup>67</sup> Ga | 66.9282017(14)   | 60.108(9)         | <sup>104</sup> Ru |                   | 103.905433(3)     | 100               |                   |                 |          |
|                  | <sup>68</sup> Ga | 67.9279801(16)   |                   | <sup>106</sup> Ru |                   | 105.907329(8)     |                   |                   |                 |          |
|                  | <sup>69</sup> Ga | 68.9255736(13)   |                   | <sup>103</sup> Rh |                   | 102.905504(3)     |                   |                   |                 |          |
|                  | <sup>71</sup> Ga | 70.9247013(11)   |                   | <sup>102</sup> Pd |                   | 101.905609(3)     |                   | 1.02(1)           |                 |          |
|                  | 32               | <sup>68</sup> Ge |                   | 67.928094(7)      | 20.38(18)         | <sup>104</sup> Pd |                   | 103.904036(4)     | 11.14(8)        |          |
|                  |                  | <sup>70</sup> Ge |                   | 69.9242474(11)    |                   | <sup>105</sup> Pd |                   | 104.905085(4)     | 22.33(8)        |          |
| <sup>72</sup> Ge |                  | 71.9220758(18)   |                   | <sup>106</sup> Pd |                   | 105.903486(4)     |                   | 27.33(3)          |                 |          |
| <sup>73</sup> Ge |                  | 72.9234589(18)   |                   | <sup>108</sup> Pd |                   | 107.903892(4)     |                   | 26.46(9)          |                 |          |
| <sup>74</sup> Ge |                  | 73.9211778(18)   |                   | <sup>110</sup> Pd |                   | 109.905153(12)    |                   | 11.72(9)          |                 |          |
| <sup>76</sup> Ge |                  | 75.9214026(18)   |                   | <sup>107</sup> Ag |                   | 106.905097(5)     |                   | 51.839(8)         |                 |          |
| <sup>75</sup> As |                  | 74.9215965(20)   | <sup>109</sup> Ag | 108.904752(3)     |                   | 48.161(8)         |                   |                   |                 |          |
| 33               |                  | <sup>74</sup> Se | 73.9224764(18)    | 0.89(4)           |                   | 48                | <sup>106</sup> Cd | 105.906459(6)     | 1.25(6)         |          |
|                  |                  | <sup>75</sup> Se | 74.9225234(18)    |                   |                   |                   | <sup>108</sup> Cd | 107.904184(6)     | 0.89(3)         |          |
|                  |                  | <sup>76</sup> Se | 75.9192136(18)    |                   |                   |                   | <sup>110</sup> Cd | 109.9030021(29)   | 12.49(18)       |          |
|                  | <sup>77</sup> Se | 76.9199140(18)   | <sup>111</sup> Cd |                   | 110.9041781(29)   |                   | 12.80(12)         |                   |                 |          |
|                  | <sup>78</sup> Se | 77.9173091(18)   | <sup>112</sup> Cd |                   | 111.9027578(29)   |                   | 24.13(21)         |                   |                 |          |
|                  | <sup>79</sup> Se | 78.9184991(18)   | <sup>113</sup> Cd |                   | 112.9044017(29)   |                   | 12.22(12)         |                   |                 |          |
|                  | <sup>80</sup> Se | 79.9165213(21)   | <sup>114</sup> Cd |                   | 113.9033585(29)   |                   | 28.73(42)         |                   |                 |          |
|                  | <sup>82</sup> Se | 81.9166994(22)   | <sup>116</sup> Cd |                   | 115.904756(3)     |                   | 7.49(18)          |                   |                 |          |
|                  | 34               | <sup>79</sup> Br | 78.9183371(22)    |                   | 50.69(7)          |                   | 49                | <sup>111</sup> In | 110.905103(5)   | 4.29(5)  |
|                  |                  | <sup>81</sup> Br | 80.9162906(21)    |                   | 49.31(7)          |                   |                   | <sup>113</sup> In | 112.904058(3)   |          |
| 35               | <sup>78</sup> Kr | 77.9203648(12)   | 0.355(3)          | 50                | <sup>115</sup> In | 114.903878(5)     | 95.71(5)          |                   |                 |          |
|                  | <sup>80</sup> Kr | 79.9163790(16)   | 2.286(10)         |                   | <sup>112</sup> Sn | 111.904818(5)     | 0.97(1)           |                   |                 |          |
|                  | <sup>82</sup> Kr | 81.9134836(19)   | 11.593(31)        |                   | <sup>113</sup> Sn | 112.905171(4)     | 0.66(1)           |                   |                 |          |
|                  | <sup>83</sup> Kr | 82.914136(3)     | 11.500(19)        |                   | <sup>114</sup> Sn | 113.902779(3)     |                   |                   |                 |          |
|                  | <sup>84</sup> Kr | 83.911507(3)     | 56.987(15)        |                   | <sup>115</sup> Sn | 114.903342(3)     | 0.34(1)           |                   |                 |          |
|                  | <sup>86</sup> Kr | 85.91061073(11)  | 17.279(41)        |                   | <sup>116</sup> Sn | 115.901741(3)     | 14.54(9)          |                   |                 |          |
|                  | 36               | <sup>85</sup> Rb | 84.911789738(12)  |                   | 72.17(2)          | <sup>117</sup> Sn | 116.902952(3)     | 7.68(7)           |                 |          |
|                  |                  | <sup>86</sup> Rb | 85.91116742(21)   |                   | 27.83(2)          | <sup>118</sup> Sn | 117.901603(3)     | 24.22(9)          |                 |          |
|                  | <sup>87</sup> Rb | 86.909180527(13) | <sup>119</sup> Sn |                   |                   | 118.903308(3)     | 8.59(4)           |                   |                 |          |
|                  | 37               | <sup>84</sup> Sr | 83.913425(3)      |                   | 0.56(1)           | 51                | <sup>120</sup> Sn | 119.9021947(27)   | 32.58(9)        |          |
| <sup>85</sup> Sr |                  | 84.912933(3)     | 82.58(1)          | <sup>122</sup> Sn | 121.9034390(29)   |                   | 4.63(3)           |                   |                 |          |
| <sup>86</sup> Sr |                  | 85.9092602(12)   |                   | <sup>124</sup> Sn | 123.9052739(15)   |                   | 5.79(5)           |                   |                 |          |
| <sup>87</sup> Sr |                  | 86.9088771(12)   |                   | <sup>121</sup> Sb | 120.9038157(24)   |                   | 57.21(5)          |                   |                 |          |
| <sup>88</sup> Sr |                  | 87.9056121(12)   |                   | <sup>123</sup> Sb | 122.9042140(22)   |                   | 42.79(5)          |                   |                 |          |
| <sup>89</sup> Sr |                  | 88.9074507(12)   |                   | 52                | <sup>120</sup> Te |                   | 119.904020(10)    | 0.09(1)           |                 |          |
| <sup>90</sup> Sr |                  | 89.907738(3)     |                   |                   | <sup>122</sup> Te |                   | 121.9030439(16)   | 2.55(12)          |                 |          |
| 38               |                  | <sup>89</sup> Y  |                   |                   | 88.9058483(27)    |                   | <sup>123</sup> Te | 122.9042700(16)   | 0.89(3)         |          |
|                  |                  | <sup>90</sup> Zr |                   |                   | 89.9047044(25)    |                   | 51.45(40)         | <sup>124</sup> Te | 123.9028179(16) | 4.74(14) |
| 39               |                  | <sup>91</sup> Zr |                   | 90.9056458(25)    | 11.22(5)          |                   | <sup>125</sup> Te | 124.9044307(16)   | 7.07(15)        |          |
|                  | <sup>92</sup> Zr | 91.9050408(25)   |                   | 17.15(8)          | <sup>126</sup> Te | 125.9033117(16)   | 18.84(25)         |                   |                 |          |
|                  | <sup>94</sup> Zr | 93.9063152(26)   | 17.38(28)         | <sup>128</sup> Te | 127.9044631(19)   | 31.74(8)          |                   |                   |                 |          |

| Z  | Isotope           | Mass in u         | Abundance in % |
|----|-------------------|-------------------|----------------|
| 53 | <sup>130</sup> Te | 129.9062244(21)   | 34.08(62)      |
|    | <sup>123</sup> I  | 122.905589(4)     |                |
|    | <sup>125</sup> I  | 124.9046302(16)   |                |
|    | <sup>127</sup> I  | 126.904473(4)     | 100            |
|    | <sup>129</sup> I  | 128.904988(3)     |                |
| 54 | <sup>131</sup> I  | 130.9061246(12)   |                |
|    | <sup>124</sup> Xe | 123.9058930(20)   | 0.0952(3)      |
|    | <sup>126</sup> Xe | 125.904274(7)     | 0.0890(2)      |
|    | <sup>128</sup> Xe | 127.9035313(15)   | 1.9102(8)      |
|    | <sup>129</sup> Xe | 128.9047794(8)    | 26.4006(82)    |
|    | <sup>130</sup> Xe | 129.9035080(8)    | 4.0710(13)     |
|    | <sup>131</sup> Xe | 130.9050824(10)   | 21.2324(30)    |
|    | <sup>132</sup> Xe | 131.9041535(10)   | 26.9086(33)    |
|    | <sup>134</sup> Xe | 133.9053945(9)    | 10.4357(21)    |
| 55 | <sup>136</sup> Xe | 135.907219(8)     | 8.8573(44)     |
|    | <sup>129</sup> Cs | 128.906064(5)     |                |
|    | <sup>133</sup> Cs | 132.905451933(24) | 100            |
|    | <sup>134</sup> Cs | 133.906718475(28) |                |
|    | <sup>136</sup> Cs | 135.9073116(20)   |                |
| 56 | <sup>137</sup> Cs | 136.9070895(5)    |                |
|    | <sup>130</sup> Ba | 129.9063208(30)   | 0.106(1)       |
|    | <sup>132</sup> Ba | 131.9050613(11)   | 0.101(1)       |
|    | <sup>133</sup> Ba | 132.9060075(11)   |                |
|    | <sup>134</sup> Ba | 133.9045084(4)    | 2.417(18)      |
|    | <sup>135</sup> Ba | 134.9056886(4)    | 6.592(12)      |
|    | <sup>136</sup> Ba | 135.9045759(4)    | 7.854(24)      |
|    | <sup>137</sup> Ba | 136.9058274(5)    | 11.232(24)     |
|    | <sup>138</sup> Ba | 137.9052472(5)    | 71.698(42)     |
|    | <sup>140</sup> Ba | 139.910605(9)     |                |
| 57 | <sup>138</sup> La | 137.907112(4)     | 0.090(1)       |
|    | <sup>139</sup> La | 138.9063533(26)   | 99.910(1)      |
| 58 | <sup>136</sup> Ce | 135.907172(14)    | 0.185(2)       |
|    | <sup>138</sup> Ce | 137.905991(11)    | 0.251(2)       |
|    | <sup>140</sup> Ce | 139.9054387(26)   | 88.450(51)     |
|    | <sup>141</sup> Ce | 140.9082763(26)   |                |
|    | <sup>142</sup> Ce | 141.909244(3)     | 11.114(51)     |
| 59 | <sup>144</sup> Ce | 143.913647(4)     |                |
|    | <sup>141</sup> Pr | 140.9076528(26)   | 100            |
| 60 | <sup>142</sup> Nd | 141.9077233(25)   | 27.2(5)        |
|    | <sup>143</sup> Nd | 142.9098143(25)   | 12.2(2)        |
|    | <sup>144</sup> Nd | 143.9100873(25)   | 23.8(3)        |
|    | <sup>145</sup> Nd | 144.9125736(25)   | 8.3(1)         |
|    | <sup>146</sup> Nd | 145.9131169(25)   | 17.2(3)        |
|    | <sup>148</sup> Nd | 147.916893(3)     | 5.7(1)         |
|    | <sup>150</sup> Nd | 149.920891(3)     | 5.6(2)         |
| 61 | <sup>145</sup> Pm | 144.912749(3)     |                |
|    | <sup>147</sup> Pm | 146.9151385(26)   |                |
| 62 | <sup>144</sup> Sm | 143.911999(3)     | 3.07(7)        |
|    | <sup>147</sup> Sm | 146.9148979(26)   | 14.99(18)      |
|    | <sup>148</sup> Sm | 147.9148227(26)   | 11.24(10)      |
|    | <sup>149</sup> Sm | 148.9171847(26)   | 13.82(7)       |
|    | <sup>150</sup> Sm | 149.9172755(26)   | 7.38(1)        |
|    | <sup>152</sup> Sm | 151.9197324(27)   | 26.75(16)      |
|    | <sup>154</sup> Sm | 153.9222093(27)   | 22.75(29)      |
| 63 | <sup>151</sup> Eu | 150.9198502(26)   | 47.81(6)       |
|    | <sup>153</sup> Eu | 152.9212303(26)   | 52.19(6)       |
| 64 | <sup>152</sup> Gd | 151.9197910(27)   | 0.20(1)        |
|    | <sup>154</sup> Gd | 153.9208656(27)   | 2.18(3)        |
|    | <sup>155</sup> Gd | 154.9226220(27)   | 14.80(12)      |
|    | <sup>156</sup> Gd | 155.9221227(27)   | 20.47(9)       |
|    | <sup>157</sup> Gd | 156.9239601(27)   | 15.65(2)       |

| Z  | Isotope           | Mass in u       | Abundance in % |
|----|-------------------|-----------------|----------------|
|    | <sup>158</sup> Gd | 157.9241039(27) | 24.84(7)       |
|    | <sup>160</sup> Gd | 159.9270541(27) | 21.86(19)      |
| 65 | <sup>159</sup> Tb | 158.9253468(27) | 100            |
| 66 | <sup>156</sup> Dy | 155.924283(7)   | 0.056(3)       |
|    | <sup>158</sup> Dy | 157.924409(4)   | 0.095(3)       |
|    | <sup>160</sup> Dy | 159.9251975(27) | 2.329(18)      |
|    | <sup>161</sup> Dy | 160.9269334(27) | 18.889(42)     |
|    | <sup>162</sup> Dy | 161.9267984(27) | 25.475(36)     |
|    | <sup>163</sup> Dy | 162.9287312(27) | 24.896(42)     |
|    | <sup>164</sup> Dy | 163.9291748(27) | 28.260(54)     |
| 67 | <sup>165</sup> Ho | 164.9303221(27) | 100            |
| 68 | <sup>162</sup> Er | 161.928778(4)   | 0.139(5)       |
|    | <sup>164</sup> Er | 163.929200(3)   | 1.601(3)       |
|    | <sup>166</sup> Er | 165.9302931(27) | 33.503(36)     |
|    | <sup>167</sup> Er | 166.9320482(27) | 22.869(9)      |
|    | <sup>168</sup> Er | 167.9323702(27) | 26.978(18)     |
|    | <sup>170</sup> Er | 169.9354643(30) | 14.910(36)     |
| 69 | <sup>169</sup> Tm | 168.9342133(27) | 100            |
| 70 | <sup>168</sup> Yb | 167.933897(5)   | 0.13(1)        |
|    | <sup>169</sup> Yb | 168.935190(5)   |                |
|    | <sup>170</sup> Yb | 169.9347618(26) | 3.04(15)       |
|    | <sup>171</sup> Yb | 170.9363258(26) | 14.28(57)      |
|    | <sup>172</sup> Yb | 171.9363815(26) | 21.83(67)      |
|    | <sup>173</sup> Yb | 172.9382108(26) | 16.13(27)      |
|    | <sup>174</sup> Yb | 173.9388621(26) | 31.83(92)      |
|    | <sup>176</sup> Yb | 175.9425717(28) | 12.76(41)      |
|    | <sup>175</sup> Lu | 174.9407718(23) | 97.41(2)       |
|    | <sup>176</sup> Lu | 175.9426863(23) | 2.59(2)        |
| 72 | <sup>174</sup> Hf | 173.940046(3)   | 0.16(1)        |
|    | <sup>176</sup> Hf | 175.9414086(24) | 5.26(7)        |
|    | <sup>177</sup> Hf | 176.9432207(23) | 18.60(9)       |
|    | <sup>178</sup> Hf | 177.9436988(23) | 27.28(7)       |
|    | <sup>179</sup> Hf | 178.9458161(23) | 13.62(2)       |
|    | <sup>180</sup> Hf | 179.9465500(23) | 35.08(16)      |
| 73 | <sup>180</sup> Ta | 179.9474648(24) | 0.012(2)       |
|    | <sup>181</sup> Ta | 180.9479958(19) | 99.988(2)      |
| 74 | <sup>180</sup> W  | 179.946704(4)   | 0.12(1)        |
|    | <sup>182</sup> W  | 181.9482042(9)  | 26.50(16)      |
|    | <sup>183</sup> W  | 182.9502230(9)  | 14.31(4)       |
|    | <sup>184</sup> W  | 183.9509312(9)  | 30.64(2)       |
|    | <sup>186</sup> W  | 185.9543641(19) | 28.43(19)      |
| 75 | <sup>185</sup> Re | 184.9529550(13) | 37.40(2)       |
|    | <sup>187</sup> Re | 186.9557531(15) | 62.60(2)       |
| 76 | <sup>184</sup> Os | 183.9524891(14) | 0.02(1)        |
|    | <sup>186</sup> Os | 185.9538382(15) | 1.59(3)        |
|    | <sup>187</sup> Os | 186.9557505(15) | 1.96(2)        |
|    | <sup>188</sup> Os | 187.9558382(15) | 13.24(8)       |
|    | <sup>189</sup> Os | 188.9581475(16) | 16.15(5)       |
|    | <sup>190</sup> Os | 189.9584470(16) | 26.26(2)       |
|    | <sup>192</sup> Os | 191.9614807(27) | 40.78(19)      |
| 77 | <sup>191</sup> Ir | 190.9605940(18) | 37.3(2)        |
|    | <sup>193</sup> Ir | 192.9629264(18) | 62.7(2)        |
| 78 | <sup>190</sup> Pt | 189.959932(6)   | 0.014(1)       |
|    | <sup>192</sup> Pt | 191.9610380(27) | 0.782(7)       |
|    | <sup>194</sup> Pt | 193.9626803(9)  | 32.967(99)     |
|    | <sup>195</sup> Pt | 194.9647911(9)  | 33.832(10)     |
|    | <sup>196</sup> Pt | 195.9649515(9)  | 25.242(41)     |
|    | <sup>198</sup> Pt | 197.967893(3)   | 7.163(55)      |
| 79 | <sup>197</sup> Au | 196.9665687(6)  | 100            |
|    | <sup>198</sup> Au | 197.9682423(6)  |                |
| 80 | <sup>196</sup> Hg | 195.965833(3)   | 0.15(1)        |

| Z  | Isotope           | Mass in u       | Abundance in % |
|----|-------------------|-----------------|----------------|
|    | <sup>197</sup> Hg | 196.967213(3)   |                |
|    | <sup>198</sup> Hg | 197.9667690(4)  | 9.97(20)       |
|    | <sup>199</sup> Hg | 198.9682799(4)  | 16.87(22)      |
|    | <sup>200</sup> Hg | 199.9683260(4)  | 23.10(19)      |
|    | <sup>201</sup> Hg | 200.9703023(6)  | 13.18(9)       |
|    | <sup>202</sup> Hg | 201.9706430(6)  | 29.86(26)      |
|    | <sup>203</sup> Hg | 202.9728725(18) |                |
|    | <sup>204</sup> Hg | 203.9734939(4)  | 6.87(15)       |
| 81 | <sup>201</sup> Tl | 200.970819(16)  |                |
|    | <sup>203</sup> Tl | 202.9723442(14) | 29.52(1)       |
|    | <sup>205</sup> Tl | 204.9744275(14) | 70.48(1)       |
| 82 | <sup>204</sup> Pb | 203.9730436(13) | 1.4(1)         |
|    | <sup>206</sup> Pb | 205.9744653(13) | 24.1(1)        |
|    | <sup>207</sup> Pb | 206.9758969(13) | 22.1(1)        |
|    | <sup>208</sup> Pb | 207.9766521(13) | 52.4(1)        |
|    | <sup>210</sup> Pb | 209.9841885(16) |                |
| 83 | <sup>207</sup> Bi | 206.9784707(26) |                |
|    | <sup>209</sup> Bi | 208.9803987(16) | 100            |
| 84 | <sup>209</sup> Po | 208.9824304(20) |                |
|    | <sup>210</sup> Po | 209.9828737(13) |                |
| 85 | <sup>210</sup> At | 209.987148(8)   |                |
|    | <sup>211</sup> At | 210.9874963(30) |                |
| 86 | <sup>211</sup> Rn | 210.990601(7)   |                |
|    | <sup>220</sup> Rn | 220.0113940(24) |                |
|    | <sup>222</sup> Rn | 222.0175777(25) |                |
| 87 | <sup>223</sup> Fr | 223.0197359(26) |                |
| 88 | <sup>223</sup> Ra | 223.0185022(27) |                |
|    | <sup>224</sup> Ra | 224.0202118(24) |                |
|    | <sup>226</sup> Ra | 226.0254098(25) |                |
|    | <sup>228</sup> Ra | 228.0310703(26) |                |
| 89 | <sup>227</sup> Ac | 227.0277521(26) |                |
| 90 | <sup>228</sup> Th | 228.0287411(24) |                |
|    | <sup>230</sup> Th | 230.0331338(19) |                |
|    | <sup>232</sup> Th | 232.0380553(21) | 100            |
| 91 | <sup>231</sup> Pa | 231.0358840(24) | 100            |
| 92 | <sup>233</sup> U  | 233.0396352(29) |                |
|    | <sup>234</sup> U  | 234.0409521(20) | 0.0054(5)      |
|    | <sup>235</sup> U  | 235.0439299(20) | 0.7204(6)      |

| Z   | Isotope           | Mass in u       | Abundance in % |
|-----|-------------------|-----------------|----------------|
|     | <sup>236</sup> U  | 236.0455680(20) |                |
|     | <sup>238</sup> U  | 238.0507882(20) | 99.2742(10)    |
| 93  | <sup>237</sup> Np | 237.0481734(20) |                |
|     | <sup>239</sup> Np | 239.0529390(22) |                |
| 94  | <sup>238</sup> Pu | 238.0495599(20) |                |
|     | <sup>239</sup> Pu | 239.0521634(20) |                |
|     | <sup>240</sup> Pu | 240.0538135(20) |                |
|     | <sup>241</sup> Pu | 241.0568515(20) |                |
|     | <sup>242</sup> Pu | 242.0587426(20) |                |
|     | <sup>244</sup> Pu | 244.064204(5)   |                |
| 95  | <sup>241</sup> Am | 241.0568291(20) |                |
|     | <sup>243</sup> Am | 243.0613811(25) |                |
| 96  | <sup>243</sup> Cm | 243.0613891(22) |                |
|     | <sup>244</sup> Cm | 244.0627526(20) |                |
|     | <sup>245</sup> Cm | 245.0654912(22) |                |
|     | <sup>246</sup> Cm | 246.0672237(22) |                |
|     | <sup>247</sup> Cm | 247.070354(5)   |                |
|     | <sup>248</sup> Cm | 248.072349(5)   |                |
| 97  | <sup>247</sup> Bk | 247.070307(6)   |                |
|     | <sup>249</sup> Bk | 249.0749867(28) |                |
| 98  | <sup>249</sup> Cf | 249.0748535(24) |                |
|     | <sup>250</sup> Cf | 250.0764061(22) |                |
|     | <sup>251</sup> Cf | 251.079587(5)   |                |
|     | <sup>252</sup> Cf | 252.081626(5)   |                |
| 99  | <sup>252</sup> Es | 252.082980(50)  |                |
| 100 | <sup>257</sup> Fm | 257.095105(7)   |                |
| 101 | <sup>256</sup> Md | 256.094060(60)  |                |
|     | <sup>258</sup> Md | 258.098431(5)   |                |
| 102 | <sup>259</sup> No | 259.10103(11)*  |                |
| 103 | <sup>262</sup> Lr | 262.10963(22)*  |                |
| 104 | <sup>261</sup> Rf | 261.108770(30)* |                |
| 105 | <sup>262</sup> Db | 262.11408(20)*  |                |
| 106 | <sup>263</sup> Sg | 263.11832(13)*  |                |
| 107 | <sup>264</sup> Bh | 264.12460(30)*  |                |
| 108 | <sup>265</sup> Hs | 265.13009(15)*  |                |
| 109 | <sup>268</sup> Mt | 268.13873(34)*  |                |
| 110 | <sup>281</sup> Ds | 281.16206(78)*  |                |
| 111 | <sup>272</sup> Rg | 273.15362(36)*  |                |

# ELECTRON CONFIGURATION AND IONIZATION ENERGY OF NEUTRAL ATOMS IN THE GROUND STATE

William C. Martin

The ground state electron configuration, ground level, and ionization energy of the elements hydrogen through rutherfordium are listed in this table. The electron configurations of elements heavier than neon are shortened by using rare-gas element symbols in brackets to represent the corresponding electrons. See the references for details of the notation for Pa, U, and Np. Ionization energies to higher states (and more precise values of the first ionization energy for certain elements) may be found in the table "Ionization Energies of Atoms and Atomic Ions" in Section 10 of this *Handbook*.

## References

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2. Martin, W. C., and Wiese, W. L., "Atomic Spectroscopy", in *Atomic, Molecular, & Optical Physics Handbook*, ed. by G.W.F. Drake (AIP, Woodbury, NY, 1996) Chapter 10, pp. 135-153.

| Z  | Element       | Ground-state configuration                            | Ground level  | Ionization energy (eV) |
|----|---------------|-------------------------------------------------------|---------------|------------------------|
| 1  | H Hydrogen    | 1s                                                    | $^2S_{1/2}$   | 13.5984                |
| 2  | He Helium     | 1s <sup>2</sup>                                       | $^1S_0$       | 24.5874                |
| 3  | Li Lithium    | 1s <sup>2</sup> 2s                                    | $^2S_{1/2}$   | 5.3917                 |
| 4  | Be Beryllium  | 1s <sup>2</sup> 2s <sup>2</sup>                       | $^1S_0$       | 9.3227                 |
| 5  | B Boron       | 1s <sup>2</sup> 2s <sup>2</sup> 2p                    | $^2P^o_{1/2}$ | 8.2980                 |
| 6  | C Carbon      | 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>2</sup>       | $^3P_0$       | 11.2603                |
| 7  | N Nitrogen    | 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>3</sup>       | $^4S^o_{3/2}$ | 14.5341                |
| 8  | O Oxygen      | 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>4</sup>       | $^3P_2$       | 13.6181                |
| 9  | F Fluorine    | 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>5</sup>       | $^2P^o_{3/2}$ | 17.4228                |
| 10 | Ne Neon       | 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup>       | $^1S_0$       | 21.5645                |
| 11 | Na Sodium     | [Ne] 3s                                               | $^2S_{1/2}$   | 5.1391                 |
| 12 | Mg Magnesium  | [Ne] 3s <sup>2</sup>                                  | $^1S_0$       | 7.6462                 |
| 13 | Al Aluminum   | [Ne] 3s <sup>2</sup> 3p                               | $^2P^o_{1/2}$ | 5.9858                 |
| 14 | Si Silicon    | [Ne] 3s <sup>2</sup> 3p <sup>2</sup>                  | $^3P_0$       | 8.1517                 |
| 15 | P Phosphorus  | [Ne] 3s <sup>2</sup> 3p <sup>3</sup>                  | $^4S^o_{3/2}$ | 10.4867                |
| 16 | S Sulfur      | [Ne] 3s <sup>2</sup> 3p <sup>4</sup>                  | $^3P_2$       | 10.3600                |
| 17 | Cl Chlorine   | [Ne] 3s <sup>2</sup> 3p <sup>5</sup>                  | $^2P^o_{3/2}$ | 12.9676                |
| 18 | Ar Argon      | [Ne] 3s <sup>2</sup> 3p <sup>6</sup>                  | $^1S_0$       | 15.7596                |
| 19 | K Potassium   | [Ar] 4s                                               | $^2S_{1/2}$   | 4.3407                 |
| 20 | Ca Calcium    | [Ar] 4s <sup>2</sup>                                  | $^1S_0$       | 6.1132                 |
| 21 | Sc Scandium   | [Ar] 3d 4s <sup>2</sup>                               | $^2D_{3/2}$   | 6.5615                 |
| 22 | Ti Titanium   | [Ar] 3d <sup>2</sup> 4s <sup>2</sup>                  | $^3F_2$       | 6.8281                 |
| 23 | V Vanadium    | [Ar] 3d <sup>3</sup> 4s <sup>2</sup>                  | $^4F_{3/2}$   | 6.7462                 |
| 24 | Cr Chromium   | [Ar] 3d <sup>5</sup> 4s                               | $^7S_3$       | 6.7665                 |
| 25 | Mn Manganese  | [Ar] 3d <sup>5</sup> 4s <sup>2</sup>                  | $^6S_{5/2}$   | 7.4340                 |
| 26 | Fe Iron       | [Ar] 3d <sup>6</sup> 4s <sup>2</sup>                  | $^5D_4$       | 7.9024                 |
| 27 | Co Cobalt     | [Ar] 3d <sup>7</sup> 4s <sup>2</sup>                  | $^4F_{9/2}$   | 7.8810                 |
| 28 | Ni Nickel     | [Ar] 3d <sup>8</sup> 4s <sup>2</sup>                  | $^3F_4$       | 7.6398                 |
| 29 | Cu Copper     | [Ar] 3d <sup>10</sup> 4s                              | $^2S_{1/2}$   | 7.7264                 |
| 30 | Zn Zinc       | [Ar] 3d <sup>10</sup> 4s <sup>2</sup>                 | $^1S_0$       | 9.3942                 |
| 31 | Ga Gallium    | [Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p              | $^2P^o_{1/2}$ | 5.9993                 |
| 32 | Ge Germanium  | [Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>2</sup> | $^3P_0$       | 7.8994                 |
| 33 | As Arsenic    | [Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>3</sup> | $^4S^o_{3/2}$ | 9.7886                 |
| 34 | Se Selenium   | [Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>4</sup> | $^3P_2$       | 9.7524                 |
| 35 | Br Bromine    | [Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>5</sup> | $^2P^o_{3/2}$ | 11.8138                |
| 36 | Kr Krypton    | [Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>6</sup> | $^1S_0$       | 13.9996                |
| 37 | Rb Rubidium   | [Kr] 5s                                               | $^2S_{1/2}$   | 4.1771                 |
| 38 | Sr Strontium  | [Kr] 5s <sup>2</sup>                                  | $^1S_0$       | 5.6949                 |
| 39 | Y Yttrium     | [Kr] 4d 5s <sup>2</sup>                               | $^2D_{3/2}$   | 6.2173                 |
| 40 | Zr Zirconium  | [Kr] 4d <sup>2</sup> 5s <sup>2</sup>                  | $^3F_2$       | 6.6339                 |
| 41 | Nb Niobium    | [Kr] 4d <sup>4</sup> 5s                               | $^6D_{1/2}$   | 6.7589                 |
| 42 | Mo Molybdenum | [Kr] 4d <sup>5</sup> 5s                               | $^7S_3$       | 7.0924                 |
| 43 | Tc Technetium | [Kr] 4d <sup>5</sup> 5s <sup>2</sup>                  | $^6S_{5/2}$   | 7.28                   |
| 44 | Ru Ruthenium  | [Kr] 4d <sup>7</sup> 5s                               | $^5F_5$       | 7.3605                 |

| Z   | Element          | Ground-state configuration       | Ground level     | Ionization energy (eV) |
|-----|------------------|----------------------------------|------------------|------------------------|
| 45  | Rh Rhodium       | [Kr] $4d^8 5s$                   | $^4F_{9/2}$      | 7.4589                 |
| 46  | Pd Palladium     | [Kr] $4d^{10}$                   | $^1S_0$          | 8.3369                 |
| 47  | Ag Silver        | [Kr] $4d^{10} 5s$                | $^2S_{1/2}$      | 7.5762                 |
| 48  | Cd Cadmium       | [Kr] $4d^{10} 5s^2$              | $^1S_0$          | 8.9938                 |
| 49  | In Indium        | [Kr] $4d^{10} 5s^2 5p$           | $^2P_{1/2}^o$    | 5.7864                 |
| 50  | Sn Tin           | [Kr] $4d^{10} 5s^2 5p^2$         | $^3P_0$          | 7.3439                 |
| 51  | Sb Antimony      | [Kr] $4d^{10} 5s^2 5p^3$         | $^4S_{3/2}^o$    | 8.6084                 |
| 52  | Te Tellurium     | [Kr] $4d^{10} 5s^2 5p^4$         | $^3P_2$          | 9.0096                 |
| 53  | I Iodine         | [Kr] $4d^{10} 5s^2 5p^5$         | $^2P_{3/2}^o$    | 10.4513                |
| 54  | Xe Xenon         | [Kr] $4d^{10} 5s^2 5p^6$         | $^1S_0$          | 12.1298                |
| 55  | Cs Cesium        | [Xe] $6s$                        | $^2S_{1/2}$      | 3.8939                 |
| 56  | Ba Barium        | [Xe] $6s^2$                      | $^1S_0$          | 5.2117                 |
| 57  | La Lanthanum     | [Xe] $5d 6s^2$                   | $^2D_{3/2}$      | 5.5769                 |
| 58  | Ce Cerium        | [Xe] $4f 5d 6s^2$                | $^1G_4^o$        | 5.5387                 |
| 59  | Pr Praseodymium  | [Xe] $4f^3 6s^2$                 | $^4I_{9/2}^o$    | 5.473                  |
| 60  | Nd Neodymium     | [Xe] $4f^4 6s^2$                 | $^5I_4$          | 5.5250                 |
| 61  | Pm Promethium    | [Xe] $4f^5 6s^2$                 | $^6H_{5/2}^o$    | 5.582                  |
| 62  | Sm Samarium      | [Xe] $4f^6 6s^2$                 | $^7F_0$          | 5.6437                 |
| 63  | Eu Europium      | [Xe] $4f^7 6s^2$                 | $^8S_{7/2}^o$    | 5.6704                 |
| 64  | Gd Gadolinium    | [Xe] $4f^7 5d 6s^2$              | $^9D_2^o$        | 6.1498                 |
| 65  | Tb Terbium       | [Xe] $4f^8 6s^2$                 | $^6H_{15/2}^o$   | 5.8638                 |
| 66  | Dy Dysprosium    | [Xe] $4f^{10} 6s^2$              | $^5I_8$          | 5.9389                 |
| 67  | Ho Holmium       | [Xe] $4f^{11} 6s^2$              | $^4I_{15/2}^o$   | 6.0215                 |
| 68  | Er Erbium        | [Xe] $4f^{12} 6s^2$              | $^3H_6$          | 6.1077                 |
| 69  | Tm Thulium       | [Xe] $4f^{13} 6s^2$              | $^2F_{7/2}^o$    | 6.1843                 |
| 70  | Yb Ytterbium     | [Xe] $4f^{14} 6s^2$              | $^1S_0$          | 6.2542                 |
| 71  | Lu Lutetium      | [Xe] $4f^{14} 5d 6s^2$           | $^2D_{3/2}$      | 5.4259                 |
| 72  | Hf Hafnium       | [Xe] $4f^{14} 5d^2 6s^2$         | $^3F_2$          | 6.8251                 |
| 73  | Ta Tantalum      | [Xe] $4f^{14} 5d^3 6s^2$         | $^4F_{3/2}$      | 7.5496                 |
| 74  | W Tungsten       | [Xe] $4f^{14} 5d^4 6s^2$         | $^5D_0$          | 7.8640                 |
| 75  | Re Rhenium       | [Xe] $4f^{14} 5d^5 6s^2$         | $^6S_{5/2}^o$    | 7.8335                 |
| 76  | Os Osmium        | [Xe] $4f^{14} 5d^6 6s^2$         | $^5D_4$          | 8.4382                 |
| 77  | Ir Iridium       | [Xe] $4f^{14} 5d^7 6s^2$         | $^4F_{9/2}$      | 8.9670                 |
| 78  | Pt Platinum      | [Xe] $4f^{14} 5d^9 6s$           | $^3D_3$          | 8.9588                 |
| 79  | Au Gold          | [Xe] $4f^{14} 5d^{10} 6s$        | $^2S_{1/2}$      | 9.2255                 |
| 80  | Hg Mercury       | [Xe] $4f^{14} 5d^{10} 6s^2$      | $^1S_0$          | 10.4375                |
| 81  | Tl Thallium      | [Xe] $4f^{14} 5d^{10} 6s^2 6p$   | $^2P_{1/2}^o$    | 6.1082                 |
| 82  | Pb Lead          | [Xe] $4f^{14} 5d^{10} 6s^2 6p^2$ | $^3P_0$          | 7.4167                 |
| 83  | Bi Bismuth       | [Xe] $4f^{14} 5d^{10} 6s^2 6p^3$ | $^4S_{3/2}^o$    | 7.2855                 |
| 84  | Po Polonium      | [Xe] $4f^{14} 5d^{10} 6s^2 6p^4$ | $^3P_2$          | 8.414                  |
| 85  | At Astatine      | [Xe] $4f^{14} 5d^{10} 6s^2 6p^5$ | $^2P_{3/2}^o$    |                        |
| 86  | Rn Radon         | [Xe] $4f^{14} 5d^{10} 6s^2 6p^6$ | $^1S_0$          | 10.7485                |
| 87  | Fr Francium      | [Rn] $7s$                        | $^2S_{1/2}$      | 4.0727                 |
| 88  | Ra Radium        | [Rn] $7s^2$                      | $^1S_0$          | 5.2784                 |
| 89  | Ac Actinium      | [Rn] $6d 7s^2$                   | $^2D_{3/2}$      | 5.17                   |
| 90  | Th Thorium       | [Rn] $6d^2 7s^2$                 | $^3F_2$          | 6.3067                 |
| 91  | Pa Protactinium  | [Rn] $5f^2(^3H_4) 6d 7s^2$       | $(4,3/2)_{11/2}$ | 5.89                   |
| 92  | U Uranium        | [Rn] $5f^3(^4I_{9/2}^o) 6d 7s^2$ | $(9/2,3/2)_6^o$  | 6.1941                 |
| 93  | Np Neptunium     | [Rn] $5f^4(^6I_4) 6d 7s^2$       | $(4,3/2)_{11/2}$ | 6.2657                 |
| 94  | Pu Plutonium     | [Rn] $5f^6 7s^2$                 | $^7F_0$          | 6.0260                 |
| 95  | Am Americium     | [Rn] $5f^7 7s^2$                 | $^8S_{7/2}^o$    | 5.9738                 |
| 96  | Cm Curium        | [Rn] $5f^8 6d 7s^2$              | $^9D_2^o$        | 5.9914                 |
| 97  | Bk Berkelium     | [Rn] $5f^9 7s^2$                 | $^6H_{15/2}^o$   | 6.1979                 |
| 98  | Cf Californium   | [Rn] $5f^{10} 7s^2$              | $^5I_8$          | 6.2817                 |
| 99  | Es Einsteinium   | [Rn] $5f^{11} 7s^2$              | $^4I_{15/2}^o$   | 6.42                   |
| 100 | Fm Fermium       | [Rn] $5f^{12} 7s^2$              | $^3H_6$          | 6.50                   |
| 101 | Md Mendelevium   | [Rn] $5f^{13} 7s^2$              | $^2F_{7/2}^o$    | 6.58                   |
| 102 | No Nobelium      | [Rn] $5f^{14} 7s^2$              | $^1S_0$          | 6.65                   |
| 103 | Lr Lawrencium    | [Rn] $5f^{14} 7s^2 7p?$          | $^2P_{1/2}^o ?$  | 4.9?                   |
| 104 | Rf Rutherfordium | [Rn] $5f^{14} 6d^2 7s^2 ?$       | $^3F_2 ?$        | 6.0?                   |



# CONVERSION OF TEMPERATURES FROM THE 1948 AND 1968 SCALES TO ITS-90

This table gives temperature corrections from older scales to the current International Temperature Scale of 1990 (see the preceding table for details on ITS-90). The first part of the table may be used for converting Celsius temperatures in the range  $-180$  to  $4000$  °C from IPTS-68 or IPTS-48 to ITS-90. Within the accuracy of the corrections, the temperature in the first column may be identified with either  $t_{68}$ ,  $t_{48}$ , or  $t_{90}$ . The second part of the table is designed for use at lower temperatures to convert values expressed in kelvins from EPT-76 or IPTS-68 to ITS-90.

The references give analytical equations for expressing these relations. Note that Reference 1 supersedes Reference 2 with respect to corrections in the 630 to 1064 °C range.

## References

1. Burns, G. W. et al., in *Temperature: Its Measurement and Control in Science and Industry*, Vol. 6, Schooley, J. F., Ed., American Institute of Physics, New York, 1993.
2. Goldberg, R. N. and Weir, R. D., *Pure and Appl. Chem.*, 64, 1545, 1992.

| $t/^{\circ}\text{C}$ | $t_{90}-t_{68}$ | $t_{90}-t_{48}$ | $t/^{\circ}\text{C}$ | $t_{90}-t_{68}$ | $t_{90}-t_{48}$ | $t/^{\circ}\text{C}$ | $t_{90}-t_{68}$ | $t_{90}-t_{48}$ | $t/^{\circ}\text{C}$ | $t_{90}-t_{68}$ | $t_{90}-t_{48}$ |
|----------------------|-----------------|-----------------|----------------------|-----------------|-----------------|----------------------|-----------------|-----------------|----------------------|-----------------|-----------------|
| -180                 | 0.008           | 0.020           | 290                  | -0.039          | 0.032           | 760                  | 0.04            | 0.60            | 2400                 | -1.00           | 3.2             |
| -170                 | 0.010           | 0.017           | 300                  | -0.039          | 0.034           | 770                  | 0.05            | 0.63            | 2500                 | -1.07           | 3.4             |
| -160                 | 0.012           | 0.007           | 310                  | -0.039          | 0.035           | 780                  | 0.05            | 0.66            | 2600                 | -1.15           | 3.7             |
| -150                 | 0.013           | 0.000           | 320                  | -0.039          | 0.036           | 790                  | 0.05            | 0.69            | 2700                 | -1.24           | 3.8             |
| -140                 | 0.014           | 0.001           | 330                  | -0.040          | 0.036           | 800                  | 0.05            | 0.72            | 2800                 | -1.32           | 4.0             |
| -130                 | 0.014           | 0.008           | 340                  | -0.040          | 0.037           | 810                  | 0.05            | 0.75            | 2900                 | -1.41           | 4.2             |
| -120                 | 0.014           | 0.017           | 350                  | -0.041          | 0.036           | 820                  | 0.04            | 0.76            | 3000                 | -1.50           | 4.4             |
| -110                 | 0.013           | 0.026           | 360                  | -0.042          | 0.035           | 830                  | 0.04            | 0.79            | 3100                 | -1.59           | 4.6             |
| -100                 | 0.013           | 0.035           | 370                  | -0.043          | 0.034           | 840                  | 0.03            | 0.81            | 3200                 | -1.69           | 4.8             |
| -90                  | 0.012           | 0.041           | 380                  | -0.045          | 0.032           | 850                  | 0.02            | 0.83            | 3300                 | -1.78           | 5.1             |
| -80                  | 0.012           | 0.045           | 390                  | -0.046          | 0.030           | 860                  | 0.01            | 0.85            | 3400                 | -1.89           | 5.3             |
| -70                  | 0.011           | 0.045           | 400                  | -0.048          | 0.028           | 870                  | 0.00            | 0.87            | 3500                 | -1.99           | 5.5             |
| -60                  | 0.010           | 0.042           | 410                  | -0.051          | 0.024           | 880                  | -0.02           | 0.87            | 3600                 | -2.10           | 5.8             |
| -50                  | 0.009           | 0.038           | 420                  | -0.053          | 0.022           | 890                  | -0.03           | 0.89            | 3700                 | -2.21           | 6.0             |
| -40                  | 0.008           | 0.032           | 430                  | -0.056          | 0.019           | 900                  | -0.05           | 0.90            | 3800                 | -2.32           | 6.3             |
| -30                  | 0.006           | 0.024           | 440                  | -0.059          | 0.015           | 910                  | -0.06           | 0.92            | 3900                 | -2.43           | 6.6             |
| -20                  | 0.004           | 0.016           | 450                  | -0.062          | 0.012           | 920                  | -0.08           | 0.93            | 4000                 | -2.55           | 6.8             |
| -10                  | 0.002           | 0.008           | 460                  | -0.065          | 0.009           | 930                  | -0.10           | 0.94            |                      |                 |                 |
| 0                    | 0.000           | 0.000           | 470                  | -0.068          | 0.007           | 940                  | -0.11           | 0.96            | $T/\text{K}$         | $T_{90}-T_{76}$ | $T_{90}-T_{68}$ |
| 10                   | -0.002          | -0.006          | 480                  | -0.072          | 0.004           | 950                  | -0.13           | 0.97            | 5                    | -0.0001         |                 |
| 20                   | -0.005          | -0.012          | 490                  | -0.075          | 0.002           | 960                  | -0.15           | 0.97            | 6                    | -0.0002         |                 |
| 30                   | -0.007          | -0.016          | 500                  | -0.079          | 0.000           | 970                  | -0.16           | 0.99            | 7                    | -0.0003         |                 |
| 40                   | -0.010          | -0.020          | 510                  | -0.083          | -0.001          | 980                  | -0.18           | 1.00            | 8                    | -0.0004         |                 |
| 50                   | -0.013          | -0.023          | 520                  | -0.087          | -0.002          | 990                  | -0.19           | 1.02            | 9                    | -0.0005         |                 |
| 60                   | -0.016          | -0.026          | 530                  | -0.090          | -0.001          | 1000                 | -0.20           | 1.04            | 10                   | -0.0006         |                 |
| 70                   | -0.018          | -0.026          | 540                  | -0.094          | 0.000           | 1010                 | -0.22           | 1.05            | 11                   | -0.0007         |                 |
| 80                   | -0.021          | -0.027          | 550                  | -0.098          | 0.002           | 1020                 | -0.23           | 1.07            | 12                   | -0.0008         |                 |
| 90                   | -0.024          | -0.027          | 560                  | -0.101          | 0.007           | 1030                 | -0.23           | 1.10            | 13                   | -0.0010         |                 |
| 100                  | -0.026          | -0.026          | 570                  | -0.105          | 0.011           | 1040                 | -0.24           | 1.12            | 14                   | -0.0011         | -0.006          |
| 110                  | -0.028          | -0.024          | 580                  | -0.108          | 0.018           | 1050                 | -0.25           | 1.14            | 15                   | -0.0013         | -0.003          |
| 120                  | -0.030          | -0.023          | 590                  | -0.112          | 0.025           | 1060                 | -0.25           | 1.17            | 16                   | -0.0014         | -0.004          |
| 130                  | -0.032          | -0.020          | 600                  | -0.115          | 0.035           | 1070                 | -0.25           | 1.19            | 17                   | -0.0016         | -0.006          |
| 140                  | -0.034          | -0.018          | 610                  | -0.118          | 0.047           | 1080                 | -0.26           | 1.20            | 18                   | -0.0018         | -0.008          |
| 150                  | -0.036          | -0.016          | 620                  | -0.122          | 0.060           | 1090                 | -0.26           | 1.20            | 19                   | -0.0020         | -0.009          |
| 160                  | -0.037          | -0.012          | 630                  | -0.125          | 0.075           | 1100                 | -0.26           | 1.2             | 20                   | -0.0022         | -0.009          |
| 170                  | -0.038          | -0.009          | 640                  | -0.11           | 0.12            | 1200                 | -0.30           | 1.4             | 21                   | -0.0025         | -0.008          |
| 180                  | -0.039          | -0.005          | 650                  | -0.10           | 0.15            | 1300                 | -0.35           | 1.5             | 22                   | -0.0027         | -0.007          |
| 190                  | -0.039          | -0.001          | 660                  | -0.09           | 0.19            | 1400                 | -0.39           | 1.6             | 23                   | -0.0030         | -0.007          |
| 200                  | -0.040          | 0.003           | 670                  | -0.07           | 0.24            | 1500                 | -0.44           | 1.8             | 24                   | -0.0032         | -0.006          |
| 210                  | -0.040          | 0.007           | 680                  | -0.05           | 0.29            | 1600                 | -0.49           | 1.9             | 25                   | -0.0035         | -0.005          |
| 220                  | -0.040          | 0.011           | 690                  | -0.04           | 0.32            | 1700                 | -0.54           | 2.1             | 26                   | -0.0038         | -0.004          |
| 230                  | -0.040          | 0.014           | 700                  | -0.02           | 0.37            | 1800                 | -0.60           | 2.2             | 27                   | -0.0041         | -0.004          |
| 240                  | -0.040          | 0.018           | 710                  | -0.01           | 0.41            | 1900                 | -0.66           | 2.3             | 28                   |                 | -0.005          |
| 250                  | -0.040          | 0.021           | 720                  | 0.00            | 0.45            | 2000                 | -0.72           | 2.5             | 29                   |                 | -0.006          |
| 260                  | -0.040          | 0.024           | 730                  | 0.02            | 0.49            | 2100                 | -0.79           | 2.7             | 30                   |                 | -0.006          |
| 270                  | -0.039          | 0.028           | 740                  | 0.03            | 0.53            | 2200                 | -0.85           | 2.9             | 31                   |                 | -0.007          |
| 280                  | -0.039          | 0.030           | 750                  | 0.03            | 0.56            | 2300                 | -0.93           | 3.1             | 32                   |                 | -0.008          |

| $T/K$ | $T_{90}-T_{76}$ | $T_{90}-T_{68}$ | $T/K$ | $T_{90}-T_{76}$ | $T_{90}-T_{68}$ | $T/K$ | $T_{90}-T_{76}$ | $T_{90}-T_{68}$ | $T/K$  | $T_{90}-T_{76}$ | $T_{90}-T_{68}$ |
|-------|-----------------|-----------------|-------|-----------------|-----------------|-------|-----------------|-----------------|--------|-----------------|-----------------|
| 33    |                 | -0.008          | 57    |                 | 0.000           | 81    |                 | 0.008           | 150    |                 | 0.014           |
| 34    |                 | -0.008          | 58    |                 | 0.001           | 82    |                 | 0.008           | 160    |                 | 0.014           |
| 35    |                 | -0.007          | 59    |                 | 0.002           | 83    |                 | 0.008           | 170    |                 | 0.013           |
| 36    |                 | -0.007          | 60    |                 | 0.003           | 84    |                 | 0.008           | 180    |                 | 0.012           |
| 37    |                 | -0.007          | 61    |                 | 0.003           | 85    |                 | 0.008           | 190    |                 | 0.012           |
| 38    |                 | -0.006          | 62    |                 | 0.004           | 86    |                 | 0.008           | 200    |                 | 0.011           |
| 39    |                 | -0.006          | 63    |                 | 0.004           | 87    |                 | 0.008           | 210    |                 | 0.010           |
| 40    |                 | -0.006          | 64    |                 | 0.005           | 88    |                 | 0.008           | 220    |                 | 0.009           |
| 41    |                 | -0.006          | 65    |                 | 0.005           | 89    |                 | 0.008           | 230    |                 | 0.008           |
| 42    |                 | -0.006          | 66    |                 | 0.006           | 90    |                 | 0.008           | 240    |                 | 0.007           |
| 43    |                 | -0.006          | 67    |                 | 0.006           | 91    |                 | 0.008           | 250    |                 | 0.005           |
| 44    |                 | -0.006          | 68    |                 | 0.007           | 92    |                 | 0.008           | 260    |                 | 0.003           |
| 45    |                 | -0.007          | 69    |                 | 0.007           | 93    |                 | 0.008           | 270    |                 | 0.001           |
| 46    |                 | -0.007          | 70    |                 | 0.007           | 94    |                 | 0.008           | 273.16 |                 | 0.000           |
| 47    |                 | -0.007          | 71    |                 | 0.007           | 95    |                 | 0.008           | 300    |                 | -0.006          |
| 48    |                 | -0.006          | 72    |                 | 0.007           | 96    |                 | 0.008           | 400    |                 | -0.031          |
| 49    |                 | -0.006          | 73    |                 | 0.007           | 97    |                 | 0.009           | 500    |                 | -0.040          |
| 50    |                 | -0.006          | 74    |                 | 0.007           | 98    |                 | 0.009           | 600    |                 | -0.040          |
| 51    |                 | -0.005          | 75    |                 | 0.008           | 99    |                 | 0.009           | 700    |                 | -0.055          |
| 52    |                 | -0.005          | 76    |                 | 0.008           | 100   |                 | 0.009           | 800    |                 | -0.089          |
| 53    |                 | -0.004          | 77    |                 | 0.008           | 110   |                 | 0.011           | 900    |                 | -0.124          |
| 54    |                 | -0.003          | 78    |                 | 0.008           | 120   |                 | 0.013           |        |                 |                 |
| 55    |                 | -0.002          | 79    |                 | 0.008           | 130   |                 | 0.014           |        |                 |                 |
| 56    |                 | -0.001          | 80    |                 | 0.008           | 140   |                 | 0.014           |        |                 |                 |

# INTERNATIONAL SYSTEM OF UNITS (SI)

**The International System of Units, abbreviated as SI (from the French name *Le Système International d'Unités*),** was established in 1960 by the 11th General Conference on Weights and Measures (CGPM) as the modern metric system of measurement. The core of the SI is the seven base units for the physical quantities length, mass, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity. These base units are:

| Base quantity             | SI base unit |        |
|---------------------------|--------------|--------|
|                           | Name         | Symbol |
| length                    | meter        | m      |
| mass                      | kilogram     | kg     |
| time                      | second       | s      |
| electric current          | ampere       | A      |
| thermodynamic temperature | kelvin       | K      |
| amount of substance       | mole         | mol    |
| luminous intensity        | candela      | cd     |

The SI base units are defined as follows:

**meter:** The meter is the length of the path travelled by light in vacuum during a time interval of  $1/299\,792\,458$  of a second.

**kilogram:** The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

**second:** The second is the duration of  $9\,192\,631\,770$  periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.

**ampere:** The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to  $2 \cdot 10^{-7}$  newton per meter of length.

**kelvin:** The kelvin, unit of thermodynamic temperature, is the fraction  $1/273.16$  of the thermodynamic temperature of the triple point of water.

**mole:** The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

**candela:** The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency  $540 \cdot 10^{12}$  hertz and that has a radiant intensity in that direction of  $1/683$  watt per steradian.

## SI derived units

Derived units are units which may be expressed in terms of base units by means of the mathematical symbols of multiplication and division (and, in the case of °C, subtraction). Certain derived units have been given special names and symbols, and these special names and symbols may themselves be used in combination with those for base and other derived units to express the units of other quantities. The next table lists some examples of derived units expressed directly in terms of base units:

| Physical quantity                      | SI derived unit          |                    |
|----------------------------------------|--------------------------|--------------------|
|                                        | Name                     | Symbol             |
| area                                   | square meter             | m <sup>2</sup>     |
| volume                                 | cubic meter              | m <sup>3</sup>     |
| speed, velocity                        | meter per second         | m/s                |
| acceleration                           | meter per second squared | m/s <sup>2</sup>   |
| wave number                            | reciprocal meter         | m <sup>-1</sup>    |
| density, mass density                  | kilogram per cubic meter | kg/m <sup>3</sup>  |
| specific volume                        | cubic meter per kilogram | m <sup>3</sup> /kg |
| current density                        | ampere per square meter  | A/m <sup>2</sup>   |
| magnetic field strength                | ampere per meter         | A/m                |
| concentration (of amount of substance) | mole per cubic meter     | mol/m <sup>3</sup> |
| luminance                              | candela per square meter | cd/m <sup>2</sup>  |
| refractive index                       | (the number) one         | 1 <sup>(a)</sup>   |

<sup>(a)</sup> The symbol "1" is generally omitted in combination with a numerical value.

For convenience, certain derived units, which are listed in the next table, have been given special names and symbols. These names and symbols may themselves be used to express other derived units. The special names and symbols are a compact form for the expression of units that are used frequently. The final column shows how the SI units concerned may be expressed in terms of SI base units. In this column, factors such as m<sup>0</sup>, kg<sup>0</sup> ..., which are all equal to 1, are not shown explicitly.

| Physical quantity                                  | Name                     | Symbol            | SI derived unit expressed in terms of:              |                                                                      |
|----------------------------------------------------|--------------------------|-------------------|-----------------------------------------------------|----------------------------------------------------------------------|
|                                                    |                          |                   | Other SI units                                      | SI base units                                                        |
| plane angle                                        | radian <sup>(a)</sup>    | rad               | m · m <sup>-1</sup> = 1 <sup>(b)</sup>              |                                                                      |
| solid angle                                        | steradian <sup>(a)</sup> | sr <sup>(c)</sup> | m <sup>2</sup> · m <sup>-2</sup> = 1 <sup>(b)</sup> |                                                                      |
| frequency                                          | hertz                    | Hz                | s <sup>-1</sup>                                     |                                                                      |
| force                                              | newton                   | N                 | m · kg · s <sup>-2</sup>                            |                                                                      |
| pressure, stress                                   | pascal                   | Pa                | N/m <sup>2</sup>                                    | m <sup>-1</sup> · kg · s <sup>-2</sup>                               |
| energy, work, quantity of heat                     | joule                    | J                 | N · m                                               | m <sup>2</sup> · kg · s <sup>-2</sup>                                |
| power, radiant flux                                | watt                     | W                 | J/s                                                 | m <sup>2</sup> · kg · s <sup>-3</sup>                                |
| electric charge, quantity of electricity           | coulomb                  | C                 | s · A                                               |                                                                      |
| electric potential difference, electromotive force | volt                     | V                 | W/A                                                 | m <sup>2</sup> · kg · s <sup>-3</sup> · A <sup>-1</sup>              |
| capacitance                                        | farad                    | F                 | C/V                                                 | m <sup>-2</sup> · kg <sup>-1</sup> · s <sup>4</sup> · A <sup>2</sup> |
| electric resistance                                | ohm                      | Ω                 | V/A                                                 | m <sup>2</sup> · kg · s <sup>-3</sup> · A <sup>-2</sup>              |
| electric conductance                               | siemens                  | S                 | A/V                                                 | m <sup>-2</sup> · kg <sup>-1</sup> · s <sup>3</sup> · A <sup>2</sup> |
| magnetic flux                                      | weber                    | Wb                | V · s                                               | m <sup>2</sup> · kg · s <sup>-2</sup> · A <sup>-1</sup>              |

|                                                                                                                        |                               |     |                        |                                                              |
|------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----|------------------------|--------------------------------------------------------------|
| magnetic flux density                                                                                                  | tesla                         | T   | Wb/m <sup>2</sup>      | kg · s <sup>-2</sup> · A <sup>-1</sup>                       |
| inductance                                                                                                             | henry                         | H   | Wb/A                   | m <sup>2</sup> · kg · s <sup>-2</sup> · A <sup>-2</sup>      |
| Celsius temperature                                                                                                    | degree Celsius <sup>(d)</sup> | °C  |                        | K                                                            |
| luminous flux                                                                                                          | lumen                         | lm  | cd · sr <sup>(c)</sup> | m <sup>2</sup> · m <sup>-2</sup> · cd = cd                   |
| illuminance                                                                                                            | lux                           | lx  | lm/m <sup>2</sup>      | m <sup>2</sup> · m <sup>-4</sup> · cd = m <sup>-2</sup> · cd |
| activity (of a radionuclide)                                                                                           | becquerel                     | Bq  |                        | s <sup>-1</sup>                                              |
| absorbed dose, specific energy (imparted), kerma                                                                       | gray                          | Gy  | J/kg                   | m <sup>2</sup> · s <sup>-2</sup>                             |
| dose equivalent, ambient dose equivalent, directional dose equivalent, personal dose equivalent, organ dose equivalent | sievert                       | Sv  | J/kg                   | m <sup>2</sup> · s <sup>-2</sup>                             |
| catalytic activity                                                                                                     | katal                         | kat |                        | s <sup>-1</sup> · mol                                        |

<sup>(a)</sup> The radian and steradian may be used with advantage in expressions for derived units to distinguish between quantities of different nature but the same dimension. Some examples of their use in forming derived units are given in the next table.

<sup>(b)</sup> In practice, the symbols rad and sr are used where appropriate, but the derived unit “1” is generally omitted in combination with a numerical value.

<sup>(c)</sup> In photometry, the name steradian and the symbol sr are usually retained in expressions for units.

<sup>(d)</sup> It is common practice to express a thermodynamic temperature, symbol  $T$ , in terms of its difference from the reference temperature  $T_0 = 273.15$  K. The numerical value of a Celsius temperature  $t$  expressed in degrees Celsius is given by  $t/°C = T/K - 273.15$ . The unit °C may be used in combination with SI prefixes, e.g., millidegree Celsius, m°C. Note that there should never be a space between the ° sign and the letter C, and that the symbol for kelvin is K, not °K.

The SI derived units with special names may be used in combinations to provide a convenient way to express more complex physical quantities. Examples are given in the next table:

| Physical Quantity                        | SI derived unit                 |                         |                                                                                                 |
|------------------------------------------|---------------------------------|-------------------------|-------------------------------------------------------------------------------------------------|
|                                          | Name                            | Symbol                  | As SI base units                                                                                |
| dynamic viscosity                        | pascal second                   | Pa · s                  | m <sup>-1</sup> · kg · s <sup>-1</sup>                                                          |
| moment of force                          | newton meter                    | N · m                   | m <sup>2</sup> · kg · s <sup>-2</sup>                                                           |
| surface tension                          | newton per meter                | N/m                     | kg · s <sup>-2</sup>                                                                            |
| angular velocity                         | radian per second               | rad/s                   | m · m <sup>-1</sup> · s <sup>-1</sup> = s <sup>-1</sup>                                         |
| angular acceleration                     | radian per second squared       | rad/s <sup>2</sup>      | m · m <sup>-1</sup> · s <sup>-2</sup> = s <sup>-2</sup>                                         |
| heat flux density, irradiance            | watt per square meter           | W/m <sup>2</sup>        | kg · s <sup>-3</sup>                                                                            |
| heat capacity, entropy                   | joule per kelvin                | J/K                     | m <sup>-3</sup> · kg · s <sup>-2</sup> · K <sup>-1</sup>                                        |
| specific heat capacity, specific entropy | joule per kilogram kelvin       | J/(kg · K)              | m <sup>2</sup> · s <sup>-2</sup> · K <sup>-1</sup>                                              |
| specific energy                          | joule per kilogram              | J/kg                    | m <sup>2</sup> · s <sup>-2</sup>                                                                |
| thermal conductivity                     | watt per meter kelvin           | W/(m · K)               | m · kg · s <sup>-3</sup> · K <sup>-1</sup>                                                      |
| energy density                           | joule per cubic meter           | J/m <sup>3</sup>        | m <sup>-1</sup> · kg · s <sup>-2</sup>                                                          |
| electric field strength                  | volt per meter                  | V/m                     | m · kg · s <sup>-3</sup> · A <sup>-1</sup>                                                      |
| electric charge density                  | coulomb per cubic meter         | C/m <sup>3</sup>        | m <sup>-3</sup> · s · A                                                                         |
| electric flux density                    | coulomb per square meter        | C/m <sup>2</sup>        | m <sup>-2</sup> · s · A                                                                         |
| permittivity                             | farad per meter                 | F/m                     | m <sup>-3</sup> · kg <sup>-1</sup> · s <sup>4</sup> · A <sup>2</sup>                            |
| permeability                             | henry per meter                 | H/m                     | m · kg · s <sup>-2</sup> · A <sup>-2</sup>                                                      |
| molar energy                             | joule per mole                  | J/mol                   | m <sup>2</sup> · kg · s <sup>-2</sup> · mol <sup>-1</sup>                                       |
| molar entropy, molar heat capacity       | joule per mole kelvin           | J/(mol · K)             | m <sup>2</sup> · kg · s <sup>-2</sup> · K <sup>-1</sup> · mol <sup>-1</sup>                     |
| exposure (x and γ rays)                  | coulomb per kilogram            | C/kg                    | kg <sup>-1</sup> · s · A                                                                        |
| absorbed dose rate                       | gray per second                 | Gy/s                    | m <sup>2</sup> · s <sup>-3</sup>                                                                |
| radiant intensity                        | watt per steradian              | W/sr                    | m <sup>2</sup> · m <sup>-2</sup> · kg · s <sup>-3</sup> = m <sup>2</sup> · kg · s <sup>-3</sup> |
| radiance                                 | watt per square meter steradian | W/(m <sup>2</sup> · sr) | m <sup>2</sup> · m <sup>-2</sup> · kg · s <sup>-3</sup> = kg · s <sup>-3</sup>                  |
| catalytic (activity) concentration       | katal per cubic meter           | kat/m <sup>3</sup>      | m <sup>-3</sup> · s <sup>-1</sup> · mol                                                         |

In practice, with certain quantities preference is given to the use of certain special unit names, or combinations of unit

names, in order to facilitate the distinction between different quantities having the same dimension. For example, the SI unit of frequency is designated the hertz, rather than the reciprocal second, and the SI unit of angular velocity is designated the radian per second rather than the reciprocal second (in this case retaining the word radian emphasizes that angular velocity is equal to  $2\pi$  times the rotational frequency). Similarly the SI unit of moment of force is designated the newton meter rather than the joule.

In the field of ionizing radiation, the SI unit of activity is designated the becquerel rather than the reciprocal second, and the SI units of absorbed dose and dose equivalent the gray and sievert, respectively, rather than the joule per kilogram. In the field of catalysis, the SI unit of catalytic activity is designated the katal rather than the mole per second. The special names becquerel, gray, sievert, and katal were specifically introduced because of the dangers to human health which might arise from mistakes involving the units reciprocal second, joule per kilogram and mole per second.

### Units for dimensionless quantities, quantities of dimension one

Certain quantities are defined as the ratios of two quantities of the same kind, and thus have a dimension which may be expressed by the number one. The unit of such quantities is necessarily a derived unit coherent with the other units of the SI and, since it is formed as the ratio of two identical SI units, the unit also may be expressed by the number one. Thus the SI unit of all quantities having the dimensional product one is the number one. Examples of such quantities are refractive index, relative permeability, and friction factor. Other quantities having the unit 1 include “characteristic numbers” like the Prandtl number and numbers which represent a count, such as a number of molecules, degeneracy (number of energy levels), and partition function in statistical thermodynamics. All of these quantities are described as being dimensionless, or of dimension one, and have the coherent SI unit 1. Their values are simply expressed as numbers and, in general, the unit 1 is not explicitly shown. In a few cases, however, a special name is given to this unit, mainly to avoid confusion between some compound derived units. This is the case for the radian, steradian and neper.

## SI prefixes

The following prefixes have been approved by the CGPM for use with SI units. Only one prefix may be used before a unit. Thus  $10^{-12}$  farad should be designated pF, not  $\mu\mu\text{F}$ .

| Factor    | Name  | Symbol | Factor     | Name  | Symbol |
|-----------|-------|--------|------------|-------|--------|
| $10^{24}$ | yotta | Y      | $10^{-1}$  | deci  | d      |
| $10^{21}$ | zetta | Z      | $10^{-2}$  | centi | c      |
| $10^{18}$ | exa   | E      | $10^{-3}$  | milli | m      |
| $10^{15}$ | peta  | P      | $10^{-6}$  | micro | $\mu$  |
| $10^{12}$ | tera  | T      | $10^{-9}$  | nano  | n      |
| $10^9$    | giga  | G      | $10^{-12}$ | pico  | p      |
| $10^6$    | mega  | M      | $10^{-15}$ | femto | f      |
| $10^3$    | kilo  | k      | $10^{-18}$ | atto  | a      |
| $10^2$    | hecto | h      | $10^{-21}$ | zepto | z      |
| $10^1$    | deka  | da     | $10^{-24}$ | yocto | y      |

## The kilogram

Among the base units of the International System, the unit of mass is the only one whose name, for historical reasons, contains a prefix. Names and symbols for decimal multiples and submultiples of the unit of mass are formed by attaching prefix names to the unit name “gram” and prefix symbols to the unit symbol “g”.

*Example :*  $10^{-6} \text{ kg} = 1 \text{ mg}$  (1 milligram) *but not*  $1 \mu\text{kg}$  (1 microkilogram).

## Units used with the SI

Many units that are not part of the SI are important and widely used in everyday life. The CGPM has adopted a classification of non-SI units: (1) units accepted for use with the SI (such as the traditional units of time and of angle); (2) units accepted for use with the SI whose values are obtained experimentally; and (3) other units currently accepted for use with the SI to satisfy the needs of special interests.

### (1) Non-SI units accepted for use with the International System

| Name                 | Symbol | Value in SI units                            |
|----------------------|--------|----------------------------------------------|
| minute               | min    | 1 min = 60 s                                 |
| hour                 | h      | 1 h = 60 min = 3600 s                        |
| day                  | d      | 1 d = 24 h = 86 400 s                        |
| degree               | °      | 1° = $(\pi/180)$ rad                         |
| minute               | '      | 1' = $(1/60)^\circ = (\pi/10\,800)$ rad      |
| second               | "      | 1" = $(1/60)'$ = $(\pi/648\,000)$ rad        |
| liter                | l, L   | 1 L = $1 \text{ dm}^3 = 10^{-3} \text{ m}^3$ |
| metric ton           | t      | 1 t = $10^3 \text{ kg}$                      |
| neper <sup>(a)</sup> | Np     | 1 Np = 1                                     |
| bel <sup>(b)</sup>   | B      | 1 B = $(1/2) \ln 10 \text{ Np}$              |

<sup>(a)</sup> The neper is used to express values of such logarithmic quantities as field level, power level, sound pressure level, and logarithmic decrement. Natural logarithms are used to obtain the numerical values of quantities expressed in nepers. The neper is coherent with the SI, but is not yet adopted by the CGPM as an SI unit. In using the neper, it is important to specify the quantity.

<sup>(b)</sup> The bel is used to express values of such logarithmic quantities as field level, power level, sound-pressure level, and attenuation. Logarithms to base ten are used to obtain the numerical values of quantities expressed in bels. The submultiple decibel, dB, is commonly used.

### (2) Non-SI units accepted for use with the International system, whose values in SI units are obtained experimentally

| Name                                    | Symbol | Value in SI Units                                              |
|-----------------------------------------|--------|----------------------------------------------------------------|
| electronvolt <sup>(b)</sup>             | eV     | 1 eV = $1.602\,176\,53(14) \cdot 10^{-19} \text{ J}^{(a)}$     |
| dalton <sup>(c)</sup>                   | Da     | 1 Da = $1.660\,538\,86(28) \cdot 10^{-27} \text{ kg}^{(a)}$    |
| unified atomic mass unit <sup>(c)</sup> | u      | 1 u = 1 Da                                                     |
| astronomical unit <sup>(d)</sup>        | ua     | 1 ua = $1.495\,978\,706\,91(06) \cdot 10^{11} \text{ m}^{(a)}$ |

<sup>(a)</sup> For the electronvolt and the dalton (unified atomic mass unit), values are quoted from the 2002 CODATA set of the Fundamental Physical Constants (p. 1-1 of this Handbook). The value given for the astronomical unit is quoted from the IERS Conventions 2003 (D.D. McCarthy and G. Petit, eds., IERS Technical Note 32, Frankfurt am Main: Verlag des Bundesamts für Kartographie und Geodäsie, 200). The value of ua in meters comes from the JPL ephemerides DE403 (Standish E.M. 1995, “Report of the IAU WGAS Sub-Group on Numerical Standards”, in “Highlights of Astronomy”, Appenzler ed., pp 180-184, Kluwer Academic Publishers, Dordrecht). It has been determined in “TDB” units using Barycentric Dynamical Time TDB as a time coordinate for the barycentric system.

<sup>(b)</sup> The electronvolt is the kinetic energy acquired by an electron in passing through a potential difference of 1 V in vacuum.

<sup>(c)</sup> The Dalton and unified atomic mass unit are alternative names for the same unit, equal to  $1/12$  of the mass of an unbound atom of the nuclide  $^{12}\text{C}$ , at rest and in its ground state. The dalton may be combined with SI prefixes to express the masses of large molecules in kilodalton, kDa, or megadalton, MDa.

<sup>(d)</sup> The astronomical unit is a unit of length approximately equal to the mean Earth-Sun distance. It is the radius of an unperturbed circular Newtonian orbit about the Sun of a particle having infinitesimal mass, moving with a mean motion of  $0.017\,202\,098\,95$  radians/day (known as the Gaussian constant).

### (3) Other non-SI units currently accepted for use with the International System

| Name          | Symbol | Value in SI Units                                             |
|---------------|--------|---------------------------------------------------------------|
| nautical mile |        | 1 nautical mile = 1852 m                                      |
|               |        | 1 nautical mile per hour = $(1852/3600) \text{ m/s}$          |
| knot          |        |                                                               |
| are           |        | 1 a = $1 \text{ dam}^2 = 10^2 \text{ m}^2$                    |
| hectare       | ha     | 1 ha = $1 \text{ hm}^2 = 10^4 \text{ m}^2$                    |
| bar           | bar    | 1 bar = $0.1 \text{ MPa} = 100 \text{ kPa} = 10^5 \text{ Pa}$ |
| ångström      | Å      | 1 Å = $0.1 \text{ nm} = 10^{-10} \text{ m}$                   |
| barn          | b      | 1 b = $100 \text{ fm}^2 = 10^{-28} \text{ m}^2$               |

## Other non-SI units

The SI does not encourage the use of cgs units, but these are frequently found in old scientific texts. The following table gives the relation of some common cgs units to SI units.

| Name    | Symbol | Value in SI units                                                         |
|---------|--------|---------------------------------------------------------------------------|
| erg     | erg    | 1 erg = $10^{-7} \text{ J}$                                               |
| dyne    | dyn    | 1 dyn = $10^{-5} \text{ N}$                                               |
| poise   | P      | 1 P = $1 \text{ dyn} \cdot \text{s/cm}^2 = 0.1 \text{ Pa} \cdot \text{s}$ |
| stokes  | St     | 1 St = $1 \text{ cm}^2/\text{s} = 10^{-4} \text{ m}^2/\text{s}$           |
| gauss   | G      | 1 G $\triangleq 10^{-4} \text{ T}$                                        |
| oersted | Oe     | 1 Oe $\triangleq (1000/4\pi) \text{ A/m}$                                 |
| maxwell | Mx     | 1 Mx $\triangleq 10^{-8} \text{ Wb}$                                      |
| stilb   | sb     | 1 sb = $1 \text{ cd/cm}^2 = 10^4 \text{ cd/m}^2$                          |
| phot    | ph     | 1 ph = $10^4 \text{ lx}$                                                  |
| gal     | Gal    | 1 Gal = $1 \text{ cm/s}^2 = 10^{-2} \text{ m/s}^2$                        |

*Note:* The symbol  $\triangleq$  should be read as “corresponds to”; these units cannot strictly be equated because of the different dimensions of the electromagnetic cgs and the SI.

Examples of other non-SI units found in the older literature and their relation to the SI are given below. Use of these units in current texts is discouraged.

| Name                   | Symbol   | Value in SI units                                                    |
|------------------------|----------|----------------------------------------------------------------------|
| curie                  | Ci       | 1 Ci = $3.7 \cdot 10^{10}$ Bq                                        |
| roentgen               | R        | 1 R = $2.58 \cdot 10^{-4}$ C/kg                                      |
| rad                    | rad      | 1 rad = 1 cGy = $10^{-2}$ Gy                                         |
| rem                    | rem      | 1 rem = 1 cSv = $10^{-2}$ Sv                                         |
| X unit                 |          | 1 X unit $\approx 1.002 \cdot 10^{-4}$ nm                            |
| gamma                  | $\gamma$ | 1 $\gamma$ = 1 nT = $10^{-9}$ T                                      |
| jansky                 | Jy       | 1 Jy = $10^{-26}$ W $\cdot$ m <sup>-2</sup> $\cdot$ Hz <sup>-1</sup> |
| fermi                  |          | 1 fermi = 1 fm = $10^{-15}$ m                                        |
| metric carat           |          | 1 metric carat = 200 mg = $2 \cdot 10^{-4}$ kg                       |
| torr                   | Torr     | 1 Torr = (101325/760) Pa                                             |
| standard atmosphere    | atm      | 1 atm = 101325 Pa                                                    |
| calorie <sup>(a)</sup> | cal      | 1 cal = 4.184 J                                                      |
| micron                 | $\mu$    | 1 $\mu$ = 1 $\mu$ m = $10^{-6}$ m                                    |

<sup>(a)</sup> Several types of calorie have been used; the value given here is the so-called "thermochemical calorie".

## References

1. Taylor, B. N., *The International System of Units (SI)*, NIST Special Publication 330, National Institute of Standards and Technology, Gaithersburg, MD, 2001.
2. Bureau International des Poids et Mesures, *Le Système International d'Unités (SI)*, 7th French and English Edition, BIPM, Sèvres, France, 1998; 8th Edition to be published 2006.
3. Taylor, B. N., *Guide for the Use of the International System of Units (SI)*, NIST Special Publication 811, National Institute of Standards and Technology, Gaithersburg, MD, 1995.
4. NIST Physical Reference Data web site, <<http://physics.nist.gov/cuu/Units/index.html>>, October 2004.

## CONVERSION FACTORS

The following table gives conversion factors from various units of measure to SI units. It is reproduced from NIST Special Publication 811, *Guide for the Use of the International System of Units (SI)*. The table gives the factor by which a quantity expressed in a non-SI unit should be multiplied in order to calculate its value in the SI. The SI values are expressed in terms of the base, supplementary, and derived units of SI in order to provide a coherent presentation of the conversion factors and facilitate computations (see the table "International System of Units" in this section). If desired, powers of ten can be avoided by using SI prefixes and shifting the decimal point if necessary.

Conversion from a non-SI unit to a different non-SI unit may be carried out by using this table in two stages, e.g.,

$$1 \text{ cal}_{\text{th}} = 4.184 \text{ J}$$

$$1 \text{ Btu}_{\text{IT}} = 1.055056 \text{ E+03 J}$$

Thus,

$$1 \text{ Btu}_{\text{IT}} = (1.055056 \text{ E+03} \div 4.184) \text{ cal}_{\text{th}} = 252.164 \text{ cal}_{\text{th}}$$

Conversion factors are presented for ready adaptation to computer readout and electronic data transmission. The factors are written as a number equal to or greater than one and less than ten with six or fewer decimal places. This number is followed by the letter E (for exponent), a plus or a minus sign, and two digits that indicate the power of 10 by which the number must be multiplied to obtain the correct value. For example:

$$3.523 \text{ 907 E-02 is } 3.523 \text{ 907} \times 10^{-2}$$

or

$$0.035 \text{ 239 07}$$

Similarly:

$$3.386 \text{ 389 E+03 is } 3.386 \text{ 389} \times 10^3$$

or

$$3 \text{ 386.389}$$

A factor in boldface is exact; i.e., all subsequent digits are zero. All other conversion factors have been rounded to the figures given in accordance with accepted practice. Where less than six digits after the decimal point are shown, more precision is not warranted.

It is often desirable to round a number obtained from a conversion of units in order to retain information on the precision of the value. The following rounding rules may be followed:

1. If the digits to be discarded begin with a digit less than 5, the digit preceding the first discarded digit is not changed.

Example: 6.974 951 5 rounded to 3 digits is 6.97

2. If the digits to be discarded begin with a digit greater than 5, the digit preceding the first discarded digit is increased by one.

Example: 6.974 951 5 rounded to 4 digits is 6.975

3. If the digits to be discarded begin with a 5 and at least one of the following digits is greater than 0, the digit preceding the 5 is increased by 1.

Example: 6.974 851 rounded to 5 digits is 6.974 9

4. If the digits to be discarded begin with a 5 and all of the following digits are 0, the digit preceding the 5 is unchanged if it is even and increased by one if it is odd. (Note that this means that the final digit is always even.)

Examples:

$$6.974 \text{ 951 5 rounded to 7 digits is } 6.974 \text{ 952}$$

$$6.974 \text{ 950 5 rounded to 7 digits is } 6.974 \text{ 950}$$

## Reference

Taylor, B. N., *Guide for the Use of the International System of Units (SI)*, NIST Special Publication 811, 1995 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, 1995.

| Factors in <b>boldface</b> are exact                     |                                                    |                      |
|----------------------------------------------------------|----------------------------------------------------|----------------------|
| To convert from                                          | to                                                 | Multiply by          |
| abampere.....                                            | ampere (A).....                                    | <b>1.0</b> E+01      |
| abcoulomb.....                                           | coulomb (C).....                                   | <b>1.0</b> E+01      |
| abfarad.....                                             | farad (F).....                                     | <b>1.0</b> E+09      |
| abhenry.....                                             | henry (H).....                                     | <b>1.0</b> E-09      |
| abmho.....                                               | siemens (S).....                                   | <b>1.0</b> E+09      |
| abohm.....                                               | ohm ( $\Omega$ ).....                              | <b>1.0</b> E-09      |
| abvolt.....                                              | volt (V).....                                      | <b>1.0</b> E-08      |
| acceleration of free fall, standard ( $g_n$ ).....       | meter per second squared ( $\text{m/s}^2$ ).....   | <b>9.806 65</b> E+00 |
| acre (based on U.S. survey foot) <sup>9</sup> .....      | square meter ( $\text{m}^2$ ).....                 | 4.046 873 E+03       |
| acre foot (based on U.S. survey foot) <sup>9</sup> ..... | cubic meter ( $\text{m}^3$ ).....                  | 1.233 489 E+03       |
| <i>ampere hour</i> (A · h).....                          | coulomb (C).....                                   | <b>3.6</b> E+03      |
| ångström (Å).....                                        | meter (m).....                                     | <b>1.0</b> E-10      |
| ångström (Å).....                                        | nanometer (nm).....                                | <b>1.0</b> E-01      |
| apostilb (asb).....                                      | candela per meter squared ( $\text{cd/m}^2$ )..... | 3.183 098 E-01       |
| <i>are</i> (a).....                                      | square meter ( $\text{m}^2$ ).....                 | <b>1.0</b> E+02      |
| astronomical unit (ua or AU).....                        | meter (m).....                                     | 1.495 979 E+11       |
| atmosphere, standard (atm).....                          | pascal (Pa).....                                   | <b>1.013 25</b> E+05 |
| atmosphere, standard (atm).....                          | kilopascal (kPa).....                              | <b>1.013 25</b> E+02 |
| atmosphere, technical (at) <sup>10</sup> .....           | pascal (Pa).....                                   | <b>9.806 65</b> E+04 |
| atmosphere, technical (at) <sup>10</sup> .....           | kilopascal (kPa).....                              | <b>9.806 65</b> E+01 |

<sup>9</sup>The U.S. survey foot equals (1200/3937) m. 1 international foot = 0.999998 survey foot.

<sup>10</sup>One technical atmosphere equals one kilogram-force per square centimeter (1 at = 1 kgf/cm<sup>2</sup>).

| To convert from                                                                                                                               | to                                                             | Multiply by               |
|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|---------------------------|
| bar (bar).....                                                                                                                                | pascal (Pa) .....                                              | <b>1.0</b> <b>E+05</b>    |
| bar (bar).....                                                                                                                                | kilopascal (kPa) .....                                         | <b>1.0</b> <b>E+02</b>    |
| barn (b).....                                                                                                                                 | square meter (m <sup>2</sup> ) .....                           | <b>1.0</b> <b>E-28</b>    |
| barrel [for petroleum, 42 gallons (U.S.)](bbl) .....                                                                                          | cubic meter (m <sup>3</sup> ) .....                            | 1.589 873 <b>E-01</b>     |
| barrel [for petroleum, 42 gallons (U.S.)](bbl) .....                                                                                          | liter (L) .....                                                | 1.589 873 <b>E+02</b>     |
| biot (Bi).....                                                                                                                                | ampere (A) .....                                               | <b>1.0</b> <b>E+01</b>    |
| British thermal unit <sub>IT</sub> (Btu <sub>IT</sub> ) <sup>11</sup> .....                                                                   | joule (J) .....                                                | 1.055 056 <b>E+03</b>     |
| British thermal unit <sub>th</sub> (Btu <sub>th</sub> ) <sup>11</sup> .....                                                                   | joule (J) .....                                                | 1.054 350 <b>E+03</b>     |
| British thermal unit (mean) (Btu).....                                                                                                        | joule (J) .....                                                | 1.055 87 <b>E+03</b>      |
| British thermal unit (39 °F) (Btu).....                                                                                                       | joule (J) .....                                                | 1.059 67 <b>E+03</b>      |
| British thermal unit (59 °F) (Btu).....                                                                                                       | joule (J) .....                                                | 1.054 80 <b>E+03</b>      |
| British thermal unit (60 °F) (Btu).....                                                                                                       | joule (J) .....                                                | 1.054 68 <b>E+03</b>      |
| British thermal unit <sub>IT</sub> foot per hour square foot degree Fahrenheit<br>[Btu <sub>IT</sub> · ft/(h · ft <sup>2</sup> · °F)].....    | watt per meter kelvin [W/(m · K)] .....                        | 1.730 735 <b>E+00</b>     |
| British thermal unit <sub>th</sub> foot per hour square foot degree Fahrenheit<br>[Btu <sub>th</sub> · ft/(h · ft <sup>2</sup> · °F)] .....   | watt per meter kelvin [W/(m · K)] .....                        | 1.729 577 <b>E+00</b>     |
| British thermal unit <sub>IT</sub> inch per hour square foot degree Fahrenheit<br>[Btu <sub>IT</sub> · in/(h · ft <sup>2</sup> · °F)] .....   | watt per meter kelvin [W/(m · K)] .....                        | 1.442 279 <b>E-01</b>     |
| British thermal unit <sub>th</sub> inch per hour square foot degree Fahrenheit<br>[Btu <sub>th</sub> · in/(h · ft <sup>2</sup> · °F)] .....   | watt per meter kelvin [W/(m · K)] .....                        | 1.441 314 <b>E-01</b>     |
| British thermal unit <sub>IT</sub> inch per second square foot degree Fahrenheit<br>[Btu <sub>IT</sub> · in/(s · ft <sup>2</sup> · °F)].....  | watt per meter kelvin [W/(m · K)] .....                        | 5.192 204 <b>E+02</b>     |
| British thermal unit <sub>th</sub> inch per second square foot degree Fahrenheit<br>[Btu <sub>th</sub> · in/(s · ft <sup>2</sup> · °F)] ..... | watt per meter kelvin [W/(m · K)] .....                        | 5.188 732 <b>E+02</b>     |
| British thermal unit <sub>IT</sub> per cubic foot<br>(Btu <sub>IT</sub> /ft <sup>3</sup> ).....                                               | joule per cubic meter (J/m <sup>3</sup> ) .....                | 3.725 895 <b>E+04</b>     |
| British thermal unit <sub>th</sub> per cubic foot<br>(Btu <sub>th</sub> /ft <sup>3</sup> ) .....                                              | joule per cubic meter (J/m <sup>3</sup> ) .....                | 3.723 403 <b>E+04</b>     |
| British thermal unit <sub>IT</sub> per degree Fahrenheit<br>(Btu <sub>IT</sub> /°F) .....                                                     | joule per kelvin (J/k) .....                                   | 1.899 101 <b>E+03</b>     |
| British thermal unit <sub>th</sub> per degree Fahrenheit<br>(Btu <sub>th</sub> /°F) .....                                                     | joule per kelvin (J/k) .....                                   | 1.897 830 <b>E+03</b>     |
| British thermal unit <sub>IT</sub> per degree Rankine<br>(Btu <sub>IT</sub> /°R).....                                                         | joule per kelvin (J/k) .....                                   | 1.899 101 <b>E+03</b>     |
| British thermal unit <sub>th</sub> per degree Rankine<br>(Btu <sub>th</sub> /°R) .....                                                        | joule per kelvin (J/k) .....                                   | 1.897 830 <b>E+03</b>     |
| British thermal unit <sub>IT</sub> per hour (Btu <sub>IT</sub> /h) .....                                                                      | watt (W) .....                                                 | 2.930 711 <b>E-01</b>     |
| British thermal unit <sub>th</sub> per hour (Btu <sub>th</sub> /h).....                                                                       | watt (W) .....                                                 | 2.928 751 <b>E-01</b>     |
| British thermal unit <sub>IT</sub> per hour square foot degree Fahrenheit<br>[Btu <sub>IT</sub> /(h · ft <sup>2</sup> · °F)].....             | watt per square meter kelvin<br>[W/(m <sup>2</sup> · K)] ..... | 5.678 263 <b>E+00</b>     |
| British thermal unit <sub>th</sub> per hour square foot degree Fahrenheit<br>[Btu <sub>th</sub> /(h · ft <sup>2</sup> · °F)] .....            | watt per square meter kelvin<br>[W/(m <sup>2</sup> · K)] ..... | 5.674 466 <b>E+00</b>     |
| British thermal unit <sub>th</sub> per minute (Btu <sub>th</sub> /min).....                                                                   | watt (W) .....                                                 | 1.757 250 <b>E+01</b>     |
| British thermal unit <sub>IT</sub> per pound (Btu <sub>IT</sub> /lb) .....                                                                    | joule per kilogram (J/kg) .....                                | <b>2.326</b> <b>E+03</b>  |
| British thermal unit <sub>th</sub> per pound (Btu <sub>th</sub> /lb).....                                                                     | joule per kilogram (J/kg) .....                                | 2.324 444 <b>E+03</b>     |
| British thermal unit <sub>IT</sub> per pound degree Fahrenheit<br>[Btu <sub>IT</sub> /(lb · °F)].....                                         | joule per kilogram kelvin [J/(kg · K)] .....                   | <b>4.1868</b> <b>E+03</b> |
| British thermal unit <sub>th</sub> per pound degree Fahrenheit<br>[Btu <sub>th</sub> /(lb · °F)] .....                                        | joule per kilogram kelvin [J/(kg · K)] .....                   | <b>4.184</b> <b>E+03</b>  |
| British thermal unit <sub>IT</sub> per pound degree Rankine<br>[Btu <sub>IT</sub> /(lb · °R)] .....                                           | joule per kilogram kelvin [J/(kg · K)] .....                   | <b>4.1868</b> <b>E+03</b> |
| British thermal unit <sub>th</sub> per pound degree Rankine<br>[Btu <sub>th</sub> /(lb · °R)] .....                                           | joule per kilogram kelvin [J/(kg · K)] .....                   | <b>4.184</b> <b>E+03</b>  |
| British thermal unit <sub>IT</sub> per second (Btu <sub>IT</sub> /s) .....                                                                    | watt (W) .....                                                 | 1.055 056 <b>E+03</b>     |
| British thermal unit <sub>th</sub> per second (Btu <sub>th</sub> /s).....                                                                     | watt (W) .....                                                 | 1.054 350 <b>E+03</b>     |

<sup>11</sup> The Fifth International Conference on the Properties of Steam (London, July 1956) defined the International Table calorie as 4.1868 J. Therefore the exact conversion factor for the International Table Btu is 1.055 055 852 62 kJ. Note that the notation for the International Table used in this listing is subscript "IT". Similarly, the notation for thermochemical is subscript "th." Further, the thermochemical Btu, Btu<sub>th</sub>, is based on the thermochemical calorie, cal<sub>th</sub>, where cal<sub>th</sub> = 4.184 J exactly.



| To convert from                                                                                                                | to                                                       | Multiply by   |             |
|--------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|---------------|-------------|
| British thermal unit <sub>IT</sub> per second square foot degree Fahrenheit<br>[Btu <sub>IT</sub> /(s · ft <sup>2</sup> · °F)] | watt per square meter kelvin<br>[W/(m <sup>2</sup> · K)] | 2.044 175     | E+04        |
| British thermal unit <sub>th</sub> per second square foot degree Fahrenheit<br>[Btu <sub>th</sub> /(s · ft <sup>2</sup> · °F)] | watt per square meter kelvin<br>[W/(m <sup>2</sup> · K)] | 2.042 808     | E+04        |
| British thermal unit <sub>IT</sub> per square foot<br>(Btu <sub>IT</sub> /ft <sup>2</sup> )                                    | joule per square meter (J/m <sup>2</sup> )               | 1.135 653     | E+04        |
| British thermal unit <sub>th</sub> per square foot<br>(Btu <sub>th</sub> /ft <sup>2</sup> )                                    | joule per square meter (J/m <sup>2</sup> )               | 1.134 893     | E+04        |
| British thermal unit <sub>IT</sub> per square foot hour<br>[(Btu <sub>IT</sub> /(ft <sup>2</sup> · h))]                        | watt per square meter (W/m <sup>2</sup> )                | 3.154 591     | E+00        |
| British thermal unit <sub>th</sub> per square foot hour<br>[Btu <sub>th</sub> /(ft <sup>2</sup> · h)]                          | watt per square meter (W/m <sup>2</sup> )                | 3.152 481     | E+00        |
| British thermal unit <sub>th</sub> per square foot minute<br>[Btu <sub>th</sub> /(ft <sup>2</sup> · min)]                      | watt per square meter (W/m <sup>2</sup> )                | 1.891 489     | E+02        |
| British thermal unit <sub>IT</sub> per square foot second<br>[(Btu <sub>IT</sub> /(ft <sup>2</sup> · s))]                      | watt per square meter (W/m <sup>2</sup> )                | 1.135 653     | E+04        |
| British thermal unit <sub>th</sub> per square foot second<br>[Btu <sub>th</sub> /(ft <sup>2</sup> · s)]                        | watt per square meter (W/m <sup>2</sup> )                | 1.134 893     | E+04        |
| British thermal unit <sub>th</sub> per square inch second<br>[Btu <sub>th</sub> /(in <sup>2</sup> · s)]                        | watt per square meter (W/m <sup>2</sup> )                | 1.634 246     | E+06        |
| bushel (U.S.) (bu)                                                                                                             | cubic meter (m <sup>3</sup> )                            | 3.523 907     | E-02        |
| bushel (U.S.) (bu)                                                                                                             | liter (L)                                                | 3.523 907     | E+01        |
| calorie <sub>IT</sub> (cal <sub>IT</sub> ) <sup>11</sup>                                                                       | joule (J)                                                | <b>4.1868</b> | <b>E+00</b> |
| calorie <sub>th</sub> (cal <sub>th</sub> ) <sup>11</sup>                                                                       | joule (J)                                                | <b>4.184</b>  | <b>E+00</b> |
| calorie (cal) (mean)                                                                                                           | joule (J)                                                | 4.190 02      | E+00        |
| calorie (15 °C) (cal <sub>15</sub> )                                                                                           | joule (J)                                                | 4.185 80      | E+00        |
| calorie (20 °C) (cal <sub>20</sub> )                                                                                           | joule (J)                                                | 4.181 90      | E+00        |
| calorie <sub>IT</sub> , kilogram (nutrition) <sup>12</sup>                                                                     | joule (J)                                                | <b>4.1868</b> | <b>E+03</b> |
| calorie <sub>th</sub> , kilogram (nutrition) <sup>12</sup>                                                                     | joule (J)                                                | <b>4.184</b>  | <b>E+03</b> |
| calorie (mean), kilogram (nutrition) <sup>12</sup>                                                                             | joule (J)                                                | 4.190 02      | E+03        |
| calorie <sub>th</sub> per centimeter second degree Celsius<br>[cal <sub>th</sub> /(cm · s · °C)]                               | watt per meter kelvin [W/(m · K)]                        | <b>4.184</b>  | <b>E+02</b> |
| calorie <sub>IT</sub> per gram (cal <sub>IT</sub> /g)                                                                          | joule per kilogram (J/kg)                                | <b>4.1868</b> | <b>E+03</b> |
| calorie <sub>th</sub> per gram (cal <sub>th</sub> /g)                                                                          | joule per kilogram (J/kg)                                | <b>4.184</b>  | <b>E+03</b> |
| calorie <sub>IT</sub> per gram degree Celsius<br>[cal <sub>IT</sub> /(g · °C)]                                                 | joule per kilogram kelvin [J/(kg · K)]                   | <b>4.1868</b> | <b>E+03</b> |
| calorie <sub>th</sub> per gram degree Celsius<br>[cal <sub>th</sub> /(g · °C)]                                                 | joule per kilogram kelvin [J/(kg · K)]                   | <b>4.184</b>  | <b>E+03</b> |
| calorie <sub>IT</sub> per gram kelvin [cal <sub>IT</sub> /(g · K)]                                                             | joule per kilogram kelvin [J/(kg · K)]                   | <b>4.1868</b> | <b>E+03</b> |
| calorie <sub>th</sub> per gram kelvin [cal <sub>th</sub> /(g · K)]                                                             | joule per kilogram kelvin [J/(kg · K)]                   | <b>4.184</b>  | <b>E+03</b> |
| calorie <sub>th</sub> per minute (cal <sub>th</sub> /min)                                                                      | watt (W)                                                 | 6.973 333     | E-02        |
| calorie <sub>th</sub> per second (cal <sub>th</sub> /s)                                                                        | watt (W)                                                 | <b>4.184</b>  | <b>E+00</b> |
| calorie <sub>th</sub> per square centimeter (cal <sub>th</sub> /cm <sup>2</sup> )                                              | joule per square meter (J/m <sup>2</sup> )               | <b>4.184</b>  | <b>E+04</b> |
| calorie <sub>th</sub> per square centimeter minute<br>[cal <sub>th</sub> /(cm <sup>2</sup> · min)]                             | watt per square meter (W/m <sup>2</sup> )                | 6.973 333     | E+02        |
| calorie <sub>th</sub> per square centimeter second<br>[cal <sub>th</sub> /(cm <sup>2</sup> · s)]                               | watt per square meter (W/m <sup>2</sup> )                | <b>4.184</b>  | <b>E+04</b> |
| candela per square inch (cd/in <sup>2</sup> )                                                                                  | candela per square meter (cd/m <sup>2</sup> )            | 1.550 003     | E+03        |
| carat, metric                                                                                                                  | kilogram (kg)                                            | <b>2.0</b>    | <b>E-04</b> |
| carat, metric                                                                                                                  | gram (g)                                                 | <b>2.0</b>    | <b>E-01</b> |
| centimeter of mercury (0 °C) <sup>13</sup>                                                                                     | pascal (Pa)                                              | 1.333 22      | E+03        |
| centimeter of mercury (0 °C) <sup>13</sup>                                                                                     | kilopascal (kPa)                                         | 1.333 22      | E+00        |
| centimeter of mercury, conventional (cmHg) <sup>13</sup>                                                                       | pascal (Pa)                                              | 1.333 224     | E+03        |

<sup>12</sup> The kilogram calorie or "large calorie" is an obsolete term used for the kilocalorie, which is the calorie used to express the energy content of foods. However, in practice, the prefix "kilo" is usually omitted.

<sup>13</sup> Conversion factors for mercury manometer pressure units are calculated using the standard value for the acceleration of gravity and the density of mercury at the stated temperature. Additional digits are not justified because the definitions of the units do not take into account the compressibility of mercury or the change in density caused by the revised practical temperature scale, ITS-90. Similar comments also apply to water manometer pressure units. Conversion factors for conventional mercury and water manometer pressure units are based on ISO 31-3.

| To convert from                                                                                                                        | to                                                  | Multiply by                       |
|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------|
| centimeter of mercury, conventional (cmHg) <sup>13</sup>                                                                               | kilopascal (kPa)                                    | 1.333 224 E+00                    |
| centimeter of water (4 °C) <sup>13</sup>                                                                                               | pascal (Pa)                                         | 9.806 38 E+01                     |
| centimeter of water, conventional (cmH <sub>2</sub> O) <sup>13</sup>                                                                   | pascal (Pa)                                         | <b>9.806 65 E+01</b>              |
| centipoise (cP)                                                                                                                        | pascal second (Pa · s)                              | <b>1.0 E-03</b>                   |
| centistokes (cSt)                                                                                                                      | meter squared per second (m <sup>2</sup> /s)        | <b>1.0 E-06</b>                   |
| chain (based on U.S. survey foot) (ch) <sup>9</sup>                                                                                    | meter (m)                                           | 2.011 684 E+01                    |
| circular mil                                                                                                                           | square meter (m <sup>2</sup> )                      | 5.067 075 E-10                    |
| circular mil                                                                                                                           | square millimeter (mm <sup>2</sup> )                | 5.067 075 E-04                    |
| clo                                                                                                                                    | square meter kelvin per watt (m <sup>2</sup> · K/W) | 1.55 E-01                         |
| cord (128 ft <sup>3</sup> )                                                                                                            | cubic meter (m <sup>3</sup> )                       | 3.624 556 E+00                    |
| cubic foot (ft <sup>3</sup> )                                                                                                          | cubic meter (m <sup>3</sup> )                       | 2.831 685 E-02                    |
| cubic foot per minute (ft <sup>3</sup> /min)                                                                                           | cubic meter per second (m <sup>3</sup> /s)          | 4.719 474 E-04                    |
| cubic foot per minute (ft <sup>3</sup> /min)                                                                                           | liter per second (L/s)                              | 4.719 474 E-01                    |
| cubic foot per second (ft <sup>3</sup> /s)                                                                                             | cubic meter per second (m <sup>3</sup> /s)          | 2.831 685 E-02                    |
| cubic inch (in <sup>3</sup> ) <sup>14</sup>                                                                                            | cubic meter (m <sup>3</sup> )                       | 1.638 706 E-05                    |
| cubic inch per minute (in <sup>3</sup> /min)                                                                                           | cubic meter per second (m <sup>3</sup> /s)          | 2.731 177 E-07                    |
| cubic mile (mi <sup>3</sup> )                                                                                                          | cubic meter (m <sup>3</sup> )                       | 4.168 182 E+09                    |
| cubic yard (yd <sup>3</sup> )                                                                                                          | cubic meter (m <sup>3</sup> )                       | 7.645 549 E-01                    |
| cubic yard per minute (yd <sup>3</sup> /min)                                                                                           | cubic meter per second (m <sup>3</sup> /s)          | 1.274 258 E-02                    |
| cup (U.S.)                                                                                                                             | cubic meter (m <sup>3</sup> )                       | 2.365 882 E-04                    |
| cup (U.S.)                                                                                                                             | liter (L)                                           | 2.365 882 E-01                    |
| cup (U.S.)                                                                                                                             | milliliter (mL)                                     | 2.365 882 E+02                    |
| curie (Ci)                                                                                                                             | becquerel (Bq)                                      | <b>3.7 E+10</b>                   |
| darcy <sup>15</sup>                                                                                                                    | meter squared (m <sup>2</sup> )                     | 9.869 233 E-13                    |
| day (d)                                                                                                                                | second (s)                                          | <b>8.64 E+04</b>                  |
| day (sidereal)                                                                                                                         | second (s)                                          | 8.616 409 E+04                    |
| debye (D)                                                                                                                              | coulomb meter (C · m)                               | 3.335 641 E-30                    |
| degree (angle) (°)                                                                                                                     | radian (rad)                                        | 1.745 329 E-02                    |
| degree Celsius (temperature) (°C)                                                                                                      | kelvin (K)                                          | $T/K = t/°C + 273.15$             |
| degree Celsius (temperature interval) (°C)                                                                                             | kelvin (K)                                          | <b>1.0 E+00</b>                   |
| degree centigrade (temperature) <sup>16</sup>                                                                                          | degree Celsius (°C)                                 | $t/°C \approx t/\text{deg.cent.}$ |
| degree centigrade (temperature interval) <sup>16</sup>                                                                                 | degree Celsius (°C)                                 | 1.0 E+00                          |
| degree Fahrenheit (temperature) (°F)                                                                                                   | degree Celsius (°C)                                 | $t/°C = (t/°F - 32)/1.8$          |
| degree Fahrenheit (temperature) (°F)                                                                                                   | kelvin (K)                                          | $T/K = (t/°F + 459.67)/1.8$       |
| degree Fahrenheit (temperature interval) (°F)                                                                                          | degree Celsius (°C)                                 | 5.555 556 E-01                    |
| degree Fahrenheit (temperature interval) (°F)                                                                                          | kelvin (K)                                          | 5.555 556 E-01                    |
| degree Fahrenheit hour per British thermal unit <sub>T</sub><br>(°F · h/Btu <sub>T</sub> )                                             | kelvin per watt (K/W)                               | 1.895 634 E+00                    |
| degree Fahrenheit hour per British thermal unit <sub>th</sub><br>(°F · h/Btu <sub>th</sub> )                                           | kelvin per watt (K/W)                               | 1.896 903 E+00                    |
| degree Fahrenheit hour square foot per British thermal unit <sub>T</sub><br>(°F · h · ft <sup>2</sup> /Btu <sub>T</sub> )              | square meter kelvin per watt (m <sup>2</sup> · K/W) | 1.761 102 E-01                    |
| degree Fahrenheit hour square foot per British thermal unit <sub>th</sub><br>(°F · h · ft <sup>2</sup> /Btu <sub>th</sub> )            | square meter kelvin per watt (m <sup>2</sup> · K/W) | 1.762 280 E-01                    |
| degree Fahrenheit hour square foot per British thermal unit <sub>T</sub> inch<br>[°F · h · ft <sup>2</sup> /(Btu <sub>T</sub> · in)]   | meter kelvin per watt (m · K/W)                     | 6.933 472 E+00                    |
| degree Fahrenheit hour square foot per British thermal unit <sub>th</sub> inch<br>[°F · h · ft <sup>2</sup> /(Btu <sub>th</sub> · in)] | meter kelvin per watt (m · K/W)                     | 6.938 112 E+00                    |
| degree Fahrenheit second per British thermal unit <sub>T</sub><br>(°F · s/Btu <sub>T</sub> )                                           | kelvin per watt (K/W)                               | 5.265 651 E-04                    |
| degree Fahrenheit second per British thermal unit <sub>th</sub><br>(°F · s/Btu <sub>th</sub> )                                         | kelvin per watt (K/W)                               | 5.269 175 E-04                    |
| degree Rankine (°R)                                                                                                                    | kelvin (K)                                          | $T/K = (T/°R)/1.8$                |
| degree Rankine (temperature interval) (°R)                                                                                             | kelvin (K)                                          | 5.555 556 E-01                    |
| denier                                                                                                                                 | kilogram per meter (kg/m)                           | 1.111 111 E-07                    |
| denier                                                                                                                                 | gram per meter (g/m)                                | 1.111 111 E-04                    |
| dyne (dyn)                                                                                                                             | newton (N)                                          | <b>1.0 E-05</b>                   |
| dyne centimeter (dyn · cm)                                                                                                             | newton meter (N · m)                                | <b>1.0 E-07</b>                   |
| dyne per square centimeter (dyn/cm <sup>2</sup> )                                                                                      | pascal (Pa)                                         | <b>1.0 E-01</b>                   |

<sup>14</sup> The exact conversion factor is 1.638 706 4 E-05.<sup>15</sup> The darcy is a unit for expressing the permeability of porous solids, not area.<sup>16</sup> The centigrade temperature scale is obsolete; the degree centigrade is only approximately equal to the degree Celsius.

| To convert from                                                      | to                                                 | Multiply by          |
|----------------------------------------------------------------------|----------------------------------------------------|----------------------|
| electronvolt (eV).....                                               | joule (J).....                                     | 1.602 177 E-19       |
| EMU of capacitance (abfarad).....                                    | farad (F).....                                     | <b>1.0</b> E+09      |
| EMU of current (abampere).....                                       | ampere (A).....                                    | <b>1.0</b> E+01      |
| EMU of electric potential (abvolt).....                              | volt (V).....                                      | <b>1.0</b> E-08      |
| EMU of inductance (abhenry).....                                     | henry (H).....                                     | <b>1.0</b> E-09      |
| EMU of resistance (abohm).....                                       | ohm ( $\Omega$ ).....                              | <b>1.0</b> E-09      |
| erg (erg).....                                                       | joule (J).....                                     | <b>1.0</b> E-07      |
| erg per second (erg/s).....                                          | watt (W).....                                      | <b>1.0</b> E-07      |
| erg per square centimeter second<br>[erg/(cm <sup>2</sup> · s)]..... | watt per square meter (W/m <sup>2</sup> ).....     | <b>1.0</b> E-03      |
| ESU of capacitance (statfarad).....                                  | farad (F).....                                     | 1.112 650 E-12       |
| ESU of current (statampere).....                                     | ampere (A).....                                    | 3.335 641 E-10       |
| ESU of electric potential (statvolt).....                            | volt (V).....                                      | 2.997 925 E+02       |
| ESU of inductance (stathenry).....                                   | henry (H).....                                     | 8.987 552 E+11       |
| ESU of resistance (statohm).....                                     | ohm ( $\Omega$ ).....                              | 8.987 552 E+11       |
| faraday (based on carbon 12).....                                    | coulomb (C).....                                   | 9.648 531 E+04       |
| fathom (based on U.S. survey foot) <sup>9</sup> .....                | meter (m).....                                     | 1.828 804 E+00       |
| fermi.....                                                           | meter (m).....                                     | <b>1.0</b> E-15      |
| fermi.....                                                           | femtometer (fm).....                               | <b>1.0</b> E+00      |
| fluid ounce (U.S.) (fl oz).....                                      | cubic meter (m <sup>3</sup> ).....                 | 2.957 353 E-05       |
| fluid ounce (U.S.) (fl oz).....                                      | milliliter (mL).....                               | 2.957 353 E+01       |
| foot (ft).....                                                       | meter (m).....                                     | <b>3.048</b> E-01    |
| foot (U.S. survey ft) <sup>9</sup> .....                             | meter (m).....                                     | 3.048 006 E-01       |
| footcandle.....                                                      | lux (lx).....                                      | 1.076 391 E+01       |
| footlambert.....                                                     | candela per square meter (cd/m <sup>2</sup> )..... | 3.426 259 E+00       |
| foot of mercury, conventional (ftHg) <sup>13</sup> .....             | pascal (Pa).....                                   | 4.063 666 E+04       |
| foot of mercury, conventional (ftHg) <sup>13</sup> .....             | kilopascal (kPa).....                              | 4.063 666 E+01       |
| foot of water (39.2 °F) <sup>13</sup> .....                          | pascal (Pa).....                                   | 2.988 98 E+03        |
| foot of water (39.2 °F) <sup>13</sup> .....                          | kilopascal (kPa).....                              | 2.988 98 E+00        |
| foot of water, conventional (ftH <sub>2</sub> O) <sup>13</sup> ..... | pascal (Pa).....                                   | 2.989 067 E+03       |
| foot of water, conventional (ftH <sub>2</sub> O) <sup>13</sup> ..... | kilopascal (kPa).....                              | 2.989 067 E+00       |
| foot per hour (ft/h).....                                            | meter per second (m/s).....                        | 8.466 667 E-05       |
| foot per minute (ft/min).....                                        | meter per second (m/s).....                        | <b>5.08</b> E-03     |
| foot per second (ft/s).....                                          | meter per second (m/s).....                        | <b>3.048</b> E-01    |
| foot per second squared (ft/s <sup>2</sup> ).....                    | meter per second squared (m/s <sup>2</sup> ).....  | <b>3.048</b> E-01    |
| foot poundal.....                                                    | joule (J).....                                     | 4.214 011 E-02       |
| foot pound-force (ft · lbf).....                                     | joule (J).....                                     | 1.355 818 E+00       |
| foot pound-force per hour (ft · lbf/h).....                          | watt (W).....                                      | 3.766 161 E-04       |
| foot pound-force per minute (ft · lbf/min).....                      | watt (W).....                                      | 2.259 697 E-02       |
| foot pound-force per second (ft · lbf/s).....                        | watt (W).....                                      | 1.355 818 E+00       |
| foot to the fourth power (ft <sup>4</sup> ) <sup>17</sup> .....      | meter to the fourth power (m <sup>4</sup> ).....   | 8.630 975 E-03       |
| franklin (Fr).....                                                   | coulomb (C).....                                   | 3.335 641 E-10       |
| gal (Gal).....                                                       | meter per second squared (m/s <sup>2</sup> ).....  | <b>1.0</b> E-02      |
| gallon [Canadian and U.K. (Imperial)] (gal).....                     | cubic meter (m <sup>3</sup> ).....                 | <b>4.546 09</b> E-03 |
| gallon [Canadian and U.K. (Imperial)] (gal).....                     | liter (L).....                                     | <b>4.546 09</b> E+00 |
| gallon (U.S.) (gal).....                                             | cubic meter (m <sup>3</sup> ).....                 | 3.785 412 E-03       |
| gallon (U.S.) (gal).....                                             | liter (L).....                                     | 3.785 412 E+00       |
| gallon (U.S.) per day (gal/d).....                                   | cubic meter per second (m <sup>3</sup> /s).....    | 4.381 264 E-08       |
| gallon (U.S.) per day (gal/d).....                                   | liter per second (L/s).....                        | 4.381 264 E-05       |
| gallon (U.S.) per horsepower hour<br>[gal/(hp · h)].....             | cubic meter per joule (m <sup>3</sup> /J).....     | 1.410 089 E-09       |
| gallon (U.S.) per horsepower hour<br>[gal/(hp · h)].....             | liter per joule (L/J).....                         | 1.410 089 E-06       |
| gallon (U.S.) per minute (gpm)(gal/min).....                         | cubic meter per second (m <sup>3</sup> /s).....    | 6.309 020 E-05       |
| gallon (U.S.) per minute (gpm)(gal/min).....                         | liter per second (L/s).....                        | 6.309 020 E-02       |
| gamma ( $\gamma$ ).....                                              | tesla (T).....                                     | <b>1.0</b> E-09      |
| gauss (Gs, G).....                                                   | tesla (T).....                                     | <b>1.0</b> E-04      |
| gilbert (Gi).....                                                    | ampere (A).....                                    | 7.957 747 E-01       |

<sup>17</sup> This is a unit for the quantity second moment of area, which is sometimes called the “moment of section” or “area moment of inertia” of a plane section about a specified axis.

| To convert from                                                   | to                                            | Multiply by                                |
|-------------------------------------------------------------------|-----------------------------------------------|--------------------------------------------|
| gill [Canadian and U.K. (Imperial)] (gi)                          | cubic meter (m <sup>3</sup> )                 | 1.420 653 E-04                             |
| gill [Canadian and U.K. (Imperial)] (gi)                          | liter (L)                                     | 1.420 653 E-01                             |
| gill (U.S.) (gi)                                                  | cubic meter (m <sup>3</sup> )                 | 1.182 941 E-04                             |
| gill (U.S.) (gi)                                                  | liter (L)                                     | 1.182 941 E-01                             |
| gon (also called grade) (gon)                                     | radian (rad)                                  | 1.570 796 E-02                             |
| gon (also called grade) (gon)                                     | degree (angle) (°)                            | 9.0 E-01                                   |
| grain (gr)                                                        | kilogram (kg)                                 | 6.479 891 E-05                             |
| grain (gr)                                                        | milligram (mg)                                | 6.479 891 E+01                             |
| grain per gallon (U.S.) (gr/gal)                                  | kilogram per cubic meter (kg/m <sup>3</sup> ) | 1.711 806 E-02                             |
| grain per gallon (U.S.) (gr/gal)                                  | milligram per liter (mg/L)                    | 1.711 806 E+01                             |
| gram-force per square centimeter (gf/cm <sup>2</sup> )            | pascal (Pa)                                   | 9.806 65 E+01                              |
| gram per cubic centimeter (g/cm <sup>3</sup> )                    | kilogram per cubic meter (kg/m <sup>3</sup> ) | 1.0 E+03                                   |
| hectare (ha)                                                      | square meter (m <sup>2</sup> )                | 1.0 E+04                                   |
| horsepower (550 ft · lbf/s) (hp)                                  | watt (W)                                      | 7.456 999 E+02                             |
| horsepower (boiler)                                               | watt (W)                                      | 9.809 50 E+03                              |
| horsepower (electric)                                             | watt (W)                                      | 7.46 E+02                                  |
| horsepower (metric)                                               | watt (W)                                      | 7.354 988 E+02                             |
| horsepower (U.K.)                                                 | watt (W)                                      | 7.4570 E+02                                |
| horsepower (water)                                                | watt (W)                                      | 7.460 43 E+02                              |
| hour (h)                                                          | second (s)                                    | 3.6 E+03                                   |
| hour (sidereal)                                                   | second (s)                                    | 3.590 170 E+03                             |
| hundredweight (long, 112 lb)                                      | kilogram (kg)                                 | 5.080 235 E+01                             |
| hundredweight (short, 100 lb)                                     | kilogram (kg)                                 | 4.535 924 E+01                             |
| inch (in)                                                         | meter (m)                                     | 2.54 E-02                                  |
| inch (in)                                                         | centimeter (cm)                               | 2.54 E+00                                  |
| inch of mercury (32 °F) <sup>13</sup>                             | pascal (Pa)                                   | 3.386 38 E+03                              |
| inch of mercury (32 °F) <sup>13</sup>                             | kilopascal (kPa)                              | 3.386 38 E+00                              |
| inch of mercury (60 °F) <sup>13</sup>                             | pascal (Pa)                                   | 3.376 85 E+03                              |
| inch of mercury (60 °F) <sup>13</sup>                             | kilopascal (kPa)                              | 3.376 85 E+00                              |
| inch of mercury, conventional (inHg) <sup>13</sup>                | pascal (Pa)                                   | 3.386 389 E+03                             |
| inch of mercury, conventional (inHg) <sup>13</sup>                | kilopascal (kPa)                              | 3.386 389 E+00                             |
| inch of water (39.2 °F) <sup>13</sup>                             | pascal (Pa)                                   | 2.490 82 E+02                              |
| inch of water (60 °F) <sup>13</sup>                               | pascal (Pa)                                   | 2.4884 E+02                                |
| inch of water, conventional (inH <sub>2</sub> O) <sup>13</sup>    | pascal (Pa)                                   | 2.490 889 E+02                             |
| inch per second (in/s)                                            | meter per second (m/s)                        | 2.54 E-02                                  |
| inch per second squared (in/s <sup>2</sup> )                      | meter per second squared (m/s <sup>2</sup> )  | 2.54 E-02                                  |
| inch to the fourth power (in <sup>4</sup> ) <sup>17</sup>         | meter to the fourth power (m <sup>4</sup> )   | 4.162 314 E-07                             |
| kayser (K)                                                        | reciprocal meter (m <sup>-1</sup> )           | 1.0 E+02                                   |
| kelvin (K)                                                        | degree Celsius (°C)                           | $t/^{\circ}\text{C} = T/\text{K} - 273.15$ |
| kilocalorie <sub>IT</sub> (kcal <sub>IT</sub> )                   | joule (J)                                     | 4.1868 E+03                                |
| kilocalorie <sub>th</sub> (kcal <sub>th</sub> )                   | joule (J)                                     | 4.184 E+03                                 |
| kilocalorie (mean) (kcal)                                         | joule (J)                                     | 4.190 02 E+03                              |
| kilocalorie <sub>th</sub> per minute (kcal <sub>th</sub> /min)    | watt (W)                                      | 6.973 333 E+01                             |
| kilocalorie <sub>th</sub> per second (kcal <sub>th</sub> /s)      | watt (W)                                      | 4.184 E+03                                 |
| kilogram-force (kgf)                                              | newton (N)                                    | 9.806 65 E+00                              |
| kilogram-force meter (kgf · m)                                    | newton meter (N · m)                          | 9.806 65 E+00                              |
| kilogram-force per square centimeter (kgf/cm <sup>2</sup> )       | pascal (Pa)                                   | 9.806 65 E+04                              |
| kilogram-force per square centimeter (kgf/cm <sup>2</sup> )       | kilopascal (kPa)                              | 9.806 65 E+01                              |
| kilogram-force per square meter (kgf/m <sup>2</sup> )             | pascal (Pa)                                   | 9.806 65 E+00                              |
| kilogram-force per square millimeter (kgf/mm <sup>2</sup> )       | pascal (Pa)                                   | 9.806 65 E+06                              |
| kilogram-force per square millimeter (kgf/mm <sup>2</sup> )       | megapascal (MPa)                              | 9.806 65 E+00                              |
| kilogram-force second squared per meter (kgf · s <sup>2</sup> /m) | kilogram (kg)                                 | 9.806 65 E+00                              |
| kilometer per hour (km/h)                                         | meter per second (m/s)                        | 2.777 778 E-01                             |
| kilopond (kilogram-force) (kp)                                    | newton (N)                                    | 9.806 65 E+00                              |
| kilowatt hour (kW · h)                                            | joule (J)                                     | 3.6 E+06                                   |
| kilowatt hour (kW · h)                                            | megajoule (MJ)                                | 3.6 E+00                                   |

| To convert from                                                            | to                                                             | Multiply by                                  |
|----------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------|
| kip (1 kip=1000 lbf) .....                                                 | newton (N).....                                                | 4.448 222 E+03                               |
| kip (1 kip=1000 lbf) .....                                                 | kilonewton (kN).....                                           | 4.448 222 E+00                               |
| kip per square inch (ksi) (kip/in <sup>2</sup> ) .....                     | pascal (Pa) .....                                              | 6.894 757 E+06                               |
| kip per square inch (ksi) (kip/in <sup>2</sup> ) .....                     | kilopascal (kPa).....                                          | 6.894 757 E+03                               |
| <i>knot</i> (nautical mile per hour) .....                                 | meter per second (m/s) .....                                   | 5.144 444 E-01                               |
| lambert <sup>18</sup> .....                                                | candela per square meter (cd/m <sup>2</sup> ) .....            | 3.183 099 E+03                               |
| langley (cal <sub>th</sub> /cm <sup>2</sup> ) .....                        | joule per square meter (J/m <sup>2</sup> ) .....               | <b>4.184 E+04</b>                            |
| light year (l.y.) <sup>19</sup> .....                                      | meter (m) .....                                                | 9.460 73 E+15                                |
| liter (L) <sup>20</sup> .....                                              | cubic meter (m <sup>3</sup> ) .....                            | <b>1.0 E-03</b>                              |
| lumen per square foot (lm/ft <sup>2</sup> ) .....                          | lux (lx) .....                                                 | 1.076 391 E+01                               |
| maxwell (Mx) .....                                                         | weber (Wb) .....                                               | <b>1.0 E-08</b>                              |
| mho .....                                                                  | siemens (S) .....                                              | <b>1.0 E+00</b>                              |
| microinch .....                                                            | meter (m) .....                                                | <b>2.54 E-08</b>                             |
| microinch .....                                                            | micrometer (μm) .....                                          | <b>2.54 E-02</b>                             |
| micron (μ) .....                                                           | meter (m) .....                                                | <b>1.0 E-06</b>                              |
| micron (μ) .....                                                           | micrometer (μm) .....                                          | <b>1.0 E+00</b>                              |
| mil (0.001 in) .....                                                       | meter (m) .....                                                | <b>2.54 E-05</b>                             |
| mil (0.001 in) .....                                                       | millimeter (mm) .....                                          | <b>2.54 E-02</b>                             |
| mil (angle) .....                                                          | radian (rad) .....                                             | 9.817 477 E-04                               |
| mil (angle) .....                                                          | degree (°) .....                                               | <b>5.625 E-02</b>                            |
| mile (mi) .....                                                            | meter (m) .....                                                | <b>1.609 344 E+03</b>                        |
| mile (mi) .....                                                            | kilometer (km) .....                                           | <b>1.609 344 E+00</b>                        |
| mile (based on U.S. survey foot) (mi) <sup>9</sup> .....                   | meter (m) .....                                                | 1.609 347 E+03                               |
| mile (based on U.S. survey foot) (mi) <sup>9</sup> .....                   | kilometer (km) .....                                           | 1.609 347 E+00                               |
| <i>mile, nautical</i> <sup>21</sup> .....                                  | meter (m) .....                                                | <b>1.852 E+03</b>                            |
| mile per gallon (U.S.) (mpg) (mi/gal) .....                                | meter per cubic meter (m/m <sup>3</sup> ) .....                | 4.251 437 E+05                               |
| mile per gallon (U.S.) (mpg) (mi/gal) .....                                | kilometer per liter (km/L) .....                               | 4.251 437 E-01                               |
| mile per gallon (U.S.) (mpg) (mi/gal) <sup>22</sup> .....                  | liter per 100 kilometer (L/100 km) .....                       | divide 235.215 by number of miles per gallon |
| mile per hour (mi/h) .....                                                 | meter per second (m/s) .....                                   | <b>4.4704 E-01</b>                           |
| mile per hour (mi/h) .....                                                 | kilometer per hour (km/h) .....                                | <b>1.609 344 E+00</b>                        |
| mile per minute (mi/min) .....                                             | meter per second (m/s) .....                                   | <b>2.682 24 E+01</b>                         |
| mile per second (mi/s) .....                                               | meter per second (m/s) .....                                   | <b>1.609 344 E+03</b>                        |
| millibar (mbar) .....                                                      | pascal (Pa) .....                                              | <b>1.0 E+02</b>                              |
| millibar (mbar) .....                                                      | kilopascal (kPa) .....                                         | <b>1.0 E-01</b>                              |
| millimeter of mercury, conventional (mmHg) <sup>13</sup> .....             | pascal (Pa) .....                                              | 1.333 224 E+02                               |
| millimeter of water, conventional (mmH <sub>2</sub> O) <sup>13</sup> ..... | pascal (Pa) .....                                              | <b>9.806 65 E+00</b>                         |
| <i>minute</i> (angle) (') .....                                            | radian (rad) .....                                             | 2.908 882 E-04                               |
| <i>minute</i> (min) .....                                                  | second (s) .....                                               | <b>6.0 E+01</b>                              |
| minute (sidereal) .....                                                    | second (s) .....                                               | 5.983 617 E+01                               |
| nit .....                                                                  | candela per meter squared (cd/m <sup>2</sup> ) .....           | <b>1.0 E+00</b>                              |
| nox .....                                                                  | lux (lx) .....                                                 | <b>1.0 E-03</b>                              |
| oersted (Oe) .....                                                         | ampere per meter (A/m) .....                                   | 7.957 747 E+01                               |
| <i>ohm centimeter</i> (Ω · cm) .....                                       | ohm meter (Ω · m) .....                                        | <b>1.0 E-02</b>                              |
| ohm circular-mil per foot .....                                            | ohm meter (Ω · m) .....                                        | 1.662 426 E-09                               |
| ohm circular-mil per foot .....                                            | ohm square millimeter per meter (Ω · mm <sup>2</sup> /m) ..... | 1.662 426 E-03                               |
| ounce (avoirdupois) (oz) .....                                             | kilogram (kg) .....                                            | 2.834 952 E-02                               |
| ounce (avoirdupois) (oz) .....                                             | gram (g) .....                                                 | 2.834 952 E+01                               |
| ounce (troy or apothecary) (oz) .....                                      | kilogram (kg) .....                                            | 3.110 348 E-02                               |
| ounce (troy or apothecary) (oz) .....                                      | gram (g) .....                                                 | 3.110 348 E+01                               |
| ounce [Canadian and U.K. fluid (Imperial)] (fl oz) .....                   | cubic meter (m <sup>3</sup> ) .....                            | 2.841 306 E-05                               |

<sup>18</sup> The exact conversion factor is 10<sup>4</sup>/π.

<sup>19</sup> This conversion factor is based on 1 d = 86 400 s; and 1 Julian century = 36 525 d. (See *The Astronomical Almanac for the Year 1995*, page K6, U.S. Government Printing Office, Washington, DC, 1994.)

<sup>20</sup> In 1964 the General Conference on Weights and Measures reestablished the name "liter" as a special name for the cubic decimeter. Between 1901 and 1964 the liter was slightly larger (1.000 028 dm<sup>3</sup>); when one uses high-accuracy volume data of that time, this fact must be kept in mind.

<sup>21</sup> The value of this unit, 1 nautical mile = 1852 m, was adopted by the First International Extraordinary Hydrographic Conference, Monaco, 1929, under the name "International nautical mile."

<sup>22</sup> For converting fuel economy, as used in the U.S., to fuel consumption.



| To convert from                                                             | to                                                                           | Multiply by          |
|-----------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------------|
| ounce [Canadian and U.K. fluid (Imperial)]                                  |                                                                              |                      |
| (fl oz).....                                                                | milliliter (mL).....                                                         | 2.841 306 E+01       |
| ounce (U.S. fluid) (fl oz).....                                             | cubic meter (m <sup>3</sup> ).....                                           | 2.957 353 E-05       |
| ounce (U.S. fluid) (fl oz).....                                             | milliliter (mL).....                                                         | 2.957 353 E+01       |
| ounce (avoirdupois)-force (ozf).....                                        | newton (N).....                                                              | 2.780 139 E-01       |
| ounce (avoirdupois)-force inch (ozf · in).....                              | newton meter (N · m).....                                                    | 7.061 552 E-03       |
| ounce (avoirdupois)-force inch (ozf · in).....                              | millinewton meter (mN · m).....                                              | 7.061 552 E+00       |
| ounce (avoirdupois) per cubic inch (oz/in <sup>3</sup> ).....               | kilogram per cubic meter (kg/m <sup>3</sup> ).....                           | 1.729 994 E+03       |
| ounce (avoirdupois) per gallon [Canadian and U.K. (Imperial)] (oz/gal)..... | kilogram per cubic meter (kg/m <sup>3</sup> ).....                           | 6.236 023 E+00       |
| ounce (avoirdupois) per gallon [Canadian and U.K. (Imperial)] (oz/gal)..... | gram per liter (g/L).....                                                    | 6.236 023 E+00       |
| ounce (avoirdupois) per gallon (U.S.)(oz/gal).....                          | kilogram per cubic meter (kg/m <sup>3</sup> ).....                           | 7.489 152 E+00       |
| ounce (avoirdupois) per gallon (U.S.)(oz/gal).....                          | gram per liter (g/L).....                                                    | 7.489 152 E+00       |
| ounce (avoirdupois) per square foot (oz/ft <sup>2</sup> ).....              | kilogram per square meter (kg/m <sup>2</sup> ).....                          | 3.051 517 E-01       |
| ounce (avoirdupois) per square inch (oz/in <sup>2</sup> ).....              | kilogram per square meter (kg/m <sup>2</sup> ).....                          | 4.394 185 E+01       |
| ounce (avoirdupois) per square yard(oz/yd <sup>2</sup> ).....               | kilogram per square meter (kg/m <sup>2</sup> ).....                          | 3.390 575 E-02       |
| parsec (pc).....                                                            | meter (m).....                                                               | 3.085 678 E+16       |
| peck (U.S.) (pk).....                                                       | cubic meter (m <sup>3</sup> ).....                                           | 8.809 768 E-03       |
| peck (U.S.) (pk).....                                                       | liter (L).....                                                               | 8.809 768 E+00       |
| pennyweight (dwt).....                                                      | kilogram (kg).....                                                           | 1.555 174 E-03       |
| pennyweight (dwt).....                                                      | gram (g).....                                                                | 1.555 174 E+00       |
| perm (0 °C).....                                                            | kilogram per pascal second square meter [kg/(Pa · s · m <sup>2</sup> )]..... | 5.721 35 E-11        |
| perm (23 °C).....                                                           | kilogram per pascal second square meter [kg/(Pa · s · m <sup>2</sup> )]..... | 5.745 25 E-11        |
| perm inch (0 °C).....                                                       | kilogram per pascal second meter [kg/(Pa · s · m)].....                      | 1.453 22 E-12        |
| perm inch (23 °C).....                                                      | kilogram per pascal second meter [kg/(Pa · s · m)].....                      | 1.459 29 E-12        |
| phot (ph).....                                                              | lux (lx).....                                                                | <b>1.0 E+04</b>      |
| pica (computer) (1/6 in).....                                               | meter (m).....                                                               | 4.233 333 E-03       |
| pica (computer) (1/6 in).....                                               | millimeter (mm).....                                                         | 4.233 333 E+00       |
| pica (printer's).....                                                       | meter (m).....                                                               | 4.217 518 E-03       |
| pica (printer's).....                                                       | millimeter (mm).....                                                         | 4.217 518 E+00       |
| pint (U.S. dry) (dry pt).....                                               | cubic meter (m <sup>3</sup> ).....                                           | 5.506 105 E-04       |
| pint (U.S. dry) (dry pt).....                                               | liter (L).....                                                               | 5.506 105 E-01       |
| pint (U.S. liquid) (liq pt).....                                            | cubic meter (m <sup>3</sup> ).....                                           | 4.731 765 E-04       |
| pint (U.S. liquid) (liq pt).....                                            | liter (L).....                                                               | 4.731 765 E-01       |
| point (computer) (1/72 in).....                                             | meter (m).....                                                               | 3.527 778 E-04       |
| point (computer) (1/72 in).....                                             | millimeter (mm).....                                                         | 3.527 778 E-01       |
| point (printer's).....                                                      | meter (m).....                                                               | 3.514 598 E-04       |
| point (printer's).....                                                      | millimeter (mm).....                                                         | 3.514 598 E-01       |
| poise (P).....                                                              | pascal second (Pa · s).....                                                  | <b>1.0 E-01</b>      |
| pound (avoirdupois) (lb) <sup>23</sup> .....                                | kilogram (kg).....                                                           | 4.535 924 E-01       |
| pound (troy or apothecary) (lb).....                                        | kilogram (kg).....                                                           | 3.732 417 E-01       |
| poundal.....                                                                | newton (N).....                                                              | 1.382 550 E-01       |
| poundal per square foot.....                                                | pascal (Pa).....                                                             | 1.488 164 E+00       |
| poundal second per square foot.....                                         | pascal second (Pa · s).....                                                  | 1.488 164 E+00       |
| pound foot squared (lb · ft <sup>2</sup> ).....                             | kilogram meter squared (kg · m <sup>2</sup> ).....                           | 4.214 011 E-02       |
| pound-force (lbf) <sup>24</sup> .....                                       | newton (N).....                                                              | 4.448 222 E+00       |
| pound-force foot (lbf · ft).....                                            | newton meter (N · m).....                                                    | 1.355 818 E+00       |
| pound-force foot per inch (lbf · ft/in).....                                | newton meter per meter (N · m/m).....                                        | 5.337 866 E+01       |
| pound-force inch (lbf · in).....                                            | newton meter (N · m).....                                                    | 1.129 848 E-01       |
| pound-force inch per inch (lbf · in/in).....                                | newton meter per meter (N · m/m).....                                        | 4.448 222 E+00       |
| pound-force per foot (lbf/ft).....                                          | newton per meter (N/m).....                                                  | 1.459 390 E+01       |
| pound-force per inch (lbf/in).....                                          | newton per meter (N/m).....                                                  | 1.751 268 E+02       |
| pound-force per pound (lbf/lb) (thrust to mass ratio).....                  | newton per kilogram (N/kg).....                                              | <b>9.806 65 E+00</b> |

<sup>23</sup> The exact conversion factor is 4.535 923 7 E-01. All units that contain the pound refer to the avoirdupois pound unless otherwise specified.

<sup>24</sup> If the local value of the acceleration of free fall is taken as  $g_n = 9.806 65 \text{ m/s}^2$  (the standard value), the exact conversion factor is 4.448 221 615 260 5 E+00.

| To convert from                                                          | to                                                 | Multiply by           |
|--------------------------------------------------------------------------|----------------------------------------------------|-----------------------|
| pound-force per square foot (lbf/ft <sup>2</sup> )                       | pascal (Pa)                                        | 4.788 026 E+01        |
| pound-force per square inch (psi) (lbf/in <sup>2</sup> )                 | pascal (Pa)                                        | 6.894 757 E+03        |
| pound-force per square inch (psi) (lbf/in <sup>2</sup> )                 | kilopascal (kPa)                                   | 6.894 757 E+00        |
| pound-force second per square foot<br>(lbf · s/ft <sup>2</sup> )         | pascal second (Pa · s)                             | 4.788 026 E+01        |
| pound-force second per square inch<br>(lbf · s/in <sup>2</sup> )         | pascal second (Pa · s)                             | 6.894 757 E+03        |
| pound inch squared (lb · in <sup>2</sup> )                               | kilogram meter squared (kg · m <sup>2</sup> )      | 2.926 397 E−04        |
| pound per cubic foot (lb/ft <sup>3</sup> )                               | kilogram per cubic meter (kg/m <sup>3</sup> )      | 1.601 846 E+01        |
| pound per cubic inch (lb/in <sup>3</sup> )                               | kilogram per cubic meter (kg/m <sup>3</sup> )      | 2.767 990 E+04        |
| pound per cubic yard (lb/yd <sup>3</sup> )                               | kilogram per cubic meter (kg/m <sup>3</sup> )      | 5.932 764 E−01        |
| pound per foot (lb/ft)                                                   | kilogram per meter (kg/m)                          | 1.488 164 E+00        |
| pound per foot hour [lb/(ft · h)]                                        | pascal second (Pa · s)                             | 4.133 789 E−04        |
| pound per foot second [lb/(ft · s)]                                      | pascal second (Pa · s)                             | 1.488 164 E+00        |
| pound per gallon [Canadian and<br>U.K. (Imperial)] (lb/gal)              | kilogram per cubic meter (kg/m <sup>3</sup> )      | 9.977 637 E+01        |
| pound per gallon [Canadian and<br>U.K. (Imperial)] (lb/gal)              | kilogram per liter (kg/L)                          | 9.977 637 E−02        |
| pound per gallon (U.S.) (lb/gal)                                         | kilogram per cubic meter (kg/m <sup>3</sup> )      | 1.198 264 E+02        |
| pound per gallon (U.S.) (lb/gal)                                         | kilogram per liter (kg/L)                          | 1.198 264 E−01        |
| pound per horsepower hour [lb/(hp · h)]                                  | kilogram per joule (kg/J)                          | 1.689 659 E−07        |
| pound per hour (lb/h)                                                    | kilogram per second (kg/s)                         | 1.259 979 E−04        |
| pound per inch (lb/in)                                                   | kilogram per meter (kg/m)                          | 1.785 797 E+01        |
| pound per minute (lb/min)                                                | kilogram per second (kg/s)                         | 7.559 873 E−03        |
| pound per second (lb/s)                                                  | kilogram per second (kg/s)                         | 4.535 924 E−01        |
| pound per square foot (lb/ft <sup>2</sup> )                              | kilogram per square meter (kg/m <sup>2</sup> )     | 4.882 428 E+00        |
| pound per square inch ( <i>not</i> pound-force)<br>(lb/in <sup>2</sup> ) | kilogram per square meter (kg/m <sup>2</sup> )     | 7.030 696 E+02        |
| pound per yard (lb/yd)                                                   | kilogram per meter (kg/m)                          | 4.960 546 E−01        |
| psi (pound-force per square inch) (lbf/in <sup>2</sup> )                 | pascal (Pa)                                        | 6.894 757 E+03        |
| psi (pound-force per square inch) (lbf/in <sup>2</sup> )                 | kilopascal (kPa)                                   | 6.894 757 E+00        |
| quad (10 <sup>15</sup> Btu <sub>T</sub> ) <sup>11</sup>                  | joule (J)                                          | 1.055 056 E+18        |
| quart (U.S. dry) (dry qt)                                                | cubic meter (m <sup>3</sup> )                      | 1.101 221 E−03        |
| quart (U.S. dry) (dry qt)                                                | liter (L)                                          | 1.101 221 E+00        |
| quart (U.S. liquid) (liq qt)                                             | cubic meter (m <sup>3</sup> )                      | 9.463 529 E−04        |
| quart (U.S. liquid) (liq qt)                                             | liter (L)                                          | 9.463 529 E−01        |
| rad (absorbed dose) (rad)                                                | gray (Gy)                                          | <b>1.0</b> E−02       |
| rem (rem)                                                                | sievert (Sv)                                       | <b>1.0</b> E−02       |
| revolution (r)                                                           | radian (rad)                                       | 6.283 185 E+00        |
| revolution per minute (rpm) (r/min)                                      | radian per second (rad/s)                          | 1.047 198 E−01        |
| rhe                                                                      | reciprocal pascal second [(Pa · s) <sup>−1</sup> ] | <b>1.0</b> E+01       |
| rod (based on U.S. survey foot) (rd) <sup>9</sup>                        | meter (m)                                          | 5.029 210 E+00        |
| roentgen (R)                                                             | coulomb per kilogram (C/kg)                        | <b>2.58</b> E−04      |
| rpm (revolution per minute) (r/min)                                      | radian per second (rad/s)                          | 1.047 198 E−01        |
| second (angle) (")                                                       | radian (rad)                                       | 4.848 137 E−06        |
| second (sidereal)                                                        | second (s)                                         | 9.972 696 E−01        |
| shake                                                                    | second (s)                                         | <b>1.0</b> E−08       |
| shake                                                                    | nanosecond (ns)                                    | <b>1.0</b> E+01       |
| skot                                                                     | candela per meter squared (cd/m <sup>2</sup> )     | 3.183 098 E−04        |
| slug (slug)                                                              | kilogram (kg)                                      | 1.459 390 E+01        |
| slug per cubic foot (slug/ft <sup>3</sup> )                              | kilogram per cubic meter (kg/m <sup>3</sup> )      | 5.153 788 E+02        |
| slug per foot second [slug/(ft · s)]                                     | pascal second (Pa · s)                             | 4.788 026 E+01        |
| square foot (ft <sup>2</sup> )                                           | square meter (m <sup>2</sup> )                     | <b>9.290 304</b> E−02 |
| square foot per hour (ft <sup>2</sup> /h)                                | square meter per second (m <sup>2</sup> /s)        | <b>2.580 64</b> E−05  |
| square foot per second (ft <sup>2</sup> /s)                              | square meter per second (m <sup>2</sup> /s)        | <b>9.290 304</b> E−02 |
| square inch (in <sup>2</sup> )                                           | square meter (m <sup>2</sup> )                     | <b>6.4516</b> E−04    |
| square inch (in <sup>2</sup> )                                           | square centimeter (cm <sup>2</sup> )               | <b>6.4516</b> E+00    |
| square mile (mi <sup>2</sup> )                                           | square meter (m <sup>2</sup> )                     | 2.589 988 E+06        |
| square mile (mi <sup>2</sup> )                                           | square kilometer (km <sup>2</sup> )                | 2.589 988 E+00        |

| To convert from                                                            | to                                            | Multiply by      | mile        |
|----------------------------------------------------------------------------|-----------------------------------------------|------------------|-------------|
| square<br>(based on U.S. survey foot) (mi <sup>2</sup> ) <sup>9</sup>      | square meter (m <sup>2</sup> )                | 2.589 998        | E+06        |
| square mile<br>(based on U.S. survey foot) (mi <sup>2</sup> ) <sup>9</sup> | square kilometer (km <sup>2</sup> )           | 2.589 998        | E+00        |
| square yard (yd <sup>2</sup> )                                             | square meter (m <sup>2</sup> )                | 8.361 274        | E-01        |
| statampere                                                                 | ampere (A)                                    | 3.335 641        | E-10        |
| statcoulomb                                                                | coulomb (C)                                   | 3.335 641        | E-10        |
| statfarad                                                                  | farad (F)                                     | 1.112 650        | E-12        |
| stathenry                                                                  | henry (H)                                     | 8.987 552        | E+11        |
| statmho                                                                    | siemens (S)                                   | 1.112 650        | E-12        |
| statohm                                                                    | ohm ( $\Omega$ )                              | 8.987 552        | E+11        |
| statvolt                                                                   | volt (V)                                      | 2.997 925        | E+02        |
| stere (st)                                                                 | cubic meter (m <sup>3</sup> )                 | <b>1.0</b>       | <b>E+00</b> |
| stilb (sb)                                                                 | candela per square meter (cd/m <sup>2</sup> ) | <b>1.0</b>       | <b>E+04</b> |
| stokes (St)                                                                | meter squared per second (m <sup>2</sup> /s)  | <b>1.0</b>       | <b>E-04</b> |
| tablespoon                                                                 | cubic meter (m <sup>3</sup> )                 | 1.478 676        | E-05        |
| tablespoon                                                                 | milliliter (mL)                               | 1.478 676        | E+01        |
| teaspoon                                                                   | cubic meter (m <sup>3</sup> )                 | 4.928 922        | E-06        |
| teaspoon                                                                   | milliliter (mL)                               | 4.928 922        | E+00        |
| tex                                                                        | kilogram per meter (kg/m)                     | <b>1.0</b>       | <b>E-06</b> |
| therm (EC) <sup>25</sup>                                                   | joule (J)                                     | <b>1.055 06</b>  | <b>E+08</b> |
| therm (U.S.) <sup>25</sup>                                                 | joule (J)                                     | <b>1.054 804</b> | <b>E+08</b> |
| ton, assay (AT)                                                            | kilogram (kg)                                 | 2.916 667        | E-02        |
| ton, assay (AT)                                                            | gram (g)                                      | 2.916 667        | E+01        |
| ton-force (2000 lbf)                                                       | newton (N)                                    | 8.896 443        | E+03        |
| ton-force (2000 lbf)                                                       | kilonewton (kN)                               | 8.896 443        | E+00        |
| ton, long (2240 lb)                                                        | kilogram (kg)                                 | 1.016 047        | E+03        |
| ton, long, per cubic yard                                                  | kilogram per cubic meter (kg/m <sup>3</sup> ) | 1.328 939        | E+03        |
| ton, metric (t)                                                            | kilogram (kg)                                 | <b>1.0</b>       | <b>E+03</b> |
| tonne (called "metric ton" in U.S.) (t)                                    | kilogram (kg)                                 | <b>1.0</b>       | <b>E+03</b> |
| ton of refrigeration (12 000 Btu <sub>IT</sub> /h)                         | watt (W)                                      | 3.516 853        | E+03        |
| ton of TNT (energy equivalent) <sup>26</sup>                               | joule (J)                                     | <b>4.184</b>     | <b>E+09</b> |
| ton, register                                                              | cubic meter (m <sup>3</sup> )                 | 2.831 685        | E+00        |
| ton, short (2000 lb)                                                       | kilogram (kg)                                 | 9.071 847        | E+02        |
| ton, short, per cubic yard                                                 | kilogram per cubic meter (kg/m <sup>3</sup> ) | 1.186 553        | E+03        |
| ton, short, per hour                                                       | kilogram per second (kg/s)                    | 2.519 958        | E-01        |
| torr (Torr)                                                                | pascal (Pa)                                   | 1.333 224        | E+02        |
| unit pole                                                                  | weber (Wb)                                    | 1.256 637        | E-07        |
| watt hour (W · h)                                                          | joule (J)                                     | <b>3.6</b>       | <b>E+03</b> |
| watt per square centimeter (W/cm <sup>2</sup> )                            | watt per square meter (W/m <sup>2</sup> )     | <b>1.0</b>       | <b>E+04</b> |
| watt per square inch (W/in <sup>2</sup> )                                  | watt per square meter (W/m <sup>2</sup> )     | 1.550 003        | E+03        |
| watt second (W · s)                                                        | joule (J)                                     | <b>1.0</b>       | <b>E+00</b> |
| yard (yd)                                                                  | meter (m)                                     | <b>9.144</b>     | <b>E-01</b> |
| year (365 days)                                                            | second (s)                                    | <b>3.1536</b>    | <b>E+07</b> |
| year (sidereal)                                                            | second (s)                                    | 3.155 815        | E+07        |
| year (tropical)                                                            | second (s)                                    | 3.155 693        | E+07        |

<sup>25</sup> The therm (EC) is legally defined in the Council Directive of 20 December 1979, Council of the European Communities (now the European Union, EU). The therm (U.S.) is legally defined in the Federal Register of July 27, 1968. Although the therm (EC), which is based on the International Table Btu, is frequently used by engineers in the United States, the therm (U.S.) is the legal unit used by the U.S. natural gas industry.

<sup>26</sup> Defined (not measured) value.



## CONVERSION OF TEMPERATURES

| From       | To         |                                                                      |
|------------|------------|----------------------------------------------------------------------|
| Celsius    | Fahrenheit | $t_{\text{F}}/^{\circ}\text{F} = (9/5) t/^{\circ}\text{C} + 32$      |
|            | Kelvin     | $T/\text{K} = t/^{\circ}\text{C} + 273.15$                           |
|            | Rankine    | $T/^{\circ}\text{R} = (9/5) (t/^{\circ}\text{C} + 273.15)$           |
| Fahrenheit | Celsius    | $t/^{\circ}\text{C} = (5/9) [(t_{\text{F}}/^{\circ}\text{F}) - 32]$  |
|            | Kelvin     | $T/\text{K} = (5/9) [(t_{\text{F}}/^{\circ}\text{F}) - 32] + 273.15$ |
|            | Rankine    | $T/^{\circ}\text{R} = t_{\text{F}}/^{\circ}\text{F} + 459.67$        |
| Kelvin     | Celsius    | $t/^{\circ}\text{C} = T/\text{K} - 273.15$                           |
|            | Rankine    | $T/^{\circ}\text{R} = (9/5) T/\text{K}$                              |
| Rankine    | Fahrenheit | $t_{\text{F}}/^{\circ}\text{F} = T/^{\circ}\text{R} - 459.67$        |
|            | Kelvin     | $T/\text{K} = (5/9) T/^{\circ}\text{R}$                              |

Definition of symbols:

$T$  = thermodynamic (absolute) temperature

$t$  = Celsius temperature (the symbol  $\theta$  is also used for Celsius temperature)

$t_{\text{F}}$  = Fahrenheit temperature

### Designation of Large Numbers

|                      | U.S.A.      | Other countries |
|----------------------|-------------|-----------------|
| $10^6$               | million     | million         |
| $10^9$               | billion     | milliard        |
| $10^{12}$            | trillion    | billion         |
| $10^{15}$            | quadrillion | billiard        |
| $10^{18}$            | quintillion | trillion        |
| $100^{100}$          | googol      |                 |
| $10^{\text{googol}}$ | googolplex  |                 |

## CONVERSION FACTORS FOR ENERGY UNITS

If greater accuracy is required, use the *Energy Equivalents* section of the *Fundamental Physical Constants* table.

|                                    | Wavenumber $\tilde{\nu}$<br>$\text{cm}^{-1}$ | Frequency $\nu$<br>$\text{MHz}$ | Energy $E$<br>$\text{aJ}$  | Energy $E$<br>$\text{eV}$ | Energy $E$<br>$E_{\text{h}}$ | Molar energy $E_{\text{m}}$<br>$\text{kJ/mol}$ | Molar energy $E_{\text{m}}$<br>$\text{kcal/mol}$ | Temperature $T$<br>$\text{K}$ |
|------------------------------------|----------------------------------------------|---------------------------------|----------------------------|---------------------------|------------------------------|------------------------------------------------|--------------------------------------------------|-------------------------------|
| $\tilde{\nu}$ : 1 $\text{cm}^{-1}$ | $\doteq 1$                                   | $2.997925 \times 10^4$          | $1.986447 \times 10^{-5}$  | $1.239842 \times 10^{-4}$ | $4.556335 \times 10^{-6}$    | $11.96266 \times 10^{-3}$                      | $2.85914 \times 10^{-3}$                         | 1.438769                      |
| $\nu$ : 1 $\text{MHz}$             | $\doteq 3.33564 \times 10^{-5}$              | 1                               | $6.626076 \times 10^{-10}$ | $4.135669 \times 10^{-9}$ | $1.519830 \times 10^{-10}$   | $3.990313 \times 10^{-7}$                      | $9.53708 \times 10^{-8}$                         | $4.79922 \times 10^{-5}$      |
| 1 $\text{aJ}$                      | $\doteq 50341.1$                             | $1.509189 \times 10^9$          | 1                          | 6.241506                  | 0.2293710                    | 602.2137                                       | 143.9325                                         | $7.24292 \times 10^4$         |
| $E$ : 1 $\text{eV}$                | $\doteq 8065.54$                             | $2.417988 \times 10^8$          | 0.1602177                  | 1                         | $3.674931 \times 10^{-2}$    | 96.4853                                        | 23.0605                                          | $1.16045 \times 10^4$         |
| $E_{\text{h}}$                     | $\doteq 219474.63$                           | $6.579684 \times 10^9$          | 4.359748                   | 27.2114                   | 1                            | 2625.500                                       | 627.510                                          | $3.15773 \times 10^5$         |
| $E_{\text{m}}$ : 1 $\text{kJ/mol}$ | $\doteq 83.5935$                             | $2.506069 \times 10^6$          | $1.660540 \times 10^{-3}$  | $1.036427 \times 10^{-2}$ | $3.808798 \times 10^{-4}$    | 1                                              | 0.239006                                         | 120.272                       |
| 1 $\text{kcal/mol}$                | $\doteq 349.755$                             | $1.048539 \times 10^7$          | $6.947700 \times 10^{-3}$  | $4.336411 \times 10^{-2}$ | $1.593601 \times 10^{-3}$    | 4.184                                          | 1                                                | 503.217                       |
| $T$ : 1 $\text{K}$                 | $\doteq 0.695039$                            | $2.08367 \times 10^4$           | $1.380658 \times 10^{-5}$  | $8.61738 \times 10^{-5}$  | $3.16683 \times 10^{-6}$     | $8.31451 \times 10^{-3}$                       | $1.98722 \times 10^{-3}$                         | 1                             |

Examples of the use of this table:

$$1 \text{ aJ} \doteq 50341 \text{ cm}^{-1}$$

$$1 \text{ eV} \doteq 96.4853 \text{ kJ mol}^{-1}$$

The symbol  $\doteq$  should be read as meaning corresponds to or is equivalent to.

$$E = h\nu = hc\tilde{\nu} = kT; E_{\text{m}} = N_{\text{A}}E; E_{\text{h}} \text{ is the Hartree energy}$$

## CONVERSION FACTORS FOR PRESSURE UNITS

|      | Pa       | kPa         | MPa                      | bar                      | atm                      | Torr      | μmHg    | psi                       |
|------|----------|-------------|--------------------------|--------------------------|--------------------------|-----------|---------|---------------------------|
| Pa   | 1        | 0.001       | 0.000001                 | 0.00001                  | $9.8692 \times 10^{-6}$  | 0.0075006 | 7.5006  | 0.0001450377              |
| kPa  | 1000     | 1           | 0.001                    | 0.01                     | 0.0098692                | 7.5006    | 7500.6  | 0.1450377                 |
| MPa  | 1000000  | 1000        | 1                        | 10                       | 9.8692                   | 7500.6    | 7500600 | 145.0377                  |
| bar  | 100000   | 100         | 0.1                      | 1                        | 0.98692                  | 750.06    | 750060  | 14.50377                  |
| atm  | 101325   | 101.325     | 0.101325                 | 1.01325                  | 1                        | 760       | 760000  | 14.69594                  |
| Torr | 133.322  | 0.133322    | 0.000133322              | 0.00133322               | 0.00131579               | 1         | 1000    | 0.01933672                |
| μmHg | 0.133322 | 0.000133322 | $1.33322 \times 10^{-7}$ | $1.33322 \times 10^{-6}$ | $1.31579 \times 10^{-6}$ | 0.001     | 1       | $1.933672 \times 10^{-5}$ |
| psi  | 6894.757 | 6.894757    | 0.006894757              | 0.06894757               | 0.068046                 | 51.7151   | 51715.1 | 1                         |

To convert a pressure value from a unit in the left-hand column to a new unit, multiply the value by the factor appearing in the column for the new unit. For example:

$$1 \text{ kPa} = 9.8692 \times 10^{-3} \text{ atm}$$

$$1 \text{ Torr} = 1.33322 \times 10^{-4} \text{ MPa}$$

**Notes:** μmHg is often referred to as “micron”

Torr is essentially identical to mmHg

psi is an abbreviation for the unit pound–force per square inch

psia (as a term for a physical quantity) implies the true (absolute) pressure

psig implies the true pressure minus the local atmospheric pressure

## CONVERSION FACTORS FOR THERMAL CONDUCTIVITY UNITS

| MULTIPLY ↓<br>by<br>appropriate<br>factor to<br>OBTAIN →                                  | $\text{Btu}_{\text{IT}} \text{ h}^{-1} \text{ ft}^{-1} \text{ }^{\circ}\text{F}^{-1}$ | $\text{Btu}_{\text{IT}} \text{ in. h}^{-1} \text{ ft}^{-2} \text{ }^{\circ}\text{F}^{-1}$ | $\text{Btu}_{\text{th}} \text{ h}^{-1} \text{ ft}^{-1} \text{ }^{\circ}\text{F}^{-1}$ | $\text{Btu}_{\text{th}} \text{ in. h}^{-1} \text{ ft}^{-2} \text{ }^{\circ}\text{F}^{-1}$ | $\text{cal}_{\text{IT}} \text{ s}^{-1} \text{ cm}^{-1} \text{ }^{\circ}\text{C}^{-1}$ | $\text{cal}_{\text{th}} \text{ s}^{-1} \text{ cm}^{-1} \text{ }^{\circ}\text{C}^{-1}$ | $\text{kcal}_{\text{th}} \text{ h}^{-1} \text{ m}^{-1} \text{ }^{\circ}\text{C}^{-1}$ | $\text{J s}^{-1} \text{ cm}^{-1} \text{ K}^{-1}$ | $\text{W cm}^{-1} \text{ K}^{-1}$ | $\text{W m}^{-1} \text{ K}^{-1}$ | $\text{mW cm}^{-1} \text{ K}^{-1}$ |
|-------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------|----------------------------------|------------------------------------|
| $\text{Btu}_{\text{IT}} \text{ h}^{-1} \text{ ft}^{-1} \text{ }^{\circ}\text{F}^{-1}$     | 1                                                                                     | 12                                                                                        | 1.00067                                                                               | 12.0080                                                                                   | $4.13379 \times 10^{-3}$                                                              | $4.13656 \times 10^{-3}$                                                              | 1.48916                                                                               | $1.73073 \times 10^{-2}$                         | $1.73073 \times 10^{-2}$          | 1.73073                          | 17.3073                            |
| $\text{Btu}_{\text{IT}} \text{ in. h}^{-1} \text{ ft}^{-2} \text{ }^{\circ}\text{F}^{-1}$ | $8.33333 \times 10^{-2}$                                                              | 1                                                                                         | $8.33891 \times 10^{-2}$                                                              | 1.00067                                                                                   | $3.44482 \times 10^{-4}$                                                              | $3.44713 \times 10^{-4}$                                                              | 0.124097                                                                              | $1.44228 \times 10^{-3}$                         | $1.44228 \times 10^{-3}$          | 0.144228                         | 1.44228                            |
| $\text{Btu}_{\text{th}} \text{ h}^{-1} \text{ ft}^{-1} \text{ }^{\circ}\text{F}^{-1}$     | 0.999331                                                                              | 11.9920                                                                                   | 1                                                                                     | 12                                                                                        | $4.13102 \times 10^{-3}$                                                              | $4.13379 \times 10^{-3}$                                                              | 1.48816                                                                               | $1.72958 \times 10^{-2}$                         | $1.72958 \times 10^{-2}$          | 1.72958                          | 17.2958                            |
| $\text{Btu}_{\text{th}} \text{ in. h}^{-1} \text{ ft}^{-2} \text{ }^{\circ}\text{F}^{-1}$ | $8.32776 \times 10^{-2}$                                                              | 0.999331                                                                                  | $8.33333 \times 10^{-2}$                                                              | 1                                                                                         | $3.44252 \times 10^{-4}$                                                              | $3.44482 \times 10^{-4}$                                                              | 0.124014                                                                              | $1.44131 \times 10^{-3}$                         | $1.44131 \times 10^{-3}$          | 0.144131                         | 1.44131                            |
| $\text{cal}_{\text{IT}} \text{ s}^{-1} \text{ cm}^{-1} \text{ }^{\circ}\text{C}^{-1}$     | $2.41909 \times 10^2$                                                                 | $2.90291 \times 10^3$                                                                     | $2.42071 \times 10^2$                                                                 | $2.90485 \times 10^3$                                                                     | 1                                                                                     | 1.00067                                                                               | $3.60241 \times 10^2$                                                                 | 4.1868                                           | 4.1868                            | $4.1868 \times 10^2$             | $4.1868 \times 10^3$               |
| $\text{cal}_{\text{th}} \text{ s}^{-1} \text{ cm}^{-1} \text{ }^{\circ}\text{C}^{-1}$     | $2.41747 \times 10^2$                                                                 | $2.90096 \times 10^3$                                                                     | $2.41909 \times 10^2$                                                                 | $2.90291 \times 10^3$                                                                     | 0.999331                                                                              | 1                                                                                     | $3.6 \times 10^2$                                                                     | 4.184                                            | 4.184                             | $4.184 \times 10^2$              | $4.184 \times 10^3$                |
| $\text{kcal}_{\text{th}} \text{ h}^{-1} \text{ m}^{-1} \text{ }^{\circ}\text{C}^{-1}$     | 0.671520                                                                              | 8.05824                                                                                   | 0.671969                                                                              | 8.06363                                                                                   | $2.77592 \times 10^{-3}$                                                              | $2.77778 \times 10^{-3}$                                                              | 1                                                                                     | $1.16222 \times 10^{-2}$                         | $1.16222 \times 10^{-2}$          | 1.16222                          | 11.6222                            |
| $\text{J s}^{-1} \text{ cm}^{-1} \text{ K}^{-1}$                                          | 57.7789                                                                               | $6.93347 \times 10^2$                                                                     | 57.8176                                                                               | $6.93811 \times 10^2$                                                                     | 0.238846                                                                              | 0.239006                                                                              | 86.0421                                                                               | 1                                                | 1                                 | $1 \times 10^2$                  | $1 \times 10^3$                    |
| $\text{W cm}^{-1} \text{ K}^{-1}$                                                         | 57.7789                                                                               | $6.93347 \times 10^2$                                                                     | 57.8176                                                                               | $6.93811 \times 10^2$                                                                     | 0.238846                                                                              | 0.239006                                                                              | 86.0421                                                                               | 1                                                | 1                                 | $1 \times 10^2$                  | $1 \times 10^3$                    |
| $\text{W m}^{-1} \text{ K}^{-1}$                                                          | 0.577789                                                                              | 6.93347                                                                                   | 0.578176                                                                              | 6.93811                                                                                   | $2.38846 \times 10^{-3}$                                                              | $2.39006 \times 10^{-3}$                                                              | 0.860421                                                                              | $1 \times 10^{-2}$                               | $1 \times 10^{-2}$                | 1                                | 10                                 |
| $\text{mW cm}^{-1} \text{ K}^{-1}$                                                        | $5.77789 \times 10^{-2}$                                                              | 0.693347                                                                                  | $5.78176 \times 10^{-2}$                                                              | 0.693811                                                                                  | $2.38846 \times 10^{-4}$                                                              | $2.39006 \times 10^{-4}$                                                              | $8.60421 \times 10^{-2}$                                                              | $1 \times 10^{-3}$                               | $1 \times 10^{-3}$                | 0.1                              | 1                                  |

## CONVERSION FACTORS FOR ELECTRICAL RESISTIVITY UNITS

| To convert FROM ↓<br>multiply by appropriate<br>factor to OBTAIN → | abΩ cm                 | μΩ cm                  | Ω cm                   | StatΩ cm                 | Ω m                    | Ω cir. mil<br>ft <sup>-1</sup> | Ω in.                   | Ω ft                    |
|--------------------------------------------------------------------|------------------------|------------------------|------------------------|--------------------------|------------------------|--------------------------------|-------------------------|-------------------------|
| abohm centimeter                                                   | 1                      | $1 \times 10^{-3}$     | $10^{-9}$              | $1.113 \times 10^{-21}$  | $10^{-11}$             | $6.015 \times 10^{-3}$         | $3.937 \times 10^{-10}$ | $3.281 \times 10^{-11}$ |
| microohm centimeter                                                | $10^3$                 | 1                      | $10^{-6}$              | $1.113 \times 10^{-18}$  | $10^{-8}$              | 6.015                          | $3.937 \times 10^{-7}$  | $3.281 \times 10^{-6}$  |
| ohm centimeter                                                     | $10^8$                 | $10^6$                 | 1                      | $1.113 \times 10^{-12}$  | $1 \times 10^{-2}$     | $6.015 \times 10^6$            | $3.937 \times 10^{-1}$  | $3.281 \times 10^{-2}$  |
| statohm centimeter (esu)                                           | $8.987 \times 10^{20}$ | $8.987 \times 10^{17}$ | $8.987 \times 10^{11}$ | 1                        | $8.987 \times 10^9$    | $5.406 \times 10^{18}$         | $3.538 \times 10^{11}$  | $2.949 \times 10^{10}$  |
| ohm meter                                                          | $10^{11}$              | $10^8$                 | $10^2$                 | $1.113 \times 10^{-10}$  | 1                      | $6.015 \times 10^8$            | $3.937 \times 10^1$     | 3.281                   |
| ohm circular mil per foot                                          | $1.662 \times 10^2$    | $1.662 \times 10^{-1}$ | $1.662 \times 10^{-7}$ | $1.850 \times 10^{-19}$  | $1.662 \times 10^{-9}$ | 1                              | $6.54 \times 10^{-6}$   | $5.45 \times 10^{-9}$   |
| ohm inch                                                           | $2.54 \times 10^9$     | $2.54 \times 10^6$     | 2.54                   | $2.827 \times 10^{-12}$  | $2.54 \times 10^{-2}$  | $1.528 \times 10^7$            | 1                       | $8.3 \times 10^{-2}$    |
| ohm foot                                                           | $3.048 \times 10^{10}$ | $3.048 \times 10^7$    | $3.048 \times 10^{-1}$ | $3.3924 \times 10^{-11}$ | $3.048 \times 10^{-1}$ | $1.833 \times 10^8$            | 12                      | 1                       |

# CONVERSION FACTORS FOR CHEMICAL KINETICS

## Equivalent Second Order Rate Constants

| A \ B                                                                       | B                                           |                                             |                                            |                                                  |                                    |                                 |                                   |                                           |
|-----------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|--------------------------------------------|--------------------------------------------------|------------------------------------|---------------------------------|-----------------------------------|-------------------------------------------|
|                                                                             | $\text{cm}^3 \text{mol}^{-1} \text{s}^{-1}$ | $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$ | $\text{m}^3 \text{mol}^{-1} \text{s}^{-1}$ | $\text{cm}^3 \text{molecule}^{-1} \text{s}^{-1}$ | $(\text{mmHg})^{-1} \text{s}^{-1}$ | $\text{atm}^{-1} \text{s}^{-1}$ | $\text{ppm}^{-1} \text{min}^{-1}$ | $\text{m}^2 \text{kN}^{-1} \text{s}^{-1}$ |
| $1 \text{ cm}^3 \text{mol}^{-1} \text{s}^{-1} =$                            | 1                                           | $10^{-3}$                                   | $10^{-6}$                                  | $1.66 \times 10^{-24}$                           | $1.604 \times 10^{-5} T^{-1}$      | $1.219 \times 10^{-2} T^{-1}$   | $2.453 \times 10^{-9}$            | $1.203 \times 10^{-4} T^{-1}$             |
| $1 \text{ dm}^3 \text{mol}^{-1} \text{s}^{-1} =$                            | $10^3$                                      | 1                                           | $10^{-3}$                                  | $1.66 \times 10^{-21}$                           | $1.604 \times 10^{-2} T^{-1}$      | $12.19 T^{-1}$                  | $2.453 \times 10^{-6}$            | $1.203 \times 10^{-1} T^{-1}$             |
| $1 \text{ m}^3 \text{mol}^{-1} \text{s}^{-1} =$                             | $10^6$                                      | $10^3$                                      | 1                                          | $1.66 \times 10^{-18}$                           | $16.04 T^{-1}$                     | $1.219 \times 10^4 T^{-1}$      | $2.453 \times 10^{-3}$            | $120.3 T^{-1}$                            |
| $1 \text{ cm}^3 \text{molecule}^{-1} \text{s}^{-1} =$                       | $6.023 \times 10^{23}$                      | $6.023 \times 10^{20}$                      | $6.023 \times 10^{17}$                     | 1                                                | $9.658 \times 10^{18} T^{-1}$      | $7.34 \times 10^{21} T^{-1}$    | $1.478 \times 10^{15}$            | $7.244 \times 10^{19} T^{-1}$             |
| $1 (\text{mmHg})^{-1} \text{s}^{-1} =$                                      | $6.236 \times 10^4 T$                       | $62.36 T$                                   | $6.236 \times 10^{-2} T$                   | $1.035 \times 10^{-19} T$                        | 1                                  | 760                             | $4.56 \times 10^{-2}$             | 7.500                                     |
| $1 \text{ atm}^{-1} \text{s}^{-1} =$                                        | $82.06 T$                                   | $8.206 \times 10^{-2} T$                    | $8.206 \times 10^{-5} T$                   | $1.362 \times 10^{-22} T$                        | $1.316 \times 10^{-3}$             | 1                               | $6 \times 10^{-5}$                | $9.869 \times 10^{-3}$                    |
| $1 \text{ ppm}^{-1} \text{min}^{-1} =$<br>at 298 K, 1 atm<br>total pressure | $4.077 \times 10^8$                         | $4.077 \times 10^5$                         | 407.7                                      | $6.76 \times 10^{-16}$                           | 21.93                              | $1.667 \times 10^4$             | 1                                 | 164.5                                     |
| $1 \text{ m}^2 \text{kN}^{-1} \text{s}^{-1} =$                              | $8314 T$                                    | $8.314 T$                                   | $8.314 \times 10^{-3} T$                   | $1.38 \times 10^{-20} T$                         | 0.1333                             | 101.325                         | $6.079 \times 10^{-3}$            | 1                                         |

To convert a rate constant from one set of units A to a new set B find the conversion factor for the row A under column B and multiply the old value by it, e.g. to convert  $\text{cm}^3 \text{molecule}^{-1} \text{s}^{-1}$  to  $\text{m}^3 \text{mol}^{-1} \text{s}^{-1}$  multiply by  $6.023 \times 10^{17}$ .

Table adapted from High Temperature Reaction Rate Data No. 5, The University, Leeds (1970).

## Equivalent Third Order Rate Constants

| A \ B                                                                      | B                                           |                                             |                                            |                                                  |                                    |                                 |                                   |                                           |
|----------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|--------------------------------------------|--------------------------------------------------|------------------------------------|---------------------------------|-----------------------------------|-------------------------------------------|
|                                                                            | $\text{cm}^6 \text{mol}^{-2} \text{s}^{-1}$ | $\text{dm}^6 \text{mol}^{-1} \text{s}^{-1}$ | $\text{m}^6 \text{mol}^{-2} \text{s}^{-1}$ | $\text{cm}^6 \text{molecule}^{-2} \text{s}^{-1}$ | $(\text{mmHg})^{-2} \text{s}^{-1}$ | $\text{atm}^{-2} \text{s}^{-1}$ | $\text{ppm}^{-2} \text{min}^{-1}$ | $\text{m}^4 \text{kN}^{-2} \text{s}^{-1}$ |
| $1 \text{ cm}^6 \text{mol}^{-2} \text{s}^{-1} =$                           | 1                                           | $10^{-6}$                                   | $10^{-12}$                                 | $2.76 \times 10^{-48}$                           | $2.57 \times 10^{-10} T^{-2}$      | $1.48 \times 10^{-4} T^{-2}$    | $1.003 \times 10^{-19}$           | $1.477 \times 10^{-8} T^{-2}$             |
| $1 \text{ dm}^6 \text{mol}^{-2} \text{s}^{-1} =$                           | $10^6$                                      | 1                                           | $10^{-6}$                                  | $2.76 \times 10^{-42}$                           | $2.57 \times 10^{-4} T^{-2}$       | $148 T^{-2}$                    | $1.003 \times 10^{-13}$           | $1.477 \times 10^{-2} T^{-2}$             |
| $1 \text{ m}^6 \text{mol}^{-2} \text{s}^{-1} =$                            | $10^{12}$                                   | $10^6$                                      | 1                                          | $2.76 \times 10^{-36}$                           | $257 T^{-2}$                       | $1.48 \times 10^8 T^{-2}$       | $1.003 \times 10^{-7}$            | $1.477 \times 10^4 T^{-2}$                |
| $1 \text{ cm}^6 \text{molecule}^{-2} \text{s}^{-1} =$                      | $3.628 \times 10^{47}$                      | $3.628 \times 10^{41}$                      | $3.628 \times 10^{35}$                     | 1                                                | $9.328 \times 10^{37} T^{-2}$      | $5.388 \times 10^{43} T^{-2}$   | $3.64 \times 10^{28}$             | $5.248 \times 10^{39} T^{-2}$             |
| $1 (\text{mmHg})^{-2} \text{s}^{-1} =$                                     | $3.89 \times 10^9 T^2$                      | $3.89 \times 10^3 T^2$                      | $3.89 \times 10^{-3} T^2$                  | $1.07 \times 10^{-38} T^2$                       | 1                                  | $5.776 \times 10^5$             | $3.46 \times 10^{-5}$             | 56.25                                     |
| $1 \text{ atm}^{-2} \text{s}^{-1} =$                                       | $6.733 \times 10^3 T^2$                     | $6.733 \times 10^{-3} T^2$                  | $6.733 \times 10^{-9} T^2$                 | $1.86 \times 10^{-44} T^2$                       | $1.73 \times 10^{-6}$              | 1                               | $6 \times 10^{-11}$               | $9.74 \times 10^{-5}$                     |
| $1 \text{ ppm}^{-2} \text{min}^{-1} =$<br>at 298K, 1 atm<br>total pressure | $9.97 \times 10^{18}$                       | $9.97 \times 10^{12}$                       | $9.97 \times 10^6$                         | $2.75 \times 10^{-29}$                           | $2.89 \times 10^4$                 | $1.667 \times 10^{10}$          | 1                                 | $1.623 \times 10^6$                       |
| $1 \text{ m}^4 \text{kN}^{-2} \text{s}^{-1} =$                             | $6.91 \times 10^7 T^2$                      | $6.91 T^2$                                  | $69.1 \times 10^{-5} T^2$                  | $1.904 \times 10^{-40} T^2$                      | 0.0178                             | $1.027 \times 10^4$             | $6.16 \times 10^{-7}$             | 1                                         |

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# CONVERSION FACTORS FOR IONIZING RADIATION

## Conversion between SI and Other Units

| Quantity                           | Symbol for quantity | Expression in SI units           | Expression in symbols for SI units | Special name for SI units | Symbols using special names | Conventional units               | Symbol for conventional unit | Value of conventional unit in SI units    |
|------------------------------------|---------------------|----------------------------------|------------------------------------|---------------------------|-----------------------------|----------------------------------|------------------------------|-------------------------------------------|
| Activity                           | $A$                 | 1 per second                     | $s^{-1}$                           | becquerel                 | Bq                          | curie                            | Ci                           | $3.7 \times 10^{10}$ Bq                   |
| Absorbed dose                      | $D$                 | joule per kilogram               | $J\ kg^{-1}$                       | gray                      | Gy                          | rad                              | rad                          | 0.01 Gy                                   |
| Absorbed dose rate                 | $\dot{D}$           | joule per kilogram second        | $J\ kg^{-1}\ s^{-1}$               |                           | $Gy\ s^{-1}$                | rad                              | $rad\ s^{-1}$                | $0.01\ Gy\ s^{-1}$                        |
| Average energy per ion pair        | $W$                 | joule                            | J                                  |                           |                             | electronvolt                     | eV                           | $1.602 \times 10^{-19}$ J                 |
| Dose equivalent                    | $H$                 | joule per kilogram               | $J\ kg^{-1}$                       | sievert                   | Sv                          | rem                              | rem                          | 0.01 Sv                                   |
| Dose equivalent rate               | $\dot{H}$           | joule per kilogram second        | $J\ kg^{-1}\ s^{-1}$               |                           | $Sv\ s^{-1}$                | rem per second                   | $rem\ s^{-1}$                | $0.01\ Sv\ s^{-1}$                        |
| Electric current                   | $I$                 | ampere                           | A                                  |                           |                             | ampere                           | A                            | 1.0 A                                     |
| Electric potential difference      | $U, V$              | watt per ampere                  | $W\ A^{-1}$                        | volt                      | V                           | volt                             | V                            | 1.0 V                                     |
| Exposure                           | $\dot{X}$           | coulomb per kilogram             | $C\ kg^{-1}$                       |                           |                             | roentgen                         | R                            | $2.58 \times 10^{-4}$ C $kg^{-1}$         |
| Exposure rate                      | $X$                 | coulomb per kilogram second      | $C\ kg^{-1}\ s^{-1}$               |                           |                             | roentgen per second              | $R\ s^{-1}$                  | $2.58 \times 10^{-4}$ C $kg^{-1}\ s^{-1}$ |
| Fluence                            | $\phi$              | 1 per meter squared              | $m^{-2}$                           |                           |                             | 1 per centimeter squared         | $cm^{-2}$                    | $1.0 \times 10^4\ m^{-2}$                 |
| Fluence rate                       | $\Phi$              | 1 per meter squared second       | $m^{-2}\ s^{-1}$                   |                           |                             | 1 per centimeter squared second  | $cm^{-2}\ s^{-1}$            | $1.0 \times 10^4\ m^{-2}\ s^{-1}$         |
| Kerma                              | $K$                 | joule per kilogram               | $J\ kg^{-1}$                       | gray                      | Gy                          | rad                              | rad                          | 0.01 Gy                                   |
| Kerma rate                         | $\dot{K}$           | joule per kilogram second        | $J\ kg^{-1}\ s^{-1}$               |                           | $Gy\ s^{-1}$                | rad per second                   | $rad\ s^{-1}$                | $0.01\ Gy\ s^{-1}$                        |
| Lineal energy                      | $y$                 | joule per meter                  | $J\ m^{-1}$                        |                           |                             | kiloelectron volt per micrometer | $keV\ \mu m^{-1}$            | $1.602 \times 10^{-10}$ J $m^{-1}$        |
| Linear energy transfer             | $L$                 | joule per meter                  | $J\ m^{-1}$                        |                           |                             | kiloelectron volt per micrometer | $keV\ \mu m^{-1}$            | $1.602 \times 10^{-10}$ J $m^{-1}$        |
| Mass attenuation coefficient       | $\mu/\rho$          | meter squared per kilogram       | $m^2\ kg^{-1}$                     |                           |                             | centimeter squared per gram      | $cm^2\ g^{-1}$               | $0.1\ m^2\ kg^{-1}$                       |
| Mass energy transfer coefficient   | $\mu_{tr}/\rho$     | meter squared per kilogram       | $m^2\ kg^{-1}$                     |                           |                             | centimeter squared per gram      | $cm^2\ g^{-1}$               | $0.1\ m^2\ kg^{-1}$                       |
| Mass energy absorption coefficient | $\mu_{en}/\rho$     | meter squared per kilogram       | $m^2\ kg^{-1}$                     |                           |                             | centimeter squared per gram      | $cm^2\ g^{-1}$               | $0.1\ m^2\ kg^{-1}$                       |
| Mass stopping power                | $S/\rho$            | joule meter squared per kilogram | $J\ m^2\ kg^{-1}$                  |                           |                             | MeV centimeter squared per gram  | $MeV\ cm^2\ g^{-1}$          | $1.602 \times 10^{-14}$ J $m^2\ kg^{-1}$  |
| Power                              | $P$                 | joule per second                 | $J\ s^{-1}$                        | watt                      | W                           | watt                             | W                            | 1.0 W                                     |
| Pressure                           | $p$                 | newton per meter squared         | $N\ m^{-2}$                        | pascal                    | Pa                          | torr                             | torr                         | (101325/760)Pa                            |
| Radiation chemical yield           | $G$                 | mole per joule                   | $mol\ J^{-1}$                      |                           |                             | molecules per 100 electron volts | molecules (100 eV) $^{-1}$   | $1.04 \times 10^{-7}$ mol $J^{-1}$        |
| Specific energy                    | $z$                 | joule per kilogram               | $J\ kg^{-1}$                       | gray                      | Gy                          | rad                              | rad                          | 0.01 Gy                                   |

Conversion of Radioactivity Units from MBq to mCi and  $\mu\text{Ci}$ 

| MBq  | mCi  | MBq | mCi  | MBq | mCi  | MBq | mCi  | MBq | mCi  |
|------|------|-----|------|-----|------|-----|------|-----|------|
| 7000 | 189. | 700 | 18.9 | 70  | 1.89 | 7   | 189  | 0.7 | 18.9 |
| 6000 | 162. | 600 | 16.2 | 60  | 1.62 | 6   | 162  | 0.6 | 16.2 |
| 5000 | 135. | 500 | 13.5 | 50  | 1.35 | 5   | 135  | 0.5 | 13.5 |
| 4000 | 108. | 400 | 10.8 | 40  | 1.08 | 4   | 108  | 0.4 | 10.8 |
| 3000 | 81.  | 300 | 8.1  | 30  | 810  | 3   | 81   | 0.3 | 8.1  |
| 2000 | 54.  | 200 | 5.4  | 20  | 540  | 2   | 54   | 0.2 | 5.4  |
| 1000 | 27.  | 100 | 2.7  | 10  | 270  | 1   | 27   | 0.1 | 2.7  |
| 900  | 24.  | 90  | 2.4  | 9   | 240  | 0.9 | 24   |     |      |
| 800  | 21.6 | 80  | 2.16 | 8   | 220  | 0.8 | 21.6 |     |      |

Conversion of Radioactivity Units from mCi and  $\mu\text{Ci}$  to MBq

| mCi | MBq  | mCi | MBq  | mCi | MBq  | $\mu\text{Ci}$ | MBq  | $\mu\text{Ci}$ | MBq  | $\mu\text{Ci}$ | MBq   |
|-----|------|-----|------|-----|------|----------------|------|----------------|------|----------------|-------|
| 200 | 7400 | 40  | 1480 | 5   | 185  | 1000           | 37.0 | 200            | 7.4  | 30             | 1.11  |
| 150 | 5550 | 30  | 1110 | 4   | 148  | 900            | 33.3 | 100            | 3.7  | 20             | 0.74  |
| 100 | 3700 | 20  | 740  | 3   | 111  | 800            | 29.6 | 90             | 3.33 | 10             | 0.37  |
| 90  | 3330 | 10  | 370  | 2   | 74.0 | 700            | 25.9 | 80             | 2.96 | 5              | 0.185 |
| 80  | 2960 | 9   | 333  | 1   | 37.0 | 600            | 22.2 | 70             | 2.59 | 2              | 0.074 |
| 70  | 2590 | 8   | 296  |     |      | 500            | 18.5 | 60             | 2.22 | 1              | 0.037 |
| 60  | 2220 | 7   | 259  |     |      | 400            | 14.8 | 50             | 1.85 |                |       |
| 50  | 1850 | 6   | 222  |     |      | 300            | 11.1 | 40             | 1.48 |                |       |

## Conversion of Radioactivity Units

|                         |   |                                               |                         |   |                                               |
|-------------------------|---|-----------------------------------------------|-------------------------|---|-----------------------------------------------|
| 100 TBq ( $10^{14}$ Bq) | = | 2.7 kCi ( $2.7 \times 10^3$ Ci)               | 100 kBq ( $10^5$ Bq)    | = | 2.7 $\mu\text{Ci}$ ( $2.7 \times 10^{-6}$ Ci) |
| 10 TBq ( $10^{13}$ Bq)  | = | 270 Ci ( $2.7 \times 10^2$ Ci)                | 10 kBq ( $10^4$ Bq)     | = | 270 nCi ( $2.7 \times 10^{-7}$ Ci)            |
| 1 TBq ( $10^{12}$ Bq)   | = | 27 Ci ( $2.7 \times 10^1$ Ci)                 | 1 kBq ( $10^3$ Bq)      | = | 27 nCi ( $2.7 \times 10^{-8}$ Ci)             |
| 100 GBq ( $10^{11}$ Bq) | = | 2.7 Ci ( $2.7 \times 10^0$ Ci)                | 100 Bq ( $10^2$ Bq)     | = | 2.7 nCi ( $2.7 \times 10^{-9}$ Ci)            |
| 10 GBq ( $10^{10}$ Bq)  | = | 270 mCi ( $2.7 \times 10^{-1}$ Ci)            | 10 Bq ( $10^1$ Bq)      | = | 270 pCi ( $2.7 \times 10^{-10}$ Ci)           |
| 1 GBq ( $10^9$ Bq)      | = | 27 mCi ( $2.7 \times 10^{-2}$ Ci)             | 1 Bq ( $10^0$ Bq)       | = | 27 pCi ( $2.7 \times 10^{-11}$ Ci)            |
| 100 MBq ( $10^8$ Bq)    | = | 2.7 mCi ( $2.7 \times 10^{-3}$ Ci)            | 100 mBq ( $10^{-1}$ Bq) | = | 2.7 pCi ( $2.7 \times 10^{-12}$ Ci)           |
| 10 MBq ( $10^7$ Bq)     | = | 270 $\mu\text{Ci}$ ( $2.7 \times 10^{-4}$ Ci) | 10 mBq ( $10^{-2}$ Bq)  | = | 270 fCi ( $2.7 \times 10^{-13}$ Ci)           |
| 1 MBq ( $10^6$ Bq)      | = | 27 $\mu\text{Ci}$ ( $2.7 \times 10^{-5}$ Ci)  | 1 mBq ( $10^{-3}$ Bq)   | = | 27 fCi ( $2.7 \times 10^{-14}$ Ci)            |

## Conversion of Absorbed Dose Units

| SI Units                | Conventional                | SI Units                           | Conventional                           |
|-------------------------|-----------------------------|------------------------------------|----------------------------------------|
| 100 Gy ( $10^2$ Gy)     | = 10,000 rad ( $10^4$ rad)  | 100 $\mu\text{Gy}$ ( $10^{-4}$ Gy) | = 10 mrad ( $10^{-2}$ rad)             |
| 10 Gy ( $10^1$ Gy)      | = 1,000 rad ( $10^3$ rad)   | 10 $\mu\text{Gy}$ ( $10^{-5}$ Gy)  | = 1 mrad ( $10^{-3}$ rad)              |
| 1 Gy ( $10^0$ Gy)       | = 100 rad ( $10^2$ rad)     | 1 $\mu\text{Gy}$ ( $10^{-6}$ Gy)   | = 100 $\mu\text{rad}$ ( $10^{-4}$ rad) |
| 100 mGy ( $10^{-1}$ Gy) | = 10 rad ( $10^1$ rad)      | 100 nGy ( $10^{-7}$ Gy)            | = 10 $\mu\text{rad}$ ( $10^{-5}$ rad)  |
| 10 mGy ( $10^{-2}$ Gy)  | = 1 rad ( $10^0$ rad)       | 10 nGy ( $10^{-8}$ Gy)             | = 1 $\mu\text{rad}$ ( $10^{-6}$ rad)   |
| 1 mGy ( $10^{-3}$ Gy)   | = 100 mrad ( $10^{-1}$ rad) | 1 nGy ( $10^{-9}$ Gy)              | = 100 nrad ( $10^{-7}$ rad)            |

## Conversion of Dose Equivalent Units

|                         |                             |                                    |                                        |
|-------------------------|-----------------------------|------------------------------------|----------------------------------------|
| 100 Sv ( $10^2$ Sv)     | = 10,000 rem ( $10^4$ rem)  | 100 $\mu\text{Sv}$ ( $10^{-4}$ Sv) | = 10 mrem ( $10^{-2}$ rem)             |
| 10 Sv ( $10^1$ Sv)      | = 1,000 rem ( $10^3$ rem)   | 10 $\mu\text{Sv}$ ( $10^{-5}$ Sv)  | = 1 mrem ( $10^{-3}$ rem)              |
| 1 Sv ( $10^0$ Sv)       | = 100 rem ( $10^2$ rem)     | 1 $\mu\text{Sv}$ ( $10^{-6}$ Sv)   | = 100 $\mu\text{rem}$ ( $10^{-4}$ rem) |
| 100 mSv ( $10^{-1}$ Sv) | = 10 rem ( $10^1$ rem)      | 100 nSv ( $10^{-7}$ Sv)            | = 10 $\mu\text{rem}$ ( $10^{-5}$ rem)  |
| 10 mSv ( $10^{-2}$ Sv)  | = 1 rem ( $10^0$ rem)       | 10 nSv ( $10^{-8}$ Sv)             | = 1 $\mu\text{rem}$ ( $10^{-6}$ rem)   |
| 1 mSv ( $10^{-3}$ Sv)   | = 100 mrem ( $10^{-1}$ rem) | 1 nSv ( $10^{-9}$ Sv)              | = 100 nrem ( $10^{-7}$ rem)            |



## VALUES OF THE GAS CONSTANT IN DIFFERENT UNIT SYSTEMS

In SI units the value of the gas constant,  $R$ , is:

$$\begin{aligned} R &= 8.314472 \text{ Pa m}^3 \text{ K}^{-1} \text{ mol}^{-1} \\ &= 8314.472 \text{ Pa L K}^{-1} \text{ mol}^{-1} \\ &= 0.08314472 \text{ bar L K}^{-1} \text{ mol}^{-1} \end{aligned}$$

$$1 \text{ torr (mmHg)} = 133.322 \text{ Pa [at } 0^\circ \text{C]}$$

$$1 \text{ in Hg} = 3386.38 \text{ Pa [at } 0^\circ \text{C]}$$

$$1 \text{ in H}_2\text{O} = 249.082 \text{ Pa [at } 4^\circ \text{C]}$$

$$1 \text{ ft H}_2\text{O} = 2988.98 \text{ Pa [at } 4^\circ \text{C]}$$

This table gives the appropriate value of  $R$  for use in the ideal gas equation,  $PV = nRT$ , when the variables are expressed in other units. The following conversion factors for pressure units were used in generating the table:

$$1 \text{ atm} = 101325 \text{ Pa}$$

$$1 \text{ psi} = 6894.757 \text{ Pa}$$

### Reference

Mohr, P. J., Taylor, B. N., and Newell, D. B., "CODATA recommended values of the fundamental physical constants: 2006", *J. Phys. Chem. Ref. Data* 37, 1187, 2008.

| Units of $V, T, n$ |     |        | Units of $P$ |              |             |           |            |                     |                     |
|--------------------|-----|--------|--------------|--------------|-------------|-----------|------------|---------------------|---------------------|
| $V$                | $T$ | $n$    | kPa          | atm          | psi         | mmHg      | in Hg      | in H <sub>2</sub> O | ft H <sub>2</sub> O |
| ft <sup>3</sup>    | K   | mol    | 0.2936228    | 0.00289784   | 0.0425864   | 2.20236   | 0.0867070  | 1.17881             | 0.0982351           |
|                    |     | lb-mol | 133.1851     | 1.31443      | 19.3168     | 998.973   | 39.3296    | 534.704             | 44.5587             |
|                    | °R  | mol    | 0.1631238    | 0.00160990   | 0.0236591   | 1.22353   | 0.0481706  | 0.654900            | 0.0545751           |
|                    |     | lb-mol | 73.99170     | 0.730242     | 10.7316     | 554.984   | 21.8498    | 297.058             | 24.7548             |
| cm <sup>3</sup>    | K   | mol    | 8314.472     | 82.0574      | 1205.91     | 62363.8   | 2455.27    | 33380.4             | 2781.71             |
|                    |     | lb-mol | 3771381      | 37220.6      | 546993      | 282878000 | 1113690    | 15141100            | 1261760             |
|                    | °R  | mol    | 4619.151     | 45.5875      | 669.951     | 34646.5   | 1364.03    | 18544.7             | 1545.39             |
|                    |     | lb-mol | 2095211      | 20678.1      | 303885      | 15715400  | 618717     | 8411730             | 700979              |
| L                  | K   | mol    | 8.314472     | 0.0820574    | 1.20591     | 62.3638   | 2.45527    | 33.3804             | 2.78171             |
|                    |     | lb-mol | 3771.381     | 37.2206      | 546.993     | 28287.8   | 1113.69    | 15141.1             | 1261.76             |
|                    | °R  | mol    | 4.619151     | 0.0455875    | 0.669951    | 34.6465   | 1.36403    | 18.5447             | 1.54539             |
|                    |     | lb-mol | 2095.211     | 20.6781      | 303.885     | 15715.4   | 618.717    | 8411.73             | 700.979             |
| m <sup>3</sup>     | K   | mol    | 0.008314472  | 0.0000820574 | 0.00120591  | 0.0623638 | 0.00245527 | 0.0333804           | 0.00278171          |
|                    |     | lb-mol | 3.771381     | 0.0372206    | 0.546993    | 28.2878   | 1.11369    | 15.1411             | 1.26176             |
|                    | °R  | mol    | 0.004619151  | 0.0000455875 | 0.000669951 | 0.0346465 | 0.00136403 | 0.0185447           | 0.00154539          |
|                    |     | lb-mol | 2.095211     | 0.0206781    | 0.303885    | 15.7154   | 0.618717   | 8.41173             | 0.700979            |

# PERIODIC TABLE OF THE ELEMENTS

| 1<br>Group<br>IA                 | 2<br>IIA                       | New Notation<br>Previous IUPAC Form<br>CAS Version |                                  |                                  |                                |                                  |                                |                                   |                                  |                                   |                                  | 13<br>IIIB<br>IIIA               | 14<br>IVB<br>IVA                 | 15<br>VB<br>VA                    | 16<br>VIB<br>VIA               | 17<br>VIIB<br>VIIA               | 18<br>VIIIA                     | Shell  |
|----------------------------------|--------------------------------|----------------------------------------------------|----------------------------------|----------------------------------|--------------------------------|----------------------------------|--------------------------------|-----------------------------------|----------------------------------|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|-----------------------------------|--------------------------------|----------------------------------|---------------------------------|--------|
| 1<br>H<br>1.00794<br>1           |                                |                                                    |                                  |                                  |                                |                                  |                                |                                   |                                  |                                   |                                  |                                  |                                  |                                   |                                |                                  | 2<br>He<br>4.002602<br>2        | K      |
| 3<br>Li<br>6.941<br>2-1          | 4<br>Be<br>9.012182<br>2-2     |                                                    |                                  |                                  |                                |                                  |                                |                                   |                                  |                                   |                                  | 5<br>B<br>10.811<br>2-3          | 6<br>C<br>12.0107<br>2-4         | 7<br>N<br>14.0067<br>2-5          | 8<br>O<br>15.9994<br>2-6       | 9<br>F<br>18.9984032<br>2-7      | 10<br>Ne<br>20.1797<br>2-8      | K-L    |
| 11<br>Na<br>22.989770<br>2-8-1   | 12<br>Mg<br>24.3050<br>2-8-2   | 3<br>IIIA<br>IIIB                                  | 4<br>IVA<br>IVB                  | 5<br>VA<br>VB                    | 6<br>VIA<br>VIB                | 7<br>VIIA<br>VIIB                | 8<br>VIIIA<br>VIII             | 9<br>VIIIA<br>VIII                | 10<br>VIIIA<br>VIII              | 11<br>IB<br>IB                    | 12<br>IIB<br>IIB                 | 13<br>Al<br>26.981538<br>2-8-3   | 14<br>Si<br>28.0855<br>2-8-4     | 15<br>P<br>30.973761<br>2-8-5     | 16<br>S<br>32.065<br>2-8-6     | 17<br>Cl<br>35.453<br>2-8-7      | 18<br>Ar<br>39.948<br>2-8-8     | K-L-M  |
| 19<br>K<br>39.0983<br>-8-8-1     | 20<br>Ca<br>40.078<br>-8-8-2   | 21<br>Sc<br>44.955910<br>-8-9-2                    | 22<br>Ti<br>47.867<br>-8-10-2    | 23<br>V<br>50.9415<br>-8-11-2    | 24<br>Cr<br>51.9961<br>-8-13-1 | 25<br>Mn<br>54.938049<br>-8-13-2 | 26<br>Fe<br>55.845<br>-8-14-2  | 27<br>Co<br>58.933200<br>-8-15-2  | 28<br>Ni<br>58.6934<br>-8-16-2   | 29<br>Cu<br>63.546<br>-8-18-1     | 30<br>Zn<br>65.409<br>-8-18-2    | 31<br>Ga<br>69.723<br>-8-18-3    | 32<br>Ge<br>72.64<br>-8-18-4     | 33<br>As<br>74.92160<br>-8-18-5   | 34<br>Se<br>78.96<br>-8-18-6   | 35<br>Br<br>79.904<br>-8-18-7    | 36<br>Kr<br>83.798<br>-8-18-8   | -L-M-N |
| 37<br>Rb<br>85.4678<br>-18-8-1   | 38<br>Sr<br>87.62<br>-18-8-2   | 39<br>Y<br>88.90585<br>-18-9-2                     | 40<br>Zr<br>91.224<br>-18-10-2   | 41<br>Nb<br>92.90638<br>-18-12-1 | 42<br>Mo<br>95.94<br>-18-13-1  | 43<br>Tc<br>(98)<br>-18-13-2     | 44<br>Ru<br>101.07<br>-18-15-1 | 45<br>Rh<br>102.90550<br>-18-16-1 | 46<br>Pd<br>106.42<br>-18-18-0   | 47<br>Ag<br>107.8682<br>-18-18-1  | 48<br>Cd<br>112.411<br>-18-18-2  | 49<br>In<br>114.818<br>-18-18-3  | 50<br>Sn<br>118.710<br>-18-18-4  | 51<br>Sb<br>121.760<br>-18-18-5   | 52<br>Te<br>127.60<br>-18-18-6 | 53<br>I<br>126.90447<br>-18-18-7 | 54<br>Xe<br>131.293<br>-18-18-8 | -M-N-O |
| 55<br>Cs<br>132.90545<br>-18-8-1 | 56<br>Ba<br>137.327<br>-18-8-2 | 57*<br>La<br>138.9055<br>-18-9-2                   | 72<br>Hf<br>178.49<br>-32-10-2   | 73<br>Ta<br>180.9479<br>-32-11-2 | 74<br>W<br>183.84<br>-32-12-2  | 75<br>Re<br>186.207<br>-32-13-2  | 76<br>Os<br>190.23<br>-32-14-2 | 77<br>Ir<br>192.217<br>-32-15-2   | 78<br>Pt<br>195.078<br>-32-17-1  | 79<br>Au<br>196.96655<br>-32-18-1 | 80<br>Hg<br>200.59<br>-32-18-2   | 81<br>Tl<br>204.3833<br>-32-18-3 | 82<br>Pb<br>207.2<br>-32-18-4    | 83<br>Bi<br>208.98038<br>-32-18-5 | 84<br>Po<br>(209)<br>-32-18-6  | 85<br>At<br>(210)<br>-32-18-7    | 86<br>Rn<br>(222)<br>-32-18-8   | -N-O-P |
| 87<br>Fr<br>(223)<br>-18-8-1     | 88<br>Ra<br>(226)<br>-18-8-2   | 89**<br>Ac<br>(227)<br>-18-9-2                     | 104<br>Rf<br>(261)<br>-32-10-2   | 105<br>Db<br>(262)<br>-32-11-2   | 106<br>Sg<br>(266)<br>-32-12-2 | 107<br>Bh<br>(264)<br>-32-13-2   | 108<br>Hs<br>(277)<br>-32-14-2 | 109<br>Mt<br>(268)<br>-32-15-2    | 110<br>Ds<br>(271)<br>-32-16-2   | 111<br>Rg<br>(272)                | 112<br>Uub<br>(285)              |                                  | 114<br>Uuq<br>(289)              |                                   | 116<br>Uuh<br>(289)            |                                  |                                 | -O-P-Q |
| * Lanthanides                    |                                | 58<br>Ce<br>140.116<br>-19-9-2                     | 59<br>Pr<br>140.90765<br>-21-8-2 | 60<br>Nd<br>144.24<br>-22-8-2    | 61<br>Pm<br>(145)<br>-23-8-2   | 62<br>Sm<br>150.36<br>-24-8-2    | 63<br>Eu<br>151.964<br>-25-8-2 | 64<br>Gd<br>157.25<br>-25-9-2     | 65<br>Tb<br>158.92534<br>-27-8-2 | 66<br>Dy<br>162.500<br>-28-8-2    | 67<br>Ho<br>164.93032<br>-29-8-2 | 68<br>Er<br>167.259<br>-30-8-2   | 69<br>Tm<br>168.93421<br>-31-8-2 | 70<br>Yb<br>173.04<br>-32-8-2     | 71<br>Lu<br>174.967<br>-32-9-2 |                                  |                                 | -N-O-P |
| ** Actinides                     |                                | 90<br>Th<br>232.0381<br>-18-10-2                   | 91<br>Pa<br>231.03588<br>-20-9-2 | 92<br>U<br>238.02891<br>-21-9-2  | 93<br>Np<br>(237)<br>-22-9-2   | 94<br>Pu<br>(244)<br>-24-8-2     | 95<br>Am<br>(243)<br>-25-8-2   | 96<br>Cm<br>(247)<br>-25-9-2      | 97<br>Bk<br>(247)<br>-27-8-2     | 98<br>Cf<br>(251)<br>-28-8-2      | 99<br>Es<br>(252)<br>-29-8-2     | 100<br>Fm<br>(257)<br>-30-8-2    | 101<br>Md<br>(258)<br>-31-8-2    | 102<br>No<br>(259)<br>-32-8-2     | 103<br>Lr<br>(262)<br>-32-8-3  |                                  |                                 | -O-P-Q |

The new IUPAC format numbers the groups from 1 to 18. The previous IUPAC numbering system and the system used by Chemical Abstracts Service (CAS) are also shown. For radioactive elements that do not occur in nature, the mass number of the most stable isotope is given in parentheses. Elements 112, 114, and 116 have been reported but not confirmed.

## References

1. G. J. Leigh, Editor, *Nomenclature of Inorganic Chemistry*, Blackwell Scientific Publications, Oxford, 1990.
2. *Chemical and Engineering News*, 63(5), 27, 1985.
3. Atomic Weights of the Elements, 2001, *Pure & Appl. Chem.*, 75, 1107, 2003.

|  |                     |
|--|---------------------|
|  | Metallic solids     |
|  | Non-metallic solids |
|  | Liquids             |
|  | Gases               |

## UNITS FOR MAGNETIC PROPERTIES

| Quantity                                             | Symbol                                   | Gaussian & cgs emu <sup>a</sup>    | Conversion factor, C <sup>b</sup> | SI & rationalized mks <sup>c</sup>       |
|------------------------------------------------------|------------------------------------------|------------------------------------|-----------------------------------|------------------------------------------|
| Magnetic flux density, magnetic induction            | $B$                                      | gauss (G) <sup>d</sup>             | $10^{-4}$                         | tesla (T), Wb/m <sup>2</sup>             |
| Magnetic flux                                        | $\Phi$                                   | maxwell (Mx), G · cm <sup>2</sup>  | $10^{-8}$                         | weber (Wb), volt second (V · s)          |
| Magnetic potential difference, magnetomotive force   | $\mathcal{U}, F$                         | gilbert (Gb)                       | $10/4\pi$                         | ampere (A)                               |
| Magnetic field strength, magnetizing force           | $H$                                      | oersted (Oe), <sup>e</sup> Gb/cm   | $10^3/4\pi$                       | A/m <sup>f</sup>                         |
| (Volume) magnetization <sup>g</sup>                  | $M$                                      | emu/cm <sup>3</sup> <sup>h</sup>   | $10^3$                            | A/m                                      |
| (Volume) magnetization                               | $4\pi M$                                 | G                                  | $10^3/4\pi$                       | A/m                                      |
| Magnetic polarization, intensity of magnetization    | $J, I$                                   | emu/cm <sup>3</sup>                | $4\pi \times 10^{-4}$             | T, Wb/m <sup>2</sup> <sup>i</sup>        |
| (Mass) magnetization                                 | $\sigma, M$                              | emu/g                              | 1                                 | A·m <sup>2</sup> /kg                     |
|                                                      |                                          |                                    | $4\pi \times 10^{-7}$             | Wb·m/kg                                  |
| Magnetic moment                                      | $m$                                      | emu, erg/G                         | $10^{-3}$                         | A·m <sup>2</sup> , joule per tesla (J/T) |
| Magnetic dipole moment                               | $j$                                      | emu, erg/G                         | $4\pi \times 10^{-10}$            | Wb·m <sup>i</sup>                        |
| (Volume) susceptibility                              | $\chi, \kappa$                           | dimensionless, emu/cm <sup>3</sup> | $4\pi$                            | dimensionless                            |
|                                                      |                                          |                                    | $(4\pi)^2 \times 10^{-7}$         | henry per meter (H/m), Wb/(A·m)          |
| (Mass) susceptibility                                | $\chi_p, \kappa_p$                       | cm <sup>3</sup> /g, emu/g          | $4\pi \times 10^{-3}$             | m <sup>3</sup> /kg                       |
|                                                      |                                          |                                    | $(4\pi)^2 \times 10^{-10}$        | H·m <sup>2</sup> /kg                     |
| (Molar) susceptibility                               | $\chi_{\text{mol}}, \kappa_{\text{mol}}$ | cm <sup>3</sup> /mol, emu/mol      | $4\pi \times 10^{-6}$             | m <sup>3</sup> /mol                      |
|                                                      |                                          |                                    | $(4\pi)^2 \times 10^{-13}$        | H·m <sup>2</sup> /mol                    |
| Permeability                                         | $\mu$                                    | dimensionless                      | $4\pi \times 10^{-7}$             | H/m, Wb/(A·m)                            |
| Relative permeability <sup>j</sup>                   | $\mu_r$                                  | not defined                        |                                   | dimensionless                            |
| (Volume) energy density, energy product <sup>k</sup> | $W$                                      | erg/cm <sup>3</sup>                | $10^{-1}$                         | J/m <sup>3</sup>                         |
| Demagnetization factor                               | $D, N$                                   | dimensionless                      | $1/4\pi$                          | dimensionless                            |

<sup>a</sup>. Gaussian units and cgs emu are the same for magnetic properties. The defining relation is  $B = H + 4\pi M$ .

<sup>b</sup>. Multiply a number in Gaussian units by C to convert it to SI (e.g.,  $1 \text{ G} \times 10^{-4} \text{ T/G} = 10^{-4} \text{ T}$ ).

<sup>c</sup>. SI (*Système International d'Unités*) has been adopted by the National Bureau of Standards. Where two conversion factors are given, the upper one is recognized under, or consistent with, SI and is based on the definition  $B = \mu_0(H + M)$ , where  $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$ . The lower one is not recognized under SI and is based on the definition  $B = \mu_0 H + J$ , where the symbol  $I$  is often used in place of  $J$ .

<sup>d</sup>. 1 gauss =  $10^5$  gamma ( $\gamma$ ).

<sup>e</sup>. Both oersted and gauss are expressed as  $\text{cm}^{-1/2} \cdot \text{g}^{1/2} \cdot \text{s}^{-1}$  in terms of base units.

<sup>f</sup>. A/m was often expressed as "ampere-turn per meter" when used for magnetic field strength.

<sup>g</sup>. Magnetic moment per unit volume.

<sup>h</sup>. The designation "emu" is not a unit.

<sup>i</sup>. Recognized under SI, even though based on the definition  $B = \mu_0 H + J$ . See footnote c.

<sup>j</sup>.  $\mu_r = \mu/\mu_0 = 1 + \chi_r$ , all in SI.  $\mu_r$  is equal to Gaussian  $\mu$ .

<sup>k</sup>.  $B \cdot H$  and  $\mu_0 M \cdot H$  have SI units J/m<sup>3</sup>;  $M \cdot H$  and  $B \cdot H/4\pi$  have Gaussian units erg/cm<sup>3</sup>.

R. B. Goldfarb and F. R. Fickett, U.S. Department of Commerce, National Bureau of Standards, Boulder, Colorado 80303, March 1985, NBS Special Publication 696. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

# SYMBOLS AND TERMINOLOGY FOR PHYSICAL AND CHEMICAL QUANTITIES

The International Organization for Standardization (ISO), International Union of Pure and Applied Chemistry (IUPAC), and the International Union of Pure and Applied Physics (IUPAP) have jointly developed a set of recommended symbols for physical and chemical quantities. Consistent use of these recommended symbols helps assure unambiguous scientific communication. The list below is reprinted from Reference 1 with permission from IUPAC. Full details may be found in the following references:

1. Ian Mills, Ed., *Quantities, Units, and Symbols in Physical Chemistry*, Blackwell Scientific Publications, Oxford, 1988.
2. E. R. Cohen and P. Giacomo, *Symbols, Units, Nomenclature, and Fundamental Constants in Physics*, Document IUPAP-25, 1987; also published in *Physica* 146A, 1-68, 1987.
3. *ISO Standards Handbook 2: Units of Measurement*, International Organization of Standardization, Geneva, 1982.

The symbol for a physical quantity is always given in italic (sloping) type, while symbols for units are given in roman type. Column headings in tables and axis labels on graphs may conveniently be written as the physical quantity symbol divided by the unit symbol, e.g.:

$$\begin{aligned} T/K \\ V/\text{cm}^3 \\ C_p/J \text{ mol}^{-1} \text{ K}^{-1} \end{aligned}$$

The values in the table or graph axis are then pure numbers. Subscripts to symbols for physical quantities should be italic if the subscript refers to another physical quantity or to a number, e.g.:

$$\begin{aligned} C_p - \text{heat capacity at constant pressure} \\ B_n - \text{nth virial coefficient} \end{aligned}$$

Subscripts that have other meanings should be in roman type:

$$\begin{aligned} m_p - \text{mass of the proton} \\ E_k - \text{kinetic energy} \end{aligned}$$

## GENERAL RULES

The value of a physical quantity is expressed as the product of a numerical value and a unit, e.g.:

$$\begin{aligned} T &= 300 \text{ K} \\ V &= 26.2 \text{ cm}^3 \\ C_p &= 45.3 \text{ J mol}^{-1} \text{ K}^{-1} \end{aligned}$$

The following tables give the recommended symbols for the major classes of physical and chemical quantities. The expression in the Definition column is given as an aid in identifying the quantity but is not necessarily the complete or unique definition. The SI Unit gives one (not necessarily unique) expression for the coherent SI unit for the quantity. Other equivalent unit expressions, including those that involve SI prefixes, may be used.

| Name                                                         | Symbol                                       | Definition           | SI unit                               |
|--------------------------------------------------------------|----------------------------------------------|----------------------|---------------------------------------|
| <b>Space and Time</b>                                        |                                              |                      |                                       |
| cartesian space coordinates                                  | $x, y, z$                                    |                      | m                                     |
| spherical polar coordinates                                  | $r, \theta, \phi$                            |                      | m, 1, 1                               |
| generalized coordinate                                       | $q, q_i$                                     |                      | (varies)                              |
| position vector                                              | $r$                                          | $r = xi + yj + zk$   | m                                     |
| length                                                       | $l$                                          |                      | m                                     |
| special symbols:                                             |                                              |                      |                                       |
| height                                                       | $h$                                          |                      |                                       |
| breadth                                                      | $b$                                          |                      |                                       |
| thickness                                                    | $d, \delta$                                  |                      |                                       |
| distance                                                     | $d$                                          |                      |                                       |
| radius                                                       | $r$                                          |                      |                                       |
| diameter                                                     | $d$                                          |                      |                                       |
| path length                                                  | $s$                                          |                      |                                       |
| length of arc                                                | $s$                                          |                      |                                       |
| area                                                         | $A, A_x, S$                                  |                      | m <sup>2</sup>                        |
| volume                                                       | $V, (v)$                                     |                      | m <sup>3</sup>                        |
| plane angle                                                  | $\alpha, \beta, \gamma, \theta, \phi, \dots$ | $\alpha = s/r$       | rad, 1                                |
| solid angle                                                  | $\omega, \Omega$                             | $\omega = A/r^2$     | sr, 1                                 |
| time                                                         | $t$                                          |                      | s                                     |
| period                                                       | $T$                                          | $T = t/N$            | s                                     |
| frequency                                                    | $\nu, f$                                     | $\nu = 1/T$          | Hz                                    |
| circular frequency, angular frequency                        | $\omega$                                     | $\omega = 2\pi\nu$   | rad s <sup>-1</sup> , s <sup>-1</sup> |
| characteristic time interval, relaxation time, time constant | $\tau, T$                                    | $\tau =  dt/d\ln x $ | s                                     |
| angular velocity                                             | $\omega$                                     | $\omega = d\phi/dt$  | rad s <sup>-1</sup> , s <sup>-1</sup> |
| velocity                                                     | $v, u, w, c, \dot{r}$                        | $v = dr/dt$          | m s <sup>-1</sup>                     |

| Name                                               | Symbol                     | Definition                                                | SI unit                               |
|----------------------------------------------------|----------------------------|-----------------------------------------------------------|---------------------------------------|
| speed                                              | $v, u, w, c$               | $v =  v $                                                 | $\text{m s}^{-1}$                     |
| acceleration                                       | $\mathbf{a}, (g)$          | $\mathbf{a} = \text{d}\mathbf{v}/\text{d}t$               | $\text{m s}^{-2}$                     |
| <b>Classical Mechanics</b>                         |                            |                                                           |                                       |
| mass                                               | $m$                        |                                                           | kg                                    |
| reduced mass                                       | $\mu$                      | $\mu = m_1 m_2 / (m_1 + m_2)$                             | kg                                    |
| density, mass density                              | $\rho$                     | $\rho = m/V$                                              | $\text{kg m}^{-3}$                    |
| relative density                                   | $d$                        | $d = \rho/\rho$                                           | 1                                     |
| surface density                                    | $\rho_A, \rho_S$           | $\rho_A = m/A$                                            | $\text{kg m}^{-2}$                    |
| specific volume                                    | $v$                        | $v = V/m = 1/\rho$                                        | $\text{m}^3 \text{kg}^{-1}$           |
| momentum                                           | $\mathbf{p}$               | $\mathbf{p} = m\mathbf{v}$                                | $\text{kg m s}^{-1}$                  |
| angular momentum, action                           | $\mathbf{L}$               | $\mathbf{L} = \mathbf{r} \times \mathbf{p}$               | J s                                   |
| moment of inertia                                  | $I, J$                     | $I = \sum m_i r_i^2$                                      | $\text{kg m}^2$                       |
| force                                              | $\mathbf{F}$               | $\mathbf{F} = \text{d}\mathbf{p}/\text{d}t = m\mathbf{a}$ | N                                     |
| torque, moment of a force                          | $\mathbf{T}, (M)$          | $\mathbf{T} = \mathbf{r} \times \mathbf{F}$               | N m                                   |
| energy                                             | $E$                        |                                                           | J                                     |
| potential energy                                   | $E_p, V, \Phi$             | $E_p = \int \mathbf{F} \cdot d\mathbf{s}$                 | J                                     |
| kinetic energy                                     | $E_k, T, K$                | $E_k = 1/2 mv^2$                                          | J                                     |
| work                                               | $W, w$                     | $W = \int \mathbf{F} \cdot d\mathbf{s}$                   | J                                     |
| Hamilton function                                  | $H$                        | $H(q, p) = T(q, p) + V(q)$                                | J                                     |
| Lagrange function                                  | $L$                        | $L(q, \dot{q}) = T(q, \dot{q}) - V(q)$                    | J                                     |
| pressure                                           | $p, P$                     | $p = F/A$                                                 | Pa, $\text{N m}^{-2}$                 |
| surface tension                                    | $\gamma, \sigma$           | $\gamma = \text{d}W/\text{d}A$                            | $\text{N m}^{-1}$ , $\text{J m}^{-2}$ |
| weight                                             | $G, (W, P)$                | $G = mg$                                                  | N                                     |
| gravitational constant                             | $G$                        | $F = Gm_1 m_2 / r^2$                                      | $\text{N m}^2 \text{kg}^{-2}$         |
| normal stress                                      | $\sigma$                   | $\sigma = F/A$                                            | Pa                                    |
| shear stress                                       | $\tau$                     | $\tau = F/A$                                              | Pa                                    |
| linear strain, relative elongation                 | $\varepsilon, e$           | $\varepsilon = \Delta l/l$                                | 1                                     |
| modulus of elasticity, Young's modulus             | $E$                        | $E = \sigma/\varepsilon$                                  | Pa                                    |
| shear strain                                       | $\gamma$                   | $\gamma = \Delta x/d$                                     | 1                                     |
| shear modulus                                      | $G$                        | $G = \tau/\gamma$                                         | Pa                                    |
| volume strain, bulk strain                         | $\theta$                   | $\theta = \Delta V/V_0$                                   | 1                                     |
| bulk modulus, compression modulus                  | $K$                        | $K = -V_0 (\text{d}p/\text{d}V)$                          | Pa                                    |
| viscosity, dynamic viscosity                       | $\eta, \mu$                | $\tau_{xz} = \eta (\text{d}v_x/\text{d}z)$                | Pa s                                  |
| fluidity                                           | $\phi$                     | $\phi = 1/\eta$                                           | $\text{m kg}^{-1} \text{s}$           |
| kinematic viscosity                                | $\nu$                      | $\nu = \eta/\rho$                                         | $\text{m}^2 \text{s}^{-1}$            |
| friction coefficient                               | $\mu, (f)$                 | $F_{\text{frict}} = \mu F_{\text{norm}}$                  | 1                                     |
| power                                              | $P$                        | $P = \text{d}W/\text{d}t$                                 | W                                     |
| sound energy flux                                  | $P, P_a$                   | $P = \text{d}E/\text{d}t$                                 | W                                     |
| <b>Acoustic factors</b>                            |                            |                                                           |                                       |
| reflection factor                                  | $\rho$                     | $\rho = P_r/P_0$                                          | 1                                     |
| acoustic absorption factor                         | $\alpha_a, (\alpha)$       | $\alpha_a = 1 - \rho$                                     | 1                                     |
| transmission factor                                | $\tau$                     | $\tau = P_t/P_0$                                          | 1                                     |
| dissipation factor                                 | $\delta$                   | $\delta = \alpha_a - \tau$                                | 1                                     |
| <b>Electricity and Magnetism</b>                   |                            |                                                           |                                       |
| quantity of electricity, electric charge           | $Q$                        |                                                           | C                                     |
| charge density                                     | $\rho$                     | $\rho = Q/V$                                              | $\text{C m}^{-3}$                     |
| surface charge density                             | $\sigma$                   | $\sigma = Q/A$                                            | $\text{C m}^{-2}$                     |
| electric potential                                 | $V, \phi$                  | $V = \text{d}W/\text{d}Q$                                 | V, $\text{J C}^{-1}$                  |
| electric potential difference                      | $U, \Delta V, \Delta \phi$ | $U = V_2 - V_1$                                           | V                                     |
| electromotive force                                | $E$                        | $E = \int (\mathbf{F}/Q) \cdot d\mathbf{s}$               | V                                     |
| electric field strength                            | $\mathbf{E}$               | $\mathbf{E} = \mathbf{F}/Q = -\text{grad } V$             | $\text{V m}^{-1}$                     |
| electric flux                                      | $\Psi$                     | $\Psi = \int \mathbf{D} \cdot d\mathbf{A}$                | C                                     |
| electric displacement                              | $\mathbf{D}$               | $\mathbf{D} = \varepsilon \mathbf{E}$                     | $\text{C m}^{-2}$                     |
| capacitance                                        | $C$                        | $C = Q/U$                                                 | F, $\text{C V}^{-1}$                  |
| permittivity                                       | $\varepsilon$              | $\mathbf{D} = \varepsilon \mathbf{E}$                     | $\text{F m}^{-1}$                     |
| permittivity of vacuum                             | $\varepsilon_0$            | $\varepsilon_0 = \mu_0^{-1} c_0^{-2}$                     | $\text{F m}^{-1}$                     |
| relative permittivity                              | $\varepsilon_r$            | $\varepsilon_r = \varepsilon/\varepsilon_0$               | 1                                     |
| dielectric polarization (dipole moment per volume) | $\mathbf{P}$               | $\mathbf{P} = \mathbf{D} - \varepsilon_0 \mathbf{E}$      | $\text{C m}^{-2}$                     |
| electric susceptibility                            | $\chi_e$                   | $\chi_e = \varepsilon_r - 1$                              | 1                                     |
| electric dipole moment                             | $\mathbf{p}, \mu$          | $\mathbf{p} = Q\mathbf{r}$                                | C m                                   |

| Name                                              | Symbol                                     | Definition                                               | SI unit                               |
|---------------------------------------------------|--------------------------------------------|----------------------------------------------------------|---------------------------------------|
| electric current                                  | $I$                                        | $I = dQ/dt$                                              | A                                     |
| electric current density                          | $j, J$                                     | $I = \int j \cdot dA$                                    | A m <sup>-2</sup>                     |
| magnetic flux density, magnetic induction         | $B$                                        | $F = Qv \times B$                                        | T                                     |
| magnetic flux                                     | $\Phi$                                     | $\Phi = \int B \cdot dA$                                 | A m <sup>-2</sup>                     |
| magnetic field strength                           | $H$                                        | $B = \mu H$                                              | A m <sup>-2</sup>                     |
| permeability                                      | $\mu$                                      | $B = \mu H$                                              | N A <sup>-2</sup> , H m <sup>-1</sup> |
| permeability of vacuum                            | $\mu_0$                                    |                                                          | H m <sup>-1</sup>                     |
| relative permeability                             | $\mu_r$                                    | $\mu_r = \mu/\mu_0$                                      | 1                                     |
| magnetization (magnetic dipole moment per volume) | $M$                                        | $M = B/\mu_0 - H$                                        | A m <sup>-1</sup>                     |
| magnetic susceptibility                           | $\chi, \kappa, (\chi_m)$                   | $\chi = \mu_r - 1$                                       | 1                                     |
| molar magnetic susceptibility                     | $\chi_m$                                   | $\chi_m = V_m \chi$                                      | m <sup>3</sup> mol <sup>-1</sup>      |
| magnetic dipole moment                            | $m, \mu$                                   | $E_p = -m \cdot B$                                       | A m <sup>2</sup> , J T <sup>-1</sup>  |
| electrical resistance                             | $R$                                        | $R = U/I$                                                | $\Omega$                              |
| conductance                                       | $G$                                        | $G = 1/R$                                                | S                                     |
| loss angle                                        | $\delta$                                   | $\delta = (\pi/2) + \phi_i - \phi_u$                     | 1, rad                                |
| reactance                                         | $X$                                        | $X = (U/I) \sin \delta$                                  | $\Omega$                              |
| impedance (complex impedance)                     | $Z$                                        | $Z = R + iX$                                             | $\Omega$                              |
| admittance (complex admittance)                   | $Y$                                        | $Y = 1/Z$                                                | S                                     |
| susceptance                                       | $B$                                        | $Y = G + iB$                                             | S                                     |
| resistivity                                       | $\rho$                                     | $\rho = E/j$                                             | $\Omega$ m                            |
| conductivity                                      | $\kappa, \gamma, \sigma$                   | $\kappa = 1/\rho$                                        | S m <sup>-1</sup>                     |
| self-inductance                                   | $L$                                        | $E = -L(dI/dt)$                                          | H                                     |
| mutual inductance                                 | $M, L_{12}$                                | $E_1 = L_{12}(dI_2/dt)$                                  | H                                     |
| magnetic vector potential                         | $A$                                        | $B = \nabla \times A$                                    | Wb m <sup>-1</sup>                    |
| Poynting vector                                   | $S$                                        | $S = E \times H$                                         | W m <sup>-2</sup>                     |
| <b>Quantum Mechanics</b>                          |                                            |                                                          |                                       |
| momentum operator                                 | $\hat{p}$                                  | $\hat{p} = -i\hbar\nabla$                                | m <sup>-1</sup> J s                   |
| kinetic energy operator                           | $\hat{T}$                                  | $\hat{T} = -(\hbar^2/2m)\nabla^2$                        | J                                     |
| Hamiltonian operator                              | $\hat{H}$                                  | $\hat{H} = \hat{T} + V$                                  | J                                     |
| wavefunction, state function                      | $\Psi, \psi, \phi$                         | $\hat{H}\psi = E\psi$                                    | (m <sup>-3/2</sup> )                  |
| probability density                               | $P$                                        | $P = \psi^*\psi$                                         | (m <sup>-3</sup> )                    |
| charge density of electrons                       | $\rho$                                     | $\rho = -eP$                                             | (C m <sup>-3</sup> )                  |
| probability current density                       | $S$                                        | $S = -i\hbar(\psi^*\nabla\psi - \psi\nabla\psi^*)/2m_e$  | (m <sup>-2</sup> s <sup>-1</sup> )    |
| electric current density of electrons             | $j$                                        | $j = -eS$                                                | (A m <sup>-2</sup> )                  |
| matrix element of operator $\hat{A}$              | $A_{ij} \langle i \hat{A} j \rangle$       | $A_{ij} = \int \psi_i^* \hat{A} \psi_j d\tau$            | (varies)                              |
| expectation value of operator $\hat{A}$           | $\langle A \rangle, \bar{A}$               | $\langle A \rangle = \int \psi^* \hat{A} \psi d\tau$     | (varies)                              |
| hermitian conjugate of $\hat{A}$                  | $\hat{A}^\dagger$                          | $(\hat{A}^\dagger)_{ij} = (A_{ji})^*$                    | (varies)                              |
| commutator of $\hat{A}$ and $\hat{B}$             | $[\hat{A}, \hat{B}], [\hat{A}, \hat{B}]_-$ | $[\hat{A}, \hat{B}] = \hat{A}\hat{B} - \hat{B}\hat{A}$   | (varies)                              |
| anticommutator                                    | $[\hat{A}, \hat{B}]_+$                     | $[\hat{A}, \hat{B}]_+ = \hat{A}\hat{B} + \hat{B}\hat{A}$ | (varies)                              |
| spin wavefunction                                 | $\alpha; \beta$                            |                                                          | 1                                     |
| coulomb integral                                  | $H_{AA}$                                   | $H_{AA} = \int \psi_A^* \hat{H} \psi_A d\tau$            | J                                     |
| resonance integral                                | $H_{AB}$                                   | $H_{AB} = \int \psi_A^* \hat{H} \psi_B d\tau$            | J                                     |
| overlap integral                                  | $S_{AB}$                                   | $S_{AB} = \int \psi_A^* \psi_B d\tau$                    | 1                                     |
| <b>Atoms and Molecules</b>                        |                                            |                                                          |                                       |
| nucleon number, mass number                       | $A$                                        |                                                          | 1                                     |
| proton number, atomic number                      | $Z$                                        |                                                          | 1                                     |
| neutron number                                    | $N$                                        | $N = A - Z$                                              | 1                                     |
| electron rest mass                                | $m_e$                                      |                                                          | kg                                    |
| mass of atom, atomic mass                         | $m_a, m$                                   |                                                          | kg                                    |
| atomic mass constant                              | $m_u$                                      | $m_u = m_a(^{12}\text{C})/12$                            | kg                                    |
| mass excess                                       | $\Delta$                                   | $\Delta = m_a - Am_u$                                    | kg                                    |
| elementary charge, proton charge                  | $e$                                        |                                                          | C                                     |
| Planck constant                                   | $h$                                        |                                                          | J s                                   |
| Planck constant/2 $\pi$                           | $\hbar$                                    | $\hbar = h/2\pi$                                         | J s                                   |
| Bohr radius                                       | $a_0$                                      | $a_0 = 4\pi\epsilon_0 \hbar^2 / m_e e^2$                 | m                                     |
| Hartree energy                                    | $E_h$                                      | $E_h = \hbar^2 / m_e a_0^2$                              | J                                     |
| Rydberg constant                                  | $R_\infty$                                 | $R_\infty = E_h / 2\hbar c$                              | m <sup>-1</sup>                       |
| fine structure constant                           | $\alpha$                                   | $\alpha = e^2 / 4\pi\epsilon_0 \hbar c$                  | 1                                     |

| Name                                                  | Symbol                                                | Definition                                                                   | SI unit                          |
|-------------------------------------------------------|-------------------------------------------------------|------------------------------------------------------------------------------|----------------------------------|
| ionization energy                                     | $E_i$                                                 |                                                                              | J                                |
| electron affinity                                     | $E_{\text{ea}}$                                       |                                                                              | J                                |
| dissociation energy                                   | $E_d, D$                                              |                                                                              | J                                |
| from the ground state                                 | $D_0$                                                 |                                                                              | J                                |
| from the potential minimum                            | $D_e$                                                 |                                                                              | J                                |
| principal quantum number (H atom)                     | $n$                                                   | $E = -hcR/n^2$                                                               | 1                                |
| angular momentum quantum numbers                      | see under Spectroscopy                                |                                                                              |                                  |
| magnetic dipole moment of a molecule                  | $\mathbf{m}, \boldsymbol{\mu}$                        | $E_p = -\mathbf{m} \cdot \mathbf{B}$                                         | J T <sup>-1</sup>                |
| magnetizability of a molecule                         | $\xi$                                                 | $\mathbf{m} = \xi \mathbf{B}$                                                | J T <sup>-2</sup>                |
| Bohr magneton                                         | $\mu_B$                                               | $\mu_B = e\hbar/2m_e$                                                        | J T <sup>-1</sup>                |
| nuclear magneton                                      | $\mu_N$                                               | $\mu_N = (m_e/m_p)\mu_B$                                                     | J T <sup>-1</sup>                |
| magnetogyric ratio (gyromagnetic ratio)               | $\gamma$                                              | $\gamma = \mu/L$                                                             | C kg <sup>-1</sup>               |
| <i>g</i> factor                                       | $g$                                                   |                                                                              | 1                                |
| Larmor circular frequency                             | $\omega_L$                                            | $\omega_L = (e/2m)B$                                                         | s <sup>-1</sup>                  |
| Larmor frequency                                      | $\nu_L$                                               | $\nu_L = \omega_L/2\pi$                                                      | Hz                               |
| longitudinal relaxation time                          | $T_1$                                                 |                                                                              | s                                |
| transverse relaxation time                            | $T_2$                                                 |                                                                              | s                                |
| electric dipole moment of a molecule                  | $\mathbf{p}, \boldsymbol{\mu}$                        | $E_p = -\mathbf{p} \cdot \mathbf{E}$                                         | C m                              |
| quadrupole moment of a molecule                       | $\mathbf{Q}; \boldsymbol{\Theta}$                     | $E_p = 1/2\mathbf{Q} : \mathbf{V}'' = 1/3\boldsymbol{\Theta} : \mathbf{V}''$ | C m <sup>2</sup>                 |
| quadrupole moment of a nucleus                        | $eQ$                                                  | $eQ = 2 \cdot \langle \Theta_{zz} \rangle$                                   | C m <sup>2</sup>                 |
| electric field gradient tensor                        | $\mathbf{q}$                                          | $q_{\alpha\beta} = -\partial^2 V / \partial \alpha \partial \beta$           | V m <sup>-2</sup>                |
| quadrupole interaction energy tensor                  | $\chi$                                                | $\chi_{\alpha\beta} = eQq_{\alpha\beta}$                                     | J                                |
| electric polarizability of a molecule                 | $\alpha$                                              | $p$ (induced) = $\alpha E$                                                   | C m <sup>2</sup> V <sup>-1</sup> |
| activity (of a radioactive substance)                 | $A$                                                   | $A = -dN_B/dt$                                                               | Bq                               |
| decay (rate) constant, disintegration (rate) constant | $\lambda$                                             | $A = \gamma N_B$                                                             | s <sup>-1</sup>                  |
| half life                                             | $t_{1/2}, T_{1/2}$                                    |                                                                              | s                                |
| mean life                                             | $\tau$                                                |                                                                              | s                                |
| level width                                           | $\Gamma$                                              | $\Gamma = \hbar/\tau$                                                        | J                                |
| disintegration energy                                 | $Q$                                                   |                                                                              | J                                |
| cross section (of a nuclear reaction)                 | $\sigma$                                              |                                                                              | m <sup>2</sup>                   |
| <b>Spectroscopy</b>                                   |                                                       |                                                                              |                                  |
| total term                                            | $T$                                                   | $T = E_{\text{tot}}/hc$                                                      | m <sup>-1</sup>                  |
| transition wavenumber                                 | $\tilde{\nu}, (\nu)$                                  | $\tilde{\nu} = T' - T''$                                                     | m <sup>-1</sup>                  |
| transition frequency                                  | $\nu$                                                 | $\nu = (E' - E'')/h$                                                         | Hz                               |
| electronic term                                       | $T_e$                                                 | $T_e = E_e/hc$                                                               | m <sup>-1</sup>                  |
| vibrational term                                      | $G$                                                   | $G = E_{\text{vib}}/hc$                                                      | m <sup>-1</sup>                  |
| rotational term                                       | $F$                                                   | $F = E_{\text{rot}}/hc$                                                      | m <sup>-1</sup>                  |
| spin orbit coupling constant                          | $A$                                                   | $T_{\text{s.o.}} = A(\hat{\mathbf{L}} \cdot \hat{\mathbf{S}})$               | m <sup>-1</sup>                  |
| principal moments of inertia                          | $I_A; I_B; I_C$                                       | $I_A \leq I_B \leq I_C$                                                      | kg m <sup>2</sup>                |
| rotational constants,                                 |                                                       |                                                                              |                                  |
| in wavenumber                                         | $\tilde{A}; \tilde{B}; \tilde{C}$                     | $\tilde{A} = h/8\pi^2 c I_A$                                                 | m <sup>-1</sup>                  |
| in frequency                                          | $A; B; C$                                             | $A = h/8\pi^2 I_A$                                                           | Hz                               |
| inertial defect                                       | $\Delta$                                              | $\Delta = I_C - I_A - I_B$                                                   | kg m <sup>2</sup>                |
| asymmetry parameter                                   | $\kappa$                                              | $\kappa = \frac{(2B - A - C)}{(A - C)}$                                      | 1                                |
| centrifugal distortion constants,                     |                                                       |                                                                              |                                  |
| S reduction                                           | $D_J; D_{JK}; D_K; d_1; d_2$                          |                                                                              | m <sup>-1</sup>                  |
| A reduction                                           | $\Delta_J; \Delta_{JK}; \Delta_K; \delta_J; \delta_K$ |                                                                              | m <sup>-1</sup>                  |
| harmonic vibration wavenumber                         | $\omega_e; \omega_r$                                  |                                                                              | m <sup>-1</sup>                  |
| vibrational anharmonicity constant                    | $\omega_e x_e; x_{rs}; g_u$                           |                                                                              | m <sup>-1</sup>                  |
| vibrational quantum numbers                           | $v_r; l_t$                                            |                                                                              | 1                                |
| Coriolis zeta constant                                | $\zeta_{rs}^a$                                        |                                                                              | 1                                |
| angular momentum quantum numbers                      | see additional information below                      |                                                                              |                                  |
| degeneracy, statistical weight                        | $g, d, \beta$                                         |                                                                              | 1                                |
| electric dipole moment of a molecule                  | $\mathbf{p}, \boldsymbol{\mu}$                        | $E_p = -\mathbf{p} \cdot \mathbf{E}$                                         | C m                              |
| transition dipole moment of a molecule                | $\mathbf{M}, \mathbf{R}$                              | $\mathbf{M} = \int \psi' \mathbf{p} \psi'' d\tau$                            | C m                              |
| molecular geometry, interatomic distances,            |                                                       |                                                                              |                                  |
| equilibrium distance                                  | $r_e$                                                 |                                                                              | m                                |
| zero-point average distance                           | $r_z$                                                 |                                                                              | m                                |

| Name                                                                    | Symbol                            | Definition                                                     | SI unit             |
|-------------------------------------------------------------------------|-----------------------------------|----------------------------------------------------------------|---------------------|
| ground state distance                                                   | $r_0$                             |                                                                | m                   |
| substitution structure distance                                         | $r_s$                             |                                                                | m                   |
| vibrational coordinates,                                                |                                   |                                                                |                     |
| internal coordinates                                                    | $R_i, r_i, \theta_j, \text{etc.}$ |                                                                | (varies)            |
| symmetry coordinates                                                    | $S_i$                             |                                                                | (varies)            |
| normal coordinates                                                      |                                   |                                                                |                     |
| mass adjusted                                                           | $Q_r$                             |                                                                | kg <sup>1/2</sup> m |
| dimensionless                                                           | $q_r$                             |                                                                | 1                   |
| vibrational force constants,                                            |                                   |                                                                |                     |
| diatomic                                                                | $f, (k)$                          | $f = \partial^2 V / \partial r^2$                              | J m <sup>-2</sup>   |
| polyatomic,                                                             |                                   |                                                                |                     |
| internal coordinates                                                    | $f_{ij}$                          | $f_{ij} = \partial^2 V / \partial r_i \partial r_j$            | (varies)            |
| symmetry coordinates                                                    | $F_{ij}$                          | $F_{ij} = \partial^2 V / \partial S_i \partial S_j$            | (varies)            |
| dimensionless normal coordinates                                        | $\phi_{rst...}, k_{rst...}$       |                                                                | m <sup>-1</sup>     |
| nuclear magnetic resonance (NMR),                                       |                                   |                                                                |                     |
| magnetogyric ratio                                                      | $\gamma$                          | $\gamma = \mu / I \hbar$                                       | C kg <sup>-1</sup>  |
| shielding constant                                                      | $\sigma_A$                        | $B_A = (1 - \sigma_A) B$                                       | 1                   |
| chemical shift, $\delta$ scale                                          | $\delta$                          | $\delta = 10^6 (\nu - \nu_0) / \nu_0$                          | 1                   |
| (indirect) spin–spin coupling constant                                  | $J_{AB}$                          | $\hat{H} / \hbar = J_{AB} \hat{I}_A \cdot \hat{I}_B$           | Hz                  |
| direct (dipolar) coupling constant                                      | $D_{AB}$                          |                                                                | Hz                  |
| longitudinal relaxation time                                            | $T_1$                             |                                                                | s                   |
| transverse relaxation time                                              | $T_2$                             |                                                                | s                   |
| electron spin resonance, electron<br>paramagnetic resonance (ESR, EPR), |                                   |                                                                |                     |
| magnetogyric ratio                                                      | $\gamma$                          | $\gamma = \mu / s \hbar$                                       | C kg <sup>-1</sup>  |
| g factor                                                                | $g$                               | $h \nu = g \mu_B B$                                            | 1                   |
| hyperfine coupling constant,                                            |                                   |                                                                |                     |
| in liquids                                                              | $a, A$                            | $\hat{H}_{\text{hfs}} / \hbar = a \hat{S} \cdot \hat{I}$       | Hz                  |
| in solids                                                               | $T$                               | $\hat{H}_{\text{hfs}} / \hbar = \hat{S} \cdot T \cdot \hat{I}$ | Hz                  |

| Angular momentum             | Operator symbol     | Quantum number symbol |        |                             |
|------------------------------|---------------------|-----------------------|--------|-----------------------------|
|                              |                     | Total                 | Z-axis | z-axis                      |
| electron orbital             | $\hat{L}$           | $L$                   | $M_L$  | $\Lambda$                   |
| one electron only            | $\hat{l}$           | $l$                   | $m_l$  | $\lambda$                   |
| electron spin                | $\hat{S}$           | $S$                   | $M_S$  | $\Sigma$                    |
| one electron only            | $\hat{s}$           | $s$                   | $m_s$  | $\sigma$                    |
| electron orbital + spin      | $\hat{L} + \hat{S}$ |                       |        | $\Omega = \Lambda + \Sigma$ |
| nuclear orbital (rotational) | $\hat{R}$           | $R$                   |        | $K_R, k_R$                  |
| nuclear spin                 | $\hat{I}$           | $I$                   | $M_I$  |                             |
| internal vibrational         |                     |                       |        |                             |
| spherical top                | $\hat{l}$           | $l(l\zeta)$           |        | $K_l$                       |
| other                        | $j, \hat{\pi}$      |                       |        | $l(l\zeta)$                 |
| sum of $R + L (+ j)$         | $\hat{N}$           | $N$                   |        | $K, k$                      |
| sum of $N + S$               | $\hat{J}$           | $J$                   | $M_J$  | $K, k$                      |
| sum of $J + I$               | $\hat{F}$           | $F$                   | $M_F$  |                             |

### Electromagnetic Radiation

| Name                         | Symbol        | Definition                                | SI unit                               |
|------------------------------|---------------|-------------------------------------------|---------------------------------------|
| wavelength                   | $\lambda$     |                                           | m                                     |
| speed of light               |               |                                           |                                       |
| in vacuum                    | $c_0$         |                                           | m s <sup>-1</sup>                     |
| in a medium                  | $c$           | $c = c_0 / n$                             | m s <sup>-1</sup>                     |
| wavenumber in vacuum         | $\tilde{\nu}$ | $\tilde{\nu} = \nu / c_0 = 1 / n \lambda$ | m <sup>-1</sup>                       |
| wavenumber (in a medium)     | $\sigma$      | $\sigma = 1 / \lambda$                    | m <sup>-1</sup>                       |
| frequency                    | $\nu$         | $\nu = c / \lambda$                       | Hz                                    |
| circular frequency, pulsance | $\omega$      | $\omega = 2 \pi \nu$                      | s <sup>-1</sup> , rad s <sup>-1</sup> |
| refractive index             | $n$           | $n = c_0 / c$                             | 1                                     |
| Planck constant              | $h$           |                                           | J s                                   |



| Name                                                                  | Symbol                            | Definition                                                            | SI unit                            |
|-----------------------------------------------------------------------|-----------------------------------|-----------------------------------------------------------------------|------------------------------------|
| Planck constant/ $2\pi$                                               | $\hbar$                           | $\hbar = h/2\pi$                                                      | J s                                |
| radiant energy                                                        | $Q, W$                            |                                                                       | J                                  |
| radiant energy density                                                | $\rho, w$                         | $\rho = Q/V$                                                          | J m <sup>-3</sup>                  |
| spectral radiant energy density                                       |                                   |                                                                       |                                    |
| in terms of frequency                                                 | $\rho_\nu, w_\nu$                 | $\rho = d\rho/d\nu$                                                   | J m <sup>-3</sup> Hz <sup>-1</sup> |
| in terms of wavenumber                                                | $\rho_{\bar{\nu}}, w_{\bar{\nu}}$ | $\rho_{\bar{\nu}} = d\rho/d\bar{\nu}$                                 | J m <sup>-2</sup>                  |
| in terms of wavelength                                                | $\rho_\lambda, w_\lambda$         | $\rho_\lambda = d\rho/d\lambda$                                       | J m <sup>-4</sup>                  |
| Einstein transition probabilities                                     |                                   |                                                                       |                                    |
| spontaneous emission                                                  | $A_{nm}$                          | $dN_n/dt = -A_{nm}N_n$                                                | s <sup>-1</sup>                    |
| stimulated emission                                                   | $B_{nm}$                          | $dN_n/dt = -\rho_\nu(\bar{\nu}_{nm}) \times B_{nm}N_n$                | s kg <sup>-1</sup>                 |
| stimulated absorption                                                 | $B_{mn}$                          | $dN_n/dt = -\rho_\nu(\bar{\nu}_{nm}) B_{mn}N_m$                       | s kg <sup>-1</sup>                 |
| radiant power, radiant energy per time                                | $\Phi, P$                         | $\Phi = dQ/dt$                                                        | W                                  |
| radiant intensity                                                     | $I$                               | $I = d\Phi/d\Omega$                                                   | W sr <sup>-1</sup>                 |
| radiant exitance (emitted radiant flux)                               | $M$                               | $M = d\Phi/dA_{\text{source}}$                                        | W m <sup>-2</sup>                  |
| irradiance, (radiant flux received)                                   | $E, (I)$                          | $E = d\Phi/dA$                                                        | W m <sup>-2</sup>                  |
| emittance                                                             | $\varepsilon$                     | $\varepsilon = M/M_{\text{bb}}$                                       | 1                                  |
| Stefan–Boltzmann constant                                             | $\sigma$                          | $M_{\text{bb}} = \sigma T^4$                                          | W m <sup>-2</sup> K <sup>-4</sup>  |
| first radiation constant                                              | $c_1$                             | $c_1 = 2\pi h c_0^2$                                                  | W m <sup>2</sup>                   |
| second radiation constant                                             | $c_2$                             | $c_2 = hc_0/k$                                                        | K m                                |
| transmittance, transmission factor                                    | $\tau, T$                         | $\tau = \Phi_{\text{tr}}/\Phi_0$                                      | 1                                  |
| absorptance, absorption factor                                        | $\alpha$                          | $\alpha = \Phi_{\text{abs}}/\Phi_0$                                   | 1                                  |
| reflectance, reflection factor                                        | $\rho$                            | $\rho = \Phi_{\text{refl}}/\Phi_0$                                    | 1                                  |
| (decadic) absorbance                                                  | $A$                               | $A = -\lg(1 - \alpha_t)$                                              | 1                                  |
| napierian absorbance                                                  | $B$                               | $B = -\ln(1 - \alpha_t)$                                              | 1                                  |
| absorption coefficient                                                |                                   |                                                                       |                                    |
| (linear) decadic                                                      | $a, K$                            | $a = A/l$                                                             | m <sup>-1</sup>                    |
| (linear) napierian                                                    | $\alpha$                          | $\alpha = B/l$                                                        | m <sup>-1</sup>                    |
| molar (decadic)                                                       | $\varepsilon$                     | $\varepsilon = a/c = A/cl$                                            | m <sup>2</sup> mol <sup>-1</sup>   |
| molar napierian                                                       | $\kappa$                          | $\kappa = \alpha/c = B/cl$                                            | m <sup>2</sup> mol <sup>-1</sup>   |
| absorption index                                                      | $k$                               | $k = \alpha/4\pi\bar{\nu}$                                            | 1                                  |
| complex refractive index                                              | $\hat{n}$                         | $\hat{n} = n + ik$                                                    | 1                                  |
| molar refraction                                                      | $R, R_m$                          | $R = \frac{(n^2 - 1)}{(n^2 + 2)} V_m$                                 | m <sup>3</sup> mol <sup>-1</sup>   |
| angle of optical rotation                                             | $\alpha$                          |                                                                       | 1, rad                             |
| <b>Solid State</b>                                                    |                                   |                                                                       |                                    |
| lattice vector                                                        | $R, R_0$                          |                                                                       | m                                  |
| fundamental translation vectors for the crystal lattice               | $a_1; a_2; a_3, a; b; c$          | $R = n_1 a_1 + n_2 a_2 + n_3 a_3$                                     | m                                  |
| (circular) reciprocal lattice vector                                  | $G$                               | $G \cdot R = 2\pi m$                                                  | m <sup>-1</sup>                    |
| (circular) fundamental translation vectors for the reciprocal lattice | $b_1; b_2; b_3, a^*; b^*; c^*$    | $a_i \cdot b_k = 2\pi \delta_{ik}$                                    | m <sup>-1</sup>                    |
| lattice plane spacing                                                 | $d$                               |                                                                       | m                                  |
| Bragg angle                                                           | $\theta$                          | $n\lambda = 2d \sin \theta$                                           | 1, rad                             |
| order of reflection                                                   | $n$                               |                                                                       | 1                                  |
| order parameters                                                      |                                   |                                                                       |                                    |
| short range                                                           | $\sigma$                          |                                                                       | 1                                  |
| long range                                                            | $s$                               |                                                                       | 1                                  |
| Burgers vector                                                        | $b$                               |                                                                       | m                                  |
| particle position vector                                              | $r, R_j$                          |                                                                       | m                                  |
| equilibrium position vector of an ion                                 | $R_0$                             |                                                                       | m                                  |
| displacement vector of an ion                                         | $u$                               | $u = R - R_0$                                                         | m                                  |
| Debye–Waller factor                                                   | $B, D$                            |                                                                       | 1                                  |
| Debye circular wavenumber                                             | $q_D$                             |                                                                       | m <sup>-1</sup>                    |
| Debye circular frequency                                              | $\omega_D$                        |                                                                       | s <sup>-1</sup>                    |
| Grüneisen parameter                                                   | $\gamma, \Gamma$                  | $\gamma = \alpha V/\kappa C_v$                                        | 1                                  |
| Madelung constant                                                     | $\alpha, \mathcal{M}$             | $E_{\text{coul}} = \frac{\alpha N_A z_+ z_- e^2}{4\pi\epsilon_0 R_0}$ | 1                                  |
| density of states                                                     | $N_E$                             | $N_E = dN(E)/dE$                                                      | J <sup>-1</sup> m <sup>-3</sup>    |
| (spectral) density of vibrational modes                               | $N_\omega, g$                     | $N_\omega = dN(\omega)/d\omega$                                       | s m <sup>-3</sup>                  |

| Name                                                       | Symbol                                                   | Definition                                                 | SI unit                                    |
|------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------|--------------------------------------------|
| resistivity tensor                                         | $\rho_{ik}$                                              | $E = \rho \cdot j$                                         | $\Omega \text{ m}$                         |
| conductivity tensor                                        | $\sigma_{ik}$                                            | $\sigma = \rho^{-1}$                                       | $\text{S m}^{-1}$                          |
| thermal conductivity tensor                                | $\lambda_{ik}$                                           | $J_q = -\lambda \cdot \text{grad } T$                      | $\text{W m}^{-1} \text{ K}^{-1}$           |
| residual resistivity                                       | $\rho_R$                                                 |                                                            | $\Omega \text{ m}$                         |
| relaxation time                                            | $\tau$                                                   | $\tau = l/v_F$                                             | s                                          |
| Lorenz coefficient                                         | $L$                                                      | $L = \lambda/\sigma T$                                     | $\text{V}^2 \text{ K}^{-2}$                |
| Hall coefficient                                           | $A_H, R_H$                                               | $E = \rho \cdot j + R_H(B \times j)$                       | $\text{m}^3 \text{ C}^{-1}$                |
| thermoelectric force                                       | $E$                                                      |                                                            | V                                          |
| Peltier coefficient                                        | $\Pi$                                                    |                                                            | V                                          |
| Thomson coefficient                                        | $\mu, (\tau)$                                            |                                                            | $\text{V K}^{-1}$                          |
| work function                                              | $\Phi$                                                   | $\Phi = E_\infty - E_F$                                    | J                                          |
| number density, number concentration                       | $n, (p)$                                                 |                                                            | $\text{m}^{-3}$                            |
| gap energy                                                 | $E_g$                                                    |                                                            | J                                          |
| donor ionization energy                                    | $E_d$                                                    |                                                            | J                                          |
| acceptor ionization energy                                 | $E_a$                                                    |                                                            | J                                          |
| Fermi energy                                               | $E_F, \epsilon_F$                                        |                                                            | J                                          |
| circular wave vector, propagation vector                   | $k, q$                                                   | $k = 2\pi/\lambda$                                         | $\text{m}^{-1}$                            |
| Bloch function                                             | $u_k(r)$                                                 | $\psi(r) = u_k(r) \exp(ik \cdot r)$                        | $\text{m}^{-3/2}$                          |
| charge density of electrons                                | $\rho$                                                   | $\rho(r) = -e\psi^*(r)\psi(r)$                             | $\text{C m}^{-3}$                          |
| effective mass                                             | $m^*$                                                    |                                                            | kg                                         |
| mobility                                                   | $\mu$                                                    | $\mu = v_{\text{drift}}/E$                                 | $\text{m}^2 \text{ V}^{-1} \text{ s}^{-1}$ |
| mobility ratio                                             | $b$                                                      | $b = \mu_n/\mu_p$                                          | 1                                          |
| diffusion coefficient                                      | $D$                                                      | $dN/dt = -DA(dn/dx)$                                       | $\text{m}^2 \text{ s}^{-1}$                |
| diffusion length                                           | $L$                                                      | $L = \sqrt{D\tau}$                                         | m                                          |
| characteristic (Weiss) temperature                         | $\theta, \theta_w$                                       |                                                            | K                                          |
| Curie temperature                                          | $T_C$                                                    |                                                            | K                                          |
| Néel temperature                                           | $T_N$                                                    |                                                            | K                                          |
| <b>Statistical Thermodynamics</b>                          |                                                          |                                                            |                                            |
| number of entities                                         | $N$                                                      |                                                            | 1                                          |
| number density of entities, number concentration           | $n, C$                                                   | $n = N/V$                                                  | $\text{m}^{-3}$                            |
| Avogadro constant                                          | $L, N_A$                                                 |                                                            | $\text{mol}^{-1}$                          |
| Boltzmann constant                                         | $k, k_B$                                                 |                                                            | $\text{J K}^{-1}$                          |
| gas constant (molar)                                       | $R$                                                      | $R = Lk$                                                   | $\text{J K}^{-1} \text{ mol}^{-1}$         |
| molecular position vector                                  | $r(x, y, z)$                                             |                                                            | m                                          |
| molecular velocity vector                                  | $c(c_x, c_y, c_z), u(u_x, u_y, u_z)$                     | $c = dr/dt$                                                | $\text{m s}^{-1}$                          |
| molecular momentum vector                                  | $p(p_x, p_y, p_z)$                                       | $p = mc$                                                   | $\text{kg m s}^{-1}$                       |
| velocity distribution function (Maxwell)                   | $f(c_x)$                                                 | $f(c_x) = (m/2\pi kT)^{1/2} \times \exp(-mc_x^2/2kT)$      | $\text{m}^{-1} \text{ s}$                  |
| speed distribution function (Maxwell–Boltzmann)            | $F(c)$                                                   | $F(c) = (m/2\pi kT)^{3/2} \times 4\pi c^2 \exp(-mc^2/2kT)$ | $\text{m}^{-1} \text{ s}$                  |
| average speed                                              | $\bar{c}, \bar{u}, \langle c \rangle, \langle u \rangle$ | $\bar{c} = \int c F(c) dc$                                 | $\text{m s}^{-1}$                          |
| generalized coordinate                                     | $q$                                                      |                                                            | (m)                                        |
| generalized momentum                                       | $p$                                                      | $p = \partial L / \partial \dot{q}$                        | $(\text{kg m s}^{-1})$                     |
| volume in phase space                                      | $\Omega$                                                 | $\Omega = (1/h) \int p dq$                                 | 1                                          |
| probability                                                | $P$                                                      |                                                            | 1                                          |
| statistical weight, degeneracy                             | $g, d, W, \omega, \beta$                                 |                                                            | 1                                          |
| density of states                                          | $\rho(E)$                                                | $\rho(E) = dN/dE$                                          | $\text{J}^{-1}$                            |
| partition function, sum over states, for a single molecule | $q, z$                                                   | $q = \sum_i g_i \exp(-\epsilon_i/kT)$                      | 1                                          |
| for a canonical ensemble (system, or assembly)             | $Q, Z$                                                   |                                                            | 1                                          |
| microcanonical ensemble                                    | $\Omega$                                                 |                                                            | 1                                          |
| grand (canonical ensemble)                                 | $\Xi$                                                    |                                                            | 1                                          |
| symmetry number                                            | $\sigma, s$                                              |                                                            | 1                                          |
| reciprocal temperature parameter                           | $\beta$                                                  | $\beta = 1/kT$                                             | $\text{J}^{-1}$                            |
| characteristic temperature                                 | $\Theta$                                                 |                                                            | K                                          |

| Name                                                            | Symbol                     | Definition                                             | SI unit                               |
|-----------------------------------------------------------------|----------------------------|--------------------------------------------------------|---------------------------------------|
| <b>General Chemistry</b>                                        |                            |                                                        |                                       |
| number of entities (e.g. molecules, atoms, ions, formula units) | $N$                        |                                                        | 1                                     |
| amount (of substance)                                           | $n$                        | $n_B = N_B/L$                                          | mol                                   |
| Avogadro constant                                               | $L, N_A$                   |                                                        | mol <sup>-1</sup>                     |
| mass of atom, atomic mass                                       | $m_a, m$                   |                                                        | kg                                    |
| mass of entity (molecule, or formula unit)                      | $m_e, m$                   |                                                        | kg                                    |
| atomic mass constant                                            | $m_u$                      | $m_u = m_a(^{12}\text{C})/12$                          | kg                                    |
| molar mass                                                      | $M$                        | $M_B = m/n_B$                                          | kg mol <sup>-1</sup>                  |
| relative molecular mass (relative molar mass, molecular weight) | $M_r$                      | $M_{r,B} = m_B/m_u$                                    | 1                                     |
| molar volume                                                    | $V_m$                      | $V_{m,B} = V/n_B$                                      | m <sup>3</sup> mol <sup>-1</sup>      |
| mass fraction                                                   | $w$                        | $w_B = m_B/\Sigma m_i$                                 | 1                                     |
| volume fraction                                                 | $\phi$                     | $\phi_B = V_B/\Sigma V_i$                              | 1                                     |
| mole fraction, amount fraction, number fraction                 | $x, y$                     | $x_B = n_B/\Sigma n_i$                                 | 1                                     |
| (total) pressure                                                | $p, P$                     |                                                        | Pa                                    |
| partial pressure                                                | $p_B$                      | $p_B = y_B p$                                          | Pa                                    |
| mass concentration (mass density)                               | $\gamma, \rho$             | $\gamma_B = m_B/V$                                     | kg m <sup>-3</sup>                    |
| number concentration, number density of entities                | $C, n$                     | $C_B = N_B/V$                                          | m <sup>-3</sup>                       |
| amount concentration, concentration                             | $c$                        | $c_B = n_B/V$                                          | mol m <sup>-3</sup>                   |
| solubility                                                      | $s$                        | $s_B = c_B$ (saturated solution)                       | mol m <sup>-3</sup>                   |
| molality (of a solute)                                          | $m, (b)$                   | $m_B = n_B/m_A$                                        | mol kg <sup>-1</sup>                  |
| surface concentration                                           | $\Gamma$                   | $\Gamma_B = n_B/A$                                     | mol m <sup>-2</sup>                   |
| stoichiometric number                                           | $\nu$                      |                                                        | 1                                     |
| extent of reaction, advancement                                 | $\xi$                      | $\Delta\xi = \Delta n_B/\nu_B$                         | mol                                   |
| degree of dissociation                                          | $\alpha$                   |                                                        | 1                                     |
| <b>Chemical Thermodynamics</b>                                  |                            |                                                        |                                       |
| heat                                                            | $q, Q$                     |                                                        | J                                     |
| work                                                            | $w, W$                     |                                                        | J                                     |
| internal energy                                                 | $U$                        | $\Delta U = q + w$                                     | J                                     |
| enthalpy                                                        | $H$                        | $H = U + pV$                                           | J                                     |
| thermodynamic temperature                                       | $T$                        |                                                        | K                                     |
| Celsius temperature                                             | $\theta, t$                | $\theta/^{\circ}\text{C} = T/\text{K} - 273.15$        | °C                                    |
| entropy                                                         | $S$                        | $\text{d}S \geq \text{d}q/T$                           | J K <sup>-1</sup>                     |
| Helmholtz energy (Helmholtz function)                           | $A$                        | $A = U - TS$                                           | J                                     |
| Gibbs energy (Gibbs function)                                   | $G$                        | $G = H - TS$                                           | J                                     |
| Massieu function                                                | $J$                        | $J = -A/T$                                             | J K <sup>-1</sup>                     |
| Planck function                                                 | $Y$                        | $Y = -G/T$                                             | J K <sup>-1</sup>                     |
| surface tension                                                 | $\gamma, \sigma$           | $\gamma = (\partial G/\partial A_s)_{T, p}$            | J m <sup>-2</sup> , N m <sup>-1</sup> |
| molar quantity $X$                                              | $X_m$                      | $X_m = X/n$                                            | (varies)                              |
| specific quantity $X$                                           | $x$                        | $x = X/m$                                              | (varies)                              |
| pressure coefficient                                            | $\beta$                    | $\beta = (\partial p/\partial T)_v$                    | Pa K <sup>-1</sup>                    |
| relative pressure coefficient                                   | $\alpha_p$                 | $\alpha_p = (1/p)(\partial p/\partial T)_v$            | K <sup>-1</sup>                       |
| compressibility,                                                |                            |                                                        |                                       |
| isothermal                                                      | $\kappa_T$                 | $\kappa_T = -(1/V)(\partial V/\partial p)_T$           | Pa <sup>-1</sup>                      |
| isentropic                                                      | $\kappa_S$                 | $\kappa_S = -(1/V)(\partial V/\partial p)_S$           | Pa <sup>-1</sup>                      |
| linear expansion coefficient                                    | $\alpha_l$                 | $\alpha_l = (1/l)(\partial l/\partial T)$              | K <sup>-1</sup>                       |
| cubic expansion coefficient                                     | $\alpha, \alpha_v, \gamma$ | $\alpha = (1/V)(\partial V/\partial T)_p$              | K <sup>-1</sup>                       |
| heat capacity,                                                  |                            |                                                        |                                       |
| at constant pressure                                            | $C_p$                      | $C_p = (\partial H/\partial T)_p$                      | J K <sup>-1</sup>                     |
| at constant volume                                              | $C_v$                      | $C_v = (\partial U/\partial T)_v$                      | J K <sup>-1</sup>                     |
| ratio of heat capacities                                        | $\gamma, (\kappa)$         | $\gamma = C_p/C_v$                                     | 1                                     |
| Joule–Thomson coefficient                                       | $\mu, \mu_T$               | $\mu = (\partial T/\partial p)_H$                      | K Pa <sup>-1</sup>                    |
| second virial coefficient                                       | $B$                        | $pV_m = RT(1 + B/V_m + \dots)$                         | m <sup>3</sup> mol <sup>-1</sup>      |
| compression factor (compressibility factor)                     | $Z$                        | $Z = pV_m/RT$                                          | 1                                     |
| partial molar quantity $X$                                      | $X_B, (X'_B)$              | $X_B = (\partial X/\partial n_B)_{T, p, n_j \neq B}$   | (varies)                              |
| chemical potential (partial molar Gibbs energy)                 | $\mu$                      | $\mu_B = (\partial G/\partial n_B)_{T, p, n_j \neq B}$ | J mol <sup>-1</sup>                   |
| absolute activity                                               | $\lambda$                  | $\lambda_B = \exp(\mu_B/RT)$                           | 1                                     |

| Name                                                                                                      | Symbol                 | Definition                                                     | SI unit                                                  |
|-----------------------------------------------------------------------------------------------------------|------------------------|----------------------------------------------------------------|----------------------------------------------------------|
| standard chemical potential                                                                               | $\mu^\circ, \mu^\circ$ |                                                                | J mol <sup>-1</sup>                                      |
| standard partial molar enthalpy                                                                           | $H_B^\circ$            | $H_B^\circ = \mu_B^\circ + TS_B^\circ$                         | J mol <sup>-1</sup>                                      |
| standard partial molar entropy                                                                            | $S_B^\circ$            | $S_B^\circ = -(\partial \mu_B^\circ / \partial T)_p$           | J mol <sup>-1</sup> K <sup>-1</sup>                      |
| standard reaction Gibbs energy (function)                                                                 | $\Delta_r G^\circ$     | $\Delta_r G^\circ = \sum_B \nu_B \mu_B^\circ$                  | J mol <sup>-1</sup>                                      |
| affinity of reaction                                                                                      | $A, (\mathcal{A})$     | $A = -(\partial G / \partial \xi)_{p,T} = -\sum_B \nu_B \mu_B$ | J mol <sup>-1</sup>                                      |
| standard reaction enthalpy                                                                                | $\Delta_r H^\circ$     | $\Delta_r H^\circ = \sum_B \nu_B H_B^\circ$                    | J mol <sup>-1</sup>                                      |
| standard reaction entropy                                                                                 | $\Delta_r S^\circ$     | $\Delta_r S^\circ = \sum_B \nu_B S_B^\circ$                    | J mol <sup>-1</sup> K <sup>-1</sup>                      |
| equilibrium constant                                                                                      | $K^\circ, K$           | $K^\circ = \exp(-\Delta_r G^\circ / RT)$                       | 1                                                        |
| equilibrium constant,<br>pressure basis                                                                   | $K_p$                  | $K_p = \prod_B p_B^{\nu_B}$                                    | Pa <sup><math>\sum \nu</math></sup>                      |
| concentration basis                                                                                       | $K_c$                  | $K_c = \prod_B c_B^{\nu_B}$                                    | (mol m <sup>-3</sup> ) <sup><math>\sum \nu</math></sup>  |
| molality basis                                                                                            | $K_m$                  | $K_m = \prod_B m_B^{\nu_B}$                                    | (mol kg <sup>-1</sup> ) <sup><math>\sum \nu</math></sup> |
| fugacity                                                                                                  | $f, \tilde{p}$         | $f_B = \lambda_B \lim_{p \rightarrow 0} (p_B / \lambda_B)_T$   | Pa                                                       |
| fugacity coefficient                                                                                      | $\phi$                 | $\phi_B = f_B / p_B$                                           | 1                                                        |
| activity and activity coefficient referenced to<br>Raoult's law, (relative) activity                      | $a$                    | $a_B = \exp\left[\frac{\mu_B - \mu_B^\circ}{RT}\right]$        | 1                                                        |
| activity coefficient                                                                                      | $f$                    | $f_B = a_B / x_B$                                              | 1                                                        |
| activities and activity coefficients referenced<br>to Henry's law, (relative) activity,<br>molality basis | $a_m$                  | $a_{m,B} = \exp\left[\frac{\mu_B - \mu_B^\circ}{RT}\right]$    | 1                                                        |
| concentration basis                                                                                       | $a_c$                  | $a_{c,B} = \exp\left[\frac{\mu_B - \mu_B^\circ}{RT}\right]$    | 1                                                        |
| mole fraction basis                                                                                       | $a_x$                  | $a_{x,B} = \exp\left[\frac{\mu_B - \mu_B^\circ}{RT}\right]$    | 1                                                        |
| activity coefficient,<br>molality basis                                                                   | $\gamma_m$             | $a_{m,B} = \gamma_{m,B} m_B^\circ / m^\circ$                   | 1                                                        |
| concentration basis                                                                                       | $\gamma_c$             | $a_{c,B} = \gamma_{c,B} c_B^\circ / c^\circ$                   | 1                                                        |
| mole fraction basis                                                                                       | $\gamma_x$             | $a_{x,B} = \gamma_{x,B} x_B$                                   | 1                                                        |
| ionic strength,<br>molality basis                                                                         | $I_m, I$               | $I_m = \frac{1}{2} \sum m_B z_B^2$                             | mol kg <sup>-1</sup>                                     |
| concentration basis                                                                                       | $I_c, I$               | $I_c = \frac{1}{2} \sum c_B z_B^2$                             | mol m <sup>-3</sup>                                      |
| osmotic coefficient,<br>molality basis                                                                    | $\phi_m$               | $\phi_m = (\mu_A^\circ - \mu_A) / (RT M_A \sum m_B)$           | 1                                                        |
| mole fraction basis                                                                                       | $\phi_x$               | $\phi_x = (\mu_A - \mu_A^\circ) / (RT \ln x_A)$                | 1                                                        |
| osmotic pressure                                                                                          | $\Pi$                  | $\Pi = c_B RT$ (ideal dilute solution)                         | Pa                                                       |

*(i) Symbols used as subscripts to denote a chemical process or reaction*

These symbols should be printed in roman (upright) type, without a full stop (period).

|                                          |     |
|------------------------------------------|-----|
| vaporization, evaporation (liquid → gas) | vap |
| sublimation (solid → gas)                | sub |
| melting, fusion (solid → liquid)         | fus |
| transition (between two phases)          | trs |
| mixing of fluids                         | mix |
| solution (of solute in solvent)          | sol |
| dilution (of a solution)                 | dil |
| adsorption                               | ads |
| displacement                             | dpl |
| immersion                                | imm |

|                     |    |
|---------------------|----|
| reaction in general | r  |
| atomization         | at |
| combustion reaction | c  |
| formation reaction  | f  |

*(ii) Recommended superscripts*

|                                     |                   |
|-------------------------------------|-------------------|
| standard                            | $\ominus, ^\circ$ |
| pure substance                      | *                 |
| infinite dilution                   | $\infty$          |
| ideal                               | id                |
| activated complex, transition state | $\ddagger$        |
| excess quantity                     | E                 |

| Name                                                                  | Symbol                                         | Definition                                                                       | SI unit                                                            |
|-----------------------------------------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Chemical Kinetics</b>                                              |                                                |                                                                                  |                                                                    |
| rate of change of quantity $X$                                        | $\dot{X}$                                      | $\dot{X} = dX/dt$                                                                | (varies)                                                           |
| rate of conversion                                                    | $\dot{\xi}$                                    | $\dot{\xi} = d\xi/dt$                                                            | mol s <sup>-1</sup>                                                |
| rate of concentration change (due to chemical reaction)               | $r_B \nu_B$                                    | $r_B = dc_B/dt$                                                                  | mol m <sup>-3</sup> s <sup>-1</sup>                                |
| rate of reaction (based on amount concentration)                      | $\nu$                                          | $\nu = \dot{\xi}/V = \nu_B^{-1} dc_B/dt$                                         | mol m <sup>-3</sup> s <sup>-1</sup>                                |
| partial order of reaction                                             | $n_B$                                          | $\nu = k \Pi c_B^{n_B}$                                                          | 1                                                                  |
| overall order of reaction                                             | $n$                                            | $n = \sum n_B$                                                                   | 1                                                                  |
| rate constant, rate coefficient                                       | $k$                                            | $\nu = k \Pi c_B^{n_B}$                                                          | (mol <sup>-1</sup> m <sup>3</sup> ) <sup>n-1</sup> s <sup>-1</sup> |
| Boltzmann constant                                                    | $k, k_B$                                       |                                                                                  | J K <sup>-1</sup>                                                  |
| half life                                                             | $t_{1/2}$                                      | $c(t_{1/2}) = c_0/2$                                                             | s                                                                  |
| relaxation time                                                       | $\tau$                                         | $\tau = 1/(k_1 + k_{-1})$                                                        | s                                                                  |
| energy of activation, activation energy                               | $E_a, E$                                       | $E_a = RT^2 d \ln k/dT$                                                          | J mol <sup>-1</sup>                                                |
| pre-exponential factor                                                | $A$                                            | $k = A \exp(-E_a/RT)$                                                            | (mol <sup>-1</sup> m <sup>3</sup> ) <sup>n-1</sup> s <sup>-1</sup> |
| volume of activation                                                  | $\Delta^\ddagger V$                            | $\Delta^\ddagger V = -RT \times (\partial \ln k / \partial p)_T$                 | m <sup>3</sup> mol <sup>-1</sup>                                   |
| collision diameter                                                    | $d$                                            | $d_{AB} = r_A + r_B$                                                             | m                                                                  |
| collision cross-section                                               | $\sigma$                                       | $\sigma_{AB} = \pi d_{AB}^2$                                                     | m <sup>2</sup>                                                     |
| collision frequency                                                   | $Z_A$                                          |                                                                                  | s <sup>-1</sup>                                                    |
| collision number                                                      | $Z_{AB}, Z_{AA}$                               |                                                                                  | m <sup>-3</sup> s <sup>-1</sup>                                    |
| collision frequency factor                                            | $z_{AB}, z_{AA}$                               | $z_{AB} = Z_{AB}/Lc_A c_B$                                                       | m <sup>3</sup> mol <sup>-1</sup> s <sup>-1</sup>                   |
| standard enthalpy of activation                                       | $\Delta^\ddagger H^\ominus, \Delta H^\ddagger$ |                                                                                  | J mol <sup>-1</sup>                                                |
| standard entropy of activation                                        | $\Delta^\ddagger S^\ominus, \Delta S^\ddagger$ |                                                                                  | J mol <sup>-1</sup> K <sup>-1</sup>                                |
| standard Gibbs energy of activation                                   | $\Delta^\ddagger G^\ominus, \Delta G^\ddagger$ |                                                                                  | J mol <sup>-1</sup>                                                |
| quantum yield, photochemical yield                                    | $\phi$                                         |                                                                                  | 1                                                                  |
| <b>Electrochemistry</b>                                               |                                                |                                                                                  |                                                                    |
| elementary charge (proton charge)                                     | $e$                                            |                                                                                  | C                                                                  |
| Faraday constant                                                      | $F$                                            | $F = eL$                                                                         | C mol <sup>-1</sup>                                                |
| charge number of an ion                                               | $z$                                            | $z_B = Q_B/e$                                                                    | 1                                                                  |
| ionic strength                                                        | $I_c, I$                                       | $I_c = \frac{1}{2} \sum c_i z_i^2$                                               | mol m <sup>-3</sup>                                                |
| mean ionic activity                                                   | $a_\pm$                                        | $a_\pm = m_\pm \gamma_\pm / m^\ominus$                                           | 1                                                                  |
| mean ionic molality                                                   | $m_\pm$                                        | $m_\pm^{(v_+ + v_-)} = m_+^{v_+} m_-^{v_-}$                                      | mol kg <sup>-1</sup>                                               |
| mean ionic activity coefficient                                       | $\gamma_\pm$                                   | $\gamma_\pm^{(v_+ + v_-)} = \gamma_+^{v_+} \gamma_-^{v_-}$                       | 1                                                                  |
| charge number of electrochemical cell reaction                        | $n, (z)$                                       |                                                                                  | 1                                                                  |
| electric potential difference (of a galvanic cell)                    | $\Delta V, E, U$                               | $\Delta V = V_R - V_L$                                                           | V                                                                  |
| emf, electromotive force                                              | $E$                                            | $E = \lim_{I \rightarrow 0} \Delta V$                                            | V                                                                  |
| standard emf, standard potential of the electrochemical cell reaction | $E^\ominus$                                    | $E^\ominus = -\Delta_r G^\ominus/nF = (RT/nF) \ln K^\ominus$                     | V                                                                  |
| standard electrode potential                                          | $E^\ominus$                                    |                                                                                  | V                                                                  |
| emf of the cell, potential of the electrochemical cell reaction       | $E$                                            | $E = E^\ominus - (RT/nF) \times \sum \nu_i \ln a_i$                              | V                                                                  |
| pH                                                                    | pH                                             | $\text{pH} \approx -\lg \left[ \frac{c(\text{H}^+)}{\text{mol dm}^{-3}} \right]$ | 1                                                                  |
| inner electric potential                                              | $\phi$                                         | $\nabla \phi = -E$                                                               | V                                                                  |
| outer electric potential                                              | $\psi$                                         | $\psi = Q/4\pi\epsilon_0 r$                                                      | V                                                                  |

| Name                                               | Symbol                                                     | Definition                                                                        | SI unit                                        |
|----------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------|
| surface electric potential                         | $\chi$                                                     | $\chi = \phi - \psi$                                                              | V                                              |
| Galvani potential difference                       | $\Delta\phi$                                               | $\Delta_{\alpha}^{\beta}\phi = \phi^{\beta} - \phi^{\alpha}$                      | V                                              |
| volta potential difference                         | $\Delta\psi$                                               | $\Delta_{\alpha}^{\beta}\psi = \psi^{\beta} - \psi^{\alpha}$                      | V                                              |
| electrochemical potential                          | $\tilde{\mu}$                                              | $\tilde{\mu}_{\text{B}}^{\alpha} = (\partial G / \partial n_{\text{B}}^{\alpha})$ | J mol <sup>-1</sup>                            |
| electric current                                   | $I$                                                        | $I = \text{d}Q/\text{d}t$                                                         | A                                              |
| (electric) current density                         | $j$                                                        | $j = I/A$                                                                         | A m <sup>-2</sup>                              |
| (surface) charge density                           | $\sigma$                                                   | $\sigma = Q/A$                                                                    | C m <sup>-2</sup>                              |
| electrode reaction rate constant                   | $k$                                                        | $k_{\text{ox}} = I_{\text{a}} / (nFA \prod_i c_i^{n_i})$                          | (varies)                                       |
| mass transfer coefficient, diffusion rate constant | $k_{\text{d}}$                                             | $k_{\text{d,B}} =  v_{\text{B}}  I_{\text{L,B}} / nF c_{\text{A}}$                | m s <sup>-1</sup>                              |
| thickness of diffusion layer                       | $\delta$                                                   | $\delta_{\text{B}} = D_{\text{B}} / k_{\text{d,B}}$                               | m                                              |
| transfer coefficient (electrochemical)             | $\alpha$                                                   | $\alpha_c = \frac{- v  RT \partial \ln  I_c }{nF \partial E}$                     | 1                                              |
| overpotential                                      | $\eta$                                                     | $\eta = E_i - E_{i=0} - IR_u$                                                     | V                                              |
| electrokinetic potential (zeta potential)          | $\zeta$                                                    |                                                                                   | V                                              |
| conductivity                                       | $\kappa, (\sigma)$                                         | $\kappa = j/E$                                                                    | S m <sup>-1</sup>                              |
| conductivity cell constant                         | $K_{\text{cell}}$                                          | $K_{\text{cell}} = \kappa R$                                                      | m <sup>-1</sup>                                |
| molar conductivity (of an electrolyte)             | $\Lambda$                                                  | $\Lambda_{\text{B}} = \kappa / c_{\text{B}}$                                      | S m <sup>2</sup> mol <sup>-1</sup>             |
| ionic conductivity, molar conductivity of an ion   | $\lambda$                                                  | $\lambda_{\text{B}} =  z_{\text{B}}  F u_{\text{B}}$                              | S m <sup>2</sup> mol <sup>-1</sup>             |
| electric mobility                                  | $u, (\mu)$                                                 | $u_{\text{B}} = v_{\text{B}} / E$                                                 | m <sup>2</sup> V <sup>-1</sup> s <sup>-1</sup> |
| transport number                                   | $t$                                                        | $t_{\text{B}} = j_{\text{B}} / \sum j_i$                                          | 1                                              |
| reciprocal radius of ionic atmosphere              | $\kappa$                                                   | $\kappa = (2F^2 I / \epsilon RT)^{1/2}$                                           | m <sup>-1</sup>                                |
| <b>Colloid and Surface Chemistry</b>               |                                                            |                                                                                   |                                                |
| specific surface area                              | $a, a_s, s$                                                | $a = A/m$                                                                         | m <sup>2</sup> kg <sup>-1</sup>                |
| surface amount of B, adsorbed amount of B          | $n_{\text{B}}^s, n_{\text{B}}^{\text{a}}$                  |                                                                                   | mol                                            |
| surface excess of B                                | $n_{\text{B}}^{\sigma}$                                    |                                                                                   | mol                                            |
| surface excess concentration of B                  | $\Gamma_{\text{B}}^{\sigma}, (\Gamma_{\text{B}}^{\sigma})$ | $\Gamma_{\text{B}} = n_{\text{B}}^{\sigma} / A$                                   | mol m <sup>-2</sup>                            |
| total surface excess concentration                 | $\Gamma, (\Gamma^{\sigma})$                                | $\Gamma = \sum_i \Gamma_i$                                                        | mol m <sup>-2</sup>                            |
| area per molecule                                  | $a, \sigma$                                                | $a_{\text{B}} = A / N_{\text{B}}^{\sigma}$                                        | m <sup>2</sup>                                 |
| area per molecule in a filled monolayer            | $a_{\text{m}}, \sigma_{\text{m}}$                          | $a_{\text{m,B}} = A / N_{\text{m,B}}$                                             | m <sup>2</sup>                                 |
| surface coverage                                   | $\theta$                                                   | $\theta = N_{\text{B}}^{\sigma} / N_{\text{m,B}}$                                 | 1                                              |
| contact angle                                      | $\theta$                                                   |                                                                                   | 1, rad                                         |
| film thickness                                     | $t, h, \delta$                                             |                                                                                   | m                                              |
| thickness of (surface or interfacial) layer        | $\tau, \delta, t$                                          |                                                                                   | m                                              |
| surface tension, interfacial tension               | $\gamma, \sigma$                                           | $\gamma = (\partial G / \partial A_s)_{T,p}$                                      | N m <sup>-1</sup> , J m <sup>-2</sup>          |
| film tension                                       | $\Sigma_{\text{f}}$                                        | $\Sigma_{\text{f}} = 2\gamma_{\text{f}}$                                          | N m <sup>-1</sup>                              |
| reciprocal thickness of the double layer           | $\kappa$                                                   | $\kappa = [2F^2 I / \epsilon RT]^{1/2}$                                           | m <sup>-1</sup>                                |
| average molar masses                               |                                                            |                                                                                   |                                                |
| number-average                                     | $M_n$                                                      | $M_n = \Sigma n_i M_i / \Sigma n_i$                                               | kg mol <sup>-1</sup>                           |
| mass-average                                       | $M_m$                                                      | $M_m = \Sigma n_i M_i^2 / \Sigma n_i M_i$                                         | kg mol <sup>-1</sup>                           |
| Z-average                                          | $M_z$                                                      | $M_z = \Sigma n_i M_i^3 / \Sigma n_i M_i^2$                                       | kg mol <sup>-1</sup>                           |
| sedimentation coefficient                          | $s$                                                        | $s = v/a$                                                                         | s                                              |
| van der Waals constant                             | $\lambda$                                                  |                                                                                   | J                                              |
| retarded van der Waals constant                    | $\beta, B$                                                 |                                                                                   | J                                              |
| van der Waals–Hamaker constant                     | $A_{\text{H}}$                                             |                                                                                   | J                                              |
| surface pressure                                   | $\pi^s, \pi$                                               | $\pi^s = \gamma^0 - \gamma$                                                       | N m <sup>-1</sup>                              |
| <b>Transport Properties</b>                        |                                                            |                                                                                   |                                                |
| flux (of a quantity X)                             | $J_X, J$                                                   | $J_X = A^{-1} \text{d}X/\text{d}t$                                                | (varies)                                       |
| volume flow rate                                   | $q_v, \dot{V}$                                             | $q_v = \text{d}V/\text{d}t$                                                       | m <sup>3</sup> s <sup>-1</sup>                 |
| mass flow rate                                     | $q_m, \dot{m}$                                             | $q_m = \text{d}m/\text{d}t$                                                       | kg s <sup>-1</sup>                             |
| mass transfer coefficient                          | $k_{\text{d}}$                                             |                                                                                   | m s <sup>-1</sup>                              |
| heat flow rate                                     | $\phi$                                                     | $\phi = \text{d}q/\text{d}t$                                                      | W                                              |
| heat flux                                          | $J_q$                                                      | $J_q = \phi/A$                                                                    | W m <sup>-2</sup>                              |
| thermal conductance                                | $G$                                                        | $G = \phi/\Delta T$                                                               | W K <sup>-1</sup>                              |
| thermal resistance                                 | $R$                                                        | $R = 1/G$                                                                         | K W <sup>-1</sup>                              |
| thermal conductivity                               | $\lambda, k$                                               | $\lambda = J_q / (\text{d}T/\text{d}l)$                                           | W m <sup>-1</sup> K <sup>-1</sup>              |

| Name                         | Symbol              | Definition             | SI unit                         |
|------------------------------|---------------------|------------------------|---------------------------------|
| coefficient of heat transfer | $h, (k, K, \alpha)$ | $h = J_q/\Delta T$     | $\text{W m}^{-2} \text{K}^{-1}$ |
| thermal diffusivity          | $a$                 | $a = \lambda/\rho c_p$ | $\text{m}^2 \text{s}^{-1}$      |
| diffusion coefficient        | $D$                 | $D = J_n/(dc/dl)$      | $\text{m}^2 \text{s}^{-1}$      |

The following symbols are used in the definitions of the dimensionless quantities: mass ( $m$ ), time ( $t$ ), volume ( $V$ ), area ( $A$ ), density ( $\rho$ ), speed ( $v$ ), length ( $l$ ), viscosity ( $\eta$ ), pressure ( $p$ ), acceleration of free fall ( $g$ ), cubic expansion coefficient ( $\alpha$ ), temperature ( $T$ ), surface tension ( $\gamma$ ), speed of sound ( $c$ ), mean free path ( $\lambda$ ), frequency ( $f$ ), thermal diffusivity ( $a$ ), coefficient of heat transfer ( $h$ ), thermal conductivity ( $k$ ), specific heat capacity at constant pressure ( $c_p$ ), diffusion coefficient ( $D$ ), mole fraction ( $x$ ), mass transfer coefficient ( $k_d$ ), permeability ( $\mu$ ), electric conductivity ( $\kappa$ ), and magnetic flux density ( $B$ ).

| Name                             | Symbol     | Definition                                                                                               | SI unit |
|----------------------------------|------------|----------------------------------------------------------------------------------------------------------|---------|
| Reynolds number                  | $Re$       | $Re = \rho v l / \eta$                                                                                   | 1       |
| Euler number                     | $Eu$       | $Eu = \Delta p / \rho v^2$                                                                               | 1       |
| Froude number                    | $Fr$       | $Fr = v / (lg)^{1/2}$                                                                                    | 1       |
| Grashof number                   | $Gr$       | $Gr = l^3 g \alpha \Delta T \rho^2 / \eta^2$                                                             | 1       |
| Weber number                     | $We$       | $We = \rho v^2 l / \gamma$                                                                               | 1       |
| Mach number                      | $Ma$       | $Ma = v / c$                                                                                             | 1       |
| Knudsen number                   | $Kn$       | $Kn = \lambda / l$                                                                                       | 1       |
| Strouhal number                  | $Sr$       | $Sr = lf / v$                                                                                            | 1       |
| Fourier number                   | $Fo$       | $Fo = at / l^2$                                                                                          | 1       |
| Péclet number                    | $Pe$       | $Pe = vl / a$                                                                                            | 1       |
| Rayleigh number                  | $Ra$       | $Ra = l^3 g \alpha \Delta T \rho / \eta a$                                                               | 1       |
| Nusselt number                   | $Nu$       | $Nu = hl / k$                                                                                            | 1       |
| Stanton number                   | $St$       | $St = h / \rho v c_p$                                                                                    | 1       |
| Fourier number for mass transfer | $Fo^*$     | $Fo^* = Dt / l^2$                                                                                        | 1       |
| Péclet number for mass transfer  | $Pe^*$     | $Pe^* = vl / D$                                                                                          | 1       |
| Grashof number for mass transfer | $Gr^*$     | $Gr^* = l^3 g \left( \frac{\partial p}{\partial x} \right)_{T,p} \left( \frac{\Delta x p}{\eta} \right)$ | 1       |
| Nusselt number for mass transfer | $Nu^*$     | $Nu^* = k_d l / D$                                                                                       | 1       |
| Stanton number for mass transfer | $St^*$     | $St^* = k_d / v$                                                                                         | 1       |
| Prandtl number                   | $Pr$       | $Pr = \eta / \rho a$                                                                                     | 1       |
| Schmidt number                   | $Sc$       | $Sc = \eta / \rho D$                                                                                     | 1       |
| Lewis number                     | $Le$       | $Le = a / D$                                                                                             | 1       |
| magnetic Reynolds number         | $Rm, Re_m$ | $Rm = v \mu \kappa l$                                                                                    | 1       |
| Alfvén number                    | $Al$       | $Al = v(\rho \mu)^{1/2} / B$                                                                             | 1       |
| Hartmann number                  | $Ha$       | $Ha = Bl (\kappa / \eta)^{1/2}$                                                                          | 1       |
| Cowling number                   | $Co$       | $Co = B^2 / \mu \rho v^2$                                                                                | 1       |

## NOMENCLATURE FOR CHEMICAL COMPOUNDS

The International Union of Pure and Applied Chemistry (IUPAC) maintains several commissions that deal with the naming of chemical substances. In general, the approach of IUPAC is to present rules for arriving at names in a systematic manner, rather than recommending a unique name for each compound. Thus there are often several alternative "IUPAC names," depending on which nomenclature system is used, each of which may have advantages in specific applications. However, each of these names will be unambiguous.

Organizations such as the Chemical Abstracts Service and the Beilstein Institute that prepare indexes to the chemical literature must adopt a system for selecting unique names in order to avoid excessive cross referencing. Chemical Abstracts Service uses a system which groups together compounds derived from a single parent compound. Thus most index names are inverted (e.g., Benzene, bromo rather than bromobenzene; Acetic acid, sodium salt rather than sodium acetate).

Recommended names for the most common substituent groups, ligands, ions, and organic rings are given in the two following tables, "Nomenclature for Inorganic Ions and Ligands" and "Organic Substituent Groups and Ring Systems." For the basics of macromolecular nomenclature, see "Nomenclature for Organic Polymers" in Section 13.

Some of the most useful recent guides to chemical nomenclature, prepared by IUPAC and other organizations such as the International Union of Biochemistry and Molecular Biology (IUBMB) and the American Chemical Society are listed below. These books contain citations to the more detailed nomenclature documents in each area. Two very useful web sites providing links to nomenclature documents are:

[www.iupac.org/publications/index.html](http://www.iupac.org/publications/index.html)  
[www.chem.qmul.ac.uk/iupac/](http://www.chem.qmul.ac.uk/iupac/)

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### Biochemistry

International Union of Biochemistry and Molecular Biology, *Biochemical Nomenclature and Related Documents, 2nd Edition*, 1992, Portland Press, London, 1993; includes recommendations of the IUPAC-IUBMB Joint Commission on Biochemical Nomenclature.

International Union of Biochemistry and Molecular Biology, *Enzyme Nomenclature*, 1992, Academic Press, Orlando, FL, 1992.

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### General

Chemical Abstracts Service, *Naming and Indexing Chemical Substances for Chemical Abstracts, Appendix IV, Chemical Abstracts 1994 Index Guide*.

*Principles of Chemical Nomenclature: a Guide to IUPAC Recommendations*, Leigh, G. J., Favre, H. A., and Metanomski, W. V., Blackwell Science, 1998.



# NOMENCLATURE FOR INORGANIC IONS AND LIGANDS

Willem H. Koppenol

The entries below were selected from Table IX of Connelly, N. G., Damhus, T., Hartshorn, R. M. and Hutton, A. T., Eds., *Nomenclature of Inorganic Chemistry. IUPAC Recommendations 2005*, The Royal Society of Chemistry, 2005. Two changes were made: in the case of the hypohalides, the oxidohalogenate names are listed, not the new halooxygenate names. Thus, for BrO<sup>-</sup> the still acceptable name “oxidobromate(1-)” is listed, not the more correct, but less palatable, “bromooxygenate(1-)”. Similarly, and for reasons of consistency, ClO<sup>•</sup> is not named oxygen (mono)chloride, but chlorine mono(o)oxide. The symbol '⊂' is used for dividing names when this is made necessary by a line break. When the name is reconstructed

from the name given in the table, this symbol should be omitted. Thus, all *hyphens* in the table are true parts of the names. The symbols ‘>’ and ‘<’ placed next to an element symbol both denote two single bonds connecting the atom in question to two other atoms. For a given compound, the various systematic names, if applicable, are given in the order: stoichiometric names, substitutive names, additive names and hydrogen names. Acceptable names which are not entirely systematic (or not formed according to any of the systems mentioned above) are given at the end after a semicolon. No order of preference is implied by the order in which formulae and names are listed. Reprinted by permission of IUPAC.

| Formula<br>for<br>uncharged<br>atom or<br>group | Name                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                  |                                                                                 |
|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
|                                                 | <i>Uncharged atoms or molecules<br/>(including zwitterions and<br/>radicals) or substituent groups<sup>a</sup></i>                                                                                                                                                                                                            | <i>Cations (including cation<br/>radicals) or cationic<br/>substituent groups<sup>a</sup></i>                                                                                                                                                                                                                           | <i>Anions (including anion<br/>radicals) or anionic substituent<br/>groups<sup>b</sup></i>                                                                                                                                                                       | <i>Ligands<sup>c</sup></i>                                                      |
| H                                               | hydrogen<br>H <sup>•</sup> , hydrogen(●), monohydrogen<br>(natural or unspecified isotopic<br>composition)<br><sup>1</sup> H <sup>•</sup> , protium(●), monoproton<br><sup>2</sup> H <sup>•</sup> = D <sup>•</sup> , deuterium(●),<br>monodeuterium<br><sup>3</sup> H <sup>•</sup> = T <sup>•</sup> , tritium(●), monotritium | hydrogen (general)<br>H <sup>+</sup> , hydrogen(1+), hydron<br>(natural or unspecified<br>isotopic composition)<br><sup>1</sup> H <sup>+</sup> , protium(1+), proton<br><sup>2</sup> H <sup>+</sup> = D <sup>+</sup> , deuterium(1+),<br>deuteron<br><sup>3</sup> H <sup>+</sup> = T <sup>+</sup> , tritium(1+), triton | hydride (general)<br>H <sup>-</sup> , hydride<br>(natural or unspecified isotopic<br>composition)<br><sup>1</sup> H <sup>-</sup> , protide<br><sup>2</sup> H <sup>-</sup> = D <sup>-</sup> , deuteride<br><sup>3</sup> H <sup>-</sup> = T <sup>-</sup> , tritide | hydrido<br><br><br><br>protido<br>deuterido<br>tritido                          |
| H <sub>2</sub>                                  | H <sub>2</sub> , dihydrogen<br>D <sub>2</sub> , dideuterium<br>T <sub>2</sub> , ditritium                                                                                                                                                                                                                                     | H <sub>2</sub> <sup>••</sup> , dihydrogen(●1+)<br><sup>1</sup> H <sub>2</sub> <sup>••</sup> , diprotium(●1+)<br>D <sub>2</sub> <sup>••</sup> , dideuterium(●1+)<br>T <sub>2</sub> <sup>••</sup> , ditritium(●1+)                                                                                                        |                                                                                                                                                                                                                                                                  |                                                                                 |
| D, see H                                        |                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                  |                                                                                 |
| D <sub>2</sub> , see H <sub>2</sub>             |                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                  |                                                                                 |
| T, see H                                        |                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                  |                                                                                 |
| T <sub>2</sub> , see H <sub>2</sub>             |                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                  |                                                                                 |
| F                                               | fluorine<br>F <sup>•</sup> , fluorine(●), monofluorine<br>-F, fluoro                                                                                                                                                                                                                                                          | fluorine (general)<br>F <sup>+</sup> , fluorine(1+)                                                                                                                                                                                                                                                                     | fluoride (general)<br>F <sup>-</sup> , fluoride(1-); fluoride                                                                                                                                                                                                    | fluorido (general)<br>F <sup>-</sup> , fluorido(1-); fluorido                   |
| F <sub>2</sub>                                  | F <sub>2</sub> , difluorine                                                                                                                                                                                                                                                                                                   | F <sub>2</sub> <sup>••</sup> , difluorine(●1+)                                                                                                                                                                                                                                                                          | F <sub>2</sub> <sup>•-</sup> , difluoride(●1-)                                                                                                                                                                                                                   | F <sub>2</sub> , difluorine                                                     |
| Cl                                              | chlorine (general)<br>Cl <sup>•</sup> , chlorine(●), monochlorine<br>-Cl, chloro                                                                                                                                                                                                                                              | chlorine (general)<br>Cl <sup>+</sup> , chlorine(1+)                                                                                                                                                                                                                                                                    | chloride (general)<br>Cl <sup>-</sup> , chloride(1-); chloride                                                                                                                                                                                                   | chlorido (general)<br>Cl <sup>-</sup> , chlorido(1-); chlorido                  |
| Cl <sub>2</sub>                                 | Cl <sub>2</sub> , dichlorine                                                                                                                                                                                                                                                                                                  | Cl <sub>2</sub> <sup>••</sup> , dichlorine(●1+)                                                                                                                                                                                                                                                                         | Cl <sub>2</sub> <sup>•-</sup> , dichloride(●1-)                                                                                                                                                                                                                  | Cl <sub>2</sub> , dichlorine<br>Cl <sub>2</sub> <sup>•-</sup> , dichlorido(●1-) |
| Br                                              | bromine (general)<br>Br <sup>•</sup> , bromine(●), monobromine<br>-Br, bromo                                                                                                                                                                                                                                                  | bromine (general)<br>Br <sup>+</sup> , bromine(1+)                                                                                                                                                                                                                                                                      | bromide (general)<br>Br <sup>-</sup> , bromide(1-); bromide                                                                                                                                                                                                      | bromido (general)<br>Br <sup>-</sup> , bromido(1-); bromido                     |
| Br <sub>2</sub>                                 | Br <sub>2</sub> , dibromine                                                                                                                                                                                                                                                                                                   | Br <sub>2</sub> <sup>••</sup> , dibromine(●1+)                                                                                                                                                                                                                                                                          | Br <sub>2</sub> <sup>•-</sup> , dibromide(●1-)                                                                                                                                                                                                                   | Br <sub>2</sub> , dibromine                                                     |
| I                                               | iodine (general)<br>I <sup>•</sup> , iodine(●), monoiodine<br>-I, iodo                                                                                                                                                                                                                                                        | iodine (general)<br>I <sup>+</sup> , iodine(1+)                                                                                                                                                                                                                                                                         | iodide (general)<br>I <sup>-</sup> , iodide(1-); iodide                                                                                                                                                                                                          | iodido (general)<br>I <sup>-</sup> , iodido(1-); iodido                         |
| I <sub>2</sub>                                  | I <sub>2</sub> , diiodine                                                                                                                                                                                                                                                                                                     | I <sub>2</sub> <sup>••</sup> , diiodine(●1+)                                                                                                                                                                                                                                                                            | I <sub>2</sub> <sup>•-</sup> , diiodide(●1-)                                                                                                                                                                                                                     | I <sub>2</sub> , diiodine                                                       |

|                  |                                                                                                                                                                                                                                                                                  |                                                                                                                                       |                                                                                                                                                                         |                                                                                                                                                                                      |
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| ClO              | ClO, chlorine mon(o)oxide<br>ClO <sup>•</sup> , oxidochlorine(•);<br>chlorosyl<br>–ClO, oxo-λ <sup>3</sup> -chloranyl;<br>chlorosyl<br>–OCl, chlorooxy                                                                                                                           |                                                                                                                                       | ClO <sup>–</sup> , oxidochlorate(1–);<br>hypochlorite                                                                                                                   | ClO <sup>–</sup> , oxidochlorato(1–);<br>hypochlorito                                                                                                                                |
| ClO <sub>2</sub> | ClO <sub>2</sub> , chlorine dioxide<br>ClO <sub>2</sub> <sup>•</sup> , dioxidochlorine(•)<br>ClOO <sup>•</sup> , chloridodioxygen $\curvearrowright$<br>(O–O) (•),<br>–ClO <sub>2</sub> , dioxo-λ <sup>3</sup> -chloranyl;<br>chloryl<br>–OClO, oxo-λ <sup>3</sup> -chloranyloxy | ClO <sub>2</sub> <sup>+</sup> , dioxidochlorine(1+)<br>(not chloryl)                                                                  | ClO <sub>2</sub> <sup>–</sup> , dioxidochlorate(1–);<br>chlorite                                                                                                        | ClO <sub>2</sub> <sup>–</sup> , dioxidochlorato(1–);<br>chlorito                                                                                                                     |
| ClO <sub>3</sub> | ClO <sub>3</sub> , chlorine trioxide<br>ClO <sub>3</sub> <sup>•</sup> , trioxidochlorine(•)<br>–ClO <sub>3</sub> , trioxo-λ <sup>7</sup> -chloranyl;<br>perchloryl<br>–OClO <sub>2</sub> , dioxo-λ <sup>5</sup> -chloranyloxy                                                    | ClO <sub>3</sub> <sup>+</sup> , trioxidochlorine(1+)<br>(not perchloryl)                                                              | ClO <sub>3</sub> <sup>–</sup> , trioxidochlorate(1–);<br>chlorate                                                                                                       | ClO <sub>3</sub> <sup>–</sup> , trioxidochlorato(1–);<br>chlorato                                                                                                                    |
| ClO <sub>4</sub> | ClO <sub>4</sub> , chlorine tetraoxide<br>ClO <sub>4</sub> <sup>•</sup> , tetraoxidochlorine(•)<br>–OClO <sub>3</sub> , trioxo-λ <sup>7</sup> -chloranyloxy                                                                                                                      |                                                                                                                                       | ClO <sub>4</sub> <sup>–</sup> , tetraoxidochlorate(1–);<br>perchlorate                                                                                                  | ClO <sub>4</sub> <sup>–</sup> , tetraoxidochlorato(1–);<br>perchlorato                                                                                                               |
| IO               | IO, iodine mon(o)oxide<br>IO <sup>•</sup> , oxidiodine(•); iodosyl<br>–IO, oxo-λ <sup>3</sup> -iodanyl; iodosyl<br>–OI, iodoxy                                                                                                                                                   | IO <sup>+</sup> , oxidiodine(1+)<br>(not iodosyl)                                                                                     | IO <sup>–</sup> , oxidiodate(1–); hypoiodite<br>IO <sup>2–</sup> , oxidiodate(•2–)                                                                                      | IO <sup>–</sup> , oxidiodato(1–);<br>hypoiodito                                                                                                                                      |
| IO <sub>2</sub>  | IO <sub>2</sub> , iodine dioxide<br>IO <sub>2</sub> <sup>•</sup> , dioxidoiodine(•)<br>–IO <sub>2</sub> , dioxo-λ <sup>3</sup> -iodanyl; iodyl<br>–OIO, oxo-λ <sup>3</sup> -iodanyloxy                                                                                           | IO <sub>2</sub> <sup>+</sup> , dioxidoiodine(1+)<br>(not iodyl)                                                                       | IO <sub>2</sub> <sup>–</sup> , dioxidoiodate(1–); iodite                                                                                                                | IO <sub>2</sub> <sup>–</sup> , dioxidoiodato(1–); iodito                                                                                                                             |
| IO <sub>3</sub>  | IO <sub>3</sub> , iodine trioxide<br>IO <sub>3</sub> <sup>•</sup> , trioxidoiodine(•)<br>–IO <sub>3</sub> , trioxo-λ <sup>7</sup> -iodanyl; periodyl<br>–OIO <sub>2</sub> , dioxo-λ <sup>5</sup> -iodanyloxy                                                                     | IO <sub>3</sub> <sup>+</sup> , trioxidoiodine(1+)<br>(not periodyl)                                                                   | IO <sub>3</sub> <sup>–</sup> , trioxidoiodate(1–); iodate                                                                                                               | IO <sub>3</sub> <sup>–</sup> , trioxidoiodato(1–); iodato                                                                                                                            |
| IO <sub>4</sub>  | IO <sub>4</sub> , iodine tetraoxide<br>IO <sub>4</sub> <sup>•</sup> , tetraoxidoiodine(•)<br>–OIO <sub>3</sub> , trioxo-λ <sup>7</sup> -iodanyloxy                                                                                                                               |                                                                                                                                       | IO <sub>4</sub> <sup>–</sup> , tetraoxidoiodate(1–);<br>periodate                                                                                                       | IO <sub>4</sub> <sup>–</sup> , tetraoxidoiodato(1–);<br>periodato                                                                                                                    |
| O                | oxygen (general)<br>O, monooxygen<br>O <sup>2•</sup> , oxidanylidene,<br>monooxygen(2•)<br>>O, oxy, epoxy (in rings)<br>=O, oxo                                                                                                                                                  | oxygen (general)<br>O <sup>•+</sup> , oxygen(•1+)                                                                                     | oxide (general)<br>O <sup>•–</sup> , oxidanidyl, oxide(•1–)<br>O <sup>2–</sup> , oxide(2–); oxide<br>–O <sup>•</sup> , oxido                                            | O <sup>2–</sup> , oxido                                                                                                                                                              |
| O <sub>2</sub>   | O <sub>2</sub> , dioxygen<br>O <sub>2</sub> <sup>2•</sup> , dioxidanediyl,<br>dioxygen(2•)<br>–OO–, dioxidanediyl; peroxy                                                                                                                                                        | O <sub>2</sub> <sup>•+</sup> , dioxidanylumyl,<br>dioxygen(•1+)<br>O <sub>2</sub> <sup>2+</sup> , dioxidanebis(ylum),<br>dioxygen(2+) | O <sub>2</sub> <sup>•–</sup> , dioxidanidyl,<br>dioxide(•1–); superoxide<br>(not hyperoxide)<br>O <sub>2</sub> <sup>2–</sup> , dioxidanediide,<br>dioxide(2–); peroxide | dioxido (general)<br>O <sub>2</sub> , dioxygen<br>O <sub>2</sub> <sup>•–</sup> , dioxido(•1–); superoxido<br>O <sub>2</sub> <sup>2–</sup> , dioxidanediido,<br>dioxido(2–); peroxido |
| O <sub>3</sub>   | O <sub>3</sub> , trioxygen; ozone<br>–OOO–, trioxidanediyl                                                                                                                                                                                                                       |                                                                                                                                       | O <sub>3</sub> <sup>•–</sup> , trioxidanidyl,<br>trioxide(•1–); ozonide                                                                                                 | O <sub>3</sub> , trioxygen; ozone<br>O <sub>3</sub> <sup>•–</sup> , trioxido(•1–); ozonido                                                                                           |
| HO               | HO <sup>•</sup> , oxidanyl,<br>hydridooxygen(•); hydroxyl<br>–OH, oxidanyl; hydroxy                                                                                                                                                                                              | HO <sup>+</sup> , oxidanylium,<br>hydridooxygen(1+);<br>hydroxylum                                                                    | HO <sup>–</sup> , oxidanide, hydroxide                                                                                                                                  | HO <sup>–</sup> , oxidanido; hydroxido                                                                                                                                               |
| HO <sub>2</sub>  | HO <sub>2</sub> <sup>•</sup> , dioxidanyl,<br>hydridodioxygen(•)<br>hydrogen dioxide<br>–OOH, dioxidanyl;<br>hydroperoxy                                                                                                                                                         | HO <sub>2</sub> <sup>+</sup> , dioxidanylum,<br>hydridodioxygen(1+)                                                                   | HO <sub>2</sub> <sup>–</sup> , dioxidanide,<br>hydrogen(peroxide)(1–)                                                                                                   | HO <sub>2</sub> <sup>–</sup> , dioxidanido,<br>hydrogen(peroxido)(1–)                                                                                                                |
| S                | sulfur (general)<br>S, monosulfur<br>=S, sulfanylidene; thioxo<br>–S–, sulfanediyl                                                                                                                                                                                               | sulfur (general)<br>S <sup>•</sup> , sulfur(1+)                                                                                       | sulfide (general)<br>S <sup>•–</sup> , sulfanidyl, sulfide(•1–)<br>S <sup>2–</sup> , sulfanediide, sulfide(2–);<br>sulfide<br>–S <sup>•</sup> , sulfido                 | sulfido (general)<br>S <sup>•–</sup> , sulfanidyl, sulfido(•1–)<br>S <sup>2–</sup> , sulfanediido, sulfido(2–)                                                                       |

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| S <sub>2</sub>                | S <sub>2</sub> , disulfur<br>–SS–, disulfanediyl<br>>S=S, sulfanylidene-λ <sup>4</sup> -sulfanediyl; sulfinothioyl                                | S <sub>2</sub> <sup>•+</sup> , disulfur(•1+)                                                                                                                    | S <sub>2</sub> <sup>•–</sup> , disulfanidyl, disulfide(•1–)<br>S <sub>2</sub> <sup>2–</sup> , disulfide(2–), disulfanediide<br>–SS–, disulfanidyl                                                                                                                                                                                                     | S <sub>2</sub> <sup>2–</sup> , disulfido(2–), disulfanediido                                                                                                                           |
| HS                            | HS <sup>•</sup> , sulfanyl, hydridosulfur(•)<br>–SH, sulfanyl                                                                                     | HS <sup>+</sup> , sulfanylium, hydridosulfur(1+)                                                                                                                | HS <sup>–</sup> , sulfanide, hydrogen(sulfide)(1–)                                                                                                                                                                                                                                                                                                    | HS <sup>–</sup> , sulfanido, hydrogen(sulfido)(1–)                                                                                                                                     |
| SO                            | SO, sulfur mon(o)oxide<br>[SO], oxidosulfur<br>>SO, oxo-λ <sup>4</sup> -sulfanediyl; sulfinyl                                                     | SO <sup>•+</sup> , oxidosulfur(•1+)<br>( <i>not</i> sulfinyl or thionyl)                                                                                        | SO <sup>•–</sup> , oxidosulfate(•1–)                                                                                                                                                                                                                                                                                                                  | [SO], oxidosulfur                                                                                                                                                                      |
| SO <sub>2</sub>               | SO <sub>2</sub> , sulfur dioxide<br>[SO <sub>2</sub> ], dioxidosulfur<br>>SO <sub>2</sub> , dioxo-λ <sup>6</sup> -sulfanediyl; sulfuryl, sulfonyl |                                                                                                                                                                 | SO <sub>2</sub> <sup>•–</sup> , dioxidosulfate(•1–)<br>SO <sub>2</sub> <sup>2–</sup> , dioxidosulfate(2–), sulfanediolate                                                                                                                                                                                                                             | [SO <sub>2</sub> ], dioxidosulfur<br>SO <sub>2</sub> <sup>2–</sup> , dioxidosulfato(2–), sulfanediolato                                                                                |
| SO <sub>3</sub>               | SO <sub>3</sub> , sulfur trioxide                                                                                                                 |                                                                                                                                                                 | SO <sub>3</sub> <sup>•–</sup> , trioxidosulfate(•1–)<br>SO <sub>3</sub> <sup>2–</sup> , trioxidosulfate(2–); sulfite<br>–S(O) <sub>2</sub> (O–), oxidodioxo-λ <sup>6</sup> -sulfanyl; sulfonato                                                                                                                                                       | SO <sub>3</sub> <sup>2–</sup> , trioxidosulfato(2–); sulfito                                                                                                                           |
| SO <sub>4</sub>               | –OS(O) <sub>2</sub> O–, sulfonylbis(oxy)                                                                                                          |                                                                                                                                                                 | SO <sub>4</sub> <sup>•–</sup> , tetraoxidosulfate(•1–)<br>SO <sub>4</sub> <sup>2–</sup> , tetraoxidosulfate(2–); sulfate                                                                                                                                                                                                                              | SO <sub>4</sub> <sup>2–</sup> , tetraoxidosulfato(2–); sulfato                                                                                                                         |
| S <sub>2</sub> O <sub>3</sub> |                                                                                                                                                   |                                                                                                                                                                 | S <sub>2</sub> O <sub>3</sub> <sup>•–</sup> = SO <sub>3</sub> S <sup>•–</sup> , trioxido-1κ <sup>3</sup> O-disulfate(S–S)(•1–), trioxidosulfidosulfate(•1–)<br>S <sub>2</sub> O <sub>3</sub> <sup>2–</sup> = SO <sub>3</sub> S <sup>2–</sup> , trioxido-1κ <sup>3</sup> O-disulfate(S–S)(2–), trioxidosulfidosulfate(2–); thiosulfate, sulfurothioate | S <sub>2</sub> O <sub>3</sub> <sup>2–</sup> = SO <sub>3</sub> S <sup>2–</sup> , trioxido-1κ <sup>3</sup> O-disulfate(S–S)(2–), trioxidosulfidosulfato(2–); thiosulfato, sulfurothioato |
| Se                            | Se (general)<br>Se, monoselenium<br>>Se, selanediyl<br>=Se, selanylidene; selenoxo                                                                | selenium                                                                                                                                                        | selenide (general)<br>Se <sup>•–</sup> , selanidyl, selenide(•1–)<br>Se <sup>2–</sup> , selanediide, selenide(2–); selenide                                                                                                                                                                                                                           | selenido (general)<br>Se <sup>•–</sup> , selanidyl, selenido(•1–)<br>Se <sup>2–</sup> , selanediido, selenido(2–)                                                                      |
| SeO                           | SeO, selenium mon(o)oxide<br>[SeO], oxidoselenium<br>>SeO, seleninyl                                                                              |                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                       | [SeO], oxidoselenium                                                                                                                                                                   |
| SeO <sub>2</sub>              | SeO <sub>2</sub> , selenium dioxide<br>[SeO <sub>2</sub> ], dioxidoselenium<br>>SeO <sub>2</sub> , selenonyl                                      |                                                                                                                                                                 | SeO <sub>2</sub> <sup>2–</sup> , dioxidoselenate(2–)                                                                                                                                                                                                                                                                                                  | [SeO <sub>2</sub> ], dioxidoselenium<br>SeO <sub>2</sub> <sup>2–</sup> , dioxidoselenato(2–)                                                                                           |
| SeO <sub>3</sub>              | SeO <sub>3</sub> , selenium trioxide                                                                                                              |                                                                                                                                                                 | SeO <sub>3</sub> <sup>•–</sup> , trioxidoselenate(•1–)<br>SeO <sub>3</sub> <sup>2–</sup> , trioxidoselenate(2–); selenite                                                                                                                                                                                                                             | SeO <sub>3</sub> <sup>2–</sup> , trioxidoselenato(2–); selenito                                                                                                                        |
| SeO <sub>4</sub>              |                                                                                                                                                   |                                                                                                                                                                 | SeO <sub>4</sub> <sup>2–</sup> , tetraoxidoselenate(2–); selenate                                                                                                                                                                                                                                                                                     | SeO <sub>4</sub> <sup>2–</sup> , tetraoxidoselenato(2–); selenato                                                                                                                      |
| Te                            | tellurium<br>>Te, tellanediyl<br>=Te, tellanylidene; telluroxo                                                                                    | tellurium                                                                                                                                                       | telluride (general)<br>Te <sup>•–</sup> , tellanidyl, telluride(•1–)<br>Te <sup>2–</sup> , tellanediide, telluride(2–); telluride                                                                                                                                                                                                                     | tellurido (general)<br>Te <sup>•–</sup> , tellanidyl, tellurido(•1–)<br>Te <sup>2–</sup> , tellanediido, tellurido(2–)                                                                 |
| CrO <sub>2</sub>              | CrO <sub>2</sub> , chromium dioxide, chromium(IV) oxide                                                                                           |                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                        |
| UO <sub>2</sub>               | UO <sub>2</sub> , uranium dioxide                                                                                                                 | UO <sub>2</sub> <sup>+</sup> , dioxidouranium(1+)<br>[ <i>not</i> uranyl(1+)]<br>UO <sub>2</sub> <sup>2+</sup> , dioxidouranium(2+)<br>[ <i>not</i> uranyl(2+)] |                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                        |

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| NpO <sub>2</sub>              | NpO <sub>2</sub> , neptunium dioxide                                                                                                                                                                                                                                                                                     | NpO <sub>2</sub> <sup>+</sup> ,<br>dioxidoneptunium(1+)<br>[not neptunyl(1+)]<br>NpO <sub>2</sub> <sup>2+</sup> ,<br>dioxidoneptunium(2+)<br>[not neptunyl(2+)] |                                                                                                                                                                 |                                                                                                                                                                                                                         |
| PuO <sub>2</sub>              | PuO <sub>2</sub> , plutonium dioxide                                                                                                                                                                                                                                                                                     | PuO <sub>2</sub> <sup>+</sup> ,<br>dioxidoplutonium(1+)<br>[not plutonyl(1+)]<br>PuO <sub>2</sub> <sup>2+</sup> ,<br>dioxidoplutonium(2+)<br>[not plutonyl(2+)] |                                                                                                                                                                 |                                                                                                                                                                                                                         |
| N                             | nitrogen<br>N <sup>•</sup> , nitrogen(•), mononitrogen<br>–N<, azanetriyl; nitrilo<br>–N=, azanylylidene<br>≡N, azanylidyne                                                                                                                                                                                              | nitrogen (general)<br>N <sup>+</sup> , nitrogen(1+)                                                                                                             | nitride (general)<br>N <sup>3-</sup> , nitride(3–), azanetriide;<br>nitride<br>=N <sup>–</sup> , azanidyldene; amidylidene<br>–N <sup>2-</sup> , azanediidyl    | N <sup>3-</sup> , nitrido(3–), azanetriido                                                                                                                                                                              |
| N <sub>2</sub>                | N <sub>2</sub> , dinitrogen<br>=N <sup>+</sup> =N <sup>–</sup> , (azanidyldene)azanilylidene; diazo<br>–N=N–, diazene-1,2-diylidene;<br>hydrazinediylidene<br>=NN=, diazene-1,2-diyl; azo                                                                                                                                | N <sub>2</sub> <sup>••</sup> , dinitrogen(1+)<br>N <sub>2</sub> <sup>2+</sup> , dinitrogen(2+)<br>–N <sup>+</sup> ≡N, diazyn-1-ium-1-yl                         | N <sub>2</sub> <sup>2-</sup> , dinitride(2–)<br>N <sub>2</sub> <sup>4-</sup> , dinitride(4–),<br>diazanetetraide;<br>hydrazinetetraide                          | N <sub>2</sub> , dinitrogen<br>N <sub>2</sub> <sup>2-</sup> , dinitrido(2–)<br>N <sub>2</sub> <sup>4-</sup> , dinitrido(4–),<br>diazanetetraido;<br>hydrazinetetraido                                                   |
| N <sub>3</sub>                | N <sub>3</sub> <sup>•</sup> , trinitrogen(•)<br>–N=N <sup>+</sup> =N <sup>–</sup> , azido                                                                                                                                                                                                                                |                                                                                                                                                                 | N <sub>3</sub> <sup>–</sup> , trinitride(1–); azide                                                                                                             | N <sub>3</sub> <sup>–</sup> , trinitrido(1–); azido                                                                                                                                                                     |
| NH                            | NH <sup>•</sup> , azanylidene,<br>hydridonitrogen(2•); nitrene<br>>NH, azanediyl<br>=NH, azanylidene; imino                                                                                                                                                                                                              | NH <sup>+</sup> , azanyliumdiyl,<br>hydridonitrogen(1+)<br>NH <sup>2+</sup> , azanebis(ylum),<br>hydridonitrogen(2+)                                            | NH <sup>–</sup> , azanidyl,<br>hydridonitrate(1–)<br>NH <sup>2-</sup> , azanediide,<br>hydridonitrate(2–); imide<br>–NH <sup>–</sup> , azanidyl; amidyl         | NH <sup>2-</sup> , azanediido,<br>hydridonitrato(2–); imido                                                                                                                                                             |
| NH <sub>2</sub>               | NH <sub>2</sub> <sup>•</sup> , azanyl,<br>dihydridonitrogen(•); aminyl<br>–NH <sub>2</sub> , azanyl; amino                                                                                                                                                                                                               | NH <sub>2</sub> <sup>+</sup> , azanylium,<br>dihydridonitrogen(1+)                                                                                              | NH <sub>2</sub> <sup>–</sup> , azanide,<br>dihydridonitrate(1–); amide                                                                                          | NH <sub>2</sub> <sup>–</sup> , azanido,<br>dihydridonitrato(1–), amido                                                                                                                                                  |
| NH <sub>3</sub>               | NH <sub>3</sub> , azane (parent hydride name), amine (parent name for certain organic derivatives), trihydridonitrogen; ammonia                                                                                                                                                                                          | NH <sub>3</sub> <sup>••</sup> , azaniumyl,<br>trihydridonitrogen(•1+)<br>–NH <sub>3</sub> <sup>+</sup> , azaniumyl;<br>ammonio                                  | NH <sub>3</sub> <sup>–</sup> , azanuidyl,<br>trihydridonitrate(•1–)                                                                                             | NH <sub>3</sub> , ammine                                                                                                                                                                                                |
| NH <sub>4</sub>               | NH <sub>4</sub> <sup>+</sup> , λ <sup>5</sup> -azanyl,<br>tetrahydridonitrogen(•)                                                                                                                                                                                                                                        | NH <sub>4</sub> <sup>+</sup> , azanium; ammonium                                                                                                                |                                                                                                                                                                 |                                                                                                                                                                                                                         |
| H <sub>2</sub> NO             | H <sub>2</sub> NO <sup>•</sup> , aminooxidanyl,<br>dihydridooxidonitrogen(•);<br>aminoxyl<br>HONH <sup>•</sup> , hydroxyazanyl,<br>hydridohydroxidonitrogen(•)<br>–NH(OH), hydroxyazanyl,<br>hydroxyamino<br>–ONH <sub>2</sub> , aminooxy<br>–NH <sub>2</sub> (O), oxo-λ <sup>5</sup> -azanyl;<br>azinoyl                |                                                                                                                                                                 | HONH <sup>–</sup> , hydroxyazanide,<br>hydridohydroxidonitrate(1–)<br>H <sub>2</sub> NO <sup>–</sup> , azanolate,<br>aminooxidane,<br>dihydridooxidonitrate(1–) | NHOH <sup>–</sup> , hydroxyazanido,<br>hydridohydroxidonitrato(1–)<br>H <sub>2</sub> NO <sup>–</sup> , azanolato,<br>aminooxidano,<br>dihydridooxidonitrato(1–)                                                         |
| N <sub>2</sub> H <sub>2</sub> | HN=NH, diazene<br>–N=NH <sub>2</sub> <sup>+</sup> , diazen-2-ium-1-ido<br>H <sub>2</sub> NN <sup>•</sup> , diazanylidene,<br>hydrazinylidene<br>=NNH <sub>2</sub> , diazanylidene;<br>hydrazinylidene<br>•HNNH <sup>•</sup> , diazene-1,2-diyl;<br>hydrazine-1,2-diyl<br>–HNNH–, diazene-1,2-diyl;<br>hydrazine-1,2-diyl | HNNH <sup>2+</sup> , diazynydiium                                                                                                                               | HNNH <sup>2-</sup> , diazene-1,2-diide,<br>hydrazine-1,2-diide<br>H <sub>2</sub> NN <sup>2-</sup> , diazene-1,1-diide,<br>hydrazine-1,1-diide                   | HN=NH, diazene<br>–N=NH <sub>2</sub> <sup>+</sup> , diazen-2-ium-1-ido<br>HNNH <sup>2-</sup> , diazene-1,2-diido,<br>hydrazine-1,2-diido<br>H <sub>2</sub> NN <sup>2-</sup> , diazene-1,1-diido,<br>hydrazine-1,1-diido |

|               |                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                           |                                                                                                                                                         |                                                                                                                                                        |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| $N_2H_3$      | $H_2NNH^+$ , diazanyl, trihydrido $\curvearrowright$ dinitrogen( <i>N–N</i> )( $\bullet$ ); hydrazinyl<br>– $NHNH_2$ , diazanyl; hydrazinyl<br>$^2-NNH_3^+$ , diazan-2-ium-1,1-diide                                                                                                                                                                               | $H_2N=NH^+$ , diazenium                                                                                                                                   | $H_2NNH^-$ , diazanide, hydrazinide                                                                                                                     | $^2-NNH_3^+$ , diazan-2-ium-1,1-diido<br>$H_2NNH^-$ , diazanido, hydrazinido                                                                           |
| $N_2H_4$      | $H_2NNH_2$ , diazane (parent hydride name), hydrazine (parent name for organic derivatives)<br>– $NHNH_3^+$ , diazan-2-ium-1-ide                                                                                                                                                                                                                                   | $H_2NNH_2^{++}$ , diazaniumyl, bis(dihydridonitrogen) $\curvearrowright$ ( <i>N–N</i> )( $\bullet 1+$ ); hydraziniumyl<br>$H_2N=NH_2^{2+}$ , diazenediium |                                                                                                                                                         | $H_2NNH_2$ , diazane, hydrazine<br>– $NHNH_3^+$ , diazan-2-ium-1-ido                                                                                   |
| NO            | NO, nitrogen mon(o)oxide ( <i>not</i> nitric oxide)<br>NO $^+$ , oxoazanyl, oxidonitrogen( $\bullet$ ); nitrosyl<br>–N=O, oxoazanyl; nitroso<br>>N(O) $^-$ , oxo- $\lambda^5$ -azanyl; azoryl<br>=N(O) $^-$ , oxo- $\lambda^5$ -azanylidene; azorylidene<br>$\equiv$ N(O), oxo- $\lambda^5$ -azanylidyne; azorylidyne<br>–O $^+$ =N $^-$ , azanidyldeneoxidaniumyl | NO $^+$ , oxidonitrogen(1+)<br>( <i>not</i> nitrosyl)<br>NO $^{2+}$ , oxidonitrogen(2+)                                                                   | NO $^-$ , oxidonitrate(1–)<br>NO $^{2+}$ , oxidonitrate(2 $\bullet$ 1–)                                                                                 | NO, oxidonitrogen (general); nitrosyl = oxidonitrogen- $\kappa$ N (general)<br>NO $^+$ , oxidonitrogen(1+)<br>NO $^-$ , oxidonitrato(1–)               |
| NO $_2$       | NO $_2$ , nitrogen dioxide<br>NO $_2^+$ = ONO $^+$ , nitrosooxidanyl, dioxidonitrogen( $\bullet$ ); nitryl<br>–NO $_2$ , nitro<br>–ONO, nitrosooxy                                                                                                                                                                                                                 | NO $_2^+$ , dioxidonitrogen(1+)<br>( <i>not</i> nitryl)                                                                                                   | NO $_2^-$ , dioxidonitrate(1–); nitrite<br>NO $_2^{*2-}$ , dioxidonitrate( $\bullet$ 2–)                                                                | NO $_2^-$ , dioxidonitrato(1–); nitrito<br>NO $_2^{*2-}$ , dioxidonitrato( $\bullet$ 2–)                                                               |
| NO $_3$       | NO $_3$ , nitrogen trioxide<br>NO $_3^+$ = O $_2$ NO $^+$ , nitrooxidanyl, trioxidonitrogen( $\bullet$ )<br>ONOO $^+$ , nitrosodioxidanyl, (dioxido)oxidonitrogen( $\bullet$ )<br>–ONO $_2$ , nitrooxy                                                                                                                                                             |                                                                                                                                                           | NO $_3^-$ , trioxidonitrate(1–); nitrate<br>NO $_3^{*2-}$ , trioxidonitrate( $\bullet$ 2–)<br>[NO(OO)] $^-$ , (dioxido)oxidonitrate(1–); peroxy nitrite | NO $_3^-$ , trioxidonitrato(1–); nitrato<br>NO $_3^{*2-}$ , trioxidonitrato( $\bullet$ 2–)<br>[NO(OO)] $^-$ , oxidoperoxidonitrato(1–); peroxy nitrito |
| N $_2$ O      | N $_2$ O, dinitrogen oxide ( <i>not</i> nitrous oxide)<br>NNO, oxidodinitrogen( <i>N–N</i> )<br>–N(O)=N $^-$ , azoxy                                                                                                                                                                                                                                               |                                                                                                                                                           | N $_2$ O $^+$ , oxidodinitrate( $\bullet$ 1–)                                                                                                           | N $_2$ O, dinitrogen oxide (general)<br>NNO, oxidodinitrogen( <i>N–N</i> )<br>N $_2$ O $^+$ , oxidodinitrato( $\bullet$ 1–)                            |
| N $_2$ O $_3$ | N $_2$ O $_3$ , dinitrogen trioxide<br>O $_2$ NNO, trioxido-1 $\kappa^2$ O,2 $\kappa$ O-dinitrogen( <i>N–N</i> )<br>NO $^+$ NO $_2^-$ , oxidonitrogen(1+)<br>dioxidonitrate(1–)<br>ONONO, dinitrosooxidane, $\mu$ -oxidobis(oxidonitrogen)                                                                                                                         |                                                                                                                                                           | N $_2$ O $_3^{2-}$ = [O $_2$ NNO] $^{2-}$ , trioxido-1 $\kappa^2$ O,2 $\kappa$ O-dinitrate( <i>N–N</i> )(2–)                                            |                                                                                                                                                        |
| N $_2$ O $_4$ | N $_2$ O $_4$ , dinitrogen tetraoxide<br>O $_2$ NNO $_2$ , bis(dioxidonitrogen) $\curvearrowright$ ( <i>N–N</i> )<br>ONOOONO, 1,2-dinitrosodioxidane, 2,5-diazy-1,3,4,6-tetraoxy-[6]catena<br>NO $^+$ NO $_3^-$ , oxidonitrogen(1+)<br>trioxidonitrate(1–)                                                                                                         |                                                                                                                                                           |                                                                                                                                                         |                                                                                                                                                        |
| N $_2$ O $_5$ | N $_2$ O $_5$ , dinitrogen pentaoxide<br>O $_3$ NONO $_2$ , dinitrooxidane, NO $_2^+$ NO $_3^-$ , dioxidonitrogen(1+)<br>trioxidonitrate(1–)                                                                                                                                                                                                                       |                                                                                                                                                           |                                                                                                                                                         |                                                                                                                                                        |
| NS            | NS, nitrogen monosulfide<br>NS $^+$ , sulfidonitrogen( $\bullet$ )<br>–N=S, sulfanylideneazanyl; thionitroso                                                                                                                                                                                                                                                       | NS $^+$ , sulfidonitrogen(1+)<br>( <i>not</i> thionitrosyl)                                                                                               | NS $^-$ , sulfidonitrate(1–)                                                                                                                            | NS, sulfidonitrogen, sulfidonitrato, thionitrosyl (general)<br>NS $^+$ , sulfidonitrogen(1+)<br>NS $^-$ , sulfidonitrato(1–)                           |

|                  |                                                                                                                                                                                                                                                                                                    |                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                        |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P                | phosphorus (general)<br>P <sup>•</sup> , phosphorus(•),<br>monophosphorus<br>>P–, phosphanetriyl                                                                                                                                                                                                   | phosphorus (general)<br>P <sup>+</sup> , phosphorus(1+)                   | phosphide (general)<br>P <sup>–</sup> , phosphide(1–)<br>P <sup>3–</sup> , phosphide(3–),<br>phosphanetriide; phosphide                                                                                                                                                                                                                                                                                                                                               | P <sup>3–</sup> , phosphido, phosphanetriido                                                                                                                                           |
| PO               | PO <sup>•</sup> , oxophosphanyl,<br>oxidophosphorus(•), phosphorus<br>mon(o)oxide; phosphoryl<br>>P(O)–, oxo-λ <sup>5</sup> -phosphanetriyl;<br>phosphoryl<br>=P(O)–,<br>oxo-λ <sup>5</sup> -phosphanylidene;<br>phosphorylidene<br>≡P(O), oxo-λ <sup>5</sup> -phosphanylidyne;<br>phosphorylidyne | PO <sup>+</sup> , oxidophosphorus(1+)<br>( <i>not</i> phosphoryl)         | PO <sup>–</sup> , oxidophosphate(1–)                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                        |
| PO <sub>2</sub>  | –P(O) <sub>2</sub> , dioxo-λ <sup>5</sup> -phosphanyl                                                                                                                                                                                                                                              |                                                                           | PO <sub>2</sub> <sup>–</sup> , dioxidophosphate(1–)                                                                                                                                                                                                                                                                                                                                                                                                                   | PO <sub>2</sub> <sup>–</sup> , dioxidophosphato(1–)                                                                                                                                    |
| PO <sub>3</sub>  |                                                                                                                                                                                                                                                                                                    |                                                                           | PO <sub>3</sub> <sup>–</sup> , trioxidophosphate(1–)<br>PO <sub>3</sub> <sup>•2–</sup> , trioxidophosphate(•2–)<br>PO <sub>3</sub> <sup>3–</sup> , trioxidophosphate(3–);<br>phosphite<br>(PO <sub>3</sub> <sup>–</sup> ) <sub>n</sub> = {P(O) <sub>2</sub> O} <sub>n</sub> <sup>n–</sup> ,<br><i>catena</i> -poly[(dioxidophosphate-<br>μ-oxido)(1–)]; metaphosphate<br>–P(O)(O <sup>–</sup> ) <sub>2</sub> , dioxidooxo-λ <sup>5</sup> -<br>phosphanyl; phosphonato | PO <sub>3</sub> <sup>–</sup> , trioxidophosphato(1–)<br>PO <sub>3</sub> <sup>•2–</sup> , trioxidophosphato(•2–)<br>PO <sub>3</sub> <sup>3–</sup> , trioxidophosphato(3–);<br>phosphito |
| PO <sub>4</sub>  |                                                                                                                                                                                                                                                                                                    |                                                                           | PO <sub>4</sub> <sup>•2–</sup> ,<br>tetraoxidophosphate(•2–)<br>PO <sub>4</sub> <sup>3–</sup> , tetraoxidophosphate(3–);<br>phosphate                                                                                                                                                                                                                                                                                                                                 | PO <sub>4</sub> <sup>3–</sup> ,<br>tetraoxidophosphato(3–);<br>phosphato                                                                                                               |
| PS               | PS <sup>•</sup> , sulfidophosphorus(•);<br>–PS, thiophosphoryl                                                                                                                                                                                                                                     | PS <sup>+</sup> , sulfidophosphorus(1+)<br>( <i>not</i> thiophosphoryl)   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                        |
| AsO <sub>3</sub> |                                                                                                                                                                                                                                                                                                    |                                                                           | AsO <sub>3</sub> <sup>3–</sup> , trioxidoarsenate(3–);<br>arsenite, arsorite<br>–As(=O)(O <sup>–</sup> ) <sub>2</sub> ,<br>dioxidooxo-λ <sup>5</sup> -arsanyl; arsonato                                                                                                                                                                                                                                                                                               | AsO <sub>3</sub> <sup>3–</sup> , trioxidoarsenato(3–);<br>arsenito, arsorito                                                                                                           |
| AsO <sub>4</sub> |                                                                                                                                                                                                                                                                                                    |                                                                           | AsO <sub>4</sub> <sup>3–</sup> , tetraoxidoarsenate(3–);<br>arsenate, arsorato                                                                                                                                                                                                                                                                                                                                                                                        | AsO <sub>4</sub> <sup>3–</sup> , tetraoxidoarsenato(3–);<br>arsenato, arsorato                                                                                                         |
| VO               | VO, vanadium(II) oxide,<br>vanadium mon(o)oxide                                                                                                                                                                                                                                                    | VO <sup>2+</sup> , oxidovanadium(2+)<br>( <i>not</i> vanadyl)             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                        |
| CO               | CO, carbon mon(o)oxide<br>>C=O, carbonyl<br>=C=O, carbonylidene                                                                                                                                                                                                                                    | CO <sup>•+</sup> , oxidocarbon(•1+)<br>CO <sup>2+</sup> , oxidocarbon(2+) | CO <sup>•–</sup> , oxidocarbonate(•1–)                                                                                                                                                                                                                                                                                                                                                                                                                                | CO, oxidocarbon,<br>oxidocarbonato (general);<br>carbonyl =<br>oxidocarbon-κC (general)<br>CO <sup>•+</sup> , oxidocarbon(•1+)<br>CO <sup>•–</sup> , oxidocarbonato(•1–)               |
| CO <sub>2</sub>  | CO <sub>2</sub> , carbon dioxide,<br>dioxidocarbon                                                                                                                                                                                                                                                 |                                                                           | CO <sub>2</sub> <sup>•–</sup> , oxidooxomethyl,<br>dioxidocarbonate(•1–)                                                                                                                                                                                                                                                                                                                                                                                              | CO <sub>2</sub> , dioxidocarbon<br>CO <sub>2</sub> <sup>•–</sup> , oxidooxomethyl,<br>dioxidocarbonato(•1–)                                                                            |
| CO <sub>3</sub>  |                                                                                                                                                                                                                                                                                                    |                                                                           | CO <sub>3</sub> <sup>•–</sup> , trioxidocarbonate(•1–),<br>OCOO <sup>•–</sup> ,<br>(dioxido)oxidocarbonate(•1–),<br>oxidoperoxidocarbonate(•1–)<br>CO <sub>3</sub> <sup>2–</sup> , trioxidocarbonate(2–);<br>carbonate                                                                                                                                                                                                                                                | CO <sub>3</sub> <sup>2–</sup> , trioxidocarbonato(2–);<br>carbonato                                                                                                                    |
| CS               | carbon monosulfide<br>>C=S, carbonothioyl;<br>thiocarbonyl<br>=C=S, carbonothioylidene                                                                                                                                                                                                             | CS <sup>•+</sup> , sulfidocarbon(•1+)                                     | CS <sup>•–</sup> , sulfidocarbonate(•1–)                                                                                                                                                                                                                                                                                                                                                                                                                              | CS, sulfidocarbon,<br>sulfidocarbonato, thiocarbonyl<br>(general);<br>CS <sup>•+</sup> , sulfidocarbon(•1+)<br>CS <sup>•–</sup> , sulfidocarbonato(•1–)                                |
| CS <sub>2</sub>  | CS <sub>2</sub> , disulfidocarbon,<br>carbon disulfide                                                                                                                                                                                                                                             |                                                                           | CS <sub>2</sub> <sup>•–</sup> , sulfidothioxomethyl,<br>disulfidocarbonate(•1–)                                                                                                                                                                                                                                                                                                                                                                                       | CS <sub>2</sub> , disulfidocarbon<br>CS <sub>2</sub> <sup>•–</sup> , sulfidothioxomethyl,<br>disulfidocarbonato(•1–)                                                                   |

|      |                                                                                                                                                                                                                                                   |                                                                |                                                                                                                                                                            |                                                                                                                            |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| CN   | CN <sup>•</sup> , nitridocarbon(•); cyanyl<br>–CN, cyano<br>–NC, isocyano                                                                                                                                                                         | CN <sup>+</sup> ,<br>azanylidynemethylum,<br>nitridocarbon(1+) | CN <sup>–</sup> , nitridocarbonate(1–);<br>cyanide                                                                                                                         | nitridocarbonato (general)<br>CN <sup>–</sup> , nitridocarbonato(1–);<br>cyanido =<br>[nitridocarbonato(1–)-κC]            |
| CNO  | OCN <sup>•</sup> , nitridooidocarbon(•)<br>–OCN, cyanato<br>–NCO, isocyanato<br>–ONC, λ <sup>2</sup> -methylidene $\curvearrowright$<br>azanylylideneoxy<br>–CNO, (oxo-λ <sup>5</sup> -<br>azanylidynemethyl                                      |                                                                | OCN <sup>–</sup> ,<br>nitridooidocarbonate(1–);<br>cyanate<br>ONC <sup>–</sup> , carbidooidonitrate(1–);<br>fulminate<br>OCN <sup>•2–</sup> ,<br>nitridooidocarbonate(•2–) | OCN <sup>–</sup> ,<br>nitridooidocarbonato(1–);<br>cyanato<br>ONC <sup>–</sup> , carbidooidonitrato(1–);<br>fulminato      |
| CNS  | SCN <sup>•</sup> , nitridosulfidocarbon(•)<br>–SCN, thiocyanato<br>–NCS, isothiocyanato<br>–SNC, λ <sup>2</sup> -methylidene $\curvearrowright$<br>azanylylidenesulfanediyl<br>–CNS, (sulfanylidene-λ <sup>5</sup> -<br>azanylidynemethyl         |                                                                | SCN <sup>–</sup> ,<br>nitridosulfidocarbonate(1–);<br>thiocyanate<br>SNC <sup>–</sup> , carbidosulfidonitrate(1–)                                                          | SCN <sup>–</sup> ,<br>nitridosulfidocarbonato(1–);<br>thiocyanato<br>SNC <sup>–</sup> , carbidosulfidonitrato(1–)          |
| CNSe | SeCN <sup>•</sup> , nitridoselenidocarbon(•)<br>–SeCN, selenocyanato<br>–NCSe, isoselenocyanato<br>–SeNC, λ <sup>2</sup> -methylidene $\curvearrowright$<br>azanylylideneselanediyl<br>–CNSe, (selanylidene-λ <sup>5</sup> -<br>azanylidynemethyl |                                                                | SeCN <sup>–</sup> ,<br>nitridoselenidocarbonate(1–);<br>selenocyanate<br>SeNC <sup>–</sup> ,<br>carbidoselenidonitrate(1–)                                                 | SeCN <sup>–</sup> ,<br>nitridoselenidocarbonato(1–);<br>selenocyanato<br>SeNC <sup>–</sup> ,<br>carbidoselenidonitrato(1–) |

<sup>a</sup> Where an element symbol occurs in the first column, the unmodified element name is listed in the second and third columns. The unmodified name is generally used when the element appears as an electropositive constituent in the construction of a stoichiometric name (Sections IR-5.2 and IR-5.4). Names of homoatomic cations consisting of the element are also constructed using the element name, adding multiplicative prefixes and charge numbers as applicable (Sections IR-5.3.2.1 to IR-5.3.2.3). The sections mentioned refer to parts of Nomenclature of Inorganic Chemistry. IUPAC Recommendations 2005, see above.

<sup>b</sup> Where an element symbol occurs in the first column, the fourth column gives the element name appropriately modified with the ending 'ide' (hydride, nitride, etc.). The 'ide' form of the element name is generally used when the element appears as an electronegative constituent in the construction of a stoichiometric name (Sections IR-5.2 and IR-5.4). Names of homoatomic anions consisting of the element in question are also constructed using this modified form, adding multiplicative prefixes and charge numbers as applicable (Sections IR-5.3.3.1 to IR-5.3.3.3). Examples are given in the Table of names of some specific anions, e.g. chloride(1–), oxide(2–), dioxide(2–). In certain cases, a particular anion has the 'ide' form itself as an accepted short name, e.g. chloride, oxide. If specific anions are named, the 'ide' form of the element name with no further modification is given as the first entry in the fourth column, with the qualifier '(general)'. The sections mentioned refer to parts of Nomenclature of Inorganic Chemistry. IUPAC Recommendations 2005, see above.

<sup>c</sup> Ligand names must be placed within enclosing marks whenever necessary to avoid ambiguity, cf. Section IR-9.2.2.3. Some ligand names must always be enclosed. For example, if 'dioxido' is cited as is, it must be enclosed so as to distinguish it from two 'oxido' ligands; if combined with a multiplicative prefix it must be enclosed because it starts with a multiplicative prefix itself. A ligand name such as 'nitridocarbonato' must always be enclosed to avoid interpreting it as two separate ligand names, 'nitrido' and 'carbonato'. In this table, however, these enclosing marks are omitted for the sake of clarity. Note that the ligand names given here with a charge number can generally also be used without if it is not desired to make any implication regarding the charge of the ligand. For example, the ligand name '[dioxido(•1–)]' may be used if one wishes explicitly to consider the ligand to be the species dioxide(•1–), whereas the ligand name '(dioxido)' can be used if no such implications are desirable. The section mentioned refer to parts of Nomenclature of Inorganic Chemistry. IUPAC Recommendations 2005, see above.

## ORGANIC SUBSTITUENT GROUPS AND RING SYSTEMS

The first part of this table lists substituent groups and their line formulas. A substituent group is defined by IUPAC as a group that replaces one or more hydrogen atoms attached to a parent structure. Such groups are sometimes called radicals, but IUPAC now reserves the term radical for a free molecular species with unpaired electrons. IUPAC does not recommend some of these names, which are marked here with asterisks (e.g., *amyl*\*), but they are included in this list because they are often encountered in the older literature. Substituent group names which are formed

by systematic rules (e.g., methyl from methane, ethyl from ethane, etc.) are included here only for the first few members of a homologous series.

In the second part of the table a number of common organic ring compounds are shown, with the conventional numbering of the ring positions indicated.

The help of Warren H. Powell in preparing this table is greatly appreciated. Pertinent references may be found in the table "Nomenclature of Chemical Compounds."

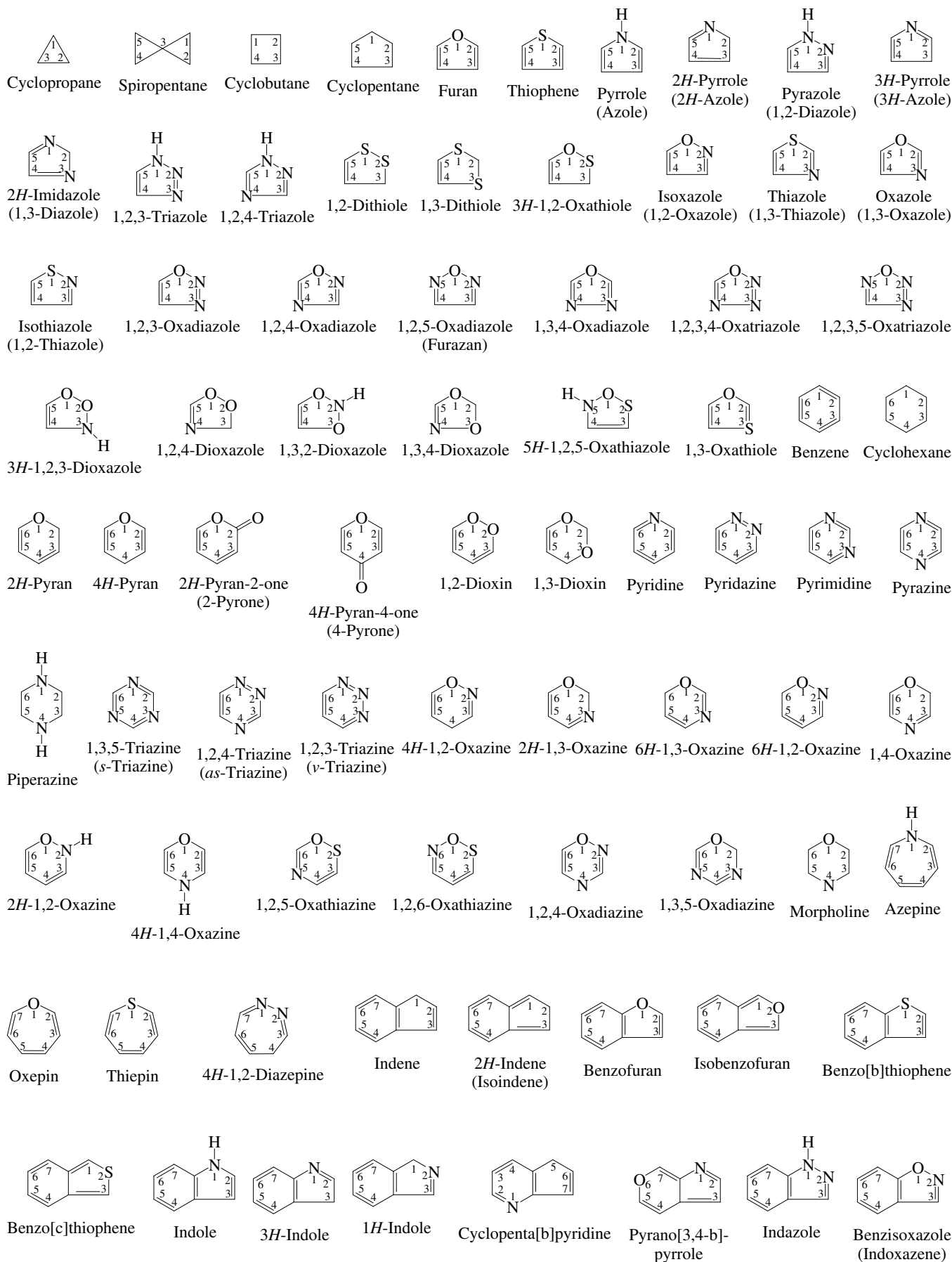
### Substituent Groups

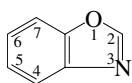
|                                  |                                                        |                                     |                                                             |
|----------------------------------|--------------------------------------------------------|-------------------------------------|-------------------------------------------------------------|
| acetamido (acetylamino)          | $\text{CH}_3\text{CONH-}$                              | cinnamoyl                           | $\text{C}_6\text{H}_5\text{CH=CHCO-}$                       |
| acetoacetyl                      | $\text{CH}_3\text{COCH}_2\text{CO-}$                   | cinnamyl (3-phenyl-2-propenyl)      | $\text{C}_6\text{H}_5\text{CH=CHCH}_2\text{-}$              |
| acetylonyl                       | $\text{CH}_3\text{COCH}_2\text{-}$                     | cinnamylidene                       | $\text{C}_6\text{H}_5\text{CH=CHCH=}$                       |
| acetyl                           | $\text{CH}_3\text{CO-}$                                | cresyl* (hydroxymethylphenyl)       | $\text{HO}(\text{CH}_2)\text{C}_6\text{H}_4\text{-}$        |
| acryloyl* (1-oxo-2-propenyl)     | $\text{CH}_2=\text{CHCO-}$                             | crotonoyl                           | $\text{CH}_3\text{CH=CHCO-}$                                |
| alanyl (from alanine)            | $\text{CH}_3\text{CH}(\text{NH}_2)\text{CO-}$          | crotyl (2-butenyl)                  | $\text{CH}_3\text{CH=CHCH}_2\text{-}$                       |
| $\beta$ -alanyl                  | $\text{H}_2\text{N}(\text{CH}_2)_2\text{CO-}$          | cyanamido (cyanoamino)              | $\text{NCNH-}$                                              |
| allyl (2-propenyl)               | $\text{CH}_2=\text{CHCH}_2\text{-}$                    | cyanato                             | $\text{NCO-}$                                               |
| allylidene (2-propenylidene)     | $\text{CH}_2=\text{CHCH=}$                             | cyano                               | $\text{NC-}$                                                |
| amidino (aminoiminomethyl)       | $\text{H}_2\text{NC(=NH)-}$                            | decanedioyl                         | $-\text{OC}(\text{CH}_2)_8\text{CO-}$                       |
| amino                            | $\text{H}_2\text{N-}$                                  | decanoyl                            | $\text{CH}_3(\text{CH}_2)_8\text{CO-}$                      |
| amyl* (pentyl)                   | $\text{CH}_3(\text{CH}_2)_4\text{-}$                   | diazo                               | $\text{N}_2=\text{-}$                                       |
| anilino (phenylamino)            | $\text{C}_6\text{H}_5\text{NH-}$                       | diazoamino                          | $-\text{NHN=N-}$                                            |
| anisidino                        | $\text{CH}_3\text{OC}_6\text{H}_4\text{NH-}$           | disilanyl                           | $\text{H}_3\text{SiSiH}_2\text{-}$                          |
| anthranoyl (2-aminobenzoyl)      | $2\text{-H}_2\text{NC}_6\text{H}_4\text{CO-}$          | disiloxanyloxy                      | $\text{H}_3\text{SiOSiH}_2\text{O-}$                        |
| arsino                           | $\text{AsH}_2\text{-}$                                 | disulfinyl                          | $-\text{S(O)S(O)-}$                                         |
| azelaoyl (from azelaic acid)     | $-\text{OC}(\text{CH}_2)_7\text{CO-}$                  | dithio                              | $-\text{SS-}$                                               |
| azido                            | $\text{N}_3\text{-}$                                   | enanthoyl* (heptanoyl)              | $\text{CH}_3(\text{CH}_2)_5\text{CO-}$                      |
| azino                            | $=\text{N=N=}$                                         | epoxy                               | $-\text{O-}$                                                |
| azo                              | $-\text{N=N-}$                                         | ethenyl (vinyl)                     | $\text{CH}_2=\text{CH-}$                                    |
| azoxy                            | $-\text{N(O)=N-}$                                      | ethynyl                             | $\text{HC}\equiv\text{C-}$                                  |
| benzal* (benzylidene)            | $\text{C}_6\text{H}_5\text{CH=}$                       | ethoxy                              | $\text{C}_2\text{H}_5\text{O-}$                             |
| benzamido (benzoylamino)         | $\text{C}_6\text{H}_5\text{CONH-}$                     | ethyl                               | $\text{CH}_3\text{CH}_2\text{-}$                            |
| benzhydryl (diphenylmethyl)      | $(\text{C}_6\text{H}_5)_2\text{CH-}$                   | ethylene                            | $-\text{CH}_2\text{CH}_2\text{-}$                           |
| benzoxy* (benzoyloxy)            | $\text{C}_6\text{H}_5\text{COO-}$                      | ethylidene                          | $\text{CH}_3\text{CH=}$                                     |
| benzoyl                          | $\text{C}_6\text{H}_5\text{CO-}$                       | ethylthio                           | $\text{C}_2\text{H}_5\text{S-}$                             |
| benzyl                           | $\text{C}_6\text{H}_5\text{CH}_2\text{-}$              | formamido (formylamino)             | $\text{HCONH-}$                                             |
| benzylidene                      | $\text{C}_6\text{H}_5\text{CH=}$                       | formyl                              | $\text{HCO-}$                                               |
| benzylidyne                      | $\text{C}_6\text{H}_5\text{C=}$                        | furmaroyl (from fumaric acid)       | $-\text{OCCCH=CHCO-}$                                       |
| biphenyl                         | $\text{C}_6\text{H}_5\text{C}_6\text{H}_5\text{-}$     | furfuryl (2-furanylmethyl)          | $\text{OC}_4\text{H}_3\text{CH}_2\text{-}$                  |
| biphenylene                      | $-\text{C}_6\text{H}_4\text{-C}_6\text{H}_4\text{-}$   | furfurylidene (2-furanylmethylene)  | $\text{OC}_4\text{H}_3\text{CH=}$                           |
| butoxy                           | $\text{C}_4\text{H}_9\text{O-}$                        | glutamoyl (from glutamic acid)      | $-\text{OC}(\text{CH}_2)_2\text{CH}(\text{NH}_2)\text{CO-}$ |
| sec-butoxy (1-methylpropoxy)     | $\text{C}_2\text{H}_5\text{CH}(\text{CH}_3)\text{O-}$  | glutaryl (from glutaric acid)       | $-\text{OC}(\text{CH}_2)_3\text{CO-}$                       |
| tert-butoxy (1,1-dimethylethoxy) | $(\text{CH}_3)_3\text{CO-}$                            | glycylamino                         | $\text{H}_2\text{NCH}_2\text{CONH-}$                        |
| butyl                            | $\text{CH}_3(\text{CH}_2)_3\text{-}$                   | glycoloyl; glycolyl (hydroxyacetyl) | $\text{HOCH}_2\text{CO-}$                                   |
| sec-butyl (1-methylpropyl)       | $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{-}$ | glycyl (aminoacetyl)                | $\text{H}_2\text{NCH}_2\text{CO-}$                          |
| tert-butyl (1,1-dimethylethyl)   | $(\text{CH}_3)_3\text{C-}$                             | glyoxyloyl; glyoxylyl (oxoacetyl)   | $\text{HCOCO-}$                                             |
| butyryl (1-oxobutyl)             | $\text{CH}_3(\text{CH}_2)_2\text{CO-}$                 | guanidino                           | $\text{H}_2\text{NC(=NH)NH-}$                               |
| caproyl* (hexanoyl)              | $\text{CH}_3(\text{CH}_2)_4\text{CO-}$                 | guanyl (aminoiminomethyl)           | $\text{H}_2\text{NC(=NH)-}$                                 |
| capryl* (decanoyl)               | $\text{CH}_3(\text{CH}_2)_8\text{CO-}$                 | heptadecanoyl                       | $\text{CH}_3(\text{CH}_2)_{15}\text{CO-}$                   |
| capryloyl* (octanoyl)            | $\text{CH}_3(\text{CH}_2)_6\text{CO-}$                 | heptanamido                         | $\text{CH}_3(\text{CH}_2)_5\text{CONH-}$                    |
| carbamido (carbamoylamino)       | $\text{H}_2\text{NCONH-}$                              | heptanedioyl                        | $-\text{OC}(\text{CH}_2)_5\text{CO-}$                       |
| carbamoyl (aminocarbonyl)        | $\text{H}_2\text{NCO-}$                                | heptanoyl                           | $\text{CH}_3(\text{CH}_2)_5\text{CO-}$                      |
| carbamyl (aminocarbonyl)         | $\text{H}_2\text{NCO-}$                                | hexadecanoyl                        | $\text{CH}_3(\text{CH}_2)_{14}\text{CO-}$                   |
| carbazoyl (hydrazinocarbonyl)    | $\text{H}_2\text{NNHCO-}$                              | hexamethylene (1,6-hexanediyl)      | $-(\text{CH}_2)_6\text{-}$                                  |
| carbethoxy (ethoxycarbonyl)      | $\text{C}_2\text{H}_5\text{OCO-}$                      | hexanedioyl                         | $-\text{OC}(\text{CH}_2)_4\text{CO-}$                       |
| carbonyl                         | $=\text{C=O}$                                          | hippuryl (N-benzoylglycyl)          | $\text{C}_6\text{H}_5\text{CONHCH}_2\text{CO-}$             |
| carboxy                          | $\text{HOOC-}$                                         | hydrazino                           | $\text{H}_2\text{NNH-}$                                     |
| cetyl* (hexadecyl)               | $\text{CH}_3(\text{CH}_2)_{15}\text{-}$                | hydrizo                             | $-\text{HNNH-}$                                             |
| chloroformyl (chlorocarbonyl)    | $\text{ClCO-}$                                         | hydrocinnamoyl                      | $\text{C}_6\text{H}_5(\text{CH}_2)_2\text{CO-}$             |



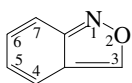
|                                      |                                                                                          |                                      |                                                                       |
|--------------------------------------|------------------------------------------------------------------------------------------|--------------------------------------|-----------------------------------------------------------------------|
| hydroperoxy                          | HOO-                                                                                     | phenylene (benzenediyl)              | -C <sub>6</sub> H <sub>4</sub> -                                      |
| hydroxyamino                         | HONH-                                                                                    | phosphino* (phosphanyl)              | H <sub>2</sub> P-                                                     |
| hydroxy                              | HO-                                                                                      | phosphinyl* (phosphinoyl)            | H <sub>2</sub> P(O)-                                                  |
| imino                                | HN=                                                                                      | phospho                              | O <sub>2</sub> P-                                                     |
| iodoso* (iodosyl)                    | OI-                                                                                      | phosphono                            | (HO) <sub>2</sub> P(O)-                                               |
| iodyl                                | O <sub>2</sub> I-                                                                        | phthaloyl (from phthalic acid)       | 1,2-C <sub>6</sub> H <sub>4</sub> (CO-) <sub>2</sub>                  |
| isoamyl* (isopentyl; 3-methylbutyl)  | (CH <sub>3</sub> ) <sub>2</sub> CH(CH <sub>2</sub> ) <sub>2</sub> -                      | picryl (2,4,6-trinitrophenyl)        | 2,4,6-(NO <sub>2</sub> ) <sub>3</sub> C <sub>6</sub> H <sub>2</sub> - |
| isobutenyl (2-methyl-1-propenyl)     | (CH <sub>3</sub> ) <sub>2</sub> C=CH-                                                    | pimeloyl (from pimelic acid)         | -OC(CH <sub>2</sub> ) <sub>5</sub> CO-                                |
| isobutoxy (2-methylpropoxy)          | (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> O-                                     | piperidino (1-piperidinyl)           | C <sub>5</sub> H <sub>10</sub> N-                                     |
| isobutyl (2-methylpropyl)            | (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> -                                      | pivaloyl (from pivalic acid)         | (CH <sub>3</sub> ) <sub>3</sub> CCO-                                  |
| isobutylidene (3-methylpropylidene)  | (CH <sub>3</sub> ) <sub>2</sub> CHCH=                                                    | prenyl (3-methyl-2-butenyl)          | (CH <sub>3</sub> ) <sub>2</sub> C=CHCH <sub>2</sub> -                 |
| isobutyryl (2-methyl-1-oxopropyl)    | (CH <sub>3</sub> ) <sub>2</sub> CHCO-                                                    | propargyl (2-propynyl)               | HC≡CCH <sub>2</sub> -                                                 |
| isocyanato                           | OCN-                                                                                     | 1-propenyl                           | -CH=CHCH <sub>2</sub>                                                 |
| isocyano                             | CN-                                                                                      | 2-propenyl (allyl)                   | CH <sub>2</sub> =CHCH <sub>2</sub> -                                  |
| isohexyl (4-methylpentyl)            | (CH <sub>3</sub> ) <sub>2</sub> CH(CH <sub>2</sub> ) <sub>3</sub> -                      | propionyl* (propanyl)                | CH <sub>3</sub> CH <sub>2</sub> CO-                                   |
| isoleucyl (from isoleucine)          | C <sub>2</sub> H <sub>5</sub> CH(CH <sub>3</sub> )CH(NH <sub>2</sub> )CO-                | propoxy                              | CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> O-                    |
| isonitroso* (hydroxyamino)           | HON=                                                                                     | propyl                               | CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> -                     |
| isopentyl (3-methylbutyl)            | (CH <sub>3</sub> ) <sub>2</sub> CH(CH <sub>2</sub> ) <sub>2</sub> -                      | propylidene                          | CH <sub>3</sub> CH <sub>2</sub> CH=                                   |
| isopentylidene (3-methylbutylidene)  | (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> CH=                                    | pyrryl (pyrrolyl)                    | C <sub>4</sub> H <sub>4</sub> N-                                      |
| isopropenyl (1-methylethenyl)        | CH <sub>2</sub> =C(CH <sub>3</sub> )-                                                    | salicyloyl (2-hydroxybenzoyl)        | 2-HOC <sub>6</sub> H <sub>4</sub> CO-                                 |
| isopropoxy (1-methylethoxy)          | (CH <sub>3</sub> ) <sub>2</sub> CHO-                                                     | selenyl* (selanyl; hydroseleno)      | HSe-                                                                  |
| isopropyl (1-methylethyl)            | (CH <sub>3</sub> ) <sub>2</sub> CH-                                                      | seryl (from serine)                  | HOCH <sub>2</sub> CH(NH <sub>2</sub> )CO-                             |
| isopropylidene (1-methylethylidene)  | (CH <sub>3</sub> ) <sub>2</sub> C=                                                       | siloxyl                              | H <sub>3</sub> SiO-                                                   |
| isothiocyanato (isothiocyano)        | SCN-                                                                                     | silyl                                | H <sub>3</sub> Si-                                                    |
| isovaleryl* (3-methyl-1-oxobutyl)    | (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> CO-                                    | silylene                             | H <sub>2</sub> Si=                                                    |
| lactoyl (from lactic acid)           | CH <sub>3</sub> CH(OH)CO-                                                                | sorboyl (from sorbic acid)           | CH <sub>3</sub> CH=CHCH=CHCO-                                         |
| lauroyl (from lauric acid)           | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>10</sub> CO-                                     | stearoyl (from stearic acid)         | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> CO-                  |
| lauryl (dodecyl)                     | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>11</sub> -                                       | stearyl (octadecyl)                  | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>17</sub> -                    |
| leucyl (from leucine)                | (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> CH(NH <sub>2</sub> )CO-                | styryl (2-phenylethenyl)             | C <sub>6</sub> H <sub>5</sub> CH=CH-                                  |
| levulinoyl (from levulinic acid)     | CH <sub>3</sub> CO(CH <sub>2</sub> ) <sub>2</sub> CO-                                    | suberoyl (from suberic acid)         | -OC(CH <sub>2</sub> ) <sub>6</sub> CO-                                |
| malonyl (from malonic acid)          | -OCCH <sub>2</sub> CO-                                                                   | succinyl (from succinic acid)        | -OCCH <sub>2</sub> CH <sub>2</sub> CO-                                |
| mandeloyl (from mandelic acid)       | C <sub>6</sub> H <sub>5</sub> CH(OH)CO-                                                  | sulfamino (sulfoamino)               | HOSO <sub>2</sub> NH-                                                 |
| mercapto                             | HS-                                                                                      | sulfamoyl (sulfamyl)                 | H <sub>2</sub> NSO <sub>2</sub> -                                     |
| mesityl                              | 2,4,6-(CH <sub>3</sub> ) <sub>3</sub> C <sub>6</sub> H <sub>2</sub> -                    | sulfanilyl [(4-aminophenyl)sulfonyl] | 4-H <sub>2</sub> NC <sub>6</sub> H <sub>4</sub> SO <sub>2</sub> -     |
| methacryloyl (from methacrylic acid) | CH <sub>2</sub> =C(CH <sub>3</sub> )CO-                                                  | sulfeno                              | HOS-                                                                  |
| methallyl (2-methyl-2-propenyl)      | CH <sub>2</sub> =C(CH <sub>3</sub> )CH <sub>2</sub> -                                    | sulfhydryl (mercapto)                | HS-                                                                   |
| methionyl (from methionine)          | CH <sub>3</sub> SCH <sub>2</sub> CH <sub>2</sub> CH(NH <sub>2</sub> )CO-                 | sulfinyl                             | OS=                                                                   |
| methoxy                              | CH <sub>3</sub> O-                                                                       | sulfo                                | HO <sub>2</sub> S-                                                    |
| methyl                               | H <sub>3</sub> C-                                                                        | sulfonyl (sulfuryl)                  | -SO <sub>2</sub> -                                                    |
| methylene                            | H <sub>2</sub> C=                                                                        | terephthaloyl                        | 1,4-C <sub>6</sub> H <sub>4</sub> (CO-) <sub>2</sub>                  |
| methylthio                           | CH <sub>3</sub> S-                                                                       | tetramethylene                       | -(CH <sub>2</sub> ) <sub>4</sub> -                                    |
| myristoyl (from myristic acid)       | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>12</sub> CO-                                     | thienyl (from thiophene)             | (C <sub>4</sub> H <sub>3</sub> S)-                                    |
| myristyl (tetradecyl)                | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>13</sub> -                                       | thiocarbonyl (carbothionyl)          | =CS                                                                   |
| naphthyl                             | (C <sub>10</sub> H <sub>7</sub> )-                                                       | thiocarboxy                          | HOSC-                                                                 |
| naphthylene                          | -(C <sub>10</sub> H <sub>6</sub> )-                                                      | thiocyanato (thiocyano)              | NCS-                                                                  |
| neopentyl (2,2-dimethylpropyl)       | (CH <sub>3</sub> ) <sub>3</sub> CCH <sub>2</sub> -                                       | thionyl* (sulfinyl)                  | -SO-                                                                  |
| nitramino (nitroamino)               | O <sub>2</sub> NNH-                                                                      | threonyl (from threonine)            | CH <sub>3</sub> CH(OH)CH(NH <sub>2</sub> )CO-                         |
| nitro                                | O <sub>2</sub> N-                                                                        | toluidino [(methylphenyl)amino]      | CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> NH-                     |
| nitrosamino (nitrosoamino)           | ONNH-                                                                                    | toluoyl (methylbenzoyl)              | CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> CO-                     |
| nitrosimino (nitrosoimino)           | ONN=                                                                                     | tolyl (methylphenyl)                 | CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> -                       |
| nitroso                              | ON-                                                                                      | α-tolyl (benzyl)                     | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> -                       |
| nonanoyl (from nonanoic acid)        | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CO-                                      | tolyene (methylphenylene)            | -(CH <sub>2</sub> C <sub>6</sub> H <sub>3</sub> )-                    |
| oleoyl (from oleic acid)             | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH=CH(CH <sub>2</sub> ) <sub>7</sub> CO- | tosyl [(4-methylphenyl) sulfonyl]    | 4-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> SO <sub>2</sub> -     |
| oxalyl (from oxalic acid)            | -OCO-                                                                                    | triazano                             | H <sub>2</sub> NNHNH-                                                 |
| oxo                                  | O=                                                                                       | trimethylene (1,3-propanediyl)       | -(CH <sub>2</sub> ) <sub>3</sub> -                                    |
| palmitoyl (from palmitic acid)       | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> CO-                                     | trityl (triphenylmethyl)             | (C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub> C-                      |
| pentamethylene (1,5-pentanediy)      | -(CH <sub>2</sub> ) <sub>5</sub> -                                                       | valeryl* (pentanoyl)                 | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CO-                   |
| pentyl                               | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> -                                        | valyl (from valine)                  | (CH <sub>3</sub> ) <sub>2</sub> CHCH(NH <sub>2</sub> )CO-             |
| tert-pentyl                          | CH <sub>3</sub> CH <sub>2</sub> C(CH <sub>3</sub> ) <sub>2</sub> -                       | vinyl (ethenyl)                      | CH <sub>2</sub> =CH-                                                  |
| phenacyl                             | C <sub>6</sub> H <sub>5</sub> COCH <sub>2</sub> -                                        | vinylidene (ethenylidene)            | CH <sub>2</sub> =C=                                                   |
| phenacylidene                        | C <sub>6</sub> H <sub>5</sub> COCH=                                                      | xylydino [(dimethylphenyl)amino]     | (CH <sub>3</sub> ) <sub>2</sub> C <sub>6</sub> H <sub>3</sub> NH-     |
| phenethyl (2-phenylethyl)            | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> CH <sub>2</sub> -                          | xylyl (dimethylphenyl)               | (CH <sub>3</sub> ) <sub>2</sub> C <sub>6</sub> H <sub>3</sub> -       |
| phenoxy                              | C <sub>6</sub> H <sub>5</sub> O-                                                         | xylylene [phenylenebis(methylene)]   | -CH <sub>2</sub> C <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> -      |
| phenyl                               | C <sub>6</sub> H <sub>5</sub> -                                                          |                                      |                                                                       |

## Organic Ring Compounds

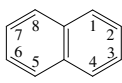




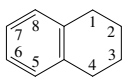
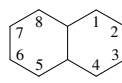
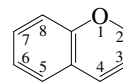
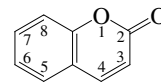
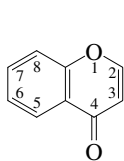
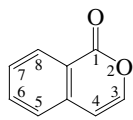
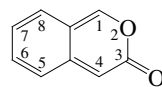
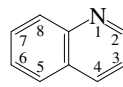
Benzoxazole



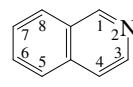
2,1-Benzisoxazole



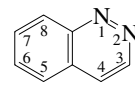
Naphthalene

1,2,3,4-Tetrahydronaphthalene  
(Tetralin)Octahydronaphthalene  
(Decalin)2H-1-Benzopyran  
(2H-Chromene)2H-1-Benzopyran-2-one  
(Coumarin)4H-1-Benzopyran-4-one  
(Chromen-4-one)1H-2-Benzopyran-1-one  
(Isocoumarin)3H-2-Benzopyran-1-one  
(Isochromen-3-one)

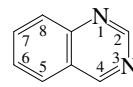
Quinoline



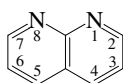
Isoquinoline



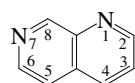
Cinnoline



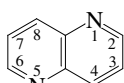
Quinazoline



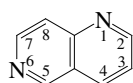
1,8-Naphthyridine



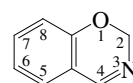
1,7-Naphthyridine



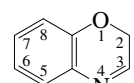
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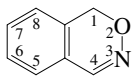
1,6-Naphthyridine



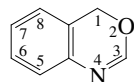
2H-1,3-Benzoxazine



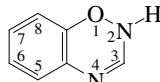
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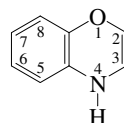
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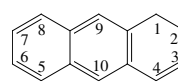
4H-3,1-Benzoxazine



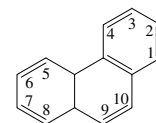
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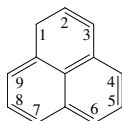
4H-1,4-Benzoxazine



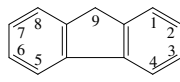
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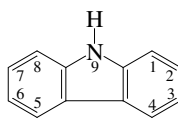
Phenanthrene



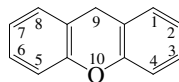
Phenalene



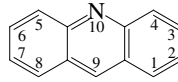
Fluorene



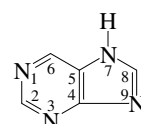
Carbazole



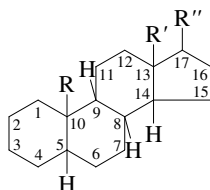
Xanthene



Acridine

Norpinane  
(Bicyclo[3.1.1]heptane)

7H-Purine



Steroid ring system

R = Nearly always methyl  
R' = Usually methyl  
R'' = Various groups

## SCIENTIFIC ABBREVIATIONS, ACRONYMS, AND SYMBOLS

This table lists some abbreviations, acronyms, and symbols encountered in the physical sciences. Most entries in italic type are symbols for physical quantities; for more details on these, see the table “Symbols and Terminology for Physical and Chemical Quantities” in this section. Additional information on units may be found in the table “International System of Units (SI)” in Section 1. Many of the terms to which these abbreviations refer are included in the tables “Definitions of Scientific Terms” in Section 2 and “Techniques for Materials Characterization” in Section 12. Useful references for further information are given below.

Publication practices vary with regard to the use of capital or lower case letters for many abbreviations. An effort has been made to follow the most common practices in this table, but much variation is found in the literature. Likewise, policies on the use of periods in an abbreviation vary considerably. Periods are generally omitted in this table unless they are necessary for clarity. Periods should never appear in SI units. The SI prefixes (m, k, M, etc.) are included here, but they should never be used alone. Selected combinations of these prefixes with SI units (e.g., mg, kV, MW) are also included.

Abbreviations are listed in alphabetical order without regard to case. Entries beginning with Greek letters fall at the end of the table.

|          |                                                                        |
|----------|------------------------------------------------------------------------|
| A        | ampere; alanine; adenine (in genetic code)                             |
| Å        | ångström                                                               |
| A        | absorbance; area; Helmholtz energy; mass number                        |
| $A_H$    | Hall coefficient                                                       |
| $A_r$    | atomic weight (relative atomic mass)                                   |
| a        | atto (SI prefix for $10^{-18}$ )                                       |
| $\alpha$ | absorption coefficient; acceleration; activity; van der Waals constant |
| $a_0$    | Bohr radius                                                            |
| A/D      | analog to digital                                                      |
| AAA      | acetoacetanilide                                                       |
| Aad      | 2-aminoadipic acid                                                     |
| AAO      | acetaldehyde oxime                                                     |
| AAS      | atomic absorption spectroscopy                                         |
| ABA      | abscisic acid                                                          |
| Abe      | abequose                                                               |
| ABL      | $\alpha$ -acetylbutyrolactone                                          |
| abs      | absolute                                                               |
| Abu      | 2-aminobutanoic acid                                                   |
| Ac       | acetyl; acetate                                                        |
| ac, AC   | alternating current                                                    |
| Aces     | 2-[(2-amino-2-oxoethyl)amino]ethanesulfonic acid                       |
| ACT      | activated complex theory                                               |
| ACTH     | adrenocorticotrophic hormone                                           |
| Ad       | adamantyl                                                              |
| Ada      | [(carbamoylmethyl)imino]diacetic acid                                  |
| Ade      | adenine                                                                |
| ADI      | acceptable daily intake                                                |
| Ado      | adenosine                                                              |
| ADP      | adenosine diphosphate; ammonium dihydrogen phosphate                   |
| ads      | adsorption                                                             |
| AE       | appearance energy                                                      |

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|            |                                                           |
|------------|-----------------------------------------------------------|
| ae         | eon ( $10^9$ years)                                       |
| AEP        | 1-(2-aminoethyl)piperazine                                |
| AES        | atomic emission spectroscopy; Auger electron spectroscopy |
| AF         | audio frequency                                           |
| AFM        | atomic force microscopy                                   |
| Ahx        | 2-aminohexanoic acid                                      |
| AI         | artificial intelligence                                   |
| AIBN       | 2,2'-azobis[isobutyronitrile]                             |
| AICA       | 5-amino-1H-imidazole-4-carboxamide                        |
| AIM        | atoms in molecules (method)                               |
| AIP        | aluminum isopropoxide                                     |
| Al         | Alfén number                                              |
| Ala        | alanine                                                   |
| alc        | alcohol                                                   |
| ALE        | atomic layer epitaxy                                      |
| aliph.     | aliphatic                                                 |
| alk.       | alkaline                                                  |
| All        | allose                                                    |
| Alt        | altrose                                                   |
| AM         | amplitude modulation                                      |
| Am         | amyl                                                      |
| am         | amorphous solid                                           |
| AMP        | adenosine monophosphate                                   |
| AMPD       | 2-amino-2-methyl-1,3-propanediol                          |
| AMTCS      | amyltrichlorosilane [trichloropentylsilane]               |
| AMS        | accelerator mass spectrometry                             |
| amu        | atomic mass unit (recommended symbol is u)                |
| AN         | acetonitrile                                              |
| anh, anhyd | anhydrous                                                 |
| ANOVA      | analysis of variance                                      |
| antilog    | antilogarithm                                             |
| ANTU       | 1-naphthalenylthiourea                                    |

|          |                                                               |                       |                                                                      |
|----------|---------------------------------------------------------------|-----------------------|----------------------------------------------------------------------|
| AO       | atomic orbital                                                | Bé                    | Baumé                                                                |
| AOM      | angular overlap model                                         | BEBO                  | bond energy bond order (method)                                      |
| APAD     | 3-acetylpyridine adenine dinucleotide                         | BEI                   | biological exposure index                                            |
| Ape      | 2-aminopentanoic acid                                         | BEM                   | biological effect monitoring                                         |
| API      | atmospheric pressure ionization                               | Bes                   | 2-[bis(2-hydroxyethyl)amino]ethanesulfonic acid                      |
| Api      | apiose                                                        | BET                   | Brunauer–Emmett–Teller (isotherm)                                    |
| APM      | atomic probe microanalysis                                    | BeV                   | billion electronvolt                                                 |
| Apm      | 2-aminopimelic acid                                           | BGE                   | butyl glycidyl ether                                                 |
| APPI     | atmospheric pressure photoionization                          | BHA                   | <i>tert</i> -butyl-4-hydroxyanisole                                  |
| APS      | appearance potential spectroscopy; adenosine phosphosulfate   | BHC                   | benzene hexachloride [hexachlorobenzene]                             |
| APW      | augmented plane wave                                          | Bhn                   | Brinell hardness number                                              |
| aq       | aqueous                                                       | BHT                   | butylated hydroxytoluene [2,6-di- <i>tert</i> -butyl-4-methylphenol] |
| Ar       | aryl                                                          | Bi                    | biot                                                                 |
| Ara      | arabinose                                                     | Bicine                | <i>N,N</i> -bis(2-hydroxyethyl)glycine                               |
| Ara-ol   | arabinitol                                                    | BIRD                  | blackbody infrared radiative dissociation                            |
| Arg      | arginine                                                      | Bistris               | 2-[bis(2-hydroxyethyl)amino]-2-(hydroxymethyl)propane-1,3-diol       |
| ARPES    | angular resolved photoelectron spectroscopy                   | Bistris-propane       | 1,3-bis[tris(hydroxymethyl)methylamino]propane                       |
| ASC      | 4-(acetylamino)benzenesulfonyl chloride                       | BLO                   | $\gamma$ -butyrolactone                                              |
| ASCII    | American National Standard Code for Information Interchange   | BN                    | bond number; benzonitrile                                            |
| ASE      | aromatic stabilization model                                  | BNS                   | nuclear backscattering spectroscopy                                  |
| Asn      | asparagine                                                    | BO                    | Born–Oppenheimer (approximation); bond order                         |
| Asp      | aspartic acid                                                 | BOD                   | biochemical oxygen demand                                            |
| at       | atomization                                                   | BON                   | $\beta$ -hydroxynaphthoic acid                                       |
| ATEE     | <i>N</i> -acetyl- <i>L</i> -tyrosine ethyl ester              | BP                    | base peak (in mass spectrometry)                                     |
| ATLC     | adsorption thin layer chromatography                          | bp                    | boiling point; base pair                                             |
| atm      | standard atmosphere                                           | BPB                   | bromophenol blue                                                     |
| ATP      | adenosine triphosphate                                        | BPG                   | 2,3-bis(phospho)- <i>D</i> -glycerate                                |
| ATR      | attenuated total internal reflection                          | bpy                   | 2,2'-bipyridine                                                      |
| at.wt.   | atomic weight                                                 | Bq                    | becquerel                                                            |
| AU       | astronomical unit (ua is also used)                           | Br                    | butyryl                                                              |
| AUC      | area under the time-concentration curve                       | BRE                   | bond resonance energy                                                |
| av       | average                                                       | BrUrd                 | 5-bromouridine                                                       |
| avdp     | avoidupois                                                    | BS                    | Birge–Spomer extrapolation                                           |
| B        | bel; asparagine or aspartic acid (unspecified)                | BSE                   | back scattered electron(s)                                           |
| <i>B</i> | magnetic flux density; second virial coefficient; susceptance | BSSE                  | basis set superposition error                                        |
| b        | barn                                                          | BTMSA                 | 1,2-bis(trimethylsilyl)acetylene                                     |
| <i>b</i> | van der Waals constant; molality                              | Btu                   | British thermal unit                                                 |
| BA       | benzyladenine                                                 | BTX                   | benzene, toluene, and xylene                                         |
| BAL      | British anti-Lewisite [2,3-dimercapto-1-propanol]             | Bu                    | butyl                                                                |
| BAP, BaP | benzo[a]pyrene                                                | bu                    | bushel                                                               |
| bar      | bar (pressure unit)                                           | Bz                    | benzoyl                                                              |
| bbl      | barrel                                                        | Bzl                   | benzyl                                                               |
| BBP      | benzyl butyl phthalate                                        | C                     | coulomb; cysteine; cytosine (in genetic code)                        |
| BCB      | bromocresol blue                                              | °C                    | degree Celsius                                                       |
| bcc      | body centered cubic                                           | <i>C</i>              | capacitance; heat capacity; number concentration                     |
| BCF      | bioconcentration factor                                       | <i>c</i>              | centi (SI prefix for 10 <sup>-2</sup> ); combustion reaction         |
| BCG      | bromocresol green                                             | <i>c</i>              | amount concentration; specific heat; velocity                        |
| BCNU     | <i>N,N'</i> -bis(2-chloroethyl)- <i>N</i> -nitrosourea        | <i>c</i> <sub>0</sub> | speed of light in vacuum                                             |
| BCP      | bromocresol purple                                            | CA                    | collisional activation                                               |
| BCPB     | bromochlorophenol blue                                        | ca.                   | approximately                                                        |
| BCS      | Bardeen–Cooper–Schrieffer (theory)                            | CADD                  | computer-assisted drug design                                        |
| BDE      | bond dissociation energy                                      | cal                   | calorie                                                              |
| BDEA     | butyldiethanolamine                                           | calc                  | calculated                                                           |
| BDMA     | benzyl dimethylamine                                          | cAMP                  | adenosine cyclic 3',5'-(hydrogen phosphate)                          |

|           |                                                               |           |                                                                   |
|-----------|---------------------------------------------------------------|-----------|-------------------------------------------------------------------|
| CAN       | ceric ammonium nitrate                                        | COSY      | correlation spectroscopy                                          |
| CARS      | coherent anti-Stokes Raman spectroscopy                       | COT       | 1,3,5,7-cyclooctatetraene                                         |
| CAS       | complete active space                                         | cot       | cotangent                                                         |
| CASRN     | Chemical Abstracts Service Registry Number                    | coth      | hyperbolic cotangent                                              |
| CAT       | computerized axial tomography; clear air turbulence           | CP        | chemically pure                                                   |
| CBE       | chemical beam epitaxy                                         | Cp        | cyclopentadienyl                                                  |
| CBS       | complete basis set (of orbitals)                              | Cp*       | pentamethylcyclopentadienyl                                       |
| CC        | coupled cluster; combustion calorimetry                       | cP        | centipoise                                                        |
| cc        | cubic centimeter                                              | cp        | candle power                                                      |
| CCD       | charge-coupled device                                         | CPA       | coherent potential approximation                                  |
| CD        | circular dichroism                                            | CPC       | centrifugal partition chromatography                              |
| cd        | candela; condensed (phase)                                    | cpd       | contact potential difference                                      |
| CDNO      | complete neglect of differential overlap                      | CPL       | circular polarization of luminescence                             |
| CDP       | cytidine 5'-diphosphate                                       | CPR       | chlorophenol red                                                  |
| CDT       | 1,5,9-cyclododecatriene                                       | cps       | cycles per second                                                 |
| CDTA      | (1,2-cyclohexylenedinitrilo)tetraacetic acid monohydrate      | CPT       | charge conjugation/space inversion/time inversion (theorem)       |
| CDW       | charge density waves                                          | CPU       | central processing unit                                           |
| CEM       | channel electron multiplier                                   | cr, cryst | crystalline (phase)                                               |
| CEP       | counter electrophoresis                                       | CRF       | charge remote fragmentation                                       |
| CEPA      | coupled electron-pair approximation                           | CRU       | constitutional repeating unit (in polymer nomenclature)           |
| cf.       | compare                                                       | CSA       | camphorsulfonic acid                                              |
| CFC       | chlorofluorocarbon compound                                   | csc       | cosecant                                                          |
| cfm       | cubic feet per minute                                         | CSR       | charge stripping reaction                                         |
| cgs       | centimeter–gram–second system                                 | CT        | charge transfer                                                   |
| Chaps     | 3-[3-(cholamidopropyl)dimethylammonio]-1-propanesulfonic acid | ct        | carat                                                             |
| Ches      | 2-( <i>N</i> -cyclohexylamino)ethanesulfonic acid             | CTEM      | conventional transmission electron microscopy                     |
| CHF       | coupled Hartree–Fock (method)                                 | CTP       | cytidine 5'-triphosphate                                          |
| Chl       | chlorophyll                                                   | CTR       | controlled thermonuclear reaction                                 |
| Cho       | choline                                                       | cu        | cubic                                                             |
| CHT       | 1,3,5-cycloheptatriene                                        | CV        | cyclic voltammetry                                                |
| Ci        | curie                                                         | CVD       | chemical vapor deposition                                         |
| CI        | configuration interaction; chemical ionization; color index   | cw        | continuous wave                                                   |
| CID       | charge-injection device; collision-induced dissociation       | cwt       | hundredweight (112 pounds)                                        |
| CIDEP     | chemically induced dynamic electron polarization              | Cy        | cyclohexyl                                                        |
| CIDNP     | chemically induced dynamic nuclear polarization               | Cya       | cysteic acid                                                      |
| CIE       | countercurrent immunoelectrophoresis                          | Cyd       | cytidine                                                          |
| cir       | circular                                                      | cyl       | cylinder                                                          |
| CKFF      | Cotton–Kraihanzel force field                                 | Cys       | cysteine                                                          |
| CL        | cathode luminescence (spectroscopy)                           | Cyt       | cytosine                                                          |
| CLT       | central limit theorem                                         | D         | debye unit; aspartic acid                                         |
| cm        | centimeter                                                    | <i>D</i>  | diffusion coefficient; dissociation energy; electric displacement |
| c.m.      | center of mass                                                | d         | day; deuteron; deci (SI prefix for 10 <sup>-1</sup> )             |
| c.m.c.    | critical micelle concentration                                | <i>d</i>  | distance; density; dextrorotatory                                 |
| CMO       | canonical molecular orbital                                   | 2,4-D     | 2,4-dichlorophenoxyacetic acid                                    |
| CMP       | cytidine 5'-monophosphate; chemical measurement process       | D/A       | digital to analog                                                 |
| CN        | coordination number                                           | Da        | dalton                                                            |
| CNDO      | complete neglect of differential overlap                      | DA        | donor–acceptor (complex)                                          |
| <i>Co</i> | Cowling number                                                | da        | deka (SI prefix for 10 <sup>1</sup> )                             |
| COD       | chemical oxygen demand; 1,4-cyclooctadiene                    | DAA       | diacetone alcohol                                                 |
| conc      | concentrated; concentration                                   | DAB       | 4-(dimethylamino)azobenzene                                       |
| const     | constant                                                      | Dab       | 2,4-diaminobutanoic acid                                          |
| COOP      | crystal orbital overlap population                            | DACH      | <i>trans</i> -1,2-diaminocyclohexane                              |
| cos       | cosine                                                        | DAP       | diammonium phosphate                                              |
| cosh      | hyperbolic cosine                                             | DART      | direct analysis in real-time mass spectrometry                    |

|        |                                                             |                      |                                                                                                                     |
|--------|-------------------------------------------------------------|----------------------|---------------------------------------------------------------------------------------------------------------------|
| dB     | decibel                                                     | DRE                  | Dewar resonance energy                                                                                              |
| DBA    | dibenz[a,h]anthracene                                       | dRib                 | 2-deoxyribose                                                                                                       |
| DBCP   | 1,2-dibromo-3-chloropropane                                 | DRIFT                | diffuse reflectance infrared Fourier transform                                                                      |
| DBMS   | database management system                                  | DRP                  | dynamic reaction path                                                                                               |
| DBP    | dibutyl phthalate                                           | DRS                  | diffuse reflectance spectroscopy                                                                                    |
| DBPC   | 2,6-di- <i>tert</i> -butyl- <i>p</i> -cresol                | DSC                  | differential scanning calorimetry                                                                                   |
| dc, DC | direct current                                              | DTA                  | differential thermal analysis                                                                                       |
| DCB    | dicyanobenzene                                              | DTBP                 | di- <i>tert</i> -butyl peroxide                                                                                     |
| DCEE   | dichloroethyl ether                                         | DVB                  | divinylbenzene                                                                                                      |
| DCHA   | dicyclohexylamine                                           | dyn                  | dyne                                                                                                                |
| DCM    | dichloromethane                                             | DZ                   | double-zeta (type of basis set)                                                                                     |
| DCPD   | dicyclopentadiene                                           | E                    | exa (SI prefix for 10 <sup>18</sup> ); glutamic acid                                                                |
| DE     | delocalization energy; delayed extraction                   | <i>E</i>             | electric field strength; electromotive force; energy; modulus of elasticity; entgegen ( <i>trans</i> configuration) |
| Dec    | decyl                                                       | <i>E<sub>h</sub></i> | Hartree energy                                                                                                      |
| dec    | decomposes                                                  | e                    | electron; base of natural logarithms                                                                                |
| DEET   | diethyltoluamide [ <i>N,N</i> -diethyl-3-methylbenzamide]   | <i>e</i>             | elementary charge; linear strain                                                                                    |
| deg    | degree                                                      | EA                   | electron affinity                                                                                                   |
| den    | density                                                     | EAN                  | effective atomic number                                                                                             |
| DESI   | desorption electrospray ionization (in mass spectrometry)   | ECD                  | electron capture dissociation                                                                                       |
| det    | determinant                                                 | ECP                  | effective core potential                                                                                            |
| dev    | deviation                                                   | ECR                  | electron cyclotron resonance                                                                                        |
| DFT    | density functional theory                                   | ED                   | electron diffraction                                                                                                |
| dGlc   | 2-deoxyglucose                                              | EDAX                 | energy dispersive analysis by x-rays                                                                                |
| DHH    | dehydroheliotridine                                         | EDB                  | ethylene dibromide [1,2-dibromoethane]                                                                              |
| DHU    | dihydrouridine                                              | EDC                  | ethylene dichloride [1,2-dichloroethane]                                                                            |
| DHR    | dehydroretroene                                             | EDI                  | estimated daily intake                                                                                              |
| DI     | desorption ionization                                       | EDS                  | energy-dispersive x-ray spectroscopy                                                                                |
| diam   | diameter                                                    | EDTA                 | ethylenediaminetetraacetic acid                                                                                     |
| dil    | dilute; dilution                                            | EEDQ                 | ethyl 2-ethoxy-1(2 <i>H</i> )-quinolinecarboxylate                                                                  |
| DIM    | diatomics in molecules (method); digital imaging microscopy | EEL                  | environmental exposure level                                                                                        |
| dm     | decimeter                                                   | EELS                 | electron energy loss spectroscopy                                                                                   |
| DMA    | <i>N,N</i> -dimethylaniline                                 | EES                  | excitation emission spectrum                                                                                        |
| DMAC   | <i>N,N</i> -dimethylacetamide                               | EFF                  | empirical force field                                                                                               |
| DBMC   | 2,4-di- <i>tert</i> -butyl-5-methylphenol                   | EEEE                 | energy factored force field                                                                                         |
| DBP    | 2,3-dibromo-1-propanol                                      | EG                   | equilibrium in the gas phase                                                                                        |
| DMF    | <i>N,N</i> -dimethylformamide                               | EGA                  | evolved gas analysis                                                                                                |
| DMP    | dimethyl phthalate                                          | EHMO,<br>EHT         | extended Hückel molecular orbital (theory)                                                                          |
| DMS    | dimethyl sulfide                                            | EIMS                 | electron impact mass spectrometry                                                                                   |
| DMSO   | dimethyl sulfoxide                                          | EIS                  | electron impact spectroscopy; electrochemical impedance spectroscopy                                                |
| DMT    | dimethyl terephthalate; dimethyl tartrate                   | ELISA                | enzyme-linked immunosorbent assay                                                                                   |
| DN     | donor number                                                | ELS                  | energy loss spectroscopy                                                                                            |
| DNA    | deoxyribonucleic acid                                       | EM                   | extended molarity; electron microscopy                                                                              |
| DNase  | deoxyribonuclease                                           | emf                  | electromotive force                                                                                                 |
| DNMR   | dynamic NMR spectroscopy                                    | EMPA,<br>EMA         | electron probe microanalysis                                                                                        |
| DNP    | dinitrophenyl                                               | emu                  | electromagnetic unit system                                                                                         |
| Dod    | dodecyl                                                     | en                   | ethylenediamine                                                                                                     |
| DOP    | dioctyl phthalate                                           | ENDOR                | electron-nuclear double resonance                                                                                   |
| DOS    | density of states; digital operating system                 | EOS                  | equation of state                                                                                                   |
| doz    | dozen                                                       | EPDS                 | electron photodetachment spectroscopy                                                                               |
| d.p.   | degree of polymerization                                    | EPR                  | electron paramagnetic resonance                                                                                     |
| dpl    | displacement                                                | EPT-76               | provisional low temperature scale of 1976                                                                           |
| Dpm    | 2,6-diaminopimelic acid                                     | EPTC                 | dipropylcarbamoithioic acid, <i>S</i> -ethyl ester                                                                  |
| dpm    | disintegrations per minute                                  | EPXMA                | electron probe x-ray microanalysis                                                                                  |
| dps    | disintegrations per second                                  | eq, eqn              | equation                                                                                                            |
| dr     | dram                                                        |                      |                                                                                                                     |

|            |                                                                                         |            |                                                                                     |
|------------|-----------------------------------------------------------------------------------------|------------|-------------------------------------------------------------------------------------|
| <i>eqQ</i> | quadrupole coupling constant                                                            | ft         | foot                                                                                |
| erf        | error function                                                                          | ft-lb      | foot pound                                                                          |
| erg        | erg (energy unit)                                                                       | FTIR       | Fourier transform infrared spectroscopy                                             |
| ES         | equilibrium in solution                                                                 | FTMS       | Fourier transform mass spectrometry                                                 |
| ESA        | electrostatic energy analyzer                                                           | FTNMR      | Fourier transform nuclear magnetic resonance                                        |
| ESCA       | electron spectroscopy for chemical analysis                                             | fus        | fusion (melting)                                                                    |
| ESD        | electron stimulated desorption                                                          | FVP        | flash vacuum pyrolysis                                                              |
| e.s.d.     | estimated standard deviation                                                            | FWHM       | full width at half maximum                                                          |
| ESI        | electrospray ionization                                                                 | G          | Gauss; guanine (in genetic code); giga (SI prefix for 10 <sup>9</sup> ); glycine    |
| ESR        | electron spin resonance                                                                 | <i>G</i>   | electrical conductance; Gibbs energy; gravitational constant; sheer modulus         |
| est        | estimated                                                                               | g          | gram; gas (phase)                                                                   |
| esu        | electrostatic unit system                                                               | <i>g</i>   | acceleration due to gravity; degeneracy; Landé <i>g</i> -factor; statistical weight |
| ET         | ephemeris time; electron transfer                                                       | GABA       | γ-aminobutyric acid                                                                 |
| Et         | ethyl                                                                                   | Gal        | gal; galactose                                                                      |
| Etn        | ethanolamine                                                                            | gal        | gallon                                                                              |
| ETS        | electron tunneling spectroscopy                                                         | GalN       | galactosamine                                                                       |
| <i>Eu</i>  | Euler number                                                                            | GB         | gas-phase basicity                                                                  |
| e.u.       | entropy unit                                                                            | GC         | gas chromatography                                                                  |
| eV         | electronvolt                                                                            | GC-MS      | gas chromatography-mass spectrometry                                                |
| EXAFS      | extended x-ray absorption fine structure (spectroscopy)                                 | GDMS       | glow discharge mass spectroscopy                                                    |
| EXELFS     | extended energy loss fine structure                                                     | GDP        | guanosine 5'-diphosphate                                                            |
| exp        | exponential function                                                                    | <i>gem</i> | geminal (on the same carbon atom)                                                   |
| expt       | experimental                                                                            | GeV        | gigaelectronvolt                                                                    |
| ext        | external                                                                                | GIAO       | gauge invariant atomic orbital                                                      |
| F          | farad; phenylalanine                                                                    | GIBMS      | guided ion beam mass spectrometry                                                   |
| °F         | degree Fahrenheit                                                                       | gl         | glacial                                                                             |
| <i>F</i>   | Faraday constant; force; angular momentum                                               | Gla        | 4-carboxyglutamic acid                                                              |
| <i>f</i>   | formation reaction; femto (SI prefix for 10 <sup>-15</sup> )                            | GLC        | gas-liquid chromatography                                                           |
| <i>f</i>   | activity coefficient; aperture ratio; focal length; force constant; frequency; fugacity | Glc        | glucose                                                                             |
| FAB        | fast atom bombardment                                                                   | GlcA       | gluconic acid                                                                       |
| FAD        | flavine adenine dinucleotide                                                            | GlcN       | glucosamine                                                                         |
| FAIMS      | high-field asymmetric waveform ion mobility spectrometry                                | GlcNAc     | <i>N</i> -acetylglucosamine                                                         |
| FA-SIFT    | flowing afterglow – selected ion-flow tube                                              | GLP        | good laboratory practice                                                            |
| fcc        | face centered cubic                                                                     | GlcU       | glucuronic acid                                                                     |
| FD         | field desorption                                                                        | Gln        | glutamine                                                                           |
| FEL        | free electron laser                                                                     | Glu        | glutamic acid                                                                       |
| FEM        | field emission microscopy                                                               | Gly        | glycine                                                                             |
| FEMO       | free electron molecular orbital                                                         | Glx        | glutamine or glutamic acid (unspecified)                                            |
| FET        | field effect transistor                                                                 | GMP        | guanosine 5'-monophosphate                                                          |
| fid        | free induction decay                                                                    | GMT        | Greenwich mean time                                                                 |
| FI         | field ionization                                                                        | GPC        | gel-permeation chromatography                                                       |
| FIM        | field ion microscopy                                                                    | gpm        | gallons per minute                                                                  |
| FIR        | far infrared                                                                            | gps        | gallon per second                                                                   |
| fl         | fluid (phase)                                                                           | <i>Gr</i>  | Grashof number                                                                      |
| FM         | frequency modulation                                                                    | gr         | grain                                                                               |
| <i>Fo</i>  | Fourier number                                                                          | Gra        | glyceraldehyde                                                                      |
| fp         | freezing point                                                                          | Gri        | glyceric acid                                                                       |
| fpm        | feet per minute                                                                         | Grn        | glycerone [dihydroxyacetone]                                                        |
| fps        | feet per second; foot-pound-second system                                               | Gro        | glycerol                                                                            |
| Fr         | franklin                                                                                | GTO        | Gaussian-type orbital                                                               |
| <i>Fr</i>  | Froude number                                                                           | GTP        | guanosine 5'-triphosphate                                                           |
| Fru        | fructose                                                                                | Gua        | guanine                                                                             |
| FSGO       | floating spherical Gaussian orbitals                                                    | Gul        | gulose                                                                              |
| FT         | Fourier transform                                                                       | Guo        | guanosine                                                                           |



|           |                                                                                                       |
|-----------|-------------------------------------------------------------------------------------------------------|
| GUT       | grand unified theory                                                                                  |
| GVB       | generalized valence bond (method)                                                                     |
| GWS       | Glashow–Weinberg–Salam (theory)                                                                       |
| Gy        | gray; gigayear                                                                                        |
| H         | henry; histidine                                                                                      |
| <i>H</i>  | enthalpy; Hamiltonian function; magnetic field                                                        |
| $H_0$     | Hubble constant                                                                                       |
| h         | helion; hour; hecto (SI prefix for $10^2$ )                                                           |
| <i>h</i>  | Planck constant                                                                                       |
| <i>Ha</i> | Hartmann number                                                                                       |
| ha        | hectare                                                                                               |
| HAM       | hydrogenic atoms in molecules                                                                         |
| hav       | haversine                                                                                             |
| Hb        | hemoglobin                                                                                            |
| HCA       | heterocyclic amine                                                                                    |
| hcp       | hexagonal closed packed                                                                               |
| Hcy       | homocysteine                                                                                          |
| HDL       | high-density lipoprotein                                                                              |
| HDS       | hydrodesulfurization                                                                                  |
| HEIS      | high-energy ion scattering                                                                            |
| HEP       | high energy physics                                                                                   |
| Hepes     | 4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid                                                    |
| Hepps     | 4-(2-hydroxyethyl)-1-piperazinepropanesulfonic acid                                                   |
| HF        | high frequency; Hartree–Fock (method)                                                                 |
| HFA       | hexafluoroacetone                                                                                     |
| HFO       | Hartree–Fock orbital                                                                                  |
| hfs       | hyperfine structure                                                                                   |
| His       | histidine                                                                                             |
| HMO       | Hückel molecular orbital                                                                              |
| HMX       | cyclotetramethylenetetranitramine                                                                     |
| HN1       | 2-chloro- <i>N</i> -(2-chloroethyl)- <i>N</i> -ethylethanamine                                        |
| HOAc      | acetic acid                                                                                           |
| HOC       | halogenated organic compound(s)                                                                       |
| HOMAS     | harmonic oscillator model of aromatic stabilization                                                   |
| HOMO      | highest occupied molecular orbital                                                                    |
| HOSE      | harmonic oscillator stabilization energy                                                              |
| Hp        | heptyl                                                                                                |
| hp        | horsepower                                                                                            |
| HPLC      | high-performance liquid chromatography                                                                |
| HPMS      | high pressure mass spectrometry                                                                       |
| HQ        | <i>p</i> -hydroquinone                                                                                |
| hr        | hour                                                                                                  |
| HRE       | Hückel resonance energy                                                                               |
| HREELS    | high resolution electron energy loss spectroscopy                                                     |
| HREM      | high resolution electron microscopy                                                                   |
| HSAB      | hard-soft acid-base (theory)                                                                          |
| HSE       | homodesmotic stabilization energy                                                                     |
| Hse       | homoserine                                                                                            |
| Hx        | hexyl                                                                                                 |
| Hyl       | 5-hydroxylysine                                                                                       |
| Hyp       | hypoxanthine; 4-hydroxyproline                                                                        |
| Hz        | hertz                                                                                                 |
| I         | isoleucine; inositol                                                                                  |
| <i>I</i>  | electric current; ionic strength; moment of inertia; nuclear spin angular momentum; radiant intensity |
| <i>i</i>  | square root of minus one                                                                              |
| <i>i</i>  | electric current                                                                                      |

|          |                                                                    |
|----------|--------------------------------------------------------------------|
| I/O      | input/output                                                       |
| IAT      | international atomic time                                          |
| IC       | integrated circuit                                                 |
| ICD      | induced circular dichroism                                         |
| ICP      | inductive-coupled plasma                                           |
| ICR      | ion cyclotron resonance                                            |
| ICVTST   | improved canonical variational transition-state theory             |
| ID       | inside diameter                                                    |
| id       | ideal (solution)                                                   |
| Ido      | iodose                                                             |
| IdoA     | iduronic acid                                                      |
| IDP      | inosine 5'-diphosphate                                             |
| IE       | ionization energy                                                  |
| i.e.p.   | isoelectric point                                                  |
| IEPA     | independent electron pair approximation                            |
| IF       | intermediate frequency                                             |
| IGLO     | individual gauge for localized orbitals                            |
| IKES     | ion kinetic energy spectrometry                                    |
| Ile      | isoleucine                                                         |
| Im       | imaginary part                                                     |
| IMFP     | inelastic mean free path (of electrons)                            |
| imm      | immersion                                                          |
| IMP      | inosine 5'-monophosphate                                           |
| IMPATT   | impact ionization avalanche transit time                           |
| IMS      | ion mobility spectrometry                                          |
| in.      | inch                                                               |
| InChI    | IUPAC International Chemical Identifier                            |
| INDO     | immediate neglect of differential overlap                          |
| Ino      | inosine                                                            |
| INS      | inelastic neutron scattering; ion neutralization spectroscopy      |
| Ins      | <i>myo</i> -inositol                                               |
| int      | internal                                                           |
| IP       | ionization potential                                               |
| IPA      | isopropyl alcohol                                                  |
| IPMA     | ion probe microanalysis                                            |
| IPN      | interpenetrating polymer network                                   |
| IPR      | isotope perturbation of resonance                                  |
| IPTS     | International Practical Temperature Scale                          |
| IQ       | 2-amino-3-methyl-3 <i>H</i> -imidazo(4,5- <i>f</i> )quinoline      |
| IR       | infrared                                                           |
| IRAS     | infrared reflection-absorption spectroscopy                        |
| IRC      | intrinsic reaction coordinate                                      |
| IRMPD    | infrared multiphoton dissociation                                  |
| IRMS     | isotope ratio mass spectrometry                                    |
| IRS      | infrared spectroscopy                                              |
| isc      | intersystem crossing                                               |
| ISE      | ion-selective electrode; isodesmic stabilization energy            |
| ISS      | ion scattering spectroscopy                                        |
| IT       | ion trap; information technology                                   |
| ITP      | inosine 5'-triphosphate                                            |
| ITS      | International Temperature Scale (1990)                             |
| IU       | international unit                                                 |
| J        | joule; leucine or isoleucine (unspecified)                         |
| <i>J</i> | angular momentum; electric current density; flux; Massieu function |
| <i>j</i> | angular momentum; electric current density                         |

|       |                                                                                        |        |                                                                                                           |
|-------|----------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------------------------------------------|
| JT    | Jahn–Teller (effect)                                                                   | LI     | laser ionization                                                                                          |
| K     | kelvin; lysine                                                                         | lim    | limit                                                                                                     |
| $K$   | absorption coefficient; bulk modulus; equilibrium constant; kinetic energy             | LIMS   | laser ionization mass spectroscopy; laboratory information management system                              |
| k     | kilo (SI prefix for $10^3$ )                                                           | liq    | liquid                                                                                                    |
| $k$   | absorption index; Boltzmann constant; rate constant; thermal conductivity; wave vector | LIT    | linear ion trap                                                                                           |
| kat   | katal (unit of catalytic activity)                                                     | LLCT   | ligand to ligand charge transfer                                                                          |
| kb    | kilobar; kilobases (DNA or RNA)                                                        | lm     | lumen                                                                                                     |
| KC-MS | Knudson cell mass spectrometry                                                         | LMCT   | ligand to metal charge transfer                                                                           |
| kcal  | kilocalorie                                                                            | LMMS   | laser microprobe mass spectrometry                                                                        |
| KDP   | potassium dihydrogen phosphate                                                         | LMO    | localized molecular orbital                                                                               |
| KE    | kinetic energy                                                                         | LMR    | laser magnetic resonance                                                                                  |
| KERD  | kinetic energy release distributions                                                   | ln     | logarithm (natural)                                                                                       |
| keV   | kiloelectronvolt                                                                       | LNDO   | local neglect of differential overlap                                                                     |
| KG    | kinetics in the gas phase                                                              | log    | logarithm (common)                                                                                        |
| kg    | kilogram                                                                               | LOMO   | lowest occupied molecular orbital                                                                         |
| kgf   | kilogram force                                                                         | long.  | longitude                                                                                                 |
| KIE   | kinetic isotope effect                                                                 | LPG    | liquid petroleum gas                                                                                      |
| kJ    | kilojoule                                                                              | LPHP   | laser-powered homogeneous pyrolysis                                                                       |
| km    | kilometer                                                                              | LPU    | law of propagation of uncertainty                                                                         |
| $Kn$  | Knudsen number                                                                         | LSFE   | linear field stabilization energy                                                                         |
| kPa   | kilopascal                                                                             | LSI    | liquid secondary ionization                                                                               |
| KS    | kinetics in solution                                                                   | LST    | local sidereal time                                                                                       |
| kt    | karat                                                                                  | LT     | local time                                                                                                |
| KTP   | potassium titanium phosphate                                                           | LTE    | local thermodynamic equilibrium                                                                           |
| kV    | kilovolt                                                                               | LUMO   | lowest unoccupied molecular orbital                                                                       |
| kva   | kilovolt ampere                                                                        | lx     | lux                                                                                                       |
| kW    | kilowatt                                                                               | ly     | langley                                                                                                   |
| kwh   | kilowatt hour                                                                          | l.y.   | light year                                                                                                |
| L     | liter; lambert; leucine                                                                | Lys    | lysine                                                                                                    |
| $L$   | Avogadro constant; inductance; Lagrange function; angular momentum                     | Lyx    | lyxose                                                                                                    |
| l     | liter; liquid (phase)                                                                  | M      | molar (as in 0.1 M solution); mega (SI prefix for $10^6$ ); methionine                                    |
| $l$   | angular momentum; length; mean free path; levorotatory                                 | $M$    | magnetization; molar mass; mutual inductance; torque; angular momentum component; median                  |
| Lac   | lactose                                                                                | $M_r$  | molecular weight (relative molar mass)                                                                    |
| LAH   | lithium aluminum hydride                                                               | m      | meter; molal (as in 0.1 m solution); metastable (isotope); milli (SI prefix for $10^{-3}$ )               |
| lat.  | latitude                                                                               | $m$    | magnetic dipole moment; mass; molality; angular momentum component; <i>meta</i> (locant on aromatic ring) |
| lb    | pound                                                                                  | $Ma$   | Mach number                                                                                               |
| lbf   | pound force                                                                            | MA     | maleic anhydride                                                                                          |
| LC    | liquid chromatography                                                                  | Mal    | maltose                                                                                                   |
| LC-MS | liquid chromatography–mass spectrometry                                                | Man    | mannose                                                                                                   |
| lc    | liquid crystal (phase)                                                                 | MASNMR | magic angle spinning nuclear magnetic resonance                                                           |
| LCAO  | linear combination of atomic orbitals                                                  | max    | maximum                                                                                                   |
| LD    | lethal dose; laser desorption                                                          | Mb     | myoglobin                                                                                                 |
| LDA   | local density approximation; lithium diisopropylamide                                  | MBE    | molecular beam epitaxy                                                                                    |
| LDL   | low-density lipoprotein                                                                | MBER   | molecular beam electron resonance                                                                         |
| LDV   | laser-Doppler velocimetry                                                              | MBPT   | many body perturbation theory                                                                             |
| $Le$  | Lewis function                                                                         | MC     | Monte Carlo (method)                                                                                      |
| LE    | localization energy                                                                    | MCAA   | monochloroacetic acid                                                                                     |
| LEC   | liquid exchange chromatography                                                         | MCD    | magnetic circular dichroism                                                                               |
| LED   | light emitting diode                                                                   | MCP    | microchannel plate                                                                                        |
| LEED  | low-energy electron diffraction                                                        | MCPA   | (4-chloro-2-methylphenoxy)acetic acid                                                                     |
| LEIS  | low-energy ion scattering                                                              | MCPF   | modified coupled pair functional                                                                          |
| Leu   | leucine                                                                                | MCS    | Monte Carlo simulation                                                                                    |
| LFER  | linear free energy relationships                                                       |        |                                                                                                           |
| LFL   | lower flammable limit                                                                  |        |                                                                                                           |

|         |                                                            |
|---------|------------------------------------------------------------|
| MCSCF   | multiconfigurational self-consistent field (approximation) |
| MD      | molecular dynamics (method)                                |
| Me      | methyl                                                     |
| MeCCNU  | 1-(2-chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea     |
| MeIQ    | 2-amino-3,4-dimethylimidazo[4,5-f]quinoline                |
| MeIQx   | 2-amino-3,8-dimethylimidazo[4,5-f]quinoxaline              |
| MEK     | methyl ethyl ketone                                        |
| MEP     | molecular electrostatic potential                          |
| MERP    | minimum energy reaction path                               |
| Mes     | 4-morpholineethanesulfonic acid                            |
| MESFET  | metal-semiconductor field-effect transistor                |
| Met     | methionine                                                 |
| MeV     | megaelectronvolt                                           |
| meV     | millielectronvolt                                          |
| MF      | molecular formula                                          |
| mg      | milligram                                                  |
| MHD     | magnetohydrodynamics                                       |
| mi      | mile                                                       |
| MIAC    | methyl isoamyl ketone                                      |
| MIKES   | mass-analyzed ion kinetic energy spectrometry              |
| min     | minimum; minute                                            |
| MINDO   | modified INDO (method)                                     |
| MIPK    | methyl isopropyl ketone                                    |
| MIR     | mid infrared                                               |
| misc    | miscible                                                   |
| MKS     | meter-kilogram-second system                               |
| MKSA    | meter-kilogram-second-ampere system                        |
| mL, ml  | milliliter                                                 |
| MM      | molecular mechanics                                        |
| mm      | millimeter                                                 |
| MMDR    | microwave-microwave double resonance                       |
| mmf     | magnetomotive force                                        |
| mmHg    | millimeter of mercury                                      |
| MNDO    | modified neglect of diatomic overlap                       |
| MO      | molecular orbital; methyl orange                           |
| MODR    | microwave-optical double resonance                         |
| mol     | mole                                                       |
| mol.wt. | molecular weight                                           |
| mon     | monomeric form                                             |
| Mops    | 4-morpholinepropanesulfonic acid                           |
| MOS     | metal-oxide semiconductor                                  |
| MOSFET  | metal-oxide semiconductor field-effect transistor          |
| mp      | melting point                                              |
| MPa     | megapascal                                                 |
| MPA     | Mulliken population analysis                               |
| Mpc     | megaparsec                                                 |
| MPI     | multiphoton ionization                                     |
| MPTP    | 1,2,3,6-tetrahydro-1-methyl-4-phenylpyridine               |
| MR      | methyl red                                                 |
| MRD     | multireference double substitution (method)                |
| MRI     | magnetic resonance imaging                                 |
| mRNA    | messenger RNA                                              |
| MS      | mass spectroscopy                                          |
| ms      | millisecond                                                |
| MSA     | methanesulfonic acid                                       |

|                      |                                                                                                                |
|----------------------|----------------------------------------------------------------------------------------------------------------|
| MSDS                 | Material Safety Data Sheet                                                                                     |
| MS-K                 | mass spectroscopy – kinetic method                                                                             |
| MSL                  | mean sea level                                                                                                 |
| MTBE                 | methyl <i>tert</i> -butyl ether                                                                                |
| MTD                  | maximum tolerable dose                                                                                         |
| Mur                  | muramic acid                                                                                                   |
| mV                   | millivolt                                                                                                      |
| MVK                  | methyl vinyl ketone                                                                                            |
| MW                   | megawatt; microwave; molecular weight                                                                          |
| mW                   | milliwatt                                                                                                      |
| Mx                   | maxwell                                                                                                        |
| N                    | newton; asparagine                                                                                             |
| <i>N</i>             | angular momentum; neutron number; number density                                                               |
| <i>N<sub>A</sub></i> | Avogadro constant                                                                                              |
| <i>n</i>             | neutron; nano (SI prefix for 10 <sup>-9</sup> )                                                                |
| <i>n</i>             | amount of substance; number density; principal quantum number; refractive index; normal (in chemical formulas) |
| NAA                  | nuclear activation analysis                                                                                    |
| NAAD                 | nicotinic acid adenine dinucleotide                                                                            |
| NAD                  | nicotinamide adenine dinucleotide                                                                              |
| NADH                 | reduced NAD                                                                                                    |
| NADP                 | NAD phosphate                                                                                                  |
| NANA                 | <i>N</i> -acetylneuraminic acid                                                                                |
| NAO                  | natural atomic orbital                                                                                         |
| NBO                  | natural bond orbital                                                                                           |
| nbp                  | normal boiling point                                                                                           |
| NEDOR                | nuclear electron double resonance                                                                              |
| Neu                  | neuraminic acid                                                                                                |
| NEXAFS               | near-edge x-ray absorption fine structure                                                                      |
| ng                   | nanogram                                                                                                       |
| NHO                  | natural hybrid orbital                                                                                         |
| NHOMO                | next-to-highest occupied molecular orbital                                                                     |
| NICI                 | negative ion chemical ionization                                                                               |
| NICS                 | nuclear independent chemical shift                                                                             |
| NIR                  | near infrared; ribosylnicotinamide                                                                             |
| nm                   | nanometer                                                                                                      |
| NMN                  | β-nicotinamide mononucleotide                                                                                  |
| NMR                  | nuclear magnetic resonance                                                                                     |
| Nn                   | nonyl                                                                                                          |
| NNDO                 | neglect of nonbonded differential overlap                                                                      |
| NO                   | natural orbital                                                                                                |
| NOE                  | nuclear Overhauser effect                                                                                      |
| NOEL                 | no-observed-effect level                                                                                       |
| NOx                  | nitrogen oxides                                                                                                |
| NP                   | nitropyrene                                                                                                    |
| NPA                  | natural population analysis                                                                                    |
| NQR                  | nuclear quadrupole resonance                                                                                   |
| NRA                  | nuclear reaction analysis                                                                                      |
| ns                   | nanosecond                                                                                                     |
| NSE                  | neutron spin echo                                                                                              |
| NTP                  | normal temperature and pressure                                                                                |
| Nu                   | nucleophile                                                                                                    |
| <i>Nu</i>            | Nusselt number                                                                                                 |
| <i>o</i>             | <i>ortho</i> (locant on aromatic ring)                                                                         |
| obs, obsd            | observed                                                                                                       |
| Oc                   | octyl                                                                                                          |
| OD                   | optical density; outside diameter                                                                              |

|           |                                                                                                                        |           |                                                                                                                        |
|-----------|------------------------------------------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------|
| ODMR      | optically detected magnetic resonance                                                                                  | PIV       | particle-image velocimetry                                                                                             |
| Oe        | oersted                                                                                                                | PIXE      | particle induced x-ray emission                                                                                        |
| OFGF      | outer valence Green's function (method)                                                                                | pK        | negative log of ionization constant                                                                                    |
| ORD       | optical rotatory dispersion                                                                                            | PLM       | principle of least motion                                                                                              |
| Oro       | orotate; orotidine                                                                                                     | PLOT      | porous-layer open-tabular (column)                                                                                     |
| oz        | ounce                                                                                                                  | PLS       | partial least squares                                                                                                  |
| P         | poise; peta (SI prefix for 10 <sup>15</sup> ); proline                                                                 | pm        | picometer                                                                                                              |
| <i>P</i>  | power; pressure; probability; sound energy flux                                                                        | PMA       | poly(methyl acrylate)                                                                                                  |
| p         | proton; pico (SI prefix for 10 <sup>-12</sup> )                                                                        | PMMA      | poly(methyl methacrylate)                                                                                              |
| <i>p</i>  | dielectric polarization; electric dipole moment; momentum; pressure; bond order; <i>para</i> (as aromatic ring locant) | PMO       | perturbation MO (theory)                                                                                               |
| Pa        | pascal                                                                                                                 | PNDO      | partial neglect of differential overlap                                                                                |
| PA        | proton affinity; pyrrolizidine alkaloid                                                                                | PNO       | pair natural orbitals                                                                                                  |
| PABA      | <i>p</i> -aminobenzoic acid                                                                                            | PNRA      | prompt nuclear reaction analysis                                                                                       |
| PAC       | photoacoustic calorimetry                                                                                              | POAV      | $\pi$ -orbital axis vector                                                                                             |
| PAH       | polycyclic aromatic hydrocarbon(s)                                                                                     | pol       | polymeric form                                                                                                         |
| PAM       | polyacrylamide                                                                                                         | POx       | phosphorus oxides                                                                                                      |
| PAN       | 1-(2-pyridylazo)-2-naphthol; polyacrylonitrile                                                                         | ppb       | parts per billion                                                                                                      |
| PAR       | 4-(2'-pyridylazo)resorcinol                                                                                            | ppm       | parts per million                                                                                                      |
| PAS       | photoacoustic spectroscopy                                                                                             | PPO       | poly(phenylene oxide)                                                                                                  |
| PBA       | poly(butyl acrylate)                                                                                                   | PPP       | Pariser–Parr–Pople (method)                                                                                            |
| PBB       | polybrominated biphenyl                                                                                                | ppt       | parts per thousand; precipitate                                                                                        |
| PBD       | poly(1,3-butadiene)                                                                                                    | Pr        | propyl                                                                                                                 |
| PBMA      | poly(butyl methacrylate)                                                                                               | <i>Pr</i> | Prandtl number                                                                                                         |
| PBT       | poly(butylene terephthalate)                                                                                           | PRDDO     | partial retention of diatomic differential overlap                                                                     |
| PC        | paper chromatography; photocalorimetry                                                                                 | Pro       | proline                                                                                                                |
| pc        | parsec                                                                                                                 | PS        | photoelectron spectroscopy                                                                                             |
| PCB       | polychlorinated biphenyl                                                                                               | ps        | picosecond                                                                                                             |
| PCM       | polarizable continuum model                                                                                            | PSD       | photon stimulated desorption                                                                                           |
| PCR       | polymerase chain reaction                                                                                              | psi       | pounds per square inch                                                                                                 |
| PD        | potential difference                                                                                                   | psia      | pounds per square inch absolute                                                                                        |
| pdl       | poundal                                                                                                                | psig      | pounds per square inch gage                                                                                            |
| PDMS      | poly(dimethylsiloxane)                                                                                                 | PT        | perturbation theory                                                                                                    |
| Pe        | pentyl                                                                                                                 | PTFE      | poly(tetrafluoroethylene)                                                                                              |
| <i>Pe</i> | Péclet number                                                                                                          | pt        | pint                                                                                                                   |
| pe        | probable error                                                                                                         | PTMS      | propyltrimethoxysilane                                                                                                 |
| PEA       | poly(ethyl acrylate)                                                                                                   | Pu        | purine                                                                                                                 |
| PEG       | poly(ethylene glycol)                                                                                                  | PVA       | poly(vinyl alcohol)                                                                                                    |
| PEL       | permissible exposure limit                                                                                             | PVAc      | poly(vinyl acetate)                                                                                                    |
| PES       | photoelectron spectroscopy; potential energy surface                                                                   | PVC       | poly(vinyl chloride)                                                                                                   |
| PET       | positron emission tomography; poly(ethylene terephthalate)                                                             | PVD       | physical vapor deposition                                                                                              |
| peth      | petroleum ether                                                                                                        | PVDF      | poly(vinylidene fluoride)                                                                                              |
| pf        | power factor                                                                                                           | PVME      | poly(methyl vinyl ether)                                                                                               |
| PFOA      | perfluorooctanoic acid                                                                                                 | PVT       | pressure–volume–temperature                                                                                            |
| pg        | picogram                                                                                                               | Py        | pyrimidine                                                                                                             |
| Ph        | phenyl                                                                                                                 | PyMS      | pyrolysis mass spectrometry                                                                                            |
| pH        | negative log of hydrogen ion concentration                                                                             | p.z.c.    | point of zero charge                                                                                                   |
| Phe       | phenylalanine                                                                                                          | Q         | electric charge; heat; partition function; quadrupole moment; radiant energy; vibrational normal coordinate; glutamine |
| PhIP      | 2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine                                                                        | <i>q</i>  | electric field gradient; flow rate; heat; wave vector (phonons)                                                        |
| PHPMS     | pulsed high pressure mass spectrometry                                                                                 | QCD       | quantum chromodynamics                                                                                                 |
| pI        | isoelectric point                                                                                                      | QCI       | quadratic configuration interaction                                                                                    |
| PIB       | polyisobutylene                                                                                                        | QCT       | quasi-classical trajectory (method)                                                                                    |
| PIMS      | photoionization mass spectrometry                                                                                      | QED       | quantum electrodynamics                                                                                                |
| PIN       | p-intrinsic-n (diode)                                                                                                  | Q.E.D.    | <i>quod erat demonstrandum</i> (which was to be proved)                                                                |
| Pipes     | 1,4-piperazinediethanesulfonic acid                                                                                    | QIT       | quadrupole ion trap                                                                                                    |

|          |                                                                                                              |           |                                                                                                                                        |
|----------|--------------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------|
| QMRE     | quantum mechanical resonance energy                                                                          | S         | siemens; serine                                                                                                                        |
| QMS      | quadrupole mass spectrometry                                                                                 | S         | area; entropy; probability current density; Poynting vector; symmetry coordinate; spin angular momentum                                |
| QSAR     | quantitative structure–activity relations                                                                    | s         | second; solid (phase)                                                                                                                  |
| QSO      | quasi-stellar object                                                                                         | s         | path length; spin angular momentum; symmetry number; sedimentation coefficient; solubility; symmetrical (as stereochemical descriptor) |
| qt       | quart                                                                                                        | SAED      | selected area electron diffraction                                                                                                     |
| quad     | quadrillion BTU (=1.055•10 <sup>18</sup> joules)                                                             | SALC      | symmetry adapted linear combinations                                                                                                   |
| Qui      | quinovose                                                                                                    | SALI      | surface analysis by laser ionization                                                                                                   |
| q.v.     | <i>quod vide</i> (which you should see)                                                                      | SAM       | scanning Auger microscopy                                                                                                              |
| R        | roentgen; arginine; alkyl radical (in chemical formulas)                                                     | SAMS      | self-assembled monolayers                                                                                                              |
| °R       | degree Rankine                                                                                               | SANS      | small angle neutron scattering                                                                                                         |
| R        | electrical resistance; gas constant; molar refraction; Rydberg constant; coefficient of multiple correlation | SAR       | structure–activity relationship                                                                                                        |
| r        | reaction (as in $\Delta_r H$ )                                                                               | Sar       | sarcosine                                                                                                                              |
| r        | position vector; radius                                                                                      | sat, satd | saturated                                                                                                                              |
| RA       | right ascension                                                                                              | SAXS      | small angle x-ray scattering                                                                                                           |
| rad      | radian                                                                                                       | Sc        | Schmidt number                                                                                                                         |
| RAIRS    | reflection-absorption infrared spectroscopy                                                                  | SC        | spin-coupled (method)                                                                                                                  |
| RAM      | random access memory                                                                                         | SCD       | state correlation diagram                                                                                                              |
| RBS      | Rutherford back scattering                                                                                   | SCE       | saturated calomel electrode                                                                                                            |
| Rbu, Rul | ribulose                                                                                                     | SCF       | self-consistent field (method); supercritical fluid                                                                                    |
| RCI      | ring current index                                                                                           | SCP       | single cell protein                                                                                                                    |
| RDA      | rubidium dihydrogen arsenate                                                                                 | SCR       | silicon-controlled rectifier                                                                                                           |
| RDS      | rate determining step                                                                                        | SCRF      | self-consistent reaction field (method)                                                                                                |
| Re       | real part                                                                                                    | sd        | standard deviation                                                                                                                     |
| RE       | resonance energy                                                                                             | SDW       | spin density wave                                                                                                                      |
| RED      | radial electron distribution                                                                                 | SE        | strain energy                                                                                                                          |
| REELS    | reflection electron energy loss spectroscopy                                                                 | SEC       | size exclusion chromatography                                                                                                          |
| REM      | reflection electron microscopy                                                                               | sec       | secant; second                                                                                                                         |
| rem      | roentgen equivalent man                                                                                      | sec       | secondary (in chemical name)                                                                                                           |
| REMPI    | resonance-enhanced multiphoton ionization                                                                    | SECSY     | spin-echo correlated spectroscopy                                                                                                      |
| REPE     | resonance energy per electron                                                                                | Sed       | sedoheptulose                                                                                                                          |
| RF       | radiofrequency                                                                                               | SEELFS    | surface extended energy loss fine structure                                                                                            |
| RGA      | residual gas analyzer                                                                                        | SEM       | scanning electron microscopy; standard error of the mean                                                                               |
| Rha      | rhamnose                                                                                                     | sepn      | separation                                                                                                                             |
| RHEED    | reflection high-energy electron diffraction                                                                  | Ser       | serine                                                                                                                                 |
| RHF      | restricted Hartree–Fock (theory)                                                                             | SERS      | surface-enhanced Raman spectroscopy                                                                                                    |
| RI       | resonance ionization                                                                                         | SET       | single electron transfer                                                                                                               |
| RIA      | radioimmunoassay                                                                                             | SEXAF     | surface extended x-ray absorption fine structure                                                                                       |
| Rib      | ribose                                                                                                       | SFC       | supercritical fluid chromatography                                                                                                     |
| Ribulo   | ribulose                                                                                                     | Sh        | Sherwood number                                                                                                                        |
| rms      | root–mean–square                                                                                             | Shy       | thiohypoxanthine                                                                                                                       |
| RNA      | ribonucleic acid                                                                                             | SI        | International System of Units; surface ionization                                                                                      |
| RNase    | ribonuclease                                                                                                 | SID       | surface-induced dissociation                                                                                                           |
| ROHF     | restricted open shell Hartree–Fock                                                                           | SILAR     | successive ionic layer adsorption and reaction                                                                                         |
| ROM      | read only memory                                                                                             | SIM       | selected ion monitoring                                                                                                                |
| RPA      | random phase approximation                                                                                   | SIMS      | secondary-ion spectroscopy                                                                                                             |
| RPH      | reaction path Hamiltonian                                                                                    | sin       | sine                                                                                                                                   |
| RPLC     | reversed-phase liquid chromatography                                                                         | sinh      | hyperbolic sine                                                                                                                        |
| rpm      | revolutions per minute                                                                                       | SIPN      | semi-interpenetrating polymer network                                                                                                  |
| rps      | revolutions per second                                                                                       | SLAM      | scanning laser acoustic microscopy                                                                                                     |
| RRK      | Rice–Ramsperger–Kassel (theory)                                                                              | SLUMO     | second lowest unoccupied molecular orbital                                                                                             |
| RRKM     | Rice–Ramsperger–Kassel–Marcus (theory)                                                                       | SMILES    | simplified molecular input line entry system                                                                                           |
| rRNA     | ribosomal RNA                                                                                                | SMO       | semiempirical molecular orbital                                                                                                        |
| RRS      | resonance Raman spectroscopy                                                                                 | SMOW      | Standard Mean Ocean Water (Vienna)                                                                                                     |
| RS       | Raman spectroscopy                                                                                           |           |                                                                                                                                        |
| RSC      | reaction-solution calorimetry                                                                                |           |                                                                                                                                        |
| Ry       | rydberg                                                                                                      |           |                                                                                                                                        |

|           |                                                                                        |                              |                                                                          |
|-----------|----------------------------------------------------------------------------------------|------------------------------|--------------------------------------------------------------------------|
| SNMS      | sputtered neutral mass spectroscopy                                                    | TEELS                        | transmission electron energy loss spectroscopy                           |
| Sno       | thiouridine                                                                            | TEM                          | transverse electromagnetic; transmission electron microscope             |
| SNU       | solar neutrino unit                                                                    | temp                         | temperature                                                              |
| SOJT      | second-order Jahn–Teller (effect)                                                      | tert                         | tertiary (in chemical name)                                              |
| sol       | soluble; solution                                                                      | Tes                          | 2-{{[2-hydroxy-1,1-bis(hydroxymethyl)ethyl]amino}-1-propanesulfonic acid |
| soln, sln | solution                                                                               | TFD                          | Thomas–Fermi–Dirac (method)                                              |
| SOMO      | singly occupied molecular orbital                                                      | TGA                          | thermogravimetric analysis                                               |
| Sor       | sorbose                                                                                | Thd                          | ribosylthymine                                                           |
| sp gr     | specific gravity                                                                       | THEED                        | transmission high energy electron diffraction                            |
| SPM       | scanned probe microscopy                                                               | theor                        | theoretical                                                              |
| SPST      | single-pulse shock tubes                                                               | thf, THF                     | tetrahydrofuran                                                          |
| sq        | square                                                                                 | Thr                          | threonine                                                                |
| Sr        | Strouhal number                                                                        | Thy                          | thymine                                                                  |
| sr        | steradian                                                                              | TI                           | thermal ionization                                                       |
| Srd       | 6-thioinosine                                                                          | TL                           | thermoluminescence                                                       |
| SSMS      | source spark mass spectroscopy                                                         | TLC                          | thin-layer chromatography                                                |
| St        | stoke                                                                                  | TLV                          | threshold limit value                                                    |
| St        | Stanton number                                                                         | TM                           | transverse magnetic                                                      |
| std, stnd | standard (state)                                                                       | TMAB                         | tetrabutylammonium bromide                                               |
| STEL      | short-term exposure limit                                                              | TMS                          | tetramethylsilane                                                        |
| STEM      | scanning transmission electron microscope                                              | TOF                          | turnover frequency                                                       |
| STM       | scanning tunneling microscopy                                                          | TOF-MS                       | time-of-flight mass spectrometer                                         |
| STO       | Slater-type orbital                                                                    | tol                          | tolyl                                                                    |
| STP       | standard temperature and pressure                                                      | TON                          | turnover number                                                          |
| sub, subl | sublimes; sublimation                                                                  | TOPO                         | trioctylphosphine oxide                                                  |
| Suc, Sac  | sucrose                                                                                | Torr                         | torr (pressure unit)                                                     |
| Sur       | thiouracil                                                                             | Tre                          | trehalose                                                                |
| Sv        | sievert                                                                                | TRE                          | topological resonance energy                                             |
| SWIFT     | stored waveform inverse Fourier transform                                              | Tricine                      | <i>N</i> -[2-hydroxy-1,1-bis(hydroxymethyl)ethyl]glycine                 |
| T         | tesla; tera (SI prefix for 10 <sup>12</sup> ); threonine                               | Tris                         | 2-amino-2-(hydroxymethyl)-1,3-propanediol                                |
| <i>T</i>  | kinetic energy; period; term value; temperature (thermodynamic); torque; transmittance | TRMC                         | time-resolved microwave conductivity                                     |
| t         | metric tonne; triton                                                                   | tRNA                         | transfer RNA                                                             |
| <i>t</i>  | Celsius temperature; thickness; time; transport number                                 | Trp                          | tryptophan                                                               |
| TAC       | time-to-amplitude converter                                                            | trs                          | transition                                                               |
| TAI       | International Atomic Time                                                              | TS                           | transition state                                                         |
| Tal       | talose                                                                                 | TSS                          | transition state spectroscopy                                            |
| tan       | tangent                                                                                | TST                          | generalized transition-state theory                                      |
| tanh      | hyperbolic tangent                                                                     | TTF                          | tetrathiofulvalene                                                       |
| Taps      | 3-{{[2-hydroxy-1,1-bis(hydroxymethyl)ethyl]amino}-1-propanesulfonic acid               | Tyr                          | tyrosine                                                                 |
| TBE       | 1,1,2,2-tetrabromoethane                                                               | U                            | uracil (in genetic code)                                                 |
| TBP       | tributyl phosphate                                                                     | <i>U</i>                     | electric potential difference; internal energy                           |
| TC        | titration calorimetry                                                                  | u                            | unified atomic mass unit                                                 |
| TCA       | trichloroacetic acid                                                                   | <i>u</i>                     | Bloch function; electric mobility; velocity                              |
| TCE       | trichloroethylene                                                                      | ua                           | astronomical unit (AU is also used)                                      |
| TCG       | Geocentric Coordinated Time                                                            | UBFF                         | Urey–Bradley force field                                                 |
| TCNE      | tetracyanoethylene                                                                     | UDMH                         | 1,1-dimethylhydrazine                                                    |
| TCNQ      | tetracyanoquinodimethane                                                               | UDP                          | uridine 5′-diphosphate                                                   |
| TCP       | tricresyl phosphate                                                                    | UHF                          | ultrahigh frequency; unrestricted Hartree–Fock (method)                  |
| TCSCF     | two configuration self-consistent field                                                | UMP                          | uridine 5′-monophosphate                                                 |
| TDI       | toluene diisocyanate                                                                   | <i>uns</i> ,<br><i>unsym</i> | unsymmetrical (as chemical descriptor)                                   |
| tDNA      | transfer DNA                                                                           | UPS,<br>UPES                 | ultraviolet photoelectron spectroscopy                                   |
| TE        | transverse electric                                                                    | Ura                          | uracil                                                                   |
| TEA       | triethanolamine; triethylamine                                                         | Urd                          | uridine                                                                  |
| TED       | transferred electron device; transmission electron diffraction                         |                              |                                                                          |



|            |                                                                                                        |            |                                                                                                                                                                 |
|------------|--------------------------------------------------------------------------------------------------------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| USP        | <i>United States Pharmacopeia</i>                                                                      | Xyl        | xylose                                                                                                                                                          |
| UT         | universal time                                                                                         | Y          | yotta (SI prefix for 10 <sup>24</sup> ); tyrosine                                                                                                               |
| UTC        | coordinated universal time                                                                             | <i>Y</i>   | admittance; Planck function; Young's modulus                                                                                                                    |
| UTP        | uridine 5'-triphosphate                                                                                | y          | yocto (SI prefix for 10 <sup>-24</sup> )                                                                                                                        |
| UV         | ultraviolet                                                                                            | <i>y</i>   | mole fraction for gas (when <i>x</i> refers to liquid phase)                                                                                                    |
| V          | volt; valine                                                                                           | y, yr      | year                                                                                                                                                            |
| <i>V</i>   | electric potential; potential energy; volume                                                           | YAG        | yttrium aluminum garnet                                                                                                                                         |
| $\nu$      | reaction rate; specific volume; velocity; vibrational quantum number; vicinal (as chemical descriptor) | yd         | yard                                                                                                                                                            |
| v/v        | volume per volume (volume of solute divided by volume of solution, expressed as percent)               | YIG        | yttrium iron garnet                                                                                                                                             |
| Val        | valine                                                                                                 | Z          | zetta (SI prefix for 10 <sup>21</sup> ); glutamine or glutamic acid (unspecified)                                                                               |
| vap        | vaporization                                                                                           | <i>Z</i>   | atomic number; compression factor; collision number; impedance; partition function; zusammen ( <i>cis</i> -configuration)                                       |
| VAT        | vibration assisted tunneling                                                                           | <i>z</i>   | zepto (SI prefix for 10 <sup>-21</sup> )                                                                                                                        |
| VB         | valence band; valence bond (theory)                                                                    | <i>z</i>   | charge number (of an ion); collision frequency factor                                                                                                           |
| VCD        | vibrational circular dichroism                                                                         | ZDO        | zero differential overlap                                                                                                                                       |
| VDW        | van der Waals interaction                                                                              | ZINDO      | Zerner's INDO method                                                                                                                                            |
| VHF        | very high frequency                                                                                    | ZPE, ZPVE  | zero point vibrational energy                                                                                                                                   |
| <i>vic</i> | vicinal (on adjacent carbon atom)                                                                      | ZULU       | Greenwich mean time                                                                                                                                             |
| VIS        | visible region of the spectrum                                                                         | $\alpha$   | alpha particle                                                                                                                                                  |
| vit        | vitreous (phase)                                                                                       | $\alpha$   | absorption coefficient; degree of dissociation; electric polarizability; expansion coefficient; fine structure constant                                         |
| VLPP       | very low pressure pyrolysis                                                                            | $\beta$    | beta particle                                                                                                                                                   |
| VOC        | volatile organic compound(s)                                                                           | $\beta$    | reciprocal temperature parameter (= 1/ <i>kT</i> )                                                                                                              |
| VOFF       | valence orbital force field                                                                            | $\gamma$   | photon; gamma (obsolete mass unit = $\mu$ g)                                                                                                                    |
| VPC        | vapor phase chromatography                                                                             | $\gamma$   | activity coefficient; conductivity; magnetogyric ratio; mass concentration; ratio of heat capacities; surface tension                                           |
| VSEPR      | valence shell electron-pair repulsion (method)                                                         | $\Gamma$   | Grüneisen parameter; level width; surface concentration                                                                                                         |
| VSIP       | valence state ionization potential                                                                     | $\delta$   | chemical shift; Dirac delta function; Kronecker delta; loss angle                                                                                               |
| VSLI       | very large scale integrated (circuit)                                                                  | $\Delta$   | inertial defect; mass excess                                                                                                                                    |
| VSMOW      | Vienna Standard Mean Ocean Water                                                                       | $\epsilon$ | emittance; Levi-Civita symbol; linear strain; molar absorption coefficient; permittivity                                                                        |
| VUV        | vacuum ultraviolet                                                                                     | $\zeta$    | Coriolis coupling constant; electrokinetic potential                                                                                                            |
| W          | watt; tryptophan                                                                                       | $\eta$     | overpotential; viscosity                                                                                                                                        |
| <i>W</i>   | radiant energy; statistical weight; work                                                               | $\kappa$   | compressibility; conductivity; magnetic susceptibility; molar absorption coefficient                                                                            |
| <i>w</i>   | energy density; mass fraction; velocity; work                                                          | $\lambda$  | absolute activity; radioactive decay constant; thermal conductivity; wavelength                                                                                 |
| w/v        | weight per volume (mass of solute divided by volume of solution, usually expressed as g/100 mL)        | $\Lambda$  | angular momentum; ionic conductivity                                                                                                                            |
| w/w        | weight per weight (mass of solute divided by mass of solution, expressed as percent)                   | $\mu$      | muon; micro (SI prefix for 10 <sup>-6</sup> )                                                                                                                   |
| WAXS       | wide angle x-ray scattering                                                                            | $\mu$      | chemical potential; electric dipole moment; electric mobility; friction coefficient; Joule-Thompson coefficient; magnetic dipole moment; mobility; permeability |
| Wb         | weber                                                                                                  | $\mu$ F    | microfarad                                                                                                                                                      |
| <i>We</i>  | Weber number                                                                                           | $\mu$ g    | microgram                                                                                                                                                       |
| WKB        | Wentzel-Kramers-Brillouin (approximation)                                                              | $\mu$ m    | micrometer                                                                                                                                                      |
| WLF        | Williams-Landel-Ferry (equation)                                                                       | $\mu$ s    | microsecond                                                                                                                                                     |
| WLN        | Wisswesser line notation                                                                               | $\nu$      | frequency; kinematic velocity; stoichiometric number                                                                                                            |
| wt         | weight                                                                                                 | $\nu_e$    | neutrino                                                                                                                                                        |
| X          | X unit; halogen (in chemical formula)                                                                  | $\nu$      | wavenumber                                                                                                                                                      |
| <i>X</i>   | reactance                                                                                              | $\pi$      | pion                                                                                                                                                            |
| <i>x</i>   | mole fraction                                                                                          | $\Pi$      | osmotic pressure; Peltier coefficient                                                                                                                           |
| X, Xaa     | unspecified amino acid                                                                                 | $\rho$     | density; reflectance; resistivity                                                                                                                               |
| XAFS       | x-ray absorption fine structure                                                                        |            |                                                                                                                                                                 |
| Xan        | xanthine                                                                                               |            |                                                                                                                                                                 |
| XANES      | x-ray absorption near-edge structure                                                                   |            |                                                                                                                                                                 |
| Xao        | xanthosine                                                                                             |            |                                                                                                                                                                 |
| Xle        | leucine or isoleucine (unspecified)                                                                    |            |                                                                                                                                                                 |
| Xlu, Xul   | xylulose                                                                                               |            |                                                                                                                                                                 |
| XPS, XPES  | x-ray photoelectron spectroscopy                                                                       |            |                                                                                                                                                                 |
| XRD        | x-ray diffraction                                                                                      |            |                                                                                                                                                                 |
| XRF        | x-ray fluorescence                                                                                     |            |                                                                                                                                                                 |
| XRS        | x-ray spectroscopy                                                                                     |            |                                                                                                                                                                 |

|          |                                                                                                                                                 |          |                                                                                         |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------------------------------------------------------------------------|
| $\sigma$ | electrical conductivity; cross section; normal stress; shielding constant (NMR); Stefan–Boltzmann constant; surface tension; standard deviation | $\chi$   | magnetic susceptibility                                                                 |
| $\tau$   | transmittance; chemical shift; shear stress; relaxation time                                                                                    | $\chi_e$ | electric susceptibility                                                                 |
| $\phi$   | electrical potential; fugacity coefficient; osmotic coefficient; quantum yield; wavefunction                                                    | $\psi$   | wavefunction                                                                            |
| $\Phi$   | magnetic flux; potential energy; radiant power; work function                                                                                   | $\omega$ | circular frequency; angular velocity; harmonic vibration wavenumber; statistical weight |
|          |                                                                                                                                                 | $\Omega$ | ohm                                                                                     |
|          |                                                                                                                                                 | $\Omega$ | axial angular momentum; solid angle                                                     |



## GREEK, RUSSIAN, AND HEBREW ALPHABETS

The following table presents the Hebrew, Greek, and Russian alphabets, their letters, the names of the letters, and the English equivalents.

| Hebrew <sup>1,3</sup> |        |                | Greek <sup>4</sup> |         |       | Russian          |  |      |
|-----------------------|--------|----------------|--------------------|---------|-------|------------------|--|------|
| א                     | aleph  | ' <sup>2</sup> | Α α                | alpha   | a     | А а              |  | a    |
| ב                     | beth   | b, bh          | Β β                | beta    | b     | Б б              |  | b    |
| ג                     | gimel  | g, gh          | Γ γ                | gamma   | g, n  | В в              |  | v    |
| ד                     | daleth | d, dh          | Δ δ                | delta   | d     | Г г              |  | g    |
| ה                     | he     | h              | Ε ε                | epsilon | e     | Д д              |  | d    |
| ו                     | waw    | w              | Ζ ζ                | zeta    | z     | Е е              |  | e    |
| ז                     | zayin  | z              | Η η                | eta     | ē     | Ж ж              |  | zh   |
| ח                     | heth   | ḥ              | Θ θ                | theta   | th    | З з              |  | z    |
| ט                     | teth   | ṭ              | Ι ι                | iota    | i     | И и Й й          |  | i, ĭ |
| י                     | yodh   | y              | Κ κ                | kappa   | k     | К к              |  | k    |
| כ                     | kaph   | k, kh          | Λ λ                | lambda  | l     | Л л              |  | l    |
| ל                     | lamedh | l              | Μ μ                | mu      | m     | М м              |  | m    |
| מ                     | mem    | m              | Ν ν                | nu      | n     | Н н              |  | n    |
| נ                     | nun    | n              | Ξ ξ                | xi      | x     | О о              |  | o    |
| ס                     | samekh | s              | Ο ο                | omicron | o     | П п              |  | p    |
| ע                     | ayin   | '              | Π π                | pi      | p     | Р р              |  | r    |
| פ                     | pe     | p, ph          | Ρ ρ                | rho     | r, rh | С с              |  | s    |
| צ                     | sadhe  | ṣ              | Σ σ ς              | sigma   | s     | Т т              |  | t    |
| ק                     | qoph   | q              | Τ τ                | tau     | t     | У у              |  | u    |
| ר                     | resh   | r              | Υ υ                | upsilon | y, u  | Ф ф              |  | f    |
| ש                     | sin    | ś              | Φ φ                | phi     | ph    | Х х              |  | kh   |
| װ                     | shin   | sh             | Σ σ ς              | sigma   | s     | Ц ц              |  | ts   |
| ת                     | taw    | t, th          | Τ τ                | tau     | t     | Ч ч              |  | ch   |
|                       |        |                | Ψ ψ                | psi     | ps    | Ш ш              |  | sh   |
|                       |        |                | Ω ω                | omega   | ō     | Щ щ              |  | shch |
|                       |        |                |                    |         |       | Ъ ъ <sup>5</sup> |  | "    |
|                       |        |                |                    |         |       | Ы ы              |  | y    |
|                       |        |                |                    |         |       | Ь ь <sup>6</sup> |  | '    |
|                       |        |                |                    |         |       | Э э              |  | e    |
|                       |        |                |                    |         |       | Ю ю              |  | yu   |
|                       |        |                |                    |         |       | Я я              |  | ya   |

<sup>1</sup> Where two forms of a letter are given, the second one is the form used at the end of a word.

<sup>2</sup> Not represented in transliteration when initial.

<sup>3</sup> The Hebrew letters are primarily consonants; a few of them are also used secondarily to represent certain vowels, when provided at all, by means of a system of dots or strokes adjacent to the consonated characters.

<sup>4</sup> The letter gamma is transliterated "n" only before velars; the letter upsilon is transliterated "u" only as the final element in diphthongs.

<sup>5</sup> This sign indicates that the immediately preceding consonant is not palatized even though immediately followed by a palatized vowel.

<sup>6</sup> This sign indicates that the immediately preceding consonant is palatized even though not immediately followed by a palatized vowel.

## DEFINITIONS OF SCIENTIFIC TERMS

Brief definitions of selected terms of importance in chemistry, physics, and related fields of science are given in this section. The selection process emphasizes the following types of terms:

- ◆ Physical quantities
- ◆ Units of measure
- ◆ Classes of chemical compounds and materials
- ◆ Important theories, laws, and basic concepts.

Individual chemical compounds are not included.

Definitions have taken wherever possible from the recommendations of international or national bodies, especially the International Union of Pure and Applied Chemistry (IUPAC) and International Organization for Standardization (ISO). For physical quantities and units, the recommended symbol is also given. The source of such definitions is indicated by the reference number in brackets following the definition. In many cases these official definitions have been edited in the interest of stylistic consistency and economy of space. The user is referred to the original source for further details.

An asterisk (\*) following a term indicates that further information can be found by consulting the index of this handbook under the entry for that term.

**Ab initio method** - An approach to quantum-mechanical calculations on molecules which starts with the Schrödinger equation and carries out a complete integration, without introducing empirical factors derived from experimental measurement.

**Absorbance (A)** - Defined as  $-\log(1-\alpha) = \log(1/\tau)$ , where  $\alpha$  is the absorbance and  $\tau$  the transmittance of a medium through which a light beam passes. [2]

**Absorbed dose (D)** - For any ionizing radiation, the mean energy imparted to an element of irradiated matter divided by the mass of that element. [1]

**Absorptance ( $\alpha$ )** - Ratio of the radiant or luminous flux in a given spectral interval absorbed in a medium to that of the incident radiation. Also called absorption factor. [1]

**Absorption coefficient ( $a$ )** - The relative decrease in the intensity of a collimated beam of electromagnetic radiation, as a result of absorption by a medium, during traversal of an infinitesimal layer of the medium, divided by the length traversed. [1]

**Absorption coefficient, molar ( $\epsilon$ )** - Absorption coefficient divided by amount-of-substance concentration of the absorbing material in the sample solution ( $\epsilon = a/c$ ). The SI unit is  $\text{m}^2/\text{mol}$ . Also called extinction coefficient, but usually in units of  $\text{mol}^{-1}\text{dm}^3\text{cm}^{-1}$ . [2]

**Acceleration** - Rate of change of velocity with respect to time.

**Acceleration due to gravity ( $g$ )**\* - The standard value ( $9.80665 \text{ m/s}^2$ ) of the acceleration experienced by a body in the earth's gravitational field. [1]

**Acenes** - Polycyclic aromatic hydrocarbons consisting of fused benzene rings in a rectilinear arrangement. [5]

**Acid** - Historically, a substance that yields an  $\text{H}^+$  ion when it dissociates in solution, resulting in a  $\text{pH} < 7$ . In the Brønsted definition, an acid is a substance that donates a proton in any type of reaction. The most general definition, due to G.N. Lewis,

classifies any chemical species capable of accepting an electron pair as an acid.

**Acid dissociation constant ( $K_a$ )**\* - The equilibrium constant for the dissociation of an acid HA through the reaction  $\text{HA} + \text{H}_2\text{O} \rightleftharpoons \text{A}^- + \text{H}_3\text{O}^+$ . The quantity  $\text{p}K_a = -\log K_a$  is often used to express the acid dissociation constant.

**Actinides** - The elements of atomic number 89 through 103, e.g., Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr. [7]

**Activation energy**\* - In general, the energy that must be added to a system in order for a process to occur, even though the process may already be thermodynamically possible. In chemical kinetics, the activation energy is the height of the potential barrier separating the products and reactants. It determines the temperature dependence of the reaction rate.

**Activity** - For a mixture of substances, the absolute activity  $\lambda$  of substance B is defined as  $\lambda_B = \exp(\mu_B/RT)$ , where  $\mu_B$  is the chemical potential of substance B,  $R$  the gas constant, and  $T$  the thermodynamic temperature. The relative activity  $a$  is defined as  $a_B = \exp[(\mu_B - \mu_B^\circ)/RT]$ , where  $\mu_B^\circ$  designates the chemical potential in the standard state. [2]

**Activity coefficient ( $\gamma$ )**\* - Ratio of the activity  $a_B$  of component B of a mixture to the concentration of that component. The value of  $\gamma$  depends on the method of stating the composition. For mole fraction  $x_B$ , the relation is  $a_B = \gamma_B x_B$ ; for molarity  $c_B$ , it is  $a_B = \gamma_B c_B/c^\circ$ , where  $c^\circ$  is the standard state composition (typically chosen as  $1 \text{ mol/L}$ ); for molality  $m_B$ , it is  $a_B = \gamma_B m_B/m^\circ$ , where  $m^\circ$  is the standard state molality (typically  $1 \text{ mol/kg}$ ). [2]

**Activity, of radioactive substance (A)** - The average number of spontaneous nuclear transitions from a particular energy state occurring in an amount of a radionuclide in a small time interval divided by that interval. [1]

## References

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**Acyl groups** - Groups formed by removing the hydroxy groups from oxoacids that have the general structure  $\text{RC}(=\text{O})(\text{OH})$  and replacement analogues of such acyl groups. [5]

**Adiabatic process** - A thermodynamic process in which no heat enters or leaves the system.

**Admittance ( $Y$ )** - Reciprocal of impedance.  $Y = G + iB$ , where  $G$  is conductance and  $B$  is susceptance. [1]

**Adsorption** - A process in which molecules of gas, of dissolved substances in liquids, or of liquids adhere in an extremely thin layer to surfaces of solid bodies with which they are in contact. [10]

**Albedo\*** - The ratio of the light reflected or scattered from a surface to the intensity of incident light. The term is often used in reference to specific types of terrain or to entire planets.

**Alcohols** - Compounds in which a hydroxy group,  $-\text{OH}$ , is attached to a saturated carbon atom. [5]

**Aldehydes** - Compounds  $\text{RC}(=\text{O})\text{H}$ , in which a carbonyl group is bonded to one hydrogen atom and to one R group. [5]

**Aldoses** - Aldehydic parent sugars (polyhydroxyaldehydes  $\text{H}[\text{CH}(\text{OH})]_n\text{C}(=\text{O})\text{H}$ ,  $n > 1$ ) and their intramolecular hemiacetals. [5]

**Aldoximes** - Oximes of aldehydes:  $\text{RCH}=\text{NOH}$ . [5]

**Alfvén number ( $Al$ )** - A dimensionless quantity used in plasma physics, defined by  $Al = v(\rho\mu)^{1/2}/B$ , where  $\rho$  is density,  $v$  is velocity,  $\mu$  is permeability, and  $B$  is magnetic flux density. [2]

**Alfvén waves** - Very low frequency waves which can exist in a plasma in the presence of a uniform magnetic field. Also called magnetohydrodynamic waves.

**Alicyclic compounds** - Aliphatic compounds having a carbocyclic ring structure which may be saturated or unsaturated, but may not be a benzenoid or other aromatic system. [5]

**Aliphatic compounds** - Acyclic or cyclic, saturated or unsaturated carbon compounds, excluding aromatic compounds. [5]

**Alkali metals** - The elements lithium, sodium, potassium, rubidium, cesium, and francium.

**Alkaline earth metals** - The elements calcium, strontium, barium, and radium. [7]

**Alkaloids** - Basic nitrogen compounds (mostly heterocyclic) occurring mostly in the plant kingdom (but not excluding those of animal origin). Amino acids, peptides, proteins, nucleotides, nucleic acids, and amino sugars are not normally regarded as alkaloids. [5]

**Alkanes** - Acyclic branched or unbranched hydrocarbons having the general formula  $\text{C}_n\text{H}_{2n+2}$ , and therefore consisting entirely of hydrogen atoms and saturated carbon atoms. [5]

**Alkenes** - Acyclic branched or unbranched hydrocarbons having one carbon-carbon double bond and the general formula  $\text{C}_n\text{H}_{2n}$ . Acyclic branched or unbranched hydrocarbons having more than one double bond are alkadienes, alkatrienes, etc. [5]

**Alkoxides** - Compounds,  $\text{ROM}$ , derivatives of alcohols,  $\text{ROH}$ , in which R is saturated at the site of its attachment to oxygen and M is a metal or other cationic species. [5]

**Alkyl groups** - Univalent groups derived from alkanes by removal of a hydrogen atom from any carbon atom:  $\text{C}_n\text{H}_{2n+1}$ -. The groups derived by removal of a hydrogen atom from a terminal carbon atom of unbranched alkanes form a subclass of normal alkyl ( $n$ -alkyl) groups. The groups  $\text{RCH}_2$ -,  $\text{R}_2\text{CH}$ -, and  $\text{R}_3\text{C}$ - (R not equal to H) are primary, secondary, and tertiary alkyl groups, respectively. [5]

**Alkynes** - Acyclic branched or unbranched hydrocarbons having a carbon-carbon triple bond and the general formula  $\text{C}_n\text{H}_{2n-2}$ ,  $\text{RC}\equiv\text{CR}$ -. Acyclic branched or unbranched hydrocarbons having more than one triple bond are known as alkadiynes, alkatriynes, etc. [5]

**Allotropy** - The occurrence of an element in two or more crystalline forms.

**Allylic groups** - The group  $\text{CH}_2=\text{CHCH}_2$ - (allyl) and derivatives formed by substitution. The term 'allylic position' or 'allylic site' refers to the saturated carbon atom. A group, such as  $-\text{OH}$ , attached at an allylic site is sometimes described as "allylic". [5]

**Amagat volume unit** - A non-SI unit previously used in high pressure science. It is defined as the molar volume of a real gas at one atmosphere pressure and 273.15 K. The approximate value is 22.4 L/mol.

**Amides** - Derivatives of oxoacids  $\text{R}(\text{C}=\text{O})(\text{OH})$  in which the hydroxy group has been replaced by an amino or substituted amino group. [5]

**Amine oxides** - Compounds derived from tertiary amines by the attachment of one oxygen atom to the nitrogen atom:  $\text{R}_3\text{N}^+-\text{O}^-$ . By extension the term includes the analogous derivatives of primary and secondary amines. [5]

**Amines** - Compounds formally derived from ammonia by replacing one, two, or three hydrogen atoms by hydrocarbyl groups, and having the general structures  $\text{RNH}_2$  (primary amines),  $\text{R}_2\text{NH}$  (secondary amines),  $\text{R}_3\text{N}$  (tertiary amines). [5]

**Amino acids\*** - Compounds containing both a carboxylic acid group ( $-\text{COOH}$ ) and an amino group ( $-\text{NH}_2$ ). The most important are the  $\alpha$ -amino acids, in which the  $-\text{NH}_2$  group is attached to the C atom adjacent to the  $-\text{COOH}$  group. In the  $\beta$ -amino acids, there is an intervening carbon atom. [4]

**Ampere (A)\*** - The SI base unit of electric current. [1]

**Ampere's law** - The defining equation for the magnetic induction  $B$ , viz.,  $d\mathbf{F} = I d\mathbf{l} \times \mathbf{B}$ , where  $d\mathbf{F}$  is the force produced by a current  $I$  flowing in an element of the conductor  $d\mathbf{l}$  pointing in the direction of the current.

**Ångström (Å)** - A unit of length used in spectroscopy, crystallography, and molecular structure, equal to  $10^{-10}$  m.

**Angular momentum ( $L$ )** - The angular momentum of a particle about a point is the vector product of the radius vector from this point to the particle and the momentum of the particle; i.e.,  $L = \mathbf{r} \times \mathbf{p}$ . [1]

**Angular velocity ( $\omega$ )** - The angle through which a body rotates per unit time.

**Anilides** - Compounds derived from oxoacids  $\text{R}(\text{C}=\text{O})(\text{OH})$  by replacing the  $-\text{OH}$  group by the  $-\text{NHPh}$  group or derivative formed by ring substitution. Also used for salts formed by replacement of a nitrogen-bound hydrogen of aniline by a metal. [5]

**Anion** - A negatively charged atomic or molecular particle.

**Antiferroelectricity\*** - An effect analogous to antiferromagnetism in which electric dipoles in a crystal are ordered in two sublattices that are polarized in opposite directions, leading to zero net polarization. The effect vanishes above a critical temperature.

**Antiferromagnetism\*** - A type of magnetism in which the magnetic moments of atoms in a solid are ordered into two antiparallel aligned sublattices. Antiferromagnets are characterized by a zero or small positive magnetic susceptibility. The

susceptibility increases with temperature up to a critical value, the Néel temperature, above which the material becomes paramagnetic.

**Antiparticle** - A particle having the same mass as a given elementary particle and a charge equal in magnitude but opposite in sign.

**Appearance potential\*** - The lowest energy which must be imparted to the parent molecule to cause it to produce a particular specified parent ion. This energy, usually stated in eV, may be imparted by electron impact, photon impact, or in other ways. More properly called appearance energy. [3]

**Appearance potential spectroscopy (APS)** - See Techniques for Materials Characterization, page 12-1.

**Are (a)** - A unit of area equal to 100 m<sup>2</sup>. [1]

**Arenes** - Monocyclic and polycyclic aromatic hydrocarbons. See aromatic compounds. [5]

**Aromatic compounds** - Compounds whose structure includes a cyclic delocalized  $\pi$ -electron system. Historical use of the term implies a ring containing only carbon (e.g., benzene, naphthalene), but it is often generalized to include heterocyclic structures such as pyridine and thiophene. [5]

**Arrhenius equation** - A key equation in chemical kinetics which expresses the rate constant  $k$  as  $k = A \exp(-E_a/RT)$ , where  $E_a$  is the activation energy,  $R$  the molar gas constant, and  $T$  the temperature.  $A$  is called the preexponential factor and, for simple gas phase reactions, may be identified with the collision frequency.

**Arsines** - AsH<sub>3</sub> and compounds derived from it by substituting one, two or three hydrogen atoms by hydrocarbyl groups. RAsH<sub>2</sub>, R<sub>2</sub>AsH, R<sub>3</sub>As (R not equal to H) are called primary, secondary and tertiary arsines, respectively. [5]

**Aryl groups** - Groups derived from arenes by removal of a hydrogen atom from a ring carbon atom. Groups similarly derived from heteroarenes are sometimes subsumed in this definition. [5]

**Astronomical unit (AU)\*** - The mean distance of the earth from the sun, equal to  $1.49597870 \times 10^{11}$  m.

**Atomic absorption spectroscopy (AAS)** - See Techniques for Materials Characterization, page 12-1.

**Atomic emission spectroscopy (AES)** - See Techniques for Materials Characterization, page 12-1.

**Atomic force microscopy (AFM)** - See Techniques for Materials Characterization, page 12-1.

**Atomic mass\*** - The mass of a nuclide, normally expressed in unified atomic mass units (u).

**Atomic mass unit (u)\*** - A unit of mass used in atomic, molecular, and nuclear science, defined as the mass of one atom of <sup>12</sup>C divided by 12. Its approximate value is  $1.66054 \times 10^{-27}$  kg. Also called the unified atomic mass unit. [1]

**Atomic number (Z)** - A characteristic property of an element, equal to the number of protons in the nucleus.

**Atomic weight (A<sub>r</sub>)\*** - The ratio of the average mass per atom of an element to 1/12 of the mass of nuclide <sup>12</sup>C. An atomic weight can be defined for a sample of any given isotopic composition. The standard atomic weight refers to a sample of normal terrestrial isotopic composition. The term relative atomic mass is synonymous with atomic weight. [2]

**Attenuated total reflection (ATR)** - See Techniques for Materials Characterization, page 12-1.

**Auger effect** - An atomic process in which an electron from a higher energy level fills a vacancy in an inner shell, transferring the released energy to another electron which is ejected.

**Aurora** - An atmospheric phenomenon in which streamers of light are produced when electrons from the sun are guided into the thermosphere by the earth's magnetic field. It occurs in the polar regions at altitudes of 95–300 km.

**Avogadro constant (N<sub>A</sub>)\*** - The number of elementary entities in one mole of a substance.

**Azeotrope** - A liquid mixture in a state where the variation of vapor pressure with composition at constant temperature (or, alternatively, the variation of normal boiling point with composition) shows either a maximum or a minimum. Thus when an azeotrope boils the vapor has the same composition as the liquid.

**Azides** - Compounds bearing the group -N<sub>3</sub>, viz. -N=N<sup>+</sup>=N<sup>-</sup>; usually attached to carbon, e.g. PhN<sub>3</sub>, phenyl azide or azidobenzene. Also used for salts of hydrazoic acid, HN<sub>3</sub>, e.g. NaN<sub>3</sub>, sodium azide. [5]

**Azines** - Condensation products, R<sub>2</sub>C=NN=CR<sub>2</sub>, of two moles of a carbonyl compound with one mole of hydrazine. [5]

**Azo compounds** - Derivatives of diazene (diimide), HN=NH, wherein both hydrogens are substituted by hydrocarbyl groups, e.g., PhN=NPh, azobenzene or diphenyldiazene. [5]

**Balmer series** - The series of lines in the spectrum of the hydrogen atom which corresponds to transitions between the state with principal quantum number  $n = 2$  and successive higher states. The wavelengths are given by  $1/\lambda = R_H(1/4 - 1/n^2)$ , where  $n = 3, 4, \dots$  and  $R_H$  is the Rydberg constant for hydrogen. The first member of the series ( $n = 2 \rightarrow 3$ ), which is often called the H $\alpha$  line, falls at a wavelength of 6563 Å.

**Bar (bar)** - A unit of pressure equal to 10<sup>5</sup> Pa.\*

**Bardeen-Cooper-Schrieffer (BCS) theory** - A theory of superconductivity which is based upon the formation of electron pairs as a result of an electron-lattice interaction. The theory relates the superconducting transition temperature to the density of states and the Debye temperature.

**Barn (b)** - A unit used for expressing cross sections of nuclear processes, equal to 10<sup>-28</sup> m<sup>2</sup>.

**Barrel** - A unit of volume equal to 158.9873 L.

**Baryon** - Any elementary particle built up from three quarks. Examples are the proton, neutron, and various short-lived hyperons. Baryons have odd half-integer spins.

**Base** - Historically, a substance that yields an OH<sup>-</sup> ion when it dissociates in solution, resulting in a pH > 7. In the Brønsted definition, a base is a substance capable of accepting a proton in any type of reaction. The more general definition, due to G.N. Lewis, classifies any chemical species capable of donating an electron pair as a base.

**Becquerel (Bq)\*** - The SI unit of radioactivity (disintegrations per unit time), equal to s<sup>-1</sup>. [1]

**Beer's law** - An approximate expression for the change in intensity of a light beam that passes through an absorbing medium, viz.,  $\log(I/I_0) = -\epsilon cl$ , where  $I_0$  is the incident intensity,  $I$  is the final intensity,  $\epsilon$  is the molar (decadic) absorption coefficient,  $c$  is the molar concentration of the absorbing substance, and  $l$  is the path length. Also called the Beer-Lambert law

**Binding energy\*** - A generic term for the energy required to decompose a system into two or more of its constituent parts. In nuclear physics, the binding energy is the energy differ-



ence between a nucleus and the separated nucleons of which it is composed (the energy equivalent of the mass defect). In atomic physics, it is the energy required to remove an electron from an atom.

**Biot (Bi)** - A name sometimes used for the unit of current in the emu system.

**Birefringence** - A property of certain crystals in which two refracted rays result from a single incident light ray. One, the ordinary ray, follows the normal laws of refraction, while the other, the extraordinary ray, exhibits a variable refractive index which depends on the direction in the crystal.

**Black body radiation\*** - The radiation emitted by a perfect black body, i.e., a body which absorbs all radiation incident on it and reflects none. The wavelength dependence of the radiated energy density  $\rho$  (energy per unit volume per unit wavelength range) is given by the Planck formula

$$\rho = \frac{8\pi hc}{\lambda^5 (e^{hc/\lambda kT} - 1)}$$

where  $\lambda$  is the wavelength,  $h$  is Planck's constant,  $c$  is the speed of light,  $k$  is the Boltzmann constant, and  $T$  is the temperature.

**Black hole** - A very dense object, formed in a supernova explosion, whose gravitational field is so large that no matter or radiation can escape from the object.

**Bloch wave function** - A solution of the Schrödinger equation for an electron moving in a spatially periodic potential; used in the band theory of solids.

**Bohr magneton ( $\mu_B$ )\*** - The atomic unit of magnetic moment, defined as  $eh/4\pi m_e$ , where  $h$  is Planck's constant,  $m_e$  the electron mass, and  $e$  the elementary charge. It is the moment associated with a single electron spin.

**Bohr, bohr radius ( $a_0$ )\*** - The radius of the lowest orbit in the Bohr model of the hydrogen atom, defined as  $\epsilon_0 h^2 / \pi m_e e^2$ , where  $\epsilon_0$  is the permittivity of a vacuum,  $h$  is Planck's constant,  $m_e$  the electron mass, and  $e$  the elementary charge. It is customarily taken as the unit of length when using atomic units.

**Boiling point** - The temperature at which the liquid and gas phases of a substance are in equilibrium at a specified pressure. The normal boiling point is the boiling point at normal atmospheric pressure (101.325 kPa).

**Boltzmann constant ( $k$ )\*** - The molar gas constant  $R$  divided by Avogadro's constant.

**Boltzmann distribution** - An expression for the equilibrium distribution of molecules as a function of their energy, in which the number of molecules in a state of energy  $E$  is proportional to  $\exp(-E/kT)$ , where  $k$  is the Boltzmann constant and  $T$  is the temperature.

**Bond strength** - See Dissociation energy.

**Born-Haber cycle\*** - A thermodynamic cycle in which a crystalline solid is converted to gaseous ions and then reconverted to the solid. The cycle permits calculation of the lattice energy of the crystal.

**Bose-Einstein distribution** - A modification of the Boltzmann distribution which applies to a system of particles that are bosons. The number of particles of energy  $E$  is proportional to  $[e^{(E-\mu)/kT} - 1]^{-1}$ , where  $\mu$  is a normalization constant,  $k$  is the Boltzmann constant, and  $T$  is the temperature.

**Boson** - A particle that obeys Bose-Einstein Statistics; specifically, any particle with spin equal to zero or an integer. This includes

the photon, pion, deuteron, and all nuclei of even mass number.

**Boyle's law** - The empirical law, exact only for an ideal gas, which states that the volume of a gas is inversely proportional to its pressure at constant temperature.

**Bragg angle ( $\theta$ )** - Defined by the equation  $n\lambda = 2d\sin\theta$ , which relates the angle  $\theta$  between a crystal plane and the diffracted x-ray beam, the wavelength  $\lambda$  of the x-rays, the crystal plane spacing  $d$ , and the diffraction order  $n$  (any integer).

**Bravais lattices\*** - The 14 distinct crystal lattices that can exist in three dimensions. They include three in the cubic crystal system, two in the tetragonal, four in the orthorhombic, two in the monoclinic, and one each in the triclinic, hexagonal, and trigonal systems.

**Breakdown voltage** - The potential difference at which an insulating substance undergoes a physical or chemical change that causes it to become a conductor, thus allowing current to flow through the sample.

**Bremsstrahlung** - Electromagnetic radiation generated when the velocity of a charged particle is reduced (literally, "braking radiation"). An example is the x-ray continuum resulting from collisions of electrons with the target in an x-ray tube.

**Brewster angle** - The angle of incidence for which the maximum degree of plane polarization occurs when a beam of unpolarized light is incident on the surface of a medium of refractive index  $n$ . At this angle, the angle between the reflected and refracted beams is  $90^\circ$ . The value of the Brewster angle is  $\tan^{-1}n$ .

**Brillouin scattering** - The scattering of light by acoustic phonons in a solid or liquid.

**Brillouin zone** - A region of allowed wave vectors and energy levels in a crystalline solid, which plays a part in the propagation of waves through the lattice.

**British thermal unit (Btu)** - A non-SI unit of energy, equal to approximately 1055 J. Several values of the Btu, defined in slightly different ways, have been used.

**Brownian motion** - The random movements of small particles suspended in a fluid, which arise from collisions with the fluid molecules.

**Brunauer-Emmett-Teller method (BET)** - See Techniques for Materials Characterization, page 12-1.

**Buffer\*** - A solution designed to maintain a constant pH when small amounts of a strong acid or base are added. Buffers usually consist of a fairly weak acid and its salt with a strong base. Suitable concentrations are chosen so that the pH of the solution remains close to the  $pK_a$  of the weak acid.

**Calorie (cal)** - A non-SI unit of energy, originally defined as the heat required to raise the temperature of 1 g of water by  $1^\circ\text{C}$ . Several calories of slightly different values have been used. The thermochemical calorie is now defined as 4.184 J.

**Candela (cd)\*** - The SI base unit of luminous intensity. [1]

**Capacitance (C)** - Ratio of the charge acquired by a body to the change in potential. [1]

**Carbamates** - Salts or esters of carbamic acid,  $\text{H}_2\text{NC(=O)OH}$ , or of N-substituted carbamic acids:  $\text{R}_2\text{NC(=O)OR}'$ , ( $\text{R}'$  = hydrocarbyl or a cation). The esters are often called urethanes or urethans, a usage that is strictly correct only for the ethyl esters. [5]

**Carbenes** - The electrically neutral species  $\text{H}_2\text{C:}$  and its derivatives, in which the carbon is covalently bonded to two univa-

lent groups of any kind or a divalent group and bears two non-bonding electrons, which may be spin-paired (singlet state) or spin-non-paired (triplet state). [5]

**Carbinols** - An obsolete term for substituted methanols, in which the name carbinol is synonymous with methanol. [5]

**Carbohydrates** - Originally, compounds such as aldoses and ketoses, having the stoichiometric formula  $C_n(H_2O)_n$  (hence "hydrates of carbon"). The generic term carbohydrate now includes mono-, oligo-, and polysaccharides, as well as their reaction products and derivatives. [5]

**Carboranes** - A contraction of carbaboranes. Compounds in which a boron atom in a polyboron hydride is replaced by a carbon atom with maintenance of the skeletal structure. [5]

**Carboxylic acids** - Oxoacids having the structure  $RC(=O)OH$ . The term is used as a suffix in systematic name formation to denote the  $-C(=O)OH$  group including its carbon atom. [5]

**Carnot cycle** - A sequence of reversible changes in a heat engine using a perfect gas as the working substance, which is used to demonstrate that entropy is a state function. The Carnot cycle also provides a means to calculate the efficiency of a heat engine.

**Catalyst** - A substance that participates in a particular chemical reaction and thereby increases its rate but without a net change in the amount of that substance in the system. [3]

**Catenanes, catena compounds** - Hydrocarbons having two or more rings connected in the manner of links of a chain, without a covalent bond. More generally, the class catena compounds embraces functional derivatives and hetero analogues. [5]

**Cation** - A positively charged atomic or molecular particle.

**Centipoise (cP)** - A common non-SI unit of viscosity, equal to mPa s.

**Centrifugal distortion** - An effect in molecular spectroscopy in which rotational levels are lowered in energy, relative to the values of a rigid rotor, as the rotational angular momentum increases. The effect may be understood classically as a stretching of the bonds in the molecule as it rotates faster, thus increasing the moment of inertia.

**Ceramic** - A nonmetallic material of very high melting point.

**Cerenkov radiation** - Light emitted when a beam of charged particles travels through a medium at a speed greater than the speed of light in the medium. It is typically blue in color.

**Cgs system of units** - A system of units based upon the centimeter, gram, and second. The cgs system has been supplanted by the International System (SI).

**Chalcogens** - The Group VIA elements (oxygen, sulfur, selenium, tellurium, and polonium). Compounds of these elements are called chalcogenides. [7]

**Chaotic system** - A complex system whose behavior is governed by deterministic laws but whose evolution can vary drastically when small changes are made in the initial conditions.

**Charge** - See Electric charge.

**Charles' law** - The empirical law, exact only for an ideal gas, which states that the volume of a gas is directly proportional to its temperature at constant pressure.

**Charm** - A quantum number introduced in particle physics to account for certain properties of elementary particles and their reactions.

**Chelate** - A compound characterized by the presence of bonds from two or more bonding sites within the same ligand to a central metal atom. [3]

**Chemical potential** - For a mixture of substances, the chemical potential of constituent B is defined as the partial derivative of the Gibbs energy  $G$  with respect to the amount (number of moles) of B, with temperature, pressure, and amounts of all other constituents held constant. Also called partial molar Gibbs energy. [2]

**Chemical shift\*** - A small change in the energy levels (and hence in the spectra associated with these levels) resulting from the effects of chemical binding in a molecule. The term is used in fields such as NMR, Mössbauer, and photoelectron spectroscopy, where the energy levels are determined primarily by nuclear or atomic effects.

**Chiral molecule** - A molecule which cannot be superimposed on its mirror image. A common example is an organic molecule containing a carbon atom to which four different atoms or groups are attached. Such molecules exhibit optical activity, i.e., they rotate the plane of a polarized light beam.

**Chlorocarbons** - Compounds consisting solely of chlorine and carbon. [5]

**Chromatography\*** - A method for separation of the components of a sample in which the components are distributed between two phases, one of which is stationary while the other moves. In gas chromatography the gas moves over a liquid or solid stationary phase. In liquid chromatography the liquid mixture moves through another liquid, a solid, or a gel. The mechanism of separation of components may be adsorption, differential solubility, ion-exchange, permeation, or other mechanisms. [6]

**Claapeyron equation** - A relation between pressure and temperature of two phases of a pure substance that are in equilibrium, viz.,  $dp/dT = \Delta_{\text{trs}} S / \Delta_{\text{trs}} V$ , where  $\Delta_{\text{trs}} S$  is the difference in entropy between the phases and  $\Delta_{\text{trs}} V$  the corresponding difference in volume.

**Clathrates** - Inclusion compounds in which the guest molecule is in a cage formed by the host molecule or by a lattice of host molecules. [5]

**Clausius (Cl)** - A non-SI unit of entropy or heat capacity defined as cal/K = 4.184 J/K. [2]

**Clausius-Claapeyron equation** - An approximation to the Claapeyron equation applicable to liquid-gas and solid-gas equilibrium, in which one assumes an ideal gas with volume much greater than the condensed phase volume. For the liquid-gas case, it takes the form  $d(\ln p)/dT = \Delta_{\text{vap}} H / RT^2$ , where  $R$  is the molar gas constant and  $\Delta_{\text{vap}} H$  is the molar enthalpy of vaporization. For the solid-gas case,  $\Delta_{\text{vap}} H$  is replaced by the molar enthalpy of sublimation,  $\Delta_{\text{sub}} H$ .

**Clausius-Mosotti equation** - A relation between the dielectric constant  $\epsilon_r$  at optical frequencies and the polarizability  $\alpha$ :

$$\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{\rho N_A \alpha}{3M\epsilon_0}$$

where  $\rho$  is density,  $N_A$  is Avogadro's number,  $M$  is molar mass, and  $\epsilon_0$  is the permittivity of a vacuum.

**Clebsch-Gordon coefficients** - A set of coefficients used to describe the vector coupling of angular momenta in atomic and nuclear physics.

**Codon** - A set of three bases, chosen from the four primary bases found in the DNA molecule (uracil, cytosine, adenine, and guanine), which specifies the production of a particular amino

acid or carries some other genetic instruction. For example, the codon UCA specifies the amino acid serine, CAG specifies glutamine, etc. There are a total of 64 codons.

**Coercive force** - The magnetizing force at which the magnetic flux density is equal to zero. [10]

**Coercivity\*** - The maximum value of coercive force that can be attained when a magnetic material is symmetrically magnetized to saturation induction. [10]

**Coherent anti-Stokes Raman spectroscopy (CARS)** - See Techniques for Materials Characterization, page 12-1.

**Colloid** - Molecules or polymolecular particles dispersed in a medium that have, at least in one direction, a dimension roughly between 1 nm and 1  $\mu$ m. [3]

**Color center** - A defect in a crystal that gives rise to optical absorption, thus changing the color of the material. A common type is the F-center, which results when an electron occupies the site of a negative ion.

**Compressibility ( $\kappa$ )\*** - The fractional change of volume as pressure is increased, viz.,  $\kappa = -(1/V)(dV/dp)$ . [1]

**Compton wavelength ( $\lambda_c$ )\*** - In the scattering of electromagnetic radiation by a free particle (e.g., electron, proton),  $\lambda_c = h/mc$  is the increase in wavelength, at a 90° scattering angle, corresponding to the transfer of energy from radiation to particle. Here  $h$  is Planck's constant,  $c$  the speed of light, and  $m$  the mass of the particle.

**Conductance ( $G$ )\*** - For direct current, the reciprocal of resistance. More generally, the real part of admittance. [1]

**Conductivity, electrical ( $\sigma$ )\*** - The reciprocal of the resistivity. [1]

**Conductivity, thermal** - See Thermal conductivity.

**Congruent transformation** - A phase transition (melting, vaporization, etc.) in which the substance preserves its exact chemical composition.

**Constitutional repeating unit (CRU)** - In polymer science, the smallest constitutional unit, the repetition of which constitutes a regular macromolecule, i.e., a macromolecule with all units connected identically with respect to directional sense. [8]

**Copolymer** - A polymer derived from more than one species of monomer. [8]

**Coriolis effect** - The deviation from simple trajectories when a mechanical system is described in a rotating coordinate system. It affects the motion of projectiles on the earth and in molecular spectroscopy leads to an important interaction between the rotational and vibrational motions. The effect may be described by an additional term in the equations of motion, called the Coriolis force.

**Cosmic rays\*** - High energy nuclear particles, electrons, and photons, originating mostly outside the solar system, which continually bombard the earth's atmosphere.

**Coulomb (C)\*** - The SI unit of electric charge, equal to A s. [1]

**Coulomb's law** - The statement that the force  $F$  between two electrical charges  $q_1$  and  $q_2$  separated by a distance  $r$  is  $F = (4\pi\epsilon_0)^{-1} q_1 q_2 / r^2$ , where  $\epsilon_0$  is the permittivity of a vacuum.

**Covalent bond** - A chemical bond between two atoms whose stability results from the sharing of two electrons, one from each atom.

**Cowling number (Co)** - A dimensionless quantity used in plasma physics, defined by  $Co = B^2 / \mu \rho v^2$ , where  $\rho$  is density,  $v$  is velocity,  $\mu$  is permeability, and  $B$  is magnetic flux density. [2]

**CPT theorem** - A theorem in particle physics which states that any local Lagrangian theory that is invariant under proper

Lorentz transformations is also invariant under the combined operations of charge conjugation, C, space inversion, P, and time reversal, T, taken in any order.

**Critical point\*** - In general, the point on the phase diagram of a two-phase system at which the two coexisting phases have identical properties and therefore represent a single phase. At the liquid-gas critical point of a pure substance, the distinction between liquid and gas vanishes, and the vapor pressure curve ends. The coordinates of this point are called the critical temperature and critical pressure. Above the critical temperature, it is not possible to liquefy the substance.

**Cross section ( $\sigma$ )\*** - A measure of the probability of collision (or other interaction) between a beam of particles and a target which it encounters. In rough terms it is the effective area the target particles present to the incident ones; however, the precise definition depends on the nature of the interaction. A general definition of  $\sigma$  is the number of encounters per unit time divided by  $n\nu$ , where  $n$  is the concentration of incident particles and  $\nu$  their velocity.

**Crosslink** - In polymer science, a small region in a macromolecule from which at least four chains emanate, and formed by reactions involving sites or groups on existing macromolecules or by interactions between existing macromolecules. [8]

**Crown compounds** - Macrocyclic polydentate compounds, usually uncharged, in which three or more coordinating ring atoms (usually oxygen or nitrogen) are or may become suitably close for easy formation of chelate complexes with metal ions or other cationic species. [5]

**Crust\*** - The outer layer of the solid earth, above the Mohorovicic discontinuity. Its thickness averages about 35 km on the continents and about 7 km below the ocean floor.

**Cryoscopic constant ( $E_f$ )\*** - The constant that expresses the amount by which the freezing point  $T_f$  of a solvent is lowered by a non-dissociating solute, through the relation  $\Delta T_f = E_f m$ , where  $m$  is the molality of the solute.

**Curie (Ci)** - A non-SI unit of radioactivity (disintegrations per unit time), equal to  $3.7 \times 10^{10} \text{ s}^{-1}$ .

**Curie temperature ( $T_c$ )\*** - For a ferromagnetic material, the critical temperature above which the material becomes paramagnetic. Also applied to the temperature at which the spontaneous polarization disappears in a ferroelectric solid. [1]

**Cyanohydrins** - Alcohols substituted by a cyano group, most commonly, but not limited to, examples having a CN and an OH group attached to the same carbon atom. They are formally derived from aldehydes or ketones by the addition of hydrogen cyanide. [5]

**Cycloalkanes** - Saturated monocyclic hydrocarbons (with or without side chains). See alicyclic compounds. Unsaturated monocyclic hydrocarbons having one endocyclic double or one triple bond are called cycloalkenes and cycloalkynes, respectively. [5]

**Cyclotron resonance** - The resonant absorption of energy from a system in which electrons or ions that are orbiting in a uniform magnetic field are subjected to radiofrequency or microwave radiation. The resonance frequency is given by  $\nu = eH/2\pi m^*c$ , where  $e$  is the elementary charge,  $H$  is the magnetic field strength,  $m^*$  is the effective mass of the charged particle, and  $c$  is the speed of light. The effect occurs in both solids (involving electrons or holes) and in low pressure gasses (involving ions)



**Dalton (Da)** - A name sometimes used in biochemistry for the unified atomic mass unit (u).

**De Broglie wavelength** - The wavelength associated with the wave representation of a moving particle, given by  $h/mv$ , where  $h$  is Planck's constant,  $m$  the particle mass, and  $v$  the velocity.

**De Haas-Van Alphen effect** - An effect observed in certain metals and semiconductors at low temperatures and high magnetic fields, characterized by a periodic variation of magnetic susceptibility with field strength.

**Debye equation\*** - The relation between the relative permittivity (dielectric constant)  $\epsilon_r$ , polarizability  $\alpha$ , and permanent dipole moment  $\mu$  in a dielectric material whose molecules are free to rotate. It takes the form

$$\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{\rho N_A}{3M\epsilon_0} \left( \alpha + \frac{\mu^2}{3kT} \right)$$

where  $\rho$  is density,  $N_A$  is Avogadro's number,  $M$  is molar mass, and  $\epsilon_0$  is the permittivity of a vacuum.

**Debye length** - In the Debye-Hückel theory of ionic solutions, the effective thickness of the cloud of ions of opposite charge which surrounds each given ion and shields the Coulomb potential produced by that ion.

**Debye temperature ( $\theta_D$ )\*** - In the Debye model of the heat capacity of a crystalline solid,  $\theta_D = hv_D/k$ , where  $h$  is Planck's constant,  $k$  is the Boltzmann constant, and  $v_D$  is the maximum vibrational frequency the crystal can support. For  $T \ll \theta_D$ , the heat capacity is proportional to  $T^3$ .

**Debye unit (D)** - A non-SI unit of electric dipole moment used in molecular physics, equal to  $3.335641 \times 10^{-30}$  C m.

**Debye-Waller factor (D)** - The factor by which the intensity of a diffraction line is reduced because of lattice vibrations. [1]

**Defect** - Any departure from the regular structure of a crystal lattice. A Frenkel defect results when an atom or ion moves to an interstitial position and leaves behind a vacancy. A Schottky defect involves either a vacancy where the atom has moved to the surface or a structure where a surface atom has moved to an interstitial position.

**Degree of polymerization** - The number of monomeric units in a macromolecule or an oligomer molecule. [8]

**Dendrite** - A tree-like crystalline pattern often observed, for example, in ice crystals and alloys in which the crystal growth branches repeatedly.

**Density ( $\rho$ )\*** - In the most common usage, mass density or mass per unit volume. More generally, the amount of some quantity (mass, charge, energy, etc.) divided by a length, area, or volume.

**Density of states ( $N_E$ ,  $\rho$ )** - The number of one-electron states in an infinitesimal interval of energy, divided by the range of that interval and by volume. [1]

**Dew point\*** - The temperature at which liquid begins to condense as the temperature of a gas mixture is lowered. In meteorology, it is the temperature at which moisture begins to condense on a surface in contact with the air.

**Diamagnetism** - A type of magnetism characterized by a negative magnetic susceptibility, so that the material, when placed in an external magnetic field, becomes weakly magnetized in the direction opposite to the field. This magnetization is independent of temperature.

**Diazo compounds** - Compounds having the divalent diazo group,  $=N^+=N^-$ , attached to a carbon atom, e.g.,  $CH_2=N_2$  diazomethane. [5]

**Dielectric constant ( $\epsilon$ )\*** - Ratio of the electric displacement in a medium to the electric field strength. Also called permittivity. [1]

**Dienes** - Compounds that contain two fixed double bonds (usually assumed to be between carbon atoms). Dienes in which the two double-bond units are linked by one single bond are termed conjugated. [5]

**Differential scanning calorimetry (DSC)** - See Techniques for Materials Characterization, page 12-1.

**Differential thermal analysis (DTA)** - See Techniques for Materials Characterization, page 12-1.

**Diffusion\*** - The migration of atoms, molecules, ions, or other particles as a result of some type of gradient (concentration, temperature, etc.).

**Dioptr** - A unit used in optics, formally equal to  $m^{-1}$ . It is used in expressing dioptric power, which is the reciprocal of the focal length of a lens.

**Dipole moment, electric ( $p, \mu$ )\*** - For a distribution of equal positive and negative charge, the magnitude of the dipole moment vector is the positive charge multiplied by the distance between the centers of positive and negative charge distribution. The direction is given by the line from the center of negative charge to the center of positive charge.

**Dipole moment, magnetic ( $m, \mu$ )** - Formally defined in electromagnetic theory as a vector quantity whose vector product with the magnetic flux density equals the torque. The magnetic dipole generated by a current  $I$  flowing in a small loop of area  $A$  has a magnetic moment of magnitude  $IA$ . In atomic and nuclear physics, a magnetic moment is associated with the angular momentum of a particle; e.g., an electron with orbital angular momentum  $l$  exhibits a magnetic moment of  $-el/2m_e$  where  $e$  is the elementary charge and  $m_e$  the mass of the electron. [1]

**Disaccharides** - Compounds in which two monosaccharides are joined by a glycosidic bond. [5]

**Dislocation** - An extended displacement of a crystal from a regular lattice. An edge dislocation results when one portion of the crystal has partially slipped with respect to the other, resulting in an extra plane of atoms extending through part of the crystal. A screw dislocation transforms successive atomic planes into the surface of a helix.

**Dispersion** - Splitting of a beam of light (or other electromagnetic radiation) of mixed wavelengths into the constituent wavelengths as a result of the variation of refractive index of the medium with wavelength.

**Dissociation constant\*** - The equilibrium constant for a chemical reaction in which a compound dissociates into its constituent parts.

**Dissociation energy ( $D_0$ )\*** - For a diatomic molecule, the difference between the energies of the free atoms at rest and the minimum in the potential energy curve. The term bond dissociation energy ( $D_0$ ), which can be applied to polyatomic molecules as well, is used for the difference between the energies of the fragments resulting when a bond is broken and the energy of the original molecule in its lowest energy state. The term bond strength implies differences in enthalpy rather than energy.



**Domain** - A small region of a solid in which the magnetic or electric moments of the individual units (atoms, molecules, or ions) are aligned in the same direction.

**Domain wall** - The transition region between adjacent ferromagnetic domains, generally a layer with a thickness of a few hundred ångström units. Also called Bloch wall.

**Doppler effect** - The change in the apparent frequency of a wave (sound, light, or other) when the source of the wave is moving relative to the observer.

**Dose equivalent ( $H$ )** - The product of the absorbed dose of radiation at a point of interest in tissue and various modifying factors which depend on the type of tissue and radiation. [1]

**Drift velocity** - The velocity of charge carriers (electrons, ions, etc.) moving under the influence of an electric field in a medium which subjects the carriers to some frictional force.

**Dyne (dyn)** - A non-SI (cgs) unit of force, equal to  $10^{-5}$  N.

**Ebullioscopic constant ( $E_b$ )\*** - The constant that expresses the amount by which the boiling point  $T_b$  of a solvent is raised by a non-dissociating solute, through the relation  $\Delta T_b = E_b m$ , where  $m$  is the molality of the solute.

**Eddy currents** - Circulating currents set up in conducting bulk materials or sheets by varying magnetic fields.

**Effinghausen effect** - The appearance of a temperature gradient in a current carrying conductor that is placed in a transverse magnetic field. The direction of the gradient is perpendicular to the current and the field.

**Eigenvalue** - An allowed value of the constant  $a$  in the equation  $Au = au$ , where  $A$  is an operator acting on a function  $u$  (which is called an eigenfunction). In quantum mechanics, the outcome of any observation is an eigenvalue of the corresponding operator. Also called characteristic value.

**Einstein** - A non-SI unit used in photochemistry, equal to one mole of photons.

**Einstein temperature ( $\theta_v$ )** - In the Einstein theory of the heat capacity of a crystalline solid,  $\theta_v = hv/k$ , where  $h$  is Planck's constant,  $k$  is the Boltzmann constant, and  $v$  is the vibrational frequency of the crystal.

**Einstein transition probability** - A constant in the Einstein relation  $A_{ij} + B_{ij}\rho$  for the probability of a transition between two energy levels  $i$  and  $j$  in a radiation field of energy density  $\rho$ . The  $A_{ij}$  coefficient describes the probability of spontaneous emission, while  $B_{ij}$  and  $B_{ji}$  govern the probability of stimulated emission and absorption, respectively ( $B_{ij} = B_{ji}$ ).

**Elastic limit** - The greatest stress which a material is capable of sustaining without any permanent strain remaining after complete release of the stress. [10]

**Elastic modulus** - See Young's modulus.

**Electric charge ( $Q$ )** - The quantity of electricity; i.e., the property that controls interactions between bodies through electrical forces.

**Electric current ( $I$ )** - The charge passing through a circuit per unit time. [1]

**Electric displacement ( $D$ )** - A vector quantity whose magnitude equals the electric field strength multiplied by the permittivity of the medium and whose direction is the same as that of the field strength.

**Electric field strength ( $E$ )** - The force exerted by an electric field on a point charge divided by the electric charge. [1]

**Electric potential ( $V$ )** - A scalar quantity whose gradient is equal to the negative of the electric field strength.

**Electrical conductance** - See Conductance.

**Electrical resistance** - See Resistance.

**Electrical resistivity** - See Resistivity.

**Electrochemical series\*** - An arrangement of reactions which produce or consume electrons in an order based on standard electrode potentials. A common arrangement places metals in decreasing order of their tendency to give up electrons.

**Electrode potential\*** - The electromotive force of a cell in which the electrode on the left is the standard hydrogen electrode and that on the right is the electrode in question. [2]

**Electrolysis** - The decomposition of a substance as a result of passing an electric current between two electrodes immersed in the sample.

**Electromotive force (emf)** - The energy supplied by a source divided by the charge transported through the source. [1]

**Electron\*** - An elementary particle in the family of leptons, with negative charge and spin of  $1/2$ .

**Electron affinity\*** - The energy difference between the ground state of a gas-phase atom or molecule and the lowest state of the corresponding negative ion.

**Electron cyclotron resonance (ECR)** - See Techniques for Materials Characterization, page 12-1.

**Electron energy loss spectroscopy (EELS)** - See Techniques for Materials Characterization, page 12-1.

**Electron nuclear double resonance (ENDOR)** - See Techniques for Materials Characterization, page 12-1.

**Electron paramagnetic resonance (EPR)** - See Techniques for Materials Characterization, page 12-1.

**Electron probe microanalysis (EPMA)** - See Techniques for Materials Characterization, page 12-1.

**Electron spectroscopy for chemical analysis (ESCA)** - See Techniques for Materials Characterization, page 12-1.

**Electron spin ( $s$ )** - The quantum number, equal to  $1/2$ , that specifies the intrinsic angular momentum of the electron.

**Electron stimulated desorption (ESD)** - See Techniques for Materials Characterization, page 12-1.

**Electron volt (eV)\*** - A non-SI unit of energy used in atomic and nuclear physics, equal to approximately  $1.602177 \times 10^{-19}$  J. The electron volt is defined as the kinetic energy acquired by an electron upon acceleration through a potential difference of 1 V. [1]

**Electronegativity\*** - A parameter originally introduced by Pauling which describes, on a relative basis, the power of an atom or group of atoms to attract electrons from the same molecular entity. [3]

**Electrophoresis** - The motion of macromolecules or colloidal particles in an electric field. [3]

**Emissivity ( $\epsilon$ )\*** - Ratio of the radiant flux emitted per unit area to that of an ideal black body at the same temperature. Also called emittance. [1]

**Emu** - The electromagnetic system of units, based upon the cm, g, and s plus the emu of current (sometimes called the abampere).

**Enantiomers** - A chiral molecule and its non-superposable mirror image. The two forms rotate the plane of polarized light by equal amounts in opposite directions. Also called optical isomers.

**Energy ( $E, U$ )\*** - The characteristic of a system that enables it to do work.

**Energy gap\*** - In the theory of solids, the region between two energy bands, in which no bound states can occur.

**Enols, alkenols** - The term refers specifically to vinylic alcohols, which have the structure  $\text{HO-CR}'=\text{CR}_2$ . Enols are tautomeric with aldehydes ( $\text{R}' = \text{H}$ ) or ketones ( $\text{R}'$  not equal to  $\text{H}$ ). [5]

**Enthalpy ( $H$ )\*** - A thermodynamic function, especially useful when dealing with constant-pressure processes, defined by  $H = E + PV$ , where  $E$  is energy,  $P$  pressure, and  $V$  volume. [1]

**Enthalpy of combustion\*** - The enthalpy change in a combustion reaction. Its negative is the heat released in combustion.

**Enthalpy of formation, standard\*** - The enthalpy change for the reaction in which a substance is formed from its constituent elements, each in its standard reference state (normally refers to 1 mol, sometimes to 1 g, of the substance).

**Enthalpy of fusion\*** - The enthalpy change in the transition from solid to liquid state.

**Enthalpy of sublimation** - The enthalpy change in the transition from solid to gas state.

**Enthalpy of vaporization\*** - The enthalpy change in the transition from liquid to gas state.

**Entropy ( $S$ )\*** - A thermodynamic function defined such that when a small quantity of heat  $dQ$  is received by a system at temperature  $T$ , the entropy of the system is increased by  $dQ/T$ , provided that no irreversible change takes place in the system. [1]

**Entropy unit (e.u.)** - A non-SI unit of entropy, equal to 4.184 J/K mol.

**Ephemeris time** - Time measured in tropical years from January 1, 1900.

**Epoxy compounds** - Compounds in which an oxygen atom is directly attached to two adjacent or non-adjacent carbon atoms of a carbon chain or ring system; thus cyclic ethers. [5]

**Equation of continuity** - Any of a class of equations that express the fact that some quantity (mass, charge, energy, etc.) cannot be created or destroyed. Such equations typically specify that the rate of increase of the quantity in a given region of space equals the net current of the quantity flowing into the region.

**Equation of state\*** - An equation relating the pressure, volume, and temperature of a substance or system.

**Equilibrium constant ( $K$ )\*** - For a chemical reaction  $aA + bB \rightleftharpoons cC + dD$ , the equilibrium constant is defined by:

$$K = \frac{a_C^c \cdot a_D^d}{a_A^a \cdot a_B^b}$$

where  $a_i$  is the activity of component  $i$ . To a certain approximation, the activities can be replaced by concentrations. The equilibrium constant is related to  $\Delta_r G^\circ$ , the standard Gibbs energy change in the reaction, by  $RT \ln K = -\Delta_r G^\circ$ .

**Equivalent conductance** - See Conductivity, electrical

**Erg (erg)** - A non-SI (cgs) unit of energy, equal to  $10^{-7}$  J.

**Esters** - Compounds formally derived from an oxoacid  $\text{RC(=O)(OH)}$  and an alcohol, phenol, heteroarenol, or enol by linking, with formal loss of water from an acidic hydroxy group of the former and a hydroxy group of the latter. [5]

**Esu** - The electrostatic system of units, based upon the cm, g, and s plus the esu of charge (sometimes called the statcoulomb or franklin).

**Ethers** - Compounds with formula  $\text{ROR}$ , where  $\text{R}$  is not equal to  $\text{H}$ . [5]

**Euler number ( $Eu$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Eu = \Delta p / \rho v^2$ , where  $p$  is pressure,  $\rho$  is density, and  $v$  is velocity. [2]

**Eutectic** - The point on a two-component solid-liquid phase diagram which represents the lowest melting point of any possible mixture. A liquid having the eutectic composition will freeze at a single temperature without change of composition.

**Excitance ( $M$ )** - Radiant energy flux leaving an element of a surface divided by the area of that element. [1]

**Exciton** - A localized excited state consisting of a bound electron-hole pair in a molecular or ionic crystal. The exciton can propagate through the crystal.

**Exosphere** - The outermost part of the earth's atmosphere, beginning at about 500 to 1000 km above the surface. It is characterized by densities so low that air molecules can escape into outer space.

**Expansion coefficient** - See thermal expansion coefficient.

**Extended electron energy loss fine structure (EXELFS)** - See Techniques for Materials Characterization, page 12-1.

**Extended x-ray absorption fine structure (EXAFS)** - See Techniques for Materials Characterization, page 12-1.

**Extinction coefficient** - See Absorption coefficient, molar.

**F-Center** - See Color center.

**Fahrenheit temperature ( $^\circ\text{F}$ )** - The temperature scale based on the assignment of  $32^\circ\text{F} = 0^\circ\text{C}$  and a temperature interval of  $^\circ\text{F} = (5/9)^\circ\text{C}$ ; i.e.,  $t/^\circ\text{F} = (9/5)t/^\circ\text{C} + 32$ .

**Farad ( $\text{F}$ )\*** - The SI unit of electric capacitance, equal to  $\text{C/V}$ . [1]

**Faraday constant ( $F$ )\*** - The electric charge of 1 mol of singly charged positive ions; i.e.,  $F = N_A e$ , where  $N_A$  is Avogadro's constant and  $e$  is the elementary charge. [1]

**Faraday effect\*** - The rotation of the plane of plane-polarized light by a medium placed in a magnetic field parallel to the direction of the light beam. The effect can be observed in solids, liquids, and gasses.

**Fatty acids** - Aliphatic monocarboxylic acids derived from or contained in esterified form in an animal or vegetable fat, oil, or wax. Natural fatty acids commonly have a chain of 4 to 28 carbons (usually unbranched and even-numbered), which may be saturated or unsaturated. By extension, the term is sometimes used to embrace all acyclic aliphatic carboxylic acids. [5]

**Fermat's principle** - The law that a ray of light traversing one or more media will follow a path which minimizes the time required to pass between two given points.

**Fermi (f)** - Name sometimes used in nuclear physics for the femtometer.

**Fermi level** - The highest energy of occupied states in a solid at zero temperature. Sometimes called Fermi energy. The Fermi surface is the surface in momentum space formed by electrons occupying the Fermi level.

**Fermi resonance** - An effect observed in vibrational spectroscopy when an overtone of one fundamental vibration closely coincides in energy with another fundamental of the same symmetry species. It leads to a splitting of vibrational bands.

**Fermi-Dirac distribution** - A modification of the Boltzmann distribution which takes into account the Pauli exclusion principle. The number of particles of energy  $E$  is proportional to  $[e^{(E-\mu)/kT} + 1]^{-1}$ , where  $\mu$  is a normalization constant,  $k$  the Boltzmann constant, and  $T$  the temperature. The distribution is applicable to a system of fermions.

**Fermion** - A particle that obeys Fermi-Dirac statistics. Specifically, any particle with spin equal to an odd multiple of  $1/2$ . Examples are the electron, proton, neutron, muon, etc.

**Ferrimagnetism\*** - A type of magnetism in which the magnetic moments of atoms in a solid are ordered into two nonequivalent sublattices with unequal magnetic moments, leading to a nonzero magnetic susceptibility.

**Ferrite** - A ferrimagnetic material of nominal formula  $MFe_2O_4$ , where  $M$  is a divalent metal; widely used in microwave switches and other solid state devices.

**Ferroelectricity\*** - The retention of electric polarization by certain materials after the external field that produced the polarization has been removed.

**Ferromagnetism\*** - A type of magnetism in which the magnetic moments of atoms in a solid are aligned within domains which can in turn be aligned with each other by a weak magnetic field. Some ferromagnetic materials can retain their magnetization when the external field is removed, as long as the temperature is below a critical value, the Curie temperature. They are characterized by a large positive magnetic susceptibility.

**Fick's law** - The statement that the flux  $J$  of a diffusing substance is proportional to the concentration gradient, i.e.,  $J = -D(dc/dx)$ , where  $D$  is called the diffusion coefficient.

**Field** - A mathematical construct which describes the interaction between particles resulting from gravity, electromagnetism, or other physical phenomena. In classical physics a field is described by equations. Quantum field theory introduces operators to represent the physical observables.

**Field emission microscopy (FEM)** - See Techniques for Materials Characterization, page 12-1.

**Field ion microscopy (FIM)** - See Techniques for Materials Characterization, page 12-1.

**Fine structure** - The splitting in spectral lines that results from interactions of the electron spin with the orbital angular momentum.

**Fine structure constant ( $\alpha$ )\*** - Defined as  $e^2/2hc\epsilon_0$ , where  $e$  is the elementary charge,  $h$  Planck's constant,  $c$  the speed of light, and  $\epsilon_0$  the permittivity of a vacuum. It is a measure of the strength of the electromagnetic interaction between particles.

**First radiation constant ( $c_1$ )\*** - Constant ( $= 2\pi hc^2$ ) in the equation for the radiant exitance  $M_\lambda$  of a black body:

$$M_\lambda = \frac{c_1 \lambda^{-5} \Delta \lambda}{e^{c_2/\lambda T} - 1}$$

where  $\lambda$  is the wavelength,  $T$  is the temperature, and  $c_2 = hc/k$  is the second radiation constant.

**Flash point** - The lowest temperature at which vapors above a volatile combustible substance will ignite in air when exposed to a flame. [10]

**Fluence ( $F$ )** - Term used in photochemistry to specify the energy per unit area delivered in a given time interval, for example by a laser pulse. [2]

**Fluorocarbons** - Compounds consisting solely of fluorine and carbon. [5]

**Fluxoid** - The quantum of magnetic flux in superconductivity theory, equal to  $hc/2e$ , where  $h$  is Planck's constant,  $c$  the velocity of light, and  $e$  the elementary charge.

**Force ( $F$ )** - The rate of change of momentum with time. [1]

**Force constants ( $f, k$ )\*** - In molecular vibrations, the coefficients in the expression of the potential energy in terms of atom displacements from their equilibrium positions. In a diatomic molecule,  $f = d^2V/dr^2$ , where  $V(r)$  is the potential energy and  $r$  is the interatomic distance. [2]

**Fourier number ( $Fo$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Fo = at/l^2$ , where  $a$  is thermal diffusivity,  $t$  is time, and  $l$  is length. [2]

**Fourier transform infrared spectroscopy (FTIR)** - A technique for obtaining an infrared spectrum by use of an interferometer in which the path length of one of the beams is varied. A Fourier transformation of the resulting interferogram yields the actual spectrum. The technique is also used for NMR and other types of spectroscopy.

**Fractals** - Geometrical objects that are self-similar under a change of scale; i.e., they appear similar at all levels of magnification. They can be considered to have fractional dimensionality. Examples occur in diverse fields such as geography (rivers and shorelines), biology (trees), and solid state physics (amorphous materials).

**Franck-Condon principle** - An important principle in molecular spectroscopy which states that the nuclei in a molecule remain essentially stationary while an electronic transition is taking place. The physical interpretation rests on the fact that the electrons move much more rapidly than the nuclei because of their much smaller mass.

**Franklin (Fr)** - Name sometimes given to the unit of charge in the esu system.

**Fraunhofer diffraction** - Diffraction of light in situations where the source and observation point are so far removed that the wave surfaces may be considered planar.

**Fraunhofer lines** - Sharp absorption lines in the spectrum of sunlight, caused by absorption of the solar blackbody radiation by atoms near the sun's surface.

**Free radical** - See Radicals. The term "free radical" is often used more broadly for molecules that have a paramagnetic ground state (e.g.,  $O_2$ ) and sometimes for any transient or highly reactive molecular species.

**Freezing point** - See Melting point.

**Frequency ( $\nu$ )\*** - Number of cycles of a periodic phenomenon divided by time. [1]

**Fresnel diffraction** - Diffraction of light in a situation where the source and observation point are sufficiently close together that the curvature of the wave surfaces must be taken into account.

**Froude number ( $Fr$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Fr = v/(lg)^{1/2}$ , where  $v$  is velocity,  $l$  is length, and  $g$  is acceleration due to gravity. [2]

**Fugacity ( $f_B$ )** - For a gas mixture, the fugacity of component B is defined as the absolute activity  $\lambda_B$  times the limit, as the pressure  $p$  approaches zero at constant temperature, of  $p_B/\lambda_B$ . [2]

**Fullerenes** - Compounds composed solely of an even number of carbon atoms, which form a cage-like fused-ring polycyclic system with twelve five-membered rings and the rest six-membered rings. The archetypal example is [60]fullerene, where the atoms and bonds delineate a truncated icosahedron. The term has been broadened to include any closed cage structure consisting entirely of three-coordinate carbon atoms. [5]

**Fulvalenes** - The hydrocarbon fulvalene and its derivatives formed by substitution (and by extension, analogues formed



by replacement of one or more carbon atoms of the fulvalene skeleton by a heteroatom). [5]

**Fulvenes** - The hydrocarbon fulvene and its derivatives formed by substitution (and by extension, analogues formed by replacement of one or more carbon atoms of the fulvene skeleton by a heteroatom). [5]

**Fundamental vibrational frequencies\*** - In molecular spectroscopy, the characteristic vibrational frequencies obtained when the vibrational energy is expressed in normal coordinates. They determine the primary features of the infrared and Raman spectra of the molecule.

**γ** - Name sometimes used for microgram.

**γ-rays\*** - Electromagnetic radiation (photons) with energy greater than about 0.1 MeV (wavelength less than about 1 pm).

**g-Factor of the electron\*** - The proportionality factor in the equation relating the magnetic moment  $\mu$  of an electron to its total angular momentum quantum number  $J$ , i.e.,  $\mu = -g\mu_B J$ , where  $\mu_B$  is the Bohr magneton. Also called Landé factor.

**Gal** - A non-SI unit of acceleration, equal to 0.01 m/s. Also called galileo.

**Gallon (US)** - A unit of volume equal to 3.785412 L.

**Gallon (UK, Imperial)** - A unit of volume equal to 4.546090 L.

**Gauss (G)** - A non-SI unit of magnetic flux density ( $B$ ) equal to  $10^{-4}$  T.

**Gaussian system of units** - A hybrid system used in electromagnetic theory, which combines features of both the esu and emu systems.

**Gel** - A colloidal system with a finite, but usually rather small, yield stress (the sheer stress at which yielding starts abruptly). [3]

**Genetic code\*** - The set of relations between each of the 64 codons of DNA and a specific amino acid (or other genetic instruction).

**Gibbs energy (G)\*** - An important function in chemical thermodynamics, defined by  $G = H - TS$ , where  $H$  is the enthalpy,  $S$  the entropy, and  $T$  the thermodynamic temperature. Sometimes called Gibbs free energy and, in older literature, simply "free energy". [2]

**Gibbs phase rule** - The relation  $F = C - P + 2$ , where  $C$  is the number of components in a mixture,  $P$  is the number of phases, and  $F$  is the degrees of freedom, i.e., the number of intensive variables that can be changed independently without affecting the number of phases.

**Glass transition temperature\*** - The temperature at which an amorphous polymer is transformed, in a reversible way, from a viscous or rubbery condition to a hard and relatively brittle one. [10]

**Glow discharge mass spectroscopy (GDMS)** - See Techniques for Materials Characterization, page 12-1.

**Gluon** - A hypothetical particle postulated to take part in the binding of quarks, in analogy to the role of the photon in electromagnetic interactions.

**Glycerides** - Esters of glycerol (propane-1,2,3-triol) with fatty acids, widely distributed in nature. They are by long-established custom subdivided into triglycerides, 1,2- or 1,3-diglycerides, and 1- or 2-monoglycerides, according to the number and positions of acyl groups. [5]

**Glycols** - Dihydric alcohols in which two hydroxy groups are on different carbon atoms, usually but not necessarily adjacent. Also called diols. [5]

**Grain (gr)** - A non-SI unit of mass, equal to 64.79891 mg.

**Grain boundary** - The interface between two regions of different crystal orientation.

**Grashof number (Gr)** - A dimensionless quantity used in fluid mechanics, defined by  $Gr = l^3 g \alpha \Delta T \rho^2 / \eta^2$ , where  $T$  is temperature,  $\rho$  is density,  $l$  is length,  $\eta$  is viscosity,  $\alpha$  is cubic expansion coefficient, and  $g$  is acceleration of gravity. [2]

**Gravitational constant (G)\*** - The universal constant in the equation for the gravitational force between two particles,  $F = Gm_1 m_2 / r^2$ , where  $r$  is the distance between the particles and  $m_1$  and  $m_2$  are their masses. [1]

**Gray (Gy)\*** - The SI unit of absorbed dose of radiation, equal to J/kg. [1]

**Gregorian calendar** - The modification of the Julian calendar introduced in 1582 by Pope Gregory XII which specified that a year divisible by 100 is a leap year only if divisible by 400.

**Grignard reagents** - Organomagnesium halides,  $RMgX$ , having a carbon-magnesium bond (or their equilibrium mixtures in solution with  $R_2Mg + MgX_2$ ). [5]

**Gruneisen parameter (γ)** - Defined by  $\gamma = \alpha_V / \kappa c_V \rho$ , where  $\alpha_V$  is the cubic thermal expansion coefficient,  $\kappa$  is the isothermal compressibility,  $c_V$  is the specific heat capacity at constant volume, and  $\rho$  is the mass density.  $\gamma$  is independent of temperature for most crystalline solids. [1]

**Gyromagnetic ratio (γ)** - Ratio of the magnetic moment of a particle to its angular momentum. Also called magnetogyric ratio.

**Hadron** - Any elementary particle that can take part in the strong interaction. Hadrons are subdivided into baryons, with odd half integer spins, and mesons, which have zero or integral spin.

**Hall effect\*** - The development of a transverse potential difference  $V$  in a conducting material when subjected to a magnetic field  $H$  perpendicular to the direction of the current. The potential difference is given by  $V = R_H B I / t$ , where  $B$  is the magnetic induction,  $I$  the current density,  $t$  the thickness of the specimen in the direction of the potential difference, and  $R_H$  is called the Hall coefficient.

**Halocarbon** - A compound containing no elements other than carbon, hydrogen, and one or more halogens. In common practice, the term is used mainly for compounds of no more than four or five carbon atoms.

**Halogens** - The elements F, Cl, Br, I, and At. Compounds of these elements are called halogenides or halides. [7]

**Hamiltonian (H)** - An expression for the total energy of a mechanical system in terms of the momenta and positions of constituent particles. In quantum mechanics, the Hamiltonian operator appears in the eigenvalue equation  $H\psi = E\psi$ , where  $E$  is an energy eigenvalue and  $\psi$  the corresponding eigenfunction.

**Hardness\*** - The resistance of a material to deformation, indentation, or scratching. Hardness is measured on various scales, such as Mohs, Brinell, Knoop, Rockwell, and Vickers. [10]

**Hartmann number (Ha)** - A dimensionless quantity used in plasma physics, defined by  $Ha = B l (\kappa / \eta)^{1/2}$ , where  $B$  is magnetic flux density,  $l$  is length,  $\kappa$  is electric conductivity, and  $\eta$  is viscosity. [2]

**Hartree ( $E_h$ )\*** - An energy unit used in atomic and molecular science, equal to approximately  $4.3597482 \times 10^{-18}$  J.

**Hartree-Fock method** - A iterative procedure for solving the Schrödinger equation for an atom or molecule in which the equation is solved for each electron in an initial assumed po-

tential from all the other electrons. The new potential that results is used to repeat the calculation and the procedure continued until convergence is reached. Also called self-consistent field (SCF) method.

**Heat capacity\*** - Defined in general as  $dQ/dT$ , where  $dQ$  is the amount of heat that must be added to a system to increase its temperature by a small amount  $dT$ . The heat capacity at constant pressure is  $C_p = (\partial H/\partial T)_p$ ; that at constant volume is  $C_v = (\partial E/\partial T)_v$ , where  $H$  is enthalpy,  $E$  is internal energy,  $p$  is pressure,  $V$  is volume, and  $T$  is temperature. An upper case  $C$  normally indicates the molar heat capacity, while a lower case  $c$  is used for the specific (per unit mass) heat capacity. [1]

**Heat of formation, vaporization, etc.** - See corresponding terms under Enthalpy.

**Hectare (ha)** - A unit of area equal to  $10^4$  m<sup>2</sup>. [1]

**Heisenberg uncertainty principle** - The statement that two observable properties of a system that are complementary, in the sense that their quantum-mechanical operators do not commute, cannot be specified simultaneously with absolute precision. An example is the position and momentum of a particle; according to this principle, the uncertainties in position  $\Delta q$  and momentum  $\Delta p$  must satisfy the relation  $\Delta p \Delta q \geq h/4\pi$ , where  $h$  is Planck's constant.

**Heitler-London model** - An early quantum-mechanical model of the hydrogen atom which introduced the concept of the exchange interaction between electrons as the primary reason for stability of the chemical bond.

**Helicon** - A low-frequency wave generated when a metal at low temperature is exposed to a uniform magnetic field and a circularly polarized electric field.

**Helmholz energy (A)** - A thermodynamic function defined by  $A = E - TS$ , where  $E$  is the energy,  $S$  the entropy, and  $T$  the thermodynamic temperature. [2]

**Hemiacetals** - Compounds having the general formula  $R_2C(OH)OR'$  ( $R'$  not equal to H). [5]

**Henry (H)\*** - The SI unit of inductance, equal to Wb/A. [1]

**Henry's law\*** - An expression which applies to an ideal dilute solution in which one or more gasses are dissolved, viz.,  $p_i = H_i x_i$ , where  $p_i$  is the partial pressure of component  $i$  above the solution,  $x_i$  is its mole fraction in the solution, and  $H_i$  is the Henry's law constant (a characteristic of the given gas and solvent, as well as the temperature).

**Hermitian operator** - An operator  $A$  that satisfies the relation  $\int u_m^* A u_n dx = (\int u_n^* A u_m dx)^*$ , where  $*$  indicates the complex conjugate. The eigenvalues of Hermitian operators are real, and eigenfunctions belonging to different eigenvalues are orthogonal.

**Hertz (Hz)** - The SI unit of frequency, equal to s<sup>-1</sup>. [1]

**Heterocyclic compounds** - Cyclic compounds having as ring members atoms of at least two different elements, e.g., quinoxaline, 1,2-thiazole, bicyclo[3.3.1]tetrasiloxane. [5]

**Heusler alloys** - Alloys of manganese, copper, aluminum, nickel, and sometimes other metals which find important uses as permanent magnets.

**Holography** - A technique for creating a three-dimensional image of a object by recording the interference pattern between a light beam diffracted from the object and a reference beam. The image can be reconstructed from this pattern by a suitable optical system.

**Homopolymer** - A polymer derived from one species of (real, implicit, or hypothetical) monomer. [8]

**Hooke's law** - The statement that the ratio of stress to strain is a constant in a totally elastic medium.

**Horse power** - A non-SI unit of energy, equal to approximately 746 W.

**Hubble constant** - The ratio of the recessional velocity of an extragalactic object to the distance of that object. Its value is about  $2 \times 10^{-18}$  s<sup>-1</sup>.

**Huckel theory** - A simple approximation for calculating the energy of conjugated molecules in which only the resonance integrals between neighboring bonds are considered. Also called CNDO method (complete neglect of differential overlap).

**Hume-Rothery rules** - A set of empirical rules for predicting the occurrence of solid solutions in metallic systems. The rules involve size, crystal structure, and electronegativity.

**Hund's rules** - A series of rules for predicting the sequence of energy states in atoms and molecules. One of the important results is that when two electrons exist in different orbitals, the state with their spins parallel (triplet state) lies at lower energy than the state with antiparallel spins (singlet).

**Hydrazines** - Hydrazine (diazane),  $H_2NNH_2$ , and its hydrocarbyl derivatives. When one or more substituents are acyl groups, the compound is a hydrazide. [5]

**Hydrocarbon** - A compound containing only carbon and hydrogen. [5]

**Hydrolysis** - A reaction occurring in water in which a chemical bond is cleaved and a new bond formed with the oxygen atom of water.

**Hyperfine structure** - Splitting of energy levels and spectral lines into several closely spaced components as a result of interaction of nuclear spin angular momentum with other angular momenta in the atom or molecule.

**Hysteresis\*** - An irreversible response of a system (parameter  $A$ ) as a function of an external force (parameter  $F$ ), usually symmetric with respect to the origin of the  $A$  vs.  $F$  graph after the initial application of the force. A common example is magnetic induction vs. magnetic field strength in a ferromagnet.

**Ideal gas law** - The equation of state  $pV = RT$ , which defines an ideal gas, where  $p$  is pressure,  $V$  molar volume,  $T$  temperature, and  $R$  the molar gas constant.

**Ideal solution** - A solution in which solvent-solvent and solvent-solute interactions are identical, so that properties such as volume and enthalpy are exactly additive. Ideal solutions follow Raoult's law, which states that the vapor pressure  $p_i$  of component  $i$  is  $p_i = x_i p_i^*$ , where  $x_i$  is the mole fraction of component  $i$  and  $p_i^*$  the vapor pressure of the pure substance  $i$ .

**Ignition temperature\*** - The lowest temperature at which combustion of a material will occur spontaneously under specified conditions. Sometimes called autoignition temperature, kindling point. [10]

**Imides** - Diacyl derivatives of ammonia or primary amines, especially those cyclic compounds derived from diacids. Also used for salts having the anion  $RN_2^-$ . [5]

**Impedance (Z)** - The complex representation of potential difference divided by the complex representation of current. In terms of reactance  $X$  and resistance  $R$ , the impedance is given by  $Z = R + iX$ . [1]

**Index of refraction (n)\*** - For a non-absorbing medium, the ratio of the velocity of electromagnetic radiation *in vacuo* to the phase velocity of radiation of a specified frequency in the medium. [1]

**Inductance** - The ratio of the electromagnetic force induced in a coil by a current to the rate of change of the current.

**Inductive coupled plasma mass spectroscopy (ICPMS)** - See Techniques for Materials Characterization, page 12-1.

**Inertial defect** - In molecular spectroscopy, the quantity  $I_c - I_a - I_b$  for a molecule whose equilibrium configuration is planar, where  $I_a$ ,  $I_b$ , and  $I_c$  are the effective principal moments of inertia. The inertial defect for a rigid planar molecule would be zero, but vibration-rotation interactions in a real molecule lead to a positive inertial defect.

**Insulator** - A material in which the highest occupied energy band (valence band) is completely filled with electrons, while the next higher band (conduction band) is empty. Solids with an energy gap of 5 eV or more are generally considered as insulators at room temperature. Their conductivity is less than  $10^{-6}$  S/m and increases with temperature.

**Intercalation compounds** - Compounds resulting from reversible inclusion, without covalent bonding, of one kind of molecule in a solid matrix of another compound, which has a laminar structure. The host compound, a solid, may be macromolecular, crystalline, or amorphous. [5]

**International System of Units (SI)\*** - The unit system adopted by the General Conference on Weights and Measures in 1960. It consists of seven base units (meter, kilogram, second, ampere, kelvin, mole, candela), plus derived units and prefixes. [1]

**International Temperature Scale (ITS-90)\*** - The official international temperature scale adopted in 1990. It consists of a set of fixed points and equations which enable the thermodynamic temperature to be determined from operational measurements. [9]

**Ion** - An atomic or molecular particle having a net electric charge. [3]

**Ion exchange** - A process involving the adsorption of one or several ionic species accompanied by the simultaneous desorption (displacement) of one or more other ionic species. [3]

**Ion neutralization spectroscopy (INS)** - See Techniques for Materials Characterization, page 12-1.

**Ionic strength ( $I$ )** - A measure of the total concentration of ions in a solution, defined by  $I = 1/2 \sum_i z_i^2 m_i$ , where  $z_i$  is the charge of ionic species  $i$  and  $m_i$  is its molality. For a 1-1 electrolyte at molality  $m$ ,  $I = m$ .

**Ionization constant\*** - The equilibrium constant for a reaction in which a substance in solution dissociates into ions.

**Ionization potential\*** - The minimum energy required to remove an electron from an isolated atom or molecule (in its vibrational ground state) in the gaseous phase. More properly called ionization energy. [3]

**Irradiance ( $E$ )** - The radiant energy flux incident on an element of a surface, divided by the area of that element. [1]

**Isentropic process** - A thermodynamic process in which the entropy of the system does not change.

**Ising model** - A model describing the coupling between two atoms in a ferromagnetic lattice, in which the interaction energy is proportional to the negative of the product of the spin components along a specified axis.

**Isobar** - A line connecting points of equal pressure on a graphical representation of a physical system.

**Isochore** - A line or surface of constant volume on a graphical representation of a physical system.

**Isoelectric point\*** - The pH of a solution or dispersion at which the net charge on the macromolecules or colloidal particles is zero. In electrophoresis there is no motion of the particles in an electric field at the isoelectric point.

**Isomers** - In chemistry, compounds that have identical molecular formulas but differ in the nature or sequence of bonding of their atoms or in the arrangement of their atoms in space. In physics, nuclei of the same atomic number  $Z$  and mass number  $A$  but in different energy states. [3]

**Isomorphs** - Substances of different chemical nature but having the same crystal structure.

**Isotactic macromolecule** - A tactic macromolecule, essentially comprising only one species of repeating unit which has chiral or prochiral atoms in the main chain in a unique arrangement with respect to its adjacent constitutional units. [8]

**Isotherm** - A line connecting points of equal temperature on a graphical representation of a physical system.

**Isothermal process** - A thermodynamic process in which the temperature of the system does not change.

**Isotones** - Nuclides having the same neutron number  $N$  but different atomic number  $Z$ . [3]

**Isotopes** - Two or more nuclides with the same atomic number  $Z$  but different mass number  $A$ . The term is sometimes used synonymously with nuclide, but it is preferable to reserve the word nuclide for a species of specific  $Z$  and  $A$ . [3]

**Jahn-Teller effect** - An interaction of vibrational and electronic motions in a nonlinear molecule which removes the degeneracy of certain electronic energy levels. It can influence the spectrum, crystal structure, and magnetic properties of the substance.

**Johnson noise** - Electrical noise generated by random thermal motion of electrons in a conductor or semiconductor. Also called thermal noise.

**Josephson effect** - The tunneling of electron pairs through a thin insulating layer which separates two superconductors. When a potential difference is applied to the superconductors, an alternating current is generated whose frequency is precisely proportional to the potential difference. This effect has important applications in metrology and determination of fundamental physical constants.

**Joule (J)\*** - The SI unit of energy, equal to N m. [1]

**Joule-Thomson coefficient ( $\mu$ )** - A parameter which describes the temperature change when a gas expands adiabatically through a nozzle from a high pressure to a low pressure region. It is defined by  $\mu = (\partial T / \partial p)_H$ , where  $H$  is enthalpy.

**Julian calendar** - The calendar introduced by Julius Caesar in 46 B.C. which divided the year into 365 days with a leap year of 366 days every fourth year.

**Julian date (JD)** - The number of days elapsed since noon Greenwich Mean Time on January 1, 4713 B.C. Thus January 1, 2000, 0h (midnight) will be JD 2,451,543.5. This dating system was introduced by Joseph Scaliger in 1582.

**Kaon** - One of the elementary particles in the family of mesons. Kaons have a spin of zero and may be neutral or charged.

**Kelvin (K)\*** - The SI base unit of thermodynamic temperature. [1]

**Kepler's laws** - The three laws of planetary motion, which established the elliptical shape of planetary orbits and the relation between orbital dimensions and the period of rotation.



- Kerr effect\*** - An electrooptical effect in which birefringence is induced in a liquid or gas when a strong electric field is applied perpendicular to the direction of an incident light beam. The Kerr constant  $k$  is given by  $n_1 - n_2 = k\lambda E^2$ , where  $\lambda$  is the wavelength,  $E$  is the electric field strength, and  $n_1$  and  $n_2$  are the indices of refraction of the ordinary and extraordinary rays, respectively.
- Ketenes** - Compounds in which a carbonyl group is connected by a double bond to an alkylidene group:  $R_2C=C=O$ . [5]
- Ketones** - Compounds in which a carbonyl group is bonded to two carbon atoms:  $R_1R_2C=O$  (neither R may be H). [5]
- Kilogram (kg)\*** - The SI base unit of mass. [1]
- Kinetic energy ( $E_k$ ,  $T$ )** - The energy associated with the motion of a system of particles in a specified reference frame. For a single particle of mass  $m$  moving at velocity  $v$ ,  $E_k = 1/2mv^2$ .
- Kirchhoff's laws** - Basic rules for electric circuits, which state (a) the algebraic sum of the currents at a network node is zero and (b) the algebraic sum of the voltage drops around a closed path is zero.
- Klein-Gordon equation** - A relativistic extension of the Schrödinger equation.
- Klein-Nishima formula** - An expression for the scattering cross section of a photon by an unbound electron, based upon the Dirac electron theory.
- Knight shift** - The change in magnetic resonance frequency of a nucleus in a metal relative to the same nucleus in a diamagnetic solid. The effect is due to the polarization of the conduction electrons in the metal.
- Knudsen number ( $Kn$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Kn = \lambda/l$ , where  $\lambda$  is mean free path and  $l$  is length. [2]
- Kondo effect** - A large increase in electrical resistance observed at low temperatures in certain dilute alloys of a magnetic metal in a nonmagnetic material.
- Kramers-Kronig relation** - A set of equations relating the real and imaginary parts of the index of refraction of a medium
- Lactams** - Cyclic amides of amino carboxylic acids, having a 1-azacycloalkan-2-one structure, or analogues having unsaturation or heteroatoms replacing one or more carbon atoms of the ring. [5]
- Lactones** - Cyclic esters of hydroxy carboxylic acids, containing a 1-oxacycloalkan-2-one structure, or analogues having unsaturation or heteroatoms replacing one or more carbon atoms of the ring. [5]
- Lagrangian function ( $L$ )** - A function used in classical mechanics, defined as the kinetic energy minus the potential energy for a system of particles.
- Lamb shift** - The small energy difference between the  $^2S_{1/2}$  and  $^2P_{1/2}$  levels in the hydrogen atom, which results from interactions between the electron and the radiation field.
- Laminar flow** - Smooth, uniform, non-turbulent flow of a gas or liquid in parallel layers, with little mixing between layers. It is characterized by small values of the Reynolds number.
- Landé g-factor** - See g-Factor of the electron
- Langevin function** - The mathematical function  $L(x) = (e^x + e^{-x}) / (e^x - e^{-x}) - 1/x$ , which occurs in the expression for the average dipole moment of a group of rotating polar molecules in an electric field:  $\mu_{av} = \mu L(\mu E/kT)$ , where  $\mu$  is the electric dipole moment of a single molecule,  $E$  is the electric field strength,  $k$  is the Boltzmann constant, and  $T$  is the temperature.
- Lanthanides** - The elements of atomic number 57 through 71, which share common chemical properties: La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu. [7]
- Larmor frequency ( $\nu_L$ )** - The precession frequency of a magnetic dipole in an applied magnetic field. In particular, a nucleus in a magnetic field of strength  $B$  has a Larmor frequency of  $\gamma B/2\pi$ , where  $\gamma$  is the magnetogyric ratio of the nucleus.
- Laser\*** - A device in which an optical cavity is filled with a medium where a population inversion can be produced by some means. When the resonant frequency of the cavity bears the proper relation to the separation of the inverted energy levels, stimulated emission occurs, producing a highly monochromatic, coherent beam of light.
- Laser ionization mass spectroscopy (LIMS)** - See Techniques for Materials Characterization, page 12-1.
- Lattice constants\*** - Parameters specifying the dimensions of a unit cell in a crystal lattice, specifically the lengths of the cell edges and the angles between them.
- Lattice energy\*** - The energy per ion pair required to separate completely the ions in a crystal lattice at a temperature of absolute zero.
- Laue diagram** - A diffraction pattern produced when an x-ray beam passes through a thin slice of a crystal and impinges on a detector behind the crystal.
- Lenz's law** - The statement that the current induced in a circuit by a change in magnetic flux is so directed as to oppose the change in flux
- Leonard-Jones potential** - A simple but useful function for approximating the interaction between two neutral atoms or molecules separated by a distance  $r$  by writing the potential energy as  $U(r) = 4\epsilon\{(r_0/r)^{12} - (r_0/r)^6\}$ , where  $\epsilon$  and  $r_0$  are adjustable parameters. In this form the depth of the potential well is  $\epsilon$  and the minimum occurs at  $2^{1/6}r_0$ . The  $(1/r)^{12}$  term is often replaced by other powers of  $1/r$ .
- Lepton** - One of the class of elementary particles that do not take part in the strong interaction. Included are the electron, muon, and neutrino. All leptons have a spin of  $1/2$ .
- Lewis number ( $Le$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Le = a/D$ , where  $a$  is thermal diffusivity and  $D$  is diffusion coefficient. [2]
- Ligand field theory** - A description of the structure of crystals containing a transition metal ion surrounded by nonmetallic ions (ligands). It is based on construction of molecular orbitals involving the  $d$ -orbitals of the central metal ion and combinations of atomic orbitals of the ligands.
- Light year (l.y.)** - A unit of distance used in astronomy, defined as the distance light travels in one year in a vacuum. Its approximate value is  $9.46073 \times 10^{15}$  m.
- Lignins** - Macromolecular constituents of wood related to lignans, composed of phenolic propylbenzene skeletal units, linked at various sites and apparently randomly. [5]
- Ligroin** - The petroleum fraction consisting mostly of  $C_7$  and  $C_8$  hydrocarbons and boiling in the range 90-140 °C; commonly used as a laboratory solvent.
- Lipids** - A loosely defined term for substances of biological origin that are soluble in nonpolar solvents. They consist of saponifiable lipids, such as glycerides (fats and oils) and phospholipids, as well as nonsaponifiable lipids, principally steroids. [5]
- Lipoproteins** - Clathrate complexes consisting of a lipid enwrapped in a protein host without covalent binding, in such a way that

the complex has a hydrophilic outer surface consisting of all the protein and the polar ends of any phospholipids. [5]

**Liter (L)\*** - A synonym for cubic decimeter. [1]

**Lithosphere\*** - The outer layer of the solid earth, extending from the base of the mantle to the surface of the crust.

**Lorentz contraction** - The reduction in length of a moving body in the direction of motion, given by the factor  $(1-v^2/c^2)^{1/2}$ , where  $v$  is the velocity of the body and  $c$  the velocity of light. Also known as the FitzGerald-Lorentz contraction.

**Lorentz force** - The force exerted on a point charge  $Q$  moving at velocity  $v$  in the presence of external fields  $E$  and  $B$ . It is given (in SI units) by  $F = Q(E + v \times B)$ .

**Loss angle ( $\delta$ )** - For a dielectric material in an alternating electromagnetic field,  $\delta$  is the phase difference between the current and the potential difference. The function  $\tan \delta$  is a measure of the ratio of the power dissipated in the dielectric to the power stored.

**Low energy electron diffraction (LEED)** - See Techniques for Materials Characterization, page 12-1.

**Lumen (lm)\*** - The SI unit of luminous flux, equal to  $\text{cd sr}$ . [1]

**Luminous flux ( $\Phi$ )** - The intensity of light from a source multiplied by the solid angle. The SI unit is lumen. [1]

**Lux (lx)\*** - The SI unit of illuminance, equal to  $\text{cd sr m}^{-2}$ . [1]

**Lyddane-Sachs-Teller relation** - A relation between the phonon frequencies and dielectric constants of an ionic crystal which states that  $(\omega_T/\omega_L)^2 = \epsilon(\infty)/\epsilon(0)$ , where  $\omega_T$  is the angular frequency of transverse optical phonons,  $\omega_L$  that of longitudinal optical phonons,  $\epsilon(0)$  is the static dielectric constant, and  $\epsilon(\infty)$  the dielectric constant at optical frequencies.

**Lyman series** - The series of lines in the spectrum of the hydrogen atom which corresponds to transitions between the ground state (principal quantum number  $n = 1$ ) and successive excited states. The wavelengths are given by  $1/\lambda = R_H(1-1/n^2)$ , where  $n = 2, 3, 4, \dots$  and  $R_H$  is the Rydberg constant for hydrogen. The first member of the series ( $n = 1 \leftrightarrow 2$ ), which is often called the Lyman- $\alpha$  line, falls at a wavelength of 1216 Å, and the series converges at 912 Å, the ionization limit of hydrogen.

**Mach number ( $Ma$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Ma = v/c$ , where  $v$  is velocity and  $c$  is the speed of sound. [2]

**Macromolecule** - A molecule of high relative molecular mass (molecular weight), the structure of which essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass. [8]

**Madelung constant\*** - A constant characteristic of a particular crystalline material which gives a measure of the electrostatic energy binding the ions in the crystal.

**Magnetic field strength ( $H$ )** - An axial vector quantity, the curl of which is equal to the current density, including the displacement current. [1]

**Magnetic induction ( $B$ )** - An axial vector quantity such that the force exerted on an element of current is equal to the vector product of this element and the magnetic induction. [1]

**Magnetic moment** - See Dipole moment, magnetic.

**Magnetic susceptibility ( $\chi_m, \kappa$ )\*** - Defined by  $\chi_m = (\mu - \mu_0)/\mu_0$ , where  $\mu$  is the permeability of the medium and  $\mu_0$  the permeability of a vacuum. [1]

**Magnetization ( $M$ )** - Defined by  $M = (B/\mu_0) - H$ , where  $B$  is magnetic induction,  $H$  magnetic field strength, and  $\mu_0$  the permeability of a vacuum. [1]

**Magnetogyric ratio ( $\gamma$ )** - Ratio of the magnetic moment of a particle to its angular momentum. Also called gyromagnetic ratio.

**Magneton** - See Bohr magneton, Nuclear magneton.

**Magnetostriction\*** - The change in dimensions of a solid sample when it is placed in a magnetic field.

**Magnon** - A quantum of magnetic energy associated with a spin wave in a ferromagnetic or antiferromagnetic crystal.

**Mantle** - The layer of the earth between the crust and the liquid outer core, which begins about 2900 km below the Earth's surface.

**Maser** - A device in which a microwave cavity is filled with a medium where a population inversion can be produced by some means. When the resonant frequency of the cavity bears the proper relation to the separation of the inverted energy levels, the device can serve as an amplifier or oscillator at that frequency.

**Mass ( $m$ )\*** - Quantity of matter. Mass can also be defined as "resistance to acceleration".

**Mass defect ( $B$ )** - Defined by  $B = Zm(^1\text{H}) + Nm_n - m_a$ , where  $Z$  is the atomic number,  $m(^1\text{H})$  is the mass of the hydrogen atom,  $N$  is the neutron number,  $m_n$  is the rest mass of the neutron, and  $m_a$  is the mass of the atom in question. Thus  $Bc^2$  can be equated to the binding energy of the nucleus if the binding energy of atomic electrons is neglected. [1]

**Mass excess ( $\Delta$ )** - Defined by  $\Delta = m_a - Am_u$ , where  $m_a$  is the mass of the atom,  $A$  the number of nucleons, and  $m_u$  the unified atomic mass constant ( $m_u = 1 \text{ u}$ ). [1]

**Mass fraction ( $w_B$ )** - The ratio of the mass of substance B to the total mass of a mixture. [1]

**Mass number ( $A$ )** - A characteristic property of a specific isotope of an element, equal to the sum of the number of protons and neutrons in the nucleus.

**Mass spectrometry** - An analytical technique in which ions are separated according to the mass/charge ratio and detected by a suitable detector. The ions may be produced by electron impact on a gas, a chemical reaction, energetic vaporization of a solid, etc. [6]

**Massieu function** - A thermodynamic function defined by  $J = -A/T$ , where  $A$  is the Helmholtz energy and  $T$  the thermodynamic temperature. [2]

**Matthiessen's rule** - The statement that the electrical resistivity  $\rho$  of a metal can be written as  $\rho = \rho_L + \rho_i$ , where  $\rho_L$  is due to scattering of conduction electrons by lattice vibrations and  $\rho_i$  to scattering by impurities and imperfections. If the impurity concentration is small,  $\rho_i$  is temperature independent.

**Maxwell (Mx)\*** - A non-SI unit of magnetic field strength ( $H$ ) equal to  $10^{-8} \text{ Wb}$ . [1]

**Maxwell's equations** - The fundamental equations of electromagnetism. In a form appropriate to SI units, they are:

$$\begin{aligned}\text{curl } H &= \partial D / \partial t + j \\ \text{div } B &= 0 \\ \text{curl } E &= -\partial B / \partial t \\ \text{div } D &= \rho\end{aligned}$$

where  $H$  is the magnetic field strength,  $B$  the magnetic induction,  $E$  the electric field strength,  $D$  the electric displacement,  $j$  the current density,  $\rho$  the charge density, and  $t$  is time.

**Maxwell-Boltzmann distribution** - An expression for the fraction of molecules  $f(v)$  in a gas that have velocity  $v$  within a specified interval. It takes the form

$$f(v) = 4\pi(M/2\pi RT)^{3/2} v^2 e^{-Mv^2/2RT}$$



where  $M$  is the molar mass,  $R$  the molar gas constant, and  $T$  the temperature.

**Mean free path\*** - The average distance a gas molecule travels between collisions.

**Meissner effect** - The complete exclusion of magnetic induction from the interior of a superconductor.

**Melting point\*** - The temperature at which the solid and liquid phases of a substance are in equilibrium at a specified pressure (normally taken to be atmospheric unless stated otherwise).

**Mercaptans** - A traditional term abandoned by IUPAC, synonymous with thiols. This term is still widely used. [5]

**Meson** - Any elementary particle that has zero or integral spin. Mesons are responsible for the forces between protons and neutrons in the nucleus.

**Mesosphere** - The part of the Earth's atmosphere extending from the top of the stratosphere (about 50 km above the surface) to 80–90 km. It is characterized by a decrease in temperature with increasing altitude.

**Metal** - A material in which the highest occupied energy band (conduction band) is only partially filled with electrons. The electrical conductivity of metals generally decreases with temperature.

**Metallocenes** - Organometallic coordination compounds in which one atom of a transition metal such as iron, ruthenium or osmium is bonded to and only to the face of two cyclopentadienyl ligands which lie in parallel planes. [5]

**Meter (m)\*** - The SI base unit of length. [1]

**Methine group** - In organic compounds, the  $-C=$  group. [5]

**Mho** - An archaic name for the SI unit siemens (reciprocal ohm).

**Micelle** - A particle formed by the aggregation of surfactant molecules (typically, 10 to 100 molecules) in solution. For aqueous solutions, the hydrophilic end of the molecule is on the surface of the micelle, while the hydrophobic end (often a hydrocarbon chain) points toward the center. At the critical micelle concentration (cmc) the previously dissolved molecules aggregate into a micelle.

**Micron ( $\mu$ )** - An obsolete name for micrometer.

**Mie scattering** - The scattering of light by spherical dielectric particles whose diameter is comparable to the wavelength of the light.

**Milky way** - The band of light in the night sky resulting from the stars in the galactic plane. The term is also used to denote the galaxy in which the sun is located.

**Miller indices ( $hkl$ )** - A set of indices used to label planes in a crystal lattice. [2]

**Millimeter of mercury (mmHg)** - A non-SI unit of pressure, equal to 133.322 Pa. The name is generally considered interchangeable with torr.

**Mobility ( $\mu$ )\*** - In solid state physics, the drift velocity of electrons or holes in a solid divided by the applied electric field strength. The term is used in a similar sense in other fields.

**Molality ( $m$ )** - A measure of concentration of a solution in which one states the amount of substance (i.e., number of moles) of solute per kilogram of solvent. Thus a 0.1 molal solution (often written as 0.1 m) has  $m = 0.1$  mol/kg.

**Molar mass** - The mass of one mole of a substance. It is normally expressed in units of g/mol, in which case its numerical value is identical with the molecular weight (relative molecular mass). [1]

**Molar quantity** - It is often convenient to express an extensive quantity (e.g., volume, enthalpy, heat capacity, etc.) as the actual value divided by amount of substance (number of moles). The resulting quantity is called molar volume, molar enthalpy, etc.

**Molar refraction ( $R$ )** - A property of a dielectric defined by the equation  $R = V_m[(n^2-1)/(n^2+2)]$ , where  $n$  is the index of refraction of the medium (at optical wavelengths) and  $V_m$  the molar volume. It is related to the polarizability  $\alpha$  of the molecules that make up the medium by the Lorenz-Lorentz equation,  $R = N_A \alpha / 3\epsilon_0$ , where  $N_A$  is Avogadro's constant and  $\epsilon_0$  is the permittivity of a vacuum.

**Molarity ( $c$ )** - A measure of concentration of a solution in which one states the amount of substance (i.e., number of moles) of solute per liter of solution. Thus a 0.1 molar solution (often referred to as 0.1 M) has a concentration  $c = 0.1$  mol/L.

**Mole (mol)\*** - The SI base unit of amount of substance. [1]

**Mole fraction ( $x_B$ )** - The ratio of the amount of substance (number of moles) of substance B to the total amount of substance in a mixture. [1]

**Molecular orbital** - See Orbital.

**Molecular weight ( $M_r$ )\*** - The ratio of the average mass per molecule or specified entity of a substance to 1/12 of the mass of nuclide  $^{12}\text{C}$ . Also called relative molar (or molecular) mass. [1]

**Moment of inertia ( $I$ )** - The moment of inertia of a body about an axis is the sum (or integral) of the products of its elements of mass and the squares of their distances from the axis. [1]

**Momentum ( $p$ )** - The product of mass and velocity. [1]

**Monomer** - A substance consisting of molecules which can undergo polymerization, thereby contributing constitutional units to the essential structure of a macromolecule. [8]

**Monosaccharides** - A term which includes aldoses, ketoses, and a wide variety of derivatives. [5]

**Mössbauer effect** - The recoilless emission of  $\gamma$ -rays from nuclei bound in a crystal under conditions where the recoil energy associated with the  $\gamma$  emission is taken up by the crystal as a whole. This results in a very narrow line width, which can be exploited in various types of precise measurements.

**Muon\*** - An unstable elementary particle of spin 1/2 and mass about 200 times that of the electron.

**Naphtha** - The petroleum fraction consisting mostly of  $\text{C}_6$  to  $\text{C}_8$  hydrocarbons and boiling in the range 80–120 °C. Solvents derived from this fraction include ligroin and petroleum ether.

**Nautical mile** - A non-SI unit of length, equal to exactly 1852 m.

**Navier-Stokes equations** - A set of complex equations for the motion of a viscous fluid subject to external forces.

**Néel temperature ( $T_N$ )\*** - The critical temperature above which an antiferromagnetic substance becomes paramagnetic. [1]

**Nernst effect** - The production of an electric field in a conductor subject to an applied magnetic field and containing a transverse temperature gradient. The electric field is perpendicular to the magnetic field and the temperature gradient.

**Network** - In polymer science, a highly ramified macromolecule in which essentially each constitutional unit is connected to each other constitutional unit and to the macroscopic phase boundary by many permanent paths through the macromolecule, the number of such paths increasing with the number of intervening bonds. The paths must on the average be coextensive with the macromolecule. [8]

**Neutrino** - A stable elementary particle in the lepton family. Neutrinos have zero (or at least near-zero) rest mass and spin 1/2.

**Neutron\*** - An elementary particle on spin 1/2 and zero charge. The free neutron has a mean lifetime of 887 seconds. Neutrons and protons, which are collectively called nucleons, are the constituents of the nucleus.

**Neutron activation analysis (NAA)** - See Techniques for Materials Characterization, page 12-1.

**Neutron number (*N*)** - A characteristic property of a specific isotope of an element, equal to the number of neutrons in the nucleus.

**Newton (*N*)\*** - The SI unit of force, equal to  $\text{m kg s}^{-2}$ . [1]

**Nitriles** - Compounds having the structure  $\text{RC}\equiv\text{N}$ ; thus C-substituted derivatives of hydrocyanic acid,  $\text{HC}\equiv\text{N}$ . [5]

**Nitrosamines** - N-Nitroso amines: compounds of the structure  $\text{R}_2\text{NNO}$ . Compounds  $\text{RNHNO}$  are not ordinarily isolatable, but they, too, are nitrosamines. The name is a contraction of N-nitrosoamine and, as such, does not require the N locant. [5]

**Nuclear magnetic resonance (NMR)\*** - A widely used technique in which the resonant absorption of radiofrequency radiation by magnetic nuclei in a magnetic field is measured. The results give important information on the local environment of each nucleus.

**Nuclear magneton ( $\mu_N$ )\*** - The unit of nuclear magnetic moment, defined as  $eh/4\pi m_p$ , where  $h$  is Planck's constant,  $m_p$  the proton mass, and  $e$  the elementary charge.

**Nuclear quadrupole resonance (NQR)** - See Techniques for Materials Characterization, page 12-1.

**Nuclear reaction analysis (NRA)** - See Techniques for Materials Characterization, page 12-1.

**Nuclear spin (*I*)** - The quantum number that specifies the intrinsic angular momentum of a particular nucleus. The magnitude of the angular momentum is given by  $[I(I+1)]^{1/2} h/2\pi$ , where  $h$  is Planck's constant.

**Nucleic acids\*** - Macromolecules, the major organic matter of the nuclei of biological cells, made up of nucleotide units, and hydrolyzable into certain pyrimidine or purine bases (usually adenine, cytosine, guanine, thymine, uracil), D-ribose or 2-deoxy-D-ribose. [5]

**Nucleon** - A collective term for the proton and neutron.

**Nucleosides** - Ribosyl or deoxyribosyl derivatives (rarely, other glycosyl derivatives) of certain pyrimidine or purine bases. They are thus glycosylamines or N-glycosides related to nucleotides by the lack of phosphorylation. [5]

**Nucleotides** - Compounds formally obtained by esterification of the 3' or 5' hydroxy group of nucleosides with phosphoric acid. They are the monomers of nucleic acids and are formed from them by hydrolytic cleavage. [5]

**Nuclide** - A species of atoms in which each atom has identical atomic number  $Z$  and identical mass number  $A$ . [3]

**Nusselt number (*Nu*)** - A dimensionless quantity used in fluid mechanics, defined by  $Nu = hl/k$ , where  $h$  is coefficient of heat transfer,  $l$  is length, and  $k$  is thermal conductivity. [2]

**Nyquist theorem** - An expression for the mean square thermal noise voltage across a resistor, given by  $4RkT\Delta f$  where  $R$  is the resistance,  $k$  the Boltzmann constant,  $T$  the temperature, and  $\Delta f$  the frequency band within which the voltage is measured.

**Octanol-water partition coefficient (*P*)\*** - A measure of the way in which a compound will partition itself between the octanol and water phases in the two-phase octanol-water system, and thus an indicator of certain types of biological activity. Specifically,  $P$  is the ratio of the concentration (in moles per liter) of the compound in the octanol phase to that in the water phase at infinite dilution. The quantity normally reported is  $\log P$ .

**Oersted (Oe)** - A non-SI unit of magnetic field ( $H$ ), equal to  $79.57747 \text{ A/m}$ .

**Ohm ( $\Omega$ )\*** - The SI unit of electric resistance, equal to  $\text{V/A}$ . [1]

**Ohm's law** - A relation among electric current  $I$ , potential difference  $V$ , and resistance  $R$ , viz.,  $I = V/R$ . At constant temperature the resistance for many materials is constant to high precision.

**Olefins** - Acyclic and cyclic hydrocarbons having one or more carbon-carbon double bonds, apart from the formal ones in aromatic compounds. The class olefins subsumes alkenes and cycloalkenes and the corresponding polyenes. [5]

**Oligomer** - A substance consisting of molecules of intermediate relative molecular mass (molecular weight), the structure of which essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass. In contrast to a polymer, the properties of an oligomer can vary significantly with the removal of one or a few of its units. [8]

**Oligopeptides** - Peptides containing from three to nine amino groups. [5]

**Onsager relations** - An important set of equations in the thermodynamics of irreversible processes. They express the symmetry between the transport coefficients describing reciprocal processes in systems with a linear dependence of flux on driving forces.

**Optical rotary power** - Angle by which the plane of polarization of a light beam is rotated by an optically active medium, divided by path length and by concentration of the active constituent. Depending on whether mass or molar concentration is used, the modifier "specific" or "molar" is attached. [2]

**Orbital** - A one-electron wavefunction. Atomic orbitals are classified as  $s$ -,  $p$ -,  $d$ -, or  $f$ -orbitals according to whether the angular momentum quantum number  $l = 0, 1, 2$ , or  $3$ . Molecular orbitals, which are usually constructed as linear combinations of atomic orbitals, describe the distribution of electrons over the entire molecule.

**Oscillator strength (*f*)** - A measure of the intensity of a spectroscopic transition, defined by

$$f = \frac{8\pi^2 \text{Mev}}{3he^2} |\mu_{ij}|^2$$

where  $\nu$  is the frequency,  $\mu_{ij}$  the transition dipole moment,  $m_e$  the mass of the electron,  $e$  the elementary charge, and  $h$  Planck's constant.

**Osmosis** - The flow of a solvent in a system in which two solutions of different concentration are separated by a semipermeable membrane which cannot pass solute molecules. The solvent will flow from the side of lower concentration to that of higher concentration, thus tending to equalize the concentrations. The pressure that must be applied to the more concentrated side to stop the flow is called the osmotic pressure.

**Osmotic coefficient ( $\phi$ )** - Defined by  $\phi = \ln a_A / (M_A \sum m_B)$ , where  $M_A$  is the molar mass of substance A (normally the solvent),  $a_A$  is its activity, and the  $m_B$  are molalities of the solutes. [1]

**Osmotic pressure ( $\Pi$ )** - The excess pressure necessary to maintain osmotic equilibrium between a solution and the pure solvent separated by a membrane permeable only to the solvent. In an ideal dilute solution  $\Pi = c_B RT$ , where  $c_B$  is the amount-of-substance concentration of the solute,  $R$  is the molar gas constant, and  $T$  the temperature. [1,2]

**Ostwald dilution law** - A relation for the concentration dependence of the molar conductivity  $\Lambda$  of an electrolyte solution, viz.,

$$\frac{1}{\Lambda} = \frac{1}{\Lambda^\circ} + \frac{\Lambda c}{K(\Lambda^\circ)^2}$$

where  $c$  is the solute concentration,  $K$  is the equilibrium constant for dissociation of the solute, and  $\Lambda^\circ$  is the conductivity at  $c\Lambda = 0$ .

**Ounce (oz)** - A non-SI unit of mass. The avoirdupois ounce equals 28.34952 g, while the troy ounce equals 31.10348 g.

**Overpotential ( $\eta$ )** - In an electrochemical cell, the difference between the potential of an electrode and its zero-current value.

**Oximes** - Compounds of structure  $R_2C=NOH$  derived from condensation of aldehydes or ketones with hydroxylamine. Oximes from aldehydes may be called aldioximes; those from ketones may be called ketoximes. [5]

**Oxo compounds** - Compounds containing an oxygen atom, =O, doubly bonded to carbon or another element. The term thus embraces aldehydes, carboxylic acids, ketones, sulfonic acids, amides and esters. [5]

**Ozonides** - The 1,2,4-trioxolanes formed by the reaction of ozone at a carbon-carbon double bond, or the analogous compounds derived from acetylenic compounds. [5]

**Pair production** - A process in which a photon is converted into a particle and its antiparticle (e.g., an electron and positron) in the electromagnetic field of a nucleus.

**Paraffins** - Obsolete term for saturated hydrocarbons, commonly but not necessarily acyclic. Still widely used in the petrochemical industry, where the term designates acyclic saturated hydrocarbons, and stands in contradistinction to naphthenes. [5]

**Paramagnetism\*** - A type of magnetism characterized by a positive magnetic susceptibility, so that the material becomes weakly magnetized in the direction of an external field. The magnetization disappears when the field is removed. In the simplest approximation (Curie's law) the susceptibility is inversely proportional to temperature.

**Parity** - The property of a quantum-mechanical wave function that describes its behavior under the symmetry operation of coordinate inversion. A parity of +1 (or even) is assigned if the wave function does not change sign when the signs of all the coordinates are changed; the parity is -1 (or odd) if the wave function changes sign under this operation.

**Parsec (pc)** - A unit of distance defined as the distance at which 1 astronomical unit (AU) subtends an angle of 1 second of arc. It is equal to 206264.806 AU or  $3.085678 \times 10^{16}$  m.

**Particle induced x-ray emission (PIXE)** - See Techniques for Materials Characterization, page 12-1.

**Partition function ( $q, z$ )** - For a single molecule,  $q = \sum_i g_i \exp(\epsilon_i/kT)$ , where  $\epsilon_i$  is an energy level of degeneracy  $g_i$ ,  $k$  the Boltzmann constant, and  $T$  the absolute temperature; the summation extends over all energy states. For a system of  $N$  non-interacting molecules which are indistinguishable, as in an ideal gas, the canonical partition function  $Q = qN/N!$ .

**Pascal (Pa)\*** - The SI unit of pressure, equal to  $N/m^2$ . [1]

**Paschen series** - The series of lines in the spectrum of the hydrogen atom which corresponds to transitions between the state with principal quantum number  $n = 3$  and successive higher states. The wavelengths are given by  $1/\lambda = R_H(1/9 - 1/n^2)$ , where  $n = 4, 5, 6, \dots$  and  $R_H$  is the Rydberg constant. The first member of the series ( $n = 3 \leftrightarrow 4$ ), which is often called the  $P_\alpha$  line, falls in the infrared at a wavelength of 1.875  $\mu m$ .

**Paschen-Back effect** - In atomic spectroscopy, the decoupling of electron spin from orbital angular momentum as the strength of an external magnetic field is increased.

**Pauli exclusion principle** - The statement that two electrons in an atom cannot have identical quantum numbers; thus if there are two electrons in the same orbital, their spin quantum numbers must be of opposite sign.

**Pearson symbol** - A code for designating crystallographic information, including the crystal system, the lattice type, and the number of atoms per unit cell.

**Péclet number ( $Pe$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Pe = vl/a$ , where  $v$  is velocity,  $l$  is length, and  $a$  is thermal diffusivity. [2]

**Peltier effect** - The absorption or generation of heat (depending on the current direction) which occurs when an electric current is passed through a junction between two materials.

**Peptides** - Amides derived from two or more amino carboxylic acid molecules (the same or different) by formation of a covalent bond from the carbonyl carbon of one to the nitrogen atom of another with formal loss of water. [5]

**Permeability ( $\mu$ )** - Magnetic induction divided by magnetic field strength; i.e.  $\mu = B/H$ . The relative permeability  $\mu_r = \mu/\mu_0$ , where  $\mu_0$  is the permeability of a vacuum. [1]

**Permittivity ( $\epsilon$ )** - Ratio of the electric displacement in a medium to the electric field strength. Also called dielectric constant. [1]

**Peroxides** - Compounds of structure ROOR in which R may be any organic group. In inorganic chemistry, salts of the anion  $O_2^{-2}$  [5]

**Peroxy acids** - Acids in which an acidic -OH group has been replaced by an -OOH group; e.g.,  $CH_3C(=O)OOH$  peroxyacetic acid,  $PhS(=O)_2OOH$  benzeneperoxydisulfonic acid. [5]

**Petroleum ether** - The petroleum fraction consisting of  $C_5$  and  $C_6$  hydrocarbons and boiling in the range 35–60 °C; commonly used as a laboratory solvent.

**pH\*** - A convenient measure of the acid-base character of a solution, usually defined by  $pH = -\log [c(H^+)/mol L^{-1}]$ , where  $c(H^+)$  is the concentration of hydrogen ions. The more precise definition is in terms of activity rather than concentration. [2]

**Phenols** - Compounds having one or more hydroxy groups attached to a benzene or other arene ring. [5]

**Phonon** - A quantum of energy associated with a vibrational mode of a crystal lattice.

**Phosphines** -  $PH_3$  and compounds derived from it by substituting one, two or three hydrogen atoms by hydrocarbyl groups.



$\text{RPH}_2$ ,  $\text{R}_2\text{PH}$  and  $\text{R}_3\text{P}$  (R not equal to H) are called primary, secondary and tertiary phosphines, respectively. [5]

**Phosphonium compounds** - Salts (and hydroxides)  $[\text{R}_4\text{P}]^+\text{X}^-$  containing tetracoordinate phosphonium ion and the associated anion. [5]

**Phosphonium ylides** - Compounds having the structure  $\text{R}_3\text{P}^+-\text{C}=\text{R}_2 \rightleftharpoons \text{R}_3\text{P}=\text{CR}_2$ . Also known as Wittig reagents. [5]

**Phosphorescence** - The process by which a molecule is excited by light to a higher electronic state and then undergoes a radiationless transition to a state of different multiplicity from which it decays, after some delay, to the ground state. The emitted light is normally of longer wavelength than the exciting light because vibrational energy has been dissipated.

**Photoelectric effect** - The complete absorption of a photon by a solid with the emission of an electron.

**Photon** - An elementary particle of zero mass and spin 1/2. The photon is involved in electromagnetic interactions and is the quantum of electromagnetic radiation.

**Photon stimulated desorption (PSD)** - See Techniques for Materials Characterization, page 12-1.

**Pinacols** - Tetra(hydrocarbyl)ethane-1,2-diols,  $\text{R}_2\text{C}(\text{OH})\text{C}(\text{OH})\text{R}_2$ , of which the tetramethyl example is the simplest one and is itself commonly known as pinacol. [5]

**Pion** - An elementary particle in the family of mesons. Pions have zero spin and may be neutral or charged. They participate in the strong interaction which holds the nucleus together.

**$\text{pK}^*$**  - The negative logarithm (base 10) of an equilibrium constant  $K$ . For  $\text{pK}_a$ , see Acid dissociation constant.

**Planck constant ( $h$ )** - The elementary quantum of action, which relates energy to frequency through the equation  $E = h\nu$ .

**Planck distribution** - See Black body radiation

**Planck function** - A thermodynamic function defined by  $Y = -G/T$ , where  $G$  is Gibbs energy and  $T$  thermodynamic temperature. [2]

**Plasma** - A highly ionized gas in which the charge of the electrons is balanced by the charge of the positive ions, so that the system as a whole is electrically neutral.

**Plasmon** - A quantum associated with a plasma oscillation in the electron gas of a solid.

**Point group** - A group of symmetry operations (rotations, reflections, etc.) that leave a molecule invariant. Every molecular conformation can be assigned to a specific point group, which plays a major role in determining the spectrum of the molecule.

**Poise (P)** - A non-SI unit of viscosity, equal to 0.1 Pa s.

**Poiseuille's equation** - A formula for the rate of flow of a viscous fluid through a tube:

$$\frac{dV}{dt} = \frac{(p_1^2 - p_2^2)\pi r^4}{16l\eta p_0}$$

where  $V$  is the volume as measured at pressure  $p_0$ ;  $p_1$  and  $p_2$  are the pressures at each end of the tube;  $r$  is the radius and  $l$  the length of the tube; and  $\eta$  is the viscosity.

**Poisson ratio ( $\mu$ )** - The absolute value of the ratio of the transverse strain to the corresponding axial strain resulting from uniformly distributed axial stress below the proportional limit (i.e., where Hooke's law is valid). [10]

**Polariton** - A quantum associated with the coupled modes of photons and optical phonons in an ionic crystal.

**Polarizability ( $\alpha$ )** - The change in dipole moment of a molecule produced by an external electric field; specifically,  $\alpha_{ab} = \partial p_a / \partial E_b$ , where  $p_a$  is the dipole moment component on the  $a$  axis and  $E_b$  is the component of the electric field strength along the  $b$  axis. [2]

**Polymer** - A substance composed of molecules of high relative molecular mass (molecular weight), the structure of which essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass. A single molecule of a polymer is called a macromolecule. [8]

**Polypeptides** - Peptides containing 10 or more amino acid residues. See also Peptides. [5]

**Polysaccharides** - Compounds consisting of a large number of monosaccharides linked glycosidically. This term is commonly used only for those containing more than ten monosaccharide residues. Also called glycans. [5]

**Porphyrins** - Natural pigments containing a fundamental skeleton of four pyrrole nuclei united through the  $\alpha$ -positions by four methine groups to form a macrocyclic structure (porphyrin is designated porphine in Chemical Abstracts indexes). [5]

**Positron** - The antiparticle of the electron. It has the same mass and spin as an electron, and an equal but opposite charge.

**Positronium** - The hydrogen-like "atom" formed from a positron nucleus and an electron. Its lifetime is very short because of annihilation of the positron and electron.

**Potential** - See Electric potential.

**Potential energy ( $E_p$ ,  $V$ ,  $U$ )** - The portion of the energy of a system that is associated with its position in a force field.

**Pound (lb)** - A non-SI unit of mass, equal to 0.4535924 kg.

**Power ( $P$ )** - Rate of energy transfer. For electrical circuits, this is equal to the product of current and potential difference,  $P = IV$ . [1]

**Poynting vector ( $S$ )** - For electromagnetic radiation, the vector product of the electric field strength and the magnetic field strength. [1]

**Prandtl number ( $Pr$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Pr = \eta/\rho a$ , where  $\eta$  is viscosity,  $\rho$  is density, and  $a$  is thermal diffusivity. [2]

**Pressure** - Force divided by area. [1]

**Proteins** - Naturally occurring and synthetic polypeptides having molecular weights greater than about 10,000 (the limit is not precise). See also Peptides. [5]

**Proton** - A stable elementary particle of unit positive charge and spin 1/2. Protons and neutrons, which are collectively called nucleons, are the constituents of the nucleus.

**Pulsar** - A neutron star which rotates rapidly and emits electromagnetic radiation in regular pulses at a frequency related to the rotation period.

**Purine bases** - Purine and its substitution derivatives, especially naturally occurring examples. [5]

**Pyrimidine bases** - Pyrimidine and its substitution derivatives, especially naturally occurring examples. [5]

**Q-switching** - A technique for obtaining very high power from a laser by keeping the  $Q$  factor of the laser cavity low while the population inversion builds up, then suddenly increasing the  $Q$  to initiate the stimulated emission.

**Quad** - A unit of energy defined as  $10^{15}$  Btu, equal to approximately  $1.055056 \times 10^{18}$  J.

- Quadrupole moment** - A coefficient of the third term (after monopole and dipole) in the power series expansion of the electric potential of an array of charges. A nucleus of spin greater than 1/2 has a non-vanishing nuclear quadrupole moment which can interact with the electric field gradient of the surrounding electrons. Molecular quadrupole moments have an influence on intermolecular forces.
- Quality factor (Q)** - The ratio of the absolute value of the reactance of an electrical system to the resistance; thus a measure of the energy stored per cycle relative to the energy dissipated.
- Quantum yield** - In photochemistry, the number of moles transformed in a specific process, either physically (e.g., by emission of photons) or chemically, per mole of photons absorbed by the system. [3]
- Quark** - An elementary entity which has not been directly observed but is considered a constituent of protons, neutrons, and other hadrons.
- Quasar** - An extragalactic object emitting electromagnetic radiation at a very high power level and showing a very large red shift, thus indicating that the object is receding at a speed approaching the speed of light.
- Quasicrystal** - A solid having conventional crystalline properties but whose lattice does not display translational periodicity.
- Quaternary ammonium compounds** - Derivatives of ammonium compounds,  $\text{NH}_4^+ \text{Y}^-$ , in which all four of the hydrogens bonded to nitrogen have been replaced with hydrocarbyl groups. Compounds having a carbon-nitrogen double bond (i.e.  $\text{R}_2\text{C}=\text{N}^+\text{R}_2\text{Y}^-$ ) are more accurately called iminium compounds. [5]
- Quinones** - Compounds having a fully conjugated cyclic dione structure, such as that of benzoquinones, derived from aromatic compounds by conversion of an even number of  $-\text{CH}=\text{}$  groups into  $-\text{C}(=\text{O})-$  groups with any necessary rearrangement of double bonds. [5]
- Racemic mixture** - A mixture of equal amounts of a pair of enantiomers (optical isomers); such a mixture is not optically active.
- Rad** - A non-SI unit of absorbed dose of radiation, equal to 0.01 Gy.
- Radiance (L)** - The radiant intensity in a given direction from an element of a surface, divided by the area of the orthogonal projection of this element on a plane perpendicular to the given direction. [1]
- Radiant intensity (I)** - The radiant energy flux leaving an element of a source within an element of solid angle, divided by that element of solid angle. [1]
- Radicals** - Molecular entities possessing an unpaired electron, such as  $\cdot\text{CH}_3$ ,  $\cdot\text{SnH}_3$ ,  $\cdot\text{Cl}$ . (In these formulas the dot, symbolizing the unpaired electron, should be placed so as to indicate the atom of highest spin density, if this is possible). [5]
- Raman effect** - The inelastic scattering of light by a molecule, in which the incident photon either gives up to, or receives energy from, one of the internal vibrational modes of the molecule. The scattered light thus has either a lower frequency (Stokes radiation) or higher frequency (anti-Stokes radiation) than the incident light. These shifts provide a measure of the normal vibrational frequencies of the molecule.
- Rankine cycle** - A thermodynamic cycle which can be used to calculate the ideal performance of a heat engine that uses a condensable vapor as the working fluid (e.g., a steam engine or a heat pump).
- Rankine temperature** - A thermodynamic temperature scale based on a temperature interval  $^\circ\text{R} = (5/9) \text{ K}$ ; i.e.,  $T/^\circ\text{R} = (9/5)T/\text{K} = t/^\circ\text{F} + 459.67$ .
- Raoult's law** - The expression for the vapor pressure  $p_i$  of component  $i$  in an ideal solution, viz.,  $p_i = x_i p_{i0}$ , where  $x_i$  is the mole fraction of component  $i$  and  $p_{i0}$  the vapor pressure of the pure substance  $i$ .
- Rare earth elements** - The elements Sc, Y, and the lanthanides (La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu). [7]
- Rayleigh number (Ra)** - A dimensionless quantity used in fluid mechanics, defined by  $Ra = l^3 g \alpha \Delta T \rho / \eta a$ , where  $l$  is length,  $g$  is acceleration of gravity,  $\alpha$  is cubic expansion coefficient,  $T$  is temperature,  $\rho$  is density,  $\eta$  is viscosity, and  $a$  is thermal diffusivity. [2]
- Rayleigh scattering** - The scattering of light by particles which are much smaller than the wavelength of the light. It is characterized by a scattered intensity which varies as the inverse fourth power of the wavelength.
- Rayleigh wave** - A guided elastic wave along the surface of a solid; also called surface acoustic wave.
- Reactance (X)** - The imaginary part of impedance. For an inductive reactance  $L$  and a capacitive reactance  $C$  in series, the reactance is  $X = L\omega - 1/(C\omega)$ , where  $\omega$  is  $2\pi$  times the frequency of the current. [1]
- Red shift** - A displacement of a spectral line toward longer wavelengths. This can occur through the Doppler effect (e.g., in the light from receding galaxies) or, in the general theory of relativity, from the effects of a star's gravitational field.
- Reflectance (p)** - Ratio of the radiant or luminous flux at a given wavelength that is reflected to that of the incident radiation. Also called reflection factor. [1]
- Reflection high energy electron diffraction (RHEED)** - See Techniques for Materials Characterization, page 12-1.
- Relative humidity\*** - The ratio of the partial pressure of water vapor in air to the saturation vapor pressure of water at the same temperature, expressed as a percentage. [10]
- Relative molar mass** - See Molecular weight.
- Rem** - A non-SI unit of dose equivalent, equal to 0.01 Sv.
- Resistance (R)** - Electric potential difference divided by current when there is no electromotive force in the conductor. This definition applies to direct current. More generally, resistance is defined as the real part of impedance. [1]
- Resistivity (p)** - Electric field strength divided by current density when there is no electromotive force in the conductor. Resistivity is an intrinsic property of a material. For a conductor of uniform cross section with area  $A$  and length  $L$ , and whose resistance is  $R$ , the resistivity is given by  $\rho = RA/L$ . [1]
- Reynolds number (Re)** - A dimensionless quantity used in fluid mechanics, defined by  $Re = \rho v l / \eta$ , where  $\rho$  is density,  $v$  is velocity,  $l$  is length, and  $\eta$  is viscosity. [2]
- Rheology** - The study of the flow of liquids and deformation of solids. Rheology addresses such phenomena as creep, stress relaxation, anelasticity, nonlinear stress deformation, and viscosity.
- Ribonucleic acids (RNA)** - Naturally occurring polyribonucleotides. See also nucleic acids, nucleosides, nucleotides, ribonucleotides. [5]
- Ribonucleotides** - Nucleotides in which the glycosyl group is a ribosyl group. See also nucleotides. [5]

**Roentgen (R)** - A unit used for expressing the charge (positive or negative) liberated by x-ray or  $\gamma$  radiation in air, divided by the mass of air. A roentgen is defined as  $2.58 \times 10^{-4}$  C/kg.

**Rotational constants** - In molecular spectroscopy, the constants appearing in the expression for the rotational energy levels as a function of the angular momentum quantum numbers. These constants are proportional to the reciprocals of the principal moments of inertia, averaged over the vibrational motion.

**Rutherford back scattering (RBS)** - See Techniques for Materials Characterization, page 12-1.

**Rydberg constant ( $R_\infty$ )\*** - The fundamental constant which appears in the equation for the energy levels of hydrogen-like atoms; i.e.,  $E_n = hcR_\infty Z^2\mu/n^2$ , where  $h$  is Planck's constant,  $c$  the speed of light,  $Z$  the atomic number,  $\mu$  the reduced mass of nucleus and electron, and  $n$  the principal quantum number ( $n = 1, 2, \dots$ ).

**Rydberg series** - A regular series of lines in the spectrum of an atom or molecule, with the spacing between successive lines becoming smaller as the frequency increases (wavelength decreases). The series eventually converges to a limit which usually corresponds to the complete removal of an electron from the atom or molecule.

**Sackur-Tetrode equation\*** - An equation for the molar entropy  $S_m$  of an ideal monatomic gas:  $S_m = R \ln(e^{5/2} V/N_A \Lambda^3)$ , where  $R$  is the molar gas constant,  $V$  is the volume, and  $N_A$  is Avogadro's number. The constant  $\Lambda$  is given by  $\Lambda = h/(2\pi mkT)^{1/2}$ , where  $h$  is Planck's constant,  $m$  the atomic mass,  $k$  the Boltzmann constant, and  $T$  the temperature.

**Salinity (S)\*** - A parameter used in oceanography to describe the concentration of dissolved salts in seawater. It is defined in terms of electrical conductivity relative to a standard solution of KCl. When expressed in units of parts per thousand,  $S$  may be roughly equated to the concentration of dissolved material in grams per kilogram of seawater.

**Salt** - An ionic compound formed by the reaction of an acid and a base.

**Scanned probe microscopy (SPM)** - See Techniques for Materials Characterization, page 12-1.

**Scanning electron microscopy (SEM)** - See Techniques for Materials Characterization, page 12-1.

**Scanning laser acoustic microscopy (SLAM)** - See Techniques for Materials Characterization, page 12-1.

**Scanning transmission electron microscopy (STEM)** - See Techniques for Materials Characterization, page 12-1.

**Scanning tunneling microscopy (STM)** - See Techniques for Materials Characterization, page 12-1.

**Schiff bases** - Imines bearing a hydrocarbyl group on the nitrogen atom:  $R_2C=NR'$  ( $R'$  not equal to H). Considered by many to be synonymous with azomethines. [5]

**Schmidt number (Sc)** - A dimensionless quantity used in fluid mechanics, defined by  $Sc = \eta/\rho D$ , where  $\eta$  is viscosity,  $\rho$  is density, and  $D$  is diffusion coefficient. [2]

**Schottky barrier** - A potential barrier associated with a metal-semiconductor contact. It forms the basis for the rectifying device known as the Schottky diode.

**Schrödinger equation** - The basic equation of wave mechanics which, for systems not dependent on time, takes the form:

$$-(\hbar/2m)\nabla^2\psi + V\psi = E\psi$$

where  $\psi$  is the wavefunction,  $V$  is the potential energy expressed as a function of the spatial coordinates,  $E$  is an energy eigenvalue,  $\nabla^2$  is the Laplacian operator,  $\hbar$  is Planck's constant divided by  $2\pi$ , and  $m$  is the mass.

**Second (s)\*** - The SI base unit of time. [1]

**Second radiation constant ( $c_2$ )\*** - See First radiation constant.

**Secondary ion mass spectroscopy (SIMS)** - See Techniques for Materials Characterization, page 12-1.

**Seebeck effect** - The development of a potential difference in a circuit where two different metals or semiconductors are joined and their junctions maintained at different temperatures. It is the basis of the thermocouple.

**Selenides** - Compounds having the structure  $RSeR$  ( $R$  not equal to H). They are thus selenium analogues of ethers. Also used for metal salts of  $H_2Se$ . [5]

**Semicarbazones** - Compounds having the structure  $R_2C=NNHC(=O)NH_2$ , formally derived by condensation of aldehydes or ketones with semicarbazide [ $NH_2NHC(=O)NH_2$ ]. [5]

**Semiconductor** - A material in which the highest occupied energy band (valence band) is completely filled with electrons at  $T = 0$  K, and the energy gap to the next highest band (conduction band) ranges from 0 to 4 or 5 eV. With increasing temperature electrons are excited into the conduction band, leading to an increase in the electrical conductivity.

**Semiquinones** - Radical anions having the structure  $-O-Z\cdot O-$  where  $Z$  is an ortho- or para-arylene group or analogous heteroarylene group; they are formally generated by the addition of an electron to a quinone. [5]

**SI units\*** - The International System of Units adopted in 1960 and recommended for use in all scientific and technical fields. [1]

**Siemens (S)\*** - The SI unit of electric conductance, equal to  $\Omega^{-1}$ . [1]

**Sievert (Sv)\*** - The SI unit of dose equivalent (of radiation), equal to J/kg. [1]

**Silanes** - Saturated silicon hydrides, analogues of the alkanes; i.e., compounds of the general formula  $Si_nH_{2n+2}$ . Silanes may be subdivided into silane, oligosilanes, and polysilanes. Hydrocarbyl derivatives are often referred to loosely as silanes. [5]

**Silicones** - Polymeric or oligomeric siloxanes, usually considered unbranched, of general formula  $[-OSiR_2-]_n$  ( $R$  not equal to H). [5]

**Siloxanes** - Saturated silicon-oxygen hydrides with unbranched or branched chains of alternating silicon and oxygen atoms (each silicon atom is separated from its nearest silicon neighbors by single oxygen atoms). [5]

**Skin effect** - The concentration of high frequency alternating currents near the surface of a conductor.

**Slater orbital** - A particular mathematical expression for the radial part of the wave function of a single electron, which is used in quantum-mechanical calculations of the energy and other properties of atoms and molecules.

**Small angle neutron scattering (SANS)** - See Techniques for Materials Characterization, page 12-1.

**Snell's law** - The relation between the angle of incidence  $i$  and the angle of refraction  $r$  of a light beam which passes from a medium of refractive index  $n_0$  to a medium of index  $n_1$ , viz.,  $\sin i/\sin r = n_1/n_0$ .

**Solar constant\*** - The mean radiant energy flux from the sun on a unit surface normal to the direction of the rays at the mean



distance of the earth from the sun. The value is approximately  $1373 \text{ W/m}^2$ .

**Solar wind** - The stream of high velocity hydrogen and helium ions emitted by the sun which flows through the solar system and beyond.

**Soliton** - A spatially localized wave in a solid or liquid that can interact strongly with other solitons but will afterwards regain its original form.

**Solubility\*** - A quantity expressing the maximum concentration of some material (the solute) that can exist in another liquid or solid material (the solvent) at thermodynamic equilibrium at specified temperature and pressure. Common measures of solubility include the mass of solute per unit mass of solution (mass fraction), mole fraction of solute, molality, molarity, and others.

**Solubility product constant ( $K_{sp}$ )\*** - The equilibrium constant for the dissolution of a sparsely soluble salt into its constituent ions.

**Space group\*** - A group of symmetry operations (reflections, rotations, etc.) that leave a crystal invariant. A total of 230 space groups have been identified.

**Spark source mass spectroscopy (SSMS)** - See Techniques for Materials Characterization, page 12-1.

**Specific gravity** - Ratio of the mass density of a material to that of water. Since one must specify the temperature of both the sample and the water to have a precisely defined quantity, the use of this term is now discouraged.

**Specific heat** - Heat capacity divided by mass. See Heat capacity.

**Specific quantity** - It is often convenient to express an extensive quantity (e.g., volume, enthalpy, heat capacity, etc.) as the actual value divided by mass. The resulting quantity is called specific volume, specific enthalpy, etc.

**Specific rotation  $[\alpha]_\lambda^0$**  - For an optically active substance, defined by  $[\alpha]_\lambda^0 = \alpha/\gamma l$ , where  $\alpha$  is the angle through which plane polarized light is rotated by a solution of mass concentration  $\gamma$  and path length  $l$ . Here  $\theta$  is the Celsius temperature and  $\lambda$  the wavelength of the light at which the measurement is carried out. Also called specific optical rotatory power. [2]

**Spin ( $s, I$ )\*** - A measure of the intrinsic angular momentum of a particle, which it possesses independent of its orbital motion. The symbol  $s$  is used for the spin quantum number of an electron, while  $I$  is generally used for nuclear spin.

**Spiro compounds** - Compounds having one atom (usually a quaternary carbon) as the only common member of two rings. [5]

**Stacking fault** - An error in the normal sequence of layer growth in a crystal.

**Standard mean ocean water (SMOW)** - A standard sample of pure water of accurately known isotopic composition which is maintained by the International Atomic Energy Agency. It is used for precise calibration of density and isotopic composition measurements.

**Standard reduction potential ( $E^\circ$ )** - The zero-current potential of a cell in which the specified reduction reaction occurs at the right-hand electrode and the left-hand electrode is the standard hydrogen electrode. Also called Standard electrode potential.

**Standard state** - A defined state (specified temperature, pressure, concentration, etc.) for tabulating thermodynamic functions and carrying out thermodynamic calculations. The standard

state pressure is usually taken as  $100,000 \text{ Pa}$  (1 bar), but various standard state temperatures are used. [2]

**Stanton number ( $St$ )** - A dimensionless quantity used in fluid mechanics, defined by  $St = h/\rho v c_p$ , where  $h$  is coefficient of heat transfer,  $\rho$  is density,  $v$  is velocity, and  $c_p$  is specific heat capacity at constant pressure. [2]

**Stark effect** - The splitting of an energy level of an atom or molecule, and hence a splitting of spectral lines arising from that level, as a result of the application of an external electric field.

**Statistical weight ( $g$ )** - The number of distinct states corresponding to the same energy level. Also called degeneracy.

**Stefan-Boltzmann constant ( $\sigma$ )\*** - Constant in the equation for the radiant exitance  $M$  (radiant energy flux per unit area) from a black body at thermodynamic temperature  $T$ , viz.  $M = \sigma T^4$ . [1]

**Stibines** -  $\text{SbH}_3$  and compounds derived from it by substituting one, two or three hydrogen atoms by hydrocarbyl groups:  $\text{R}_3\text{Sb}$ ,  $\text{RSbH}_2$ ,  $\text{R}_2\text{SbH}$ , and  $\text{R}_3\text{Sb}$  ( $\text{R}$  not equal to  $\text{H}$ ) are called primary, secondary and tertiary stibines, respectively. [5]

**Stochastic process** - A process which involves random variables and whose outcome can thus be described only in terms of probabilities.

**Stoichiometric number ( $v$ )** - The number appearing before the symbol for each compound in the equation for a chemical reaction. By convention, it is negative for reactants and positive for products. [2]

**Stokes ( $St$ )** - A non-SI unit of kinematic viscosity, equal to  $10^{-4} \text{ m}^2/\text{s}$ .

**Stokes' law** - The statement, valid under certain conditions, that the viscous force  $F$  experienced by a sphere of radius  $a$  moving at velocity  $v$  in a medium of viscosity  $\eta$  is given by  $F = -6\pi\eta av$ .

**Strain** - The deformation of a body that results from an applied stress.

**Stratosphere** - The part of the earth's atmosphere extending from the top of the troposphere (typically 10 to 15 km above the surface) to about 50 km. It is characterized by an increase in temperature with increasing altitude.

**Stress** - Force per unit area (pressure) applied to a body. Tensile stress tends to stretch or compress the body in the direction of the applied force. Shear stress results from a tangential force which tends to twist the body.

**Strong interaction** - The short range (order of 1 fm) attractive forces between protons, neutrons, and other hadrons which are responsible for the stability of the nucleus.

**Strouhal number ( $Sr$ )** - A dimensionless quantity used in fluid mechanics, defined by  $Sr = lf/v$ , where  $l$  is length,  $f$  is frequency, and  $v$  is velocity. [2]

**Structure factor** - In x-ray crystallography, the sum of the scattering factors of all the atoms in a unit cell, weighted by an appropriate phase factor. The intensity of a given reflection is proportional to the square of the structure factor.

**Sublimation pressure** - The pressure of a gas in equilibrium with a solid at a specified temperature.

**Sulfides** - Compounds having the structure  $\text{RSR}$  ( $\text{R}$  not equal to  $\text{H}$ ). Such compounds were once called thioethers. In an inorganic sense, salts or other derivatives of hydrogen sulfide. [5]

**Sulfones** - Compounds having the structure,  $\text{RS(=O)}_2\text{R}$  ( $\text{R}$  not equal to  $\text{H}$ ), e.g.  $\text{C}_2\text{H}_5\text{S(=O)}_2\text{CH}_3$ , ethyl methyl sulfone. [5]

**Sulfonic acids** -  $\text{HS(=O)}_2\text{OH}$ , sulfonic acid, and its S-hydrocarbyl derivatives. [5]

**Sulfoxides** - Compounds having the structure  $\text{R}_2\text{S=O}$  (R not equal to H), e.g.,  $\text{Ph}_2\text{S=O}$ , diphenyl sulfoxide. [5]

**Superconductor** - A material that experiences a nearly total loss of electrical resistivity below a critical temperature  $T_c$ . The effect can occur in pure metals, alloys, semiconductors, organic compounds, and certain inorganic solids.

**Superfluid** - A fluid with near-zero viscosity and extremely high thermal conductivity. Liquid helium exhibits these properties below 2.186 K (the  $\lambda$  point).

**Supernova** - A star in the process of exploding because of instabilities which follow the exhaustion of its nuclear fuel.

**Surface analysis by laser ionization (SALI)** - See Techniques for Materials Characterization, page 12-1.

**Surface tension ( $\gamma, \sigma$ )\*** - The force per unit length in the plane of the interface between a liquid and a gas, which resists an increase in the area of that surface. It can also be equated to the surface Gibbs energy per unit area.

**Surfactant** - A substance which lowers the surface tension of the medium in which it is dissolved, and/or the interfacial tension with other phases, and accordingly is positively adsorbed at the liquid-vapor or other interfaces. [3]

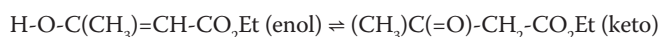
**Susceptance ( $B$ )** - Imaginary part of admittance. [1]

**Svedberg** - A non-SI unit of time, used to express sedimentation coefficients, equal to  $10^{-13}$  s.

**Syndiotactic macromolecule** - A tactic macromolecule, essentially comprising alternating enantiomeric configurational base units which have chiral or prochiral atoms in the main chain in a unique arrangement with respect to their adjacent constitutional units. In this case the repeating unit consists of two configurational base units that are enantiomeric. [8]

**Tacticity** - The orderliness of the succession of configurational repeating units of a macromolecule or oligomer molecule. In a tactic macromolecule essentially all the configurational repeating units are identical with respect to directional sense. See Configurational repeating unit, Isotactic, Syndiotactic. [8]

**Tautomerism** - Isomerism of the general form  $\text{G-X-Y-Z} \rightleftharpoons \text{X=Y-Z-G}$ , where the isomers (called tautomers) are readily interconvertible; the atoms connecting the groups X, Y, Z are typically any of C, H, O, or S, and G is a group which becomes an electrofuge (i.e., a group that does not carry away the bonding electron pair when it leaves its position in the molecule) or nucleofuge (a group that does carry away the bonding electrons when leaving) during isomerization. The commonest case, when the electrofuge is  $\text{H}^+$ , is also known as prototropy. A common example, written so as to illustrate the general pattern given above, is keto-enol tautomerism, such as



In some cases the interconversion rate between tautomers is slow enough to permit isolation of the separate keto and enol forms. [5]

**Tensile strength\*** - In tensile testing, the ratio of maximum load a body can bear before breaking to original cross-sectional area. Also called ultimate strength. [11]

**Terpenes** - Hydrocarbons of biological origin having carbon skeletons formally derived from isoprene  $[\text{CH}_2=\text{C}(\text{CH}_3)\text{CH}=\text{CH}_2]$ . [5]

**Terpenoids** - Natural products and related compounds formally derived from isoprene units. They contain oxygen in various functional groups. The skeleton of terpenoids may differ from strict additivity of isoprene units by the loss or shift of a methyl (or other) group. [5]

**Tesla (T)\*** - The SI unit of magnetic flux density ( $B$ ), equal to  $\text{Vs/m}^2$ . [1]

**Thermal conductivity\*** - Rate of heat flow divided by area and by temperature gradient. [1]

**Thermal diffusivity** - Thermal conductivity divided by density and by specific heat capacity at constant pressure. [1]

**Thermal expansion coefficient ( $\alpha$ )\*** - The linear expansion coefficient is defined by  $\alpha_l = (1/l)(dl/dT)$ ; the volume expansion coefficient by  $\alpha_v = (1/V)(dV/dT)$ . [1]

**Thermionic emission** - The emission of electrons from a solid as a result of heat. The effect requires a high enough temperature to impart sufficient kinetic energy to the electrons to exceed the work function of the solid.

**Thermodynamic laws** - The foundation of the science of thermodynamics:

**First law:** The internal energy of an isolated system is constant; if energy is supplied to the system in the form of heat  $dq$  and work  $dw$ , then the change in energy  $dU = dq + dw$ .

**Second law:** No process is possible in which the only result is the transfer of heat from a reservoir and its complete conversion to work.

**Third law:** The entropy of a perfect crystal approaches zero as the thermodynamic temperature approaches zero.

**Thermoelectric power** - For a bar of a pure material whose ends are at different temperatures, the potential difference divided by the difference in temperature of the ends. See also Seebeck effect.

**Thermogravimetric analysis (TGA)** - See Techniques for Materials Characterization, page 12-1.

**Thermosphere** - The layer of the Earth's atmosphere extending from the top of the mesosphere (typically 80–90 km above the surface) to about 500 km. It is characterized by a rapid increase in temperature with increasing altitude up to about 200 km, followed by a leveling off in the 300–500 km region.

**Thiols** - Compounds having the structure  $\text{RSH}$  (R not equal to H). Also known by the term mercaptans (abandoned by IUPAC); e.g.,  $\text{CH}_3\text{CH}_2\text{SH}$ , ethanethiol. [5]

**Thomson coefficient ( $\mu, \tau$ )** - The heat power developed in the Thomson effect (whereby heat is evolved in a conductor when a current is flowing in the presence of a temperature gradient), divided by the current and the temperature difference. [1]

**Tonne (t)** - An alternative name for megagram (1000 kg). [1]

**Torque ( $T$ )** - For a force  $F$  that produces a torsional motion,  $T = r \times F$ , where  $r$  is a vector from some reference point to the point of application of the force.

**Torr** - A non-SI unit of pressure, equal to 133.322 Pa. The name is generally considered interchangeable with millimeter of mercury.

**Townsend coefficient** - In a radiation counter, the number of ionizing collisions by an electron per unit path length in the direction of an applied electric field.

**Transducer** - Any device that converts a signal from acoustical, optical, or some other form of energy into an electrical signal (or vice versa) while preserving the information content of the original signal.



**Transistor** - A voltage amplifier using controlled electron currents inside a semiconductor.

**Transition metals** - Elements characterized by a partially filled  $d$  subshell. The First Transition Series comprises Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu. The Second and Third Transition Series include the lanthanides and actinides, respectively. [7]

**Transition probability\*** - See Einstein transition probability.

**Transmittance ( $\tau$ )** - Ratio of the radiant or luminous flux at a given wavelength that is transmitted to that of the incident radiation. Also called transmission factor. [1]

**Tribology** - The study of frictional forces between solid surfaces.

**Triple point\*** - The point in  $p, T$  space where the solid, liquid, and gas phases of a substance are in thermodynamic equilibrium. The corresponding temperature and pressure are called the triple point temperature and triple point pressure.

**Troposphere** - The lowest part of the earth's atmosphere, extending to 10–15 km above the surface. It is characterized by a decrease in temperature with increasing altitude. The exact height varies with latitude and season.

**Tunnel diode** - A device involving a p-n junction in which both sides are so heavily doped that the Fermi level on the p-side lies in the valence band and on the n-side in the conduction band. This leads to a current-voltage curve with a maximum, so that the device exhibits a negative resistance in some regions.

**Ultraviolet photoelectron spectroscopy (UPS)** - See Techniques for Materials Characterization, page 12-1.

**Umklapp process** - A process involving the interaction of three or more waves (lattice or electron) in a solid in which the sum of the wave vectors does not equal zero.

**Unified atomic mass unit ( $u$ )\*** - A unit of mass used in atomic, molecular, and nuclear science, defined as the mass of one atom of  $^{12}\text{C}$  divided by 12. Its approximate value is  $1.66054 \times 10^{-27}$  kg. [1]

**Universal time ( $t_u$ , UT)** - Mean solar time counted from midnight at the Greenwich meridian. Also called Greenwich mean time (GMT). The interval of mean solar time is based on the average, over one year, of the time between successive transits of the sun across the observer's meridian.

**Vacancy** - A missing atom or ion in a crystal lattice.

**Van Allen belts** - Two toroidal regions above the earth's atmosphere containing protons and electrons. The outer belt at about 25,000 km above the surface is probably of solar origin. The inner belt at about 3000 km contains more energetic particles from outside the solar system.

**Van der Waals' equation\*** - An equation of state for fluids which takes the form:

$$pV_m = RT \left( \frac{1}{V_m - b} - \frac{a}{V_m^2} \right)$$

where  $p$  is pressure,  $V_m$  is molar volume,  $T$  is temperature,  $R$  is the molar gas constant, and  $a$  and  $b$  are characteristic parameters of the substance which describe the effect of attractive and repulsive intermolecular forces, respectively.

**Van der Waals' force** - The weak attractive force between two molecules which arises from electric dipole interactions. It can lead to the formation of stable but weakly bound dimer molecules or clusters.

**Van't Hoff equation** - The equation expressing the temperature dependence of the equilibrium constant  $K$  of a chemical reaction:

$$\frac{d \ln K}{dT} = \frac{\Delta_r H^\circ}{RT^2}$$

where  $\Delta_r H^\circ$  is the standard enthalpy of reaction,  $R$  the molar gas constant, and  $T$  the temperature. Also called van't Hoff isochore.

**Vapor pressure\*** - The pressure of a gas in equilibrium with a liquid (or, in some usage, a solid) at a specified temperature.

**Varistor** - A device that utilizes the properties of certain metal oxides with small amounts of impurities, which show abrupt nonlinearities at specific voltages where the material changes from a semiconductor to an insulator.

**Velocity ( $v$ )** - Rate of change of distance with time.

**Verdet constants ( $V$ )\*** - Angle of rotation of a plane polarized light beam passing through a medium in a magnetic field, divided by the field strength and by the path length.

**Virial equation of state\*** - An equation relating the pressure  $p$ , molar volume  $V_m$ , and temperature  $T$  of a real gas in the form of an expansion in powers of the molar volume, viz.,  $pV_m = RT(1 + BV_m^{-1} + CV_m^{-2} + \dots)$ , where  $R$  is the molar gas constant.  $B$  is called the second virial coefficient,  $C$  the third virial coefficient, etc. The virial coefficients are functions of temperature.

**Viscosity ( $\eta$ )\*** - The proportionality factor between sheer rate and sheer stress, defined through the equation  $F = \eta A(dv/dx)$ , where  $F$  is the tangential force required to move a planar surface of area  $A$  at velocity  $v$  relative to a parallel surface separated from the first by a distance  $x$ . Sometimes called dynamic or absolute viscosity. The term kinematic viscosity (symbol  $\nu$ ) is defined as  $\eta$  divided by the mass density.

**Volt ( $V$ )\*** - The SI unit of electric potential, equal to W/A. [1]

**Volume fraction ( $\phi_i$ )** - Defined as  $V_i/\sum_i V_i$ , where  $V_i$  is the volume of the specified component and the  $V_i$  are the volumes of all the components of a mixture prior to mixing. [2]

**Watt ( $W$ )\*** - The SI unit of power, equal to J/s. [1]

**Wave function** - A function of the coordinates of all the particles in a quantum mechanical system (and, in general, of time) which fully describes the state of the system. The product of the wave function and its complex conjugate is proportional to the probability of finding a particle at a particular point in space.

**Weak interaction** - The weak forces (order of  $10^{-12}$  of the strong interaction) between elementary particles which are responsible for beta decay and other nuclear effects.

**Weber (Wb)\*** - The SI unit of magnetic flux, equal to V s. [1]

**Weber number ( $We$ )** - A dimensionless quantity used in fluid mechanics, defined by  $We = \rho v^2 l / \gamma$ , where  $\rho$  is density,  $v$  is velocity,  $l$  is length, and  $\gamma$  is surface tension. [2]

**Weight** - That force which, when applied to a body, would give it an acceleration equal to the local acceleration of gravity. [1]

**Wiedeman-Franz law** - The law stating that the thermal conductivity  $k$  and electrical conductivity  $\sigma$  of a pure metal are related by  $k = L\sigma T$ , where  $T$  is the temperature and  $L$  (called the Lorenz ratio) has the approximate value  $2.45 \times 10^{-8}$  V<sup>2</sup>/K<sup>2</sup>.

**Wien displacement law** - The relation, which can be derived from the Planck formula for black body radiation, that

$\lambda_{\max} T = 0.0028978 \text{ m K}$ , where  $\lambda_{\max}$  is the wavelength of maximum radiance at temperature  $T$ .

**Wigner-Seitz method** - A method of calculating electron energy levels in a solid using a model in which each electron is subject to a spherically symmetric potential.

**Wittig reagents** - See phosphonium ylides.

**Work (W)** - Force multiplied by the displacement in the direction of the force. [1]

**Work function ( $\Phi$ )\*** - The energy difference between an electron at rest at infinity and an electron at the Fermi level in the interior of a substance. It is thus the minimum energy required to remove an electron from the interior of a solid to a point just outside the surface. [1]

**X unit (X)** - A unit of length used in x-ray crystallography, equal to approximately  $1.002 \times 10^{-13} \text{ m}$ .

**X-ray photoelectron spectroscopy (XPS)** - See Techniques for Materials Characterization, page 12-1.

**Yield strength** - The stress at which a material exhibits a specified deviation (often chosen as 0.2% for metals) from proportionality of stress and strain. [11]

**Young's modulus (E)** - In tension or compression of a body below its elastic limit, the ratio of stress to corresponding strain. Since strain is normally expressed on a fractional basis, Young's modulus has dimensions of pressure. Also called elastic modulus. [11]

**Zeeman effect** - The splitting of an energy level of an atom or molecule, and hence a splitting of spectral lines arising from that level, as a result of the application of an external magnetic field.

**Zener diode** - A control device utilizing a p-n junction with a well defined reverse-bias avalanche breakdown voltage.

**Zeotrope** - A liquid mixture that shows no maximum or minimum when vapor pressure is plotted against composition at constant temperature. See Azeotrope.

**Zero-point energy** - The energy possessed by a quantum mechanical system as a result of the uncertainty principle even when it is in its lowest energy state; e.g., the difference between the lowest energy level of a harmonic oscillator and the minimum in the potential well.

**Zeta potential ( $\zeta$ )** - The electric potential at the surface of a colloidal particle relative to the potential in the bulk medium at a long distance. Also called electrokinetic potential.

**Zwitterions** - Neutral compounds having formal unit electrical charges of opposite sign. Some chemists restrict the term to compounds with the charges on non-adjacent atoms. Sometimes referred to as inner salts, dipolar ions (a misnomer). [5]

## THERMODYNAMIC FUNCTIONS AND RELATIONS

$p$  = pressure       $V$  = volume       $T$  = temperature

$n_i$  = amount of substance  $i$

$x_i = n_i / \sum_j n_j$  = mole fraction of substance  $i$

|                                     |                                                                                        |
|-------------------------------------|----------------------------------------------------------------------------------------|
| Energy                              | $U$                                                                                    |
| Entropy                             | $S$                                                                                    |
| Enthalpy                            | $H = U + pV$                                                                           |
| Helmholtz energy                    | $A = U - TS$                                                                           |
| Gibbs energy                        | $G = U + pV - TS$                                                                      |
| Isobaric heat capacity              | $C_p = (\partial H / \partial T)_p$                                                    |
| Isochoric heat capacity             | $C_V = (\partial U / \partial T)_V$                                                    |
| Isobaric expansivity                | $\alpha = V^{-1}(\partial V / \partial T)_p$                                           |
| Isothermal compressibility          | $\kappa_T = -V^{-1}(\partial V / \partial p)_T$                                        |
| Isentropic compressibility          | $\kappa_S = -V^{-1}(\partial V / \partial p)_S$                                        |
|                                     | $\kappa_T - \kappa_S = T\alpha^2 V / C_p$                                              |
|                                     | $C_p - C_V = T\alpha^2 V / \kappa_T$                                                   |
| Gibbs-Helmholtz equation            | $H = G - T(\partial G / \partial T)_p$                                                 |
| Maxwell relations                   | $(\partial S / \partial p)_T = -(\partial V / \partial T)_p$                           |
|                                     | $(\partial S / \partial V)_T = -(\partial p / \partial T)_V$                           |
| Joule-Thomson expansion             | $\mu_{JT} = (\partial T / \partial p)_H = -\{V - T(\partial V / \partial T)_p\} / C_p$ |
|                                     | $\Phi_{JT} = (\partial H / \partial p)_T = V - T(\partial V / \partial T)_p$           |
| Partial molar quantity              | $X_i = (\partial X / \partial n_i)_{T,p,n_j \neq i}$                                   |
| Chemical potential                  | $\mu_i = (\partial G / \partial n_i)_{T,p,n_j \neq i}$                                 |
| Perfect gas [symbol <sup>pg</sup> ] | $pV = (\sum_i n_i)RT$                                                                  |
|                                     | $\mu_i^{pg} = \mu_i^\ominus + RT \ln(x_i p / p^\ominus)$                               |
| Fugacity                            | $f_i = (x_i p) \exp\{(\mu_i - \mu_i^{pg}) / RT\}$                                      |
| Activity coefficient                | $\gamma_i = f_i / (x_i f_i^\ominus)$                                                   |
| Gibbs-Duhem relation                | $0 = SdT - Vdp + \sum_i n_i d\mu_i$                                                    |

[Superscript  $\theta$  in above equations indicates standard state]

Notation for chemical and physical changes ( $X = H, S, G$ , etc.):

|                                      |                  |
|--------------------------------------|------------------|
| Chemical reaction                    | $\Delta_r X$     |
| Formation from elements              | $\Delta_f X$     |
| Combustion                           | $\Delta_c X$     |
| Fusion (cry $\rightarrow$ liq)       | $\Delta_{fus} X$ |
| Vaporization (liq $\rightarrow$ gas) | $\Delta_{vap} X$ |
| Sublimation (cry $\rightarrow$ gas)  | $\Delta_{sub} X$ |
| Phase transition                     | $\Delta_{trs} X$ |
| Solution                             | $\Delta_{sol} X$ |
| Mixing                               | $\Delta_{mix} X$ |
| Dilution                             | $\Delta_{dil} X$ |

# REPRESENTATION OF CHEMICAL STRUCTURES WITH THE IUPAC INTERNATIONAL CHEMICAL IDENTIFIER (INCHI)

Stephen R. Heller and Alan D. McNaught

The IUPAC International Chemical Identifier (InChI) is a freely available, non-proprietary identifier for chemical substances that can be used in both printed and electronic data sources. It is generated from a computerized representation of a molecular structure diagram, which can be produced by chemical structure-drawing software. Its use enables linking of diverse data compilations and unambiguous identification of chemical substances. A full description of the Identifier and software for its generation are available from the IUPAC Web site (Ref. 1), and a helpful compilation of answers to frequently asked questions has been put together at the Unilever Centre for Molecular Science Informatics (Ref. 2). Commercial structure-drawing software that will generate the Identifier is available from several organizations, listed on the IUPAC Web site.

The conversion of structural information to the Identifier is based on a set of IUPAC structure conventions, and rules for normalization and canonicalization (conversion to a single, predictable sequence) of an input structure representation. The resulting InChI is simply a series of characters that serve to uniquely identify the structure from which it was derived. The InChI uses a layered format to represent all available structural information relevant to compound identity. InChI layers are listed below. Each layer in an InChI representation contains a specific type of structural information. These layers, automatically extracted from the input structure, are designed so that each successive layer adds additional detail to the Identifier. The specific layers generated depend on the level of structural detail available and whether or not allowance is made for tautomerism. Of course, any ambiguities or uncertainties in the original structure will remain in the InChI.

This layered structure design offers a number of advantages. If two structures for the same substance are drawn at different levels of detail, the one with the lower level of detail will, in effect, be contained within the other. Specifically, if one substance is drawn with stereo-bonds and the other without, the layers in the latter will be a subset of the former. The same will hold for compounds treated by one author as tautomers and by another as exact structures with all H-atoms fixed. This can work at a finer level. For example, if one author includes double bond and tetrahedral stereochemistry, but another omits stereochemistry, the latter InChI will be contained in the former.

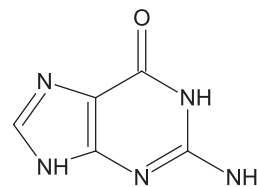
The InChI layers are

1. Formula
2. Connectivity (no formal bond orders)
  - a. disconnected metals
  - b. connected metals
3. Isotopes
4. Stereochemistry
  - a. double bond (Z/E)
  - b. tetrahedral (sp<sup>3</sup>)
5. Tautomers (on or off)

Charges are not part of the basic InChI, but rather are added at the end of the InChI string.

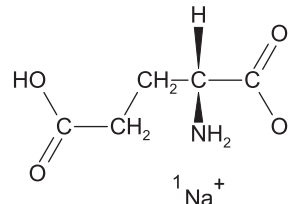
Two examples of InChI representations are given below. It is important to recognize, however, that InChI strings are intended for use by computers and end users need not understand any of their

details. In fact, the open nature of InChI and its flexibility of representation, after implementation into software systems, may allow chemists to be even less concerned with the details of structure representation by computers.



guanine

InChI=1/C5H5N5O/c6-5-9-3-2(4(11)10-5)7-1-8-3/h1H,(H4,6,7,8,9,10,11)/f/h8,10H,6H2



monosodium glutamate

InChI=1/C5H9NO4.Na/c6-3(5(9)10)1-2-4(7)8;/h3H,1-2,6H2,(H,7,8)(H,9,10);/q;+1/p-1/t3-;/m1./s1/fC5H8NO4.Na/h7H;/q-1;m

The layers in the InChI string are separated by the '/' character followed by a lowercase letter (except for the first layer, the chemical formula), with the layers arranged in predefined order. In the examples the following segments are included

InChI version number

/- chemical formula

/c connectivity-1.1 (excluding terminal H)

/h connectivity-1.2 (locations of terminal H, including mobile H attachment points)

/q charge

/p proton balance

/t sp<sup>3</sup> (tetrahedral) parity

/m parity inverted to obtain relative stereo (1 = inverted, 0 = not inverted)

/s stereo type (1 = absolute, 2 = relative, 3 = racemic)

/f chemical formula of the fixed-H structure if it is different

/h connectivity-2 (locations of fixed mobile H)

/q charge

/t sp<sup>3</sup> (tetrahedral) parity

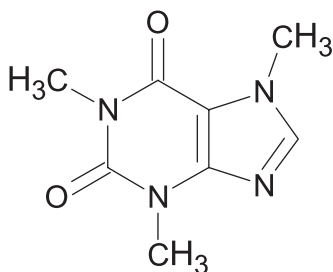
/m parity inverted to obtain relative stereo (1 = inverted, 0 = not inverted, . = inversion does not affect the parity)

/s stereo type (1 = absolute, 2 = relative, 3 = racemic)

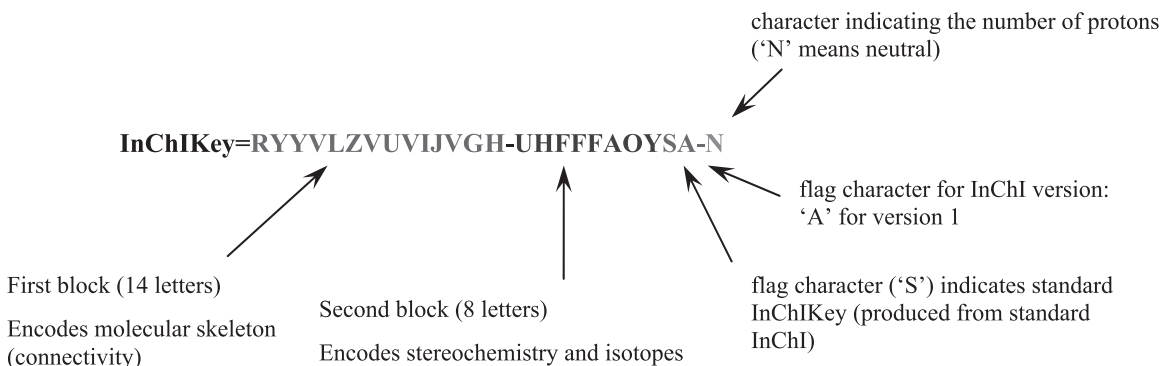
One of the most important applications of InChI is the facility to locate mention of a chemical substance using Internet-based search

engines. This is made easier by using a shorter (compressed) form of InChI, known as InChIKey. The InChIKey is a 27-character representation that, because it is compressed, cannot be reconverted into the original structure, but it is not subject to the undesirable and unpredictable breaking of longer character strings by some search en-

gines. The usefulness of the InChIKey as a search tool is enhanced by its derivation from a "standard" InChI. i.e., an InChI produced with standard option settings for features such as tautomerism and stereochemistry. An example is shown below; the "standard" InChI is denoted by the letter "S" after the version number.



InChI=1S/C8H10N4O2/c1-10-4-9-6-5(10)7(13)12(3)8(14)11(6)2/h4H,1-3H3 (caffeine)



Use of InChIKey also allows searches based solely on atomic connectivity (first 14 characters). Software for generating InChIKey is available from the IUPAC Web site (Ref. 1).

The enormous databases compiled by organizations such as PubChem (Ref. 4), the U.S. National Cancer Institute (NCI), and ChemSpider (Ref. 5) contain millions of InChIs and InChIKeys, which allow sophisticated searching of these collections. PubChem provides InChI-based structure-search facilities for both identical and similar structures (Ref. 6), and ChemSpider offers both search facilities and Web services enabling a variety of InChI and InChIKey conversions (Ref. 7). The NCI Chemical Structure Lookup Service (Ref. 8) provides InChI-based search access to over 39 million chemical structures from over 80 different public and commercial data sources.

## References

1. <http://www.iupac.org/inchi>
2. <http://wwwmm.ch.cam.ac.uk/inchifaq/>
3. *Pure Appl. Chem.*, in preparation.
4. <http://pubchem.ncbi.nlm.nih.gov>
5. <http://www.chemspider.com>
6. <http://pubchem.ncbi.nlm.nih.gov/search>
7. <http://www.chemspider.com/InChI.aspx>
8. <http://cholla.chemnavigator.com/cgi-bin/lookup/new/search>

## EXPRESSION OF UNCERTAINTY OF MEASUREMENTS

In general, the result of a measurement is only an approximation or estimate of the true value of the quantity subject to measurement, and thus the result is of limited value unless accompanied by a statement of its uncertainty. Much (but not all) of the scientific data appearing in the literature does include some indication of the uncertainty, but this may be stated in many different ways and is often explained poorly. In an effort to encourage consistency in uncertainty statements, the International Committee for Weights and Measures (CIPM) initiated a project, in collaboration with several other international organizations, to prepare a set of guidelines expressing international consensus on the recommended method of stating uncertainties. This project resulted in the publication of the *Guide to the Expression of Uncertainty in Measurement* (Reference 1), which is often referred to as *GUM*. The recommendations of *GUM* have been summarized by the National Institute of Standards and Technology in *NIST Technical Note 1297, Guidelines for Evaluating the Uncertainty of NIST Measurement Results* (Reference 2).

In the notation of *GUM*, we are concerned with the **measurand**, i.e., the quantity that is being measured. In physics and chemistry this is usually called a **physical quantity** and represents some inherent characteristic of a material, system, or process that can be expressed in numerical terms — specifically as the product of a number and a reference, commonly called a **unit**. Thus the density of water at room temperature is (approximately) 0.998 g/mL (grams per milliliter) or, alternatively 998 kg m<sup>-3</sup> (kilograms per meter cubed). This statement gives the most likely value of the measurand, to this level of precision, but gives no information on how much the stated value might differ from the true value.

It is important to differentiate between the terms **error** and **uncertainty**. The error in a measurement is the difference between the measured value and the true value; the error can be stated if the true value is known (to some level of accuracy). The uncertainty is an estimate of the maximum reasonable extent to which the measured value is believed to deviate from the true value, in a situation where the true value is not known (most often the case). The result of a measurement can unknowably be very close to the true value, and thus have negligible error, even though its uncertainty is large.

The uncertainty of the result of a measurement generally consists of several components, which may be grouped in two types according to the method used to estimate their numerical values:

### Type A. Those which are evaluated by statistical methods

### Type B. Those which are evaluated by other means

The terms “random uncertainty” and “systematic uncertainty” are often used, but these terms do not always correspond in a simple way to the A and B categories. This is because the nature of an uncertainty component is conditioned by how the quantity appears in the mathematical model that describes the current measurement process. An uncertainty component arising from a systematic effect may in some cases be evaluated by methods of Type A while in other cases by methods of Type B.

In the *GUM* formulation, each component of uncertainty, whether in the A or B category, is represented by an estimated standard deviation, termed **standard uncertainty**, symbol  $u_i$ , and equal to the positive square root of the estimated variance  $u_i^2$ .

For an uncertainty component of Type A,  $u_i = s_i$ , where  $s_i$  is the statistically estimated standard deviation, as determined from a

series of observations by appropriate statistical analysis. Any valid statistical method may be used. Examples are calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to data in order to estimate parameters of the curve and their standard deviations; and carrying out an analysis of variance (ANOVA) in order to identify and quantify random effects in certain types of measurements. Details of statistical analysis are given in References 4–7 and many other places.

In a similar manner, each uncertainty component of Type B is represented by a quantity  $u_j$ , which is obtained from an assumed probability distribution based on all the available information about the measurement process. Since  $u_j$  is treated like a standard deviation, the standard uncertainty in each Type B component is simply  $u_j$ . The evaluation of  $u_j$  is usually based on scientific judgment using all the relevant information available, which may include

- previous measurement data
- experience with, or general knowledge of, the behavior and properties of relevant materials and instruments
- manufacturer's specifications
- data provided in calibrations and other reports
- uncertainties assigned to reference data taken from handbooks.

The specific approach to evaluating the standard uncertainty  $u_j$  of a Type B uncertainty will depend on the detailed model of the measurement process. The following are examples of steps that may be used:

1. Convert a quoted uncertainty (for example, in a calibration factor) that is a stated multiple of an estimated standard deviation to a standard uncertainty by dividing the quoted uncertainty by the multiplier.
2. Convert a quoted uncertainty that defines a “confidence interval” having a stated level of confidence, such as 95% or 99%, to a standard uncertainty by treating the quoted uncertainty as if a normal distribution had been used to calculate it (unless otherwise indicated) and dividing it by the appropriate factor for such a distribution. These factors are 1.960 and 2.576 for the two levels of confidence given.
3. Model knowledge of the quantity in question by a normal distribution and estimate lower and upper limits  $a_-$  and  $a_+$  such that the best estimated value of the quantity is  $(a_- + a_+)/2$  (i.e., the midpoint of the limits) and there is 1 chance out of 2 (i.e., a 50 percent probability) that the value of the quantity lies in the interval  $a_-$  to  $a_+$ . Then  $u_j \approx 1.48 a$ , where  $a = (a_+ - a_-)/2$  is the half-width of the interval.
4. Model knowledge of the quantity in question by a normal distribution and estimate lower and upper limits  $a_-$  and  $a_+$  such that the best estimated value of the quantity is  $(a_- + a_+)/2$  and there is about a 2 out of 3 chance (i.e., a 67 percent probability) that the value of the quantity lies in the interval  $a_-$  to  $a_+$ . Then  $u_j \approx a$ , where  $a = (a_+ - a_-)/2$ .
5. Estimate lower and upper limits  $a_-$  and  $a_+$  for the value of the quantity in question such that the probability that the value lies in the interval  $a_-$  to  $a_+$  is, for all practical purposes, 100 percent. Provided that there is no contradictory information, treat the quantity as if it is equally probable for its value to lie anywhere within the interval  $a_-$  to  $a_+$ ;



that is, model it by a uniform or rectangular probability distribution. The best estimate of the value of the quantity is then  $(a_+ + a_-)/2$  with  $u_j = a/\sqrt{3}$  where  $a = (a_+ - a_-)/2$ . If the distribution used to model the quantity is triangular rather than rectangular, then  $u_j = a/\sqrt{6}$ . The rectangular distribution is a reasonable default model in the absence of any other information. But if it is known that values of the quantity in question near the center of the limits are more likely than values close to the limits, a triangular or a normal distribution may be a better model.

When all the standard uncertainties of Type A and Type B have been determined in this way, they should be combined to produce the **combined standard uncertainty** (suggested symbol  $u_c$ ), which may be regarded as the estimated standard deviation of the measurement result. This process, often called the *law of propagation of uncertainty* or “root-sum-of-squares,” involves taking the square root of the sum of the squares of all the  $u_i$ . In many practical measurement situations, the probability distribution characterized by the measurement result  $y$  and its combined standard uncertainty  $u_c(y)$  is approximately normal (Gaussian). When this is the case,  $u_c(y)$  defines an interval  $y - u_c(y)$  to  $y + u_c(y)$  about the measurement result  $y$  within which the value of the measurand  $Y$  estimated by  $y$  is believed to lie with a level of confidence of approximately 68 percent. That is, it is believed with an approximate level of confidence of 68 percent that  $y - u_c(y) \leq Y \leq y + u_c(y)$ , which is commonly written as  $Y = y \pm u_c(y)$ .

In fundamental metrological research (involving physical constants, calibration standards, and the like) the combined standard uncertainty  $u_c$  is normally used as the statement of uncertainty in a measurement. In most cases, however, it is desirable to use a measure of uncertainty that defines an interval about the measurement result  $y$  within which the value of the measurand  $Y$  is confidently believed to lie. The measure of uncertainty intended to meet this requirement is termed **expanded uncertainty**, suggested symbol  $U$ , and is obtained by multiplying  $u_c(y)$  by a **coverage factor**, suggested symbol  $k$ . Thus  $U = ku_c(y)$  and it is believed with high confidence that  $y - U \leq Y \leq y + U$ , which is commonly written as  $Y = y \pm U$ . The value of the coverage factor  $k$  is chosen on the basis of the desired level of confidence to be associated with the interval defined by  $U = ku_c$ . Typically,  $k$  is in the range 2 to 3. When the normal distribution applies,  $U = 2u_c$  (i.e.,  $k = 2$ ) defines an interval having a level of confidence of approximately 95 percent, and  $U = 3u_c$  defines an interval having a confidence level greater than 99 percent. In current international practice it is most common to use  $k = 2$ , corresponding to about 95 percent confidence, but the

value of  $k$  should be stated in each case to avoid confusion. See References 1 and 2 for methods of calculating  $k$  when a value other than  $k = 2$  is needed for a specific requirement.

## Summary of Key Steps

- Group the uncertainty components into Type A (can be evaluated by statistical methods) and Type B (must be evaluated by other means).
- Determine the standard uncertainty for each component of Type A by statistical methods and for each component of Type B by other suitable methods, based on modeling the measurement process.
- Take the square root of the sum of the squares of all the standard uncertainties to get the combined standard uncertainty  $u_c$ .
- Specify a coverage factor  $k$  which, when multiplied by  $u_c$ , gives the expanded uncertainty  $U$ . In fundamental metrological research  $k = 1$  is usually chosen; in other cases,  $k = 2$  (corresponding to a confidence level of about 95%) is the most common choice.

## References

1. ISO, *Guide to the Expression of Uncertainty in Measurement*, International Organization for Standardization, Geneva, Switzerland, 1993. Several supplements have been published; see Bich, W., Cox, M. C., and Harris, P. M., “Evolution of the *Guide to the Expression of Uncertainty in Measurement*,” *Metrologia* 43, S161, 2006.
2. Taylor, B. N., and Kuyatt, C. E., *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, National Institute of Standards and Technology, Gaithersburg, MD, 1994; available for free download at <physics.nist.gov/cuu/Uncertainty/bibliography.html>.
3. Bell, S., *A Beginner's Guide to Uncertainty of Measurement*, National Physical Laboratory, Teddington, Middlesex, UK, 2001; available on the Internet through <www.npl.co.uk/server.php?show=ConWebDoc.1785>.
4. Eisenhart, C., “Realistic Evaluation of the Precision and Accuracy of Instrument Calibration Systems,” *J. Res. Natl. Bur. Stand. (U.S.)* 67C, 161, 1963.
5. Mandel, J., *The Statistical Analysis of Experimental Data*, Dover Publishers, New York, 1984.
6. Nantrella, M. G., *Experimental Statistics*, NBS Handbook 91, U.S. Government Printing Office, Washington, DC, 1966.
7. Box, G. E. P., Hunter, J. S., and Hunter, W. G., *Statistics for Experimenters: Design, Innovation, and Discovery, 2nd Edition*, John Wiley & Sons, Hoboken, NJ, 2005.



## NOBEL LAUREATES IN CHEMISTRY AND PHYSICS

Full details on nationality and basis of the awards can be found at [nobelprize.org/](http://nobelprize.org/).

### Chemistry

|             |                                                          |             |                                                       |
|-------------|----------------------------------------------------------|-------------|-------------------------------------------------------|
| <b>2008</b> | Martin Chalfie, Osamu Shimomura, Roger Y. Tsien          | <b>1954</b> | Linus Pauling                                         |
| <b>2007</b> | Gerhard Ertl                                             | <b>1953</b> | Hermann Staudinger                                    |
| <b>2006</b> | Roger D. Kornberg                                        | <b>1952</b> | Archer J.P. Martin, Richard L.M. Synge                |
| <b>2005</b> | Yves Chauvin, Robert H. Grubbs, Richard R. Schrock       | <b>1951</b> | Edwin M. McMillan, Glenn T. Seaborg                   |
| <b>2004</b> | Aaron Ciechanover, Avram Hershko, Irwin Rose             | <b>1950</b> | Otto Diels, Kurt Alder                                |
| <b>2003</b> | Peter Agre, Roderick MacKinnon                           | <b>1949</b> | William F. Giauque                                    |
| <b>2002</b> | John B. Fenn, Koichi Tanaka, Kurt Wüthrich               | <b>1948</b> | Arne Tiselius                                         |
| <b>2001</b> | William S. Knowles, Ryoji Noyori, K. Barry Sharpless     | <b>1947</b> | Sir Robert Robinson                                   |
| <b>2000</b> | Alan Heeger, Alan G. MacDiarmid, Hideki Shirakawa        | <b>1946</b> | James B. Sumner, John H. Northrop, Wendell M. Stanley |
| <b>1999</b> | Ahmed Zewail                                             | <b>1945</b> | Artturi Virtanen                                      |
| <b>1998</b> | Walter Kohn, John Pople                                  | <b>1944</b> | Otto Hahn                                             |
| <b>1997</b> | Paul D. Boyer, John E. Walker, Jens C. Skou              | <b>1943</b> | George de Hevesy                                      |
| <b>1996</b> | Robert F. Curl Jr., Sir Harold Kroto, Richard E. Smalley | <b>1942</b> | <i>No prize awarded</i>                               |
| <b>1995</b> | Paul J. Crutzen, Mario J. Molina, F. Sherwood Rowland    | <b>1941</b> | <i>No prize awarded</i>                               |
| <b>1994</b> | George A. Olah                                           | <b>1940</b> | <i>No prize awarded</i>                               |
| <b>1993</b> | Kary B. Mullis, Michael Smith                            | <b>1939</b> | Adolf Butenandt, Leopold Ruzicka                      |
| <b>1992</b> | Rudolph A. Marcus                                        | <b>1938</b> | Richard Kuhn                                          |
| <b>1991</b> | Richard R. Ernst                                         | <b>1937</b> | Norman Haworth, Paul Karrer                           |
| <b>1990</b> | Elias James Corey                                        | <b>1936</b> | Peter Debye                                           |
| <b>1989</b> | Sidney Altman, Thomas R. Cech                            | <b>1935</b> | Frédéric Joliot, Irène Joliot-Curie                   |
| <b>1988</b> | Johann Deisenhofer, Robert Huber, Hartmut Michel         | <b>1934</b> | Harold C. Urey                                        |
| <b>1987</b> | Donald J. Cram, Jean-Marie Lehn, Charles J. Pedersen     | <b>1933</b> | <i>No prize awarded</i>                               |
| <b>1986</b> | Dudley R. Herschbach, Yuan T. Lee, John C. Polanyi       | <b>1932</b> | Irving Langmuir                                       |
| <b>1985</b> | Herbert A. Hauptman, Jerome Karle                        | <b>1931</b> | Carl Bosch, Friedrich Bergius                         |
| <b>1984</b> | Bruce Merrifield                                         | <b>1930</b> | Hans Fischer                                          |
| <b>1983</b> | Henry Taube                                              | <b>1929</b> | Arthur Harden, Hans von Euler-Chelpin                 |
| <b>1982</b> | Aaron Klug                                               | <b>1928</b> | Adolf Windaus                                         |
| <b>1981</b> | Kenichi Fukui, Roald Hoffmann                            | <b>1927</b> | Heinrich Wieland                                      |
| <b>1980</b> | Paul Berg, Walter Gilbert, Frederick Sanger              | <b>1926</b> | The Svedberg                                          |
| <b>1979</b> | Herbert C. Brown, Georg Wittig                           | <b>1925</b> | Richard Zsigmondy                                     |
| <b>1978</b> | Peter Mitchell                                           | <b>1924</b> | <i>No prize awarded</i>                               |
| <b>1977</b> | Ilya Prigogine                                           | <b>1923</b> | Fritz Pregl                                           |
| <b>1976</b> | William Lipscomb                                         | <b>1922</b> | Francis W. Aston                                      |
| <b>1975</b> | John Cornforth, Vladimir Prelog                          | <b>1921</b> | Frederick Soddy                                       |
| <b>1974</b> | Paul J. Flory                                            | <b>1920</b> | Walther Nernst                                        |
| <b>1973</b> | Ernst Otto Fischer, Geoffrey Wilkinson                   | <b>1919</b> | <i>No prize awarded</i>                               |
| <b>1972</b> | Christian Anfinsen, Stanford Moore, William H. Stein     | <b>1918</b> | Fritz Haber                                           |
| <b>1971</b> | Gerhard Herzberg                                         | <b>1917</b> | <i>No prize awarded</i>                               |
| <b>1970</b> | Luis Leloir                                              | <b>1916</b> | <i>No prize awarded</i>                               |
| <b>1969</b> | Derek Barton, Odd Hassel                                 | <b>1915</b> | Richard Willstätter                                   |
| <b>1968</b> | Lars Onsager                                             | <b>1914</b> | Theodore W. Richards                                  |
| <b>1967</b> | Manfred Eigen, Ronald G.W. Norrish, George Porter        | <b>1913</b> | Alfred Werner                                         |
| <b>1966</b> | Robert S. Mulliken                                       | <b>1912</b> | Victor Grignard, Paul Sabatier                        |
| <b>1965</b> | Robert B. Woodward                                       | <b>1911</b> | Marie Curie                                           |
| <b>1964</b> | Dorothy Crowfoot Hodgkin                                 | <b>1910</b> | Otto Wallach                                          |
| <b>1963</b> | Karl Ziegler, Giulio Natta                               | <b>1909</b> | Wilhelm Ostwald                                       |
| <b>1962</b> | Max F. Perutz, John C. Kendrew                           | <b>1908</b> | Ernest Rutherford                                     |
| <b>1961</b> | Melvin Calvin                                            | <b>1907</b> | Eduard Buchner                                        |
| <b>1960</b> | Willard F. Libby                                         | <b>1906</b> | Henri Moissan                                         |
| <b>1959</b> | Jaroslav Heyrovsky                                       | <b>1905</b> | Adolf von Baeyer                                      |
| <b>1958</b> | Frederick Sanger                                         | <b>1904</b> | Sir William Ramsay                                    |
| <b>1957</b> | Lord Todd                                                | <b>1903</b> | Svante Arrhenius                                      |
| <b>1956</b> | Sir Cyril Hinshelwood, Nikolay Semenov                   | <b>1902</b> | Emil Fischer                                          |
| <b>1955</b> | Vincent du Vigneaud                                      | <b>1901</b> | Jacobus H. van't Hoff                                 |

## Physics

|      |                                                             |      |                                                       |
|------|-------------------------------------------------------------|------|-------------------------------------------------------|
| 2008 | Makoto Kobayashi, Toshihide Maskawa, Yoichiro Nambu         | 1957 | Chen Ning Yang, Tsung-Dao Lee                         |
| 2007 | Albert Fert, Peter Grünberg                                 | 1956 | William B. Shockley, John Bardeen, Walter H. Brattain |
| 2006 | John C. Mather, George F. Smoot                             | 1955 | Willis E. Lamb, Polykarp Kusch                        |
| 2005 | Roy J. Glauber, John L. Hall, Theodor W. Hänsch             | 1954 | Max Born, Walther Bothe                               |
| 2004 | David J. Gross, H. David Politzer, Frank Wilczek            | 1953 | Frits Zernike                                         |
| 2003 | Alexei A. Abrikosov, Vitaly L. Ginzburg, Anthony J. Leggett | 1952 | Felix Bloch, E. M. Purcell                            |
| 2002 | Raymond Davis Jr., Masatoshi Koshihara, Riccardo Giacconi   | 1951 | John Cockcroft, Ernest T.S. Walton                    |
| 2001 | Eric A. Cornell, Wolfgang Ketterle, Carl E. Wieman          | 1950 | Cecil Powell                                          |
| 2000 | Zhores I. Alferov, Herbert Kroemer, Jack S. Kilby           | 1949 | Hideki Yukawa                                         |
| 1999 | Gerardus't Hooft, Martinus J.G. Veltman                     | 1948 | Patrick M.S. Blackett                                 |
| 1998 | Robert B. Laughlin, Horst L. Störmer, Daniel C. Tsui        | 1947 | Edward V. Appleton                                    |
| 1997 | Steven Chu, Claude Cohen-Tannoudji, William D. Phillips     | 1946 | Percy W. Bridgman                                     |
| 1996 | David M. Lee, Douglas D. Osheroff, Robert C. Richardson     | 1945 | Wolfgang Pauli                                        |
| 1995 | Martin L. Perl, Frederick Reines                            | 1944 | Isidor Isaac Rabi                                     |
| 1994 | Bertram N. Brockhouse, Clifford G. Shull                    | 1943 | Otto Stern                                            |
| 1993 | Russell A. Hulse, Joseph H. Taylor Jr.                      | 1942 | <i>No prize awarded</i>                               |
| 1992 | Georges Charpak                                             | 1941 | <i>No prize awarded</i>                               |
| 1991 | Pierre-Gilles de Gennes                                     | 1940 | <i>No prize awarded</i>                               |
| 1990 | Jerome I. Friedman, Henry W. Kendall, Richard E. Taylor     | 1939 | Ernest Lawrence                                       |
| 1989 | Norman F. Ramsey, Hans G. Dehmelt, Wolfgang Paul            | 1938 | Enrico Fermi                                          |
| 1988 | Leon M. Lederman, Melvin Schwartz, Jack Steinberger         | 1937 | Clinton Davisson, George Paget Thomson                |
| 1987 | J. Georg Bednorz, K. Alex Müller                            | 1936 | Victor F. Hess, Carl D. Anderson                      |
| 1986 | Ernst Ruska, Gerd Binnig, Heinrich Rohrer                   | 1935 | James Chadwick                                        |
| 1985 | Klaus von Klitzing                                          | 1934 | <i>No prize awarded</i>                               |
| 1984 | Carlo Rubbia, Simon van der Meer                            | 1933 | Erwin Schrödinger, Paul A.M. Dirac                    |
| 1983 | Subramanyan Chandrasekhar, William A. Fowler                | 1932 | Werner Heisenberg                                     |
| 1982 | Kenneth G. Wilson                                           | 1931 | <i>No prize awarded</i>                               |
| 1981 | Nicolaas Bloembergen, Arthur L. Schawlow, Kai M. Siegbahn   | 1930 | Sir Venkata Raman                                     |
| 1980 | James Cronin, Val Fitch                                     | 1929 | Louis de Broglie                                      |
| 1979 | Sheldon Glashow, Abdus Salam, Steven Weinberg               | 1928 | Owen Willans Richardson                               |
| 1978 | Pyotr Kapitsa, Arno Penzias, Robert Woodrow Wilson          | 1927 | Arthur H. Compton, C.T.R. Wilson                      |
| 1977 | Philip W. Anderson, Sir Nevill F. Mott, John H. van Vleck   | 1926 | Jean Baptiste Perrin                                  |
| 1976 | Burton Richter, Samuel C.C. Ting                            | 1925 | James Franck, Gustav Hertz                            |
| 1975 | Aage N. Bohr, Ben R. Mottelson, James Rainwater             | 1924 | Manne Siegbahn                                        |
| 1974 | Martin Ryle, Antony Hewish                                  | 1923 | Robert A. Millikan                                    |
| 1973 | Leo Esaki, Ivar Giaever, Brian D. Josephson                 | 1922 | Niels Bohr                                            |
| 1972 | John Bardeen, Leon N. Cooper, Robert Schrieffer             | 1921 | Albert Einstein                                       |
| 1971 | Dennis Gabor                                                | 1920 | Charles Edouard Guillaume                             |
| 1970 | Hannes Alfvén, Louis Néel                                   | 1919 | Johannes Stark                                        |
| 1969 | Murray Gell-Mann                                            | 1918 | Max Planck                                            |
| 1968 | Luis Alvarez                                                | 1917 | Charles Glover Barkla                                 |
| 1967 | Hans Bethe                                                  | 1916 | <i>No prize awarded</i>                               |
| 1966 | Alfred Kastler                                              | 1915 | William Bragg, Lawrence Bragg                         |
| 1965 | Sin-Itiro Tomonaga, Julian Schwinger, Richard P. Feynman    | 1914 | Max von Laue                                          |
| 1964 | Charles H. Townes, Nicolay G. Basov, Aleksandr M. Prokhorov | 1913 | Heike Kamerlingh Onnes                                |
| 1963 | Eugene Wigner, Maria Goeppert-Mayer, J. Hans D. Jensen      | 1912 | Gustaf Dalén                                          |
| 1962 | Lev Landau                                                  | 1911 | Wilhelm Wien                                          |
| 1961 | Robert Hofstadter, Rudolf Mössbauer                         | 1910 | Johannes Diderik van der Waals                        |
| 1960 | Donald A. Glaser                                            | 1909 | Guglielmo Marconi, Ferdinand Braun                    |
| 1959 | Emilio Segrè, Owen Chamberlain                              | 1908 | Gabriel Lippmann                                      |
| 1958 | Pavel A. Cherenkov, Il'ja M. Frank, Igor Y. Tamm            | 1907 | Albert A. Michelson                                   |
|      |                                                             | 1906 | J.J. Thomson                                          |
|      |                                                             | 1905 | Philipp Lenard                                        |
|      |                                                             | 1904 | Lord Rayleigh                                         |
|      |                                                             | 1903 | Henri Becquerel, Pierre Curie, Marie Curie            |
|      |                                                             | 1902 | Hendrik A. Lorentz, Pieter Zeeman                     |
|      |                                                             | 1901 | Wilhelm Conrad Röntgen                                |

## PHYSICAL CONSTANTS OF ORGANIC COMPOUNDS

The basic physical constants and structure diagrams for about 10,900 organic compounds are presented in this table. An effort has been made to include the compounds most frequently encountered in the laboratory, the workplace, and the environment. Particular emphasis has been given to substances that are considered environmental or human health hazards. In making the selection of compounds for the table, added weight was assigned to the appearance of a compound in various lists or reference sources such as:

- Laboratory reagent lists, e.g., the *ACS Reagent Chemicals* volume (Ref. 1)
- The DIPPR list of industrially important compounds (Ref. 2) and the (much larger) TSCA inventory of chemicals used in commerce
- The *Hazardous Substances Data Bank* (Ref. 3)
- The UNEP list *Persistent Organic Pollutants* (Ref. 4)
- Chemicals on Reporting Rules (CORR), a database of about 7500 regulated compounds prepared by the Environmental Protection Agency (Ref. 5)
- The EPA Integrated Risk Information System (IRIS), a database of human health effects of exposure to chemicals in the environment (Ref. 6)
- Compendia of chemicals of biochemical or medical importance, such as *The Merck Index* (Ref. 10)
- Specialized tables in this *Handbook*

It should be noted that the above lists vary widely in their choice of chemical names, and even in the use of Chemical Abstracts Registry Numbers. To the extent possible, we have attempted to systematize the names and registry numbers for this table.

Clearly, criteria of this type are somewhat subjective, and compounds considered important by some users have undoubtedly been omitted. Suggestions for additional compounds or other improvements are welcomed.

The data in the table have been derived from many sources, including both the primary literature and evaluated compilations. The *Handbook of Data on Organic Compounds, Third Edition* (Ref. 7) and the *Chapman & Hall/CRC Combined Chemical Dictionary* (Ref. 8) were important sources. Other useful compilations of physical property data for organic compounds are listed in Refs. 9–19. Many boiling point values (and some melting point and density values) were taken from recent physical chemistry literature dealing with fluid properties. Where conflicts were found, the value deemed most reliable was chosen.

The table is arranged alphabetically by substance name, which generally is either an IUPAC systematic name or, in the case of pesticides, pharmaceuticals, and other complex compounds, a simple trivial name. Names in ubiquitous use, such as acetic acid and formaldehyde, are adopted rather than their systematic equivalents. Synonyms are given in the column following the primary name, and structure diagrams are given on the page facing the data listing. The explanation of the data columns follows:

- **No.:** An identification number used in the indexes.
- **Name:** Primary name of the substance.
- **Synonym:** A synonym in common use. When the primary name is non-systematic, a systematic name may appear here.
- **Mol. Form.:** The molecular formula written in the Hill convention.

- **CAS RN:** The Chemical Abstracts Service Registry Number for the compound.
- **Mol. Wt:** Molecular weight (relative molar mass) as calculated with the 2001 IUPAC Standard Atomic Weights.
- **Physical Form:** A notation of the physical phase, color, crystal type, or other features of the compound at ambient temperature. Abbreviations are given below.
- **mp:** Normal melting point in °C. A value is sometimes followed by “dec,” indicating decomposition is observed at the stated temperature (so that it is probably not a true melting point). The notation “tp” indicates a triple point, where solid, liquid, and gas are in equilibrium.
- **bp:** Normal boiling point in °C, if it is available. This is the temperature at which the liquid phase is in equilibrium with the vapor at a pressure of 760 mmHg (101.325 kPa). A notation “sp” following the value indicates a sublimation point, where the vapor pressure of the solid phase reaches 760 mmHg. When a notation such as “dec” or “exp” (explodes) follows the value, the temperature may not be a true boiling point. A simply entry “sub” indicates the solid has a significant sublimation pressure at ambient temperatures. The boiling point at reduced pressure is listed in some cases, with or without the normal boiling point. Here the superscript indicates the pressure in mmHg.
- **den:** Density (mass per unit volume) in g/cm<sup>3</sup>. The temperature in °C is indicated by a superscript. Values refer to the liquid or solid phase, and all values are true densities, not specific gravities. The number of decimal places gives a rough estimate of the accuracy of the value.
- **n<sub>D</sub>:** Refractive index, at the temperature in °C indicated by the superscript. Unless otherwise indicated, all values refer to a wavelength of 589 nm (sodium D line). Values are given only for liquids and solids.
- **Solubility:** Qualitative indication of solubility in common solvents. Abbreviations are:

|     |                  |
|-----|------------------|
| i   | insoluble        |
| sl  | slightly soluble |
| s   | soluble          |
| vs  | very soluble     |
| msc | miscible         |
| dec | decomposes       |

Abbreviations for solvents are given below.

In order to facilitate the location of compounds in the table, three indexes are provided:

- **Synonym Index:** Includes common synonyms, but not the primary name by which the table is arranged.
- **Molecular Formula Index:** Lists compounds by molecular formula in the Hill Order (see Preface to this *Handbook*).
- **CAS Registry Number Index:** Lists compounds by Chemical Abstracts Service Registry Number. Note there is some redundancy in this index, because many compounds have several Registry Numbers associated with them. Thus the CAS RN in a table entry may differ from the CAS RN that points to it in the index. For example, CAS RN 1319-77-3 in the index points to all three cresol isomers, each of which has its own specific CAS RN.

The assistance of Fiona Macdonald in checking names and formulas is gratefully acknowledged, as well as the efforts of Janice

Shackleton, Trupti Desai, Nazila Kamaly, Matt Griffiths, and Lawrence Braschi in preparing the structure diagrams.

## List of Abbreviations

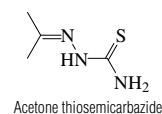
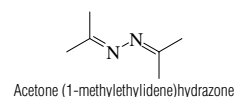
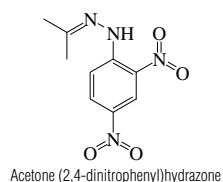
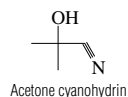
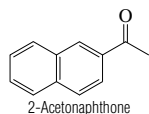
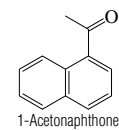
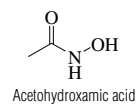
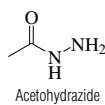
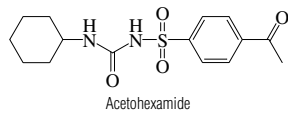
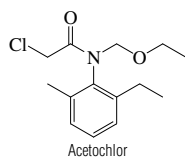
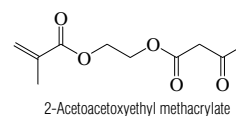
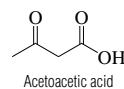
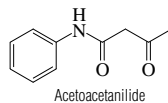
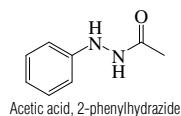
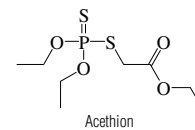
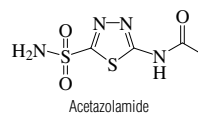
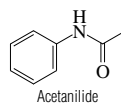
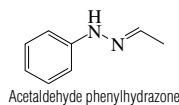
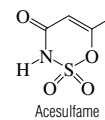
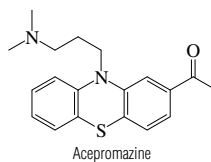
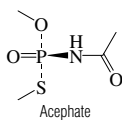
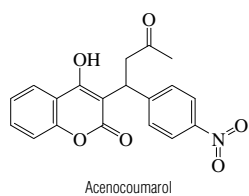
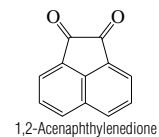
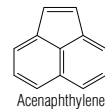
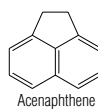
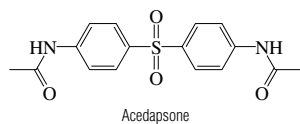
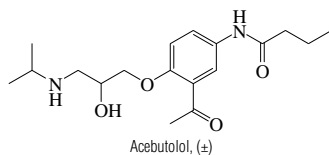
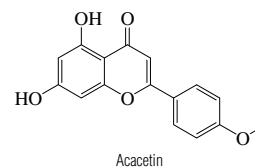
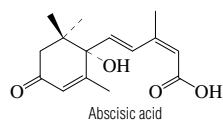
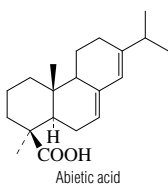
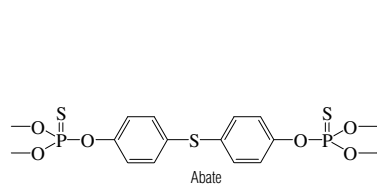
|                   |                      |                   |                       |
|-------------------|----------------------|-------------------|-----------------------|
| Ac                | acetyl               | mcl               | monoclinic            |
| Ac <sub>2</sub> O | acetic anhydride     | Me                | methyl                |
| AcOEt             | ethyl acetate        | MeCN              | acetonitrile          |
| ac                | acid                 | MeOH              | methanol              |
| ace               | acetone              | misc, msc         | miscible              |
| al                | alcohol (ethanol)    | mp                | melting point         |
| alk               | alkali               | n                 | refractive index      |
| amor              | amorphous            | nd                | needles               |
| anh               | anhydrous            | oct               | octahedra, octahedral |
| aq                | aqueous              | oran              | orange                |
| bipym             | bipyramidal          | orth              | orthorhombic          |
| bl                | blue                 | os                | organic solvents      |
| blk               | black                | pa                | pale                  |
| bp                | boiling point        | peth              | petroleum ether       |
| br                | brown                | Ph                | phenyl                |
| bt                | bright               | PhCl              | chlorobenzene         |
| Bu                | butyl                | PhNH <sub>2</sub> | aniline               |
| BuOH              | 1-butanol            | PhNO <sub>2</sub> | nitrobenzene          |
| bz                | benzene              | pl                | plates                |
| chl               | chloroform           | pow               | powder                |
| col               | colorless            | Pr                | propyl                |
| con, conc         | concentrated         | PrOH              | 1-propanol            |
| cry               | crystals             | pr                | prisms                |
| ctc               | carbon tetrachloride | purp              | purple                |
| cy, cyhex         | cyclohexane          | py                | pyridine              |
| dec               | decomposes           | pym               | pyramids, pyramidal   |
| den               | density              | reac              | reacts                |
| dil               | dilute               | rhom              | rhombic               |
| diox              | dioxane              | s                 | soluble               |
| dk                | dark                 | sat               | saturated             |
| DMF               | dimethylformamide    | sc                | scales                |
| DMSO              | dimethyl sulfoxide   | sl                | slightly soluble      |
| efflor            | efflorescent         | soln              | solution              |
| Et                | ethyl                | sp                | sublimation point     |
| EtOH              | ethanol              | stab              | stable                |
| eth               | diethyl ether        | sub               | sublimes              |
| exp               | explodes             | sulf              | sulfuric acid         |
| fl                | flakes               | syr               | syrup                 |
| flr               | fluorescent          | tab               | tablets               |
| fum               | fumes, fuming        | tcl               | triclinic             |
| gl                | glacial              | tetr              | tetragonal            |
| gr                | gray                 | tfa               | trifluoroacetic acid  |
| gran              | granular             | thf, THF          | tetrahydrofuran       |
| grn               | green                | tol               | toluene               |
| hex               | hexagonal            | tp                | triple point          |
| HOAc              | acetic acid          | trg               | trigonal              |
| hp                | heptane              | unstab            | unstable              |
| hx                | hexane               | vap               | vapor                 |
| hyd               | hydrate              | viol              | violet                |
| hyg               | hygroscopic          | visc              | viscous               |
| i                 | insoluble            | vol               | volatile              |
| i-                | iso-                 | vs                | very soluble          |
| iso               | isooctane            | w                 | water                 |
| lf                | leaves               | wh                | white                 |
| lig               | ligroin              | xyl               | xylene                |
| liq               | liquid               | ye                | yellow                |
| lo                | long                 |                   |                       |

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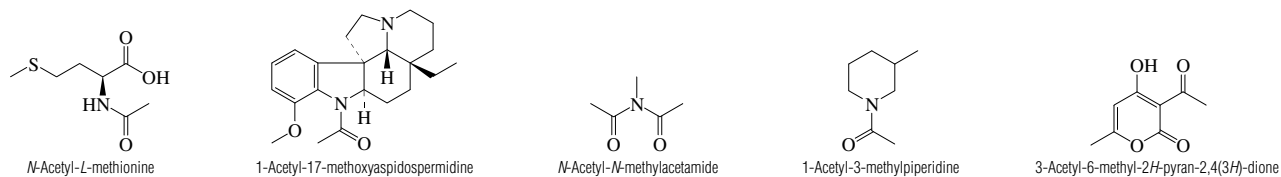
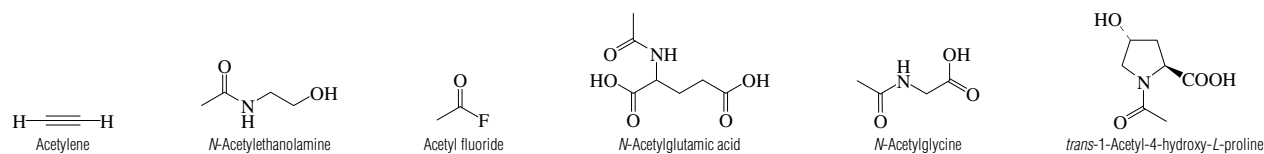
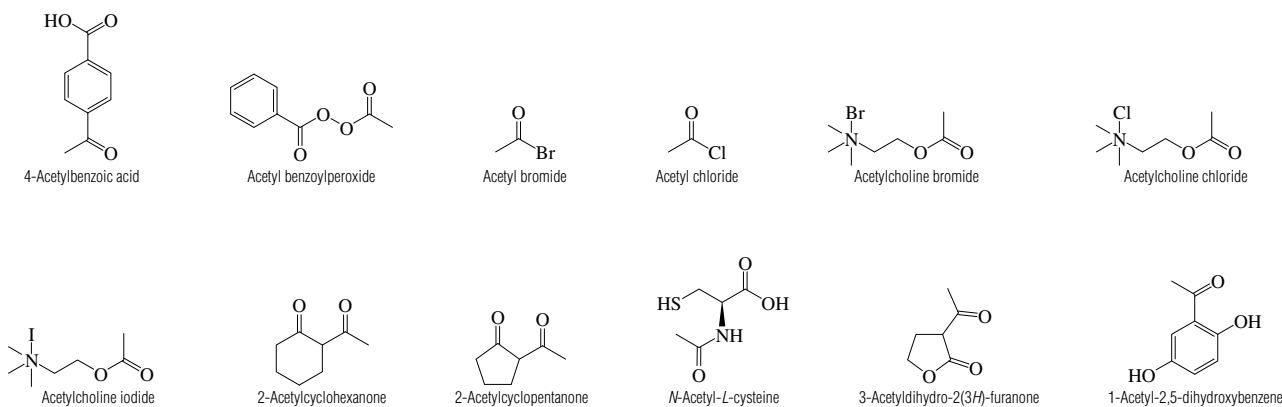
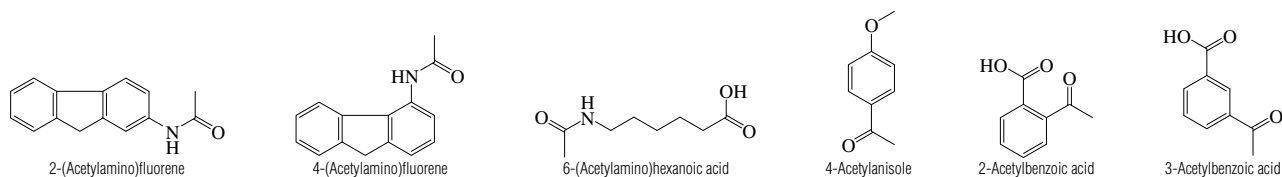
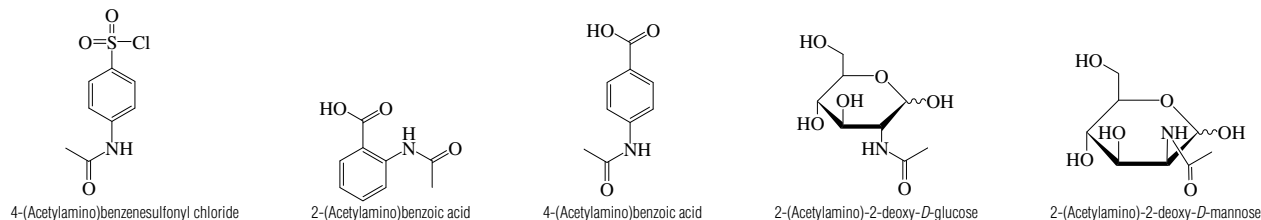
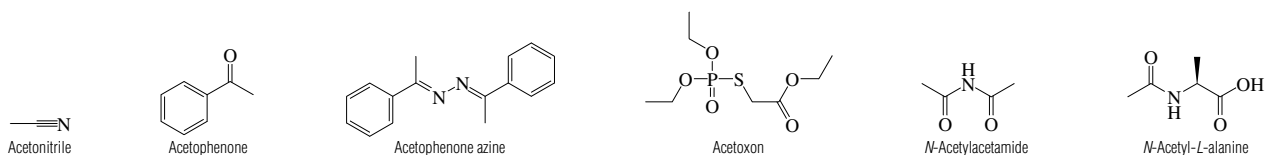
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| No. | Name                                   | Synonym                                                          | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                       |
|-----|----------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|----------------------------|---------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------------------|
| 1   | Abate                                  | Temephos                                                         | C <sub>16</sub> H <sub>20</sub> O <sub>6</sub> P <sub>2</sub> S <sub>3</sub> | 3383-96-8  | 466.469  |                            | 30      |                                       | 1.32                       |                      |                                                                  |
| 2   | Abietic acid                           |                                                                  | C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>                               | 514-10-3   | 302.451  | mcl pl (al-w)              | 173.5   | 250 <sup>9</sup>                      |                            |                      | vs ace, bz, eth, EtOH                                            |
| 3   | Absciscic acid                         |                                                                  | C <sub>15</sub> H <sub>20</sub> O <sub>4</sub>                               | 21293-29-8 | 264.318  | cry (chl-peth)             | 160     | sub 120                               |                            |                      | vs ace, eth, chl                                                 |
| 4   | Acacetin                               | 5,7-Dihydroxy-2-(4-methoxyphenyl)-4 <i>H</i> -1-benzopyran-4-one | C <sub>16</sub> H <sub>12</sub> O <sub>5</sub>                               | 480-44-4   | 284.263  | ye nd (95% al)             | 263     |                                       |                            |                      | vs EtOH                                                          |
| 5   | Acebutolol, (±)                        |                                                                  | C <sub>18</sub> H <sub>28</sub> N <sub>2</sub> O <sub>4</sub>                | 37517-30-9 | 336.426  | cry                        | 121     |                                       |                            |                      |                                                                  |
| 6   | Acedapsone                             |                                                                  | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub> S              | 77-46-3    | 332.374  | pa ye nd (eth) lf (dil al) | 290     |                                       |                            |                      | sl H <sub>2</sub> O                                              |
| 7   | Acenaphthene                           | 1,2-Dihydroacenaphthylene                                        | C <sub>12</sub> H <sub>10</sub>                                              | 83-32-9    | 154.207  |                            | 93.4    | 279                                   | 1.222 <sup>20</sup>        | 1.6048 <sup>85</sup> | i H <sub>2</sub> O; sl EtOH, chl; vs bz; s HOAc                  |
| 8   | Acenaphthylene                         | Acenaphthalene                                                   | C <sub>12</sub> H <sub>8</sub>                                               | 208-96-8   | 152.192  |                            | 91.8    | 280                                   | 0.8987 <sup>16</sup>       |                      | i H <sub>2</sub> O; vs EtOH, eth, bz; sl chl                     |
| 9   | 1,2-Acenaphthylenedione                |                                                                  | C <sub>12</sub> H <sub>6</sub> O <sub>2</sub>                                | 82-86-0    | 182.175  | ye nd (HOAc)               | 261     | sub                                   | 1.4800 <sup>20</sup>       |                      | i H <sub>2</sub> O; sl EtOH, bz, HOAc; s lig                     |
| 10  | Acenocoumarol                          | Nicoumalone                                                      | C <sub>19</sub> H <sub>16</sub> NO <sub>6</sub>                              | 152-72-7   | 353.325  | cry (ace aq)               | 198     |                                       |                            |                      | i H <sub>2</sub> O                                               |
| 11  | Acephate                               | Phosphoramidothioic acid, acetyl-, <i>O,S</i> -dimethyl ester    | C <sub>4</sub> H <sub>10</sub> NO <sub>3</sub> PS                            | 30560-19-1 | 183.166  |                            | 88      |                                       | 1.35 <sup>20</sup>         |                      |                                                                  |
| 12  | Acepromazine                           |                                                                  | C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> OS                            | 61-00-7    | 326.455  | oran oil                   |         | 230 <sup>0.5</sup>                    |                            |                      |                                                                  |
| 13  | Acesulfame                             |                                                                  | C <sub>4</sub> H <sub>5</sub> NO <sub>4</sub> S                              | 33665-90-6 | 163.153  | nd (bz)                    | 123.2   |                                       |                            |                      | s bz, chl                                                        |
| 14  | Acetaldehyde                           | Ethanal                                                          | C <sub>2</sub> H <sub>4</sub> O                                              | 75-07-0    | 44.052   | vol liq or gas             | -123.37 | 20.1                                  | 0.7834 <sup>18</sup>       | 1.3316 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, bz; sl chl                      |
| 15  | Acetaldehyde phenylhydrazone           |                                                                  | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub>                                | 935-07-9   | 134.178  |                            | 99.5    | 150 <sup>40</sup> , 135 <sup>21</sup> |                            |                      | vs EtOH                                                          |
| 16  | Acetaldoxime                           | Acetaldehyde oxime                                               | C <sub>2</sub> H <sub>5</sub> NO                                             | 107-29-9   | 59.067   | nd                         | 45      | 115                                   | 0.9656 <sup>20</sup>       | 1.4264 <sup>20</sup> | s H <sub>2</sub> O, chl; msc EtOH, eth                           |
| 17  | Acetamide                              | Ethanamide                                                       | C <sub>2</sub> H <sub>5</sub> NO                                             | 60-35-5    | 59.067   | trg mcl (al-eth)           | 80.16   | 222.0                                 | 0.9986 <sup>85</sup>       | 1.4278               | vs H <sub>2</sub> O, EtOH                                        |
| 18  | Acetanilide                            | <i>N</i> -Phenylacetamide                                        | C <sub>8</sub> H <sub>9</sub> NO                                             | 103-84-4   | 135.163  |                            | 114.3   | 304                                   | 1.2190 <sup>15</sup>       |                      | sl H <sub>2</sub> O; vs EtOH, ace; s eth, s bz, tol              |
| 19  | Acetazolamide                          | <i>N</i> -[5-(Aminosulfonyl)-1,3,4-thiadiazol-2-yl]acetamide     | C <sub>4</sub> H <sub>6</sub> N <sub>4</sub> O <sub>3</sub> S <sub>2</sub>   | 59-66-5    | 222.246  |                            | 260.5   |                                       |                            |                      | sl H <sub>2</sub> O                                              |
| 20  | Acethion                               |                                                                  | C <sub>8</sub> H <sub>17</sub> O <sub>4</sub> PS <sub>2</sub>                | 919-54-0   | 272.322  | liq                        |         | 137 <sup>1.5</sup>                    | 1.18 <sup>20</sup>         |                      |                                                                  |
| 21  | Acetic acid                            | Ethanoic acid                                                    | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                                 | 64-19-7    | 60.052   |                            | 16.64   | 117.9                                 | 1.0446 <sup>25</sup>       | 1.3720 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, bz; s chl, CS <sub>2</sub> |
| 22  | Acetic acid, 2-phenylhydrazide         |                                                                  | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O                              | 114-83-0   | 150.177  | hex pr (eth)               | 130.0   |                                       |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth, chl, tfa; s bz                |
| 23  | Acetic anhydride                       |                                                                  | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                                 | 108-24-7   | 102.089  | liq                        | -74.1   | 139.5                                 | 1.082 <sup>20</sup>        | 1.3901 <sup>20</sup> | vs H <sub>2</sub> O; s EtOH, bz; msc eth; sl ctc                 |
| 24  | Acetoacetanilide                       |                                                                  | C <sub>10</sub> H <sub>11</sub> NO <sub>2</sub>                              | 102-01-2   | 177.200  | pr or nd (bz or lig)       | 86      |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl, acid, lig             |
| 25  | Acetoacetic acid                       |                                                                  | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                                 | 541-50-4   | 102.089  | cry (eth)                  | 36.5    | dec 100                               |                            |                      | vs H <sub>2</sub> O, eth, EtOH                                   |
| 26  | 2-Acetoacetoxyethyl methacrylate       | 2-(Methacryloyloxy)ethyl acetoacetate                            | C <sub>10</sub> H <sub>14</sub> O <sub>5</sub>                               | 21282-97-3 | 214.215  | liq                        |         | 100 <sup>0.8</sup>                    | 1.122                      | 1.4560 <sup>20</sup> |                                                                  |
| 27  | Acetochlor                             |                                                                  | C <sub>14</sub> H <sub>20</sub> ClNO <sub>2</sub>                            | 34256-82-1 | 269.768  | ye liq                     |         | 134 <sup>0.4</sup>                    |                            | 1.5272 <sup>20</sup> | sl H <sub>2</sub> O                                              |
| 28  | Acetohexamide                          |                                                                  | C <sub>15</sub> H <sub>20</sub> N <sub>2</sub> O <sub>4</sub> S              | 968-81-0   | 324.396  | cry (EtOH aq)              | 188     |                                       |                            |                      | i H <sub>2</sub> O, eth; sl EtOH, chl; s py                      |
| 29  | Acetohydrazide                         |                                                                  | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O                               | 1068-57-1  | 74.081   |                            | 67      | 137 <sup>25</sup>                     |                            |                      | s H <sub>2</sub> O, EtOH; sl eth                                 |
| 30  | Acetohydroxamic acid                   | <i>N</i> -Hydroxyacetamide                                       | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                                | 546-88-3   | 75.067   | hyg cry                    | 90      |                                       |                            |                      |                                                                  |
| 31  | 1-Acetonaphthone                       |                                                                  | C <sub>12</sub> H <sub>10</sub> O                                            | 941-98-0   | 170.206  |                            | 34      | 297                                   | 1.1171 <sup>21</sup>       | 1.6280 <sup>22</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, chl                        |
| 32  | 2-Acetonaphthone                       |                                                                  | C <sub>12</sub> H <sub>10</sub> O                                            | 93-08-3    | 170.206  | nd (lig, dil al)           | 56      | 302                                   |                            |                      | sl EtOH, ctc                                                     |
| 33  | Acetone                                | 2-Propanone                                                      | C <sub>3</sub> H <sub>6</sub> O                                              | 67-64-1    | 58.079   | liq                        | -94.7   | 56.05                                 | 0.7845 <sup>25</sup>       | 1.3588 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, bz, chl                    |
| 34  | Acetone cyanohydrin                    |                                                                  | C <sub>4</sub> H <sub>7</sub> NO                                             | 75-86-5    | 85.105   |                            | -19     | 82 <sup>23</sup>                      | 0.932 <sup>19</sup>        | 1.3992 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; s ace, bz, chl; i peth           |
| 35  | Acetone (2,4-dinitrophenyl) hydrazone  |                                                                  | C <sub>9</sub> H <sub>10</sub> N <sub>4</sub> O <sub>4</sub>                 | 1567-89-1  | 238.200  | ye nd or pl (al)           | 128     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl, AcOEt                  |
| 36  | Acetone (1-methylethylidene) hydrazone | Dimethyl ketazine                                                | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>                                | 627-70-3   | 112.172  | liq                        | -12.5   | 133                                   | 0.8390 <sup>20</sup>       | 1.4535 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace                           |
| 37  | Acetone thiosemicarbazide              |                                                                  | C <sub>4</sub> H <sub>9</sub> N <sub>3</sub> S                               | 1752-30-3  | 131.199  | ye cry                     | 176     |                                       |                            |                      | s ace                                                            |

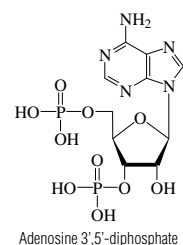
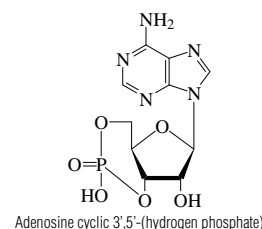
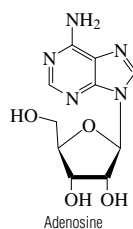
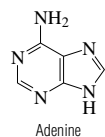
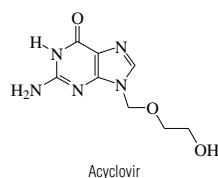
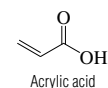
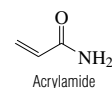
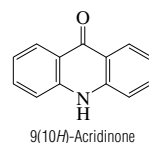
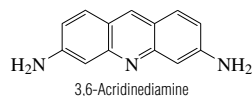
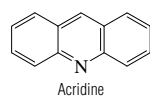
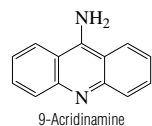
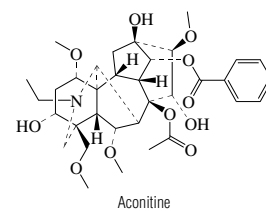
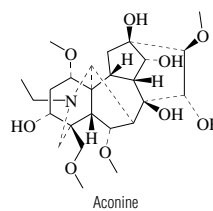
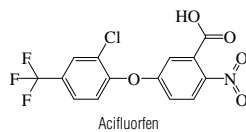
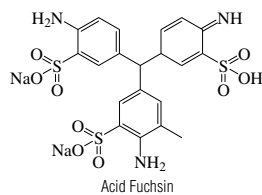
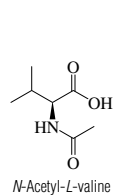
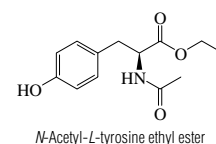
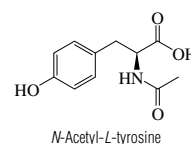
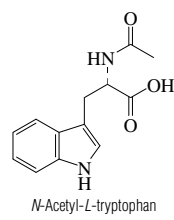
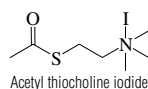
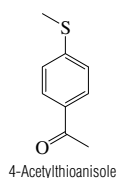
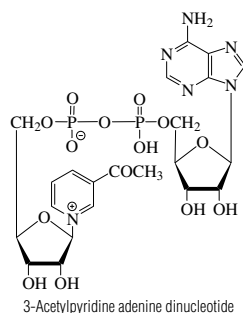
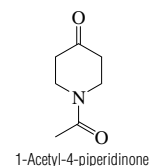
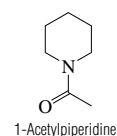
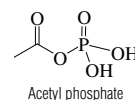
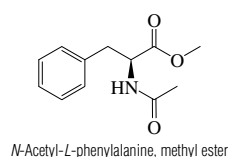
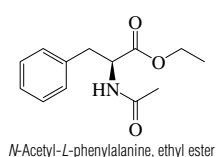
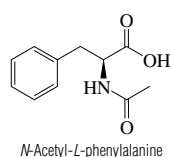
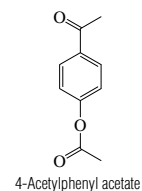
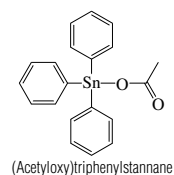
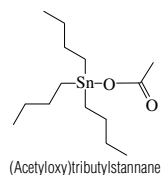
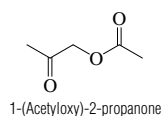
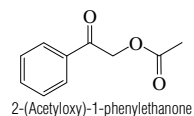
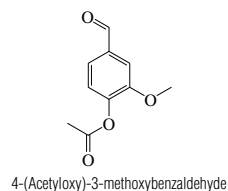
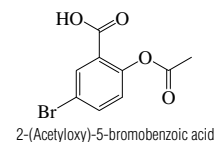
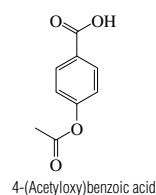
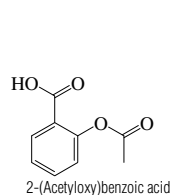
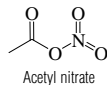
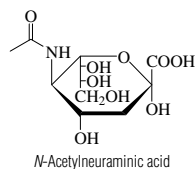
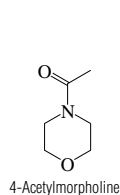




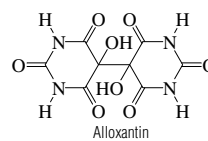
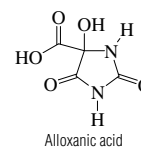
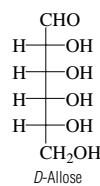
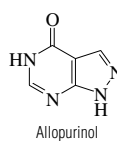
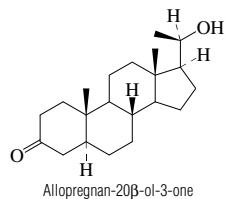
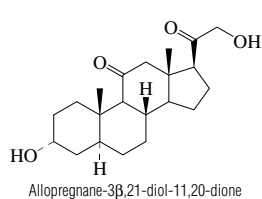
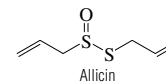
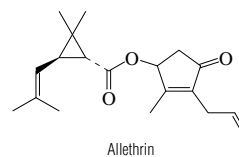
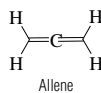
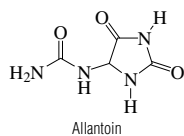
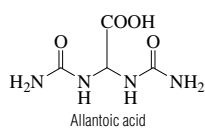
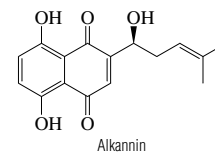
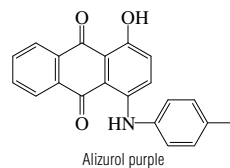
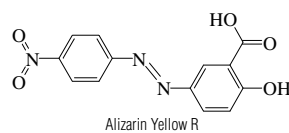
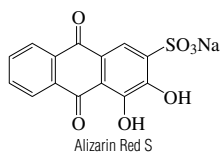
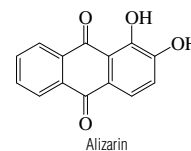
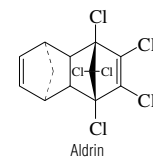
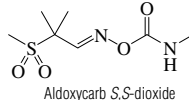
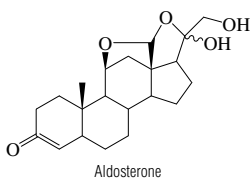
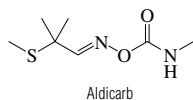
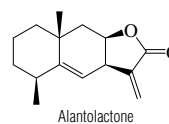
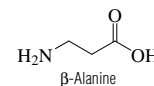
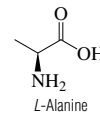
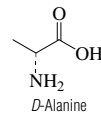
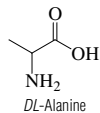
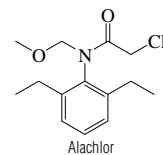
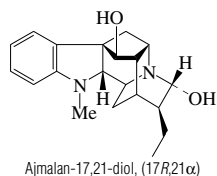
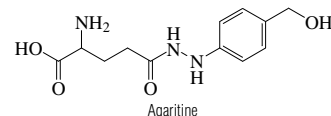
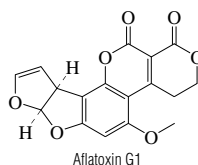
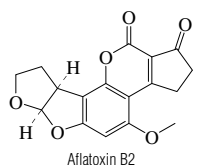
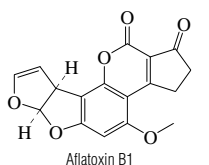
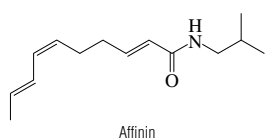
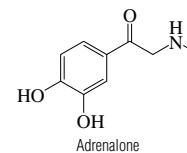
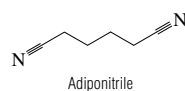
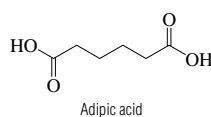
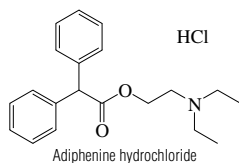
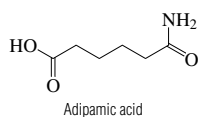
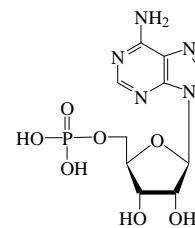
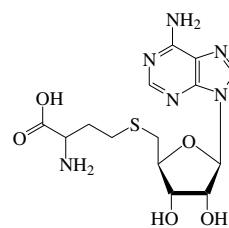
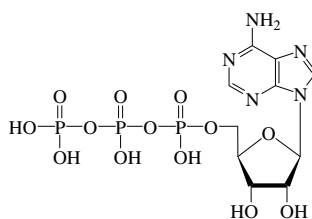
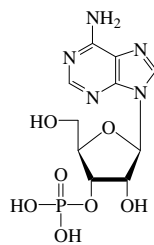
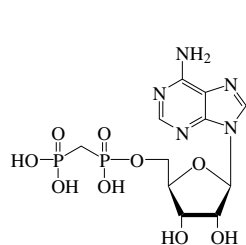
| No. | Name                                                       | Synonym                                 | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form           | mp/°C                | bp/°C                                 | den/<br>g cm <sup>-3</sup>    | n <sub>D</sub>       | Solubility                                                  |
|-----|------------------------------------------------------------|-----------------------------------------|---------------------------------------------------------------|------------|----------|-------------------------|----------------------|---------------------------------------|-------------------------------|----------------------|-------------------------------------------------------------|
| 38  | Acetonitrile                                               | Methyl cyanide                          | C <sub>2</sub> H <sub>3</sub> N                               | 75-05-8    | 41.052   | liq                     | -43.82               | 81.65                                 | 0.7857 <sup>20</sup>          | 1.3442 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, bz, ctc               |
| 39  | Acetophenone                                               | Methyl phenyl ketone                    | C <sub>8</sub> H <sub>8</sub> O                               | 98-86-2    | 120.149  | mcl pr or pl            | 20.5                 | 202                                   | 1.0281 <sup>20</sup>          | 1.5372 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, con sulf, chl    |
| 40  | Acetophenone azine                                         | Methylphenyl ketazine                   | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub>                | 729-43-1   | 236.311  |                         | 120                  |                                       |                               |                      |                                                             |
| 41  | Acetoxon                                                   | Acetophos                               | C <sub>8</sub> H <sub>17</sub> O <sub>5</sub> PS              | 2425-25-4  | 256.257  | liq                     |                      | 73 <sup>0.005</sup>                   |                               |                      |                                                             |
| 42  | <i>N</i> -Acetylacetamide                                  |                                         | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 625-77-4   | 101.105  | nd (eth)                | 79                   | 223.5                                 |                               |                      | s H <sub>2</sub> O, EtOH, eth, chl, lig                     |
| 43  | <i>N</i> -Acetyl- <i>L</i> -alanine                        |                                         | C <sub>7</sub> H <sub>9</sub> NO <sub>3</sub>                 | 97-69-8    | 131.130  |                         | 125                  |                                       |                               |                      |                                                             |
| 44  | 4-(Acetylamino)benzenesulfonyl chloride                    | Acetylsulfanilyl chloride               | C <sub>8</sub> H <sub>9</sub> ClNO <sub>3</sub> S             | 121-60-8   | 233.673  | nd (bz), pr (bz-chl)    | 149                  |                                       |                               |                      | vs EtOH, eth; s bz, chl                                     |
| 45  | 2-(Acetylamino)benzoic acid                                |                                         | C <sub>9</sub> H <sub>9</sub> NO <sub>3</sub>                 | 89-52-1    | 179.172  | nd (HOAc)               | 187.5                |                                       |                               |                      | sl H <sub>2</sub> O; s EtOH; vs eth, ace, bz, HOAc          |
| 46  | 4-(Acetylamino)benzoic acid                                |                                         | C <sub>9</sub> H <sub>9</sub> NO <sub>3</sub>                 | 556-08-1   | 179.172  | nd (HOAc)               | 256.5                |                                       |                               |                      | i H <sub>2</sub> O; s EtOH; sl eth, tfa                     |
| 47  | 2-(Acetylamino)-2-deoxy- <i>D</i> -glucose                 | <i>N</i> -Acetyl- <i>D</i> -glucosamine | C <sub>8</sub> H <sub>15</sub> NO <sub>6</sub>                | 7512-17-6  | 221.208  |                         | 205                  |                                       |                               |                      |                                                             |
| 48  | 2-(Acetylamino)-2-deoxy- <i>D</i> -mannose                 | <i>N</i> -Acetyl- <i>D</i> -mannosamine | C <sub>8</sub> H <sub>15</sub> NO <sub>6</sub>                | 3615-17-6  | 221.208  | cry (ace aq)            | 128                  |                                       |                               |                      | dec alk                                                     |
| 49  | 2-(Acetylamino)fluorene                                    |                                         | C <sub>15</sub> H <sub>13</sub> NO                            | 53-96-3    | 223.270  | cry (dil al)            | 193                  |                                       |                               |                      | i H <sub>2</sub> O; s EtOH, eth, HOAc                       |
| 50  | 4-(Acetylamino)fluorene                                    |                                         | C <sub>15</sub> H <sub>13</sub> NO                            | 28322-02-3 | 223.270  | br cry (bz)             | 200                  |                                       |                               |                      |                                                             |
| 51  | 6-(Acetylamino)hexanoic acid                               | ε-Acetamidocaproic acid                 | C <sub>8</sub> H <sub>15</sub> NO <sub>3</sub>                | 57-08-9    | 173.210  | cry (ace)               | 104.5                |                                       |                               |                      |                                                             |
| 52  | 4-Acetylanisole                                            |                                         | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 100-06-1   | 150.174  | pl (peth)               | 38.5                 | 258                                   | 1.0818 <sup>41</sup>          | 1.547 <sup>41</sup>  | sl H <sub>2</sub> O; s EtOH, eth, ace, chl                  |
| 53  | 2-Acetylbenzoic acid                                       |                                         | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                  | 577-56-0   | 164.158  | nd (w), pr (bz)         | 114.5                | 111 <sup>2</sup>                      |                               |                      | vs H <sub>2</sub> O, eth, EtOH                              |
| 54  | 3-Acetylbenzoic acid                                       |                                         | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                  | 586-42-5   | 164.158  |                         | 172                  | 111 <sup>2</sup>                      |                               |                      | s H <sub>2</sub> O; msc EtOH                                |
| 55  | 4-Acetylbenzoic acid                                       |                                         | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                  | 586-89-0   | 164.158  | nd (w)                  | 208                  | sub                                   |                               |                      | vs H <sub>2</sub> O                                         |
| 56  | Acetyl benzoylperoxide                                     | Acetozone                               | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                  | 644-31-5   | 180.158  | wh nd (lig)             | 37                   | 130 <sup>19</sup>                     |                               |                      | vs eth                                                      |
| 57  | Acetyl bromide                                             | Ethanoyl bromide                        | C <sub>2</sub> H <sub>3</sub> BrO                             | 506-96-7   | 122.948  | liq                     | -96                  | 76                                    | 1.6625 <sup>16</sup>          | 1.4486 <sup>20</sup> | msc eth, bz, chl; s ace                                     |
| 58  | Acetyl chloride                                            | Ethanoyl chloride                       | C <sub>2</sub> H <sub>3</sub> ClO                             | 75-36-5    | 78.497   | liq                     | -112.8               | 50.7                                  | 1.1051 <sup>20</sup>          | 1.3886 <sup>20</sup> | msc eth, ace, bz, chl; s ctc                                |
| 59  | Acetylcholine bromide                                      |                                         | C <sub>7</sub> H <sub>16</sub> BrNO <sub>2</sub>              | 66-23-9    | 226.112  | hyg cry                 | 146                  |                                       |                               |                      | vs H <sub>2</sub> O                                         |
| 60  | Acetylcholine chloride                                     |                                         | C <sub>7</sub> H <sub>16</sub> ClNO <sub>2</sub>              | 60-31-1    | 181.661  |                         | 150                  |                                       |                               |                      | s H <sub>2</sub> O, EtOH; i eth                             |
| 61  | Acetylcholine iodide                                       |                                         | C <sub>7</sub> H <sub>16</sub> INO <sub>2</sub>               | 2260-50-6  | 273.112  | hyg                     | 163                  |                                       |                               |                      |                                                             |
| 62  | 2-Acetylcyclohexanone                                      |                                         | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                 | 874-23-7   | 140.180  |                         | -11                  | 112 <sup>18</sup> , 101 <sup>14</sup> | 1.0782 <sup>25</sup>          | 1.5138 <sup>20</sup> | s ctc                                                       |
| 63  | 2-Acetylcyclopentanone                                     |                                         | C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>                 | 1670-46-8  | 126.153  |                         |                      | 73 <sup>20</sup>                      | 1.0431 <sup>25</sup>          | 1.4906 <sup>20</sup> |                                                             |
| 64  | <i>N</i> -Acetyl- <i>L</i> -cysteine                       | Acetylcysteine                          | C <sub>7</sub> H <sub>9</sub> NO <sub>3</sub> S               | 616-91-1   | 163.195  | cry (w)                 | 109.5                |                                       |                               |                      |                                                             |
| 65  | 3-Acetyldihydro-2(3 <i>H</i> )-furanone                    | α-Acetylbutyrolactone                   | C <sub>6</sub> H <sub>8</sub> O <sub>3</sub>                  | 517-23-7   | 128.126  |                         |                      | 107 <sup>5</sup>                      | 1.1846 <sup>20</sup>          | 1.4585 <sup>20</sup> | vs H <sub>2</sub> O                                         |
| 66  | 1-Acetyl-2,5-dihydroxybenzene                              | 2,5-Dihydroxyacetophenone               | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 490-78-8   | 152.148  | ye grn nd (dil al or w) | 205.3                |                                       |                               |                      | sl H <sub>2</sub> O, eth, bz; s EtOH                        |
| 67  | Acetylene                                                  | Ethyne                                  | C <sub>2</sub> H <sub>2</sub>                                 | 74-86-2    | 26.037   | col gas                 | -80.7 (triple point) | -84.7 sp                              | 0.377 <sup>25</sup> (p>1 atm) |                      | sl H <sub>2</sub> O, EtOH, CS <sub>2</sub> ; s ace, bz, chl |
| 68  | <i>N</i> -Acetyethanolamine                                |                                         | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                 | 142-26-7   | 103.120  |                         | 63.5                 | 166 <sup>8</sup>                      | 1.1079 <sup>25</sup>          | 1.4674 <sup>20</sup> | msc H <sub>2</sub> O; s ace; sl bz, lig                     |
| 69  | Acetyl fluoride                                            | Ethanoyl fluoride                       | C <sub>2</sub> H <sub>3</sub> FO                              | 557-99-3   | 62.042   | vol liq or gas          | -84                  | 20.8                                  | 1.032 <sup>25</sup>           |                      | msc EtOH, eth; s bz, chl; sl CS <sub>2</sub>                |
| 70  | <i>N</i> -Acetylglutamic acid                              |                                         | C <sub>7</sub> H <sub>11</sub> NO <sub>5</sub>                | 1188-37-0  | 189.166  | pr (w)                  | 199                  |                                       |                               |                      | s H <sub>2</sub> O, EtOH                                    |
| 71  | <i>N</i> -Acetylglycine                                    | Aceturic acid                           | C <sub>4</sub> H <sub>7</sub> NO <sub>3</sub>                 | 543-24-8   | 117.104  | lo nd (w, MeOH)         | 206                  |                                       |                               |                      | vs H <sub>2</sub> O, ace, EtOH                              |
| 72  | <i>trans</i> -1-Acetyl-4-hydroxy- <i>L</i> -proline        | Oxaceprol                               | C <sub>7</sub> H <sub>11</sub> NO <sub>4</sub>                | 33996-33-7 | 173.167  | cry (Ac)                | 132                  |                                       |                               |                      | vs H <sub>2</sub> O, MeOH                                   |
| 73  | 1-Acetyl-1 <i>H</i> -imidazole                             |                                         | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub> O                | 2466-76-4  | 110.114  |                         | 104.5                |                                       |                               |                      | sl H <sub>2</sub> O; s EtOH, eth, chl, THF                  |
| 74  | Acetyl iodide                                              | Ethanoyl iodide                         | C <sub>2</sub> H <sub>3</sub> IO                              | 507-02-8   | 169.948  |                         |                      | 108                                   | 2.0673 <sup>20</sup>          | 1.5491 <sup>20</sup> | vs eth                                                      |
| 75  | Acetyl isothiocyanate                                      |                                         | C <sub>3</sub> H <sub>3</sub> NOS                             | 13250-46-9 | 101.127  |                         |                      | 132.5                                 | 1.1523 <sup>13</sup>          | 1.5231 <sup>18</sup> | s eth, CS <sub>2</sub>                                      |
| 76  | <i>N</i> 6-Acetyl- <i>L</i> -lysine                        |                                         | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub>  | 692-04-6   | 188.224  |                         | 265 dec              |                                       |                               |                      |                                                             |
| 77  | <i>N</i> -Acetyl- <i>DL</i> -methionine                    |                                         | C <sub>7</sub> H <sub>13</sub> NO <sub>3</sub> S              | 1115-47-5  | 191.248  |                         | 114.5                |                                       |                               |                      |                                                             |
| 78  | <i>N</i> -Acetyl- <i>L</i> -methionine                     | Methionamine                            | C <sub>7</sub> H <sub>13</sub> NO <sub>3</sub> S              | 65-82-7    | 191.248  |                         | 105.5                |                                       |                               |                      |                                                             |
| 79  | 1-Acetyl-17-methoxyaspidospermidine                        | Aspidospermine                          | C <sub>22</sub> H <sub>30</sub> N <sub>2</sub> O <sub>2</sub> | 466-49-9   | 354.485  | nd or pr (al) nd (peth) | 208                  | 220 <sup>2</sup>                      |                               |                      | sl H <sub>2</sub> O, eth; s EtOH, bz, chl                   |
| 80  | <i>N</i> -Acetyl- <i>N</i> -methylacetamide                |                                         | C <sub>8</sub> H <sub>13</sub> NO <sub>2</sub>                | 1113-68-4  | 115.131  | liq                     | -25                  | 195; 114.5 <sup>61</sup>              | 1.0663 <sup>25</sup>          | 1.4502 <sup>25</sup> | msc H <sub>2</sub> O; i eth                                 |
| 81  | 1-Acetyl-3-methylpiperidine                                |                                         | C <sub>8</sub> H <sub>15</sub> NO                             | 4593-16-2  | 141.211  | liq                     | -13.6                | 239                                   | 0.9684 <sup>25</sup>          | 1.4731 <sup>25</sup> | vs H <sub>2</sub> O                                         |
| 82  | 3-Acetyl-6-methyl-2 <i>H</i> -pyran-2,4(3 <i>H</i> )-dione | Dehydroacetic acid                      | C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                  | 520-45-6   | 168.148  |                         | 109                  | 270                                   |                               |                      | vs H <sub>2</sub> O, eth; sl EtOH, chl                      |



| No. | Name                                                    | Synonym                                                     | Mol. Form.                                                                                   | CAS RN     | Mol. Wt. | Physical Form               | mp/°C                    | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|-----|---------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------|----------|-----------------------------|--------------------------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------|
| 83  | 4-Acetylmorpholine                                      |                                                             | C <sub>8</sub> H <sub>11</sub> NO <sub>2</sub>                                               | 1696-20-4  | 129.157  |                             | 14.5                     | 152 <sup>50</sup> , 118 <sup>12</sup> | 1.1145 <sup>20</sup>       | 1.4827 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, ace, ctc            |
| 84  | <i>N</i> -Acetylneuraminic acid                         | Aceneuramic acid                                            | C <sub>11</sub> H <sub>19</sub> NO <sub>9</sub>                                              | 131-48-6   | 309.271  |                             | 186                      |                                       |                            |                      |                                                   |
| 85  | Acetyl nitrate                                          |                                                             | C <sub>2</sub> H <sub>3</sub> NO <sub>4</sub>                                                | 591-09-3   | 105.050  |                             |                          | exp 60; 22 <sup>70</sup>              | 1.24 <sup>15</sup>         |                      |                                                   |
| 86  | 2-(Acetyloxy)benzoic acid                               | Acetylsalicylic acid                                        | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                                                 | 50-78-2    | 180.158  | nd (w), mcl tab (w)         | 135                      |                                       |                            |                      | s H <sub>2</sub> O, eth, chl; vs EtOH; sl bz      |
| 87  | 4-(Acetyloxy)benzoic acid                               |                                                             | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                                                 | 2345-34-8  | 180.158  |                             | 188.5                    |                                       |                            |                      |                                                   |
| 88  | 2-(Acetyloxy)-5-bromobenzoic acid                       | 5-Bromoacetylsalicylic acid                                 | C <sub>9</sub> H <sub>7</sub> BrO <sub>4</sub>                                               | 1503-53-3  | 259.054  | nd (al)                     | 60                       |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                  |
| 89  | 4-(Acetyloxy)-3-methoxybenzaldehyde                     |                                                             | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                                               | 881-68-5   | 194.184  |                             | 78                       |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth                 |
| 90  | 2-(Acetyloxy)-1-phenylethanone                          |                                                             | C <sub>10</sub> H <sub>10</sub> O <sub>3</sub>                                               | 2243-35-8  | 178.184  | orth pl                     | 49                       | 270                                   | 1.1169 <sup>65</sup>       | 1.5036 <sup>65</sup> | i H <sub>2</sub> O; vs EtOH, eth, chl; sl bz, lig |
| 91  | 1-(Acetyloxy)-2-propanone                               | Acetoxycetone                                               | C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>                                                 | 592-20-1   | 116.116  |                             |                          | 171; 63 <sup>11</sup>                 | 1.0757 <sup>20</sup>       | 1.4141 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                    |
| 92  | (Acetyloxy)tributylstannane                             | Tributyltin acetate                                         | C <sub>14</sub> H <sub>30</sub> O <sub>2</sub> Sn                                            | 56-36-0    | 349.097  |                             | 84.7                     |                                       |                            |                      |                                                   |
| 93  | (Acetyloxy)triphenylstannane                            | Triphenyltin acetate                                        | C <sub>20</sub> H <sub>18</sub> O <sub>2</sub> Sn                                            | 900-95-8   | 409.066  |                             | 121.5                    |                                       |                            |                      |                                                   |
| 94  | 4-Acetylphenyl acetate                                  |                                                             | C <sub>10</sub> H <sub>10</sub> O <sub>3</sub>                                               | 13031-43-1 | 178.184  |                             |                          |                                       |                            |                      | s ctc, CS <sub>2</sub>                            |
| 95  | <i>N</i> -Acetyl- <i>L</i> -phenylalanine               |                                                             | C <sub>11</sub> H <sub>13</sub> NO <sub>3</sub>                                              | 2018-61-3  | 207.226  |                             | 173.5                    |                                       |                            |                      | s EtOH                                            |
| 96  | <i>N</i> -Acetyl- <i>L</i> -phenylalanine, ethyl ester  |                                                             | C <sub>13</sub> H <sub>17</sub> NO <sub>3</sub>                                              | 2361-96-8  | 235.279  | cry (EtOH aq)               | 93                       |                                       |                            |                      |                                                   |
| 97  | <i>N</i> -Acetyl- <i>L</i> -phenylalanine, methyl ester |                                                             | C <sub>12</sub> H <sub>15</sub> NO <sub>3</sub>                                              | 3618-96-0  | 221.252  | nd (peth) or visc oil (chl) | 91                       |                                       |                            |                      |                                                   |
| 98  | Acetyl phosphate                                        |                                                             | C <sub>2</sub> H <sub>5</sub> O <sub>5</sub> P                                               | 590-54-5   | 140.032  | unstab in soln              |                          |                                       |                            |                      |                                                   |
| 99  | 1-Acetylpyridine                                        |                                                             | C <sub>7</sub> H <sub>13</sub> NO                                                            | 618-42-8   | 127.184  | liq                         | -13.4                    | 226.5                                 | 1.011 <sup>9</sup>         | 1.4790 <sup>25</sup> | vs H <sub>2</sub> O, EtOH                         |
| 100 | 1-Acetyl-4-piperidinone                                 |                                                             | C <sub>7</sub> H <sub>11</sub> NO <sub>2</sub>                                               | 32161-06-1 | 141.168  |                             |                          | 218; 124 <sup>02</sup>                | 1.146 <sup>25</sup>        | 1.5026 <sup>20</sup> |                                                   |
| 101 | 3-Acetylpyridine adenine dinucleotide                   | 3-Acetyl NAD                                                | C <sub>22</sub> H <sub>28</sub> N <sub>6</sub> O <sub>14</sub> P <sub>2</sub>                | 86-08-8    | 662.436  | solid                       |                          |                                       |                            |                      |                                                   |
| 102 | 4-Acetylthioanisole                                     |                                                             | C <sub>9</sub> H <sub>10</sub> OS                                                            | 1778-09-2  | 166.239  |                             | 81.5                     |                                       |                            |                      |                                                   |
| 103 | Acetyl thiocholine iodide                               |                                                             | C <sub>7</sub> H <sub>16</sub> INOS                                                          | 1866-15-5  | 289.177  |                             | 205                      |                                       |                            |                      |                                                   |
| 104 | <i>N</i> -Acetyl- <i>L</i> -tryptophan                  |                                                             | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>                                | 1218-34-4  | 246.261  | nd (dil MeOH)               | 189.5                    |                                       |                            |                      | s H <sub>2</sub> O, EtOH, alk                     |
| 105 | <i>N</i> -Acetyl- <i>L</i> -tyrosine                    |                                                             | C <sub>11</sub> H <sub>13</sub> NO <sub>4</sub>                                              | 537-55-3   | 223.226  | cry (w); pl (diox)          | 153                      |                                       |                            |                      |                                                   |
| 106 | <i>N</i> -Acetyl- <i>L</i> -tyrosine ethyl ester        |                                                             | C <sub>13</sub> H <sub>17</sub> NO <sub>4</sub>                                              | 840-97-1   | 251.279  |                             | 80.5                     |                                       |                            |                      |                                                   |
| 107 | <i>N</i> -Acetyl- <i>L</i> -valine                      |                                                             | C <sub>7</sub> H <sub>13</sub> NO <sub>3</sub>                                               | 96-81-1    | 159.183  |                             | 164                      |                                       |                            |                      |                                                   |
| 108 | Acid Fuchsin                                            | Fuchsin, acid                                               | C <sub>20</sub> H <sub>17</sub> N <sub>3</sub> Na <sub>2</sub> O <sub>9</sub> S <sub>3</sub> | 3244-88-0  | 585.539  |                             |                          |                                       |                            |                      | sl H <sub>2</sub> O, EtOH                         |
| 109 | Acifluorfen                                             | 5-[2-Chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid | C <sub>14</sub> H <sub>7</sub> ClF <sub>3</sub> NO <sub>5</sub>                              | 50594-66-6 | 361.658  |                             | 150                      |                                       |                            |                      |                                                   |
| 110 | Aconine                                                 |                                                             | C <sub>25</sub> H <sub>41</sub> NO <sub>9</sub>                                              | 509-20-6   | 499.596  | amor                        | 132                      |                                       |                            |                      | s H <sub>2</sub> O, EtOH, chl; sl eth, lig        |
| 111 | Aconitine                                               |                                                             | C <sub>34</sub> H <sub>47</sub> NO <sub>11</sub>                                             | 302-27-2   | 645.737  | orth lf                     | 204                      |                                       |                            |                      | vs bz, EtOH, chl                                  |
| 112 | 9-Acridinamine                                          | Aminacrine                                                  | C <sub>13</sub> H <sub>10</sub> N <sub>2</sub>                                               | 90-45-9    | 194.231  | ye nd (ace or al)           | 241                      |                                       |                            |                      | s EtOH, ace; sl DMSO; vs dil HCl                  |
| 113 | Acridine                                                | Dibenzo[b,e]pyridine                                        | C <sub>13</sub> H <sub>9</sub> N                                                             | 260-94-6   | 179.217  | orth nd or pr (al)          | 106(form a); 110(form b) | 344.86                                | 1.005 <sup>20</sup>        |                      | i H <sub>2</sub> O; sl ctc; vs EtOH, eth, bz      |
| 114 | 3,6-Acridinediamine                                     | Proflavine                                                  | C <sub>13</sub> H <sub>11</sub> N <sub>3</sub>                                               | 92-62-6    | 209.246  | ye nd (al or w)             | 285                      |                                       |                            |                      | s H <sub>2</sub> O; vs EtOH; sl eth, bz           |
| 115 | 9(10 <i>H</i> )-Acridinone                              |                                                             | C <sub>13</sub> H <sub>9</sub> NO                                                            | 578-95-0   | 195.216  | ye lf (al)                  | >300                     |                                       |                            |                      | i H <sub>2</sub> O, eth, bz; sl EtOH; s HOAc, alk |
| 116 | Acrolein                                                | 2-Propenal                                                  | C <sub>3</sub> H <sub>4</sub> O                                                              | 107-02-8   | 56.063   | liq                         | -87.7                    | 52.6                                  | 0.840 <sup>20</sup>        | 1.4017 <sup>20</sup> | vs H <sub>2</sub> O; s EtOH, eth, ace; sl chl     |
| 117 | Acrylamide                                              | 2-Propenamide                                               | C <sub>3</sub> H <sub>5</sub> NO                                                             | 79-06-1    | 71.078   | lf (bz)                     | 84.5                     | 192.6                                 |                            |                      | vs H <sub>2</sub> O, chl; s EtOH, eth, ace        |
| 118 | Acrylic acid                                            | 2-Propenoic acid                                            | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                                                 | 79-10-7    | 72.063   |                             | 12.5                     | 141                                   | 1.0511 <sup>20</sup>       | 1.4224 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace, bz, ctc   |
| 119 | Acrylonitrile                                           | Propenenitrile                                              | C <sub>3</sub> H <sub>3</sub> N                                                              | 107-13-1   | 53.063   | liq                         | -83.48                   | 77.3                                  | 0.8007 <sup>25</sup>       | 1.3911 <sup>20</sup> | s H <sub>2</sub> O; vs ace, bz, eth, EtOH         |
| 120 | Acyclovir                                               |                                                             | C <sub>8</sub> H <sub>11</sub> N <sub>5</sub> O <sub>3</sub>                                 | 59277-89-3 | 225.205  | cry (EtOH)                  | 225                      |                                       |                            |                      |                                                   |
| 121 | Adenine                                                 | 1 <i>H</i> -Purin-6-amine                                   | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub>                                                 | 73-24-5    | 135.128  | orth nd (+3w)               | 360 dec                  | sub 220                               |                            |                      | s H <sub>2</sub> O; sl EtOH; i eth, chl           |
| 122 | Adenosine                                               | β- <i>D</i> -Ribofuranoside, adenine-9                      | C <sub>10</sub> H <sub>13</sub> N <sub>5</sub> O <sub>4</sub>                                | 58-61-7    | 267.242  | n(w+3/2)                    | 235.5                    |                                       |                            |                      | sl H <sub>2</sub> O; i EtOH                       |
| 123 | Adenosine cyclic 3',5'-(hydrogen phosphate)             | cAMP                                                        | C <sub>10</sub> H <sub>12</sub> N <sub>5</sub> O <sub>6</sub> P                              | 60-92-4    | 329.206  | cry                         | 219                      |                                       |                            |                      |                                                   |
| 124 | Adenosine 3',5'-diphosphate                             | 3'-Adenylic acid, 5'-(dihydrogen phosphate)                 | C <sub>10</sub> H <sub>15</sub> N <sub>5</sub> O <sub>10</sub> P <sub>2</sub>                | 1053-73-2  | 427.202  | amor pow                    |                          |                                       |                            |                      |                                                   |

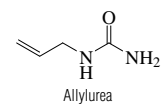
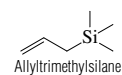
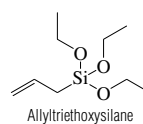
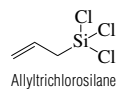
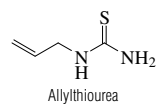
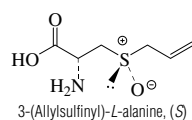
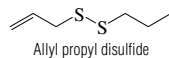
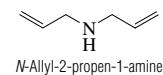
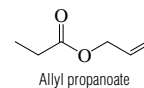
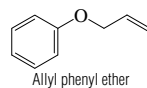
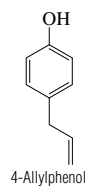
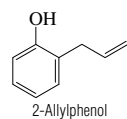
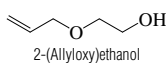
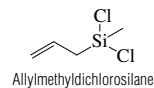
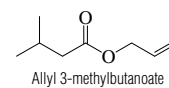
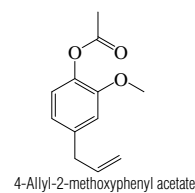
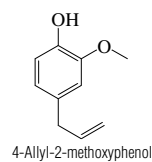
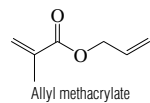
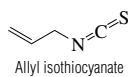
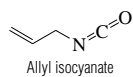
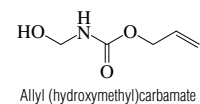
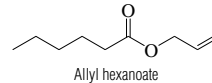
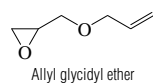
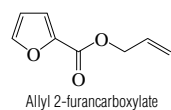
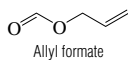
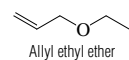
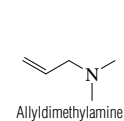
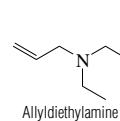
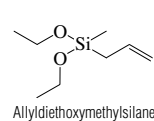
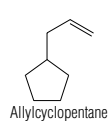
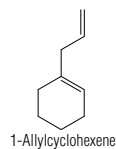
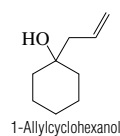
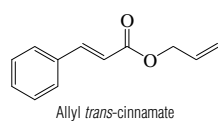
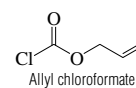
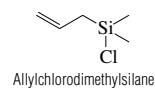
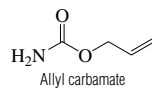
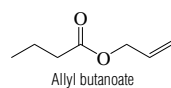
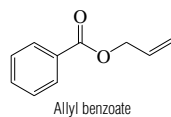
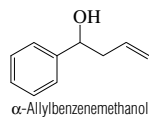
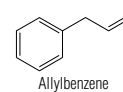
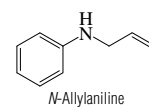
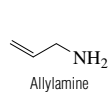
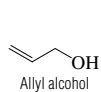
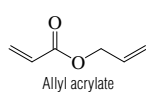
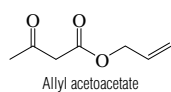
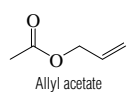


| No. | Name                                            | Synonym                                                         | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form                 | mp/°C   | bp/°C               | den/<br>g cm <sup>-3</sup>    | n <sub>D</sub>       | Solubility                                       |
|-----|-------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|-------------------------------|---------|---------------------|-------------------------------|----------------------|--------------------------------------------------|
| 125 | Adenosine 5'-methylenediphosphonate             | Adenosine, 5'-[hydrogen (phosphonomethyl) phosphonate]          | C <sub>11</sub> H <sub>17</sub> N <sub>5</sub> O <sub>9</sub> P <sub>2</sub>  | 3768-14-7  | 425.229  | cry (w)                       | 204     |                     |                               |                      | s H <sub>2</sub> O                               |
| 126 | Adenosine 3'-phosphate                          | 3'-Adenylic acid                                                | C <sub>10</sub> H <sub>14</sub> N <sub>5</sub> O <sub>7</sub> P               | 84-21-9    | 347.222  | col nd                        | 195 dec |                     |                               |                      |                                                  |
| 127 | Adenosine 5'-triphosphate                       | ATP                                                             | C <sub>10</sub> H <sub>16</sub> N <sub>5</sub> O <sub>13</sub> P <sub>3</sub> | 56-65-5    | 507.181  |                               | 144 dec |                     |                               |                      |                                                  |
| 128 | S-Adenosyl-L-homocysteine                       |                                                                 | C <sub>14</sub> H <sub>20</sub> N <sub>6</sub> O <sub>5</sub> S               | 979-92-0   | 384.411  |                               | 210 dec |                     |                               |                      |                                                  |
| 129 | 5'-Adenylic acid                                | Adenosine 5'-monophosphate                                      | C <sub>10</sub> H <sub>14</sub> N <sub>5</sub> O <sub>7</sub> P               | 61-19-8    | 347.222  |                               | 195 dec |                     |                               |                      | vs H <sub>2</sub> O; s EtOH, 10% HCl             |
| 130 | Adipamic acid                                   |                                                                 | C <sub>8</sub> H <sub>11</sub> NO <sub>3</sub>                                | 334-25-8   | 145.156  | nd (w)                        | 161.5   |                     |                               |                      |                                                  |
| 131 | Adiphenine hydrochloride                        |                                                                 | C <sub>20</sub> H <sub>26</sub> ClNO <sub>2</sub>                             | 50-42-0    | 347.879  | cry                           | 113.5   |                     |                               |                      | vs H <sub>2</sub> O; sl EtOH, eth                |
| 132 | Adipic acid                                     | 1,6-Hexanedioic acid                                            | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                                 | 124-04-9   | 146.141  | mcl pr (w, ace, lig)          | 152.5   | 337.5               | 1.360 <sup>25</sup>           |                      | sl H <sub>2</sub> O; vs EtOH; s eth; i HOAc, lig |
| 133 | Adiponitrile                                    | Hexanedinitrile                                                 | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                  | 111-69-3   | 108.141  | nd (eth)                      | 1       | 295                 | 0.9676 <sup>20</sup>          | 1.4380 <sup>20</sup> | sl H <sub>2</sub> O, eth; s chl, EtOH            |
| 134 | Adrenalone                                      |                                                                 | C <sub>9</sub> H <sub>11</sub> NO <sub>3</sub>                                | 99-45-6    | 181.188  | nd                            | 235 dec |                     |                               |                      | sl H <sub>2</sub> O, EtOH, eth                   |
| 135 | Affinin                                         | N-(2-Methylpropyl)-2,6,8-decatrienamide                         | C <sub>14</sub> H <sub>23</sub> NO                                            | 25394-57-4 | 221.339  | ye oil                        | 23      | 162 <sup>0.5</sup>  |                               | 1.5134 <sup>25</sup> | i H <sub>2</sub> O                               |
| 136 | Aflatoxin B1                                    |                                                                 | C <sub>17</sub> H <sub>12</sub> O <sub>6</sub>                                | 1162-65-8  | 312.273  | cry                           | 268     |                     |                               |                      |                                                  |
| 137 | Aflatoxin B2                                    |                                                                 | C <sub>17</sub> H <sub>14</sub> O <sub>6</sub>                                | 7220-81-7  | 314.289  |                               | 287.5   |                     |                               |                      |                                                  |
| 138 | Aflatoxin G1                                    |                                                                 | C <sub>17</sub> H <sub>12</sub> O <sub>7</sub>                                | 1165-39-5  | 328.273  | cry                           | 245     |                     |                               |                      |                                                  |
| 139 | Agaritine                                       | L-Glutamic acid, 5-[2-[4-(hydroxymethyl)phenyl]hydrazide]       | C <sub>12</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub>                 | 2757-90-6  | 267.281  | cry (dil al)                  | 207 dec |                     |                               |                      | vs H <sub>2</sub> O                              |
| 140 | Ajmalan-17,21-diol, (17 <i>R</i> ,21 <i>α</i> ) | Ajmaline                                                        | C <sub>20</sub> H <sub>26</sub> N <sub>2</sub> O <sub>2</sub>                 | 4360-12-7  | 326.432  | pl (+3.5w) (aq AcOEt)         | 206     |                     |                               |                      | i H <sub>2</sub> O; s EtOH, chl; sl eth, bz      |
| 141 | Alachlor                                        |                                                                 | C <sub>14</sub> H <sub>26</sub> ClNO <sub>2</sub>                             | 15972-60-8 | 269.768  |                               | 40      | 100 <sup>0.02</sup> | 1.133 <sup>25</sup>           |                      |                                                  |
| 142 | DL-Alanine                                      | DL-2-Aminopropanoic acid                                        | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                                 | 302-72-7   | 89.094   | orth pr or nd (w)             | 300 dec | sub 250             | 1.424 <sup>25</sup>           |                      | s H <sub>2</sub> O; vs EtOH                      |
| 143 | D-Alanine                                       | 2-Aminopropanoic acid, ( <i>R</i> )                             | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                                 | 338-69-2   | 89.094   | nd (w, al)                    | 314 dec | sub                 |                               |                      | s H <sub>2</sub> O; sl EtOH; i eth               |
| 144 | L-Alanine                                       | 2-Aminopropanoic acid, ( <i>S</i> )                             | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                                 | 56-41-7    | 89.094   | orth (w)                      | 297 dec | sub 250             | 1.432 <sup>22</sup>           |                      | s H <sub>2</sub> O; sl EtOH, py; i eth, ace      |
| 145 | β-Alanine                                       | 3-Aminopropanoic acid                                           | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                                 | 107-95-9   | 89.094   | nd, orth pr (al)              | 200 dec |                     | 1.437 <sup>19</sup>           |                      | s H <sub>2</sub> O; sl EtOH; i eth, ace          |
| 146 | Alantolactone                                   |                                                                 | C <sub>15</sub> H <sub>20</sub> O <sub>2</sub>                                | 546-43-0   | 232.319  | nd                            | 76      | 275                 |                               |                      | vs bz, eth, EtOH, chl                            |
| 147 | Aldicarb                                        |                                                                 | C <sub>7</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub> S                | 116-06-3   | 190.263  |                               | 99      |                     | 1.195 <sup>25</sup>           |                      |                                                  |
| 148 | Aldosterone                                     |                                                                 | C <sub>21</sub> H <sub>28</sub> O <sub>5</sub>                                | 52-39-1    | 360.444  | cry (HOAc)                    | 166.5   |                     |                               |                      |                                                  |
| 149 | Aldoxycarb S,S-dioxide                          |                                                                 | C <sub>7</sub> H <sub>14</sub> N <sub>2</sub> O <sub>4</sub> S                | 1646-88-4  | 222.262  | cry                           | 141     |                     |                               |                      | sl H <sub>2</sub> O                              |
| 150 | Aldrin                                          |                                                                 | C <sub>12</sub> H <sub>8</sub> Cl <sub>6</sub>                                | 309-00-2   | 364.910  |                               | 104     |                     |                               |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz         |
| 151 | Alizarin                                        | 1,2-Dihydroxy-9,10-anthracenedione                              | C <sub>14</sub> H <sub>8</sub> O <sub>4</sub>                                 | 72-48-0    | 240.212  | oran or red tcl nd or pr (al) | 289.5   |                     |                               |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, bz; i chl |
| 152 | Alizarin Red S                                  | Sodium alizarinesulfonate                                       | C <sub>14</sub> H <sub>7</sub> NaO <sub>7</sub> S                             | 130-22-3   | 342.257  |                               |         |                     |                               |                      | vs H <sub>2</sub> O; s EtOH                      |
| 153 | Alizarin Yellow R                               |                                                                 | C <sub>13</sub> H <sub>9</sub> N <sub>3</sub> O <sub>5</sub>                  | 2243-76-7  | 287.227  | oran-br nd (dil HOAc)         | 253 dec |                     |                               |                      | vs H <sub>2</sub> O, EtOH                        |
| 154 | Alizuroil purple                                | 1-Hydroxy-4-[(4-methylphenyl) amino]-9,10-anthracenedione       | C <sub>21</sub> H <sub>15</sub> NO <sub>3</sub>                               | 81-48-1    | 329.349  | flat viol nd                  |         |                     |                               |                      | s H <sub>2</sub> SO <sub>4</sub>                 |
| 155 | Alkannin                                        |                                                                 | C <sub>16</sub> H <sub>16</sub> O <sub>5</sub>                                | 23444-65-7 | 288.295  | br-red pr (bz)                | 149     | sub 140             |                               |                      | vs EtOH                                          |
| 156 | Allantoic acid                                  | Bis[(aminocarbonyl)amino] acetic acid                           | C <sub>4</sub> H <sub>8</sub> N <sub>4</sub> O <sub>4</sub>                   | 99-16-1    | 176.132  | nd                            | 170 dec |                     |                               |                      | sl H <sub>2</sub> O, os, dil acid                |
| 157 | Allantoin                                       |                                                                 | C <sub>4</sub> H <sub>6</sub> N <sub>4</sub> O <sub>3</sub>                   | 97-59-6    | 158.116  | mcl pl or                     | 239     |                     |                               |                      | sl H <sub>2</sub> O; s EtOH, NaOH; i eth, MeOH   |
| 158 | Allene                                          |                                                                 | C <sub>3</sub> H <sub>4</sub>                                                 | 463-49-0   | 40.064   | col gas                       | -136.6  | -34.4               | 0.584 <sup>25</sup> (p>1 atm) | 1.4168               | vs bz, peth                                      |
| 159 | Allethrin                                       |                                                                 | C <sub>19</sub> H <sub>26</sub> O <sub>3</sub>                                | 584-79-2   | 302.407  |                               |         |                     | 1.010 <sup>20</sup>           |                      |                                                  |
| 160 | Allicin                                         |                                                                 | C <sub>6</sub> H <sub>10</sub> OS <sub>2</sub>                                | 539-86-6   | 162.272  |                               |         | dec                 | 1.112 <sup>20</sup>           | 1.561 <sup>20</sup>  | vs H <sub>2</sub> O                              |
| 161 | Allopregnane-3β,21-diol-11,20-dione             |                                                                 | C <sub>21</sub> H <sub>32</sub> O <sub>4</sub>                                | 566-02-9   | 348.477  | cry (aq, ac, +w) nd (bz, ac)  | 190     |                     |                               |                      |                                                  |
| 162 | Allopregnan-20β-ol-3-one                        | 5α-Pregnan-20β-ol-3-one                                         | C <sub>21</sub> H <sub>34</sub> O <sub>2</sub>                                | 516-58-5   | 318.494  |                               | 185     |                     |                               |                      |                                                  |
| 163 | Allopurinol                                     | 1,5-Dihydro-4 <i>H</i> -pyrazolo[3,4- <i>d</i> ]pyrimidin-4-one | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O                                | 315-30-0   | 136.112  | cry                           | 350     |                     |                               |                      |                                                  |
| 164 | D-Allose                                        |                                                                 | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                 | 2595-97-3  | 180.155  | cry (w)                       | 128     |                     |                               |                      | vs H <sub>2</sub> O                              |
| 165 | Alloxanic acid                                  |                                                                 | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                   | 470-44-0   | 160.085  | tcl pr (eth)                  | 162 dec |                     |                               |                      | vs H <sub>2</sub> O, EtOH                        |
| 166 | Alloxantin                                      |                                                                 | C <sub>8</sub> H <sub>8</sub> N <sub>4</sub> O <sub>8</sub>                   | 76-24-4    | 286.156  | orth pr (w+2)                 | 254 dec |                     |                               |                      | sl H <sub>2</sub> O, EtOH, eth                   |

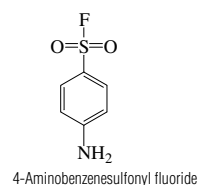
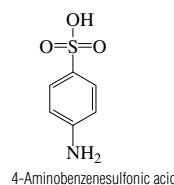
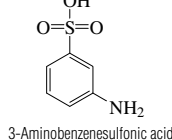
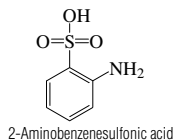
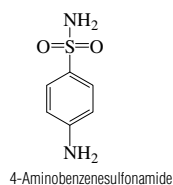
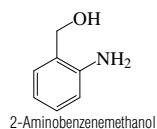
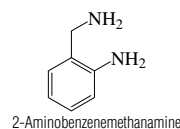
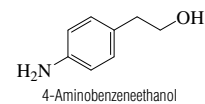
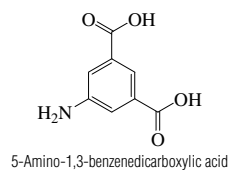
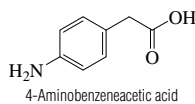
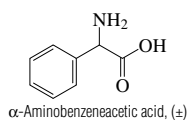
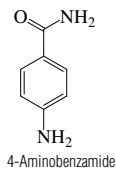
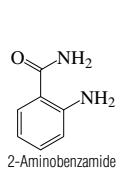
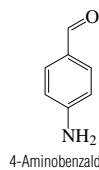
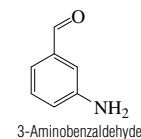
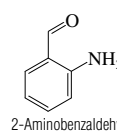
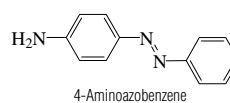
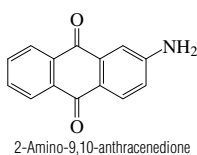
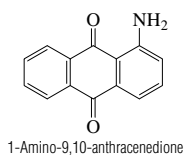
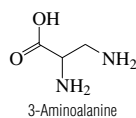
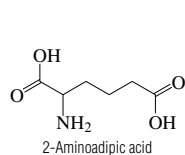
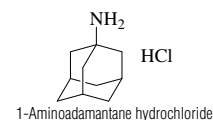
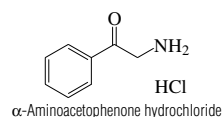
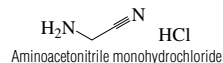
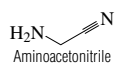
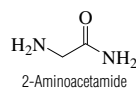
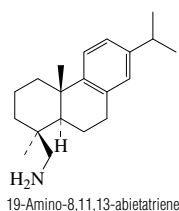
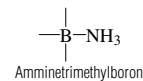
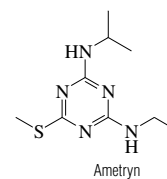
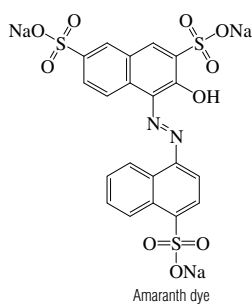
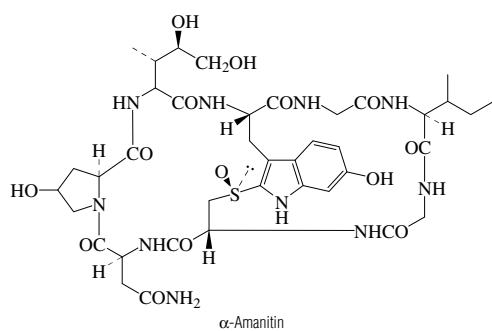
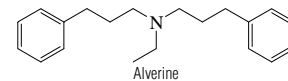
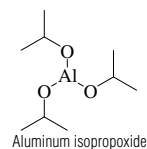
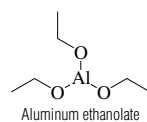
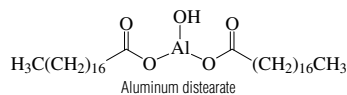
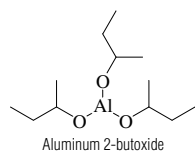
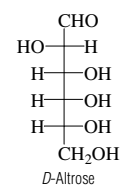
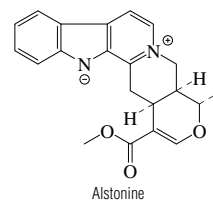
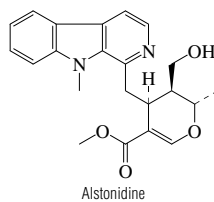
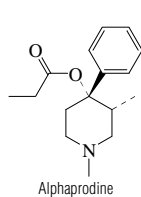
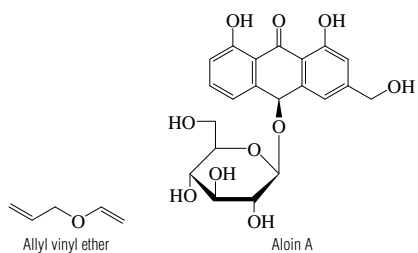


| No. | Name                                      | Synonym                                   | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form         | mp/°C  | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|-----|-------------------------------------------|-------------------------------------------|--------------------------------------------------|------------|----------|-----------------------|--------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 167 | Allyl acetate                             |                                           | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>     | 591-87-7   | 100.117  |                       |        | 103.5                                | 0.9275 <sup>20</sup>       | 1.4049 <sup>20</sup> | sl H <sub>2</sub> O; s ace;<br>msc EtOH, eth               |
| 168 | Allyl acetoacetate                        |                                           | C <sub>7</sub> H <sub>10</sub> O <sub>3</sub>    | 1118-84-9  | 142.152  | liq                   | -85    | 196; 66.5 <sup>14</sup>              | 1.0366 <sup>20</sup>       | 1.4398 <sup>20</sup> | s H <sub>2</sub> O, lig; msc<br>EtOH, bz                   |
| 169 | Allyl acrylate                            |                                           | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>     | 999-55-3   | 112.127  |                       |        | 121                                  | 0.9441 <sup>20</sup>       | 1.4320 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth, acid                  |
| 170 | Allyl alcohol                             | 2-Propen-1-ol                             | C <sub>3</sub> H <sub>6</sub> O                  | 107-18-6   | 58.079   | liq                   | -129   | 97.4                                 | 0.8540 <sup>20</sup>       | 1.4135 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; s chl                  |
| 171 | Allylamine                                | 2-Propen-1-amine                          | C <sub>3</sub> H <sub>7</sub> N                  | 107-11-9   | 57.095   | liq                   | -88.2  | 53.3                                 | 0.758 <sup>20</sup>        | 1.4205 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; s chl                  |
| 172 | <i>N</i> -Allylaniline                    | Allylphenylamine                          | C <sub>9</sub> H <sub>11</sub> N                 | 589-09-3   | 133.190  |                       |        | 219; 106 <sup>12</sup>               | 0.9736 <sup>25</sup>       | 1.563 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH,<br>ace; msc eth               |
| 173 | Allylbenzene                              | 2-Propenylbenzene                         | C <sub>9</sub> H <sub>10</sub>                   | 300-57-2   | 118.175  | liq                   | -40    | 156                                  | 0.8920 <sup>20</sup>       | 1.5131 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz, ctc                |
| 174 | α-Allylbenzenemethanol                    |                                           | C <sub>10</sub> H <sub>12</sub> O                | 936-58-3   | 148.201  |                       |        | 228.5                                | 1.004 <sup>18</sup>        | 1.5289 <sup>21</sup> |                                                            |
| 175 | Allyl benzoate                            |                                           | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>   | 583-04-0   | 162.185  |                       |        |                                      | 1.0569 <sup>15</sup>       | 1.5178 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace,<br>MeOH           |
| 176 | Allyl butanoate                           |                                           | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>    | 2051-78-7  | 128.169  |                       |        | 142; 44.5 <sup>15</sup>              | 0.9017 <sup>20</sup>       | 1.4158 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; sl<br>ctc            |
| 177 | Allyl carbamate                           |                                           | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>    | 2114-11-6  | 101.105  |                       |        |                                      |                            |                      | sl ctc                                                     |
| 178 | Allylchlorodimethylsilane                 |                                           | C <sub>6</sub> H <sub>11</sub> ClSi              | 4028-23-3  | 134.680  |                       |        | 111                                  | 0.8964 <sup>20</sup>       | 1.4195 <sup>20</sup> |                                                            |
| 179 | Allyl chloroformate                       |                                           | C <sub>4</sub> H <sub>5</sub> ClO <sub>2</sub>   | 2937-50-0  | 120.535  | hyg liq               |        | 109.5                                | 1.136                      | 1.4220 <sup>20</sup> |                                                            |
| 180 | Allyl <i>trans</i> -cinnamate             | Allyl <i>trans</i> -3-phenyl-2-propenoate | C <sub>12</sub> H <sub>12</sub> O <sub>2</sub>   | 1866-31-5  | 188.222  |                       |        | dec 268; 163 <sup>17</sup>           | 1.048 <sup>23</sup>        | 1.530 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH;<br>msc eth; sl ctc            |
| 181 | 1-Allylcyclohexanol                       |                                           | C <sub>8</sub> H <sub>16</sub> O                 | 1123-34-8  | 140.222  |                       |        | 190                                  | 0.9341 <sup>22</sup>       | 1.4756 <sup>22</sup> |                                                            |
| 182 | 1-Allylcyclohexene                        | 1-(2-Propenyl)cyclohexene                 | C <sub>8</sub> H <sub>14</sub>                   | 13511-13-2 | 122.207  | liq                   |        | 156                                  |                            |                      |                                                            |
| 183 | Allylcyclopentane                         |                                           | C <sub>8</sub> H <sub>14</sub>                   | 3524-75-2  | 110.197  | liq                   | -110.7 | 125                                  | 0.793 <sup>25</sup>        | 1.4412 <sup>20</sup> | s chl                                                      |
| 184 | Allyldiethoxymethylsilane                 |                                           | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub> Si | 18388-45-9 | 174.314  |                       |        | 155                                  | 0.8572 <sup>25</sup>       | 1.4104 <sup>20</sup> |                                                            |
| 185 | Allyldiethylamine                         | <i>N,N</i> -Diethyl-2-propen-1-amine      | C <sub>7</sub> H <sub>15</sub> N                 | 5666-17-1  | 113.201  |                       |        | 110                                  | 0.7477 <sup>25</sup>       | 1.4209 <sup>20</sup> |                                                            |
| 186 | Allyldimethylamine                        | <i>N,N</i> -Dimethyl-2-propen-1-amine     | C <sub>5</sub> H <sub>11</sub> N                 | 2155-94-4  | 85.148   |                       |        | 63.5                                 | 0.7094 <sup>25</sup>       | 1.4010 <sup>20</sup> |                                                            |
| 187 | Allyl ethyl ether                         |                                           | C <sub>5</sub> H <sub>10</sub> O                 | 557-31-3   | 86.132   |                       |        | 67.6                                 | 0.7651 <sup>20</sup>       | 1.3881 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ace             |
| 188 | Allyl formate                             |                                           | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>     | 1838-59-1  | 86.090   |                       |        | 83.6                                 | 0.9460 <sup>20</sup>       |                      | sl H <sub>2</sub> O; s EtOH;<br>msc eth                    |
| 189 | Allyl 2-furancarboxylate                  | Allyl 2-furanoate                         | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>     | 4208-49-5  | 152.148  |                       |        | 207.5                                | 1.115 <sup>25</sup>        | 1.4945 <sup>20</sup> | s eth, ace; sl ctc                                         |
| 190 | Allyl glycidyl ether                      |                                           | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | 106-92-3   | 114.142  |                       |        | 154                                  | 0.9698 <sup>20</sup>       | 1.4332 <sup>20</sup> |                                                            |
| 191 | Allyl hexanoate                           |                                           | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>    | 123-68-2   | 156.222  |                       |        | 186                                  | 0.8869 <sup>20</sup>       |                      |                                                            |
| 192 | Allyl (hydroxymethyl)carbamate            |                                           | C <sub>6</sub> H <sub>9</sub> NO <sub>3</sub>    | 24935-97-5 | 131.130  | cry (tol)             | 57     |                                      |                            |                      |                                                            |
| 193 | Allyl isocyanate                          |                                           | C <sub>4</sub> H <sub>5</sub> NO                 | 1476-23-9  | 83.089   |                       |        | 88                                   |                            |                      |                                                            |
| 194 | Allyl isothiocyanate                      |                                           | C <sub>4</sub> H <sub>5</sub> NS                 | 57-06-7    | 99.155   | liq                   | -80    | 152                                  | 1.0126 <sup>20</sup>       | 1.5306 <sup>20</sup> | vs bz, eth, EtOH                                           |
| 195 | Allyl methacrylate                        |                                           | C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>    | 96-05-9    | 126.153  |                       |        | 67 <sup>30</sup> , 55 <sup>30</sup>  | 0.9335 <sup>20</sup>       | 1.4360 <sup>20</sup> |                                                            |
| 196 | 4-Allyl-2-methoxyphenol                   | Eugenol                                   | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>   | 97-53-0    | 164.201  | liq                   | -7.5   | 253.2                                | 1.0652 <sup>20</sup>       | 1.5405 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>chl, HOAc, oils |
| 197 | 4-Allyl-2-methoxyphenyl acetate           | 1,3,4-Eugenol acetate                     | C <sub>12</sub> H <sub>14</sub> O <sub>3</sub>   | 93-28-7    | 206.237  | pr (al)               | 30.5   | 281; 127 <sup>6</sup>                | 1.0806 <sup>20</sup>       | 1.5205 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; sl<br>ctc                      |
| 198 | Allyl 3-methylbutanoate                   |                                           | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>    | 2835-39-4  | 142.196  |                       |        | 154                                  |                            |                      |                                                            |
| 199 | Allylmethylchlorosilane                   |                                           | C <sub>4</sub> H <sub>9</sub> Cl <sub>2</sub> Si | 1873-92-3  | 155.099  |                       |        | 119.5                                | 1.0758 <sup>20</sup>       | 1.4419 <sup>20</sup> |                                                            |
| 200 | 2-(Allyloxy)ethanol                       | Ethylene glycol monoallyl ether           | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>    | 111-45-5   | 102.132  |                       |        | 158.5                                | 0.9580 <sup>20</sup>       | 1.4358 <sup>20</sup> | msc H <sub>2</sub> O; vs<br>EtOH; s bz, ctc,<br>MeOH       |
| 201 | 2-Allylphenol                             |                                           | C <sub>9</sub> H <sub>10</sub> O                 | 1745-81-9  | 134.174  | liq                   | -6     | 220                                  | 1.0246 <sup>15</sup>       | 1.5181 <sup>20</sup> | vs eth                                                     |
| 202 | 4-Allylphenol                             | Chavicol                                  | C <sub>9</sub> H <sub>10</sub> O                 | 501-92-8   | 134.174  |                       | 15.8   | 238                                  | 1.0203 <sup>15</sup>       | 1.5441 <sup>18</sup> | vs eth, EtOH,<br>chl                                       |
| 203 | Allyl phenyl ether                        |                                           | C <sub>9</sub> H <sub>10</sub> O                 | 1746-13-0  | 134.174  |                       |        | 191.7                                | 0.9811 <sup>20</sup>       | 1.5223 <sup>20</sup> | i H <sub>2</sub> O; s EtOH;<br>msc eth; sl ctc             |
| 204 | Allyl propanoate                          | 2-Propenyl propanoate                     | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | 2408-20-0  | 114.142  |                       |        | 123                                  | 0.9140 <sup>20</sup>       | 1.4105 <sup>20</sup> | s EtOH, eth, ace                                           |
| 205 | <i>N</i> -Allyl-2-propen-1-amine          | Diallylamine                              | C <sub>6</sub> H <sub>11</sub> N                 | 124-02-7   | 97.158   |                       |        | 111                                  |                            | 1.4387 <sup>20</sup> | s EtOH, eth                                                |
| 206 | Allyl propyl disulfide                    |                                           | C <sub>6</sub> H <sub>12</sub> S <sub>2</sub>    | 2179-59-1  | 148.289  |                       |        | 79 <sup>13</sup>                     |                            | 1.5219 <sup>20</sup> |                                                            |
| 207 | 3-(Allylsulfinyl)- <i>L</i> -alanine, (S) | Alliin                                    | C <sub>6</sub> H <sub>11</sub> NO <sub>3</sub> S | 556-27-4   | 177.221  | nd (dil ac)           | 165    |                                      |                            |                      | vs H <sub>2</sub> O                                        |
| 208 | Allylthiourea                             | Thiosinamine                              | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> S   | 109-57-9   | 116.185  | mcl or orth<br>pr (w) | 78     |                                      | 1.217 <sup>20</sup>        | 1.5936 <sup>78</sup> | s H <sub>2</sub> O, EtOH; sl<br>eth; i bz                  |
| 209 | Allyltrichlorosilane                      | Trichloro-2-propenylsilane                | C <sub>3</sub> H <sub>3</sub> Cl <sub>3</sub> Si | 107-37-9   | 175.517  |                       | 35     | 117.5                                | 1.2011 <sup>20</sup>       | 1.4460 <sup>20</sup> |                                                            |
| 210 | Allyltriethoxysilane                      |                                           | C <sub>9</sub> H <sub>20</sub> O <sub>3</sub> Si | 2550-04-1  | 204.339  |                       |        | 100 <sup>50</sup> , 82 <sup>28</sup> | 0.9030 <sup>20</sup>       | 1.4072 <sup>20</sup> |                                                            |
| 211 | Allyltrimethylsilane                      |                                           | C <sub>6</sub> H <sub>14</sub> Si                | 762-72-1   | 114.261  |                       |        | 85                                   | 0.7158 <sup>25</sup>       | 1.4074 <sup>20</sup> | i H <sub>2</sub> O                                         |
| 212 | Allylurea                                 |                                           | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O   | 557-11-9   | 100.119  | nd (al)               | 85     |                                      |                            |                      | msc H <sub>2</sub> O, EtOH;<br>sl eth, chl; i<br>peth      |

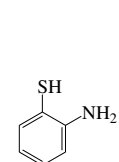




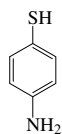
| No. | Name                                 | Synonym                           | Mol. Form.                                                                                    | CAS RN     | Mol. Wt. | Physical Form        | mp/°C     | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|-----|--------------------------------------|-----------------------------------|-----------------------------------------------------------------------------------------------|------------|----------|----------------------|-----------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 213 | Allyl vinyl ether                    | 3-(Ethenyloxy)-1-propene          | C <sub>5</sub> H <sub>8</sub> O                                                               | 3917-15-5  | 84.117   |                      |           | 66                                    | 0.7900 <sup>20</sup>       | 1.4062 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, chl                 |
| 214 | Alolin A                             |                                   | C <sub>21</sub> H <sub>22</sub> O <sub>9</sub>                                                | 1415-73-2  | 418.395  |                      | 149.3     |                                       |                            |                      | s H <sub>2</sub> O, EtOH, ace; sl eth, bz; i chl    |
| 215 | Alphaprodine                         |                                   | C <sub>16</sub> H <sub>23</sub> NO <sub>2</sub>                                               | 15867-21-7 | 261.360  | cry                  | 103       |                                       |                            |                      |                                                     |
| 216 | Alstonidine                          |                                   | C <sub>22</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub>                                 | 25394-75-6 | 380.437  | cry (eth)            | 189       |                                       |                            |                      | vs ace, EtOH                                        |
| 217 | Alstonine                            |                                   | C <sub>21</sub> H <sub>20</sub> N <sub>2</sub> O <sub>3</sub>                                 | 642-18-2   | 348.395  | ye nd (ace)          | 207 dec   |                                       |                            |                      |                                                     |
| 218 | D-Altrose                            |                                   | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                                 | 1990-29-0  | 180.155  | pr (MeOH,al)         | 103.5     |                                       |                            |                      | vs H <sub>2</sub> O                                 |
| 219 | Aluminum 2-butoxide                  | 2-Butanol, aluminum salt          | C <sub>12</sub> H <sub>27</sub> AlO <sub>3</sub>                                              | 2269-22-9  | 246.322  |                      |           | 197 <sup>20</sup>                     |                            |                      |                                                     |
| 220 | Aluminum distearate                  | Hydroxyaluminum distearate        | C <sub>36</sub> H <sub>71</sub> AlO <sub>5</sub>                                              | 300-92-5   | 610.928  | wh pow               | 145       |                                       |                            |                      | i H <sub>2</sub> O                                  |
| 221 | Aluminum ethanolate                  | Aluminum ethoxide                 | C <sub>6</sub> H <sub>15</sub> AlO <sub>3</sub>                                               | 555-75-9   | 162.163  | liq/wh solid         | 140       | 200 <sup>7</sup>                      |                            |                      | dec H <sub>2</sub> O; sl xyl                        |
| 222 | Aluminum isopropoxide                |                                   | C <sub>9</sub> H <sub>21</sub> AlO <sub>3</sub>                                               | 555-31-7   | 204.243  | hyg wh solid         | 119       | 135 <sup>10</sup> , 94 <sup>0.5</sup> |                            |                      | reac H <sub>2</sub> O; s EtOH, bz, peth, chl        |
| 223 | Alverine                             | N-Ethyl-bis(3-phenylpropyl) amine | C <sub>20</sub> H <sub>27</sub> N                                                             | 150-59-4   | 281.435  | oil                  |           | 166 <sup>0.3</sup>                    |                            |                      |                                                     |
| 224 | α-Amanitin                           |                                   | C <sub>39</sub> H <sub>54</sub> N <sub>10</sub> O <sub>14</sub> S                             | 23109-05-9 | 918.970  | nd                   | 254 dec   |                                       |                            |                      |                                                     |
| 225 | Amaranth dye                         |                                   | C <sub>20</sub> H <sub>11</sub> N <sub>2</sub> Na <sub>3</sub> O <sub>10</sub> S <sub>3</sub> | 915-67-3   | 604.472  | dk red pow           |           |                                       |                            |                      | s H <sub>2</sub> O                                  |
| 226 | Ametryn                              |                                   | C <sub>8</sub> H <sub>17</sub> N <sub>5</sub> S                                               | 834-12-8   | 227.330  |                      | 88        |                                       |                            |                      |                                                     |
| 227 | Amminetrimethylboron                 |                                   | C <sub>2</sub> H <sub>12</sub> BN                                                             | 1830-95-1  | 72.945   |                      | 73.5      |                                       |                            |                      |                                                     |
| 228 | 19-Amino-8,11,13-abietatriene        |                                   | C <sub>20</sub> H <sub>31</sub> N                                                             | 1446-61-3  | 285.467  | cry                  | 44.5      |                                       |                            |                      |                                                     |
| 229 | 2-Aminoacetamide                     |                                   | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O                                                | 598-41-4   | 74.081   | hyg nd (chl)         | 67.5      |                                       |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth, bz; s ace, chl   |
| 230 | Aminoacetonitrile                    |                                   | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub>                                                  | 540-61-4   | 56.066   |                      |           | 58 <sup>15</sup>                      |                            |                      | vs EtOH                                             |
| 231 | Aminoacetonitrile monohydrochloride  |                                   | C <sub>2</sub> H <sub>5</sub> ClN <sub>2</sub>                                                | 6011-14-9  | 92.527   | hyg cry (al)         | 165 dec   |                                       |                            |                      |                                                     |
| 232 | α-Aminoacetophenone hydrochloride    |                                   | C <sub>8</sub> H <sub>10</sub> ClNO                                                           | 5468-37-1  | 171.624  |                      | 194 dec   |                                       |                            |                      |                                                     |
| 233 | 1-Aminoadamantane hydrochloride      | Adamantanamine hydrochloride      | C <sub>10</sub> H <sub>16</sub> ClN                                                           | 665-66-7   | 187.710  | cry (al-eth)         | 360 dec   |                                       |                            |                      | vs H <sub>2</sub> O, EtOH                           |
| 234 | 2-Aminoadipic acid                   |                                   | C <sub>6</sub> H <sub>11</sub> NO <sub>4</sub>                                                | 626-71-1   | 161.156  | pl (w)               | 207.0     |                                       |                            |                      | sl H <sub>2</sub> O, EtOH, eth                      |
| 235 | 3-Aminoalanine                       | 2,3-Diaminopropionic acid         | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                                   | 515-94-6   | 104.108  | hyg rosettes         | 110       |                                       |                            |                      | vs H <sub>2</sub> O                                 |
| 236 | 1-Amino-9,10-anthracenedione         | 1-Aminoanthraquinone              | C <sub>14</sub> H <sub>9</sub> NO <sub>2</sub>                                                | 82-45-1    | 223.227  | red nd (al)          | 253.5     | sub                                   |                            |                      | vs ace, bz, EtOH, chl                               |
| 237 | 2-Amino-9,10-anthracenedione         | 2-Aminoanthraquinone              | C <sub>14</sub> H <sub>9</sub> NO <sub>2</sub>                                                | 117-79-3   | 223.227  | red nd (al, HOAc)    | 304.5     | sub                                   |                            |                      | i H <sub>2</sub> O, eth; sl EtOH; s ace, bz, chl    |
| 238 | 4-Aminoazobenzene                    |                                   | C <sub>12</sub> H <sub>11</sub> N <sub>3</sub>                                                | 60-09-3    | 197.235  | oran mcl nd (al)     | 127       | >360                                  |                            |                      | sl H <sub>2</sub> O, liq; s EtOH, eth, bz, chl      |
| 239 | 2-Aminobenzaldehyde                  |                                   | C <sub>7</sub> H <sub>7</sub> NO                                                              | 529-23-7   | 121.137  | silv lf              | 40.5      | 80 <sup>2</sup>                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz, chl; i lig |
| 240 | 3-Aminobenzaldehyde                  |                                   | C <sub>7</sub> H <sub>7</sub> NO                                                              | 1709-44-0  | 121.137  | nd (AcOEt)           | 29        |                                       |                            |                      | s eth, acid                                         |
| 241 | 4-Aminobenzaldehyde                  |                                   | C <sub>7</sub> H <sub>7</sub> NO                                                              | 556-18-3   | 121.137  | pl (w)               | 71.5      |                                       |                            |                      | s H <sub>2</sub> O, EtOH, eth, acid                 |
| 242 | 2-Aminobenzamide                     |                                   | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O                                                | 88-68-6    | 136.151  |                      | 110.5 dec |                                       |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, bz; vs AcOEt      |
| 243 | 4-Aminobenzamide                     |                                   | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O                                                | 2835-68-9  | 136.151  | ye cry (+1/4w)       | 183       |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH, eth                    |
| 244 | α-Aminobenzenecetic acid, (±)        | α-Phenylglycine                   | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                                                 | 2835-06-5  | 151.163  | pl                   | 292 dec   | sub 255                               |                            |                      | s alk; sl os                                        |
| 245 | 4-Aminobenzenecetic acid             | p-Aminophenylacetic acid          | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                                                 | 1197-55-3  | 151.163  | pl (w)               | 200 dec   |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH, DMSO                   |
| 246 | 5-Amino-1,3-benzenedicarboxylic acid |                                   | C <sub>6</sub> H <sub>4</sub> NO <sub>4</sub>                                                 | 99-31-0    | 181.147  | pr(al), pl(w)        | 360       | sub                                   |                            |                      | i H <sub>2</sub> O; sl EtOH                         |
| 247 | 4-Aminobenzenethanol                 |                                   | C <sub>8</sub> H <sub>11</sub> NO                                                             | 104-10-9   | 137.179  | nd (al)              | 108       |                                       |                            |                      |                                                     |
| 248 | 2-Aminobenzenemethanamine            |                                   | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                                                 | 4403-69-4  | 122.167  |                      | 61        | 269                                   |                            |                      | vs EtOH                                             |
| 249 | 2-Aminobenzenemethanol               |                                   | C <sub>7</sub> H <sub>9</sub> NO                                                              | 5344-90-1  | 123.152  |                      | 83.5      | 273                                   |                            |                      | s H <sub>2</sub> O, EtOH, eth, HOAc; vs bz, chl     |
| 250 | 4-Aminobenzenesulfonamide            | Sulfanilamide                     | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> S                                 | 63-74-1    | 172.205  | lf (dil al)          | 165.5     |                                       | 1.08 <sup>25</sup>         |                      | s H <sub>2</sub> O, EtOH, eth, ace; sl chl, peth    |
| 251 | 2-Aminobenzenesulfonic acid          | Orthanilic acid                   | C <sub>6</sub> H <sub>7</sub> NO <sub>3</sub> S                                               | 88-21-1    | 173.190  | pr (+ 1/2w)          | >320 dec  |                                       |                            |                      | sl H <sub>2</sub> O; i EtOH, eth                    |
| 252 | 3-Aminobenzenesulfonic acid          | Metanilic acid                    | C <sub>6</sub> H <sub>7</sub> NO <sub>3</sub> S                                               | 121-47-1   | 173.190  | nd, pr (w +1)        | dec       |                                       |                            |                      | sl H <sub>2</sub> O, EtOH; i eth                    |
| 253 | 4-Aminobenzenesulfonic acid          | Sulfanilic acid                   | C <sub>6</sub> H <sub>7</sub> NO <sub>3</sub> S                                               | 121-57-3   | 173.190  | orth pl or mcl (w+2) | 288       |                                       | 1.485 <sup>25</sup>        |                      | sl H <sub>2</sub> O; i EtOH, eth                    |
| 254 | 4-Aminobenzenesulfonyl fluoride      | p-Sulfanilyl fluoride             | C <sub>6</sub> H <sub>6</sub> FN <sub>2</sub> O <sub>2</sub> S                                | 98-62-4    | 175.181  |                      | 68.5      |                                       |                            |                      |                                                     |



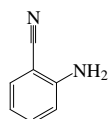
| No. | Name                                                              | Synonym                                       | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form                         | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|-----|-------------------------------------------------------------------|-----------------------------------------------|------------------------------------------------------------------------------|------------|----------|---------------------------------------|---------|------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 255 | 2-Aminobenzenethiol                                               |                                               | C <sub>6</sub> H <sub>7</sub> NS                                             | 137-07-5   | 125.192  |                                       | 26      | 234                    |                            | 1.4606 <sup>20</sup> | s EtOH, eth                                              |
| 256 | 4-Aminobenzenethiol                                               |                                               | C <sub>6</sub> H <sub>7</sub> NS                                             | 1193-02-8  | 125.192  |                                       | 46      | 143 <sup>17</sup>      |                            |                      | s H <sub>2</sub> O, EtOH                                 |
| 257 | 2-Aminobenzonitrile                                               |                                               | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                 | 1885-29-6  | 118.136  | ye pr (CS <sub>2</sub> )<br>nd (peth) | 51      | 263                    |                            |                      | sl H <sub>2</sub> O; vs EtOH,<br>eth, ace, bz; i<br>peth |
| 258 | 3-Aminobenzonitrile                                               |                                               | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                 | 2237-30-1  | 118.136  | nd (dil al or<br>CCl <sub>4</sub> )   | 54.3    | 289                    |                            |                      | sl H <sub>2</sub> O; vs EtOH,<br>eth, ace, chl           |
| 259 | 4-Aminobenzonitrile                                               |                                               | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                 | 873-74-5   | 118.136  | pr or pl (w)                          | 87.0    |                        |                            |                      | sl H <sub>2</sub> O, ctc; vs<br>EtOH, eth, ace,<br>bz    |
| 260 | 4-Aminobenzophenone                                               |                                               | C <sub>13</sub> H <sub>11</sub> NO                                           | 1137-41-3  | 197.232  | lf (dil al)                           | 124     | 246 <sup>13</sup>      |                            |                      | sl H <sub>2</sub> O, tfa; s<br>EtOH, eth,<br>HOAc        |
| 261 | <i>N</i> -(4-Aminobenzoyl)- <i>L</i> -glutamic acid               |                                               | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub> O <sub>5</sub>                | 4271-30-1  | 266.249  | cry (w)                               | 173     |                        |                            |                      |                                                          |
| 262 | <i>N</i> -(4-Aminobenzoyl)glycine                                 | <i>p</i> -Aminohippuric acid                  | C <sub>9</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>                 | 61-78-9    | 194.186  | pr or nd (w)                          | 198.5   |                        |                            |                      | vs ace, bz, EtOH                                         |
| 263 | 2-Aminobiphenyl                                                   |                                               | C <sub>12</sub> H <sub>11</sub> N                                            | 90-41-5    | 169.222  | lf (dil al)                           | 51      | 299                    |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, bz; sl<br>DMSO, peth |
| 264 | 3-Aminobiphenyl                                                   |                                               | C <sub>12</sub> H <sub>11</sub> N                                            | 2243-47-2  | 169.222  | nd                                    | 31.5    |                        |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, ace, bz             |
| 265 | 4-Aminobiphenyl                                                   | <i>p</i> -Biphenylamine                       | C <sub>12</sub> H <sub>11</sub> N                                            | 92-67-1    | 169.222  | lf (dil al)                           | 53.5    | 302                    |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, ace, chl            |
| 266 | 2-Amino-5-bromobenzoic acid                                       | 5-Bromoanthranilic acid                       | C <sub>7</sub> H <sub>6</sub> BrNO <sub>2</sub>                              | 5794-88-7  | 216.033  | nd                                    | 219.5   |                        |                            |                      | s DMSO                                                   |
| 267 | 1-Amino-4-bromo-9,10-dihydro-9,10-dioxo-2-anthracenesulfonic acid | 1-Amino-4-bromoanthraquinone-2-sulfonic acid  | C <sub>14</sub> H <sub>8</sub> BrNO <sub>5</sub> S                           | 116-81-4   | 382.187  | red nd (w)                            |         |                        |                            |                      |                                                          |
| 268 | <i>DL</i> -2-Aminobutanoic acid                                   |                                               | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                                | 2835-81-6  | 103.120  | lf (w)                                | 304 dec | sub                    | 1.2300 <sup>20</sup>       |                      | vs H <sub>2</sub> O; sl EtOH;<br>i eth, bz               |
| 269 | <i>L</i> -2-Aminobutanoic acid                                    |                                               | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                                | 1492-24-6  | 103.120  | lf (dil al), cry<br>(al)              | 292 dec |                        |                            |                      | s H <sub>2</sub> O; sl EtOH,<br>eth; i bz                |
| 270 | <i>DL</i> -3-Aminobutanoic acid                                   |                                               | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                                | 2835-82-7  | 103.120  | nd (al)                               | 194.3   |                        |                            |                      | vs H <sub>2</sub> O; i EtOH,<br>eth, bz                  |
| 271 | 4-Aminobutanoic acid                                              | <i>γ</i> -Aminobutyric acid                   | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                                | 56-12-2    | 103.120  | pr or nd (al)<br>lf (MeOH-<br>eth)    | 203 dec |                        |                            |                      | vs H <sub>2</sub> O; sl EtOH,<br>ace; i eth, bz          |
| 272 | 2-Amino-1-butanol, (±)                                            |                                               | C <sub>4</sub> H <sub>11</sub> NO                                            | 13054-87-0 | 89.136   | liq                                   | -1.0    | 178                    | 0.9162 <sup>20</sup>       | 1.4489 <sup>25</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; sl chl               |
| 273 | 4-Amino-1-butanol                                                 |                                               | C <sub>4</sub> H <sub>11</sub> NO                                            | 13325-10-5 | 89.136   |                                       |         | 205; 125 <sup>34</sup> | 0.967 <sup>12</sup>        | 1.4625 <sup>20</sup> | s H <sub>2</sub> O, EtOH; i<br>eth                       |
| 274 | 4-Amino- <i>N</i> -[(butylamino)carbonyl]benzenesulfonamide       | Carbutamide                                   | C <sub>11</sub> H <sub>17</sub> N <sub>3</sub> O <sub>3</sub> S              | 339-43-5   | 271.336  |                                       | 144.5   |                        |                            |                      |                                                          |
| 275 | Aminocarb                                                         |                                               | C <sub>11</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>                | 2032-59-9  | 208.257  | cry                                   | 94      |                        |                            |                      | sl H <sub>2</sub> O, bz; s ace                           |
| 276 | <i>N</i> -(Aminocarbonyl)acetamide                                |                                               | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                  | 591-07-1   | 102.092  |                                       | 218     | sub 180                |                            |                      | sl H <sub>2</sub> O, eth; s<br>EtOH                      |
| 277 | [4-[(Aminocarbonyl)amino]phenyl]arsonic acid                      | Carbarsone                                    | C <sub>7</sub> H <sub>9</sub> AsN <sub>2</sub> O <sub>4</sub>                | 121-59-5   | 260.079  | nd (w)                                | 174     |                        |                            |                      | sl H <sub>2</sub> O, DMSO,<br>EtOH; i eth,<br>chl; s alk |
| 278 | <i>N</i> -(Aminocarbonyl)-2-bromo-2-ethylbutanamide               | Carbromal                                     | C <sub>7</sub> H <sub>13</sub> BrN <sub>2</sub> O <sub>2</sub>               | 77-65-6    | 237.094  | orth (dil al)                         | 118     |                        | 1.544 <sup>25</sup>        |                      | sl H <sub>2</sub> O, chl; s<br>ace, bz                   |
| 279 | <i>N</i> -(Aminocarbonyl)-2-bromo-3-methylbutanamide              | Bromisovalum                                  | C <sub>6</sub> H <sub>11</sub> BrN <sub>2</sub> O <sub>2</sub>               | 496-67-3   | 223.067  | nd or lf (to)                         | 154     | sub                    | 1.56 <sup>15</sup>         |                      | vs ace, bz, eth,<br>EtOH                                 |
| 280 | [2-(Aminocarbonyl)phenoxy]acetic acid                             | Salicylamide <i>O</i> -acetic acid            | C <sub>9</sub> H <sub>9</sub> NO <sub>4</sub>                                | 25395-22-6 | 195.172  |                                       | 221     |                        |                            |                      | s alk                                                    |
| 281 | 7-Aminocephalosporanic acid                                       |                                               | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub> S              | 957-68-6   | 272.277  | cry                                   |         |                        |                            |                      |                                                          |
| 282 | 1-Amino-5-chloro-9,10-anthracenedione                             | 1-Amino-5-chloroanthraquinone                 | C <sub>14</sub> H <sub>8</sub> ClNO <sub>2</sub>                             | 117-11-3   | 257.673  |                                       | 212     |                        |                            |                      |                                                          |
| 283 | 4-Amino-6-chloro-1,3-benzenedisulfonamide                         | Chloraminophenamide                           | C <sub>6</sub> H <sub>6</sub> ClN <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 121-30-2   | 285.729  |                                       | 254.5   |                        |                            |                      |                                                          |
| 284 | 5-Amino-2-chlorobenzenesulfonic acid                              | 6-Chlorometanilic acid                        | C <sub>6</sub> H <sub>6</sub> ClNO <sub>3</sub> S                            | 88-43-7    | 207.635  | nd (w)                                | 280 dec |                        |                            |                      |                                                          |
| 285 | 2-Amino-5-chlorobenzoic acid                                      |                                               | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>                              | 635-21-2   | 171.582  |                                       | 211     |                        |                            |                      |                                                          |
| 286 | 5-Amino-2-chlorobenzoic acid                                      |                                               | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>                              | 89-54-3    | 171.582  |                                       | 188     |                        | 1.519 <sup>15</sup>        |                      | vs EtOH                                                  |
| 287 | 2-Amino-5-chlorobenzophenone                                      | 2-Benzoyl-4-chloroaniline                     | C <sub>13</sub> H <sub>10</sub> ClNO                                         | 719-59-5   | 231.677  | ye nd                                 | 100.5   |                        |                            |                      | vs H <sub>2</sub> O, EtOH,<br>peth, chl                  |
| 288 | 2-Amino-4-chloro-5-methylbenzenesulfonic acid                     | 2-Chloro- <i>p</i> -toluidine-5-sulfonic acid | C <sub>7</sub> H <sub>8</sub> ClNO <sub>3</sub> S                            | 88-51-7    | 221.662  | short nd (w)                          |         |                        |                            |                      |                                                          |
| 289 | 2-Amino-4-chlorophenol                                            | 2-Hydroxy-5-chloroaniline                     | C <sub>6</sub> H <sub>6</sub> ClNO                                           | 95-85-2    | 143.571  |                                       | 140     |                        |                            |                      | sl DMSO                                                  |
| 290 | 1-Aminocyclopentanecarboxylic acid                                | Cycloleucine                                  | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                               | 52-52-8    | 129.157  | cry (al-w)                            | 330 dec |                        |                            |                      |                                                          |
| 291 | 7-Aminodeacetoxycephalosporanic acid                              |                                               | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>5</sub> S               | 22252-43-3 | 214.241  |                                       | 241 dec |                        |                            |                      |                                                          |
| 292 | 1-Amino-1-deoxy- <i>D</i> -glucitol                               | Glucamine                                     | C <sub>6</sub> H <sub>15</sub> NO <sub>5</sub>                               | 488-43-7   | 181.187  | cry (MeOH)                            | 127     |                        |                            |                      | vs H <sub>2</sub> O, EtOH                                |
| 293 | 2-Amino-2-deoxy- <i>D</i> -glucose                                | <i>D</i> -Glucosamine                         | C <sub>6</sub> H <sub>13</sub> NO <sub>5</sub>                               | 3416-24-8  | 179.171  |                                       |         |                        |                            |                      | vs H <sub>2</sub> O                                      |



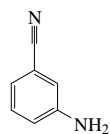
2-Aminobenzenethiol



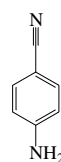
4-Aminobenzenethiol



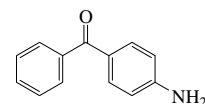
2-Aminobenzonitrile



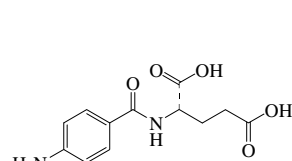
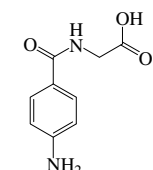
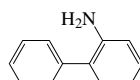
3-Aminobenzonitrile



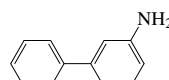
4-Aminobenzonitrile



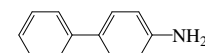
4-Aminobenzophenone

*N*-(4-Aminobenzoyl)-L-glutamic acid*N*-(4-Aminobenzoyl)glycine

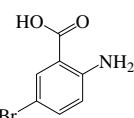
2-Aminobiphenyl



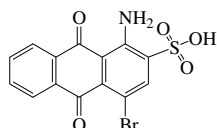
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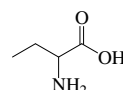
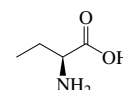
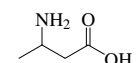
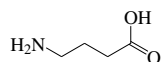
4-Aminobiphenyl



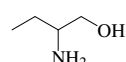
2-Amino-5-bromobenzoic acid



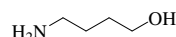
1-Amino-4-bromo-9,10-dihydro-9,10-dioxo-2-anthracenesulfonic acid

*DL*-2-Aminobutanoic acid*L*-2-Aminobutanoic acid*DL*-3-Aminobutanoic acid

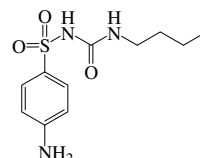
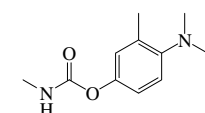
4-Aminobutanoic acid



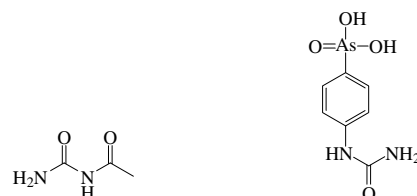
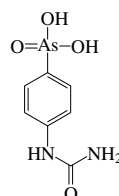
2-Amino-1-butanol, (±)



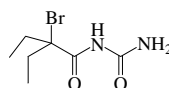
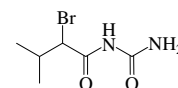
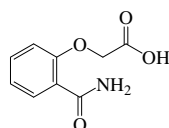
4-Amino-1-butanol

4-Amino-*N*-[(butylamino)carbonyl]benzenesulfonamide

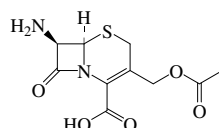
Aminocarb

*N*-(Aminocarbonyl)acetamide

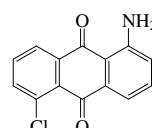
[4-[(Aminocarbonyl)amino]phenyl]arsonic acid

*N*-(Aminocarbonyl)-2-bromo-2-ethylbutanamide*N*-(Aminocarbonyl)-2-bromo-3-methylbutanamide

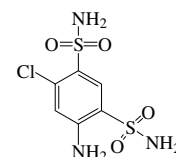
[2-(Aminocarbonyl)phenoxy]acetic acid



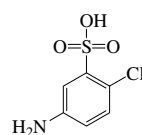
7-Aminocephalosporanic acid



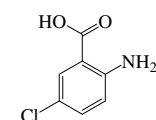
1-Amino-5-chloro-9,10-anthracenedione



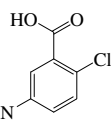
4-Amino-6-chloro-1,3-benzenedisulfonamide



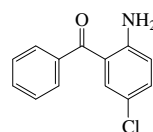
5-Amino-2-chlorobenzenesulfonic acid



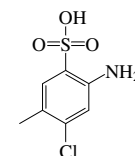
2-Amino-5-chlorobenzoic acid



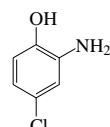
5-Amino-2-chlorobenzoic acid



2-Amino-5-chlorobenzophenone



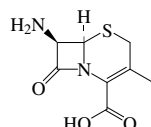
2-Amino-4-chloro-5-methylbenzenesulfonic acid



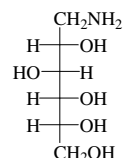
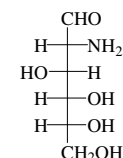
2-Amino-4-chlorophenol



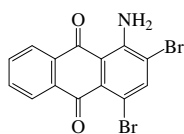
1-Aminocyclopentanecarboxylic acid



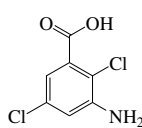
7-Aminodeacetoxycephalosporanic acid

1-Amino-1-deoxy-*D*-glucitol2-Amino-2-deoxy-*D*-glucose

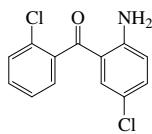
| No. | Name                                                                             | Synonym                                       | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form              | mp/°C    | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|-----|----------------------------------------------------------------------------------|-----------------------------------------------|----------------------------------------------------------------|------------|----------|----------------------------|----------|------------------------|----------------------------|----------------------|------------------------------------------------------|
| 294 | 1-Amino-2,4-dibromo-9,10-anthracenedione                                         |                                               | C <sub>14</sub> H <sub>7</sub> Br <sub>2</sub> NO <sub>2</sub> | 81-49-2    | 381.020  | red nd (xyl)               | 226      |                        |                            |                      |                                                      |
| 295 | 3-Amino-2,5-dichlorobenzoic acid                                                 | Chloramben                                    | C <sub>7</sub> H <sub>5</sub> Cl <sub>2</sub> NO <sub>2</sub>  | 133-90-4   | 206.027  |                            | 200      |                        |                            |                      | sl DMSO                                              |
| 296 | 2-Amino-2',5'-dichlorobenzophenone                                               |                                               | C <sub>13</sub> H <sub>5</sub> Cl <sub>2</sub> NO              | 2958-36-3  | 266.122  |                            | ≈80      |                        |                            |                      |                                                      |
| 297 | 2-Amino-4,6-dichlorophenol                                                       |                                               | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO               | 527-62-8   | 178.016  | long nd (CS <sub>2</sub> ) | 95.5     | sub 70                 |                            |                      |                                                      |
| 298 | 4-Amino-2,6-dichlorophenol                                                       |                                               | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO               | 5930-28-9  | 178.016  | nd or lf (w, bz)           | 168      | sub                    |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s ace; sl bz, HOAc |
| 299 | 2-Amino-1,7-dihydro-7-methyl-6 <i>H</i> -purin-6-one                             | 7-Methylguanine                               | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O                 | 578-76-7   | 165.153  |                            | 370      |                        |                            |                      |                                                      |
| 300 | 5-Amino-2,3-dihydro-1,4-phthalazinedione                                         | Luminol                                       | C <sub>8</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>    | 521-31-3   | 177.161  | ye nd (al)                 | 330.5    |                        |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; vs alk; s HOAc     |
| 301 | 2-Amino-1,7-dihydro-6 <i>H</i> -purine-6-thione                                  | Thioguanine                                   | C <sub>5</sub> H <sub>5</sub> N <sub>3</sub> S                 | 154-42-7   | 167.193  |                            | >360     |                        |                            |                      |                                                      |
| 302 | 6-Amino-1,3-dihydro-2 <i>H</i> -purin-2-one                                      | Isoguanine                                    | C <sub>5</sub> H <sub>5</sub> N <sub>3</sub> O                 | 3373-53-3  | 151.127  |                            | >360     |                        |                            |                      | i H <sub>2</sub> O                                   |
| 303 | 2-Amino-3,4-dimethylimidazo[4,5-f]quinoline                                      | Me-IQ                                         | C <sub>12</sub> H <sub>12</sub> N <sub>4</sub>                 | 77094-11-2 | 212.250  | cry                        | 297      |                        |                            |                      |                                                      |
| 304 | 2-Amino-4,6-dinitrophenol                                                        | Picramic acid                                 | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>5</sub>    | 96-91-3    | 199.121  | dk red nd (al) pr (chl)    | 169      |                        |                            |                      | vs bz, EtOH                                          |
| 305 | 2-Aminoethanesulfonic acid                                                       | Taurine                                       | C <sub>2</sub> H <sub>7</sub> NO <sub>3</sub> S                | 107-35-7   | 125.147  | mcl pr (w)                 | 328      |                        |                            |                      | vs H <sub>2</sub> O                                  |
| 306 | 1-Aminoethanol                                                                   | Acetaldehyde ammonia                          | C <sub>2</sub> H <sub>7</sub> NO                               | 75-39-8    | 61.083   | orth (eth-al)              | 97       | dec 110                |                            |                      | s H <sub>2</sub> O; sl eth                           |
| 307 | 2-(2-Aminoethoxy)ethanol                                                         | Diglycolamine                                 | C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>                 | 929-06-6   | 105.136  |                            | -12.5    | 221                    | 1.0572 <sup>20</sup>       |                      |                                                      |
| 308 | <i>N</i> -(2-Aminoethyl)acetamide                                                |                                               | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O                | 1001-53-2  | 102.134  |                            | 51       |                        |                            |                      | s H <sub>2</sub> O, EtOH, bz; i eth                  |
| 309 | 6-Amino-3-ethyl-1-allyl-2,4(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione             | Aminometradine                                | C <sub>9</sub> H <sub>13</sub> N <sub>3</sub> O <sub>2</sub>   | 642-44-4   | 195.218  | cry (+1w, w)               | 143      |                        |                            |                      |                                                      |
| 310 | 1-[(2-Aminoethyl)amino]-2-propanol                                               | <i>N</i> -(2-Hydroxypropyl)ethylenediamine    | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O                | 123-84-2   | 118.177  |                            |          | 94 <sup>3</sup>        | 0.9837 <sup>25</sup>       | 1.4738 <sup>20</sup> |                                                      |
| 311 | 4-(2-Aminoethyl)-1,2-benzenediol, hydrochloride                                  | Dopamine hydrochloride                        | C <sub>8</sub> H <sub>12</sub> ClNO <sub>2</sub>               | 62-31-7    | 189.640  | nd (w)                     | 241 dec  |                        |                            |                      | vs H <sub>2</sub> O, MeOH                            |
| 312 | $\alpha$ -(1-Aminoethyl)benzenemethanol, [ <i>S</i> -( <i>R</i> *, <i>R</i> *)]- |                                               | C <sub>9</sub> H <sub>13</sub> NO                              | 492-39-7   | 151.205  | pl(MeOH)                   | 77.5     |                        |                            |                      | vs eth, EtOH, chl                                    |
| 313 | $\alpha$ -(1-Aminoethyl)benzenemethanol, hydrochloride                           |                                               | C <sub>9</sub> H <sub>14</sub> ClNO                            | 53631-70-2 | 187.666  |                            | 198.5    |                        |                            |                      | s H <sub>2</sub> O                                   |
| 314 | <i>N</i> -(2-Aminoethyl)ethanolamine                                             |                                               | C <sub>4</sub> H <sub>12</sub> N <sub>2</sub> O                | 111-41-1   | 104.150  |                            |          | 239; 105 <sup>10</sup> | 1.0286 <sup>20</sup>       | 1.4863 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; s ace; sl bz, lig        |
| 315 | 4-(2-Aminoethyl)phenol                                                           | Tyramine                                      | C <sub>8</sub> H <sub>11</sub> NO                              | 51-67-2    | 137.179  | pl or nd (bz, w), cry (al) | 164.5    | 206 <sup>25</sup>      |                            |                      | sl H <sub>2</sub> O, bz, DMSO; s EtOH, xyl; i tol    |
| 316 | <i>N</i> -(2-Aminoethyl)-1,3-propanediamine                                      | <i>N</i> -(3-Aminopropyl)ethylenediamine      | C <sub>7</sub> H <sub>15</sub> N <sub>3</sub>                  | 13531-52-7 | 117.193  |                            |          | 87 <sup>3</sup>        |                            | 1.4805 <sup>25</sup> |                                                      |
| 317 | 2-Amino-2-ethyl-1,3-propanediol                                                  |                                               | C <sub>5</sub> H <sub>13</sub> NO <sub>2</sub>                 | 115-70-8   | 119.163  |                            | 37.5     | 152 <sup>10</sup>      | 1.099 <sup>20</sup>        | 1.490 <sup>20</sup>  | msc H <sub>2</sub> O                                 |
| 318 | <i>L</i> -2-Aminohexanedioic acid                                                | 2-Aminoadipic acid                            | C <sub>6</sub> H <sub>11</sub> NO <sub>4</sub>                 | 542-32-5   | 161.156  | cry (EtOH, w)              | 205 dec  |                        |                            |                      | sl H <sub>2</sub> O, EtOH, eth                       |
| 319 | 6-Aminohexanenitrile                                                             | 5-Cyano-1-pentylamine                         | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>                  | 2432-74-8  | 112.172  | liq                        |          | 118 <sup>16</sup>      |                            |                      |                                                      |
| 320 | 6-Aminohexanoic acid                                                             | $\epsilon$ -Aminocaproic acid                 | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                 | 60-32-2    | 131.173  | lf (eth)                   | 205      |                        |                            |                      | vs H <sub>2</sub> O; i EtOH; sl MeOH                 |
| 321 | 6-Amino-1-hexanol                                                                |                                               | C <sub>6</sub> H <sub>15</sub> NO                              | 4048-33-3  | 117.189  |                            | 57       | 137 <sup>30</sup>      |                            |                      |                                                      |
| 322 | 1-Amino-4-hydroxy-9,10-anthracenedione                                           |                                               | C <sub>14</sub> H <sub>9</sub> NO <sub>3</sub>                 | 116-85-8   | 239.226  |                            | 216.5    |                        |                            |                      | s EtOH, ace                                          |
| 323 | 3-Amino-4-hydroxybenzenesulfonic acid                                            |                                               | C <sub>6</sub> H <sub>7</sub> NO <sub>3</sub> S                | 98-37-3    | 189.190  | orth (w+1)                 | >300     |                        |                            |                      | sl H <sub>2</sub> O; i EtOH, eth                     |
| 324 | 4-Amino-2-hydroxybenzohydrazide                                                  | <i>p</i> -Aminosalicylic acid hydrazide       | C <sub>7</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>    | 6946-29-8  | 167.165  | nd (al)                    | 195      |                        |                            |                      | vs EtOH                                              |
| 325 | 2-Amino-3-hydroxybenzoic acid                                                    |                                               | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                  | 548-93-6   | 153.136  | lf (w)                     | 253.5    |                        |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, chl                |
| 326 | 4-Amino-2-hydroxybenzoic acid                                                    | <i>p</i> -Aminosalicylic acid                 | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                  | 65-49-6    | 153.136  | nd, pl (al-eth)            | 150 dec  |                        |                            |                      | s H <sub>2</sub> O, EtOH, eth, ace; i bz, peth, chl  |
| 327 | 5-Amino-2-hydroxybenzoic acid                                                    | Mesalamine                                    | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                  | 89-57-6    | 153.136  |                            | 283      |                        |                            |                      | sl H <sub>2</sub> O; i EtOH                          |
| 328 | 3-Amino-4-hydroxybutanoic acid                                                   | $\gamma$ -Hydroxy- $\beta$ -aminobutyric acid | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                  | 589-44-6   | 119.119  | pr                         | 216      |                        |                            |                      | vs H <sub>2</sub> O; sl EtOH, chl, eth, AcOEt        |
| 329 | 4-Amino-3-hydroxybutanoic acid, ( $\pm$ )                                        |                                               | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                  | 924-49-2   | 119.119  | pr (w), cry (dil al)       | 218      |                        |                            |                      | vs H <sub>2</sub> O                                  |
| 330 | 4-(2-Amino-1-hydroxyethyl)-1,2-benzenediol, ( $\pm$ )                            |                                               | C <sub>8</sub> H <sub>11</sub> NO <sub>3</sub>                 | 138-65-8   | 169.178  |                            |          | 189 dec                |                            |                      |                                                      |
| 331 | 1-Amino-4-hydroxy-2-methoxy-9,10-anthracenedione                                 |                                               | C <sub>15</sub> H <sub>11</sub> NO <sub>4</sub>                | 2379-90-0  | 269.253  |                            |          |                        |                            |                      | sl chl                                               |
| 332 | 4-Amino-5-(hydroxymethyl)-2(1 <i>H</i> )-pyrimidinone                            | 5-Hydroxymethylcytosine                       | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>    | 1123-95-1  | 141.129  |                            | >300 dec |                        |                            |                      |                                                      |



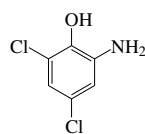
1-Amino-2,4-dibromo-9,10-anthracenedione



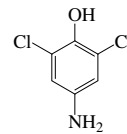
3-Amino-2,5-dichlorobenzoic acid



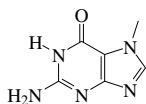
2-Amino-2',5-dichlorobenzophenone



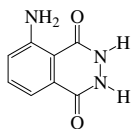
2-Amino-4,6-dichlorophenol



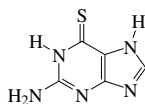
4-Amino-2,6-dichlorophenol



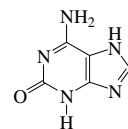
2-Amino-1,7-dihydro-7-methyl-6H-purin-6-one



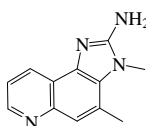
5-Amino-2,3-dihydro-1,4-phthalazinedione



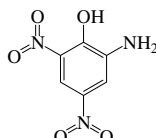
2-Amino-1,7-dihydro-6H-purine-6-thione



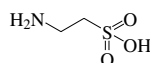
6-Amino-1,3-dihydro-2H-purin-2-one



2-Amino-3,4-dimethylimidazo[4,5-f]quinoline



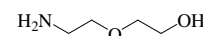
2-Amino-4,6-dinitrophenol



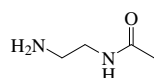
2-Aminoethanesulfonic acid



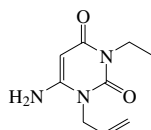
1-Aminoethanol



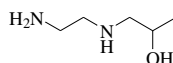
2-(2-Aminoethoxy)ethanol



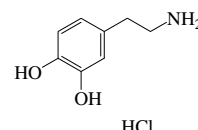
N-(2-Aminoethyl)acetamide



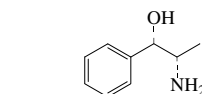
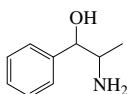
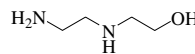
6-Amino-3-ethyl-1-allyl-2,4-(1H,3H)-pyrimidinedione



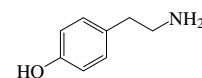
1-[(2-Aminoethyl)amino]-2-propanol



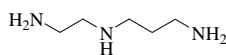
4-(2-Aminoethyl)-1,2-benzenediol, hydrochloride

 $\alpha$ -(1-Aminoethyl)benzenemethanol, [S-(R\*,R\*)]- $\alpha$ -(1-Aminoethyl)benzenemethanol, hydrochloride

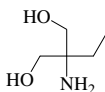
N-(2-Aminoethyl)ethanolamine



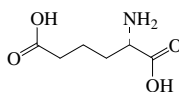
4-(2-Aminoethyl)phenol



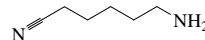
N-(2-Aminoethyl)-1,3-propanediamine



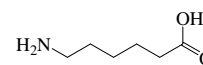
2-Amino-2-ethyl-1,3-propanediol



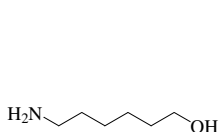
L-2-Aminohexanedioic acid



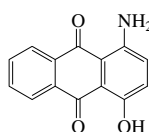
6-Aminohexanenitrile



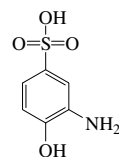
6-Aminohexanoic acid



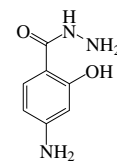
6-Amino-1-hexanol



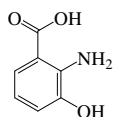
1-Amino-4-hydroxy-9,10-anthracenedione



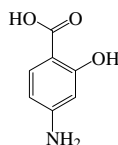
3-Amino-4-hydroxybenzenesulfonic acid



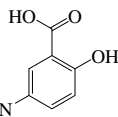
4-Amino-2-hydroxybenzohydrazide



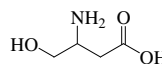
2-Amino-3-hydroxybenzoic acid



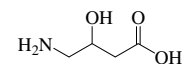
4-Amino-2-hydroxybenzoic acid



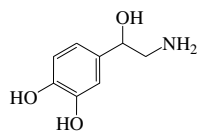
5-Amino-2-hydroxybenzoic acid



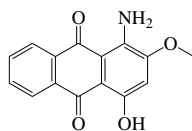
3-Amino-4-hydroxybutanoic acid



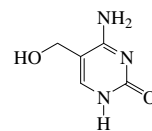
4-Amino-3-hydroxybutanoic acid, (±)



4-(2-Amino-1-hydroxyethyl)-1,2-benzenediol, (±)



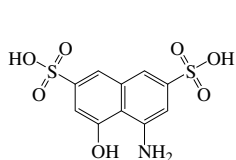
1-Amino-4-hydroxy-2-methoxy-9,10-anthracenedione



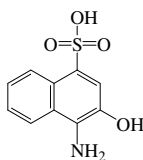
4-Amino-5-(hydroxymethyl)-2(1H)-pyrimidinone



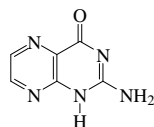
| No. | Name                                                      | Synonym                                            | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                | mp/°C   | bp/°C              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                       |
|-----|-----------------------------------------------------------|----------------------------------------------------|---------------------------------------------------------------|------------|----------|------------------------------|---------|--------------------|----------------------------|----------------------|------------------------------------------------------------------|
| 333 | 4-Amino-5-hydroxy-2,7-naphthalenedisulfonic acid          | 1-Naphthol-8-amino-3,6-disulfonic acid             | C <sub>10</sub> H <sub>9</sub> NO <sub>7</sub> S <sub>2</sub> | 90-20-0    | 319.311  |                              |         |                    |                            |                      | sl H <sub>2</sub> O, EtOH, eth                                   |
| 334 | 4-Amino-3-hydroxy-1-naphthalenesulfonic acid              | 1-Amino-2-naphthol-4-sulfonic acid                 | C <sub>10</sub> H <sub>9</sub> NO <sub>4</sub> S              | 116-63-2   | 239.248  | gray nd                      |         |                    |                            |                      | i H <sub>2</sub> O, EtOH, bz; s alk                              |
| 335 | 2-Amino-4-hydroxypteridine                                |                                                    | C <sub>6</sub> H <sub>4</sub> N <sub>6</sub> O                | 2236-60-4  | 163.137  | ye cry                       | >360    |                    |                            |                      |                                                                  |
| 336 | 5-Amino-1 <i>H</i> -imidazole-4-carboxamide               |                                                    | C <sub>4</sub> H <sub>6</sub> N <sub>4</sub> O                | 360-97-4   | 126.117  | cry (EtOH)                   | 170     |                    |                            |                      |                                                                  |
| 337 | <i>O</i> -[(Aminoiminomethyl)amino]- <i>L</i> -homoserine | Canavanine                                         | C <sub>5</sub> H <sub>12</sub> N <sub>4</sub> O <sub>3</sub>  | 543-38-4   | 176.174  | cry (al)                     |         |                    |                            |                      | vs H <sub>2</sub> O                                              |
| 338 | (Aminoiminomethyl)urea                                    |                                                    | C <sub>2</sub> H <sub>6</sub> N <sub>4</sub> O                | 141-83-3   | 102.095  | pr                           | 105     | dec 160            |                            |                      | s H <sub>2</sub> O, py; sl EtOH; i eth, bz, chl, CS <sub>2</sub> |
| 339 | 2-Amino-5-iodobenzoic acid                                |                                                    | C <sub>7</sub> H <sub>6</sub> INO <sub>2</sub>                | 5326-47-6  | 263.033  |                              | 220 dec |                    |                            |                      | sl H <sub>2</sub> O, tfa; vs EtOH, eth, ace; s bz                |
| 340 | 4-Amino-1 <i>H</i> -isindole-1,3(2 <i>H</i> )-dione       |                                                    | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 2518-24-3  | 162.146  |                              | 269.5   |                    |                            |                      |                                                                  |
| 341 | 4-Amino-3-isoxazolidinone, ( <i>R</i> )                   | Cycloserine                                        | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 68-41-7    | 102.092  |                              | 155 dec |                    |                            |                      | s H <sub>2</sub> O; sl MeOH                                      |
| 342 | 1-Amino-2-methyl-9,10-anthracenedione                     | 1-Amino-2-methylantraquinone                       | C <sub>15</sub> H <sub>11</sub> NO <sub>2</sub>               | 82-28-0    | 237.254  |                              | 205.5   |                    |                            |                      | i H <sub>2</sub> O; s EtOH, bz, chl; sl eth                      |
| 343 | α-(Aminomethyl)benzenemethanol                            | Phenylethanamine                                   | C <sub>8</sub> H <sub>11</sub> NO                             | 7568-93-6  | 137.179  |                              | 56.5    | 160 <sup>17</sup>  |                            |                      | vs H <sub>2</sub> O; s EtOH                                      |
| 344 | β-(Aminomethyl)benzenepranoic acid                        | 4-Amino-3-phenylbutyric acid                       | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>               | 1078-21-3  | 179.216  |                              | 252 dec |                    |                            |                      |                                                                  |
| 345 | 2-Amino-5-methylbenzenesulfonic acid                      |                                                    | C <sub>7</sub> H <sub>9</sub> NO <sub>3</sub> S               | 88-44-8    | 187.216  | lt ye nd                     | 132 dec |                    |                            |                      | vs H <sub>2</sub> O                                              |
| 346 | <i>trans</i> -4-(Aminomethyl)cyclohexanecarboxylic acid   | Tranexamic acid                                    | C <sub>8</sub> H <sub>15</sub> NO <sub>2</sub>                | 1197-18-8  | 157.211  |                              | >300    |                    |                            |                      | vs H <sub>2</sub> O                                              |
| 347 | 4-Amino-4-methyl-2-pentanone                              | Diacetonamine                                      | C <sub>6</sub> H <sub>13</sub> NO                             | 625-04-7   | 115.173  |                              |         | 25 <sup>9,14</sup> |                            |                      | s H <sub>2</sub> O; msc EtOH, eth                                |
| 348 | 2-Amino-4-methylphenol                                    |                                                    | C <sub>7</sub> H <sub>9</sub> NO                              | 95-84-1    | 123.152  | cry (w), orth (bz), lf or nd | 136     | sub                |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, eth, chl; i lig                 |
| 349 | 4-Amino-2-methylphenol                                    |                                                    | C <sub>7</sub> H <sub>9</sub> NO                              | 2835-96-3  | 123.152  | nd or lf (bz)                | 176.5   | sub                |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, eth                             |
| 350 | 4-Amino-3-methylphenol                                    |                                                    | C <sub>7</sub> H <sub>9</sub> NO                              | 2835-99-6  | 123.152  | pr (dil al) cry (bz)         | 179     |                    |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s DMSO                        |
| 351 | (Aminomethyl)phosphonic acid                              |                                                    | CH <sub>6</sub> NO <sub>3</sub> P                             | 1066-51-9  | 111.038  | cry                          | 309     |                    |                            |                      |                                                                  |
| 352 | 2-Amino-2-methyl-1,3-propanediol                          |                                                    | C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>                | 115-69-5   | 105.136  |                              | 110     | 151 <sup>10</sup>  |                            |                      | vs H <sub>2</sub> O; s EtOH                                      |
| 353 | <i>L</i> -3-Amino-2-methylpropanoic acid                  |                                                    | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                 | 144-90-1   | 103.120  | cry (w)                      | 182     |                    |                            |                      |                                                                  |
| 354 | 2-Amino-2-methyl-1-propanol                               | 2-Aminoisobutanol                                  | C <sub>4</sub> H <sub>11</sub> NO                             | 124-68-5   | 89.136   |                              | 25.5    | 165.5              | 0.934 <sup>20</sup>        | 1.449 <sup>20</sup>  | msc H <sub>2</sub> O; s ctc                                      |
| 355 | 4-Amino-5-methyl-2(1 <i>H</i> )-pyrimidinone              | 5-Methylcytosine                                   | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O                | 554-01-8   | 125.129  | pr (w+1/2)                   | 270 dec |                    |                            |                      | s H <sub>2</sub> O, acid; sl EtOH; i eth                         |
| 356 | 3-(Aminomethyl)-3,5,5-trimethylcyclohexanol               | 1-Hydroxy-3-aminomethyl-3,5,5-trimethylcyclohexane | C <sub>10</sub> H <sub>21</sub> NO                            | 15647-11-7 | 171.280  |                              | 45.5    | 265                | 0.969 <sup>25</sup>        | 1.4904 <sup>20</sup> |                                                                  |
| 357 | 3-Amino-2-naphthalenecarboxylic acid                      | 3-Amino-2-naphthoic acid                           | C <sub>11</sub> H <sub>9</sub> NO <sub>2</sub>                | 5959-52-4  | 187.195  | ye lf (dil al)               | 216.5   |                    |                            |                      | s EtOH, eth                                                      |
| 358 | 2-Amino-1,4-naphthalenedione                              |                                                    | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>                | 2348-81-4  | 173.169  |                              | 207     |                    |                            |                      | i H <sub>2</sub> O, alk; s EtOH, eth, HOAc                       |
| 359 | 7-Amino-1,3-naphthalenedisulfonic acid                    | Amido-G-Acid                                       | C <sub>10</sub> H <sub>9</sub> NO <sub>6</sub> S <sub>2</sub> | 86-65-7    | 303.311  | mcl pr or nd (w+4)           | 274     |                    |                            |                      | vs H <sub>2</sub> O, EtOH                                        |
| 360 | 2-Amino-1,5-naphthalenedisulfonic acid                    | 2-Naphthylamine-1,5-disulfonic acid                | C <sub>10</sub> H <sub>9</sub> NO <sub>6</sub> S <sub>2</sub> | 117-62-4   | 303.311  |                              | >300    |                    |                            |                      |                                                                  |
| 361 | 4-Amino-1,6-naphthalenedisulfonic acid                    | 1-Naphthylamine-4,7-disulfonic acid                | C <sub>10</sub> H <sub>9</sub> NO <sub>6</sub> S <sub>2</sub> | 85-75-6    | 303.311  |                              |         |                    |                            |                      | vs H <sub>2</sub> O                                              |
| 362 | 4-Amino-1,7-naphthalenedisulfonic acid                    | 1-Naphthylamine-4,6-disulfonic acid                | C <sub>10</sub> H <sub>9</sub> NO <sub>6</sub> S <sub>2</sub> | 85-74-5    | 303.311  |                              |         |                    |                            |                      | vs H <sub>2</sub> O, EtOH                                        |
| 363 | 2-Amino-1-naphthalenesulfonic acid                        | 2-Naphthylamine-1-sulfonic acid                    | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub> S              | 81-16-3    | 223.248  | sc(hot w)                    |         |                    |                            |                      | s DMSO                                                           |
| 364 | 4-Amino-1-naphthalenesulfonic acid                        | 1-Naphthylamine-4-sulfonic acid                    | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub> S              | 84-86-6    | 223.248  | wh nd (w+1/2) red-br cry     | dec     |                    | 1.6703 <sup>25</sup>       |                      | i H <sub>2</sub> O; sl EtOH; s MeOH, py                          |
| 365 | 5-Amino-1-naphthalenesulfonic acid                        | 1-Naphthylamine-5-sulfonic acid                    | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub> S              | 84-89-9    | 223.248  | wh cry                       |         |                    |                            |                      | s H <sub>2</sub> O; i eth                                        |
| 366 | 6-Amino-1-naphthalenesulfonic acid                        | 2-Naphthylamine-5-sulfonic acid                    | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub> S              | 81-05-0    | 223.248  | nd(w)                        |         |                    |                            |                      | i H <sub>2</sub> O, EtOH, eth                                    |
| 367 | 7-Amino-1-naphthalenesulfonic acid                        | Badische acid                                      | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub> S              | 86-60-2    | 223.248  | nd (w+1), pl (aq ace)        |         |                    |                            |                      | vs HOAc                                                          |
| 368 | 8-Amino-1-naphthalenesulfonic acid                        | 1-Naphthylamine-8-sulfonic acid                    | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub> S              | 82-75-7    | 223.248  | nd                           |         |                    |                            |                      | vs gl HOAc                                                       |
| 369 | 6-Amino-2-naphthalenesulfonic acid                        | Bronner acid                                       | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub> S              | 93-00-5    | 223.248  | lf                           |         |                    |                            |                      | i cold H <sub>2</sub> O; sl hot H <sub>2</sub> O                 |



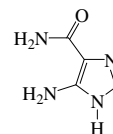
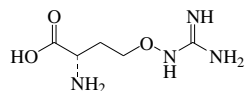
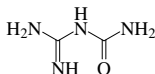
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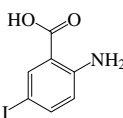
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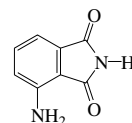
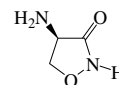
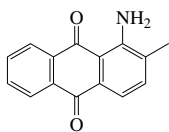
2-Amino-4-hydroxypteridine

5-Amino-1*H*-imidazole-4-carboxamide*O*-((Aminoiminomethyl)amino)-*L*-homoserine

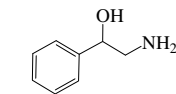
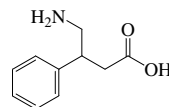
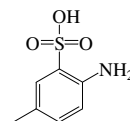
(Aminoiminomethyl)urea



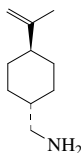
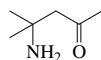
2-Amino-5-iodobenzoic acid

4-Amino-1*H*-isoindole-1,3(2*H*)-dione4-Amino-3-isoxazolidinone, (*R*)

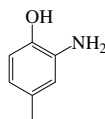
1-Amino-2-methyl-9,10-anthracenedione

 $\alpha$ -(Aminomethyl)benzenemethanol $\beta$ -(Aminomethyl)benzenepropanoic acid

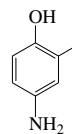
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*trans*-4-(Aminomethyl)cyclohexanecarboxylic acid

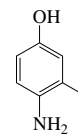
4-Amino-4-methyl-2-pentanone



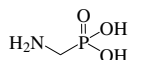
2-Amino-4-methylphenol



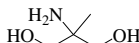
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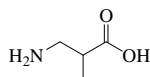
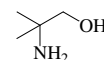
4-Amino-3-methylphenol



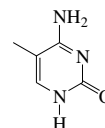
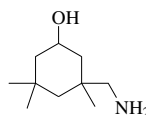
(Aminomethyl)phosphonic acid



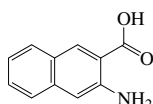
2-Amino-2-methyl-1,3-propanediol

*L*-3-Amino-2-methylpropanoic acid

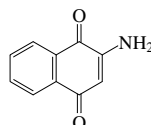
2-Amino-2-methyl-1-propanol

4-Amino-5-methyl-2(1*H*)-pyrimidinone

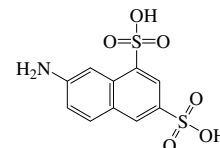
3-(Aminomethyl)-3,5,5-trimethylcyclohexanol



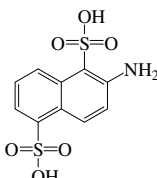
3-Amino-2-naphthalenecarboxylic acid



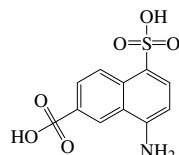
2-Amino-1,4-naphthalenedione



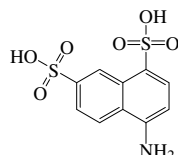
7-Amino-1,3-naphthalenedisulfonic acid



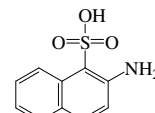
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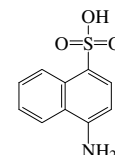
4-Amino-1,6-naphthalenedisulfonic acid



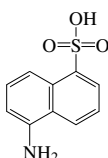
4-Amino-1,7-naphthalenedisulfonic acid



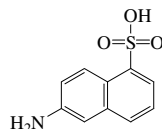
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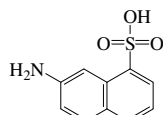
4-Amino-1-naphthalenesulfonic acid



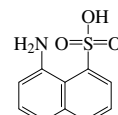
5-Amino-1-naphthalenesulfonic acid



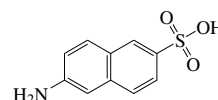
6-Amino-1-naphthalenesulfonic acid



7-Amino-1-naphthalenesulfonic acid

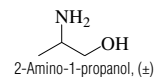
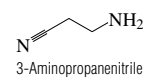
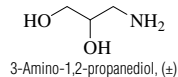
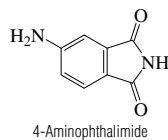
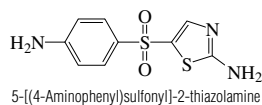
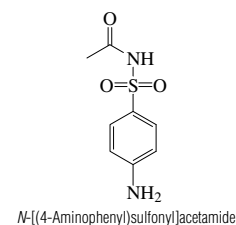
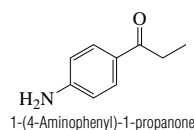
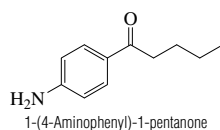
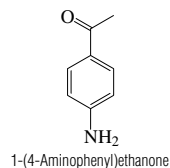
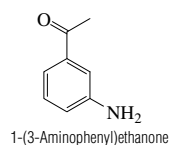
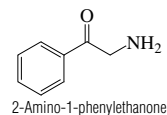
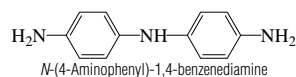
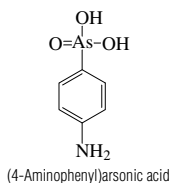
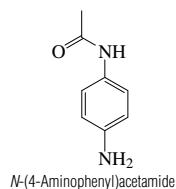
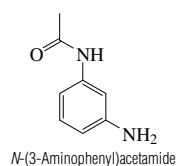
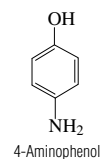
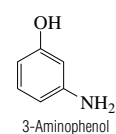
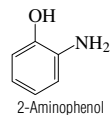
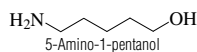
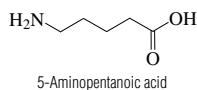
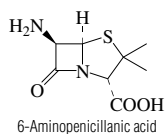
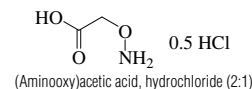
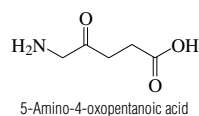
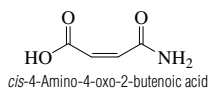
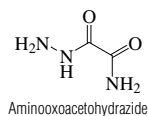
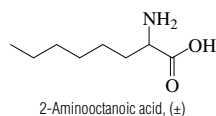
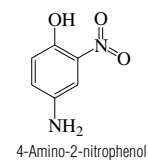
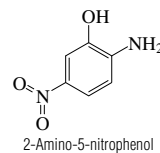
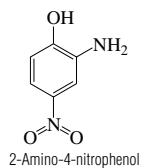
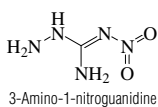
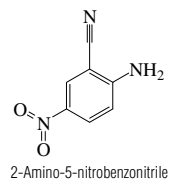
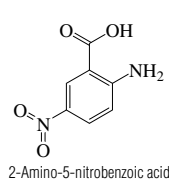
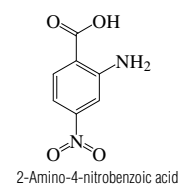
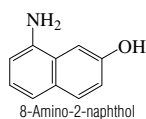
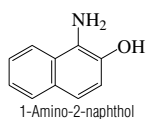
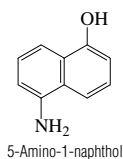
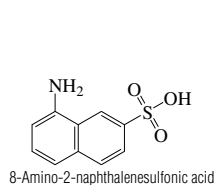


8-Amino-1-naphthalenesulfonic acid

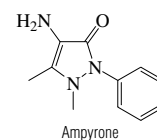
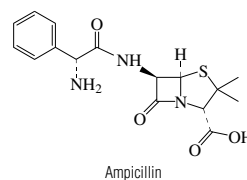
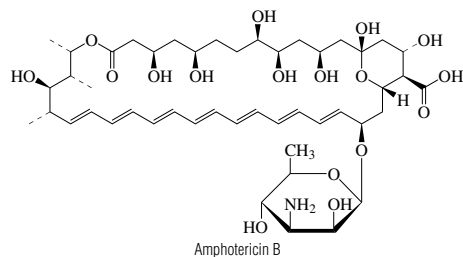
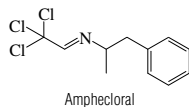
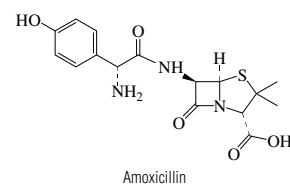
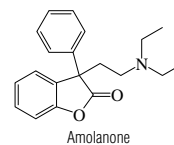
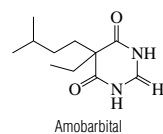
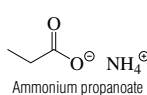
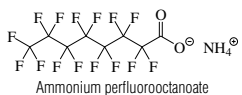
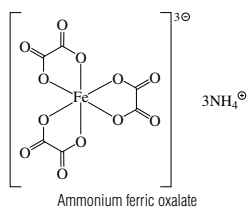
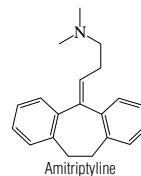
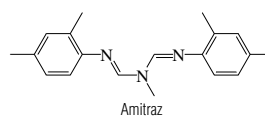
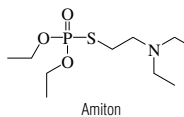
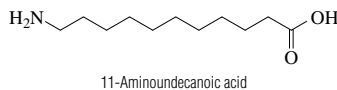
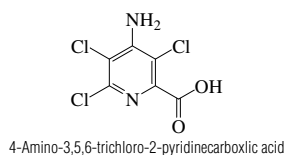
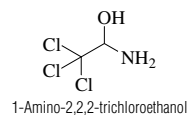
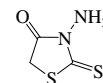
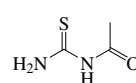
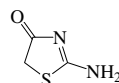
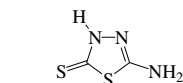
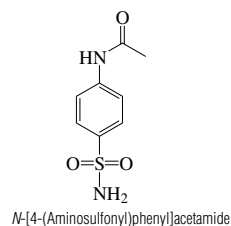
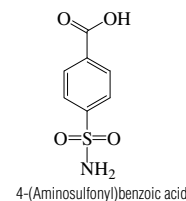
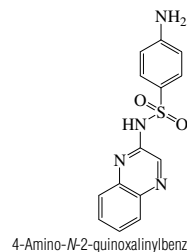
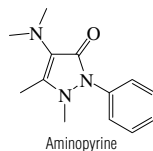
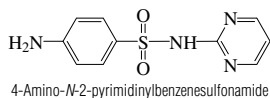
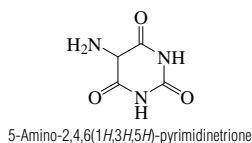
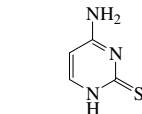
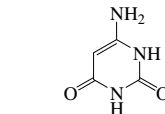
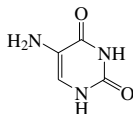
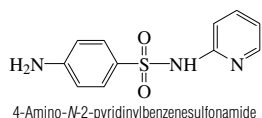
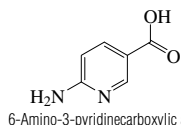
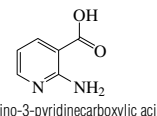
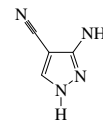
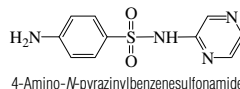
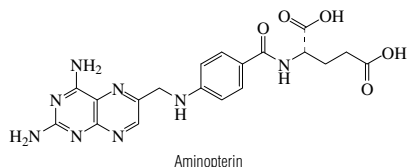
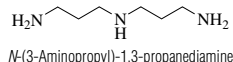
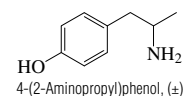
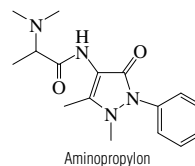
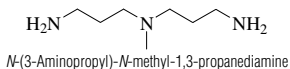
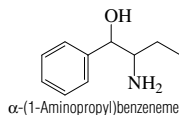
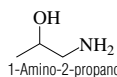
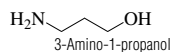


6-Amino-2-naphthalenesulfonic acid

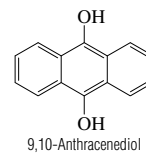
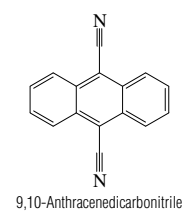
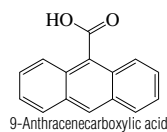
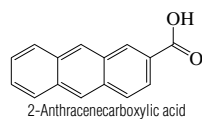
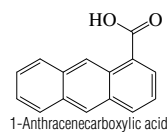
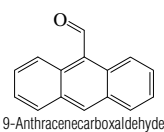
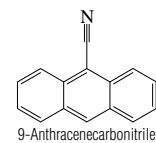
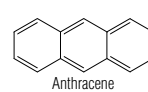
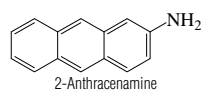
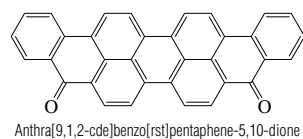
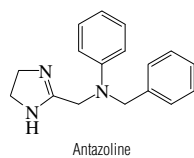
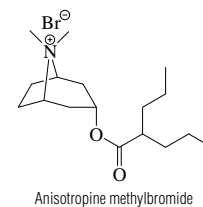
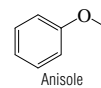
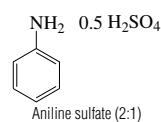
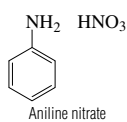
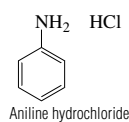
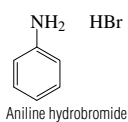
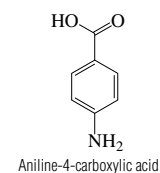
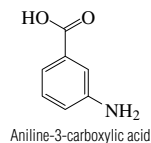
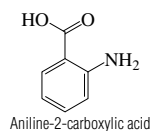
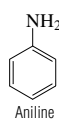
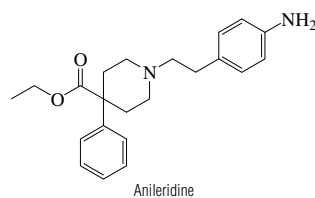
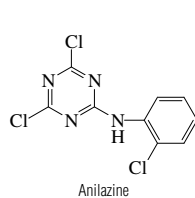
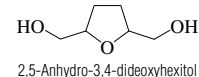
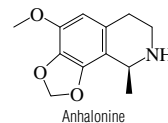
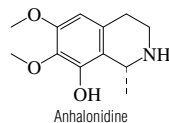
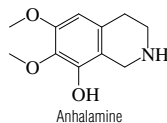
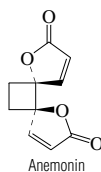
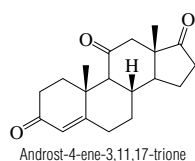
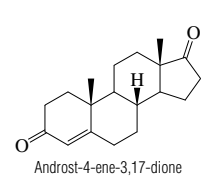
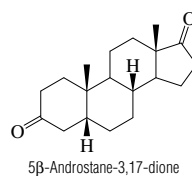
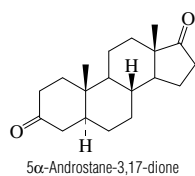
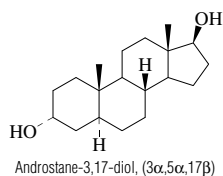
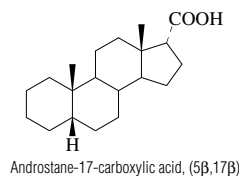
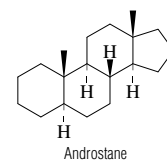
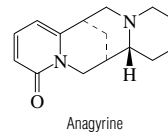
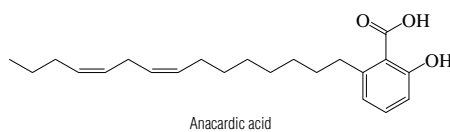
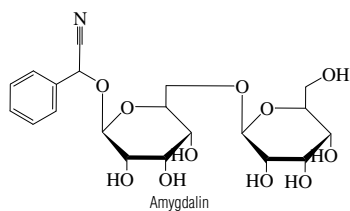
| No. | Name                                         | Synonym                                              | Mol. Form.                                                                 | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|-----|----------------------------------------------|------------------------------------------------------|----------------------------------------------------------------------------|------------|----------|----------------------------|---------|---------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 370 | 8-Amino-2-naphthalenesulfonic acid           | 1,7-Cleve's acid                                     | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub> S                           | 119-28-8   | 223.248  | nd or pr (w)               |         |                           |                            |                      | sl EtOH; s eth                                      |
| 371 | 5-Amino-1-naphthol                           | 1-Amino-6-hydroxynaphthalene                         | C <sub>10</sub> H <sub>9</sub> NO                                          | 83-55-6    | 159.184  |                            | 170     |                           |                            |                      | sl DMSO                                             |
| 372 | 1-Amino-2-naphthol                           |                                                      | C <sub>10</sub> H <sub>9</sub> NO                                          | 2834-92-6  | 159.184  | silvery lf (bz, eth)       | 150 dec |                           |                            |                      | sl H <sub>2</sub> O, eth; s EtOH; vs dil alk, acid  |
| 373 | 8-Amino-2-naphthol                           | 8-Amino-β-naphthol                                   | C <sub>10</sub> H <sub>9</sub> NO                                          | 118-46-7   | 159.184  | nd (w, al)                 | 206     | sub                       |                            |                      | s H <sub>2</sub> O, eth; vs EtOH; sl bz, lig        |
| 374 | 2-Amino-4-nitrobenzoic acid                  |                                                      | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                | 619-17-0   | 182.134  | oran pr (dil al)           | 269     |                           |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, ace; s xyl        |
| 375 | 2-Amino-5-nitrobenzoic acid                  |                                                      | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                | 616-79-5   | 182.134  | lf (al), ye nd (w, dil al) | 269     |                           |                            |                      | i H <sub>2</sub> O, bz, chl, xyl; s EtOH, eth       |
| 376 | 2-Amino-5-nitrobenzonitrile                  |                                                      | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>                | 17420-30-3 | 163.134  |                            | 203.5   |                           |                            |                      | sl DMSO                                             |
| 377 | 3-Amino-1-nitroguanidine                     |                                                      | CH <sub>3</sub> N <sub>6</sub> O <sub>2</sub>                              | 18264-75-0 | 119.084  |                            | 187.8   |                           |                            |                      | sl H <sub>2</sub> O                                 |
| 378 | 2-Amino-4-nitrophenol                        |                                                      | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>3</sub>                | 99-57-0    | 154.123  | oran pr (+w)               | 146     |                           |                            |                      | sl H <sub>2</sub> O, ace; vs EtOH; s eth, bz, HOAc  |
| 379 | 2-Amino-5-nitrophenol                        |                                                      | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>3</sub>                | 121-88-0   | 154.123  |                            | 205.8   |                           |                            |                      | s H <sub>2</sub> O, EtOH, bz                        |
| 380 | 4-Amino-2-nitrophenol                        |                                                      | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>3</sub>                | 119-34-6   | 154.123  | dk red pl or nd (w, al)    | 131     | 110 <sup>12</sup>         |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl DMSO              |
| 381 | 2-Aminooctanoic acid, (±)                    |                                                      | C <sub>8</sub> H <sub>17</sub> NO <sub>2</sub>                             | 644-90-6   | 159.227  | lf (w)                     | 270     | sub                       |                            |                      | sl H <sub>2</sub> O, EtOH, eth, bz; s HOAc          |
| 382 | Aminooxoacetohydrazide                       | Semioxamazide                                        | C <sub>2</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>                | 515-96-8   | 103.080  |                            | 221 dec |                           |                            |                      | sl H <sub>2</sub> O; i EtOH, eth; vs alk, acid      |
| 383 | <i>cis</i> -4-Amino-4-oxo-2-butenic acid     | Maleamic acid                                        | C <sub>4</sub> H <sub>5</sub> NO <sub>3</sub>                              | 557-24-4   | 115.088  | cry (al)                   | 172.5   |                           |                            |                      | vs H <sub>2</sub> O, EtOH                           |
| 384 | 5-Amino-4-oxopentanoic acid                  | 5-Aminolevulinic acid                                | C <sub>5</sub> H <sub>7</sub> NO <sub>3</sub>                              | 106-60-5   | 131.130  | cry (EtOH)                 | 118     |                           |                            |                      |                                                     |
| 385 | (Aminoxy)acetic acid, hydrochloride (2:1)    |                                                      | C <sub>4</sub> H <sub>11</sub> ClN <sub>2</sub> O <sub>6</sub>             | 2921-14-4  | 218.592  |                            | 152.5   |                           |                            |                      |                                                     |
| 386 | 6-Aminopenicillanic acid                     | Penicillin                                           | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub> S             | 551-16-6   | 216.257  | cry (w)                    | 208     |                           |                            |                      |                                                     |
| 387 | 5-Aminopentanoic acid                        |                                                      | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                             | 660-88-8   | 117.147  | lf (dil al)                | 157 dec | dec                       |                            |                      | s H <sub>2</sub> O; sl EtOH; i eth, bz, lig         |
| 388 | 5-Amino-1-pentanol                           |                                                      | C <sub>5</sub> H <sub>13</sub> NO                                          | 2508-29-4  | 103.163  |                            | 38.5    | 221.5                     | 0.9488 <sup>17</sup>       | 1.4618 <sup>17</sup> | msc H <sub>2</sub> O, EtOH, ace                     |
| 389 | 2-Aminophenol                                |                                                      | C <sub>6</sub> H <sub>7</sub> NO                                           | 95-55-6    | 109.126  | wh orth bipym nd (bz)      | 174     | sub 153                   | 1.328 <sup>25</sup>        |                      | s H <sub>2</sub> O, eth; vs EtOH; sl bz, tfa        |
| 390 | 3-Aminophenol                                |                                                      | C <sub>6</sub> H <sub>7</sub> NO                                           | 591-27-5   | 109.126  | pr (to)                    | 123     | 164 <sup>11</sup>         |                            |                      | s H <sub>2</sub> O, tol; vs EtOH, eth; sl bz, DMSO  |
| 391 | 4-Aminophenol                                |                                                      | C <sub>6</sub> H <sub>7</sub> NO                                           | 123-30-8   | 109.126  | wh pl (w)                  | 187.5   | 110 <sup>0.3</sup>        |                            |                      | sl H <sub>2</sub> O, tfa; vs EtOH; i bz, chl; s alk |
| 392 | <i>N</i> -(3-Aminophenyl)acetamide           |                                                      | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O                            | 102-28-3   | 150.177  | nd or pl (bz)              | 88      |                           |                            |                      | vs H <sub>2</sub> O, EtOH, ace; sl eth, bz          |
| 393 | <i>N</i> -(4-Aminophenyl)acetamide           | <i>p</i> -Aminoacetanilide                           | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O                            | 122-80-5   | 150.177  | nd (w)                     | 166.5   | 267                       |                            |                      | s H <sub>2</sub> O; vs EtOH, eth                    |
| 394 | (4-Aminophenyl)arsonic acid                  | Arsanilic acid                                       | C <sub>6</sub> H <sub>6</sub> AsNO <sub>3</sub>                            | 98-50-0    | 217.055  | mcl nd (w, al)             | 232     |                           | 1.9571 <sup>10</sup>       |                      | s H <sub>2</sub> O, eth; sl EtOH, DMSO; i ace, bz   |
| 395 | <i>N</i> -(4-Aminophenyl)-1,4-benzenediamine | 4,4'-Diaminodiphenylamine                            | C <sub>12</sub> H <sub>13</sub> N <sub>3</sub>                             | 537-65-5   | 199.251  | lf (w)                     | 158     | dec                       |                            |                      | vs eth, EtOH                                        |
| 396 | 2-Amino-1-phenylethanone                     | Phenacylamine                                        | C <sub>8</sub> H <sub>9</sub> NO                                           | 613-89-8   | 135.163  | ye cry                     | 20      | 251                       |                            | 1.6160 <sup>20</sup> | i H <sub>2</sub> O; s eth; sl ctc                   |
| 397 | 1-(3-Aminophenyl)ethanone                    | <i>m</i> -Aminoacetophenone                          | C <sub>8</sub> H <sub>9</sub> NO                                           | 99-03-6    | 135.163  | pa ye pl (al), lf (eth)    | 98.5    | 289.5                     |                            |                      | sl H <sub>2</sub> O; s EtOH                         |
| 398 | 1-(4-Aminophenyl)ethanone                    | <i>p</i> -Aminoacetophenone                          | C <sub>8</sub> H <sub>9</sub> NO                                           | 99-92-3    | 135.163  | ye mcl pr (al)             | 106     | 294; 195 <sup>15</sup>    |                            |                      | vs eth, EtOH                                        |
| 399 | 1-(4-Aminophenyl)-1-pentanone                |                                                      | C <sub>11</sub> H <sub>15</sub> NO                                         | 38237-74-0 | 177.243  | cry (bz-peth)              | 74.5    | 161 <sup>3</sup>          |                            |                      | i H <sub>2</sub> O; s EtOH, eth                     |
| 400 | 1-(4-Aminophenyl)-1-propanone                | <i>p</i> -Aminopropiophenone                         | C <sub>9</sub> H <sub>11</sub> NO                                          | 70-69-9    | 149.189  | pl (al, w), nd (w)         | 140     |                           |                            |                      | s DMSO                                              |
| 401 | <i>N</i> [(4-Aminophenyl)sulfonyl]acetamide  | Sulfacetamide                                        | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub> S             | 144-80-9   | 214.241  |                            | 183     |                           |                            |                      | sl H <sub>2</sub> O; s EtOH; i eth; vs ace, alk     |
| 402 | 5-[(4-Aminophenyl)sulfonyl]-2-thiazolamine   | Thiazolsulfone                                       | C <sub>8</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub> S <sub>2</sub> | 473-30-3   | 255.316  | nd (al)                    | 220 dec |                           |                            |                      | vs ace, eth, EtOH, diox                             |
| 403 | 4-Aminophthalimide                           | 5-Amino-1 <i>H</i> -isoindole-1,3(2 <i>H</i> )-dione | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                | 3676-85-5  | 162.146  |                            |         | 224 <sup>0.5</sup>        |                            |                      |                                                     |
| 404 | 3-Amino-1,2-propanediol, (±)                 |                                                      | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                              | 13552-31-3 | 91.109   |                            |         | dec 265; 145 <sup>9</sup> | 1.1752 <sup>20</sup>       | 1.4910 <sup>25</sup> | s H <sub>2</sub> O, EtOH; i eth, bz                 |
| 405 | 3-Aminopropanenitrile                        | 3-Aminopropionitrile                                 | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub>                               | 151-18-8   | 70.093   |                            |         | 185; 88 <sup>20</sup>     | 0.9584 <sup>20</sup>       | 1.4396 <sup>20</sup> |                                                     |
| 406 | 2-Amino-1-propanol, (±)                      |                                                      | C <sub>3</sub> H <sub>9</sub> NO                                           | 6168-72-5  | 75.109   |                            |         | 174.5                     |                            | 1.4502 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; sl chl              |



| No. | Name                                                                | Synonym                                                                         | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form           | mp/°C     | bp/°C                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|-----|---------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------|------------|----------|-------------------------|-----------|-------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 407 | 3-Amino-1-propanol                                                  | Propanolamine                                                                   | C <sub>3</sub> H <sub>9</sub> NO                                            | 156-87-6   | 75.109   |                         | 12.4      | 187.5                   | 0.9824 <sup>26</sup>       | 1.4617 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth                              |
| 408 | 1-Amino-2-propanol                                                  | Isopropanolamine                                                                | C <sub>3</sub> H <sub>9</sub> NO                                            | 1674-56-2  | 75.109   |                         | 0.9       | 159.4                   | 0.9611 <sup>20</sup>       | 1.4479 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth, ace, bz,<br>ctc        |
| 409 | $\alpha$ -(1-Aminopropyl)benzenemethanol                            | $\alpha$ -( $\alpha$ -Aminopropyl)benzyl alcohol                                | C <sub>10</sub> H <sub>13</sub> NO                                          | 5897-76-7  | 165.232  | pl (bz-eth)             | 79.5      |                         |                            |                      |                                                            |
| 410 | <i>N</i> -(3-Aminopropyl)- <i>N</i> -methyl-1,3-propanediamine      |                                                                                 | C <sub>7</sub> H <sub>19</sub> N <sub>3</sub>                               | 105-83-9   | 145.246  |                         |           | 232.5; 112 <sup>6</sup> | 0.9023 <sup>20</sup>       | 1.4705 <sup>25</sup> |                                                            |
| 411 | Aminopropylon                                                       |                                                                                 | C <sub>16</sub> H <sub>22</sub> N <sub>4</sub> O <sub>2</sub>               | 3690-04-8  | 302.372  | pr (bz)                 | 181       |                         |                            |                      | vs H <sub>2</sub> O                                        |
| 412 | 4-(2-Aminopropyl)phenol, ( $\pm$ )                                  | Hydroxyamphetamine                                                              | C <sub>9</sub> H <sub>13</sub> NO                                           | 1518-86-1  | 151.205  | cry (bz)                | 125.5     |                         |                            |                      | s H <sub>2</sub> O, EtOH, bz,<br>chl, AcOEt                |
| 413 | <i>N</i> -(3-Aminopropyl)-1,3-propanediamine                        | Bis(3-aminopropyl)amine                                                         | C <sub>6</sub> H <sub>17</sub> N <sub>3</sub>                               | 56-18-8    | 131.219  |                         | -14       | 151 <sup>50</sup>       | 0.938 <sup>25</sup>        | 1.4810 <sup>20</sup> | s chl                                                      |
| 414 | Aminopterin                                                         |                                                                                 | C <sub>19</sub> H <sub>20</sub> N <sub>8</sub> O <sub>5</sub>               | 54-62-6    | 440.413  | ye cry                  | 262 dec   |                         |                            |                      |                                                            |
| 415 | 4-Amino- <i>N</i> -pyrazinylbenzenesulfonamide                      | Sulfapyrazine                                                                   | C <sub>10</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub> S             | 116-44-9   | 250.277  | nd (PhNO <sub>2</sub> ) | 251       |                         |                            |                      | i H <sub>2</sub> O, EtOH,<br>eth, bz, chl; s<br>py; sl ace |
| 416 | 3-Amino-1 <i>H</i> -pyrazole-4-carbonitrile                         | 3-Amino-4-cyanopyrazole                                                         | C <sub>4</sub> H <sub>4</sub> N <sub>4</sub>                                | 16617-46-2 | 108.102  | cry (w)                 | 173       |                         |                            |                      |                                                            |
| 417 | 2-Amino-3-pyridinecarboxylic acid                                   |                                                                                 | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                 | 5345-47-1  | 138.124  |                         | 296 dec   |                         |                            |                      | sl H <sub>2</sub> O                                        |
| 418 | 6-Amino-3-pyridinecarboxylic acid                                   | 6-Aminonicotinic acid                                                           | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                 | 3167-49-5  | 138.124  | cry (dil HOAc, +2w)     | 312       |                         |                            |                      |                                                            |
| 419 | 4-Amino- <i>N</i> -2-pyridinylbenzenesulfonamide                    | Sulfapyridine                                                                   | C <sub>11</sub> H <sub>11</sub> N <sub>3</sub> O <sub>2</sub> S             | 144-83-2   | 249.289  | ye oran (al)            | 192       |                         |                            |                      | i H <sub>2</sub> O, bz, ctc; s<br>EtOH                     |
| 420 | 5-Amino-2,4(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione                | 5-Aminouracil                                                                   | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>                 | 932-52-5   | 127.102  | nd (w)                  | dec       |                         |                            |                      | i H <sub>2</sub> O; s alk, acid                            |
| 421 | 6-Amino-2,4(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione                |                                                                                 | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>                 | 873-83-6   | 127.102  | cry (w)                 | dec       |                         |                            |                      | vs H <sub>2</sub> O                                        |
| 422 | 4-Amino-2(1 <i>H</i> )-pyrimidinethione                             | 2-Thiocytosine                                                                  | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> S                              | 333-49-3   | 127.168  |                         |           |                         |                            |                      | sl DMSO                                                    |
| 423 | 5-Amino-2,4,6(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | Uramil                                                                          | C <sub>4</sub> H <sub>3</sub> N <sub>3</sub> O <sub>3</sub>                 | 118-78-5   | 143.101  | nd or pl (w)            | >400      |                         |                            |                      | s H <sub>2</sub> O, chl; i eth,<br>bz                      |
| 424 | 4-Amino- <i>N</i> -2-pyrimidinylbenzenesulfonamide                  | Sulfadiazine                                                                    | C <sub>10</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub> S             | 68-35-9    | 250.277  | cry (w), wh pow         | 255 dec   |                         |                            |                      | sl H <sub>2</sub> O, EtOH,<br>ace, DMSO                    |
| 425 | Aminopyrine                                                         |                                                                                 | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O                            | 58-15-1    | 231.293  | pr or pl (lig or AcOEt) | 134.5     |                         |                            |                      | vs H <sub>2</sub> O, bz,<br>EtOH                           |
| 426 | 4-Amino- <i>N</i> -2-quinoxalinybenzenesulfonamide                  | Sulfaquinolaxaline                                                              | C <sub>14</sub> H <sub>12</sub> N <sub>4</sub> O <sub>2</sub> S             | 59-40-5    | 300.336  |                         | 247.5     |                         |                            |                      | sl H <sub>2</sub> O, EtOH,<br>ace; s aq alk                |
| 427 | 4-(Aminosulfonyl)benzoic acid                                       | Carzenide                                                                       | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub> S                             | 138-41-0   | 201.201  | pr or lf (w)            | 291 dec   |                         |                            |                      | i H <sub>2</sub> O; vs EtOH;<br>sl eth; i bz               |
| 428 | <i>N</i> -[4-(Aminosulfonyl)phenyl]acetamide                        | Acetyl-sulfanilamide                                                            | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub> S              | 121-61-9   | 214.241  | nd (HOAc)               | 219.5     |                         |                            |                      | s H <sub>2</sub> O, EtOH,<br>ace                           |
| 429 | 5-Amino-1,3,4-thiadiazole-2(3 <i>H</i> )-thione                     |                                                                                 | C <sub>2</sub> H <sub>3</sub> N <sub>3</sub> S <sub>2</sub>                 | 2349-67-9  | 133.195  |                         | 243.0     |                         |                            |                      |                                                            |
| 430 | 2-Amino-4(5 <i>H</i> )-thiazolone                                   |                                                                                 | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> OS                             | 556-90-1   | 116.141  | pr or nd (w)            | 256 dec   |                         |                            |                      | sl H <sub>2</sub> O; i EtOH,<br>eth                        |
| 431 | <i>N</i> -(Aminothioxomethyl)acetamide                              | Acetylthiourea                                                                  | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> OS                             | 591-08-2   | 118.157  | pr (w), orth (al)       | 165       |                         |                            |                      | sl H <sub>2</sub> O, eth; s<br>DMSO, EtOH                  |
| 432 | <i>N</i> -Amino-2-thioxo-4-thiazolidinone                           | 3-Aminorhodanine                                                                | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> OS <sub>2</sub>                | 1438-16-0  | 148.206  |                         | 101.5     |                         |                            |                      | s DMSO                                                     |
| 433 | 1-Amino-2,2,2-trichloroethanol                                      | Chloral ammonia                                                                 | C <sub>2</sub> H <sub>2</sub> Cl <sub>3</sub> NO                            | 507-47-1   | 164.418  | nd (al)                 | 73        | dec 100                 |                            |                      | vs bz, eth, EtOH                                           |
| 434 | 4-Amino-3,5,6-trichloro-2-pyridinecarboxylic acid                   | Picloram                                                                        | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> N <sub>2</sub> O <sub>2</sub> | 1918-02-1  | 241.459  |                         | 218.5     |                         |                            |                      |                                                            |
| 435 | 11-Aminoundecanoic acid                                             |                                                                                 | C <sub>11</sub> H <sub>23</sub> NO <sub>2</sub>                             | 2432-99-7  | 201.307  |                         | 189.0     |                         |                            |                      |                                                            |
| 436 | Amiton                                                              |                                                                                 | C <sub>10</sub> H <sub>24</sub> NO <sub>3</sub> PS                          | 78-53-5    | 269.342  | liq                     |           | 76 <sup>0.01</sup>      |                            | 1.4655 <sup>27</sup> |                                                            |
| 437 | Amitraz                                                             | <i>N</i> -Methylbis(2,4-xylyliminomethyl)amine                                  | C <sub>19</sub> H <sub>23</sub> N <sub>3</sub>                              | 33089-61-1 | 293.406  |                         | 86        |                         | 1.128 <sup>20</sup>        |                      |                                                            |
| 438 | Amitriptyline                                                       |                                                                                 | C <sub>20</sub> H <sub>23</sub> N                                           | 50-48-6    | 277.404  | cry                     | 196 (HCl) |                         |                            |                      |                                                            |
| 439 | Ammonium ferric oxalate                                             |                                                                                 | C <sub>6</sub> H <sub>12</sub> FeN <sub>3</sub> O <sub>12</sub>             | 14221-47-7 | 374.017  |                         | 165 dec   |                         | 1.78 <sup>17.5</sup>       |                      | vs H <sub>2</sub> O; i EtOH                                |
| 440 | Ammonium perfluorooctanoate                                         |                                                                                 | C <sub>8</sub> H <sub>4</sub> F <sub>13</sub> NO <sub>2</sub>               | 3825-26-1  | 431.100  | solid                   |           |                         |                            |                      |                                                            |
| 441 | Ammonium propanoate                                                 |                                                                                 | C <sub>3</sub> H <sub>9</sub> NO <sub>2</sub>                               | 17496-08-1 | 91.109   | hyg cry                 | 45        |                         |                            |                      | s H <sub>2</sub> O                                         |
| 442 | Amobarbital                                                         | 5-Ethyl-5-isopentyl-2,4,6(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | C <sub>11</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub>               | 57-43-2    | 226.272  |                         | 157       |                         |                            |                      | vs bz, EtOH, chl                                           |
| 443 | Amolanone                                                           | 3-[2-(Diethylamino)ethyl]-3-phenyl-2(3 <i>H</i> )-benzofuranone                 | C <sub>20</sub> H <sub>23</sub> NO <sub>2</sub>                             | 76-65-3    | 309.403  | cry (peth)              | 43.4      | 193 <sup>2.0</sup>      |                            | 1.5614 <sup>25</sup> |                                                            |
| 444 | Amoxicillin                                                         |                                                                                 | C <sub>16</sub> H <sub>19</sub> N <sub>3</sub> O <sub>5</sub> S             | 26787-78-0 | 365.404  | cry (w)                 |           |                         |                            |                      | s H <sub>2</sub> O                                         |
| 445 | Amphchloral                                                         |                                                                                 | C <sub>11</sub> H <sub>12</sub> Cl <sub>3</sub> N                           | 5581-35-1  | 264.579  |                         |           | 96 <sup>0.5</sup>       |                            | 1.530                |                                                            |
| 446 | Amphotericin B                                                      |                                                                                 | C <sub>47</sub> H <sub>73</sub> NO <sub>17</sub>                            | 1397-89-3  | 924.080  | ye pr (DMF)             | 170 dec   |                         |                            |                      | i H <sub>2</sub> O; sl DMF; s<br>DMSO                      |
| 447 | Ampicillin                                                          |                                                                                 | C <sub>16</sub> H <sub>19</sub> N <sub>3</sub> O <sub>4</sub> S             | 69-53-4    | 349.405  | cry                     | 200 dec   |                         |                            |                      | sl H <sub>2</sub> O                                        |
| 448 | Ampyrone                                                            |                                                                                 | C <sub>11</sub> H <sub>13</sub> N <sub>3</sub> O                            | 83-07-8    | 203.240  | pa ye cry (bz)          | 109       |                         |                            |                      | s H <sub>2</sub> O, EtOH, bz,<br>chl; sl eth               |

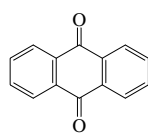


| No. | Name                                             | Synonym                                                           | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form                          | mp/°C                    | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|-----|--------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------|------------|----------|----------------------------------------|--------------------------|--------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 449 | Amygdalin                                        |                                                                   | C <sub>20</sub> H <sub>27</sub> NO <sub>11</sub>                | 29883-15-6 | 457.428  |                                        | 224.5                    |                                      |                            |                      | vs H <sub>2</sub> O; sl EtOH; i eth, chl              |
| 450 | Anacardic acid                                   |                                                                   | C <sub>22</sub> H <sub>32</sub> O <sub>3</sub>                  | 11034-77-8 | 344.487  | cry (ace)                              | 35.5                     |                                      |                            |                      | vs eth, EtOH, peth                                    |
| 451 | Anagyrene                                        |                                                                   | C <sub>15</sub> H <sub>20</sub> N <sub>2</sub> O                | 486-89-5   | 244.332  | pe ye glass                            |                          | 265 <sup>12</sup> , 212 <sup>4</sup> |                            |                      | s H <sub>2</sub> O, eth, bz; vs EtOH, chl; i lig      |
| 452 | Androstane                                       |                                                                   | C <sub>19</sub> H <sub>32</sub>                                 | 24887-75-0 | 260.457  | lf (ace-MeOH)                          | 50                       | 60 <sup>0.003</sup>                  |                            |                      | vs ace, eth, EtOH, peth                               |
| 453 | Androstane-17-carboxylic acid, (5β,17β)          | Etiocolanic acid                                                  | C <sub>20</sub> H <sub>32</sub> O <sub>2</sub>                  | 438-08-4   | 304.467  | nd (gl HOAc)                           | 228.5                    | sub 160                              |                            |                      |                                                       |
| 454 | Androstane-3,17-diol, (3α,5α,17β)                | Epiandrostanediol                                                 | C <sub>19</sub> H <sub>32</sub> O <sub>2</sub>                  | 1852-53-5  | 292.456  | nd (ace aq)                            | 223                      |                                      |                            |                      |                                                       |
| 455 | 5α-Androstane-3,17-dione                         |                                                                   | C <sub>19</sub> H <sub>28</sub> O <sub>2</sub>                  | 846-46-8   | 288.424  | cry (MeOH)                             | 135                      |                                      |                            |                      |                                                       |
| 456 | 5β-Androstane-3,17-dione                         |                                                                   | C <sub>19</sub> H <sub>28</sub> O <sub>2</sub>                  | 1229-12-5  | 288.424  | cry (ace-hx)                           | 135                      |                                      |                            |                      |                                                       |
| 457 | Androst-4-ene-3,17-dione                         | 4-Androstene-3,17-dione                                           | C <sub>19</sub> H <sub>26</sub> O <sub>2</sub>                  | 63-05-8    | 286.408  |                                        | 143(form a); 173(form b) |                                      |                            |                      |                                                       |
| 458 | Androst-4-ene-3,11,17-trione                     | Adrenosterone                                                     | C <sub>19</sub> H <sub>24</sub> O <sub>3</sub>                  | 382-45-6   | 300.392  | nd (al)                                | 222                      | sub                                  |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, chl            |
| 459 | Anemonin                                         | <i>trans</i> -1,7-Dioxadispiro[4.0.4.2]dodeca-3,9-diene-2,8-dione | C <sub>10</sub> H <sub>6</sub> O <sub>4</sub>                   | 508-44-1   | 192.169  | orth pl (chl) nd (al or bz)            | 158                      |                                      |                            |                      | vs chl                                                |
| 460 | Anhalamine                                       |                                                                   | C <sub>11</sub> H <sub>15</sub> NO <sub>3</sub>                 | 643-60-7   | 209.242  | nd (al)                                | 187.5                    |                                      |                            |                      | vs eth, EtOH                                          |
| 461 | Anhalonidine                                     |                                                                   | C <sub>12</sub> H <sub>17</sub> NO <sub>3</sub>                 | 17627-77-9 | 223.268  | oct cry (bz, eth)                      | 160.5                    |                                      |                            |                      | vs H <sub>2</sub> O, EtOH                             |
| 462 | Anhalonine                                       |                                                                   | C <sub>12</sub> H <sub>15</sub> NO <sub>3</sub>                 | 519-04-0   | 221.252  | rhomb nd                               | 86                       | 140 <sup>0.02</sup>                  |                            |                      | vs EtOH, bz, chl, eth, peth                           |
| 463 | 2,5-Anhydro-3,4-dideoxyhexitol                   | Tetrahydro-2,5-furandimethanol                                    | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                   | 104-80-3   | 132.157  |                                        | <-50                     | 265                                  | 1.154 <sup>20</sup>        |                      | vs H <sub>2</sub> O, ace, bz, EtOH                    |
| 464 | Anilazine                                        | 2,4-Dichloro-6-( <i>o</i> -chloroanilino)- <i>s</i> -triazine     | C <sub>8</sub> H <sub>5</sub> Cl <sub>3</sub> N <sub>4</sub>    | 101-05-3   | 275.522  |                                        | 160                      |                                      | 1.8 <sup>20</sup>          |                      |                                                       |
| 465 | Anileridine                                      |                                                                   | C <sub>22</sub> H <sub>28</sub> N <sub>2</sub> O <sub>2</sub>   | 144-14-9   | 352.469  | cry                                    | 83                       |                                      |                            |                      | s H <sub>2</sub> O                                    |
| 466 | Aniline                                          | Benzenamine                                                       | C <sub>6</sub> H <sub>7</sub> N                                 | 62-53-3    | 93.127   | oily liq                               | -6.02                    | 184.17                               | 1.0217 <sup>20</sup>       | 1.5863 <sup>20</sup> | s H <sub>2</sub> O, ctc, liq; msc EtOH, eth, ace, bz  |
| 467 | Aniline-2-carboxylic acid                        | <i>o</i> -Anthranilic acid                                        | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                   | 118-92-3   | 137.137  | lf (al)                                | 146.5                    | sub                                  | 1.412 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH, eth; sl bz, tfa; vs chl, py |
| 468 | Aniline-3-carboxylic acid                        | <i>m</i> -Anthranilic acid                                        | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                   | 99-05-8    | 137.137  |                                        | 173                      |                                      | 1.51 <sup>25</sup>         |                      | sl H <sub>2</sub> O, EtOH; s eth, tfa; vs ace; i bz   |
| 469 | Aniline-4-carboxylic acid                        | <i>p</i> -Anthranilic acid                                        | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                   | 150-13-0   | 137.137  | mcl pr (w)                             | 188.2                    |                                      | 1.374 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH, eth; sl ace; i bz, chl      |
| 470 | Aniline hydrobromide                             |                                                                   | C <sub>6</sub> H <sub>5</sub> BrN                               | 542-11-0   | 174.039  |                                        | 286                      |                                      |                            |                      |                                                       |
| 471 | Aniline hydrochloride                            | Benzenamine hydrochloride                                         | C <sub>6</sub> H <sub>5</sub> ClN                               | 142-04-1   | 129.588  | lf or nd                               | 198                      |                                      | 1.2215 <sup>4</sup>        |                      | vs H <sub>2</sub> O, EtOH; i eth, chl; sl DMSO        |
| 472 | Aniline nitrate                                  |                                                                   | C <sub>6</sub> H <sub>5</sub> N <sub>2</sub> O <sub>3</sub>     | 542-15-4   | 156.139  | orth                                   | 190 dec                  |                                      | 1.356 <sup>4</sup>         |                      | vs H <sub>2</sub> O, eth, EtOH                        |
| 473 | Aniline sulfate (2:1)                            |                                                                   | C <sub>12</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub> S | 542-16-5   | 284.331  |                                        |                          |                                      | 1.377 <sup>4</sup>         |                      | s H <sub>2</sub> O; sl EtOH, tfa; i eth               |
| 474 | Anisole                                          | Methoxybenzene                                                    | C <sub>7</sub> H <sub>8</sub> O                                 | 100-66-3   | 108.138  | liq                                    | -37.13                   | 153.7                                | 0.9940 <sup>20</sup>       | 1.5174 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl; vs ace, bz      |
| 475 | Anisotropine methylbromide                       | Octatropine methylbromide                                         | C <sub>17</sub> H <sub>32</sub> BrNO <sub>2</sub>               | 80-50-2    | 362.346  | cry (ace)                              | 329                      |                                      |                            |                      |                                                       |
| 476 | Antazoline                                       |                                                                   | C <sub>17</sub> H <sub>19</sub> N <sub>3</sub>                  | 91-75-8    | 265.353  | cry                                    | 122                      |                                      |                            |                      |                                                       |
| 477 | Anthra[9,1,2-cde]benzo[rst]pentaphene-5,10-dione |                                                                   | C <sub>34</sub> H <sub>16</sub> O <sub>2</sub>                  | 116-71-2   | 456.490  | viol-bl or blk nd (PhNO <sub>2</sub> ) | 492 dec                  |                                      |                            |                      | i EtOH, bz, HOAc; s xyl, py, sulf                     |
| 478 | 2-Anthracenamine                                 |                                                                   | C <sub>14</sub> H <sub>11</sub> N                               | 613-13-8   | 193.244  | ye lf (al)                             | 238.8                    | sub                                  |                            |                      | i H <sub>2</sub> O; s EtOH; i con sulf                |
| 479 | Anthracene                                       |                                                                   | C <sub>14</sub> H <sub>10</sub>                                 | 120-12-7   | 178.229  | tab or mcl pr (al)                     | 215.76                   | 339.9                                | 1.28 <sup>25</sup>         |                      | i H <sub>2</sub> O; sl EtOH, eth, ace, bz, chl, ctc   |
| 480 | 9-Anthracenecarbonitrile                         |                                                                   | C <sub>15</sub> H <sub>9</sub> N                                | 1210-12-4  | 203.239  |                                        | 177.5                    |                                      | 1.3000 <sup>20</sup>       |                      |                                                       |
| 481 | 9-Anthracenecarboxaldehyde                       |                                                                   | C <sub>15</sub> H <sub>10</sub> O                               | 642-31-9   | 206.239  | oran nd (dil HOAc)                     | 104.5                    |                                      |                            |                      | i H <sub>2</sub> O; s bz, HOAc                        |
| 482 | 1-Anthracenecarboxylic acid                      | 1-Anthroic acid                                                   | C <sub>15</sub> H <sub>10</sub> O <sub>2</sub>                  | 607-42-1   | 222.239  | ye nd (HOAc) ye pr (al)                | 251.5                    | sub                                  |                            |                      | i H <sub>2</sub> O; s EtOH, eth; sl bz, chl           |
| 483 | 2-Anthracenecarboxylic acid                      | 2-Anthroic acid                                                   | C <sub>15</sub> H <sub>10</sub> O <sub>2</sub>                  | 613-08-1   | 222.239  | ye lf (al) nd, lf (sub)                | 281                      | sub                                  |                            |                      | vs HOAc                                               |
| 484 | 9-Anthracenecarboxylic acid                      | 9-Anthroic acid                                                   | C <sub>15</sub> H <sub>10</sub> O <sub>2</sub>                  | 723-62-6   | 222.239  |                                        | 217 dec                  | sub                                  |                            |                      | i H <sub>2</sub> O; s EtOH                            |
| 485 | 9,10-Anthracenedicarbonitrile                    |                                                                   | C <sub>16</sub> H <sub>8</sub> N <sub>2</sub>                   | 1217-45-4  | 228.248  |                                        | 337 dec                  |                                      |                            |                      |                                                       |
| 486 | 9,10-Anthracenediol                              |                                                                   | C <sub>14</sub> H <sub>10</sub> O <sub>2</sub>                  | 4981-66-2  | 210.228  | br or ye nd                            | 180                      |                                      |                            |                      | vs eth, EtOH                                          |

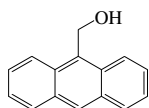




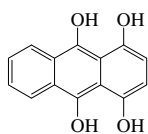
| No. | Name                                                                   | Synonym                                                                          | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                                      | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                         |
|-----|------------------------------------------------------------------------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|------------------------------|---------|--------------------------------------------|----------------------------|----------------------|----------------------------------------------------|
| 487 | 9,10-Anthracenedione                                                   | Anthraquinone                                                                    | C <sub>14</sub> H <sub>8</sub> O <sub>2</sub>                                 | 84-65-1    | 208.213  | ye orth nd (al, bz)          | 286     | 377                                        | 1.438 <sup>20</sup>        |                      | i H <sub>2</sub> O; sl EtOH, eth, bz, chl          |
| 488 | 9-Anthracenemethanol                                                   |                                                                                  | C <sub>15</sub> H <sub>12</sub> O                                             | 1468-95-7  | 208.255  |                              | 160.5   |                                            |                            |                      |                                                    |
| 489 | 1,4,9,10-Anthracenetetrol                                              |                                                                                  | C <sub>14</sub> H <sub>10</sub> O <sub>4</sub>                                | 476-60-8   | 242.227  |                              | 148     |                                            |                            |                      |                                                    |
| 490 | 1,2,10-Anthracenetriol                                                 | Anthrarobin                                                                      | C <sub>14</sub> H <sub>10</sub> O <sub>3</sub>                                | 577-33-3   | 226.227  | ye lf, nd (al-w)             | 208     |                                            |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, ace; s bz       |
| 491 | 1,8,9-Anthracenetriol                                                  | Anthralin                                                                        | C <sub>14</sub> H <sub>10</sub> O <sub>3</sub>                                | 1143-38-0  | 226.227  | ye pl or nd (lig)            | 179     |                                            |                            |                      | i H <sub>2</sub> O; s EtOH, ace, bz; sl eth; vs py |
| 492 | 1-Anthracenol                                                          |                                                                                  | C <sub>14</sub> H <sub>10</sub> O                                             | 610-50-4   | 194.228  | cry (bz), br nd or lf (al)   | 158     | 234 <sup>13</sup>                          |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s NaOH           |
| 493 | 9-Anthracenol                                                          | Anthranol                                                                        | C <sub>14</sub> H <sub>10</sub> O                                             | 529-86-2   | 194.228  | ye red lf (dil al)           | 152     |                                            |                            |                      |                                                    |
| 494 | 9(10 <i>H</i> )-Anthracenone                                           | Anthrone                                                                         | C <sub>14</sub> H <sub>10</sub> O                                             | 90-44-8    | 194.228  | nd (bz-lig, HOAc)            | 155     |                                            |                            |                      | s ace, bz, con sulf, dil alk                       |
| 495 | Antimony potassium tartrate trihydrate                                 | Tartar emetic                                                                    | C <sub>8</sub> H <sub>10</sub> K <sub>2</sub> O <sub>15</sub> Sb <sub>2</sub> | 28300-74-5 | 667.873  | col cry                      |         |                                            | 2.6                        |                      | sl H <sub>2</sub> O                                |
| 496 | Apholate                                                               |                                                                                  | C <sub>12</sub> H <sub>24</sub> N <sub>6</sub> P <sub>3</sub>                 | 52-46-0    | 387.300  |                              | 148     |                                            |                            |                      |                                                    |
| 497 | Aphylline                                                              |                                                                                  | C <sub>15</sub> H <sub>24</sub> N <sub>2</sub> O                              | 577-37-7   | 248.364  | cry                          | 52.5    | 200 <sup>4</sup>                           |                            |                      | vs ace, bz, eth, EtOH                              |
| 498 | Apigenin                                                               | 5,7-Dihydroxy-2-(4-hydroxyphenyl)-4 <i>H</i> -1-benzopyran-4-one                 | C <sub>15</sub> H <sub>10</sub> O <sub>5</sub>                                | 520-36-5   | 270.237  | ye nd (aq py)                | 347.5   |                                            |                            |                      | i H <sub>2</sub> O; s EtOH, py; vs dil alk         |
| 499 | Apoatropine                                                            |                                                                                  | C <sub>17</sub> H <sub>21</sub> NO <sub>2</sub>                               | 500-55-0   | 271.355  | pr (chl)                     | 62      |                                            |                            |                      | sl H <sub>2</sub> O; lig; vs EtOH, eth, ace, bz    |
| 500 | Apocodeine                                                             |                                                                                  | C <sub>18</sub> H <sub>19</sub> NO <sub>2</sub>                               | 641-36-1   | 281.350  | pr (MeOH)                    | 123.5   |                                            |                            |                      | sl EtOH; s eth, ace, bz, lig                       |
| 501 | Apomorphine                                                            |                                                                                  | C <sub>17</sub> H <sub>17</sub> NO <sub>2</sub>                               | 58-00-4    | 267.323  | hex pl (chl-peth) rods (eth) | 195 dec |                                            |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, alk     |
| 502 | Apomorphine, hydrochloride                                             |                                                                                  | C <sub>17</sub> H <sub>18</sub> ClNO <sub>2</sub>                             | 314-19-2   | 303.784  | grn in air mcl pr            | 205 dec |                                            |                            |                      |                                                    |
| 503 | Aprobarbital                                                           | 5-Isopropyl-5-allyl-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>                 | 77-02-1    | 210.229  | cry                          | 141     |                                            |                            |                      | vs ace, eth, EtOH, chl                             |
| 504 | <i>L</i> -Arabinitol                                                   |                                                                                  | C <sub>5</sub> H <sub>12</sub> O <sub>5</sub>                                 | 7643-75-6  | 152.146  |                              | 102.5   |                                            |                            |                      | vs H <sub>2</sub> O; sl EtOH; i eth                |
| 505 | $\alpha$ - <i>D</i> -Arabinopyranose                                   |                                                                                  | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                                 | 608-45-7   | 150.130  | cry (MeOH)                   | 155.5   |                                            | 1.585 <sup>25</sup>        |                      |                                                    |
| 506 | 6- <i>O</i> - $\alpha$ - <i>L</i> -Arabinopyranosyl- <i>D</i> -Glucose | Vicianose                                                                        | C <sub>11</sub> H <sub>20</sub> O <sub>10</sub>                               | 14116-69-9 | 312.271  | nd (dil al)                  | 210 dec |                                            |                            |                      | vs H <sub>2</sub> O                                |
| 507 | <i>DL</i> -Arabinose                                                   |                                                                                  | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                                 | 20235-19-2 | 150.130  | pr, nd (al)                  | 164.5   |                                            | 1.585 <sup>20</sup>        |                      | vs H <sub>2</sub> O; sl EtOH; i eth, bz            |
| 508 | $\alpha$ - <i>D</i> -Arabinose                                         |                                                                                  | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                                 | 31178-68-4 | 150.130  |                              | 156     |                                            | 1.585 <sup>25</sup>        |                      | vs H <sub>2</sub> O; sl EtOH; i eth, ace, MeOH     |
| 509 | $\beta$ - <i>D</i> -Arabinose                                          |                                                                                  | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                                 | 31178-69-5 | 150.130  |                              | 156     |                                            | 1.625 <sup>25</sup>        |                      | vs H <sub>2</sub> O; sl EtOH; i eth, ace, MeOH     |
| 510 | Aramite                                                                |                                                                                  | C <sub>15</sub> H <sub>23</sub> ClO <sub>4</sub> S                            | 140-57-8   | 334.860  |                              | -37.3   | 195 <sup>2</sup>                           | 1.143 <sup>20</sup>        | 1.5100 <sup>20</sup> | vs ace, bz, eth, EtOH                              |
| 511 | Arecaidine                                                             | 1,2,5,6-Tetrahydro-1-methyl-3-pyridinecarboxylic acid                            | C <sub>7</sub> H <sub>11</sub> NO <sub>2</sub>                                | 499-04-7   | 141.168  | pl (dil al) tab (dil al +1w) | 232 dec |                                            |                            |                      | vs H <sub>2</sub> O; i EtOH, eth, bz, chl          |
| 512 | Arecoline                                                              |                                                                                  | C <sub>8</sub> H <sub>13</sub> NO <sub>2</sub>                                | 63-75-2    | 155.195  |                              |         | 209                                        | 1.0485 <sup>20</sup>       | 1.486 <sup>-20</sup> | msc H <sub>2</sub> O, EtOH, eth; s chl             |
| 513 | <i>D</i> -Arginine                                                     |                                                                                  | C <sub>6</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub>                  | 7200-25-1  | 174.201  |                              | 217 dec |                                            |                            |                      | i H <sub>2</sub> O, EtOH, eth, bz                  |
| 514 | <i>L</i> -Arginine                                                     |                                                                                  | C <sub>6</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub>                  | 74-79-3    | 174.201  |                              | 244 dec |                                            |                            |                      | s H <sub>2</sub> O; sl EtOH; i eth                 |
| 515 | <i>L</i> -Arginine, monohydrochloride                                  |                                                                                  | C <sub>6</sub> H <sub>15</sub> ClN <sub>4</sub> O <sub>2</sub>                | 1119-34-2  | 210.662  |                              | 219     |                                            |                            |                      |                                                    |
| 516 | Artemisin                                                              | 8-Hydroxysantonin                                                                | C <sub>15</sub> H <sub>18</sub> O <sub>4</sub>                                | 481-05-0   | 262.302  | cry                          | 203     | 260 <sup>0.1</sup>                         |                            |                      | sl H <sub>2</sub> O, chl; s AcOEt; i peth          |
| 517 | Ascaridole                                                             | 1-Methyl-4-isopropyl-2,3-dioxabicyclo[2.2.2]oct-5-ene                            | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>                                | 512-85-6   | 168.233  | liq                          | 3.3     | exp; 115 <sup>15</sup> , 39 <sup>0.2</sup> | 1.0103 <sup>20</sup>       | 1.4769 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, bz, tol; sl chl   |
| 518 | <i>L</i> -Ascorbic acid                                                | Vitamin C                                                                        | C <sub>6</sub> H <sub>8</sub> O <sub>6</sub>                                  | 50-81-7    | 176.124  |                              | 191 dec |                                            | 1.65 <sup>25</sup>         |                      | vs H <sub>2</sub> O; s EtOH; i eth, bz, chl, peth  |
| 519 | Ascorbyl palmitate                                                     | 6-Hexadecanoylascorbic acid                                                      | C <sub>22</sub> H <sub>38</sub> O <sub>7</sub>                                | 137-66-6   | 414.533  |                              | 112     |                                            |                            |                      |                                                    |
| 520 | <i>L</i> -Asparagine                                                   | $\alpha$ -Aminosuccinamic acid                                                   | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>                   | 70-47-3    | 132.118  | orth (w+1)                   | 235     |                                            | 1.543 <sup>15</sup>        |                      | s H <sub>2</sub> O; i EtOH, eth, MeOH              |
| 521 | <i>D</i> -Asparagine, monohydrate                                      |                                                                                  | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub>                  | 5794-24-1  | 150.133  |                              | 215     |                                            | 1.523 <sup>15</sup>        |                      | sl H <sub>2</sub> O; i EtOH, eth, bz, MeOH         |
| 522 | <i>L</i> -Asparagine, monohydrate                                      |                                                                                  | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub>                  | 5794-13-8  | 150.133  |                              | 234     |                                            | 1.543 <sup>15</sup>        |                      | sl H <sub>2</sub> O; i EtOH, eth, bz, MeOH         |



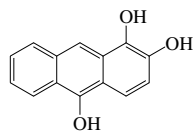
9,10-Anthracenedione



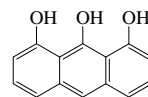
9-Anthracenemethanol



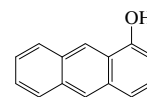
1,4,9,10-Anthracenetetrol



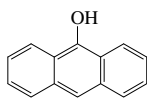
1,2,10-Anthracenetriol



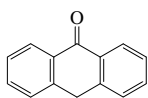
1,8,9-Anthracenetriol



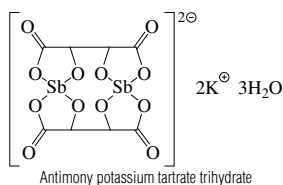
1-Anthracenol



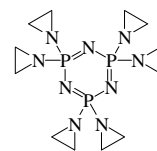
9-Anthracenol



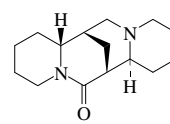
9(10H)-Anthracenone



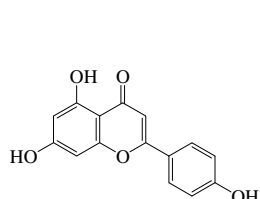
Antimony potassium tartrate trihydrate



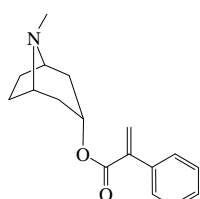
Apholate



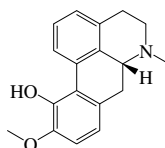
Aphylline



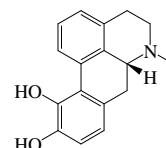
Apigenin



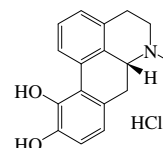
Apotropine



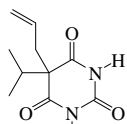
Apocodeine



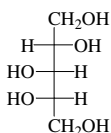
Apomorphine



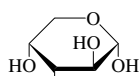
Apomorphine, hydrochloride



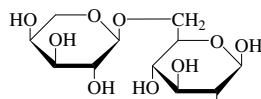
Aprobarbital



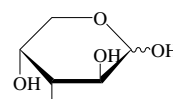
L-Arabinitol



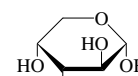
α-D-Arabinopyranose



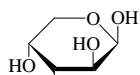
6-O-α-L-Arabinopyranosyl-D-Glucose



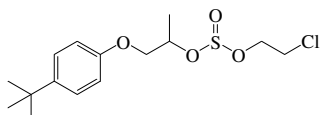
DL-Arabinose



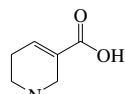
α-D-Arabinose



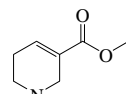
β-D-Arabinose



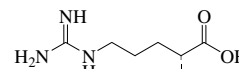
Aramite



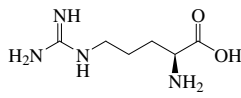
Arecaidine



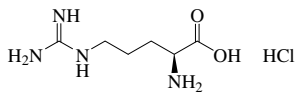
Arecoline



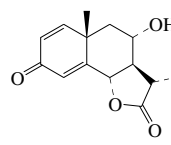
D-Arginine



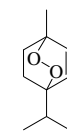
L-Arginine



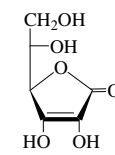
L-Arginine, monohydrochloride



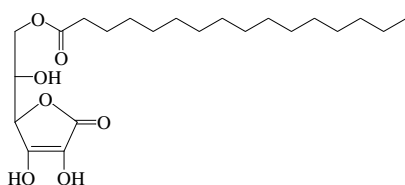
Artemisin



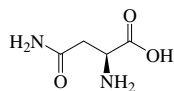
Ascaridole



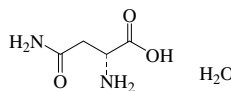
L-Ascorbic acid



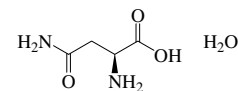
Ascorbyl palmitate



L-Asparagine

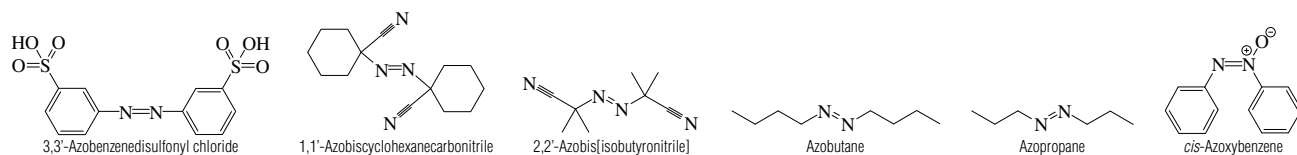
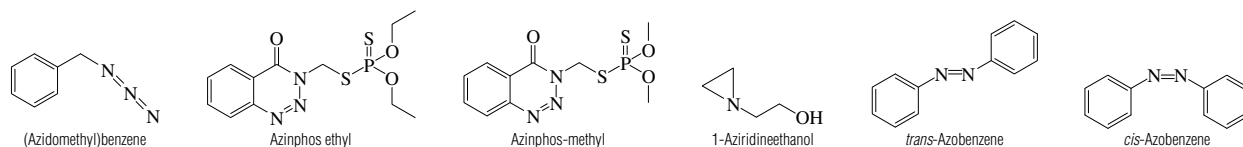
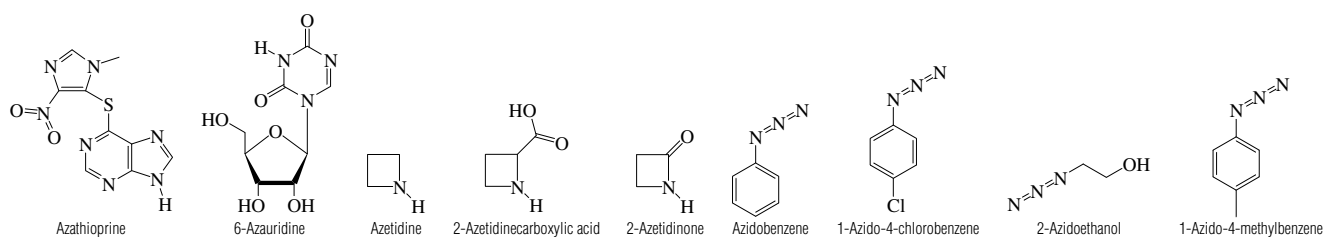
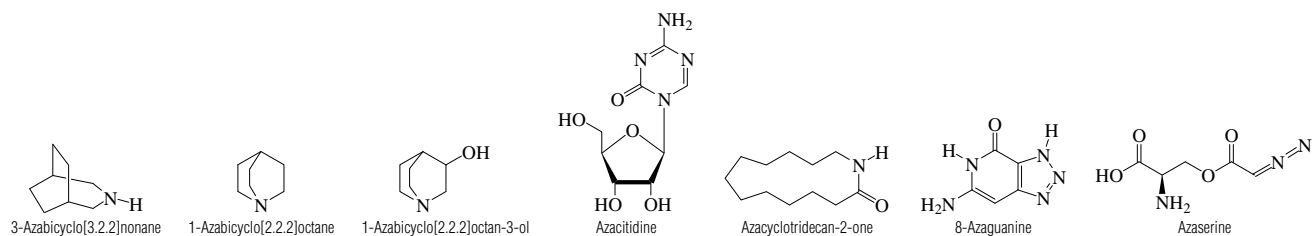
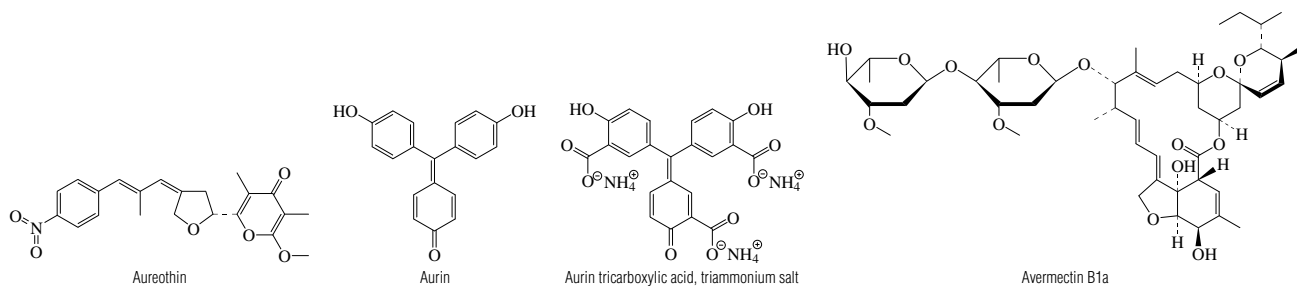
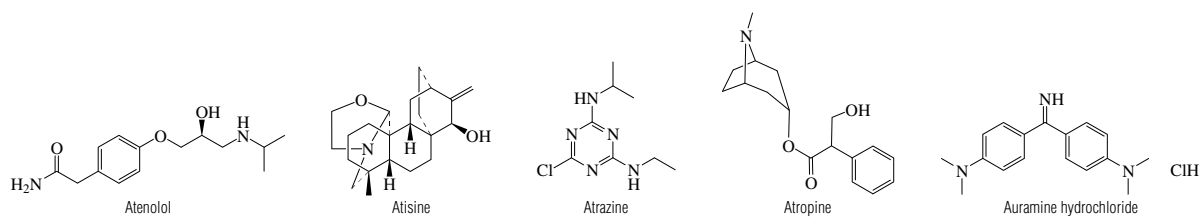
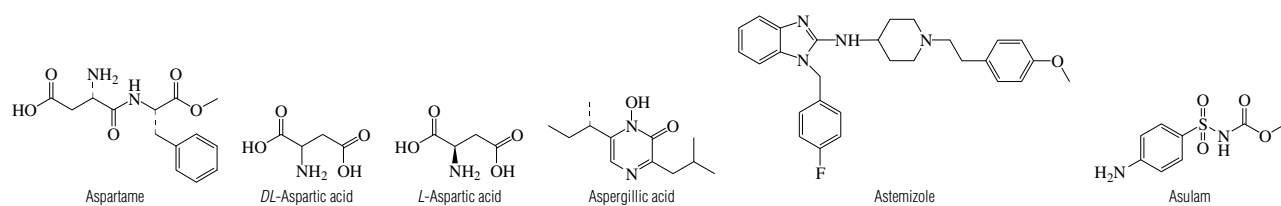


D-Asparagine, monohydrate

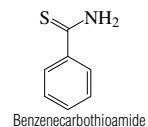
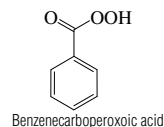
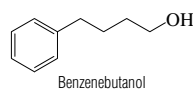
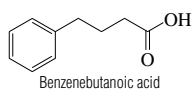
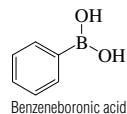
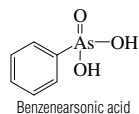
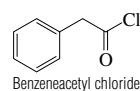
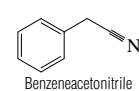
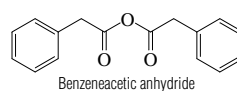
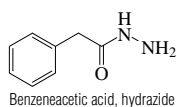
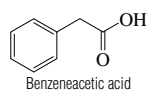
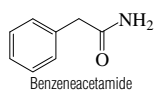
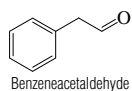
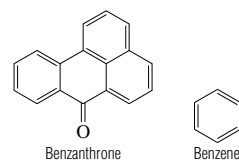
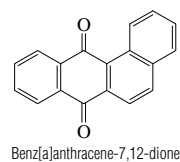
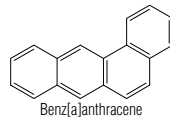
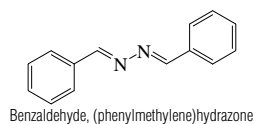
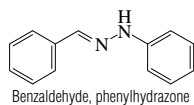
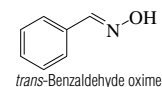
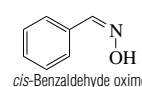
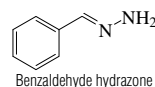
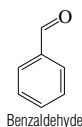
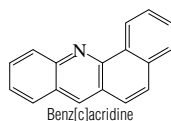
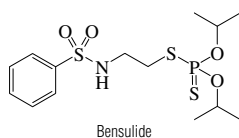
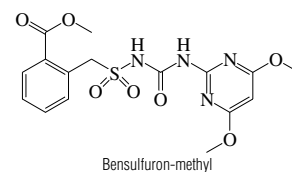
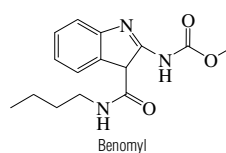
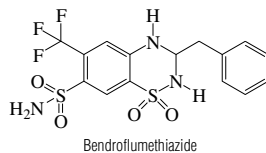
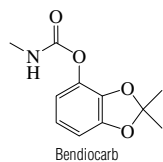
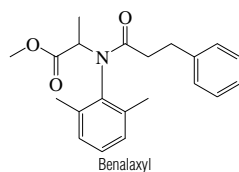
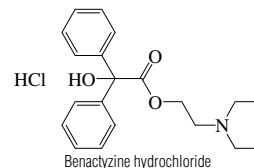
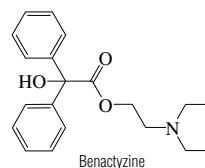
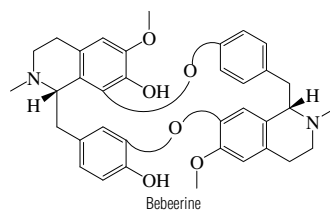
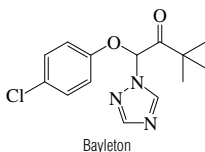
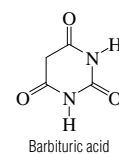
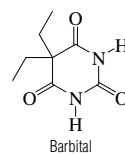
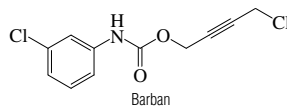
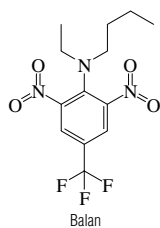
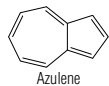
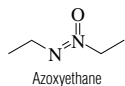
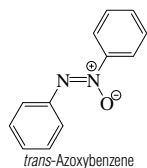


L-Asparagine, monohydrate

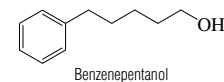
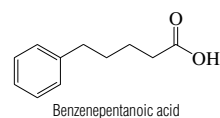
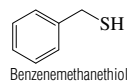
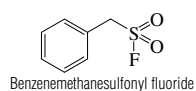
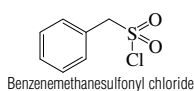
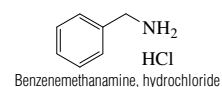
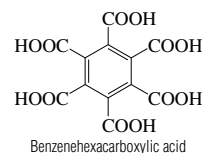
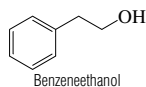
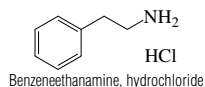
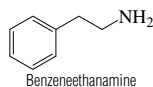
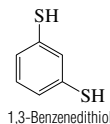
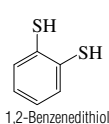
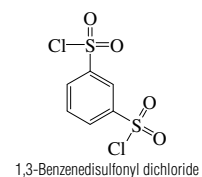
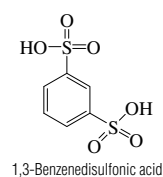
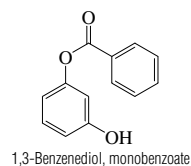
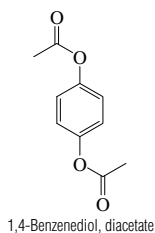
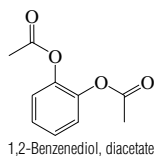
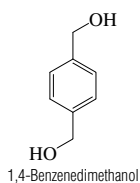
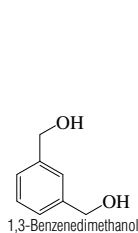
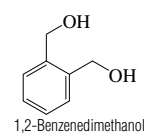
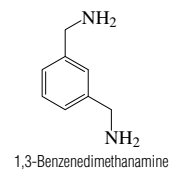
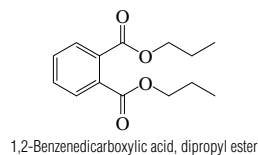
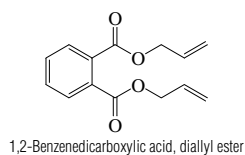
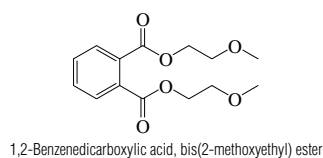
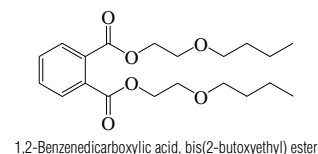
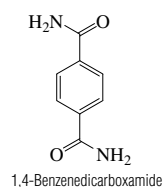
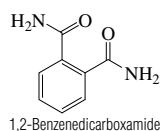
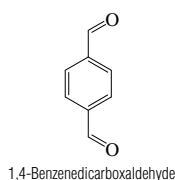
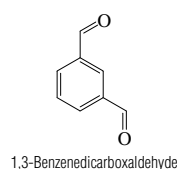
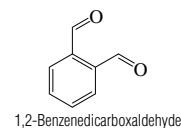
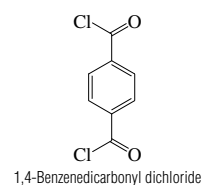
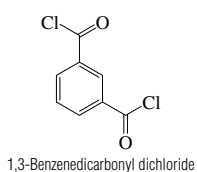
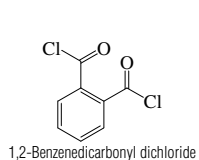
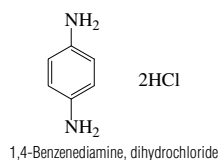
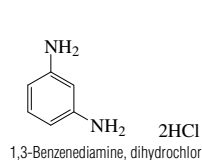
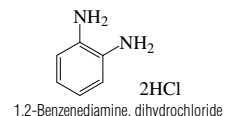
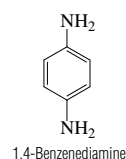
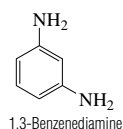
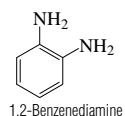
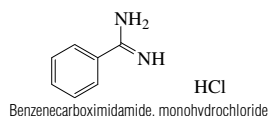
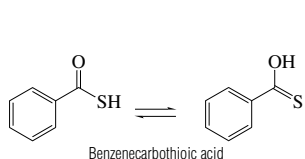
| No. | Name                                       | Synonym                                                                        | Mol. Form.                                                                                  | CAS RN      | Mol. Wt. | Physical Form        | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|-----|--------------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------|----------|----------------------|---------|--------------------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 523 | Aspartame                                  | <i>L</i> -α-Aspartyl- <i>L</i> -phenylalanine, 2-methyl ester                  | C <sub>14</sub> H <sub>18</sub> N <sub>2</sub> O <sub>5</sub>                               | 22839-47-0  | 294.303  | nd (w)               | 246.5   |                                      |                            |                      |                                                     |
| 524 | <i>DL</i> -Aspartic acid                   |                                                                                | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>                                               | 617-45-8    | 133.104  | mcl pr (w)           | 277.5   |                                      | 1.6622 <sup>13</sup>       |                      | sl H <sub>2</sub> O; i EtOH, eth, bz, py            |
| 525 | <i>L</i> -Aspartic acid                    | <i>L</i> -Aminosuccinic acid                                                   | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>                                               | 56-84-8     | 133.104  | orth lf (w)          | 270     |                                      | 1.6603 <sup>13</sup>       |                      | sl H <sub>2</sub> O; i EtOH, eth, bz; s dil HCl, py |
| 526 | Aspergillilic acid                         |                                                                                | C <sub>12</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub>                               | 490-02-8    | 224.299  | pa ye rods           | 98      |                                      |                            |                      | vs bz, eth, EtOH                                    |
| 527 | Astemizole                                 |                                                                                | C <sub>28</sub> H <sub>31</sub> FN <sub>4</sub> O                                           | 68844-77-9  | 458.570  | wh cry               | 149.1   |                                      |                            |                      | i H <sub>2</sub> O; s os                            |
| 528 | Asulam                                     | Methyl [(4-aminophenyl) sulfonyl]carbamate                                     | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub> S                              | 3337-71-1   | 230.241  |                      | 144     |                                      |                            |                      |                                                     |
| 529 | Atenolol                                   |                                                                                | C <sub>14</sub> H <sub>22</sub> N <sub>2</sub> O <sub>3</sub>                               | 29122-68-7  | 266.336  | cry (AcOEt)          | 147     |                                      |                            |                      | sl H <sub>2</sub> O, diox, ace; i chl; s MeOH, HOAc |
| 530 | Atisine                                    | Anthorine                                                                      | C <sub>22</sub> H <sub>33</sub> NO <sub>2</sub>                                             | 466-43-3    | 343.503  | orth bipym           | 58.5    |                                      |                            |                      | vs eth, EtOH, chl                                   |
| 531 | Atrazine                                   |                                                                                | C <sub>6</sub> H <sub>14</sub> ClN <sub>5</sub>                                             | 1912-24-9   | 215.684  |                      | 173     |                                      |                            |                      |                                                     |
| 532 | Atropine                                   |                                                                                | C <sub>17</sub> H <sub>23</sub> NO <sub>3</sub>                                             | 51-55-8     | 289.370  | orth nd (dil al)     | 118.5   | sub 95                               |                            |                      | vs H <sub>2</sub> O, EtOH; i eth; sl chl            |
| 533 | Auramine hydrochloride                     |                                                                                | C <sub>17</sub> H <sub>24</sub> ClN <sub>3</sub> O                                          | 2465-27-2   | 321.845  | ye nd (w)            | 267     |                                      |                            |                      | sl H <sub>2</sub> O                                 |
| 534 | Aureothin                                  |                                                                                | C <sub>22</sub> H <sub>23</sub> NO <sub>6</sub>                                             | 2825-00-5   | 397.421  | ye pr                | 158     |                                      |                            |                      | vs ace, EtOH, chl                                   |
| 535 | Aurin                                      |                                                                                | C <sub>19</sub> H <sub>14</sub> O <sub>3</sub>                                              | 603-45-2    | 290.312  | dk red lf or orth    | 309 dec |                                      |                            |                      | i H <sub>2</sub> O, bz; s EtOH, alk; sl eth, chl    |
| 536 | Aurin tricarboxylic acid, triammonium salt | Aluminon                                                                       | C <sub>22</sub> H <sub>23</sub> N <sub>3</sub> O <sub>9</sub>                               | 569-58-4    | 473.433  | red-br pow           |         |                                      |                            |                      | s H <sub>2</sub> O; sl EtOH; i peth                 |
| 537 | Avermectin B1a                             | Abamectin                                                                      | C <sub>48</sub> H <sub>72</sub> O <sub>14</sub>                                             | 71751-41-2  | 873.078  |                      | 152     |                                      |                            |                      |                                                     |
| 538 | 3-Azabicyclo[3.2.2]nonane                  |                                                                                | C <sub>8</sub> H <sub>15</sub> N                                                            | 283-24-9    | 125.212  |                      |         | 166 <sup>500</sup>                   |                            |                      |                                                     |
| 539 | 1-Azabicyclo[2.2.2]octane                  | Quinuclidine                                                                   | C <sub>7</sub> H <sub>13</sub> N                                                            | 100-76-5    | 111.185  | cry (eth)            | 158     |                                      |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH                 |
| 540 | 1-Azabicyclo[2.2.2]octan-3-ol              | 3-Quinuclidinol                                                                | C <sub>7</sub> H <sub>13</sub> NO                                                           | 1619-34-7   | 127.184  | cry (bz)             | 221     | sub 120                              |                            |                      | s ace                                               |
| 541 | Azacididine                                | 4-Amino-1-β- <i>D</i> -ribofuranosyl-1,3,5-triazine-2(1 <i>H</i> )-one         | C <sub>8</sub> H <sub>12</sub> N <sub>4</sub> O <sub>5</sub>                                | 320-67-2    | 244.205  | cry                  | 229     |                                      |                            |                      |                                                     |
| 542 | Azacyclotridecan-2-one                     |                                                                                | C <sub>12</sub> H <sub>23</sub> NO                                                          | 947-04-6    | 197.317  |                      | 152.5   |                                      |                            |                      |                                                     |
| 543 | 8-Azaguanine                               |                                                                                | C <sub>4</sub> H <sub>4</sub> N <sub>6</sub> O                                              | 134-58-7    | 152.114  |                      | 300     |                                      |                            |                      |                                                     |
| 544 | Azaserine                                  |                                                                                | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub> O <sub>4</sub>                                 | 115-02-6    | 173.128  | ye-grn orth cry      | 150 dec |                                      |                            |                      | vs H <sub>2</sub> O; sl EtOH, ace, MeOH             |
| 545 | Azathioprine                               | 6-[(1-Methyl-4-nitro-1 <i>H</i> -imidazol-5-yl)thio]-1 <i>H</i> -purine        | C <sub>9</sub> H <sub>7</sub> N <sub>7</sub> O <sub>2</sub> S                               | 446-86-6    | 277.263  | ye cry               | 243 dec |                                      |                            |                      | sl H <sub>2</sub> O, EtOH, chl                      |
| 546 | 6-Azauridine                               | 2-β- <i>D</i> -Ribofuranosyl-1,2,4-triazine-3,5(2 <i>H</i> ,4 <i>H</i> )-dione | C <sub>8</sub> H <sub>11</sub> N <sub>3</sub> O <sub>6</sub>                                | 54-25-1     | 245.189  |                      | 158     |                                      |                            |                      | s H <sub>2</sub> O                                  |
| 547 | Azetidine                                  |                                                                                | C <sub>3</sub> H <sub>7</sub> N                                                             | 503-29-7    | 57.095   | liq                  | -70.0   | 63                                   | 0.8436 <sup>20</sup>       | 1.4287 <sup>25</sup> | vs ace, bz, eth, EtOH                               |
| 548 | 2-Azetidinecarboxylic acid                 |                                                                                | C <sub>4</sub> H <sub>7</sub> NO <sub>2</sub>                                               | 2517-04-6   | 101.105  | cry (95% MeOH)       | 217 dec |                                      |                            |                      |                                                     |
| 549 | 2-Azetidinone                              |                                                                                | C <sub>3</sub> H <sub>5</sub> NO                                                            | 930-21-2    | 71.078   |                      | 73.5    | 106 <sup>15</sup>                    |                            |                      | vs eth, EtOH, chl                                   |
| 550 | Azidobenzene                               |                                                                                | C <sub>6</sub> H <sub>5</sub> N <sub>3</sub>                                                | 622-37-7    | 119.124  | pa ye oil            | -27.5   | 70 <sup>11</sup>                     | 1.0860 <sup>20</sup>       | 1.5589 <sup>25</sup> | i H <sub>2</sub> O; sl EtOH, eth                    |
| 551 | 1-Azido-4-chlorobenzene                    |                                                                                | C <sub>6</sub> H <sub>4</sub> ClN <sub>3</sub>                                              | 3296-05-7   | 153.569  |                      | 20      | 96 <sup>20</sup>                     | 1.2634 <sup>25</sup>       |                      | i H <sub>2</sub> O; s eth                           |
| 552 | 2-Azidoethanol                             |                                                                                | C <sub>2</sub> H <sub>5</sub> N <sub>3</sub> O                                              | 1517-05-1   | 87.080   |                      |         | 75 <sup>40</sup>                     | 1.146 <sup>24</sup>        |                      | vs H <sub>2</sub> O                                 |
| 553 | 1-Azido-4-methylbenzene                    |                                                                                | C <sub>7</sub> H <sub>7</sub> N <sub>3</sub>                                                | 2101-86-2   | 133.151  |                      | -29.0   | dec 180; 80 <sup>10</sup>            | 1.0527 <sup>23</sup>       |                      | vs eth, EtOH                                        |
| 554 | (Azidomethyl)benzene                       |                                                                                | C <sub>7</sub> H <sub>7</sub> N <sub>3</sub>                                                | 622-79-7    | 133.151  |                      |         | 108 <sup>23</sup> , 78 <sup>12</sup> | 1.0730 <sup>19</sup>       | 1.5341 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, eth                   |
| 555 | Azinphos ethyl                             |                                                                                | C <sub>12</sub> H <sub>18</sub> N <sub>3</sub> O <sub>3</sub> PS <sub>2</sub>               | 2642-71-9   | 345.377  | nd                   | 53      | 111 <sup>0.001</sup>                 | 1.284 <sup>20</sup>        |                      | reac alk                                            |
| 556 | Azinphos-methyl                            |                                                                                | C <sub>10</sub> H <sub>12</sub> N <sub>3</sub> O <sub>3</sub> PS <sub>2</sub>               | 86-50-0     | 317.324  |                      | 73      |                                      | 1.44 <sup>20</sup>         |                      |                                                     |
| 557 | 1-Aziridineethanol                         |                                                                                | C <sub>4</sub> H <sub>9</sub> NO                                                            | 1072-52-2   | 87.120   |                      |         | 168                                  | 1.088 <sup>25</sup>        | 1.4560 <sup>20</sup> |                                                     |
| 558 | <i>trans</i> -Azobenzene                   | <i>trans</i> -Diphenyldiazene                                                  | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub>                                              | 17082-12-1  | 182.220  | oran-red mcl lf (al) | 67.88   | 293                                  | 1.203 <sup>20</sup>        | 1.6266 <sup>78</sup> | sl H <sub>2</sub> O; s EtOH, eth, bz, chl; vs py    |
| 559 | <i>cis</i> -Azobenzene                     | <i>cis</i> -Diphenyldiazene                                                    | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub>                                              | 1080-16-6   | 182.220  | oran-red pl (peth)   | 71      |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, HOAc, lig     |
| 560 | 3,3'-Azobenzenedisulfonyl chloride         |                                                                                | C <sub>12</sub> H <sub>6</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 104115-88-0 | 379.239  | red nd (eth)         | 166.5   |                                      |                            |                      | vs eth                                              |
| 561 | 1,1'-Azobiscyclohexanecarbonitrile         |                                                                                | C <sub>14</sub> H <sub>20</sub> N <sub>4</sub>                                              | 2094-98-6   | 244.336  |                      | 100     |                                      |                            |                      | i H <sub>2</sub> O; s lig                           |
| 562 | 2,2'-Azobis[isobutyronitrile]              | 2,2'-Azobis[2-methylpropionitrile]                                             | C <sub>8</sub> H <sub>12</sub> N <sub>4</sub>                                               | 78-67-1     | 164.208  |                      |         |                                      |                            |                      | i H <sub>2</sub> O; sl EtOH, eth                    |
| 563 | Azobutane                                  |                                                                                | C <sub>8</sub> H <sub>18</sub> N <sub>2</sub>                                               | 2159-75-3   | 142.242  |                      |         | 60 <sup>18</sup>                     |                            |                      |                                                     |
| 564 | Azopropane                                 |                                                                                | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                                               | 821-67-0    | 114.188  |                      |         | 114                                  |                            |                      |                                                     |
| 565 | <i>cis</i> -Azoxybenzene                   | Diphenyldiazene 1-oxide, ( <i>E</i> )                                          | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O                                            | 21650-65-7  | 198.219  |                      | 87      |                                      | 1.166 <sup>20</sup>        | 1.633 <sup>20</sup>  |                                                     |



| No. | Name                                      | Synonym                                                                 | Mol. Form.                                                                                  | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                  |
|-----|-------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------|----------|-------------------------|---------|----------------------------------------|----------------------------|----------------------|-------------------------------------------------------------|
| 566 | <i>trans</i> -Azoxybenzene                | Diphenyldiazene 1-oxide, (Z)                                            | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O                                            | 20972-43-4 | 198.219  |                         | 34.6    |                                        | 1.1590 <sup>26</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                             |
| 567 | Azoxyethane                               | Diethyldiazene 1-oxide                                                  | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O                                             | 16301-26-1 | 102.134  | liq                     |         | 46                                     |                            |                      |                                                             |
| 568 | Azulene                                   | Bicyclo[5.3.0]decapentaene                                              | C <sub>10</sub> H <sub>8</sub>                                                              | 275-51-4   | 128.171  | bl or gr-blk lf (al)    | 99      | dec 270; 125 <sup>10</sup>             |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, acid; sl chl          |
| 569 | Balan                                     | <i>N</i> -Butyl- <i>N</i> -ethyl-2,6-dinitro-4-(trifluoromethyl)aniline | C <sub>13</sub> H <sub>16</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub>                | 1861-40-1  | 335.279  |                         | 66      | 121 <sup>0.5</sup> , 148 <sup>7</sup>  |                            |                      |                                                             |
| 570 | Barban                                    |                                                                         | C <sub>11</sub> H <sub>8</sub> Cl <sub>2</sub> NO <sub>2</sub>                              | 101-27-9   | 258.101  |                         | 75      |                                        |                            |                      |                                                             |
| 571 | Barbital                                  | 5,5-Diethylbarbituric acid                                              | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>                                | 57-44-3    | 184.192  | nd (w)                  | 190     |                                        | 1.220 <sup>25</sup>        |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, chl, lig, tfa        |
| 572 | Barbituric acid                           |                                                                         | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>3</sub>                                 | 67-52-7    | 128.086  | orth pr (w +2)          | 248     | dec 260                                |                            |                      | s H <sub>2</sub> O, eth; sl EtOH                            |
| 573 | Bayleton                                  | Triadimefon                                                             | C <sub>14</sub> H <sub>16</sub> ClN <sub>3</sub> O <sub>2</sub>                             | 43121-43-3 | 293.749  |                         | 82      |                                        | 1.22 <sup>20</sup>         |                      |                                                             |
| 574 | Bebeerine                                 |                                                                         | C <sub>36</sub> H <sub>38</sub> N <sub>2</sub> O <sub>6</sub>                               | 477-60-1   | 594.696  | cry (bz, eth, chl-MeOH) | 221     |                                        |                            |                      | s EtOH, MeOH, eth; vs ace, chl                              |
| 575 | Benactyzine                               | 2-(Diethylamino)ethyl benzilate                                         | C <sub>20</sub> H <sub>25</sub> NO <sub>3</sub>                                             | 302-40-9   | 327.418  | cry                     | 51      |                                        |                            |                      |                                                             |
| 576 | Benactyzine hydrochloride                 | 2-Diethylaminoethyl benzilate hydrochloride                             | C <sub>20</sub> H <sub>26</sub> ClNO <sub>3</sub>                                           | 57-37-4    | 363.878  |                         | 177.5   |                                        |                            |                      | s H <sub>2</sub> O; i eth                                   |
| 577 | Benalaxyl                                 |                                                                         | C <sub>20</sub> H <sub>22</sub> NO <sub>3</sub>                                             | 71626-11-4 | 325.402  |                         | 79      |                                        | 1.27 <sup>25</sup>         |                      |                                                             |
| 578 | Bendiocarb                                | 1,3-Benzodioxol-4-ol, 2,2-dimethyl-, methylcarbamate                    | C <sub>11</sub> H <sub>13</sub> NO <sub>4</sub>                                             | 22781-23-3 | 223.226  |                         | 130     |                                        | 1.25 <sup>20</sup>         |                      |                                                             |
| 579 | Bendroflumethiazide                       |                                                                         | C <sub>15</sub> H <sub>14</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 73-48-3    | 421.415  | cry                     | 225     |                                        |                            |                      | i H <sub>2</sub> O, bz, eth; s EtOH, ace                    |
| 580 | Benomyl                                   |                                                                         | C <sub>14</sub> H <sub>18</sub> N <sub>4</sub> O <sub>3</sub>                               | 17804-35-2 | 290.318  |                         | dec     |                                        |                            |                      |                                                             |
| 581 | Bensulfuron-methyl                        |                                                                         | C <sub>16</sub> H <sub>18</sub> N <sub>4</sub> O <sub>3</sub> S                             | 83055-99-6 | 410.402  |                         | 187     |                                        |                            |                      |                                                             |
| 582 | Bensulide                                 |                                                                         | C <sub>14</sub> H <sub>24</sub> NO <sub>4</sub> PS <sub>3</sub>                             | 741-58-2   | 397.514  |                         | 34.4    |                                        | 1.224 <sup>20</sup>        |                      |                                                             |
| 583 | Bentazon                                  |                                                                         | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub> S                             | 25057-89-0 | 240.278  |                         | 138     |                                        |                            |                      |                                                             |
| 584 | Benz[C]acridine                           | 12-Azabenz[a]anthracene                                                 | C <sub>17</sub> H <sub>11</sub> N                                                           | 225-51-4   | 229.276  | nd (dil al)             | 132     |                                        |                            |                      | vs bz, eth, EtOH                                            |
| 585 | Benzaldehyde                              | Benzenecarboxaldehyde                                                   | C <sub>7</sub> H <sub>6</sub> O                                                             | 100-52-7   | 106.122  | liq                     | -57.1   | 178.8                                  | 1.0401 <sup>25</sup>       | 1.5463 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace, bz              |
| 586 | Benzaldehyde hydrazone                    | Benzylidene hydrazine                                                   | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub>                                                | 5281-18-5  | 120.152  | lf                      | 16      | 140 <sup>14</sup>                      |                            |                      | s EtOH                                                      |
| 587 | <i>cis</i> -Benzaldehyde oxime            |                                                                         | C <sub>7</sub> H <sub>7</sub> NO                                                            | 622-32-2   | 121.137  | pr                      | 36.5    | 200                                    | 1.1111 <sup>20</sup>       | 1.5908 <sup>20</sup> | vs bz, eth, EtOH                                            |
| 588 | <i>trans</i> -Benzaldehyde oxime          |                                                                         | C <sub>7</sub> H <sub>7</sub> NO                                                            | 622-31-1   | 121.137  | nd (eth)                | 35      | 119 <sup>10</sup>                      | 1.145 <sup>20</sup>        |                      | s H <sub>2</sub> O; vs EtOH, eth                            |
| 589 | Benzaldehyde, phenylhydrazone             |                                                                         | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub>                                              | 588-64-7   | 196.247  | nd (lig), pr            | 157.0   |                                        |                            |                      | sl EtOH, eth; s ace, bz, liq NH <sub>3</sub>                |
| 590 | Benzaldehyde, (phenylmethylene) hydrazone |                                                                         | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub>                                              | 588-68-1   | 208.258  | ye pr (al)              | 93      |                                        |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl; sl ctc       |
| 591 | Benzamide                                 | Benzoic acid amide                                                      | C <sub>7</sub> H <sub>7</sub> NO                                                            | 55-21-0    | 121.137  | mcl pr or pl (w)        | 127.3   | 290                                    | 1.0792 <sup>130</sup>      |                      | sl H <sub>2</sub> O, eth, bz; vs EtOH, ctc, CS <sub>2</sub> |
| 592 | Benz[a]anthracene                         | 1,2-Benzanthracene                                                      | C <sub>18</sub> H <sub>12</sub>                                                             | 56-55-3    | 228.288  | lf (al)                 | 160.5   | 438                                    |                            |                      | i H <sub>2</sub> O; vs EtOH                                 |
| 593 | Benz[a]anthracene-7,12-dione              |                                                                         | C <sub>18</sub> H <sub>10</sub> O <sub>2</sub>                                              | 2498-66-0  | 258.271  |                         | 170.5   |                                        |                            |                      | sl EtOH, eth, lig; s ace; vs bz, chl                        |
| 594 | Benzanthrone                              |                                                                         | C <sub>17</sub> H <sub>10</sub> O                                                           | 82-05-3    | 230.260  |                         | 170     |                                        |                            |                      | sl bz                                                       |
| 595 | Benzene                                   | [6]Annulene                                                             | C <sub>6</sub> H <sub>6</sub>                                                               | 71-43-2    | 78.112   | orth pr or liq          | 5.49    | 80.09                                  | 0.8765 <sup>20</sup>       | 1.5011 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, ace, chl; s ctc         |
| 596 | Benzeneacetaldehyde                       | Phenylacetaldehyde                                                      | C <sub>8</sub> H <sub>8</sub> O                                                             | 122-78-1   | 120.149  |                         | 33.5    | 195                                    | 1.0272 <sup>20</sup>       | 1.5255 <sup>20</sup> | sl H <sub>2</sub> O; s ace; msc EtOH, eth                   |
| 597 | Benzeneacetamide                          | α-Phenylacetamide                                                       | C <sub>8</sub> H <sub>9</sub> NO                                                            | 103-81-1   | 135.163  |                         | 157     |                                        |                            |                      | sl H <sub>2</sub> O, eth, bz; s EtOH                        |
| 598 | Benzeneacetic acid                        | Phenylacetic acid                                                       | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                                                | 103-82-2   | 136.149  | lf, pl (peth)           | 76.5    | 265.5                                  | 1.228 <sup>6</sup>         |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth; s ace; i lig        |
| 599 | Benzeneacetic acid, hydrazide             |                                                                         | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O                                             | 937-39-3   | 150.177  |                         | 115.5   |                                        |                            |                      |                                                             |
| 600 | Benzeneacetic anhydride                   |                                                                         | C <sub>16</sub> H <sub>14</sub> O <sub>3</sub>                                              | 1555-80-2  | 254.280  | pr or nd (eth)          | 73.3    | 195 <sup>12</sup>                      |                            |                      | vs eth, chl                                                 |
| 601 | Benzeneacetonitrile                       | Benzyl cyanide                                                          | C <sub>8</sub> H <sub>7</sub> N                                                             | 140-29-4   | 117.149  | liq                     | -23.8   | 233.5                                  | 1.0205 <sup>15</sup>       | 1.5211 <sup>25</sup> |                                                             |
| 602 | Benzeneacetyl chloride                    | Phenylacetyl chloride                                                   | C <sub>8</sub> H <sub>7</sub> ClO                                                           | 103-80-0   | 154.594  |                         |         | 170 <sup>250</sup> , 105 <sup>24</sup> | 1.1682 <sup>20</sup>       | 1.5325 <sup>20</sup> | vs eth                                                      |
| 603 | Benzenearsonic acid                       |                                                                         | C <sub>6</sub> H <sub>7</sub> AsO <sub>3</sub>                                              | 98-05-5    | 202.040  | cry (w)                 | 158 dec |                                        |                            |                      | vs H <sub>2</sub> O, EtOH                                   |
| 604 | Benzeneboronic acid                       |                                                                         | C <sub>6</sub> H <sub>7</sub> BO <sub>2</sub>                                               | 98-80-6    | 121.930  |                         | 219     |                                        |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz                        |
| 605 | Benzenebutanoic acid                      |                                                                         | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                                              | 1821-12-1  | 164.201  | lf (w)                  | 52      | 290                                    |                            |                      | s H <sub>2</sub> O, EtOH, eth                               |
| 606 | Benzenebutanol                            |                                                                         | C <sub>10</sub> H <sub>14</sub> O                                                           | 3360-41-6  | 150.217  |                         |         | 140 <sup>14</sup>                      |                            | 1.5214 <sup>20</sup> |                                                             |
| 607 | Benzenecarboperoxoic acid                 | Perbenzoic acid                                                         | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                                                | 93-59-4    | 138.121  | mcl pl (peth)           | 42      | 100 <sup>14</sup>                      |                            |                      | vs ace, bz, eth, EtOH                                       |
| 608 | Benzenecarbothioamide                     |                                                                         | C <sub>7</sub> H <sub>7</sub> NS                                                            | 2227-79-4  | 137.203  |                         | 117     |                                        |                            |                      |                                                             |

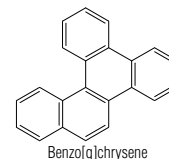
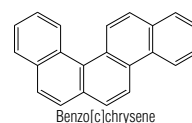
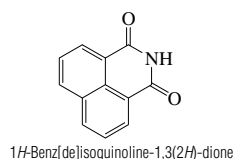
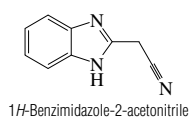
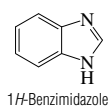
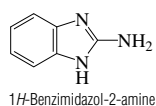
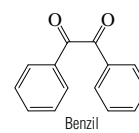
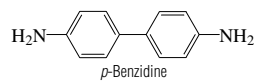
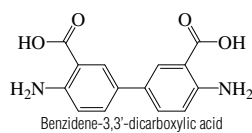
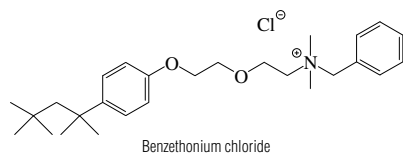
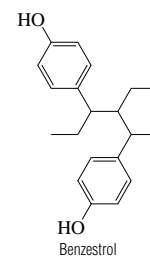
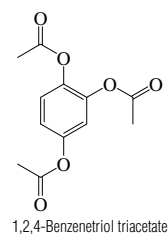
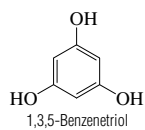
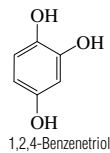
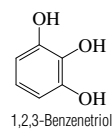
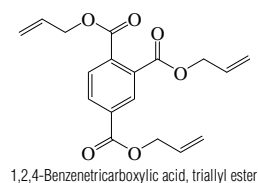
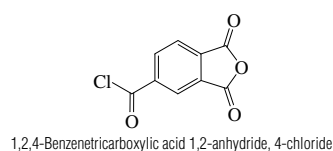
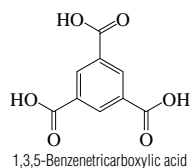
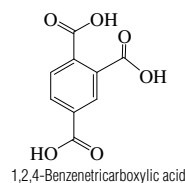
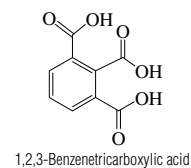
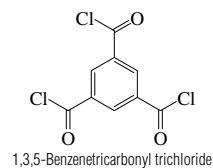
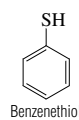
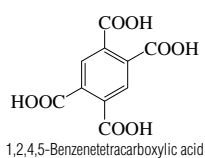
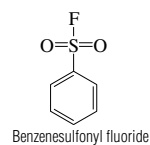
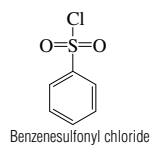
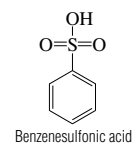
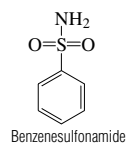
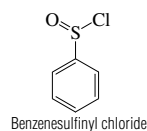
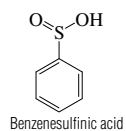
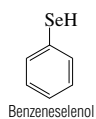
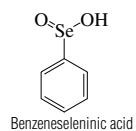
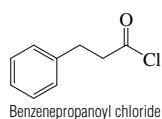
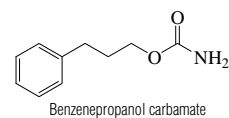
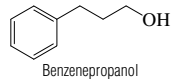
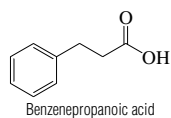
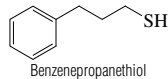
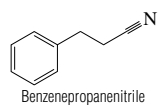
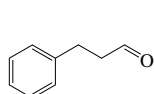


| No. | Name                                                    | Synonym                       | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form          | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                  |
|-----|---------------------------------------------------------|-------------------------------|-----------------------------------------------------------------------------|------------|----------|------------------------|---------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------------------|
| 609 | Benzenecarbothioic acid                                 |                               | C <sub>6</sub> H <sub>5</sub> OS                                            | 98-91-9    | 138.187  | ye pl (HOAc)           | 24      | 86 <sup>10</sup>                      | 1.28 <sup>20</sup>         | 1.6040 <sup>20</sup> | vs ace, bz, eth, EtOH                                       |
| 610 | Benzenecarboximidamide, monohydrochloride               |                               | C <sub>6</sub> H <sub>9</sub> ClN <sub>2</sub>                              | 1670-14-0  | 156.612  | orth pr (w +2)         | 169     |                                       |                            |                      | s H <sub>2</sub> O, EtOH; sl tfa                            |
| 611 | 1,2-Benzenediamine                                      | <i>o</i> -Phenylenediamine    | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                | 95-54-5    | 108.141  | brsh ye lf (w pl (chl) | 102.1   | 257                                   |                            |                      | s H <sub>2</sub> O, eth, bz, chl; vs EtOH                   |
| 612 | 1,3-Benzenediamine                                      | <i>m</i> -Phenylenediamine    | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                | 108-45-2   | 108.141  | orth (al)              | 66.0    | 285                                   | 1.0096 <sup>58</sup>       | 1.6339 <sup>58</sup> | vs H <sub>2</sub> O; s EtOH, eth, bz                        |
| 613 | 1,4-Benzenediamine                                      | <i>p</i> -Phenylenediamine    | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                | 106-50-3   | 108.141  | wh pl (bz, eth)        | 141.1   | 267                                   |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                   |
| 614 | 1,2-Benzenediamine, dihydrochloride                     |                               | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub>               | 615-28-1   | 181.062  |                        | 250 dec |                                       |                            |                      |                                                             |
| 615 | 1,3-Benzenediamine, dihydrochloride                     |                               | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub>               | 541-69-5   | 181.062  |                        |         |                                       |                            |                      | s H <sub>2</sub> O                                          |
| 616 | 1,4-Benzenediamine, dihydrochloride                     |                               | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub>               | 624-18-0   | 181.062  |                        |         |                                       |                            |                      | s H <sub>2</sub> O                                          |
| 617 | 1,2-Benzenedicarbonyl dichloride                        | Phthaloyl chloride            | C <sub>8</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                | 88-95-9    | 203.023  |                        | 15.5    | 281.1                                 | 1.4089 <sup>20</sup>       | 1.5684 <sup>20</sup> |                                                             |
| 618 | 1,3-Benzenedicarbonyl dichloride                        |                               | C <sub>8</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                | 99-63-8    | 203.023  | pr(eth)                | 43.5    | 276                                   | 1.3880 <sup>17</sup>       | 1.570 <sup>47</sup>  | sl H <sub>2</sub> O, EtOH; s eth                            |
| 619 | 1,4-Benzenedicarbonyl dichloride                        |                               | C <sub>8</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                | 100-20-9   | 203.023  | nd or pl (liq)         | 83.5    | 258; 125 <sup>9</sup>                 |                            |                      | s eth                                                       |
| 620 | 1,2-Benzenedicarboxaldehyde                             |                               | C <sub>8</sub> H <sub>6</sub> O <sub>2</sub>                                | 643-79-8   | 134.133  | ye cry or nd (liq)     | 55.8    | 83 <sup>0,8</sup>                     |                            |                      | vs eth, EtOH                                                |
| 621 | 1,3-Benzenedicarboxaldehyde                             |                               | C <sub>8</sub> H <sub>6</sub> O <sub>2</sub>                                | 626-19-7   | 134.133  | nd (dil al)            | 89.5    | 246; 136 <sup>13</sup>                |                            |                      | sl H <sub>2</sub> O, eth, chl; vs EtOH; s ace, bz           |
| 622 | 1,4-Benzenedicarboxaldehyde                             |                               | C <sub>8</sub> H <sub>6</sub> O <sub>2</sub>                                | 623-27-8   | 134.133  | nd (w)                 | 117     | 246                                   |                            |                      | sl H <sub>2</sub> O; vs EtOH; s eth, chl, alk               |
| 623 | 1,2-Benzenedicarboxamide                                | Phthalamide                   | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                 | 88-96-0    | 164.162  | cry                    | 222     | dec                                   |                            |                      | sl H <sub>2</sub> O, EtOH; i eth                            |
| 624 | 1,4-Benzenedicarboxamide                                |                               | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                 | 3010-82-0  | 164.162  | nd (w), pl (HOAc)      | 322.3   |                                       |                            |                      |                                                             |
| 625 | 1,2-Benzenedicarboxylic acid, bis(2-butoxyethyl) ester  | Bis(2-butoxyethyl) phthalate  | C <sub>20</sub> H <sub>30</sub> O <sub>6</sub>                              | 117-83-9   | 366.448  |                        |         | 270                                   |                            |                      |                                                             |
| 626 | 1,2-Benzenedicarboxylic acid, bis(2-methoxyethyl) ester | Bis(2-methoxyethyl) phthalate | C <sub>14</sub> H <sub>18</sub> O <sub>6</sub>                              | 117-82-8   | 282.289  |                        | -60.0   | 230 <sup>10</sup>                     | 1.1596 <sup>20</sup>       |                      |                                                             |
| 627 | 1,2-Benzenedicarboxylic acid, diallyl ester             | Diallyl phthalate             | C <sub>14</sub> H <sub>14</sub> O <sub>4</sub>                              | 131-17-9   | 246.259  |                        |         | 161 <sup>4</sup>                      |                            |                      |                                                             |
| 628 | 1,2-Benzenedicarboxylic acid, dipropyl ester            | Dipropyl phthalate            | C <sub>14</sub> H <sub>18</sub> O <sub>4</sub>                              | 131-16-8   | 250.291  | liq                    | -31.0   | 304.5                                 | 1.0767 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                             |
| 629 | 1,3-Benzenedimethanamine                                | <i>m</i> -Xylene diamine      | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                               | 1477-55-0  | 136.194  |                        |         | 247                                   | 1.052 <sup>20</sup>        |                      | vs H <sub>2</sub> O, eth, EtOH                              |
| 630 | 1,2-Benzenedimethanol                                   |                               | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                               | 612-14-6   | 138.164  | pl (eth, peth)         | 64.8    | 145 <sup>3</sup>                      |                            |                      | s H <sub>2</sub> O, EtOH; vs eth; sl bz                     |
| 631 | 1,3-Benzenedimethanol                                   |                               | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                               | 626-18-6   | 138.164  | nd (bz)                | 57      | 156 <sup>13</sup>                     | 1.1610 <sup>18</sup>       |                      | vs H <sub>2</sub> O, eth, EtOH                              |
| 632 | 1,4-Benzenedimethanol                                   |                               | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                               | 589-29-7   | 138.164  | nd (w)                 | 117.5   | 140 <sup>1</sup>                      |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH                         |
| 633 | 1,2-Benzenediol, diacetate                              |                               | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                              | 635-67-6   | 194.184  | nd (al)                | 64.5    | 142 <sup>9</sup>                      |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, chl; s peth               |
| 634 | 1,4-Benzenediol, diacetate                              |                               | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                              | 1205-91-0  | 194.184  | pl (w, al)             | 123.5   |                                       | 0.8731 <sup>25</sup>       |                      | s H <sub>2</sub> O; vs EtOH, eth, chl, lig                  |
| 635 | 1,3-Benzenediol, monobenzoate                           |                               | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                              | 136-36-7   | 214.216  |                        | 134.5   |                                       |                            |                      |                                                             |
| 636 | 1,3-Benzenedisulfonic acid                              |                               | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub> S <sub>2</sub>                 | 98-48-6    | 238.238  | hyg cry                |         |                                       |                            |                      |                                                             |
| 637 | 1,3-Benzenedisulfonyl dichloride                        |                               | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub> S <sub>2</sub> | 585-47-7   | 275.130  |                        | 61.8    | 195 <sup>10,5</sup>                   |                            |                      |                                                             |
| 638 | 1,2-Benzenedithiol                                      |                               | C <sub>6</sub> H <sub>6</sub> S <sub>2</sub>                                | 17534-15-5 | 142.242  |                        | 28.5    | 238.5                                 |                            |                      | vs EtOH, eth, bz; s AcOEt                                   |
| 639 | 1,3-Benzenedithiol                                      |                               | C <sub>6</sub> H <sub>6</sub> S <sub>2</sub>                                | 626-04-0   | 142.242  | lf                     | 27      | 245                                   |                            |                      | vs bz, eth, EtOH                                            |
| 640 | Benzenethanamine                                        | 1-Amino-2-phenylethane        | C <sub>8</sub> H <sub>11</sub> N                                            | 64-04-0    | 121.180  | liq                    | <0      | 195                                   | 0.9640 <sup>25</sup>       | 1.5290 <sup>25</sup> | s H <sub>2</sub> O, etc; vs EtOH, eth                       |
| 641 | Benzenethanamine, hydrochloride                         |                               | C <sub>8</sub> H <sub>12</sub> ClN                                          | 156-28-5   | 157.641  | pl or lf (al)          | 218.5   |                                       |                            |                      | vs H <sub>2</sub> O, EtOH                                   |
| 642 | Benzenethanol                                           | Phenethyl alcohol             | C <sub>8</sub> H <sub>10</sub> O                                            | 60-12-8    | 122.164  | liq                    | -27     | 218.8                                 | 1.0202 <sup>20</sup>       | 1.5325 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                          |
| 643 | Benzenehexacarboxylic acid                              | Mellitic acid                 | C <sub>12</sub> H <sub>6</sub> O <sub>12</sub>                              | 517-60-2   | 342.169  | nd (al)                | 287 dec |                                       |                            |                      | vs H <sub>2</sub> O; s EtOH, sulf                           |
| 644 | Benzenemethanamine, hydrochloride                       |                               | C <sub>7</sub> H <sub>10</sub> ClN                                          | 3287-99-8  | 143.614  |                        | 258.3   |                                       |                            |                      | vs H <sub>2</sub> O, EtOH                                   |
| 645 | Benzenemethanesulfonyl chloride                         |                               | C <sub>7</sub> H <sub>7</sub> ClO <sub>2</sub> S                            | 1939-99-7  | 190.648  | pr (eth), nd (bz)      | 93      |                                       |                            |                      | vs eth, bz                                                  |
| 646 | Benzenemethanesulfonyl fluoride                         |                               | C <sub>7</sub> H <sub>7</sub> FO <sub>2</sub> S                             | 329-98-6   | 174.193  |                        | 92.0    |                                       |                            |                      |                                                             |
| 647 | Benzenemethanethiol                                     | Thiobenzyl alcohol            | C <sub>7</sub> H <sub>8</sub> S                                             | 100-53-8   | 124.204  | liq                    | -30     | 194.5                                 | 1.058 <sup>20</sup>        | 1.5151 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; sl etc; s CS <sub>2</sub> |
| 648 | Benzenepentanoic acid                                   | 5-Phenylvaleric acid          | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                              | 2270-20-4  | 178.228  | pl (w), pr (peth)      | 57.5    | 190 <sup>30</sup>                     |                            |                      | sl H <sub>2</sub> O; vs EtOH; s os                          |
| 649 | Benzenepentanol                                         |                               | C <sub>11</sub> H <sub>16</sub> O                                           | 10521-91-2 | 164.244  |                        |         | 155 <sup>20</sup> , 150 <sup>18</sup> | 0.9725 <sup>20</sup>       | 1.5156 <sup>20</sup> | vs eth, EtOH                                                |

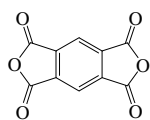
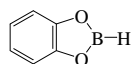




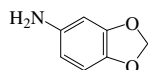
| No. | Name                                                      | Synonym                                           | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C     | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|-----|-----------------------------------------------------------|---------------------------------------------------|---------------------------------------------------------------|------------|----------|----------------------------|-----------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 650 | Benzenepropanal                                           | Hydrocinnamic aldehyde                            | C <sub>9</sub> H <sub>10</sub> O                              | 104-53-0   | 134.174  | mcl                        | 47        | 224; 117 <sup>28</sup>                | 1.0190 <sup>20</sup>       |                      | i H <sub>2</sub> O; vs EtOH; msc eth                          |
| 651 | Benzenepropanenitrile                                     | Hydrocinnamonitrile                               | C <sub>9</sub> H <sub>9</sub> N                               | 645-59-0   | 131.174  | liq                        | -1        | 261; 141 <sup>25</sup>                | 1.0016 <sup>20</sup>       | 1.5266 <sup>28</sup> | s EtOH, eth; sl chl                                           |
| 652 | Benzenepropanethiol                                       |                                                   | C <sub>9</sub> H <sub>12</sub> S                              | 24734-68-7 | 152.256  |                            |           | 121 <sup>23</sup> , 109 <sup>10</sup> | 1.01 <sup>25</sup>         | 1.5494 <sup>20</sup> |                                                               |
| 653 | Benzenepropanoic acid                                     | Hydrocinnamic acid                                | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 501-52-0   | 150.174  | nd (w)                     | 48        | 279.8                                 | 1.0712 <sup>49</sup>       |                      | s H <sub>2</sub> O, EtOH, eth, ctc, CS <sub>2</sub> ; vs bz   |
| 654 | Benzenepropanol                                           | Hydrocinnamyl alcohol                             | C <sub>9</sub> H <sub>12</sub> O                              | 122-97-4   | 136.190  |                            | <-18      | 235                                   | 0.995 <sup>25</sup>        | 1.5357 <sup>25</sup> | s H <sub>2</sub> O, ctc; msc EtOH, eth                        |
| 655 | Benzenepropanol carbamate                                 | Phenprobamate                                     | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>               | 673-31-4   | 179.216  |                            | 102       |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, chl                               |
| 656 | Benzenepropanoyl chloride                                 |                                                   | C <sub>9</sub> H <sub>9</sub> ClO                             | 645-45-4   | 168.619  |                            |           | dec 225; 105 <sup>10</sup>            | 1.135 <sup>21</sup>        |                      | s eth, CS <sub>2</sub>                                        |
| 657 | Benzeneseleninic acid                                     | Phenylseleninic acid                              | C <sub>6</sub> H <sub>5</sub> O <sub>2</sub> Se               | 6996-92-5  | 189.07   |                            | 124.5     |                                       | 1.93 <sup>20</sup>         |                      | sl H <sub>2</sub> O; i bz; vs alk                             |
| 658 | Benzeneselenol                                            |                                                   | C <sub>6</sub> H <sub>5</sub> Se                              | 645-96-5   | 157.07   |                            |           | 183.6; 84 <sup>25</sup>               | 1.4865 <sup>15</sup>       |                      | i H <sub>2</sub> O; s EtOH; vs eth, ctc                       |
| 659 | Benzenesulfonic acid                                      |                                                   | C <sub>6</sub> H <sub>5</sub> O <sub>2</sub> S                | 618-41-7   | 142.176  | pr (w)                     | 84        | dec                                   |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz; i peth                  |
| 660 | Benzenesulfinyl chloride                                  |                                                   | C <sub>6</sub> H <sub>5</sub> ClOS                            | 4972-29-6  | 160.621  | pl (peth)                  | 38        | 71 <sup>15</sup>                      | 1.3469 <sup>25</sup>       | 1.3470 <sup>25</sup> | s eth, chl                                                    |
| 661 | Benzenesulfonamide                                        |                                                   | C <sub>6</sub> H <sub>7</sub> NO <sub>2</sub> S               | 98-10-2    | 157.191  | lf, nd (w)                 | 156       |                                       |                            |                      | sl H <sub>2</sub> O, tfa; s EtOH, eth                         |
| 662 | Benzenesulfonic acid                                      | Besyllic acid                                     | C <sub>6</sub> H <sub>5</sub> O <sub>3</sub> S                | 98-11-3    | 158.175  | nd (bz)                    | 65        |                                       |                            |                      | vs H <sub>2</sub> O, EtOH; i eth; sl bz; s HOAc               |
| 663 | Benzenesulfonyl chloride                                  | Phenylsulfonyl chloride                           | C <sub>6</sub> H <sub>5</sub> ClO <sub>2</sub> S              | 98-09-9    | 176.621  |                            | 14.5      | dec 251                               | 1.3470 <sup>15</sup>       |                      | i H <sub>2</sub> O; vs EtOH; s eth, ctc                       |
| 664 | Benzenesulfonyl fluoride                                  | Phenylsulfonyl fluoride                           | C <sub>6</sub> H <sub>5</sub> FO <sub>2</sub> S               | 368-43-4   | 160.166  |                            |           | 203.5                                 | 1.3286 <sup>20</sup>       | 1.4932 <sup>18</sup> | s EtOH, eth                                                   |
| 665 | 1,2,4,5-Benzenetetracarboxylic acid                       | Pyromellitic acid                                 | C <sub>10</sub> H <sub>6</sub> O <sub>8</sub>                 | 89-05-4    | 254.150  | tcl pr (w+2)               | 276       |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH                                   |
| 666 | Benzenethiol                                              | Phenyl mercaptan                                  | C <sub>6</sub> H <sub>5</sub> S                               | 108-98-5   | 110.177  | liq                        | -14.93    | 169.1                                 | 1.0775 <sup>20</sup>       | 1.5893 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz; sl ctc                   |
| 667 | 1,3,5-Benzenetricarbonyl trichloride                      |                                                   | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O <sub>3</sub>  | 4422-95-1  | 265.477  |                            | 36.3      | 180 <sup>16</sup>                     |                            |                      | s chl                                                         |
| 668 | 1,2,3-Benzenetricarboxylic acid                           | Hemimellitic acid                                 | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                  | 569-51-7   | 210.140  | pr (al)                    | 200       |                                       | 1.546 <sup>20</sup>        |                      | vs eth, EtOH                                                  |
| 669 | 1,2,4-Benzenetricarboxylic acid                           | Trimellitic acid                                  | C <sub>9</sub> H <sub>6</sub> O <sub>6</sub>                  | 528-44-9   | 210.140  | nd (w) cry (al) cry (HOAc) | 219       |                                       |                            |                      | vs H <sub>2</sub> O, eth, EtOH                                |
| 670 | 1,3,5-Benzenetricarboxylic acid                           |                                                   | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                  | 554-95-0   | 210.140  | pr or nd (w+1)             | 380       |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth                             |
| 671 | 1,2,4-Benzenetricarboxylic acid 1,2-anhydride, 4-chloride | 4-(Chloroformyl)phthalic anhydride                | C <sub>9</sub> H <sub>3</sub> ClO <sub>4</sub>                | 1204-28-0  | 210.571  |                            | 66        |                                       |                            |                      |                                                               |
| 672 | 1,2,4-Benzenetricarboxylic acid, triallyl ester           |                                                   | C <sub>18</sub> H <sub>16</sub> O <sub>6</sub>                | 2694-54-4  | 330.332  |                            | <-30      |                                       | 1.164 <sup>20</sup>        |                      |                                                               |
| 673 | 1,2,3-Benzenetriol                                        | Pyrogallol                                        | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                  | 87-66-1    | 126.110  | lf or nd (bz)              | 133       | 309                                   | 1.453 <sup>4</sup>         | 1.561 <sup>134</sup> | vs H <sub>2</sub> O, EtOH, eth, NH <sub>3</sub> ; s ace; i bz |
| 674 | 1,2,4-Benzenetriol                                        | Hydroxyhydroquinone                               | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                  | 533-73-3   | 126.110  | pl (eth), lf or pl (w)     | 140.5     |                                       |                            |                      | vs H <sub>2</sub> O, EtOH, eth; i bz, chl                     |
| 675 | 1,3,5-Benzenetriol                                        | Phloroglucinol                                    | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                  | 108-73-6   | 126.110  | lf or pl (w+2)             | 218.5     | sub                                   | 1.46 <sup>25</sup>         |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz, py; s ace              |
| 676 | 1,2,4-Benzenetriol triacetate                             |                                                   | C <sub>12</sub> H <sub>12</sub> O <sub>6</sub>                | 613-03-6   | 252.219  |                            | 99        | 300                                   |                            |                      | s EtOH, chl, MeOH                                             |
| 677 | Benzestrol                                                |                                                   | C <sub>20</sub> H <sub>26</sub> O <sub>2</sub>                | 85-95-0    | 298.419  | cry (al)                   | 164       |                                       |                            |                      | vs ace, eth, EtOH, HOAc                                       |
| 678 | Benzethonium chloride                                     |                                                   | C <sub>27</sub> H <sub>42</sub> ClNO <sub>2</sub>             | 121-54-0   | 448.081  | pl (chl/eth)               | 165 (hyd) |                                       |                            |                      | vs H <sub>2</sub> O; s ace, chl, EtOH                         |
| 679 | Benzidene-3,3'-dicarboxylic acid                          | 3,3'-Dicarboxybenzidine                           | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> | 2130-56-5  | 272.256  | nd                         | 300 dec   |                                       |                            |                      |                                                               |
| 680 | <i>p</i> -Benzidine                                       | [1,1'-Biphenyl]-4,4'-diamine                      | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                | 92-87-5    | 184.236  | nd (w)                     | 120       | 401                                   |                            |                      | sl H <sub>2</sub> O, eth, DMSO; s EtOH                        |
| 681 | Benzil                                                    | Diphenylethanedione                               | C <sub>14</sub> H <sub>10</sub> O <sub>2</sub>                | 134-81-6   | 210.228  | ye pr (al)                 | 94.87     | 347                                   | 1.084 <sup>102</sup>       |                      | i H <sub>2</sub> O; vs EtOH, eth; s ace; sl ctc               |
| 682 | 1 <i>H</i> -Benzimidazol-2-amine                          |                                                   | C <sub>7</sub> H <sub>7</sub> N <sub>3</sub>                  | 934-32-7   | 133.151  | pl (w)                     | 224       |                                       |                            |                      | s H <sub>2</sub> O, EtOH, ace; sl eth, bz, DMSO               |
| 683 | 1 <i>H</i> -Benzimidazole                                 | <i>N,N'</i> -Methenyl- <i>o</i> -phenylenediamine | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                  | 51-17-2    | 118.136  | orth bipym pl (w)          | 170.5     | >360                                  |                            |                      | sl H <sub>2</sub> O, eth; vs EtOH; i bz; s dil alk            |
| 684 | 1 <i>H</i> -Benzimidazole-2-acetonitrile                  |                                                   | C <sub>9</sub> H <sub>7</sub> N <sub>3</sub>                  | 4414-88-4  | 157.172  |                            | 208.4     |                                       |                            |                      |                                                               |
| 685 | 1 <i>H</i> -Benz[de]isoquinoline-1,3(2 <i>H</i> )-dione   |                                                   | C <sub>12</sub> H <sub>7</sub> NO <sub>2</sub>                | 81-83-4    | 197.190  | nd (chl-al)                | 300       |                                       |                            |                      |                                                               |
| 686 | Benzo[c]chrysene                                          |                                                   | C <sub>22</sub> H <sub>14</sub>                               | 194-69-4   | 278.346  | nd (AcOH)                  | 126.5     |                                       |                            |                      |                                                               |
| 687 | Benzo[g]chrysene                                          | Benzo[a]triphenylene                              | C <sub>22</sub> H <sub>14</sub>                               | 196-78-1   | 278.346  | nd (AcOH)                  | 114.5     |                                       |                            |                      |                                                               |



| No. | Name                                                                                 | Synonym                                                 | Mol. Form.                                                                                   | CAS RN     | Mol. Wt. | Physical Form                | mp/°C            | bp/°C                                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|-----|--------------------------------------------------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------|------------|----------|------------------------------|------------------|-----------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 688 | 1 <i>H</i> ,3 <i>H</i> -Benzo[1,2- <i>c</i> :4,5- <i>c'</i> ]difuran-1,3,5,7-tetrone |                                                         | C <sub>10</sub> H <sub>2</sub> O <sub>6</sub>                                                | 89-32-7    | 218.119  |                              | 285.3            |                                         |                            |                      |                                                              |
| 689 | 1,3,2-Benzodioxaborole                                                               |                                                         | C <sub>6</sub> H <sub>5</sub> BO <sub>2</sub>                                                | 274-07-7   | 119.914  |                              | 12               | 88 <sup>156</sup> , 50 <sup>50</sup>    | 1.2700 <sup>20</sup>       | 1.5070 <sup>20</sup> |                                                              |
| 690 | 1,3-Benzodioxol-5-amine                                                              |                                                         | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                                | 14268-66-7 | 137.137  |                              | 42               | 144 <sup>16</sup>                       |                            |                      |                                                              |
| 691 | 1,3-Benzodioxole                                                                     |                                                         | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                                 | 274-09-9   | 122.122  |                              |                  | 172.5; 77 <sup>27</sup>                 | 1.064 <sup>25</sup>        | 1.5398 <sup>20</sup> |                                                              |
| 692 | 1,3-Benzodioxole-5-carboxaldehyde                                                    | Piperonal                                               | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                                                 | 120-57-0   | 150.132  |                              | 37               | 263                                     |                            |                      | sl H <sub>2</sub> O; vs EtOH; msc eth; s ace, chl            |
| 693 | 1,3-Benzodioxole-5-carboxylic acid                                                   | Piperonylic acid                                        | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                                                 | 94-53-1    | 166.132  |                              | 229              |                                         |                            |                      |                                                              |
| 694 | 1,3-Benzodioxole-5-ethanamine                                                        |                                                         | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                                               | 1484-85-1  | 165.189  |                              |                  | 166 <sup>20</sup> , 101 <sup>1</sup>    | 1.225 <sup>20</sup>        | 1.5620 <sup>20</sup> |                                                              |
| 695 | 1,3-Benzodioxole-5-methanamine                                                       |                                                         | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                                                | 2620-50-0  | 151.163  |                              |                  | 139 <sup>13</sup> , 100 <sup>0.07</sup> | 1.214 <sup>25</sup>        | 1.5635 <sup>20</sup> |                                                              |
| 696 | 1,3-Benzodioxole-5-methanol                                                          |                                                         | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                                                 | 495-76-1   | 152.148  | nd (peth)                    | 58               | 157 <sup>16</sup>                       |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl; i lig             |
| 697 | 1,3-Benzodioxol-5-ol                                                                 |                                                         | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                                                 | 533-31-3   | 138.121  |                              | 64.9             |                                         |                            |                      |                                                              |
| 698 | <i>trans,trans</i> -5-(1,3-Benzodioxol-5-yl)-2,4-pentadienoic acid                   | Piperinic acid                                          | C <sub>12</sub> H <sub>10</sub> O <sub>4</sub>                                               | 136-72-1   | 218.205  | nd (al), ye nd (sub)         | 215.8            | sub                                     |                            |                      | vs EtOH                                                      |
| 699 | 7,8-Benzoflavone                                                                     | 2-Phenyl-4 <i>H</i> -naphtho[1,2- <i>b</i> ]pyran-4-one | C <sub>19</sub> H <sub>12</sub> O <sub>2</sub>                                               | 604-59-1   | 272.297  | ye pl (al)                   | 157              |                                         |                            |                      | sl EtOH, chl; s sulf                                         |
| 700 | Benzo[ <i>b</i> ]fluoranthene                                                        | Benz[ <i>e</i> ]acephenanthrylene                       | C <sub>20</sub> H <sub>12</sub>                                                              | 205-99-2   | 252.309  | nd (bz)                      | 168              |                                         |                            |                      | i H <sub>2</sub> O; msc bz                                   |
| 701 | Benzo[ <i>j</i> ]fluoranthene                                                        | Dibenzo[ <i>a,jk</i> ]fluorene                          | C <sub>20</sub> H <sub>12</sub>                                                              | 205-82-3   | 252.309  | ye pl (al) nd (HOAc)         | 166              |                                         |                            |                      | i H <sub>2</sub> O; sl EtOH, HOAc                            |
| 702 | Benzo[ <i>k</i> ]fluoranthene                                                        | 2,3,1',8'-Binaphthylene                                 | C <sub>20</sub> H <sub>12</sub>                                                              | 207-08-9   | 252.309  | pa ye nd (bz)                | 217              | 480                                     |                            |                      | i H <sub>2</sub> O; s EtOH, bz, HOAc                         |
| 703 | 11 <i>H</i> -Benzo[ <i>a</i> ]fluorene                                               |                                                         | C <sub>17</sub> H <sub>12</sub>                                                              | 238-84-6   | 216.277  | pl (ace or HOAc)             | 189.5            | 405                                     |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, chl                  |
| 704 | 11 <i>H</i> -Benzo[ <i>b</i> ]fluorene                                               |                                                         | C <sub>17</sub> H <sub>12</sub>                                                              | 243-17-4   | 216.277  |                              | 212              | 401                                     |                            |                      | i H <sub>2</sub> O                                           |
| 705 | Benzo[ <i>f</i> ]furan                                                               | Coumarone                                               | C <sub>8</sub> H <sub>6</sub> O                                                              | 271-89-6   | 118.133  |                              | <-18             | 174                                     | 1.0913 <sup>25</sup>       | 1.5615 <sup>17</sup> | i H <sub>2</sub> O; s EtOH, eth                              |
| 706 | 2-Benzofurancarboxylic acid                                                          | Coumarilic acid                                         | C <sub>9</sub> H <sub>6</sub> O <sub>3</sub>                                                 | 496-41-3   | 162.142  | nd (w)                       | 192.5            | 312.5                                   |                            |                      | vs EtOH                                                      |
| 707 | 2(3 <i>H</i> )-Benzofuranone                                                         |                                                         | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>                                                 | 553-86-6   | 134.133  |                              | 50               | 249                                     | 1.2236 <sup>14</sup>       |                      |                                                              |
| 708 | 3(2 <i>H</i> )-Benzofuranone                                                         |                                                         | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>                                                 | 7169-34-8  | 134.133  | red nd (al)                  | 102.5            | 152 <sup>15</sup>                       |                            |                      | vs bz                                                        |
| 709 | 1-(2-Benzofuranyl)ethanone                                                           |                                                         | C <sub>10</sub> H <sub>6</sub> O <sub>2</sub>                                                | 1646-26-0  | 160.170  |                              | 76               | 126 <sup>11</sup>                       |                            |                      | s H <sub>2</sub> O                                           |
| 710 | Benzo[ <i>f</i> ]furan, 1-oxide                                                      |                                                         | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                                  | 480-96-6   | 136.108  |                              | 71.5             |                                         | 1.280 <sup>80</sup>        |                      |                                                              |
| 711 | Benzohydrazide                                                                       | Benzoic acid, hydrazide                                 | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O                                               | 613-94-5   | 136.151  | pl (w)                       | 115              | dec 267                                 |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, ace, chl                   |
| 712 | Benzoic acid                                                                         | Benzenecarboxylic acid                                  | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                                 | 65-85-0    | 122.122  | mcl lf or nd                 | 122.35           | 249.2                                   | 1.2659 <sup>15</sup>       | 1.504 <sup>132</sup> | sl H <sub>2</sub> O; vs EtOH, eth; s ace, bz, chl            |
| 713 | Benzoic anhydride                                                                    |                                                         | C <sub>14</sub> H <sub>10</sub> O <sub>3</sub>                                               | 93-97-0    | 226.227  | pr (eth)                     | 42.5             | 360                                     | 1.989 <sup>15</sup>        | 1.5767 <sup>15</sup> | i H <sub>2</sub> O, lig; s EtOH, eth; sl chl                 |
| 714 | Benzooin                                                                             | 2-Hydroxy-1,2-diphenylethanone, (±)                     | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>                                               | 579-44-2   | 212.244  |                              | 137              | 344; 194 <sup>12</sup>                  | 1.310 <sup>20</sup>        |                      | vs EtOH, chl                                                 |
| 715 | Benzonitrile                                                                         | Phenyl cyanide                                          | C <sub>7</sub> H <sub>5</sub> N                                                              | 100-47-0   | 103.122  | liq                          | -13.99           | 191.1                                   | 1.0093 <sup>15</sup>       | 1.5289 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH; vs ace, bz; s ctc             |
| 716 | Benzo[ <i>ghi</i> ]perylene                                                          | 1,12-Benzperylene                                       | C <sub>22</sub> H <sub>12</sub>                                                              | 191-24-2   | 276.330  | ye-grn lf (bz)               | 272.5            |                                         |                            |                      | i H <sub>2</sub> O                                           |
| 717 | Benzo[ <i>c</i> ]phenanthrene                                                        | Tetrahelcene                                            | C <sub>18</sub> H <sub>12</sub>                                                              | 195-19-7   | 228.288  |                              | 68               |                                         |                            |                      | i H <sub>2</sub> O; sl EtOH, lig                             |
| 718 | Benzophenone                                                                         | Diphenyl ketone                                         | C <sub>13</sub> H <sub>10</sub> O                                                            | 119-61-9   | 182.217  | (α) orth pr (al); (β) mcl pr | 47.9 (α); 26 (β) | 305.4                                   | 1.111 <sup>18</sup>        | 1.6077 <sup>19</sup> | i H <sub>2</sub> O; vs EtOH, eth, chl, ace; s bz             |
| 719 | Benzophenone hydrazone                                                               |                                                         | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub>                                               | 5350-57-2  | 196.247  |                              | 97.3             | 227 <sup>55</sup>                       |                            |                      |                                                              |
| 720 | Benzophenone, oxime                                                                  | Diphenyl ketoxime                                       | C <sub>13</sub> H <sub>11</sub> NO                                                           | 574-66-3   | 197.232  | nd (al)                      | 144              |                                         |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, chl, ace; s bz             |
| 721 | 3,3',4,4'-Benzophenonetetracarboxylic acid dianhydride                               | 4,4'-Carbonyldipthalic anhydride                        | C <sub>17</sub> H <sub>6</sub> O <sub>7</sub>                                                | 2421-28-5  | 322.226  |                              | 216              |                                         |                            |                      |                                                              |
| 722 | Benzo-2-phenylhydrazide                                                              |                                                         | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O                                             | 532-96-7   | 212.246  | pr (al), nd (w)              | 168              | 314                                     |                            |                      | sl H <sub>2</sub> O, eth; s EtOH, bz, chl                    |
| 723 | Benzopurpurine 4B                                                                    | C.I. Direct Red 2, disodium salt                        | C <sub>34</sub> H <sub>26</sub> N <sub>6</sub> Na <sub>2</sub> O <sub>6</sub> S <sub>2</sub> | 992-59-6   | 724.716  | br pow                       |                  |                                         |                            |                      | s H <sub>2</sub> O, EtOH, ac, H <sub>2</sub> SO <sub>4</sub> |
| 724 | 2 <i>H</i> -1-Benzopyran                                                             | 1,2-Chromene                                            | C <sub>9</sub> H <sub>8</sub> O                                                              | 254-04-6   | 132.159  |                              |                  | 132 <sup>102</sup> , 91 <sup>13</sup>   | 1.0993 <sup>16</sup>       | 1.5869 <sup>24</sup> | i H <sub>2</sub> O                                           |
| 725 | [2]Benzopyrano[6,5,4- <i>def</i> ][2]benzopyran-1,3,6,8-tetrone                      | 1,4,5,8-Naphthalenetetracarboxylic acid anhydride       | C <sub>14</sub> H <sub>4</sub> O <sub>6</sub>                                                | 81-30-1    | 268.178  | nd (al)                      | 450              | sub 320                                 |                            |                      | i H <sub>2</sub> O; s Na <sub>2</sub> CO <sub>3</sub> , HOAc |
| 726 | 1 <i>H</i> -2-Benzopyran-1-one                                                       | Isocoumarin                                             | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>                                                 | 491-31-6   | 146.143  | pl (bz)                      | 47               | 286                                     |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, bz, CS <sub>2</sub>        |
| 727 | 2 <i>H</i> -1-Benzopyran-2-one                                                       | Coumarin                                                | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>                                                 | 91-64-5    | 146.143  | orth pym (eth)               | 71               | 301.7                                   | 0.935 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH, alk; vs eth, chl, py               |

1*H*,3*H*-Benzo[1,2-*c*:4,5-*c'*]difuran-1,3,5,7-tetrone

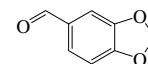
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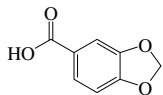
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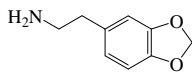
1,3-Benzodioxole



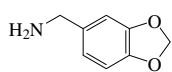
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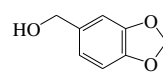
1,3-Benzodioxole-5-carboxylic acid



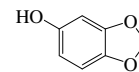
1,3-Benzodioxole-5-ethanamine



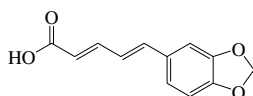
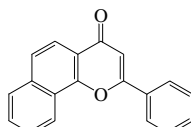
1,3-Benzodioxole-5-methanamine



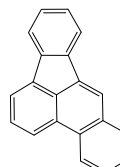
1,3-Benzodioxole-5-methanol



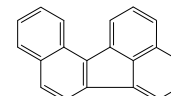
1,3-Benzodioxol-5-ol

*trans,trans*-5-(1,3-Benzodioxol-5-yl)-2,4-pentadienoic acid

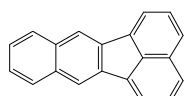
7,8-Benzoflavone



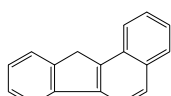
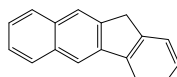
Benzo[b]fluoranthene



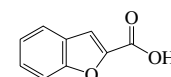
Benzo[j]fluoranthene



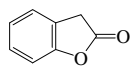
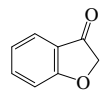
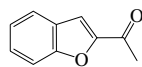
Benzo[k]fluoranthene

11*H*-Benzo[a]fluorene11*H*-Benzo[b]fluorene

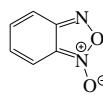
Benzofuran



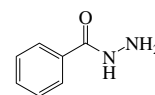
2-Benzofurancarboxylic acid

2(3*H*)-Benzofuranone3(2*H*)-Benzofuranone

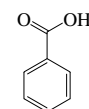
1-(2-Benzofuranyl)ethanone



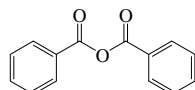
Benzofurazan, 1-oxide



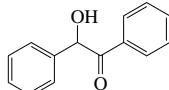
Benzohydrazide



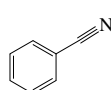
Benzoic acid



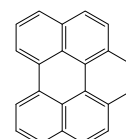
Benzoic anhydride



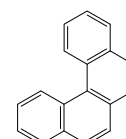
Benzoin



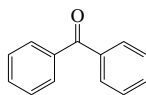
Benzonitrile



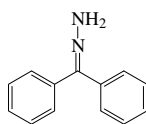
Benzo[ghi]perylene



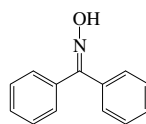
Benzo[c]phenanthrene



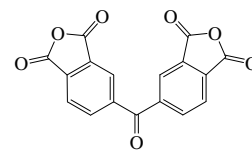
Benzophenone



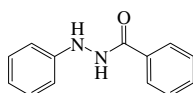
Benzophenone hydrazone



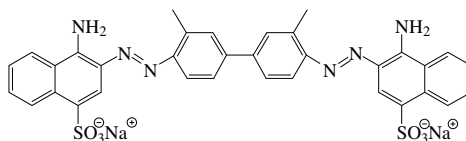
Benzophenone, oxime



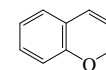
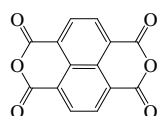
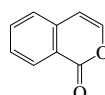
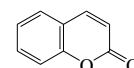
3,3',4,4'-Benzophenonetetracarboxylic acid dianhydride



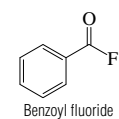
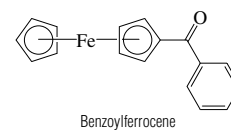
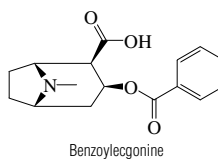
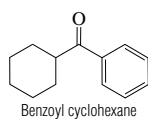
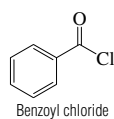
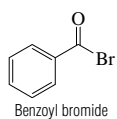
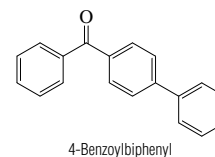
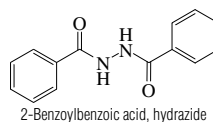
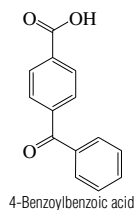
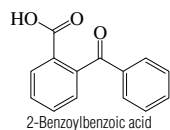
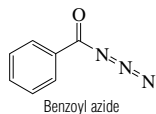
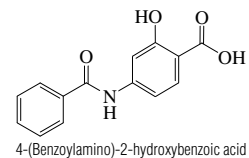
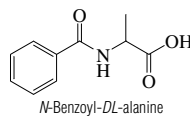
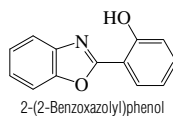
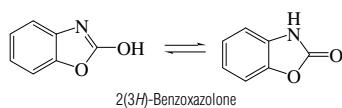
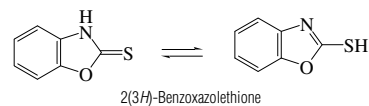
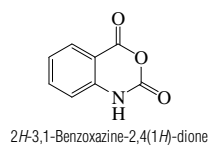
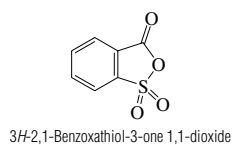
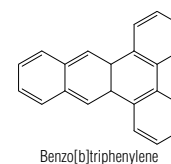
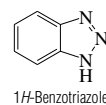
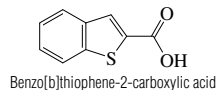
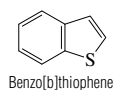
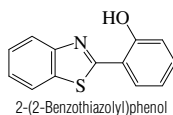
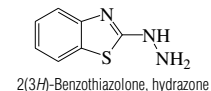
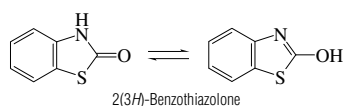
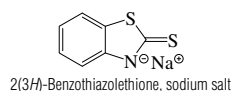
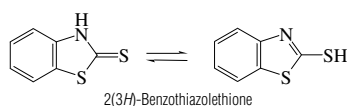
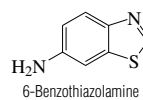
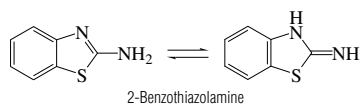
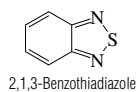
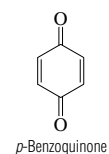
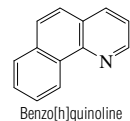
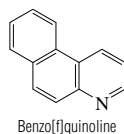
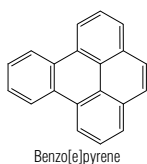
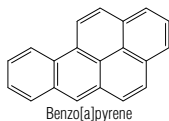
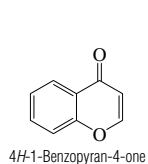
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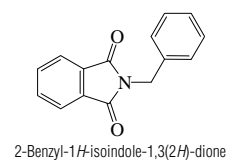
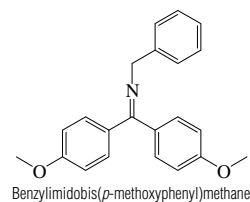
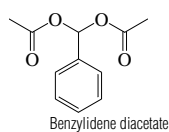
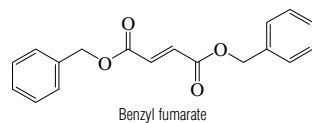
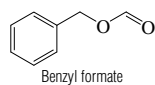
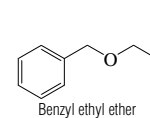
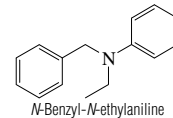
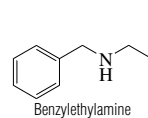
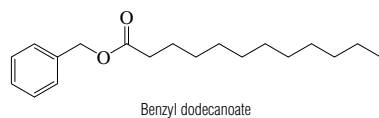
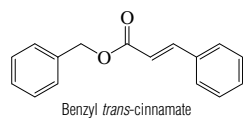
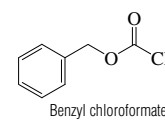
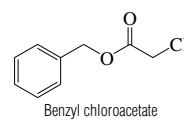
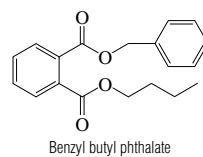
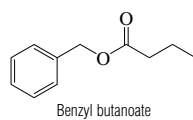
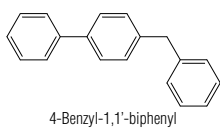
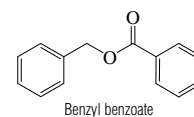
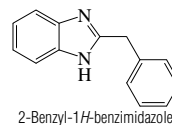
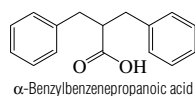
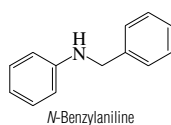
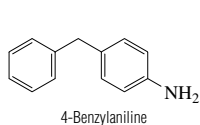
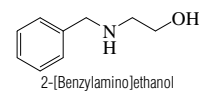
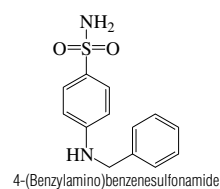
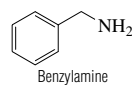
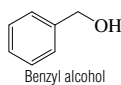
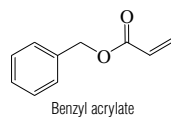
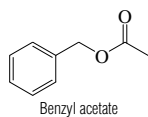
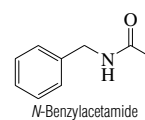
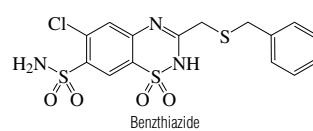
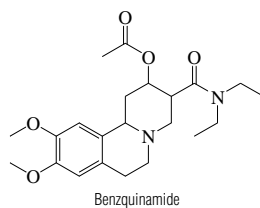
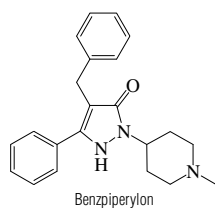
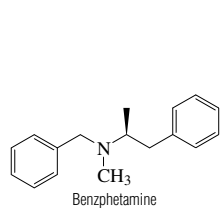
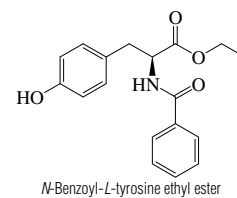
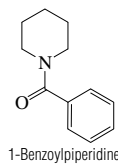
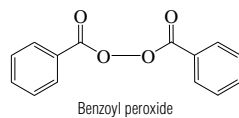
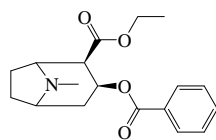
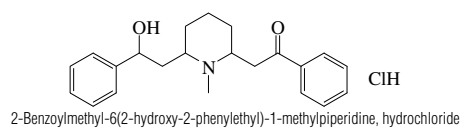
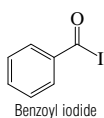
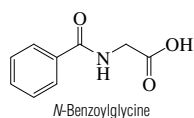
Benzopurpurine 4B

2*H*-1-Benzopyran[2]Benzopyrano[6,5,4-*def*][2]benzopyran-1,3,6,8-tetrone1*H*-2-Benzopyran-1-one2*H*-1-Benzopyran-2-one

| No. | Name                                               | Synonym                         | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                 | mp/°C   | bp/°C                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|-----|----------------------------------------------------|---------------------------------|---------------------------------------------------------------|------------|----------|-------------------------------|---------|-------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 728 | 4 <i>H</i> -1-Benzopyran-4-one                     |                                 | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>                  | 491-38-3   | 146.143  | nd (peth w)                   | 59      | sub                     | 1.2900 <sup>20</sup>       |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                  |
| 729 | Benzo[a]pyrene                                     | 2,3-Benzopyrene                 | C <sub>20</sub> H <sub>12</sub>                               | 50-32-8    | 252.309  |                               | 181.1   |                         |                            |                      | i H <sub>2</sub> O; vs chl                                 |
| 730 | Benzo[e]pyrene                                     | 1,2-Benzopyrene                 | C <sub>20</sub> H <sub>12</sub>                               | 192-97-2   | 252.309  | pa ye nd (bz-MeOH)            | 181.4   | 311                     |                            |                      | i H <sub>2</sub> O                                         |
| 731 | Benzo[f]quinoline                                  | β-Naphthoquinoline              | C <sub>13</sub> H <sub>9</sub> N                              | 85-02-9    | 179.217  | lf (peth or w)                | 94      | 352; 203 <sup>8</sup>   |                            |                      | sl H <sub>2</sub> O; vs EtOH, bz, eth; s ace               |
| 732 | Benzo[h]quinoline                                  |                                 | C <sub>13</sub> H <sub>9</sub> N                              | 230-27-3   | 179.217  | lf (eth), pl (peth)           | 52      | 339; 233 <sup>47</sup>  | 1.2340 <sup>20</sup>       |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, ctc             |
| 733 | <i>p</i> -Benzoquinone                             | 2,5-Cyclohexadiene-1,4-dione    | C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>                  | 106-51-4   | 108.095  | ye mcl pr (w)                 | 115     | sub                     | 1.318 <sup>20</sup>        |                      | sl H <sub>2</sub> O, peth; s EtOH, eth, chl                |
| 734 | 2,1,3-Benzothiadiazole                             |                                 | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> S                | 273-13-2   | 136.174  |                               | 43      | 206                     |                            |                      |                                                            |
| 735 | 2-Benzothiazolamine                                | 2-Aminobenzothiazole            | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> S                | 136-95-8   | 150.201  | pl (w), lf (w)                | 132     |                         |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, chl, con HCl             |
| 736 | 6-Benzothiazolamine                                | 6-Aminobenzothiazole            | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> S                | 533-30-2   | 150.201  | pr (w)                        | 87      |                         |                            |                      | i H <sub>2</sub> O, eth; s EtOH                            |
| 737 | Benzo[thiazole]                                    | Benzosulfonazole                | C <sub>7</sub> H <sub>5</sub> NS                              | 95-16-9    | 135.187  |                               | 1.0     | 231                     | 1.2460 <sup>20</sup>       | 1.6379 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth, CS <sub>2</sub> ; s ace |
| 738 | 2(3 <i>H</i> )-Benzo[thiazole]thione               | 2-Mercaptobenzothiazole         | C <sub>7</sub> H <sub>5</sub> NS <sub>2</sub>                 | 149-30-4   | 167.252  | pa ye mcl nd(al, MeOH)        | 181     |                         | 1.42 <sup>20</sup>         |                      | i H <sub>2</sub> O; s EtOH; sl eth, bz, DMSO               |
| 739 | 2(3 <i>H</i> )-Benzo[thiazole]thione, sodium salt  |                                 | C <sub>7</sub> H <sub>4</sub> NNaS <sub>2</sub>               | 2492-26-4  | 189.234  |                               |         |                         |                            |                      | sl H <sub>2</sub> O                                        |
| 740 | 2(3 <i>H</i> )-Benzo[thiazolone]                   |                                 | C <sub>7</sub> H <sub>5</sub> NOS                             | 934-34-9   | 151.186  | pr (dil al), nd               | 139     | 360                     |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                           |
| 741 | 2(3 <i>H</i> )-Benzo[thiazolone], hydrazone        |                                 | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> S                | 615-21-4   | 165.216  |                               | 202.8   |                         |                            |                      |                                                            |
| 742 | 2-(2-Benzothiazolyl)phenol                         |                                 | C <sub>13</sub> H <sub>9</sub> NOS                            | 3411-95-8  | 227.281  | nd or lf (al)                 | 131     | 179 <sup>3</sup>        |                            |                      | s EtOH                                                     |
| 743 | Benzo[b]thiophene                                  | Thianaphthene                   | C <sub>8</sub> H <sub>6</sub> S                               | 95-15-8    | 134.199  | lf                            | 32      | 221                     | 1.1484 <sup>32</sup>       | 1.6374 <sup>37</sup> | i H <sub>2</sub> O; vs EtOH; s eth, ace, bz; sl chl        |
| 744 | Benzo[b]thiophene-2-carboxylic acid                | Thionaphthene-2-carboxylic acid | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub> S                | 6314-28-9  | 178.208  | nd (w)                        | 240.5   |                         |                            |                      | vs eth                                                     |
| 745 | 1 <i>H</i> -Benzotriazole                          | 1,2,3-Triaza-1 <i>H</i> -indene | C <sub>6</sub> H <sub>5</sub> N <sub>3</sub>                  | 95-14-7    | 119.124  | nd (chl or bz)                | 100     | 204 <sup>15</sup>       |                            |                      | sl H <sub>2</sub> O; s EtOH, bz, chl, tol, DMF             |
| 746 | Benzo[b]triphenylene                               |                                 | C <sub>22</sub> H <sub>14</sub>                               | 215-58-7   | 278.346  | nd (al, HOAc)                 | 205     |                         |                            |                      | i H <sub>2</sub> O; vs bz                                  |
| 747 | 3 <i>H</i> -2,1-Benzoxathiol-3-one 1,1-dioxide     |                                 | C <sub>7</sub> H <sub>4</sub> O <sub>4</sub> S                | 81-08-3    | 184.170  | nd or pr (bz)                 | 129.5   | 184 <sup>18</sup>       |                            |                      | vs bz, chl                                                 |
| 748 | 2 <i>H</i> -3,1-Benzoxazine-2,4(1 <i>H</i> )-dione |                                 | C <sub>8</sub> H <sub>5</sub> NO <sub>3</sub>                 | 118-48-9   | 163.131  | pr (al, gl HOAc) cry (al)     | 243 dec |                         |                            |                      | sl H <sub>2</sub> O, EtOH, ace; i eth, bz, chl             |
| 749 | Benzoxazole                                        | 1-Oxa-3-azaindene               | C <sub>7</sub> H <sub>5</sub> NO                              | 273-53-0   | 119.121  | pr (dil al)                   | 31      | 182.5                   | 1.1754 <sup>20</sup>       | 1.5594 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, sulf                           |
| 750 | 2(3 <i>H</i> )-Benzoxazothione                     |                                 | C <sub>7</sub> H <sub>5</sub> NOS                             | 2382-96-9  | 151.186  | nd (w)                        | 196     |                         |                            |                      | sl H <sub>2</sub> O, ace, EtOH; vs eth, HOAc               |
| 751 | 2(3 <i>H</i> )-Benzoxazolone                       |                                 | C <sub>7</sub> H <sub>5</sub> NO <sub>2</sub>                 | 59-49-4    | 135.121  |                               | 138     | 335; 230 <sup>30</sup>  |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, tfa                      |
| 752 | 2-(2-Benzoxazolyl)phenol                           |                                 | C <sub>13</sub> H <sub>9</sub> NO <sub>2</sub>                | 835-64-3   | 211.216  | pink nd (al, HOAc)            | 123.5   | 338                     |                            |                      | sl H <sub>2</sub> O; vs EtOH; s eth, ace, bz               |
| 753 | <i>N</i> -Benzoyl- <i>DL</i> -alanine              |                                 | C <sub>10</sub> H <sub>11</sub> NO <sub>3</sub>               | 1205-02-3  | 193.199  | pl, pr or lf (eth)            | 165.5   | dec                     |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, DMSO                     |
| 754 | 4-(Benzoylamino)-2-hydroxybenzoic acid             | Benzoylpas                      | C <sub>14</sub> H <sub>11</sub> NO <sub>4</sub>               | 13898-58-3 | 257.242  |                               | 260.5   |                         |                            |                      |                                                            |
| 755 | Benzoyl azide                                      | Benzazide                       | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O                | 582-61-6   | 147.134  | pl (ace)                      | 32      | exp                     | 1.1680 <sup>35</sup>       |                      | vs eth, EtOH                                               |
| 756 | 2-Benzoylbenzoic acid                              |                                 | C <sub>14</sub> H <sub>10</sub> O <sub>3</sub>                | 85-52-9    | 226.227  | tcl nd (w+1)                  | 129.0   |                         |                            |                      | vs EtOH, eth; s bz; sl chl                                 |
| 757 | 4-Benzoylbenzoic acid                              |                                 | C <sub>14</sub> H <sub>10</sub> O <sub>3</sub>                | 611-95-0   | 226.227  | nd (HOAc), pl (al) mcl lf (w) | 199     | sub                     |                            |                      | sl H <sub>2</sub> O, tfa, bz; s EtOH, eth, HOAc            |
| 758 | 2-Benzoylbenzoic acid, hydrazide                   |                                 | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> | 787-84-8   | 240.257  | nd (al)                       | 242.3   |                         |                            |                      | sl H <sub>2</sub> O; i EtOH, eth, chl; s MeOH              |
| 759 | 4-Benzoylbiphenyl                                  | 4-Phenylbenzophenone            | C <sub>19</sub> H <sub>14</sub> O                             | 2128-93-0  | 258.313  |                               | 101.5   | 420; 156 <sup>0.1</sup> |                            |                      |                                                            |
| 760 | Benzoyl bromide                                    | Benzoic acid, bromide           | C <sub>7</sub> H <sub>5</sub> BrO                             | 618-32-6   | 185.018  | liq                           | -24     | 218.5                   | 1.570 <sup>15</sup>        | 1.5868 <sup>25</sup> | msc eth                                                    |
| 761 | Benzoyl chloride                                   | Benzoic acid, chloride          | C <sub>7</sub> H <sub>5</sub> ClO                             | 98-88-4    | 140.567  | liq                           | -0.4    | 197.2; 71 <sup>9</sup>  | 1.2120 <sup>20</sup>       | 1.5537 <sup>20</sup> | msc eth; s bz, ctc, CS <sub>2</sub>                        |
| 762 | Benzoyl cyclohexane                                | Cyclohexyl phenyl ketone        | C <sub>13</sub> H <sub>16</sub> O                             | 712-50-5   | 188.265  | nd (peth)                     | 59.5    | 164 <sup>18</sup>       |                            |                      |                                                            |
| 763 | Benzoyllecgonine                                   |                                 | C <sub>16</sub> H <sub>19</sub> NO <sub>4</sub>               | 519-09-5   | 289.327  | nd (w)                        | 195     |                         |                            |                      | vs bz, EtOH                                                |
| 764 | Benzoylferrocene                                   |                                 | C <sub>17</sub> H <sub>14</sub> FeO                           | 1272-44-2  | 290.137  |                               | 110.0   |                         |                            |                      |                                                            |
| 765 | Benzoyl fluoride                                   | Benzoic acid, fluoride          | C <sub>7</sub> H <sub>5</sub> FO                              | 455-32-3   | 124.112  | liq                           | -28     | 154.5                   | 1.1400 <sup>20</sup>       |                      | vs EtOH, eth; s ctc                                        |

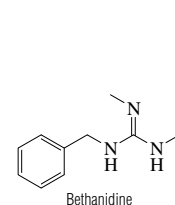
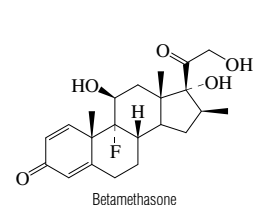
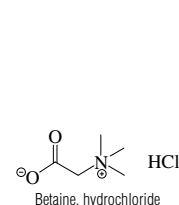
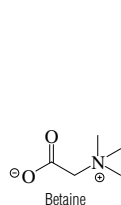
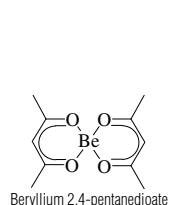
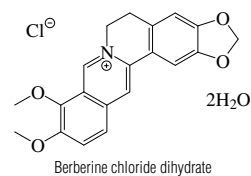
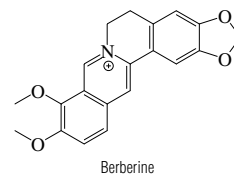
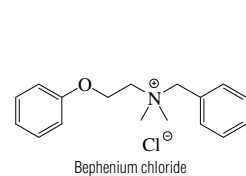
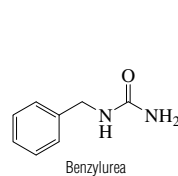
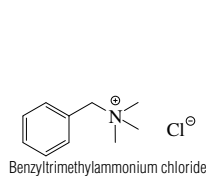
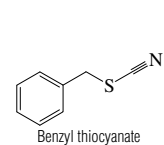
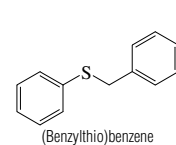
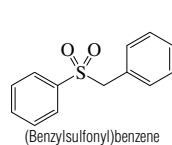
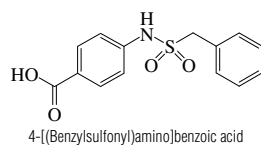
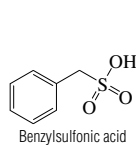
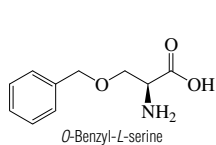
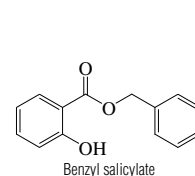
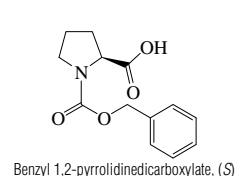
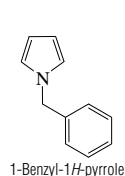
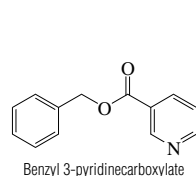
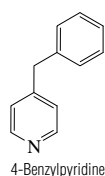
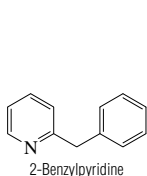
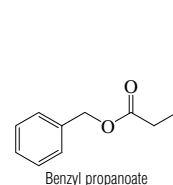
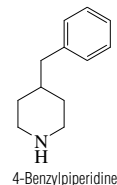
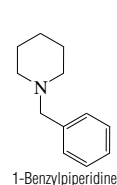
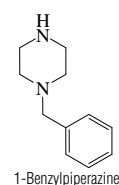
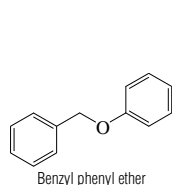
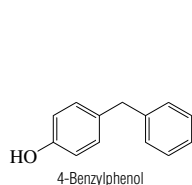
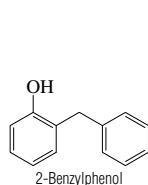
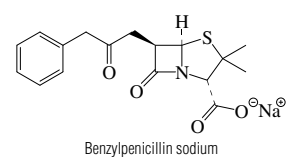
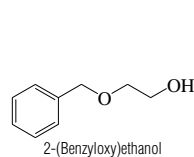
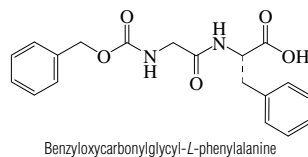
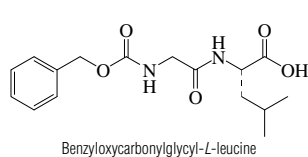
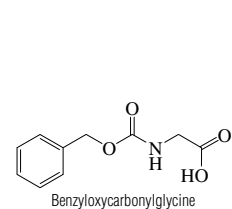
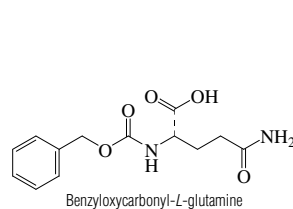
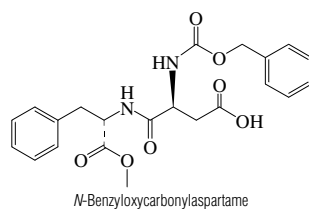
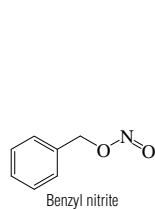
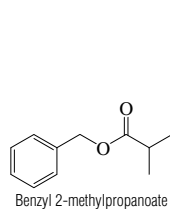
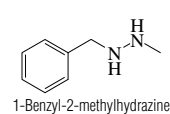
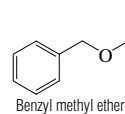
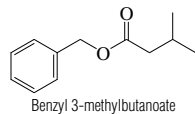
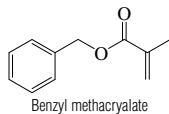
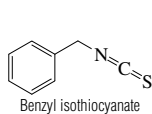
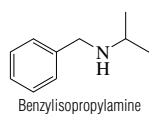


| No. | Name                                                                                                                        | Synonym                                    | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form         | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|-----|-----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------|------------|----------|-----------------------|---------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 766 | <i>N</i> -Benzoylglycine                                                                                                    | Hippuric acid                              | C <sub>9</sub> H <sub>9</sub> NO <sub>3</sub>                                  | 495-69-2   | 179.172  | pr (w or al)          | 191.5   |                                      | 1.371 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH; sl eth, bz, chl; i peth          |
| 767 | Benzoyl iodide                                                                                                              | Benzoic acid, iodide                       | C <sub>7</sub> H <sub>5</sub> IO                                               | 618-38-2   | 232.018  | nd                    | 1.5     | 128 <sup>20</sup>                    | 1.746 <sup>18</sup>        |                      | vs eth, EtOH                                               |
| 768 | 2-Benzoylmethyl-6-(2-hydroxy-2-phenylethyl)-1-methylpiperidine, hydrochloride                                               |                                            | C <sub>22</sub> H <sub>28</sub> ClNO <sub>2</sub>                              | 63990-84-1 | 373.916  |                       | 183.5   |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH; vs chl                        |
| 769 | 3-(Benzoyloxy)-8-methyl-8-azabicyclo[3.2.1]octane-2-carboxylic acid, ethyl ester, [1 <i>R</i> -( <i>exo</i> , <i>exo</i> )] | Cocaethylene                               | C <sub>18</sub> H <sub>23</sub> NO <sub>4</sub>                                | 529-38-4   | 317.381  | pr (eth)              | 109     |                                      |                            |                      | vs eth, EtOH                                               |
| 770 | Benzoyl peroxide                                                                                                            |                                            | C <sub>14</sub> H <sub>10</sub> O <sub>4</sub>                                 | 94-36-0    | 242.227  | orth (eth), pr        | 105     | exp                                  |                            | 1.543                | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, CS <sub>2</sub> |
| 771 | 1-Benzoylpiperidine                                                                                                         |                                            | C <sub>12</sub> H <sub>15</sub> NO                                             | 776-75-0   | 189.253  | tcl                   | 49      | 320.5                                |                            |                      | i H <sub>2</sub> O; s EtOH, eth; sl ctc                    |
| 772 | <i>N</i> -Benzoyl- <i>L</i> -tyrosine ethyl ester                                                                           |                                            | C <sub>18</sub> H <sub>19</sub> NO <sub>4</sub>                                | 3483-82-7  | 313.349  |                       | 119.5   |                                      |                            |                      |                                                            |
| 773 | Benzphetamine                                                                                                               |                                            | C <sub>17</sub> H <sub>21</sub> N                                              | 156-08-1   | 239.356  |                       |         | 127 <sup>0.02</sup>                  |                            | 1.5515 <sup>19</sup> | vs eth, EtOH, MeOH, chl                                    |
| 774 | Benzpiperylon                                                                                                               |                                            | C <sub>22</sub> H <sub>25</sub> N <sub>3</sub> O                               | 53-89-4    | 347.453  | cry (al)              | 182 dec |                                      |                            |                      |                                                            |
| 775 | Benzoquinamide                                                                                                              |                                            | C <sub>22</sub> H <sub>32</sub> N <sub>2</sub> O <sub>5</sub>                  | 63-12-7    | 404.499  | cry                   | 131     |                                      |                            |                      |                                                            |
| 776 | Benzthiazide                                                                                                                |                                            | C <sub>15</sub> H <sub>14</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>3</sub> | 91-33-8    | 431.938  | cry (EtOH)            | 236     |                                      |                            |                      | i H <sub>2</sub> O; s alk                                  |
| 777 | <i>N</i> -Benzylacetamide                                                                                                   |                                            | C <sub>9</sub> H <sub>11</sub> NO                                              | 588-46-5   | 149.189  |                       | 61      | 157 <sup>2</sup>                     |                            |                      | vs EtOH, eth                                               |
| 778 | Benzyl acetate                                                                                                              |                                            | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                                  | 140-11-4   | 150.174  | liq                   | -51.3   | 213                                  | 1.0550 <sup>20</sup>       | 1.5232 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH; s eth, ace, chl             |
| 779 | Benzyl acrylate                                                                                                             |                                            | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                                 | 2495-35-4  | 162.185  |                       |         | 228                                  | 1.0573 <sup>20</sup>       | 1.5143 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, ctc                  |
| 780 | Benzyl alcohol                                                                                                              | Benzenemethanol                            | C <sub>7</sub> H <sub>8</sub> O                                                | 100-51-6   | 108.138  | liq                   | -15.4   | 205.31                               | 1.0419 <sup>24</sup>       | 1.5396 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ace, bz, MeOH, chl          |
| 781 | Benzylamine                                                                                                                 | Benzenemethanamine                         | C <sub>7</sub> H <sub>9</sub> N                                                | 100-46-9   | 107.153  |                       |         | 185; 90 <sup>12</sup>                | 0.9813 <sup>20</sup>       | 1.5401 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; vs ace; s bz; sl chl      |
| 782 | 4-(Benzylamino) benzenesulfonamide                                                                                          | <i>N</i> 4-Benzylsulfanilamide             | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub> S                | 104-22-3   | 262.327  |                       | 171     |                                      |                            |                      |                                                            |
| 783 | 2-[Benzylamino]ethanol                                                                                                      |                                            | C <sub>9</sub> H <sub>13</sub> NO                                              | 104-63-2   | 151.205  |                       |         | 225; 154 <sup>12</sup>               | 1.065 <sup>25</sup>        | 1.5430 <sup>20</sup> |                                                            |
| 784 | 4-Benzylaniline                                                                                                             |                                            | C <sub>13</sub> H <sub>13</sub> N                                              | 1135-12-2  | 183.249  | mcl (lig)             | 34.5    | 300                                  | 1.038 <sup>25</sup>        |                      | vs eth, EtOH, lig                                          |
| 785 | <i>N</i> -Benzylaniline                                                                                                     | <i>N</i> -Phenylbenzenemethanamine         | C <sub>13</sub> H <sub>13</sub> N                                              | 103-32-2   | 183.249  | pr                    | 37.5    | 306.5                                | 1.0298 <sup>65</sup>       | 1.6118 <sup>25</sup> | vs eth, EtOH                                               |
| 786 | $\alpha$ -Benzylbenzenepropanoic acid                                                                                       |                                            | C <sub>16</sub> H <sub>16</sub> O <sub>2</sub>                                 | 618-68-8   | 240.297  | pl (peth HOAc) nd (w) | 90      | 235 <sup>18</sup>                    |                            |                      | vs bz, eth, EtOH                                           |
| 787 | 2-Benzyl-1 <i>H</i> -benzimidazole                                                                                          | Benzadiazol                                | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub>                                 | 621-72-7   | 208.258  | nd (bz)               | 187     |                                      |                            |                      | vs bz, EtOH, gl HOAc                                       |
| 788 | Benzyl benzoate                                                                                                             |                                            | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>                                 | 120-51-4   | 212.244  | nd or lf              | 21      | 323.5                                | 1.1121 <sup>25</sup>       | 1.5680 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, MeOH, chl        |
| 789 | 4-Benzyl-1,1'-biphenyl                                                                                                      |                                            | C <sub>19</sub> H <sub>16</sub>                                                | 613-42-3   | 244.330  | lf                    | 85      | 285 <sup>110</sup>                   | 1.171 <sup>0</sup>         |                      | i H <sub>2</sub> O; s EtOH, ctc; vs eth, bz                |
| 790 | Benzyl butanoate                                                                                                            |                                            | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                                 | 103-37-7   | 178.228  |                       |         | 239                                  | 1.0111 <sup>20</sup>       | 1.4920 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ctc                    |
| 791 | Benzyl butyl phthalate                                                                                                      | Butyl benzyl phthalate                     | C <sub>19</sub> H <sub>20</sub> O <sub>4</sub>                                 | 85-68-7    | 312.360  | liq                   |         | 370                                  | 1.119 <sup>25</sup>        |                      | i H <sub>2</sub> O                                         |
| 792 | Benzyl chloroacetate                                                                                                        |                                            | C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>                                 | 140-18-1   | 184.619  |                       |         | 147 <sup>9</sup> , 85 <sup>0.4</sup> | 1.2223 <sup>4</sup>        | 1.5426 <sup>18</sup> | vs eth, EtOH                                               |
| 793 | Benzyl chloroformate                                                                                                        | Carbobenzoxy chloride                      | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                                 | 501-53-1   | 170.594  | oily liq              |         | 103 <sup>20</sup>                    | 1.195 <sup>25</sup>        | 1.5190 <sup>20</sup> | s eth, ace, bz                                             |
| 794 | Benzyl <i>trans</i> -cinnamate                                                                                              | Benzyl <i>trans</i> -3-phenyl-2-propenoate | C <sub>16</sub> H <sub>14</sub> O <sub>2</sub>                                 | 78277-23-3 | 238.281  | pr                    | 39      | dec 350; 244 <sup>5</sup>            | 1.109 <sup>15</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth; sl bz                     |
| 795 | Benzyl dodecanoate                                                                                                          | Benzyl laurate                             | C <sub>19</sub> H <sub>30</sub> O <sub>2</sub>                                 | 140-25-0   | 290.440  |                       | 8.5     | 210 <sup>12</sup>                    | 0.9429 <sup>25</sup>       | 1.4812 <sup>24</sup> | vs bz, eth, EtOH, peth                                     |
| 796 | Benzylethylamine                                                                                                            | <i>N</i> -Ethylbenzenemethanamine          | C <sub>9</sub> H <sub>13</sub> N                                               | 14321-27-8 | 135.206  |                       |         | 194                                  | 0.9342 <sup>17</sup>       | 1.5117 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, bz, chl             |
| 797 | <i>N</i> -Benzyl- <i>N</i> -ethylaniline                                                                                    | Ethylbenzylaniline                         | C <sub>15</sub> H <sub>17</sub> N                                              | 92-59-1    | 211.303  | pa ye oil             | 35      | 288; 185 <sup>22</sup>               | 1.001 <sup>55</sup>        | 1.5943 <sup>23</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                       |
| 798 | Benzyl ethyl ether                                                                                                          |                                            | C <sub>9</sub> H <sub>12</sub> O                                               | 539-30-0   | 136.190  |                       |         | 186                                  | 0.9478 <sup>20</sup>       | 1.4955 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                          |
| 799 | Benzyl formate                                                                                                              |                                            | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                                   | 104-57-4   | 136.149  |                       |         | 203; 84 <sup>10</sup>                | 1.081 <sup>20</sup>        | 1.5154 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace; msc eth; sl ctc           |
| 800 | Benzyl fumarate                                                                                                             |                                            | C <sub>18</sub> H <sub>16</sub> O <sub>4</sub>                                 | 538-64-7   | 296.318  | cry pow               | 59      | 210 <sup>5</sup>                     |                            |                      | vs eth, EtOH, chl                                          |
| 801 | Benzylidene diacetate                                                                                                       | Toluene- $\alpha,\alpha$ -diol, diacetate  | C <sub>11</sub> H <sub>12</sub> O <sub>4</sub>                                 | 581-55-5   | 208.211  | pl (eth)              | 46      | 220                                  | 1.11 <sup>20</sup>         |                      | vs bz, eth, EtOH                                           |
| 802 | Benzylimidobis( <i>p</i> -methoxyphenyl) methane                                                                            |                                            | C <sub>22</sub> H <sub>21</sub> NO <sub>2</sub>                                | 524-96-9   | 331.408  | pa ye cry             | 90      |                                      |                            |                      | vs eth, chl                                                |
| 803 | 2-Benzyl-1 <i>H</i> -isoindole-1,3(2 <i>H</i> )-dione                                                                       |                                            | C <sub>15</sub> H <sub>11</sub> NO <sub>2</sub>                                | 2142-01-0  | 237.254  | ye nd (al)            | 116     |                                      | 1.343 <sup>18</sup>        |                      | s EtOH, HOAc; sl DMSO                                      |

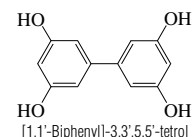
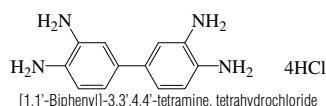
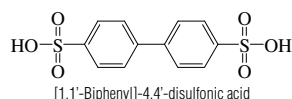
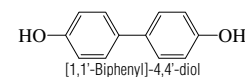
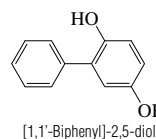
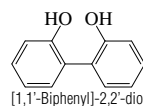
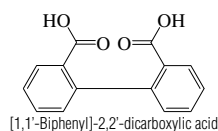
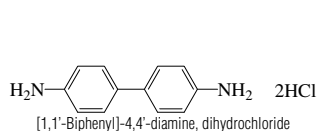
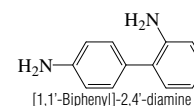
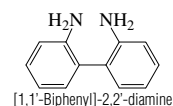
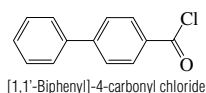
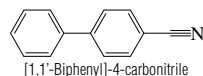
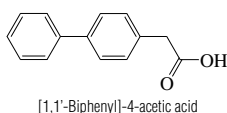
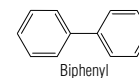
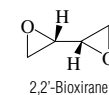
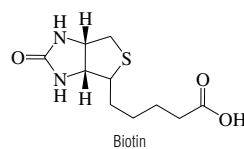
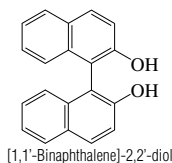
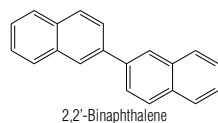
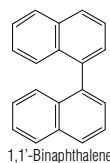
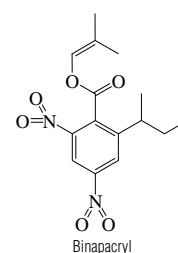
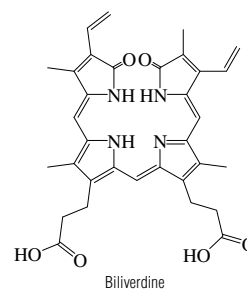
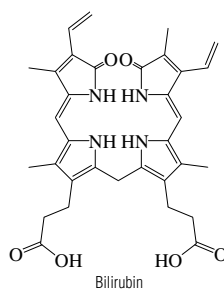
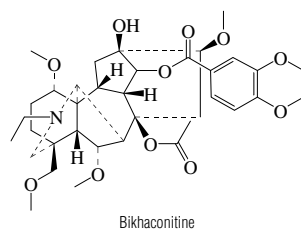
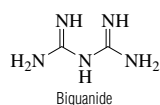
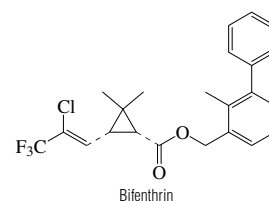
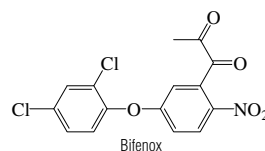
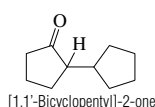
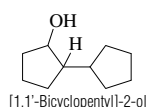
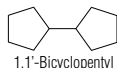
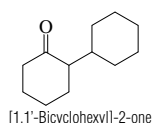
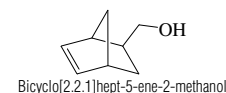
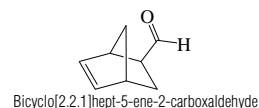
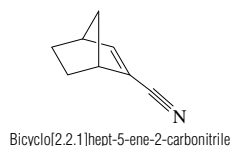
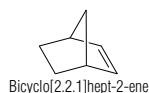
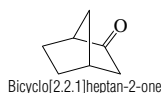
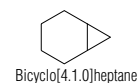
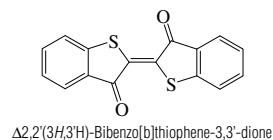
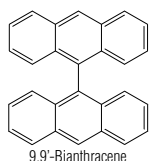
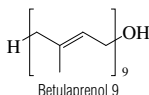
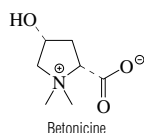




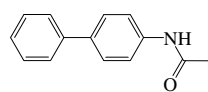
| No. | Name                                              | Synonym                                                     | Mol. Form.                                                        | CAS RN     | Mol. Wt. | Physical Form                   | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|-----|---------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------------|------------|----------|---------------------------------|---------|------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 804 | Benzylisopropylamine                              | <i>N</i> -Isopropylbenzenemethanamine                       | C <sub>10</sub> H <sub>15</sub> N                                 | 102-97-6   | 149.233  |                                 |         | 200; 93 <sup>10</sup>  | 0.892 <sup>25</sup>        | 1.5025 <sup>20</sup> |                                                          |
| 805 | Benzyl isothiocyanate                             | (Isothiocyanatomethyl)benzene                               | C <sub>8</sub> H <sub>7</sub> NS                                  | 622-78-6   | 149.214  | ye oil                          |         | 243                    | 1.1246 <sup>16</sup>       | 1.6049 <sup>15</sup> | i H <sub>2</sub> O; msc<br>EtOH; s eth                   |
| 806 | Benzyl methacrylate                               |                                                             | C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>                    | 2495-37-6  | 176.212  |                                 |         | 144 <sup>50</sup>      |                            |                      |                                                          |
| 807 | Benzyl 3-methylbutanoate                          |                                                             | C <sub>12</sub> H <sub>16</sub> O <sub>2</sub>                    | 103-38-8   | 192.254  |                                 |         | 245; 136 <sup>25</sup> | 0.9983 <sup>15</sup>       | 1.4884 <sup>20</sup> |                                                          |
| 808 | Benzyl methyl ether                               |                                                             | C <sub>8</sub> H <sub>10</sub> O                                  | 538-86-3   | 122.164  | liq                             | -52.6   | 170                    | 0.9634 <sup>20</sup>       | 1.5008 <sup>20</sup> | i H <sub>2</sub> O, lig; vs<br>EtOH, eth; s bz           |
| 809 | 1-Benzyl-2-methylhydrazine                        | 1-Methyl-2-phenylmethylhydrazine                            | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                     | 10309-79-2 | 136.194  | liq                             |         | 117 <sup>20</sup>      |                            |                      |                                                          |
| 810 | Benzyl 2-methylpropanoate                         | Benzyl isobutyrate                                          | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                    | 103-28-6   | 178.228  |                                 |         | 228; 114 <sup>20</sup> | 1.0159 <sup>18</sup>       | 1.4883 <sup>20</sup> |                                                          |
| 811 | Benzyl nitrite                                    |                                                             | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                     | 935-05-7   | 137.137  | oil                             |         | 81 <sup>35</sup>       | 1.075 <sup>25</sup>        | 1.4989 <sup>25</sup> |                                                          |
| 812 | <i>N</i> -Benzylloxycarbonylaspartame             |                                                             | C <sub>22</sub> H <sub>24</sub> N <sub>2</sub> O <sub>7</sub>     | 33605-72-0 | 428.435  | cry                             | 122     |                        |                            |                      |                                                          |
| 813 | Benzylloxycarbonyl- <i>L</i> -glutamine           |                                                             | C <sub>13</sub> H <sub>16</sub> N <sub>2</sub> O <sub>5</sub>     | 2650-64-8  | 280.276  |                                 | 134.5   |                        |                            |                      | s DMSO                                                   |
| 814 | Benzylloxycarbonylglycine                         |                                                             | C <sub>10</sub> H <sub>11</sub> NO <sub>4</sub>                   | 1138-80-3  | 209.199  |                                 | 121     |                        |                            |                      | s ace                                                    |
| 815 | Benzylloxycarbonylglycyl- <i>L</i> -leucine       |                                                             | C <sub>16</sub> H <sub>22</sub> N <sub>2</sub> O <sub>5</sub>     | 1421-69-8  | 322.356  |                                 | 100     |                        |                            |                      |                                                          |
| 816 | Benzylloxycarbonylglycyl- <i>L</i> -phenylalanine |                                                             | C <sub>19</sub> H <sub>20</sub> N <sub>2</sub> O <sub>5</sub>     | 1170-76-9  | 356.372  |                                 | 126     |                        |                            |                      |                                                          |
| 817 | 2-(Benzylloxy)ethanol                             | Ethylene glycol monobenzyl ether                            | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                     | 622-08-2   | 152.190  | oil                             | <-75    | 256                    | 1.0640 <sup>20</sup>       | 1.5233 <sup>20</sup> | vs H <sub>2</sub> O, eth,<br>EtOH                        |
| 818 | Benzylpenicillin sodium                           |                                                             | C <sub>16</sub> H <sub>17</sub> N <sub>2</sub> NaO <sub>4</sub> S | 69-57-8    | 356.372  | nd (BuOH<br>aq)                 | 215     |                        | 1.41                       |                      | vs H <sub>2</sub> O; s<br>MeOH; i ace,<br>eth, chl       |
| 819 | 2-Benzylphenol                                    | <i>o</i> -Benzylphenol                                      | C <sub>13</sub> H <sub>12</sub> O                                 | 28994-41-4 | 184.233  |                                 | 21      | 312                    |                            | 1.5994 <sup>20</sup> | vs ace, bz, EtOH                                         |
| 820 | 4-Benzylphenol                                    | <i>p</i> -Benzylphenol                                      | C <sub>13</sub> H <sub>12</sub> O                                 | 101-53-1   | 184.233  |                                 | 84      | 322                    |                            |                      | s H <sub>2</sub> O, EtOH,<br>eth, bz, ctc,<br>HOAc, chl  |
| 821 | Benzyl phenyl ether                               |                                                             | C <sub>13</sub> H <sub>12</sub> O                                 | 946-80-5   | 184.233  | lf (al)                         | 40      | 286.5                  |                            |                      |                                                          |
| 822 | 1-Benzylpiperazine                                |                                                             | C <sub>11</sub> H <sub>16</sub> N <sub>2</sub>                    | 2759-28-6  | 176.258  |                                 |         | 146 <sup>12</sup>      |                            | 1.5430 <sup>28</sup> | s H <sub>2</sub> O, EtOH,<br>eth; sl chl                 |
| 823 | 1-Benzylpiperidine                                |                                                             | C <sub>12</sub> H <sub>17</sub> N                                 | 2905-56-8  | 175.270  |                                 |         | 245                    | 0.9625 <sup>16</sup>       | 1.5227 <sup>20</sup> |                                                          |
| 824 | 4-Benzylpiperidine                                |                                                             | C <sub>12</sub> H <sub>17</sub> N                                 | 31252-42-3 | 175.270  |                                 | 16.8    | 270; 150 <sup>17</sup> | 0.9970 <sup>20</sup>       | 1.5337 <sup>25</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                       |
| 825 | Benzyl propanoate                                 |                                                             | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                    | 122-63-4   | 164.201  |                                 |         | 221                    | 1.0335 <sup>20</sup>       |                      |                                                          |
| 826 | 2-Benzylpyridine                                  |                                                             | C <sub>12</sub> H <sub>11</sub> N                                 | 101-82-6   | 169.222  | nd                              | 12.5    | 277; 149 <sup>16</sup> | 1.067 <sup>0</sup>         | 1.5785 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, chl                  |
| 827 | 4-Benzylpyridine                                  |                                                             | C <sub>12</sub> H <sub>11</sub> N                                 | 2116-65-6  | 169.222  |                                 | 12.4    | 288; 180 <sup>31</sup> | 1.0612 <sup>20</sup>       | 1.5818 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>ctc; vs eth               |
| 828 | Benzyl 3-pyridinecarboxylate                      | Benzyl nicotinate                                           | C <sub>13</sub> H <sub>11</sub> NO <sub>2</sub>                   | 94-44-0    | 213.232  |                                 |         | 170 <sup>3</sup>       |                            |                      |                                                          |
| 829 | 1-Benzyl-1 <i>H</i> -pyrrole                      |                                                             | C <sub>11</sub> H <sub>11</sub> N                                 | 2051-97-0  | 157.212  |                                 | 15      | 247                    | 1.0183 <sup>20</sup>       | 1.5655 <sup>24</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth                      |
| 830 | Benzyl 1,2-pyrrolidinedicarboxylate, (S)          | <i>N</i> -(Benzylloxycarbonyl)- <i>L</i> -proline           | C <sub>13</sub> H <sub>15</sub> NO <sub>4</sub>                   | 1148-11-4  | 249.263  |                                 | 78.5    |                        |                            | 1.5310 <sup>20</sup> | sl chl                                                   |
| 831 | Benzyl salicylate                                 |                                                             | C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>                    | 118-58-1   | 228.243  |                                 |         | 320                    | 1.1799 <sup>20</sup>       | 1.5805 <sup>20</sup> | sl EtOH; s EtOH,<br>eth, ctc                             |
| 832 | <i>O</i> -Benzyl- <i>L</i> -serine                | 3-(Benzylloxy)- <i>L</i> -alanine                           | C <sub>10</sub> H <sub>13</sub> NO <sub>3</sub>                   | 4726-96-9  | 195.215  |                                 | 218 dec |                        |                            |                      |                                                          |
| 833 | Benzylsulfonic acid                               |                                                             | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub> S                    | 100-87-8   | 172.202  | hyg cry                         |         |                        |                            |                      |                                                          |
| 834 | 4-[(Benzylsulfonyl)amino]benzoic acid             | <i>p</i> -(Benzylsulfonamido)benzoic acid                   | C <sub>14</sub> H <sub>13</sub> NO <sub>4</sub> S                 | 536-95-8   | 291.323  |                                 | 229.5   |                        |                            |                      | vs EtOH                                                  |
| 835 | (Benzylsulfonyl)benzene                           |                                                             | C <sub>13</sub> H <sub>12</sub> O <sub>2</sub> S                  | 3112-88-7  | 232.298  | nd (al)                         | 146     |                        | 1.1261 <sup>153</sup>      |                      | i H <sub>2</sub> O; sl EtOH,<br>eth, bz                  |
| 836 | (Benzylthio)benzene                               |                                                             | C <sub>13</sub> H <sub>12</sub> S                                 | 831-91-4   | 200.299  | lf (al)                         | 43.5    | 197 <sup>27</sup>      |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, con sulf             |
| 837 | Benzyl thiocyanate                                | $\alpha$ -Thiocyanatotoluene                                | C <sub>8</sub> H <sub>7</sub> NS                                  | 3012-37-1  | 149.214  | pr (al)                         | 43      | 232                    |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, chl, CS <sub>2</sub> |
| 838 | Benzyltrimethylammonium chloride                  |                                                             | C <sub>10</sub> H <sub>16</sub> ClN                               | 56-93-9    | 185.694  |                                 | 243     |                        |                            |                      | vs H <sub>2</sub> O; s ace                               |
| 839 | Benzylurea                                        |                                                             | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O                   | 538-32-9   | 150.177  | nd (al)                         | 148     | dec 200                |                            |                      | vs ace, EtOH                                             |
| 840 | Bephonium chloride                                |                                                             | C <sub>17</sub> H <sub>22</sub> ClNO                              | 13928-81-9 | 291.816  | cry (ace)                       | 135     |                        |                            |                      |                                                          |
| 841 | Berberine                                         |                                                             | C <sub>20</sub> H <sub>19</sub> NO <sub>5</sub>                   | 2086-83-1  | 353.369  | red-ye nd<br>(w+6) cry<br>(chl) | 145     |                        |                            |                      | vs eth, EtOH                                             |
| 842 | Berberine chloride dihydrate                      |                                                             | C <sub>20</sub> H <sub>22</sub> ClNO <sub>6</sub>                 | 633-65-8   | 407.845  | ye cry                          |         |                        |                            |                      |                                                          |
| 843 | Bergenin                                          |                                                             | C <sub>14</sub> H <sub>16</sub> O <sub>9</sub>                    | 477-90-7   | 328.272  | cry (MeOH)                      | 238     |                        |                            |                      | vs H <sub>2</sub> O, EtOH                                |
| 844 | Beryllium 2,4-pentanedioate                       | Beryllium acetylacetonate                                   | C <sub>10</sub> H <sub>14</sub> BeO <sub>4</sub>                  | 10210-64-7 | 207.228  |                                 | 108     | 270                    | 1.168 <sup>20</sup>        |                      |                                                          |
| 845 | Betaine                                           | 1-Carboxy- <i>N,N,N</i> -trimethylmethanaminium, inner salt | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                    | 107-43-7   | 117.147  | pr or lf (al)                   | 293 dec |                        |                            |                      | vs H <sub>2</sub> O, MeOH;<br>s EtOH; sl eth,<br>chl     |
| 846 | Betaine, hydrochloride                            |                                                             | C <sub>5</sub> H <sub>12</sub> ClNO <sub>2</sub>                  | 590-46-5   | 153.608  | mcl cry (al)                    | 227.5   |                        |                            |                      | vs H <sub>2</sub> O                                      |
| 847 | Betamethasone                                     |                                                             | C <sub>22</sub> H <sub>26</sub> FO <sub>5</sub>                   | 378-44-9   | 392.460  | cry (AcOMe)                     | 232 dec |                        |                            |                      |                                                          |
| 848 | Bethanidine                                       |                                                             | C <sub>10</sub> H <sub>13</sub> N <sub>3</sub>                    | 55-73-2    | 177.246  | cry (aq<br>MeOH)                | 196     |                        |                            |                      |                                                          |



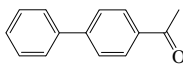
| No. | Name                                                           | Synonym                                        | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form                    | mp/°C   | bp/°C                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|-----|----------------------------------------------------------------|------------------------------------------------|-----------------------------------------------------------------|------------|----------|----------------------------------|---------|-------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 849 | Betonidine                                                     |                                                | C <sub>7</sub> H <sub>13</sub> NO <sub>3</sub>                  | 515-25-3   | 159.183  | pr (dil al, +1w)                 | 252 dec |                         |                            |                      | vs EtOH                                                       |
| 850 | Betulaprenol 9                                                 | Nonaisoprenol                                  | C <sub>45</sub> H <sub>74</sub> O                               | 13190-97-1 | 631.069  | oil or cry                       | 41      |                         |                            |                      | s chl                                                         |
| 851 | 9,9'-Bianthracene                                              |                                                | C <sub>28</sub> H <sub>18</sub>                                 | 1055-23-8  | 354.443  |                                  | 321.3   |                         |                            |                      |                                                               |
| 852 | Δ2,2'(3 <i>H</i> ,3' <i>H</i> )-Bibenzo[b]thiophene-3,3'-dione | Durindone Red                                  | C <sub>16</sub> H <sub>6</sub> O <sub>2</sub> S <sub>2</sub>    | 522-75-8   | 296.364  | br nd (xyl)<br>red mcl nd (bz)   | 359     | sub                     |                            |                      | i H <sub>2</sub> O, EtOH; sl chl, CS <sub>2</sub> ; s bz, xyl |
| 853 | Bicyclo[2.2.1]heptane                                          |                                                | C <sub>7</sub> H <sub>12</sub>                                  | 279-23-2   | 96.170   |                                  | 87.5    | 105.3                   |                            |                      | vs ace, bz, eth, EtOH                                         |
| 854 | Bicyclo[4.1.0]heptane                                          | Norcarane                                      | C <sub>7</sub> H <sub>12</sub>                                  | 286-08-8   | 96.170   |                                  |         | 116.5                   | 0.853 <sup>25</sup>        | 1.4564 <sup>20</sup> |                                                               |
| 855 | Bicyclo[2.2.1]heptan-2-one                                     |                                                | C <sub>7</sub> H <sub>10</sub> O                                | 497-38-1   | 110.153  |                                  | 89.5    | 170                     |                            |                      |                                                               |
| 856 | Bicyclo[2.2.1]hept-2-ene                                       |                                                | C <sub>7</sub> H <sub>10</sub>                                  | 498-66-8   | 94.154   |                                  | 45      | 96                      |                            |                      |                                                               |
| 857 | Bicyclo[2.2.1]hept-5-ene-2-carbonitrile                        |                                                | C <sub>8</sub> H <sub>8</sub> N                                 | 95-11-4    | 119.164  |                                  | 13      | 84 <sup>10</sup>        | 0.999 <sup>25</sup>        | 1.4885 <sup>20</sup> |                                                               |
| 858 | Bicyclo[2.2.1]hept-5-ene-2-carboxaldehyde                      |                                                | C <sub>8</sub> H <sub>10</sub> O                                | 5453-80-5  | 122.164  |                                  |         | 71 <sup>20</sup>        | 1.018 <sup>25</sup>        | 1.4893 <sup>20</sup> |                                                               |
| 859 | Bicyclo[2.2.1]hept-5-ene-2-methanol                            |                                                | C <sub>8</sub> H <sub>12</sub> O                                | 95-12-5    | 124.180  |                                  |         | 103 <sup>20</sup>       |                            |                      |                                                               |
| 860 | [1,1'-Bicyclohexyl]-2-one                                      | 2-Cyclohexylcyclohexanone                      | C <sub>12</sub> H <sub>20</sub> O                               | 90-42-6    | 180.286  | liq                              | -32     | 264                     | 0.9696 <sup>25</sup>       | 1.4877 <sup>25</sup> |                                                               |
| 861 | 1,1'-Bicyclopentyl                                             |                                                | C <sub>10</sub> H <sub>18</sub>                                 | 1636-39-1  | 138.250  |                                  |         |                         |                            |                      | s ctc, CS <sub>2</sub>                                        |
| 862 | [1,1'-Bicyclopentyl]-2-ol                                      | 2-Hydroxybicyclopentyl                         | C <sub>10</sub> H <sub>18</sub> O                               | 4884-25-7  | 154.249  |                                  | 20      | 235.5                   | 0.9785 <sup>15</sup>       | 1.4884 <sup>17</sup> |                                                               |
| 863 | [1,1'-Bicyclopentyl]-2-one                                     |                                                | C <sub>10</sub> H <sub>16</sub> O                               | 4884-24-6  | 152.233  | liq                              | -13     | 232.5                   | 0.9745 <sup>21</sup>       | 1.4763               |                                                               |
| 864 | Bifenox                                                        | Methyl 5-(2,4-dichlorophenoxy)-2-nitrobenzoate | C <sub>14</sub> H <sub>9</sub> Cl <sub>2</sub> NO <sub>5</sub>  | 42576-02-3 | 342.131  |                                  | 85      |                         |                            |                      |                                                               |
| 865 | Bifenthrin                                                     |                                                | C <sub>23</sub> H <sub>22</sub> ClF <sub>3</sub> O <sub>2</sub> | 82657-04-3 | 422.868  |                                  | 69      |                         | 1.2 <sup>125</sup>         |                      |                                                               |
| 866 | Biguanide                                                      | Imidodicarbonimidic diamide                    | C <sub>2</sub> H <sub>4</sub> N <sub>5</sub>                    | 56-03-1    | 101.111  | pr or nd (al)                    | 136     | dec 142                 |                            |                      | vs H <sub>2</sub> O; s EtOH; i bz, chl                        |
| 867 | Bikhaconitine                                                  | 3-Deoxypseudoaconitine                         | C <sub>36</sub> H <sub>51</sub> NO <sub>11</sub>                | 6078-26-8  | 673.790  |                                  | 164     |                         |                            |                      | vs eth, EtOH, chl                                             |
| 868 | Bilirubin                                                      |                                                | C <sub>33</sub> H <sub>36</sub> N <sub>4</sub> O <sub>6</sub>   | 635-65-4   | 584.662  | red mcl pr or pl (chl)           |         |                         |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s bz, chl                   |
| 869 | Biliverdine                                                    | Dehydrobilirubin                               | C <sub>33</sub> H <sub>34</sub> N <sub>4</sub> O <sub>6</sub>   | 114-25-0   | 582.646  | dk grn pl or pr (MeOH)           | >300    |                         |                            |                      | i H <sub>2</sub> O; s EtOH, bz; sl eth, chl, CS <sub>2</sub>  |
| 870 | Binapacryl                                                     |                                                | C <sub>15</sub> H <sub>18</sub> N <sub>2</sub> O <sub>6</sub>   | 485-31-4   | 322.313  |                                  | 70      |                         | 1.27 <sup>20</sup>         |                      |                                                               |
| 871 | 1,1'-Binaphthalene                                             | 1,1'-Binaphthyl                                | C <sub>20</sub> H <sub>14</sub>                                 | 604-53-5   | 254.325  | (i) pl(HOAc)<br>(ii) orth (peth) | 160     | >360; 240 <sup>12</sup> | 1.3000 <sup>20</sup>       |                      | i H <sub>2</sub> O; sl EtOH; s eth, ace, bz, CS <sub>2</sub>  |
| 872 | 2,2'-Binaphthalene                                             |                                                | C <sub>20</sub> H <sub>14</sub>                                 | 612-78-2   | 254.325  | bl flr pl (al)                   | 187.9   | 452                     |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, CS <sub>2</sub>       |
| 873 | [1,1'-Binaphthalene]-2,2'-diol                                 |                                                | C <sub>20</sub> H <sub>14</sub> O <sub>2</sub>                  | 602-09-5   | 286.324  | nd (al), cry (w)                 | 220     |                         |                            |                      | i H <sub>2</sub> O; s EtOH, eth, alk; sl chl                  |
| 874 | Biotin                                                         | Coenzyme R                                     | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> S | 58-85-5    | 244.310  | nd (w)                           | 232 dec |                         |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, chl                         |
| 875 | 2,2'-Bioxirane                                                 | Diepoxybutane                                  | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                    | 1464-53-5  | 86.090   |                                  | 2.0     | 144                     | 1.113 <sup>20</sup>        | 1.435 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH                                     |
| 876 | Biphenyl                                                       | Diphenyl                                       | C <sub>12</sub> H <sub>10</sub>                                 | 92-52-4    | 154.207  | lf (dil al)                      | 68.93   | 256.1                   | 1.04 <sup>20</sup>         | 1.588 <sup>77</sup>  | i H <sub>2</sub> O; s EtOH, eth; vs bz, ctc, MeOH             |
| 877 | [1,1'-Biphenyl]-4-acetic acid                                  | Felbinac                                       | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>                  | 5728-52-9  | 212.244  |                                  | 160.5   |                         |                            |                      |                                                               |
| 878 | [1,1'-Biphenyl]-4-carbonitrile                                 |                                                | C <sub>13</sub> H <sub>9</sub> N                                | 2920-38-9  | 179.217  |                                  | 88      | 190 <sup>20</sup>       |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                              |
| 879 | [1,1'-Biphenyl]-4-carbonyl chloride                            |                                                | C <sub>13</sub> H <sub>9</sub> ClO                              | 14002-51-8 | 216.662  |                                  | 111     | 160 <sup>2</sup>        |                            |                      |                                                               |
| 880 | [1,1'-Biphenyl]-2,2'-diamine                                   |                                                | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                  | 1454-80-4  | 184.236  | pr or nd (al)                    | 81      | 162 <sup>4</sup>        | 1.3090 <sup>20</sup>       |                      | s H <sub>2</sub> O, ace, bz                                   |
| 881 | [1,1'-Biphenyl]-2,4'-diamine                                   |                                                | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                  | 492-17-1   | 184.236  | nd (dil al)                      | 54.5    | 363                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth                               |
| 882 | [1,1'-Biphenyl]-4,4'-diamine, dihydrochloride                  |                                                | C <sub>12</sub> H <sub>14</sub> Cl <sub>2</sub> N <sub>2</sub>  | 531-85-1   | 257.158  |                                  | >300    |                         |                            |                      |                                                               |
| 883 | [1,1'-Biphenyl]-2,2'-dicarboxylic acid                         | <i>o,o'</i> -Diphenic acid                     | C <sub>14</sub> H <sub>10</sub> O <sub>4</sub>                  | 482-05-3   | 242.227  | mcl pr or lf (w) cry (HOAc)      | 233.5   | sub                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth                               |
| 884 | [1,1'-Biphenyl]-2,2'-diol                                      |                                                | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                  | 1806-29-7  | 186.206  |                                  | 109     | 320                     | 1.3420 <sup>20</sup>       |                      | s H <sub>2</sub> O, EtOH, eth, ace, bz; sl peth, chl          |
| 885 | [1,1'-Biphenyl]-2,5-diol                                       |                                                | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                  | 1079-21-6  | 186.206  | nd (dil al)                      | 97.5    |                         |                            |                      | vs EtOH                                                       |
| 886 | [1,1'-Biphenyl]-4,4'-diol                                      |                                                | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                  | 92-88-6    | 186.206  |                                  | 278 dec |                         |                            |                      | sl H <sub>2</sub> O, bz, DMSO; s EtOH, eth                    |
| 887 | [1,1'-Biphenyl]-4,4'-disulfonic acid                           |                                                | C <sub>12</sub> H <sub>10</sub> O <sub>6</sub> S <sub>2</sub>   | 5314-37-4  | 314.333  | pr                               | 72.5    | >200                    |                            |                      | vs H <sub>2</sub> O                                           |
| 888 | [1,1'-Biphenyl]-3,3',4,4'-tetramine, tetrahydrochloride        |                                                | C <sub>12</sub> H <sub>16</sub> Cl <sub>4</sub> N <sub>4</sub>  | 7411-49-6  | 360.110  |                                  | 245 dec |                         |                            |                      |                                                               |
| 889 | [1,1'-Biphenyl]-3,3',5,5'-tetrol                               | Diresorcinol                                   | C <sub>12</sub> H <sub>10</sub> O <sub>4</sub>                  | 531-02-2   | 218.205  | pl or nd (w+2)                   | 310     |                         |                            |                      | vs H <sub>2</sub> O, eth, EtOH                                |



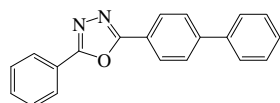
| No. | Name                                                                  | Synonym                                             | Mol. Form.                                                      | CAS RN    | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|-----|-----------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------|-----------|----------|----------------------------|---------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 890 | <i>N</i> -[1,1'-Biphenyl]-4-ylacetamide                               |                                                     | C <sub>14</sub> H <sub>13</sub> NO                              | 4075-79-0 | 211.259  | cry (dil MeOH)             | 172.8   |                                      |                            |                      | i H <sub>2</sub> O; vs EtOH, ace, MeOH               |
| 891 | 1-[1,1'-Biphenyl]-4-ylethanone                                        |                                                     | C <sub>14</sub> H <sub>12</sub> O                               | 92-91-1   | 196.244  | pr (ace), cry (al)         | 121     | 326                                  | 1.2510 <sup>9</sup>        |                      | i H <sub>2</sub> O; vs EtOH, ace; sl chl             |
| 892 | 2-[1,1'-Biphenyl]-4-yl-5-phenyl-1,3,4-oxadiazole                      |                                                     | C <sub>20</sub> H <sub>14</sub> N <sub>2</sub> O                | 852-38-0  | 298.337  |                            | 168     |                                      |                            |                      |                                                      |
| 893 | 2,2'-Bipyridine                                                       | α,α'-Dipyridyl                                      | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                   | 366-18-7  | 156.184  | pr (peth)                  | 72      | 273.5                                |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl           |
| 894 | 2,3'-Bipyridine                                                       | 2,3'-Bipyridyl                                      | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                   | 581-50-0  | 156.184  |                            |         | 295.5                                | 1.140 <sup>20</sup>        | 1.6223 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz, chl; sl peth   |
| 895 | 2,4'-Bipyridine                                                       | 2,4'-Bipyridyl                                      | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                   | 581-47-5  | 156.184  |                            | 61.5    | 281                                  |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, chl               |
| 896 | 3,3'-Bipyridine                                                       | 3,3'-Bipyridyl                                      | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                   | 581-46-4  | 156.184  |                            | 68      | 291.5                                | 1.1614 <sup>20</sup>       |                      | vs H <sub>2</sub> O, EtOH; sl eth                    |
| 897 | 4,4'-Bipyridine                                                       | γ,γ'-Dipyridyl                                      | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                   | 553-26-4  | 156.184  | nd (w+2)                   | 114     | 305                                  |                            |                      | sl H <sub>2</sub> O; vs EtOH, bz, chl; s eth         |
| 898 | 2,2'-Biquinoline                                                      |                                                     | C <sub>18</sub> H <sub>12</sub> N <sub>2</sub>                  | 119-91-5  | 256.301  | pl or lf (al)              | 196     |                                      |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, ace, bz          |
| 899 | 4,4'-Bis(acetoacetamido)-3,3'-dimethyl-1,1'-biphenyl                  | <i>N,N</i> -Bis(acetoacetyl)-3,3'-dimethylbenzidine | C <sub>22</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub>   | 91-96-3   | 380.437  |                            | 212     |                                      |                            |                      | sl DMSO                                              |
| 900 | Bisacodyl                                                             |                                                     | C <sub>22</sub> H <sub>16</sub> NO <sub>4</sub>                 | 603-50-9  | 361.391  |                            | 133.5   |                                      |                            |                      |                                                      |
| 901 | Bis(4-amino-3-chlorophenyl)methane                                    | 4,4'-Methylene-bis(2-chloroaniline)                 | C <sub>13</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>2</sub>  | 101-14-4  | 267.153  |                            |         |                                      |                            |                      | s ctc                                                |
| 902 | Bis(4-aminocyclohexyl)methane                                         |                                                     | C <sub>13</sub> H <sub>26</sub> N <sub>2</sub>                  | 1761-71-3 | 210.358  |                            | 15      | 320                                  | 0.92 <sup>75</sup>         |                      |                                                      |
| 903 | Bis(2-aminoethyl)amine                                                | Diethylenetriamine                                  | C <sub>4</sub> H <sub>13</sub> N <sub>3</sub>                   | 111-40-0  | 103.166  | ye hyg liq                 | -39     | 207                                  | 0.9569 <sup>20</sup>       | 1.4810 <sup>25</sup> | msc H <sub>2</sub> O, EtOH; i eth; s lig             |
| 904 | <i>N,N</i> '-Bis(2-aminoethyl)-1,2-ethanediamine                      | Triethylenetetramine                                | C <sub>6</sub> H <sub>18</sub> N <sub>4</sub>                   | 112-24-3  | 146.234  |                            | 12      | 266.5                                |                            | 1.4971 <sup>20</sup> | s H <sub>2</sub> O, EtOH, acid                       |
| 905 | Bis(2-aminophenyl)disulfide                                           |                                                     | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> S <sub>2</sub>   | 1141-88-4 | 248.366  |                            | 93      |                                      |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                     |
| 906 | Bis(4-aminophenyl)disulfide                                           |                                                     | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> S <sub>2</sub>   | 722-27-0  | 248.366  |                            | 85      |                                      |                            |                      | s H <sub>2</sub> O; vs EtOH, eth, chl; sl bz, lig    |
| 907 | 1,2-Bis(4-aminophenyl)ethane                                          |                                                     | C <sub>14</sub> H <sub>18</sub> N <sub>2</sub>                  | 621-95-4  | 212.290  | pl (w)                     | 137     | sub                                  |                            |                      | i H <sub>2</sub> O; vs EtOH                          |
| 908 | Bis(4-aminophenyl) sulfone                                            | Dapsone                                             | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> S | 80-08-0   | 248.300  | cry (95% al)               | 175.5   |                                      |                            |                      | s EtOH; sl DMSO                                      |
| 909 | Bis(4-aminophenyl) sulfoxide                                          | 4,4'-Sulfinyldianiline                              | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> OS               | 119-59-5  | 232.300  | pr (w, al)                 | 175 dec |                                      |                            |                      | s H <sub>2</sub> O, EtOH                             |
| 910 | 1,4-Bis(3-aminopropoxy)butane                                         | 1,4-Butanediol bis(3-aminopropyl) ether             | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>   | 7300-34-7 | 204.310  | liq                        |         | 135 <sup>3</sup>                     | 0.96 <sup>20</sup>         | 1.4619 <sup>20</sup> |                                                      |
| 911 | <i>N,N</i> '-Bis(3-aminopropyl)-1,4-butanediamine                     | Spermine                                            | C <sub>10</sub> H <sub>26</sub> N <sub>4</sub>                  | 71-44-3   | 202.340  |                            | 29      | 150 <sup>5</sup>                     |                            |                      |                                                      |
| 912 | <i>N,N</i> '-Bis(3-aminopropyl)-1,4-butanediamine, tetrahydrochloride |                                                     | C <sub>10</sub> H <sub>30</sub> Cl <sub>4</sub> N <sub>4</sub>  | 306-67-2  | 348.184  |                            | 301.5   |                                      |                            |                      | s H <sub>2</sub> O                                   |
| 913 | Bis(2-bromoethyl) ether                                               | Bromex                                              | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub> O                 | 5414-19-7 | 231.914  |                            |         | 115 <sup>32</sup> , 92 <sup>12</sup> | 1.8452 <sup>20</sup>       | 1.5131 <sup>27</sup> |                                                      |
| 914 | 1,2-Bis(bromomethyl)benzene                                           |                                                     | C <sub>6</sub> H <sub>8</sub> Br <sub>2</sub>                   | 91-13-4   | 263.958  | orth (chl)                 | 95      | 129 <sup>4,5</sup>                   | 1.988 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, ctc, chl, peth, lig |
| 915 | 1,3-Bis(bromomethyl)benzene                                           |                                                     | C <sub>6</sub> H <sub>8</sub> Br <sub>2</sub>                   | 626-15-3  | 263.958  | nd (chl), pr (ace)         | 77      | 137 <sup>20</sup>                    | 1.959 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, chl, lig            |
| 916 | 1,4-Bis(bromomethyl)benzene                                           |                                                     | C <sub>6</sub> H <sub>8</sub> Br <sub>2</sub>                   | 623-24-5  | 263.958  | mcl pr (al), cry (chl, bz) | 144.5   | 245                                  | 2.012 <sup>25</sup>        |                      | i H <sub>2</sub> O; vs EtOH, chl; sl eth; s bz       |
| 917 | 2,2-Bis(bromomethyl)-1,3-propanediol                                  | Pentaerythritol dibromide                           | C <sub>6</sub> H <sub>10</sub> Br <sub>2</sub> O <sub>2</sub>   | 3296-90-0 | 261.940  | nd (bz)                    | 113     |                                      |                            |                      |                                                      |
| 918 | 1,3-Bis(bromomethyl)tetramethyldisiloxane                             |                                                     | C <sub>6</sub> H <sub>16</sub> Br <sub>2</sub> OSi <sub>2</sub> | 2351-13-5 | 320.169  |                            |         | 233; 103 <sup>15</sup>               | 1.3918 <sup>25</sup>       | 1.4719 <sup>25</sup> |                                                      |
| 919 | Bis(4-bromophenyl) ether                                              |                                                     | C <sub>12</sub> H <sub>8</sub> Br <sub>2</sub> O                | 2050-47-7 | 327.999  | lf (al)                    | 60.5    | 339                                  | 1.8 <sup>25</sup>          |                      | i H <sub>2</sub> O; s EtOH, bz; vs eth; sl chl       |
| 920 | Bis(2-(2-butoxyethoxy)ethyl) adipate                                  |                                                     | C <sub>22</sub> H <sub>42</sub> O <sub>8</sub>                  | 141-17-3  | 434.563  | liq                        |         |                                      | 1.1 <sup>25</sup>          |                      |                                                      |
| 921 | 1,4-Bis(α-( <i>tert</i> -butyldioxy)isopropyl)benzene                 |                                                     | C <sub>20</sub> H <sub>34</sub> O <sub>4</sub>                  | 2781-00-2 | 338.482  | cry                        | 79      |                                      |                            |                      |                                                      |
| 922 | Bis(3- <i>tert</i> -butyl-5-ethyl-2-hydroxyphenyl)methane             |                                                     | C <sub>25</sub> H <sub>36</sub> O <sub>2</sub>                  | 88-24-4   | 368.553  | cry                        | 123     |                                      |                            |                      |                                                      |
| 923 | Bis(4-chlorobenzoyl) peroxide                                         |                                                     | C <sub>14</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>4</sub>   | 94-17-7   | 311.118  | pr cry (bz)                | 141     |                                      |                            |                      |                                                      |
| 924 | 1,2-Bis(2-chloroethoxy)ethane                                         |                                                     | C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub> O <sub>2</sub>   | 112-26-5  | 187.064  |                            |         | 232                                  | 1.195 <sup>20</sup>        | 1.4592 <sup>25</sup> | s ctc                                                |
| 925 | Bis(2-chloroethoxy)methane                                            |                                                     | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>2</sub>   | 111-91-1  | 173.037  |                            |         | 215.0                                |                            |                      |                                                      |
| 926 | <i>N,N</i> -Bis(2-chloroethyl)aniline                                 | Aniline mustard                                     | C <sub>10</sub> H <sub>13</sub> Cl <sub>2</sub> N               | 553-27-5  | 218.123  | pr                         | 45      | 164 <sup>14</sup>                    |                            |                      | sl eth; s EtOH, MeOH                                 |
| 927 | Bis(2-chloroethyl) carbonate                                          |                                                     | C <sub>6</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>3</sub>    | 623-97-2  | 187.021  |                            | 8       | 241                                  | 1.3506 <sup>20</sup>       | 1.461 <sup>20</sup>  | i H <sub>2</sub> O                                   |
| 928 | Bis(2-chloroethyl) 2-chloroethylphosphonate                           |                                                     | C <sub>6</sub> H <sub>12</sub> Cl <sub>3</sub> O <sub>3</sub> P | 6294-34-4 | 269.490  |                            |         | 170.2 <sup>5</sup>                   |                            | 1.488 <sup>25</sup>  |                                                      |



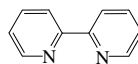
N-[1,1'-Biphenyl]-4-ylacetamide



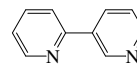
1-[1,1'-Biphenyl]-4-ylethanone



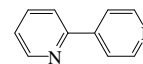
2-[1,1'-Biphenyl]-4-yl-5-phenyl-1,3,4-oxadiazole



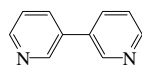
2,2'-Bipyridine



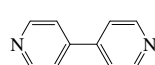
2,3'-Bipyridine



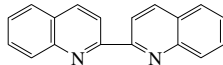
2,4'-Bipyridine



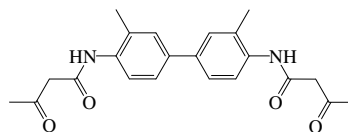
3,3'-Bipyridine



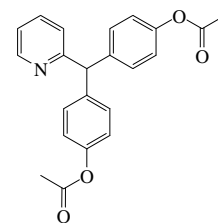
4,4'-Bipyridine



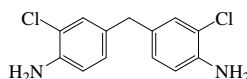
2,2'-Biquinoline



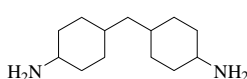
4,4'-Bis(acetoacetamido)-3,3'-dimethyl-1,1'-biphenyl



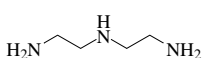
Bisacodyl



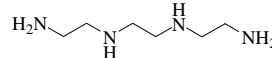
Bis(4-amino-3-chlorophenyl)methane



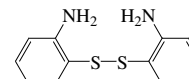
Bis(4-aminocyclohexyl)methane



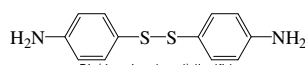
Bis(2-aminoethyl)amine



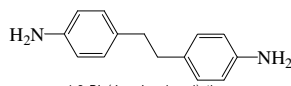
N,N'-Bis(2-aminoethyl)-1,2-ethanediamine



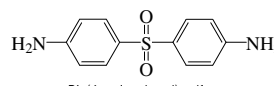
Bis(2-aminophenyl)disulfide



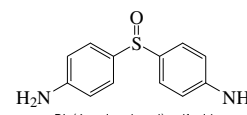
Bis(4-aminophenyl)disulfide



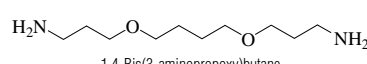
1,2-Bis(4-aminophenyl)ethane



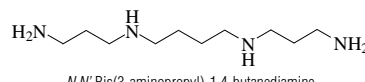
Bis(4-aminophenyl) sulfone



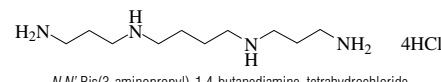
Bis(4-aminophenyl) sulfoxide



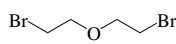
1,4-Bis(3-aminopropoxy)butane



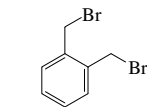
N,N'-Bis(3-aminopropyl)-1,4-butanediamine



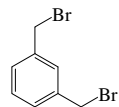
N,N'-Bis(3-aminopropyl)-1,4-butanediamine, tetrahydrochloride



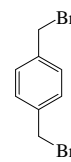
Bis(2-bromoethyl) ether



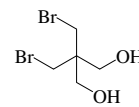
1,2-Bis(bromomethyl)benzene



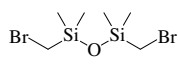
1,3-Bis(bromomethyl)benzene



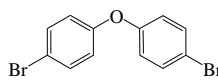
1,4-Bis(bromomethyl)benzene



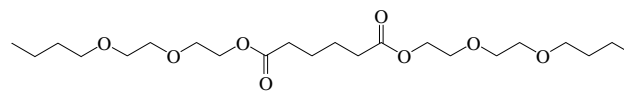
2,2-Bis(bromomethyl)-1,3-propanediol



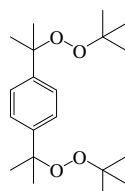
1,3-Bis(bromomethyl)tetramethyldisiloxane



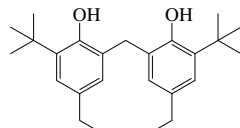
Bis(4-bromophenyl) ether



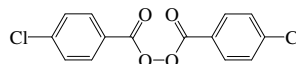
Bis(2-(2-butoxyethoxy)ethyl) adipate



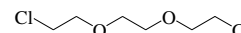
1,4-Bis(alpha-tert-butyl-dioxy)isopropylbenzene



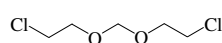
Bis(3-tert-butyl-5-ethyl-2-hydroxyphenyl)methane



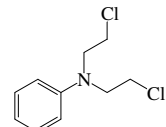
Bis(4-chlorobenzoyl) peroxide



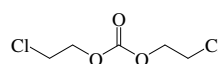
1,2-Bis(2-chloroethoxy)ethane



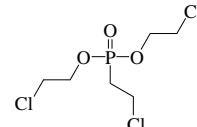
Bis(2-chloroethoxy)methane



N,N-Bis(2-chloroethyl)aniline

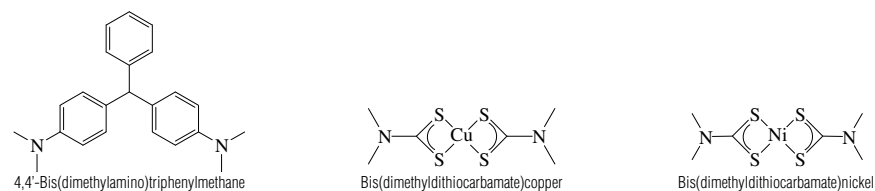
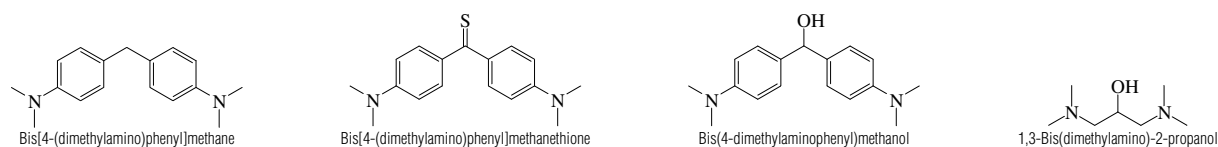
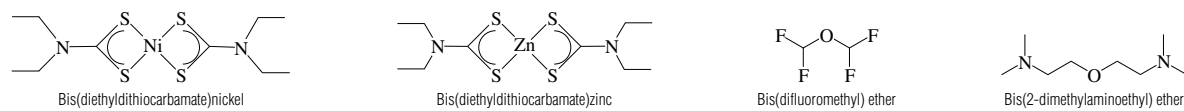
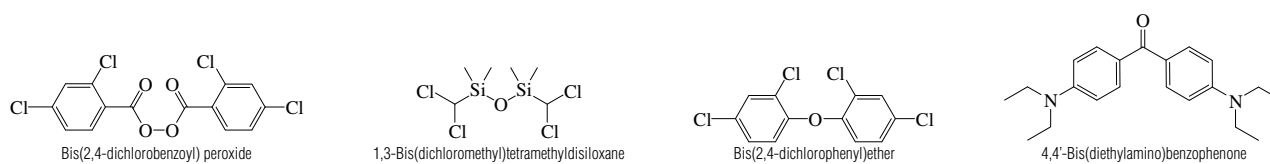
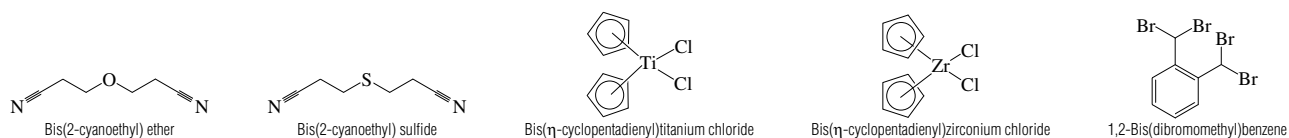
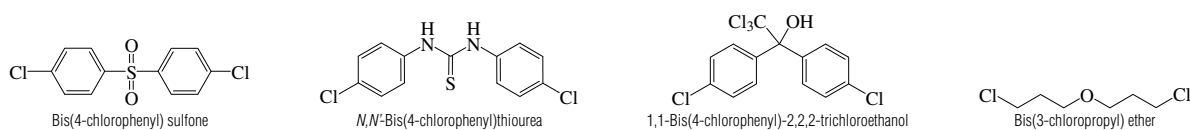
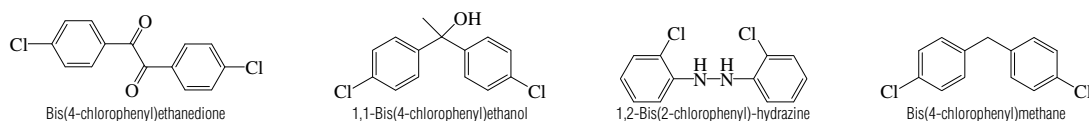
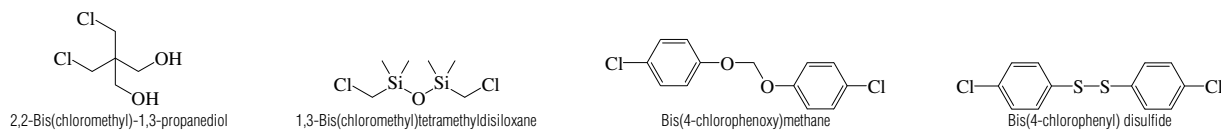
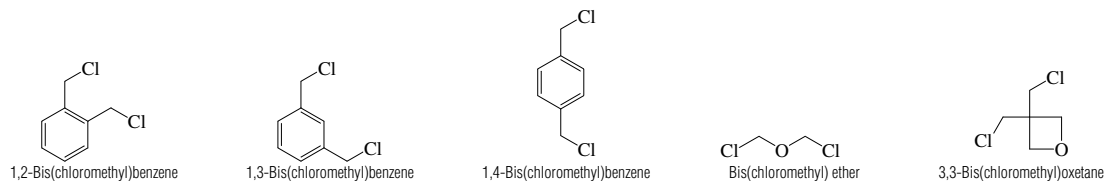
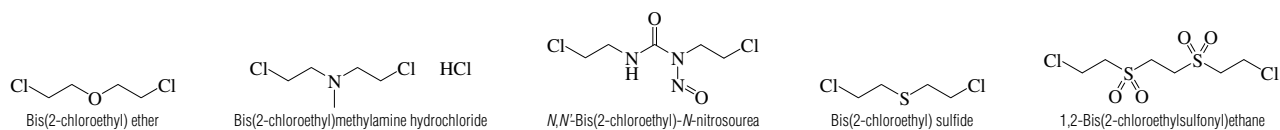


Bis(2-chloroethyl) carbonate



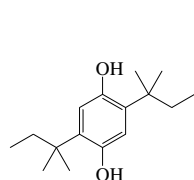
Bis(2-chloroethyl) 2-chloroethylphosphonate

| No. | Name                                                   | Synonym                                      | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form       | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|-----|--------------------------------------------------------|----------------------------------------------|------------------------------------------------------------------------------|------------|----------|---------------------|-------|---------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 929 | Bis(2-chloroethyl) ether                               | Dichloroethyl ether                          | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O                              | 111-44-4   | 143.012  | liq                 | -51.9 | 178.5                                 | 1.22 <sup>20</sup>         | 1.451 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace; msc bz           |
| 930 | Bis(2-chloroethyl)methylamine hydrochloride            | Nitrogen mustard hydrochloride               | C <sub>5</sub> H <sub>12</sub> Cl <sub>3</sub> N                             | 55-86-7    | 192.515  | hyg nd              | 111.5 |                                       |                            |                      |                                                        |
| 931 | <i>N,N'</i> -Bis(2-chloroethyl)- <i>N</i> -nitrosourea | Carmustine                                   | C <sub>5</sub> H <sub>8</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>2</sub>  | 154-93-8   | 214.049  | lt ye pow           | 31    |                                       |                            |                      | vs H <sub>2</sub> O, EtOH                              |
| 932 | Bis(2-chloroethyl) sulfide                             | Mustard gas                                  | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> S                              | 505-60-2   | 159.078  |                     | 13.5  | 216                                   | 1.2741 <sup>20</sup>       | 1.5313 <sup>20</sup> |                                                        |
| 933 | 1,2-Bis(2-chloroethylsulfonyl) ethane                  |                                              | C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 3944-87-4  | 283.193  | cry (MeOH/HOAc)     | 205   |                                       |                            |                      |                                                        |
| 934 | 1,2-Bis(chloromethyl)benzene                           |                                              | C <sub>6</sub> H <sub>8</sub> Cl <sub>2</sub>                                | 612-12-4   | 175.056  | mcl (lig)           | 55    | 239.5                                 | 1.393 <sup>25</sup>        |                      | i H <sub>2</sub> O; vs EtOH, eth, chl; s ctc           |
| 935 | 1,3-Bis(chloromethyl)benzene                           |                                              | C <sub>6</sub> H <sub>8</sub> Cl <sub>2</sub>                                | 626-16-4   | 175.056  | cry                 | 34.2  | 251.5                                 | 1.302 <sup>20</sup>        |                      | i H <sub>2</sub> O; vs EtOH, eth; sl chl               |
| 936 | 1,4-Bis(chloromethyl)benzene                           |                                              | C <sub>6</sub> H <sub>8</sub> Cl <sub>2</sub>                                | 623-25-6   | 175.056  | pl (al)             | 100   | dec 245; 135 <sup>16</sup>            | 1.417 <sup>25</sup>        |                      | i H <sub>2</sub> O; vs EtOH, eth, ace, chl; sl HOAc    |
| 937 | Bis(chloromethyl) ether                                |                                              | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> O                              | 542-88-1   | 114.958  | liq                 | -41.5 | 106                                   | 1.323 <sup>15</sup>        | 1.435 <sup>21</sup>  | msc EtOH, eth                                          |
| 938 | 3,3-Bis(chloromethyl)oxetane                           |                                              | C <sub>5</sub> H <sub>8</sub> Cl <sub>2</sub> O                              | 78-71-7    | 155.022  | liq                 | 18.7  | 101 <sup>27</sup>                     | 1.295 <sup>25</sup>        |                      |                                                        |
| 939 | 2,2-Bis(chloromethyl)-1,3-propanediol                  | Pentaerythritol dichlorohydrin               | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>2</sub>                | 2209-86-1  | 173.037  | cry                 | 83    | 159 <sup>12</sup>                     |                            |                      |                                                        |
| 940 | 1,3-Bis(chloromethyl) tetramethyldisiloxane            |                                              | C <sub>6</sub> H <sub>16</sub> Cl <sub>2</sub> OSi <sub>2</sub>              | 2362-10-9  | 231.267  | liq                 | -90   | 204; 92 <sup>21</sup>                 | 1.045 <sup>20</sup>        | 1.4398 <sup>20</sup> |                                                        |
| 941 | Bis(4-chlorophenoxy)methane                            | Di(4-chlorophenoxy)methane                   | C <sub>13</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>2</sub>               | 555-89-5   | 269.123  | cry (peth)          | 70.5  | 191 <sup>6</sup>                      |                            |                      | vs ace, bz                                             |
| 942 | Bis(4-chlorophenyl) disulfide                          |                                              | C <sub>12</sub> H <sub>6</sub> Cl <sub>2</sub> S <sub>2</sub>                | 1142-19-4  | 287.228  |                     | 72.8  |                                       |                            |                      | s chl                                                  |
| 943 | Bis(4-chlorophenyl)ethanedione                         |                                              | C <sub>14</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>2</sub>                | 3457-46-3  | 279.119  |                     | 197.8 |                                       |                            |                      |                                                        |
| 944 | 1,1-Bis(4-chlorophenyl)ethanol                         |                                              | C <sub>14</sub> H <sub>12</sub> Cl <sub>2</sub> O                            | 80-06-8    | 267.150  |                     | 70    |                                       |                            |                      | i H <sub>2</sub> O, EtOH; s eth, bz                    |
| 945 | 1,2-Bis(2-chlorophenyl)-hydrazine                      | 2,2'-Dichlorohydrazobenzene                  | C <sub>12</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub>               | 782-74-1   | 253.126  |                     | 87    |                                       |                            |                      |                                                        |
| 946 | Bis(4-chlorophenyl)methane                             |                                              | C <sub>13</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 101-76-8   | 237.124  |                     | 55.5  | 188 <sup>18</sup>                     | 1.365 <sup>17</sup>        |                      | s EtOH                                                 |
| 947 | Bis(4-chlorophenyl) sulfone                            |                                              | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>2</sub> S              | 80-07-9    | 287.162  |                     | 147.9 | 250 <sup>10</sup>                     |                            |                      | sl H <sub>2</sub> O; s EtOH, chl                       |
| 948 | <i>N,N'</i> -Bis(4-chlorophenyl)thiourea               | Di( <i>p</i> -chlorophenyl)thiourea          | C <sub>13</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> S             | 1220-00-4  | 297.202  | nd                  | 176   |                                       |                            |                      |                                                        |
| 949 | 1,1-Bis(4-chlorophenyl)-2,2,2-trichloroethanol         |                                              | C <sub>14</sub> H <sub>9</sub> Cl <sub>5</sub> O                             | 115-32-2   | 370.485  | cry (petr)          | 77.5  | 180 <sup>0.1</sup>                    |                            |                      | i H <sub>2</sub> O, os                                 |
| 950 | Bis(3-chloropropyl) ether                              | 3-Chloropropyl ether                         | C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub> O                             | 629-36-7   | 171.064  |                     |       | 216; 90.5 <sup>11</sup>               | 1.136 <sup>20</sup>        | 1.4158 <sup>20</sup> | s EtOH, eth                                            |
| 951 | Bis(2-cyanoethyl) ether                                |                                              | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O                               | 1656-48-0  | 124.140  |                     |       | 161 <sup>5</sup> , 111 <sup>0.5</sup> | 1.0504 <sup>20</sup>       | 1.4405 <sup>20</sup> |                                                        |
| 952 | Bis(2-cyanoethyl) sulfide                              |                                              | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> S                               | 111-97-7   | 140.206  |                     |       | 163 <sup>1.5</sup>                    |                            | 1.5047 <sup>20</sup> |                                                        |
| 953 | Bis(η-cyclopentadienyl)titanium chloride               |                                              | C <sub>10</sub> H <sub>10</sub> Cl <sub>2</sub> Ti                           | 1271-19-8  | 248.959  | red cry             | 289   | 258 <sup>10</sup>                     | 1.60                       |                      | sl H <sub>2</sub> O, bz; s chl, EtOH, tol              |
| 954 | Bis(η-cyclopentadienyl)zirconium chloride              |                                              | C <sub>10</sub> H <sub>10</sub> Cl <sub>2</sub> Zr                           | 1291-32-3  | 292.316  |                     |       | 180 <sup>0.5</sup>                    |                            |                      |                                                        |
| 955 | 1,2-Bis(dibromomethyl)benzene                          |                                              | C <sub>6</sub> H <sub>8</sub> Br <sub>4</sub>                                | 13209-15-9 | 421.750  | mcl                 | 116.5 |                                       |                            |                      | sl H <sub>2</sub> O; vs chl; i lig                     |
| 956 | Bis(2,4-dichlorobenzoyl) peroxide                      |                                              | C <sub>14</sub> H <sub>6</sub> Cl <sub>4</sub> O <sub>4</sub>                | 133-14-2   | 380.008  |                     | 106   |                                       |                            |                      |                                                        |
| 957 | 1,3-Bis(dichloromethyl) tetramethyldisiloxane          |                                              | C <sub>6</sub> H <sub>14</sub> Cl <sub>4</sub> OSi <sub>2</sub>              | 2943-70-6  | 300.157  |                     |       | 149 <sup>50</sup> , 117 <sup>11</sup> | 1.2213 <sup>20</sup>       | 1.4660 <sup>20</sup> |                                                        |
| 958 | Bis(2,4-dichlorophenyl)ether                           | 2,2',4,4'-Tetrachlorodiphenyl ether          | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub> O                             | 28076-73-5 | 307.987  | cry (eth)           | 71    |                                       |                            |                      |                                                        |
| 959 | 4,4'-Bis(diethylamino) benzophenone                    | Michler's ethyl ketone                       | C <sub>21</sub> H <sub>28</sub> N <sub>2</sub> O                             | 90-93-7    | 324.459  | lf (al)             | 95.3  |                                       |                            |                      |                                                        |
| 960 | Bis(diethyldithiocarbamate)nickel                      |                                              | C <sub>10</sub> H <sub>20</sub> N <sub>2</sub> NiS <sub>4</sub>              | 14267-17-5 | 355.232  |                     |       | 202 <sup>0.02</sup>                   |                            |                      |                                                        |
| 961 | Bis(diethyldithiocarbamate)zinc                        |                                              | C <sub>10</sub> H <sub>20</sub> N <sub>2</sub> S <sub>4</sub> Zn             | 14324-55-1 | 361.948  |                     |       | 178 <sup>0.05</sup>                   |                            |                      |                                                        |
| 962 | Bis(difluoromethyl) ether                              | Difluoromethyl ether                         | C <sub>2</sub> H <sub>2</sub> F <sub>4</sub> O                               | 1691-17-4  | 118.030  | col gas             |       | 2                                     | 1.43 <sup>20</sup>         |                      |                                                        |
| 963 | Bis(2-dimethylaminoethyl) ether                        | 2,2'-Oxybis[ <i>N,N</i> -dimethylethanamine] | C <sub>8</sub> H <sub>20</sub> N <sub>2</sub> O                              | 3033-62-3  | 160.257  | liq                 |       | 80 <sup>15</sup>                      |                            |                      |                                                        |
| 964 | Bis[4-(dimethylamino)phenyl] methane                   | Michler's Base                               | C <sub>17</sub> H <sub>22</sub> N <sub>2</sub>                               | 101-61-1   | 254.370  | pl or tab (al, lig) | 91.5  | dec 390; 183 <sup>3</sup>             |                            |                      | i H <sub>2</sub> O; sl EtOH; vs eth, bz; s acid        |
| 965 | Bis[4-(dimethylamino)phenyl] methanethione             | 4,4'-Bis(dimethylamino) thiobenzophenone     | C <sub>17</sub> H <sub>20</sub> N <sub>2</sub> S                             | 1226-46-6  | 284.419  | pl                  | 204   |                                       |                            |                      | i H <sub>2</sub> O, EtOH, lig; sl eth; s bz, chl, HOAc |
| 966 | Bis(4-dimethylaminophenyl) methanol                    | 4,4'-Bis(dimethylamino) benzhydrol           | C <sub>17</sub> H <sub>22</sub> N <sub>2</sub> O                             | 119-58-4   | 270.369  |                     | 102.0 |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, bz, HOAc           |
| 967 | 1,3-Bis(dimethylamino)-2-propanol                      |                                              | C <sub>7</sub> H <sub>18</sub> N <sub>2</sub> O                              | 5966-51-8  | 146.230  |                     |       | 181.5                                 | 0.8788 <sup>20</sup>       | 1.4418 <sup>20</sup> | vs H <sub>2</sub> O                                    |
| 968 | 4,4'-Bis(dimethylamino) triphenylmethane               |                                              | C <sub>23</sub> H <sub>26</sub> N <sub>2</sub>                               | 129-73-7   | 330.465  | nd or lf (al, bz)   | 102   |                                       |                            |                      | vs bz, eth                                             |
| 969 | Bis(dimethyldithiocarbamate) copper                    |                                              | C <sub>6</sub> H <sub>12</sub> CuN <sub>2</sub> S <sub>4</sub>               | 137-29-1   | 303.978  |                     |       | 206 <sup>0.01</sup>                   |                            |                      |                                                        |
| 970 | Bis(dimethyldithiocarbamate) nickel                    |                                              | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> NiS <sub>4</sub>               | 15521-65-0 | 299.125  |                     |       | 208 <sup>0.002</sup>                  |                            |                      |                                                        |

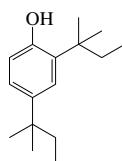




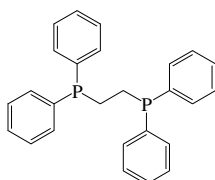
| No.  | Name                                                             | Synonym                                      | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|------------------------------------------------------------------|----------------------------------------------|-----------------------------------------------------------------|------------|----------|---------------|---------|------------------------|----------------------------|----------------------|------------------------------------------------------|
| 971  | 2,5-Bis(1,1-dimethylpropyl)-1,4-benzenediol                      | 2,5-Di- <i>tert</i> -pentylhydroquinone      | C <sub>16</sub> H <sub>26</sub> O <sub>2</sub>                  | 79-74-3    | 250.376  |               | 180     |                        |                            |                      |                                                      |
| 972  | 2,4-Bis(1,1-dimethylpropyl)phenol                                |                                              | C <sub>16</sub> H <sub>26</sub> O                               | 120-95-6   | 234.376  |               | 26.0    | 169 <sup>22</sup>      |                            |                      |                                                      |
| 973  | 1,2-Bis(diphenylphosphino)ethane                                 | Diphos                                       | C <sub>26</sub> H <sub>24</sub> P <sub>2</sub>                  | 1663-45-2  | 398.417  |               | 143.5   |                        |                            |                      |                                                      |
| 974  | 1,3-Bis(2,3-epoxypropoxy)benzene                                 | Diglycidyl resorcinol ether                  | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                  | 101-90-6   | 222.237  |               | 42.5    | 147 <sup>0.4</sup>     | 1.2183 <sup>90</sup>       | 1.5408 <sup>20</sup> |                                                      |
| 975  | Bis(2-ethoxyethyl) phthalate                                     |                                              | C <sub>16</sub> H <sub>22</sub> O <sub>6</sub>                  | 605-54-9   | 310.342  |               | 34      | 345                    | 1.1229 <sup>21</sup>       |                      |                                                      |
| 976  | Bis(ethoxymethyl) ether                                          |                                              | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                   | 5648-29-3  | 134.173  |               |         | 140.6                  |                            |                      |                                                      |
| 977  | <i>N,N</i> -Bis(4-ethoxyphenyl)ethanimidamide monohydrochloride  | Phenacaine hydrochloride                     | C <sub>18</sub> H <sub>23</sub> ClN <sub>2</sub> O <sub>2</sub> | 620-99-5   | 334.841  | cry (w+1)     | 191     |                        |                            |                      | vs H <sub>2</sub> O, EtOH, chl                       |
| 978  | Bis(ethylenediamine)copper dichloride                            | Cupriethylenediamine dichloride              | C <sub>4</sub> H <sub>16</sub> Cl <sub>2</sub> CuN <sub>4</sub> | 15243-01-3 | 254.649  | dk bl cry     |         |                        |                            |                      | s EtOH                                               |
| 979  | Bis(2-ethylhexyl) adipate                                        |                                              | C <sub>22</sub> H <sub>42</sub> O <sub>4</sub>                  | 103-23-1   | 370.566  |               | -67.8   | 214 <sup>5</sup>       | 0.922 <sup>25</sup>        | 1.4474 <sup>20</sup> | vs ace, eth, EtOH                                    |
| 980  | Bis(2-ethylhexyl)amine                                           |                                              | C <sub>16</sub> H <sub>36</sub> N                               | 106-20-7   | 241.456  |               |         | 161 <sup>21</sup>      |                            |                      |                                                      |
| 981  | Bis(2-ethylhexyl) azelate                                        |                                              | C <sub>25</sub> H <sub>48</sub> O <sub>4</sub>                  | 103-24-2   | 412.647  |               | -78     | 237 <sup>5</sup>       | 0.915 <sup>25</sup>        | 1.446 <sup>25</sup>  | i H <sub>2</sub> O; s EtOH, ace, bz; sl ctc          |
| 982  | Bis(2-ethylhexyl) ether                                          | 2,2'-Diethyldihexyl ether                    | C <sub>16</sub> H <sub>34</sub> O                               | 10143-60-9 | 242.440  |               |         | 269; 144 <sup>13</sup> |                            | 1.4325 <sup>20</sup> | sl ctc                                               |
| 983  | Bis(2-ethylhexyl) phosphate                                      |                                              | C <sub>16</sub> H <sub>35</sub> O <sub>4</sub> P                | 298-07-7   | 322.420  | visc liq      |         | 155 <sup>0.015</sup>   | 0.975 <sup>25</sup>        |                      | sl H <sub>2</sub> O; s bz, hx                        |
| 984  | Bis(2-ethylhexyl) phosphonate                                    | Bis(2-ethylhexyl) phosphite                  | C <sub>16</sub> H <sub>35</sub> O <sub>3</sub> P                | 3658-48-8  | 306.421  | liq           |         | 150 <sup>1</sup>       | 0.93 <sup>25</sup>         | 1.4420 <sup>20</sup> |                                                      |
| 985  | Bis(2-ethylhexyl) phosphorodithioate                             |                                              | C <sub>16</sub> H <sub>35</sub> O <sub>2</sub> PS <sub>2</sub>  | 5810-88-8  | 354.552  | cry           |         |                        |                            |                      | s bz, hp, chl                                        |
| 986  | Bis(2-ethylhexyl) phthalate                                      | Di- <i>sec</i> -octyl phthalate              | C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                  | 117-81-7   | 390.557  | liq           | -55     | 384                    | 0.981 <sup>25</sup>        | 1.4853 <sup>20</sup> | sl ctc                                               |
| 987  | Bis(2-ethylhexyl) sebacate                                       |                                              | C <sub>26</sub> H <sub>50</sub> O <sub>4</sub>                  | 122-62-3   | 426.673  |               | -48     | 256 <sup>5</sup>       | 0.912 <sup>25</sup>        | 1.451 <sup>25</sup>  | vs ace, bz, EtOH                                     |
| 988  | Bis(2-ethylhexyl) sodium sulfosuccinate                          | Docusate sodium                              | C <sub>20</sub> H <sub>37</sub> NaO <sub>7</sub> S              | 577-11-7   | 444.559  | waxy solid    |         |                        |                            |                      | s peth, ctc, eth, ace                                |
| 989  | Bis(2-ethylhexyl) terephthalate                                  |                                              | C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                  | 6422-86-2  | 390.557  |               |         | 383                    |                            |                      |                                                      |
| 990  | 2,2-Bis(ethylsulfonyl)butane                                     | Sulfonethylmethane                           | C <sub>8</sub> H <sub>18</sub> O <sub>4</sub> S <sub>2</sub>    | 76-20-0    | 242.357  | pl (w)        | 76      | dec                    | 1.199 <sup>65</sup>        |                      | s chl                                                |
| 991  | Bis[4-(hexyloxy)phenyl]diazene, 1-oxide                          |                                              | C <sub>24</sub> H <sub>34</sub> N <sub>2</sub> O <sub>3</sub>   | 2587-42-0  | 398.538  |               |         |                        |                            |                      | s chl                                                |
| 992  | <i>N,N</i> -Bis(2-hydroxybenzylidene)-1,2-ethylenediamine        | Disalicylidene-1,2-ethanediamine             | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>   | 94-93-9    | 268.310  |               | 125.5   |                        |                            |                      | sl EtOH, eth; s bz, chl                              |
| 993  | Bis(2-hydroxy-3- <i>tert</i> -butyl-5-methylphenyl)methane       |                                              | C <sub>23</sub> H <sub>32</sub> O <sub>2</sub>                  | 119-47-1   | 340.499  | nd (peth)     | 131     |                        |                            |                      |                                                      |
| 994  | Bis(2-hydroxy-5-chlorophenyl) sulfide                            | Fenticlor                                    | C <sub>12</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub> S | 97-24-5    | 287.162  |               | 174     |                        |                            |                      | i H <sub>2</sub> O; s EtOH, eth, gl HOAc             |
| 995  | 2-[Bis(2-hydroxyethyl)amino]ethanol hydrochloride                | Triethanolamine hydrochloride                | C <sub>6</sub> H <sub>16</sub> ClNO <sub>3</sub>                | 637-39-8   | 185.649  | cry (al)      | 179.5   |                        |                            |                      | vs H <sub>2</sub> O                                  |
| 996  | <i>N,N</i> -Bis(2-hydroxyethyl)butylamine                        | Butylbis(2-hydroxyethyl)amine                | C <sub>8</sub> H <sub>19</sub> NO <sub>2</sub>                  | 102-79-4   | 161.243  |               |         | 275; 80 <sup>35</sup>  | 0.9681 <sup>20</sup>       | 1.4625 <sup>20</sup> | s chl                                                |
| 997  | Bis(2-hydroxyethyl) disulfide                                    |                                              | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub> S <sub>2</sub>    | 1892-29-1  | 154.251  |               | 26      | 160 <sup>3.5</sup>     |                            |                      |                                                      |
| 998  | <i>N,N</i> -Bis(2-hydroxyethyl) dodecanamide                     |                                              | C <sub>16</sub> H <sub>33</sub> NO <sub>3</sub>                 | 120-40-1   | 287.438  | waxy solid    | 38.7    |                        |                            |                      |                                                      |
| 999  | <i>N,N</i> -Bis(2-hydroxyethyl)ethylamine                        | <i>N</i> -Ethyl-diethanolamine               | C <sub>6</sub> H <sub>15</sub> NO <sub>2</sub>                  | 139-87-7   | 133.189  | ye liq        | -50     | 247                    | 1.0135 <sup>20</sup>       | 1.4663 <sup>20</sup> | vs H <sub>2</sub> O, EtOH; sl eth                    |
| 1000 | <i>N,N</i> -Bis(2-hydroxyethyl)ethylenediamine                   |                                              | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>    | 4439-20-7  | 148.203  |               | 97.5    | 136 <sup>1</sup>       |                            |                      | s H <sub>2</sub> O                                   |
| 1001 | <i>N,N</i> -Bis(2-hydroxyethyl)glycine                           | Bicine                                       | C <sub>6</sub> H <sub>13</sub> NO <sub>4</sub>                  | 150-25-4   | 163.172  | nd (al)       | 194 dec |                        |                            |                      | vs H <sub>2</sub> O; i EtOH                          |
| 1002 | Bis(2-hydroxyethyl)methylamine                                   | Methyldiethanolamine                         | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                  | 105-59-9   | 119.163  | liq           | -21     | 247                    | 1.043 <sup>25</sup>        | 1.4685 <sup>20</sup> | vs H <sub>2</sub> O                                  |
| 1003 | <i>N,N</i> -Bis(2-hydroxyethyl)-3-methylaniline                  | Diethanol- <i>m</i> -toluidine               | C <sub>11</sub> H <sub>17</sub> NO <sub>2</sub>                 | 91-99-6    | 195.259  |               | 64.5    | 160 <sup>1</sup>       |                            |                      | sl chl                                               |
| 1004 | <i>N,N</i> -Bis(2-hydroxyethyl)-1,3-propanediamine               | 3-(Aminopropyl)diethanolamine                | C <sub>7</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub>    | 4985-85-7  | 162.230  |               |         | 160 <sup>1</sup>       |                            |                      |                                                      |
| 1005 | Bis(2-hydroxyethyl) sulfide                                      | 2,2'-Thiodiethanol                           | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub> S                 | 111-48-8   | 122.186  | liq           | -10.2   | 282                    | 1.1793 <sup>25</sup>       | 1.5211 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, chl, AcOEt; s eth; sl bz |
| 1006 | Bis(2-hydroxyethyl) terephthalate                                | Bis(2-hydroxyethyl) 1,4-benzenedicarboxylate | C <sub>12</sub> H <sub>14</sub> O <sub>6</sub>                  | 959-26-2   | 254.235  | cry (w)       | 109.5   |                        |                            |                      |                                                      |
| 1007 | 1,2-Bis(2-hydroxyethylthio)ethane                                |                                              | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> S <sub>2</sub>    | 5244-34-8  | 182.304  |               | 64.8    | 170 <sup>0.5</sup>     |                            |                      | s H <sub>2</sub> O, EtOH, bz, peth                   |
| 1008 | Bis(2-hydroxy-4-methoxyphenyl) methanone                         | 2,2'-Dihydroxy-4,4'-dimethoxybenzophenone    | C <sub>15</sub> H <sub>14</sub> O <sub>5</sub>                  | 131-54-4   | 274.269  |               | 139.5   |                        |                            |                      |                                                      |
| 1009 | 1,3-Bis(hydroxymethyl)-2-imidazolidone                           | 1,3-Dimethylolethyleneurea                   | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>    | 136-84-5   | 146.144  | cry (MeOH)    | 101     |                        |                            |                      |                                                      |
| 1010 | 2,2-Bis(4-hydroxy-3-methylphenyl)propane                         | Bisphenol C                                  | C <sub>17</sub> H <sub>20</sub> O <sub>2</sub>                  | 79-97-0    | 256.340  | nd (xyl)      | 140     |                        |                            |                      |                                                      |
| 1011 | 2,2-Bis(hydroxymethyl)-1,3-propanediol, tetra(2-propenoyl) ester | Pentaerythritol tetraacrylate                | C <sub>17</sub> H <sub>20</sub> O <sub>8</sub>                  | 4986-89-4  | 352.336  |               | 17.3    |                        | 1.185 <sup>25</sup>        |                      |                                                      |
| 1012 | 2,2-Bis(hydroxymethyl)-1,3-propanediol, tri(2-propenoyl) ester   | Pentaerythritol triacrylate                  | C <sub>14</sub> H <sub>16</sub> O <sub>7</sub>                  | 3524-68-3  | 298.289  |               |         |                        | 1.180 <sup>20</sup>        |                      |                                                      |



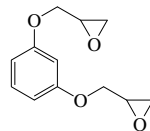
2,5-Bis(1,1-dimethylpropyl)-1,4-benzenediol



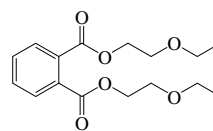
2,4-Bis(1,1-dimethylpropyl)phenol



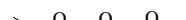
1,2-Bis(diphenylphosphino)ethane



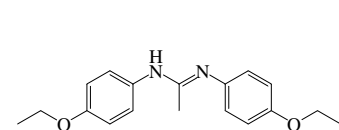
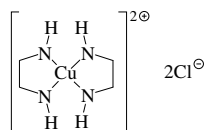
1,3-Bis(2,3-epoxypropoxy)benzene



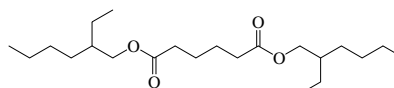
Bis(2-ethoxyethyl) phthalate



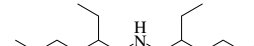
Bis(ethoxymethyl) ether

*N,N'*-Bis(4-ethoxyphenyl)ethanimidamide monohydrochloride

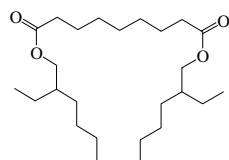
Bis(ethylenediamine)copper dichloride



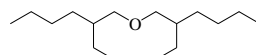
Bis(2-ethylhexyl) adipate



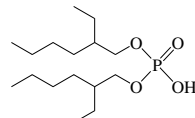
Bis(2-ethylhexyl)amine



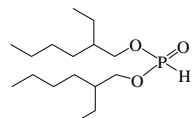
Bis(2-ethylhexyl) azelate



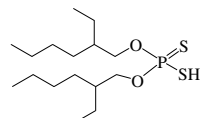
Bis(2-ethylhexyl) ether



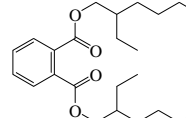
Bis(2-ethylhexyl) phosphate



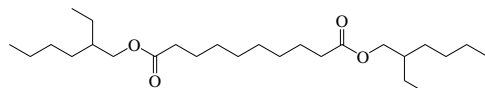
Bis(2-ethylhexyl) phosphonate



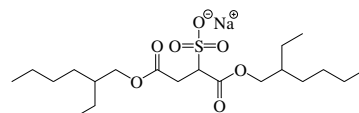
Bis(2-ethylhexyl) phosphorodithioate



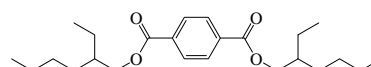
Bis(2-ethylhexyl) phthalate



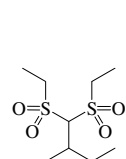
Bis(2-ethylhexyl) sebacate



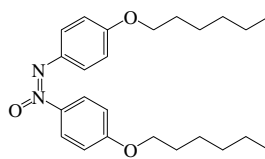
Bis(2-ethylhexyl) sodium sulfosuccinate



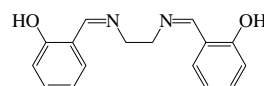
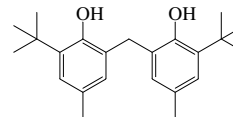
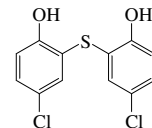
Bis(2-ethylhexyl) terephthalate



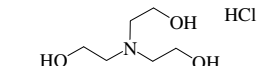
2,2-Bis(ethylsulfonyl)butane



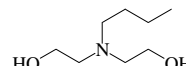
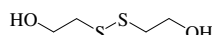
Bis[4-(hexyloxy)phenyl]diazene, 1-oxide

*N,N'*-Bis(2-hydroxybenzylidene)-1,2-ethylenediamineBis(2-hydroxy-3-*tert*-butyl-5-methylphenyl)methane

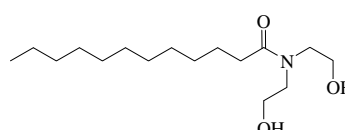
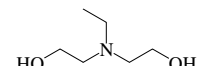
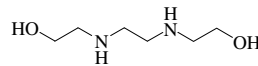
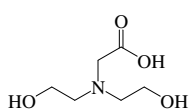
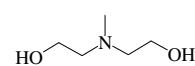
Bis(2-hydroxy-5-chlorophenyl) sulfide



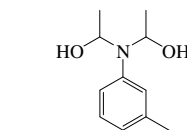
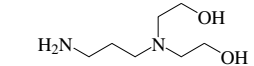
2-[Bis(2-hydroxyethyl)amino]ethanol hydrochloride

*N,N*-Bis(2-hydroxyethyl)butylamine

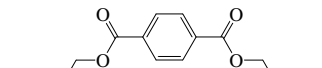
Bis(2-hydroxyethyl) disulfide

*N,N*-Bis(2-hydroxyethyl)dodecanamide*N,N*-Bis(2-hydroxyethyl)ethylamine*N,N'*-Bis(2-hydroxyethyl)ethylenediamine*N,N*-Bis(2-hydroxyethyl)glycine

Bis(2-hydroxyethyl)methylamine

*N,N*-Bis(2-hydroxyethyl)-3-methylaniline*N,N*-Bis(2-hydroxyethyl)-1,3-propanediamine

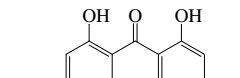
Bis(2-hydroxyethyl) sulfide



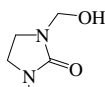
Bis(2-hydroxyethyl) terephthalate



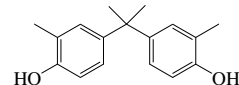
1,2-Bis(2-hydroxyethylthio)ethane



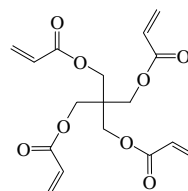
Bis(2-hydroxy-4-methoxyphenyl)methanone



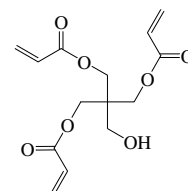
1,3-Bis(hydroxymethyl)-2-imidazolidone



2,2-Bis(4-hydroxy-3-methylphenyl)propane

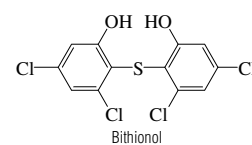
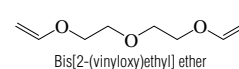
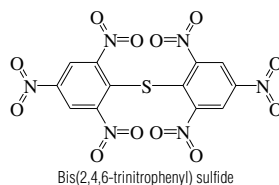
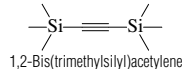
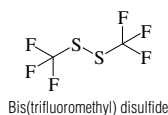
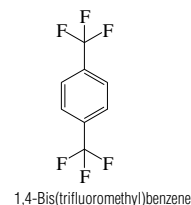
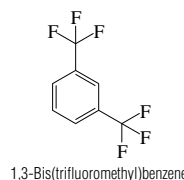
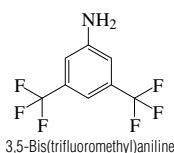
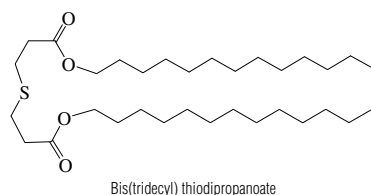
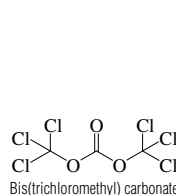
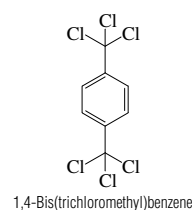
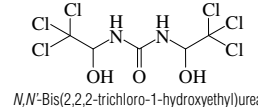
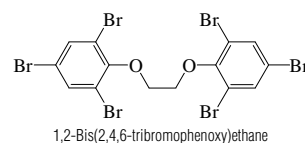
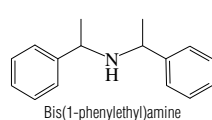
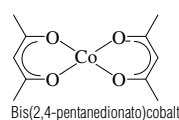
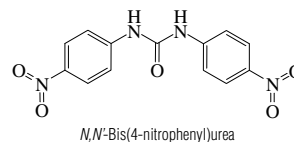
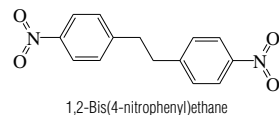
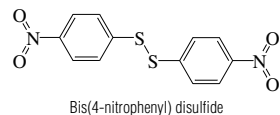
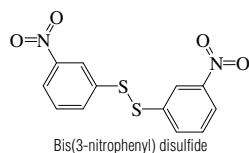
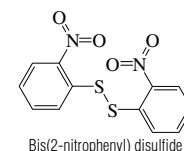
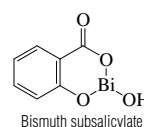
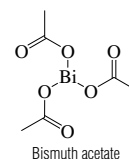
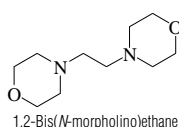
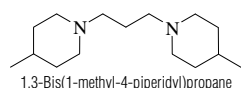
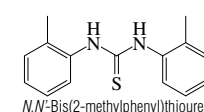
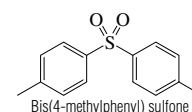
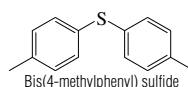
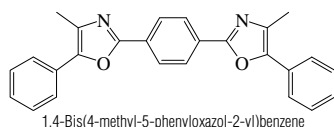
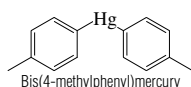
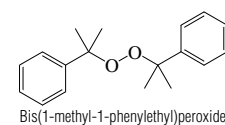
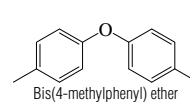
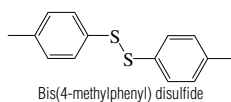
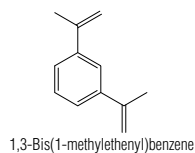
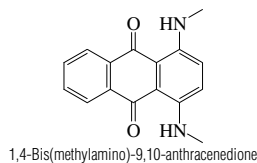
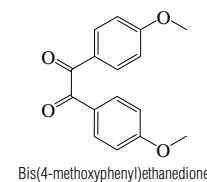
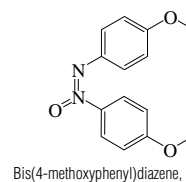
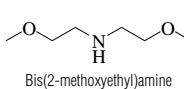
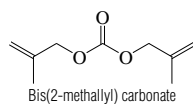
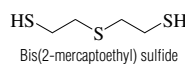
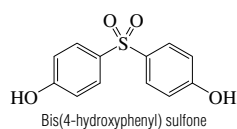
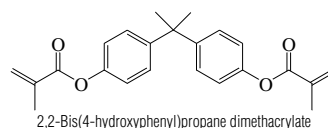
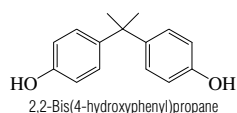
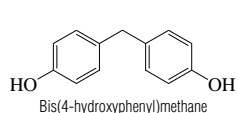
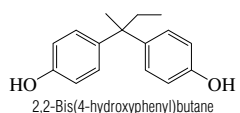


2,2-Bis(hydroxymethyl)-1,3-propanediol, tetra(2-propenyl) ester

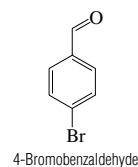
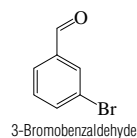
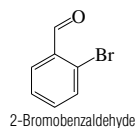
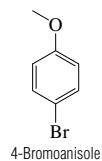
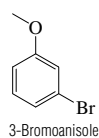
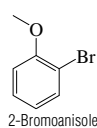
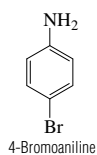
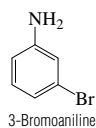
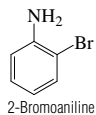
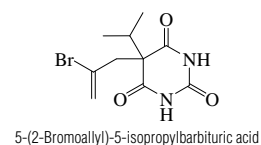
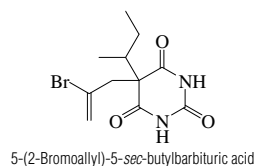
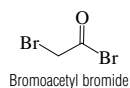
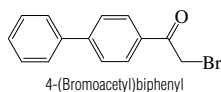
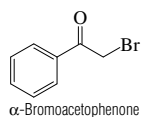
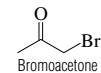
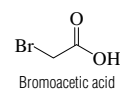
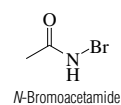
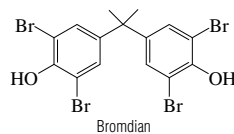
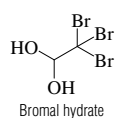
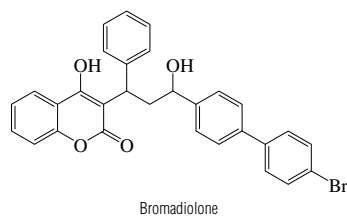
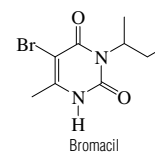
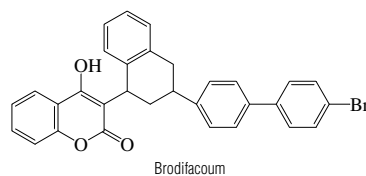
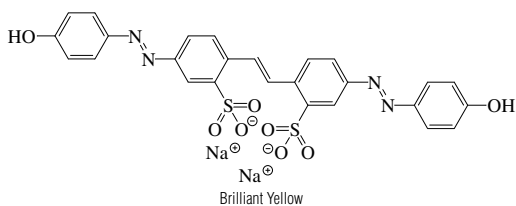
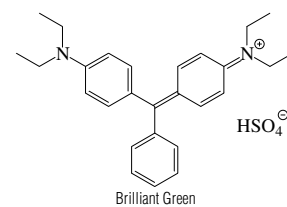
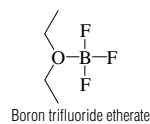
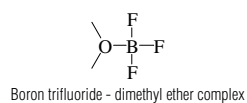
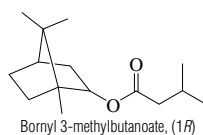
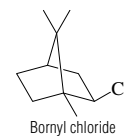
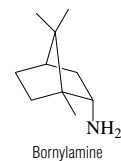
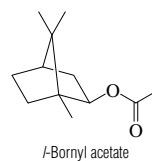
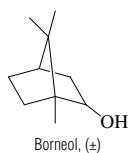
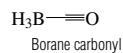
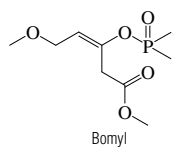
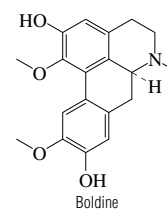
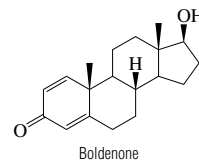
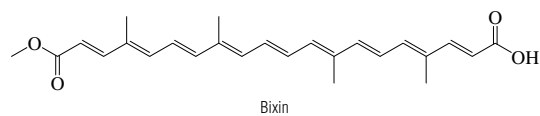
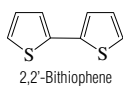


2,2-Bis(hydroxymethyl)-1,3-propanediol, tri(2-propenyl) ester

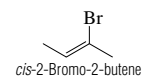
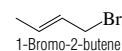
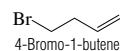
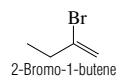
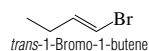
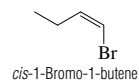
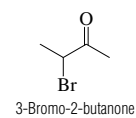
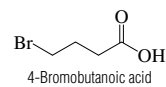
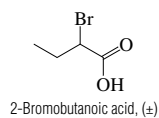
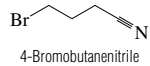
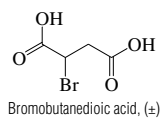
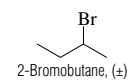
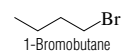
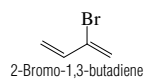
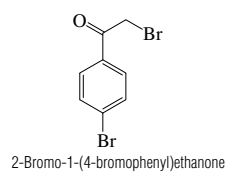
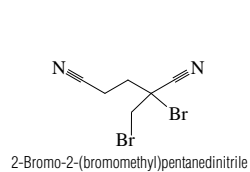
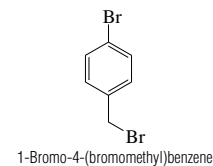
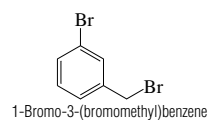
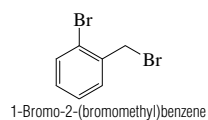
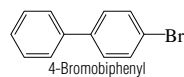
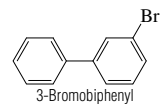
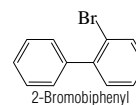
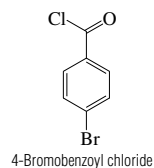
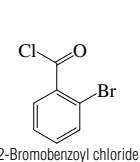
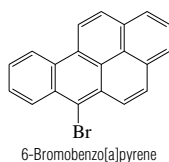
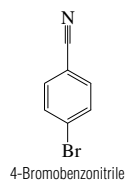
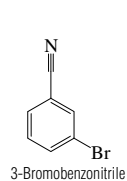
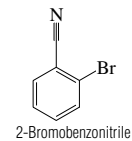
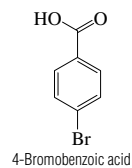
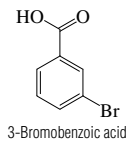
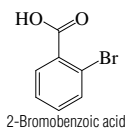
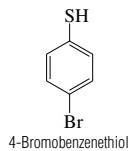
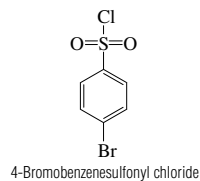
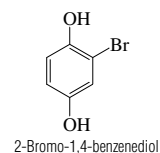
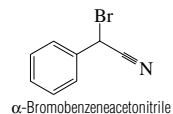
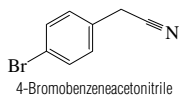
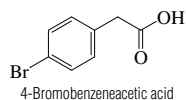
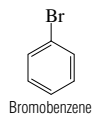
| No.  | Name                                                 | Synonym                                                | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|------------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------------------|------------|----------|--------------------|---------|-------------------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 1013 | 2,2-Bis(4-hydroxyphenyl)butane                       | Bisphenol B                                            | C <sub>16</sub> H <sub>18</sub> O <sub>2</sub>                              | 77-40-7    | 242.313  |                    | 120.5   |                                     |                            |                      | vs ace, MeOH                                               |
| 1014 | Bis(4-hydroxyphenyl)methane                          | Bisphenol AD                                           | C <sub>13</sub> H <sub>12</sub> O <sub>2</sub>                              | 620-92-8   | 200.233  |                    | 162.5   | sub                                 |                            |                      | s EtOH, eth, chl, alk; sl DMSO; i CS <sub>2</sub>          |
| 1015 | 2,2-Bis(4-hydroxyphenyl)propane                      | Bisphenol A                                            | C <sub>15</sub> H <sub>16</sub> O <sub>2</sub>                              | 80-05-7    | 228.287  | cry or fl          | 153     | 220 <sup>4</sup> , 222 <sup>3</sup> |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, bz, alk; s HOAc          |
| 1016 | 2,2-Bis(4-hydroxyphenyl)propane dimethacrylate       | Bisphenol A dimethacrylate                             | C <sub>23</sub> H <sub>24</sub> O <sub>4</sub>                              | 3253-39-2  | 364.435  |                    | 73      |                                     |                            |                      |                                                            |
| 1017 | Bis(4-hydroxyphenyl) sulfone                         | Bisphenol S                                            | C <sub>12</sub> H <sub>10</sub> O <sub>4</sub> S                            | 80-09-1    | 250.270  | nd (w), orth bipym | 240.5   |                                     | 1.3663 <sup>15</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth; sl bz, DMSO               |
| 1018 | Bis(2-mercaptoethyl) sulfide                         | 2,2'-Dimercaptodiethyl sulfide                         | C <sub>4</sub> H <sub>10</sub> S <sub>3</sub>                               | 3570-55-6  | 154.317  |                    | -11     | 135 <sup>18</sup>                   | 1.183 <sup>25</sup>        | 1.598 <sup>20</sup>  |                                                            |
| 1019 | Bis(2-methylthyl) carbonate                          |                                                        | C <sub>9</sub> H <sub>14</sub> O <sub>3</sub>                               | 64057-79-0 | 170.205  |                    | 201.3   | 66 <sup>3</sup>                     | 0.943 <sup>25</sup>        | 1.4371 <sup>20</sup> |                                                            |
| 1020 | Bis(2-methoxyethyl)amine                             | 2-Methoxy- <i>N</i> -(2-methoxyethyl) ethanamine       | C <sub>8</sub> H <sub>15</sub> NO <sub>2</sub>                              | 111-95-5   | 133.189  |                    |         |                                     |                            |                      | s ctc                                                      |
| 1021 | Bis(4-methoxyphenyl)diazene, 1-oxide                 |                                                        | C <sub>14</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>               | 1562-94-3  | 258.272  | ye nd (al)         |         |                                     | 1.1711 <sup>11</sup>       |                      | s EtOH, ace, bz; sl chl                                    |
| 1022 | Bis(4-methoxyphenyl)ethanedione                      |                                                        | C <sub>16</sub> H <sub>14</sub> O <sub>4</sub>                              | 1226-42-2  | 270.280  |                    | 133     |                                     |                            |                      | sl EtOH, chl                                               |
| 1023 | 1,4-Bis(methylamino)-9,10-anthracenedione            |                                                        | C <sub>16</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>               | 2475-44-7  | 266.294  |                    |         |                                     |                            |                      | sl chl                                                     |
| 1024 | 1,3-Bis(1-methylethenyl)benzene                      | 1,3-Diisopropenylbenzene                               | C <sub>12</sub> H <sub>14</sub>                                             | 3748-13-8  | 158.239  | liq                |         | 231                                 | 0.925                      | 1.5570 <sup>20</sup> |                                                            |
| 1025 | Bis(4-methylphenyl) disulfide                        | Di- <i>p</i> -Tolyl disulfide                          | C <sub>14</sub> H <sub>14</sub> S <sub>2</sub>                              | 103-19-5   | 246.391  | nd or lf (al)      | 47.5    | 212 <sup>20</sup>                   | 1.114 <sup>51</sup>        |                      | i H <sub>2</sub> O; s EtOH, ace; vs eth                    |
| 1026 | Bis(4-methylphenyl) ether                            | <i>p</i> -Tolyl ether                                  | C <sub>14</sub> H <sub>14</sub> O                                           | 1579-40-4  | 198.260  |                    | 51      | 285                                 |                            |                      | vs bz, eth, EtOH                                           |
| 1027 | Bis(1-methyl-1-phenylethyl) peroxide                 | Dicumyl peroxide                                       | C <sub>18</sub> H <sub>22</sub> O <sub>2</sub>                              | 80-43-3    | 270.367  | cry (EtOH)         | 40      | 100 <sup>0.2</sup>                  |                            |                      |                                                            |
| 1028 | Bis(4-methylphenyl)mercury                           | Di- <i>p</i> -tolylmercury                             | C <sub>14</sub> H <sub>14</sub> Hg                                          | 537-64-4   | 382.85   |                    | 245.7   |                                     |                            |                      |                                                            |
| 1029 | 1,4-Bis(4-methyl-5-phenyloxazol-2-yl)benzene         | 2,2'- <i>p</i> -Phenylenebis(4-methyl-5-phenyloxazole) | C <sub>26</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub>               | 3073-87-8  | 392.449  |                    | 232     |                                     |                            |                      | sl chl                                                     |
| 1030 | Bis(4-methylphenyl) sulfide                          | Di- <i>p</i> -tolyl sulfide                            | C <sub>14</sub> H <sub>14</sub> S                                           | 620-94-0   | 214.326  | nd (al)            | 57.3    | >300; 175 <sup>16</sup>             |                            |                      | i H <sub>2</sub> O; s EtOH, ace, bz, HOAc; sl chl          |
| 1031 | Bis(4-methylphenyl) sulfone                          | Di- <i>p</i> -tolyl sulfone                            | C <sub>14</sub> H <sub>14</sub> O <sub>2</sub> S                            | 599-66-6   | 246.325  | pr(bz), nd(w,al)   | 159     | 406                                 |                            |                      | sl H <sub>2</sub> O, eth; s EtOH, bz, chl, CS <sub>2</sub> |
| 1032 | <i>N,N'</i> -Bis(2-methylphenyl)thiourea             |                                                        | C <sub>15</sub> H <sub>16</sub> N <sub>2</sub> S                            | 137-97-3   | 256.366  | nd (al, sub)       |         |                                     |                            |                      | vs bz, EtOH, chl                                           |
| 1033 | 1,3-Bis(1-methyl-4-piperidyl) propane                |                                                        | C <sub>15</sub> H <sub>30</sub> N <sub>2</sub>                              | 64168-11-2 | 238.412  |                    | 13.7    | 215 <sup>50</sup>                   | 0.8962 <sup>25</sup>       | 1.4804 <sup>25</sup> |                                                            |
| 1034 | Bis(methylthio)methane                               |                                                        | C <sub>3</sub> H <sub>6</sub> S <sub>2</sub>                                | 1618-26-4  | 108.226  |                    |         | 148                                 |                            |                      |                                                            |
| 1035 | 1,2-Bis( <i>N</i> -morpholino)ethane                 |                                                        | C <sub>10</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub>               | 1723-94-0  | 200.278  | wh-ye (eth, liq)   | 75      | 285; 160 <sup>25</sup>              |                            |                      | vs H <sub>2</sub> O, ace, bz, EtOH                         |
| 1036 | Bismuth acetate                                      |                                                        | C <sub>6</sub> H <sub>9</sub> BiO <sub>5</sub>                              | 22306-37-2 | 386.111  | col tablets        | 250     |                                     |                            |                      | i H <sub>2</sub> O                                         |
| 1037 | Bismuth subsalicylate                                |                                                        | C <sub>7</sub> H <sub>5</sub> BiO <sub>4</sub>                              | 14882-18-9 | 362.093  | pr                 |         |                                     |                            |                      | i H <sub>2</sub> O, EtOH; reac alk                         |
| 1038 | Bis(2-nitrophenyl) disulfide                         |                                                        | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 1155-00-6  | 308.333  |                    | 198.5   |                                     |                            |                      | i H <sub>2</sub> O, eth; sl EtOH, ace, bz, HOAc            |
| 1039 | Bis(3-nitrophenyl) disulfide                         | Nitrophenide                                           | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 537-91-7   | 308.333  |                    | 84      |                                     |                            |                      | sl EtOH, chl; s eth                                        |
| 1040 | Bis(4-nitrophenyl) disulfide                         |                                                        | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 100-32-3   | 308.333  |                    | 182     | 255 <sup>0.1</sup>                  |                            |                      | sl EtOH, HOAc                                              |
| 1041 | 1,2-Bis(4-nitrophenyl)ethane                         | 4,4'-Dinitrobenzyl                                     | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub>               | 736-30-1   | 272.256  | ye nd (al,bz)      | 181.8   |                                     |                            |                      | i EtOH; sl eth, bz, chl, HOAc                              |
| 1042 | <i>N,N'</i> -Bis(4-nitrophenyl)urea                  | 4,4'-Dinitrocarbanilide                                | C <sub>13</sub> H <sub>10</sub> N <sub>4</sub> O <sub>5</sub>               | 587-90-6   | 302.242  |                    | 312 dec |                                     |                            |                      |                                                            |
| 1043 | Bis(2,4-pentanedionato)cobalt                        | Cobalt(II) bis(acetylacetonate)                        | C <sub>10</sub> H <sub>14</sub> CoO <sub>4</sub>                            | 14024-48-7 | 257.149  | bl-viol cry        | 167     |                                     |                            |                      |                                                            |
| 1044 | Bis(1-phenylethyl)amine                              |                                                        | C <sub>16</sub> H <sub>18</sub> N                                           | 10024-74-5 | 225.329  |                    |         | 296.5                               | 1.018 <sup>15</sup>        | 1.573                |                                                            |
| 1045 | 1,2-Bis(2,4,6-tribromophenoxy) ethane                |                                                        | C <sub>14</sub> H <sub>6</sub> Br <sub>6</sub> O <sub>2</sub>               | 37853-59-1 | 687.637  | nd (bz/EtOH)       | 222     |                                     |                            |                      |                                                            |
| 1046 | <i>N,N'</i> -Bis(2,2,2-trichloro-1-hydroxyethyl)urea |                                                        | C <sub>5</sub> H <sub>6</sub> Cl <sub>6</sub> N <sub>2</sub> O <sub>3</sub> | 116-52-9   | 354.831  |                    | 196     |                                     |                            |                      | vs ace, EtOH                                               |
| 1047 | 1,4-Bis(trichloromethyl)benzene                      |                                                        | C <sub>6</sub> H <sub>4</sub> Cl <sub>6</sub>                               | 68-36-0    | 312.836  | cry (bz, eth)      | 109     |                                     |                            |                      | s chl                                                      |
| 1048 | Bis(trichloromethyl) carbonate                       | Triphosgene                                            | C <sub>3</sub> Cl <sub>6</sub> O <sub>3</sub>                               | 32315-10-9 | 296.748  | cry (eth, peth)    | 79      | 203                                 | 1.6290 <sup>60</sup>       |                      |                                                            |
| 1049 | Bis(tridecyl) thiopropionate                         | Di(tridecyl) thiopropionate                            | C <sub>32</sub> H <sub>62</sub> O <sub>2</sub> S                            | 10595-72-9 | 542.897  |                    |         | 265 <sup>0.25</sup>                 |                            |                      | vs EtOH                                                    |
| 1050 | 3,5-Bis(trifluoromethyl)aniline                      |                                                        | C <sub>8</sub> H <sub>6</sub> F <sub>6</sub> N                              | 328-74-5   | 229.123  |                    |         | 85 <sup>15</sup> , 76 <sup>10</sup> | 1.487 <sup>25</sup>        | 1.4335 <sup>20</sup> |                                                            |
| 1051 | 1,3-Bis(trifluoromethyl)benzene                      |                                                        | C <sub>8</sub> H <sub>4</sub> F <sub>6</sub>                                | 402-31-3   | 214.108  |                    |         | 116                                 | 1.3790 <sup>25</sup>       | 1.3916 <sup>25</sup> | i H <sub>2</sub> O                                         |
| 1052 | 1,4-Bis(trifluoromethyl)benzene                      |                                                        | C <sub>8</sub> H <sub>4</sub> F <sub>6</sub>                                | 433-19-2   | 214.108  | liq                |         | 115                                 |                            |                      |                                                            |
| 1053 | Bis(trifluoromethyl) disulfide                       |                                                        | C <sub>2</sub> F <sub>6</sub> S <sub>2</sub>                                | 372-64-5   | 202.141  |                    |         | 34.6                                |                            |                      | vs EtOH, peth                                              |
| 1054 | 1,2-Bis(trimethylsilyl)acetylene                     |                                                        | C <sub>6</sub> H <sub>18</sub> Si <sub>2</sub>                              | 14630-40-1 | 170.400  |                    | 26      | 134                                 | 0.770 <sup>20</sup>        | 1.413 <sup>20</sup>  |                                                            |
| 1055 | Bis(2,4,6-trinitrophenyl) sulfide                    | Dipicryl sulfide                                       | C <sub>12</sub> H <sub>4</sub> N <sub>6</sub> O <sub>12</sub> S             | 2217-06-3  | 456.258  | ye cry             | 230     | exp                                 |                            |                      |                                                            |
| 1056 | Bis[2-(vinylloxy)ethyl] ether                        | Diethylene glycol divinyl ether                        | C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>                               | 764-99-8   | 158.195  |                    |         | 81 <sup>10</sup>                    |                            |                      |                                                            |
| 1057 | Bithionol                                            |                                                        | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub> O <sub>2</sub> S             | 97-18-7    | 356.052  |                    | 188     |                                     | 1.73 <sup>25</sup>         |                      | vs ace                                                     |



| No.  | Name                                                 | Synonym                                                    | Mol. Form.                                                                                   | CAS RN     | Mol. Wt. | Physical Form                 | mp/°C | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|------------------------------------------------------|------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------|----------|-------------------------------|-------|------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 1058 | 2,2'-Bithiophene                                     |                                                            | C <sub>8</sub> H <sub>6</sub> S <sub>2</sub>                                                 | 492-97-7   | 166.264  |                               | 33    | 260                    |                            |                      | i H <sub>2</sub> O; vs EtOH;<br>s eth, ctc,<br>HOAc      |
| 1059 | Bixin                                                |                                                            | C <sub>25</sub> H <sub>30</sub> O <sub>4</sub>                                               | 6983-79-5  | 394.504  | viol pr (ace)                 | 198   |                        |                            |                      | i H <sub>2</sub> O; s EtOH,<br>ace; sl eth, bz,<br>HOAc  |
| 1060 | Boldenone                                            | Dehydrotestosterone                                        | C <sub>19</sub> H <sub>26</sub> O <sub>2</sub>                                               | 846-48-0   | 286.408  |                               | 165   |                        |                            |                      | vs EtOH, chl                                             |
| 1061 | Boldine                                              |                                                            | C <sub>19</sub> H <sub>21</sub> NO <sub>4</sub>                                              | 476-70-0   | 327.375  | cry (eth)                     | 163   |                        |                            |                      | vs EtOH, chl                                             |
| 1062 | Bornyl                                               |                                                            | C <sub>9</sub> H <sub>15</sub> O <sub>8</sub> P                                              | 122-10-1   | 282.184  | ye oil                        |       | 160 <sup>17</sup>      |                            |                      | sl H <sub>2</sub> O; vs ace,<br>EtOH, xyl                |
| 1063 | Borane carbonyl                                      |                                                            | CH <sub>3</sub> BO                                                                           | 13205-44-2 | 41.845   | col gas                       | -137  | -64                    |                            |                      | dec H <sub>2</sub> O                                     |
| 1064 | Borneol, (±)                                         |                                                            | C <sub>10</sub> H <sub>18</sub> O                                                            | 6627-72-1  | 154.249  | lf (lig)                      | 208   | sub                    | 1.011 <sup>20</sup>        |                      | i H <sub>2</sub> O; vs EtOH,<br>eth, bz                  |
| 1065 | <i>l</i> -Bornyl acetate                             |                                                            | C <sub>12</sub> H <sub>20</sub> O <sub>2</sub>                                               | 5655-61-8  | 196.286  |                               | 27    | 223.5                  | 0.982 <sup>25</sup>        | 1.4626 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth                      |
| 1066 | Bornylamine                                          |                                                            | C <sub>10</sub> H <sub>19</sub> N                                                            | 32511-34-5 | 153.265  |                               | 163   |                        |                            |                      | vs ace, bz, eth,<br>EtOH                                 |
| 1067 | Bornyl chloride                                      | 2-Chloro-1,7,7-trimethylbicyclo[2.2.1]heptane, <i>endo</i> | C <sub>10</sub> H <sub>17</sub> Cl                                                           | 464-41-5   | 172.695  | nd                            | 132   | 207.5                  |                            |                      | vs bz, eth, EtOH,<br>peth                                |
| 1068 | Bornyl 3-methylbutanoate, (1 <i>R</i> )              | <i>d</i> -Bornyl isovalerate                               | C <sub>15</sub> H <sub>26</sub> O <sub>2</sub>                                               | 53022-14-3 | 238.366  |                               |       | 257.5                  | 0.955 <sup>25</sup>        |                      | vs eth, EtOH                                             |
| 1069 | Boron trifluoride - dimethyl ether complex           |                                                            | C <sub>2</sub> H <sub>6</sub> BF <sub>3</sub> O                                              | 353-42-4   | 113.874  |                               | -14   | dec 127                | 1.2410 <sup>20</sup>       | 1.302 <sup>20</sup>  |                                                          |
| 1070 | Boron trifluoride etherate                           |                                                            | C <sub>4</sub> H <sub>10</sub> BF <sub>3</sub> O                                             | 109-63-7   | 141.927  | liq                           | -60.4 | 125.5                  | 1.125 <sup>25</sup>        | 1.348 <sup>20</sup>  | dec H <sub>2</sub> O; vs eth,<br>EtOH                    |
| 1071 | Brilliant Green                                      |                                                            | C <sub>27</sub> H <sub>34</sub> N <sub>2</sub> O <sub>4</sub> S                              | 633-03-4   | 482.635  | small gold cry                |       |                        |                            |                      | vs H <sub>2</sub> O, EtOH                                |
| 1072 | Brilliant Yellow                                     |                                                            | C <sub>26</sub> H <sub>20</sub> N <sub>4</sub> Na <sub>2</sub> O <sub>6</sub> S <sub>2</sub> | 3051-11-4  | 626.569  | ye cry (w)                    |       |                        |                            |                      | s H <sub>2</sub> O, EtOH; sl<br>ace                      |
| 1073 | Brodifacoum                                          |                                                            | C <sub>31</sub> H <sub>23</sub> BrO <sub>3</sub>                                             | 56073-10-0 | 523.417  | off-wh pow                    | 230   |                        |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>bz; s ace, chl           |
| 1074 | Bromacil                                             | 5-Bromo-3- <i>sec</i> -butyl-6-methyluracil                | C <sub>9</sub> H <sub>13</sub> BrN <sub>2</sub> O <sub>2</sub>                               | 314-40-9   | 261.115  |                               | 158   |                        | 1.55 <sup>25</sup>         |                      |                                                          |
| 1075 | Bromadiolone                                         |                                                            | C <sub>30</sub> H <sub>23</sub> BrO <sub>4</sub>                                             | 28772-56-7 | 527.406  | ye-wh pow                     | 205   |                        |                            |                      | vs DMF; sl ace,<br>chl, EtOH, eth;<br>i hx               |
| 1076 | Bromal hydrate                                       |                                                            | C <sub>2</sub> H <sub>2</sub> Br <sub>3</sub> O <sub>2</sub>                                 | 507-42-6   | 298.756  | mcl pr (w+1)                  | 53.5  | dec                    | 2.5661 <sup>40</sup>       |                      | vs eth, EtOH                                             |
| 1077 | Bromdian                                             | Tetrabromobisphenol A                                      | C <sub>15</sub> H <sub>12</sub> Br <sub>4</sub> O <sub>2</sub>                               | 79-94-7    | 543.871  |                               | 179   |                        |                            |                      | s EtOH, eth, bz,<br>chl                                  |
| 1078 | <i>N</i> -Bromoacetamide                             |                                                            | C <sub>2</sub> H <sub>4</sub> BrNO                                                           | 79-15-2    | 137.963  | nd (chl-hx)                   | 103.5 |                        |                            |                      | vs eth                                                   |
| 1079 | Bromoacetic acid                                     |                                                            | C <sub>2</sub> H <sub>3</sub> BrO <sub>2</sub>                                               | 79-08-3    | 138.948  | hex or orth cry               | 50    | 208                    | 1.9335 <sup>50</sup>       | 1.4804 <sup>50</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; s ace, bz;<br>sl chl |
| 1080 | Bromoacetone                                         |                                                            | C <sub>3</sub> H <sub>5</sub> BrO                                                            | 598-31-2   | 136.975  | liq                           | -36.5 | 138; 31.5 <sup>8</sup> | 1.634 <sup>23</sup>        | 1.4697 <sup>15</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth, ace                 |
| 1081 | $\alpha$ -Bromoacetophenone                          | $\omega$ -Bromoacetophenone                                | C <sub>8</sub> H <sub>7</sub> BrO                                                            | 70-11-1    | 199.045  | nd (al) orth pr (al) pl(peth) | 50.5  | 135 <sup>18</sup>      | 1.647 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH,<br>peth; vs eth,<br>bz, chl  |
| 1082 | 4-(Bromoacetyl)biphenyl                              | 2-Bromo-4'-phenylacetophenone                              | C <sub>14</sub> H <sub>11</sub> BrO                                                          | 135-73-9   | 275.140  | nd (95% al)                   | 127   |                        |                            |                      |                                                          |
| 1083 | Bromoacetyl bromide                                  |                                                            | C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> O                                              | 598-21-0   | 201.844  |                               |       | 148.5                  | 2.312 <sup>22</sup>        | 1.5449 <sup>20</sup> | s ace, ctc                                               |
| 1084 | Bromoacetylene                                       |                                                            | C <sub>2</sub> HBr                                                                           | 593-61-3   | 104.933  | col gas                       |       | 4.7                    |                            |                      | vs eth                                                   |
| 1085 | 5-(2-Bromoallyl)-5- <i>sec</i> -butylbarbituric acid | Butallylonal                                               | C <sub>11</sub> H <sub>15</sub> BrN <sub>2</sub> O <sub>3</sub>                              | 1142-70-7  | 303.152  |                               | 131.5 |                        |                            |                      | vs eth, EtOH                                             |
| 1086 | 5-(2-Bromoallyl)-5-isopropylbarbituric acid          | Propallylonal                                              | C <sub>10</sub> H <sub>13</sub> BrN <sub>2</sub> O <sub>3</sub>                              | 545-93-7   | 289.125  | cry (dil HOAc, dil al)        | 181   |                        |                            |                      | sl H <sub>2</sub> O, eth, bz;<br>vs EtOH, ace,<br>HOAc   |
| 1087 | 2-Bromoaniline                                       |                                                            | C <sub>6</sub> H <sub>6</sub> BrN                                                            | 615-36-1   | 172.023  |                               | 32    | 229                    | 1.578 <sup>20</sup>        | 1.6113 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                       |
| 1088 | 3-Bromoaniline                                       |                                                            | C <sub>6</sub> H <sub>6</sub> BrN                                                            | 591-19-5   | 172.023  |                               | 18.5  | 251                    | 1.5793 <sup>20</sup>       | 1.6260 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth                      |
| 1089 | 4-Bromoaniline                                       |                                                            | C <sub>6</sub> H <sub>6</sub> BrN                                                            | 106-40-1   | 172.023  | orth bipym nd (60% al)        | 66.4  | dec                    | 1.4970 <sup>100</sup>      |                      | i H <sub>2</sub> O; s EtOH,<br>eth; sl chl               |
| 1090 | 2-Bromoanisole                                       |                                                            | C <sub>7</sub> H <sub>7</sub> BrO                                                            | 578-57-4   | 187.034  |                               | 1.3   | 216                    | 1.5018 <sup>20</sup>       | 1.5727 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth                      |
| 1091 | 3-Bromoanisole                                       |                                                            | C <sub>7</sub> H <sub>7</sub> BrO                                                            | 2398-37-0  | 187.034  |                               |       | 211; 105 <sup>16</sup> |                            | 1.5635 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz, CS <sub>2</sub>  |
| 1092 | 4-Bromoanisole                                       |                                                            | C <sub>7</sub> H <sub>7</sub> BrO                                                            | 104-92-7   | 187.034  |                               | 13.5  | 215                    | 1.4564 <sup>20</sup>       | 1.5642 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH,<br>eth, chl; s ctc         |
| 1093 | 2-Bromobenzaldehyde                                  |                                                            | C <sub>7</sub> H <sub>5</sub> BrO                                                            | 6630-33-7  | 185.018  |                               | 21.5  | 230                    |                            | 1.5925 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>bz; sl ctc               |
| 1094 | 3-Bromobenzaldehyde                                  |                                                            | C <sub>7</sub> H <sub>5</sub> BrO                                                            | 3132-99-8  | 185.018  |                               |       | 234                    |                            | 1.5935 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth; sl ctc              |
| 1095 | 4-Bromobenzaldehyde                                  |                                                            | C <sub>7</sub> H <sub>5</sub> BrO                                                            | 1122-91-4  | 185.018  | lf (dil al)                   | 58    | 67 <sup>2</sup>        |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>bz; sl chl               |

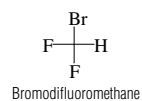
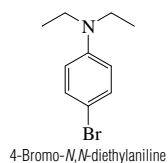
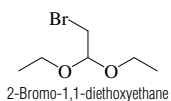
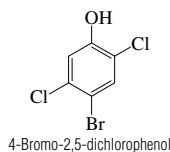
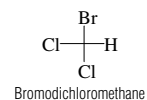
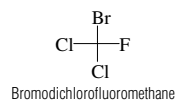
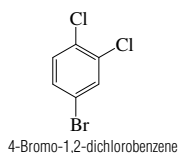
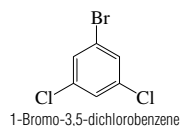
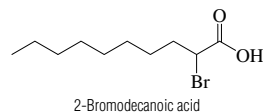
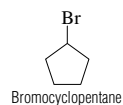
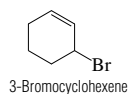
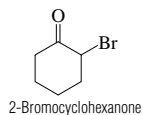
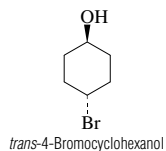
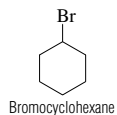
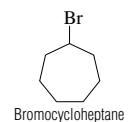
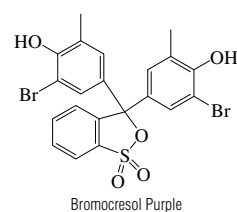
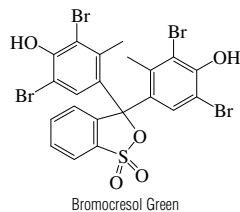
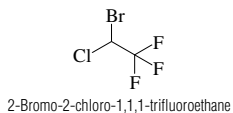
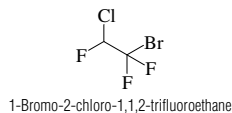
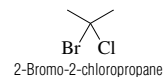
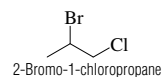
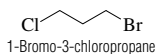
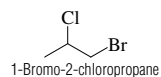
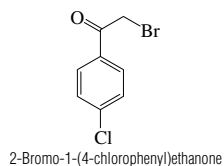
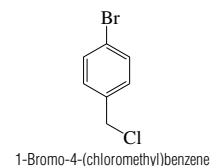
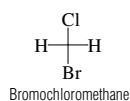
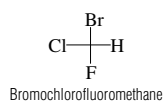
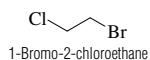
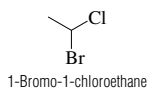
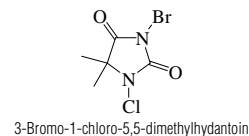
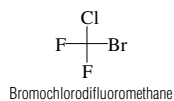
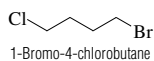
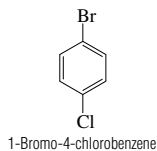
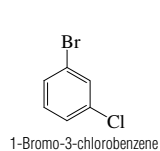
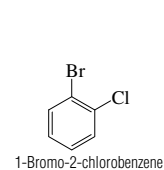
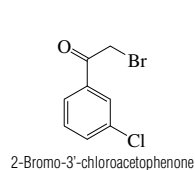
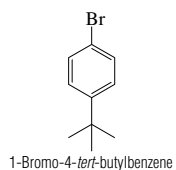
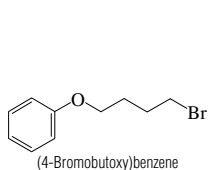
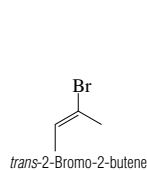


| No.  | Name                                     | Synonym                       | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form            | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|------------------------------------------|-------------------------------|--------------------------------------------------------------|------------|----------|--------------------------|---------|--------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 1096 | Bromobenzene                             | Phenyl bromide                | C <sub>6</sub> H <sub>5</sub> Br                             | 108-86-1   | 157.008  | liq                      | -30.72  | 156.06                               | 1.4950 <sup>20</sup>       | 1.5597 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz; s ctc                   |
| 1097 | 4-Bromobenzenecetic acid                 |                               | C <sub>8</sub> H <sub>7</sub> BrO <sub>2</sub>               | 1878-68-8  | 215.045  | nd (w)                   | 116     | sub                                  |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, CS <sub>2</sub>            |
| 1098 | 4-Bromobenzenecetonitrile                |                               | C <sub>8</sub> H <sub>6</sub> BrN                            | 16532-79-9 | 196.045  | pa ye cry (al)           | 48.0    |                                      |                            |                      | vs bz, EtOH                                                   |
| 1099 | α-Bromobenzenecetonitrile                | α-Bromobenzyl cyanide         | C <sub>8</sub> H <sub>6</sub> BrN                            | 5798-79-8  | 196.045  | ye cry (dil al)          | 29      | dec 242; 133 <sup>12</sup>           | 1.539 <sup>29</sup>        |                      | i H <sub>2</sub> O; vs EtOH, eth, ace, bz, chl                |
| 1100 | 2-Bromo-1,4-benzenediol                  |                               | C <sub>6</sub> H <sub>3</sub> BrO <sub>2</sub>               | 583-69-7   | 189.007  | lf (lig), cry (chl)      | 111.5   | sub                                  |                            |                      | vs H <sub>2</sub> O, EtOH, eth, bz; sl chl, lig; s HOAc       |
| 1101 | 4-Bromobenzenesulfonyl chloride          | p-Brosyl chloride             | C <sub>6</sub> H <sub>4</sub> BrClO <sub>2</sub> S           | 98-58-8    | 255.517  | tcl or mcl pl (eth)      | 76      | 153 <sup>15</sup>                    |                            |                      | i H <sub>2</sub> O; vs eth; s chl                             |
| 1102 | 4-Bromobenzenethiol                      |                               | C <sub>6</sub> H <sub>4</sub> BrS                            | 106-53-6   | 189.073  | lf (al)                  | 73      | 230.5                                | 1.5260 <sup>83</sup>       |                      | sl H <sub>2</sub> O, EtOH; vs eth, ctc, chl                   |
| 1103 | 2-Bromobenzoic acid                      |                               | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>               | 88-65-3    | 201.018  | mcl pr (w), nd           | 150     | sub                                  | 1.929 <sup>25</sup>        |                      | sl H <sub>2</sub> O, DMSO; s EtOH, eth, ace, chl              |
| 1104 | 3-Bromobenzoic acid                      |                               | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>               | 585-76-2   | 201.018  | mcl nd (dil al)          | 155     | >280                                 | 1.845 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth                               |
| 1105 | 4-Bromobenzoic acid                      |                               | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>               | 586-76-5   | 201.018  | nd (eth), lf (w), mcl pr | 254.5   |                                      | 1.894 <sup>20</sup>        |                      | sl H <sub>2</sub> O, DMSO; s EtOH, eth                        |
| 1106 | 2-Bromobenzonitrile                      |                               | C <sub>7</sub> H <sub>4</sub> BrN                            | 2042-37-7  | 182.018  | nd (w)                   | 55.5    | 252                                  |                            |                      | s H <sub>2</sub> O; vs EtOH; sl chl                           |
| 1107 | 3-Bromobenzonitrile                      |                               | C <sub>7</sub> H <sub>4</sub> BrN                            | 6952-59-6  | 182.018  |                          | 39.5    | 225                                  |                            |                      | vs EtOH, eth; sl chl                                          |
| 1108 | 4-Bromobenzonitrile                      |                               | C <sub>7</sub> H <sub>4</sub> BrN                            | 623-00-7   | 182.018  | nd (w, al)               | 114     | 236                                  |                            |                      | s H <sub>2</sub> O, EtOH, eth, chl                            |
| 1109 | 6-Bromobenzo[a]pyrene                    |                               | C <sub>20</sub> H <sub>11</sub> Br                           | 21248-00-0 | 331.205  | cry (ace/MeOH)           | 223     |                                      |                            |                      |                                                               |
| 1110 | 2-Bromobenzoyl chloride                  |                               | C <sub>7</sub> H <sub>5</sub> BrClO                          | 7154-66-7  | 219.463  | nd                       | 11      | 243                                  |                            | 1.5963 <sup>20</sup> | sl ctc                                                        |
| 1111 | 4-Bromobenzoyl chloride                  |                               | C <sub>7</sub> H <sub>5</sub> BrClO                          | 586-75-4   | 219.463  | nd (peth)                | 42      | 246; 181 <sup>125</sup>              |                            |                      | vs EtOH, eth, bz, lig                                         |
| 1112 | 2-Bromobiphenyl                          |                               | C <sub>12</sub> H <sub>9</sub> Br                            | 2052-07-5  | 233.103  |                          | 0.8     | 297                                  | 1.2175 <sup>26</sup>       | 1.6248 <sup>25</sup> | vs eth, EtOH                                                  |
| 1113 | 3-Bromobiphenyl                          |                               | C <sub>12</sub> H <sub>9</sub> Br                            | 2113-57-7  | 233.103  |                          |         | 300; 171 <sup>17</sup>               |                            | 1.6411 <sup>20</sup> | i H <sub>2</sub> O                                            |
| 1114 | 4-Bromobiphenyl                          |                               | C <sub>12</sub> H <sub>9</sub> Br                            | 92-66-0    | 233.103  | pl (al)                  | 91.5    | 310                                  | 0.9327 <sup>25</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, bz, HOAc; sl chl             |
| 1115 | 1-Bromo-2-(bromomethyl) benzene          |                               | C <sub>7</sub> H <sub>8</sub> Br <sub>2</sub>                | 3433-80-5  | 249.931  | cry (al, lig)            | 31      | 129 <sup>19</sup>                    |                            |                      | vs eth, EtOH, HOAc                                            |
| 1116 | 1-Bromo-3-(bromomethyl) benzene          |                               | C <sub>7</sub> H <sub>8</sub> Br <sub>2</sub>                | 823-78-9   | 249.931  | nd or lf                 | 42      | 122 <sup>12</sup>                    |                            |                      | s chl                                                         |
| 1117 | 1-Bromo-4-(bromomethyl) benzene          | p-Bromobenzyl bromide         | C <sub>7</sub> H <sub>8</sub> Br <sub>2</sub>                | 589-15-1   | 249.931  | nd (al)                  | 63      |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH, bz, chl; vs eth, CS <sub>2</sub> |
| 1118 | 2-Bromo-2-(bromomethyl) pentanedinitrile | 1,2-Dibromo-2,4-dicyanobutane | C <sub>6</sub> H <sub>6</sub> Br <sub>2</sub> N <sub>2</sub> | 35691-65-7 | 265.933  |                          | 52      |                                      |                            |                      | i H <sub>2</sub> O; vs ace, bz, DMF                           |
| 1119 | 2-Bromo-1-(4-bromophenyl) ethanone       | p-Bromophenacyl bromide       | C <sub>8</sub> H <sub>6</sub> Br <sub>2</sub> O              | 99-73-0    | 277.941  | nd (al)                  | 111     |                                      |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl                          |
| 1120 | 2-Bromo-1,3-butadiene                    |                               | C <sub>4</sub> H <sub>5</sub> Br                             | 1822-86-2  | 132.987  |                          |         | 42 <sup>165</sup>                    | 1.397 <sup>20</sup>        | 1.4988 <sup>20</sup> | vs eth, EtOH                                                  |
| 1121 | 1-Bromobutane                            | Butyl bromide                 | C <sub>4</sub> H <sub>9</sub> Br                             | 109-65-9   | 137.018  | liq                      | -112.6  | 101.6                                | 1.2758 <sup>20</sup>       | 1.4401 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace; sl ctc; s chl         |
| 1122 | 2-Bromobutane, (±)                       | (±)-sec-Butyl bromide         | C <sub>4</sub> H <sub>9</sub> Br                             | 5787-31-5  | 137.018  | liq                      | -112.65 | 91.3                                 | 1.2585 <sup>20</sup>       | 1.4366 <sup>20</sup> | vs ace, eth, chl                                              |
| 1123 | Bromobutanedioic acid, (±)               | Bromosuccinic acid            | C <sub>4</sub> H <sub>5</sub> BrO <sub>4</sub>               | 584-98-5   | 196.985  |                          | 161     |                                      | 2.073 <sup>25</sup>        |                      | s H <sub>2</sub> O, EtOH; sl HOAc                             |
| 1124 | 4-Bromobutanenitrile                     |                               | C <sub>4</sub> H <sub>6</sub> BrN                            | 5332-06-9  | 148.002  |                          |         | 206                                  | 1.4967 <sup>20</sup>       | 1.4818 <sup>20</sup> | s EtOH, eth, chl                                              |
| 1125 | 2-Bromobutanoic acid, (±)                | DL-α-Bromobutyric acid        | C <sub>4</sub> H <sub>7</sub> BrO <sub>2</sub>               | 2385-70-8  | 167.002  |                          | -2.0    | dec 217; 127 <sup>25</sup>           | 1.5641 <sup>20</sup>       |                      | s H <sub>2</sub> O, EtOH, eth                                 |
| 1126 | 4-Bromobutanoic acid                     |                               | C <sub>4</sub> H <sub>7</sub> BrO <sub>2</sub>               | 2623-87-2  | 167.002  |                          | 33      | 142 <sup>25</sup> , 125 <sup>7</sup> |                            |                      |                                                               |
| 1127 | 3-Bromo-2-butanone                       |                               | C <sub>4</sub> H <sub>7</sub> BrO                            | 814-75-5   | 151.002  |                          |         | 36 <sup>11</sup>                     |                            |                      |                                                               |
| 1128 | cis-1-Bromo-1-butene                     |                               | C <sub>4</sub> H <sub>7</sub> Br                             | 31849-78-2 | 135.003  |                          |         | 86.1                                 | 1.3265 <sup>15</sup>       | 1.4536 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, bz, chl; sl ctc               |
| 1129 | trans-1-Bromo-1-butene                   |                               | C <sub>4</sub> H <sub>7</sub> Br                             | 32620-08-9 | 135.003  | liq                      | -100.3  | 94.7                                 | 1.3209 <sup>15</sup>       | 1.4527 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, bz, chl; sl ctc               |
| 1130 | 2-Bromo-1-butene                         |                               | C <sub>4</sub> H <sub>7</sub> Br                             | 23074-36-4 | 135.003  | liq                      | -133.4  | 88                                   | 1.3209 <sup>15</sup>       | 1.4527 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, bz, chl; sl ctc               |
| 1131 | 4-Bromo-1-butene                         |                               | C <sub>4</sub> H <sub>7</sub> Br                             | 5162-44-7  | 135.003  |                          |         | 98.5                                 | 1.3230 <sup>20</sup>       | 1.4622 <sup>20</sup> | sl H <sub>2</sub> O; vs bz, eth, EtOH                         |
| 1132 | 1-Bromo-2-butene                         |                               | C <sub>4</sub> H <sub>7</sub> Br                             | 4784-77-4  | 135.003  |                          |         | 104.5                                | 1.3371 <sup>25</sup>       | 1.4822 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc; vs chl, bz              |
| 1133 | cis-2-Bromo-2-butene                     |                               | C <sub>4</sub> H <sub>7</sub> Br                             | 3017-68-3  | 135.003  | liq                      | -111.5  | 93.9                                 | 1.3416 <sup>15</sup>       | 1.4631 <sup>19</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc; vs chl, bz              |

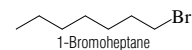
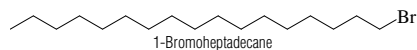
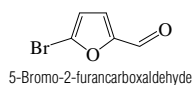
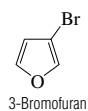
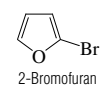
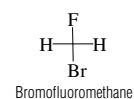
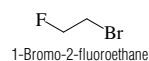
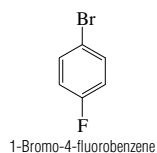
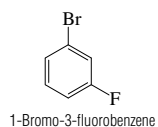
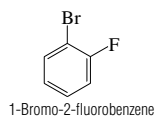
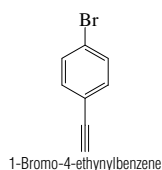
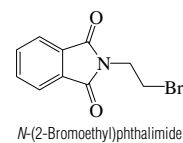
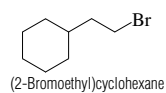
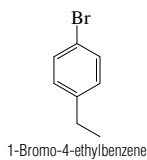
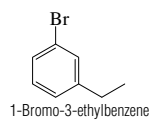
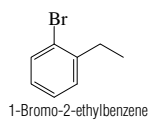
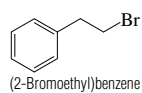
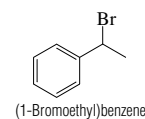
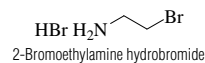
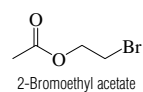
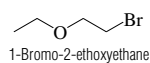
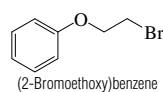
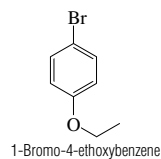
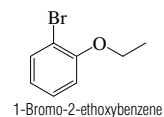
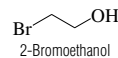
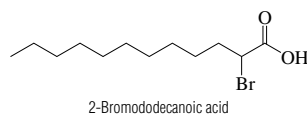
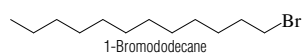
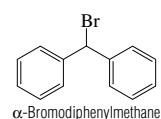
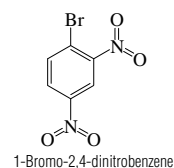
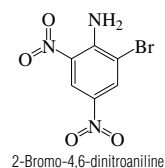
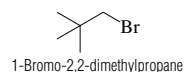
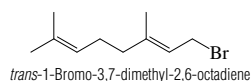
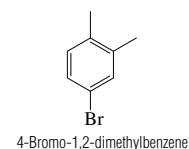
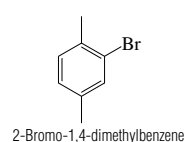
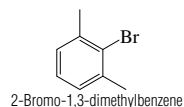
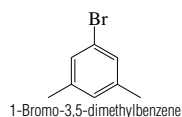
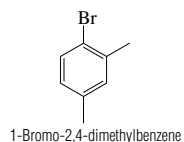
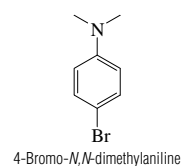
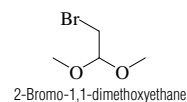
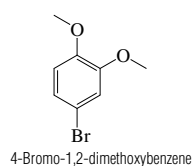
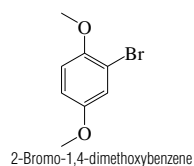
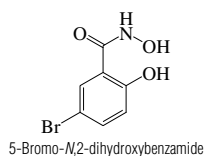




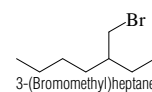
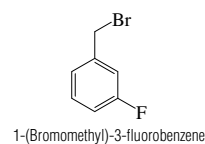
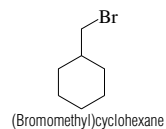
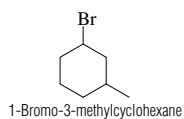
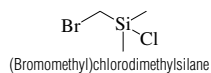
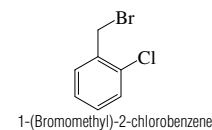
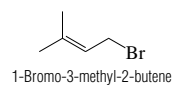
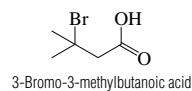
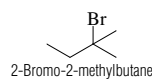
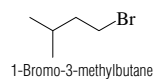
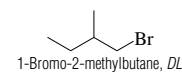
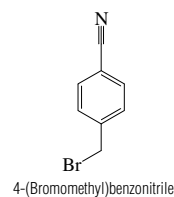
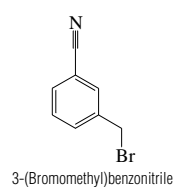
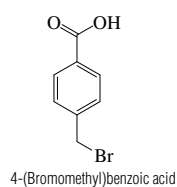
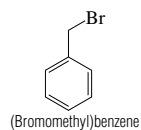
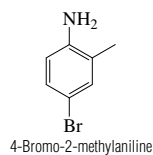
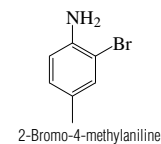
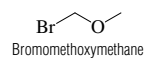
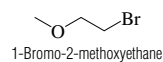
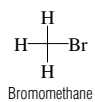
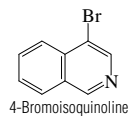
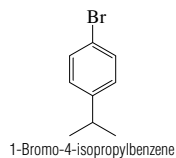
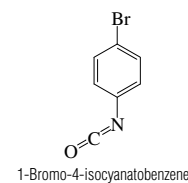
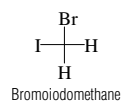
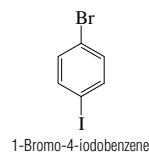
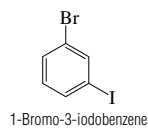
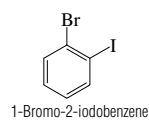
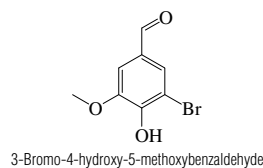
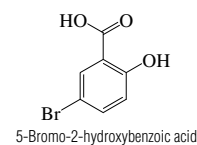
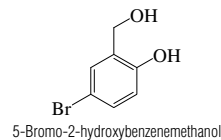
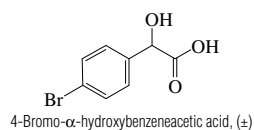
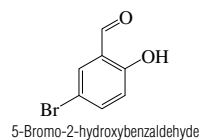
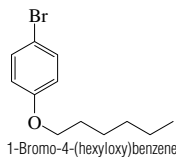
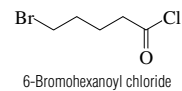
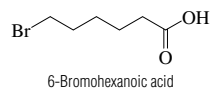
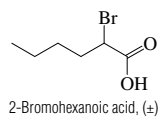
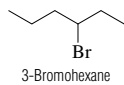
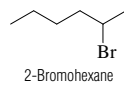
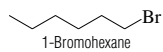
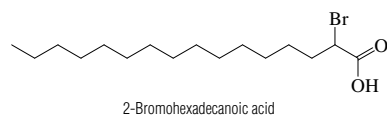
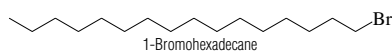
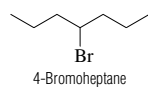
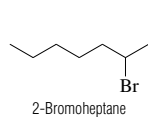
| No.  | Name                                        | Synonym                                  | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form             | mp/°C  | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|---------------------------------------------|------------------------------------------|------------------------------------------------------------------|------------|----------|---------------------------|--------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 1134 | <i>trans</i> -2-Bromo-2-butene              |                                          | C <sub>4</sub> H <sub>7</sub> Br                                 | 3017-71-8  | 135.003  | liq                       | -114.6 | 85.6                                 | 1.3323 <sup>15</sup>       | 1.4602 <sup>16</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc; vs chl, bz     |
| 1135 | (4-Bromobutoxy)benzene                      |                                          | C <sub>10</sub> H <sub>13</sub> BrO                              | 1200-03-9  | 229.113  | cry (al)                  | 41     | 154 <sup>18</sup>                    |                            |                      | sl EtOH, ctc                                         |
| 1136 | 1-Bromo-4- <i>tert</i> -butylbenzene        |                                          | C <sub>10</sub> H <sub>13</sub> Br                               | 3972-65-4  | 213.114  |                           | 19     | 231.5                                | 1.2286 <sup>20</sup>       | 1.5436 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl                   |
| 1137 | 2-Bromo-3'-chloroacetophenone               | 3-Chlorophenacyl bromide                 | C <sub>8</sub> H <sub>6</sub> BrClO                              | 41011-01-2 | 233.490  | nd                        | 40     | 397.5                                |                            |                      | vs EtOH                                              |
| 1138 | 1-Bromo-2-chlorobenzene                     |                                          | C <sub>6</sub> H <sub>4</sub> BrCl                               | 694-80-4   | 191.453  | liq                       | -12.3  | 204                                  | 1.6387 <sup>25</sup>       | 1.5809 <sup>20</sup> | i H <sub>2</sub> O; vs bz; sl ctc                    |
| 1139 | 1-Bromo-3-chlorobenzene                     |                                          | C <sub>6</sub> H <sub>4</sub> BrCl                               | 108-37-2   | 191.453  | liq                       | -21.5  | 196                                  | 1.6302 <sup>20</sup>       | 1.5771 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                     |
| 1140 | 1-Bromo-4-chlorobenzene                     |                                          | C <sub>6</sub> H <sub>4</sub> BrCl                               | 106-39-8   | 191.453  | nd or pl (al, eth)        | 68     | 196                                  | 1.576 <sup>71</sup>        | 1.5531 <sup>70</sup> | i H <sub>2</sub> O; sl EtOH; s eth, bz, ctc, chl     |
| 1141 | 1-Bromo-4-chlorobutane                      |                                          | C <sub>4</sub> H <sub>8</sub> BrCl                               | 6940-78-9  | 171.464  |                           |        | 175; 63 <sup>10</sup>                | 1.489 <sup>20</sup>        | 1.4885 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl; sl ctc         |
| 1142 | Bromochlorodifluoromethane                  | Halon 1211                               | CBrClF <sub>2</sub>                                              | 353-59-3   | 165.365  | col gas                   | -159.5 | -3.7                                 |                            |                      |                                                      |
| 1143 | 3-Bromo-1-chloro-5,5-dimethylhydantoin      |                                          | C <sub>8</sub> H <sub>8</sub> BrClN <sub>2</sub> O <sub>2</sub>  | 126-06-7   | 241.471  |                           | 162    |                                      |                            |                      |                                                      |
| 1144 | 1-Bromo-1-chloroethane                      |                                          | C <sub>2</sub> H <sub>4</sub> BrCl                               | 593-96-4   | 143.410  |                           |        | 83                                   | 1.667 <sup>10</sup>        | 1.4660 <sup>20</sup> |                                                      |
| 1145 | 1-Bromo-2-chloroethane                      |                                          | C <sub>2</sub> H <sub>4</sub> BrCl                               | 107-04-0   | 143.410  | liq                       | -16.7  | 107                                  | 1.7392 <sup>20</sup>       | 1.4908 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, chl                |
| 1146 | Bromochlorofluoromethane                    |                                          | CHBrClF                                                          | 593-98-6   | 147.374  | liq                       | -115   | 36                                   | 1.9771 <sup>0</sup>        | 1.4144 <sup>25</sup> | i H <sub>2</sub> O; s eth, ace, chl                  |
| 1147 | Bromochloromethane                          | Halon 1011                               | CH <sub>2</sub> BrCl                                             | 74-97-5    | 129.384  | liq                       | -87.9  | 68.0                                 | 1.9344 <sup>20</sup>       | 1.4838 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz             |
| 1148 | 1-Bromo-4-(chloromethyl)benzene             | <i>p</i> -Bromobenzyl chloride           | C <sub>7</sub> H <sub>6</sub> BrCl                               | 589-17-3   | 205.480  | nd (al, peth)             | 50     | 236                                  |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s peth             |
| 1149 | 2-Bromo-1-(4-chlorophenyl)ethanone          | <i>p</i> -Chlorophenacyl bromide         | C <sub>8</sub> H <sub>6</sub> BrClO                              | 536-38-9   | 233.490  | nd                        | 96.5   |                                      |                            |                      |                                                      |
| 1150 | 1-Bromo-2-chloropropane                     |                                          | C <sub>3</sub> H <sub>6</sub> BrCl                               | 3017-96-7  | 157.437  |                           |        | 118                                  | 1.531 <sup>20</sup>        | 1.4745 <sup>20</sup> | vs ace, bz, eth, EtOH                                |
| 1151 | 1-Bromo-3-chloropropane                     |                                          | C <sub>3</sub> H <sub>6</sub> BrCl                               | 109-70-6   | 157.437  | liq                       | -58.9  | 143.3                                | 1.5969 <sup>20</sup>       | 1.4864 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, chl                |
| 1152 | 2-Bromo-1-chloropropane                     |                                          | C <sub>3</sub> H <sub>6</sub> BrCl                               | 3017-95-6  | 157.437  |                           |        | 117                                  | 1.537 <sup>20</sup>        | 1.4795 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz          |
| 1153 | 2-Bromo-2-chloropropane                     |                                          | C <sub>3</sub> H <sub>6</sub> BrCl                               | 2310-98-7  | 157.437  |                           |        | 95                                   | 1.495 <sup>20</sup>        | 1.4575 <sup>20</sup> | vs ace, bz, eth, EtOH                                |
| 1154 | 1-Bromo-2-chloro-1,1,2-trifluoroethane      |                                          | C <sub>2</sub> HBrClF <sub>3</sub>                               | 354-06-3   | 197.381  |                           |        | 52.5                                 | 1.8574 <sup>25</sup>       | 1.3738 <sup>20</sup> |                                                      |
| 1155 | 2-Bromo-2-chloro-1,1,1-trifluoroethane      | Halothane                                | C <sub>2</sub> HBrClF <sub>3</sub>                               | 151-67-7   | 197.381  |                           |        | 50.2; 20 <sup>243</sup>              | 1.8563 <sup>25</sup>       | 1.3697 <sup>0</sup>  | sl H <sub>2</sub> O; s peth                          |
| 1156 | Bromocresol Green                           | Bromocresol Green                        | C <sub>21</sub> H <sub>14</sub> Br <sub>4</sub> O <sub>3</sub> S | 76-60-8    | 698.014  | wh or red (+7w) ye (HOAc) | 218.5  |                                      |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, AcOEt; s bz       |
| 1157 | Bromocresol Purple                          | Bromocresol Purple                       | C <sub>21</sub> H <sub>16</sub> Br <sub>2</sub> O <sub>3</sub> S | 115-40-2   | 540.222  |                           | 241.5  |                                      |                            |                      |                                                      |
| 1158 | Bromocycloheptane                           | Cycloheptyl bromide                      | C <sub>7</sub> H <sub>13</sub> Br                                | 2404-35-5  | 177.082  |                           |        | 101 <sup>40</sup> , 75 <sup>12</sup> | 1.3080 <sup>20</sup>       | 1.4996 <sup>20</sup> | i H <sub>2</sub> O; vs eth, chl                      |
| 1159 | Bromocyclohexane                            | Cyclohexyl bromide                       | C <sub>6</sub> H <sub>11</sub> Br                                | 108-85-0   | 163.055  | liq                       | -56.5  | 166.2                                | 1.3359 <sup>20</sup>       | 1.4957 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc |
| 1160 | <i>trans</i> -4-Bromocyclohexanol           |                                          | C <sub>6</sub> H <sub>11</sub> BrO                               | 32388-22-0 | 179.054  | pl (hx)                   | 81.5   |                                      |                            |                      |                                                      |
| 1161 | 2-Bromocyclohexanone                        |                                          | C <sub>6</sub> H <sub>9</sub> BrO                                | 822-85-5   | 177.038  |                           |        | 114 <sup>32</sup> , 90 <sup>14</sup> | 1.340 <sup>25</sup>        | 1.5085 <sup>25</sup> |                                                      |
| 1162 | 3-Bromocyclohexene                          |                                          | C <sub>6</sub> H <sub>9</sub> Br                                 | 1521-51-3  | 161.039  |                           |        | 81 <sup>40</sup> , 56 <sup>11</sup>  | 1.3890 <sup>20</sup>       | 1.5320 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl                   |
| 1163 | Bromocyclopentane                           | Cyclopentyl bromide                      | C <sub>5</sub> H <sub>9</sub> Br                                 | 137-43-9   | 149.029  |                           |        | 137.5                                | 1.3873 <sup>20</sup>       | 1.4886 <sup>20</sup> | sl ctc                                               |
| 1164 | 1-Bromodecane                               |                                          | C <sub>10</sub> H <sub>21</sub> Br                               | 112-29-8   | 221.178  | liq                       | -29.2  | 240.6                                | 1.0702 <sup>20</sup>       | 1.4557 <sup>20</sup> | i H <sub>2</sub> O; vs eth, chl; s ctc               |
| 1165 | 2-Bromodecanoic acid                        |                                          | C <sub>10</sub> H <sub>19</sub> BrO <sub>2</sub>                 | 2623-95-2  | 251.161  |                           | 2.0    | 140 <sup>2</sup>                     | 1.1912 <sup>24</sup>       | 1.4595 <sup>24</sup> | vs eth                                               |
| 1166 | 1-Bromo-3,5-dichlorobenzene                 |                                          | C <sub>6</sub> H <sub>3</sub> BrCl <sub>2</sub>                  | 19752-55-7 | 225.898  | pr (al)                   | 83     | 232                                  |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl; vs bz          |
| 1167 | 4-Bromo-1,2-dichlorobenzene                 |                                          | C <sub>6</sub> H <sub>3</sub> BrCl <sub>2</sub>                  | 18282-59-2 | 225.898  | pr                        | 25     | 237                                  |                            |                      | i H <sub>2</sub> O; sl EtOH; vs eth, bz, chl         |
| 1168 | Bromodichlorofluoromethane                  | Halon 1121                               | CBrCl <sub>2</sub> F                                             | 353-58-2   | 181.819  | liq                       |        | 52.8                                 | 1.95 <sup>22</sup>         |                      |                                                      |
| 1169 | Bromodichloromethane                        |                                          | CHBrCl <sub>2</sub>                                              | 75-27-4    | 163.829  | liq                       | -57    | 90                                   | 1.980 <sup>20</sup>        | 1.4964 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace, bz; sl ctc    |
| 1170 | 4-Bromo-2,5-dichlorophenol                  |                                          | C <sub>6</sub> H <sub>3</sub> BrCl <sub>2</sub> O                | 1940-42-7  | 241.897  | nd                        | 71.5   |                                      |                            |                      |                                                      |
| 1171 | 2-Bromo-1,1-diethoxyethane                  |                                          | C <sub>6</sub> H <sub>13</sub> BrO <sub>2</sub>                  | 2032-35-1  | 197.070  |                           |        | 170; 66 <sup>18</sup>                | 1.283 <sup>20</sup>        | 1.4387 <sup>20</sup> | s EtOH, eth                                          |
| 1172 | 4-Bromo- <i>N,N</i> -diethylaniline         |                                          | C <sub>10</sub> H <sub>14</sub> BrN                              | 2052-06-4  | 228.129  | nd or pr                  | 38     | 270                                  |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                     |
| 1173 | Bromodifluoromethane                        |                                          | CHBrF <sub>2</sub>                                               | 1511-62-2  | 130.920  |                           | -145   | -14.6                                | 1.55 <sup>16</sup>         |                      | s H <sub>2</sub> O; vs EtOH                          |
| 1174 | 3-Bromo-4,5-dihydro-2(3 <i>H</i> )-furanone | $\alpha$ -Bromo- $\gamma$ -butyrolactone | C <sub>4</sub> H <sub>5</sub> BrO <sub>2</sub>                   | 5061-21-2  | 164.986  |                           |        | 130 <sup>20</sup>                    | 1.8 <sup>20</sup>          | 1.5059 <sup>20</sup> |                                                      |



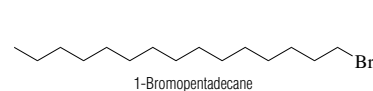
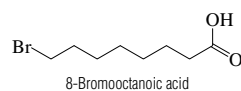
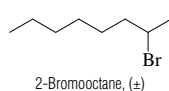
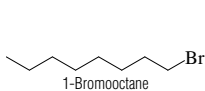
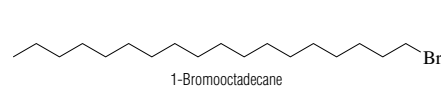
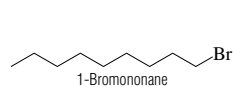
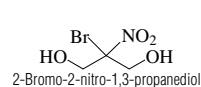
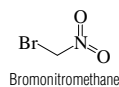
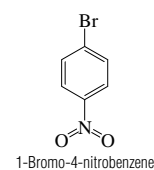
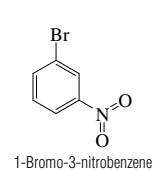
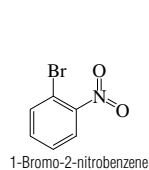
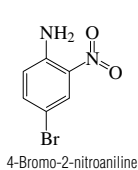
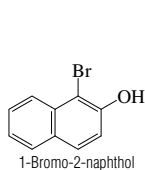
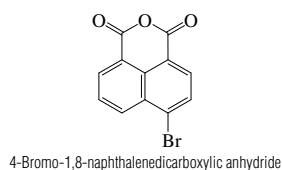
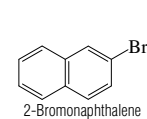
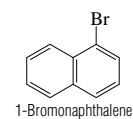
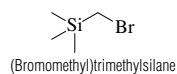
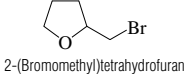
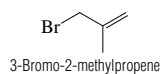
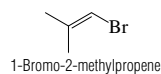
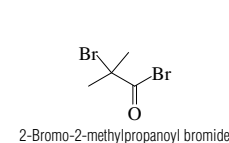
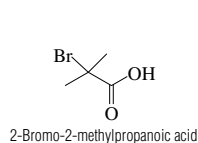
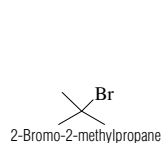
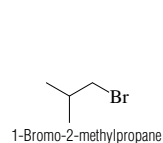
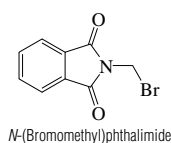
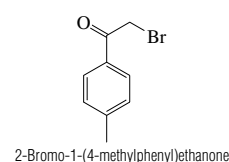
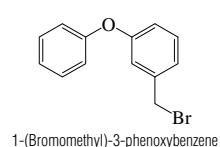
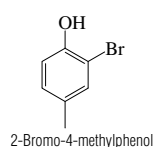
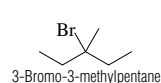
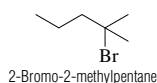
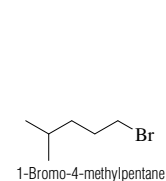
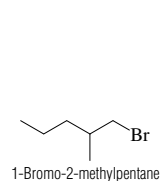
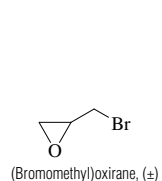
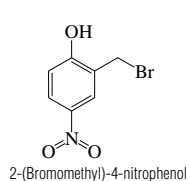
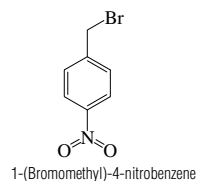
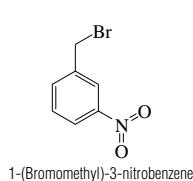
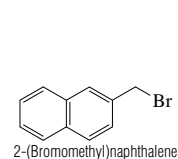
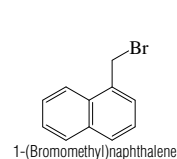
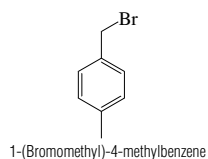
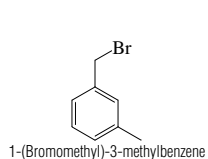
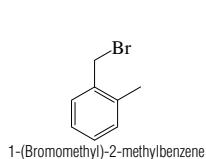
| No.  | Name                                             | Synonym                        | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                       |
|------|--------------------------------------------------|--------------------------------|---------------------------------------------------------------|------------|----------|--------------------|---------|-----------------------------------------|----------------------------|----------------------|--------------------------------------------------|
| 1175 | 5-Bromo- <i>N</i> ,2-dihydroxybenzamide          | 5-Bromosalicylhydroxamic acid  | C <sub>7</sub> H <sub>5</sub> BrNO <sub>3</sub>               | 5798-94-7  | 232.032  | cry (al)           | 232 dec |                                         |                            |                      |                                                  |
| 1176 | 2-Bromo-1,4-dimethoxybenzene                     |                                | C <sub>8</sub> H <sub>9</sub> BrO <sub>2</sub>                | 25245-34-5 | 217.060  | oil                |         | 262; 130 <sup>10</sup>                  | 1.445                      | 1.5700 <sup>20</sup> |                                                  |
| 1177 | 4-Bromo-1,2-dimethoxybenzene                     |                                | C <sub>8</sub> H <sub>9</sub> BrO <sub>2</sub>                | 2859-78-1  | 217.060  |                    |         | 254.5                                   | 1.702 <sup>25</sup>        | 1.5743 <sup>20</sup> |                                                  |
| 1178 | 2-Bromo-1,1-dimethoxyethane                      |                                | C <sub>4</sub> H <sub>9</sub> BrO <sub>2</sub>                | 7252-83-7  | 169.017  |                    |         | 149                                     | 1.430 <sup>20</sup>        | 1.4450 <sup>20</sup> | s eth, ace, chl                                  |
| 1179 | 4-Bromo- <i>N</i> , <i>N</i> -dimethylaniline    |                                | C <sub>8</sub> H <sub>10</sub> BrN                            | 586-77-6   | 200.076  |                    | 55      | 264                                     | 1.3220 <sup>100</sup>      |                      | i H <sub>2</sub> O; s EtOH; vs eth               |
| 1180 | 1-Bromo-2,4-dimethylbenzene                      |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 583-70-0   | 185.061  | liq                | -17     | 205                                     | 1.3419 <sup>20</sup>       | 1.5501 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace            |
| 1181 | 1-Bromo-3,5-dimethylbenzene                      |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 556-96-7   | 185.061  |                    |         | 204                                     | 1.362 <sup>20</sup>        | 1.5462 <sup>22</sup> | vs eth; s ace, bz                                |
| 1182 | 2-Bromo-1,3-dimethylbenzene                      |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 576-22-7   | 185.061  |                    |         | 203.5; 100 <sup>20</sup>                |                            | 1.5552 <sup>20</sup> | vs eth; s ace, bz                                |
| 1183 | 2-Bromo-1,4-dimethylbenzene                      |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 553-94-6   | 185.061  | lf or pl           | 9       | 199; 88 <sup>13</sup>                   | 1.3582 <sup>18</sup>       | 1.5514 <sup>18</sup> | i H <sub>2</sub> O; vs EtOH; s bz                |
| 1184 | 4-Bromo-1,2-dimethylbenzene                      |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 583-71-1   | 185.061  | liq                | -0.2    | 214.5                                   | 1.3708 <sup>20</sup>       | 1.5530 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                 |
| 1185 | <i>trans</i> -1-Bromo-3,7-dimethyl-2,6-octadiene | <i>trans</i> -Geranyl bromide  | C <sub>10</sub> H <sub>17</sub> Br                            | 6138-90-5  | 217.146  |                    |         | 101 <sup>12</sup> , 47 <sup>0.005</sup> | 1.0940 <sup>22</sup>       | 1.5027 <sup>20</sup> |                                                  |
| 1186 | 1-Bromo-2,2-dimethylpropane                      |                                | C <sub>5</sub> H <sub>11</sub> Br                             | 630-17-1   | 151.045  |                    |         | 106                                     | 1.1997 <sup>20</sup>       | 1.4370 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz; vs chl |
| 1187 | 2-Bromo-4,6-dinitroaniline                       |                                | C <sub>6</sub> H <sub>4</sub> BrN <sub>2</sub> O <sub>4</sub> | 1817-73-8  | 262.018  | ye nd (al or HOAc) | 153.5   | sub                                     |                            |                      | vs EtOH, ace; s HOAc                             |
| 1188 | 1-Bromo-2,4-dinitrobenzene                       |                                | C <sub>6</sub> H <sub>3</sub> BrN <sub>2</sub> O <sub>4</sub> | 584-48-5   | 247.003  | ye nd (al)         | 75      |                                         |                            |                      | vs EtOH                                          |
| 1189 | α-Bromodiphenylmethane                           |                                | C <sub>13</sub> H <sub>11</sub> Br                            | 776-74-9   | 247.130  |                    | 45      | 184 <sup>20</sup> , 152 <sup>2</sup>    |                            |                      | s EtOH, chl; vs bz                               |
| 1190 | 1-Bromododecane                                  | Lauryl bromide                 | C <sub>12</sub> H <sub>25</sub> Br                            | 143-15-7   | 249.231  | liq                | -9.5    | 276                                     | 1.0399 <sup>20</sup>       | 1.4583 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc; msc ace    |
| 1191 | 2-Bromododecanoic acid                           |                                | C <sub>12</sub> H <sub>23</sub> BrO <sub>2</sub>              | 111-56-8   | 279.214  | pl                 | 32      | 158 <sup>2</sup>                        | 1.1474 <sup>74</sup>       | 1.4585 <sup>24</sup> | vs bz, eth, EtOH, lig                            |
| 1192 | Bromoethane                                      | Ethyl bromide                  | C <sub>2</sub> H <sub>5</sub> Br                              | 74-96-4    | 108.965  | liq                | -118.6  | 38.5                                    | 1.4604 <sup>20</sup>       | 1.4239 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, chl          |
| 1193 | 2-Bromoethanol                                   | Ethylene bromohydrin           | C <sub>2</sub> H <sub>5</sub> BrO                             | 540-51-2   | 124.964  |                    |         | 150; 51 <sup>4</sup>                    | 1.7629 <sup>20</sup>       | 1.4915 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; sl lig          |
| 1194 | Bromoethene                                      | Vinyl bromide                  | C <sub>2</sub> H <sub>3</sub> Br                              | 593-60-2   | 106.949  | vol liq or gas     | -139.54 | 15.8                                    | 1.4933 <sup>20</sup>       | 1.4380 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl    |
| 1195 | 1-Bromo-2-ethoxybenzene                          |                                | C <sub>8</sub> H <sub>9</sub> BrO                             | 583-19-7   | 201.060  |                    |         | 223                                     | 1.4223 <sup>20</sup>       |                      | vs eth, EtOH                                     |
| 1196 | 1-Bromo-4-ethoxybenzene                          |                                | C <sub>8</sub> H <sub>9</sub> BrO                             | 588-96-5   | 201.060  |                    | 2.0     | 231                                     | 1.4071 <sup>25</sup>       | 1.5517 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s chl          |
| 1197 | (2-Bromoethoxy)benzene                           |                                | C <sub>8</sub> H <sub>9</sub> BrO                             | 589-10-6   | 201.060  |                    | 39      | dec 240; 128 <sup>20</sup>              | 1.3555 <sup>20</sup>       |                      | i H <sub>2</sub> O; vs EtOH, eth                 |
| 1198 | 1-Bromo-2-ethoxyethane                           | 2-Bromoethyl ethyl ether       | C <sub>4</sub> H <sub>9</sub> BrO                             | 592-55-2   | 153.017  |                    |         | 127.5                                   | 1.3852 <sup>20</sup>       | 1.4447 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth               |
| 1199 | 2-Bromoethyl acetate                             |                                | C <sub>4</sub> H <sub>7</sub> BrO <sub>2</sub>                | 927-68-4   | 167.002  | liq                | -13.8   | 162.5                                   | 1.514 <sup>20</sup>        | 1.457 <sup>23</sup>  | vs H <sub>2</sub> O, chl; msc EtOH, eth          |
| 1200 | 2-Bromoethylamine hydrobromide                   | 2-Bromoethanamine hydrobromide | C <sub>2</sub> H <sub>7</sub> Br <sub>2</sub> N               | 2576-47-8  | 204.892  |                    | 174.0   |                                         |                            |                      |                                                  |
| 1201 | (1-Bromoethyl)benzene                            |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 585-71-7   | 185.061  |                    |         | 219; 92 <sup>11</sup>                   | 1.3535 <sup>25</sup>       | 1.5543 <sup>25</sup> |                                                  |
| 1202 | (2-Bromoethyl)benzene                            |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 103-63-9   | 185.061  | liq                | -55.9   | 219; 105 <sup>18</sup>                  | 1.3643 <sup>20</sup>       | 1.5372 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz; sl ctc            |
| 1203 | 1-Bromo-2-ethylbenzene                           |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 1973-22-4  | 185.061  | liq                | -67.9   | 199.3                                   | 1.3548 <sup>20</sup>       | 1.5472 <sup>20</sup> | vs ace, bz, eth, EtOH                            |
| 1204 | 1-Bromo-3-ethylbenzene                           |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 2725-82-8  | 185.061  |                    |         | 202                                     | 1.3493 <sup>20</sup>       | 1.5465 <sup>20</sup> |                                                  |
| 1205 | 1-Bromo-4-ethylbenzene                           |                                | C <sub>8</sub> H <sub>9</sub> Br                              | 1585-07-5  | 185.061  | liq                | -43.5   | 204                                     | 1.3423 <sup>20</sup>       | 1.5445 <sup>20</sup> | vs ace, bz, eth, EtOH                            |
| 1206 | (2-Bromoethyl)cyclohexane                        |                                | C <sub>8</sub> H <sub>15</sub> Br                             | 1647-26-3  | 191.109  | liq                | -57     | 212                                     | 1.2357 <sup>20</sup>       | 1.4899 <sup>20</sup> |                                                  |
| 1207 | <i>N</i> -(2-Bromoethyl)phthalimide              |                                | C <sub>10</sub> H <sub>9</sub> BrNO <sub>2</sub>              | 574-98-1   | 254.081  | nd (w)             | 83      |                                         |                            |                      | vs eth; sl chl                                   |
| 1208 | 1-Bromo-4-ethynylbenzene                         |                                | C <sub>8</sub> H <sub>7</sub> Br                              | 766-96-1   | 181.030  |                    | 64.5    | 89 <sup>16</sup>                        |                            |                      | s chl                                            |
| 1209 | 1-Bromo-2-fluorobenzene                          |                                | C <sub>6</sub> H <sub>4</sub> BrF                             | 1072-85-1  | 174.998  |                    |         | 154                                     | 1.0738 <sup>21</sup>       | 1.5337 <sup>20</sup> |                                                  |
| 1210 | 1-Bromo-3-fluorobenzene                          |                                | C <sub>6</sub> H <sub>4</sub> BrF                             | 1073-06-9  | 174.998  |                    |         | 150                                     | 1.7081 <sup>20</sup>       | 1.5257 <sup>20</sup> | s ctc                                            |
| 1211 | 1-Bromo-4-fluorobenzene                          |                                | C <sub>6</sub> H <sub>4</sub> BrF                             | 460-00-4   | 174.998  | liq                | -17.4   | 151.5                                   | 1.593 <sup>15</sup>        | 1.5310 <sup>15</sup> | i H <sub>2</sub> O; s EtOH, eth, chl             |
| 1212 | 1-Bromo-2-fluoroethane                           |                                | C <sub>2</sub> H <sub>4</sub> BrF                             | 762-49-2   | 126.955  |                    |         | 71.5                                    | 1.7044 <sup>25</sup>       | 1.4236 <sup>20</sup> | vs eth, EtOH                                     |
| 1213 | Bromofluoromethane                               |                                | CH <sub>2</sub> BrF                                           | 373-52-4   | 112.929  | vol liq or gas     |         | 19                                      |                            |                      | s EtOH; vs chl                                   |
| 1214 | 2-Bromofuran                                     |                                | C <sub>4</sub> H <sub>3</sub> BrO                             | 584-12-3   | 146.970  |                    |         | 103                                     | 1.6500 <sup>20</sup>       | 1.4980 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz        |
| 1215 | 3-Bromofuran                                     |                                | C <sub>4</sub> H <sub>3</sub> BrO                             | 22037-28-1 | 146.970  |                    |         | 103                                     | 1.6606 <sup>20</sup>       | 1.4958 <sup>20</sup> | vs ace, bz, eth, EtOH                            |
| 1216 | 5-Bromo-2-furancarboxaldehyde                    |                                | C <sub>5</sub> H <sub>3</sub> BrO <sub>2</sub>                | 1899-24-7  | 174.981  | cry (50% al)       | 83.5    | 201; 112 <sup>16</sup>                  |                            |                      | vs eth, EtOH                                     |
| 1217 | 1-Bromoheptadecane                               |                                | C <sub>17</sub> H <sub>35</sub> Br                            | 3508-00-7  | 319.364  |                    | 29.6    | 349                                     | 0.9916 <sup>20</sup>       | 1.4625 <sup>20</sup> | i H <sub>2</sub> O; vs chl                       |
| 1218 | 1-Bromoheptane                                   | Heptyl bromide                 | C <sub>7</sub> H <sub>15</sub> Br                             | 629-04-9   | 179.098  | liq                | -56.1   | 178.9                                   | 1.1400 <sup>20</sup>       | 1.4502 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; sl ctc; s chl  |



| No.  | Name                                     | Synonym                    | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form          | mp/°C  | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                               |
|------|------------------------------------------|----------------------------|--------------------------------------------------|------------|----------|------------------------|--------|---------------------------|----------------------------|-----------------------|----------------------------------------------------------|
| 1219 | 2-Bromoheptane                           | 2-Heptyl bromide           | C <sub>7</sub> H <sub>15</sub> Br                | 1974-04-5  | 179.098  |                        | 47     | 166                       | 1.1277 <sup>20</sup>       | 1.4503 <sup>20</sup>  | i H <sub>2</sub> O; vs bz; s ctc, chl                    |
| 1220 | 4-Bromoheptane                           | 4-Heptyl bromide           | C <sub>7</sub> H <sub>15</sub> Br                | 998-93-6   | 179.098  |                        |        | 161; 84 <sup>72</sup>     | 1.1351 <sup>20</sup>       | 1.4495 <sup>20</sup>  | i H <sub>2</sub> O; s bz, ctc, chl                       |
| 1221 | 1-Bromohexadecane                        |                            | C <sub>16</sub> H <sub>33</sub> Br               | 112-82-3   | 305.337  |                        | 18     | 336                       | 0.9991 <sup>20</sup>       | 1.4618 <sup>25</sup>  | i H <sub>2</sub> O; s eth                                |
| 1222 | 2-Bromohexadecanoic acid                 |                            | C <sub>16</sub> H <sub>31</sub> BrO <sub>2</sub> | 18263-25-7 | 335.320  |                        | 52.8   |                           |                            |                       |                                                          |
| 1223 | 1-Bromohexane                            | Hexyl bromide              | C <sub>6</sub> H <sub>13</sub> Br                | 111-25-1   | 165.071  | liq                    | -83.7  | 155.3                     | 1.1744 <sup>20</sup>       | 1.4478 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s ace; vs chl         |
| 1224 | 2-Bromohexane                            |                            | C <sub>6</sub> H <sub>13</sub> Br                | 3377-86-4  | 165.071  |                        |        | 143; 78 <sup>90</sup>     | 1.1658 <sup>20</sup>       | 1.4832 <sup>25</sup>  | i H <sub>2</sub> O; vs EtOH; s eth, ace; sl ctc          |
| 1225 | 3-Bromohexane                            |                            | C <sub>6</sub> H <sub>13</sub> Br                | 3377-87-5  | 165.071  |                        |        | 142                       | 1.1799 <sup>20</sup>       | 1.4472 <sup>20</sup>  | vs ace, eth, EtOH, chl                                   |
| 1226 | 2-Bromohexanoic acid, (±)                |                            | C <sub>6</sub> H <sub>11</sub> BrO <sub>2</sub>  | 2681-83-6  | 195.054  |                        | 2.0    | 240; 140 <sup>23</sup>    | 1.2810 <sup>33</sup>       |                       | s EtOH, eth                                              |
| 1227 | 6-Bromohexanoic acid                     |                            | C <sub>6</sub> H <sub>11</sub> BrO <sub>2</sub>  | 4224-70-8  | 195.054  | cry (peth)             | 35     | 167 <sup>20</sup>         |                            |                       | vs peth                                                  |
| 1228 | 6-Bromohexanoyl chloride                 |                            | C <sub>6</sub> H <sub>10</sub> BrClO             | 22809-37-6 | 213.499  |                        |        | 101 <sup>6</sup>          |                            |                       |                                                          |
| 1229 | 1-Bromo-4-(hexyloxy)benzene              |                            | C <sub>12</sub> H <sub>17</sub> BrO              | 30752-19-3 | 257.166  |                        |        | 156 <sup>13</sup>         | 1.2306 <sup>20</sup>       | 1.5262 <sup>20</sup>  |                                                          |
| 1230 | 5-Bromo-2-hydroxybenzaldehyde            |                            | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>   | 1761-61-1  | 201.018  | nd (al), lf (eth)      | 105.5  |                           |                            |                       | i H <sub>2</sub> O; s EtOH, eth; sl chl                  |
| 1231 | 4-Bromo-α-hydroxybenzeneacetic acid, (±) | p-Bromomandelic acid       | C <sub>8</sub> H <sub>7</sub> BrO <sub>3</sub>   | 7021-04-7  | 231.044  |                        | 119    |                           |                            |                       | vs H <sub>2</sub> O, EtOH, eth, bz, chl                  |
| 1232 | 5-Bromo-2-hydroxybenzenemethanol         | Bromosaligenin             | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>   | 2316-64-5  | 203.034  | lf (bz)                | 113    |                           |                            |                       | vs bz, eth, EtOH, chl                                    |
| 1233 | 5-Bromo-2-hydroxybenzoic acid            |                            | C <sub>7</sub> H <sub>5</sub> BrO <sub>3</sub>   | 89-55-4    | 217.017  | nd (w, dil al)         | 169.8  | sub 100                   |                            |                       | sl H <sub>2</sub> O, ace; vs EtOH, eth                   |
| 1234 | 3-Bromo-4-hydroxy-5-methoxybenzaldehyde  |                            | C <sub>8</sub> H <sub>7</sub> BrO <sub>3</sub>   | 2973-76-4  | 231.044  | pl (HOAc), nd, pl (al) | 167.0  |                           |                            |                       | i H <sub>2</sub> O; s EtOH, DMSO; sl eth, bz             |
| 1235 | 1-Bromo-2-iodobenzene                    |                            | C <sub>6</sub> H <sub>4</sub> BrI                | 583-55-1   | 282.904  |                        | 9.5    | 257; 120 <sup>15</sup>    | 2.2570 <sup>25</sup>       | 1.6618 <sup>25</sup>  | i H <sub>2</sub> O; sl EtOH, HOAc; s ace                 |
| 1236 | 1-Bromo-3-iodobenzene                    |                            | C <sub>6</sub> H <sub>4</sub> BrI                | 591-18-4   | 282.904  | liq                    | -9.3   | 252; 120 <sup>18</sup>    |                            |                       | i H <sub>2</sub> O; sl EtOH, HOAc                        |
| 1237 | 1-Bromo-4-iodobenzene                    |                            | C <sub>6</sub> H <sub>4</sub> BrI                | 589-87-7   | 282.904  | pr or pl (eth-al)      | 92     | 252                       |                            |                       | i H <sub>2</sub> O; sl EtOH, chl; s eth                  |
| 1238 | Bromiodomethane                          |                            | CH <sub>2</sub> BrI                              | 557-68-6   | 220.835  |                        |        | 139.5                     | 2.926 <sup>17</sup>        | 1.6410 <sup>20</sup>  | vs chl                                                   |
| 1239 | 1-Bromo-4-isocyanatobenzene              | p-Bromophenyl isocyanate   | C <sub>7</sub> H <sub>4</sub> BrNO               | 2493-02-9  | 198.017  | nd                     |        | 226                       |                            |                       | vs eth                                                   |
| 1240 | 1-Bromo-4-isopropylbenzene               |                            | C <sub>9</sub> H <sub>11</sub> Br                | 586-61-8   | 199.087  | liq                    | -22.5  | 218.7                     | 1.3145 <sup>20</sup>       | 1.5569 <sup>20</sup>  | i H <sub>2</sub> O; s eth, bz, chl; sl ctc               |
| 1241 | 4-Bromoisquinoline                       |                            | C <sub>9</sub> H <sub>6</sub> BrN                | 1532-97-4  | 208.055  | cry (peth)             | 41.5   | 282.5                     |                            |                       | vs eth                                                   |
| 1242 | Bromomethane                             | Methyl bromide             | CH <sub>3</sub> Br                               | 74-83-9    | 94.939   | col gas                | -93.68 | 3.5                       | 1.6755 <sup>20</sup>       | 1.4218 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth, chl, CS <sub>2</sub> |
| 1243 | 1-Bromo-2-methoxyethane                  |                            | C <sub>3</sub> H <sub>7</sub> BrO                | 6482-24-2  | 138.991  |                        |        | 110                       | 1.4623 <sup>20</sup>       | 1.44753 <sup>20</sup> |                                                          |
| 1244 | Bromomethoxymethane                      |                            | C <sub>2</sub> H <sub>5</sub> BrO                | 13057-17-5 | 124.964  |                        |        | 87                        | 1.5976 <sup>20</sup>       | 1.4562 <sup>20</sup>  |                                                          |
| 1245 | 2-Bromo-4-methylaniline                  |                            | C <sub>7</sub> H <sub>8</sub> BrN                | 583-68-6   | 186.050  | lf                     | 26     | 240                       | 1.510 <sup>20</sup>        | 1.5999 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                          |
| 1246 | 4-Bromo-2-methylaniline                  |                            | C <sub>7</sub> H <sub>8</sub> BrN                | 583-75-5   | 186.050  | cry (al)               | 59.5   | 240                       |                            |                       | sl H <sub>2</sub> O, chl; s EtOH; vs eth, HOAc           |
| 1247 | (Bromomethyl)benzene                     | Benzyl bromide             | C <sub>7</sub> H <sub>7</sub> Br                 | 100-39-0   | 171.035  | liq                    | -1.5   | 201                       | 1.4380 <sup>25</sup>       | 1.5752 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s ctc                 |
| 1248 | 4-(Bromomethyl)benzoic acid              |                            | C <sub>8</sub> H <sub>7</sub> BrO <sub>2</sub>   | 6232-88-8  | 215.045  |                        | 226.3  |                           |                            |                       |                                                          |
| 1249 | 3-(Bromomethyl)benzonitrile              |                            | C <sub>8</sub> H <sub>6</sub> BrN                | 28188-41-2 | 196.045  |                        | 96.5   | 130 <sup>4</sup>          |                            |                       |                                                          |
| 1250 | 4-(Bromomethyl)benzonitrile              |                            | C <sub>8</sub> H <sub>6</sub> BrN                | 17201-43-3 | 196.045  |                        | 114    |                           |                            |                       |                                                          |
| 1251 | 1-Bromo-2-methylbutane, DL               |                            | C <sub>6</sub> H <sub>11</sub> Br                | 5973-11-5  | 151.045  |                        |        | 119                       | 1.2205 <sup>20</sup>       | 1.4452 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; vs chl                  |
| 1252 | 1-Bromo-3-methylbutane                   | Isopentyl bromide          | C <sub>6</sub> H <sub>11</sub> Br                | 107-82-4   | 151.045  | liq                    | -112   | 120.4                     | 1.2071 <sup>20</sup>       | 1.4420 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl ctc; vs chl          |
| 1253 | 2-Bromo-2-methylbutane                   | tert-Pentyl bromide        | C <sub>6</sub> H <sub>11</sub> Br                | 507-36-8   | 151.045  |                        |        | 108                       | 1.197 <sup>18</sup>        | 1.4421                |                                                          |
| 1254 | 3-Bromo-3-methylbutanoic acid            | β-Bromoisovaleric acid     | C <sub>6</sub> H <sub>9</sub> BrO <sub>2</sub>   | 5798-88-9  | 181.028  | nd (lig)               | 74     |                           |                            |                       | vs bz, eth, EtOH                                         |
| 1255 | 1-Bromo-3-methyl-2-butene                |                            | C <sub>6</sub> H <sub>9</sub> Br                 | 870-63-3   | 149.029  |                        |        | dec 131; 50 <sup>40</sup> | 1.2930 <sup>15</sup>       | 1.4930 <sup>15</sup>  | vs ace, bz, eth, EtOH                                    |
| 1256 | 1-(Bromomethyl)-2-chlorobenzene          |                            | C <sub>7</sub> H <sub>5</sub> BrCl               | 611-17-6   | 205.480  |                        |        | 109 <sup>10</sup>         |                            |                       |                                                          |
| 1257 | (Bromomethyl)chlorodimethylsilane        |                            | C <sub>3</sub> H <sub>6</sub> BrClSi             | 16532-02-8 | 187.539  |                        |        | 131                       | 1.375 <sup>25</sup>        | 1.4630 <sup>25</sup>  |                                                          |
| 1258 | 1-Bromo-3-methylcyclohexane              | 3-Methylcyclohexyl bromide | C <sub>7</sub> H <sub>13</sub> Br                | 13905-48-1 | 177.082  |                        |        | 181; 60 <sup>11</sup>     | 1.2676 <sup>15</sup>       | 1.4979 <sup>20</sup>  | i H <sub>2</sub> O; vs eth; s bz                         |
| 1259 | (Bromomethyl)cyclohexane                 |                            | C <sub>7</sub> H <sub>13</sub> Br                | 2550-36-9  | 177.082  |                        |        | 76 <sup>25</sup>          | 1.283 <sup>20</sup>        | 1.4907 <sup>20</sup>  | vs bz, eth, chl                                          |
| 1260 | 1-(Bromomethyl)-3-fluorobenzene          |                            | C <sub>7</sub> H <sub>6</sub> BrF                | 456-41-7   | 189.025  |                        |        | 88 <sup>20</sup>          |                            | 1.5474 <sup>20</sup>  |                                                          |
| 1261 | 3-(Bromomethyl)heptane                   |                            | C <sub>8</sub> H <sub>17</sub> Br                | 18908-66-2 | 193.125  |                        |        | 67 <sup>10</sup>          |                            |                       |                                                          |

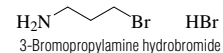
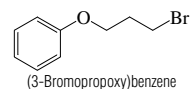
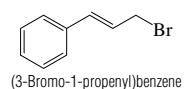
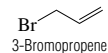
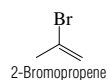
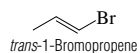
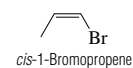
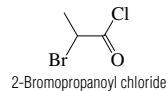
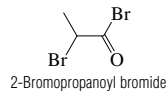
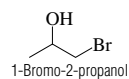
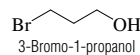
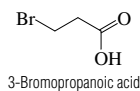
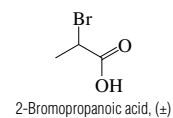
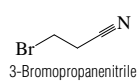
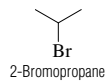
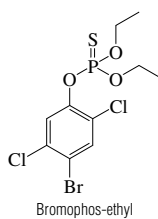
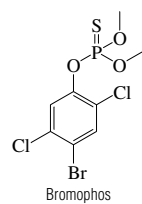
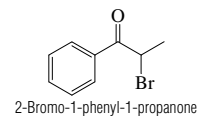
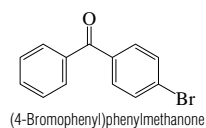
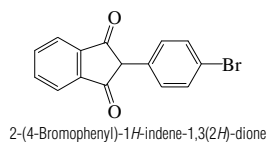
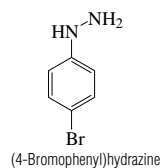
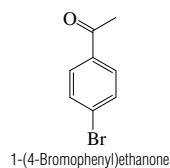
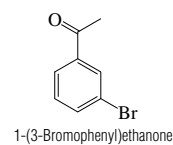
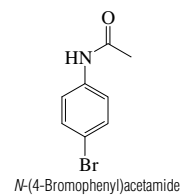
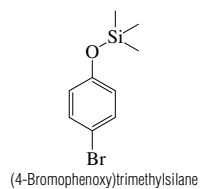
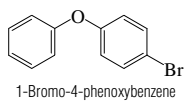
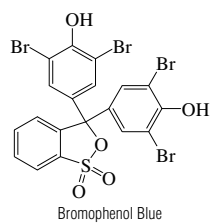
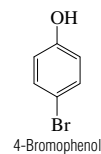
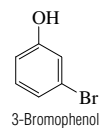
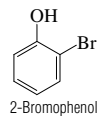
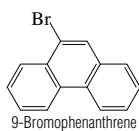
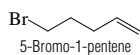
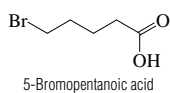
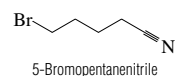
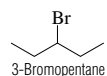
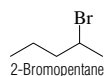
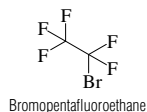
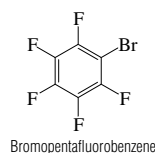


| No.  | Name                                          | Synonym                                    | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|-----------------------------------------------|--------------------------------------------|---------------------------------------------------------------|------------|----------|----------------------------|-------|----------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 1262 | 1-(Bromomethyl)-2-methylbenzene               |                                            | C <sub>8</sub> H <sub>9</sub> Br                              | 89-92-9    | 185.061  | pr                         | 21    | 217; 108 <sup>16</sup>                 | 1.3811 <sup>23</sup>       | 1.5730 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz                      |
| 1263 | 1-(Bromomethyl)-3-methylbenzene               |                                            | C <sub>8</sub> H <sub>9</sub> Br                              | 620-13-3   | 185.061  |                            |       | 212.5                                  | 1.3711 <sup>23</sup>       | 1.5660 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                              |
| 1264 | 1-(Bromomethyl)-4-methylbenzene               |                                            | C <sub>8</sub> H <sub>9</sub> Br                              | 104-81-4   | 185.061  | nd (al)                    | 35    | 220                                    | 1.324 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH; vs eth, chl                       |
| 1265 | 1-(Bromomethyl)naphthalene                    |                                            | C <sub>11</sub> H <sub>9</sub> Br                             | 3163-27-7  | 221.093  | cry (peth, al)             | 56    | 183 <sup>18</sup> , 167 <sup>10</sup>  |                            |                      | vs ace, bz, eth, EtOH                                         |
| 1266 | 2-(Bromomethyl)naphthalene                    |                                            | C <sub>11</sub> H <sub>9</sub> Br                             | 939-26-4   | 221.093  | lf (al)                    | 56    | 213 <sup>100</sup> , 167 <sup>14</sup> |                            |                      | s EtOH, eth, chl, HOAc                                        |
| 1267 | 1-(Bromomethyl)-3-nitrobenzene                |                                            | C <sub>7</sub> H <sub>6</sub> BrNO <sub>2</sub>               | 3958-57-4  | 216.033  | nd or pl (al)              | 59.3  | 162 <sup>13</sup>                      |                            |                      | i H <sub>2</sub> O; s EtOH                                    |
| 1268 | 1-(Bromomethyl)-4-nitrobenzene                |                                            | C <sub>7</sub> H <sub>6</sub> BrNO <sub>2</sub>               | 100-11-8   | 216.033  | nd (al)                    | 99.5  |                                        |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth; s HOAc                |
| 1269 | 2-(Bromomethyl)-4-nitrophenol                 |                                            | C <sub>7</sub> H <sub>6</sub> BrNO <sub>3</sub>               | 772-33-8   | 232.032  |                            | 148   |                                        |                            |                      |                                                               |
| 1270 | (Bromomethyl)oxirane, (±)                     |                                            | C <sub>3</sub> H <sub>5</sub> BrO                             | 82584-73-4 | 136.975  | liq                        | -40   | 137                                    | 1.615 <sup>14</sup>        | 1.4841 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl                      |
| 1271 | 1-Bromo-2-methylpentane                       | 2-Methylpentyl bromide                     | C <sub>6</sub> H <sub>13</sub> Br                             | 25346-33-2 | 165.071  |                            |       | 141                                    | 1.1624 <sup>20</sup>       | 1.4495 <sup>20</sup> | vs eth, chl                                                   |
| 1272 | 1-Bromo-4-methylpentane                       |                                            | C <sub>6</sub> H <sub>13</sub> Br                             | 626-88-0   | 165.071  |                            |       | 145                                    | 1.1683 <sup>20</sup>       | 1.4490               | vs eth, chl                                                   |
| 1273 | 2-Bromo-2-methylpentane                       |                                            | C <sub>6</sub> H <sub>13</sub> Br                             | 4283-80-1  | 165.071  |                            |       | 142.5; 70 <sup>100</sup>               |                            | 1.442 <sup>23</sup>  | vs eth, chl                                                   |
| 1274 | 3-Bromo-3-methylpentane                       |                                            | C <sub>6</sub> H <sub>13</sub> Br                             | 25346-31-0 | 165.071  |                            |       | 130; 76 <sup>100</sup>                 | 1.1835 <sup>20</sup>       | 1.4525 <sup>20</sup> | vs eth, chl                                                   |
| 1275 | 2-Bromo-4-methylphenol                        |                                            | C <sub>7</sub> H <sub>7</sub> BrO                             | 6627-55-0  | 187.034  | nd (peth)                  | 56.5  | 213.5                                  | 1.5422 <sup>25</sup>       | 1.5772 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, bz, chl                          |
| 1276 | 1-(Bromomethyl)-3-phenoxybenzene              | 3-Phenoxybenzyl bromide                    | C <sub>13</sub> H <sub>11</sub> BrO                           | 51632-16-7 | 263.129  | oil                        |       |                                        |                            |                      |                                                               |
| 1277 | 2-Bromo-1-(4-methylphenyl)ethanone            |                                            | C <sub>9</sub> H <sub>9</sub> BrO                             | 619-41-0   | 213.070  | nd or lf (al)              | 51    | 157 <sup>14</sup>                      |                            |                      | vs eth, EtOH                                                  |
| 1278 | N-(Bromomethyl)phthalimide                    | 2-(Bromomethyl)-1H-isoindole-1,3(2H)-dione | C <sub>9</sub> H <sub>6</sub> BrNO <sub>2</sub>               | 5332-26-3  | 240.054  | pr (chl, bz)               | 151.5 |                                        |                            |                      | s ace; sl bz, chl; vs AcOEt                                   |
| 1279 | 1-Bromo-2-methylpropane                       | Isobutyl bromide                           | C <sub>4</sub> H <sub>9</sub> Br                              | 78-77-3    | 137.018  | liq                        | -119  | 91.1                                   | 1.272 <sup>15</sup>        | 1.4348 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace, chl, bz; s ctc         |
| 1280 | 2-Bromo-2-methylpropane                       | tert-Butyl bromide                         | C <sub>4</sub> H <sub>9</sub> Br                              | 507-19-7   | 137.018  | liq                        | -16.2 | 73.3                                   | 1.4278 <sup>20</sup>       | 1.4278 <sup>20</sup> | i H <sub>2</sub> O; sl ctc                                    |
| 1281 | 2-Bromo-2-methylpropanoic acid                | α-Bromoisobutyric acid                     | C <sub>4</sub> H <sub>7</sub> BrO <sub>2</sub>                | 2052-01-9  | 167.002  | cry (peth)                 | 48.5  | 199; 115 <sup>24</sup>                 | 1.4969 <sup>20</sup>       |                      |                                                               |
| 1282 | 2-Bromo-2-methylpropanoyl bromide             |                                            | C <sub>4</sub> H <sub>6</sub> Br <sub>2</sub> O               | 20769-85-1 | 229.898  |                            |       | 163                                    | 1.4067 <sup>14</sup>       |                      | vs ace, CS <sub>2</sub>                                       |
| 1283 | 1-Bromo-2-methylpropene                       |                                            | C <sub>4</sub> H <sub>7</sub> Br                              | 3017-69-4  | 135.003  |                            |       | 91                                     | 1.336 <sup>20</sup>        |                      |                                                               |
| 1284 | 3-Bromo-2-methylpropene                       |                                            | C <sub>4</sub> H <sub>7</sub> Br                              | 1458-98-6  | 135.003  |                            |       | 95                                     | 1.313 <sup>20</sup>        |                      |                                                               |
| 1285 | 2-(Bromomethyl)tetrahydrofuran                |                                            | C <sub>5</sub> H <sub>9</sub> BrO                             | 1192-30-9  | 165.028  |                            |       | 170; 70 <sup>22</sup>                  | 1.4679 <sup>20</sup>       | 1.4850 <sup>20</sup> | s EtOH, eth                                                   |
| 1286 | (Bromomethyl)trimethylsilane                  |                                            | C <sub>4</sub> H <sub>11</sub> BrSi                           | 18243-41-9 | 167.120  |                            |       | 116.5                                  | 1.170 <sup>25</sup>        | 1.4460 <sup>20</sup> |                                                               |
| 1287 | 1-Bromonaphthalene                            | 1-Naphthyl bromide                         | C <sub>10</sub> H <sub>7</sub> Br                             | 90-11-9    | 207.067  | oily liq                   | 6.1   | 281                                    | 1.4785 <sup>20</sup>       | 1.658 <sup>20</sup>  | s H <sub>2</sub> O, ace; msc EtOH, eth, bz; sl ctc            |
| 1288 | 2-Bromonaphthalene                            |                                            | C <sub>10</sub> H <sub>7</sub> Br                             | 580-13-2   | 207.067  | pl or orth lf (al)         | 55.9  | 281.5                                  | 1.605 <sup>25</sup>        | 1.6382 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, CS <sub>2</sub> ; sl ctc |
| 1289 | 4-Bromo-1,8-naphthalenedicarboxylic anhydride |                                            | C <sub>12</sub> H <sub>6</sub> BrO <sub>3</sub>               | 81-86-7    | 277.070  |                            | 222   |                                        |                            |                      |                                                               |
| 1290 | 1-Bromo-2-naphthol                            | 1-Bromo-β-naphthol                         | C <sub>10</sub> H <sub>7</sub> BrO                            | 573-97-7   | 223.066  | orth pr (bz-lig) nd (HOAc) | 84    | 130                                    |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz; sl chl; vs HOAc          |
| 1291 | 4-Bromo-2-nitroaniline                        |                                            | C <sub>6</sub> H <sub>6</sub> BrN <sub>2</sub> O <sub>2</sub> | 875-51-4   | 217.020  | oran-ye nd (w)             | 111.5 | sub                                    |                            |                      | vs EtOH                                                       |
| 1292 | 1-Bromo-2-nitrobenzene                        |                                            | C <sub>6</sub> H <sub>4</sub> BrNO <sub>2</sub>               | 577-19-5   | 202.006  | pa ye (al)                 | 43    | 258                                    | 1.6245 <sup>20</sup>       |                      | i H <sub>2</sub> O; vs EtOH; s eth, ace, bz; sl chl           |
| 1293 | 1-Bromo-3-nitrobenzene                        |                                            | C <sub>6</sub> H <sub>4</sub> BrNO <sub>2</sub>               | 585-79-5   | 202.006  | orth                       | 56    | 265                                    | 1.7036 <sup>20</sup>       | 1.5979 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, bz                          |
| 1294 | 1-Bromo-4-nitrobenzene                        | p-Nitrobromobenzene                        | C <sub>6</sub> H <sub>4</sub> BrNO <sub>2</sub>               | 586-78-7   | 202.006  | orth or mcl pr (al)        | 127   | 256                                    | 1.948 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, bz; sl chl                   |
| 1295 | Bromonitromethane                             |                                            | CH <sub>2</sub> BrNO <sub>2</sub>                             | 563-70-2   | 139.937  |                            |       | 149; 71 <sup>40</sup>                  |                            | 1.4880 <sup>20</sup> | vs EtOH                                                       |
| 1296 | 2-Bromo-2-nitro-1,3-propanediol               | Bronopol                                   | C <sub>3</sub> H <sub>6</sub> BrNO <sub>4</sub>               | 52-51-7    | 199.989  |                            | 131.5 |                                        |                            |                      |                                                               |
| 1297 | 1-Bromononane                                 |                                            | C <sub>9</sub> H <sub>19</sub> Br                             | 693-58-3   | 207.151  | liq                        | -29.0 | 221.4; 88 <sup>4</sup>                 | 1.0845 <sup>25</sup>       | 1.4522 <sup>25</sup> |                                                               |
| 1298 | 1-Bromooctadecane                             |                                            | C <sub>18</sub> H <sub>37</sub> Br                            | 112-89-0   | 333.391  | cry (al)                   | 28.2  | 362; 210 <sup>10</sup>                 | 0.9848 <sup>20</sup>       | 1.4631 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                       |
| 1299 | 1-Bromooctane                                 | Octyl bromide                              | C <sub>8</sub> H <sub>17</sub> Br                             | 111-83-1   | 193.125  | liq                        | -55.0 | 200.8                                  | 1.1072 <sup>25</sup>       | 1.4503 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl ctc                     |
| 1300 | 2-Bromooctane, (±)                            |                                            | C <sub>8</sub> H <sub>17</sub> Br                             | 60251-57-2 | 193.125  |                            |       | 188.5                                  | 1.0878 <sup>25</sup>       | 1.4442 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, eth                             |
| 1301 | 8-Bromooctanoic acid                          |                                            | C <sub>8</sub> H <sub>15</sub> BrO <sub>2</sub>               | 17696-11-6 | 223.108  | nd (peth)                  | 38.5  | 147 <sup>2</sup>                       |                            |                      | vs bz, eth, EtOH                                              |
| 1302 | 1-Bromopentadecane                            |                                            | C <sub>15</sub> H <sub>31</sub> Br                            | 629-72-1   | 291.311  |                            | 19    | 322                                    | 1.0675 <sup>20</sup>       | 1.4611 <sup>20</sup> | i H <sub>2</sub> O; s ace; vs chl                             |

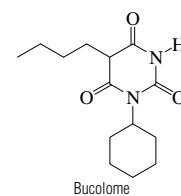
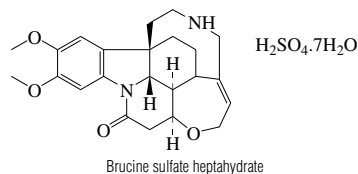
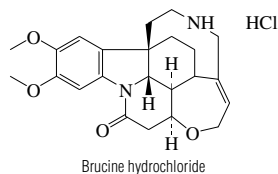
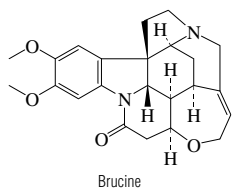
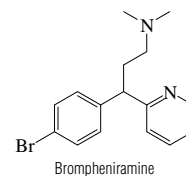
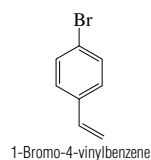
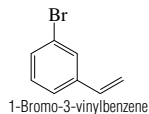
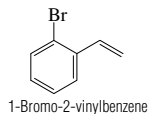
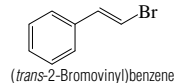
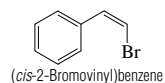
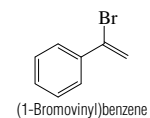
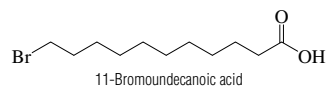
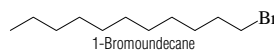
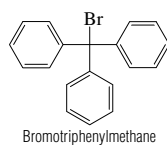
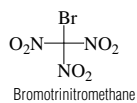
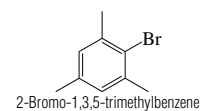
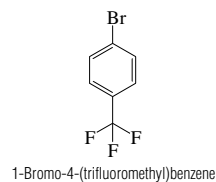
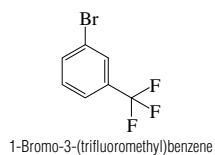
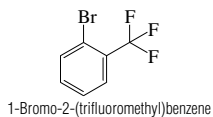
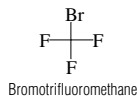
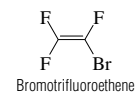
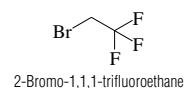
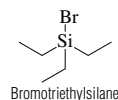
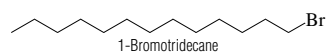
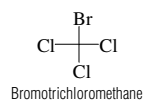
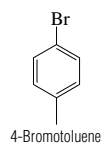
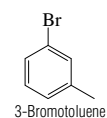
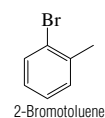
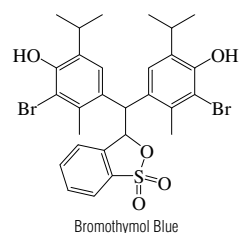
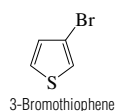
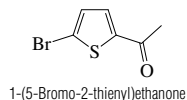
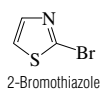
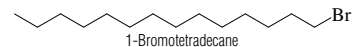
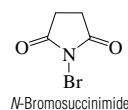
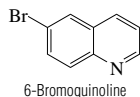
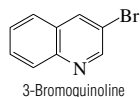
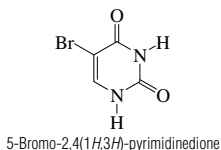
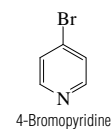
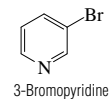
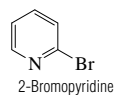
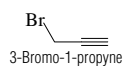
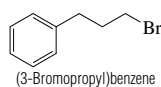
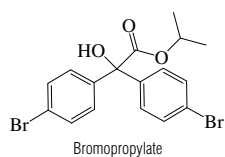




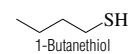
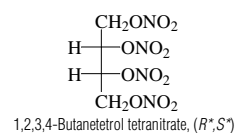
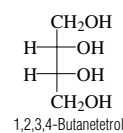
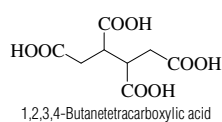
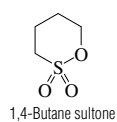
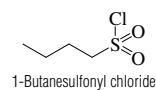
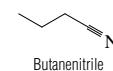
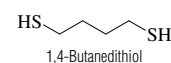
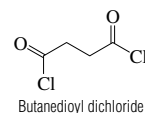
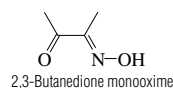
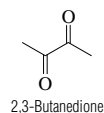
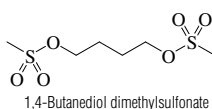
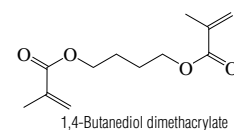
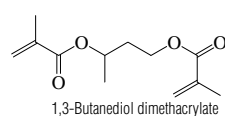
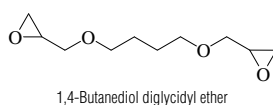
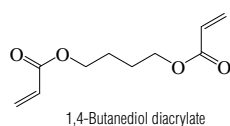
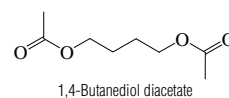
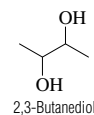
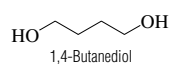
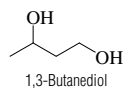
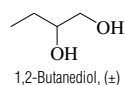
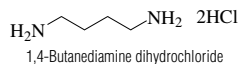
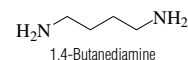
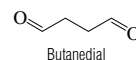
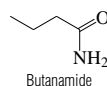
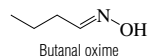
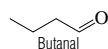
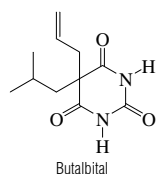
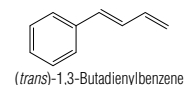
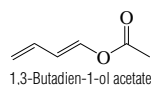
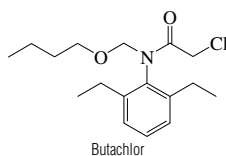
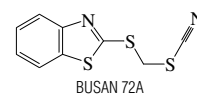
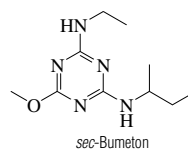
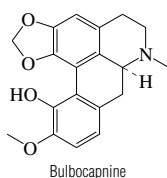
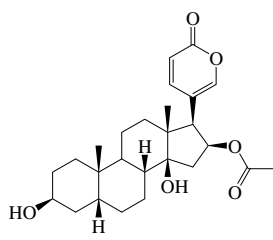
| No.  | Name                                                        | Synonym                            | Mol. Form.                                                          | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                     |
|------|-------------------------------------------------------------|------------------------------------|---------------------------------------------------------------------|------------|----------|----------------------------|---------|---------------------------------------|----------------------------|----------------------|----------------------------------------------------------------|
| 1303 | Bromopentafluorobenzene                                     |                                    | C <sub>6</sub> BrF <sub>5</sub>                                     | 344-04-7   | 246.960  | liq                        | -31     | 137                                   | 1.981 <sup>25</sup>        | 1.4490 <sup>20</sup> |                                                                |
| 1304 | Bromopentafluoroethane                                      |                                    | C <sub>2</sub> BrF <sub>5</sub>                                     | 354-55-2   | 198.917  | col gas                    |         | -21                                   | 1.8098 <sup>25</sup>       |                      |                                                                |
| 1305 | 1-Bromopentane                                              | Pentyl bromide                     | C <sub>5</sub> H <sub>11</sub> Br                                   | 110-53-2   | 151.045  | liq                        | -88.0   | 129.8                                 | 1.2182 <sup>20</sup>       | 1.4447 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, chl; sl ctc; msc eth           |
| 1306 | 2-Bromopentane                                              |                                    | C <sub>5</sub> H <sub>11</sub> Br                                   | 107-81-3   | 151.045  | liq                        | -95.5   | 117.4                                 | 1.2075 <sup>20</sup>       | 1.4413 <sup>20</sup> | vs bz, eth, EtOH, chl                                          |
| 1307 | 3-Bromopentane                                              |                                    | C <sub>5</sub> H <sub>11</sub> Br                                   | 1809-10-5  | 151.045  | liq                        | -126.2  | 118.6                                 | 1.214 <sup>20</sup>        | 1.4441 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl                       |
| 1308 | 5-Bromopentanenitrile                                       |                                    | C <sub>5</sub> H <sub>9</sub> BrN                                   | 5414-21-1  | 162.029  |                            |         | 111 <sup>12</sup> , 103 <sup>10</sup> | 1.3989 <sup>20</sup>       | 1.4780 <sup>20</sup> |                                                                |
| 1309 | 5-Bromopentanoic acid                                       |                                    | C <sub>5</sub> H <sub>9</sub> BrO <sub>2</sub>                      | 2067-33-6  | 181.028  |                            | 40.0    | 142 <sup>13</sup>                     |                            |                      | s chl                                                          |
| 1310 | 5-Bromo-1-pentene                                           |                                    | C <sub>5</sub> H <sub>9</sub> Br                                    | 1119-51-3  | 149.029  |                            |         | 125.5                                 | 1.2581 <sup>20</sup>       | 1.4640 <sup>20</sup> |                                                                |
| 1311 | 9-Bromophenanthrene                                         | 9-Phenanthryl bromide              | C <sub>14</sub> H <sub>9</sub> Br                                   | 573-17-1   | 257.125  | pr (al)                    | 64.5    | >360                                  | 1.4093 <sup>10</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub> ; sl chl      |
| 1312 | 2-Bromophenol                                               |                                    | C <sub>6</sub> H <sub>6</sub> BrO                                   | 95-56-7    | 173.007  |                            | 5.6     | 194.5                                 | 1.4924 <sup>20</sup>       | 1.589 <sup>20</sup>  | sl H <sub>2</sub> O, chl; s EtOH, eth, alk                     |
| 1313 | 3-Bromophenol                                               |                                    | C <sub>6</sub> H <sub>6</sub> BrO                                   | 591-20-8   | 173.007  |                            | 33      | 236.5                                 |                            |                      | sl H <sub>2</sub> O, ctc; vs EtOH, eth; s chl, alk             |
| 1314 | 4-Bromophenol                                               |                                    | C <sub>6</sub> H <sub>6</sub> BrO                                   | 106-41-2   | 173.007  |                            | 66.4    | 238                                   | 1.840 <sup>15</sup>        |                      | s H <sub>2</sub> O, chl; vs EtOH, eth                          |
| 1315 | Bromophenol Blue                                            | Bromphenol Blue                    | C <sub>19</sub> H <sub>10</sub> Br <sub>4</sub> O <sub>5</sub> S    | 115-39-9   | 669.960  | hex pr (HOAc-ace)          | 279 dec |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH, bz, HOAc                          |
| 1316 | 1-Bromo-4-phenoxybenzene                                    | 4-Bromophenyl phenyl ether         | C <sub>12</sub> H <sub>9</sub> BrO                                  | 101-55-3   | 249.102  |                            | 18.72   | 126 <sup>3,5</sup>                    | 1.6088 <sup>20</sup>       | 1.6084 <sup>20</sup> | i H <sub>2</sub> O; s eth, ctc                                 |
| 1317 | (4-Bromophenoxy)trimethylsilane                             |                                    | C <sub>8</sub> H <sub>13</sub> BrOSi                                | 17878-44-3 | 245.188  |                            |         | 126 <sup>25</sup>                     | 1.2619 <sup>20</sup>       | 1.5145 <sup>20</sup> |                                                                |
| 1318 | <i>N</i> -(4-Bromophenyl)acetamide                          | <i>p</i> -Bromoacetanilide         | C <sub>8</sub> H <sub>8</sub> BrNO                                  | 103-88-8   | 214.060  | nd (60% al)                | 168     |                                       | 1.717 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, chl; sl eth, bz                    |
| 1319 | 1-(3-Bromophenyl)ethanone                                   |                                    | C <sub>8</sub> H <sub>7</sub> BrO                                   | 2142-63-4  | 199.045  |                            | 7.5     | 133 <sup>19</sup>                     |                            | 1.5755 <sup>20</sup> | i H <sub>2</sub> O; s ace, bz                                  |
| 1320 | 1-(4-Bromophenyl)ethanone                                   | <i>p</i> -Bromoacetophenone        | C <sub>8</sub> H <sub>7</sub> BrO                                   | 99-90-1    | 199.045  | lf (al)                    | 50.5    | 257; 130 <sup>11</sup>                | 1.647 <sup>25</sup>        | 1.647                | i H <sub>2</sub> O; s EtOH, eth, bz, ctc, HOAc                 |
| 1321 | (4-Bromophenyl)hydrazine                                    | ( <i>p</i> -Bromophenyl)hydrazine  | C <sub>6</sub> H <sub>6</sub> BrN <sub>2</sub>                      | 589-21-9   | 187.037  | nd (w), lf (lig), cry (al) | 108     |                                       |                            |                      | vs eth, EtOH, lig                                              |
| 1322 | 2-(4-Bromophenyl)-1 <i>H</i> -indene-1,3(2 <i>H</i> )-dione | Bromindione                        | C <sub>15</sub> H <sub>9</sub> BrO <sub>2</sub>                     | 1146-98-1  | 301.135  | cry (lig)                  | 138     |                                       |                            |                      |                                                                |
| 1323 | (4-Bromophenyl)phenylmethanone                              |                                    | C <sub>13</sub> H <sub>9</sub> BrO                                  | 90-90-4    | 261.113  | lf (al)                    | 82.5    | 350                                   |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, bz, peth                     |
| 1324 | 2-Bromo-1-phenyl-1-propanone                                |                                    | C <sub>9</sub> H <sub>9</sub> BrO                                   | 2114-00-3  | 213.070  |                            |         | 247.5                                 | 1.4298 <sup>20</sup>       | 1.5720 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, ctc                  |
| 1325 | Bromophos                                                   |                                    | C <sub>8</sub> H <sub>6</sub> BrCl <sub>2</sub> PS                  | 2104-96-3  | 317.999  | ye cry                     | 54      | 141 <sup>0.01</sup>                   |                            |                      | sl H <sub>2</sub> O; s eth, ctc, tol                           |
| 1326 | Bromophos-ethyl                                             |                                    | C <sub>10</sub> H <sub>12</sub> BrCl <sub>2</sub> O <sub>3</sub> PS | 4824-78-6  | 394.049  | pale-ye liq                |         | 122 <sup>0.004</sup>                  |                            |                      |                                                                |
| 1327 | 1-Bromopropane                                              | Propyl bromide                     | C <sub>3</sub> H <sub>7</sub> Br                                    | 106-94-5   | 122.992  | liq                        | -110.3  | 71.1                                  | 1.3537 <sup>20</sup>       | 1.4343 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, chl, ctc            |
| 1328 | 2-Bromopropane                                              | Isopropyl bromide                  | C <sub>3</sub> H <sub>7</sub> Br                                    | 75-26-3    | 122.992  | liq                        | -89.0   | 59.5                                  | 1.3140 <sup>20</sup>       | 1.4251 <sup>20</sup> | sl H <sub>2</sub> O; s ace, bz, chl; msc EtOH, eth             |
| 1329 | 3-Bromopropanenitrile                                       |                                    | C <sub>3</sub> H <sub>5</sub> BrN                                   | 2417-90-5  | 133.975  |                            |         | 92 <sup>25</sup> , 69 <sup>7</sup>    | 1.6152 <sup>20</sup>       | 1.4800 <sup>20</sup> | vs EtOH, eth; sl ctc                                           |
| 1330 | 2-Bromopropanoic acid, (±)                                  |                                    | C <sub>3</sub> H <sub>5</sub> BrO <sub>2</sub>                      | 10327-08-9 | 152.975  | pr                         | 25.7    | 203.5                                 | 1.7000 <sup>20</sup>       | 1.4753 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; sl chl                         |
| 1331 | 3-Bromopropanoic acid                                       | β-Bromopropionic acid              | C <sub>3</sub> H <sub>5</sub> BrO <sub>2</sub>                      | 590-92-1   | 152.975  | pl (CCl <sub>4</sub> )     | 62.5    | 141 <sup>45</sup>                     | 1.48 <sup>25</sup>         |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl                         |
| 1332 | 3-Bromo-1-propanol                                          |                                    | C <sub>3</sub> H <sub>7</sub> BrO                                   | 627-18-9   | 138.991  |                            |         | 105 <sup>185</sup> , 80 <sup>22</sup> | 1.5374 <sup>20</sup>       | 1.4834 <sup>25</sup> | s H <sub>2</sub> O; msc EtOH, eth                              |
| 1333 | 1-Bromo-2-propanol                                          |                                    | C <sub>3</sub> H <sub>7</sub> BrO                                   | 19686-73-8 | 138.991  |                            |         | 146.5                                 | 1.5585 <sup>30</sup>       | 1.4801 <sup>20</sup> | s H <sub>2</sub> O; vs EtOH, eth                               |
| 1334 | 2-Bromopropanoyl bromide                                    |                                    | C <sub>3</sub> H <sub>5</sub> Br <sub>2</sub> O                     | 563-76-8   | 215.871  |                            |         | 153                                   | 2.0611 <sup>16</sup>       |                      |                                                                |
| 1335 | 2-Bromopropanoyl chloride                                   |                                    | C <sub>3</sub> H <sub>5</sub> BrClO                                 | 7148-74-5  | 171.420  |                            |         | 132                                   | 1.697 <sup>11</sup>        | 1.4780 <sup>20</sup> | s eth, chl; sl ctc                                             |
| 1336 | <i>cis</i> -1-Bromopropene                                  |                                    | C <sub>3</sub> H <sub>5</sub> Br                                    | 590-13-6   | 120.976  | liq                        | -113    | 57.8                                  | 1.4291 <sup>20</sup>       | 1.4560 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, chl                            |
| 1337 | <i>trans</i> -1-Bromopropene                                |                                    | C <sub>3</sub> H <sub>5</sub> Br                                    | 590-15-8   | 120.976  |                            |         | 63.2                                  |                            |                      |                                                                |
| 1338 | 2-Bromopropene                                              |                                    | C <sub>3</sub> H <sub>5</sub> Br                                    | 557-93-7   | 120.976  | liq                        | -126    | 48.4                                  | 1.3965 <sup>16</sup>       | 1.4467 <sup>16</sup> | i H <sub>2</sub> O; s eth, ace, chl                            |
| 1339 | 3-Bromopropene                                              | Allyl bromide                      | C <sub>3</sub> H <sub>5</sub> Br                                    | 106-95-6   | 120.976  | liq                        | -119    | 70.1                                  | 1.398 <sup>20</sup>        | 1.4697 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc, chl, CS <sub>2</sub> |
| 1340 | (3-Bromo-1-propenyl)benzene                                 |                                    | C <sub>9</sub> H <sub>9</sub> Br                                    | 4392-24-9  | 197.071  | nd (al, eth)               | 34      | 130 <sup>10</sup>                     | 1.3428 <sup>30</sup>       | 1.613 <sup>20</sup>  | vs EtOH                                                        |
| 1341 | (3-Bromopropoxy)benzene                                     |                                    | C <sub>9</sub> H <sub>11</sub> BrO                                  | 588-63-6   | 215.086  |                            | 10.7    | 127 <sup>18</sup>                     | 1.364 <sup>16</sup>        |                      | vs eth                                                         |
| 1342 | 3-Bromopropylamine hydrobromide                             | 3-Bromo-1-propanamine hydrobromide | C <sub>3</sub> H <sub>9</sub> Br <sub>2</sub> N                     | 5003-71-4  | 218.918  |                            | 171.5   |                                       |                            |                      |                                                                |



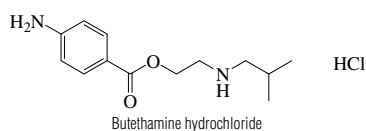
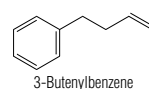
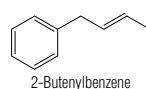
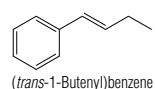
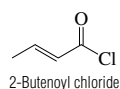
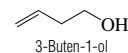
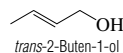
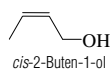
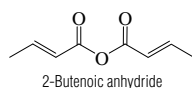
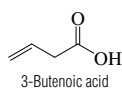
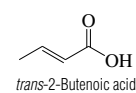
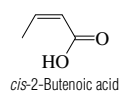
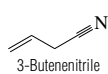
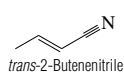
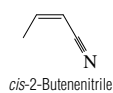
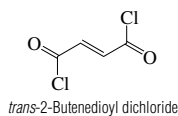
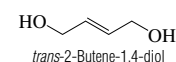
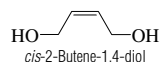
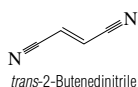
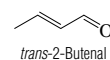
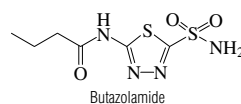
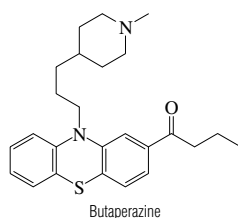
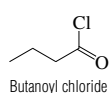
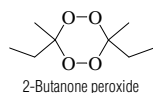
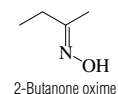
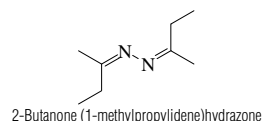
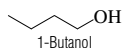
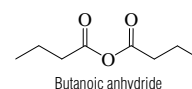
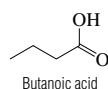
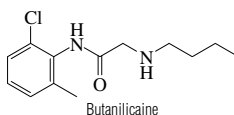
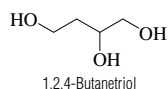
| No.  | Name                                                 | Synonym                                                                          | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form  | mp/°C | bp/°C                              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|------------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------------------------|------------|----------|----------------|-------|------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 1343 | Bromopropylate                                       | 4,4'-Dibromobenzilic acid isopropyl ester                                        | C <sub>17</sub> H <sub>16</sub> Br <sub>2</sub> O <sub>3</sub>   | 18181-80-1 | 428.115  |                | 77    |                                    | 1.59 <sup>20</sup>         |                      |                                                       |
| 1344 | (3-Bromopropyl)benzene                               |                                                                                  | C <sub>9</sub> H <sub>11</sub> Br                                | 637-59-2   | 199.087  |                |       | 219.5; 117 <sup>25</sup>           | 1.3106 <sup>25</sup>       | 1.5440 <sup>25</sup> | i H <sub>2</sub> O; vs eth                            |
| 1345 | 3-Bromo-1-propyne                                    | Propargyl bromide                                                                | C <sub>3</sub> H <sub>3</sub> Br                                 | 106-96-7   | 118.960  |                |       | 89                                 | 1.579 <sup>19</sup>        | 1.4922 <sup>20</sup> | s EtOH, eth, bz, ctc, chl                             |
| 1346 | 2-Bromopyridine                                      |                                                                                  | C <sub>5</sub> H <sub>4</sub> BrN                                | 109-04-6   | 157.997  | liq            | -40.1 | 193; 75 <sup>13</sup>              | 1.6337 <sup>20</sup>       | 1.5734 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc                 |
| 1347 | 3-Bromopyridine                                      |                                                                                  | C <sub>5</sub> H <sub>4</sub> BrN                                | 626-55-1   | 157.997  | liq            | -27.3 | 173; 69 <sup>18</sup>              | 1.645 <sup>0</sup>         | 1.5694 <sup>20</sup> | s H <sub>2</sub> O; vs EtOH, eth                      |
| 1348 | 4-Bromopyridine                                      |                                                                                  | C <sub>5</sub> H <sub>4</sub> BrN                                | 1120-87-2  | 157.997  |                | 0.5   | 29 <sup>0.4</sup>                  | 1.6450 <sup>0</sup>        | 1.5694 <sup>20</sup> | s ace, bz                                             |
| 1349 | 5-Bromo-2,4(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione | 5-Bromouracil                                                                    | C <sub>4</sub> H <sub>3</sub> BrN <sub>2</sub> O <sub>2</sub>    | 51-20-7    | 190.983  |                | 310   |                                    |                            |                      |                                                       |
| 1350 | 3-Bromoquinoline                                     |                                                                                  | C <sub>8</sub> H <sub>6</sub> BrN                                | 5332-24-1  | 208.055  | ye oil         | 13.3  | 275                                |                            | 1.6641 <sup>20</sup> | s chl; vs HOAc                                        |
| 1351 | 6-Bromoquinoline                                     |                                                                                  | C <sub>8</sub> H <sub>6</sub> BrN                                | 5332-25-2  | 208.055  |                | 24    | 281                                |                            |                      | s EtOH, eth, acid                                     |
| 1352 | <i>N</i> -Bromosuccinimide                           |                                                                                  | C <sub>4</sub> H <sub>4</sub> BrNO <sub>2</sub>                  | 128-08-5   | 177.985  | cry (bz)       | 174   |                                    | 2.098 <sup>25</sup>        |                      | sl H <sub>2</sub> O, AcOEt, eth; vs ace; i hx         |
| 1353 | 1-Bromotetradecane                                   |                                                                                  | C <sub>14</sub> H <sub>28</sub> Br                               | 112-71-0   | 277.284  |                | 5.6   | 307                                | 1.0170 <sup>20</sup>       | 1.4603 <sup>20</sup> | vs ace, bz, EtOH                                      |
| 1354 | 2-Bromothiazole                                      |                                                                                  | C <sub>3</sub> H <sub>2</sub> BrNS                               | 3034-53-5  | 164.024  |                |       | 171                                | 1.82 <sup>25</sup>         | 1.5927 <sup>20</sup> |                                                       |
| 1355 | 1-(5-Bromo-2-thienyl)ethanone                        |                                                                                  | C <sub>6</sub> H <sub>5</sub> BrOS                               | 5370-25-2  | 205.072  | nd (al)        | 94.5  | 103 <sup>4</sup>                   |                            |                      | sl EtOH; s ctc                                        |
| 1356 | 2-Bromothiophene                                     | 2-Thienyl bromide                                                                | C <sub>4</sub> H <sub>3</sub> BrS                                | 1003-09-4  | 163.036  |                |       | 150                                | 1.684 <sup>20</sup>        | 1.5868 <sup>20</sup> | i H <sub>2</sub> O; vs eth, ace; s ctc                |
| 1357 | 3-Bromothiophene                                     |                                                                                  | C <sub>4</sub> H <sub>3</sub> BrS                                | 872-31-1   | 163.036  |                |       | 159.5                              | 1.735 <sup>20</sup>        | 1.5919 <sup>20</sup> | i H <sub>2</sub> O; s ace, bz; sl chl                 |
| 1358 | Bromothymol Blue                                     | Bromthymol Blue                                                                  | C <sub>27</sub> H <sub>28</sub> Br <sub>2</sub> O <sub>5</sub> S | 76-59-5    | 624.381  |                | 201   |                                    |                            |                      | vs eth, EtOH                                          |
| 1359 | 2-Bromotoluene                                       |                                                                                  | C <sub>7</sub> H <sub>7</sub> Br                                 | 95-46-5    | 171.035  | liq            | -27.8 | 181.7                              | 1.4232 <sup>20</sup>       | 1.5565 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz; msc ctc         |
| 1360 | 3-Bromotoluene                                       |                                                                                  | C <sub>7</sub> H <sub>7</sub> Br                                 | 591-17-3   | 171.035  | liq            | -39.8 | 183.7                              | 1.4099 <sup>20</sup>       | 1.5510 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, chl; msc eth; sl ctc |
| 1361 | 4-Bromotoluene                                       |                                                                                  | C <sub>7</sub> H <sub>7</sub> Br                                 | 106-38-7   | 171.035  | cry (al)       | 28.5  | 184.3                              | 1.3959 <sup>35</sup>       | 1.5477 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl; sl ctc |
| 1362 | Bromotrichloromethane                                |                                                                                  | CBrCl <sub>3</sub>                                               | 75-62-7    | 198.274  | liq            | -5.65 | 105                                | 2.012 <sup>25</sup>        | 1.5065 <sup>20</sup> | vs eth, EtOH                                          |
| 1363 | 1-Bromotridecane                                     |                                                                                  | C <sub>13</sub> H <sub>27</sub> Br                               | 765-09-3   | 263.257  |                | 6.2   | 292                                | 1.0234 <sup>25</sup>       | 1.4574 <sup>25</sup> | i H <sub>2</sub> O; vs chl                            |
| 1364 | Bromotriethylsilane                                  |                                                                                  | C <sub>6</sub> H <sub>15</sub> BrSi                              | 1112-48-7  | 195.173  | liq            | -49.3 | 163; 66 <sup>24</sup>              | 1.143 <sup>20</sup>        | 1.4561 <sup>20</sup> |                                                       |
| 1365 | 2-Bromo-1,1,1-trifluoroethane                        |                                                                                  | C <sub>2</sub> H <sub>2</sub> BrF <sub>3</sub>                   | 421-06-7   | 162.936  | vol liq or gas | -93.9 | 26                                 | 1.7881 <sup>20</sup>       | 1.3331 <sup>20</sup> |                                                       |
| 1366 | Bromotrifluoroethene                                 |                                                                                  | C <sub>2</sub> BrF <sub>3</sub>                                  | 598-73-2   | 160.920  | col gas        |       | -2.5                               |                            |                      |                                                       |
| 1367 | Bromotrifluoromethane                                |                                                                                  | CBrF <sub>3</sub>                                                | 75-63-8    | 148.910  | col gas        | -172  | -57.8                              | 1.5800 <sup>20</sup>       |                      | i H <sub>2</sub> O; vs chl                            |
| 1368 | 1-Bromo-2-(trifluoromethyl)benzene                   |                                                                                  | C <sub>7</sub> H <sub>4</sub> BrF <sub>3</sub>                   | 392-83-6   | 225.006  |                |       | 167.5                              | 1.652 <sup>25</sup>        | 1.4817 <sup>20</sup> |                                                       |
| 1369 | 1-Bromo-3-(trifluoromethyl)benzene                   |                                                                                  | C <sub>7</sub> H <sub>4</sub> BrF <sub>3</sub>                   | 401-78-5   | 225.006  |                | 1     | 151.5                              | 1.613 <sup>25</sup>        | 1.4716 <sup>20</sup> |                                                       |
| 1370 | 1-Bromo-4-(trifluoromethyl)benzene                   |                                                                                  | C <sub>7</sub> H <sub>4</sub> BrF <sub>3</sub>                   | 402-43-7   | 225.006  |                |       | 160                                | 1.607 <sup>25</sup>        | 1.4705 <sup>25</sup> |                                                       |
| 1371 | 2-Bromo-1,3,5-trimethylbenzene                       |                                                                                  | C <sub>9</sub> H <sub>11</sub> Br                                | 576-83-0   | 199.087  | liq            | -1    | 225                                | 1.3191 <sup>10</sup>       | 1.5510 <sup>20</sup> | i H <sub>2</sub> O; vs eth; s bz; sl ctc              |
| 1372 | Bromotrinitromethane                                 |                                                                                  | CBrN <sub>3</sub> O <sub>6</sub>                                 | 560-95-2   | 229.931  |                | 17.5  | 56 <sup>10</sup>                   | 2.0312 <sup>20</sup>       | 1.4808 <sup>20</sup> | vs EtOH, chl                                          |
| 1373 | Bromotriphenylmethane                                | Triphenylmethyl bromide                                                          | C <sub>19</sub> H <sub>15</sub> Br                               | 596-43-0   | 323.226  |                | 153   | 230 <sup>15</sup>                  | 1.5500 <sup>20</sup>       |                      |                                                       |
| 1374 | 1-Bromoundecane                                      |                                                                                  | C <sub>11</sub> H <sub>23</sub> Br                               | 693-67-4   | 235.205  | liq            | -9.7  | 258.8                              | 1.0494 <sup>25</sup>       | 1.4552 <sup>25</sup> | sl ctc                                                |
| 1375 | 11-Bromoundecanoic acid                              |                                                                                  | C <sub>11</sub> H <sub>21</sub> BrO <sub>2</sub>                 | 2834-05-1  | 265.188  | nd (liq)       | 57    | 188 <sup>18</sup>                  |                            |                      | vs ace, bz, eth, EtOH                                 |
| 1376 | (1-Bromovinyl)benzene                                |                                                                                  | C <sub>8</sub> H <sub>7</sub> Br                                 | 98-81-7    | 183.046  |                | -44   | 86 <sup>14</sup> , 71 <sup>3</sup> | 1.4025 <sup>23</sup>       | 1.5881 <sup>20</sup> |                                                       |
| 1377 | ( <i>cis</i> -2-Bromovinyl)benzene                   |                                                                                  | C <sub>8</sub> H <sub>7</sub> Br                                 | 588-73-8   | 183.046  |                | -7    | 55 <sup>2</sup>                    | 1.4322 <sup>10</sup>       | 1.5990 <sup>22</sup> |                                                       |
| 1378 | ( <i>trans</i> -2-Bromovinyl)benzene                 |                                                                                  | C <sub>8</sub> H <sub>7</sub> Br                                 | 588-72-7   | 183.046  |                | 7     | dec 219; 108 <sup>20</sup>         | 1.4269 <sup>16</sup>       | 1.6093 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl              |
| 1379 | 1-Bromo-2-vinylbenzene                               |                                                                                  | C <sub>8</sub> H <sub>7</sub> Br                                 | 2039-88-5  | 183.046  | liq            | -52.8 | 209.2; 98 <sup>20</sup>            | 1.4160 <sup>20</sup>       | 1.5927 <sup>20</sup> |                                                       |
| 1380 | 1-Bromo-3-vinylbenzene                               |                                                                                  | C <sub>8</sub> H <sub>7</sub> Br                                 | 2039-86-3  | 183.046  |                |       | 92 <sup>20</sup>                   | 1.4059 <sup>20</sup>       | 1.5933 <sup>20</sup> |                                                       |
| 1381 | 1-Bromo-4-vinylbenzene                               |                                                                                  | C <sub>8</sub> H <sub>7</sub> Br                                 | 2039-82-9  | 183.046  |                | 7.7   | 212; 103 <sup>20</sup>             | 1.3984 <sup>20</sup>       | 1.5947 <sup>20</sup> | i H <sub>2</sub> O; vs chl; s HOAc                    |
| 1382 | Brompheniramine                                      |                                                                                  | C <sub>16</sub> H <sub>15</sub> BrN <sub>2</sub>                 | 86-22-6    | 319.239  | ye oily liq    |       | 150 <sup>0.5</sup>                 |                            |                      | s dil acid                                            |
| 1383 | Brucine                                              |                                                                                  | C <sub>23</sub> H <sub>26</sub> N <sub>2</sub> O <sub>4</sub>    | 357-57-3   | 394.463  | mcl pr (w +4)  | 178   |                                    |                            |                      | sl H <sub>2</sub> O, eth, bz; vs EtOH, chl            |
| 1384 | Brucine hydrochloride                                | 2,3-Dimethoxystrychnidin-10-one, monohydrochloride                               | C <sub>23</sub> H <sub>27</sub> ClN <sub>2</sub> O <sub>4</sub>  | 5786-96-9  | 430.924  | pr             |       |                                    |                            |                      | vs H <sub>2</sub> O, EtOH                             |
| 1385 | Brucine sulfate heptahydrate                         | 2,3-Dimethoxystrychnidin-10-one, sulfate, heptahydrate                           | C <sub>46</sub> H <sub>68</sub> N <sub>4</sub> O <sub>19</sub> S | 60583-39-3 | 1013.113 | nd (w)         |       |                                    |                            |                      | s H <sub>2</sub> O; sl EtOH, chl, tta; vs MeOH; i bz  |
| 1386 | Bucolome                                             | 5-Butyl-1-cyclohexyl-2,4,6(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | C <sub>14</sub> H <sub>22</sub> N <sub>2</sub> O <sub>3</sub>    | 841-73-6   | 266.336  | nd (MeOH)      | 84    | 186 <sup>0.8</sup>                 |                            |                      |                                                       |



| No.  | Name                                                         | Synonym                                                                         | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form    | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup>        | n <sub>D</sub>        | Solubility                                         |
|------|--------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------|------------|----------|------------------|---------|----------------------------------------|-----------------------------------|-----------------------|----------------------------------------------------|
| 1387 | Bufotalin                                                    |                                                                                 | C <sub>26</sub> H <sub>36</sub> O <sub>6</sub>                | 471-95-4   | 444.560  | cry (+1 al)      | 223 dec |                                        |                                   |                       | i H <sub>2</sub> O; s EtOH, chl                    |
| 1388 | Bulbocapnine                                                 |                                                                                 | C <sub>19</sub> H <sub>19</sub> NO <sub>4</sub>               | 298-45-3   | 325.359  | pr (al)          | 199.5   |                                        |                                   |                       | i H <sub>2</sub> O; s EtOH; vs chl                 |
| 1389 | sec-Bumeton                                                  | <i>N</i> -sec-Butyl- <i>N'</i> -ethyl-6-methoxy-1,3,5-triazine-2,4-diamine      | C <sub>10</sub> H <sub>19</sub> N <sub>5</sub> O              | 26259-45-0 | 225.291  |                  | 87      |                                        |                                   |                       |                                                    |
| 1390 | BUSAN 72A                                                    | (2-Benzothiazolylthio)methyl thiocyanate                                        | C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> S <sub>3</sub>   | 21564-17-0 | 238.352  | liq              |         | dec                                    |                                   |                       |                                                    |
| 1391 | Butachlor                                                    |                                                                                 | C <sub>17</sub> H <sub>26</sub> ClNO <sub>2</sub>             | 23184-66-9 | 311.847  |                  | <-5     | 156 <sup>5</sup>                       | 1.070 <sup>25</sup>               |                       |                                                    |
| 1392 | 1,2-Butadiene                                                | Methylallene                                                                    | C <sub>4</sub> H <sub>6</sub>                                 | 590-19-2   | 54.091   | vol liq or gas   | -136.2  | 10.9                                   | 0.676 <sup>0</sup>                | 1.4205 <sup>1</sup>   | i H <sub>2</sub> O; msc EtOH, eth; vs bz           |
| 1393 | 1,3-Butadiene                                                | Divinyl                                                                         | C <sub>4</sub> H <sub>6</sub>                                 | 106-99-0   | 54.091   | col gas          | -108.91 | -4.41                                  | 0.6149 <sup>25</sup><br>(p>1 atm) | 1.4292 <sup>25</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz; vs ace        |
| 1394 | 1,3-Butadien-1-ol acetate                                    |                                                                                 | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                  | 1515-76-0  | 112.127  |                  |         | 58 <sup>40</sup>                       | 0.945 <sup>25</sup>               | 1.4690 <sup>20</sup>  |                                                    |
| 1395 | ( <i>trans</i> )-1,3-Butadienylbenzene                       |                                                                                 | C <sub>10</sub> H <sub>10</sub>                               | 16939-57-4 | 130.186  |                  | 2.3     | 76 <sup>11</sup>                       | 0.9286 <sup>20</sup>              | 1.6089 <sup>25</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, bz           |
| 1396 | 1,3-Butadiyne                                                | Diacetylene                                                                     | C <sub>4</sub> H <sub>2</sub>                                 | 460-12-8   | 50.059   | vol liq or gas   | -36.4   | 10.3                                   | 0.7364 <sup>0</sup>               | 1.4189 <sup>5</sup>   | vs H <sub>2</sub> O, eth, ace; s chl, EtOH         |
| 1397 | Butalbitol                                                   | 5-Isobutyl-5-allyl-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | C <sub>11</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> | 77-26-9    | 224.256  | pr               | 138.5   |                                        |                                   |                       | sl H <sub>2</sub> O; s EtOH, eth, ace, chl; i lig  |
| 1398 | Butanal                                                      | Butyraldehyde                                                                   | C <sub>4</sub> H <sub>8</sub> O                               | 123-72-8   | 72.106   | liq              | -96.86  | 74.8                                   | 0.8016 <sup>20</sup>              | 1.3843 <sup>20</sup>  | s H <sub>2</sub> O; msc EtOH; vs ace, bz; sl chl   |
| 1399 | Butanal oxime                                                |                                                                                 | C <sub>4</sub> H <sub>9</sub> NO                              | 110-69-0   | 87.120   | liq              | -29.5   | 154                                    | 0.923 <sup>20</sup>               |                       | vs H <sub>2</sub> O, ace, bz; msc EtOH, eth; s chl |
| 1400 | Butanamide                                                   | Butyramide                                                                      | C <sub>4</sub> H <sub>9</sub> NO                              | 541-35-5   | 87.120   | lf (bz)          | 114.8   | 216                                    | 0.8850 <sup>120</sup>             | 1.4087 <sup>130</sup> | sl H <sub>2</sub> O, eth; i bz; s EtOH             |
| 1401 | Butane                                                       |                                                                                 | C <sub>4</sub> H <sub>10</sub>                                | 106-97-8   | 58.122   | col gas          | -138.3  | -0.5                                   | 0.573 <sup>25</sup><br>(p>1 atm)  | 1.3326 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth, chl              |
| 1402 | Butanediol                                                   |                                                                                 | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 638-37-9   | 86.090   |                  |         | dec 170; 58 <sup>9</sup>               | 1.065 <sup>20</sup>               | 1.4262 <sup>18</sup>  | vs H <sub>2</sub> O, ace, eth, EtOH                |
| 1403 | 1,4-Butanediolamine                                          | Putrescine                                                                      | C <sub>4</sub> H <sub>12</sub> N <sub>2</sub>                 | 110-60-1   | 88.151   | lf               | 21.91   | 158.5                                  | 0.877 <sup>25</sup>               | 1.4969 <sup>20</sup>  | s H <sub>2</sub> O                                 |
| 1404 | 1,4-Butanediolamine dihydrochloride                          |                                                                                 | C <sub>4</sub> H <sub>14</sub> Cl <sub>2</sub> N <sub>2</sub> | 333-93-7   | 161.073  | nd or lf (al, w) | 280 dec | sub                                    |                                   |                       | vs H <sub>2</sub> O, EtOH; i eth, bz, MeOH         |
| 1405 | 1,2-Butanediol, (±)                                          |                                                                                 | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 26171-83-5 | 90.121   |                  |         | 190.5                                  | 1.0024 <sup>20</sup>              | 1.4378 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, ace                      |
| 1406 | 1,3-Butanediol                                               | 1,3-Butylene glycol                                                             | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 107-88-0   | 90.121   |                  | <-50    | 207.5                                  | 1.0053 <sup>20</sup>              | 1.4401 <sup>20</sup>  |                                                    |
| 1407 | 1,4-Butanediol                                               | Tetramethylene glycol                                                           | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 110-63-4   | 90.121   |                  | 20.4    | 235                                    | 1.0171 <sup>20</sup>              | 1.4460 <sup>20</sup>  | msc H <sub>2</sub> O; s EtOH, DMSO; sl eth         |
| 1408 | 2,3-Butanediol                                               |                                                                                 | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 6982-25-8  | 90.121   | cry (eth)        | 7.6     | 182.5                                  | 1.0033 <sup>20</sup>              | 1.4310 <sup>25</sup>  | msc H <sub>2</sub> O, EtOH; s eth, ace, chl        |
| 1409 | 1,4-Butanediol diacetate                                     |                                                                                 | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                 | 628-67-1   | 174.195  |                  | 12      | 229                                    | 1.0479 <sup>15</sup>              | 1.4251 <sup>15</sup>  |                                                    |
| 1410 | 1,4-Butanediol diacrylate                                    |                                                                                 | C <sub>10</sub> H <sub>14</sub> O <sub>4</sub>                | 1070-70-8  | 198.216  |                  |         | 83 <sup>3,3</sup>                      | 1.105 <sup>25</sup>               |                       |                                                    |
| 1411 | 1,4-Butanediol diglycidyl ether                              | 1,4-Bis(2,3-epoxypropoxy) butane                                                | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                | 2425-79-8  | 202.248  |                  |         | 266; 155 <sup>11</sup>                 | 1.1 <sup>25</sup>                 | 1.4611 <sup>20</sup>  |                                                    |
| 1412 | 1,3-Butanediol dimethacrylate                                |                                                                                 | C <sub>12</sub> H <sub>18</sub> O <sub>4</sub>                | 1189-08-8  | 226.269  |                  |         | 290                                    |                                   | 1.4495 <sup>25</sup>  | vs ace, eth, EtOH, lig                             |
| 1413 | 1,4-Butanediol dimethacrylate                                |                                                                                 | C <sub>12</sub> H <sub>18</sub> O <sub>4</sub>                | 2082-81-7  | 226.269  | liq              |         | 133 <sup>4</sup> , 76 <sup>0,027</sup> | 1.025 <sup>20</sup>               | 1.4560 <sup>20</sup>  | sl H <sub>2</sub> O                                |
| 1414 | 1,4-Butanediol dimethylsulfonate                             | Busulfan                                                                        | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub> S <sub>2</sub>  | 55-98-1    | 246.301  | cry              | 116     |                                        |                                   |                       | i H <sub>2</sub> O; sl EtOH, ace                   |
| 1415 | 2,3-Butanedione                                              | Diacetyl                                                                        | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                  | 431-03-8   | 86.090   | liq              | -1.2    | 88                                     | 0.9808 <sup>18</sup>              | 1.3951 <sup>20</sup>  | vs H <sub>2</sub> O; msc EtOH, eth; s bz, ctc      |
| 1416 | 2,3-Butanedione monooxime                                    |                                                                                 | C <sub>4</sub> H <sub>7</sub> NO <sub>2</sub>                 | 57-71-6    | 101.105  | pr (chl), lf (w) | 76.8    | 185.5                                  |                                   |                       | sl H <sub>2</sub> O; vs EtOH, eth, chl; s alk      |
| 1417 | Butanedioyl dichloride                                       | Succinyl chloride                                                               | C <sub>4</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>  | 543-20-4   | 154.980  | pl or lf         | 20      | 193.3                                  | 1.3748 <sup>20</sup>              | 1.4683 <sup>20</sup>  | s eth, ace, bz                                     |
| 1418 | 1,4-Butanedithiol                                            | Tetramethylenedithiol                                                           | C <sub>4</sub> H <sub>10</sub> S <sub>2</sub>                 | 1191-08-8  | 122.252  | liq              | -53.9   | 195.5                                  | 1.0021 <sup>0</sup>               | 1.5290 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH; sl ctc                |
| 1419 | Butanenitrile                                                | Propyl cyanide                                                                  | C <sub>4</sub> H <sub>7</sub> N                               | 109-74-0   | 69.106   | liq              | -111.9  | 117.6                                  | 0.7936 <sup>20</sup>              | 1.3842 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; msc EtOH, eth; s bz      |
| 1420 | 1-Butanesulfonyl chloride                                    |                                                                                 | C <sub>4</sub> H <sub>9</sub> ClO <sub>2</sub> S              | 2386-60-9  | 156.631  |                  |         | 75 <sup>10</sup>                       |                                   | 1.4559 <sup>20</sup>  |                                                    |
| 1421 | 1,4-Butane sultone                                           | 1,2-Oxathiane 2,2-dioxide                                                       | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub> S                | 1633-83-6  | 136.170  | liq              | 13.5    | 135 <sup>4</sup>                       | 1.331 <sup>20</sup>               | 1.4640 <sup>20</sup>  |                                                    |
| 1422 | 1,2,3,4-Butanetetra-carboxylic acid                          |                                                                                 | C <sub>8</sub> H <sub>10</sub> O <sub>8</sub>                 | 1703-58-8  | 234.160  | lf (w) cry (ace) | 236.5   |                                        |                                   |                       | vs H <sub>2</sub> O, EtOH                          |
| 1423 | 1,2,3,4-Butanetetrol                                         | Erythritol                                                                      | C <sub>4</sub> H <sub>10</sub> O <sub>4</sub>                 | 149-32-6   | 122.120  | bipym tet pr     | 121.5   | 330.5                                  | 1.451 <sup>20</sup>               |                       | s H <sub>2</sub> O; i eth, bz                      |
| 1424 | 1,2,3,4-Butanetetrol tetranitrate, ( <i>R</i> *, <i>S</i> *) | Erythrityl tetranitrate                                                         | C <sub>4</sub> H <sub>6</sub> N <sub>4</sub> O <sub>12</sub>  | 7297-25-8  | 302.111  |                  | 61      |                                        |                                   |                       | vs EtOH                                            |
| 1425 | 1-Butanethiol                                                | Butyl mercaptan                                                                 | C <sub>4</sub> H <sub>10</sub> S                              | 109-79-5   | 90.187   | liq              | -115.7  | 98.5                                   | 0.8416 <sup>20</sup>              | 1.4440 <sup>20</sup>  | sl H <sub>2</sub> O, chl; vs EtOH, eth             |

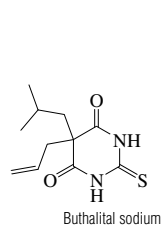
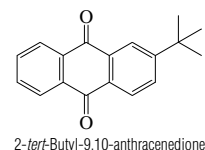
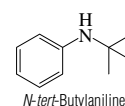
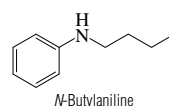
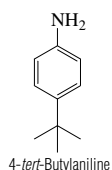
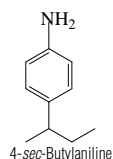
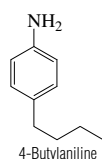
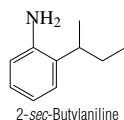
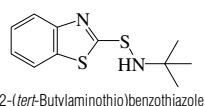
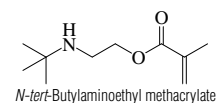
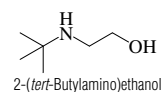
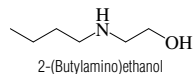
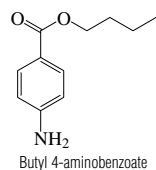
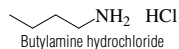
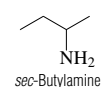
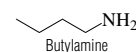
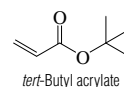
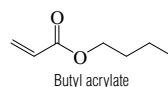
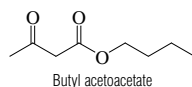
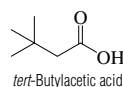
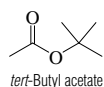
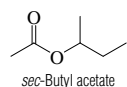
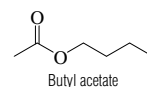
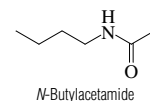
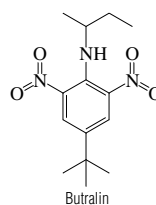
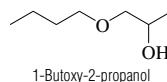
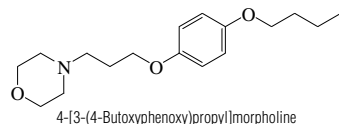
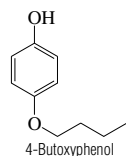
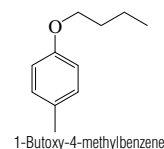
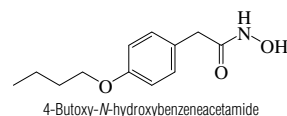
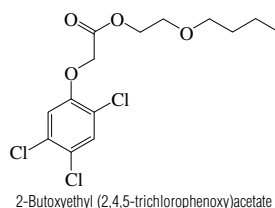
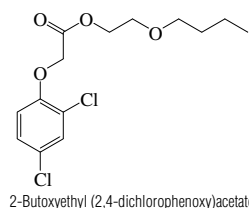
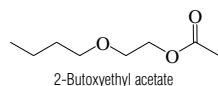
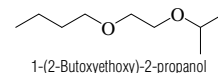
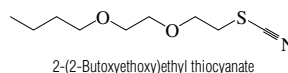
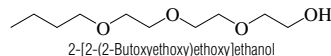
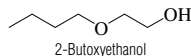
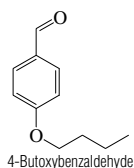
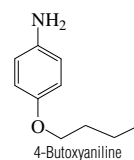
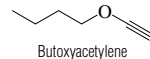
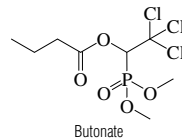
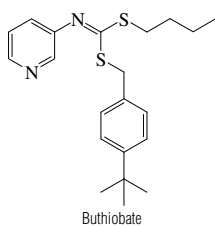
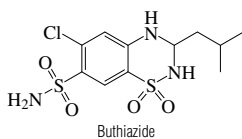


| No.  | Name                                       | Synonym                                               | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form         | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>        | Solubility                                           |
|------|--------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------|------------|----------|-----------------------|---------|---------------------------------------|----------------------------------|-----------------------|------------------------------------------------------|
| 1426 | 2-Butanethiol                              | sec-Butyl mercaptan                                   | C <sub>4</sub> H <sub>10</sub> S                                            | 91840-99-2 | 90.187   | liq                   | -165    | 85.0                                  | 0.8295 <sup>20</sup>             | 1.4366 <sup>20</sup>  | s EtOH, eth, bz, peth; sl ctc                        |
| 1427 | 1,2,4-Butanetriol                          |                                                       | C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>                               | 3068-00-6  | 106.120  |                       |         | 190 <sup>18</sup> , 172 <sup>12</sup> | 1.18 <sup>20</sup>               | 1.4688 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH                            |
| 1428 | Butanilcaine                               | 2-(Butylamino)-N-(2-chloro-6-methylphenyl)acetamide   | C <sub>13</sub> H <sub>19</sub> ClN <sub>2</sub> O                          | 3785-21-5  | 254.755  | cry                   | 46      | 145 <sup>0.001</sup>                  |                                  |                       |                                                      |
| 1429 | Butanoic acid                              | Butyric acid                                          | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                                | 107-92-6   | 88.106   | liq                   | -5.1    | 163.75                                | 0.9528 <sup>25</sup>             | 1.3980 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH, eth; sl ctc              |
| 1430 | Butanoic anhydride                         | Butyric anhydride                                     | C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>                               | 106-31-0   | 158.195  | liq                   | -75     | 200                                   | 0.9668 <sup>20</sup>             | 1.4070 <sup>20</sup>  | s eth; sl ctc                                        |
| 1431 | 1-Butanol                                  | Butyl alcohol                                         | C <sub>4</sub> H <sub>10</sub> O                                            | 71-36-3    | 74.121   | liq                   | -88.6   | 117.73                                | 0.8095 <sup>20</sup>             | 1.3988 <sup>20</sup>  | s H <sub>2</sub> O, bz; msc EtOH, eth; vs ace        |
| 1432 | 2-Butanol                                  | sec-Butyl alcohol                                     | C <sub>4</sub> H <sub>10</sub> O                                            | 78-92-2    | 74.121   | liq                   | -88.5   | 99.51                                 | 0.8063 <sup>20</sup>             | 1.3978 <sup>20</sup>  | vs H <sub>2</sub> O; msc EtOH, eth; s bz, ctc        |
| 1433 | 2-Butanone                                 | Methyl ethyl ketone                                   | C <sub>4</sub> H <sub>8</sub> O                                             | 78-93-3    | 72.106   | liq                   | -86.64  | 79.59                                 | 0.7999 <sup>25</sup>             | 1.3788 <sup>20</sup>  | vs H <sub>2</sub> O; msc EtOH, eth, ace, bz; s chl   |
| 1434 | 2-Butanone (1-methylpropylidene) hydrazone |                                                       | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub>                               | 5921-54-0  | 140.226  |                       |         | 171.5                                 | 0.8404 <sup>20</sup>             | 1.4511 <sup>20</sup>  |                                                      |
| 1435 | 2-Butanone oxime                           |                                                       | C <sub>4</sub> H <sub>9</sub> NO                                            | 96-29-7    | 87.120   | liq                   | -29.5   | 152.5                                 | 0.9232 <sup>20</sup>             | 1.4410 <sup>20</sup>  | s H <sub>2</sub> O, chl; msc EtOH, eth               |
| 1436 | 2-Butanone peroxide                        | Methyl ethyl ketone peroxide                          | C <sub>8</sub> H <sub>16</sub> O <sub>4</sub>                               | 1338-23-4  | 176.211  | col liq               |         | exp 110                               |                                  |                       | sl H <sub>2</sub> O; misc os                         |
| 1437 | Butanoyl chloride                          | n-Butyryl chloride                                    | C <sub>4</sub> H <sub>7</sub> ClO                                           | 141-75-3   | 106.551  | liq                   | -89     | 102                                   | 1.0277 <sup>20</sup>             | 1.4121 <sup>20</sup>  | msc eth                                              |
| 1438 | Butaperazine                               |                                                       | C <sub>24</sub> H <sub>31</sub> N <sub>3</sub> O <sub>5</sub> S             | 653-03-2   | 409.587  |                       |         | 275 <sup>0.05</sup>                   |                                  |                       |                                                      |
| 1439 | Butazolamide                               | N-[5-(Aminosulfonyl)-1,3,4-thiadiazol-2-yl]butanamide | C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>3</sub> S <sub>2</sub> | 16790-49-1 | 250.298  | cry                   | 261 dec |                                       |                                  |                       |                                                      |
| 1440 | trans-2-Butenal                            | trans-Crotonaldehyde                                  | C <sub>4</sub> H <sub>6</sub> O                                             | 123-73-9   | 70.090   | liq                   | -76     | 102.2                                 | 0.8516 <sup>20</sup>             | 1.4366 <sup>20</sup>  | s H <sub>2</sub> O, chl; vs EtOH, eth, ace; msc bz   |
| 1441 | 1-Butene                                   | 1-Butylene                                            | C <sub>4</sub> H <sub>8</sub>                                               | 106-98-9   | 56.107   | col gas               | -185.34 | -6.26                                 | 0.588 <sup>25</sup><br>(p>1 atm) | 1.3962 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth; s bz               |
| 1442 | cis-2-Butene                               |                                                       | C <sub>4</sub> H <sub>8</sub>                                               | 590-18-1   | 56.107   | col gas               | -138.88 | 3.71                                  | 0.616 <sup>25</sup><br>(p>1 atm) | 1.3931 <sup>-25</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz               |
| 1443 | trans-2-Butene                             |                                                       | C <sub>4</sub> H <sub>8</sub>                                               | 624-64-6   | 56.107   | col gas               | -105.52 | 0.88                                  | 0.599 <sup>25</sup><br>(p>1 atm) | 1.3848 <sup>-25</sup> | s bz                                                 |
| 1444 | trans-2-Butenedinitrile                    |                                                       | C <sub>4</sub> H <sub>2</sub> N <sub>2</sub>                                | 764-42-1   | 78.072   | nd (bz-peth)          | 96.8    | 186                                   | 0.9416 <sup>111</sup>            | 1.4349 <sup>111</sup> | s H <sub>2</sub> O, EtOH, eth, ace, bz, chl; sl peth |
| 1445 | cis-2-Butene-1,4-diol                      |                                                       | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                                | 6117-80-2  | 88.106   |                       | 2.0     | 235                                   | 1.0698 <sup>20</sup>             | 1.4782 <sup>20</sup>  | s H <sub>2</sub> O; vs EtOH                          |
| 1446 | trans-2-Butene-1,4-diol                    |                                                       | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                                | 821-11-4   | 88.106   |                       | 25      | 131 <sup>13</sup>                     | 1.0700 <sup>20</sup>             | 1.4755 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH                            |
| 1447 | trans-2-Butenediyl dichloride              | Fumaric acid dichloride                               | C <sub>4</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>                | 627-63-4   | 152.964  | pa ye lig             |         | 159                                   | 1.408 <sup>20</sup>              | 1.5004 <sup>18</sup>  |                                                      |
| 1448 | cis-2-Butenenitrile                        | Isocrotonitrile                                       | C <sub>4</sub> H <sub>5</sub> N                                             | 1190-76-7  | 67.090   | liq                   |         | 107.4                                 |                                  |                       |                                                      |
| 1449 | trans-2-Butenenitrile                      | Crotonitrile                                          | C <sub>4</sub> H <sub>5</sub> N                                             | 627-26-9   | 67.090   | liq                   | -51.5   | 120                                   | 0.8239 <sup>20</sup>             | 1.4225 <sup>20</sup>  | s eth, ace                                           |
| 1450 | 3-Butenenitrile                            | Allyl cyanide                                         | C <sub>4</sub> H <sub>5</sub> N                                             | 109-75-1   | 67.090   | liq                   | -87     | 119                                   | 0.8341 <sup>20</sup>             | 1.4060 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth                   |
| 1451 | cis-2-Butenoic acid                        | Isocrotonic acid                                      | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                | 503-64-0   | 86.090   | nd or pr (peth)       | 15      | 169                                   | 1.0267 <sup>20</sup>             | 1.4450 <sup>20</sup>  | vs H <sub>2</sub> O; s EtOH                          |
| 1452 | trans-2-Butenoic acid                      | Crotonic acid                                         | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                | 107-93-7   | 86.090   | mcl pr or nd (w, lig) | 71.5    | 184.7                                 | 0.9604 <sup>77</sup>             | 1.4249 <sup>77</sup>  | vs H <sub>2</sub> O, EtOH; s eth, ace, lig           |
| 1453 | 3-Butenoic acid                            |                                                       | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                | 625-38-7   | 86.090   | liq                   | -35     | 169                                   | 1.0091 <sup>20</sup>             | 1.4239 <sup>20</sup>  | s H <sub>2</sub> O; msc EtOH, eth                    |
| 1454 | 2-Butenoic anhydride                       | Crotonic acid anhydride                               | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                               | 623-68-7   | 154.163  |                       |         | 247; 129 <sup>19</sup>                | 1.0397 <sup>20</sup>             | 1.4745 <sup>20</sup>  | vs eth                                               |
| 1455 | cis-2-Buten-1-ol                           | cis-Crotyl alcohol                                    | C <sub>4</sub> H <sub>8</sub> O                                             | 4088-60-2  | 72.106   |                       |         | 123                                   | 0.8662 <sup>20</sup>             | 1.4342 <sup>25</sup>  | s H <sub>2</sub> O                                   |
| 1456 | trans-2-Buten-1-ol                         | trans-Crotyl alcohol                                  | C <sub>4</sub> H <sub>8</sub> O                                             | 504-61-0   | 72.106   |                       | <-30    | 121.2                                 | 0.8521 <sup>20</sup>             | 1.4288 <sup>20</sup>  | vs H <sub>2</sub> O; msc EtOH, eth; s chl            |
| 1457 | 3-Buten-1-ol                               |                                                       | C <sub>4</sub> H <sub>8</sub> O                                             | 627-27-0   | 72.106   |                       |         | 113.5                                 | 0.8424 <sup>20</sup>             | 1.4224 <sup>20</sup>  | s H <sub>2</sub> O, ace; msc EtOH, eth; sl chl       |
| 1458 | 3-Buten-2-ol                               |                                                       | C <sub>4</sub> H <sub>8</sub> O                                             | 598-32-3   | 72.106   |                       |         | 97                                    |                                  |                       |                                                      |
| 1459 | 3-Buten-2-one                              | Methyl vinyl ketone                                   | C <sub>4</sub> H <sub>6</sub> O                                             | 78-94-4    | 70.090   |                       |         | 81.4                                  | 0.864 <sup>20</sup>              | 1.4081 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, bz; vs eth, ace; sl ctc    |
| 1460 | 2-Butenyl chloride                         |                                                       | C <sub>4</sub> H <sub>7</sub> ClO                                           | 10487-71-5 | 104.535  |                       |         | 124.5                                 | 1.0905 <sup>20</sup>             | 1.460 <sup>18</sup>   | vs ace                                               |
| 1461 | (trans-1-Butenyl)benzene                   |                                                       | C <sub>10</sub> H <sub>12</sub>                                             | 1005-64-7  | 132.202  | liq                   | -43.1   | 198.7                                 | 0.9019 <sup>20</sup>             | 1.5420 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, ctc             |
| 1462 | 2-Butenylbenzene                           |                                                       | C <sub>10</sub> H <sub>12</sub>                                             | 1560-06-1  | 132.202  |                       |         | 176                                   | 0.8831 <sup>20</sup>             | 1.5101 <sup>20</sup>  |                                                      |
| 1463 | 3-Butenylbenzene                           |                                                       | C <sub>10</sub> H <sub>12</sub>                                             | 768-56-9   | 132.202  | liq                   | -70     | 177                                   | 0.8831 <sup>20</sup>             | 1.5059 <sup>20</sup>  | i H <sub>2</sub> O; s eth, bz                        |
| 1464 | 1-Buten-3-yne                              | Vinylacetylene                                        | C <sub>4</sub> H <sub>4</sub>                                               | 689-97-4   | 52.075   | col gas               |         | 5.1                                   | 0.7094 <sup>0</sup>              | 1.4161 <sup>1</sup>   | i H <sub>2</sub> O; s bz                             |
| 1465 | Butethamine hydrochloride                  | 2-Isobutylaminoethyl 4-aminobenzoate                  | C <sub>13</sub> H <sub>21</sub> ClN <sub>2</sub> O <sub>2</sub>             | 553-68-4   | 272.771  | cry                   | 194     |                                       |                                  |                       | s H <sub>2</sub> O; sl EtOH, bz, chl; i eth          |

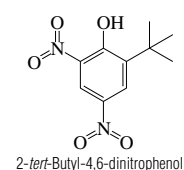
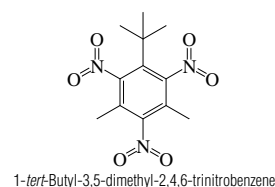
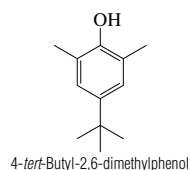
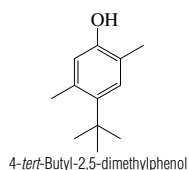
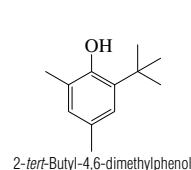
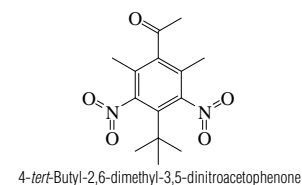
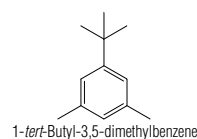
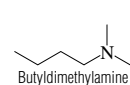
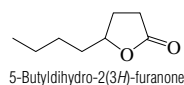
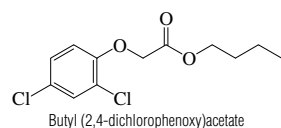
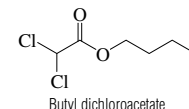
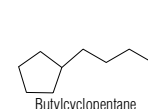
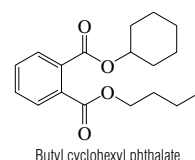
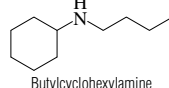
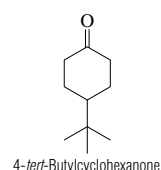
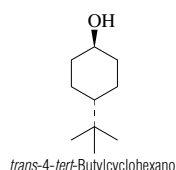
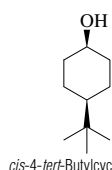
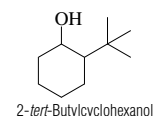
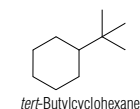
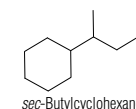
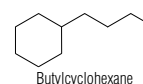
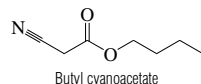
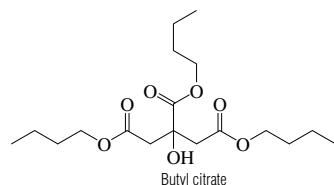
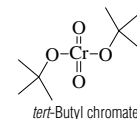
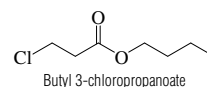
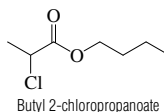
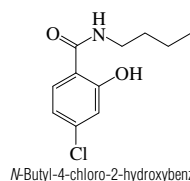
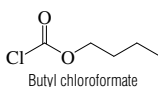
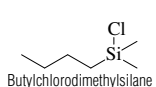
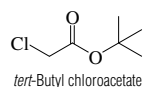
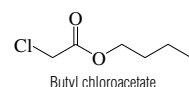
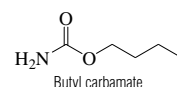
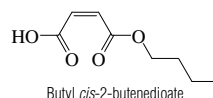
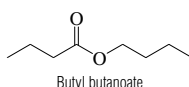
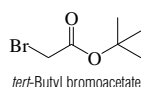
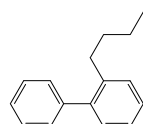
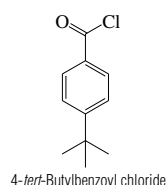
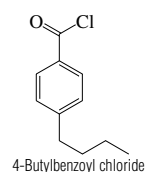
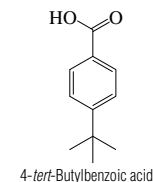
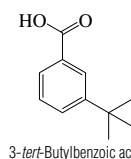
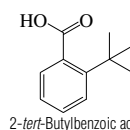
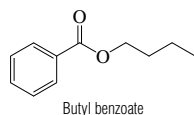
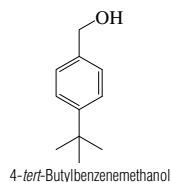
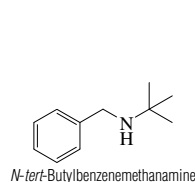
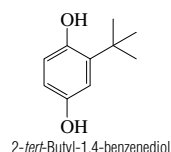
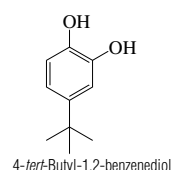
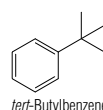
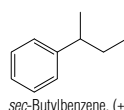
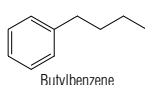
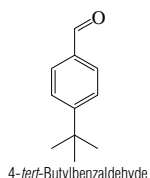
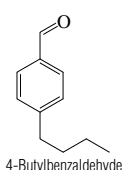
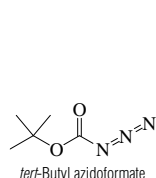




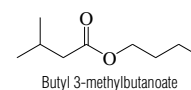
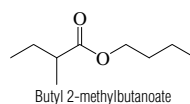
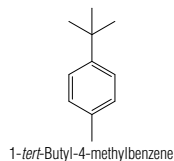
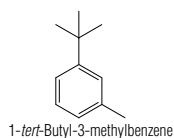
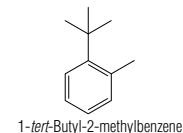
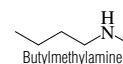
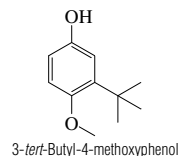
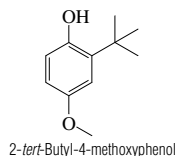
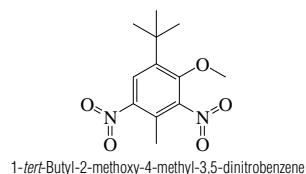
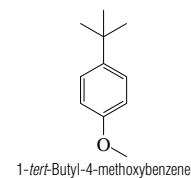
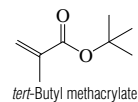
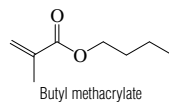
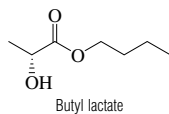
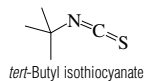
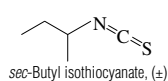
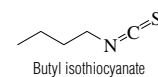
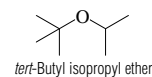
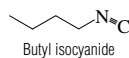
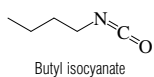
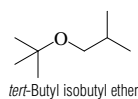
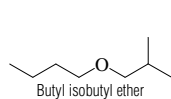
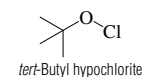
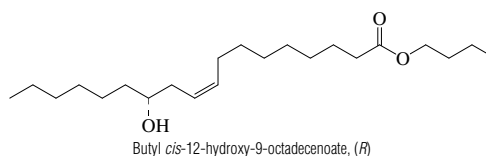
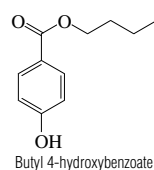
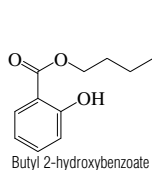
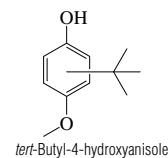
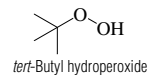
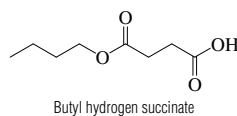
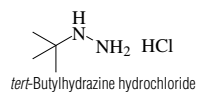
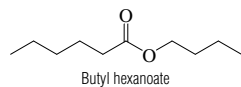
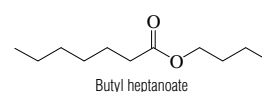
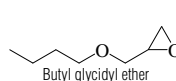
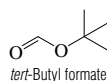
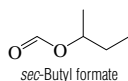
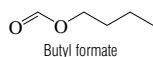
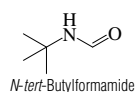
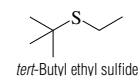
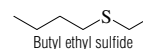
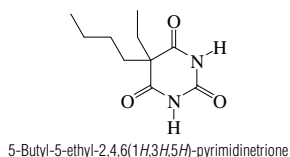
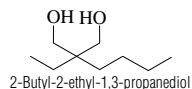
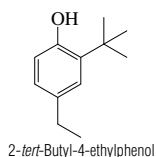
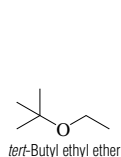
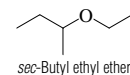
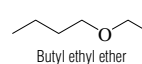
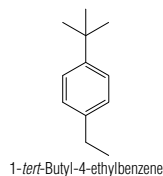
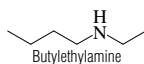
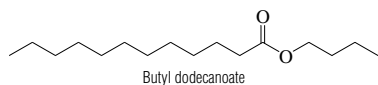
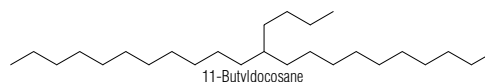
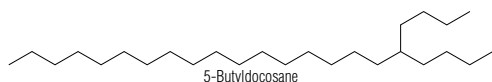
| No.  | Name                                                    | Synonym                                                                    | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form  | mp/°C  | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|---------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------|----------|----------------|--------|-------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 1466 | Buthalital sodium                                       |                                                                            | C <sub>11</sub> H <sub>15</sub> N <sub>2</sub> NaO <sub>2</sub> S              | 510-90-7   | 262.304  |                |        |                                     |                            |                      | vs H <sub>2</sub> O; sl EtOH;<br>i eth, bz             |
| 1467 | Buthiazide                                              |                                                                            | C <sub>11</sub> H <sub>16</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 2043-38-1  | 353.846  |                | 221.5  |                                     |                            |                      |                                                        |
| 1468 | Buthiobate                                              | Denmert                                                                    | C <sub>21</sub> H <sub>28</sub> N <sub>2</sub> S <sub>2</sub>                  | 51308-54-4 | 372.590  | ye oil         | 32     |                                     | 1.0865 <sup>25</sup>       | 1.596 <sup>26</sup>  | i H <sub>2</sub> O; s os                               |
| 1469 | Butonate                                                |                                                                            | C <sub>8</sub> H <sub>14</sub> Cl <sub>3</sub> O <sub>3</sub> P                | 126-22-7   | 327.527  |                |        | 129 <sup>0.5</sup>                  |                            |                      |                                                        |
| 1470 | Butoxyacetylene                                         |                                                                            | C <sub>6</sub> H <sub>10</sub> O                                               | 3329-56-4  | 98.142   |                |        | 104                                 | 0.8200 <sup>20</sup>       | 1.4067               | vs eth, EtOH                                           |
| 1471 | 4-Butoxyaniline                                         |                                                                            | C <sub>10</sub> H <sub>12</sub> NO                                             | 4344-55-2  | 165.232  |                |        | 132 <sup>4</sup>                    |                            |                      |                                                        |
| 1472 | 4-Butoxybenzaldehyde                                    |                                                                            | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                                 | 5736-88-9  | 178.228  |                |        | 148 <sup>10</sup>                   |                            |                      |                                                        |
| 1473 | 2-Butoxyethanol                                         | Ethylene glycol monobutyl ether                                            | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                                  | 111-76-2   | 118.174  | liq            | -74.8  | 168.4                               | 0.9015 <sup>20</sup>       | 1.4198 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; sl ctc             |
| 1474 | 2-[2-(2-Butoxyethoxy)ethoxy]<br>ethanol                 |                                                                            | C <sub>10</sub> H <sub>22</sub> O <sub>4</sub>                                 | 143-22-6   | 206.280  |                |        | 278                                 | 0.9890 <sup>20</sup>       | 1.4389 <sup>20</sup> | vs EtOH, MeOH                                          |
| 1475 | 2-(2-Butoxyethoxy)ethyl<br>thiocyanate                  | Lethane 384                                                                | C <sub>9</sub> H <sub>17</sub> NO <sub>2</sub> S                               | 112-56-1   | 203.302  | liq            |        | 122 <sup>0.25</sup>                 |                            |                      | i H <sub>2</sub> O; vs os                              |
| 1476 | 1-(2-Butoxyethoxy)-2-propanol                           |                                                                            | C <sub>9</sub> H <sub>20</sub> O <sub>3</sub>                                  | 124-16-3   | 176.253  | col liq        | -90    | 230                                 | 0.931 <sup>20</sup>        |                      | s H <sub>2</sub> O                                     |
| 1477 | 2-Butoxyethyl acetate                                   | Ethylene glycol monobutyl ether<br>acetate                                 | C <sub>8</sub> H <sub>16</sub> O <sub>3</sub>                                  | 112-07-2   | 160.211  | liq            |        | 192                                 |                            |                      |                                                        |
| 1478 | 2-Butoxyethyl (2,4-<br>dichlorophenoxy)acetate          | 2,4-D 2-Butoxyethyl ester                                                  | C <sub>14</sub> H <sub>18</sub> Cl <sub>2</sub> O <sub>4</sub>                 | 1929-73-3  | 321.197  |                |        | 159 <sup>1</sup>                    | 1.232 <sup>20</sup>        |                      |                                                        |
| 1479 | 2-Butoxyethyl (2,4,5-<br>trichlorophenoxy)acetate       | 2,4,5-T Butoxyethyl ester                                                  | C <sub>14</sub> H <sub>17</sub> Cl <sub>3</sub> O <sub>4</sub>                 | 2545-59-7  | 355.642  |                |        | 164 <sup>1</sup>                    | 1.280 <sup>20</sup>        |                      | s ctc                                                  |
| 1480 | 4-Butoxy- <i>N</i> -<br>hydroxybenzeneacetamide         | Bufexamac                                                                  | C <sub>12</sub> H <sub>17</sub> NO <sub>3</sub>                                | 2438-72-4  | 223.268  | nd (ace)       | 154    |                                     |                            |                      |                                                        |
| 1481 | 1-Butoxy-4-methylbenzene                                |                                                                            | C <sub>11</sub> H <sub>16</sub> O                                              | 10519-06-9 | 164.244  |                |        | 229.5                               | 0.9205 <sup>25</sup>       | 1.4970 <sup>20</sup> | s eth                                                  |
| 1482 | 4-Butoxyphenol                                          |                                                                            | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                                 | 122-94-1   | 166.217  |                | 65.5   | 125 <sup>4</sup>                    |                            |                      | vs ace, bz, eth,<br>EtOH                               |
| 1483 | 4-[3-(4-Butoxyphenoxy)propyl]<br>morpholine             | Pramoxine                                                                  | C <sub>17</sub> H <sub>27</sub> NO <sub>3</sub>                                | 140-65-8   | 293.401  |                |        | 196 <sup>6</sup>                    |                            |                      |                                                        |
| 1484 | 1-Butoxy-2-propanol                                     |                                                                            | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>                                  | 5131-66-8  | 132.201  |                |        | 171.5; 71 <sup>20</sup>             | 0.882 <sup>20</sup>        | 1.4168 <sup>20</sup> | s EtOH, eth, bz,<br>ctc, MeOH                          |
| 1485 | Butralin                                                | 4- <i>tert</i> -Butyl- <i>N</i> - <i>sec</i> -butyl-2,6-<br>dinitroaniline | C <sub>14</sub> H <sub>21</sub> N <sub>3</sub> O <sub>4</sub>                  | 33629-47-9 | 295.335  |                | 60     | 135 <sup>0.5</sup>                  |                            |                      |                                                        |
| 1486 | <i>N</i> -Butylacetamide                                |                                                                            | C <sub>8</sub> H <sub>13</sub> NO                                              | 1119-49-9  | 115.173  |                |        | 229                                 | 0.8960 <sup>25</sup>       | 1.4388 <sup>25</sup> |                                                        |
| 1487 | Butyl acetate                                           |                                                                            | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                                  | 123-86-4   | 116.158  | liq            | -78    | 126.1                               | 0.8825 <sup>20</sup>       | 1.3941 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ace, chl   |
| 1488 | <i>sec</i> -Butyl acetate                               |                                                                            | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                                  | 105-46-4   | 116.158  | liq            | -98.9  | 112                                 | 0.8748 <sup>20</sup>       | 1.3888 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s<br>EtOH, eth               |
| 1489 | <i>tert</i> -Butyl acetate                              |                                                                            | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                                  | 540-88-5   | 116.158  |                |        | 95.1                                | 0.8665 <sup>20</sup>       | 1.3855 <sup>20</sup> | s EtOH, eth, chl,<br>HOAc                              |
| 1490 | <i>tert</i> -Butylacetic acid                           |                                                                            | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                                  | 1070-83-3  | 116.158  |                | 6.5    | 190                                 | 0.9124 <sup>20</sup>       | 1.4096 <sup>20</sup> | s EtOH, eth                                            |
| 1491 | Butyl acetoacetate                                      |                                                                            | C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>                                  | 591-60-6   | 158.195  |                | -35.6  | 127 <sup>50</sup> , 85 <sup>8</sup> | 0.9671 <sup>25</sup>       | 1.4137 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, bz, lig              |
| 1492 | Butyl acrylate                                          |                                                                            | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                                  | 141-32-2   | 128.169  | liq            | -64.6  | 145                                 | 0.8898 <sup>20</sup>       | 1.4185 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace; sl ctc        |
| 1493 | <i>tert</i> -Butyl acrylate                             |                                                                            | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                                  | 1663-39-4  | 128.169  | liq            |        | 120; 62 <sup>80</sup>               | 0.879 <sup>25</sup>        | 1.4110 <sup>20</sup> |                                                        |
| 1494 | Butylamine                                              | 1-Butanamine                                                               | C <sub>4</sub> H <sub>11</sub> N                                               | 109-73-9   | 73.137   | liq            | -49.1  | 77.00                               | 0.7414 <sup>20</sup>       | 1.4031 <sup>20</sup> | msc H <sub>2</sub> O; s<br>EtOH, eth                   |
| 1495 | <i>sec</i> -Butylamine                                  | 2-Butanamine, (±)-                                                         | C <sub>4</sub> H <sub>11</sub> N                                               | 33966-50-6 | 73.137   |                | <-72   | 62.73                               | 0.7246 <sup>20</sup>       | 1.3932 <sup>20</sup> | s H <sub>2</sub> O, chl; msc<br>EtOH, eth; vs<br>ace   |
| 1496 | <i>tert</i> -Butylamine                                 | 2-Methyl-2-propanamine                                                     | C <sub>4</sub> H <sub>11</sub> N                                               | 75-64-9    | 73.137   | liq            | -66.94 | 44.04                               | 0.6958 <sup>20</sup>       | 1.3784 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; s chl              |
| 1497 | Butylamine hydrochloride                                | 1-Butanamine hydrochloride                                                 | C <sub>4</sub> H <sub>12</sub> ClN                                             | 3858-78-4  | 109.598  |                | 213    |                                     | 0.982 <sup>20</sup>        |                      | sl H <sub>2</sub> O, EtOH                              |
| 1498 | Butyl 4-aminobenzoate                                   | Butamben                                                                   | C <sub>11</sub> H <sub>15</sub> NO <sub>2</sub>                                | 94-25-7    | 193.243  | cry (al or bz) | 58     | 173 <sup>8</sup>                    |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl            |
| 1499 | 2-(Butylamino)ethanol                                   |                                                                            | C <sub>8</sub> H <sub>15</sub> NO                                              | 111-75-1   | 117.189  |                |        | 199; 91 <sup>11</sup>               | 0.8907 <sup>20</sup>       | 1.4437 <sup>20</sup> | vs H <sub>2</sub> O, EtOH,<br>eth                      |
| 1500 | 2-( <i>tert</i> -Butylamino)ethanol                     |                                                                            | C <sub>8</sub> H <sub>15</sub> NO                                              | 4620-70-6  | 117.189  |                | 44     | 176.5; 72 <sup>14</sup>             | 0.8818 <sup>20</sup>       |                      |                                                        |
| 1501 | <i>N</i> - <i>tert</i> -Butylaminoethyl<br>methacrylate |                                                                            | C <sub>10</sub> H <sub>19</sub> NO <sub>2</sub>                                | 3775-90-4  | 185.264  |                |        | 102 <sup>12</sup>                   |                            |                      | s chl                                                  |
| 1502 | 2-( <i>tert</i> -Butylaminothio)<br>benzothiazole       | <i>N</i> - <i>tert</i> -Butyl-2-<br>benzothiazolesulfenamide               | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> S <sub>2</sub>                  | 95-31-8    | 238.372  |                | 108    |                                     |                            |                      |                                                        |
| 1503 | 2- <i>sec</i> -Butylaniline                             |                                                                            | C <sub>10</sub> H <sub>15</sub> N                                              | 55751-54-7 | 149.233  |                |        | 120 <sup>16</sup>                   | 0.9574 <sup>20</sup>       |                      | s EtOH, ace, bz;<br>sl ctc                             |
| 1504 | 4-Butylaniline                                          |                                                                            | C <sub>10</sub> H <sub>15</sub> N                                              | 104-13-2   | 149.233  | pa ye          |        | 261                                 | 0.945 <sup>20</sup>        |                      | sl ctc                                                 |
| 1505 | 4- <i>sec</i> -Butylaniline                             |                                                                            | C <sub>10</sub> H <sub>15</sub> N                                              | 30273-11-1 | 149.233  |                |        | 238; 118 <sup>15</sup>              | 0.949 <sup>15</sup>        | 1.5360 <sup>29</sup> | vs bz, eth                                             |
| 1506 | 4- <i>tert</i> -Butylaniline                            |                                                                            | C <sub>10</sub> H <sub>15</sub> N                                              | 769-92-6   | 149.233  | ye rd (peth)   | 17     | 241                                 | 0.9525 <sup>15</sup>       | 1.5380 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth; vs<br>bz; s ctc |
| 1507 | <i>N</i> -Butylaniline                                  |                                                                            | C <sub>10</sub> H <sub>15</sub> N                                              | 1126-78-9  | 149.233  | liq            | -14.4  | 243.5                               | 0.9323 <sup>20</sup>       | 1.5341 <sup>20</sup> | vs eth, EtOH                                           |
| 1508 | <i>N</i> - <i>tert</i> -Butylaniline                    |                                                                            | C <sub>10</sub> H <sub>15</sub> N                                              | 937-33-7   | 149.233  |                |        | 215; 95 <sup>19</sup>               |                            | 1.5270 <sup>20</sup> | s EtOH; vs ace,<br>bz, chl                             |
| 1509 | 2- <i>tert</i> -Butyl-9,10-anthracenedione              |                                                                            | C <sub>18</sub> H <sub>16</sub> O <sub>2</sub>                                 | 84-47-9    | 264.319  |                | 99     |                                     |                            |                      | s ctc, CS <sub>2</sub>                                 |

Na<sup>+</sup>

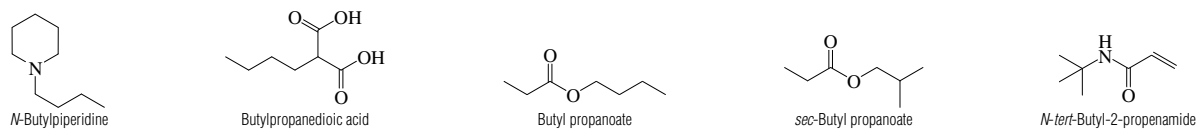
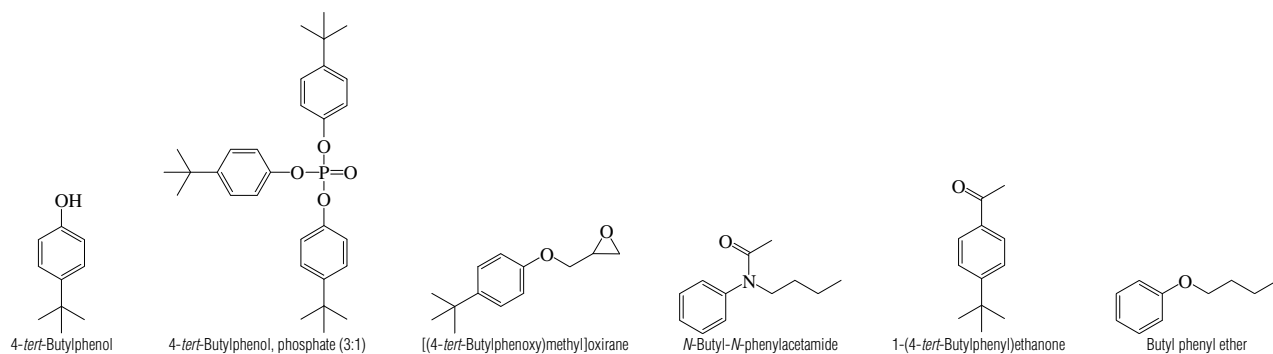
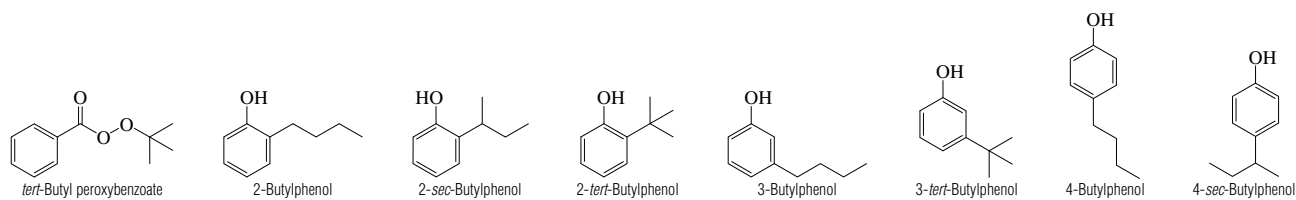
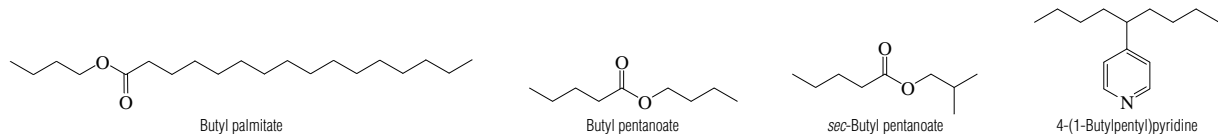
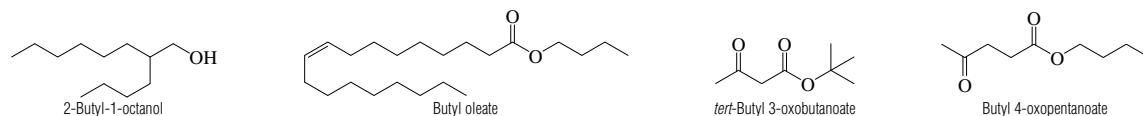
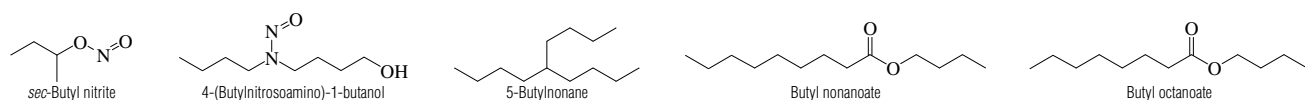
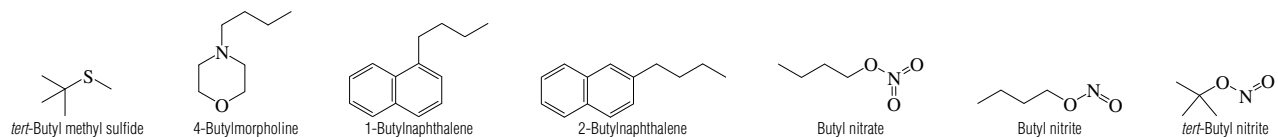
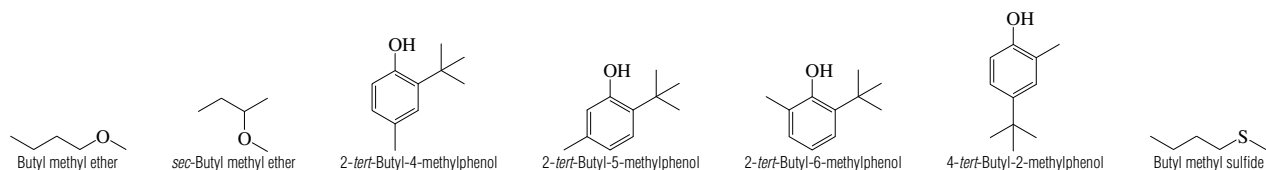
| No.  | Name                                                       | Synonym                           | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form     | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                  |
|------|------------------------------------------------------------|-----------------------------------|----------------------------------------------------------------|------------|----------|-------------------|--------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------------------|
| 1510 | <i>tert</i> -Butyl azidoformate                            | <i>tert</i> -Butyl carbonazidate  | C <sub>5</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>    | 1070-19-5  | 143.144  | unstab            | >80    | 73 <sup>70</sup>                      |                            |                      |                                                             |
| 1511 | 4-Butylbenzaldehyde                                        |                                   | C <sub>11</sub> H <sub>14</sub> O                              | 1200-14-2  | 162.228  |                   |        | 123 <sup>7</sup>                      |                            | 1.5265               |                                                             |
| 1512 | 4- <i>tert</i> -Butylbenzaldehyde                          |                                   | C <sub>11</sub> H <sub>14</sub> O                              | 939-97-9   | 162.228  | liq               |        | 107 <sup>11</sup> , 130 <sup>25</sup> | 0.970                      | 1.5270 <sup>20</sup> |                                                             |
| 1513 | Butylbenzene                                               |                                   | C <sub>10</sub> H <sub>14</sub>                                | 104-51-8   | 134.218  | liq               | -87.85 | 183.31                                | 0.8601 <sup>20</sup>       | 1.4898 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, peth, ctc |
| 1514 | <i>sec</i> -Butylbenzene, (±)                              | 2-Phenylbutane                    | C <sub>10</sub> H <sub>14</sub>                                | 36383-15-0 | 134.218  | liq               | -82.7  | 173.3                                 | 0.8621 <sup>20</sup>       | 1.4902 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, peth, ctc |
| 1515 | <i>tert</i> -Butylbenzene                                  |                                   | C <sub>10</sub> H <sub>14</sub>                                | 98-06-6    | 134.218  | liq               | -57.8  | 169.1                                 | 0.8665 <sup>20</sup>       | 1.4927 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth; msc ace,<br>bz         |
| 1516 | 4- <i>tert</i> -Butyl-1,2-benzenediol                      |                                   | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                 | 98-29-3    | 166.217  |                   | 54.3   | 285; 160 <sup>22</sup>                |                            |                      | s tfa                                                       |
| 1517 | 2- <i>tert</i> -Butyl-1,4-benzenediol                      |                                   | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                 | 1948-33-0  | 166.217  |                   | 128    |                                       |                            |                      |                                                             |
| 1518 | <i>N</i> - <i>tert</i> -Butylbenzenemethanamine            |                                   | C <sub>11</sub> H <sub>17</sub> N                              | 3378-72-1  | 163.260  |                   |        | 75 <sup>5</sup>                       |                            | 1.4951 <sup>25</sup> |                                                             |
| 1519 | 4- <i>tert</i> -Butylbenzenemethanol                       |                                   | C <sub>11</sub> H <sub>16</sub> O                              | 877-65-6   | 164.244  |                   |        | 236; 140 <sup>20</sup>                | 0.928 <sup>25</sup>        | 1.5179 <sup>20</sup> |                                                             |
| 1520 | Butyl benzoate                                             |                                   | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | 136-60-7   | 178.228  | liq               | -22.4  | 250.3                                 | 1.000 <sup>20</sup>        | 1.4940 <sup>25</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ace; sl ctc      |
| 1521 | 2- <i>tert</i> -Butylbenzoic acid                          |                                   | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | 1077-58-3  | 178.228  | pl (dil al)       | 80.5   |                                       |                            |                      | vs EtOH                                                     |
| 1522 | 3- <i>tert</i> -Butylbenzoic acid                          |                                   | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | 7498-54-6  | 178.228  | nd (peth)         | 128.8  |                                       |                            |                      | vs EtOH, peth                                               |
| 1523 | 4- <i>tert</i> -Butylbenzoic acid                          |                                   | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | 98-73-7    | 178.228  | nd (dil al)       | 164.5  |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>bz; s chl                   |
| 1524 | 4-Butylbenzoyl chloride                                    |                                   | C <sub>11</sub> H <sub>13</sub> ClO                            | 28788-62-7 | 196.673  |                   |        | 155 <sup>26</sup>                     | 1.051 <sup>25</sup>        | 1.5351 <sup>20</sup> |                                                             |
| 1525 | 4- <i>tert</i> -Butylbenzoyl chloride                      |                                   | C <sub>11</sub> H <sub>13</sub> ClO                            | 1710-98-1  | 196.673  |                   |        | 266; 135 <sup>20</sup>                | 1.007 <sup>25</sup>        | 1.5364 <sup>20</sup> |                                                             |
| 1526 | 2-Butyl-1,1'-biphenyl                                      |                                   | C <sub>16</sub> H <sub>18</sub>                                | 54532-97-7 | 210.314  | liq               | -9.65  | 291.2                                 | 0.9676 <sup>20</sup>       | 1.5604 <sup>20</sup> |                                                             |
| 1527 | <i>tert</i> -Butyl bromoacetate                            |                                   | C <sub>6</sub> H <sub>11</sub> BrO <sub>2</sub>                | 5292-43-3  | 195.054  |                   |        | 73 <sup>25</sup>                      |                            | 1.4430 <sup>20</sup> | vs eth, EtOH                                                |
| 1528 | Butyl butanoate                                            |                                   | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                  | 109-21-7   | 144.212  | liq               | -91.5  | 166                                   | 0.8700 <sup>20</sup>       | 1.4075 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ctc              |
| 1529 | Butyl <i>cis</i> -2-butenedioate                           | Monobutyl maleate                 | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                  | 925-21-3   | 172.179  | oil               |        |                                       | 1.09 <sup>25</sup>         |                      |                                                             |
| 1530 | Butyl carbamate                                            |                                   | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                 | 592-35-8   | 117.147  | pr                | 53     | dec 204; 108 <sup>14</sup>            |                            |                      | vs EtOH; sl chl                                             |
| 1531 | Butyl chloroacetate                                        |                                   | C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>                | 590-02-3   | 150.603  |                   |        | 183                                   | 1.0704 <sup>20</sup>       | 1.4297 <sup>20</sup> | vs eth, EtOH                                                |
| 1532 | <i>tert</i> -Butyl chloroacetate                           |                                   | C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>                | 107-59-5   | 150.603  |                   |        | 150; 50 <sup>10</sup>                 |                            | 1.4268 <sup>20</sup> | dec H <sub>2</sub> O                                        |
| 1533 | Butylchlorodimethylsilane                                  |                                   | C <sub>6</sub> H <sub>15</sub> ClSi                            | 1000-50-6  | 150.722  |                   |        | 139                                   | 0.876 <sup>20</sup>        | 1.5145 <sup>20</sup> |                                                             |
| 1534 | Butyl chloroformate                                        |                                   | C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>                 | 592-34-7   | 136.577  |                   |        | 142                                   | 1.074 <sup>25</sup>        | 1.4114 <sup>20</sup> | msc eth; s ace;<br>sl ctc                                   |
| 1535 | <i>N</i> -Butyl-4-chloro-2-hydroxybenzamide                | Buclosamide                       | C <sub>11</sub> H <sub>14</sub> ClNO <sub>2</sub>              | 575-74-6   | 227.688  |                   | 91.5   |                                       |                            |                      |                                                             |
| 1536 | Butyl 2-chloropropanoate                                   |                                   | C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>                | 54819-86-2 | 164.630  |                   |        | 184                                   | 1.0253 <sup>20</sup>       | 1.4263 <sup>20</sup> | vs eth                                                      |
| 1537 | Butyl 3-chloropropanoate                                   |                                   | C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>                | 27387-79-7 | 164.630  |                   |        | 104 <sup>22</sup> , 92 <sup>6</sup>   | 1.0370 <sup>20</sup>       | 1.4321 <sup>20</sup> | vs H <sub>2</sub> O, eth                                    |
| 1538 | <i>tert</i> -Butyl chromate                                |                                   | C <sub>8</sub> H <sub>16</sub> CrO <sub>4</sub>                | 1189-85-1  | 230.223  | red cry<br>(peth) | -5     |                                       |                            |                      | reac H <sub>2</sub> O                                       |
| 1539 | Butyl citrate                                              |                                   | C <sub>18</sub> H <sub>32</sub> O <sub>7</sub>                 | 77-94-1    | 360.443  |                   | -20    | 233 <sup>22</sup>                     | 1.043 <sup>20</sup>        | 1.4460 <sup>20</sup> |                                                             |
| 1540 | Butyl cyanoacetate                                         |                                   | C <sub>7</sub> H <sub>11</sub> NO <sub>2</sub>                 | 5459-58-5  | 141.168  |                   |        | 231; 115 <sup>15</sup>                | 1.0010 <sup>20</sup>       | 1.4200 <sup>20</sup> |                                                             |
| 1541 | Butylcyclohexane                                           |                                   | C <sub>10</sub> H <sub>20</sub>                                | 1678-93-9  | 140.266  | liq               | -74.73 | 180                                   | 0.7902 <sup>20</sup>       | 1.4408 <sup>20</sup> | i H <sub>2</sub> O                                          |
| 1542 | <i>sec</i> -Butylcyclohexane                               |                                   | C <sub>10</sub> H <sub>20</sub>                                | 7058-01-7  | 140.266  |                   |        | 179.3                                 | 0.8131 <sup>20</sup>       | 1.4467 <sup>20</sup> | i H <sub>2</sub> O; s ace                                   |
| 1543 | <i>tert</i> -Butylcyclohexane                              |                                   | C <sub>10</sub> H <sub>20</sub>                                | 3178-22-1  | 140.266  | liq               | -41.2  | 171.5                                 | 0.8127 <sup>20</sup>       | 1.4469 <sup>20</sup> | i H <sub>2</sub> O                                          |
| 1544 | 2- <i>tert</i> -Butylcyclohexanol                          |                                   | C <sub>10</sub> H <sub>20</sub> O                              | 13491-79-7 | 156.265  |                   | 45     | 139 <sup>95</sup>                     | 0.902 <sup>25</sup>        |                      |                                                             |
| 1545 | <i>cis</i> -4- <i>tert</i> -Butylcyclohexanol              |                                   | C <sub>10</sub> H <sub>20</sub> O                              | 937-05-3   | 156.265  |                   | 83     | 112 <sup>15</sup>                     |                            |                      |                                                             |
| 1546 | <i>trans</i> -4- <i>tert</i> -Butylcyclohexanol            |                                   | C <sub>10</sub> H <sub>20</sub> O                              | 21862-63-5 | 156.265  |                   | 83     | 112 <sup>15</sup>                     |                            |                      |                                                             |
| 1547 | 4- <i>tert</i> -Butylcyclohexanone                         |                                   | C <sub>10</sub> H <sub>18</sub> O                              | 98-53-3    | 154.249  |                   | 48     | 90 <sup>9</sup>                       |                            |                      |                                                             |
| 1548 | Butylcyclohexylamine                                       | <i>N</i> -Butylcyclohexanamine    | C <sub>10</sub> H <sub>21</sub> N                              | 10108-56-2 | 155.281  |                   | 208.3  |                                       |                            |                      | sl H <sub>2</sub> O, ctc; vs<br>EtOH, eth                   |
| 1549 | Butyl cyclohexyl phthalate                                 |                                   | C <sub>18</sub> H <sub>24</sub> O <sub>4</sub>                 | 84-64-0    | 304.382  | col liq           |        | ≈205 <sup>5</sup>                     | 1.076 <sup>25</sup>        |                      | sl H <sub>2</sub> O; misc os                                |
| 1550 | Butylcyclopentane                                          |                                   | C <sub>9</sub> H <sub>18</sub>                                 | 2040-95-1  | 126.239  | liq               | -108   | 156.6                                 | 0.7846 <sup>20</sup>       | 1.4316 <sup>20</sup> | vs ace, bz, eth,<br>EtOH                                    |
| 1551 | Butyl dichloroacetate                                      |                                   | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>2</sub>  | 29003-73-4 | 185.048  |                   |        | 193.5                                 | 1.1820 <sup>20</sup>       | 1.4420 <sup>20</sup> | vs eth, EtOH                                                |
| 1552 | Butyl (2,4-dichlorophenoxy) acetate                        | 2,4-D Butyl ester                 | C <sub>12</sub> H <sub>14</sub> Cl <sub>2</sub> O <sub>3</sub> | 94-80-4    | 277.143  |                   | 9      | 133 <sup>1</sup>                      |                            |                      |                                                             |
| 1553 | 5-Butyldihydro-2(3 <i>H</i> )-furanone                     |                                   | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                  | 104-50-7   | 142.196  |                   |        | 132 <sup>20</sup>                     | 0.9796 <sup>19</sup>       | 1.4451 <sup>19</sup> | s EtOH; sl ctc                                              |
| 1554 | Butyldimethylamine                                         | <i>N,N</i> -Dimethyl-1-butanamine | C <sub>6</sub> H <sub>15</sub> N                               | 927-62-8   | 101.190  |                   |        | 95                                    | 0.7206 <sup>20</sup>       | 1.3970 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth, ace, bz                 |
| 1555 | 1- <i>tert</i> -Butyl-3,5-dimethylbenzene                  |                                   | C <sub>12</sub> H <sub>18</sub>                                | 98-19-1    | 162.271  | liq               | -18    | 207                                   | 0.8668 <sup>20</sup>       |                      | s ctc                                                       |
| 1556 | 4- <i>tert</i> -Butyl-2,6-dimethyl-3,5-dinitroacetophenone | Musk ketone                       | C <sub>14</sub> H <sub>18</sub> N <sub>2</sub> O <sub>5</sub>  | 81-14-1    | 294.303  | ye cry            | 135.5  |                                       |                            |                      | vs chl                                                      |
| 1557 | 2- <i>tert</i> -Butyl-4,6-dimethylphenol                   |                                   | C <sub>12</sub> H <sub>18</sub> O                              | 1879-09-0  | 178.270  |                   | 22.3   | 249                                   | 0.917 <sup>80</sup>        | 1.5183 <sup>20</sup> | i alk                                                       |
| 1558 | 4- <i>tert</i> -Butyl-2,5-dimethylphenol                   |                                   | C <sub>12</sub> H <sub>18</sub> O                              | 17696-37-6 | 178.270  |                   | 71.2   | 264                                   | 0.939 <sup>80</sup>        | 1.5311 <sup>20</sup> | s alk                                                       |
| 1559 | 4- <i>tert</i> -Butyl-2,6-dimethylphenol                   |                                   | C <sub>12</sub> H <sub>18</sub> O                              | 879-97-0   | 178.270  |                   | 82.4   | 248                                   | 0.916 <sup>80</sup>        |                      | s alk                                                       |
| 1560 | 1- <i>tert</i> -Butyl-3,5-dimethyl-2,4,6-trinitrobenzene   |                                   | C <sub>12</sub> H <sub>15</sub> N <sub>3</sub> O <sub>6</sub>  | 81-15-2    | 297.263  | pl, nd (al)       | 110    |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH;<br>s eth, chl                  |
| 1561 | 2- <i>tert</i> -Butyl-4,6-dinitrophenol                    |                                   | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub>  | 1420-07-1  | 240.212  | ye solid          | 126    |                                       |                            |                      |                                                             |



| No.  | Name                                                                         | Synonym                          | Mol. Form.                                                    | CAS RN      | Mol. Wt. | Physical Form | mp/°C | bp/°C                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|------|------------------------------------------------------------------------------|----------------------------------|---------------------------------------------------------------|-------------|----------|---------------|-------|--------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 1562 | 5-Butyldocosane                                                              |                                  | C <sub>26</sub> H <sub>54</sub>                               | 55282-16-1  | 366.707  |               | 208   | 244 <sup>10</sup>        | 0.8058 <sup>20</sup>       | 1.4503 <sup>20</sup> |                                                     |
| 1563 | 11-Butyldocosane                                                             |                                  | C <sub>26</sub> H <sub>54</sub>                               | 13475-76-8  | 366.707  |               |       | 242.5 <sup>10</sup>      | 0.8041 <sup>20</sup>       | 1.4499 <sup>20</sup> |                                                     |
| 1564 | Butyl dodecanoate                                                            |                                  | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                | 106-18-3    | 256.424  |               |       | 180 <sup>18</sup>        |                            |                      |                                                     |
| 1565 | Butylethylamine                                                              | <i>N</i> -Ethyl-1-butanamine     | C <sub>6</sub> H <sub>15</sub> N                              | 13360-63-9  | 101.190  |               |       | 107.5                    | 0.7398 <sup>20</sup>       | 1.4040 <sup>20</sup> | msc EtOH, eth, ace, bz                              |
| 1566 | 1- <i>tert</i> -Butyl-4-ethylbenzene                                         |                                  | C <sub>12</sub> H <sub>18</sub>                               | 7364-19-4   | 162.271  | liq           | -38.4 | 211                      | 0.8641 <sup>20</sup>       |                      |                                                     |
| 1567 | Butyl ethyl ether                                                            |                                  | C <sub>6</sub> H <sub>14</sub> O                              | 628-81-9    | 102.174  | liq           | -124  | 92.3                     | 0.7495 <sup>20</sup>       | 1.3818 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs ace           |
| 1568 | <i>sec</i> -Butyl ethyl ether                                                |                                  | C <sub>6</sub> H <sub>14</sub> O                              | 2679-87-0   | 102.174  |               |       | 81                       | 0.7503 <sup>20</sup>       | 1.3802 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                    |
| 1569 | <i>tert</i> -Butyl ethyl ether                                               | Ethyl <i>tert</i> -butyl ether   | C <sub>6</sub> H <sub>14</sub> O                              | 637-92-3    | 102.174  | liq           | -94   | 72.6                     | 0.736 <sup>25</sup>        | 1.3756 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                    |
| 1570 | 2- <i>tert</i> -Butyl-4-ethylphenol                                          |                                  | C <sub>12</sub> H <sub>16</sub> O                             | 96-70-8     | 178.270  |               | 23    | 250                      |                            |                      |                                                     |
| 1571 | 2-Butyl-2-ethyl-1,3-propanediol                                              |                                  | C <sub>9</sub> H <sub>20</sub> O <sub>2</sub>                 | 115-84-4    | 160.254  | wh cry        | 43.8  | 262                      | 0.927 <sup>50</sup>        | 1.4587 <sup>25</sup> | sl H <sub>2</sub> O, ace; s EtOH                    |
| 1572 | 5-Butyl-5-ethyl-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | Butethal                         | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> | 77-28-1     | 212.245  |               | 128.5 |                          |                            |                      |                                                     |
| 1573 | Butyl ethyl sulfide                                                          |                                  | C <sub>6</sub> H <sub>14</sub> S                              | 638-46-0    | 118.240  | liq           | -95.1 | 144.3                    | 0.8376 <sup>20</sup>       | 1.4492 <sup>10</sup> | vs EtOH; s chl                                      |
| 1574 | <i>tert</i> -Butyl ethyl sulfide                                             | 2-Methyl-2-propanethiol          | C <sub>6</sub> H <sub>14</sub> S                              | 14290-92-7  | 118.240  | liq           | -88.9 | 120.4; 56 <sup>109</sup> |                            |                      |                                                     |
| 1575 | <i>N</i> - <i>tert</i> -Butylformamide                                       |                                  | C <sub>5</sub> H <sub>11</sub> NO                             | 2425-74-3   | 101.147  | liq           | 16    | 202                      | 0.903                      | 1.4330 <sup>20</sup> |                                                     |
| 1576 | Butyl formate                                                                |                                  | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                 | 592-84-7    | 102.132  | liq           | -91.5 | 106.1                    | 0.8958 <sup>20</sup>       | 1.3887 <sup>20</sup> | sl H <sub>2</sub> O; s ace; msc EtOH, eth           |
| 1577 | <i>sec</i> -Butyl formate                                                    |                                  | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                 | 589-40-2    | 102.132  |               |       | 97                       | 0.8846 <sup>20</sup>       | 1.3865 <sup>20</sup> | sl H <sub>2</sub> O; s ace; msc EtOH, eth           |
| 1578 | <i>tert</i> -Butyl formate                                                   | 1,1-Dimethylethyl formate        | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                 | 762-75-4    | 102.132  | liq           |       | 82                       | 0.872                      | 1.3790 <sup>20</sup> |                                                     |
| 1579 | Butyl glycidyl ether                                                         |                                  | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | 2426-08-6   | 130.185  |               |       | 169; 75 <sup>26</sup>    | 0.918 <sup>20</sup>        |                      |                                                     |
| 1580 | Butyl heptanoate                                                             | Butyl enanthate                  | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                | 5454-28-4   | 186.292  | liq           | -67.5 | 226.2                    | 0.8638 <sup>20</sup>       | 1.4204 <sup>20</sup> | vs ace, bz, eth, EtOH                               |
| 1581 | Butyl hexanoate                                                              | Butyl caproate                   | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                | 626-82-4    | 172.265  | liq           | -64.3 | 208                      | 0.8653 <sup>20</sup>       | 1.4152 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; msc eth                 |
| 1582 | <i>tert</i> -Butylhydrazine hydrochloride                                    |                                  | C <sub>4</sub> H <sub>13</sub> ClN <sub>2</sub>               | 7400-27-3   | 124.612  |               | 192.5 |                          |                            |                      |                                                     |
| 1583 | Butyl hydrogen succinate                                                     | Monobutyl succinate              | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                 | 5150-93-6   | 174.195  |               | 8.6   | 136.5 <sup>3</sup>       | 1.0732 <sup>20</sup>       | 1.4360 <sup>20</sup> |                                                     |
| 1584 | <i>tert</i> -Butyl hydroperoxide                                             |                                  | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 75-91-2     | 90.121   |               | 6     | dec 89; 36 <sup>17</sup> | 0.8960 <sup>20</sup>       | 1.4015 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ctc, chl             |
| 1585 | <i>tert</i> -Butyl-4-hydroxyanisole                                          | Butylated hydroxyanisole         | C <sub>11</sub> H <sub>16</sub> O <sub>2</sub>                | 25013-16-5  | 180.244  | wax           | 51    | 268                      |                            |                      | i H <sub>2</sub> O; s peth, EtOH                    |
| 1586 | Butyl 2-hydroxybenzoate                                                      |                                  | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>                | 2052-14-4   | 194.227  | liq           | -5.9  | 271                      | 1.0728 <sup>20</sup>       | 1.5115 <sup>20</sup> | sl ctc                                              |
| 1587 | Butyl 4-hydroxybenzoate                                                      | Butylparaben                     | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>                | 94-26-8     | 194.227  |               | 68.5  |                          |                            |                      | sl H <sub>2</sub> O, ctc; s EtOH                    |
| 1588 | Butyl <i>cis</i> -12-hydroxy-9-octadecenoate, ( <i>R</i> )                   | Butyl ricinoleate                | C <sub>22</sub> H <sub>42</sub> O <sub>3</sub>                | 151-13-3    | 354.566  |               |       | 275 <sup>13</sup>        | 0.9058 <sup>22</sup>       | 1.4566 <sup>22</sup> | vs eth                                              |
| 1589 | <i>tert</i> -Butyl hypochlorite                                              |                                  | C <sub>4</sub> H <sub>9</sub> ClO                             | 507-40-4    | 108.566  | ye liq        |       | 77.5                     | 0.9583 <sup>18</sup>       | 1.403 <sup>20</sup>  | i H <sub>2</sub> O; vs eth, bz; s ace               |
| 1590 | Butyl isobutyl ether                                                         |                                  | C <sub>8</sub> H <sub>18</sub> O                              | 17071-47-5  | 130.228  | liq           |       | 151                      | 0.763 <sup>15</sup>        | 1.4077 <sup>21</sup> | vs ace, eth, EtOH                                   |
| 1591 | <i>tert</i> -Butyl isobutyl ether                                            |                                  | C <sub>8</sub> H <sub>18</sub> O                              | 33021-02-2  | 130.228  | liq           |       | 112.0                    |                            |                      |                                                     |
| 1592 | Butyl isocyanate                                                             |                                  | C <sub>5</sub> H <sub>9</sub> NO                              | 111-36-4    | 99.131   |               |       | 115                      | 0.880 <sup>20</sup>        | 1.4060 <sup>20</sup> |                                                     |
| 1593 | Butyl isocyanide                                                             |                                  | C <sub>5</sub> H <sub>9</sub> N                               | 2769-64-4   | 83.132   |               |       | 120                      | 0.78 <sup>20</sup>         |                      | vs eth, EtOH                                        |
| 1594 | <i>tert</i> -Butyl isopropyl ether                                           |                                  | C <sub>7</sub> H <sub>16</sub> O                              | 17348-59-3  | 116.201  | liq           | -88   | 87.6                     | 0.7365 <sup>25</sup>       |                      | s chl                                               |
| 1595 | Butyl isothiocyanate                                                         | 1-Isothiocyanatobutane           | C <sub>5</sub> H <sub>9</sub> NS                              | 592-82-5    | 115.197  |               |       | 168                      | 0.9546 <sup>20</sup>       | 1.501 <sup>20</sup>  | vs eth, EtOH                                        |
| 1596 | <i>sec</i> -Butyl isothiocyanate, (±)                                        | 2-Isothiocyanatobutane, (±)      | C <sub>5</sub> H <sub>9</sub> NS                              | 116724-11-9 | 115.197  |               |       | 159.5                    | 0.944 <sup>12</sup>        |                      | vs eth, EtOH                                        |
| 1597 | <i>tert</i> -Butyl isothiocyanate                                            | 2-Isothiocyanato-2-methylpropane | C <sub>5</sub> H <sub>9</sub> NS                              | 590-42-1    | 115.197  |               | 10.5  | 140                      | 0.9187 <sup>10</sup>       |                      |                                                     |
| 1598 | Butyl lactate                                                                |                                  | C <sub>7</sub> H <sub>14</sub> O <sub>3</sub>                 | 34451-18-8  | 146.184  |               |       | 77 <sup>10</sup>         | 0.9744 <sup>27</sup>       |                      | vs eth, EtOH                                        |
| 1599 | Butyl methacrylate                                                           |                                  | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                 | 97-88-1     | 142.196  |               |       | 160                      | 0.8936 <sup>20</sup>       | 1.4240 <sup>20</sup> | vs eth, EtOH                                        |
| 1600 | <i>tert</i> -Butyl methacrylate                                              |                                  | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                 | 585-07-9    | 142.196  |               |       | 135.2                    |                            |                      |                                                     |
| 1601 | 1- <i>tert</i> -Butyl-4-methoxybenzene                                       |                                  | C <sub>11</sub> H <sub>16</sub> O                             | 5396-38-3   | 164.244  |               | 19.0  | 238                      | 0.9383 <sup>20</sup>       | 1.5039 <sup>20</sup> |                                                     |
| 1602 | 1- <i>tert</i> -Butyl-2-methoxy-4-methyl-3,5-dinitrobenzene                  |                                  | C <sub>12</sub> H <sub>16</sub> N <sub>2</sub> O <sub>5</sub> | 83-66-9     | 268.265  | pa ye lf (al) | 85    | 185 <sup>16</sup>        |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, chl             |
| 1603 | 2- <i>tert</i> -Butyl-4-methoxyphenol                                        |                                  | C <sub>11</sub> H <sub>16</sub> O <sub>2</sub>                | 121-00-6    | 180.244  |               |       | 184 <sup>50</sup>        |                            |                      |                                                     |
| 1604 | 3- <i>tert</i> -Butyl-4-methoxyphenol                                        |                                  | C <sub>11</sub> H <sub>16</sub> O <sub>2</sub>                | 88-32-4     | 180.244  |               | 65    |                          |                            |                      |                                                     |
| 1605 | Butylmethylamine                                                             | <i>N</i> -Methyl-1-butanamine    | C <sub>5</sub> H <sub>13</sub> N                              | 110-68-9    | 87.164   |               |       | 91                       | 0.7637 <sup>15</sup>       |                      |                                                     |
| 1606 | 1- <i>tert</i> -Butyl-2-methylbenzene                                        | 2- <i>tert</i> -Butyltoluene     | C <sub>11</sub> H <sub>16</sub>                               | 1074-92-6   | 148.245  | liq           | -50.3 | 200.4                    | 0.8897 <sup>20</sup>       | 1.5076 <sup>20</sup> | vs ace, bz, eth, EtOH                               |
| 1607 | 1- <i>tert</i> -Butyl-3-methylbenzene                                        | 3- <i>tert</i> -Butyltoluene     | C <sub>11</sub> H <sub>16</sub>                               | 1075-38-3   | 148.245  | liq           | -41.4 | 189.3                    | 0.8657 <sup>20</sup>       | 1.4944 <sup>20</sup> | vs ace, bz, eth, EtOH                               |
| 1608 | 1- <i>tert</i> -Butyl-4-methylbenzene                                        | 4- <i>tert</i> -Butyltoluene     | C <sub>11</sub> H <sub>16</sub>                               | 98-51-1     | 148.245  | liq           | -52   | 190                      | 0.8612 <sup>20</sup>       | 1.4918 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH; vs eth, chl; s ace, bz |
| 1609 | Butyl 2-methylbutanoate                                                      | Butyl <i>o</i> -toluate          | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                 | 15706-73-7  | 158.238  |               |       | 179                      | 0.8620 <sup>20</sup>       | 1.4135 <sup>20</sup> |                                                     |
| 1610 | Butyl 3-methylbutanoate                                                      | Butyl <i>p</i> -toluate          | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                 | 109-19-3    | 158.238  |               |       |                          |                            |                      | 1.4058 <sup>25</sup>                                |

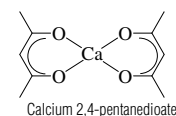
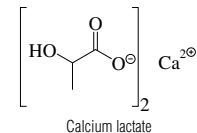
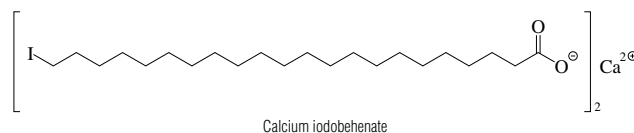
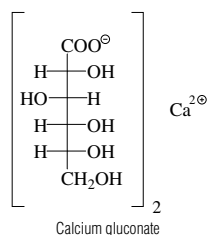
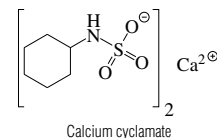
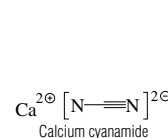
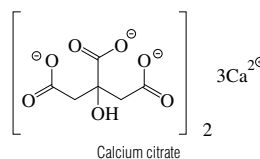
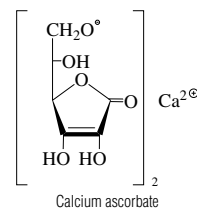
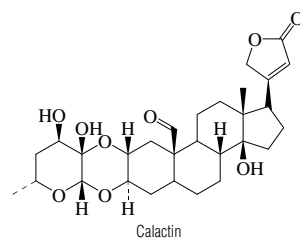
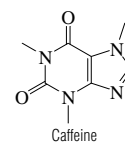
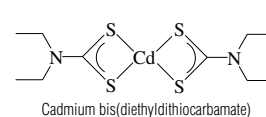
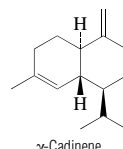
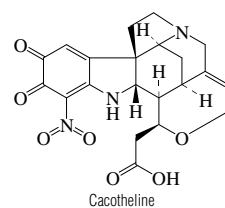
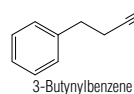
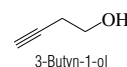
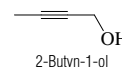
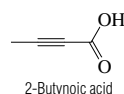
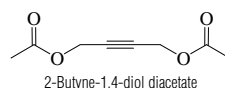
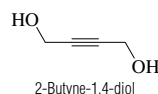
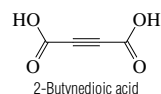
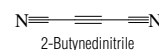
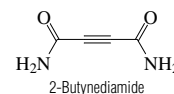
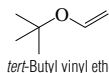
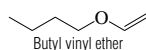
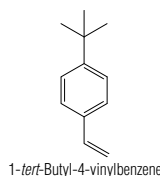
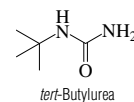
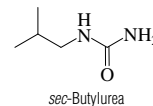
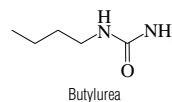
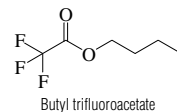
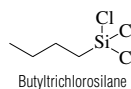
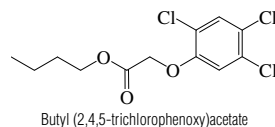
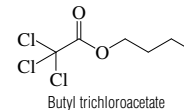
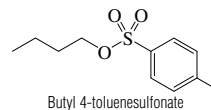
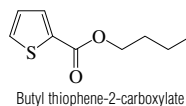
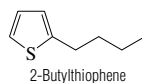
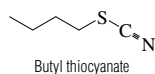
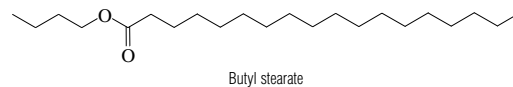
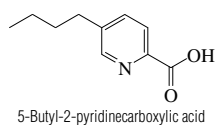
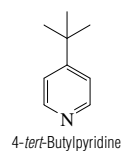
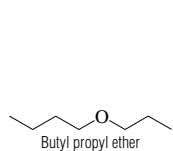


| No.  | Name                                  | Synonym                                | Mol. Form.                                                   | CAS RN      | Mol. Wt. | Physical Form | mp/°C  | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                             |
|------|---------------------------------------|----------------------------------------|--------------------------------------------------------------|-------------|----------|---------------|--------|----------------------------------------|----------------------------|-----------------------|--------------------------------------------------------|
| 1611 | Butyl methyl ether                    |                                        | C <sub>5</sub> H <sub>12</sub> O                             | 628-28-4    | 88.148   | liq           | -115.7 | 70.16                                  | 0.7392 <sup>25</sup>       | 1.3736 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s ace               |
| 1612 | sec-Butyl methyl ether                |                                        | C <sub>5</sub> H <sub>12</sub> O                             | 116783-23-4 | 88.148   |               |        | 59.1                                   | 0.7415 <sup>20</sup>       | 1.3680 <sup>25</sup>  | vs ace, eth, EtOH                                      |
| 1613 | 2-tert-Butyl-4-methylphenol           |                                        | C <sub>11</sub> H <sub>16</sub> O                            | 2409-55-4   | 164.244  |               | 51.5   | 237                                    | 0.9247 <sup>75</sup>       | 1.4969 <sup>75</sup>  | sl H <sub>2</sub> O; s ace, bz, chl                    |
| 1614 | 2-tert-Butyl-5-methylphenol           |                                        | C <sub>11</sub> H <sub>16</sub> O                            | 88-60-8     | 164.244  |               | 46.5   | 127 <sup>11</sup>                      | 0.922 <sup>80</sup>        | 1.5250 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace                   |
| 1615 | 2-tert-Butyl-6-methylphenol           |                                        | C <sub>11</sub> H <sub>16</sub> O                            | 2219-82-1   | 164.244  |               | 31     | 230                                    | 0.9240 <sup>80</sup>       | 1.5195 <sup>20</sup>  |                                                        |
| 1616 | 4-tert-Butyl-2-methylphenol           |                                        | C <sub>11</sub> H <sub>16</sub> O                            | 98-27-1     | 164.244  |               | 27.5   | 237; 132 <sup>20</sup>                 | 0.965 <sup>20</sup>        | 1.5230 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ace, bz                     |
| 1617 | Butyl methyl sulfide                  |                                        | C <sub>5</sub> H <sub>12</sub> S                             | 628-29-5    | 104.214  | liq           | -97.8  | 123.4                                  | 0.8426 <sup>20</sup>       | 1.4477 <sup>20</sup>  | vs EtOH, MeOH                                          |
| 1618 | tert-Butyl methyl sulfide             |                                        | C <sub>5</sub> H <sub>12</sub> S                             | 6163-64-0   | 104.214  | liq           |        | 98.9                                   |                            |                       |                                                        |
| 1619 | 4-Butylmorpholine                     |                                        | C <sub>8</sub> H <sub>17</sub> NO                            | 1005-67-0   | 143.227  | liq           | -57.1  | 213.5                                  | 0.9068 <sup>20</sup>       | 1.4451 <sup>20</sup>  | vs H <sub>2</sub> O, ace, bz, EtOH                     |
| 1620 | 1-Butylnaphthalene                    |                                        | C <sub>14</sub> H <sub>16</sub>                              | 1634-09-9   | 184.277  | liq           | -19.8  | 289.3                                  | 0.9738 <sup>20</sup>       | 1.5819 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, bz               |
| 1621 | 2-Butylnaphthalene                    |                                        | C <sub>14</sub> H <sub>16</sub>                              | 1134-62-9   | 184.277  | liq           | -2.5   | 292                                    | 0.9673 <sup>20</sup>       | 1.5777 <sup>20</sup>  | vs ace, bz, EtOH                                       |
| 1622 | Butyl nitrate                         |                                        | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | 928-45-0    | 119.119  |               |        | 133                                    | 1.0228 <sup>20</sup>       | 1.4013 <sup>23</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl ctc                |
| 1623 | Butyl nitrite                         |                                        | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 544-16-1    | 103.120  |               |        | 78                                     | 0.9114 <sup>25</sup>       | 1.3762 <sup>20</sup>  | msc EtOH, eth                                          |
| 1624 | tert-Butyl nitrite                    |                                        | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 540-80-7    | 103.120  | pa ye liq     |        | 63                                     | 0.8670 <sup>20</sup>       | 1.368 <sup>20</sup>   | sl H <sub>2</sub> O; s EtOH, eth, chl, CS <sub>2</sub> |
| 1625 | sec-Butyl nitrite                     |                                        | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 924-43-6    | 103.120  |               |        | 68.5                                   | 0.8726 <sup>20</sup>       | 1.3710 <sup>20</sup>  | vs eth, EtOH, chl                                      |
| 1626 | 4-(Butylnitrosoamino)-1-butanol       | N-Butyl-N-(4-hydroxybutyl) nitrosamine | C <sub>8</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub> | 3817-11-6   | 174.241  |               |        | 115 <sup>0.01</sup>                    |                            |                       |                                                        |
| 1627 | 5-Butylnonane                         |                                        | C <sub>13</sub> H <sub>28</sub>                              | 17312-63-9  | 184.361  |               |        | 217.5                                  | 0.7635 <sup>18</sup>       | 1.4273 <sup>18</sup>  |                                                        |
| 1628 | Butyl nonanoate                       | Butyl pelargonate                      | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>               | 50623-57-9  | 214.344  |               | -38    | 123 <sup>20</sup>                      | 0.8520 <sup>25</sup>       | 1.4262 <sup>25</sup>  |                                                        |
| 1629 | Butyl octanoate                       |                                        | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>               | 589-75-3    | 200.318  | liq           | -42.9  | 240.5                                  | 0.8628 <sup>20</sup>       | 1.4232 <sup>25</sup>  | vs ace, eth, EtOH                                      |
| 1630 | 2-Butyl-1-octanol                     |                                        | C <sub>12</sub> H <sub>26</sub> O                            | 3913-02-8   | 186.333  |               |        | 246.5; 132 <sup>15</sup>               | 0.891 <sup>20</sup>        |                       |                                                        |
| 1631 | Butyl oleate                          | Butyl cis-9-octadecenoate              | C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>               | 142-77-8    | 338.567  | ye cry        | -26.4  | 227 <sup>15</sup>                      | 0.8704 <sup>15</sup>       | 1.4480 <sup>25</sup>  | vs EtOH                                                |
| 1632 | tert-Butyl 3-oxobutanoate             |                                        | C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>                | 1694-31-1   | 158.195  |               |        | 71.5 <sup>11</sup>                     | 0.9756 <sup>20</sup>       | 1.4180 <sup>20</sup>  |                                                        |
| 1633 | Butyl 4-oxopentanoate                 | Butyl levulinate                       | C <sub>9</sub> H <sub>16</sub> O <sub>3</sub>                | 2052-15-5   | 172.221  |               |        | 237.5                                  | 0.9735 <sup>20</sup>       | 1.4290 <sup>20</sup>  | sl chl                                                 |
| 1634 | Butyl palmitate                       | Butyl hexadecanoate                    | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>               | 111-06-8    | 312.531  | cry (dil al)  | 16.9   |                                        |                            | 1.4312 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                        |
| 1635 | Butyl pentanoate                      |                                        | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                | 591-68-4    | 158.238  | liq           | -92.8  | 185.8                                  | 0.8710 <sup>15</sup>       | 1.4128 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth                       |
| 1636 | sec-Butyl pentanoate                  |                                        | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                | 116836-32-9 | 158.238  |               |        | 174.5                                  | 0.8605 <sup>20</sup>       | 1.4070 <sup>20</sup>  | vs bz, eth, py, EtOH                                   |
| 1637 | 4-(1-Butylpentyl)pyridine             |                                        | C <sub>14</sub> H <sub>23</sub> N                            | 2961-47-9   | 205.340  |               |        | 265; 181 <sup>50</sup>                 | 0.8878 <sup>25</sup>       | 1.4846 <sup>25</sup>  |                                                        |
| 1638 | tert-Butyl peroxybenzoate             | Benzoyl tert-butyl peroxide            | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>               | 614-45-9    | 194.227  |               |        | 75 <sup>0.2</sup>                      | 1.021 <sup>25</sup>        | 1.4990 <sup>20</sup>  |                                                        |
| 1639 | 2-Butylphenol                         |                                        | C <sub>10</sub> H <sub>14</sub> O                            | 3180-09-4   | 150.217  | liq           | -20    | 235                                    | 0.975 <sup>20</sup>        | 1.5180 <sup>25</sup>  | i H <sub>2</sub> O; s EtOH, eth, alk                   |
| 1640 | 2-sec-Butylphenol                     |                                        | C <sub>10</sub> H <sub>14</sub> O                            | 89-72-5     | 150.217  |               | 16     | 228; 116 <sup>21</sup>                 | 0.9804 <sup>25</sup>       | 1.5200 <sup>25</sup>  |                                                        |
| 1641 | 2-tert-Butylphenol                    |                                        | C <sub>10</sub> H <sub>14</sub> O                            | 88-18-6     | 150.217  | liq           | -6.8   | 223                                    | 0.9783 <sup>20</sup>       | 1.5160 <sup>20</sup>  | s EtOH, ctc, alk; vs eth                               |
| 1642 | 3-Butylphenol                         |                                        | C <sub>10</sub> H <sub>14</sub> O                            | 4074-43-5   | 150.217  |               |        | 248                                    | 0.974 <sup>20</sup>        |                       | vs eth, EtOH                                           |
| 1643 | 3-tert-Butylphenol                    |                                        | C <sub>10</sub> H <sub>14</sub> O                            | 585-34-2    | 150.217  | nd (peth)     | 42.3   | 240                                    |                            |                       | s EtOH, alk; vs eth                                    |
| 1644 | 4-Butylphenol                         |                                        | C <sub>10</sub> H <sub>14</sub> O                            | 1638-22-8   | 150.217  |               | 22     | 248                                    | 0.976 <sup>22</sup>        | 1.5165 <sup>25</sup>  | i H <sub>2</sub> O; s EtOH, eth, alk; sl ctc           |
| 1645 | 4-sec-Butylphenol                     | 4-(1-Methylpropyl)phenol               | C <sub>10</sub> H <sub>14</sub> O                            | 99-71-8     | 150.217  |               | 61.5   | 241                                    | 0.986 <sup>20</sup>        | 1.5182 <sup>21</sup>  | i H <sub>2</sub> O; s EtOH, alk; vs eth                |
| 1646 | 4-tert-Butylphenol                    |                                        | C <sub>10</sub> H <sub>14</sub> O                            | 98-54-4     | 150.217  | nd (lig)      | 98     | 237                                    | 0.908 <sup>80</sup>        | 1.4787 <sup>114</sup> | s H <sub>2</sub> O, EtOH, eth, chl, alk                |
| 1647 | 4-tert-Butylphenol, phosphate (3:1)   |                                        | C <sub>30</sub> H <sub>39</sub> O <sub>4</sub> P             | 78-33-1     | 494.602  |               |        |                                        |                            |                       | i EtOH; sl eth, bz                                     |
| 1648 | [(4-tert-Butylphenoxy)methyl] oxirane |                                        | C <sub>13</sub> H <sub>18</sub> O <sub>2</sub>               | 3101-60-8   | 206.281  |               |        | 167 <sup>14</sup> , 145 <sup>0.5</sup> | 1.036 <sup>25</sup>        | 1.5145 <sup>20</sup>  |                                                        |
| 1649 | N-Butyl-N-phenylacetamide             |                                        | C <sub>12</sub> H <sub>17</sub> NO                           | 91-49-6     | 191.269  |               | 24.5   | 281                                    | 0.9912 <sup>20</sup>       | 1.5146 <sup>20</sup>  | sl chl                                                 |
| 1650 | 1-(4-tert-Butylphenyl)ethanone        |                                        | C <sub>12</sub> H <sub>16</sub> O                            | 943-27-1    | 176.254  |               | 17.7   | 263; 137 <sup>20</sup>                 | 0.9635 <sup>20</sup>       | 1.518 <sup>15</sup>   |                                                        |
| 1651 | Butyl phenyl ether                    | Butoxybenzene                          | C <sub>10</sub> H <sub>14</sub> O                            | 1126-79-0   | 150.217  | liq           | -19.4  | 210                                    | 0.9351 <sup>20</sup>       | 1.4969 <sup>20</sup>  | s eth, ace                                             |
| 1652 | N-Butylpiperidine                     |                                        | C <sub>9</sub> H <sub>19</sub> N                             | 4945-48-6   | 141.254  |               |        | 176                                    | 0.8245 <sup>20</sup>       | 1.4467 <sup>20</sup>  |                                                        |
| 1653 | Butylpropanedioic acid                | Butylmalonic acid                      | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                | 534-59-8    | 160.168  | pr (w)        | 104.5  |                                        |                            |                       | vs H <sub>2</sub> O; s EtOH, eth                       |
| 1654 | Butyl propanoate                      | Butyl propionate                       | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                | 590-01-2    | 130.185  | liq           | -89    | 146.8                                  | 0.8754 <sup>20</sup>       | 1.4014 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; msc EtOH, eth                |
| 1655 | sec-Butyl propanoate                  |                                        | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                | 591-34-4    | 130.185  |               |        | 133                                    | 0.8657 <sup>20</sup>       | 1.3952 <sup>20</sup>  | s EtOH, eth                                            |
| 1656 | N-tert-Butyl-2-propenamide            | N-tert-Butylacrylamide                 | C <sub>7</sub> H <sub>13</sub> NO                            | 107-58-4    | 127.184  | cry (bz)      | 128    |                                        |                            |                       | sl H <sub>2</sub> O; i peth                            |

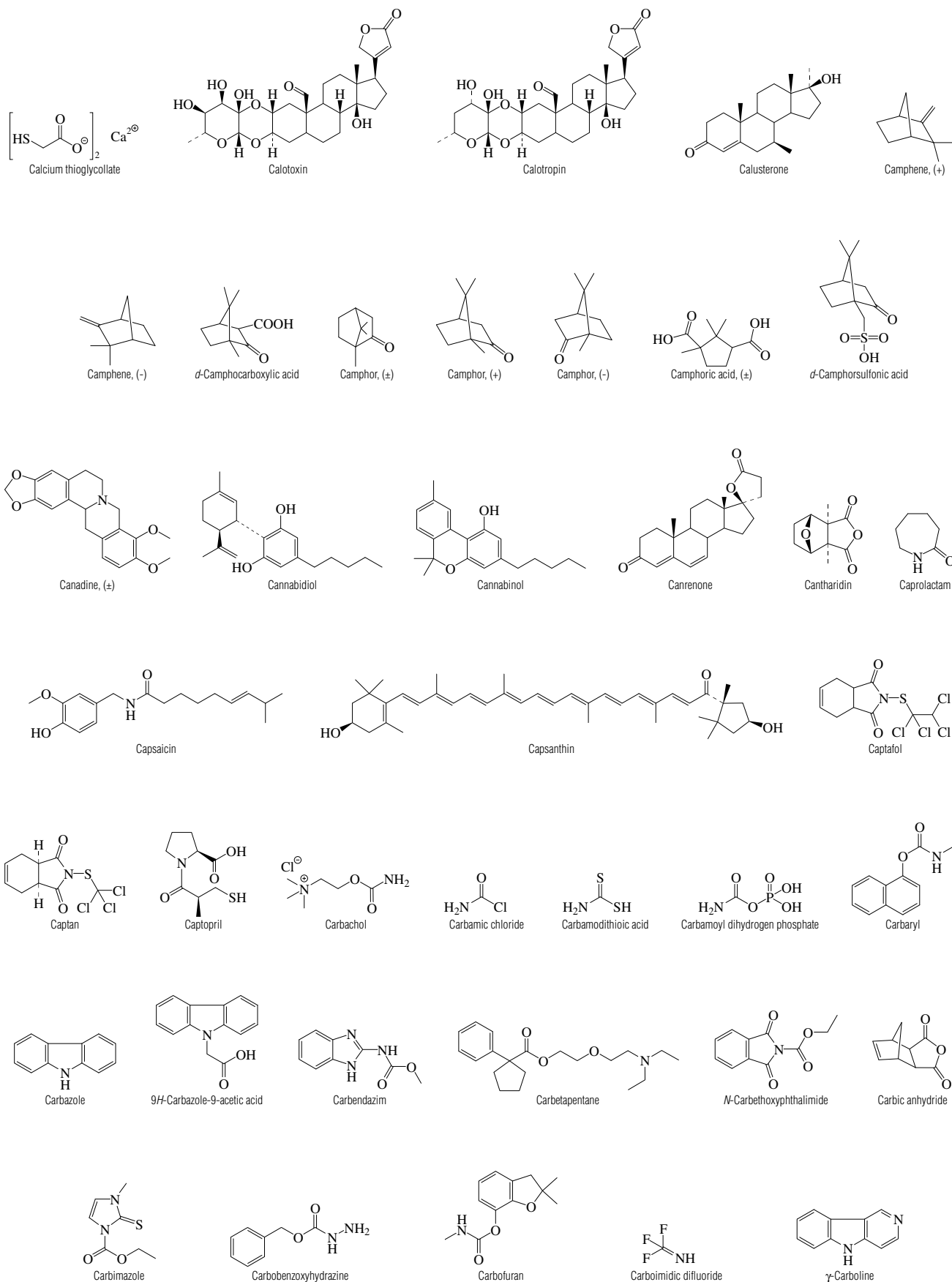




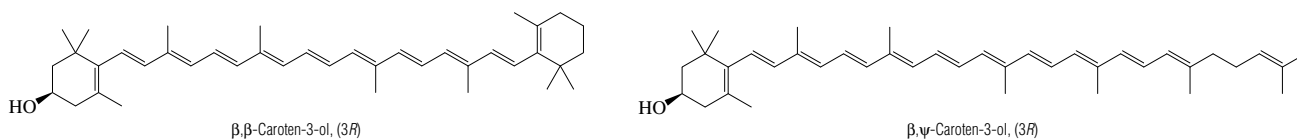
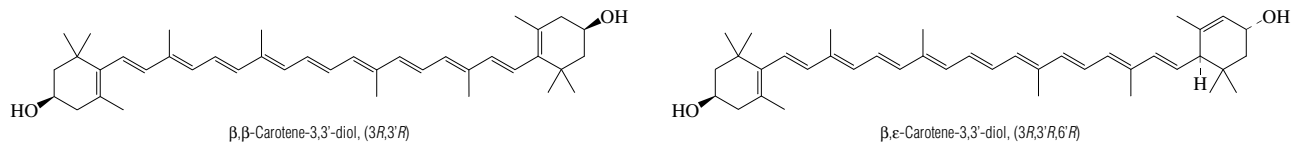
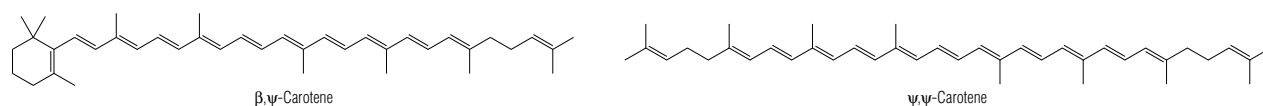
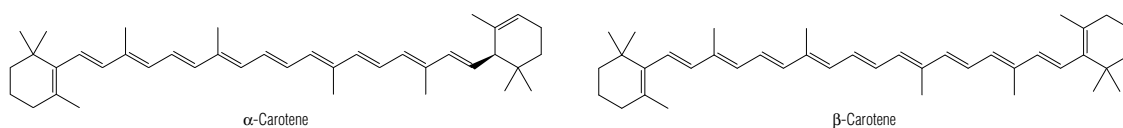
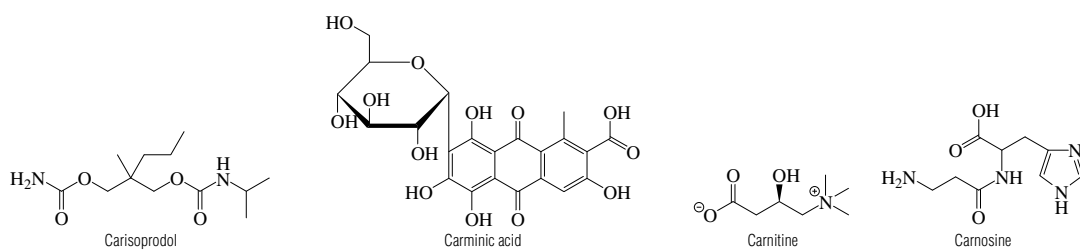
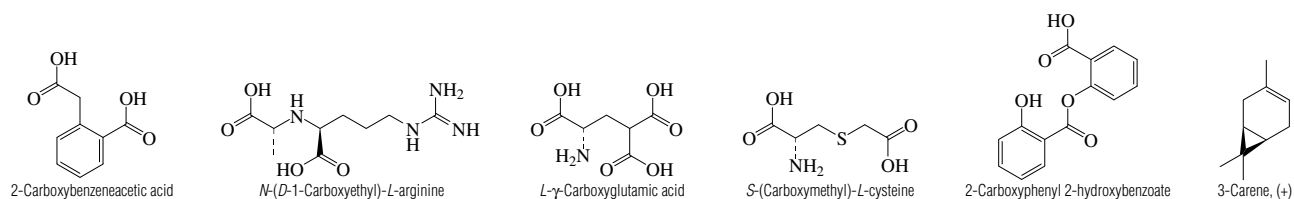
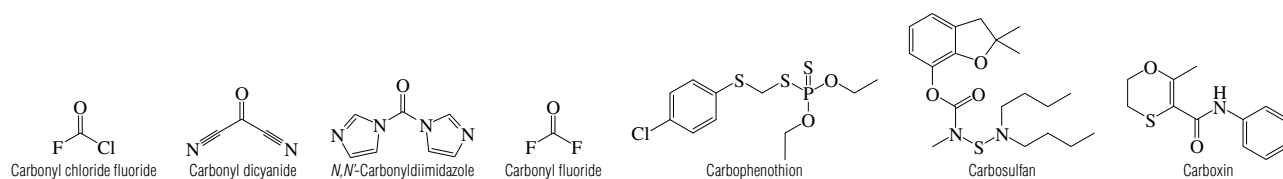
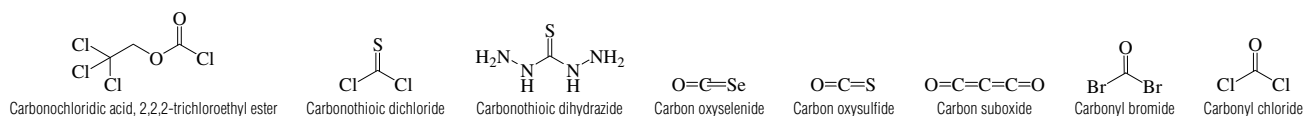
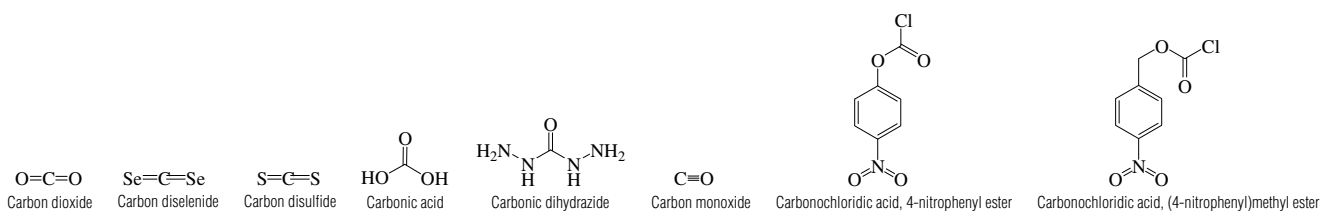
| No.  | Name                                  | Synonym                           | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form             | mp/°C          | bp/°C              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                         |
|------|---------------------------------------|-----------------------------------|--------------------------------------------------------------------------------|------------|----------|---------------------------|----------------|--------------------|----------------------------|----------------------|----------------------------------------------------|
| 1657 | Butyl propyl ether                    |                                   | C <sub>7</sub> H <sub>16</sub> O                                               | 3073-92-5  | 116.201  |                           |                | 118.1              | 0.7772 <sup>20</sup>       |                      | i H <sub>2</sub> O; vs EtOH, eth                   |
| 1658 | 4- <i>tert</i> -Butylpyridine         |                                   | C <sub>9</sub> H <sub>13</sub> N                                               | 3978-81-2  | 135.206  | liq                       | -41            | 196.5              | 0.915 <sup>25</sup>        | 1.4958 <sup>20</sup> | s ctc, CS <sub>2</sub>                             |
| 1659 | 5-Butyl-2-pyridinecarboxylic acid     | Fusaric acid                      | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>                                | 536-69-6   | 179.216  |                           | 97             |                    |                            |                      |                                                    |
| 1660 | Butyl stearate                        |                                   | C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>                                 | 123-95-5   | 340.583  |                           | 27             | 343                | 0.854 <sup>25</sup>        | 1.4328 <sup>50</sup> | i H <sub>2</sub> O; s EtOH; vs ace                 |
| 1661 | Butyl thiocyanate                     | 1-Thiocyanobutane                 | C <sub>5</sub> H <sub>9</sub> NS                                               | 628-83-1   | 115.197  |                           |                | 186                | 0.9563 <sup>15</sup>       | 1.4360 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                    |
| 1662 | 2-Butylthiophene                      |                                   | C <sub>8</sub> H <sub>12</sub> S                                               | 1455-20-5  | 140.246  |                           |                | 181.5              | 0.9537 <sup>20</sup>       | 1.5090 <sup>20</sup> |                                                    |
| 1663 | Butyl thiophene-2-carboxylate         | Butyl 2-thiophenecarboxylate      | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub> S                                | 56053-84-0 | 184.255  |                           |                | 58 <sup>9,15</sup> |                            |                      |                                                    |
| 1664 | Butyl 4-toluenesulfonate              |                                   | C <sub>11</sub> H <sub>16</sub> O <sub>3</sub> S                               | 778-28-9   | 228.308  |                           |                | 165 <sup>6</sup>   | 1.1319 <sup>20</sup>       | 1.5050 <sup>20</sup> | i H <sub>2</sub> O; s eth; sl ctc                  |
| 1665 | Butyl trichloroacetate                |                                   | C <sub>6</sub> H <sub>9</sub> Cl <sub>3</sub> O <sub>2</sub>                   | 3657-07-6  | 219.493  |                           |                | 204                | 1.2778 <sup>20</sup>       | 1.4525 <sup>25</sup> | s ctc                                              |
| 1666 | Butyl (2,4,5-trichlorophenoxy)acetate | 2,4,5-T Butyl ester               | C <sub>12</sub> H <sub>13</sub> Cl <sub>3</sub> O <sub>3</sub>                 | 93-79-8    | 311.588  |                           | 28.5           | 337                |                            |                      |                                                    |
| 1667 | Butyltrichlorosilane                  | Trichlorobutylsilane              | C <sub>4</sub> H <sub>9</sub> Cl <sub>3</sub> Si                               | 7521-80-4  | 191.559  |                           |                | 148.5              | 1.1606 <sup>20</sup>       | 1.4363 <sup>20</sup> | s eth, bz, tol, AcOEt                              |
| 1668 | Butyl trifluoroacetate                |                                   | C <sub>6</sub> H <sub>9</sub> F <sub>3</sub> O <sub>2</sub>                    | 367-64-6   | 170.129  |                           |                | 102                | 1.0268 <sup>22</sup>       | 1.353 <sup>22</sup>  | s chl                                              |
| 1669 | Butylurea                             |                                   | C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O                                | 592-31-4   | 116.161  | tab (w), nd (bz)          | 97.0           |                    |                            |                      | vs H <sub>2</sub> O, EtOH; sl chl                  |
| 1670 | <i>sec</i> -Butylurea                 | (1-Methylpropyl)urea              | C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O                                | 689-11-2   | 116.161  | pr (w)                    | 169            |                    |                            |                      |                                                    |
| 1671 | <i>tert</i> -Butylurea                |                                   | C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O                                | 1118-12-3  | 116.161  |                           | 176 dec        |                    |                            |                      | s H <sub>2</sub> O; vs EtOH; sl bz                 |
| 1672 | 1- <i>tert</i> -Butyl-4-vinylbenzene  | <i>p-tert</i> -Butylstyrene       | C <sub>12</sub> H <sub>16</sub>                                                | 1746-23-2  | 160.255  | liq                       | -36.9          | 99 <sup>14</sup>   | 0.89 <sup>20</sup>         |                      |                                                    |
| 1673 | Butyl vinyl ether                     | 1-(Ethenyloxy)butane              | C <sub>6</sub> H <sub>12</sub> O                                               | 111-34-2   | 100.158  | liq                       | -92            | 94                 | 0.7888 <sup>20</sup>       | 1.4026 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, ace; msc eth; s bz    |
| 1674 | <i>tert</i> -Butyl vinyl ether        | 2-(Ethenyloxy)-2-methylpropane    | C <sub>6</sub> H <sub>12</sub> O                                               | 926-02-3   | 100.158  | liq                       | -112           | 75                 | 0.7691 <sup>20</sup>       | 1.3922 <sup>20</sup> |                                                    |
| 1675 | 1-Butyne                              | Ethylacetylene                    | C <sub>4</sub> H <sub>6</sub>                                                  | 107-00-6   | 54.091   | col gas                   | -125.7         | 8.08               | 0.6783 <sup>9</sup>        | 1.3962 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                    |
| 1676 | 2-Butyne                              | Dimethylacetylene                 | C <sub>4</sub> H <sub>6</sub>                                                  | 503-17-3   | 54.091   | vol liq or gas            | -32.2          | 26.9               | 0.6910 <sup>20</sup>       | 1.3921 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc               |
| 1677 | 2-Butynediarnide                      | Cellocidin                        | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                    | 543-21-5   | 112.087  | cry (dil MeOH)            | 217 dec        |                    |                            |                      | sl H <sub>2</sub> O, chl, EtOH, eth, gl HOAc       |
| 1678 | 2-Butynedinitrile                     |                                   | C <sub>4</sub> N <sub>2</sub>                                                  | 1071-98-3  | 76.056   |                           | 20.5           | 76.5               | 0.9708 <sup>25</sup>       | 1.4647 <sup>25</sup> |                                                    |
| 1679 | 2-Butynedioic acid                    |                                   | C <sub>4</sub> H <sub>2</sub> O <sub>4</sub>                                   | 142-45-0   | 114.057  |                           | 183 dec        |                    |                            |                      | vs H <sub>2</sub> O, EtOH, eth                     |
| 1680 | 2-Butyne-1,4-diol                     | Bis(hydroxymethyl)acetylene       | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                   | 110-65-6   | 86.090   | pl (bz, AcOEt)            | 50             | 238                |                            | 1.4804 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, ace; sl eth; i bz, peth |
| 1681 | 2-Butyne-1,4-diol diacetate           | 1,4-Diacetoxy-2-butyne            | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>                                  | 1573-17-7  | 170.163  |                           |                | 122 <sup>10</sup>  |                            | 1.4611 <sup>20</sup> | s ctc                                              |
| 1682 | 2-Butynoic acid                       |                                   | C <sub>4</sub> H <sub>4</sub> O <sub>2</sub>                                   | 590-93-2   | 84.074   | pl (eth, peth)            | 78             | 203                | 0.9641 <sup>20</sup>       |                      | vs H <sub>2</sub> O, eth, EtOH, chl                |
| 1683 | 2-Butyn-1-ol                          |                                   | C <sub>4</sub> H <sub>6</sub> O                                                | 764-01-2   | 70.090   | liq                       | -1.1           | 148                | 0.9370 <sup>20</sup>       | 1.4530 <sup>20</sup> | vs eth, EtOH                                       |
| 1684 | 3-Butyn-1-ol                          |                                   | C <sub>4</sub> H <sub>6</sub> O                                                | 927-74-2   | 70.090   | liq                       | -63.6          | 129                | 0.9257 <sup>20</sup>       | 1.4409 <sup>20</sup> | vs H <sub>2</sub> O, EtOH                          |
| 1685 | 3-Butyn-2-ol                          |                                   | C <sub>4</sub> H <sub>6</sub> O                                                | 2028-63-9  | 70.090   | liq                       | -1.5           | 106.5              | 0.8618 <sup>20</sup>       | 1.4207 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                     |
| 1686 | 3-Butyn-2-one                         | Ethynyl methyl ketone             | C <sub>4</sub> H <sub>6</sub> O                                                | 1423-60-5  | 68.074   |                           |                | 84                 | 0.8793 <sup>20</sup>       | 1.4070 <sup>20</sup> |                                                    |
| 1687 | 3-Butynylbenzene                      |                                   | C <sub>10</sub> H <sub>10</sub>                                                | 16520-62-0 | 130.186  |                           |                | 190                | 0.9258 <sup>20</sup>       | 1.5208 <sup>20</sup> |                                                    |
| 1688 | γ-Butyrolactone                       | Oxolan-2-one                      | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                   | 96-48-0    | 86.090   | liq                       | -43.61         | 204                | 1.1296 <sup>20</sup>       | 1.4341 <sup>20</sup> | vs ace, bz, eth, EtOH                              |
| 1689 | Cacotheline                           |                                   | C <sub>21</sub> H <sub>21</sub> N <sub>3</sub> O <sub>7</sub>                  | 561-20-6   | 427.408  | ye cry                    | >300           |                    |                            |                      | sl H <sub>2</sub> O                                |
| 1690 | γ-Cadinene                            |                                   | C <sub>15</sub> H <sub>24</sub>                                                | 39029-41-9 | 204.352  |                           |                | 126 <sup>12</sup>  | 0.9182 <sup>15</sup>       | 1.3166 <sup>20</sup> |                                                    |
| 1691 | Cadmium bis(diethyldithiocarbamate)   |                                   | C <sub>10</sub> H <sub>20</sub> CdN <sub>2</sub> S <sub>4</sub>                | 14239-68-0 | 408.950  | wh cry                    | 255            |                    |                            |                      |                                                    |
| 1692 | Caffeine                              |                                   | C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub>                   | 58-08-2    | 194.191  | wh nd (w+1), hex pr (sub) | 238            | sub 90             | 1.23 <sup>19</sup>         |                      | sl H <sub>2</sub> O, EtOH; i eth, ctc; s chl, py   |
| 1693 | Calactin                              | 19-Oxogomphoside                  | C <sub>29</sub> H <sub>40</sub> O <sub>9</sub>                                 | 20304-47-6 | 532.623  | small pr (ace)            | 271            |                    |                            |                      |                                                    |
| 1694 | Calcium ascorbate                     |                                   | C <sub>12</sub> H <sub>14</sub> CaO <sub>12</sub>                              | 5743-27-1  | 390.310  | tricl cry (w)             |                |                    |                            |                      | s H <sub>2</sub> O; i MeOH, EtOH                   |
| 1695 | Calcium citrate                       |                                   | C <sub>12</sub> H <sub>10</sub> Ca <sub>3</sub> O <sub>14</sub>                | 7693-13-2  | 498.433  | cry (w)                   | ≈100 dec (hyd) |                    |                            |                      | sl H <sub>2</sub> O; i EtOH                        |
| 1696 | Calcium cyanamide                     | Calcium carbimide                 | CCaN <sub>2</sub>                                                              | 156-62-7   | 80.102   | col hex cry               | ≈1340          | sub                | 2.29                       |                      | dec H <sub>2</sub> O                               |
| 1697 | Calcium cyclamate                     |                                   | C <sub>12</sub> H <sub>24</sub> CaN <sub>2</sub> O <sub>6</sub> S <sub>2</sub> | 139-06-0   | 396.535  | cry                       |                |                    |                            |                      | vs H <sub>2</sub> O                                |
| 1698 | Calcium gluconate                     |                                   | C <sub>12</sub> H <sub>22</sub> CaO <sub>14</sub>                              | 299-28-5   | 430.373  | cry                       |                |                    |                            |                      | i EtOH, os                                         |
| 1699 | Calcium iodobenzenate                 | Iododocosanoic acid, calcium salt | C <sub>44</sub> H <sub>84</sub> CaI <sub>2</sub> O <sub>4</sub>                | 1319-91-1  | 971.023  | wh-ye pow                 |                |                    |                            |                      | i H <sub>2</sub> O, EtOH, eth; s chl               |
| 1700 | Calcium lactate                       |                                   | C <sub>6</sub> H <sub>10</sub> CaO <sub>6</sub>                                | 814-80-2   | 218.217  | wh pow (w)                |                |                    |                            |                      | s H <sub>2</sub> O; i EtOH                         |
| 1701 | Calcium 2,4-pentanedioate             | Calcium acetylacetonate           | C <sub>10</sub> H <sub>14</sub> CaO <sub>4</sub>                               | 19372-44-2 | 238.294  | col cry (MeOH)            | dec            |                    |                            |                      |                                                    |



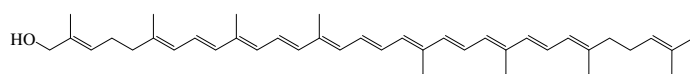
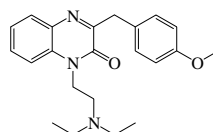
| No.  | Name                                | Synonym                                                                         | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|-------------------------------------|---------------------------------------------------------------------------------|------------------------------------------------------------------|------------|----------|-------------------------|---------|---------------------|----------------------------|----------------------|----------------------------------------------------------|
| 1702 | Calcium thioglycollate              |                                                                                 | C <sub>4</sub> H <sub>6</sub> CaO <sub>4</sub> S <sub>2</sub>    | 814-71-1   | 222.297  | pr (w)                  | 220 dec |                     |                            |                      | s H <sub>2</sub> O, chl; sl EtOH; i eth, bz              |
| 1703 | Calotoxin                           | 4β-Hydroxy-19-oxogomphoside                                                     | C <sub>29</sub> H <sub>40</sub> O <sub>10</sub>                  | 20304-49-8 | 548.622  | cry (EtOH)              | 268     |                     |                            |                      |                                                          |
| 1704 | Calotropin                          |                                                                                 | C <sub>29</sub> H <sub>40</sub> O <sub>9</sub>                   | 1986-70-5  | 532.623  | pl (EtOH)               | 221     |                     |                            |                      | s H <sub>2</sub> O, EtOH; i eth                          |
| 1705 | Calusterone                         |                                                                                 | C <sub>28</sub> H <sub>48</sub> O                                | 17021-26-0 | 400.680  | cry (ace)               | 157.5   |                     |                            |                      |                                                          |
| 1706 | Camphene, (+)                       | 2,2-Dimethyl-3-methylenebicyclo[2.2.1]heptane, (1 <i>R</i> )-                   | C <sub>10</sub> H <sub>16</sub>                                  | 5794-03-6  | 136.234  | nd                      | 52      | 161                 | 0.8950 <sup>50</sup>       | 1.4570 <sup>25</sup> | vs eth                                                   |
| 1707 | Camphene, (-)                       | 2,2-Dimethyl-3-methylenebicyclo[2.2.1]heptane, (1 <i>S</i> )-                   | C <sub>10</sub> H <sub>16</sub>                                  | 5794-04-7  | 136.234  |                         | 52      | 158                 | 0.8446 <sup>50</sup>       | 1.4564 <sup>54</sup> | vs eth                                                   |
| 1708 | <i>d</i> -Camphocarboxylic acid     |                                                                                 | C <sub>11</sub> H <sub>16</sub> O <sub>3</sub>                   | 18530-30-8 | 196.243  | pr (eth, 50% al)        | 127.5   |                     |                            |                      | vs bz, eth, EtOH                                         |
| 1709 | Camphor, (±)                        | 1,7,7-Trimethylbicyclo[2.2.1]heptan-2-one, (±)                                  | C <sub>10</sub> H <sub>16</sub> O                                | 21368-68-3 | 152.233  | wh rhom cry (EtOH)      | 178.3   | sub                 |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz, ctc         |
| 1710 | Camphor, (+)                        | 1,7,7-Trimethylbicyclo[2.2.1]heptan-2-one, (1 <i>R</i> )                        | C <sub>10</sub> H <sub>16</sub> O                                | 464-49-3   | 152.233  | pl                      | 178.8   | 207.4               | 0.990 <sup>25</sup>        | 1.5462               | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz              |
| 1711 | Camphor, (-)                        | 1,7,7-Trimethylbicyclo[2.2.1]heptan-2-one, (1 <i>S</i> )                        | C <sub>10</sub> H <sub>16</sub> O                                | 464-48-2   | 152.233  |                         | 178.6   |                     | 0.9853 <sup>18</sup>       |                      | i H <sub>2</sub> O; vs EtOH, eth, HOAc; s ace, bz        |
| 1712 | Camphoric acid, (±)                 | 1,2,2-Trimethyl-1,3-cyclopentanedicarboxylic acid, (1 <i>RS</i> , 3 <i>SR</i> ) | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>                   | 5394-83-2  | 200.232  | pr, lf                  | 202     |                     | 1.186                      |                      | sl H <sub>2</sub> O; s chl, eth, EtOH                    |
| 1713 | <i>d</i> -Camphorsulfonic acid      |                                                                                 | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub> S                 | 3144-16-9  | 232.297  | pr (HOAc)               | 195 dec |                     |                            |                      | vs H <sub>2</sub> O; i eth; sl HOAc                      |
| 1714 | Canadine, (±)                       | <i>DL</i> -Tetrahydroberberine                                                  | C <sub>20</sub> H <sub>21</sub> NO <sub>4</sub>                  | 29074-38-2 | 339.386  | mcl nd (al)             | 134     |                     |                            |                      | vs EtOH, chl                                             |
| 1715 | Cannabidiol                         |                                                                                 | C <sub>21</sub> H <sub>30</sub> O <sub>2</sub>                   | 13956-29-1 | 314.462  | rods (peth)             | 67      | 188 <sup>2</sup>    | 1.040 <sup>40</sup>        | 1.5404 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl                 |
| 1716 | Cannabinol                          | 6,6,9-Trimethyl-3-pentyl-6 <i>H</i> -dibenzo[ <i>b,d</i> ]pyran-1-ol            | C <sub>21</sub> H <sub>26</sub> O <sub>2</sub>                   | 521-35-7   | 310.430  | pl, lf (peth)           | 77      | 185 <sup>0.05</sup> |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, peth, alk      |
| 1717 | Canrenone                           |                                                                                 | C <sub>22</sub> H <sub>28</sub> O <sub>3</sub>                   | 976-71-6   | 340.455  | cry (AcOEt)             | 150     |                     |                            |                      |                                                          |
| 1718 | Cantharidin                         |                                                                                 | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                   | 56-25-7    | 196.200  | orth pl                 | 218     | sub 84              |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, ace, bz; s HOAc        |
| 1719 | Caprolactam                         | 6-Hexanelactam                                                                  | C <sub>6</sub> H <sub>11</sub> NO                                | 105-60-2   | 113.157  | lf (lig)                | 69.3    | 270                 |                            |                      | vs H <sub>2</sub> O, bz, EtOH, chl                       |
| 1720 | Capsaicin                           |                                                                                 | C <sub>18</sub> H <sub>27</sub> NO <sub>3</sub>                  | 404-86-4   | 305.412  | mcl pl or sc (peth)     | 65      | 215 <sup>0.01</sup> |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, bz, peth; sl con HCl |
| 1721 | Capsanthin                          | 3,3'-Dihydroxy-β,κ-caroten-6'-one, (3 <i>R</i> ,3' <i>S</i> ,5' <i>R</i> )      | C <sub>40</sub> H <sub>56</sub> O <sub>3</sub>                   | 465-42-9   | 584.871  |                         | 176     |                     |                            |                      |                                                          |
| 1722 | Captafol                            |                                                                                 | C <sub>10</sub> H <sub>9</sub> Cl <sub>4</sub> NO <sub>2</sub> S | 2425-06-1  | 349.061  | cry                     | 161     |                     |                            |                      |                                                          |
| 1723 | Captan                              |                                                                                 | C <sub>9</sub> H <sub>8</sub> Cl <sub>3</sub> NO <sub>2</sub> S  | 133-06-2   | 300.590  | cry (CCl <sub>4</sub> ) | 172.5   |                     | 1.74 <sup>25</sup>         |                      | vs chl                                                   |
| 1724 | Captopril                           | 1-(3-Mercapto-2-methyl-1-oxypropyl)proline                                      | C <sub>9</sub> H <sub>15</sub> NO <sub>3</sub> S                 | 62571-86-2 | 217.285  | cry (AcOEt)             | 105     |                     |                            |                      | s H <sub>2</sub> O, EtOH, chl                            |
| 1725 | Carbachol                           |                                                                                 | C <sub>6</sub> H <sub>15</sub> ClN <sub>2</sub> O <sub>2</sub>   | 51-83-2    | 182.648  |                         | 210 dec |                     |                            |                      | vs H <sub>2</sub> O, MeOH; sl EtOH; i eth, chl           |
| 1726 | Carbamic chloride                   | Carbamyl chloride                                                               | CH <sub>3</sub> ClNO                                             | 463-72-9   | 79.486   |                         |         | dec 62              |                            |                      |                                                          |
| 1727 | Carbamodithioic acid                |                                                                                 | CH <sub>3</sub> NS <sub>2</sub>                                  | 594-07-0   | 93.172   |                         |         |                     |                            |                      | vs EtOH, eth                                             |
| 1728 | Carbamoyl dihydrogen phosphate      |                                                                                 | CH <sub>3</sub> NO <sub>3</sub> P                                | 590-55-6   | 141.021  | unstab in soln          |         |                     |                            |                      |                                                          |
| 1729 | Carbaryl                            |                                                                                 | C <sub>12</sub> H <sub>11</sub> NO <sub>2</sub>                  | 63-25-2    | 201.221  |                         | 145     |                     | 1.228 <sup>25</sup>        |                      | vs ace, DMF                                              |
| 1730 | Carbazole                           | Dibenzopyrrole                                                                  | C <sub>12</sub> H <sub>9</sub> N                                 | 86-74-8    | 167.206  | pl or lf                | 246.3   | 354.69              |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, bz, chl; s ace         |
| 1731 | 9 <i>H</i> -Carbazole-9-acetic acid |                                                                                 | C <sub>14</sub> H <sub>11</sub> NO <sub>2</sub>                  | 524-80-1   | 225.243  | lf (AcOEt)              | 215     |                     |                            |                      | vs eth, EtOH, chl, HOAc                                  |
| 1732 | Carbendazim                         | Carbamic acid, 1 <i>H</i> -benzimidazol-2-yl-, methyl ester                     | C <sub>9</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>      | 10605-21-7 | 191.186  |                         | 300 dec |                     | 1.45                       |                      |                                                          |
| 1733 | Carbetapentane                      | Pentoxiverine                                                                   | C <sub>20</sub> H <sub>31</sub> NO <sub>3</sub>                  | 77-23-6    | 333.465  |                         |         | 165 <sup>0.01</sup> |                            |                      |                                                          |
| 1734 | <i>N</i> -Carbethoxyphthalimide     | <i>N</i> -(Ethoxycarbonyl)phthalimide                                           | C <sub>11</sub> H <sub>9</sub> NO <sub>4</sub>                   | 22509-74-6 | 219.194  |                         | 91      |                     |                            |                      |                                                          |
| 1735 | Carbic anhydride                    |                                                                                 | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                     | 129-64-6   | 164.158  | orth cry (peth)         | 164.5   |                     | 1.417 <sup>25</sup>        |                      | vs ace, bz, EtOH, chl                                    |
| 1736 | Carbimazole                         |                                                                                 | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> S   | 22232-54-8 | 186.231  | cry, pow                | 123.5   |                     |                            |                      | vs ace, chl                                              |
| 1737 | Carbobenzoxylhydrazine              | Benzyl carbazate                                                                | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>     | 5331-43-1  | 166.177  |                         | 69.5    |                     |                            |                      |                                                          |
| 1738 | Carbofuran                          |                                                                                 | C <sub>12</sub> H <sub>15</sub> NO <sub>3</sub>                  | 1563-66-2  | 221.252  |                         | 151     |                     | 1.18                       |                      |                                                          |
| 1739 | Carboimidic difluoride              |                                                                                 | CHF <sub>2</sub> N                                               | 2712-98-3  | 65.023   | gas                     | -90     | -13 dec             |                            |                      |                                                          |



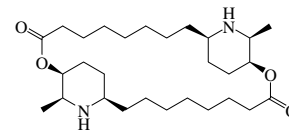
| No.  | Name                                                            | Synonym                                         | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form                   | mp/°C     | bp/°C                   | den/<br>g cm <sup>-3</sup>        | n <sub>D</sub>       | Solubility                                           |
|------|-----------------------------------------------------------------|-------------------------------------------------|------------------------------------------------------------------|------------|----------|---------------------------------|-----------|-------------------------|-----------------------------------|----------------------|------------------------------------------------------|
| 1740 | γ-Carboline                                                     | 5 <i>H</i> -Pyrido[4,3- <i>b</i> ]indole        | C <sub>11</sub> H <sub>8</sub> N <sub>2</sub>                    | 244-69-9   | 168.195  | nd                              | 225       |                         | 1.352                             |                      | sl H <sub>2</sub> O, bz; vs MeOH; s EtOH             |
| 1741 | Carbon dioxide                                                  | Carbonic anhydride                              | CO <sub>2</sub>                                                  | 124-38-9   | 44.010   | col gas                         | -56.56 tp | -78.5 sp                | 0.720 <sup>25</sup><br>(p>1 atm)  |                      | sl H <sub>2</sub> O                                  |
| 1742 | Carbon diselenide                                               | Carbon selenide                                 | CSe <sub>2</sub>                                                 | 506-80-9   | 169.93   | ye liq                          | -43.7     | 125.5                   | 2.6823 <sup>20</sup>              | 1.8454 <sup>20</sup> |                                                      |
| 1743 | Carbon disulfide                                                | Carbon bisulfide                                | CS <sub>2</sub>                                                  | 75-15-0    | 76.141   | col liq                         | -112.1    | 46                      | 1.2632 <sup>20</sup>              | 1.6319 <sup>20</sup> | s H <sub>2</sub> O, chl; msc EtOH, eth               |
| 1744 | Carbonic acid                                                   |                                                 | CH <sub>2</sub> O <sub>3</sub>                                   | 463-79-6   | 62.025   |                                 |           |                         |                                   |                      | Aq. soln. of CO <sub>2</sub>                         |
| 1745 | Carbonic dihydrazide                                            | Carbohydrazide                                  | CH <sub>6</sub> N <sub>4</sub> O                                 | 497-18-7   | 90.085   | nd (dil al)                     | 154       |                         | 1.616 <sup>20</sup>               |                      | vs H <sub>2</sub> O, EtOH                            |
| 1746 | Carbon monoxide                                                 | Carbon oxide                                    | CO                                                               | 630-08-0   | 28.010   | col gas                         | -205.02   | -191.5                  | 0.7909 <sup>-19</sup>             |                      | sl H <sub>2</sub> O; s bz, HOAc                      |
| 1747 | Carbonochloridic acid, 4-nitrophenyl ester                      |                                                 | C <sub>7</sub> H <sub>4</sub> ClNO <sub>4</sub>                  | 7693-46-1  | 201.565  |                                 | 80        | 160 <sup>19</sup>       |                                   |                      |                                                      |
| 1748 | Carbonochloridic acid, (4-nitrophenyl)methyl ester              |                                                 | C <sub>8</sub> H <sub>6</sub> ClNO <sub>4</sub>                  | 4457-32-3  | 215.592  |                                 | 32.8      |                         |                                   |                      |                                                      |
| 1749 | Carbonochloridic acid, 2,2,2-trichloroethyl ester               |                                                 | C <sub>3</sub> H <sub>2</sub> Cl <sub>4</sub> O <sub>2</sub>     | 17341-93-4 | 211.859  |                                 |           | 63 <sup>11</sup>        |                                   |                      |                                                      |
| 1750 | Carbonothioic dichloride                                        | Thiophosgene                                    | CCl <sub>2</sub> S                                               | 463-71-8   | 114.982  | red liq                         |           | 73                      | 1.508 <sup>15</sup>               | 1.5442 <sup>20</sup> | dec H <sub>2</sub> O, EtOH; s eth                    |
| 1751 | Carbonothioic dihydrazide                                       | 1,3-Diamino-2-thiourea                          | CH <sub>6</sub> N <sub>4</sub> S                                 | 2231-57-4  | 106.151  | nd, pl (w) nd, pl (w)           | 170 dec   |                         |                                   |                      | vs H <sub>2</sub> O                                  |
| 1752 | Carbon oxyselelide                                              | Carbonyl selenide                               | COSe                                                             | 1603-84-5  | 106.97   | col gas; unstab                 | -122      | -21.5                   |                                   |                      | dec H <sub>2</sub> O                                 |
| 1753 | Carbon oxysulfide                                               | Carbonyl sulfide                                | COS                                                              | 463-58-1   | 60.075   | col gas                         | -138.8    | -50                     | 1.028 <sup>17</sup>               | 1.24 <sup>87</sup>   | sl H <sub>2</sub> O; s EtOH; vs KOH                  |
| 1754 | Carbon suboxide                                                 | 1,2-Propadiene-1,3-dione                        | C <sub>3</sub> O <sub>2</sub>                                    | 504-64-3   | 68.031   | col gas                         | -107      | 6.8                     | 1.114 <sup>0</sup>                | 1.4538 <sup>0</sup>  | s eth, bz, CS <sub>2</sub>                           |
| 1755 | Carbonyl bromide                                                | Bromophosgene                                   | CBr <sub>2</sub> O                                               | 593-95-3   | 187.818  |                                 |           | 64.5                    | 2.52 <sup>15</sup>                |                      |                                                      |
| 1756 | Carbonyl chloride                                               | Phosgene                                        | CCl <sub>2</sub> O                                               | 75-44-5    | 98.916   | col gas                         | -127.78   | 8                       | 1.3719 <sup>25</sup><br>(p>1 atm) |                      | s bz, ctc, chl, tol, HOAc                            |
| 1757 | Carbonyl chloride fluoride                                      | Carbonic chloride fluoride                      | CClFO                                                            | 353-49-1   | 82.461   | col gas                         | -148      | -47.2                   |                                   |                      | reac H <sub>2</sub> O                                |
| 1758 | Carbonyl dicyanide                                              |                                                 | C <sub>2</sub> N <sub>2</sub> O                                  | 1115-12-4  | 80.044   | liq                             | -36       | 65.5                    | 1.124 <sup>20</sup>               | 1.3919 <sup>20</sup> | s eth, ace, ctc, chl                                 |
| 1759 | <i>N,N'</i> -Carbonyldiimidazole                                |                                                 | C <sub>7</sub> H <sub>8</sub> N <sub>4</sub> O                   | 530-62-1   | 162.149  | cry (bz)                        | 119       |                         |                                   |                      |                                                      |
| 1760 | Carbonyl fluoride                                               |                                                 | CF <sub>2</sub> O                                                | 353-50-4   | 66.007   | col gas                         | -111.2    | -84.5                   | 1.139 <sup>25</sup>               |                      |                                                      |
| 1761 | Carbophenothion                                                 |                                                 | C <sub>11</sub> H <sub>16</sub> ClO <sub>2</sub> PS <sub>3</sub> | 786-19-6   | 342.866  |                                 |           | 82 <sup>0.01</sup>      | 1.271 <sup>20</sup>               |                      |                                                      |
| 1762 | Carbosulfan                                                     |                                                 | C <sub>20</sub> H <sub>32</sub> N <sub>2</sub> O <sub>3</sub> S  | 55285-14-8 | 380.544  |                                 |           | 126                     | 1.056 <sup>20</sup>               |                      |                                                      |
| 1763 | Carboxin                                                        |                                                 | C <sub>12</sub> H <sub>13</sub> NO <sub>2</sub> S                | 5234-68-4  | 235.302  |                                 | 94        |                         |                                   |                      |                                                      |
| 1764 | 2-Carboxybenzeneacetic acid                                     |                                                 | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                     | 89-51-0    | 180.158  |                                 | 184.5     |                         | 1.4100 <sup>20</sup>              |                      | s H <sub>2</sub> O, EtOH; sl eth; i bz, chl          |
| 1765 | <i>N</i> -( <i>D</i> -1-Carboxyethyl)- <i>L</i> -arginine       | Octopine                                        | C <sub>9</sub> H <sub>18</sub> N <sub>4</sub> O <sub>4</sub>     | 34522-32-2 | 246.264  | nd (w)                          | 281       |                         |                                   |                      |                                                      |
| 1766 | <i>L</i> -γ-Carboxyglutamic acid                                |                                                 | C <sub>6</sub> H <sub>9</sub> NO <sub>6</sub>                    | 53861-57-7 | 191.138  | cry                             | 167       |                         |                                   |                      |                                                      |
| 1767 | <i>S</i> -(Carboxymethyl)- <i>L</i> -cysteine                   | Carbocysteine                                   | C <sub>6</sub> H <sub>9</sub> NO <sub>3</sub> S                  | 638-23-3   | 179.195  | nd                              | 206       |                         |                                   |                      |                                                      |
| 1768 | 2-Carboxyphenyl 2-hydroxybenzoate                               | Salsalate                                       | C <sub>14</sub> H <sub>10</sub> O <sub>5</sub>                   | 552-94-3   | 258.226  |                                 | 147       |                         |                                   |                      | sl ace                                               |
| 1769 | 3-Carene, (+)                                                   |                                                 | C <sub>10</sub> H <sub>16</sub>                                  | 498-15-7   | 136.234  |                                 |           | 171; 123 <sup>200</sup> | 0.8549 <sup>30</sup>              | 1.469 <sup>3</sup>   | vs ace, bz, eth                                      |
| 1770 | Carisoprodol                                                    |                                                 | C <sub>12</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub>    | 78-44-4    | 260.330  | cry                             | 92        |                         |                                   |                      | s os                                                 |
| 1771 | Carminic acid                                                   |                                                 | C <sub>22</sub> H <sub>20</sub> O <sub>13</sub>                  | 1260-17-9  | 492.386  | red mcl pr (aq, MeOH)           | 136 dec   |                         |                                   |                      | s H <sub>2</sub> O, EtOH; sl eth; i bz, chl          |
| 1772 | Carnitine                                                       | 4-Amino-3-hydroxybutanoic acid trimethylbetaine | C <sub>7</sub> H <sub>15</sub> NO <sub>3</sub>                   | 541-15-1   | 161.199  | cry (al-ace), hyg               | 197 dec   |                         |                                   |                      | vs H <sub>2</sub> O, EtOH                            |
| 1773 | Carnosine                                                       | <i>N</i> -β-Alanyl- <i>L</i> -histidine         | C <sub>9</sub> H <sub>14</sub> N <sub>4</sub> O <sub>3</sub>     | 305-84-0   | 226.232  |                                 | 260       |                         |                                   |                      | vs H <sub>2</sub> O                                  |
| 1774 | α-Carotene                                                      |                                                 | C <sub>40</sub> H <sub>56</sub>                                  | 7488-99-5  | 536.873  | red pl or pr (peth, bz-MeOH)    | 187.5     |                         | 1.00 <sup>20</sup>                |                      | vs bz, eth, chl                                      |
| 1775 | β-Carotene                                                      |                                                 | C <sub>40</sub> H <sub>56</sub>                                  | 7235-40-7  | 536.873  | red br hex pr (bz-MeOH)         | 183       |                         | 1.00 <sup>20</sup>                |                      | i H <sub>2</sub> O; sl EtOH, chl; s eth, ace, bz     |
| 1776 | β,ψ-Carotene                                                    | γ-Carotene                                      | C <sub>40</sub> H <sub>56</sub>                                  | 472-93-5   | 536.873  | red pr (bz-MeOH), viol pr (eth) | 153       |                         |                                   |                      | i H <sub>2</sub> O, EtOH; sl eth, peth; s bz, chl    |
| 1777 | ψ,ψ-Carotene                                                    | <i>trans</i> -Lycopene                          | C <sub>40</sub> H <sub>56</sub>                                  | 502-65-8   | 536.873  | red pr or nd (peth)             | 175       |                         |                                   |                      | sl EtOH, peth; s eth; vs bz, chl, CS <sub>2</sub>    |
| 1778 | β,β-Carotene-3,3'-diol, (3 <i>R</i> ,3' <i>R</i> )              | Zeaxanthin                                      | C <sub>40</sub> H <sub>56</sub> O <sub>2</sub>                   | 144-68-3   | 568.872  | ye pr (MeOH) orth (chl-eth)     | 215.5     | 227 <sup>0.06</sup>     |                                   |                      | i H <sub>2</sub> O; sl EtOH; s eth, ace, bz, py, chl |
| 1779 | β,ε-Carotene-3,3'-diol, (3 <i>R</i> ,3' <i>R</i> ,6' <i>R</i> ) | Xanthophyll                                     | C <sub>40</sub> H <sub>56</sub> O <sub>2</sub>                   | 127-40-2   | 568.872  | ye or viol pr (eth-MeOH)        | 196       |                         |                                   |                      | vs bz, eth, EtOH, peth                               |
| 1780 | β,β-Caroten-3-ol, (3 <i>R</i> )                                 | Cryptoxanthin                                   | C <sub>40</sub> H <sub>56</sub> O                                | 472-70-8   | 552.872  | garnet red pr (bz-MeOH)         | 160       |                         |                                   |                      | vs bz, chl                                           |



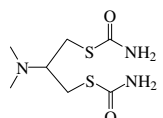
| No.  | Name                            | Synonym                                                                     | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form                                   | mp/°C     | bp/°C                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|---------------------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|-------------------------------------------------|-----------|--------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 1781 | β,ψ-Caroten-3-ol, (3 <i>R</i> ) | Rubixanthin                                                                 | C <sub>40</sub> H <sub>56</sub> O                                             | 3763-55-1  | 552.872  | dk red nd<br>(bz-MeOH)<br>oran-red<br>(bz-peth) | 160       |                          |                            |                      | sl EtOH, peth; s<br>bz, chl                           |
| 1782 | ψ,ψ-Caroten-16-ol               | Lycoxanthin                                                                 | C <sub>40</sub> H <sub>56</sub> O                                             | 19891-74-8 | 552.872  | red pl (bz-<br>MeOH)                            | 168       |                          |                            |                      | i H <sub>2</sub> O; sl EtOH;<br>s bz, CS <sub>2</sub> |
| 1783 | Caroverine                      |                                                                             | C <sub>22</sub> H <sub>27</sub> N <sub>3</sub> O <sub>2</sub>                 | 23465-76-1 | 365.468  | cry                                             | 69        | 202 <sup>0.01</sup>      |                            |                      | sl i-PrOH                                             |
| 1784 | Carpaine                        |                                                                             | C <sub>28</sub> H <sub>50</sub> N <sub>2</sub> O <sub>4</sub>                 | 3463-92-1  | 478.708  | mcl pr (al,<br>ace)                             | 121       |                          |                            |                      | vs ace, bz, eth,<br>EtOH                              |
| 1785 | Cartap hydrochloride            |                                                                             | C <sub>7</sub> H <sub>16</sub> ClN <sub>3</sub> O <sub>2</sub> S <sub>2</sub> | 22042-59-7 | 273.804  | cry                                             | 180       |                          |                            |                      | s H <sub>2</sub> O; sl EtOH,<br>MeOH                  |
| 1786 | Carvenone, (S)                  |                                                                             | C <sub>10</sub> H <sub>16</sub> O                                             | 10395-45-6 | 152.233  |                                                 |           | 233                      | 0.9289 <sup>20</sup>       | 1.4805 <sup>20</sup> | i H <sub>2</sub> O; s ace                             |
| 1787 | ( <i>R</i> )-Carvone            | <i>p</i> -Mentha-1,8-dien-6-one, ( <i>R</i> )                               | C <sub>10</sub> H <sub>14</sub> O                                             | 6485-40-1  | 150.217  |                                                 | 25.2      | 231                      | 0.9593 <sup>20</sup>       | 1.4988 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH;<br>s eth, ctc, chl      |
| 1788 | ( <i>S</i> )-Carvone            | <i>p</i> -Mentha-1,8-dien-6-one, ( <i>S</i> )                               | C <sub>10</sub> H <sub>14</sub> O                                             | 2244-16-8  | 150.217  |                                                 | <15       | 231                      | 0.965 <sup>20</sup>        | 1.4989 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH;<br>s eth, chl           |
| 1789 | Caryophyllene                   |                                                                             | C <sub>15</sub> H <sub>24</sub>                                               | 87-44-5    | 204.352  |                                                 |           | 122 <sup>13.5</sup>      | 0.9075 <sup>20</sup>       | 1.4986 <sup>20</sup> | vs bz                                                 |
| 1790 | Casimiroin                      | 6-Methoxy-9-methyl-1,3-dioxolo[4,5- <i>h</i> ]quinolin-8(9 <i>H</i> )-one   | C <sub>12</sub> H <sub>11</sub> NO <sub>4</sub>                               | 477-89-4   | 233.220  |                                                 |           |                          |                            |                      | sl chl                                                |
| 1791 | Cassaine                        |                                                                             | C <sub>24</sub> H <sub>35</sub> NO <sub>4</sub>                               | 468-76-8   | 405.572  | fl (eth)                                        | 142.5     |                          |                            |                      | s EtOH, ace, chl,<br>eth, bz, MeOH                    |
| 1792 | Caulophylline                   |                                                                             | C <sub>12</sub> H <sub>16</sub> N <sub>2</sub> O                              | 486-86-2   | 204.267  | cry (w+2), nd<br>(al, bz)                       | 137       |                          |                            |                      | vs H <sub>2</sub> O, ace, bz,<br>EtOH                 |
| 1793 | α-Cedrene                       |                                                                             | C <sub>15</sub> H <sub>24</sub>                                               | 469-61-4   | 204.352  | oil                                             |           | 262.5; 125 <sup>12</sup> |                            |                      |                                                       |
| 1794 | Cedrol                          |                                                                             | C <sub>15</sub> H <sub>26</sub> O                                             | 77-53-2    | 222.366  |                                                 | 86        |                          | 0.9479 <sup>90</sup>       | 1.4824 <sup>90</sup> |                                                       |
| 1795 | Cefazolin                       |                                                                             | C <sub>14</sub> H <sub>14</sub> N <sub>6</sub> O <sub>4</sub> S <sub>3</sub>  | 25953-19-9 | 454.508  | nd (ace aq)                                     | 200 dec   |                          |                            |                      | s DMF, py; sl<br>MeOH; i chl,<br>bz, eth              |
| 1796 | β-Cellobiose                    |                                                                             | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                               | 13360-52-6 | 342.296  | cry (dil al)                                    | 225 dec   |                          |                            |                      | s H <sub>2</sub> O; i EtOH,<br>eth, ace, bz           |
| 1797 | Cellotriose                     |                                                                             | C <sub>18</sub> H <sub>30</sub> O <sub>16</sub>                               | 33404-34-1 | 504.437  |                                                 | 208       |                          |                            |                      |                                                       |
| 1798 | Cephalexin                      |                                                                             | C <sub>16</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub> S               | 15686-71-2 | 347.389  | cry                                             |           |                          |                            |                      |                                                       |
| 1799 | Cephaloglycin                   | Kafocin                                                                     | C <sub>18</sub> H <sub>19</sub> N <sub>3</sub> O <sub>6</sub> S               | 3577-01-3  | 405.425  | cry (w)                                         | ≈220 dec  |                          |                            |                      |                                                       |
| 1800 | Cephaloridine                   |                                                                             | C <sub>19</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub>  | 50-59-9    | 415.486  | cry                                             |           |                          |                            |                      | s H <sub>2</sub> O                                    |
| 1801 | Cephalothin                     |                                                                             | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>6</sub> S <sub>2</sub>  | 153-61-7   | 396.437  |                                                 | 160       |                          |                            |                      |                                                       |
| 1802 | Cephapirin                      |                                                                             | C <sub>17</sub> H <sub>17</sub> N <sub>3</sub> O <sub>6</sub> S <sub>2</sub>  | 21593-23-7 | 423.463  | cry (ace aq)                                    | 155       |                          |                            |                      |                                                       |
| 1803 | Cepharanthine                   |                                                                             | C <sub>37</sub> H <sub>38</sub> N <sub>2</sub> O <sub>6</sub>                 | 481-49-2   | 606.707  | ye amor pow                                     | 150       |                          |                            |                      |                                                       |
| 1804 | Cephadrine                      |                                                                             | C <sub>16</sub> H <sub>19</sub> N <sub>3</sub> O <sub>4</sub> S               | 38821-53-3 | 349.405  | col cry (w)                                     | 141 dec   |                          |                            |                      |                                                       |
| 1805 | Cerulenin                       | 2,3-Epoxy-4-oxo-7,10-dodecadienamide, (2 <i>R</i> ,3 <i>S</i> )-            | C <sub>12</sub> H <sub>17</sub> NO <sub>3</sub>                               | 17397-89-6 | 223.268  | wh nd                                           | 94        |                          |                            |                      | sl H <sub>2</sub> O; s bz,<br>EtOH, ace; i<br>peth    |
| 1806 | Cevadine                        |                                                                             | C <sub>22</sub> H <sub>40</sub> NO <sub>3</sub>                               | 62-59-9    | 591.733  | flat nd (eth)                                   | 213 dec   |                          |                            |                      |                                                       |
| 1807 | Chavicine                       |                                                                             | C <sub>17</sub> H <sub>19</sub> NO <sub>3</sub>                               | 495-91-0   | 285.338  |                                                 |           |                          |                            |                      | vs eth, EtOH,<br>peth                                 |
| 1808 | Cheirolin                       |                                                                             | C <sub>9</sub> H <sub>9</sub> NO <sub>2</sub> S <sub>2</sub>                  | 505-34-0   | 179.261  | cry (eth)                                       | 47.5      | 200 <sup>3</sup>         |                            |                      | vs EtOH, chl                                          |
| 1809 | Chelerythrine                   |                                                                             | C <sub>21</sub> H <sub>19</sub> NO <sub>5</sub>                               | 34316-15-9 | 365.380  | cry (chl-<br>MeOH)                              |           | 207                      |                            |                      | vs chl                                                |
| 1810 | Chelidonine                     | Stylophorine                                                                | C <sub>20</sub> H <sub>19</sub> NO <sub>5</sub>                               | 476-32-4   | 353.369  | mcl pr (al)                                     | 135.5     | 220 <sup>0.002</sup>     |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, chl               |
| 1811 | Chinomethionat                  |                                                                             | C <sub>10</sub> H <sub>6</sub> N <sub>2</sub> OS <sub>2</sub>                 | 2439-01-2  | 234.297  |                                                 | 170       |                          |                            |                      |                                                       |
| 1812 | Chloral hydrate                 |                                                                             | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> O <sub>2</sub>                  | 302-17-0   | 165.403  |                                                 | 57        | dec 96                   | 1.9081 <sup>20</sup>       |                      | vs H <sub>2</sub> O, bz, eth,<br>EtOH                 |
| 1813 | Chlorambucil                    |                                                                             | C <sub>14</sub> H <sub>15</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 305-03-3   | 304.213  |                                                 | 65        |                          |                            |                      |                                                       |
| 1814 | Chloramine B                    | <i>N</i> -Chlorobenzenesulfonamide sodium                                   | C <sub>6</sub> H <sub>5</sub> ClNNaO <sub>2</sub> S                           | 127-52-6   | 213.618  | pr (w)                                          | 190       |                          |                            |                      | sl EtOH; i chl,<br>eth                                |
| 1815 | Chloramine T                    | <i>N</i> -Chloro-4-methylbenzenesulfonamide sodium                          | C <sub>7</sub> H <sub>7</sub> ClNNaO <sub>2</sub> S                           | 127-65-1   | 227.645  | pr (hyd)                                        | 180 (hyd) |                          |                            |                      | s H <sub>2</sub> O; i bz, chl,<br>eth                 |
| 1816 | Chloramphenicol                 |                                                                             | C <sub>11</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>5</sub> | 56-75-7    | 323.129  | pa ye pl or<br>nd (w)                           | 150.5     | sub                      |                            |                      | vs ace, EtOH,<br>chl                                  |
| 1817 | Chloramphenicol palmitate       |                                                                             | C <sub>27</sub> H <sub>42</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>6</sub> | 530-43-8   | 561.537  | cry (bz)                                        | 90        |                          |                            |                      | vs bz, eth, EtOH                                      |
| 1818 | Chloranilic acid                | 2,5-Dichloro-3,6-dihydroxy-2,5-cyclohexadiene-1,4-dione                     | C <sub>6</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>4</sub>                  | 87-88-7    | 208.984  | red lf (w+2)                                    | 283.5     |                          |                            |                      | s H <sub>2</sub> O                                    |
| 1819 | Chlorbenside                    | 1-Chloro-4[[[(4-chlorophenyl)methyl]thio]benzene                            | C <sub>13</sub> H <sub>10</sub> Cl <sub>2</sub> S                             | 103-17-3   | 269.189  |                                                 | 75        |                          | 1.4210 <sup>20</sup>       |                      |                                                       |
| 1820 | Chlorbicyclen                   |                                                                             | C <sub>9</sub> H <sub>6</sub> Cl <sub>6</sub>                                 | 2550-75-6  | 397.768  | pow                                             | 105       | 174 <sup>2</sup>         |                            |                      |                                                       |
| 1821 | Chlorbromuron                   | <i>N</i> -(4-Bromo-3-chlorophenyl)- <i>N</i> -methoxy- <i>N</i> -methylurea | C <sub>9</sub> H <sub>10</sub> BrClN <sub>2</sub> O <sub>2</sub>              | 13360-45-7 | 293.544  |                                                 | 96        |                          | 1.69 <sup>20</sup>         |                      |                                                       |
| 1822 | Chlorbutam                      | 1-Methyl-2-propenyl(3-chlorophenyl)carbamate                                | C <sub>11</sub> H <sub>10</sub> ClNO <sub>2</sub>                             | 1967-16-4  | 223.656  | cry                                             | 45.5      |                          |                            |                      | sl H <sub>2</sub> O; s MeOH,<br>EtOH, ace             |
| 1823 | Chlorcyclizine                  |                                                                             | C <sub>18</sub> H <sub>21</sub> ClN <sub>2</sub>                              | 82-93-9    | 300.826  | oil                                             |           | 140 <sup>0.12</sup>      |                            |                      |                                                       |
| 1824 | Chlordane                       |                                                                             | C <sub>10</sub> H <sub>6</sub> Cl <sub>8</sub>                                | 57-74-9    | 409.779  |                                                 | 106       | 175 <sup>1</sup>         | 1.60 <sup>25</sup>         |                      |                                                       |

 $\psi,\psi$ -Caroten-16-ol

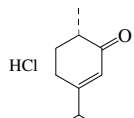
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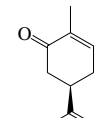
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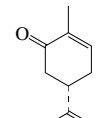
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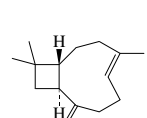
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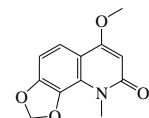
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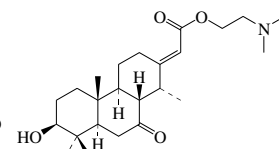
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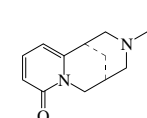
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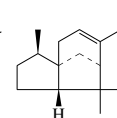
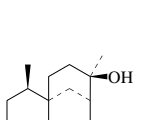
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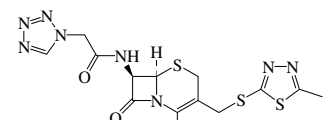
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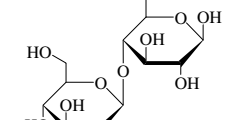
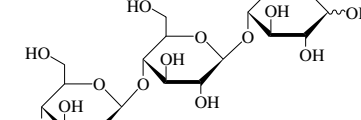
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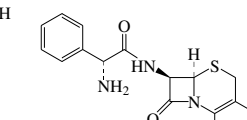
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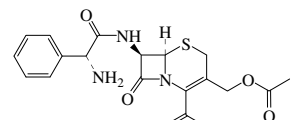
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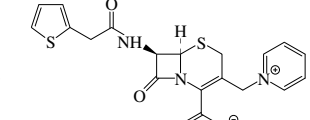
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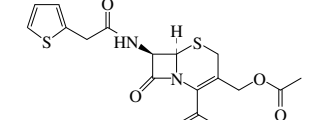
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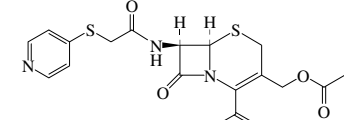
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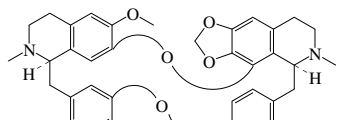
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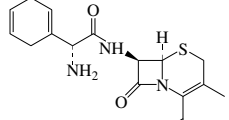
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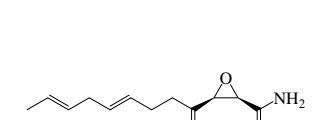
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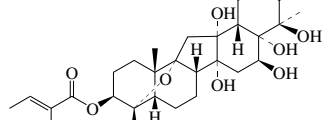
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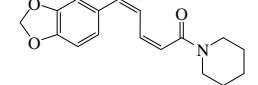
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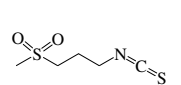
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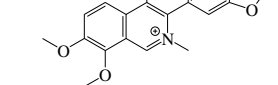
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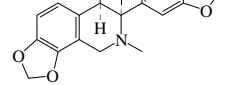
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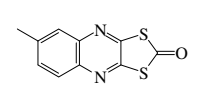
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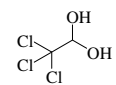
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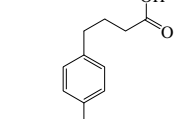
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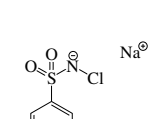
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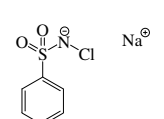
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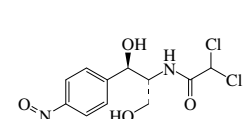
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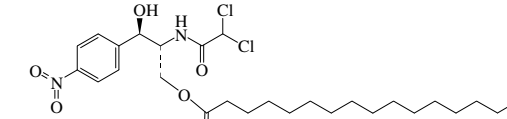
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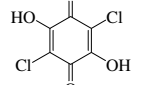
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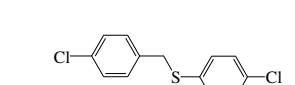
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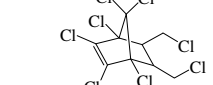
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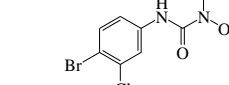
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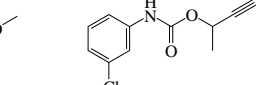
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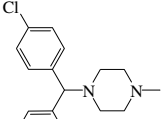
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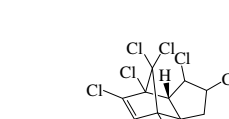
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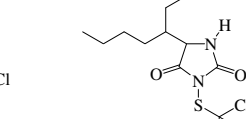
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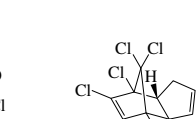
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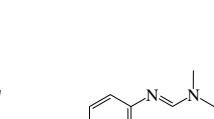
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Chlordantoin



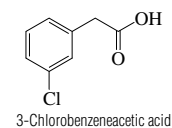
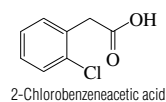
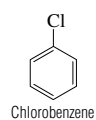
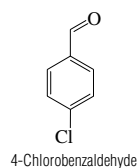
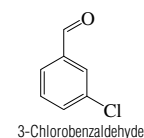
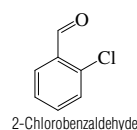
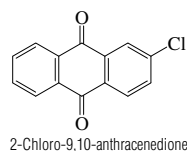
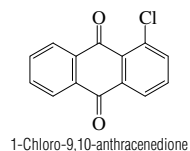
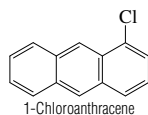
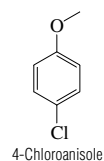
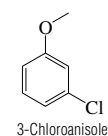
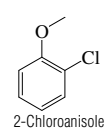
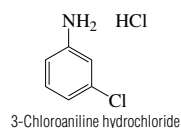
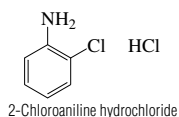
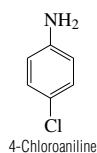
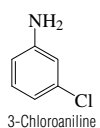
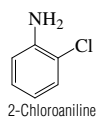
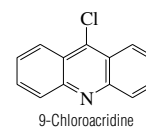
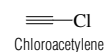
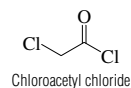
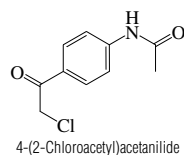
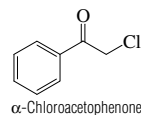
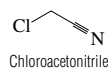
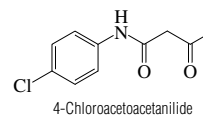
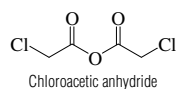
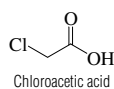
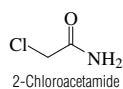
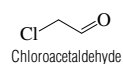
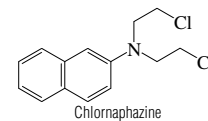
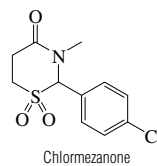
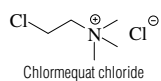
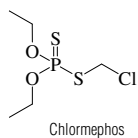
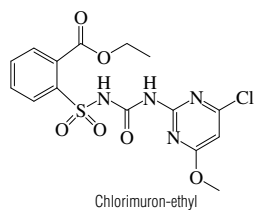
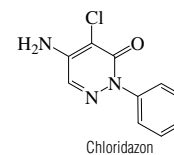
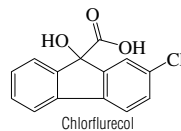
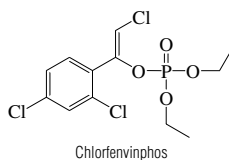
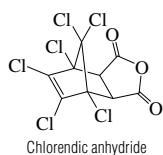
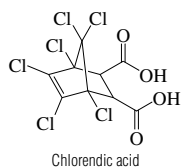
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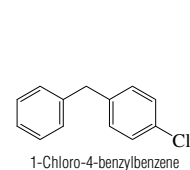
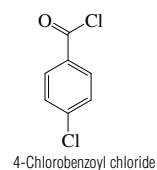
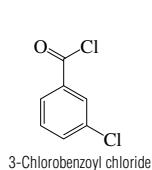
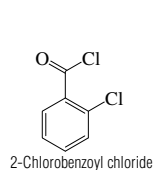
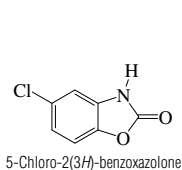
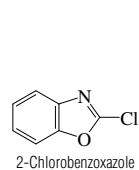
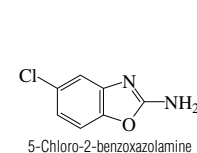
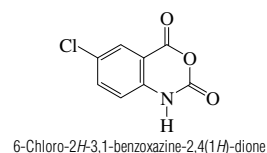
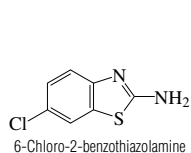
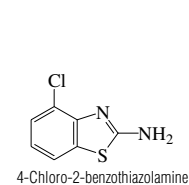
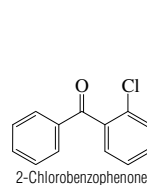
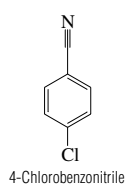
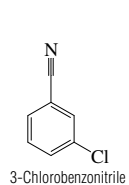
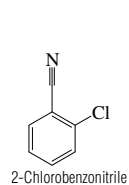
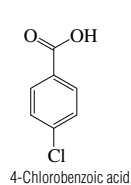
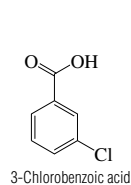
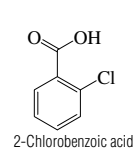
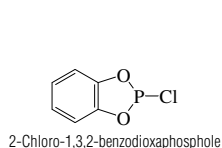
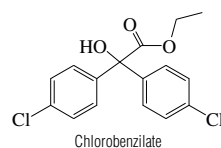
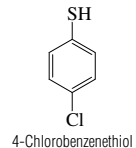
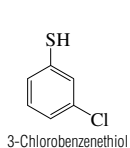
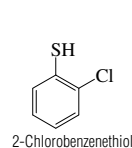
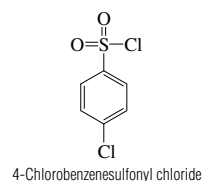
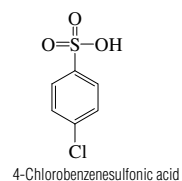
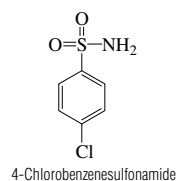
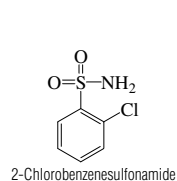
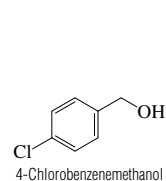
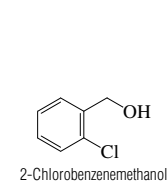
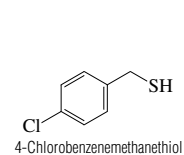
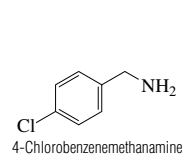
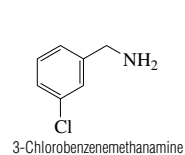
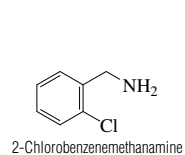
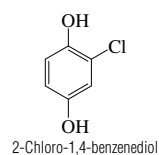
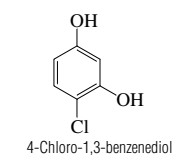
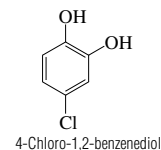
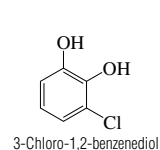
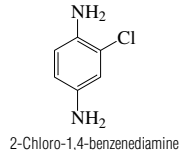
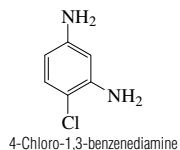
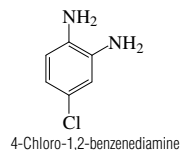
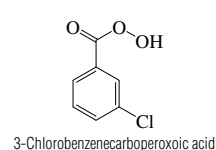
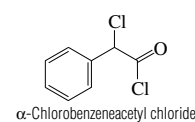
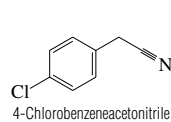
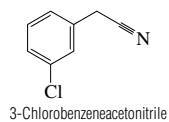
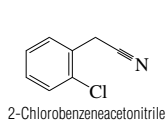
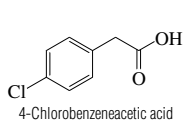
Chlordimeform



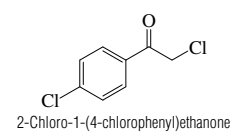
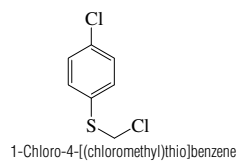
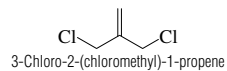
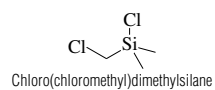
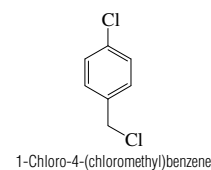
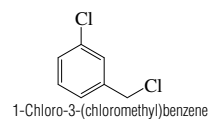
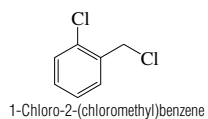
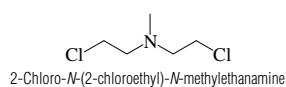
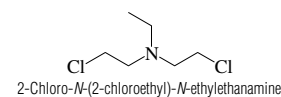
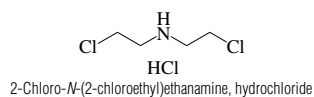
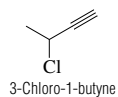
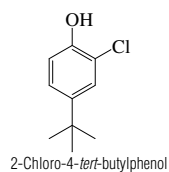
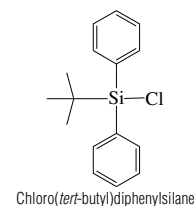
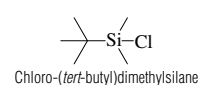
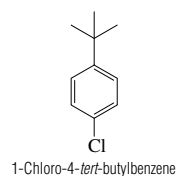
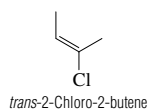
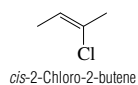
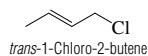
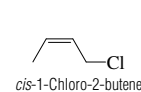
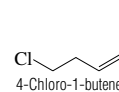
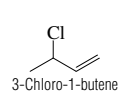
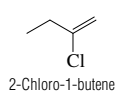
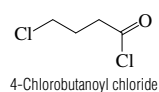
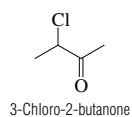
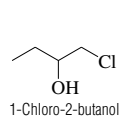
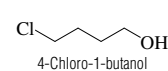
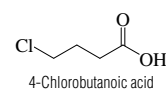
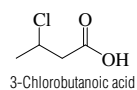
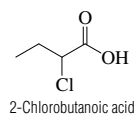
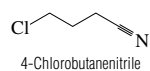
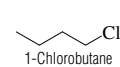
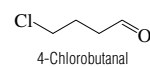
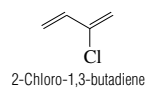
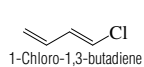
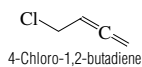
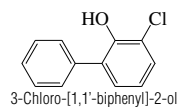
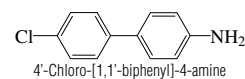
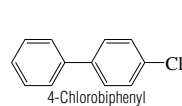
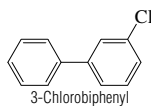
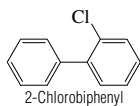
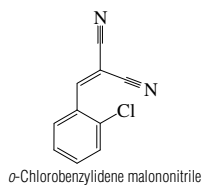
| No.  | Name                          | Synonym                                                   | Mol. Form.                                                                      | CAS RN     | Mol. Wt. | Physical Form               | mp/°C   | bp/°C               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                        |
|------|-------------------------------|-----------------------------------------------------------|---------------------------------------------------------------------------------|------------|----------|-----------------------------|---------|---------------------|----------------------------|-----------------------|-------------------------------------------------------------------|
| 1825 | Chlordantoin                  |                                                           | C <sub>11</sub> H <sub>17</sub> Cl <sub>3</sub> N <sub>2</sub> O <sub>2</sub> S | 5588-20-5  | 347.689  |                             |         |                     |                            |                       | s CS <sub>2</sub>                                                 |
| 1826 | Chlordene                     |                                                           | C <sub>10</sub> H <sub>6</sub> Cl <sub>6</sub>                                  | 3734-48-3  | 338.873  | cry (EtOH)                  | 155     |                     |                            |                       |                                                                   |
| 1827 | Chlordimeform                 |                                                           | C <sub>10</sub> H <sub>13</sub> ClN <sub>2</sub>                                | 6164-98-3  | 196.676  |                             | 35      | 156 <sup>0.4</sup>  | 1.105 <sup>25</sup>        | 1.5885 <sup>25</sup>  | vs bz, eth, EtOH                                                  |
| 1828 | Chlorendic acid               | 1,4,5,6,7,7-Hexachloro-5-norbornene-2,3-dicarboxylic acid | C <sub>9</sub> H <sub>4</sub> Cl <sub>6</sub> O <sub>4</sub>                    | 115-28-6   | 388.844  | cry (w)                     | 232     |                     |                            |                       |                                                                   |
| 1829 | Chlorendic anhydride          |                                                           | C <sub>9</sub> H <sub>2</sub> Cl <sub>6</sub> O <sub>3</sub>                    | 115-27-5   | 370.828  |                             | 235     |                     |                            |                       |                                                                   |
| 1830 | Chlorfenvinphos               |                                                           | C <sub>12</sub> H <sub>14</sub> Cl <sub>3</sub> O <sub>4</sub> P                | 470-90-6   | 359.569  |                             |         | 170 <sup>0.05</sup> |                            |                       |                                                                   |
| 1831 | Chlorflurecol                 | 9H-Fluorene-9-carboxylic acid, 2-chloro-9-hydroxy-        | C <sub>14</sub> H <sub>9</sub> ClO <sub>3</sub>                                 | 2464-37-1  | 260.672  |                             |         |                     | 1.496 <sup>20</sup>        |                       |                                                                   |
| 1832 | Chloridazon                   | 3(2H)-Pyridazinone, 5-amino-4-chloro-2-phenyl-            | C <sub>10</sub> H <sub>6</sub> ClN <sub>3</sub> O                               | 1698-60-8  | 221.643  |                             | 205     |                     |                            |                       |                                                                   |
| 1833 | Chlorimuron-ethyl             |                                                           | C <sub>15</sub> H <sub>15</sub> ClN <sub>4</sub> O <sub>6</sub> S               | 90982-32-4 | 414.821  |                             | 186     |                     |                            |                       |                                                                   |
| 1834 | Chlormephos                   | Chloromethyl O,O-diethyl dithiophosphate                  | C <sub>6</sub> H <sub>12</sub> ClO <sub>2</sub> PS <sub>2</sub>                 | 24934-91-6 | 234.705  | oil                         |         | 83 <sup>0.1</sup>   |                            | 1.5244                | sl H <sub>2</sub> O; misc os                                      |
| 1835 | Chlormequat chloride          |                                                           | C <sub>3</sub> H <sub>3</sub> Cl <sub>2</sub> N                                 | 999-81-5   | 158.069  |                             | 239 dec |                     |                            |                       |                                                                   |
| 1836 | Chlormezanone                 |                                                           | C <sub>11</sub> H <sub>12</sub> ClNO <sub>3</sub> S                             | 80-77-3    | 273.736  | cry                         | 117     |                     |                            |                       | sl EtOH                                                           |
| 1837 | Chlornaphazine                |                                                           | C <sub>14</sub> H <sub>9</sub> Cl <sub>2</sub> N                                | 494-03-1   | 268.182  | pl (peth)                   | 55      | 210 <sup>5</sup>    |                            |                       | vs ace, bz, eth, EtOH                                             |
| 1838 | Chloroacetaldehyde            |                                                           | C <sub>2</sub> H <sub>3</sub> ClO                                               | 107-20-0   | 78.497   | liq                         | -16.3   | 85.5                | 1.19                       |                       | s eth                                                             |
| 1839 | 2-Chloroacetamide             |                                                           | C <sub>2</sub> H <sub>4</sub> ClNO                                              | 79-07-2    | 93.512   |                             | 121     | 225                 |                            |                       | s H <sub>2</sub> O; vs EtOH; sl eth                               |
| 1840 | Chloroacetic acid             |                                                           | C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>                                  | 79-11-8    | 94.497   | mcl pl                      | 63      | 189.3               | 1.4043 <sup>40</sup>       | 1.4351 <sup>55</sup>  | vs H <sub>2</sub> O; s EtOH, eth, bz, chl; sl ctc                 |
| 1841 | Chloroacetic anhydride        |                                                           | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>3</sub>                    | 541-88-8   | 170.979  | pr (bz)                     | 46      | 203                 | 1.5497 <sup>20</sup>       |                       |                                                                   |
| 1842 | 4-Chloroacetoacetanilide      | N-Acetoacetyl-4-chloroaniline                             | C <sub>10</sub> H <sub>10</sub> ClNO <sub>2</sub>                               | 101-92-8   | 211.645  |                             | 132     |                     |                            |                       |                                                                   |
| 1843 | Chloroacetone                 |                                                           | C <sub>3</sub> H <sub>5</sub> ClO                                               | 78-95-5    | 92.524   | liq                         | -44.5   | 119                 | 1.15 <sup>20</sup>         |                       | s H <sub>2</sub> O, EtOH, eth, chl                                |
| 1844 | Chloroacetonitrile            | Chloromethyl cyanide                                      | C <sub>2</sub> H <sub>2</sub> ClN                                               | 107-14-2   | 75.497   |                             |         | 126.5               | 1.1930 <sup>20</sup>       | 1.4202 <sup>25</sup>  | vs eth, EtOH                                                      |
| 1845 | α-Chloroacetophenone          | ω-Chloroacetophenone                                      | C <sub>8</sub> H <sub>7</sub> ClO                                               | 532-27-4   | 154.594  | pl(dil al), rhom, lf (peth) | 56.5    | 247                 | 1.324 <sup>15</sup>        |                       | i H <sub>2</sub> O; vs EtOH, eth, bz; s ace, peth                 |
| 1846 | 4-(2-Chloroacetyl)acetanilide |                                                           | C <sub>10</sub> H <sub>10</sub> ClNO <sub>2</sub>                               | 140-49-8   | 211.645  |                             | 218     |                     |                            |                       |                                                                   |
| 1847 | Chloroacetyl chloride         |                                                           | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O                                 | 79-04-9    | 112.942  | liq                         | -22     | 106                 | 1.4202 <sup>20</sup>       | 1.4530 <sup>20</sup>  | msc eth; s ace, ctc                                               |
| 1848 | Chloroacetylene               |                                                           | C <sub>2</sub> HCl                                                              | 593-63-5   | 60.482   | col gas                     | -126    | -30                 |                            |                       | sl EtOH                                                           |
| 1849 | 9-Chloroacridine              |                                                           | C <sub>13</sub> H <sub>8</sub> ClN                                              | 1207-69-8  | 213.663  | nd (al)                     | 121     | sub                 |                            |                       | vs H <sub>2</sub> O, EtOH                                         |
| 1850 | 2-Chloroaniline               |                                                           | C <sub>6</sub> H <sub>6</sub> ClN                                               | 95-51-2    | 127.572  | liq                         | -1.9    | 208.8               |                            | 1.5895 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH; s eth, ace                          |
| 1851 | 3-Chloroaniline               |                                                           | C <sub>6</sub> H <sub>6</sub> ClN                                               | 108-42-9   | 127.572  | liq                         | -10.28  | 230.5               | 1.2161 <sup>20</sup>       | 1.5941 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; s chl                 |
| 1852 | 4-Chloroaniline               |                                                           | C <sub>6</sub> H <sub>6</sub> ClN                                               | 106-47-8   | 127.572  | orth pr                     | 70.5    | 232                 | 1.429 <sup>19</sup>        | 1.5546 <sup>87</sup>  | s H <sub>2</sub> O, EtOH, eth, chl                                |
| 1853 | 2-Chloroaniline hydrochloride |                                                           | C <sub>6</sub> H <sub>7</sub> Cl <sub>2</sub> N                                 | 137-04-2   | 164.033  | pl (w, aq al)               | 235     |                     | 1.505 <sup>18</sup>        |                       | vs H <sub>2</sub> O                                               |
| 1854 | 3-Chloroaniline hydrochloride |                                                           | C <sub>6</sub> H <sub>7</sub> Cl <sub>2</sub> N                                 | 141-85-5   | 164.033  | pl                          | 222     |                     |                            |                       | vs H <sub>2</sub> O, EtOH                                         |
| 1855 | 2-Chloroanisole               | 1-Chloro-2-methoxybenzene                                 | C <sub>7</sub> H <sub>7</sub> ClO                                               | 766-51-8   | 142.583  | liq                         | -26.8   | 198.5               | 1.1911 <sup>20</sup>       | 1.5480 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl chl                           |
| 1856 | 3-Chloroanisole               | 1-Chloro-3-methoxybenzene                                 | C <sub>7</sub> H <sub>7</sub> ClO                                               | 2845-89-8  | 142.583  |                             |         | 193.5               | 1.1759 <sup>12</sup>       | 1.5365 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                                   |
| 1857 | 4-Chloroanisole               | 1-Chloro-4-methoxybenzene                                 | C <sub>7</sub> H <sub>7</sub> ClO                                               | 623-12-1   | 142.583  |                             | <-18    | 197.5               | 1.201 <sup>20</sup>        | 1.5390 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth, chl; s ctc                      |
| 1858 | 1-Chloroanthracene            |                                                           | C <sub>14</sub> H <sub>9</sub> Cl                                               | 4985-70-0  | 212.674  | lf (HOAc)                   | 83.5    |                     | 1.1707 <sup>100</sup>      | 1.6959 <sup>100</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc                          |
| 1859 | 1-Chloro-9,10-anthracenedione |                                                           | C <sub>14</sub> H <sub>7</sub> ClO <sub>2</sub>                                 | 82-44-0    | 242.658  | ye nd (to or al)            | 163     | sub                 |                            |                       | i H <sub>2</sub> O; sl EtOH, ctc; msc eth; s bz                   |
| 1860 | 2-Chloro-9,10-anthracenedione |                                                           | C <sub>14</sub> H <sub>7</sub> ClO <sub>2</sub>                                 | 131-09-9   | 242.658  | pa ye nd (al, HOAc)         | 211     | sub                 |                            |                       | i H <sub>2</sub> O, eth; sl EtOH, bz; vs tol; s PhNO <sub>2</sub> |
| 1861 | 2-Chlorobenzaldehyde          |                                                           | C <sub>7</sub> H <sub>5</sub> ClO                                               | 89-98-5    | 140.567  | nd                          | 12.4    | 211.9               | 1.2483 <sup>20</sup>       | 1.5662 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, ctc                    |
| 1862 | 3-Chlorobenzaldehyde          |                                                           | C <sub>7</sub> H <sub>5</sub> ClO                                               | 587-04-2   | 140.567  | pr                          | 17.5    | 213.5               | 1.2410 <sup>20</sup>       | 1.5650 <sup>20</sup>  | sl H <sub>2</sub> O, chl; s EtOH, eth, ace, bz                    |
| 1863 | 4-Chlorobenzaldehyde          |                                                           | C <sub>7</sub> H <sub>5</sub> ClO                                               | 104-88-1   | 140.567  | pl                          | 47.5    | 213.5               | 1.196 <sup>61</sup>        | 1.555 <sup>61</sup>   | s H <sub>2</sub> O, ace, chl; vs EtOH, eth, bz                    |
| 1864 | 2-Chlorobenzamide             |                                                           | C <sub>7</sub> H <sub>6</sub> ClNO                                              | 609-66-5   | 155.582  | orth nd (w)                 | 141.8   |                     |                            |                       | s H <sub>2</sub> O, EtOH, eth                                     |
| 1865 | Chlorobenzene                 | Phenyl chloride                                           | C <sub>6</sub> H <sub>5</sub> Cl                                                | 108-90-7   | 112.557  | liq                         | -45.31  | 131.72              | 1.1058 <sup>20</sup>       | 1.5241 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; vs bz, ctc                     |



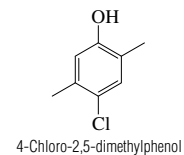
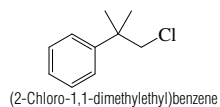
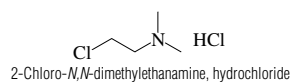
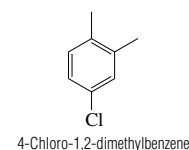
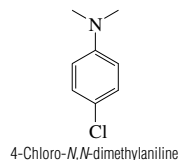
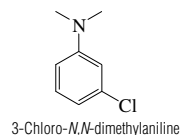
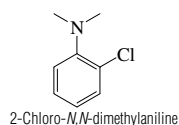
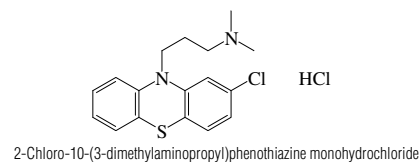
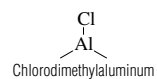
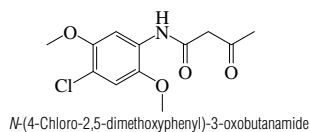
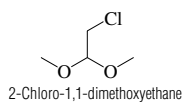
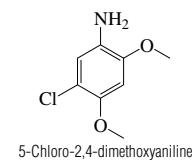
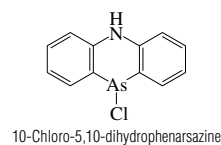
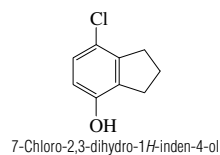
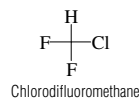
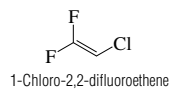
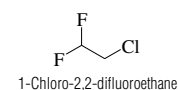
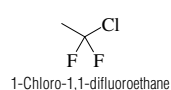
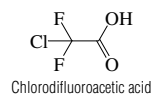
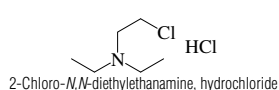
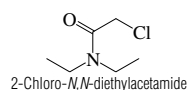
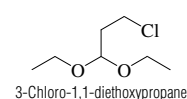
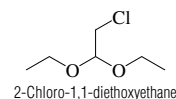
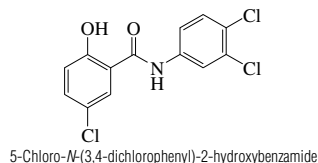
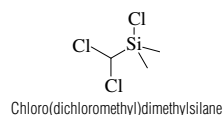
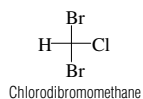
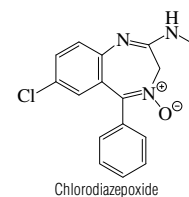
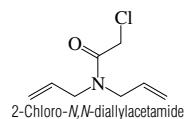
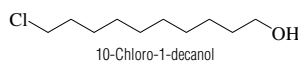
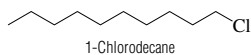
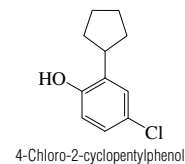
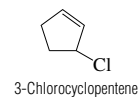
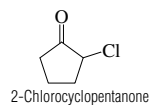
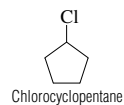
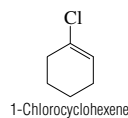
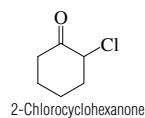
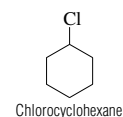
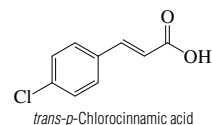
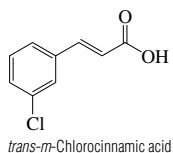
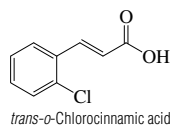
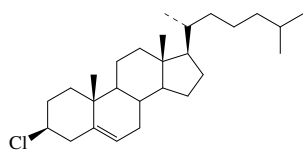
| No.  | Name                                                        | Synonym                              | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|-------------------------------------------------------------|--------------------------------------|----------------------------------------------------------------|------------|----------|---------------------------|---------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 1866 | 2-Chlorobenzeneacetic acid                                  |                                      | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                 | 2444-36-2  | 170.594  | nd (w)                    | 96      |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH                                  |
| 1867 | 3-Chlorobenzeneacetic acid                                  |                                      | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                 | 1878-65-5  | 170.594  | pl (dil al), nd (lig)     | 77.5    |                                       |                            |                      | sl H <sub>2</sub> O, bz, ctc, EtOH; msc eth                   |
| 1868 | 4-Chlorobenzeneacetic acid                                  |                                      | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                 | 1878-66-6  | 170.594  | nd (w)                    | 105.5   |                                       |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz                             |
| 1869 | 2-Chlorobenzeneacetonitrile                                 |                                      | C <sub>8</sub> H <sub>6</sub> ClN                              | 2856-63-5  | 151.594  |                           | 24      | 251                                   | 1.1737 <sup>18</sup>       |                      |                                                               |
| 1870 | 3-Chlorobenzeneacetonitrile                                 |                                      | C <sub>8</sub> H <sub>6</sub> ClN                              | 1529-41-5  | 151.594  |                           | 11.5    | 261; 135 <sup>10</sup>                | 1.1806 <sup>30</sup>       | 1.5437 <sup>20</sup> |                                                               |
| 1871 | 4-Chlorobenzeneacetonitrile                                 |                                      | C <sub>8</sub> H <sub>6</sub> ClN                              | 140-53-4   | 151.594  |                           | 29      | 265.0                                 | 1.1778 <sup>30</sup>       |                      | s ctc                                                         |
| 1872 | α-Chlorobenzeneacetyl chloride                              |                                      | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> O                | 2912-62-1  | 189.039  |                           |         | 120 <sup>23</sup> , 110 <sup>14</sup> | 1.196 <sup>25</sup>        | 1.5440 <sup>20</sup> |                                                               |
| 1873 | 3-Chlorobenzeneperoxydicarboxylic acid                      |                                      | C <sub>7</sub> H <sub>5</sub> ClO <sub>3</sub>                 | 937-14-4   | 172.566  |                           | 92 dec  |                                       |                            |                      |                                                               |
| 1874 | 4-Chloro-1,2-benzenediamine                                 | 4-Chloro- <i>o</i> -phenylenediamine | C <sub>6</sub> H <sub>7</sub> ClN <sub>2</sub>                 | 95-83-0    | 142.586  | pl (bz-lig) lf (w)        | 76      |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz, lig                  |
| 1875 | 4-Chloro-1,3-benzenediamine                                 |                                      | C <sub>6</sub> H <sub>7</sub> ClN <sub>2</sub>                 | 5131-60-2  | 142.586  | pl or nd                  | 91      |                                       |                            |                      | vs EtOH                                                       |
| 1876 | 2-Chloro-1,4-benzenediamine                                 | 2-Chloro- <i>p</i> -phenylenediamine | C <sub>6</sub> H <sub>7</sub> ClN <sub>2</sub>                 | 615-66-7   | 142.586  | nd                        | 64      |                                       |                            |                      |                                                               |
| 1877 | 3-Chloro-1,2-benzenediol                                    |                                      | C <sub>6</sub> H <sub>5</sub> ClO <sub>2</sub>                 | 4018-65-9  | 144.556  | cry (lig)                 | 48.5    | 110 <sup>11</sup>                     |                            |                      | vs lig                                                        |
| 1878 | 4-Chloro-1,2-benzenediol                                    |                                      | C <sub>6</sub> H <sub>5</sub> ClO <sub>2</sub>                 | 2138-22-9  | 144.556  | lf (bz-peth)              | 90.5    | 139 <sup>10,5</sup>                   |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH                           |
| 1879 | 4-Chloro-1,3-benzenediol                                    |                                      | C <sub>6</sub> H <sub>5</sub> ClO <sub>2</sub>                 | 95-88-5    | 144.556  |                           |         | 257                                   |                            |                      | vs H <sub>2</sub> O, EtOH, eth, ace, bz, CS <sub>2</sub>      |
| 1880 | 2-Chloro-1,4-benzenediol                                    |                                      | C <sub>6</sub> H <sub>5</sub> ClO <sub>2</sub>                 | 615-67-8   | 144.556  | red lf (chl), nd (bz)     | 108     | 263                                   |                            |                      | vs H <sub>2</sub> O, chl; s EtOH, eth; vs bz                  |
| 1881 | 2-Chlorobenzenemethanamine                                  |                                      | C <sub>7</sub> H <sub>8</sub> ClN                              | 89-97-4    | 141.599  |                           |         | 72 <sup>2</sup>                       |                            | 1.5594 <sup>25</sup> |                                                               |
| 1882 | 3-Chlorobenzenemethanamine                                  |                                      | C <sub>7</sub> H <sub>8</sub> ClN                              | 4152-90-3  | 141.599  |                           |         | 89 <sup>2</sup>                       |                            | 1.5570 <sup>25</sup> |                                                               |
| 1883 | 4-Chlorobenzenemethanamine                                  |                                      | C <sub>7</sub> H <sub>8</sub> ClN                              | 104-86-9   | 141.599  |                           |         | 109 <sup>13</sup>                     |                            | 1.5566 <sup>25</sup> |                                                               |
| 1884 | 4-Chlorobenzenemethanethiol                                 |                                      | C <sub>7</sub> H <sub>7</sub> ClS                              | 6258-66-8  | 158.649  |                           | 19.5    | 113 <sup>17</sup>                     | 1.202 <sup>25</sup>        | 1.5893 <sup>20</sup> |                                                               |
| 1885 | 2-Chlorobenzenemethanol                                     |                                      | C <sub>7</sub> H <sub>7</sub> ClO                              | 17849-38-6 | 142.583  | lf or nd (dil al)         | 73      | 230                                   |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, lig                        |
| 1886 | 4-Chlorobenzenemethanol                                     |                                      | C <sub>7</sub> H <sub>7</sub> ClO                              | 873-76-7   | 142.583  | nd (w), pl (bz or bz-lig) | 75      | 235                                   |                            |                      | vs bz, eth, EtOH                                              |
| 1887 | 2-Chlorobenzenesulfonamide                                  |                                      | C <sub>6</sub> H <sub>6</sub> ClNO <sub>2</sub> S              | 6961-82-6  | 191.636  | lf (al)                   | 188     |                                       |                            |                      | vs EtOH                                                       |
| 1888 | 4-Chlorobenzenesulfonamide                                  |                                      | C <sub>6</sub> H <sub>6</sub> ClNO <sub>2</sub> S              | 98-64-6    | 191.636  | pr or pl (eth)            | 146     |                                       |                            |                      | vs bz, eth                                                    |
| 1889 | 4-Chlorobenzenesulfonic acid                                | <i>p</i> -Chlorobenzenesulfonic acid | C <sub>6</sub> H <sub>5</sub> ClO <sub>3</sub> S               | 98-66-8    | 192.620  | nd (w+1)                  | 67      | 147 <sup>25</sup>                     |                            |                      | s H <sub>2</sub> O, EtOH; i eth, bz                           |
| 1890 | 4-Chlorobenzenesulfonyl chloride                            |                                      | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub> S | 98-60-2    | 211.066  |                           | 51      | 141 <sup>15</sup>                     |                            |                      | vs eth, bz                                                    |
| 1891 | 2-Chlorobenzenethiol                                        |                                      | C <sub>6</sub> H <sub>5</sub> ClS                              | 6320-03-2  | 144.622  |                           |         | 205.5                                 | 1.2752 <sup>10</sup>       |                      | sl H <sub>2</sub> O, EtOH                                     |
| 1892 | 3-Chlorobenzenethiol                                        |                                      | C <sub>6</sub> H <sub>5</sub> ClS                              | 2037-31-2  | 144.622  |                           |         | 206                                   | 1.2637 <sup>13</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, chl, peth                    |
| 1893 | 4-Chlorobenzenethiol                                        |                                      | C <sub>6</sub> H <sub>5</sub> ClS                              | 106-54-7   | 144.622  |                           | 61      | 206                                   | 1.1911 <sup>20</sup>       | 1.5480 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz; sl chl                  |
| 1894 | Chlorobenzilate                                             |                                      | C <sub>16</sub> H <sub>14</sub> Cl <sub>2</sub> O <sub>3</sub> | 510-15-6   | 325.186  |                           | 37      | 157 <sup>0,07</sup>                   | 1.2816 <sup>20</sup>       |                      |                                                               |
| 1895 | 2-Chloro-1,3,2-benzodioxaphosphole                          |                                      | C <sub>6</sub> H <sub>4</sub> ClO <sub>2</sub> P               | 1641-40-3  | 174.522  |                           | 30      | 80 <sup>20</sup>                      | 1.4650 <sup>20</sup>       | 1.5712 <sup>20</sup> |                                                               |
| 1896 | 2-Chlorobenzoic acid                                        |                                      | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                 | 118-91-2   | 156.567  | mcl pr (w)                | 140.2   | sub                                   | 1.544 <sup>20</sup>        |                      | s H <sub>2</sub> O, bz; vs EtOH, eth, ace; sl CS <sub>2</sub> |
| 1897 | 3-Chlorobenzoic acid                                        |                                      | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                 | 535-80-8   | 156.567  | pr (w)                    | 158     | sub                                   | 1.496 <sup>25</sup>        |                      | sl H <sub>2</sub> O, bz, ctc, CS <sub>2</sub> ; s EtOH, eth   |
| 1898 | 4-Chlorobenzoic acid                                        |                                      | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                 | 74-11-3    | 156.567  | tcl pr (al-eth)           | 243     |                                       |                            |                      | i H <sub>2</sub> O, bz, ctc; vs EtOH; sl eth, ace             |
| 1899 | 2-Chlorobenzonitrile                                        |                                      | C <sub>7</sub> H <sub>4</sub> ClN                              | 873-32-5   | 137.567  | nd                        | 46.3    | 232                                   |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, chl                         |
| 1900 | 3-Chlorobenzonitrile                                        |                                      | C <sub>7</sub> H <sub>4</sub> ClN                              | 766-84-7   | 137.567  |                           | 41      | 100 <sup>15</sup>                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth                               |
| 1901 | 4-Chlorobenzonitrile                                        |                                      | C <sub>7</sub> H <sub>4</sub> ClN                              | 623-03-0   | 137.567  | nd (al)                   | 95      | 223; 95 <sup>5</sup>                  | 1.1133 <sup>17</sup>       |                      | sl H <sub>2</sub> O, lig; s EtOH, eth, bz, chl                |
| 1902 | 2-Chlorobenzophenone                                        | 2-Chlorophenyl phenyl ketone         | C <sub>13</sub> H <sub>9</sub> ClO                             | 5162-03-8  | 216.662  | pl (chl-lig)              | 54      | 330                                   |                            |                      |                                                               |
| 1903 | 4-Chloro-2-benzothiazolamine                                |                                      | C <sub>7</sub> H <sub>6</sub> ClN <sub>2</sub> S               | 19952-47-7 | 184.646  |                           | 204     |                                       |                            |                      |                                                               |
| 1904 | 6-Chloro-2-benzothiazolamine                                |                                      | C <sub>7</sub> H <sub>6</sub> ClN <sub>2</sub> S               | 95-24-9    | 184.646  |                           | 200     |                                       |                            |                      |                                                               |
| 1905 | 2-Chlorobenzothiazole                                       |                                      | C <sub>7</sub> H <sub>4</sub> ClNS                             | 615-20-3   | 169.632  |                           | 24      | 248                                   | 1.3715 <sup>10</sup>       | 1.6338 <sup>10</sup> | vs ace, eth, EtOH                                             |
| 1906 | 5-Chloro-1 <i>H</i> -benzotriazole                          |                                      | C <sub>6</sub> H <sub>4</sub> ClN <sub>3</sub>                 | 94-97-3    | 153.569  |                           | 158     |                                       |                            |                      |                                                               |
| 1907 | 6-Chloro-2 <i>H</i> -3,1-benzoxazine-2,4(1 <i>H</i> )-dione | 5-Chloroisatoic anhydride            | C <sub>8</sub> H <sub>4</sub> ClNO <sub>3</sub>                | 4743-17-3  | 197.576  |                           | 280 dec |                                       |                            |                      |                                                               |
| 1908 | 5-Chloro-2-benzoxazolamine                                  | Zoxazolamine                         | C <sub>7</sub> H <sub>6</sub> ClN <sub>2</sub> O               | 61-80-3    | 168.580  | pl (bz)                   | 184.5   |                                       |                            |                      | vs EtOH                                                       |
| 1909 | 2-Chlorobenzoxazole                                         |                                      | C <sub>7</sub> H <sub>4</sub> ClNO                             | 615-18-9   | 153.566  |                           | 7       | 201.5                                 | 1.3453 <sup>18</sup>       | 1.5678 <sup>20</sup> |                                                               |
| 1910 | 5-Chloro-2(3 <i>H</i> )-benzoxazolone                       | Chloroxazone                         | C <sub>7</sub> H <sub>4</sub> ClNO <sub>2</sub>                | 95-25-0    | 169.566  | cry (ace)                 | 191.5   |                                       |                            |                      | vs EtOH, MeOH                                                 |
| 1911 | 2-Chlorobenzoyl chloride                                    |                                      | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O                | 609-65-4   | 175.012  | liq                       | -4      | 238                                   |                            | 1.5726 <sup>16</sup> | s ctc                                                         |



| No.  | Name                                                            | Synonym                         | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form  | mp/°C  | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                   |
|------|-----------------------------------------------------------------|---------------------------------|--------------------------------------------------|------------|----------|----------------|--------|----------------------------------------|----------------------------|----------------------|----------------------------------------------|
| 1912 | 3-Chlorobenzoyl chloride                                        |                                 | C <sub>7</sub> H <sub>5</sub> Cl <sub>2</sub> O  | 618-46-2   | 175.012  |                |        | 225                                    |                            | 1.5677 <sup>20</sup> |                                              |
| 1913 | 4-Chlorobenzoyl chloride                                        |                                 | C <sub>7</sub> H <sub>5</sub> Cl <sub>2</sub> O  | 122-01-0   | 175.012  |                | 16     | 222                                    | 1.3770 <sup>20</sup>       | 1.5756 <sup>20</sup> | sl chl                                       |
| 1914 | 1-Chloro-4-benzylbenzene                                        |                                 | C <sub>13</sub> H <sub>11</sub> Cl               | 831-81-2   | 202.679  |                | 7.5    | 299; 147 <sup>8</sup>                  | 1.1247 <sup>20</sup>       |                      | vs ace                                       |
| 1915 | <i>o</i> -Chlorobenzylidene malononitrile                       |                                 | C <sub>10</sub> H <sub>5</sub> CN <sub>2</sub>   | 2698-41-1  | 188.613  | wh cry         | 96     | 312                                    |                            |                      | sl H <sub>2</sub> O; s bz, diox, EtOAc, ace  |
| 1916 | 2-Chlorobiphenyl                                                |                                 | C <sub>12</sub> H <sub>9</sub> Cl                | 2051-60-7  | 188.652  | mcl (dil al)   | 34     | 274                                    | 1.1499 <sup>32</sup>       |                      | i H <sub>2</sub> O; vs eth, EtOH, lig        |
| 1917 | 3-Chlorobiphenyl                                                |                                 | C <sub>12</sub> H <sub>9</sub> Cl                | 2051-61-8  | 188.652  |                | 16     | 284.5                                  | 1.1579 <sup>25</sup>       | 1.6181 <sup>25</sup> | vs ace, eth, EtOH                            |
| 1918 | 4-Chlorobiphenyl                                                |                                 | C <sub>12</sub> H <sub>9</sub> Cl                | 2051-62-9  | 188.652  | lf (lig or al) | 78.8   | 292.9; 146 <sup>10</sup>               |                            |                      | i H <sub>2</sub> O; s EtOH, eth, lig         |
| 1919 | 4'-Chloro-[1,1'-biphenyl]-4-amine                               | 4-Amino-4'-chlorodiphenyl       | C <sub>12</sub> H <sub>10</sub> ClN              | 135-68-2   | 203.667  | cry (peth)     | 134    |                                        |                            |                      | vs ace, bz, eth                              |
| 1920 | 3-Chloro-[1,1'-biphenyl]-2-ol                                   | 2-Phenyl-6-chlorophenol         | C <sub>12</sub> H <sub>9</sub> ClO               | 85-97-2    | 204.651  |                | 6      | dec 317                                | 1.24 <sup>25</sup>         | 1.6237 <sup>30</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz     |
| 1921 | 4-Chloro-1,2-butadiene                                          |                                 | C <sub>4</sub> H <sub>5</sub> Cl                 | 25790-55-0 | 88.536   |                |        | 88                                     | 0.9891 <sup>20</sup>       | 1.4775 <sup>20</sup> | vs ace, bz, eth                              |
| 1922 | 1-Chloro-1,3-butadiene                                          |                                 | C <sub>4</sub> H <sub>5</sub> Cl                 | 627-22-5   | 88.536   |                |        | 68                                     | 0.9606 <sup>20</sup>       | 1.4712 <sup>20</sup> | vs eth, EtOH, chl                            |
| 1923 | 2-Chloro-1,3-butadiene                                          | Chloroprene                     | C <sub>4</sub> H <sub>5</sub> Cl                 | 126-99-8   | 88.536   | liq            | -130   | 59.4                                   | 0.956 <sup>20</sup>        | 1.4583 <sup>20</sup> | sl H <sub>2</sub> O; msc eth, ace, bz        |
| 1924 | 4-Chlorobutanal                                                 |                                 | C <sub>4</sub> H <sub>7</sub> ClO                | 6139-84-0  | 106.551  |                |        | 51 <sup>13</sup>                       | 1.106 <sup>8</sup>         | 1.4466 <sup>8</sup>  | vs ace, eth, EtOH                            |
| 1925 | 1-Chlorobutane                                                  | Butyl chloride                  | C <sub>4</sub> H <sub>9</sub> Cl                 | 109-69-3   | 92.567   | liq            | -123.1 | 78.4                                   | 0.8857 <sup>20</sup>       | 1.4023 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl ctc    |
| 1926 | 2-Chlorobutane                                                  | (±)- <i>sec</i> -Butyl chloride | C <sub>4</sub> H <sub>9</sub> Cl                 | 53178-20-4 | 92.567   | liq            | -131.3 | 68.2                                   | 0.8732 <sup>20</sup>       | 1.3971 <sup>20</sup> | vs bz, eth, EtOH, chl                        |
| 1927 | 4-Chlorobutanenitrile                                           |                                 | C <sub>4</sub> H <sub>6</sub> ClN                | 628-20-6   | 103.551  |                |        | 192                                    | 1.0934 <sup>15</sup>       | 1.4413 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc      |
| 1928 | 2-Chlorobutanoic acid                                           |                                 | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>   | 4170-24-5  | 122.551  |                |        | 189 <sup>627</sup> , 101 <sup>15</sup> | 1.1796 <sup>20</sup>       | 1.441 <sup>20</sup>  | sl H <sub>2</sub> O; vs EtOH, eth            |
| 1929 | 3-Chlorobutanoic acid                                           |                                 | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>   | 625-68-3   | 122.551  | cry (eth)      | 16     | 116 <sup>22</sup>                      | 1.1898 <sup>20</sup>       | 1.4221 <sup>20</sup> | s EtOH; vs eth; sl ctc                       |
| 1930 | 4-Chlorobutanoic acid                                           |                                 | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>   | 627-00-9   | 122.551  |                | 16     | 196 <sup>22</sup> , 68 <sup>0.2</sup>  | 1.2236 <sup>20</sup>       | 1.4642 <sup>20</sup> | vs EtOH                                      |
| 1931 | 4-Chloro-1-butanol                                              |                                 | C <sub>4</sub> H <sub>9</sub> ClO                | 928-51-8   | 108.566  |                |        | 84 <sup>16</sup>                       | 1.0883 <sup>20</sup>       | 1.4518 <sup>20</sup> | vs eth, EtOH                                 |
| 1932 | 1-Chloro-2-butanol                                              | α-Butylene chlorohydrin         | C <sub>4</sub> H <sub>9</sub> ClO                | 1873-25-2  | 108.566  |                |        | 141                                    | 1.068 <sup>25</sup>        | 1.4400 <sup>20</sup> | s EtOH, eth                                  |
| 1933 | 3-Chloro-2-butanone                                             |                                 | C <sub>4</sub> H <sub>7</sub> ClO                | 4091-39-8  | 106.551  |                |        | 115                                    | 1.0554 <sup>25</sup>       | 1.4219 <sup>20</sup> |                                              |
| 1934 | 4-Chlorobutanoyl chloride                                       |                                 | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub> O  | 4635-59-0  | 140.996  |                |        | 173.5                                  | 1.2581 <sup>20</sup>       | 1.4616 <sup>20</sup> | s eth                                        |
| 1935 | 2-Chloro-1-butene                                               |                                 | C <sub>4</sub> H <sub>7</sub> Cl                 | 2211-70-3  | 90.552   |                |        | 58.5                                   | 0.9107 <sup>15</sup>       | 1.4165 <sup>21</sup> | vs ace, bz, eth, EtOH                        |
| 1936 | 3-Chloro-1-butene                                               |                                 | C <sub>4</sub> H <sub>7</sub> Cl                 | 563-52-0   | 90.552   |                |        | 64.5                                   | 0.8978 <sup>20</sup>       | 1.4149 <sup>20</sup> | vs eth, ace; s chl                           |
| 1937 | 4-Chloro-1-butene                                               |                                 | C <sub>4</sub> H <sub>7</sub> Cl                 | 927-73-1   | 90.552   |                |        | 75                                     | 0.9211 <sup>20</sup>       | 1.4233 <sup>20</sup> | vs ace, eth, chl                             |
| 1938 | <i>cis</i> -1-Chloro-2-butene                                   |                                 | C <sub>4</sub> H <sub>7</sub> Cl                 | 4628-21-1  | 90.552   |                |        | 84.1                                   | 0.9426 <sup>20</sup>       | 1.4390 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, chl         |
| 1939 | <i>trans</i> -1-Chloro-2-butene                                 |                                 | C <sub>4</sub> H <sub>7</sub> Cl                 | 4894-61-5  | 90.552   |                |        | 85                                     | 0.9295 <sup>20</sup>       | 1.4350 <sup>20</sup> | i H <sub>2</sub> O; s ace, chl               |
| 1940 | <i>cis</i> -2-Chloro-2-butene                                   |                                 | C <sub>4</sub> H <sub>7</sub> Cl                 | 2211-69-0  | 90.552   | liq            | -117.3 | 70.6                                   | 0.9239 <sup>20</sup>       | 1.4240 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH; s ace, chl     |
| 1941 | <i>trans</i> -2-Chloro-2-butene                                 |                                 | C <sub>4</sub> H <sub>7</sub> Cl                 | 2211-68-9  | 90.552   | liq            | -105.8 | 62.8                                   | 0.9138 <sup>20</sup>       | 1.4190 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH; s ace, chl     |
| 1942 | 1-Chloro-4- <i>tert</i> -butylbenzene                           |                                 | C <sub>10</sub> H <sub>13</sub> Cl               | 3972-56-3  | 168.663  |                |        | 213                                    | 1.0075 <sup>18</sup>       | 1.5123 <sup>20</sup> |                                              |
| 1943 | Chloro-( <i>tert</i> -butyl)dimethylsilane                      |                                 | C <sub>6</sub> H <sub>15</sub> ClSi              | 18162-48-6 | 150.722  |                | 89.5   | 125                                    |                            |                      |                                              |
| 1944 | Chloro( <i>tert</i> -butyl)diphenylsilane                       |                                 | C <sub>16</sub> H <sub>19</sub> ClSi             | 58479-61-1 | 274.861  |                |        | 120 <sup>0.06</sup>                    | 1.07 <sup>20</sup>         | 1.5675 <sup>20</sup> |                                              |
| 1945 | 2-Chloro-4- <i>tert</i> -butylphenol                            |                                 | C <sub>10</sub> H <sub>13</sub> ClO              | 98-28-2    | 184.662  |                |        | 114 <sup>8</sup>                       |                            |                      |                                              |
| 1946 | 3-Chloro-1-butyne                                               |                                 | C <sub>4</sub> H <sub>5</sub> Cl                 | 21020-24-6 | 88.536   |                |        | 68.5                                   | 1.4218 <sup>25</sup>       | 1.4218 <sup>25</sup> |                                              |
| 1947 | 2-Chloro- <i>N</i> -(2-chloroethyl)ethanamine, hydrochloride    |                                 | C <sub>4</sub> H <sub>10</sub> Cl <sub>2</sub> N | 821-48-7   | 178.488  |                | 215.0  |                                        |                            |                      |                                              |
| 1948 | 2-Chloro- <i>N</i> -(2-chloroethyl)- <i>N</i> -ethylethanamine  | HN1                             | C <sub>6</sub> H <sub>13</sub> Cl <sub>2</sub> N | 538-07-8   | 170.080  | col liq        | -34    | 66 <sup>12</sup>                       | 1.0861 <sup>23</sup>       | 1.4653 <sup>25</sup> | i H <sub>2</sub> O                           |
| 1949 | 2-Chloro- <i>N</i> -(2-chloroethyl)- <i>N</i> -methylethanamine | Mechlorethamine                 | C <sub>6</sub> H <sub>11</sub> Cl <sub>2</sub> N | 51-75-2    | 156.053  |                | -60    | 87 <sup>18</sup> , 64 <sup>5</sup>     |                            |                      | sl H <sub>2</sub> O; msc ctc, DMF            |
| 1950 | 1-Chloro-2-(chloromethyl)benzene                                | 2-Chlorobenzyl chloride         | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>    | 611-19-8   | 161.029  | liq            | -17    | 217                                    | 1.2699 <sup>0</sup>        | 1.5530 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH, ctc; vs eth, bz |
| 1951 | 1-Chloro-3-(chloromethyl)benzene                                | 3-Chlorobenzyl chloride         | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>    | 620-20-2   | 161.029  |                |        | 216; 110 <sup>25</sup>                 | 1.2695 <sup>15</sup>       | 1.5554 <sup>20</sup> | vs EtOH                                      |
| 1952 | 1-Chloro-4-(chloromethyl)benzene                                | 4-Chlorobenzyl chloride         | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>    | 104-83-6   | 161.029  | nd (dil al)    | 31     | 223                                    |                            |                      | sl ctc                                       |
| 1953 | Chloro(chloromethyl)dimethylsilane                              |                                 | C <sub>3</sub> H <sub>8</sub> Cl <sub>2</sub> Si | 1719-57-9  | 143.088  |                |        | 115.5                                  | 1.0865 <sup>20</sup>       | 1.4360 <sup>20</sup> |                                              |
| 1954 | 3-Chloro-2-(chloromethyl)-1-propene                             |                                 | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub>    | 1871-57-4  | 124.997  | liq            | -14    | 138                                    | 1.1782 <sup>20</sup>       | 1.4753               | vs EtOH, chl                                 |

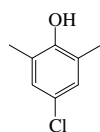


| No.  | Name                                                               | Synonym                              | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|--------------------------------------------------------------------|--------------------------------------|------------------------------------------------------------------|------------|----------|---------------|---------|--------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 1955 | 1-Chloro-4-[(chloromethyl)thio]benzene                             |                                      | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> S                  | 7205-90-5  | 193.094  |               | 21.5    | 128 <sup>12</sup>                    | 1.346 <sup>25</sup>        | 1.6055 <sup>20</sup> |                                                              |
| 1956 | 2-Chloro-1-(4-chlorophenyl)ethanone                                |                                      | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> O                  | 937-20-2   | 189.039  | nd (al)       | 101.5   | 270                                  |                            |                      | s EtOH, bz, MeOH                                             |
| 1957 | 3-Chlorocholest-5-ene, (3β)                                        |                                      | C <sub>27</sub> H <sub>46</sub> Cl                               | 910-31-6   | 405.099  | nd (al, ace)  | 96      |                                      |                            |                      | i H <sub>2</sub> O; s EtOH, ace, bz, chl; vs CS <sub>2</sub> |
| 1958 | <i>trans</i> -o-Chlorocinnamic acid                                |                                      | C <sub>9</sub> H <sub>7</sub> ClO <sub>2</sub>                   | 939-58-2   | 182.604  |               | 212     |                                      |                            |                      | vs eth, EtOH                                                 |
| 1959 | <i>trans</i> -m-Chlorocinnamic acid                                |                                      | C <sub>9</sub> H <sub>7</sub> ClO <sub>2</sub>                   | 14473-90-6 | 182.604  |               | 165     |                                      |                            |                      | s EtOH, eth                                                  |
| 1960 | <i>trans</i> -p-Chlorocinnamic acid                                |                                      | C <sub>9</sub> H <sub>7</sub> ClO <sub>2</sub>                   | 940-62-5   | 182.604  |               | 249.5   |                                      |                            |                      | vs ace, eth, EtOH                                            |
| 1961 | Chlorocyclohexane                                                  | Cyclohexyl chloride                  | C <sub>6</sub> H <sub>11</sub> Cl                                | 542-18-7   | 118.604  | liq           | -43.81  | 142                                  | 1.000 <sup>20</sup>        | 1.4626 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; vs chl           |
| 1962 | 2-Chlorocyclohexanone                                              |                                      | C <sub>6</sub> H <sub>9</sub> ClO                                | 822-87-7   | 132.587  |               | 23      | 82 <sup>15</sup>                     | 1.160 <sup>20</sup>        | 1.4825 <sup>20</sup> | s eth, bz, diox; sl ctc                                      |
| 1963 | 1-Chlorocyclohexene                                                |                                      | C <sub>6</sub> H <sub>9</sub> Cl                                 | 930-66-5   | 116.588  |               |         | 142.5                                | 1.0361 <sup>19</sup>       | 1.4797 <sup>20</sup> | s eth, ace, ctc, chl                                         |
| 1964 | Chlorocyclopentane                                                 | Cyclopentyl chloride                 | C <sub>5</sub> H <sub>9</sub> Cl                                 | 930-28-9   | 104.578  |               |         | 114                                  | 1.0051 <sup>20</sup>       | 1.4510 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, bz, ctc                      |
| 1965 | 2-Chlorocyclopentanone                                             |                                      | C <sub>5</sub> H <sub>7</sub> ClO                                | 694-28-0   | 118.562  |               |         | 87 <sup>19</sup> , 73 <sup>12</sup>  | 1.185 <sup>25</sup>        | 1.4750 <sup>20</sup> |                                                              |
| 1966 | 3-Chlorocyclopentene                                               |                                      | C <sub>5</sub> H <sub>7</sub> Cl                                 | 96-40-2    | 102.563  |               |         | 40 <sup>40</sup> , 27 <sup>40</sup>  | 1.0388 <sup>25</sup>       | 1.4708 <sup>26</sup> | vs eth, EtOH, chl                                            |
| 1967 | 4-Chloro-2-cyclopentylphenol                                       | Dowicide 9                           | C <sub>11</sub> H <sub>13</sub> ClO                              | 13347-42-7 | 196.673  |               |         | 183 <sup>18</sup>                    |                            |                      |                                                              |
| 1968 | 1-Chlorodecane                                                     |                                      | C <sub>10</sub> H <sub>21</sub> Cl                               | 1002-69-3  | 176.727  | liq           | -31.3   | 225.9                                | 0.8696 <sup>20</sup>       | 1.4380 <sup>20</sup> | i H <sub>2</sub> O; vs eth, chl; s ctc                       |
| 1969 | 10-Chloro-1-decanol                                                |                                      | C <sub>10</sub> H <sub>21</sub> ClO                              | 51309-10-5 | 192.726  |               | 12.5    | 187 <sup>15</sup>                    | 0.9630 <sup>25</sup>       | 1.4578 <sup>20</sup> | vs eth, EtOH                                                 |
| 1970 | 2-Chloro- <i>N,N</i> -diallylacetamide                             | Allidochlor                          | C <sub>8</sub> H <sub>12</sub> ClNO                              | 93-71-0    | 173.640  | liq           |         | 116 <sup>1</sup> , 92 <sup>0.7</sup> | 1.088 <sup>25</sup>        | 1.4932 <sup>25</sup> | sl H <sub>2</sub> O; s EtOH                                  |
| 1971 | Chlorodiazepoxide                                                  |                                      | C <sub>16</sub> H <sub>14</sub> ClN <sub>3</sub> O               | 58-25-3    | 299.754  |               | 236.2   |                                      |                            |                      |                                                              |
| 1972 | Chlorodibromomethane                                               |                                      | CHBr <sub>2</sub> Cl                                             | 124-48-1   | 208.280  | liq           | -20     | 120                                  | 2.451 <sup>20</sup>        | 1.5482 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz                     |
| 1973 | Chloro(dichloromethyl)dimethylsilane                               | (Dichloromethyl)dimethylchlorosilane | C <sub>3</sub> H <sub>7</sub> Cl <sub>3</sub> Si                 | 18171-59-0 | 177.533  | liq           | -48     | 149                                  | 1.2369 <sup>20</sup>       | 1.461 <sup>20</sup>  |                                                              |
| 1974 | 5-Chloro- <i>N</i> -(3,4-dichlorophenyl)-2-hydroxybenzamide        | 3',4',5-Trichlorosalicylanilide      | C <sub>13</sub> H <sub>6</sub> Cl <sub>3</sub> NO <sub>2</sub>   | 642-84-2   | 316.568  |               | 247     |                                      |                            |                      |                                                              |
| 1975 | 2-Chloro-1,1-diethoxyethane                                        |                                      | C <sub>6</sub> H <sub>13</sub> ClO <sub>2</sub>                  | 621-62-5   | 152.619  |               |         | 157.4                                | 1.0180 <sup>20</sup>       | 1.4170 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth                      |
| 1976 | 3-Chloro-1,1-diethoxypropane                                       |                                      | C <sub>7</sub> H <sub>15</sub> ClO <sub>2</sub>                  | 35573-93-4 | 166.646  |               |         | 84 <sup>25</sup>                     | 0.9951 <sup>19</sup>       | 1.4268 <sup>20</sup> | vs ace, bz                                                   |
| 1977 | 2-Chloro- <i>N,N</i> -diethylacetamide                             |                                      | C <sub>8</sub> H <sub>17</sub> ClNO                              | 2315-36-8  | 149.618  |               |         | 192 <sup>25</sup>                    |                            |                      |                                                              |
| 1978 | 2-Chloro- <i>N,N</i> -diethylethanamine, hydrochloride             |                                      | C <sub>8</sub> H <sub>15</sub> Cl <sub>2</sub> N                 | 869-24-9   | 172.096  |               | 200     |                                      |                            |                      | sl H <sub>2</sub> O                                          |
| 1979 | Chlorodifluoroacetic acid                                          |                                      | C <sub>2</sub> HFClF <sub>2</sub> O <sub>2</sub>                 | 76-04-0    | 130.478  | hyg           | 25      | 122                                  |                            | 1.3559 <sup>20</sup> | s chl                                                        |
| 1980 | 1-Chloro-1,1-difluoroethane                                        | Refrigerant 142b                     | C <sub>2</sub> H <sub>2</sub> ClF <sub>2</sub>                   | 75-68-3    | 100.495  | col gas       | -130.8  | -9.1                                 | 1.107 <sup>25</sup>        |                      | i H <sub>2</sub> O; s bz                                     |
| 1981 | 1-Chloro-2,2-difluoroethane                                        |                                      | C <sub>2</sub> H <sub>2</sub> ClF <sub>2</sub>                   | 338-65-8   | 100.495  |               |         | 35.1                                 |                            |                      |                                                              |
| 1982 | 1-Chloro-2,2-difluoroethene                                        | 1-Chloro-2,2-difluoroethylene        | C <sub>2</sub> HFClF <sub>2</sub>                                | 359-10-4   | 98.479   | col gas       | -138.5  | -18.5                                |                            |                      |                                                              |
| 1983 | Chlorodifluoromethane                                              | Refrigerant 22                       | CHClF <sub>2</sub>                                               | 75-45-6    | 86.469   | col gas       | -157.42 | -40.7                                | 1.4909 <sup>69</sup>       |                      | sl H <sub>2</sub> O; s eth, ace, chl                         |
| 1984 | 7-Chloro-2,3-dihydro-1 <i>H</i> -inden-4-ol                        | Chlorindanol                         | C <sub>9</sub> H <sub>7</sub> ClO                                | 145-94-8   | 168.619  | nd (peth)     | 92      |                                      |                            |                      |                                                              |
| 1985 | 10-Chloro-5,10-dihydrophenarsazine                                 | Phenarsazine chloride                | C <sub>12</sub> H <sub>6</sub> AsClN                             | 578-94-9   | 277.581  | ye cry        | 195     |                                      | 1.65                       |                      | i H <sub>2</sub> O; sl ctc, bz, xyl                          |
| 1986 | 5-Chloro-2,4-dimethoxyaniline                                      |                                      | C <sub>8</sub> H <sub>10</sub> ClNO <sub>2</sub>                 | 97-50-7    | 187.624  |               | 91      |                                      |                            |                      |                                                              |
| 1987 | 2-Chloro-1,1-dimethoxyethane                                       |                                      | C <sub>4</sub> H <sub>9</sub> ClO <sub>2</sub>                   | 97-97-2    | 124.566  |               |         | 127.5                                | 1.068 <sup>20</sup>        | 1.4150 <sup>20</sup> | sl EtOH, eth, bz, ctc                                        |
| 1988 | <i>N</i> -(4-Chloro-2,5-dimethoxyphenyl)-3-oxobutanamide           |                                      | C <sub>12</sub> H <sub>14</sub> ClNO <sub>4</sub>                | 4433-79-8  | 271.697  |               | 107     |                                      |                            |                      | s chl                                                        |
| 1989 | Chlorodimethylaluminum                                             | Dimethylaluminum chloride            | C <sub>2</sub> H <sub>6</sub> AlCl                               | 1184-58-3  | 92.504   | hyg liq       | -21     | 126                                  | 0.996                      |                      | reac H <sub>2</sub> O; s hx                                  |
| 1990 | 2-Chloro-10-(3-dimethylaminopropyl)phenothiazine monohydrochloride | Aminazin hydrochloride               | C <sub>17</sub> H <sub>20</sub> Cl <sub>2</sub> N <sub>2</sub> S | 69-09-0    | 355.325  |               | 195 dec |                                      |                            |                      | s H <sub>2</sub> O; i eth, bz; vs chl, EtOH                  |
| 1991 | 2-Chloro- <i>N,N</i> -dimethylaniline                              |                                      | C <sub>8</sub> H <sub>10</sub> ClN                               | 698-01-1   | 155.625  |               |         | 205                                  | 1.1067 <sup>20</sup>       | 1.5578 <sup>20</sup> | vs bz, EtOH                                                  |
| 1992 | 3-Chloro- <i>N,N</i> -dimethylaniline                              |                                      | C <sub>8</sub> H <sub>10</sub> ClN                               | 6848-13-1  | 155.625  |               |         | 232                                  |                            |                      | sl H <sub>2</sub> O; s EtOH, ace, bz                         |
| 1993 | 4-Chloro- <i>N,N</i> -dimethylaniline                              |                                      | C <sub>8</sub> H <sub>10</sub> ClN                               | 698-69-1   | 155.625  | nd (al)       | 35.5    | 231                                  | 1.0480 <sup>100</sup>      |                      | s EtOH                                                       |
| 1994 | 2-Chloro-1,4-dimethylbenzene                                       |                                      | C <sub>8</sub> H <sub>9</sub> Cl                                 | 95-72-7    | 140.610  |               | 0.8     | 187                                  | 1.0589 <sup>15</sup>       |                      | i H <sub>2</sub> O; s ace, ctc; vs bz                        |
| 1995 | 4-Chloro-1,2-dimethylbenzene                                       |                                      | C <sub>8</sub> H <sub>9</sub> Cl                                 | 615-60-1   | 140.610  | liq           | -6      | 194                                  | 1.0682 <sup>15</sup>       |                      | i H <sub>2</sub> O; s ace, ctc; vs bz                        |
| 1996 | 2-Chloro- <i>N,N</i> -dimethylethanamine, hydrochloride            |                                      | C <sub>4</sub> H <sub>11</sub> Cl <sub>2</sub> N                 | 4584-46-7  | 144.043  |               | 201.0   |                                      |                            |                      | sl H <sub>2</sub> O                                          |
| 1997 | (2-Chloro-1,1-dimethylethyl)benzene                                | Neophyl chloride                     | C <sub>10</sub> H <sub>13</sub> Cl                               | 515-40-2   | 168.663  |               |         | 223; 105 <sup>18</sup>               | 1.047 <sup>20</sup>        | 1.5247 <sup>20</sup> | vs ace, bz, eth, EtOH                                        |

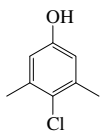




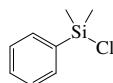
| No.  | Name                                                        | Synonym                          | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                   | den/<br>g cm <sup>-3</sup>        | n <sub>D</sub>       | Solubility                                                |
|------|-------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------|------------|----------|------------------------------|---------|-------------------------|-----------------------------------|----------------------|-----------------------------------------------------------|
| 1998 | 4-Chloro-2,5-dimethylphenol                                 |                                  | C <sub>8</sub> H <sub>9</sub> ClO                                            | 1124-06-7  | 156.609  | silv-grn nd (lig)            | 74.5    |                         |                                   |                      | sl H <sub>2</sub> O; vs bz, EtOH, peth                    |
| 1999 | 4-Chloro-2,6-dimethylphenol                                 |                                  | C <sub>8</sub> H <sub>9</sub> ClO                                            | 1123-63-3  | 156.609  | nd (w)                       | 83      |                         |                                   |                      | sl H <sub>2</sub> O; vs bz, EtOH, HOAc                    |
| 2000 | 4-Chloro-3,5-dimethylphenol                                 | Chloroxylenol                    | C <sub>8</sub> H <sub>9</sub> ClO                                            | 88-04-0    | 156.609  |                              | 115     | 246                     |                                   |                      | sl H <sub>2</sub> O, bz, peth; s EtOH, eth                |
| 2001 | Chlorodimethylphenylsilane                                  |                                  | C <sub>8</sub> H <sub>11</sub> ClSi                                          | 768-33-2   | 170.712  |                              |         | 195; 82 <sup>16</sup>   | 1.032 <sup>20</sup>               | 1.5082 <sup>20</sup> |                                                           |
| 2002 | 1-Chloro- <i>N,N</i> -dimethyl-2-propanamine, hydrochloride |                                  | C <sub>5</sub> H <sub>13</sub> Cl <sub>2</sub> N                             | 17256-39-2 | 158.069  |                              |         |                         |                                   |                      | s chl                                                     |
| 2003 | 1-Chloro-2,2-dimethylpropane                                |                                  | C <sub>5</sub> H <sub>11</sub> Cl                                            | 753-89-9   | 106.594  | liq                          | -20     | 84.3                    | 0.8660 <sup>20</sup>              | 1.4044 <sup>20</sup> | vs bz, eth, EtOH, chl                                     |
| 2004 | 3-Chloro-2,2-dimethylpropanoic acid                         |                                  | C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>                               | 13511-38-1 | 136.577  |                              | 41.5    | 110 <sup>10</sup>       |                                   |                      | vs ctc                                                    |
| 2005 | Chlorodimethylsilane                                        |                                  | C <sub>2</sub> H <sub>6</sub> ClSi                                           | 1066-35-9  | 94.616   | liq                          | -111    | 34.7                    | 0.852                             | 1.3830 <sup>20</sup> |                                                           |
| 2006 | 2-Chloro-4,6-dinitroaniline                                 |                                  | C <sub>6</sub> H <sub>4</sub> ClN <sub>2</sub> O <sub>4</sub>                | 3531-19-9  | 217.567  | ye cry (DMF aq)              | 157     |                         |                                   |                      |                                                           |
| 2007 | 4-Chloro-2,6-dinitroaniline                                 |                                  | C <sub>6</sub> H <sub>4</sub> ClN <sub>2</sub> O <sub>4</sub>                | 5388-62-5  | 217.567  | oran-ye nd (al)              | 147     |                         |                                   |                      | s EtOH                                                    |
| 2008 | 1-Chloro-2,4-dinitrobenzene                                 |                                  | C <sub>6</sub> H <sub>3</sub> ClN <sub>2</sub> O <sub>4</sub>                | 97-00-7    | 202.552  | ye orth (eth) nd (al) ye cry | 53      | 315                     | 1.4982 <sup>75</sup>              | 1.5857 <sup>60</sup> | i H <sub>2</sub> O; sl EtOH; s eth, bz, CS <sub>2</sub>   |
| 2009 | 2-Chloro-1,3-dinitrobenzene                                 |                                  | C <sub>6</sub> H <sub>3</sub> ClN <sub>2</sub> O <sub>4</sub>                | 606-21-3   | 202.552  | ye nd (al, HOAc)             | 88      | 315                     | 1.6867 <sup>16</sup>              |                      | i H <sub>2</sub> O; s EtOH, eth, tol; sl chl              |
| 2010 | 1-Chloro-2,4-dinitronaphthalene                             |                                  | C <sub>10</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>4</sub>               | 2401-85-6  | 252.611  | ye nd (bz)                   | 146.5   |                         |                                   |                      |                                                           |
| 2011 | 4-Chloro-2,6-dinitrophenol                                  |                                  | C <sub>6</sub> H <sub>3</sub> ClN <sub>2</sub> O <sub>5</sub>                | 88-87-9    | 218.551  | pa ye cry                    | 81      |                         | 1.74 <sup>22</sup>                |                      | vs eth, EtOH, chl                                         |
| 2012 | 2-Chloro-3,5-dinitropyridine                                |                                  | C <sub>5</sub> H <sub>2</sub> ClN <sub>3</sub> O <sub>4</sub>                | 2578-45-2  | 203.541  |                              | 66.5    |                         |                                   |                      |                                                           |
| 2013 | 2-Chloro-1,3-dinitro-5-(trifluoromethyl)benzene             |                                  | C <sub>7</sub> H <sub>2</sub> ClF <sub>3</sub> N <sub>2</sub> O <sub>4</sub> | 393-75-9   | 270.550  |                              | 57      |                         |                                   |                      |                                                           |
| 2014 | 4-Chloro-1,3-dioxolan-2-one                                 | Chloroethylene carbonate         | C <sub>3</sub> H <sub>3</sub> ClO <sub>3</sub>                               | 3967-54-2  | 122.507  | liq                          | 110     | 213; 122 <sup>18</sup>  | 1.504                             | 1.4540 <sup>20</sup> |                                                           |
| 2015 | 2-Chloro-1,2-diphenylethanone                               |                                  | C <sub>14</sub> H <sub>11</sub> ClO                                          | 447-31-4   | 230.689  | nd (al)                      | 68.5    | dec                     |                                   |                      | s EtOH; sl chl; i alk                                     |
| 2016 | Chlorodiphenylmethane                                       |                                  | C <sub>13</sub> H <sub>11</sub> Cl                                           | 90-99-3    | 202.679  |                              | 16      | 140 <sup>3</sup>        | 1.140 <sup>25</sup>               | 1.5951 <sup>20</sup> | s chl                                                     |
| 2017 | 1-Chlorododecane                                            | Lauryl chloride                  | C <sub>12</sub> H <sub>25</sub> Cl                                           | 112-52-7   | 204.780  | liq                          | -9.3    | 263.2                   | 0.8673 <sup>20</sup>              | 1.4434 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc ace, ctc; s bz           |
| 2018 | Chloroethane                                                | Ethyl chloride                   | C <sub>2</sub> H <sub>5</sub> Cl                                             | 75-00-3    | 64.514   | vol liq or gas               | -138.4  | 12.3                    | 0.8902 <sup>25</sup><br>(p>1 atm) | 1.3676 <sup>20</sup> | sl H <sub>2</sub> O, chl; vs EtOH; msc eth                |
| 2019 | 2-Chloroethanesulfonyl chloride                             |                                  | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub> S               | 1622-32-8  | 163.023  |                              |         | 201.5                   | 1.555 <sup>20</sup>               | 1.4920 <sup>20</sup> |                                                           |
| 2020 | 2-Chloroethanol                                             | Ethylene chlorohydrin            | C <sub>2</sub> H <sub>5</sub> ClO                                            | 107-07-3   | 80.513   | liq                          | -67.5   | 128.6                   | 1.2019 <sup>20</sup>              | 1.4419 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; sl eth; s chl                 |
| 2021 | 2-Chloroethanol, 4-methylbenzenesulfonate                   |                                  | C <sub>9</sub> H <sub>11</sub> ClO <sub>3</sub> S                            | 80-41-1    | 234.699  |                              |         | 210 <sup>21</sup>       |                                   |                      | i H <sub>2</sub> O; s ctc                                 |
| 2022 | Chloroethene                                                | Vinyl chloride                   | C <sub>2</sub> H <sub>3</sub> Cl                                             | 75-01-4    | 62.498   | col gas                      | -153.84 | -13.8                   | 0.9106 <sup>20</sup>              | 1.3700 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH; vs eth                       |
| 2023 | 1-Chloro-4-ethoxybenzene                                    |                                  | C <sub>8</sub> H <sub>9</sub> ClO                                            | 622-61-7   | 156.609  |                              | 21      | 213                     | 1.1254 <sup>20</sup>              | 1.5252 <sup>20</sup> | s EtOH, eth, HOAc; vs bz; sl ctc                          |
| 2024 | (2-Chloroethoxy)benzene                                     |                                  | C <sub>8</sub> H <sub>9</sub> ClO                                            | 622-86-6   | 156.609  |                              | 28      | 218.5                   |                                   |                      | i H <sub>2</sub> O; vs EtOH, eth, ace, bz; sl ctc         |
| 2025 | 1-Chloro-1-ethoxyethane                                     |                                  | C <sub>4</sub> H <sub>9</sub> ClO                                            | 7081-78-9  | 108.566  |                              |         | 93.5                    | 0.9655 <sup>20</sup>              | 1.4053 <sup>20</sup> |                                                           |
| 2026 | 2-(2-Chloroethoxy)ethanol                                   |                                  | C <sub>4</sub> H <sub>9</sub> ClO <sub>2</sub>                               | 628-89-7   | 124.566  |                              |         | 180; 80 <sup>9</sup>    | 1.18 <sup>25</sup>                | 1.4529 <sup>20</sup> | vs H <sub>2</sub> O; msc EtOH, eth                        |
| 2027 | 2-Chloroethyl acetate                                       | β-Chloroethyl acetate            | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>                               | 542-58-5   | 122.551  |                              |         | 145                     | 1.178 <sup>20</sup>               | 1.4234 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc                  |
| 2028 | 2-Chloroethyl acetoacetate                                  |                                  | C <sub>6</sub> H <sub>9</sub> ClO <sub>3</sub>                               | 54527-68-3 | 164.586  |                              |         | 198; 120 <sup>19</sup>  | 1.2055 <sup>21</sup>              | 1.4430 <sup>20</sup> | vs bz, eth, EtOH                                          |
| 2029 | 2-Chloroethylamine hydrochloride                            | 2-Chloroethanamine hydrochloride | C <sub>2</sub> H <sub>5</sub> Cl <sub>2</sub> N                              | 870-24-6   | 115.990  |                              | 146.3   |                         |                                   |                      | vs H <sub>2</sub> O, ace, EtOH                            |
| 2030 | (1-Chloroethyl)benzene                                      |                                  | C <sub>8</sub> H <sub>9</sub> Cl                                             | 672-65-1   | 140.610  |                              |         | 105 <sup>50</sup>       |                                   |                      |                                                           |
| 2031 | (2-Chloroethyl)benzene                                      |                                  | C <sub>8</sub> H <sub>9</sub> Cl                                             | 622-24-2   | 140.610  |                              |         | 197.5; 92 <sup>20</sup> | 1.069 <sup>25</sup>               | 1.5276 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, CS <sub>2</sub> |
| 2032 | 1-Chloro-2-ethylbenzene                                     |                                  | C <sub>8</sub> H <sub>9</sub> Cl                                             | 89-96-3    | 140.610  | liq                          | -82.7   | 178.4                   | 1.0569 <sup>20</sup>              | 1.5218 <sup>20</sup> | i H <sub>2</sub> O; s ace, bz, ctc, chl                   |
| 2033 | 1-Chloro-3-ethylbenzene                                     |                                  | C <sub>8</sub> H <sub>9</sub> Cl                                             | 620-16-6   | 140.610  | liq                          | -55     | 183.8                   | 1.0529 <sup>20</sup>              | 1.5195 <sup>20</sup> | vs ace, bz, eth, EtOH                                     |
| 2034 | 1-Chloro-4-ethylbenzene                                     |                                  | C <sub>8</sub> H <sub>9</sub> Cl                                             | 622-98-0   | 140.610  | liq                          | -62.6   | 184.4                   | 1.0455 <sup>20</sup>              | 1.5175 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, peth; s HOAc      |
| 2035 | 2-Chloroethyl chloroformate                                 |                                  | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                 | 627-11-2   | 142.969  |                              |         | 155                     | 1.3847 <sup>20</sup>              | 1.4483 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz; sl ctc          |



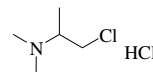
4-Chloro-2,6-dimethylphenol



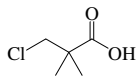
4-Chloro-3,5-dimethylphenol



Chlorodimethylphenylsilane

1-Chloro-*N,N*-dimethyl-2-propanamine, hydrochloride

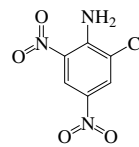
1-Chloro-2,2-dimethylpropane



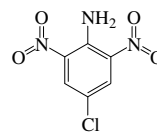
3-Chloro-2,2-dimethylpropanoic acid



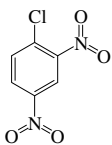
Chlorodimethylsilane



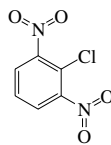
2-Chloro-4,6-dinitroaniline



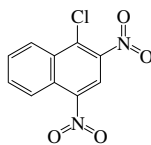
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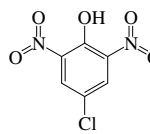
1-Chloro-2,4-dinitrobenzene



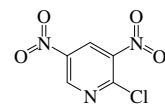
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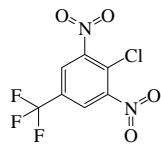
1-Chloro-2,4-dinitronaphthalene



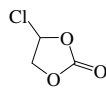
4-Chloro-2,6-dinitrophenol



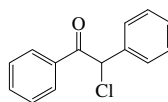
2-Chloro-3,5-dinitropyridine



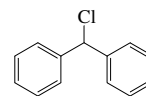
2-Chloro-1,3-dinitro-5-(trifluoromethyl)benzene



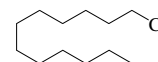
4-Chloro-1,3-dioxolan-2-one



2-Chloro-1,2-diphenylethanone



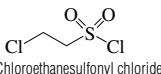
Chlorodiphenylmethane



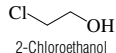
1-Chlorododecane



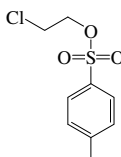
Chloroethane



2-Chloroethanesulfonyl chloride



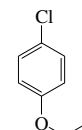
2-Chloroethanol



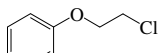
2-Chloroethanol, 4-methylbenzenesulfonate



Chloroethene



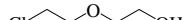
1-Chloro-4-ethoxybenzene



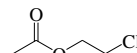
(2-Chloroethoxy)benzene



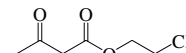
1-Chloro-1-ethoxyethane



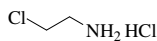
2-(2-Chloroethoxy)ethanol



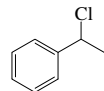
2-Chloroethyl acetate



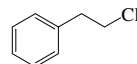
2-Chloroethyl acetoacetate



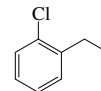
2-Chloroethylamine hydrochloride



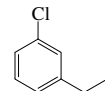
(1-Chloroethyl)benzene



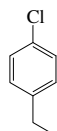
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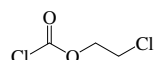
1-Chloro-2-ethylbenzene



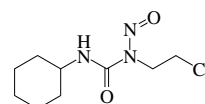
1-Chloro-3-ethylbenzene



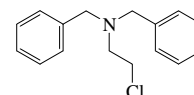
1-Chloro-4-ethylbenzene



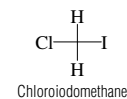
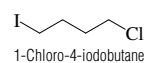
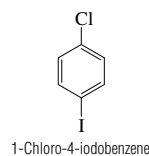
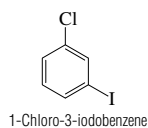
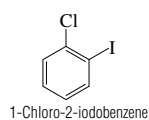
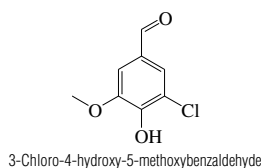
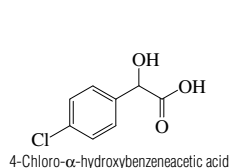
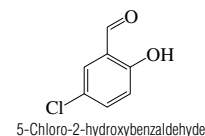
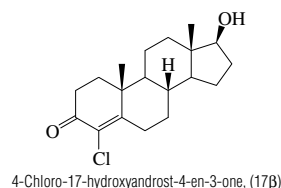
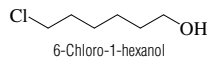
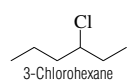
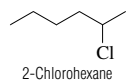
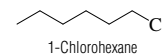
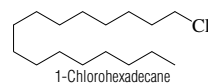
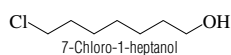
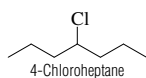
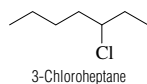
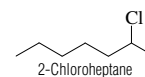
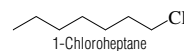
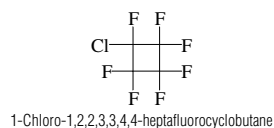
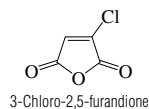
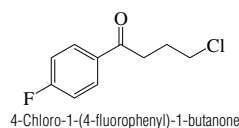
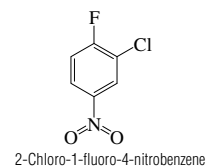
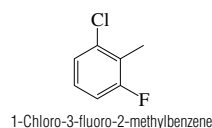
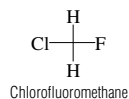
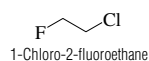
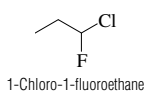
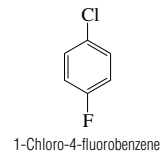
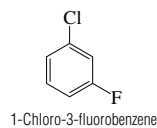
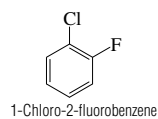
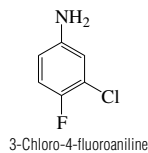
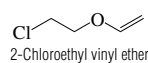
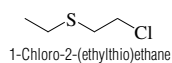
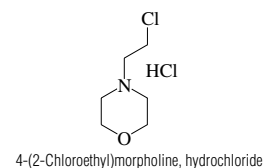
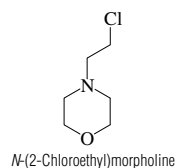
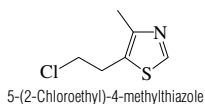
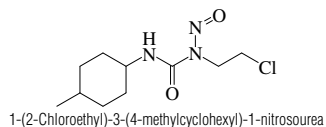
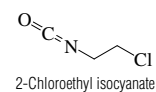
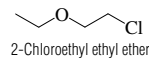
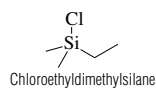
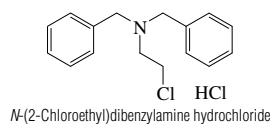
2-Chloroethyl chloroformate



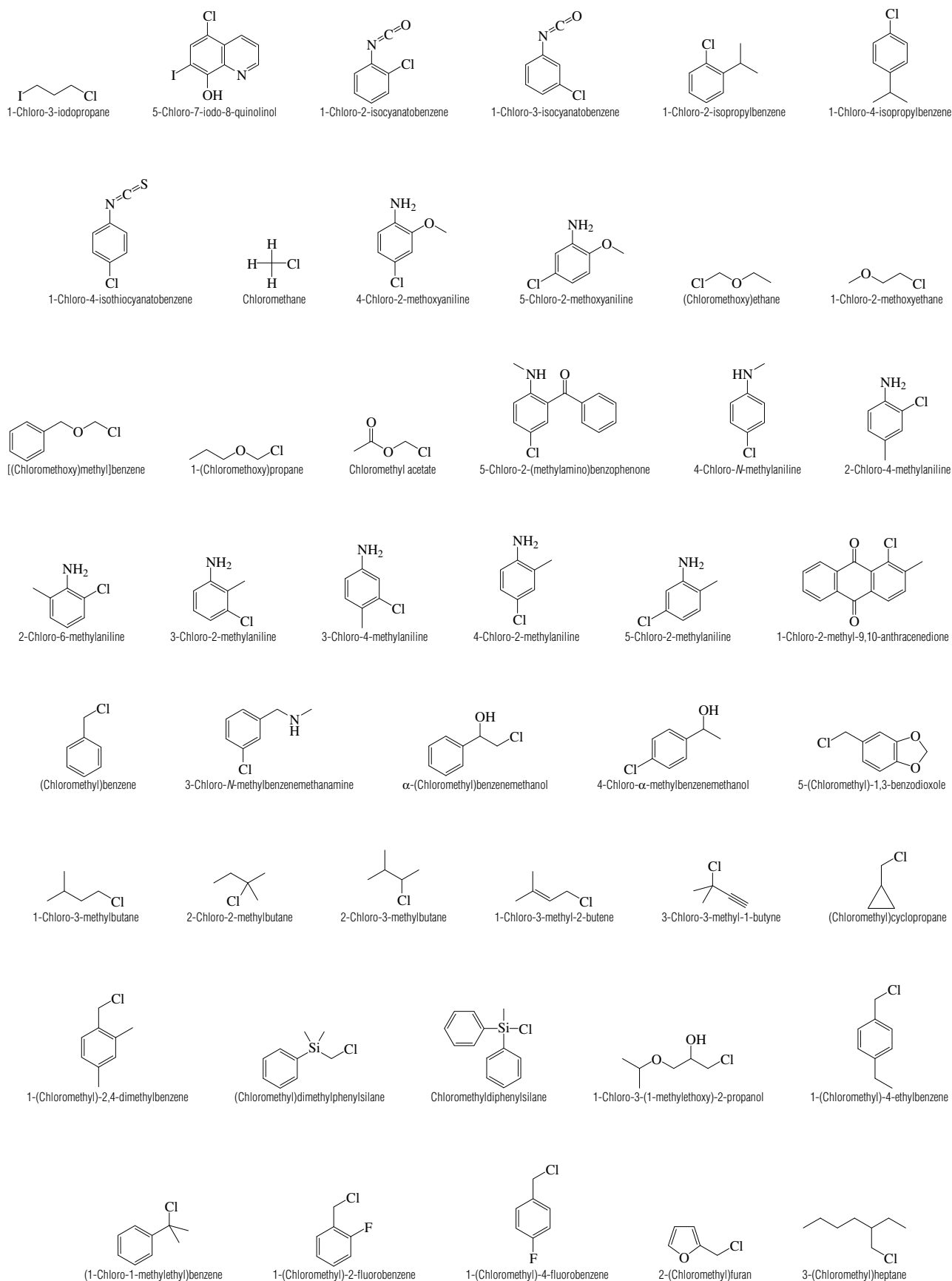
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea

*N*-(2-Chloroethyl)dibenzylamine

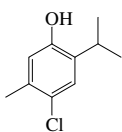
| No.  | Name                                                   | Synonym                       | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form  | mp/°C  | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|--------------------------------------------------------|-------------------------------|-----------------------------------------------------------------|------------|----------|----------------|--------|-------------------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 2036 | 1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea           | Lomustine                     | C <sub>9</sub> H <sub>16</sub> ClN <sub>3</sub> O <sub>2</sub>  | 13010-47-4 | 233.695  | ye pow         | 90     |                                     |                            |                      | i H <sub>2</sub> O; s EtOH                               |
| 2037 | <i>N</i> -(2-Chloroethyl)dibenzylamine                 | Dibenamine                    | C <sub>16</sub> H <sub>18</sub> ClN                             | 51-50-3    | 259.774  | oily liq       |        | 169 <sup>3</sup>                    |                            |                      |                                                          |
| 2038 | <i>N</i> -(2-Chloroethyl)dibenzylamine hydrochloride   | Dibenamine hydrochloride      | C <sub>16</sub> H <sub>15</sub> Cl <sub>2</sub> N               | 55-43-6    | 296.235  | cry            | 194    |                                     |                            |                      | i H <sub>2</sub> O; s EtOH, dil acid                     |
| 2039 | Chloroethyldimethylsilane                              |                               | C <sub>6</sub> H <sub>11</sub> ClSi                             | 6917-76-6  | 122.669  |                |        | 89.5                                | 0.8675 <sup>20</sup>       | 1.4105 <sup>20</sup> |                                                          |
| 2040 | 2-Chloroethyl ethyl ether                              |                               | C <sub>4</sub> H <sub>9</sub> ClO                               | 628-34-2   | 108.566  |                |        | 107.5                               | 0.9895 <sup>20</sup>       | 1.4113 <sup>20</sup> | sl H <sub>2</sub> O; msc eth; s chl                      |
| 2041 | 2-Chloroethyl isocyanate                               |                               | C <sub>3</sub> H <sub>5</sub> ClNO                              | 1943-83-5  | 105.523  |                |        | 44 <sup>17</sup>                    |                            |                      |                                                          |
| 2042 | 1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea | Semustine                     | C <sub>10</sub> H <sub>18</sub> ClN <sub>3</sub> O <sub>2</sub> | 13909-09-6 | 247.722  | cry            | 64 dec |                                     |                            |                      |                                                          |
| 2043 | 5-(2-Chloroethyl)-4-methylthiazole                     | Clomethiazole                 | C <sub>6</sub> H <sub>8</sub> ClNS                              | 533-45-9   | 161.653  | oil            |        | 92 <sup>7</sup>                     | 1.233 <sup>25</sup>        |                      |                                                          |
| 2044 | <i>N</i> -(2-Chloroethyl)morpholine                    |                               | C <sub>6</sub> H <sub>12</sub> ClNO                             | 3240-94-6  | 149.618  |                |        | 42 <sup>1</sup>                     |                            |                      |                                                          |
| 2045 | 4-(2-Chloroethyl)morpholine, hydrochloride             |                               | C <sub>6</sub> H <sub>13</sub> Cl <sub>2</sub> NO               | 3647-69-6  | 186.079  |                | 185    |                                     |                            |                      |                                                          |
| 2046 | 1-Chloro-2-(ethylthio)ethane                           |                               | C <sub>4</sub> H <sub>9</sub> ClS                               | 693-07-2   | 124.632  |                |        | 157                                 | 1.0663 <sup>25</sup>       |                      |                                                          |
| 2047 | 2-Chloroethyl vinyl ether                              |                               | C <sub>4</sub> H <sub>7</sub> ClO                               | 110-75-8   | 106.551  | liq            | -70    | 108                                 | 1.0495 <sup>20</sup>       | 1.4378 <sup>20</sup> | vs EtOH, eth; sl chl                                     |
| 2048 | 3-Chloro-4-fluoroaniline                               |                               | C <sub>6</sub> H <sub>6</sub> ClFN                              | 367-21-5   | 145.562  |                | 45.0   | 227.0                               |                            |                      |                                                          |
| 2049 | 1-Chloro-2-fluorobenzene                               |                               | C <sub>6</sub> H <sub>4</sub> ClF                               | 348-51-6   | 130.547  | liq            | -43    | 137.6                               | 1.2233 <sup>20</sup>       | 1.4918 <sup>20</sup> | i H <sub>2</sub> O; s ace, bz                            |
| 2050 | 1-Chloro-3-fluorobenzene                               |                               | C <sub>6</sub> H <sub>4</sub> ClF                               | 625-98-9   | 130.547  |                |        | 127.6                               | 1.221 <sup>25</sup>        | 1.4911               |                                                          |
| 2051 | 1-Chloro-4-fluorobenzene                               |                               | C <sub>6</sub> H <sub>4</sub> ClF                               | 352-33-0   | 130.547  | liq            | -26.8  | 130                                 | 1.4990 <sup>15</sup>       | 1.4990 <sup>15</sup> | i H <sub>2</sub> O; s EtOH, eth, bz                      |
| 2052 | 1-Chloro-1-fluoroethane                                |                               | C <sub>2</sub> H <sub>4</sub> ClF                               | 1615-75-4  | 82.504   | vol liq or gas |        | 16.2                                |                            |                      |                                                          |
| 2053 | 1-Chloro-2-fluoroethane                                |                               | C <sub>2</sub> H <sub>4</sub> ClF                               | 762-50-5   | 82.504   |                |        | 52.8                                | 1.1747 <sup>20</sup>       | 1.3775 <sup>20</sup> | vs eth, EtOH                                             |
| 2054 | Chlorofluoromethane                                    |                               | CH <sub>2</sub> ClF                                             | 593-70-4   | 68.478   | col gas        | -135.1 | -9.1                                |                            |                      | sl H <sub>2</sub> O; vs chl                              |
| 2055 | 1-Chloro-3-fluoro-2-methylbenzene                      |                               | C <sub>7</sub> H <sub>6</sub> ClF                               | 443-83-4   | 144.574  |                |        | 154                                 | 1.191 <sup>25</sup>        | 1.5026 <sup>20</sup> |                                                          |
| 2056 | 2-Chloro-1-fluoro-4-nitrobenzene                       | 3-Chloro-4-fluoronitrobenzene | C <sub>6</sub> H <sub>3</sub> ClFNO <sub>2</sub>                | 350-30-1   | 175.545  |                | 41.5   | 229.5                               |                            |                      |                                                          |
| 2057 | 4-Chloro-1-(4-fluorophenyl)-1-butanone                 |                               | C <sub>10</sub> H <sub>10</sub> ClFO                            | 3874-54-2  | 200.636  |                |        | 136 <sup>6</sup>                    | 1.22 <sup>25</sup>         | 1.5255 <sup>20</sup> |                                                          |
| 2058 | 3-Chloro-2,5-furandione                                |                               | C <sub>4</sub> HClO <sub>3</sub>                                | 96-02-6    | 132.502  |                | 33     | 196                                 | 1.5375 <sup>25</sup>       | 1.4980 <sup>20</sup> |                                                          |
| 2059 | 1-Chloro-1,2,2,3,3,4,4-heptafluorocyclobutane          | Refrigerant C317              | C <sub>4</sub> ClF <sub>7</sub>                                 | 377-41-3   | 216.485  | liq or gas     | -39.1  | 25                                  | 1.602 <sup>15</sup>        |                      |                                                          |
| 2060 | 1-Chloroheptane                                        | Heptyl chloride               | C <sub>7</sub> H <sub>15</sub> Cl                               | 629-06-1   | 134.647  | liq            | -69.5  | 160.4                               | 0.8762 <sup>20</sup>       | 1.4264 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl ctc; s chl         |
| 2061 | 2-Chloroheptane                                        |                               | C <sub>7</sub> H <sub>15</sub> Cl                               | 1001-89-4  | 134.647  |                |        | 61 <sup>32</sup> , 46 <sup>19</sup> | 0.8672 <sup>20</sup>       | 1.4221 <sup>20</sup> | i H <sub>2</sub> O; vs eth; s bz, chl, HOAc              |
| 2062 | 3-Chloroheptane                                        |                               | C <sub>7</sub> H <sub>15</sub> Cl                               | 999-52-0   | 134.647  |                |        | 144; 48 <sup>20</sup>               | 0.8690 <sup>20</sup>       | 1.4228 <sup>20</sup> | vs bz, eth                                               |
| 2063 | 4-Chloroheptane                                        |                               | C <sub>7</sub> H <sub>15</sub> Cl                               | 998-95-8   | 134.647  |                |        | 144                                 | 0.8710 <sup>20</sup>       | 1.4237 <sup>20</sup> | vs bz, eth                                               |
| 2064 | 7-Chloro-1-heptanol                                    | Heptamethylene chlorohydrin   | C <sub>7</sub> H <sub>15</sub> ClO                              | 55944-70-2 | 150.646  | cry (peth, bz) | 11     | 150 <sup>20</sup>                   | 0.9998 <sup>15</sup>       | 1.4537 <sup>25</sup> | vs EtOH, peth                                            |
| 2065 | 1-Chlorohexadecane                                     |                               | C <sub>16</sub> H <sub>33</sub> Cl                              | 4860-03-1  | 260.886  |                | 17.9   | 326.6                               | 0.8635 <sup>20</sup>       | 1.4503 <sup>20</sup> | i H <sub>2</sub> O                                       |
| 2066 | 1-Chlorohexane                                         | Hexyl chloride                | C <sub>6</sub> H <sub>13</sub> Cl                               | 544-10-5   | 120.620  | liq            | -94.0  | 135.1                               | 0.8738 <sup>25</sup>       | 1.4200 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz; vs chl; sl ctc |
| 2067 | 2-Chlorohexane                                         | 2-Hexyl chloride              | C <sub>6</sub> H <sub>13</sub> Cl                               | 638-28-8   | 120.620  |                |        | 122.5                               | 0.8694 <sup>21</sup>       | 1.4142 <sup>22</sup> | vs ace, bz, eth, EtOH                                    |
| 2068 | 3-Chlorohexane                                         | 3-Hexyl chloride              | C <sub>6</sub> H <sub>13</sub> Cl                               | 2346-81-8  | 120.620  |                |        | 123                                 | 0.8684 <sup>20</sup>       | 1.4163 <sup>20</sup> | vs ace, bz, eth, EtOH                                    |
| 2069 | 6-Chloro-1-hexanol                                     |                               | C <sub>6</sub> H <sub>13</sub> ClO                              | 2009-83-8  | 136.619  |                |        | 107 <sup>12</sup>                   | 1.0241 <sup>20</sup>       | 1.4550 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth                        |
| 2070 | 4-Chloro-17-hydroxyandrost-4-en-3-one, (17β)           | Clostebol                     | C <sub>19</sub> H <sub>27</sub> ClO <sub>2</sub>                | 1093-58-9  | 322.869  |                | 189    |                                     |                            |                      |                                                          |
| 2071 | 5-Chloro-2-hydroxybenzaldehyde                         |                               | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                  | 635-93-8   | 156.567  | pl (al)        | 100.3  | 105 <sup>12</sup>                   |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, alk                  |
| 2072 | 4-Chloro-α-hydroxybenzeneacetic acid                   |                               | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                  | 492-86-4   | 186.593  |                | 120.3  |                                     |                            |                      | vs bz, EtOH                                              |
| 2073 | 3-Chloro-4-hydroxybenzoic acid                         |                               | C <sub>7</sub> H <sub>5</sub> ClO <sub>3</sub>                  | 3964-58-7  | 172.566  | nd (w)         | 171    | sub                                 |                            |                      | sl H <sub>2</sub> O, bz, chl; vs EtOH, eth, ace          |
| 2074 | 5-Chloro-2-hydroxybenzoic acid                         |                               | C <sub>7</sub> H <sub>5</sub> ClO <sub>3</sub>                  | 321-14-2   | 172.566  | nd (w, al)     | 174.8  |                                     |                            |                      | s H <sub>2</sub> O, eth; vs EtOH, bz; sl ace             |
| 2075 | 2-Chloro-5-hydroxybenzophenone                         |                               | C <sub>13</sub> H <sub>9</sub> ClO <sub>2</sub>                 | 85-19-8    | 232.662  |                | 95.3   |                                     |                            |                      | i H <sub>2</sub> O                                       |
| 2076 | 3-Chloro-4-hydroxy-5-methoxybenzaldehyde               |                               | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                  | 19463-48-0 | 186.593  | tetr           | 165    |                                     |                            |                      | i H <sub>2</sub> O; s EtOH, HOAc                         |
| 2077 | 1-Chloro-2-iodobenzene                                 |                               | C <sub>6</sub> H <sub>4</sub> ClI                               | 615-41-8   | 238.453  |                | 0.7    | 234.5                               | 1.9515 <sup>25</sup>       | 1.6331 <sup>25</sup> | i H <sub>2</sub> O; s ace; sl ctc                        |
| 2078 | 1-Chloro-3-iodobenzene                                 |                               | C <sub>6</sub> H <sub>4</sub> ClI                               | 625-99-0   | 238.453  |                |        | 230                                 | 1.9255 <sup>20</sup>       |                      | i H <sub>2</sub> O; s ace                                |
| 2079 | 1-Chloro-4-iodobenzene                                 |                               | C <sub>6</sub> H <sub>4</sub> ClI                               | 637-87-6   | 238.453  | lf (ace, al)   | 57     | 227                                 | 1.886 <sup>27</sup>        |                      | i H <sub>2</sub> O; s EtOH, PhNO <sub>2</sub> ; sl chl   |
| 2080 | 1-Chloro-4-iodobutane                                  |                               | C <sub>4</sub> H <sub>9</sub> ClI                               | 10297-05-9 | 218.464  | liq            |        | 116; 89 <sup>19</sup>               | 1.785                      | 1.5400 <sup>20</sup> |                                                          |
| 2081 | Chloriodomethane                                       |                               | CH <sub>2</sub> ClI                                             | 593-71-5   | 176.384  |                |        | 109                                 | 2.422 <sup>20</sup>        | 1.5822 <sup>20</sup> | vs ace, bz, eth, EtOH                                    |



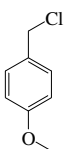
| No.  | Name                                         | Synonym                                       | Mol. Form.                                      | CAS RN     | Mol. Wt. | Physical Form     | mp/°C                 | bp/°C                                 | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>       | Solubility                                         |
|------|----------------------------------------------|-----------------------------------------------|-------------------------------------------------|------------|----------|-------------------|-----------------------|---------------------------------------|----------------------------------|----------------------|----------------------------------------------------|
| 2082 | 1-Chloro-3-iodopropane                       |                                               | C <sub>3</sub> H <sub>6</sub> ClI               | 6940-76-7  | 204.437  |                   |                       | 171                                   | 1.904 <sup>20</sup>              | 1.5472 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl; sl ctc         |
| 2083 | 5-Chloro-7-iodo-8-quinolinol                 | Iodochlorhydroxyquin                          | C <sub>9</sub> H <sub>6</sub> ClINO             | 130-26-7   | 305.499  | ye br nd (al)     | 178.5                 |                                       |                                  |                      | sl EtOH; s HOAc                                    |
| 2084 | 1-Chloro-2-isocyanatobenzene                 |                                               | C <sub>7</sub> H <sub>4</sub> ClNO              | 3320-83-0  | 153.566  |                   | 30.5                  | 200; 115 <sup>43</sup>                |                                  |                      | sl ctc                                             |
| 2085 | 1-Chloro-3-isocyanatobenzene                 |                                               | C <sub>7</sub> H <sub>4</sub> ClNO              | 2909-38-8  | 153.566  |                   |                       | 113 <sup>43</sup>                     |                                  |                      | sl chl                                             |
| 2086 | 1-Chloro-2-isopropylbenzene                  |                                               | C <sub>9</sub> H <sub>11</sub> Cl               | 2077-13-6  | 154.636  | liq               | -74.4                 | 191.1                                 | 1.0341 <sup>20</sup>             | 1.5168 <sup>20</sup> | vs ace, bz, eth, EtOH                              |
| 2087 | 1-Chloro-4-isopropylbenzene                  |                                               | C <sub>9</sub> H <sub>11</sub> Cl               | 2621-46-7  | 154.636  | liq               | -12.3                 | 198.3                                 | 1.0208 <sup>20</sup>             | 1.5117 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, ctc; vs bz |
| 2088 | 1-Chloro-4-isothiocyantobenzene              |                                               | C <sub>7</sub> H <sub>4</sub> ClNS              | 2131-55-7  | 169.632  | nd (al)           | 46                    | 249.5                                 |                                  |                      | i H <sub>2</sub> O; s EtOH                         |
| 2089 | Chloromethane                                | Methyl chloride                               | CH <sub>3</sub> Cl                              | 74-87-3    | 50.488   | col gas           | -97.7                 | -24.09                                | 0.911 <sup>25</sup><br>(p>1 atm) | 1.3389 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH; msc eth, ace, bz, chl |
| 2090 | 4-Chloro-2-methoxyaniline                    | 4-Chloro-2-anisidine                          | C <sub>7</sub> H <sub>6</sub> ClNO              | 93-50-5    | 157.598  | nd or pr (dil al) | 52                    | 260                                   |                                  |                      | s EtOH, eth, bz, chl                               |
| 2091 | 5-Chloro-2-methoxyaniline                    |                                               | C <sub>7</sub> H <sub>6</sub> ClNO              | 95-03-4    | 157.598  | nd (dil al)       | 84                    |                                       |                                  |                      | s EtOH; sl lig                                     |
| 2092 | (Chloromethoxy)ethane                        | Chloromethyl ethyl ether                      | C <sub>2</sub> H <sub>5</sub> ClO               | 3188-13-4  | 94.540   |                   |                       | 83                                    | 1.0188 <sup>15</sup>             | 1.4040 <sup>20</sup> |                                                    |
| 2093 | 1-Chloro-2-methoxyethane                     |                                               | C <sub>2</sub> H <sub>5</sub> ClO               | 627-42-9   | 94.540   |                   |                       | 92.5                                  | 1.0345 <sup>20</sup>             | 1.4111 <sup>20</sup> | vs H <sub>2</sub> O, eth                           |
| 2094 | [(Chloromethoxy)methyl]benzene               |                                               | C <sub>8</sub> H <sub>9</sub> ClO               | 3587-60-8  | 156.609  |                   |                       | 103 <sup>13</sup>                     | 1.1350 <sup>20</sup>             | 1.5192 <sup>20</sup> |                                                    |
| 2095 | 1-(Chloromethoxy)propane                     |                                               | C <sub>3</sub> H <sub>7</sub> ClO               | 3587-57-3  | 108.566  |                   |                       | 109                                   | 0.9884 <sup>20</sup>             | 1.4125 <sup>20</sup> | vs eth, EtOH                                       |
| 2096 | Chloromethyl acetate                         |                                               | C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>  | 625-56-9   | 108.524  |                   |                       | 116                                   | 1.194 <sup>20</sup>              | 1.409 <sup>20</sup>  | vs eth, EtOH                                       |
| 2097 | 5-Chloro-2-(methylamino)-benzophenone        | <i>N</i> -Methyl-2-amino-5-chlorobenzophenone | C <sub>14</sub> H <sub>12</sub> ClNO            | 1022-13-5  | 245.704  |                   | 92                    |                                       |                                  |                      |                                                    |
| 2098 | 4-Chloro- <i>N</i> -methylaniline            |                                               | C <sub>7</sub> H <sub>8</sub> ClN               | 932-96-7   | 141.599  |                   |                       | 240                                   | 1.169 <sup>11</sup>              | 1.5835 <sup>20</sup> | s EtOH, ace, bz                                    |
| 2099 | 2-Chloro-4-methylaniline                     |                                               | C <sub>7</sub> H <sub>8</sub> ClN               | 615-65-6   | 141.599  |                   | 7                     | 220                                   | 1.151 <sup>20</sup>              | 1.5748 <sup>22</sup> | sl EtOH, bz                                        |
| 2100 | 2-Chloro-6-methylaniline                     |                                               | C <sub>7</sub> H <sub>8</sub> ClN               | 87-63-8    | 141.599  |                   |                       | 215; 97 <sup>10</sup>                 |                                  |                      |                                                    |
| 2101 | 3-Chloro-2-methylaniline                     |                                               | C <sub>7</sub> H <sub>8</sub> ClN               | 87-60-5    | 141.599  |                   | 1                     | 245                                   |                                  | 1.5880 <sup>20</sup> | s H <sub>2</sub> O, EtOH; i eth, bz                |
| 2102 | 3-Chloro-4-methylaniline                     |                                               | C <sub>7</sub> H <sub>8</sub> ClN               | 95-74-9    | 141.599  |                   | 26                    | 243                                   |                                  |                      | s EtOH; sl ctc                                     |
| 2103 | 4-Chloro-2-methylaniline                     | <i>p</i> -Chloro- <i>o</i> -toluidine         | C <sub>7</sub> H <sub>8</sub> ClN               | 95-69-2    | 141.599  | lf (al)           | 30.3                  | 244                                   |                                  |                      | s EtOH; sl ctc                                     |
| 2104 | 5-Chloro-2-methylaniline                     |                                               | C <sub>7</sub> H <sub>8</sub> ClN               | 95-79-4    | 141.599  |                   | 26                    | 239; 140 <sup>38</sup>                |                                  |                      | vs EtOH                                            |
| 2105 | 1-Chloro-2-methyl-9,10-anthracenedione       |                                               | C <sub>15</sub> H <sub>9</sub> ClO <sub>2</sub> | 129-35-1   | 256.684  |                   | 170.5                 |                                       |                                  |                      | i EtOH, eth; sl py                                 |
| 2106 | (Chloromethyl)benzene                        | Benzyl chloride                               | C <sub>7</sub> H <sub>7</sub> Cl                | 100-44-7   | 126.584  | liq               | -45                   | 179                                   | 1.1004 <sup>20</sup>             | 1.5391 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, chl; sl ctc     |
| 2107 | 3-Chloro- <i>N</i> -methylbenzenemethanamine |                                               | C <sub>8</sub> H <sub>10</sub> ClN              | 39191-07-6 | 155.625  |                   |                       | 88 <sup>4</sup>                       |                                  | 1.5350 <sup>25</sup> | s chl                                              |
| 2108 | $\alpha$ -(Chloromethyl)benzenemethanol      |                                               | C <sub>8</sub> H <sub>9</sub> ClO               | 1674-30-2  | 156.609  |                   |                       | 128 <sup>17</sup> , 121 <sup>11</sup> | 1.1926 <sup>20</sup>             | 1.5523 <sup>20</sup> | s EtOH; vs eth                                     |
| 2109 | 4-Chloro- $\alpha$ -methylbenzenemethanol    |                                               | C <sub>8</sub> H <sub>9</sub> ClO               | 3391-10-4  | 156.609  |                   |                       | 121 <sup>15</sup>                     |                                  | 1.5505 <sup>20</sup> | s ctc                                              |
| 2110 | 5-(Chloromethyl)-1,3-benzodioxole            |                                               | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>  | 20850-43-5 | 170.594  |                   | 20.5                  | 134 <sup>14</sup>                     | 1.312 <sup>25</sup>              | 1.5660 <sup>20</sup> |                                                    |
| 2111 | 1-Chloro-3-methylbutane                      | Isopentyl chloride                            | C <sub>5</sub> H <sub>11</sub> Cl               | 107-84-6   | 106.594  | liq               | -104.4                | 98.9                                  | 0.8750 <sup>20</sup>             | 1.4084 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs chl         |
| 2112 | 2-Chloro-2-methylbutane                      |                                               | C <sub>5</sub> H <sub>11</sub> Cl               | 594-36-5   | 106.594  | liq               | -73.5                 | 85.6                                  | 0.8653 <sup>20</sup>             | 1.4055 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc              |
| 2113 | 2-Chloro-3-methylbutane                      |                                               | C <sub>5</sub> H <sub>11</sub> Cl               | 631-65-2   | 106.594  |                   |                       | 91.5                                  | 0.878 <sup>20</sup>              |                      |                                                    |
| 2114 | 1-Chloro-3-methyl-2-butene                   |                                               | C <sub>5</sub> H <sub>9</sub> Cl                | 503-60-6   | 104.578  |                   |                       | 109                                   | 0.9273 <sup>20</sup>             | 1.4485 <sup>20</sup> | vs ace, eth, EtOH, chl                             |
| 2115 | 3-Chloro-3-methyl-1-butyne                   |                                               | C <sub>5</sub> H <sub>7</sub> Cl                | 1111-97-3  | 102.563  | liq               | -61                   | 76                                    | 0.9061 <sup>20</sup>             |                      |                                                    |
| 2116 | (Chloromethyl)cyclopropane                   |                                               | C <sub>3</sub> H <sub>5</sub> Cl                | 5911-08-0  | 90.552   | liq               | -90.9                 | 88                                    | 0.98 <sup>25</sup>               | 1.4350 <sup>20</sup> |                                                    |
| 2117 | 1-(Chloromethyl)-2,4-dimethylbenzene         |                                               | C <sub>9</sub> H <sub>11</sub> Cl               | 824-55-5   | 154.636  |                   |                       | 215.5; 110 <sup>20</sup>              | 1.0580 <sup>19</sup>             |                      | vs bz, eth, EtOH                                   |
| 2118 | (Chloromethyl)dimethylphenylsilane           |                                               | C <sub>9</sub> H <sub>13</sub> ClSi             | 1833-51-8  | 184.738  |                   |                       | 225                                   | 1.0240 <sup>25</sup>             |                      | s ctc, CS <sub>2</sub>                             |
| 2119 | Chloromethyldiphenylsilane                   |                                               | C <sub>13</sub> H <sub>13</sub> ClSi            | 144-79-6   | 232.781  |                   |                       | 295                                   | 1.1277 <sup>20</sup>             | 1.5742 <sup>20</sup> |                                                    |
| 2120 | 1-Chloro-3-(1-methylethoxy)-2-propanol       |                                               | C <sub>6</sub> H <sub>13</sub> ClO <sub>2</sub> | 4288-84-0  | 152.619  |                   |                       | 182; 87 <sup>20</sup>                 | 1.0910 <sup>20</sup>             | 1.4370 <sup>25</sup> | s EtOH, eth                                        |
| 2121 | 1-(Chloromethyl)-4-ethylbenzene              |                                               | C <sub>9</sub> H <sub>11</sub> Cl               | 1467-05-6  | 154.636  |                   |                       | 95 <sup>15</sup>                      |                                  | 1.5290 <sup>25</sup> | vs bz, EtOH, chl                                   |
| 2122 | (1-Chloro-1-methylethyl)benzene              |                                               | C <sub>9</sub> H <sub>11</sub> Cl               | 934-53-2   | 154.636  |                   |                       | 98 <sup>1</sup>                       | 1.192 <sup>25</sup>              | 1.5290 <sup>25</sup> |                                                    |
| 2123 | 1-(Chloromethyl)-2-fluorobenzene             |                                               | C <sub>7</sub> H <sub>6</sub> ClF               | 345-35-7   | 144.574  |                   | 172; 86 <sup>40</sup> |                                       | 1.216 <sup>25</sup>              | 1.5150 <sup>20</sup> |                                                    |
| 2124 | 1-(Chloromethyl)-4-fluorobenzene             |                                               | C <sub>7</sub> H <sub>6</sub> ClF               | 352-11-4   | 144.574  |                   |                       | 82 <sup>26</sup> , 76 <sup>20</sup>   | 1.2143 <sup>20</sup>             | 1.5130               |                                                    |
| 2125 | 2-(Chloromethyl)furan                        |                                               | C <sub>5</sub> H <sub>6</sub> ClO               | 617-88-9   | 116.546  |                   |                       | 49 <sup>26</sup>                      | 1.1783 <sup>20</sup>             | 1.4941 <sup>20</sup> | vs bz, eth, EtOH                                   |
| 2126 | 3-(Chloromethyl)heptane                      |                                               | C <sub>8</sub> H <sub>17</sub> Cl               | 123-04-6   | 148.674  |                   |                       | 172                                   | 0.8769 <sup>20</sup>             | 1.4319 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz; sl ctc   |



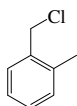
| No.  | Name                                      | Synonym                                                     | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form              | mp/°C  | bp/°C                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-------------------------------------------|-------------------------------------------------------------|--------------------------------------------------|------------|----------|----------------------------|--------|--------------------------|----------------------------|----------------------|------------------------------------------------------|
| 2127 | 4-Chloro-5-methyl-2-isopropylphenol       | Chlorothymol                                                | C <sub>10</sub> H <sub>13</sub> ClO              | 89-68-9    | 184.662  |                            | 63     | 258.5                    |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, bz, ctc, peth, alk |
| 2128 | 1-(Chloromethyl)-4-methoxybenzene         |                                                             | C <sub>8</sub> H <sub>9</sub> ClO                | 824-94-2   | 156.609  | nd                         | 24.5   | 262.5                    | 1.261 <sup>20</sup>        | 1.580 <sup>20</sup>  | vs ace, bz, eth                                      |
| 2129 | 1-(Chloromethyl)-2-methylbenzene          |                                                             | C <sub>8</sub> H <sub>9</sub> Cl                 | 552-45-4   | 140.610  |                            |        | 198; 90 <sup>20</sup>    | 1.063 <sup>25</sup>        | 1.5410 <sup>25</sup> | vs eth, EtOH                                         |
| 2130 | 1-(Chloromethyl)-3-methylbenzene          |                                                             | C <sub>8</sub> H <sub>9</sub> Cl                 | 620-19-9   | 140.610  |                            |        | 195.5                    | 1.064 <sup>20</sup>        | 1.5345 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                      |
| 2131 | 1-(Chloromethyl)-4-methylbenzene          |                                                             | C <sub>8</sub> H <sub>9</sub> Cl                 | 104-82-5   | 140.610  |                            |        | 201; 90 <sup>20</sup>    | 1.0512 <sup>20</sup>       | 1.5380               | i H <sub>2</sub> O; s EtOH; msc eth                  |
| 2132 | Chloromethyl methyl ether                 |                                                             | C <sub>2</sub> H <sub>5</sub> ClO                | 107-30-2   | 80.513   | liq                        | -103.5 | 59.5                     | 1.063 <sup>10</sup>        | 1.397 <sup>20</sup>  | s EtOH, eth, ace, chl                                |
| 2133 | 2-(Chloromethyl)-2-methyloxirane          |                                                             | C <sub>4</sub> H <sub>7</sub> ClO                | 598-09-4   | 106.551  |                            |        | 122                      | 1.1011 <sup>20</sup>       | 1.4310 <sup>20</sup> | vs H <sub>2</sub> O, eth                             |
| 2134 | 1-(Chloromethyl)naphthalene               |                                                             | C <sub>11</sub> H <sub>9</sub> Cl                | 86-52-2    | 176.642  | pr                         | 32     | 291.5                    | 1.1813 <sup>20</sup>       | 1.6380 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ctc, peth                |
| 2135 | 2-(Chloromethyl)naphthalene               |                                                             | C <sub>11</sub> H <sub>9</sub> Cl                | 2506-41-4  | 176.642  | lf (al)                    | 48.5   | 169 <sup>20</sup>        |                            |                      | i H <sub>2</sub> O; s EtOH, peth                     |
| 2136 | 1-(Chloromethyl)-2-nitrobenzene           |                                                             | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 612-23-7   | 171.582  | cry (lig)                  | 50.0   | 125 <sup>4</sup>         |                            | 1.5557 <sup>62</sup> | i H <sub>2</sub> O; s EtOH, eth, HOAc; vs ace, bz    |
| 2137 | 1-(Chloromethyl)-3-nitrobenzene           |                                                             | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 619-23-8   | 171.582  | pa ye nd (lig)             | 46     | 173 <sup>34</sup>        |                            | 1.5577 <sup>62</sup> | vs ace, bz, eth, EtOH                                |
| 2138 | 1-(Chloromethyl)-4-nitrobenzene           | 4-Nitrobenzyl chloride                                      | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 100-14-1   | 171.582  | pl or nd (al)              | 71     |                          |                            | 1.5647 <sup>62</sup> | i H <sub>2</sub> O; s EtOH, eth; vs ace, bz, AcOEt   |
| 2139 | 1-Chloro-2-methyl-3-nitrobenzene          |                                                             | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 83-42-1    | 171.582  | nd (dil al)                | 37.8   | 238                      |                            | 1.5377 <sup>69</sup> | i H <sub>2</sub> O; s EtOH                           |
| 2140 | 1-Chloro-2-methyl-4-nitrobenzene          |                                                             | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 13290-74-9 | 171.582  | ye cry                     | 42.5   | 249                      |                            |                      | vs eth                                               |
| 2141 | 1-Chloro-4-methyl-2-nitrobenzene          | 4-Chloro-3-nitrotoluene                                     | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 89-60-1    | 171.582  |                            | 7      | 261; 118 <sup>11</sup>   |                            | 1.5572 <sup>20</sup> | i H <sub>2</sub> O; s ctc                            |
| 2142 | 2-Chloro-1-methyl-4-nitrobenzene          |                                                             | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 121-86-8   | 171.582  | nd (al)                    | 66.5   | 260                      |                            | 1.5470 <sup>69</sup> | sl H <sub>2</sub> O, chl; s EtOH, eth, HOAc          |
| 2143 | 4-Chloro-1-methyl-2-nitrobenzene          |                                                             | C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 89-59-8    | 171.582  | mcl nd                     | 38     | 242; 115.5 <sup>11</sup> | 1.2559 <sup>60</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth; sl chl              |
| 2144 | 2-Chloro-4-methylpentane                  |                                                             | C <sub>8</sub> H <sub>13</sub> Cl                | 25346-32-1 | 120.620  |                            |        | 113                      | 0.8610 <sup>20</sup>       | 1.4113 <sup>20</sup> | vs eth                                               |
| 2145 | 3-(Chloromethyl)pentane                   |                                                             | C <sub>8</sub> H <sub>13</sub> Cl                | 4737-41-1  | 120.620  |                            |        | 126; 83 <sup>202</sup>   | 0.8914 <sup>20</sup>       | 1.4222 <sup>20</sup> | vs bz, eth, chl                                      |
| 2146 | 2-Chloro-4-methylphenol                   | 2-Chloro- <i>p</i> -cresol                                  | C <sub>7</sub> H <sub>7</sub> ClO                | 6640-27-3  | 142.583  |                            |        | 195.5                    | 1.1785 <sup>27</sup>       | 1.5200 <sup>27</sup> | vs bz, eth, EtOH                                     |
| 2147 | 2-Chloro-5-methylphenol                   | 6-Chloro- <i>m</i> -cresol                                  | C <sub>7</sub> H <sub>7</sub> ClO                | 615-74-7   | 142.583  | pr (peth)                  | 45.5   | 196                      | 1.215 <sup>15</sup>        |                      | vs H <sub>2</sub> O, EtOH                            |
| 2148 | 2-Chloro-6-methylphenol                   | 6-Chloro- <i>o</i> -cresol                                  | C <sub>7</sub> H <sub>7</sub> ClO                | 87-64-9    | 142.583  |                            |        | 189; 80 <sup>20</sup>    |                            | 1.5449 <sup>20</sup> | sl H <sub>2</sub> O; s eth                           |
| 2149 | 3-Chloro-4-methylphenol                   | 3-Chloro- <i>p</i> -cresol                                  | C <sub>7</sub> H <sub>7</sub> ClO                | 615-62-3   | 142.583  | nd (al)                    | 55.5   | 228                      |                            |                      | vs bz, eth, EtOH                                     |
| 2150 | 4-Chloro-2-methylphenol                   | 4-Chloro- <i>o</i> -cresol                                  | C <sub>7</sub> H <sub>7</sub> ClO                | 1570-64-5  | 142.583  | nd (peth)                  | 51     | 223                      |                            |                      | sl H <sub>2</sub> O; s peth                          |
| 2151 | 4-Chloro-3-methylphenol                   | 4-Chloro- <i>m</i> -cresol                                  | C <sub>7</sub> H <sub>7</sub> ClO                | 59-50-7    | 142.583  | nd (peth)                  | 67     | 235                      |                            |                      | sl H <sub>2</sub> O, chl; s EtOH, eth, peth          |
| 2152 | (4-Chloro-2-methylphenoxy)acetic acid     | MCPA                                                        | C <sub>9</sub> H <sub>9</sub> ClO <sub>3</sub>   | 94-74-6    | 200.618  | pl (bz, to)                | 120    |                          |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz, ctc         |
| 2153 | 4-(4-Chloro-2-methylphenoxy)butanoic acid |                                                             | C <sub>11</sub> H <sub>13</sub> ClO <sub>3</sub> | 94-81-5    | 228.672  |                            | 100    |                          |                            |                      |                                                      |
| 2154 | Chloromethylphenylsilane                  |                                                             | C <sub>7</sub> H <sub>9</sub> ClSi               | 1631-82-9  | 156.685  |                            |        | 113 <sup>100</sup>       | 1.043 <sup>20</sup>        | 1.5171 <sup>20</sup> |                                                      |
| 2155 | (Chloromethyl)phosphonic acid             |                                                             | CH <sub>2</sub> ClO <sub>3</sub> P               | 2565-58-4  | 130.468  | nd (bz/MeNO <sub>2</sub> ) | 90     |                          |                            |                      |                                                      |
| 2156 | <i>N</i> -Chloromethylphthalimide         |                                                             | C <sub>9</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 17564-64-6 | 195.603  |                            | 135.5  |                          |                            |                      |                                                      |
| 2157 | 2-Chloro-2-methylpropanal                 |                                                             | C <sub>4</sub> H <sub>7</sub> ClO                | 917-93-1   | 106.551  |                            |        | 90                       | 1.053 <sup>15</sup>        | 1.4160 <sup>16</sup> | vs eth, EtOH                                         |
| 2158 | 1-Chloro-2-methylpropane                  | Isobutyl chloride                                           | C <sub>4</sub> H <sub>9</sub> Cl                 | 513-36-0   | 92.567   | liq                        | -130.3 | 68.5                     | 0.8773 <sup>20</sup>       | 1.3984 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s eth, ace, chl            |
| 2159 | 2-Chloro-2-methylpropane                  | <i>tert</i> -Butyl chloride                                 | C <sub>4</sub> H <sub>9</sub> Cl                 | 507-20-0   | 92.567   | liq                        | -25.60 | 50.9                     | 0.8420 <sup>20</sup>       | 1.3857 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s bz, ctc, chl   |
| 2160 | 1-Chloro-2-methylpropene                  | Dimethylvinyl chloride                                      | C <sub>4</sub> H <sub>7</sub> Cl                 | 513-37-1   | 90.552   |                            |        | 68                       | 0.9186 <sup>20</sup>       | 1.4221 <sup>20</sup> | sl H <sub>2</sub> O; s chl                           |
| 2161 | 3-Chloro-2-methylpropene                  |                                                             | C <sub>4</sub> H <sub>7</sub> Cl                 | 563-47-3   | 90.552   |                            |        | 71.5                     | 0.9165 <sup>20</sup>       | 1.4291 <sup>20</sup> | msc EtOH, eth; s ace; vs chl                         |
| 2162 | 3-(Chloromethyl)pyridine, hydrochloride   |                                                             | C <sub>6</sub> H <sub>7</sub> Cl <sub>2</sub> N  | 6959-48-4  | 164.033  | hyg                        | 143.8  |                          |                            |                      |                                                      |
| 2163 | Chloromethylsilane                        |                                                             | CH <sub>3</sub> ClSi                             | 993-00-0   | 80.590   | col gas                    | -135   | 7; -45 <sup>63</sup>     |                            |                      |                                                      |
| 2164 | 1-Chloro-4-(methylsulfonyl)benzene        | 4-Chlorobenzenethiol, <i>S</i> -methyl, <i>S,S</i> -dioxide | C <sub>7</sub> H <sub>7</sub> ClO <sub>2</sub> S | 98-57-7    | 190.648  |                            | 98     |                          |                            |                      |                                                      |
| 2165 | 1-Chloro-4-(methylthio)benzene            |                                                             | C <sub>7</sub> H <sub>7</sub> ClS                | 123-09-1   | 158.649  |                            |        | 105 <sup>10</sup>        |                            |                      |                                                      |
| 2166 | 1-Chloro-2-(methylthio)ethane             |                                                             | C <sub>3</sub> H <sub>7</sub> ClS                | 542-81-4   | 110.606  |                            |        | 140; 60 <sup>30</sup>    | 1.123 <sup>20</sup>        | 1.4902 <sup>20</sup> | s EtOH, eth, ace                                     |
| 2167 | Chloro(methylthio)methane                 |                                                             | C <sub>2</sub> H <sub>5</sub> ClS                | 2373-51-5  | 96.579   |                            |        | 105                      | 1.153 <sup>25</sup>        | 1.4963 <sup>20</sup> |                                                      |
| 2168 | (Chloromethyl)trimethylsilane             |                                                             | C <sub>4</sub> H <sub>11</sub> ClSi              | 2344-80-1  | 122.669  |                            |        | 98.5                     | 0.879 <sup>25</sup>        | 1.4175 <sup>20</sup> |                                                      |



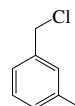
4-Chloro-5-methyl-2-isopropylphenol



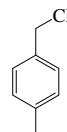
1-(Chloromethyl)-4-methoxybenzene



1-(Chloromethyl)-2-methylbenzene



1-(Chloromethyl)-3-methylbenzene



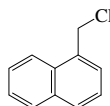
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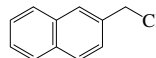
Chloromethyl methyl ether



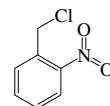
2-(Chloromethyl)-2-methyloxirane



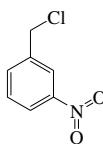
1-(Chloromethyl)naphthalene



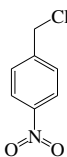
2-(Chloromethyl)naphthalene



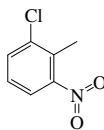
1-(Chloromethyl)-2-nitrobenzene



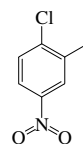
1-(Chloromethyl)-3-nitrobenzene



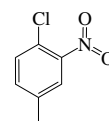
1-(Chloromethyl)-4-nitrobenzene



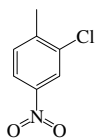
1-Chloro-2-methyl-3-nitrobenzene



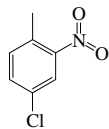
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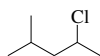
1-Chloro-4-methyl-2-nitrobenzene



2-Chloro-1-methyl-4-nitrobenzene



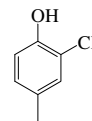
4-Chloro-1-methyl-2-nitrobenzene



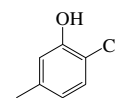
2-Chloro-4-methylpentane



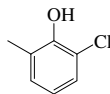
3-(Chloromethyl)pentane



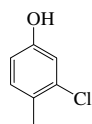
2-Chloro-4-methylphenol



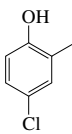
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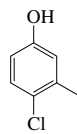
2-Chloro-6-methylphenol



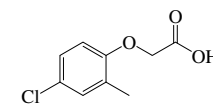
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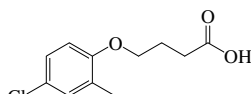
4-Chloro-2-methylphenol



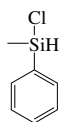
4-Chloro-3-methylphenol



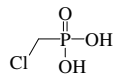
(4-Chloro-2-methylphenoxy)acetic acid



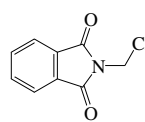
4-(4-Chloro-2-methylphenoxy)butanoic acid



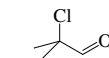
Chloromethylphenylsilane



(Chloromethyl)phosphonic acid



N-Chloromethylphthalimide



2-Chloro-2-methylpropanal



1-Chloro-2-methylpropane



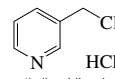
2-Chloro-2-methylpropane



1-Chloro-2-methylpropene



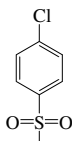
3-Chloro-2-methylpropene



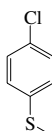
3-(Chloromethyl)pyridine, hydrochloride



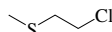
Chloromethylsilane



1-Chloro-4-(methylsulfonyl)benzene



1-Chloro-4-(methylthio)benzene



1-Chloro-2-(methylthio)ethane



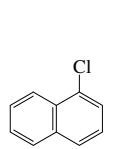
Chloro(methylthio)methane



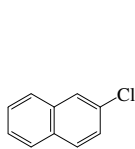
(Chloromethyl)trimethylsilane



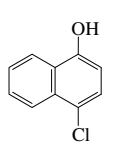
| No.  | Name                                        | Synonym                           | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form                           | mp/°C | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                    |
|------|---------------------------------------------|-----------------------------------|-----------------------------------------------------------------|------------|----------|-----------------------------------------|-------|---------------------------|----------------------------|-----------------------|---------------------------------------------------------------|
| 2169 | 1-Chloronaphthalene                         | 1-Naphthyl chloride               | C <sub>10</sub> H <sub>7</sub> Cl                               | 90-13-1    | 162.616  | oily liq                                | -2.5  | 259; 106.5 <sup>5</sup>   | 1.1880 <sup>25</sup>       | 1.6326 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, CS <sub>2</sub> ; sl ctc |
| 2170 | 2-Chloronaphthalene                         |                                   | C <sub>10</sub> H <sub>7</sub> Cl                               | 91-58-7    | 162.616  | pl (dil al), lf                         | 58.0  | 256                       | 1.1377 <sup>71</sup>       | 1.6079 <sup>13</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl, CS <sub>2</sub>     |
| 2171 | 4-Chloro-1-naphthol                         |                                   | C <sub>10</sub> H <sub>7</sub> ClO                              | 604-44-4   | 178.615  | nd (chl, aq al)                         | 120.5 |                           |                            |                       | s EtOH, eth, ace, bz, chl                                     |
| 2172 | Chloroneb                                   | 1,4-Dichloro-2,5-dimethoxybenzene | C <sub>8</sub> H <sub>5</sub> Cl <sub>2</sub> O <sub>2</sub>    | 2675-77-6  | 207.055  |                                         | 134   | 268                       |                            |                       |                                                               |
| 2173 | 2-Chloro-4-nitroaniline                     |                                   | C <sub>6</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>2</sub>   | 121-87-9   | 172.569  | ye nd (w)                               | 108   |                           |                            |                       | vs eth, EtOH, HOAc                                            |
| 2174 | 2-Chloro-5-nitroaniline                     |                                   | C <sub>6</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>2</sub>   | 6283-25-6  | 172.569  | ye nd (lig)                             | 121   |                           |                            |                       | vs eth, EtOH, HOAc                                            |
| 2175 | 4-Chloro-2-nitroaniline                     |                                   | C <sub>6</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>2</sub>   | 89-63-4    | 172.569  | dk oran-ye pr (dil al)                  | 116.5 |                           |                            |                       | vs EtOH, eth, HOAc; sl ace, lig                               |
| 2176 | 4-Chloro-3-nitroaniline                     |                                   | C <sub>6</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>2</sub>   | 635-22-3   | 172.569  | ye nd or pr (w) nd (peth)               | 103   |                           |                            |                       | s H <sub>2</sub> O, eth, chl; vs EtOH; sl lig                 |
| 2177 | 5-Chloro-2-nitroaniline                     |                                   | C <sub>6</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>2</sub>   | 1635-61-6  | 172.569  | ye nd (CS <sub>2</sub> ) ye lf (al, bz) | 127.8 | sub                       |                            |                       | vs eth, EtOH                                                  |
| 2178 | 1-Chloro-5-nitro-9,10-anthracenedione       |                                   | C <sub>14</sub> H <sub>5</sub> ClNO <sub>4</sub>                | 129-40-8   | 287.656  |                                         | 315.3 |                           |                            |                       | i H <sub>2</sub> O, EtOH, eth, lig; sl bz; s py               |
| 2179 | 2-Chloro-5-nitrobenzaldehyde                |                                   | C <sub>7</sub> H <sub>4</sub> ClNO <sub>3</sub>                 | 6361-21-3  | 185.565  | cry (al)                                | 81.3  |                           |                            |                       | vs EtOH, chl                                                  |
| 2180 | 4-Chloro-3-nitrobenzaldehyde                |                                   | C <sub>7</sub> H <sub>4</sub> ClNO <sub>3</sub>                 | 16588-34-4 | 185.565  |                                         | 64.5  |                           |                            |                       | sl H <sub>2</sub> O; s chl                                    |
| 2181 | 1-Chloro-2-nitrobenzene                     | <i>o</i> -Chloronitrobenzene      | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>                 | 88-73-3    | 157.555  | mcl nd                                  | 32.1  | 245.5                     | 1.368 <sup>242</sup>       |                       | i H <sub>2</sub> O; s EtOH, eth, bz; vs ace, tol, py          |
| 2182 | 1-Chloro-3-nitrobenzene                     | <i>m</i> -Chloronitrobenzene      | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>                 | 121-73-3   | 157.555  | pa ye orth pr (al)                      | 44.4  | 235.5                     | 1.343 <sup>50</sup>        | 1.5374 <sup>80</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl, CS <sub>2</sub>     |
| 2183 | 1-Chloro-4-nitrobenzene                     | <i>p</i> -Chloronitrobenzene      | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>                 | 100-00-5   | 157.555  | mcl pr                                  | 82    | 242                       | 1.2979 <sup>90</sup>       | 1.5376 <sup>100</sup> | i H <sub>2</sub> O; sl EtOH; s eth, chl, CS <sub>2</sub>      |
| 2184 | 5-Chloro-3-nitro-1,2-benzenediamine         |                                   | C <sub>6</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>2</sub>   | 42389-30-0 | 187.584  |                                         | 167   |                           |                            |                       |                                                               |
| 2185 | 4-Chloro-3-nitrobenzenesulfonamide          |                                   | C <sub>6</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>2</sub> S | 97-09-6    | 236.633  | ye cry (EtOH)                           | 175   |                           |                            |                       |                                                               |
| 2186 | 4-Chloro-3-nitrobenzenesulfonyl chloride    |                                   | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> NO <sub>2</sub> S | 97-08-5    | 256.064  |                                         | 60.8  |                           |                            |                       |                                                               |
| 2187 | 2-Chloro-4-nitrobenzoic acid                |                                   | C <sub>7</sub> H <sub>4</sub> ClNO <sub>4</sub>                 | 99-60-5    | 201.565  | nd (w)                                  | 141.8 |                           |                            |                       | s H <sub>2</sub> O, EtOH, eth, bz                             |
| 2188 | 2-Chloro-5-nitrobenzoic acid                |                                   | C <sub>7</sub> H <sub>4</sub> ClNO <sub>4</sub>                 | 2516-96-3  | 201.565  | nd or pr (w)                            | 166.5 |                           | 1.608 <sup>18</sup>        |                       | sl H <sub>2</sub> O, ace; s EtOH, eth, bz                     |
| 2189 | 4-Chloro-3-nitrobenzoic acid                |                                   | C <sub>7</sub> H <sub>4</sub> ClNO <sub>4</sub>                 | 96-99-1    | 201.565  | nd or pl (w)                            | 182.8 |                           | 1.645 <sup>18</sup>        |                       | i H <sub>2</sub> O; sl EtOH, ace                              |
| 2190 | 1-Chloro-1-nitroethane                      |                                   | C <sub>2</sub> H <sub>4</sub> ClNO <sub>2</sub>                 | 598-92-5   | 109.512  |                                         |       | 124.5                     | 1.2837 <sup>20</sup>       | 1.4224 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, ctc, alk                          |
| 2191 | 2-Chloro-4-nitrophenol                      |                                   | C <sub>6</sub> H <sub>4</sub> ClNO <sub>3</sub>                 | 619-08-9   | 173.554  | wh nd (50% al)                          | 111   |                           |                            |                       | s H <sub>2</sub> O, EtOH, eth, chl; sl bz                     |
| 2192 | 4-Chloro-2-nitrophenol                      |                                   | C <sub>6</sub> H <sub>4</sub> ClNO <sub>3</sub>                 | 89-64-5    | 173.554  | ye mcl pr (al)                          | 88.5  |                           |                            |                       | i H <sub>2</sub> O; s EtOH, eth, chl; sl ace                  |
| 2193 | 5-Chloro-2-nitrophenol                      |                                   | C <sub>6</sub> H <sub>4</sub> ClNO <sub>3</sub>                 | 611-07-4   | 173.554  | ye pr or nd (w)                         | 41    | sub                       |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, HOAc                        |
| 2194 | 1-Chloro-1-nitropropane                     |                                   | C <sub>3</sub> H <sub>5</sub> ClNO <sub>2</sub>                 | 600-25-9   | 123.539  |                                         |       | 142                       | 1.207 <sup>20</sup>        | 1.4251 <sup>20</sup>  | sl H <sub>2</sub> O, chl; s EtOH, eth, oils                   |
| 2195 | 2-Chloro-2-nitropropane                     |                                   | C <sub>3</sub> H <sub>5</sub> ClNO <sub>2</sub>                 | 594-71-8   | 123.539  |                                         | -21.5 | dec 134; 57 <sup>50</sup> | 1.2 <sup>20</sup>          | 1.4378 <sup>19</sup>  | sl H <sub>2</sub> O; s EtOH, eth, ctc, oils; i KOH            |
| 2196 | 2-Chloro-3-nitropyridine                    |                                   | C <sub>5</sub> H <sub>3</sub> ClN <sub>2</sub> O <sub>2</sub>   | 5470-18-8  | 158.543  | nd (w)                                  | 104.0 |                           |                            |                       |                                                               |
| 2197 | 1-Chloro-2-nitro-4-(trifluoromethyl)benzene |                                   | C <sub>7</sub> H <sub>3</sub> ClF <sub>3</sub> NO <sub>2</sub>  | 121-17-5   | 225.553  | liq                                     | -1.3  | 222; 95 <sup>10</sup>     | 1.511 <sup>25</sup>        | 1.4893 <sup>30</sup>  |                                                               |
| 2198 | 1-Chloro-4-nitro-2-(trifluoromethyl)benzene |                                   | C <sub>7</sub> H <sub>3</sub> ClF <sub>3</sub> NO <sub>2</sub>  | 777-37-7   | 225.553  |                                         | 22    | 232                       | 1.527 <sup>25</sup>        | 1.5083 <sup>36</sup>  |                                                               |
| 2199 | 1-Chlorononane                              |                                   | C <sub>9</sub> H <sub>19</sub> Cl                               | 2473-01-0  | 162.700  | liq                                     | -39.4 | 205.2                     | 0.8674 <sup>25</sup>       | 1.4343 <sup>20</sup>  | i H <sub>2</sub> O; s eth, chl                                |
| 2200 | 9-Chloro-1-nonanol                          |                                   | C <sub>9</sub> H <sub>19</sub> ClO                              | 51308-99-7 | 178.699  |                                         | 28    | 147 <sup>14</sup>         |                            | 1.4575 <sup>20</sup>  | vs eth, EtOH                                                  |
| 2201 | 1-Chlorooctadecane                          |                                   | C <sub>18</sub> H <sub>37</sub> Cl                              | 3386-33-2  | 288.940  |                                         | 28.6  | 352                       | 0.8616 <sup>20</sup>       | 1.4524 <sup>20</sup>  | i H <sub>2</sub> O; sl ctc                                    |
| 2202 | 1-Chlorooctane                              | Octyl chloride                    | C <sub>8</sub> H <sub>17</sub> Cl                               | 111-85-3   | 148.674  | liq                                     | -57.8 | 183.5                     | 0.8734 <sup>20</sup>       | 1.4309 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth; sl ctc                      |
| 2203 | 2-Chlorooctane                              |                                   | C <sub>8</sub> H <sub>17</sub> Cl                               | 628-61-5   | 148.674  |                                         |       | 172; 75 <sup>28</sup>     | 0.8658 <sup>17</sup>       | 1.4273 <sup>21</sup>  | i H <sub>2</sub> O; vs EtOH, eth                              |
| 2204 | 8-Chloro-1-octanol                          |                                   | C <sub>8</sub> H <sub>17</sub> ClO                              | 23144-52-7 | 164.673  |                                         |       | 139 <sup>19</sup>         |                            | 1.4563 <sup>25</sup>  | vs eth, EtOH                                                  |
| 2205 | Chloropentafluoroacetone                    |                                   | C <sub>2</sub> ClF <sub>5</sub> O                               | 79-53-8    | 182.476  | col gas                                 | -133  | 8                         |                            |                       |                                                               |
| 2206 | Chloropentafluorobenzene                    |                                   | C <sub>6</sub> ClF <sub>5</sub>                                 | 344-07-0   | 202.509  |                                         |       | 117.96                    | 1.568 <sup>25</sup>        | 1.4256 <sup>20</sup>  |                                                               |



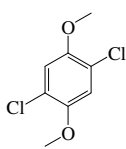
1-Chloronaphthalene



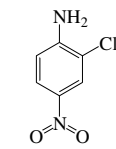
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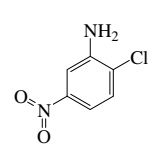
4-Chloro-1-naphthol



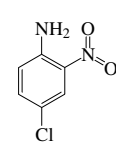
Chloroneb



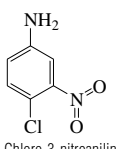
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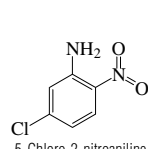
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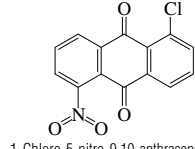
4-Chloro-2-nitroaniline



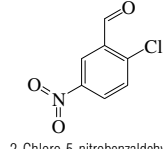
4-Chloro-3-nitroaniline



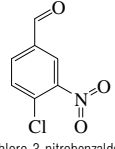
5-Chloro-2-nitroaniline



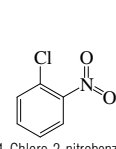
1-Chloro-5-nitro-9,10-anthracenedione



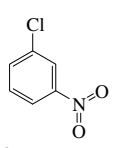
2-Chloro-5-nitrobenzaldehyde



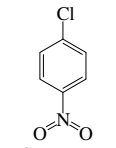
4-Chloro-3-nitrobenzaldehyde



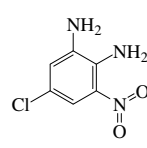
1-Chloro-2-nitrobenzene



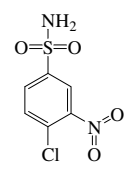
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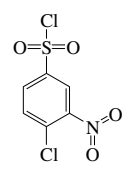
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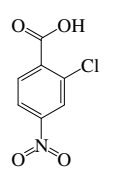
5-Chloro-3-nitro-1,2-benzenediamine



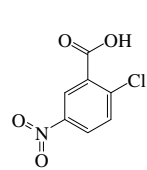
4-Chloro-3-nitrobenzenesulfonamide



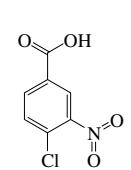
4-Chloro-3-nitrobenzenesulfonyl chloride



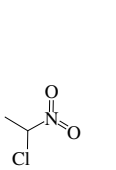
2-Chloro-4-nitrobenzoic acid



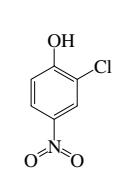
2-Chloro-5-nitrobenzoic acid



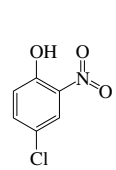
4-Chloro-3-nitrobenzoic acid



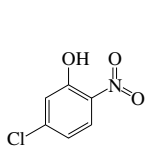
1-Chloro-1-nitroethane



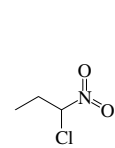
2-Chloro-4-nitrophenol



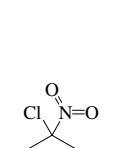
4-Chloro-2-nitrophenol



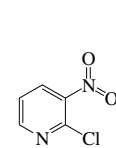
5-Chloro-2-nitrophenol



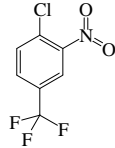
1-Chloro-1-nitropropane



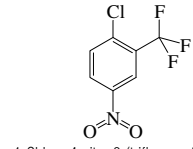
2-Chloro-2-nitropropane



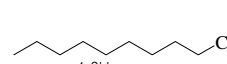
2-Chloro-1-nitropyridine



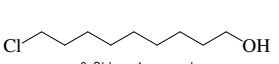
1-Chloro-2-nitro-4-(trifluoromethyl)benzene



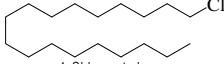
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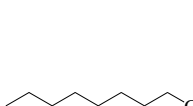
1-Chlorononane



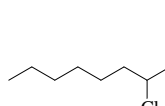
9-Chloro-1-nonanol



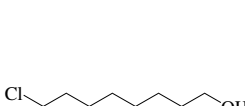
1-Chlorooctadecane



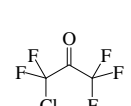
1-Chlorooctane



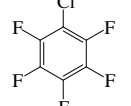
2-Chlorooctane



8-Chloro-1-octanol

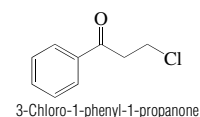
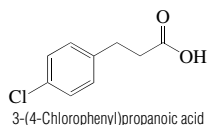
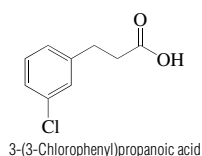
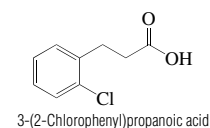
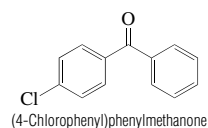
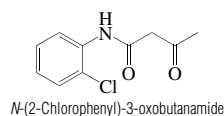
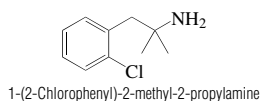
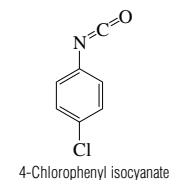
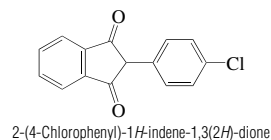
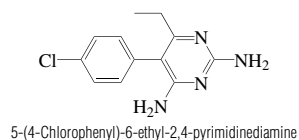
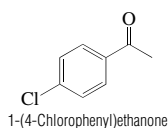
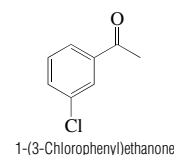
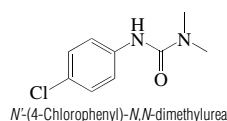
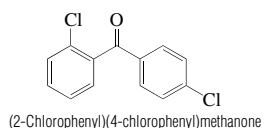
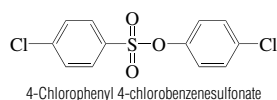
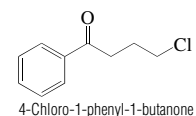
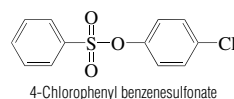
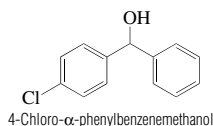
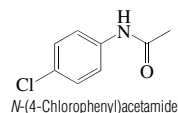
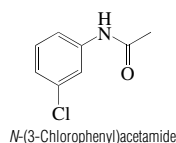
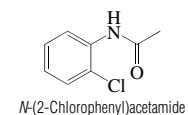
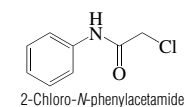
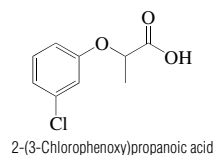
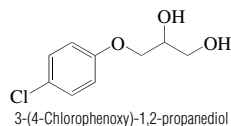
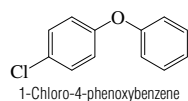
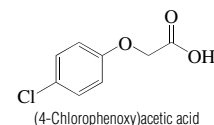
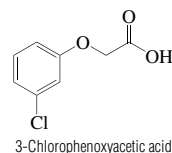
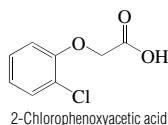
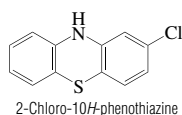
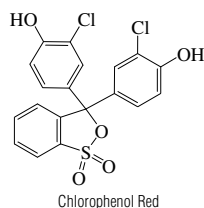
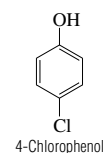
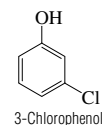
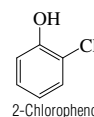
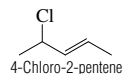
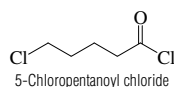
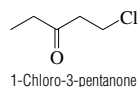
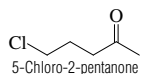
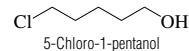
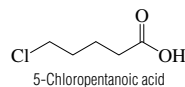
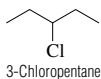
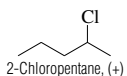
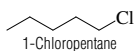
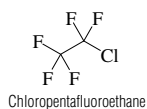


Chloropentafluoroacetone

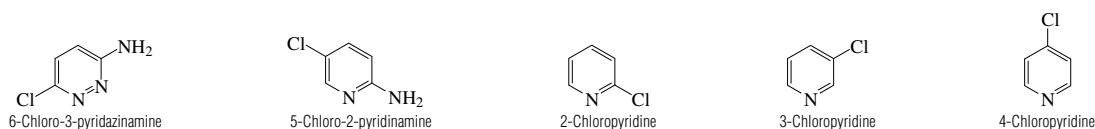
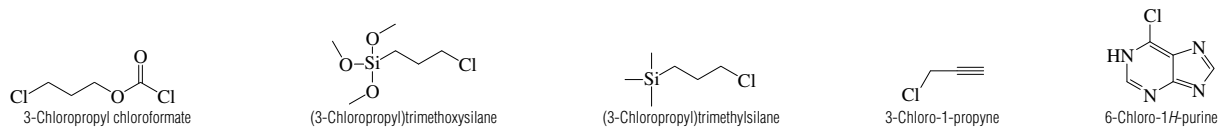
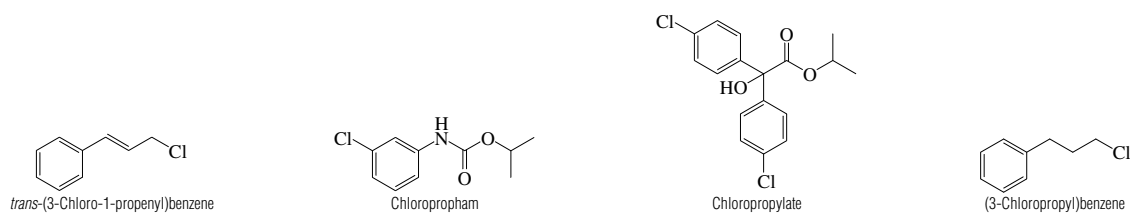
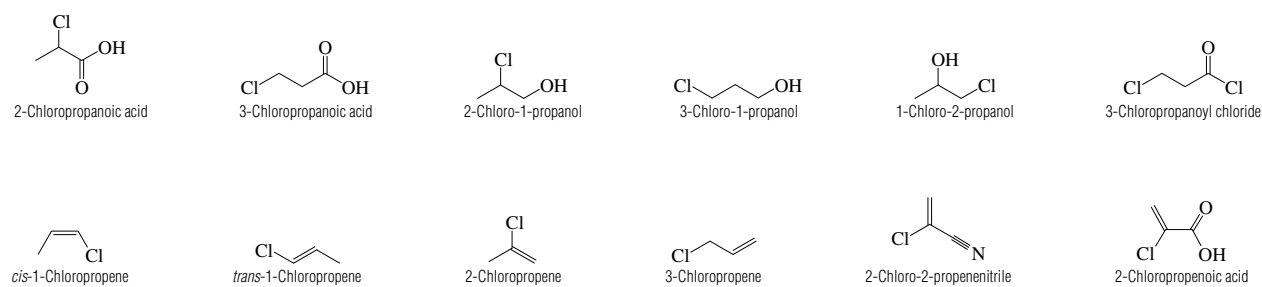
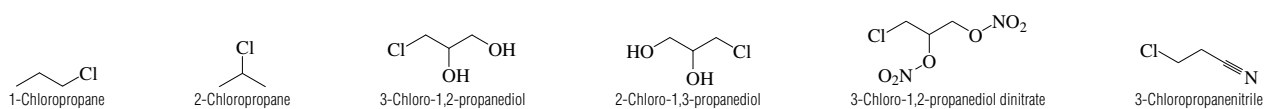
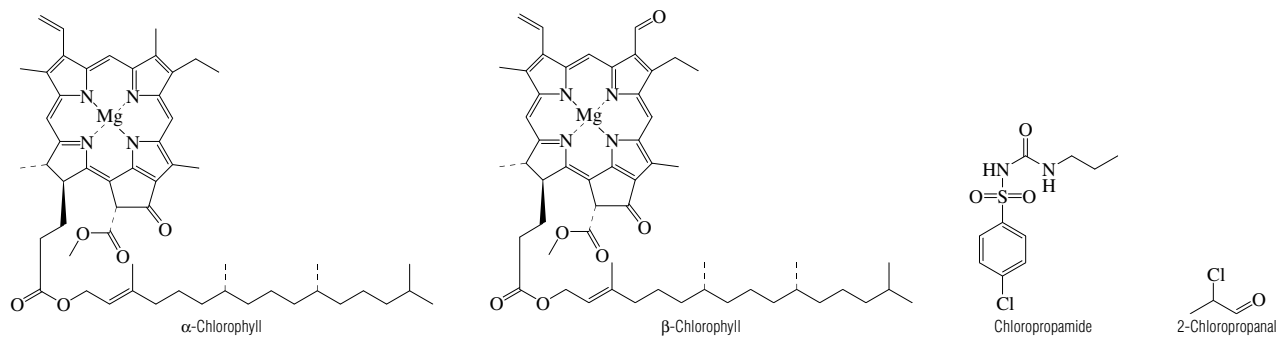
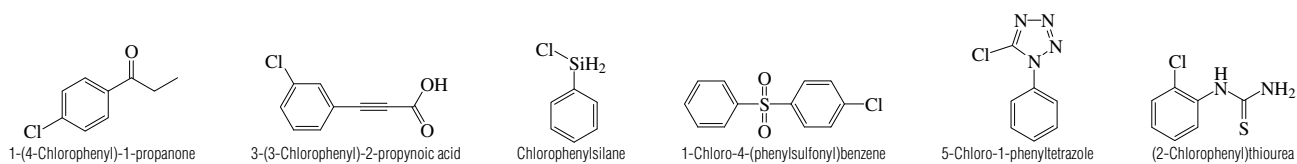


Chloropentafluorobenzene

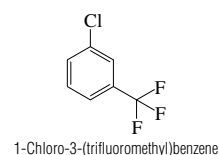
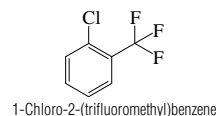
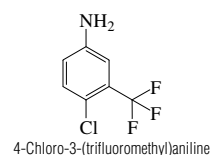
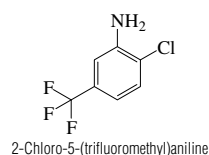
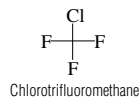
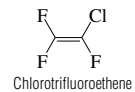
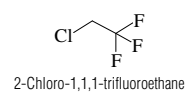
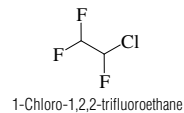
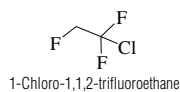
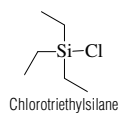
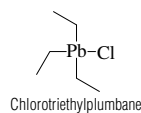
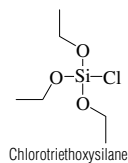
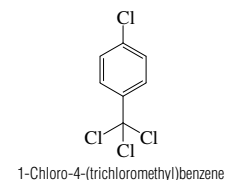
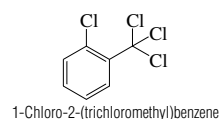
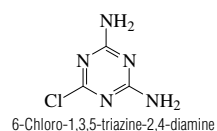
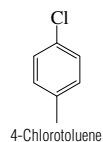
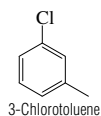
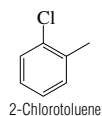
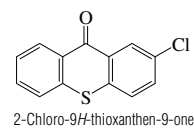
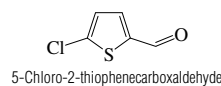
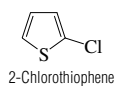
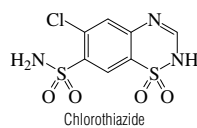
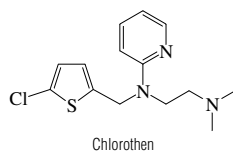
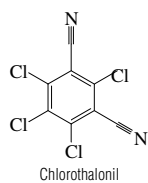
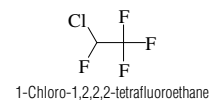
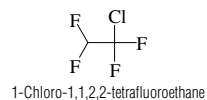
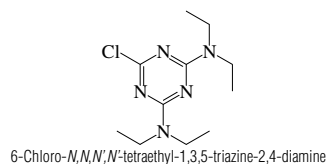
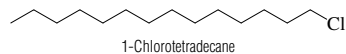
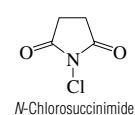
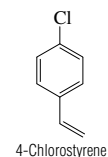
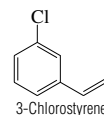
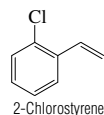
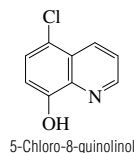
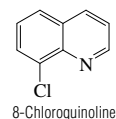
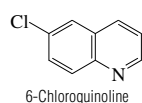
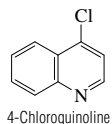
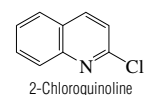
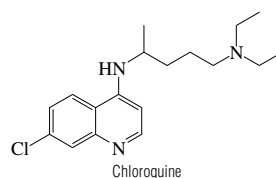
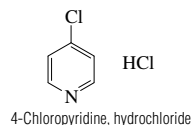
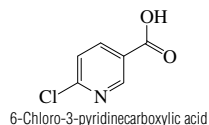
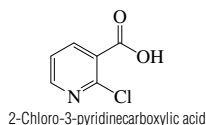
| No.  | Name                                                         | Synonym                      | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form            | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                     |
|------|--------------------------------------------------------------|------------------------------|------------------------------------------------------------------|------------|----------|--------------------------|-------|---------------------------------------|----------------------------|----------------------|----------------------------------------------------------------|
| 2207 | Chloropentafluoroethane                                      | Refrigerant 115              | C <sub>2</sub> ClF <sub>5</sub>                                  | 76-15-3    | 154.466  | col gas                  | -99.4 | -39.1                                 | 1.5678 <sup>42</sup>       | 1.2678 <sup>42</sup> | i H <sub>2</sub> O; s EtOH, eth                                |
| 2208 | 1-Chloropentane                                              | Pentyl chloride              | C <sub>5</sub> H <sub>11</sub> Cl                                | 543-59-9   | 106.594  | liq                      | -99.0 | 108.4                                 | 0.8820 <sup>20</sup>       | 1.4126 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz, ctc; vs chl           |
| 2209 | 2-Chloropentane, (+)                                         | sec-Pentyl chloride          | C <sub>5</sub> H <sub>11</sub> Cl                                | 29882-57-3 | 106.594  | liq                      | -137  | 97.0                                  | 0.8698 <sup>20</sup>       | 1.4069 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz; vs chl                    |
| 2210 | 3-Chloropentane                                              |                              | C <sub>5</sub> H <sub>11</sub> Cl                                | 616-20-6   | 106.594  | liq                      | -105  | 97.5                                  | 0.8731 <sup>20</sup>       | 1.4082 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz; sl ace                    |
| 2211 | 5-Chloropentanoic acid                                       |                              | C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>                   | 1119-46-6  | 136.577  |                          | 18    | 230                                   | 1.3416 <sup>25</sup>       | 1.4555 <sup>20</sup> | vs eth, EtOH                                                   |
| 2212 | 5-Chloro-1-pentanol                                          |                              | C <sub>5</sub> H <sub>11</sub> ClO                               | 5259-98-3  | 122.593  |                          |       | 112 <sup>12</sup>                     |                            | 1.4518 <sup>20</sup> | vs eth, EtOH                                                   |
| 2213 | 5-Chloro-2-pentanone                                         |                              | C <sub>5</sub> H <sub>9</sub> ClO                                | 5891-21-4  | 120.577  |                          |       | 106 <sup>110</sup> , 76 <sup>34</sup> | 1.0523 <sup>20</sup>       | 1.4375 <sup>20</sup> | s eth, ace; sl ctc                                             |
| 2214 | 1-Chloro-3-pentanone                                         |                              | C <sub>5</sub> H <sub>9</sub> ClO                                | 32830-97-0 | 120.577  |                          |       | 68 <sup>20</sup>                      |                            | 1.4361 <sup>20</sup> | vs eth, EtOH                                                   |
| 2215 | 5-Chloropentanoyl chloride                                   |                              | C <sub>5</sub> H <sub>9</sub> Cl <sub>2</sub> O                  | 1575-61-7  | 155.022  |                          |       | 83 <sup>12</sup>                      | 1.210 <sup>18</sup>        | 1.4639 <sup>20</sup> | vs eth                                                         |
| 2216 | 4-Chloro-2-pentene                                           |                              | C <sub>5</sub> H <sub>9</sub> Cl                                 | 1458-99-7  | 104.578  |                          |       | 103; 47 <sup>25</sup>                 | 0.8988 <sup>20</sup>       | 1.4322 <sup>20</sup> | vs ace, eth, chl                                               |
| 2217 | 2-Chlorophenol                                               |                              | C <sub>6</sub> H <sub>5</sub> ClO                                | 95-57-8    | 128.556  |                          | 9.4   | 174.9                                 | 1.2634 <sup>20</sup>       | 1.5524 <sup>20</sup> | sl H <sub>2</sub> O, chl; s EtOH, eth; vs bz                   |
| 2218 | 3-Chlorophenol                                               |                              | C <sub>6</sub> H <sub>5</sub> ClO                                | 108-43-0   | 128.556  |                          | 32.6  | 214                                   | 1.245 <sup>45</sup>        | 1.5565 <sup>40</sup> | sl H <sub>2</sub> O, chl; s EtOH, eth; vs bz                   |
| 2219 | 4-Chlorophenol                                               |                              | C <sub>6</sub> H <sub>5</sub> ClO                                | 106-48-9   | 128.556  |                          | 42.8  | 220                                   | 1.2651 <sup>40</sup>       | 1.5579 <sup>40</sup> | sl H <sub>2</sub> O; vs EtOH, eth, bz; s alk                   |
| 2220 | Chlorophenol Red                                             |                              | C <sub>19</sub> H <sub>12</sub> Cl <sub>2</sub> O <sub>5</sub> S | 4430-20-0  | 423.266  | grn-br cry               | 261   |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH                                    |
| 2221 | 2-Chloro-10 <i>H</i> -phenothiazine                          |                              | C <sub>12</sub> H <sub>8</sub> CINS                              | 92-39-7    | 233.717  |                          | 198.5 |                                       |                            |                      |                                                                |
| 2222 | 2-Chlorophenoxyacetic acid                                   |                              | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                   | 614-61-9   | 186.593  | nd (w, al)               | 148.5 |                                       |                            |                      | s H <sub>2</sub> O, EtOH                                       |
| 2223 | 3-Chlorophenoxyacetic acid                                   |                              | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                   | 588-32-9   | 186.593  | cry (w)                  | 110   |                                       |                            |                      | i H <sub>2</sub> O                                             |
| 2224 | (4-Chlorophenoxy)acetic acid                                 |                              | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                   | 122-88-3   | 186.593  | pr or nd (w)             | 156.5 |                                       |                            |                      | vs H <sub>2</sub> O; sl chl                                    |
| 2225 | 1-Chloro-4-phenoxybenzene                                    | 4-Chlorophenyl phenyl ether  | C <sub>12</sub> H <sub>9</sub> ClO                               | 7005-72-3  | 204.651  |                          |       | 284.5                                 | 1.2026 <sup>15</sup>       | 1.599                |                                                                |
| 2226 | 3-(4-Chlorophenoxy)-1,2-propanediol                          | Chlorphenesin                | C <sub>9</sub> H <sub>11</sub> ClO <sub>3</sub>                  | 104-29-0   | 202.634  | cry                      | 78    | 214 <sup>19</sup>                     |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s bz, con sulf               |
| 2227 | 2-(3-Chlorophenoxy)propanoic acid                            | Cloprop                      | C <sub>9</sub> H <sub>9</sub> ClO <sub>3</sub>                   | 101-10-0   | 200.618  | cry                      | 113   | 100 <sup>15</sup>                     |                            |                      |                                                                |
| 2228 | 2-Chloro- <i>N</i> -phenylacetamide                          |                              | C <sub>8</sub> H <sub>8</sub> ClNO                               | 587-65-5   | 169.609  | nd (dil HOAc)            |       | sub                                   |                            |                      | vs bz, eth, EtOH                                               |
| 2229 | <i>N</i> -(2-Chlorophenyl)acetamide                          |                              | C <sub>8</sub> H <sub>8</sub> ClNO                               | 533-17-5   | 169.609  |                          | 88.3  |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, bz, chl; vs eth                    |
| 2230 | <i>N</i> -(3-Chlorophenyl)acetamide                          |                              | C <sub>8</sub> H <sub>8</sub> ClNO                               | 588-07-8   | 169.609  | nd                       | 79    | 333                                   |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz, CS <sub>2</sub> ; s chl |
| 2231 | <i>N</i> -(4-Chlorophenyl)acetamide                          |                              | C <sub>8</sub> H <sub>8</sub> ClNO                               | 539-03-7   | 169.609  |                          | 179   | 333                                   | 1.385 <sup>22</sup>        |                      | i H <sub>2</sub> O; s EtOH; vs eth; sl ctc                     |
| 2232 | 4-Chloro- $\alpha$ -phenylbenzenemethanol                    |                              | C <sub>13</sub> H <sub>11</sub> ClO                              | 119-56-2   | 218.678  |                          | 59    |                                       |                            |                      | sl chl                                                         |
| 2233 | 4-Chlorophenyl benzenesulfonate                              |                              | C <sub>12</sub> H <sub>9</sub> ClO <sub>3</sub> S                | 80-38-6    | 268.715  | col cry                  | 62    |                                       | 1.33                       |                      | sl H <sub>2</sub> O                                            |
| 2234 | 4-Chloro-1-phenyl-1-butanone                                 |                              | C <sub>10</sub> H <sub>11</sub> ClO                              | 939-52-6   | 182.646  |                          | 19.5  | 131 <sup>4</sup>                      | 1.137 <sup>25</sup>        | 1.5459 <sup>20</sup> |                                                                |
| 2235 | 4-Chlorophenyl 4-chlorobenzenesulfonate                      | Ovex                         | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>3</sub> S  | 80-33-1    | 303.161  |                          | 86.5  |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH; s ace                             |
| 2236 | (2-Chlorophenyl)(4-chlorophenyl) methanone                   | 2,4'-Dichlorodiphenyl ketone | C <sub>13</sub> H <sub>8</sub> Cl <sub>2</sub> O                 | 85-29-0    | 251.108  | pr (al)                  | 67    | 214 <sup>22</sup>                     | 1.393 <sup>14</sup>        |                      | s EtOH; sl chl                                                 |
| 2237 | <i>N'</i> -(4-Chlorophenyl)- <i>N,N</i> -dimethylurea        | Monuron                      | C <sub>9</sub> H <sub>11</sub> ClN <sub>2</sub> O                | 150-68-5   | 198.648  | wh pl (MeOH)             | 170.5 |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH, ace                               |
| 2238 | 1-(3-Chlorophenyl)ethanone                                   | <i>m</i> -Chloroacetophenone | C <sub>8</sub> H <sub>7</sub> ClO                                | 99-02-5    | 154.594  |                          |       | 244; 129 <sup>30</sup>                | 1.2130 <sup>40</sup>       | 1.5494 <sup>20</sup> | s EtOH, eth, ace                                               |
| 2239 | 1-(4-Chlorophenyl)ethanone                                   | <i>p</i> -Chloroacetophenone | C <sub>8</sub> H <sub>7</sub> ClO                                | 99-91-2    | 154.594  |                          | 20    | 232                                   | 1.1922 <sup>20</sup>       | 1.5550 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl                       |
| 2240 | 5-(4-Chlorophenyl)-6-ethyl-2,4-pyrimidinediamine             | Pyrimethamine                | C <sub>12</sub> H <sub>13</sub> ClN <sub>4</sub>                 | 58-14-0    | 248.711  |                          | 233.5 |                                       |                            |                      |                                                                |
| 2241 | 2-(4-Chlorophenyl)-1 <i>H</i> -indene-1,3(2 <i>H</i> )-dione | Clorindione                  | C <sub>15</sub> H <sub>9</sub> ClO <sub>2</sub>                  | 1146-99-2  | 256.684  | dk red nd (al)           | 145.5 |                                       |                            |                      | vs bz, eth, EtOH                                               |
| 2242 | 4-Chlorophenyl isocyanate                                    |                              | C <sub>7</sub> H <sub>4</sub> ClNO                               | 104-12-1   | 153.566  |                          | 31.3  | 116 <sup>45</sup>                     |                            |                      |                                                                |
| 2243 | 1-(2-Chlorophenyl)-2-methyl-2-propylamine                    | Clortermine                  | C <sub>10</sub> H <sub>14</sub> ClN                              | 10389-73-8 | 183.678  | liq                      |       | 117 <sup>16</sup>                     |                            |                      |                                                                |
| 2244 | <i>N</i> -(2-Chlorophenyl)-3-oxobutanamide                   |                              | C <sub>10</sub> H <sub>10</sub> ClNO <sub>2</sub>                | 93-70-9    | 211.645  |                          | 106.5 |                                       |                            |                      | s EtOH; i eth, liq                                             |
| 2245 | (4-Chlorophenyl) phenylmethanone                             |                              | C <sub>13</sub> H <sub>9</sub> ClO                               | 134-85-0   | 216.662  | nd (al)                  | 77.5  | 332                                   |                            |                      | s EtOH, eth, ace; sl ctc                                       |
| 2246 | 3-(2-Chlorophenyl)propanoic acid                             |                              | C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>                   | 1643-28-3  | 184.619  | nd or lf (w)             | 102   |                                       |                            |                      |                                                                |
| 2247 | 3-(3-Chlorophenyl)propanoic acid                             |                              | C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>                   | 21640-48-2 | 184.619  | lf (peth)                | 77    |                                       |                            |                      |                                                                |
| 2248 | 3-(4-Chlorophenyl)propanoic acid                             |                              | C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>                   | 2019-34-3  | 184.619  |                          | 126   |                                       |                            |                      |                                                                |
| 2249 | 3-Chloro-1-phenyl-1-propanone                                | 2-Chloroethyl phenyl ketone  | C <sub>9</sub> H <sub>9</sub> ClO                                | 936-59-4   | 168.619  | lf (eth), cry (al, peth) | 49.5  | 113 <sup>4</sup>                      |                            |                      |                                                                |



| No.  | Name                                | Synonym                                              | Mol. Form.                                                        | CAS RN     | Mol. Wt. | Physical Form            | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|-------------------------------------|------------------------------------------------------|-------------------------------------------------------------------|------------|----------|--------------------------|---------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 2250 | 1-(4-Chlorophenyl)-1-propanone      |                                                      | C <sub>9</sub> H <sub>9</sub> ClO                                 | 6285-05-8  | 168.619  |                          | 37.3    | 135 <sup>31</sup> , 114 <sup>2</sup>  |                            |                      | i H <sub>2</sub> O; s EtOH;<br>CS <sub>2</sub> ; sl chl       |
| 2251 | 3-(3-Chlorophenyl)-2-propynoic acid |                                                      | C <sub>9</sub> H <sub>7</sub> ClO <sub>2</sub>                    | 7396-28-3  | 180.588  | cry (HOAc, bz-peth)      | 144.5   |                                       |                            |                      | vs HOAc                                                       |
| 2252 | Chlorophenylsilane                  | Phenylchlorosilane                                   | C <sub>6</sub> H <sub>5</sub> ClSi                                | 4206-75-1  | 142.659  |                          |         | 162.5                                 | 1.0683 <sup>20</sup>       | 1.5340 <sup>20</sup> |                                                               |
| 2253 | 1-Chloro-4-(phenylsulfonyl)benzene  | Sulphenone                                           | C <sub>12</sub> H <sub>9</sub> ClO <sub>2</sub> S                 | 80-00-2    | 252.716  |                          | 94      |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH;<br>s eth; vs ace,<br>bz          |
| 2254 | 5-Chloro-1-phenyltetrazole          |                                                      | C <sub>7</sub> H <sub>5</sub> ClN <sub>4</sub>                    | 14210-25-4 | 180.595  |                          | 123     |                                       |                            |                      |                                                               |
| 2255 | (2-Chlorophenyl)thiourea            |                                                      | C <sub>7</sub> H <sub>7</sub> ClN <sub>2</sub> S                  | 5344-82-1  | 186.662  | nd or pl                 | 146     |                                       |                            |                      | vs bz, EtOH                                                   |
| 2256 | α-Chlorophyll                       |                                                      | C <sub>55</sub> H <sub>72</sub> MgN <sub>4</sub> O <sub>5</sub>   | 479-61-8   | 893.490  | bl blk hex pl            | 152.3   |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth; s lig                    |
| 2257 | β-Chlorophyll                       |                                                      | C <sub>55</sub> H <sub>70</sub> MgN <sub>4</sub> O <sub>6</sub>   | 519-62-0   | 907.473  | bl-blk or grn<br>pow     | 125     |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth, py; s<br>MeOH            |
| 2258 | Chloropropamide                     | 4-Chloro-N-[(propylamino)carbonyl]benzenesulfonamide | C <sub>10</sub> H <sub>13</sub> ClN <sub>2</sub> O <sub>3</sub> S | 94-20-2    | 276.739  | cry (EtOH)               | 128     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH; sl<br>eth, bz                     |
| 2259 | 2-Chloropropanal                    |                                                      | C <sub>3</sub> H <sub>5</sub> ClO                                 | 683-50-1   | 92.524   |                          |         | 86                                    | 1.182 <sup>15</sup>        | 1.431 <sup>17</sup>  | vs bz, eth                                                    |
| 2260 | 1-Chloropropane                     | Propyl chloride                                      | C <sub>3</sub> H <sub>7</sub> Cl                                  | 540-54-5   | 78.541   | liq                      | -122.9  | 46.5                                  | 0.8899 <sup>20</sup>       | 1.3879 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc<br>EtOH, eth; s<br>bz, chl      |
| 2261 | 2-Chloropropane                     | Isopropyl chloride                                   | C <sub>3</sub> H <sub>7</sub> Cl                                  | 75-29-6    | 78.541   | liq                      | -117.18 | 35.7                                  | 0.8617 <sup>20</sup>       | 1.3777 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth; s<br>bz, ctc, chl      |
| 2262 | 3-Chloro-1,2-propanediol            | α-Chlorohydrin                                       | C <sub>3</sub> H <sub>7</sub> ClO <sub>2</sub>                    | 96-24-2    | 110.540  | ye liq                   |         | dec 213; 116 <sup>11</sup>            | 1.325 <sup>18</sup>        | 1.4809 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth                                 |
| 2263 | 2-Chloro-1,3-propanediol            | Glycerol β-chlorohydrin                              | C <sub>3</sub> H <sub>7</sub> ClO <sub>2</sub>                    | 497-04-1   | 110.540  |                          |         | 146 <sup>18</sup> , 124 <sup>14</sup> | 1.3219 <sup>20</sup>       | 1.4831 <sup>20</sup> | vs H <sub>2</sub> O, ace,<br>EtOH                             |
| 2264 | 3-Chloro-1,2-propanediol dinitrate  | Clonitrate                                           | C <sub>3</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>6</sub>     | 2612-33-1  | 200.534  | sl ye liq                |         | 192.5                                 | 1.5112 <sup>9</sup>        |                      | vs ace, EtOH,<br>chl                                          |
| 2265 | 3-Chloropropanenitrile              | β-Chloropropionitrile                                | C <sub>3</sub> H <sub>4</sub> ClN                                 | 542-76-7   | 89.524   | liq                      | -51     | 175.5                                 | 1.1573 <sup>20</sup>       | 1.4360 <sup>20</sup> | sl ctc                                                        |
| 2266 | 2-Chloropropanoic acid              | 2-Chloropropionic acid                               | C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>                    | 598-78-7   | 108.524  |                          |         | 185                                   | 1.2585 <sup>20</sup>       | 1.4380 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; s ace                     |
| 2267 | 3-Chloropropanoic acid              | β-Chloropropionic acid                               | C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>                    | 107-94-8   | 108.524  | lf (w), hyg<br>cry (lig) | 41      | dec 204                               |                            |                      | s H <sub>2</sub> O, EtOH,<br>chl; msc eth                     |
| 2268 | 2-Chloro-1-propanol                 | Propylene chlorohydrin                               | C <sub>3</sub> H <sub>7</sub> ClO                                 | 78-89-7    | 94.540   |                          |         | 133.5                                 | 1.103 <sup>20</sup>        | 1.4390 <sup>20</sup> | vs H <sub>2</sub> O, eth,<br>EtOH                             |
| 2269 | 3-Chloro-1-propanol                 |                                                      | C <sub>3</sub> H <sub>7</sub> ClO                                 | 627-30-5   | 94.540   |                          |         | 165                                   | 1.1309 <sup>20</sup>       | 1.4459 <sup>20</sup> | vs H <sub>2</sub> O; s EtOH,<br>eth; sl ctc                   |
| 2270 | 1-Chloro-2-propanol                 | sec-Propylene chlorohydrin                           | C <sub>3</sub> H <sub>7</sub> ClO                                 | 127-00-4   | 94.540   |                          |         | 127                                   | 1.113 <sup>20</sup>        | 1.4392 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; sl ctc                    |
| 2271 | 3-Chloropropanoyl chloride          |                                                      | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> O                   | 625-36-5   | 126.969  |                          |         | 144                                   | 1.3307 <sup>13</sup>       | 1.4549 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH,<br>eth, chl                     |
| 2272 | cis-1-Chloropropene                 |                                                      | C <sub>3</sub> H <sub>5</sub> Cl                                  | 16136-84-8 | 76.525   | liq                      | -134.8  | 32.8                                  | 0.9347 <sup>20</sup>       | 1.4055 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace,<br>bz, chl                    |
| 2273 | trans-1-Chloropropene               |                                                      | C <sub>3</sub> H <sub>5</sub> Cl                                  | 16136-85-9 | 76.525   | liq                      | -99     | 37.4                                  | 0.9349 <sup>20</sup>       | 1.4054 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace,<br>bz, chl                    |
| 2274 | 2-Chloropropene                     | Isoprenyl chloride                                   | C <sub>3</sub> H <sub>5</sub> Cl                                  | 557-98-2   | 76.525   | vol liq or gas           | -137.4  | 22.6                                  | 0.9017 <sup>20</sup>       | 1.3973 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace,<br>bz, chl                    |
| 2275 | 3-Chloropropene                     | Allyl chloride                                       | C <sub>3</sub> H <sub>5</sub> Cl                                  | 107-05-1   | 76.525   | liq                      | -134.5  | 45.1                                  | 0.9376 <sup>20</sup>       | 1.4157 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, lig; sl ctc |
| 2276 | 2-Chloro-2-propenenitrile           |                                                      | C <sub>3</sub> H <sub>3</sub> ClN                                 | 920-37-6   | 87.508   | liq                      | -65     | 88.5                                  | 1.096 <sup>25</sup>        | 1.4290 <sup>20</sup> |                                                               |
| 2277 | 2-Chloropropenoic acid              | 2-Chloroacrylic acid                                 | C <sub>3</sub> H <sub>3</sub> ClO <sub>2</sub>                    | 598-79-8   | 106.508  |                          | 66      | sub                                   |                            |                      |                                                               |
| 2278 | trans-(3-Chloro-1-propenyl)benzene  |                                                      | C <sub>9</sub> H <sub>9</sub> Cl                                  | 21087-29-6 | 152.620  |                          | 8.5     | 106 <sup>13</sup>                     | 1.0926 <sup>20</sup>       | 1.5851 <sup>20</sup> | vs ace, bz, eth,<br>EtOH                                      |
| 2279 | Chloropropham                       |                                                      | C <sub>10</sub> H <sub>12</sub> ClNO <sub>2</sub>                 | 101-21-3   | 213.661  |                          | 41      | 149 <sup>2</sup>                      | 1.18 <sup>30</sup>         | 1.5388 <sup>20</sup> |                                                               |
| 2280 | Chloropropylate                     |                                                      | C <sub>17</sub> H <sub>16</sub> Cl <sub>2</sub> O <sub>3</sub>    | 5836-10-2  | 339.213  | pow                      | 73      |                                       |                            |                      | sl H <sub>2</sub> O; s os                                     |
| 2281 | (3-Chloropropyl)benzene             |                                                      | C <sub>9</sub> H <sub>11</sub> Cl                                 | 104-52-9   | 154.636  |                          |         | 219.5                                 | 1.056 <sup>21</sup>        | 1.5160 <sup>25</sup> | sl ctc                                                        |
| 2282 | 3-Chloropropyl chloroformate        |                                                      | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>      | 628-11-5   | 156.996  |                          |         | 177                                   | 1.2926 <sup>25</sup>       | 1.4456 <sup>20</sup> | i H <sub>2</sub> O                                            |
| 2283 | (3-Chloropropyl)trimethoxysilane    |                                                      | C <sub>6</sub> H <sub>15</sub> ClO <sub>3</sub> Si                | 2530-87-2  | 198.720  |                          |         | 91                                    | 1.077 <sup>25</sup>        | 1.4183 <sup>25</sup> |                                                               |
| 2284 | (3-Chloropropyl)trimethylsilane     |                                                      | C <sub>6</sub> H <sub>15</sub> ClSi                               | 2344-83-4  | 150.722  |                          |         | 151                                   | 0.8789 <sup>20</sup>       | 1.4319 <sup>20</sup> |                                                               |
| 2285 | 3-Chloro-1-propyne                  | Propargyl chloride                                   | C <sub>3</sub> H <sub>3</sub> Cl                                  | 624-65-7   | 74.509   |                          | -78     | 58                                    | 1.030 <sup>25</sup>        | 1.4349 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth, bz;<br>s ctc            |
| 2286 | 6-Chloro-1-H-purine                 | 6-Chloropurine                                       | C <sub>5</sub> H <sub>5</sub> ClN <sub>4</sub>                    | 87-42-3    | 154.558  | nd (w)                   | 176 dec |                                       |                            |                      |                                                               |
| 2287 | 6-Chloro-3-pyridazinamine           |                                                      | C <sub>6</sub> H <sub>4</sub> ClN <sub>3</sub>                    | 5469-69-2  | 129.548  |                          | 220     |                                       |                            |                      |                                                               |
| 2288 | 5-Chloro-2-pyridinamine             |                                                      | C <sub>6</sub> H <sub>5</sub> ClN <sub>2</sub>                    | 1072-98-6  | 128.560  | pl                       | 137     | 127 <sup>11</sup>                     |                            |                      | s H <sub>2</sub> O, EtOH; sl<br>DMSO; i peth,<br>lig          |
| 2289 | 2-Chloropyridine                    |                                                      | C <sub>6</sub> H <sub>5</sub> ClN                                 | 109-09-1   | 113.546  | oil                      |         | 170                                   | 1.205 <sup>15</sup>        | 1.5320 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth                           |
| 2290 | 3-Chloropyridine                    |                                                      | C <sub>6</sub> H <sub>5</sub> ClN                                 | 626-60-8   | 113.546  |                          |         | 148; 86 <sup>100</sup>                |                            | 1.5304 <sup>20</sup> | sl H <sub>2</sub> O                                           |
| 2291 | 4-Chloropyridine                    |                                                      | C <sub>6</sub> H <sub>5</sub> ClN                                 | 626-61-9   | 113.546  | liq                      | -43.5   | 147.5                                 | 1.2000 <sup>25</sup>       |                      | s H <sub>2</sub> O; msc<br>EtOH                               |

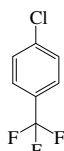


| No.  | Name                                                              | Synonym                          | Mol. Form.                                                                   | CAS RN    | Mol. Wt. | Physical Form          | mp/°C    | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|------|-------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------|-----------|----------|------------------------|----------|--------------------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 2292 | 2-Chloro-3-pyridinecarboxylic acid                                |                                  | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>                              | 2942-59-8 | 157.555  |                        | >175 dec |                                      |                            |                      |                                                     |
| 2293 | 6-Chloro-3-pyridinecarboxylic acid                                |                                  | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>                              | 5326-23-8 | 157.555  |                        | 198 dec  |                                      |                            |                      |                                                     |
| 2294 | 4-Chloropyridine, hydrochloride                                   |                                  | C <sub>5</sub> H <sub>5</sub> Cl <sub>2</sub> N                              | 7379-35-3 | 150.006  |                        |          | sub 210                              |                            |                      |                                                     |
| 2295 | Chloroquine                                                       |                                  | C <sub>18</sub> H <sub>26</sub> ClN <sub>3</sub>                             | 54-05-7   | 319.872  |                        | 90       |                                      |                            |                      |                                                     |
| 2296 | 2-Chloroquinoline                                                 |                                  | C <sub>9</sub> H <sub>6</sub> ClN                                            | 612-62-4  | 163.604  | nd (aq al)             | 38       | 266; 153 <sup>22</sup>               | 1.2464 <sup>25</sup>       | 1.6342 <sup>25</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz, chl         |
| 2297 | 4-Chloroquinoline                                                 |                                  | C <sub>9</sub> H <sub>6</sub> ClN                                            | 611-35-8  | 163.604  | cry                    | 34.5     | 262; 130 <sup>15</sup>               | 1.251 <sup>25</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth; s dil HCl        |
| 2298 | 6-Chloroquinoline                                                 |                                  | C <sub>9</sub> H <sub>6</sub> ClN                                            | 612-57-7  | 163.604  | pr (eth), nd (al)      | 43.8     | 263                                  |                            | 1.6110 <sup>56</sup> |                                                     |
| 2299 | 8-Chloroquinoline                                                 |                                  | C <sub>9</sub> H <sub>6</sub> ClN                                            | 611-33-6  | 163.604  | liq                    | -20      | 288.5                                | 1.2834 <sup>14</sup>       | 1.6408 <sup>14</sup> | s H <sub>2</sub> O; vs EtOH, eth, ace, bz, chl      |
| 2300 | 5-Chloro-8-quinolinol                                             | Cloxyquin                        | C <sub>9</sub> H <sub>6</sub> ClNO                                           | 130-16-5  | 179.603  | cry (al)               | 130      |                                      |                            |                      |                                                     |
| 2301 | 2-Chlorostyrene                                                   |                                  | C <sub>8</sub> H <sub>7</sub> Cl                                             | 2039-87-4 | 138.595  | liq                    | -63.1    | 188.7                                | 1.1000 <sup>20</sup>       | 1.5649 <sup>20</sup> | s EtOH, eth, ace, ctc, HOAc; msc peth               |
| 2302 | 3-Chlorostyrene                                                   |                                  | C <sub>8</sub> H <sub>7</sub> Cl                                             | 2039-85-2 | 138.595  |                        |          | 63 <sup>6</sup>                      | 1.1033 <sup>20</sup>       | 1.5625 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                     |
| 2303 | 4-Chlorostyrene                                                   |                                  | C <sub>8</sub> H <sub>7</sub> Cl                                             | 1073-67-2 | 138.595  |                        | 15.9     | 192                                  | 1.0868 <sup>20</sup>       | 1.5660 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, ctc   |
| 2304 | <i>N</i> -Chlorosuccinimide                                       |                                  | C <sub>4</sub> H <sub>4</sub> ClNO <sub>2</sub>                              | 128-09-6  | 133.534  | pl (CCl <sub>4</sub> ) | 150      |                                      | 1.65 <sup>25</sup>         |                      | sl H <sub>2</sub> O, EtOH, bz, lig; s ace, HOAc     |
| 2305 | 1-Chlorotetradecane                                               |                                  | C <sub>14</sub> H <sub>29</sub> Cl                                           | 2425-54-9 | 232.833  |                        | 4.9      | 296.8                                | 0.8654 <sup>20</sup>       | 1.4474 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, chl; vs ace, bz; sl ctc |
| 2306 | 6-Chloro- <i>N,N,N',N'</i> -tetraethyl-1,3,5-triazine-2,4-diamine |                                  | C <sub>11</sub> H <sub>20</sub> ClN <sub>5</sub>                             | 580-48-3  | 257.764  | oily liq               | 27       | 155 <sup>9</sup>                     | 1.0956 <sup>20</sup>       | 1.5320 <sup>20</sup> | vs bz, chl, EtOH, lig                               |
| 2307 | 1-Chloro-1,1,2,2-tetrafluoroethane                                |                                  | C <sub>2</sub> HClF <sub>4</sub>                                             | 354-25-6  | 136.476  | col gas                | -117     | -11.7                                |                            |                      |                                                     |
| 2308 | 1-Chloro-1,2,2,2-tetrafluoroethane                                |                                  | C <sub>2</sub> HClF <sub>4</sub>                                             | 2837-89-0 | 136.476  | col gas                |          | -12                                  |                            |                      |                                                     |
| 2309 | Chlorothalonil                                                    |                                  | C <sub>6</sub> Cl <sub>4</sub> N <sub>2</sub>                                | 1897-45-6 | 265.911  |                        | 250      | 350                                  | 1.7 <sup>25</sup>          |                      | i H <sub>2</sub> O; sl ace, cyhex                   |
| 2310 | Chlorothen                                                        | Chloromethapyrilene              | C <sub>14</sub> H <sub>16</sub> ClN <sub>2</sub> S                           | 148-65-2  | 295.831  |                        |          | 155 <sup>10</sup> , 192 <sup>5</sup> | 1.1751 <sup>25</sup>       |                      |                                                     |
| 2311 | Chlorothiazide                                                    |                                  | C <sub>7</sub> H <sub>6</sub> ClN <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 58-94-6   | 295.724  |                        | 350 dec  |                                      |                            |                      |                                                     |
| 2312 | 2-Chlorothiophene                                                 | 2-Thienyl chloride               | C <sub>4</sub> H <sub>3</sub> ClS                                            | 96-43-5   | 118.585  | liq                    | -71.9    | 128.3                                | 1.2863 <sup>20</sup>       | 1.5487 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl chl           |
| 2313 | 5-Chloro-2-thiophenecarboxaldehyde                                |                                  | C <sub>6</sub> H <sub>3</sub> ClOS                                           | 7283-96-7 | 146.595  |                        |          | 77.5 <sup>5</sup>                    |                            | 1.6036 <sup>25</sup> | sl chl                                              |
| 2314 | 2-Chloro-9 <i>H</i> -thioxanthen-9-one                            |                                  | C <sub>13</sub> H <sub>7</sub> ClOS                                          | 86-39-5   | 246.712  |                        | 153.5    |                                      |                            |                      |                                                     |
| 2315 | 2-Chlorotoluene                                                   |                                  | C <sub>7</sub> H <sub>7</sub> Cl                                             | 95-49-8   | 126.584  | liq                    | -35.8    | 159.0                                | 1.0825 <sup>20</sup>       | 1.5268 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz; msc eth, ace, chl   |
| 2316 | 3-Chlorotoluene                                                   |                                  | C <sub>7</sub> H <sub>7</sub> Cl                                             | 108-41-8  | 126.584  | liq                    | -47.8    | 161.8                                | 1.075 <sup>20</sup>        | 1.5214 <sup>19</sup> | i H <sub>2</sub> O; s EtOH, bz, ctc, chl; msc eth   |
| 2317 | 4-Chlorotoluene                                                   |                                  | C <sub>7</sub> H <sub>7</sub> Cl                                             | 106-43-4  | 126.584  |                        | 7.5      | 162.4                                | 1.0697 <sup>20</sup>       | 1.5150 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ctc, chl; msc eth       |
| 2318 | 6-Chloro-1,3,5-triazine-2,4-diamine                               |                                  | C <sub>3</sub> H <sub>4</sub> ClN <sub>5</sub>                               | 3397-62-4 | 145.551  |                        | >330     |                                      |                            |                      |                                                     |
| 2319 | 1-Chloro-2-(trichloromethyl)benzene                               |                                  | C <sub>7</sub> H <sub>4</sub> Cl <sub>4</sub>                                | 2136-89-2 | 229.919  |                        | 29.4     | 264.3                                | 1.5187 <sup>20</sup>       | 1.5836 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace; sl ctc              |
| 2320 | 1-Chloro-4-(trichloromethyl)benzene                               |                                  | C <sub>7</sub> H <sub>4</sub> Cl <sub>4</sub>                                | 5216-25-1 | 229.919  |                        |          | 245                                  | 1.4463 <sup>20</sup>       |                      | vs ace, eth                                         |
| 2321 | Chlorotriethoxysilane                                             |                                  | C <sub>6</sub> H <sub>15</sub> ClO <sub>3</sub> Si                           | 4667-99-6 | 198.720  | liq                    | -51      | 156                                  | 1.030 <sup>20</sup>        | 1.3999 <sup>20</sup> | vs EtOH                                             |
| 2322 | Chlorotriethylplumbane                                            | Lead triethyl chloride           | C <sub>6</sub> H <sub>15</sub> ClPb                                          | 1067-14-7 | 329.8    |                        | 123 dec  |                                      |                            |                      | s H <sub>2</sub> O                                  |
| 2323 | Chlorotriethylsilane                                              |                                  | C <sub>6</sub> H <sub>15</sub> ClSi                                          | 994-30-9  | 150.722  |                        |          | 144.5                                | 0.8967 <sup>20</sup>       | 1.4314 <sup>20</sup> |                                                     |
| 2324 | 1-Chloro-1,1,2-trifluoroethane                                    |                                  | C <sub>2</sub> H <sub>2</sub> ClF <sub>3</sub>                               | 421-04-5  | 118.485  | vol liq or gas         |          | 12                                   |                            |                      |                                                     |
| 2325 | 1-Chloro-1,2,2-trifluoroethane                                    |                                  | C <sub>2</sub> H <sub>2</sub> ClF <sub>3</sub>                               | 431-07-2  | 118.485  | vol liq or gas         |          | 17.3                                 |                            |                      |                                                     |
| 2326 | 2-Chloro-1,1,1-trifluoroethane                                    |                                  | C <sub>2</sub> H <sub>2</sub> ClF <sub>3</sub>                               | 75-88-7   | 118.485  | col gas                | -105.5   | 6.1                                  | 1.389 <sup>0</sup>         | 1.3090 <sup>0</sup>  |                                                     |
| 2327 | Chlorotrifluoroethene                                             | Chlorotrifluoroethylene          | C <sub>2</sub> ClF <sub>3</sub>                                              | 79-38-9   | 116.469  | col gas                | -158.2   | -27.8                                | 1.54 <sup>60</sup>         | 1.38 <sup>0</sup>    | s bz, chl                                           |
| 2328 | Chlorotrifluoromethane                                            | Refrigerant 13                   | CClF <sub>3</sub>                                                            | 75-72-9   | 104.459  | col gas                | -181.2   | -81.4                                |                            |                      | i H <sub>2</sub> O                                  |
| 2329 | 2-Chloro-5-(trifluoromethyl)aniline                               |                                  | C <sub>7</sub> H <sub>5</sub> ClF <sub>3</sub> N                             | 121-50-6  | 195.570  |                        |          | 103 <sup>25</sup>                    | 1.428 <sup>25</sup>        | 1.4975 <sup>20</sup> |                                                     |
| 2330 | 4-Chloro-3-(trifluoromethyl)aniline                               |                                  | C <sub>7</sub> H <sub>5</sub> ClF <sub>3</sub> N                             | 320-51-4  | 195.570  |                        | 36.5     | 132 <sup>27</sup>                    |                            |                      |                                                     |
| 2331 | 1-Chloro-2-(trifluoromethyl)benzene                               | <i>o</i> -Chlorobenzotrifluoride | C <sub>7</sub> H <sub>4</sub> ClF <sub>3</sub>                               | 88-16-4   | 180.555  | liq                    | -6       | 152.2                                | 1.2540 <sup>30</sup>       | 1.4513 <sup>25</sup> | s chl                                               |
| 2332 | 1-Chloro-3-(trifluoromethyl)benzene                               | <i>m</i> -Chlorobenzotrifluoride | C <sub>7</sub> H <sub>4</sub> ClF <sub>3</sub>                               | 98-15-7   | 180.555  | liq                    | -56      | 137.5                                | 1.3311 <sup>25</sup>       | 1.4438 <sup>25</sup> |                                                     |

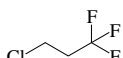




| No.  | Name                                                 | Synonym                                                                  | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                 |
|------|------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------|----------|------------------------------|---------|---------------------------|----------------------------|-----------------------|------------------------------------------------------------|
| 2333 | 1-Chloro-4-(trifluoromethyl)benzene                  | <i>p</i> -Chlorobenzotrifluoride                                         | C <sub>7</sub> H <sub>4</sub> ClF <sub>3</sub>                                 | 98-56-6    | 180.555  | liq                          | -33     | 138.5                     | 1.3340 <sup>25</sup>       | 1.4431 <sup>30</sup>  |                                                            |
| 2334 | 3-Chloro-1,1,1-trifluoropropane                      |                                                                          | C <sub>3</sub> H <sub>2</sub> ClF <sub>3</sub>                                 | 460-35-5   | 132.512  | liq                          | -106.5  | 45.1                      | 1.3253 <sup>20</sup>       | 1.3350 <sup>20</sup>  | i H <sub>2</sub> O                                         |
| 2335 | 2-Chloro-2,4,4-trimethylpentane                      |                                                                          | C <sub>9</sub> H <sub>17</sub> Cl                                              | 6111-88-2  | 148.674  |                              | -26     | dec 147; 44 <sup>16</sup> | 0.8746 <sup>20</sup>       | 1.4308 <sup>20</sup>  | vs EtOH                                                    |
| 2336 | Chlorotrimethylstannane                              |                                                                          | C <sub>3</sub> H <sub>9</sub> ClSn                                             | 1066-45-1  | 199.266  |                              | 38.5    | 148                       |                            |                       | s H <sub>2</sub> O, chl, os                                |
| 2337 | 2-Chloro-1,3,5-trinitrobenzene                       | Picryl chloride                                                          | C <sub>6</sub> H <sub>2</sub> ClN <sub>3</sub> O <sub>6</sub>                  | 88-88-0    | 247.549  | wh nd or pl<br>(chl, al-lig) | 83      |                           | 1.797 <sup>20</sup>        |                       | i H <sub>2</sub> O; s EtOH,<br>bz, sl eth; vs<br>ace, tol  |
| 2338 | Chlorotrinitromethane                                |                                                                          | CClN <sub>3</sub> O <sub>6</sub>                                               | 1943-16-4  | 185.480  |                              | 2.3     | dec 134; 56 <sup>40</sup> | 1.6769 <sup>20</sup>       | 1.4500 <sup>20</sup>  | vs eth, EtOH,<br>chl                                       |
| 2339 | Chlorotriphenylmethane                               |                                                                          | C <sub>19</sub> H <sub>15</sub> Cl                                             | 76-83-5    | 278.775  | nd or pr (bz-<br>peth)       | 113.5   | 310                       |                            |                       | i H <sub>2</sub> O; sl EtOH;<br>vs eth, bz, chl;<br>s ace  |
| 2340 | Chlorotriphenylsilane                                |                                                                          | C <sub>18</sub> H <sub>15</sub> ClSi                                           | 76-86-8    | 294.851  |                              |         | 241 <sup>35</sup>         |                            |                       |                                                            |
| 2341 | Chlorotriphenylstannane                              | Triphenyltin chloride                                                    | C <sub>18</sub> H <sub>15</sub> ClSn                                           | 639-58-7   | 385.475  |                              | 103.5   |                           |                            |                       | s chl                                                      |
| 2342 | Chlorotripropylstannane                              |                                                                          | C <sub>9</sub> H <sub>21</sub> ClSn                                            | 2279-76-7  | 283.426  |                              | -23.5   | 123 <sup>13</sup>         | 1.2678 <sup>28</sup>       | 1.49102 <sup>28</sup> | s ctc, os                                                  |
| 2343 | Chlorovinyl dimethylsilane                           |                                                                          | C <sub>4</sub> H <sub>6</sub> ClSi                                             | 1719-58-0  | 120.653  |                              |         | 83.5                      | 0.8744 <sup>20</sup>       | 1.4141 <sup>20</sup>  |                                                            |
| 2344 | Chloroxuron                                          | <i>N</i> '-[4-(4-Chlorophenoxy)phenyl]- <i>N,N</i> -dimethylurea         | C <sub>15</sub> H <sub>15</sub> ClN <sub>2</sub> O <sub>2</sub>                | 1982-47-4  | 290.745  |                              | 151     |                           |                            |                       |                                                            |
| 2345 | Chlorozotocin                                        |                                                                          | C <sub>9</sub> H <sub>16</sub> ClN <sub>3</sub> O <sub>7</sub>                 | 54749-90-5 | 313.692  | cry                          | 147 dec |                           |                            |                       | s H <sub>2</sub> O                                         |
| 2346 | Chlorphenesin carbamate                              |                                                                          | C <sub>10</sub> H <sub>12</sub> ClNO <sub>4</sub>                              | 886-74-8   | 245.660  | cry (bz)                     | 90      |                           |                            |                       | vs ace, EtOH,<br>diox                                      |
| 2347 | Chlorpheniramine                                     |                                                                          | C <sub>16</sub> H <sub>19</sub> ClN <sub>2</sub>                               | 132-22-9   | 274.788  | oily liq                     |         | 142 <sup>1</sup>          |                            |                       |                                                            |
| 2348 | Chlorpheniramine maleate                             | Chloropropenpyridamine                                                   | C <sub>20</sub> H <sub>23</sub> ClN <sub>2</sub> O <sub>4</sub>                | 113-92-8   | 390.861  |                              | 132.5   |                           |                            |                       |                                                            |
| 2349 | Chlorphentermine                                     | 2-(4-Chlorobenzyl)-2-propylamine                                         | C <sub>10</sub> H <sub>14</sub> ClN                                            | 461-78-9   | 183.678  | liq                          |         | 231; 101 <sup>2</sup>     |                            |                       |                                                            |
| 2350 | Chlorpromazine                                       | 2-Chloro- <i>N,N</i> -dimethyl-10 <i>H</i> -phenothiazine-10-propanamine | C <sub>17</sub> H <sub>19</sub> ClN <sub>2</sub> S                             | 50-53-3    | 318.864  |                              |         | 202 <sup>0.8</sup>        |                            |                       | i H <sub>2</sub> O; vs EtOH,<br>eth, bz, chl; s<br>dil HCl |
| 2351 | Chlorprothixene                                      |                                                                          | C <sub>18</sub> H <sub>18</sub> ClNS                                           | 113-59-7   | 315.861  | pale ye cry                  | 97      |                           |                            |                       | i H <sub>2</sub> O, EtOH,<br>eth, chl                      |
| 2352 | Chlorpyrifos                                         |                                                                          | C <sub>9</sub> H <sub>11</sub> Cl <sub>3</sub> NO <sub>3</sub> PS              | 2921-88-2  | 350.586  |                              | 42      |                           |                            |                       |                                                            |
| 2353 | Chlorpyrifos-methyl                                  |                                                                          | C <sub>7</sub> H <sub>7</sub> Cl <sub>3</sub> NO <sub>3</sub> PS               | 5598-13-0  | 322.534  |                              | 43      |                           |                            |                       |                                                            |
| 2354 | Chlorsulfuron                                        |                                                                          | C <sub>12</sub> H <sub>12</sub> ClN <sub>6</sub> O <sub>5</sub> S              | 64902-72-3 | 357.773  |                              | 176     |                           |                            |                       |                                                            |
| 2355 | Chlortetracycline                                    |                                                                          | C <sub>22</sub> H <sub>23</sub> ClN <sub>2</sub> O <sub>8</sub>                | 57-62-5    | 478.879  | gold-ye                      | 168.5   |                           |                            |                       | i H <sub>2</sub> O, eth; sl<br>EtOH, ace, bz;<br>s diox    |
| 2356 | Chlorthalidone                                       |                                                                          | C <sub>14</sub> H <sub>11</sub> ClN <sub>2</sub> O <sub>4</sub> S              | 77-36-1    | 338.765  | wh pow or<br>cry             | 225 dec |                           |                            |                       | s alk, EtOH; sl<br>eth                                     |
| 2357 | Chlorthion                                           |                                                                          | C <sub>8</sub> H <sub>9</sub> ClNO <sub>3</sub> PS                             | 500-28-7   | 297.653  | ye cry                       | 21      | 125 <sup>0.1</sup>        | 1.437 <sup>20</sup>        | 1.5661 <sup>20</sup>  | i H <sub>2</sub> O; vs bz, eth,<br>EtOH                    |
| 2358 | Chlorthiophos                                        |                                                                          | C <sub>11</sub> H <sub>15</sub> Cl <sub>2</sub> O <sub>3</sub> PS <sub>2</sub> | 21923-23-9 | 361.245  |                              |         | 150 <sup>0.001</sup>      |                            |                       |                                                            |
| 2359 | Chlortoluron                                         | <i>N</i> '-(3-Chloro-4-methylphenyl)- <i>N,N</i> -dimethylurea           | C <sub>10</sub> H <sub>13</sub> ClN <sub>2</sub> O                             | 15545-48-9 | 212.675  | cry                          | 147     |                           |                            |                       | sl H <sub>2</sub> O; s os                                  |
| 2360 | Cholane                                              |                                                                          | C <sub>24</sub> H <sub>42</sub>                                                | 548-98-1   | 330.590  | pr (al)                      | 90      | 190 <sup>0.001</sup>      |                            |                       |                                                            |
| 2361 | Cholan-24-oic acid                                   | Cholanic acid                                                            | C <sub>24</sub> H <sub>40</sub> O <sub>2</sub>                                 | 25312-65-6 | 360.574  | nd (al), cry<br>(HOAc)       | 163.5   |                           |                            |                       | s EtOH, chl,<br>HOAc                                       |
| 2362 | Cholesta-3,5-diene                                   |                                                                          | C <sub>27</sub> H <sub>44</sub>                                                | 747-90-0   | 368.638  | wh nd (al)                   | 80      | 260 <sup>13</sup>         | 0.925 <sup>100</sup>       |                       | i H <sub>2</sub> O; s EtOH;<br>msc eth, bz,<br>chl; vs lig |
| 2363 | Cholesta-5,7-dien-3-ol, (3β)                         | 7-Dehydrocholesterol                                                     | C <sub>27</sub> H <sub>44</sub> O                                              | 434-16-2   | 384.637  | pl (+1w),<br>(eth-<br>MeOH)  | 150.5   |                           |                            |                       | i H <sub>2</sub> O; sl EtOH;<br>s eth, ace                 |
| 2364 | Cholesta-8,24-dien-3-ol, (3β,5α)                     |                                                                          | C <sub>27</sub> H <sub>44</sub> O                                              | 128-33-6   | 384.637  | pl (MeOH)<br>,nd             | 110     | 160 <sup>0.001</sup>      |                            |                       | s ace, chl,<br>MeOH                                        |
| 2365 | Cholestane, (5α)                                     | 28,29,30-Trinorlanostane                                                 | C <sub>27</sub> H <sub>48</sub>                                                | 481-21-0   | 372.670  | sc or pl (eth-<br>al, ace)   | 80      | 250 <sup>1</sup>          | 0.9090 <sup>88</sup>       | 1.4887 <sup>88</sup>  | i H <sub>2</sub> O; sl EtOH;<br>vs eth, bz, chl            |
| 2366 | Cholestane, (5β)                                     | Coprostan                                                                | C <sub>27</sub> H <sub>48</sub>                                                | 481-20-9   | 372.670  | orth nd (al,<br>ace)         | 72      |                           | 0.9119 <sup>87</sup>       | 1.4884 <sup>88</sup>  | vs eth, chl                                                |
| 2367 | Cholestanol                                          | Dihydrocholesterol                                                       | C <sub>27</sub> H <sub>48</sub> O                                              | 80-97-7    | 388.669  | sc (al,+1w)                  | 141.5   |                           |                            |                       | vs eth, chl                                                |
| 2368 | Cholestan-3-ol, (3α,5α)                              | Epicholestanol                                                           | C <sub>27</sub> H <sub>48</sub> O                                              | 516-95-0   | 388.669  | nd (al)                      | 185.5   |                           |                            |                       | s chl                                                      |
| 2369 | Cholest-4-en-3-ol, (3β)                              | Allocholesterol                                                          | C <sub>27</sub> H <sub>48</sub> O                                              | 517-10-2   | 386.653  | nd (eth-<br>MeOH)            | 132     |                           |                            |                       | i H <sub>2</sub> O; s EtOH;<br>vs eth, ace, bz,<br>chl     |
| 2370 | Cholest-5-en-3-ol, (3α)                              | Epicholesterol                                                           | C <sub>27</sub> H <sub>48</sub> O                                              | 474-77-1   | 386.653  | cry (al, chl-<br>MeOH)       | 141.5   |                           |                            |                       | sl EtOH                                                    |
| 2371 | Cholest-5-en-3-ol (3β), acetate                      |                                                                          | C <sub>29</sub> H <sub>48</sub> O <sub>2</sub>                                 | 604-35-3   | 428.690  | wh nd (ace,<br>al)           | 115.5   |                           |                            |                       | vs bz, eth, chl                                            |
| 2372 | Cholest-5-en-3-ol (3β), benzoate                     |                                                                          | C <sub>34</sub> H <sub>50</sub> O <sub>2</sub>                                 | 604-32-0   | 490.760  | wh nd                        | 151.3   |                           | 0.9413 <sup>200</sup>      |                       | i EtOH; s eth,<br>chl                                      |
| 2373 | Cholest-5-en-3-ol (3β)-, hexadecanoate               |                                                                          | C <sub>43</sub> H <sub>76</sub> O <sub>2</sub>                                 | 601-34-3   | 625.062  | wh nd (eth<br>al)            | 79.3    |                           |                            |                       | vs bz, chl                                                 |
| 2374 | Cholest-5-en-3-ol (3β)-, <i>cis</i> -9-octadecenoate |                                                                          | C <sub>45</sub> H <sub>78</sub> O <sub>2</sub>                                 | 303-43-5   | 651.100  |                              | 46.3    |                           |                            |                       | s chl                                                      |



1-Chloro-4-(trifluoromethyl)benzene



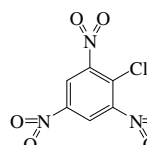
3-Chloro-1,1,1-trifluoropropane



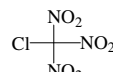
2-Chloro-2,4,4-trimethylpentane



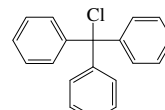
Chlorotrimethylstannane



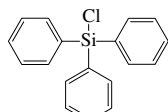
2-Chloro-1,3,5-trinitrobenzene



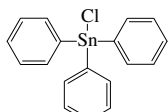
Chlorotrinitromethane



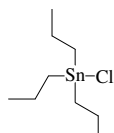
Chlorotriphenylmethane



Chlorotriphenylsilane



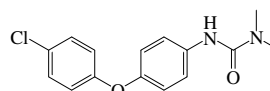
Chlorotriphenylstannane



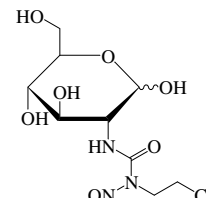
Chlorotripropylstannane



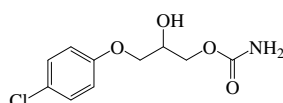
Chlorovinylidimethylsilane



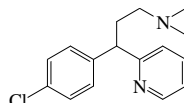
Chloroxuron



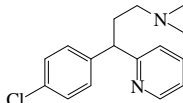
Chlorozotocin



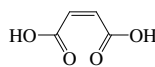
Chlorphenesin carbamate



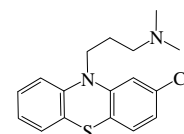
Chlorpheniramine



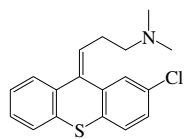
Chlorpheniramine maleate



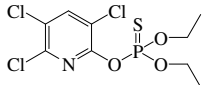
Chlorphentermine



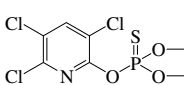
Chlorpromazine



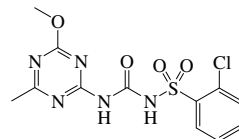
Chlorprothixene



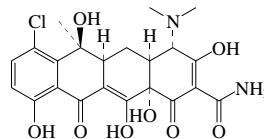
Chlorpyrifos



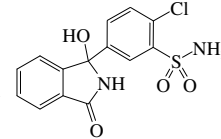
Chlorpyrifos-methyl



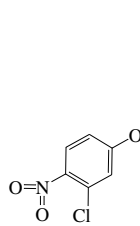
Chlorsulfuron



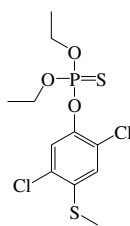
Chlortetracycline



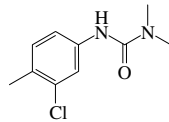
Chlorthalidone



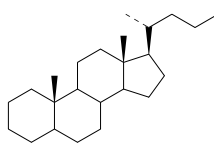
Chlorthion



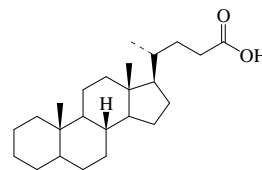
Chlorthiophos



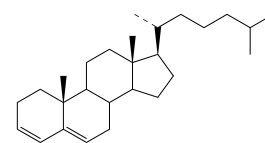
Chlortoluron



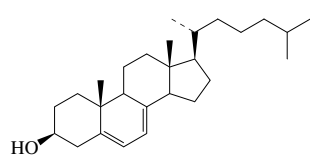
Cholan



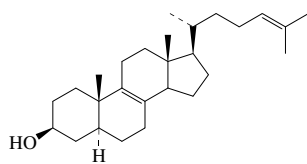
Cholan-24-oic acid



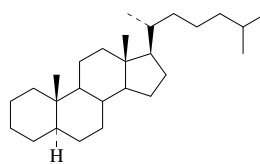
Cholesta-3,5-diene



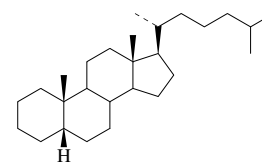
Cholesta-5,7-dien-3-ol, (3β)



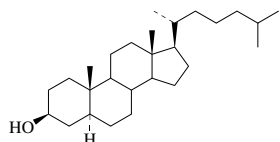
Cholesta-8,24-dien-3-ol, (3β,5α)



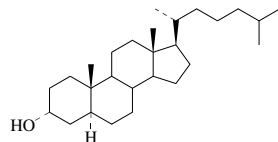
Cholestane, (5α)



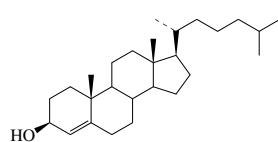
Cholestane, (5β)



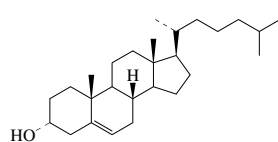
Cholesterol



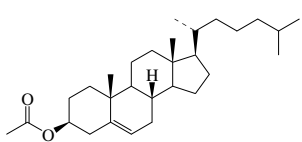
Cholestan-3-ol, (3α,5α)



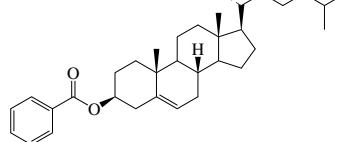
Cholest-4-en-3-ol, (3β)



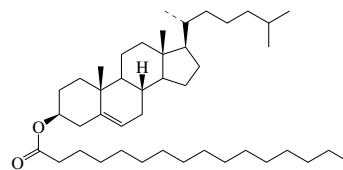
Cholest-5-en-3-ol, (3α)



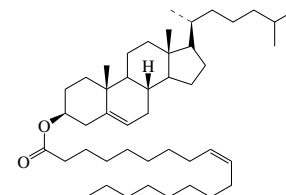
Cholest-5-en-3-ol (3β), acetate



Cholest-5-en-3-ol (3β), benzoate

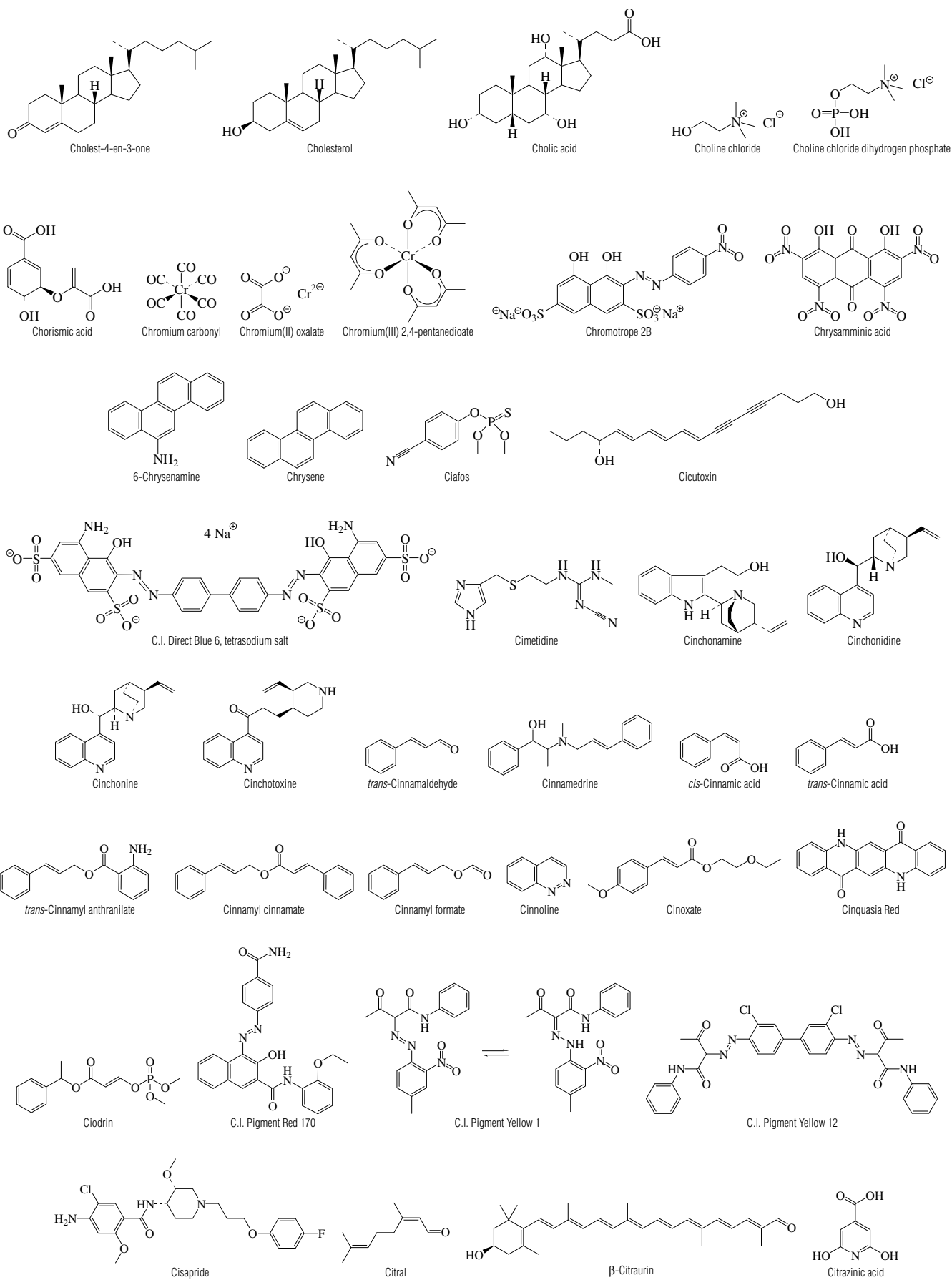


Cholest-5-en-3-ol (3β)-, hexadecanoate

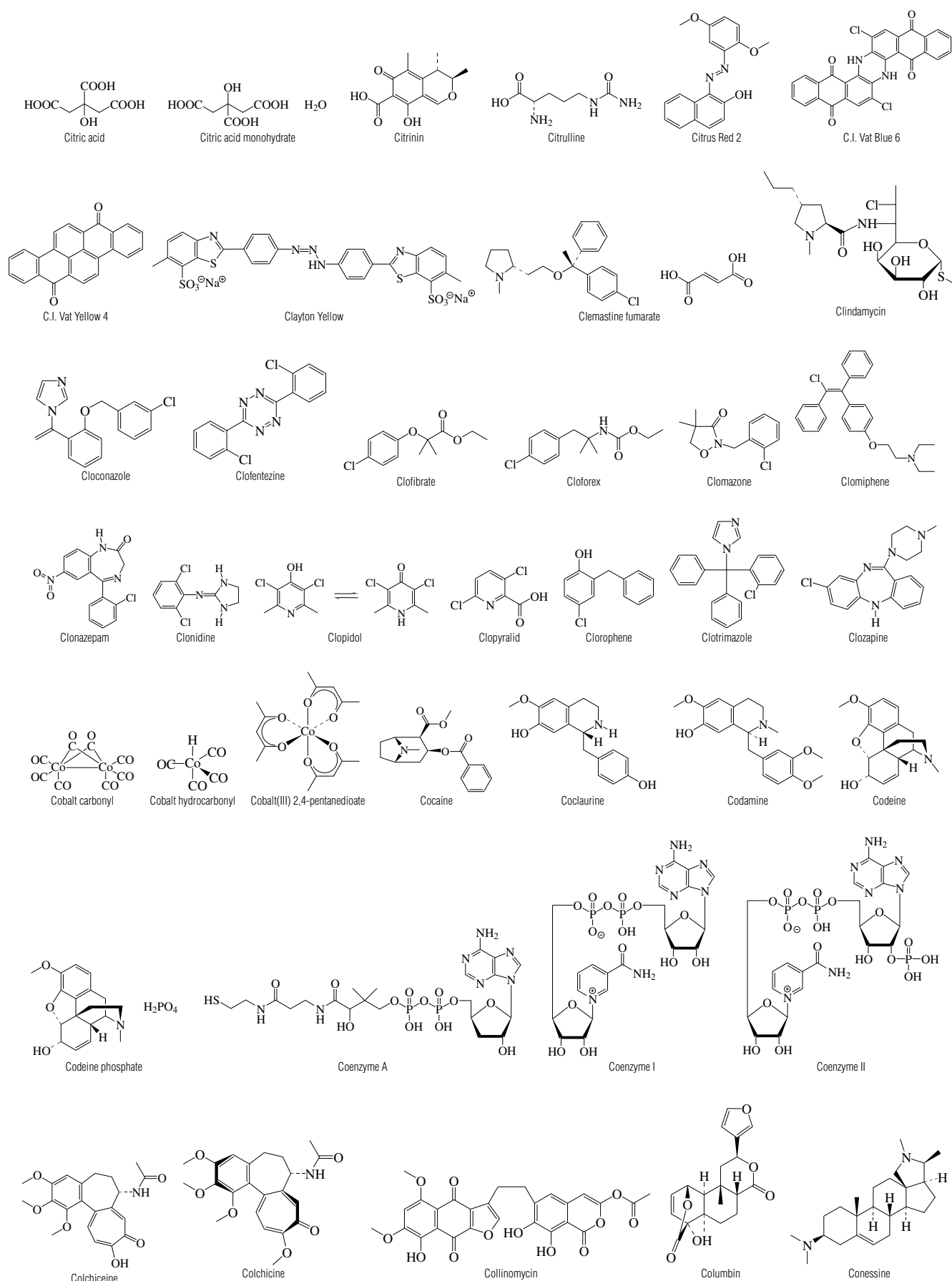


Cholest-5-en-3-ol (3β)-, cis-9-octadecenoate

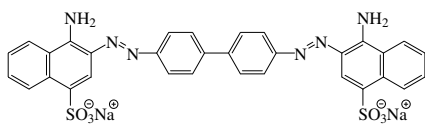
| No.  | Name                                  | Synonym                                                                                | Mol. Form.                                                                                    | CAS RN     | Mol. Wt. | Physical Form                         | mp/°C    | bp/°C                          | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                               |
|------|---------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------|----------|---------------------------------------|----------|--------------------------------|----------------------------|----------------------|--------------------------------------------------------------------------|
| 2375 | Cholest-4-en-3-one                    |                                                                                        | C <sub>27</sub> H <sub>44</sub> O                                                             | 601-57-0   | 384.637  | nd or pl (al)                         | 81.5     | 245 <sup>0.03</sup>            |                            |                      |                                                                          |
| 2376 | Cholesterol                           |                                                                                        | C <sub>27</sub> H <sub>46</sub> O                                                             | 57-88-5    | 386.653  | orth or tcl lf<br>(al) nd (eth)       | 148.5    | dec 360;<br>233 <sup>0.5</sup> | 1.067 <sup>20</sup>        |                      | i H <sub>2</sub> O; sl EtOH,<br>ace; s bz,<br>HOAc; vs diox              |
| 2377 | Cholic acid                           | 3,7,12-Trihydroxycholan-24-oic acid, (3 $\alpha$ ,5 $\beta$ ,7 $\alpha$ ,12 $\alpha$ ) | C <sub>24</sub> H <sub>40</sub> O <sub>5</sub>                                                | 81-25-4    | 408.572  |                                       | 198      |                                |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>ace, alk; vs<br>eth, chl                 |
| 2378 | Choline chloride                      |                                                                                        | C <sub>5</sub> H <sub>14</sub> ClNO                                                           | 67-48-1    | 139.624  | hyg cry                               | 305 dec  |                                |                            |                      | vs H <sub>2</sub> O, EtOH                                                |
| 2379 | Choline chloride dihydrogen phosphate | Phosphorylcholine                                                                      | C <sub>5</sub> H <sub>15</sub> ClNO <sub>4</sub> P                                            | 107-73-3   | 219.605  | visc liq                              |          |                                |                            |                      |                                                                          |
| 2380 | Chorismic acid                        |                                                                                        | C <sub>10</sub> H <sub>10</sub> O <sub>6</sub>                                                | 617-12-9   | 226.182  | cry                                   | 148      |                                |                            |                      | s H <sub>2</sub> O                                                       |
| 2381 | Chromium carbonyl                     |                                                                                        | C <sub>6</sub> CrO <sub>6</sub>                                                               | 13007-92-6 | 220.056  | col orth cry                          | dec 130  | sub                            | 1.77                       |                      | i H <sub>2</sub> O, EtOH; s<br>eth, chl                                  |
| 2382 | Chromium(II) oxalate                  |                                                                                        | C <sub>2</sub> CrO <sub>4</sub>                                                               | 814-90-4   | 140.015  | ye-grn pow<br>(hyd)                   |          |                                |                            |                      | i H <sub>2</sub> O, EtOH; s<br>dil acid                                  |
| 2383 | Chromium(III) 2,4-pentanedioate       | Chromium acetylacetonate                                                               | C <sub>15</sub> H <sub>21</sub> CrO <sub>6</sub>                                              | 21679-31-2 | 349.320  | red mcl cry                           | 208      | 345                            | 1.34                       |                      | i H <sub>2</sub> O; s bz                                                 |
| 2384 | Chromotrope 2B                        |                                                                                        | C <sub>18</sub> H <sub>19</sub> N <sub>3</sub> Na <sub>2</sub> O <sub>10</sub> S <sub>2</sub> | 548-80-1   | 513.366  | red-br pow                            | 300      |                                |                            |                      | s H <sub>2</sub> O; i EtOH                                               |
| 2385 | Chrysaminic acid                      | 1,8-Dihydroxy-2,4,5,7-tetranitro-9,10-anthracenedione                                  | C <sub>14</sub> H <sub>4</sub> N <sub>4</sub> O <sub>12</sub>                                 | 517-92-0   | 420.202  | ye pl or lf                           | exp      | dec                            |                            |                      | vs eth, EtOH                                                             |
| 2386 | 6-Chrysenamine                        | 6-Aminochrysene                                                                        | C <sub>18</sub> H <sub>13</sub> N                                                             | 2642-98-0  | 243.303  | lf (al)                               | 210.5    |                                |                            |                      |                                                                          |
| 2387 | Chrysene                              | Benzo[a]phenanthrene                                                                   | C <sub>18</sub> H <sub>12</sub>                                                               | 218-01-9   | 228.288  | red bl lf or<br>orth pl (bz,<br>HOAc) | 255.5    | 448                            | 1.274 <sup>20</sup>        |                      | i H <sub>2</sub> O; sl EtOH,<br>eth, ace, bz,<br>CS <sub>2</sub> ; s tol |
| 2388 | Ciafos                                |                                                                                        | C <sub>9</sub> H <sub>10</sub> NO <sub>3</sub> PS                                             | 2636-26-2  | 243.219  | ye to red-ye<br>liq                   | 15       | 120 <sup>0.03</sup> dec        |                            | 1.5404 <sup>32</sup> | sl H <sub>2</sub> O; vs chl,<br>EtOH, ace,<br>MeOH                       |
| 2389 | Cicutoxin                             | 8,10,12-Heptadecatriene-4,6-diyne-1,14-diol                                            | C <sub>17</sub> H <sub>22</sub> O <sub>2</sub>                                                | 505-75-9   | 258.356  | pr (eth/peth)                         | 54       |                                |                            |                      | s hot H <sub>2</sub> O,<br>EtOH, eth, chl                                |
| 2390 | C.I. Direct Blue 6, tetrasodium salt  | Direct Blue 6                                                                          | C <sub>32</sub> H <sub>20</sub> N <sub>6</sub> Na <sub>4</sub> O <sub>14</sub> S <sub>4</sub> | 2602-46-2  | 932.752  | dk bronze<br>pow                      |          |                                |                            |                      |                                                                          |
| 2391 | Cimetidine                            |                                                                                        | C <sub>10</sub> H <sub>16</sub> N <sub>6</sub> S                                              | 51481-61-9 | 252.339  | cry                                   | 142      |                                |                            |                      |                                                                          |
| 2392 | Cinchonamine                          |                                                                                        | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub> O                                              | 482-28-0   | 296.406  | orth nd (al)<br>orth pr<br>(MeOH)     | 186      |                                |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth; s bz, chl                           |
| 2393 | Cinchonidine                          |                                                                                        | C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> O                                              | 485-71-2   | 294.390  | or pl or pr<br>(al)                   | 210.5    | sub                            |                            |                      | i H <sub>2</sub> O, bz; s<br>EtOH, chl, py;<br>sl eth                    |
| 2394 | Cinchonine                            |                                                                                        | C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> O                                              | 118-10-5   | 294.390  | pr nd (al,<br>eth)                    | 265      |                                |                            |                      |                                                                          |
| 2395 | Cinchotoxine                          |                                                                                        | C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> O                                              | 69-24-9    | 294.390  | nd or pr (eth)                        | 59       |                                |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth, ace, bz,<br>chl                     |
| 2396 | trans-Cinnamaldehyde                  | 3-Phenyl-2-propenal, (E)-                                                              | C <sub>9</sub> H <sub>8</sub> O                                                               | 14371-10-9 | 132.159  | ye liq                                | -7.5     | 246                            | 1.0497 <sup>20</sup>       | 1.6195 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth, chl; i lig                          |
| 2397 | Cinnamedrine                          | $\alpha$ -[1-[Methyl(3-phenylallyl)amino]ethyl]benzenemethanol                         | C <sub>19</sub> H <sub>23</sub> NO                                                            | 90-86-8    | 281.392  |                                       | 75       |                                |                            |                      |                                                                          |
| 2398 | cis-Cinnamic acid                     | 3-Phenyl-2-propenoic acid, (Z)                                                         | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                                                  | 102-94-3   | 148.159  | mcl pr (w)                            | 42       |                                |                            |                      | vs EtOH, HOAc,<br>lig                                                    |
| 2399 | trans-Cinnamic acid                   | 3-Phenyl-2-propenoic acid, (E)                                                         | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                                                  | 140-10-3   | 148.159  | mcl pr (dil<br>al)                    | 133      | 300                            | 1.2475 <sup>4</sup>        |                      | i H <sub>2</sub> O, lig; vs<br>EtOH; s eth,<br>ace, bz                   |
| 2400 | trans-Cinnamyl anthranilate           |                                                                                        | C <sub>18</sub> H <sub>15</sub> NO <sub>2</sub>                                               | 87-29-6    | 253.296  | cry                                   | 64       |                                |                            |                      |                                                                          |
| 2401 | Cinnamyl cinnamate                    |                                                                                        | C <sub>18</sub> H <sub>16</sub> O <sub>2</sub>                                                | 122-69-0   | 264.319  | nd (al)                               | 44       |                                | 1.1565 <sup>4</sup>        |                      | i H <sub>2</sub> O; s EtOH,<br>chl; vs eth                               |
| 2402 | Cinnamyl formate                      | 3-Phenyl-2-propen-1-ol, formate                                                        | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                                                | 104-65-4   | 162.185  |                                       | 0        | 252                            | 1.086 <sup>25</sup>        |                      |                                                                          |
| 2403 | Cinnoline                             | 1,2-Benzodiazine                                                                       | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                                                  | 253-66-7   | 130.147  | pa ye cry<br>(lig)                    | 38       | 114 <sup>0.3</sup>             |                            |                      | vs eth, EtOH                                                             |
| 2404 | Cinoxate                              | 3-(4-Methoxyphenyl)-2-propenoic acid, 2-ethoxyethyl ester                              | C <sub>14</sub> H <sub>16</sub> O <sub>4</sub>                                                | 104-28-9   | 250.291  | col liq                               | -25      | 185 <sup>2</sup>               | 1.102 <sup>25</sup>        | 1.567 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH                                             |
| 2405 | Cinquasia Red                         | Quinacridone                                                                           | C <sub>20</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                                 | 1047-16-1  | 312.321  | red-viol cry                          | 390      |                                |                            |                      | i H <sub>2</sub> O, os                                                   |
| 2406 | Ciodrin                               |                                                                                        | C <sub>14</sub> H <sub>19</sub> O <sub>6</sub> P                                              | 7700-17-6  | 314.271  |                                       |          | 135 <sup>0.03</sup>            | 1.19 <sup>25</sup>         |                      |                                                                          |
| 2407 | C.I. Pigment Red 170                  |                                                                                        | C <sub>26</sub> H <sub>22</sub> N <sub>4</sub> O <sub>4</sub>                                 | 2786-76-7  | 454.478  | red solid                             |          |                                |                            |                      |                                                                          |
| 2408 | C.I. Pigment Yellow 1                 |                                                                                        | C <sub>17</sub> H <sub>16</sub> N <sub>4</sub> O <sub>4</sub>                                 | 2512-29-0  | 340.334  | ye cry                                | 256      |                                |                            |                      |                                                                          |
| 2409 | C.I. Pigment Yellow 12                |                                                                                        | C <sub>32</sub> H <sub>26</sub> Cl <sub>2</sub> N <sub>6</sub> O <sub>4</sub>                 | 6358-85-6  | 629.492  | ye cry                                | 317      |                                |                            |                      |                                                                          |
| 2410 | Cisapride                             |                                                                                        | C <sub>23</sub> H <sub>29</sub> ClFN <sub>3</sub> O <sub>4</sub>                              | 81098-60-4 | 465.945  | cry (hp)                              | 132      |                                |                            |                      |                                                                          |
| 2411 | Citral                                | 3,7-Dimethyl-2,6-octadienal                                                            | C <sub>10</sub> H <sub>16</sub> O                                                             | 5392-40-5  | 152.233  |                                       |          | 228.3                          | 0.8888 <sup>20</sup>       | 1.4898 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                                     |
| 2412 | $\beta$ -Citraurin                    |                                                                                        | C <sub>30</sub> H <sub>40</sub> O <sub>2</sub>                                                | 650-69-1   | 432.638  | pl (bz-peth),<br>cry (al)             | 147      |                                |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth, ace, bz; sl<br>lig                  |
| 2413 | Citrazinic acid                       | 1,2-Dihydro-6-hydroxy-2-oxo-4-pyridinecarboxylic acid                                  | C <sub>6</sub> H <sub>5</sub> NO <sub>4</sub>                                                 | 99-11-6    | 155.109  | ye pow                                | >300 dec |                                |                            |                      | s H <sub>2</sub> O, alk; sl<br>HCl                                       |



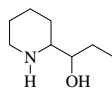
| No.  | Name                          | Synonym                                                | Mol. Form.                                                                                   | CAS RN     | Mol. Wt. | Physical Form               | mp/°C | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|-------------------------------|--------------------------------------------------------|----------------------------------------------------------------------------------------------|------------|----------|-----------------------------|-------|----------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 2414 | Citric acid                   | 2-Hydroxy-1,2,3-propanetricarboxylic acid              | C <sub>6</sub> H <sub>8</sub> O <sub>7</sub>                                                 | 77-92-9    | 192.124  | orth (w+1)                  | 153   | dec                                    | 1.665 <sup>20</sup>        |                      | vs H <sub>2</sub> O, EtOH; s eth, AcOEt; i bz, chl           |
| 2415 | Citric acid monohydrate       | 2-Hydroxy-1,2,3-propanetricarboxylic acid, monohydrate | C <sub>6</sub> H <sub>10</sub> O <sub>8</sub>                                                | 5949-29-1  | 210.138  | cry (w)                     | 135   |                                        | 1.542                      |                      | vs H <sub>2</sub> O; vs EtOH, eth                            |
| 2416 | Citrinin                      | Antimycin                                              | C <sub>13</sub> H <sub>14</sub> O <sub>5</sub>                                               | 518-75-2   | 250.247  | ye nd (MeOH)                | 178   | dec                                    |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s ace, bz                  |
| 2417 | Citrulline                    | N <sup>5</sup> -(Aminocarbonyl)-L-ornithine            | C <sub>6</sub> H <sub>13</sub> N <sub>3</sub> O <sub>3</sub>                                 | 372-75-8   | 175.185  | pr (aq MeOH)                | 222   |                                        |                            |                      | s H <sub>2</sub> O; i EtOH, MeOH                             |
| 2418 | Citrus Red 2                  |                                                        | C <sub>18</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub>                                | 6358-53-8  | 308.331  | cry                         | 156   |                                        |                            |                      | sl H <sub>2</sub> O; s EtOH                                  |
| 2419 | C.I. Vat Blue 6               | 7,16-Dichloro-6,15-dihydro-5,9,14,18-anthrazinetetrone | C <sub>28</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>4</sub>                | 130-20-1   | 511.312  | viol-bl pow                 |       |                                        |                            |                      |                                                              |
| 2420 | C.I. Vat Yellow 4             | Anthanthrone                                           | C <sub>24</sub> H <sub>12</sub> O <sub>2</sub>                                               | 128-66-5   | 332.351  | ye cry                      |       |                                        |                            |                      |                                                              |
| 2421 | Clayton Yellow                | Thiazol Yellow G                                       | C <sub>28</sub> H <sub>18</sub> N <sub>4</sub> Na <sub>2</sub> O <sub>6</sub> S <sub>4</sub> | 1829-00-1  | 695.721  | ye-br pow                   |       |                                        |                            |                      | s H <sub>2</sub> O, EtOH, H <sub>2</sub> SO <sub>4</sub>     |
| 2422 | Clemastine fumarate           |                                                        | C <sub>25</sub> H <sub>30</sub> ClNO <sub>5</sub>                                            | 14976-57-9 | 459.963  |                             | 181   |                                        |                            |                      |                                                              |
| 2423 | Clindamycin                   |                                                        | C <sub>18</sub> H <sub>33</sub> ClN <sub>2</sub> O <sub>5</sub> S                            | 18323-44-9 | 424.983  | ye amorp solid              |       |                                        |                            |                      | s EtOAc                                                      |
| 2424 | Cloconazole                   |                                                        | C <sub>18</sub> H <sub>15</sub> ClN <sub>2</sub> O                                           | 77175-51-0 | 310.777  |                             | 73    |                                        |                            |                      |                                                              |
| 2425 | Clofentazine                  | 3,6-Bis(2-chlorophenyl)-1,2,4,5-tetrazine              | C <sub>14</sub> H <sub>8</sub> Cl <sub>2</sub> N <sub>4</sub>                                | 74115-24-5 | 303.147  |                             | 182   |                                        |                            |                      |                                                              |
| 2426 | Clofibrate                    |                                                        | C <sub>12</sub> H <sub>15</sub> ClO <sub>3</sub>                                             | 637-07-0   | 242.698  |                             |       | 149 <sup>20</sup>                      |                            |                      |                                                              |
| 2427 | Cloforex                      |                                                        | C <sub>13</sub> H <sub>18</sub> ClNO <sub>2</sub>                                            | 14261-75-7 | 255.741  | cry                         | 52.8  | 89 <sup>005</sup>                      |                            |                      |                                                              |
| 2428 | Clomazone                     | 2-(2-Chlorobenzyl)-4,4-dimethyl-1,2-oxazolidin-3-one   | C <sub>12</sub> H <sub>14</sub> ClNO <sub>2</sub>                                            | 81777-89-1 | 239.698  |                             |       |                                        | 1.192 <sup>20</sup>        |                      |                                                              |
| 2429 | Clomiphene                    |                                                        | C <sub>26</sub> H <sub>28</sub> ClNO                                                         | 911-45-5   | 405.959  |                             | 117   |                                        |                            |                      |                                                              |
| 2430 | Clonazepam                    |                                                        | C <sub>15</sub> H <sub>10</sub> ClN <sub>3</sub> O <sub>3</sub>                              | 1622-61-3  | 315.711  | wh cry                      | 237.5 |                                        |                            |                      | i H <sub>2</sub> O, bz; sl ace, MeOH, chl                    |
| 2431 | Clonidine                     |                                                        | C <sub>9</sub> H <sub>9</sub> Cl <sub>2</sub> N <sub>3</sub>                                 | 4205-90-7  | 230.093  | cry                         | 137   |                                        |                            |                      |                                                              |
| 2432 | Clopidol                      |                                                        | C <sub>7</sub> H <sub>7</sub> Cl <sub>2</sub> NO                                             | 2971-90-6  | 192.043  | pow                         | >320  |                                        |                            |                      | i H <sub>2</sub> O                                           |
| 2433 | Clopyralid                    | 3,6-Dichloro-2-pyridinecarboxylic acid                 | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>                                | 1702-17-6  | 192.000  |                             | 151   |                                        |                            |                      |                                                              |
| 2434 | Clorophene                    |                                                        | C <sub>13</sub> H <sub>11</sub> ClO                                                          | 120-32-1   | 218.678  |                             | 48.5  | 161 <sup>3.5</sup>                     | 1.185 <sup>58</sup>        |                      | s ctc, CS <sub>2</sub>                                       |
| 2435 | Clotrimazole                  |                                                        | C <sub>22</sub> H <sub>17</sub> ClN <sub>2</sub>                                             | 23593-75-1 | 344.836  | cry                         | 148   |                                        |                            |                      | sl H <sub>2</sub> O, bz; s ace, chl, AcOEt, DMF              |
| 2436 | Clozapine                     | Clozaril                                               | C <sub>18</sub> H <sub>19</sub> ClN <sub>4</sub>                                             | 5786-21-0  | 326.824  | ye cry                      | 183.5 |                                        |                            |                      |                                                              |
| 2437 | Cobalt carbonyl               | Dicobalt octacarbonyl                                  | C <sub>8</sub> Co <sub>2</sub> O <sub>8</sub>                                                | 10210-68-1 | 341.947  | oran cry                    | 51    | dec                                    | 1.78                       |                      | i H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub>             |
| 2438 | Cobalt hydrocarbonyl          | Tetracarbonylhydrocobalt                               | C <sub>4</sub> HCoO <sub>4</sub>                                                             | 16842-03-8 | 171.982  | ye liq or gas               | ≈-30  | 10                                     |                            |                      | s os                                                         |
| 2439 | Cobalt(III) 2,4-pentanedioate | Cobalt(III) acetylacetonate                            | C <sub>15</sub> H <sub>21</sub> CoO <sub>6</sub>                                             | 21679-46-9 | 356.257  |                             | 240   |                                        |                            |                      |                                                              |
| 2440 | Cocaine                       |                                                        | C <sub>17</sub> H <sub>21</sub> NO <sub>4</sub>                                              | 50-36-2    | 303.354  | mcl pr (al)                 | 98    | 187 <sup>0.1</sup>                     |                            | 1.5022 <sup>28</sup> | sl H <sub>2</sub> O; vs EtOH, eth, bz, py; s CS <sub>2</sub> |
| 2441 | Coclaurine                    |                                                        | C <sub>17</sub> H <sub>19</sub> NO <sub>3</sub>                                              | 486-39-5   | 285.338  | pl (al)                     | 220.5 |                                        |                            |                      |                                                              |
| 2442 | Codamine                      |                                                        | C <sub>20</sub> H <sub>25</sub> NO <sub>4</sub>                                              | 21040-59-5 | 343.418  | pr (bz, eth)                | 127   |                                        |                            |                      | vs eth, EtOH, chl                                            |
| 2443 | Codeine                       |                                                        | C <sub>18</sub> H <sub>21</sub> NO <sub>3</sub>                                              | 76-57-3    | 299.365  | orth cry (w, dil al, eth)   | 157.5 | 250 <sup>22</sup> , 140 <sup>1.5</sup> | 1.32 <sup>25</sup>         |                      | s H <sub>2</sub> O, eth, bz, chl, tol; vs EtOH; i peth       |
| 2444 | Codeine phosphate             |                                                        | C <sub>18</sub> H <sub>24</sub> NO <sub>7</sub> P                                            | 52-28-8    | 397.361  | lf or pr (dil al)           | 227   | dec                                    |                            |                      | vs EtOH, chl                                                 |
| 2445 | Coenzyme A                    |                                                        | C <sub>21</sub> H <sub>36</sub> N <sub>7</sub> O <sub>16</sub> P <sub>3</sub> S              | 85-61-0    | 767.535  | pow; unstab in air          |       |                                        |                            |                      | s H <sub>2</sub> O                                           |
| 2446 | Coenzyme I                    | Nicotinamide adenine dinucleotide                      | C <sub>21</sub> H <sub>27</sub> N <sub>7</sub> O <sub>14</sub> P <sub>2</sub>                | 53-84-9    | 663.425  | hyg pow                     |       |                                        |                            |                      | s H <sub>2</sub> O                                           |
| 2447 | Coenzyme II                   | Nicotinamide adenine dinucleotide phosphate            | C <sub>21</sub> H <sub>28</sub> N <sub>7</sub> O <sub>17</sub> P <sub>3</sub>                | 53-59-8    | 743.405  | gray-wh pow                 |       |                                        |                            |                      | s H <sub>2</sub> O                                           |
| 2448 | Colchicine                    |                                                        | C <sub>21</sub> H <sub>23</sub> NO <sub>6</sub>                                              | 477-27-0   | 385.411  | pa ye nd (diox)             | 178.5 |                                        | 1.24 <sup>25</sup>         |                      | sl H <sub>2</sub> O; vs EtOH, chl; i eth, bz                 |
| 2449 | Colchicine                    |                                                        | C <sub>22</sub> H <sub>25</sub> NO <sub>6</sub>                                              | 64-86-8    | 399.437  | ye pl (w + 1/2) ye cry (bz) | 156   |                                        |                            |                      | vs H <sub>2</sub> O, EtOH                                    |
| 2450 | Colistin A                    |                                                        | C <sub>53</sub> H <sub>100</sub> N <sub>16</sub> O <sub>13</sub>                             | 7722-44-3  | 1169.47  | amorp pow                   |       |                                        |                            |                      | sl H <sub>2</sub> O, EtOH, hx; s acids, MeOH                 |
| 2451 | Collinomycin                  |                                                        | C <sub>27</sub> H <sub>20</sub> O <sub>12</sub>                                              | 27267-69-2 | 536.441  | oran pr (chl-MeOH)          | 281   |                                        |                            |                      | vs ace, diox, chl                                            |
| 2452 | Columbin                      |                                                        | C <sub>20</sub> H <sub>22</sub> O <sub>6</sub>                                               | 546-97-4   | 358.385  | nd (MeOH)                   | 195.5 |                                        |                            |                      | i H <sub>2</sub> O; sl ace, AcOEt, MeOH; s chl               |
| 2453 | Conessine                     |                                                        | C <sub>24</sub> H <sub>40</sub> N <sub>2</sub>                                               | 546-06-5   | 356.588  | lf or pl (ace)              | 125.5 | 166 <sup>0.1</sup>                     |                            |                      | sl H <sub>2</sub> O; s chl, HOAc                             |



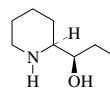
| No.  | Name                                 | Synonym                                                                        | Mol. Form.                                                                                   | CAS RN     | Mol. Wt. | Physical Form                      | mp/°C   | bp/°C               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                          |
|------|--------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------|----------|------------------------------------|---------|---------------------|----------------------------|----------------------|---------------------------------------------------------------------|
| 2454 | Congo Red                            |                                                                                | C <sub>32</sub> H <sub>22</sub> N <sub>6</sub> Na <sub>2</sub> O <sub>6</sub> S <sub>2</sub> | 573-58-0   | 696.663  | pow                                | >360    |                     |                            |                      | sl H <sub>2</sub> O; s EtOH;<br>i eth                               |
| 2455 | Conhydrine                           |                                                                                | C <sub>8</sub> H <sub>17</sub> NO                                                            | 3238-62-8  | 143.227  | nd (peth)                          | 121     | 226                 |                            |                      | sl H <sub>2</sub> O; vs bz,<br>eth, EtOH                            |
| 2456 | Conhydrine, (+)                      | 2-( $\alpha$ -Hydroxypropyl)piperidine                                         | C <sub>8</sub> H <sub>17</sub> NO                                                            | 495-20-5   | 143.227  | lf (eth)                           | 121     | 226                 |                            |                      | sl H <sub>2</sub> O; vs eth,<br>EtOH, chl                           |
| 2457 | Coniferin                            |                                                                                | C <sub>16</sub> H <sub>22</sub> O <sub>8</sub>                                               | 531-29-3   | 342.341  | nd (w+2)                           | 186     |                     |                            |                      | s H <sub>2</sub> O, py; sl<br>EtOH; i eth                           |
| 2458 | Conquinamine                         |                                                                                | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>                                | 464-86-8   | 312.406  | ye tetr                            | 123     |                     |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, chl                            |
| 2459 | Convallatoxin                        |                                                                                | C <sub>29</sub> H <sub>42</sub> O <sub>10</sub>                                              | 508-75-8   | 550.637  | pr (eth/<br>MeOH)                  | 238     |                     |                            |                      | s EtOH, ace; sl<br>chl; i eth                                       |
| 2460 | Copaene                              |                                                                                | C <sub>15</sub> H <sub>24</sub>                                                              | 3856-25-5  | 204.352  |                                    |         | 248.5               | 0.8996 <sup>20</sup>       | 1.4894 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace,<br>HOAc, lig                        |
| 2461 | Copper(II) ethylacetoacetate         | Bis(ethylacetoacetato)copper                                                   | C <sub>12</sub> H <sub>16</sub> CuO <sub>6</sub>                                             | 14284-06-1 | 321.813  | grn cry<br>(EtOH)                  | 192     |                     |                            |                      | s EtOH, chl                                                         |
| 2462 | Copper(II) gluconate                 | Cupric gluconate                                                               | C <sub>12</sub> H <sub>22</sub> CuO <sub>14</sub>                                            | 527-09-3   | 453.841  | bl-grn cry                         | 156     |                     |                            |                      | sl EtOH; i os                                                       |
| 2463 | Copper(II) 2,4-pentanedioate         | Copper(II) acetylacetonate                                                     | C <sub>10</sub> H <sub>14</sub> CuO <sub>4</sub>                                             | 13395-16-9 | 261.762  | bl pow                             | 284 dec | sub                 |                            |                      | sl H <sub>2</sub> O; s chl                                          |
| 2464 | Copper phthalocyanine                | Pigment Blue 15                                                                | C <sub>32</sub> H <sub>16</sub> CuN <sub>8</sub>                                             | 147-14-8   | 576.069  | bl-purp cry                        |         |                     |                            |                      | i H <sub>2</sub> O, EtOH; s<br>conc H <sub>2</sub> SO <sub>4</sub>  |
| 2465 | Coronene                             |                                                                                | C <sub>24</sub> H <sub>12</sub>                                                              | 191-07-1   | 300.352  | ye nd (bz)                         | 437.4   | 525                 | 1.371 <sup>25</sup>        |                      | i H <sub>2</sub> O, con sulf;<br>sl bz                              |
| 2466 | Corticosterone                       |                                                                                | C <sub>21</sub> H <sub>30</sub> O <sub>4</sub>                                               | 50-22-6    | 346.461  | nd (al, pl)<br>(ace)               | 181     |                     |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, ace                             |
| 2467 | Corybulbine                          |                                                                                | C <sub>21</sub> H <sub>25</sub> NO <sub>4</sub>                                              | 518-77-4   | 355.429  | nd (al)                            | 237.5   |                     |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>eth; s ace, bz,<br>HCl              |
| 2468 | Corycavamine                         |                                                                                | C <sub>21</sub> H <sub>21</sub> NO <sub>5</sub>                                              | 521-85-7   | 367.396  | pr (eth, al)                       | 149     |                     |                            |                      | vs EtOH, chl                                                        |
| 2469 | Corydaline                           |                                                                                | C <sub>22</sub> H <sub>27</sub> NO <sub>4</sub>                                              | 518-69-4   | 369.454  | pr (al)                            | 136     |                     |                            |                      | vs bz, eth, EtOH,<br>chl                                            |
| 2470 | Corydine                             |                                                                                | C <sub>20</sub> H <sub>23</sub> NO <sub>4</sub>                                              | 476-69-7   | 341.402  | tetr pr (eth)                      | 149     |                     |                            |                      | vs eth, EtOH,<br>chl                                                |
| 2471 | Corynantheine                        |                                                                                | C <sub>22</sub> H <sub>26</sub> N <sub>2</sub> O <sub>3</sub>                                | 18904-54-6 | 366.452  |                                    | 165.5   |                     |                            |                      | vs EtOH                                                             |
| 2472 | Cotarnine                            |                                                                                | C <sub>12</sub> H <sub>15</sub> NO <sub>4</sub>                                              | 82-54-2    | 237.252  | nd (bz), cry<br>(eth)              | 132 dec |                     |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, bz, chl,<br>NH <sub>4</sub> OH |
| 2473 | Coumaphos                            |                                                                                | C <sub>14</sub> H <sub>16</sub> ClO <sub>5</sub> PS                                          | 56-72-4    | 362.766  |                                    | 93      |                     | 1.474                      |                      |                                                                     |
| 2474 | Coumestrol                           | 3,9-Dihydroxy-6 <i>H</i> -<br>benzofuro[3,2- <i>c</i> ][1]<br>benzopyran-6-one | C <sub>15</sub> H <sub>8</sub> O <sub>5</sub>                                                | 479-13-0   | 268.222  | cry rods                           | 385 dec |                     |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>ace; i eth                          |
| 2475 | Creatine                             |                                                                                | C <sub>4</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                                  | 57-00-1    | 131.133  | mcl pr (w+1)                       | 303 dec |                     | 1.33 <sup>25</sup>         |                      | s H <sub>2</sub> O; sl EtOH;<br>i eth                               |
| 2476 | Creatinine                           |                                                                                | C <sub>4</sub> H <sub>7</sub> N <sub>3</sub> O                                               | 60-27-5    | 113.118  | orth pr (w+2)<br>lf (w)            | 300 dec |                     |                            |                      | s H <sub>2</sub> O; sl EtOH;<br>i eth, ace, chl                     |
| 2477 | <i>o</i> -Cresol                     | 2-Methylphenol                                                                 | C <sub>7</sub> H <sub>8</sub> O                                                              | 95-48-7    | 108.138  |                                    | 31.03   | 191.04              | 1.0327 <sup>35</sup>       | 1.5386 <sup>35</sup> | s H <sub>2</sub> O; vs EtOH,<br>eth; msc ace,<br>bz, ctc            |
| 2478 | <i>m</i> -Cresol                     | 3-Methylphenol                                                                 | C <sub>7</sub> H <sub>8</sub> O                                                              | 108-39-4   | 108.138  |                                    | 12.24   | 202.27              | 1.0339 <sup>20</sup>       | 1.5401 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, ctc              |
| 2479 | <i>p</i> -Cresol                     | 4-Methylphenol                                                                 | C <sub>7</sub> H <sub>8</sub> O                                                              | 106-44-5   | 108.138  | pr                                 | 34.77   | 201.98              | 1.0185 <sup>40</sup>       | 1.5312 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, ctc              |
| 2480 | <i>o</i> -Cresolphthalein            |                                                                                | C <sub>22</sub> H <sub>18</sub> O <sub>4</sub>                                               | 596-27-0   | 346.376  | cry (al)                           | 223     |                     |                            |                      | vs EtOH                                                             |
| 2481 | <i>o</i> -Cresolphthalein complexone | Metalphthalein                                                                 | C <sub>32</sub> H <sub>32</sub> N <sub>2</sub> O <sub>12</sub>                               | 2411-89-4  | 636.602  | ye cry pow                         | 186     |                     |                            |                      | i H <sub>2</sub> O; s EtOH,<br>ace, alk                             |
| 2482 | Cresol Red                           | <i>o</i> -Cresolsulfonphthalein                                                | C <sub>21</sub> H <sub>16</sub> O <sub>5</sub> S                                             | 1733-12-6  | 382.430  | red-br cry<br>pow                  | >300    |                     |                            |                      | vs H <sub>2</sub> O, EtOH                                           |
| 2483 | <i>p</i> -Cresyl diphenyl phosphate  |                                                                                | C <sub>19</sub> H <sub>17</sub> O <sub>4</sub> P                                             | 78-31-9    | 340.309  | col liq                            | -40     |                     | 1.208 <sup>25</sup>        |                      | i H <sub>2</sub> O; s os                                            |
| 2484 | Crimidine                            |                                                                                | C <sub>7</sub> H <sub>10</sub> ClN <sub>3</sub>                                              | 535-89-7   | 171.627  | br wax                             | 87      | 143 <sup>4</sup>    |                            |                      | vs EtOH                                                             |
| 2485 | Cromolyn                             | Cromoglicic acid                                                               | C <sub>23</sub> H <sub>16</sub> O <sub>11</sub>                                              | 16110-51-3 | 468.366  | col cry                            | 241 dec |                     |                            |                      |                                                                     |
| 2486 | Cruformate                           |                                                                                | C <sub>12</sub> H <sub>16</sub> ClNO <sub>3</sub> P                                          | 299-86-5   | 291.711  |                                    | 60      | 118 <sup>0.01</sup> |                            |                      |                                                                     |
| 2487 | Cryptopine                           | Cryptocavine                                                                   | C <sub>21</sub> H <sub>23</sub> NO <sub>5</sub>                                              | 482-74-6   | 369.412  | pr or pl (bz)<br>nd (chl-<br>MeOH) | 223     |                     | 1.315 <sup>20</sup>        |                      | i H <sub>2</sub> O; sl EtOH,<br>eth, bz; s chl,<br>HOAc             |
| 2488 | Crystal Violet                       | Gentian violet                                                                 | C <sub>25</sub> H <sub>30</sub> ClN <sub>3</sub>                                             | 548-62-9   | 407.979  | grn pow                            | 215 dec |                     |                            |                      | vs H <sub>2</sub> O, chl                                            |
| 2489 | Cubebin                              |                                                                                | C <sub>20</sub> H <sub>20</sub> O <sub>6</sub>                                               | 18423-69-3 | 356.369  | nd (al, bz)                        | 131.5   |                     |                            |                      | vs eth, EtOH,<br>chl                                                |
| 2490 | Cucurbitacin B                       |                                                                                | C <sub>32</sub> H <sub>46</sub> O <sub>8</sub>                                               | 6199-67-3  | 558.702  | cry (EtOH)                         | 181     |                     |                            |                      |                                                                     |
| 2491 | Cucurbitacin C                       |                                                                                | C <sub>32</sub> H <sub>46</sub> O <sub>8</sub>                                               | 5988-76-1  | 560.718  | cry (AcOEt)                        | 207.5   |                     |                            |                      |                                                                     |
| 2492 | Cupferron                            |                                                                                | C <sub>8</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                                  | 135-20-6   | 155.154  |                                    | 163.5   |                     |                            |                      | sl DMSO                                                             |
| 2493 | Cupreine                             |                                                                                | C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>                                | 524-63-0   | 310.390  | pr (eth)                           | 202     |                     |                            |                      | vs EtOH                                                             |
| 2494 | Curan-17-ol, (16 $\alpha$ )          | Geissoschizoline                                                               | C <sub>19</sub> H <sub>26</sub> N <sub>2</sub> O                                             | 18397-07-4 | 298.421  | pa ye amor<br>pow                  | 135 dec |                     |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth, chl                            |



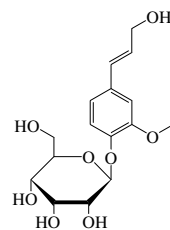
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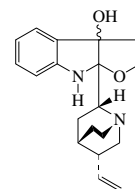
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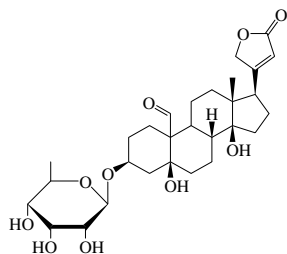
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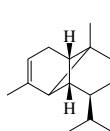
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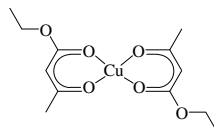
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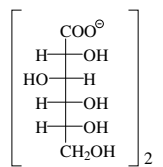
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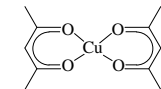
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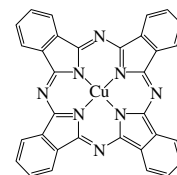
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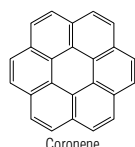
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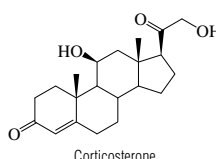
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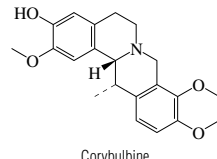
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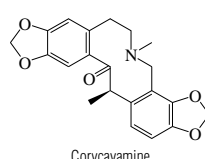
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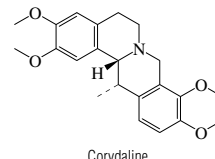
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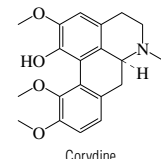
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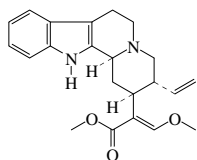
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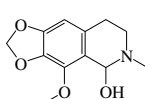
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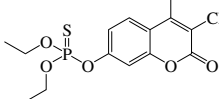
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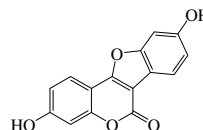
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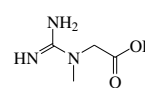
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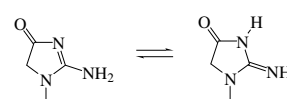
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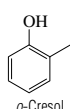
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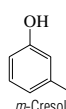
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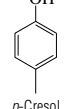
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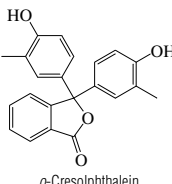
o-Cresol



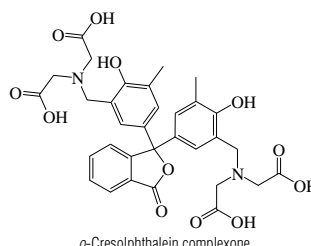
m-Cresol



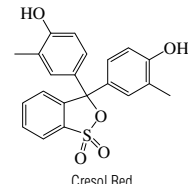
p-Cresol



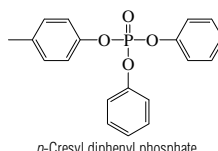
o-Cresolphthalein



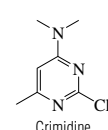
o-Cresolphthalein complexone



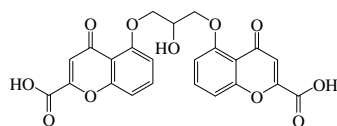
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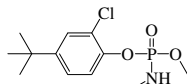
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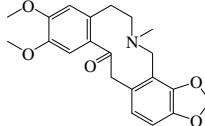
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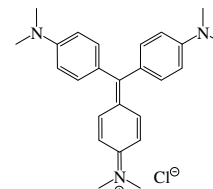
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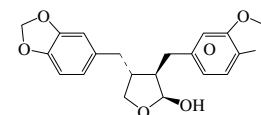
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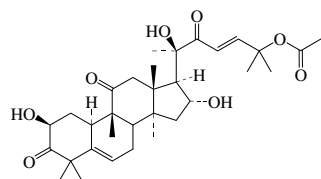
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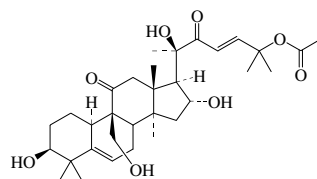
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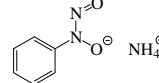
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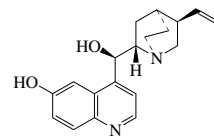
Cucurbitacin B



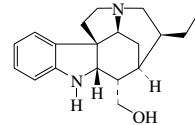
Cucurbitacin C



Cupferron



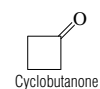
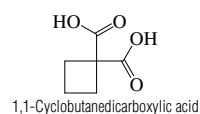
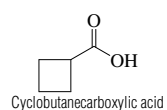
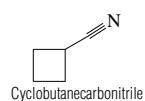
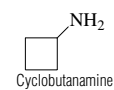
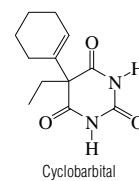
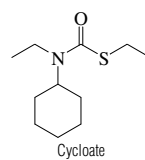
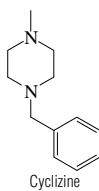
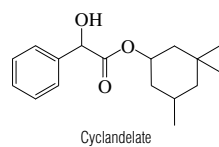
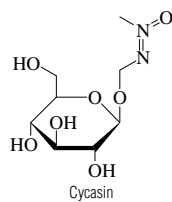
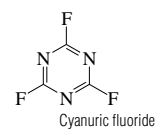
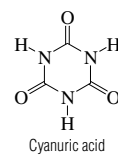
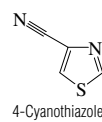
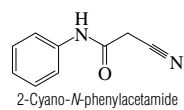
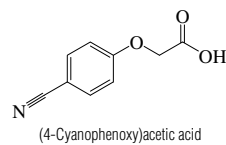
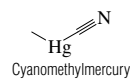
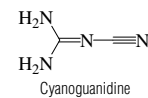
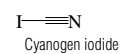
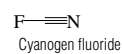
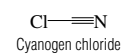
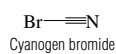
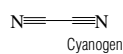
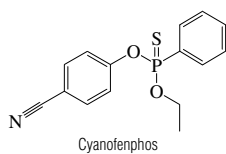
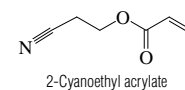
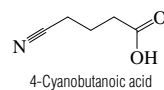
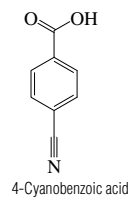
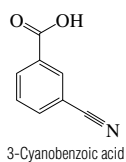
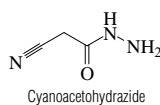
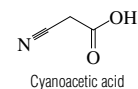
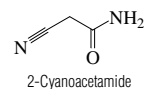
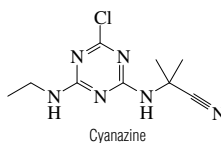
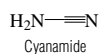
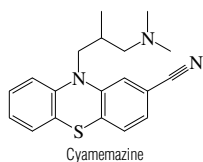
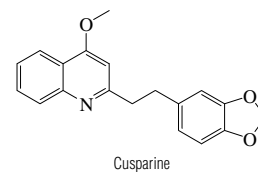
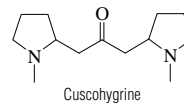
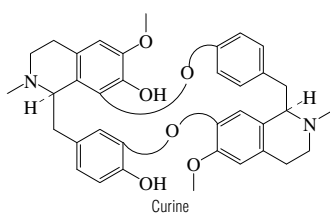
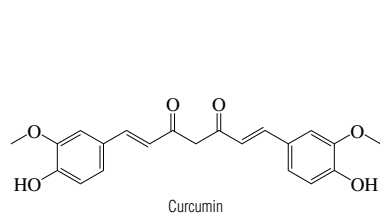
Cupreine



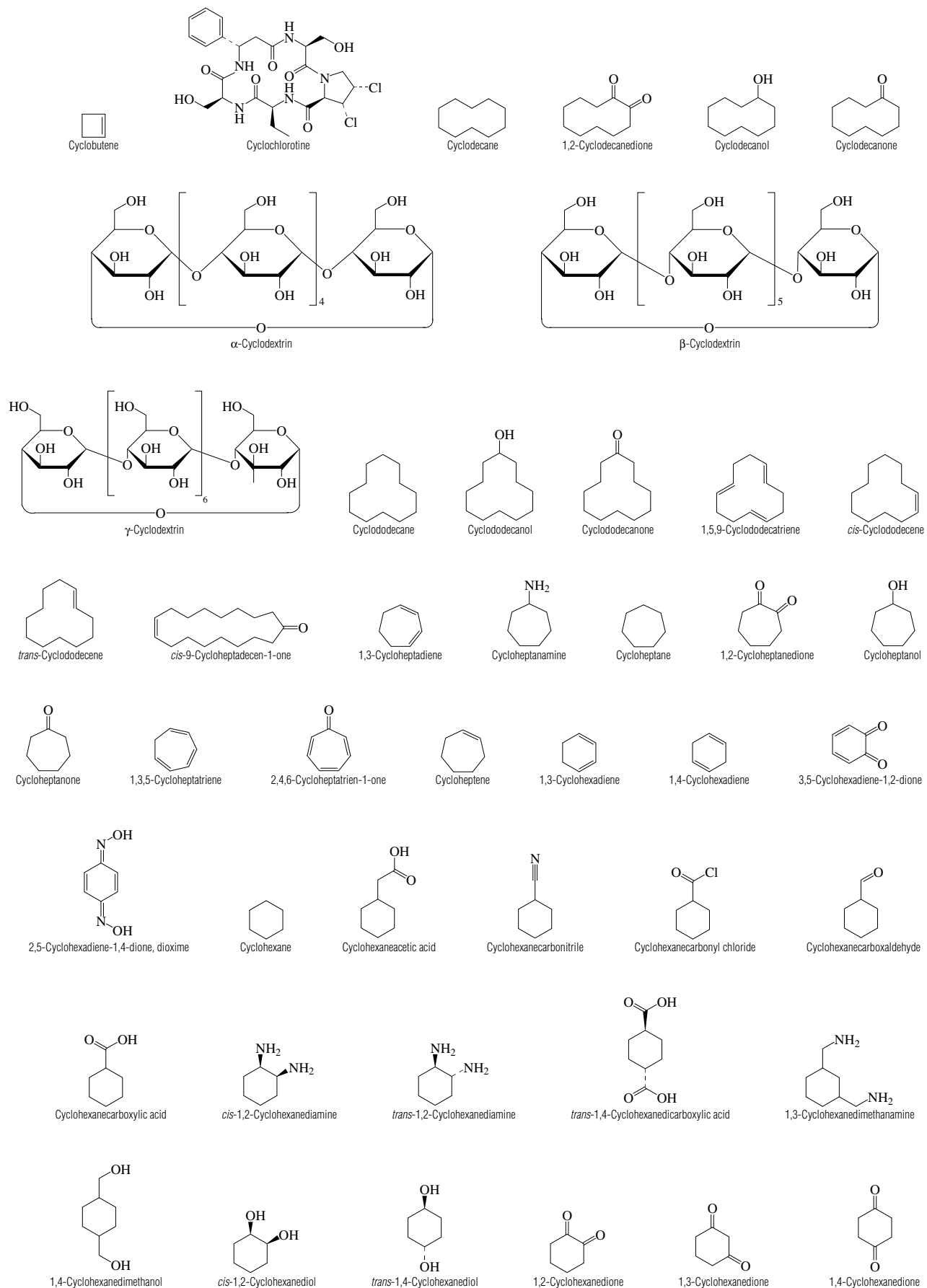
Curan-17-ol, (16α)



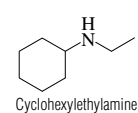
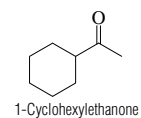
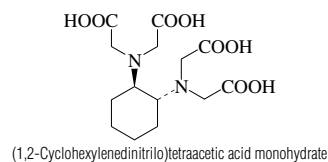
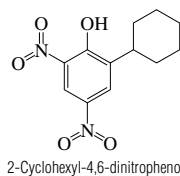
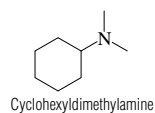
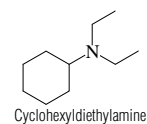
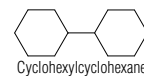
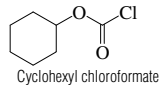
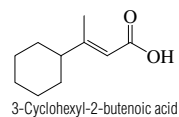
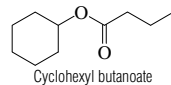
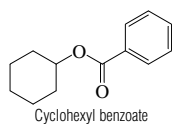
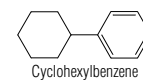
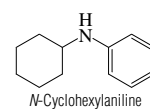
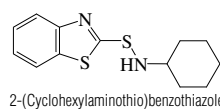
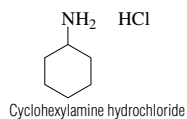
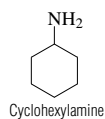
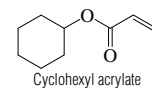
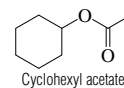
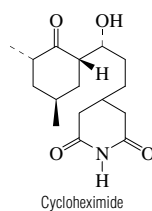
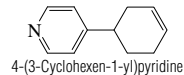
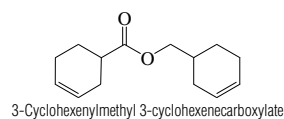
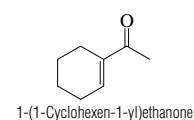
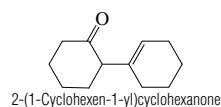
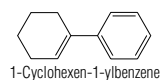
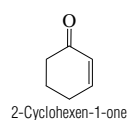
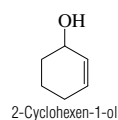
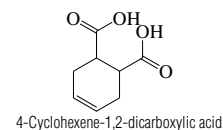
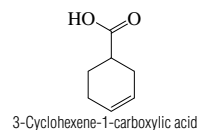
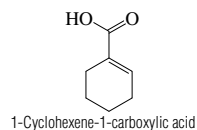
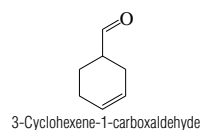
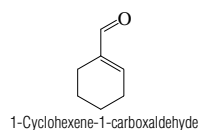
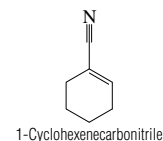
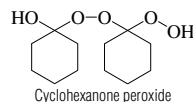
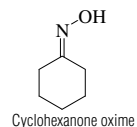
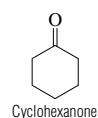
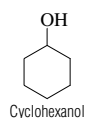
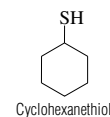
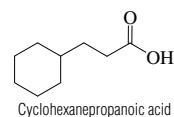
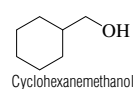
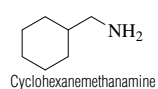
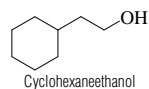
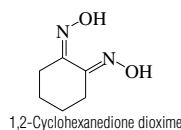
| No.  | Name                               | Synonym                                                              | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                                 | mp/°C                      | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                          |
|------|------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------|------------|----------|-----------------------------------------------|----------------------------|--------------------------------------|----------------------------|----------------------|---------------------------------------------------------------------|
| 2495 | Curcumin                           | Turmeric                                                             | C <sub>21</sub> H <sub>20</sub> O <sub>6</sub>                | 458-37-7   | 368.380  | oran ye pr,<br>orth pr<br>(MeOH)              | 183                        |                                      |                            |                      | vs EtOH, HOAc                                                       |
| 2496 | Curine                             |                                                                      | C <sub>36</sub> H <sub>38</sub> N <sub>2</sub> O <sub>6</sub> | 436-05-5   | 594.696  | pr, nd (chl-<br>MeOH)                         | 221                        |                                      |                            |                      | vs ace, bz, py                                                      |
| 2497 | Cuscohygrine                       |                                                                      | C <sub>13</sub> H <sub>24</sub> N <sub>2</sub> O              | 454-14-8   | 224.342  | oil                                           |                            | 169 <sup>23</sup> , 122 <sup>2</sup> | 0.9733 <sup>20</sup>       | 1.4832 <sup>20</sup> | vs H <sub>2</sub> O, bz, eth,<br>EtOH                               |
| 2498 | Cusparine                          | 2-[2-(1,3-Benzodioxol-5-yl)<br>ethyl]-4-methoxyquinoline             | C <sub>19</sub> H <sub>17</sub> NO <sub>3</sub>               | 529-92-0   | 307.343  | (α) wh or ye<br>nd (peth);<br>(β) amber<br>pr | 92(α form);<br>111(β form) |                                      |                            |                      | i H <sub>2</sub> O; vs ace,<br>bz, eth, EtOH                        |
| 2499 | Cyamemazine                        |                                                                      | C <sub>19</sub> H <sub>21</sub> N <sub>3</sub> S              | 3546-03-0  | 323.455  | ye pow                                        | 92                         | 212 <sup>0,25</sup>                  |                            |                      | i H <sub>2</sub> O; s EtOH                                          |
| 2500 | Cyanamide                          | Cyanogenamide                                                        | CH <sub>2</sub> N <sub>2</sub>                                | 420-04-2   | 42.040   | nd                                            | 45.56                      | 140 <sup>19</sup>                    | 1.282 <sup>20</sup>        | 1.4418 <sup>48</sup> | vs H <sub>2</sub> O, EtOH; s<br>eth, ace, bz; sl<br>CS <sub>2</sub> |
| 2501 | Cyanazine                          |                                                                      | C <sub>3</sub> H <sub>3</sub> ClN <sub>6</sub>                | 21725-46-2 | 240.692  |                                               | 168                        |                                      |                            |                      |                                                                     |
| 2502 | Cyanic acid                        | Hydrogen cyanate                                                     | CHNO                                                          | 420-05-3   | 43.025   | unstab liq or<br>gas                          | -86                        | 23                                   | 1.140 <sup>20</sup>        |                      | vs H <sub>2</sub> O, bz, eth,<br>chl                                |
| 2503 | 2-Cyanoacetamide                   |                                                                      | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> O                | 107-91-5   | 84.076   | pl (w)                                        | 121.5                      |                                      |                            |                      | vs H <sub>2</sub> O                                                 |
| 2504 | Cyanoacetic acid                   |                                                                      | C <sub>3</sub> H <sub>3</sub> NO <sub>2</sub>                 | 372-09-8   | 85.062   |                                               | 66                         | dec 160; 108 <sup>15</sup>           |                            |                      | s H <sub>2</sub> O, EtOH,<br>eth; sl chl,<br>HOAc                   |
| 2505 | Cyanoacetohydrazide                | Cyacetacide                                                          | C <sub>3</sub> H <sub>5</sub> N <sub>3</sub> O                | 140-87-4   | 99.091   | pr (al)                                       | 114.5                      |                                      |                            |                      | vs H <sub>2</sub> O, EtOH                                           |
| 2506 | Cyanoacetylene                     |                                                                      | C <sub>2</sub> HN                                             | 1070-71-9  | 51.047   |                                               | 5                          | 42.5                                 | 0.8167 <sup>17</sup>       | 1.3868 <sup>25</sup> | sl H <sub>2</sub> O; s EtOH                                         |
| 2507 | 3-Cyanobenzoic acid                |                                                                      | C <sub>8</sub> H <sub>5</sub> NO <sub>2</sub>                 | 1877-72-1  | 147.132  | nd (w)                                        | 219                        | sub                                  |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth                                 |
| 2508 | 4-Cyanobenzoic acid                |                                                                      | C <sub>8</sub> H <sub>5</sub> NO <sub>2</sub>                 | 619-65-8   | 147.132  |                                               | 219                        |                                      |                            |                      | s H <sub>2</sub> O, EtOH,<br>eth, HOAc; sl<br>tfa                   |
| 2509 | 4-Cyanobutanoic acid               |                                                                      | C <sub>6</sub> H <sub>7</sub> NO <sub>2</sub>                 | 39201-33-7 | 113.116  | hyg cry                                       | 45                         |                                      |                            |                      | s H <sub>2</sub> O, EtOH,<br>eth, bz                                |
| 2510 | 2-Cyanoethyl acrylate              |                                                                      | C <sub>6</sub> H <sub>7</sub> NO <sub>2</sub>                 | 106-71-8   | 125.126  |                                               |                            | 108 <sup>12</sup>                    | 1.062 <sup>20</sup>        |                      |                                                                     |
| 2511 | Cyanofenphos                       |                                                                      | C <sub>15</sub> H <sub>14</sub> NO <sub>2</sub> PS            | 13067-93-1 | 303.317  |                                               | 83                         |                                      |                            | 1.5839 <sup>25</sup> | sl H <sub>2</sub> O                                                 |
| 2512 | Cyanogen                           | Ethane dinitrile                                                     | C <sub>2</sub> N <sub>2</sub>                                 | 460-19-5   | 52.034   | col gas                                       | -27.83                     | -21.1                                | 0.9537 <sup>21</sup>       |                      | s H <sub>2</sub> O, EtOH, eth                                       |
| 2513 | Cyanogen bromide                   | Bromine cyanide                                                      | CBrN                                                          | 506-68-3   | 105.922  | nd                                            | 52                         | 61.5                                 | 2.015 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH, eth                                       |
| 2514 | Cyanogen chloride                  | Chlorine cyanide                                                     | CCIN                                                          | 506-77-4   | 61.471   | col vol liq or<br>gas                         | -6.5                       | 13                                   | 1.186 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH; vs<br>eth                                 |
| 2515 | Cyanogen fluoride                  | Fluorine cyanide                                                     | CFN                                                           | 1495-50-7  | 45.016   | col gas                                       | -82                        | -46                                  |                            |                      |                                                                     |
| 2516 | Cyanogen iodide                    | Iodine cyanide                                                       | CIN                                                           | 506-78-5   | 152.922  | nd (al, eth)                                  | 146.7                      | sub                                  | 2.84 <sup>18</sup>         |                      | vs eth, EtOH                                                        |
| 2517 | Cyanoguanidine                     | Dicyanodiamide                                                       | C <sub>2</sub> H <sub>4</sub> N <sub>4</sub>                  | 461-58-5   | 84.080   |                                               | 211                        |                                      | 1.404 <sup>14</sup>        |                      | s H <sub>2</sub> O, EtOH,<br>ace; i eth, bz,<br>chl                 |
| 2518 | Cyanomethylmercury                 | Methylmercurynitrile                                                 | C <sub>2</sub> H <sub>3</sub> HgN                             | 2597-97-9  | 241.64   | cry (chl)                                     | 92                         | subl                                 |                            |                      | vs H <sub>2</sub> O, EtOH,<br>bz; s eth                             |
| 2519 | (4-Cyanophenoxy)acetic acid        |                                                                      | C <sub>8</sub> H <sub>7</sub> NO <sub>3</sub>                 | 1878-82-6  | 177.157  | cry (w)                                       | 178                        |                                      |                            |                      |                                                                     |
| 2520 | 2-Cyano- <i>N</i> -phenylacetamide |                                                                      | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub> O                | 621-03-4   | 160.172  | nd (al)                                       | 199.5                      |                                      |                            |                      |                                                                     |
| 2521 | 4-Cyanothiazole                    |                                                                      | C <sub>4</sub> H <sub>2</sub> N <sub>2</sub> S                | 1452-15-9  | 110.137  | nd                                            | 58                         |                                      |                            |                      |                                                                     |
| 2522 | Cyanuric acid                      | 1,3,5-Triazine-2,4,6(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-<br>trione | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub> O <sub>3</sub>   | 108-80-5   | 129.074  | wh cry                                        | >330                       | sub                                  | 1.75 <sup>25</sup>         |                      | sl hot H <sub>2</sub> O, ace,<br>bz, EtOH; s<br>conc HCl            |
| 2523 | Cyanuric fluoride                  | 2,4,6-Trifluoro-1,3,5-triazine                                       | C <sub>3</sub> F <sub>3</sub> N <sub>3</sub>                  | 675-14-9   | 135.047  |                                               |                            | 72.8                                 |                            |                      |                                                                     |
| 2524 | Cycasin                            |                                                                      | C <sub>8</sub> H <sub>18</sub> N <sub>2</sub> O <sub>7</sub>  | 14901-08-7 | 252.222  | nd (ace aq)                                   | 154 dec                    |                                      |                            |                      |                                                                     |
| 2525 | Cyclandelate                       |                                                                      | C <sub>17</sub> H <sub>24</sub> O <sub>3</sub>                | 456-59-7   | 276.371  |                                               | 52                         | 193 <sup>14</sup>                    |                            |                      | i H <sub>2</sub> O                                                  |
| 2526 | Cyclizine                          |                                                                      | C <sub>18</sub> H <sub>22</sub> N <sub>2</sub>                | 82-92-8    | 266.381  | cry (peth)                                    | 106                        |                                      |                            |                      | i H <sub>2</sub> O; s chl; sl<br>EtOH                               |
| 2527 | Cycloate                           | Carbamothioic acid,<br>cyclohexylethyl-, <i>S</i> -ethyl ester       | C <sub>11</sub> H <sub>21</sub> NOS                           | 1134-23-2  | 215.356  |                                               | 11.5                       | 145 <sup>10</sup>                    | 1.0156 <sup>30</sup>       |                      |                                                                     |
| 2528 | Cyclobarbitol                      |                                                                      | C <sub>12</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> | 52-31-3    | 236.266  | lf (w)                                        | 173                        |                                      |                            |                      | i H <sub>2</sub> O; vs EtOH;<br>s eth, dil alk; sl<br>HOAc          |
| 2529 | Cyclobutanamine                    | Aminocyclobutane                                                     | C <sub>4</sub> H <sub>9</sub> N                               | 2516-34-9  | 71.121   |                                               |                            | 82                                   | 0.8328 <sup>20</sup>       | 1.4363 <sup>19</sup> |                                                                     |
| 2530 | Cyclobutane                        | Tetramethylene                                                       | C <sub>4</sub> H <sub>8</sub>                                 | 287-23-0   | 56.107   | vol liq or gas                                | -90.7                      | 12.6                                 | 0.7038 <sup>0</sup>        | 1.375 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH,<br>ace; msc eth; s<br>bz               |
| 2531 | Cyclobutanecarbonitrile            | Cyanocyclobutane                                                     | C <sub>4</sub> H <sub>5</sub> N                               | 4426-11-3  | 81.117   |                                               |                            | 149.6                                |                            |                      |                                                                     |
| 2532 | Cyclobutanecarboxylic acid         |                                                                      | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                  | 3721-95-7  | 100.117  | liq                                           | -1.0                       | 190; 74 <sup>2</sup>                 | 1.0599 <sup>20</sup>       | 1.4400 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth                               |
| 2533 | 1,1-Cyclobutanedicarboxylic acid   |                                                                      | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                  | 5445-51-2  | 144.126  | pr (w, eth)                                   | 158.0                      |                                      |                            |                      | vs H <sub>2</sub> O; s EtOH,<br>eth, bz; sl liq                     |
| 2534 | Cyclobutanol                       | Hydroxycyclobutane                                                   | C <sub>4</sub> H <sub>8</sub> O                               | 2919-23-5  | 72.106   |                                               |                            | 124                                  | 0.9218 <sup>15</sup>       | 1.4371 <sup>20</sup> |                                                                     |
| 2535 | Cyclobutanone                      |                                                                      | C <sub>4</sub> H <sub>6</sub> O                               | 1191-95-3  | 70.090   | liq                                           | -50.9                      | 99                                   | 0.9547 <sup>0</sup>        | 1.4215 <sup>20</sup> | s H <sub>2</sub> O, eth, bz,<br>chl, tol; vs<br>EtOH; i peth        |



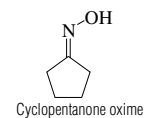
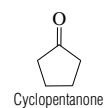
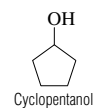
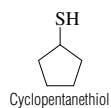
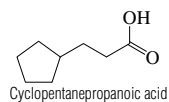
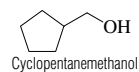
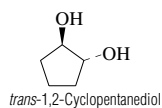
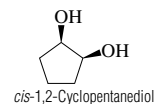
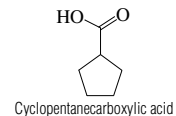
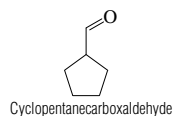
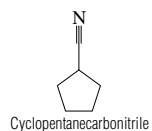
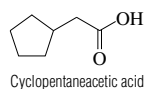
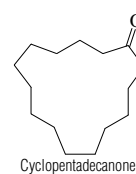
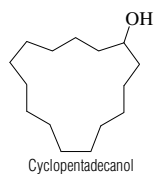
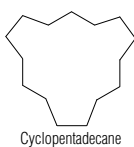
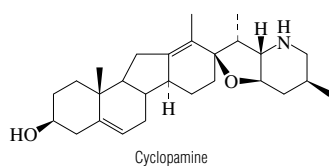
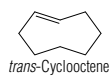
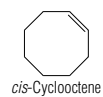
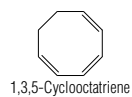
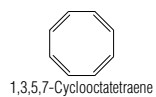
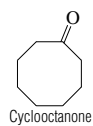
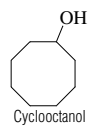
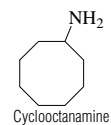
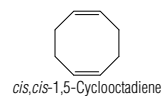
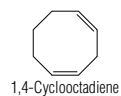
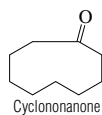
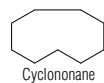
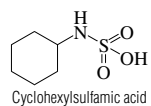
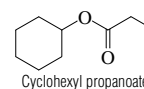
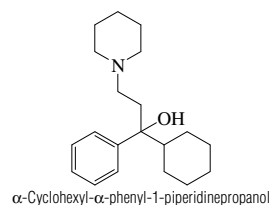
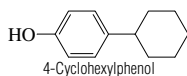
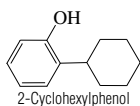
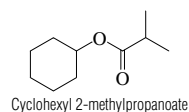
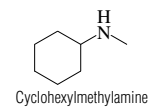
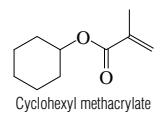
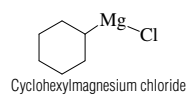
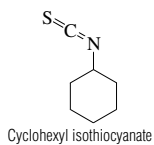
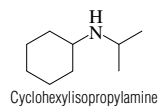
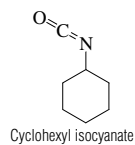
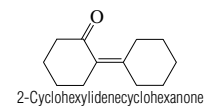
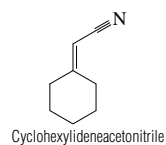
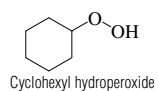
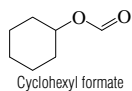
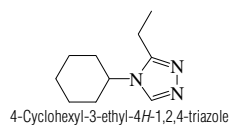
| No.  | Name                                   | Synonym                      | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                           |
|------|----------------------------------------|------------------------------|-------------------------------------------------------------------------------|------------|----------|-------------------------|---------|-------------------------------------|----------------------------|-----------------------|------------------------------------------------------|
| 2536 | Cyclobutene                            |                              | C <sub>4</sub> H <sub>6</sub>                                                 | 822-35-5   | 54.091   | col gas                 |         | 2                                   | 0.733 <sup>0</sup>         |                       | vs ace; s bz, peth                                   |
| 2537 | Cyclochlorotene                        |                              | C <sub>24</sub> H <sub>31</sub> Cl <sub>2</sub> N <sub>5</sub> O <sub>7</sub> | 12663-46-6 | 572.439  | nd (MeOH)               | 255 dec |                                     |                            |                       |                                                      |
| 2538 | Cyclodecane                            |                              | C <sub>10</sub> H <sub>20</sub>                                               | 293-96-9   | 140.266  |                         | 10      | 202                                 | 0.8538 <sup>25</sup>       | 1.4716 <sup>20</sup>  |                                                      |
| 2539 | 1,2-Cyclodecanedione                   | Sebacil                      | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>                                | 96-01-5    | 168.233  |                         | 40.5    | 104 <sup>10</sup>                   |                            |                       |                                                      |
| 2540 | Cyclodecanol                           |                              | C <sub>10</sub> H <sub>20</sub> O                                             | 1502-05-2  | 156.265  |                         | 40.5    | 125 <sup>12</sup>                   | 0.9606 <sup>20</sup>       | 1.4926 <sup>20</sup>  | s EtOH                                               |
| 2541 | Cyclodecanone                          |                              | C <sub>10</sub> H <sub>18</sub> O                                             | 1502-06-3  | 154.249  | amor pow                | 28      | 106 <sup>13</sup>                   | 0.9654 <sup>20</sup>       | 1.4806 <sup>20</sup>  | vs bz, eth, chl                                      |
| 2542 | α-Cyclodextrin                         | Cyclomaltohexaose            | C <sub>36</sub> H <sub>60</sub> O <sub>30</sub>                               | 10016-20-3 | 972.843  | hx pl or nd             |         |                                     |                            |                       | vs cold H <sub>2</sub> O; i hot H <sub>2</sub> O     |
| 2543 | β-Cyclodextrin                         | Cyclomaltoheptaose           | C <sub>42</sub> H <sub>70</sub> O <sub>35</sub>                               | 7585-39-9  | 1134.984 | mcl cry (w)             | 260 dec |                                     |                            |                       |                                                      |
| 2544 | γ-Cyclodextrin                         | Cyclomaltooctaose            | C <sub>48</sub> H <sub>80</sub> O <sub>40</sub>                               | 17465-86-0 | 1297.125 | sq pl or rods           |         |                                     |                            |                       |                                                      |
| 2545 | Cyclododecane                          |                              | C <sub>12</sub> H <sub>24</sub>                                               | 294-62-2   | 168.319  | nd (al)                 | 60.4    | 247                                 | 0.82 <sup>90</sup>         |                       |                                                      |
| 2546 | Cyclododecanol                         |                              | C <sub>12</sub> H <sub>24</sub> O                                             | 1724-39-6  | 184.318  |                         |         | 286                                 |                            |                       |                                                      |
| 2547 | Cyclododecanone                        |                              | C <sub>12</sub> H <sub>22</sub> O                                             | 830-13-7   | 182.302  |                         | 59      | 127 <sup>12</sup>                   | 0.9059 <sup>66</sup>       | 1.4571 <sup>60</sup>  |                                                      |
| 2548 | 1,5,9-Cyclododecatriene                | CDT                          | C <sub>12</sub> H <sub>18</sub>                                               | 4904-61-4  | 162.271  | liq                     | -17     | 240                                 | 0.84 <sup>100</sup>        |                       |                                                      |
| 2549 | cis-Cyclododecene                      |                              | C <sub>12</sub> H <sub>22</sub>                                               | 1129-89-1  | 166.303  |                         |         | 133 <sup>35</sup> , 71 <sup>2</sup> |                            | 1.4840 <sup>20</sup>  | vs bz, chl                                           |
| 2550 | trans-Cyclododecene                    |                              | C <sub>12</sub> H <sub>22</sub>                                               | 1486-75-5  | 166.303  |                         |         | 113 <sup>17</sup>                   |                            | 1.4850 <sup>20</sup>  | vs bz, chl                                           |
| 2551 | cis-9-Cycloheptadecen-1-one            | Civetone                     | C <sub>17</sub> H <sub>30</sub> O                                             | 542-46-1   | 250.419  |                         | 32.5    | 343; 159 <sup>2</sup>               |                            |                       |                                                      |
| 2552 | 1,3-Cycloheptadiene                    |                              | C <sub>7</sub> H <sub>10</sub>                                                | 4054-38-0  | 94.154   | liq                     | -110.4  | 120.5                               | 0.868 <sup>25</sup>        | 1.4978 <sup>20</sup>  |                                                      |
| 2553 | Cycloheptanamine                       |                              | C <sub>7</sub> H <sub>15</sub> N                                              | 5452-35-7  | 113.201  |                         |         | 54 <sup>11</sup>                    |                            | 1.4724 <sup>20</sup>  |                                                      |
| 2554 | Cycloheptane                           |                              | C <sub>7</sub> H <sub>14</sub>                                                | 291-64-5   | 98.186   | liq                     | -8.46   | 118.4                               | 0.8098 <sup>20</sup>       | 1.4436 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth; s bz, chl          |
| 2555 | 1,2-Cycloheptanedione                  |                              | C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>                                 | 3008-39-7  | 126.153  |                         | -40     | 108 <sup>17</sup>                   | 1.0583 <sup>22</sup>       | 1.4689 <sup>22</sup>  | s EtOH                                               |
| 2556 | Cycloheptanol                          |                              | C <sub>7</sub> H <sub>14</sub> O                                              | 502-41-0   | 114.185  |                         | 7.2     | 185                                 | 0.9554 <sup>20</sup>       | 1.40705 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth                    |
| 2557 | Cycloheptanone                         | Suberone                     | C <sub>7</sub> H <sub>12</sub> O                                              | 502-42-1   | 112.169  |                         |         | 178.5                               | 0.9508 <sup>20</sup>       | 1.4608 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth                     |
| 2558 | 1,3,5-Cycloheptatriene                 | Tropilidene                  | C <sub>7</sub> H <sub>8</sub>                                                 | 544-25-2   | 92.139   | liq; cub cry (-80°C)    | -79.5   | 117; 60.5 <sup>122</sup>            | 0.8875 <sup>19</sup>       | 1.5343 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; vs bz, chl          |
| 2559 | 2,4,6-Cycloheptatrien-1-one            |                              | C <sub>7</sub> H <sub>6</sub> O                                               | 539-80-0   | 106.122  |                         | -7      | 113 <sup>15</sup> , 84 <sup>6</sup> | 1.095 <sup>22</sup>        | 1.6172 <sup>22</sup>  | vs bz, chl                                           |
| 2560 | Cycloheptene                           |                              | C <sub>7</sub> H <sub>12</sub>                                                | 628-92-2   | 96.170   | liq                     | -56     | 115                                 | 0.8228 <sup>20</sup>       | 1.4552 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl; sl ctc     |
| 2561 | 1,3-Cyclohexadiene                     |                              | C <sub>6</sub> H <sub>8</sub>                                                 | 592-57-4   | 80.128   | liq                     | -89     | 80.5                                | 0.8405 <sup>20</sup>       | 1.4755 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, bz, chl, peth; vs eth    |
| 2562 | 1,4-Cyclohexadiene                     | 1,4-Dihydrobenzene           | C <sub>6</sub> H <sub>8</sub>                                                 | 628-41-1   | 80.128   | liq                     | -49.2   | 85.5                                | 0.8471 <sup>20</sup>       | 1.4725 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s bz, chl, peth   |
| 2563 | 3,5-Cyclohexadiene-1,2-dione           |                              | C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>                                  | 583-63-1   | 108.095  | red pl or pr            | ≈65 dec |                                     |                            |                       | s eth, ace, bz; i peth                               |
| 2564 | 2,5-Cyclohexadiene-1,4-dione, dioxime  |                              | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                   | 105-11-3   | 138.124  | pa ye nd (w)            | 240 dec |                                     |                            |                       | s H <sub>2</sub> O                                   |
| 2565 | Cyclohexane                            | Hexahydrobenzene             | C <sub>6</sub> H <sub>12</sub>                                                | 110-82-7   | 84.159   |                         | 6.59    | 80.73                               | 0.7739 <sup>25</sup>       | 1.4235 <sup>25</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc |
| 2566 | Cyclohexanecetic acid                  |                              | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                                 | 5292-21-7  | 142.196  | nd (HCO <sub>2</sub> H) | 33      | 245                                 | 1.0423 <sup>18</sup>       | 1.4775 <sup>20</sup>  | sl H <sub>2</sub> O; s eth, ace                      |
| 2567 | Cyclohexanecarbonitrile                | Cyclohexyl cyanide           | C <sub>7</sub> H <sub>11</sub> N                                              | 766-05-2   | 109.169  | liq                     | 11      | 184; 76 <sup>16</sup>               | 0.919                      | 1.4505 <sup>20</sup>  |                                                      |
| 2568 | Cyclohexanecarbonyl chloride           |                              | C <sub>7</sub> H <sub>11</sub> ClO                                            | 2719-27-9  | 146.614  |                         |         | 180                                 | 1.0962 <sup>15</sup>       | 1.4711 <sup>29</sup>  |                                                      |
| 2569 | Cyclohexanecarboxaldehyde              |                              | C <sub>7</sub> H <sub>12</sub> O                                              | 2043-61-0  | 112.169  |                         |         | 159.3                               | 0.9035 <sup>20</sup>       | 1.4496 <sup>20</sup>  | s H <sub>2</sub> O, eth                              |
| 2570 | Cyclohexanecarboxylic acid             | Hexahydrobenzoic acid        | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                                 | 98-89-5    | 128.169  | mcl pr                  | 31.5    | 232.5                               | 1.0334 <sup>22</sup>       | 1.4530 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; vs EtOH, bz, chl           |
| 2571 | cis-1,2-Cyclohexanediamine             | cis-1,2-Diaminocyclohexane   | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                                 | 1436-59-5  | 114.188  | liq                     |         | 40 <sup>2</sup>                     | 0.952 <sup>20</sup>        | 1.4951 <sup>20</sup>  |                                                      |
| 2572 | trans-1,2-Cyclohexanediamine           | trans-1,2-Diaminocyclohexane | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                                 | 1121-22-8  | 114.188  |                         | 14.8    | 80 <sup>15</sup> , 41 <sup>2</sup>  | 0.951 <sup>20</sup>        |                       |                                                      |
| 2573 | trans-1,4-Cyclohexanedicarboxylic acid |                              | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                                 | 619-82-9   | 172.179  | pr (w)                  | 312.5   | sub 300                             |                            |                       | sl H <sub>2</sub> O, eth; vs EtOH; s ace; i chl      |
| 2574 | 1,3-Cyclohexanedimethanamine           |                              | C <sub>8</sub> H <sub>18</sub> N <sub>2</sub>                                 | 2579-20-6  | 142.242  |                         | <-70    | 220                                 | 0.945 <sup>20</sup>        |                       | vs H <sub>2</sub> O, eth, EtOH                       |
| 2575 | 1,4-Cyclohexanedimethanol              |                              | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                                 | 105-08-8   | 144.212  |                         | 43      | 283; 167 <sup>10</sup>              |                            |                       |                                                      |
| 2576 | cis-1,2-Cyclohexanediol                |                              | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                                 | 1792-81-0  | 116.158  |                         | 100     | 120 <sup>15</sup>                   | 1.0297 <sup>101</sup>      |                       | s EtOH, ace, bz; sl chl                              |
| 2577 | trans-1,4-Cyclohexanediol              |                              | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                                 | 6995-79-5  | 116.158  | mcl pr (ace)            | 143     |                                     | 1.18 <sup>20</sup>         |                       | s H <sub>2</sub> O, EtOH, MeOH; i eth; sl ace        |
| 2578 | 1,2-Cyclohexanedione                   | 1,2-Dioxocyclohexane         | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                                  | 765-87-7   | 112.127  | cry (peth)              | 40      | 194                                 | 1.1187 <sup>21</sup>       | 1.4995 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, eth, bz                    |
| 2579 | 1,3-Cyclohexanedione                   | Dihydroresorcinol            | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                                  | 504-02-9   | 112.127  | pr (bz)                 | 105.5   |                                     | 1.0861 <sup>91</sup>       | 1.4576 <sup>102</sup> | s H <sub>2</sub> O, EtOH, ace, chl; i sl eth, bz     |
| 2580 | 1,4-Cyclohexanedione                   | Tetrahydroquinone            | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                                  | 637-88-7   | 112.127  | mcl pl (w),nd (peth)    | 78      | 132 <sup>20</sup>                   | 1.0861 <sup>91</sup>       |                       | s H <sub>2</sub> O, EtOH, eth, ace, bz, chl          |



| No.  | Name                                                         | Synonym                             | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form     | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|--------------------------------------------------------------|-------------------------------------|---------------------------------------------------------------|------------|----------|-------------------|--------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 2581 | 1,2-Cyclohexanedione dioxime                                 | Nioxime                             | C <sub>6</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>  | 492-99-9   | 142.155  | nd (w, HOAc)      | 192    |                                       |                            |                      | s H <sub>2</sub> O, ace, chl;<br>sl tfa                    |
| 2582 | Cyclohexaneethanol                                           |                                     | C <sub>8</sub> H <sub>16</sub> O                              | 4442-79-9  | 128.212  |                   |        | 208                                   | 0.9229 <sup>20</sup>       | 1.4641 <sup>20</sup> | s EtOH, eth, bz                                            |
| 2583 | Cyclohexanemethanamine                                       |                                     | C <sub>7</sub> H <sub>13</sub> N                              | 3218-02-8  | 113.201  |                   |        | 160                                   | 0.87 <sup>25</sup>         | 1.4630 <sup>20</sup> |                                                            |
| 2584 | Cyclohexanemethanol                                          | Cyclohexylcarbinol                  | C <sub>7</sub> H <sub>14</sub> O                              | 100-49-2   | 114.185  | liq               | -43    | 183                                   | 0.9297 <sup>20</sup>       | 1.4644 <sup>20</sup> | vs eth, EtOH                                               |
| 2585 | Cyclohexanepropanoic acid                                    |                                     | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>                 | 701-97-3   | 156.222  |                   | 16     | 276.5                                 | 0.912 <sup>25</sup>        | 1.4638 <sup>20</sup> | s H <sub>2</sub> O, eth; sl ctc                            |
| 2586 | Cyclohexanethiol                                             | Cyclohexyl mercaptan                | C <sub>6</sub> H <sub>12</sub> S                              | 1569-69-3  | 116.224  |                   |        | 158.8                                 | 0.9782 <sup>20</sup>       | 1.4921 <sup>20</sup> | vs ace, bz, eth,<br>EtOH                                   |
| 2587 | Cyclohexanol                                                 | Cyclohexyl alcohol                  | C <sub>6</sub> H <sub>12</sub> O                              | 108-93-0   | 100.158  | hyg nd            | 25.93  | 160.84                                | 0.9624 <sup>20</sup>       | 1.4641 <sup>20</sup> | s H <sub>2</sub> O, EtOH,<br>eth, ace; msc<br>bz; sl chl   |
| 2588 | Cyclohexanone                                                | Pimelic ketone                      | C <sub>6</sub> H <sub>10</sub> O                              | 108-94-1   | 98.142   | liq               | -27.9  | 155.43                                | 0.9478 <sup>20</sup>       | 1.4507 <sup>20</sup> | s H <sub>2</sub> O, EtOH,<br>eth, ace, bz,<br>chl, ctc     |
| 2589 | Cyclohexanone oxime                                          |                                     | C <sub>6</sub> H <sub>11</sub> NO                             | 100-64-1   | 113.157  | hex pr (lig)      | 90     | 206                                   |                            |                      | s H <sub>2</sub> O, EtOH,<br>eth, MeOH; sl<br>chl          |
| 2590 | Cyclohexanone peroxide                                       |                                     | C <sub>12</sub> H <sub>22</sub> O <sub>5</sub>                | 78-18-2    | 246.300  | cry or long<br>nd | 79     |                                       |                            |                      |                                                            |
| 2591 | Cyclohexene                                                  | Tetrahydrobenzene                   | C <sub>6</sub> H <sub>10</sub>                                | 110-83-8   | 82.143   | liq               | -103.5 | 82.98                                 | 0.8110 <sup>20</sup>       | 1.4465 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, lig, ctc |
| 2592 | 1-Cyclohexenecarbonitrile                                    | 1-Cyanocyclohexene                  | C <sub>7</sub> H <sub>9</sub> N                               | 1855-63-6  | 107.153  |                   |        | 81 <sup>12</sup>                      |                            |                      |                                                            |
| 2593 | 1-Cyclohexene-1-carboxaldehyde                               |                                     | C <sub>7</sub> H <sub>10</sub> O                              | 1192-88-7  | 110.153  |                   |        | 69 <sup>18</sup>                      | 0.9694 <sup>20</sup>       | 1.5005 <sup>20</sup> | s EtOH, eth                                                |
| 2594 | 3-Cyclohexene-1-carboxaldehyde                               |                                     | C <sub>7</sub> H <sub>10</sub> O                              | 100-50-5   | 110.153  |                   | 1.0    | 105                                   | 0.9692 <sup>20</sup>       | 1.4745 <sup>20</sup> | s ace, MeOH; sl<br>ctc                                     |
| 2595 | 1-Cyclohexene-1-carboxylic acid                              |                                     | C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>                 | 636-82-8   | 126.153  |                   | 38     | 241                                   | 1.109 <sup>20</sup>        | 1.4902 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>ace                        |
| 2596 | 3-Cyclohexene-1-carboxylic acid                              |                                     | C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>                 | 4771-80-6  | 126.153  |                   | 17     | 234.5                                 | 1.0820 <sup>20</sup>       | 1.4814 <sup>20</sup> | vs H <sub>2</sub> O; s EtOH,<br>ace                        |
| 2597 | 4-Cyclohexene-1,2-dicarboxylic acid                          |                                     | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>                 | 88-98-2    | 170.163  | pr (w)            | 173.0  |                                       |                            |                      |                                                            |
| 2598 | 2-Cyclohexen-1-ol                                            |                                     | C <sub>6</sub> H <sub>10</sub> O                              | 822-67-3   | 98.142   |                   |        | 164                                   | 0.9923 <sup>15</sup>       | 1.4790 <sup>25</sup> | s EtOH, ace                                                |
| 2599 | 2-Cyclohexen-1-one                                           |                                     | C <sub>6</sub> H <sub>8</sub> O                               | 930-68-7   | 96.127   | liq               | -53    | 170                                   | 0.9620 <sup>25</sup>       | 1.4883 <sup>20</sup> | vs EtOH; s ace                                             |
| 2600 | 1-Cyclohexen-1-ylbenzene                                     |                                     | C <sub>12</sub> H <sub>14</sub>                               | 771-98-2   | 158.239  | liq               | -11    | 252                                   | 0.9939 <sup>20</sup>       | 1.5718 <sup>20</sup> | vs MeOH                                                    |
| 2601 | 2-(1-Cyclohexen-1-yl)<br>cyclohexanone                       |                                     | C <sub>12</sub> H <sub>18</sub> O                             | 1502-22-3  | 178.270  |                   |        | 116 <sup>3</sup>                      |                            | 1.5070 <sup>20</sup> |                                                            |
| 2602 | 1-(1-Cyclohexen-1-yl)ethanone                                |                                     | C <sub>8</sub> H <sub>12</sub> O                              | 932-66-1   | 124.180  |                   | 73     | 201.5                                 | 0.9655 <sup>20</sup>       | 1.4881 <sup>20</sup> | s EtOH, eth                                                |
| 2603 | 3-Cyclohexenylmethyl 3-<br>cyclohexenecarboxylate            |                                     | C <sub>14</sub> H <sub>20</sub> O <sub>2</sub>                | 2611-00-9  | 220.308  | liq               |        | 153 <sup>7</sup> , 109 <sup>0.6</sup> |                            |                      |                                                            |
| 2604 | 4-(3-Cyclohexen-1-yl)pyridine                                |                                     | C <sub>11</sub> H <sub>13</sub> N                             | 70644-46-1 | 159.228  |                   | 22.1   | 226                                   | 1.0222 <sup>25</sup>       | 1.5466 <sup>25</sup> |                                                            |
| 2605 | Cycloheximide                                                |                                     | C <sub>15</sub> H <sub>23</sub> NO <sub>4</sub>               | 66-81-9    | 281.349  | pl (al)           | 119    |                                       |                            |                      | vs EtOH                                                    |
| 2606 | Cyclohexyl acetate                                           |                                     | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                 | 622-45-7   | 142.196  |                   |        | 173; 96 <sup>25</sup>                 | 0.968 <sup>20</sup>        | 1.442 <sup>20</sup>  | vs eth, EtOH                                               |
| 2607 | Cyclohexyl acrylate                                          |                                     | C <sub>9</sub> H <sub>14</sub> O <sub>2</sub>                 | 3066-71-5  | 154.206  |                   |        | 183; 88 <sup>20</sup>                 | 1.0275 <sup>20</sup>       | 1.4673 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>chl             |
| 2608 | Cyclohexylamine                                              | Cyclohexanamine                     | C <sub>6</sub> H <sub>13</sub> N                              | 108-91-8   | 99.174   | liq               | -17.8  | 134                                   | 0.8191 <sup>20</sup>       | 1.4625 <sup>15</sup> | s H <sub>2</sub> O, ctc; vs<br>EtOH; msc eth,<br>ace, bz   |
| 2609 | Cyclohexylamine hydrochloride                                | Cyclohexanamine hydrochloride       | C <sub>6</sub> H <sub>14</sub> ClN                            | 4998-76-9  | 135.635  | nd (w, al-eth)    | 206.5  |                                       |                            |                      | vs H <sub>2</sub> O, EtOH                                  |
| 2610 | 2-(Cyclohexylaminiothio)<br>benzothiazole                    |                                     | C <sub>13</sub> H <sub>16</sub> N <sub>2</sub> S <sub>2</sub> | 95-33-0    | 264.409  |                   | 103    |                                       |                            |                      |                                                            |
| 2611 | <i>N</i> -Cyclohexylaniline                                  |                                     | C <sub>12</sub> H <sub>17</sub> N                             | 1821-36-9  | 175.270  | mcl pr            | 16     | 279; 192 <sup>73</sup>                | 1.0155 <sup>20</sup>       | 1.5610 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz                     |
| 2612 | Cyclohexylbenzene                                            |                                     | C <sub>12</sub> H <sub>16</sub>                               | 827-52-1   | 160.255  | pl                | 7.07   | 240.1                                 | 0.9427 <sup>20</sup>       | 1.5329 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH;<br>s eth; sl ctc              |
| 2613 | Cyclohexyl benzoate                                          |                                     | C <sub>13</sub> H <sub>16</sub> O <sub>2</sub>                | 2412-73-9  | 204.265  |                   | <-10   | 285                                   | 1.0429 <sup>20</sup>       | 1.5200 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                         |
| 2614 | Cyclohexyl butanoate                                         |                                     | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>                | 1551-44-6  | 170.249  |                   |        | 213                                   | 0.9572 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH; sl<br>ctc                      |
| 2615 | 3-Cyclohexyl-2-butenic acid                                  | Cicrotoic acid                      | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>                | 25229-42-9 | 168.233  | pr (aq-<br>MeOH)  | 85.5   |                                       |                            |                      |                                                            |
| 2616 | Cyclohexyl chloroformate                                     |                                     | C <sub>7</sub> H <sub>11</sub> ClO <sub>2</sub>               | 13248-54-9 | 162.614  |                   |        | 87.5 <sup>27</sup>                    |                            |                      | vs eth                                                     |
| 2617 | Cyclohexylcyclohexane                                        |                                     | C <sub>12</sub> H <sub>22</sub>                               | 92-51-3    | 166.303  |                   | 4      | 238                                   |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth                        |
| 2618 | Cyclohexyldiethylamine                                       | <i>N,N</i> -Diethylcyclohexanamine  | C <sub>10</sub> H <sub>21</sub> N                             | 91-65-6    | 155.281  |                   |        | 192; 85 <sup>20</sup>                 | 0.8443 <sup>25</sup>       |                      | s EtOH; sl ctc                                             |
| 2619 | Cyclohexyldimethylamine                                      | <i>N,N</i> -Dimethylcyclohexanamine | C <sub>8</sub> H <sub>17</sub> N                              | 98-94-2    | 127.228  |                   |        | 162                                   |                            |                      |                                                            |
| 2620 | 2-Cyclohexyl-4,6-dinitrophenol                               |                                     | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub> O <sub>5</sub> | 131-89-5   | 266.249  | cry               | 104    |                                       |                            |                      | sl H <sub>2</sub> O; s bz,<br>DMF                          |
| 2621 | (1,2-Cyclohexylenedinitrilo)<br>tetraacetic acid monohydrate | CDTA                                | C <sub>14</sub> H <sub>24</sub> N <sub>2</sub> O <sub>9</sub> | 13291-61-7 | 364.349  | cry (w)           | 215    |                                       |                            |                      |                                                            |
| 2622 | 1-Cyclohexylethanone                                         |                                     | C <sub>8</sub> H <sub>14</sub> O                              | 823-76-7   | 126.196  |                   |        | 180.5                                 | 0.9176 <sup>20</sup>       | 1.4565 <sup>16</sup> | i H <sub>2</sub> O; s eth                                  |
| 2623 | Cyclohexylethylamine                                         | <i>N</i> -Ethylcyclohexanamine      | C <sub>8</sub> H <sub>17</sub> N                              | 5459-93-8  | 127.228  |                   |        | 164                                   | 0.868 <sup>0</sup>         |                      | sl H <sub>2</sub> O, ctc; msc<br>EtOH, eth                 |

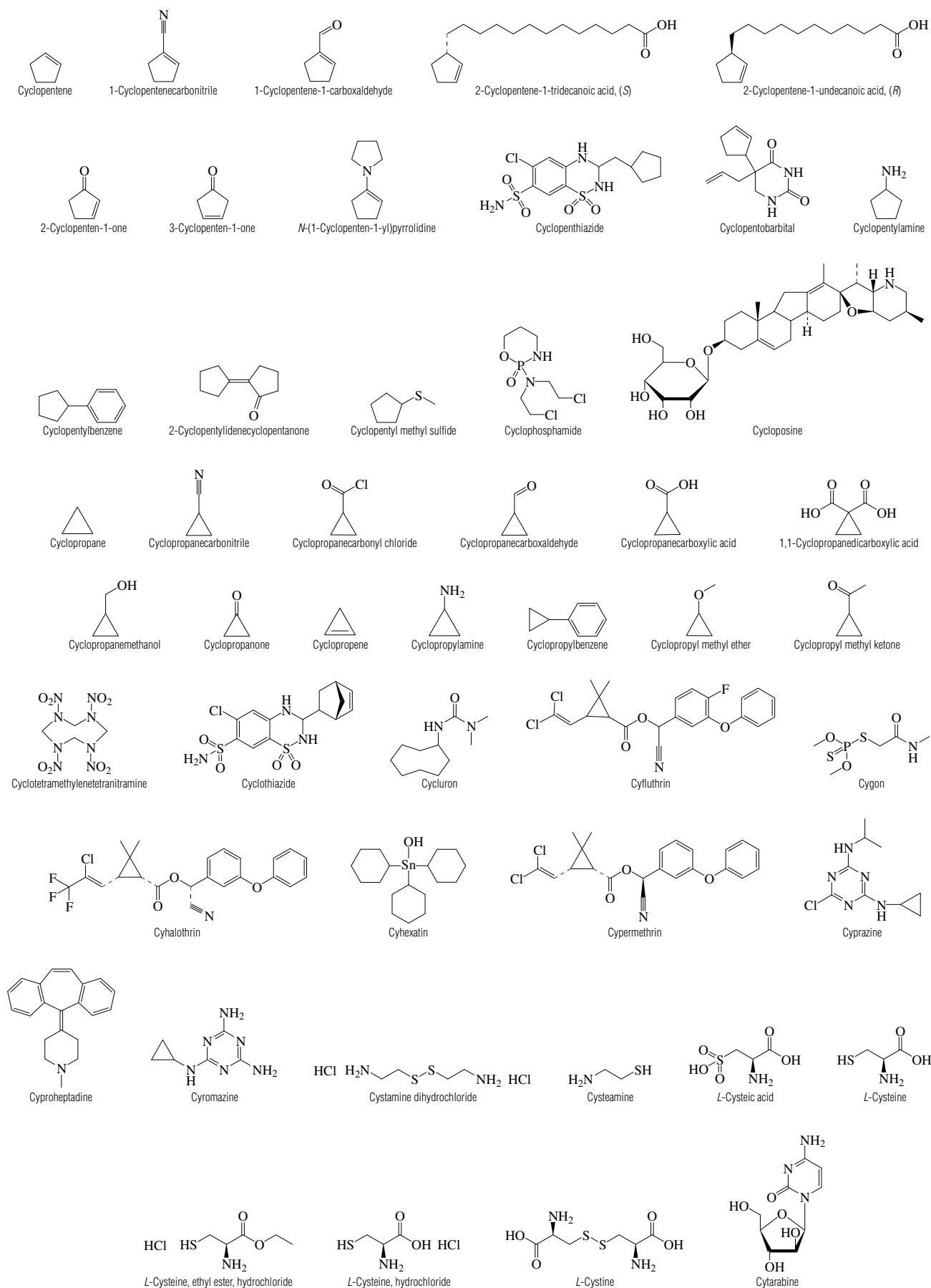


| No.  | Name                                            | Synonym                            | Mol. Form.                                       | CAS RN    | Mol. Wt. | Physical Form | mp/°C  | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|-------------------------------------------------|------------------------------------|--------------------------------------------------|-----------|----------|---------------|--------|----------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 2624 | 4-Cyclohexyl-3-ethyl-4 <i>H</i> -1,2,4-triazole | Hexazole                           | C <sub>10</sub> H <sub>17</sub> N <sub>3</sub>   | 4671-03-8 | 179.262  | pr (eth)      | 89.5   | 227 <sup>10</sup>                      |                            |                      | vs H <sub>2</sub> O; bz, chl                          |
| 2625 | Cyclohexyl formate                              |                                    | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>    | 4351-54-6 | 128.169  |               |        | 162                                    | 1.0057 <sup>0</sup>        | 1.4430 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, HOAc, HCOOH; vs eth       |
| 2626 | Cyclohexyl hydroperoxide                        |                                    | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>    | 766-07-4  | 116.158  |               | -20    | 42 <sup>0,1</sup>                      | 1.019 <sup>20</sup>        | 1.4645 <sup>25</sup> | vs eth, EtOH, HOAc                                    |
| 2627 | Cyclohexylideneacetone                          |                                    | C <sub>8</sub> H <sub>11</sub> N                 | 4435-18-1 | 121.180  |               |        | 107 <sup>22</sup>                      | 0.9483 <sup>15</sup>       | 1.4382 <sup>25</sup> | vs eth, EtOH                                          |
| 2628 | 2-Cyclohexylidenecyclohexanone                  |                                    | C <sub>12</sub> H <sub>18</sub> O                | 1011-12-7 | 178.270  | cry (MeOH aq) | 56.5   |                                        |                            |                      |                                                       |
| 2629 | Cyclohexyl isocyanate                           | Isocyanatocyclohexane              | C <sub>7</sub> H <sub>11</sub> NO                | 3173-53-3 | 125.168  |               |        | 172                                    | 0.98 <sup>25</sup>         | 1.4551 <sup>20</sup> |                                                       |
| 2630 | Cyclohexylisopropylamine                        | <i>N</i> -Isopropylcyclohexanamine | C <sub>9</sub> H <sub>19</sub> N                 | 1195-42-2 | 141.254  |               |        | 62 <sup>12</sup>                       | 0.859 <sup>25</sup>        | 1.4480 <sup>20</sup> |                                                       |
| 2631 | Cyclohexyl isothiocyanate                       | Isothiocyanatocyclohexane          | C <sub>7</sub> H <sub>11</sub> NS                | 1122-82-3 | 141.234  |               |        | 221                                    | 1.0339 <sup>20</sup>       | 1.5375 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc               |
| 2632 | Cyclohexylmagnesium chloride                    |                                    | C <sub>6</sub> H <sub>11</sub> ClMg              | 931-51-1  | 142.909  | hyg liq       |        |                                        |                            |                      | s eth                                                 |
| 2633 | Cyclohexyl methacrylate                         |                                    | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>   | 101-43-9  | 168.233  |               |        | 210                                    | 0.9626 <sup>20</sup>       | 1.4578 <sup>20</sup> |                                                       |
| 2634 | Cyclohexylmethylaniline                         | <i>N</i> -Methylcyclohexanamine    | C <sub>7</sub> H <sub>15</sub> N                 | 100-60-7  | 113.201  |               |        | 147                                    | 0.8660 <sup>23</sup>       | 1.4560 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH; msc eth; s chl          |
| 2635 | Cyclohexyl 2-methylpropanoate                   |                                    | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>   | 1129-47-1 | 170.249  |               |        | 204                                    | 0.9489 <sup>0</sup>        |                      | vs eth, EtOH                                          |
| 2636 | 2-Cyclohexylphenol                              |                                    | C <sub>12</sub> H <sub>16</sub> O                | 119-42-6  | 176.254  | nd (lig)      | 56.5   |                                        |                            |                      | vs EtOH, HOAc                                         |
| 2637 | 4-Cyclohexylphenol                              |                                    | C <sub>12</sub> H <sub>16</sub> O                | 1131-60-8 | 176.254  | nd (bz)       | 133    | 294; 133 <sup>4</sup>                  |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s bz; sl lig        |
| 2638 | α-Cyclohexyl-α-phenyl-1-piperidinepropanol      | Trihexphenidyl                     | C <sub>20</sub> H <sub>31</sub> NO               | 144-11-6  | 301.466  |               | 114    |                                        |                            |                      |                                                       |
| 2639 | Cyclohexyl propanoate                           |                                    | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>    | 6222-35-1 | 156.222  |               |        | 193; 93 <sup>35</sup>                  | 0.9359 <sup>20</sup>       | 1.4403 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, ctc             |
| 2640 | Cyclohexylsulfamic acid                         | Cyclamic acid                      | C <sub>6</sub> H <sub>13</sub> NO <sub>3</sub> S | 100-88-9  | 179.237  |               | 169.5  |                                        |                            |                      | vs alk                                                |
| 2641 | Cyclononane                                     |                                    | C <sub>9</sub> H <sub>18</sub>                   | 293-55-0  | 126.239  |               | 11     | 178.4                                  | 0.8463 <sup>25</sup>       | 1.4666 <sup>20</sup> |                                                       |
| 2642 | Cyclononane                                     |                                    | C <sub>9</sub> H <sub>18</sub> O                 | 3350-30-9 | 140.222  |               | 34     | 148 <sup>24</sup> , 94 <sup>12</sup>   | 0.9560 <sup>20</sup>       | 1.4729 <sup>20</sup> | s EtOH                                                |
| 2643 | 1,4-Cyclooctadiene                              |                                    | C <sub>8</sub> H <sub>12</sub>                   | 1073-07-0 | 108.181  | liq           | -53    | 145                                    | 0.8754 <sup>20</sup>       |                      |                                                       |
| 2644 | <i>cis</i> , <i>cis</i> -1,5-Cyclooctadiene     |                                    | C <sub>8</sub> H <sub>12</sub>                   | 111-78-4  | 108.181  | liq           | -56.4  | 150.5                                  | 0.883 <sup>20</sup>        | 1.4905 <sup>25</sup> | vs bz                                                 |
| 2645 | Cyclooctanamine                                 | Aminocyclooctane                   | C <sub>8</sub> H <sub>17</sub> N                 | 5452-37-9 | 127.228  | liq           | -48    | 190                                    | 0.928 <sup>25</sup>        | 1.4804 <sup>20</sup> |                                                       |
| 2646 | Cyclooctane                                     |                                    | C <sub>8</sub> H <sub>16</sub>                   | 292-64-8  | 112.213  |               | 14.59  | 149                                    | 0.8349 <sup>20</sup>       | 1.4586 <sup>20</sup> | i H <sub>2</sub> O; s bz, lig                         |
| 2647 | Cyclooctanol                                    |                                    | C <sub>8</sub> H <sub>16</sub> O                 | 696-71-9  | 128.212  |               | 25.1   | 99 <sup>16</sup>                       | 0.9740 <sup>20</sup>       | 1.4871 <sup>20</sup> | s EtOH                                                |
| 2648 | Cyclooctanone                                   |                                    | C <sub>8</sub> H <sub>14</sub> O                 | 502-49-8  | 126.196  |               | 29     | 196                                    | 0.9581 <sup>20</sup>       | 1.4694 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, bz; sl ctc           |
| 2649 | 1,3,5,7-Cyclooctatetraene                       | [8]Annulene                        | C <sub>8</sub> H <sub>8</sub>                    | 629-20-9  | 104.150  | liq           | -2.4   | 140.5                                  | 0.9206 <sup>20</sup>       | 1.5381 <sup>20</sup> | s EtOH, eth, ace, bz                                  |
| 2650 | 1,3,5-Cyclooctatriene                           |                                    | C <sub>8</sub> H <sub>10</sub>                   | 1871-52-9 | 106.165  | liq           | -83    | 145.5                                  | 0.8971 <sup>25</sup>       | 1.5035 <sup>25</sup> |                                                       |
| 2651 | <i>cis</i> -Cyclooctene                         |                                    | C <sub>8</sub> H <sub>14</sub>                   | 931-87-3  | 110.197  | liq           | -12    | 138                                    | 0.8472 <sup>20</sup>       | 1.4698 <sup>20</sup> | s EtOH, eth, ctc                                      |
| 2652 | <i>trans</i> -Cyclooctene                       |                                    | C <sub>8</sub> H <sub>14</sub>                   | 931-89-5  | 110.197  | liq           | -59    | 143                                    | 0.8483 <sup>20</sup>       | 1.4741 <sup>25</sup> | s EtOH, chl; sl ctc                                   |
| 2653 | Cyclooctyne                                     |                                    | C <sub>8</sub> H <sub>12</sub>                   | 1781-78-8 | 108.181  |               |        | 158                                    | 0.868 <sup>20</sup>        | 1.4850 <sup>20</sup> |                                                       |
| 2654 | Cyclopamine                                     | 11-Deoxojervine                    | C <sub>27</sub> H <sub>41</sub> NO <sub>2</sub>  | 4449-51-8 | 411.621  | nd (EtOH)     | 237    |                                        |                            |                      |                                                       |
| 2655 | Cyclopentadecane                                |                                    | C <sub>15</sub> H <sub>30</sub>                  | 295-48-7  | 210.399  | nd (MeOH)     | 61.3   |                                        | 0.8364 <sup>61</sup>       | 1.4592 <sup>61</sup> |                                                       |
| 2656 | Cyclopentadecanol                               | Exaltol                            | C <sub>15</sub> H <sub>30</sub> O                | 4727-17-7 | 226.398  | cry (MeOH)    | 80.5   | 177 <sup>11</sup> , 145 <sup>0,3</sup> | 0.930 <sup>20</sup>        | 1.4555 <sup>98</sup> |                                                       |
| 2657 | Cyclopentadecanone                              |                                    | C <sub>15</sub> H <sub>28</sub> O                | 502-72-7  | 224.382  |               | 63     | 120 <sup>0,3</sup>                     | 0.8895 <sup>25</sup>       | 1.4637 <sup>60</sup> | sl H <sub>2</sub> O; s EtOH, ace                      |
| 2658 | 1,3-Cyclopentadiene                             | Pyropentylene                      | C <sub>5</sub> H <sub>6</sub>                    | 542-92-7  | 66.102   | liq           | -85    | 41                                     | 0.8021 <sup>20</sup>       | 1.4440 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, bz; s ace          |
| 2659 | Cyclopentane                                    | Pentamethylene                     | C <sub>5</sub> H <sub>10</sub>                   | 287-92-3  | 70.133   | liq           | -93.4  | 49.3                                   | 0.7457 <sup>20</sup>       | 1.4065 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 2660 | Cyclopentaneacetic acid                         |                                    | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>    | 1123-00-8 | 128.169  | pl            | 13.5   | 228                                    | 1.0216 <sup>18</sup>       | 1.4523 <sup>18</sup> |                                                       |
| 2661 | Cyclopentanecarbonitrile                        | Cyanocyclopentane                  | C <sub>6</sub> H <sub>9</sub> N                  | 4254-02-8 | 95.142   | liq           | -76    | 170; 67 <sup>10</sup>                  | 0.912                      | 1.4410 <sup>20</sup> |                                                       |
| 2662 | Cyclopentanecarboxaldehyde                      |                                    | C <sub>6</sub> H <sub>10</sub> O                 | 872-53-7  | 98.142   |               |        | 133.5                                  | 0.9371 <sup>20</sup>       | 1.4432 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                        |
| 2663 | Cyclopentanecarboxylic acid                     | Cyclopentanoic acid                | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | 3400-45-1 | 114.142  | liq           | -7     | 212; 104 <sup>11</sup>                 | 1.0527 <sup>20</sup>       | 1.4532 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s MeOH                      |
| 2664 | <i>cis</i> -1,2-Cyclopentanediol                |                                    | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>    | 5057-98-7 | 102.132  |               | 30     | 124 <sup>29</sup> , 100 <sup>10</sup>  |                            |                      |                                                       |
| 2665 | <i>trans</i> -1,2-Cyclopentanediol              |                                    | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>    | 5057-99-8 | 102.132  |               | 54.7   | 226; 136 <sup>21</sup>                 |                            |                      |                                                       |
| 2666 | Cyclopentanemethanol                            |                                    | C <sub>6</sub> H <sub>12</sub> O                 | 3637-61-4 | 100.158  |               |        | 163                                    | 0.9332 <sup>20</sup>       | 1.4579 <sup>20</sup> |                                                       |
| 2667 | Cyclopentanepropanoic acid                      |                                    | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>    | 140-77-2  | 142.196  |               |        | 158 <sup>26</sup> , 131 <sup>12</sup>  | 1.0100 <sup>17</sup>       | 1.4570 <sup>20</sup> |                                                       |
| 2668 | Cyclopentanethiol                               | Cyclopentyl mercaptan              | C <sub>5</sub> H <sub>10</sub> S                 | 1679-07-8 | 102.198  |               |        | 132.1                                  | 0.9550 <sup>20</sup>       |                      |                                                       |
| 2669 | Cyclopentanol                                   | Cyclopentyl alcohol                | C <sub>5</sub> H <sub>10</sub> O                 | 96-41-3   | 86.132   | liq           | -17.5  | 140.42                                 | 0.9488 <sup>20</sup>       | 1.4530 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, ace            |
| 2670 | Cyclopentanone                                  | Adipic ketone                      | C <sub>5</sub> H <sub>8</sub> O                  | 120-92-3  | 84.117   | liq           | -51.90 | 130.57                                 | 0.9487 <sup>20</sup>       | 1.4366 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, ctc, hx; msc eth     |
| 2671 | Cyclopentanone oxime                            |                                    | C <sub>5</sub> H <sub>9</sub> NO                 | 1192-28-5 | 99.131   |               | 57.8   | 196                                    |                            |                      | vs H <sub>2</sub> O, bz                               |

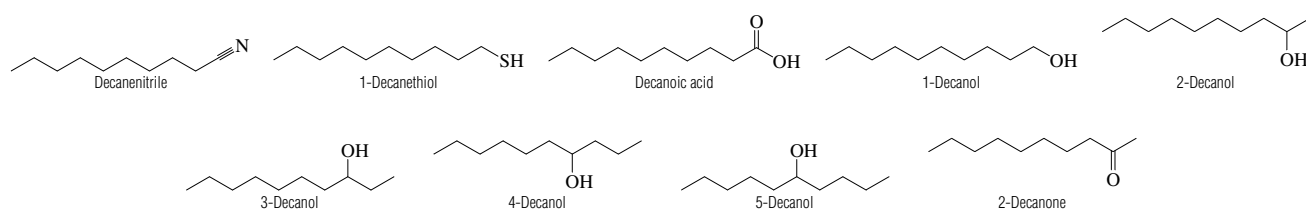
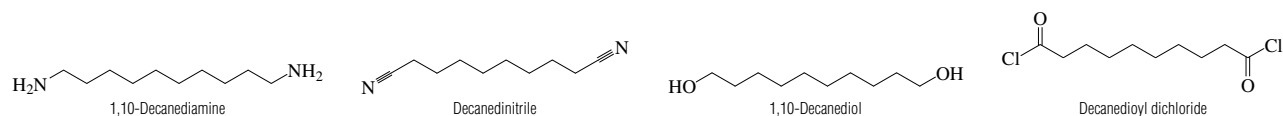
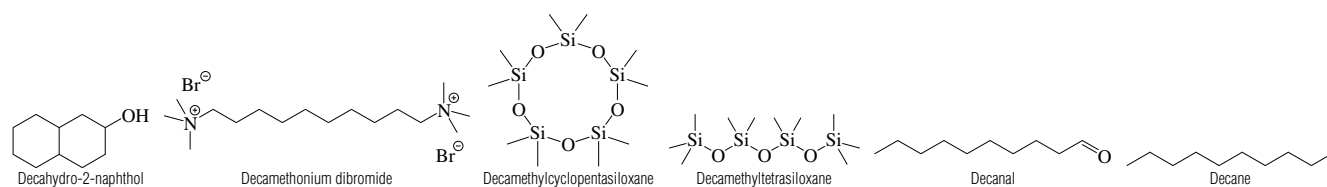
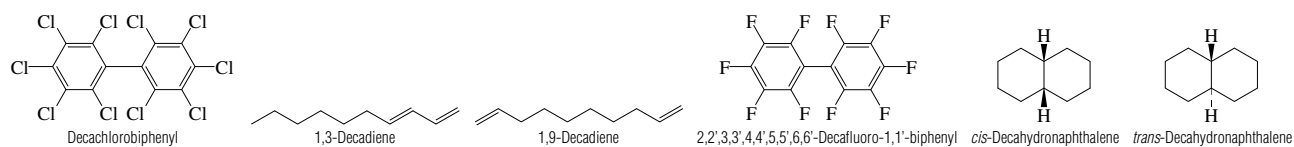
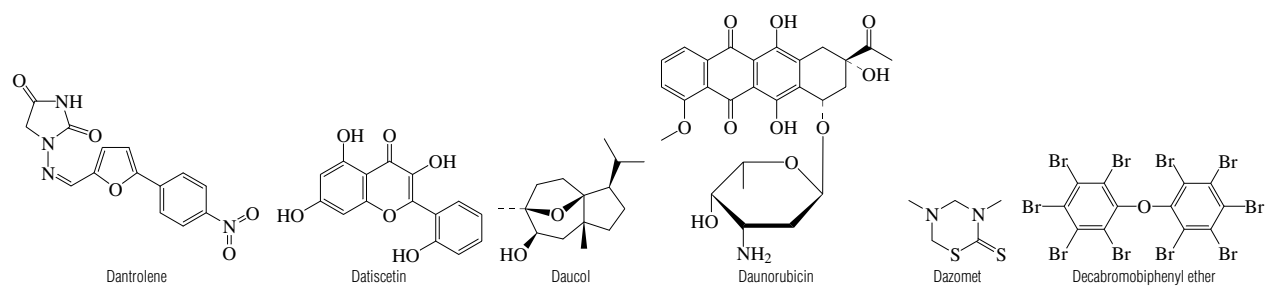
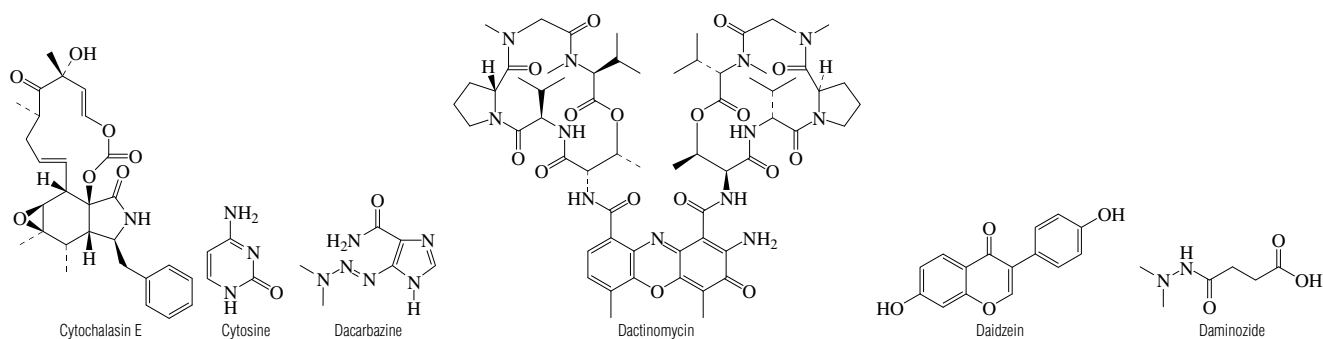
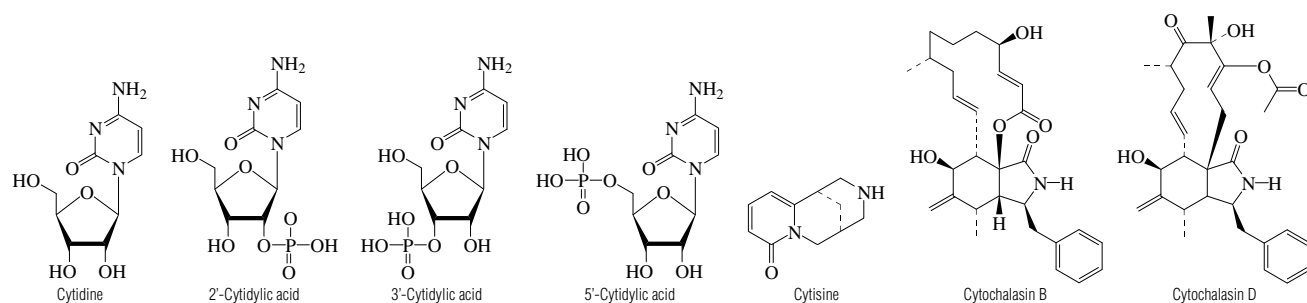




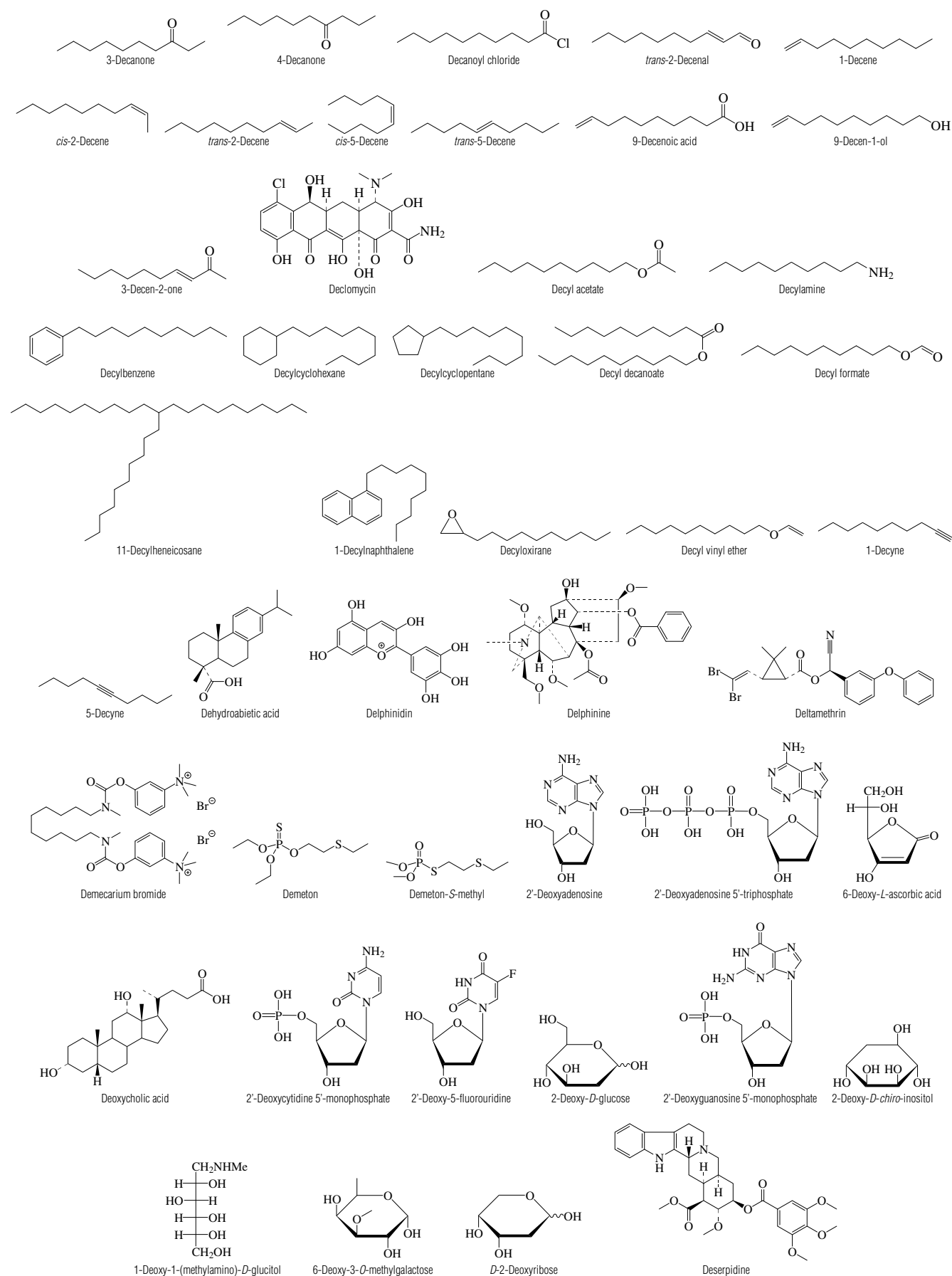
| No.  | Name                                   | Synonym                                     | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form               | mp/°C                    | bp/°C                   | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>        | Solubility                                        |
|------|----------------------------------------|---------------------------------------------|--------------------------------------------------------------------------------|------------|----------|-----------------------------|--------------------------|-------------------------|----------------------------------|-----------------------|---------------------------------------------------|
| 2672 | Cyclopentene                           |                                             | C <sub>5</sub> H <sub>8</sub>                                                  | 142-29-0   | 68.118   | liq                         | -135.0                   | 44.2                    | 0.7720 <sup>20</sup>             | 1.4225 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, ctc, peth    |
| 2673 | 1-Cyclopentenecarbonitrile             | 1-Cyanocyclopentene                         | C <sub>6</sub> H <sub>7</sub> N                                                | 3047-38-9  | 93.127   | liq                         |                          | 81 <sup>30</sup>        |                                  |                       |                                                   |
| 2674 | 1-Cyclopentene-1-carboxaldehyde        |                                             | C <sub>6</sub> H <sub>8</sub> O                                                | 6140-65-4  | 96.127   | liq                         | -32                      | 146                     | 0.970 <sup>21</sup>              | 1.4872 <sup>17</sup>  |                                                   |
| 2675 | 2-Cyclopentene-1-tridecanoic acid, (S) | Chaulmoogric acid                           | C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>                                 | 29106-32-9 | 280.446  | pl or lf (al, HOAc)         | 68.5                     | 247 <sup>20</sup>       |                                  |                       | vs eth, chl                                       |
| 2676 | 2-Cyclopentene-1-undecanoic acid, (R)  | Hydnocarpic acid                            | C <sub>16</sub> H <sub>28</sub> O <sub>2</sub>                                 | 459-67-6   | 252.392  |                             | 60.5                     |                         |                                  |                       | vs EtOH, chl, peth                                |
| 2677 | 2-Cyclopenten-1-one                    |                                             | C <sub>6</sub> H <sub>8</sub> O                                                | 930-30-3   | 82.101   |                             |                          | 136; 40 <sup>12</sup>   | 0.989 <sup>15</sup>              | 1.4629 <sup>15</sup>  | vs eth, EtOH                                      |
| 2678 | 3-Cyclopenten-1-one                    |                                             | C <sub>6</sub> H <sub>8</sub> O                                                | 14320-37-7 | 82.101   | liq                         |                          | 28 <sup>17</sup>        |                                  |                       |                                                   |
| 2679 | N-(1-Cyclopenten-1-yl)pyrrolidine      | 1-Pyrrolidinylcyclopentene                  | C <sub>9</sub> H <sub>13</sub> N                                               | 7148-07-4  | 137.222  |                             |                          | 105 <sup>15</sup>       |                                  | 1.5128 <sup>20</sup>  |                                                   |
| 2680 | Cyclopenthiiazide                      |                                             | C <sub>13</sub> H <sub>18</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 742-20-1   | 379.883  |                             | 238                      |                         |                                  |                       |                                                   |
| 2681 | Cyclopentobarbital                     |                                             | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>                  | 76-68-6    | 234.250  | cry (w, dil al)             | 139.5                    |                         |                                  |                       | sl H <sub>2</sub> O; vs EtOH                      |
| 2682 | Cyclopentylamine                       | Cyclopentanamine                            | C <sub>6</sub> H <sub>11</sub> N                                               | 1003-03-8  | 85.148   | liq                         | -82.7                    | 108                     | 0.8689 <sup>20</sup>             | 1.4728 <sup>25</sup>  | s ace, bz, chl                                    |
| 2683 | Cyclopentylbenzene                     |                                             | C <sub>11</sub> H <sub>14</sub>                                                | 700-88-9   | 146.229  |                             |                          | 219                     | 0.9462 <sup>20</sup>             | 1.5280 <sup>20</sup>  | vs eth                                            |
| 2684 | 2-Cyclopentylidenecyclopentanone       |                                             | C <sub>10</sub> H <sub>14</sub> O                                              | 825-25-2   | 150.217  |                             |                          | 135 <sup>25</sup>       | 1.0179 <sup>18</sup>             | 1.5215 <sup>18</sup>  |                                                   |
| 2685 | Cyclopentyl methyl sulfide             |                                             | C <sub>9</sub> H <sub>12</sub> S                                               | 7133-36-0  | 116.224  |                             |                          | 156.2                   |                                  |                       |                                                   |
| 2686 | Cyclophosphamide                       | Cyclophosphane                              | C <sub>7</sub> H <sub>15</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub> P | 50-18-0    | 261.086  |                             | 43                       |                         |                                  |                       | vs H <sub>2</sub> O; sl bz, chl, diox, EtOH       |
| 2687 | Cycloposine                            |                                             | C <sub>33</sub> H <sub>51</sub> NO <sub>7</sub>                                | 23185-94-6 | 573.761  |                             | 268                      |                         |                                  |                       |                                                   |
| 2688 | Cyclopropane                           | Trimethylene                                | C <sub>3</sub> H <sub>6</sub>                                                  | 75-19-4    | 42.080   | col gas                     | -127.58                  | -32.81                  | 0.617 <sup>25</sup><br>(p>1 atm) | 1.3799 <sup>-42</sup> | s H <sub>2</sub> O, bz, peth; vs EtOH, eth        |
| 2689 | Cyclopropanecarbonitrile               | Cyclopropyl cyanide                         | C <sub>4</sub> H <sub>5</sub> N                                                | 5500-21-0  | 67.090   |                             |                          | 135.1                   | 0.8946 <sup>20</sup>             | 1.4229 <sup>20</sup>  | s eth, hx; sl ctc                                 |
| 2690 | Cyclopropanecarbonyl chloride          |                                             | C <sub>4</sub> H <sub>5</sub> ClO                                              | 4023-34-1  | 104.535  |                             |                          | 119                     | 1.1516 <sup>20</sup>             |                       |                                                   |
| 2691 | Cyclopropanecarboxaldehyde             | Formylcyclopropane                          | C <sub>4</sub> H <sub>6</sub> O                                                | 1489-69-6  | 70.090   | liq                         |                          | 100                     | 0.938                            | 1.4298 <sup>20</sup>  |                                                   |
| 2692 | Cyclopropanecarboxylic acid            |                                             | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                   | 1759-53-1  | 86.090   |                             | 18.5                     | 183                     | 1.0885 <sup>20</sup>             | 1.4390 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, eth; sl ctc             |
| 2693 | 1,1-Cyclopropanedicarboxylic acid      |                                             | C <sub>5</sub> H <sub>6</sub> O <sub>4</sub>                                   | 598-10-7   | 130.100  | pr or nd (chl)<br>pr (w +1) | 140.5                    |                         |                                  |                       | vs H <sub>2</sub> O, eth                          |
| 2694 | Cyclopropanemethanol                   |                                             | C <sub>4</sub> H <sub>8</sub> O                                                | 2516-33-8  | 72.106   |                             |                          | 124                     | 0.911 <sup>25</sup>              |                       | sl ctc                                            |
| 2695 | Cyclopropanone                         |                                             | C <sub>3</sub> H <sub>4</sub> O                                                | 5009-27-8  | 56.063   |                             | stable only at low temp. |                         |                                  |                       |                                                   |
| 2696 | Cyclopropene                           |                                             | C <sub>3</sub> H <sub>4</sub>                                                  | 2781-85-3  | 40.064   | gas                         |                          | dec -36                 |                                  |                       |                                                   |
| 2697 | Cyclopropylamine                       | Cyclopropanamine                            | C <sub>3</sub> H <sub>7</sub> N                                                | 765-30-0   | 57.095   | liq                         | -35.39                   | 50.5                    | 0.8240 <sup>20</sup>             | 1.4210 <sup>20</sup>  | msc H <sub>2</sub> O; s EtOH, eth, chl            |
| 2698 | Cyclopropylbenzene                     |                                             | C <sub>9</sub> H <sub>10</sub>                                                 | 873-49-4   | 118.175  | liq                         | -31                      | 173.6; 80 <sup>37</sup> | 0.9317 <sup>20</sup>             | 1.5285 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ace, chl               |
| 2699 | Cyclopropyl methyl ether               |                                             | C <sub>4</sub> H <sub>8</sub> O                                                | 540-47-6   | 72.106   | liq                         | -119                     | 44.7                    | 0.8100 <sup>20</sup>             | 1.3802 <sup>20</sup>  | vs H <sub>2</sub> O, bz, eth, EtOH                |
| 2700 | Cyclopropyl methyl ketone              |                                             | C <sub>5</sub> H <sub>8</sub> O                                                | 765-43-5   | 84.117   | liq                         | -68.3                    | 111.3                   | 0.8984 <sup>20</sup>             | 1.4251 <sup>20</sup>  | vs H <sub>2</sub> O, eth, EtOH                    |
| 2701 | Cyclotetramethylenetetranitramine      | HMX                                         | C <sub>4</sub> H <sub>8</sub> N <sub>8</sub> O <sub>8</sub>                    | 2691-41-0  | 296.156  | cry                         | 286                      | exp                     |                                  |                       |                                                   |
| 2702 | Cyclothiazide                          |                                             | C <sub>14</sub> H <sub>18</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 2259-96-3  | 389.878  |                             | 234                      |                         |                                  |                       |                                                   |
| 2703 | Cycluron                               | N'-Cyclooctyl-N,N-dimethylurea              | C <sub>11</sub> H <sub>22</sub> N <sub>2</sub> O                               | 2163-69-1  | 198.305  | cry                         | 138                      |                         |                                  |                       | sl H <sub>2</sub> O; s bz, ace; vs MeOH           |
| 2704 | Cyfluthrin                             |                                             | C <sub>22</sub> H <sub>18</sub> Cl <sub>2</sub> FNO <sub>3</sub>               | 68359-37-5 | 434.287  |                             | 60                       |                         |                                  |                       |                                                   |
| 2705 | Cygon                                  |                                             | C <sub>6</sub> H <sub>12</sub> NO <sub>3</sub> PS <sub>2</sub>                 | 60-51-5    | 229.258  |                             | 52                       | 117 <sup>0.1</sup>      | 1.277 <sup>65</sup>              |                       |                                                   |
| 2706 | Cyhalothrin                            | 2,2-Dimethylcyclopropanecarboxylate         | C <sub>23</sub> H <sub>19</sub> ClF <sub>3</sub> NO <sub>3</sub>               | 91465-08-6 | 449.850  |                             | 49.2                     |                         |                                  |                       |                                                   |
| 2707 | Cyhexatin                              | Stannane, tricyclohexylhydroxy-             | C <sub>18</sub> H <sub>34</sub> OSn                                            | 13121-70-5 | 385.172  |                             | 196                      |                         |                                  |                       |                                                   |
| 2708 | Cypermethrin                           |                                             | C <sub>22</sub> H <sub>19</sub> Cl <sub>2</sub> NO <sub>3</sub>                | 52315-07-8 | 416.297  |                             | 70                       |                         | 1.25 <sup>20</sup>               |                       |                                                   |
| 2709 | Cyprazine                              |                                             | C <sub>9</sub> H <sub>14</sub> ClN <sub>5</sub>                                | 22936-86-3 | 227.694  |                             | 167                      |                         |                                  |                       |                                                   |
| 2710 | Cyproheptadine                         |                                             | C <sub>21</sub> H <sub>21</sub> N                                              | 129-03-3   | 287.399  | cry (EtOH aq)               | 113                      |                         |                                  |                       |                                                   |
| 2711 | Cyromazine                             | N-Cyclopropyl-1,3,5-triazine-2,4,6-triamine | C <sub>6</sub> H <sub>10</sub> N <sub>6</sub>                                  | 66215-27-8 | 166.183  | cry                         | 220                      |                         |                                  |                       |                                                   |
| 2712 | Cystamine dihydrochloride              |                                             | C <sub>4</sub> H <sub>14</sub> Cl <sub>2</sub> N <sub>2</sub> S <sub>2</sub>   | 56-17-7    | 225.203  | nd (MeOH)                   | 218 dec                  |                         |                                  |                       | vs H <sub>2</sub> O, EtOH                         |
| 2713 | Cysteamine                             |                                             | C <sub>4</sub> H <sub>9</sub> NS                                               | 60-23-1    | 77.149   | cry (sub)                   | 99.5                     | dec                     |                                  |                       | vs H <sub>2</sub> O, EtOH                         |
| 2714 | L-Cysteic acid                         |                                             | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub> S                                | 13100-82-8 | 169.157  | cry                         | 260 dec                  |                         |                                  |                       | s H <sub>2</sub> O; i EtOH                        |
| 2715 | L-Cysteine                             | Propanoic acid, 2-amino-3-mercaptop-, (R)-  | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub> S                                | 52-90-4    | 121.159  | cry (w)                     | 240 dec                  |                         |                                  |                       | vs H <sub>2</sub> O, ace, EtOH                    |
| 2716 | L-Cysteine, ethyl ester, hydrochloride |                                             | C <sub>5</sub> H <sub>12</sub> ClNO <sub>2</sub> S                             | 868-59-7   | 185.673  |                             | 125.8                    |                         |                                  |                       | vs H <sub>2</sub> O                               |
| 2717 | L-Cysteine, hydrochloride              |                                             | C <sub>3</sub> H <sub>8</sub> ClNO <sub>2</sub> S                              | 52-89-1    | 157.620  | cry                         | 175 dec                  |                         |                                  |                       | s H <sub>2</sub> O                                |
| 2718 | L-Cystine                              | 3,3'-Dithiobis(2-aminopropanoic acid)       | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub>    | 56-89-3    | 240.300  | hex pl or pr (w)            | 260 dec                  |                         | 1.677 <sup>25</sup>              |                       | sl H <sub>2</sub> O; i EtOH, eth, bz; s acid, alk |
| 2719 | Cytarabine                             | Cytosine arabinoside                        | C <sub>9</sub> H <sub>13</sub> N <sub>5</sub> O <sub>5</sub>                   | 147-94-4   | 243.216  | pr (EtOH aq)                | 212                      |                         |                                  |                       | s H <sub>2</sub> O                                |



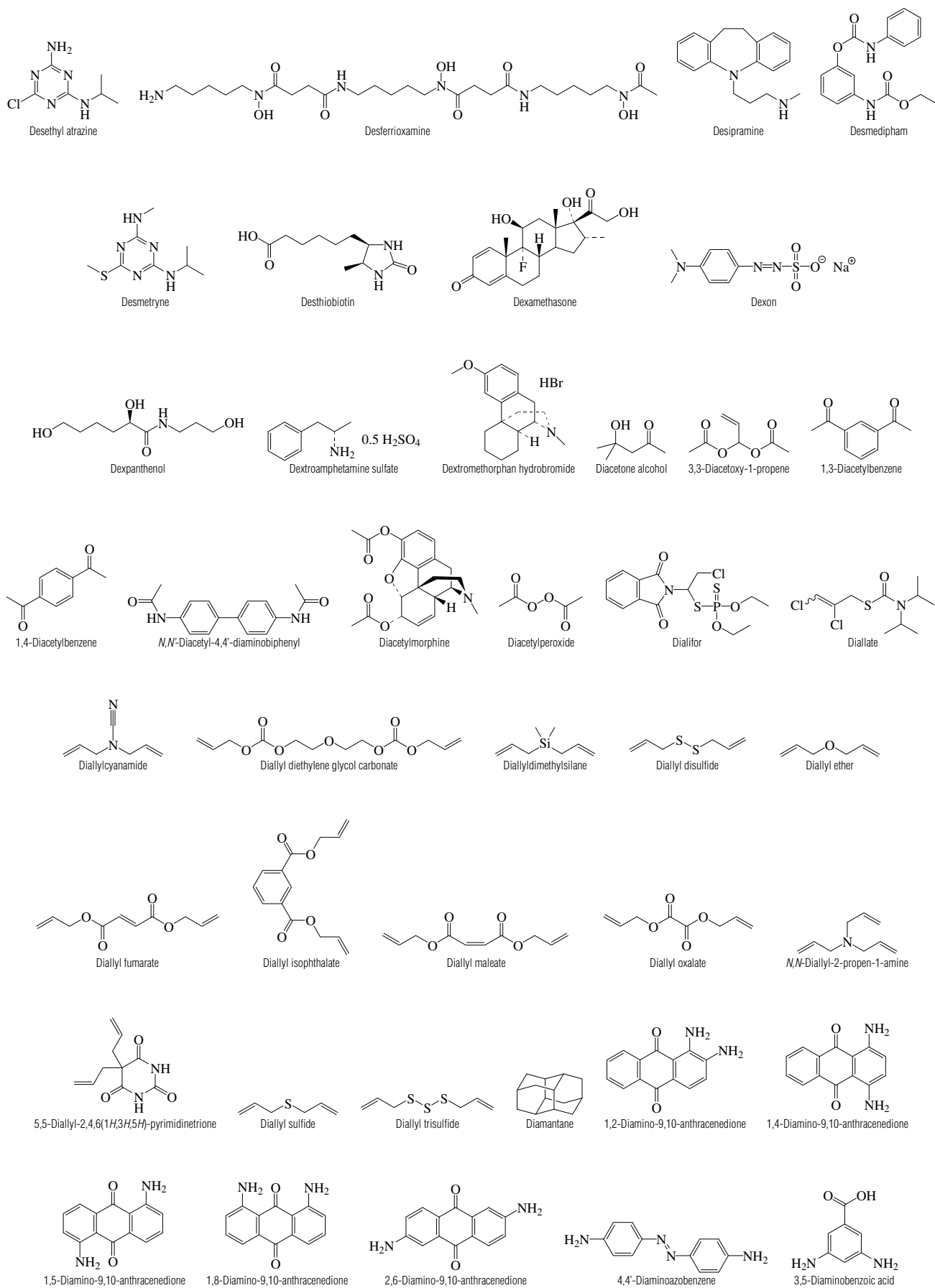
| No.  | Name                                              | Synonym                                                          | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form          | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|---------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|------------|----------|------------------------|---------|---------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 2720 | Cytidine                                          | 4-Amino-1-β-D-ribofuranosyl-2(1 <i>H</i> )-pyrimidinone          | C <sub>9</sub> H <sub>13</sub> N <sub>3</sub> O <sub>5</sub>    | 65-46-3    | 243.216  | nd (dil al)            | 230 dec |                                       |                            |                      | vs H <sub>2</sub> O; sl EtOH                           |
| 2721 | 2'-Cytidylic acid                                 | Cytidine 2'-monophosphate                                        | C <sub>9</sub> H <sub>14</sub> N <sub>3</sub> O <sub>8</sub> P  | 85-94-9    | 323.196  |                        | 239 dec |                                       |                            |                      |                                                        |
| 2722 | 3'-Cytidylic acid                                 | Cytidine 3'-monophosphate                                        | C <sub>9</sub> H <sub>14</sub> N <sub>3</sub> O <sub>8</sub> P  | 84-52-6    | 323.196  |                        | 233 dec |                                       |                            |                      | s H <sub>2</sub> O, EtOH                               |
| 2723 | 5'-Cytidylic acid                                 | Cytidine 5'-monophosphate                                        | C <sub>9</sub> H <sub>14</sub> N <sub>3</sub> O <sub>8</sub> P  | 63-37-6    | 323.196  | orth nd                | 233 dec |                                       |                            |                      | vs H <sub>2</sub> O, EtOH                              |
| 2724 | Cytisine                                          | Sophorine                                                        | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> O                | 485-35-8   | 190.241  | pr                     | 153     | 218 <sup>2</sup>                      |                            |                      | vs H <sub>2</sub> O, EtOH, MeOH; s bz, ace             |
| 2725 | Cytochalasin B                                    |                                                                  | C <sub>29</sub> H <sub>37</sub> NO <sub>5</sub>                 | 14930-96-2 | 479.608  | nd (ace)               | 219     |                                       |                            |                      |                                                        |
| 2726 | Cytochalasin D                                    | Zygosporin A                                                     | C <sub>30</sub> H <sub>37</sub> NO <sub>6</sub>                 | 22144-77-0 | 507.618  | nd (ace/peth)          | 270     |                                       |                            |                      |                                                        |
| 2727 | Cytochalasin E                                    |                                                                  | C <sub>28</sub> H <sub>33</sub> NO <sub>7</sub>                 | 36011-19-5 | 495.565  |                        | 207     |                                       |                            |                      |                                                        |
| 2728 | Cytosine                                          |                                                                  | C <sub>4</sub> H <sub>5</sub> N <sub>3</sub> O                  | 71-30-7    | 111.102  | mcl or tcl pl (w+1)    | 322 dec |                                       |                            |                      | s H <sub>2</sub> O; sl EtOH, chl; i eth                |
| 2729 | Dacarbazine                                       | 5-(3,3-Dimethyl-1-triazenyl)-1 <i>H</i> -imidazole-4-carboxamide | C <sub>6</sub> H <sub>10</sub> N <sub>6</sub> O                 | 4342-03-4  | 182.182  | cry                    | 205     |                                       |                            |                      |                                                        |
| 2730 | Dactinomycin                                      |                                                                  | C <sub>62</sub> H <sub>86</sub> N <sub>12</sub> O <sub>16</sub> | 50-76-0    | 1255.416 |                        | 245 dec |                                       |                            |                      |                                                        |
| 2731 | Daidzein                                          | 7-Hydroxy-3-(4-hydroxyphenyl)-4 <i>H</i> -1-benzopyran-4-one     | C <sub>15</sub> H <sub>10</sub> O <sub>4</sub>                  | 486-66-8   | 254.238  | pa ye pr (50% al)      | 323 dec | sub                                   |                            |                      | s EtOH, eth                                            |
| 2732 | Daminozide                                        | Butanedioic acid, mono(2,2-dimethylhydrazide)                    | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>    | 1596-84-5  | 160.170  |                        | 154.5   |                                       |                            |                      |                                                        |
| 2733 | Dantrolene                                        |                                                                  | C <sub>14</sub> H <sub>10</sub> N <sub>4</sub> O <sub>5</sub>   | 7261-97-4  | 314.253  | cry (DMF aq)           | 280     |                                       |                            |                      |                                                        |
| 2734 | Datisetatin                                       |                                                                  | C <sub>15</sub> H <sub>10</sub> O <sub>6</sub>                  | 480-15-9   | 286.236  | pa ye nd (al, aq HOAc) | 277.5   |                                       |                            |                      | vs ace, eth, EtOH                                      |
| 2735 | Daucol                                            |                                                                  | C <sub>15</sub> H <sub>26</sub> O <sub>2</sub>                  | 887-08-1   | 238.366  | cry                    | 114     | 128 <sup>2</sup>                      |                            |                      |                                                        |
| 2736 | Daunorubicin                                      |                                                                  | C <sub>27</sub> H <sub>29</sub> NO <sub>10</sub>                | 20830-81-3 | 527.520  | red nd                 | 208     |                                       |                            |                      |                                                        |
| 2737 | Dazomet                                           |                                                                  | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> S <sub>2</sub>    | 533-74-4   | 162.276  | nd (bz)                | 106     |                                       |                            |                      | reac H <sub>2</sub> O; s EtOH                          |
| 2738 | Decabromobiphenyl ether                           | Bis(pentabromophenyl) ether                                      | C <sub>12</sub> Br <sub>10</sub> O                              | 1163-19-5  | 959.167  | ye pr (tol)            | 305     |                                       |                            |                      | i H <sub>2</sub> O                                     |
| 2739 | Decachlorobiphenyl                                |                                                                  | C <sub>12</sub> Cl <sub>10</sub>                                | 2051-24-3  | 498.658  | cry (bz)               | 309     |                                       |                            |                      | i H <sub>2</sub> O                                     |
| 2740 | 1,3-Decadiene                                     | 1-Hexyl-1,3-butadiene                                            | C <sub>10</sub> H <sub>18</sub>                                 | 2051-25-4  | 138.250  |                        |         | 169                                   | 0.752 <sup>30</sup>        |                      | vs bz                                                  |
| 2741 | 1,9-Decadiene                                     |                                                                  | C <sub>10</sub> H <sub>18</sub>                                 | 1647-16-1  | 138.250  |                        |         | 167                                   | 0.75 <sup>25</sup>         | 1.4325 <sup>20</sup> |                                                        |
| 2742 | 2,2',3,3',4,4',5,5',6,6'-Decafluoro-1,1'-biphenyl |                                                                  | C <sub>12</sub> F <sub>10</sub>                                 | 434-90-2   | 334.112  |                        | 67.5    | 206                                   | 1.785 <sup>20</sup>        |                      |                                                        |
| 2743 | <i>cis</i> -Decahydronaphthalene                  | <i>cis</i> -Decalin                                              | C <sub>10</sub> H <sub>18</sub>                                 | 493-01-6   | 138.250  | liq                    | -42.9   | 195.8                                 | 0.8965 <sup>20</sup>       | 1.4810 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH; vs eth, ace, chl         |
| 2744 | <i>trans</i> -Decahydronaphthalene                | <i>trans</i> -Decalin                                            | C <sub>10</sub> H <sub>18</sub>                                 | 493-02-7   | 138.250  | liq                    | -30.4   | 187.3                                 | 0.8659 <sup>25</sup>       | 1.4695 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace; msc bz; sl MeOH |
| 2745 | Decahydro-2-naphthol                              | Decahydro-β-naphthol                                             | C <sub>10</sub> H <sub>18</sub> O                               | 825-51-4   | 154.249  |                        |         | 109 <sup>14</sup>                     | 0.996 <sup>25</sup>        | 1.4992 <sup>20</sup> |                                                        |
| 2746 | Decamethonium dibromide                           |                                                                  | C <sub>16</sub> H <sub>38</sub> Br <sub>2</sub> N <sub>2</sub>  | 541-22-0   | 418.294  | cry (MeOH/ace)         | 269 dec |                                       |                            |                      | i eth                                                  |
| 2747 | Decamethylcyclopentasiloxane                      |                                                                  | C <sub>10</sub> H <sub>30</sub> O <sub>5</sub> Si <sub>5</sub>  | 541-02-6   | 370.770  | liq                    | -38     | 210                                   | 0.9593 <sup>20</sup>       | 1.3982 <sup>20</sup> | i H <sub>2</sub> O                                     |
| 2748 | Decamethyltetrasiloxane                           |                                                                  | C <sub>10</sub> H <sub>30</sub> O <sub>3</sub> Si <sub>4</sub>  | 141-62-8   | 310.685  | liq                    | -76     | 194                                   | 0.8536 <sup>25</sup>       | 1.3895 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH; s bz, peth                |
| 2749 | Decanal                                           | Capraldehyde                                                     | C <sub>10</sub> H <sub>20</sub> O                               | 112-31-2   | 156.265  | liq                    | -4.0    | 208.5                                 | 0.830 <sup>15</sup>        | 1.4287 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace; sl ctc           |
| 2750 | Decane                                            |                                                                  | C <sub>10</sub> H <sub>22</sub>                                 | 124-18-5   | 142.282  | liq                    | -29.6   | 174.15                                | 0.7266 <sup>25</sup>       | 1.4090 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH; s eth; sl ctc            |
| 2751 | 1,10-Decanediamine                                |                                                                  | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub>                  | 646-25-3   | 172.311  |                        | 59.73   | 140 <sup>12</sup>                     |                            |                      |                                                        |
| 2752 | Decanedinitrile                                   |                                                                  | C <sub>10</sub> H <sub>18</sub> N <sub>2</sub>                  | 1871-96-1  | 164.247  |                        | 7.6     | 204 <sup>16</sup>                     | 0.913 <sup>20</sup>        | 1.4474 <sup>20</sup> | i H <sub>2</sub> O; s chl                              |
| 2753 | 1,10-Decanediol                                   | Decamethylene glycol                                             | C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>                  | 112-47-0   | 174.281  | nd (w, dil al)         | 74      | 192 <sup>20</sup>                     |                            |                      | sl H <sub>2</sub> O, eth; vs EtOH; s DMSO; i lig       |
| 2754 | Decanedioyl dichloride                            |                                                                  | C <sub>10</sub> H <sub>16</sub> Cl <sub>2</sub> O <sub>2</sub>  | 111-19-3   | 239.139  |                        | -1.3    | 220 <sup>75</sup> , 165 <sup>11</sup> | 1.1212 <sup>20</sup>       | 1.4684 <sup>18</sup> |                                                        |
| 2755 | Decanenitrile                                     | Caprinitrile                                                     | C <sub>10</sub> H <sub>19</sub> N                               | 1975-78-6  | 153.265  | liq                    | -17.9   | 243; 106 <sup>10</sup>                | 0.8199 <sup>20</sup>       | 1.4296 <sup>20</sup> | vs ace, eth, EtOH, chl                                 |
| 2756 | 1-Decanethiol                                     | Decyl mercaptan                                                  | C <sub>10</sub> H <sub>22</sub> S                               | 143-10-2   | 174.347  | liq                    | -26     | 240.6                                 | 0.8443 <sup>20</sup>       | 1.4509 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                        |
| 2757 | Decanoic acid                                     | Capric acid                                                      | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                  | 334-48-5   | 172.265  | nd                     | 31.4    | 268.7                                 | 0.8858 <sup>40</sup>       | 1.4288 <sup>40</sup> | i H <sub>2</sub> O; vs ace, bz, eth, EtOH              |
| 2758 | 1-Decanol                                         | Capric alcohol                                                   | C <sub>10</sub> H <sub>22</sub> O                               | 112-30-1   | 158.281  |                        | 6.9     | 231.1                                 | 0.8297 <sup>20</sup>       | 1.4372 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, chl; s ctc |
| 2759 | 2-Decanol                                         |                                                                  | C <sub>10</sub> H <sub>22</sub> O                               | 74742-10-2 | 158.281  | liq                    | -1.2    | 211                                   | 0.8250 <sup>20</sup>       | 1.4326 <sup>25</sup> | s EtOH, bz; msc eth, ace; sl ctc                       |
| 2760 | 3-Decanol                                         |                                                                  | C <sub>10</sub> H <sub>22</sub> O                               | 1565-81-7  | 158.281  | liq                    | -7.5    | 213; 101 <sup>12</sup>                | 0.827 <sup>20</sup>        | 1.434 <sup>20</sup>  |                                                        |
| 2761 | 4-Decanol                                         | 1-Propylheptyl alcohol                                           | C <sub>10</sub> H <sub>22</sub> O                               | 2051-31-2  | 158.281  | liq                    | -11     | 210.5                                 | 0.8261 <sup>20</sup>       | 1.4320 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ctc                        |
| 2762 | 5-Decanol                                         |                                                                  | C <sub>10</sub> H <sub>22</sub> O                               | 5205-34-5  | 158.281  | liq                    | 8.7     | 201                                   | 0.824 <sup>20</sup>        | 1.4333 <sup>20</sup> |                                                        |
| 2763 | 2-Decanone                                        | Methyl octyl ketone                                              | C <sub>10</sub> H <sub>20</sub> O                               | 693-54-9   | 156.265  | nd                     | 14      | 210; 96 <sup>12</sup>                 | 0.8248 <sup>20</sup>       | 1.4255 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                |



| No.  | Name                               | Synonym                                       | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form    | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|------------------------------------|-----------------------------------------------|-------------------------------------------------------------------------------|------------|----------|------------------|---------|--------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 2764 | 3-Decanone                         | Ethyl heptyl ketone                           | C <sub>10</sub> H <sub>20</sub> O                                             | 928-80-3   | 156.265  | liq              | 1.3     | 203                                  | 0.8251 <sup>20</sup>       | 1.4252 <sup>20</sup> | s EtOH, eth, ctc                                       |
| 2765 | 4-Decanone                         | Hexyl propyl ketone                           | C <sub>10</sub> H <sub>20</sub> O                                             | 624-16-8   | 156.265  | liq              | -9      | 206.5                                | 0.824 <sup>20</sup>        | 1.4240 <sup>21</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                   |
| 2766 | Decanoyl chloride                  | Caprinoyl chloride                            | C <sub>10</sub> H <sub>19</sub> ClO                                           | 112-13-0   | 190.710  | liq              | -34.5   | 95                                   | 0.919 <sup>25</sup>        | 1.4410 <sup>20</sup> | s eth, ctc                                             |
| 2767 | trans-2-Decenal                    |                                               | C <sub>10</sub> H <sub>18</sub> O                                             | 3913-81-3  | 154.249  |                  |         | 230; 107 <sup>11</sup>               |                            |                      |                                                        |
| 2768 | 1-Decene                           |                                               | C <sub>10</sub> H <sub>20</sub>                                               | 872-05-9   | 140.266  | liq              | -66.3   | 170.5                                | 0.7408 <sup>20</sup>       | 1.4215 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                   |
| 2769 | cis-2-Decene                       |                                               | C <sub>10</sub> H <sub>20</sub>                                               | 20348-51-0 | 140.266  | col liq          |         | 174.2                                |                            |                      |                                                        |
| 2770 | trans-2-Decene                     |                                               | C <sub>10</sub> H <sub>20</sub>                                               | 20063-97-2 | 140.266  | col liq          |         | 173.3                                |                            |                      |                                                        |
| 2771 | cis-5-Decene                       |                                               | C <sub>10</sub> H <sub>20</sub>                                               | 7433-78-5  | 140.266  | col liq          | -112    | 171; 73 <sup>20</sup>                | 0.7445 <sup>20</sup>       | 1.4258 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; sl<br>ctc        |
| 2772 | trans-5-Decene                     |                                               | C <sub>10</sub> H <sub>20</sub>                                               | 7433-56-9  | 140.266  | col liq          | -73     | 171                                  | 0.7401 <sup>20</sup>       | 1.4243 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; sl<br>ctc        |
| 2773 | 9-Decenoic acid                    | Caproic acid                                  | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>                                | 14436-32-9 | 170.249  |                  | 26.5    | 158 <sup>21</sup> , 142 <sup>4</sup> | 0.9238 <sup>15</sup>       | 1.4507 <sup>15</sup> | vs eth, EtOH                                           |
| 2774 | 9-Decen-1-ol                       | Decylenic alcohol                             | C <sub>10</sub> H <sub>20</sub> O                                             | 13019-22-2 | 156.265  |                  |         | 236                                  | 0.876 <sup>25</sup>        | 1.4480 <sup>20</sup> |                                                        |
| 2775 | 3-Decen-2-one                      | Heptylidene acetone                           | C <sub>10</sub> H <sub>18</sub> O                                             | 10519-33-2 | 154.249  |                  |         | 102 <sup>15,3</sup>                  | 0.8473 <sup>20</sup>       | 1.4480 <sup>20</sup> |                                                        |
| 2776 | Declomycin                         | Demeclocycline                                | C <sub>21</sub> H <sub>21</sub> ClN <sub>2</sub> O <sub>6</sub>               | 127-33-3   | 464.853  | cry              | 176 dec |                                      |                            |                      |                                                        |
| 2777 | Decyl acetate                      |                                               | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                                | 112-17-4   | 200.318  | liq              | -15     | 244                                  | 0.8671 <sup>20</sup>       | 1.4273 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz, ctc,<br>HOAc   |
| 2778 | Decylamine                         | 1-Decanamine                                  | C <sub>10</sub> H <sub>23</sub> N                                             | 2016-57-1  | 157.297  |                  | 17      | 220.5                                | 0.7936 <sup>20</sup>       | 1.4369 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, chl |
| 2779 | Decylbenzene                       |                                               | C <sub>16</sub> H <sub>26</sub>                                               | 104-72-3   | 218.377  | liq              | -14.4   | 293                                  | 0.8555 <sup>20</sup>       | 1.4832 <sup>20</sup> | vs ace, bz, eth,<br>EtOH                               |
| 2780 | Decylcyclohexane                   |                                               | C <sub>16</sub> H <sub>32</sub>                                               | 1795-16-0  | 224.425  | liq              | -0.9    | 299                                  | 0.8186 <sup>20</sup>       | 1.4534 <sup>20</sup> |                                                        |
| 2781 | Decylcyclopentane                  |                                               | C <sub>15</sub> H <sub>30</sub>                                               | 1795-21-7  | 210.399  | liq              | -22     | 279                                  | 0.8110 <sup>20</sup>       | 1.4486 <sup>20</sup> | vs ace, bz, eth,<br>EtOH                               |
| 2782 | Decyl decanoate                    |                                               | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>                                | 1654-86-0  | 312.531  |                  | 9.7     | 219 <sup>15</sup>                    | 0.8586 <sup>20</sup>       | 1.4423 <sup>20</sup> | vs eth                                                 |
| 2783 | Decyl formate                      |                                               | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                                | 5451-52-5  | 186.292  | liq              |         | 243                                  |                            |                      |                                                        |
| 2784 | 11-Decylheneicosane                |                                               | C <sub>31</sub> H <sub>64</sub>                                               | 55320-06-4 | 436.840  |                  | 10.0    | 282.0 <sup>10</sup>                  | 0.8116 <sup>20</sup>       | 1.4540 <sup>20</sup> |                                                        |
| 2785 | 1-Decylnaphthalene                 |                                               | C <sub>20</sub> H <sub>28</sub>                                               | 26438-27-7 | 268.436  |                  | 15      | 379                                  | 0.9322 <sup>20</sup>       | 1.5435 <sup>20</sup> |                                                        |
| 2786 | Decyloxirane                       |                                               | C <sub>12</sub> H <sub>24</sub> O                                             | 2855-19-8  | 184.318  |                  |         |                                      |                            | 1.4347 <sup>25</sup> | sl ctc                                                 |
| 2787 | Decyl vinyl ether                  | 1-(Ethenyloxy)decane                          | C <sub>12</sub> H <sub>24</sub> O                                             | 765-05-9   | 184.318  |                  | -41     | 101 <sup>10</sup>                    | 0.812 <sup>20</sup>        | 1.4346 <sup>20</sup> |                                                        |
| 2788 | 1-Decyne                           | Octylacetylene                                | C <sub>10</sub> H <sub>18</sub>                                               | 764-93-2   | 138.250  | liq              | -44     | 174                                  | 0.7655 <sup>20</sup>       | 1.4265 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                     |
| 2789 | 5-Decyne                           | Dibutylacetylene                              | C <sub>10</sub> H <sub>18</sub>                                               | 1942-46-7  | 138.250  | liq              | -73     | 177; 78.2 <sup>25</sup>              | 0.7690 <sup>20</sup>       | 1.4331 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                     |
| 2790 | Dehydroabietic acid                | 8,11,13-Abietatrien-18-oic acid               | C <sub>20</sub> H <sub>28</sub> O <sub>2</sub>                                | 1740-19-8  | 300.435  | cry (EtOH<br>aq) | 172     |                                      |                            |                      |                                                        |
| 2791 | Delphinidin                        |                                               | C <sub>15</sub> H <sub>11</sub> ClO <sub>7</sub>                              | 528-53-0   | 338.697  |                  | >350    |                                      |                            |                      | vs H <sub>2</sub> O, EtOH,<br>MeOH; s<br>AcOEt         |
| 2792 | Delphinine                         |                                               | C <sub>33</sub> H <sub>45</sub> NO <sub>9</sub>                               | 561-07-9   | 599.712  | orth (al)        | 199     |                                      |                            |                      | i H <sub>2</sub> O; s chl, ace,<br>eth; vs EtOH        |
| 2793 | Deltamethrin                       |                                               | C <sub>22</sub> H <sub>19</sub> Br <sub>2</sub> NO <sub>3</sub>               | 52918-63-5 | 505.199  |                  | 99      |                                      |                            |                      |                                                        |
| 2794 | Demecarium bromide                 |                                               | C <sub>32</sub> H <sub>52</sub> Br <sub>2</sub> N <sub>4</sub> O <sub>4</sub> | 56-94-0    | 716.588  | hyg pow          | 165 dec |                                      |                            |                      | vs H <sub>2</sub> O; sl ace; i<br>ace, eth             |
| 2795 | Demeton                            | Systox                                        | C <sub>8</sub> H <sub>19</sub> O <sub>3</sub> PS <sub>2</sub>                 | 8065-48-3  | 258.339  | oily liq         |         | 134 <sup>2</sup>                     |                            |                      | i H <sub>2</sub> O; s EtOH,<br>tol                     |
| 2796 | Demeton-S-methyl                   |                                               | C <sub>8</sub> H <sub>15</sub> O <sub>3</sub> PS <sub>2</sub>                 | 919-86-8   | 230.285  | ye liq           |         | 89 <sup>15</sup> , 118 <sup>1</sup>  | 1.20 <sup>20</sup>         | 1.5063 <sup>20</sup> | i H <sub>2</sub> O; s os                               |
| 2797 | 2'-Deoxyadenosine                  |                                               | C <sub>10</sub> H <sub>13</sub> N <sub>5</sub> O <sub>5</sub>                 | 958-09-8   | 251.242  |                  |         |                                      |                            |                      | sl H <sub>2</sub> O                                    |
| 2798 | 2'-Deoxyadenosine 5'-triphosphate  |                                               | C <sub>10</sub> H <sub>16</sub> N <sub>5</sub> O <sub>12</sub> P <sub>3</sub> | 1927-31-7  | 491.182  | cry (EtOH<br>aq) |         |                                      |                            |                      |                                                        |
| 2799 | 6-Deoxy-L-ascorbic acid            |                                               | C <sub>8</sub> H <sub>8</sub> O <sub>5</sub>                                  | 528-81-4   | 160.125  | pr (AcOEt)       | 168     | sub 160                              |                            |                      | vs H <sub>2</sub> O, ace,<br>EtOH                      |
| 2800 | Deoxycholic acid                   | 3,12-Dihydroxycholan-24-oic acid, (3α,5β,12α) | C <sub>24</sub> H <sub>40</sub> O <sub>4</sub>                                | 83-44-3    | 392.573  | cry (al)         | 177     |                                      |                            |                      |                                                        |
| 2801 | 2'-Deoxycytidine 5'-monophosphate  | 2'-Deoxy-5'-cytidylic acid                    | C <sub>9</sub> H <sub>14</sub> N <sub>3</sub> O <sub>7</sub> P                | 1032-65-1  | 307.197  | pow              | 183 dec |                                      |                            |                      |                                                        |
| 2802 | 2'-Deoxy-5-fluorouridine           | Floxuridine                                   | C <sub>9</sub> H <sub>11</sub> FN <sub>2</sub> O <sub>5</sub>                 | 50-91-9    | 246.191  | cry              | 150     |                                      |                            |                      |                                                        |
| 2803 | 2-Deoxy-D-glucose                  |                                               | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                                 | 154-17-6   | 164.156  |                  | 146.5   |                                      |                            |                      |                                                        |
| 2804 | 2'-Deoxyguanosine 5'-monophosphate | 2'-Deoxy-5'-guanylic acid                     | C <sub>10</sub> H <sub>14</sub> N <sub>5</sub> O <sub>7</sub> P               | 902-04-5   | 347.222  |                  |         |                                      |                            |                      | s H <sub>2</sub> O                                     |
| 2805 | 2-Deoxy-D-chiro-inositol           | D-Quercitol                                   | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                                 | 488-73-3   | 164.156  | pr (w, dil al)   | 236     |                                      | 1.5845 <sup>13</sup>       |                      | vs H <sub>2</sub> O                                    |
| 2806 | 1-Deoxy-1-(methylamino)-D-glucitol | N-Methylglucamine                             | C <sub>7</sub> H <sub>17</sub> NO <sub>5</sub>                                | 6284-40-8  | 195.214  | cry (MeOH)       | 128.5   |                                      |                            |                      | s H <sub>2</sub> O                                     |
| 2807 | 6-Deoxy-3-O-methylgalactose        | Digitalose                                    | C <sub>7</sub> H <sub>14</sub> O <sub>5</sub>                                 | 4481-08-7  | 178.183  | nd (AcOEt)       | 119     |                                      |                            |                      | vs H <sub>2</sub> O                                    |
| 2808 | D-2-Deoxyribose                    |                                               | C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>                                 | 533-67-5   | 134.131  |                  | 90      |                                      |                            |                      |                                                        |
| 2809 | Deserpidine                        |                                               | C <sub>32</sub> H <sub>38</sub> N <sub>2</sub> O <sub>6</sub>                 | 131-01-1   | 578.652  | nd or pr         | 230.5   |                                      |                            |                      | i H <sub>2</sub> O; s EtOH,<br>chl                     |

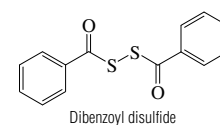
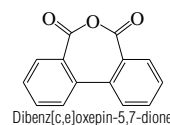
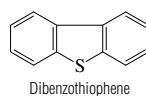
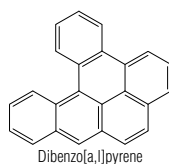
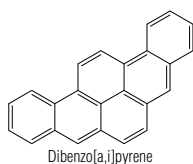
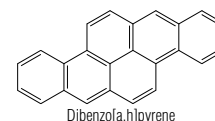
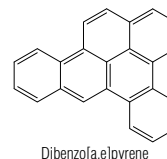
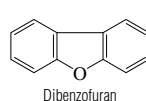
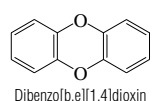
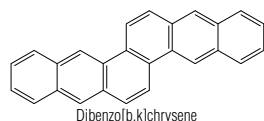
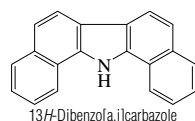
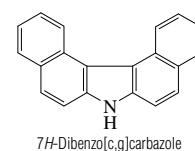
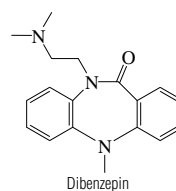
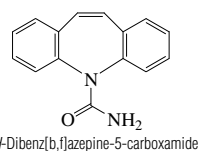
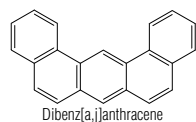
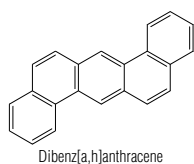
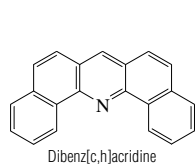
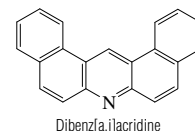
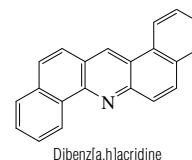
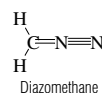
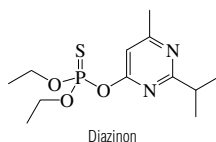
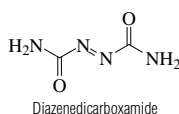
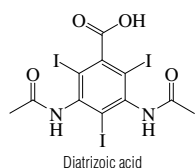
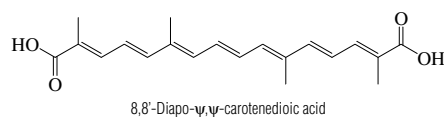
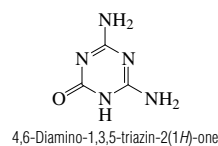
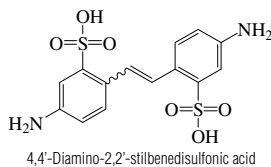
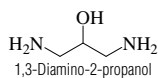
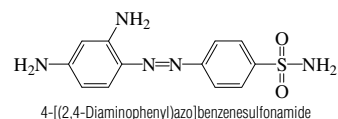
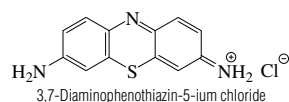
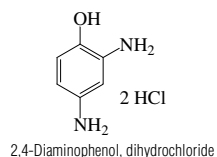
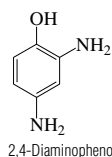
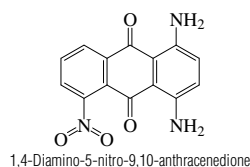
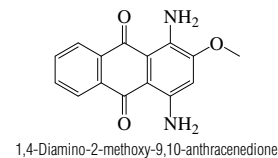
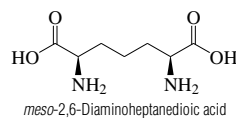
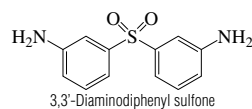
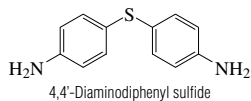
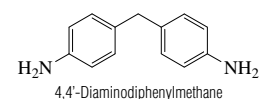
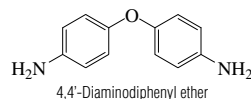
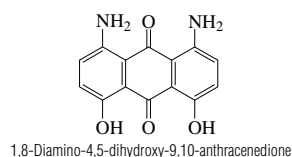
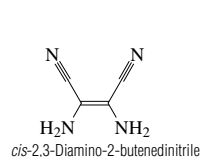
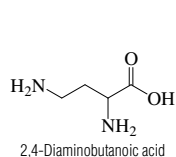


| No.  | Name                                                                     | Synonym                                                  | Mol. Form.                                                        | CAS RN     | Mol. Wt. | Physical Form               | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                     |
|------|--------------------------------------------------------------------------|----------------------------------------------------------|-------------------------------------------------------------------|------------|----------|-----------------------------|---------|--------------------------------------|----------------------------|----------------------|----------------------------------------------------------------|
| 2810 | Desethyl atrazine                                                        | 6-Chloro- <i>N</i> -isopropyl-1,3,5-triazine-2,4-diamine | C <sub>8</sub> H <sub>10</sub> ClN <sub>5</sub>                   | 6190-65-4  | 187.630  | cry                         | 136     |                                      |                            |                      |                                                                |
| 2811 | Desferrioxamine                                                          | Deferoxamine                                             | C <sub>25</sub> H <sub>48</sub> N <sub>6</sub> O <sub>8</sub>     | 70-51-9    | 560.684  | cry (EtOH aq)               | 139     |                                      |                            |                      |                                                                |
| 2812 | Desipramine                                                              |                                                          | C <sub>18</sub> H <sub>22</sub> N <sub>2</sub>                    | 50-47-5    | 266.381  |                             |         | 173 <sup>0.02</sup>                  |                            |                      |                                                                |
| 2813 | Desmedipham                                                              |                                                          | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub>     | 13684-56-5 | 300.309  |                             | 120     |                                      |                            |                      |                                                                |
| 2814 | Desmetryne                                                               |                                                          | C <sub>8</sub> H <sub>15</sub> N <sub>5</sub> S                   | 1014-69-3  | 213.304  | cry                         | 85      |                                      |                            |                      |                                                                |
| 2815 | Desthiobiotin                                                            |                                                          | C <sub>10</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub>     | 533-48-2   | 214.261  | lo nd (H <sub>2</sub> O)    | 157     |                                      |                            |                      | s H <sub>2</sub> O                                             |
| 2816 | Dexamethasone                                                            |                                                          | C <sub>22</sub> H <sub>26</sub> FO <sub>5</sub>                   | 50-02-2    | 392.460  |                             | 262     |                                      |                            |                      |                                                                |
| 2817 | Dexon                                                                    | Sodium dimethylaminobenzenediazosulfonate                | C <sub>8</sub> H <sub>10</sub> N <sub>3</sub> NaO <sub>3</sub> S  | 140-56-7   | 251.238  | ye-br pow                   |         |                                      |                            |                      | sl H <sub>2</sub> O; s DMF                                     |
| 2818 | Dexpanthenol                                                             |                                                          | C <sub>9</sub> H <sub>19</sub> NO <sub>4</sub>                    | 81-13-0    | 205.252  | hyg oil                     |         | dec                                  | 1.20 <sup>20</sup>         | 1.497 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH, MeOH; sl eth                        |
| 2819 | Dextroamphetamine sulfate                                                |                                                          | C <sub>18</sub> H <sub>28</sub> N <sub>2</sub> O <sub>4</sub> S   | 51-63-8    | 368.491  |                             | >300    |                                      | 1.15 <sup>25</sup>         |                      | vs H <sub>2</sub> O                                            |
| 2820 | Dextromethorphan hydrobromide                                            |                                                          | C <sub>18</sub> H <sub>26</sub> BrNO                              | 125-69-9   | 352.309  | wh cry pow                  | 123     |                                      |                            |                      | s EtOH, chl; i eth                                             |
| 2821 | Diacetone alcohol                                                        | 4-Hydroxy-4-methyl-2-pentanone                           | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                     | 123-42-2   | 116.158  | liq                         | -44     | 167.9                                | 0.9387 <sup>20</sup>       | 1.4213 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s chl                         |
| 2822 | 3,3-Diacetoxy-1-propene                                                  |                                                          | C <sub>7</sub> H <sub>10</sub> O <sub>4</sub>                     | 869-29-4   | 158.152  | liq                         | -37.6   | 180                                  | 1.0760 <sup>20</sup>       | 1.4193 <sup>20</sup> | vs ace, bz, eth, EtOH                                          |
| 2823 | 1,3-Diacetylbenzene                                                      |                                                          | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                    | 6781-42-6  | 162.185  |                             | 32      | 152 <sup>15</sup>                    |                            |                      | sl H <sub>2</sub> O, peth; s EtOH, bz, chl, HOAc               |
| 2824 | 1,4-Diacetylbenzene                                                      | 4-Acetylacetophenone                                     | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                    | 1009-61-6  | 162.185  |                             | 113.0   | 128 <sup>3</sup>                     |                            |                      | vs EtOH; sl chl                                                |
| 2825 | <i>N,N'</i> -Diacetyl-4,4'-diaminobiphenyl                               |                                                          | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>     | 613-35-4   | 268.310  | nd (HOAc)                   | 328.3   |                                      |                            |                      |                                                                |
| 2826 | Diacetylmorphine                                                         |                                                          | C <sub>21</sub> H <sub>23</sub> NO <sub>5</sub>                   | 561-27-3   | 369.412  | orth                        | 173     | 273 <sup>12</sup>                    | 1.56 <sup>25</sup>         |                      | vs bz, chl                                                     |
| 2827 | Diacetylperoxide                                                         | Acetyl peroxide                                          | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                      | 110-22-5   | 118.089  | nd (eth) lf                 | 30      | 63 <sup>21</sup>                     |                            |                      | vs eth, EtOH                                                   |
| 2828 | Dialifor                                                                 |                                                          | C <sub>14</sub> H <sub>17</sub> ClNO <sub>4</sub> PS <sub>2</sub> | 10311-84-9 | 393.846  |                             | 68      |                                      |                            |                      |                                                                |
| 2829 | Diallate                                                                 |                                                          | C <sub>10</sub> H <sub>17</sub> Cl <sub>2</sub> NOS               | 2303-16-4  | 270.219  |                             |         | 150 <sup>9</sup>                     |                            |                      |                                                                |
| 2830 | Diallylcyanamide                                                         |                                                          | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                     | 538-08-9   | 122.167  |                             |         | 142 <sup>90</sup> , 95 <sup>9</sup>  |                            |                      | s EtOH; sl eth, ctc                                            |
| 2831 | Diallyl diethylene glycol carbonate                                      | Diethylene glycol bis(allyl carbonate)                   | C <sub>12</sub> H <sub>18</sub> O <sub>7</sub>                    | 142-22-3   | 274.267  | col liq                     | -4      | 161 <sup>2</sup>                     | 1.14 <sup>20</sup>         |                      | i H <sub>2</sub> O; s os                                       |
| 2832 | Diallyldimethylsilane                                                    |                                                          | C <sub>8</sub> H <sub>16</sub> Si                                 | 1113-12-8  | 140.299  |                             |         | 137; 68 <sup>20</sup>                | 0.7679 <sup>20</sup>       | 1.4420 <sup>20</sup> |                                                                |
| 2833 | Diallyl disulfide                                                        |                                                          | C <sub>6</sub> H <sub>10</sub> S <sub>2</sub>                     | 2179-57-9  | 146.273  |                             |         | 100 <sup>48</sup> , 79 <sup>16</sup> | 1.0237 <sup>15</sup>       |                      |                                                                |
| 2834 | Diallyl ether                                                            | Allyl ether                                              | C <sub>6</sub> H <sub>10</sub> O                                  | 557-40-4   | 98.142   | liq                         | -6      | 94                                   | 0.8260 <sup>20</sup>       | 1.4163 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs ace; s chl               |
| 2835 | Diallyl fumarate                                                         |                                                          | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                    | 2807-54-7  | 196.200  |                             |         | 140 <sup>3</sup>                     | 1.0768 <sup>20</sup>       | 1.4670 <sup>25</sup> | vs ace, bz, eth, EtOH                                          |
| 2836 | Diallyl isophthalate                                                     | Di-2-propenyl 1,3-benzenedicarboxylate                   | C <sub>14</sub> H <sub>14</sub> O <sub>4</sub>                    | 1087-21-4  | 246.259  |                             |         | 176 <sup>5</sup>                     |                            |                      |                                                                |
| 2837 | Diallyl maleate                                                          |                                                          | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                    | 999-21-3   | 196.200  |                             |         | 129 <sup>10</sup> , 109 <sup>3</sup> | 1.075 <sup>20</sup>        | 1.4699 <sup>20</sup> | s chl                                                          |
| 2838 | Diallyl oxalate                                                          |                                                          | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>                     | 615-99-6   | 170.163  |                             |         | 217                                  | 1.1582 <sup>20</sup>       | 1.4481 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, bz; sl chl                    |
| 2839 | <i>N,N</i> -Diallyl-2-propen-1-amine                                     | Triallylamine                                            | C <sub>9</sub> H <sub>15</sub> N                                  | 102-70-5   | 137.222  |                             | 94      | 155.5                                | 0.809 <sup>20</sup>        | 1.4502 <sup>20</sup> | s EtOH, eth, ace, bz, acid                                     |
| 2840 | 5,5-Diallyl-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | Allobarbitol                                             | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>     | 52-43-7    | 208.213  | lf                          | 172     |                                      |                            |                      | sl H <sub>2</sub> O, DMSO; s EtOH, eth, bz                     |
| 2841 | Diallyl sulfide                                                          |                                                          | C <sub>6</sub> H <sub>10</sub> S                                  | 592-88-1   | 114.208  | liq                         | -85     | 138.6                                | 0.8877 <sup>27</sup>       | 1.4870 <sup>25</sup> | vs eth, EtOH                                                   |
| 2842 | Diallyl trisulfide                                                       |                                                          | C <sub>6</sub> H <sub>10</sub> S <sub>3</sub>                     | 2050-87-5  | 178.338  |                             |         | 117 <sup>16</sup>                    | 1.0845 <sup>15</sup>       |                      | vs eth                                                         |
| 2843 | Diamantane                                                               | Congressane                                              | C <sub>14</sub> H <sub>20</sub>                                   | 2292-79-7  | 188.309  | cry                         | 236     |                                      |                            |                      |                                                                |
| 2844 | 1,2-Diamino-9,10-anthracenedione                                         |                                                          | C <sub>14</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>     | 1758-68-5  | 238.241  | viol nd                     | 303.5   |                                      |                            |                      | sl EtOH, eth, chl, xyl; s py, con sulf                         |
| 2845 | 1,4-Diamino-9,10-anthracenedione                                         |                                                          | C <sub>14</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>     | 128-95-0   | 238.241  | dk viol nd (py)             | 268     |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH, bz, PhNO <sub>2</sub> ; vs py     |
| 2846 | 1,5-Diamino-9,10-anthracenedione                                         |                                                          | C <sub>14</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>     | 129-44-2   | 238.241  | dk red nd (al, HOAc)        | 319     | sub                                  |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, ace, bz; s PhNO <sub>2</sub> |
| 2847 | 1,8-Diamino-9,10-anthracenedione                                         |                                                          | C <sub>14</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>     | 129-42-0   | 238.241  | red nd (al, HOAc)           | 265     |                                      |                            |                      | i H <sub>2</sub> O; s EtOH, py; sl eth, HOAc                   |
| 2848 | 2,6-Diamino-9,10-anthracenedione                                         |                                                          | C <sub>14</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>     | 131-14-6   | 238.241  | red-br pr (aq-py)           | 320 dec |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH, chl, con sulf, xyl, py            |
| 2849 | 4,4'-Diaminoazobenzene                                                   |                                                          | C <sub>12</sub> H <sub>12</sub> N <sub>4</sub>                    | 538-41-0   | 212.250  | ye nd (al), oran-ye pr (al) | 250.5   |                                      |                            |                      | sl H <sub>2</sub> O, lig; s EtOH; vs bz, chl                   |
| 2850 | 3,5-Diaminobenzoic acid                                                  |                                                          | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>       | 535-87-5   | 152.151  | nd (+1w)                    | 228     |                                      |                            |                      | sl H <sub>2</sub> O, tta; s EtOH; vs eth                       |

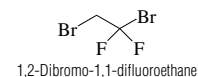
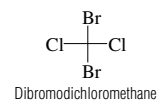
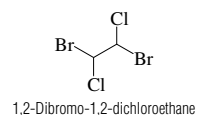
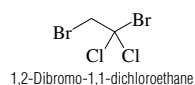
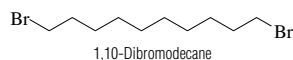
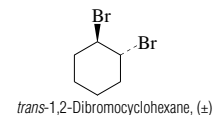
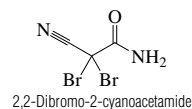
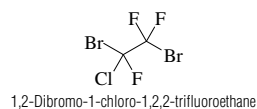
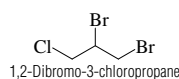
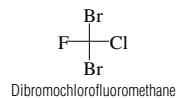
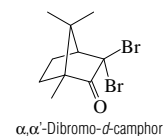
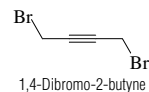
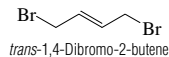
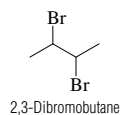
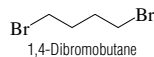
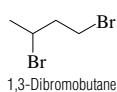
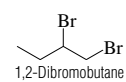
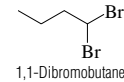
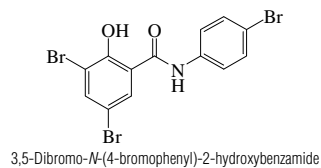
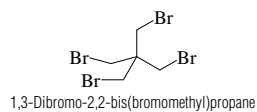
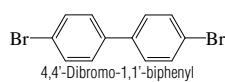
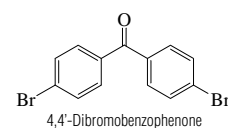
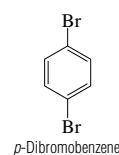
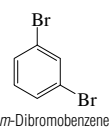
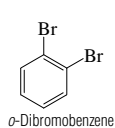
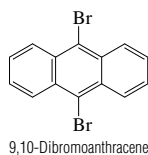
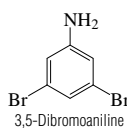
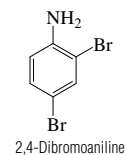
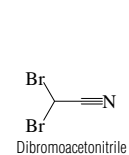
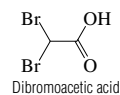
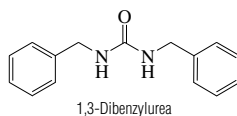
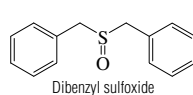
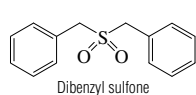
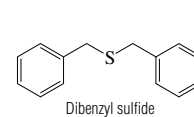
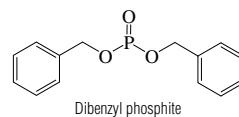
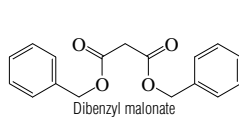
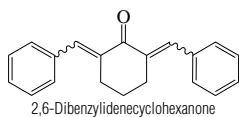
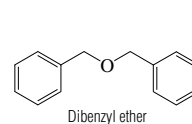
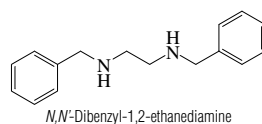
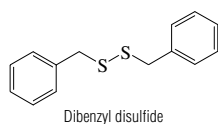
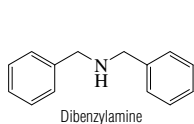




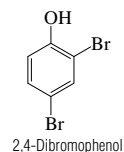
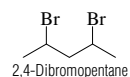
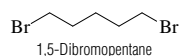
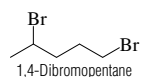
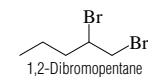
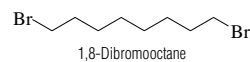
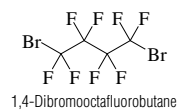
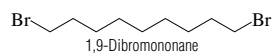
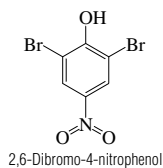
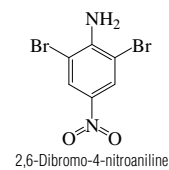
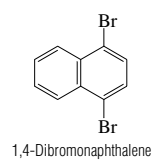
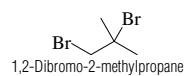
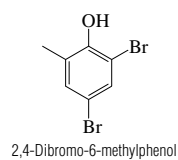
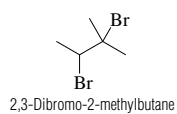
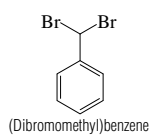
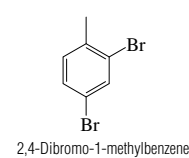
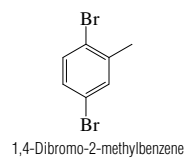
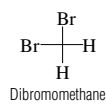
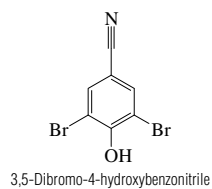
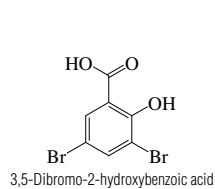
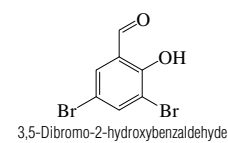
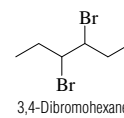
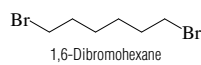
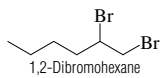
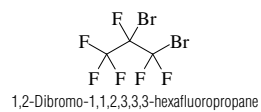
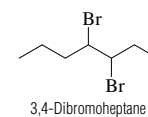
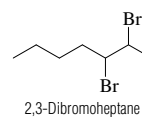
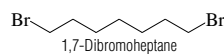
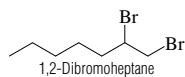
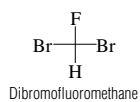
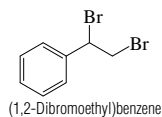
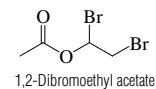
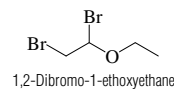
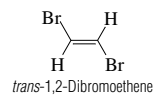
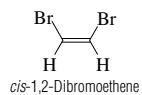
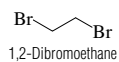
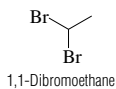
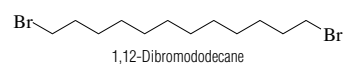
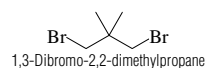
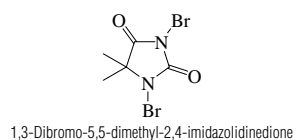
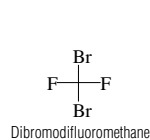
| No.  | Name                                           | Synonym                                                     | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form                            | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|------------------------------------------|---------|------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 2851 | 2,4-Diaminobutanoic acid                       |                                                             | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>                 | 305-62-4   | 118.134  | hyg cry                                  |         |                        |                            |                      | s H <sub>2</sub> O; sl EtOH, MeOH                       |
| 2852 | <i>cis</i> -2,3-Diamino-2-butenedinitrile      |                                                             | C <sub>4</sub> H <sub>4</sub> N <sub>4</sub>                                 | 1187-42-4  | 108.102  |                                          | 178.5   |                        | 1.41 <sup>20</sup>         |                      |                                                         |
| 2853 | 1,8-Diamino-4,5-dihydroxy-9,10-anthracenedione |                                                             | C <sub>14</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub>                | 128-94-9   | 270.240  | bl nd (xyl)                              |         |                        |                            |                      | i H <sub>2</sub> O; s bz, xyl, EtOH                     |
| 2854 | 4,4'-Diaminodiphenyl ether                     | 4,4'-Oxydianiline                                           | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> O                             | 101-80-4   | 200.235  |                                          | 189 dec | >300                   |                            |                      |                                                         |
| 2855 | 4,4'-Diaminodiphenylmethane                    | 4,4'-Methylenedianiline                                     | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub>                               | 101-77-9   | 198.263  | pl or nd (w)<br>pl (bz)                  | 92.5    | 398; 257 <sup>18</sup> |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz                   |
| 2856 | 4,4'-Diaminodiphenyl sulfide                   | 4,4'-Thiodianiline                                          | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> S                             | 139-65-1   | 216.301  | nd (w)                                   | 108.5   |                        |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz; s tfa            |
| 2857 | 3,3'-Diaminodiphenyl sulfone                   | 3,3'-Sulfonyldianiline                                      | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> S              | 599-61-1   | 248.300  |                                          | 168.5   |                        |                            |                      | vs H <sub>2</sub> O, EtOH                               |
| 2858 | <i>meso</i> -2,6-Diaminoheptanedioic acid      | 2,6-Diaminopimelic acid                                     | C <sub>7</sub> H <sub>14</sub> N <sub>2</sub> O <sub>4</sub>                 | 922-54-3   | 190.197  | nd (w)                                   | 314 dec |                        |                            |                      | s H <sub>2</sub> O                                      |
| 2859 | 1,4-Diamino-2-methoxy-9,10-anthracenedione     |                                                             | C <sub>15</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>                | 2872-48-2  | 268.267  |                                          | 235     |                        |                            |                      |                                                         |
| 2860 | 1,4-Diamino-5-nitro-9,10-anthracenedione       |                                                             | C <sub>14</sub> H <sub>8</sub> N <sub>3</sub> O <sub>4</sub>                 | 82-33-7    | 283.239  |                                          | 278     |                        |                            |                      |                                                         |
| 2861 | 2,4-Diaminophenol                              |                                                             | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O                               | 95-86-3    | 124.140  | lf                                       | 79 dec  |                        |                            |                      | vs H <sub>2</sub> O, ace, EtOH                          |
| 2862 | 2,4-Diaminophenol, dihydrochloride             |                                                             | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> O              | 137-09-7   | 197.061  | nd                                       | 235 dec |                        |                            |                      | vs H <sub>2</sub> O                                     |
| 2863 | 3,7-Diaminophenothiazin-5-ium chloride         | Thionine                                                    | C <sub>12</sub> H <sub>10</sub> ClN <sub>3</sub> S                           | 581-64-6   | 263.745  |                                          |         |                        |                            |                      | sl H <sub>2</sub> O, EtOH, eth; s bz, chl, acid         |
| 2864 | 4-[(2,4-Diaminophenyl)azo] benzenesulfonamide  | Prontosil                                                   | C <sub>12</sub> H <sub>14</sub> ClN <sub>5</sub> O <sub>2</sub> S            | 103-12-8   | 327.790  |                                          | 249.5   |                        |                            |                      | sl H <sub>2</sub> O; s EtOH, ace, oils, fats            |
| 2865 | 1,3-Diamino-2-propanol                         |                                                             | C <sub>3</sub> H <sub>10</sub> N <sub>2</sub> O                              | 616-29-5   | 90.123   | cry                                      | 42.8    |                        |                            |                      | i eth, bz                                               |
| 2866 | 4,4'-Diamino-2,2'-stilbenedisulfonic acid      | Amsonic acid                                                | C <sub>14</sub> H <sub>14</sub> N <sub>2</sub> O <sub>6</sub> S <sub>2</sub> | 81-11-8    | 370.400  | ye nd                                    | 300     |                        |                            |                      | sl H <sub>2</sub> O                                     |
| 2867 | 4,6-Diamino-1,3,5-triazin-2(1 <i>H</i> )-one   |                                                             | C <sub>3</sub> H <sub>5</sub> N <sub>5</sub> O                               | 645-92-1   | 127.105  | nd (aq Na <sub>2</sub> CO <sub>3</sub> ) | dec     |                        |                            |                      | i H <sub>2</sub> O, EtOH, eth, bz, HOAc; s acid, alk    |
| 2868 | 8,8'-Diapo- $\psi,\psi$ -carotenedioic acid    | Crocetin                                                    | C <sub>20</sub> H <sub>24</sub> O <sub>4</sub>                               | 27876-94-4 | 328.403  | brick red orth                           | 286     |                        |                            |                      | sl H <sub>2</sub> O, EtOH; i eth, bz; s py; vs NaOH     |
| 2869 | Diatrizoic acid                                | <i>N,N'</i> -Diacetyl-3,5-diamino-2,4,6-triiodobenzoic acid | C <sub>11</sub> H <sub>9</sub> I <sub>3</sub> N <sub>2</sub> O <sub>4</sub>  | 117-96-4   | 613.913  | cry (EtOH aq)                            | 300     |                        |                            |                      |                                                         |
| 2870 | Diazenedicarboxamide                           | Azodicarbonamide                                            | C <sub>2</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub>                  | 123-77-3   | 116.079  |                                          | 212 dec |                        |                            |                      |                                                         |
| 2871 | Diazinon                                       |                                                             | C <sub>12</sub> H <sub>21</sub> N <sub>2</sub> O <sub>3</sub> PS             | 333-41-5   | 304.345  |                                          |         | 87 <sup>0.05</sup>     | 1.1088 <sup>20</sup>       | 1.4922 <sup>20</sup> |                                                         |
| 2872 | Diazomethane                                   |                                                             | CH <sub>2</sub> N <sub>2</sub>                                               | 334-88-3   | 42.040   | ye gas                                   | -145    | -23                    |                            |                      | vs eth, diox                                            |
| 2873 | Dibenz[a,h]acridine                            |                                                             | C <sub>21</sub> H <sub>13</sub> N                                            | 226-36-8   | 279.335  | ye cry                                   | 228     |                        |                            |                      |                                                         |
| 2874 | Dibenz[a,j]acridine                            | 7-Azadibenz[a,j]anthracene                                  | C <sub>21</sub> H <sub>13</sub> N                                            | 224-42-0   | 279.335  |                                          | 216     |                        |                            |                      | i H <sub>2</sub> O                                      |
| 2875 | Dibenz[c,h]acridine                            |                                                             | C <sub>21</sub> H <sub>13</sub> N                                            | 224-53-3   | 279.335  | ye cry (EtOH)                            | 189     |                        |                            |                      |                                                         |
| 2876 | Dibenz[a,h]anthracene                          | 1,2:5,6-Dibenzanthracene                                    | C <sub>22</sub> H <sub>14</sub>                                              | 53-70-3    | 278.346  | pl (dil ace)                             | 269.5   |                        |                            |                      | i H <sub>2</sub> O; sl EtOH; s ace, bz, CS <sub>2</sub> |
| 2877 | Dibenz[a,j]anthracene                          |                                                             | C <sub>22</sub> H <sub>14</sub>                                              | 224-41-9   | 278.346  | oran lf or nd (bz)                       | 197.5   |                        |                            |                      | i H <sub>2</sub> O, HOAc; sl EtOH, eth, bz; s peth      |
| 2878 | 5 <i>H</i> -Dibenz[b,f]azepine-5-carboxamide   | Carbamazepine                                               | C <sub>15</sub> H <sub>12</sub> N <sub>2</sub> O                             | 298-46-4   | 236.268  |                                          | 190.2   |                        |                            |                      |                                                         |
| 2879 | Dibenzepin                                     |                                                             | C <sub>18</sub> H <sub>21</sub> N <sub>3</sub> O                             | 4498-32-2  | 295.379  |                                          | 117     | 185 <sup>0.01</sup>    |                            |                      |                                                         |
| 2880 | 7 <i>H</i> -Dibenzo[c,g]carbazole              |                                                             | C <sub>20</sub> H <sub>13</sub> N                                            | 194-59-2   | 267.324  | cry (EtOH)                               | 158     |                        |                            |                      |                                                         |
| 2881 | 13 <i>H</i> -Dibenzo[a,i]carbazole             |                                                             | C <sub>20</sub> H <sub>13</sub> N                                            | 239-64-5   | 267.324  |                                          | 221.3   |                        |                            |                      | i H <sub>2</sub> O                                      |
| 2882 | Dibenzo[b,k]chrysene                           |                                                             | C <sub>26</sub> H <sub>16</sub>                                              | 217-54-9   | 328.405  |                                          | 400     |                        |                            |                      |                                                         |
| 2883 | Dibenzo[b,e][1,4]dioxin                        | Diphenylene dioxide                                         | C <sub>12</sub> H <sub>6</sub> O <sub>2</sub>                                | 262-12-4   | 184.191  | nd (MeOH)                                | 120.5   |                        |                            |                      |                                                         |
| 2884 | Dibenzofuran                                   | 2,2'-Biphenylene oxide                                      | C <sub>12</sub> H <sub>8</sub> O                                             | 132-64-9   | 168.191  | lf or nd (al)                            | 86.5    | 287                    | 1.0886 <sup>99</sup>       | 1.6079 <sup>99</sup> | i H <sub>2</sub> O; s EtOH, ace, bz; vs eth, HOAc       |
| 2885 | Dibenzo[a,e]pyrene                             | Naphtho[1,2,3,4-def]chrysene                                | C <sub>24</sub> H <sub>14</sub>                                              | 192-65-4   | 302.368  | pa ye nd(xyl)                            | 233.5   |                        |                            |                      | sl EtOH, ace, bz, HOAc; s tol, con sulf                 |
| 2886 | Dibenzo[a,h]pyrene                             | Dibenzo[b,def]chrysene                                      | C <sub>24</sub> H <sub>14</sub>                                              | 189-64-0   | 302.368  | oran pl                                  | 315     |                        |                            |                      |                                                         |
| 2887 | Dibenzo[a,i]pyrene                             | Benzo[ <i>rst</i> ]pentaphene                               | C <sub>24</sub> H <sub>14</sub>                                              | 189-55-9   | 302.368  |                                          | 281.5   | 275 <sup>0.05</sup>    |                            |                      |                                                         |
| 2888 | Dibenzo[a,l]pyrene                             | Dibenzo[def,p]chrysene                                      | C <sub>24</sub> H <sub>14</sub>                                              | 191-30-0   | 302.368  | ye pl (bz/ EtOH)                         | 164.5   |                        |                            |                      |                                                         |
| 2889 | Dibenzothiophene                               |                                                             | C <sub>12</sub> H <sub>8</sub> S                                             | 132-65-0   | 184.257  | nd (dil al, lig)                         | 98.2    | 332.5                  |                            |                      | i H <sub>2</sub> O; s chl, MeOH; vs EtOH, bz            |
| 2890 | Dibenz[c,e]oxepin-5,7-dione                    |                                                             | C <sub>14</sub> H <sub>6</sub> O <sub>3</sub>                                | 6050-13-1  | 224.212  | nd (HOAc or bz)                          | 217     | sub                    |                            |                      | i H <sub>2</sub> O; sl eth                              |
| 2891 | Dibenzoyl disulfide                            | Benzoyl disulfide                                           | C <sub>14</sub> H <sub>10</sub> O <sub>2</sub> S <sub>2</sub>                | 644-32-6   | 274.358  | pr(al), sc(chl-peth)                     | 134.5   | dec                    |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s CS <sub>2</sub>     |



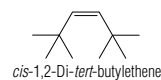
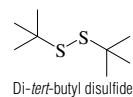
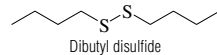
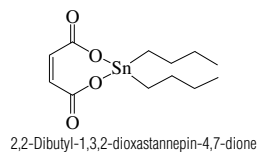
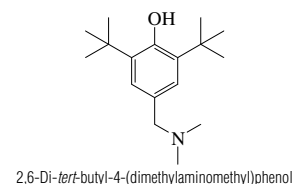
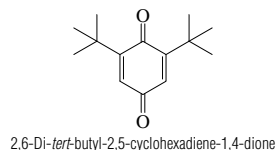
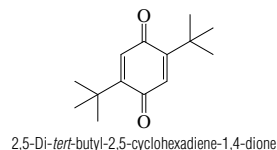
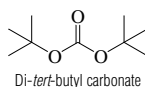
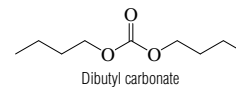
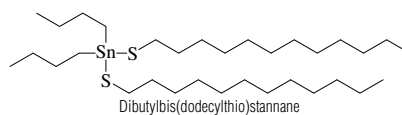
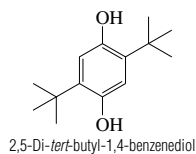
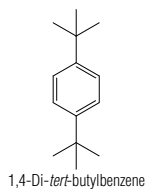
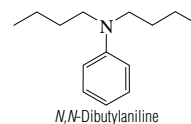
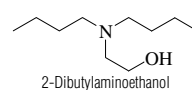
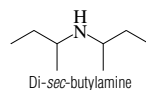
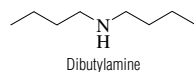
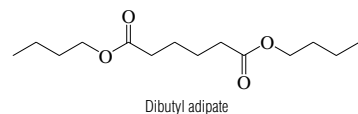
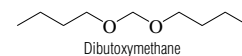
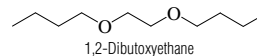
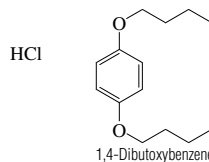
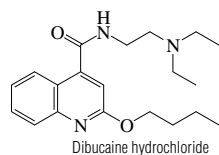
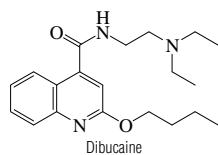
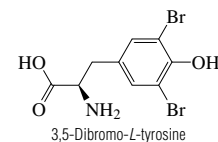
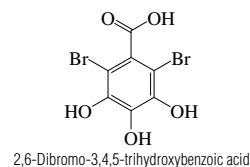
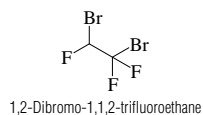
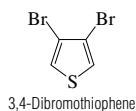
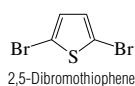
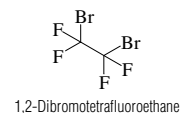
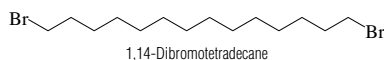
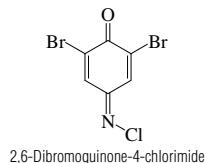
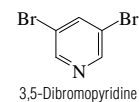
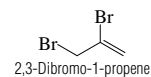
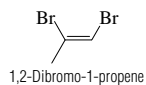
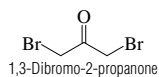
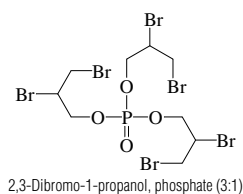
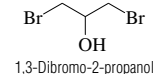
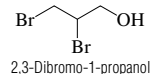
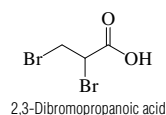
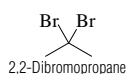
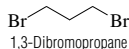
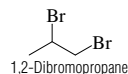
| No.  | Name                                                      | Synonym                            | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form                        | mp/°C | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                         |
|------|-----------------------------------------------------------|------------------------------------|----------------------------------------------------------------|------------|----------|--------------------------------------|-------|----------------------------------------|----------------------------|----------------------|--------------------------------------------------------------------|
| 2892 | Dibenzylamine                                             | <i>N</i> -Benzylbenzenemethanamine | C <sub>14</sub> H <sub>15</sub> N                              | 103-49-1   | 197.276  |                                      | -26   | dec 300;<br>270 <sup>250</sup>         | 1.0256 <sup>22</sup>       | 1.5781 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth; s ctc                         |
| 2893 | Dibenzyl disulfide                                        |                                    | C <sub>14</sub> H <sub>14</sub> S <sub>2</sub>                 | 150-60-7   | 246.391  | lf (al)                              | 71.5  |                                        |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, bz, MeOH                      |
| 2894 | <i>N,N'</i> -Dibenzyl-1,2-ethanediamine                   | Benzathine                         | C <sub>16</sub> H <sub>20</sub> N <sub>2</sub>                 | 140-28-3   | 240.343  | oily lig                             | 26    | 195 <sup>4</sup>                       | 1.024 <sup>20</sup>        | 1.5635 <sup>20</sup> | vs bz, eth, EtOH                                                   |
| 2895 | Dibenzyl ether                                            | Benzyl ether                       | C <sub>14</sub> H <sub>14</sub> O                              | 103-50-4   | 198.260  |                                      | 1.8   | 298                                    | 1.0428 <sup>20</sup>       | 1.5168 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ctc                     |
| 2896 | 2,6-Dibenzylidenecyclohexanone                            |                                    | C <sub>20</sub> H <sub>18</sub> O                              | 897-78-9   | 274.356  |                                      | 117.5 | 190 <sup>20</sup>                      |                            |                      | sl EtOH; s bz,<br>HOAc                                             |
| 2897 | Dibenzyl malonate                                         |                                    | C <sub>17</sub> H <sub>16</sub> O <sub>4</sub>                 | 15014-25-2 | 284.307  |                                      |       | 187 <sup>2</sup>                       | 1.137 <sup>25</sup>        | 1.5447 <sup>20</sup> |                                                                    |
| 2898 | Dibenzyl phosphite                                        |                                    | C <sub>14</sub> H <sub>15</sub> O <sub>3</sub> P               | 17176-77-1 | 262.241  |                                      | -2.5  | 162 <sup>0.1</sup>                     |                            | 1.5521 <sup>18</sup> |                                                                    |
| 2899 | Dibenzyl sulfide                                          | Benzyl sulfide                     | C <sub>14</sub> H <sub>14</sub> S                              | 538-74-9   | 214.326  | pl (eth or<br>chl)                   | 49.5  | dec                                    | 1.0583 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH,<br>eth, CS <sub>2</sub>                |
| 2900 | Dibenzyl sulfone                                          |                                    | C <sub>14</sub> H <sub>14</sub> O <sub>2</sub> S               | 620-32-6   | 246.325  | nd (al-bz)                           | 152   | dec 290                                |                            |                      | i H <sub>2</sub> O; sl EtOH;<br>vs ace; s bz,<br>HOAc              |
| 2901 | Dibenzyl sulfoxide                                        |                                    | C <sub>14</sub> H <sub>14</sub> OS                             | 621-08-9   | 230.325  | lf (al, w)                           | 134   | dec 210                                |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth                                |
| 2902 | 1,3-Dibenzylurea                                          |                                    | C <sub>15</sub> H <sub>16</sub> N <sub>2</sub> O               | 1466-67-7  | 240.300  | nd (al)                              | 169.5 |                                        |                            |                      | vs EtOH, HOAc                                                      |
| 2903 | Dibromoacetic acid                                        |                                    | C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> O <sub>2</sub>   | 631-64-1   | 217.844  | hyg cry                              | 49    | 195 <sup>250</sup> , 130 <sup>16</sup> |                            |                      | vs H <sub>2</sub> O; vs<br>EtOH, eth                               |
| 2904 | Dibromoacetonitrile                                       |                                    | C <sub>2</sub> HBr <sub>2</sub> N                              | 3252-43-5  | 198.844  |                                      |       | 169; 68 <sup>24</sup>                  | 2.369 <sup>20</sup>        | 1.5393 <sup>20</sup> |                                                                    |
| 2905 | 2,4-Dibromoaniline                                        |                                    | C <sub>6</sub> H <sub>3</sub> Br <sub>2</sub> N                | 615-57-6   | 250.919  | orth bipym<br>(chl) nd or<br>lf (al) | 79.5  | 156 <sup>74</sup>                      | 2.260 <sup>20</sup>        |                      | s EtOH, eth, chl,<br>HOAc                                          |
| 2906 | 3,5-Dibromoaniline                                        |                                    | C <sub>6</sub> H <sub>3</sub> Br <sub>2</sub> N                | 626-40-4   | 250.919  | nd (dil al)                          | 57    |                                        |                            |                      | vs EtOH, eth, bz                                                   |
| 2907 | 9,10-Dibromoanthracene                                    |                                    | C <sub>14</sub> H <sub>8</sub> Br <sub>2</sub>                 | 523-27-3   | 336.022  | ye nd (to or<br>xyl)                 | 226   | sub                                    |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>eth, bz; s chl                     |
| 2908 | <i>o</i> -Dibromobenzene                                  | 1,2-Dibromobenzene                 | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>                  | 583-53-9   | 235.904  |                                      | 7.1   | 225                                    | 1.9843 <sup>20</sup>       | 1.6155 <sup>20</sup> | i H <sub>2</sub> O; s EtOH;<br>msc eth, ace,<br>bz, ctc            |
| 2909 | <i>m</i> -Dibromobenzene                                  | 1,3-Dibromobenzene                 | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>                  | 108-36-1   | 235.904  | liq                                  | -7    | 218                                    | 1.9523 <sup>20</sup>       | 1.6083 <sup>17</sup> | i H <sub>2</sub> O; s EtOH;<br>msc eth                             |
| 2910 | <i>p</i> -Dibromobenzene                                  | 1,4-Dibromobenzene                 | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>                  | 106-37-6   | 235.904  | pl                                   | 87.43 | 218.5                                  | 2.261 <sup>17</sup>        | 1.5742               | i H <sub>2</sub> O; s EtOH,<br>bz; vs eth, ace,<br>CS <sub>2</sub> |
| 2911 | 4,4'-Dibromobenzophenone                                  | Bis(4-bromophenyl) ketone          | C <sub>13</sub> H <sub>8</sub> Br <sub>2</sub> O               | 3988-03-2  | 340.010  | pl (al)                              | 177   | 395                                    |                            |                      | vs bz, HOAc, chl                                                   |
| 2912 | 4,4'-Dibromo-1,1'-biphenyl                                |                                    | C <sub>12</sub> H <sub>8</sub> Br <sub>2</sub>                 | 92-86-4    | 312.000  | mcl pr<br>(MeOH)                     | 164   | 357.5                                  |                            |                      | i H <sub>2</sub> O; sl EtOH;<br>s bz                               |
| 2913 | 1,3-Dibromo-2,2-bis(bromomethyl)propane                   | Pentaerythritol tetrabromide       | C <sub>3</sub> H <sub>8</sub> Br <sub>4</sub>                  | 3229-00-3  | 387.734  | cry (ace), nd<br>(lig)               | 163   | 305.5                                  | 2.596 <sup>15</sup>        |                      | s EtOH, bz, tol;<br>sl eth, chl                                    |
| 2914 | 3,5-Dibromo- <i>N</i> -(4-bromophenyl)-2-hydroxybenzamide | Tribromsalan                       | C <sub>13</sub> H <sub>8</sub> Br <sub>3</sub> NO <sub>2</sub> | 87-10-5    | 449.921  |                                      | 227   |                                        |                            |                      |                                                                    |
| 2915 | 1,1-Dibromobutane                                         |                                    | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                  | 62168-25-6 | 215.915  |                                      |       | 158; 91 <sup>101</sup>                 | 1.784 <sup>25</sup>        | 1.4988 <sup>25</sup> |                                                                    |
| 2916 | 1,2-Dibromobutane                                         | $\alpha$ -Butylene dibromide       | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                  | 533-98-2   | 215.915  | liq                                  | -65.4 | 166.3                                  | 1.7915 <sup>20</sup>       | 1.4025 <sup>20</sup> | i H <sub>2</sub> O; s eth, chl                                     |
| 2917 | 1,3-Dibromobutane                                         |                                    | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                  | 107-80-2   | 215.915  |                                      |       | 174                                    | 1.800 <sup>20</sup>        | 1.507 <sup>20</sup>  | i H <sub>2</sub> O; s eth, chl;<br>sl ctc                          |
| 2918 | 1,4-Dibromobutane                                         |                                    | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                  | 110-52-1   | 215.915  | liq                                  | -16.5 | 197                                    | 1.8199 <sup>25</sup>       | 1.5167 <sup>25</sup> | i H <sub>2</sub> O; sl ctc; s<br>chl                               |
| 2919 | 2,3-Dibromobutane                                         |                                    | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                  | 5408-86-6  | 215.915  | liq                                  | -24   | 161                                    | 1.7893 <sup>22</sup>       | 1.5133 <sup>22</sup> | i H <sub>2</sub> O; s eth                                          |
| 2920 | <i>trans</i> -1,4-Dibromo-2-butene                        |                                    | C <sub>4</sub> H <sub>6</sub> Br <sub>2</sub>                  | 821-06-7   | 213.899  | pl (peth)                            | 53.4  | 203; 74 <sup>14</sup>                  |                            |                      | sl H <sub>2</sub> O, chl; vs<br>EtOH, peth; s<br>ace               |
| 2921 | 1,4-Dibromo-2-butyne                                      |                                    | C <sub>4</sub> H <sub>4</sub> Br <sub>2</sub>                  | 2219-66-1  | 211.883  |                                      |       | 92 <sup>15</sup>                       | 2.014 <sup>18</sup>        | 1.588 <sup>18</sup>  | s eth, ace; vs chl                                                 |
| 2922 | $\alpha,\alpha'$ -Dibromo- <i>d</i> -camphor              |                                    | C <sub>10</sub> H <sub>14</sub> Br <sub>2</sub> O              | 514-12-5   | 310.025  |                                      | 61    |                                        | 1.854 <sup>21</sup>        |                      | i H <sub>2</sub> O; vs EtOH,<br>eth, bz, chl; s<br>AcOEt           |
| 2923 | Dibromochlorofluoromethane                                |                                    | CBF <sub>2</sub> ClF                                           | 353-55-9   | 226.270  |                                      |       | 80.3                                   | 2.3173 <sup>22</sup>       | 1.4570 <sup>20</sup> |                                                                    |
| 2924 | 1,2-Dibromo-3-chloropropane                               |                                    | C <sub>3</sub> H <sub>5</sub> Br <sub>2</sub> Cl               | 96-12-8    | 236.333  |                                      |       | 196                                    | 2.093 <sup>14</sup>        | 1.553 <sup>14</sup>  | i H <sub>2</sub> O                                                 |
| 2925 | 1,2-Dibromo-1-chloro-1,2,2-trifluoroethane                |                                    | C <sub>2</sub> Br <sub>2</sub> ClF <sub>3</sub>                | 354-51-8   | 276.277  |                                      | 50    | 93                                     |                            |                      |                                                                    |
| 2926 | 2,2-Dibromo-2-cyanoacetamide                              |                                    | C <sub>3</sub> H <sub>3</sub> Br <sub>2</sub> N <sub>2</sub> O | 10222-01-2 | 241.868  | cry (bz)                             | 126   |                                        |                            |                      |                                                                    |
| 2927 | <i>trans</i> -1,2-Dibromocyclohexane, ( $\pm$ )           |                                    | C <sub>6</sub> H <sub>10</sub> Br <sub>2</sub>                 | 5183-77-7  | 241.951  |                                      | -2.0  | 145 <sup>100</sup> , 105 <sup>20</sup> | 1.7759 <sup>20</sup>       | 1.5445 <sup>19</sup> | vs ace, bz, eth,<br>EtOH                                           |
| 2928 | 1,10-Dibromodecane                                        | Decamethylene dibromide            | C <sub>10</sub> H <sub>20</sub> Br <sub>2</sub>                | 4101-68-2  | 300.074  | pl (al)                              | 28    | 161 <sup>9</sup> , 128 <sup>4</sup>    | 1.335 <sup>30</sup>        | 1.4927 <sup>25</sup> | i H <sub>2</sub> O; sl EtOH;<br>s eth                              |
| 2929 | 1,2-Dibromo-1,1-dichloroethane                            |                                    | C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> Cl <sub>2</sub>  | 75-81-0    | 256.751  | liq                                  | -26   | 195                                    | 2.135 <sup>20</sup>        | 1.5662 <sup>20</sup> | vs ace, bz, eth,<br>EtOH                                           |
| 2930 | 1,2-Dibromo-1,2-dichloroethane                            |                                    | C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> Cl <sub>2</sub>  | 683-68-1   | 256.751  | liq                                  | -26   | 195                                    | 2.135 <sup>20</sup>        | 1.5662 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz                        |
| 2931 | Dibromodichloromethane                                    |                                    | CBF <sub>2</sub> Cl <sub>2</sub>                               | 594-18-3   | 242.725  |                                      | 38    | 150.2                                  | 2.42 <sup>25</sup>         |                      | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz                        |
| 2932 | 1,2-Dibromo-1,1-difluoroethane                            | Genetron 132b-B2                   | C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> F <sub>2</sub>   | 75-82-1    | 223.842  | liq                                  | -61.3 | 92.5                                   | 2.2238 <sup>20</sup>       | 1.4456 <sup>20</sup> |                                                                    |



| No.  | Name                                            | Synonym                           | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form       | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-------------------------------------------------|-----------------------------------|-----------------------------------------------------------------------------|------------|----------|---------------------|---------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 2933 | Dibromodifluoromethane                          |                                   | CBr <sub>2</sub> F <sub>2</sub>                                             | 75-61-6    | 209.816  | vol liq or gas      | -110.1  | 22.76                                 |                            |                      | s H <sub>2</sub> O, eth, ace, bz                     |
| 2934 | 1,3-Dibromo-5,5-dimethyl-2,4-imidazolidinedione | Dibromantine                      | C <sub>5</sub> H <sub>8</sub> Br <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 77-48-5    | 285.922  |                     | 198 dec |                                       |                            |                      |                                                      |
| 2935 | 1,3-Dibromo-2,2-dimethylpropane                 |                                   | C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>                              | 5434-27-5  | 229.941  |                     |         | 184; 80 <sup>26</sup>                 | 1.6775 <sup>20</sup>       | 1.5090               |                                                      |
| 2936 | 1,12-Dibromodecane                              |                                   | C <sub>12</sub> H <sub>24</sub> Br <sub>2</sub>                             | 3344-70-5  | 328.127  | nd (al,HOAc)        | 41      | 215 <sup>15</sup>                     |                            |                      | i H <sub>2</sub> O; vs EtOH, chl; s eth, HOAc        |
| 2937 | 1,1-Dibromoethane                               | Ethylidene dibromide              | C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>                               | 557-91-5   | 187.861  | liq                 | -63     | 108.0                                 | 2.0555 <sup>20</sup>       | 1.5128 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, ace, bz; sl chl; vs eth |
| 2938 | 1,2-Dibromoethane                               | Ethylene dibromide                | C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>                               | 106-93-4   | 187.861  |                     | 9.84    | 131.6                                 | 2.1683 <sup>25</sup>       | 1.5356 <sup>25</sup> | vs ace, bz, eth, EtOH                                |
| 2939 | <i>cis</i> -1,2-Dibromoethene                   | <i>cis</i> -1,2-Dibromoethylene   | C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub>                               | 590-11-4   | 185.845  | liq                 | -53     | 112.5                                 | 2.2464 <sup>20</sup>       | 1.5428 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz, chl     |
| 2940 | <i>trans</i> -1,2-Dibromoethene                 | <i>trans</i> -1,2-Dibromoethylene | C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub>                               | 590-12-5   | 185.845  | liq                 | -6.5    | 108                                   | 2.2308 <sup>20</sup>       | 1.5505 <sup>18</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz, chl     |
| 2941 | 1,2-Dibromo-1-ethoxyethane                      |                                   | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub> O                             | 2983-26-8  | 231.914  |                     |         | 80 <sup>20</sup>                      | 1.7320 <sup>20</sup>       | 1.5044 <sup>20</sup> | vs EtOH, chl                                         |
| 2942 | 1,2-Dibromoethyl acetate                        |                                   | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub> O <sub>2</sub>                | 24442-57-7 | 245.898  | liq                 |         | 89.5 <sup>16</sup>                    | 1.91 <sup>20</sup>         |                      |                                                      |
| 2943 | (1,2-Dibromoethyl)benzene                       |                                   | C <sub>8</sub> H <sub>8</sub> Br <sub>2</sub>                               | 93-52-7    | 263.958  |                     | 75      | 133 <sup>19</sup>                     |                            |                      | s EtOH, eth, bz, chl, HOAc, MeOH, lig                |
| 2944 | Dibromofluoromethane                            |                                   | CHBr <sub>2</sub> F                                                         | 1868-53-7  | 191.825  | liq                 | -78     | 64.9                                  | 2.421 <sup>20</sup>        | 1.4685 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl        |
| 2945 | 1,2-Dibromoheptane                              |                                   | C <sub>7</sub> H <sub>14</sub> Br <sub>2</sub>                              | 42474-21-5 | 257.994  |                     |         | 228                                   | 1.5086 <sup>20</sup>       | 1.4986 <sup>20</sup> |                                                      |
| 2946 | 1,7-Dibromoheptane                              | Heptamethylene dibromide          | C <sub>7</sub> H <sub>14</sub> Br <sub>2</sub>                              | 4549-31-9  | 257.994  |                     | 41.7    | 263                                   | 1.5306 <sup>20</sup>       | 1.5034 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, bz, ctc, chl         |
| 2947 | 2,3-Dibromoheptane                              |                                   | C <sub>7</sub> H <sub>14</sub> Br <sub>2</sub>                              | 21266-88-6 | 257.994  |                     |         | 101 <sup>17</sup>                     | 1.5139 <sup>20</sup>       | 1.4992 <sup>20</sup> |                                                      |
| 2948 | 3,4-Dibromoheptane                              |                                   | C <sub>7</sub> H <sub>14</sub> Br <sub>2</sub>                              | 21266-90-0 | 257.994  |                     |         | 107 <sup>24</sup>                     | 1.5182 <sup>20</sup>       | 1.5010 <sup>20</sup> |                                                      |
| 2949 | 1,2-Dibromo-1,1,2,2,3,3-hexafluoropropane       |                                   | C <sub>3</sub> Br <sub>2</sub> F <sub>6</sub>                               | 661-95-0   | 309.830  |                     |         | 72.8                                  | 2.1630 <sup>20</sup>       |                      | i H <sub>2</sub> O                                   |
| 2950 | 1,2-Dibromohexane                               |                                   | C <sub>6</sub> H <sub>12</sub> Br <sub>2</sub>                              | 624-20-4   | 243.967  |                     |         | 103 <sup>36</sup>                     | 1.5774 <sup>20</sup>       | 1.5024 <sup>20</sup> | vs bz, eth, chl                                      |
| 2951 | 1,6-Dibromohexane                               |                                   | C <sub>6</sub> H <sub>12</sub> Br <sub>2</sub>                              | 629-03-8   | 243.967  | liq                 | -1.2    | 245.5                                 | 1.6025 <sup>25</sup>       | 1.5054 <sup>25</sup> | i H <sub>2</sub> O; s eth, ace, chl; sl ctc          |
| 2952 | 3,4-Dibromohexane                               |                                   | C <sub>6</sub> H <sub>12</sub> Br <sub>2</sub>                              | 89583-12-0 | 243.967  |                     |         | 80 <sup>13</sup>                      | 1.6027 <sup>20</sup>       | 1.5043 <sup>20</sup> |                                                      |
| 2953 | 3,5-Dibromo-2-hydroxybenzaldehyde               | 3,5-Dibromosalicylaldehyde        | C <sub>7</sub> H <sub>4</sub> Br <sub>2</sub> O <sub>2</sub>                | 90-59-5    | 279.914  | pa ye pr            | 86      | sub                                   |                            |                      | vs bz, eth, chl                                      |
| 2954 | 3,5-Dibromo-2-hydroxybenzoic acid               | 3,5-Dibromosalicylic acid         | C <sub>7</sub> H <sub>4</sub> Br <sub>2</sub> O <sub>3</sub>                | 3147-55-5  | 295.913  | nd                  | 228     |                                       |                            |                      | s ace                                                |
| 2955 | 3,5-Dibromo-4-hydroxybenzonitrile               | Bromoxynil                        | C <sub>7</sub> H <sub>3</sub> Br <sub>2</sub> NO                            | 1689-84-5  | 276.913  |                     | 190     |                                       |                            |                      |                                                      |
| 2956 | Dibromomethane                                  | Methylene bromide                 | CH <sub>2</sub> Br <sub>2</sub>                                             | 74-95-3    | 173.835  | liq                 | -52.5   | 97                                    | 2.4969 <sup>20</sup>       | 1.5420 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, ace; s ctc       |
| 2957 | 1,4-Dibromo-2-methylbenzene                     | 2,5-Dibromotoluene                | C <sub>7</sub> H <sub>6</sub> Br <sub>2</sub>                               | 615-59-8   | 249.931  |                     | 5.6     | 236                                   | 1.8127 <sup>17</sup>       | 1.5982 <sup>18</sup> | i H <sub>2</sub> O                                   |
| 2958 | 2,4-Dibromo-1-methylbenzene                     |                                   | C <sub>7</sub> H <sub>6</sub> Br <sub>2</sub>                               | 31543-75-6 | 249.931  |                     | -9.7    | 103 <sup>11</sup>                     | 1.8176 <sup>25</sup>       | 1.5964 <sup>25</sup> |                                                      |
| 2959 | (Dibromomethyl)benzene                          |                                   | C <sub>7</sub> H <sub>6</sub> Br <sub>2</sub>                               | 618-31-5   | 249.931  |                     | 1.0     | 156 <sup>23</sup>                     | 1.8365 <sup>28</sup>       | 1.6147 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                    |
| 2960 | 2,3-Dibromo-2-methylbutane                      |                                   | C <sub>6</sub> H <sub>10</sub> Br <sub>2</sub>                              | 594-51-4   | 229.941  |                     | 7       | 62 <sup>17</sup>                      | 1.6717 <sup>20</sup>       | 1.5729 <sup>25</sup> |                                                      |
| 2961 | 2,4-Dibromo-6-methylphenol                      |                                   | C <sub>7</sub> H <sub>6</sub> Br <sub>2</sub> O                             | 609-22-3   | 265.930  | nd (peth)           | 58      | dec 265; 105 <sup>4</sup>             |                            |                      | s chl                                                |
| 2962 | 1,2-Dibromo-2-methylpropane                     |                                   | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                               | 594-34-3   | 215.915  |                     | 10.5    | 150                                   | 1.7827 <sup>20</sup>       | 1.5119 <sup>20</sup> | s EtOH, eth, chl                                     |
| 2963 | 1,4-Dibromonaphthalene                          |                                   | C <sub>10</sub> H <sub>6</sub> Br <sub>2</sub>                              | 83-53-4    | 285.963  |                     | 83      | 310                                   |                            |                      | i H <sub>2</sub> O; s EtOH, eth; sl HOAc             |
| 2964 | 2,6-Dibromo-4-nitroaniline                      |                                   | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 827-94-1   | 295.916  | ye nd (al, HOAc)    | 207     |                                       |                            |                      | sl H <sub>2</sub> O; s HOAc                          |
| 2965 | 2,6-Dibromo-4-nitrophenol                       |                                   | C <sub>6</sub> H <sub>3</sub> Br <sub>2</sub> NO <sub>3</sub>               | 99-28-5    | 296.901  | pa ye pr or lf (al) | 145 dec |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; sl ace, bz, HOAc   |
| 2966 | 1,9-Dibromononane                               |                                   | C <sub>9</sub> H <sub>18</sub> Br <sub>2</sub>                              | 4549-33-1  | 286.047  | liq                 | -22.5   | 285; 154 <sup>10</sup>                | 1.4229 <sup>20</sup>       |                      |                                                      |
| 2967 | 1,4-Dibromooctafluorobutane                     |                                   | C <sub>2</sub> Br <sub>2</sub> F <sub>8</sub>                               | 335-48-8   | 359.838  |                     |         | 97                                    |                            |                      |                                                      |
| 2968 | 1,8-Dibromooctane                               | Octamethylene dibromide           | C <sub>8</sub> H <sub>16</sub> Br <sub>2</sub>                              | 4549-32-0  | 272.021  |                     | 15.5    | 271                                   | 1.4594 <sup>25</sup>       | 1.4971 <sup>25</sup> | i H <sub>2</sub> O; s eth, ctc, chl                  |
| 2969 | 1,2-Dibromopentane                              |                                   | C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>                              | 3234-49-9  | 229.941  |                     |         | 184                                   | 1.668 <sup>18</sup>        |                      |                                                      |
| 2970 | 1,4-Dibromopentane                              |                                   | C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>                              | 626-87-9   | 229.941  |                     | -34.4   | 146 <sup>150</sup> , 99 <sup>14</sup> | 1.6222 <sup>20</sup>       | 1.5086 <sup>20</sup> |                                                      |
| 2971 | 1,5-Dibromopentane                              |                                   | C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>                              | 111-24-0   | 229.941  | liq                 | -39.5   | 222.3                                 | 1.6928 <sup>25</sup>       | 1.5102 <sup>25</sup> | i H <sub>2</sub> O; s bz, chl; sl ctc                |
| 2972 | 2,4-Dibromopentane                              |                                   | C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>                              | 19398-53-9 | 229.941  |                     |         | 75 <sup>21</sup> , 60 <sup>12</sup>   | 1.6659 <sup>20</sup>       | 1.4987 <sup>20</sup> |                                                      |
| 2973 | 2,4-Dibromophenol                               |                                   | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub> O                             | 615-58-7   | 251.903  | nd (peth)           | 38      | 238.5                                 | 2.0700 <sup>20</sup>       |                      | sl H <sub>2</sub> O, ctc; vs EtOH, eth, bz           |
| 2974 | 2,6-Dibromophenol                               |                                   | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub> O                             | 608-33-3   | 251.903  | nd (w)              | 56.5    | 255; 162 <sup>21</sup>                |                            |                      | s H <sub>2</sub> O; vs EtOH, eth                     |

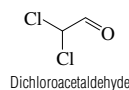
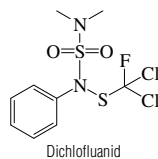
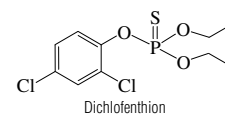
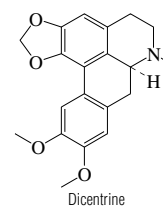
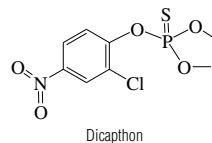
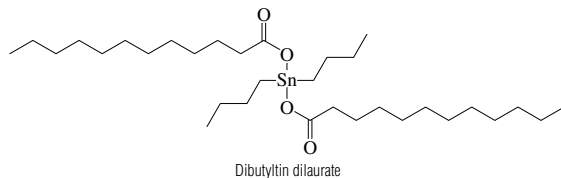
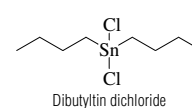
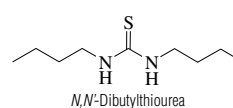
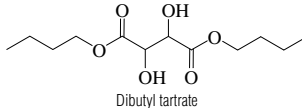
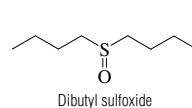
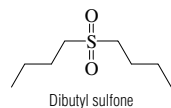
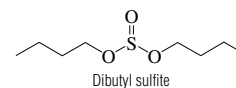
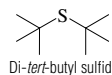
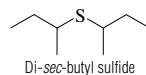
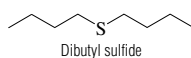
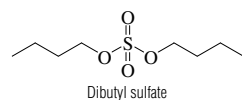
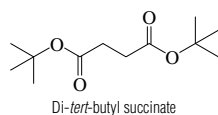
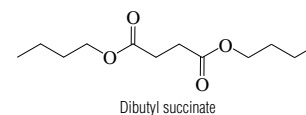
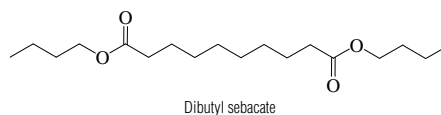
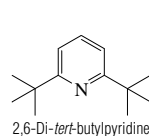
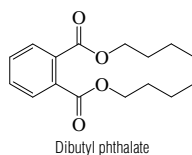
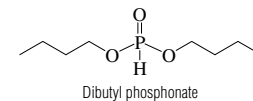
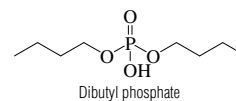
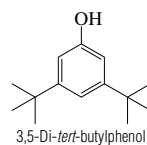
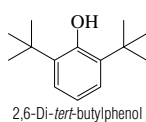
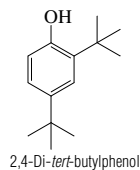
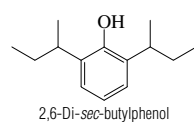
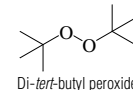
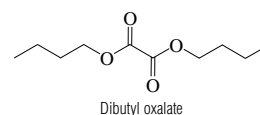
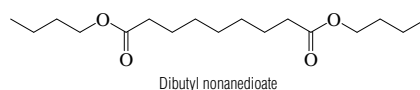
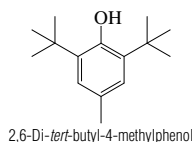
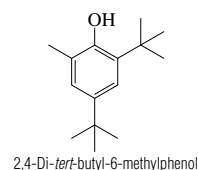
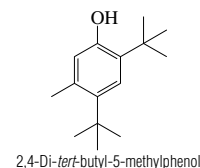
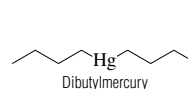
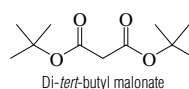
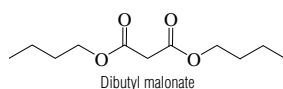
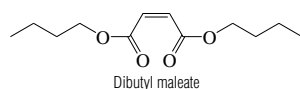
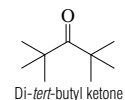
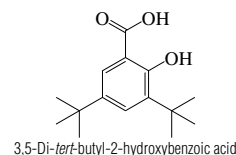
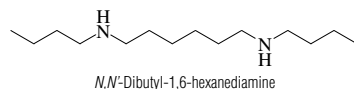
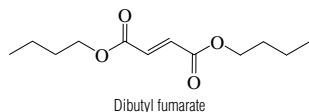
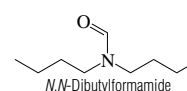
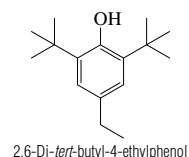
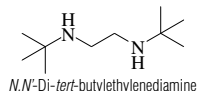
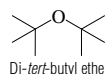
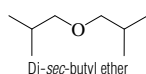
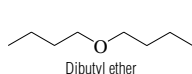


| No.  | Name                                                         | Synonym                                                 | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|--------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------|------------|----------|-------------------------|---------|---------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 2975 | 1,2-Dibromopropane                                           | Propylene dibromide                                     | C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>                   | 78-75-1    | 201.888  | liq                     | -55.49  | 141.9                                 | 1.9324 <sup>20</sup>       | 1.5201 <sup>20</sup> | s EtOH, eth, chl;<br>sl ctc                                  |
| 2976 | 1,3-Dibromopropane                                           |                                                         | C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>                   | 109-64-8   | 201.888  | liq                     | -34.5   | 167.3                                 | 1.9701 <sup>25</sup>       | 1.5204 <sup>25</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, chl; sl ctc              |
| 2977 | 2,2-Dibromopropane                                           |                                                         | C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>                   | 594-16-1   | 201.888  |                         |         | 113                                   | 1.880 <sup>20</sup>        |                      | vs eth, EtOH,<br>chl                                         |
| 2978 | 2,3-Dibromopropanoic acid                                    |                                                         | C <sub>3</sub> H <sub>4</sub> Br <sub>2</sub> O <sub>2</sub>    | 600-05-5   | 231.871  |                         | 66.5    | 160 <sup>20</sup> , 138 <sup>12</sup> |                            |                      | vs bz, eth, EtOH                                             |
| 2979 | 2,3-Dibromo-1-propanol                                       |                                                         | C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub> O                 | 96-13-9    | 217.887  |                         |         | 219                                   | 2.120 <sup>20</sup>        |                      |                                                              |
| 2980 | 1,3-Dibromo-2-propanol                                       |                                                         | C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub> O                 | 96-21-9    | 217.887  | ye liq                  |         | dec 219; 105 <sup>16</sup>            | 2.1364 <sup>20</sup>       | 1.5495 <sup>25</sup> | vs ace, eth,<br>EtOH                                         |
| 2981 | 2,3-Dibromo-1-propanol,<br>phosphate (3:1)                   | Tris(2,3-dibromopropyl)<br>phosphate                    | C <sub>9</sub> H <sub>15</sub> Br <sub>6</sub> O <sub>4</sub> P | 126-72-7   | 697.610  |                         |         |                                       |                            |                      | s chl                                                        |
| 2982 | 1,3-Dibromo-2-propanone                                      | 1,3-Dibromoacetone                                      | C <sub>3</sub> H <sub>4</sub> Br <sub>2</sub> O                 | 816-39-7   | 215.871  | nd                      | 26      | 97 <sup>22</sup>                      | 2.1670 <sup>18</sup>       |                      | vs eth, CS <sub>2</sub>                                      |
| 2983 | 1,1-Dibromo-1-propene                                        |                                                         | C <sub>3</sub> H <sub>4</sub> Br <sub>2</sub>                   | 13195-80-7 | 199.872  |                         |         | 125                                   | 1.9767 <sup>20</sup>       | 1.5260 <sup>20</sup> | sl H <sub>2</sub> O; s bz, ctc,<br>chl                       |
| 2984 | 1,2-Dibromo-1-propene                                        |                                                         | C <sub>3</sub> H <sub>4</sub> Br <sub>2</sub>                   | 26391-16-2 | 199.872  |                         |         | 131.5                                 | 2.0076 <sup>20</sup>       |                      |                                                              |
| 2985 | 2,3-Dibromo-1-propene                                        |                                                         | C <sub>3</sub> H <sub>4</sub> Br <sub>2</sub>                   | 513-31-5   | 199.872  |                         |         | 141; 37.7 <sup>11</sup>               | 2.0345 <sup>25</sup>       | 1.5416 <sup>25</sup> | i H <sub>2</sub> O; s eth, ace,<br>chl                       |
| 2986 | 3,5-Dibromopyridine                                          |                                                         | C <sub>5</sub> H <sub>4</sub> Br <sub>2</sub> N                 | 625-92-3   | 236.893  | nd (al)                 | 112     | 222                                   |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth                          |
| 2987 | 5,7-Dibromo-8-quinolinol                                     | Broxyquinoline                                          | C <sub>9</sub> H <sub>6</sub> Br <sub>2</sub> NO                | 521-74-4   | 302.950  | nd (al)                 | 196     | sub                                   |                            |                      | i H <sub>2</sub> O; s EtOH,<br>ace, bz, chl,<br>HOAc; sl eth |
| 2988 | 2,6-Dibromoquinone-4-<br>chlorimide                          | 2,6-Dibromo-4-(chloroimino)-<br>2,5-cyclohexadien-1-one | C <sub>8</sub> H <sub>4</sub> Br <sub>2</sub> ClNO              | 537-45-1   | 299.347  | ye pr (al or<br>HOAc)   | 83      |                                       |                            |                      | vs EtOH                                                      |
| 2989 | 1,14-Dibromotetradecane                                      | Tetradecamethylene dibromide                            | C <sub>14</sub> H <sub>28</sub> Br <sub>2</sub>                 | 37688-96-3 | 356.180  | lf (al-eth) cry<br>(al) | 50.4    | 190 <sup>8</sup>                      |                            |                      | vs eth, EtOH,<br>chl                                         |
| 2990 | 1,2-Dibromotetrafluoroethane                                 | Refrigerant 114B2                                       | C <sub>2</sub> Br <sub>2</sub> F <sub>4</sub>                   | 124-73-2   | 259.823  | liq                     | -110.32 | 47.35                                 | 2.149 <sup>25</sup>        | 1.361 <sup>25</sup>  | i H <sub>2</sub> O                                           |
| 2991 | 2,3-Dibromothiophene                                         |                                                         | C <sub>4</sub> H <sub>2</sub> Br <sub>2</sub> S                 | 3140-93-0  | 241.932  | liq                     | -17.5   | 218.5; 89 <sup>13</sup>               |                            | 1.6304 <sup>22</sup> |                                                              |
| 2992 | 2,5-Dibromothiophene                                         |                                                         | C <sub>4</sub> H <sub>2</sub> Br <sub>2</sub> S                 | 3141-27-3  | 241.932  | liq                     | -6      | 210.3                                 | 2.142 <sup>23</sup>        | 1.6288 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth; s ctc                   |
| 2993 | 3,4-Dibromothiophene                                         |                                                         | C <sub>4</sub> H <sub>2</sub> Br <sub>2</sub> S                 | 3141-26-2  | 241.932  |                         | 4.5     | 221.5                                 |                            |                      |                                                              |
| 2994 | 1,2-Dibromo-1,1,2-trifluoroethane                            | Halon 2302                                              | C <sub>2</sub> HBr <sub>2</sub> F <sub>3</sub>                  | 354-04-1   | 241.832  |                         |         | 76                                    | 2.274 <sup>27</sup>        | 1.4191 <sup>24</sup> |                                                              |
| 2995 | 2,6-Dibromo-3,4,5-<br>trihydroxybenzoic acid                 | Dibromogallic acid                                      | C <sub>7</sub> H <sub>4</sub> Br <sub>2</sub> O <sub>5</sub>    | 602-92-6   | 327.912  | nd, pr or lf<br>(w+1)   | 150     |                                       |                            |                      | vs H <sub>2</sub> O, eth,<br>EtOH                            |
| 2996 | 3,5-Dibromo- <i>L</i> -tyrosine                              |                                                         | C <sub>9</sub> H <sub>8</sub> Br <sub>2</sub> NO <sub>3</sub>   | 300-38-9   | 338.980  | nd or pl                | 245     |                                       |                            |                      | sl H <sub>2</sub> O, EtOH; i<br>eth; s alk, acid             |
| 2997 | Dibucaine                                                    | Cinchocaine                                             | C <sub>20</sub> H <sub>29</sub> N <sub>3</sub> O <sub>2</sub>   | 85-79-0    | 343.463  | hyg cry                 | 64      |                                       |                            |                      |                                                              |
| 2998 | Dibucaine hydrochloride                                      |                                                         | C <sub>20</sub> H <sub>30</sub> ClN <sub>3</sub> O <sub>2</sub> | 61-12-1    | 379.924  |                         | 94 dec  |                                       |                            |                      | s chl                                                        |
| 2999 | 1,4-Dibutoxybenzene                                          |                                                         | C <sub>14</sub> H <sub>22</sub> O <sub>2</sub>                  | 104-36-9   | 222.324  |                         | 45.5    | 158 <sup>15</sup>                     |                            |                      | s ctc                                                        |
| 3000 | 1,2-Dibutoxyethane                                           | Ethylene glycol dibutyl ether                           | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                  | 112-48-1   | 174.281  | liq                     | -69.1   | 203.3                                 | 0.8319 <sup>25</sup>       | 1.4112 <sup>25</sup> |                                                              |
| 3001 | Dibutoxymethane                                              | Butylal                                                 | C <sub>9</sub> H <sub>20</sub> O <sub>2</sub>                   | 2568-90-3  | 160.254  | liq                     | -58.1   | 179.2                                 | 0.8339 <sup>20</sup>       | 1.4072 <sup>17</sup> |                                                              |
| 3002 | Dibutyl adipate                                              |                                                         | C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>                  | 105-99-7   | 258.354  |                         | -32.4   | 165 <sup>10</sup>                     | 0.9613 <sup>20</sup>       | 1.4369 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                         |
| 3003 | Dibutylamine                                                 | <i>N</i> -Butylbutanamine                               | C <sub>8</sub> H <sub>19</sub> N                                | 111-92-2   | 129.244  | liq                     | -62     | 159.6                                 | 0.7670 <sup>20</sup>       | 1.4177 <sup>20</sup> | s H <sub>2</sub> O, ace, bz;<br>vs EtOH, eth                 |
| 3004 | Di- <i>sec</i> -butylamine                                   | <i>N</i> - <i>sec</i> -Butyl-2-butanamine               | C <sub>8</sub> H <sub>19</sub> N                                | 626-23-3   | 129.244  |                         |         | 134                                   | 0.7534 <sup>20</sup>       | 1.4162 <sup>20</sup> | vs H <sub>2</sub> O; s EtOH                                  |
| 3005 | 2-Dibutylaminoethanol                                        |                                                         | C <sub>10</sub> H <sub>23</sub> NO                              | 102-81-8   | 173.296  |                         |         | 114 <sup>18</sup>                     |                            |                      |                                                              |
| 3006 | <i>N,N</i> -Dibutylaniline                                   |                                                         | C <sub>14</sub> H <sub>23</sub> N                               | 613-29-6   | 205.340  | liq                     | -32.2   | 274.8                                 | 0.9037 <sup>20</sup>       | 1.5186 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; vs<br>ace, bz; s ctc   |
| 3007 | 1,4-Di- <i>tert</i> -butylbenzene                            |                                                         | C <sub>14</sub> H <sub>22</sub>                                 | 1012-72-2  | 190.325  | nd (MeOH)               | 79.5    | 238; 109 <sup>15</sup>                | 0.9850 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH,<br>eth                           |
| 3008 | 2,5-Di- <i>tert</i> -butyl-1,4-benzenediol                   |                                                         | C <sub>14</sub> H <sub>22</sub> O <sub>2</sub>                  | 88-58-4    | 222.324  | cry (aq<br>HOAc)        | 213.5   |                                       |                            |                      |                                                              |
| 3009 | Dibutylbis(dodecylthio)stannane                              | Dibutyltin bis(dodecyl sulfide)                         | C <sub>32</sub> H <sub>66</sub> S <sub>2</sub> Sn               | 1185-81-5  | 635.722  | col liq                 |         | 122 <sup>0.3</sup>                    | 1.05 <sup>20</sup>         |                      | s tol, hp                                                    |
| 3010 | Dibutyl carbonate                                            |                                                         | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>                   | 542-52-9   | 174.237  |                         |         | 207                                   | 0.9251 <sup>20</sup>       | 1.4117 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                           |
| 3011 | Di- <i>tert</i> -butyl carbonate                             |                                                         | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>                   | 34619-03-9 | 174.237  | cry (al)                | 40      | 158                                   |                            |                      | vs EtOH                                                      |
| 3012 | 2,5-Di- <i>tert</i> -butyl-2,5-<br>cyclohexadiene-1,4-dione  |                                                         | C <sub>14</sub> H <sub>20</sub> O <sub>2</sub>                  | 2460-77-7  | 220.308  | ye cry (al)             | 152.5   |                                       |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl,<br>HOAc         |
| 3013 | 2,6-Di- <i>tert</i> -butyl-2,5-<br>cyclohexadiene-1,4-dione  |                                                         | C <sub>14</sub> H <sub>20</sub> O <sub>2</sub>                  | 719-22-2   | 220.308  |                         | 69      | 60 <sup>0.01</sup>                    |                            |                      |                                                              |
| 3014 | 2,6-Di- <i>tert</i> -butyl-4-<br>(dimethylaminomethyl)phenol |                                                         | C <sub>17</sub> H <sub>29</sub> NO                              | 88-27-7    | 263.418  | pl (EtOH)               | 94      | 179 <sup>40</sup>                     |                            |                      |                                                              |
| 3015 | 2,2-Dibutyl-1,3,2-dioxastannepin-<br>4,7-dione               |                                                         | C <sub>12</sub> H <sub>20</sub> O <sub>4</sub> Sn               | 78-04-6    | 346.995  | ye solid                | 110     |                                       |                            |                      |                                                              |
| 3016 | Dibutyl disulfide                                            |                                                         | C <sub>8</sub> H <sub>18</sub> S <sub>2</sub>                   | 629-45-8   | 178.359  | oil                     |         | 226; 117 <sup>20</sup>                | 0.938 <sup>20</sup>        | 1.4923 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                         |
| 3017 | Di- <i>tert</i> -butyl disulfide                             |                                                         | C <sub>8</sub> H <sub>18</sub> S <sub>2</sub>                   | 110-06-5   | 178.359  |                         | -2.5    | 88 <sup>21</sup>                      | 0.9226 <sup>20</sup>       | 1.4899 <sup>20</sup> |                                                              |
| 3018 | <i>cis</i> -1,2-Di- <i>tert</i> -butylethene                 | <i>cis</i> -2,2,5,5-Tetramethyl-3-<br>hexene            | C <sub>10</sub> H <sub>20</sub>                                 | 692-47-7   | 140.266  | liq                     |         | 144                                   | 0.744 <sup>20</sup>        | 1.4270 <sup>20</sup> |                                                              |

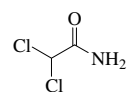




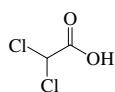
| No.  | Name                                               | Synonym                                            | Mol. Form.                                                                                   | CAS RN     | Mol. Wt. | Physical Form | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|------|----------------------------------------------------|----------------------------------------------------|----------------------------------------------------------------------------------------------|------------|----------|---------------|-------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 3019 | Dibutyl ether                                      |                                                    | C <sub>8</sub> H <sub>18</sub> O                                                             | 142-96-1   | 130.228  | liq           | -95.2 | 140.28                                | 0.7684 <sup>20</sup>       | 1.3992 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs ace; sl ctc   |
| 3020 | Di- <i>sec</i> -butyl ether                        |                                                    | C <sub>8</sub> H <sub>18</sub> O                                                             | 6863-58-7  | 130.228  | liq           |       | 121.1                                 | 0.756 <sup>25</sup>        |                      |                                                     |
| 3021 | Di- <i>tert</i> -butyl ether                       |                                                    | C <sub>8</sub> H <sub>18</sub> O                                                             | 6163-66-2  | 130.228  | liq           |       | 107.23                                | 0.7658 <sup>20</sup>       | 1.3949 <sup>20</sup> |                                                     |
| 3022 | <i>N,N'</i> -Di- <i>tert</i> -butylethylenediamine | <i>N,N'</i> -Di- <i>tert</i> -butylethylenediamine | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub>                                               | 4062-60-6  | 172.311  | cry           | 53.3  | 189                                   | 0.69                       |                      |                                                     |
| 3023 | 2,6-Di- <i>tert</i> -butyl-4-ethylphenol           |                                                    | C <sub>16</sub> H <sub>26</sub> O                                                            | 4130-42-1  | 234.376  |               | 44    | 272                                   |                            |                      | i alk                                               |
| 3024 | <i>N,N</i> -Dibutylformamide                       |                                                    | C <sub>9</sub> H <sub>19</sub> NO                                                            | 761-65-9   | 157.253  |               |       |                                       |                            |                      | s ctc, CS <sub>2</sub>                              |
| 3025 | Dibutyl fumarate                                   |                                                    | C <sub>12</sub> H <sub>20</sub> O <sub>4</sub>                                               | 105-75-9   | 228.285  | liq           | -13.5 | 285; 150 <sup>4</sup>                 | 0.9775 <sup>20</sup>       | 1.4469 <sup>20</sup> | i H <sub>2</sub> O; s ace, chl                      |
| 3026 | <i>N,N'</i> -Dibutyl-1,6-hexanediamine             |                                                    | C <sub>14</sub> H <sub>32</sub> N <sub>2</sub>                                               | 4835-11-4  | 228.417  |               |       | 138 <sup>3,5</sup>                    |                            | 1.4470 <sup>25</sup> |                                                     |
| 3027 | 3,5-Di- <i>tert</i> -butyl-2-hydroxybenzoic acid   |                                                    | C <sub>15</sub> H <sub>22</sub> O <sub>3</sub>                                               | 19715-19-6 | 250.334  |               | 163.3 |                                       |                            |                      | s chl                                               |
| 3028 | Di- <i>tert</i> -butyl ketone                      |                                                    | C <sub>9</sub> H <sub>18</sub> O                                                             | 815-24-7   | 142.238  | liq           | -25.2 | 152                                   | 0.8240 <sup>18</sup>       | 1.4194 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, chl, HOAc     |
| 3029 | Dibutyl maleate                                    |                                                    | C <sub>12</sub> H <sub>20</sub> O <sub>4</sub>                                               | 105-76-0   | 228.285  |               | <-80  | 280; 142 <sup>10</sup>                |                            |                      |                                                     |
| 3030 | Dibutyl malonate                                   |                                                    | C <sub>11</sub> H <sub>20</sub> O <sub>4</sub>                                               | 1190-39-2  | 216.275  | liq           | -83   | 251.5                                 | 0.9824 <sup>20</sup>       | 1.4262 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, HOAc, ctc |
| 3031 | Di- <i>tert</i> -butyl malonate                    |                                                    | C <sub>11</sub> H <sub>20</sub> O <sub>4</sub>                                               | 541-16-2   | 216.275  |               | -6    | 113 <sup>31</sup> , 66 <sup>2</sup>   | 1.4184 <sup>20</sup>       | 1.4184 <sup>29</sup> | s ace, chl                                          |
| 3032 | Dibutylmercury                                     |                                                    | C <sub>8</sub> H <sub>18</sub> Hg                                                            | 629-35-6   | 314.82   |               |       | 223; 105 <sup>10</sup>                | 1.7779 <sup>20</sup>       | 1.5057 <sup>20</sup> |                                                     |
| 3033 | 2,4-Di- <i>tert</i> -butyl-5-methylphenol          | DBMC                                               | C <sub>15</sub> H <sub>24</sub> O                                                            | 497-39-2   | 220.351  |               | 62.1  | 282                                   | 0.912 <sup>80</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, ctc       |
| 3034 | 2,4-Di- <i>tert</i> -butyl-6-methylphenol          |                                                    | C <sub>15</sub> H <sub>24</sub> O                                                            | 616-55-7   | 220.351  |               | 51    | 269                                   | 0.891 <sup>80</sup>        |                      | i alk                                               |
| 3035 | 2,6-Di- <i>tert</i> -butyl-4-methylphenol          |                                                    | C <sub>15</sub> H <sub>24</sub> O                                                            | 128-37-0   | 220.351  |               | 71    | 265                                   | 0.8937 <sup>75</sup>       | 1.4859 <sup>75</sup> | i H <sub>2</sub> O; s EtOH, ace, bz, peth; i alk    |
| 3036 | Dibutyl nonanedioate                               |                                                    | C <sub>17</sub> H <sub>32</sub> O <sub>4</sub>                                               | 2917-73-9  | 300.434  |               |       | 170 <sup>2</sup>                      |                            |                      | sl chl                                              |
| 3037 | Dibutyl oxalate                                    |                                                    | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                                               | 2050-60-4  | 202.248  | liq           | -30.5 | 241; 96 <sup>2</sup>                  | 0.9873 <sup>20</sup>       | 1.4234 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                     |
| 3038 | Di- <i>tert</i> -butyl peroxide                    | DTBP                                               | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                                                | 110-05-4   | 146.228  | liq           | -40   | 111                                   | 0.704 <sup>20</sup>        | 1.3890 <sup>20</sup> | i H <sub>2</sub> O; msc ace; s ctc, lig             |
| 3039 | 2,6-Di- <i>sec</i> -butylphenol                    |                                                    | C <sub>14</sub> H <sub>22</sub> O                                                            | 5510-99-6  | 206.324  | liq           | -42   | 257.5                                 |                            | 1.5080 <sup>20</sup> |                                                     |
| 3040 | 2,4-Di- <i>tert</i> -butylphenol                   |                                                    | C <sub>14</sub> H <sub>22</sub> O                                                            | 96-76-4    | 206.324  |               | 56.5  | 263.5                                 |                            | 1.5080 <sup>20</sup> | sl ctc; i alk                                       |
| 3041 | 2,6-Di- <i>tert</i> -butylphenol                   |                                                    | C <sub>14</sub> H <sub>22</sub> O                                                            | 128-39-2   | 206.324  | pr (al)       | 39    | 161 <sup>50</sup> , 133 <sup>20</sup> |                            | 1.5001 <sup>20</sup> | sl EtOH; s ctc; i alk                               |
| 3042 | 3,5-Di- <i>tert</i> -butylphenol                   |                                                    | C <sub>14</sub> H <sub>22</sub> O                                                            | 1138-52-9  | 206.324  |               | 88    |                                       |                            |                      |                                                     |
| 3043 | Dibutyl phosphate                                  |                                                    | C <sub>8</sub> H <sub>19</sub> O <sub>4</sub> P                                              | 107-66-4   | 210.208  | oil           |       | 136 <sup>0,05</sup>                   | 1.06 <sup>20</sup>         |                      | s ctc, BuOH                                         |
| 3044 | Dibutyl phosphonate                                |                                                    | C <sub>8</sub> H <sub>19</sub> O <sub>3</sub> P                                              | 1809-19-4  | 194.209  | oil           |       | 230; 131 <sup>19</sup>                | 0.985 <sup>25</sup>        | 1.4220 <sup>20</sup> |                                                     |
| 3045 | Dibutyl phthalate                                  |                                                    | C <sub>16</sub> H <sub>22</sub> O <sub>4</sub>                                               | 84-74-2    | 278.344  | liq           | -35   | 340                                   | 1.0465 <sup>20</sup>       | 1.4911 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, bz; s ctc        |
| 3046 | 2,6-Di- <i>tert</i> -butylpyridine                 |                                                    | C <sub>13</sub> H <sub>21</sub> N                                                            | 585-48-8   | 191.313  |               |       | 120 <sup>20</sup>                     |                            |                      |                                                     |
| 3047 | Dibutyl sebacate                                   |                                                    | C <sub>18</sub> H <sub>34</sub> O <sub>4</sub>                                               | 109-43-3   | 314.461  | liq           | -10   | 344.5                                 | 0.9405 <sup>15</sup>       | 1.4433 <sup>15</sup> | i H <sub>2</sub> O; s eth, ctc                      |
| 3048 | Dibutyl succinate                                  |                                                    | C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                                               | 141-03-7   | 230.301  | liq           | -29.2 | 274.5                                 | 0.9752 <sup>20</sup>       | 1.4299 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc            |
| 3049 | Di- <i>tert</i> -butyl succinate                   |                                                    | C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                                               | 926-26-1   | 230.301  |               | 36.5  | 109 <sup>9</sup>                      |                            |                      |                                                     |
| 3050 | Dibutyl sulfate                                    | Butyl sulfate                                      | C <sub>8</sub> H <sub>18</sub> O <sub>4</sub> S                                              | 625-22-9   | 210.292  | liq           |       | 115 <sup>6</sup>                      |                            |                      |                                                     |
| 3051 | Dibutyl sulfide                                    |                                                    | C <sub>8</sub> H <sub>18</sub> S                                                             | 544-40-1   | 146.294  | liq           | -79.7 | 185                                   | 0.8386 <sup>20</sup>       | 1.4530 <sup>20</sup> | vs eth, EtOH, chl                                   |
| 3052 | Di- <i>sec</i> -butyl sulfide                      |                                                    | C <sub>8</sub> H <sub>18</sub> S                                                             | 626-26-6   | 146.294  |               |       | 165                                   | 0.8348 <sup>20</sup>       | 1.4506 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                    |
| 3053 | Di- <i>tert</i> -butyl sulfide                     |                                                    | C <sub>8</sub> H <sub>18</sub> S                                                             | 107-47-1   | 146.294  | liq           | -9.0  | 149.1                                 | 0.815 <sup>25</sup>        | 1.4506 <sup>20</sup> |                                                     |
| 3054 | Dibutyl sulfite                                    | Butyl sulfite                                      | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub> S                                              | 626-85-7   | 194.292  |               |       | 230                                   | 0.9957 <sup>20</sup>       | 1.4310 <sup>20</sup> | s EtOH, eth                                         |
| 3055 | Dibutyl sulfone                                    |                                                    | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub> S                                              | 598-04-9   | 178.293  |               | 45    | 291                                   | 0.9885 <sup>47</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                     |
| 3056 | Dibutyl sulfoxide                                  |                                                    | C <sub>8</sub> H <sub>18</sub> OS                                                            | 2168-93-6  | 162.293  | nd (dil al)   | 32.6  | dec                                   | 0.8317 <sup>23</sup>       | 1.4669 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                     |
| 3057 | Dibutyl tartrate                                   |                                                    | C <sub>12</sub> H <sub>22</sub> O <sub>6</sub>                                               | 87-92-3    | 262.299  | pr            | 22    | 320                                   | 1.0909 <sup>20</sup>       | 1.4451 <sup>20</sup> | vs H <sub>2</sub> O, ace, EtOH                      |
| 3058 | <i>N,N'</i> -Dibutylthiourea                       |                                                    | C <sub>9</sub> H <sub>20</sub> N <sub>2</sub> S                                              | 109-46-6   | 188.333  | nd (al)       | 78    |                                       |                            |                      |                                                     |
| 3059 | Dibutyltin dichloride                              | Dibutylidichlorostannane                           | C <sub>8</sub> H <sub>18</sub> Cl <sub>2</sub> Sn                                            | 683-18-1   | 303.845  | solid         | 43    | 135 <sup>10</sup>                     |                            |                      | s hx, eth, thf                                      |
| 3060 | Dibutyltin dilaurate                               |                                                    | C <sub>32</sub> H <sub>64</sub> O <sub>4</sub> Sn                                            | 77-58-7    | 631.558  | ye liq or cry | 23    |                                       |                            |                      | i H <sub>2</sub> O, MeOH; s eth, bz, ctc            |
| 3061 | Dicapthon                                          |                                                    | C <sub>8</sub> H <sub>9</sub> ClNO <sub>3</sub> PS                                           | 2463-84-5  | 297.653  | cry (MeOH)    | 53    |                                       |                            |                      | i H <sub>2</sub> O; s ace, tol, xyl, AcOEt          |
| 3062 | Dicentrine                                         |                                                    | C <sub>20</sub> H <sub>21</sub> NO <sub>4</sub>                                              | 517-66-8   | 339.386  |               |       |                                       |                            |                      | s chl                                               |
| 3063 | Dichlofenthion                                     |                                                    | C <sub>10</sub> H <sub>13</sub> Cl <sub>2</sub> O <sub>3</sub> PS                            | 97-17-6    | 315.153  |               |       |                                       |                            |                      | s ctc, CS <sub>2</sub>                              |
| 3064 | Dichlofluanid                                      |                                                    | C <sub>9</sub> H <sub>11</sub> Cl <sub>2</sub> FN <sub>2</sub> O <sub>2</sub> S <sub>2</sub> | 1085-98-9  | 333.229  | wh pow        | 105.3 |                                       |                            |                      | i H <sub>2</sub> O; s ace, MeOH, xyl                |
| 3065 | Dichloroacetaldehyde                               |                                                    | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O                                              | 79-02-7    | 112.942  |               |       | 90.5                                  | 1.436 <sup>25</sup>        |                      | sl EtOH                                             |



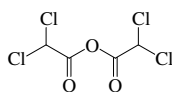
| No.  | Name                                     | Synonym                    | Mol. Form.                                                                                 | CAS RN     | Mol. Wt. | Physical Form                        | mp/°C   | bp/°C                      | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                 |
|------|------------------------------------------|----------------------------|--------------------------------------------------------------------------------------------|------------|----------|--------------------------------------|---------|----------------------------|----------------------------|-----------------------|------------------------------------------------------------|
| 3066 | 2,2-Dichloroacetamide                    |                            | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> NO                                           | 683-72-7   | 127.957  |                                      | 99.4    | 234                        |                            |                       | s H <sub>2</sub> O, EtOH, eth; sl ace                      |
| 3067 | Dichloroacetic acid                      |                            | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>                               | 79-43-6    | 128.942  |                                      | 13.5    | 194; 102 <sup>20</sup>     | 1.5634 <sup>20</sup>       | 1.4658 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH, eth; s ace; sl ctc             |
| 3068 | Dichloroacetic anhydride                 |                            | C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub> O <sub>3</sub>                               | 4124-30-5  | 239.869  |                                      | 18.0    | dec 215; 100 <sup>10</sup> | 1.574 <sup>24</sup>        |                       |                                                            |
| 3069 | 1,1-Dichloroacetone                      |                            | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> O                                            | 513-88-2   | 126.969  |                                      |         | 120                        | 1.304 <sup>18</sup>        |                       | sl H <sub>2</sub> O; s EtOH; msc eth                       |
| 3070 | 1,3-Dichloroacetone                      |                            | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> O                                            | 534-07-6   | 126.969  | pr or nd                             | 45      | 173.4                      | 1.3826 <sup>46</sup>       | 1.4716 <sup>40</sup>  | s H <sub>2</sub> O, EtOH, eth                              |
| 3071 | Dichloroacetonitrile                     |                            | C <sub>2</sub> HCl <sub>2</sub> N                                                          | 3018-12-0  | 109.942  |                                      |         | 112.5                      | 1.369 <sup>20</sup>        | 1.4391 <sup>25</sup>  | s MeOH                                                     |
| 3072 | Dichloroacetyl chloride                  |                            | C <sub>2</sub> HCl <sub>3</sub> O                                                          | 79-36-7    | 147.387  |                                      |         | 108                        | 1.5315 <sup>16</sup>       | 1.4591 <sup>20</sup>  | dec H <sub>2</sub> O, EtOH; msc eth                        |
| 3073 | Dichloroacetylene                        |                            | C <sub>2</sub> Cl <sub>2</sub>                                                             | 7572-29-4  | 94.927   | liq                                  | -66     | 33                         | 1.261 <sup>20</sup>        | 1.42790 <sup>20</sup> | s EtOH, eth, ace                                           |
| 3074 | 4-[(Dichloroamino)sulfonyl] benzoic acid | Halazone                   | C <sub>7</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>4</sub> S                            | 80-13-7    | 270.091  | pr (HOAc)                            | 195 dec |                            |                            |                       | sl H <sub>2</sub> O, chl; vs HOAc; i peth                  |
| 3075 | 2,3-Dichloroaniline                      |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N                                            | 608-27-5   | 162.017  | nd (lig)                             | 24      | 252                        |                            |                       | s EtOH, ace; vs eth; sl bz, ctc, lig                       |
| 3076 | 2,4-Dichloroaniline                      |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N                                            | 554-00-7   | 162.017  | pr (ace) nd (dil al) (lig)           | 63.5    | 245                        | 1.567 <sup>20</sup>        |                       | sl H <sub>2</sub> O, chl; s EtOH, eth                      |
| 3077 | 2,5-Dichloroaniline                      |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N                                            | 95-82-9    | 162.017  | nd (lig)                             | 50      | 251                        |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, bz, chl, CS <sub>2</sub> |
| 3078 | 2,6-Dichloroaniline                      |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N                                            | 608-31-1   | 162.017  |                                      | 39      |                            |                            |                       | sl H <sub>2</sub> O; s EtOH, eth                           |
| 3079 | 3,4-Dichloroaniline                      |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N                                            | 95-76-1    | 162.017  | nd (lig)                             | 72      | 272                        |                            |                       | s EtOH, eth; sl bz, chl                                    |
| 3080 | 3,5-Dichloroaniline                      |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N                                            | 626-43-7   | 162.017  | nd (lig, dil al)                     | 52      | 261                        |                            |                       | i H <sub>2</sub> O; s EtOH, eth, ctc, lig                  |
| 3081 | 9,10-Dichloroanthracene                  |                            | C <sub>14</sub> H <sub>8</sub> Cl <sub>2</sub>                                             | 605-48-1   | 247.120  | ye nd (MeCOEt or CCl <sub>4</sub> )  | 213.5   |                            |                            |                       | sl EtOH, eth, chl; s bz                                    |
| 3082 | 1,5-Dichloro-9,10-anthracenedione        |                            | C <sub>14</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>                              | 82-46-2    | 277.103  | ye nd (to)                           | 252     |                            |                            |                       | i H <sub>2</sub> O; sl EtOH, ace; s bz, HOAc               |
| 3083 | 1,8-Dichloro-9,10-anthracenedione        |                            | C <sub>14</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>                              | 82-43-9    | 277.103  | ye nd (HOAc)                         | 202.5   |                            |                            |                       | i H <sub>2</sub> O; sl EtOH; s bz, tol, PhNO <sub>2</sub>  |
| 3084 | <i>trans</i> -4,4'-Dichloroazobenzene    |                            | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub> N <sub>2</sub>                              | 1602-00-2  | 251.111  | ye nd (ace)                          | 189     |                            |                            |                       |                                                            |
| 3085 | 4,4'-Dichloroazoxybenzene                |                            | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub> N <sub>2</sub> O                            | 614-26-6   | 267.110  | ye nd (EtOH)                         | 158     |                            |                            |                       |                                                            |
| 3086 | 2,3-Dichlorobenzaldehyde                 |                            | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O                                            | 6334-18-5  | 175.012  | cry (dil al)                         | 66      |                            |                            |                       | vs eth, EtOH                                               |
| 3087 | 2,4-Dichlorobenzaldehyde                 |                            | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O                                            | 874-42-0   | 175.012  | pr                                   | 73.3    | 105 <sup>15</sup>          |                            |                       | i H <sub>2</sub> O; s EtOH, eth, bz, chl, HOAc             |
| 3088 | 2,6-Dichlorobenzaldehyde                 |                            | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O                                            | 83-38-5    | 175.012  | nd (lig)                             | 71.8    |                            |                            |                       | vs eth, EtOH, lig                                          |
| 3089 | 3,4-Dichlorobenzaldehyde                 |                            | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O                                            | 6287-38-3  | 175.012  |                                      | 44      | 247.5                      |                            |                       | i H <sub>2</sub> O; s EtOH, eth; sl ctc                    |
| 3090 | 3,5-Dichlorobenzaldehyde                 |                            | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O                                            | 10203-08-4 | 175.012  | nd or lf (dil HOAc)                  | 65      | 240                        |                            |                       | vs ace, bz, eth, EtOH                                      |
| 3091 | 2,6-Dichlorobenzamide                    |                            | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> NO                                           | 2008-58-4  | 190.027  | cry                                  | 198     |                            |                            |                       |                                                            |
| 3092 | <i>o</i> -Dichlorobenzene                | 1,2-Dichlorobenzene        | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                                              | 95-50-1    | 147.002  | liq                                  | -17.0   | 180                        | 1.3059 <sup>20</sup>       | 1.5515 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, ctc          |
| 3093 | <i>m</i> -Dichlorobenzene                | 1,3-Dichlorobenzene        | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                                              | 541-73-1   | 147.002  | liq                                  | -24.8   | 173                        | 1.2884 <sup>20</sup>       | 1.5459 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz; msc ace               |
| 3094 | <i>p</i> -Dichlorobenzene                | 1,4-Dichlorobenzene        | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                                              | 106-46-7   | 147.002  | mcl pr, lf (ace)                     | 53.09   | 174                        | 1.2475 <sup>55</sup>       | 1.5285 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, ace, bz; s eth, ctc          |
| 3095 | 2,5-Dichloro-1,4-benzenediamine          |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N <sub>2</sub>                               | 20103-09-7 | 177.031  | pr (w)                               | 170     |                            |                            |                       |                                                            |
| 3096 | 2,6-Dichloro-1,4-benzenediamine          |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N <sub>2</sub>                               | 609-20-1   | 177.031  | nd, pr (dil al)                      | 125     |                            |                            |                       | s EtOH, eth, ace, bz                                       |
| 3097 | 3,5-Dichloro-1,2-benzenediol             |                            | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                               | 13673-92-2 | 179.001  | pr                                   | 83.5    |                            |                            |                       | sl H <sub>2</sub> O; s EtOH; vs ace                        |
| 3098 | 4,5-Dichloro-1,2-benzenediol             |                            | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                               | 3428-24-8  | 179.001  | pr(chl-CS <sub>2</sub> ) nd(bz-peth) | 116.5   |                            |                            |                       | s H <sub>2</sub> O; vs EtOH, bz                            |
| 3099 | 4,6-Dichloro-1,3-benzenediol             |                            | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                               | 137-19-9   | 179.001  |                                      | 113     | 254                        |                            |                       | vs H <sub>2</sub> O, EtOH, eth, ace; sl lig                |
| 3100 | 2,5-Dichloro-1,4-benzenediol             |                            | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                               | 824-69-1   | 179.001  | nd or pr w, ace, bz)                 | 172.5   |                            | 1.8150 <sup>24</sup>       |                       | s H <sub>2</sub> O; vs EtOH, eth, ace                      |
| 3101 | 4,5-Dichloro-1,3-benzenedisulfonamide    | Dichlorphenamide           | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub> S <sub>2</sub> | 120-97-8   | 305.159  |                                      | 228.7   |                            |                            |                       |                                                            |
| 3102 | 2,4-Dichlorobenzenemethanamine           |                            | C <sub>7</sub> H <sub>7</sub> Cl <sub>2</sub> N                                            | 95-00-1    | 176.044  |                                      |         | 125 <sup>13</sup>          |                            | 1.5762 <sup>25</sup>  | s chl                                                      |
| 3103 | 2,4-Dichlorobenzenemethanol              | 2,4-Dichlorobenzyl alcohol | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                                            | 1777-82-8  | 177.028  |                                      | 59.5    | 150 <sup>25</sup>          |                            |                       | s chl                                                      |
| 3104 | <i>N,N</i> -Dichlorobenzenesulfonamide   |                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub> S                            | 473-29-0   | 226.081  | ye mcl or pl                         | 76      |                            |                            |                       | s EtOH; sl ctc                                             |



2,2-Dichloroacetamide



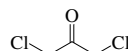
Dichloroacetic acid



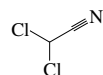
Dichloroacetic anhydride



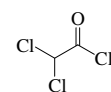
1,1-Dichloroacetone



1,3-Dichloroacetone



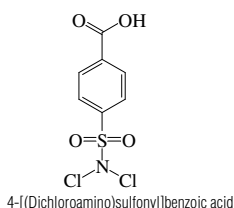
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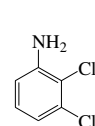
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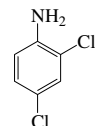
Dichloroacetylene



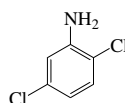
4-[(Dichloroamino)sulfonyl]benzoic acid



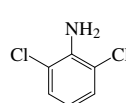
2,3-Dichloroaniline



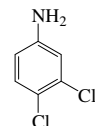
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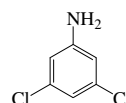
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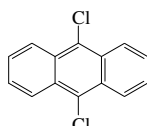
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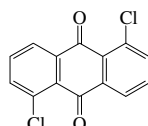
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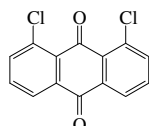
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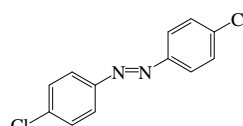
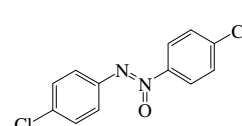
9,10-Dichloroanthracene



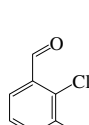
1,5-Dichloro-9,10-anthracenedione



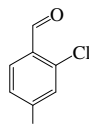
1,8-Dichloro-9,10-anthracenedione

*trans*-4,4'-Dichloroazobenzene

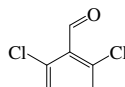
4,4'-Dichloroazoxybenzene



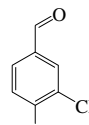
2,3-Dichlorobenzaldehyde



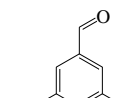
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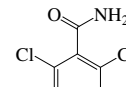
2,6-Dichlorobenzaldehyde



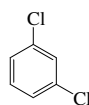
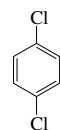
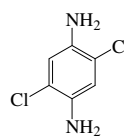
3,4-Dichlorobenzaldehyde



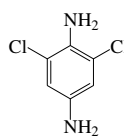
3,5-Dichlorobenzaldehyde



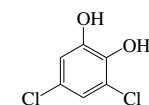
2,6-Dichlorobenzamide

*o*-Dichlorobenzene*m*-Dichlorobenzene*p*-Dichlorobenzene

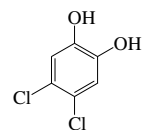
2,5-Dichloro-1,4-benzenediamine



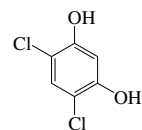
2,6-Dichloro-1,4-benzenediamine



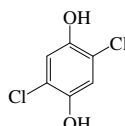
3,5-Dichloro-1,2-benzenediol



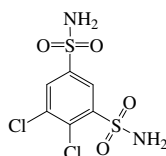
4,5-Dichloro-1,2-benzenediol



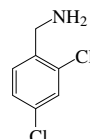
4,6-Dichloro-1,3-benzenediol



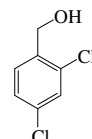
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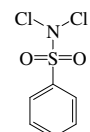
4,5-Dichloro-1,3-benzenedisulfonamide



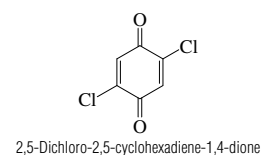
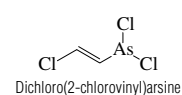
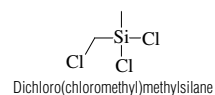
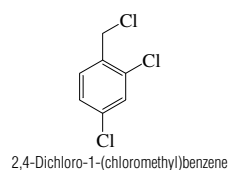
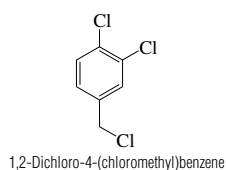
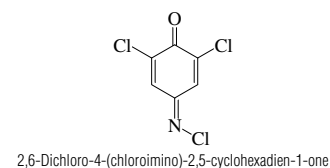
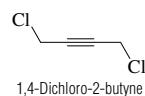
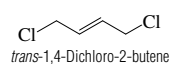
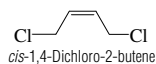
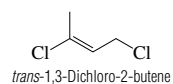
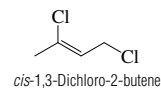
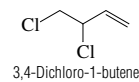
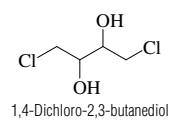
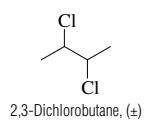
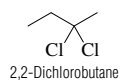
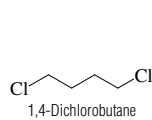
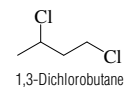
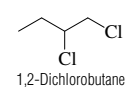
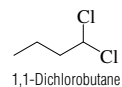
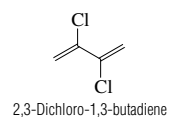
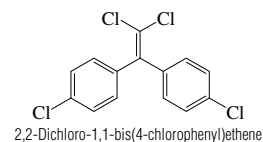
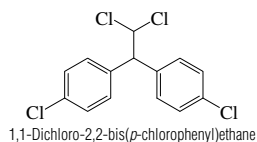
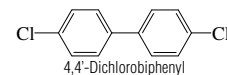
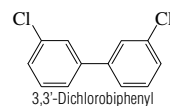
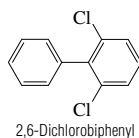
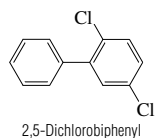
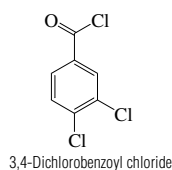
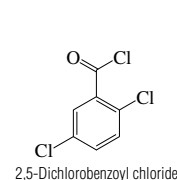
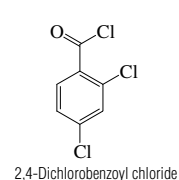
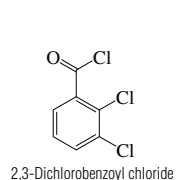
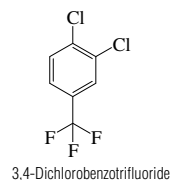
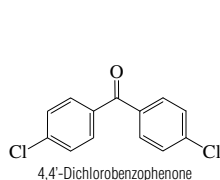
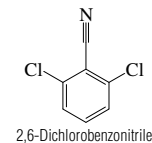
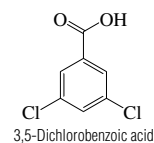
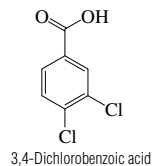
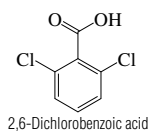
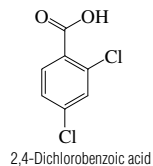
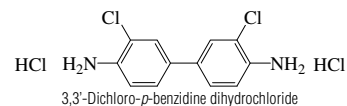
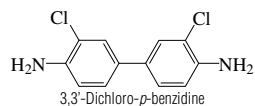
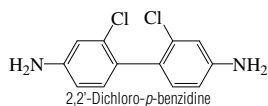
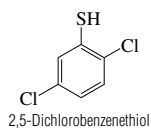
2,4-Dichlorobenzenemethanamine



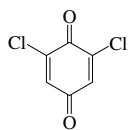
2,4-Dichlorobenzenemethanol

*N,N*-Dichlorobenzenesulfonamide

| No.  | Name                                                 | Synonym                                      | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form          | mp/°C | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                       |
|------|------------------------------------------------------|----------------------------------------------|----------------------------------------------------------------|------------|----------|------------------------|-------|----------------------------------------|----------------------------|----------------------|--------------------------------------------------|
| 3105 | 2,5-Dichlorobenzenethiol                             |                                              | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> S                | 5858-18-4  | 179.067  |                        |       | 115 <sup>50</sup>                      |                            |                      |                                                  |
| 3106 | 2,2'-Dichloro- <i>p</i> -benzidine                   | [1,1'-Biphenyl]-4,4'-diamine, 2,2'-dichloro- | C <sub>12</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> | 84-68-4    | 253.126  | nd (w), pr (al)        | 165   |                                        |                            |                      | vs eth, EtOH                                     |
| 3107 | 3,3'-Dichloro- <i>p</i> -benzidine                   | [1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro- | C <sub>12</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> | 91-94-1    | 253.126  | nd                     | 132.5 |                                        |                            |                      | i H <sub>2</sub> O; s EtOH, bz, HOAc             |
| 3108 | 3,3'-Dichloro- <i>p</i> -benzidine dihydrochloride   |                                              | C <sub>12</sub> H <sub>12</sub> Cl <sub>4</sub> N <sub>2</sub> | 612-83-9   | 326.048  |                        |       |                                        |                            |                      | i H <sub>2</sub> O; vs EtOH                      |
| 3109 | 2,4-Dichlorobenzoic acid                             |                                              | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>   | 50-84-0    | 191.012  | nd (w or bz)           | 164.2 | sub                                    |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl; sl ace   |
| 3110 | 2,5-Dichlorobenzoic acid                             |                                              | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>   | 50-79-3    | 191.012  | nd (w)                 | 154.4 | 301                                    |                            |                      | sl H <sub>2</sub> O, DMSO; s EtOH, eth           |
| 3111 | 2,6-Dichlorobenzoic acid                             |                                              | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>   | 50-30-6    | 191.012  | nd (al), pr (w)        | 144   | sub                                    |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl           |
| 3112 | 3,4-Dichlorobenzoic acid                             |                                              | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>   | 51-44-5    | 191.012  | nd (w, al, bz)         | 208.5 |                                        |                            |                      | s H <sub>2</sub> O, eth; vs EtOH; sl DMSO        |
| 3113 | 3,5-Dichlorobenzoic acid                             |                                              | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>   | 51-36-5    | 191.012  | nd (al, w)             | 188   | sub                                    |                            |                      | sl H <sub>2</sub> O, lig, DMSO; s EtOH, eth      |
| 3114 | 2,6-Dichlorobenzonitrile                             | Dichlobenil                                  | C <sub>7</sub> H <sub>3</sub> Cl <sub>2</sub> N                | 1194-65-6  | 172.012  | cry (peth)             | 144.5 | 270                                    |                            |                      |                                                  |
| 3115 | 4,4'-Dichlorobenzophenone                            | Bis(4-chlorophenyl) ketone                   | C <sub>13</sub> H <sub>8</sub> Cl <sub>2</sub> O               | 90-98-2    | 251.108  | pl (al)                | 147.5 | 353                                    | 1.4500 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH; vs eth, chl; sl ace  |
| 3116 | 3,4-Dichlorobenzotrifluoride                         | 1,2-Dichloro-4-(trifluoromethyl) benzene     | C <sub>7</sub> H <sub>3</sub> Cl <sub>2</sub> F <sub>3</sub>   | 328-84-7   | 215.000  | liq                    |       | 173.5; 64 <sup>14</sup>                | 1.4729 <sup>25</sup>       |                      |                                                  |
| 3117 | 2,3-Dichlorobenzoyl chloride                         |                                              | C <sub>7</sub> H <sub>3</sub> Cl <sub>3</sub> O                | 2905-60-4  | 209.457  | liq                    |       | 140 <sup>14</sup>                      |                            |                      |                                                  |
| 3118 | 2,4-Dichlorobenzoyl chloride                         |                                              | C <sub>7</sub> H <sub>3</sub> Cl <sub>3</sub> O                | 89-75-8    | 209.457  |                        | 16.5  | 150 <sup>34</sup> , 111 <sup>7.5</sup> | 1.5895 <sup>20</sup>       | s ctc                |                                                  |
| 3119 | 2,5-Dichlorobenzoyl chloride                         |                                              | C <sub>7</sub> H <sub>3</sub> Cl <sub>3</sub> O                | 2905-61-5  | 209.457  | liq                    |       | 95.4 <sup>1</sup>                      |                            |                      |                                                  |
| 3120 | 3,4-Dichlorobenzoyl chloride                         |                                              | C <sub>7</sub> H <sub>3</sub> Cl <sub>3</sub> O                | 3024-72-4  | 209.457  |                        | 25    | 242                                    |                            |                      | sl ctc                                           |
| 3121 | 2,5-Dichlorobiphenyl                                 |                                              | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub>                 | 34883-39-1 | 223.098  |                        |       | 182 <sup>30</sup> , 171 <sup>15</sup>  |                            |                      | i H <sub>2</sub> O                               |
| 3122 | 2,6-Dichlorobiphenyl                                 |                                              | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub>                 | 33146-45-1 | 223.098  | cry                    | 35.5  |                                        |                            |                      | i H <sub>2</sub> O                               |
| 3123 | 3,3'-Dichlorobiphenyl                                |                                              | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub>                 | 2050-67-1  | 223.098  | nd (dil al)            | 29    | 320                                    |                            |                      | vs bz, eth, EtOH                                 |
| 3124 | 4,4'-Dichlorobiphenyl                                |                                              | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub>                 | 2050-68-2  | 223.098  | pr or nd (al, to-peth) | 149.3 | 317                                    | 1.4420 <sup>9</sup>        |                      | i H <sub>2</sub> O; sl EtOH, chl; s bz           |
| 3125 | 1,1-Dichloro-2,2-bis( <i>p</i> -chlorophenyl)ethane  |                                              | C <sub>14</sub> H <sub>10</sub> Cl <sub>4</sub>                | 72-54-8    | 320.041  |                        | 109.5 | 193 <sup>1</sup>                       |                            |                      | sl chl                                           |
| 3126 | 2,2-Dichloro-1,1-bis(4-chlorophenyl)ethene           |                                              | C <sub>14</sub> H <sub>8</sub> Cl <sub>4</sub>                 | 72-55-9    | 318.026  |                        | 89    |                                        |                            |                      |                                                  |
| 3127 | 2,3-Dichloro-1,3-butadiene                           |                                              | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub>                  | 1653-19-6  | 122.981  |                        |       | 98                                     | 1.1829 <sup>20</sup>       | 1.4890 <sup>20</sup> | vs chl                                           |
| 3128 | 1,1-Dichlorobutane                                   | Butylidene chloride                          | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 541-33-3   | 127.013  |                        |       | 113.8                                  | 1.0863 <sup>20</sup>       | 1.4355 <sup>20</sup> | i H <sub>2</sub> O; s chl                        |
| 3129 | 1,2-Dichlorobutane                                   |                                              | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 616-21-7   | 127.013  |                        |       | 124.1                                  | 1.1116 <sup>25</sup>       | 1.4450 <sup>20</sup> | i H <sub>2</sub> O; s eth, chl; sl ctc           |
| 3130 | 1,3-Dichlorobutane                                   |                                              | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 1190-22-3  | 127.013  |                        |       | 134                                    | 1.1158 <sup>20</sup>       | 1.4445 <sup>20</sup> | i H <sub>2</sub> O; s eth, chl; sl ctc           |
| 3131 | 1,4-Dichlorobutane                                   |                                              | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 110-56-5   | 127.013  | liq                    | -37.3 | 161                                    | 1.1331 <sup>25</sup>       | 1.4522 <sup>25</sup> | i H <sub>2</sub> O; vs chl                       |
| 3132 | 2,2-Dichlorobutane                                   |                                              | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 4279-22-5  | 127.013  | liq                    | -74   | 104                                    | 1.1048 <sup>25</sup>       | 1.4295               | i H <sub>2</sub> O; s chl                        |
| 3133 | 2,3-Dichlorobutane, (±)                              |                                              | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 2211-67-8  | 127.013  | liq                    | -80   | 119; 53 <sup>30</sup>                  | 1.105 <sup>25</sup>        | 1.4409 <sup>25</sup> | i H <sub>2</sub> O                               |
| 3134 | 1,4-Dichloro-2,3-butanediol                          |                                              | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>2</sub>   | 2419-73-0  | 159.012  |                        | 126.5 | 150 <sup>30</sup>                      |                            |                      | vs EtOH                                          |
| 3135 | 3,4-Dichloro-1-butene                                |                                              | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub>                  | 760-23-6   | 124.997  | liq                    | -61   | 116                                    | 1.1170 <sup>20</sup>       | 1.4641 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc; vs chl, bz |
| 3136 | <i>cis</i> -1,3-Dichloro-2-butene                    |                                              | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub>                  | 10075-38-4 | 124.997  |                        |       | 130; 34 <sup>20</sup>                  | 1.1605 <sup>20</sup>       | 1.4735 <sup>20</sup> | vs ace, bz, eth, EtOH                            |
| 3137 | <i>trans</i> -1,3-Dichloro-2-butene                  |                                              | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub>                  | 7415-31-8  | 124.997  |                        |       | 132; 53 <sup>30</sup>                  | 1.160 <sup>20</sup>        | 1.4719 <sup>20</sup> | vs ace, bz, eth, EtOH                            |
| 3138 | <i>cis</i> -1,4-Dichloro-2-butene                    |                                              | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub>                  | 1476-11-5  | 124.997  | liq                    | -48   | 152.5                                  | 1.188 <sup>25</sup>        | 1.4887 <sup>25</sup> | vs ace, bz, eth, EtOH                            |
| 3139 | <i>trans</i> -1,4-Dichloro-2-butene                  |                                              | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub>                  | 110-57-6   | 124.997  |                        | 1.0   | 155.4                                  | 1.183 <sup>25</sup>        | 1.4871 <sup>25</sup> | vs ace, bz, eth, EtOH                            |
| 3140 | 1,4-Dichloro-2-butyne                                |                                              | C <sub>4</sub> H <sub>4</sub> Cl <sub>2</sub>                  | 821-10-3   | 122.981  |                        |       | 165.5                                  | 1.258 <sup>20</sup>        | 1.5058 <sup>20</sup> | s eth, ace; sl ctc; vs chl                       |
| 3141 | 2,6-Dichloro-4-(chloroimino)-2,5-cyclohexadien-1-one | Gibbs' reagent                               | C <sub>6</sub> H <sub>7</sub> Cl <sub>3</sub> NO               | 101-38-2   | 210.445  |                        | 66    |                                        |                            |                      |                                                  |
| 3142 | 1,2-Dichloro-4-(chloromethyl) benzene                |                                              | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub>                  | 102-47-6   | 195.474  |                        | 37.5  | 241                                    |                            |                      | i H <sub>2</sub> O; s EtOH, ctc                  |
| 3143 | 2,4-Dichloro-1-(chloromethyl) benzene                |                                              | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub>                  | 94-99-5    | 195.474  |                        |       | 120 <sup>13</sup>                      |                            |                      |                                                  |
| 3144 | Dichloro(chloromethyl) methylsilane                  |                                              | C <sub>2</sub> H <sub>5</sub> Cl <sub>3</sub> Si               | 1558-33-4  | 163.506  |                        |       | 121.5                                  | 1.2858 <sup>20</sup>       | 1.4500 <sup>20</sup> |                                                  |
| 3145 | Dichloro(2-chlorovinyl)arsine                        |                                              | C <sub>2</sub> H <sub>2</sub> AsCl <sub>3</sub>                | 541-25-3   | 207.318  | liq                    | 0.1   | 190                                    | 1.888 <sup>20</sup>        |                      |                                                  |
| 3146 | 2,5-Dichloro-2,5-cyclohexadiene-1,4-dione            |                                              | C <sub>6</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>   | 615-93-0   | 176.985  | pa ye mcl pr (al)      | 162.3 |                                        |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, chl          |



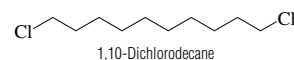
| No.  | Name                                      | Synonym                           | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form     | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                            |
|------|-------------------------------------------|-----------------------------------|-----------------------------------------------------------------------------|------------|----------|-------------------|---------|-------------------------------------|----------------------------|-----------------------|-------------------------------------------------------|
| 3147 | 2,6-Dichloro-2,5-cyclohexadiene-1,4-dione |                                   | C <sub>6</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>                | 697-91-6   | 176.985  | ye orth (liq, bz) | 121.8   |                                     |                            |                       | sl H <sub>2</sub> O, EtOH; s chl                      |
| 3148 | 1,1-Dichlorocyclohexane                   |                                   | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 2108-92-1  | 153.049  | liq               | -47     | 171                                 | 1.1559 <sup>20</sup>       | 1.4803 <sup>20</sup>  |                                                       |
| 3149 | cis-1,2-Dichlorocyclohexane               |                                   | C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 10498-35-8 | 153.049  | liq               | -1.5    | 206.9                               | 1.2021 <sup>20</sup>       | 1.4967 <sup>20</sup>  | vs bz                                                 |
| 3150 | 1,10-Dichlorodecane                       |                                   | C <sub>10</sub> H <sub>20</sub> Cl <sub>2</sub>                             | 2162-98-3  | 211.172  |                   | 15.6    | 167 <sup>28</sup>                   | 0.9945 <sup>25</sup>       | 1.4586 <sup>25</sup>  |                                                       |
| 3151 | 2,7-Dichlorodibenzo- <i>p</i> -dioxin     |                                   | C <sub>12</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>               | 33857-26-0 | 253.081  | cry               | 201     |                                     |                            |                       |                                                       |
| 3152 | 1,2-Dichloro-4-(dichloromethyl)benzene    |                                   | C <sub>7</sub> H <sub>4</sub> Cl <sub>4</sub>                               | 56961-84-3 | 229.919  |                   |         | 257                                 | 1.515 <sup>22</sup>        |                       | vs bz, eth, EtOH                                      |
| 3153 | Dichloro(dichloromethyl)methylsilane      |                                   | C <sub>2</sub> H <sub>4</sub> Cl <sub>4</sub> Si                            | 1558-31-2  | 197.951  |                   |         | 149                                 | 1.4116 <sup>20</sup>       | 1.4700 <sup>20</sup>  |                                                       |
| 3154 | 2,3-Dichloro-5,6-dicyanobenzoquinone      |                                   | C <sub>8</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub>                | 84-58-2    | 227.004  | ye-oran cry       | 214.5   |                                     |                            |                       | vs bz, HOAc, diox                                     |
| 3155 | Dichlorodiethylsilane                     |                                   | C <sub>4</sub> H <sub>10</sub> Cl <sub>2</sub> Si                           | 1719-53-5  | 157.114  |                   | -96.5   | dec 129                             | 1.0504 <sup>20</sup>       | 1.4309 <sup>20</sup>  |                                                       |
| 3156 | 1,1-Dichloro-1,2-difluoroethane           |                                   | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>                | 25915-78-0 | 134.940  | col liq           |         | 48.4                                |                            |                       |                                                       |
| 3157 | 1,2-Dichloro-1,1-difluoroethane           |                                   | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>                | 1649-08-7  | 134.940  | liq               | -101.2  | 46.2                                | 1.4163 <sup>20</sup>       | 1.36193 <sup>20</sup> | sl H <sub>2</sub> O                                   |
| 3158 | 1,2-Dichloro-1,2-difluoroethane           |                                   | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>                | 431-06-1   | 134.940  | liq               | -101.2  | 59.6                                | 1.4163 <sup>20</sup>       | 1.3619 <sup>20</sup>  |                                                       |
| 3159 | 1,1-Dichloro-2,2-difluoroethene           | 1,1-Dichloro-2,2-difluoroethylene | C <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>                               | 79-35-6    | 132.924  | vol liq or gas    | -116    | 19                                  | 1.555 <sup>-20</sup>       | 1.383 <sup>-20</sup>  |                                                       |
| 3160 | cis-1,2-Dichloro-1,2-difluoroethene       | Fluorocarbon 1112                 | C <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>                               | 311-81-9   | 132.924  | vol liq           | -119.6  | 21.1                                | 1.495 <sup>0</sup>         |                       |                                                       |
| 3161 | trans-1,2-Dichloro-1,2-difluoroethene     |                                   | C <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>                               | 381-71-5   | 132.924  | vol liq           | -93.3   | 22                                  | 1.494 <sup>0</sup>         |                       |                                                       |
| 3162 | Dichlorodifluoromethane                   | Refrigerant 12                    | CCl <sub>2</sub> F <sub>2</sub>                                             | 75-71-8    | 120.914  | col gas           | -157.1  | -29.8                               |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, HOAc                |
| 3163 | 2,2-Dichloro-1,1-difluoro-1-methoxyethane | Methoxyflurane                    | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> F <sub>2</sub> O              | 76-38-0    | 164.966  | col liq           | -35     | 105                                 | 1.43 <sup>20</sup>         | 1.3861 <sup>20</sup>  |                                                       |
| 3164 | 2,2'-Dichlorodisopropyl ether             |                                   | C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub> O                            | 108-60-1   | 171.064  |                   |         | 187                                 | 1.103 <sup>20</sup>        | 1.4505 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace; vs bz         |
| 3165 | 1,4-Dichloro-2,5-dimethylbenzene          |                                   | C <sub>8</sub> H <sub>8</sub> Cl <sub>2</sub>                               | 1124-05-6  | 175.056  |                   | 71      | 222                                 |                            |                       | s chl                                                 |
| 3166 | 2,5-Dichloro-2,5-dimethylhexane           |                                   | C <sub>8</sub> H <sub>16</sub> Cl <sub>2</sub>                              | 6223-78-5  | 183.119  | lf, nd            | 67.5    |                                     | 0.9543 <sup>20</sup>       |                       | vs bz, eth, EtOH, chl                                 |
| 3167 | 1,3-Dichloro-5,5-dimethylhydantoin        |                                   | C <sub>8</sub> H <sub>8</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 118-52-5   | 197.019  | pr                | 132     |                                     | 1.5 <sup>20</sup>          |                       | sl H <sub>2</sub> O; s chl, ctc, bz                   |
| 3168 | 2,4-Dichloro-3,5-dimethylphenol           | Dichloroxylenol                   | C <sub>8</sub> H <sub>8</sub> Cl <sub>2</sub> O                             | 133-53-9   | 191.055  |                   | 83      |                                     |                            |                       | vs eth                                                |
| 3169 | Dichlorodimethylsilane                    |                                   | C <sub>2</sub> H <sub>6</sub> Cl <sub>2</sub> Si                            | 75-78-5    | 129.061  | liq               | -16     | 70.3                                | 1.064 <sup>25</sup>        | 1.4038 <sup>20</sup>  | dec H <sub>2</sub> O, EtOH                            |
| 3170 | 2,3-Dichloro-1,4-dioxane                  |                                   | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>                | 95-59-0    | 156.996  |                   | 30      | 81 <sup>10</sup>                    | 1.468 <sup>20</sup>        | 1.4928 <sup>20</sup>  | i H <sub>2</sub> O; vs eth, ace, bz, ctc, diox        |
| 3171 | Dichlorodiphenylmethane                   |                                   | C <sub>13</sub> H <sub>10</sub> Cl <sub>2</sub>                             | 2051-90-3  | 237.124  |                   |         | dec 305; 190 <sup>21</sup>          | 1.235 <sup>18</sup>        |                       | s eth, bz, ctc                                        |
| 3172 | Dichlorodiphenylsilane                    |                                   | C <sub>12</sub> H <sub>10</sub> Cl <sub>2</sub> Si                          | 80-10-4    | 253.199  |                   |         | 305                                 | 1.204 <sup>25</sup>        | 1.5800 <sup>20</sup>  | s EtOH, eth, ace, bz, ctc                             |
| 3173 | 1,1-Dichloroethane                        | Ethylidene dichloride             | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 75-34-3    | 98.959   | liq               | -96.9   | 57.3                                | 1.1757 <sup>20</sup>       | 1.4164 <sup>20</sup>  | sl H <sub>2</sub> O; vs EtOH, eth; s ace, bz          |
| 3174 | 1,2-Dichloroethane                        | Ethylene dichloride               | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 107-06-2   | 98.959   | liq               | -35.7   | 83.5                                | 1.2454 <sup>25</sup>       | 1.4422 <sup>25</sup>  | sl H <sub>2</sub> O; vs EtOH; msc eth; s ace, bz, chl |
| 3175 | 2,2-Dichloroethanol                       |                                   | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 598-38-9   | 114.958  |                   |         | 146                                 | 1.4040 <sup>25</sup>       | 1.4626 <sup>25</sup>  | sl H <sub>2</sub> O, ctc; s EtOH, eth                 |
| 3176 | 1,1-Dichloroethene                        | Vinylidene chloride               | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                               | 75-35-4    | 96.943   | liq               | -122.56 | 31.6                                | 1.213 <sup>20</sup>        | 1.4249 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, ace, bz; vs eth, chl      |
| 3177 | cis-1,2-Dichloroethene                    | cis-1,2-Dichloroethylene          | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                               | 156-59-2   | 96.943   | liq               | -80.0   | 60.1                                | 1.2837 <sup>20</sup>       | 1.4490 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth, ace; vs bz, chl   |
| 3178 | trans-1,2-Dichloroethene                  | trans-1,2-Dichloroethylene        | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                               | 156-60-5   | 96.943   | liq               | -49.8   | 48.7                                | 1.2565 <sup>20</sup>       | 1.4454 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth, ace; vs bz, chl   |
| 3179 | 1,2-Dichloro-1-ethoxyethane               |                                   | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O                             | 623-46-1   | 143.012  |                   |         | 145                                 | 1.1370 <sup>20</sup>       | 1.4435 <sup>20</sup>  | sl chl                                                |
| 3180 | 1,2-Dichloroethyl acetate                 |                                   | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>                | 10140-87-1 | 156.996  | liq               |         | 79 <sup>33</sup> , 32 <sup>10</sup> |                            |                       |                                                       |
| 3181 | Dichloroethylaluminum                     | Ethylaluminum chloride            | C <sub>2</sub> H <sub>5</sub> AlCl <sub>2</sub>                             | 563-43-9   | 126.949  | hyg solid or liq  | 32      | 115 <sup>50</sup>                   | 1.207                      |                       | reac H <sub>2</sub> O                                 |
| 3182 | Dichloroethylmethylsilane                 |                                   | C <sub>3</sub> H <sub>8</sub> Cl <sub>2</sub> Si                            | 4525-44-4  | 143.088  |                   |         | 101                                 | 1.0047 <sup>20</sup>       | 1.4197 <sup>20</sup>  |                                                       |
| 3183 | 2',7'-Dichlorofluorescein                 | 2',7'-Dichloro-3,6-fluorandiol    | C <sub>20</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>5</sub>              | 76-54-0    | 401.196  |                   |         |                                     |                            |                       | sl DMSO                                               |
| 3184 | 1,1-Dichloro-1-fluoroethane               |                                   | C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> F                             | 1717-00-6  | 116.949  | liq               | -103.5  | 32.0                                | 1.250 <sup>10</sup>        | 1.3600 <sup>10</sup>  | i H <sub>2</sub> O                                    |
| 3185 | 1,2-Dichloro-1-fluoroethane               |                                   | C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> F                             | 430-57-9   | 116.949  | liq               | -60     | 73.8                                | 1.3814 <sup>20</sup>       | 1.4132 <sup>20</sup>  |                                                       |
| 3186 | 1,1-Dichloro-2-fluoroethene               | 1,1-Dichloro-2-fluoroethylene     | C <sub>2</sub> HCl <sub>2</sub> F                                           | 359-02-4   | 114.933  | liq               | -108.8  | 37.5                                | 1.3732 <sup>16</sup>       | 1.4031 <sup>16</sup>  |                                                       |
| 3187 | Dichlorofluoromethane                     | Refrigerant 21                    | CHCl <sub>2</sub> F                                                         | 75-43-4    | 102.923  | col gas           | -130.4  | 8.9                                 | 1.405 <sup>9</sup>         | 1.3724 <sup>9</sup>   | i H <sub>2</sub> O; s EtOH, eth, ctc, chl, HOAc       |
| 3188 | (Dichlorofluoromethyl)benzene             |                                   | C <sub>7</sub> H <sub>5</sub> Cl <sub>2</sub> F                             | 498-67-9   | 179.019  | liq               | -26.8   | 179                                 | 1.3138 <sup>11</sup>       | 1.5180 <sup>11</sup>  | vs EtOH                                               |
| 3189 | 1,1-Dichloro-2-fluoropropene              |                                   | C <sub>3</sub> H <sub>3</sub> Cl <sub>2</sub> F                             | 430-95-5   | 128.960  |                   |         | 78                                  | 1.3026 <sup>25</sup>       | 1.4196 <sup>25</sup>  |                                                       |
| 3190 | 1,7-Dichloroheptane                       |                                   | C <sub>7</sub> H <sub>14</sub> Cl <sub>2</sub>                              | 821-76-1   | 169.092  |                   |         | 124 <sup>35</sup>                   | 1.0408 <sup>25</sup>       | 1.4565 <sup>25</sup>  |                                                       |



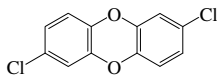
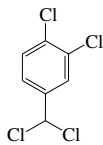
2,6-Dichloro-2,5-cyclohexadiene-1,4-dione



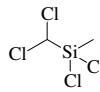
1,1-Dichlorocyclohexane

*cis*-1,2-Dichlorocyclohexane

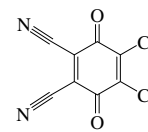
1,10-Dichlorodecane

2,7-Dichlorodibenzo-*p*-dioxin

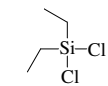
1,2-Dichloro-4-(dichloromethyl)benzene



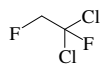
Dichloro(dichloromethyl)methylsilane



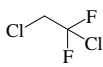
2,3-Dichloro-5,6-dicyanobenzoquinone



Dichlorodiethylsilane



1,1-Dichloro-1,2-difluoroethane



1,2-Dichloro-1,1-difluoroethane



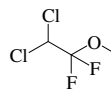
1,2-Dichloro-1,2-difluoroethane



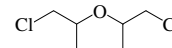
1,1-Dichloro-2,2-difluoroethene

*cis*-1,2-Dichloro-1,2-difluoroethene*trans*-1,2-Dichloro-1,2-difluoroethene

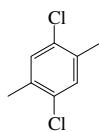
Dichlorodifluoromethane



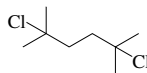
2,2-Dichloro-1,1-difluoro-1-methoxyethane



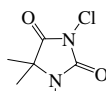
2,2'-Dichlorodiisopropyl ether



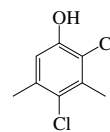
1,4-Dichloro-2,5-dimethylbenzene



2,5-Dichloro-2,5-dimethylhexane



1,3-Dichloro-5,5-dimethyl hydantoin



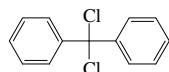
2,4-Dichloro-3,5-dimethylphenol



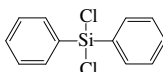
Dichlorodimethylsilane



2,3-Dichloro-1,4-dioxane



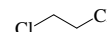
Dichlorodiphenylmethane



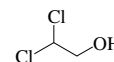
Dichlorodiphenylsilane



1,1-Dichloroethane



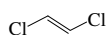
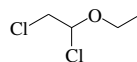
1,2-Dichloroethane



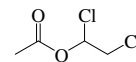
2,2-Dichloroethanol



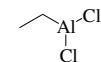
1,1-Dichloroethene

*cis*-1,2-Dichloroethene*trans*-1,2-Dichloroethene

1,2-Dichloro-1-ethoxyethane



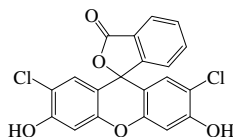
1,2-Dichloroethyl acetate



Dichloroethylaluminum



Dichloroethylmethylsilane



2',7'-Dichlorofluorescein



1,1-Dichloro-1-fluoroethane



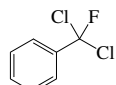
1,2-Dichloro-1-fluoroethane



1,1-Dichloro-2-fluoroethene



Dichlorofluoromethane



(Dichlorofluoromethyl)benzene



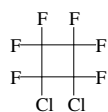
1,1-Dichloro-2-fluoropropene



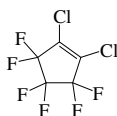
1,7-Dichloroheptane



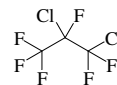
| No.  | Name                                            | Synonym                        | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C  | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                              |
|------|-------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------|------------|----------|----------------------------|--------|------------------------|----------------------------|-----------------------|---------------------------------------------------------|
| 3191 | 1,2-Dichloro-1,2,3,3,4,4-hexafluorocyclobutane  |                                | C <sub>4</sub> Cl <sub>2</sub> F <sub>6</sub>                                 | 356-18-3   | 232.939  | liq                        | -24.2  | 59.5                   |                            |                       |                                                         |
| 3192 | 1,2-Dichloro-3,3,4,4,5,5-hexafluorocyclopentene |                                | C <sub>5</sub> Cl <sub>2</sub> F <sub>6</sub>                                 | 706-79-6   | 244.949  | liq                        | -105.8 | 90.7                   | 1.6546 <sup>20</sup>       | 1.3676 <sup>20</sup>  |                                                         |
| 3193 | 1,2-Dichloro-1,1,2,3,3,3-hexafluoropropane      |                                | C <sub>3</sub> Cl <sub>2</sub> F <sub>6</sub>                                 | 661-97-2   | 220.928  |                            |        | 34.1                   |                            |                       | i H <sub>2</sub> O                                      |
| 3194 | 1,3-Dichloro-1,1,2,2,3,3-hexafluoropropane      | Refrigerant 216                | C <sub>3</sub> Cl <sub>2</sub> F <sub>6</sub>                                 | 662-01-1   | 220.928  | liq                        | -125.4 | 35.7                   | 1.573 <sup>20</sup>        | 1.3030 <sup>20</sup>  |                                                         |
| 3195 | 1,5-Dichloro-1,1,3,3,5,5-hexamethyltrisiloxane  |                                | C <sub>6</sub> H <sub>18</sub> Cl <sub>2</sub> O <sub>2</sub> Si <sub>3</sub> | 3582-71-6  | 277.369  | liq                        | -53    | 184                    | 1.018 <sup>20</sup>        |                       | dec H <sub>2</sub> O                                    |
| 3196 | 1,2-Dichlorohexane                              |                                | C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub>                                | 2162-92-7  | 155.065  |                            |        | 173                    | 1.085 <sup>15</sup>        |                       | vs eth, chl                                             |
| 3197 | 1,6-Dichlorohexane                              |                                | C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub>                                | 2163-00-0  | 155.065  |                            |        | 204                    | 1.0676 <sup>25</sup>       | 1.4555 <sup>25</sup>  | i H <sub>2</sub> O; s eth, ctc, chl                     |
| 3198 | 3,5-Dichloro-2-hydroxybenzaldehyde              |                                | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                  | 90-60-8    | 191.012  | ye orth (HOAc)             | 95     |                        |                            |                       | i H <sub>2</sub> O                                      |
| 3199 | 3,5-Dichloro-2-hydroxybenzoic acid              |                                | C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>3</sub>                  | 320-72-9   | 207.011  | nd (dil al) orth pr        | 220.5  | sub                    |                            |                       | sl H <sub>2</sub> O; vs EtOH, eth                       |
| 3200 | 2,6-Dichloroindophenol, sodium salt             | Tillman's reagent              | C <sub>12</sub> H <sub>6</sub> Cl <sub>2</sub> NNaO <sub>2</sub>              | 620-45-1   | 290.078  | dk grn cry                 |        |                        |                            |                       | s H <sub>2</sub> O, EtOH, ace                           |
| 3201 | 5,6-Dichloro-1,3-isobenzofurandione             | 4,5-Dichlorophthalic anhydride | C <sub>8</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>3</sub>                  | 942-06-3   | 217.006  | tab or pr (to)             | 188    | 313                    |                            |                       | vs eth, EtOH, tol                                       |
| 3202 | Dichloromethane                                 | Methylene chloride             | CH <sub>2</sub> Cl <sub>2</sub>                                               | 75-09-2    | 84.933   | liq                        | -97.2  | 40                     | 1.3266 <sup>20</sup>       | 1.4242 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth; s ctc               |
| 3203 | 1,2-Dichloro-3-methoxybenzene                   |                                | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                               | 1984-59-4  | 177.028  |                            | 32     |                        |                            |                       |                                                         |
| 3204 | 1,3-Dichloro-2-methoxybenzene                   | 2,6-Dichloroanisole            | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                               | 1984-65-2  | 177.028  | liq                        | 10     | 105 <sup>20</sup>      | 1.291                      | 1.5430 <sup>20</sup>  |                                                         |
| 3205 | 2,4-Dichloro-1-methoxybenzene                   |                                | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                               | 553-82-2   | 177.028  | pr                         | 28.5   | 232; 125 <sup>10</sup> |                            |                       | sl chl                                                  |
| 3206 | 3,6-Dichloro-2-methoxybenzoic acid              | Dicamba                        | C <sub>8</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>3</sub>                  | 1918-00-9  | 221.038  | cry (pent)                 | 115    |                        | 1.57 <sup>25</sup>         |                       |                                                         |
| 3207 | (Dichloromethyl)benzene                         | Benzal chloride                | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                                 | 98-87-3    | 161.029  | liq                        | -17    | 205                    | 1.26 <sup>25</sup>         | 1.5502 <sup>20</sup>  | i H <sub>2</sub> O; vs eth, EtOH                        |
| 3208 | <i>N,N</i> -Dichloro-4-methylbenzenesulfonamide | Dichloramine-T                 | C <sub>7</sub> H <sub>7</sub> Cl <sub>2</sub> NO <sub>2</sub> S               | 473-34-7   | 240.108  | pr(chl-peth)               | 83     |                        |                            |                       | i H <sub>2</sub> O; s EtOH, eth, bz, ctc, HOAc          |
| 3209 | Dichloromethylborane                            | Methyldichloroborane           | CH <sub>3</sub> BCl <sub>2</sub>                                              | 7318-78-7  | 96.752   | col gas                    |        | 11                     |                            |                       |                                                         |
| 3210 | 2,3-Dichloro-2-methylbutane                     | Amylene dichloride             | C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>                                | 507-45-9   | 141.038  |                            |        | 129                    | 1.0696 <sup>15</sup>       | 1.4450 <sup>18</sup>  | i H <sub>2</sub> O; vs eth, EtOH                        |
| 3211 | 1,1-Dichloromethyl methyl ether                 | Methoxydichloromethane         | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> O                               | 4885-02-3  | 114.958  |                            |        | 85                     | 1.271 <sup>25</sup>        | 1.4300 <sup>20</sup>  |                                                         |
| 3212 | 2,4-Dichloro-3-methylphenol                     |                                | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                               | 17788-00-0 | 177.028  | pr (peth)                  | 58     | 236; 77 <sup>4</sup>   |                            |                       | vs eth, chl                                             |
| 3213 | 2,4-Dichloro-6-methylphenol                     |                                | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                               | 1570-65-6  | 177.028  | nd (w, peth)               | 55     |                        |                            |                       | sl H <sub>2</sub> O; vs EtOH, eth, chl, CS <sub>2</sub> |
| 3214 | 2,6-Dichloro-4-methylphenol                     |                                | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                               | 2432-12-4  | 177.028  | nd (lig)                   | 39     | 231; 138 <sup>28</sup> |                            |                       | i H <sub>2</sub> O; vs eth, EtOH, HOAc                  |
| 3215 | Dichloromethylphenylsilane                      |                                | C <sub>7</sub> H <sub>7</sub> Cl <sub>2</sub> Si                              | 149-74-6   | 191.131  |                            |        | 206.5                  | 1.1866 <sup>20</sup>       | 1.5180 <sup>20</sup>  |                                                         |
| 3216 | Dichloromethylphosphine                         | Methylphosphonous dichloride   | CH <sub>3</sub> Cl <sub>2</sub> P                                             | 676-83-5   | 116.915  |                            |        | 12 <sup>20</sup>       | 1.304 <sup>20</sup>        | 1.4940 <sup>20</sup>  |                                                         |
| 3217 | 1,2-Dichloro-2-methylpropane                    | 1,2-Dichloroisobutane          | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                                 | 594-37-6   | 127.013  |                            |        | 106.5                  | 1.093 <sup>20</sup>        | 1.4370 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, ctc         |
| 3218 | 2,4-Dichloro-5-methylpyrimidine                 |                                | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> N <sub>2</sub>                  | 1780-31-0  | 163.004  | pl (al)                    | 26     | 235                    |                            |                       | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl              |
| 3219 | 2,4-Dichloro-6-methylpyrimidine                 |                                | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> N <sub>2</sub>                  | 5424-21-5  | 163.004  | nd (lig)                   | 46.5   | 219                    |                            |                       | vs bz, eth, EtOH, chl                                   |
| 3220 | Dichloromethylsilane                            |                                | CH <sub>3</sub> Cl <sub>2</sub> Si                                            | 75-54-7    | 115.035  | liq                        | -93    | 41                     | 1.105 <sup>25</sup>        |                       |                                                         |
| 3221 | 1,2-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 2050-69-3  | 197.061  | pl (al)                    | 36     | 296.5                  | 1.3147 <sup>49</sup>       | 1.5338 <sup>49</sup>  | s EtOH, eth                                             |
| 3222 | 1,3-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 2198-75-6  | 197.061  | nd or pr (al)              | 62.3   | 291                    |                            |                       | s EtOH                                                  |
| 3223 | 1,4-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 1825-31-6  | 197.061  | nd or pr (al, ace)         | 67.5   | 288; 147 <sup>12</sup> | 1.2997 <sup>76</sup>       | 1.6228 <sup>76</sup>  | i H <sub>2</sub> O; sl EtOH; s eth, bz, HOAc; vs ace    |
| 3224 | 1,5-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 1825-30-5  | 197.061  | nd or lf (al) pr (sub)     | 107    | sub                    | 1.4900 <sup>20</sup>       |                       | i H <sub>2</sub> O; sl EtOH; s eth                      |
| 3225 | 1,6-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 2050-72-8  | 197.061  | nd or pr (al, peth)        | 49     | sub                    |                            |                       |                                                         |
| 3226 | 1,7-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 2050-73-9  | 197.061  | nd or pr (al, HOAc)        | 63.5   | 285.5                  | 1.2611 <sup>100</sup>      | 1.6092 <sup>100</sup> | s EtOH, eth, bz, HOAc                                   |
| 3227 | 1,8-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 2050-74-0  | 197.061  | orth pl (hx) nd (al, sub)  | 89     | sub                    | 1.2924 <sup>100</sup>      | 1.6236 <sup>100</sup> | s EtOH, peth                                            |
| 3228 | 2,3-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 2050-75-1  | 197.061  | orth lf (al)               | 120    |                        |                            |                       | i H <sub>2</sub> O; sl EtOH; vs eth                     |
| 3229 | 2,6-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 2065-70-5  | 197.061  | nd or lf (al) pl (eth, bz) | 140.5  | 285                    |                            |                       | sl EtOH; s eth, bz, chl, HOAc                           |
| 3230 | 2,7-Dichloronaphthalene                         |                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub>                                | 2198-77-8  | 197.061  | pl or lf (al)              | 115.0  |                        |                            |                       | vs EtOH; s hx, HOAc                                     |
| 3231 | 2,3-Dichloro-1,4-naphthalenedione               | Dichlone                       | C <sub>10</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                 | 117-80-6   | 227.044  | ye nd (al)                 | 195    |                        |                            |                       | i H <sub>2</sub> O; sl EtOH, eth, bz; s chl             |



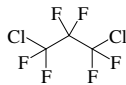
1,2-Dichloro-1,2,3,3,4,4-hexafluorocyclobutane



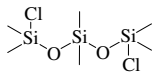
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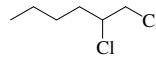
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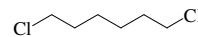
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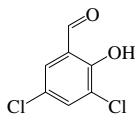
1,5-Dichloro-1,1,3,3,5,5-hexamethyltrisiloxane



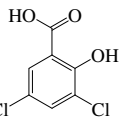
1,2-Dichlorohexane



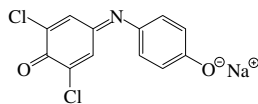
1,6-Dichlorohexane



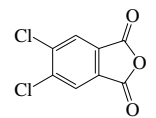
3,5-Dichloro-2-hydroxybenzaldehyde



3,5-Dichloro-2-hydroxybenzoic acid



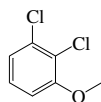
2,6-Dichloroindophenol, sodium salt



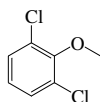
5,6-Dichloro-1,3-isobenzofurandione



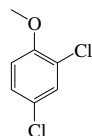
Dichloromethane



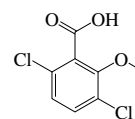
1,2-Dichloro-3-methoxybenzene



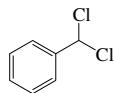
1,3-Dichloro-2-methoxybenzene



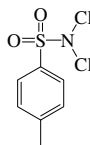
2,4-Dichloro-1-methoxybenzene



3,6-Dichloro-2-methoxybenzoic acid



(Dichloromethyl)benzene



N,N-Dichloro-4-methylbenzenesulfonamide



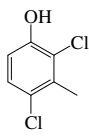
Dichloromethylborane



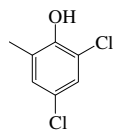
2,3-Dichloro-2-methylbutane



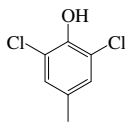
1,1-Dichloromethyl methyl ether



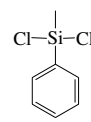
2,4-Dichloro-3-methylphenol



2,4-Dichloro-6-methylphenol



2,6-Dichloro-4-methylphenol



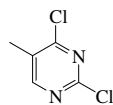
Dichloromethylphenylsilane



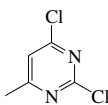
Dichloromethylphosphine



1,2-Dichloro-2-methylpropane



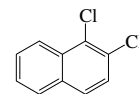
2,4-Dichloro-5-methylpyrimidine



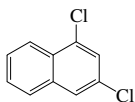
2,4-Dichloro-6-methylpyrimidine



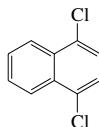
Dichloromethylsilane



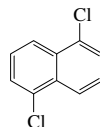
1,2-Dichloronaphthalene



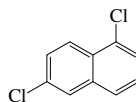
1,3-Dichloronaphthalene



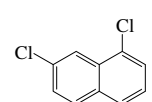
1,4-Dichloronaphthalene



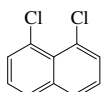
1,5-Dichloronaphthalene



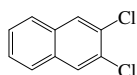
1,6-Dichloronaphthalene



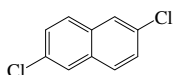
1,7-Dichloronaphthalene



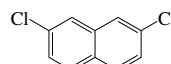
1,8-Dichloronaphthalene



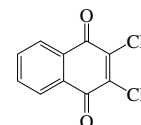
2,3-Dichloronaphthalene



2,6-Dichloronaphthalene

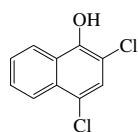


2,7-Dichloronaphthalene

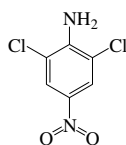


2,3-Dichloro-1,4-naphthalenedione

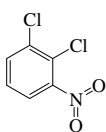
| No.  | Name                                                  | Synonym                          | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form            | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|-------------------------------------------------------|----------------------------------|-----------------------------------------------------------------------------|------------|----------|--------------------------|---------|------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 3232 | 2,4-Dichloro-1-naphthol                               | 2,4-Dichloro- $\alpha$ -naphthol | C <sub>10</sub> H <sub>6</sub> Cl <sub>2</sub> O                            | 2050-76-2  | 213.060  | nd (al, bz)              | 107.5   | 180                    |                            |                      | vs bz, eth, EtOH                                              |
| 3233 | 2,6-Dichloro-4-nitroaniline                           |                                  | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 99-30-9    | 207.014  | ye nd (al, HOAc)         | 191     |                        |                            |                      | s EtOH, acid; sl DMSO                                         |
| 3234 | 1,2-Dichloro-3-nitrobenzene                           |                                  | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 3209-22-1  | 192.000  | mcl nd (peth, HOAc)      | 61.5    | 257.5                  | 1.721 <sup>14</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, peth; sl chl        |
| 3235 | 1,2-Dichloro-4-nitrobenzene                           |                                  | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 99-54-7    | 192.000  | nd (al)                  | 43      | 255.5                  | 1.4558 <sup>75</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth; sl ctc                       |
| 3236 | 1,3-Dichloro-5-nitrobenzene                           |                                  | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 618-62-2   | 192.000  | mcl pr or lf (HOAc, al)  | 65.4    |                        | 1.4000 <sup>100</sup>      |                      | i H <sub>2</sub> O; s EtOH, eth                               |
| 3237 | 1,4-Dichloro-2-nitrobenzene                           |                                  | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 89-61-2    | 192.000  | pl or pr (al) pl (AcOEt) | 56      | 267                    | 1.439 <sup>75</sup>        | 1.4390 <sup>75</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, CS <sub>2</sub> ; sl ctc |
| 3238 | 2,4-Dichloro-1-nitrobenzene                           |                                  | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 611-06-3   | 192.000  | nd (al)                  | 34      | 258.5                  | 1.4790 <sup>80</sup>       | 1.5512 <sup>70</sup> | i H <sub>2</sub> O; s EtOH, eth; sl chl                       |
| 3239 | 1,1-Dichloro-1-nitroethane                            | Ethide                           | C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 594-72-9   | 143.957  |                          |         | 123.5                  |                            |                      | s ctc                                                         |
| 3240 | 2,6-Dichloro-4-nitrophenol                            |                                  | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>3</sub>               | 618-80-4   | 207.999  | br nd (w)                | 127 exp |                        | 1.822 <sup>25</sup>        |                      | vs eth, chl                                                   |
| 3241 | 1,1-Dichloro-1-nitropropane                           |                                  | C <sub>3</sub> H <sub>5</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 595-44-8   | 157.984  |                          |         | 145                    | 1.312 <sup>20</sup>        |                      | s ctc                                                         |
| 3242 | 1,9-Dichlorononane                                    |                                  | C <sub>9</sub> H <sub>19</sub> Cl <sub>2</sub>                              | 821-99-8   | 197.145  |                          |         | 260; 138 <sup>17</sup> | 1.0173 <sup>25</sup>       | 1.4586 <sup>25</sup> |                                                               |
| 3243 | 1,8-Dichlorooctane                                    |                                  | C <sub>8</sub> H <sub>16</sub> Cl <sub>2</sub>                              | 2162-99-4  | 183.119  |                          |         | 241                    | 1.0248 <sup>25</sup>       | 1.4572 <sup>25</sup> |                                                               |
| 3244 | 1,3-Dichloro-1,1,2,2,3-pentafluoropropane             |                                  | C <sub>3</sub> HCl <sub>2</sub> F <sub>5</sub>                              | 507-55-1   | 202.938  | liq                      |         | 52                     | 1.55 <sup>25</sup>         |                      |                                                               |
| 3245 | 3,3-Dichloro-1,1,1,2,2-pentafluoropropane             | Refrigerant 225ca                | C <sub>3</sub> HCl <sub>2</sub> F <sub>5</sub>                              | 422-56-0   | 202.938  | liq                      |         | 45.5                   | 1.54 <sup>25</sup>         |                      |                                                               |
| 3246 | 1,2-Dichloropentane                                   |                                  | C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 1674-33-5  | 141.038  |                          |         | 148.3                  | 1.0872 <sup>20</sup>       | 1.4485 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; vs chl                            |
| 3247 | 1,5-Dichloropentane                                   |                                  | C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 628-76-2   | 141.038  | liq                      | -72.8   | 179                    | 1.0956 <sup>25</sup>       | 1.4545 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc                      |
| 3248 | 2,3-Dichloropentane                                   |                                  | C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 600-11-3   | 141.038  | liq                      | -77.3   | 139                    | 1.0789 <sup>20</sup>       | 1.4464 <sup>20</sup> | i H <sub>2</sub> O                                            |
| 3249 | Dichlorophene                                         |                                  | C <sub>13</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>2</sub>              | 97-23-4    | 269.123  | cry (bz, peth)           | 177.5   |                        |                            |                      | i H <sub>2</sub> O; s EtOH, ace                               |
| 3250 | 2,3-Dichlorophenol                                    |                                  | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 576-24-9   | 163.001  | cry (lig, bz)            | 58      |                        |                            |                      | s EtOH, eth, bz, lig                                          |
| 3251 | 2,4-Dichlorophenol                                    |                                  | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 120-83-2   | 163.001  | hex nd (bz)              | 45      | 210                    |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                     |
| 3252 | 2,5-Dichlorophenol                                    |                                  | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 583-78-8   | 163.001  | pr (bz, peth)            | 59      | 211                    |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz, peth                 |
| 3253 | 2,6-Dichlorophenol                                    |                                  | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 87-65-0    | 163.001  | nd (peth)                | 68.5    | 220; 82 <sup>4</sup>   | 1.653 <sup>20</sup>        |                      | vs EtOH, eth; s bz, peth                                      |
| 3254 | 3,4-Dichlorophenol                                    |                                  | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 95-77-2    | 163.001  | nd (bz-peth)             | 68      | 253                    |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz, peth                 |
| 3255 | 3,5-Dichlorophenol                                    |                                  | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 591-35-5   | 163.001  | pr (peth)                | 68      | 233                    |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s peth                     |
| 3256 | (2,4-Dichlorophenoxy)acetic acid                      | 2,4-D                            | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>3</sub>                | 94-75-7    | 221.038  | cry (bz)                 | 140.5   | 160 <sup>9,4</sup>     |                            |                      | i H <sub>2</sub> O; s EtOH; sl bz, DMSO                       |
| 3257 | 4-(2,4-Dichlorophenoxy)butanoic acid                  | Butyrac 118                      | C <sub>10</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>3</sub>              | 94-82-6    | 249.090  |                          | 118     |                        |                            |                      |                                                               |
| 3258 | 2-(2,4-Dichlorophenoxy)propanoic acid                 | Dichlorprop                      | C <sub>9</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>3</sub>                | 120-36-5   | 235.064  |                          | 117.5   |                        |                            |                      | sl H <sub>2</sub> O, lig; s EtOH, eth                         |
| 3259 | Dichlorophenylarsine                                  |                                  | C <sub>6</sub> H <sub>5</sub> AsCl <sub>2</sub>                             | 696-28-6   | 222.932  | liq                      | -19     | 255                    | 1.6516 <sup>20</sup>       | 1.6386 <sup>15</sup> | vs bz, eth, EtOH                                              |
| 3260 | 2,4-Dichlorophenyl benzenesulfonate                   | Genite                           | C <sub>12</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>3</sub> S             | 97-16-5    | 303.161  |                          | 45.5    |                        |                            |                      | s ctc, CS <sub>2</sub>                                        |
| 3261 | 2,2-Dichloro-1-phenylethanone                         |                                  | C <sub>8</sub> H <sub>8</sub> Cl <sub>2</sub> O                             | 2648-61-5  | 189.039  | amor                     | 20.5    | 249                    | 1.340 <sup>16</sup>        | 1.5686 <sup>20</sup> | s EtOH, bz, ctc                                               |
| 3262 | 1-(2,4-Dichlorophenyl)ethanone                        |                                  | C <sub>8</sub> H <sub>8</sub> Cl <sub>2</sub> O                             | 2234-16-4  | 189.039  |                          | 33.5    |                        |                            | 1.5640 <sup>20</sup> | i H <sub>2</sub> O                                            |
| 3263 | 1-(2,5-Dichlorophenyl)ethanone                        |                                  | C <sub>8</sub> H <sub>8</sub> Cl <sub>2</sub> O                             | 2476-37-1  | 189.039  |                          | 12      | 118 <sup>12</sup>      | 1.321 <sup>30</sup>        | 1.5595 <sup>30</sup> |                                                               |
| 3264 | 1-(3,4-Dichlorophenyl)ethanone                        |                                  | C <sub>8</sub> H <sub>8</sub> Cl <sub>2</sub> O                             | 2642-63-9  | 189.039  | nd (peth)                | 76      | 135 <sup>12</sup>      |                            |                      | i H <sub>2</sub> O; s ctc, lig                                |
| 3265 | 3,4-Dichlorophenyl isocyanate                         | 1,2-Dichloro-5-isocyanatobenzene | C <sub>7</sub> H <sub>3</sub> Cl <sub>2</sub> NO                            | 102-36-3   | 188.011  | cry                      | 42      | 112 <sup>12</sup>      |                            |                      |                                                               |
| 3266 | 3,5-Dichlorophenyl isocyanate                         | 1,3-Dichloro-5-isocyanatobenzene | C <sub>7</sub> H <sub>3</sub> Cl <sub>2</sub> NO                            | 34893-92-0 | 188.011  |                          | 33      |                        | 1.380                      |                      |                                                               |
| 3267 | <i>N</i> -(3,4-Dichlorophenyl)-2-methyl-2-propenamide | Dicryl                           | C <sub>10</sub> H <sub>9</sub> Cl <sub>2</sub> NO                           | 2164-09-2  | 230.090  | cry (al-peth)            | 128     |                        |                            |                      | vs ace, EtOH                                                  |
| 3268 | 3-(2,4-Dichlorophenyl)-2-propenoic acid               |                                  | C <sub>9</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>                | 1201-99-6  | 217.049  |                          | 234     |                        |                            |                      | s DMSO                                                        |
| 3269 | Dichlorophenylsilane                                  | Phenyldichlorosilane             | C <sub>6</sub> H <sub>5</sub> Cl <sub>2</sub> Si                            | 1631-84-1  | 177.104  |                          |         | 181                    | 1.221 <sup>25</sup>        |                      | dec H <sub>2</sub> O                                          |
| 3270 | 1,1-Dichloropropane                                   | Propylidene chloride             | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 78-99-9    | 112.986  |                          |         | 88.1                   | 1.1321 <sup>20</sup>       | 1.4289 <sup>20</sup> | s EtOH, eth, bz, chl                                          |
| 3271 | 1,2-Dichloropropane, ( $\pm$ )                        | Propylene dichloride             | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 26198-63-0 | 112.986  | liq                      | -100.53 | 96.4                   | 1.1560 <sup>20</sup>       | 1.4394 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                     |
| 3272 | 1,3-Dichloropropane                                   |                                  | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 142-28-9   | 112.986  | liq                      | -99.5   | 120.9                  | 1.1785 <sup>25</sup>       | 1.4455 <sup>25</sup> | sl H <sub>2</sub> O; vs EtOH, eth; s bz, chl                  |
| 3273 | 2,2-Dichloropropane                                   |                                  | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 594-20-7   | 112.986  | liq                      | -33.9   | 69.3                   | 1.1136 <sup>20</sup>       | 1.4148 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, chl; msc eth                  |



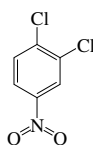
2,4-Dichloro-1-naphthol



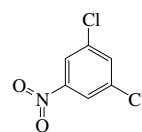
2,6-Dichloro-4-nitroaniline



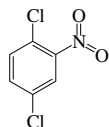
1,2-Dichloro-3-nitrobenzene



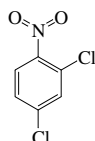
1,2-Dichloro-4-nitrobenzene



1,3-Dichloro-5-nitrobenzene



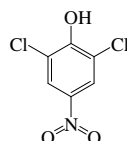
1,4-Dichloro-2-nitrobenzene



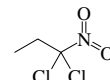
2,4-Dichloro-1-nitrobenzene



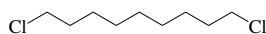
1,1-Dichloro-1-nitroethane



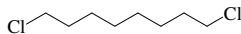
2,6-Dichloro-4-nitrophenol



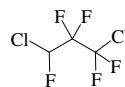
1,1-Dichloro-1-nitropropane



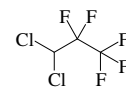
1,9-Dichlorononane



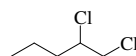
1,8-Dichlorooctane



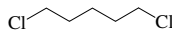
1,3-Dichloro-1,1,2,2,3-pentafluoropropane



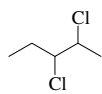
3,3-Dichloro-1,1,1,2,2-pentafluoropropane



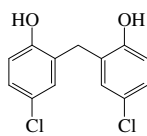
1,2-Dichloropentane



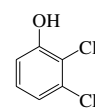
1,5-Dichloropentane



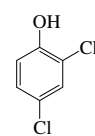
2,3-Dichloropentane



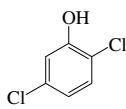
Dichlorophene



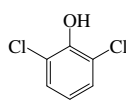
2,3-Dichlorophenol



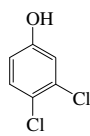
2,4-Dichlorophenol



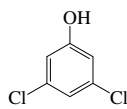
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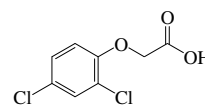
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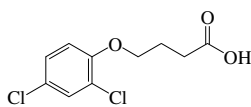
3,4-Dichlorophenol



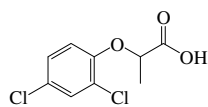
3,5-Dichlorophenol



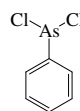
(2,4-Dichlorophenoxy)acetic acid



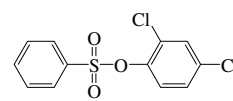
4-(2,4-Dichlorophenoxy)butanoic acid



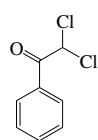
2-(2,4-Dichlorophenoxy)propanoic acid



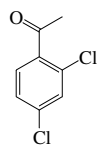
Dichlorophenylarsine



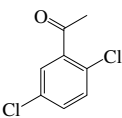
2,4-Dichlorophenyl benzenesulfonate



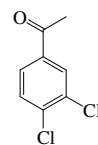
2,2-Dichloro-1-phenylethanone



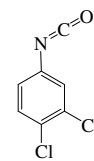
1-(2,4-Dichlorophenyl)ethanone



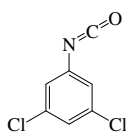
1-(2,5-Dichlorophenyl)ethanone



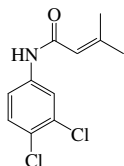
1-(3,4-Dichlorophenyl)ethanone



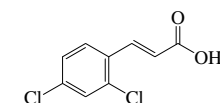
3,4-Dichlorophenyl isocyanate



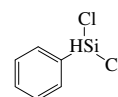
3,5-Dichlorophenyl isocyanate



N-(3,4-Dichlorophenyl)-2-methyl-2-propenamide



3-(2,4-Dichlorophenyl)-2-propenoic acid



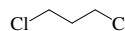
Dichlorophenylsilane



1,1-Dichloropropane



1,2-Dichloropropane, (±)

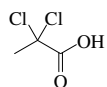


1,3-Dichloropropane

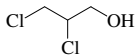


2,2-Dichloropropane

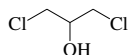
| No.  | Name                                                                           | Synonym                                             | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form           | mp/°C  | bp/°C                               | den/<br>g cm <sup>-3</sup>    | n <sub>D</sub>       | Solubility                                           |
|------|--------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------------------|------------|----------|-------------------------|--------|-------------------------------------|-------------------------------|----------------------|------------------------------------------------------|
| 3274 | 2,2-Dichloropropanoic acid                                                     | 2,2-Dichloropropionic acid                          | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                | 75-99-0    | 142.969  |                         |        | 187.5; 92 <sup>14</sup>             | 1.389 <sup>12</sup>           |                      | vs H <sub>2</sub> O, alk, EtOH; s eth, ctc           |
| 3275 | 2,3-Dichloro-1-propanol                                                        |                                                     | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub> O                             | 616-23-9   | 128.985  | visc                    |        | 184                                 | 1.3607 <sup>20</sup>          | 1.4819 <sup>20</sup> | sl H <sub>2</sub> O, lig; msc EtOH, eth, ace, bz     |
| 3276 | 1,3-Dichloro-2-propanol                                                        |                                                     | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub> O                             | 96-23-1    | 128.985  |                         |        | 176                                 | 1.3506 <sup>17</sup>          | 1.4837 <sup>20</sup> | vs H <sub>2</sub> O, EtOH; msc eth; s ace, chl       |
| 3277 | 2,3-Dichloro-1-propanol, phosphate (3:1)                                       |                                                     | C <sub>9</sub> H <sub>15</sub> Cl <sub>6</sub> O <sub>4</sub> P             | 78-43-3    | 430.904  |                         |        | 190 <sup>0.1</sup>                  | 1.517 <sup>22</sup>           |                      |                                                      |
| 3278 | 2,3-Dichloropropanoyl chloride                                                 |                                                     | C <sub>3</sub> H <sub>3</sub> Cl <sub>3</sub> O                             | 7623-13-4  | 161.414  |                         |        | 53 <sup>17</sup>                    | 1.4757 <sup>20</sup>          | 1.4764 <sup>20</sup> |                                                      |
| 3279 | 1,1-Dichloropropene                                                            |                                                     | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 563-58-6   | 110.970  |                         |        | 76.5                                | 1.1864 <sup>25</sup>          | 1.4430 <sup>25</sup> | i H <sub>2</sub> O; s eth, ace, chl                  |
| 3280 | cis-1,2-Dichloropropene                                                        |                                                     | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 6923-20-2  | 110.970  |                         |        | 93                                  |                               | 1.4549 <sup>20</sup> | i H <sub>2</sub> O; s ace, bz, chl                   |
| 3281 | trans-1,2-Dichloropropene                                                      |                                                     | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 7069-38-7  | 110.970  |                         |        | 77                                  | 1.1818 <sup>20</sup>          | 1.4471 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, ctc, MeOH               |
| 3282 | cis-1,3-Dichloropropene                                                        | cis-1,3-Dichloropropylene                           | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 10061-01-5 | 110.970  |                         |        | 104.3                               | 1.224 <sup>20</sup>           | 1.4682 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl                   |
| 3283 | trans-1,3-Dichloropropene                                                      | trans-1,3-Dichloropropylene                         | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 10061-02-6 | 110.970  |                         |        | 112                                 | 1.217 <sup>20</sup>           | 1.4730 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl                   |
| 3284 | 2,3-Dichloropropene                                                            |                                                     | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 78-88-6    | 110.970  |                         | 10     | 94                                  | 1.211 <sup>20</sup>           | 1.4603 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH; s eth, bz, chl         |
| 3285 | 3,6-Dichloropyridazine                                                         |                                                     | C <sub>4</sub> H <sub>2</sub> Cl <sub>2</sub> N <sub>2</sub>                | 141-30-0   | 148.978  |                         | 68.8   | 89 <sup>0.2</sup>                   |                               |                      | s chl                                                |
| 3286 | 2,6-Dichloropyridine                                                           |                                                     | C <sub>5</sub> H <sub>3</sub> Cl <sub>2</sub> N                             | 2402-78-0  | 147.990  |                         | 87     | 211                                 |                               |                      |                                                      |
| 3287 | 4,6-Dichloro-2-pyrimidinamine                                                  |                                                     | C <sub>4</sub> H <sub>3</sub> Cl <sub>2</sub> N <sub>3</sub>                | 56-05-3    | 163.993  |                         | 215    |                                     |                               |                      | s DMSO                                               |
| 3288 | 2,4-Dichloropyrimidine                                                         |                                                     | C <sub>4</sub> H <sub>2</sub> Cl <sub>2</sub> N <sub>2</sub>                | 3934-20-1  | 148.978  |                         | 59     | 198; 101 <sup>23</sup>              |                               |                      |                                                      |
| 3289 | 4,7-Dichloroquinoline                                                          |                                                     | C <sub>9</sub> H <sub>5</sub> Cl <sub>2</sub> N                             | 86-98-6    | 198.049  | cry (MeOH), nd (80% al) | 93     | 148 <sup>10</sup>                   |                               |                      | sl chl                                               |
| 3290 | 5,7-Dichloro-8-quinolinol                                                      | Chloroxine                                          | C <sub>9</sub> H <sub>5</sub> Cl <sub>2</sub> NO                            | 773-76-2   | 214.048  | cry (al)                | 179.5  |                                     |                               |                      | sl EtOH, ace, chl, DMSO; s alk, bz, peth             |
| 3291 | 2,3-Dichloroquinoxaline                                                        |                                                     | C <sub>8</sub> H <sub>4</sub> Cl <sub>2</sub> N <sub>2</sub>                | 2213-63-0  | 199.037  | cry (al, bz)            | 152    |                                     |                               |                      | i H <sub>2</sub> O; vs EtOH, bz, chl, HOAc           |
| 3292 | 2,5-Dichlorostyrene                                                            |                                                     | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 1123-84-8  | 173.040  |                         | 8.0    | 93 <sup>5</sup> , 74 <sup>3</sup>   | 1.246 <sup>20</sup>           | 1.5798 <sup>20</sup> |                                                      |
| 3293 | 1,2-Dichloro-3,4,5,6-tetrafluorobenzene                                        |                                                     | C <sub>6</sub> Cl <sub>2</sub> F <sub>4</sub>                               | 1198-59-0  | 218.964  |                         |        | 157.7                               |                               |                      |                                                      |
| 3294 | 1,1-Dichloro-1,2,2,2-tetrafluoroethane                                         | Refrigerant 114a                                    | C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>                               | 374-07-2   | 170.921  | col gas                 | -56.6  | 3.4                                 | 1.455 <sup>25</sup> (p>1 atm) | 1.3092 <sup>0</sup>  | vs bz, eth, EtOH                                     |
| 3295 | 1,2-Dichloro-1,1,2,2-tetrafluoroethane                                         | Refrigerant 114                                     | C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>                               | 76-14-2    | 170.921  | col gas                 | -92.53 | 3.5                                 | 1.455 <sup>25</sup> (p>1 atm) | 1.3092 <sup>0</sup>  | i H <sub>2</sub> O; vs eth, EtOH                     |
| 3296 | 1,2-Dichloro-1,1,2,2-tetramethyldisilane                                       |                                                     | C <sub>4</sub> H <sub>12</sub> Cl <sub>2</sub> Si <sub>2</sub>              | 4342-61-4  | 187.215  |                         |        | 148; 49 <sup>18</sup>               | 1.010 <sup>20</sup>           | 1.4548 <sup>20</sup> |                                                      |
| 3297 | 1,3-Dichloro-1,1,3,3-tetramethyldisiloxane                                     |                                                     | C <sub>4</sub> H <sub>12</sub> Cl <sub>2</sub> OSi <sub>2</sub>             | 2401-73-2  | 203.214  | liq                     | -37.5  | 138                                 | 1.038 <sup>20</sup>           |                      |                                                      |
| 3298 | 2,5-Dichlorothiophene                                                          |                                                     | C <sub>4</sub> H <sub>2</sub> Cl <sub>2</sub> S                             | 3172-52-9  | 153.030  | liq                     | -40.5  | 162                                 | 1.4422 <sup>20</sup>          | 1.5626 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc             |
| 3299 | 2,3-Dichlorotoluene                                                            |                                                     | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 32768-54-0 | 161.029  |                         | 6      | 207.5                               | 1.2458 <sup>20</sup>          | 1.5511 <sup>20</sup> | vs bz                                                |
| 3300 | 2,4-Dichlorotoluene                                                            |                                                     | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 95-73-8    | 161.029  | liq                     | -13.5  | 201                                 | 1.2476 <sup>20</sup>          | 1.5511 <sup>20</sup> | i H <sub>2</sub> O; s ctc                            |
| 3301 | 2,5-Dichlorotoluene                                                            |                                                     | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 19398-61-9 | 161.029  |                         | 2.5    | 200                                 | 1.2535 <sup>20</sup>          | 1.5449 <sup>20</sup> | i H <sub>2</sub> O; s bz                             |
| 3302 | 2,6-Dichlorotoluene                                                            |                                                     | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 118-69-4   | 161.029  |                         | 25.8   | 198                                 | 1.2686 <sup>20</sup>          | 1.5507 <sup>20</sup> | i H <sub>2</sub> O; s chl                            |
| 3303 | 3,4-Dichlorotoluene                                                            |                                                     | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 95-75-0    | 161.029  | liq                     | -15.2  | 208.9                               | 1.2564 <sup>20</sup>          | 1.5471 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc |
| 3304 | 1,3-Dichloro-1,3,5-triazine-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-trione | Dichlorocyanuric acid                               | C <sub>3</sub> HCl <sub>2</sub> N <sub>3</sub> O <sub>3</sub>               | 2782-57-2  | 197.964  | cry                     | 226.6  |                                     |                               |                      |                                                      |
| 3305 | 1,2-Dichloro-4-(trichloromethyl)benzene                                        |                                                     | C <sub>7</sub> H <sub>3</sub> Cl <sub>5</sub>                               | 13014-24-9 | 264.364  |                         | 25.8   | 283.1                               | 1.5913 <sup>20</sup>          | 1.5886 <sup>20</sup> |                                                      |
| 3306 | 1,2-Dichloro-1,1,2-trifluoroethane                                             | Refrigerant 123a                                    | C <sub>2</sub> HClF <sub>3</sub>                                            | 354-23-4   | 152.930  | vol liq or gas          | -78    | 29.5                                | 1.50 <sup>25</sup>            |                      |                                                      |
| 3307 | 2,2-Dichloro-1,1,1-trifluoroethane                                             |                                                     | C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>                              | 306-83-2   | 152.930  | vol liq or gas          | -107   | 27.82                               | 1.4638 <sup>25</sup>          |                      | sl H <sub>2</sub> O                                  |
| 3308 | 2,2-Dichloro-1,1,2-trifluoroethane                                             | Refrigerant 123b                                    | C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>                              | 812-04-4   | 152.930  |                         |        | 30.2                                |                               |                      |                                                      |
| 3309 | 2,4-Dichloro-1-(trifluoromethyl)benzene                                        | 2,4-Dichlorobenzotrifluoride                        | C <sub>7</sub> H <sub>3</sub> Cl <sub>2</sub> F <sub>3</sub>                | 320-60-5   | 215.000  |                         |        |                                     |                               | 1.4802 <sup>20</sup> |                                                      |
| 3310 | 4,5-Dichloro-2-(trifluoromethyl)-1 <i>H</i> -benzimidazole                     | Chloroflurazole                                     | C <sub>8</sub> H <sub>3</sub> Cl <sub>2</sub> F <sub>3</sub> N <sub>2</sub> | 3615-21-2  | 255.024  |                         | 213.5  |                                     |                               |                      |                                                      |
| 3311 | Dichlorovinylmethylsilane                                                      |                                                     | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub> Si                            | 124-70-9   | 141.072  |                         |        | 92.5                                | 1.0868 <sup>20</sup>          | 1.4270 <sup>20</sup> | dec H <sub>2</sub> O                                 |
| 3312 | Dichlorvos                                                                     | Phosphoric acid, 2,2-dichloroethenyl dimethyl ester | C <sub>4</sub> H <sub>7</sub> Cl <sub>2</sub> O <sub>4</sub> P              | 62-73-7    | 220.976  |                         |        | 140 <sup>20</sup> , 84 <sup>1</sup> | 1.415 <sup>25</sup>           |                      |                                                      |



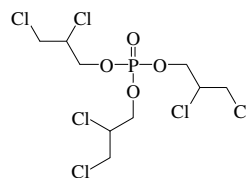
2,2-Dichloropropanoic acid



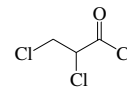
2,3-Dichloro-1-propanol



1,3-Dichloro-2-propanol



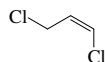
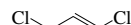
2,3-Dichloro-1-propanol, phosphate (3:1)



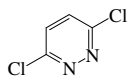
2,3-Dichloropropanoyl chloride



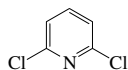
1,1-Dichloropropene

*cis*-1,2-Dichloropropene*trans*-1,2-Dichloropropene*cis*-1,3-Dichloropropene*trans*-1,3-Dichloropropene

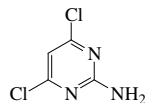
2,3-Dichloropropene



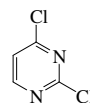
3,6-Dichloropyridazine



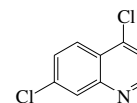
2,6-Dichloropyridine



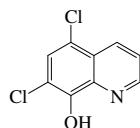
4,6-Dichloro-2-pyrimidinamine



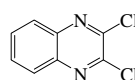
2,4-Dichloropyrimidine



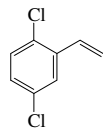
4,7-Dichloroquinoline



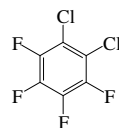
5,7-Dichloro-8-quinolinol



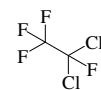
2,3-Dichloroquinoxaline



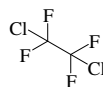
2,5-Dichlorostyrene



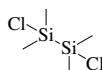
1,2-Dichloro-3,4,5,6-tetrafluorobenzene



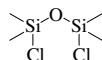
1,1-Dichloro-1,2,2,2-tetrafluoroethane



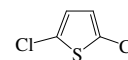
1,2-Dichloro-1,1,2,2-tetrafluoroethane



1,2-Dichloro-1,1,2,2-tetramethyldisilane



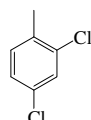
1,3-Dichloro-1,1,3,3-tetramethyldisiloxane



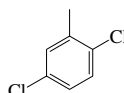
2,5-Dichlorothiophene



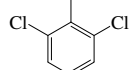
2,3-Dichlorotoluene



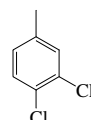
2,4-Dichlorotoluene



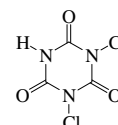
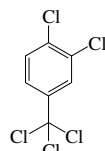
2,5-Dichlorotoluene



2,6-Dichlorotoluene



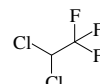
3,4-Dichlorotoluene

1,3-Dichloro-1,3,5-triazine-2,4,6-(1*H*,3*H*,5*H*)-trione

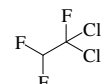
1,2-Dichloro-4-(trichloromethyl)benzene



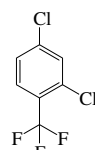
1,2-Dichloro-1,1,2-trifluoroethane



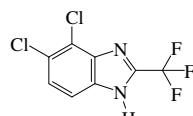
2,2-Dichloro-1,1,1-trifluoroethane



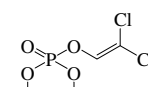
2,2-Dichloro-1,1,2-trifluoroethane



2,4-Dichloro-1-(trifluoromethyl)benzene

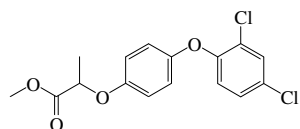
4,5-Dichloro-2-(trifluoromethyl)-1*H*-benzimidazole

Dichlorovinylmethylsilane

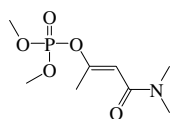


Dichlorvos

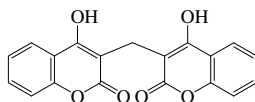
| No.  | Name                                                 | Synonym                                             | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form          | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------|------------|----------|------------------------|---------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 3313 | Diclofop-methyl                                      | Methyl 2-[4-(2,4-dichlorophenoxy)phenoxy]propanoate | C <sub>16</sub> H <sub>14</sub> Cl <sub>2</sub> O <sub>4</sub> | 51338-27-3 | 341.186  |                        | 40      | 176 <sup>0.1</sup>                   |                            |                      |                                                      |
| 3314 | Dicrotophos                                          |                                                     | C <sub>8</sub> H <sub>16</sub> NO <sub>5</sub> P               | 141-66-2   | 237.191  |                        |         | 400; 130 <sup>0.1</sup>              | 1.216 <sup>15</sup>        |                      |                                                      |
| 3315 | Dicumarol                                            |                                                     | C <sub>19</sub> H <sub>12</sub> O <sub>6</sub>                 | 66-76-2    | 336.294  | nd                     | 290     |                                      |                            |                      |                                                      |
| 3316 | Dicyanamide                                          | Cyanocyanamide                                      | C <sub>2</sub> H <sub>2</sub> N <sub>3</sub>                   | 504-66-5   | 67.049   | aq soln only           |         |                                      |                            |                      |                                                      |
| 3317 | <i>o</i> -Dicyanobenzene                             | <i>o</i> -Phthalodinitrile                          | C <sub>8</sub> H <sub>4</sub> N <sub>2</sub>                   | 91-15-6    | 128.131  | nd (w, lig)            | 141     | 150 <sup>10</sup>                    | 1.1250 <sup>25</sup>       |                      | sl H <sub>2</sub> O, lig; vs EtOH, bz; s eth, ace    |
| 3318 | <i>m</i> -Dicyanobenzene                             | <i>m</i> -Phthalodinitrile                          | C <sub>8</sub> H <sub>4</sub> N <sub>2</sub>                   | 626-17-5   | 128.131  | nd(al)                 | 162     | sub                                  | 0.992 <sup>40</sup>        |                      | sl H <sub>2</sub> O; vs EtOH; s eth, bz, chl; i peth |
| 3319 | <i>p</i> -Dicyanobenzene                             | <i>p</i> -Phthalodinitrile                          | C <sub>8</sub> H <sub>4</sub> N <sub>2</sub>                   | 623-26-7   | 128.131  | nd (w, MeOH)           | 224     | sub                                  |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s bz; vs HOAc      |
| 3320 | Dicyclohexyl adipate                                 |                                                     | C <sub>18</sub> H <sub>30</sub> O <sub>4</sub>                 | 849-99-0   | 310.429  |                        | 35      |                                      |                            |                      | s chl                                                |
| 3321 | Dicyclohexylamine                                    | <i>N</i> -Cyclohexylcyclohexanamine                 | C <sub>12</sub> H <sub>23</sub> N                              | 101-83-7   | 181.318  |                        | -0.1    | dec 256; 114 <sup>9</sup>            | 0.9123 <sup>20</sup>       | 1.4842 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, bz            |
| 3322 | Dicyclohexylamine nitrite                            | <i>N</i> -Cyclohexylcyclohexanamine, nitrite        | C <sub>12</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>  | 3129-91-7  | 228.331  | cry                    | 182 dec |                                      |                            |                      |                                                      |
| 3323 | Dicyclohexylcarbodiimide                             |                                                     | C <sub>13</sub> H <sub>22</sub> N <sub>2</sub>                 | 538-75-0   | 206.327  |                        | 34.5    | 123 <sup>6</sup> , 99 <sup>0.5</sup> |                            |                      |                                                      |
| 3324 | Dicyclohexyl disulfide                               |                                                     | C <sub>12</sub> H <sub>22</sub> S <sub>2</sub>                 | 2550-40-5  | 230.433  | liq                    |         | 195 <sup>20</sup>                    |                            |                      |                                                      |
| 3325 | Dicyclohexyl ether                                   |                                                     | C <sub>12</sub> H <sub>22</sub> O                              | 4645-15-2  | 182.302  | liq                    | -36     | 242.5                                | 0.9227 <sup>20</sup>       | 1.4741 <sup>20</sup> |                                                      |
| 3326 | Dicyclohexylmethanone                                |                                                     | C <sub>13</sub> H <sub>22</sub> O                              | 119-60-8   | 194.313  |                        | 57      | 159 <sup>20</sup>                    | 0.986 <sup>0</sup>         | 1.4860 <sup>20</sup> | s eth, ace, ctc                                      |
| 3327 | Dicyclohexylphosphine                                |                                                     | C <sub>12</sub> H <sub>23</sub> P                              | 829-84-5   | 198.285  |                        |         | 281; 129 <sup>8</sup>                | 0.904 <sup>25</sup>        | 1.5163 <sup>20</sup> |                                                      |
| 3328 | Dicyclohexyl phthalate                               |                                                     | C <sub>20</sub> H <sub>26</sub> O <sub>4</sub>                 | 84-61-7    | 330.418  | pr (al)                | 66      | 225 <sup>4</sup>                     | 1.383 <sup>20</sup>        | 1.431 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl chl              |
| 3329 | <i>N,N'</i> -Dicyclohexylthiourea                    |                                                     | C <sub>13</sub> H <sub>24</sub> N <sub>2</sub> S               | 1212-29-9  | 240.408  | cry (MeOH)             | 180     |                                      |                            |                      |                                                      |
| 3330 | 1,3-Dicyclohexylurea                                 |                                                     | C <sub>13</sub> H <sub>24</sub> N <sub>2</sub> O               | 2387-23-7  | 224.342  |                        | 233.8   |                                      |                            |                      |                                                      |
| 3331 | Dicyclomine hydrochloride                            | Dicycloverine hydrochloride                         | C <sub>19</sub> H <sub>36</sub> ClNO <sub>2</sub>              | 67-92-5    | 345.948  | cry                    | 165     |                                      |                            |                      |                                                      |
| 3332 | Dicyclopentadiene                                    |                                                     | C <sub>10</sub> H <sub>12</sub>                                | 1755-01-7  | 132.202  |                        | 32      | dec 170; 65 <sup>14</sup>            | 0.9302 <sup>35</sup>       | 1.5050 <sup>35</sup> | vs eth, EtOH                                         |
| 3333 | Dicyclopentyl ether                                  | Cyclopentyl ether                                   | C <sub>10</sub> H <sub>18</sub> O                              | 10137-73-2 | 154.249  | liq                    |         | 80 <sup>13</sup>                     |                            |                      |                                                      |
| 3334 | Dicyclopropyl ketone                                 |                                                     | C <sub>7</sub> H <sub>10</sub> O                               | 1121-37-5  | 110.153  |                        |         | 161                                  | 0.977 <sup>25</sup>        | 1.4670 <sup>20</sup> |                                                      |
| 3335 | Didecylamine                                         | <i>N</i> -Decyl-1-decanamine                        | C <sub>20</sub> H <sub>43</sub> N                              | 1120-49-6  | 297.562  |                        |         | 359.0                                |                            |                      |                                                      |
| 3336 | Didecyl ether                                        |                                                     | C <sub>20</sub> H <sub>42</sub> O                              | 2456-28-2  | 298.546  |                        | 16      | 196 <sup>15.5</sup>                  | 0.8187 <sup>20</sup>       |                      |                                                      |
| 3337 | Didecyl phthalate                                    |                                                     | C <sub>28</sub> H <sub>46</sub> O <sub>4</sub>                 | 84-77-5    | 446.663  |                        | 2.5     | 240 <sup>3</sup>                     | 0.9639 <sup>20</sup>       |                      |                                                      |
| 3338 | 3',4'-Didehydro-β,ψ-caroten-16'-oic acid             | Torularhodin                                        | C <sub>40</sub> H <sub>52</sub> O <sub>2</sub>                 | 514-92-1   | 564.840  | purp nd (MeOH-eth)     | 211     |                                      |                            |                      | vs py, chl, CS <sub>2</sub>                          |
| 3339 | 2',3'-Dideoxyinosine                                 | Didanosine                                          | C <sub>10</sub> H <sub>12</sub> N <sub>4</sub> O <sub>3</sub>  | 69655-05-6 | 236.227  | wh cry (EtOH aq)       | 162     |                                      |                            |                      |                                                      |
| 3340 | 2,6-Dideoxy-3- <i>O</i> -methyl- <i>ribo</i> -hexose | Cymarose                                            | C <sub>7</sub> H <sub>14</sub> O <sub>4</sub>                  | 579-04-4   | 162.184  | pr (eth-peth) nd (ace) | 101     |                                      |                            |                      | vs H <sub>2</sub> O, ace, EtOH                       |
| 3341 | Didodecanoyl peroxide                                | Lauroyl peroxide                                    | C <sub>24</sub> H <sub>46</sub> O <sub>4</sub>                 | 105-74-8   | 398.620  | wh pl                  | 49      |                                      |                            |                      | i H <sub>2</sub> O; s chl                            |
| 3342 | Didodecylamine                                       | <i>N</i> -Dodecyl-1-dodecanamine                    | C <sub>24</sub> H <sub>51</sub> N                              | 3007-31-6  | 353.669  |                        | 53.7    | 263 <sup>27</sup>                    |                            |                      | vs bz, eth, EtOH, chl                                |
| 3343 | Didodecyl phosphate                                  |                                                     | C <sub>24</sub> H <sub>51</sub> O <sub>4</sub> P               | 7057-92-3  | 434.633  | cry (MeOH)             | 59      |                                      |                            |                      |                                                      |
| 3344 | Didodecyl phthalate                                  | 1,2-Benzenedicarboxylic acid, didodecyl ester       | C <sub>32</sub> H <sub>54</sub> O <sub>4</sub>                 | 2432-90-8  | 502.769  |                        | 22.0    | 256 <sup>1</sup>                     | 0.9389 <sup>20</sup>       |                      |                                                      |
| 3345 | Dieldrin                                             |                                                     | C <sub>12</sub> H <sub>6</sub> Cl <sub>6</sub> O               | 60-57-1    | 380.909  |                        | 175.5   |                                      | 1.75 <sup>25</sup>         |                      | i H <sub>2</sub> O; sl EtOH; s ace, bz               |
| 3346 | Dienestrol                                           |                                                     | C <sub>18</sub> H <sub>18</sub> O <sub>2</sub>                 | 84-17-3    | 266.335  | cry (dil al)           | 227.5   | sub 130                              |                            |                      | vs ace, eth, EtOH                                    |
| 3347 | 1,2:8,9-Diepoxy- <i>p</i> -menthane                  | Limonene diepoxide                                  | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>                 | 96-08-2    | 168.233  |                        | 242     |                                      |                            |                      |                                                      |
| 3348 | Diethanolamine                                       | Bis(2-hydroxyethyl)amine                            | C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>                 | 111-42-2   | 105.136  |                        | 28      | 268.8                                | 1.0966 <sup>20</sup>       | 1.4776 <sup>20</sup> | vs H <sub>2</sub> O, EtOH; sl eth, bz                |
| 3349 | Diethylal, ethyl ester                               |                                                     | C <sub>16</sub> H <sub>22</sub> ClNO <sub>3</sub>              | 38727-55-8 | 311.804  | cry                    | 49.5    |                                      |                            |                      |                                                      |
| 3350 | 4,4'-Diethoxyazobenzene                              |                                                     | C <sub>16</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub>  | 588-52-3   | 270.326  | ye lf (al)             | 162     | dec                                  |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, chl; vs HOAc |
| 3351 | 3,4-Diethoxybenzaldehyde                             |                                                     | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>                 | 2029-94-9  | 194.227  |                        | 22      | 279; 200 <sup>50</sup>               | 1.0100 <sup>22</sup>       |                      | vs EtOH                                              |
| 3352 | 1,2-Diethoxybenzene                                  |                                                     | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                 | 2050-46-6  | 166.217  | pr (peth, dil al)      | 44      | 219                                  | 1.0075 <sup>20</sup>       | 1.5083 <sup>25</sup> | s EtOH, ctc; vs eth                                  |
| 3353 | 1,4-Diethoxybenzene                                  |                                                     | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                 | 122-95-2   | 166.217  | pl (dil al)            | 72      | 246                                  |                            |                      | vs EtOH; s eth, bz, ctc, chl                         |
| 3354 | 4,4-Diethoxy-1-butanamine                            |                                                     | C <sub>8</sub> H <sub>19</sub> NO <sub>2</sub>                 | 6346-09-4  | 161.243  |                        |         | 196                                  | 0.933 <sup>25</sup>        | 1.4275 <sup>20</sup> |                                                      |
| 3355 | 1,1-Diethoxy- <i>N,N</i> -dimethylmethanamine        |                                                     | C <sub>7</sub> H <sub>17</sub> NO <sub>2</sub>                 | 1188-33-6  | 147.216  |                        |         | 129                                  | 0.859 <sup>25</sup>        | 1.4007 <sup>20</sup> |                                                      |
| 3356 | Diethoxydimethylsilane                               | Dimethyldiethoxysilane                              | C <sub>6</sub> H <sub>16</sub> O <sub>2</sub> Si               | 78-62-6    | 148.276  | liq                    | -87     | 114                                  | 0.865 <sup>25</sup>        | 1.3811 <sup>20</sup> | s ctc                                                |
| 3357 | Diethoxydiphenylsilane                               |                                                     | C <sub>16</sub> H <sub>20</sub> O <sub>2</sub> Si              | 2553-19-7  | 272.415  |                        |         | 302; 167 <sup>15</sup>               | 1.0329 <sup>20</sup>       | 1.5269 <sup>20</sup> |                                                      |
| 3358 | 2,2-Diethoxyethanamine                               |                                                     | C <sub>6</sub> H <sub>15</sub> NO <sub>2</sub>                 | 645-36-3   | 133.189  | liq                    | -78     | 163                                  | 0.9159 <sup>25</sup>       | 1.4123 <sup>25</sup> | vs H <sub>2</sub> O, eth, EtOH, chl                  |



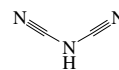
Diclofop-methyl



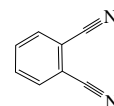
Dicrotophos



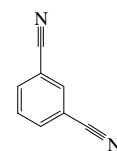
Dicumarol



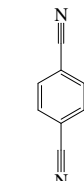
Dicyanamide



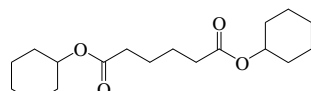
o-Dicyanobenzene



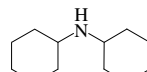
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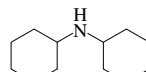
p-Dicyanobenzene



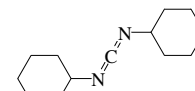
Dicyclohexyl adipate



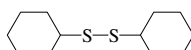
Dicyclohexylamine



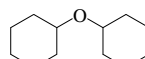
Dicyclohexylamine nitrite



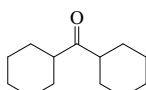
Dicyclohexylcarbodiimide



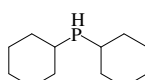
Dicyclohexyl disulfide



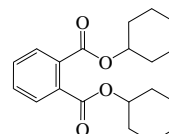
Dicyclohexyl ether



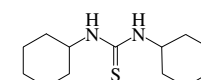
Dicyclohexylmethanone



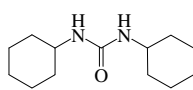
Dicyclohexylphosphine



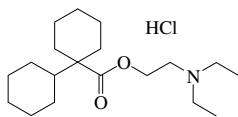
Dicyclohexyl phthalate



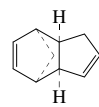
N,N'-Dicyclohexylthiourea



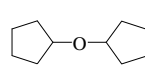
1,3-Dicyclohexylurea



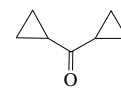
Diclomine hydrochloride



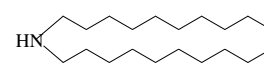
Dicyclopentadiene



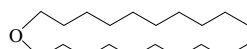
Dicyclopentyl ether



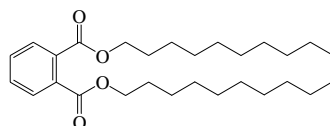
Dicyclopropyl ketone



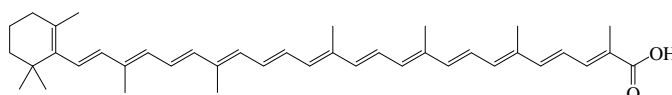
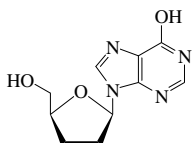
Didecylamine



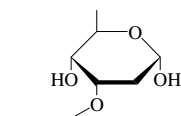
Didecyl ether



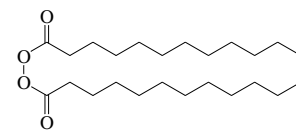
Didecyl phthalate

3',4'-Didehydro- $\beta,\psi$ -caroten-16'-oic acid

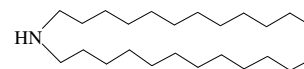
2',3'-Dideoxyinosine



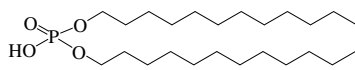
2,6-Dideoxy-3-O-methyl-ribo-hexose



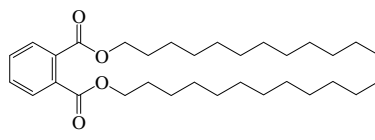
Didodecanoyl peroxide



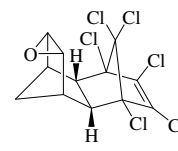
Didodecylamine



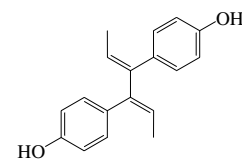
Didodecyl phosphate



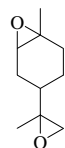
Didodecyl phthalate



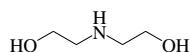
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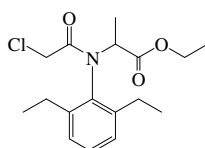
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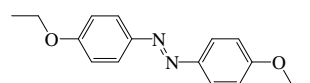
1,2,8,9-Diepoxy-p-menthane



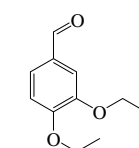
Diethanolamine



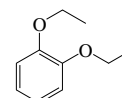
Diethyl, ethyl ester



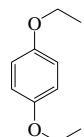
4,4'-Diethoxyazobenzene



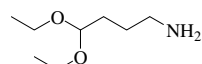
3,4-Diethoxybenzaldehyde



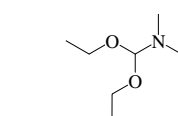
1,2-Diethoxybenzene



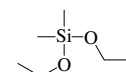
1,4-Diethoxybenzene



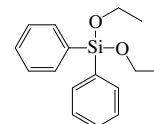
4,4-Diethoxy-1-butanamine



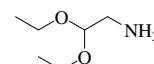
1,1-Diethoxy-N,N-dimethylmethanamine



Diethoxydimethylsilane



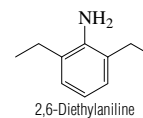
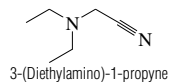
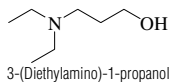
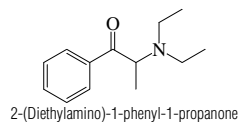
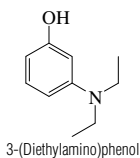
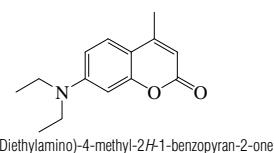
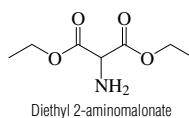
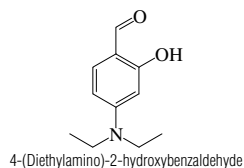
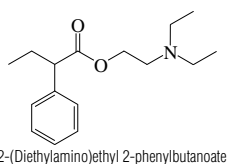
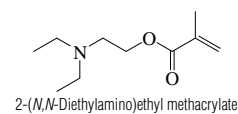
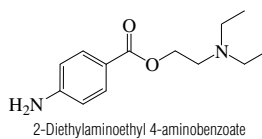
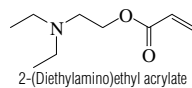
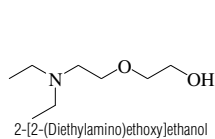
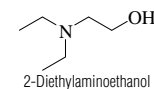
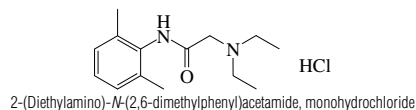
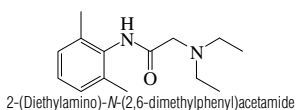
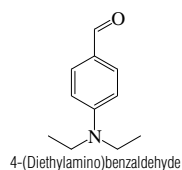
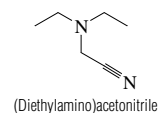
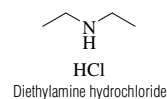
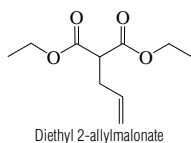
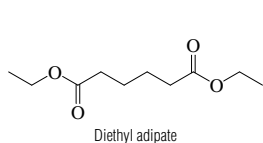
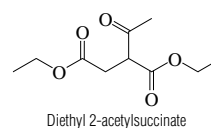
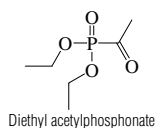
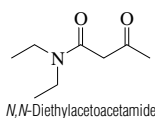
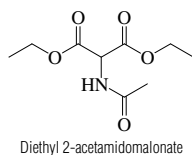
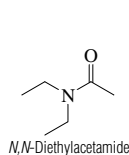
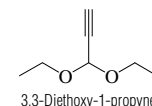
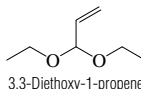
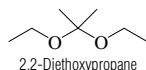
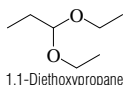
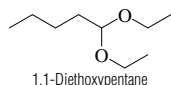
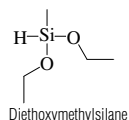
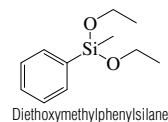
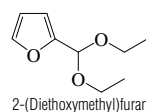
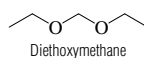
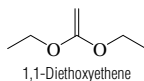
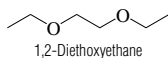
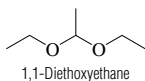
Diethoxydiphenylsilane



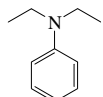
2,2-Diethoxyethanamine



| No.  | Name                                                                         | Synonym                                 | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                     | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|------------------------------------------------------------------------------|-----------------------------------------|---------------------------------------------------------------|------------|----------|-----------------------------------|-------|---------------------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 3359 | 1,1-Diethoxyethane                                                           | Acetal                                  | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | 105-57-7   | 118.174  | liq                               | -100  | 102.25                                | 0.8254 <sup>20</sup>       | 1.3834 <sup>20</sup> | s H <sub>2</sub> O, chl; msc EtOH, eth; vs ace           |
| 3360 | 1,2-Diethoxyethane                                                           | Ethylene glycol diethyl ether           | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | 629-14-1   | 118.174  | liq                               | -74.0 | 121.2                                 | 0.8351 <sup>25</sup>       | 1.3898 <sup>25</sup> | vs ace, bz, eth, EtOH                                    |
| 3361 | 1,1-Diethoxyethene                                                           |                                         | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 2678-54-8  | 116.158  |                                   |       | 68 <sup>100</sup>                     | 0.7932 <sup>20</sup>       | 1.3643 <sup>21</sup> |                                                          |
| 3362 | Diethoxymethane                                                              |                                         | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                 | 462-95-3   | 104.148  | liq                               | -66.5 | 88                                    | 0.8319 <sup>20</sup>       | 1.3748 <sup>18</sup> | s H <sub>2</sub> O; msc EtOH; vs ace, bz; sl chl         |
| 3363 | 2-(Diethoxymethyl)furan                                                      |                                         | C <sub>9</sub> H <sub>14</sub> O <sub>3</sub>                 | 13529-27-6 | 170.205  |                                   |       | 191.5                                 | 0.9976 <sup>20</sup>       | 1.4451 <sup>20</sup> | vs EtOH                                                  |
| 3364 | Diethoxymethylphenylsilane                                                   |                                         | C <sub>11</sub> H <sub>16</sub> O <sub>2</sub> Si             | 775-56-4   | 210.346  |                                   |       | 218                                   | 0.9627 <sup>20</sup>       | 1.4690 <sup>20</sup> |                                                          |
| 3365 | Diethoxymethylsilane                                                         |                                         | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> Si              | 2031-62-1  | 134.250  |                                   |       | 98                                    | 0.829 <sup>25</sup>        |                      |                                                          |
| 3366 | 1,1-Diethoxypentane                                                          |                                         | C <sub>9</sub> H <sub>20</sub> O <sub>2</sub>                 | 3658-79-5  | 160.254  |                                   |       | 59 <sup>12</sup>                      | 0.829 <sup>22</sup>        | 1.4029 <sup>22</sup> |                                                          |
| 3367 | 1,1-Diethoxypropane                                                          |                                         | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>                 | 4744-08-5  | 132.201  |                                   |       | 123                                   | 0.825 <sup>20</sup>        | 1.3924 <sup>19</sup> | s H <sub>2</sub> O, ace, bz; vs EtOH, eth                |
| 3368 | 2,2-Diethoxypropane                                                          |                                         | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>                 | 126-84-1   | 132.201  |                                   |       | 114                                   | 0.8200 <sup>21</sup>       | 1.3891 <sup>20</sup> | s EtOH, ace, bz; vs eth; sl ctc                          |
| 3369 | 3,3-Diethoxy-1-propene                                                       | Acrolein, diethyl acetal                | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | 3054-95-3  | 130.185  |                                   |       | 123.5                                 | 0.8543 <sup>15</sup>       | 1.4000 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                       |
| 3370 | 3,3-Diethoxy-1-propyne                                                       |                                         | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                 | 10160-87-9 | 128.169  |                                   |       | 139                                   | 0.8942 <sup>22</sup>       | 1.4140 <sup>20</sup> | vs ace, eth, EtOH, chl                                   |
| 3371 | <i>N,N</i> -Diethylacetamide                                                 |                                         | C <sub>8</sub> H <sub>13</sub> NO                             | 685-91-6   | 115.173  |                                   |       | 185.5                                 | 0.9130 <sup>17</sup>       | 1.4374 <sup>17</sup> | s H <sub>2</sub> O, EtOH; msc eth, ace, bz; sl ctc       |
| 3372 | Diethyl 2-acetamidomalate                                                    |                                         | C <sub>9</sub> H <sub>15</sub> NO <sub>5</sub>                | 1068-90-2  | 217.219  | cry (al,bz-peth)                  | 96.3  | 185 <sup>20</sup>                     |                            |                      | sl H <sub>2</sub> O, eth; s tfa, EtOH                    |
| 3373 | <i>N,N</i> -Diethylacetacetamide                                             |                                         | C <sub>8</sub> H <sub>15</sub> NO <sub>2</sub>                | 2235-46-3  | 157.211  | liq                               |       | 76 <sup>13</sup>                      |                            |                      |                                                          |
| 3374 | Diethyl acetylphosphonate                                                    |                                         | C <sub>8</sub> H <sub>13</sub> O <sub>4</sub> P               | 919-19-7   | 180.138  |                                   |       | 114 <sup>20</sup>                     | 1.1005 <sup>20</sup>       | 1.4200 <sup>26</sup> |                                                          |
| 3375 | Diethyl 2-acetylsuccinate                                                    |                                         | C <sub>10</sub> H <sub>16</sub> O <sub>5</sub>                | 1115-30-6  | 216.231  |                                   |       | 255; 133 <sup>17</sup>                | 1.081 <sup>20</sup>        | 1.4346 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz; sl chl              |
| 3376 | Diethyl adipate                                                              |                                         | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                | 141-28-6   | 202.248  | liq                               | -19.8 | 245                                   | 1.0076 <sup>20</sup>       | 1.4272 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                          |
| 3377 | Diethyl 2-allylmalonate                                                      |                                         | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>                | 2049-80-1  | 200.232  |                                   |       | 222.5; 93 <sup>6</sup>                | 1.0098 <sup>20</sup>       | 1.4305 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ctc                  |
| 3378 | Diethylamine                                                                 | <i>N</i> -Ethylethanamine               | C <sub>4</sub> H <sub>11</sub> N                              | 109-89-7   | 73.137   | liq                               | -49.8 | 55.5                                  | 0.7056 <sup>20</sup>       | 1.3864 <sup>20</sup> | vs H <sub>2</sub> O; msc EtOH; s eth, ctc                |
| 3379 | Diethylamine hydrochloride                                                   | <i>N</i> -Ethylethanamine hydrochloride | C <sub>4</sub> H <sub>12</sub> ClN                            | 660-68-4   | 109.598  | lf (al-eth)                       | 228.5 |                                       | 1.0477 <sup>22</sup>       |                      | vs H <sub>2</sub> O, EtOH                                |
| 3380 | (Diethylamino)acetonitrile                                                   |                                         | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                 | 3010-02-4  | 112.172  |                                   |       | 170                                   | 0.8660 <sup>20</sup>       | 1.4260 <sup>20</sup> | s H <sub>2</sub> O                                       |
| 3381 | 4-(Diethylamino)benzaldehyde                                                 |                                         | C <sub>11</sub> H <sub>15</sub> NO                            | 120-21-8   | 177.243  | ye nd (w)                         | 41    | 172 <sup>10</sup>                     |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, bz, ctc                |
| 3382 | 2-(Diethylamino)- <i>N</i> -(2,6-dimethylphenyl)acetamide                    | Lidocaine                               | C <sub>14</sub> H <sub>22</sub> N <sub>2</sub> O              | 137-58-6   | 234.337  | nd (bz, al)                       | 68.5  | 181 <sup>4</sup>                      |                            |                      | vs bz, eth, EtOH, chl                                    |
| 3383 | 2-(Diethylamino)- <i>N</i> -(2,6-dimethylphenyl)acetamide, monohydrochloride |                                         | C <sub>14</sub> H <sub>23</sub> ClN <sub>2</sub> O            | 73-78-9    | 270.798  |                                   | 128   |                                       |                            |                      | vs H <sub>2</sub> O                                      |
| 3384 | 2-Diethylaminoethanol                                                        |                                         | C <sub>8</sub> H <sub>15</sub> NO                             | 100-37-8   | 117.189  | hyg                               |       | 163                                   | 0.8921 <sup>20</sup>       | 1.4412 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth, ace, bz, peth; sl ctc |
| 3385 | 2-[2-(Diethylamino)ethoxy]ethanol                                            |                                         | C <sub>8</sub> H <sub>19</sub> NO <sub>2</sub>                | 140-82-9   | 161.243  |                                   |       | 221.5; 92 <sup>7</sup>                | 0.9421 <sup>25</sup>       | 1.4480 <sup>20</sup> |                                                          |
| 3386 | 2-(Diethylamino)ethyl acrylate                                               |                                         | C <sub>9</sub> H <sub>17</sub> NO <sub>2</sub>                | 2426-54-2  | 171.237  |                                   | <-60  | 81 <sup>10</sup>                      | 0.937 <sup>20</sup>        | 1.4376 <sup>25</sup> |                                                          |
| 3387 | 2-Diethylaminoethyl 4-aminobenzoate                                          | Procaine                                | C <sub>13</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub> | 59-46-1    | 236.310  | nd (w+2) pl (lig or eth)          | 61    |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                |
| 3388 | 2-( <i>N,N</i> -Diethylamino)ethyl methacrylate                              |                                         | C <sub>10</sub> H <sub>19</sub> NO <sub>2</sub>               | 105-16-8   | 185.264  |                                   |       | 80 <sup>10</sup>                      | 0.92 <sup>30</sup>         |                      |                                                          |
| 3389 | 2-(Diethylamino)ethyl 2-phenylbutanoate                                      | Butethamate                             | C <sub>16</sub> H <sub>25</sub> NO <sub>2</sub>               | 14007-64-8 | 263.376  |                                   |       | 168 <sup>11</sup>                     |                            | 1.4909 <sup>20</sup> |                                                          |
| 3390 | 4-(Diethylamino)-2-hydroxybenzaldehyde                                       |                                         | C <sub>11</sub> H <sub>15</sub> NO <sub>2</sub>               | 17754-90-4 | 193.243  |                                   | 65.0  |                                       |                            |                      |                                                          |
| 3391 | Diethyl 2-aminomalate                                                        |                                         | C <sub>7</sub> H <sub>13</sub> NO <sub>4</sub>                | 6829-40-9  | 175.183  |                                   |       | 122 <sup>16</sup> , 116 <sup>12</sup> | 1.100 <sup>16</sup>        | 1.4353 <sup>16</sup> | vs H <sub>2</sub> O, EtOH, eth; s ace, bz; i lig         |
| 3392 | 7-(Diethylamino)-4-methyl-2 <i>H</i> -1-benzopyran-2-one                     |                                         | C <sub>14</sub> H <sub>17</sub> NO <sub>2</sub>               | 91-44-1    | 231.291  | cry (al, bz-lig)                  |       |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace                    |
| 3393 | 3-(Diethylamino)phenol                                                       |                                         | C <sub>10</sub> H <sub>15</sub> NO                            | 91-68-9    | 165.232  | orth bipym (CS <sub>2</sub> -lig) | 78    | 276; 170 <sup>15</sup>                |                            |                      | s H <sub>2</sub> O, EtOH, eth, CS <sub>2</sub> ; sl lig  |
| 3394 | 2-(Diethylamino)-1-phenyl-1-propanone                                        | Diethylpropion                          | C <sub>13</sub> H <sub>19</sub> NO                            | 90-84-6    | 205.296  | liq                               |       | 111 <sup>14</sup>                     |                            |                      |                                                          |
| 3395 | 3-(Diethylamino)-1-propanol                                                  |                                         | C <sub>7</sub> H <sub>17</sub> NO                             | 622-93-5   | 131.216  |                                   |       | 189.5                                 | 0.8600 <sup>20</sup>       | 1.4439 <sup>20</sup> | s EtOH; s eth, ace, bz; sl chl                           |
| 3396 | 3-(Diethylamino)-1-propyne                                                   | <i>N,N</i> -Diethyl-2-propargylamine    | C <sub>7</sub> H <sub>13</sub> N                              | 4079-68-9  | 111.185  | liq                               |       | 120                                   |                            |                      |                                                          |
| 3397 | 2,6-Diethylaniline                                                           |                                         | C <sub>10</sub> H <sub>15</sub> N                             | 579-66-8   | 149.233  |                                   | 1.5   | 243                                   | 0.906 <sup>25</sup>        | 1.5452 <sup>20</sup> |                                                          |



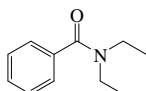
| No.  | Name                                                              | Synonym                                      | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form     | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                |
|------|-------------------------------------------------------------------|----------------------------------------------|---------------------------------------------------------------|------------|----------|-------------------|--------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------------|
| 3398 | <i>N,N</i> -Diethylaniline                                        |                                              | C <sub>10</sub> H <sub>15</sub> N                             | 91-66-7    | 149.233  | ye oil            | -38.8  | 216.3                                 | 0.9307 <sup>20</sup>       | 1.5409 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, ace, ctc; vs eth, chl        |
| 3399 | Diethylarsine                                                     |                                              | C <sub>4</sub> H <sub>11</sub> As                             | 692-42-2   | 134.052  |                   |        | 105                                   | 1.1338 <sup>24</sup>       | 1.4709               | vs ace, bz, eth, EtOH                                     |
| 3400 | <i>N,N</i> -Diethylbenzamide                                      |                                              | C <sub>11</sub> H <sub>15</sub> NO                            | 1696-17-9  | 177.243  |                   |        | 132 <sup>5</sup>                      |                            |                      |                                                           |
| 3401 | <i>o</i> -Diethylbenzene                                          | 1,2-Diethylbenzene                           | C <sub>10</sub> H <sub>14</sub>                               | 135-01-3   | 134.218  | liq               | -31.2  | 184                                   | 0.8800 <sup>20</sup>       | 1.5035 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc      |
| 3402 | <i>m</i> -Diethylbenzene                                          | 1,3-Diethylbenzene                           | C <sub>10</sub> H <sub>14</sub>                               | 141-93-5   | 134.218  | liq               | -83.9  | 181.1                                 | 0.8602 <sup>20</sup>       | 1.4955 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc      |
| 3403 | <i>p</i> -Diethylbenzene                                          | 1,4-Diethylbenzene                           | C <sub>10</sub> H <sub>14</sub>                               | 105-05-5   | 134.218  | liq               | -42.83 | 183.7                                 | 0.8620 <sup>20</sup>       | 1.4967 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc      |
| 3404 | <i>N,N</i> -Diethyl-1,4-benzenediamine                            |                                              | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub>                | 93-05-0    | 164.247  |                   |        | 261                                   |                            |                      | vs bz                                                     |
| 3405 | Diethyl benzylidenemalonate                                       | Diethyl benzalmalonate                       | C <sub>14</sub> H <sub>18</sub> O <sub>4</sub>                | 5292-53-5  | 248.275  |                   | 32     | 216 <sup>30</sup> , 196 <sup>14</sup> | 1.1045 <sup>20</sup>       | 1.5389 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz                  |
| 3406 | Diethyl benzylmalonate                                            |                                              | C <sub>14</sub> H <sub>18</sub> O <sub>4</sub>                | 607-81-8   | 250.291  |                   |        | 300                                   | 1.076 <sup>15</sup>        | 1.4872 <sup>20</sup> | i H <sub>2</sub> O; sl chl                                |
| 3407 | Diethyl benzylphosphonate                                         |                                              | C <sub>11</sub> H <sub>17</sub> O <sub>3</sub> P              | 1080-32-6  | 228.225  |                   |        | 110 <sup>2</sup>                      |                            | 1.4930 <sup>20</sup> | s ctc                                                     |
| 3408 | Diethylbromoacetamide                                             | 2-Bromo-2-ethylbutanamide                    | C <sub>6</sub> H <sub>12</sub> BrNO                           | 511-70-6   | 194.069  |                   | 67     |                                       |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth, bz                |
| 3409 | Diethyl 2-bromomalonate                                           | Ethyl bromomalonate                          | C <sub>7</sub> H <sub>11</sub> BrO <sub>4</sub>               | 685-87-0   | 239.064  |                   | -54    | dec 254                               | 1.4022 <sup>25</sup>       | 1.4521 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace, ctc             |
| 3410 | <i>N,N</i> -Diethylbutanamide                                     |                                              | C <sub>8</sub> H <sub>17</sub> NO                             | 1114-76-7  | 143.227  |                   |        | 206                                   | 0.8884 <sup>20</sup>       | 1.4403 <sup>25</sup> | vs H <sub>2</sub> O, EtOH                                 |
| 3411 | Diethyl 2-butylmalonate                                           | Pentane-1,1-dicarboxylic acid, diethyl ester | C <sub>11</sub> H <sub>20</sub> O <sub>4</sub>                | 133-08-4   | 216.275  |                   |        | 238                                   | 0.9764 <sup>20</sup>       | 1.4250 <sup>20</sup> | vs EtOH, eth                                              |
| 3412 | Diethyl 2-butyndioate                                             |                                              | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>                 | 762-21-0   | 170.163  |                   | 0.8    | 184 <sup>200</sup>                    | 1.0075 <sup>20</sup>       | 1.4425 <sup>20</sup> | s EtOH, eth, ctc                                          |
| 3413 | Diethylcarbamazine citrate                                        |                                              | C <sub>16</sub> H <sub>26</sub> N <sub>2</sub> O <sub>8</sub> | 1642-54-2  | 391.416  | cry               | 138    |                                       |                            |                      |                                                           |
| 3414 | Diethylcarbamate chloride                                         |                                              | C <sub>6</sub> H <sub>10</sub> ClNO                           | 88-10-8    | 135.592  |                   |        | 186                                   |                            |                      |                                                           |
| 3415 | <i>N,N'</i> -Diethylcarbanilide                                   |                                              | C <sub>17</sub> H <sub>20</sub> N <sub>2</sub> O              | 85-98-3    | 268.353  | cry (al)          | 79     |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH; s chl                        |
| 3416 | Diethyl carbonate                                                 | Ethyl carbonate                              | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>                 | 105-58-8   | 118.131  | liq               | -43    | 126                                   | 0.9692 <sup>25</sup>       | 1.3845 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                      |
| 3417 | <i>O,O</i> -Diethyl chloridothionophosphate                       | Diethyl thiophosphoryl chloride              | C <sub>4</sub> H <sub>10</sub> ClO <sub>2</sub> PS            | 2524-04-1  | 188.613  |                   |        | 45 <sup>3</sup>                       |                            |                      | s ctc                                                     |
| 3418 | Diethylchloroaluminum                                             |                                              | C <sub>4</sub> H <sub>10</sub> AlCl                           | 96-10-6    | 120.557  |                   |        | 134 <sup>70</sup>                     |                            |                      |                                                           |
| 3419 | Diethyl chloromalonate                                            | Ethyl chloromalonate                         | C <sub>7</sub> H <sub>11</sub> ClO <sub>4</sub>               | 14064-10-9 | 194.613  |                   |        | 222                                   | 1.2040 <sup>20</sup>       | 1.4327 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, chl; s CS <sub>2</sub> |
| 3420 | Diethyl chlorophosphonate                                         | Diethoxyphosphoryl chloride                  | C <sub>4</sub> H <sub>10</sub> ClO <sub>3</sub> P             | 814-49-3   | 172.547  |                   |        | 93.5                                  | 1.205 <sup>19</sup>        | 1.4170 <sup>20</sup> |                                                           |
| 3421 | Diethylcyanamide                                                  |                                              | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub>                 | 617-83-4   | 98.146   | liq               | -80.6  | 188                                   | 0.854 <sup>20</sup>        | 1.4126 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth                           |
| 3422 | Diethyl 1,1-cyclobutanedicarboxylate                              |                                              | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>                | 3779-29-1  | 200.232  |                   |        | 224                                   | 1.0456 <sup>20</sup>       | 1.4330 <sup>26</sup> | vs EtOH; sl ctc                                           |
| 3423 | 1,1-Diethylcyclohexane                                            |                                              | C <sub>10</sub> H <sub>20</sub>                               | 78-01-3    | 140.266  |                   |        | 179.5                                 |                            |                      |                                                           |
| 3424 | Diethyl 1,1-cyclopropanedicarboxylate                             |                                              | C <sub>9</sub> H <sub>14</sub> O <sub>4</sub>                 | 1559-02-0  | 186.205  |                   |        | 215; 100 <sup>12</sup>                | 1.055 <sup>25</sup>        | 1.4345 <sup>18</sup> | vs EtOH, eth                                              |
| 3425 | Diethyl dibutylmalonate                                           |                                              | C <sub>15</sub> H <sub>28</sub> O <sub>4</sub>                | 596-75-8   | 272.381  |                   |        | 150 <sup>12</sup>                     | 0.9457 <sup>20</sup>       | 1.4341 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                      |
| 3426 | Diethyl dicarbonate                                               | Pyrocarbonic acid diethyl ester              | C <sub>6</sub> H <sub>10</sub> O <sub>5</sub>                 | 1609-47-8  | 162.140  |                   |        | 93 <sup>18</sup>                      | 1.120 <sup>20</sup>        | 1.3960 <sup>20</sup> | vs ace, EtOH, lig                                         |
| 3427 | Diethyl [(diethanolamino)methyl] phosphonate                      |                                              | C <sub>9</sub> H <sub>22</sub> NO <sub>5</sub> P              | 2781-11-5  | 255.249  | liq               |        | 150 <sup>0.01</sup>                   |                            |                      |                                                           |
| 3428 | 5,5-Diethyldihydro-2 <i>H</i> -1,3-oxazine-2,4(3 <i>H</i> )-dione | Diethadione                                  | C <sub>8</sub> H <sub>13</sub> NO <sub>3</sub>                | 702-54-5   | 171.194  | cry (eth)         | 97.5   |                                       |                            |                      |                                                           |
| 3429 | Diethyl 1,4-dihydro-2,4,6-trimethyl-3,5-pyridinedicarboxylate     | 3,5-Diethoxycarbonyl-1,4-dihydrocollidine    | C <sub>14</sub> H <sub>21</sub> NO <sub>4</sub>               | 632-93-9   | 267.322  | lt bl flr pl (al) | 131    |                                       |                            |                      | sl H <sub>2</sub> O, EtOH, eth, CS <sub>2</sub> ; vs chl  |
| 3430 | Diethyldimethyllead                                               | Diethyldimethylplumbane                      | C <sub>6</sub> H <sub>16</sub> Pb                             | 1762-27-2  | 295.4    | col liq           |        | 51 <sup>13</sup>                      | 1.79 <sup>20</sup>         |                      |                                                           |
| 3431 | Diethyl 2,6-dimethyl-3,5-pyridinedicarboxylate                    |                                              | C <sub>13</sub> H <sub>17</sub> NO <sub>4</sub>               | 1149-24-2  | 251.279  |                   | 71     | 301; 208 <sup>40</sup>                |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl, lig             |
| 3432 | Diethyl 3,5-dimethylpyrrole-2,4-dicarboxylate                     |                                              | C <sub>12</sub> H <sub>17</sub> NO <sub>4</sub>               | 2436-79-5  | 239.268  | nd (dil al)       | 137.8  |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s ace, bz, HOAc         |
| 3433 | Diethyl disulfide                                                 |                                              | C <sub>4</sub> H <sub>10</sub> S <sub>2</sub>                 | 110-81-6   | 122.252  | liq               | -101.5 | 154.0                                 | 0.9931 <sup>20</sup>       | 1.5073 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                        |
| 3434 | <i>N,N</i> -Diethyldodecanamide                                   |                                              | C <sub>16</sub> H <sub>33</sub> NO                            | 3352-87-2  | 255.439  |                   |        | 166 <sup>2</sup>                      | 0.847 <sup>25</sup>        | 1.4545 <sup>20</sup> | s chl                                                     |
| 3435 | Diethylene glycol                                                 | Diglycol                                     | C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>                 | 111-46-6   | 106.120  | liq               | -10.4  | 245.8                                 | 1.1197 <sup>15</sup>       | 1.4472 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, chl                        |
| 3436 | Diethylene glycol, bischloroformate                               | Oxydi-2,1-ethanediyl carbonochloridate       | C <sub>6</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>5</sub>  | 106-75-2   | 231.031  | liq               |        | 126 <sup>5</sup>                      | 1.39 <sup>20</sup>         | 1.4542 <sup>20</sup> |                                                           |
| 3437 | Diethylene glycol diacetate                                       |                                              | C <sub>8</sub> H <sub>14</sub> O <sub>5</sub>                 | 628-68-2   | 190.194  |                   | 18     | 200                                   | 1.1068 <sup>15</sup>       | 1.4348 <sup>20</sup> | vs EtOH                                                   |
| 3438 | Diethylene glycol dibenzoate                                      |                                              | C <sub>18</sub> H <sub>18</sub> O <sub>5</sub>                | 120-55-8   | 314.333  |                   | 33.5   | 280 <sup>24</sup> , 250 <sup>1</sup>  | 1.1690 <sup>15</sup>       |                      | vs H <sub>2</sub> O, EtOH                                 |



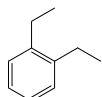
N,N-Diethylaniline



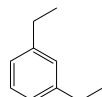
Diethylarsine



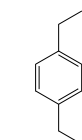
N,N-Diethylbenzamide



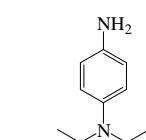
o-Diethylbenzene



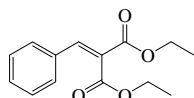
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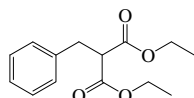
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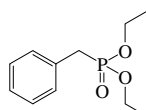
N,N-Diethyl-1,4-benzenediamine



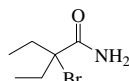
Diethyl benzylidenemalonate



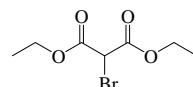
Diethyl benzylmalonate



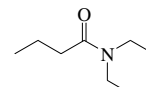
Diethyl benzylphosphonate



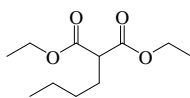
Diethylbromoacetamide



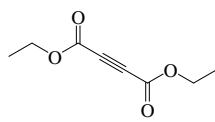
Diethyl 2-bromomalonate



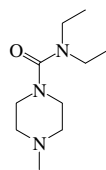
N,N-Diethylbutanamide



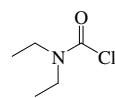
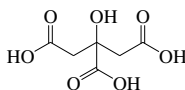
Diethyl 2-butylmalonate



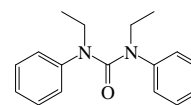
Diethyl 2-butyndioate



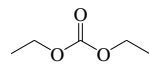
Diethylcarbamazine citrate



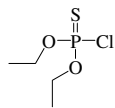
Diethylcarbamoyl chloride



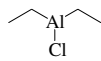
N,N'-Diethylcarbanilide



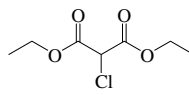
Diethyl carbonate



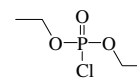
O,O-Diethyl chlorodithionophosphate



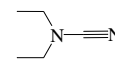
Diethylchloroaluminum



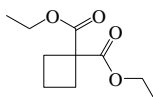
Diethyl chloromalonate



Diethyl chlorophosphonate



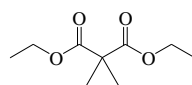
Diethylcyanamide



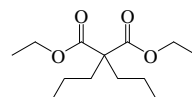
Diethyl 1,1-cyclobutanedicarboxylate



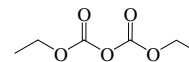
1,1-Diethylcyclohexane



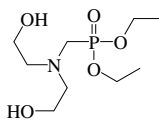
Diethyl 1,1-cyclopropanedicarboxylate



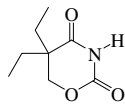
Diethyl dibutylmalonate



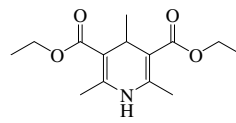
Diethyl dicarbonate



Diethyl ((diethanolamino)methyl)phosphonate



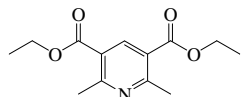
5,5-Diethyldihydro-2H-1,3-oxazine-2,4(3H)-dione



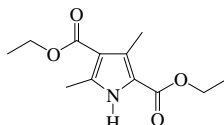
Diethyl 1,4-dihydro-2,4,6-trimethyl-3,5-pyridinedicarboxylate



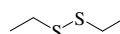
Diethyldimethyllead



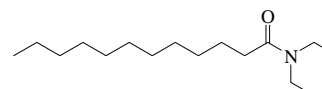
Diethyl 2,6-dimethyl-3,5-pyridinedicarboxylate



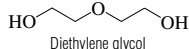
Diethyl 3,5-dimethylpyrrole-2,4-dicarboxylate



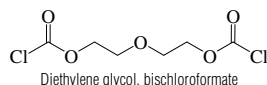
Diethyl disulfide



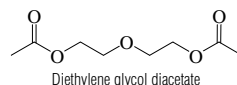
N,N-Diethyldodecanamide



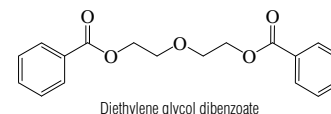
Diethylene glycol



Diethylene glycol, bischloroformate

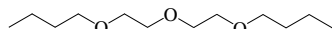


Diethylene glycol diacetate

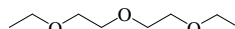


Diethylene glycol dibenzoate

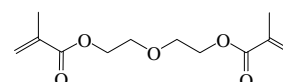
| No.  | Name                                             | Synonym                                     | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form    | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|--------------------------------------------------|---------------------------------------------|--------------------------------------------------------------|------------|----------|------------------|---------|-------------------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 3439 | Diethylene glycol dibutyl ether                  | Bis(2-butoxyethyl) ether                    | C <sub>12</sub> H <sub>26</sub> O <sub>3</sub>               | 112-73-2   | 218.332  | liq              | -60     | 256                                 | 0.885 <sup>25</sup>        | 1.4235 <sup>20</sup> |                                                          |
| 3440 | Diethylene glycol diethyl ether                  | Bis(2-ethoxyethyl) ether                    | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>                | 112-36-7   | 162.227  | liq              | -45     | 188                                 | 0.9063 <sup>20</sup>       | 1.4115 <sup>20</sup> | vs H <sub>2</sub> O, EtOH; s eth                         |
| 3441 | Diethylene glycol dimethacrylate                 | Oxydiethylene methacrylate                  | C <sub>12</sub> H <sub>18</sub> O <sub>5</sub>               | 2358-84-1  | 242.268  |                  |         | >200; 150 <sup>8</sup>              | 1.0821 <sup>20</sup>       | 1.4571 <sup>25</sup> |                                                          |
| 3442 | Diethylene glycol dimethyl ether                 | Diglyme                                     | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                | 111-96-6   | 134.173  | liq              | -68     | 162                                 | 0.9434 <sup>20</sup>       | 1.4097 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth                          |
| 3443 | Diethylene glycol dinitrate                      | 2,2'-Oxybisethanol, dinitrate               | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>7</sub>  | 693-21-0   | 196.116  |                  |         | 44 <sup>0.01</sup>                  |                            |                      |                                                          |
| 3444 | Diethylene glycol monobutyl ether                |                                             | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>                | 112-34-5   | 162.227  | liq              | -68     | 231                                 | 0.9553 <sup>20</sup>       | 1.4306 <sup>20</sup> | msc H <sub>2</sub> O; vs EtOH, eth, ace; s bz            |
| 3445 | Diethylene glycol monobutyl ether acetate        | 2-(2-Butoxyethoxy)ethyl acetate             | C <sub>10</sub> H <sub>20</sub> O <sub>4</sub>               | 124-17-4   | 204.264  | liq              | -32     | 245                                 | 0.985 <sup>20</sup>        | 1.4262 <sup>20</sup> | vs ace, eth, EtOH                                        |
| 3446 | Diethylene glycol monododecanoate                | 2-(2-Hydroxyethoxy)ethyl laurate            | C <sub>16</sub> H <sub>32</sub> O <sub>4</sub>               | 141-20-8   | 288.423  | lt ye            | 17.5    | >270                                | 0.96 <sup>25</sup>         |                      | msc EtOH, eth, ace; s bz, tol                            |
| 3447 | Diethylene glycol monoethyl ether                | Carbitol                                    | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                | 111-90-0   | 134.173  | hyg liq          |         | 196                                 | 0.9885 <sup>20</sup>       | 1.4300 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, ace, bz; vs eth              |
| 3448 | Diethylene glycol monoethyl ether acetate        | Carbitol acetate                            | C <sub>8</sub> H <sub>16</sub> O <sub>4</sub>                | 112-15-2   | 176.211  | liq              | -25     | 218.5                               | 1.0096 <sup>20</sup>       | 1.4213 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                      |
| 3449 | Diethylene glycol monohexyl ether                | 2-[2-(Hexyloxy)ethoxy]ethanol               | C <sub>10</sub> H <sub>22</sub> O <sub>3</sub>               | 112-59-4   | 190.280  | col liq          | -28     | 258; 192 <sup>100</sup>             |                            |                      |                                                          |
| 3450 | Diethylene glycol monomethyl ether               | 2-(2-Methoxyethoxy)ethanol                  | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                | 111-77-3   | 120.147  |                  |         | 193                                 | 1.035 <sup>20</sup>        | 1.4264 <sup>20</sup> | msc H <sub>2</sub> O, ace; vs EtOH, eth                  |
| 3451 | Diethylene glycol monopropyl ether               |                                             | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>                | 6881-94-3  | 148.200  | liq              | -53.3   | 213; 124 <sup>4</sup>               |                            |                      |                                                          |
| 3452 | <i>N,N</i> -Diethyl-1,2-ethanediamine            | <i>N,N</i> -Diethylethylenediamine          | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                | 100-36-7   | 116.204  |                  |         | 144                                 | 0.8280 <sup>20</sup>       | 1.4340 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth, ctc, tol              |
| 3453 | <i>N,N'</i> -Diethyl-1,2-ethanediamine           |                                             | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                | 111-74-0   | 116.204  |                  |         | 146                                 | 0.8280 <sup>20</sup>       | 1.4340 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH, tol                      |
| 3454 | Diethyl ether                                    | Ethyl ether                                 | C <sub>4</sub> H <sub>10</sub> O                             | 60-29-7    | 74.121   | liq              | -116.2  | 34.5                                | 0.7138 <sup>20</sup>       | 1.3526 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, bz, eth; vs ace           |
| 3455 | Diethyl (ethoxymethylene) malonate               | 2-Ethoxy-1,1-bis(ethoxycarbonyl)ethene      | C <sub>10</sub> H <sub>16</sub> O <sub>5</sub>               | 87-13-8    | 216.231  |                  |         | dec 280; 165 <sup>19</sup>          |                            | 1.4600 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl chl                  |
| 3456 | Diethyl ethylenemalonate                         |                                             | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                | 1462-12-0  | 186.205  |                  |         | 116 <sup>17</sup> , 86 <sup>3</sup> | 1.0404 <sup>20</sup>       | 1.4308 <sup>17</sup> | vs eth, EtOH                                             |
| 3457 | Diethyl ethylmalonate                            |                                             | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                | 133-13-1   | 188.221  |                  |         | 208; 98 <sup>12</sup>               | 1.006 <sup>20</sup>        | 1.4166 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth, ace, chl              |
| 3458 | Diethyl ethylphenylmalonate                      |                                             | C <sub>15</sub> H <sub>20</sub> O <sub>4</sub>               | 76-67-5    | 264.318  |                  |         | 170 <sup>19</sup>                   | 1.071 <sup>20</sup>        | 1.4896 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth; sl chl                  |
| 3459 | Diethyl ethylphosphonate                         |                                             | C <sub>6</sub> H <sub>15</sub> O <sub>3</sub> P              | 78-38-6    | 166.155  |                  |         | 198; 90 <sup>16</sup>               | 1.0259 <sup>20</sup>       | 1.4163 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                         |
| 3460 | <i>N,N</i> -Diethylformamide                     |                                             | C <sub>5</sub> H <sub>11</sub> NO                            | 617-84-5   | 101.147  |                  |         | 177.5                               | 0.9080 <sup>19</sup>       | 1.4321 <sup>25</sup> | msc H <sub>2</sub> O, ace, bz; vs EtOH, eth              |
| 3461 | Diethyl fumarate                                 |                                             | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                | 623-91-6   | 172.179  |                  | 0.8     | 214                                 | 1.0452 <sup>20</sup>       | 1.4412 <sup>20</sup> | i H <sub>2</sub> O; s ace, chl                           |
| 3462 | Diethyl glutarate                                |                                             | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                | 818-38-2   | 188.221  | syr liq          | -24.1   | 236.5                               | 1.0220 <sup>20</sup>       | 1.4241 <sup>20</sup> | vs eth                                                   |
| 3463 | 3,4-Diethylhexane                                |                                             | C <sub>10</sub> H <sub>22</sub>                              | 19398-77-7 | 142.282  |                  |         | 163.9                               | 0.7472 <sup>25</sup>       | 1.4190 <sup>20</sup> |                                                          |
| 3464 | Di-2-ethylhexyl maleate                          |                                             | C <sub>20</sub> H <sub>36</sub> O <sub>4</sub>               | 142-16-5   | 340.498  |                  |         | 156 <sup>7</sup>                    | 0.94 <sup>20</sup>         |                      |                                                          |
| 3465 | 1,2-Diethylhydrazine                             |                                             | C <sub>4</sub> H <sub>12</sub> N <sub>2</sub>                | 1615-80-1  | 88.151   |                  |         | 85.5                                | 0.797 <sup>26</sup>        | 1.4204 <sup>20</sup> | vs bz, eth, EtOH                                         |
| 3466 | Diethyl 1,2-hydrazinedicarboxylate               | Diethyl bicarbamate                         | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> | 4114-28-7  | 176.170  | nd (chl), pr (w) | 135     | dec 250                             | 1.324 <sup>8</sup>         |                      | vs eth, EtOH                                             |
| 3467 | Diethyl hydrogen phosphate                       | Diethyl phosphate                           | C <sub>4</sub> H <sub>11</sub> O <sub>4</sub> P              | 598-02-7   | 154.101  | syr              |         | dec 203; 87 <sup>0.0001</sup>       | 1.1800 <sup>20</sup>       | 1.4170 <sup>20</sup> | vs eth                                                   |
| 3468 | <i>N,N</i> -Diethyl-4-hydroxy-3-methoxybenzamide | Ethamivan                                   | C <sub>12</sub> H <sub>17</sub> NO <sub>3</sub>              | 304-84-7   | 223.268  |                  | 95      |                                     |                            |                      | s chl                                                    |
| 3469 | Diethyl iminodiacetate                           |                                             | C <sub>8</sub> H <sub>15</sub> NO <sub>4</sub>               | 6290-05-7  | 189.210  | orth cry         | 247 dec |                                     |                            |                      |                                                          |
| 3470 | Diethyl isobutylmalonate                         |                                             | C <sub>11</sub> H <sub>20</sub> O <sub>4</sub>               | 10203-58-4 | 216.275  |                  |         |                                     | 0.9804 <sup>20</sup>       | 1.4236 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s chl                  |
| 3471 | Diethyl isophthalate                             |                                             | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>               | 636-53-3   | 222.237  |                  | 11.5    | 302                                 | 1.1239 <sup>17</sup>       | 1.508 <sup>18</sup>  | i H <sub>2</sub> O                                       |
| 3472 | Diethyl isopropylidenemalonate                   |                                             | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>               | 6802-75-1  | 200.232  |                  |         | 176.5; 116 <sup>14</sup>            | 1.0282 <sup>18</sup>       | 1.4486 <sup>17</sup> | vs ace, EtOH                                             |
| 3473 | Diethyl isopropylmalonate                        | Ethyl isopropylmalonate                     | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>               | 759-36-4   | 202.248  |                  |         | 215                                 | 0.9961 <sup>20</sup>       | 1.4188 <sup>21</sup> | sl H <sub>2</sub> O, ctc; vs EtOH, eth; s chl            |
| 3474 | Diethyl ketomalonate                             | Ethyl mesoxalate                            | C <sub>7</sub> H <sub>10</sub> O <sub>5</sub>                | 609-09-6   | 174.151  | pa ye grn oil    | -30     | 210; 105 <sup>19</sup>              | 1.1419 <sup>16</sup>       | 1.4310 <sup>22</sup> | vs H <sub>2</sub> O; s EtOH, eth, chl; i CS <sub>2</sub> |
| 3475 | Diethyl malate                                   | Diethyl hydroxybutanedioate                 | C <sub>8</sub> H <sub>14</sub> O <sub>5</sub>                | 7554-12-3  | 190.194  |                  |         | 253; 124 <sup>13</sup>              | 1.1290 <sup>20</sup>       |                      |                                                          |
| 3476 | Diethyl maleate                                  |                                             | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                | 141-05-9   | 172.179  | liq              | -8.8    | 223                                 | 1.0662 <sup>20</sup>       | 1.4416 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl chl                  |
| 3477 | Diethyl malonate                                 |                                             | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                | 105-53-3   | 160.168  | liq              | -50     | 200                                 | 1.0551 <sup>20</sup>       | 1.4139 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace, bz           |
| 3478 | Diethyl mercury                                  |                                             | C <sub>4</sub> H <sub>10</sub> Hg                            | 627-44-1   | 258.71   |                  |         | 159; 57 <sup>16</sup>               | 2.43 <sup>20</sup>         |                      | s eth; sl EtOH                                           |
| 3479 | Diethylmethylamine                               | <i>N</i> -Ethyl- <i>N</i> -methylethanamine | C <sub>5</sub> H <sub>13</sub> N                             | 616-39-7   | 87.164   | liq              | -196    | 66                                  | 0.703 <sup>25</sup>        | 1.3879 <sup>25</sup> | vs H <sub>2</sub> O, EtOH, eth                           |



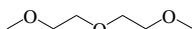
Diethylene glycol dibutyl ether



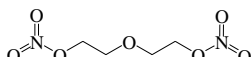
Diethylene glycol diethyl ether



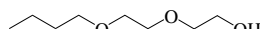
Diethylene glycol dimethacrylate



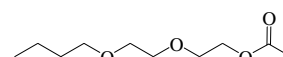
Diethylene glycol dimethyl ether



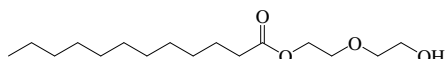
Diethylene glycol dinitrate



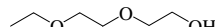
Diethylene glycol monobutyl ether



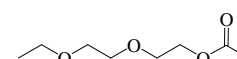
Diethylene glycol monobutyl ether acetate



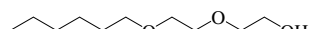
Diethylene glycol monododecanoate



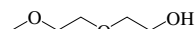
Diethylene glycol monoethyl ether



Diethylene glycol monoethyl ether acetate



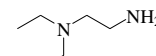
Diethylene glycol monohexyl ether



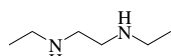
Diethylene glycol monomethyl ether



Diethylene glycol monopropyl ether



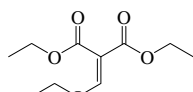
N,N-Diethyl-1,2-ethanediamine



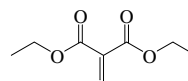
N,N-Diethyl-1,2-ethanediamine



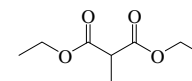
Diethyl ether



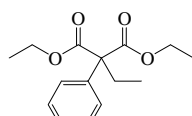
Diethyl (ethoxymethylene)malonate



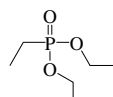
Diethyl ethylenemalonate



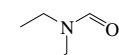
Diethyl ethylmalonate



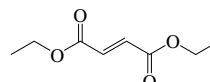
Diethyl ethylphenylmalonate



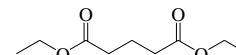
Diethyl ethylphosphonate



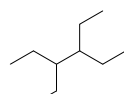
N,N-Diethylformamide



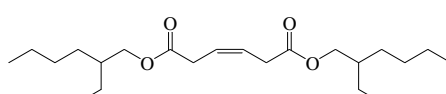
Diethyl fumarate



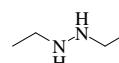
Diethyl glutarate



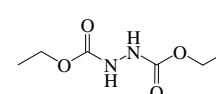
3,4-Diethylhexane



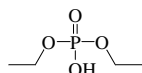
Di-2-ethylhexyl maleate



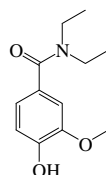
1,2-Diethylhydrazine



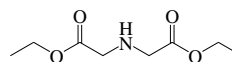
Diethyl 1,2-hydrazinedicarboxylate



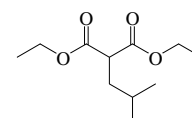
Diethyl hydrogen phosphate



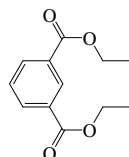
N,N-Diethyl-4-hydroxy-3-methoxybenzamide



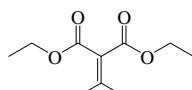
Diethyl iminodiacetate



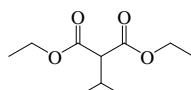
Diethyl isobutylmalonate



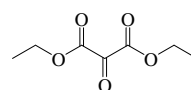
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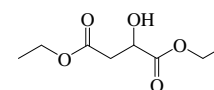
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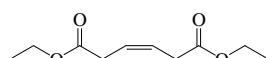
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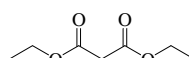
Diethyl ketomalonate



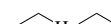
Diethyl malate



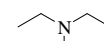
Diethyl maleate



Diethyl malonate

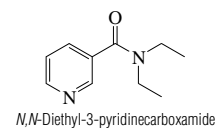
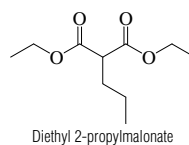
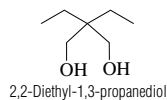
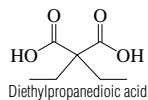
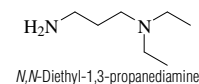
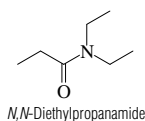
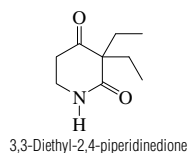
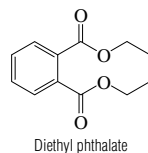
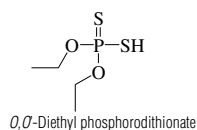
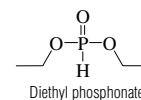
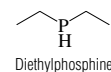
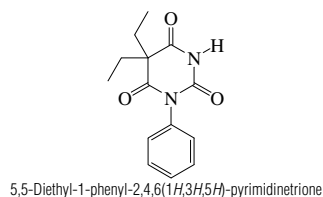
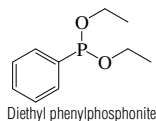
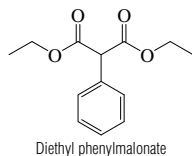
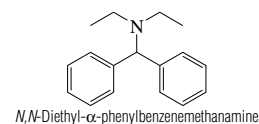
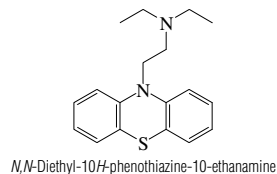
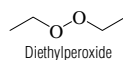
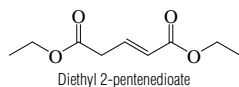
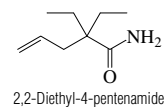
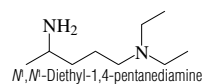
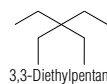
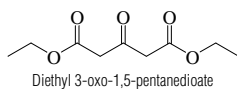
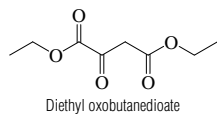
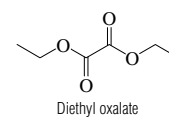
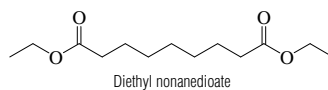
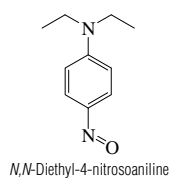
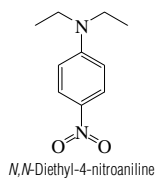
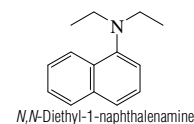
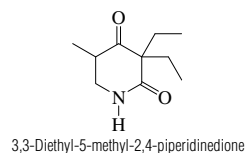
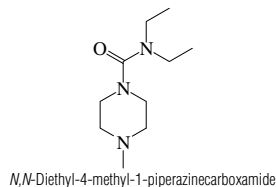
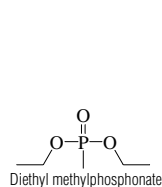
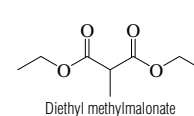
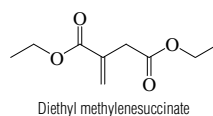
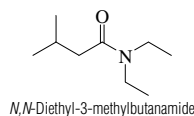
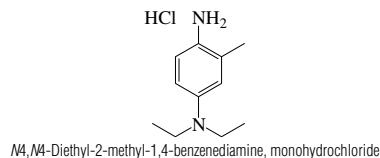
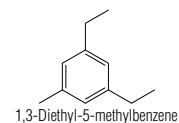
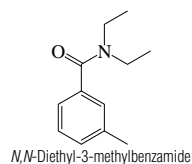
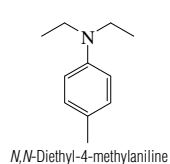
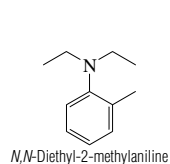


Diethyl mercury



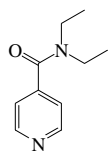
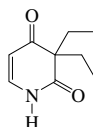
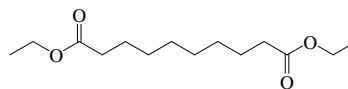
Diethylmethylaniline

| No.  | Name                                                                              | Synonym                                                           | Mol. Form.                                                    | CAS RN    | Mol. Wt. | Physical Form                 | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------|-----------|----------|-------------------------------|---------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 3480 | <i>N,N</i> -Diethyl-2-methylaniline                                               |                                                                   | C <sub>11</sub> H <sub>17</sub> N                             | 606-46-2  | 163.260  | liq                           | -60     | 209                                  | 0.9286 <sup>20</sup>       | 1.5153 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ctc            |
| 3481 | <i>N,N</i> -Diethyl-4-methylaniline                                               |                                                                   | C <sub>11</sub> H <sub>17</sub> N                             | 613-48-9  | 163.260  |                               |         | 229                                  | 0.9242 <sup>16</sup>       |                      | sl H <sub>2</sub> O; msc EtOH, eth                   |
| 3482 | <i>N,N</i> -Diethyl-3-methylbenzamide                                             | DEET                                                              | C <sub>12</sub> H <sub>17</sub> NO                            | 134-62-3  | 191.269  |                               |         | 160 <sup>19</sup> , 111 <sup>1</sup> | 0.996 <sup>20</sup>        | 1.5212 <sup>20</sup> | vs H <sub>2</sub> O, bz, eth, EtOH                   |
| 3483 | 1,3-Diethyl-5-methylbenzene                                                       |                                                                   | C <sub>11</sub> H <sub>16</sub>                               | 2050-24-0 | 148.245  | liq                           | -74.1   | 205                                  | 0.8748 <sup>20</sup>       | 1.5027 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc |
| 3484 | <i>N,N,N',N'</i> -Diethyl-2-methyl-1,4-benzenediamine, monohydrochloride          | 4- <i>N,N</i> -Diethyl-1,4-diamino-2-methylbenzene, hydrochloride | C <sub>11</sub> H <sub>15</sub> ClN <sub>2</sub>              | 2051-79-8 | 214.735  | cry                           | 250 dec |                                      |                            |                      |                                                      |
| 3485 | <i>N,N</i> -Diethyl-3-methylbutanamide                                            | Isovaleryl diethylamide                                           | C <sub>9</sub> H <sub>19</sub> NO                             | 533-32-4  | 157.253  |                               |         | 211                                  | 0.8764 <sup>20</sup>       | 1.4422 <sup>20</sup> | vs eth, EtOH                                         |
| 3486 | Diethyl methylenesuccinate                                                        |                                                                   | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                 | 2409-52-1 | 186.205  |                               | 58.5    | 228                                  | 1.0467 <sup>20</sup>       | 1.4377 <sup>20</sup> | msc EtOH; s eth, bz; vs ace                          |
| 3487 | Diethyl methylmalonate                                                            |                                                                   | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                 | 609-08-5  | 174.195  |                               |         | 201                                  | 1.0225 <sup>20</sup>       | 1.4126 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth, ace, chl          |
| 3488 | Diethyl methylphosphonate                                                         |                                                                   | C <sub>6</sub> H <sub>13</sub> O <sub>3</sub> P               | 683-08-9  | 152.129  |                               |         | 194                                  | 1.0406 <sup>30</sup>       | 1.4101 <sup>30</sup> | s H <sub>2</sub> O, EtOH, eth; i bz                  |
| 3489 | <i>N,N</i> -Diethyl-4-methyl-1-piperazincarboxamide                               | Diethylcarbamazine                                                | C <sub>10</sub> H <sub>21</sub> N <sub>3</sub> O              | 90-89-1   | 199.293  |                               | 48      | 110 <sup>3</sup>                     |                            |                      |                                                      |
| 3490 | 3,3-Diethyl-5-methyl-2,4-piperidinedione                                          |                                                                   | C <sub>10</sub> H <sub>17</sub> NO <sub>2</sub>               | 125-64-4  | 183.248  |                               | 75.5    |                                      |                            |                      | s H <sub>2</sub> O, bz, chl, EtOH                    |
| 3491 | <i>N,N</i> -Diethyl-1-naphthalenamine                                             |                                                                   | C <sub>14</sub> H <sub>17</sub> N                             | 84-95-7   | 199.292  |                               |         | 285                                  | 1.013 <sup>20</sup>        | 1.5961 <sup>20</sup> | s EtOH, eth, bz; sl ctc                              |
| 3492 | <i>N,N</i> -Diethyl-4-nitroaniline                                                |                                                                   | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub> | 2216-15-1 | 194.230  | ye nd (lig) pl (al)           | 77.5    |                                      | 1.225 <sup>25</sup>        |                      | s EtOH; sl lig                                       |
| 3493 | <i>N,N</i> -Diethyl-4-nitrosoaniline                                              |                                                                   | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O              | 120-22-9  | 178.230  | grn mcl pr (eth) grn lf (ace) | 87.5    |                                      | 1.24 <sup>15</sup>         |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, chl           |
| 3494 | Diethyl nonanedioate                                                              | Diethyl azelate                                                   | C <sub>13</sub> H <sub>24</sub> O <sub>4</sub>                | 624-17-9  | 244.328  | liq                           | -18.5   | 291.5                                | 0.9729 <sup>20</sup>       | 1.4351 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                      |
| 3495 | Diethyl oxalate                                                                   |                                                                   | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                 | 95-92-1   | 146.141  | liq                           | -40.6   | 185.7                                | 1.0785 <sup>20</sup>       | 1.4101 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, ace; s ctc       |
| 3496 | Diethyl oxobutanedioate                                                           | Diethyl oxalacetate                                               | C <sub>8</sub> H <sub>12</sub> O <sub>5</sub>                 | 108-56-5  | 188.178  |                               |         | 131 <sup>24</sup>                    | 1.131 <sup>20</sup>        | 1.4561 <sup>17</sup> | i H <sub>2</sub> O; msc EtOH, eth, bz; vs ace        |
| 3497 | Diethyl 3-oxo-1,5-pentanedioate                                                   | Diethyl 1,3-acetonedicarboxylate                                  | C <sub>9</sub> H <sub>14</sub> O <sub>5</sub>                 | 105-50-0  | 202.204  |                               |         | 250                                  | 1.113 <sup>20</sup>        |                      | sl H <sub>2</sub> O; msc EtOH                        |
| 3498 | 3,3-Diethylpentane                                                                | Tetraethylmethane                                                 | C <sub>8</sub> H <sub>20</sub>                                | 1067-20-5 | 128.255  | liq                           | -33.1   | 146.3                                | 0.7536 <sup>20</sup>       | 1.4206 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz                        |
| 3499 | <i>N,N'</i> -Diethyl-1,4-pentanediamine                                           | Novoldiamine                                                      | C <sub>9</sub> H <sub>22</sub> N <sub>2</sub>                 | 140-80-7  | 158.284  |                               |         | 201                                  | 0.814 <sup>20</sup>        | 1.4429 <sup>20</sup> |                                                      |
| 3500 | 2,2-Diethyl-4-pentenamide                                                         | Novonal                                                           | C <sub>8</sub> H <sub>17</sub> NO                             | 512-48-1  | 155.237  | wh pow                        | 75.5    |                                      |                            |                      | vs eth, EtOH                                         |
| 3501 | Diethyl 2-pentenedioate                                                           | Diethyl glutaconate                                               | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                 | 2049-67-4 | 186.205  |                               |         | 237                                  | 1.0496 <sup>20</sup>       | 1.4411 <sup>20</sup> | vs eth, EtOH                                         |
| 3502 | Diethylperoxide                                                                   |                                                                   | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 628-37-5  | 90.121   | liq                           | -70     | 65                                   | 0.8240 <sup>19</sup>       | 1.3715 <sup>17</sup> | sl H <sub>2</sub> O; msc EtOH, eth                   |
| 3503 | <i>N,N</i> -Diethyl-10- <i>H</i> -phenothiazine-10-ethanamine                     | Diethazine                                                        | C <sub>18</sub> H <sub>22</sub> N <sub>2</sub> S              | 60-91-3   | 298.446  | oil                           |         | 167 <sup>0.5</sup>                   |                            |                      | i H <sub>2</sub> O; s dil HCl                        |
| 3504 | <i>N,N</i> -Diethyl- $\alpha$ -phenylbenzenemethanamine                           | <i>N,N</i> -Diethylbenzhydramine                                  | C <sub>17</sub> H <sub>21</sub> N                             | 519-72-2  | 239.356  |                               | 58.5    | 170 <sup>17</sup>                    |                            |                      |                                                      |
| 3505 | Diethyl phenylmalonate                                                            |                                                                   | C <sub>13</sub> H <sub>16</sub> O <sub>4</sub>                | 83-13-6   | 236.264  |                               | 16.5    | dec 205; 168 <sup>12</sup>           | 1.0950 <sup>20</sup>       | 1.4977 <sup>20</sup> | vs ace, EtOH                                         |
| 3506 | Diethyl phenylphosphonite                                                         |                                                                   | C <sub>10</sub> H <sub>15</sub> O <sub>2</sub> P              | 1638-86-4 | 198.199  |                               |         | 235; 62 <sup>1</sup>                 | 1.032 <sup>16</sup>        |                      |                                                      |
| 3507 | 5,5-Diethyl-1-phenyl-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | Phenetharbital                                                    | C <sub>14</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> | 357-67-5  | 260.288  |                               | 178     |                                      |                            |                      | vs EtOH                                              |
| 3508 | Diethylphosphine                                                                  |                                                                   | C <sub>4</sub> H <sub>11</sub> P                              | 627-49-6  | 90.104   |                               |         | 85                                   | 0.786 <sup>20</sup>        |                      |                                                      |
| 3509 | Diethyl phosphonate                                                               |                                                                   | C <sub>6</sub> H <sub>11</sub> O <sub>3</sub> P               | 762-04-9  | 138.102  |                               |         | 54 <sup>6</sup>                      |                            |                      | s ctc                                                |
| 3510 | <i>O,O'</i> -Diethyl phosphorodithionate                                          |                                                                   | C <sub>4</sub> H <sub>11</sub> O <sub>2</sub> PS <sub>2</sub> | 298-06-6  | 186.233  |                               |         |                                      |                            |                      | s H <sub>2</sub> O                                   |
| 3511 | Diethyl phthalate                                                                 |                                                                   | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                | 84-66-2   | 222.237  | liq                           | -40.5   | 295                                  | 1.232 <sup>14</sup>        | 1.5000 <sup>21</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace, bz, ctc    |
| 3512 | 3,3-Diethyl-2,4-piperidinedione                                                   | Piperidione                                                       | C <sub>9</sub> H <sub>15</sub> NO <sub>2</sub>                | 77-03-2   | 169.221  | nd (w)                        | 104     |                                      |                            |                      | vs H <sub>2</sub> O, EtOH, chl, MeOH                 |
| 3513 | <i>N,N</i> -Diethylpropanamide                                                    |                                                                   | C <sub>7</sub> H <sub>15</sub> NO                             | 1114-51-8 | 129.200  |                               |         | 191                                  | 0.8972 <sup>20</sup>       | 1.4425 <sup>20</sup> | vs EtOH                                              |
| 3514 | <i>N,N</i> -Diethyl-1,3-propanediamine                                            |                                                                   | C <sub>7</sub> H <sub>18</sub> N <sub>2</sub>                 | 104-78-9  | 130.231  |                               |         | 168.5                                | 0.822 <sup>20</sup>        | 1.443 <sup>20</sup>  |                                                      |
| 3515 | Diethylpropanedioic acid                                                          | Diethylmalonic acid                                               | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | 510-20-3  | 160.168  | pr (w,bz)                     | 127 dec |                                      |                            |                      | vs H <sub>2</sub> O, EtOH, eth; sl bz, chl           |
| 3516 | 2,2-Diethyl-1,3-propanediol                                                       |                                                                   | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>                 | 115-76-4  | 132.201  |                               | 61.5    | 240.5                                | 1.050 <sup>20</sup>        | 1.4574 <sup>25</sup> | vs H <sub>2</sub> O, EtOH, eth; s chl                |
| 3517 | Diethyl 2-propylmalonate                                                          |                                                                   | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                | 2163-48-6 | 202.248  |                               |         | 221; 114 <sup>22</sup>               | 0.989 <sup>20</sup>        | 1.4197 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth                    |
| 3518 | <i>N,N</i> -Diethyl-3-pyridinecarboxamide                                         | Nikethamide                                                       | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O              | 59-26-7   | 178.230  | ye solid or visc liq          | 25      | dec 280; 175 <sup>25</sup>           | 1.060 <sup>25</sup>        | 1.525 <sup>20</sup>  | sl DMSO                                              |

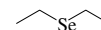




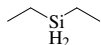
| No.  | Name                                                   | Synonym                                                            | Mol. Form.                                                                    | CAS RN      | Mol. Wt. | Physical Form          | mp/°C     | bp/°C                                | den/<br>g cm <sup>-3</sup>    | n <sub>D</sub>        | Solubility                                       |
|------|--------------------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------------------------------------|-------------|----------|------------------------|-----------|--------------------------------------|-------------------------------|-----------------------|--------------------------------------------------|
| 3519 | <i>N,N</i> -Diethyl-4-pyridinecarboxamide              | Isonicotinic acid diethylamide                                     | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O                              | 530-40-5    | 178.230  |                        |           | 119 <sup>1</sup>                     |                               | 1.525 <sup>20</sup>   | vs H <sub>2</sub> O, ace, eth, EtOH              |
| 3520 | 3,3-Diethyl-2,4(1 <i>H</i> ,3 <i>H</i> )-pyridinedione | Pyrrithyldione                                                     | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                                | 77-04-3     | 167.205  |                        | 90.7      |                                      |                               |                       |                                                  |
| 3521 | Diethyl sebacate                                       |                                                                    | C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>                                | 110-40-7    | 258.354  |                        | 2.5       | 305; 188 <sup>19</sup>               | 0.9646 <sup>20</sup>          | 1.4306 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; s EtOH, ace; i bz      |
| 3522 | Diethyl selenide                                       |                                                                    | C <sub>4</sub> H <sub>10</sub> Se                                             | 627-53-2    | 137.08   | pa ye                  | 55        | 108                                  | 1.2300 <sup>20</sup>          | 1.4768 <sup>20</sup>  |                                                  |
| 3523 | Diethylsilane                                          |                                                                    | C <sub>2</sub> H <sub>12</sub> Si                                             | 542-91-6    | 88.224   | liq                    | -134.3    | 57                                   | 0.6843 <sup>20</sup>          | 1.3921 <sup>20</sup>  | i H <sub>2</sub> O                               |
| 3524 | <i>trans</i> -Diethylstilbestrol                       |                                                                    | C <sub>18</sub> H <sub>20</sub> O <sub>2</sub>                                | 56-53-1     | 268.351  | pl (bz)                | 170.5     |                                      |                               |                       | vs eth, EtOH, chl                                |
| 3525 | <i>trans</i> -Diethylstilbestrol dipropionate          | Clinestrol                                                         | C <sub>24</sub> H <sub>28</sub> O <sub>4</sub>                                | 130-80-3    | 380.477  | pr (MeOH)              | 104       |                                      |                               |                       | vs bz, eth, EtOH                                 |
| 3526 | <i>trans</i> -Diethylstilbestrol monomethyl ether      | Mestilbol                                                          | C <sub>19</sub> H <sub>22</sub> O <sub>2</sub>                                | 18839-90-2  | 282.377  | nd (bz-peth)           | 117.5     | 190 <sup>0.3</sup>                   |                               |                       | vs ace, eth, EtOH                                |
| 3527 | Diethyl succinate                                      | Ethyl succinate                                                    | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                                 | 123-25-1    | 174.195  | liq                    | -21       | 217.7                                | 1.0402 <sup>20</sup>          | 1.4201 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s ace, chl    |
| 3528 | Diethyl sulfate                                        |                                                                    | C <sub>4</sub> H <sub>10</sub> O <sub>4</sub> S                               | 64-67-5     | 154.185  | oil                    | -24       | 208                                  | 1.172 <sup>25</sup>           | 1.3989 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth                |
| 3529 | Diethyl sulfide                                        |                                                                    | C <sub>4</sub> H <sub>10</sub> S                                              | 352-93-2    | 90.187   | liq                    | -103.91   | 92.1                                 | 0.8362 <sup>20</sup>          | 1.4430 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; s EtOH, eth            |
| 3530 | Diethyl sulfite                                        | Ethyl sulfite                                                      | C <sub>4</sub> H <sub>10</sub> O <sub>3</sub> S                               | 623-81-4    | 138.185  |                        |           | 158; 51 <sup>13</sup>                | 1.1 <sup>20</sup>             | 1.4310 <sup>20</sup>  | s EtOH, eth                                      |
| 3531 | Diethyl sulfone                                        | Ethyl sulfone                                                      | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub> S                               | 597-35-3    | 122.186  | orth pl                | 73.5      | 248                                  | 1.357 <sup>20</sup>           |                       | s H <sub>2</sub> O, eth; vs bz; i peth           |
| 3532 | Diethyl sulfoxide                                      |                                                                    | C <sub>4</sub> H <sub>10</sub> OS                                             | 70-29-1     | 106.186  | syr                    | 14        | 104 <sup>25</sup> , 90 <sup>15</sup> | 1.0092 <sup>22</sup>          |                       | vs H <sub>2</sub> O, eth, EtOH                   |
| 3533 | Diethyl <i>DL</i> -tartrate                            |                                                                    | C <sub>8</sub> H <sub>14</sub> O <sub>6</sub>                                 | 57968-71-5  | 206.193  |                        | 18.7      | 281; 158 <sup>14</sup>               | 1.2046 <sup>20</sup>          | 1.4438 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth; s ace, ctc   |
| 3534 | Diethyl telluride                                      |                                                                    | C <sub>4</sub> H <sub>10</sub> Te                                             | 627-54-3    | 185.72   | red-ye                 |           | 137.5                                | 1.599 <sup>15</sup>           | 1.5182 <sup>15</sup>  | vs EtOH                                          |
| 3535 | Diethyl terephthalate                                  |                                                                    | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                                | 636-09-9    | 222.237  | mcl pr (al, peth)      | 44        | 302                                  | 1.0989 <sup>45</sup>          |                       | i H <sub>2</sub> O; vs EtOH, eth                 |
| 3536 | Diethyl thiodipropionate                               |                                                                    | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub> S                              | 673-79-0    | 234.313  |                        |           | 174 <sup>15</sup> , 121 <sup>2</sup> | 1.1034 <sup>20</sup>          | 1.4655 <sup>20</sup>  |                                                  |
| 3537 | <i>N,N'</i> -Diethylthiourea                           |                                                                    | C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> S                               | 105-55-5    | 132.227  |                        | 78        | dec                                  |                               |                       | s H <sub>2</sub> O, EtOH; vs eth; sl ctc         |
| 3538 | <i>N,N</i> -Diethyl-1,1,1-trimethylsilanamine          | (Diethylamino)trimethylsilane                                      | C <sub>7</sub> H <sub>19</sub> NSi                                            | 996-50-9    | 145.319  |                        |           | 126.3                                | 0.7627 <sup>20</sup>          | 1.4112 <sup>20</sup>  |                                                  |
| 3539 | Diethyltrisulfide                                      |                                                                    | C <sub>4</sub> H <sub>10</sub> S <sub>3</sub>                                 | 3600-24-6   | 154.317  |                        | -72.6     | 85 <sup>26</sup>                     | 1.1082 <sup>20</sup>          | 1.5689 <sup>13</sup>  |                                                  |
| 3540 | <i>N,N</i> -Diethylurea                                |                                                                    | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O                               | 634-95-7    | 116.161  | pl, nd (eth)           | 75        | 95 <sup>0.02</sup>                   |                               |                       | vs H <sub>2</sub> O, EtOH, bz, lig; s eth        |
| 3541 | <i>N,N'</i> -Diethylurea                               |                                                                    | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O                               | 623-76-7    | 116.161  | tab (lig), hyg nd (al) | 112.5     | 263                                  | 1.0415 <sup>25</sup>          | 1.4616 <sup>40</sup>  | vs H <sub>2</sub> O, EtOH, eth                   |
| 3542 | Diethyl vinylphosphonate                               |                                                                    | C <sub>6</sub> H <sub>13</sub> O <sub>3</sub> P                               | 682-30-4    | 164.139  |                        |           | 110 <sup>2</sup>                     | 1.068 <sup>25</sup>           | 1.4290 <sup>20</sup>  |                                                  |
| 3543 | Diethyl zinc                                           | Zinc diethyl                                                       | C <sub>4</sub> H <sub>10</sub> Zn                                             | 557-20-0    | 123.531  | col liq                | -28       | 118; 80 <sup>200</sup>               | 1.2065 <sup>20</sup>          | 1.4936 <sup>20</sup>  | dec H <sub>2</sub> O; msc eth, peth, bz          |
| 3544 | Difenoconazole                                         |                                                                    | C <sub>19</sub> H <sub>17</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>3</sub> | 119446-68-3 | 406.262  |                        | 76        | 220 <sup>0.03</sup>                  |                               |                       |                                                  |
| 3545 | Difenzoquat methyl sulfate                             | 1 <i>H</i> -Pyrazolium, 1,2-dimethyl-3,5-diphenyl-, methyl sulfate | C <sub>18</sub> H <sub>20</sub> N <sub>2</sub> O <sub>4</sub> S               | 43222-48-6  | 360.428  |                        | 157       |                                      |                               |                       |                                                  |
| 3546 | Diflubenzuron                                          | <i>N</i> -[[[4-Chlorophenyl]amino]carbonyl]-2,6-difluorobenzamide  | C <sub>14</sub> H <sub>9</sub> ClF <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 35367-38-5  | 310.683  |                        | 239       |                                      |                               |                       |                                                  |
| 3547 | Difluoroacetic acid                                    |                                                                    | C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> O <sub>2</sub>                   | 381-73-7    | 96.033   | liq                    | -1        | 133                                  | 1.526 <sup>25</sup>           | 1.3470 <sup>20</sup>  |                                                  |
| 3548 | 2,4-Difluoroaniline                                    |                                                                    | C <sub>6</sub> H <sub>6</sub> F <sub>2</sub> N                                | 367-25-9    | 129.108  | liq                    | -7.5      | 170                                  | 1.268 <sup>25</sup>           | 1.5063 <sup>20</sup>  |                                                  |
| 3549 | <i>o</i> -Difluorobenzene                              | 1,2-Difluorobenzene                                                | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                                  | 367-11-3    | 114.093  | liq                    | -47.1     | 94                                   | 1.1599 <sup>18</sup>          | 1.4451 <sup>18</sup>  | i H <sub>2</sub> O; s ace, bz, chl               |
| 3550 | <i>m</i> -Difluorobenzene                              | 1,3-Difluorobenzene                                                | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                                  | 372-18-9    | 114.093  | liq                    | -69.12    | 82.6                                 | 1.1572 <sup>20</sup>          | 1.4374 <sup>20</sup>  | i H <sub>2</sub> O; s ace, bz                    |
| 3551 | <i>p</i> -Difluorobenzene                              | 1,4-Difluorobenzene                                                | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                                  | 540-36-3    | 114.093  | liq                    | -23.55    | 89                                   | 1.1701 <sup>20</sup>          | 1.4422 <sup>20</sup>  | i H <sub>2</sub> O; s ace, bz; sl ctc            |
| 3552 | 4,4'-Difluoro-1,1'-biphenyl                            | 4,4'-Difluorodiphenyl                                              | C <sub>12</sub> H <sub>8</sub> F <sub>2</sub>                                 | 398-23-2    | 190.189  | mcl pr (al) lf (w)     | 94.5      | 254.5                                |                               |                       | i H <sub>2</sub> O; vs EtOH, bz, chl; s eth, ace |
| 3553 | 1,1-Difluorocyclohexane                                |                                                                    | C <sub>6</sub> H <sub>10</sub> F <sub>2</sub>                                 | 371-90-4    | 120.140  | liq                    |           | 99.5                                 |                               |                       |                                                  |
| 3554 | 3,3-Difluorocyclopropene                               |                                                                    | C <sub>3</sub> H <sub>2</sub> F <sub>2</sub>                                  | 56830-75-2  | 76.045   | liq                    |           | 34                                   |                               |                       |                                                  |
| 3555 | Difluorodimethylsilane                                 |                                                                    | C <sub>2</sub> H <sub>6</sub> F <sub>2</sub> Si                               | 353-66-2    | 96.152   | col gas                | -87.5     | 2.5                                  |                               |                       |                                                  |
| 3556 | 1,5-Difluoro-2,4-dinitrobenzene                        |                                                                    | C <sub>6</sub> H <sub>2</sub> F <sub>2</sub> N <sub>2</sub> O <sub>4</sub>    | 327-92-4    | 204.088  |                        | 75.5      | 132 <sup>2</sup>                     |                               |                       | sl EtOH                                          |
| 3557 | Difluorodiphenylsilane                                 |                                                                    | C <sub>12</sub> H <sub>10</sub> F <sub>2</sub> Si                             | 312-40-3    | 220.290  |                        |           | 246; 157 <sup>50</sup>               | 1.145 <sup>17</sup>           | 1.5221 <sup>25</sup>  |                                                  |
| 3558 | 1,1-Difluoroethane                                     | Ethylidene difluoride                                              | C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>                                  | 75-37-6     | 66.050   | col gas                | -118.6    | -24.05                               | 0.896 <sup>25</sup> (p>1 atm) | 1.3011 <sup>-72</sup> |                                                  |
| 3559 | 1,2-Difluoroethane                                     | Ethylene difluoride                                                | C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>                                  | 624-72-6    | 66.050   | vol liq                |           | 26                                   |                               |                       | vs bz, eth, chl                                  |
| 3560 | 1,1-Difluoroethene                                     | Vinylidene fluoride                                                | C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>                                  | 75-38-7     | 64.034   | col gas                | -144      | -85.7                                |                               |                       | vs eth, EtOH                                     |
| 3561 | <i>cis</i> -1,2-Difluoroethene                         | <i>cis</i> -1,2-Difluoroethylene                                   | C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>                                  | 1630-77-9   | 64.034   | col gas                |           | -26                                  |                               |                       |                                                  |
| 3562 | <i>trans</i> -1,2-Difluoroethene                       | <i>trans</i> -1,2-Difluoroethylene                                 | C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>                                  | 1630-78-0   | 64.034   | col gas                |           | -53.1                                |                               |                       |                                                  |
| 3563 | Difluoromethane                                        | Methylene fluoride                                                 | CH <sub>2</sub> F <sub>2</sub>                                                | 75-10-5     | 52.024   | col gas                | -136.8 tp | -51.6                                | 1.2139 <sup>-52</sup>         |                       | i H <sub>2</sub> O; s EtOH                       |

*N,N*-Diethyl-4-pyridinecarboxamide3,3-Diethyl-2,4-(1*H*,3*H*)-pyridinedione

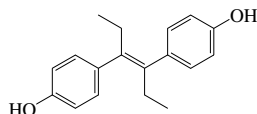
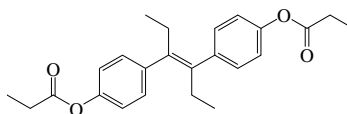
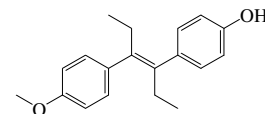
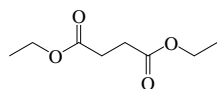
Diethyl sebacate



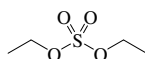
Diethyl selenide



Diethylsilane

*trans*-Diethylstilbestrol*trans*-Diethylstilbestrol dipropionate*trans*-Diethylstilbestrol monomethyl ether

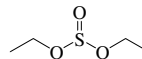
Diethyl succinate



Diethyl sulfate



Diethyl sulfide



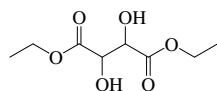
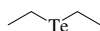
Diethyl sulfoxide



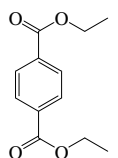
Diethyl sulfone



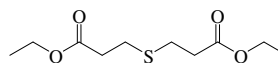
Diethyl sulfoxide

Diethyl *DL*-tartrate

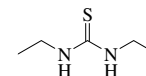
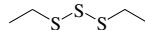
Diethyl telluride



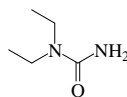
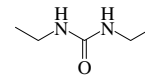
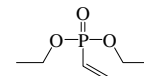
Diethyl terephthalate



Diethyl thiodipropionate

*N,N'*-Diethylthiourea*N,N*-Diethyl-1,1,1-trimethylsilanamine

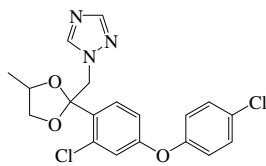
Diethyltrisulfide

*N,N*-Diethylurea*N,N'*-Diethylurea

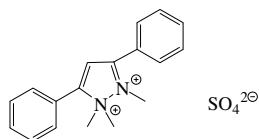
Diethyl vinylphosphonate



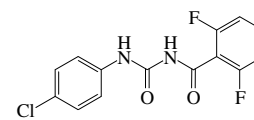
Diethyl zinc



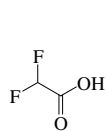
Difenoconazole



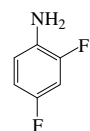
Difenzoquat methyl sulfate



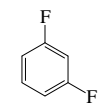
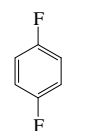
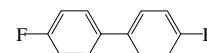
Diflubenzuron



Difluoroacetic acid



2,4-Difluoroaniline

*o*-Difluorobenzene*m*-Difluorobenzene*p*-Difluorobenzene

4,4'-Difluoro-1,1'-biphenyl



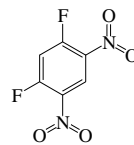
1,1-Difluorocyclohexane



3,3-Difluorocyclopropene



Difluorodimethylsilane



1,5-Difluoro-2,4-dinitrobenzene



Difluorodiphenylsilane



1,1-Difluoroethane



1,2-Difluoroethane

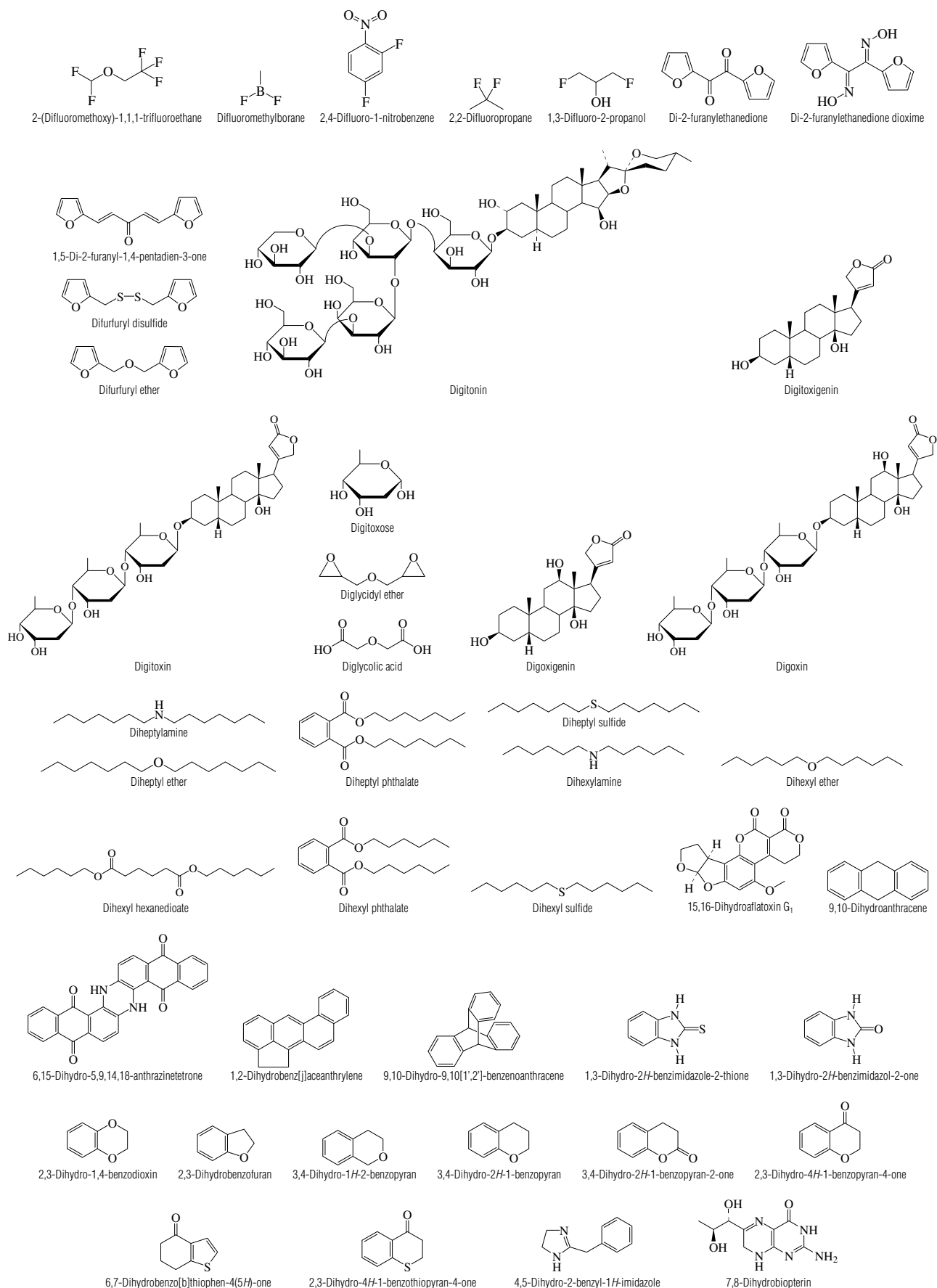


1,1-Difluoroethene

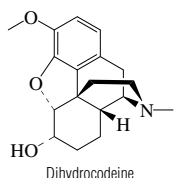
*cis*-1,2-Difluoroethene*trans*-1,2-Difluoroethene

Difluoromethane

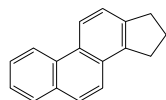
| No.  | Name                                                    | Synonym                                   | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                      | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup>        | n <sub>D</sub>       | Solubility                                                                  |
|------|---------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------|------------|----------|------------------------------------|---------|----------------------------------------|-----------------------------------|----------------------|-----------------------------------------------------------------------------|
| 3564 | 2-(Difluoromethoxy)-1,1,1-trifluoroethane               | Difluoromethyl 2,2,2-trifluoroethyl ether | C <sub>3</sub> H <sub>3</sub> F <sub>5</sub> O                | 1885-48-9  | 150.047  | col liq                            |         | 29                                     |                                   |                      |                                                                             |
| 3565 | Difluoromethylborane                                    |                                           | CH <sub>3</sub> BF <sub>2</sub>                               | 373-64-8   | 63.843   | gas                                |         | -78.5 <sup>287</sup>                   |                                   |                      | reac H <sub>2</sub> O                                                       |
| 3566 | 2,4-Difluoro-1-nitrobenzene                             |                                           | C <sub>6</sub> H <sub>3</sub> F <sub>2</sub> NO <sub>2</sub>  | 446-35-5   | 159.091  |                                    | 9.8     | 207                                    | 1.4571 <sup>14</sup>              | 1.5149 <sup>14</sup> | sl chl                                                                      |
| 3567 | 2,2-Difluoropropane                                     |                                           | C <sub>3</sub> H <sub>6</sub> F <sub>2</sub>                  | 420-45-1   | 80.077   | col gas                            | -104.8  | -0.4                                   | 0.9205 <sup>20</sup><br>(p>1 atm) | 1.2904 <sup>20</sup> |                                                                             |
| 3568 | 1,3-Difluoro-2-propanol                                 |                                           | C <sub>3</sub> H <sub>6</sub> F <sub>2</sub> O                | 453-13-4   | 96.076   |                                    |         | 127; 55 <sup>34</sup>                  | 1.24 <sup>25</sup>                | 1.3725 <sup>20</sup> |                                                                             |
| 3569 | Di-2-furanylethanedione                                 |                                           | C <sub>10</sub> H <sub>6</sub> O <sub>4</sub>                 | 492-94-4   | 190.153  | ye nd (al),<br>cry (bz)            | 166.3   |                                        |                                   |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, bz, chl                                |
| 3570 | Di-2-furanylethanedione dioxime                         | α-Furildioxime                            | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub>  | 522-27-0   | 220.182  |                                    | 167     |                                        |                                   |                      | sl EtOH, eth, bz,<br>lig                                                    |
| 3571 | 1,5-Di-2-furanyl-1,4-pentadien-3-one                    |                                           | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                | 886-77-1   | 214.216  | hyg pr (peth)<br>ye pr (lig)       | 60.5    | 181 <sup>4</sup>                       |                                   |                      | vs eth, EtOH,<br>chl                                                        |
| 3572 | Difurfuryl disulfide                                    | Furfuryl disulfide                        | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub> S <sub>2</sub> | 4437-20-1  | 226.315  |                                    | 10      | 167 <sup>13</sup> , 112 <sup>0.5</sup> |                                   |                      | vs EtOH                                                                     |
| 3573 | Difurfuryl ether                                        | Furfuryl ether                            | C <sub>10</sub> H <sub>10</sub> O <sub>3</sub>                | 4437-22-3  | 178.184  |                                    |         | 101 <sup>2</sup>                       | 1.1405 <sup>20</sup>              | 1.5088 <sup>20</sup> | i H <sub>2</sub> O                                                          |
| 3574 | Digitonin                                               |                                           | C <sub>55</sub> H <sub>92</sub> O <sub>29</sub>               | 11024-24-1 | 1229.312 |                                    | 237.5   |                                        |                                   |                      |                                                                             |
| 3575 | Digitoxigenin                                           |                                           | C <sub>23</sub> H <sub>34</sub> O <sub>4</sub>                | 143-62-4   | 374.514  |                                    | 253     |                                        |                                   |                      | s EtOH; vs<br>MeOH                                                          |
| 3576 | Digitoxin                                               |                                           | C <sub>41</sub> H <sub>64</sub> O <sub>13</sub>               | 71-63-6    | 764.939  | pr (dil al)                        | 255.5   |                                        |                                   |                      | sl H <sub>2</sub> O; vs EtOH;<br>s eth, chl,<br>MeOH, py                    |
| 3577 | Digitoxose                                              |                                           | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>                 | 527-52-6   | 148.157  | cry<br>(MeOH+eth)                  | 112     |                                        |                                   |                      | vs H <sub>2</sub> O, ace; s<br>py, AcOEt                                    |
| 3578 | Diglycidyl ether                                        | Bis(2,3-epoxypropyl) ether                | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                 | 2238-07-5  | 130.141  |                                    |         | 260                                    | 1.1195 <sup>20</sup>              |                      |                                                                             |
| 3579 | Diglycolic acid                                         | 2,2'-Oxydiacetic acid                     | C <sub>4</sub> H <sub>6</sub> O <sub>5</sub>                  | 110-99-6   | 134.088  | mcl pr (w +<br>1)                  | 148     | dec                                    |                                   |                      | vs H <sub>2</sub> O, eth,<br>EtOH                                           |
| 3580 | Digoxigenin                                             |                                           | C <sub>23</sub> H <sub>34</sub> O <sub>5</sub>                | 1672-46-4  | 390.513  | pr (AcOEt)                         | 222     |                                        |                                   |                      | vs EtOH, MeOH;<br>sl chl                                                    |
| 3581 | Digoxin                                                 |                                           | C <sub>41</sub> H <sub>64</sub> O <sub>14</sub>               | 20830-75-5 | 780.939  | trc pl (dil al,<br>py)             | 249 dec |                                        |                                   |                      | vs EtOH                                                                     |
| 3582 | Diheptylamine                                           | N-Heptyl-1-heptanamine                    | C <sub>14</sub> H <sub>31</sub> N                             | 2470-68-0  | 213.403  | nd                                 | 31.5    | 271; 135 <sup>9</sup>                  | 0.7956 <sup>21</sup>              |                      | sl H <sub>2</sub> O; s EtOH;<br>vs eth                                      |
| 3583 | Diheptyl ether                                          | Heptyl ether                              | C <sub>14</sub> H <sub>30</sub> O                             | 629-64-1   | 214.387  |                                    |         | 258.5                                  | 0.8008 <sup>20</sup>              | 1.4275 <sup>20</sup> | vs eth, EtOH                                                                |
| 3584 | Diheptyl phthalate                                      |                                           | C <sub>22</sub> H <sub>34</sub> O <sub>4</sub>                | 3648-21-3  | 362.503  |                                    |         | 360                                    |                                   |                      |                                                                             |
| 3585 | Diheptyl sulfide                                        | Heptyl sulfide                            | C <sub>14</sub> H <sub>30</sub> S                             | 629-65-2   | 230.453  |                                    | 70      | 298                                    | 0.8416 <sup>20</sup>              | 1.4606 <sup>20</sup> | i H <sub>2</sub> O; s eth                                                   |
| 3586 | Dihexylamine                                            | N-Hexyl-1-hexanamine                      | C <sub>12</sub> H <sub>27</sub> N                             | 143-16-8   | 185.349  | liq                                | -13.1   | 236; 75 <sup>1</sup>                   | 0.7889 <sup>20</sup>              | 1.4339 <sup>20</sup> | s EtOH, eth                                                                 |
| 3587 | Dihexyl ether                                           | Hexyl ether                               | C <sub>12</sub> H <sub>26</sub> O                             | 112-58-3   | 186.333  |                                    |         | 226                                    | 0.7936 <sup>20</sup>              | 1.4204 <sup>20</sup> | i H <sub>2</sub> O; s eth; sl<br>ctc                                        |
| 3588 | Dihexyl hexanedioate                                    |                                           | C <sub>18</sub> H <sub>34</sub> O <sub>4</sub>                | 110-33-8   | 314.461  | liq                                | -9      | 348; 182.5 <sup>4</sup>                | 0.941 <sup>20</sup>               |                      |                                                                             |
| 3589 | Dihexyl phthalate                                       |                                           | C <sub>20</sub> H <sub>30</sub> O <sub>4</sub>                | 84-75-3    | 334.450  |                                    |         | 210 <sup>5</sup>                       |                                   |                      |                                                                             |
| 3590 | Dihexyl sulfide                                         | Hexyl sulfide                             | C <sub>12</sub> H <sub>26</sub> S                             | 6294-31-1  | 202.399  |                                    |         | 230; 136 <sup>20</sup>                 | 0.8411 <sup>20</sup>              | 1.4586 <sup>20</sup> |                                                                             |
| 3591 | 15,16-Dihydroaflatoxin G <sub>1</sub>                   | Aflatoxin G <sub>2</sub>                  | C <sub>17</sub> H <sub>14</sub> O <sub>7</sub>                | 7241-98-7  | 330.289  |                                    | 239.3   |                                        |                                   |                      |                                                                             |
| 3592 | 9,10-Dihydroanthracene                                  |                                           | C <sub>14</sub> H <sub>12</sub>                               | 613-31-0   | 180.245  | tab or pr                          | 111     | 305                                    | 1.215 <sup>20</sup>               |                      | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl                                 |
| 3593 | 6,15-Dihydro-5,9,14,18-anthrazinetetrone                | Indanthrene                               | C <sub>28</sub> H <sub>14</sub> N <sub>2</sub> O <sub>4</sub> | 81-77-6    | 442.422  | bl nd                              | 485 dec |                                        |                                   |                      | i H <sub>2</sub> O, EtOH,<br>eth, ace, bz; s<br>PhNO <sub>2</sub> , dil alk |
| 3594 | 1,2-Dihydrobenz[ <i>j</i> ]aceanthrylene                | Cholanthrene                              | C <sub>20</sub> H <sub>14</sub>                               | 479-23-2   | 254.325  | pa ye lf (bz-<br>al)               | 170.4   |                                        |                                   |                      | i H <sub>2</sub> O; s EtOH,<br>bz, HOAc, lig,<br>tol                        |
| 3595 | 9,10-Dihydro-9,10[1',2']-benzoanthracene                | Triptycene                                | C <sub>20</sub> H <sub>14</sub>                               | 477-75-8   | 254.325  | cry (cyhex)                        | 256     |                                        |                                   |                      |                                                                             |
| 3596 | 1,3-Dihydro-2 <i>H</i> -benzimidazole-2-thione          | 2-Benzimidazolethiol                      | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> S                | 583-39-1   | 150.201  | pl (dil al or<br>NH <sub>3</sub> ) | 298     |                                        |                                   |                      | vs EtOH                                                                     |
| 3597 | 1,3-Dihydro-2 <i>H</i> -benzimidazol-2-one              |                                           | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O                | 615-16-7   | 134.135  | lf (w or al)                       | 318 dec |                                        |                                   |                      | sl H <sub>2</sub> O, eth, bz;<br>s ace; vs EtOH                             |
| 3598 | 2,3-Dihydro-1,4-benzodioxin                             |                                           | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                  | 493-09-4   | 136.149  |                                    |         | 212; 103 <sup>6</sup>                  | 1.180 <sup>20</sup>               | 1.5485 <sup>20</sup> |                                                                             |
| 3599 | 2,3-Dihydrobenzofuran                                   | Coumaran                                  | C <sub>8</sub> H <sub>8</sub> O                               | 496-16-2   | 120.149  | liq                                | -21.5   | 188.5                                  | 1.058 <sup>25</sup>               | 1.5497 <sup>20</sup> | vs eth, EtOH,<br>chl                                                        |
| 3600 | 3,4-Dihydro-1 <i>H</i> -2-benzopyran                    | Isochroman                                | C <sub>9</sub> H <sub>10</sub> O                              | 493-05-0   | 134.174  |                                    | 4       | 110 <sup>25</sup> , 90 <sup>12</sup>   | 1.067 <sup>25</sup>               | 1.5444 <sup>20</sup> |                                                                             |
| 3601 | 3,4-Dihydro-2 <i>H</i> -1-benzopyran                    |                                           | C <sub>9</sub> H <sub>10</sub> O                              | 493-08-3   | 134.174  |                                    | 4.8     | 215; 98 <sup>18</sup>                  | 1.072 <sup>20</sup>               | 1.5444 <sup>20</sup> | s H <sub>2</sub> O; msc os                                                  |
| 3602 | 3,4-Dihydro-2 <i>H</i> -1-benzopyran-2-one              |                                           | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                  | 119-84-6   | 148.159  | lf                                 | 25      | 272                                    | 1.169 <sup>18</sup>               | 1.5563 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH,<br>eth, ctc; s chl                             |
| 3603 | 2,3-Dihydro-4 <i>H</i> -1-benzopyran-4-one              | 4-Chromanone                              | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                  | 491-37-2   | 148.159  |                                    | 36.5    | 160 <sup>50</sup> , 127 <sup>13</sup>  | 1.1291 <sup>100</sup>             | 1.5750               | s EtOH; vs eth,<br>ace, bz, chl; sl<br>ctc                                  |
| 3604 | 6,7-Dihydrobenzo[ <i>b</i> ]thiophen-4(5 <i>H</i> )-one | 4,5,6,7-Tetrahydro-4-benzothiophenone     | C <sub>8</sub> H <sub>8</sub> OS                              | 13414-95-4 | 152.214  |                                    |         |                                        |                                   |                      | sl chl                                                                      |
| 3605 | 2,3-Dihydro-4 <i>H</i> -1-benzothiopyran-4-one          |                                           | C <sub>9</sub> H <sub>8</sub> OS                              | 3528-17-4  | 164.224  |                                    | 29      | 154 <sup>12</sup>                      | 1.2487 <sup>14</sup>              | 1.6395 <sup>20</sup> |                                                                             |
| 3606 | 4,5-Dihydro-2-benzyl-1 <i>H</i> -imidazole              | Tolazoline                                | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub>                | 59-98-3    | 160.215  | cry (peth)                         | 67      |                                        |                                   |                      |                                                                             |
| 3607 | 7,8-Dihydrobiopterin                                    |                                           | C <sub>9</sub> H <sub>13</sub> N <sub>5</sub> O <sub>3</sub>  | 6779-87-9  | 239.231  | hyg nd (w)                         |         |                                        |                                   |                      | s H <sub>2</sub> O                                                          |



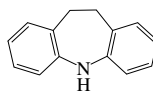
| No.  | Name                                                           | Synonym                          | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                   | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|------|----------------------------------------------------------------|----------------------------------|---------------------------------------------------------------|------------|----------|---------------------------------|---------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------|
| 3608 | Dihydrocodeine                                                 |                                  | C <sub>18</sub> H <sub>23</sub> NO <sub>3</sub>               | 125-28-0   | 301.381  | cry (aq, MeOH)                  | 112.5   | 248 <sup>15</sup>                     |                            |                      |                                                   |
| 3609 | 16,17-Dihydro-15H-cyclopenta[a]phenanthrene                    | 1,2-Cyclopentenophenanthrene     | C <sub>17</sub> H <sub>14</sub>                               | 482-66-6   | 218.293  | nd (al, petr)                   | 135.5   |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, peth                  |
| 3610 | 10,11-Dihydro-5H-dibenz[b,f]azepine                            |                                  | C <sub>14</sub> H <sub>13</sub> N                             | 494-19-9   | 195.260  |                                 |         |                                       |                            |                      | s chl                                             |
| 3611 | 10,11-Dihydro-5H-dibenzo[a,d]cyclohepten-5-one                 |                                  | C <sub>15</sub> H <sub>12</sub> O                             | 1210-35-1  | 208.255  |                                 | 30      | 203 <sup>7</sup>                      | 1.1635 <sup>20</sup>       | 1.6324 <sup>20</sup> |                                                   |
| 3612 | 2,5-Dihydro-2,5-dimethoxyfuran                                 |                                  | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                 | 332-77-4   | 130.141  |                                 |         | 161                                   | 1.073 <sup>25</sup>        | 1.4339 <sup>20</sup> |                                                   |
| 3613 | 3,4-Dihydro-6,7-dimethoxy-1(2H)-isoquinolinone                 | Corydaldine                      | C <sub>11</sub> H <sub>13</sub> NO <sub>3</sub>               | 493-49-2   | 207.226  | mcl pr (w, al)                  | 175     |                                       |                            |                      | vs H <sub>2</sub> O, bz, eth, EtOH                |
| 3614 | 1,2-Dihydro-1,5-dimethyl-2-phenyl-3H-pyrazol-3-one             | Antipyrine                       | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O              | 60-80-0    | 188.225  | lf or sc (eth, bz)              | 114     | 319                                   |                            |                      | vs H <sub>2</sub> O, EtOH                         |
| 3615 | 2,3-Dihydro-1,4-dioxin                                         |                                  | C <sub>8</sub> H <sub>6</sub> O <sub>2</sub>                  | 543-75-9   | 86.090   |                                 |         | 94.1                                  | 1.0836 <sup>20</sup>       | 1.4372 <sup>20</sup> | s ctc                                             |
| 3616 | 9,10-Dihydro-9,10-dioxo-2-anthracenecarboxylic acid            |                                  | C <sub>15</sub> H <sub>8</sub> O <sub>4</sub>                 | 117-78-2   | 252.223  | ye nd (HOAc)                    | 291     | sub                                   |                            |                      | sl EtOH, HOAc; i eth, bz; s ace                   |
| 3617 | 9,10-Dihydro-9,10-dioxo-1,5-anthracenedisulfonic acid          |                                  | C <sub>14</sub> H <sub>6</sub> O <sub>8</sub> S <sub>2</sub>  | 117-14-6   | 368.339  | ye nd (HCl +4w) pl (dil HOAc)   | 310 dec |                                       |                            |                      | vs H <sub>2</sub> O, EtOH, HOAc                   |
| 3618 | 9,10-Dihydro-9,10-dioxo-2,6-anthracenedisulfonic acid          |                                  | C <sub>14</sub> H <sub>6</sub> O <sub>8</sub> S <sub>2</sub>  | 84-50-4    | 368.339  |                                 |         |                                       |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth, bz            |
| 3619 | 9,10-Dihydro-9,10-dioxo-1-anthracenesulfonic acid              |                                  | C <sub>14</sub> H <sub>6</sub> O <sub>5</sub> S               | 82-49-5    | 288.276  | lf (HOAc) ye lf (conc HCl, +3w) | 216.0   |                                       |                            |                      | vs H <sub>2</sub> O, HOAc; s EtOH                 |
| 3620 | 9,10-Dihydro-9,10-dioxo-2-anthracenesulfonic acid              |                                  | C <sub>14</sub> H <sub>6</sub> O <sub>5</sub> S               | 84-48-0    | 288.276  | ye lf (+3w)                     |         |                                       |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth                |
| 3621 | 9,10-Dihydro-9,10-dioxo-1-anthracenesulfonic acid, sodium salt | Sodium anthraquinone-1-sulfonate | C <sub>14</sub> H <sub>7</sub> NaO <sub>5</sub> S             | 128-56-3   | 310.258  | ye lf (w)                       |         |                                       |                            |                      | sl H <sub>2</sub> O                               |
| 3622 | 9,10-Dihydro-9,10-dioxo-2-anthracenesulfonic acid, sodium salt |                                  | C <sub>14</sub> H <sub>7</sub> NaO <sub>5</sub> S             | 131-08-8   | 310.258  |                                 |         |                                       |                            |                      | sl DMSO                                           |
| 3623 | 7,8-Dihydrofolic acid                                          |                                  | C <sub>19</sub> H <sub>21</sub> N <sub>7</sub> O <sub>6</sub> | 4033-27-6  | 443.413  | ye cry                          |         |                                       |                            |                      |                                                   |
| 3624 | 2,3-Dihydrofuran                                               |                                  | C <sub>4</sub> H <sub>6</sub> O                               | 1191-99-7  | 70.090   |                                 |         | 54.5                                  | 0.927 <sup>25</sup>        | 1.4239 <sup>20</sup> |                                                   |
| 3625 | 2,5-Dihydrofuran                                               |                                  | C <sub>4</sub> H <sub>6</sub> O                               | 1708-29-8  | 70.090   |                                 |         |                                       |                            | 1.4311 <sup>20</sup> |                                                   |
| 3626 | 2,3-Dihydro-3-hydroxy-1-methyl-1H-indole-5,6-dione             | Adrenochrome                     | C <sub>9</sub> H <sub>8</sub> NO <sub>3</sub>                 | 54-06-8    | 179.172  |                                 | 125 dec |                                       |                            |                      | vs H <sub>2</sub> O, EtOH; i eth, bz              |
| 3627 | 2,3-Dihydro-1H-inden-5-amine                                   |                                  | C <sub>9</sub> H <sub>11</sub> N                              | 24425-40-9 | 133.190  | nd (peth)                       | 37.5    | 248; 131 <sup>15</sup>                |                            |                      | sl H <sub>2</sub> O, chl; s eth, ace, bz          |
| 3628 | 2,3-Dihydro-1H-inden-1-ol                                      |                                  | C <sub>9</sub> H <sub>10</sub> O                              | 6351-10-6  | 134.174  | pl (peth)                       | 54.8    | 220; 128 <sup>12</sup>                |                            |                      | vs bz, EtOH, chl                                  |
| 3629 | 2,3-Dihydro-1H-inden-5-ol                                      |                                  | C <sub>9</sub> H <sub>10</sub> O                              | 1470-94-6  | 134.174  |                                 | 58      | 253                                   |                            |                      | sl H <sub>2</sub> O, peth; vs EtOH, eth; s sulf   |
| 3630 | 2,3-Dihydro-1H-inden-1-one                                     |                                  | C <sub>9</sub> H <sub>8</sub> O                               | 83-33-0    | 132.159  | ta, nd (w + 3)                  | 42      | 243; 129 <sup>12</sup>                | 1.0943 <sup>40</sup>       | 1.561 <sup>25</sup>  | sl H <sub>2</sub> O; vs EtOH, eth, ace, chl       |
| 3631 | 1,3-Dihydro-2H-inden-2-one                                     | 2-Indanone                       | C <sub>9</sub> H <sub>8</sub> O                               | 615-13-4   | 132.159  | nd (al, eth)                    | 59      | dec 218                               | 1.0712 <sup>69</sup>       | 1.538 <sup>67</sup>  | i H <sub>2</sub> O; vs EtOH, eth, ace, chl        |
| 3632 | 1a,6a-Dihydro-6H-indeno[1,2-b]oxirene                          |                                  | C <sub>9</sub> H <sub>8</sub> O                               | 768-22-9   | 132.159  |                                 | 24.5    | 113 <sup>20</sup> , 98 <sup>6</sup>   | 1.1255 <sup>24</sup>       |                      | s chl                                             |
| 3633 | 2,3-Dihydro-1H-indole                                          |                                  | C <sub>8</sub> H <sub>9</sub> N                               | 496-15-1   | 119.164  |                                 |         | 229                                   | 1.069 <sup>20</sup>        | 1.5923 <sup>20</sup> | sl H <sub>2</sub> O; s eth, ace, bz               |
| 3634 | 1,3-Dihydro-2H-indol-2-one                                     |                                  | C <sub>8</sub> H <sub>7</sub> NO                              | 59-48-3    | 133.148  | nd (w)                          | 128     | 227 <sup>23</sup> , 195 <sup>17</sup> |                            |                      | s H <sub>2</sub> O, EtOH, eth                     |
| 3635 | 2,3-Dihydro-1H-isindol-1-one                                   |                                  | C <sub>8</sub> H <sub>7</sub> NO                              | 480-91-1   | 133.148  | nd (w)                          | 151     | 338; 103 <sup>18</sup>                |                            |                      | vs eth, EtOH, chl                                 |
| 3636 | Dihydro-α-lipoic acid                                          | 6,8-Dimercaptooctanoic acid      | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> S <sub>2</sub>  | 462-20-4   | 208.342  | ye liq                          |         | 145 <sup>0,2</sup>                    |                            |                      |                                                   |
| 3637 | 3,4-Dihydro-6-methoxy-1(2H)-naphthalenone                      | 6-Methoxy-α-tetralone            | C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>                | 1078-19-9  | 176.212  | cry (MeOH, liq)                 | 78      | 171 <sup>11</sup>                     |                            |                      |                                                   |
| 3638 | 3,4-Dihydro-2-methoxy-2H-pyran                                 |                                  | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 4454-05-1  | 114.142  | liq                             |         | 128                                   | 1.006                      | 1.4420 <sup>20</sup> |                                                   |
| 3639 | 1,2-Dihydro-3-methylbenz[j]aceanthrylene                       | 3-Methylcholanthrene             | C <sub>21</sub> H <sub>16</sub>                               | 56-49-5    | 268.352  | ye nd (bz)                      | 180     | 280 <sup>80</sup>                     | 1.28 <sup>20</sup>         |                      | i H <sub>2</sub> O                                |
| 3640 | 2,3-Dihydro-2-methylbenzofuran                                 |                                  | C <sub>9</sub> H <sub>10</sub> O                              | 1746-11-8  | 134.174  |                                 |         | 197.5                                 | 1.061 <sup>25</sup>        | 1.5308               |                                                   |
| 3641 | Dihydro-3-methylene-2,5-furandione                             |                                  | C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                  | 2170-03-8  | 112.084  | orth bipym pr (eth, chl)        | 69      | 139 <sup>30</sup> , 114 <sup>18</sup> |                            |                      | sl eth; vs chl                                    |
| 3642 | Dihydro-3-methylene-2(3H)-furanone                             | α-Methylene butyrolactone        | C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                  | 547-65-9   | 98.101   |                                 |         | 85 <sup>10</sup>                      | 1.1206 <sup>20</sup>       | 1.4650 <sup>20</sup> | s H <sub>2</sub> O, eth, ace, bz; sl ctc; vs EtOH |
| 3643 | Dihydro-3-methyl-2,5-furandione                                |                                  | C <sub>5</sub> H <sub>6</sub> O <sub>3</sub>                  | 4100-80-5  | 114.100  |                                 | 34      | 239                                   | 1.22 <sup>25</sup>         |                      |                                                   |
| 3644 | Dihydro-3-methyl-2(3H)-furanone                                | 2-Methyl-γ-butyrolactone         | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                  | 1679-47-6  | 100.117  | liq                             |         | 200; 79 <sup>10</sup>                 | 1.0570 <sup>20</sup>       | 1.4325 <sup>20</sup> |                                                   |
| 3645 | Dihydro-4-methyl-2(3H)-furanone                                | 3-Methyl-γ-butyrolactone         | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                  | 1679-49-8  | 100.117  | liq                             |         | 76 <sup>11</sup>                      | 1.058 <sup>20</sup>        | 1.4339 <sup>20</sup> |                                                   |
| 3646 | Dihydro-5-methyl-2(3H)-furanone, (±)                           | (±)-γ-Valerolactone              | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                  | 57129-69-8 | 100.117  | liq                             | -31     | 206                                   | 1.0551 <sup>20</sup>       | 1.4328 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, ace; sl ctc         |
| 3647 | 4,5-Dihydro-2-methyl-1H-imidazole                              | Lysidine                         | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub>                  | 534-26-9   | 84.120   | hyg                             | 107     | 196.5                                 |                            |                      | vs H <sub>2</sub> O, EtOH; i eth; s chl           |



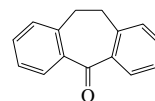
Dihydrocodeine



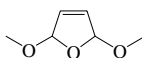
16,17-Dihydro-15H-cyclopenta[a]phenanthrene



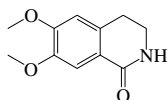
10,11-Dihydro-5H-dibenz[b,f]azepine



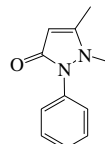
10,11-Dihydro-5H-dibenzo[a,d]cyclohepten-5-one



2,5-Dihydro-2,5-dimethoxyfuran



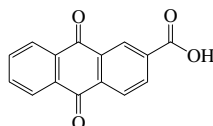
3,4-Dihydro-6,7-dimethoxy-1(2H)-isoquinolinone



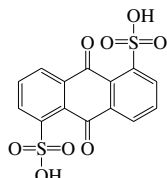
1,2-Dihydro-1,5-dimethyl-2-phenyl-3H-pyrazol-3-one



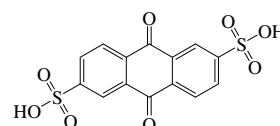
2,3-Dihydro-1,4-dioxin



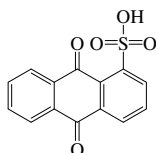
9,10-Dihydro-9,10-dioxo-2-anthracenecarboxylic acid



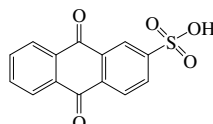
9,10-Dihydro-9,10-dioxo-1,5-anthracenedisulfonic acid



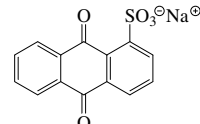
9,10-Dihydro-9,10-dioxo-2,6-anthracenedisulfonic acid



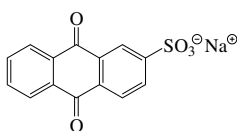
9,10-Dihydro-9,10-dioxo-1-anthracenesulfonic acid



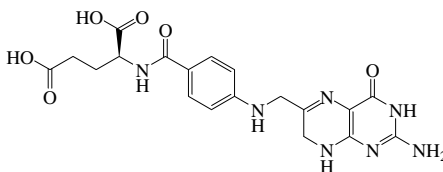
9,10-Dihydro-9,10-dioxo-2-anthracenesulfonic acid



9,10-Dihydro-9,10-dioxo-1-anthracenesulfonic acid, sodium salt



9,10-Dihydro-9,10-dioxo-2-anthracenesulfonic acid, sodium salt



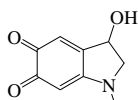
7,8-Dihydrofolic acid



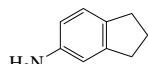
2,3-Dihydrofuran



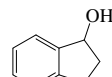
2,5-Dihydrofuran



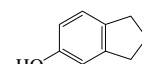
2,3-Dihydro-3-hydroxy-1-methyl-1H-indole-5,6-dione



2,3-Dihydro-1H-inden-5-amine



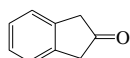
2,3-Dihydro-1H-inden-1-ol



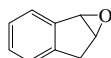
2,3-Dihydro-1H-inden-5-ol



2,3-Dihydro-1H-inden-1-one



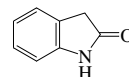
1,3-Dihydro-2H-inden-2-one



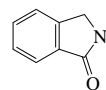
1a,6a-Dihydro-6H-indeno[1,2-b]oxirene



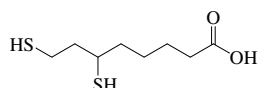
2,3-Dihydro-1H-indole



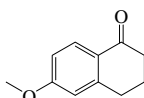
1,3-Dihydro-2H-indol-2-one



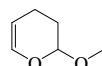
2,3-Dihydro-1H-isoindol-1-one



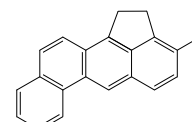
Dihydro-α-lipoic acid



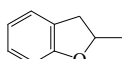
3,4-Dihydro-6-methoxy-1(2H)-naphthalenone



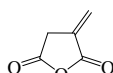
3,4-Dihydro-2-methoxy-2H-pyran



1,2-Dihydro-3-methylbenz[j]aceanthrylene



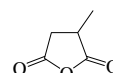
2,3-Dihydro-2-methylbenzofuran



Dihydro-3-methylene-2,5-furandione



Dihydro-3-methylene-2(3H)-furanone



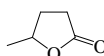
Dihydro-3-methyl-2,5-furandione



Dihydro-3-methyl-2(3H)-furanone



Dihydro-4-methyl-2(3H)-furanone



Dihydro-5-methyl-2(3H)-furanone, (±)



4,5-Dihydro-2-methyl-1H-imidazole

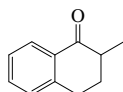
| No.  | Name                                                                        | Synonym                                   | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form    | mp/°C | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|------|-----------------------------------------------------------------------------|-------------------------------------------|-----------------------------------------------------------------|------------|----------|------------------|-------|----------------------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 3648 | 1,3-Dihydro-1-methyl-2 <i>H</i> -imidazole-2-thione                         | Methimazole                               | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> S                  | 60-56-0    | 114.169  | lf (al)          | 146   | dec 280                                |                            |                      | vs H <sub>2</sub> O; s EtOH, chl; sl eth, bz, lig   |
| 3649 | 2,3-Dihydro-1-methyl-1 <i>H</i> -indene                                     |                                           | C <sub>10</sub> H <sub>12</sub>                                 | 767-58-8   | 132.202  |                  |       | 190.6                                  | 0.938 <sup>25</sup>        | 1.5266 <sup>20</sup> | i H <sub>2</sub> O                                  |
| 3650 | 3,4-Dihydro-2-methyl-1(2 <i>H</i> )-naphthalene                             |                                           | C <sub>11</sub> H <sub>12</sub> O                               | 1590-08-5  | 160.212  |                  | 15    | 136 <sup>16</sup>                      | 1.057 <sup>25</sup>        | 1.5535 <sup>20</sup> |                                                     |
| 3651 | 4-(4,5-Dihydro-3-methyl-5-oxo-1 <i>H</i> -pyrazol-1-yl)benzenesulfonic acid |                                           | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub> S | 89-36-1    | 254.262  | nd (w+1)         | ≈300  | dec                                    |                            |                      |                                                     |
| 3652 | 1,2-Dihydro-5-methyl-2-phenyl-3 <i>H</i> -pyrazol-3-one                     | 5-Hydroxy-3-methyl-1-phenylpyrazole       | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub> O                | 19735-89-8 | 174.198  |                  | 128   | 287 <sup>105</sup> , 191 <sup>17</sup> | 1.2600 <sup>20</sup>       | 1.637                | s H <sub>2</sub> O, EtOH; sl bz; i peth             |
| 3653 | 2,4-Dihydro-5-methyl-2-phenyl-3 <i>H</i> -pyrazol-3-one                     |                                           | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub> O                | 89-25-8    | 174.198  | mcl pr (w)       | 127   | 287 <sup>105</sup> , 191 <sup>17</sup> |                            | 1.637                |                                                     |
| 3654 | 3,6-Dihydro-4-methyl-2 <i>H</i> -pyran                                      |                                           | C <sub>6</sub> H <sub>10</sub> O                                | 16302-35-5 | 98.142   |                  |       | 117.5                                  | 0.912 <sup>25</sup>        | 1.4495 <sup>20</sup> |                                                     |
| 3655 | 4,5-Dihydro-2-methylthiazole                                                |                                           | C <sub>4</sub> H <sub>6</sub> NS                                | 2346-00-1  | 101.171  | liq              | -101  | 145                                    | 1.067 <sup>25</sup>        | 1.5200 <sup>20</sup> |                                                     |
| 3656 | 1,2-Dihydronaphthalene                                                      |                                           | C <sub>10</sub> H <sub>10</sub>                                 | 447-53-0   | 130.186  | liq              | -8    | 206.5                                  | 0.9974 <sup>20</sup>       | 1.5814 <sup>20</sup> |                                                     |
| 3657 | 1,4-Dihydronaphthalene                                                      | Δ 2-Dialin                                | C <sub>10</sub> H <sub>10</sub>                                 | 612-17-9   | 130.186  | pl               | 25    | 211.5                                  | 0.9928 <sup>33</sup>       | 1.5577 <sup>20</sup> |                                                     |
| 3658 | 3,4-Dihydro-2(1 <i>H</i> )-naphthalene                                      |                                           | C <sub>10</sub> H <sub>10</sub> O                               | 530-93-8   | 146.185  |                  | 18    | 237                                    | 1.1055 <sup>27</sup>       | 1.5598 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz                       |
| 3659 | 1,2-Dihydro-5-nitroacenaphthylene                                           |                                           | C <sub>12</sub> H <sub>8</sub> NO <sub>2</sub>                  | 602-87-9   | 199.205  |                  | 103   |                                        |                            |                      | s H <sub>2</sub> O, EtOH, eth, lig                  |
| 3660 | 1,6-Dihydro-6-oxo-3-pyridinecarboxylic acid                                 |                                           | C <sub>6</sub> H <sub>6</sub> NO <sub>3</sub>                   | 5006-66-6  | 139.109  | nd(w)            | 310   | dec                                    | sub                        |                      | sl H <sub>2</sub> O, tfa; i EtOH, eth, bz, chl      |
| 3661 | Dihydro-5-pentyl-2(3 <i>H</i> )-furanone                                    | 4-Hydroxynonanoic acid lactone            | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>                   | 104-61-0   | 156.222  | oil              |       | 134 <sup>12</sup>                      |                            |                      |                                                     |
| 3662 | 9,10-Dihydrophenanthrene                                                    |                                           | C <sub>14</sub> H <sub>12</sub>                                 | 776-35-2   | 180.245  | nd (MeOH)        | 34.5  | 168 <sup>15</sup>                      | 1.0757 <sup>40</sup>       | 1.6415 <sup>20</sup> | s chl                                               |
| 3663 | 2,3-Dihydro-2-phenyl-4 <i>H</i> -1-benzopyran-4-one                         |                                           | C <sub>15</sub> H <sub>12</sub> O <sub>2</sub>                  | 487-26-3   | 224.255  | nd (lig)         | 76    |                                        |                            |                      | i H <sub>2</sub> O; s ace, bz; sl ctc               |
| 3664 | 4,5-Dihydro-2-(phenylmethyl)-1 <i>H</i> -imidazole, monohydrochloride       |                                           | C <sub>10</sub> H <sub>13</sub> ClN <sub>2</sub>                | 59-97-2    | 196.676  |                  | 174   |                                        |                            |                      |                                                     |
| 3665 | 4,5-Dihydro-5-phenyl-2-oxazolamine                                          | Aminorex                                  | C <sub>9</sub> H <sub>10</sub> N <sub>2</sub> O                 | 2207-50-3  | 162.187  | cry (bz)         | 137   |                                        |                            |                      |                                                     |
| 3666 | 1,4-Dihydro-1-phenyl-5 <i>H</i> -tetrazole-5-thione                         | 1-Phenyl-5-mercapto-1 <i>H</i> -tetrazole | C <sub>7</sub> H <sub>6</sub> N <sub>4</sub> S                  | 86-93-1    | 178.215  |                  | 145   |                                        |                            |                      |                                                     |
| 3667 | Dihydro-5-propyl-2(3 <i>H</i> )-furanone                                    | γ-Propyl-γ-butyrolactone                  | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                   | 105-21-5   | 128.169  |                  |       | 84 <sup>5</sup>                        |                            | 1.4385 <sup>25</sup> |                                                     |
| 3668 | 2,3-Dihydro-6-propyl-2-thioxo-4(1 <i>H</i> )-pyrimidinone                   | Propylthiouracil                          | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> OS                | 51-52-5    | 170.231  | w pow (w)        | 219   |                                        |                            |                      | sl H <sub>2</sub> O, chl, DMSO, EtOH; i eth, bz     |
| 3669 | 1,7-Dihydro-6 <i>H</i> -purine-6-thione                                     | 6-Mercaptopurine                          | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> S                  | 50-44-2    | 152.178  | ye pr (w, + l w) | 313   | dec                                    |                            |                      | i H <sub>2</sub> O; s alk                           |
| 3670 | 3,4-Dihydro-2 <i>H</i> -pyran                                               |                                           | C <sub>5</sub> H <sub>8</sub> O                                 | 110-87-2   | 84.117   |                  |       | 86                                     | 0.921 <sup>19</sup>        | 1.4402 <sup>19</sup> | s H <sub>2</sub> O, EtOH; sl chl                    |
| 3671 | 3,6-Dihydro-2 <i>H</i> -pyran                                               |                                           | C <sub>5</sub> H <sub>8</sub> O                                 | 3174-74-1  | 84.117   | liq              |       | 95                                     | 0.94 <sup>19</sup>         |                      |                                                     |
| 3672 | Dihydro-2 <i>H</i> -pyran-2,6(3 <i>H</i> )-dione                            |                                           | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                    | 108-55-4   | 114.100  |                  | 56.3  | 158 <sup>15</sup>                      | 1.4110 <sup>20</sup>       |                      |                                                     |
| 3673 | 4,5-Dihydro-1 <i>H</i> -pyrazole                                            | 2-Pyrazoline                              | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub>                    | 109-98-8   | 70.093   |                  |       | 144                                    | 1.0200 <sup>17</sup>       | 1.4796 <sup>17</sup> | vs H <sub>2</sub> O, eth, EtOH                      |
| 3674 | 1,2-Dihydro-3,6-pyridazinedione                                             | Maleic hydrazide                          | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>     | 123-33-1   | 112.087  | cry (w)          | 307   |                                        |                            |                      | sl H <sub>2</sub> O, EtOH, tfa                      |
| 3675 | Dihydro-2,4(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione                        | 5,6-Dihydrouracil                         | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>     | 504-07-4   | 114.103  | nd (w)           | 275.5 |                                        |                            |                      | vs H <sub>2</sub> O; s EtOH, chl, MeOH              |
| 3676 | 2,5-Dihydro-1 <i>H</i> -pyrrole                                             | 3-Pyrroline                               | C <sub>4</sub> H <sub>7</sub> N                                 | 109-96-6   | 69.106   |                  |       | 90.5                                   | 0.9097 <sup>20</sup>       | 1.4664 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                 |
| 3677 | 3,4-Dihydro-2(1 <i>H</i> )-quinolinone                                      | Hydrocarbostyrl                           | C <sub>9</sub> H <sub>8</sub> NO                                | 553-03-7   | 147.173  | pr (al, eth)     | 163.5 | 201 <sup>45</sup>                      |                            |                      | vs eth, EtOH                                        |
| 3678 | 1,4-Dihydro-2,3-quinoxalinedione                                            | 2,3-Quinoxalinediol                       | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>     | 15804-19-0 | 162.146  | nd (w)           | 410   |                                        |                            |                      | vs H <sub>2</sub> O; sl EtOH, eth; s bz, DMSO, HOAc |
| 3679 | Dihydrotachysterol                                                          |                                           | C <sub>28</sub> H <sub>46</sub> O                               | 67-96-9    | 398.664  | cry (MeOH)       | 131   |                                        |                            |                      | i H <sub>2</sub> O; s os                            |
| 3680 | Dihydrothebaine                                                             |                                           | C <sub>19</sub> H <sub>23</sub> NO <sub>3</sub>                 | 561-25-1   | 313.391  |                  | 162.5 |                                        |                            |                      | i H <sub>2</sub> O; s EtOH, bz, AcOEt               |
| 3681 | 4,5-Dihydro-2-thiazolamine                                                  |                                           | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> S                  | 1779-81-3  | 102.158  | nd or lf (bz)    | 85.3  | dec                                    |                            |                      | vs H <sub>2</sub> O, EtOH, bz, chl                  |
| 3682 | 2,3-Dihydrothiophene                                                        |                                           | C <sub>4</sub> H <sub>6</sub> S                                 | 1120-59-8  | 86.156   |                  |       | 112.1                                  |                            |                      |                                                     |
| 3683 | 2,5-Dihydrothiophene                                                        |                                           | C <sub>4</sub> H <sub>6</sub> S                                 | 1708-32-3  | 86.156   |                  |       | 122.4                                  |                            |                      |                                                     |
| 3684 | 2,5-Dihydrothiophene 1,1-dioxide                                            | 3-Sulfolene                               | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub> S                  | 77-79-2    | 118.155  |                  | 64.5  |                                        |                            |                      | s chl                                               |
| 3685 | Dihydro-2(3 <i>H</i> )-thiophenone                                          |                                           | C <sub>4</sub> H <sub>6</sub> OS                                | 1003-10-7  | 102.155  |                  |       | 111 <sup>52</sup> , 39 <sup>1</sup>    | 1.18 <sup>25</sup>         | 1.5230 <sup>20</sup> |                                                     |
| 3686 | Dihydro-2-thioxo-4,6(1 <i>H</i> ,5 <i>H</i> )-pyrimidinedione               | 2-Thiobarbituric acid                     | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> S   | 504-17-6   | 144.152  | pl (w)           | 235   | dec                                    |                            |                      | sl H <sub>2</sub> O; s EtOH, dil alk, dil HCl       |
| 3687 | 2,3-Dihydro-2-thioxo-4(1 <i>H</i> )-pyrimidinone                            | 2-Thiouracil                              | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> OS                 | 141-90-2   | 128.152  | pr (w, al)       | >340  | dec                                    |                            |                      | sl H <sub>2</sub> O, EtOH, DMSO; s anh HF           |
| 3688 | 1,2-Dihydro-3 <i>H</i> -1,2,4-triazole-3-thione                             |                                           | C <sub>2</sub> H <sub>3</sub> N <sub>3</sub> S                  | 3179-31-5  | 101.130  |                  | 222.5 |                                        |                            |                      | s DMSO                                              |
| 3689 | (1,3-Dihydro-1,3,3-trimethyl-2 <i>H</i> -indol-2-ylidene)acetaldehyde       |                                           | C <sub>13</sub> H <sub>15</sub> NO                              | 84-83-3    | 201.264  |                  |       |                                        |                            |                      | s chl                                               |



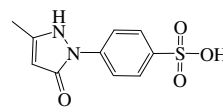
1,3-Dihydro-1-methyl-2H-imidazole-2-thione



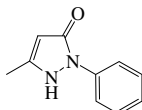
2,3-Dihydro-1-methyl-1H-indene



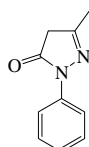
3,4-Dihydro-2-methyl-1(2H)-naphthalenone



4-(4,5-Dihydro-3-methyl-5-oxo-1H-pyrazol-1-yl)benzenesulfonic acid



1,2-Dihydro-5-methyl-2-phenyl-3H-pyrazol-3-one



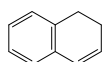
2,4-Dihydro-5-methyl-2-phenyl-3H-pyrazol-3-one



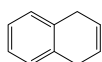
3,6-Dihydro-4-methyl-2H-pyran



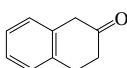
4,5-Dihydro-2-methylthiazole



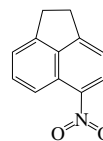
1,2-Dihydronaphthalene



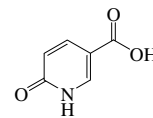
1,4-Dihydronaphthalene



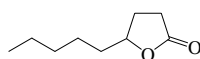
3,4-Dihydro-2(1H)-naphthalenone



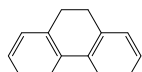
1,2-Dihydro-5-nitroacenaphthylene



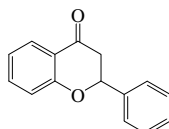
1,6-Dihydro-6-oxo-3-pyridinecarboxylic acid



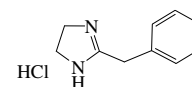
Dihydro-5-pentyl-2(3H)-furanone



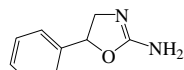
9,10-Dihydrophenanthrene



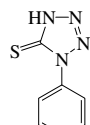
2,3-Dihydro-2-phenyl-4H-1-benzopyran-4-one



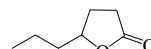
4,5-Dihydro-2-(phenylmethyl)-1H-imidazole, monohydrochloride



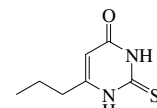
4,5-Dihydro-5-phenyl-2-oxazolamine



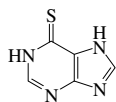
1,4-Dihydro-1-phenyl-5H-tetrazole-5-thione



Dihydro-5-propyl-2(3H)-furanone



2,3-Dihydro-6-propyl-2-thioxo-4(1H)-pyrimidinone



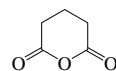
1,7-Dihydro-6H-purine-6-thione



3,4-Dihydro-2H-pyran



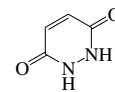
3,6-Dihydro-2H-pyran



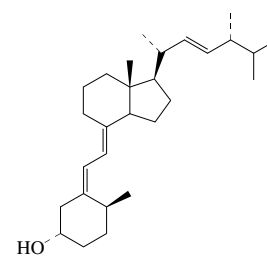
Dihydro-2H-pyran-2,6(3H)-dione



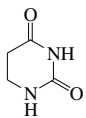
4,5-Dihydro-1H-pyrazole



1,2-Dihydro-3,6-pyridazinedione



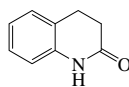
Dihydrotachysterol



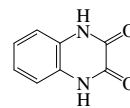
Dihydro-2,4(1H,3H)-pyrimidinedione



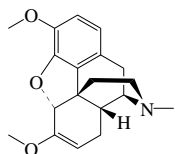
2,5-Dihydro-1H-pyrrole



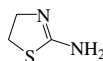
3,4-Dihydro-2(1H)-quinolinone



1,4-Dihydro-2,3-quinoxalinedione



Dihydrothebaine



4,5-Dihydro-2-thiazolamine



2,3-Dihydrothiophene



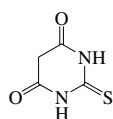
2,5-Dihydrothiophene



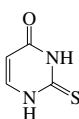
2,5-Dihydrothiophene 1,1-dioxide



Dihydro-2(3H)-thiophenone



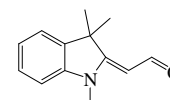
Dihydro-2-thioxo-4,6(1H,5H)-pyrimidinedione



2,3-Dihydro-2-thioxo-4(1H)-pyrimidinone



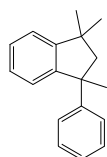
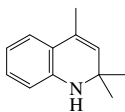
1,2-Dihydro-3H-1,2,4-triazole-3-thione



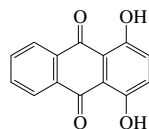
(1,3-Dihydro-1,3,3-trimethyl-2H-indol-2-ylidene)acetaldehyde



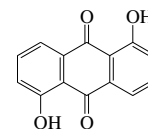
| No.  | Name                                                    | Synonym                     | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                  | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                        |
|------|---------------------------------------------------------|-----------------------------|---------------------------------------------------------------|------------|----------|--------------------------------|---------|------------------------|----------------------------|----------------------|-------------------------------------------------------------------|
| 3690 | 2,3-Dihydro-1,1,3-trimethyl-3-phenyl-1 <i>H</i> -indene |                             | C <sub>18</sub> H <sub>20</sub>                               | 3910-35-8  | 236.352  | tcl pr (al)                    | 52.5    | 308.5                  | 1.0009 <sup>20</sup>       | 1.5681 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, MeOH                              |
| 3691 | 1,2-Dihydro-2,2,4-trimethylquinoline                    |                             | C <sub>12</sub> H <sub>13</sub> N                             | 147-47-7   | 173.254  |                                | 26.5    | 260; 132 <sup>13</sup> |                            |                      |                                                                   |
| 3692 | 1,4-Dihydroxy-9,10-anthracenedione                      | Quinizarin                  | C <sub>14</sub> H <sub>8</sub> O <sub>4</sub>                 | 81-64-1    | 240.212  | ye red lf (eth)<br>dk red nd   | 200     |                        |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, KOH, sulf                      |
| 3693 | 1,5-Dihydroxy-9,10-anthracenedione                      | Anthrarufin                 | C <sub>14</sub> H <sub>8</sub> O <sub>4</sub>                 | 117-12-4   | 240.212  | pa ye pl (gl HOAc)             | 280     | sub                    |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, ace, CS <sub>2</sub> ; s bz     |
| 3694 | 1,8-Dihydroxy-9,10-anthracenedione                      | Danthron                    | C <sub>14</sub> H <sub>8</sub> O <sub>4</sub>                 | 117-10-2   | 240.212  | red or red-ye<br>nd or lf (al) | 193     | sub                    |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s ace, HOAc, alk                |
| 3695 | 2,6-Dihydroxy-9,10-anthracenedione                      |                             | C <sub>14</sub> H <sub>8</sub> O <sub>4</sub>                 | 84-60-6    | 240.212  | ye nd (al)                     | 360 dec |                        |                            |                      | sl H <sub>2</sub> O, EtOH; i eth, bz, chl; s alk                  |
| 3696 | 2,7-Dihydroxy-9,10-anthracenedione                      |                             | C <sub>14</sub> H <sub>8</sub> O <sub>4</sub>                 | 572-93-0   | 240.212  | ye nd (+1w, dil al) nd (sub)   | 353.8   | sub                    |                            |                      | i H <sub>2</sub> O; s EtOH; sl eth, bz, chl                       |
| 3697 | 2,2'-Dihydroxyazobenzene                                |                             | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | 2050-14-8  | 214.219  | gold-ye lf (bz), nd (al)       | 173     | 140 <sup>0.001</sup>   |                            |                      | i H <sub>2</sub> O; sl EtOH, bz; vs eth; s con alk                |
| 3698 | 2,3-Dihydroxybenzaldehyde                               |                             | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                  | 24677-78-9 | 138.121  | ye nd                          | 108     | 235; 120 <sup>16</sup> |                            |                      | vs ace, EtOH, HOAc                                                |
| 3699 | 2,4-Dihydroxybenzaldehyde                               | β-Resorcyllaldehyde         | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                  | 95-01-2    | 138.121  | nd (eth-lig)                   | 135     | 226 <sup>22</sup>      |                            |                      | s H <sub>2</sub> O, HOAc; vs EtOH, eth, chl; sl bz                |
| 3700 | 2,5-Dihydroxybenzaldehyde                               |                             | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                  | 1194-98-5  | 138.121  | ye nd (bz)                     | 100.0   |                        |                            |                      | vs H <sub>2</sub> O, EtOH, chl                                    |
| 3701 | 3,4-Dihydroxybenzaldehyde                               | Protocatechualdehyde        | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                  | 139-85-5   | 138.121  | lf (w, to)                     | 153 dec |                        |                            |                      | s H <sub>2</sub> O; vs EtOH, eth                                  |
| 3702 | <i>N</i> ,2'-Dihydroxybenzamide                         | Salicylhydroxamic acid      | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                 | 89-73-6    | 153.136  | nd (HOAc)                      | 168     | sub                    |                            |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth; s HOAc                   |
| 3703 | 2,5-Dihydroxybenzeneacetic acid                         | Homogentisic acid           | C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                  | 451-13-8   | 168.148  | pr (w+1), lf (al-chl)          | 153     |                        |                            |                      | vs H <sub>2</sub> O, EtOH, eth; i bz, chl                         |
| 3704 | 2,3-Dihydroxybenzoic acid                               |                             | C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                  | 303-38-8   | 154.121  | pr or nd (w+1)                 | 205.5   |                        | 1.542 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH, eth; sl ace                             |
| 3705 | 2,4-Dihydroxybenzoic acid                               | β-Resorcylic acid           | C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                  | 89-86-1    | 154.121  | cry (+w)                       | 226 dec |                        |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz; i CS <sub>2</sub>              |
| 3706 | 2,5-Dihydroxybenzoic acid                               | Gentisic acid               | C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                  | 490-79-9   | 154.121  | nd or pr (w)                   | 199.5   |                        |                            |                      | vs H <sub>2</sub> O, EtOH, eth; s ace; i bz, chl, CS <sub>2</sub> |
| 3707 | 2,6-Dihydroxybenzoic acid                               |                             | C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                  | 303-07-1   | 154.121  | nd (+w)                        | 167 dec |                        |                            |                      | s H <sub>2</sub> O, EtOH, eth; i chl; sl tfa                      |
| 3708 | 3,4-Dihydroxybenzoic acid                               | Protocatechuic acid         | C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                  | 99-50-3    | 154.121  | mcl nd (w+1)                   | 201 dec |                        | 1.524 <sup>4</sup>         |                      | sl H <sub>2</sub> O; vs EtOH; s eth; i bz                         |
| 3709 | 3,5-Dihydroxybenzoic acid                               |                             | C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                  | 99-10-5    | 154.121  | pr or nd                       | 239     |                        |                            |                      | sl H <sub>2</sub> O, ace; vs EtOH, eth                            |
| 3710 | 2,2'-Dihydroxybenzophenone                              | Bis(2-hydroxyphenyl) ketone | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                | 835-11-0   | 214.216  |                                | 59.5    | 333                    |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl                              |
| 3711 | 4,4'-Dihydroxybenzophenone                              | Bis(4-hydroxyphenyl) ketone | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                | 611-99-4   | 214.216  | nd (lig), cry (w)              | 210     |                        | 1.133 <sup>131</sup>       |                      | sl H <sub>2</sub> O; s EtOH, eth, ace; i bz, CS <sub>2</sub>      |
| 3712 | 6,7-Dihydroxy-2 <i>H</i> -1-benzopyran-2-one            | Esculetin                   | C <sub>9</sub> H <sub>6</sub> O <sub>4</sub>                  | 305-01-1   | 178.142  | nd (w), pr (HOAc) lf (sub)     | 276     | sub                    |                            |                      | sl H <sub>2</sub> O, eth; s EtOH, ace, chl, AcOEt                 |
| 3713 | 7,8-Dihydroxy-2 <i>H</i> -1-benzopyran-2-one            | Daphnetin                   | C <sub>9</sub> H <sub>6</sub> O <sub>4</sub>                  | 486-35-1   | 178.142  | ye nd (dil al)                 | 262     | sub                    |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, bz, chl, CS <sub>2</sub>        |
| 3714 | 2,4-Dihydroxybutanoic acid                              |                             | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                  | 1518-62-3  | 120.105  | liq                            |         | 96 <sup>3</sup>        |                            |                      |                                                                   |
| 3715 | 3,6-Dihydroxycholan-24-oic acid, (3α,5β,6α)             | Hydoxycholic acid           | C <sub>24</sub> H <sub>40</sub> O <sub>4</sub>                | 83-49-8    | 392.573  | cry (AcOEt)                    | 198.5   |                        |                            |                      | sl H <sub>2</sub> O, eth, ace, bz; s EtOH, HOAc                   |
| 3716 | 3,7-Dihydroxycholan-24-oic acid, (3α,5β,7β)             | Ursodiol                    | C <sub>24</sub> H <sub>40</sub> O <sub>4</sub>                | 128-13-2   | 392.573  | pl (al)                        | 203     |                        |                            |                      | vs EtOH; sl eth                                                   |
| 3717 | 3,7-Dihydroxycholan-24-oic acid, (3α,5β,7α)             | Chenodiol                   | C <sub>24</sub> H <sub>40</sub> O <sub>4</sub>                | 474-25-9   | 392.573  | nd (EtOAc+he p)                | 119     |                        |                            |                      | i H <sub>2</sub> O, bz; vs EtOH, ace; s eth, HOAc                 |
| 3718 | 1,25-Dihydroxycholecalciferol                           | Calcitriol                  | C <sub>27</sub> H <sub>44</sub> O <sub>3</sub>                | 32222-06-3 | 416.636  | wh cry pow                     | 115     |                        |                            |                      | sl EtOH, MeOH, thf, AcOEt                                         |
| 3719 | 2,5-Dihydroxy-2,5-cyclohexadiene-1,4-dione              |                             | C <sub>6</sub> H <sub>4</sub> O <sub>4</sub>                  | 615-94-1   | 140.094  | dk ye nd                       | 211     |                        |                            |                      | sl H <sub>2</sub> O, ace, DMSO; s EtOH, HOAc; i eth               |

2,3-Dihydro-1,1,3-trimethyl-3-phenyl-1*H*-indene

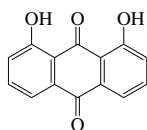
1,2-Dihydro-2,2,4-trimethylquinoline



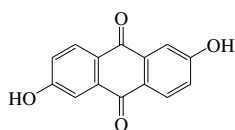
1,4-Dihydroxy-9,10-anthracenedione



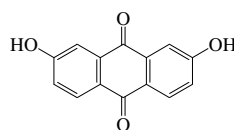
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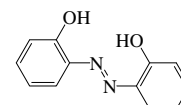
1,8-Dihydroxy-9,10-anthracenedione



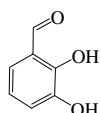
2,6-Dihydroxy-9,10-anthracenedione



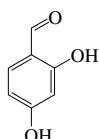
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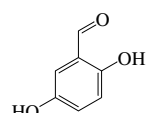
2,2'-Dihydroxyazobenzene



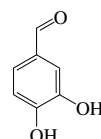
2,3-Dihydroxybenzaldehyde



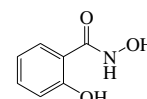
2,4-Dihydroxybenzaldehyde



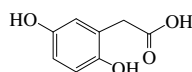
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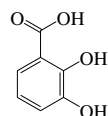
3,4-Dihydroxybenzaldehyde



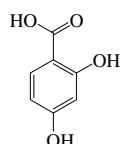
N,2-Dihydroxybenzamide



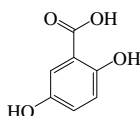
2,5-Dihydroxybenzeneacetic acid



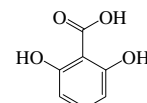
2,3-Dihydroxybenzoic acid



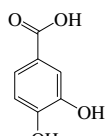
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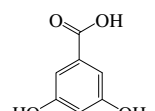
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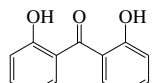
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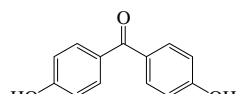
3,4-Dihydroxybenzoic acid



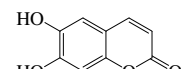
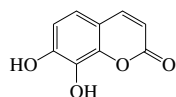
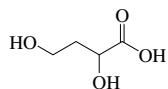
3,5-Dihydroxybenzoic acid



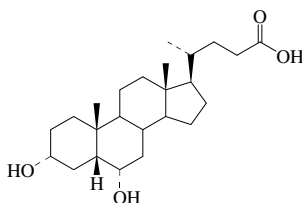
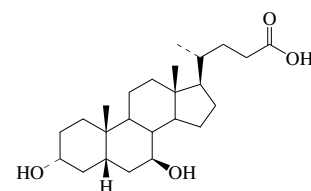
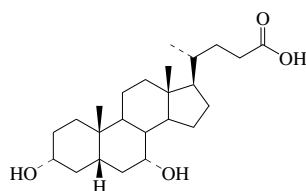
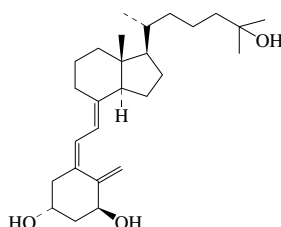
2,2'-Dihydroxybiphenyl



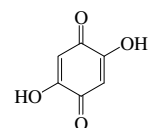
4,4'-Dihydroxybiphenyl

6,7-Dihydroxy-2*H*-1-benzopyran-2-one7,8-Dihydroxy-2*H*-1-benzopyran-2-one

2,4-Dihydroxybutanoic acid

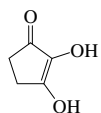
3,6-Dihydroxycholestan-24-oic acid, (3 $\alpha$ ,5 $\beta$ ,6 $\alpha$ )3,7-Dihydroxycholestan-24-oic acid, (3 $\alpha$ ,5 $\beta$ ,7 $\beta$ )3,7-Dihydroxycholestan-24-oic acid, (3 $\alpha$ ,5 $\beta$ ,7 $\alpha$ )

1,25-Dihydroxycholecalciferol

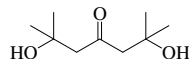


2,5-Dihydroxy-2,5-cyclohexadiene-1,4-dione

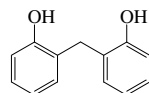
| No.  | Name                                                              | Synonym                             | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form                     | mp/°C   | bp/°C              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub> | Solubility                                                   |
|------|-------------------------------------------------------------------|-------------------------------------|--------------------------------------------------------------|------------|----------|-----------------------------------|---------|--------------------|----------------------------|----------------|--------------------------------------------------------------|
| 3720 | 2,3-Dihydroxy-2-cyclopenten-1-one                                 | Reductic acid                       | C <sub>5</sub> H <sub>6</sub> O <sub>3</sub>                 | 80-72-8    | 114.100  |                                   | 212     |                    |                            |                | s H <sub>2</sub> O, EtOH; sl eth, ace, AcOEt; i bz           |
| 3721 | 2,6-Dihydroxy-2,6-dimethyl-4-heptanone                            | Di(2-hydroxy-2-methylpropyl) ketone | C <sub>9</sub> H <sub>18</sub> O <sub>3</sub>                | 3682-91-5  | 174.237  | pale ye cry                       |         |                    |                            |                |                                                              |
| 3722 | 2,2'-Dihydroxydiphenylmethane                                     | 2,2'-Methylenebisphenol             | C <sub>13</sub> H <sub>12</sub> O <sub>2</sub>               | 2467-02-9  | 200.233  |                                   | 118.3   | 363                | 1.280 <sup>25</sup>        |                |                                                              |
| 3723 | 4,4'-Dihydroxydiphenyl sulfide                                    | 4,4'-Thiobisphenol                  | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub> S             | 2664-63-3  | 218.271  | mcl pr or lf (al)                 | 151     |                    |                            |                | sl H <sub>2</sub> O, EtOH, eth, CS <sub>2</sub>              |
| 3724 | 1,8-Dihydroxy-3-(hydroxymethyl)-9,10-anthracenedione              | Aloe-emodol                         | C <sub>15</sub> H <sub>10</sub> O <sub>5</sub>               | 481-72-1   | 270.237  | oran ye nd (to, al)               | 223.5   | sub                |                            |                | vs bz, eth, EtOH                                             |
| 3725 | 2,3-Dihydroxymaleic acid                                          | Dihydroxymaleic acid                | C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                 | 526-84-1   | 148.071  | pl (w+2)                          | 155 dec |                    |                            |                | sl H <sub>2</sub> O, eth, MeOH; s EtOH                       |
| 3726 | α,4-Dihydroxy-3-methoxybenzeneacetic acid                         | Vanilmandelic acid                  | C <sub>9</sub> H <sub>10</sub> O <sub>5</sub>                | 55-10-7    | 198.172  | sc (bz-eth)                       | 132 dec |                    |                            |                | vs H <sub>2</sub> O, ace, eth                                |
| 3727 | 7,8-Dihydroxy-6-methoxy-2 <i>H</i> -1-benzopyran-2-one            | Fraxetin                            | C <sub>10</sub> H <sub>8</sub> O <sub>5</sub>                | 574-84-5   | 208.168  | pl (dil al)                       | 231     |                    |                            |                | vs EtOH                                                      |
| 3728 | 5,7-Dihydroxy-3-(4-methoxyphenyl)-4 <i>H</i> -1-benzopyran-4-one  |                                     | C <sub>16</sub> H <sub>12</sub> O <sub>5</sub>               | 491-80-5   | 284.263  |                                   | 214.8   |                    |                            |                |                                                              |
| 3729 | (2,6-Dihydroxy-4-methoxyphenyl) phenylmethanone                   | Cotoin                              | C <sub>14</sub> H <sub>12</sub> O <sub>4</sub>               | 479-21-0   | 244.243  | ye pr (chl) lf or nd (w)          | 130.5   |                    |                            |                | vs ace, bz, eth, EtOH                                        |
| 3730 | 1,7-Dihydroxy-3-methoxy-9 <i>H</i> -xanthen-9-one                 | Gentisin                            | C <sub>14</sub> H <sub>10</sub> O <sub>5</sub>               | 437-50-3   | 258.226  | ye orth                           | 266.5   |                    |                            |                | i H <sub>2</sub> O; vs EtOH; i ace; s py                     |
| 3731 | 1,8-Dihydroxy-3-methyl-9,10-anthracenedione                       | Chrysophanic acid                   | C <sub>15</sub> H <sub>10</sub> O <sub>4</sub>               | 481-74-3   | 254.238  | ye hex or mcl nd (sub)            | 196     | sub                | 0.92 <sup>25</sup>         |                | vs bz, HOAc                                                  |
| 3732 | 2,4-Dihydroxy-6-methylbenzoic acid                                | <i>o</i> -Orsellinic acid           | C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                 | 480-64-8   | 168.148  | nd (dil HOAc, +1w)                | 176 dec |                    |                            |                | s EtOH, eth                                                  |
| 3733 | 5,7-Dihydroxy-4-methyl-2 <i>H</i> -1-benzopyran-2-one             |                                     | C <sub>10</sub> H <sub>8</sub> O <sub>4</sub>                | 2107-76-8  | 192.169  | nd (al), lf (HOAc)                | 283     |                    |                            |                | sl H <sub>2</sub> O, eth, bz, chl; vs EtOH, alk              |
| 3734 | 6,7-Dihydroxy-4-methyl-2 <i>H</i> -1-benzopyran-2-one             |                                     | C <sub>10</sub> H <sub>8</sub> O <sub>4</sub>                | 529-84-0   | 192.169  | ye nd (dil al)                    | 275     |                    |                            |                | s H <sub>2</sub> O, EtOH, HOAc                               |
| 3735 | 5,8-Dihydroxy-1,4-naphthalenedione                                |                                     | C <sub>10</sub> H <sub>6</sub> O <sub>4</sub>                | 475-38-7   | 190.153  | dk red mcl pr (bz) red-br nd (al) | 232     | sub                |                            |                | sl H <sub>2</sub> O, EtOH, eth; s HOAc                       |
| 3736 | 4,5-Dihydroxy-2,7-naphthalenedisulfonic acid                      | Chromotropic acid                   | C <sub>10</sub> H <sub>6</sub> O <sub>8</sub> S <sub>2</sub> | 148-25-4   | 320.296  | nd or lf (w+2)                    |         |                    |                            |                | s H <sub>2</sub> O, alk; i EtOH, eth                         |
| 3737 | 5,6-Dihydroxynaphtho[2,3- <i>f</i> ]quinoline-7,12-dione          | Alizarin Blue                       | C <sub>17</sub> H <sub>9</sub> NO <sub>4</sub>               | 568-02-5   | 291.258  | br-viol nd (bz)                   | 269     |                    |                            |                | vs bz, gl HOAc                                               |
| 3738 | 1,2-Dihydroxy-3-nitro-9,10-anthracenedione                        | Alizarin Orange                     | C <sub>14</sub> H <sub>7</sub> NO <sub>6</sub>               | 568-93-4   | 285.209  | oran nd or pl (HOAc)              | 244 dec | sub                |                            |                | sl H <sub>2</sub> O; s EtOH, bz, chl, sulf, HOAc             |
| 3739 | 9,10-Dihydroxyoctadecanedioic acid, ( <i>R</i> *, <i>R</i> *)-(±) | Phloionic acid                      | C <sub>18</sub> H <sub>34</sub> O <sub>6</sub>               | 23843-52-9 | 346.459  | cry (al)                          | 126     |                    |                            |                |                                                              |
| 3740 | 9,10-Dihydroxyoctadecanoic acid                                   | 9,10-Dihydroxystearic acid          | C <sub>18</sub> H <sub>36</sub> O <sub>4</sub>               | 120-87-6   | 316.477  |                                   | 90      |                    |                            |                | i H <sub>2</sub> O; sl EtOH, eth                             |
| 3741 | 5,7-Dihydroxy-2-phenyl-4 <i>H</i> -1-benzopyran-4-one             | Chrysin                             | C <sub>15</sub> H <sub>10</sub> O <sub>4</sub>               | 480-40-0   | 254.238  | lf ye pr (MeOH)                   | 285.5   |                    |                            |                | i H <sub>2</sub> O; s EtOH, ace; sl eth, bz, CS <sub>2</sub> |
| 3742 | 1-(2,4-Dihydroxyphenyl)ethanone                                   | Resacetophenone                     | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | 89-84-9    | 152.148  | nd or lf                          | 146     |                    | 1.18 <sup>141</sup>        |                | i H <sub>2</sub> O, chl; s EtOH, py; sl eth, bz              |
| 3743 | (2,4-Dihydroxyphenyl) phenylmethanone                             | Benzoiresorcinol                    | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>               | 131-56-6   | 214.216  | nd (w)                            | 144     |                    |                            |                | i H <sub>2</sub> O; s EtOH; vs eth; sl bz, chl               |
| 3744 | 3-(3,4-Dihydroxyphenyl)-2-propenoic acid                          | Caffeic acid                        | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                 | 331-39-5   | 180.158  | ye pr, pl (w)                     | 225 dec |                    |                            |                | vs EtOH                                                      |
| 3745 | Dihydroxyphenylstibine oxide                                      | Benzenestibonic acid                | C <sub>6</sub> H <sub>7</sub> O <sub>3</sub> Sb              | 535-46-6   | 248.878  | nd (HOAc)                         | 139     |                    |                            |                |                                                              |
| 3746 | 17,21-Dihydroxypregna-1,4-diene-3,11,20-trione                    | Prednisone                          | C <sub>21</sub> H <sub>26</sub> O <sub>5</sub>               | 53-03-2    | 358.428  |                                   | 234 dec |                    |                            |                |                                                              |
| 3747 | 17,21-Dihydroxypregn-4-ene-3,20-dione                             | 11-Deoxy-17-hydrocortisterone       | C <sub>21</sub> H <sub>30</sub> O <sub>4</sub>               | 152-58-9   | 346.461  |                                   | 215     |                    |                            |                | vs ace, EtOH, chl                                            |
| 3748 | 17,21-Dihydroxypregn-4-ene-3,11,20-trione                         | Cortisone                           | C <sub>21</sub> H <sub>28</sub> O <sub>5</sub>               | 53-06-5    | 360.444  |                                   | 222     |                    |                            |                | sl H <sub>2</sub> O, eth, bz, chl; s EtOH, ace               |
| 3749 | 2,3-Dihydroxypropanal, (±)                                        |                                     | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                 | 56-82-6    | 90.078   | nd or pr (40% MeOH)               | 145     | 145 <sup>0.8</sup> | 1.453 <sup>18</sup>        |                | s H <sub>2</sub> O; sl EtOH, eth; i bz, peth, lig            |
| 3750 | 2,3-Dihydroxypropanoic acid, ( <i>R</i> )                         | Glyceric acid                       | C <sub>3</sub> H <sub>6</sub> O <sub>4</sub>                 | 6000-40-4  | 106.078  | thick gum                         |         | dec                |                            |                |                                                              |
| 3751 | 1,3-Dihydroxy-2-propanone                                         | Dihydroxyacetone                    | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                 | 96-26-4    | 90.078   |                                   | 90      |                    |                            |                | s H <sub>2</sub> O, EtOH, eth, ace; i lig                    |
| 3752 | 2,3-Dihydroxypropyl decanoate                                     | Decanoic acid glycerol monoester    | C <sub>13</sub> H <sub>26</sub> O <sub>4</sub>               | 2277-23-8  | 246.343  | pr (peth)                         | 53      |                    |                            |                |                                                              |
| 3753 | 2,3-Dihydroxypropyl octanoate                                     | Octanoic acid glycerol monoester    | C <sub>11</sub> H <sub>22</sub> O <sub>4</sub>               | 26402-26-6 | 218.291  | cry (peth)                        | 40      |                    |                            |                |                                                              |



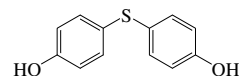
2,3-Dihydroxy-2-cyclopenten-1-one



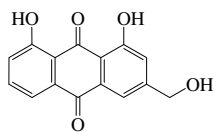
2,6-Dihydroxy-2,6-dimethyl-4-heptanone



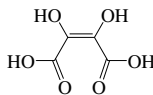
2,2'-Dihydroxydiphenylmethane



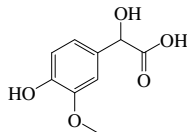
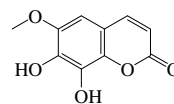
4,4'-Dihydroxydiphenyl sulfide



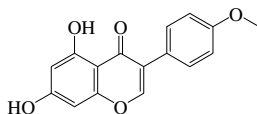
1,8-Dihydroxy-3-(hydroxymethyl)-9,10-anthracenedione



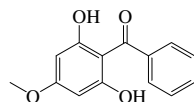
2,3-Dihydroxymaleic acid

 $\alpha$ ,4-Dihydroxy-3-methoxybenzeneacetic acid

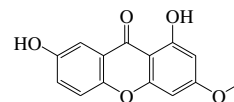
7,8-Dihydroxy-6-methoxy-2H-1-benzopyran-2-one



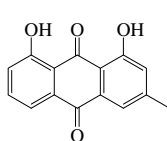
5,7-Dihydroxy-3-(4-methoxyphenyl)-4H-1-benzopyran-4-one



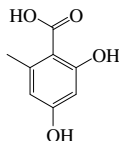
(2,6-Dihydroxy-4-methoxyphenyl)phenylmethanone



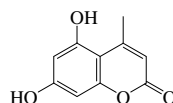
1,7-Dihydroxy-3-methoxy-9H-xanthen-9-one



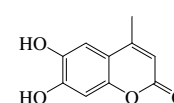
1,8-Dihydroxy-3-methyl-9,10-anthracenedione



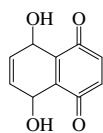
2,4-Dihydroxy-6-methylbenzoic acid



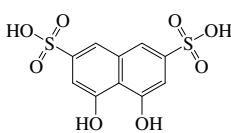
5,7-Dihydroxy-4-methyl-2H-1-benzopyran-2-one



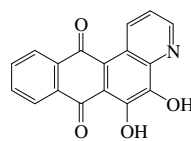
6,7-Dihydroxy-4-methyl-2H-1-benzopyran-2-one



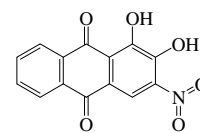
5,8-Dihydroxy-1,4-naphthalenedione



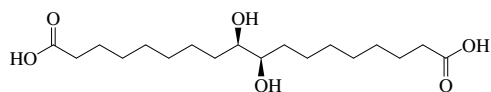
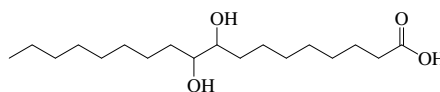
4,5-Dihydroxy-2,7-naphthalenedisulfonic acid



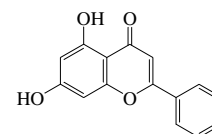
5,6-Dihydroxynaphtho[2,3-f]quinoline-7,12-dione



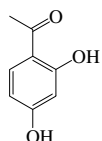
1,2-Dihydroxy-3-nitro-9,10-anthracenedione

9,10-Dihydroxyoctadecanedioic acid, (*R*\*, *R*\*)-(±)

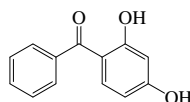
9,10-Dihydroxyoctadecanoic acid



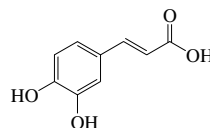
5,7-Dihydroxy-2-phenyl-4H-1-benzopyran-4-one



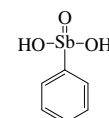
1-(2,4-Dihydroxyphenyl)ethanone



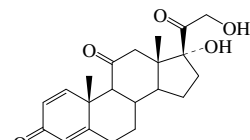
(2,4-Dihydroxyphenyl)phenylmethanone



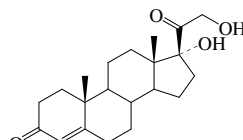
3-(3,4-Dihydroxyphenyl)-2-propenoic acid



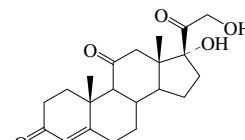
Dihydroxyphenylstibine oxide



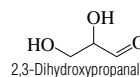
17,21-Dihydroxypregna-1,4-diene-3,11,20-trione



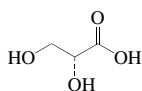
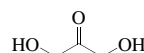
17,21-Dihydroxypregn-4-ene-3,20-dione



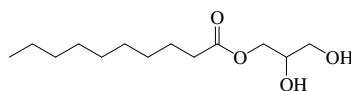
17,21-Dihydroxypregn-4-ene-3,11,20-trione



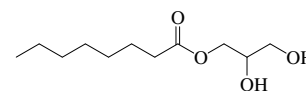
2,3-Dihydroxypropanal, (±)

2,3-Dihydroxypropanoic acid, (*R*)

1,3-Dihydroxy-2-propanone

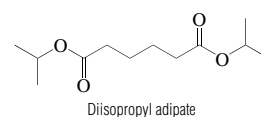
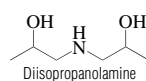
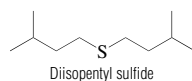
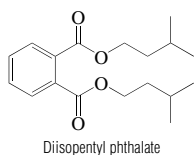
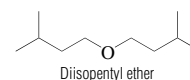
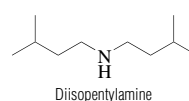
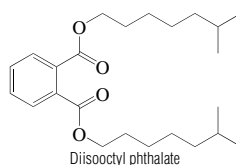
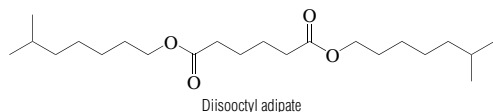
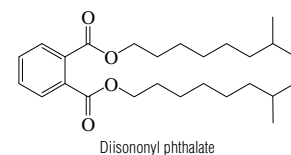
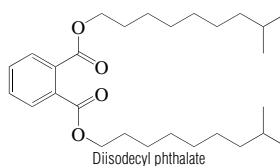
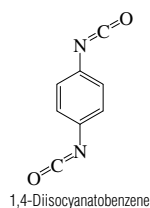
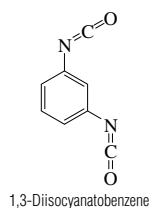
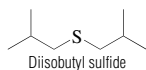
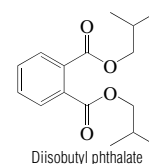
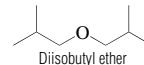
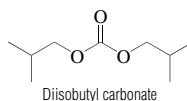
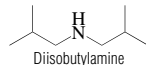
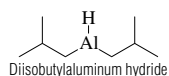
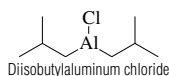
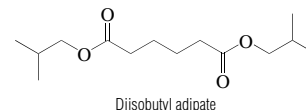
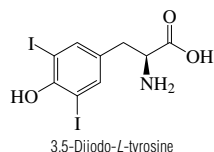
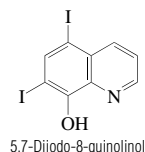
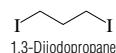
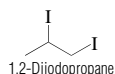
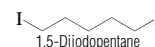
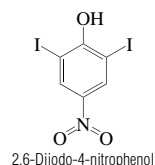
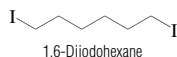
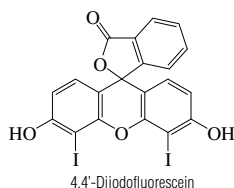
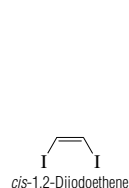
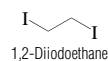
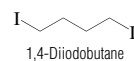
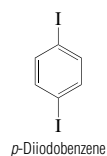
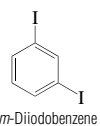
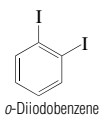
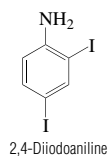
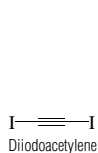
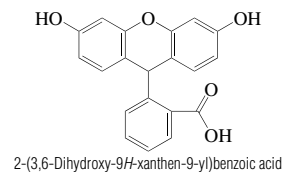
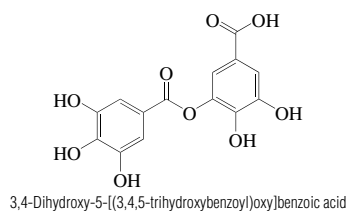
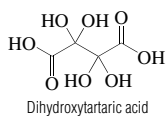
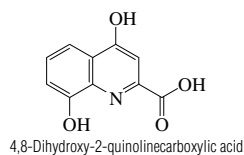


2,3-Dihydroxypropyl decanoate

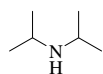


2,3-Dihydroxypropyl octanoate

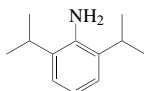
| No.  | Name                                                       | Synonym                                            | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form               | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|------|------------------------------------------------------------|----------------------------------------------------|---------------------------------------------------------------|------------|----------|-----------------------------|---------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------|
| 3754 | 4,8-Dihydroxy-2-quinolinecarboxylic acid                   | Xanthurenic acid                                   | C <sub>10</sub> H <sub>7</sub> NO <sub>4</sub>                | 59-00-7    | 205.168  | ye micry cry (w)            | 289     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, dil HCl; sl eth, bz   |
| 3755 | Dihydroxytartaric acid                                     |                                                    | C <sub>4</sub> H <sub>6</sub> O <sub>8</sub>                  | 76-30-2    | 182.086  |                             | 114.5   |                                       |                            |                      |                                                   |
| 3756 | 3,4-Dihydroxy-5-[(3,4,5-trihydroxybenzoyl)oxy]benzoic acid | Digallic acid                                      | C <sub>14</sub> H <sub>10</sub> O <sub>9</sub>                | 536-08-3   | 322.224  | nf (dil al + 1w)            | 269 dec |                                       |                            |                      | vs ace, EtOH                                      |
| 3757 | 2-(3,6-Dihydroxy-9H-xanthen-9-yl)benzoic acid              | Fluorescein                                        | C <sub>20</sub> H <sub>14</sub> O <sub>5</sub>                | 518-44-5   | 334.322  | col or ye nd (eth), pl (bz) | 126     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, HOAc    |
| 3758 | Diiodoacetylene                                            |                                                    | C <sub>2</sub> I <sub>2</sub>                                 | 624-74-8   | 277.830  | orth nd (lig)               | 81.5    | exp                                   |                            |                      | vs ace, bz, eth, EtOH                             |
| 3759 | 2,4-Diiodoaniline                                          |                                                    | C <sub>6</sub> H <sub>5</sub> I <sub>2</sub> N                | 533-70-0   | 344.920  | br nd or orth cry (al)      | 95.5    |                                       | 2.748 <sup>25</sup>        |                      | vs ace, bz, eth, EtOH                             |
| 3760 | <i>o</i> -Diiodobenzene                                    | 1,2-Diiodobenzene                                  | C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                  | 615-42-9   | 329.905  | pl or pr (lig)              | 27      | 287; 100 <sup>3</sup>                 | 2.54 <sup>20</sup>         | 1.7179 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH                       |
| 3761 | <i>m</i> -Diiodobenzene                                    | 1,3-Diiodobenzene                                  | C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                  | 626-00-6   | 329.905  | orth pl or pr (eth-al)      | 40.4    | 285                                   | 2.47 <sup>25</sup>         |                      | i H <sub>2</sub> O; vs eth, EtOH, chl             |
| 3762 | <i>p</i> -Diiodobenzene                                    | 1,4-Diiodobenzene                                  | C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                  | 624-38-4   | 329.905  | orth lf (al)                | 131.5   | 285                                   |                            |                      | i H <sub>2</sub> O; s EtOH; vs eth; sl chl        |
| 3763 | 1,4-Diiodobutane                                           |                                                    | C <sub>4</sub> H <sub>8</sub> I <sub>2</sub>                  | 628-21-7   | 309.916  |                             | 5.8     | 125 <sup>15</sup> dec                 | 2.3494 <sup>25</sup>       | 1.6184 <sup>25</sup> | i H <sub>2</sub> O; sl ctc; s os                  |
| 3764 | 1,2-Diiodoethane                                           |                                                    | C <sub>2</sub> H <sub>4</sub> I <sub>2</sub>                  | 624-73-7   | 281.862  | ye mol pr or orth (eth)     | 83      | 200                                   | 3.325 <sup>20</sup>        | 1.871 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth, ace, chl        |
| 3765 | <i>cis</i> -1,2-Diiodoethene                               | <i>cis</i> -1,2-Diiodoethylene                     | C <sub>2</sub> H <sub>2</sub> I <sub>2</sub>                  | 590-26-1   | 279.846  |                             | -14     | 72.5 <sup>16</sup>                    | 3.0625 <sup>20</sup>       |                      | i H <sub>2</sub> O; s eth, chl                    |
| 3766 | 4,4'-Diiodofluorescein                                     |                                                    | C <sub>20</sub> H <sub>10</sub> I <sub>2</sub> O <sub>5</sub> | 38577-97-8 | 584.099  | oran-red pow                |         |                                       |                            |                      | sl H <sub>2</sub> O; s alk, EtOH                  |
| 3767 | 1,6-Diiodohexane                                           | Hexamethylene diiodide                             | C <sub>6</sub> H <sub>12</sub> I <sub>2</sub>                 | 629-09-4   | 337.968  | nd                          | 9.5     | 163 <sup>17</sup> , 141 <sup>10</sup> | 2.0342 <sup>25</sup>       | 1.5837 <sup>25</sup> | i H <sub>2</sub> O; vs EtOH, eth                  |
| 3768 | Diiodomethane                                              | Methylene iodide                                   | CH <sub>2</sub> I <sub>2</sub>                                | 75-11-6    | 267.836  | ye nd or lf                 | 6.1     | 182                                   | 3.3211 <sup>20</sup>       | 1.7411 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, bz, chl    |
| 3769 | 2,6-Diiodo-4-nitrophenol                                   | Disophenol                                         | C <sub>6</sub> H <sub>3</sub> I <sub>2</sub> NO <sub>3</sub>  | 305-85-1   | 390.902  | lt ye cry (gl HOAc)         | 157     |                                       |                            |                      | vs EtOH                                           |
| 3770 | 1,5-Diiodopentane                                          | Pentamethylene diiodide                            | C <sub>5</sub> H <sub>10</sub> I <sub>2</sub>                 | 628-77-3   | 323.942  |                             | 9       | 149 <sup>20</sup> , 101 <sup>13</sup> | 2.1692 <sup>25</sup>       | 1.5987 <sup>25</sup> | i H <sub>2</sub> O; s eth, chl                    |
| 3771 | 1,2-Diiodopropane                                          |                                                    | C <sub>3</sub> H <sub>6</sub> I <sub>2</sub>                  | 598-29-8   | 295.889  |                             |         |                                       | 2.490 <sup>18</sup>        |                      | vs eth, EtOH                                      |
| 3772 | 1,3-Diiodopropane                                          | Trimethylene diiodide                              | C <sub>3</sub> H <sub>6</sub> I <sub>2</sub>                  | 627-31-6   | 295.889  |                             | -20     | dec 227; 110 <sup>19</sup>            | 2.5612 <sup>25</sup>       | 1.6391 <sup>25</sup> | i H <sub>2</sub> O; s eth, ctc, chl               |
| 3773 | 5,7-Diiodo-8-quinolinol                                    | Iodoquinol                                         | C <sub>9</sub> H <sub>5</sub> I <sub>2</sub> NO               | 83-73-8    | 396.951  | ye nd (HOAc, xyl)           | 210     |                                       |                            |                      | sl H <sub>2</sub> O, bz, chl, eth; vs EtOH; s alk |
| 3774 | 3,5-Diiodo- <i>L</i> -tyrosine                             |                                                    | C <sub>9</sub> H <sub>9</sub> I <sub>2</sub> NO <sub>3</sub>  | 300-39-0   | 432.981  | ye nd (w, 70% al)           | 213     |                                       |                            |                      | sl H <sub>2</sub> O; i EtOH, eth, bz              |
| 3775 | Diisobutyl adipate                                         |                                                    | C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>                | 141-04-8   | 258.354  |                             |         | 293; 187 <sup>15</sup>                | 0.9543 <sup>19</sup>       | 1.4301 <sup>20</sup> |                                                   |
| 3776 | Diisobutylaluminum chloride                                |                                                    | C <sub>8</sub> H <sub>16</sub> AlCl                           | 1779-25-5  | 176.664  | hyg col liq                 | -40     | 152 <sup>10</sup>                     | 0.905                      | 1.4506 <sup>20</sup> | s eth, hx                                         |
| 3777 | Diisobutylaluminum hydride                                 |                                                    | C <sub>8</sub> H <sub>19</sub> Al                             | 1191-15-7  | 142.219  | liq                         |         | 140 <sup>4</sup> , 85 <sup>0.5</sup>  |                            |                      | s cyhex, eth, bz, tol                             |
| 3778 | Diisobutylamine                                            | 2-Methyl- <i>N</i> -(2-methylpropyl)-1-propanamine | C <sub>8</sub> H <sub>19</sub> N                              | 110-96-3   | 129.244  | liq                         | -73.5   | 139.6                                 |                            | 1.4090 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, ace, bz    |
| 3779 | Diisobutyl carbonate                                       |                                                    | C <sub>9</sub> H <sub>18</sub> O <sub>3</sub>                 | 539-92-4   | 174.237  |                             |         | 190                                   | 0.9138 <sup>20</sup>       | 1.4072 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                 |
| 3780 | Diisobutyl ether                                           | 1,1'-Oxybis[2-methylpropane]                       | C <sub>8</sub> H <sub>18</sub> O                              | 628-55-7   | 130.228  |                             |         | 122.6                                 | 0.761 <sup>15</sup>        |                      | i H <sub>2</sub> O; msc EtOH, eth                 |
| 3781 | Diisobutyl phthalate                                       |                                                    | C <sub>18</sub> H <sub>22</sub> O <sub>4</sub>                | 84-69-5    | 278.344  |                             |         | 296.5; 159 <sup>4</sup>               | 1.0490 <sup>15</sup>       |                      | s ctc                                             |
| 3782 | Diisobutyl sulfide                                         |                                                    | C <sub>8</sub> H <sub>18</sub> S                              | 592-65-4   | 146.294  | liq                         | -105.5  | 171                                   | 0.8363 <sup>10</sup>       |                      |                                                   |
| 3783 | 1,3-Diisocyanatobenzene                                    |                                                    | C <sub>8</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>   | 123-61-5   | 160.130  | cry                         | 51      | 103 <sup>8</sup>                      |                            |                      |                                                   |
| 3784 | 1,4-Diisocyanatobenzene                                    |                                                    | C <sub>8</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>   | 104-49-4   | 160.130  | cry                         | 95      | 117 <sup>14</sup>                     |                            |                      |                                                   |
| 3785 | Diisodecyl phthalate                                       | Bis(8-methylnonyl)phthalate                        | C <sub>28</sub> H <sub>46</sub> O <sub>4</sub>                | 26761-40-0 | 446.663  | liq                         | -50     | 253 <sup>4</sup>                      | 0.966 <sup>20</sup>        |                      | i H <sub>2</sub> O; s os                          |
| 3786 | Diisononyl phthalate                                       | Bis(7-methyloctyl)phthalate                        | C <sub>26</sub> H <sub>42</sub> O <sub>4</sub>                | 28553-12-0 | 418.609  | col liq                     |         |                                       |                            |                      | i H <sub>2</sub> O; s ace, MeOH; bz, eth          |
| 3787 | Diisooctyl adipate                                         |                                                    | C <sub>22</sub> H <sub>42</sub> O <sub>4</sub>                | 1330-86-5  | 370.566  |                             |         | 210 <sup>4</sup>                      |                            |                      |                                                   |
| 3788 | Diisooctyl phthalate                                       |                                                    | C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                | 27554-26-3 | 390.557  |                             |         | 370                                   |                            |                      |                                                   |
| 3789 | Diisopentylamine                                           | 3-Methyl- <i>N</i> -isopentyl-1-butanamine         | C <sub>10</sub> H <sub>23</sub> N                             | 544-00-3   | 157.297  | liq                         | -44     | 188                                   | 0.7672 <sup>21</sup>       | 1.4235 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; msc eth               |
| 3790 | Diisopentyl ether                                          | Diisoamyl ether                                    | C <sub>10</sub> H <sub>22</sub> O                             | 544-01-4   | 158.281  |                             |         | 172.5                                 | 0.7777 <sup>20</sup>       | 1.4085 <sup>20</sup> | i H <sub>2</sub> O; vs ace, EtOH, chl             |
| 3791 | Diisopentyl phthalate                                      | Diisoamyl phthalate                                | C <sub>18</sub> H <sub>26</sub> O <sub>4</sub>                | 605-50-5   | 306.397  |                             |         | dec 334                               | 1.0209 <sup>16</sup>       | 1.4871 <sup>20</sup> | vs EtOH                                           |
| 3792 | Diisopentyl sulfide                                        |                                                    | C <sub>10</sub> H <sub>22</sub> S                             | 544-02-5   | 174.347  | liq                         | -74.6   | 211                                   | 0.8323 <sup>20</sup>       | 1.4520 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH; vs eth              |
| 3793 | Diisopropanolamine                                         | 1,1'-Iminobis-2-propanol                           | C <sub>6</sub> H <sub>15</sub> NO <sub>2</sub>                | 110-97-4   | 133.189  | cry                         | 44.5    | 250; 151 <sup>23</sup>                | 0.989 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH; sl eth                  |
| 3794 | Diisopropyl adipate                                        |                                                    | C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                | 6938-94-9  | 230.301  |                             | -0.6    | 120 <sup>6.5</sup>                    | 0.9569 <sup>20</sup>       | 1.4247 <sup>20</sup> | vs ace, eth, EtOH                                 |



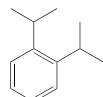
| No.  | Name                                               | Synonym                                                         | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form  | mp/°C | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                      |
|------|----------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------|------------|----------|----------------|-------|-------------------------------------|----------------------------|----------------------|-------------------------------------------------|
| 3795 | Diisopropylamine                                   | <i>N</i> -Isopropyl-2-propanamine                               | C <sub>6</sub> H <sub>15</sub> N                              | 108-18-9   | 101.190  | liq            | -61   | 83.9                                | 0.7153 <sup>20</sup>       | 1.3924 <sup>20</sup> | vs ace, bz, eth, EtOH                           |
| 3796 | 2,6-Diisopropylaniline                             |                                                                 | C <sub>12</sub> H <sub>19</sub> N                             | 24544-04-5 | 177.286  | liq            | -45   | 257                                 | 0.94 <sup>25</sup>         | 1.5332 <sup>20</sup> |                                                 |
| 3797 | 1,2-Diisopropylbenzene                             |                                                                 | C <sub>12</sub> H <sub>18</sub>                               | 577-55-9   | 162.271  | liq            | -57   | 204                                 | 0.8701 <sup>20</sup>       | 1.4960 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, ctc |
| 3798 | 1,3-Diisopropylbenzene                             |                                                                 | C <sub>12</sub> H <sub>18</sub>                               | 99-62-7    | 162.271  | liq            | -63.1 | 203.2                               | 0.8559 <sup>20</sup>       | 1.4883 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, ctc |
| 3799 | 1,4-Diisopropylbenzene                             |                                                                 | C <sub>12</sub> H <sub>18</sub>                               | 100-18-5   | 162.271  | liq            | -17   | 210.3                               | 0.8568 <sup>20</sup>       | 1.4898 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, ctc |
| 3800 | <i>p</i> -Diisopropylbenzene hydroperoxide         |                                                                 | C <sub>12</sub> H <sub>18</sub> O <sub>2</sub>                | 98-49-7    | 194.270  | waxy cry       | 30.1  | 123 <sup>1</sup>                    | 0.9932 <sup>20</sup>       |                      | i H <sub>2</sub> O                              |
| 3801 | <i>N,N</i> -Diisopropyl-2-benzothiazolesulfenamide |                                                                 | C <sub>13</sub> H <sub>18</sub> N <sub>2</sub> S <sub>2</sub> | 95-29-4    | 266.425  |                | 59.0  |                                     |                            |                      |                                                 |
| 3802 | <i>N,N'</i> -Diisopropylcarbodiimide               |                                                                 | C <sub>7</sub> H <sub>14</sub> N <sub>2</sub>                 | 693-13-0   | 126.199  |                |       | 147                                 | 0.806 <sup>25</sup>        | 1.4320 <sup>20</sup> |                                                 |
| 3803 | Diisopropyl disulfide                              |                                                                 | C <sub>6</sub> H <sub>14</sub> S <sub>2</sub>                 | 4253-89-8  | 150.305  | liq            | -69   | 177                                 | 0.9435 <sup>20</sup>       | 1.4916 <sup>20</sup> |                                                 |
| 3804 | <i>N,N</i> -Diisopropylethanolamine                | <i>N,N</i> -Diisopropyl-2-aminoethanol                          | C <sub>8</sub> H <sub>19</sub> NO                             | 96-80-0    | 145.243  |                |       | 190                                 | 0.826 <sup>25</sup>        | 1.4417 <sup>20</sup> |                                                 |
| 3805 | Diisopropyl ether                                  | Isopropyl ether                                                 | C <sub>6</sub> H <sub>14</sub> O                              | 108-20-3   | 102.174  | liq            | -85.4 | 68.4                                | 0.7192 <sup>25</sup>       | 1.3658 <sup>25</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ace, ctc  |
| 3806 | Diisopropyl methylphosphonate                      |                                                                 | C <sub>7</sub> H <sub>17</sub> O <sub>3</sub> P               | 1445-75-6  | 180.182  |                |       | 66 <sup>3</sup>                     |                            | 1.4120 <sup>18</sup> |                                                 |
| 3807 | 2,6-Diisopropyl-naphthalene                        |                                                                 | C <sub>18</sub> H <sub>20</sub>                               | 24157-81-1 | 212.330  | cry (MeOH)     | 70    |                                     |                            |                      |                                                 |
| 3808 | Diisopropyl oxalate                                |                                                                 | C <sub>6</sub> H <sub>14</sub> O <sub>4</sub>                 | 615-81-6   | 174.195  |                |       | 190                                 | 1.002 <sup>20</sup>        | 1.4100 <sup>20</sup> | vs eth, EtOH                                    |
| 3809 | Diisopropyl phosphonate                            |                                                                 | C <sub>6</sub> H <sub>15</sub> O <sub>3</sub> P               | 1809-20-7  | 166.155  |                |       | 97 <sup>40</sup> , 76 <sup>10</sup> | 0.9970 <sup>18</sup>       |                      |                                                 |
| 3810 | <i>O,O</i> -Diisopropyl phosphorodithioate         |                                                                 | C <sub>6</sub> H <sub>15</sub> O <sub>2</sub> PS <sub>2</sub> | 107-56-2   | 214.286  | liq            |       | 71 <sup>3</sup>                     | 1.09 <sup>20</sup>         |                      | s EtOH, bz, ace, ctc, chl                       |
| 3811 | Diisopropyl phthalate                              | 1,2-Benzenedicarboxylic acid, diisopropyl ester                 | C <sub>14</sub> H <sub>18</sub> O <sub>4</sub>                | 605-45-8   | 250.291  |                |       | 130 <sup>12</sup>                   | 1.0615 <sup>15</sup>       | 1.4900 <sup>20</sup> |                                                 |
| 3812 | Diisopropyl sulfide                                |                                                                 | C <sub>6</sub> H <sub>14</sub> S                              | 625-80-9   | 118.240  | liq            | -78.1 | 120.0                               | 0.8142 <sup>20</sup>       | 1.4438 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                 |
| 3813 | Diisopropyl tartrate, (±)                          |                                                                 | C <sub>10</sub> H <sub>18</sub> O <sub>6</sub>                | 58167-01-4 | 234.246  |                | 34    | 275; 154 <sup>12</sup>              | 1.1166 <sup>20</sup>       |                      | vs ace, eth, EtOH                               |
| 3814 | Diisopropyl thioperoxycarbonate                    | Diisopropyl dioxanthogen                                        | C <sub>9</sub> H <sub>14</sub> O <sub>3</sub> S <sub>4</sub>  | 105-65-7   | 270.456  |                | 52    |                                     |                            |                      | s chl                                           |
| 3815 | 1,4-Diisothiocyantobenzene                         | Bitoscanate                                                     | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> S <sub>2</sub>   | 4044-65-9  | 192.261  | nd (ace, HOAc) | 132   |                                     |                            |                      |                                                 |
| 3816 | Diketene                                           |                                                                 | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                  | 674-82-8   | 84.074   | liq            | -6.5  | 126.1                               | 1.0877 <sup>20</sup>       | 1.4379 <sup>20</sup> |                                                 |
| 3817 | Dilactic acid                                      | 2,2'-Oxybispropanoic acid                                       | C <sub>6</sub> H <sub>10</sub> O <sub>5</sub>                 | 19201-34-4 | 162.140  | orth           | 112.5 |                                     |                            |                      | vs H <sub>2</sub> O, eth                        |
| 3818 | Dimetline                                          |                                                                 | C <sub>20</sub> H <sub>21</sub> NO <sub>3</sub>               | 1165-48-6  | 323.386  |                | 109.5 |                                     |                            |                      | s chl                                           |
| 3819 | Dimetox                                            | Tetramethylphosphorodiamidic fluoride                           | C <sub>4</sub> H <sub>12</sub> FN <sub>2</sub> OP             | 115-26-4   | 154.122  | liq            |       | 86 <sup>15</sup>                    | 1.1151 <sup>20</sup>       | 1.4267 <sup>20</sup> | vs H <sub>2</sub> O, bz, eth                    |
| 3820 | Dimemorfan                                         | 3,17-Dimethylmorphinan, (9 α,13 α,14 α)-                        | C <sub>18</sub> H <sub>25</sub> N                             | 36309-01-0 | 255.399  | ye oil         | 92    | 133 <sup>0,3</sup>                  |                            |                      |                                                 |
| 3821 | 2,3-Dimercaptobutanedioic acid                     |                                                                 | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub> S <sub>2</sub>   | 2418-14-6  | 182.219  | wh cry (MeOH)  | 193   |                                     |                            |                      |                                                 |
| 3822 | 1,4-Dimercapto-2,3-butanediol                      |                                                                 | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub> S <sub>2</sub>  | 7634-42-6  | 154.251  |                | 42.5  |                                     |                            |                      | s chl                                           |
| 3823 | 2,2'-Dimercaptodiethyl ether                       | 2-Mercaptoethyl ether                                           | C <sub>6</sub> H <sub>10</sub> OS <sub>2</sub>                | 2150-02-9  | 138.251  | liq            | -80   | 217; 64 <sup>2</sup>                | 1.114 <sup>20</sup>        |                      |                                                 |
| 3824 | 2,3-Dimercapto-1-propanol                          | Dimercaprol                                                     | C <sub>3</sub> H <sub>6</sub> OS <sub>2</sub>                 | 59-52-9    | 124.225  |                |       | 83 <sup>0,8</sup>                   | 1.2463 <sup>20</sup>       | 1.5749 <sup>20</sup> | s EtOH, eth, oils; sl chl                       |
| 3825 | Dimetan®                                           |                                                                 | C <sub>11</sub> H <sub>17</sub> NO <sub>3</sub>               | 122-15-6   | 211.258  | cry            | 46    | 175 <sup>11</sup>                   |                            |                      | s H <sub>2</sub> O, cyhex; vs EtOH, eth, ace    |
| 3826 | Dimethipin                                         | 2,3-Dihydro-5,6-dimethyl-1,4-dithiin, 1,1,4,4-tetraoxide        | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub> S <sub>2</sub>  | 55290-64-7 | 210.271  |                | 165   |                                     |                            |                      |                                                 |
| 3827 | Dimethirimol                                       | 5-Butyl-2-(dimethylamino)-6-methylpyrimidin-4(1 <i>H</i> )-one  | C <sub>11</sub> H <sub>19</sub> N <sub>3</sub> O              | 5221-53-4  | 209.288  | nd             | 102   |                                     |                            |                      | sl H <sub>2</sub> O; vs chl, xyl; s EtOH, ace   |
| 3828 | Dimethisoquin                                      | 2-[(3-Butyl-1-isoquinolinyloxy)- <i>N,N</i> -dimethylethanamine | C <sub>17</sub> H <sub>24</sub> N <sub>2</sub> O              | 86-80-6    | 272.385  |                | 146   | 156 <sup>3</sup>                    |                            | 1.5486 <sup>20</sup> | s H <sub>2</sub> O, EtOH                        |
| 3829 | Dimethoxane                                        | 2,6-Dimethyl-1,3-dioxan-4-ol acetate                            | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                 | 828-00-2   | 174.195  | liq            |       | 86 <sup>10</sup>                    | 1.0655 <sup>20</sup>       | 1.4310 <sup>20</sup> | msc H <sub>2</sub> O; s os                      |
| 3830 | 2',5'-Dimethoxyacetophenone                        |                                                                 | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                | 1201-38-3  | 180.200  | cry            | 21    | 156 <sup>14</sup>                   | 1.139                      | 1.5441 <sup>20</sup> |                                                 |
| 3831 | 1,2-Dimethoxy-4-allylbenzene                       |                                                                 | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                | 93-15-2    | 178.228  | liq            | -2.0  | 254.7                               | 1.0396 <sup>20</sup>       | 1.5340 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                 |
| 3832 | 4,7-Dimethoxy-5-allyl-1,3-benzodioxole             | Apiole                                                          | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                | 523-80-8   | 222.237  | nd             | 29.5  | 294; 179 <sup>35</sup>              | 1.015 <sup>20</sup>        | 1.5360 <sup>20</sup> | vs ace, bz, EtOH, lig                           |
| 3833 | 2,4-Dimethoxyaniline                               |                                                                 | C <sub>8</sub> H <sub>11</sub> NO <sub>2</sub>                | 2735-04-8  | 153.179  | pl (liq)       | 33.5  | 262.0                               |                            |                      | sl H <sub>2</sub> O, chl; s EtOH, eth, bz, lig  |
| 3834 | 2,5-Dimethoxyaniline                               |                                                                 | C <sub>8</sub> H <sub>11</sub> NO <sub>2</sub>                | 102-56-7   | 153.179  |                | 82.5  | 270                                 |                            |                      | s H <sub>2</sub> O, EtOH, chl, lig              |
| 3835 | 3,4-Dimethoxyaniline                               |                                                                 | C <sub>8</sub> H <sub>11</sub> NO <sub>2</sub>                | 6315-89-5  | 153.179  | lf (eth)       | 87.5  | 159 <sup>14</sup>                   |                            |                      | s eth, chl                                      |



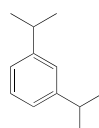
Diisopropylamine



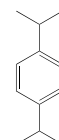
2,6-Diisopropylaniline



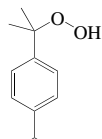
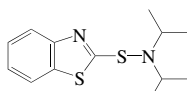
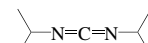
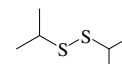
1,2-Diisopropylbenzene



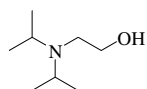
1,3-Diisopropylbenzene



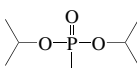
1,4-Diisopropylbenzene

*p*-Diisopropylbenzene hydroperoxide*N,N*-Diisopropyl-2-benzothiazolesulfenamide*N,N'*-Diisopropylcarbodiimide

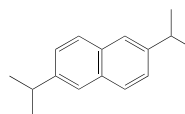
Diisopropyl disulfide

*N,N*-Diisopropylethanolamine

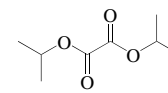
Diisopropyl ether



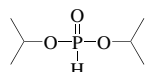
Diisopropyl methylphosphonate



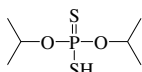
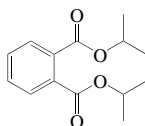
2,6-Diisopropynaphthalene



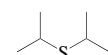
Diisopropyl oxalate



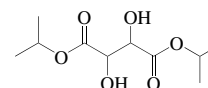
Diisopropyl phosphonate

*O,O*-Diisopropyl phosphorodithioate

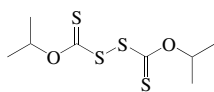
Diisopropyl phthalate



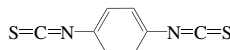
Diisopropyl sulfide



Diisopropyl tartrate, (+)



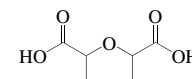
Diisopropyl thioperoxydicarbonate



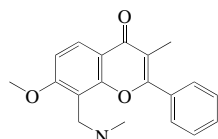
1,4-Diisothiocyanatobenzene



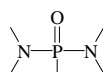
Diketene



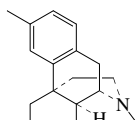
Dilactic acid



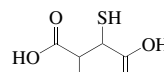
Dimetline



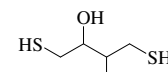
Dimetox



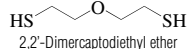
Dimemorfan



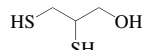
2,3-Dimercaptobutanedioic acid



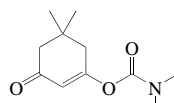
1,4-Dimercapto-2,3-butanediol



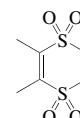
2,2'-Dimercaptodiethyl ether



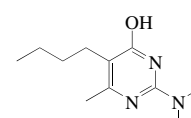
2,3-Dimercapto-1-propanol



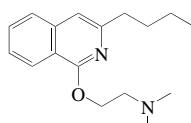
Dimetan®



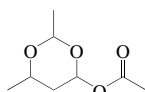
Dimethipin



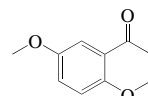
Dimethirimol



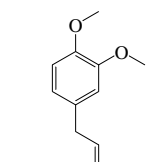
Dimethisoquin



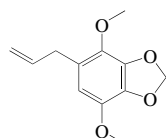
Dimethoxane



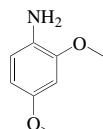
2',5'-Dimethoxyacetophenone



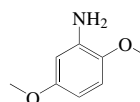
1,2-Dimethoxy-4-allylbenzene



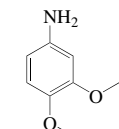
4,7-Dimethoxy-5-allyl-1,3-benzodioxole



2,4-Dimethoxyaniline



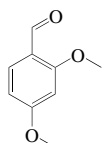
2,5-Dimethoxyaniline



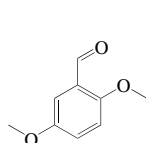
3,4-Dimethoxyaniline



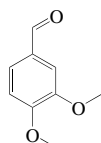
| No.  | Name                                          | Synonym                           | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-----------------------------------------------|-----------------------------------|---------------------------------------------------------------|------------|----------|---------------------------|---------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 3836 | 2,4-Dimethoxybenzaldehyde                     |                                   | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 613-45-6   | 166.173  | nd (al or lig)            | 72      | 290; 165 <sup>10</sup>               |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz; sl chl          |
| 3837 | 2,5-Dimethoxybenzaldehyde                     |                                   | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 93-02-7    | 166.173  |                           | 52      | 270; 146 <sup>10</sup>               |                            |                      | sl H <sub>2</sub> O; s EtOH, eth                     |
| 3838 | 3,4-Dimethoxybenzaldehyde                     | Veratraldehyde                    | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 120-14-9   | 166.173  | nd (eth, lig, to)         | 43      | 281; 155 <sup>10</sup>               |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth               |
| 3839 | 3,5-Dimethoxybenzaldehyde                     |                                   | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 7311-34-4  | 166.173  |                           | 46.3    | 151 <sup>16</sup>                    |                            |                      | sl H <sub>2</sub> O, peth; s EtOH, bz                |
| 3840 | 1,2-Dimethoxybenzene                          | Veratrole                         | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 91-16-7    | 138.164  |                           | 22.5    | 206                                  | 1.0810 <sup>25</sup>       | 1.5827 <sup>21</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc                |
| 3841 | 1,3-Dimethoxybenzene                          |                                   | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 151-10-0   | 138.164  | liq                       | -52     | 217.5                                | 1.0521 <sup>25</sup>       | 1.5231 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, bz, ctc, sulf      |
| 3842 | 1,4-Dimethoxybenzene                          |                                   | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 150-78-7   | 138.164  | lf (w)                    | 59      | 212.6                                | 1.0375 <sup>55</sup>       |                      | sl H <sub>2</sub> O; s EtOH, chl; vs eth, bz         |
| 3843 | 3,4-Dimethoxybenzeneacetic acid               |                                   | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                | 93-40-3    | 196.200  | cry (bz-peth) nd (w+1)    | 98      |                                      |                            |                      | s H <sub>2</sub> O, chl; vs EtOH, eth                |
| 3844 | 3,4-Dimethoxybenzeneethanamine                |                                   | C <sub>10</sub> H <sub>12</sub> NO <sub>2</sub>               | 120-20-7   | 181.232  |                           |         | 164 <sup>14</sup>                    |                            | 1.5464 <sup>20</sup> | s ctc                                                |
| 3845 | 3,4-Dimethoxybenzenemethanamine               |                                   | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                | 5763-61-1  | 167.205  |                           |         | 156 <sup>12</sup> , 120 <sup>3</sup> | 1.143 <sup>25</sup>        |                      | s chl                                                |
| 3846 | 3,4-Dimethoxybenzenemethanol                  |                                   | C <sub>9</sub> H <sub>12</sub> O <sub>3</sub>                 | 93-03-8    | 168.189  | visc oil                  |         | 298; 172 <sup>12</sup>               | 1.178 <sup>17</sup>        | 1.555 <sup>17</sup>  | s H <sub>2</sub> O, EtOH                             |
| 3847 | 3,3'-Dimethoxybenzidine                       | Dianisidine                       | C <sub>14</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub> | 119-90-4   | 244.289  | lf or nd (w)              | 137     |                                      |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl        |
| 3848 | 3,3'-Dimethoxybenzidine-4,4'-diisocyanate     |                                   | C <sub>16</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> | 91-93-0    | 296.277  | cry                       | 112     |                                      |                            |                      |                                                      |
| 3849 | 2,4-Dimethoxybenzoic acid                     |                                   | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 91-52-1    | 182.173  |                           | 108.5   |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, chl, HOAc          |
| 3850 | 2,6-Dimethoxybenzoic acid                     |                                   | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 1466-76-8  | 182.173  |                           | 186 dec |                                      |                            |                      |                                                      |
| 3851 | 3,4-Dimethoxybenzoic acid                     | Veratric acid                     | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 93-07-2    | 182.173  | nd (w or HOAc) orth (sub) | 181     | sub                                  |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; sl chl             |
| 3852 | 3,5-Dimethoxybenzoic acid                     |                                   | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 1132-21-4  | 182.173  | nd (w), pr (al)           | 185.5   | sub                                  |                            |                      | vs eth, EtOH                                         |
| 3853 | 4,4'-Dimethoxybenzoin                         | <i>p</i> -Anisoin                 | C <sub>16</sub> H <sub>16</sub> O <sub>4</sub>                | 119-52-8   | 272.296  | pr (dil al)               | 114.0   |                                      |                            |                      | sl H <sub>2</sub> O, chl, EtOH, eth; s ace           |
| 3854 | 5,7-Dimethoxy-2 <i>H</i> -1-benzopyran-2-one  | Limettin                          | C <sub>11</sub> H <sub>10</sub> O <sub>4</sub>                | 487-06-9   | 206.195  | pr or nd (al)             | 149     | dec 200                              |                            |                      | sl H <sub>2</sub> O; vs EtOH, ace, chl; i eth, lig   |
| 3855 | 4,4'-Dimethoxy-1,1'-biphenyl                  |                                   | C <sub>14</sub> H <sub>14</sub> O <sub>2</sub>                | 2132-80-1  | 214.260  | lf (bz)                   | 175     | sub                                  |                            |                      | i H <sub>2</sub> O, peth; vs EtOH, bz, chl; sl eth   |
| 3856 | Dimethoxyborane                               |                                   | C <sub>2</sub> H <sub>2</sub> BO <sub>2</sub>                 | 4542-61-4  | 73.887   | vol liq or gas            | -130.6  | 25.9                                 |                            |                      | dec H <sub>2</sub> O                                 |
| 3857 | 4,4-Dimethoxy-2-butanone                      |                                   | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                 | 5436-21-5  | 132.157  |                           |         | 50 <sup>5</sup>                      |                            |                      | s ctc                                                |
| 3858 | 2,6-Dimethoxy-2,5-cyclohexadiene-1,4-dione    | 2,6-Dimethoxy- <i>p</i> -quinone  | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                  | 530-55-2   | 168.148  | ye mcl pr (HOAc)          | 256     | sub                                  |                            |                      | sl H <sub>2</sub> O, EtOH, eth; s tfa; vs alk, HOAc  |
| 3859 | Dimethoxydimethylsilane                       |                                   | C <sub>4</sub> H <sub>12</sub> O <sub>2</sub> Si              | 1112-39-6  | 120.223  |                           |         | 82                                   | 0.8646 <sup>20</sup>       | 1.3708 <sup>20</sup> | dec H <sub>2</sub> O                                 |
| 3860 | Dimethoxydiphenylsilane                       |                                   | C <sub>14</sub> H <sub>16</sub> O <sub>2</sub> Si             | 6843-66-9  | 244.362  |                           |         | 286; 161 <sup>15</sup>               | 1.0771 <sup>20</sup>       | 1.5447 <sup>20</sup> |                                                      |
| 3861 | 1,1-Dimethoxydodecane                         | Lauraldehyde, dimethyl acetal     | C <sub>14</sub> H <sub>30</sub> O <sub>2</sub>                | 14620-52-1 | 230.387  |                           |         | 133 <sup>5</sup>                     |                            | 1.4310 <sup>25</sup> | vs eth, EtOH                                         |
| 3862 | 2,2-Dimethoxyethanamine                       |                                   | C <sub>2</sub> H <sub>11</sub> NO <sub>2</sub>                | 22483-09-6 | 105.136  |                           | -78     | 137 <sup>95</sup>                    | 0.966 <sup>25</sup>        | 1.4170 <sup>20</sup> |                                                      |
| 3863 | 1,2-Dimethoxyethane                           | Ethylene glycol dimethyl ether    | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 110-71-4   | 90.121   | liq                       | -69.20  | 84.50                                | 0.8637 <sup>25</sup>       | 1.3770 <sup>25</sup> | s H <sub>2</sub> O, EtOH, eth, ace, bz, chl, ctc     |
| 3864 | (2,2-Dimethoxyethyl)benzene                   |                                   | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                | 101-48-4   | 166.217  |                           |         | 193.5                                |                            |                      |                                                      |
| 3865 | 4,8-Dimethoxyfuro[2,3- <i>b</i> ]quinoline    | Fagarine                          | C <sub>13</sub> H <sub>11</sub> NO <sub>3</sub>               | 524-15-2   | 229.231  | pr (al)                   | 142     |                                      |                            |                      | sl H <sub>2</sub> O, peth; s EtOH, eth, bz, chl      |
| 3866 | 1,1-Dimethoxyhexadecane                       | Palmitaldehyde, dimethyl acetal   | C <sub>18</sub> H <sub>38</sub> O <sub>2</sub>                | 2791-29-9  | 286.494  |                           | 10      | 144 <sup>2</sup>                     | 0.8542 <sup>20</sup>       | 1.4382 <sup>25</sup> | vs ace, eth, EtOH                                    |
| 3867 | 2,4-Dimethoxy-6-hydroxyacetophenone           | Xanthoxylin                       | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                | 90-24-4    | 196.200  | cry (al)                  | 82      | 185 <sup>20</sup>                    |                            |                      | vs eth, EtOH                                         |
| 3868 | 5,6-Dimethoxy-1-indanone                      |                                   | C <sub>11</sub> H <sub>12</sub> O <sub>3</sub>                | 2107-69-9  | 192.211  |                           | 119.5   |                                      |                            |                      | sl ctc                                               |
| 3869 | 6,7-Dimethoxy-1(3 <i>H</i> )-isobenzofuranone | Meconin                           | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                | 569-31-3   | 194.184  | wh nd (w)                 | 102.5   |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, HOAc, chl |
| 3870 | Dimethoxymethane                              | Methylal                          | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                  | 109-87-5   | 76.095   | liq                       | -105.1  | 42                                   | 0.8593 <sup>20</sup>       | 1.3513 <sup>20</sup> | s H <sub>2</sub> O; vs ace, bz, eth, EtOH            |
| 3871 | 1,2-Dimethoxy-4-methylbenzene                 |                                   | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                 | 494-99-5   | 152.190  | pr (eth)                  | 24      | 220                                  | 1.0509 <sup>25</sup>       | 1.5257 <sup>25</sup> | i H <sub>2</sub> O; sl ctc; vs os                    |
| 3872 | 1,3-Dimethoxy-5-methylbenzene                 |                                   | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                 | 4179-19-5  | 152.190  |                           |         | 244                                  | 1.0478 <sup>15</sup>       | 1.5234 <sup>20</sup> | vs bz, eth, EtOH                                     |
| 3873 | 1,4-Dimethoxy-2-methylbenzene                 |                                   | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                 | 24599-58-4 | 152.190  |                           | 21      | 214.0                                |                            |                      |                                                      |
| 3874 | <i>N</i> -(Dimethoxymethyl)dimethylamine      | Dimethylformamide dimethyl acetal | C <sub>5</sub> H <sub>13</sub> NO <sub>2</sub>                | 4637-24-5  | 119.163  |                           |         | 104                                  | 0.897 <sup>25</sup>        | 1.3972 <sup>20</sup> |                                                      |



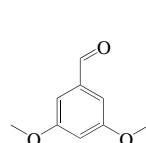
2,4-Dimethoxybenzaldehyde



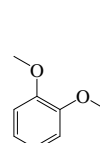
2,5-Dimethoxybenzaldehyde



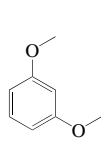
3,4-Dimethoxybenzaldehyde



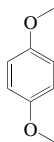
3,5-Dimethoxybenzaldehyde



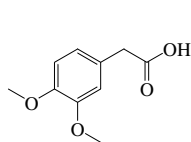
1,2-Dimethoxybenzene



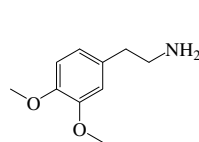
1,3-Dimethoxybenzene



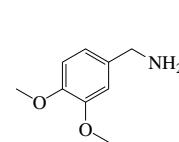
1,4-Dimethoxybenzene



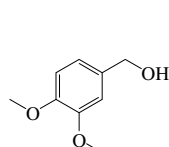
3,4-Dimethoxybenzoic acid



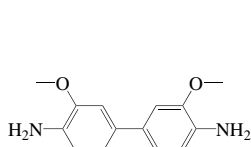
3,4-Dimethoxybenzenethanamine



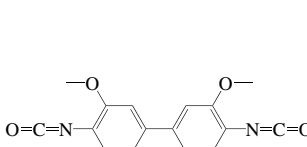
3,4-Dimethoxybenzenemethanamine



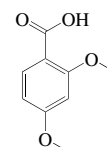
3,4-Dimethoxybenzenemethanol



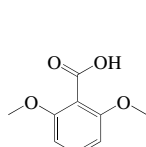
3,3'-Dimethoxybiphenyl



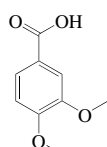
3,3'-Dimethoxybiphenyl-4,4'-diisocyanate



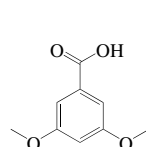
2,4-Dimethoxybenzoic acid



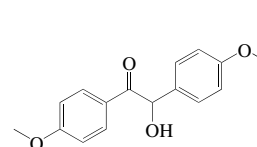
2,6-Dimethoxybenzoic acid



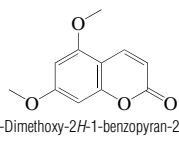
3,4-Dimethoxybenzoic acid



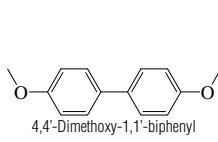
3,5-Dimethoxybenzoic acid



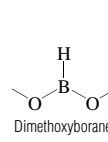
4,4'-Dimethoxybenzoin



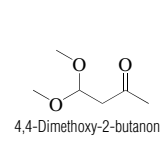
5,7-Dimethoxy-2H-1-benzopyran-2-one



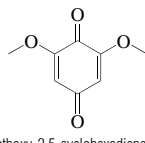
4,4'-Dimethoxy-1,1'-biphenyl



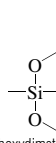
Dimethoxyborane



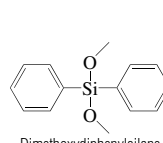
4,4'-Dimethoxy-2-butanone



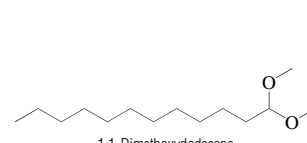
2,6-Dimethoxy-2,5-cyclohexadiene-1,4-dione



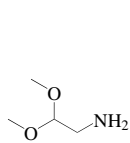
Dimethoxydimethylsilane



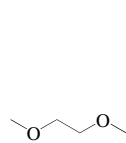
Dimethoxydiphenylsilane



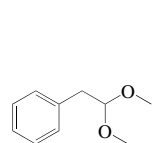
1,1-Dimethoxydodecane



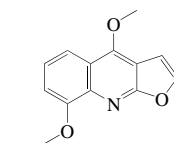
2,2-Dimethoxyethanamine



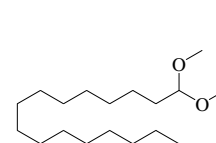
1,2-Dimethoxyethane



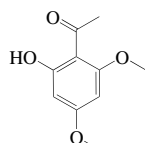
(2,2-Dimethoxyethyl)benzene



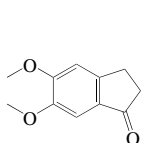
4,8-Dimethoxyfuro[2,3-b]quinoline



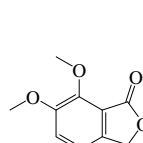
1,1-Dimethoxyhexadecane



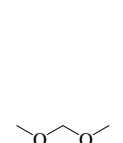
2,4-Dimethoxy-6-hydroxyacetophenone



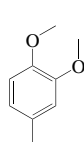
5,6-Dimethoxy-1-indanone



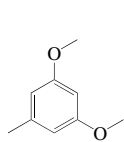
6,7-Dimethoxy-1(3H)-isobenzofuranone



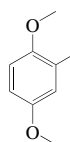
Dimethoxymethane



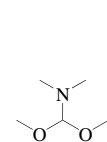
1,2-Dimethoxy-4-methylbenzene



1,3-Dimethoxy-5-methylbenzene

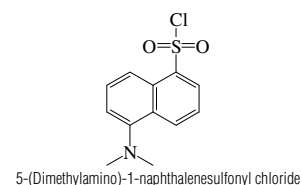
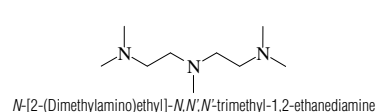
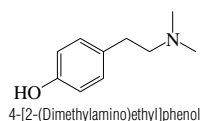
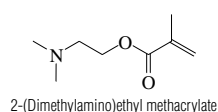
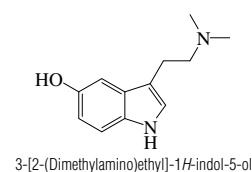
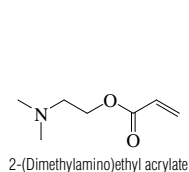
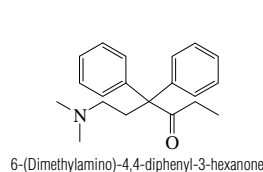
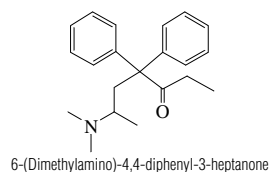
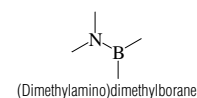
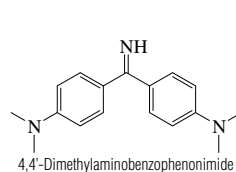
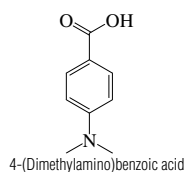
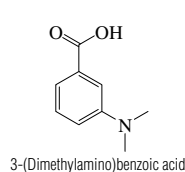
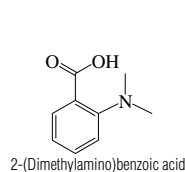
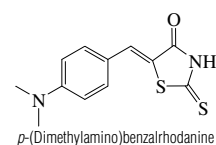
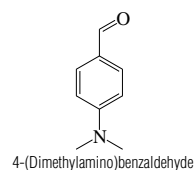
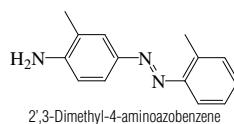
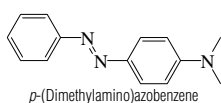
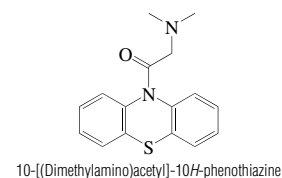
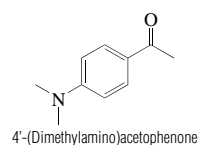
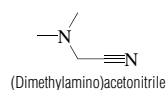
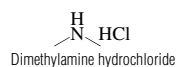
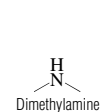
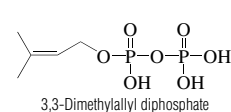
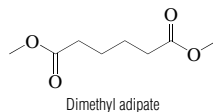
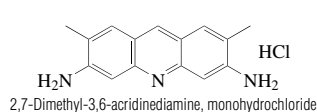
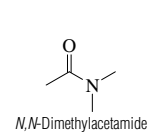
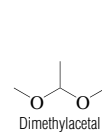
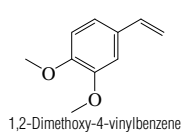
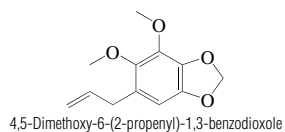
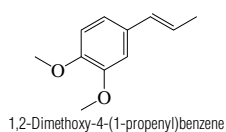
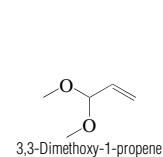
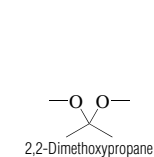
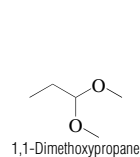
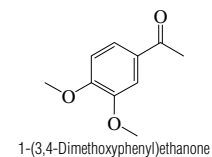
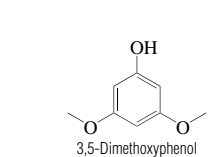
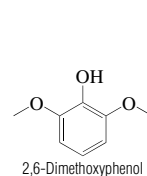
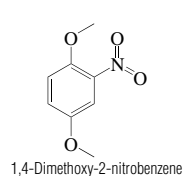
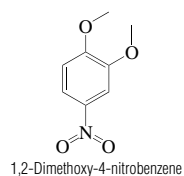
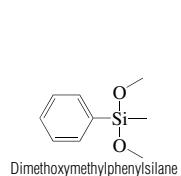
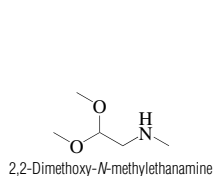


1,4-Dimethoxy-2-methylbenzene

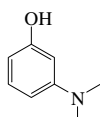


N-(Dimethoxymethyl)dimethylamine

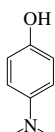
| No.  | Name                                                                           | Synonym                                    | Mol. Form.                                                     | CAS RN    | Mol. Wt. | Physical Form        | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|------|--------------------------------------------------------------------------------|--------------------------------------------|----------------------------------------------------------------|-----------|----------|----------------------|---------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 3875 | 2,2-Dimethoxy- <i>N</i> -methylethanamine                                      |                                            | C <sub>5</sub> H <sub>13</sub> NO <sub>2</sub>                 | 122-07-6  | 119.163  |                      |         | 140                                   | 0.928 <sup>25</sup>        | 1.4115 <sup>20</sup> |                                                     |
| 3876 | Dimethoxymethylphenylsilane                                                    |                                            | C <sub>9</sub> H <sub>14</sub> O <sub>2</sub> Si               | 3027-21-2 | 182.292  |                      |         | 129 <sup>79</sup>                     |                            | 1.4795 <sup>20</sup> |                                                     |
| 3877 | 1,2-Dimethoxy-4-nitrobenzene                                                   |                                            | C <sub>8</sub> H <sub>9</sub> NO <sub>4</sub>                  | 709-09-1  | 183.162  | ye nd (al-w)         | 98      | 230 <sup>15</sup>                     | 1.1888 <sup>133</sup>      |                      | i H <sub>2</sub> O; vs EtOH, eth; s chl; sl lig     |
| 3878 | 1,4-Dimethoxy-2-nitrobenzene                                                   |                                            | C <sub>8</sub> H <sub>9</sub> NO <sub>4</sub>                  | 89-39-4   | 183.162  | gold-ye nd (dil al)  | 72.5    |                                       | 1.1666 <sup>132</sup>      |                      | i H <sub>2</sub> O; s EtOH, bz, chl, sulf           |
| 3879 | 2,6-Dimethoxyphenol                                                            |                                            | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                  | 91-10-1   | 154.163  | mcl pr (w)           | 56.5    | 261                                   |                            |                      | vs eth, EtOH                                        |
| 3880 | 3,5-Dimethoxyphenol                                                            |                                            | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                  | 500-99-2  | 154.163  |                      | 37      | 199 <sup>35</sup> , 170 <sup>10</sup> |                            |                      | s eth, bz; sl lig                                   |
| 3881 | 1-(3,4-Dimethoxyphenyl)ethanone                                                |                                            | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                 | 1131-62-0 | 180.200  | pr (dil al)          | 51      | 287                                   |                            |                      | vs H <sub>2</sub> O, bz, EtOH, chl                  |
| 3882 | 1,1-Dimethoxypropane                                                           |                                            | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                  | 4744-10-9 | 104.148  |                      |         | 86                                    | 0.8648 <sup>20</sup>       |                      |                                                     |
| 3883 | 2,2-Dimethoxypropane                                                           |                                            | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                  | 77-76-9   | 104.148  | liq                  | -47     | 83                                    | 0.847 <sup>25</sup>        | 1.3780 <sup>20</sup> |                                                     |
| 3884 | 3,3-Dimethoxy-1-propene                                                        |                                            | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                  | 6044-68-4 | 102.132  |                      |         | 88                                    | 0.862 <sup>25</sup>        | 1.3954 <sup>20</sup> |                                                     |
| 3885 | 1,2-Dimethoxy-4-(1-propenyl)benzene                                            |                                            | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | 93-16-3   | 178.228  |                      | 18      | 270.5                                 | 1.0521 <sup>20</sup>       | 1.5616 <sup>20</sup> |                                                     |
| 3886 | 4,5-Dimethoxy-6-(2-propenyl)-1,3-benzodioxole                                  | Apiole (Dill)                              | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                 | 484-31-1  | 222.237  | oil                  | 29.5    | 285                                   | 1.1598 <sup>15</sup>       | 1.5305 <sup>17</sup> |                                                     |
| 3887 | 1,2-Dimethoxy-4-vinylbenzene                                                   |                                            | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                 | 6380-23-0 | 164.201  |                      |         |                                       |                            | 1.5711 <sup>20</sup> | s chl                                               |
| 3888 | Dimethylacetal                                                                 |                                            | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                  | 534-15-6  | 90.121   | liq                  | -113.2  | 64.5                                  | 0.8501 <sup>20</sup>       | 1.3668 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ctc, chl; vs ace     |
| 3889 | <i>N,N</i> -Dimethylacetamide                                                  | <i>N,N</i> -Dimethylethanamide             | C <sub>4</sub> H <sub>9</sub> NO                               | 127-19-5  | 87.120   | liq                  | -18.59  | 165                                   | 0.9372 <sup>25</sup>       | 1.4341 <sup>25</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, bz, chl       |
| 3890 | 2,7-Dimethyl-3,6-acridinediamine, monohydrochloride                            | Acridine Yellow                            | C <sub>15</sub> H <sub>16</sub> ClN <sub>3</sub>               | 135-49-9  | 273.761  | red cry pow          |         |                                       |                            |                      | s hot H <sub>2</sub> O, EtOH                        |
| 3891 | Dimethyl adipate                                                               |                                            | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                  | 627-93-0  | 174.195  | cry                  | 10.3    | 115 <sup>13</sup>                     | 1.0600 <sup>20</sup>       | 1.4283 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc, HOAc          |
| 3892 | 3,3-Dimethylallyl diphosphate                                                  | 3-Methyl-2-butenyl pyrophosphate           | C <sub>5</sub> H <sub>12</sub> O <sub>7</sub> P <sub>2</sub>   | 358-72-5  | 246.092  | cry (MeOH)           |         |                                       |                            |                      |                                                     |
| 3893 | Dimethylamine                                                                  | <i>N</i> -Methylmethanamine                | C <sub>2</sub> H <sub>7</sub> N                                | 124-40-3  | 45.084   | col gas              | -92.18  | 6.88                                  | 0.6804 <sup>0</sup>        | 1.3501 <sup>17</sup> | vs H <sub>2</sub> O; s EtOH, eth                    |
| 3894 | Dimethylamine hydrochloride                                                    | <i>N</i> -Methylmethanamine hydrochloride  | C <sub>2</sub> H <sub>8</sub> ClN                              | 506-59-2  | 81.545   | orth nd (al)         | 171     |                                       |                            |                      | vs H <sub>2</sub> O, EtOH, chl                      |
| 3895 | (Dimethylamino)acetonitrile                                                    |                                            | C <sub>4</sub> H <sub>9</sub> N <sub>2</sub>                   | 926-64-7  | 84.120   |                      |         | 137.5                                 | 0.8649 <sup>20</sup>       | 1.4095 <sup>20</sup> | vs H <sub>2</sub> O, EtOH                           |
| 3896 | 4'-(Dimethylamino)acetophenone                                                 | 4-Acetyl- <i>N,N</i> -dimethylaniline      | C <sub>10</sub> H <sub>13</sub> NO                             | 2124-31-4 | 163.216  | nd (w, peth)         | 105.5   |                                       |                            |                      | vs H <sub>2</sub> O, eth, lig; sl chl               |
| 3897 | 10-[(Dimethylamino)acetyl]-10- <i>H</i> -phenothiazine                         | Ahistan                                    | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> QS              | 518-61-6  | 284.375  | cry                  | 144.5   |                                       |                            |                      |                                                     |
| 3898 | <i>p</i> -(Dimethylamino)azobenzene                                            |                                            | C <sub>14</sub> H <sub>15</sub> N <sub>3</sub>                 | 60-11-7   | 225.289  | ye lf (al)           | 117     | dec                                   |                            |                      | i H <sub>2</sub> O; vs EtOH, py; s eth; sl chl, lig |
| 3899 | 2',3-Dimethyl-4-aminoazobenzene                                                | 4- <i>o</i> -Tolylazo- <i>o</i> -toluidine | C <sub>14</sub> H <sub>15</sub> N <sub>3</sub>                 | 97-56-3   | 225.289  | ye lf (al)           | 102     |                                       |                            |                      | vs eth, EtOH                                        |
| 3900 | 4-(Dimethylamino)benzaldehyde                                                  | Ehrlich's reagent                          | C <sub>9</sub> H <sub>11</sub> NO                              | 100-10-7  | 149.189  | lf (w)               | 74.5    | 176 <sup>17</sup>                     | 1.0254 <sup>100</sup>      |                      | sl H <sub>2</sub> O, chl; s EtOH, eth, ace, bz      |
| 3901 | <i>p</i> -(Dimethylamino)benzalrhodanine                                       |                                            | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> QS <sub>2</sub> | 536-17-4  | 264.365  | dp red nd (xyl)      | 270 dec |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH, bz; vs eth, ctc; s ace |
| 3902 | 2-(Dimethylamino)benzoic acid                                                  |                                            | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                 | 610-16-2  | 165.189  | pr, nd (eth)         | 72      | sub                                   |                            |                      | vs H <sub>2</sub> O, eth, EtOH                      |
| 3903 | 3-(Dimethylamino)benzoic acid                                                  |                                            | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                 | 99-64-9   | 165.189  | nd (w)               | 152.5   |                                       |                            |                      | sl H <sub>2</sub> O, chl; s EtOH                    |
| 3904 | 4-(Dimethylamino)benzoic acid                                                  |                                            | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                 | 619-84-1  | 165.189  | nd (al)              | 242.5   |                                       |                            |                      | s EtOH; sl eth                                      |
| 3905 | 4,4'-Dimethylaminobenzophenonimide                                             | Brilliant Oil Yellow                       | C <sub>17</sub> H <sub>21</sub> N <sub>3</sub>                 | 492-80-8  | 267.369  | ye or col pl (al)    | 136     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH; sl eth                  |
| 3906 | (Dimethylamino)dimethylborane                                                  |                                            | C <sub>4</sub> H <sub>12</sub> BN                              | 1113-30-0 | 84.956   | liq                  | -92     | 65                                    |                            |                      | vs eth, ace                                         |
| 3907 | 6-(Dimethylamino)-4,4-diphenyl-3-heptanone                                     |                                            | C <sub>21</sub> H <sub>27</sub> NO                             | 76-99-3   | 309.445  |                      | 99.5    |                                       |                            |                      | vs EtOH                                             |
| 3908 | 6-(Dimethylamino)-4,4-diphenyl-3-hexanone                                      | Normethadone                               | C <sub>20</sub> H <sub>25</sub> NO                             | 467-85-6  | 295.419  | oily liq             |         | 165 <sup>3</sup>                      |                            |                      |                                                     |
| 3909 | 2-(Dimethylamino)ethyl acrylate                                                |                                            | C <sub>7</sub> H <sub>13</sub> NO <sub>2</sub>                 | 2439-35-2 | 143.184  |                      | <-60    | 95 <sup>30</sup>                      | 0.938 <sup>20</sup>        |                      |                                                     |
| 3910 | 3-[2-(Dimethylamino)ethyl]-1- <i>H</i> -indol-5-ol                             | Bufotenine                                 | C <sub>12</sub> H <sub>16</sub> N <sub>2</sub> O               | 487-93-4  | 204.267  | pr (EtOAc)           | 146.5   | 320 <sup>0.1</sup>                    |                            |                      | vs eth, EtOH                                        |
| 3911 | 2-(Dimethylamino)ethyl methacrylate                                            |                                            | C <sub>8</sub> H <sub>15</sub> NO <sub>2</sub>                 | 2867-47-2 | 157.211  |                      |         | 63 <sup>6</sup>                       |                            |                      |                                                     |
| 3912 | 4-[2-(Dimethylamino)ethyl]phenol                                               | Hordenine                                  | C <sub>10</sub> H <sub>15</sub> NO                             | 539-15-1  | 165.232  | orth pr (al), nd (w) | 117.5   | 173 <sup>11</sup>                     |                            |                      | vs eth, EtOH, chl                                   |
| 3913 | <i>N</i> -[2-(Dimethylamino)ethyl]- <i>N,N,N'</i> -trimethyl-1,2-ethanediamine |                                            | C <sub>9</sub> H <sub>23</sub> N <sub>3</sub>                  | 3030-47-5 | 173.299  |                      |         | 84 <sup>12</sup>                      |                            | 1.4413 <sup>25</sup> |                                                     |
| 3914 | 5-(Dimethylamino)-1-naphthalenesulfonyl chloride                               | Dansyl chloride                            | C <sub>12</sub> H <sub>12</sub> ClNO <sub>2</sub> S            | 605-65-2  | 269.747  |                      | 70      |                                       |                            |                      |                                                     |



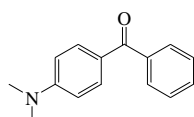
| No.  | Name                                                  | Synonym                                        | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form        | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|-------------------------------------------------------|------------------------------------------------|--------------------------------------------------|------------|----------|----------------------|---------|------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 3915 | 3-(Dimethylamino)phenol                               |                                                | C <sub>8</sub> H <sub>11</sub> NO                | 99-07-0    | 137.179  | nd (lig)             | 86      | 266.5                  |                            | 1.5895 <sup>26</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, CS <sub>2</sub>     |
| 3916 | 4-(Dimethylamino)phenol                               |                                                | C <sub>8</sub> H <sub>11</sub> NO                | 619-60-3   | 137.179  |                      | 77      | 165 <sup>30</sup>      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth                              |
| 3917 | [4-(Dimethylamino)phenyl] phenylmethanone             | 4-(Dimethylamino) benzophenone                 | C <sub>15</sub> H <sub>15</sub> NO               | 530-44-9   | 225.286  | ye lf (al) nd (peth) | 92.5    |                        |                            |                      | i H <sub>2</sub> O; sl EtOH; vs eth; s chl, peth              |
| 3918 | 3-(Dimethylamino)-1-phenyl-1-propanone, hydrochloride |                                                | C <sub>11</sub> H <sub>16</sub> ClNO             | 879-72-1   | 213.704  |                      |         | 153.5                  |                            |                      |                                                               |
| 3919 | 3-[4-(Dimethylamino)phenyl]-2-propenal                | 4-(Dimethylamino) cinnamaldehyde               | C <sub>11</sub> H <sub>13</sub> NO               | 6203-18-5  | 175.227  |                      |         | 139.5                  |                            |                      |                                                               |
| 3920 | 3-(Dimethylamino)propanenitrile                       |                                                | C <sub>6</sub> H <sub>10</sub> N <sub>2</sub>    | 1738-25-6  | 98.146   |                      |         | 173                    | 0.8705 <sup>20</sup>       |                      |                                                               |
| 3921 | 2-(Dimethylamino)-1-propanol                          |                                                | C <sub>6</sub> H <sub>13</sub> NO                | 15521-18-3 | 103.163  |                      |         | 150.3                  | 0.8820 <sup>26</sup>       |                      | s H <sub>2</sub> O                                            |
| 3922 | 3-(Dimethylamino)-1-propanol                          |                                                | C <sub>6</sub> H <sub>13</sub> NO                | 3179-63-3  | 103.163  |                      |         | 163.5                  | 0.872 <sup>25</sup>        | 1.4360 <sup>20</sup> | s ctc                                                         |
| 3923 | 1-(Dimethylamino)-2-propanol                          |                                                | C <sub>6</sub> H <sub>13</sub> NO                | 108-16-7   | 103.163  |                      |         | 124.5                  | 0.837 <sup>25</sup>        | 1.4193 <sup>20</sup> | s ctc                                                         |
| 3924 | 3-(Dimethylamino)-1-propyne                           | <i>N,N</i> -Dimethyl-2-propargylamine          | C <sub>5</sub> H <sub>9</sub> N                  | 7223-38-3  | 83.132   |                      |         | 80                     | 0.7792 <sup>20</sup>       | 1.4195 <sup>20</sup> |                                                               |
| 3925 | 2-Dimethylaminopurine                                 | <i>N,N</i> -Dimethyl-1 <i>H</i> -purin-6-amine | C <sub>7</sub> H <sub>9</sub> N <sub>5</sub>     | 938-55-6   | 163.180  |                      | 263     |                        |                            |                      |                                                               |
| 3926 | 2-( <i>p</i> -Dimethylaminostyryl) benzothiazole      |                                                | C <sub>17</sub> H <sub>16</sub> N <sub>2</sub> S | 1628-58-6  | 280.387  | ye nd (MeOH)         | 207 dec |                        |                            |                      |                                                               |
| 3927 | 2,3-Dimethylaniline                                   | 2,3-Xylidine                                   | C <sub>8</sub> H <sub>11</sub> N                 | 87-59-2    | 121.180  |                      | <-15    | 221.5                  | 0.9931 <sup>20</sup>       | 1.5684 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth; s ctc                      |
| 3928 | 2,4-Dimethylaniline                                   | 2,4-Xylidine                                   | C <sub>8</sub> H <sub>11</sub> N                 | 95-68-1    | 121.180  | liq                  | -14.3   | 214                    | 0.9723 <sup>20</sup>       | 1.5569 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, bz                     |
| 3929 | 2,5-Dimethylaniline                                   | 2,5-Xylidine                                   | C <sub>8</sub> H <sub>11</sub> N                 | 95-78-3    | 121.180  | ye lf (lig)          | 15.5    | 214                    | 0.9790 <sup>21</sup>       | 1.5591 <sup>21</sup> | sl H <sub>2</sub> O; s eth, ctc                               |
| 3930 | 2,6-Dimethylaniline                                   | 2,6-Xylidine                                   | C <sub>8</sub> H <sub>11</sub> N                 | 87-62-7    | 121.180  |                      | 11.2    | 215                    | 0.9842 <sup>20</sup>       | 1.5610 <sup>20</sup> | vs eth, EtOH                                                  |
| 3931 | 3,4-Dimethylaniline                                   | 3,4-Xylidine                                   | C <sub>8</sub> H <sub>11</sub> N                 | 95-64-7    | 121.180  | pl or pr (lig)       | 51      | 228                    | 1.076 <sup>18</sup>        |                      | sl H <sub>2</sub> O, chl; s eth; vs lig                       |
| 3932 | 3,5-Dimethylaniline                                   | 3,5-Xylidine                                   | C <sub>8</sub> H <sub>11</sub> N                 | 108-69-0   | 121.180  |                      | 9.8     | 220.5                  | 0.9706 <sup>20</sup>       | 1.5581 <sup>20</sup> | sl H <sub>2</sub> O; s eth, ctc                               |
| 3933 | <i>N</i> ,2-Dimethylaniline                           |                                                | C <sub>8</sub> H <sub>11</sub> N                 | 611-21-2   | 121.180  |                      |         | 207.5                  | 0.9709 <sup>20</sup>       | 1.5649 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace                      |
| 3934 | <i>N</i> ,3-Dimethylaniline                           |                                                | C <sub>8</sub> H <sub>11</sub> N                 | 696-44-6   | 121.180  |                      |         | 206.5                  | 0.9660 <sup>20</sup>       | 1.5557 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace                      |
| 3935 | <i>N</i> ,4-Dimethylaniline                           |                                                | C <sub>8</sub> H <sub>11</sub> N                 | 623-08-5   | 121.180  |                      |         | 210                    | 0.9348 <sup>55</sup>       | 1.5568 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace                      |
| 3936 | <i>N,N</i> -Dimethylaniline                           |                                                | C <sub>8</sub> H <sub>11</sub> N                 | 121-69-7   | 121.180  | pa ye                | 2.42    | 194.15                 | 0.9557 <sup>20</sup>       | 1.5582 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz; vs chl             |
| 3937 | <i>N,N</i> -Dimethylaniline hydrochloride             |                                                | C <sub>8</sub> H <sub>12</sub> ClN               | 5882-44-0  | 157.641  | hyg pl (w, bz)       | 90      |                        | 1.1156 <sup>19</sup>       |                      | vs H <sub>2</sub> O, EtOH, chl                                |
| 3938 | 2,6-Dimethylanisole                                   |                                                | C <sub>9</sub> H <sub>12</sub> O                 | 1004-66-6  | 136.190  |                      |         | 182.5                  | 0.9619 <sup>14</sup>       | 1.5053 <sup>14</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc                      |
| 3939 | 3,5-Dimethylanisole                                   |                                                | C <sub>9</sub> H <sub>12</sub> O                 | 874-63-5   | 136.190  |                      |         | 194; 89 <sup>15</sup>  | 0.9627 <sup>15</sup>       | 1.5110 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, CS <sub>2</sub> ; sl ctc |
| 3940 | 9,10-Dimethylantracene                                |                                                | C <sub>16</sub> H <sub>14</sub>                  | 781-43-1   | 206.282  |                      | 183.6   | 360.0                  |                            |                      | i H <sub>2</sub> O                                            |
| 3941 | 1,4-Dimethyl-9,10-anthracenedione                     |                                                | C <sub>16</sub> H <sub>12</sub> O <sub>2</sub>   | 1519-36-4  | 236.265  | ye nd (al, sub)      | 140.5   | sub                    |                            |                      | i H <sub>2</sub> O; sl EtOH; s bz, xyl, HOAc                  |
| 3942 | Dimethylarsine                                        |                                                | C <sub>2</sub> H <sub>7</sub> As                 | 593-57-7   | 105.999  | liq, ign in air      | -136.1  | 36                     | 1.208 <sup>29</sup>        |                      | vs ace, bz, eth, EtOH                                         |
| 3943 | Dimethylarsinic acid                                  | Cacodylic acid                                 | C <sub>2</sub> H <sub>7</sub> AsO <sub>2</sub>   | 75-60-5    | 137.998  |                      | 195     | >200                   |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth                            |
| 3944 | 2,4-Dimethylbenzaldehyde                              |                                                | C <sub>9</sub> H <sub>10</sub> O                 | 15764-16-6 | 134.174  | liq                  | -9      | 218                    |                            |                      | s EtOH; s eth, ace, bz; sl chl                                |
| 3945 | 2,5-Dimethylbenzaldehyde                              | Isoxylaldehyde                                 | C <sub>9</sub> H <sub>10</sub> O                 | 5779-94-2  | 134.174  |                      |         | 220                    | 0.9500 <sup>20</sup>       |                      | vs EtOH; s eth, ace, bz, ctc                                  |
| 3946 | 3,5-Dimethylbenzaldehyde                              |                                                | C <sub>9</sub> H <sub>10</sub> O                 | 5779-95-3  | 134.174  |                      | 9       | 221                    |                            |                      | vs ace, bz, eth, EtOH                                         |
| 3947 | <i>N,N</i> -Dimethylbenzamide                         |                                                | C <sub>9</sub> H <sub>11</sub> NO                | 611-74-5   | 149.189  |                      | 44.8    | 272.0                  |                            |                      |                                                               |
| 3948 | 7,12-Dimethylbenz[ <i>a</i> ]anthracene               | 9,10-Dimethyl-1,2-benzanthracene               | C <sub>20</sub> H <sub>16</sub>                  | 57-97-6    | 256.341  | pa ye pl (al, HOAc)  | 122.5   |                        |                            |                      | vs ace, bz                                                    |
| 3949 | 4,5-Dimethyl-1,2-benzenediamine                       |                                                | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>    | 3171-45-7  | 136.194  |                      | 128     |                        |                            |                      |                                                               |
| 3950 | <i>N,N</i> -Dimethyl-1,2-benzenediamine               |                                                | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>    | 2836-03-5  | 136.194  | oil                  |         | 218; 90 <sup>22</sup>  | 0.995 <sup>22</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth, ace, bz                    |
| 3951 | <i>N,N</i> -Dimethyl-1,3-benzenediamine               |                                                | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>    | 2836-04-6  | 136.194  |                      | <-20    | 270; 138 <sup>10</sup> | 0.995 <sup>25</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth                             |
| 3952 | <i>N,N</i> -Dimethyl-1,4-benzenediamine               | Dimethyl- <i>p</i> -phenylenediamine           | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>    | 99-98-9    | 136.194  | nd (bz)              | 53      | 263                    | 1.036 <sup>20</sup>        |                      | s H <sub>2</sub> O, chl; vs EtOH, eth, bz; sl lig             |
| 3953 | 2,5-Dimethyl-1,3-benzenediol                          |                                                | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>    | 488-87-9   | 138.164  | nd (bz), pr (w)      | 163     | 278.5                  |                            |                      | s H <sub>2</sub> O, EtOH, eth                                 |



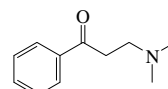
3-(Dimethylamino)phenol



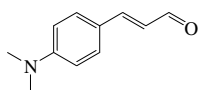
4-(Dimethylamino)phenol



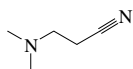
[4-(Dimethylamino)phenyl]phenylmethanone



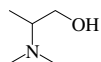
3-(Dimethylamino)-1-phenyl-1-propanone, hydrochloride



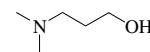
3-[4-(Dimethylamino)phenyl]-2-propenal



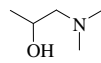
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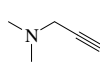
2-(Dimethylamino)-1-propanol



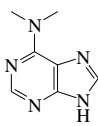
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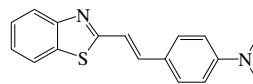
1-(Dimethylamino)-2-propanol



3-(Dimethylamino)-1-propyne



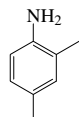
2-Dimethylaminopurine



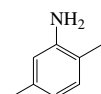
2-(p-Dimethylaminostyryl)benzothiazole



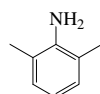
2,3-Dimethylaniline



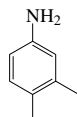
2,4-Dimethylaniline



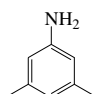
2,5-Dimethylaniline



2,6-Dimethylaniline



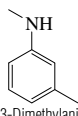
3,4-Dimethylaniline



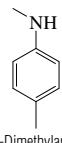
3,5-Dimethylaniline



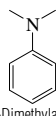
N,2-Dimethylaniline



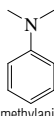
N,3-Dimethylaniline



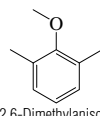
N,4-Dimethylaniline



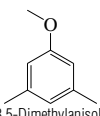
N,N-Dimethylaniline



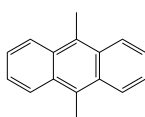
N,N-Dimethylaniline hydrochloride



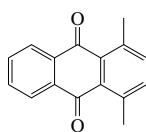
2,6-Dimethylanisole



3,5-Dimethylanisole



9,10-Dimethylantracene



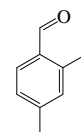
1,4-Dimethyl-9,10-anthracenedione



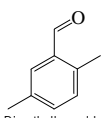
Dimethylarsine



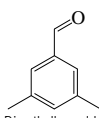
Dimethylarsinic acid



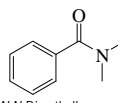
2,4-Dimethylbenzaldehyde



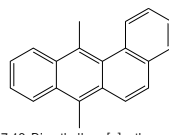
2,5-Dimethylbenzaldehyde



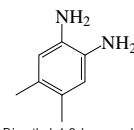
3,5-Dimethylbenzaldehyde



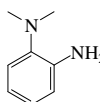
N,N-Dimethylbenzamide



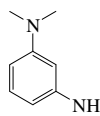
7,12-Dimethylbenz[a]anthracene



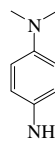
4,5-Dimethyl-1,2-benzenediamine



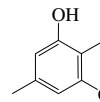
N,N-Dimethyl-1,2-benzenediamine



N,N-Dimethyl-1,3-benzenediamine

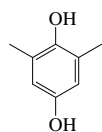


N,N-Dimethyl-1,4-benzenediamine

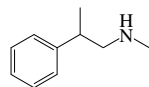
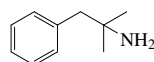
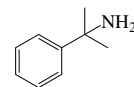
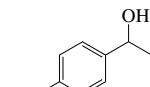
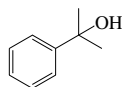
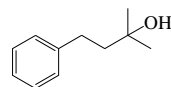
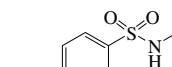
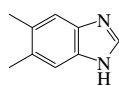
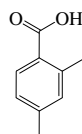


2,5-Dimethyl-1,3-benzenediol

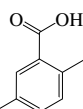
| No.  | Name                                                                                       | Synonym                                                             | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form     | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------|------------|----------|-------------------|---------|---------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 3954 | 2,6-Dimethyl-1,4-benzenediol                                                               |                                                                     | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 654-42-2   | 138.164  | nd (xyl), cry (w) | 152.3   |                                       |                            |                      | vs eth, EtOH                                                 |
| 3955 | <i>N</i> ,β-Dimethylbenzeneethanamine                                                      | Phenylpropylmethylamine                                             | C <sub>10</sub> H <sub>13</sub> N                             | 93-88-9    | 149.233  |                   |         | 207.5                                 | 0.915 <sup>25</sup>        |                      | vs bz, eth, EtOH                                             |
| 3956 | α,α-Dimethylbenzeneethanamine                                                              | Phentermine                                                         | C <sub>10</sub> H <sub>13</sub> N                             | 122-09-8   | 149.233  | oily liq          |         | 205; 100 <sup>21</sup>                |                            |                      |                                                              |
| 3957 | α,α-Dimethylbenzenemethanamine                                                             |                                                                     | C <sub>9</sub> H <sub>13</sub> N                              | 585-32-0   | 135.206  |                   |         | 196.5                                 | 0.9423 <sup>20</sup>       | 1.5181 <sup>25</sup> |                                                              |
| 3958 | α,4-Dimethylbenzenemethanol                                                                | 1-(4-Methylphenyl)ethanol                                           | C <sub>9</sub> H <sub>12</sub> O                              | 536-50-5   | 136.190  |                   |         | 219                                   | 0.9668 <sup>25</sup>       | 1.5246 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                             |
| 3959 | α,α-Dimethylbenzenemethanol                                                                | α-Cumyl alcohol                                                     | C <sub>9</sub> H <sub>12</sub> O                              | 617-94-7   | 136.190  | pr                | 36      | 202                                   | 0.9735 <sup>20</sup>       | 1.5325 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, HOAc                    |
| 3960 | α,α-Dimethylbenzenepropanol                                                                | Benzyl- <i>tert</i> -butanol                                        | C <sub>11</sub> H <sub>16</sub> O                             | 103-05-9   | 164.244  | nd                | 24.5    | 121 <sup>13</sup>                     | 0.9626 <sup>21</sup>       | 1.5077 <sup>21</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace, bz                    |
| 3961 | <i>N</i> ,4-Dimethylbenzenesulfonamide                                                     |                                                                     | C <sub>8</sub> H <sub>11</sub> NO <sub>2</sub> S              | 640-61-9   | 185.244  | pl (dil al)       | 78.5    |                                       | 1.340 <sup>25</sup>        |                      | vs eth, EtOH                                                 |
| 3962 | 5,6-Dimethyl-1 <i>H</i> -benzimidazole                                                     | Dimedazole                                                          | C <sub>9</sub> H <sub>10</sub> N <sub>2</sub>                 | 582-60-5   | 146.188  | cry (eth)         | 205.5   | sub                                   |                            |                      | s H <sub>2</sub> O, EtOH, eth, chl, DMSO                     |
| 3963 | 2,4-Dimethylbenzoic acid                                                                   |                                                                     | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 611-01-8   | 150.174  | mcl or tcl nd (w) | 90      | 268                                   |                            |                      | sl H <sub>2</sub> O; s EtOH, ace, bz, chl, HOAc, tol         |
| 3964 | 2,5-Dimethylbenzoic acid                                                                   |                                                                     | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 610-72-0   | 150.174  | nd (al)           | 132     | sub                                   | 1.069 <sup>21</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz                     |
| 3965 | 2,6-Dimethylbenzoic acid                                                                   |                                                                     | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 632-46-2   | 150.174  | nd (lig)          | 116     | 274.5; 155 <sup>17</sup>              |                            |                      | sl H <sub>2</sub> O; lig; s EtOH, eth                        |
| 3966 | 3,4-Dimethylbenzoic acid                                                                   |                                                                     | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 619-04-5   | 150.174  | pr (al)           | 167.3   |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz                          |
| 3967 | 3,5-Dimethylbenzoic acid                                                                   | Mesitylenic acid                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 499-06-9   | 150.174  | nd (w, al)        | 171.1   | sub                                   |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth                            |
| 3968 | 4,4'-Dimethylbenzophenone                                                                  | Bis(4-methylphenyl) ketone                                          | C <sub>15</sub> H <sub>14</sub> O                             | 611-97-2   | 210.271  | orth (al)         | 96.5    | 334                                   |                            |                      | vs ace, bz, eth, EtOH                                        |
| 3969 | 7,8-Dimethylbenzo[g]pteridine-2,4(1 <i>H</i> ,3 <i>H</i> )-dione                           | Lumichrome                                                          | C <sub>12</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub> | 1086-80-2  | 242.233  | ye cry (chl)      | 300     |                                       |                            |                      | sl H <sub>2</sub> O, EtOH, chl                               |
| 3970 | 2,5-Dimethylbenzoxazole                                                                    |                                                                     | C <sub>9</sub> H <sub>7</sub> NO                              | 5676-58-4  | 147.173  |                   |         | 218.5                                 | 1.0880 <sup>18</sup>       | 1.5412 <sup>20</sup> | s ctc                                                        |
| 3971 | <i>N</i> , <i>N</i> -Dimethylbenzylamine                                                   | Dimethylbenzylamine                                                 | C <sub>9</sub> H <sub>13</sub> N                              | 103-83-3   | 135.206  |                   |         | 181                                   | 0.915 <sup>0</sup>         | 1.5011 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                           |
| 3972 | <i>N</i> , <i>N</i> -Dimethyl- <i>N'</i> -benzyl-1,2-ethanediamine                         | <i>N</i> -Benzyl- <i>N'</i> , <i>N'</i> -dimethyl-1,2-ethanediamine | C <sub>11</sub> H <sub>18</sub> N <sub>2</sub>                | 103-55-9   | 178.274  |                   |         | 145 <sup>30</sup> , 123 <sup>11</sup> | 0.9343 <sup>20</sup>       | 1.5089 <sup>20</sup> |                                                              |
| 3973 | <i>N</i> , <i>N</i> -Dimethyl- <i>N'</i> -benzyl- <i>N'</i> -2-pyridinyl-1,2-ethanediamine | Tripelennamine                                                      | C <sub>16</sub> H <sub>21</sub> N <sub>3</sub>                | 91-81-6    | 255.358  | ye oil            |         | 140 <sup>0.1</sup>                    |                            | 1.576 <sup>25</sup>  | misc H <sub>2</sub> O                                        |
| 3974 | 6,6-Dimethylbicyclo[3.1.1]heptan-2-one, (1 <i>R</i> )                                      |                                                                     | C <sub>9</sub> H <sub>14</sub> O                              | 38651-65-9 | 138.206  | liq               | -1      | 209                                   | 0.9807 <sup>20</sup>       | 1.4787 <sup>20</sup> | vs eth, EtOH                                                 |
| 3975 | 2,3-Dimethylbicyclo[2.2.1]hept-2-ene                                                       | 2,3-Dimethyl-2-norbornene                                           | C <sub>9</sub> H <sub>14</sub>                                | 529-16-8   | 122.207  |                   |         | 140.5                                 | 0.8698 <sup>17</sup>       | 1.4688 <sup>17</sup> | s eth, ace, bz                                               |
| 3976 | 6,6-Dimethylbicyclo[3.1.1]hept-2-ene-2-ethanol                                             |                                                                     | C <sub>11</sub> H <sub>18</sub> O                             | 128-50-7   | 166.260  |                   |         | 235; 110 <sup>10</sup>                | 0.973 <sup>25</sup>        | 1.4930 <sup>20</sup> | s chl                                                        |
| 3977 | 2,2'-Dimethylbiphenyl                                                                      |                                                                     | C <sub>14</sub> H <sub>14</sub>                               | 605-39-0   | 182.261  | cry (al)          | 19.5    | 256                                   | 0.9906 <sup>20</sup>       | 1.5752 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz; s ace                  |
| 3978 | 3,3'-Dimethylbiphenyl                                                                      |                                                                     | C <sub>14</sub> H <sub>14</sub>                               | 612-75-9   | 182.261  |                   | 9       | 280                                   | 0.9995 <sup>20</sup>       | 1.5946 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz; s ace                  |
| 3979 | 4,4'-Dimethylbiphenyl                                                                      |                                                                     | C <sub>14</sub> H <sub>14</sub>                               | 613-33-2   | 182.261  | mcl pr (eth)      | 125     | 295                                   | 0.917 <sup>121</sup>       |                      | i H <sub>2</sub> O; sl EtOH; s eth, ace, bz, CS <sub>2</sub> |
| 3980 | 4,4'-Dimethyl-2,2'-bipyridine                                                              |                                                                     | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                | 1134-35-6  | 184.236  |                   | 171.5   |                                       |                            |                      | s chl                                                        |
| 3981 | 2,3-Dimethyl-1,3-butadiene                                                                 | Diisopropenyl                                                       | C <sub>6</sub> H <sub>10</sub>                                | 513-81-5   | 82.143   | liq               | -76     | 68.8                                  | 0.7222 <sup>25</sup>       | 1.4394 <sup>20</sup> | s ctc                                                        |
| 3982 | <i>N</i> , <i>N</i> -Dimethylbutanamide                                                    |                                                                     | C <sub>8</sub> H <sub>13</sub> NO                             | 760-79-2   | 115.173  | liq               | -40     | 186; 125 <sup>100</sup>               | 0.9064 <sup>25</sup>       | 1.4391 <sup>25</sup> | vs ace, bz, eth, EtOH                                        |
| 3983 | 3,3-Dimethyl-2-butanamine                                                                  |                                                                     | C <sub>8</sub> H <sub>15</sub> N                              | 3850-30-4  | 101.190  | liq               | -20     | 102                                   | 0.7668 <sup>20</sup>       | 1.4105 <sup>25</sup> | vs H <sub>2</sub> O                                          |
| 3984 | 2,2-Dimethylbutane                                                                         | Neohexane                                                           | C <sub>6</sub> H <sub>14</sub>                                | 75-83-2    | 86.175   | liq               | -98.8   | 49.73                                 | 0.6444 <sup>25</sup>       | 1.3688 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; vs ace, bz, peth, ctc       |
| 3985 | 2,3-Dimethylbutane                                                                         |                                                                     | C <sub>6</sub> H <sub>14</sub>                                | 79-29-8    | 86.175   | liq               | -128.10 | 57.93                                 | 0.6616 <sup>20</sup>       | 1.3750 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; vs ace, bz, peth, ctc       |
| 3986 | 2,3-Dimethyl-2,3-butanediol                                                                | Pinacol                                                             | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | 76-09-5    | 118.174  | nd (al, eth)      | 43.32   | 174.4                                 |                            |                      | sl H <sub>2</sub> O, CS <sub>2</sub> ; vs EtOH, eth          |
| 3987 | 2,3-Dimethyl-2-butanethiol                                                                 |                                                                     | C <sub>6</sub> H <sub>14</sub> S                              | 1639-01-6  | 118.240  | liq               |         | 126.1                                 |                            |                      |                                                              |
| 3988 | 2,2-Dimethylbutanoic acid                                                                  |                                                                     | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 595-37-9   | 116.158  | liq               | -14     | 186                                   | 0.9276 <sup>20</sup>       | 1.4145 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                             |
| 3989 | 2,2-Dimethyl-1-butanol                                                                     |                                                                     | C <sub>6</sub> H <sub>14</sub> O                              | 1185-33-7  | 102.174  |                   | <-15    | 136.5                                 | 0.8283 <sup>20</sup>       | 1.4208 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                             |
| 3990 | 3,3-Dimethyl-1-butanol                                                                     |                                                                     | C <sub>6</sub> H <sub>14</sub> O                              | 624-95-3   | 102.174  | liq               | -60     | 143                                   | 0.844 <sup>15</sup>        | 1.4323 <sup>15</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace                        |
| 3991 | 2,3-Dimethyl-2-butanol                                                                     |                                                                     | C <sub>6</sub> H <sub>14</sub> O                              | 594-60-5   | 102.174  | liq               | -14     | 118.4                                 | 0.8236 <sup>20</sup>       | 1.4176 <sup>20</sup> | s H <sub>2</sub> O; msc EtOH, eth                            |
| 3992 | 3,3-Dimethyl-2-butanol, (±)                                                                |                                                                     | C <sub>6</sub> H <sub>14</sub> O                              | 20281-91-8 | 102.174  |                   | 5.6     | 120.4                                 | 0.8122 <sup>25</sup>       | 1.4148 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth                            |



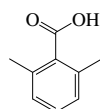
2,6-Dimethyl-1,4-benzenediol

*N*, $\beta$ -Dimethylbenzeneethanamine $\alpha,\alpha$ -Dimethylbenzeneethanamine $\alpha,\alpha$ -Dimethylbenzenemethanamine $\alpha,4$ -Dimethylbenzenemethanol $\alpha,\alpha$ -Dimethylbenzenemethanol $\alpha,\alpha$ -Dimethylbenzenepropanol*N*,4-Dimethylbenzenesulfonamide5,6-Dimethyl-1*H*-benzimidazole

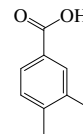
2,4-Dimethylbenzoic acid



2,5-Dimethylbenzoic acid



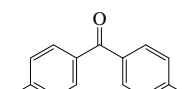
2,6-Dimethylbenzoic acid



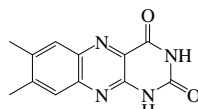
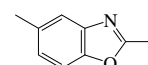
3,4-Dimethylbenzoic acid



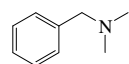
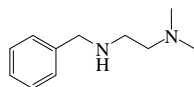
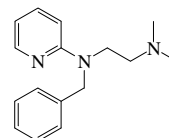
3,5-Dimethylbenzoic acid



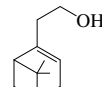
4,4'-Dimethylbenzophenone

7,8-Dimethylbenzo(*g*)pteridine-2,4(1*H*,3*H*)-dione

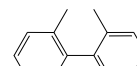
2,5-Dimethylbenzoxazole

*N,N*-Dimethylbenzylamine*N,N*-Dimethyl-*N'*-benzyl-1,2-ethanediamine*N,N*-Dimethyl-*N'*-benzyl-*N'*-2-pyridinyl-1,2-ethanediamine6,6-Dimethylbicyclo[3.1.1]heptan-2-one, (1*R*)

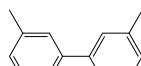
2,3-Dimethylbicyclo[2.2.1]hept-2-ene



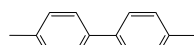
6,6-Dimethylbicyclo[3.1.1]hept-2-ene-2-ethanol



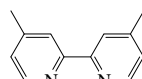
2,2'-Dimethylbiphenyl



3,3'-Dimethylbiphenyl



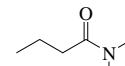
4,4'-Dimethylbiphenyl



4,4'-Dimethyl-2,2'-bipyridine



2,3-Dimethyl-1,3-butadiene

*N,N*-Dimethylbutanamide

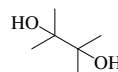
3,3-Dimethyl-2-butanamine



2,2-Dimethylbutane



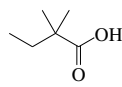
2,3-Dimethylbutane



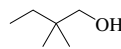
2,3-Dimethyl-2,3-butanediol



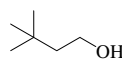
2,3-Dimethyl-2-butanethiol



2,2-Dimethylbutanoic acid



2,2-Dimethyl-1-butanol



3,3-Dimethyl-1-butanol



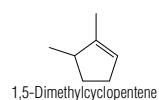
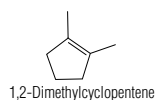
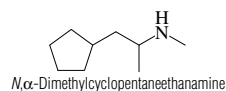
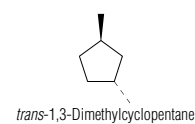
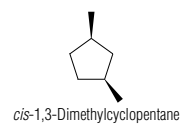
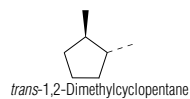
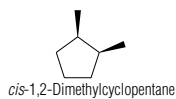
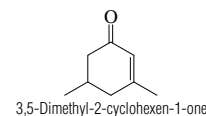
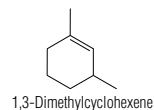
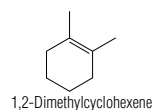
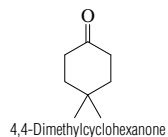
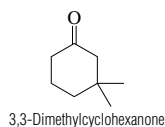
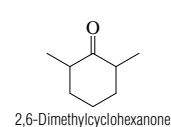
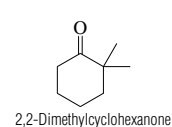
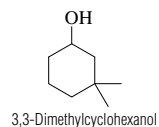
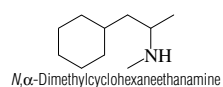
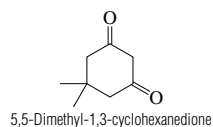
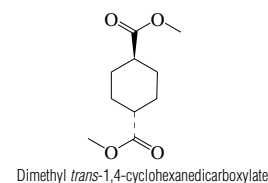
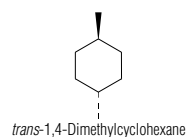
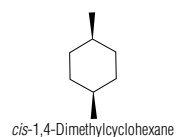
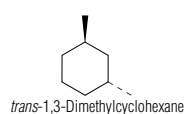
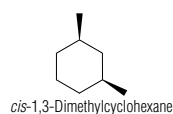
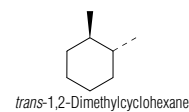
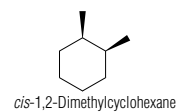
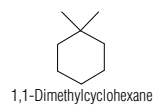
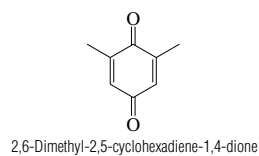
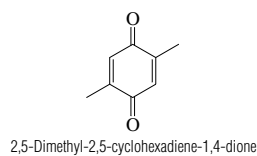
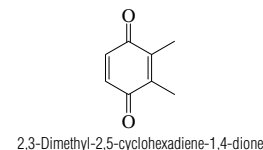
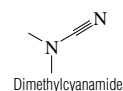
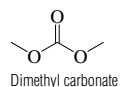
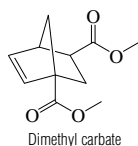
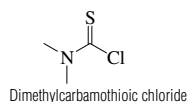
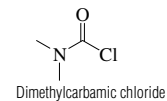
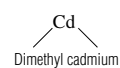
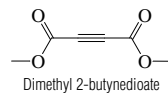
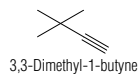
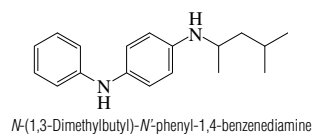
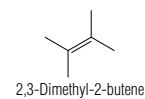
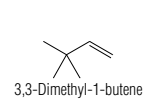
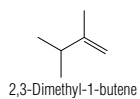
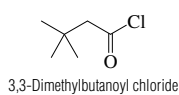
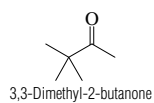
2,3-Dimethyl-2-butanol



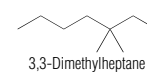
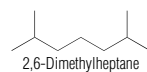
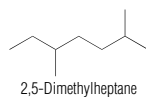
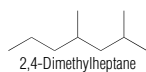
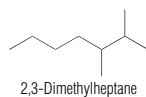
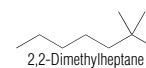
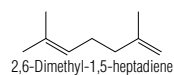
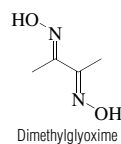
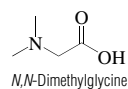
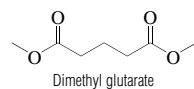
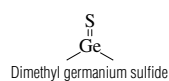
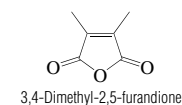
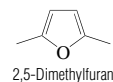
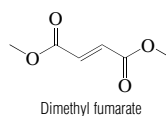
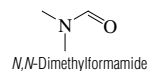
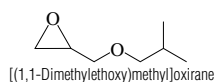
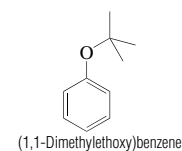
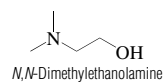
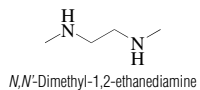
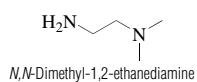
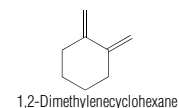
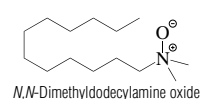
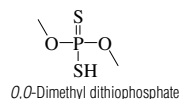
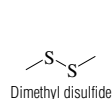
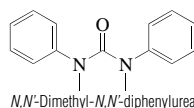
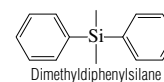
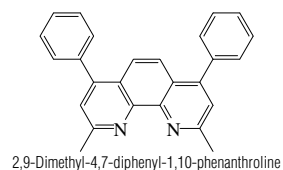
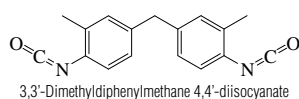
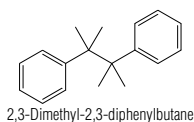
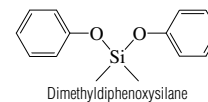
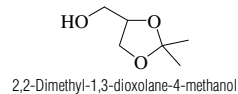
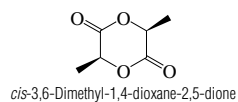
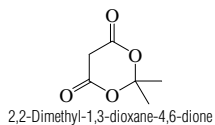
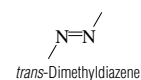
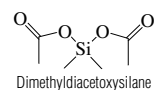
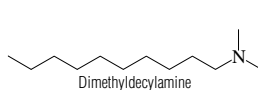
3,3-Dimethyl-2-butanol, (±)



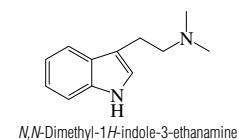
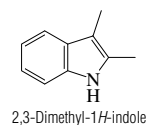
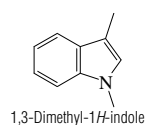
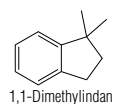
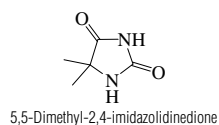
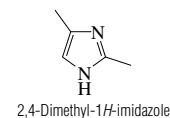
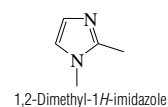
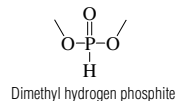
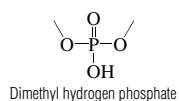
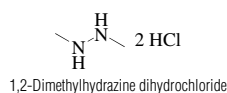
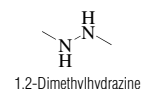
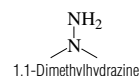
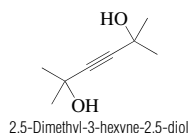
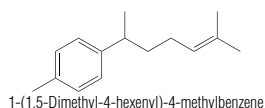
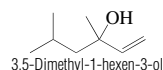
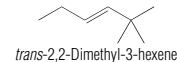
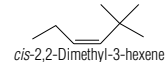
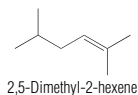
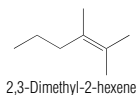
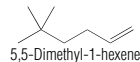
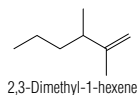
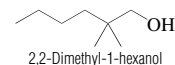
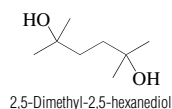
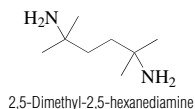
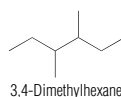
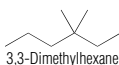
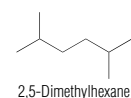
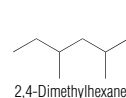
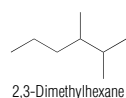
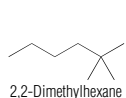
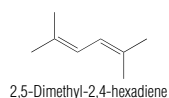
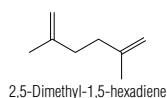
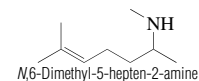
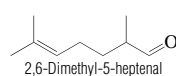
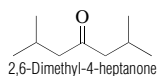
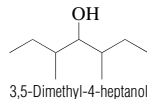
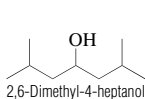
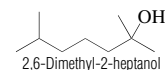
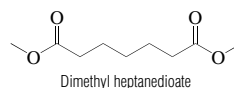
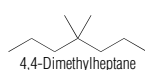
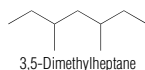
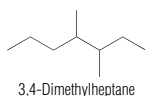
| No.  | Name                                                                | Synonym                       | Mol. Form.                                     | CAS RN     | Mol. Wt. | Physical Form  | mp/°C   | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|---------------------------------------------------------------------|-------------------------------|------------------------------------------------|------------|----------|----------------|---------|---------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 3993 | 3,3-Dimethyl-2-butanone                                             | Pinacolone                    | C <sub>6</sub> H <sub>12</sub> O               | 75-97-8    | 100.158  | liq            | -52.5   | 106.1                     | 0.7229 <sup>25</sup>       | 1.3952 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, ctc                 |
| 3994 | 3,3-Dimethylbutanoyl chloride                                       |                               | C <sub>6</sub> H <sub>11</sub> ClO             | 7065-46-5  | 134.603  |                |         | 130; 68 <sup>100</sup>    | 0.969 <sup>20</sup>        | 1.4210 <sup>20</sup> | vs eth                                                     |
| 3995 | 2,3-Dimethyl-1-butene                                               |                               | C <sub>6</sub> H <sub>12</sub>                 | 563-78-0   | 84.159   | liq            | -157.3  | 55.6                      | 0.6803 <sup>20</sup>       | 1.3995 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, ctc, CS <sub>2</sub> |
| 3996 | 3,3-Dimethyl-1-butene                                               |                               | C <sub>6</sub> H <sub>12</sub>                 | 558-37-2   | 84.159   | liq            | -115.2  | 41.2                      | 0.6529 <sup>20</sup>       | 1.3763 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc, chl                  |
| 3997 | 2,3-Dimethyl-2-butene                                               |                               | C <sub>6</sub> H <sub>12</sub>                 | 563-79-1   | 84.159   | liq            | -74.19  | 73.3                      | 0.7080 <sup>20</sup>       | 1.4122 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, chl                  |
| 3998 | <i>N</i> -(1,3-Dimethylbutyl)- <i>N'</i> -phenyl-1,4-benzenediamine |                               | C <sub>18</sub> H <sub>24</sub> N <sub>2</sub> | 793-24-8   | 268.397  |                | 46      | 164 <sup>1</sup>          |                            |                      |                                                            |
| 3999 | 3,3-Dimethyl-1-butyne                                               | <i>tert</i> -Butylacetylene   | C <sub>6</sub> H <sub>10</sub>                 | 917-92-0   | 82.143   | liq            | -78.2   | 37.7                      | 0.6623 <sup>25</sup>       | 1.3736 <sup>20</sup> |                                                            |
| 4000 | Dimethyl 2-butyndioate                                              |                               | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>   | 762-42-5   | 142.110  |                |         | dec 197; 98 <sup>20</sup> | 1.1564 <sup>20</sup>       | 1.4434 <sup>20</sup> | s EtOH, eth, ctc                                           |
| 4001 | Dimethyl cadmium                                                    |                               | C <sub>2</sub> H <sub>6</sub> Cd               | 506-82-1   | 142.480  |                | -4.5    | 105.5 (exp 150)           | 1.9846 <sup>18</sup>       | 1.5488               | s peth                                                     |
| 4002 | Dimethylcarbamyl chloride                                           | Dimethylcarbamoyl chloride    | C <sub>3</sub> H <sub>6</sub> CINO             | 79-44-7    | 107.539  | liq            | -33     | 167                       | 1.168 <sup>25</sup>        | 1.4540 <sup>20</sup> |                                                            |
| 4003 | Dimethylcarbamothioic chloride                                      |                               | C <sub>3</sub> H <sub>6</sub> CINS             | 16420-13-6 | 123.605  | pr             | 42.5    | 98 <sup>10</sup>          |                            |                      | vs eth; s chl, peth                                        |
| 4004 | Dimethyl carbate                                                    |                               | C <sub>11</sub> H <sub>14</sub> O <sub>4</sub> | 39589-98-5 | 210.227  | cry            | 38      | 137 <sup>12.5</sup>       | 1.164 <sup>21</sup>        | 1.4852 <sup>20</sup> | i H <sub>2</sub> O                                         |
| 4005 | Dimethyl carbonate                                                  | Methyl carbonate              | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>   | 616-38-6   | 90.078   |                | 0.5     | 90.5                      | 1.0636 <sup>25</sup>       | 1.3687 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                    |
| 4006 | Dimethylcyanamide                                                   |                               | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub>   | 1467-79-4  | 70.093   |                |         | 163.5                     |                            | 1.4089 <sup>19</sup> | vs ace, eth, EtOH                                          |
| 4007 | 2,3-Dimethyl-2,5-cyclohexadiene-1,4-dione                           |                               | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>   | 526-86-3   | 136.149  | ye nd          | 55      | sub                       |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, chl                      |
| 4008 | 2,5-Dimethyl-2,5-cyclohexadiene-1,4-dione                           |                               | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>   | 137-18-8   | 136.149  | ye nd (al)     | 126.0   |                           |                            |                      | sl H <sub>2</sub> O, EtOH; s eth, bz, chl                  |
| 4009 | 2,6-Dimethyl-2,5-cyclohexadiene-1,4-dione                           |                               | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>   | 527-61-7   | 136.149  | ye nd          | 72.5    | sub                       | 1.0479 <sup>28</sup>       |                      | s chl                                                      |
| 4010 | 1,1-Dimethylcyclohexane                                             |                               | C <sub>8</sub> H <sub>16</sub>                 | 590-66-9   | 112.213  | liq            | -33.3   | 119.6                     | 0.7809 <sup>20</sup>       | 1.4290 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz; msc ctc          |
| 4011 | <i>cis</i> -1,2-Dimethylcyclohexane                                 |                               | C <sub>8</sub> H <sub>16</sub>                 | 2207-01-4  | 112.213  | liq            | -49.8   | 129.8                     | 0.7963 <sup>20</sup>       | 1.4360 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, ctc; msc eth, ace          |
| 4012 | <i>trans</i> -1,2-Dimethylcyclohexane                               |                               | C <sub>8</sub> H <sub>16</sub>                 | 6876-23-9  | 112.213  | liq            | -88.15  | 123.5                     | 0.7760 <sup>20</sup>       | 1.4270 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz; vs lig       |
| 4013 | <i>cis</i> -1,3-Dimethylcyclohexane                                 |                               | C <sub>8</sub> H <sub>16</sub>                 | 638-04-0   | 112.213  | liq            | -75.53  | 120.1                     | 0.7660 <sup>20</sup>       | 1.4229 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc       |
| 4014 | <i>trans</i> -1,3-Dimethylcyclohexane                               |                               | C <sub>8</sub> H <sub>16</sub>                 | 2207-03-6  | 112.213  | liq            | -90.07  | 124.5                     | 0.79 <sup>15</sup>         | 1.4284 <sup>25</sup> |                                                            |
| 4015 | <i>cis</i> -1,4-Dimethylcyclohexane                                 |                               | C <sub>8</sub> H <sub>16</sub>                 | 624-29-3   | 112.213  | liq            | -87.39  | 124.4                     | 0.7829 <sup>20</sup>       | 1.4230 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc       |
| 4016 | <i>trans</i> -1,4-Dimethylcyclohexane                               |                               | C <sub>8</sub> H <sub>16</sub>                 | 2207-04-7  | 112.213  | liq            | -36.93  | 119.4                     | 0.77 <sup>15</sup>         | 1.4185 <sup>25</sup> | i H <sub>2</sub> O                                         |
| 4017 | Dimethyl <i>trans</i> -1,4-cyclohexanedicarboxylate                 |                               | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub> | 3399-22-2  | 200.232  | ndl (eth)      | 71      |                           |                            |                      | s eth                                                      |
| 4018 | 5,5-Dimethyl-1,3-cyclohexanedione                                   | 5,5-Dimethyldihydroresorcinol | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>  | 126-81-8   | 140.180  | nd (w)         | 150 dec |                           |                            |                      | sl H <sub>2</sub> O, eth; s ace, ctc; vs chl, HOAc         |
| 4019 | <i>N</i> , $\alpha$ -Dimethylcyclohexaneethanamine                  | Propylhexedrine               | C <sub>10</sub> H <sub>21</sub> N              | 101-40-6   | 155.281  |                |         | 205; 82 <sup>10</sup>     | 0.8501 <sup>20</sup>       | 1.4600 <sup>20</sup> | vs EtOH                                                    |
| 4020 | 3,3-Dimethylcyclohexanol                                            |                               | C <sub>8</sub> H <sub>16</sub> O               | 767-12-4   | 128.212  |                | 11.5    | 185; 99.5 <sup>35</sup>   | 0.9128 <sup>14</sup>       | 1.4606 <sup>15</sup> |                                                            |
| 4021 | 2,2-Dimethylcyclohexanone                                           |                               | C <sub>8</sub> H <sub>14</sub> O               | 1193-47-1  | 126.196  | liq            | -20.5   | 172                       | 0.9145 <sup>20</sup>       | 1.4486 <sup>20</sup> |                                                            |
| 4022 | 2,6-Dimethylcyclohexanone                                           |                               | C <sub>8</sub> H <sub>14</sub> O               | 2816-57-1  | 126.196  |                |         | 175                       | 0.925 <sup>25</sup>        | 1.4460 <sup>20</sup> |                                                            |
| 4023 | 3,3-Dimethylcyclohexanone                                           |                               | C <sub>8</sub> H <sub>14</sub> O               | 2979-19-3  | 126.196  |                |         | 180; 72 <sup>25</sup>     | 0.909 <sup>15</sup>        | 1.4482 <sup>17</sup> |                                                            |
| 4024 | 4,4-Dimethylcyclohexanone                                           |                               | C <sub>8</sub> H <sub>14</sub> O               | 4255-62-3  | 126.196  |                | 39      | 73 <sup>14</sup>          | 0.932 <sup>20</sup>        | 1.4537 <sup>24</sup> |                                                            |
| 4025 | 1,2-Dimethylcyclohexene                                             |                               | C <sub>8</sub> H <sub>14</sub>                 | 1674-10-8  | 110.197  | liq            | -84.1   | 138                       | 0.8220 <sup>25</sup>       | 1.4620 <sup>20</sup> |                                                            |
| 4026 | 1,3-Dimethylcyclohexene                                             |                               | C <sub>8</sub> H <sub>14</sub>                 | 2808-76-6  | 110.197  |                |         | 127                       | 0.799 <sup>25</sup>        | 1.449 <sup>20</sup>  |                                                            |
| 4027 | 3,5-Dimethyl-2-cyclohexen-1-one                                     |                               | C <sub>8</sub> H <sub>12</sub> O               | 1123-09-7  | 124.180  |                |         | 208.5                     | 0.9400 <sup>20</sup>       | 1.4812 <sup>20</sup> | s EtOH, eth                                                |
| 4028 | 1,1-Dimethylcyclopentane                                            |                               | C <sub>7</sub> H <sub>14</sub>                 | 1638-26-2  | 98.186   | liq            | -69.8   | 87.5                      | 0.7499 <sup>25</sup>       | 1.4136 <sup>20</sup> |                                                            |
| 4029 | <i>cis</i> -1,2-Dimethylcyclopentane                                |                               | C <sub>7</sub> H <sub>14</sub>                 | 1192-18-3  | 98.186   | liq            | -54     | 99.5                      | 0.7680 <sup>25</sup>       | 1.4222 <sup>20</sup> |                                                            |
| 4030 | <i>trans</i> -1,2-Dimethylcyclopentane                              |                               | C <sub>7</sub> H <sub>14</sub>                 | 822-50-4   | 98.186   | liq            | -117.6  | 91.9                      | 0.7468 <sup>25</sup>       | 1.4120 <sup>20</sup> |                                                            |
| 4031 | <i>cis</i> -1,3-Dimethylcyclopentane                                |                               | C <sub>7</sub> H <sub>14</sub>                 | 2532-58-3  | 98.186   | liq            | -133.7  | 90.8                      | 0.7402 <sup>25</sup>       | 1.4089 <sup>20</sup> |                                                            |
| 4032 | <i>trans</i> -1,3-Dimethylcyclopentane                              |                               | C <sub>7</sub> H <sub>14</sub>                 | 1759-58-6  | 98.186   | liq            | -134    | 91.7                      | 0.7443 <sup>25</sup>       | 1.4107 <sup>20</sup> |                                                            |
| 4033 | <i>N</i> , $\alpha$ -Dimethylcyclopentaneethanamine                 | Cyclopentamine                | C <sub>9</sub> H <sub>19</sub> N               | 102-45-4   | 141.254  |                |         | 171                       |                            | 1.4500 <sup>20</sup> |                                                            |
| 4034 | 1,2-Dimethylcyclopentene                                            |                               | C <sub>7</sub> H <sub>12</sub>                 | 765-47-9   | 96.170   | liq            | -90.4   | 105.8                     | 0.7928 <sup>25</sup>       | 1.4448 <sup>20</sup> |                                                            |
| 4035 | 1,5-Dimethylcyclopentene                                            |                               | C <sub>7</sub> H <sub>12</sub>                 | 16491-15-9 | 96.170   | liq            | -118    | 99                        | 0.780 <sup>20</sup>        | 1.4331 <sup>20</sup> |                                                            |
| 4036 | 1,1-Dimethylcyclopropane                                            |                               | C <sub>5</sub> H <sub>10</sub>                 | 1630-94-0  | 70.133   | vol liq or gas | -109    | 20.6                      | 0.6604 <sup>20</sup>       | 1.3668 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; vs eth, sulf                   |



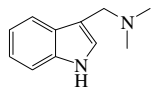
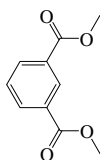
| No.  | Name                                             | Synonym                                  | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form        | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                        |
|------|--------------------------------------------------|------------------------------------------|---------------------------------------------------------------|------------|----------|----------------------|---------|------------------------|----------------------------|-----------------------|-------------------------------------------------------------------|
| 4037 | <i>cis</i> -1,2-Dimethylcyclopropane             |                                          | C <sub>5</sub> H <sub>10</sub>                                | 930-18-7   | 70.133   | liq                  | -140.9  | 37.0                   | 0.6889 <sup>25</sup>       | 1.3829 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH;<br>vs eth; sl ctc                     |
| 4038 | <i>trans</i> -1,2-Dimethylcyclopropane           |                                          | C <sub>5</sub> H <sub>10</sub>                                | 2402-06-4  | 70.133   | vol liq or gas       | -149.6  | 28.2                   | 0.6648 <sup>25</sup>       | 1.3713 <sup>20</sup>  | vs eth, EtOH                                                      |
| 4039 | Dimethyldodecylamine                             | <i>N,N</i> -Dimethyl-1-decanamine        | C <sub>12</sub> H <sub>27</sub> N                             | 1120-24-7  | 185.349  |                      |         | 234.5                  |                            |                       |                                                                   |
| 4040 | Dimethyldiacetoxysilane                          | Bis(acetyloxy)dimethylsilane             | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub> Si              | 2182-66-3  | 176.243  | liq                  | -12.5   | 165                    | 1.0540 <sup>20</sup>       | 1.4030 <sup>20</sup>  |                                                                   |
| 4041 | <i>trans</i> -Dimethyldiazene                    | Azomethane                               | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub>                  | 4143-41-3  | 58.082   | gas                  | -78     | 1.5                    | 0.743 <sup>0</sup>         | 1.4199 <sup>19</sup>  | vs ace, EtOH,<br>eth; s ctc, hp                                   |
| 4042 | 2,2-Dimethyl-1,3-dioxane-4,6-dione               | Meldrum's acid                           | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                  | 2033-24-1  | 144.126  |                      | 94      |                        |                            |                       |                                                                   |
| 4043 | <i>cis</i> -3,6-Dimethyl-1,4-dioxane-2,5-dione   |                                          | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                  | 4511-42-6  | 144.126  | orth (eth)           | 96.8    | 150 <sup>25</sup>      |                            |                       |                                                                   |
| 4044 | 2,2-Dimethyl-1,3-dioxolane-4-methanol            | Isopropylidene glycerol                  | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                 | 100-79-8   | 132.157  |                      |         | 82 <sup>10</sup>       | 1.064 <sup>20</sup>        | 1.4383 <sup>20</sup>  |                                                                   |
| 4045 | Dimethyldiphenoxysilane                          |                                          | C <sub>14</sub> H <sub>16</sub> O <sub>2</sub> Si             | 3440-02-6  | 244.362  |                      | -23     | 131 <sup>5</sup>       | 1.0599 <sup>25</sup>       | 1.5330 <sup>20</sup>  |                                                                   |
| 4046 | 2,3-Dimethyl-2,3-diphenylbutane                  | Dicumene                                 | C <sub>18</sub> H <sub>22</sub>                               | 1889-67-4  | 238.368  | cry (MeOH)           | 119.5   |                        |                            |                       |                                                                   |
| 4047 | 3,3'-Dimethyldiphenylmethane 4,4'-diisocyanate   |                                          | C <sub>17</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub> | 139-25-3   | 278.305  |                      |         |                        |                            |                       | s chl                                                             |
| 4048 | 2,9-Dimethyl-4,7-diphenyl-1,10-phenanthroline    |                                          | C <sub>26</sub> H <sub>20</sub> N <sub>2</sub>                | 4733-39-5  | 360.450  |                      | 280 dec |                        |                            |                       |                                                                   |
| 4049 | Dimethyldiphenylsilane                           |                                          | C <sub>14</sub> H <sub>16</sub> Si                            | 778-24-5   | 212.363  |                      |         | 277; 173 <sup>45</sup> | 0.9867 <sup>20</sup>       | 1.5644 <sup>20</sup>  |                                                                   |
| 4050 | <i>N,N'</i> -Dimethyl- <i>N,N'</i> -diphenylurea |                                          | C <sub>15</sub> H <sub>16</sub> N <sub>2</sub> O              | 611-92-7   | 240.300  | pl (al)              | 122     | 350                    |                            |                       | vs H <sub>2</sub> O, EtOH,<br>ace; sl eth, bz,<br>CS <sub>2</sub> |
| 4051 | Dimethyl disulfide                               | Methyl disulfide                         | C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>                  | 624-92-0   | 94.199   | liq                  | -84.67  | 109.74                 | 1.0625 <sup>20</sup>       | 1.5289 <sup>20</sup>  | i H <sub>2</sub> O; msc<br>EtOH, eth                              |
| 4052 | <i>O,O</i> -Dimethyl dithiophosphate             | <i>O,O</i> -Dimethyl phosphorodithionate | C <sub>2</sub> H <sub>2</sub> O <sub>2</sub> PS <sub>2</sub>  | 756-80-9   | 158.180  | liq                  |         | 56 <sup>4</sup>        | 1.29 <sup>20</sup>         |                       |                                                                   |
| 4053 | <i>N,N</i> -Dimethyldodecylamine oxide           |                                          | C <sub>14</sub> H <sub>31</sub> NO                            | 1643-20-5  | 229.402  | hyg nd (tol)         | 130.5   |                        |                            |                       |                                                                   |
| 4054 | 1,2-Dimethylenecyclohexane                       |                                          | C <sub>8</sub> H <sub>12</sub>                                | 2819-48-9  | 108.181  |                      |         | 127; 60 <sup>90</sup>  | 0.8361 <sup>20</sup>       | 1.4718 <sup>25</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl; vs<br>ace            |
| 4055 | <i>N,N</i> -Dimethyl-1,2-ethanediamine           |                                          | C <sub>4</sub> H <sub>12</sub> N <sub>2</sub>                 | 108-00-9   | 88.151   |                      |         | 104                    | 0.803 <sup>25</sup>        | 1.4260 <sup>20</sup>  |                                                                   |
| 4056 | <i>N,N'</i> -Dimethyl-1,2-ethanediamine          |                                          | C <sub>4</sub> H <sub>12</sub> N <sub>2</sub>                 | 110-70-3   | 88.151   |                      |         | 120                    | 0.828 <sup>15</sup>        |                       | s EtOH, eth, dil<br>HCl                                           |
| 4057 | <i>N,N</i> -Dimethylethanolamine                 | Deanol                                   | C <sub>4</sub> H <sub>11</sub> NO                             | 108-01-0   | 89.136   | liq                  | -59     | 134                    | 0.8866 <sup>20</sup>       | 1.4300 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH,<br>eth; s chl                         |
| 4058 | Dimethyl ether                                   | Methyl ether                             | C <sub>2</sub> H <sub>6</sub> O                               | 115-10-6   | 46.068   | col gas              | -141.5  | -24.8                  |                            |                       | s H <sub>2</sub> O, EtOH,<br>eth, ace, chl; sl<br>bz              |
| 4059 | (1,1-Dimethylethoxy)benzene                      |                                          | C <sub>10</sub> H <sub>14</sub> O                             | 6669-13-2  | 150.217  | liq                  | -24     | 185.5                  | 0.9214 <sup>20</sup>       |                       |                                                                   |
| 4060 | [(1,1-Dimethylethoxy)methyl]oxirane              |                                          | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | 7665-72-7  | 130.185  | liq                  | -70     | 152                    | 0.898 <sup>20</sup>        |                       |                                                                   |
| 4061 | <i>N,N</i> -Dimethylformamide                    | DMF                                      | C <sub>3</sub> H <sub>7</sub> NO                              | 68-12-2    | 73.094   | liq                  | -60.48  | 153                    | 0.9445 <sup>25</sup>       | 1.4305 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH,<br>eth, ace, bz; sl<br>lig            |
| 4062 | Dimethyl fumarate                                |                                          | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                  | 624-49-7   | 144.126  |                      | 103.5   | 193                    | 1.37 <sup>20</sup>         | 1.4062 <sup>111</sup> | i H <sub>2</sub> O; s ace, chl                                    |
| 4063 | 2,5-Dimethylfuran                                |                                          | C <sub>6</sub> H <sub>8</sub> O                               | 625-86-5   | 96.127   | liq                  | -62.8   | 93                     | 0.8883 <sup>20</sup>       | 1.4363 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz,<br>HOAc, chl         |
| 4064 | 3,4-Dimethyl-2,5-furandione                      |                                          | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                  | 766-39-2   | 126.110  | pl or lf (dil<br>al) | 96      | 223                    | 1.107 <sup>100</sup>       |                       | sl H <sub>2</sub> O; vs EtOH,<br>eth, bz, chl                     |
| 4065 | Dimethyl germanium sulfide                       |                                          | C <sub>2</sub> H <sub>6</sub> GeS                             | 16090-49-6 | 134.77   | col cry              | 54.5    | 302                    |                            |                       |                                                                   |
| 4066 | Dimethyl glutarate                               |                                          | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | 1119-40-0  | 160.168  | liq                  | -42.5   | 214; 109 <sup>21</sup> | 1.0876 <sup>20</sup>       | 1.4242 <sup>20</sup>  | vs EtOH, eth; s<br>chl                                            |
| 4067 | <i>N,N</i> -Dimethylglycine                      |                                          | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                 | 1118-68-9  | 103.120  | hyg nd<br>(PrOH)     | 185.5   |                        |                            |                       | vs H <sub>2</sub> O, MeOH;<br>s EtOH, eth,<br>ace                 |
| 4068 | Dimethylglyoxime                                 |                                          | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>   | 95-45-4    | 116.119  | nd (to or dil<br>al) | 245.5   | sub 234                |                            |                       | i H <sub>2</sub> O; vs EtOH,<br>eth; sl bz, tol                   |
| 4069 | 2,6-Dimethyl-1,5-heptadiene                      |                                          | C <sub>9</sub> H <sub>16</sub>                                | 6709-39-3  | 124.223  | liq                  | -70     | 143                    | 0.7648 <sup>25</sup>       |                       |                                                                   |
| 4070 | 2,2-Dimethylheptane                              |                                          | C <sub>9</sub> H <sub>20</sub>                                | 1071-26-7  | 128.255  | liq                  | -113    | 132.7                  | 0.7105 <sup>20</sup>       | 1.4016 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ctc;<br>vs ace, chl;<br>msc bz         |
| 4071 | 2,3-Dimethylheptane                              |                                          | C <sub>9</sub> H <sub>20</sub>                                | 3074-71-3  | 128.255  | liq                  | -116    | 140.5                  | 0.7260 <sup>20</sup>       | 1.4088 <sup>20</sup>  | i H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, peth, chl       |
| 4072 | 2,4-Dimethylheptane                              |                                          | C <sub>9</sub> H <sub>20</sub>                                | 2213-23-2  | 128.255  |                      |         | 132.9                  | 0.7115 <sup>25</sup>       | 1.4034 <sup>20</sup>  | i H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>bz, chl, peth       |
| 4073 | 2,5-Dimethylheptane                              |                                          | C <sub>9</sub> H <sub>20</sub>                                | 2216-30-0  | 128.255  |                      |         | 136                    | 0.7198 <sup>20</sup>       | 1.4033 <sup>20</sup>  | vs ace, bz, eth,<br>EtOH                                          |
| 4074 | 2,6-Dimethylheptane                              |                                          | C <sub>9</sub> H <sub>20</sub>                                | 1072-05-5  | 128.255  | liq                  | -102.9  | 135.2                  | 0.7089 <sup>20</sup>       | 1.4011 <sup>20</sup>  | sl chl                                                            |
| 4075 | 3,3-Dimethylheptane                              |                                          | C <sub>9</sub> H <sub>20</sub>                                | 4032-86-4  | 128.255  |                      |         | 137.3                  | 0.7254 <sup>20</sup>       | 1.4087 <sup>20</sup>  | i H <sub>2</sub> O; msc<br>EtOH; s eth; vs<br>ace, bz             |



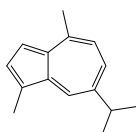
| No.  | Name                                       | Synonym                            | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                 |
|------|--------------------------------------------|------------------------------------|---------------------------------------------------------------|------------|----------|-------------------------|---------|-------------------------------------|----------------------------|-----------------------|------------------------------------------------------------|
| 4076 | 3,4-Dimethylheptane                        |                                    | C <sub>9</sub> H <sub>20</sub>                                | 922-28-1   | 128.255  |                         |         | 140.6                               | 0.7314 <sup>20</sup>       | 1.4108 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ctc;<br>vs ace, chl;<br>msc bz  |
| 4077 | 3,5-Dimethylheptane                        |                                    | C <sub>9</sub> H <sub>20</sub>                                | 926-82-9   | 128.255  |                         |         | 136                                 | 0.7225 <sup>20</sup>       | 1.4083 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ctc;<br>vs ace, chl;<br>msc bz  |
| 4078 | 4,4-Dimethylheptane                        |                                    | C <sub>9</sub> H <sub>20</sub>                                | 1068-19-5  | 128.255  |                         |         | 135.2                               | 0.7221 <sup>20</sup>       | 1.4076 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ctc;<br>vs ace, chl;<br>msc bz  |
| 4079 | Dimethyl heptanedioate                     | Dimethyl pimelate                  | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                 | 1732-08-7  | 188.221  |                         | -21     | 120 <sup>10</sup> , 80 <sup>1</sup> | 1.0625 <sup>20</sup>       | 1.4309 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH,<br>eth, bz                    |
| 4080 | 2,6-Dimethyl-2-heptanol                    |                                    | C <sub>9</sub> H <sub>20</sub> O                              | 13254-34-7 | 144.254  |                         |         | 173                                 | 0.8186 <sup>20</sup>       | 1.4242 <sup>20</sup>  |                                                            |
| 4081 | 2,6-Dimethyl-4-heptanol                    | Diisobutylcarbinol                 | C <sub>9</sub> H <sub>20</sub> O                              | 108-82-7   | 144.254  |                         |         | 174.5                               | 0.8114 <sup>20</sup>       | 1.4242 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth; sl ctc                 |
| 4082 | 3,5-Dimethyl-4-heptanol                    |                                    | C <sub>9</sub> H <sub>20</sub> O                              | 19549-79-2 | 144.254  |                         |         | 186                                 | 0.836 <sup>18</sup>        | 1.4283 <sup>20</sup>  | sl H <sub>2</sub> O                                        |
| 4083 | 2,6-Dimethyl-4-heptanone                   | Diisobutyl ketone                  | C <sub>9</sub> H <sub>18</sub> O                              | 108-83-8   | 142.238  | liq                     | -41.5   | 169.4                               | 0.8062 <sup>20</sup>       | 1.412 <sup>21</sup>   | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ctc             |
| 4084 | 2,6-Dimethyl-5-heptenal                    |                                    | C <sub>9</sub> H <sub>16</sub> O                              | 106-72-9   | 140.222  | oil                     |         | 120 <sup>100</sup>                  |                            |                       |                                                            |
| 4085 | N,6-Dimethyl-5-hepten-2-amine              | Isometheptene                      | C <sub>9</sub> H <sub>19</sub> N                              | 503-01-5   | 141.254  |                         |         | 177                                 |                            |                       | vs eth, EtOH                                               |
| 4086 | 2,5-Dimethyl-1,5-hexadiene                 |                                    | C <sub>8</sub> H <sub>14</sub>                                | 627-58-7   | 110.197  | liq                     | -75.6   | 114.3                               | 0.743 <sup>20</sup>        | 1.43995 <sup>21</sup> | i H <sub>2</sub> O; s ace, chl                             |
| 4087 | 2,5-Dimethyl-2,4-hexadiene                 |                                    | C <sub>8</sub> H <sub>14</sub>                                | 764-13-6   | 110.197  |                         | 14      | 134.5                               | 0.7577 <sup>25</sup>       | 1.4785 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl                |
| 4088 | 2,2-Dimethylhexane                         |                                    | C <sub>8</sub> H <sub>18</sub>                                | 590-73-8   | 114.229  | liq                     | -121.1  | 106.86                              | 0.6953 <sup>20</sup>       | 1.3935 <sup>20</sup>  | vs ace, bz, eth,<br>EtOH                                   |
| 4089 | 2,3-Dimethylhexane                         |                                    | C <sub>8</sub> H <sub>18</sub>                                | 584-94-1   | 114.229  |                         |         | 115.62                              | 0.6912 <sup>25</sup>       | 1.4011 <sup>20</sup>  | vs ace, bz,<br>EtOH, lig                                   |
| 4090 | 2,4-Dimethylhexane                         |                                    | C <sub>8</sub> H <sub>18</sub>                                | 589-43-5   | 114.229  |                         |         | 109.5                               | 0.6962 <sup>25</sup>       | 1.3929 <sup>25</sup>  |                                                            |
| 4091 | 2,5-Dimethylhexane                         |                                    | C <sub>8</sub> H <sub>18</sub>                                | 592-13-2   | 114.229  | liq                     | -91     | 109.12                              | 0.6901 <sup>25</sup>       | 1.3925 <sup>20</sup>  | i H <sub>2</sub> O; msc<br>EtOH, ace, bz;<br>s eth         |
| 4092 | 3,3-Dimethylhexane                         |                                    | C <sub>8</sub> H <sub>18</sub>                                | 563-16-6   | 114.229  | liq                     | -126.1  | 111.97                              | 0.7100 <sup>20</sup>       | 1.4001 <sup>20</sup>  | i H <sub>2</sub> O; msc<br>EtOH; vs eth,<br>ace, bz        |
| 4093 | 3,4-Dimethylhexane                         |                                    | C <sub>8</sub> H <sub>18</sub>                                | 583-48-2   | 114.229  |                         |         | 117.73                              | 0.7151 <sup>25</sup>       | 1.4041 <sup>20</sup>  | i H <sub>2</sub> O; s eth;<br>msc EtOH,<br>ace, bz         |
| 4094 | 2,5-Dimethyl-2,5-hexanediamine             |                                    | C <sub>8</sub> H <sub>20</sub> N <sub>2</sub>                 | 23578-35-0 | 144.258  |                         |         | 184; 63 <sup>8</sup>                | 0.8485 <sup>15</sup>       | 1.4459 <sup>20</sup>  |                                                            |
| 4095 | 2,5-Dimethyl-2,5-hexanediol                | 1,1,4,4-Tetramethyl-1,4-butanediol | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                 | 110-03-2   | 146.228  | pr (AcOEt) fl<br>(peth) | 88.50   | 214                                 | 0.898 <sup>20</sup>        |                       | s H <sub>2</sub> O; vs EtOH,<br>bz, chl                    |
| 4096 | 2,2-Dimethyl-1-hexanol                     |                                    | C <sub>8</sub> H <sub>18</sub> O                              | 2370-13-0  | 130.228  |                         |         | 95 <sup>29</sup>                    |                            |                       |                                                            |
| 4097 | 2,3-Dimethyl-1-hexene                      |                                    | C <sub>8</sub> H <sub>16</sub>                                | 16746-86-4 | 112.213  |                         |         | 110.5                               | 0.7172 <sup>25</sup>       | 1.4113 <sup>20</sup>  |                                                            |
| 4098 | 5,5-Dimethyl-1-hexene                      |                                    | C <sub>8</sub> H <sub>16</sub>                                | 7116-86-1  | 112.213  |                         |         | 104                                 | 0.705 <sup>25</sup>        | 1.4049 <sup>20</sup>  |                                                            |
| 4099 | 2,3-Dimethyl-2-hexene                      |                                    | C <sub>8</sub> H <sub>16</sub>                                | 7145-20-2  | 112.213  | liq                     | -115.1  | 121.8                               | 0.7366 <sup>25</sup>       | 1.4268 <sup>20</sup>  |                                                            |
| 4100 | 2,5-Dimethyl-2-hexene                      |                                    | C <sub>8</sub> H <sub>16</sub>                                | 3404-78-2  | 112.213  |                         |         | 112.2                               | 0.7182 <sup>20</sup>       | 1.4140 <sup>20</sup>  |                                                            |
| 4101 | cis-2,2-Dimethyl-3-hexene                  |                                    | C <sub>8</sub> H <sub>16</sub>                                | 690-92-6   | 112.213  | liq                     | -137.4  | 105.5                               | 0.7086 <sup>25</sup>       | 1.4099 <sup>20</sup>  |                                                            |
| 4102 | trans-2,2-Dimethyl-3-hexene                |                                    | C <sub>8</sub> H <sub>16</sub>                                | 690-93-7   | 112.213  |                         |         | 100.8                               | 0.6995 <sup>25</sup>       | 1.4063 <sup>20</sup>  |                                                            |
| 4103 | 3,5-Dimethyl-1-hexen-3-ol                  |                                    | C <sub>8</sub> H <sub>16</sub> O                              | 3329-48-4  | 128.212  |                         |         | 146.5                               | 0.8382 <sup>20</sup>       | 1.4342 <sup>20</sup>  |                                                            |
| 4104 | 1-(1,5-Dimethyl-4-hexenyl)-4-methylbenzene | α-Curcumene                        | C <sub>15</sub> H <sub>22</sub>                               | 644-30-4   | 202.336  |                         |         | 140 <sup>19</sup>                   | 0.8805 <sup>20</sup>       | 1.4989 <sup>20</sup>  | i H <sub>2</sub> O; s bz                                   |
| 4105 | 2,5-Dimethyl-3-hexyne-2,5-diol             |                                    | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                 | 142-30-3   | 142.196  |                         | 95      | 205                                 | 0.947 <sup>20</sup>        |                       | s H <sub>2</sub> O, chl; vs<br>EtOH, eth, ace,<br>bz       |
| 4106 | 1,1-Dimethylhydrazine                      |                                    | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub>                  | 57-14-7    | 60.098   | liq, fumes in<br>air    | -57.20  | 63.9                                | 0.791 <sup>22</sup>        | 1.4075 <sup>22</sup>  | vs H <sub>2</sub> O, EtOH,<br>eth, MeOH                    |
| 4107 | 1,2-Dimethylhydrazine                      |                                    | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub>                  | 540-73-8   | 60.098   | fumes (air)             | -8.9    | 81                                  | 0.8274 <sup>20</sup>       | 1.4209 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH,<br>eth                         |
| 4108 | 1,2-Dimethylhydrazine dihydrochloride      |                                    | C <sub>2</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> | 306-37-6   | 133.019  | pr (w)                  | 170 dec |                                     |                            |                       | vs H <sub>2</sub> O, EtOH                                  |
| 4109 | Dimethyl hydrogen phosphate                | Dimethyl phosphate                 | C <sub>2</sub> H <sub>4</sub> O <sub>4</sub> P                | 813-78-5   | 126.048  |                         |         | dec 174                             | 1.3225 <sup>20</sup>       | 1.408 <sup>25</sup>   | vs H <sub>2</sub> O, ace,<br>EtOH                          |
| 4110 | Dimethyl hydrogen phosphite                |                                    | C <sub>2</sub> H <sub>4</sub> O <sub>3</sub> P                | 868-85-9   | 110.049  |                         |         | 170.5                               | 1.2002 <sup>20</sup>       | 1.4036 <sup>20</sup>  | s EtOH, py; sl<br>ctc                                      |
| 4111 | 1,2-Dimethyl-1H-imidazole                  |                                    | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub>                  | 1739-84-0  | 96.131   |                         |         | 206                                 | 1.0051 <sup>11</sup>       |                       | vs H <sub>2</sub> O, eth,<br>EtOH                          |
| 4112 | 2,4-Dimethyl-1H-imidazole                  |                                    | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub>                  | 930-62-1   | 96.131   |                         | 92      | 267                                 |                            |                       |                                                            |
| 4113 | 5,5-Dimethyl-2,4-imidazolidinedione        |                                    | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>   | 77-71-4    | 128.130  | pr (dil al)             | 178     | sub                                 |                            |                       | vs H <sub>2</sub> O, EtOH,<br>eth, ace, bz,<br>chl; s DMSO |
| 4114 | 1,1-Dimethylindan                          |                                    | C <sub>11</sub> H <sub>14</sub>                               | 4912-92-9  | 146.229  |                         |         | 191                                 | 0.919 <sup>20</sup>        | 1.5135 <sup>25</sup>  |                                                            |
| 4115 | 1,3-Dimethyl-1H-indole                     |                                    | C <sub>10</sub> H <sub>11</sub> N                             | 875-30-9   | 145.201  | nd                      | 142     | 258.5                               |                            |                       | s eth                                                      |
| 4116 | 2,3-Dimethyl-1H-indole                     |                                    | C <sub>10</sub> H <sub>11</sub> N                             | 91-55-4    | 145.201  |                         | 107.5   | 287                                 |                            |                       |                                                            |
| 4117 | N,N-Dimethyl-1H-indole-3-ethanamine        | N,N-Dimethyltryptamine             | C <sub>12</sub> H <sub>16</sub> N <sub>2</sub>                | 61-50-7    | 188.268  |                         | 46      |                                     |                            |                       |                                                            |



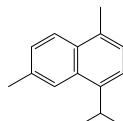
| No.  | Name                                                                          | Synonym                           | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form    | mp/°C   | bp/°C                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                         |
|------|-------------------------------------------------------------------------------|-----------------------------------|---------------------------------------------------------------|------------|----------|------------------|---------|-------------------------|----------------------------|----------------------|----------------------------------------------------|
| 4118 | <i>N,N</i> -Dimethyl-1- <i>H</i> -indole-3-methanamine                        | Gramine                           | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub>                | 87-52-5    | 174.242  | nd or pl (ace)   | 138.5   |                         |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl; i peth       |
| 4119 | Dimethyl isophthalate                                                         |                                   | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                | 1459-93-4  | 194.184  | nd(dil al)       | 67.5    | 282                     | 1.194 <sup>20</sup>        | 1.5168 <sup>20</sup> | sl H <sub>2</sub> O                                |
| 4120 | 1,4-Dimethyl-7-isopropylazulene                                               | Guaiazulene                       | C <sub>15</sub> H <sub>18</sub>                               | 489-84-9   | 198.304  | bl-viol pl (al)  | 31.5    | 167 <sup>12</sup>       | 0.973 <sup>20</sup>        |                      | s EtOH, eth, AcOEt                                 |
| 4121 | 1,6-Dimethyl-4-isopropyl-naphthalene                                          | Cadalene                          | C <sub>15</sub> H <sub>18</sub>                               | 483-78-3   | 198.304  |                  |         | 294; 149 <sup>10</sup>  | 0.9667 <sup>25</sup>       | 1.5785 <sup>25</sup> | vs oils                                            |
| 4122 | 2,4-Dimethyl-3-isopropylpentane                                               |                                   | C <sub>10</sub> H <sub>22</sub>                               | 13475-79-1 | 142.282  | liq              | -81.7   | 157.1                   | 0.7545 <sup>25</sup>       | 1.4246 <sup>20</sup> |                                                    |
| 4123 | 3,5-Dimethylisoxazole                                                         |                                   | C <sub>5</sub> H <sub>6</sub> NO                              | 300-87-8   | 97.116   |                  |         | 143                     | 0.99 <sup>25</sup>         | 1.4421 <sup>20</sup> |                                                    |
| 4124 | Dimethylmagnesium                                                             | Magnesium dimethyl                | C <sub>2</sub> H <sub>6</sub> Mg                              | 2999-74-8  | 54.374   | solid            | 220 dec | subl                    |                            |                      |                                                    |
| 4125 | Dimethyl maleate                                                              | Methyl <i>cis</i> -butenedioate   | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                  | 624-48-6   | 144.126  | liq              | -19     | 202                     | 1.1606 <sup>20</sup>       | 1.4416 <sup>20</sup> | sl H <sub>2</sub> O, lig; s eth, ctc               |
| 4126 | Dimethyl malonate                                                             | Methyl malonate                   | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                  | 108-59-8   | 132.116  | liq              | -61.9   | 181.4                   | 1.528 <sup>20</sup>        | 1.4135 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH; vs ace, bz; s chl   |
| 4127 | Dimethylmalonic acid                                                          | Dimethylpropanedioic acid         | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                  | 595-46-0   | 132.116  | pr (bz/peth)     | 192.5   | subl                    |                            |                      | s hot H <sub>2</sub> O                             |
| 4128 | Dimethyl mercury                                                              |                                   | C <sub>2</sub> H <sub>6</sub> Hg                              | 593-74-8   | 230.66   |                  |         | 93                      | 3.17 <sup>25</sup>         | 1.5452 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                   |
| 4129 | Dimethyl <i>cis</i> -2-methyl-2-butenedioate                                  | Dimethyl citraconate              | C <sub>7</sub> H <sub>10</sub> O <sub>4</sub>                 | 617-54-9   | 158.152  |                  |         | 210.5                   | 1.1153 <sup>20</sup>       | 1.4473 <sup>20</sup> | vs ace, eth, EtOH                                  |
| 4130 | Dimethyl methylenesuccinate                                                   |                                   | C <sub>7</sub> H <sub>10</sub> O <sub>4</sub>                 | 617-52-7   | 158.152  | hyg mcl (MeOH)   | 38      | 208                     | 1.1241 <sup>18</sup>       | 1.4457 <sup>20</sup> | s EtOH, eth, MeOH; vs ace                          |
| 4131 | Dimethyl methylmalonate                                                       |                                   | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                 | 609-02-9   | 146.141  |                  |         | 174                     | 1.0977 <sup>20</sup>       | 1.4128 <sup>20</sup> | vs ace, eth, EtOH, chl                             |
| 4132 | Dimethyl methylphosphonate                                                    |                                   | C <sub>3</sub> H <sub>8</sub> O <sub>3</sub> P                | 756-79-6   | 124.075  |                  |         | 181; 79.5 <sup>20</sup> | 1.1684 <sup>20</sup>       | 1.4099 <sup>30</sup> | s H <sub>2</sub> O, EtOH, eth                      |
| 4133 | <i>trans</i> -2,2-Dimethyl-3-(2-methyl-1-propenyl)cyclopropanecarboxylic acid |                                   | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>                | 4638-92-0  | 168.233  | pr               | 20.0    | 245                     |                            |                      | vs eth, EtOH, chl                                  |
| 4134 | Dimethyl 2-methylsuccinate                                                    |                                   | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | 1604-11-1  | 160.168  |                  |         | 196                     | 1.076 <sup>25</sup>        | 1.4200 <sup>20</sup> |                                                    |
| 4135 | Dimethyl <i>p</i> -(methylthio)phenyl phosphate                               |                                   | C <sub>9</sub> H <sub>13</sub> O <sub>4</sub> PS              | 3254-63-5  | 248.235  | liq              |         |                         | 1.273 <sup>21</sup>        |                      | sl H <sub>2</sub> O; s ace, EtOH, diox, ctc, xyl   |
| 4136 | 2,6-Dimethylmorpholine                                                        |                                   | C <sub>6</sub> H <sub>13</sub> NO                             | 141-91-3   | 115.173  | liq              | -88     | 146.6                   | 0.9329 <sup>20</sup>       | 1.4460 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, bz, lig; s ace; sl chl |
| 4137 | Dimethyl morpholinophosphoramidate                                            | Dimethyl 4-morpholinylphosphonate | C <sub>6</sub> H <sub>14</sub> NO <sub>4</sub> P              | 597-25-1   | 195.153  | liq              |         | 96 <sup>1</sup>         |                            |                      |                                                    |
| 4138 | 1,2-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 573-98-8   | 156.223  |                  | 0.8     | 266.5                   | 1.0179 <sup>20</sup>       | 1.6166 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz                      |
| 4139 | 1,3-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 575-41-7   | 156.223  | liq              | -6      | 263                     | 1.0144 <sup>20</sup>       | 1.6140 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz                      |
| 4140 | 1,4-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 571-58-4   | 156.223  |                  | 7.6     | 268                     | 1.0166 <sup>20</sup>       | 1.6127 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth, ace, bz, ctc |
| 4141 | 1,5-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 571-61-9   | 156.223  |                  | 82      | 265                     |                            |                      | i H <sub>2</sub> O; vs bz, eth                     |
| 4142 | 1,6-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 575-43-9   | 156.223  | liq              | -16.9   | 264                     | 1.0021 <sup>20</sup>       | 1.6166 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz                      |
| 4143 | 1,7-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 575-37-1   | 156.223  | liq              | -13.9   | 263                     | 1.0115 <sup>20</sup>       | 1.6083 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz                      |
| 4144 | 1,8-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 569-41-5   | 156.223  |                  | 65      | 270                     | 1.003 <sup>20</sup>        |                      | i H <sub>2</sub> O; s eth, bz                      |
| 4145 | 2,3-Dimethylnaphthalene                                                       | Guajen                            | C <sub>12</sub> H <sub>12</sub>                               | 581-40-8   | 156.223  | lf (al)          | 105     | 268                     | 1.003 <sup>20</sup>        | 1.5060 <sup>20</sup> | i H <sub>2</sub> O; vs bz, eth                     |
| 4146 | 2,6-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 581-42-0   | 156.223  |                  | 112     | 262                     | 1.003 <sup>20</sup>        |                      | i H <sub>2</sub> O                                 |
| 4147 | 2,7-Dimethylnaphthalene                                                       |                                   | C <sub>12</sub> H <sub>12</sub>                               | 582-16-1   | 156.223  |                  | 97      | 265                     | 1.003 <sup>20</sup>        |                      |                                                    |
| 4148 | <i>N,N</i> -Dimethyl-1-naphthylamine                                          |                                   | C <sub>12</sub> H <sub>13</sub> N                             | 86-56-6    | 171.238  | viol flr cry     |         | 250; 140 <sup>13</sup>  | 1.0423 <sup>20</sup>       | 1.624 <sup>15</sup>  | i H <sub>2</sub> O; s EtOH, eth, ctc               |
| 4149 | <i>N,N</i> -Dimethyl-2-naphthylamine                                          |                                   | C <sub>12</sub> H <sub>13</sub> N                             | 2436-85-3  | 171.238  | dk red nd        | 52.5    | 305                     | 1.0279 <sup>20</sup>       | 1.6443 <sup>33</sup> | i H <sub>2</sub> O; s EtOH, eth                    |
| 4150 | <i>N,N</i> -Dimethyl-2-nitroaniline                                           |                                   | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>  | 610-17-3   | 166.177  | ye-oran          | -20     | 146 <sup>20</sup>       | 1.1794 <sup>20</sup>       | 1.6102 <sup>20</sup> | s H <sub>2</sub> O, eth; vs EtOH, chl              |
| 4151 | <i>N,N</i> -Dimethyl-3-nitroaniline                                           |                                   | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>  | 619-31-8   | 166.177  | red mcl pr (eth) | 60.5    | 282.5                   | 1.313 <sup>17</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth                    |
| 4152 | <i>N,N</i> -Dimethyl-4-nitroaniline                                           |                                   | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>  | 100-23-2   | 166.177  | ye nd (al)       | 164.5   |                         |                            |                      | i H <sub>2</sub> O; s EtOH, eth, HOAc              |
| 4153 | 1,2-Dimethyl-3-nitrobenzene                                                   |                                   | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 83-41-0    | 151.163  | nd (al)          | 15      | 240                     | 1.1402 <sup>20</sup>       | 1.5441 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ctc                    |
| 4154 | 1,2-Dimethyl-4-nitrobenzene                                                   | 4-Nitro- <i>o</i> -xylene         | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 99-51-4    | 151.163  | ye pr (al)       | 30.5    | 251; 143 <sup>21</sup>  | 1.112 <sup>15</sup>        | 1.5202 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH                       |
| 4155 | 1,3-Dimethyl-2-nitrobenzene                                                   |                                   | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 81-20-9    | 151.163  |                  | 15      | 226                     | 1.112 <sup>15</sup>        | 1.5202 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; s ctc                 |
| 4156 | 1,3-Dimethyl-5-nitrobenzene                                                   |                                   | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 99-12-7    | 151.163  | nd (al)          | 75      | 274                     |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                   |
| 4157 | 1,4-Dimethyl-2-nitrobenzene                                                   |                                   | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 89-58-7    | 151.163  | pa ye liq        | -25     | 240.5                   | 1.132 <sup>15</sup>        | 1.5413 <sup>20</sup> | i H <sub>2</sub> O; s EtOH                         |
| 4158 | 2,4-Dimethyl-1-nitrobenzene                                                   |                                   | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 89-87-2    | 151.163  |                  | 9       | 247; 122 <sup>18</sup>  | 1.135 <sup>15</sup>        | 1.5473 <sup>25</sup> | i H <sub>2</sub> O; s eth, ace, bz, chl            |
| 4159 | 1,2-Dimethyl-5-nitro-1- <i>H</i> -imidazole                                   | Dimetridazole                     | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>   | 551-92-8   | 141.129  | nd (w)           | 138.5   |                         |                            |                      | vs eth, EtOH                                       |
| 4160 | <i>N,N</i> -Dimethyl-4-[2-(4-nitrophenyl)ethenyl]aniline                      |                                   | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub> | 4584-57-0  | 268.310  |                  | 258.3   |                         |                            |                      |                                                    |

*N,N*-Dimethyl-1*H*-indole-3-methanamine

Dimethyl isophthalate



1,4-Dimethyl-7-isopropylazulene



1,6-Dimethyl-4-isopropyl-naphthalene



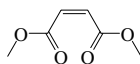
2,4-Dimethyl-3-isopropylpentane



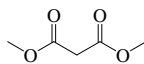
3,5-Dimethylisoxazole



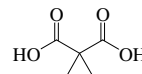
Dimethylmagnesium



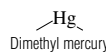
Dimethyl maleate



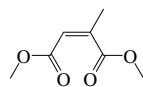
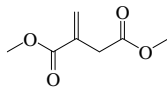
Dimethyl malonate



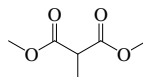
Dimethylmalonic acid



Dimethyl mercury

Dimethyl *cis*-2-methyl-2-butenedioate

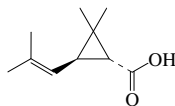
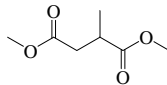
Dimethyl methylenesuccinate



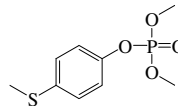
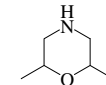
Dimethyl methylmalonate



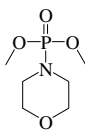
Dimethyl methylphosphonate

*trans*-2,2-Dimethyl-3-(2-methyl-1-propenyl)cyclopropanecarboxylic acid

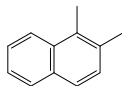
Dimethyl 2-methylsuccinate

Dimethyl *p*-(methylthio)phenyl phosphate

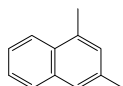
2,6-Dimethylmorpholine



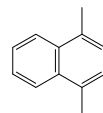
Dimethyl morpholinophosphoramidate



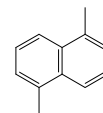
1,2-Dimethylnaphthalene



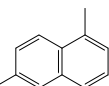
1,3-Dimethylnaphthalene



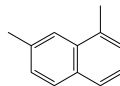
1,4-Dimethylnaphthalene



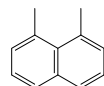
1,5-Dimethylnaphthalene



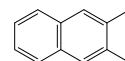
1,6-Dimethylnaphthalene



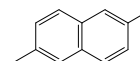
1,7-Dimethylnaphthalene



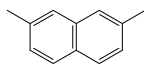
1,8-Dimethylnaphthalene



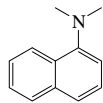
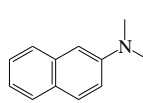
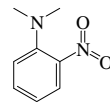
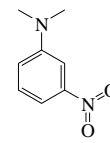
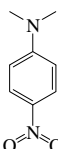
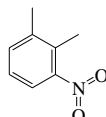
2,3-Dimethylnaphthalene



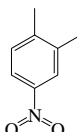
2,6-Dimethylnaphthalene



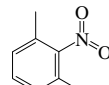
2,7-Dimethylnaphthalene

*N,N*-Dimethyl-1-naphthylamine*N,N*-Dimethyl-2-naphthylamine*N,N*-Dimethyl-2-nitroaniline*N,N*-Dimethyl-3-nitroaniline*N,N*-Dimethyl-4-nitroaniline

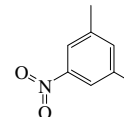
1,2-Dimethyl-3-nitrobenzene



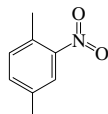
1,2-Dimethyl-4-nitrobenzene



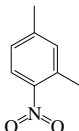
1,3-Dimethyl-2-nitrobenzene



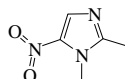
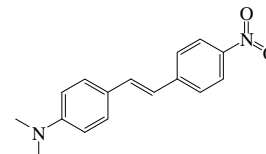
1,3-Dimethyl-5-nitrobenzene



1,4-Dimethyl-2-nitrobenzene

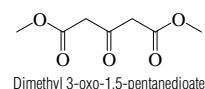
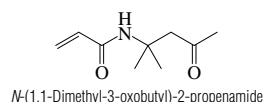
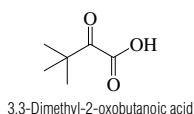
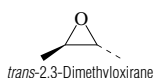
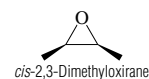
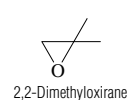
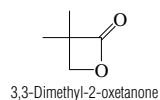
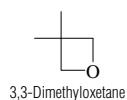
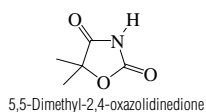
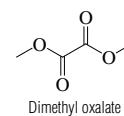
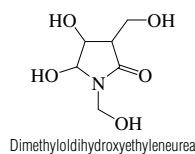
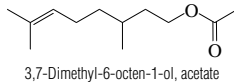
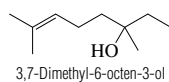
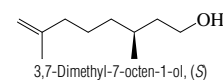
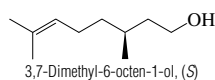
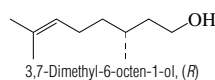
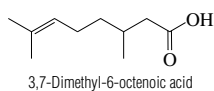
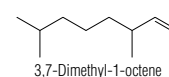
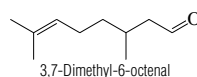
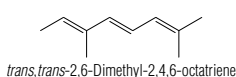
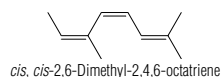
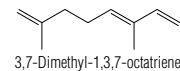
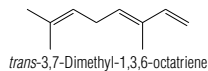
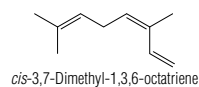
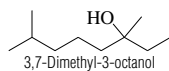
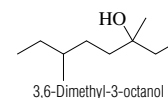
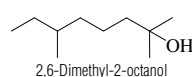
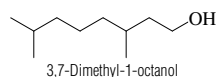
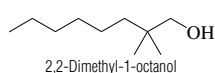
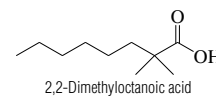
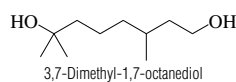
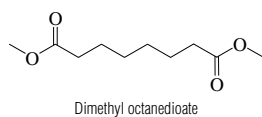
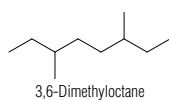
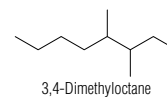
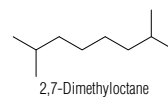
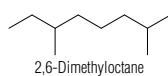
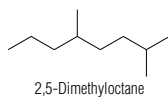
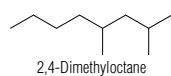
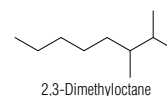
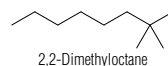
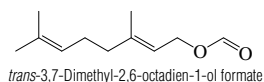
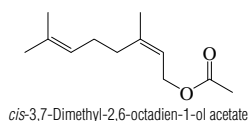
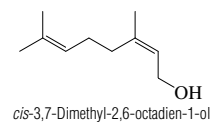
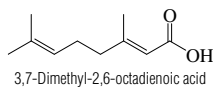
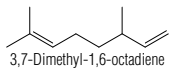
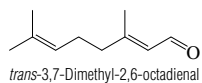
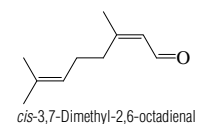
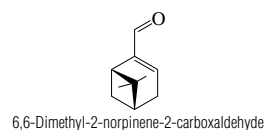
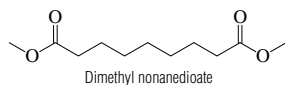
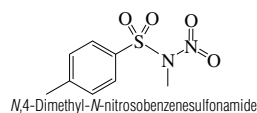


2,4-Dimethyl-1-nitrobenzene

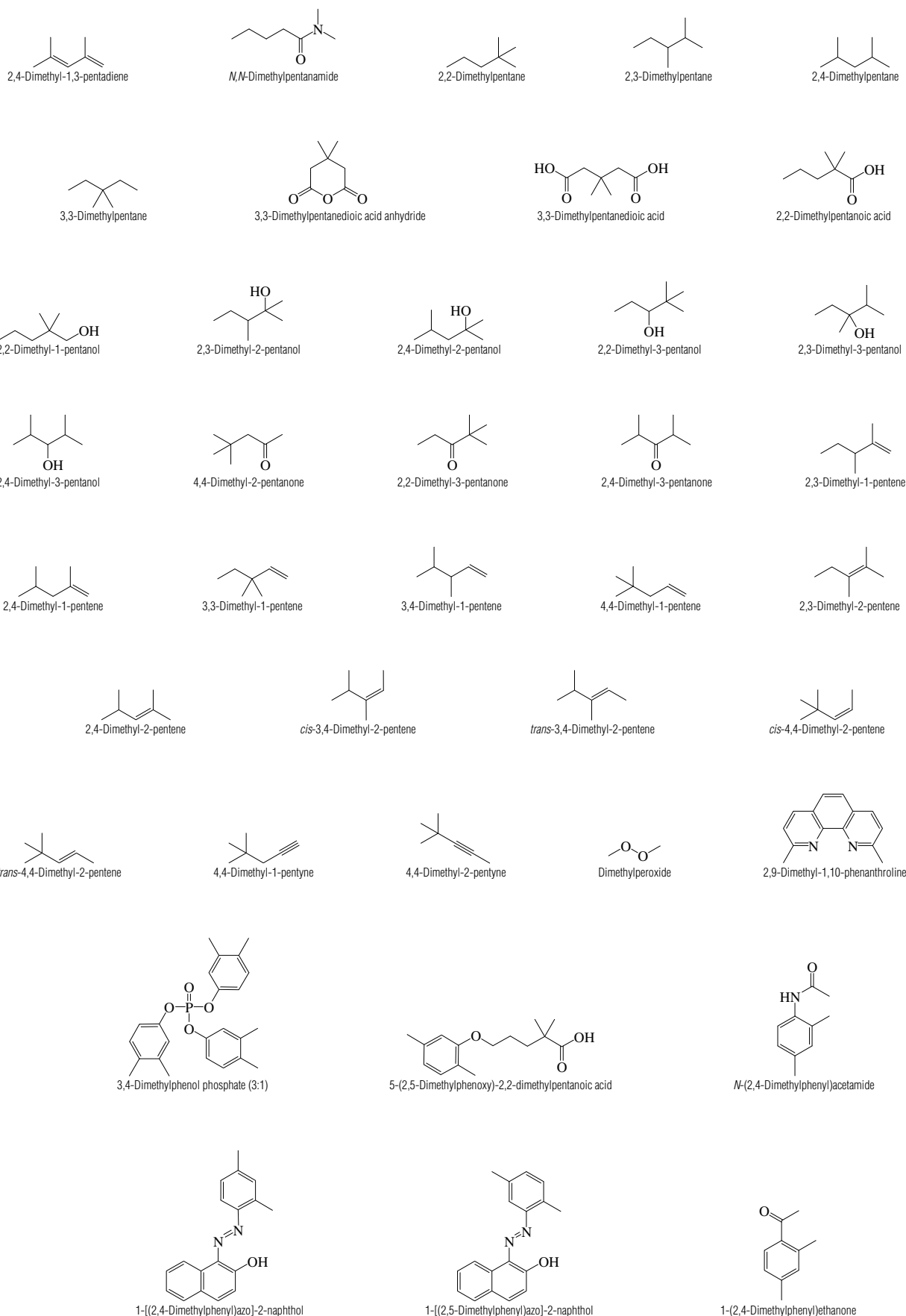
1,2-Dimethyl-5-nitro-1*H*-imidazole*N,N*-Dimethyl-4-[2-(4-nitrophenyl)ethenyl]aniline



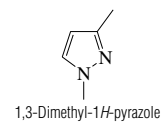
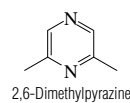
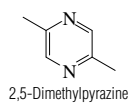
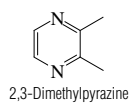
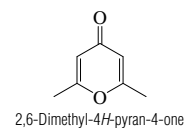
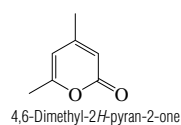
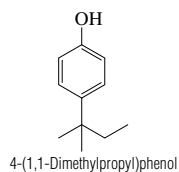
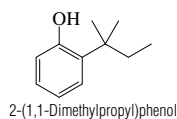
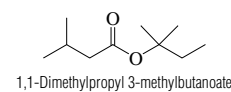
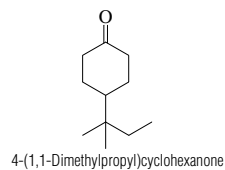
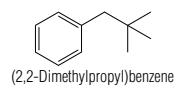
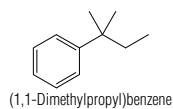
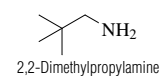
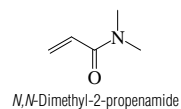
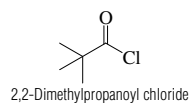
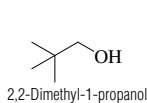
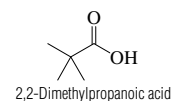
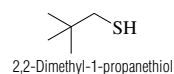
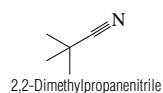
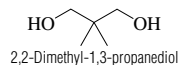
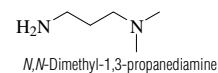
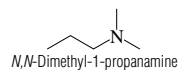
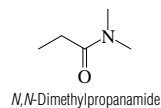
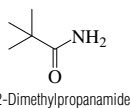
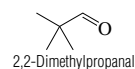
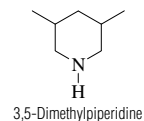
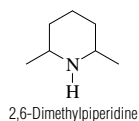
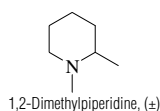
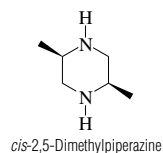
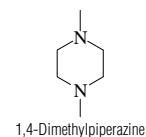
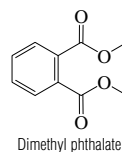
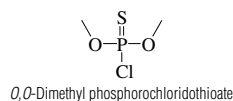
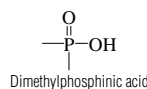
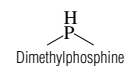
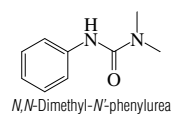
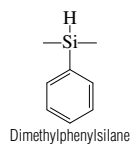
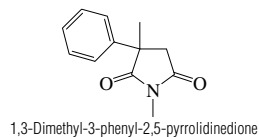
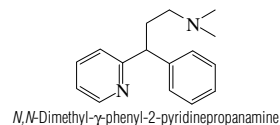
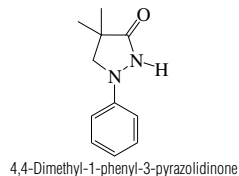
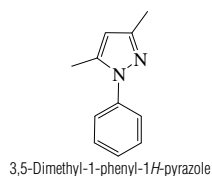
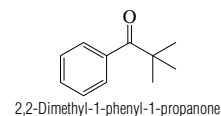
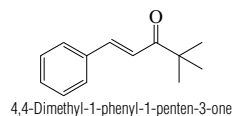
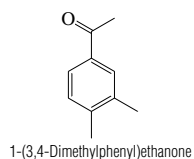
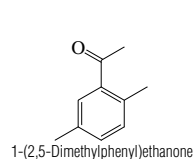
| No.  | Name                                                       | Synonym                                                | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form  | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------------|------------|----------|----------------|-------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 4161 | <i>N</i> ,4-Dimethyl- <i>N</i> -nitrosobenzenesulfonamide  | <i>p</i> -Tolylsulfonylethylmethylnitrosamide          | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub> S | 80-11-5    | 214.241  | cry            | 60    |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                     |
| 4162 | Dimethyl nonanedioate                                      | Methyl azelate                                         | C <sub>11</sub> H <sub>20</sub> O <sub>4</sub>                 | 1732-10-1  | 216.275  |                | -0.8  | 156 <sup>20</sup>                     | 1.0082 <sup>20</sup>       | 1.4367 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, bz, ctc             |
| 4163 | 6,6-Dimethyl-2-norpinene-2-carboxaldehyde                  | Myrtenal                                               | C <sub>10</sub> H <sub>14</sub> O                              | 564-94-3   | 150.217  | unstab oil     |       | 99 <sup>15</sup>                      |                            |                      |                                                      |
| 4164 | <i>cis</i> -3,7-Dimethyl-2,6-octadienal                    |                                                        | C <sub>10</sub> H <sub>16</sub> O                              | 106-26-3   | 152.233  |                |       | 120 <sup>20</sup>                     | 0.8869 <sup>20</sup>       | 1.4869 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                    |
| 4165 | <i>trans</i> -3,7-Dimethyl-2,6-octadienal                  |                                                        | C <sub>10</sub> H <sub>16</sub> O                              | 141-27-5   | 152.233  |                |       | 229                                   | 0.8888 <sup>20</sup>       | 1.4898 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                    |
| 4166 | 3,7-Dimethyl-1,6-octadiene                                 | Citronellene                                           | C <sub>10</sub> H <sub>18</sub>                                | 2436-90-0  | 138.250  |                |       |                                       | 0.7601 <sup>20</sup>       | 1.4362 <sup>20</sup> |                                                      |
| 4167 | 3,7-Dimethyl-2,6-octadienoic acid                          | Geranic acid                                           | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>                 | 459-80-3   | 168.233  | oil            |       |                                       |                            |                      |                                                      |
| 4168 | <i>cis</i> -3,7-Dimethyl-2,6-octadien-1-ol                 | Nerol                                                  | C <sub>10</sub> H <sub>18</sub> O                              | 106-25-2   | 154.249  |                | <-15  | 225; 125 <sup>25</sup>                | 0.8756 <sup>20</sup>       | 1.4746 <sup>20</sup> | vs EtOH                                              |
| 4169 | <i>cis</i> -3,7-Dimethyl-2,6-octadien-1-ol acetate         |                                                        | C <sub>12</sub> H <sub>20</sub> O <sub>2</sub>                 | 141-12-8   | 196.286  |                |       | 134 <sup>25</sup> , 93 <sup>3</sup>   | 0.905 <sup>15</sup>        | 1.452 <sup>20</sup>  |                                                      |
| 4170 | <i>trans</i> -3,7-Dimethyl-2,6-octadien-1-ol formate       |                                                        | C <sub>11</sub> H <sub>18</sub> O <sub>2</sub>                 | 105-86-2   | 182.260  |                |       | dec 229; 113 <sup>25</sup>            | 0.9086 <sup>25</sup>       | 1.4659 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; s eth, ace              |
| 4171 | 2,2-Dimethyloctane                                         |                                                        | C <sub>10</sub> H <sub>22</sub>                                | 15869-87-1 | 142.282  |                |       | 155                                   | 0.7208 <sup>25</sup>       | 1.4082 <sup>20</sup> |                                                      |
| 4172 | 2,3-Dimethyloctane                                         |                                                        | C <sub>10</sub> H <sub>22</sub>                                | 7146-60-3  | 142.282  |                |       | 164.3                                 | 0.7377 <sup>20</sup>       | 1.4146 <sup>20</sup> |                                                      |
| 4173 | 2,4-Dimethyloctane                                         |                                                        | C <sub>10</sub> H <sub>22</sub>                                | 4032-94-4  | 142.282  |                |       | 156                                   | 0.7226 <sup>25</sup>       | 1.4091 <sup>20</sup> |                                                      |
| 4174 | 2,5-Dimethyloctane                                         |                                                        | C <sub>10</sub> H <sub>22</sub>                                | 15869-89-3 | 142.282  |                |       | 158.5                                 | 0.7264 <sup>25</sup>       | 1.4112 <sup>20</sup> |                                                      |
| 4175 | 2,6-Dimethyloctane                                         |                                                        | C <sub>10</sub> H <sub>22</sub>                                | 2051-30-1  | 142.282  |                |       | 160.4                                 | 0.7313 <sup>20</sup>       | 1.4097 <sup>20</sup> |                                                      |
| 4176 | 2,7-Dimethyloctane                                         |                                                        | C <sub>10</sub> H <sub>22</sub>                                | 1072-16-8  | 142.282  | liq            | -54.9 | 159.9                                 | 0.7202 <sup>25</sup>       | 1.4086 <sup>20</sup> | s eth, HOAc                                          |
| 4177 | 3,4-Dimethyloctane                                         |                                                        | C <sub>10</sub> H <sub>22</sub>                                | 15869-92-8 | 142.282  |                |       | 163.4                                 | 0.7410 <sup>25</sup>       | 1.4182 <sup>20</sup> |                                                      |
| 4178 | 3,6-Dimethyloctane                                         |                                                        | C <sub>10</sub> H <sub>22</sub>                                | 15869-94-0 | 142.282  |                |       | 160.8                                 | 0.7324 <sup>25</sup>       | 1.4139 <sup>20</sup> |                                                      |
| 4179 | Dimethyl octanedioate                                      | Dimethyl suberate                                      | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                 | 1732-09-8  | 202.248  | liq            | -1.6  | 268                                   | 1.0217 <sup>20</sup>       | 1.4341 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace; sl ctc         |
| 4180 | 3,7-Dimethyl-1,7-octanediol                                |                                                        | C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>                 | 107-74-4   | 174.281  |                |       | 265                                   | 0.937 <sup>20</sup>        | 1.4599 <sup>20</sup> | sl bz, tol                                           |
| 4181 | 2,2-Dimethyloctanoic acid                                  |                                                        | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | 29662-90-6 | 172.265  |                |       | 140 <sup>13</sup>                     |                            |                      |                                                      |
| 4182 | 2,2-Dimethyl-1-octanol                                     |                                                        | C <sub>10</sub> H <sub>22</sub> O                              | 2370-14-1  | 158.281  | liq            |       | 97                                    | 0.84 <sup>20</sup>         |                      |                                                      |
| 4183 | 3,7-Dimethyl-1-octanol                                     |                                                        | C <sub>10</sub> H <sub>22</sub> O                              | 106-21-8   | 158.281  |                |       | 212.5                                 | 0.832 <sup>25</sup>        | 1.438 <sup>25</sup>  | s eth                                                |
| 4184 | 2,6-Dimethyl-2-octanol                                     | Tetrahydromyrcenol                                     | C <sub>10</sub> H <sub>20</sub> O                              | 18479-57-7 | 158.281  |                |       | 80.5 <sup>10</sup>                    | 0.8023 <sup>25</sup>       | 1.4220 <sup>25</sup> |                                                      |
| 4185 | 3,6-Dimethyl-3-octanol                                     |                                                        | C <sub>10</sub> H <sub>22</sub> O                              | 151-19-9   | 158.281  | liq            | -67.5 | 202.2                                 | 0.8347 <sup>22</sup>       | 1.4370 <sup>20</sup> |                                                      |
| 4186 | 3,7-Dimethyl-3-octanol                                     |                                                        | C <sub>10</sub> H <sub>22</sub> O                              | 78-69-3    | 158.281  |                |       | 205.1                                 | 0.826 <sup>25</sup>        | 1.433 <sup>25</sup>  |                                                      |
| 4187 | <i>cis</i> -3,7-Dimethyl-1,3,6-octatriene                  | <i>cis</i> -β-Ocimene                                  | C <sub>10</sub> H <sub>16</sub>                                | 3338-55-4  | 136.234  |                |       | 0.799 <sup>20</sup>                   |                            |                      |                                                      |
| 4188 | <i>trans</i> -3,7-Dimethyl-1,3,6-octatriene                | <i>trans</i> -β-Ocimene                                | C <sub>10</sub> H <sub>16</sub>                                | 3779-61-1  | 136.234  |                |       | 0.799 <sup>20</sup>                   |                            |                      |                                                      |
| 4189 | 3,7-Dimethyl-1,3,7-octatriene                              | α-Ocimene                                              | C <sub>10</sub> H <sub>16</sub>                                | 502-99-8   | 136.234  |                |       | dec 177                               | 0.8000 <sup>20</sup>       | 1.4862 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl, HOAc           |
| 4190 | <i>cis</i> , <i>cis</i> -2,6-Dimethyl-2,4,6-octatriene     | <i>cis</i> - <i>allo</i> -Ocimene                      | C <sub>10</sub> H <sub>16</sub>                                | 17202-20-9 | 136.234  | liq            |       |                                       |                            |                      |                                                      |
| 4191 | <i>trans</i> , <i>trans</i> -2,6-Dimethyl-2,4,6-octatriene | <i>trans</i> - <i>allo</i> -Ocimene                    | C <sub>10</sub> H <sub>16</sub>                                | 3016-19-1  | 136.234  | liq            | -35.4 | 188; 91 <sup>20</sup>                 | 0.8118 <sup>20</sup>       | 1.5446 <sup>20</sup> |                                                      |
| 4192 | 3,7-Dimethyl-6-octenal                                     | Citronellal                                            | C <sub>10</sub> H <sub>18</sub> O                              | 106-23-0   | 154.249  | nd or orth cry |       | 207.5                                 | 0.853 <sup>20</sup>        | 1.4473 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH                          |
| 4193 | 3,7-Dimethyl-1-octene                                      |                                                        | C <sub>10</sub> H <sub>20</sub>                                | 4984-01-4  | 140.266  | col liq        |       | 154                                   | 0.7396 <sup>20</sup>       | 1.4212 <sup>20</sup> |                                                      |
| 4194 | 3,7-Dimethyl-6-octenoic acid                               | Citronellic acid                                       | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>                 | 502-47-6   | 170.249  |                |       | 257; 157 <sup>23</sup>                | 0.9234 <sup>21</sup>       |                      |                                                      |
| 4195 | 3,7-Dimethyl-6-octen-1-ol, ( <i>R</i> )                    | Citronellol, (+)                                       | C <sub>10</sub> H <sub>20</sub> O                              | 1117-61-9  | 156.265  | oil            |       | 224; 108 <sup>10</sup>                | 0.8550 <sup>20</sup>       | 1.4565 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                   |
| 4196 | 3,7-Dimethyl-6-octen-1-ol, ( <i>S</i> )                    | Citronellol, (-)                                       | C <sub>10</sub> H <sub>20</sub> O                              | 7540-51-4  | 156.265  | oil            |       | 224; 108 <sup>10</sup>                | 0.859 <sup>18</sup>        | 1.4576 <sup>18</sup> | vs eth, EtOH                                         |
| 4197 | 3,7-Dimethyl-7-octen-1-ol, ( <i>S</i> )                    | Rhodinol                                               | C <sub>10</sub> H <sub>20</sub> O                              | 6812-78-8  | 156.265  |                |       | 114 <sup>12</sup>                     | 0.8549 <sup>20</sup>       | 1.4556 <sup>20</sup> | vs eth, EtOH                                         |
| 4198 | 3,7-Dimethyl-6-octen-3-ol                                  |                                                        | C <sub>10</sub> H <sub>20</sub> O                              | 18479-51-1 | 156.265  |                |       | 94 <sup>14</sup>                      | 0.8695 <sup>15</sup>       | 1.4569 <sup>15</sup> |                                                      |
| 4199 | 3,7-Dimethyl-6-octen-1-ol, acetate                         | Citronellol acetate                                    | C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>                 | 150-84-5   | 198.302  |                |       | 115 <sup>10</sup>                     |                            |                      |                                                      |
| 4200 | Dimethyloldihydroxyethyleneurea                            | 4,5-Dihydroxy-1,3-bis(hydroxymethyl)-2-imidazolidinone | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>5</sub>   | 1854-26-8  | 178.143  | hyg cry        |       |                                       |                            |                      |                                                      |
| 4201 | Dimethyl oxalate                                           |                                                        | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                   | 553-90-2   | 118.089  | mcl tab        | 54.8  | 163.5                                 | 1.1716 <sup>60</sup>       | 1.379 <sup>82</sup>  | sl H <sub>2</sub> O; s EtOH, eth, ace, chl           |
| 4202 | 5,5-Dimethyl-2,4-oxazolidinedione                          | Dimethadione                                           | C <sub>5</sub> H <sub>8</sub> NO <sub>3</sub>                  | 695-53-4   | 129.115  |                | 76.5  |                                       |                            |                      |                                                      |
| 4203 | 3,3-Dimethyloxetane                                        |                                                        | C <sub>5</sub> H <sub>10</sub> O                               | 6921-35-3  | 86.132   |                |       | 80.6                                  | 0.834 <sup>25</sup>        | 1.3965 <sup>20</sup> |                                                      |
| 4204 | 3,3-Dimethyl-2-oxetanone                                   |                                                        | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                   | 1955-45-9  | 100.117  |                |       | 58 <sup>15</sup>                      |                            |                      |                                                      |
| 4205 | 2,2-Dimethyloxirane                                        | 2-Methyl-1,2-epoxypropane                              | C <sub>4</sub> H <sub>8</sub> O                                | 558-30-5   | 72.106   |                |       | 52                                    | 0.8112 <sup>20</sup>       | 1.3712 <sup>22</sup> | s EtOH, eth                                          |
| 4206 | <i>cis</i> -2,3-Dimethyloxirane                            |                                                        | C <sub>4</sub> H <sub>8</sub> O                                | 1758-33-4  | 72.106   | liq            | -80   | 60                                    | 0.8226 <sup>25</sup>       | 1.3802 <sup>20</sup> | vs eth, ace, bz                                      |
| 4207 | <i>trans</i> -2,3-Dimethyloxirane                          |                                                        | C <sub>4</sub> H <sub>8</sub> O                                | 6189-41-9  | 72.106   | liq            | -85   | 56.5                                  | 0.8010 <sup>25</sup>       | 1.3736 <sup>20</sup> | vs eth, ace, bz                                      |
| 4208 | 3,3-Dimethyl-2-oxobutanoic acid                            |                                                        | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                  | 815-17-8   | 130.141  |                | 90.5  | 189; 80 <sup>15</sup>                 |                            |                      | sl H <sub>2</sub> O; s eth, bz, chl, CS <sub>2</sub> |
| 4209 | <i>N</i> -(1,1-Dimethyl-3-oxobutyl)-2-propenamide          | Diacetone acrylamide                                   | C <sub>9</sub> H <sub>15</sub> NO <sub>2</sub>                 | 2873-97-4  | 169.221  |                |       |                                       |                            |                      | s chl                                                |
| 4210 | Dimethyl 3-oxo-1,5-pentanedioate                           | Dimethyl 1,3-acetonedicarboxylate                      | C <sub>7</sub> H <sub>10</sub> O <sub>5</sub>                  | 1830-54-2  | 174.151  |                |       | 150 <sup>25</sup> , 77 <sup>0.6</sup> | 1.185 <sup>25</sup>        | 1.4434 <sup>20</sup> |                                                      |



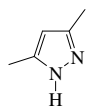
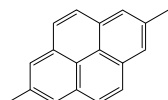
| No.  | Name                                               | Synonym                                                       | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form      | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|----------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------|------------|----------|--------------------|--------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 4211 | 2,4-Dimethyl-1,3-pentadiene                        |                                                               | C <sub>7</sub> H <sub>12</sub>                   | 1000-86-8  | 96.170   | liq                | -114   | 93.2                                  | 0.7343 <sup>23</sup>       | 1.4390 <sup>23</sup> |                                                       |
| 4212 | <i>N,N</i> -Dimethylpentanamide                    |                                                               | C <sub>7</sub> H <sub>15</sub> NO                | 6225-06-5  | 129.200  |                    | -51    | 141 <sup>100</sup>                    | 0.8962 <sup>25</sup>       | 1.4419 <sup>25</sup> | vs H <sub>2</sub> O, eth, EtOH                        |
| 4213 | 2,2-Dimethylpentane                                |                                                               | C <sub>7</sub> H <sub>16</sub>                   | 590-35-2   | 100.202  | liq                | -123.7 | 79.2                                  | 0.6739 <sup>20</sup>       | 1.3822 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, hp, chl |
| 4214 | 2,3-Dimethylpentane                                |                                                               | C <sub>7</sub> H <sub>16</sub>                   | 565-59-3   | 100.202  |                    |        | 89.78                                 | 0.6908 <sup>25</sup>       | 1.3894 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, chl     |
| 4215 | 2,4-Dimethylpentane                                |                                                               | C <sub>7</sub> H <sub>16</sub>                   | 108-08-7   | 100.202  | liq                | -119.2 | 80.49                                 | 0.6727 <sup>20</sup>       | 1.3815 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, chl, hp |
| 4216 | 3,3-Dimethylpentane                                |                                                               | C <sub>7</sub> H <sub>16</sub>                   | 562-49-2   | 100.202  | liq                | -134.4 | 86.06                                 | 0.6936 <sup>20</sup>       | 1.3909 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, hp, chl |
| 4217 | 3,3-Dimethylpentanedioic acid anhydride            | Dihydro-4,4-dimethyl-2 <i>H</i> -pyran-2,6(3 <i>H</i> )-dione | C <sub>7</sub> H <sub>10</sub> O <sub>3</sub>    | 4160-82-1  | 142.152  |                    | 125.8  | 181 <sup>25</sup> , 156 <sup>20</sup> |                            |                      |                                                       |
| 4218 | 3,3-Dimethylpentanedioic acid                      |                                                               | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>    | 4839-46-7  | 160.168  | mcl pl, nd (bz)    | 103.5  | 126 <sup>415</sup> , 89 <sup>2</sup>  | 1.4278 <sup>20</sup>       |                      | vs H <sub>2</sub> O, EtOH, eth; sl bz; i lig          |
| 4219 | 2,2-Dimethylpentanoic acid                         |                                                               | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>    | 1185-39-3  | 130.185  | liq                |        | 98 <sup>3</sup>                       | 0.9189 <sup>20</sup>       |                      |                                                       |
| 4220 | 2,2-Dimethyl-1-pentanol                            |                                                               | C <sub>7</sub> H <sub>16</sub> O                 | 2370-12-9  | 116.201  |                    |        |                                       |                            |                      | s chl                                                 |
| 4221 | 2,3-Dimethyl-2-pentanol                            |                                                               | C <sub>7</sub> H <sub>16</sub> O                 | 4911-70-0  | 116.201  |                    |        |                                       | 0.804 <sup>20</sup>        |                      | sl H <sub>2</sub> O                                   |
| 4222 | 2,4-Dimethyl-2-pentanol                            |                                                               | C <sub>7</sub> H <sub>16</sub> O                 | 625-06-9   | 116.201  |                    | <-20   | 133.1                                 | 0.8103 <sup>20</sup>       | 1.4172 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc                 |
| 4223 | 2,2-Dimethyl-3-pentanol                            |                                                               | C <sub>7</sub> H <sub>16</sub> O                 | 3970-62-5  | 116.201  | liq                | -2.5   | 135                                   | 0.8253 <sup>20</sup>       | 1.4223 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                       |
| 4224 | 2,3-Dimethyl-3-pentanol                            |                                                               | C <sub>7</sub> H <sub>16</sub> O                 | 595-41-5   | 116.201  |                    | <-30   | 139.7                                 | 0.833 <sup>20</sup>        | 1.4287 <sup>20</sup> | sl H <sub>2</sub> O, bz; s EtOH, eth                  |
| 4225 | 2,4-Dimethyl-3-pentanol                            |                                                               | C <sub>7</sub> H <sub>16</sub> O                 | 600-36-2   | 116.201  |                    | <-70   | 138.7                                 | 0.8288 <sup>20</sup>       | 1.4250 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                      |
| 4226 | 4,4-Dimethyl-2-pentanone                           |                                                               | C <sub>7</sub> H <sub>14</sub> O                 | 590-50-1   | 114.185  | liq                | -64    | 126                                   | 0.809 <sup>25</sup>        | 1.4036 <sup>20</sup> |                                                       |
| 4227 | 2,2-Dimethyl-3-pentanone                           |                                                               | C <sub>7</sub> H <sub>14</sub> O                 | 564-04-5   | 114.185  | liq                | -45    | 125.6                                 | 0.8125 <sup>20</sup>       | 1.4065 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, chl            |
| 4228 | 2,4-Dimethyl-3-pentanone                           | Diisopropyl ketone                                            | C <sub>7</sub> H <sub>14</sub> O                 | 565-80-0   | 114.185  | liq                | -69    | 125.4                                 | 0.8108 <sup>20</sup>       | 1.3999 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s bz; sl ctc      |
| 4229 | 2,3-Dimethyl-1-pentene                             |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 3404-72-6  | 98.186   | liq                | -134.3 | 84.3                                  | 0.7051 <sup>20</sup>       | 1.4033 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs dil sulf        |
| 4230 | 2,4-Dimethyl-1-pentene                             |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 2213-32-3  | 98.186   | liq                | -124.1 | 81.6                                  | 0.6943 <sup>20</sup>       | 1.3986 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz, ctc, chl     |
| 4231 | 3,3-Dimethyl-1-pentene                             |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 3404-73-7  | 98.186   | liq                | -134.3 | 77.5                                  | 0.6974 <sup>20</sup>       | 1.3984 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz, chl          |
| 4232 | 3,4-Dimethyl-1-pentene                             |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 7385-78-6  | 98.186   |                    |        | 80.8                                  | 0.6934 <sup>25</sup>       | 1.3992 <sup>20</sup> |                                                       |
| 4233 | 4,4-Dimethyl-1-pentene                             |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 762-62-9   | 98.186   | liq                | -136.6 | 72.5                                  | 0.6827 <sup>20</sup>       | 1.3818 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz, ctc, chl     |
| 4234 | 2,3-Dimethyl-2-pentene                             |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 10574-37-5 | 98.186   | liq                | -118.3 | 97.5                                  | 0.7277 <sup>20</sup>       | 1.4208 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl              |
| 4235 | 2,4-Dimethyl-2-pentene                             |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 625-65-0   | 98.186   | liq                | -127.7 | 83.4                                  | 0.6954 <sup>20</sup>       | 1.4040 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc              |
| 4236 | <i>cis</i> -3,4-Dimethyl-2-pentene                 |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 4914-91-4  | 98.186   | liq                | -113.4 | 89.3                                  | 0.7092 <sup>25</sup>       | 1.4104 <sup>20</sup> |                                                       |
| 4237 | <i>trans</i> -3,4-Dimethyl-2-pentene               |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 4914-92-5  | 98.186   | liq                | -124.2 | 91.5                                  | 0.7124 <sup>25</sup>       | 1.4128 <sup>20</sup> |                                                       |
| 4238 | <i>cis</i> -4,4-Dimethyl-2-pentene                 |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 762-63-0   | 98.186   | liq                | -135.4 | 80.4                                  | 0.6951 <sup>25</sup>       | 1.4026 <sup>20</sup> |                                                       |
| 4239 | <i>trans</i> -4,4-Dimethyl-2-pentene               |                                                               | C <sub>7</sub> H <sub>14</sub>                   | 690-08-4   | 98.186   | liq                | -115.2 | 76.7                                  | 0.6889 <sup>20</sup>       | 1.3982 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl              |
| 4240 | 4,4-Dimethyl-1-pentyne                             |                                                               | C <sub>7</sub> H <sub>12</sub>                   | 13361-63-2 | 96.170   | liq                | -75.7  | 76.1                                  | 0.7142 <sup>20</sup>       | 1.3983 <sup>20</sup> | vs bz, eth, chl                                       |
| 4241 | 4,4-Dimethyl-2-pentyne                             |                                                               | C <sub>7</sub> H <sub>12</sub>                   | 999-78-0   | 96.170   | liq                | -82.4  | 83                                    | 0.7176 <sup>20</sup>       | 1.4071 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl; sl ctc            |
| 4242 | Dimethylperoxide                                   |                                                               | C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>     | 690-02-8   | 62.068   | vol liq or gas     | -100   | 14                                    | 0.8677 <sup>9</sup>        | 1.3503 <sup>9</sup>  | sl EtOH, eth; s tol, HOAc                             |
| 4243 | 2,9-Dimethyl-1,10-phenanthroline                   | Neocuproine                                                   | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub>   | 484-11-7   | 208.258  | cry, 1/2w (w, lig) | 159.5  |                                       |                            |                      |                                                       |
| 4244 | 3,4-Dimethylphenol phosphate (3:1)                 |                                                               | C <sub>24</sub> H <sub>27</sub> O <sub>4</sub> P | 3862-11-1  | 410.442  |                    | 72     | 261 <sup>7</sup>                      |                            |                      | i H <sub>2</sub> O; sl EtOH, chl, hx; s bz            |
| 4245 | 5-(2,5-Dimethylphenoxy)-2,2-dimethylpentanoic acid | Gemfibrozil                                                   | C <sub>15</sub> H <sub>22</sub> O <sub>3</sub>   | 25812-30-0 | 250.334  | cry                | 62     | 159 <sup>0.02</sup>                   |                            |                      |                                                       |
| 4246 | <i>N</i> -(2,4-Dimethylphenyl)acetamide            |                                                               | C <sub>10</sub> H <sub>13</sub> NO               | 2050-43-3  | 163.216  | nd (al)            | 129.3  | 170 <sup>10</sup>                     |                            |                      | vs EtOH, chl                                          |
| 4247 | 1-[(2,4-Dimethylphenyl)azo]-2-naphthol             | 1-(2,4-Xylylazo)-2-naphthol                                   | C <sub>18</sub> H <sub>16</sub> N <sub>2</sub> O | 3118-97-6  | 276.332  | red nd (al)        | 166    |                                       |                            |                      | vs eth, EtOH                                          |
| 4248 | 1-[(2,5-Dimethylphenyl)azo]-2-naphthol             | 1-(2,5-Xylylazo)-2-naphthol                                   | C <sub>18</sub> H <sub>16</sub> N <sub>2</sub> O | 85-82-5    | 276.332  | nd (al)            | 153    |                                       |                            |                      |                                                       |
| 4249 | 1-(2,4-Dimethylphenyl)ethanone                     | 2,4-Dimethylacetophenone                                      | C <sub>10</sub> H <sub>12</sub> O                | 89-74-7    | 148.201  |                    |        | 228                                   | 1.0121 <sup>15</sup>       | 1.5340 <sup>20</sup> | vs eth, EtOH                                          |



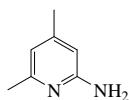
| No.  | Name                                                | Synonym                           | Mol. Form.                                        | CAS RN     | Mol. Wt. | Physical Form                   | mp/°C  | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|-----------------------------------------------------|-----------------------------------|---------------------------------------------------|------------|----------|---------------------------------|--------|----------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 4250 | 1-(2,5-Dimethylphenyl)ethanone                      | 2,5-Dimethylacetophenone          | C <sub>10</sub> H <sub>12</sub> O                 | 2142-73-6  | 148.201  | liq                             | -18.1  | 232.5                                  | 0.9963 <sup>19</sup>       | 1.5291 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz, CS <sub>2</sub> |
| 4251 | 1-(3,4-Dimethylphenyl)ethanone                      | 3,4-Dimethylacetophenone          | C <sub>10</sub> H <sub>12</sub> O                 | 3637-01-2  | 148.201  | liq                             | -1.5   | 246.5                                  | 1.0090 <sup>14</sup>       | 1.5413 <sup>15</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz; s ctc, HOAc     |
| 4252 | 4,4-Dimethyl-1-phenyl-1-penten-3-one                |                                   | C <sub>13</sub> H <sub>16</sub> O                 | 538-44-3   | 188.265  |                                 | 43     | 154 <sup>25</sup>                      | 0.9508 <sup>46</sup>       | 1.5523 <sup>25</sup> |                                                       |
| 4253 | 2,2-Dimethyl-1-phenyl-1-propanone                   |                                   | C <sub>11</sub> H <sub>14</sub> O                 | 938-16-9   | 162.228  |                                 |        | 220                                    | 0.963 <sup>26</sup>        | 1.5086 <sup>19</sup> | s ace                                                 |
| 4254 | 3,5-Dimethyl-1-phenyl-1 <i>H</i> -pyrazole          |                                   | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub>    | 1131-16-4  | 172.226  |                                 |        | 272; 145 <sup>12,5</sup>               | 1.0566 <sup>20</sup>       | 1.5738 <sup>19</sup> | vs eth, EtOH, chl                                     |
| 4255 | 4,4-Dimethyl-1-phenyl-3-pyrazolidinone              | 4,4-Dimethylphenidone             | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> O  | 2654-58-2  | 190.241  |                                 | 176    |                                        |                            |                      |                                                       |
| 4256 | <i>N,N</i> -Dimethyl-γ-phenyl-2-pyridinepropanamine | Pheniramine                       | C <sub>16</sub> H <sub>20</sub> N <sub>2</sub>    | 86-21-5    | 240.343  |                                 |        | 181 <sup>13</sup> ; 135 <sup>0,5</sup> | 1.0081 <sup>25</sup>       | 1.5519 <sup>25</sup> | vs bz, eth, EtOH, chl                                 |
| 4257 | 1,3-Dimethyl-3-phenyl-2,5-pyrrolidinedione          | Methsuximide                      | C <sub>12</sub> H <sub>13</sub> NO <sub>2</sub>   | 77-41-8    | 203.237  |                                 | 52.5   | 121 <sup>0,1</sup>                     |                            |                      |                                                       |
| 4258 | Dimethylphenylsilane                                |                                   | C <sub>8</sub> H <sub>12</sub> Si                 | 766-77-8   | 136.267  |                                 |        | 156.5                                  | 0.8891 <sup>20</sup>       | 1.4995 <sup>20</sup> | i H <sub>2</sub> O                                    |
| 4259 | <i>N,N</i> -Dimethyl- <i>N'</i> -phenylurea         | Fenuron                           | C <sub>9</sub> H <sub>12</sub> N <sub>2</sub> O   | 101-42-8   | 164.203  | cry (hx)                        | 132    |                                        |                            |                      |                                                       |
| 4260 | Dimethylphosphine                                   |                                   | C <sub>2</sub> H <sub>7</sub> P                   | 676-59-5   | 62.051   | vol liq or gas                  |        | 25                                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth                       |
| 4261 | Dimethylphosphinic acid                             |                                   | C <sub>2</sub> H <sub>7</sub> O <sub>2</sub> P    | 3283-12-3  | 94.050   | cry (bz)                        | 92     | 377                                    |                            |                      | vs H <sub>2</sub> O, EtOH, eth; s bz                  |
| 4262 | <i>O,O</i> -Dimethyl phosphorochloridothioate       | Dimethyl chlorothiophosphate      | C <sub>2</sub> H <sub>6</sub> ClO <sub>2</sub> PS | 2524-03-0  | 160.560  | hyg liq                         |        | 68 <sup>12</sup>                       | 1.322                      | 1.4820 <sup>20</sup> |                                                       |
| 4263 | Dimethyl phthalate                                  |                                   | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>    | 131-11-3   | 194.184  | pa ye                           | 5.5    | 283.7                                  | 1.1905 <sup>20</sup>       | 1.5138 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz; sl ctc       |
| 4264 | 1,4-Dimethylpiperazine                              |                                   | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>     | 106-58-1   | 114.188  | liq                             | -0.59  | 131                                    | 0.8600 <sup>20</sup>       | 1.4474 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth                        |
| 4265 | <i>cis</i> -2,5-Dimethylpiperazine                  |                                   | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>     | 6284-84-0  | 114.188  | orth bipym<br>nd or pr<br>(chl) | 114    | 162                                    |                            | 1.4720 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, chl; sl eth, bz            |
| 4266 | 1,2-Dimethylpiperidine, (±)                         |                                   | C <sub>7</sub> H <sub>15</sub> N                  | 2512-81-4  | 113.201  |                                 |        | 127.5                                  | 0.824 <sup>15</sup>        | 1.4395 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                        |
| 4267 | 2,6-Dimethylpiperidine                              |                                   | C <sub>7</sub> H <sub>15</sub> N                  | 504-03-0   | 113.201  |                                 |        | 127                                    | 0.8158 <sup>25</sup>       | 1.4377 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; sl ctc; s acid       |
| 4268 | 3,5-Dimethylpiperidine                              | 3,5-Lupetidine                    | C <sub>7</sub> H <sub>15</sub> N                  | 35794-11-7 | 113.201  |                                 |        | 144                                    | 0.853 <sup>25</sup>        | 1.4454 <sup>20</sup> |                                                       |
| 4269 | 2,2-Dimethylpropanal                                | Pivaldehyde                       | C <sub>5</sub> H <sub>10</sub> O                  | 630-19-3   | 86.132   |                                 | 6      | 77.5                                   | 0.7923 <sup>17</sup>       | 1.3791 <sup>20</sup> | s EtOH, eth                                           |
| 4270 | 2,2-Dimethylpropanamide                             |                                   | C <sub>5</sub> H <sub>11</sub> NO                 | 754-10-9   | 101.147  |                                 |        |                                        |                            |                      | s tfa                                                 |
| 4271 | <i>N,N</i> -Dimethylpropanamide                     |                                   | C <sub>5</sub> H <sub>11</sub> NO                 | 758-96-3   | 101.147  | liq                             | -45    | 175                                    | 0.9269 <sup>20</sup>       |                      |                                                       |
| 4272 | <i>N,N</i> -Dimethyl-1-propanamine                  | Dimethylpropylamine               | C <sub>5</sub> H <sub>13</sub> N                  | 926-63-6   | 87.164   |                                 |        | 66                                     | 0.7152 <sup>20</sup>       | 1.3860 <sup>20</sup> | vs bz, eth, EtOH                                      |
| 4273 | <i>N,N</i> -Dimethyl-1,3-propanediamine             |                                   | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>     | 109-55-7   | 102.178  |                                 |        | 132                                    | 0.8272 <sup>20</sup>       |                      |                                                       |
| 4274 | 2,2-Dimethyl-1,3-propanediol                        | Neopentyl glycol                  | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>     | 126-30-7   | 104.148  | nd (bz)                         | 129.13 | 208                                    |                            |                      | s H <sub>2</sub> O, bz, chl; vs EtOH, eth             |
| 4275 | 2,2-Dimethylpropanenitrile                          | <i>tert</i> -Butyl cyanide        | C <sub>5</sub> H <sub>9</sub> N                   | 630-18-2   | 83.132   |                                 | 15     | 106.1                                  | 0.7586 <sup>25</sup>       | 1.3774 <sup>20</sup> |                                                       |
| 4276 | 2,2-Dimethyl-1-propanethiol                         | Neopentyl mercaptan               | C <sub>5</sub> H <sub>12</sub> S                  | 1679-08-9  | 104.214  | liq                             |        | 103.7                                  |                            |                      |                                                       |
| 4277 | 2,2-Dimethylpropanoic acid                          | Trimethylacetic acid              | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>     | 75-98-9    | 102.132  | nd                              | 35     | 164                                    | 0.905 <sup>50</sup>        | 1.3931 <sup>30</sup> | sl H <sub>2</sub> O; vs EtOH, eth                     |
| 4278 | 2,2-Dimethyl-1-propanol                             | Neopentyl alcohol                 | C <sub>5</sub> H <sub>12</sub> O                  | 75-84-3    | 88.148   |                                 | 52.5   | 113.5                                  | 0.812 <sup>20</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth; s ctc              |
| 4279 | 2,2-Dimethylpropanoyl chloride                      | Pivalic acid chloride             | C <sub>5</sub> H <sub>9</sub> ClO                 | 3282-30-2  | 120.577  |                                 |        | 107                                    | 1.003 <sup>20</sup>        | 1.4139 <sup>20</sup> | vs eth                                                |
| 4280 | <i>N,N</i> -Dimethyl-2-propenamide                  | <i>N,N</i> -Dimethylacrylamide    | C <sub>5</sub> H <sub>9</sub> NO                  | 2680-03-7  | 99.131   | liq                             |        | 81 <sup>20</sup>                       | 0.962 <sup>25</sup>        | 1.4730 <sup>20</sup> |                                                       |
| 4281 | 2,2-Dimethylpropylamine                             | 2,2-Dimethyl-1-propanamine        | C <sub>5</sub> H <sub>13</sub> N                  | 5813-64-9  | 87.164   |                                 |        | 82                                     | 0.7455 <sup>20</sup>       | 1.4023 <sup>20</sup> | vs eth                                                |
| 4282 | (1,1-Dimethylpropyl)benzene                         |                                   | C <sub>11</sub> H <sub>16</sub>                   | 2049-95-8  | 148.245  |                                 |        | 192.4                                  | 0.8748 <sup>20</sup>       | 1.4958 <sup>20</sup> |                                                       |
| 4283 | (2,2-Dimethylpropyl)benzene                         |                                   | C <sub>11</sub> H <sub>16</sub>                   | 1007-26-7  | 148.245  |                                 |        | 185                                    | 0.8581 <sup>18</sup>       | 1.4884 <sup>18</sup> |                                                       |
| 4284 | 4-(1,1-Dimethylpropyl)cyclohexanone                 |                                   | C <sub>11</sub> H <sub>20</sub> O                 | 16587-71-6 | 168.276  |                                 | 96     | 125 <sup>16</sup> ; 109 <sup>11</sup>  | 0.920 <sup>25</sup>        | 1.4677 <sup>20</sup> |                                                       |
| 4285 | 1,1-Dimethylpropyl 3-methylbutanoate                | <i>tert</i> -Pentyl isopentanoate | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>    | 542-37-0   | 172.265  |                                 |        | 173.5                                  | 0.8729 <sup>0</sup>        |                      | vs EtOH                                               |
| 4286 | 2-(1,1-Dimethylpropyl)phenol                        |                                   | C <sub>11</sub> H <sub>16</sub> O                 | 3279-27-4  | 164.244  |                                 |        |                                        |                            |                      | sl ctc                                                |
| 4287 | 4-(1,1-Dimethylpropyl)phenol                        | <i>p-tert</i> -Pentylphenol       | C <sub>11</sub> H <sub>16</sub> O                 | 80-46-6    | 164.244  |                                 | 95     | 262.5                                  |                            |                      |                                                       |
| 4288 | 4,6-Dimethyl-2 <i>H</i> -pyran-2-one                |                                   | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>      | 675-09-2   | 124.138  | lf (eth)                        | 51.5   | 245                                    |                            |                      | vs H <sub>2</sub> O, eth, EtOH                        |
| 4289 | 2,6-Dimethyl-4 <i>H</i> -pyran-4-one                |                                   | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>      | 1004-36-0  | 124.138  | pl, nd (sub)                    | 132    | 251; 140 <sup>25</sup>                 | 0.9953 <sup>137</sup>      |                      | s H <sub>2</sub> O, EtOH, eth, ace                    |
| 4290 | 2,3-Dimethylpyrazine                                |                                   | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>      | 5910-89-4  | 108.141  |                                 |        | 156                                    | 1.0281 <sup>0</sup>        |                      | s H <sub>2</sub> O, EtOH, eth                         |
| 4291 | 2,5-Dimethylpyrazine                                |                                   | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>      | 123-32-0   | 108.141  |                                 | 15     | 155                                    | 0.9887 <sup>20</sup>       | 1.4980 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace, chl           |
| 4292 | 2,6-Dimethylpyrazine                                |                                   | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>      | 108-50-9   | 108.141  | pr                              | 47.5   | 155.6                                  | 0.9647 <sup>50</sup>       |                      | s H <sub>2</sub> O, EtOH, eth; sl ctc                 |
| 4293 | 1,3-Dimethyl-1 <i>H</i> -pyrazole                   |                                   | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub>      | 694-48-4   | 96.131   |                                 |        | 137                                    | 0.9561 <sup>17</sup>       | 1.4734 <sup>15</sup> | vs H <sub>2</sub> O                                   |



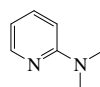
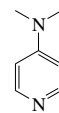
| No.  | Name                                                      | Synonym                                                                     | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                | mp/°C                     | bp/°C                                | den/<br>g cm <sup>-3</sup> | $n_D$                | Solubility                                                    |
|------|-----------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------|------------|----------|------------------------------|---------------------------|--------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 4294 | 3,5-Dimethyl-1 <i>H</i> -pyrazole                         |                                                                             | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub>                  | 67-51-6    | 96.131   | cry (peth, al)               | 107.5                     | 218                                  | 0.8839 <sup>16</sup>       |                      | s H <sub>2</sub> O, ace; vs EtOH, eth, bz, MeOH               |
| 4295 | 2,7-Dimethylpyrene                                        |                                                                             | C <sub>18</sub> H <sub>14</sub>                               | 15679-24-0 | 230.304  |                              | 230                       |                                      |                            |                      |                                                               |
| 4296 | 4,6-Dimethyl-2-pyridinamine                               |                                                                             | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                 | 5407-87-4  | 122.167  |                              | 61                        | 235                                  |                            |                      |                                                               |
| 4297 | <i>N,N</i> -Dimethyl-2-pyridinamine                       |                                                                             | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                 | 5683-33-0  | 122.167  |                              | 182                       | 196                                  | 1.0149 <sup>14</sup>       | 1.5663 <sup>20</sup> | s EtOH, eth, bz                                               |
| 4298 | <i>N,N</i> -Dimethyl-4-pyridinamine                       |                                                                             | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                 | 1122-58-3  | 122.167  | pl (eth)                     | 114                       |                                      |                            |                      | vs H <sub>2</sub> O, EtOH, bz, chl; s eth                     |
| 4299 | 2,3-Dimethylpyridine                                      | 2,3-Lutidine                                                                | C <sub>7</sub> H <sub>9</sub> N                               | 583-61-9   | 107.153  |                              |                           | 161.12                               | 0.9319 <sup>25</sup>       | 1.5057 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth                                 |
| 4300 | 2,4-Dimethylpyridine                                      | 2,4-Lutidine                                                                | C <sub>7</sub> H <sub>9</sub> N                               | 108-47-4   | 107.153  | liq                          | -64                       | 158.38                               | 0.9309 <sup>20</sup>       | 1.5010 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; s ace                         |
| 4301 | 2,5-Dimethylpyridine                                      | 2,5-Lutidine                                                                | C <sub>7</sub> H <sub>9</sub> N                               | 589-93-5   | 107.153  | liq                          | -16                       | 156.98                               | 0.9297 <sup>20</sup>       | 1.5006 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH; msc eth; s ace                  |
| 4302 | 2,6-Dimethylpyridine                                      | 2,6-Lutidine                                                                | C <sub>7</sub> H <sub>9</sub> N                               | 108-48-5   | 107.153  | liq                          | -6.1                      | 144.01                               | 0.9226 <sup>20</sup>       | 1.4953 <sup>20</sup> | msc H <sub>2</sub> O; sl EtOH; s eth, ace, chl                |
| 4303 | 3,4-Dimethylpyridine                                      | 3,4-Lutidine                                                                | C <sub>7</sub> H <sub>9</sub> N                               | 583-58-4   | 107.153  | liq                          | -11                       | 179.10                               | 0.9281 <sup>20</sup>       | 1.5096 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, ace, chl               |
| 4304 | 3,5-Dimethylpyridine                                      | 3,5-Lutidine                                                                | C <sub>7</sub> H <sub>9</sub> N                               | 591-22-0   | 107.153  | liq                          | -6.6                      | 171.84                               | 0.9419 <sup>20</sup>       | 1.5061 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ace; sl ctc                    |
| 4305 | 2,6-Dimethylpyridine-1-oxide                              |                                                                             | C <sub>7</sub> H <sub>9</sub> NO                              | 1073-23-0  | 123.152  | hyg                          | 35                        | 133 <sup>22</sup>                    | 1.073 <sup>25</sup>        | 1.5706 <sup>20</sup> |                                                               |
| 4306 | 4,6-Dimethyl-2-pyrimidinamine                             |                                                                             | C <sub>6</sub> H <sub>8</sub> N <sub>3</sub>                  | 767-15-7   | 123.155  |                              | 153.5                     |                                      |                            |                      | s H <sub>2</sub> O, EtOH, ace, bz; i eth; vs chl              |
| 4307 | 2,6-Dimethyl-4-pyrimidinamine                             | Kyanmethin                                                                  | C <sub>6</sub> H <sub>8</sub> N <sub>3</sub>                  | 461-98-3   | 123.155  | nd (al), pl (bz)             | 183                       | sub                                  |                            |                      | sl H <sub>2</sub> O, EtOH, bz, chl                            |
| 4308 | 4,6-Dimethylpyrimidine                                    |                                                                             | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                  | 1558-17-4  | 108.141  |                              | 25                        | 159                                  |                            | 1.4880 <sup>20</sup> | vs H <sub>2</sub> O                                           |
| 4309 | 1,3-Dimethyl-2,4(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione |                                                                             | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>   | 874-14-6   | 140.140  |                              | 123.5                     |                                      |                            |                      | sl EtOH; s eth, chl                                           |
| 4310 | 2,4-Dimethylpyrrole                                       |                                                                             | C <sub>6</sub> H <sub>8</sub> N                               | 625-82-1   | 95.142   | pa bl flr cry                |                           | 168                                  | 0.9236 <sup>20</sup>       | 1.5048 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth, bz; s chl                  |
| 4311 | 2,5-Dimethylpyrrole                                       |                                                                             | C <sub>6</sub> H <sub>8</sub> N                               | 625-84-3   | 95.142   |                              | 6.5                       | 171; 51 <sup>8</sup>                 | 0.9353 <sup>20</sup>       | 1.5036 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                              |
| 4312 | 1,2-Dimethylpyrrolidine                                   |                                                                             | C <sub>6</sub> H <sub>13</sub> N                              | 765-48-0   | 99.174   | oil                          |                           | 99                                   | 0.799 <sup>20</sup>        |                      | s H <sub>2</sub> O                                            |
| 4313 | 2,4-Dimethylquinoline                                     | 4-Methylquinaldine                                                          | C <sub>11</sub> H <sub>11</sub> N                             | 1198-37-4  | 157.212  | orth pr (eth)                |                           | 265                                  | 1.0611 <sup>15</sup>       | 1.6075 <sup>20</sup> | sl H <sub>2</sub> O, chl; vs EtOH, eth                        |
| 4314 | 2,6-Dimethylquinoline                                     |                                                                             | C <sub>11</sub> H <sub>11</sub> N                             | 877-43-0   | 157.212  | orth pr (eth)                | 60                        | 266.5                                |                            |                      | sl H <sub>2</sub> O, EtOH, eth, chl; vs bz                    |
| 4315 | 2,7-Dimethylquinoline                                     | <i>m</i> -Toluquinaldine                                                    | C <sub>11</sub> H <sub>11</sub> N                             | 93-37-8    | 157.212  |                              | 61                        | 264.5                                |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, chl                         |
| 4316 | 2,3-Dimethylquinoxaline                                   |                                                                             | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub>                | 2379-55-7  | 158.199  | nd (w+3, ace)                | 106                       |                                      |                            |                      | s EtOH, eth, ace, bz, chl, acid                               |
| 4317 | Dimethyl sebacate                                         |                                                                             | C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                | 106-79-6   | 230.301  | lo pr                        | 38                        | 175 <sup>20</sup> , 144 <sup>5</sup> | 0.9882 <sup>28</sup>       | 1.4355 <sup>28</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, ctc                     |
| 4318 | Dimethyl selenide                                         | Methyl selenide                                                             | C <sub>2</sub> H <sub>6</sub> Se                              | 593-79-3   | 109.03   |                              |                           | 57                                   | 1.4077 <sup>15</sup>       |                      | vs eth, EtOH, chl                                             |
| 4319 | Dimethylsilane                                            | 2-Silapropane                                                               | C <sub>2</sub> H <sub>6</sub> Si                              | 1111-74-6  | 60.171   | col gas                      | -150                      | -20                                  | 0.68 <sup>80</sup>         |                      |                                                               |
| 4320 | Dimethylstearylamine                                      | Dymanthine                                                                  | C <sub>20</sub> H <sub>43</sub> N                             | 124-28-7   | 297.562  |                              | 22.9                      |                                      |                            |                      |                                                               |
| 4321 | Dimethyl succinate                                        |                                                                             | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                 | 106-65-0   | 146.141  |                              | 19                        | 196.4                                | 1.1198 <sup>20</sup>       | 1.4197 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, ace; vs eth                 |
| 4322 | Dimethylsulfamoyl chloride                                | Dimethylaminosulfonyl chloride                                              | C <sub>2</sub> H <sub>6</sub> ClNO <sub>2</sub> S             | 13360-57-1 | 143.593  |                              |                           | 80 <sup>16</sup>                     |                            |                      |                                                               |
| 4323 | Dimethyl sulfate                                          |                                                                             | C <sub>2</sub> H <sub>6</sub> O <sub>4</sub> S                | 77-78-1    | 126.132  |                              | -27                       | dec 188; 76 <sup>15</sup>            | 1.3322 <sup>20</sup>       | 1.3874 <sup>20</sup> | s H <sub>2</sub> O, eth, bz, ctc; msc EtOH; i CS <sub>2</sub> |
| 4324 | Dimethyl sulfide                                          |                                                                             | C <sub>2</sub> H <sub>6</sub> S                               | 75-18-3    | 62.134   | liq                          | -98.24                    | 37.33                                | 0.8483 <sup>20</sup>       | 1.4438 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                              |
| 4325 | Dimethyl sulfite                                          |                                                                             | C <sub>2</sub> H <sub>6</sub> O <sub>3</sub> S                | 616-42-2   | 110.132  |                              |                           | 126                                  | 1.2129 <sup>20</sup>       | 1.4083 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth                                 |
| 4326 | 2,4-Dimethylsulfolane                                     |                                                                             | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> S               | 1003-78-7  | 148.223  | liq                          | -1.5                      | 281                                  | 1.1362 <sup>20</sup>       | 1.4732 <sup>20</sup> | vs lig                                                        |
| 4327 | Dimethyl sulfone                                          |                                                                             | C <sub>2</sub> H <sub>6</sub> O <sub>2</sub> S                | 67-71-0    | 94.133   | pr                           | 108.9                     | 238                                  | 1.1700 <sup>110</sup>      | 1.4226               | s H <sub>2</sub> O, EtOH, bz                                  |
| 4328 | Dimethyl sulfoxide                                        | DMSO                                                                        | C <sub>2</sub> H <sub>6</sub> OS                              | 67-68-5    | 78.133   |                              | 17.89                     | 189                                  | 1.1010 <sup>25</sup>       | 1.4793 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ace, ctc, AcOEt                |
| 4329 | Dimethyl <i>L</i> -tartrate                               | Dimethyl 2,3-dihydroxybutanedioate, [ <i>R</i> -( <i>R</i> *, <i>R</i> *)]- | C <sub>6</sub> H <sub>10</sub> O <sub>6</sub>                 | 608-68-4   | 178.139  | (i) cry (bz)<br>(ii) cry (w) | 50(form a);<br>61(form b) | 280                                  | 1.306 <sup>45</sup>        |                      | vs H <sub>2</sub> O, ace, eth, EtOH                           |
| 4330 | Dimethyl telluride                                        |                                                                             | C <sub>2</sub> H <sub>6</sub> Te                              | 593-80-6   | 157.67   | pa ye                        |                           | 94                                   |                            |                      | vs EtOH                                                       |
| 4331 | Dimethyl terephthalate                                    |                                                                             | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                | 120-61-6   | 194.184  |                              | 141                       | 288                                  | 1.075 <sup>141</sup>       |                      | sl H <sub>2</sub> O, EtOH, MeOH; s eth, chl                   |
| 4332 | Dimethyl tetrachloroterephthalate                         |                                                                             | C <sub>10</sub> H <sub>6</sub> Cl <sub>4</sub> O <sub>4</sub> | 1861-32-1  | 331.965  |                              | 155                       |                                      |                            |                      |                                                               |
| 4333 | 2,7-Dimethylthiachromine-8-ethanol                        |                                                                             | C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> OS             | 92-35-3    | 262.330  | ye pr (chl)                  | 228.8                     | sub                                  |                            |                      | s H <sub>2</sub> O, MeOH; sl EtOH, eth, ace, chl              |

3,5-Dimethyl-1*H*-pyrazole

2,7-Dimethylpyrene



4,6-Dimethyl-2-pyridinamine

*N,N*-Dimethyl-2-pyridinamine*N,N*-Dimethyl-4-pyridinamine

2,3-Dimethylpyridine



2,4-Dimethylpyridine



2,5-Dimethylpyridine



2,6-Dimethylpyridine



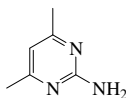
3,4-Dimethylpyridine



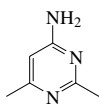
3,5-Dimethylpyridine



2,6-Dimethylpyridine-1-oxide



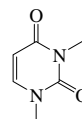
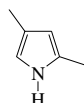
4,6-Dimethyl-2-pyrimidinamine



2,6-Dimethyl-4-pyrimidinamine



4,6-Dimethylpyrimidine

1,3-Dimethyl-2,4-(1*H*,3*H*)-pyrimidinedione

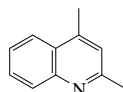
2,4-Dimethylpyrrole



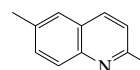
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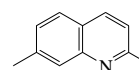
1,2-Dimethylpyrrolidine



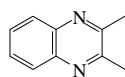
2,4-Dimethylquinoline



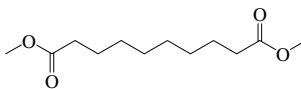
2,6-Dimethylquinoline



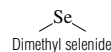
2,7-Dimethylquinoline



2,3-Dimethylquinoxaline



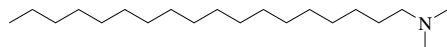
Dimethyl sebacate



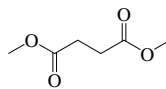
Dimethyl selenide



Dimethylsilane



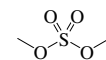
Dimethylstearylamine



Dimethyl succinate



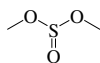
Dimethylsulfamoyl chloride



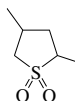
Dimethyl sulfate



Dimethyl sulfide



Dimethyl sulfite



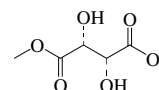
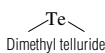
2,4-Dimethylsulfolane



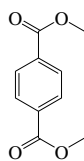
Dimethyl sulfone



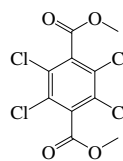
Dimethyl sulfoxide

Dimethyl *L*-tartrate

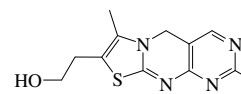
Dimethyl telluride



Dimethyl terephthalate



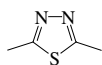
Dimethyl tetrachloroterephthalate



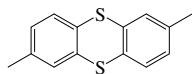
2,7-Dimethylthiachromine-8-ethanol



| No.  | Name                                                             | Synonym                  | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form               | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|------------------------------------------------------------------|--------------------------|------------------------------------------------------------------------------|------------|----------|-----------------------------|-------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 4334 | 2,5-Dimethyl-1,3,4-thiadiazole                                   |                          | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> S                               | 27464-82-0 | 114.169  |                             | 65    | 202.5                                 |                            |                      | sl H <sub>2</sub> O, EtOH, eth                                |
| 4335 | 2,7-Dimethylthianthrene                                          | Mesulphen                | C <sub>14</sub> H <sub>12</sub> S <sub>2</sub>                               | 135-58-0   | 244.375  | nd (HOAc, al)               | 123   | 184 <sup>3</sup>                      |                            |                      | vs ace, eth, peth, chl                                        |
| 4336 | 2,4-Dimethylthiazole                                             |                          | C <sub>5</sub> H <sub>7</sub> NS                                             | 541-58-2   | 113.182  |                             |       | 146; 71 <sup>50</sup>                 | 1.0562 <sup>15</sup>       | 1.5091 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, chl                         |
| 4337 | 4,5-Dimethylthiazole                                             |                          | C <sub>5</sub> H <sub>7</sub> NS                                             | 3581-91-7  | 113.182  |                             | 83.5  | 158                                   | 1.0699 <sup>20</sup>       |                      | vs eth, EtOH                                                  |
| 4338 | <i>N,N</i> -Dimethylthioacetamide                                |                          | C <sub>4</sub> H <sub>8</sub> NS                                             | 631-67-4   | 103.186  |                             | 74.5  |                                       |                            |                      |                                                               |
| 4339 | Dimethyl thiodipropionate                                        |                          | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub> S                              | 4131-74-2  | 206.260  |                             |       | 162 <sup>18</sup> , 148 <sup>18</sup> | 1.1559 <sup>20</sup>       | 1.4740 <sup>20</sup> |                                                               |
| 4340 | 2,3-Dimethylthiophene                                            |                          | C <sub>6</sub> H <sub>6</sub> S                                              | 632-16-6   | 112.193  | liq                         | -49   | 141.6                                 | 1.0021 <sup>20</sup>       | 1.5192 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz                        |
| 4341 | 2,4-Dimethylthiophene                                            |                          | C <sub>6</sub> H <sub>6</sub> S                                              | 638-00-6   | 112.193  |                             |       | 140.7                                 | 0.9938 <sup>20</sup>       | 1.5104 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz                           |
| 4342 | 2,5-Dimethylthiophene                                            |                          | C <sub>6</sub> H <sub>6</sub> S                                              | 638-02-8   | 112.193  | liq                         | -62.6 | 136.5                                 | 0.9850 <sup>20</sup>       | 1.5129 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz                           |
| 4343 | 3,4-Dimethylthiophene                                            |                          | C <sub>6</sub> H <sub>6</sub> S                                              | 632-15-5   | 112.193  |                             |       | 145                                   | 0.993 <sup>25</sup>        | 1.5206 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; vs eth                            |
| 4344 | <i>N,N</i> -Dimethylthiourea                                     |                          | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> S                               | 6972-05-0  | 104.174  | cry (w)                     | 161.5 |                                       |                            |                      |                                                               |
| 4345 | <i>N,N'</i> -Dimethylthiourea                                    |                          | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> S                               | 534-13-4   | 104.174  | hyg pl                      | 62    |                                       |                            |                      | vs H <sub>2</sub> O, EtOH, ace; sl eth, bz; i CS <sub>2</sub> |
| 4346 | 2,6-Dimethyl-4-tridecylmorpholine                                | Tridemorph               | C <sub>19</sub> H <sub>35</sub> NO                                           | 24602-86-6 | 297.519  |                             |       | 141 <sup>1,3</sup>                    | 0.86                       |                      |                                                               |
| 4347 | <i>N,N</i> -Dimethyl- <i>N'</i> -(3-(trifluoromethyl)phenyl)urea | Fluometuron              | C <sub>10</sub> H <sub>11</sub> F <sub>3</sub> N <sub>2</sub> O              | 2164-17-2  | 232.201  |                             | 164   |                                       |                            |                      | vs ace, EtOH                                                  |
| 4348 | Dimethyl trisulfide                                              |                          | C <sub>2</sub> H <sub>6</sub> S <sub>3</sub>                                 | 3658-80-8  | 126.264  |                             |       | 41 <sup>6</sup>                       |                            |                      |                                                               |
| 4349 | 6,10-Dimethyl-3,5,9-undecatrien-2-one                            | Pseudoionone             | C <sub>13</sub> H <sub>20</sub> O                                            | 141-10-6   | 192.297  | pa ye oil                   |       | 144 <sup>12</sup>                     | 0.8984 <sup>20</sup>       | 1.5335 <sup>20</sup> | s EtOH, eth, chl, MeOH                                        |
| 4350 | <i>N,N</i> -Dimethylurea                                         |                          | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O                               | 598-94-7   | 88.108   | mcl pr (al, chl)            | 182.1 |                                       | 1.2555 <sup>25</sup>       |                      | s H <sub>2</sub> O; sl EtOH, tta; i eth                       |
| 4351 | <i>N,N'</i> -Dimethylurea                                        |                          | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O                               | 96-31-1    | 88.108   | orth bipym (chl-eth)        | 106.6 | 269                                   | 1.142 <sup>25</sup>        |                      | vs H <sub>2</sub> O, EtOH; i eth; sl chl                      |
| 4352 | Dimethyl zinc                                                    |                          | C <sub>2</sub> H <sub>6</sub> Zn                                             | 544-97-8   | 95.478   | liq, ign in air             | -43.0 | 46                                    | 1.386 <sup>10</sup>        |                      | s eth; msc peth                                               |
| 4353 | Dimetilan                                                        |                          | C <sub>10</sub> H <sub>16</sub> N <sub>4</sub> O <sub>3</sub>                | 644-64-4   | 240.259  | col solid                   | 69    | 205 <sup>13</sup>                     |                            |                      | s H <sub>2</sub> O, chl, EtOH, ace, xyl                       |
| 4354 | Dimorpholamine                                                   |                          | C <sub>20</sub> H <sub>38</sub> N <sub>4</sub> O <sub>4</sub>                | 119-48-2   | 398.541  | cry (peth)                  | 41.5  | 229 <sup>0,4</sup>                    |                            |                      | vs H <sub>2</sub> O                                           |
| 4355 | <i>N,N'</i> -Di-2-naphthyl-1,4-benzenediamine                    |                          | C <sub>26</sub> H <sub>20</sub> N <sub>2</sub>                               | 93-46-9    | 360.450  |                             | 235   |                                       |                            |                      | i EtOH, eth, bz                                               |
| 4356 | Di-2-naphthyl disulfide                                          |                          | C <sub>20</sub> H <sub>14</sub> S <sub>2</sub>                               | 5586-15-2  | 318.455  | nd                          | 139.5 |                                       | 1.144 <sup>145</sup>       | 1.4555 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; i lig                       |
| 4357 | <i>N,N'</i> -Di-1-naphthylurea                                   |                          | C <sub>21</sub> H <sub>16</sub> N <sub>2</sub> O                             | 607-56-7   | 312.364  | nd (py, HOAc)               | 296   | sub                                   |                            |                      | vs py                                                         |
| 4358 | Diniconazole                                                     |                          | C <sub>15</sub> H <sub>17</sub> Cl <sub>2</sub> N <sub>3</sub> O             | 83657-24-3 | 326.221  | cry                         | 149   |                                       |                            |                      | s H <sub>2</sub> O, ace, MeOH, xyl                            |
| 4359 | Dinitramine                                                      |                          | C <sub>11</sub> H <sub>13</sub> F <sub>3</sub> N <sub>4</sub> O <sub>4</sub> | 29091-05-2 | 322.241  |                             | 98    |                                       |                            |                      |                                                               |
| 4360 | 2,3-Dinitroaniline                                               |                          | C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>                  | 602-03-9   | 183.122  |                             | 128   |                                       | 1.646 <sup>50</sup>        |                      | i H <sub>2</sub> O; s EtOH; sl eth                            |
| 4361 | 2,4-Dinitroaniline                                               |                          | C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>                  | 97-02-9    | 183.122  | ye nd (ace) grn ye tab (al) | 180.0 |                                       | 1.615 <sup>14</sup>        |                      | i H <sub>2</sub> O; sl EtOH, ace, HCl                         |
| 4362 | 2,5-Dinitroaniline                                               |                          | C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>                  | 619-18-1   | 183.122  | oran nd (al)                | 138.0 |                                       |                            |                      | vs EtOH                                                       |
| 4363 | 2,6-Dinitroaniline                                               |                          | C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>                  | 606-22-4   | 183.122  | gold lf (HOAc) ye nd (al)   | 141.5 |                                       |                            |                      | i H <sub>2</sub> O, lig; sl EtOH; s eth, bz                   |
| 4364 | 3,5-Dinitroaniline                                               |                          | C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>                  | 618-87-1   | 183.122  | ye nd (dil al)              | 163   |                                       | 1.601 <sup>50</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth; sl ace, bz                   |
| 4365 | 1,5-Dinitro-9,10-anthracenedione                                 |                          | C <sub>14</sub> H <sub>6</sub> N <sub>2</sub> O <sub>6</sub>                 | 82-35-9    | 298.207  | pa ye nd (xyl)              | 385   | sub                                   |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, bz; vs PhNO <sub>2</sub>    |
| 4366 | 1,8-Dinitro-9,10-anthracenedione                                 |                          | C <sub>14</sub> H <sub>6</sub> N <sub>2</sub> O <sub>6</sub>                 | 129-39-5   | 298.207  |                             | 312   |                                       |                            |                      |                                                               |
| 4367 | 2,4-Dinitrobenzaldehyde                                          |                          | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                  | 528-75-6   | 196.117  | pa ye pr (al), pl (bz)      | 72    | 200 <sup>15</sup>                     |                            |                      | sl H <sub>2</sub> O, chl, lig; s EtOH, eth, bz                |
| 4368 | 3,5-Dinitrobenzamide                                             | Nitromide                | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>5</sub>                  | 121-81-3   | 211.132  | lf (w)                      | 184   |                                       |                            |                      | vs H <sub>2</sub> O                                           |
| 4369 | 1,2-Dinitrobenzene                                               | <i>o</i> -Dinitrobenzene | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>                  | 528-29-0   | 168.107  | nd (bz), pl (al)            | 116.5 | 318; 194 <sup>30</sup>                | 1.3119 <sup>120</sup>      | 1.565 <sup>17</sup>  | i H <sub>2</sub> O; s EtOH, bz, chl, AcOEt; sl DMSO           |
| 4370 | 1,3-Dinitrobenzene                                               | <i>m</i> -Dinitrobenzene | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>                  | 99-65-0    | 168.107  | orth pl (al)                | 90.3  | 291; 167 <sup>14</sup>                | 1.5751 <sup>18</sup>       |                      | sl H <sub>2</sub> O; vs EtOH, ace, py; s eth, tol             |
| 4371 | 1,4-Dinitrobenzene                                               | <i>p</i> -Dinitrobenzene | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>                  | 100-25-4   | 168.107  | nd (al)                     | 173.5 | 297; 183 <sup>34</sup>                | 1.625 <sup>18</sup>        |                      | i H <sub>2</sub> O; sl EtOH, chl; s ace, bz, tol              |
| 4372 | 2,4-Dinitro-1,3-benzenediol                                      | 2,4-Dinitroresorcinol    | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>                  | 519-44-8   | 200.105  | ye lf (al)                  | 147.5 |                                       |                            |                      | sl H <sub>2</sub> O, EtOH                                     |
| 4373 | 2,4-Dinitrobenzenesulfonyl chloride                              |                          | C <sub>6</sub> H <sub>3</sub> ClIN <sub>2</sub> O <sub>4</sub> S             | 528-76-7   | 234.617  | ye pr (bz-peth)             | 99    |                                       |                            |                      | vs bz, chl, HOAc; sl peth                                     |



2,5-Dimethyl-1,3,4-thiadiazole



2,7-Dimethylthianthrene



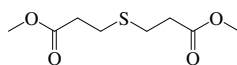
2,4-Dimethylthiazole



4,5-Dimethylthiazole



N,N-Dimethylthioacetamide



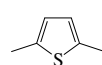
Dimethyl thiodipropionate



2,3-Dimethylthiophene



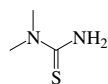
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2,5-Dimethylthiophene



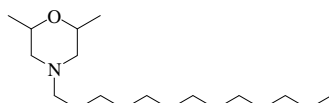
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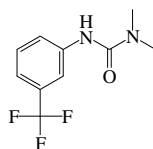
N,N-Dimethylthiourea



N,N'-Dimethylthiourea



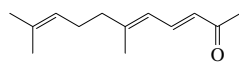
2,6-Dimethyl-4-tridecylmorpholine



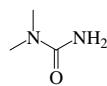
N,N-Dimethyl-N'-[3-(trifluoromethyl)phenyl]urea



Dimethyl trisulfide



6,10-Dimethyl-3,5,9-undecatrien-2-one



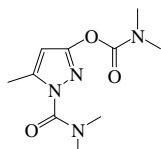
N,N-Dimethylurea



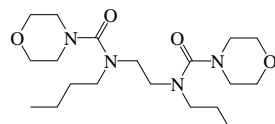
N,N'-Dimethylurea



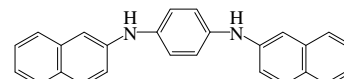
Dimethyl zinc



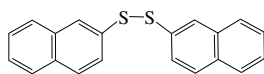
Dimetilan



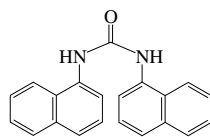
Dimorpholamine



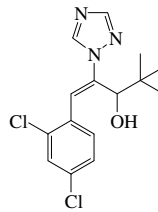
N,N-Di-2-naphthyl-1,4-benzenediamine



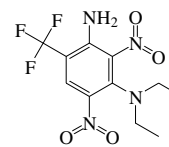
Di-2-naphthyl disulfide



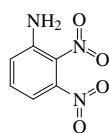
N,N'-Di-1-naphthylurea



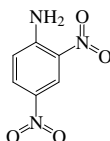
Diniconazole



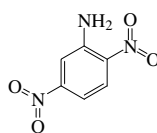
Dinitramine



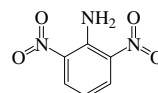
2,3-Dinitroaniline



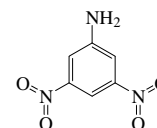
2,4-Dinitroaniline



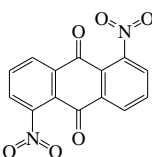
2,5-Dinitroaniline



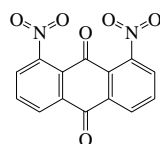
2,6-Dinitroaniline



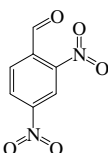
3,5-Dinitroaniline



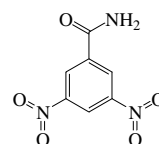
1,5-Dinitro-9,10-anthracenedione



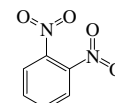
1,8-Dinitro-9,10-anthracenedione



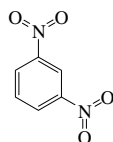
2,4-Dinitrobenzaldehyde



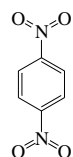
3,5-Dinitrobenzamide



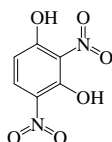
1,2-Dinitrobenzene



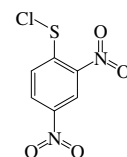
1,3-Dinitrobenzene



1,4-Dinitrobenzene

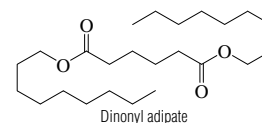
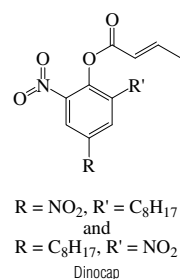
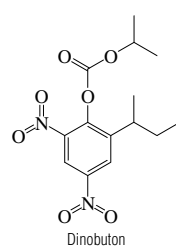
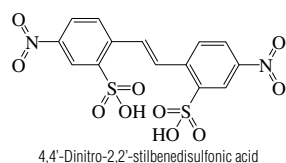
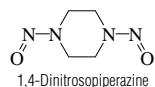
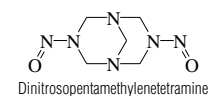
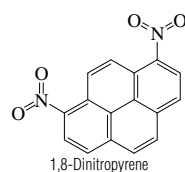
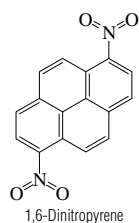
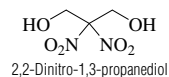
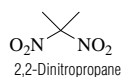
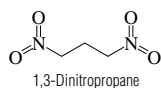
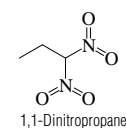
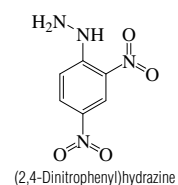
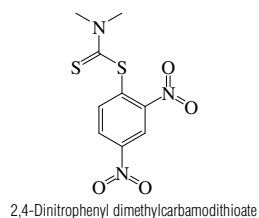
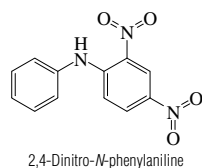
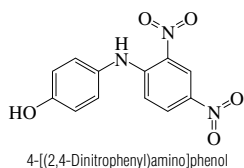
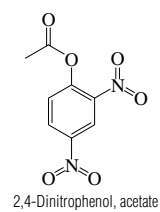
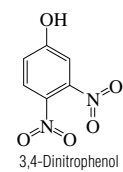
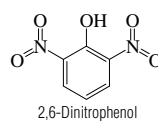
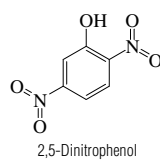
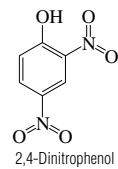
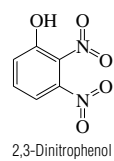
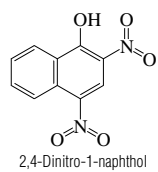
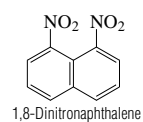
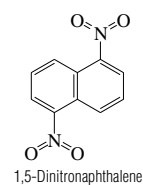
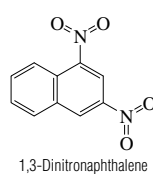
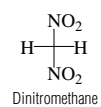
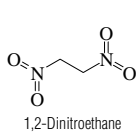
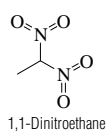
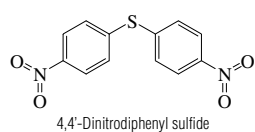
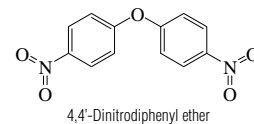
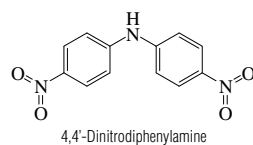
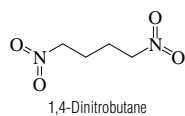
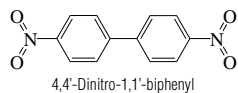
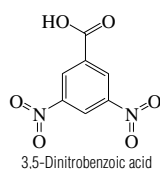
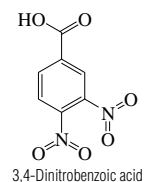
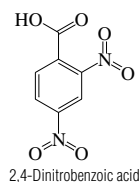
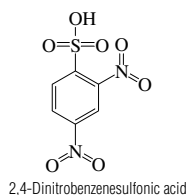


2,4-Dinitro-1,3-benzenediol

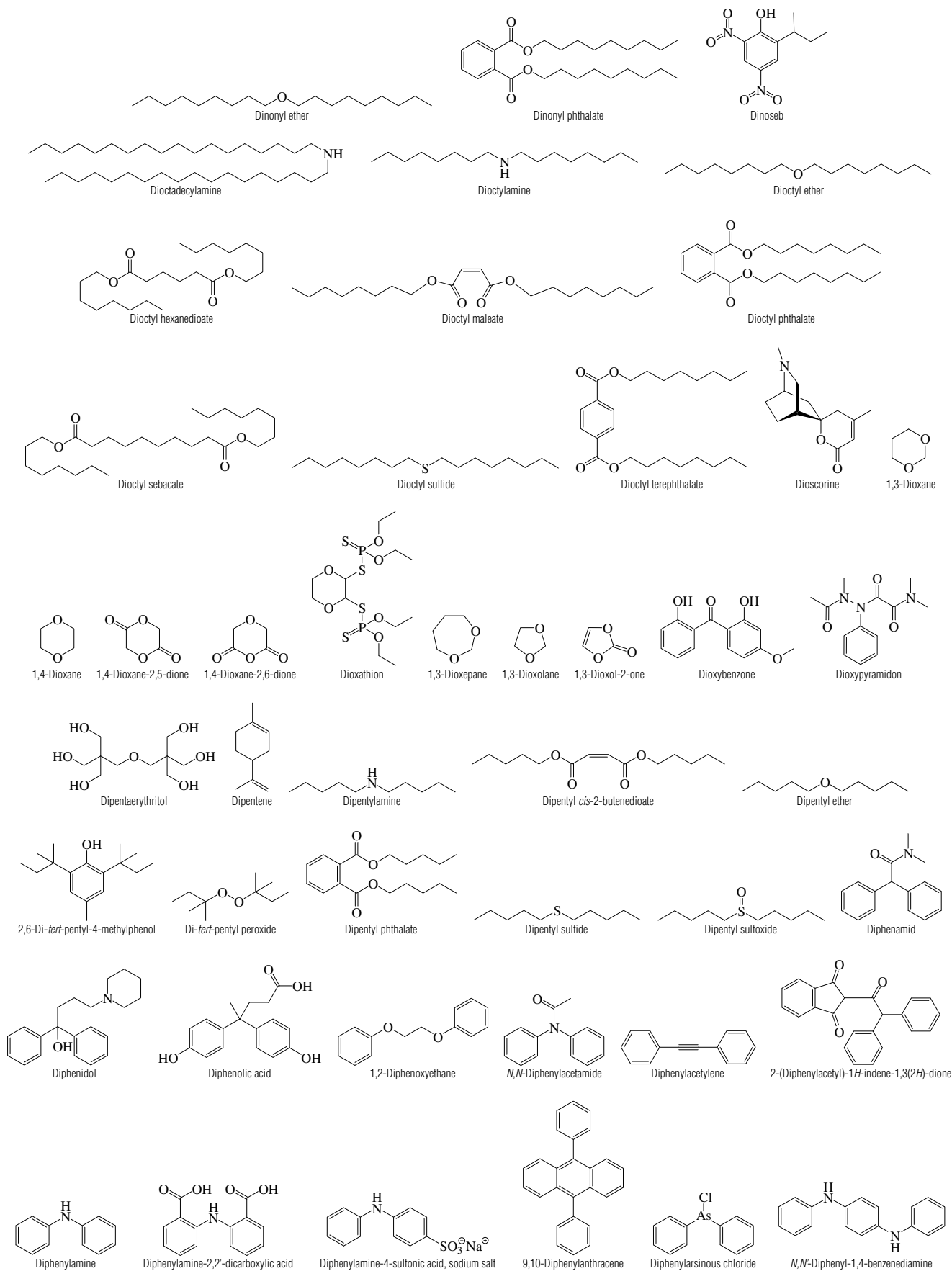


2,4-Dinitrobenzenesulfonyl chloride

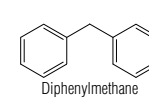
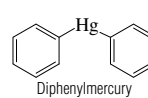
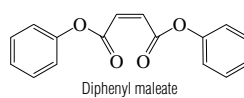
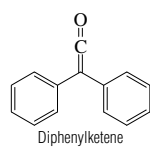
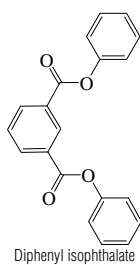
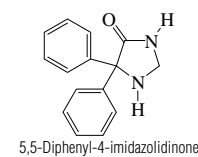
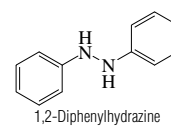
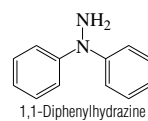
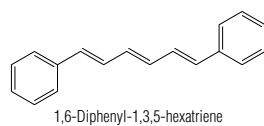
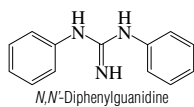
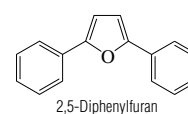
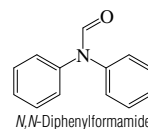
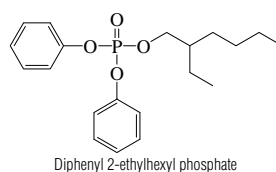
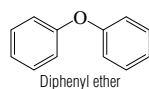
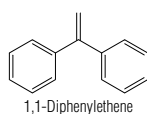
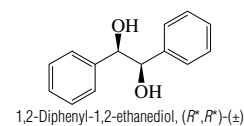
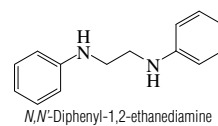
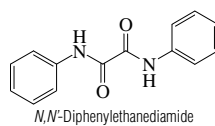
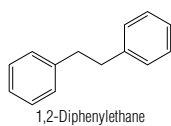
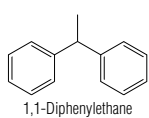
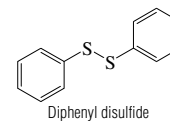
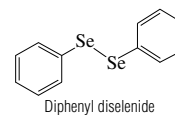
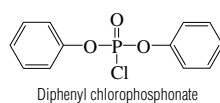
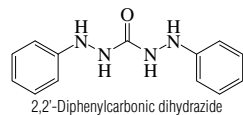
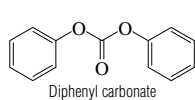
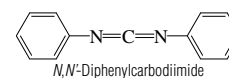
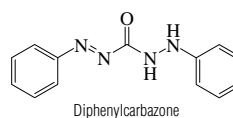
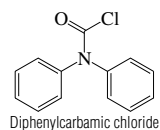
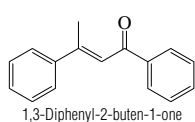
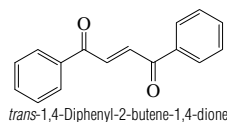
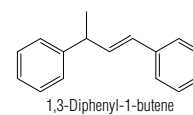
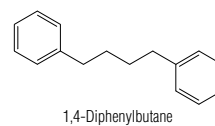
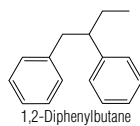
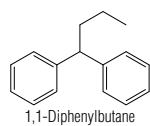
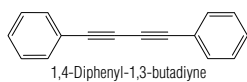
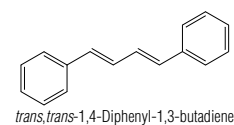
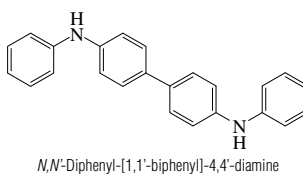
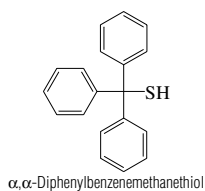
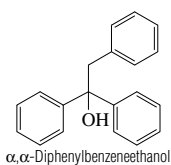
| No.  | Name                                       | Synonym                                   | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form                | mp/°C | bp/°C               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|--------------------------------------------|-------------------------------------------|-------------------------------------------------------------------------------|------------|----------|------------------------------|-------|---------------------|----------------------------|----------------------|---------------------------------------------------------|
| 4374 | 2,4-Dinitrobenzenesulfonic acid            |                                           | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>7</sub> S                 | 89-02-1    | 248.170  | nd (w+3)                     | 108   |                     |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth; i bz, peth           |
| 4375 | 2,4-Dinitrobenzoic acid                    |                                           | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>                   | 610-30-0   | 212.116  | nd (w)                       | 183   |                     | 1.672 <sup>20</sup>        |                      | sl H <sub>2</sub> O, EtOH, bz                           |
| 4376 | 3,4-Dinitrobenzoic acid                    |                                           | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>                   | 528-45-0   | 212.116  | cry (dil al)                 | 166   |                     |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth                       |
| 4377 | 3,5-Dinitrobenzoic acid                    |                                           | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>                   | 99-34-3    | 212.116  | mcl pr (al)                  | 205   |                     |                            |                      | sl H <sub>2</sub> O; vs EtOH, HOAc                      |
| 4378 | 3,5-Dinitrobenzoyl chloride                |                                           | C <sub>7</sub> H <sub>3</sub> ClN <sub>2</sub> O <sub>5</sub>                 | 99-33-2    | 230.562  | ye nd (bz)                   | 74    | 196 <sup>12</sup>   |                            |                      | s eth, chl                                              |
| 4379 | 2,2'-Dinitro-1,1'-biphenyl                 |                                           | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub>                  | 2436-96-6  | 244.203  | ye mcl pr or nd (al)         | 126   | 305                 | 1.45 <sup>25</sup>         |                      | i H <sub>2</sub> O; vs EtOH; s eth, bz; sl ace, lig     |
| 4380 | 4,4'-Dinitro-1,1'-biphenyl                 |                                           | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub>                  | 1528-74-1  | 244.203  | nd (al)                      | 242.3 |                     |                            |                      | i H <sub>2</sub> O; sl EtOH; s bz, HOAc                 |
| 4381 | 1,4-Dinitrobutane                          |                                           | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub>                   | 4286-49-1  | 148.118  | pl (al)                      | 33.5  | 176 <sup>13</sup>   |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, MeOH            |
| 4382 | 4,4'-Dinitrodiphenylamine                  | 4-Nitro- <i>N</i> -(4-nitrophenyl)aniline | C <sub>12</sub> H <sub>9</sub> N <sub>3</sub> O <sub>4</sub>                  | 1821-27-8  | 259.217  | ye nd(al)                    | 217.5 |                     |                            |                      | i H <sub>2</sub> O, tol; sl EtOH, bz; s ace, HOAc       |
| 4383 | 4,4'-Dinitrodiphenyl ether                 | Bis(4-nitrophenyl) ether                  | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O <sub>5</sub>                  | 101-63-3   | 260.202  |                              | 146.0 |                     |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s bz, HOAc            |
| 4384 | 4,4'-Dinitrodiphenyl sulfide               | Bis(4-nitrophenyl) sulfide                | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub> S                | 1223-31-0  | 276.268  | oran pl (HOAc)               | 160.5 |                     |                            |                      | i H <sub>2</sub> O; sl EtOH; s con sulf                 |
| 4385 | 1,1-Dinitroethane                          |                                           | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>                   | 600-40-8   | 120.064  | ye mcl (bz, MeOH)            |       | 185.5               | 1.349 <sup>24</sup>        |                      | sl H <sub>2</sub> O; s EtOH, eth                        |
| 4386 | 1,2-Dinitroethane                          |                                           | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>                   | 7570-26-5  | 120.064  |                              | 39.5  | 95 <sup>5</sup>     | 1.4597 <sup>20</sup>       | 1.4468 <sup>20</sup> | vs eth, EtOH                                            |
| 4387 | Dinitromethane                             |                                           | CH <sub>2</sub> N <sub>2</sub> O <sub>4</sub>                                 | 625-76-3   | 106.038  | ye nd                        | <-15  | exp 100             |                            |                      | i H <sub>2</sub> O; s EtOH, eth                         |
| 4388 | 1,3-Dinitronaphthalene                     |                                           | C <sub>10</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                  | 606-37-1   | 218.166  | ye nd (bz, py-w)             | 148   | sub                 |                            |                      | i H <sub>2</sub> O; s EtOH, ace                         |
| 4389 | 1,5-Dinitronaphthalene                     |                                           | C <sub>10</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                  | 605-71-0   | 218.166  | hex nd (ace, HOAc)           | 219   | sub                 | 1.5860 <sup>20</sup>       |                      | i H <sub>2</sub> O; sl EtOH, ace; s bz, py; vs eth      |
| 4390 | 1,8-Dinitronaphthalene                     |                                           | C <sub>10</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                  | 602-38-0   | 218.166  | ye orth pl (chl)             | 173   | dec 445             |                            |                      | i H <sub>2</sub> O; sl EtOH, bz; s ace, chl, py         |
| 4391 | 2,4-Dinitro-1-naphthol                     |                                           | C <sub>10</sub> H <sub>6</sub> N <sub>2</sub> O <sub>5</sub>                  | 605-69-6   | 234.165  | ye nd (al, chl)              | 138.8 |                     |                            |                      |                                                         |
| 4392 | 2,3-Dinitrophenol                          |                                           | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                   | 66-56-8    | 184.106  | ye nd (w)                    | 144.5 |                     | 1.681 <sup>20</sup>        |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth; s bz           |
| 4393 | 2,4-Dinitrophenol                          |                                           | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                   | 51-28-5    | 184.106  | pa ye pl or lf (w)           | 114.8 | sub                 | 1.683 <sup>24</sup>        |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, tol, chl, py |
| 4394 | 2,5-Dinitrophenol                          |                                           | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                   | 329-71-5   | 184.106  | ye mcl pr or nd (w,lig)      | 108   |                     |                            |                      | vs bz, eth                                              |
| 4395 | 2,6-Dinitrophenol                          |                                           | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                   | 573-56-8   | 184.106  | pa ye orth nd or lf (dil al) | 63.5  |                     |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s bz, chl; sl ctc     |
| 4396 | 3,4-Dinitrophenol                          |                                           | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                   | 577-71-9   | 184.106  | tcl nd (w)                   | 134   |                     | 1.672 <sup>25</sup>        |                      | vs bz, eth, EtOH                                        |
| 4397 | 2,4-Dinitrophenol, acetate                 |                                           | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> O <sub>6</sub>                   | 4232-27-3  | 226.143  | cry (MeOH)                   | 72.5  |                     |                            |                      |                                                         |
| 4398 | 4-[(2,4-Dinitrophenyl)amino]phenol         |                                           | C <sub>12</sub> H <sub>9</sub> N <sub>3</sub> O <sub>5</sub>                  | 119-15-3   | 275.216  | red lf                       | 195.5 |                     |                            |                      | s alk                                                   |
| 4399 | 2,4-Dinitro- <i>N</i> -phenylaniline       |                                           | C <sub>12</sub> H <sub>9</sub> N <sub>3</sub> O <sub>4</sub>                  | 961-68-2   | 259.217  | ye red nd (al)               | 157.8 |                     |                            |                      | i H <sub>2</sub> O; s EtOH, ace; sl eth, bz, DMSO       |
| 4400 | 2,4-Dinitrophenyl dimethylcarbamodithioate |                                           | C <sub>8</sub> H <sub>9</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub>    | 89-37-2    | 287.315  |                              | 152.5 |                     | 1.54 <sup>20</sup>         |                      | i H <sub>2</sub> O; s EtOH, ace, bz                     |
| 4401 | (2,4-Dinitrophenyl)hydrazine               |                                           | C <sub>6</sub> H <sub>6</sub> N <sub>4</sub> O <sub>4</sub>                   | 119-26-6   | 198.137  | blsh-red (al)                | 194   |                     |                            |                      | i H <sub>2</sub> O; s EtOH; sl eth, bz, chl, DMSO       |
| 4402 | 1,1-Dinitropropane                         |                                           | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                   | 601-76-3   | 134.091  | liq                          | -42   | 184                 | 1.2610 <sup>25</sup>       | 1.4339 <sup>20</sup> | s alk                                                   |
| 4403 | 1,3-Dinitropropane                         |                                           | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                   | 6125-21-9  | 134.091  |                              | -21.4 | 103 <sup>1</sup>    | 1.353 <sup>26</sup>        | 1.4654 <sup>20</sup> | i H <sub>2</sub> O; s eth                               |
| 4404 | 2,2-Dinitropropane                         |                                           | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                   | 595-49-3   | 134.091  |                              | 53    | 185.5               | 1.30 <sup>25</sup>         |                      | sl H <sub>2</sub> O                                     |
| 4405 | 2,2-Dinitro-1,3-propanediol                |                                           | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>6</sub>                   | 2736-80-3  | 166.089  | wh pl (bz)                   | 142   |                     |                            |                      |                                                         |
| 4406 | 1,6-Dinitropyrene                          |                                           | C <sub>16</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                  | 42397-64-8 | 292.246  |                              | >300  |                     |                            |                      |                                                         |
| 4407 | 1,8-Dinitropyrene                          |                                           | C <sub>16</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                  | 42397-65-9 | 292.246  |                              | 300   |                     |                            |                      |                                                         |
| 4408 | Dinitrosopentamethylenetetramine           |                                           | C <sub>5</sub> H <sub>10</sub> N <sub>6</sub> O <sub>2</sub>                  | 101-25-7   | 186.172  | cry (MeOH)                   | 207   |                     |                            |                      |                                                         |
| 4409 | 1,4-Dinitrosopiperazine                    |                                           | C <sub>4</sub> H <sub>8</sub> N <sub>4</sub> O <sub>2</sub>                   | 140-79-4   | 144.133  | pa ye pl (w)                 | 159.0 |                     |                            |                      | vs EtOH                                                 |
| 4410 | 4,4'-Dinitro-2,2'-stilbenedisulfonic acid  |                                           | C <sub>14</sub> H <sub>10</sub> N <sub>2</sub> O <sub>10</sub> S <sub>2</sub> | 128-42-7   | 430.366  | cry (AcOH)                   | 266   |                     |                            |                      |                                                         |
| 4411 | Dinobuton                                  | Dessin                                    | C <sub>14</sub> H <sub>18</sub> N <sub>2</sub> O <sub>7</sub>                 | 973-21-7   | 326.302  | ye cry (EtOH)                | 60    |                     |                            |                      |                                                         |
| 4412 | Dinocap                                    |                                           | C <sub>18</sub> H <sub>24</sub> N <sub>2</sub> O <sub>6</sub>                 | 6119-92-2  | 364.393  |                              |       | 136 <sup>0.01</sup> |                            |                      |                                                         |
| 4413 | Dinonyl adipate                            |                                           | C <sub>24</sub> H <sub>46</sub> O <sub>4</sub>                                | 151-32-6   | 398.620  |                              |       | 205 <sup>1</sup>    |                            |                      |                                                         |



| No.  | Name                                                         | Synonym                                                   | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form     | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                      |
|------|--------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|-------------------|---------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------|
| 4414 | Dinonyl ether                                                |                                                           | C <sub>18</sub> H <sub>38</sub> O                                            | 2456-27-1  | 270.494  | liq               |         | 318                                   | 0.81                       | 1.4356 <sup>20</sup> |                                                 |
| 4415 | Dinonyl phthalate                                            |                                                           | C <sub>26</sub> H <sub>42</sub> O <sub>4</sub>                               | 84-76-4    | 418.609  |                   |         | 413                                   |                            |                      |                                                 |
| 4416 | Dinoseb                                                      | Phenol, 2-(1-methylpropyl)-4,6-dinitro-                   | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub>                | 88-85-7    | 240.212  |                   | 40      |                                       | 1.265 <sup>45</sup>        |                      |                                                 |
| 4417 | Diocetadecylamine                                            | Distearylamine                                            | C <sub>36</sub> H <sub>72</sub> N                                            | 112-99-2   | 521.988  |                   | 72.9    | 268 <sup>2</sup>                      |                            |                      | vs chl                                          |
| 4418 | Diocetylamine                                                | <i>N</i> -Octyl-1-octanamine                              | C <sub>16</sub> H <sub>32</sub> N                                            | 1120-48-5  | 241.456  | nd                | 35.5    | 297.5                                 | 0.7963 <sup>26</sup>       | 1.4415 <sup>26</sup> | vs eth, EtOH                                    |
| 4419 | Diocetyl ether                                               |                                                           | C <sub>16</sub> H <sub>34</sub> O                                            | 629-82-3   | 242.440  | liq               | -7.6    | 283                                   | 0.8063 <sup>20</sup>       | 1.4327 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc           |
| 4420 | Diocetyl hexanedioate                                        |                                                           | C <sub>22</sub> H <sub>42</sub> O <sub>4</sub>                               | 123-79-5   | 370.566  |                   | 9.6     | 191 <sup>2</sup>                      | 0.922 <sup>25</sup>        |                      |                                                 |
| 4421 | Diocetyl maleate                                             |                                                           | C <sub>20</sub> H <sub>36</sub> O <sub>4</sub>                               | 2915-53-9  | 340.498  | liq               |         | 242 <sup>0.002</sup>                  | 0.94 <sup>20</sup>         | 1.4539 <sup>20</sup> |                                                 |
| 4422 | Diocetyl phthalate                                           |                                                           | C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                               | 117-84-0   | 390.557  |                   | 25      | 220 <sup>4</sup>                      |                            |                      |                                                 |
| 4423 | Diocetyl sebacate                                            | Diocetyl decanedioate                                     | C <sub>26</sub> H <sub>50</sub> O <sub>4</sub>                               | 2432-87-3  | 426.673  |                   | 18      | 218 <sup>0.5</sup>                    | 0.9074 <sup>25</sup>       |                      | s ctc                                           |
| 4424 | Diocetyl sulfide                                             | Octyl sulfide                                             | C <sub>16</sub> H <sub>34</sub> S                                            | 2690-08-6  | 258.506  |                   |         | 202 <sup>29</sup> , 180 <sup>10</sup> | 0.842 <sup>25</sup>        | 1.4610 <sup>20</sup> |                                                 |
| 4425 | Diocetyl terephthalate                                       |                                                           | C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                               | 4654-26-6  | 390.557  | cry               |         | 425                                   | 1.21 <sup>62</sup>         |                      |                                                 |
| 4426 | Dioscorine                                                   |                                                           | C <sub>13</sub> H <sub>19</sub> NO <sub>2</sub>                              | 3329-91-7  | 221.296  | grn-ye pr (eth)   | 34      |                                       |                            |                      | s H <sub>2</sub> O, ace, chl, EtOH; sl eth, bz  |
| 4427 | 1,3-Dioxane                                                  | 1,3-Dioxacyclohexane                                      | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                                 | 505-22-6   | 88.106   | liq               | -45     | 106.1                                 | 1.0286 <sup>25</sup>       | 1.4165 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, bz        |
| 4428 | 1,4-Dioxane                                                  | 1,4-Dioxacyclohexane                                      | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                                 | 123-91-1   | 88.106   |                   | 11.85   | 101.5                                 | 1.0337 <sup>20</sup>       | 1.4224 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, bz; s ctc |
| 4429 | 1,4-Dioxane-2,5-dione                                        |                                                           | C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                                 | 502-97-6   | 116.073  | lf (al, al-chl)   | 85.4    |                                       |                            |                      | vs ace                                          |
| 4430 | 1,4-Dioxane-2,6-dione                                        | Diglycolic anhydride                                      | C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                                 | 4480-83-5  | 116.073  | cry (bz)          | 92.5    | 240.5; 120 <sup>12</sup>              |                            |                      |                                                 |
| 4431 | Dioxathion                                                   |                                                           | C <sub>12</sub> H <sub>26</sub> O <sub>6</sub> P <sub>2</sub> S <sub>4</sub> | 78-34-2    | 456.538  |                   | -20     |                                       | 1.257 <sup>26</sup>        |                      |                                                 |
| 4432 | 1,3-Dioxepane                                                |                                                           | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                                | 505-65-7   | 102.132  |                   |         |                                       |                            |                      | s chl                                           |
| 4433 | 1,3-Dioxolane                                                | 1,3-Dioxacyclopentane                                     | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                                 | 646-06-0   | 74.079   | liq               | -97.22  | 78                                    | 1.060 <sup>20</sup>        | 1.3974 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth, ace          |
| 4434 | 1,3-Dioxol-2-one                                             |                                                           | C <sub>3</sub> H <sub>4</sub> O <sub>3</sub>                                 | 872-36-6   | 86.046   | liq               | 22      | 162; 73 <sup>32</sup>                 | 1.35 <sup>25</sup>         |                      |                                                 |
| 4435 | Dioxybenzone                                                 | (2-Hydroxy-4-methoxyphenyl)(2-hydroxyphenyl)methanone     | C <sub>14</sub> H <sub>12</sub> O <sub>4</sub>                               | 131-53-3   | 244.243  |                   |         | 172 <sup>1</sup>                      |                            |                      |                                                 |
| 4436 | Dioxypyrimidon                                               |                                                           | C <sub>13</sub> H <sub>17</sub> N <sub>3</sub> O <sub>3</sub>                | 519-65-3   | 263.292  | pr                | 105.5   | 197 <sup>2</sup>                      |                            |                      | s H <sub>2</sub> O, EtOH                        |
| 4437 | Dipentaerythritol                                            |                                                           | C <sub>10</sub> H <sub>22</sub> O <sub>7</sub>                               | 126-58-9   | 254.278  | cry (w)           | 221     |                                       | 1.366 <sup>15</sup>        |                      | s hot H <sub>2</sub> O                          |
| 4438 | Dipentene                                                    | <i>p</i> -Menthadiene                                     | C <sub>10</sub> H <sub>16</sub>                                              | 7705-14-8  | 136.234  | liq               | -95.5   | 178                                   | 0.8402 <sup>21</sup>       | 1.4727 <sup>20</sup> |                                                 |
| 4439 | Dipentylamine                                                | Diamylamine                                               | C <sub>10</sub> H <sub>23</sub> N                                            | 2050-92-2  | 157.297  |                   |         | 202.5                                 | 0.7771 <sup>20</sup>       | 1.4272 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH; msc eth; s ace    |
| 4440 | Dipentyl <i>cis</i> -2-butenedioate                          | Dipentyl maleate                                          | C <sub>14</sub> H <sub>24</sub> O <sub>4</sub>                               | 10099-71-5 | 256.339  | liq               |         | 161 <sup>10</sup>                     | 0.974 <sup>20</sup>        |                      |                                                 |
| 4441 | Dipentyl ether                                               | Amyl ether                                                | C <sub>10</sub> H <sub>22</sub> O                                            | 693-65-2   | 158.281  | liq               | -69     | 190                                   | 0.7833 <sup>20</sup>       | 1.4119 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl        |
| 4442 | 2,6-Di- <i>tert</i> -pentyl-4-methylphenol                   | 2,6-Bis(1,1-dimethylpropyl)-4-methylphenol                | C <sub>17</sub> H <sub>28</sub> O                                            | 56103-67-4 | 248.403  |                   |         | 283                                   | 0.931 <sup>25</sup>        | 1.4950 <sup>20</sup> |                                                 |
| 4443 | Di- <i>tert</i> -pentyl peroxide                             |                                                           | C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>                               | 10508-09-5 | 174.281  |                   | -55     | 58 <sup>14</sup> , 38 <sup>9</sup>    | 0.808 <sup>20</sup>        | 1.4095 <sup>20</sup> |                                                 |
| 4444 | Dipentyl phthalate                                           |                                                           | C <sub>18</sub> H <sub>26</sub> O <sub>4</sub>                               | 131-18-0   | 306.397  |                   |         | 205 <sup>11</sup>                     |                            |                      | s ctc, CS <sub>2</sub>                          |
| 4445 | Dipentyl sulfide                                             |                                                           | C <sub>10</sub> H <sub>22</sub> S                                            | 872-10-6   | 174.347  |                   | -51.3   | 86 <sup>3.7</sup>                     | 0.8407 <sup>20</sup>       | 1.4561 <sup>20</sup> | i H <sub>2</sub> O; s eth                       |
| 4446 | Dipentyl sulfoxide                                           |                                                           | C <sub>10</sub> H <sub>22</sub> OS                                           | 1986-90-9  | 190.346  |                   | 58      | 120 <sup>1</sup>                      |                            |                      |                                                 |
| 4447 | Diphenamid                                                   | Benzeneacetamide, <i>N,N</i> -dimethyl- $\alpha$ -phenyl- | C <sub>16</sub> H <sub>17</sub> NO                                           | 957-51-7   | 239.312  |                   | 135     |                                       | 1.17 <sup>23.3</sup>       |                      |                                                 |
| 4448 | Diphenidol                                                   | 1,1-Diphenyl-4-piperidinyl-1-butanol                      | C <sub>21</sub> H <sub>27</sub> NO                                           | 972-02-1   | 309.445  | nd (peth)         | 104.5   |                                       |                            |                      |                                                 |
| 4449 | Diphenolic acid                                              |                                                           | C <sub>17</sub> H <sub>18</sub> O <sub>4</sub>                               | 126-00-1   | 286.323  | cry (w)           | 171.5   |                                       |                            |                      | vs H <sub>2</sub> O, ace, EtOH                  |
| 4450 | 1,2-Diphenoxyethane                                          | Ethylene glycol diphenyl ether                            | C <sub>14</sub> H <sub>14</sub> O <sub>2</sub>                               | 104-66-5   | 214.260  | lf (al)           | 98      | 182 <sup>12</sup>                     |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, chl         |
| 4451 | <i>N,N</i> -Diphenylacetamide                                |                                                           | C <sub>14</sub> H <sub>13</sub> NO                                           | 519-87-9   | 211.259  | wh cry pow        | 103     | sub                                   |                            |                      | sl H <sub>2</sub> O, eth, chl; s EtOH           |
| 4452 | Diphenylacetylene                                            |                                                           | C <sub>14</sub> H <sub>10</sub>                                              | 501-65-5   | 178.229  | mcl pr or pl (al) | 62.5    | 300                                   | 0.9657 <sup>100</sup>      |                      | i H <sub>2</sub> O; sl EtOH, chl; vs eth        |
| 4453 | 2-(Diphenylacetyl)-1 <i>H</i> -indene-1,3(2 <i>H</i> )-dione | Diphenadione                                              | C <sub>23</sub> H <sub>16</sub> O <sub>3</sub>                               | 82-66-6    | 340.371  | pa ye mcl (al)    | 146.5   |                                       |                            | 1.670                | vs ace, HOAc                                    |
| 4454 | Diphenylamine                                                | <i>N</i> -Phenylbenzenamine                               | C <sub>12</sub> H <sub>11</sub> N                                            | 122-39-4   | 169.222  | mcl lf(dil al)    | 53.2    | 302                                   | 1.158 <sup>22</sup>        |                      | i H <sub>2</sub> O; vs EtOH, ace; s eth; sl chl |
| 4455 | Diphenylamine-2,2'-dicarboxylic acid                         |                                                           | C <sub>14</sub> H <sub>11</sub> NO <sub>4</sub>                              | 579-92-0   | 257.242  | ye cry (al)       | 296 dec |                                       |                            |                      |                                                 |
| 4456 | Diphenylamine-4-sulfonic acid, sodium salt                   | Sodium diphenylamine-4-sulfonate                          | C <sub>12</sub> H <sub>10</sub> NNaO <sub>3</sub> S                          | 6152-67-6  | 271.267  | ye cry            |         |                                       |                            |                      |                                                 |
| 4457 | 9,10-Diphenylanthracene                                      |                                                           | C <sub>26</sub> H <sub>18</sub>                                              | 1499-10-1  | 330.421  |                   | 246.5   |                                       |                            |                      |                                                 |
| 4458 | Diphenylarsinous chloride                                    | Chlorodiphenylarsine                                      | C <sub>12</sub> H <sub>10</sub> AsCl                                         | 712-48-1   | 264.582  | orth pl (peth)    | 44      | 337                                   | 1.4820 <sup>16</sup>       | 1.6332 <sup>56</sup> | vs ace, bz, eth, EtOH                           |
| 4459 | <i>N,N'</i> -Diphenyl-1,4-benzenediamine                     | <i>N,N'</i> -Diphenyl- <i>p</i> -phenylenediamine         | C <sub>18</sub> H <sub>16</sub> N <sub>2</sub>                               | 74-31-7    | 260.333  |                   | 150     | 222 <sup>0.5</sup>                    |                            |                      | sl EtOH, eth, bz, chl; i acid                   |

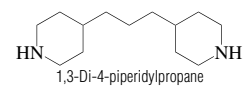
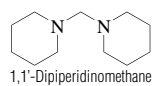
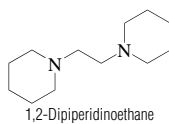
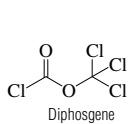
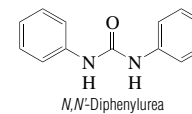
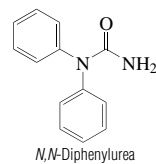
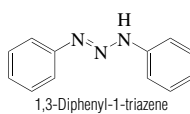
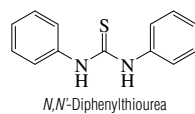
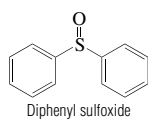
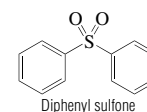
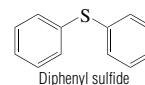
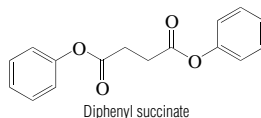
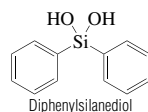
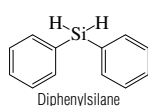
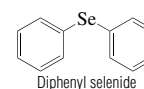
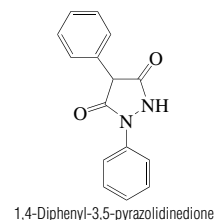
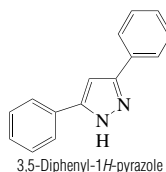
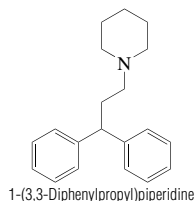
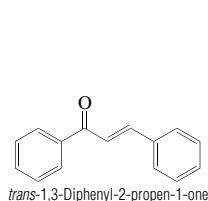
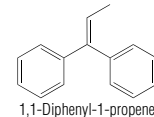
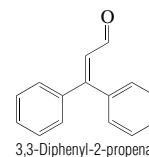
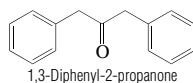
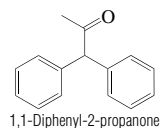
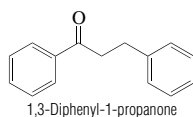
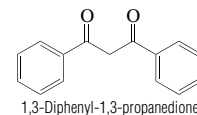
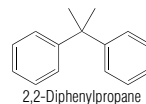
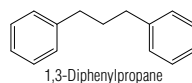
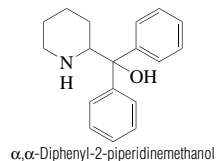
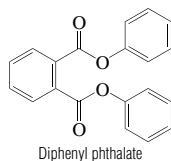
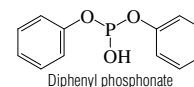
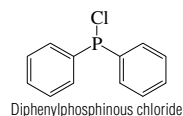
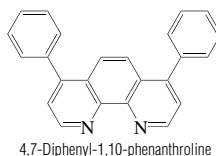
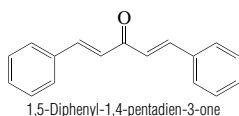
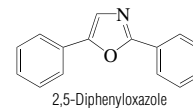
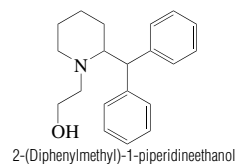
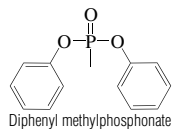
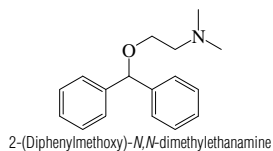
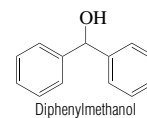
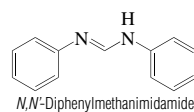
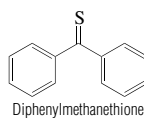
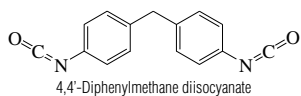


| No.  | Name                                               | Synonym                        | Mol. Form.                                                    | CAS RN    | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|----------------------------------------------------|--------------------------------|---------------------------------------------------------------|-----------|----------|---------------------------|---------|--------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 4460 | $\alpha,\alpha$ -Diphenylbenzeneethanol            |                                | C <sub>20</sub> H <sub>18</sub> O                             | 4428-13-1 | 274.356  | nd(bz-lig) pr (peth)      | 89.5    | 222 <sup>11</sup>                    |                            |                      | i H <sub>2</sub> O; vs EtOH; sl eth, chl, peth         |
| 4461 | $\alpha,\alpha$ -Diphenylbenzenemethanethiol       | Triphenylmethyl mercaptan      | C <sub>19</sub> H <sub>16</sub> S                             | 3695-77-0 | 276.395  |                           | 105.8   |                                      |                            |                      |                                                        |
| 4462 | <i>N,N'</i> -Diphenyl-[1,1'-biphenyl]-4,4'-diamine | <i>N,N'</i> -Diphenylbenzidine | C <sub>24</sub> H <sub>20</sub> N <sub>2</sub>                | 531-91-9  | 336.429  | lf or pl                  | 247     |                                      |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, bz; vs tol, HOAc     |
| 4463 | <i>trans,trans</i> -1,4-Diphenyl-1,3-butadiene     |                                | C <sub>16</sub> H <sub>14</sub>                               | 538-81-8  | 206.282  | lf (al, HOAc)             | 154.3   | 352                                  |                            |                      | vs bz, eth, EtOH, peth                                 |
| 4464 | 1,4-Diphenyl-1,3-butadiyne                         | Diphenyldiacetylene            | C <sub>16</sub> H <sub>10</sub>                               | 886-66-8  | 202.250  |                           | 86.5    |                                      |                            |                      |                                                        |
| 4465 | 1,1-Diphenylbutane                                 |                                | C <sub>16</sub> H <sub>18</sub>                               | 719-79-9  | 210.314  |                           | 27      | 287                                  | 0.9928 <sup>20</sup>       | 1.5664 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl               |
| 4466 | 1,2-Diphenylbutane                                 |                                | C <sub>16</sub> H <sub>18</sub>                               | 5223-59-6 | 210.314  |                           |         | 291; 152 <sup>11</sup>               | 0.9673 <sup>20</sup>       | 1.5554 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl               |
| 4467 | 1,4-Diphenylbutane                                 |                                | C <sub>16</sub> H <sub>18</sub>                               | 1083-56-3 | 210.314  |                           | 52.5    | 317                                  | 0.9880 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, chl                   |
| 4468 | 1,3-Diphenyl-1-butene                              |                                | C <sub>16</sub> H <sub>16</sub>                               | 7614-93-9 | 208.298  |                           | 47.5    | 311                                  | 0.9996 <sup>20</sup>       | 1.590 <sup>15</sup>  |                                                        |
| 4469 | <i>trans</i> -1,4-Diphenyl-2-butene-1,4-dione      |                                | C <sub>16</sub> H <sub>12</sub> O <sub>2</sub>                | 959-28-4  | 236.265  | ye nd (al, bz)            | 111     |                                      |                            |                      | sl EtOH; s bz, HOAc; vs chl; i lig                     |
| 4470 | 1,3-Diphenyl-2-buten-1-one                         | Dynone                         | C <sub>16</sub> H <sub>14</sub> O                             | 495-45-4  | 222.281  |                           |         | 342.5                                | 1.1080 <sup>15</sup>       | 1.6343 <sup>20</sup> | vs eth, EtOH                                           |
| 4471 | Diphenylcarbamic chloride                          |                                | C <sub>13</sub> H <sub>10</sub> ClNO                          | 83-01-2   | 231.677  | lf (al)                   | 84.5    |                                      |                            |                      |                                                        |
| 4472 | Diphenylcarbazon                                   |                                | C <sub>13</sub> H <sub>12</sub> N <sub>4</sub> O              | 538-62-5  | 240.260  | oran oran nd (bz) pr (al) | 157 dec |                                      |                            |                      | i H <sub>2</sub> O; vs EtOH, bz, chl                   |
| 4473 | <i>N,N'</i> -Diphenylcarbodiimide                  |                                | C <sub>13</sub> H <sub>10</sub> N <sub>2</sub>                | 622-16-2  | 194.231  |                           | 169     | 331; 175 <sup>20</sup>               |                            |                      | sl H <sub>2</sub> O, EtOH, eth; s bz                   |
| 4474 | Diphenyl carbonate                                 | Phenyl carbonate               | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                | 102-09-0  | 214.216  | nd (al, bz)               | 83      | 306                                  | 1.1215 <sup>67</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, ctc, HOAc             |
| 4475 | 2,2'-Diphenylcarbonic dihydrazide                  | <i>sym</i> -Diphenylcarbazine  | C <sub>13</sub> H <sub>14</sub> N <sub>4</sub> O              | 140-22-7  | 242.276  | cry (al + 1) cry (HOAc)   | 170     | dec                                  |                            |                      | sl H <sub>2</sub> O, eth; s EtOH, ace, bz              |
| 4476 | Diphenyl chlorophosphonate                         |                                | C <sub>12</sub> H <sub>10</sub> ClO <sub>3</sub> P            | 2524-64-3 | 268.632  |                           |         | 314 <sup>272</sup>                   | 1.296 <sup>25</sup>        | 1.5500 <sup>20</sup> | s tfa                                                  |
| 4477 | Diphenyl diselenide                                | Phenyl diselenide              | C <sub>12</sub> H <sub>10</sub> Se <sub>2</sub>               | 1666-13-3 | 312.13   | ye nd                     | 63.5    | 202 <sup>11</sup>                    | 1.557 <sup>80</sup>        | 1.743 <sup>20</sup>  | s EtOH, eth, xyl, MeOH                                 |
| 4478 | Diphenyl disulfide                                 | Phenyl disulfide               | C <sub>12</sub> H <sub>10</sub> S <sub>2</sub>                | 882-33-7  | 218.337  | nd(al) or orth            | 62      | 310                                  | 1.353 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, bz, CS <sub>2</sub>   |
| 4479 | 1,1-Diphenylethane                                 |                                | C <sub>14</sub> H <sub>14</sub>                               | 612-00-0  | 182.261  | liq                       | -17.9   | 272.6                                | 0.9997 <sup>20</sup>       | 1.5756 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz                |
| 4480 | 1,2-Diphenylethane                                 | Dibenzyl                       | C <sub>14</sub> H <sub>14</sub>                               | 103-29-7  | 182.261  | mcl pr (MeOH)             | 52.5    | 284                                  | 0.9780 <sup>25</sup>       | 1.5476 <sup>60</sup> | i H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub>       |
| 4481 | <i>N,N'</i> -Diphenylethanediamide                 |                                | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> | 620-81-5  | 240.257  | lf (bz)                   | 254     | >360                                 |                            |                      | vs bz                                                  |
| 4482 | <i>N,N'</i> -Diphenyl-1,2-ethanediamine            | 1,2-Dianilinoethane            | C <sub>14</sub> H <sub>16</sub> N <sub>2</sub>                | 150-61-8  | 212.290  | cry (dil al)              | 74      | 229 <sup>12</sup> , 178 <sup>2</sup> |                            |                      | i H <sub>2</sub> O; s EtOH, eth; sl tfa                |
| 4483 | 1,2-Diphenyl-1,2-ethanediol, ( <i>R*,R*</i> )-(±)  |                                | C <sub>14</sub> H <sub>14</sub> O <sub>2</sub>                | 655-48-1  | 214.260  | nd (w.al), tab (eth)      | 122.5   | >300                                 |                            |                      | i H <sub>2</sub> O, lig; vs EtOH, eth; s ace           |
| 4484 | 1,1-Diphenylethene                                 |                                | C <sub>14</sub> H <sub>12</sub>                               | 530-48-3  | 180.245  |                           | 8.2     | 277                                  | 1.0232 <sup>20</sup>       | 1.6085 <sup>20</sup> | i H <sub>2</sub> O; s eth, chl                         |
| 4485 | Diphenyl ether                                     |                                | C <sub>12</sub> H <sub>10</sub> O                             | 101-84-8  | 170.206  |                           | 26.87   | 258.0                                | 1.0661 <sup>30</sup>       | 1.5787 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, HOAc; sl chl      |
| 4486 | Diphenyl 2-ethylhexyl phosphate                    |                                | C <sub>20</sub> H <sub>27</sub> O <sub>4</sub> P              | 1241-94-7 | 362.399  |                           |         | 232 <sup>5</sup>                     | 1.090 <sup>25</sup>        | 1.510 <sup>25</sup>  |                                                        |
| 4487 | <i>N,N'</i> -Diphenylformamide                     |                                | C <sub>13</sub> H <sub>11</sub> NO                            | 607-00-1  | 197.232  | orth (dil al)             | 73.5    | 337.5; 189 <sup>13</sup>             |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz; sl ctc            |
| 4488 | 2,5-Diphenylfuran                                  |                                | C <sub>16</sub> H <sub>12</sub> O                             | 955-83-9  | 220.265  | nd or lf (dil al)         | 91      | 344                                  |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz            |
| 4489 | <i>N,N'</i> -Diphenylguanidine                     | 1,3-Diphenylguanidine          | C <sub>13</sub> H <sub>13</sub> N <sub>3</sub>                | 102-06-7  | 211.262  | mcl nd (al, to)           | 150     | dec 170                              | 1.13 <sup>20</sup>         |                      | sl H <sub>2</sub> O; s EtOH, ctc chl, tol; vs eth      |
| 4490 | 1,6-Diphenyl-1,3,5-hexatriene                      |                                | C <sub>18</sub> H <sub>16</sub>                               | 1720-32-7 | 232.320  | lf (ace)                  | 202.3   |                                      |                            |                      | i H <sub>2</sub> O, EtOH, eth, HOAc; s ace; sl bz, chl |
| 4491 | 1,1-Diphenylhydrazine                              |                                | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                | 530-50-7  | 184.236  | tab (lig)                 | 50.5    | 220 <sup>40</sup>                    | 1.190 <sup>16</sup>        |                      | vs bz, eth, EtOH, chl                                  |
| 4492 | 1,2-Diphenylhydrazine                              | Hydrazobenzene                 | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                | 122-66-7  | 184.236  | tab (al-eth)              | 131     |                                      | 1.158 <sup>16</sup>        |                      | vs EtOH; sl bz, DMSO; i HOAc                           |
| 4493 | 5,5-Diphenyl-4-imidazolidinone                     | Doxenitoin                     | C <sub>15</sub> H <sub>14</sub> N <sub>2</sub> O              | 3254-93-1 | 238.284  | pl (MeOH)                 | 183     |                                      |                            |                      |                                                        |
| 4494 | Diphenyl isophthalate                              |                                | C <sub>20</sub> H <sub>16</sub> O <sub>4</sub>                | 744-45-6  | 318.323  |                           | 138     |                                      |                            |                      | s chl                                                  |
| 4495 | Diphenylketene                                     | Diphenylethenone               | C <sub>14</sub> H <sub>10</sub> O                             | 525-06-4  | 194.228  | red-ye liq                |         | 267.5                                | 1.1107 <sup>13</sup>       | 1.615 <sup>14</sup>  |                                                        |
| 4496 | Diphenyl maleate                                   |                                | C <sub>16</sub> H <sub>12</sub> O <sub>4</sub>                | 7242-17-3 | 268.264  | pl (lig)                  | 73      | 226 <sup>15</sup>                    |                            |                      | vs ace, bz, eth, EtOH                                  |
| 4497 | Diphenylmercury                                    | Mercuriodibenzene              | C <sub>12</sub> H <sub>10</sub> Hg                            | 587-85-9  | 354.80   |                           |         | 204 <sup>10</sup>                    | 2.318 <sup>25</sup>        |                      | i H <sub>2</sub> O; sl EtOH, eth; s bz, chl            |
| 4498 | Diphenylmethane                                    |                                | C <sub>13</sub> H <sub>12</sub>                               | 101-81-5  | 168.234  | pr nd                     | 25.4    | 265.0                                | 1.001 <sup>26</sup>        | 1.5753 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                   |

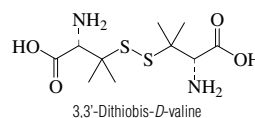
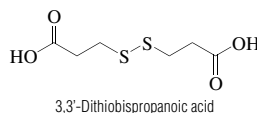
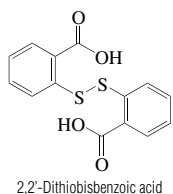
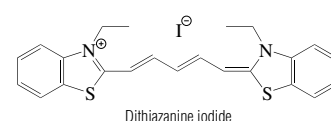
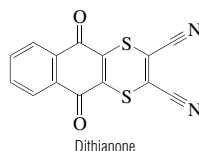
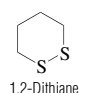
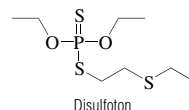
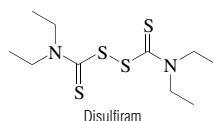
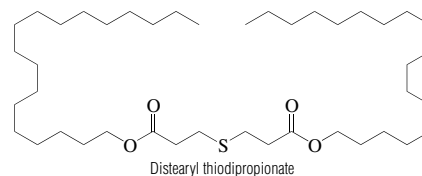
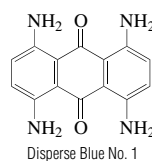
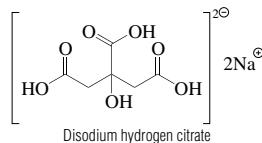
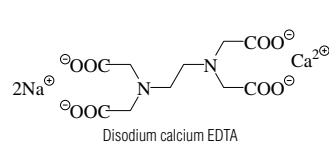
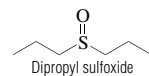
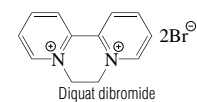
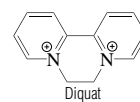
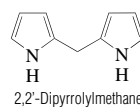
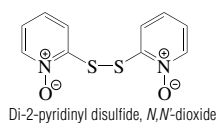
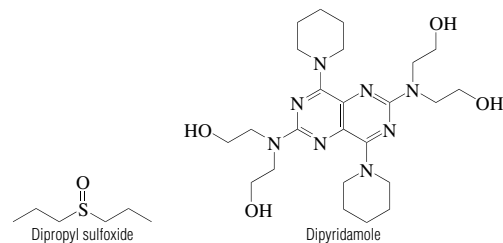
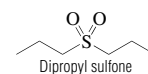
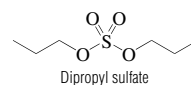
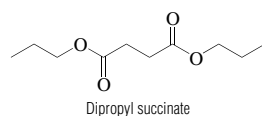
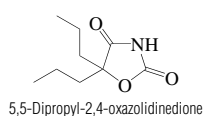
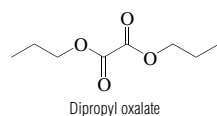
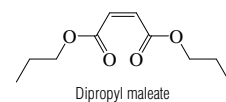
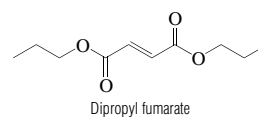
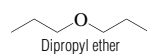
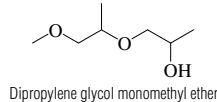
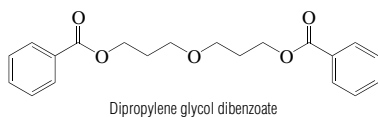
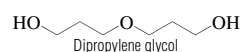
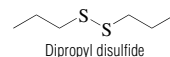
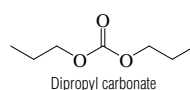
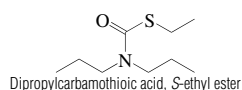
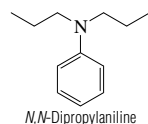
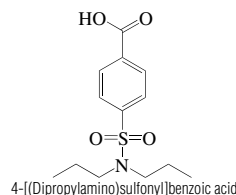
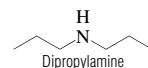
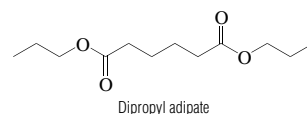
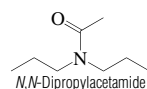
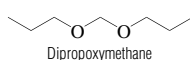
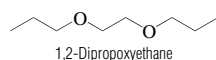
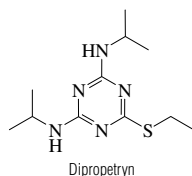
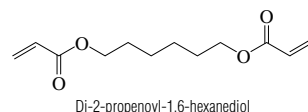
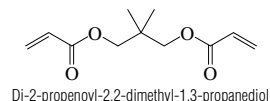
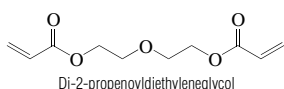
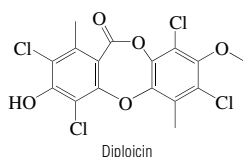




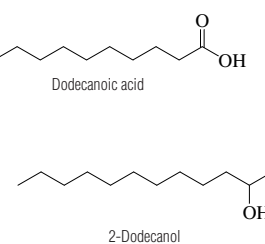
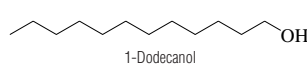
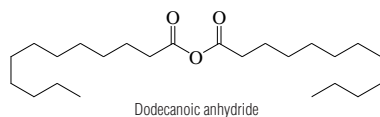
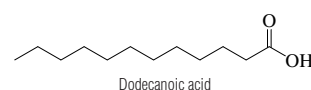
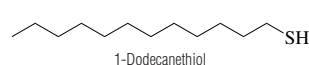
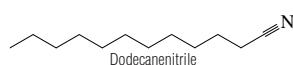
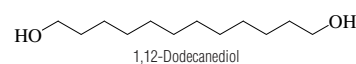
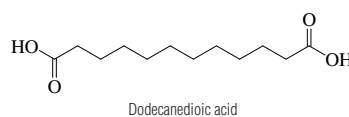
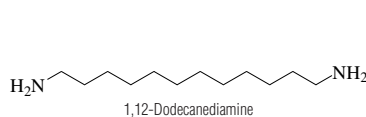
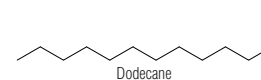
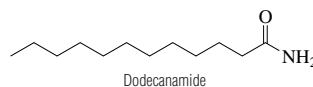
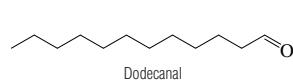
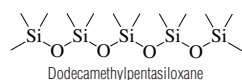
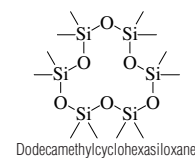
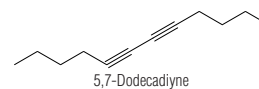
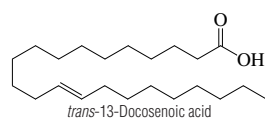
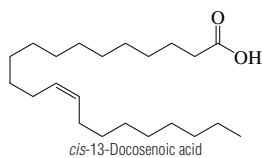
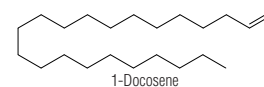
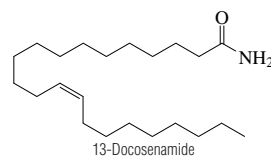
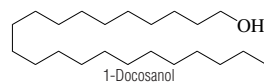
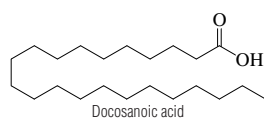
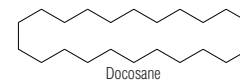
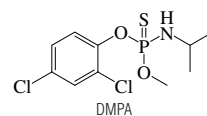
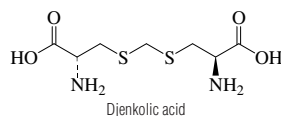
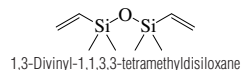
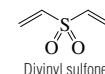
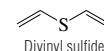
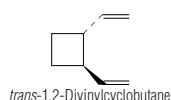
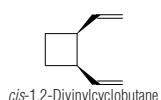
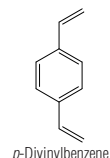
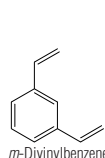
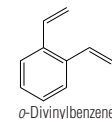
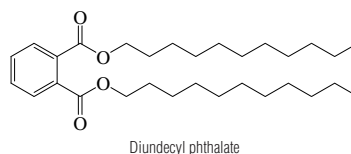
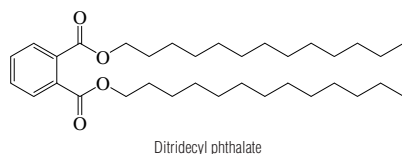
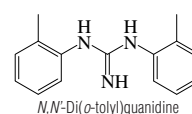
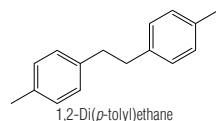
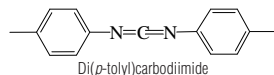
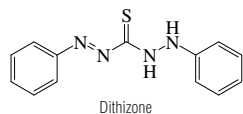
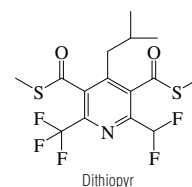
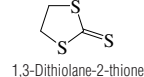
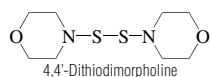
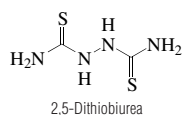
| No.  | Name                                                | Synonym                                      | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                    |
|------|-----------------------------------------------------|----------------------------------------------|---------------------------------------------------------------|------------|----------|-------------------------|---------|--------------------------------------|----------------------------|-----------------------|---------------------------------------------------------------|
| 4499 | 4,4'-Diphenylmethane diisocyanate                   | Methylene diphenyl diisocyanate              | C <sub>15</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | 101-68-8   | 250.252  |                         | 37      | 196 <sup>5</sup>                     | 1.197 <sup>70</sup>        | 1.5906 <sup>50</sup>  | s ace, bz, PhNO <sub>2</sub>                                  |
| 4500 | Diphenylmethanethione                               |                                              | C <sub>13</sub> H <sub>10</sub> S                             | 1450-31-3  | 198.283  |                         | 53.5    | 174 <sup>14</sup>                    |                            |                       | sl EtOH, eth, peth; vs bz, chl                                |
| 4501 | <i>N,N'</i> -Diphenylmethanimidamide                |                                              | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub>                | 622-15-1   | 196.247  | nd (al)                 | 142     | >250                                 |                            |                       | sl H <sub>2</sub> O, peth; s EtOH, ace, bz; vs eth            |
| 4502 | Diphenylmethanol                                    | Benzohydrol                                  | C <sub>13</sub> H <sub>12</sub> O                             | 91-01-0    | 184.233  | nd (lig)                | 69      | 298; 180 <sup>20</sup>               |                            |                       | sl H <sub>2</sub> O; vs EtOH, eth, ctc, chl; s HOAc           |
| 4503 | 2-(Diphenylmethoxy)- <i>N,N</i> -dimethylethanamine | Diphenhydramine                              | C <sub>17</sub> H <sub>21</sub> NO                            | 58-73-1    | 255.355  | oil                     |         | 165 <sup>3</sup>                     |                            |                       |                                                               |
| 4504 | Diphenyl methylphosphonate                          |                                              | C <sub>13</sub> H <sub>13</sub> O <sub>3</sub> P              | 7526-26-3  | 248.214  |                         | 35      | 205 <sup>13</sup>                    | 1.2051 <sup>20</sup>       |                       | i H <sub>2</sub> O                                            |
| 4505 | 2-(Diphenylmethyl)-1-piperidineethanol              | Diphemethoxidine                             | C <sub>20</sub> H <sub>26</sub> NO                            | 13862-07-2 | 295.419  |                         | 106.5   | 180 <sup>0.1</sup>                   |                            |                       |                                                               |
| 4506 | 2,5-Diphenyloxazole                                 |                                              | C <sub>15</sub> H <sub>11</sub> NO                            | 92-71-7    | 221.254  | nd (lig)                | 74      | 360                                  | 1.0940 <sup>100</sup>      | 1.6231 <sup>100</sup> | i H <sub>2</sub> O; vs EtOH, eth; sl chl                      |
| 4507 | 1,5-Diphenyl-1,4-pentadien-3-one                    | Dibenzalacetone                              | C <sub>17</sub> H <sub>14</sub> O                             | 538-58-9   | 234.292  | pl or lf (ace, AcOEt)   | 113 dec | dec                                  |                            |                       | i H <sub>2</sub> O; sl EtOH, eth; s ace, chl                  |
| 4508 | 4,7-Diphenyl-1,10-phenanthroline                    |                                              | C <sub>24</sub> H <sub>16</sub> N <sub>2</sub>                | 1662-01-7  | 332.397  |                         | 220 dec |                                      |                            |                       |                                                               |
| 4509 | Diphenylphosphinous chloride                        | Chlorodiphenylphosphine                      | C <sub>12</sub> H <sub>10</sub> ClP                           | 1079-66-9  | 220.634  | hyg ye liq              |         | 320; 174 <sup>5</sup>                | 1.229                      | 1.6360 <sup>20</sup>  |                                                               |
| 4510 | Diphenyl phosphonate                                |                                              | C <sub>12</sub> H <sub>11</sub> O <sub>3</sub> P              | 4712-55-4  | 234.187  |                         | 12      | 218 <sup>26</sup>                    | 1.223 <sup>25</sup>        | 1.5575 <sup>20</sup>  |                                                               |
| 4511 | Diphenyl phthalate                                  | Phenyl phthalate                             | C <sub>20</sub> H <sub>14</sub> O <sub>4</sub>                | 84-62-8    | 318.323  | pr (al, lig)            | 73      | 253 <sup>14</sup>                    |                            |                       | i H <sub>2</sub> O; sl EtOH, eth, ctc                         |
| 4512 | $\alpha,\alpha$ -Diphenyl-2-piperidinemethanol      | Pipradrol                                    | C <sub>18</sub> H <sub>21</sub> NO                            | 467-60-7   | 267.366  | cry (hx)                | 97.5    |                                      |                            |                       |                                                               |
| 4513 | 1,3-Diphenylpropane                                 |                                              | C <sub>15</sub> H <sub>16</sub>                               | 1081-75-0  | 196.288  | liq                     | 6       | 300; 123 <sup>1.7</sup>              | 1.007 <sup>20</sup>        | 1.5760 <sup>20</sup>  |                                                               |
| 4514 | 2,2-Diphenylpropane                                 |                                              | C <sub>15</sub> H <sub>16</sub>                               | 778-22-3   | 196.288  |                         | 29      | 282.5                                | 0.9980 <sup>20</sup>       |                       |                                                               |
| 4515 | 1,3-Diphenyl-1,3-propanedione                       | Dibenzoylmethane                             | C <sub>15</sub> H <sub>12</sub> O <sub>2</sub>                | 120-46-7   | 224.255  |                         | 70.5    |                                      |                            |                       | s EtOH, eth, chl, dil NaOH                                    |
| 4516 | 1,3-Diphenyl-1-propanone                            | Phenethyl phenyl ketone                      | C <sub>15</sub> H <sub>14</sub> O                             | 1083-30-3  | 210.271  | lf (EtOH)               | 72.5    | 360                                  |                            |                       |                                                               |
| 4517 | 1,1-Diphenyl-2-propanone                            | 1,1-Diphenylacetone                          | C <sub>15</sub> H <sub>14</sub> O                             | 781-35-1   | 210.271  |                         | 46      | 307; 174 <sup>10</sup>               |                            | 1.5361 <sup>16</sup>  | s EtOH, eth, bz, chl, lig                                     |
| 4518 | 1,3-Diphenyl-2-propanone                            | Dibenzyl ketone                              | C <sub>15</sub> H <sub>14</sub> O                             | 102-04-5   | 210.271  | cry (al, peth)          | 35      | 331                                  | 1.195 <sup>0</sup>         |                       | i H <sub>2</sub> O; s EtOH, eth, peth                         |
| 4519 | 3,3-Diphenyl-2-propenal                             | $\beta$ -Phenylcinnamaldehyde                | C <sub>15</sub> H <sub>12</sub> O                             | 1210-39-5  | 208.255  | pa ye pr (lig)          | 44.8    | 205 <sup>14</sup>                    |                            |                       |                                                               |
| 4520 | 1,1-Diphenyl-1-propene                              |                                              | C <sub>15</sub> H <sub>14</sub>                               | 778-66-5   | 194.272  |                         | 52      | 280; 149 <sup>11</sup>               | 1.0250 <sup>20</sup>       | 1.5880 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, bz                                |
| 4521 | <i>trans</i> -1,3-Diphenyl-2-propen-1-one           | Chalcone                                     | C <sub>15</sub> H <sub>12</sub> O                             | 614-47-1   | 208.255  | pa ye lf, pr, nd (peth) | 59      | dec 346                              | 1.0712 <sup>62</sup>       |                       | i H <sub>2</sub> O; sl EtOH; s eth, bz, chl, CS <sub>2</sub>  |
| 4522 | 1-(3,3-Diphenylpropyl)piperidine                    | Fenpiprane                                   | C <sub>20</sub> H <sub>25</sub> N                             | 3540-95-2  | 279.420  |                         | 41.5    | 215 <sup>8</sup>                     |                            |                       |                                                               |
| 4523 | 3,5-Diphenyl-1 <i>H</i> -pyrazole                   |                                              | C <sub>15</sub> H <sub>12</sub> N <sub>2</sub>                | 1145-01-3  | 220.269  | cry (al)                | 200     |                                      |                            |                       |                                                               |
| 4524 | 1,4-Diphenyl-3,5-pyrazolidinedione                  | Phenopyrazone                                | C <sub>15</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> | 3426-01-5  | 252.268  | cry (EtOAc, Diox)       | 233.5   |                                      |                            |                       |                                                               |
| 4525 | Diphenyl selenide                                   |                                              | C <sub>12</sub> H <sub>10</sub> Se                            | 1132-39-4  | 233.17   | ye nd (bz)              | 1.3     | 301.5                                | 1.351 <sup>20</sup>        | 1.5500 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s bz, xyl                  |
| 4526 | Diphenylsilane                                      |                                              | C <sub>12</sub> H <sub>12</sub> Si                            | 775-12-2   | 184.309  |                         |         | 134 <sup>16</sup> , 96 <sup>13</sup> | 0.9969 <sup>20</sup>       | 1.5800 <sup>20</sup>  | s ctc, CS <sub>2</sub>                                        |
| 4527 | Diphenylsilanediol                                  |                                              | C <sub>12</sub> H <sub>12</sub> O <sub>2</sub> Si             | 947-42-2   | 216.308  |                         |         |                                      |                            |                       | sl DMSO                                                       |
| 4528 | Diphenyl succinate                                  |                                              | C <sub>16</sub> H <sub>14</sub> O <sub>4</sub>                | 621-14-7   | 270.280  | lf (al)                 | 121     | 330; 222.5 <sup>15</sup>             |                            |                       | i H <sub>2</sub> O; s EtOH, eth, ace, bz                      |
| 4529 | Diphenyl sulfide                                    | Phenyl sulfide                               | C <sub>12</sub> H <sub>10</sub> S                             | 139-66-2   | 186.272  | liq                     | -25.9   | 296                                  | 1.1136 <sup>20</sup>       | 1.6334 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, ctc; msc eth, bz, CS <sub>2</sub> |
| 4530 | Diphenyl sulfone                                    |                                              | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub> S              | 127-63-9   | 218.271  | mcl pr(bz) pl(al)       | 128.5   | 379                                  | 1.252 <sup>20</sup>        |                       | i H <sub>2</sub> O; s EtOH, eth, bz                           |
| 4531 | Diphenyl sulfoxide                                  |                                              | C <sub>12</sub> H <sub>10</sub> OS                            | 945-51-7   | 202.271  | pr(lig)                 | 71.2    | 340 <sup>16</sup>                    |                            |                       | vs EtOH, eth, bz, HOAc; sl chl; i peth                        |
| 4532 | <i>N,N'</i> -Diphenylthiourea                       | <i>sym</i> -Diphenylthiourea                 | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> S              | 102-08-9   | 228.312  |                         | 154.5   |                                      | 1.32 <sup>25</sup>         |                       | sl H <sub>2</sub> O; vs EtOH, eth, chl, oils                  |
| 4533 | 1,3-Diphenyl-1-triazene                             | Diazoaminobenzene                            | C <sub>12</sub> H <sub>11</sub> N <sub>3</sub>                | 136-35-6   | 197.235  | ye lf or pr (al)        | 98      |                                      |                            |                       | i H <sub>2</sub> O; vs EtOH, eth, bz, py                      |
| 4534 | <i>N,N</i> -Diphenylurea                            |                                              | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O              | 603-54-3   | 212.246  | tab (al)                | 189     | dec                                  | 1.276 <sup>25</sup>        |                       | sl H <sub>2</sub> O; s EtOH, eth, chl                         |
| 4535 | <i>N,N'</i> -Diphenylurea                           | Carbanilide                                  | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O              | 102-07-8   | 212.246  | orth pr (al)            | 239     | 260 dec                              | 1.239 <sup>25</sup>        |                       | sl H <sub>2</sub> O, EtOH; s eth, py, HOAc; i bz              |
| 4536 | Diphosgene                                          | Carbonochloridic acid, trichloromethyl ester | C <sub>2</sub> Cl <sub>4</sub> O <sub>2</sub>                 | 503-38-8   | 197.832  | liq                     | -57     | 128                                  | 1.6525 <sup>14</sup>       | 1.4566 <sup>22</sup>  | vs eth, EtOH                                                  |
| 4537 | 1,2-Dipiperidinoethane                              |                                              | C <sub>12</sub> H <sub>22</sub> N <sub>2</sub>                | 1932-04-3  | 196.332  | liq                     | -0.5    | 265                                  | 0.9160 <sup>25</sup>       | 1.4853 <sup>25</sup>  |                                                               |
| 4538 | 1,1'-Dipiperidinomethane                            | 1,1'-Methylenedipiperidine                   | C <sub>11</sub> H <sub>22</sub> N <sub>2</sub>                | 880-09-1   | 182.306  |                         |         | 230; 122 <sup>15</sup>               | 0.9269 <sup>20</sup>       | 1.4820 <sup>20</sup>  |                                                               |
| 4539 | 1,3-Di-4-piperidylpropane                           | 4,4'-Trimethylenedipiperidine                | C <sub>13</sub> H <sub>26</sub> N <sub>2</sub>                | 16898-52-5 | 210.358  |                         | 67.1    | 329                                  |                            |                       | vs H <sub>2</sub> O                                           |



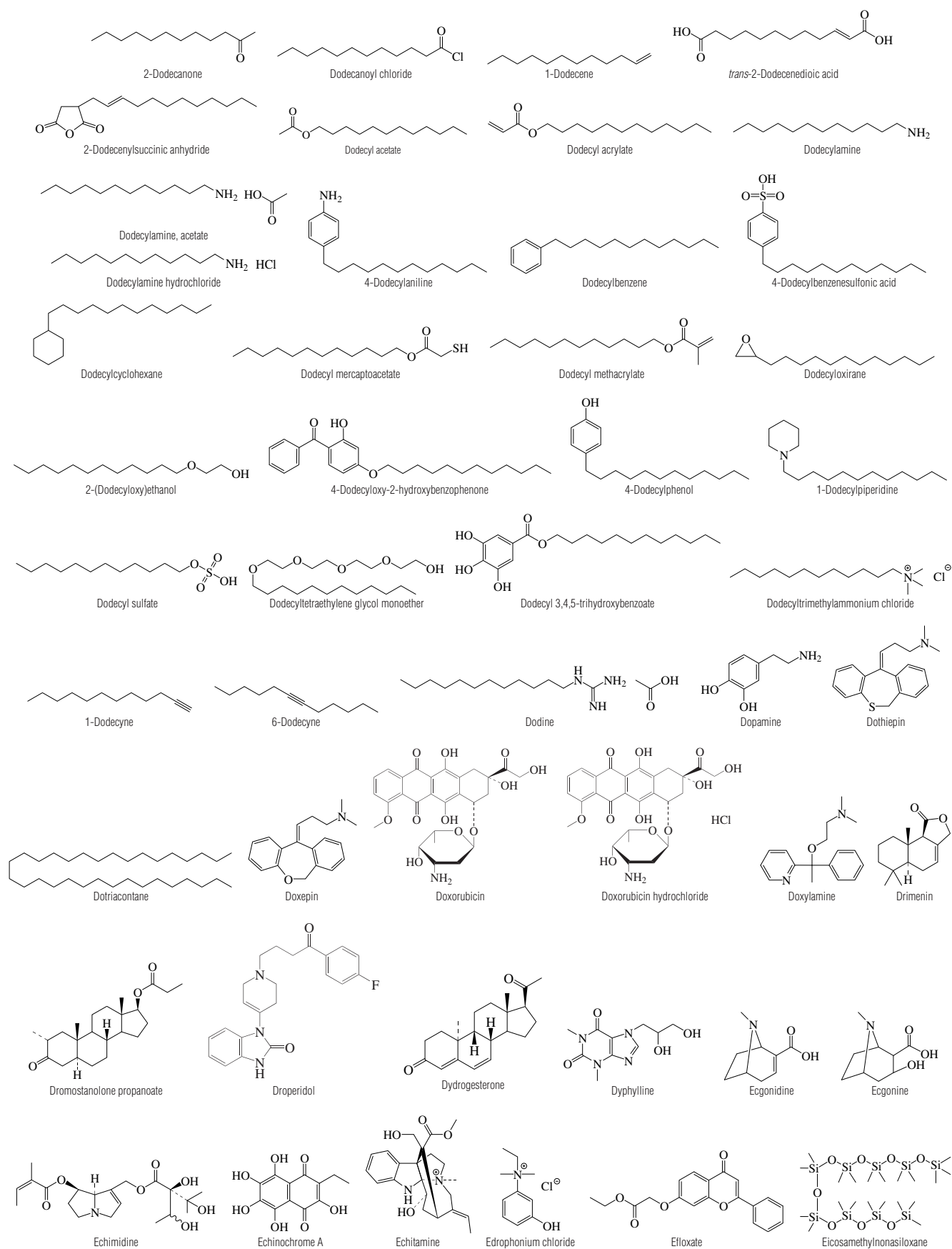
| No.  | Name                                              | Synonym                                                            | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|---------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|---------------|---------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 4540 | Diploicin                                         |                                                                    | C <sub>18</sub> H <sub>10</sub> Cl <sub>4</sub> O <sub>5</sub>               | 527-93-5   | 424.059  |               | 232     |                                       |                            |                      |                                                               |
| 4541 | Di-2-propenoyldiethyleneglycol                    |                                                                    | C <sub>10</sub> H <sub>14</sub> O <sub>5</sub>                               | 4074-88-8  | 214.215  |               |         | 200                                   | 1.1110 <sup>25</sup>       | 1.4595 <sup>25</sup> |                                                               |
| 4542 | Di-2-propenoyl-2,2-dimethyl-1,3-propanediol       | 2-Propenoic acid, 2,2-dimethyl-1,3-propanediyl ester               | C <sub>11</sub> H <sub>16</sub> O <sub>4</sub>                               | 2223-82-7  | 212.243  |               |         |                                       |                            | 1.4542 <sup>25</sup> |                                                               |
| 4543 | Di-2-propenoyl-1,6-hexanediol                     | 2-Propenoic acid, 1,6-hexanediyl ester                             | C <sub>12</sub> H <sub>18</sub> O <sub>4</sub>                               | 13048-33-4 | 226.269  |               |         |                                       | 1.010 <sup>25</sup>        |                      |                                                               |
| 4544 | Dipropetryn                                       | 6-(Ethylthio)- <i>N,N'</i> -diisopropyl-1,3,5-triazine-2,4-diamine | C <sub>11</sub> H <sub>21</sub> N <sub>3</sub> S                             | 4147-51-7  | 255.384  |               | 105     |                                       |                            |                      |                                                               |
| 4545 | 1,2-Dipropoxyethane                               |                                                                    | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                                | 18854-56-3 | 146.228  | liq           |         | 163.2 dec                             | 0.8312 <sup>25</sup>       | 1.4013 <sup>25</sup> |                                                               |
| 4546 | Dipropoxymethane                                  | Formaldehyde, dipropyl acetal                                      | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>                                | 505-84-0   | 132.201  | liq           | -97.3   | 140.5                                 | 0.8345 <sup>20</sup>       | 1.3939 <sup>19</sup> | vs ace, bz, eth, EtOH                                         |
| 4547 | <i>N,N</i> -Dipropylacetamide                     |                                                                    | C <sub>9</sub> H <sub>17</sub> NO                                            | 1116-24-1  | 143.227  |               |         | 209.5                                 | 0.8992 <sup>17</sup>       | 1.4419 <sup>17</sup> | vs EtOH                                                       |
| 4548 | Dipropyl adipate                                  |                                                                    | C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                               | 106-19-4   | 230.301  |               | -15.7   | 151 <sup>11</sup>                     | 0.9790 <sup>20</sup>       | 1.4314 <sup>20</sup> | vs eth, EtOH, chl                                             |
| 4549 | Dipropylamine                                     | <i>N</i> -Propyl-1-propanamine                                     | C <sub>6</sub> H <sub>15</sub> N                                             | 142-84-7   | 101.190  | liq           | -63     | 109.3                                 | 0.7400 <sup>20</sup>       | 1.4050 <sup>20</sup> | s H <sub>2</sub> O, EtOH; msc eth; vs ace, bz                 |
| 4550 | 4-[(Dipropylamino)sulfonyl]benzoic acid           | Probenecid                                                         | C <sub>13</sub> H <sub>15</sub> NO <sub>4</sub> S                            | 57-66-9    | 285.360  |               | 195     |                                       |                            |                      |                                                               |
| 4551 | <i>N,N</i> -Dipropylaniline                       |                                                                    | C <sub>12</sub> H <sub>15</sub> N                                            | 2217-07-4  | 177.286  | ye lf         |         | 242                                   | 0.9104 <sup>20</sup>       | 1.5271 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz; sl ctc              |
| 4552 | Dipropylcarbamothioic acid, <i>S</i> -ethyl ester | EPTC                                                               | C <sub>9</sub> H <sub>19</sub> NOS                                           | 759-94-4   | 189.318  |               |         | 127 <sup>20</sup>                     | 0.9546 <sup>30</sup>       |                      |                                                               |
| 4553 | Dipropyl carbonate                                |                                                                    | C <sub>7</sub> H <sub>14</sub> O <sub>3</sub>                                | 623-96-1   | 146.184  |               |         | 168                                   | 0.9435 <sup>20</sup>       | 1.4008 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                            |
| 4554 | Dipropyl disulfide                                |                                                                    | C <sub>6</sub> H <sub>14</sub> S <sub>2</sub>                                | 629-19-6   | 150.305  | liq           | -85.6   | 195.8                                 | 0.9599 <sup>20</sup>       | 1.4981 <sup>20</sup> |                                                               |
| 4555 | Dipropylene glycol                                |                                                                    | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                                | 25265-71-8 | 134.173  |               |         | 230.5                                 | 1.0206 <sup>20</sup>       |                      | msc H <sub>2</sub> O; s EtOH                                  |
| 4556 | Dipropylene glycol dibenzoate                     |                                                                    | C <sub>20</sub> H <sub>22</sub> O <sub>5</sub>                               | 27138-31-4 | 342.386  |               |         | 197 <sup>1</sup>                      |                            |                      |                                                               |
| 4557 | Dipropylene glycol monomethyl ether               | 1-(2-Methoxyisopropoxy)-2-propanol                                 | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>                                | 34590-94-8 | 148.200  | liq           | -80     | 188.3                                 | 0.95                       | 1.4190 <sup>20</sup> |                                                               |
| 4558 | Dipropyl ether                                    | Propyl ether                                                       | C <sub>6</sub> H <sub>14</sub> O                                             | 111-43-3   | 102.174  | liq           | -114.8  | 90.08                                 | 0.7466 <sup>20</sup>       | 1.3809 <sup>20</sup> | sl H <sub>2</sub> O; vs eth, EtOH                             |
| 4559 | Dipropyl fumarate                                 |                                                                    | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>                               | 14595-35-8 | 200.232  |               |         | 110 <sup>5</sup>                      | 1.0129 <sup>20</sup>       | 1.4435 <sup>20</sup> | s EtOH, eth                                                   |
| 4560 | Dipropyl maleate                                  |                                                                    | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>                               | 2432-63-5  | 200.232  |               |         | 126 <sup>12</sup>                     | 1.0245 <sup>20</sup>       | 1.4434 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz                      |
| 4561 | Dipropyl oxalate                                  |                                                                    | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                                | 615-98-5   | 174.195  | liq           | -44.3   | 211                                   | 1.0188 <sup>20</sup>       | 1.4158 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH; s eth                          |
| 4562 | 5,5-Dipropyl-2,4-oxazolidinedione                 |                                                                    | C <sub>9</sub> H <sub>15</sub> NO <sub>3</sub>                               | 512-12-9   | 185.220  |               | 42.5    | 149 <sup>3</sup>                      |                            |                      |                                                               |
| 4563 | Dipropyl succinate                                |                                                                    | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                               | 925-15-5   | 202.248  | liq           | -5.9    | 250.8                                 | 1.0020 <sup>20</sup>       | 1.4250 <sup>20</sup> | vs ace, bz, eth                                               |
| 4564 | Dipropyl sulfate                                  |                                                                    | C <sub>6</sub> H <sub>14</sub> O <sub>4</sub> S                              | 598-05-0   | 182.238  |               |         | 120 <sup>20</sup>                     | 1.1064 <sup>20</sup>       | 1.4135 <sup>20</sup> | vs peth                                                       |
| 4565 | Dipropyl sulfide                                  |                                                                    | C <sub>6</sub> H <sub>14</sub> S                                             | 111-47-7   | 118.240  | liq           | -102.5  | 142.9                                 | 0.814 <sup>17</sup>        | 1.4487 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                               |
| 4566 | Dipropyl sulfone                                  |                                                                    | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> S                              | 598-03-8   | 150.239  | cry           | 29.5    |                                       | 1.0278 <sup>20</sup>       | 1.4456 <sup>30</sup> | sl H <sub>2</sub> O; s EtOH, eth                              |
| 4567 | Dipropyl sulfoxide                                |                                                                    | C <sub>6</sub> H <sub>14</sub> OS                                            | 4253-91-2  | 134.239  | nd            | 22.5    | 80 <sup>2</sup>                       | 0.9654 <sup>20</sup>       | 1.4663 <sup>20</sup> | vs eth, EtOH                                                  |
| 4568 | Dipyridamole                                      |                                                                    | C <sub>24</sub> H <sub>40</sub> N <sub>6</sub> O <sub>4</sub>                | 58-32-2    | 504.627  |               | 163     |                                       |                            |                      |                                                               |
| 4569 | Di-2-pyridinyl disulfide, <i>N,N'</i> -dioxide    | Dipyrrithione                                                      | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> S <sub>2</sub>  | 3696-28-4  | 252.313  | cry (MeOH)    | 205     |                                       |                            |                      |                                                               |
| 4570 | 2,2'-Dipyrrolylmethane                            |                                                                    | C <sub>9</sub> H <sub>10</sub> N <sub>2</sub>                                | 21211-65-4 | 146.188  | lf or nd (al) | 73      | 164 <sup>12</sup>                     |                            |                      | vs bz, eth, EtOH                                              |
| 4571 | Diquat                                            |                                                                    | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                               | 2764-72-9  | 184.236  | Cation        |         |                                       |                            |                      |                                                               |
| 4572 | Diquat dibromide                                  |                                                                    | C <sub>12</sub> H <sub>12</sub> Br <sub>2</sub> N <sub>2</sub>               | 85-00-7    | 344.044  |               | 337     |                                       | 1.24 <sup>20</sup>         |                      |                                                               |
| 4573 | Disodium calcium EDTA                             | Edetate calcium disodium                                           | C <sub>10</sub> H <sub>12</sub> CaNa <sub>2</sub> O <sub>8</sub>             | 62-33-9    | 374.268  | pow           |         |                                       |                            |                      | s H <sub>2</sub> O                                            |
| 4574 | Disodium hydrogen citrate                         | Sodium acid citrate                                                | C <sub>6</sub> H <sub>6</sub> Na <sub>2</sub> O <sub>7</sub>                 | 144-33-2   | 236.088  | wh pow (w)    | 149 dec |                                       |                            |                      | vs H <sub>2</sub> O                                           |
| 4575 | Disperse Blue No. 1                               | 1,4,5,8-Tetraamino-9,10-anthracenedione                            | C <sub>14</sub> H <sub>12</sub> N <sub>4</sub> O <sub>2</sub>                | 2475-45-8  | 268.271  | red-br nd     | 331     |                                       |                            |                      |                                                               |
| 4576 | Distearyl thiodipropionate                        | Diocetadecyl thiobispropanoate                                     | C <sub>42</sub> H <sub>82</sub> O <sub>4</sub> S                             | 693-36-7   | 683.163  | cry           | 61      |                                       |                            |                      |                                                               |
| 4577 | Disulfiram                                        |                                                                    | C <sub>10</sub> H <sub>20</sub> N <sub>2</sub> S <sub>4</sub>                | 97-77-8    | 296.539  |               | 71.5    | 117 <sup>17</sup>                     |                            |                      | i H <sub>2</sub> O; s EtOH; sl eth; vs chl                    |
| 4578 | Disulfoton                                        |                                                                    | C <sub>8</sub> H <sub>19</sub> O <sub>2</sub> PS <sub>3</sub>                | 298-04-4   | 274.405  |               | -25     | 108 <sup>001</sup> , 128 <sup>1</sup> | 1.144 <sup>20</sup>        |                      |                                                               |
| 4579 | 1,2-Dithiane                                      |                                                                    | C <sub>4</sub> H <sub>8</sub> S <sub>2</sub>                                 | 505-20-4   | 120.237  | nd            | 32.5    | 80 <sup>14</sup> , 60 <sup>1</sup>    |                            | 1.5981 <sup>25</sup> | s eth, bz, chl                                                |
| 4580 | 1,3-Dithiane                                      |                                                                    | C <sub>4</sub> H <sub>8</sub> S <sub>2</sub>                                 | 505-23-7   | 120.237  |               | 54      | 89 <sup>14</sup>                      |                            | 1.5981 <sup>25</sup> | vs bz, eth, chl                                               |
| 4581 | 1,4-Dithiane                                      |                                                                    | C <sub>4</sub> H <sub>8</sub> S <sub>2</sub>                                 | 505-29-3   | 120.237  | mcl pr        | 112.3   | 199.5                                 |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ctc, CS <sub>2</sub> , HOAc |
| 4582 | Dithianone                                        |                                                                    | C <sub>14</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub> S <sub>2</sub> | 3347-22-6  | 296.324  | nd (ace)      | 220     |                                       |                            |                      |                                                               |
| 4583 | Dithiazanine iodide                               |                                                                    | C <sub>23</sub> H <sub>23</sub> IN <sub>3</sub> S <sub>2</sub>               | 514-73-8   | 518.476  | grn nd (MeOH) | 248 dec |                                       |                            |                      | i H <sub>2</sub> O                                            |
| 4584 | 2,2'-Dithiobisbenzoic acid                        | Diphenyl disulfide-2,2'-dicarboxylic acid                          | C <sub>14</sub> H <sub>10</sub> O <sub>4</sub> S <sub>2</sub>                | 119-80-2   | 306.357  |               | 289.5   |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth                               |
| 4585 | 3,3'-Dithiobispropanoic acid                      |                                                                    | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub> S <sub>2</sub>                 | 1119-62-6  | 210.271  |               | 158     |                                       |                            |                      |                                                               |
| 4586 | 3,3'-Dithiobis- <i>D</i> -valine                  |                                                                    | C <sub>10</sub> H <sub>20</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 20902-45-8 | 296.407  |               | 204.5   |                                       |                            |                      |                                                               |



| No.  | Name                                       | Synonym                         | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form     | mp/°C    | bp/°C                                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                       |
|------|--------------------------------------------|---------------------------------|-------------------------------------------------------------------------------|------------|----------|-------------------|----------|-----------------------------------------|----------------------------|-----------------------|--------------------------------------------------|
| 4587 | 2,5-Dithiobiurea                           | 1,2-Hydrazinedicarbothioamide   | C <sub>2</sub> H <sub>6</sub> N <sub>4</sub> S <sub>2</sub>                   | 142-46-1   | 150.226  | nd (w)            | 214      |                                         |                            |                       |                                                  |
| 4588 | 4,4'-Dithiodimorpholine                    |                                 | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> S <sub>2</sub>   | 103-34-4   | 236.355  |                   | 124.5    |                                         |                            |                       | s chl                                            |
| 4589 | 1,2-Dithiolane                             |                                 | C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>                                  | 557-22-2   | 106.210  |                   | 77       | 90 <sup>27</sup>                        |                            |                       |                                                  |
| 4590 | 1,3-Dithiolane                             | 1,3-Dithiacyclopentane          | C <sub>3</sub> H <sub>6</sub> S <sub>2</sub>                                  | 4829-04-3  | 106.210  | liq               | -50      | 175                                     | 1.259 <sup>17</sup>        | 1.5975 <sup>15</sup>  | s EtOH, eth, xyl                                 |
| 4591 | 1,3-Dithiolane-2-thione                    |                                 | C <sub>2</sub> H <sub>4</sub> S <sub>3</sub>                                  | 822-38-8   | 136.259  |                   | 35       | 307                                     |                            |                       |                                                  |
| 4592 | Dithiopyr                                  |                                 | C <sub>15</sub> H <sub>18</sub> F <sub>5</sub> NO <sub>2</sub> S <sub>2</sub> | 97886-45-8 | 401.416  |                   | 65       |                                         |                            |                       |                                                  |
| 4593 | Dithizone                                  |                                 | C <sub>13</sub> H <sub>12</sub> N <sub>4</sub> S                              | 60-10-6    | 256.326  | bl-blk (chl-al)   | 167 dec  |                                         |                            |                       | i H <sub>2</sub> O; sl EtOH, eth; s chl, alk     |
| 4594 | Di( <i>p</i> -tolyl)carbodiimide           |                                 | C <sub>15</sub> H <sub>14</sub> N <sub>2</sub>                                | 726-42-1   | 222.285  |                   | 58.5     | 221 <sup>20</sup>                       | 1.1500 <sup>20</sup>       |                       |                                                  |
| 4595 | 1,2-Di( <i>p</i> -tolyl)ethane             | 1,2-Bis( <i>p</i> -tolyl)ethane | C <sub>16</sub> H <sub>18</sub>                                               | 538-39-6   | 210.314  | lf (al)           | 85       | 178 <sup>18</sup>                       |                            |                       | i H <sub>2</sub> O; sl EtOH; s bz, peth          |
| 4596 | <i>N,N'</i> -Di( <i>o</i> -tolyl)guanidine |                                 | C <sub>15</sub> H <sub>17</sub> N <sub>3</sub>                                | 97-39-2    | 239.316  | cry (dil al)      | 179      |                                         | 1.10 <sup>20</sup>         |                       | sl H <sub>2</sub> O, tfa, EtOH; vs eth; s chl    |
| 4597 | Ditridecyl phthalate                       |                                 | C <sub>34</sub> H <sub>58</sub> O <sub>4</sub>                                | 119-06-2   | 530.823  | liq               |          | 285 <sup>3,5</sup>                      | 0.952 <sup>25</sup>        |                       |                                                  |
| 4598 | Diundecyl phthalate                        |                                 | C <sub>30</sub> H <sub>50</sub> O <sub>4</sub>                                | 3648-20-2  | 474.716  | cry (EtOH)        | 35.5     |                                         |                            |                       |                                                  |
| 4599 | Diuron                                     |                                 | C <sub>9</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> O               | 330-54-1   | 233.093  |                   | 158      |                                         |                            |                       |                                                  |
| 4600 | <i>o</i> -Divinylbenzene                   | 1,2-Divinylbenzene              | C <sub>10</sub> H <sub>10</sub>                                               | 91-14-5    | 130.186  |                   |          | 82 <sup>14</sup>                        | 0.9325 <sup>22</sup>       | 1.5767 <sup>20</sup>  | s ace, bz                                        |
| 4601 | <i>m</i> -Divinylbenzene                   | 1,3-Divinylbenzene              | C <sub>10</sub> H <sub>10</sub>                                               | 108-57-6   | 130.186  |                   | -52.3    | 121 <sup>76</sup> , 52 <sup>3</sup>     | 0.9294 <sup>20</sup>       | 1.5760 <sup>20</sup>  | s ace, bz                                        |
| 4602 | <i>p</i> -Divinylbenzene                   | 1,4-Divinylbenzene              | C <sub>10</sub> H <sub>10</sub>                                               | 105-06-6   | 130.186  |                   | 31       | 95 <sup>18</sup> , 34 <sup>0,2</sup>    | 0.913 <sup>40</sup>        | 1.5835 <sup>25</sup>  | s ace, bz                                        |
| 4603 | <i>cis</i> -1,2-Divinylcyclobutane         |                                 | C <sub>8</sub> H <sub>12</sub>                                                | 16177-46-1 | 108.181  |                   |          | 38 <sup>28</sup>                        | 0.8010 <sup>20</sup>       | 1.4563 <sup>20</sup>  |                                                  |
| 4604 | <i>trans</i> -1,2-Divinylcyclobutane       |                                 | C <sub>8</sub> H <sub>12</sub>                                                | 6553-48-6  | 108.181  |                   |          | 112.5                                   | 0.7817 <sup>20</sup>       | 1.4451 <sup>20</sup>  |                                                  |
| 4605 | Divinyl ether                              |                                 | C <sub>4</sub> H <sub>6</sub> O                                               | 109-93-3   | 70.090   | vol liq or gas    | -100.6   | 28.3                                    | 0.773 <sup>20</sup>        | 1.3989 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, chl      |
| 4606 | Divinyl sulfide                            | Vinyl sulfide                   | C <sub>4</sub> H <sub>6</sub> S                                               | 627-51-0   | 86.156   |                   | 20       | 84                                      | 0.9174 <sup>15</sup>       |                       | sl H <sub>2</sub> O; s ace; msc EtOH, eth        |
| 4607 | Divinyl sulfone                            | Vinyl sulfone                   | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub> S                                | 77-77-0    | 118.155  | liq               | -26      | 234.5                                   | 1.177 <sup>25</sup>        | 1.4765 <sup>20</sup>  |                                                  |
| 4608 | 1,3-Divinyl-1,1,3,3-tetramethyldisiloxane  |                                 | C <sub>8</sub> H <sub>18</sub> OSi <sub>2</sub>                               | 2627-95-4  | 186.399  | liq               | -99.7    | 39                                      | 0.811 <sup>20</sup>        | 1.4123 <sup>20</sup>  |                                                  |
| 4609 | Djenkolic acid                             |                                 | C <sub>7</sub> H <sub>14</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub>   | 498-59-9   | 254.327  | nd(w)             | ≈325 dec |                                         |                            |                       |                                                  |
| 4610 | DMPA                                       |                                 | C <sub>10</sub> H <sub>14</sub> Cl <sub>2</sub> NO <sub>2</sub> PS            | 299-85-4   | 314.169  | solid             | 51.4     | 150 <sup>2</sup>                        |                            |                       | sl H <sub>2</sub> O; vs bz, ctc, ace             |
| 4611 | Docosane                                   |                                 | C <sub>22</sub> H <sub>46</sub>                                               | 629-97-0   | 310.600  | pl(to), cry (eth) | 43.6     | 368.6                                   | 0.7944 <sup>20</sup>       | 1.4455 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, chl; vs eth          |
| 4612 | Docosanoic acid                            | Behenic acid                    | C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>                                | 112-85-6   | 340.583  | nd                | 81.5     | 306 <sup>60</sup>                       | 0.8223 <sup>90</sup>       | 1.4270 <sup>100</sup> | sl H <sub>2</sub> O, EtOH, eth                   |
| 4613 | 1-Docosanol                                |                                 | C <sub>22</sub> H <sub>46</sub> O                                             | 661-19-8   | 326.599  | cry (ace, chl)    | 72.5     | 180 <sup>0,22</sup>                     |                            |                       | sl H <sub>2</sub> O, eth; vs EtOH, MeOH; s chl   |
| 4614 | 13-Docosenamide                            | Erucamide                       | C <sub>22</sub> H <sub>43</sub> NO                                            | 112-84-5   | 337.582  | cry               | 94       |                                         |                            |                       |                                                  |
| 4615 | 1-Docosene                                 |                                 | C <sub>22</sub> H <sub>44</sub>                                               | 1599-67-3  | 308.584  |                   | 38       | 367                                     | 0.794 <sup>25</sup>        |                       |                                                  |
| 4616 | <i>cis</i> -13-Docosenoic acid             | Erucic acid                     | C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>                                | 112-86-7   | 338.567  | nd (al)           | 34.7     | 265 <sup>15</sup>                       | 0.860 <sup>55</sup>        | 1.4758 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, ctc; vs eth, MeOH    |
| 4617 | <i>trans</i> -13-Docosenoic acid           | Brassicic acid                  | C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>                                | 506-33-2   | 338.567  | pl (al)           | 61.9     | 282 <sup>30</sup> , 256 <sup>10</sup>   | 0.8585 <sup>57</sup>       | 1.4347 <sup>100</sup> |                                                  |
| 4618 | 5,7-Dodecadiyne                            | Dibutylbutadiyne                | C <sub>12</sub> H <sub>18</sub>                                               | 1120-29-2  | 162.271  |                   |          | 103 <sup>8</sup>                        |                            |                       |                                                  |
| 4619 | Dodecamethylcyclohexasiloxane              |                                 | C <sub>12</sub> H <sub>36</sub> O <sub>6</sub> Si <sub>6</sub>                | 540-97-6   | 444.923  | liq               | -1.5     | 245                                     | 0.9672 <sup>25</sup>       | 1.4015 <sup>20</sup>  | i H <sub>2</sub> O                               |
| 4620 | Dodecamethylpentasiloxane                  |                                 | C <sub>12</sub> H <sub>36</sub> O <sub>5</sub> Si <sub>5</sub>                | 141-63-9   | 384.840  | liq               | -80      | 232; 105 <sup>12</sup>                  | 0.8755 <sup>20</sup>       | 1.3925 <sup>20</sup>  | s ctc, CS <sub>2</sub>                           |
| 4621 | Dodecanal                                  | Lauraldehyde                    | C <sub>12</sub> H <sub>24</sub> O                                             | 112-54-9   | 184.318  | lf                | 44.5     | 185 <sup>100</sup> , 100 <sup>2,5</sup> | 0.8352 <sup>15</sup>       | 1.435 <sup>22</sup>   | i H <sub>2</sub> O; sl EtOH; s eth               |
| 4622 | Dodecanamide                               |                                 | C <sub>12</sub> H <sub>25</sub> NO                                            | 1120-16-7  | 199.333  | nd                | 110      | 199 <sup>12</sup>                       |                            | 1.4287 <sup>110</sup> | i H <sub>2</sub> O; s EtOH, ace, ctc; sl eth, bz |
| 4623 | Dodecane                                   |                                 | C <sub>12</sub> H <sub>26</sub>                                               | 112-40-3   | 170.334  | liq               | -9.57    | 216.32                                  | 0.7495 <sup>20</sup>       | 1.4210 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth, ace, ctc, chl  |
| 4624 | 1,12-Dodecanediamine                       |                                 | C <sub>12</sub> H <sub>28</sub> N <sub>2</sub>                                | 2783-17-7  | 200.363  |                   | 67.38    | 135 <sup>3</sup>                        |                            |                       |                                                  |
| 4625 | Dodecanedioic acid                         |                                 | C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                                | 693-23-2   | 230.301  |                   | 128      | 222 <sup>25</sup>                       | 1.15 <sup>25</sup>         |                       | s tfa                                            |
| 4626 | 1,12-Dodecanediol                          |                                 | C <sub>12</sub> H <sub>26</sub> O <sub>2</sub>                                | 5675-51-4  | 202.333  | cry (bz, dil al)  | 81.3     | 189 <sup>12</sup>                       |                            |                       | s tfa                                            |
| 4627 | Dodecanenitrile                            | Lauronitrile                    | C <sub>12</sub> H <sub>23</sub> N                                             | 2437-25-4  | 181.318  |                   | 4        | 277; 198 <sup>100</sup>                 | 0.8240 <sup>20</sup>       | 1.4361 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, chl  |
| 4628 | 1-Dodecanethiol                            |                                 | C <sub>12</sub> H <sub>26</sub> S                                             | 112-55-0   | 202.399  | liq               | -6.7     | 277; 143 <sup>15</sup>                  | 0.844 <sup>20</sup>        | 1.4589 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, chl             |
| 4629 | Dodecanoic acid                            | Lauric acid                     | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                                | 143-07-7   | 200.318  | nd (al)           | 43.8     | 225 <sup>100</sup>                      | 0.8679 <sup>90</sup>       | 1.4183 <sup>82</sup>  | i H <sub>2</sub> O; vs EtOH, eth; s ace; msc bz  |
| 4630 | Dodecanoic anhydride                       |                                 | C <sub>24</sub> H <sub>46</sub> O <sub>3</sub>                                | 645-66-9   | 382.620  | lf (al, eth)      | 41.8     |                                         | 0.8533 <sup>70</sup>       | 1.4292 <sup>70</sup>  | vs EtOH                                          |
| 4631 | 1-Dodecanol                                | Lauryl alcohol                  | C <sub>12</sub> H <sub>26</sub> O                                             | 112-53-8   | 186.333  | lf (dil al)       | 23.9     | 260                                     | 0.8309 <sup>24</sup>       |                       | i H <sub>2</sub> O; s EtOH, eth; sl bz           |
| 4632 | 2-Dodecanol                                |                                 | C <sub>12</sub> H <sub>26</sub> O                                             | 10203-28-8 | 186.333  |                   | 19       | 252                                     | 0.8286 <sup>20</sup>       | 1.4400 <sup>20</sup>  |                                                  |

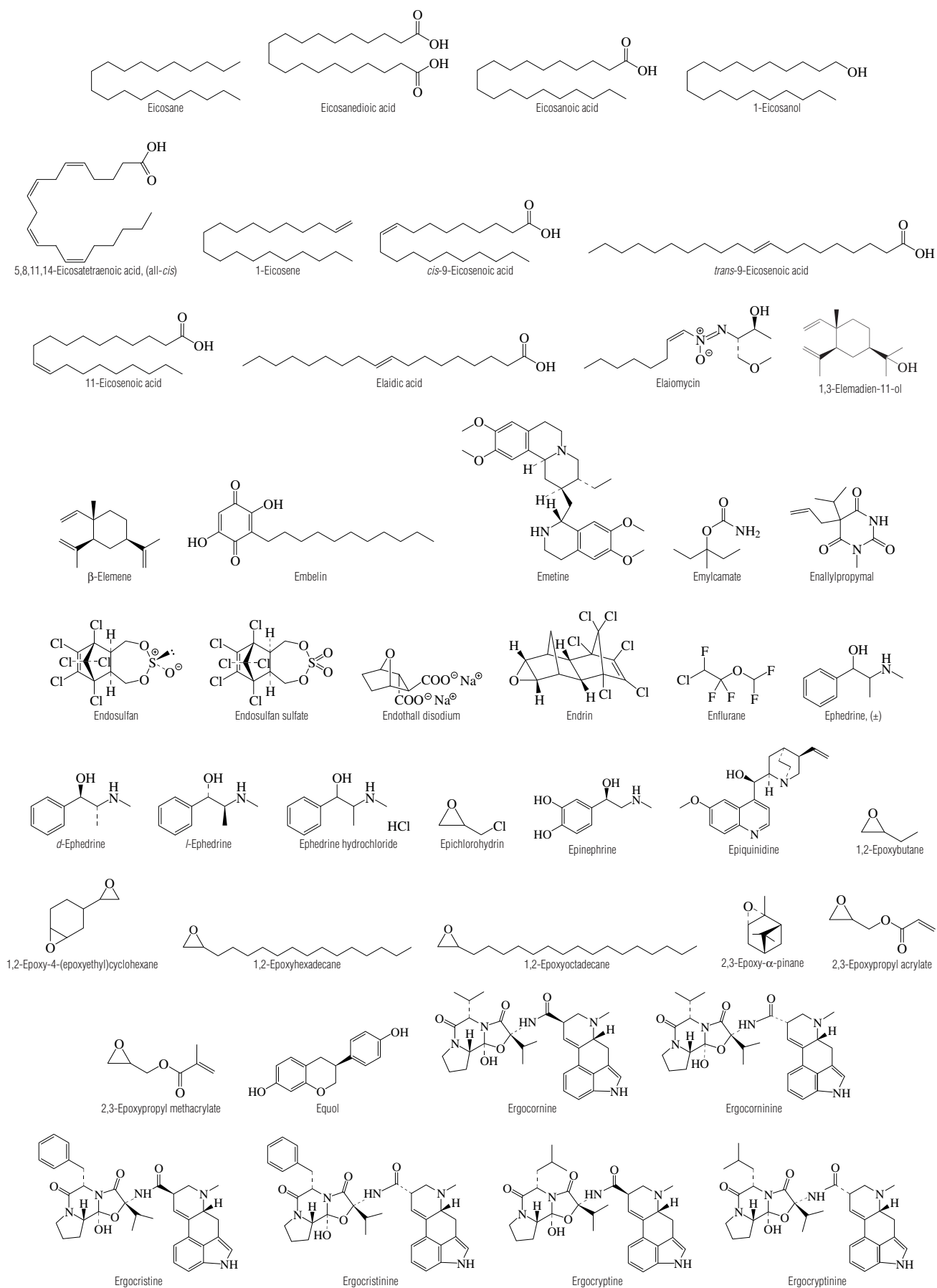


| No.  | Name                                  | Synonym                                                          | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form         | mp/°C     | bp/°C                                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|---------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------|------------|----------|-----------------------|-----------|------------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 4633 | 2-Dodecanone                          | Decyl methyl ketone                                              | C <sub>12</sub> H <sub>24</sub> O                              | 6175-49-1  | 184.318  |                       | 21        | 246.5                                    | 0.8198 <sup>20</sup>       | 1.4330 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace; sl ctc         |
| 4634 | Dodecanoyl chloride                   |                                                                  | C <sub>12</sub> H <sub>23</sub> ClO                            | 112-16-3   | 218.763  |                       | -17       | 145 <sup>18</sup>                        | 0.9169 <sup>25</sup>       | 1.4458 <sup>20</sup> | vs eth                                               |
| 4635 | 1-Dodecene                            |                                                                  | C <sub>12</sub> H <sub>24</sub>                                | 112-41-4   | 168.319  | liq                   | -35.2     | 213.8                                    | 0.7584 <sup>20</sup>       | 1.4300 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, ctc, peth      |
| 4636 | <i>trans</i> -2-Dodecenedioic acid    | Traumatic acid                                                   | C <sub>12</sub> H <sub>20</sub> O <sub>4</sub>                 | 6402-36-4  | 228.285  | cry (al,ace)          | 165.5     |                                          |                            |                      | vs eth, EtOH, chl                                    |
| 4637 | 2-Dodecenylsuccinic anhydride         |                                                                  | C <sub>18</sub> H <sub>28</sub> O <sub>3</sub>                 | 19780-11-1 | 266.375  | hyg cry               | 42        | 181 <sup>5</sup>                         |                            |                      |                                                      |
| 4638 | Dodecyl acetate                       |                                                                  | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                 | 112-66-3   | 228.371  |                       | 0.7       | 265; 180 <sup>40</sup>                   | 0.8652 <sup>22</sup>       | 1.4439 <sup>20</sup> |                                                      |
| 4639 | Dodecyl acrylate                      | Lauryl 2-propenoate                                              | C <sub>15</sub> H <sub>28</sub> O <sub>2</sub>                 | 2156-97-0  | 240.382  |                       | 4         | 120 <sup>0.8</sup>                       | 0.8727 <sup>20</sup>       |                      |                                                      |
| 4640 | Dodecylamine                          | 1-Dodecanamine                                                   | C <sub>12</sub> H <sub>27</sub> N                              | 124-22-1   | 185.349  |                       | 28.3      | 259                                      | 0.8015 <sup>20</sup>       | 1.4421 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, bz, chl          |
| 4641 | Dodecylamine, acetate                 | 1-Dodecanamine, acetate                                          | C <sub>14</sub> H <sub>31</sub> NO <sub>2</sub>                | 2016-56-0  | 245.402  |                       | 69.5      |                                          |                            |                      | vs H <sub>2</sub> O, EtOH                            |
| 4642 | Dodecylamine hydrochloride            | Lauryl amine hydrochloride                                       | C <sub>12</sub> H <sub>26</sub> ClN                            | 929-73-7   | 221.810  |                       | 186       |                                          |                            |                      | vs H <sub>2</sub> O, EtOH                            |
| 4643 | 4-Dodecylaniline                      |                                                                  | C <sub>18</sub> H <sub>31</sub> N                              | 104-42-7   | 261.446  |                       | 41.5      | 211 <sup>10</sup>                        |                            |                      |                                                      |
| 4644 | Dodecylbenzene                        | Laurylbenzene                                                    | C <sub>18</sub> H <sub>30</sub>                                | 123-01-3   | 246.431  |                       | 3         | 328                                      | 0.8551 <sup>20</sup>       | 1.4824 <sup>20</sup> | i H <sub>2</sub> O                                   |
| 4645 | 4-Dodecylbenzenesulfonic acid         |                                                                  | C <sub>18</sub> H <sub>30</sub> O <sub>3</sub> S               | 121-65-3   | 326.494  |                       |           | >205                                     |                            |                      |                                                      |
| 4646 | Dodecylcyclohexane                    |                                                                  | C <sub>18</sub> H <sub>36</sub>                                | 1795-17-1  | 252.479  |                       | 12.5      | 331                                      | 0.8223 <sup>20</sup>       | 1.4559 <sup>20</sup> |                                                      |
| 4647 | Dodecyl mercaptoacetate               |                                                                  | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub> S               | 3746-39-2  | 260.436  |                       | 1.5       | 171 <sup>3</sup>                         |                            |                      |                                                      |
| 4648 | Dodecyl methacrylate                  |                                                                  | C <sub>16</sub> H <sub>30</sub> O <sub>2</sub>                 | 142-90-5   | 254.408  |                       |           | 142 <sup>4</sup>                         | 0.866 <sup>20</sup>        |                      |                                                      |
| 4649 | Dodecyloxirane                        | 1,2-Epoxytetradecane                                             | C <sub>14</sub> H <sub>28</sub> O                              | 3234-28-4  | 212.371  | oil                   |           | 95 <sup>0.4</sup>                        | 0.845                      | 1.4408 <sup>20</sup> |                                                      |
| 4650 | 2-(Dodecyloxy)ethanol                 |                                                                  | C <sub>14</sub> H <sub>30</sub> O <sub>2</sub>                 | 4536-30-5  | 230.387  |                       |           | 143 <sup>0.8</sup>                       |                            |                      |                                                      |
| 4651 | 4-Dodecyloxy-2-hydroxybenzophenone    |                                                                  | C <sub>25</sub> H <sub>34</sub> O <sub>3</sub>                 | 2985-59-3  | 382.536  |                       | 43.5      |                                          |                            |                      |                                                      |
| 4652 | 4-Dodecylphenol                       |                                                                  | C <sub>18</sub> H <sub>30</sub> O                              | 104-43-8   | 262.430  | nd (bz)               | 66        | 175 <sup>2</sup>                         |                            |                      |                                                      |
| 4653 | 1-Dodecylpiperidine                   |                                                                  | C <sub>17</sub> H <sub>35</sub> N                              | 5917-47-5  | 253.467  | pa ye                 |           | 161 <sup>5</sup> , 115 <sup>0.6</sup>    | 0.8378 <sup>20</sup>       | 1.4588 <sup>20</sup> |                                                      |
| 4654 | Dodecyl sulfate                       | Lauryl sulfate                                                   | C <sub>12</sub> H <sub>26</sub> O <sub>4</sub> S               | 151-41-7   | 266.397  | cry                   |           |                                          |                            |                      | s H <sub>2</sub> O                                   |
| 4655 | Dodecyltetraethylene glycol monoether | 3,6,9,12-Tetraoxatetracosan-1-ol                                 | C <sub>20</sub> H <sub>42</sub> O <sub>5</sub>                 | 5274-68-0  | 362.544  |                       |           | 247 <sup>10</sup>                        |                            |                      |                                                      |
| 4656 | Dodecyl 3,4,5-trihydroxybenzoate      |                                                                  | C <sub>19</sub> H <sub>30</sub> O <sub>5</sub>                 | 1166-52-5  | 338.438  |                       | 96.5      |                                          |                            |                      | s ace                                                |
| 4657 | Dodecyltrimethylammonium chloride     |                                                                  | C <sub>15</sub> H <sub>34</sub> ClN                            | 112-00-5   | 263.891  |                       | 246 dec   |                                          |                            |                      | vs H <sub>2</sub> O, ace, EtOH, chl                  |
| 4658 | 1-Dodecyne                            | Decylacetylene                                                   | C <sub>12</sub> H <sub>22</sub>                                | 765-03-7   | 166.303  | liq                   | -19       | 215                                      | 0.7788 <sup>20</sup>       | 1.4340 <sup>20</sup> |                                                      |
| 4659 | 6-Dodecyne                            |                                                                  | C <sub>12</sub> H <sub>22</sub>                                | 6975-99-1  | 166.303  |                       |           | 210; 100 <sup>14</sup>                   | 0.785 <sup>20</sup>        | 1.4442 <sup>20</sup> | vs ace, eth, EtOH                                    |
| 4660 | Dodine                                | Dodecylguanidine, monoacetate                                    | C <sub>15</sub> H <sub>33</sub> N <sub>3</sub> O <sub>2</sub>  | 2439-10-3  | 287.442  |                       | 136       |                                          |                            |                      |                                                      |
| 4661 | Dopamine                              | 4(2-Aminoethyl)-1,2-benzenediol                                  | C <sub>8</sub> H <sub>11</sub> NO <sub>2</sub>                 | 51-61-6    | 153.179  | pr                    |           |                                          |                            |                      |                                                      |
| 4662 | Dothiepin                             |                                                                  | C <sub>19</sub> H <sub>21</sub> NS                             | 113-53-1   | 295.442  |                       | 56        | 172 <sup>0.05</sup>                      |                            |                      |                                                      |
| 4663 | Dotriacontane                         | Bicetyl                                                          | C <sub>32</sub> H <sub>66</sub>                                | 544-85-4   | 450.866  | pl (bz,chl,HO Ac,eth) | 69.4      | 467                                      | 0.8124 <sup>20</sup>       | 1.4550 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH, chl; s eth, ctc; vs bz  |
| 4664 | Doxepin                               |                                                                  | C <sub>19</sub> H <sub>21</sub> NO                             | 1668-19-5  | 279.376  | oily liq              |           | 155 <sup>0.03</sup> , 265 <sup>0.2</sup> |                            |                      |                                                      |
| 4665 | Doxorubicin                           | Adriamycin                                                       | C <sub>27</sub> H <sub>29</sub> NO <sub>11</sub>               | 23214-92-8 | 543.519  | cry                   | 230       |                                          |                            |                      |                                                      |
| 4666 | Doxorubicin hydrochloride             | Adriamycin hydrochloride                                         | C <sub>27</sub> H <sub>35</sub> ClNO <sub>11</sub>             | 25316-40-9 | 579.980  | oran-red nd           | 204 dec   |                                          |                            |                      | s H <sub>2</sub> O, MeOH; i ace, bz, chl, eth, peth  |
| 4667 | Doxylamine                            |                                                                  | C <sub>17</sub> H <sub>22</sub> N <sub>2</sub> O               | 469-21-6   | 270.369  | liq                   |           | 139 <sup>0.5</sup>                       |                            |                      |                                                      |
| 4668 | Drimenin                              |                                                                  | C <sub>15</sub> H <sub>22</sub> O <sub>2</sub>                 | 2326-89-8  | 234.335  | cry                   | 133       | 110 <sup>0.1</sup>                       |                            |                      | i H <sub>2</sub> O                                   |
| 4669 | Dromostanolone propanoate             | 2-Methyl-17-(1-oxopropoxy)androstan-3-one, (2α,5α,17β)           | C <sub>23</sub> H <sub>36</sub> O <sub>3</sub>                 | 521-12-0   | 360.530  |                       | 128       |                                          |                            |                      |                                                      |
| 4670 | Droperidol                            | Dehydrobenzperidol                                               | C <sub>22</sub> H <sub>22</sub> FN <sub>3</sub> O <sub>2</sub> | 548-73-2   | 379.427  | cry (w)               | 146 (hyd) |                                          |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, bz; s chl, DMF     |
| 4671 | Dyrogesterone                         |                                                                  | C <sub>21</sub> H <sub>28</sub> O <sub>2</sub>                 | 152-62-5   | 312.446  | cry (ace/hx)          | 170       |                                          |                            |                      |                                                      |
| 4672 | Dyphylline                            |                                                                  | C <sub>10</sub> H <sub>14</sub> N <sub>4</sub> O <sub>4</sub>  | 479-18-5   | 254.243  |                       | 161.5     |                                          |                            |                      |                                                      |
| 4673 | Ecgonidine                            |                                                                  | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                 | 484-93-5   | 167.205  | cry (MeOH) (MeOH-eth) | 228 dec   |                                          |                            |                      | vs H <sub>2</sub> O                                  |
| 4674 | Ecgonine                              |                                                                  | C <sub>9</sub> H <sub>15</sub> NO <sub>3</sub>                 | 481-37-8   | 185.220  | mcl pr                | 205       |                                          |                            |                      | vs H <sub>2</sub> O, EtOH                            |
| 4675 | Echimidine                            |                                                                  | C <sub>20</sub> H <sub>31</sub> NO <sub>7</sub>                | 520-68-3   | 397.463  | glass                 |           |                                          |                            |                      |                                                      |
| 4676 | Echinochrome A                        | 2-Ethyl-3,5,6,7,8-pentahydroxy-1,4-naphthalenedione              | C <sub>12</sub> H <sub>10</sub> O <sub>7</sub>                 | 517-82-8   | 266.203  | red nd (Diox-w)       | 220 dec   | sub 120                                  |                            |                      | sl H <sub>2</sub> O; s EtOH, ace; vs eth, bz         |
| 4677 | Echitamine                            |                                                                  | C <sub>22</sub> H <sub>30</sub> N <sub>2</sub> O <sub>5</sub>  | 6871-44-9  | 402.483  |                       | 206       |                                          |                            |                      | s H <sub>2</sub> O, EtOH, eth, chl, con sulf; i peth |
| 4678 | Edrophonium chloride                  |                                                                  | C <sub>10</sub> H <sub>16</sub> ClNO                           | 116-38-1   | 201.693  | cry                   | 162       |                                          |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth, chl              |
| 4679 | Efloxate                              | Ethyl [(4-oxo-2-phenyl-4 <i>H</i> -1-benzopyran-7-yl)oxy]acetate | C <sub>19</sub> H <sub>16</sub> O <sub>5</sub>                 | 119-41-5   | 324.327  |                       | 123.7     |                                          |                            |                      | s chl                                                |
| 4680 | Eicosamethylnonasiloxane              |                                                                  | C <sub>20</sub> H <sub>60</sub> O <sub>8</sub> Si <sub>9</sub> | 2652-13-3  | 681.455  |                       |           | 307.5; 198 <sup>16</sup>                 | 0.9173 <sup>20</sup>       | 1.3980 <sup>20</sup> | vs bz                                                |

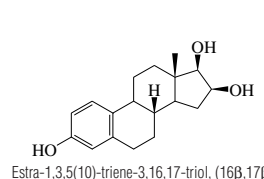
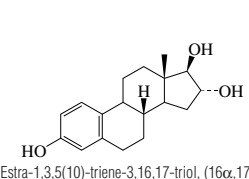
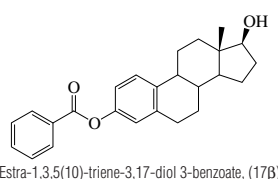
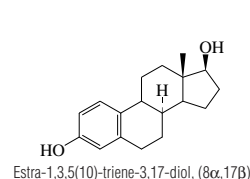
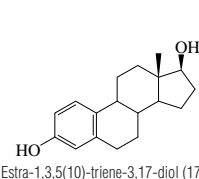
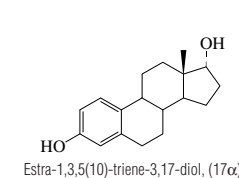
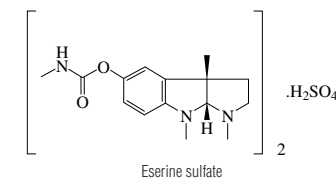
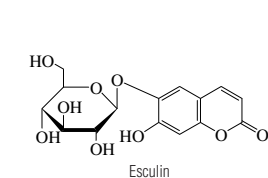
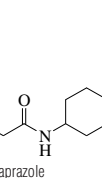
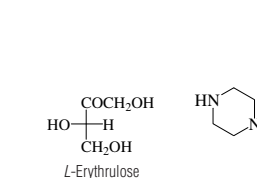
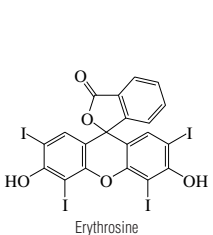
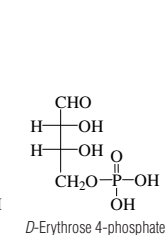
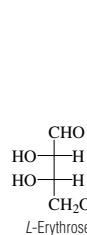
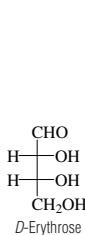
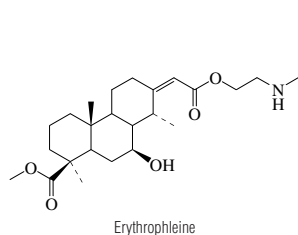
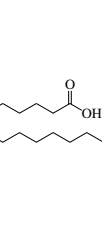
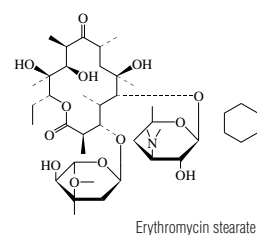
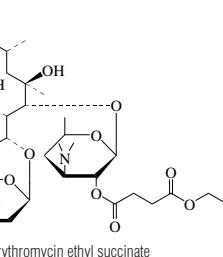
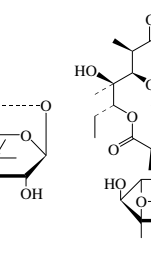
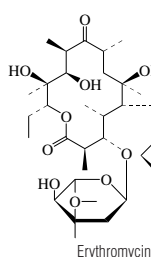
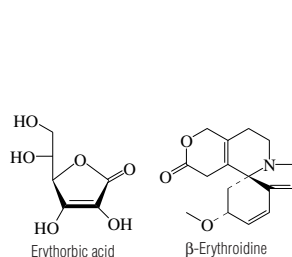
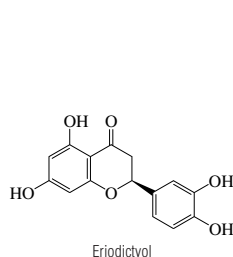
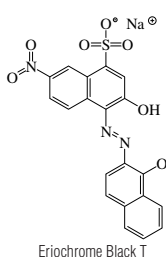
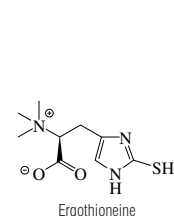
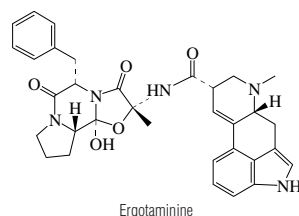
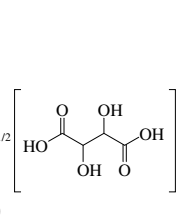
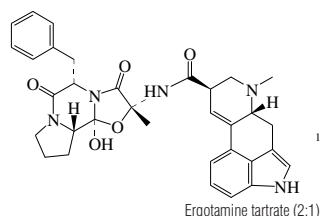
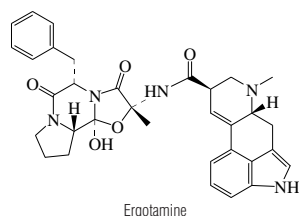
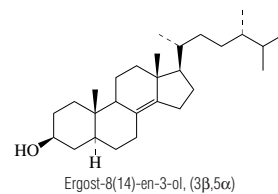
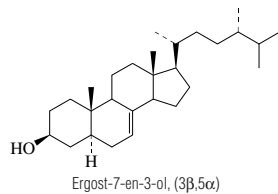
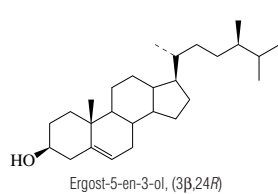
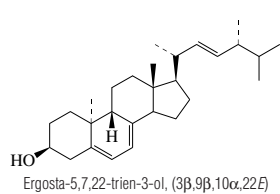
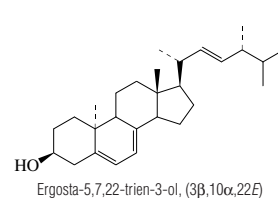
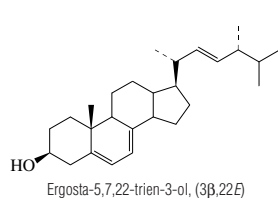
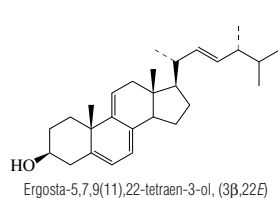
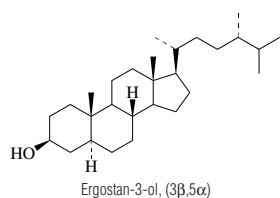
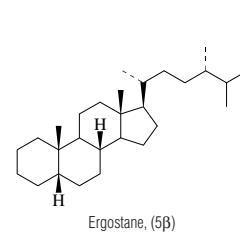
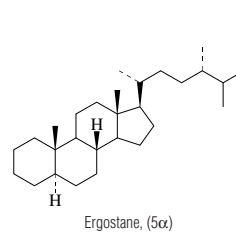
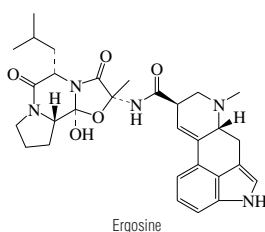
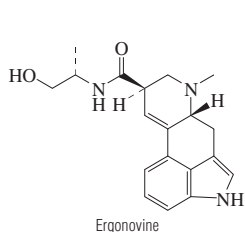
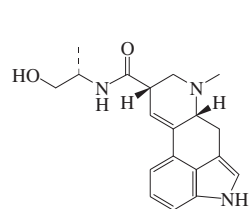




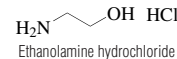
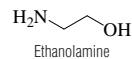
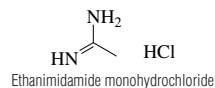
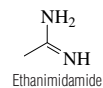
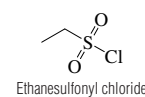
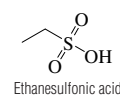
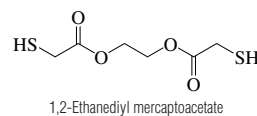
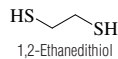
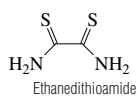
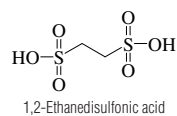
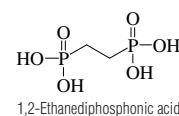
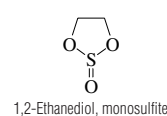
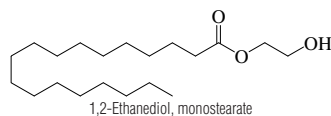
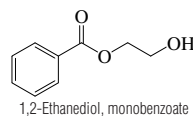
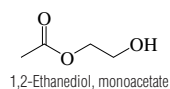
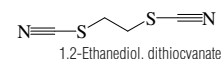
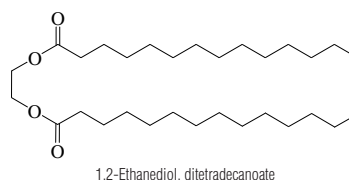
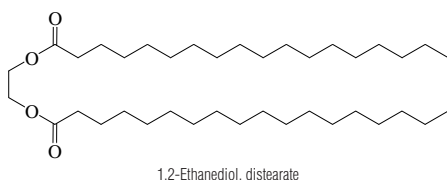
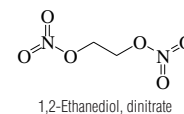
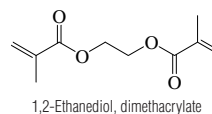
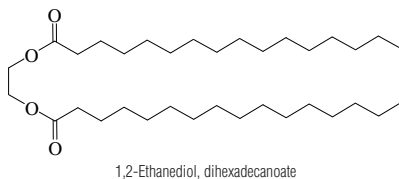
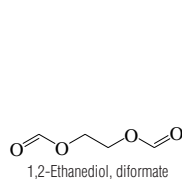
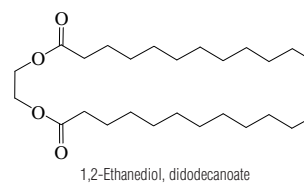
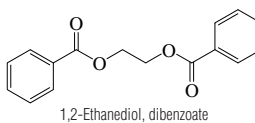
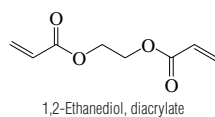
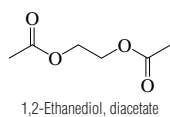
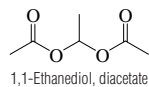
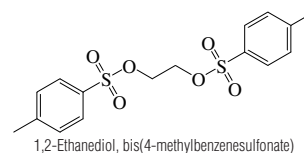
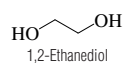
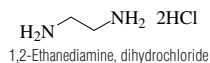
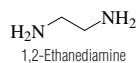
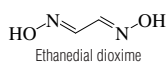
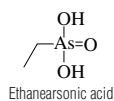
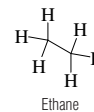
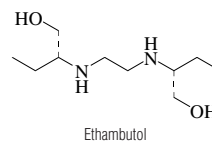
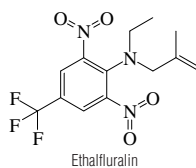
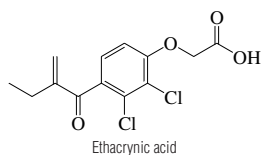
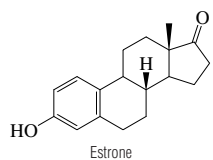
| No.  | Name                                                | Synonym                                                                           | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form        | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-----------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------|------------|----------|----------------------|---------|----------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 4681 | Eicosane                                            | Icosane                                                                           | C <sub>20</sub> H <sub>42</sub>                                | 112-95-8   | 282.547  | lf (al)              | 36.6    | 343                                    | 0.7886 <sup>20</sup>       | 1.4425 <sup>20</sup> | i H <sub>2</sub> O; s eth, peth, bz; sl chl; vs ace  |
| 4682 | Eicosanedioic acid                                  | 1,18-Octadecanedicarboxylic acid                                                  | C <sub>20</sub> H <sub>38</sub> O <sub>4</sub>                 | 2424-92-2  | 342.514  | cry (bz,al)          | 125.5   | 233 <sup>2</sup>                       |                            |                      | s eth                                                |
| 4683 | Eicosanoic acid                                     | Arachidic acid                                                                    | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>                 | 506-30-9   | 312.531  | pl (al)              | 76.5    | dec 328; 204 <sup>1</sup>              | 0.8240 <sup>100</sup>      | 1.425 <sup>100</sup> | i H <sub>2</sub> O; sl EtOH; vs eth; s bz, chl       |
| 4684 | 1-Eicosanol                                         | Arachic alcohol                                                                   | C <sub>20</sub> H <sub>42</sub> O                              | 629-96-9   | 298.546  | wax (al), cry (chl)  | 65.4    | 356; 222 <sup>3</sup>                  | 0.8405 <sup>20</sup>       | 1.4350 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH, chl; vs ace; s bz, peth |
| 4685 | 5,8,11,14-Eicosatetraenoic acid, (all- <i>cis</i> ) | Arachidonic acid                                                                  | C <sub>20</sub> H <sub>32</sub> O <sub>2</sub>                 | 506-32-1   | 304.467  |                      | -49.5   | 163 <sup>1</sup>                       | 0.9082 <sup>20</sup>       | 1.4824 <sup>20</sup> | i H <sub>2</sub> O; vs ace, eth, EtOH, peth          |
| 4686 | 1-Eicosene                                          |                                                                                   | C <sub>20</sub> H <sub>40</sub>                                | 3452-07-1  | 280.532  |                      | 28.5    | 341; 151 <sup>2</sup>                  | 0.7882 <sup>30</sup>       | 1.4440 <sup>30</sup> | i H <sub>2</sub> O; s bz, peth                       |
| 4687 | <i>cis</i> -9-Eicosenoic acid                       |                                                                                   | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub>                 | 29204-02-2 | 310.515  |                      | 24.5    | 220 <sup>6</sup>                       | 0.8882 <sup>25</sup>       |                      |                                                      |
| 4688 | <i>trans</i> -9-Eicosenoic acid                     |                                                                                   | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub>                 | 506-31-0   | 310.515  |                      | 54      |                                        |                            |                      |                                                      |
| 4689 | 11-Eicosenoic acid                                  |                                                                                   | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub>                 | 2462-94-4  | 310.515  |                      | 24      | 267 <sup>15</sup>                      | 0.8826 <sup>25</sup>       |                      | vs EtOH, MeOH                                        |
| 4690 | Elaidic acid                                        | <i>trans</i> -9-Octadecenoic acid                                                 | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>                 | 112-79-8   | 282.462  | pl (al)              | 45      | 288 <sup>100</sup> , 234 <sup>15</sup> | 0.8734 <sup>45</sup>       | 1.4499 <sup>45</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl             |
| 4691 | Elaiomycin                                          |                                                                                   | C <sub>13</sub> H <sub>26</sub> N <sub>2</sub> O <sub>3</sub>  | 23315-05-1 | 258.356  | ye oil               |         |                                        |                            | 1.4798 <sup>25</sup> | sl H <sub>2</sub> O; s os                            |
| 4692 | 1,3-Elemadien-11-ol                                 | Elemol                                                                            | C <sub>15</sub> H <sub>26</sub> O                              | 639-99-6   | 222.366  | cry (al)             | 52.5    | 142 <sup>12</sup>                      | 0.9345 <sup>18</sup>       | 1.4980 <sup>18</sup> |                                                      |
| 4693 | β-Elementene                                        |                                                                                   | C <sub>15</sub> H <sub>24</sub>                                | 33880-83-0 | 204.352  |                      |         | 120 <sup>16</sup> , 104 <sup>11</sup>  | 0.8749 <sup>20</sup>       | 1.4935 <sup>20</sup> |                                                      |
| 4694 | Embelin                                             | 2,5-Dihydroxy-3-undecyl-2,5-cyclohexadiene-1,4-dione                              | C <sub>17</sub> H <sub>26</sub> O <sub>4</sub>                 | 550-24-3   | 294.386  | oran pl (al)         | 142.5   |                                        |                            |                      | vs bz, eth, EtOH                                     |
| 4695 | Emetine                                             | 6',7',10,11-Tetramethoxyemetan                                                    | C <sub>29</sub> H <sub>40</sub> N <sub>2</sub> O <sub>4</sub>  | 483-18-1   | 480.639  | amor pow             | 74      |                                        |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace; sl bz, chl     |
| 4696 | Emylcamate                                          | 3-Methyl-3-pentanol, carbamate                                                    | C <sub>7</sub> H <sub>15</sub> NO <sub>2</sub>                 | 78-28-4    | 145.200  | nd                   | 57      | 35 <sup>1</sup>                        |                            |                      | sl H <sub>2</sub> O; vs bz, eth, EtOH                |
| 4697 | Enallylpropymal                                     |                                                                                   | C <sub>11</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub>  | 1861-21-8  | 224.256  | cry (w, dil al)      | 56.5    | 177 <sup>12</sup>                      |                            |                      | vs bz, eth, EtOH, chl                                |
| 4698 | Endosulfan                                          |                                                                                   | C <sub>9</sub> H <sub>6</sub> Cl <sub>6</sub> O <sub>3</sub> S | 115-29-7   | 406.925  |                      | 106     | 106 <sup>0.7</sup>                     | 1.745 <sup>20</sup>        |                      |                                                      |
| 4699 | Endosulfan sulfate                                  |                                                                                   | C <sub>9</sub> H <sub>6</sub> Cl <sub>6</sub> O <sub>4</sub> S | 1031-07-8  | 422.925  | cry (cyhex)          | 181     |                                        |                            |                      |                                                      |
| 4700 | Endothall disodium                                  |                                                                                   | C <sub>8</sub> H <sub>10</sub> Na <sub>2</sub> O <sub>5</sub>  | 145-73-3   | 232.142  |                      | 144     |                                        | 1.431 <sup>20</sup>        |                      |                                                      |
| 4701 | Endrin                                              |                                                                                   | C <sub>12</sub> H <sub>6</sub> Cl <sub>6</sub> O               | 72-20-8    | 380.909  | cry                  | dec 245 |                                        |                            |                      | vs ace, bz, xyl; s ctc, hx                           |
| 4702 | Enflurane                                           |                                                                                   | C <sub>3</sub> H <sub>2</sub> ClF <sub>5</sub> O               | 13838-16-9 | 184.492  | liq                  |         | 56.5                                   | 1.5121 <sup>25</sup>       | 1.3025 <sup>20</sup> | vs os                                                |
| 4703 | Ephedrine, (±)                                      | α-[1-(Methylamino)ethyl] benzenemethanol, ( <i>R</i> *, <i>S</i> *)-(±)-          | C <sub>10</sub> H <sub>15</sub> NO                             | 90-81-3    | 165.232  | nd (eth, peth)       | 76.5    | 135 <sup>12</sup>                      | 1.1220 <sup>20</sup>       |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl               |
| 4704 | <i>d</i> -Ephedrine                                 | α-[1-(Methylamino)ethyl] benzenemethanol, [ <i>S</i> -( <i>R</i> *, <i>S</i> *)]- | C <sub>10</sub> H <sub>15</sub> NO                             | 321-98-2   | 165.232  | pl (w)               | 40      | 225                                    |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl               |
| 4705 | <i>l</i> -Ephedrine                                 | α-[1-(Methylamino)ethyl] benzenemethanol, [ <i>R</i> -( <i>R</i> *, <i>S</i> *)]- | C <sub>10</sub> H <sub>15</sub> NO                             | 299-42-3   | 165.232  | pl (w + 1)           | 40      | 225                                    | 1.0085 <sup>22</sup>       |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl               |
| 4706 | Ephedrine hydrochloride                             | 2-(Methylamino)-1-phenyl-1-propanol, hydrochloride                                | C <sub>10</sub> H <sub>16</sub> ClNO                           | 50-98-6    | 201.693  | orth nd              | 219     |                                        | 1.0208 <sup>20</sup>       |                      |                                                      |
| 4707 | Epichlorohydrin                                     | (Chloromethyl)oxirane                                                             | C <sub>3</sub> H <sub>5</sub> ClO                              | 13403-37-7 | 92.524   | liq                  | -26     | 118; 62 <sup>100</sup>                 | 1.1812 <sup>20</sup>       | 1.4358 <sup>25</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s bz, ctc        |
| 4708 | Epinephrine                                         | <i>D</i> -Adrenaline                                                              | C <sub>9</sub> H <sub>13</sub> NO <sub>3</sub>                 | 51-43-4    | 183.204  | br (in air)          | 211.5   |                                        |                            |                      | sl H <sub>2</sub> O; i EtOH; s HOAc, acid            |
| 4709 | Epiquinidine                                        |                                                                                   | C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>  | 572-59-8   | 324.417  | cry (AcOEt) lf (eth) | 113     |                                        |                            |                      | vs EtOH; s eth                                       |
| 4710 | 1,2-Epoxybutane                                     | Ethyloxirane                                                                      | C <sub>4</sub> H <sub>8</sub> O                                | 106-88-7   | 72.106   | liq                  | -150    | 63.4                                   | 0.8297 <sup>20</sup>       | 1.3851 <sup>20</sup> | vs EtOH, ace; msc eth                                |
| 4711 | 1,2-Epoxy-4-(epoxyethyl)cyclohexane                 | 4-Vinyl-1-cyclohexene dioxide                                                     | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                  | 106-87-6   | 140.180  |                      | <-55    | 227                                    | 1.0966 <sup>20</sup>       | 1.4787 <sup>20</sup> | vs H <sub>2</sub> O                                  |
| 4712 | 1,2-Epoxyhexadecane                                 | Tetradecyloxirane                                                                 | C <sub>16</sub> H <sub>32</sub> O                              | 7320-37-8  | 240.424  | hyg cry or liq       | 24.1    | 178 <sup>12</sup>                      | 0.846                      | 1.2240               |                                                      |
| 4713 | 1,2-Epoxyoctadecane                                 | Hexadecyloxirane                                                                  | C <sub>18</sub> H <sub>36</sub> O                              | 7390-81-0  | 268.478  | hyg cry              | 26.1    | 137 <sup>0.5</sup>                     |                            |                      |                                                      |
| 4714 | 2,3-Epoxy-α-pinane                                  |                                                                                   | C <sub>10</sub> H <sub>16</sub> O                              | 1686-14-2  | 152.233  |                      |         | 85 <sup>24</sup>                       |                            |                      |                                                      |
| 4715 | 2,3-Epoxypropyl acrylate                            | Glycidyl acrylate                                                                 | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                   | 106-90-1   | 128.126  |                      |         | 53 <sup>10</sup>                       | 1.1109 <sup>20</sup>       | 1.4490 <sup>20</sup> | vs bz                                                |
| 4716 | 2,3-Epoxypropyl methacrylate                        | Glycidol methacrylate                                                             | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                  | 106-91-2   | 142.152  |                      |         | 189; 75 <sup>10</sup>                  | 1.042 <sup>20</sup>        | 1.448 <sup>25</sup>  | vs bz, eth, EtOH                                     |
| 4717 | Equol                                               |                                                                                   | C <sub>14</sub> H <sub>14</sub> O <sub>3</sub>                 | 531-95-3   | 230.259  | cry (aq, al)         | 189.5   |                                        |                            |                      |                                                      |
| 4718 | Ergocornine                                         |                                                                                   | C <sub>31</sub> H <sub>39</sub> N <sub>5</sub> O <sub>3</sub>  | 564-36-3   | 561.673  | cry (MeOH)           | 183 dec |                                        |                            |                      | i H <sub>2</sub> O; s EtOH, ace, bz, chl, AcOEt      |
| 4719 | Ergocorninine                                       |                                                                                   | C <sub>31</sub> H <sub>39</sub> N <sub>5</sub> O <sub>3</sub>  | 564-37-4   | 561.673  | lo pr (al)           | 228 dec |                                        |                            |                      | vs ace, bz, EtOH, chl                                |
| 4720 | Ergocristine                                        |                                                                                   | C <sub>35</sub> H <sub>39</sub> N <sub>5</sub> O <sub>3</sub>  | 511-08-0   | 609.716  | orth (bz)            | 175 dec |                                        |                            |                      | i H <sub>2</sub> O; s EtOH, ace, chl                 |
| 4721 | Ergocristinine                                      |                                                                                   | C <sub>35</sub> H <sub>39</sub> N <sub>5</sub> O <sub>3</sub>  | 511-07-9   | 609.716  | pr (al)              | 237 dec |                                        |                            |                      | i H <sub>2</sub> O; sl EtOH, ace, chl                |
| 4722 | Ergocryptine                                        |                                                                                   | C <sub>32</sub> H <sub>41</sub> N <sub>5</sub> O <sub>3</sub>  | 511-09-1   | 575.699  | pr (al)              | 213 dec |                                        |                            |                      | i H <sub>2</sub> O; s EtOH, chl                      |
| 4723 | Ergocryptinine                                      |                                                                                   | C <sub>33</sub> H <sub>41</sub> N <sub>5</sub> O <sub>3</sub>  | 511-10-4   | 587.710  | lo pr (al)           | 245 dec |                                        |                            |                      | vs ace, chl                                          |



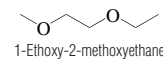
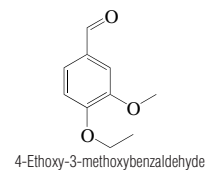
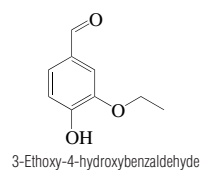
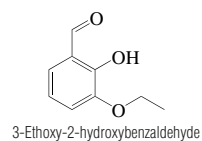
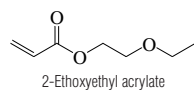
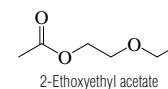
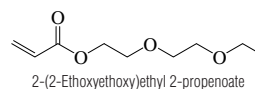
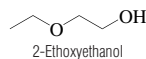
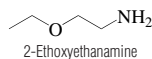
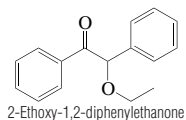
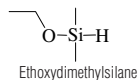
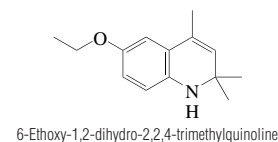
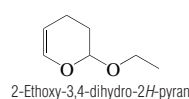
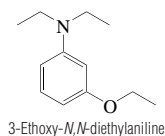
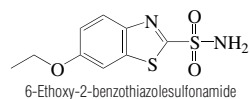
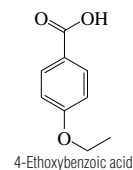
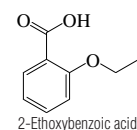
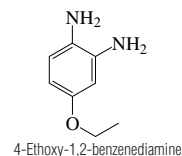
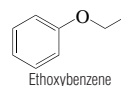
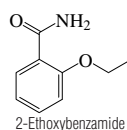
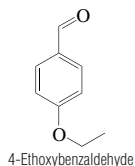
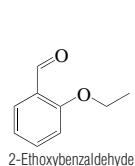
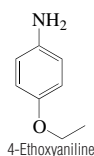
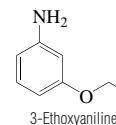
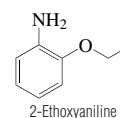
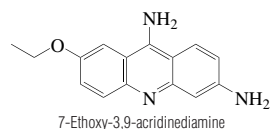
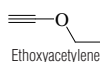
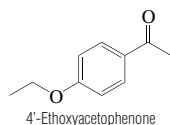
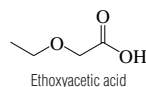
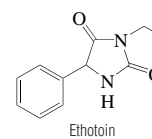
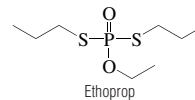
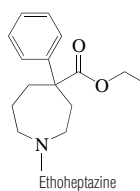
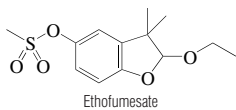
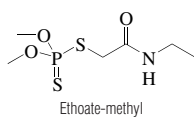
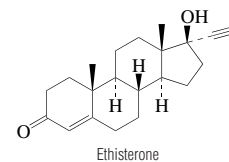
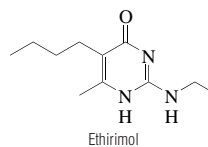
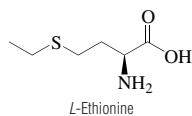
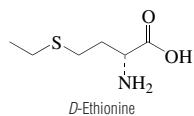
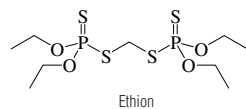
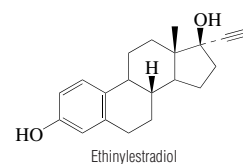
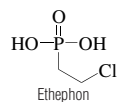
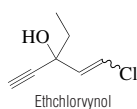
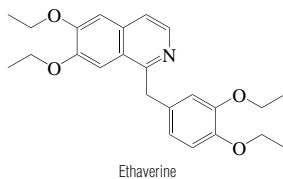
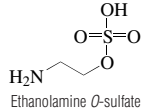
| No.  | Name                                               | Synonym                                                   | Mol. Form.                                                        | CAS RN     | Mol. Wt. | Physical Form             | mp/°C              | bp/°C               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub> | Solubility                                         |
|------|----------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------|------------|----------|---------------------------|--------------------|---------------------|----------------------------|----------------|----------------------------------------------------|
| 4724 | Ergometrinine                                      |                                                           | C <sub>19</sub> H <sub>23</sub> N <sub>3</sub> O <sub>2</sub>     | 479-00-5   | 325.405  | pr (ace)                  | 196 dec            |                     |                            |                | vs chl                                             |
| 4725 | Ergonovine                                         | Ergometrine                                               | C <sub>19</sub> H <sub>23</sub> N <sub>3</sub> O <sub>2</sub>     | 60-79-7    | 325.405  | pl or nd                  | 162 dec            |                     |                            |                | s H <sub>2</sub> O, ace; vs EtOH; sl chl           |
| 4726 | Ergosine                                           |                                                           | C <sub>30</sub> H <sub>37</sub> N <sub>5</sub> O <sub>5</sub>     | 561-94-4   | 547.646  | pr (MeOH, AcOEt)          | 228 dec            |                     |                            |                | s ace, chl; sl MeOH                                |
| 4727 | Ergostane, (5α)                                    |                                                           | C <sub>28</sub> H <sub>50</sub>                                   | 511-20-6   | 386.697  | lf or pl (ace, eth- MeOH) | 85                 |                     |                            |                | vs ace, eth, chl                                   |
| 4728 | Ergostane, (5β)                                    | Coproergostane                                            | C <sub>28</sub> H <sub>50</sub>                                   | 511-21-7   | 386.697  | nd (ace)                  | 64                 |                     |                            |                | vs eth, chl                                        |
| 4729 | Ergostan-3-ol, (3β,5α)                             | Ergostanol                                                | C <sub>28</sub> H <sub>50</sub> O                                 | 6538-02-9  | 402.696  | nd (MeOH-eth)             | 144.5              |                     |                            |                | i H <sub>2</sub> O; s eth, chl                     |
| 4730 | Ergosta-5,7,9(11),22-tetraen-3-ol, (3β,22E)        | Dehydroergosterol                                         | C <sub>28</sub> H <sub>42</sub> O                                 | 516-85-8   | 394.632  | lf (al) nd (eth), pl (al) | 146                | 230 <sup>0.5</sup>  |                            |                | vs ace, bz, eth, EtOH                              |
| 4731 | Ergosta-5,7,22-trien-3-ol, (3β,22E)                | Ergosterol                                                | C <sub>28</sub> H <sub>44</sub> O                                 | 57-87-4    | 396.648  | pl (+w, al) nd (eth)      | 170                | 250 <sup>0.01</sup> |                            |                | i H <sub>2</sub> O; sl EtOH, eth, peth; s bz, chl  |
| 4732 | Ergosta-5,7,22-trien-3-ol, (3β,10α,22E)            | Pyrocalciferol                                            | C <sub>28</sub> H <sub>44</sub> O                                 | 128-27-8   | 396.648  | nd (MeOH)                 | 94                 |                     |                            |                | i H <sub>2</sub> O; s EtOH, chl, MeOH              |
| 4733 | Ergosta-5,7,22-trien-3-ol, (3β,9β,10α,22E)         | Lumisterol                                                | C <sub>28</sub> H <sub>44</sub> O                                 | 474-69-1   | 396.648  | nd (ace-MeOH)             | 118                |                     |                            |                | i H <sub>2</sub> O; s EtOH, HOAc; vs eth, ace, chl |
| 4734 | Ergost-5-en-3-ol, (3β,24R)                         | Campesterol                                               | C <sub>28</sub> H <sub>48</sub> O                                 | 474-62-4   | 400.680  | cry (ace)                 | 157.5              |                     |                            |                |                                                    |
| 4735 | Ergost-7-en-3-ol, (3β,5α)                          | γ-Ergosterol                                              | C <sub>28</sub> H <sub>48</sub> O                                 | 516-78-9   | 400.680  | nd (MeOH) cry (PrOH)      | 146                |                     |                            |                | s eth                                              |
| 4736 | Ergost-8(14)-en-3-ol, (3β,5α)                      | α-Ergosterol                                              | C <sub>28</sub> H <sub>48</sub> O                                 | 632-32-6   | 400.680  | lf or nd (MeOH)           | 131                |                     |                            |                | sl EtOH; s eth, bz, chl                            |
| 4737 | Ergotamine                                         |                                                           | C <sub>33</sub> H <sub>55</sub> N <sub>5</sub> O <sub>5</sub>     | 113-15-5   | 601.821  | nd (al), pr (bz) pl (ace) | 213 dec            |                     |                            |                | vs bz, eth, chl                                    |
| 4738 | Ergotamine tartrate (2:1)                          | Gynergen                                                  | C <sub>35</sub> H <sub>58</sub> N <sub>5</sub> O <sub>8</sub>     | 379-79-3   | 656.706  |                           | 192 dec            |                     |                            |                |                                                    |
| 4739 | Ergotaminine                                       |                                                           | C <sub>33</sub> H <sub>55</sub> N <sub>5</sub> O <sub>5</sub>     | 639-81-6   | 581.662  | orth pl (MeOH) pl (al)    | 252 dec            |                     |                            |                | i H <sub>2</sub> O; sl EtOH, ace, bz; s chl; vs py |
| 4740 | Ergothioneine                                      |                                                           | C <sub>9</sub> H <sub>15</sub> N <sub>3</sub> O <sub>2</sub> S    | 497-30-3   | 229.299  | nd or lf (dil EtOH)       | 290 dec            |                     |                            |                | vs H <sub>2</sub> O; sl EtOH, ace; i eth, bz, chl  |
| 4741 | Eriochrome Black T                                 |                                                           | C <sub>20</sub> H <sub>12</sub> N <sub>3</sub> NaO <sub>7</sub> S | 1787-61-7  | 461.380  | br-blk pow                |                    |                     |                            |                | s H <sub>2</sub> O, EtOH, MeOH                     |
| 4742 | Eriodictyol                                        | 3',4',5,7-Tetrahydroxyflavanone, (S)                      | C <sub>15</sub> H <sub>12</sub> O <sub>6</sub>                    | 552-58-9   | 288.252  | pl or nd (EtOH)           | 267 dec            |                     |                            |                | vs EtOH, HOAc                                      |
| 4743 | Erythorbic acid                                    | Isoascorbic acid                                          | C <sub>8</sub> H <sub>8</sub> O <sub>6</sub>                      | 89-65-6    | 176.124  | gran cry                  | 168                |                     |                            |                | s H <sub>2</sub> O, py; sl ace                     |
| 4744 | β-Erythroidine                                     |                                                           | C <sub>16</sub> H <sub>19</sub> NO <sub>3</sub>                   | 466-81-9   | 273.327  | cry (al)                  | 99.5               |                     |                            |                | s H <sub>2</sub> O, eth, chl; vs EtOH, bz          |
| 4745 | Erythromycin                                       | Propiocrine                                               | C <sub>37</sub> H <sub>67</sub> NO <sub>13</sub>                  | 114-07-8   | 733.927  | cry (w)                   | 191                |                     |                            |                | vs ace, eth, EtOH, chl                             |
| 4746 | Erythromycin ethyl succinate                       |                                                           | C <sub>43</sub> H <sub>75</sub> NO <sub>16</sub>                  | 1264-62-6  | 862.053  | cry (ace aq)              | 222                |                     |                            |                |                                                    |
| 4747 | Erythromycin stearate                              |                                                           | C <sub>55</sub> H <sub>103</sub> NO <sub>15</sub>                 | 643-22-1   | 1018.405 | cry                       | 92                 |                     |                            |                | i H <sub>2</sub> O; sl EtOH, eth, chl              |
| 4748 | Erythrophleine                                     | Norcassamidine                                            | C <sub>24</sub> H <sub>39</sub> NO <sub>5</sub>                   | 36150-73-9 | 421.571  | glass                     | 115                |                     |                            |                | s H <sub>2</sub> O, EtOH                           |
| 4749 | D-Erythrose                                        |                                                           | C <sub>4</sub> H <sub>8</sub> O <sub>4</sub>                      | 583-50-6   | 120.105  | syr                       |                    |                     |                            |                | s H <sub>2</sub> O; vs EtOH                        |
| 4750 | L-Erythrose                                        |                                                           | C <sub>4</sub> H <sub>8</sub> O <sub>4</sub>                      | 533-49-3   | 120.105  | syr                       |                    |                     |                            |                | vs H <sub>2</sub> O, EtOH                          |
| 4751 | D-Erythrose 4-phosphate                            | 2,3-Dihydroxy-4-(phosphonoxy)butanal                      | C <sub>4</sub> H <sub>8</sub> O <sub>7</sub> P                    | 585-18-2   | 200.084  | stab in aq soln only      |                    |                     |                            |                | s H <sub>2</sub> O                                 |
| 4752 | Erythrosine                                        |                                                           | C <sub>20</sub> H <sub>16</sub> I <sub>4</sub> O <sub>5</sub>     | 15905-32-5 | 835.893  | br pow (Na salt)          |                    |                     |                            |                | s H <sub>2</sub> ; vs eth, EtOH                    |
| 4753 | L-Erythrulose                                      |                                                           | C <sub>4</sub> H <sub>8</sub> O <sub>4</sub>                      | 533-50-6   | 120.105  | syr                       | dec                | dec                 |                            |                | vs H <sub>2</sub> O, EtOH                          |
| 4754 | Esaprazole                                         | N-Cyclohexyl-1-piperazineacetamide                        | C <sub>12</sub> H <sub>23</sub> N <sub>3</sub> O                  | 64204-55-3 | 225.330  |                           | 112                | 190 <sup>0.5</sup>  |                            |                |                                                    |
| 4755 | Esculin                                            | 6-(β-D-Glucopyranosyloxy)-7-hydroxy-2H-1-benzopyran-2-one | C <sub>15</sub> H <sub>16</sub> O <sub>9</sub>                    | 531-75-9   | 340.283  | pr (w+2)                  | 205 (pentahydrate) |                     |                            |                | sl H <sub>2</sub> O, EtOH, eth; s chl, py, HOAc    |
| 4756 | Eserine sulfate                                    | Physostigmine sulfate                                     | C <sub>30</sub> H <sub>44</sub> N <sub>6</sub> O <sub>8</sub> S   | 64-47-1    | 648.770  | hyg cry (ace-eth)         | 141                |                     |                            |                | vs ace, EtOH                                       |
| 4757 | Estra-1,3,5(10)-triene-3,17-diol, (17α)            | α-Estradiol                                               | C <sub>18</sub> H <sub>24</sub> O <sub>2</sub>                    | 57-91-0    | 272.383  | nd (+1/2 w) (80% al)      | 221.5              |                     |                            |                | i H <sub>2</sub> O; s EtOH, ace; sl eth, bz        |
| 4758 | Estra-1,3,5(10)-triene-3,17-diol (17β)             | β-Estradiol                                               | C <sub>18</sub> H <sub>24</sub> O <sub>2</sub>                    | 50-28-2    | 272.383  | pr (80% al),              | 178.5              |                     |                            |                | vs ace, EtOH, Diox                                 |
| 4759 | Estra-1,3,5(10)-triene-3,17-diol, (8α,17β)         | Isoestradiol                                              | C <sub>18</sub> H <sub>24</sub> O <sub>2</sub>                    | 517-04-4   | 272.383  | cry (dil MeOH-chl)        | 181                |                     |                            |                | s EtOH, diox                                       |
| 4760 | Estra-1,3,5(10)-triene-3,17-diol 3-benzoate, (17β) | Estradiol benzoate                                        | C <sub>25</sub> H <sub>28</sub> O <sub>3</sub>                    | 50-50-0    | 376.488  |                           | 196                |                     |                            |                |                                                    |
| 4761 | Estra-1,3,5(10)-triene-3,16,17-triol, (16α,17β)    | Estriol                                                   | C <sub>18</sub> H <sub>24</sub> O <sub>3</sub>                    | 50-27-1    | 288.382  | lf (al), mcl (dil al)     | 288 dec            |                     | 1.27 <sup>25</sup>         |                | s EtOH; sl eth, bz, tfa; vs py                     |
| 4762 | Estra-1,3,5(10)-triene-3,16,17-triol, (16β,17β)    | 16-Epiestriol                                             | C <sub>18</sub> H <sub>24</sub> O <sub>3</sub>                    | 547-81-9   | 288.382  | cry (MeOH-bz)             | 290                |                     |                            |                |                                                    |



| No.  | Name                                          | Synonym                          | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form                   | mp/°C   | bp/°C              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|-----------------------------------------------|----------------------------------|------------------------------------------------------------------------------|------------|----------|---------------------------------|---------|--------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 4763 | Estrone                                       |                                  | C <sub>18</sub> H <sub>22</sub> O <sub>2</sub>                               | 53-16-7    | 270.367  | mcl, orth (al)                  | 260.2   |                    | 1.236 <sup>25</sup>        |                      | i H <sub>2</sub> O; sl EtOH, eth, bz; s ace, diox            |
| 4764 | Ethacrynic acid                               |                                  | C <sub>13</sub> H <sub>12</sub> Cl <sub>2</sub> O <sub>4</sub>               | 58-54-8    | 303.138  |                                 | 122.5   |                    |                            |                      |                                                              |
| 4765 | Ethalfuralin                                  |                                  | C <sub>13</sub> H <sub>14</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub> | 55283-68-6 | 333.263  |                                 | 57      | dec 256            |                            |                      |                                                              |
| 4766 | Ethambutol                                    |                                  | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>                | 74-55-5    | 204.310  | cry                             | 89      |                    |                            |                      | sl H <sub>2</sub> O; s bz, chl                               |
| 4767 | Ethane                                        |                                  | C <sub>2</sub> H <sub>6</sub>                                                | 74-84-0    | 30.069   | col gas                         | -182.79 | -88.6              | 0.5446 <sup>89</sup>       |                      | i H <sub>2</sub> O; vs bz                                    |
| 4768 | Ethane arsonic acid                           |                                  | C <sub>2</sub> H <sub>7</sub> AsO <sub>3</sub>                               | 507-32-4   | 153.997  | nd (al), orth<br>nd (w)         | 99.5    | 210 <sup>12</sup>  |                            |                      | vs H <sub>2</sub> O, EtOH                                    |
| 4769 | Ethanedial dioxime                            |                                  | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>                  | 557-30-2   | 88.065   | orth pl (w)                     | 178 dec | sub                |                            |                      | vs H <sub>2</sub> O, EtOH, eth                               |
| 4770 | 1,2-Ethanediamine                             | Ethylenediamine                  | C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                                 | 107-15-3   | 60.098   |                                 | 11.14   | 117                | 0.8979 <sup>20</sup>       | 1.4565 <sup>20</sup> | vs H <sub>2</sub> O; msc EtOH; i eth, bz; s ctc              |
| 4771 | 1,2-Ethanediamine, dihydrochloride            | Ethylenediamine dihydrochloride  | C <sub>2</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub>                | 333-18-6   | 133.019  |                                 |         |                    |                            | 1.633                | vs H <sub>2</sub> O                                          |
| 4772 | 1,2-Ethanediol                                | Ethylene glycol                  | C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>                                 | 107-21-1   | 62.068   | liq                             | -12.69  | 197.3              | 1.1135 <sup>20</sup>       | 1.4318 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, ace; s eth, chl; sl bz           |
| 4773 | 1,2-Ethanediol, bis(4-methylbenzenesulfonate) |                                  | C <sub>16</sub> H <sub>18</sub> O <sub>6</sub> S <sub>2</sub>                | 6315-52-2  | 370.440  | cry (bz)                        | 128     |                    |                            |                      |                                                              |
| 4774 | 1,1-Ethanediol, diacetate                     | Ethylidene diacetate             | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                                | 542-10-9   | 146.141  |                                 | 18.9    | 169                | 1.070 <sup>25</sup>        | 1.3985 <sup>25</sup> | vs eth, EtOH                                                 |
| 4775 | 1,2-Ethanediol, diacetate                     | Ethylene glycol diacetate        | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                                | 111-55-7   | 146.141  | liq                             | -31     | 190                | 1.1043 <sup>20</sup>       | 1.4159 <sup>20</sup> | vs H <sub>2</sub> O; msc EtOH, eth, ace, bz, CS <sub>2</sub> |
| 4776 | 1,2-Ethanediol, diacrylate                    | Ethylene glycol diacrylate       | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>                                | 2274-11-5  | 170.163  | liq                             |         | 55 <sup>0,6</sup>  | 1.0935 <sup>26</sup>       |                      |                                                              |
| 4777 | 1,2-Ethanediol, dibenzoate                    | Ethylene glycol dibenzoate       | C <sub>16</sub> H <sub>14</sub> O <sub>4</sub>                               | 94-49-5    | 270.280  | orth pr (eth)                   | 73.5    | dec 360            |                            |                      | i H <sub>2</sub> O; s eth, chl                               |
| 4778 | 1,2-Ethanediol, didodecanoate                 | Ethylene glycol didodecanoate    | C <sub>26</sub> H <sub>50</sub> O <sub>4</sub>                               | 624-04-4   | 426.673  | pl (al)                         | 56.6    | 188 <sup>20</sup>  |                            |                      | vs eth, EtOH                                                 |
| 4779 | 1,2-Ethanediol, diformate                     | Ethylene glycol diformate        | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                                 | 629-15-2   | 118.089  |                                 |         | 174                | 1.193 <sup>0</sup>         | 1.3580               | sl H <sub>2</sub> O; s EtOH, eth                             |
| 4780 | 1,2-Ethanediol, dihexadecanoate               | Ethylene glycol dipalmitate      | C <sub>34</sub> H <sub>66</sub> O <sub>4</sub>                               | 624-03-3   | 538.886  | lf or nd (al-chl)               | 72      |                    | 0.8594 <sup>78</sup>       |                      | i H <sub>2</sub> O, EtOH; s eth; vs ace                      |
| 4781 | 1,2-Ethanediol, dimethacrylate                | Ethylene glycol dimethacrylate   | C <sub>10</sub> H <sub>14</sub> O <sub>4</sub>                               | 97-90-5    | 198.216  | liq                             | -40     | 260                | 1.053 <sup>20</sup>        | 1.4532 <sup>25</sup> | vs bz, EtOH, lig                                             |
| 4782 | 1,2-Ethanediol, dinitrate                     | Ethylene glycol dinitrate        | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>                  | 628-96-6   | 152.062  | ye liq                          | -22.3   | 198.5              | 1.4918 <sup>20</sup>       |                      | vs eth, EtOH                                                 |
| 4783 | 1,2-Ethanediol, distearate                    | Ethylene glycol distearate       | C <sub>38</sub> H <sub>74</sub> O <sub>4</sub>                               | 627-83-8   | 594.993  | lf                              | 79      | 241 <sup>20</sup>  | 0.8581 <sup>78</sup>       |                      | i H <sub>2</sub> O, EtOH; vs eth, ace                        |
| 4784 | 1,2-Ethanediol, ditetradecanoate              | Ethylene glycol ditetradecanoate | C <sub>30</sub> H <sub>58</sub> O <sub>4</sub>                               | 627-84-9   | 482.780  | cry (eth, ace)                  | 65      | 208 <sup>20</sup>  | 0.8600 <sup>90</sup>       |                      | i H <sub>2</sub> O, EtOH; s eth; vs ace, bz, ctc             |
| 4785 | 1,2-Ethanediol, dithiocyanate                 | Ethylene glycol dithiocyanate    | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> S <sub>2</sub>                  | 629-17-4   | 144.218  | orth pl or nd (w)               | 90      | dec                | 1.4200 <sup>9</sup>        |                      | sl H <sub>2</sub> O, bz; s EtOH, eth; vs ace                 |
| 4786 | 1,2-Ethanediol, monoacetate                   | Ethylene glycol monoacetate      | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                                 | 542-59-6   | 104.105  |                                 |         | 188                | 1.108 <sup>15</sup>        |                      | msc H <sub>2</sub> O, EtOH, eth                              |
| 4787 | 1,2-Ethanediol, monobenzoate                  | Ethylene glycol monobenzoate     | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                                | 94-33-7    | 166.173  |                                 | 45      | 150 <sup>10</sup>  | 1.1101 <sup>30</sup>       |                      | vs EtOH                                                      |
| 4788 | 1,2-Ethanediol, monostearate                  | Ethylene glycol monostearate     | C <sub>20</sub> H <sub>40</sub> O <sub>3</sub>                               | 111-60-4   | 328.530  | cry (peth)                      | 60.5    | 190 <sup>3</sup>   | 0.8780 <sup>60</sup>       | 1.4310 <sup>60</sup> | sl EtOH; s eth                                               |
| 4789 | 1,2-Ethanediol, monosulfite                   | Ethylene glycol monosulfite      | C <sub>2</sub> H <sub>4</sub> O <sub>3</sub> S                               | 3741-38-6  | 108.116  | liq                             | -11     | 173                | 1.4402 <sup>20</sup>       | 1.4463 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth, ace, bz, AcOEt; sl chl       |
| 4790 | 1,2-Ethanediphosphonic acid                   | 1,2-Diphosphonoethane            | C <sub>2</sub> H <sub>6</sub> O <sub>6</sub> P <sub>2</sub>                  | 6145-31-9  | 190.029  | nd (EtOH/eth)                   | 223     |                    |                            |                      |                                                              |
| 4791 | 1,2-Ethanedisulfonic acid                     | Ethylene disulfonic acid         | C <sub>2</sub> H <sub>6</sub> O <sub>6</sub> S <sub>2</sub>                  | 110-04-3   | 190.195  |                                 | 173     |                    |                            |                      | vs diox                                                      |
| 4792 | Ethanedithioamide                             | Rubeanic acid                    | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> S <sub>2</sub>                  | 79-40-3    | 120.196  | red cry                         | 170 dec |                    |                            |                      | sl H <sub>2</sub> O, EtOH; s con sulf                        |
| 4793 | 1,2-Ethanedithiol                             | Ethylene dimercaptan             | C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>                                 | 540-63-6   | 94.199   | liq                             | -41.2   | 146.1              | 1.234 <sup>20</sup>        | 1.5590 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz; vs alk             |
| 4794 | 1,2-Ethanedithiol mercaptoacetate             |                                  | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub> S <sub>2</sub>                 | 123-81-9   | 210.271  |                                 |         | 138 <sup>1,5</sup> |                            |                      |                                                              |
| 4795 | Ethanesulfonic acid                           | Ethylsulfonic acid               | C <sub>2</sub> H <sub>6</sub> O <sub>3</sub> S                               | 594-45-6   | 110.132  | hyg                             | -17     | 123 <sup>1</sup>   | 1.3341 <sup>25</sup>       | 1.4335 <sup>20</sup> | vs H <sub>2</sub> O, EtOH                                    |
| 4796 | Ethanesulfonyl chloride                       |                                  | C <sub>2</sub> H <sub>5</sub> ClO <sub>2</sub> S                             | 594-44-5   | 128.578  | pa ye                           |         | 174                | 1.357 <sup>22</sup>        | 1.4531 <sup>20</sup> | vs eth; s CS <sub>2</sub>                                    |
| 4797 | Ethanethiol                                   | Ethyl mercaptan                  | C <sub>2</sub> H <sub>6</sub> S                                              | 75-08-1    | 62.134   | liq                             | -147.88 | 35.0               | 0.8315 <sup>25</sup>       | 1.4310 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, dil alk               |
| 4798 | Ethanimidamide                                |                                  | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub>                                 | 143-37-3   | 58.082   |                                 | -35     |                    |                            |                      | sl H <sub>2</sub> O; s EtOH, acid                            |
| 4799 | Ethanimidamide monohydrochloride              | Acetamidine hydrochloride        | C <sub>2</sub> H <sub>7</sub> ClN <sub>2</sub>                               | 124-42-5   | 94.543   | nd or pr (al)<br>hyg lo pr (al) | 177.5   |                    |                            |                      | vs H <sub>2</sub> O, EtOH                                    |
| 4800 | Ethanol                                       | Ethyl alcohol                    | C <sub>2</sub> H <sub>6</sub> O                                              | 64-17-5    | 46.068   | liq                             | -114.14 | 78.29              | 0.7893 <sup>20</sup>       | 1.3611 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, chl; s bz              |
| 4801 | Ethanolamine                                  | Glycinol                         | C <sub>2</sub> H <sub>7</sub> NO                                             | 141-43-5   | 61.083   |                                 | 10.5    | 171                | 1.0180 <sup>20</sup>       | 1.4541 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; sl eth, lig, bz; s chl           |
| 4802 | Ethanolamine hydrochloride                    | 2-Aminoethanol hydrochloride     | C <sub>2</sub> H <sub>8</sub> ClNO                                           | 2002-24-6  | 97.544   | hyg cry (EtOH)                  | 85      |                    |                            |                      |                                                              |

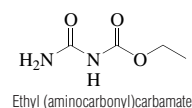
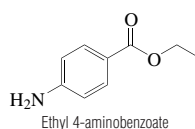
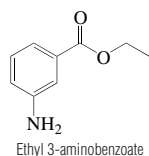
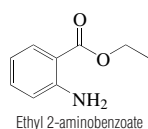
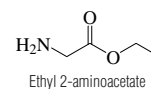
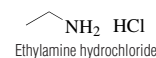
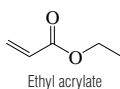
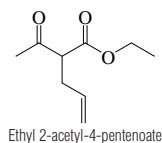
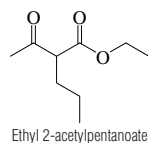
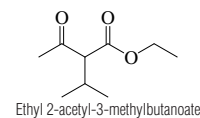
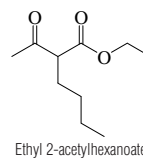
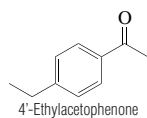
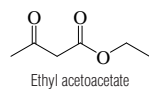
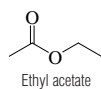
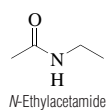
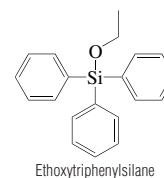
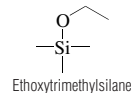
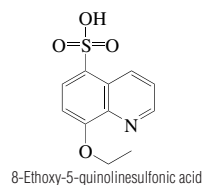
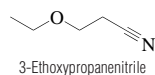
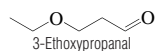
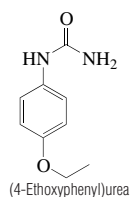
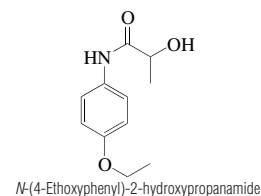
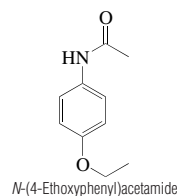
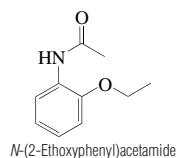
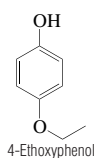
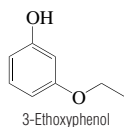
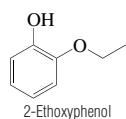
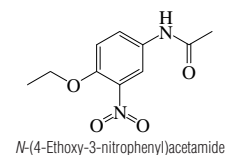
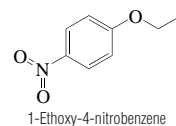
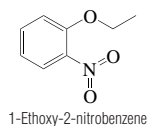
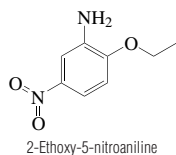
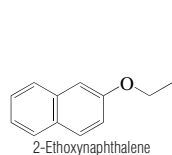
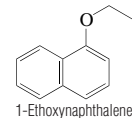
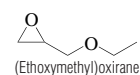
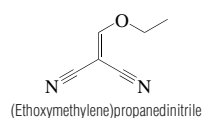
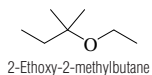
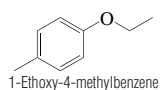
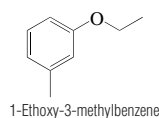


| No.  | Name                                          | Synonym                                                            | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form          | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                         |
|------|-----------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------|------------|----------|------------------------|---------|------------------------|----------------------------|----------------------|----------------------------------------------------|
| 4803 | Ethanolamine <i>O</i> -sulfate                | 2-Aminoethyl sulfate                                               | C <sub>2</sub> H <sub>7</sub> NO <sub>3</sub> S                             | 926-39-6   | 141.147  |                        | 230 dec |                        |                            |                      | s H <sub>2</sub> O; i EtOH                         |
| 4804 | Ethaverine                                    | 1-[(3,4-Diethoxyphenyl)methyl]-6,7-diethoxyisoquinoline            | C <sub>24</sub> H <sub>29</sub> NO <sub>4</sub>                             | 486-47-5   | 395.492  |                        | 100     |                        |                            |                      | i H <sub>2</sub> O; s EtOH; sl eth, chl            |
| 4805 | Ethchlorvynol                                 | 1-Chloro-3-ethyl-1-penten-4-yn-ol                                  | C <sub>7</sub> H <sub>9</sub> ClO                                           | 113-18-8   | 144.598  | liq                    |         | 181; 30 <sup>0.1</sup> | 1.07 <sup>25</sup>         | 1.474 <sup>25</sup>  | i H <sub>2</sub> O; s os                           |
| 4806 | Ethephon                                      | Phosphonic acid, (2-chloroethyl)-                                  | C <sub>2</sub> H <sub>5</sub> ClO <sub>3</sub> P                            | 16672-87-0 | 144.494  |                        | 74      |                        | 1.2                        |                      |                                                    |
| 4807 | Ethinylestradiol                              | 19-Norpregna-1,3,5(10)-trien-20-yne-3,17-diol, (17 $\alpha$ )-     | C <sub>20</sub> H <sub>24</sub> O <sub>2</sub>                              | 57-63-6    | 296.404  |                        |         |                        |                            |                      | sl chl                                             |
| 4808 | Ethion                                        |                                                                    | C <sub>8</sub> H <sub>22</sub> O <sub>4</sub> P <sub>2</sub> S <sub>4</sub> | 563-12-2   | 384.476  |                        | -13     | 165 <sup>0.3</sup>     | 1.22 <sup>20</sup>         |                      |                                                    |
| 4809 | <i>D</i> -Ethionine                           | 3-Ethylhomocysteine, ( <i>R</i> )                                  | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub> S                            | 535-32-0   | 163.238  | cry (H <sub>2</sub> O) | 278 dec |                        |                            |                      |                                                    |
| 4810 | <i>L</i> -Ethionine                           | 3-Ethylhomocysteine, ( <i>S</i> )                                  | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub> S                            | 13073-35-3 | 163.238  | cry (H <sub>2</sub> O) | 273 dec |                        |                            |                      |                                                    |
| 4811 | Ethirimol                                     | 4(1 <i>H</i> )-Pyrimidinone, 5-butyl-2-(ethylamino)-6-methyl-      | C <sub>11</sub> H <sub>19</sub> N <sub>3</sub> O                            | 23947-60-6 | 209.288  |                        | 160     |                        | 1.21 <sup>25</sup>         |                      |                                                    |
| 4812 | Ethisterone                                   |                                                                    | C <sub>21</sub> H <sub>28</sub> O <sub>2</sub>                              | 434-03-7   | 312.446  |                        | 272     |                        |                            |                      |                                                    |
| 4813 | Ethoate-methyl                                |                                                                    | C <sub>6</sub> H <sub>14</sub> NO <sub>3</sub> PS <sub>2</sub>              | 116-01-8   | 243.284  | cry (tol/hp)           | 67      |                        |                            |                      |                                                    |
| 4814 | Ethofumesate                                  |                                                                    | C <sub>13</sub> H <sub>18</sub> O <sub>5</sub> S                            | 26225-79-6 | 286.344  |                        | 71      |                        | 1.14                       |                      |                                                    |
| 4815 | Ethoheptazine                                 | 4-Carbethoxymethyl-4-phenylazacycloheptane                         | C <sub>16</sub> H <sub>23</sub> NO <sub>2</sub>                             | 77-15-6    | 261.360  | liq                    |         | 134 <sup>1</sup>       | 1.038 <sup>26</sup>        | 1.5210 <sup>26</sup> |                                                    |
| 4816 | Ethoprop                                      | Phosphorodithioic acid, <i>O</i> -ethyl <i>S,S</i> -dipropyl ester | C <sub>8</sub> H <sub>19</sub> O <sub>2</sub> PS <sub>2</sub>               | 13194-48-4 | 242.340  |                        |         | 88 <sup>0.2</sup>      | 1.094 <sup>20</sup>        |                      |                                                    |
| 4817 | Ethotoin                                      |                                                                    | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>               | 86-35-1    | 204.225  | pr (w)                 | 94      |                        |                            |                      | s hot H <sub>2</sub> O; vs EtOH, bz, eth           |
| 4818 | Ethoxyacetic acid                             |                                                                    | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                                | 627-03-2   | 104.105  |                        |         | 206.5                  | 1.1021 <sup>20</sup>       | 1.4194 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; s chl              |
| 4819 | 4'-Ethoxyacetophenone                         |                                                                    | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                              | 1676-63-7  | 164.201  | pl (eth)               | 39      | 268                    |                            |                      | vs eth, EtOH                                       |
| 4820 | Ethoxyacetylene                               |                                                                    | C <sub>4</sub> H <sub>6</sub> O                                             | 927-80-0   | 70.090   |                        |         | 50                     | 0.8000 <sup>20</sup>       | 1.3796 <sup>20</sup> |                                                    |
| 4821 | 7-Ethoxy-3,9-acridinediamine                  | Ethacridine                                                        | C <sub>15</sub> H <sub>15</sub> N <sub>3</sub> O                            | 442-16-0   | 253.299  | ye nd                  | 226     |                        |                            |                      |                                                    |
| 4822 | 2-Ethoxyaniline                               | <i>o</i> -Phenetidine                                              | C <sub>8</sub> H <sub>11</sub> NO                                           | 94-70-2    | 137.179  |                        | <-21    | 232.5                  |                            | 1.5560 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth              |
| 4823 | 3-Ethoxyaniline                               | <i>m</i> -Phenetidine                                              | C <sub>8</sub> H <sub>11</sub> NO                                           | 621-33-0   | 137.179  |                        |         | 248                    |                            |                      | vs eth, EtOH                                       |
| 4824 | 4-Ethoxyaniline                               | <i>p</i> -Phenetidine                                              | C <sub>8</sub> H <sub>11</sub> NO                                           | 156-43-4   | 137.179  |                        | 1.2     | 254                    | 1.0652 <sup>16</sup>       | 1.5528 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, chl              |
| 4825 | 2-Ethoxybenzaldehyde                          |                                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                               | 613-69-4   | 150.174  |                        | 21      | 248                    |                            |                      | msc EtOH, eth; sl chl                              |
| 4826 | 4-Ethoxybenzaldehyde                          |                                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                               | 10031-82-0 | 150.174  |                        | 13.5    | 249                    | 1.08 <sup>21</sup>         |                      | vs EtOH, eth, bz                                   |
| 4827 | 2-Ethoxybenzamide                             | Ethenzamide                                                        | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                              | 938-73-8   | 165.189  | nd (w, al)             | 133     |                        |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth             |
| 4828 | Ethoxybenzene                                 | Phenetole                                                          | C <sub>8</sub> H <sub>10</sub> O                                            | 103-73-1   | 122.164  | liq                    | -29.43  | 169.81                 | 0.9651 <sup>20</sup>       | 1.5076 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc               |
| 4829 | 4-Ethoxy-1,2-benzenediamine                   |                                                                    | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O                             | 1197-37-1  | 152.193  |                        | 71.5    | 295                    |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, chl              |
| 4830 | 2-Ethoxybenzoic acid                          |                                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                               | 134-11-2   | 166.173  |                        | 20.7    | 211 <sup>39</sup>      |                            |                      | sl H <sub>2</sub> O, EtOH, ctc                     |
| 4831 | 4-Ethoxybenzoic acid                          |                                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                               | 619-86-3   | 166.173  | nd (w)                 | 198.5   |                        |                            |                      | sl H <sub>2</sub> O, tfa; s EtOH, eth, bz          |
| 4832 | 6-Ethoxy-2-benzothiazolesulfonamide           | Ethoxzolamide                                                      | C <sub>9</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub> S <sub>2</sub> | 452-35-7   | 258.316  |                        | 189     |                        |                            |                      |                                                    |
| 4833 | 3-Ethoxy- <i>N,N</i> -diethylaniline          |                                                                    | C <sub>12</sub> H <sub>19</sub> NO                                          | 1864-92-2  | 193.285  |                        |         | 286; 97 <sup>0.6</sup> |                            | 1.5325 <sup>25</sup> | s EtOH, bz, HOAc                                   |
| 4834 | 2-Ethoxy-3,4-dihydro-2 <i>H</i> -pyran        |                                                                    | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                               | 103-75-3   | 128.169  |                        |         | 132; 42 <sup>16</sup>  | 0.9658 <sup>25</sup>       | 1.4394 <sup>20</sup> |                                                    |
| 4835 | 6-Ethoxy-1,2-dihydro-2,2,4-trimethylquinoline | Ethoxyquin                                                         | C <sub>14</sub> H <sub>19</sub> NO                                          | 91-53-2    | 217.307  |                        |         | 124 <sup>2</sup>       | 1.026 <sup>25</sup>        | 1.569 <sup>25</sup>  |                                                    |
| 4836 | Ethoxydimethylsilane                          | Dimethylethoxysilane                                               | C <sub>4</sub> H <sub>12</sub> OSi                                          | 14857-34-2 | 104.223  | liq                    |         | 54                     | 0.76 <sup>20</sup>         |                      |                                                    |
| 4837 | 2-Ethoxy-1,2-diphenylethanone                 |                                                                    | C <sub>16</sub> H <sub>16</sub> O <sub>2</sub>                              | 574-09-4   | 240.297  | nd (lig)               | 62      | 194 <sup>20</sup>      | 1.1016 <sup>17</sup>       | 1.5727 <sup>17</sup> | vs bz, eth, EtOH, lig                              |
| 4838 | 2-Ethoxyethanamine                            |                                                                    | C <sub>4</sub> H <sub>11</sub> NO                                           | 110-76-9   | 89.136   |                        |         | 107                    | 0.8512 <sup>20</sup>       | 1.4101 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace, bz; sl chl |
| 4839 | 2-Ethoxyethanol                               | Ethylene glycol monoethyl ether                                    | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                               | 110-80-5   | 90.121   | liq                    | -70     | 135                    | 0.9253 <sup>25</sup>       | 1.4054 <sup>25</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                |
| 4840 | 2-(2-Ethoxyethoxy)ethyl 2-propenoate          | Diethylene glycol ethyl ether acrylate                             | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                               | 7328-17-8  | 188.221  |                        |         |                        | 1.13 <sup>25</sup>         |                      |                                                    |
| 4841 | 2-Ethoxyethyl acetate                         | Ethylene glycol monoethyl ether acetate                            | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                               | 111-15-9   | 132.157  | liq                    | -61.7   | 156.4                  | 0.9740 <sup>20</sup>       | 1.4054 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                |
| 4842 | 2-Ethoxyethyl acrylate                        | Ethylene glycol monoethyl ether acrylate                           | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>                               | 106-74-1   | 144.168  | liq                    | -47     | 174                    | 0.983 <sup>20</sup>        | 1.4274 <sup>20</sup> |                                                    |
| 4843 | 3-Ethoxy-2-hydroxybenzaldehyde                |                                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                               | 492-88-6   | 166.173  |                        | 65.3    | 264                    |                            |                      |                                                    |
| 4844 | 3-Ethoxy-4-hydroxybenzaldehyde                | Ethyl vanillin                                                     | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                               | 121-32-4   | 166.173  |                        | 77.5    | 285                    |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl          |
| 4845 | 4-Ethoxy-3-methoxybenzaldehyde                |                                                                    | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                              | 120-25-2   | 180.200  | mcl pr                 | 64.5    | 168 <sup>13</sup>      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl, HOAc    |
| 4846 | 1-Ethoxy-2-methoxyethane                      |                                                                    | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                               | 5137-45-1  | 104.148  | liq                    |         | 103.5                  | 0.8460 <sup>25</sup>       | 1.3843 <sup>25</sup> |                                                    |

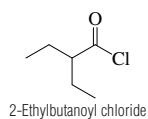
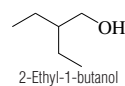
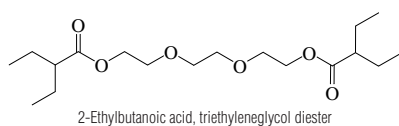
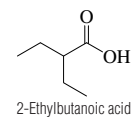
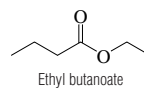
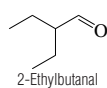
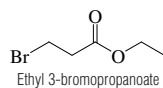
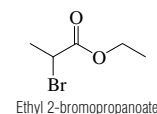
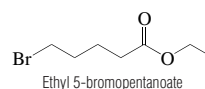
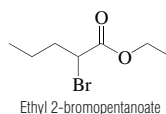
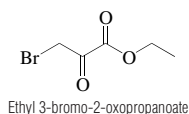
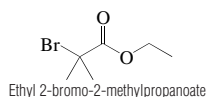
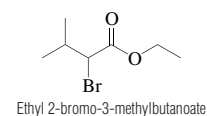
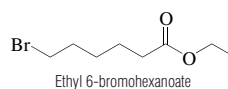
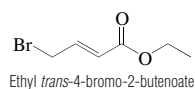
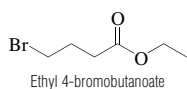
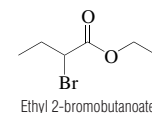
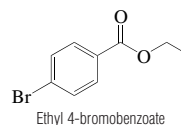
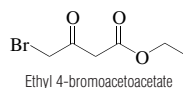
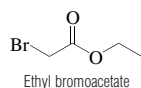
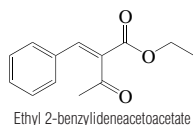
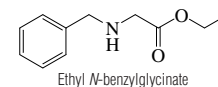
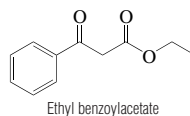
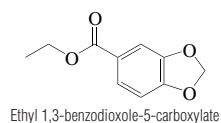
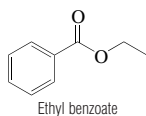
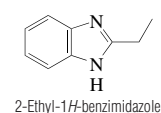
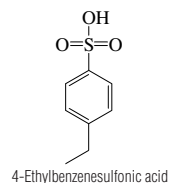
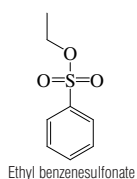
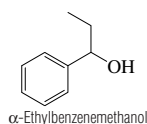
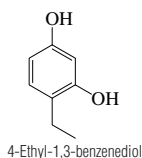
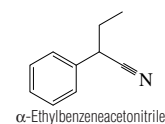
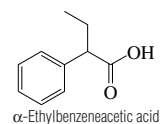
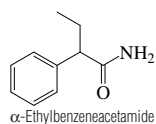
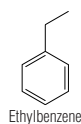
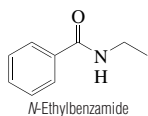
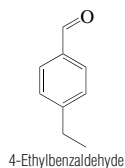
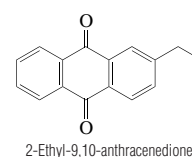
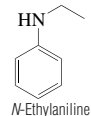
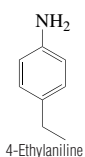
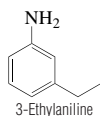
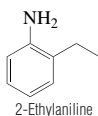
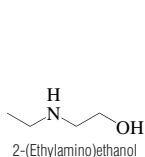




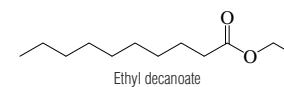
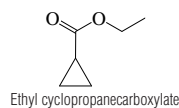
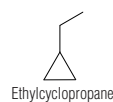
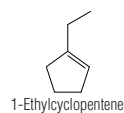
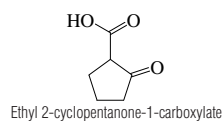
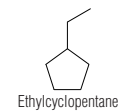
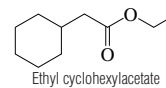
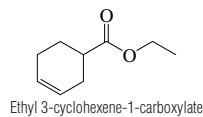
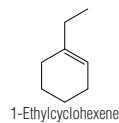
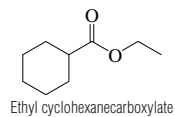
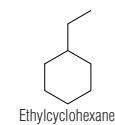
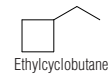
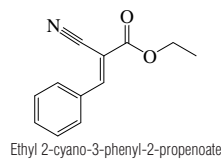
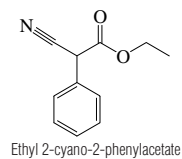
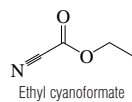
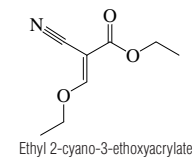
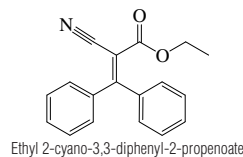
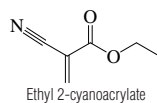
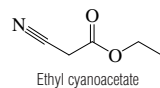
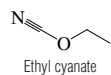
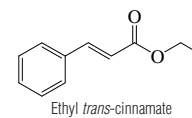
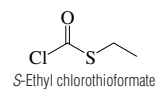
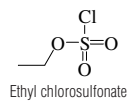
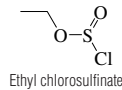
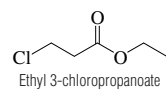
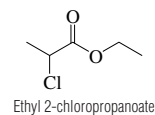
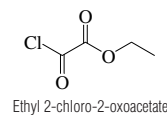
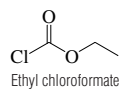
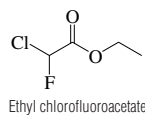
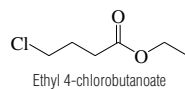
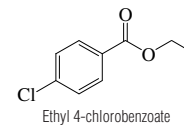
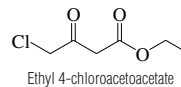
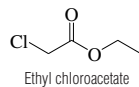
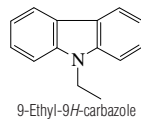
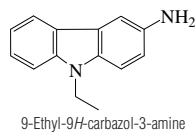
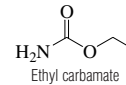
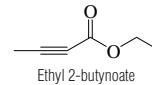
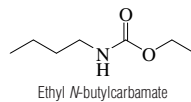
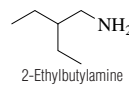
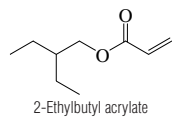
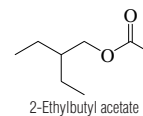
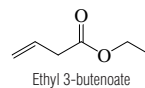
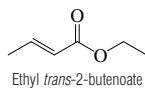
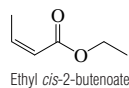
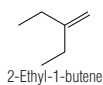
| No.  | Name                                            | Synonym                         | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form       | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>       | Solubility                                                 |
|------|-------------------------------------------------|---------------------------------|---------------------------------------------------------------|------------|----------|---------------------|---------|------------------------|----------------------------------|----------------------|------------------------------------------------------------|
| 4847 | 1-Ethoxy-3-methylbenzene                        |                                 | C <sub>9</sub> H <sub>12</sub> O                              | 621-32-9   | 136.190  |                     |         | 192                    | 0.949 <sup>20</sup>              | 1.513 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                            |
| 4848 | 1-Ethoxy-4-methylbenzene                        |                                 | C <sub>9</sub> H <sub>12</sub> O                              | 622-60-6   | 136.190  |                     |         | 188.5                  | 0.9509 <sup>18</sup>             | 1.5058 <sup>18</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                    |
| 4849 | 2-Ethoxy-2-methylbutane                         | Ethyl <i>tert</i> -pentyl ether | C <sub>7</sub> H <sub>16</sub> O                              | 919-94-8   | 116.201  |                     |         | 101.4                  | 0.7606 <sup>25</sup>             | 1.3886 <sup>25</sup> | vs eth, EtOH                                               |
| 4850 | (Ethoxymethylene)propanedinitrile               |                                 | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O                | 123-06-8   | 122.124  |                     | 66      | 160 <sup>12</sup>      |                                  |                      | s EtOH, eth; sl chl                                        |
| 4851 | (Ethoxymethyl)oxirane                           | 2,3-Epoxypropyl ethyl ether     | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                 | 4016-11-9  | 102.132  |                     |         | 128                    | 0.9700 <sup>20</sup>             | 1.4320 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth; sl ctc                      |
| 4852 | 1-Ethoxynaphthalene                             |                                 | C <sub>12</sub> H <sub>12</sub> O                             | 5328-01-8  | 172.222  | nd                  | 5.5     | 280.5                  | 1.060 <sup>20</sup>              | 1.5953 <sup>25</sup> | i H <sub>2</sub> O; vs EtOH, eth                           |
| 4853 | 2-Ethoxynaphthalene                             |                                 | C <sub>12</sub> H <sub>12</sub> O                             | 93-18-5    | 172.222  | pl (al)             | 37.5    | 282                    | 1.0640 <sup>20</sup>             | 1.5975 <sup>36</sup> | i H <sub>2</sub> O; s EtOH, eth, tol, lig, CS <sub>2</sub> |
| 4854 | 2-Ethoxy-5-nitroaniline                         | 5-Nitro- <i>o</i> -phenetidine  | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>  | 136-79-8   | 182.176  | ye nd (dil al)      | 96.5    | 205 <sup>14</sup>      |                                  |                      | vs eth, EtOH                                               |
| 4855 | 1-Ethoxy-2-nitrobenzene                         |                                 | C <sub>8</sub> H <sub>9</sub> NO <sub>3</sub>                 | 610-67-3   | 167.162  | br ye               | 1.1     | 267                    | 1.1903 <sup>15</sup>             | 1.5425 <sup>20</sup> | vs eth, EtOH                                               |
| 4856 | 1-Ethoxy-4-nitrobenzene                         |                                 | C <sub>8</sub> H <sub>9</sub> NO <sub>3</sub>                 | 100-29-8   | 167.162  | pr (dil al, eth)    | 60      | 283                    | 1.1176 <sup>100</sup>            |                      | sl H <sub>2</sub> O, EtOH; vs eth; msc ace, bz; s peth     |
| 4857 | <i>N</i> -(4-Ethoxy-3-nitrophenyl)acetamide     |                                 | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> | 1777-84-0  | 224.213  | nd (dil al)         | 124.0   |                        |                                  |                      | vs ace, bz, EtOH                                           |
| 4858 | 2-Ethoxyphenol                                  | Catechol monoethyl ether        | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 94-71-3    | 138.164  |                     | 29      | 217                    | 1.0903 <sup>25</sup>             |                      | sl H <sub>2</sub> O, ctc; msc EtOH, eth                    |
| 4859 | 3-Ethoxyphenol                                  | Resorcinol monoethyl ether      | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 621-34-1   | 138.164  |                     |         | 246; 131 <sup>10</sup> | 1.105 <sup>15</sup>              |                      | i H <sub>2</sub> O; s EtOH, eth, bz; sl chl                |
| 4860 | 4-Ethoxyphenol                                  | Hydroquinone monoethyl ether    | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 622-62-8   | 138.164  | pr or lf (w)        | 66.5    | 246.5                  |                                  |                      | sl H <sub>2</sub> O; vs EtOH, eth; s chl                   |
| 4861 | <i>N</i> -(2-Ethoxyphenyl)acetamide             |                                 | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>               | 581-08-8   | 179.216  | lf (dil al)         | 79      | >240                   |                                  |                      | i H <sub>2</sub> O; s EtOH, eth, chl                       |
| 4862 | <i>N</i> -(4-Ethoxyphenyl)acetamide             | Phenacetin                      | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>               | 62-44-2    | 179.216  | mcl pr              | 137.5   |                        |                                  | 1.571                | sl H <sub>2</sub> O, eth, bz; s EtOH, ace; vs py           |
| 4863 | <i>N</i> -(4-Ethoxyphenyl)-2-hydroxypropanamide | <i>p</i> -Lactophenetide        | C <sub>11</sub> H <sub>15</sub> NO <sub>3</sub>               | 539-08-2   | 209.242  |                     | 118     |                        |                                  |                      | s H <sub>2</sub> O; vs EtOH; sl eth, bz, chl, peth         |
| 4864 | (4-Ethoxyphenyl)urea                            | Dulcin                          | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>  | 150-69-6   | 180.203  | lf (dil al), pl (w) | 173.5   | dec                    |                                  |                      | sl H <sub>2</sub> O; s EtOH; vs AcOEt                      |
| 4865 | 3-Ethoxypropanal                                |                                 | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                 | 2806-85-1  | 102.132  |                     |         | 135.2                  | 0.9165 <sup>20</sup>             |                      |                                                            |
| 4866 | 3-Ethoxypropanenitrile                          |                                 | C <sub>5</sub> H <sub>9</sub> NO                              | 2141-62-0  | 99.131   |                     |         | 171                    | 0.9285 <sup>15</sup>             | 1.4068 <sup>20</sup> | vs eth, EtOH                                               |
| 4867 | 8-Ethoxy-5-quinolinesulfonic acid               | Actinoquinol                    | C <sub>11</sub> H <sub>11</sub> NO <sub>4</sub> S             | 15301-40-3 | 253.275  | br nd (w)           | 286 dec |                        |                                  |                      | s alk                                                      |
| 4868 | Ethoxytrimethylsilane                           |                                 | C <sub>5</sub> H <sub>14</sub> OSi                            | 1825-62-3  | 118.250  |                     |         | 76                     | 0.7573 <sup>20</sup>             | 1.3741 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace                       |
| 4869 | Ethoxytriphenylsilane                           |                                 | C <sub>20</sub> H <sub>26</sub> OSi                           | 1516-80-9  | 304.458  |                     | 65      | 344                    |                                  |                      | s chl                                                      |
| 4870 | <i>N</i> -Ethylacetamide                        |                                 | C <sub>4</sub> H <sub>9</sub> NO                              | 625-50-3   | 87.120   |                     |         | 205; 104 <sup>18</sup> | 0.942 <sup>4</sup>               | 1.4338 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; s chl, HOAc                    |
| 4871 | Ethyl acetate                                   |                                 | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 141-78-6   | 88.106   | liq                 | -83.8   | 77.11                  | 0.9003 <sup>20</sup>             | 1.3723 <sup>20</sup> | s H <sub>2</sub> O; msc EtOH, eth; vs ace, bz              |
| 4872 | Ethyl acetoacetate                              |                                 | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                 | 141-97-9   | 130.141  | liq                 | -45     | 180.8                  | 1.0368 <sup>10</sup>             | 1.4171 <sup>20</sup> | s H <sub>2</sub> O; msc EtOH, eth; s bz, chl               |
| 4873 | 4'-Ethylacetophenone                            |                                 | C <sub>10</sub> H <sub>12</sub> O                             | 937-30-4   | 148.201  |                     |         | 114 <sup>11</sup>      |                                  |                      |                                                            |
| 4874 | Ethyl 2-acetylhexanoate                         |                                 | C <sub>10</sub> H <sub>18</sub> O <sub>3</sub>                | 1540-29-0  | 186.248  |                     |         | 221.5                  | 0.9523 <sup>20</sup>             | 1.4301 <sup>20</sup> | vs ace, eth                                                |
| 4875 | Ethyl 2-acetyl-3-methylbutanoate                |                                 | C <sub>9</sub> H <sub>16</sub> O <sub>3</sub>                 | 1522-46-9  | 172.221  |                     |         | 201; 97 <sup>20</sup>  | 0.9648 <sup>18</sup>             | 1.4256 <sup>18</sup> | i H <sub>2</sub> O; msc EtOH, eth                          |
| 4876 | Ethyl 2-acetylpentanoate                        |                                 | C <sub>9</sub> H <sub>16</sub> O <sub>3</sub>                 | 1540-28-9  | 172.221  |                     |         | 224; 90 <sup>15</sup>  | 0.9661 <sup>20</sup>             | 1.4255 <sup>20</sup> | vs eth, EtOH                                               |
| 4877 | Ethyl 2-acetyl-4-pentenoate                     | Ethyl 2-allylacetoacetate       | C <sub>9</sub> H <sub>14</sub> O <sub>3</sub>                 | 610-89-9   | 170.205  |                     |         | 208                    | 0.9898 <sup>20</sup>             | 1.4388 <sup>18</sup> | msc EtOH, eth, bz                                          |
| 4878 | Ethyl acrylate                                  | Ethyl propenoate                | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                  | 140-88-5   | 100.117  | liq                 | -71.2   | 99.4                   | 0.9234 <sup>20</sup>             | 1.4068 <sup>20</sup> | sl H <sub>2</sub> O, DMSO; msc EtOH, eth; s chl            |
| 4879 | Ethylamine                                      | Ethanamine                      | C <sub>2</sub> H <sub>7</sub> N                               | 75-04-7    | 45.084   | vol liq or gas      | -80.5   | 16.5                   | 0.677 <sup>25</sup><br>(p>1 atm) | 1.3663 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth                            |
| 4880 | Ethylamine hydrochloride                        | Ethanamine hydrochloride        | C <sub>2</sub> H <sub>8</sub> ClN                             | 557-66-4   | 81.545   | mcl pl (al)         | 109.5   |                        | 1.2160 <sup>20</sup>             |                      | vs H <sub>2</sub> O, EtOH                                  |
| 4881 | Ethyl 2-aminoacetate                            | Glycine, ethyl ester            | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                 | 459-73-4   | 103.120  |                     |         | 149; 58 <sup>18</sup>  | 1.0275 <sup>10</sup>             | 1.4242 <sup>10</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, bz; vs lig           |
| 4882 | Ethyl 2-aminobenzoate                           |                                 | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                | 87-25-2    | 165.189  |                     | 13      | 268                    | 1.1174 <sup>20</sup>             | 1.5646 <sup>20</sup> | vs eth, EtOH                                               |
| 4883 | Ethyl 3-aminobenzoate                           |                                 | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                | 582-33-2   | 165.189  |                     |         | 294; 160 <sup>5</sup>  | 1.171 <sup>20</sup>              | 1.5600 <sup>22</sup> | sl H <sub>2</sub> O; vs EtOH, eth; s ctc                   |
| 4884 | Ethyl 4-aminobenzoate                           | Ethyl aminobenzoate             | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                | 94-09-7    | 165.189  | nd (w), orth (eth)  | 92      | 310                    |                                  |                      | i H <sub>2</sub> O; vs EtOH, eth; s chl, acid              |
| 4885 | Ethyl (aminocarbonyl)carbamate                  |                                 | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>   | 626-36-8   | 132.118  | nd (w, bz)          | 196.5   | dec                    |                                  |                      | i H <sub>2</sub> O, eth; sl EtOH, bz, tfa                  |



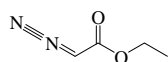
| No.  | Name                                            | Synonym                         | Mol. Form.                                      | CAS RN     | Mol. Wt. | Physical Form    | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-------------------------------------------------|---------------------------------|-------------------------------------------------|------------|----------|------------------|--------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 4886 | 2-(Ethylamino)ethanol                           |                                 | C <sub>4</sub> H <sub>11</sub> NO               | 110-73-6   | 89.136   |                  |        | 169.5                                 | 0.914 <sup>20</sup>        | 1.444 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH, eth; s chl                |
| 4887 | 2-Ethylaniline                                  |                                 | C <sub>8</sub> H <sub>11</sub> N                | 578-54-1   | 121.180  | liq              | -43    | 209.5                                 | 0.983 <sup>22</sup>        | 1.5584 <sup>22</sup> | sl H <sub>2</sub> O, chl; vs EtOH, eth               |
| 4888 | 3-Ethylaniline                                  |                                 | C <sub>8</sub> H <sub>11</sub> N                | 587-02-0   | 121.180  | liq              | -64    | 214; 94 <sup>6</sup>                  | 0.9896 <sup>25</sup>       |                      | vs eth, EtOH                                         |
| 4889 | 4-Ethylaniline                                  |                                 | C <sub>8</sub> H <sub>11</sub> N                | 589-16-2   | 121.180  | liq              | -2.4   | 217.5                                 | 0.9679 <sup>20</sup>       | 1.5554 <sup>20</sup> | sl H <sub>2</sub> O, ctc; vs EtOH, eth               |
| 4890 | <i>N</i> -Ethylaniline                          |                                 | C <sub>8</sub> H <sub>11</sub> N                | 103-69-5   | 121.180  | liq              | -63.5  | 203.0                                 | 0.9625 <sup>20</sup>       | 1.5559 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs ace, bz; s ctc |
| 4891 | 2-Ethyl-9,10-anthracenedione                    |                                 | C <sub>16</sub> H <sub>12</sub> O <sub>2</sub>  | 84-51-5    | 236.265  |                  | 108.8  |                                       |                            |                      |                                                      |
| 4892 | 4-Ethylbenzaldehyde                             |                                 | C <sub>9</sub> H <sub>10</sub> O                | 4748-78-1  | 134.174  |                  |        | 221                                   | 0.9790 <sup>20</sup>       |                      |                                                      |
| 4893 | <i>N</i> -Ethylbenzamide                        |                                 | C <sub>9</sub> H <sub>11</sub> NO               | 614-17-5   | 149.189  | nd (w)           | 70.5   |                                       |                            |                      |                                                      |
| 4894 | Ethylbenzene                                    | Phenylethane                    | C <sub>8</sub> H <sub>10</sub>                  | 100-41-4   | 106.165  | liq              | -94.96 | 136.16                                | 0.8626 <sup>25</sup>       | 1.4959 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl chl            |
| 4895 | $\alpha$ -Ethylbenzeneacetamide                 | $\alpha$ -Phenylbutyramide      | C <sub>10</sub> H <sub>13</sub> NO              | 90-26-6    | 163.216  | cry              | 86     | 185 <sup>16</sup>                     |                            |                      | s H <sub>2</sub> O, ctc; sl ace                      |
| 4896 | $\alpha$ -Ethylbenzeneacetic acid               |                                 | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>  | 90-27-7    | 164.201  | pl (eth)         | 47.5   | 271                                   |                            |                      | s eth, bz, ctc                                       |
| 4897 | $\alpha$ -Ethylbenzeneacetonitrile              |                                 | C <sub>10</sub> H <sub>11</sub> N               | 769-68-6   | 145.201  |                  |        | 241                                   | 0.977 <sup>14</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, bz                  |
| 4898 | 4-Ethyl-1,3-benzenediol                         |                                 | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>   | 2896-60-8  | 138.164  | pr (chl, bz)     | 98.5   | 160 <sup>24</sup> , 131 <sup>15</sup> |                            |                      | sl H <sub>2</sub> O, EtOH, eth                       |
| 4899 | $\alpha$ -Ethylbenzenemethanol                  | $\alpha$ -Ethylbenzyl alcohol   | C <sub>9</sub> H <sub>12</sub> O                | 93-54-9    | 136.190  |                  |        | 219                                   | 0.9915 <sup>25</sup>       | 1.5169 <sup>23</sup> | vs bz, eth, EtOH, MeOH                               |
| 4900 | Ethyl benzenesulfonate                          |                                 | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub> S | 515-46-8   | 186.228  |                  |        | 156 <sup>15</sup>                     | 1.2167 <sup>20</sup>       | 1.5081 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH; vs eth, chl             |
| 4901 | 4-Ethylbenzenesulfonic acid                     |                                 | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub> S | 98-69-1    | 186.228  |                  |        |                                       | 1.23                       |                      |                                                      |
| 4902 | 2-Ethyl-1 <i>H</i> -benzimidazole               |                                 | C <sub>9</sub> H <sub>10</sub> N <sub>2</sub>   | 1848-84-6  | 146.188  |                  | 176.5  |                                       |                            |                      | sl chl                                               |
| 4903 | Ethyl benzoate                                  |                                 | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>   | 93-89-0    | 150.174  | liq              | -34    | 212                                   | 1.0415 <sup>25</sup>       | 1.5007 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, bz; msc eth; sl ctc |
| 4904 | Ethyl 1,3-benzodioxole-5-carboxylate            |                                 | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>  | 6951-08-2  | 194.184  | pr               | 18.5   | 285.5; 135 <sup>6</sup>               |                            |                      | vs eth, EtOH, peth                                   |
| 4905 | Ethyl benzoylacetate                            |                                 | C <sub>11</sub> H <sub>12</sub> O <sub>3</sub>  | 94-02-0    | 192.211  |                  | <0     | dec 267; 167 <sup>20</sup>            | 1.1202 <sup>15</sup>       | 1.5317 <sup>15</sup> | sl H <sub>2</sub> O; s EtOH, eth                     |
| 4906 | Ethyl <i>N</i> -benzylglycinate                 |                                 | C <sub>11</sub> H <sub>13</sub> NO <sub>2</sub> | 6436-90-4  | 193.243  |                  |        | 177 <sup>50</sup>                     |                            | 1.5041 <sup>20</sup> | vs EtOH, eth, bz                                     |
| 4907 | Ethyl 2-benzylideneacetoacetate                 |                                 | C <sub>13</sub> H <sub>14</sub> O <sub>3</sub>  | 620-80-4   | 218.248  | orth pl (dil al) | 60.5   | 296; 180 <sup>17</sup>                |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, bz; vs chl         |
| 4908 | Ethyl bromoacetate                              |                                 | C <sub>4</sub> H <sub>7</sub> BrO <sub>2</sub>  | 105-36-2   | 167.002  |                  |        | 168.5                                 | 1.5032 <sup>20</sup>       | 1.4489 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace; sl ctc     |
| 4909 | Ethyl 4-bromoacetoacetate                       |                                 | C <sub>6</sub> H <sub>9</sub> BrO <sub>3</sub>  | 13176-46-0 | 209.037  |                  |        | 115 <sup>14</sup> , 110 <sup>10</sup> | 1.5278 <sup>18</sup>       | 1.5281 <sup>20</sup> | vs eth, EtOH                                         |
| 4910 | Ethyl 4-bromobenzoate                           |                                 | C <sub>9</sub> H <sub>9</sub> BrO <sub>2</sub>  | 5798-75-4  | 229.070  | liq              | -18    | 263; 125 <sup>15</sup>                | 1.4332 <sup>17</sup>       | 1.5438 <sup>17</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz            |
| 4911 | Ethyl 2-bromobutanoate                          |                                 | C <sub>8</sub> H <sub>11</sub> BrO <sub>2</sub> | 533-68-6   | 195.054  |                  |        | 177; 43 <sup>5</sup>                  | 1.3273 <sup>20</sup>       | 1.4475 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl             |
| 4912 | Ethyl 4-bromobutanoate                          |                                 | C <sub>8</sub> H <sub>11</sub> BrO <sub>2</sub> | 2969-81-5  | 195.054  |                  |        | 192; 82 <sup>10</sup>                 | 1.3540 <sup>20</sup>       | 1.4559 <sup>20</sup> |                                                      |
| 4913 | Ethyl <i>trans</i> -4-bromo-2-butenate          |                                 | C <sub>8</sub> H <sub>9</sub> BrO <sub>2</sub>  | 37746-78-4 | 193.038  |                  |        | 100 <sup>14</sup>                     | 1.402 <sup>16</sup>        | 1.4925 <sup>20</sup> | vs EtOH                                              |
| 4914 | Ethyl 6-bromohexanoate                          | Ethyl 6-bromocaproate           | C <sub>8</sub> H <sub>15</sub> BrO <sub>2</sub> | 25542-62-5 | 223.108  | cry (peth)       | 33     | 126 <sup>21</sup>                     | 1.238 <sup>23</sup>        | 1.4566 <sup>21</sup> |                                                      |
| 4915 | Ethyl 2-bromo-3-methylbutanoate                 |                                 | C <sub>7</sub> H <sub>13</sub> BrO <sub>2</sub> | 609-12-1   | 209.081  |                  |        | 186                                   | 1.2760 <sup>20</sup>       | 1.4496 <sup>20</sup> | vs eth, EtOH                                         |
| 4916 | Ethyl 2-bromo-2-methylpropanoate                |                                 | C <sub>6</sub> H <sub>11</sub> BrO <sub>2</sub> | 600-00-0   | 195.054  |                  |        | 163                                   | 1.3263 <sup>20</sup>       | 1.4446 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; msc eth                  |
| 4917 | Ethyl 3-bromo-2-oxopropanoate                   | Ethyl 3-bromopyruvate           | C <sub>5</sub> H <sub>7</sub> BrO <sub>3</sub>  | 70-23-5    | 195.012  |                  |        | 87 <sup>9</sup>                       |                            |                      |                                                      |
| 4918 | Ethyl 2-bromopentanoate                         |                                 | C <sub>7</sub> H <sub>13</sub> BrO <sub>2</sub> | 615-83-8   | 209.081  |                  |        | 191                                   | 1.226 <sup>18</sup>        | 1.4496 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                      |
| 4919 | Ethyl 5-bromopentanoate                         |                                 | C <sub>7</sub> H <sub>13</sub> BrO <sub>2</sub> | 14660-52-7 | 209.081  |                  |        | 129 <sup>35</sup> , 107 <sup>20</sup> | 1.3085 <sup>20</sup>       | 1.4543 <sup>20</sup> | sl ctc                                               |
| 4920 | Ethyl 2-bromopropanoate                         | Ethyl $\alpha$ -bromopropionate | C <sub>5</sub> H <sub>9</sub> BrO <sub>2</sub>  | 535-11-5   | 181.028  |                  |        | dec 160; 71 <sup>26</sup>             | 1.4135 <sup>20</sup>       | 1.4490 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl             |
| 4921 | Ethyl 3-bromopropanoate                         |                                 | C <sub>5</sub> H <sub>9</sub> BrO <sub>2</sub>  | 539-74-2   | 181.028  |                  |        | 179; 65 <sup>15</sup>                 | 1.4123 <sup>18</sup>       | 1.4516 <sup>20</sup> | s EtOH, eth, ace; sl ctc                             |
| 4922 | 2-Ethylbutanal                                  | Diethylacetaldehyde             | C <sub>6</sub> H <sub>12</sub> O                | 97-96-1    | 100.158  |                  |        | 118 <sup>60</sup>                     | 0.8110 <sup>20</sup>       | 1.4025 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth              |
| 4923 | Ethyl butanoate                                 |                                 | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>   | 105-54-4   | 116.158  | liq              | -98    | 121.3                                 | 0.8735 <sup>25</sup>       | 1.3898 <sup>25</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth                |
| 4924 | 2-Ethylbutanoic acid                            | Diethylacetic acid              | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>   | 88-09-5    | 116.158  | liq              | -31.8  | 194                                   | 0.9239 <sup>20</sup>       | 1.4132 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth              |
| 4925 | 2-Ethylbutanoic acid, triethyleneglycol diester |                                 | C <sub>18</sub> H <sub>34</sub> O <sub>6</sub>  | 95-08-9    | 346.459  |                  |        | 181 <sup>3,5</sup>                    |                            |                      |                                                      |
| 4926 | 2-Ethyl-1-butanol                               |                                 | C <sub>6</sub> H <sub>14</sub> O                | 97-95-0    | 102.174  |                  | <-15   | 147                                   | 0.8326 <sup>20</sup>       | 1.4220 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, chl                |
| 4927 | 2-Ethylbutanoyl chloride                        |                                 | C <sub>6</sub> H <sub>11</sub> ClO              | 2736-40-5  | 134.603  |                  |        | 140                                   | 0.9825 <sup>20</sup>       | 1.4234 <sup>20</sup> | vs eth                                               |



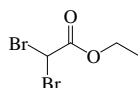
| No.  | Name                                    | Synonym                                   | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form        | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-----------------------------------------|-------------------------------------------|--------------------------------------------------|------------|----------|----------------------|--------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 4928 | 2-Ethyl-1-butene                        |                                           | C <sub>6</sub> H <sub>12</sub>                   | 760-21-4   | 84.159   | liq                  | -131.5 | 64.7                                  | 0.6894 <sup>20</sup>       | 1.3969 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, bz, chl              |
| 4929 | Ethyl <i>cis</i> -2-butenolate          | Ethyl isocrotonate                        | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | 6776-19-8  | 114.142  |                      |        | 136                                   | 0.9182 <sup>20</sup>       | 1.4242 <sup>20</sup> | vs ace, eth, EtOH                                    |
| 4930 | Ethyl <i>trans</i> -2-butenolate        | Ethyl crotonate                           | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | 623-70-1   | 114.142  |                      |        | 138                                   | 0.9175 <sup>20</sup>       | 1.4243 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                      |
| 4931 | Ethyl 3-butenolate                      |                                           | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | 1617-18-1  | 114.142  |                      |        | 119                                   | 0.9122 <sup>20</sup>       | 1.4105 <sup>20</sup> | s EtOH                                               |
| 4932 | 2-Ethylbutyl acetate                    |                                           | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>    | 10031-87-5 | 144.212  |                      | <-100  | 162.5                                 | 0.8790 <sup>20</sup>       | 1.4109 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                 |
| 4933 | 2-Ethylbutyl acrylate                   |                                           | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>    | 3953-10-4  | 156.222  | liq                  |        | 80 <sup>20</sup>                      |                            |                      |                                                      |
| 4934 | 2-Ethylbutylamine                       | 2-Ethyl-1-butanamine                      | C <sub>6</sub> H <sub>15</sub> N                 | 617-79-8   | 101.190  | liq                  | 125    |                                       |                            |                      |                                                      |
| 4935 | Ethyl <i>N</i> -butylcarbamate          |                                           | C <sub>7</sub> H <sub>15</sub> NO <sub>2</sub>   | 591-62-8   | 145.200  | liq                  | -22    | 202; 100 <sup>15</sup>                | 0.9434 <sup>26</sup>       | 1.4278 <sup>26</sup> |                                                      |
| 4936 | Ethyl 2-butyrate                        |                                           | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | 4341-76-8  | 112.127  |                      |        | 163                                   | 0.9641 <sup>20</sup>       | 1.4372 <sup>20</sup> |                                                      |
| 4937 | Ethyl carbamate                         | Urethane                                  | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>    | 51-79-6    | 89.094   | pr (bz, to)          | 49     | 185                                   | 0.9862 <sup>21</sup>       | 1.4144 <sup>51</sup> | vs H <sub>2</sub> O; EtOH, eth, bz, chl, py; sl lig  |
| 4938 | 9-Ethyl-9 <i>H</i> -carbazol-3-amine    |                                           | C <sub>14</sub> H <sub>14</sub> N <sub>2</sub>   | 132-32-1   | 210.274  |                      | 99     |                                       |                            |                      |                                                      |
| 4939 | 9-Ethyl-9 <i>H</i> -carbazole           |                                           | C <sub>14</sub> H <sub>13</sub> N                | 86-28-2    | 195.260  | nd (al)              | 68     | 190 <sup>10</sup>                     | 1.059 <sup>80</sup>        | 1.6394 <sup>80</sup> | i H <sub>2</sub> O; vs EtOH, eth                     |
| 4940 | Ethyl chloroacetate                     |                                           | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>   | 105-39-5   | 122.551  | liq                  | -21    | 144.3                                 | 1.1585 <sup>20</sup>       | 1.4215 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace; s bz         |
| 4941 | Ethyl 4-chloroacetoacetate              |                                           | C <sub>6</sub> H <sub>9</sub> ClO <sub>3</sub>   | 638-07-3   | 164.586  |                      | -8     | dec 220; 115 <sup>14</sup>            | 1.218 <sup>25</sup>        | 1.4520 <sup>20</sup> |                                                      |
| 4942 | Ethyl 4-chlorobenzoate                  |                                           | C <sub>9</sub> H <sub>7</sub> ClO <sub>2</sub>   | 7335-27-5  | 184.619  |                      |        | 237.5                                 | 1.1873 <sup>14</sup>       |                      | vs EtOH                                              |
| 4943 | Ethyl 4-chlorobutanoate                 |                                           | C <sub>8</sub> H <sub>11</sub> ClO <sub>2</sub>  | 3153-36-4  | 150.603  |                      |        | 184                                   | 1.0756 <sup>20</sup>       | 1.4311 <sup>20</sup> | vs ace, eth, EtOH                                    |
| 4944 | Ethyl chlorofluoroacetate               |                                           | C <sub>4</sub> H <sub>6</sub> ClFO <sub>2</sub>  | 401-56-9   | 140.541  |                      |        | 129                                   | 1.225 <sup>20</sup>        | 1.3927 <sup>20</sup> |                                                      |
| 4945 | Ethyl chloroformate                     |                                           | C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>   | 541-41-3   | 108.524  | liq                  | -80.6  | 95                                    | 1.1352 <sup>20</sup>       | 1.3974 <sup>20</sup> | vs bz, eth, chl                                      |
| 4946 | Ethyl 2-chloro-2-oxoacetate             | Ethyl oxalyl chloride                     | C <sub>4</sub> H <sub>5</sub> ClO <sub>3</sub>   | 4755-77-5  | 136.534  | hyg                  |        | 137                                   | 1.2226 <sup>20</sup>       |                      | vs bz, eth                                           |
| 4947 | Ethyl 2-chloropropanoate                | Ethyl $\alpha$ -chloropropionate          | C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>   | 535-13-7   | 136.577  |                      |        | 147                                   | 1.0793 <sup>20</sup>       | 1.4178 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl ctc            |
| 4948 | Ethyl 3-chloropropanoate                |                                           | C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>   | 623-71-2   | 136.577  |                      |        | 162                                   | 1.1086 <sup>20</sup>       | 1.4254 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                   |
| 4949 | Ethyl chlorosulfinate                   |                                           | C <sub>2</sub> H <sub>5</sub> ClO <sub>2</sub> S | 6378-11-6  | 128.578  |                      |        | 52.5 <sup>44</sup> ; 32 <sup>16</sup> | 1.2837 <sup>20</sup>       | 1.4550 <sup>25</sup> | vs eth                                               |
| 4950 | Ethyl chlorosulfonate                   |                                           | C <sub>2</sub> H <sub>5</sub> ClO <sub>3</sub> S | 625-01-4   | 144.577  |                      |        | 152.5; 93 <sup>100</sup>              | 1.3502 <sup>25</sup>       | 1.416 <sup>20</sup>  | vs eth, chl, lig                                     |
| 4951 | <i>S</i> -Ethyl chlorothioformate       |                                           | C <sub>3</sub> H <sub>5</sub> ClOS               | 2941-64-2  | 124.589  | liq                  |        | 136                                   | 1.195 <sup>20</sup>        | 1.4820 <sup>20</sup> |                                                      |
| 4952 | Ethyl <i>trans</i> -cinnamate           | Ethyl <i>trans</i> -3-phenyl-2-propenoate | C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>   | 4192-77-2  | 176.212  |                      | 10     | 271.5                                 | 1.0491 <sup>20</sup>       | 1.5598 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace; s bz, ctc     |
| 4953 | Ethyl cyanate                           |                                           | C <sub>3</sub> H <sub>5</sub> NO                 | 627-48-5   | 71.078   |                      |        | dec 162; 30 <sup>12</sup>             | 0.89 <sup>20</sup>         | 1.3788 <sup>25</sup> | vs eth, EtOH                                         |
| 4954 | Ethyl cyanoacetate                      |                                           | C <sub>5</sub> H <sub>7</sub> NO <sub>2</sub>    | 105-56-6   | 113.116  | liq                  | -22.5  | 205                                   | 1.0654 <sup>20</sup>       | 1.4175 <sup>20</sup> | s H <sub>2</sub> O; vs eth, EtOH                     |
| 4955 | Ethyl 2-cyanoacrylate                   | Ethyl 2-cyano-2-propenoate                | C <sub>6</sub> H <sub>7</sub> NO <sub>2</sub>    | 7085-85-0  | 125.126  | liq                  |        | 55 <sup>3</sup>                       |                            |                      |                                                      |
| 4956 | Ethyl 2-cyano-3,3-diphenyl-2-propenoate | Etocrilene                                | C <sub>18</sub> H <sub>15</sub> NO <sub>2</sub>  | 5232-99-5  | 277.318  |                      | 110.5  | 195 <sup>3</sup>                      |                            |                      |                                                      |
| 4957 | Ethyl 2-cyano-3-ethoxyacrylate          |                                           | C <sub>8</sub> H <sub>11</sub> NO <sub>3</sub>   | 94-05-3    | 169.178  |                      | 52     | 190.5                                 |                            |                      |                                                      |
| 4958 | Ethyl cyanoformate                      |                                           | C <sub>4</sub> H <sub>5</sub> NO <sub>2</sub>    | 623-49-4   | 99.089   |                      |        | 115.5                                 | 1.003 <sup>25</sup>        | 1.3820 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                 |
| 4959 | Ethyl 2-cyano-2-phenylacetate           |                                           | C <sub>11</sub> H <sub>11</sub> NO <sub>2</sub>  | 4553-07-5  | 189.211  | oil                  |        | dec 275; 165 <sup>20</sup>            | 1.091 <sup>20</sup>        | 1.5012 <sup>25</sup> | vs ace, bz, eth, EtOH                                |
| 4960 | Ethyl 2-cyano-3-phenyl-2-propenoate     | Ethyl 2-benzylidene-2-cyanoacetate        | C <sub>12</sub> H <sub>11</sub> NO <sub>2</sub>  | 2025-40-3  | 201.221  | (i) nd (al) (ii) oil | 51     | 188 <sup>15</sup>                     | 1.1076 <sup>25</sup>       | 1.5033               | vs ace, chl                                          |
| 4961 | Ethylcyclobutane                        |                                           | C <sub>6</sub> H <sub>12</sub>                   | 4806-61-5  | 84.159   | liq                  | -142.9 | 70.8                                  | 0.7284 <sup>20</sup>       | 1.4020 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace, bz, peth   |
| 4962 | Ethylcyclohexane                        |                                           | C <sub>8</sub> H <sub>16</sub>                   | 1678-91-7  | 112.213  | liq                  | -111.3 | 131.9                                 | 0.7880 <sup>20</sup>       | 1.4330 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, bz; vs lig; msc ctc |
| 4963 | Ethyl cyclohexanecarboxylate            |                                           | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>    | 3289-28-9  | 156.222  |                      |        | 196                                   | 0.9362 <sup>20</sup>       | 1.4501 <sup>15</sup> | vs ace, eth, EtOH, chl                               |
| 4964 | 1-Ethylcyclohexene                      |                                           | C <sub>8</sub> H <sub>14</sub>                   | 1453-24-3  | 110.197  | liq                  | -109.9 | 137                                   | 0.8176 <sup>25</sup>       | 1.4567 <sup>20</sup> |                                                      |
| 4965 | Ethyl 3-cyclohexene-1-carboxylate       |                                           | C <sub>9</sub> H <sub>14</sub> O <sub>2</sub>    | 15111-56-5 | 154.206  |                      |        | 194.5                                 | 0.9688 <sup>20</sup>       | 1.4578 <sup>20</sup> |                                                      |
| 4966 | Ethyl cyclohexylacetate                 |                                           | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>   | 5452-75-5  | 170.249  |                      |        | 211                                   | 0.9537 <sup>14</sup>       | 1.451 <sup>14</sup>  |                                                      |
| 4967 | Ethylcyclopentane                       |                                           | C <sub>7</sub> H <sub>14</sub>                   | 1640-89-7  | 98.186   | liq                  | -138.4 | 103.5                                 | 0.7665 <sup>20</sup>       | 1.4198 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace; s bz, tol    |
| 4968 | Ethyl 2-cyclopentanone-1-carboxylate    |                                           | C <sub>8</sub> H <sub>12</sub> O <sub>3</sub>    | 611-10-9   | 156.179  |                      |        | 221; 110 <sup>16</sup>                | 1.0781 <sup>21</sup>       | 1.4519 <sup>20</sup> | s eth, bz                                            |
| 4969 | 1-Ethylcyclopentene                     |                                           | C <sub>7</sub> H <sub>12</sub>                   | 2146-38-5  | 96.170   | liq                  | -118.5 | 106.3                                 | 0.7936 <sup>25</sup>       | 1.4412 <sup>20</sup> |                                                      |
| 4970 | Ethylcyclopropane                       |                                           | C <sub>5</sub> H <sub>10</sub>                   | 1191-96-4  | 70.133   | liq                  | -149.2 | 35.9                                  | 0.6790 <sup>25</sup>       | 1.3786 <sup>20</sup> |                                                      |
| 4971 | Ethyl cyclopropanecarboxylate           |                                           | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | 4606-07-9  | 114.142  |                      |        | 134                                   | 0.9608 <sup>15</sup>       | 1.4190 <sup>20</sup> |                                                      |
| 4972 | Ethyl decanoate                         | Ethyl caprate                             | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>   | 110-38-3   | 200.318  | liq                  | -20    | 241.5                                 | 0.8650 <sup>20</sup>       | 1.4256 <sup>20</sup> | i H <sub>2</sub> O; vs eth, EtOH, chl                |



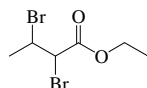
| No.  | Name                                                                                       | Synonym                        | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form       | mp/°C  | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|--------------------------------------------------------------------------------------------|--------------------------------|-----------------------------------------------------------------|------------|----------|---------------------|--------|-------------------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 4973 | Ethyl diazoacetate                                                                         | Diazoacetic ester              | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>     | 623-73-4   | 114.103  | ye orth cry         | -22    | dec 140                             | 1.0852 <sup>18</sup>       | 1.4605 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, bz, lig             |
| 4974 | Ethyl dibromoacetate                                                                       |                                | C <sub>4</sub> H <sub>6</sub> Br <sub>2</sub> O <sub>2</sub>    | 617-33-4   | 245.898  |                     |        | 194                                 | 1.8991 <sup>20</sup>       | 1.5017 <sup>13</sup> | i H <sub>2</sub> O; msc EtOH, eth                       |
| 4975 | Ethyl 2,3-dibromobutanoate                                                                 |                                | C <sub>6</sub> H <sub>10</sub> Br <sub>2</sub> O <sub>2</sub>   | 609-11-0   | 273.950  | nd                  | 58.5   | 113 <sup>30</sup>                   | 1.6800 <sup>20</sup>       |                      | sl H <sub>2</sub> O; ctc; s EtOH, eth                   |
| 4976 | Ethyl 2,4-dibromobutanoate                                                                 |                                | C <sub>6</sub> H <sub>10</sub> Br <sub>2</sub> O <sub>2</sub>   | 36847-51-5 | 273.950  |                     |        | 149 <sup>52</sup>                   | 1.6987 <sup>20</sup>       | 1.4960 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                         |
| 4977 | Ethyl 2,3-dibromopropanoate                                                                |                                | C <sub>5</sub> H <sub>8</sub> Br <sub>2</sub> O <sub>2</sub>    | 3674-13-3  | 259.925  |                     |        | 214.5                               | 1.7966 <sup>20</sup>       | 1.5007 <sup>20</sup> | s EtOH, eth                                             |
| 4978 | Ethyl 3,6-di( <i>tert</i> -butyl)-1-naphthalenesulfonate                                   | Ethyl dibunate                 | C <sub>20</sub> H <sub>28</sub> O <sub>3</sub> S                | 5560-69-0  | 348.499  |                     |        |                                     |                            |                      | s chl                                                   |
| 4979 | Ethyl dichloroacetate                                                                      |                                | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>    | 535-15-9   | 156.996  |                     |        | 155; 56 <sup>10</sup>               | 1.2827 <sup>20</sup>       | 1.4386 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ace, chl          |
| 4980 | Ethyl dichloroarsine                                                                       | Dichloroethylarsine            | C <sub>2</sub> H <sub>5</sub> AsCl <sub>2</sub>                 | 598-14-1   | 174.889  |                     |        | 155.3; 74 <sup>50</sup>             | 1.66 <sup>20</sup>         |                      | s H <sub>2</sub> O; misc EtOH, bz                       |
| 4981 | Ethyl dichlorocarbamate                                                                    |                                | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub> NO <sub>2</sub>   | 13698-16-3 | 157.984  |                     |        | 66 <sup>18</sup> , 55 <sup>15</sup> | 1.304 <sup>30</sup>        | 1.4595 <sup>20</sup> |                                                         |
| 4982 | Ethyl 2,3-dichloropropanoate                                                               |                                | C <sub>5</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>2</sub>    | 6628-21-3  | 171.022  |                     |        | 183.5                               | 1.2401 <sup>20</sup>       | 1.4482 <sup>20</sup> | vs eth, EtOH                                            |
| 4983 | Ethyl diethoxyacetate                                                                      |                                | C <sub>8</sub> H <sub>16</sub> O <sub>4</sub>                   | 6065-82-3  | 176.211  |                     |        | 199                                 | 0.985 <sup>25</sup>        | 1.4100 <sup>20</sup> |                                                         |
| 4984 | Ethyl diethylmalonate                                                                      |                                | C <sub>11</sub> H <sub>20</sub> O <sub>4</sub>                  | 77-25-8    | 216.275  |                     |        | 230                                 | 0.9643 <sup>30</sup>       | 1.4240 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc                |
| 4985 | Ethyl difluoroacetate                                                                      |                                | C <sub>4</sub> H <sub>6</sub> F <sub>2</sub> O <sub>2</sub>     | 454-31-9   | 124.087  |                     |        | 100                                 | 1.1765 <sup>20</sup>       |                      | i H <sub>2</sub> O                                      |
| 4986 | Ethyl difluoroarsine                                                                       |                                | C <sub>2</sub> H <sub>5</sub> AsF <sub>2</sub>                  | 430-40-0   | 141.980  | liq, fumes in air   | -38.7  | 94.3                                | 1.708 <sup>17</sup>        |                      |                                                         |
| 4987 | 5-Ethylidihydro-5- <i>sec</i> -butyl-2-thioxo-4,6(1 <i>H</i> ,5 <i>H</i> )-pyrimidinedione | Thiobutabarbital               | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub> S | 2095-57-0  | 228.311  |                     | 169    |                                     |                            |                      |                                                         |
| 4988 | 5-Ethylidihydro-2(3 <i>H</i> )-furanone                                                    |                                | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                   | 695-06-7   | 114.142  | liq                 | -18    | 215.5                               | 1.0261 <sup>20</sup>       | 1.4495 <sup>20</sup> | vs H <sub>2</sub> O, EtOH                               |
| 4989 | Ethyl dihydrogen phosphate                                                                 |                                | C <sub>2</sub> H <sub>7</sub> O <sub>4</sub> P                  | 1623-14-9  | 126.048  | hyg cry             |        | dec                                 | 1.430 <sup>25</sup>        | 1.427                | vs H <sub>2</sub> O, ace, eth, EtOH                     |
| 4990 | 5-Ethylidihydro-5-phenyl-4,6(1 <i>H</i> ,5 <i>H</i> )-pyrimidinedione                      | Primidone                      | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>   | 125-33-7   | 218.251  |                     | 281.5  |                                     |                            |                      |                                                         |
| 4991 | Ethyl 2,4-dihydroxy-6-methylbenzoate                                                       |                                | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                  | 2524-37-0  | 196.200  | lf (HOAc), pr (al)  | 132    | sub                                 |                            |                      | vs eth, EtOH                                            |
| 4992 | <i>O</i> -Ethyl <i>S</i> -(2-(diisopropylamino)ethyl)methylphosphonothioate                | VX Nerve agent                 | C <sub>11</sub> H <sub>26</sub> NO <sub>2</sub> PS              | 50782-69-9 | 267.369  | very toxic liq      |        |                                     |                            |                      |                                                         |
| 4993 | Ethylidimethylamine                                                                        | <i>N,N</i> -Dimethylethanamine | C <sub>4</sub> H <sub>11</sub> N                                | 598-56-1   | 73.137   | liq                 | -140   | 36.5                                | 0.675 <sup>20</sup>        | 1.3705 <sup>25</sup> |                                                         |
| 4994 | Ethyl 4-(dimethylamino)benzoate                                                            |                                | C <sub>11</sub> H <sub>15</sub> NO <sub>2</sub>                 | 10287-53-3 | 193.243  |                     | 66.5   | 190 <sup>14</sup>                   | 1.0099 <sup>100</sup>      |                      |                                                         |
| 4995 | 1-Ethyl-2,4-dimethylbenzene                                                                |                                | C <sub>10</sub> H <sub>14</sub>                                 | 874-41-9   | 134.218  | liq                 | -62.9  | 188.4                               | 0.8763 <sup>20</sup>       | 1.5038 <sup>20</sup> | vs ace, bz, eth, EtOH                                   |
| 4996 | 1-Ethyl-3,5-dimethylbenzene                                                                |                                | C <sub>10</sub> H <sub>14</sub>                                 | 934-74-7   | 134.218  | liq                 | -84.3  | 183.6                               | 0.8608 <sup>25</sup>       | 1.4981 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; s peth, ctc |
| 4997 | 2-Ethyl-1,3-dimethylbenzene                                                                |                                | C <sub>10</sub> H <sub>14</sub>                                 | 2870-04-4  | 134.218  | liq                 | -16.2  | 190                                 | 0.8864 <sup>25</sup>       | 1.5107 <sup>20</sup> |                                                         |
| 4998 | 2-Ethyl-1,4-dimethylbenzene                                                                |                                | C <sub>10</sub> H <sub>14</sub>                                 | 1758-88-9  | 134.218  | liq                 | -53.7  | 186.9                               | 0.8732 <sup>25</sup>       | 1.5043 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; s peth, ctc |
| 4999 | 3-Ethyl-1,2-dimethylbenzene                                                                |                                | C <sub>10</sub> H <sub>14</sub>                                 | 933-98-2   | 134.218  | liq                 | -49.5  | 194                                 | 0.8881 <sup>25</sup>       | 1.5117 <sup>20</sup> |                                                         |
| 5000 | 4-Ethyl-1,2-dimethylbenzene                                                                |                                | C <sub>10</sub> H <sub>14</sub>                                 | 934-80-5   | 134.218  | liq                 | -66.9  | 189.5                               | 0.8706 <sup>25</sup>       | 1.5031 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; s peth, ctc |
| 5001 | <i>N'</i> -Ethyl- <i>N,N</i> -dimethyl-1,2-ethanediamine                                   |                                | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                   | 123-83-1   | 116.204  |                     |        | 134.5                               | 0.738 <sup>25</sup>        | 1.4222 <sup>20</sup> |                                                         |
| 5002 | Ethyl 4,4-dimethyl-3-oxopentanoate                                                         | Ethyl pivaloylacetate          | C <sub>9</sub> H <sub>16</sub> O <sub>3</sub>                   | 17094-34-7 | 172.221  | liq                 |        | 83 <sup>17</sup>                    | 0.97 <sup>18</sup>         |                      |                                                         |
| 5003 | 3-Ethyl-2,2-dimethylpentane                                                                |                                | C <sub>9</sub> H <sub>20</sub>                                  | 16747-32-3 | 128.255  | liq                 | -99.3  | 133.8                               | 0.7438 <sup>20</sup>       | 1.4123 <sup>20</sup> |                                                         |
| 5004 | 3-Ethyl-2,3-dimethylpentane                                                                |                                | C <sub>9</sub> H <sub>20</sub>                                  | 16747-33-4 | 128.255  |                     |        | 144.7                               | 0.7508 <sup>25</sup>       | 1.4221 <sup>20</sup> |                                                         |
| 5005 | 3-Ethyl-2,4-dimethylpentane                                                                |                                | C <sub>9</sub> H <sub>20</sub>                                  | 1068-87-7  | 128.255  | liq                 | -122.4 | 136.7                               | 0.7365 <sup>20</sup>       | 1.4131 <sup>20</sup> |                                                         |
| 5006 | Ethyl 2,2-dimethylpropanoate                                                               | Ethyl 2,2-dimethylpropionate   | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                   | 3938-95-2  | 130.185  | liq                 | -89.5  | 118.4                               | 0.856 <sup>20</sup>        | 1.3906 <sup>20</sup> | s EtOH, eth                                             |
| 5007 | 3-Ethyl-2,5-dimethylpyrazine                                                               |                                | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                   | 13360-65-1 | 136.194  |                     |        | 180.5                               | 0.9657 <sup>24</sup>       | 1.5014 <sup>24</sup> | sl H <sub>2</sub> O, EtOH, eth                          |
| 5008 | 3-Ethyl-2,4-dimethyl-1 <i>H</i> -pyrrole                                                   |                                | C <sub>8</sub> H <sub>13</sub> N                                | 517-22-6   | 123.196  | pr                  | 0      | 199; 96 <sup>16</sup>               | 0.913 <sup>20</sup>        | 1.4961 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, bz, chl               |
| 5009 | Ethyl 3,5-dimethylpyrrole-2-carboxylate                                                    |                                | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | 2199-44-2  | 167.205  | cry (al)            | 125    | 135 <sup>10.5</sup>                 |                            |                      | s EtOH, ace                                             |
| 5010 | Ethyl 2,4-dimethylpyrrole-3-carboxylate                                                    |                                | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | 2199-51-1  | 167.205  | cry (eth-liq, peth) | 78.5   | 291                                 |                            |                      | vs eth, EtOH                                            |
| 5011 | Ethyl 2,5-dimethylpyrrole-3-carboxylate                                                    |                                | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | 2199-52-2  | 167.205  | orth (al)           | 117.5  | 291; 130 <sup>15</sup>              |                            |                      | vs EtOH                                                 |
| 5012 | Ethyl 4,5-dimethylpyrrole-3-carboxylate                                                    |                                | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | 2199-53-3  | 167.205  | cry (dil al)        | 111.3  |                                     |                            |                      | vs eth, EtOH, chl                                       |
| 5013 | Ethyl 2,4-dioxopentanoate                                                                  |                                | C <sub>7</sub> H <sub>10</sub> O <sub>4</sub>                   | 615-79-2   | 158.152  |                     | 18     | 214                                 | 1.1251 <sup>20</sup>       | 1.4757 <sup>17</sup> | vs eth, EtOH                                            |



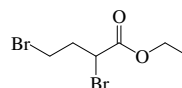
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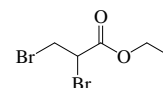
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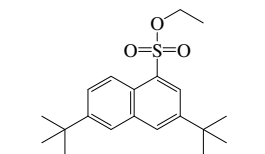
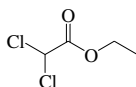
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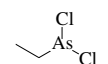
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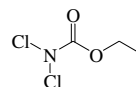
Ethyl 2,3-dibromopropanoate

Ethyl 3,6-di(*tert*-butyl)-1-naphthalenesulfonate

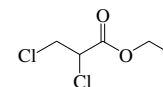
Ethyl dichloroacetate



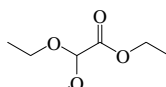
Ethyldichloroarsine



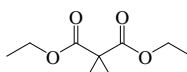
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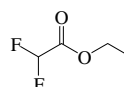
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Ethyl diethoxyacetate



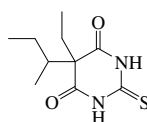
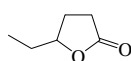
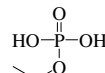
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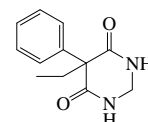
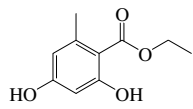
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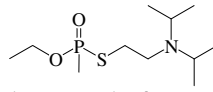
Ethyldifluoroarsine

5-Ethylidihydro-5-*sec*-butyl-2-thioxo-4,6(1*H*,5*H*)-pyrimidinedione5-Ethylidihydro-2(3*H*)-furanone

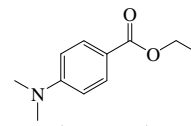
Ethyl dihydrogen phosphate

5-Ethylidihydro-5-phenyl-4,6(1*H*,5*H*)-pyrimidinedione

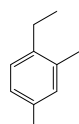
Ethyl 2,4-dihydroxy-6-methylbenzoate

*O*-Ethyl *S*-[2-(diisopropylamino)ethyl] methylphosphonothioate

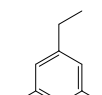
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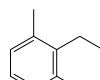
Ethyl 4-(dimethylamino)benzoate



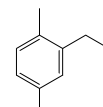
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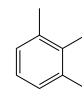
1-Ethyl-3,5-dimethylbenzene



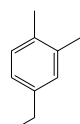
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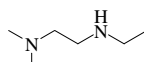
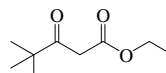
2-Ethyl-1,4-dimethylbenzene



3-Ethyl-1,2-dimethylbenzene



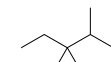
4-Ethyl-1,2-dimethylbenzene

*N'*-Ethyl-*N,N*-dimethyl-1,2-ethanediamine

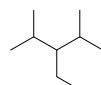
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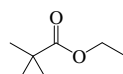
3-Ethyl-2,2-dimethylpentane



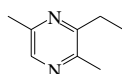
3-Ethyl-2,3-dimethylpentane



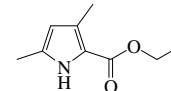
3-Ethyl-2,4-dimethylpentane



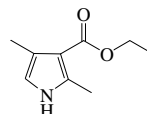
Ethyl 2,2-dimethylpropanoate



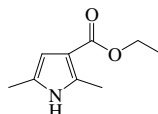
3-Ethyl-2,5-dimethylpyrazine

3-Ethyl-2,4-dimethyl-1*H*-pyrrole

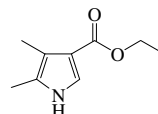
Ethyl 3,5-dimethylpyrrole-2-carboxylate



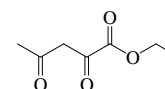
Ethyl 2,4-dimethylpyrrole-3-carboxylate



Ethyl 2,5-dimethylpyrrole-3-carboxylate



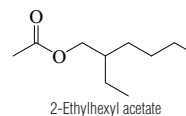
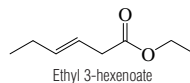
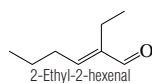
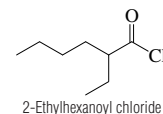
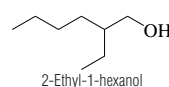
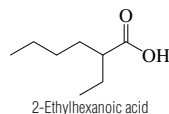
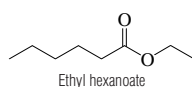
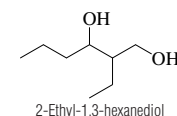
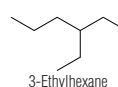
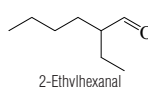
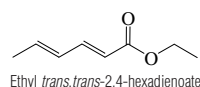
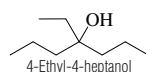
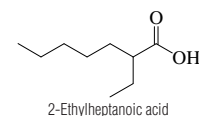
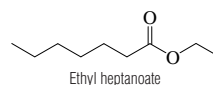
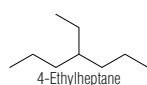
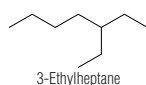
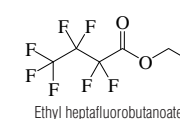
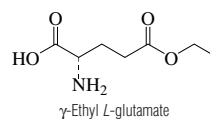
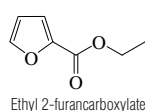
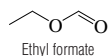
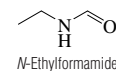
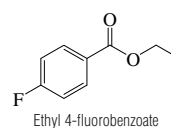
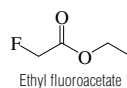
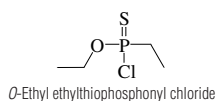
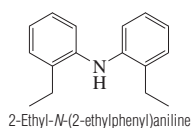
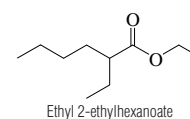
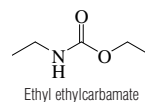
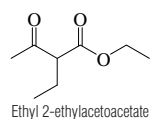
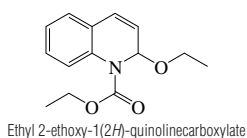
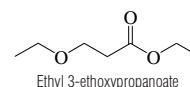
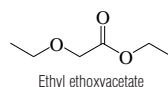
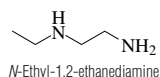
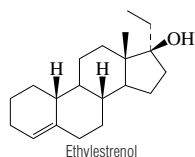
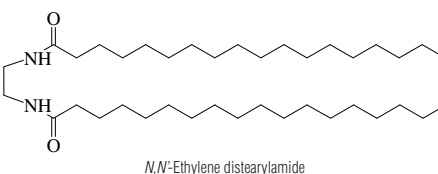
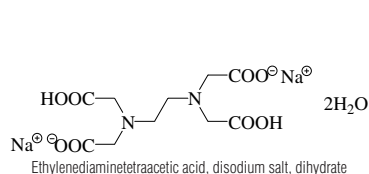
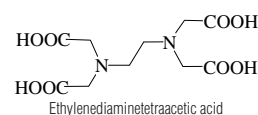
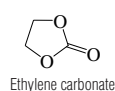
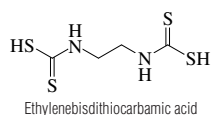
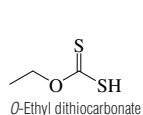
Ethyl 4,5-dimethylpyrrole-3-carboxylate



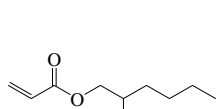
Ethyl 2,4-dioxopentanoate



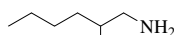
| No.  | Name                                                      | Synonym                                   | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                             |
|------|-----------------------------------------------------------|-------------------------------------------|--------------------------------------------------------------------------------|------------|----------|---------------|---------|----------------------------------------|----------------------------|-----------------------|--------------------------------------------------------|
| 5014 | <i>O</i> -Ethyl dithiocarbonate                           | Xanthogenic acid                          | C <sub>3</sub> H <sub>6</sub> OS <sub>2</sub>                                  | 151-01-9   | 122.209  | unstab liq    | -53     | 25                                     |                            |                       |                                                        |
| 5015 | Ethylene                                                  | Ethene                                    | C <sub>2</sub> H <sub>4</sub>                                                  | 74-85-1    | 28.053   | col gas       | -169.15 | -103.77                                | 0.5678 <sup>-104</sup>     | 1.363 <sup>-100</sup> | i H <sub>2</sub> O; sl EtOH, bz, ace; s eth            |
| 5016 | Ethylenebisdithiocarbamic acid                            |                                           | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> S <sub>4</sub>                    | 111-54-6   | 212.380  | unstab liq    |         |                                        |                            |                       |                                                        |
| 5017 | Ethylene carbonate                                        | Vinylene carbonate                        | C <sub>3</sub> H <sub>4</sub> O <sub>3</sub>                                   | 96-49-1    | 88.062   | mcl pl (al)   | 36.4    | 248                                    | 1.3214 <sup>99</sup>       | 1.4148 <sup>50</sup>  | msc H <sub>2</sub> O, EtOH, eth, bz, chl, AcOEt        |
| 5018 | Ethylenediaminetetraacetic acid                           | EDTA                                      | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub> O <sub>8</sub>                  | 60-00-4    | 292.242  | cry (w)       | 245 dec |                                        |                            |                       |                                                        |
| 5019 | Ethylenediaminetetraacetic acid, disodium salt, dihydrate | EDTA disodium                             | C <sub>10</sub> H <sub>18</sub> N <sub>2</sub> Na <sub>2</sub> O <sub>10</sub> | 6381-92-6  | 372.237  |               | 242 dec |                                        |                            |                       |                                                        |
| 5020 | <i>N,N'</i> -Ethylene distearylamine                      | <i>N,N'</i> -Diocladecanoyl ethanediamine | C <sub>38</sub> H <sub>76</sub> N <sub>2</sub> O <sub>2</sub>                  | 110-30-5   | 593.022  | cry (EtOH)    | 149     |                                        |                            |                       |                                                        |
| 5021 | Ethyleneimine                                             | Aziridine                                 | C <sub>2</sub> H <sub>3</sub> N                                                | 151-56-4   | 43.068   | liq           | -77.9   | 56                                     | 0.832 <sup>25</sup>        |                       | msc H <sub>2</sub> O; s EtOH; vs eth; sl chl           |
| 5022 | Ethylestrenol                                             |                                           | C <sub>20</sub> H <sub>32</sub> O                                              | 965-90-2   | 288.467  | cry           | 77      |                                        |                            |                       |                                                        |
| 5023 | <i>N</i> -Ethyl-1,2-ethanediamine                         |                                           | C <sub>4</sub> H <sub>12</sub> N <sub>2</sub>                                  | 110-72-5   | 88.151   |               |         | 129                                    | 0.837 <sup>25</sup>        | 1.4385 <sup>20</sup>  |                                                        |
| 5024 | Ethyl ethoxyacetate                                       |                                           | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                                  | 817-95-8   | 132.157  |               |         | 158                                    | 0.9702 <sup>20</sup>       | 1.4039 <sup>20</sup>  | s EtOH, eth, ace                                       |
| 5025 | Ethyl 3-ethoxypropanoate                                  |                                           | C <sub>7</sub> H <sub>14</sub> O <sub>3</sub>                                  | 763-69-9   | 146.184  |               |         | 166; 48 <sup>5</sup>                   | 0.9490 <sup>20</sup>       | 1.4065 <sup>20</sup>  |                                                        |
| 5026 | Ethyl 2-ethoxy-1(2- <i>H</i> )-quinolinecarboxylate       | EEDQ                                      | C <sub>14</sub> H <sub>17</sub> NO <sub>3</sub>                                | 16357-59-8 | 247.290  |               | 56.5    | 126 <sup>0.1</sup>                     |                            |                       | s chl                                                  |
| 5027 | Ethyl 2-ethylacetoacetate                                 |                                           | C <sub>9</sub> H <sub>14</sub> O <sub>3</sub>                                  | 607-97-6   | 158.195  |               |         | 198.0; 80 <sup>10</sup>                | 0.9847 <sup>16</sup>       | 1.4214 <sup>25</sup>  | msc EtOH, eth                                          |
| 5028 | Ethyl ethylcarbamate                                      |                                           | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                                 | 623-78-9   | 117.147  |               |         | 176                                    | 0.9813 <sup>20</sup>       | 1.4215 <sup>20</sup>  | vs H <sub>2</sub> O, eth, EtOH                         |
| 5029 | Ethyl 2-ethylhexanoate                                    | Ethyl 2-ethylcaproate                     | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                                 | 2983-37-1  | 172.265  |               |         | 90 <sup>28</sup>                       | 0.8586 <sup>25</sup>       | 1.4123 <sup>25</sup>  |                                                        |
| 5030 | 2-Ethyl- <i>N</i> -(2-ethylphenyl)aniline                 |                                           | C <sub>18</sub> H <sub>19</sub> N                                              | 64653-59-4 | 225.329  |               | 29      | 336 <sup>603</sup> , 173 <sup>10</sup> |                            | 1.5550 <sup>25</sup>  | i H <sub>2</sub> O; vs EtOH, eth; sl chl; s acid       |
| 5031 | <i>O</i> -Ethyl ethylthiophosphonyl chloride              |                                           | C <sub>4</sub> H <sub>10</sub> ClOPS                                           | 1497-68-3  | 172.613  | liq           |         | 35 <sup>0.7</sup>                      | 1.15 <sup>20</sup>         |                       |                                                        |
| 5032 | Ethyl fluoroacetate                                       |                                           | C <sub>4</sub> H <sub>7</sub> FO <sub>2</sub>                                  | 459-72-3   | 106.096  |               |         | 120                                    | 1.0912 <sup>20</sup>       | 1.3755 <sup>20</sup>  | vs H <sub>2</sub> O                                    |
| 5033 | Ethyl 4-fluorobenzoate                                    |                                           | C <sub>9</sub> H <sub>9</sub> FO <sub>2</sub>                                  | 451-46-7   | 168.164  | mcl pr (w)    | 26      | 210                                    | 1.146 <sup>25</sup>        | 1.4864 <sup>20</sup>  | vs eth, EtOH                                           |
| 5034 | <i>N</i> -Ethylformamide                                  |                                           | C <sub>3</sub> H <sub>7</sub> NO                                               | 627-45-2   | 73.094   |               |         | 198                                    | 0.9552 <sup>20</sup>       | 1.4320 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH, eth                        |
| 5035 | Ethyl formate                                             |                                           | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                                   | 109-94-4   | 74.079   | liq           | -79.6   | 54.4                                   | 0.9208 <sup>20</sup>       | 1.3609 <sup>20</sup>  | s H <sub>2</sub> O; msc EtOH, eth; vs ace; sl ctc      |
| 5036 | 2-Ethylfuran                                              |                                           | C <sub>6</sub> H <sub>8</sub> O                                                | 3208-16-0  | 96.127   |               |         | 92.5                                   | 0.9018 <sup>20</sup>       | 1.4403 <sup>20</sup>  | s EtOH, eth, ace, bz                                   |
| 5037 | Ethyl 2-furancarboxylate                                  | Ethyl 2-furanoate                         | C <sub>7</sub> H <sub>8</sub> O <sub>3</sub>                                   | 614-99-3   | 140.137  | lf or pr      | 34.5    | 196.8                                  | 1.1174 <sup>21</sup>       | 1.4797 <sup>21</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace; s bz           |
| 5038 | γ-Ethyl <i>L</i> -glutamate                               |                                           | C <sub>7</sub> H <sub>13</sub> NO <sub>4</sub>                                 | 1119-33-1  | 175.183  |               | 191     |                                        |                            |                       | sl H <sub>2</sub> O                                    |
| 5039 | Ethyl heptafluorobutanoate                                |                                           | C <sub>6</sub> H <sub>5</sub> F <sub>7</sub> O <sub>2</sub>                    | 356-27-4   | 242.092  |               |         | 95                                     | 1.394 <sup>20</sup>        | 1.3011 <sup>20</sup>  | sl H <sub>2</sub> O; s eth, ace                        |
| 5040 | 3-Ethylheptane                                            |                                           | C <sub>9</sub> H <sub>20</sub>                                                 | 15869-80-4 | 128.255  | liq           | -114.9  | 143.0                                  | 0.7225 <sup>25</sup>       | 1.4093 <sup>20</sup>  |                                                        |
| 5041 | 4-Ethylheptane                                            |                                           | C <sub>9</sub> H <sub>20</sub>                                                 | 2216-32-2  | 128.255  |               |         | 141.2                                  | 0.7241 <sup>25</sup>       | 1.4096 <sup>20</sup>  | i H <sub>2</sub> O; s eth; msc EtOH, ace, bz           |
| 5042 | Ethyl heptanoate                                          | Ethyl oenanthane                          | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                                  | 106-30-9   | 158.238  | liq           | -66.1   | 187                                    | 0.8817 <sup>20</sup>       | 1.4100 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; s EtOH, eth                  |
| 5043 | 2-Ethylheptanoic acid                                     |                                           | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                                  | 3274-29-1  | 158.238  | liq           |         | 153 <sup>31</sup>                      |                            | 1.4255 <sup>27</sup>  |                                                        |
| 5044 | 4-Ethyl-4-heptanol                                        |                                           | C <sub>9</sub> H <sub>20</sub> O                                               | 597-90-0   | 144.254  |               |         | 182                                    | 0.8350 <sup>20</sup>       | 1.4332 <sup>20</sup>  | vs eth, EtOH                                           |
| 5045 | Ethyl <i>trans,trans</i> -2,4-hexadienoate                | Ethyl sorbate                             | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                                  | 2396-84-1  | 140.180  |               |         | 195.5                                  | 0.9506 <sup>20</sup>       | 1.4951 <sup>20</sup>  | vs eth, EtOH, chl                                      |
| 5046 | 2-Ethylhexanal                                            |                                           | C <sub>8</sub> H <sub>16</sub> O                                               | 123-05-7   | 128.212  |               | <-100   | 163                                    | 0.8540 <sup>20</sup>       | 1.4142 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl ctc                |
| 5047 | 3-Ethylhexane                                             |                                           | C <sub>8</sub> H <sub>18</sub>                                                 | 619-99-8   | 114.229  |               |         | 118.6                                  | 0.7136 <sup>20</sup>       | 1.4018 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, chl; s ctc |
| 5048 | 2-Ethyl-1,3-hexanediol                                    | Ethohexadiol                              | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                                  | 94-96-2    | 146.228  | liq           | -40     | 244                                    | 0.9325 <sup>22</sup>       | 1.4497 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth                       |
| 5049 | Ethyl hexanoate                                           |                                           | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                                  | 123-66-0   | 144.212  | liq           | -67     | 167                                    | 0.873 <sup>20</sup>        | 1.4073 <sup>20</sup>  | sl H <sub>2</sub> O; vs eth, EtOH                      |
| 5050 | 2-Ethylhexanoic acid                                      |                                           | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                                  | 149-57-5   | 144.212  |               |         | 228; 120 <sup>13</sup>                 | 0.9031 <sup>25</sup>       | 1.4241 <sup>20</sup>  | s H <sub>2</sub> O, eth, ctc; sl EtOH                  |
| 5051 | 2-Ethyl-1-hexanol                                         |                                           | C <sub>8</sub> H <sub>18</sub> O                                               | 104-76-7   | 130.228  | liq           | -70     | 184.6                                  | 0.8319 <sup>25</sup>       | 1.4300 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl          |
| 5052 | 2-Ethylhexanoyl chloride                                  |                                           | C <sub>8</sub> H <sub>15</sub> ClO                                             | 760-67-8   | 162.657  |               |         | 101 <sup>40</sup> , 67 <sup>11</sup>   | 0.939 <sup>25</sup>        | 1.4335 <sup>20</sup>  |                                                        |
| 5053 | 2-Ethyl-2-hexenal                                         |                                           | C <sub>8</sub> H <sub>14</sub> O                                               | 645-62-5   | 126.196  |               |         | 175                                    | 0.8554 <sup>20</sup>       |                       |                                                        |
| 5054 | Ethyl 3-hexenoate                                         | Ethyl hydrosorbate                        | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                                  | 2396-83-0  | 142.196  |               |         | 166.5                                  | 0.8957 <sup>20</sup>       | 1.4255 <sup>20</sup>  |                                                        |
| 5055 | 2-Ethylhexyl acetate                                      |                                           | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                                 | 103-09-3   | 172.265  | liq           | -80     | 199                                    | 0.8718 <sup>20</sup>       | 1.4204 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                        |



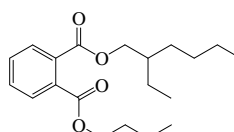
| No.  | Name                                        | Synonym                                  | Mol. Form.                                                  | CAS RN     | Mol. Wt. | Physical Form       | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                     |
|------|---------------------------------------------|------------------------------------------|-------------------------------------------------------------|------------|----------|---------------------|--------|---------------------------------------|----------------------------|----------------------|----------------------------------------------------------------|
| 5056 | 2-Ethylhexyl acrylate                       |                                          | C <sub>11</sub> H <sub>20</sub> O <sub>2</sub>              | 103-11-7   | 184.276  |                     | -90    | 125 <sup>60</sup>                     | 0.880 <sup>25</sup>        | 1.4332 <sup>25</sup> |                                                                |
| 5057 | 2-Ethylhexylamine                           | 2-Ethyl-1-hexanamine                     | C <sub>8</sub> H <sub>19</sub> N                            | 104-75-6   | 129.244  |                     |        | 169.2                                 |                            |                      | sl H <sub>2</sub> O                                            |
| 5058 | 2-Ethylhexyl butyl phthalate                | Butyl 2-ethylhexyl phthalate             | C <sub>20</sub> H <sub>36</sub> O <sub>4</sub>              | 85-69-8    | 334.450  | col liq             |        |                                       |                            |                      | sl H <sub>2</sub> O                                            |
| 5059 | 2-Ethylhexyl dihydrogen phosphate           | Mono(2-ethylhexyl) phosphate             | C <sub>8</sub> H <sub>19</sub> O <sub>4</sub> P             | 1070-03-7  | 210.208  | liq                 |        |                                       |                            |                      | s H <sub>2</sub> O, bz                                         |
| 5060 | 2-Ethylhexyl diphenyl phosphite             | Forstab                                  | C <sub>20</sub> H <sub>27</sub> O <sub>3</sub> P            | 15647-08-2 | 346.400  |                     |        | 152 <sup>20,15</sup>                  | 1.054 <sup>20</sup>        | 1.5207 <sup>27</sup> |                                                                |
| 5061 | Ethyl hexyl ether                           | 1-Ethoxyhexane                           | C <sub>9</sub> H <sub>19</sub> O                            | 5756-43-4  | 130.228  |                     |        | 143                                   | 0.7722 <sup>20</sup>       | 1.4008 <sup>20</sup> | vs eth, EtOH                                                   |
| 5062 | 2-Ethylhexyl 2-hydroxybenzoate              | Octisalate                               | C <sub>15</sub> H <sub>22</sub> O <sub>3</sub>              | 118-60-5   | 250.334  | liq                 |        | 190 <sup>21</sup>                     | 1.01                       |                      |                                                                |
| 5063 | 2-Ethylhexyl methacrylate                   |                                          | C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>              | 688-84-6   | 198.302  |                     |        | 120 <sup>18</sup> , 110 <sup>14</sup> | 0.880 <sup>25</sup>        | 1.436 <sup>25</sup>  |                                                                |
| 5064 | 2-[(2-Ethylhexyl)oxy]ethanol                | Ethylene glycol mono(2-ethylhexyl) ether | C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>              | 1559-35-9  | 174.281  |                     |        | 227.7                                 |                            |                      |                                                                |
| 5065 | Ethylhydrazine                              |                                          | C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                | 624-80-6   | 60.098   |                     |        | 101                                   |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH                            |
| 5066 | Ethyl hydrazinecarboxylate                  | Ethyl carbazate                          | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> | 4114-31-2  | 104.108  | cry                 | 46     | dec 198; 93 <sup>9</sup>              |                            |                      | s EtOH, eth; sl chl                                            |
| 5067 | Ethyl hydrogen adipate                      |                                          | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>               | 626-86-8   | 174.195  | hyg cry (eth, peth) | 29     | 285                                   | 0.9796 <sup>20</sup>       | 1.4311 <sup>20</sup> | s EtOH, eth, peth                                              |
| 5068 | Ethyl hydrogen fumarate                     |                                          | C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                | 2459-05-4  | 144.126  |                     | 70     | 147 <sup>16</sup>                     | 1.1109 <sup>87</sup>       |                      | s EtOH, ace; sl chl                                            |
| 5069 | Ethyl hydrogen succinate                    | Butanedioic acid, monoethyl ester        | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>               | 1070-34-4  | 146.141  | pr or nd            | 8      | 172 <sup>42</sup> , 119 <sup>3</sup>  | 1.1466 <sup>20</sup>       | 1.4327 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                                 |
| 5070 | Ethyl hydroperoxide                         | Ethyl hydrogen peroxide                  | C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>                | 3031-74-1  | 62.068   | liq                 | -100   | 95                                    | 0.9332 <sup>20</sup>       | 1.3800 <sup>20</sup> | vs H <sub>2</sub> O, bz, eth, EtOH                             |
| 5071 | Ethyl hydroxyacetate                        |                                          | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                | 623-50-7   | 104.105  |                     |        | 160                                   | 1.0826 <sup>23</sup>       | 1.4180 <sup>20</sup> | vs eth, EtOH                                                   |
| 5072 | Ethyl 3-hydroxybenzoate                     |                                          | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>               | 7781-98-8  | 166.173  | pl (bz)             | 74     |                                       | 1.0680 <sup>131</sup>      |                      | sl H <sub>2</sub> O, chl; s EtOH, eth                          |
| 5073 | Ethyl 4-hydroxybenzoate                     | Ethylparaben                             | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>               | 120-47-8   | 166.173  | cry (dil al)        | 117    | 297.5                                 |                            |                      | sl H <sub>2</sub> O, chl, tfa; vs EtOH, eth; i CS <sub>2</sub> |
| 5074 | Ethyl 3-hydroxybutanoate, (±)               |                                          | C <sub>8</sub> H <sub>12</sub> O <sub>3</sub>               | 35608-64-1 | 132.157  |                     |        | 185; 76 <sup>15</sup>                 | 1.017 <sup>20</sup>        | 1.4182 <sup>20</sup> | s H <sub>2</sub> O, EtOH; sl ctc                               |
| 5075 | Ethyl 2-hydroxy-3-butenate                  |                                          | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>               | 91890-87-8 | 130.141  |                     |        | dec 173; 68 <sup>15</sup>             | 1.0470 <sup>15</sup>       | 1.436 <sup>13</sup>  | vs H <sub>2</sub> O, eth, EtOH                                 |
| 5076 | α-Ethyl-1-hydroxycyclohexanecarboxylic acid | Cyclobutylol                             | C <sub>10</sub> H <sub>18</sub> O <sub>3</sub>              | 512-16-3   | 186.248  | cry (eth-peth)      | 81.5   | 164 <sup>24</sup>                     | 1.0010 <sup>18</sup>       | 1.4680 <sup>18</sup> | vs ace, eth, EtOH, chl                                         |
| 5077 | N-Ethyl-N-hydroxyethanamine                 | N,N-Diethylhydroxylamine                 | C <sub>4</sub> H <sub>11</sub> NO                           | 3710-84-7  | 89.136   |                     | 10     | 133                                   | 0.8669 <sup>20</sup>       | 1.4195 <sup>20</sup> |                                                                |
| 5078 | 2-Ethyl-3-hydroxyhexanal                    |                                          | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>               | 496-03-7   | 144.212  |                     |        | 138 <sup>50</sup> , 101 <sup>9</sup>  |                            |                      |                                                                |
| 5079 | Ethyl 4-hydroxy-3-methoxybenzoate           |                                          | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>              | 617-05-0   | 196.200  | nd (dil al)         | 44     | 292                                   |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s chl                        |
| 5080 | Ethyl cis-12-hydroxy-9-octadecenoate, (R)   | Ethyl ricinoleate                        | C <sub>20</sub> H <sub>38</sub> O <sub>3</sub>              | 55066-53-0 | 326.514  |                     |        | 258 <sup>13</sup>                     | 0.9180 <sup>20</sup>       | 1.4618 <sup>22</sup> |                                                                |
| 5081 | Ethylidenecyclohexane                       |                                          | C <sub>8</sub> H <sub>14</sub>                              | 1003-64-1  | 110.197  |                     |        | 136                                   | 0.822 <sup>25</sup>        | 1.4618 <sup>20</sup> |                                                                |
| 5082 | 5-Ethylidene-2-norbornene                   | 5-Ethylidenebicyclo[2.2.1]hept-2-ene     | C <sub>9</sub> H <sub>12</sub>                              | 16219-75-3 | 120.191  | liq                 |        | 146                                   | 0.893                      | 1.4900 <sup>20</sup> |                                                                |
| 5083 | 1-Ethyl-1H-imidazole                        |                                          | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub>                | 7098-07-9  | 96.131   |                     |        | 208                                   | 0.999 <sup>25</sup>        |                      | msc H <sub>2</sub> O                                           |
| 5084 | Ethyl iodoacetate                           |                                          | C <sub>4</sub> H <sub>7</sub> IO <sub>2</sub>               | 623-48-3   | 214.002  | oil                 |        | 179                                   | 1.8173 <sup>13</sup>       | 1.5079 <sup>13</sup> | s EtOH, eth                                                    |
| 5085 | Ethyl isobutylcarbamate                     | Isobutyl urethane                        | C <sub>7</sub> H <sub>15</sub> NO <sub>2</sub>              | 539-89-9   | 145.200  |                     | <-65   | 110 <sup>30</sup>                     | 0.9432 <sup>20</sup>       | 1.4288 <sup>20</sup> | vs eth, EtOH                                                   |
| 5086 | Ethyl isocyanate                            |                                          | C <sub>3</sub> H <sub>5</sub> NO                            | 109-90-0   | 71.078   |                     |        | 60                                    | 0.9031 <sup>20</sup>       | 1.3808 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                              |
| 5087 | Ethyl isocyanide                            |                                          | C <sub>3</sub> H <sub>5</sub> N                             | 624-79-3   | 55.079   |                     | <-66   | 79                                    | 0.7402 <sup>20</sup>       | 1.3622 <sup>20</sup> | vs H <sub>2</sub> O; msc EtOH, eth; s ace                      |
| 5088 | N-Ethyl-1H-isoindole-1,3(2H)-dione          |                                          | C <sub>10</sub> H <sub>9</sub> NO <sub>2</sub>              | 5022-29-7  | 175.184  | nd (al)             | 79     | 285.5                                 |                            |                      | s EtOH, eth                                                    |
| 5089 | Ethyl isopentyl ether                       |                                          | C <sub>7</sub> H <sub>16</sub> O                            | 628-04-6   | 116.201  |                     |        | 112.5                                 | 0.7688 <sup>21</sup>       |                      | vs eth, EtOH                                                   |
| 5090 | Ethylisopropylamine                         | N-Ethyl-2-propanamine                    | C <sub>5</sub> H <sub>13</sub> N                            | 19961-27-4 | 87.164   |                     |        | 69.6                                  |                            | 1.3872 <sup>25</sup> |                                                                |
| 5091 | 1-Ethyl-2-isopropylbenzene                  |                                          | C <sub>11</sub> H <sub>16</sub>                             | 18970-44-0 | 148.245  |                     |        | 193                                   | 0.888 <sup>20</sup>        | 1.508 <sup>20</sup>  | vs ace, bz, eth, EtOH                                          |
| 5092 | Ethyl isopropyl ether                       |                                          | C <sub>5</sub> H <sub>12</sub> O                            | 625-54-7   | 88.148   |                     |        | 54.1                                  | 0.720 <sup>25</sup>        | 1.3698 <sup>25</sup> | s H <sub>2</sub> O, ace, chl; msc EtOH, eth                    |
| 5093 | N-Ethyl-N-isopropyl-2-propanamine           |                                          | C <sub>8</sub> H <sub>19</sub> N                            | 7087-68-5  | 129.244  |                     |        | 126.5                                 | 0.742 <sup>25</sup>        | 1.4138 <sup>20</sup> | s ctc                                                          |
| 5094 | Ethyl isopropyl sulfide                     |                                          | C <sub>5</sub> H <sub>12</sub> S                            | 5145-99-3  | 104.214  | liq                 | -122.2 | 107.5                                 | 0.8246 <sup>20</sup>       |                      |                                                                |
| 5095 | Ethyl isothiocyanate                        |                                          | C <sub>3</sub> H <sub>5</sub> NS                            | 542-85-8   | 87.144   | liq                 | -5.9   | 131.5                                 | 0.9990 <sup>20</sup>       | 1.5130 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                              |
| 5096 | Ethyl lactate                               | Ethyl 2-hydroxypropionate                | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>               | 2676-33-7  | 118.131  | liq                 | -26    | 154.5                                 | 1.0328 <sup>20</sup>       | 1.4124 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                                 |
| 5097 | Ethyl laurate                               |                                          | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>              | 106-33-2   | 228.371  | liq                 | -10    | 271; 154 <sup>15</sup>                | 0.8618 <sup>20</sup>       | 1.4311 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth; sl ctc                   |
| 5098 | Ethyl levulinate                            |                                          | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>               | 539-88-8   | 144.168  |                     |        | 205.8                                 | 1.0111 <sup>20</sup>       | 1.4229 <sup>20</sup> | vs H <sub>2</sub> O, EtOH                                      |
| 5099 | Ethyl mercaptoacetate                       |                                          | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S              | 623-51-8   | 120.171  |                     |        | 157                                   | 1.0964 <sup>15</sup>       | 1.4582 <sup>20</sup> | s EtOH, eth; sl ctc                                            |
| 5100 | Ethyl methacrylate                          |                                          | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>               | 97-63-2    | 114.142  |                     |        | 117                                   | 0.9135 <sup>20</sup>       | 1.4147 <sup>20</sup> | sl H <sub>2</sub> O, chl; msc EtOH, eth                        |



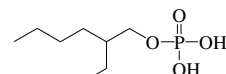
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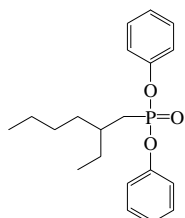
2-Ethylhexylamine



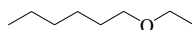
2-Ethylhexyl butyl phthalate



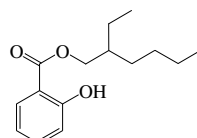
2-Ethylhexyl dihydrogen phosphate



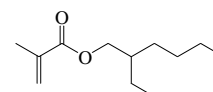
2-Ethylhexyl diphenyl phosphite



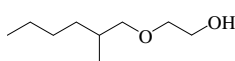
Ethyl hexyl ether



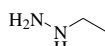
2-Ethylhexyl 2-hydroxybenzoate



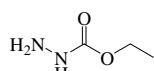
2-Ethylhexyl methacrylate



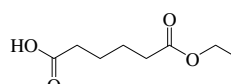
2-[(2-Ethylhexyl)oxy]ethanol



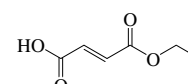
Ethylhydrazine



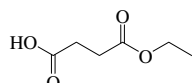
Ethyl hydrazinecarboxylate



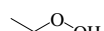
Ethyl hydrogen adipate



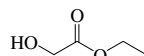
Ethyl hydrogen fumarate



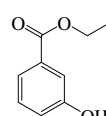
Ethyl hydrogen succinate



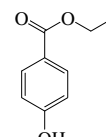
Ethyl hydroperoxide



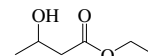
Ethyl hydroxyacetate



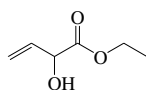
Ethyl 3-hydroxybenzoate



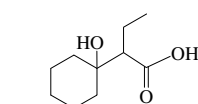
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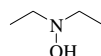
Ethyl 3-hydroxybutanoate, (±)



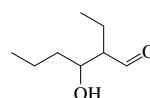
Ethyl 2-hydroxy-3-butenate



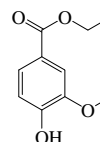
α-Ethyl-1-hydroxycyclohexanecarboxylic acid



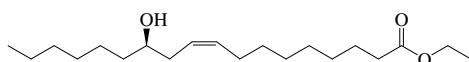
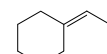
N-Ethyl-N-hydroxyethanamine



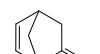
2-Ethyl-3-hydroxyhexanal



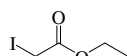
Ethyl 4-hydroxy-3-methoxybenzoate

Ethyl *cis*-12-hydroxy-9-octadecenoate, (*R*)

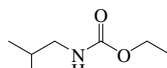
Ethylidenecyclohexane



5-Ethylidene-2-norbornene

1-Ethyl-1*H*-imidazole

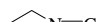
Ethyl iodoacetate



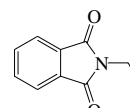
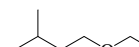
Ethyl isobutylcarbamate



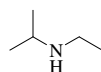
Ethyl isocyanate



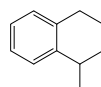
Ethyl isocyanide

N-Ethyl-1*H*-isoindole-1,3(2*H*)-dione

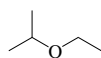
Ethyl isopentyl ether



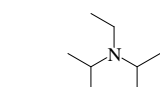
Ethylisopropylamine



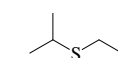
1-Ethyl-2-isopropylbenzene



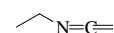
Ethyl isopropyl ether



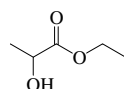
N-Ethyl-N-isopropyl-2-propanamine



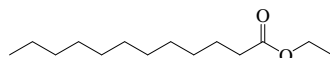
Ethyl isopropyl sulfide



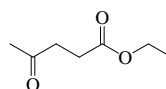
Ethyl isothiocyanate



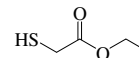
Ethyl lactate



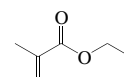
Ethyl laurate



Ethyl levulinate

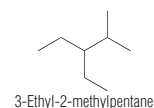
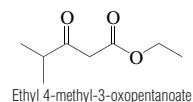
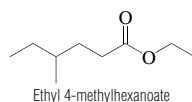
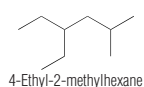
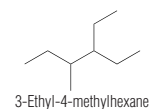
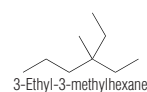
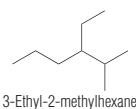
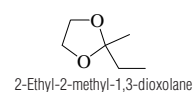
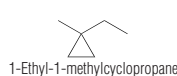
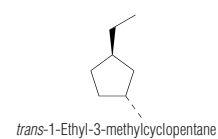
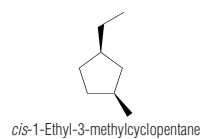
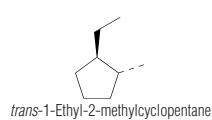
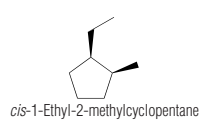
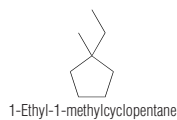
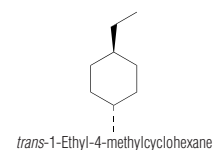
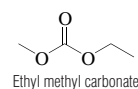
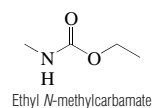
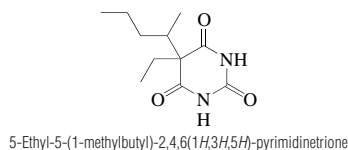
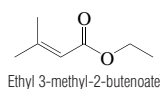
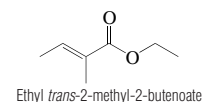
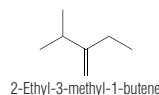
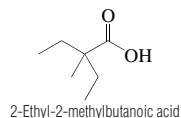
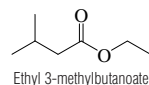
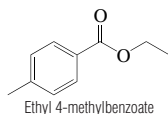
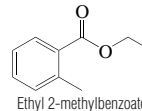
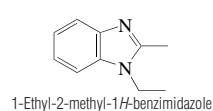
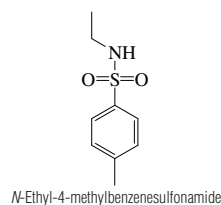
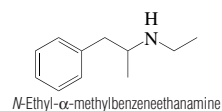
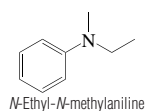
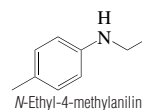
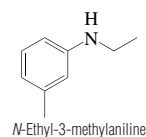
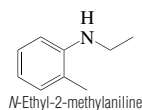
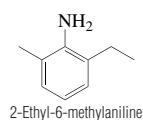
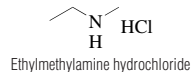
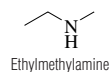
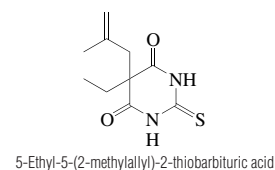
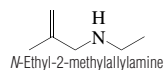
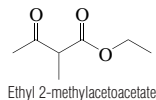
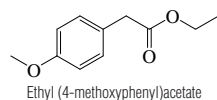
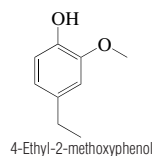
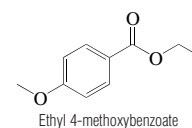
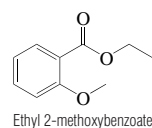
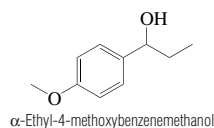
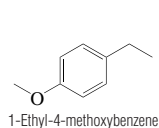
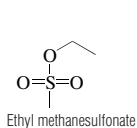


Ethyl mercaptoacetate

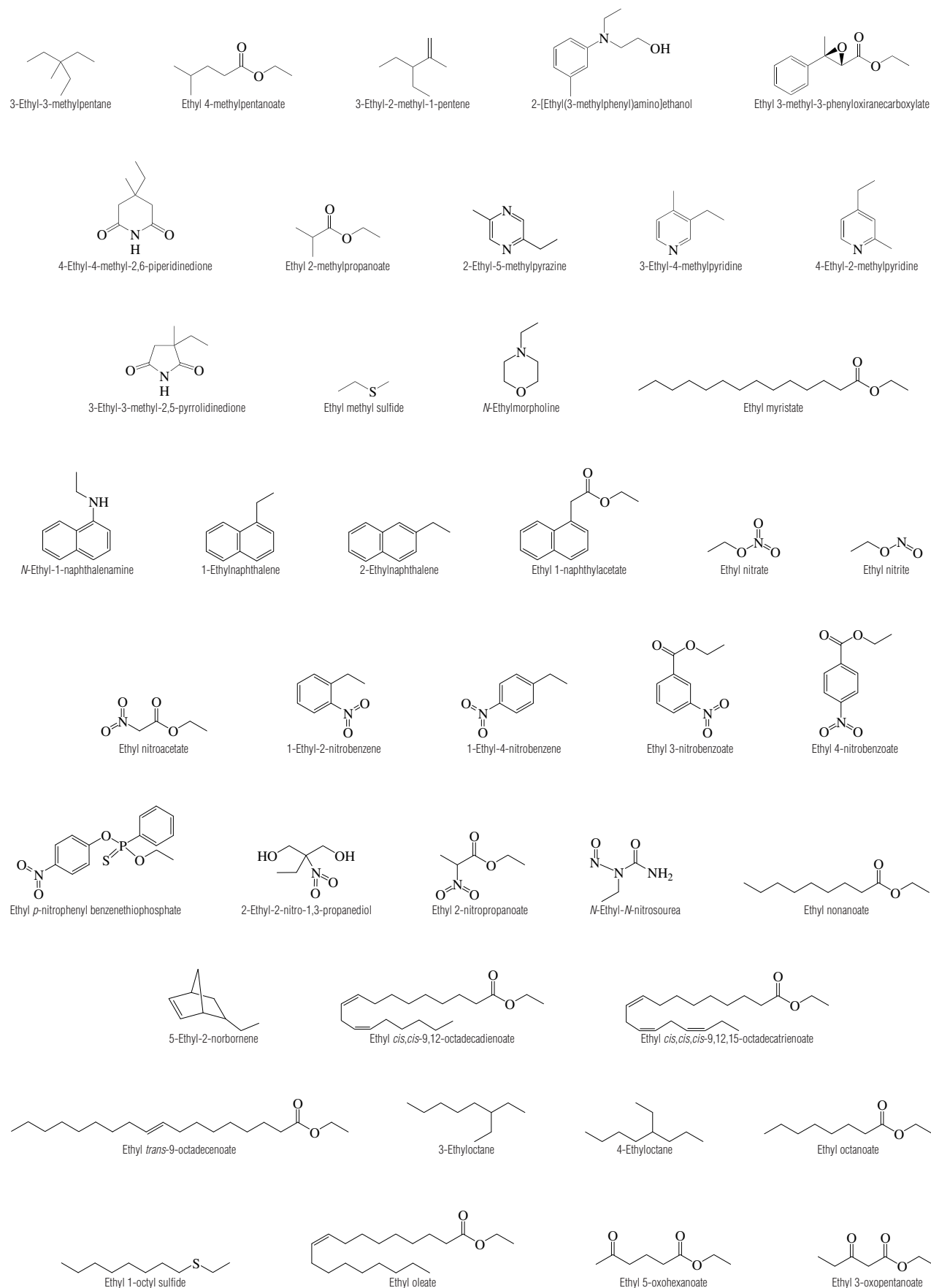


Ethyl methacrylate

| No.  | Name                                                       | Synonym                           | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form | mp/°C  | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                   |
|------|------------------------------------------------------------|-----------------------------------|-----------------------------------------------------------------|------------|----------|---------------|--------|------------------------|----------------------------|----------------------|----------------------------------------------|
| 5101 | Ethyl methanesulfonate                                     |                                   | C <sub>3</sub> H <sub>8</sub> O <sub>3</sub> S                  | 62-50-0    | 124.159  |               |        | 86 <sup>10</sup>       |                            |                      |                                              |
| 5102 | 1-Ethyl-4-methoxybenzene                                   |                                   | C <sub>9</sub> H <sub>12</sub> O                                | 1515-95-3  | 136.190  |               |        | 198                    | 0.9624 <sup>15</sup>       | 1.5120 <sup>20</sup> | vs bz, eth                                   |
| 5103 | α-Ethyl-4-methoxybenzenemethanol                           |                                   | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                  | 5349-60-0  | 166.217  |               |        | 143 <sup>20</sup>      |                            | 1.5277 <sup>20</sup> | s ctc                                        |
| 5104 | Ethyl 2-methoxybenzoate                                    |                                   | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                  | 7335-26-4  | 180.200  |               |        | 261                    | 1.1124 <sup>20</sup>       | 1.5224 <sup>20</sup> | vs eth, EtOH                                 |
| 5105 | Ethyl 4-methoxybenzoate                                    |                                   | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                  | 94-30-4    | 180.200  |               | 7.5    | 269.5                  | 1.1038 <sup>20</sup>       | 1.5254 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth              |
| 5106 | 4-Ethyl-2-methoxyphenol                                    |                                   | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                   | 2785-89-9  | 152.190  | liq           | -7     | 236.5                  | 1.0931 <sup>18</sup>       |                      |                                              |
| 5107 | Ethyl (4-methoxyphenyl)acetate                             |                                   | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>                  | 14062-18-1 | 194.227  |               |        | 139 <sup>70</sup>      | 1.097 <sup>25</sup>        | 1.5075 <sup>20</sup> |                                              |
| 5108 | Ethyl 2-methylacetoacetate                                 |                                   | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>                   | 609-14-3   | 144.168  |               |        | 187                    | 0.9941 <sup>20</sup>       | 1.4185 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth; vs ace     |
| 5109 | N-Ethyl-2-methylallylamine                                 | N-Ethyl-2-methyl-2-propen-1-amine | C <sub>6</sub> H <sub>13</sub> N                                | 18328-90-0 | 99.174   | liq           |        | 104.7                  | 0.753                      | 1.4221 <sup>20</sup> | msc H <sub>2</sub> O                         |
| 5110 | 5-Ethyl-5-(2-methylallyl)-2-thiobarbituric acid            | Methallatal                       | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub> S | 115-56-0   | 226.295  |               | 160.5  |                        |                            |                      |                                              |
| 5111 | Ethylmethylaniline                                         | N-Methylethanamine                | C <sub>3</sub> H <sub>9</sub> N                                 | 624-78-2   | 59.110   |               |        | 36.7                   |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH          |
| 5112 | Ethylmethylaniline hydrochloride                           | N-Methylethanamine hydrochloride  | C <sub>3</sub> H <sub>10</sub> ClN                              | 624-60-2   | 95.571   | pl (al-eth)   | 128    |                        | 1.0874 <sup>20</sup>       |                      | vs H <sub>2</sub> O, EtOH; i eth; s chl      |
| 5113 | 2-Ethyl-6-methylaniline                                    |                                   | C <sub>9</sub> H <sub>13</sub> N                                | 24549-06-2 | 135.206  | liq           | -33    | 231                    | 0.968 <sup>25</sup>        | 1.5525 <sup>20</sup> |                                              |
| 5114 | N-Ethyl-2-methylaniline                                    |                                   | C <sub>9</sub> H <sub>13</sub> N                                | 94-68-8    | 135.206  |               | <-15   | 216                    | 0.948 <sup>25</sup>        | 1.5456 <sup>20</sup> | s EtOH, eth                                  |
| 5115 | N-Ethyl-3-methylaniline                                    |                                   | C <sub>9</sub> H <sub>13</sub> N                                | 102-27-2   | 135.206  |               |        | 221                    | 0.9263 <sup>15</sup>       | 1.5451 <sup>20</sup> | s EtOH, eth                                  |
| 5116 | N-Ethyl-4-methylaniline                                    | N-Ethyl-4-toluidine               | C <sub>9</sub> H <sub>13</sub> N                                | 622-57-1   | 135.206  |               |        | 217                    | 0.9391 <sup>16</sup>       |                      | s EtOH, eth                                  |
| 5117 | N-Ethyl-N-methylaniline                                    |                                   | C <sub>9</sub> H <sub>13</sub> N                                | 613-97-8   | 135.206  |               |        | 204                    | 0.92 <sup>55</sup>         |                      | i H <sub>2</sub> O; msc EtOH, eth; s ctc     |
| 5118 | N-Ethyl-α-methylbenzeneethanamine                          | N-Ethylamphetamine                | C <sub>11</sub> H <sub>17</sub> N                               | 457-87-4   | 163.260  |               |        | 105 <sup>14</sup>      |                            | 1.4986 <sup>25</sup> |                                              |
| 5119 | N-Ethyl-4-methylbenzenesulfonamide                         |                                   | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub> S                | 80-39-7    | 199.270  |               | 64     |                        |                            |                      | s EtOH                                       |
| 5120 | 1-Ethyl-2-methyl-1H-benzimidazole                          |                                   | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub>                  | 5805-76-5  | 160.215  |               | 51     | 296                    | 1.073 <sup>25</sup>        |                      |                                              |
| 5121 | Ethyl 2-methylbenzoate                                     |                                   | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                  | 87-24-1    | 164.201  |               | <-10   | 227; 113 <sup>18</sup> | 1.0325 <sup>21</sup>       | 1.507 <sup>22</sup>  | i H <sub>2</sub> O; msc EtOH, eth            |
| 5122 | Ethyl 4-methylbenzoate                                     |                                   | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                  | 94-08-6    | 164.201  |               |        | 232                    | 1.0269 <sup>18</sup>       | 1.5089 <sup>18</sup> | i H <sub>2</sub> O; msc EtOH, eth            |
| 5123 | Ethyl 3-methylbutanoate                                    | Ethyl isovalerate                 | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                   | 108-64-5   | 130.185  | liq           | -99.3  | 135.0                  | 0.8656 <sup>20</sup>       | 1.3962 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth            |
| 5124 | 2-Ethyl-2-methylbutanoic acid                              |                                   | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                   | 19889-37-3 | 130.185  |               | <-20   | 207                    |                            | 1.4250 <sup>20</sup> | vs EtOH                                      |
| 5125 | 2-Ethyl-3-methyl-1-butene                                  |                                   | C <sub>7</sub> H <sub>14</sub>                                  | 7357-93-9  | 98.186   |               |        | 89                     | 0.7150 <sup>20</sup>       | 1.410 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ace, bz, chl      |
| 5126 | Ethyl trans-2-methyl-2-butenolate                          |                                   | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                   | 5837-78-5  | 128.169  |               |        | 156                    | 0.9200 <sup>20</sup>       | 1.4340 <sup>20</sup> |                                              |
| 5127 | Ethyl 3-methyl-2-butenolate                                |                                   | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                   | 638-10-8   | 128.169  |               |        | 153.5                  | 0.9199 <sup>21</sup>       | 1.4345 <sup>20</sup> |                                              |
| 5128 | 5-Ethyl-5-(1-methylbutyl)-2,4,6(1H,3H,5H)-pyrimidinetrione |                                   | C <sub>11</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub>   | 76-74-4    | 226.272  |               | 130    |                        |                            |                      | sl H <sub>2</sub> O; s EtOH, eth             |
| 5129 | Ethyl N-methylcarbamate                                    |                                   | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                   | 105-40-8   | 103.120  |               |        | 170                    | 1.0115 <sup>20</sup>       | 1.4183 <sup>20</sup> | vs H <sub>2</sub> O, EtOH                    |
| 5130 | Ethyl methyl carbonate                                     |                                   | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                    | 623-53-0   | 104.105  | liq           | -14    | 107.5                  | 1.012 <sup>20</sup>        | 1.3778 <sup>20</sup> | vs eth, EtOH                                 |
| 5131 | trans-1-Ethyl-4-methylcyclohexane                          |                                   | C <sub>8</sub> H <sub>18</sub>                                  | 6236-88-0  | 126.239  | liq           | -80.8  | 149                    | 0.7798 <sup>20</sup>       | 1.4304 <sup>20</sup> |                                              |
| 5132 | 1-Ethyl-1-methylcyclopentane                               |                                   | C <sub>8</sub> H <sub>16</sub>                                  | 16747-50-5 | 112.213  | liq           | -143.8 | 121.6                  | 0.7767 <sup>25</sup>       | 1.4272 <sup>20</sup> | vs ace, bz, eth, EtOH                        |
| 5133 | cis-1-Ethyl-2-methylcyclopentane                           |                                   | C <sub>8</sub> H <sub>16</sub>                                  | 930-89-2   | 112.213  | liq           | -106   | 128                    | 0.7852 <sup>20</sup>       | 1.4293 <sup>20</sup> |                                              |
| 5134 | trans-1-Ethyl-2-methylcyclopentane                         |                                   | C <sub>8</sub> H <sub>16</sub>                                  | 930-90-5   | 112.213  | liq           | -105.9 | 121.2                  | 0.7649 <sup>25</sup>       | 1.4219 <sup>20</sup> |                                              |
| 5135 | cis-1-Ethyl-3-methylcyclopentane                           |                                   | C <sub>8</sub> H <sub>16</sub>                                  | 2613-66-3  | 112.213  |               |        | 121                    | 0.7724 <sup>20</sup>       | 1.4203 <sup>20</sup> | vs ace, bz, eth, EtOH                        |
| 5136 | trans-1-Ethyl-3-methylcyclopentane                         |                                   | C <sub>8</sub> H <sub>16</sub>                                  | 2613-65-2  | 112.213  | liq           | -108   | 121                    | 0.7619 <sup>20</sup>       | 1.4186 <sup>20</sup> |                                              |
| 5137 | 1-Ethyl-1-methylcyclopropane                               |                                   | C <sub>6</sub> H <sub>12</sub>                                  | 53778-43-1 | 84.159   | liq           | -130.2 | 56.8                   | 0.6968 <sup>25</sup>       | 1.3887 <sup>20</sup> |                                              |
| 5138 | 2-Ethyl-2-methyl-1,3-dioxolane                             |                                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                   | 126-39-6   | 116.158  |               |        | 118                    | 0.9360 <sup>20</sup>       |                      |                                              |
| 5139 | Ethyl methyl ether                                         |                                   | C <sub>3</sub> H <sub>8</sub> O                                 | 540-67-0   | 60.095   | col gas       | -113   | 7.4                    | 0.7251 <sup>10</sup>       | 1.3420 <sup>4</sup>  | s H <sub>2</sub> O, ace, chl; msc EtOH, eth  |
| 5140 | 3-Ethyl-2-methylhexane                                     |                                   | C <sub>9</sub> H <sub>20</sub>                                  | 16789-46-1 | 128.255  |               |        | 138                    | 0.7310 <sup>20</sup>       | 1.4106 <sup>20</sup> |                                              |
| 5141 | 3-Ethyl-3-methylhexane                                     |                                   | C <sub>9</sub> H <sub>20</sub>                                  | 3074-76-8  | 128.255  |               |        | 140.6                  | 0.7371 <sup>25</sup>       | 1.4140 <sup>20</sup> |                                              |
| 5142 | 3-Ethyl-4-methylhexane                                     | 2,3-Diethylpentane                | C <sub>9</sub> H <sub>20</sub>                                  | 3074-77-9  | 128.255  |               |        | 140                    | 0.7420 <sup>20</sup>       | 1.4134 <sup>20</sup> |                                              |
| 5143 | 4-Ethyl-2-methylhexane                                     |                                   | C <sub>9</sub> H <sub>20</sub>                                  | 3074-75-7  | 128.255  |               |        | 133.8                  | 0.7195 <sup>25</sup>       | 1.4063 <sup>20</sup> |                                              |
| 5144 | Ethyl 4-methylhexanoate                                    | Ethyl 4-methylcaproate            | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                   | 1561-10-0  | 158.238  |               |        | 180                    | 0.8708 <sup>20</sup>       | 1.4051 <sup>20</sup> |                                              |
| 5145 | Ethyl 4-methyl-3-oxopentanoate                             |                                   | C <sub>9</sub> H <sub>16</sub> O <sub>3</sub>                   | 7152-15-0  | 158.195  | liq           | -9     | 173                    | 0.98 <sup>25</sup>         | 1.250 <sup>20</sup>  |                                              |
| 5146 | 3-Ethyl-2-methylpentane                                    |                                   | C <sub>8</sub> H <sub>18</sub>                                  | 609-26-7   | 114.229  | liq           | -114.9 | 115.66                 | 0.7193 <sup>20</sup>       | 1.4040 <sup>20</sup> | i H <sub>2</sub> O; s eth; msc EtOH, ace, bz |

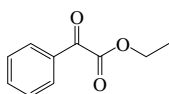


| No.  | Name                                                | Synonym                                | Mol. Form.                                                  | CAS RN     | Mol. Wt. | Physical Form        | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|-----------------------------------------------------|----------------------------------------|-------------------------------------------------------------|------------|----------|----------------------|---------|----------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 5147 | 3-Ethyl-3-methylpentane                             |                                        | C <sub>8</sub> H <sub>18</sub>                              | 1067-08-9  | 114.229  | liq                  | -90.9   | 118.27                                 | 0.7274 <sup>20</sup>       | 1.4078 <sup>20</sup> | i H <sub>2</sub> O; s eth;<br>msc EtOH,<br>ace, bz     |
| 5148 | Ethyl 4-methylpentanoate                            |                                        | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>               | 25415-67-2 | 144.212  |                      |         | 163; 52 <sup>10</sup>                  | 0.8705 <sup>20</sup>       | 1.4050 <sup>20</sup> |                                                        |
| 5149 | 3-Ethyl-2-methyl-1-pentene                          |                                        | C <sub>8</sub> H <sub>16</sub>                              | 19780-66-6 | 112.213  | liq                  | -112.9  | 109.5                                  | 0.7262 <sup>20</sup>       | 1.4140 <sup>20</sup> |                                                        |
| 5150 | 2-[Ethyl(3-methylphenyl)amino]<br>ethanol           |                                        | C <sub>11</sub> H <sub>17</sub> NO                          | 91-88-3    | 179.259  |                      |         | 118 <sup>1.5</sup>                     |                            | 1.5540 <sup>20</sup> | s ctc                                                  |
| 5151 | Ethyl 3-methyl-3-phenyloxiranecarboxylate           | Ethyl 3-methyl-3-phenylglycidate       | C <sub>12</sub> H <sub>14</sub> O <sub>3</sub>              | 77-83-8    | 206.237  |                      |         | 273.5                                  | 1.044 <sup>20</sup>        | 1.5182 <sup>20</sup> |                                                        |
| 5152 | 4-Ethyl-4-methyl-2,6-piperidinedione                | Bemegride                              | C <sub>8</sub> H <sub>13</sub> NO <sub>2</sub>              | 64-65-3    | 155.195  | pl (w. ace-eth)      | 126.5   | sub 100                                |                            |                      | s chl                                                  |
| 5153 | Ethyl 2-methylpropanoate                            | Ethyl isobutanoate                     | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>               | 97-62-1    | 116.158  | liq                  | -88.2   | 110.1                                  | 0.868 <sup>20</sup>        | 1.3869 <sup>18</sup> | sl H <sub>2</sub> O, ctc; msc<br>EtOH, eth; s<br>ace   |
| 5154 | 2-Ethyl-5-methylpyrazine                            |                                        | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>               | 13360-64-0 | 122.167  | liq                  |         | 79 <sup>25</sup>                       |                            |                      |                                                        |
| 5155 | 3-Ethyl-4-methylpyridine                            | 3-Ethyl-4-picoline                     | C <sub>8</sub> H <sub>11</sub> N                            | 529-21-5   | 121.180  |                      |         | 198                                    | 0.9286 <sup>17</sup>       |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, chl; vs ace       |
| 5156 | 4-Ethyl-2-methylpyridine                            | 4-Ethyl-2-picoline                     | C <sub>8</sub> H <sub>11</sub> N                            | 536-88-9   | 121.180  |                      |         | 179                                    | 0.9130 <sup>25</sup>       |                      | vs ace, bz, eth,<br>EtOH                               |
| 5157 | 3-Ethyl-3-methyl-2,5-pyrrolidinedione               | Ethosuximide                           | C <sub>7</sub> H <sub>11</sub> NO <sub>2</sub>              | 77-67-8    | 141.168  | cry (ace-eth)        | 64.5    |                                        |                            |                      | vs H <sub>2</sub> O                                    |
| 5158 | Ethyl methyl sulfide                                |                                        | C <sub>3</sub> H <sub>8</sub> S                             | 624-89-5   | 76.161   | liq                  | -105.93 | 66.7                                   | 0.8422 <sup>20</sup>       | 1.4404 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH; s eth,<br>chl         |
| 5159 | <i>N</i> -Ethylmorpholine                           |                                        | C <sub>6</sub> H <sub>13</sub> NO                           | 100-74-3   | 115.173  |                      |         | 138.5                                  | 0.8996 <sup>20</sup>       | 1.4400 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; s ace, bz          |
| 5160 | Ethyl myristate                                     |                                        | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>              | 124-06-1   | 256.424  |                      | 12.3    | 295                                    | 0.8573 <sup>25</sup>       | 1.4362 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>ctc, lig; sl eth        |
| 5161 | <i>N</i> -Ethyl-1-naphthalenamine                   |                                        | C <sub>12</sub> H <sub>13</sub> N                           | 118-44-5   | 171.238  |                      |         | 305; 191 <sup>16</sup>                 | 1.0652 <sup>15</sup>       | 1.6477 <sup>15</sup> | vs eth, EtOH                                           |
| 5162 | 1-Ethyl-naphthalene                                 |                                        | C <sub>12</sub> H <sub>12</sub>                             | 1127-76-0  | 156.223  | liq                  | -13.9   | 258.6                                  | 1.0082 <sup>20</sup>       | 1.6062 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                   |
| 5163 | 2-Ethyl-naphthalene                                 |                                        | C <sub>12</sub> H <sub>12</sub>                             | 939-27-5   | 156.223  | liq                  | -7.4    | 258                                    | 0.9922 <sup>20</sup>       | 1.5999 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; sl<br>chl        |
| 5164 | Ethyl 1-naphthylacetate                             |                                        | C <sub>14</sub> H <sub>14</sub> O <sub>2</sub>              | 2122-70-5  | 214.260  | oil                  | 88.5    | 222 <sup>20</sup> , 118 <sup>13</sup>  |                            |                      | s EtOH, eth                                            |
| 5165 | Ethyl nitrate                                       |                                        | C <sub>2</sub> H <sub>5</sub> NO <sub>3</sub>               | 625-58-1   | 91.066   | liq                  | -94.6   | 87.2                                   | 1.1084 <sup>20</sup>       | 1.3852 <sup>20</sup> | s H <sub>2</sub> O; msc<br>EtOH, eth                   |
| 5166 | Ethyl nitrite                                       |                                        | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>               | 109-95-5   | 75.067   | ye vol liq or<br>gas |         | 18                                     | 0.899 <sup>15</sup>        | 1.3418 <sup>10</sup> | msc EtOH, eth                                          |
| 5167 | Ethyl nitroacetate                                  |                                        | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>               | 626-35-7   | 133.104  |                      |         | 106 <sup>25</sup> , 83 <sup>6</sup>    | 1.1953 <sup>20</sup>       | 1.4250 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH; vs eth; s<br>dil alk |
| 5168 | 1-Ethyl-2-nitrobenzene                              |                                        | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>               | 612-22-6   | 151.163  | liq                  | -12.3   | 232.5                                  | 1.1207 <sup>20</sup>       | 1.5356 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth; s ace; sl<br>ctc  |
| 5169 | 1-Ethyl-4-nitrobenzene                              |                                        | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>               | 100-12-9   | 151.163  | liq                  | -12.3   | 245.5                                  | 1.1192 <sup>20</sup>       | 1.5455 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth; s ace; sl<br>ctc  |
| 5170 | Ethyl 3-nitrobenzoate                               |                                        | C <sub>9</sub> H <sub>9</sub> NO <sub>4</sub>               | 618-98-4   | 195.172  |                      | 47      | 297                                    |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth                    |
| 5171 | Ethyl 4-nitrobenzoate                               |                                        | C <sub>9</sub> H <sub>9</sub> NO <sub>4</sub>               | 99-77-4    | 195.172  |                      | 57      | 186.3; 153 <sup>8</sup>                |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth                     |
| 5172 | Ethyl <i>p</i> -nitrophenyl<br>benzenethiophosphate |                                        | C <sub>14</sub> H <sub>14</sub> NO <sub>4</sub> PS          | 2104-64-5  | 323.304  |                      | 36      |                                        | 1.27 <sup>25</sup>         | 1.5978 <sup>30</sup> | vs bz, eth, EtOH                                       |
| 5173 | 2-Ethyl-2-nitro-1,3-propanediol                     |                                        | C <sub>5</sub> H <sub>11</sub> NO <sub>4</sub>              | 597-09-1   | 149.146  | nd (w)               | 57.5    | dec                                    |                            |                      | vs H <sub>2</sub> O, eth,<br>EtOH                      |
| 5174 | Ethyl 2-nitropropanoate                             |                                        | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>               | 2531-80-8  | 147.130  |                      |         | 190.5                                  |                            | 1.4210 <sup>20</sup> | vs bz, eth, EtOH                                       |
| 5175 | <i>N</i> -Ethyl- <i>N</i> -nitroso-urea             | <i>N</i> -Nitroso- <i>N</i> -ethylurea | C <sub>3</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub> | 759-73-9   | 117.107  |                      | 100 dec |                                        |                            |                      | s chl                                                  |
| 5176 | Ethyl nonanoate                                     |                                        | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>              | 123-29-5   | 186.292  | liq                  | -36.7   | 227.0                                  | 0.8657 <sup>20</sup>       | 1.4220 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace, ctc           |
| 5177 | 5-Ethyl-2-norbornene                                |                                        | C <sub>9</sub> H <sub>14</sub>                              | 15403-89-1 | 122.207  | liq                  |         | 143.6                                  | 0.86                       | 1.4630 <sup>20</sup> |                                                        |
| 5178 | Ethyl <i>cis,cis</i> -9,12-octadecadienoate         | Ethyl linoleate                        | C <sub>20</sub> H <sub>36</sub> O <sub>2</sub>              | 544-35-4   | 308.499  | ye or col            |         | 272 <sup>180</sup> , 212 <sup>12</sup> | 0.8865 <sup>20</sup>       |                      | vs eth, EtOH                                           |
| 5179 | Ethyl <i>cis,cis,cis</i> -9,12,15-octadecatrienoate | Ethyl linolenate                       | C <sub>20</sub> H <sub>34</sub> O <sub>2</sub>              | 1191-41-9  | 306.483  |                      |         | 218 <sup>15</sup>                      | 0.8919 <sup>20</sup>       | 1.4694 <sup>20</sup> | vs eth, EtOH                                           |
| 5180 | Ethyl <i>trans</i> -9-octadecenoate                 |                                        | C <sub>20</sub> H <sub>36</sub> O <sub>2</sub>              | 6114-18-7  | 310.515  |                      | 5.8     | 218 <sup>15</sup>                      | 0.8664 <sup>25</sup>       | 1.4480 <sup>25</sup> | vs eth, EtOH                                           |
| 5181 | 3-Ethyl-octane                                      |                                        | C <sub>10</sub> H <sub>22</sub>                             | 5881-17-4  | 142.282  |                      |         | 166.5                                  | 0.7359 <sup>25</sup>       | 1.4156 <sup>20</sup> |                                                        |
| 5182 | 4-Ethyl-octane                                      |                                        | C <sub>10</sub> H <sub>22</sub>                             | 15869-86-0 | 142.282  |                      |         | 163.7                                  | 0.7343 <sup>25</sup>       | 1.4151 <sup>20</sup> |                                                        |
| 5183 | Ethyl octanoate                                     |                                        | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>              | 106-32-1   | 172.265  | liq                  | -43.1   | 208.5                                  | 0.866 <sup>18</sup>        | 1.4178 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth; sl ctc            |
| 5184 | Ethyl 1-octyl sulfide                               | 1-(Ethylthio)octane                    | C <sub>10</sub> H <sub>22</sub> S                           | 3698-94-0  | 174.347  | liq                  |         | 109 <sup>14</sup>                      |                            |                      |                                                        |
| 5185 | Ethyl oleate                                        | Ethyl <i>cis</i> -9-octadecenoate      | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub>              | 111-62-6   | 310.515  |                      |         | 216 <sup>15</sup> , 207 <sup>13</sup>  | 0.8720 <sup>20</sup>       | 1.4515 <sup>20</sup> | vs eth, EtOH                                           |
| 5186 | Ethyl 5-oxohexanoate                                |                                        | C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>               | 13984-57-1 | 158.195  |                      |         | 221.5                                  | 0.989 <sup>25</sup>        | 1.4277 <sup>20</sup> |                                                        |
| 5187 | Ethyl 3-oxopentanoate                               |                                        | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>               | 4949-44-4  | 144.168  |                      |         | 191                                    | 1.0120 <sup>20</sup>       | 1.4230 <sup>20</sup> | vs bz, eth, EtOH                                       |

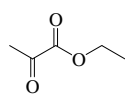




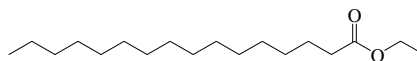
| No.  | Name                                       | Synonym                          | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form            | mp/°C   | bp/°C                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                  |
|------|--------------------------------------------|----------------------------------|----------------------------------------------------------------|------------|----------|--------------------------|---------|-------------------------|----------------------------|-----------------------|-------------------------------------------------------------|
| 5188 | Ethyl 2-oxo-2-phenylacetate                | Ethyl phenylglyoxylate           | C <sub>10</sub> H <sub>10</sub> O <sub>3</sub>                 | 1603-79-8  | 178.184  |                          |         | 256.5                   | 1.1222 <sup>25</sup>       | 1.5190 <sup>25</sup>  |                                                             |
| 5189 | Ethyl 2-oxopropanoate                      | Ethyl pyruvate                   | C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>                   | 617-35-6   | 116.116  | liq                      | -50     | 155                     | 1.0596 <sup>15</sup>       | 1.4052 <sup>20</sup>  | sl H <sub>2</sub> O; s ace;<br>msc EtOH, eth                |
| 5190 | Ethyl palmitate                            |                                  | C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>                 | 628-97-7   | 284.478  | nd                       | 24      | 191 <sup>10</sup>       | 0.8577 <sup>25</sup>       | 1.4347 <sup>34</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz,<br>chl         |
| 5191 | 3-Ethylpentane                             |                                  | C <sub>7</sub> H <sub>16</sub>                                 | 617-78-7   | 100.202  | liq                      | -118.55 | 93.5                    | 0.6982 <sup>20</sup>       | 1.3934 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth; msc ace,<br>bz, hp, chl |
| 5192 | 3-Ethyl-2,4-pentanedione                   |                                  | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                  | 1540-34-7  | 128.169  |                          |         | 178.5                   | 0.9531 <sup>19</sup>       | 1.4408 <sup>19</sup>  | vs eth, EtOH,<br>chl                                        |
| 5193 | Ethyl pentanoate                           | Ethyl valerate                   | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 539-82-2   | 130.185  | liq                      | -91.2   | 146.1                   | 0.8770 <sup>20</sup>       | 1.4120 <sup>20</sup>  | i H <sub>2</sub> O; msc<br>EtOH, eth; sl<br>ctc             |
| 5194 | 3-Ethyl-3-pentanol                         |                                  | C <sub>7</sub> H <sub>16</sub> O                               | 597-49-9   | 116.201  | liq                      | -12.5   | 142                     | 0.8407 <sup>22</sup>       | 1.4294 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH,<br>eth                         |
| 5195 | 2-Ethyl-1-pentene                          |                                  | C <sub>7</sub> H <sub>14</sub>                                 | 3404-71-5  | 98.186   |                          |         | 94                      | 0.7079 <sup>20</sup>       | 1.405 <sup>20</sup>   | vs bz, eth, EtOH                                            |
| 5196 | 3-Ethyl-1-pentene                          |                                  | C <sub>7</sub> H <sub>14</sub>                                 | 4038-04-4  | 98.186   | liq                      | -127.5  | 84.1                    | 0.6917 <sup>25</sup>       | 1.3982 <sup>20</sup>  |                                                             |
| 5197 | 3-Ethyl-2-pentene                          |                                  | C <sub>7</sub> H <sub>14</sub>                                 | 816-79-5   | 98.186   |                          |         | 96                      | 0.7204 <sup>20</sup>       | 1.4148 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl                 |
| 5198 | Ethyl pentyl ether                         |                                  | C <sub>7</sub> H <sub>16</sub> O                               | 17952-11-3 | 116.201  |                          |         | 117.6                   | 0.7622 <sup>20</sup>       | 1.3927 <sup>20</sup>  | vs eth, EtOH                                                |
| 5199 | Ethyl 2-pentynoate                         |                                  | C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>                  | 55314-57-3 | 126.153  |                          |         | 67 <sup>18</sup>        | 0.962 <sup>25</sup>        |                       |                                                             |
| 5200 | 2-Ethylphenol                              |                                  | C <sub>8</sub> H <sub>10</sub> O                               | 90-00-6    | 122.164  |                          | 18      | 204.5                   | 1.0146 <sup>25</sup>       | 1.5367 <sup>20</sup>  | vs ace, bz, eth,<br>EtOH                                    |
| 5201 | 3-Ethylphenol                              |                                  | C <sub>8</sub> H <sub>10</sub> O                               | 620-17-7   | 122.164  | liq                      | -4      | 218.4                   | 1.0283 <sup>20</sup>       |                       | sl H <sub>2</sub> O, chl; vs<br>EtOH, eth                   |
| 5202 | 4-Ethylphenol                              |                                  | C <sub>8</sub> H <sub>10</sub> O                               | 123-07-9   | 122.164  | nd                       | 45.0    | 217.9                   |                            | 1.5239 <sup>25</sup>  | sl H <sub>2</sub> O, chl; vs<br>EtOH, eth, bz;<br>s ace     |
| 5203 | Ethyl phenoxycetate                        |                                  | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                 | 2555-49-9  | 180.200  |                          |         | 247; 110 <sup>3</sup>   | 1.0958 <sup>30</sup>       | 1.5080 <sup>20</sup>  |                                                             |
| 5204 | <i>N</i> -Ethyl- <i>N</i> -phenylacetamide |                                  | C <sub>10</sub> H <sub>13</sub> NO                             | 529-65-7   | 163.216  |                          | 55      | 260                     | 0.9938 <sup>30</sup>       |                       | s H <sub>2</sub> O, eth, ctc                                |
| 5205 | Ethyl phenylacetate                        | Benzeneacetic acid, ethyl ester  | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                 | 101-97-3   | 164.201  | liq                      | -29.4   | 227                     | 1.0333 <sup>20</sup>       | 1.4980 <sup>20</sup>  | vs eth, EtOH                                                |
| 5206 | 2-(Ethylphenylamino)ethanol                |                                  | C <sub>10</sub> H <sub>15</sub> NO                             | 92-50-2    | 165.232  |                          |         |                         |                            |                       | s chl                                                       |
| 5207 | Ethyl phenylcarbamate                      | Phenylurethane                   | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                 | 101-99-5   | 165.189  | wh nd (w) pl<br>(dil al) | 53      | dec 237                 | 1.1064 <sup>30</sup>       | 1.5376 <sup>30</sup>  | i H <sub>2</sub> O; vs EtOH,<br>eth; s bz; sl ctc           |
| 5208 | Ethyl <i>N</i> -phenylformimidate          |                                  | C <sub>9</sub> H <sub>11</sub> NO                              | 6780-49-0  | 149.189  |                          |         | 214; 87 <sup>10</sup>   | 1.0051 <sup>20</sup>       | 1.5279 <sup>20</sup>  | s eth, bz                                                   |
| 5209 | Ethyl <i>N</i> -phenylglycinate            |                                  | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>                | 2216-92-4  | 179.216  | lf (dil al)              | 58      | 273.5                   |                            |                       | vs eth, EtOH                                                |
| 5210 | 1-(4-Ethylphenyl)-2-phenylethane           |                                  | C <sub>16</sub> H <sub>18</sub>                                | 7439-15-8  | 210.314  | cry                      |         | 294                     | 1.028 <sup>50</sup>        |                       |                                                             |
| 5211 | Ethyl 3-phenylpropanoate                   |                                  | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | 2021-28-5  | 178.228  |                          |         | 247.2                   | 1.0147 <sup>20</sup>       | 1.4954 <sup>20</sup>  | vs eth, EtOH                                                |
| 5212 | Ethyl 3-phenylpropynoate                   | Ethyl phenylacetylenecarboxylate | C <sub>11</sub> H <sub>10</sub> O <sub>2</sub>                 | 2216-94-6  | 174.196  |                          |         | 265; 128 <sup>1,6</sup> | 1.055 <sup>25</sup>        | 1.5520 <sup>20</sup>  | s eth                                                       |
| 5213 | Ethyl phenyl sulfone                       |                                  | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub> S                | 599-70-2   | 170.229  | lf (dil al)              | 42      | 160 <sup>12</sup>       | 1.1410 <sup>20</sup>       |                       | vs bz, eth, EtOH,<br>chl                                    |
| 5214 | Ethylphosphonic acid                       |                                  | C <sub>2</sub> H <sub>5</sub> O <sub>3</sub> P                 | 6779-09-5  | 110.049  | hyg pl or nd             | 61.5    | 335 <sup>8</sup>        |                            |                       | vs H <sub>2</sub> O, eth,<br>EtOH                           |
| 5215 | Ethyl phosphorodichloridate                | Ethylphosphoric acid dichloride  | C <sub>2</sub> H <sub>5</sub> Cl <sub>2</sub> O <sub>2</sub> P | 1498-51-7  | 162.940  |                          |         | 62 <sup>10</sup>        |                            | 1.4338 <sup>20</sup>  |                                                             |
| 5216 | 5-Ethyl-2-picoline                         |                                  | C <sub>8</sub> H <sub>11</sub> N                               | 104-90-5   | 121.180  |                          |         | 178.3                   | 0.9202 <sup>20</sup>       | 1.4971 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH,<br>eth, bz; vs ace             |
| 5217 | Ethyl 1-piperazinecarboxylate              | 1-Carbethoxypiperazine           | C <sub>7</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>   | 120-43-4   | 158.198  |                          |         | 237                     |                            | 1.4760 <sup>25</sup>  | vs H <sub>2</sub> O, eth,<br>EtOH                           |
| 5218 | 1-Ethylpiperidine                          |                                  | C <sub>7</sub> H <sub>15</sub> N                               | 766-09-6   | 113.201  |                          |         | 130.8                   | 0.8237 <sup>20</sup>       | 1.4480 <sup>20</sup>  |                                                             |
| 5219 | Ethyl 4-piperidinecarboxylate              |                                  | C <sub>8</sub> H <sub>15</sub> NO <sub>2</sub>                 | 1126-09-6  | 157.211  | col oil                  |         | 100 <sup>10</sup>       |                            | 1.4591 <sup>20</sup>  | vs H <sub>2</sub> O, bz, eth,<br>EtOH                       |
| 5220 | Ethyl 1-piperidinepropanoate               |                                  | C <sub>10</sub> H <sub>19</sub> NO <sub>2</sub>                | 19653-33-9 | 185.264  |                          |         | 217; 139 <sup>50</sup>  | 0.9627 <sup>25</sup>       | 1.4525 <sup>25</sup>  | vs H <sub>2</sub> O                                         |
| 5221 | 1-Ethyl-3-piperidinol                      |                                  | C <sub>7</sub> H <sub>13</sub> NO                              | 13444-24-1 | 129.200  |                          |         | 94 <sup>15</sup>        |                            | 1.4777 <sup>14</sup>  |                                                             |
| 5222 | <i>N</i> -Ethyl-1-propanamine              |                                  | C <sub>6</sub> H <sub>13</sub> N                               | 20193-20-8 | 87.164   |                          |         | 81                      | 0.7204 <sup>17</sup>       | 1.3858 <sup>25</sup>  | sl H <sub>2</sub> O; vs ace,<br>EtOH                        |
| 5223 | Ethylpropanedioic acid                     |                                  | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                   | 601-75-2   | 132.116  | pr (w+1)                 | 114     | 180 <sup>0,15</sup>     |                            |                       | vs H <sub>2</sub> O; s EtOH,<br>eth, bz; i ace;<br>sl tfa   |
| 5224 | Ethyl propanoate                           | Ethyl propionate                 | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                  | 105-37-3   | 102.132  | liq                      | -73.9   | 99.1                    | 0.8843 <sup>25</sup>       | 1.3839 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; msc<br>EtOH, eth; s<br>ace        |
| 5225 | Ethyl propyl ether                         |                                  | C <sub>5</sub> H <sub>12</sub> O                               | 628-32-0   | 88.148   | liq                      | -127.5  | 63.21                   | 0.7386 <sup>20</sup>       | 1.3695 <sup>20</sup>  | vs eth, EtOH,<br>HOAc                                       |
| 5226 | 2-(1-Ethylpropyl)pyridine                  |                                  | C <sub>10</sub> H <sub>15</sub> N                              | 7399-50-0  | 149.233  |                          |         | 195.4                   | 0.8981 <sup>20</sup>       | 1.4850 <sup>25</sup>  |                                                             |
| 5227 | 4-(1-Ethylpropyl)pyridine                  |                                  | C <sub>10</sub> H <sub>15</sub> N                              | 35182-51-5 | 149.233  |                          | 125.5   | 217; 80 <sup>12</sup>   | 0.9085 <sup>25</sup>       | 1.40905 <sup>25</sup> |                                                             |
| 5228 | Ethyl propyl sulfide                       |                                  | C <sub>5</sub> H <sub>12</sub> S                               | 4110-50-3  | 104.214  | liq                      | -117    | 118.6                   | 0.8370 <sup>20</sup>       | 1.4462 <sup>20</sup>  | s EtOH                                                      |
| 5229 | Ethyl 2-propynoate                         | (Ethoxycarbonyl)acetylene        | C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                   | 623-47-2   | 98.101   |                          |         | 120                     | 0.9645 <sup>16</sup>       | 1.4105 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH,<br>eth, chl                    |
| 5230 | 2-Ethylpyrazine                            |                                  | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                   | 13925-00-3 | 108.141  |                          |         | 112 <sup>200</sup>      |                            |                       |                                                             |
| 5231 | 2-Ethylpyridine                            |                                  | C <sub>7</sub> H <sub>9</sub> N                                | 100-71-0   | 107.153  | liq                      | -63.1   | 148.6                   | 0.9502 <sup>25</sup>       | 1.4964 <sup>20</sup>  | s H <sub>2</sub> O; msc<br>EtOH; vs eth,<br>ace; sl ctc     |



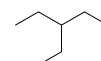
Ethyl 2-oxo-2-phenylacetate



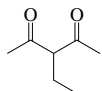
Ethyl 2-oxopropanoate



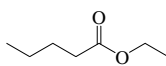
Ethyl palmitate



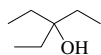
3-Ethylpentane



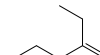
3-Ethyl-2,4-pentanedione



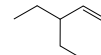
Ethyl pentanoate



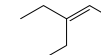
3-Ethyl-3-pentanol



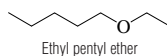
2-Ethyl-1-pentene



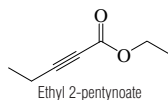
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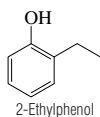
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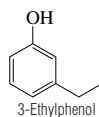
Ethyl pentyl ether



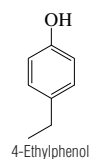
Ethyl 2-pentynoate



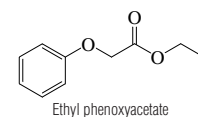
2-Ethylphenol



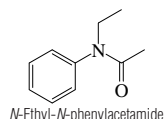
3-Ethylphenol



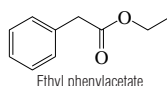
4-Ethylphenol



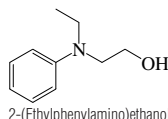
Ethyl phenoxyacetate



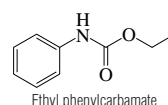
N-Ethyl-N-phenylacetamide



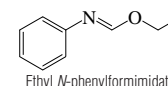
Ethyl phenylacetate



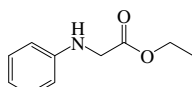
2-(Ethylphenylamino)ethanol



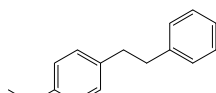
Ethyl phenylcarbamate



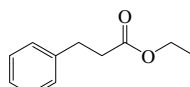
Ethyl N-phenylformimidate



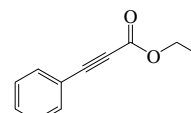
Ethyl N-phenylglycinate



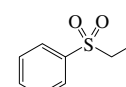
1-(4-Ethylphenyl)-2-phenylethane



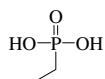
Ethyl 3-phenylpropanoate



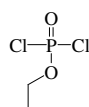
Ethyl 3-phenylpropynoate



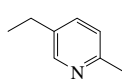
Ethyl phenyl sulfone



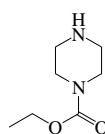
Ethylphosphonic acid



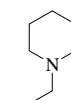
Ethyl phosphorodichloridate



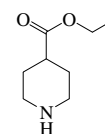
5-Ethyl-2-picoline



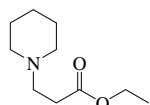
Ethyl 1-piperazinecarboxylate



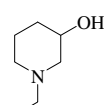
1-Ethylpiperidine



Ethyl 4-piperidinecarboxylate



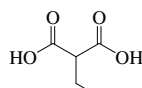
Ethyl 1-piperidinepropanoate



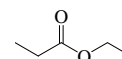
1-Ethyl-3-piperidinol



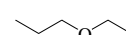
N-Ethyl-1-propanamine



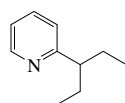
Ethylpropanedioic acid



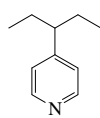
Ethyl propanoate



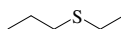
Ethyl propyl ether



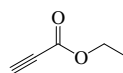
2-(1-Ethylpropyl)pyridine



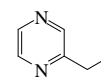
4-(1-Ethylpropyl)pyridine



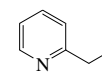
Ethyl propyl sulfide



Ethyl 2-propynoate

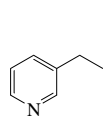


2-Ethylpyrazine

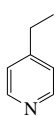


2-Ethylpyridine

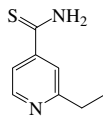
| No.  | Name                                                         | Synonym                                  | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|--------------------------------------------------------------|------------------------------------------|---------------------------------------------------------------|------------|----------|---------------------------|---------|--------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 5232 | 3-Ethylpyridine                                              |                                          | C <sub>7</sub> H <sub>9</sub> N                               | 536-78-7   | 107.153  | liq                       | -76.9   | 165                                  | 0.9539 <sup>25</sup>       | 1.5021 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth; vs ace; sl ctc         |
| 5233 | 4-Ethylpyridine                                              |                                          | C <sub>7</sub> H <sub>9</sub> N                               | 536-75-4   | 107.153  | liq                       | -90.5   | 168.3                                | 0.9417 <sup>20</sup>       | 1.5009 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth; vs ace; sl ctc         |
| 5234 | 2-Ethyl-4-pyridinecarbothioamide                             | Ethionamide                              | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> S               | 536-33-4   | 166.243  |                           | 163     |                                      |                            |                      |                                                       |
| 5235 | Ethyl 2-pyridinecarboxylate                                  | Ethyl 2-picolinate                       | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 2524-52-9  | 151.163  | ye cry in air             | 1       | 243                                  | 1.1194 <sup>20</sup>       | 1.5104 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                        |
| 5236 | Ethyl 3-pyridinecarboxylate                                  | Ethyl nicotinate                         | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 614-18-6   | 151.163  |                           | 8.5     | 224                                  | 1.1070 <sup>20</sup>       | 1.5024 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth, bz; sl ctc            |
| 5237 | Ethyl 4-pyridinecarboxylate                                  |                                          | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 1570-45-2  | 151.163  |                           | 23      | 219.5                                | 1.0091 <sup>15</sup>       | 1.5017 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, bz; vs eth, chl          |
| 5238 | <i>N</i> -Ethylpyridinium bromide                            |                                          | C <sub>7</sub> H <sub>10</sub> BrN                            | 1906-79-2  | 188.065  | cry (al)                  | 111.5   |                                      |                            |                      | s H <sub>2</sub> O, EtOH; i eth                       |
| 5239 | 1-Ethyl-1 <i>H</i> -pyrrole                                  |                                          | C <sub>6</sub> H <sub>9</sub> N                               | 617-92-5   | 95.142   |                           |         | 129.5                                | 0.9009 <sup>20</sup>       | 1.4841 <sup>20</sup> | vs EtOH                                               |
| 5240 | 1-Ethyl-1 <i>H</i> -pyrrole-2,5-dione                        | <i>N</i> -Ethylmaleimide                 | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>                 | 128-53-0   | 125.126  | cry (bz)                  | 45.5    |                                      |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s chl              |
| 5241 | 1-Ethyl-2-pyrrolidinemethanamine                             |                                          | C <sub>7</sub> H <sub>16</sub> N <sub>2</sub>                 | 26116-12-1 | 128.215  |                           |         | 59 <sup>16</sup> , 40 <sup>10</sup>  | 0.887 <sup>25</sup>        | 1.4665 <sup>20</sup> |                                                       |
| 5242 | Ethyl Red                                                    | 2-(4-Diethylaminophenylazo) benzoic acid | C <sub>17</sub> H <sub>19</sub> N <sub>3</sub> O <sub>2</sub> | 76058-33-8 | 297.352  |                           | 135     |                                      |                            |                      |                                                       |
| 5243 | Ethyl salicylate                                             |                                          | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 118-61-6   | 166.173  |                           | 45      | 150 <sup>10</sup>                    | 1.1326 <sup>20</sup>       | 1.5296 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH; vs eth; s ctc           |
| 5244 | Ethyl silicate                                               |                                          | C <sub>8</sub> H <sub>20</sub> O <sub>4</sub> Si              | 78-10-4    | 208.329  | liq                       | -82.5   | 168.8                                | 0.9320 <sup>20</sup>       | 1.3928 <sup>20</sup> | dec H <sub>2</sub> O                                  |
| 5245 | Ethyl stearate                                               | Ethyl octadecanoate                      | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>                | 111-61-5   | 312.531  |                           | 33      | 199 <sup>10</sup>                    | 1.057 <sup>20</sup>        | 1.4349 <sup>40</sup> | i H <sub>2</sub> O; s EtOH, eth, chl; vs ace          |
| 5246 | 2-Ethylstyrene                                               |                                          | C <sub>10</sub> H <sub>12</sub>                               | 7564-63-8  | 132.202  | liq                       | -75.5   | 187.3; 68 <sup>12</sup>              | 0.9017 <sup>25</sup>       | 1.5380 <sup>20</sup> |                                                       |
| 5247 | 3-Ethylstyrene                                               |                                          | C <sub>10</sub> H <sub>12</sub>                               | 7525-62-4  | 132.202  | liq                       | -101    | 190.0                                | 0.8945 <sup>20</sup>       | 1.5351 <sup>20</sup> |                                                       |
| 5248 | 4-Ethylstyrene                                               |                                          | C <sub>10</sub> H <sub>12</sub>                               | 3454-07-7  | 132.202  | liq                       | -49.7   | 192.3; 86 <sup>20</sup>              | 0.8884 <sup>25</sup>       | 1.5376 <sup>20</sup> |                                                       |
| 5249 | Ethyl sulfate                                                |                                          | C <sub>2</sub> H <sub>6</sub> O <sub>4</sub> S                | 540-82-9   | 126.132  |                           |         | dec 280                              | 1.3657 <sup>20</sup>       | 1.4105 <sup>20</sup> | vs H <sub>2</sub> O                                   |
| 5250 | 2-(Ethylsulfonyl)ethanol                                     | Ethylsulfonylethyl alcohol               | C <sub>4</sub> H <sub>10</sub> O <sub>3</sub> S               | 513-12-2   | 138.185  |                           |         |                                      |                            |                      | sl chl                                                |
| 5251 | 2-Ethyl-5-(3-sulphophenyl) isoxazolium hydroxide, inner salt | Woodward's Reagent K                     | C <sub>11</sub> H <sub>11</sub> NO <sub>4</sub> S             | 4156-16-5  | 253.275  |                           | dec 207 |                                      |                            |                      |                                                       |
| 5252 | Ethyl tartrate                                               | Ethyl tartrate, acid                     | C <sub>8</sub> H <sub>10</sub> O <sub>6</sub>                 | 608-89-9   | 178.139  |                           | 90      |                                      |                            |                      | vs H <sub>2</sub> O, EtOH                             |
| 5253 | 2-Ethyltetrahydrofuran                                       |                                          | C <sub>6</sub> H <sub>12</sub> O                              | 1003-30-1  | 100.158  |                           |         | 109                                  | 0.8570 <sup>19</sup>       | 1.4147 <sup>19</sup> | vs ace, bz, eth, EtOH                                 |
| 5254 | 5-Ethyl-1,3,4-thiadiazol-2-amine                             |                                          | C <sub>4</sub> H <sub>6</sub> N <sub>3</sub> S                | 14068-53-2 | 129.184  |                           | 200.8   |                                      |                            |                      |                                                       |
| 5255 | <i>S</i> -Ethyl thioacetate                                  |                                          | C <sub>4</sub> H <sub>8</sub> OS                              | 625-60-5   | 104.171  |                           |         | 116.4                                | 0.9792 <sup>20</sup>       | 1.4583 <sup>21</sup> | i H <sub>2</sub> O; vs EtOH, eth                      |
| 5256 | (Ethylthio)acetic acid                                       |                                          | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S                | 627-04-3   | 120.171  |                           | -8.5    | 164 <sup>83</sup> , 109 <sup>5</sup> | 1.1497 <sup>20</sup>       |                      | vs H <sub>2</sub> O, EtOH, eth                        |
| 5257 | (Ethylthio)benzene                                           | Thiophenetole                            | C <sub>8</sub> H <sub>10</sub> S                              | 622-38-8   | 138.230  |                           |         | 205                                  | 1.0211 <sup>20</sup>       | 1.5670 <sup>20</sup> | s EtOH                                                |
| 5258 | Ethyl thiocyanate                                            |                                          | C <sub>3</sub> H <sub>5</sub> NS                              | 542-90-5   | 87.144   | liq                       | -85.5   | 146                                  | 1.007 <sup>23</sup>        | 1.4684 <sup>15</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl              |
| 5259 | 2-(Ethylthio)ethanol                                         |                                          | C <sub>4</sub> H <sub>10</sub> OS                             | 110-77-0   | 106.186  | liq                       | -100    | 184                                  | 1.0166 <sup>20</sup>       | 1.4867 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH; vs ace                   |
| 5260 | 1-(Ethylthio)-4-methylbenzene                                |                                          | C <sub>9</sub> H <sub>12</sub> S                              | 622-63-9   | 152.256  |                           |         | 220                                  | 0.9996 <sup>20</sup>       | 1.555 <sup>20</sup>  |                                                       |
| 5261 | 2-Ethylthiophene                                             |                                          | C <sub>6</sub> H <sub>6</sub> S                               | 872-55-9   | 112.193  |                           |         | 134                                  | 0.9930 <sup>20</sup>       | 1.5122 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                      |
| 5262 | Ethyl thiophene-2-carboxylate                                |                                          | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub> S                | 2810-04-0  | 156.203  |                           |         | 218                                  | 1.1623 <sup>16</sup>       | 1.5248 <sup>20</sup> | s EtOH, ace; sl ctc                                   |
| 5263 | 3-Ethyl-2-thioxo-4-thiazolidinone                            | 3-Ethylrhodanine                         | C <sub>8</sub> H <sub>7</sub> NOS <sub>2</sub>                | 7648-01-3  | 161.246  |                           | 35.5    |                                      |                            |                      |                                                       |
| 5264 | 2-Ethyltoluene                                               |                                          | C <sub>9</sub> H <sub>12</sub>                                | 611-14-3   | 120.191  | liq                       | -79.83  | 165.2                                | 0.8807 <sup>20</sup>       | 1.5046 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 5265 | 3-Ethyltoluene                                               |                                          | C <sub>9</sub> H <sub>12</sub>                                | 620-14-4   | 120.191  | liq                       | -95.6   | 161.3                                | 0.8645 <sup>20</sup>       | 1.4966 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; msc ace, bz         |
| 5266 | 4-Ethyltoluene                                               |                                          | C <sub>9</sub> H <sub>12</sub>                                | 622-96-8   | 120.191  | liq                       | -62.35  | 162                                  | 0.8614 <sup>20</sup>       | 1.4959 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; msc ace, bz         |
| 5267 | Ethyl <i>p</i> -toluenesulfonate                             |                                          | C <sub>9</sub> H <sub>12</sub> O <sub>3</sub> S               | 80-40-0    | 200.254  |                           | 34.5    | 173 <sup>15</sup>                    | 1.166 <sup>48</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, AcOEt; sl ctc        |
| 5268 | Ethyl trichloroacetate                                       |                                          | C <sub>4</sub> H <sub>5</sub> Cl <sub>3</sub> O <sub>2</sub>  | 515-84-4   | 191.441  |                           |         | 167.5                                | 1.3836 <sup>20</sup>       | 1.4505 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz; sl chl           |
| 5269 | Ethyl trifluoroacetate                                       |                                          | C <sub>4</sub> H <sub>5</sub> F <sub>3</sub> O <sub>2</sub>   | 383-63-1   | 142.077  |                           |         | 61                                   | 1.194 <sup>20</sup>        | 1.308 <sup>20</sup>  |                                                       |
| 5270 | Ethyl 4,4,4-trifluoroacetoacetate                            |                                          | C <sub>6</sub> H <sub>7</sub> F <sub>3</sub> O <sub>3</sub>   | 372-31-6   | 184.113  | liq                       | -39.1   | 132                                  | 1.2586 <sup>15</sup>       | 1.3783 <sup>15</sup> | s EtOH, eth                                           |
| 5271 | Ethyl trifluoromethanesulfonate                              |                                          | C <sub>3</sub> H <sub>5</sub> F <sub>3</sub> O <sub>3</sub> S | 425-75-2   | 178.130  |                           |         | 115                                  | 1.3740 <sup>0</sup>        |                      | s eth                                                 |
| 5272 | Ethyl 3,4,5-trihydroxybenzoate                               |                                          | C <sub>9</sub> H <sub>10</sub> O <sub>5</sub>                 | 831-61-8   | 198.172  | mcl pr (w+2 1/2) nd (chl) | 163.0   |                                      |                            |                      | sl H <sub>2</sub> O, chl; s EtOH, eth, AcOEt          |



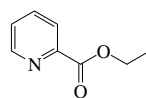
3-Ethylpyridine



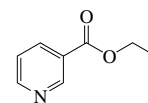
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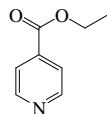
2-Ethyl-4-pyridinecarbothioamide



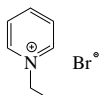
Ethyl 2-pyridinecarboxylate



Ethyl 3-pyridinecarboxylate



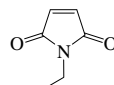
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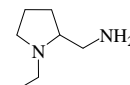
N-Ethylpyridinium bromide



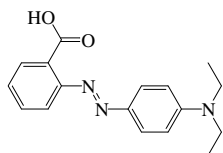
1-Ethyl-1H-pyrrole



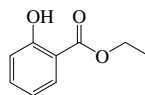
1-Ethyl-1H-pyrrole-2,5-dione



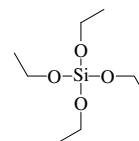
1-Ethyl-2-pyrrolidinemethanamine



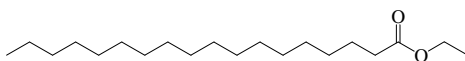
Ethyl Red



Ethyl salicylate



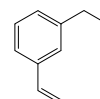
Ethyl silicate



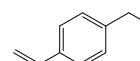
Ethyl stearate



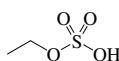
2-Ethylstyrene



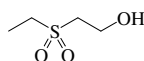
3-Ethylstyrene



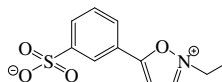
4-Ethylstyrene



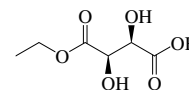
Ethyl sulfate



2-(Ethylsulfonyl)ethanol



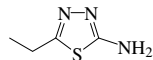
2-Ethyl-5-(3-sulfonylphenyl)isoxazolium hydroxide, inner salt



Ethyl tartrate



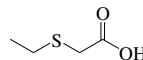
2-Ethyltetrahydrofuran



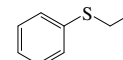
5-Ethyl-1,3,4-thiadiazol-2-amine



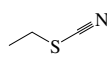
S-Ethyl thioacetate



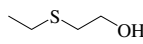
(Ethylthio)acetic acid



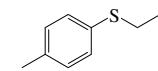
(Ethylthio)benzene



Ethyl thiocyanate



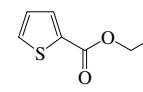
2-(Ethylthio)ethanol



1-(Ethylthio)-4-methylbenzene



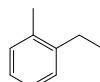
2-Ethylthiophene



Ethyl thiophene-2-carboxylate



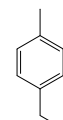
3-Ethyl-2-thioxo-4-thiazolidinone



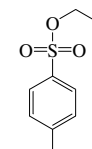
2-Ethyltoluene



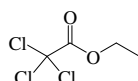
3-Ethyltoluene



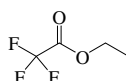
4-Ethyltoluene



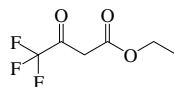
Ethyl p-toluenesulfonate



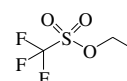
Ethyl trichloroacetate



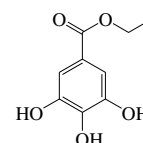
Ethyl trifluoroacetate



Ethyl 4,4,4-trifluoroacetoacetate

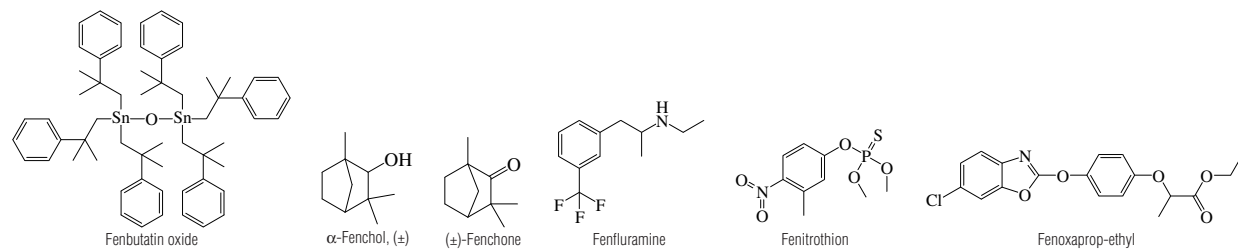
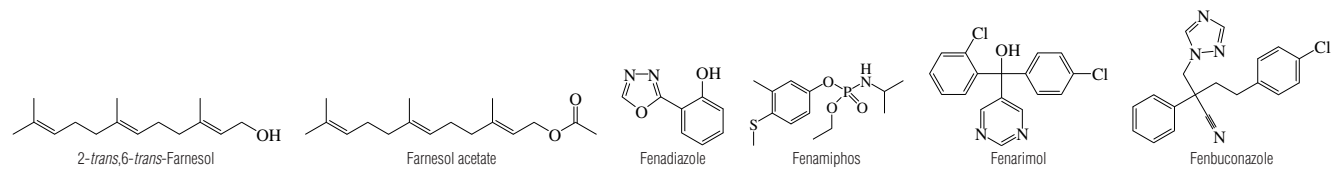
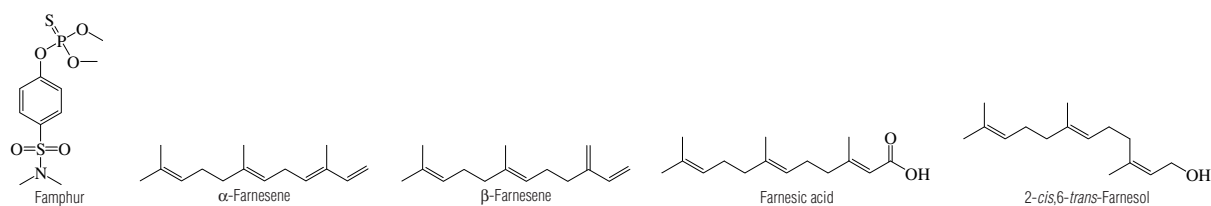
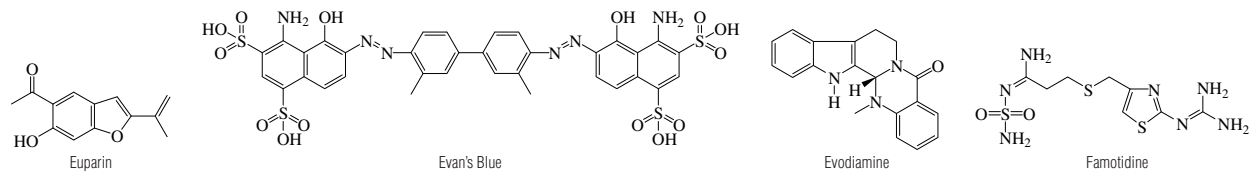
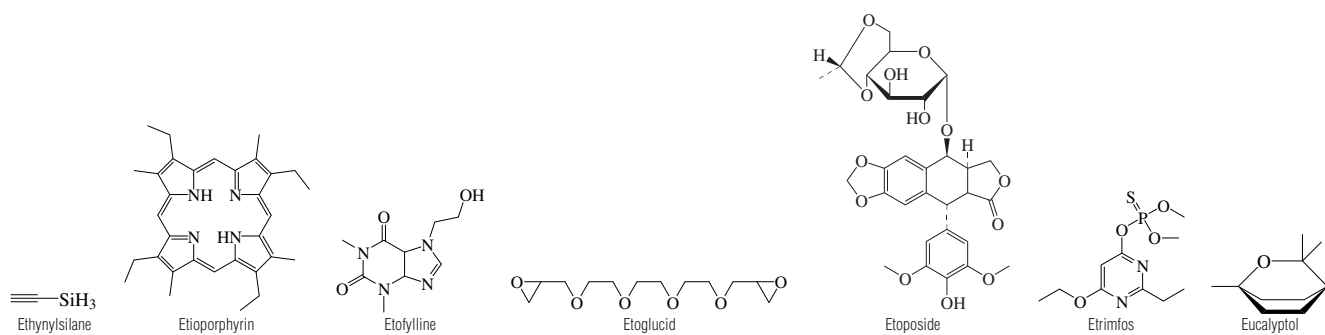
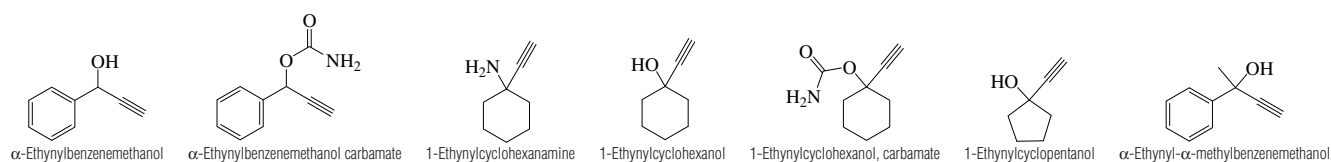
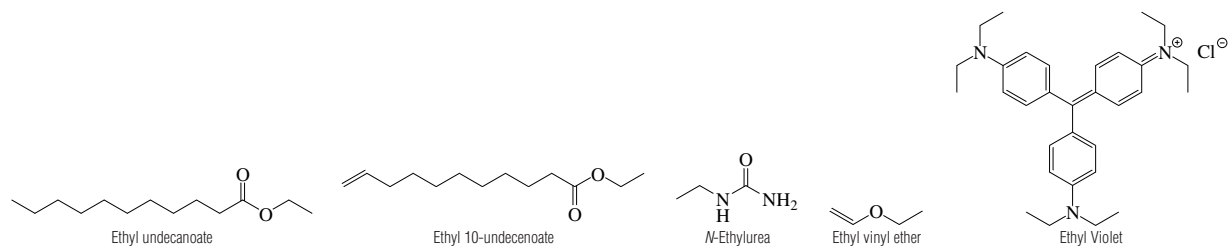
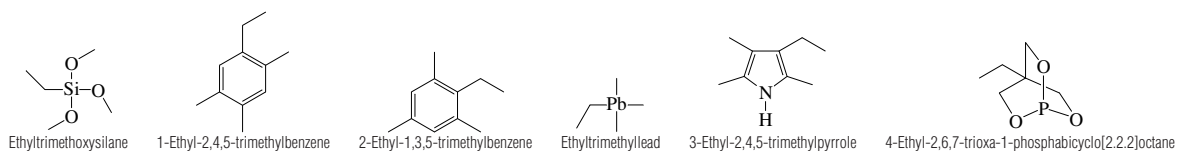


Ethyl trifluoromethanesulfonate

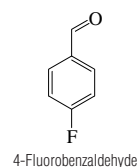
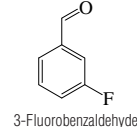
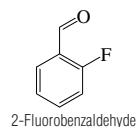
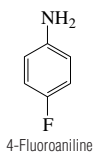
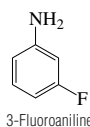
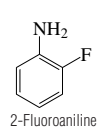
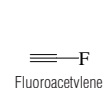
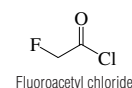
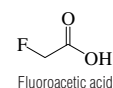
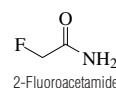
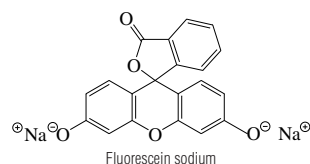
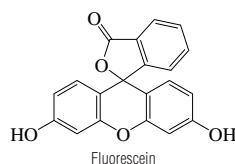
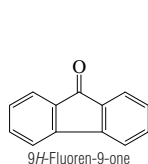
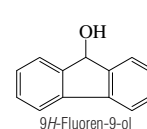
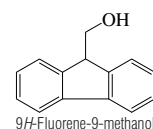
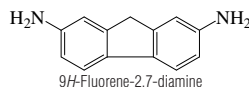
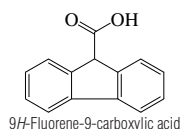
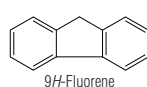
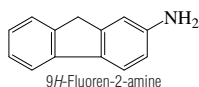
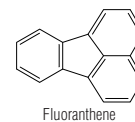
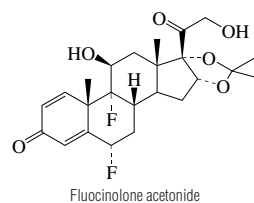
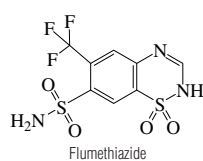
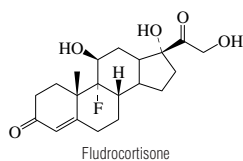
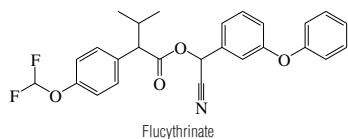
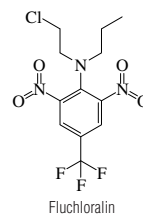
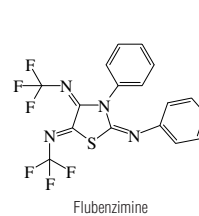
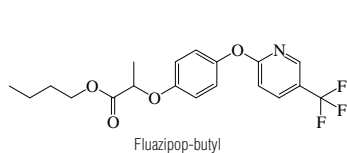
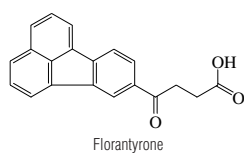
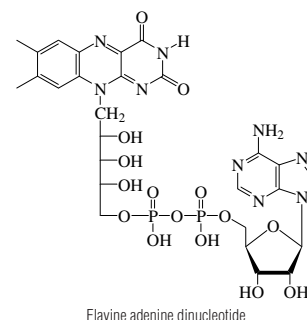
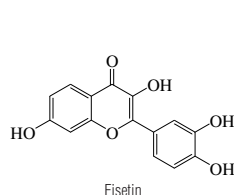
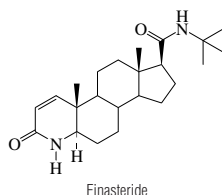
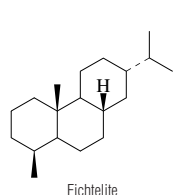
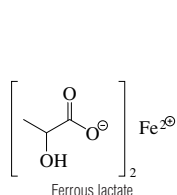
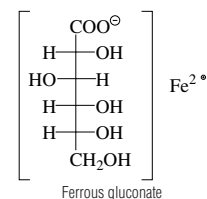
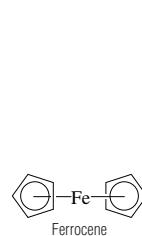
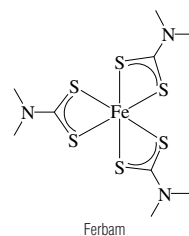
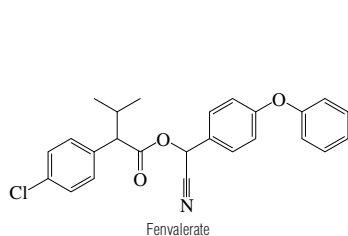
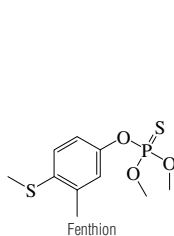
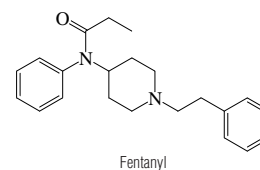
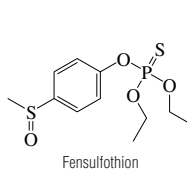
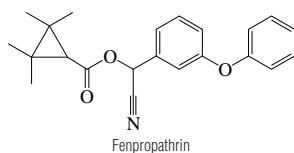
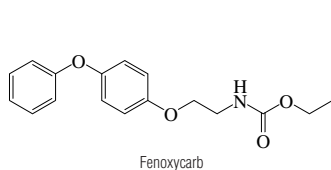


Ethyl 3,4,5-trihydroxybenzoate

| No.  | Name                                               | Synonym                                                          | Mol. Form.                                                                                    | CAS RN      | Mol. Wt. | Physical Form   | mp/°C  | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|----------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------|----------|-----------------|--------|----------------------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 5273 | Ethyltrimethoxysilane                              |                                                                  | C <sub>5</sub> H <sub>14</sub> O <sub>3</sub> Si                                              | 5314-55-6   | 150.249  |                 |        | 124.3                                  | 0.9488 <sup>20</sup>       | 1.3838 <sup>20</sup> | vs EtOH                                                 |
| 5274 | 1-Ethyl-2,4,5-trimethylbenzene                     |                                                                  | C <sub>11</sub> H <sub>16</sub>                                                               | 17851-27-3  | 148.245  | liq             | -13.5  | 213                                    | 0.883 <sup>20</sup>        | 1.5075 <sup>20</sup> | vs ace, bz, eth, EtOH                                   |
| 5275 | 2-Ethyl-1,3,5-trimethylbenzene                     |                                                                  | C <sub>11</sub> H <sub>16</sub>                                                               | 3982-67-0   | 148.245  | liq             | -15.5  | 212.4                                  | 0.883 <sup>20</sup>        | 1.5074 <sup>20</sup> | vs ace, bz, eth, EtOH                                   |
| 5276 | Ethyltrimethyllead                                 | Ethyltrimethylplumbane                                           | C <sub>5</sub> H <sub>14</sub> Pb                                                             | 1762-26-1   | 281.4    | col liq         |        | 27 <sup>10,5</sup>                     | 1.88 <sup>20</sup>         |                      |                                                         |
| 5277 | 3-Ethyl-2,4,5-trimethylpyrrole                     |                                                                  | C <sub>9</sub> H <sub>15</sub> N                                                              | 520-69-4    | 137.222  | lf (eth)        | 66.5   | 214; 110 <sup>35</sup>                 |                            |                      |                                                         |
| 5278 | 4-Ethyl-2,6,7-trioxa-1-phosphabicyclo[2.2.2]octane | Trimethylolpropane phosphite                                     | C <sub>6</sub> H <sub>11</sub> O <sub>3</sub> P                                               | 824-11-3    | 162.123  |                 | 53.7   |                                        |                            |                      | s chl                                                   |
| 5279 | Ethyl undecanoate                                  | Ethyl undecylate                                                 | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                                                | 627-90-7    | 214.344  |                 | -15    | 131 <sup>14</sup>                      | 0.8633 <sup>20</sup>       | 1.4285 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz                |
| 5280 | Ethyl 10-undecenoate                               |                                                                  | C <sub>13</sub> H <sub>24</sub> O <sub>2</sub>                                                | 692-86-4    | 212.329  | liq             | -38    | 264.5                                  | 0.8827 <sup>15</sup>       | 1.4449 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, HOAc; sl ctc           |
| 5281 | <i>N</i> -Ethylurea                                |                                                                  | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O                                                | 625-52-5    | 88.108   | nd (bz, al-eth) | 92.5   | dec                                    | 1.2130 <sup>18</sup>       |                      | vs H <sub>2</sub> O, EtOH, bz; s eth; i CS <sub>2</sub> |
| 5282 | Ethyl vinyl ether                                  |                                                                  | C <sub>4</sub> H <sub>8</sub> O                                                               | 109-92-2    | 72.106   | liq             | -115.8 | 35.5                                   | 0.7589 <sup>20</sup>       | 1.3767 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH; msc eth               |
| 5283 | Ethyl Violet                                       |                                                                  | C <sub>31</sub> H <sub>42</sub> ClN <sub>3</sub>                                              | 2390-59-2   | 492.138  | gray-viol cry   |        |                                        |                            |                      | s H <sub>2</sub> O, EtOH                                |
| 5284 | $\alpha$ -Ethynylbenzenemethanol                   | 1-Phenylpropargyl alcohol                                        | C <sub>9</sub> H <sub>8</sub> O                                                               | 4187-87-5   | 132.159  | pr              | 22     | 114 <sup>12</sup>                      | 1.0655 <sup>20</sup>       | 1.5508 <sup>20</sup> |                                                         |
| 5285 | $\alpha$ -Ethynylbenzenemethanol carbamate         | Carbimate                                                        | C <sub>10</sub> H <sub>9</sub> NO <sub>2</sub>                                                | 3567-38-2   | 175.184  | cry (al)        | 86.5   |                                        |                            |                      |                                                         |
| 5286 | 1-Ethynylcyclohexanamine                           |                                                                  | C <sub>8</sub> H <sub>13</sub> N                                                              | 30389-18-5  | 123.196  |                 |        | 65 <sup>20</sup>                       | 0.913 <sup>25</sup>        | 1.4817 <sup>20</sup> |                                                         |
| 5287 | 1-Ethynylcyclohexanol                              |                                                                  | C <sub>8</sub> H <sub>12</sub> O                                                              | 78-27-3     | 124.180  | cry (peth)      | 31.5   | 174                                    | 0.9873 <sup>20</sup>       | 1.4822 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, peth; sl chl            |
| 5288 | 1-Ethynylcyclohexanol, carbamate                   | Ethinamate                                                       | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                                                | 126-52-3    | 167.205  | nd              | 97     | 120 <sup>3</sup>                       |                            | 1.4441 <sup>21</sup> | sl H <sub>2</sub> O; vs EtOH; s hx                      |
| 5289 | 1-Ethynylcyclopentanol                             |                                                                  | C <sub>7</sub> H <sub>10</sub> O                                                              | 17356-19-3  | 110.153  |                 | 27     | 157.5                                  | 0.962 <sup>25</sup>        | 1.4751 <sup>20</sup> |                                                         |
| 5290 | $\alpha$ -Ethynyl- $\alpha$ -methylbenzenemethanol |                                                                  | C <sub>10</sub> H <sub>10</sub> O                                                             | 127-66-2    | 146.185  |                 | 52.3   | 217.5; 102 <sup>12</sup>               | 1.0314 <sup>20</sup>       |                      |                                                         |
| 5291 | Ethynylsilane                                      | Silylacetylene                                                   | C <sub>2</sub> H <sub>4</sub> Si                                                              | 1066-27-9   | 56.139   | col gas         |        | -22.5                                  |                            |                      |                                                         |
| 5292 | Etioporphyrin                                      |                                                                  | C <sub>32</sub> H <sub>38</sub> N <sub>4</sub>                                                | 448-71-5    | 478.671  |                 | 362    |                                        |                            |                      |                                                         |
| 5293 | Etofilline                                         |                                                                  | C <sub>9</sub> H <sub>12</sub> N <sub>4</sub> O <sub>3</sub>                                  | 519-37-9    | 224.216  |                 | 158    |                                        |                            |                      | vs H <sub>2</sub> O; s EtOH; sl eth, bz                 |
| 5294 | Etoglucid                                          | Oxirane, 2,2'-(2,5,8,11-tetraoxadodecane-1,12-diyl) bis-         | C <sub>12</sub> H <sub>22</sub> O <sub>6</sub>                                                | 1954-28-5   | 262.299  | col liq         | -13    | 196 <sup>2</sup>                       | 1.1312 <sup>20</sup>       | 1.4622 <sup>20</sup> |                                                         |
| 5295 | Etoposide                                          |                                                                  | C <sub>29</sub> H <sub>32</sub> O <sub>13</sub>                                               | 33419-42-0  | 588.556  | cry (MeOH)      | ≈243   |                                        |                            |                      | s MeOH                                                  |
| 5296 | Etrifos                                            |                                                                  | C <sub>10</sub> H <sub>17</sub> N <sub>2</sub> O <sub>4</sub> PS                              | 38260-54-7  | 292.291  |                 | -1.7   |                                        | 1.195 <sup>20</sup>        |                      |                                                         |
| 5297 | Eucalyptol                                         | Cineole                                                          | C <sub>10</sub> H <sub>18</sub> O                                                             | 470-82-6    | 154.249  |                 | 0.8    | 176.4                                  | 0.9267 <sup>20</sup>       | 1.4586 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl; sl ctc            |
| 5298 | Euparin                                            | 1-[6-Hydroxy-2-(1-methylvinyl)-5-benzofuranyl]ethanone           | C <sub>13</sub> H <sub>12</sub> O <sub>3</sub>                                                | 532-48-9    | 216.232  |                 | 121.5  |                                        |                            |                      | s eth, bz, chl; sl NaOH                                 |
| 5299 | Evan's Blue                                        |                                                                  | C <sub>34</sub> H <sub>24</sub> N <sub>6</sub> Na <sub>4</sub> O <sub>14</sub> S <sub>4</sub> | 314-13-6    | 960.806  |                 |        |                                        |                            |                      | s H <sub>2</sub> O, EtOH, acid                          |
| 5300 | Evodiamine                                         |                                                                  | C <sub>19</sub> H <sub>17</sub> N <sub>3</sub> O                                              | 518-17-2    | 303.357  | ye lf (al)      | 28     |                                        |                            |                      |                                                         |
| 5301 | Famotidine                                         |                                                                  | C <sub>8</sub> H <sub>13</sub> N <sub>7</sub> O <sub>2</sub> S <sub>3</sub>                   | 76824-35-6  | 337.446  | cry             | 163    |                                        |                            |                      | i EtOH, chl; vs DMF; s HOAc; sl MeOH                    |
| 5302 | Famphur                                            |                                                                  | C <sub>10</sub> H <sub>16</sub> NO <sub>3</sub> PS <sub>2</sub>                               | 52-85-7     | 325.342  |                 | 53     |                                        |                            |                      |                                                         |
| 5303 | $\alpha$ -Farnesene                                |                                                                  | C <sub>15</sub> H <sub>24</sub>                                                               | 502-61-4    | 204.352  |                 |        | 130 <sup>12</sup>                      | 0.8410 <sup>20</sup>       | 1.4836 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace; msc peth, lig           |
| 5304 | $\beta$ -Farnesene                                 |                                                                  | C <sub>15</sub> H <sub>24</sub>                                                               | 18794-84-8  | 204.352  |                 |        | 121 <sup>9</sup>                       | 0.8363 <sup>20</sup>       | 1.4899 <sup>20</sup> | vs ace, eth, chl                                        |
| 5305 | Farnesic acid                                      |                                                                  | C <sub>15</sub> H <sub>24</sub> O <sub>2</sub>                                                | 7548-13-2   | 236.351  | oil             |        | 204 <sup>16</sup>                      |                            |                      |                                                         |
| 5306 | 2- <i>cis</i> ,6- <i>trans</i> -Farnesol           |                                                                  | C <sub>15</sub> H <sub>26</sub> O                                                             | 3790-71-4   | 222.366  | oil             |        | 156 <sup>12</sup> , 120 <sup>9,3</sup> | 0.8908 <sup>20</sup>       | 1.4877 <sup>20</sup> | vs ace, eth, EtOH                                       |
| 5307 | 2- <i>trans</i> ,6- <i>trans</i> -Farnesol         |                                                                  | C <sub>15</sub> H <sub>26</sub> O                                                             | 106-28-5    | 222.366  | oil             |        | 160 <sup>10</sup> , 137 <sup>3</sup>   | 0.888 <sup>20</sup>        | 1.4877 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; s eth, ace                 |
| 5308 | Farnesol acetate                                   |                                                                  | C <sub>17</sub> H <sub>28</sub> O <sub>2</sub>                                                | 29548-30-9  | 264.403  |                 |        | 168 <sup>10</sup>                      |                            |                      |                                                         |
| 5309 | Fenadiazole                                        | 2-(1,2,4-Oxadiazol-2-yl)phenol                                   | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub>                                   | 1008-65-7   | 194.145  | cry             | 112    | 180 <sup>0,1</sup>                     |                            |                      |                                                         |
| 5310 | Fenamiphos                                         |                                                                  | C <sub>13</sub> H <sub>22</sub> NO <sub>3</sub> PS                                            | 22224-92-6  | 303.358  |                 | 49     |                                        | 1.15 <sup>20</sup>         |                      |                                                         |
| 5311 | Fenarimol                                          |                                                                  | C <sub>17</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>2</sub> O                              | 60168-88-9  | 331.195  |                 | 118    |                                        |                            |                      |                                                         |
| 5312 | Fenbuconazole                                      |                                                                  | C <sub>20</sub> H <sub>19</sub> ClN <sub>4</sub>                                              | 114369-43-6 | 350.845  |                 | 125    |                                        |                            |                      |                                                         |
| 5313 | Fenbutatin oxide                                   | Distannoxane, hexakis(2-methyl-2-phenylpropyl)-                  | C <sub>60</sub> H <sub>76</sub> OSn <sub>2</sub>                                              | 13356-08-6  | 1052.680 |                 | 138    |                                        |                            |                      |                                                         |
| 5314 | $\alpha$ -Fenchol, ( $\pm$ )                       | 1,3,3-Trimethylbicyclo[2.2.1]heptan-2-ol, <i>endo</i> -( $\pm$ ) | C <sub>10</sub> H <sub>18</sub> O                                                             | 36386-49-9  | 154.249  |                 | 39     | 199.5                                  | 0.9420 <sup>40</sup>       |                      | vs eth, EtOH                                            |
| 5315 | ( $\pm$ )-Fenchone                                 |                                                                  | C <sub>10</sub> H <sub>16</sub> O                                                             | 18492-37-0  | 152.233  | oily liq        | 6.1    | 193.5                                  | 0.9492 <sup>15</sup>       | 1.4702 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; s eth, ace                 |
| 5316 | Fenfluramine                                       |                                                                  | C <sub>12</sub> H <sub>16</sub> F <sub>3</sub> N                                              | 458-24-2    | 231.257  | cry (AcOEt)     |        | 110 <sup>12</sup>                      |                            |                      |                                                         |
| 5317 | Fenitrothion                                       |                                                                  | C <sub>9</sub> H <sub>12</sub> NO <sub>3</sub> PS                                             | 122-14-5    | 277.234  |                 |        | 118 <sup>0,05</sup> , 164 <sup>1</sup> | 1.3227 <sup>25</sup>       |                      |                                                         |
| 5318 | Fenoxprop-ethyl                                    |                                                                  | C <sub>18</sub> H <sub>16</sub> ClNO <sub>5</sub>                                             | 82110-72-3  | 361.777  |                 | 85     | 200 <sup>0,001</sup>                   |                            |                      | sl H <sub>2</sub> O, hx; s eth; vs ace, tol             |



| No.  | Name                                   | Synonym                                                        | Mol. Form.                                                                                | CAS RN     | Mol. Wt. | Physical Form               | mp/°C   | bp/°C                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|----------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------|------------|----------|-----------------------------|---------|-----------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 5319 | Fenoxycarb                             | Ethyl 2-(4-phenoxyphenoxy) ethylcarbamate                      | C <sub>17</sub> H <sub>19</sub> NO <sub>4</sub>                                           | 79127-80-3 | 301.338  |                             | 53      |                       |                            |                      |                                                              |
| 5320 | Fenpropathrin                          |                                                                | C <sub>22</sub> H <sub>23</sub> NO <sub>3</sub>                                           | 64257-84-7 | 349.423  |                             | 47      |                       | 1.15 <sup>25</sup>         |                      |                                                              |
| 5321 | Fensulfothion                          |                                                                | C <sub>11</sub> H <sub>17</sub> O <sub>4</sub> PS <sub>2</sub>                            | 115-90-2   | 308.354  |                             |         | 140 <sup>0.01</sup>   | 1.202 <sup>20</sup>        |                      |                                                              |
| 5322 | Fentanyl                               |                                                                | C <sub>22</sub> H <sub>28</sub> N <sub>2</sub> O                                          | 437-38-7   | 336.469  |                             | 87.5    |                       |                            |                      |                                                              |
| 5323 | Fenthion                               |                                                                | C <sub>10</sub> H <sub>15</sub> O <sub>3</sub> PS <sub>2</sub>                            | 55-38-9    | 278.328  |                             | 7.5     | 87 <sup>0.01</sup>    | 1.246 <sup>20</sup>        |                      |                                                              |
| 5324 | Fenvalerate                            |                                                                | C <sub>25</sub> H <sub>22</sub> ClNO <sub>3</sub>                                         | 51630-58-1 | 419.901  |                             |         | dec                   | 1.15 <sup>25</sup>         |                      |                                                              |
| 5325 | Ferbam                                 | Iron, tris(dimethylcarbamodithioato- <i>S,S</i> )-, (OC-6-11)- | C <sub>9</sub> H <sub>18</sub> FeN <sub>3</sub> S <sub>6</sub>                            | 14484-64-1 | 416.494  |                             | 180 dec |                       |                            |                      |                                                              |
| 5326 | Ferrocene                              | Dicyclopentadienyl iron                                        | C <sub>10</sub> H <sub>10</sub> Fe                                                        | 102-54-5   | 186.031  |                             | 172.5   | 249                   |                            |                      | i H <sub>2</sub> O                                           |
| 5327 | Ferrous gluconate                      |                                                                | C <sub>12</sub> H <sub>22</sub> FeO <sub>14</sub>                                         | 299-29-6   | 446.140  | ye-gray pow (w)             |         |                       |                            |                      | s H <sub>2</sub> O; i EtOH                                   |
| 5328 | Ferrous lactate                        |                                                                | C <sub>6</sub> H <sub>10</sub> FeO <sub>6</sub>                                           | 5905-52-2  | 233.984  | grn-wh pow (hyd)            |         |                       |                            |                      | s H <sub>2</sub> O; i EtOH                                   |
| 5329 | Fichtelite                             | 18-Norabietane                                                 | C <sub>19</sub> H <sub>34</sub>                                                           | 2221-95-6  | 262.473  | cry                         | 46      | 236 <sup>43</sup>     | 0.9380 <sup>22</sup>       | 1.5052 <sup>20</sup> |                                                              |
| 5330 | Finasteride                            | Proscar                                                        | C <sub>23</sub> H <sub>36</sub> N <sub>2</sub> O <sub>2</sub>                             | 98319-26-7 | 372.544  | wh cry                      | 252     |                       |                            |                      | sl H <sub>2</sub> O; s chl, EtOH, MeOH, DMSO                 |
| 5331 | Fisetin                                |                                                                | C <sub>15</sub> H <sub>10</sub> O <sub>6</sub>                                            | 528-48-3   | 286.236  | lt ye nd (dil al, + 1 w)    | 330     |                       |                            |                      | i H <sub>2</sub> O; s EtOH, ace; sl eth, bz, peth            |
| 5332 | Flavine adenine dinucleotide           | FAD                                                            | C <sub>27</sub> H <sub>33</sub> N <sub>9</sub> O <sub>15</sub> P <sub>2</sub>             | 146-14-5   | 785.550  | ye cry (w)                  |         |                       |                            |                      |                                                              |
| 5333 | Florantyrone                           |                                                                | C <sub>20</sub> H <sub>14</sub> O <sub>3</sub>                                            | 519-95-9   | 302.323  | ye cry (HOAc)               | 208     |                       |                            |                      | s EtOH, MeOH                                                 |
| 5334 | Fluazipop-butyl                        |                                                                | C <sub>19</sub> H <sub>20</sub> F <sub>3</sub> NO <sub>4</sub>                            | 79241-46-6 | 383.362  | pale ye liq                 | 5       |                       |                            |                      |                                                              |
| 5335 | Flubenzimine                           |                                                                | C <sub>17</sub> H <sub>10</sub> F <sub>6</sub> N <sub>4</sub> S                           | 37893-02-0 | 416.343  | ye cry                      | 119     |                       |                            |                      | sl H <sub>2</sub> O                                          |
| 5336 | Fluchloralin                           |                                                                | C <sub>12</sub> H <sub>12</sub> ClF <sub>3</sub> N <sub>3</sub> O <sub>4</sub>            | 33245-39-5 | 355.697  |                             | 42      |                       |                            |                      |                                                              |
| 5337 | Flucythrinate                          | Cythrín                                                        | C <sub>26</sub> H <sub>23</sub> F <sub>2</sub> NO <sub>4</sub>                            | 70124-77-5 | 451.463  |                             |         | 108 <sup>0.35</sup>   | 1.189 <sup>22</sup>        |                      |                                                              |
| 5338 | Fludrocortisone                        |                                                                | C <sub>21</sub> H <sub>29</sub> FO <sub>5</sub>                                           | 127-31-1   | 380.450  | cry (EtOH)                  | 261 dec |                       |                            |                      |                                                              |
| 5339 | Flumethiazide                          | Trifluoromethylthiazide                                        | C <sub>8</sub> H <sub>6</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 148-56-1   | 329.277  | cry                         | 306     |                       |                            |                      | sl H <sub>2</sub> O; i bz, tol; s MeOH, EtOH, DMF            |
| 5340 | Fluocinolone acetonide                 |                                                                | C <sub>24</sub> H <sub>30</sub> F <sub>2</sub> O <sub>6</sub>                             | 67-73-2    | 452.488  | cry (ace/hx)                | 266 dec |                       |                            |                      |                                                              |
| 5341 | Fluoranthene                           | 1,2-(1,8-Naphthylene)benzene                                   | C <sub>16</sub> H <sub>10</sub>                                                           | 206-44-0   | 202.250  | pa ye nd or pl (al)         | 110.19  | 384                   | 1.252 <sup>0</sup>         |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl, CS <sub>2</sub>    |
| 5342 | 9 <i>H</i> -Fluoren-2-amine            |                                                                | C <sub>13</sub> H <sub>11</sub> N                                                         | 153-78-6   | 181.233  | pl or nd (dil al)           | 130.3   |                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ctc, CS <sub>2</sub>        |
| 5343 | 9 <i>H</i> -Fluorene                   | 2,2'-Methylenebiphenyl                                         | C <sub>13</sub> H <sub>10</sub>                                                           | 86-73-7    | 166.218  | lf (al)                     | 114.77  | 295                   | 1.203 <sup>0</sup>         |                      | i H <sub>2</sub> O; sl EtOH; s eth, ace, bz, CS <sub>2</sub> |
| 5344 | 9 <i>H</i> -Fluorene-9-carboxylic acid |                                                                | C <sub>14</sub> H <sub>10</sub> O <sub>2</sub>                                            | 1989-33-9  | 210.228  |                             | 226     |                       |                            |                      |                                                              |
| 5345 | 9 <i>H</i> -Fluorene-2,7-diamine       | 2,7-Diaminofluorene                                            | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub>                                            | 525-64-4   | 196.247  | nd (w), pr (bz), pl (eth)   | 166     |                       |                            |                      | i H <sub>2</sub> O; s EtOH, chl                              |
| 5346 | 9 <i>H</i> -Fluorene-9-methanol        |                                                                | C <sub>14</sub> H <sub>12</sub> O                                                         | 24324-17-2 | 196.244  |                             | 105.0   |                       |                            |                      |                                                              |
| 5347 | 9 <i>H</i> -Fluoren-9-ol               |                                                                | C <sub>13</sub> H <sub>10</sub> O                                                         | 1689-64-1  | 182.217  | hex nd (w, peth)            | 156.0   |                       |                            |                      | sl H <sub>2</sub> O, peth, EtOH; s eth, ace; vs bz           |
| 5348 | 9 <i>H</i> -Fluoren-9-one              |                                                                | C <sub>13</sub> H <sub>8</sub> O                                                          | 486-25-9   | 180.202  | ye orth bipym (al, bz-peth) | 84      | 341.5                 | 1.1300 <sup>99</sup>       | 1.6309 <sup>99</sup> | i H <sub>2</sub> O; s EtOH, ace, bz; vs tol; sl ctc          |
| 5349 | Fluorescein                            |                                                                | C <sub>20</sub> H <sub>12</sub> O <sub>5</sub>                                            | 2321-07-5  | 332.306  | red orth pr                 | 315 dec |                       |                            |                      | sl H <sub>2</sub> O, EtOH, eth; vs ace; s py, MeOH           |
| 5350 | Fluorescein sodium                     | Cl Acid Yellow 73                                              | C <sub>20</sub> H <sub>10</sub> Na <sub>2</sub> O <sub>5</sub>                            | 518-47-8   | 376.270  | ye pow                      |         |                       |                            |                      | s H <sub>2</sub> O, EtOH, glycerol, dil acid                 |
| 5351 | 2-Fluoroacetamide                      | Fluoroacetic acid amide                                        | C <sub>2</sub> H <sub>4</sub> FNO                                                         | 640-19-7   | 77.057   |                             | 108     | sub                   |                            |                      | s H <sub>2</sub> O, ace; sl chl                              |
| 5352 | Fluoroacetic acid                      | Fluoroethanoic acid                                            | C <sub>2</sub> H <sub>3</sub> FO <sub>2</sub>                                             | 144-49-0   | 78.042   | nd                          | 35.2    | 168                   | 1.3693 <sup>36</sup>       |                      | s H <sub>2</sub> O, EtOH                                     |
| 5353 | Fluoroacetyl chloride                  |                                                                | C <sub>2</sub> H <sub>3</sub> ClFO                                                        | 359-06-8   | 96.487   | liq                         |         | 72; 23 <sup>105</sup> |                            |                      |                                                              |
| 5354 | Fluoroacetylene                        | Fluoroethyne                                                   | C <sub>2</sub> HF                                                                         | 2713-09-9  | 44.027   | gas                         | -196    | -105 exp              |                            |                      |                                                              |
| 5355 | 2-Fluoroaniline                        |                                                                | C <sub>6</sub> H <sub>6</sub> FN                                                          | 348-54-9   | 111.117  | pa ye liq                   | -34.6   | 175; 55 <sup>12</sup> | 1.1513 <sup>21</sup>       | 1.5421 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                      |
| 5356 | 3-Fluoroaniline                        |                                                                | C <sub>6</sub> H <sub>6</sub> FN                                                          | 372-19-0   | 111.117  |                             |         | 188                   | 1.1561 <sup>19</sup>       | 1.5436 <sup>20</sup> | sl H <sub>2</sub> O, chl; s EtOH, eth                        |
| 5357 | 4-Fluoroaniline                        |                                                                | C <sub>6</sub> H <sub>6</sub> FN                                                          | 371-40-4   | 111.117  | pa ye liq                   | -0.8    | 182; 85 <sup>19</sup> | 1.1725 <sup>20</sup>       | 1.5195 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth                        |
| 5358 | 2-Fluorobenzaldehyde                   |                                                                | C <sub>7</sub> H <sub>5</sub> FO                                                          | 446-52-6   | 124.112  | liq                         | -44.5   | 175                   | 1.178 <sup>25</sup>        | 1.5234 <sup>20</sup> |                                                              |
| 5359 | 3-Fluorobenzaldehyde                   |                                                                | C <sub>7</sub> H <sub>5</sub> FO                                                          | 456-48-4   | 124.112  |                             |         | 173                   | 1.17 <sup>25</sup>         | 1.5206 <sup>20</sup> |                                                              |
| 5360 | 4-Fluorobenzaldehyde                   |                                                                | C <sub>7</sub> H <sub>5</sub> FO                                                          | 459-57-4   | 124.112  | liq                         | -10     | 181.5                 | 1.1810 <sup>19</sup>       |                      |                                                              |

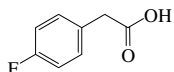




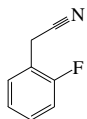
| No.  | Name                             | Synonym                                               | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup>        | n <sub>D</sub>       | Solubility                                      |
|------|----------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------|------------|----------|--------------------|---------|------------------------|-----------------------------------|----------------------|-------------------------------------------------|
| 5361 | Fluorobenzene                    |                                                       | C <sub>6</sub> H <sub>5</sub> F                                             | 462-06-6   | 96.102   | liq                | -42.18  | 84.73                  | 1.0225 <sup>20</sup>              | 1.4684 <sup>30</sup> | sl H <sub>2</sub> O; vs bz, eth, EtOH, liq      |
| 5362 | 4-Fluorobenzenecetic acid        |                                                       | C <sub>8</sub> H <sub>7</sub> FO <sub>2</sub>                               | 405-50-5   | 154.139  | cry (chl)          | 86      | 164 <sup>2</sup>       |                                   |                      |                                                 |
| 5363 | 2-Fluorobenzenecetonitrile       |                                                       | C <sub>8</sub> H <sub>6</sub> FN                                            | 326-62-5   | 135.139  |                    |         | 232; 102 <sup>10</sup> | 1.059 <sup>25</sup>               | 1.5009 <sup>20</sup> |                                                 |
| 5364 | 4-Fluorobenzenecetonitrile       |                                                       | C <sub>8</sub> H <sub>6</sub> FN                                            | 459-22-3   | 135.139  |                    | 86.0    | 228; 119 <sup>18</sup> | 1.1390 <sup>20</sup>              | 1.5002 <sup>20</sup> |                                                 |
| 5365 | 4-Fluorobenzenemethanamine       |                                                       | C <sub>7</sub> H <sub>8</sub> FN                                            | 140-75-0   | 125.144  |                    |         | 183                    |                                   | 1.5139 <sup>20</sup> |                                                 |
| 5366 | 4-Fluorobenzenemethanol          |                                                       | C <sub>7</sub> H <sub>7</sub> FO                                            | 459-56-3   | 126.128  |                    | 23      | 210                    |                                   | 1.5080 <sup>20</sup> |                                                 |
| 5367 | 4-Fluorobenzenesulfonyl chloride |                                                       | C <sub>8</sub> H <sub>6</sub> ClFO <sub>2</sub> S                           | 349-88-2   | 194.611  | pl or nd           | 30      | 106 <sup>9</sup>       |                                   |                      | vs bz, eth, chl                                 |
| 5368 | 2-Fluorobenzoic acid             |                                                       | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                               | 445-29-4   | 140.112  | nd (a)             | 126.5   |                        | 1.460 <sup>25</sup>               |                      | sl H <sub>2</sub> O; vs EtOH, eth; i bz; s chl  |
| 5369 | 3-Fluorobenzoic acid             |                                                       | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                               | 455-38-9   | 140.112  | lf (w)             | 124     |                        | 1.474 <sup>25</sup>               |                      | sl H <sub>2</sub> O; s eth                      |
| 5370 | 4-Fluorobenzoic acid             |                                                       | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                               | 456-22-4   | 140.112  | pr (w), mcl pr (w) | 185     |                        | 1.479 <sup>25</sup>               |                      | sl H <sub>2</sub> O, ace; s EtOH, eth           |
| 5371 | 2-Fluorobenzonitrile             |                                                       | C <sub>7</sub> H <sub>5</sub> FN                                            | 394-47-8   | 121.112  |                    |         | 93 <sup>22</sup>       |                                   |                      |                                                 |
| 5372 | 4-Fluorobenzonitrile             |                                                       | C <sub>7</sub> H <sub>5</sub> FN                                            | 1194-02-1  | 121.112  | nd (peth)          | 34.8    | 188.8                  | 1.1070 <sup>55</sup>              | 1.4925 <sup>55</sup> | sl chl; s peth                                  |
| 5373 | 2-Fluorobenzoyl chloride         |                                                       | C <sub>7</sub> H <sub>4</sub> ClFO                                          | 393-52-2   | 158.557  |                    | 2.0     | 91 <sup>15</sup>       | 1.328 <sup>25</sup>               | 1.5365 <sup>20</sup> |                                                 |
| 5374 | 3-Fluorobenzoyl chloride         |                                                       | C <sub>7</sub> H <sub>4</sub> ClFO                                          | 1711-07-5  | 158.557  | liq                | -30     | 189                    | 1.304 <sup>25</sup>               | 1.5285 <sup>20</sup> |                                                 |
| 5375 | 4-Fluorobenzoyl chloride         |                                                       | C <sub>7</sub> H <sub>4</sub> ClFO                                          | 403-43-0   | 158.557  |                    | 9       | 82 <sup>20</sup>       | 1.342 <sup>25</sup>               | 1.5296 <sup>20</sup> |                                                 |
| 5376 | 2-Fluoro-1,1'-biphenyl           |                                                       | C <sub>12</sub> H <sub>9</sub> F                                            | 321-60-8   | 172.197  |                    | 73.5    | 248                    | 1.2452 <sup>25</sup>              |                      | s EtOH, eth, chl, peth; sl liq                  |
| 5377 | 4-Fluoro-1,1'-biphenyl           |                                                       | C <sub>12</sub> H <sub>9</sub> F                                            | 324-74-3   | 172.197  | pr                 | 74.2    | 253                    | 1.247 <sup>25</sup>               |                      | sl EtOH; s eth, gl HOAc                         |
| 5378 | 1-Fluorobutane                   | Butyl fluoride                                        | C <sub>4</sub> H <sub>9</sub> F                                             | 2366-52-1  | 76.112   | liq                | -134    | 32.5                   | 0.7789 <sup>20</sup>              | 1.3396 <sup>20</sup> | vs EtOH                                         |
| 5379 | 2-Fluorobutane                   | sec-Butyl fluoride                                    | C <sub>4</sub> H <sub>9</sub> F                                             | 359-01-3   | 76.112   | vol liq or gas     | -121.4  | 25.1                   | 0.7559 <sup>25</sup>              |                      |                                                 |
| 5380 | Fluorocyclohexane                | Cyclohexyl fluoride                                   | C <sub>6</sub> H <sub>11</sub> F                                            | 372-46-3   | 102.149  |                    | 13      | 101                    | 0.9279 <sup>20</sup>              | 1.4146 <sup>20</sup> | i H <sub>2</sub> O; s py                        |
| 5381 | 1-Fluorocyclohexene              |                                                       | C <sub>6</sub> H <sub>9</sub> F                                             | 694-51-9   | 100.133  |                    |         | 96.5                   |                                   | 1.4441 <sup>25</sup> |                                                 |
| 5382 | 5-Fluorocytosine                 | 4-Amino-5-fluoro-2-hydroxypyrimidine                  | C <sub>4</sub> H <sub>4</sub> FN <sub>3</sub> O                             | 2022-85-7  | 129.092  | wh cry             | 296 dec |                        |                                   |                      |                                                 |
| 5383 | 1-Fluorodecane                   | Decyl fluoride                                        | C <sub>10</sub> H <sub>21</sub> F                                           | 334-56-5   | 160.272  | liq                | -35     | 186.2                  | 0.8194 <sup>20</sup>              | 1.4085               | vs eth                                          |
| 5384 | Fluorodifen                      | 2-Nitro-1-(4-nitrophenoxy)-4-(trifluoromethyl)benzene | C <sub>13</sub> H <sub>7</sub> F <sub>3</sub> N <sub>2</sub> O <sub>5</sub> | 15457-05-3 | 328.200  |                    | 94      |                        |                                   |                      |                                                 |
| 5385 | 1-Fluoro-2,4-dinitrobenzene      | 2,4-Dinitrophenyl fluoride                            | C <sub>6</sub> H <sub>3</sub> FN <sub>2</sub> O <sub>4</sub>                | 70-34-8    | 186.097  |                    | 25.8    | 296                    | 1.4718 <sup>54</sup>              | 1.5690 <sup>20</sup> | s EtOH; sl chl                                  |
| 5386 | Fluoroethane                     | Ethyl fluoride                                        | C <sub>2</sub> H <sub>5</sub> F                                             | 353-36-6   | 48.059   | col gas            | -143.2  | -37.7                  | 0.7182 <sup>20</sup><br>(p>1 atm) | 1.2656 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth               |
| 5387 | 2-Fluoroethanol                  | Ethylene fluorohydrin                                 | C <sub>2</sub> H <sub>5</sub> FO                                            | 371-62-0   | 64.058   | liq                | -26.4   | 103.5                  | 1.1040 <sup>20</sup>              | 1.3647 <sup>18</sup> | msc H <sub>2</sub> O, EtOH, eth; vs ace; sl chl |
| 5388 | Fluoroethene                     | Vinyl fluoride                                        | C <sub>2</sub> H <sub>3</sub> F                                             | 75-02-5    | 46.043   | col gas            | -160.5  | -72                    |                                   |                      | i H <sub>2</sub> O; s EtOH, ace                 |
| 5389 | 1-Fluoroheptane                  |                                                       | C <sub>7</sub> H <sub>15</sub> F                                            | 661-11-0   | 118.192  | liq                | -73     | 117.9                  | 0.8062 <sup>20</sup>              | 1.3854 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, bz; vs peth     |
| 5390 | 1-Fluorohexane                   | Hexyl fluoride                                        | C <sub>6</sub> H <sub>13</sub> F                                            | 373-14-8   | 104.165  | liq                | -103    | 91.5                   | 0.7995 <sup>20</sup>              | 1.3738 <sup>20</sup> | s eth, bz                                       |
| 5391 | 1-Fluoro-2-iodobenzene           |                                                       | C <sub>6</sub> H <sub>4</sub> FI                                            | 348-52-7   | 221.998  | liq                | -41.5   | 188.6                  |                                   | 1.5910 <sup>20</sup> | s ace, bz, chl                                  |
| 5392 | 1-Fluoro-4-iodobenzene           |                                                       | C <sub>6</sub> H <sub>4</sub> FI                                            | 352-34-1   | 221.998  | liq                | -27     | 183                    | 1.9523 <sup>15</sup>              | 1.5270 <sup>22</sup> | i H <sub>2</sub> O; s EtOH, eth, ace            |
| 5393 | 1-Fluoro-3-isothiocyanatobenzene |                                                       | C <sub>7</sub> H <sub>4</sub> FNS                                           | 404-72-8   | 153.177  |                    |         | 227                    | 1.27 <sup>25</sup>                | 1.6186 <sup>20</sup> |                                                 |
| 5394 | 1-Fluoro-4-isothiocyanatobenzene |                                                       | C <sub>7</sub> H <sub>4</sub> FNS                                           | 1544-68-9  | 153.177  |                    | 27      | 228                    |                                   |                      |                                                 |
| 5395 | Fluoromethane                    | Methyl fluoride                                       | CH <sub>3</sub> F                                                           | 593-53-3   | 34.033   | col gas            | -143.3  | -78.4                  | 0.557 <sup>25</sup><br>(p>1 atm)  | 1.1674 <sup>25</sup> | sl H <sub>2</sub> O, bz, chl; vs EtOH, eth      |
| 5396 | 1-Fluoro-2-methoxybenzene        |                                                       | C <sub>7</sub> H <sub>7</sub> FO                                            | 321-28-8   | 126.128  | liq                | -39     | 154.5                  | 1.5489 <sup>17</sup>              | 1.4969 <sup>17</sup> | i H <sub>2</sub> O; s eth, ctc                  |
| 5397 | 1-Fluoro-3-methoxybenzene        |                                                       | C <sub>7</sub> H <sub>7</sub> FO                                            | 456-49-5   | 126.128  | liq                | -35     | 159; 51 <sup>14</sup>  | 1.104 <sup>25</sup>               | 1.4876 <sup>20</sup> |                                                 |
| 5398 | 1-Fluoro-4-methoxybenzene        |                                                       | C <sub>7</sub> H <sub>7</sub> FO                                            | 459-60-9   | 126.128  | liq                | -45     | 157                    | 1.1781 <sup>18</sup>              | 1.4886 <sup>18</sup> | s eth                                           |
| 5399 | 4-Fluoro-2-methylaniline         |                                                       | C <sub>7</sub> H <sub>8</sub> FN                                            | 452-71-1   | 125.144  |                    | 14.2    | 94 <sup>16</sup>       | 1.1263 <sup>18</sup>              | 1.5363 <sup>18</sup> | s eth, ace, bz, ctc                             |
| 5400 | (Fluoromethyl)benzene            |                                                       | C <sub>7</sub> H <sub>7</sub> F                                             | 350-50-5   | 110.129  | liq                | -35     | 140; 40 <sup>14</sup>  | 1.0228 <sup>25</sup>              | 1.4892 <sup>25</sup> | s ctc                                           |
| 5401 | 2-Fluoro-4-methyl-1-nitrobenzene | 3-Fluoro-4-nitrotoluene                               | C <sub>7</sub> H <sub>6</sub> FNO <sub>2</sub>                              | 446-34-4   | 155.127  | nd (al)            | 53.2    | 97 <sup>3</sup>        | 1.4380 <sup>25</sup>              |                      |                                                 |
| 5402 | 2-Fluoro-2-methylpropane         | tert-Butyl fluoride                                   | C <sub>4</sub> H <sub>9</sub> F                                             | 353-61-7   | 76.112   | col gas            |         | 12.1                   |                                   |                      |                                                 |
| 5403 | 1-Fluoronaphthalene              |                                                       | C <sub>10</sub> H <sub>7</sub> F                                            | 321-38-0   | 146.161  | liq                | -9      | 215; 80 <sup>11</sup>  | 1.1322 <sup>20</sup>              | 1.5939 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl, HOAc  |
| 5404 | 2-Fluoronaphthalene              |                                                       | C <sub>10</sub> H <sub>7</sub> F                                            | 323-09-1   | 146.161  | nd (al)            | 61      | 212; 90 <sup>16</sup>  |                                   |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl, HOAc  |
| 5405 | 1-Fluoro-2-nitrobenzene          | o-Fluoronitrobenzene                                  | C <sub>6</sub> H <sub>4</sub> FNO <sub>2</sub>                              | 1493-27-2  | 141.100  | ye liq             | -6      | dec 215                | 1.3285 <sup>18</sup>              | 1.5489 <sup>17</sup> | vs eth, EtOH                                    |
| 5406 | 1-Fluoro-3-nitrobenzene          | m-Fluoronitrobenzene                                  | C <sub>6</sub> H <sub>4</sub> FNO <sub>2</sub>                              | 402-67-5   | 141.100  | ye cry             | 41      | 199; 86 <sup>19</sup>  | 1.3254 <sup>19</sup>              | 1.5262 <sup>15</sup> | i H <sub>2</sub> O; s EtOH, eth; sl bz          |
| 5407 | 1-Fluoro-4-nitrobenzene          | p-Fluoronitrobenzene                                  | C <sub>6</sub> H <sub>4</sub> FNO <sub>2</sub>                              | 350-46-9   | 141.100  | ye nd              | 21      | 205                    | 1.3300 <sup>20</sup>              | 1.5316 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc         |
| 5408 | 1-Fluorooctane                   | Octyl fluoride                                        | C <sub>8</sub> H <sub>17</sub> F                                            | 463-11-6   | 132.219  | liq                | -64     | 142.3                  | 0.8116 <sup>20</sup>              | 1.3946 <sup>20</sup> |                                                 |
| 5409 | 1-Fluoropentane                  | Pentyl fluoride                                       | C <sub>5</sub> H <sub>11</sub> F                                            | 592-50-7   | 90.139   | liq                | -120    | 62.8                   | 0.7907 <sup>20</sup>              | 1.3591 <sup>2</sup>  | vs eth, EtOH                                    |
| 5410 | 2-Fluorophenol                   |                                                       | C <sub>6</sub> H <sub>5</sub> FO                                            | 367-12-4   | 112.101  |                    | 16.1    | 151.5                  | 1.120 <sup>25</sup>               | 1.5144 <sup>20</sup> | s H <sub>2</sub> O                              |



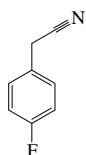
Fluorobenzene



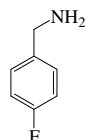
4-Fluorobenzeneacetic acid



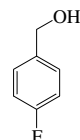
2-Fluorobenzeneacetonitrile



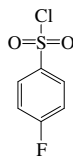
4-Fluorobenzeneacetonitrile



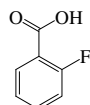
4-Fluorobenzenemethanamine



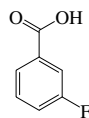
4-Fluorobenzenemethanol



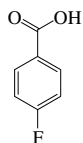
4-Fluorobenzenesulfonyl chloride



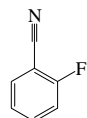
2-Fluorobenzoic acid



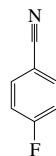
3-Fluorobenzoic acid



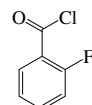
4-Fluorobenzoic acid



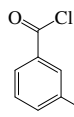
2-Fluorobenzonitrile



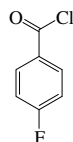
4-Fluorobenzonitrile



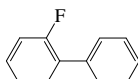
2-Fluorobenzoyl chloride



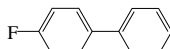
3-Fluorobenzoyl chloride



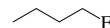
4-Fluorobenzoyl chloride



2-Fluoro-1,1'-biphenyl



4-Fluoro-1,1'-biphenyl



1-Fluorobutane



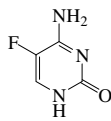
2-Fluorobutane



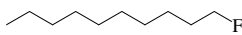
Fluorocyclohexane



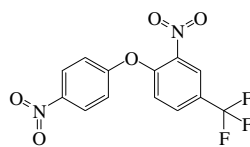
1-Fluorocyclohexene



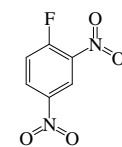
5-Fluorocytosine



1-Fluorodecane



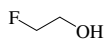
Fluorodifen



1-Fluoro-2,4-dinitrobenzene



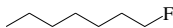
Fluoroethane



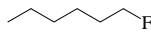
2-Fluoroethanol



Fluoroethene



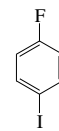
1-Fluoroheptane



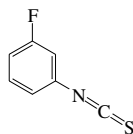
1-Fluorohexane



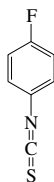
1-Fluoro-2-iodobenzene



1-Fluoro-4-iodobenzene



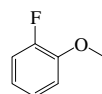
1-Fluoro-3-isothiocyanatobenzene



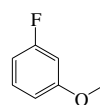
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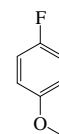
Fluoromethane



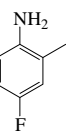
1-Fluoro-2-methoxybenzene



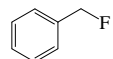
1-Fluoro-3-methoxybenzene



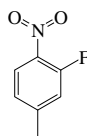
1-Fluoro-4-methoxybenzene



4-Fluoro-2-methylaniline



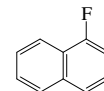
(Fluoromethyl)benzene



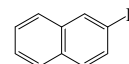
2-Fluoro-4-methyl-1-nitrobenzene



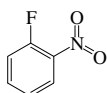
2-Fluoro-2-methylpropane



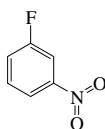
1-Fluoronaphthalene



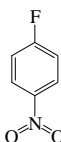
2-Fluoronaphthalene



1-Fluoro-2-nitrobenzene



1-Fluoro-3-nitrobenzene



1-Fluoro-4-nitrobenzene



1-Fluorooctane

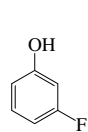


1-Fluoropentane

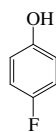


2-Fluorophenol

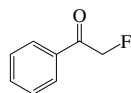
| No.  | Name                                           | Synonym                                                                  | Mol. Form.                                                                       | CAS RN      | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                              | den/<br>g cm <sup>-3</sup>        | n <sub>D</sub>       | Solubility                                           |
|------|------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------|-------------|----------|--------------------|---------|------------------------------------|-----------------------------------|----------------------|------------------------------------------------------|
| 5411 | 3-Fluorophenol                                 |                                                                          | C <sub>6</sub> H <sub>5</sub> FO                                                 | 372-20-3    | 112.101  |                    | 13.7    | 178                                | 1.238 <sup>25</sup>               | 1.5140 <sup>20</sup> |                                                      |
| 5412 | 4-Fluorophenol                                 |                                                                          | C <sub>6</sub> H <sub>5</sub> FO                                                 | 371-41-5    | 112.101  |                    | 48      | 185.5                              | 1.1889 <sup>56</sup>              |                      | sl H <sub>2</sub> O; s ace, peth                     |
| 5413 | 2-Fluoro-1-phenylethanone                      |                                                                          | C <sub>9</sub> H <sub>7</sub> FO                                                 | 450-95-3    | 138.139  | pl                 | 29      | 90 <sup>12</sup>                   | 1.152 <sup>20</sup>               | 1.5200 <sup>20</sup> |                                                      |
| 5414 | 1-(4-Fluorophenyl)ethanone                     |                                                                          | C <sub>9</sub> H <sub>7</sub> FO                                                 | 403-42-9    | 138.139  | liq                | -45     | 196                                | 1.1382 <sup>25</sup>              | 1.5081 <sup>25</sup> | i H <sub>2</sub> O; s bz, chl                        |
| 5415 | 1-Fluoropropane                                | Propyl fluoride                                                          | C <sub>3</sub> H <sub>7</sub> F                                                  | 460-13-9    | 62.086   | col gas            | -159    | -2.5                               | 0.7596 <sup>20</sup><br>(p>1 atm) | 1.3115 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth                    |
| 5416 | 2-Fluoropropane                                | Isopropyl fluoride                                                       | C <sub>3</sub> H <sub>7</sub> F                                                  | 420-26-8    | 62.086   | gas                |         | -9.4                               |                                   |                      | sl H <sub>2</sub> O                                  |
| 5417 | 1-Fluoro-2-propanone                           | Fluoroacetone                                                            | C <sub>3</sub> H <sub>5</sub> FO                                                 | 430-51-3    | 76.069   |                    |         | 77                                 | 1.0288 <sup>20</sup>              | 1.3700 <sup>20</sup> |                                                      |
| 5418 | <i>cis</i> -1-Fluoropropene                    |                                                                          | C <sub>3</sub> H <sub>5</sub> F                                                  | 19184-10-2  | 60.070   | col gas            |         | ≈-20                               |                                   |                      |                                                      |
| 5419 | <i>trans</i> -1-Fluoropropene                  |                                                                          | C <sub>3</sub> H <sub>5</sub> F                                                  | 20327-65-5  | 60.070   | col gas            | ≈-20    |                                    |                                   |                      |                                                      |
| 5420 | 2-Fluoropropene                                |                                                                          | C <sub>3</sub> H <sub>5</sub> F                                                  | 1184-60-7   | 60.070   | col gas            |         | -24                                |                                   |                      |                                                      |
| 5421 | 3-Fluoropropene                                |                                                                          | C <sub>3</sub> H <sub>5</sub> F                                                  | 818-92-8    | 60.070   | col gas            |         | -3                                 |                                   |                      | sl H <sub>2</sub> O; vs EtOH, eth; s chl             |
| 5422 | 2-Fluoropyridine                               |                                                                          | C <sub>5</sub> H <sub>4</sub> FN                                                 | 372-48-5    | 97.091   |                    |         | 125                                | 1.1280 <sup>20</sup>              | 1.4574 <sup>20</sup> |                                                      |
| 5423 | 3-Fluoropyridine                               |                                                                          | C <sub>5</sub> H <sub>4</sub> FN                                                 | 372-47-4    | 97.091   | liq                |         | 107                                | 1.130                             | 1.4720 <sup>20</sup> |                                                      |
| 5424 | 2-Fluorotoluene                                |                                                                          | C <sub>7</sub> H <sub>7</sub> F                                                  | 95-52-3     | 110.129  | liq                | -62     | 115                                | 1.0041 <sup>13</sup>              | 1.4704 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                     |
| 5425 | 3-Fluorotoluene                                |                                                                          | C <sub>7</sub> H <sub>7</sub> F                                                  | 352-70-5    | 110.129  | liq                | -87     | 115                                | 0.9974 <sup>20</sup>              | 1.4691 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                     |
| 5426 | 4-Fluorotoluene                                |                                                                          | C <sub>7</sub> H <sub>7</sub> F                                                  | 352-32-9    | 110.129  | liq                | -56     | 116.6                              | 0.9975 <sup>20</sup>              | 1.4699 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                     |
| 5427 | 1-Fluoro-2-(trichloromethyl)benzene            |                                                                          | C <sub>7</sub> H <sub>4</sub> Cl <sub>3</sub> F                                  | 488-98-2    | 213.464  |                    |         | 95 <sup>12</sup> , 75 <sup>5</sup> | 1.453 <sup>25</sup>               | 1.5432 <sup>20</sup> |                                                      |
| 5428 | 1-Fluoro-2-(trifluoromethyl)benzene            |                                                                          | C <sub>7</sub> H <sub>4</sub> F <sub>4</sub>                                     | 392-85-8    | 164.101  |                    |         | 114.5                              | 1.293 <sup>25</sup>               | 1.4040 <sup>25</sup> |                                                      |
| 5429 | 1-Fluoro-3-(trifluoromethyl)benzene            |                                                                          | C <sub>7</sub> H <sub>4</sub> F <sub>4</sub>                                     | 401-80-9    | 164.101  | liq                | -81.5   | 101.5                              | 1.3021 <sup>17</sup>              |                      |                                                      |
| 5430 | 1-Fluoro-4-(trifluoromethyl)benzene            |                                                                          | C <sub>7</sub> H <sub>4</sub> F <sub>4</sub>                                     | 402-44-8    | 164.101  | liq                | -41.7   | 103.5                              | 1.293 <sup>25</sup>               | 1.4025 <sup>20</sup> |                                                      |
| 5431 | Fluorotrimethylsilane                          |                                                                          | C <sub>3</sub> H <sub>9</sub> FSi                                                | 420-56-4    | 92.187   | vol liq or gas     |         | 16.4                               |                                   |                      |                                                      |
| 5432 | 5-Fluorouracil                                 | 5-Fluoro-2,4(1 <i>H</i> ,3 <i>H</i> )-Pyrimidinedione                    | C <sub>4</sub> H <sub>3</sub> FN <sub>2</sub> O <sub>2</sub>                     | 51-21-8     | 130.077  | cry (w, MeOH-eth)  | 283     | sub 190                            |                                   |                      |                                                      |
| 5433 | Fluoxetine                                     |                                                                          | C <sub>17</sub> H <sub>18</sub> F <sub>3</sub> NO                                | 54910-89-3  | 309.326  | oil                |         |                                    |                                   |                      |                                                      |
| 5434 | Fluoxymesterone                                |                                                                          | C <sub>20</sub> H <sub>28</sub> FO <sub>3</sub>                                  | 76-43-7     | 336.440  |                    | 270     |                                    |                                   |                      |                                                      |
| 5435 | Fluphenazine                                   |                                                                          | C <sub>22</sub> H <sub>26</sub> F <sub>3</sub> N <sub>3</sub> OS                 | 69-23-8     | 437.520  |                    |         | 251 <sup>0.3</sup>                 |                                   |                      |                                                      |
| 5436 | Fluprednisolone                                |                                                                          | C <sub>21</sub> H <sub>27</sub> FO <sub>5</sub>                                  | 53-34-9     | 378.434  |                    | 210     |                                    |                                   |                      |                                                      |
| 5437 | Flurandrenolide                                | Fludroxycortide                                                          | C <sub>24</sub> H <sub>33</sub> FO <sub>6</sub>                                  | 1524-88-5   | 436.513  | cry (ace/hx)       | 251     |                                    |                                   |                      |                                                      |
| 5438 | Flurazepam                                     |                                                                          | C <sub>21</sub> H <sub>23</sub> ClFN <sub>3</sub> O                              | 17617-23-1  | 387.878  | wh rods (eth/peth) | 80      |                                    |                                   |                      |                                                      |
| 5439 | Fluridone                                      |                                                                          | C <sub>19</sub> H <sub>14</sub> F <sub>3</sub> NO                                | 59756-60-4  | 329.315  |                    | 155     |                                    |                                   |                      |                                                      |
| 5440 | Fluroxypyr                                     | [(4-Amino-3,5-dichloro-6-fluoro-2-pyridyl)oxy]acetic acid                | C <sub>7</sub> H <sub>5</sub> Cl <sub>2</sub> FN <sub>2</sub> O <sub>3</sub>     | 69377-81-7  | 255.030  |                    | 232     |                                    |                                   |                      |                                                      |
| 5441 | Fluvalinate                                    |                                                                          | C <sub>28</sub> H <sub>22</sub> ClF <sub>3</sub> N <sub>2</sub> O <sub>3</sub>   | 102851-06-9 | 502.912  |                    |         | >450                               | 1.29 <sup>25</sup>                |                      |                                                      |
| 5442 | Folic acid                                     | Vitamin B <sub>9</sub>                                                   | C <sub>19</sub> H <sub>19</sub> N <sub>7</sub> O <sub>6</sub>                    | 59-30-3     | 441.397  | ye-oran nd (w)     | 250 dec |                                    |                                   |                      | vs py, EtOH, HOAc                                    |
| 5443 | Folinic acid                                   | 5-Formyl-5,6,7,8-tetrahydrofolic acid                                    | C <sub>20</sub> H <sub>23</sub> N <sub>7</sub> O <sub>7</sub>                    | 58-05-9     | 473.440  | cry (w + 3)        | 245 dec |                                    |                                   |                      | sl H <sub>2</sub> O                                  |
| 5444 | Folpet                                         | 1 <i>H</i> -Isoindole-1,3(2 <i>H</i> )-dione, 2-[(trichloromethyl)thio]- | C <sub>9</sub> H <sub>4</sub> Cl <sub>3</sub> NO <sub>2</sub> S                  | 133-07-3    | 296.558  |                    | 177     |                                    |                                   |                      |                                                      |
| 5445 | Fomesafen                                      |                                                                          | C <sub>15</sub> H <sub>10</sub> ClF <sub>3</sub> N <sub>2</sub> O <sub>6</sub> S | 72178-02-0  | 438.762  |                    | 220     |                                    | 1.28 <sup>20</sup>                |                      |                                                      |
| 5446 | Fomocaine                                      | 4-[3-[4-(Phenoxymethyl)phenyl]propyl]morpholine                          | C <sub>20</sub> H <sub>25</sub> NO <sub>2</sub>                                  | 17692-39-6  | 311.419  | col cry            | 53      | 239 <sup>1.1</sup>                 |                                   |                      |                                                      |
| 5447 | Fonofos                                        | Phosphonodithioic acid, ethyl-, <i>O</i> -ethyl <i>S</i> -phenyl ester   | C <sub>10</sub> H <sub>15</sub> OPS <sub>2</sub>                                 | 944-22-9    | 246.329  |                    |         | 130 <sup>0.1</sup>                 | 1.16 <sup>25</sup>                |                      |                                                      |
| 5448 | Formaldehyde                                   | Methanal                                                                 | CH <sub>2</sub> O                                                                | 50-00-0     | 30.026   | col gas            | -92     | -19.1                              | 0.815 <sup>-20</sup>              |                      | s H <sub>2</sub> O, EtOH, chl; msc eth, ace, bz      |
| 5449 | Formaldehyde oxime                             |                                                                          | CH <sub>3</sub> NO                                                               | 75-17-2     | 45.041   |                    | 1.3     | 109 <sup>15</sup>                  | 1.133 <sup>25</sup>               |                      | s H <sub>2</sub> O; vs EtOH, eth                     |
| 5450 | Formamide                                      | Methanamide                                                              | CH <sub>3</sub> NO                                                               | 75-12-7     | 45.041   |                    | 2.49    | 220                                | 1.1334 <sup>20</sup>              | 1.4472 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; sl eth; s ace; i bz, chl |
| 5451 | Formamidesulfonic acid                         | Aminoiminomethanesulfonic acid                                           | CH <sub>4</sub> N <sub>2</sub> O <sub>2</sub> S                                  | 1758-73-2   | 108.120  | nd (al)            | 144 dec |                                    |                                   |                      | vs H <sub>2</sub> O; i eth, bz                       |
| 5452 | Formetate hydrochloride                        |                                                                          | C <sub>11</sub> H <sub>16</sub> ClN <sub>3</sub> O <sub>2</sub>                  | 23422-53-9  | 257.717  | pow                | 201 dec |                                    |                                   |                      | vs H <sub>2</sub> O; s MeOH; sl ace, hx, chl         |
| 5453 | Formic acid                                    | Methanoic acid                                                           | CH <sub>2</sub> O <sub>2</sub>                                                   | 64-18-6     | 46.026   |                    | 8.3     | 101                                | 1.220 <sup>20</sup>               | 1.3714 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; vs ace; s bz, tol   |
| 5454 | <i>N</i> -Formimidoyl- <i>L</i> -glutamic acid | <i>N</i> -(Iminomethyl)- <i>L</i> -glutamic acid                         | C <sub>6</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub>                     | 816-90-0    | 174.154  |                    | 90      |                                    |                                   |                      |                                                      |
| 5455 | Formononetin                                   | 7-Hydroxy-3-(4-methoxyphenyl)-4 <i>H</i> -1-benzopyran-4-one             | C <sub>16</sub> H <sub>12</sub> O <sub>4</sub>                                   | 485-72-3    | 268.264  |                    | 256.5   |                                    |                                   |                      |                                                      |



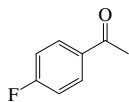
3-Fluorophenol



4-Fluorophenol



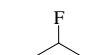
2-Fluoro-1-phenylethanone



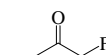
1-(4-Fluorophenyl)ethanone



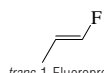
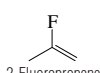
1-Fluoropropane



2-Fluoropropane



1-Fluoro-2-propanone

*cis*-1-Fluoropropene*trans*-1-Fluoropropene

2-Fluoropropene



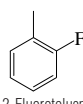
3-Fluoropropene



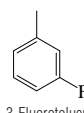
2-Fluoropyridine



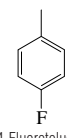
3-Fluoropyridine



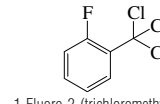
2-Fluorotoluene



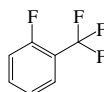
3-Fluorotoluene



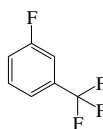
4-Fluorotoluene



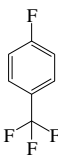
1-Fluoro-2-(trichloromethyl)benzene



1-Fluoro-2-(trifluoromethyl)benzene



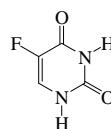
1-Fluoro-3-(trifluoromethyl)benzene



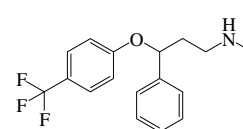
1-Fluoro-4-(trifluoromethyl)benzene



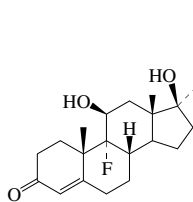
Fluorotrimethylsilane



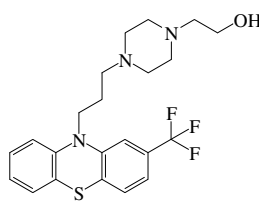
5-Fluorouracil



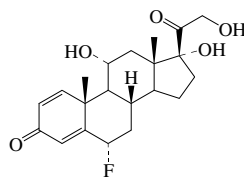
Fluoxetine



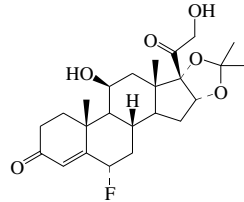
Fluoxymesterone



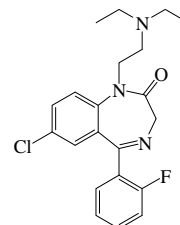
Fluphenazine



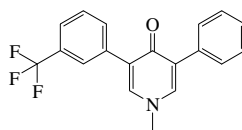
Fluprednisolone



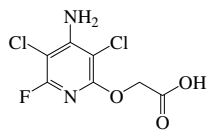
Flurandrenolide



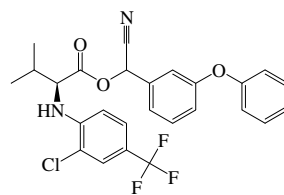
Flurazepam



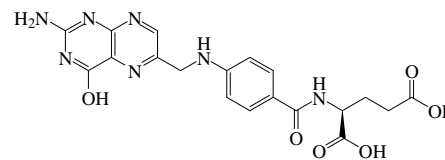
Fluridone



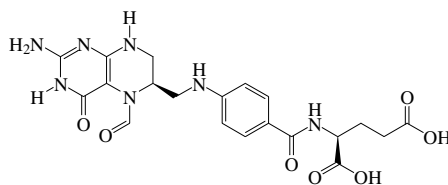
Fluoroxypyr



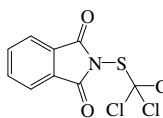
Fluvastatin



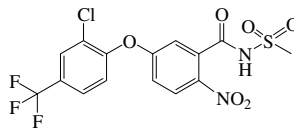
Folic acid



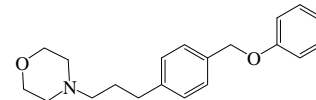
Folinic acid



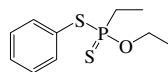
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Fomesafen



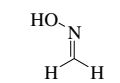
Fomocaine



Fonofos



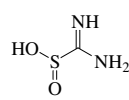
Formaldehyde



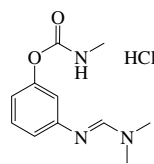
Formaldehyde oxime



Formamide



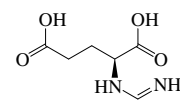
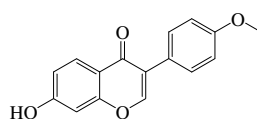
Formamidesulfonic acid



Formetanate hydrochloride

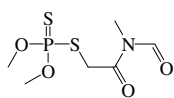


Formic acid

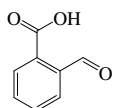
*N*-Formimidoyl-*L*-glutamic acid

Formononetin

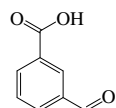
| No.  | Name                                  | Synonym                                                   | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                      | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|------|---------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------|------------|----------|------------------------------|---------|----------------------------|----------------------------|----------------------|---------------------------------------------------|
| 5456 | Formothion                            |                                                           | C <sub>6</sub> H <sub>12</sub> NO <sub>4</sub> PS <sub>2</sub> | 2540-82-1  | 257.267  | visc ye oil                  | 25.5    | dec                        | 1.361 <sup>20</sup>        | 1.5541 <sup>20</sup> | sl H <sub>2</sub> O; misc os                      |
| 5457 | 2-Formylbenzoic acid                  |                                                           | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                   | 119-67-5   | 150.132  |                              | 98      |                            | 1.404 <sup>25</sup>        |                      | s H <sub>2</sub> O; vs EtOH, eth                  |
| 5458 | 3-Formylbenzoic acid                  |                                                           | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                   | 619-21-6   | 150.132  | nd (w)                       | 175     |                            |                            |                      | vs H <sub>2</sub> O, eth, EtOH                    |
| 5459 | 4-Formylbenzoic acid                  |                                                           | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                   | 619-66-9   | 150.132  |                              | 247     |                            |                            |                      | sl H <sub>2</sub> O; vs EtOH; s eth, chl          |
| 5460 | 3-Formylbenzonitrile                  |                                                           | C <sub>8</sub> H <sub>5</sub> NO                               | 24964-64-5 | 131.132  |                              | 76.5    | 210                        |                            |                      | vs H <sub>2</sub> O, EtOH, eth, chl               |
| 5461 | 4-Formylbenzonitrile                  |                                                           | C <sub>8</sub> H <sub>5</sub> NO                               | 105-07-7   | 131.132  |                              | 100.5   | 133 <sup>12</sup>          |                            |                      | s H <sub>2</sub> O; vs EtOH, eth, chl             |
| 5462 | 6-Formyl-2,3-dimethoxybenzoic acid    | Opianic acid                                              | C <sub>10</sub> H <sub>10</sub> O <sub>5</sub>                 | 519-05-1   | 210.183  | nd (w)                       | 150     |                            |                            |                      | s EtOH, eth                                       |
| 5463 | Formylferrocene                       |                                                           | C <sub>11</sub> H <sub>10</sub> FeO                            | 12093-10-6 | 214.041  |                              | 118.5   | 70 <sup>0.1</sup>          |                            |                      |                                                   |
| 5464 | Formyl fluoride                       | Fluoroformaldehyde                                        | CHFO                                                           | 1493-02-3  | 48.016   | col gas                      | -142.2  | -26.5                      | 1.1950 <sup>30</sup>       |                      |                                                   |
| 5465 | <i>N</i> -(4-Formylphenyl)acetamide   |                                                           | C <sub>9</sub> H <sub>9</sub> NO <sub>2</sub>                  | 122-85-0   | 163.173  | pr (w)                       | 158.0   |                            |                            |                      | vs H <sub>2</sub> O, bz                           |
| 5466 | Fosetyl-Al                            | Aluminum tris( <i>O</i> -ethylphosphonate)                | C <sub>6</sub> H <sub>18</sub> AlO <sub>9</sub> P <sub>3</sub> | 39148-24-8 | 354.105  |                              | >300    |                            |                            |                      |                                                   |
| 5467 | Fosthietan                            |                                                           | C <sub>6</sub> H <sub>12</sub> NO <sub>3</sub> PS <sub>2</sub> | 21548-32-3 | 241.268  | ye oil                       |         |                            | 1.3 <sup>25</sup>          | 1.5348 <sup>25</sup> | s ace, chl, MeOH, tol                             |
| 5468 | Fraxin                                |                                                           | C <sub>16</sub> H <sub>18</sub> O <sub>10</sub>                | 524-30-1   | 370.308  | ye nd (al)                   | 205     |                            |                            |                      |                                                   |
| 5469 | <i>DL</i> -Fructose                   | α-Acrose                                                  | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                  | 6035-50-3  | 180.155  | nd                           | 130     |                            | 1.665 <sup>16</sup>        |                      |                                                   |
| 5470 | <i>L</i> -Fructose                    |                                                           | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                  | 7776-48-9  | 180.155  | wh cry                       | 102     |                            |                            |                      | s H <sub>2</sub> O                                |
| 5471 | β- <i>D</i> -Fructose                 | β-Levulose                                                | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                  | 53188-23-1 | 180.155  | pr or nd (w) orth pr (al)    | 103 dec |                            | 1.60 <sup>20</sup>         |                      | vs H <sub>2</sub> O, ace; s EtOH, MeOH, py        |
| 5472 | <i>D</i> -Fructose 6-phosphate        | Hexose monophosphate                                      | C <sub>6</sub> H <sub>13</sub> O <sub>9</sub> P                | 643-13-0   | 260.135  |                              |         |                            |                            |                      | vs H <sub>2</sub> O                               |
| 5473 | Fucoxanthin                           |                                                           | C <sub>42</sub> H <sub>58</sub> O <sub>6</sub>                 | 3351-86-8  | 658.905  | red pl (eth) hex pl (dil al) | 168     |                            |                            |                      | vs eth, EtOH                                      |
| 5474 | Fulminic acid                         | Carbyloxime                                               | CHNO                                                           | 506-85-4   | 43.025   |                              |         | unstable in pure form      |                            |                      | s eth                                             |
| 5475 | Fulvene                               |                                                           | C <sub>6</sub> H <sub>6</sub>                                  | 497-20-1   | 78.112   |                              |         | 7 <sup>56</sup>            | 0.8241 <sup>20</sup>       | 1.4920 <sup>20</sup> | i H <sub>2</sub> O; s bz, chl                     |
| 5476 | Fumaric acid                          | <i>trans</i> -2-Butenedioic acid                          | C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                   | 110-17-8   | 116.073  | nd, mcl pr or lf (w)         | 287 dec | sub 165                    | 1.635 <sup>20</sup>        |                      | sl H <sub>2</sub> O, eth, ace; s EtOH, con sulf   |
| 5477 | Fumigatin                             | 3-Hydroxy-2-methoxy-5-methyl-2,5-cyclohexadiene-1,4-dione | C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                   | 484-89-9   | 168.148  | br nd or pl (peth)           | 116     |                            |                            |                      | vs ace, bz, eth, EtOH                             |
| 5478 | Furan                                 | Oxacyclopentadiene                                        | C <sub>4</sub> H <sub>4</sub> O                                | 110-00-9   | 68.074   | liq                          | -85.61  | 31.5                       | 0.9514 <sup>20</sup>       | 1.4214 <sup>20</sup> | sl H <sub>2</sub> O, chl; vs EtOH, eth; s ace, bz |
| 5479 | 2-Furanacetic acid                    |                                                           | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                   | 2745-26-8  | 126.110  | lf(peth)                     | 68.5    | 102 <sup>0.4</sup>         |                            |                      | s H <sub>2</sub> O, bz, MeOH, peth                |
| 5480 | 2-Furancarbonitrile                   |                                                           | C <sub>5</sub> H <sub>3</sub> NO                               | 617-90-3   | 93.084   |                              |         | 147                        | 1.0822 <sup>20</sup>       | 1.4798 <sup>20</sup> | s EtOH, eth                                       |
| 5481 | 2-Furancarbonyl chloride              |                                                           | C <sub>5</sub> H <sub>3</sub> ClO <sub>2</sub>                 | 527-69-5   | 130.530  | liq                          | -1.0    | 173                        | 1.324 <sup>25</sup>        | 1.5310 <sup>20</sup> | i H <sub>2</sub> O; s eth, chl; sl ctc            |
| 5482 | 3-Furancarboxaldehyde                 |                                                           | C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                   | 498-60-2   | 96.085   |                              |         | 145; 71 <sup>43</sup>      | 1.110 <sup>20</sup>        | 1.4945 <sup>20</sup> |                                                   |
| 5483 | 2-Furancarboxylic acid                | 2-Furoic acid                                             | C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                   | 88-14-2    | 112.084  | mcl nd or lf (w)             | 133.5   | 231                        |                            |                      | s H <sub>2</sub> O, EtOH; vs eth; sl ace          |
| 5484 | 3-Furancarboxylic acid                |                                                           | C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                   | 488-93-7   | 112.084  | nd (w)                       | 122.5   | sub 105                    |                            |                      | sl H <sub>2</sub> O; s EtOH, AcOEt; vs eth        |
| 5485 | 2,5-Furandicarboxylic acid            | Dehydromucic acid                                         | C <sub>6</sub> H <sub>4</sub> O <sub>5</sub>                   | 3238-40-2  | 156.093  | nd (w), lf (al)              | 342     | sub                        | 1.7400 <sup>20</sup>       |                      | sl H <sub>2</sub> O, EtOH                         |
| 5486 | 2-Furanmethanamine                    | Furfurylamine                                             | C <sub>5</sub> H <sub>7</sub> NO                               | 617-89-0   | 97.116   |                              |         | 145.5                      | 1.0995 <sup>20</sup>       | 1.4908 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; s eth, chl            |
| 5487 | 2-Furanmethanediol diacetate          |                                                           | C <sub>9</sub> H <sub>10</sub> O <sub>5</sub>                  | 613-75-2   | 198.172  | nd or pl (eth-peth)          | 53.3    | 220                        |                            |                      | vs bz, eth, EtOH                                  |
| 5488 | 2-Furanmethanethiol                   |                                                           | C <sub>5</sub> H <sub>6</sub> OS                               | 98-02-2    | 114.166  |                              |         | 157                        | 1.1319 <sup>20</sup>       | 1.5329 <sup>20</sup> | i H <sub>2</sub> O; sl chl                        |
| 5489 | 2-Furanmethanol acetate               |                                                           | C <sub>7</sub> H <sub>8</sub> O <sub>3</sub>                   | 623-17-6   | 140.137  |                              |         | 179                        | 1.1175 <sup>20</sup>       | 1.4327 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                   |
| 5490 | 4-(2-Furanyl)-2-butanone              |                                                           | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                  | 699-17-2   | 138.164  | oil                          |         | 203                        | 1.0361 <sup>19</sup>       | 1.4696 <sup>17</sup> |                                                   |
| 5491 | 4-(2-Furanyl)-3-buten-2-one           |                                                           | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                   | 623-15-4   | 136.149  |                              | 39.5    | dec 229; 113 <sup>10</sup> | 1.0496 <sup>57</sup>       | 1.5788 <sup>45</sup> | i H <sub>2</sub> O; vs EtOH, eth, chl; s peth     |
| 5492 | 1-(2-Furanyl)ethanone                 |                                                           | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                   | 1192-62-7  | 110.111  | cry (lig)                    | 33      | 175                        | 1.098 <sup>20</sup>        | 1.5017 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                   |
| 5493 | 2-Furanylmethyl pentanoate            | Furfuryl valerate                                         | C <sub>10</sub> H <sub>14</sub> O <sub>3</sub>                 | 36701-01-6 | 182.216  |                              |         | 228; 82 <sup>1</sup>       | 1.0284 <sup>20</sup>       |                      | vs eth, EtOH                                      |
| 5494 | 3-(2-Furanyl)-1-phenyl-2-propen-1-one |                                                           | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                 | 717-21-5   | 198.217  |                              | 47      | 317                        | 1.1140 <sup>20</sup>       |                      | s EtOH, eth                                       |
| 5495 | 1-(2-Furanyl)-1-propanone             |                                                           | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                   | 3194-15-8  | 124.138  | cry                          | 28      | 88 <sup>14</sup>           | 1.0626 <sup>28</sup>       | 1.4922 <sup>25</sup> | s eth; sl ctc                                     |
| 5496 | 1-(2-Furanyl)-2-propanone             | 2-Furfuryl methyl ketone                                  | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                   | 6975-60-6  | 124.138  |                              | 29      | 179.5                      | 1.104 <sup>20</sup>        | 1.5035 <sup>20</sup> |                                                   |
| 5497 | 3-(2-Furanyl)-2-propenal              |                                                           | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                   | 623-30-3   | 122.122  |                              | 54      | 135 <sup>14</sup>          |                            |                      | i H <sub>2</sub> O; msc EtOH; s eth; sl chl       |
| 5498 | 3-(2-Furanyl)-2-propenenitrile        | 2-Furanacrylonitrile                                      | C <sub>7</sub> H <sub>5</sub> NO                               | 7187-01-1  | 119.121  |                              | 38      | 96                         |                            | 1.5824 <sup>25</sup> | vs tol                                            |



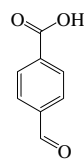
Formothion



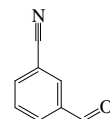
2-Formylbenzoic acid



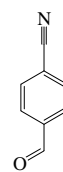
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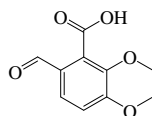
4-Formylbenzoic acid



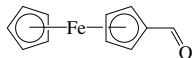
3-Formylbenzonitrile



4-Formylbenzonitrile



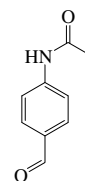
6-Formyl-2,3-dimethoxybenzoic acid



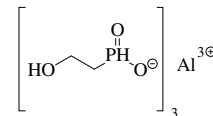
Ferrocenylferrocene



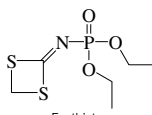
Formyl fluoride



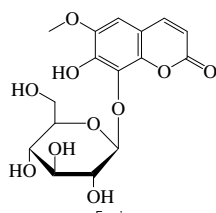
N-(4-Formylphenyl)acetamide



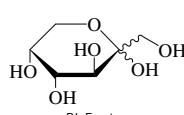
Fosetyl-Al



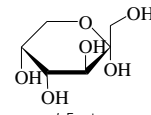
Fosthietan



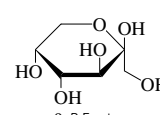
Fraxin



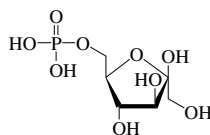
DL-Fructose



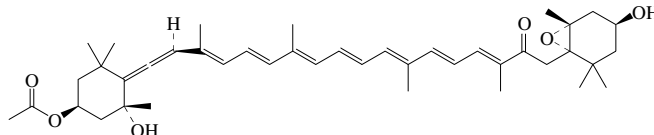
L-Fructose



β-D-Fructose



D-Fructose 6-phosphate



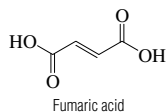
Fucoxanthin



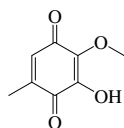
Fulminic acid



Fulvene



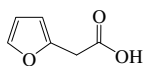
Fumaric acid



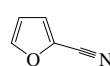
Fumigatin



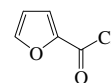
Furan



2-Furanacetic acid



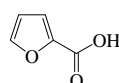
2-Furancarbonitrile



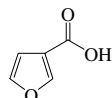
2-Furancarbonyl chloride



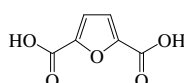
3-Furancarboxaldehyde



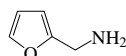
2-Furancarboxylic acid



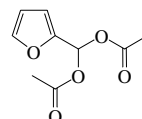
3-Furancarboxylic acid



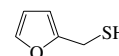
2,5-Furandicarboxylic acid



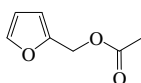
2-Furanmethanamine



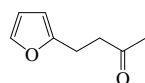
2-Furanmethanediol diacetate



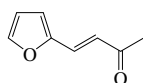
2-Furanmethanethiol



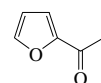
2-Furanmethanol acetate



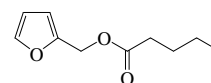
4-(2-Furanyl)-2-butanone



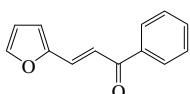
4-(2-Furanyl)-3-buten-2-one



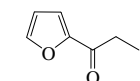
1-(2-Furanyl)ethanone



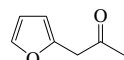
2-Furanylmethyl pentanoate



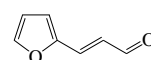
3-(2-Furanyl)-1-phenyl-2-propen-1-one



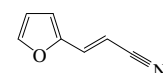
1-(2-Furanyl)-1-propanone



1-(2-Furanyl)-2-propanone

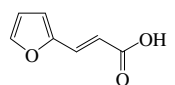


3-(2-Furanyl)-2-propenal

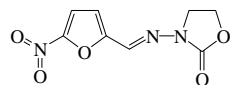


3-(2-Furanyl)-2-propenenitrile

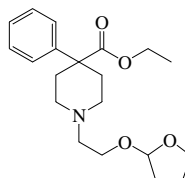
| No.  | Name                                     | Synonym                                                  | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form                      | mp/°C   | bp/°C              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|------------------------------------|---------|--------------------|----------------------------|----------------------|----------------------------------------------------------|
| 5499 | 3-(2-Furanyl)-2-propenoic acid           | 2-Furanacrylic acid                                      | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                                 | 539-47-9   | 138.121  | nd (w)                             | 141     | 286                |                            |                      | vs eth, EtOH                                             |
| 5500 | Furazolidone                             | 3-[[[(5-Nitro-2-furanyl)methylene]amino]-2-oxazolidinone | C <sub>8</sub> H <sub>7</sub> N <sub>3</sub> O <sub>5</sub>                  | 67-45-8    | 225.159  |                                    | 255     |                    |                            |                      |                                                          |
| 5501 | Furethidine                              |                                                          | C <sub>21</sub> H <sub>31</sub> NO <sub>4</sub>                              | 2385-81-1  | 361.476  |                                    | 28      | 210 <sup>0.5</sup> |                            | 1.5219 <sup>20</sup> |                                                          |
| 5502 | Furfural                                 | 2-Furaldehyde                                            | C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                                 | 98-01-1    | 96.085   | liq                                | -38.1   | 161.7              | 1.1594 <sup>20</sup>       | 1.5261 <sup>20</sup> | s H <sub>2</sub> O, bz, chl;<br>vs EtOH, ace;<br>msc eth |
| 5503 | Furfuryl alcohol                         | 2-Furanmethanol                                          | C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                                 | 98-00-0    | 98.101   | col-ye liq                         | -14.6   | 171                | 1.1296 <sup>20</sup>       | 1.4869 <sup>20</sup> | msc H <sub>2</sub> O; vs<br>EtOH, eth; s<br>chl          |
| 5504 | Furfuryl propanoate                      | 2-Furanmethanol, propanoate                              | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                                | 623-19-8   | 154.163  |                                    |         | 195                | 1.1085 <sup>20</sup>       |                      | sl H <sub>2</sub> O; s EtOH,<br>ace; msc eth             |
| 5505 | Furoin                                   | 1,2-Di-2-furanyl-2-hydroxyethanone                       | C <sub>10</sub> H <sub>8</sub> O <sub>4</sub>                                | 552-86-3   | 192.169  | nd (al)                            | 138.5   |                    |                            |                      | sl H <sub>2</sub> O, EtOH,<br>chl; s eth,<br>MeOH        |
| 5506 | Furonazide                               |                                                          | C <sub>12</sub> H <sub>11</sub> N <sub>3</sub> O <sub>2</sub>                | 3460-67-1  | 229.234  |                                    | 202.3   |                    |                            |                      |                                                          |
| 5507 | Furosemide                               |                                                          | C <sub>12</sub> H <sub>11</sub> ClN <sub>2</sub> O <sub>5</sub> S            | 54-31-9    | 330.743  |                                    | 204 dec |                    |                            |                      |                                                          |
| 5508 | Fursultiamine                            |                                                          | C <sub>17</sub> H <sub>26</sub> N <sub>4</sub> O <sub>3</sub> S <sub>2</sub> | 804-30-8   | 398.543  | col pr                             | 132 dec |                    | 1.29                       |                      | sl H <sub>2</sub> O                                      |
| 5509 | Furylfuramide, (E)                       | 2-(2-Furanyl)-3-(5-nitro-2-furanyl)-2-propenamide        | C <sub>11</sub> H <sub>8</sub> N <sub>2</sub> O <sub>5</sub>                 | 18819-45-9 | 248.192  | cry                                | 154     |                    |                            |                      |                                                          |
| 5510 | Fusarenon X                              |                                                          | C <sub>17</sub> H <sub>22</sub> O <sub>8</sub>                               | 23255-69-8 | 354.352  | cry                                | 182     |                    |                            |                      |                                                          |
| 5511 | Galactaric acid                          | Mucic acid                                               | C <sub>8</sub> H <sub>10</sub> O <sub>6</sub>                                | 526-99-8   | 210.138  | pr (w)                             | 255 dec |                    |                            |                      |                                                          |
| 5512 | Galactitol                               | Dulcose                                                  | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                                | 608-66-2   | 182.171  | cry (dil MeOH)                     | 189.5   | 277 <sup>1</sup>   | 1.47 <sup>20</sup>         |                      | s H <sub>2</sub> O; sl EtOH,<br>py; i eth, bz            |
| 5513 | D-Galactonic acid, γ-lactone             |                                                          | C <sub>6</sub> H <sub>10</sub> O <sub>6</sub>                                | 2782-07-2  | 178.139  | nd (w+1), nd (al)                  | 112     |                    |                            |                      | vs H <sub>2</sub> O                                      |
| 5514 | α-D-Galactopyranose                      |                                                          | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                | 3646-73-9  | 180.155  |                                    | 167     |                    |                            |                      |                                                          |
| 5515 | 4-O-β-D-Galactopyranosyl-D-gluconic acid | Lactobionic acid                                         | C <sub>12</sub> H <sub>22</sub> O <sub>12</sub>                              | 96-82-2    | 358.296  | syr                                |         |                    |                            |                      | vs H <sub>2</sub> O; sl EtOH,<br>MeOH, HOAc;<br>i eth    |
| 5516 | D-Galactose                              |                                                          | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                | 59-23-4    | 180.155  | pl or pr (al)pr<br>or nd (w+1)     | 170     |                    |                            |                      | vs H <sub>2</sub> O; sl EtOH;<br>i eth, bz; s py         |
| 5517 | D-Galacturonic acid                      |                                                          | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>                                | 685-73-4   | 194.139  | nd (w)                             | 166 (β) |                    |                            |                      | s H <sub>2</sub> O, EtOH; i<br>eth                       |
| 5518 | Galanthamine                             | Lycoremine                                               | C <sub>17</sub> H <sub>21</sub> NO <sub>3</sub>                              | 357-70-0   | 287.354  | cry (bz)                           | 126.5   |                    |                            |                      | vs ace, EtOH,<br>chl                                     |
| 5519 | Galipine                                 | 2-[2-(3,4-Dimethoxyphenyl)ethyl]-4-methoxyquinoline      | C <sub>20</sub> H <sub>21</sub> NO <sub>3</sub>                              | 525-68-8   | 323.386  | pr (al, eth)<br>nd (peth)          | 115.5   |                    |                            |                      | vs ace, bz, eth,<br>EtOH                                 |
| 5520 | Gallamine triethiodide                   |                                                          | C <sub>30</sub> H <sub>60</sub> I <sub>3</sub> N <sub>3</sub> O <sub>3</sub> | 65-29-2    | 891.528  |                                    | 147.5   |                    |                            |                      | vs H <sub>2</sub> O, EtOH; sl<br>eth, ace, bz,<br>chl    |
| 5521 | Gallein                                  |                                                          | C <sub>20</sub> H <sub>12</sub> O <sub>5</sub>                               | 2103-64-2  | 332.306  | br-red pow<br>(+1.5w) red<br>(anh) | >300    |                    |                            |                      | vs ace, EtOH                                             |
| 5522 | Ganciclovir                              |                                                          | C <sub>9</sub> H <sub>13</sub> N <sub>5</sub> O <sub>4</sub>                 | 82410-32-0 | 255.231  | cry (MeOH)                         | 250 dec |                    |                            |                      |                                                          |
| 5523 | Gardol                                   |                                                          | C <sub>15</sub> H <sub>28</sub> NNaO <sub>3</sub>                            | 137-16-6   | 293.378  |                                    |         |                    |                            |                      | sl H <sub>2</sub> O                                      |
| 5524 | Gelsemine                                |                                                          | C <sub>20</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>                | 509-15-9   | 322.401  | cry (ace)                          | 178     |                    |                            |                      | vs ace, bz, eth,<br>EtOH                                 |
| 5525 | Gelsemine, monohydrochloride             |                                                          | C <sub>20</sub> H <sub>23</sub> ClN <sub>2</sub> O <sub>2</sub>              | 35306-33-3 | 358.862  |                                    | 326     |                    |                            |                      | s H <sub>2</sub> O; sl EtOH                              |
| 5526 | Genistein                                | 5,7-Dihydroxy-3-(4-hydroxyphenyl)-4H-1-benzopyran-4-one  | C <sub>15</sub> H <sub>10</sub> O <sub>5</sub>                               | 446-72-0   | 270.237  | nd(eth),<br>pr(dil al)             | 301 dec |                    |                            |                      |                                                          |
| 5527 | β-Gentiobiose                            | 6-O-β-D-Glucopyranosyl-D-glucose                         | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                              | 554-91-6   | 342.296  | cry (EtOH)                         | 192     |                    |                            |                      | s hot H <sub>2</sub> O, hot<br>MeOH                      |
| 5528 | trans-Geraniol                           |                                                          | C <sub>10</sub> H <sub>18</sub> O                                            | 106-24-1   | 154.249  |                                    | <-15    | 230                | 0.8894 <sup>20</sup>       | 1.4766 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace, chl             |
| 5529 | Geranyl 2-methylpropanoate               |                                                          | C <sub>14</sub> H <sub>24</sub> O <sub>2</sub>                               | 2345-26-8  | 224.340  |                                    |         | 136 <sup>13</sup>  | 0.8997 <sup>15</sup>       | 1.4576 <sup>20</sup> |                                                          |
| 5530 | Geranyl acetate                          |                                                          | C <sub>12</sub> H <sub>20</sub> O <sub>2</sub>                               | 16409-44-2 | 196.286  |                                    |         | 115 <sup>12</sup>  | 0.9163 <sup>15</sup>       | 1.4624 <sup>20</sup> |                                                          |
| 5531 | Germin                                   |                                                          | C <sub>27</sub> H <sub>43</sub> NO <sub>8</sub>                              | 508-65-6   | 509.632  | pr or cry<br>(MeOH)                | 220     |                    |                            |                      | s bz, MeOH, alk,<br>acid                                 |
| 5532 | Gibberellic acid                         |                                                          | C <sub>19</sub> H <sub>22</sub> O <sub>6</sub>                               | 77-06-5    | 346.374  | cry (EtOAc)                        | 234     |                    |                            |                      | vs ace, EtOH,<br>MeOH                                    |
| 5533 | Gitoxigenin                              |                                                          | C <sub>23</sub> H <sub>34</sub> O <sub>5</sub>                               | 545-26-6   | 390.513  | pr (AcOEt) pr<br>(+w, dil al)      | 234     |                    |                            |                      | i H <sub>2</sub> O; sl eth; s<br>chl                     |
| 5534 | Gitoxin                                  |                                                          | C <sub>41</sub> H <sub>64</sub> O <sub>14</sub>                              | 4562-36-1  | 780.939  | pr (chl-MeOH)                      | 285 dec |                    |                            |                      |                                                          |
| 5535 | α-Glucine                                |                                                          | C <sub>21</sub> H <sub>25</sub> NO <sub>4</sub>                              | 475-81-0   | 355.429  | pl, pr (eth,<br>AcOEt)             | 120     |                    |                            |                      | vs ace, EtOH,<br>chl                                     |
| 5536 | D-Glucaric acid                          | D-Tetrahydroxyadipic acid                                | C <sub>6</sub> H <sub>10</sub> O <sub>8</sub>                                | 87-73-0    | 210.138  | nd (45% al)                        | 125.5   |                    |                            |                      | vs H <sub>2</sub> O, EtOH; sl<br>eth, chl                |
| 5537 | D-Glucitol                               | Sorbitol                                                 | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                                | 50-70-4    | 182.171  | nd (w)                             | 111     | 295 <sup>3.5</sup> | 1.489 <sup>20</sup>        | 1.3330 <sup>20</sup> | vs H <sub>2</sub> O, ace                                 |
| 5538 | D-Glucitol, hexaacetate                  | Sorbitol hexaacetate                                     | C <sub>18</sub> H <sub>26</sub> O <sub>12</sub>                              | 7208-47-1  | 434.392  | pr (w)                             | 100.8   |                    | 1.30 <sup>20</sup>         |                      | sl H <sub>2</sub> O, eth; vs<br>EtOH; s chl,<br>AcOEt    |



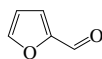
3-(2-Furanyl)-2-propenoic acid



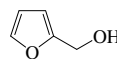
Furazolidone



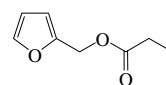
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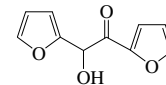
Furfural



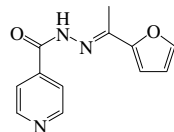
Furfuryl alcohol



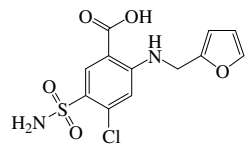
Furfuryl propanoate



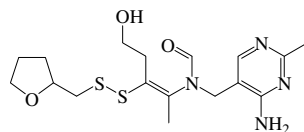
Furoin



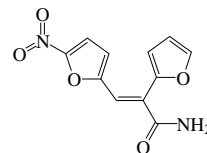
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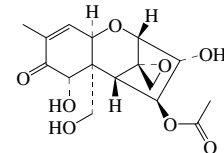
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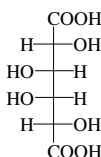
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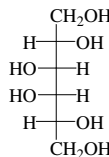
Furflyturamide, (E)



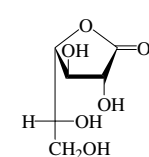
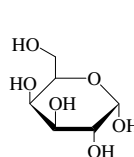
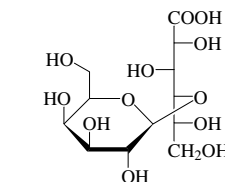
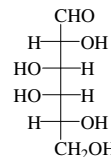
Fusarenon X



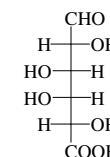
Galactaric acid



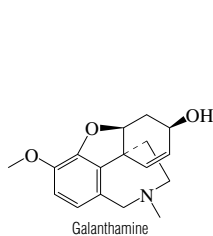
Galactitol

D-Galactonic acid,  $\gamma$ -lactone $\alpha$ -D-Galactopyranose4-O- $\beta$ -D-Galactopyranosyl-D-gluconic acid

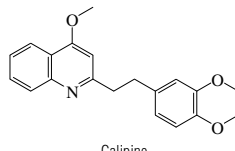
D-Galactose



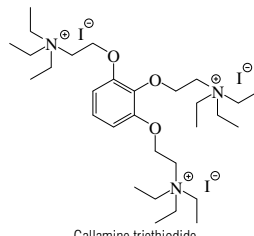
D-Galacturonic acid



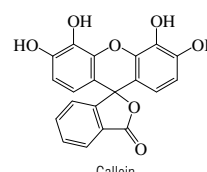
Galanthamine



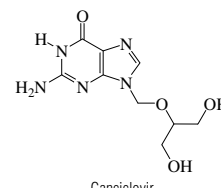
Galipine



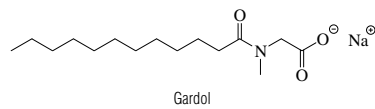
Gallamine triethiodide



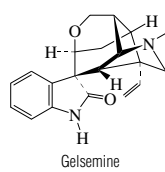
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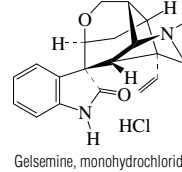
Ganciclovir



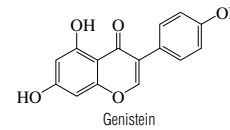
Gardol



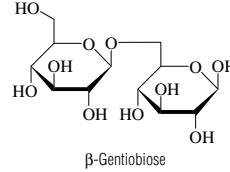
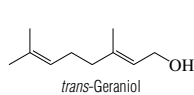
Gelsemine



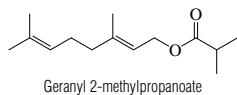
Gelsemine, monohydrochloride



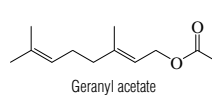
Genistein

 $\beta$ -Gentiobiose

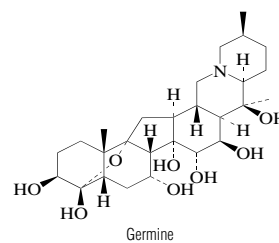
trans-Geraniol



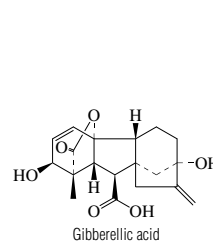
Geranyl 2-methylpropanoate



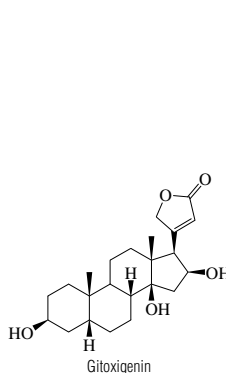
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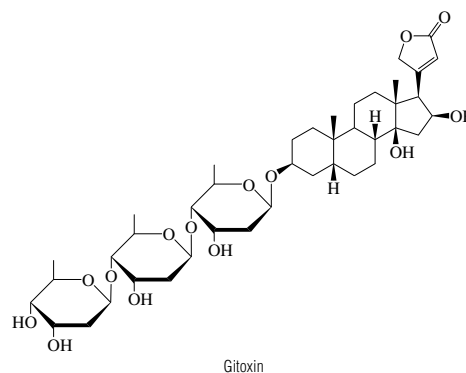
Germine



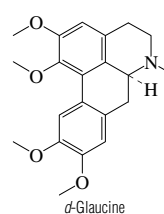
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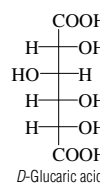
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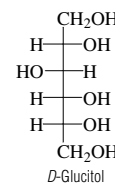
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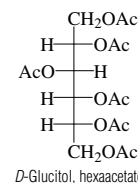
d-Glucose



D-Glucaric acid



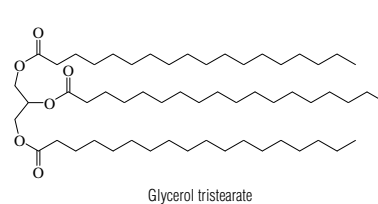
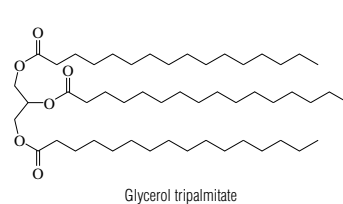
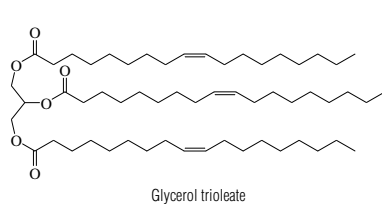
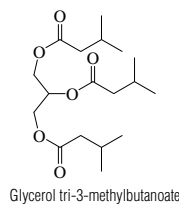
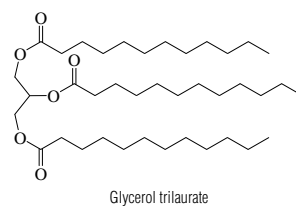
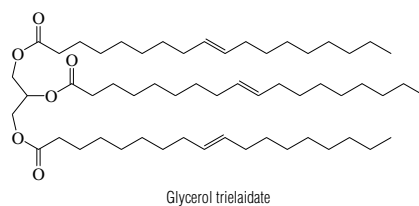
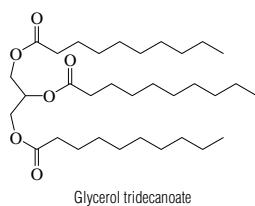
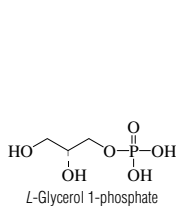
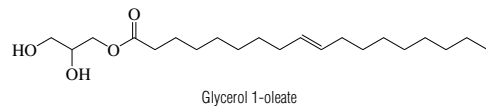
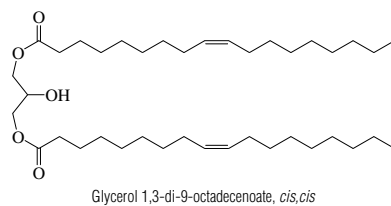
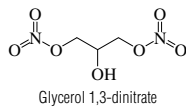
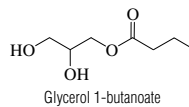
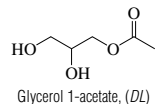
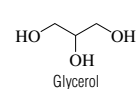
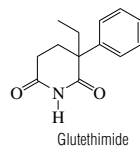
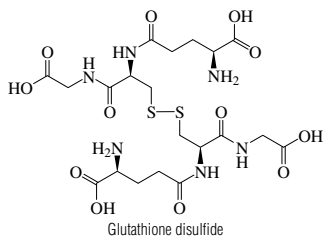
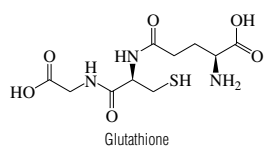
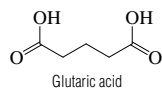
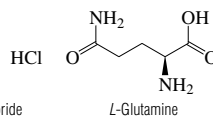
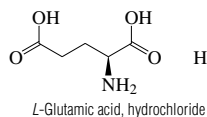
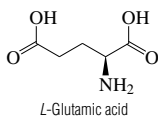
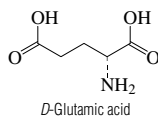
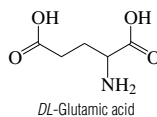
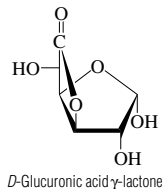
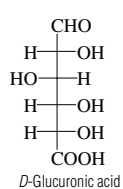
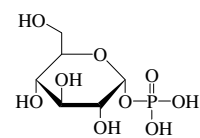
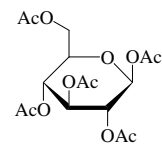
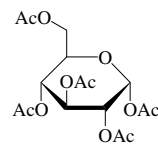
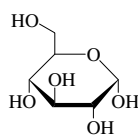
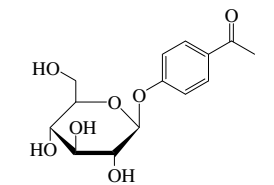
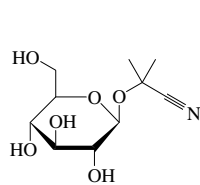
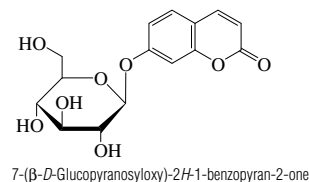
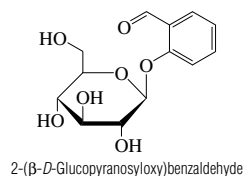
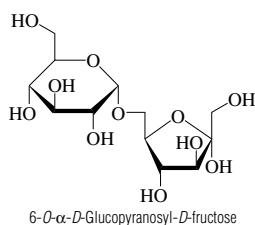
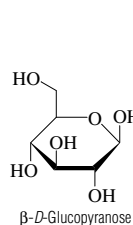
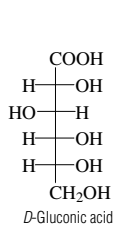
D-Glucitol



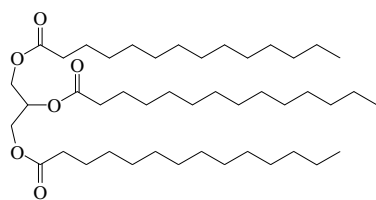
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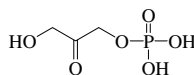
| No.  | Name                                                              | Synonym                                                    | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form       | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                    |
|------|-------------------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|---------------------|---------|----------------------------------------|----------------------------|-----------------------|---------------------------------------------------------------|
| 5539 | <i>D</i> -Gluconic acid                                           |                                                            | C <sub>6</sub> H <sub>12</sub> O <sub>7</sub>                                 | 526-95-4   | 196.155  | nd (al-eth)         | 131     |                                        |                            |                       | s H <sub>2</sub> O; sl EtOH; i eth, bz                        |
| 5540 | β- <i>D</i> -Glucopyranose                                        |                                                            | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                 | 492-61-5   | 180.155  | cry (hot EtOH)      | 149     |                                        |                            |                       |                                                               |
| 5541 | 6- <i>O</i> -α- <i>D</i> -Glucopyranosyl- <i>D</i> -fructose      | Palatinose                                                 | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                               | 13718-94-0 | 342.296  |                     |         |                                        |                            |                       | s H <sub>2</sub> O                                            |
| 5542 | 2-(β- <i>D</i> -Glucopyranosyloxy) benzaldehyde                   | Helicin                                                    | C <sub>13</sub> H <sub>16</sub> O <sub>7</sub>                                | 618-65-5   | 284.262  | nd (w)              | 175     |                                        |                            |                       | vs H <sub>2</sub> O, EtOH                                     |
| 5543 | 7-(β- <i>D</i> -Glucopyranosyloxy)-2 <i>H</i> -1-benzopyran-2-one | Skimmin                                                    | C <sub>15</sub> H <sub>16</sub> O <sub>8</sub>                                | 93-39-0    | 324.283  | cry (w + 1)         | 220     |                                        |                            |                       | s H <sub>2</sub> O, EtOH; i eth, chl                          |
| 5544 | 2-(β- <i>D</i> -Glucopyranosyloxy)-2-methylpropanenitrile         | Linamarin                                                  | C <sub>10</sub> H <sub>17</sub> NO <sub>6</sub>                               | 554-35-8   | 247.245  | nd (w, al)          | 145     |                                        |                            |                       | vs ace                                                        |
| 5545 | 1-[4-(β- <i>D</i> -Glucopyranosyloxy) phenyl]ethanone             | Picein                                                     | C <sub>14</sub> H <sub>18</sub> O <sub>7</sub>                                | 530-14-3   | 298.289  | nd (w+1), nd (MeOH) | 195.5   |                                        |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, HOAc; i chl                 |
| 5546 | α- <i>D</i> -Glucose                                              |                                                            | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                 | 26655-34-5 | 180.155  |                     | 146 dec |                                        | 1.5620 <sup>18</sup>       |                       | vs H <sub>2</sub> O; sl EtOH; i ace, AcOEt; s py              |
| 5547 | α- <i>D</i> -Glucose pentaacetate                                 |                                                            | C <sub>16</sub> H <sub>22</sub> O <sub>11</sub>                               | 604-68-2   | 390.339  | pl or nd (al)       | 113.3   | sub                                    |                            |                       | sl H <sub>2</sub> O, EtOH, CS <sub>2</sub> ; s eth, chl, HOAc |
| 5548 | β- <i>D</i> -Glucose pentaacetate                                 |                                                            | C <sub>16</sub> H <sub>22</sub> O <sub>11</sub>                               | 604-69-3   | 390.339  | nd (al)             | 134     | sub                                    | 1.2740 <sup>20</sup>       |                       | i H <sub>2</sub> O; sl EtOH, peth, eth; s bz; msc chl         |
| 5549 | α- <i>D</i> -Glucose 1-phosphate                                  |                                                            | C <sub>6</sub> H <sub>13</sub> O <sub>9</sub> P                               | 59-56-3    | 260.135  |                     |         |                                        |                            |                       | vs H <sub>2</sub> O                                           |
| 5550 | <i>D</i> -Glucuronic acid                                         |                                                            | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>                                 | 6556-12-3  | 194.139  | nd (al)             | 165     |                                        |                            |                       | vs H <sub>2</sub> O, EtOH                                     |
| 5551 | <i>D</i> -Glucuronic acid γ-lactone                               | <i>D</i> -Glucuronolactone                                 | C <sub>6</sub> H <sub>8</sub> O <sub>6</sub>                                  | 32449-92-6 | 176.124  | mcl pl (w) cry (al) | 177.5   |                                        | 1.76 <sup>20</sup>         |                       | s H <sub>2</sub> O; sl EtOH, DMSO, MeOH; i bz                 |
| 5552 | <i>DL</i> -Glutamic acid                                          |                                                            | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                                 | 617-65-2   | 147.130  | orth (al,w)         | 199 dec |                                        | 1.4601 <sup>20</sup>       |                       | sl H <sub>2</sub> O, eth; i EtOH, CS <sub>2</sub> , lig       |
| 5553 | <i>D</i> -Glutamic acid                                           |                                                            | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                                 | 6893-26-1  | 147.130  | lf (w)              | 213 dec |                                        | 1.538 <sup>20</sup>        |                       | sl H <sub>2</sub> O; i EtOH, eth, ace, bz, HOAc, MeOH         |
| 5554 | <i>L</i> -Glutamic acid                                           | ( <i>S</i> )-2-Aminopentanedioic acid                      | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                                 | 56-86-0    | 147.130  | orth (dil al)       | 160 dec | sub 175                                | 1.538 <sup>20</sup>        |                       | sl H <sub>2</sub> O                                           |
| 5555 | <i>L</i> -Glutamic acid, hydrochloride                            |                                                            | C <sub>5</sub> H <sub>10</sub> ClNO <sub>4</sub>                              | 138-15-8   | 183.591  | orth pl (w)         | 214 dec |                                        |                            |                       | vs H <sub>2</sub> O, EtOH                                     |
| 5556 | <i>L</i> -Glutamine                                               | 2-Aminoglutaramic acid                                     | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>                  | 56-85-9    | 146.144  | nd (w, dil al)      | 185 dec |                                        |                            |                       | s H <sub>2</sub> O; i EtOH, eth, bz, MeOH                     |
| 5557 | Glutaric acid                                                     | Pentanedioic acid                                          | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                                  | 110-94-1   | 132.116  | nd (bz)             | 97.8    | dec 303                                | 1.429 <sup>15</sup>        | 1.4188 <sup>106</sup> | vs H <sub>2</sub> O, EtOH, eth; i bz; s chl, lig              |
| 5558 | Glutathione                                                       | <i>L</i> -γ-Glutamyl- <i>L</i> -cysteinylglycine           | C <sub>10</sub> H <sub>17</sub> N <sub>3</sub> O <sub>6</sub> S               | 70-18-8    | 307.323  | cry (50% al)        | 195     |                                        |                            |                       | vs H <sub>2</sub> O; i EtOH, eth; s DMF                       |
| 5559 | Glutathione disulfide                                             | <i>L</i> -γ-Glutamyl- <i>L</i> -cysteinylglycine disulfide | C <sub>20</sub> H <sub>32</sub> N <sub>6</sub> O <sub>12</sub> S <sub>2</sub> | 27025-41-8 | 612.631  | cry (EtOH aq)       | 179     |                                        |                            |                       |                                                               |
| 5560 | Glutethimide                                                      |                                                            | C <sub>13</sub> H <sub>15</sub> NO <sub>2</sub>                               | 77-21-4    | 217.264  | cry (eth)           | 84      |                                        |                            |                       | i H <sub>2</sub> O; s EtOH; vs eth, ace                       |
| 5561 | Glycerol                                                          | 1,2,3-Propanetriol                                         | C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>                                  | 56-81-5    | 92.094   | syr, orth pl        | 18.1    | 290                                    | 1.2613 <sup>20</sup>       | 1.4746 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH; sl eth; i bz, ctc, chl            |
| 5562 | Glycerol 1-acetate, ( <i>DL</i> )                                 | 1,2,3-Propanetriol 1-acetate, (±)                          | C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>                                 | 93713-40-7 | 134.131  |                     |         | 158 <sup>165</sup> , 130 <sup>3</sup>  | 1.2060 <sup>20</sup>       | 1.4157 <sup>20</sup>  | s H <sub>2</sub> O, EtOH; sl eth; i bz                        |
| 5563 | Glycerol 1-butanoate                                              |                                                            | C <sub>7</sub> H <sub>14</sub> O <sub>4</sub>                                 | 557-25-5   | 162.184  |                     |         | 280; 117 <sup>10</sup>                 | 1.129 <sup>18</sup>        | 1.4531 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH                                     |
| 5564 | Glycerol 1,3-dinitrate                                            | 1,2,3-Propanetriol, 1,3-dinitrate                          | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>7</sub>                   | 623-87-0   | 182.089  | pr (w), cry (eth)   | 26      | 148 <sup>15</sup> , 116 <sup>0.6</sup> | 1.523 <sup>20</sup>        | 1.4715 <sup>20</sup>  | vs H <sub>2</sub> O, eth, EtOH                                |
| 5565 | Glycerol 1,3-di-9-octadecenoate, <i>cis,cis</i>                   |                                                            | C <sub>39</sub> H <sub>72</sub> O <sub>5</sub>                                | 2465-32-9  | 620.986  | cry (eth/ EtOH)     | 50.1    |                                        |                            |                       |                                                               |
| 5566 | Glycerol 1-oleate                                                 | 1-Monoolein                                                | C <sub>21</sub> H <sub>40</sub> O <sub>4</sub>                                | 111-03-5   | 356.541  | pl (al)             | 35      | 239 <sup>3</sup>                       | 0.9420 <sup>20</sup>       | 1.4626 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, chl                          |
| 5567 | <i>L</i> -Glycerol 1-phosphate                                    | α-Glycerophosphoric acid                                   | C <sub>3</sub> H <sub>5</sub> O <sub>6</sub> P                                | 5746-57-6  | 172.073  | syr                 |         | dec                                    |                            |                       | dec H <sub>2</sub> O                                          |
| 5568 | Glycerol tridecanoate                                             | Decanoic acid glycerol triester                            | C <sub>33</sub> H <sub>62</sub> O <sub>6</sub>                                | 621-71-6   | 554.841  | cry (peth)          | 32      |                                        |                            |                       |                                                               |
| 5569 | Glycerol trielaidate                                              | Trielaidin                                                 | C <sub>57</sub> H <sub>104</sub> O <sub>6</sub>                               | 537-39-3   | 885.432  |                     |         |                                        |                            |                       | vs bz, eth, chl                                               |
| 5570 | Glycerol trilaurate                                               | Trilaurin                                                  | C <sub>39</sub> H <sub>74</sub> O <sub>6</sub>                                | 538-24-9   | 639.001  | nd (al)             |         |                                        | 0.8986 <sup>55</sup>       | 1.4404 <sup>60</sup>  | i H <sub>2</sub> O; s EtOH, eth, peth; vs ace, bz             |
| 5571 | Glycerol tri-3-methylbutanoate                                    | Triisovalerin                                              | C <sub>18</sub> H <sub>32</sub> O <sub>6</sub>                                | 620-63-3   | 344.443  |                     |         | 332.5                                  | 0.9984 <sup>20</sup>       | 1.4354 <sup>20</sup>  | vs eth, EtOH                                                  |
| 5572 | Glycerol trioleate                                                | Triolein                                                   | C <sub>57</sub> H <sub>104</sub> O <sub>6</sub>                               | 122-32-7   | 885.432  | col-ye oil          | -4      | 237 <sup>18</sup>                      | 0.915 <sup>15</sup>        | 1.4676 <sup>15</sup>  | i H <sub>2</sub> O; sl EtOH; vs eth; s chl, peth              |
| 5573 | Glycerol tripalmitate                                             | Tripalmitin                                                | C <sub>51</sub> H <sub>98</sub> O <sub>6</sub>                                | 555-44-2   | 807.320  | nd (eth)            | 66.5    | 315                                    | 0.8752 <sup>70</sup>       | 1.4381 <sup>80</sup>  | i H <sub>2</sub> O; sl EtOH; vs eth; s bz, chl                |
| 5574 | Glycerol tristearate                                              | Tristearin                                                 | C <sub>57</sub> H <sub>110</sub> O <sub>6</sub>                               | 555-43-1   | 891.479  |                     |         |                                        | 0.8559 <sup>90</sup>       | 1.4395 <sup>80</sup>  | i H <sub>2</sub> O, EtOH; sl bz, ctc; s ace, chl              |



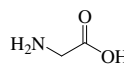
| No.  | Name                                       | Synonym                                                                  | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form                               | mp/°C   | bp/°C                      | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                            |
|------|--------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|---------------------------------------------|---------|----------------------------|----------------------------|-----------------------|-------------------------------------------------------|
| 5575 | Glycerol tritridecanoate                   | Trimyristin                                                              | C <sub>45</sub> H <sub>86</sub> O <sub>6</sub>                                | 555-45-3   | 723.161  | wh-ye solid                                 | 58.5    | 311                        | 0.8848 <sup>60</sup>       | 1.4428 <sup>60</sup>  | i H <sub>2</sub> O; sl EtOH, lig; s eth, ace, bz      |
| 5576 | Glycerone phosphate                        | 1-Hydroxy-3-(phosphonoxy)-2-propanone                                    | C <sub>3</sub> H <sub>7</sub> O <sub>6</sub> P                                | 57-04-5    | 170.058  |                                             |         |                            |                            |                       | dec H <sub>2</sub> O                                  |
| 5577 | Glycine                                    | Aminoacetic acid                                                         | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                                 | 56-40-6    | 75.067   | mcl or trg pr (dil al)                      | 290 dec |                            | 1.161 <sup>20</sup>        |                       | vs H <sub>2</sub> O; i EtOH, eth; sl ace, py          |
| 5578 | Glycine, ethyl ester, hydrochloride        | Ethyl aminoacetate hydrochloride                                         | C <sub>4</sub> H <sub>10</sub> ClNO <sub>2</sub>                              | 623-33-6   | 139.581  |                                             | 144     |                            |                            |                       | vs H <sub>2</sub> O, EtOH                             |
| 5579 | Glycine, hydrochloride                     |                                                                          | C <sub>2</sub> H <sub>6</sub> ClNO <sub>2</sub>                               | 6000-43-7  | 111.528  | hyg orth nd (w)                             | 200.5   |                            |                            |                       | vs H <sub>2</sub> O                                   |
| 5580 | Glycocholic acid                           |                                                                          | C <sub>26</sub> H <sub>43</sub> NO <sub>6</sub>                               | 475-31-0   | 465.622  | nd (w)                                      | 166.5   |                            |                            |                       | sl H <sub>2</sub> O, eth; vs EtOH                     |
| 5581 | Glycocyamine                               |                                                                          | C <sub>3</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>                   | 352-97-6   | 117.107  | pl or nd (w)                                | 282     |                            |                            |                       | sl H <sub>2</sub> O, EtOH, eth                        |
| 5582 | Glycogen                                   |                                                                          | (C <sub>6</sub> H <sub>10</sub> O <sub>5</sub> ) <sub>x</sub>                 | 9005-79-2  | 162.140  | wh pow                                      |         |                            |                            |                       | vs H <sub>2</sub> O; i EtOH, eth                      |
| 5583 | Glycolaldehyde                             |                                                                          | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                                  | 141-46-8   | 60.052   | pl                                          | 97      |                            | 1.366 <sup>100</sup>       | 1.4772 <sup>19</sup>  | s chl                                                 |
| 5584 | Glycolic acid                              |                                                                          | C <sub>2</sub> H <sub>4</sub> O <sub>3</sub>                                  | 79-14-1    | 76.051   | orth nd (w) lf (eth)                        | 79.5    | 100                        |                            |                       | s H <sub>2</sub> O, EtOH, eth                         |
| 5585 | <i>N</i> -Glycolylneuraminic acid          | <i>N</i> -(Hydroxyacetyl)neuraminic acid                                 | C <sub>11</sub> H <sub>19</sub> NO <sub>10</sub>                              | 1113-83-3  | 325.270  |                                             | 186     |                            |                            |                       |                                                       |
| 5586 | Glycopyrrolate                             |                                                                          | C <sub>19</sub> H <sub>28</sub> BrNO <sub>3</sub>                             | 596-51-0   | 398.334  |                                             | 192.5   |                            |                            |                       |                                                       |
| 5587 | Glycylalanine                              | <i>N</i> -Alanylglycine                                                  | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>                  | 1188-01-8  | 146.144  |                                             | 237 dec |                            |                            |                       | s H <sub>2</sub> O; i EtOH, eth                       |
| 5588 | <i>L</i> -Glycylasparagine                 |                                                                          | C <sub>8</sub> H <sub>11</sub> N <sub>3</sub> O <sub>4</sub>                  | 1999-33-3  | 189.169  | nd (EtOH aq)                                | 216     |                            |                            |                       | s H <sub>2</sub> O; sl EtOH                           |
| 5589 | <i>N</i> -Glycylglycine                    | 2-(Aminoacetamido)acetic acid                                            | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>                   | 556-50-3   | 132.118  |                                             | 263 dec |                            |                            |                       | s H <sub>2</sub> O                                    |
| 5590 | <i>N</i> -( <i>N</i> -Glycylglycyl)glycine |                                                                          | C <sub>6</sub> H <sub>11</sub> N <sub>3</sub> O <sub>4</sub>                  | 556-33-2   | 189.169  | nd (dil al)                                 | 246 dec |                            |                            |                       | s H <sub>2</sub> O; i EtOH, eth                       |
| 5591 | <i>N</i> -Glycyl- <i>L</i> -leucine        |                                                                          | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub>                  | 869-19-2   | 188.224  | pl (dil al) pl (dil al)                     | 256 dec |                            |                            |                       | vs H <sub>2</sub> O; i EtOH                           |
| 5592 | <i>N</i> -Glycyl- <i>L</i> -phenylalanine  |                                                                          | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>                 | 3321-03-7  | 222.240  |                                             | 266     |                            |                            |                       | s H <sub>2</sub> O                                    |
| 5593 | <i>N</i> -Glycylserine, ( <i>DL</i> )      |                                                                          | C <sub>6</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub>                  | 687-38-7   | 162.144  |                                             | 198 dec |                            |                            |                       |                                                       |
| 5594 | Glycyrrhizic acid                          |                                                                          | C <sub>42</sub> H <sub>62</sub> O <sub>16</sub>                               | 1405-86-3  | 822.931  | pl or pr (HOAc)                             | 220 dec |                            |                            |                       | vs H <sub>2</sub> O, EtOH; i eth                      |
| 5595 | Glyodin                                    | 1 <i>H</i> -Imidazole, 2-heptadecyl-4,5-dihydro-, monoacetate            | C <sub>22</sub> H <sub>44</sub> N <sub>2</sub> O <sub>2</sub>                 | 556-22-9   | 368.596  |                                             |         |                            | 1.035 <sup>20</sup>        |                       |                                                       |
| 5596 | Glyoxal                                    |                                                                          | C <sub>2</sub> H <sub>2</sub> O <sub>2</sub>                                  | 107-22-2   | 58.036   | ye pr                                       | 15      | 50.4                       | 1.14 <sup>20</sup>         | 1.3826 <sup>20</sup>  | vs H <sub>2</sub> O; s EtOH, eth                      |
| 5597 | Glyoxal bis(2-hydroxyanil)                 | 2,2'-Benzoxazoline                                                       | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                 | 1149-16-2  | 240.257  |                                             | 202     |                            |                            |                       | s DMSO                                                |
| 5598 | Glyoxylic acid                             |                                                                          | C <sub>2</sub> H <sub>2</sub> O <sub>3</sub>                                  | 298-12-4   | 74.035   | orth pr (w+1/2)                             | 98      |                            |                            |                       | vs H <sub>2</sub> O; sl EtOH, eth, bz                 |
| 5599 | Glyphosate                                 | Glycine, <i>N</i> -(phosphonomethyl)-                                    | C <sub>3</sub> H <sub>8</sub> NO <sub>3</sub> P                               | 1071-83-6  | 169.074  |                                             | 230 dec |                            |                            |                       |                                                       |
| 5600 | Glyphosate isopropylamine salt             |                                                                          | C <sub>6</sub> H <sub>17</sub> N <sub>2</sub> O <sub>5</sub> P                | 38641-94-0 | 228.183  | cry                                         |         |                            |                            |                       | vs H <sub>2</sub> O                                   |
| 5601 | Glyphosine                                 | Glycine, <i>N,N</i> -bis(phosphonomethyl)-                               | C <sub>4</sub> H <sub>11</sub> NO <sub>6</sub> P <sub>2</sub>                 | 2439-99-8  | 263.080  | wh cry                                      |         |                            |                            |                       | s H <sub>2</sub> O                                    |
| 5602 | Grayanotoxin I                             |                                                                          | C <sub>22</sub> H <sub>36</sub> O <sub>7</sub>                                | 4720-09-6  | 412.517  | cry (AcOEI/C <sub>3</sub> H <sub>12</sub> ) | 268     |                            |                            |                       |                                                       |
| 5603 | Griseofulvin, (+)                          |                                                                          | C <sub>17</sub> H <sub>17</sub> ClO <sub>6</sub>                              | 126-07-8   | 352.766  | oct or orth cry (bz)                        | 220     |                            |                            |                       | i H <sub>2</sub> O; sl EtOH, eth, ace, bz, AcOEI, chl |
| 5604 | Guaiol                                     |                                                                          | C <sub>15</sub> H <sub>26</sub> O                                             | 489-86-1   | 222.366  | trg pr (al)                                 | 91      | dec 288; 165 <sup>17</sup> | 0.9074 <sup>100</sup>      | 1.4716 <sup>100</sup> | i H <sub>2</sub> O; s EtOH, eth                       |
| 5605 | Guanabenz                                  |                                                                          | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> N <sub>4</sub>                  | 5051-62-7  | 231.083  | wh solid                                    | 228 dec |                            |                            |                       |                                                       |
| 5606 | Guanadrel sulfate (2:1)                    |                                                                          | C <sub>20</sub> H <sub>40</sub> N <sub>6</sub> O <sub>8</sub> S               | 22195-34-2 | 524.632  | cry (MeOH/EtOH)                             | 214     |                            |                            |                       |                                                       |
| 5607 | Guanethidine                               |                                                                          | C <sub>10</sub> H <sub>22</sub> N <sub>4</sub>                                | 55-65-2    | 198.309  | wh cry (MeOH)                               | 226     |                            |                            |                       |                                                       |
| 5608 | Guanidine                                  | Aminomethanamide                                                         | CH <sub>5</sub> N <sub>3</sub>                                                | 113-00-8   | 59.071   | cry                                         | 50      |                            |                            |                       | vs H <sub>2</sub> O, EtOH                             |
| 5609 | Guanidine monohydrochloride                |                                                                          | CH <sub>6</sub> ClN <sub>3</sub>                                              | 50-01-1    | 95.532   | orth bipym (al)                             | 182.3   |                            | 1.354 <sup>20</sup>        |                       | vs H <sub>2</sub> O, EtOH                             |
| 5610 | Guanidine mononitrate                      |                                                                          | CH <sub>5</sub> N <sub>3</sub> O <sub>3</sub>                                 | 506-93-4   | 122.084  | lf (w)                                      | 217     | dec                        |                            |                       | vs H <sub>2</sub> O, EtOH                             |
| 5611 | Guanidine, sulfate (2:1)                   |                                                                          | C <sub>2</sub> H <sub>12</sub> N <sub>6</sub> O <sub>4</sub> S                | 594-14-9   | 216.219  |                                             | 292 dec |                            |                            |                       |                                                       |
| 5612 | 2-Guanidinoethanesulfonic acid             | Taurocyamine                                                             | C <sub>3</sub> H <sub>9</sub> N <sub>3</sub> O <sub>3</sub> S                 | 543-18-0   | 167.186  | cry (EtOH, ace)                             | 227     |                            |                            |                       |                                                       |
| 5613 | 3-Guanidinopropanoic acid                  | <i>N</i> -Amidino-β-alanine                                              | C <sub>4</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                   | 353-09-3   | 131.133  | cry (EtOH)                                  | 210     |                            |                            |                       |                                                       |
| 5614 | Guanine                                    |                                                                          | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub> O                                | 73-40-5    | 151.127  | nd or pl (aq NH <sub>3</sub> )              | 360 dec | sub                        |                            |                       | i H <sub>2</sub> O, HOAc; sl EtOH, eth; s alk, acid   |
| 5615 | Guanosine                                  | 2-Amino-1,9-dihydro-9-β- <i>D</i> -ribofuranosyl-6 <i>H</i> -purin-6-one | C <sub>10</sub> H <sub>13</sub> N <sub>5</sub> O <sub>5</sub>                 | 118-00-3   | 283.241  | nd (w)                                      | 239 dec |                            |                            |                       | sl H <sub>2</sub> O; i EtOH, eth; vs HOAc             |
| 5616 | Guanosine 5'-diphosphate                   | Guanosine 5'-(trihydrogen diphosphate)                                   | C <sub>10</sub> H <sub>15</sub> N <sub>5</sub> O <sub>11</sub> P <sub>2</sub> | 146-91-8   | 443.201  | amorp solid                                 |         |                            |                            |                       |                                                       |
| 5617 | Guanosine 5'-monophosphate                 | 5'-Guanylic acid                                                         | C <sub>10</sub> H <sub>14</sub> N <sub>5</sub> O <sub>8</sub> P               | 85-32-5    | 363.221  | hyg cry                                     | 190 dec |                            |                            |                       | sl H <sub>2</sub> O                                   |



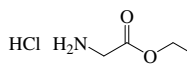
Glycerol tritridecanoate



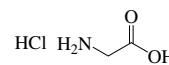
Glycerone phosphate



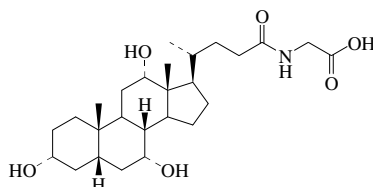
Glycine



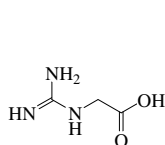
Glycine, ethyl ester, hydrochloride



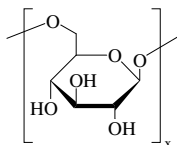
Glycine, hydrochloride



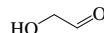
Glycocholic acid



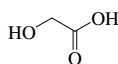
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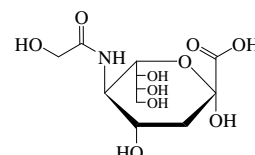
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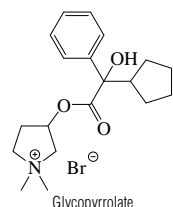
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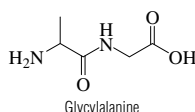
Glycolic acid



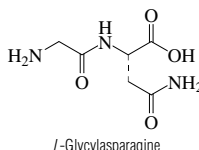
N-Glycolylneuraminic acid



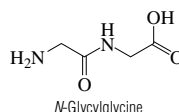
Glycopyrrolate



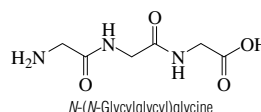
Glycylalanine



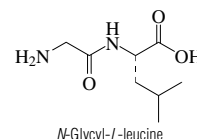
L-Glycylasparagine



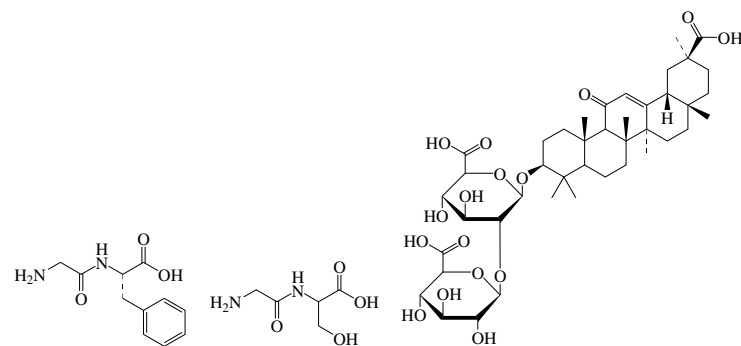
N-Glycylglycine



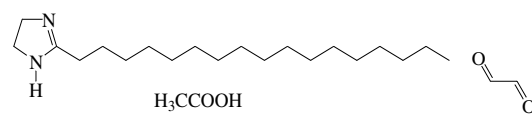
N-(N-Glycylglycyl)glycine



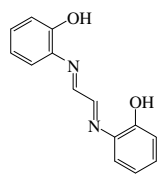
N-Glycyl-L-leucine



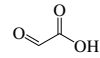
Glycyrrhizic acid

H<sub>3</sub>CCOOH  
Glyodin

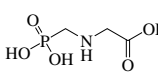
Glyoxal



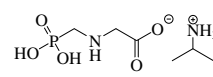
Glyoxal bis(2-hydroxyanil)



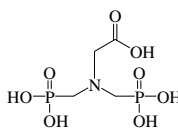
Glyoxylic acid



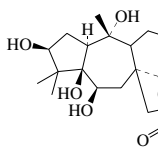
Glyphosate



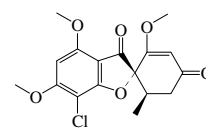
Glyphosate isopropylamine salt



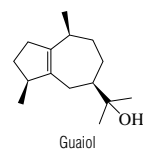
Glyphosine



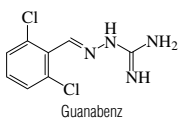
Grayanotoxin I



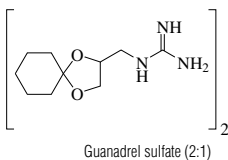
Griseofulvin, (+)



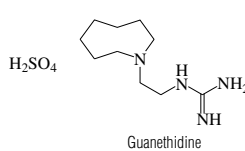
Guaiol



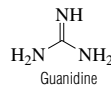
Guanabenz



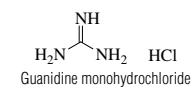
Guanadrel sulfate (2:1)



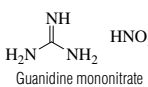
Guanethidine



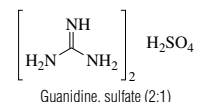
Guanidine



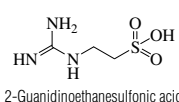
Guanidine monohydrochloride



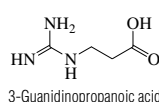
Guanidine mononitrate



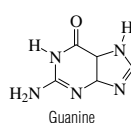
Guanidine, sulfate (2:1)



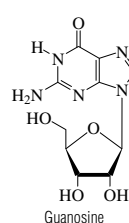
2-Guanidinoethanesulfonic acid



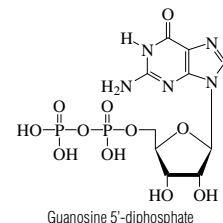
3-Guanidinopropanoic acid



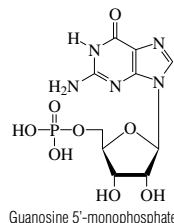
Guanine



Guanosine

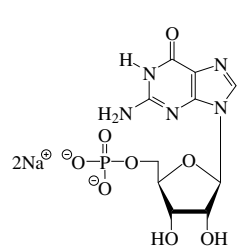


Guanosine 5'-diphosphate

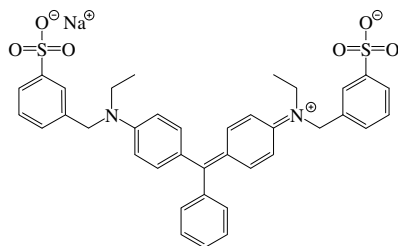


Guanosine 5'-monophosphate

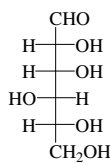
| No.  | Name                                      | Synonym                                                                 | Mol. Form.                                                                      | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|-------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------|------------|----------|----------------------------|---------|--------------------|----------------------------|----------------------|------------------------------------------------------------|
| 5618 | Guanosine 5'-monophosphate, disodium salt | 5'-Guanylic acid, disodium salt                                         | C <sub>10</sub> H <sub>12</sub> N <sub>5</sub> Na <sub>2</sub> O <sub>8</sub> P | 5550-12-9  | 407.185  |                            | 195 dec |                    |                            |                      | sl H <sub>2</sub> O                                        |
| 5619 | Guinea Green B                            | C.I. Acid Green 3                                                       | C <sub>37</sub> H <sub>35</sub> N <sub>7</sub> NaO <sub>6</sub> S <sub>2</sub>  | 4680-78-8  | 690.803  | dk grn pow                 |         |                    |                            |                      | s H <sub>2</sub> O; sl EtOH                                |
| 5620 | D-Gulose                                  |                                                                         | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                   | 4205-23-6  | 180.155  | syr                        |         | dec                |                            |                      | vs H <sub>2</sub> O                                        |
| 5621 | L-Gulose                                  |                                                                         | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                   | 6027-89-0  | 180.155  | syr                        |         | dec                |                            |                      | vs H <sub>2</sub> O                                        |
| 5622 | Haloperidol                               |                                                                         | C <sub>21</sub> H <sub>23</sub> ClFNO <sub>2</sub>                              | 52-86-8    | 375.865  |                            | 151.5   |                    |                            |                      |                                                            |
| 5623 | Harmaline                                 | 4,9-Dihydro-7-methoxy-1-methyl-3 <i>H</i> -pyrido[3,4- <i>b</i> ]indole | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> O                                | 304-21-2   | 214.262  | tab (MeOH)<br>orth pr (al) | 230     |                    |                            |                      | sl H <sub>2</sub> O, EtOH,<br>eth; s chl, py               |
| 5624 | Harman                                    | 1-Methyl-9 <i>H</i> -pyrido[3,4- <i>b</i> ]indole                       | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub>                                  | 486-84-0   | 182.220  | bl flr orth cry<br>(hp)    | 236.5   |                    |                            |                      |                                                            |
| 5625 | Harmine                                   | 7-Methoxy-1-methyl-9 <i>H</i> -pyrido[3,4- <i>b</i> ]indole             | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O                                | 442-51-3   | 212.246  | orth (al), pr<br>(MeOH)    | 273     | sub                |                            |                      | sl H <sub>2</sub> O, chl,<br>EtOH, eth; s py               |
| 5626 | HC Blue No. 1                             |                                                                         | C <sub>11</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub>                   | 2784-94-3  | 255.271  | blk cry                    | 100     |                    |                            |                      |                                                            |
| 5627 | HC Blue No. 2                             |                                                                         | C <sub>12</sub> H <sub>19</sub> N <sub>3</sub> O <sub>5</sub>                   | 33229-34-4 | 285.296  | dk bl-blk cry              | 110     |                    |                            |                      |                                                            |
| 5628 | Hectane                                   |                                                                         | C <sub>100</sub> H <sub>202</sub>                                               | 6703-98-6  | 1404.67  |                            | 117     |                    |                            |                      |                                                            |
| 5629 | Hederagenin                               |                                                                         | C <sub>30</sub> H <sub>48</sub> O <sub>4</sub>                                  | 465-99-6   | 472.700  | pr (al)                    | 333     |                    |                            |                      |                                                            |
| 5630 | Helenalin                                 |                                                                         | C <sub>15</sub> H <sub>18</sub> O <sub>4</sub>                                  | 6754-13-8  | 262.302  | cry (EtOH)                 | 226     |                    |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>chl                        |
| 5631 | Helminthosporal                           |                                                                         | C <sub>15</sub> H <sub>22</sub> O <sub>2</sub>                                  | 723-61-5   | 234.335  |                            | 58      | 1170.015           |                            |                      |                                                            |
| 5632 | Helvolic acid                             |                                                                         | C <sub>33</sub> H <sub>44</sub> O <sub>8</sub>                                  | 29400-42-8 | 568.697  | nd (dil<br>HOAc)           | 212 dec |                    |                            |                      | sl H <sub>2</sub> O, EtOH; s<br>eth, ace, bz,<br>diox      |
| 5633 | Hematein                                  |                                                                         | C <sub>16</sub> H <sub>12</sub> O <sub>6</sub>                                  | 475-25-2   | 300.262  | red-br cry                 | 250 dec |                    |                            |                      | i H <sub>2</sub> O, eth, bz,<br>chl; sl EtOH,<br>HOAc      |
| 5634 | Hematin                                   |                                                                         | C <sub>34</sub> H <sub>33</sub> FeN <sub>4</sub> O <sub>5</sub>                 | 15489-90-4 | 633.495  | br pow (py)                | >200    |                    |                            |                      | i H <sub>2</sub> O, eth; s<br>EtOH, alk; sl<br>py, HOAc    |
| 5635 | Hematoporphyrin                           |                                                                         | C <sub>34</sub> H <sub>38</sub> N <sub>4</sub> O <sub>6</sub>                   | 14459-29-1 | 598.689  | deep red cry               | 172.5   |                    |                            |                      | i H <sub>2</sub> O; s EtOH; sl<br>eth, chl                 |
| 5636 | Hematoxylin                               |                                                                         | C <sub>16</sub> H <sub>14</sub> O <sub>6</sub>                                  | 517-28-2   | 302.278  | ye cry                     | 140     |                    |                            |                      | sl H <sub>2</sub> O, eth; s<br>alk, EtOH                   |
| 5637 | Hemin                                     |                                                                         | C <sub>34</sub> H <sub>32</sub> ClFeN <sub>4</sub> O <sub>4</sub>               | 16009-13-5 | 651.941  | long blades<br>(gl HOAc)   | >300    |                    |                            |                      |                                                            |
| 5638 | Heneicosane                               |                                                                         | C <sub>21</sub> H <sub>44</sub>                                                 | 629-94-7   | 296.574  | cry (w)                    | 40.01   | 356.5              | 0.7919 <sup>20</sup>       | 1.4441 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH;<br>s peth                     |
| 5639 | Hentriacontane                            | Untriacontane                                                           | C <sub>31</sub> H <sub>64</sub>                                                 | 630-04-6   | 436.840  | lf (AcOEt)                 | 67.9    | 458                | 0.781 <sup>68</sup>        | 1.4278 <sup>60</sup> | sl EtOH, eth, bz,<br>chl; s peth                           |
| 5640 | Heptachlor                                |                                                                         | C <sub>10</sub> H <sub>5</sub> Cl <sub>7</sub>                                  | 76-44-8    | 373.318  | wh cry                     | 95.5    |                    | 1.57 <sup>9</sup>          |                      | vs bz, eth, EtOH,<br>lig                                   |
| 5641 | Heptachlor epoxide                        |                                                                         | C <sub>10</sub> H <sub>5</sub> Cl <sub>7</sub> O                                | 1024-57-3  | 389.317  |                            | 160     |                    |                            |                      |                                                            |
| 5642 | 2,2',3,3',4,4',6'-Heptachlorobiphenyl     |                                                                         | C <sub>12</sub> H <sub>3</sub> Cl <sub>7</sub>                                  | 52663-71-5 | 395.323  | cry                        | 117.5   |                    |                            |                      | i H <sub>2</sub> O                                         |
| 5643 | 1,1,1,2,3,3,3-Heptachloropropane          |                                                                         | C <sub>3</sub> HCl <sub>7</sub>                                                 | 3849-33-0  | 285.211  |                            | 11      | 249                | 1.7921 <sup>34</sup>       | 1.5427 <sup>21</sup> | vs chl                                                     |
| 5644 | Heptacontane                              |                                                                         | C <sub>70</sub> H <sub>142</sub>                                                | 7719-93-9  | 983.876  |                            | 107     | 647                |                            |                      |                                                            |
| 5645 | Heptacosane                               |                                                                         | C <sub>27</sub> H <sub>56</sub>                                                 | 593-49-7   | 380.734  | cry (al, bz) lf<br>(AcOEt) | 59.23   | 442                | 0.7796 <sup>60</sup>       | 1.4345 <sup>65</sup> | i H <sub>2</sub> O, EtOH; sl<br>eth                        |
| 5646 | Heptadecanal                              | Margaric aldehyde                                                       | C <sub>17</sub> H <sub>34</sub> O                                               | 629-90-3   | 254.451  | nd (peth),<br>cry (al)     | 36      | 204 <sup>26</sup>  |                            |                      | vs bz, eth                                                 |
| 5647 | 1-Heptadecanamine                         |                                                                         | C <sub>17</sub> H <sub>37</sub> N                                               | 4200-95-7  | 255.483  |                            | 49      | 336                | 0.8510 <sup>20</sup>       | 1.4510 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                         |
| 5648 | Heptadecane                               |                                                                         | C <sub>17</sub> H <sub>36</sub>                                                 | 629-78-7   | 240.468  | hex lf                     | 22.0    | 302.0              | 0.7780 <sup>20</sup>       | 1.4369 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH,<br>ctc; s eth                 |
| 5649 | Heptadecanenitrile                        |                                                                         | C <sub>17</sub> H <sub>33</sub> N                                               | 5399-02-0  | 251.451  | cry (al)                   | 34      | 349                | 0.8315 <sup>20</sup>       | 1.4467 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH,<br>chl; vs eth                |
| 5650 | Heptadecanoic acid                        | Margaric acid                                                           | C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>                                  | 506-12-7   | 270.451  | pl (peth)                  | 61.3    | 227 <sup>100</sup> | 0.8532 <sup>60</sup>       | 1.4342 <sup>60</sup> | i H <sub>2</sub> O; sl EtOH;<br>s eth, ace, bz,<br>chl     |
| 5651 | 1-Heptadecanol                            | Margaryl alcohol                                                        | C <sub>17</sub> H <sub>36</sub> O                                               | 1454-85-9  | 256.467  | lf (al), cry<br>(ace)      | 53.9    | 324                | 0.8475 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH,<br>eth                         |
| 5652 | 2-Heptadecanone                           | Pentadecyl methyl ketone                                                | C <sub>17</sub> H <sub>34</sub> O                                               | 2922-51-2  | 254.451  | pl (dil al)                | 48      | 320                | 0.8049 <sup>48</sup>       |                      | i H <sub>2</sub> O; sl EtOH;<br>s ace, peth; vs<br>bz, eth |
| 5653 | 9-Heptadecanone                           |                                                                         | C <sub>17</sub> H <sub>34</sub> O                                               | 540-08-9   | 254.451  | pl (MeOH)                  | 53      | 251.5; 1421.5      | 0.8140 <sup>48</sup>       |                      | sl EtOH; s<br>MeOH                                         |
| 5654 | 1-Heptadecene                             | Hexahydroaplotaxene                                                     | C <sub>17</sub> H <sub>34</sub>                                                 | 6765-39-5  | 238.452  |                            | 11.5    | 300                | 0.7852 <sup>20</sup>       | 1.4432 <sup>20</sup> | i H <sub>2</sub> O; vs eth; s<br>bz, msc lig               |
| 5655 | Heptadecylbenzene                         | 1-Phenylheptadecane                                                     | C <sub>23</sub> H <sub>40</sub>                                                 | 14752-75-1 | 316.564  |                            | 32      | 397                | 0.8546 <sup>20</sup>       | 1.4810 <sup>20</sup> |                                                            |
| 5656 | trans,trans-2,4-Heptadienal               |                                                                         | C <sub>7</sub> H <sub>10</sub> O                                                | 4313-03-5  | 110.153  |                            |         | 84.5               | 0.881 <sup>25</sup>        | 1.5315 <sup>20</sup> |                                                            |
| 5657 | 1,6-Heptadiene                            |                                                                         | C <sub>7</sub> H <sub>12</sub>                                                  | 3070-53-9  | 96.170   | liq                        |         | 90                 |                            |                      |                                                            |
| 5658 | 1,6-Heptadiyne                            |                                                                         | C <sub>7</sub> H <sub>8</sub>                                                   | 2396-63-6  | 92.139   | liq                        | -85     | 112                | 0.8164 <sup>17</sup>       | 1.451 <sup>17</sup>  | i H <sub>2</sub> O; s bz,<br>HOAc                          |
| 5659 | Heptafluorobutanoic acid                  |                                                                         | C <sub>4</sub> HF <sub>7</sub> O <sub>2</sub>                                   | 375-22-4   | 214.039  | liq                        | -17.5   | 121                | 1.651 <sup>20</sup>        | 1.295 <sup>25</sup>  | s H <sub>2</sub> O, eth, tol; i<br>peth                    |



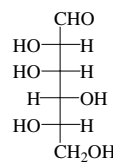
Guanosine 5'-monophosphate, disodium salt



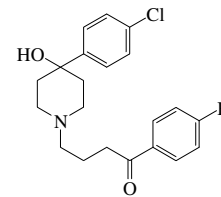
Guinea Green B



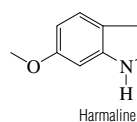
D-Gulose



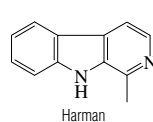
L-Gulose



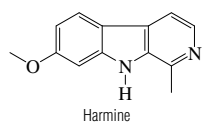
Haloperidol



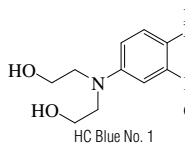
Harmaline



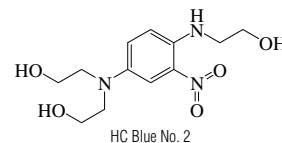
Harman



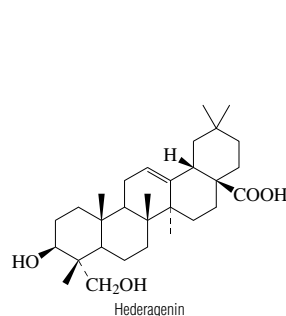
Harmine



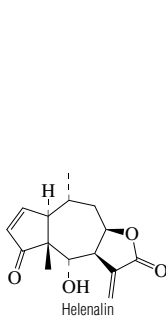
HC Blue No. 1



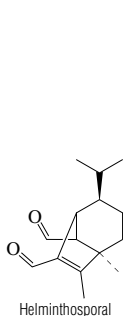
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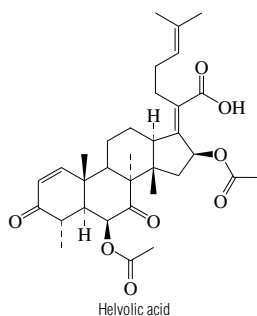
Hederagenin



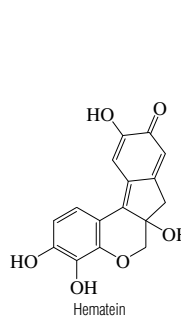
Helenalin



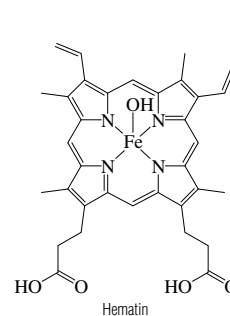
Helminthosporal



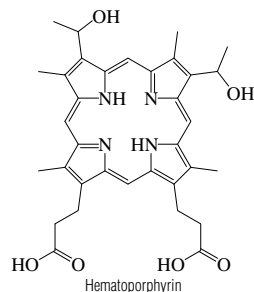
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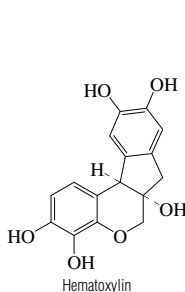
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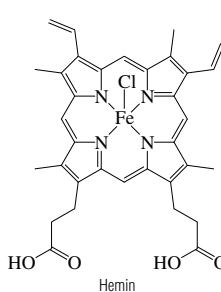
Hematin



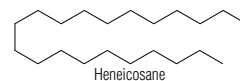
Hematoporphyrin



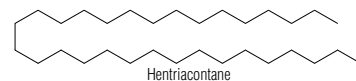
Hematoxylin



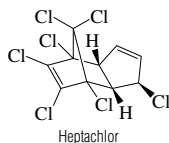
Hemin



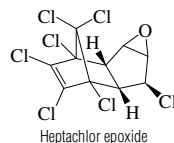
Heneicosane



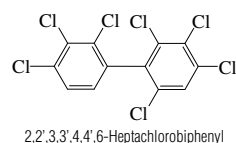
Hentriacontane



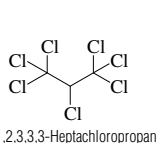
Heptachlor



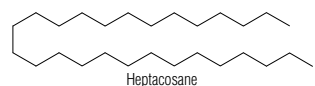
Heptachlor epoxide



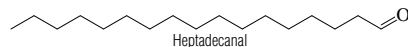
2,2',3,3',4,4',6-Heptachlorobiphenyl



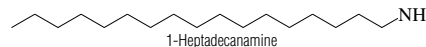
1,1,1,2,3,3,3-Heptachloropropane



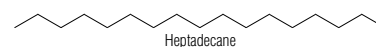
Heptacosane



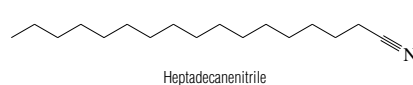
Heptadecanal



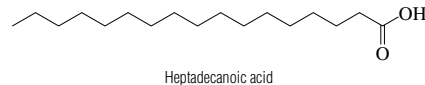
1-Heptadecanamine



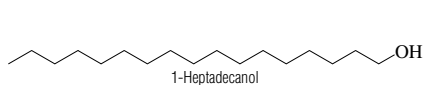
Heptadecane



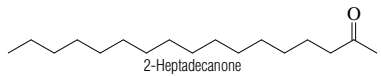
Heptadecanenitrile



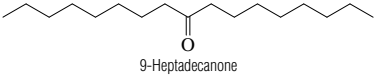
Heptadecanoic acid



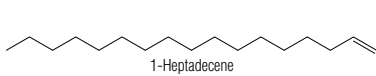
1-Heptadecanol



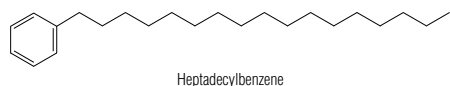
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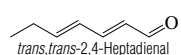
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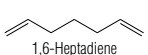
1-Heptadecene



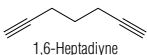
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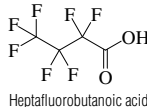
trans,trans-2,4-Heptadienal



1,6-Heptadiene

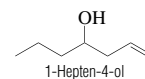
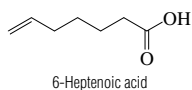
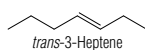
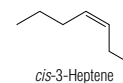
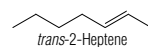
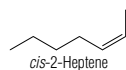
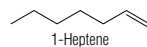
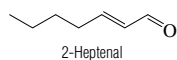
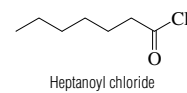
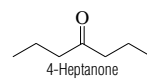
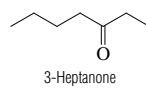
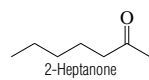
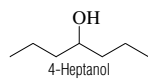
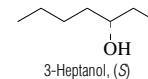
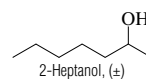
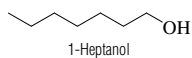
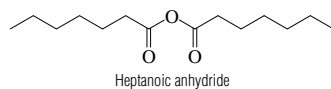
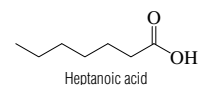
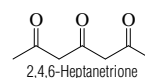
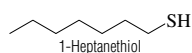
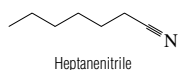
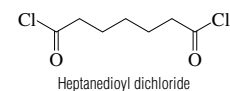
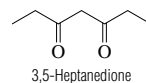
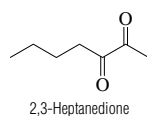
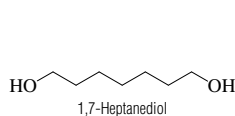
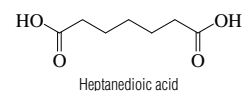
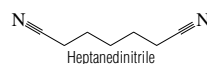
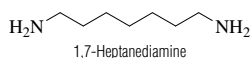
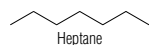
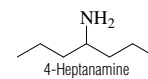
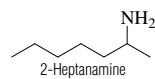
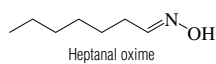
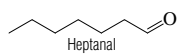
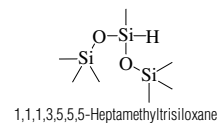
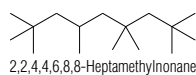
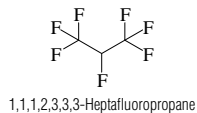
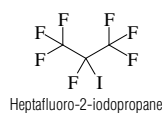
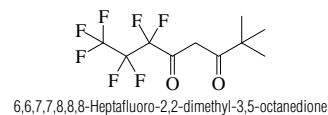
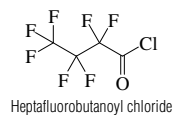
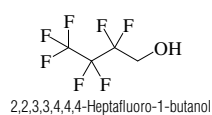
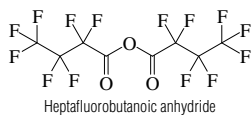


1,6-Heptadiyne



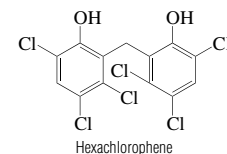
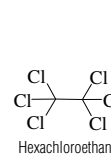
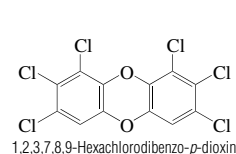
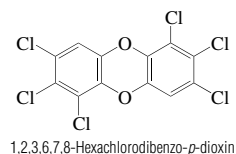
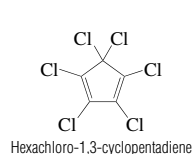
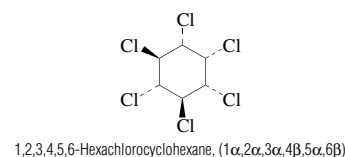
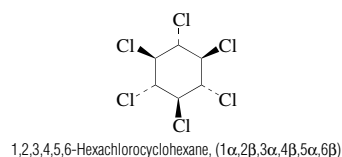
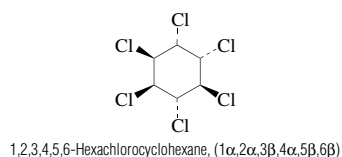
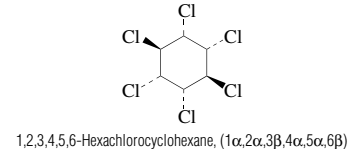
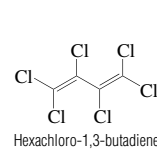
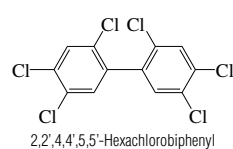
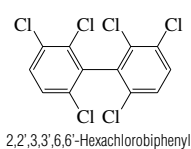
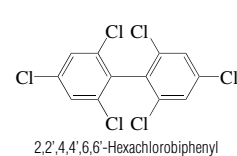
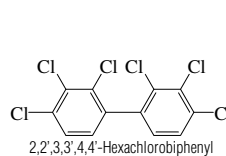
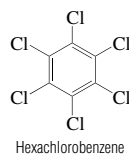
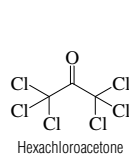
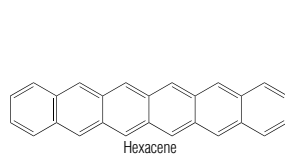
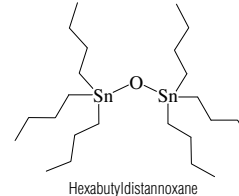
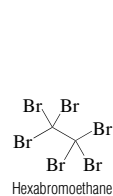
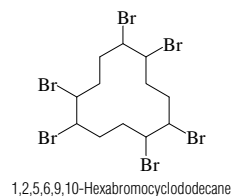
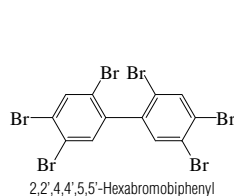
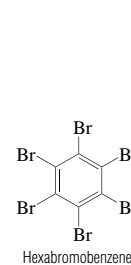
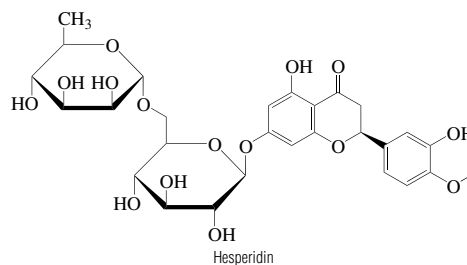
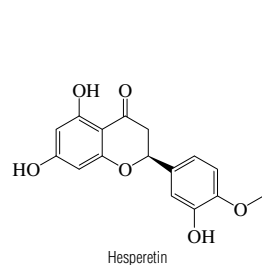
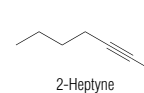
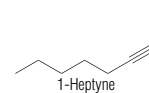
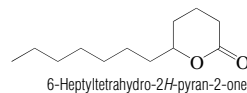
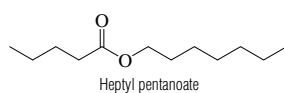
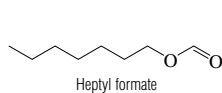
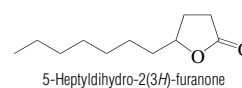
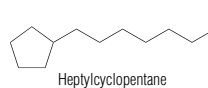
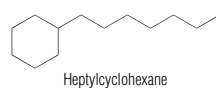
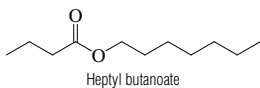
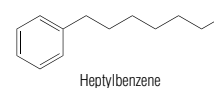
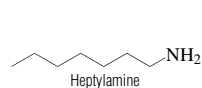
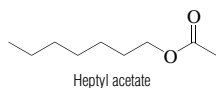
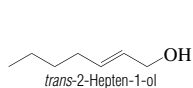
Heptafluorobutanoic acid

| No.  | Name                                                   | Synonym                   | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form | mp/°C  | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|--------------------------------------------------------|---------------------------|---------------------------------------------------------------|------------|----------|---------------|--------|---------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 5660 | Heptafluorobutanoic anhydride                          |                           | C <sub>8</sub> F <sub>14</sub> O <sub>3</sub>                 | 336-59-4   | 410.062  | liq           | -43    | 106.5                     | 1.665 <sup>20</sup>        | 1.285 <sup>20</sup>  |                                                       |
| 5661 | 2,2,3,3,4,4,4-Heptafluoro-1-butanol                    |                           | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O                | 375-01-9   | 200.055  |               |        | 95                        | 1.600 <sup>20</sup>        | 1.294 <sup>20</sup>  | s EtOH, ace                                           |
| 5662 | Heptafluorobutanoyl chloride                           |                           | C <sub>4</sub> ClF <sub>7</sub> O                             | 375-16-6   | 232.484  |               |        | 38.5                      | 1.55 <sup>20</sup>         | 1.288 <sup>20</sup>  |                                                       |
| 5663 | 6,6,7,7,8,8,8-Heptafluoro-2,2-dimethyl-3,5-octanedione |                           | C <sub>10</sub> H <sub>11</sub> F <sub>7</sub> O <sub>2</sub> | 17587-22-3 | 296.182  |               | 38     | 46 <sup>5</sup>           | 1.273 <sup>25</sup>        | 1.3766 <sup>20</sup> |                                                       |
| 5664 | Heptafluoro-2-iodopropane                              | Perfluoroisopropyl iodide | C <sub>3</sub> F <sub>7</sub> I                               | 677-69-0   | 295.925  |               |        | 38                        | 1.3298 <sup>20</sup>       |                      |                                                       |
| 5665 | 1,1,1,2,3,3,3-Heptafluoropropane                       | Refrigerant 227ea         | C <sub>3</sub> HF <sub>7</sub>                                | 431-89-0   | 170.029  | col gas       | -126.8 | -16.34                    |                            |                      |                                                       |
| 5666 | 2,2,4,4,6,8,8-Heptamethylnonane                        |                           | C <sub>16</sub> H <sub>34</sub>                               | 4390-04-9  | 226.441  |               |        | 246.3                     |                            |                      |                                                       |
| 5667 | 1,1,1,3,5,5,5-Heptamethyltrisiloxane                   |                           | C <sub>7</sub> H <sub>22</sub> O <sub>2</sub> Si <sub>3</sub> | 1873-88-7  | 222.506  |               |        | 142                       | 0.8194 <sup>20</sup>       | 1.3818 <sup>20</sup> |                                                       |
| 5668 | Heptanal                                               | Heptaldehyde              | C <sub>7</sub> H <sub>14</sub> O                              | 111-71-7   | 114.185  | liq           | -43.4  | 152.8                     | 0.8132 <sup>25</sup>       | 1.4113 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth               |
| 5669 | Heptanal oxime                                         | Enanthaldoxime            | C <sub>7</sub> H <sub>13</sub> NO                             | 629-31-2   | 129.200  | pl (al)       | 57.5   | 195                       | 0.8583 <sup>55</sup>       | 1.4210 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                      |
| 5670 | 2-Heptanamine                                          | Tuaminoheptane            | C <sub>7</sub> H <sub>17</sub> N                              | 123-82-0   | 115.217  |               |        | 142                       | 0.7665 <sup>19</sup>       | 1.4199 <sup>19</sup> | sl H <sub>2</sub> O, chl; s EtOH, eth, peth           |
| 5671 | 4-Heptanamine                                          |                           | C <sub>7</sub> H <sub>17</sub> N                              | 16751-59-0 | 115.217  |               |        | 139.5                     | 0.767 <sup>20</sup>        | 1.4172 <sup>20</sup> |                                                       |
| 5672 | Heptane                                                |                           | C <sub>7</sub> H <sub>16</sub>                                | 142-82-5   | 100.202  | liq           | -90.55 | 98.4                      | 0.6795 <sup>25</sup>       | 1.3855 <sup>25</sup> | i H <sub>2</sub> O; vs EtOH; msc eth, bz, chl; s ctc  |
| 5673 | 1,7-Heptanediamine                                     |                           | C <sub>7</sub> H <sub>18</sub> N <sub>2</sub>                 | 646-19-5   | 130.231  |               | 25.32  | 224                       |                            |                      | s EtOH, eth, ace                                      |
| 5674 | Heptanedinitrile                                       |                           | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                 | 646-20-8   | 122.167  |               | -31.4  | 155 <sup>14</sup>         | 0.949 <sup>18</sup>        | 1.4472 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, chl                |
| 5675 | Heptanedioic acid                                      | Pimelic acid              | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | 111-16-0   | 160.168  | pr (w)        | 106    | 342.0; 272 <sup>100</sup> | 1.329 <sup>15</sup>        |                      | s H <sub>2</sub> O, EtOH, eth; i bz                   |
| 5676 | 1,7-Heptanediol                                        |                           | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>                 | 629-30-1   | 132.201  |               | 22.5   | 262                       | 0.9569 <sup>25</sup>       | 1.4520 <sup>25</sup> | vs eth, EtOH                                          |
| 5677 | 2,3-Heptanedione                                       | Acetyl valeryl            | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                 | 96-04-8    | 128.169  |               |        | 144; 46 <sup>13</sup>     | 0.919 <sup>18</sup>        | 1.4150 <sup>18</sup> |                                                       |
| 5678 | 3,5-Heptanedione                                       | Dipropionylmethane        | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                 | 7424-54-6  | 128.169  |               |        | 175; 79 <sup>30</sup>     | 0.945 <sup>20</sup>        |                      |                                                       |
| 5679 | Heptanedioyl dichloride                                |                           | C <sub>7</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>2</sub> | 142-79-0   | 197.059  |               |        | 137 <sup>15</sup>         |                            |                      |                                                       |
| 5680 | Heptanenitrile                                         |                           | C <sub>7</sub> H <sub>13</sub> N                              | 629-08-3   | 111.185  | liq           | -64    | 183; 71 <sup>10</sup>     | 0.8106 <sup>20</sup>       | 1.4104 <sup>30</sup> | i H <sub>2</sub> O; s eth, ace, bz, HOAc              |
| 5681 | 1-Heptanethiol                                         | Heptyl mercaptan          | C <sub>7</sub> H <sub>16</sub> S                              | 1639-09-4  | 132.267  | liq           | -43    | 176.9                     | 0.8427 <sup>20</sup>       | 1.4521 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl              |
| 5682 | 2,4,6-Heptanetrione                                    |                           | C <sub>7</sub> H <sub>10</sub> O <sub>3</sub>                 | 626-53-9   | 142.152  | lf            | 49     | 121 <sup>10</sup>         | 1.0599 <sup>40</sup>       | 1.4930 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                        |
| 5683 | Heptanoic acid                                         | Enanthic acid             | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | 111-14-8   | 130.185  | liq           | -7.17  | 222.2                     | 0.9124 <sup>25</sup>       | 1.4170 <sup>20</sup> | sl H <sub>2</sub> O; ctc; s EtOH, eth, ace            |
| 5684 | Heptanoic anhydride                                    |                           | C <sub>14</sub> H <sub>26</sub> O <sub>3</sub>                | 626-27-7   | 242.354  | liq           | -12.4  | 269.5                     | 0.9321 <sup>20</sup>       | 1.4335 <sup>15</sup> | i H <sub>2</sub> O; s EtOH, eth                       |
| 5685 | 1-Heptanol                                             | Heptyl alcohol            | C <sub>7</sub> H <sub>16</sub> O                              | 111-70-6   | 116.201  | liq           | -33.2  | 176.45                    | 0.8219 <sup>20</sup>       | 1.4249 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth               |
| 5686 | 2-Heptanol, (±)                                        |                           | C <sub>7</sub> H <sub>16</sub> O                              | 52390-72-4 | 116.201  |               |        | 159                       | 0.8167 <sup>20</sup>       | 1.4210 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth                 |
| 5687 | 3-Heptanol, (S)                                        |                           | C <sub>7</sub> H <sub>16</sub> O                              | 26549-25-7 | 116.201  | liq           | -70    | 157; 66 <sup>18</sup>     | 0.8227 <sup>20</sup>       | 1.4201 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth                 |
| 5688 | 4-Heptanol                                             | Dipropylcarbinol          | C <sub>7</sub> H <sub>16</sub> O                              | 589-55-9   | 116.201  | liq           | -41.2  | 156                       | 0.8183 <sup>20</sup>       | 1.4205 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                      |
| 5689 | 2-Heptanone                                            | Methyl pentyl ketone      | C <sub>7</sub> H <sub>14</sub> O                              | 110-43-0   | 114.185  | liq           | -35    | 151.05                    | 0.8111 <sup>20</sup>       | 1.4088 <sup>20</sup> | vs H <sub>2</sub> O; s EtOH, eth                      |
| 5690 | 3-Heptanone                                            | Ethyl butyl ketone        | C <sub>7</sub> H <sub>14</sub> O                              | 106-35-4   | 114.185  | liq           | -39    | 147                       | 0.8183 <sup>20</sup>       | 1.4057 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth               |
| 5691 | 4-Heptanone                                            | Dipropyl ketone           | C <sub>7</sub> H <sub>14</sub> O                              | 123-19-3   | 114.185  | liq           | -33    | 144                       | 0.8174 <sup>20</sup>       | 1.4069 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc              |
| 5692 | Heptanoyl chloride                                     |                           | C <sub>7</sub> H <sub>13</sub> ClO                            | 2528-61-2  | 148.630  | liq           | -83.8  | 125.2                     | 0.9590 <sup>20</sup>       | 1.4345 <sup>18</sup> | s eth; sl ctc; vs lig                                 |
| 5693 | 2-Heptenal                                             | Butylacrolein             | C <sub>7</sub> H <sub>12</sub> O                              | 2463-63-0  | 112.169  |               |        | 166                       | 0.864 <sup>17</sup>        | 1.4468 <sup>17</sup> |                                                       |
| 5694 | 1-Heptene                                              |                           | C <sub>7</sub> H <sub>14</sub>                                | 592-76-7   | 98.186   | liq           | -118.9 | 93.64                     | 0.6970 <sup>20</sup>       | 1.3998 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc               |
| 5695 | cis-2-Heptene                                          |                           | C <sub>7</sub> H <sub>14</sub>                                | 6443-92-1  | 98.186   |               |        | 98.4                      | 0.708 <sup>20</sup>        | 1.406 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl; sl ctc |
| 5696 | trans-2-Heptene                                        |                           | C <sub>7</sub> H <sub>14</sub>                                | 14686-13-6 | 98.186   | liq           | -109.5 | 98                        | 0.7012 <sup>20</sup>       | 1.4045 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, peth, chl   |
| 5697 | cis-3-Heptene                                          |                           | C <sub>7</sub> H <sub>14</sub>                                | 7642-10-6  | 98.186   | liq           | -136.6 | 95.8                      | 0.7030 <sup>20</sup>       | 1.4059 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, peth, chl   |
| 5698 | trans-3-Heptene                                        |                           | C <sub>7</sub> H <sub>14</sub>                                | 14686-14-7 | 98.186   | liq           | -136.6 | 95.7                      | 0.6981 <sup>20</sup>       | 1.4043 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl; sl ctc |
| 5699 | 6-Heptenoic acid                                       |                           | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                 | 1119-60-4  | 128.169  | liq           | -6.5   | 226                       | 0.9515 <sup>14</sup>       | 1.4404 <sup>14</sup> |                                                       |
| 5700 | 1-Hepten-4-ol                                          |                           | C <sub>7</sub> H <sub>14</sub> O                              | 3521-91-3  | 114.185  |               |        | 152.1                     | 0.8384 <sup>22</sup>       | 1.4347 <sup>20</sup> |                                                       |

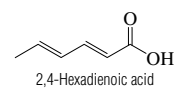
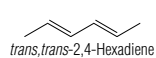
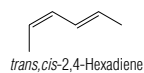
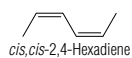
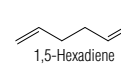
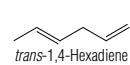
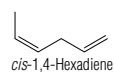
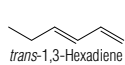
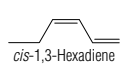
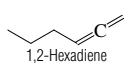
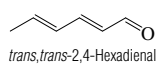
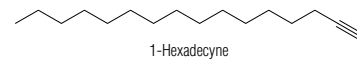
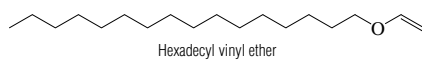
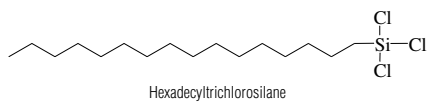
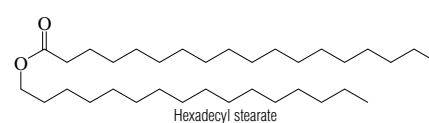
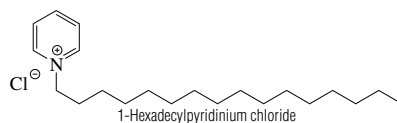
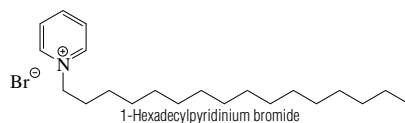
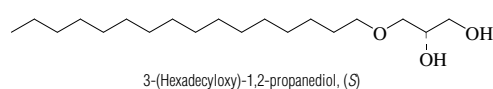
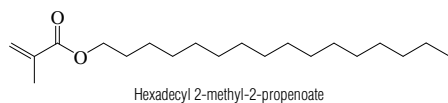
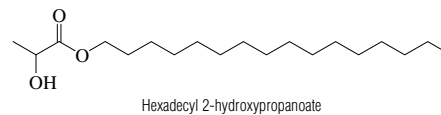
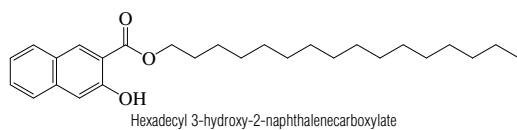
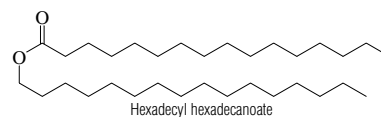
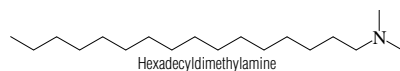
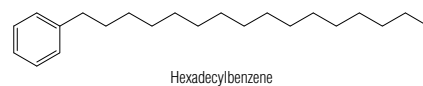
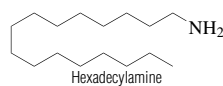
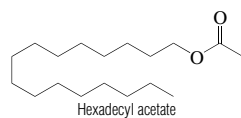
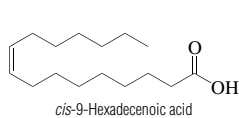
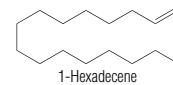
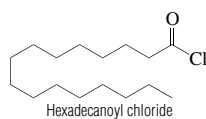
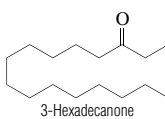
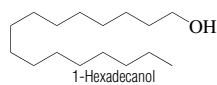
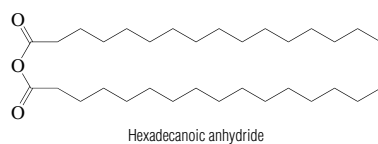
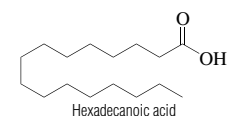
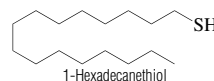
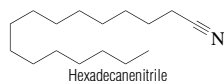
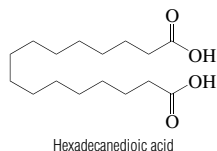
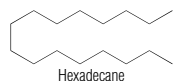
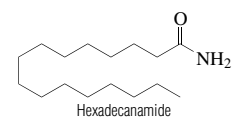
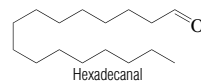
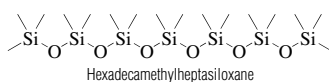
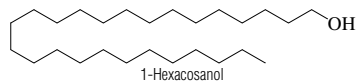
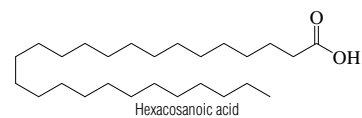
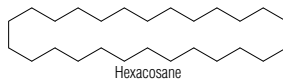
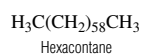
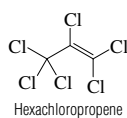




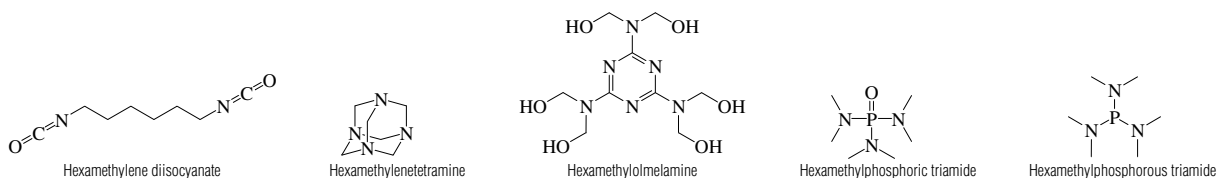
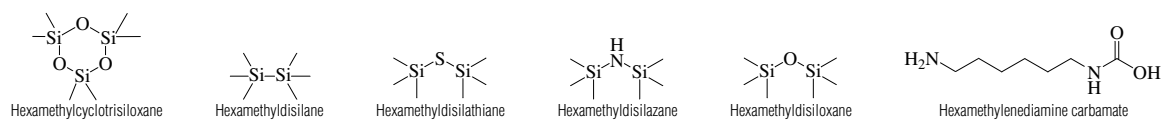
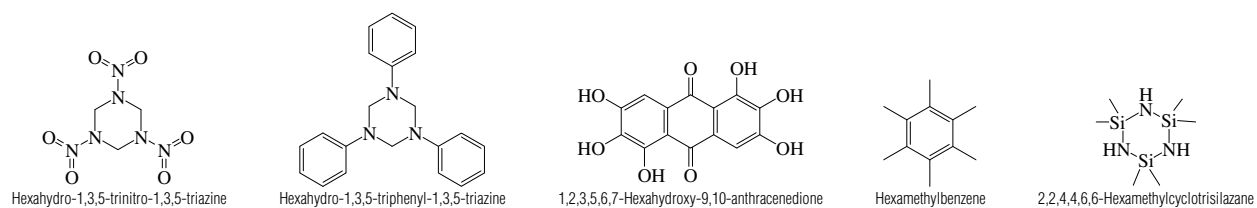
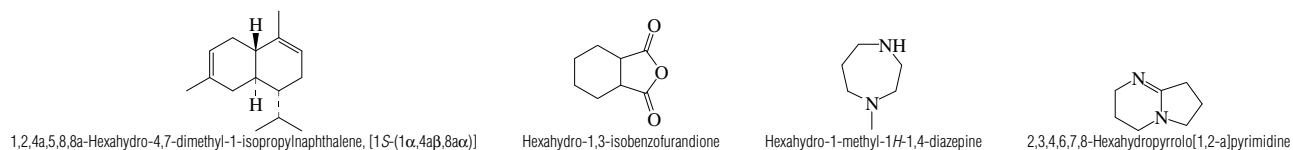
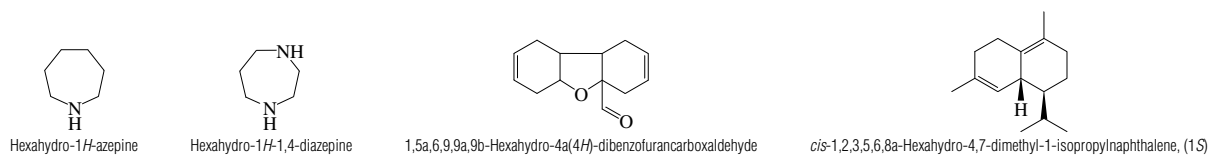
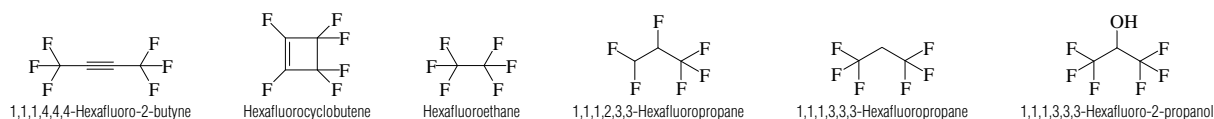
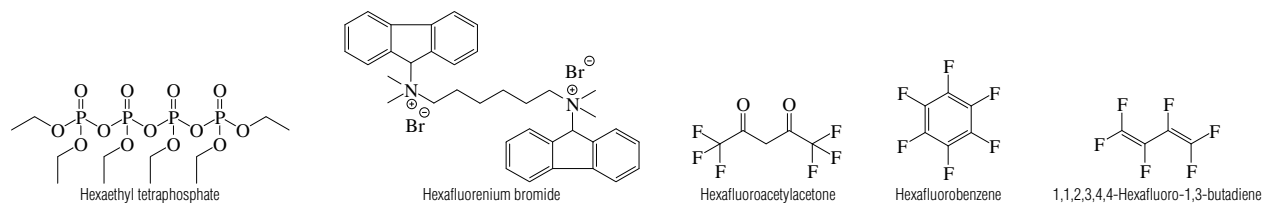
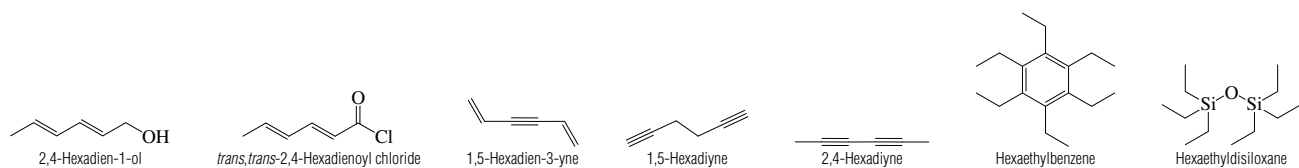
| No.  | Name                                                                                                       | Synonym                          | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form          | mp/°C    | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|------|------------------------------------------------------------------------------------------------------------|----------------------------------|---------------------------------------------------------------|------------|----------|------------------------|----------|------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 5701 | <i>trans</i> -2-Hepten-1-ol                                                                                |                                  | C <sub>7</sub> H <sub>14</sub> O                              | 33467-76-4 | 114.185  |                        |          | 178; 75 <sup>10</sup>  | 0.8516 <sup>20</sup>       | 1.4460 <sup>20</sup> | s EtOH, ace                                         |
| 5702 | Heptyl acetate                                                                                             |                                  | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                 | 112-06-1   | 158.238  | liq                    | -50.2    | 193                    | 0.8750 <sup>15</sup>       | 1.4150 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                |
| 5703 | Heptylamine                                                                                                | 1-Heptanamine                    | C <sub>7</sub> H <sub>17</sub> N                              | 111-68-2   | 115.217  | liq                    | -18      | 156                    | 0.7754 <sup>20</sup>       | 1.4251 <sup>20</sup> | sl H <sub>2</sub> O, chl; msc EtOH, eth             |
| 5704 | Heptylbenzene                                                                                              |                                  | C <sub>13</sub> H <sub>20</sub>                               | 1078-71-3  | 176.298  | liq                    | -48      | 240; 109 <sup>10</sup> | 0.8567 <sup>20</sup>       | 1.4865 <sup>20</sup> | i H <sub>2</sub> O; s bz, chl                       |
| 5705 | Heptyl butanoate                                                                                           |                                  | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                | 5870-93-9  | 186.292  | liq                    | -57.5    | 225.8                  | 0.8637 <sup>20</sup>       | 1.4231 <sup>20</sup> | vs EtOH                                             |
| 5706 | Heptylcyclohexane                                                                                          |                                  | C <sub>13</sub> H <sub>26</sub>                               | 5617-41-4  | 182.345  | liq                    | -30      | 244                    | 0.8109 <sup>20</sup>       | 1.4484 <sup>20</sup> |                                                     |
| 5707 | Heptylcyclopentane                                                                                         |                                  | C <sub>12</sub> H <sub>24</sub>                               | 5617-42-5  | 168.319  | liq                    | -53      | 224                    | 0.8010 <sup>20</sup>       | 1.4421 <sup>20</sup> | vs ace, bz, eth, EtOH                               |
| 5708 | 5-Heptyldihydro-2(3 <i>H</i> )-furanone                                                                    | 4-Hydroxyundecanoic acid lactone | C <sub>11</sub> H <sub>20</sub> O <sub>2</sub>                | 104-67-6   | 184.276  |                        |          | 286                    | 0.9494 <sup>20</sup>       | 1.4512 <sup>20</sup> | vs EtOH                                             |
| 5709 | Heptyl formate                                                                                             |                                  | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                 | 112-23-2   | 144.212  |                        |          | 178.1                  | 0.8784 <sup>20</sup>       | 1.4140 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                   |
| 5710 | Heptyl pentanoate                                                                                          |                                  | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                | 5451-80-9  | 200.318  | liq                    | -46.4    | 245.2                  | 0.8623 <sup>20</sup>       | 1.4254 <sup>15</sup> | vs ace, eth, EtOH                                   |
| 5711 | 6-Heptyltetrahydro-2 <i>H</i> -pyran-2-one                                                                 | 5-Dodecanolide                   | C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>                | 713-95-1   | 198.302  | liq                    | -12      | 101 <sup>0.03</sup>    |                            |                      |                                                     |
| 5712 | 1-Heptyne                                                                                                  |                                  | C <sub>7</sub> H <sub>12</sub>                                | 628-71-7   | 96.170   | liq                    | -81      | 99.7                   | 0.7328 <sup>20</sup>       | 1.4087 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s bz, chl, peth |
| 5713 | 2-Heptyne                                                                                                  | 1-Methyl-2-butylacetylene        | C <sub>7</sub> H <sub>12</sub>                                | 1119-65-9  | 96.170   |                        |          | 112                    | 0.744 <sup>25</sup>        | 1.4230 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz, chl, peth  |
| 5714 | 3-Heptyne                                                                                                  | 1-Ethyl-2-propylacetylene        | C <sub>7</sub> H <sub>12</sub>                                | 2586-89-2  | 96.170   | liq                    | -130.5   | 107.2                  | 0.7336 <sup>25</sup>       | 1.4189 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz, chl, peth  |
| 5715 | Hesperetin                                                                                                 |                                  | C <sub>16</sub> H <sub>14</sub> O <sub>6</sub>                | 520-33-2   | 302.278  | pl (dil al + 1/2 w)    | 227.5    | sub 205                |                            |                      | vs eth, EtOH                                        |
| 5716 | Hesperidin                                                                                                 |                                  | C <sub>28</sub> H <sub>34</sub> O <sub>15</sub>               | 520-26-3   | 610.561  | wh nd (dil MeOH, HOAc) | 262      |                        |                            |                      | vs py, EtOH, HOAc                                   |
| 5717 | Hexabromobenzene                                                                                           |                                  | C <sub>6</sub> Br <sub>6</sub>                                | 87-82-1    | 551.488  | mcl nd (bz)            | 327      |                        |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s bz, chl         |
| 5718 | 2,2',4,4',5,5'-Hexabromobiphenyl                                                                           |                                  | C <sub>12</sub> H <sub>6</sub> Br <sub>6</sub>                | 59080-40-9 | 627.584  | cry (ctc)              | 160      |                        |                            |                      |                                                     |
| 5719 | 1,2,5,6,9,10-Hexabromocyclododecane                                                                        |                                  | C <sub>12</sub> H <sub>18</sub> Br <sub>6</sub>               | 3194-55-6  | 641.695  | cry                    | 167      |                        |                            |                      |                                                     |
| 5720 | Hexabromoethane                                                                                            |                                  | C <sub>2</sub> Br <sub>6</sub>                                | 594-73-0   | 503.445  | orth pr (bz)           |          | dec 200                | 3.823 <sup>20</sup>        | 1.863                | sl EtOH, eth, CS <sub>2</sub>                       |
| 5721 | Hexabutyldistannoxane                                                                                      | Bis(tributyltin) oxide           | C <sub>24</sub> H <sub>54</sub> OSn <sub>2</sub>              | 56-35-9    | 596.105  | liq                    | -45      | 225 <sup>10</sup>      | 1.17 <sup>20</sup>         | 1.4870               |                                                     |
| 5722 | Hexacene                                                                                                   |                                  | C <sub>26</sub> H <sub>16</sub>                               | 258-31-1   | 328.405  | dk bl-grn cry (sub)    | 380      | sub                    |                            |                      | i H <sub>2</sub> O, EtOH                            |
| 5723 | Hexachloroacetone                                                                                          |                                  | C <sub>2</sub> Cl <sub>6</sub> O                              | 116-16-5   | 264.749  | liq                    | -1.0     | 203                    | 1.7434 <sup>12</sup>       | 1.5112 <sup>20</sup> | sl H <sub>2</sub> O; s ace                          |
| 5724 | Hexachlorobenzene                                                                                          | Perchlorobenzene                 | C <sub>6</sub> Cl <sub>6</sub>                                | 118-74-1   | 284.782  | nd (sub)               | 228.83   | 325                    | 2.044 <sup>23</sup>        | 1.5691 <sup>23</sup> | i H <sub>2</sub> O; sl EtOH; s eth, chl; vs bz      |
| 5725 | 2,2',3,3',4,4'-Hexachlorobiphenyl                                                                          |                                  | C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub>                | 38380-07-3 | 360.878  | cry                    | 151      |                        |                            |                      | i H <sub>2</sub> O                                  |
| 5726 | 2,2',4,4',6,6'-Hexachlorobiphenyl                                                                          |                                  | C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub>                | 33979-03-2 | 360.878  | cry                    | 112.5    |                        |                            |                      | i H <sub>2</sub> O                                  |
| 5727 | 2,2',3,3',6,6'-Hexachlorobiphenyl                                                                          |                                  | C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub>                | 38411-22-2 | 360.878  | cry (hx)               | 114.2    |                        |                            |                      | i H <sub>2</sub> O                                  |
| 5728 | 2,2',4,4',5,5'-Hexachlorobiphenyl                                                                          |                                  | C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub>                | 35065-27-1 | 360.878  | cry                    | 103.5    |                        |                            |                      |                                                     |
| 5729 | Hexachloro-1,3-butadiene                                                                                   |                                  | C <sub>4</sub> Cl <sub>6</sub>                                | 87-68-3    | 260.761  | liq                    | -21      | 215                    | 1.556 <sup>25</sup>        | 1.5542 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                     |
| 5730 | 1,2,3,4,5,6-Hexachlorocyclohexane, (1 $\alpha$ ,2 $\alpha$ ,3 $\beta$ ,4 $\alpha$ ,5 $\alpha$ ,6 $\beta$ ) | Lindane                          | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub>                 | 58-89-9    | 290.830  | nd (al)                | 112.5    | 323.4                  |                            |                      | vs ace, bz                                          |
| 5731 | 1,2,3,4,5,6-Hexachlorocyclohexane, (1 $\alpha$ ,2 $\alpha$ ,3 $\beta$ ,4 $\alpha$ ,5 $\beta$ ,6 $\beta$ )  | $\alpha$ -Hexachlorocyclohexane  | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub>                 | 319-84-6   | 290.830  | cry                    | 158      |                        |                            |                      |                                                     |
| 5732 | 1,2,3,4,5,6-Hexachlorocyclohexane, (1 $\alpha$ ,2 $\beta$ ,3 $\alpha$ ,4 $\beta$ ,5 $\alpha$ ,6 $\beta$ )  | $\beta$ -Hexachlorocyclohexane   | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub>                 | 319-85-7   | 290.830  | cry (bz, al, xyl)      |          | 60 <sup>0.50</sup>     | 1.89 <sup>19</sup>         |                      | i H <sub>2</sub> O; sl EtOH, bz, chl, HOAc          |
| 5733 | 1,2,3,4,5,6-Hexachlorocyclohexane, (1 $\alpha$ ,2 $\alpha$ ,3 $\alpha$ ,4 $\beta$ ,5 $\alpha$ ,6 $\beta$ ) | $\delta$ -Lindane                | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub>                 | 319-86-8   | 290.830  | pl                     | 141.5    | 60 <sup>0.36</sup>     |                            |                      |                                                     |
| 5734 | Hexachloro-1,3-cyclopentadiene                                                                             | Perchlorocyclopentadiene         | C <sub>5</sub> Cl <sub>6</sub>                                | 77-47-4    | 272.772  | ye grn liq             | -9       | 239; 48 <sup>0.3</sup> | 1.7019 <sup>25</sup>       | 1.5658 <sup>20</sup> |                                                     |
| 5735 | 1,2,3,6,7,8-Hexachlorodibenzo- <i>p</i> -dioxin                                                            |                                  | C <sub>12</sub> H <sub>2</sub> Cl <sub>6</sub> O <sub>2</sub> | 57653-85-7 | 390.861  | cry                    | 285      |                        |                            |                      |                                                     |
| 5736 | 1,2,3,7,8,9-Hexachlorodibenzo- <i>p</i> -dioxin                                                            |                                  | C <sub>12</sub> H <sub>2</sub> Cl <sub>6</sub> O <sub>2</sub> | 19408-74-3 | 390.861  | cry                    | 243      |                        |                            |                      |                                                     |
| 5737 | Hexachloroethane                                                                                           | Perchloroethane                  | C <sub>2</sub> Cl <sub>6</sub>                                | 67-72-1    | 236.739  | orth (al-eth)          | 186.8 tp | 184.7 sp               | 2.091 <sup>20</sup>        |                      | i H <sub>2</sub> O; vs EtOH, eth; s bz; sl liq HF   |
| 5738 | Hexachlorophene                                                                                            |                                  | C <sub>13</sub> H <sub>6</sub> Cl <sub>6</sub> O <sub>2</sub> | 70-30-4    | 406.904  | nd (bz)                | 166.5    |                        |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, chl, dil alk  |



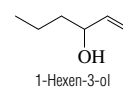
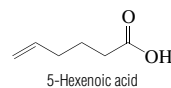
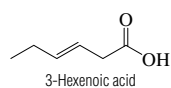
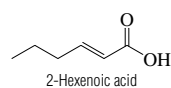
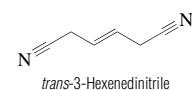
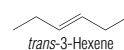
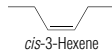
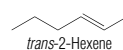
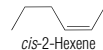
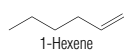
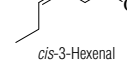
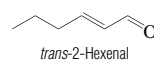
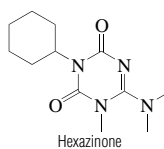
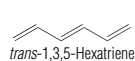
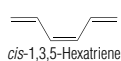
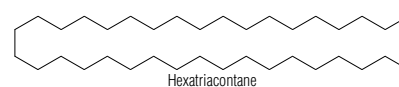
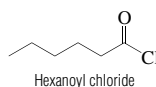
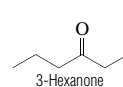
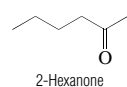
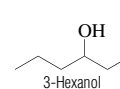
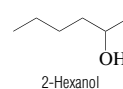
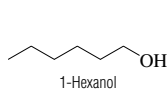
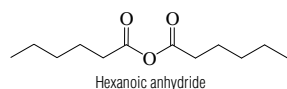
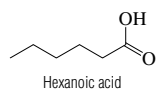
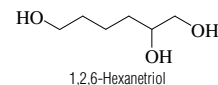
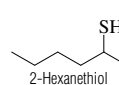
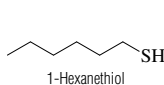
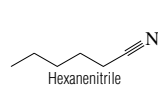
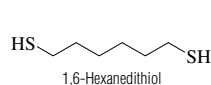
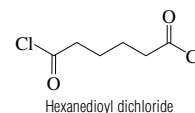
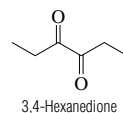
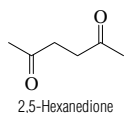
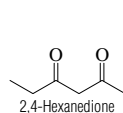
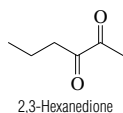
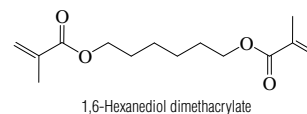
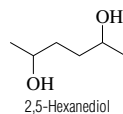
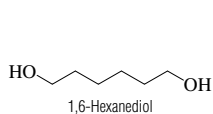
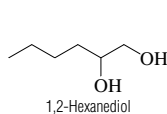
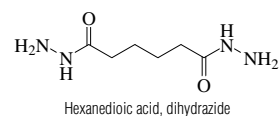
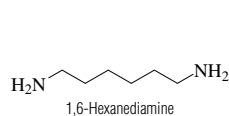
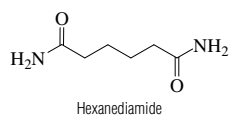
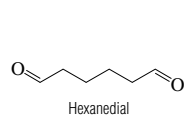
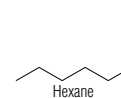
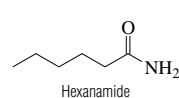
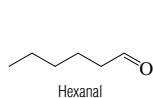
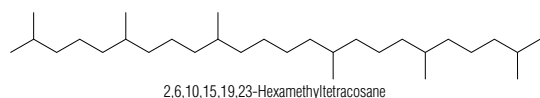
| No.  | Name                                           | Synonym                               | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form                         | mp/°C  | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                  |
|------|------------------------------------------------|---------------------------------------|----------------------------------------------------------------|------------|----------|---------------------------------------|--------|--------------------------------------|----------------------------|-----------------------|-------------------------------------------------------------|
| 5739 | Hexachloropropene                              |                                       | C <sub>3</sub> Cl <sub>6</sub>                                 | 1888-71-7  | 248.750  | liq                                   | -72.9  | 209.5                                | 1.7632 <sup>20</sup>       | 1.5091 <sup>20</sup>  | i H <sub>2</sub> O; s ctc, chl                              |
| 5740 | Hexacontane                                    |                                       | C <sub>60</sub> H <sub>122</sub>                               | 7667-80-3  | 843.611  |                                       | 99.3   |                                      |                            |                       |                                                             |
| 5741 | Hexacosane                                     |                                       | C <sub>26</sub> H <sub>54</sub>                                | 630-01-3   | 366.707  | mcl, tcl or<br>orth (bz)<br>cry (eth) | 56.1   | 412.2                                | 0.7783 <sup>60</sup>       | 1.4357 <sup>60</sup>  | vs bz, lig, chl                                             |
| 5742 | Hexacosanoic acid                              | Cerotic acid                          | C <sub>26</sub> H <sub>52</sub> O <sub>2</sub>                 | 506-46-7   | 396.690  |                                       | 88.5   |                                      | 0.8198 <sup>100</sup>      | 1.4301 <sup>100</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth                         |
| 5743 | 1-Hexacosanol                                  |                                       | C <sub>26</sub> H <sub>54</sub> O                              | 506-52-5   | 382.706  | orth pl (dil<br>al)                   | 80     | 305 <sup>20</sup> dec                |                            |                       | i H <sub>2</sub> O; s EtOH,<br>eth                          |
| 5744 | Hexadecamethylheptasiloxane                    |                                       | C <sub>16</sub> H <sub>48</sub> O <sub>6</sub> Si <sub>7</sub> | 541-01-5   | 533.147  | liq                                   | -78    | 270                                  | 0.9012 <sup>20</sup>       | 1.3965 <sup>20</sup>  | vs bz, lig                                                  |
| 5745 | Hexadecanal                                    |                                       | C <sub>16</sub> H <sub>32</sub> O                              | 629-80-1   | 240.424  | pl (eth), nd<br>(peth)                | 35     | 200 <sup>29</sup>                    |                            |                       | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz                 |
| 5746 | Hexadecanamide                                 |                                       | C <sub>16</sub> H <sub>33</sub> NO                             | 629-54-9   | 255.439  | lf                                    | 107    | 236 <sup>12</sup>                    | 1.0000 <sup>20</sup>       |                       | i H <sub>2</sub> O; sl EtOH,<br>bz, ace, eth                |
| 5747 | Hexadecane                                     | Cetane                                | C <sub>16</sub> H <sub>34</sub>                                | 544-76-3   | 226.441  | lf (HOAc)                             | 18.12  | 286.86                               | 0.7701 <sup>25</sup>       | 1.4329 <sup>25</sup>  | i H <sub>2</sub> O; sl EtOH;<br>msc eth; s ctc              |
| 5748 | Hexadecanedioic acid                           |                                       | C <sub>16</sub> H <sub>30</sub> O <sub>4</sub>                 | 505-54-4   | 286.407  | pl (al)                               | 126.6  |                                      |                            |                       | vs ace, EtOH                                                |
| 5749 | Hexadecanenitrile                              |                                       | C <sub>16</sub> H <sub>31</sub> N                              | 629-79-8   | 237.424  | hex                                   | 31     | 333                                  | 0.8303 <sup>20</sup>       | 1.4450 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH,<br>eth, ace, bz,<br>chl        |
| 5750 | 1-Hexadecanethiol                              | Cetyl mercaptan                       | C <sub>16</sub> H <sub>34</sub> S                              | 2917-26-2  | 258.506  | cry (lig)                             | 19     | 125 <sup>0.5</sup>                   |                            |                       | i H <sub>2</sub> O; sl EtOH,<br>ctc; s eth                  |
| 5751 | Hexadecanoic acid                              | Palmitic acid                         | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                 | 57-10-3    | 256.424  | nd (al)                               | 62.5   | 351.5                                | 0.8527 <sup>62</sup>       | 1.43345 <sup>60</sup> | i H <sub>2</sub> O; s EtOH,<br>ace, bz; msc<br>eth; vs chl  |
| 5752 | Hexadecanoic anhydride                         |                                       | C <sub>32</sub> H <sub>62</sub> O <sub>3</sub>                 | 623-65-4   | 494.832  | lf (peth)                             | 64     |                                      | 0.8388 <sup>63</sup>       | 1.4364 <sup>68</sup>  | vs eth                                                      |
| 5753 | 1-Hexadecanol                                  | Cetyl alcohol                         | C <sub>16</sub> H <sub>34</sub> O                              | 36653-82-4 | 242.440  | fl (AcOEt)                            | 49.2   | 312                                  | 0.8187 <sup>50</sup>       | 1.4283 <sup>79</sup>  | i H <sub>2</sub> O; sl EtOH;<br>vs eth, bz, chl;<br>s ace   |
| 5754 | 3-Hexadecanone                                 |                                       | C <sub>16</sub> H <sub>32</sub> O                              | 18787-64-9 | 240.424  | lf (peth)                             | 43     | 184 <sup>17</sup> , 140 <sup>2</sup> |                            |                       | s chl                                                       |
| 5755 | Hexadecanoyl chloride                          |                                       | C <sub>16</sub> H <sub>31</sub> ClO                            | 112-67-4   | 274.869  |                                       | 12     | 199 <sup>20</sup>                    | 0.9016 <sup>25</sup>       | 1.4514 <sup>20</sup>  | vs eth                                                      |
| 5756 | 1-Hexadecene                                   | 1-Cetene                              | C <sub>16</sub> H <sub>32</sub>                                | 629-73-2   | 224.425  | lf                                    | 2.1    | 284.9                                | 0.7811 <sup>20</sup>       | 1.4412 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, ctc, peth               |
| 5757 | <i>cis</i> -9-Hexadecenoic acid                | Palmitoleic acid                      | C <sub>16</sub> H <sub>30</sub> O <sub>2</sub>                 | 373-49-9   | 254.408  |                                       | 0.5    | 182 <sup>1</sup>                     |                            |                       |                                                             |
| 5758 | Hexadecyl acetate                              |                                       | C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>                 | 629-70-9   | 284.478  |                                       | -18.5  | 222 <sup>205</sup>                   | 0.8574 <sup>25</sup>       | 1.4438 <sup>20</sup>  | i H <sub>2</sub> O; sl EtOH;<br>s ctc                       |
| 5759 | Hexadecylamine                                 | 1-Hexadecanamine                      | C <sub>16</sub> H <sub>35</sub> N                              | 143-27-1   | 241.456  | lf                                    | 46.8   | 322.5                                | 0.8129 <sup>20</sup>       | 1.4496 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH,<br>eth, bz; s ace              |
| 5760 | Hexadecylbenzene                               |                                       | C <sub>22</sub> H <sub>38</sub>                                | 1459-09-2  | 302.537  |                                       | 27     | 385                                  | 0.8547 <sup>20</sup>       | 1.4813 <sup>20</sup>  | i H <sub>2</sub> O; sl EtOH;<br>vs eth, bz, CS <sub>2</sub> |
| 5761 | Hexadecyldimethylamine                         | <i>N,N</i> -Dimethyl-1-hexadecanamine | C <sub>18</sub> H <sub>39</sub> N                              | 112-69-6   | 269.510  |                                       |        | 330.0                                |                            |                       |                                                             |
| 5762 | Hexadecyl hexadecanoate                        | Cetyl palmitate                       | C <sub>32</sub> H <sub>64</sub> O <sub>2</sub>                 | 540-10-3   | 480.849  | mcl lf                                | 54     |                                      | 0.989 <sup>20</sup>        | 1.4398 <sup>70</sup>  | vs eth, EtOH                                                |
| 5763 | Hexadecyl 3-hydroxy-2-naphthalenecarboxylate   | Hexadecyl 3-hydroxy-2-naphthoate      | C <sub>27</sub> H <sub>46</sub> O <sub>3</sub>                 | 531-84-0   | 412.605  | grn-wh fl                             | 72.5   |                                      |                            |                       | vs bz, HOAc                                                 |
| 5764 | Hexadecyl 2-hydroxypropanoate                  | Cetyl lactate                         | C <sub>19</sub> H <sub>38</sub> O <sub>3</sub>                 | 35274-05-6 | 314.503  | wax                                   | 41     | 219 <sup>10</sup> , 170 <sup>1</sup> |                            | 1.4410 <sup>40</sup>  |                                                             |
| 5765 | Hexadecyl 2-methyl-2-propenoate                |                                       | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub>                 | 2495-27-4  | 310.515  |                                       | 24     | 183 <sup>2</sup>                     | 0.87 <sup>20</sup>         |                       |                                                             |
| 5766 | 3-(Hexadecyloxy)-1,2-propanediol, ( <i>S</i> ) | Chimyl alcohol                        | C <sub>19</sub> H <sub>40</sub> O <sub>3</sub>                 | 506-03-6   | 316.519  | lf (hx)                               | 64     | 120 <sup>0.005</sup>                 |                            |                       | vs ace, peth, chl                                           |
| 5767 | 1-Hexadecylpyridinium bromide                  |                                       | C <sub>21</sub> H <sub>38</sub> BrN                            | 140-72-7   | 384.438  |                                       | 61     |                                      |                            |                       |                                                             |
| 5768 | 1-Hexadecylpyridinium chloride                 | Cetylpyridinium chloride              | C <sub>21</sub> H <sub>38</sub> ClN                            | 123-03-5   | 339.987  | wh pow                                | 80     |                                      |                            |                       | vs H <sub>2</sub> O, chl                                    |
| 5769 | Hexadecyl stearate                             | Cetyl stearate                        | C <sub>34</sub> H <sub>68</sub> O <sub>2</sub>                 | 1190-63-2  | 508.903  | lf or pl (eth,<br>HOAc)               | 57     |                                      |                            | 1.4410 <sup>70</sup>  | vs ace, eth, chl                                            |
| 5770 | Hexadecyltrichlorosilane                       |                                       | C <sub>16</sub> H <sub>33</sub> Cl <sub>3</sub> Si             | 5894-60-0  | 359.878  |                                       |        | 269                                  |                            |                       |                                                             |
| 5771 | Hexadecyl vinyl ether                          | 1-(Ethenyloxy)hexadecane              | C <sub>18</sub> H <sub>36</sub> O                              | 822-28-6   | 268.478  |                                       | 16     | 160 <sup>2</sup>                     | 0.821 <sup>27</sup>        | 1.4444 <sup>25</sup>  |                                                             |
| 5772 | 1-Hexadecyne                                   |                                       | C <sub>16</sub> H <sub>30</sub>                                | 629-74-3   | 222.409  |                                       | 15     | 284                                  | 0.7965 <sup>20</sup>       | 1.4440 <sup>20</sup>  | vs bz                                                       |
| 5773 | <i>trans,trans</i> -2,4-Hexadienal             | Sorbinaldehyde                        | C <sub>6</sub> H <sub>8</sub> O                                | 142-83-6   | 96.127   | liq                                   | -16.5  | 174; 76 <sup>30</sup>                | 0.898 <sup>20</sup>        | 1.5384 <sup>20</sup>  |                                                             |
| 5774 | 1,2-Hexadiene                                  | Propylallene                          | C <sub>6</sub> H <sub>10</sub>                                 | 592-44-9   | 82.143   |                                       |        | 76                                   | 0.7149 <sup>20</sup>       | 1.4282 <sup>20</sup>  | vs eth, chl                                                 |
| 5775 | <i>cis</i> -1,3-Hexadiene                      |                                       | C <sub>6</sub> H <sub>10</sub>                                 | 14596-92-0 | 82.143   |                                       |        | 73.1                                 | 0.7033 <sup>25</sup>       | 1.4379 <sup>20</sup>  |                                                             |
| 5776 | <i>trans</i> -1,3-Hexadiene                    |                                       | C <sub>6</sub> H <sub>10</sub>                                 | 20237-34-7 | 82.143   | liq                                   | -102.4 | 73.2                                 | 0.6995 <sup>25</sup>       | 1.4406 <sup>20</sup>  |                                                             |
| 5777 | <i>cis</i> -1,4-Hexadiene                      |                                       | C <sub>6</sub> H <sub>10</sub>                                 | 7318-67-4  | 82.143   |                                       |        | 66.3                                 | 0.695 <sup>25</sup>        | 1.4049 <sup>20</sup>  | vs eth                                                      |
| 5778 | <i>trans</i> -1,4-Hexadiene                    |                                       | C <sub>6</sub> H <sub>10</sub>                                 | 7319-00-8  | 82.143   | liq                                   | -138.7 | 65.0                                 | 0.695 <sup>25</sup>        | 1.4104 <sup>20</sup>  |                                                             |
| 5779 | 1,5-Hexadiene                                  | Biallyl                               | C <sub>6</sub> H <sub>10</sub>                                 | 592-42-7   | 82.143   | liq                                   | -140.7 | 59.4                                 | 0.6878 <sup>25</sup>       | 1.4042 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl; sl<br>ctc      |
| 5780 | <i>cis,cis</i> -2,4-Hexadiene                  |                                       | C <sub>6</sub> H <sub>10</sub>                                 | 6108-61-8  | 82.143   | liq                                   |        | 85                                   | 0.7298 <sup>25</sup>       | 1.4606 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, chl                     |
| 5781 | <i>trans,cis</i> -2,4-Hexadiene                |                                       | C <sub>6</sub> H <sub>10</sub>                                 | 5194-50-3  | 82.143   | liq                                   | -96.1  | 83.5                                 | 0.7185 <sup>25</sup>       | 1.4560 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, chl                     |
| 5782 | <i>trans,trans</i> -2,4-Hexadiene              |                                       | C <sub>6</sub> H <sub>10</sub>                                 | 5194-51-4  | 82.143   | liq                                   | -44.9  | 82.2                                 | 0.7101 <sup>25</sup>       | 1.4510 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, chl                     |
| 5783 | 2,4-Hexadienoic acid                           | Sorbic acid                           | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                   | 110-44-1   | 112.127  | nd (dil al) nd<br>(w)                 | 134.5  | dec 228; 153 <sup>50</sup>           | 1.204 <sup>19</sup>        |                       | s H <sub>2</sub> O, EtOH,<br>chl; vs eth                    |



| No.  | Name                                                                                     | Synonym                            | Mol. Form.                                                     | CAS RN    | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                              |
|------|------------------------------------------------------------------------------------------|------------------------------------|----------------------------------------------------------------|-----------|----------|---------------------------|---------|-------------------------------------|----------------------------|-----------------------|---------------------------------------------------------|
| 5784 | 2,4-Hexadien-1-ol                                                                        | Sorbic alcohol                     | C <sub>6</sub> H <sub>10</sub> O                               | 111-28-4  | 98.142   | nd                        | 30.5    | 76 <sup>12</sup>                    | 0.8967 <sup>23</sup>       | 1.4981 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                         |
| 5785 | <i>trans,trans</i> -2,4-Hexadienoyl chloride                                             |                                    | C <sub>6</sub> H <sub>7</sub> ClO                              | 2614-88-2 | 130.572  |                           |         | 82 <sup>22</sup>                    | 1.0666 <sup>19</sup>       | 1.5545 <sup>20</sup>  | vs ace                                                  |
| 5786 | 1,5-Hexadien-3-yne                                                                       | Divinylacetylene                   | C <sub>6</sub> H <sub>6</sub>                                  | 821-08-9  | 78.112   | liq                       | -88     | 85                                  | 0.7851 <sup>20</sup>       | 1.5035 <sup>20</sup>  | i H <sub>2</sub> O; s bz                                |
| 5787 | 1,5-Hexadiyne                                                                            | Bipropargyl                        | C <sub>6</sub> H <sub>6</sub>                                  | 628-16-0  | 78.112   | liq                       | -6      | 86                                  | 0.8049 <sup>20</sup>       | 1.4380 <sup>23</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, bz                |
| 5788 | 2,4-Hexadiyne                                                                            | Dimethyldiacetylene                | C <sub>6</sub> H <sub>6</sub>                                  | 2809-69-0 | 78.112   | pr (sub)                  | 67.8    | 129.5                               |                            |                       | vs EtOH, eth                                            |
| 5789 | Hexaethylbenzene                                                                         |                                    | C <sub>18</sub> H <sub>30</sub>                                | 604-88-6  | 246.431  | mcl pr (al or bz)         | 129     | 298                                 | 0.8305 <sup>130</sup>      | 1.4736 <sup>130</sup> | i H <sub>2</sub> O; s EtOH, sulf; vs eth, bz            |
| 5790 | Hexaethyldisiloxane                                                                      |                                    | C <sub>12</sub> H <sub>30</sub> OSi <sub>2</sub>               | 994-49-0  | 246.536  |                           |         | 233; 129 <sup>30</sup>              | 0.8457 <sup>20</sup>       | 1.4340 <sup>20</sup>  |                                                         |
| 5791 | Hexaethyl tetraphosphate                                                                 | Ethyl tetraphosphate               | C <sub>12</sub> H <sub>30</sub> O <sub>13</sub> P <sub>4</sub> | 757-58-4  | 506.253  | hyg                       | -40     | dec 150                             | 1.2917 <sup>27</sup>       | 1.4273 <sup>27</sup>  | vs ace, bz, EtOH                                        |
| 5792 | Hexafluoronium bromide                                                                   |                                    | C <sub>36</sub> H <sub>42</sub> Br <sub>2</sub> N <sub>2</sub> | 317-52-2  | 662.539  | cry (PrOH)                | 188     |                                     |                            |                       |                                                         |
| 5793 | Hexafluoroacetylacetone                                                                  |                                    | C <sub>8</sub> H <sub>2</sub> F <sub>6</sub> O <sub>2</sub>    | 1522-22-1 | 208.059  |                           |         | 54.15                               | 1.485 <sup>20</sup>        | 1.3333 <sup>20</sup>  |                                                         |
| 5794 | Hexafluorobenzene                                                                        | Perfluorobenzene                   | C <sub>6</sub> F <sub>6</sub>                                  | 392-56-3  | 186.054  |                           | 5.03    | 80.32                               | 1.6175 <sup>20</sup>       | 1.3777 <sup>20</sup>  |                                                         |
| 5795 | 1,1,2,3,4,4-Hexafluoro-1,3-butadiene                                                     |                                    | C <sub>4</sub> F <sub>6</sub>                                  | 685-63-2  | 162.033  | col gas                   | -132    | 5.47                                | 1.553 <sup>-20</sup>       | 1.378 <sup>-20</sup>  |                                                         |
| 5796 | 1,1,1,4,4,4-Hexafluoro-2-butyne                                                          |                                    | C <sub>4</sub> F <sub>6</sub>                                  | 692-50-2  | 162.033  | col gas                   | -117.4  | -24.6                               |                            |                       | s EtOH, eth, ace, ctc, HOAc                             |
| 5797 | Hexafluorocyclobutene                                                                    |                                    | C <sub>4</sub> F <sub>6</sub>                                  | 697-11-0  | 162.033  | col gas                   | -60     | 5.5                                 | 1.602 <sup>-20</sup>       | 1.298 <sup>-20</sup>  |                                                         |
| 5798 | Hexafluoroethane                                                                         | Perfluoroethane                    | C <sub>2</sub> F <sub>6</sub>                                  | 76-16-4   | 138.011  | col gas                   | -100.05 | -78.1                               | 1.590 <sup>-78</sup>       |                       | i H <sub>2</sub> O; sl EtOH, eth                        |
| 5799 | 1,1,1,2,3,3-Hexafluoropropane                                                            | Refrigerant 236ea                  | C <sub>3</sub> H <sub>2</sub> F <sub>6</sub>                   | 431-63-0  | 152.038  | col gas                   |         | 6.2                                 | 1.5026 <sup>9</sup>        |                       |                                                         |
| 5800 | 1,1,1,3,3,3-Hexafluoropropane                                                            | Refrigerant 236fa                  | C <sub>3</sub> H <sub>2</sub> F <sub>6</sub>                   | 690-39-1  | 152.038  | col gas                   | -93.6   | -1.0                                | 1.4343 <sup>9</sup>        |                       |                                                         |
| 5801 | 1,1,1,3,3,3-Hexafluoro-2-propanol                                                        |                                    | C <sub>3</sub> H <sub>2</sub> F <sub>6</sub> O                 | 920-66-1  | 168.037  | liq                       | -2.0    | 59                                  | 1.4600 <sup>21</sup>       |                       |                                                         |
| 5802 | Hexahydro-1 <i>H</i> -azepine                                                            | Hexamethylenimine                  | C <sub>6</sub> H <sub>13</sub> N                               | 111-49-9  | 99.174   |                           |         | 138                                 | 0.8643 <sup>22</sup>       | 1.4631 <sup>20</sup>  | s H <sub>2</sub> O; vs EtOH, eth                        |
| 5803 | Hexahydro-1 <i>H</i> -1,4-diazepine                                                      |                                    | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>                  | 505-66-8  | 100.162  | hyg                       | 40.5    | 169                                 |                            |                       |                                                         |
| 5804 | 1,5a,6,9,9a,9b-Hexahydro-4a(4 <i>H</i> )-dibenzofuran-carboxaldehyde                     |                                    | C <sub>13</sub> H <sub>16</sub> O <sub>2</sub>                 | 126-15-8  | 204.265  | liq                       | -80     | 307                                 | 1.10 <sup>20</sup>         | 1.5254 <sup>20</sup>  | i H <sub>2</sub> O                                      |
| 5805 | <i>cis</i> -1,2,3,5,6,8a-Hexahydro-4,7-dimethyl-1-isopropyl-naphthalene, (1 <i>S</i> )   |                                    | C <sub>15</sub> H <sub>24</sub>                                | 483-76-1  | 204.352  |                           |         | 125 <sup>12</sup>                   | 0.9160 <sup>15</sup>       | 1.5089 <sup>15</sup>  |                                                         |
| 5806 | 1,2,4a,5,8,8a-Hexahydro-4,7-dimethyl-1-isopropyl-naphthalene, [1 <i>S</i> -(1α,4aβ,8aα)] |                                    | C <sub>15</sub> H <sub>24</sub>                                | 523-47-7  | 204.352  |                           |         | 274; 136 <sup>11</sup>              | 0.9230 <sup>20</sup>       | 1.5059 <sup>20</sup>  | vs eth, lig                                             |
| 5807 | Hexahydro-1,3-isobenzofurandione                                                         | Hexahydrophthalic anhydride        | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                  | 85-42-7   | 154.163  |                           | 32      | 145 <sup>18</sup>                   |                            |                       |                                                         |
| 5808 | Hexahydro-1-methyl-1 <i>H</i> -1,4-diazepine                                             |                                    | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                  | 4318-37-0 | 114.188  |                           |         | 154                                 | 0.9111 <sup>20</sup>       | 1.4769 <sup>20</sup>  |                                                         |
| 5809 | 2,3,4,6,7,8-Hexahydropyrrolo[1,2- <i>a</i> ]pyrimidine                                   |                                    | C <sub>7</sub> H <sub>12</sub> N <sub>2</sub>                  | 3001-72-7 | 124.183  |                           |         | 96 <sup>7</sup> , 81 <sup>2</sup>   | 1.005 <sup>25</sup>        | 1.5190 <sup>20</sup>  |                                                         |
| 5810 | Hexahydro-1,3,5-trinitro-1,3,5-triazine                                                  | Cyclonite                          | C <sub>3</sub> H <sub>6</sub> N <sub>6</sub> O <sub>6</sub>    | 121-82-4  | 222.116  | orth cry (ace)            | 205.5   |                                     | 1.82 <sup>20</sup>         |                       | i H <sub>2</sub> O, EtOH, bz; sl eth, MeOH; s ace, HOAc |
| 5811 | Hexahydro-1,3,5-triphenyl-1,3,5-triazine                                                 |                                    | C <sub>21</sub> H <sub>21</sub> N <sub>3</sub>                 | 91-78-1   | 315.412  |                           | 144     | 185; 60 <sup>29</sup>               |                            |                       | i H <sub>2</sub> O; sl EtOH; s eth, ace, bz, tol        |
| 5812 | 1,2,3,5,6,7-Hexahydroxy-9,10-anthracenedione                                             | Rufigallol                         | C <sub>14</sub> H <sub>6</sub> O <sub>8</sub>                  | 82-12-2   | 304.209  | red rhom, red-ye nd (sub) |         | sub                                 |                            |                       | i H <sub>2</sub> O; sl EtOH, eth; s ace, alk            |
| 5813 | Hexamethylbenzene                                                                        | Mellitene                          | C <sub>12</sub> H <sub>18</sub>                                | 87-85-4   | 162.271  | orth pr or nd (al)        | 165.5   | 263.4                               | 1.0630 <sup>25</sup>       |                       | i H <sub>2</sub> O; s EtOH, eth, ace, bz, HOAc, chl     |
| 5814 | 2,2,4,4,6,6-Hexamethylcyclotrisilazane                                                   |                                    | C <sub>6</sub> H <sub>21</sub> N <sub>3</sub> Si <sub>3</sub>  | 1009-93-4 | 219.508  | liq                       | -10     | 188                                 | 0.9196 <sup>20</sup>       | 1.448 <sup>20</sup>   |                                                         |
| 5815 | Hexamethylcyclotrisiloxane                                                               | Dimethylsiloxane cyclic trimer     | C <sub>6</sub> H <sub>18</sub> O <sub>3</sub> Si <sub>3</sub>  | 541-05-9  | 222.462  |                           | 64.5    | 134                                 | 1.1200 <sup>20</sup>       |                       | i H <sub>2</sub> O                                      |
| 5816 | Hexamethyldisilane                                                                       |                                    | C <sub>6</sub> H <sub>18</sub> Si <sub>2</sub>                 | 1450-14-2 | 146.378  |                           | 13.5    | 113.5                               | 0.7247 <sup>22</sup>       | 1.4229 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ace, bz; dec alk             |
| 5817 | Hexamethyldisilathiane                                                                   |                                    | C <sub>6</sub> H <sub>18</sub> SSi <sub>2</sub>                | 3385-94-2 | 178.443  |                           |         | 162.5                               | 0.851 <sup>20</sup>        |                       |                                                         |
| 5818 | Hexamethyldisilazane                                                                     |                                    | C <sub>6</sub> H <sub>19</sub> NSi <sub>2</sub>                | 999-97-3  | 161.393  |                           |         | 125                                 | 0.7741 <sup>25</sup>       | 1.4090 <sup>20</sup>  |                                                         |
| 5819 | Hexamethyldisiloxane                                                                     |                                    | C <sub>6</sub> H <sub>18</sub> OSi <sub>2</sub>                | 107-46-0  | 162.377  | liq                       | -66     | 99                                  | 0.7638 <sup>20</sup>       | 1.3774 <sup>20</sup>  | i H <sub>2</sub> O                                      |
| 5820 | Hexamethylenediamine carbamate (6-Aminoethyl)carbamic acid                               |                                    | C <sub>7</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>   | 143-06-6  | 160.214  | cry                       | 150     |                                     |                            |                       |                                                         |
| 5821 | Hexamethylene diisocyanate                                                               |                                    | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>   | 822-06-0  | 168.193  |                           |         | 122 <sup>10</sup> , 94 <sup>1</sup> | 1.0528 <sup>20</sup>       | 1.4585 <sup>20</sup>  |                                                         |
| 5822 | Hexamethylenetetramine                                                                   | Methenamine                        | C <sub>6</sub> H <sub>12</sub> N <sub>4</sub>                  | 100-97-0  | 140.186  | orth (al)                 | >250    | sub                                 | 1.331 <sup>-5</sup>        |                       | vs H <sub>2</sub> O; s EtOH, ace, chl; sl eth, bz       |
| 5823 | Hexamethylolmelamine                                                                     |                                    | C <sub>9</sub> H <sub>18</sub> N <sub>6</sub> O <sub>6</sub>   | 531-18-0  | 306.275  |                           | 137     |                                     |                            |                       | vs H <sub>2</sub> O                                     |
| 5824 | Hexamethylphosphoric triamide                                                            | Tris(dimethylamino)phosphine oxide | C <sub>6</sub> H <sub>18</sub> N <sub>3</sub> OP               | 680-31-9  | 179.200  |                           |         | 232.5                               | 1.03 <sup>20</sup>         | 1.4579 <sup>20</sup>  | s EtOH, eth                                             |
| 5825 | Hexamethylphosphorous triamide                                                           | Tris(dimethylamino)phosphine       | C <sub>6</sub> H <sub>18</sub> N <sub>3</sub> P                | 1608-26-0 | 163.201  |                           |         |                                     |                            |                       | s chl                                                   |

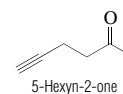
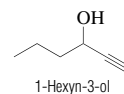
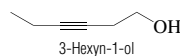
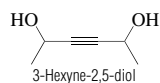
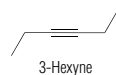
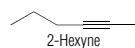
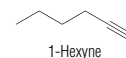
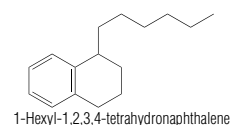
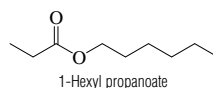
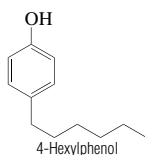
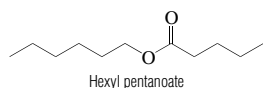
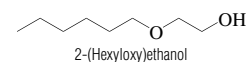
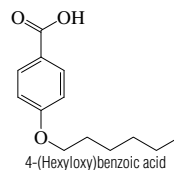
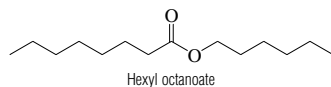
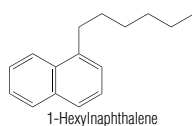
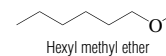
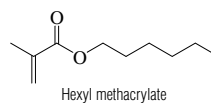
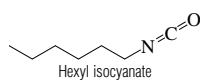
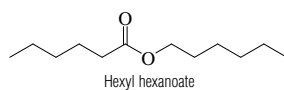
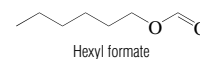
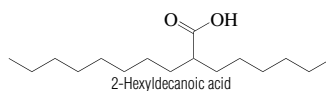
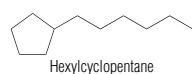
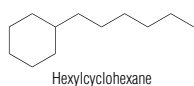
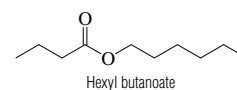
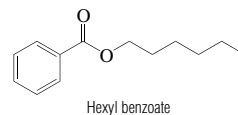
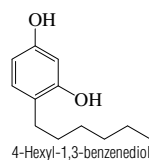
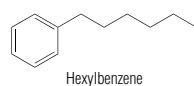
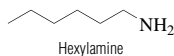
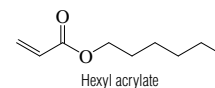
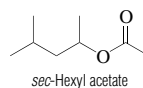
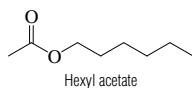
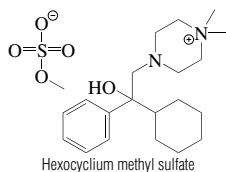
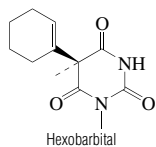
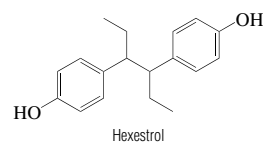
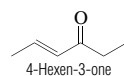
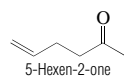
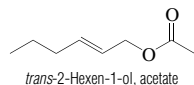
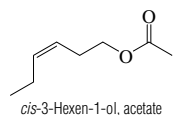
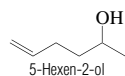
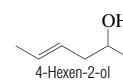
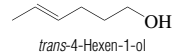
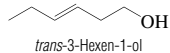
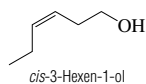
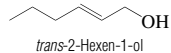
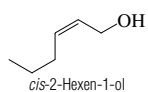


| No.  | Name                                  | Synonym                            | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                           |
|------|---------------------------------------|------------------------------------|---------------------------------------------------------------|------------|----------|---------------|---------|-------------------------------------|----------------------------|-----------------------|------------------------------------------------------|
| 5826 | 2,6,10,15,19,23-Hexamethyltetracosane | Squalane                           | C <sub>30</sub> H <sub>62</sub>                               | 111-01-3   | 422.813  | liq           | -38     | 350                                 | 0.8115 <sup>15</sup>       | 1.4530 <sup>15</sup>  | i H <sub>2</sub> O; sl EtOH, ace; s eth, chl; msc bz |
| 5827 | Hexanal                               | Caproaldehyde                      | C <sub>6</sub> H <sub>12</sub> O                              | 66-25-1    | 100.158  | liq           | -56     | 131                                 | 0.8335 <sup>20</sup>       | 1.4039 <sup>20</sup>  | sl H <sub>2</sub> O; vs EtOH, eth; s ace, bz         |
| 5828 | Hexanamide                            |                                    | C <sub>6</sub> H <sub>13</sub> NO                             | 628-02-4   | 115.173  | cry (ace)     | 101     | 255                                 | 0.999 <sup>20</sup>        | 1.4200 <sup>110</sup> | vs bz, eth, EtOH, chl                                |
| 5829 | Hexane                                |                                    | C <sub>6</sub> H <sub>14</sub>                                | 110-54-3   | 86.175   | liq           | -95.35  | 68.73                               | 0.6606 <sup>25</sup>       | 1.3727 <sup>25</sup>  | i H <sub>2</sub> O; vs EtOH; s eth, chl              |
| 5830 | Hexanedial                            |                                    | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 1072-21-5  | 114.142  |               | -8      | 93 <sup>a</sup>                     | 1.003 <sup>19</sup>        | 1.4350 <sup>20</sup>  | vs bz, eth, EtOH                                     |
| 5831 | Hexanediamide                         |                                    | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>  | 628-94-4   | 144.171  | pl            | 220     |                                     |                            |                       | vs EtOH                                              |
| 5832 | 1,6-Hexanediamine                     | Hexamethylenediamine               | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                 | 124-09-4   | 116.204  | orth bipym pl | 39.13   | 204.6                               |                            |                       | vs H <sub>2</sub> O; s EtOH, bz                      |
| 5833 | Hexanedioic acid, dihydrazide         |                                    | C <sub>6</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub>  | 1071-93-8  | 174.201  |               | 181.8   |                                     |                            |                       |                                                      |
| 5834 | 1,2-Hexanediol                        |                                    | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | 6920-22-5  | 118.174  |               | 45      | 224; 87 <sup>15</sup>               |                            | 1.4431 <sup>20</sup>  |                                                      |
| 5835 | 1,6-Hexanediol                        | Hexamethylene glycol               | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | 629-11-8   | 118.174  |               | 41.5    | 208                                 |                            | 1.4579 <sup>25</sup>  | s H <sub>2</sub> O, EtOH, ace; sl eth; i bz          |
| 5836 | 2,5-Hexanediol                        | Diisopropanol                      | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | 2935-44-6  | 118.174  | cry (eth)     | 43      | 218; 86 <sup>1</sup>                | 0.9610 <sup>20</sup>       | 1.4475 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, eth; sl ctc                |
| 5837 | 1,6-Hexanediol dimethacrylate         | Hexamethylene methacrylate         | C <sub>14</sub> H <sub>22</sub> O <sub>4</sub>                | 6606-59-3  | 254.323  |               |         |                                     | 0.998 <sup>25</sup>        |                       |                                                      |
| 5838 | 2,3-Hexanedione                       | Acetylbutyryl                      | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 3848-24-6  | 114.142  |               |         | 128                                 | 0.934 <sup>19</sup>        |                       |                                                      |
| 5839 | 2,4-Hexanedione                       | Propionylacetone                   | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 3002-24-2  | 114.142  | oil           |         | 160                                 | 0.959 <sup>20</sup>        | 1.4516 <sup>20</sup>  |                                                      |
| 5840 | 2,5-Hexanedione                       | Acetylacetone                      | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 110-13-4   | 114.142  | liq           | -5.5    | 194                                 | 0.7370 <sup>20</sup>       | 1.4232 <sup>20</sup>  | vs H <sub>2</sub> O, bz, eth, EtOH                   |
| 5841 | 3,4-Hexanedione                       | Bipropionyl                        | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 4437-51-8  | 114.142  | liq           | -10     | 130                                 | 0.941 <sup>21</sup>        | 1.4130 <sup>21</sup>  |                                                      |
| 5842 | Hexanedioyl dichloride                |                                    | C <sub>6</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>2</sub>  | 111-50-2   | 183.033  |               |         | 126 <sup>12</sup>                   |                            |                       | sl chl                                               |
| 5843 | 1,6-Hexanedithiol                     |                                    | C <sub>6</sub> H <sub>14</sub> S <sub>2</sub>                 | 1191-43-1  | 150.305  | liq           | -21     | 237; 118 <sup>15</sup>              | 0.9886 <sup>25</sup>       | 1.5110 <sup>20</sup>  |                                                      |
| 5844 | Hexanenitrile                         | Capronitrile                       | C <sub>6</sub> H <sub>11</sub> N                              | 628-73-9   | 97.158   | liq           | -80.3   | 163.65                              | 0.8051 <sup>20</sup>       | 1.4068 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl chl              |
| 5845 | 1-Hexanethiol                         | Hexyl mercaptan                    | C <sub>6</sub> H <sub>14</sub> S                              | 111-31-9   | 118.240  | liq           | -81     | 152.7                               | 0.8424 <sup>20</sup>       | 1.4496 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth                     |
| 5846 | 2-Hexanethiol                         |                                    | C <sub>6</sub> H <sub>14</sub> S                              | 1679-06-7  | 118.240  | liq           | -147    | 142                                 | 0.8345 <sup>20</sup>       | 1.4451 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz                  |
| 5847 | 1,2,6-Hexanetriol                     | 1,2,6-Trihydroxyhexane             | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                 | 106-69-4   | 134.173  |               |         | 170 <sup>3</sup> , 161 <sup>1</sup> | 1.1049 <sup>20</sup>       | 1.58 <sup>20</sup>    |                                                      |
| 5848 | Hexanoic acid                         | Caproic acid                       | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 142-62-1   | 116.158  | liq           | -3      | 205.2                               | 0.9212 <sup>25</sup>       | 1.4163 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth, chl                |
| 5849 | Hexanoic anhydride                    |                                    | C <sub>12</sub> H <sub>22</sub> O <sub>3</sub>                | 2051-49-2  | 214.301  |               | -41     | dec 255                             | 0.9240 <sup>15</sup>       | 1.4297 <sup>20</sup>  | vs eth, EtOH                                         |
| 5850 | 1-Hexanol                             | Caproyl alcohol                    | C <sub>6</sub> H <sub>14</sub> O                              | 111-27-3   | 102.174  | liq           | -47.4   | 157.6                               | 0.8136 <sup>20</sup>       | 1.4178 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, ace, chl; msc eth, bz   |
| 5851 | 2-Hexanol                             |                                    | C <sub>6</sub> H <sub>14</sub> O                              | 20281-86-1 | 102.174  |               |         | 140                                 | 0.8159 <sup>20</sup>       | 1.4144 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; s EtOH, eth                |
| 5852 | 3-Hexanol                             |                                    | C <sub>6</sub> H <sub>14</sub> O                              | 17015-11-1 | 102.174  |               |         | 135                                 | 0.8182 <sup>20</sup>       | 1.4167 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, ace; msc eth            |
| 5853 | 2-Hexanone                            | Butyl methyl ketone                | C <sub>6</sub> H <sub>12</sub> O                              | 591-78-6   | 100.158  | liq           | -55.5   | 127.6                               | 0.8113 <sup>20</sup>       | 1.4007 <sup>20</sup>  | sl H <sub>2</sub> O; s ace; msc EtOH, eth            |
| 5854 | 3-Hexanone                            | Ethyl propyl ketone                | C <sub>6</sub> H <sub>12</sub> O                              | 589-38-8   | 100.158  | liq           | -55.4   | 123.5                               | 0.8118 <sup>20</sup>       | 1.4004 <sup>20</sup>  | sl H <sub>2</sub> O; s ace; msc EtOH, eth            |
| 5855 | Hexanoyl chloride                     | Caproyl chloride                   | C <sub>6</sub> H <sub>11</sub> ClO                            | 142-61-0   | 134.603  | liq           | -87     | 153                                 | 0.9784 <sup>20</sup>       | 1.4264 <sup>20</sup>  | s eth, ace                                           |
| 5856 | Hexatriacontane                       |                                    | C <sub>36</sub> H <sub>74</sub>                               | 630-06-8   | 506.973  |               | 75.8    | 298.4 <sup>3</sup>                  | 0.7803 <sup>80</sup>       | 1.4397 <sup>80</sup>  |                                                      |
| 5857 | <i>cis</i> -1,3,5-Hexatriene          |                                    | C <sub>6</sub> H <sub>8</sub>                                 | 2612-46-6  | 80.128   | liq           | -12     | 78                                  | 0.7175 <sup>20</sup>       | 1.4577 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, ace, chl, peth           |
| 5858 | <i>trans</i> -1,3,5-Hexatriene        |                                    | C <sub>6</sub> H <sub>8</sub>                                 | 821-07-8   | 80.128   | liq           | -12     | 78.5                                | 0.7369 <sup>15</sup>       | 1.5135 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, ace, chl, peth           |
| 5859 | Hexazinone                            |                                    | C <sub>12</sub> H <sub>20</sub> N <sub>4</sub> O <sub>2</sub> | 51235-04-2 | 252.313  |               | 99      | dec                                 | 1.25                       |                       |                                                      |
| 5860 | <i>trans</i> -2-Hexenal               |                                    | C <sub>6</sub> H <sub>10</sub> O                              | 6728-26-3  | 98.142   |               |         | 146.5; 50 <sup>20</sup>             | 0.8491 <sup>20</sup>       | 1.4480 <sup>20</sup>  |                                                      |
| 5861 | <i>cis</i> -3-Hexenal                 |                                    | C <sub>6</sub> H <sub>10</sub> O                              | 6789-80-6  | 98.142   |               |         | 121                                 | 0.8533 <sup>22</sup>       | 1.4300 <sup>21</sup>  |                                                      |
| 5862 | 1-Hexene                              |                                    | C <sub>6</sub> H <sub>12</sub>                                | 592-41-6   | 84.159   | liq           | -139.76 | 63.48                               | 0.6685 <sup>25</sup>       | 1.3852 <sup>25</sup>  | i H <sub>2</sub> O; vs bz, eth, EtOH, peth           |
| 5863 | <i>cis</i> -2-Hexene                  |                                    | C <sub>6</sub> H <sub>12</sub>                                | 7688-21-3  | 84.159   | liq           | -141.11 | 68.8                                | 0.6824 <sup>25</sup>       | 1.3979 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl, lig        |
| 5864 | <i>trans</i> -2-Hexene                |                                    | C <sub>6</sub> H <sub>12</sub>                                | 4050-45-7  | 84.159   | liq           | -133    | 67.9                                | 0.6733 <sup>25</sup>       | 1.3936 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl, lig        |
| 5865 | <i>cis</i> -3-Hexene                  |                                    | C <sub>6</sub> H <sub>12</sub>                                | 7642-09-3  | 84.159   | liq           | -137.8  | 66.4                                | 0.6778 <sup>20</sup>       | 1.3947 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl, lig        |
| 5866 | <i>trans</i> -3-Hexene                |                                    | C <sub>6</sub> H <sub>12</sub>                                | 13269-52-8 | 84.159   | liq           | -115.4  | 67.1                                | 0.6772 <sup>20</sup>       | 1.3943 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl, lig        |
| 5867 | <i>trans</i> -3-Hexenedinitrile       | <i>trans</i> -1,4-Dicyano-2-butene | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                  | 1119-85-3  | 106.125  | cry           | 76      |                                     |                            |                       |                                                      |
| 5868 | 2-Hexenoic acid                       |                                    | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 1191-04-4  | 114.142  | nd (w, al)    | 36.5    | 216.5                               | 0.965 <sup>20</sup>        | 1.4460 <sup>40</sup>  | vs eth                                               |
| 5869 | 3-Hexenoic acid                       | Hydrosorbic acid                   | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 4219-24-3  | 114.142  |               | 12      | 208                                 | 0.9640 <sup>23</sup>       | 1.4935 <sup>20</sup>  |                                                      |
| 5870 | 5-Hexenoic acid                       |                                    | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 1577-22-6  | 114.142  | liq           | -37     | 203                                 | 0.9610 <sup>20</sup>       | 1.4343 <sup>20</sup>  | vs eth, EtOH                                         |
| 5871 | 1-Hexen-3-ol                          |                                    | C <sub>6</sub> H <sub>12</sub> O                              | 4798-44-1  | 100.158  |               |         | 134                                 | 0.834 <sup>22</sup>        | 1.4297 <sup>18</sup>  | sl H <sub>2</sub> O; vs ace, eth, EtOH               |

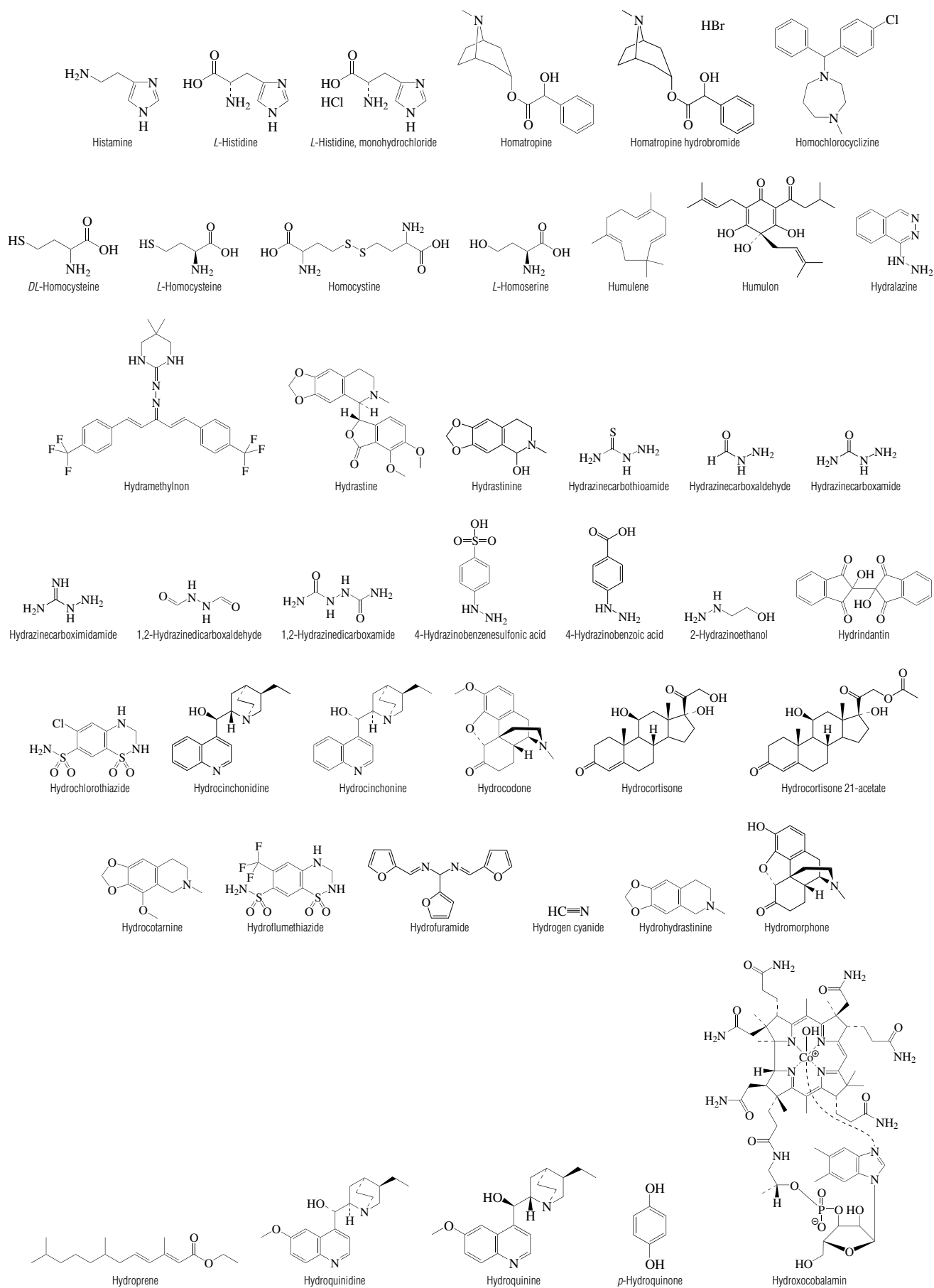




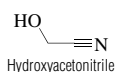
| No.  | Name                                  | Synonym                         | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form | mp/°C  | bp/°C                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|---------------------------------------|---------------------------------|-----------------------------------------------------------------|------------|----------|---------------|--------|-----------------------|----------------------------|----------------------|----------------------------------------------------------|
| 5872 | <i>cis</i> -2-Hexen-1-ol              |                                 | C <sub>6</sub> H <sub>12</sub> O                                | 928-94-9   | 100.158  |               |        | 157                   | 0.8472 <sup>20</sup>       | 1.4397 <sup>20</sup> | s H <sub>2</sub> O; vs EtOH;<br>s eth, ace; sl<br>ctc    |
| 5873 | <i>trans</i> -2-Hexen-1-ol            |                                 | C <sub>6</sub> H <sub>12</sub> O                                | 928-95-0   | 100.158  |               |        | 157                   | 0.8490 <sup>16</sup>       | 1.4340 <sup>20</sup> |                                                          |
| 5874 | <i>cis</i> -3-Hexen-1-ol              |                                 | C <sub>6</sub> H <sub>12</sub> O                                | 928-96-1   | 100.158  |               |        | 156.5                 | 0.8478 <sup>22</sup>       | 1.4380 <sup>20</sup> | s H <sub>2</sub> O; vs EtOH,<br>eth                      |
| 5875 | <i>trans</i> -3-Hexen-1-ol            |                                 | C <sub>6</sub> H <sub>12</sub> O                                | 928-97-2   | 100.158  |               |        | 154.5                 |                            | 1.4374 <sup>20</sup> |                                                          |
| 5876 | <i>trans</i> -4-Hexen-1-ol            |                                 | C <sub>6</sub> H <sub>12</sub> O                                | 928-92-7   | 100.158  |               |        | 159                   | 0.8513 <sup>20</sup>       | 1.4402 <sup>20</sup> |                                                          |
| 5877 | 4-Hexen-2-ol                          |                                 | C <sub>6</sub> H <sub>12</sub> O                                | 52387-50-5 | 100.158  |               |        | 137.5                 | 0.8405 <sup>18</sup>       | 1.4392 <sup>20</sup> | sl H <sub>2</sub> O                                      |
| 5878 | 5-Hexen-2-ol                          |                                 | C <sub>6</sub> H <sub>12</sub> O                                | 626-94-8   | 100.158  |               |        | 139                   | 0.842 <sup>16</sup>        |                      | sl H <sub>2</sub> O                                      |
| 5879 | <i>cis</i> -3-Hexen-1-ol, acetate     |                                 | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                   | 3681-71-8  | 142.196  | liq           |        | 66 <sup>12</sup>      |                            |                      |                                                          |
| 5880 | <i>trans</i> -2-Hexen-1-ol, acetate   |                                 | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                   | 2497-18-9  | 142.196  | liq           |        | 166; 68 <sup>15</sup> | 0.898                      | 1.4270 <sup>20</sup> |                                                          |
| 5881 | 5-Hexen-2-one                         |                                 | C <sub>6</sub> H <sub>10</sub> O                                | 109-49-9   | 98.142   |               |        | 129.5                 | 0.833 <sup>27</sup>        | 1.4178 <sup>27</sup> |                                                          |
| 5882 | 4-Hexen-3-one                         |                                 | C <sub>6</sub> H <sub>10</sub> O                                | 2497-21-4  | 98.142   |               |        | 138.5                 | 0.8559 <sup>20</sup>       | 1.4388 <sup>20</sup> | s EtOH, eth; vs<br>ace                                   |
| 5883 | Hexestrol                             |                                 | C <sub>18</sub> H <sub>22</sub> O <sub>2</sub>                  | 84-16-2    | 270.367  | nd (bz)       | 186.5  |                       |                            |                      | vs ace, eth,<br>EtOH                                     |
| 5884 | Hexobarbital                          |                                 | C <sub>12</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub>   | 56-29-1    | 236.266  |               | 146.5  |                       |                            |                      |                                                          |
| 5885 | Hexocyclium methyl sulfate            |                                 | C <sub>21</sub> H <sub>38</sub> N <sub>2</sub> O <sub>5</sub> S | 115-63-9   | 428.586  | cry           | 205    |                       |                            |                      | sl chl; i eth                                            |
| 5886 | Hexyl acetate                         |                                 | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                   | 142-92-7   | 144.212  | liq           | -80.9  | 171.5                 | 0.8779 <sup>15</sup>       | 1.4092 <sup>20</sup> | i H <sub>2</sub> O; vs eth,<br>EtOH                      |
| 5887 | <i>sec</i> -Hexyl acetate             |                                 | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                   | 108-84-9   | 144.212  |               |        | 147.5                 | 0.8805 <sup>25</sup>       | 1.3980 <sup>20</sup> | sl H <sub>2</sub> O; vs eth,<br>EtOH                     |
| 5888 | Hexyl acrylate                        |                                 | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>                   | 2499-95-8  | 156.222  |               | -45    | 40 <sup>1</sup>       | 0.878 <sup>20</sup>        |                      |                                                          |
| 5889 | Hexylamine                            | 1-Hexanamine                    | C <sub>6</sub> H <sub>13</sub> N                                | 111-26-2   | 101.190  | liq           | -22.9  | 132.8                 | 0.7660 <sup>20</sup>       | 1.4180 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth; s<br>chl          |
| 5890 | Hexylbenzene                          |                                 | C <sub>12</sub> H <sub>18</sub>                                 | 1077-16-3  | 162.271  | liq           | -61    | 226.1                 | 0.8575 <sup>20</sup>       | 1.4864 <sup>20</sup> | i H <sub>2</sub> O; msc eth;<br>s bz, peth               |
| 5891 | 4-Hexyl-1,3-benzenediol               | 4-Hexylresorcinol               | C <sub>12</sub> H <sub>18</sub> O <sub>2</sub>                  | 136-77-6   | 194.270  | nd (bz)       | 68     | 334                   |                            |                      | vs ace, eth,<br>EtOH, chl                                |
| 5892 | Hexyl benzoate                        |                                 | C <sub>13</sub> H <sub>18</sub> O <sub>2</sub>                  | 6789-88-4  | 206.281  |               |        | 272; 139 <sup>8</sup> | 0.9793 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH,<br>ace                       |
| 5893 | Hexyl butanoate                       |                                 | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                  | 2639-63-6  | 172.265  | liq           | -78    | 208                   | 0.8652 <sup>20</sup>       | 1.4160 <sup>15</sup> | i H <sub>2</sub> O; s EtOH; sl<br>chl                    |
| 5894 | Hexylcyclohexane                      |                                 | C <sub>12</sub> H <sub>24</sub>                                 | 4292-75-5  | 168.319  | liq           | -43    | 224                   | 0.8076 <sup>20</sup>       | 1.4462 <sup>20</sup> |                                                          |
| 5895 | Hexylcyclopentane                     |                                 | C <sub>11</sub> H <sub>22</sub>                                 | 4457-00-5  | 154.293  | liq           | -73    | 203                   | 0.7965 <sup>20</sup>       | 1.4392 <sup>20</sup> | vs ace, bz, eth,<br>EtOH                                 |
| 5896 | 2-Hexyldecanoic acid                  |                                 | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                  | 25354-97-6 | 256.424  | visc oil      |        | 145 <sup>0.02</sup>   |                            | 1.4432 <sup>24</sup> |                                                          |
| 5897 | Hexyl formate                         |                                 | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                   | 629-33-4   | 130.185  | liq           | -62.6  | 155.5                 | 0.8813 <sup>20</sup>       | 1.4071 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                     |
| 5898 | Hexyl hexanoate                       | Hexyl caproate                  | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                  | 6378-65-0  | 200.318  | liq           | -55    | 246                   | 0.865 <sup>18</sup>        | 1.4264 <sup>15</sup> | vs ace, bz, eth,<br>EtOH                                 |
| 5899 | Hexyl isocyanate                      |                                 | C <sub>7</sub> H <sub>13</sub> NO                               | 2525-62-4  | 127.184  |               |        | 44 <sup>7</sup>       |                            |                      |                                                          |
| 5900 | Hexyl methacrylate                    |                                 | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>                  | 142-09-6   | 170.249  |               |        | 162; 86 <sup>17</sup> | 0.880 <sup>25</sup>        | 1.429 <sup>25</sup>  | vs ace, bz, eth,<br>EtOH                                 |
| 5901 | Hexyl methyl ether                    |                                 | C <sub>7</sub> H <sub>16</sub> O                                | 4747-07-3  | 116.201  |               |        | 126.1                 |                            |                      |                                                          |
| 5902 | 1-Hexylnaphthalene                    |                                 | C <sub>18</sub> H <sub>20</sub>                                 | 2876-53-1  | 212.330  | liq           | -18    | 322                   | 0.9566 <sup>20</sup>       | 1.5647 <sup>20</sup> |                                                          |
| 5903 | Hexyl octanoate                       |                                 | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                  | 1117-55-1  | 228.371  | liq           | -30.6  | 277.4                 | 0.8603 <sup>20</sup>       | 1.4323 <sup>25</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace                  |
| 5904 | 4-(Hexyloxy)benzoic acid              |                                 | C <sub>13</sub> H <sub>18</sub> O <sub>3</sub>                  | 1142-39-8  | 222.280  | cry           | 106    |                       |                            |                      |                                                          |
| 5905 | 2-(Hexyloxy)ethanol                   | Ethylene glycol monohexyl ether | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                   | 112-25-4   | 146.228  | liq           | -45.1  | 208                   | 0.8878 <sup>20</sup>       | 1.4291 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH,<br>eth                     |
| 5906 | Hexyl pentanoate                      |                                 | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                  | 1117-59-5  | 186.292  | liq           | -63.1  | 226.3                 | 0.8635 <sup>20</sup>       | 1.4228 <sup>15</sup> | vs ace, eth,<br>EtOH                                     |
| 5907 | 4-Hexylphenol                         |                                 | C <sub>12</sub> H <sub>18</sub> O                               | 2446-69-7  | 178.270  |               |        | 148 <sup>9</sup>      |                            |                      |                                                          |
| 5908 | 1-Hexyl propanoate                    |                                 | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                   | 2445-76-3  | 158.238  | liq           | -57.5  | 190                   | 0.8698 <sup>20</sup>       | 1.4162 <sup>15</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace, AcOE            |
| 5909 | 1-Hexyl-1,2,3,4-tetrahydronaphthalene |                                 | C <sub>16</sub> H <sub>24</sub>                                 | 66325-11-9 | 216.362  | liq           |        | 305                   | 0.9176 <sup>25</sup>       | 1.5127 <sup>25</sup> |                                                          |
| 5910 | 1-Hexyne                              | Butylacetylene                  | C <sub>6</sub> H <sub>10</sub>                                  | 693-02-7   | 82.143   | liq           | -131.9 | 71.3                  | 0.7155 <sup>25</sup>       | 1.3989 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl; sl<br>ctc   |
| 5911 | 2-Hexyne                              | 1-Methyl-2-propylacetylene      | C <sub>6</sub> H <sub>10</sub>                                  | 764-35-2   | 82.143   | liq           | -89.6  | 84.5                  | 0.7315 <sup>20</sup>       | 1.4138 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>bz, chl, peth |
| 5912 | 3-Hexyne                              | Diethylacetylene                | C <sub>6</sub> H <sub>10</sub>                                  | 928-49-4   | 82.143   | liq           | -103   | 81                    | 0.7231 <sup>20</sup>       | 1.4115 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl,<br>peth     |
| 5913 | 3-Hexyne-2,5-diol                     |                                 | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                   | 3031-66-1  | 114.142  |               |        | 121 <sup>15</sup>     | 1.0180 <sup>20</sup>       | 1.4691 <sup>20</sup> |                                                          |
| 5914 | 3-Hexyn-1-ol                          | 3-Hexynol                       | C <sub>6</sub> H <sub>10</sub> O                                | 1002-28-4  | 98.142   |               |        | 162; 65 <sup>12</sup> | 0.8982 <sup>20</sup>       | 1.4530 <sup>20</sup> |                                                          |
| 5915 | 1-Hexyn-3-ol                          |                                 | C <sub>6</sub> H <sub>10</sub> O                                | 105-31-7   | 98.142   | liq           | -80    | 142                   | 0.8704 <sup>20</sup>       | 1.4340 <sup>25</sup> | s ctc                                                    |
| 5916 | 5-Hexyn-2-one                         |                                 | C <sub>6</sub> H <sub>8</sub> O                                 | 2550-28-9  | 96.127   |               |        | 149                   | 0.9065 <sup>20</sup>       | 1.4366 <sup>20</sup> |                                                          |



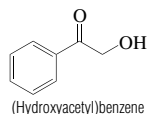
| No.  | Name                            | Synonym                             | Mol. Form.                                                                                | CAS RN     | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                       |
|------|---------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------|------------|----------|------------------------------|---------|--------------------------|----------------------------|----------------------|--------------------------------------------------|
| 5917 | Histamine                       |                                     | C <sub>5</sub> H <sub>9</sub> N <sub>3</sub>                                              | 51-45-6    | 111.145  | wh nd (chl)                  | 83      | 209 <sup>18</sup>        |                            |                      | s H <sub>2</sub> O, EtOH, chl; sl eth            |
| 5918 | L-Histidine                     | Glyoxaline-5-alanine                | C <sub>6</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                               | 71-00-1    | 155.154  | nd or pl (dil al)            | 287 dec |                          |                            |                      | s H <sub>2</sub> O; sl EtOH; l eth, ace, bz, chl |
| 5919 | L-Histidine, monohydrochloride  |                                     | C <sub>6</sub> H <sub>10</sub> ClN <sub>3</sub> O <sub>2</sub>                            | 645-35-2   | 191.615  |                              | 245 dec |                          |                            |                      | s H <sub>2</sub> O                               |
| 5920 | Homatropine                     |                                     | C <sub>16</sub> H <sub>21</sub> NO <sub>3</sub>                                           | 87-00-3    | 275.343  | pr (al, eth)                 | 99.5    |                          |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, eth, ace, chl   |
| 5921 | Homatropine hydrobromide        | Tropanol mandelate                  | C <sub>16</sub> H <sub>22</sub> BrNO <sub>3</sub>                                         | 51-56-9    | 356.255  | orth pym or pl (w)           | 217 dec |                          |                            |                      | vs H <sub>2</sub> O, EtOH                        |
| 5922 | Homochlorocyclizine             |                                     | C <sub>19</sub> H <sub>23</sub> ClN <sub>2</sub>                                          | 848-53-3   | 314.852  | oil                          |         | 177 <sup>0.8</sup>       |                            |                      |                                                  |
| 5923 | DL-Homocysteine                 | DL-2-Amino-4-mercaptobutanoic acid  | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub> S                                           | 454-29-5   | 135.185  |                              | 272 dec |                          |                            |                      | s H <sub>2</sub> O; i eth, bz                    |
| 5924 | L-Homocysteine                  | L-2-Amino-4-mercaptobutanoic acid   | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub> S                                           | 6027-13-0  | 135.185  | platelets                    | 232     |                          |                            |                      |                                                  |
| 5925 | Homocystine                     |                                     | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub>               | 870-93-9   | 268.354  |                              | 264     |                          |                            |                      | sl H <sub>2</sub> O; i eth, bz                   |
| 5926 | L-Homoserine                    | 2-Amino-4-hydroxybutanoic acid, (S) | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                                             | 672-15-1   | 119.119  | pr (90% al)                  | 203 dec |                          |                            |                      | vs H <sub>2</sub> O; sl EtOH; i eth, bz          |
| 5927 | Humulene                        |                                     | C <sub>15</sub> H <sub>24</sub>                                                           | 6753-98-6  | 204.352  |                              |         | 123 <sup>10</sup>        | 0.8905 <sup>20</sup>       | 1.5038 <sup>20</sup> |                                                  |
| 5928 | Humulon                         |                                     | C <sub>21</sub> H <sub>30</sub> O <sub>5</sub>                                            | 26472-41-3 | 362.460  | ye cry (eth)                 | 66.5    |                          |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, alk   |
| 5929 | Hydralazine                     | 1-Hydrazinophthalazine              | C <sub>8</sub> H <sub>8</sub> N <sub>4</sub>                                              | 86-54-4    | 160.177  | ye cry (MeOH)                | 172     |                          |                            |                      | s acid                                           |
| 5930 | Hydramethylnon                  |                                     | C <sub>25</sub> H <sub>24</sub> F <sub>6</sub> N <sub>4</sub>                             | 67485-29-4 | 494.476  |                              | 190     |                          |                            |                      |                                                  |
| 5931 | Hydrastine                      |                                     | C <sub>21</sub> H <sub>21</sub> NO <sub>6</sub>                                           | 118-08-1   | 383.395  | ye pr (al)                   | 132     |                          |                            |                      | i H <sub>2</sub> O; s ace, bz                    |
| 5932 | Hydrastinine                    |                                     | C <sub>11</sub> H <sub>13</sub> NO <sub>3</sub>                                           | 6592-85-4  | 207.226  | nd (lig), cry (eth)          | 116.5   |                          |                            |                      | s H <sub>2</sub> O; vs EtOH, eth, chl            |
| 5933 | Hydrazinecarbothioamide         | Thiosemicarbazide                   | CH <sub>3</sub> N <sub>3</sub> S                                                          | 79-19-6    | 91.136   | lo nd (w)                    | 183     |                          |                            |                      | vs H <sub>2</sub> O, EtOH                        |
| 5934 | Hydrazinecarboxaldehyde         |                                     | CH <sub>4</sub> N <sub>2</sub> O                                                          | 624-84-0   | 60.055   | ye lf or nd (al)             | 54      |                          |                            |                      | vs bz, eth, EtOH, chl                            |
| 5935 | Hydrazinecarboxamide            |                                     | CH <sub>3</sub> N <sub>3</sub> O                                                          | 57-56-7    | 75.070   | pr (al)                      | 96      |                          | 1.484 <sup>8</sup>         |                      | vs H <sub>2</sub> O; s EtOH; i eth, bz, chl      |
| 5936 | Hydrazinecarboximidamide        | Aminoguanidine                      | CH <sub>5</sub> N <sub>4</sub>                                                            | 79-17-4    | 74.086   | cry                          | dec     |                          |                            |                      | vs H <sub>2</sub> O, EtOH                        |
| 5937 | 1,2-Hydrazinedicarboxaldehyde   |                                     | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>                               | 628-36-4   | 88.065   | pr (al)                      | 161.0   |                          |                            |                      | vs H <sub>2</sub> O; sl EtOH, DMSO; i eth        |
| 5938 | 1,2-Hydrazinedicarboxamide      |                                     | C <sub>2</sub> H <sub>6</sub> N <sub>4</sub> O <sub>2</sub>                               | 110-21-4   | 118.095  | pl (w)                       | 258     |                          | 1.604 <sup>17</sup>        |                      |                                                  |
| 5939 | 4-Hydrazinobenzenesulfonic acid | Phenylhydrazine-4-sulfonic acid     | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> S                             | 98-71-5    | 188.204  | nd, lf (w)                   | 286     |                          |                            |                      | sl H <sub>2</sub> O, EtOH                        |
| 5940 | 4-Hydrazinobenzoic acid         |                                     | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                               | 619-67-0   | 152.151  | ye nd or pl (w)              | 221 dec |                          |                            |                      | sl H <sub>2</sub> O; i eth                       |
| 5941 | 2-Hydrazinoethanol              |                                     | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O                                            | 109-84-2   | 76.097   | liq                          | -70     | 219; 120 <sup>17.5</sup> | 1.119 <sup>25</sup>        |                      | vs H <sub>2</sub> O, EtOH, MeOH                  |
| 5942 | Hydrindantin                    |                                     | C <sub>18</sub> H <sub>10</sub> O <sub>6</sub>                                            | 5103-42-4  | 322.268  | pr (ace)                     | 250 dec |                          |                            |                      |                                                  |
| 5943 | Hydrochlorothiazide             |                                     | C <sub>7</sub> H <sub>8</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>2</sub>              | 58-93-5    | 297.740  |                              | 274     |                          |                            |                      |                                                  |
| 5944 | Hydrocinchonidine               |                                     | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub> O                                          | 485-64-3   | 296.406  | lf (al)                      | 229     |                          |                            |                      | vs EtOH                                          |
| 5945 | Hydrocinchonine                 |                                     | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub> O                                          | 485-65-4   | 296.406  | pr                           | 268.5   |                          |                            |                      | s H <sub>2</sub> O; sl EtOH; i eth               |
| 5946 | Hydrocodone                     |                                     | C <sub>18</sub> H <sub>21</sub> NO <sub>3</sub>                                           | 125-29-1   | 299.365  |                              | 198     |                          |                            |                      | i H <sub>2</sub> O; s EtOH                       |
| 5947 | Hydrocortisone                  |                                     | C <sub>21</sub> H <sub>30</sub> O <sub>5</sub>                                            | 50-23-7    | 362.460  | pl (al or i-PrOH)            | 220     |                          |                            |                      | sl H <sub>2</sub> O; s EtOH, diox, HOAc          |
| 5948 | Hydrocortisone 21-acetate       | Cortisol acetate                    | C <sub>23</sub> H <sub>32</sub> O <sub>6</sub>                                            | 50-03-3    | 404.496  |                              | 223 dec |                          | 1.289 <sup>20</sup>        |                      |                                                  |
| 5949 | Hydrocotarnine                  |                                     | C <sub>12</sub> H <sub>15</sub> NO <sub>3</sub>                                           | 550-10-7   | 221.252  |                              | 56      |                          |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl    |
| 5950 | Hydroflumethiazide              |                                     | C <sub>8</sub> H <sub>8</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 135-09-1   | 331.293  |                              | 270.5   |                          |                            |                      |                                                  |
| 5951 | Hydrofuramide                   |                                     | C <sub>15</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>                             | 494-47-3   | 268.267  | nd (al)                      | 117     |                          |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                 |
| 5952 | Hydrogen cyanide                | Hydrocyanic acid                    | HCN                                                                                       | 74-90-8    | 27.026   | vol liq or gas               | -13.29  | 26                       | 0.6876 <sup>20</sup>       | 1.2614 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth                  |
| 5953 | Hydrohydrastinine               |                                     | C <sub>11</sub> H <sub>13</sub> NO <sub>2</sub>                                           | 494-55-3   | 191.227  | nd (lig), cry (peth)         | 66      | 303                      |                            |                      | vs ace, bz, eth, EtOH                            |
| 5954 | Hydromorphone                   | 7,8-Dihydromorphin-6-one            | C <sub>17</sub> H <sub>19</sub> NO <sub>3</sub>                                           | 466-99-9   | 285.338  | cry (EtOH)                   | 266.5   |                          |                            |                      |                                                  |
| 5955 | Hydroprene                      |                                     | C <sub>17</sub> H <sub>30</sub> O <sub>2</sub>                                            | 41096-46-2 | 266.419  |                              |         | 174 <sup>19</sup>        | 0.8955 <sup>20</sup>       |                      |                                                  |
| 5956 | Hydroquinidine                  |                                     | C <sub>20</sub> H <sub>26</sub> N <sub>2</sub> O <sub>2</sub>                             | 1435-55-8  | 326.432  | nd (al)                      | 168.5   |                          |                            |                      | s EtOH, eth, ace, chl                            |
| 5957 | Hydroquinine                    |                                     | C <sub>20</sub> H <sub>28</sub> N <sub>2</sub> O <sub>2</sub>                             | 522-66-7   | 326.432  | nd (eth, chl)                | 172.5   |                          |                            |                      | vs ace, eth, EtOH, chl                           |
| 5958 | p-Hydroquinone                  | 1,4-Benzenediol                     | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                                              | 123-31-9   | 110.111  | mcl pr (sub) nd(w) pr (MeOH) | 172.4   | 285                      | 1.330 <sup>20</sup>        | 1.632 <sup>25</sup>  | s H <sub>2</sub> O, eth; vs EtOH, ace; i bz      |
| 5959 | Hydroxocobalamin                | Vitamin B-12a                       | C <sub>62</sub> H <sub>88</sub> CoN <sub>13</sub> O <sub>15</sub> P                       | 13422-51-0 | 1346.355 | red cry (ace aq)             | 200 dec |                          |                            |                      | s H <sub>2</sub> O, EtOH; i ace, eth, bz         |



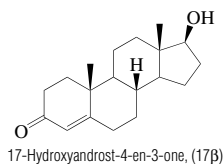
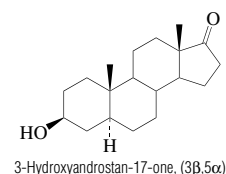
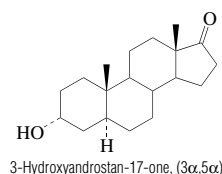
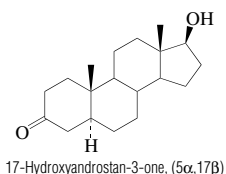
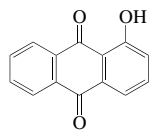
| No.  | Name                                                          | Synonym                       | Mol. Form.                                                    | CAS RN   | Mol. Wt. | Physical Form                    | mp/°C    | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                  |
|------|---------------------------------------------------------------|-------------------------------|---------------------------------------------------------------|----------|----------|----------------------------------|----------|-------------------------------------|----------------------------|-----------------------|-------------------------------------------------------------|
| 5960 | Hydroxyacetonitrile                                           | Glyconitrile                  | C <sub>2</sub> H <sub>3</sub> NO                              | 107-16-4 | 57.051   |                                  | <-72     | dec 183; 119 <sup>24</sup>          |                            | 1.4117 <sup>19</sup>  | vs H <sub>2</sub> O, EtOH, eth; i bz, chl                   |
| 5961 | (Hydroxyacetyl)benzene                                        |                               | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                  | 582-24-1 | 136.149  | hex pl (al), pl (w or dil al)    | 90       | 125 <sup>12</sup> , 56 <sup>1</sup> | 1.0963 <sup>99</sup>       |                       | s H <sub>2</sub> O, EtOH, eth, chl; sl lig                  |
| 5962 | 17-Hydroxyandrost-3-one, (5 $\alpha$ ,17 $\beta$ )            | Stanolone                     | C <sub>19</sub> H <sub>30</sub> O <sub>2</sub>                | 521-18-6 | 290.440  |                                  | 181      | sub 135                             |                            |                       |                                                             |
| 5963 | 3-Hydroxyandrost-17-one, (3 $\alpha$ ,5 $\alpha$ )            | Androsterone                  | C <sub>19</sub> H <sub>30</sub> O <sub>2</sub>                | 53-41-8  | 290.440  | lf or nd (al, ace)               | 185      |                                     |                            |                       | sl H <sub>2</sub> O, chl; s EtOH, eth, ace, bz              |
| 5964 | 3-Hydroxyandrost-17-one, (3 $\beta$ ,5 $\alpha$ )             | Epiandrosterone               | C <sub>19</sub> H <sub>30</sub> O <sub>2</sub>                | 481-29-8 | 290.440  | cry (bz-peth, ace)               | 178      |                                     |                            |                       |                                                             |
| 5965 | 17-Hydroxyandrost-4-en-3-one, (17 $\beta$ )                   | Testosterone                  | C <sub>19</sub> H <sub>28</sub> O <sub>2</sub>                | 58-22-0  | 288.424  | nd (dil ace)                     | 155      |                                     |                            |                       | i H <sub>2</sub> O; s EtOH, eth, ace                        |
| 5966 | 1-Hydroxy-9,10-anthracenedione                                |                               | C <sub>14</sub> H <sub>8</sub> O <sub>3</sub>                 | 129-43-1 | 224.212  | red-oran nd (al)                 | 193.8    | sub                                 |                            |                       | i H <sub>2</sub> O; s EtOH, eth, bz; sl liq NH <sub>3</sub> |
| 5967 | 2-Hydroxy-9,10-anthracenedione                                |                               | C <sub>14</sub> H <sub>8</sub> O <sub>3</sub>                 | 605-32-3 | 224.212  | ye pl or nd (al or HOAc)         | 306      | sub                                 |                            |                       | i H <sub>2</sub> O; s EtOH, eth, aq NH <sub>3</sub> , KOH   |
| 5968 | 3-Hydroxybenzaldehyde                                         | 3-Formylphenol                | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                  | 100-83-4 | 122.122  | nd (w)                           | 108      | 240                                 | 1.1179 <sup>130</sup>      |                       | sl H <sub>2</sub> O; s EtOH, eth, ace, bz; i lig            |
| 5969 | 4-Hydroxybenzaldehyde                                         | 4-Formylphenol                | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                  | 123-08-0 | 122.122  | nd (w)                           | 117      |                                     | 1.129 <sup>130</sup>       | 1.5705 <sup>130</sup> | sl H <sub>2</sub> O, ace; vs EtOH, eth; s bz                |
| 5970 | 2-Hydroxybenzaldehyde, [(2-hydroxyphenyl)methylene] hydrazone |                               | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> | 959-36-4 | 240.257  |                                  | 214      |                                     |                            |                       | i H <sub>2</sub> O; s EtOH, chl; vs bz, alk                 |
| 5971 | 2-Hydroxybenzamide                                            | Salicylamide                  | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                 | 65-45-2  | 137.137  |                                  | 142      | 181.5 <sup>14</sup>                 | 1.175 <sup>140</sup>       |                       | sl H <sub>2</sub> O, eth, DMSO; s EtOH                      |
| 5972 | N-Hydroxybenzamide                                            |                               | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                 | 495-18-1 | 137.137  | orth ta, lf (eth)                | 131 exp  |                                     |                            |                       | s H <sub>2</sub> O, EtOH; sl eth, bz                        |
| 5973 | $\alpha$ -Hydroxybenzeneacetic acid, ( $\pm$ )                | DL-Mandelic acid              | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 611-72-3 | 152.148  | orth pl                          | 119      |                                     | 1.2890 <sup>20</sup>       |                       | s H <sub>2</sub> O, eth, EtOH, i-PrOH                       |
| 5974 | 2-Hydroxybenzeneacetic acid                                   |                               | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 614-75-5 | 152.148  |                                  | 148      | 240                                 |                            |                       | sl H <sub>2</sub> O, chl; s eth                             |
| 5975 | 3-Hydroxybenzeneacetic acid                                   |                               | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 621-37-4 | 152.148  | nd (bz-lig)                      | 132      | 190 <sup>11</sup>                   |                            |                       | vs H <sub>2</sub> O, EtOH, eth; s bz; sl lig                |
| 5976 | 4-Hydroxybenzeneacetic acid                                   |                               | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 156-38-7 | 152.148  | nd (w)                           | 152      | sub                                 |                            |                       | sl H <sub>2</sub> O; vs EtOH, eth                           |
| 5977 | $\alpha$ -Hydroxybenzeneacetonitrile                          | Mandelonitrile                | C <sub>8</sub> H <sub>7</sub> NO                              | 532-28-5 | 133.148  | ye oily liq                      | -10      |                                     | 1.12                       |                       | i H <sub>2</sub> O; vs chl, eth, EtOH                       |
| 5978 | 2-Hydroxybenzenecarbothioic acid                              | Dithiosalicylic acid          | C <sub>7</sub> H <sub>6</sub> OS <sub>2</sub>                 | 527-89-9 | 170.252  | oran-ye nd                       | 49       |                                     |                            |                       | vs bz, eth, EtOH                                            |
| 5979 | 4-Hydroxy-1,3-benzenedicarboxylic acid                        | 4-Hydroxyisophthalic acid     | C <sub>8</sub> H <sub>6</sub> O <sub>5</sub>                  | 636-46-4 | 182.131  | nd(w), lf (dil al)               | 310      |                                     |                            |                       | i H <sub>2</sub> O, chl; vs EtOH, eth; s HOAc               |
| 5980 | 5-Hydroxy-1,3-benzenedicarboxylic acid                        |                               | C <sub>8</sub> H <sub>6</sub> O <sub>5</sub>                  | 618-83-7 | 182.131  | nd(w+2) cr(aq-al)                |          | sub                                 |                            |                       | vs bz, eth, EtOH                                            |
| 5981 | 4-Hydroxy-1,3-benzenedisulfonic acid                          | Phenoldisulfonic acid         | C <sub>6</sub> H <sub>6</sub> O <sub>7</sub> S <sub>2</sub>   | 96-77-5  | 254.238  | nd (w)                           | >100 dec |                                     |                            |                       | vs H <sub>2</sub> O, EtOH                                   |
| 5982 | 4-Hydroxybenzeneethanol                                       |                               | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 501-94-0 | 138.164  |                                  | 91.8     | 310.0                               |                            |                       |                                                             |
| 5983 | 2-Hydroxybenzenemethanol                                      | Salicyl alcohol               | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                  | 90-01-7  | 124.138  | lf (bz), nd or pl (w, eth)       | 87       | sub                                 | 1.1613 <sup>25</sup>       |                       | s H <sub>2</sub> O, EtOH, eth, bz; vs chl                   |
| 5984 | 3-Hydroxybenzenemethanol                                      | 3-Hydroxybenzyl alcohol       | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                  | 620-24-6 | 124.138  | nd (bz), cry (CCl <sub>4</sub> ) | 73       | dec 300                             | 1.161 <sup>25</sup>        |                       | vs H <sub>2</sub> O, EtOH, eth; sl chl                      |
| 5985 | 4-Hydroxybenzenemethanol                                      | 4-Hydroxybenzyl alcohol       | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                  | 623-05-2 | 124.138  | pr or nd (w)                     | 124.5    | 252                                 |                            |                       | vs H <sub>2</sub> O, EtOH, bz, chl; s eth; sl DMSO          |
| 5986 | 4-Hydroxybenzenepropanoic acid                                | p-Hydroxyhydrocinnamic acid   | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 501-97-3 | 166.173  |                                  | 130.8    | 209 <sup>14</sup>                   |                            |                       | s H <sub>2</sub> O, EtOH, eth, bz; i CS <sub>2</sub>        |
| 5987 | $\alpha$ -Hydroxybenzenepropanoic acid, ( $\pm$ )             | ( $\pm$ )-3-Phenyllactic acid | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 828-01-3 | 166.173  | cry (chl, bz), pr (w)            | 98       | 149 <sup>15</sup>                   |                            |                       | vs H <sub>2</sub> O, ace, eth, EtOH                         |
| 5988 | 3-Hydroxybenzenesulfonic acid                                 | m-Phenolsulfonic acid         | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub> S                | 585-38-6 | 174.175  | nd (w+2)                         |          |                                     |                            |                       |                                                             |
| 5989 | 4-Hydroxybenzenesulfonic acid                                 | p-Phenolsulfonic acid         | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub> S                | 98-67-9  | 174.175  | nd                               |          |                                     |                            |                       | vs H <sub>2</sub> O, EtOH                                   |
| 5990 | 2-Hydroxybenzoic acid                                         | Salicylic acid                | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                  | 69-72-7  | 138.121  | nd (w), mcl pr (al)              | 159.0    | 211 <sup>20</sup>                   | 1.443 <sup>20</sup>        | 1.565                 | sl H <sub>2</sub> O, bz, chl, ctc; vs EtOH, eth, ace        |
| 5991 | 3-Hydroxybenzoic acid                                         |                               | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                  | 99-06-9  | 138.121  | nd (w) pl, pr (al)               | 202.5    |                                     | 1.485 <sup>25</sup>        |                       | sl H <sub>2</sub> O; s EtOH, eth, ace; i bz                 |
| 5992 | 4-Hydroxybenzoic acid                                         |                               | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                  | 99-96-7  | 138.121  | pr or pl (w, al) cry (ace)       | 214.5    |                                     | 1.46 <sup>25</sup>         |                       | sl H <sub>2</sub> O, bz; vs EtOH; s eth, ace                |
| 5993 | 2-Hydroxybenzoic acid, hydrazide                              |                               | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 936-02-7 | 152.151  |                                  | 148      |                                     |                            |                       | vs bz, EtOH                                                 |
| 5994 | 2-Hydroxybenzonitrile                                         |                               | C <sub>7</sub> H <sub>5</sub> NO                              | 611-20-1 | 119.121  |                                  | 98       | 149 <sup>14</sup>                   | 1.1052 <sup>100</sup>      | 1.5372 <sup>100</sup> | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl                  |



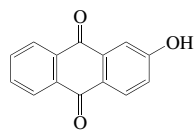
Hydroxyacetonitrile



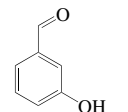
(Hydroxyacetyl)benzene

17-Hydroxyandrost-4-en-3-one, (17 $\beta$ )

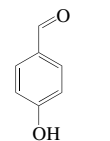
1-Hydroxy-9,10-anthracenedione



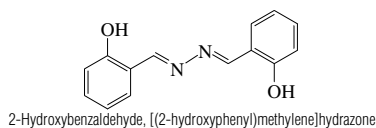
2-Hydroxy-9,10-anthracenedione



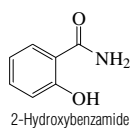
3-Hydroxybenzaldehyde



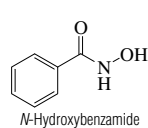
4-Hydroxybenzaldehyde



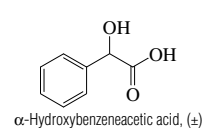
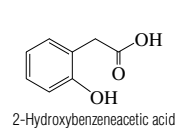
2-Hydroxybenzaldehyde, [(2-hydroxyphenyl)methylene]hydrazone



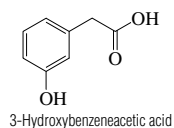
2-Hydroxybenzamide



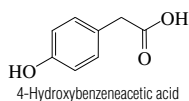
N-Hydroxybenzamide

 $\alpha$ -Hydroxybenzeneacetic acid, ( $\pm$ )

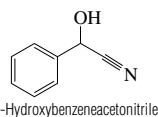
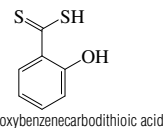
2-Hydroxybenzeneacetic acid



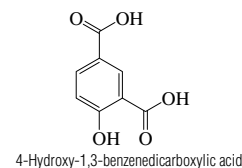
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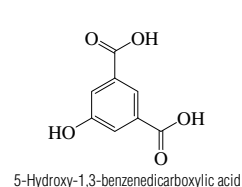
4-Hydroxybenzeneacetic acid

 $\alpha$ -Hydroxybenzeneacetonitrile

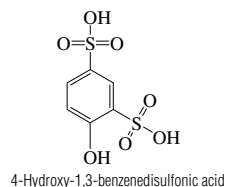
2-Hydroxybenzenecarbothioic acid



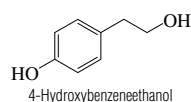
4-Hydroxy-1,3-benzenedicarboxylic acid



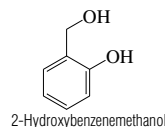
5-Hydroxy-1,3-benzenedicarboxylic acid



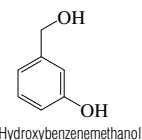
4-Hydroxy-1,3-benzenedisulfonic acid



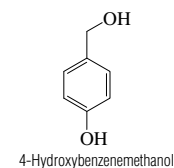
4-Hydroxybenzeneethanol



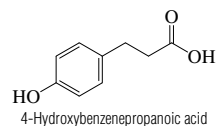
2-Hydroxybenzenemethanol



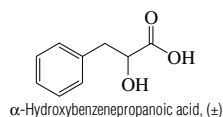
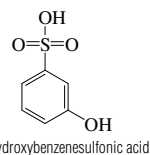
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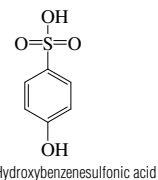
4-Hydroxybenzenemethanol



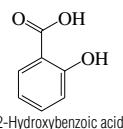
4-Hydroxybenzenepropanoic acid

 $\alpha$ -Hydroxybenzenepropanoic acid, ( $\pm$ )

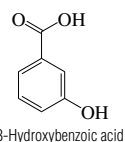
3-Hydroxybenzenesulfonic acid



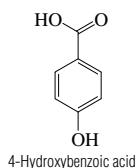
4-Hydroxybenzenesulfonic acid



2-Hydroxybenzoic acid



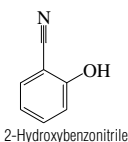
3-Hydroxybenzoic acid



4-Hydroxybenzoic acid

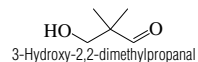
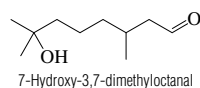
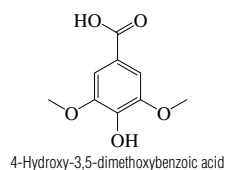
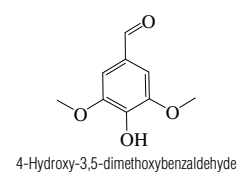
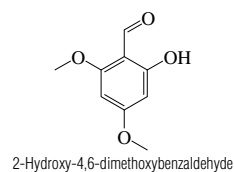
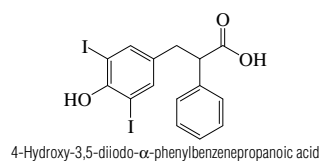
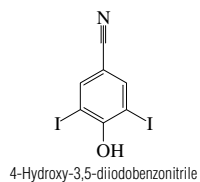
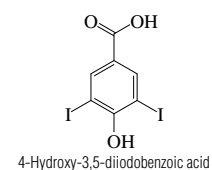
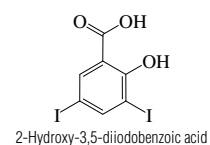
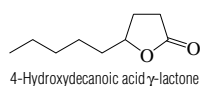
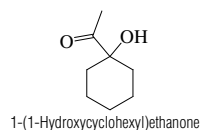
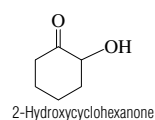
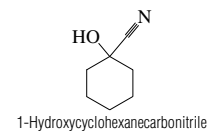
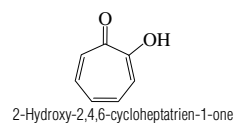
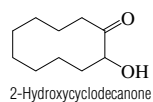
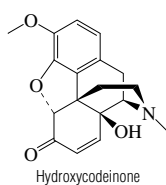
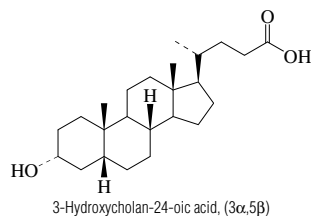
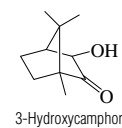
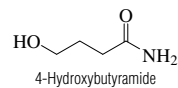
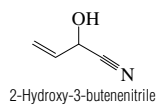
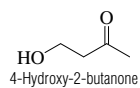
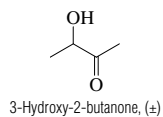
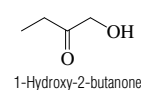
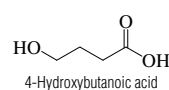
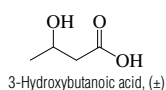
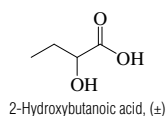
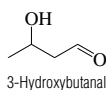
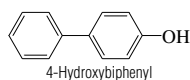
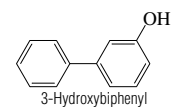
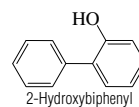
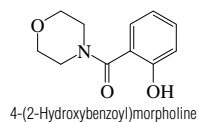
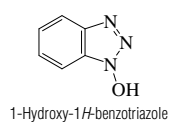
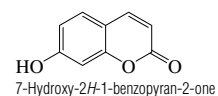
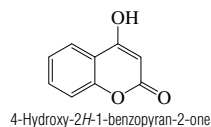
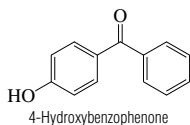
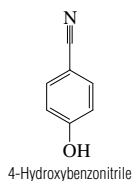
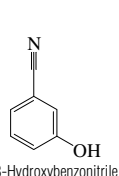


2-Hydroxybenzoic acid, hydrazide



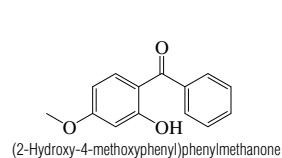
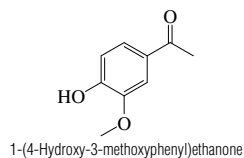
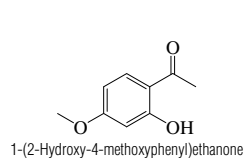
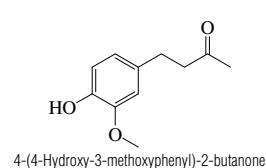
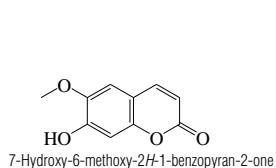
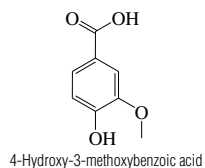
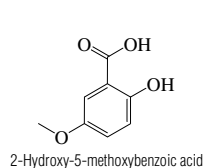
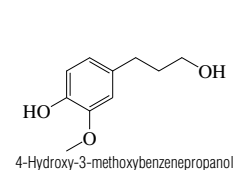
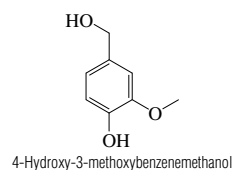
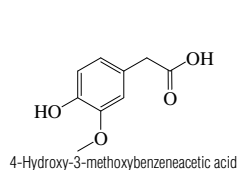
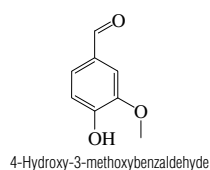
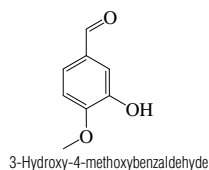
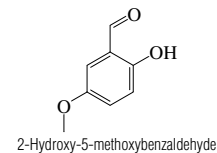
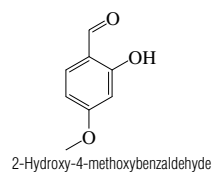
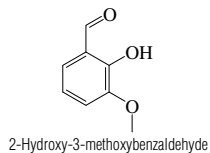
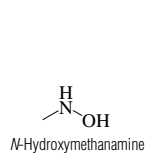
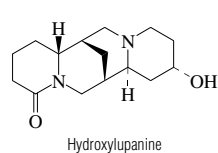
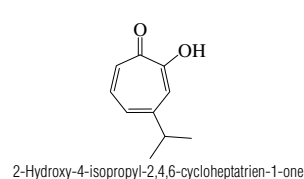
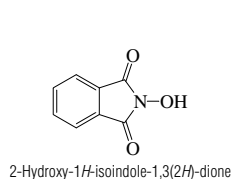
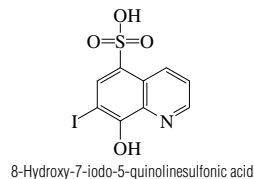
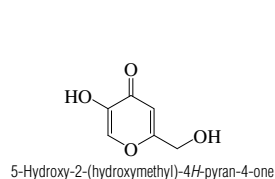
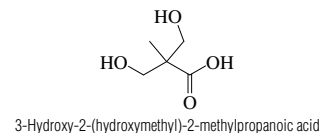
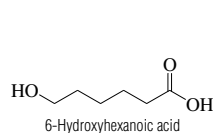
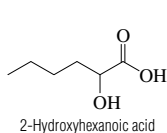
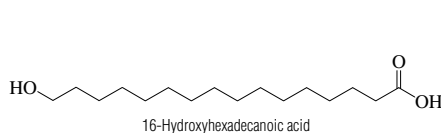
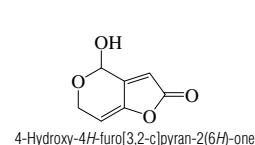
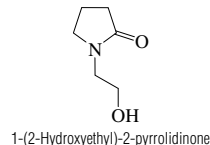
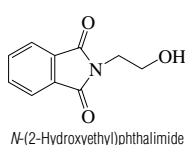
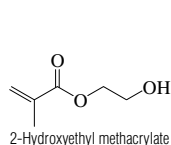
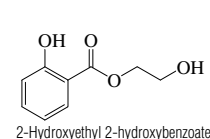
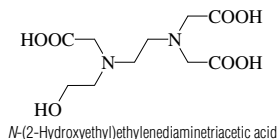
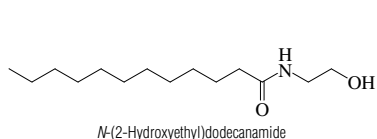
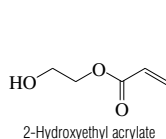
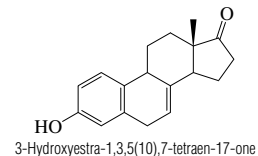
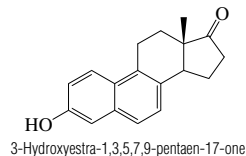
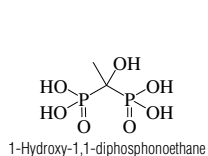
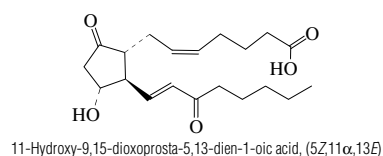
2-Hydroxybenzonitrile

| No.  | Name                                               | Synonym                                             | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|----------------------------------------------------|-----------------------------------------------------|---------------------------------------------------------------|------------|----------|-------------------------|---------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 5995 | 3-Hydroxybenzonitrile                              |                                                     | C <sub>7</sub> H <sub>5</sub> NO                              | 873-62-1   | 119.121  | pr (al, eth) lf (w)     | 82.8    |                                       |                            |                      | vs H <sub>2</sub> O, EtOH, eth, bz, chl               |
| 5996 | 4-Hydroxybenzonitrile                              |                                                     | C <sub>7</sub> H <sub>5</sub> NO                              | 767-00-0   | 119.121  | lf (w)                  | 113     | 148 <sup>1</sup>                      |                            |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth, chl          |
| 5997 | 4-Hydroxybenzophenone                              | 4-Hydroxyphenyl phenyl ketone                       | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                | 1137-42-4  | 198.217  | nd (al), pr (dil al)    | 135     |                                       | 1.133 <sup>172</sup>       |                      | sl H <sub>2</sub> O; vs EtOH, eth, HOAc               |
| 5998 | 4-Hydroxy-2 <i>H</i> -1-benzopyran-2-one           |                                                     | C <sub>9</sub> H <sub>6</sub> O <sub>3</sub>                  | 1076-38-6  | 162.142  | nd (w)                  | 213.5   |                                       |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl DMSO                |
| 5999 | 7-Hydroxy-2 <i>H</i> -1-benzopyran-2-one           | Umbelliferone                                       | C <sub>9</sub> H <sub>6</sub> O <sub>3</sub>                  | 93-35-6    | 162.142  | nd (w)                  | 230.5   | sub                                   |                            |                      | vs EtOH, HOAc, chl                                    |
| 6000 | 1-Hydroxy-1 <i>H</i> -benzotriazole                |                                                     | C <sub>6</sub> H <sub>4</sub> N <sub>3</sub> O                | 2592-95-2  | 135.123  |                         | 157.8   |                                       |                            |                      |                                                       |
| 6001 | 2-Hydroxybenzoyl chloride                          |                                                     | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                | 1441-87-8  | 156.567  |                         | 19      | 92 <sup>15</sup>                      | 1.3112 <sup>20</sup>       | 1.5812 <sup>20</sup> | vs eth                                                |
| 6002 | 4-(2-Hydroxybenzoyl)morpholine                     | 4-Salicyloylmorpholine                              | C <sub>11</sub> H <sub>10</sub> NO <sub>3</sub>               | 3202-84-4  | 204.202  |                         |         |                                       |                            |                      | s DMSO                                                |
| 6003 | 2-Hydroxybiphenyl                                  | [1,1'-Biphenyl]-2-ol                                | C <sub>12</sub> H <sub>10</sub> O                             | 90-43-7    | 170.206  |                         | 57.5    | 286                                   | 1.213 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, ace, bz; vs eth, py       |
| 6004 | 3-Hydroxybiphenyl                                  | [1,1'-Biphenyl]-3-ol                                | C <sub>12</sub> H <sub>10</sub> O                             | 580-51-8   | 170.206  |                         | 78      | >300                                  |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz, py; s chl      |
| 6005 | 4-Hydroxybiphenyl                                  | [1,1'-Biphenyl]-4-ol                                | C <sub>12</sub> H <sub>10</sub> O                             | 92-69-3    | 170.206  |                         | 166     | 305                                   |                            |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth, chl, py      |
| 6006 | 3-Hydroxybutanal                                   | Aldol                                               | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 107-89-1   | 88.106   |                         |         | 83 <sup>20</sup>                      | 1.103 <sup>20</sup>        | 1.4238 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; s eth; vs ace             |
| 6007 | 2-Hydroxybutanoic acid, (±)                        |                                                     | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                  | 600-15-7   | 104.105  |                         | 44.2    | dec 260; 140 <sup>14</sup>            | 1.125 <sup>20</sup>        |                      | s H <sub>2</sub> O, EtOH, eth                         |
| 6008 | 3-Hydroxybutanoic acid, (±)                        |                                                     | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                  | 625-71-8   | 104.105  |                         | 49      | 130 <sup>12</sup> , 94 <sup>0.1</sup> |                            | 1.4424 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; i bz                  |
| 6009 | 4-Hydroxybutanoic acid                             |                                                     | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                  | 591-81-1   | 104.105  |                         | <-17    | dec 180                               |                            |                      |                                                       |
| 6010 | 1-Hydroxy-2-butanone                               |                                                     | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 5077-67-8  | 88.106   |                         |         | 160; 78 <sup>60</sup>                 | 1.0272 <sup>20</sup>       | 1.4189 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth                        |
| 6011 | 3-Hydroxy-2-butanone, (±)                          | Acetoin                                             | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 52217-02-4 | 88.106   |                         | 15      | 148                                   | 1.0044 <sup>20</sup>       | 1.4171 <sup>20</sup> | msc H <sub>2</sub> O; sl EtOH, eth; s ace, chl; i lig |
| 6012 | 4-Hydroxy-2-butanone                               |                                                     | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 590-90-9   | 88.106   |                         |         | 182; 90 <sup>11</sup>                 | 1.0233 <sup>20</sup>       | 1.4585 <sup>14</sup> | msc H <sub>2</sub> O, EtOH, eth; vs ace               |
| 6013 | 2-Hydroxy-3-butenenitrile                          |                                                     | C <sub>4</sub> H <sub>5</sub> NO                              | 5809-59-6  | 83.089   | liq                     |         | 94 <sup>17</sup>                      |                            |                      |                                                       |
| 6014 | 4-Hydroxybutyramide                                |                                                     | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                 | 927-60-6   | 103.120  |                         | 52      |                                       |                            |                      |                                                       |
| 6015 | 3-Hydroxycamphor                                   | 3-Hydroxy-1,7,7-trimethylbicyclo[2.2.1]heptan-2-one | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>                | 10373-81-6 | 168.233  | nd (bz-peth)            | 205.5   |                                       |                            |                      | vs eth, EtOH, chl                                     |
| 6016 | 3-Hydroxycholan-24-oic acid, (3α,5β)               | Lithocholic acid                                    | C <sub>24</sub> H <sub>40</sub> O <sub>3</sub>                | 434-13-9   | 376.573  | hex lf (al) pr (dil al) | 186     |                                       |                            |                      | i H <sub>2</sub> O, lig; s EtOH, chl, HOAc; sl eth    |
| 6017 | Hydroxycodone                                      |                                                     | C <sub>18</sub> H <sub>19</sub> NO <sub>4</sub>               | 508-54-3   | 313.349  |                         | 275 dec |                                       |                            |                      |                                                       |
| 6018 | 2-Hydroxycyclodecanone                             | Sebacoin                                            | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>                | 96-00-4    | 170.249  | cry (peth)              | 38.5    | 136 <sup>14</sup>                     |                            |                      |                                                       |
| 6019 | 2-Hydroxy-2,4,6-cycloheptatrien-1-one              |                                                     | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                  | 533-75-5   | 122.122  | nd                      | 50.8    | sub 40                                |                            |                      | s H <sub>2</sub> O, eth, ace                          |
| 6020 | 1-Hydroxycyclohexanecarbonitrile                   |                                                     | C <sub>6</sub> H <sub>11</sub> NO                             | 931-97-5   | 125.168  |                         | 35      | 132 <sup>20</sup>                     | 1.0172 <sup>20</sup>       | 1.4693 <sup>20</sup> | vs H <sub>2</sub> O, eth                              |
| 6021 | 2-Hydroxycyclohexanone                             |                                                     | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 533-60-8   | 114.142  | nd (al)                 |         |                                       |                            | 1.4785 <sup>21</sup> | vs H <sub>2</sub> O, EtOH; i eth, bz, peth            |
| 6022 | 1-(1-Hydroxycyclohexyl)ethanone                    |                                                     | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                 | 1123-27-9  | 142.196  |                         |         | 125.5; 91 <sup>11</sup>               | 1.0248 <sup>25</sup>       | 1.4670 <sup>25</sup> | vs eth, EtOH                                          |
| 6023 | 4-Hydroxydecanoic acid γ-lactone                   | 5-Hexyldihydro-2(3 <i>H</i> )-furanone              | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>                | 706-14-9   | 170.249  | liq                     |         | 281                                   |                            |                      |                                                       |
| 6024 | 2-Hydroxy-3,5-diiodobenzoic acid                   | 3,5-Diiodosalicylic acid                            | C <sub>7</sub> H <sub>4</sub> I <sub>2</sub> O <sub>3</sub>   | 133-91-5   | 389.914  | nd (al)                 | 235.5   |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; i bz, chl          |
| 6025 | 4-Hydroxy-3,5-diiodobenzoic acid                   |                                                     | C <sub>7</sub> H <sub>4</sub> I <sub>2</sub> O <sub>3</sub>   | 618-76-8   | 389.914  |                         | 237     | dec 260                               |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; sl bz, chl, lig     |
| 6026 | 4-Hydroxy-3,5-diiodobenzonitrile                   |                                                     | C <sub>7</sub> H <sub>3</sub> I <sub>2</sub> NO               | 1689-83-4  | 370.914  |                         | 201 dec |                                       |                            |                      |                                                       |
| 6027 | 4-Hydroxy-3,5-diiodo-α-phenylbenzenepropanoic acid | Iodoalphonic acid                                   | C <sub>15</sub> H <sub>12</sub> I <sub>2</sub> O <sub>3</sub> | 577-91-3   | 494.063  |                         | 164     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth; sl bz, chl           |
| 6028 | 2-Hydroxy-4,6-dimethoxybenzaldehyde                |                                                     | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 708-76-9   | 182.173  |                         | 70      | 193 <sup>25</sup> , 165 <sup>10</sup> |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, bz, chl, HOAc       |
| 6029 | 4-Hydroxy-3,5-dimethoxybenzaldehyde                | Syringaldehyde                                      | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 134-96-3   | 182.173  | br nd (lig)             | 113     | 192 <sup>14</sup>                     |                            |                      | sl H <sub>2</sub> O, lig; vs EtOH, eth, bz, chl       |
| 6030 | 4-Hydroxy-3,5-dimethoxybenzoic acid                |                                                     | C <sub>9</sub> H <sub>10</sub> O <sub>5</sub>                 | 530-57-4   | 198.172  | nd (w)                  | 204.5   |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH                          |
| 6031 | 7-Hydroxy-3,7-dimethyloctanal                      |                                                     | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                | 107-75-5   | 172.265  |                         |         | 103 <sup>3</sup>                      | 0.9220 <sup>20</sup>       | 1.4494 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, ace                      |
| 6032 | 3-Hydroxy-2,2-dimethylpropanal                     | Hydroxypivaldehyde                                  | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                 | 597-31-9   | 102.132  | nd (w)                  | 89.5    | 173; 68 <sup>14</sup>                 |                            |                      |                                                       |
| 6033 | 2-Hydroxy-3,5-dinitrobenzoic acid                  |                                                     | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>7</sub>   | 609-99-4   | 228.116  | ye nd or pl (+1w)       | 182     |                                       |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz                     |

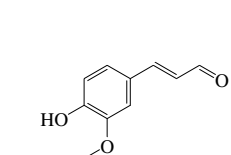




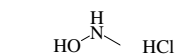
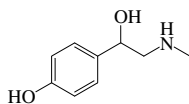
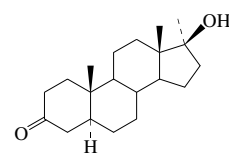
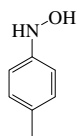
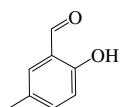
| No.  | Name                                                                                        | Synonym                          | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|---------------------------------------------------------------------------------------------|----------------------------------|---------------------------------------------------------------|------------|----------|---------------------------|---------|-------------------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 6034 | 11-Hydroxy-9,15-dioxoprostano-5,13-dien-1-oic acid, (5 <i>Z</i> ,11 <i>α</i> ,13 <i>E</i> ) | 15-Oxo-prostaglandin E2          | C <sub>20</sub> H <sub>30</sub> O <sub>5</sub>                | 26441-05-4 | 350.449  | cry                       |         |                                     |                            |                      |                                                         |
| 6035 | 1-Hydroxy-1,1-diphosphonoethane                                                             | Etidronic acid                   | C <sub>2</sub> H <sub>6</sub> O <sub>7</sub> P <sub>2</sub>   | 2809-21-4  | 206.028  | cry (w)                   | 105     |                                     |                            |                      | s H <sub>2</sub> O, EtOH, MeOH                          |
| 6036 | 3-Hydroxyestra-1,3,5,7,9-pentaen-17-one                                                     | Equilenin                        | C <sub>18</sub> H <sub>18</sub> O <sub>2</sub>                | 517-09-9   | 266.335  |                           | 258.5   | sub 170                             |                            |                      | sl EtOH, ace, chl                                       |
| 6037 | 3-Hydroxyestra-1,3,5(10),7-tetraen-17-one                                                   | Equilin                          | C <sub>18</sub> H <sub>20</sub> O <sub>2</sub>                | 474-86-2   | 268.351  | pl (AcOEt)                | 239     | sub 170                             |                            |                      | sl H <sub>2</sub> O; s EtOH, ace, diox, AcOEt           |
| 6038 | 2-Hydroxyethyl acrylate                                                                     | 2-Hydroxyethyl 2-propenoate      | C <sub>6</sub> H <sub>8</sub> O <sub>3</sub>                  | 818-61-1   | 116.116  | liq                       |         | 191; 91 <sup>12</sup>               | 1.011 <sup>23</sup>        |                      |                                                         |
| 6039 | <i>N</i> -(2-Hydroxyethyl)dodecanamide                                                      |                                  | C <sub>14</sub> H <sub>29</sub> NO <sub>2</sub>               | 142-78-9   | 243.386  |                           | 88.5    |                                     |                            |                      |                                                         |
| 6040 | <i>N</i> -(2-Hydroxyethyl)ethylenediaminetriacetic acid                                     |                                  | C <sub>10</sub> H <sub>18</sub> N <sub>2</sub> O <sub>7</sub> | 150-39-0   | 278.259  | cry                       | 165 dec |                                     |                            |                      |                                                         |
| 6041 | 2-Hydroxyethyl 2-hydroxybenzoate                                                            | Glycol salicylate                | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 87-28-5    | 182.173  |                           | 37      | 173 <sup>15</sup>                   | 1.2526 <sup>15</sup>       |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl              |
| 6042 | 2-Hydroxyethyl methacrylate                                                                 | Ethylene glycol monomethacrylate | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                 | 868-77-9   | 130.141  |                           |         | 103 <sup>13</sup> , 67 <sup>3</sup> | 1.079 <sup>20</sup>        | 1.4515 <sup>20</sup> |                                                         |
| 6043 | <i>N</i> -(2-Hydroxyethyl)phthalimide                                                       |                                  | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub>                | 3891-07-4  | 191.183  | nd (al), lf (w)           | 130.3   |                                     |                            |                      | sl H <sub>2</sub> O                                     |
| 6044 | 1-(2-Hydroxyethyl)-2-pyrrolidinone                                                          |                                  | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                | 3445-11-2  | 129.157  |                           | 20      | 295                                 | 1.1435 <sup>20</sup>       |                      |                                                         |
| 6045 | 4-Hydroxy-4 <i>H</i> -furo[3,2- <i>c</i> ]pyran-2(6 <i>H</i> )-one                          | Patulin                          | C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                  | 149-29-1   | 154.121  | pl or pr (eth, chl)       | 111     |                                     |                            |                      | s H <sub>2</sub> O, EtOH, eth, ace, bz; i peth          |
| 6046 | 16-Hydroxyhexadecanoic acid                                                                 | 16-Hydroxypalmitic acid          | C <sub>16</sub> H <sub>32</sub> O <sub>3</sub>                | 506-13-8   | 272.423  |                           | 96.5    |                                     |                            |                      | i H <sub>2</sub> O; s EtOH, ace; sl eth, bz             |
| 6047 | 2-Hydroxyhexanoic acid                                                                      |                                  | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                 | 6064-63-7  | 132.157  | pr (eth)                  | 60      |                                     |                            |                      | vs H <sub>2</sub> O                                     |
| 6048 | 6-Hydroxyhexanoic acid                                                                      |                                  | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                 | 1191-25-9  | 132.157  | liq                       |         |                                     |                            |                      |                                                         |
| 6049 | 3-Hydroxy-2-(hydroxymethyl)-2-methylpropanoic acid                                          | Dimethylolpropionic acid         | C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>                 | 4767-03-7  | 134.131  |                           | 190     |                                     |                            |                      |                                                         |
| 6050 | 5-Hydroxy-2-(hydroxymethyl)-4 <i>H</i> -pyran-4-one                                         | Kojic acid                       | C <sub>6</sub> H <sub>6</sub> O <sub>4</sub>                  | 501-30-4   | 142.110  | pr nd (ace)               | 153.5   |                                     |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, eth, ace, DMSO         |
| 6051 | 8-Hydroxy-7-iodo-5-quinolinesulfonic acid                                                   | Ferron                           | C <sub>9</sub> H <sub>6</sub> INO <sub>3</sub> S              | 547-91-1   | 351.118  | ye pr, lf (al)            | 260 dec |                                     |                            |                      | sl H <sub>2</sub> O, EtOH; i eth, bz, chl; s con sulf   |
| 6052 | 2-Hydroxy-1 <i>H</i> -isoindole-1,3(2 <i>H</i> )-dione                                      |                                  | C <sub>8</sub> H <sub>6</sub> NO <sub>3</sub>                 | 524-38-9   | 163.131  |                           | 232     |                                     |                            |                      | s DMSO                                                  |
| 6053 | 2-Hydroxy-4-isopropyl-2,4,6-cycloheptatrien-1-one                                           |                                  | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 499-44-5   | 164.201  | pa ye (peth)              | 51.5    | 137 <sup>10</sup>                   | 1.0606 <sup>65</sup>       |                      | sl H <sub>2</sub> O, bz, lig; s ctc                     |
| 6054 | Hydroxylupanine                                                                             |                                  | C <sub>15</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub> | 15358-48-2 | 264.364  | cry (ace)                 | 169.5   |                                     |                            |                      | vs H <sub>2</sub> O, EtOH, chl                          |
| 6055 | <i>N</i> -Hydroxymethanamine                                                                | <i>N</i> -Methylhydroxylamine    | CH <sub>3</sub> NO                                            | 593-77-1   | 47.057   | hyg nd                    | 87.5    | 62.5 <sup>15</sup>                  | 1.0003 <sup>20</sup>       | 1.4164 <sup>20</sup> | vs H <sub>2</sub> O, EtOH                               |
| 6056 | 2-Hydroxy-3-methoxybenzaldehyde                                                             |                                  | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 148-53-8   | 152.148  | lt ye lf, grn nd (w, lig) | 44.5    | 265.5                               |                            |                      | sl H <sub>2</sub> O, lig; vs EtOH, eth, ctc             |
| 6057 | 2-Hydroxy-4-methoxybenzaldehyde                                                             |                                  | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 673-22-3   | 152.148  | nd (w), cry (al)          | 42.0    |                                     |                            |                      | s EtOH, eth, bz, lig                                    |
| 6058 | 2-Hydroxy-5-methoxybenzaldehyde                                                             |                                  | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 672-13-9   | 152.148  | ye liq (w)                | 4       | 247.5                               |                            |                      | vs eth, EtOH                                            |
| 6059 | 3-Hydroxy-4-methoxybenzaldehyde                                                             |                                  | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 621-59-0   | 152.148  |                           | 114     | 179 <sup>15</sup>                   | 1.196 <sup>25</sup>        |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, HOAc; vs chl      |
| 6060 | 4-Hydroxy-3-methoxybenzaldehyde                                                             | Vanillin                         | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 121-33-5   | 152.148  | tetr (w, lig)             | 81.5    | 285                                 | 1.056 <sup>25</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth, ace; s bz, lig       |
| 6061 | 4-Hydroxy-3-methoxybenzeneacetic acid                                                       | Homovanillic acid                | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 306-08-1   | 182.173  |                           | 143.5   |                                     |                            |                      |                                                         |
| 6062 | 4-Hydroxy-3-methoxybenzenemethanol                                                          |                                  | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                 | 498-00-0   | 154.163  | pr (w), nd (bz)           | 115     | dec                                 |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz                       |
| 6063 | 4-Hydroxy-3-methoxybenzenepropanol                                                          |                                  | C <sub>10</sub> H <sub>14</sub> O <sub>3</sub>                | 2305-13-7  | 182.216  |                           | 65      | 197 <sup>15</sup>                   |                            | 1.5545 <sup>25</sup> | vs eth, EtOH                                            |
| 6064 | 2-Hydroxy-5-methoxybenzoic acid                                                             |                                  | C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                  | 2612-02-4  | 168.148  |                           | 142     |                                     |                            |                      |                                                         |
| 6065 | 4-Hydroxy-3-methoxybenzoic acid                                                             | Vanillic acid                    | C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                  | 121-34-6   | 168.148  | wh nd                     | 211.5   | sub                                 |                            |                      | sl H <sub>2</sub> O; vs EtOH; s eth, DMSO               |
| 6066 | 7-Hydroxy-6-methoxy-2 <i>H</i> -1-benzopyran-2-one                                          | Scopoletin                       | C <sub>10</sub> H <sub>8</sub> O <sub>4</sub>                 | 92-61-5    | 192.169  | nd or pr (al)             | 204     |                                     |                            |                      | sl H <sub>2</sub> O, EtOH; s chl; i bz, CS <sub>2</sub> |
| 6067 | 4-(4-Hydroxy-3-methoxyphenyl)-2-butanone                                                    | Zingerone                        | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>                | 122-48-5   | 194.227  | cry (ace, eth)            | 40.5    | 187 <sup>14</sup>                   |                            |                      | vs eth                                                  |
| 6068 | 1-(2-Hydroxy-4-methoxyphenyl)ethanone                                                       |                                  | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 552-41-0   | 166.173  | nd (al)                   | 52.5    | 158 <sup>20</sup>                   | 1.3102 <sup>61</sup>       | 1.5452 <sup>61</sup> | vs bz, eth, EtOH, chl                                   |
| 6069 | 1-(4-Hydroxy-3-methoxyphenyl)ethanone                                                       | Apocynin                         | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 498-02-2   | 166.173  | pr (w)                    | 115     | 297; 234 <sup>15</sup>              |                            |                      | sl H <sub>2</sub> O; s EtOH, ace, bz; vs eth, chl       |
| 6070 | (2-Hydroxy-4-methoxyphenyl)phenylmethanone                                                  | Oxybenzone                       | C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>                | 131-57-7   | 228.243  |                           | 65.5    |                                     |                            |                      | s ctc                                                   |



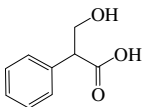
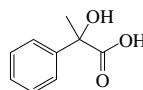
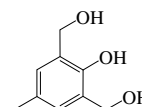
| No.  | Name                                                             | Synonym                                     | Mol. Form.                                     | CAS RN     | Mol. Wt. | Physical Form                  | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | <i>n</i> <sub>D</sub> | Solubility                                                   |
|------|------------------------------------------------------------------|---------------------------------------------|------------------------------------------------|------------|----------|--------------------------------|---------|------------------------|----------------------------|-----------------------|--------------------------------------------------------------|
| 6071 | 3-(4-Hydroxy-3-methoxyphenyl)-2-propenal                         |                                             | C <sub>10</sub> H <sub>10</sub> O <sub>3</sub> | 458-36-6   | 178.184  | cry (bz)                       | 84      |                        | 1.1562 <sup>102</sup>      |                       | vs bz, eth, EtOH                                             |
| 6072 | <i>N</i> -Hydroxymethylamine hydrochloride                       | <i>N</i> -Methylhydroxylamine hydrochloride | CH <sub>6</sub> ClNO                           | 4229-44-1  | 83.518   |                                | 83.5    |                        |                            |                       |                                                              |
| 6073 | 4-Hydroxy- $\alpha$ -[(methylamino)methyl]benzenemethanol        | Synephrine                                  | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub> | 94-07-5    | 167.205  |                                | 184.5   |                        |                            |                       |                                                              |
| 6074 | 17-Hydroxy-17-methylandrostan-3-one, (5 $\alpha$ ,17 $\beta$ )   | Mestanolone                                 | C <sub>20</sub> H <sub>32</sub> O <sub>2</sub> | 521-11-9   | 304.467  |                                | 192.5   |                        |                            |                       | sl AcOEt                                                     |
| 6075 | <i>N</i> -Hydroxy-4-methylaniline                                |                                             | C <sub>7</sub> H <sub>9</sub> NO               | 623-10-9   | 123.152  | lf (bz)                        | 96      | dec 117                |                            |                       | vs eth, EtOH, chl                                            |
| 6076 | 2-Hydroxy-5-methylbenzaldehyde                                   |                                             | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>   | 613-84-3   | 136.149  | pl (aq, al)                    | 56      | 217.5                  | 1.0913 <sup>99</sup>       | 1.547 <sup>99</sup>   | vs eth, EtOH, chl                                            |
| 6077 | $\alpha$ -(Hydroxymethyl)benzeneacetic acid, ( $\pm$ )           | Tropic acid                                 | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>  | 552-63-6   | 166.173  | nd, pl (al, bz, w)             | 118     | dec                    |                            |                       | vs H <sub>2</sub> O, eth, EtOH                               |
| 6078 | $\alpha$ -Hydroxy- $\alpha$ -methylbenzeneacetic acid, ( $\pm$ ) | Atrolactic acid                             | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>  | 4607-38-9  | 166.173  | nd, pl (lig)                   | 94      |                        |                            |                       | vs ace, bz                                                   |
| 6079 | 2-Hydroxy-5-methyl-1,3-benzenedimethanol                         |                                             | C <sub>9</sub> H <sub>12</sub> O <sub>3</sub>  | 91-04-3    | 168.189  |                                | 130.5   |                        |                            |                       |                                                              |
| 6080 | 2-(Hydroxymethyl)-1,4-benzenediol                                | Gentisyl alcohol                            | C <sub>7</sub> H <sub>8</sub> O <sub>3</sub>   | 495-08-9   | 140.137  | nd (chl)                       | 100     | sub 75                 |                            |                       | vs H <sub>2</sub> O, EtOH, chl                               |
| 6081 | 2-Hydroxy-5-methylbenzoic acid                                   | <i>p</i> -Cresotic acid                     | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>   | 89-56-5    | 152.148  |                                | 151     |                        |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, bz, chl; i CS <sub>2</sub> |
| 6082 | 2-Hydroxy-3-methylbenzoic acid                                   | <i>o</i> -Cresotic acid                     | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>   | 83-40-9    | 152.148  |                                | 165.5   |                        |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                    |
| 6083 | 2-Hydroxy-4-methylbenzoic acid                                   | <i>m</i> -Cresotic acid                     | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>   | 50-85-1    | 152.148  | cry, lf                        | 177     |                        |                            |                       | sl H <sub>2</sub> O; s EtOH, bz, chl; vs eth                 |
| 6084 | 7-Hydroxy-4-methyl-2 <i>H</i> -1-benzopyran-2-one                | Hymecromone                                 | C <sub>10</sub> H <sub>8</sub> O <sub>3</sub>  | 90-33-5    | 176.169  | nd (al)                        | 194.5   |                        |                            |                       | sl H <sub>2</sub> O, eth, chl; s EtOH, alk, HOAc             |
| 6085 | 3-Hydroxy-3-methylbutanoic acid                                  |                                             | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>  | 625-08-1   | 118.131  |                                | <-32    | 162 <sup>12</sup>      | 0.9384 <sup>20</sup>       | 1.5081 <sup>20</sup>  | vs H <sub>2</sub> O, eth, EtOH                               |
| 6086 | 3-Hydroxy-3-methyl-2-butanone                                    |                                             | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>  | 115-22-0   | 102.132  |                                |         | 140                    | 0.9526 <sup>20</sup>       |                       | s chl                                                        |
| 6087 | 2-Hydroxy-3-methyl-2-cyclopenten-1-one                           |                                             | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>   | 80-71-7    | 112.127  |                                | 104.8   |                        |                            |                       |                                                              |
| 6088 | 5-(Hydroxymethyl)-2-furancarboxaldehyde                          | 5-(Hydroxymethyl)-2-furaldehyde             | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>   | 67-47-0    | 126.110  | nd (eth-peth)                  | 31.5    | 115 <sup>1</sup>       | 1.2062 <sup>25</sup>       | 1.5627 <sup>18</sup>  | s H <sub>2</sub> O, EtOH, bz, chl; sl eth, ctc               |
| 6089 | 2-Hydroxy-6-methyl-3-isopropylbenzoic acid                       | <i>o</i> -Thymotic acid                     | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub> | 548-51-6   | 194.227  | nd (w, bz, lig)                | 127     | sub                    |                            |                       | vs bz, eth, EtOH                                             |
| 6090 | 2-Hydroxy-3-methyl-6-isopropyl-2-cyclohexen-1-one                | Diosphenol                                  | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub> | 490-03-9   | 168.233  |                                | 83      | 109 <sup>10</sup>      |                            |                       |                                                              |
| 6091 | 2-(Hydroxymethyl)-2-methyl-1,3-propanediol                       |                                             | C <sub>5</sub> H <sub>12</sub> O <sub>3</sub>  | 77-85-0    | 120.147  | wh pow or nd (al)              | 204     | 136 <sup>15</sup>      |                            |                       | msc H <sub>2</sub> O, EtOH; i eth, bz; vs HOAc               |
| 6092 | 2-Hydroxy-3-methyl-1,4-naphthalenedione                          | Phthiocol                                   | C <sub>11</sub> H <sub>8</sub> O <sub>3</sub>  | 483-55-6   | 188.180  | ye pr (eth-peth)               | 173.5   | sub                    |                            |                       | vs ace, eth                                                  |
| 6093 | 5-Hydroxy-2-methyl-1,4-naphthalenedione                          | Plumbagin                                   | C <sub>11</sub> H <sub>8</sub> O <sub>3</sub>  | 481-42-5   | 188.180  | gold pr or oran-ye nd (dil al) | 78.5    | sub                    |                            |                       | vs ace, bz, eth, EtOH                                        |
| 6094 | 2-(Hydroxymethyl)-2-nitro-1,3-propanediol                        | Tris(hydroxymethyl)nitromethane             | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>  | 126-11-4   | 151.118  | nd or pr                       | 165     | dec                    |                            |                       | vs H <sub>2</sub> O, eth, EtOH                               |
| 6095 | 2-Hydroxy-4-methylpentanoic acid, (S)                            | <i>L</i> -Leucic acid                       | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>  | 13748-90-8 | 132.157  | orth (eth)                     | 81.5    |                        |                            |                       | vs H <sub>2</sub> O, eth, EtOH                               |
| 6096 | 1-(2-Hydroxy-4-methylphenyl)ethanone                             |                                             | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>  | 6921-64-8  | 150.174  |                                | 21      | 245                    | 1.1012 <sup>10</sup>       | 1.5527 <sup>13</sup>  |                                                              |
| 6097 | 1-(2-Hydroxy-5-methylphenyl)ethanone                             |                                             | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>  | 1450-72-2  | 150.174  | pr (lig)                       | 50      | 210; 120 <sup>20</sup> | 1.0797 <sup>53</sup>       |                       | vs bz, eth, EtOH, chl                                        |
| 6098 | 2-(Hydroxymethyl)phenyl- $\beta$ -D-glucopyranoside              | Salicin                                     | C <sub>13</sub> H <sub>18</sub> O <sub>7</sub> | 138-52-3   | 286.278  | orth nd or lf (w)              | 207     | dec 240                | 1.434 <sup>20</sup>        |                       | vs H <sub>2</sub> O, EtOH, HOAc                              |
| 6099 | 1-(2-Hydroxy-5-methylphenyl)-1-propanone                         |                                             | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> | 938-45-4   | 164.201  |                                | 1.0     | 129 <sup>16.5</sup>    | 1.0841 <sup>14</sup>       | 1.549 <sup>13</sup>   | s chl                                                        |
| 6100 | <i>N</i> -(Hydroxymethyl)phthalimide                             |                                             | C <sub>9</sub> H <sub>7</sub> NO <sub>3</sub>  | 118-29-6   | 177.157  | lf, pr (to)                    | 141.5   |                        |                            |                       | i H <sub>2</sub> O, eth, ctc; sl EtOH, bz; s tol             |
| 6101 | 3-Hydroxy-2-methylpropanal                                       |                                             | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 38433-80-6 | 88.106   | oil                            |         |                        |                            |                       |                                                              |
| 6102 | 2-Hydroxy-2-methylpropanoic acid                                 |                                             | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>   | 594-61-6   | 104.105  | hyg pr (eth) nd (bz)           | 82.5    | 212                    |                            |                       | vs H <sub>2</sub> O, EtOH, eth; sl bz                        |
| 6103 | 3-Hydroxy-2-methylpropanoic acid                                 |                                             | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>   | 2068-83-9  | 104.105  | oil                            |         |                        |                            |                       |                                                              |
| 6104 | <i>N</i> -(Hydroxymethyl)-2-propenamide                          | <i>N</i> -(Hydroxymethyl)acrylamide         | C <sub>4</sub> H <sub>7</sub> NO <sub>2</sub>  | 924-42-5   | 101.105  | cry                            | 76      |                        |                            |                       |                                                              |
| 6105 | 4-Hydroxy-6-methyl-2 <i>H</i> -pyran-2-one                       | Triacetic acid lactone                      | C <sub>6</sub> H <sub>8</sub> O <sub>3</sub>   | 675-10-5   | 126.110  |                                | 189 dec |                        |                            |                       |                                                              |
| 6106 | 3-Hydroxy-2-methyl-4 <i>H</i> -pyran-4-one                       | Maltol                                      | C <sub>6</sub> H <sub>8</sub> O <sub>3</sub>   | 118-71-8   | 126.110  | mcl pr (chl)                   | 161.5   | sub 93                 |                            |                       | sl H <sub>2</sub> O, eth, bz; vs chl; s alk; peth            |



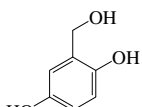
3-(4-Hydroxy-3-methoxyphenyl)-2-propenal

*N*-Hydroxymethylamine hydrochloride4-Hydroxy- $\alpha$ -[(methylamino)methyl]benzenemethanol17-Hydroxy-17-methylandrostan-3-one, (5 $\alpha$ ,17 $\beta$ )*N*-Hydroxy-4-methylaniline

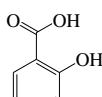
2-Hydroxy-5-methylbenzaldehyde

 $\alpha$ -(Hydroxymethyl)benzeneacetic acid, ( $\pm$ ) $\alpha$ -Hydroxy- $\alpha$ -methylbenzeneacetic acid, ( $\pm$ )

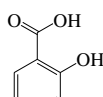
2-Hydroxy-5-methyl-1,3-benzenedimethanol



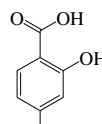
2-(Hydroxymethyl)-1,4-benzenediol



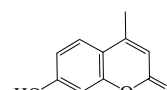
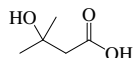
2-Hydroxy-5-methylbenzoic acid



2-Hydroxy-3-methylbenzoic acid



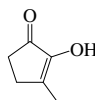
2-Hydroxy-4-methylbenzoic acid

7-Hydroxy-4-methyl-2*H*-1-benzopyran-2-one

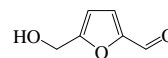
3-Hydroxy-3-methylbutanoic acid



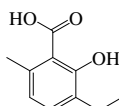
3-Hydroxy-3-methyl-2-butanone



2-Hydroxy-3-methyl-2-cyclopenten-1-one



5-(Hydroxymethyl)-2-furancarboxaldehyde



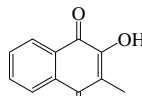
2-Hydroxy-6-methyl-3-isopropylbenzoic acid



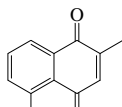
2-Hydroxy-3-methyl-6-isopropyl-2-cyclohexen-1-one



2-(Hydroxymethyl)-2-methyl-1,3-propanediol



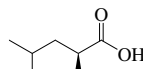
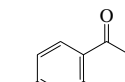
2-Hydroxy-3-methyl-1,4-naphthalenedione



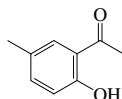
5-Hydroxy-2-methyl-1,4-naphthalenedione



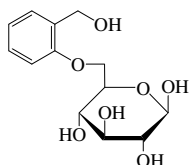
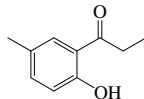
2-(Hydroxymethyl)-2-nitro-1,3-propanediol

2-Hydroxy-4-methylpentanoic acid, (*S*)

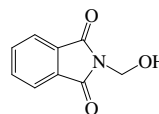
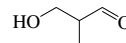
1-(2-Hydroxy-4-methylphenyl)ethanone



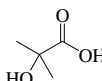
1-(2-Hydroxy-5-methylphenyl)ethanone

2-(Hydroxymethyl)phenyl- $\beta$ -*D*-glucopyranoside

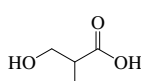
1-(2-Hydroxy-5-methylphenyl)-1-propanone

*N*-(Hydroxymethyl)phthalimide

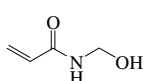
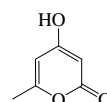
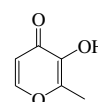
3-Hydroxy-2-methylpropanal



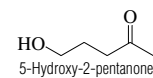
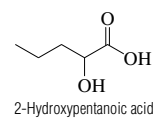
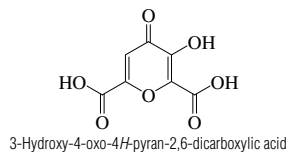
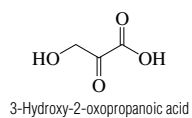
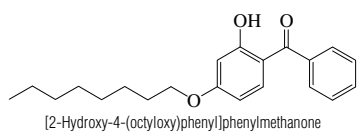
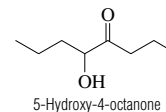
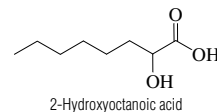
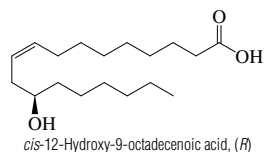
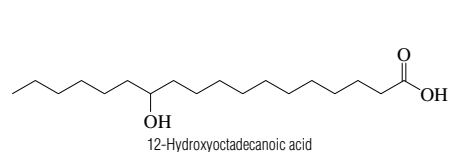
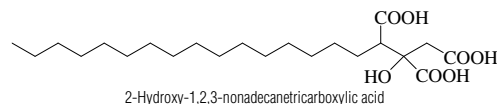
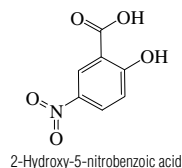
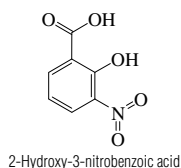
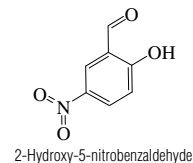
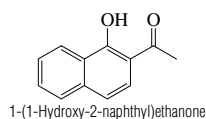
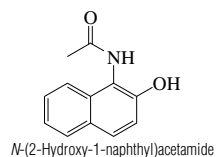
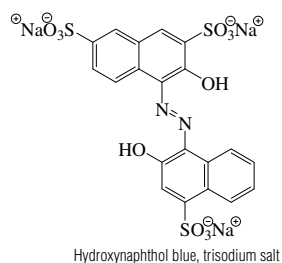
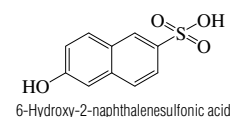
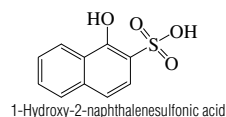
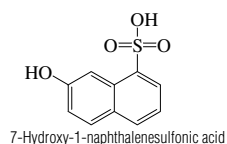
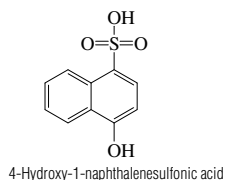
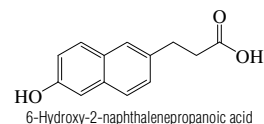
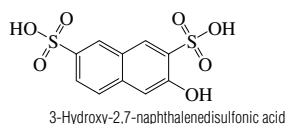
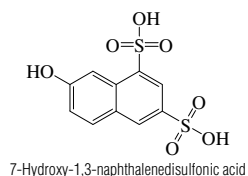
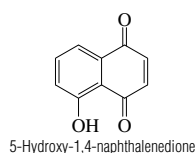
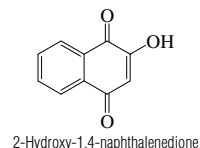
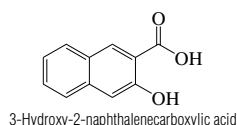
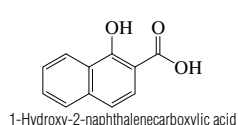
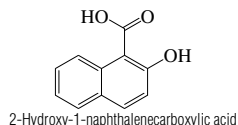
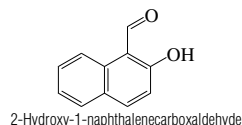
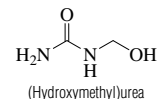
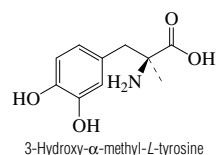
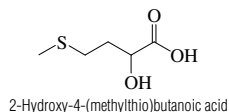
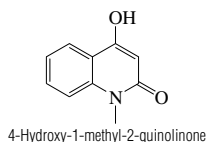
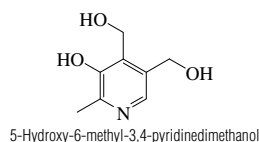
2-Hydroxy-2-methylpropanoic acid



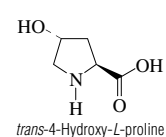
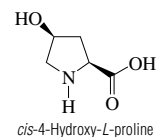
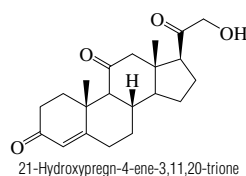
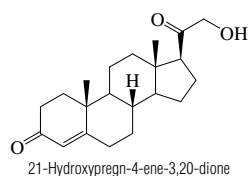
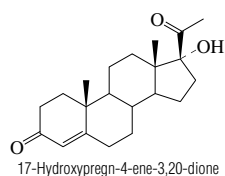
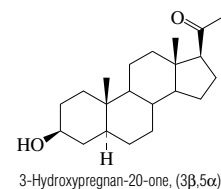
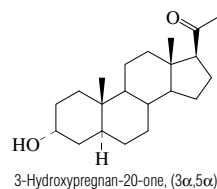
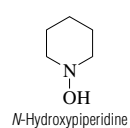
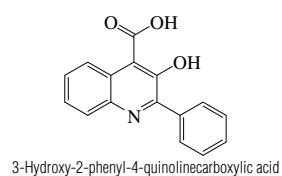
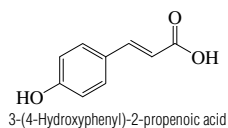
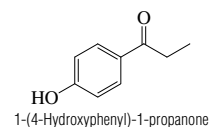
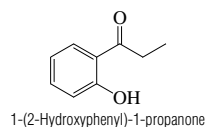
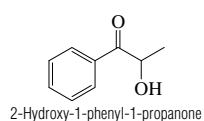
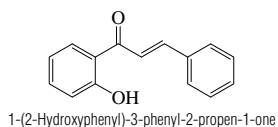
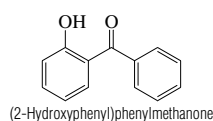
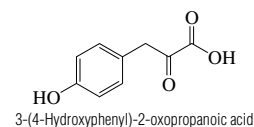
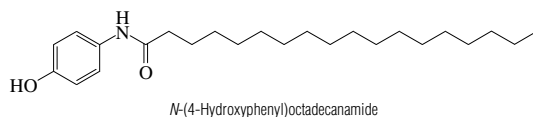
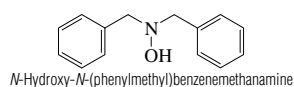
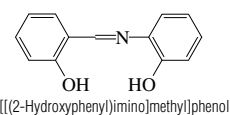
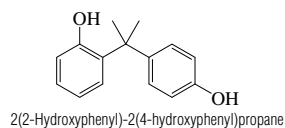
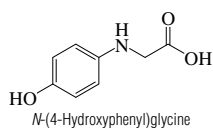
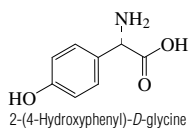
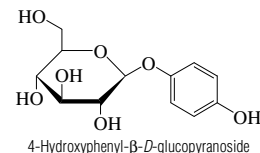
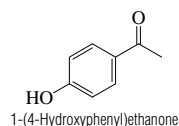
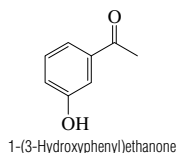
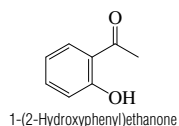
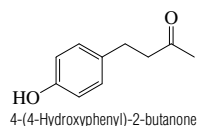
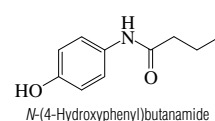
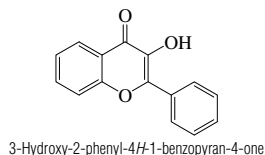
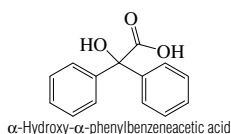
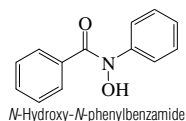
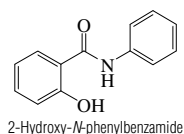
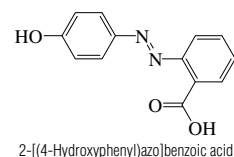
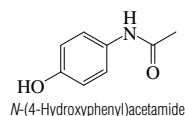
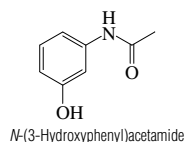
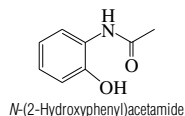
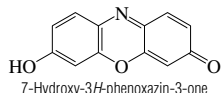
3-Hydroxy-2-methylpropanoic acid

*N*-(Hydroxymethyl)-2-propenamide4-Hydroxy-6-methyl-2*H*-pyran-2-one3-Hydroxy-2-methyl-4*H*-pyran-4-one

| No.  | Name                                                     | Synonym                                | Mol. Form.                                                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|----------------------------------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------|------------|----------|----------------------------|---------|------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 6107 | 5-Hydroxy-6-methyl-3,4-pyridinedimethanol                | Pyridoxin                              | C <sub>8</sub> H <sub>11</sub> NO <sub>3</sub>                                                | 65-23-6    | 169.178  | nd (HOAc)                  | 160     | 140 <sup>0.0001</sup>  |                            |                      |                                                        |
| 6108 | 4-Hydroxy-1-methyl-2-quinolinone                         | 4-Hydroxy- <i>N</i> -methylcarbostyryl | C <sub>10</sub> H <sub>9</sub> NO <sub>2</sub>                                                | 1677-46-9  | 175.184  |                            | 265     |                        |                            |                      | sl DMSO                                                |
| 6109 | 2-Hydroxy-4-(methylthio)butanoic acid                    | Methionine hydroxy analog              | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub> S                                               | 583-91-5   | 150.196  | oil                        |         |                        |                            |                      |                                                        |
| 6110 | 3-Hydroxy- $\alpha$ -methyl- <i>L</i> -tyrosine          | Methyl dopa                            | C <sub>10</sub> H <sub>13</sub> NO <sub>4</sub>                                               | 555-30-6   | 211.215  | cry (MeOH)                 | 300 dec |                        |                            |                      |                                                        |
| 6111 | (Hydroxymethyl)urea                                      |                                        | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                                   | 1000-82-4  | 90.081   | pr (al)                    | 111     |                        |                            |                      | vs H <sub>2</sub> O; s EtOH, MeOH, HOAc; i eth         |
| 6112 | 2-Hydroxy-1-naphthalenecarboxaldehyde                    |                                        | C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                                                 | 708-06-5   | 172.181  | pr (al), nd (AcOEt)        | 83      | 192 <sup>27</sup>      |                            |                      | i H <sub>2</sub> O; s EtOH, eth, aq alk, sulf, peth    |
| 6113 | 2-Hydroxy-1-naphthalenecarboxylic acid                   | 2-Hydroxy-1-naphthoic acid             | C <sub>11</sub> H <sub>8</sub> O <sub>3</sub>                                                 | 2283-08-1  | 188.180  |                            | 157.3   |                        |                            |                      | sl H <sub>2</sub> O; vs EtOH; s eth, ace, bz, lig, chl |
| 6114 | 1-Hydroxy-2-naphthalenecarboxylic acid                   | 1-Hydroxy-2-naphthoic acid             | C <sub>11</sub> H <sub>8</sub> O <sub>3</sub>                                                 | 86-48-6    | 188.180  | cry (al) nd (al, eth, bz)  | 195     |                        |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz                |
| 6115 | 3-Hydroxy-2-naphthalenecarboxylic acid                   | 3-Hydroxy-2-naphthoic acid             | C <sub>11</sub> H <sub>8</sub> O <sub>3</sub>                                                 | 92-70-6    | 188.180  | nd (dil al) ye lf (dil al) | 222.5   |                        |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz, chl, tol      |
| 6116 | 2-Hydroxy-1,4-naphthalenedione                           | Lawsone                                | C <sub>10</sub> H <sub>6</sub> O <sub>3</sub>                                                 | 83-72-7    | 174.153  | ye pr (HOAc)               | 195 dec |                        |                            |                      | vs EtOH; i eth, bz, chl; s HOAc                        |
| 6117 | 5-Hydroxy-1,4-naphthalenedione                           | Juglone                                | C <sub>10</sub> H <sub>6</sub> O <sub>3</sub>                                                 | 481-39-0   | 174.153  | ye nd (bz) peth            | 155     | sub                    |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz; vs chl; sl lig    |
| 6118 | 7-Hydroxy-1,3-naphthalenedisulfonic acid                 | 2-Naphthol-6,8-disulfonic acid         | C <sub>10</sub> H <sub>6</sub> O <sub>7</sub> S <sub>2</sub>                                  | 118-32-1   | 304.297  |                            |         |                        |                            |                      | s H <sub>2</sub> O                                     |
| 6119 | 3-Hydroxy-2,7-naphthalenedisulfonic acid                 | 2-Naphthol-3,6-disulfonic acid         | C <sub>10</sub> H <sub>6</sub> O <sub>7</sub> S <sub>2</sub>                                  | 148-75-4   | 304.297  | hyg nd                     | dec     |                        |                            |                      | vs H <sub>2</sub> O, EtOH                              |
| 6120 | 6-Hydroxy-2-naphthalenepropanoic acid                    | Allenolic acid                         | C <sub>13</sub> H <sub>12</sub> O <sub>3</sub>                                                | 553-39-9   | 216.232  | cry (dil MeOH)             | 180.5   |                        |                            |                      | vs py, EtOH, MeOH                                      |
| 6121 | 4-Hydroxy-1-naphthalenesulfonic acid                     | 1-Naphthol-4-sulfonic acid             | C <sub>10</sub> H <sub>6</sub> O <sub>4</sub> S                                               | 84-87-7    | 224.234  | tab or pl (w)              | 170 dec |                        |                            |                      | vs H <sub>2</sub> O; i eth                             |
| 6122 | 7-Hydroxy-1-naphthalenesulfonic acid                     | Croceic acid                           | C <sub>10</sub> H <sub>6</sub> O <sub>4</sub> S                                               | 132-57-0   | 224.234  |                            |         |                        |                            |                      | s H <sub>2</sub> O                                     |
| 6123 | 1-Hydroxy-2-naphthalenesulfonic acid                     | 1-Naphthol-2-sulfonic acid             | C <sub>10</sub> H <sub>6</sub> O <sub>4</sub> S                                               | 567-18-0   | 224.234  | pl (w)                     | >250    |                        |                            |                      | sl H <sub>2</sub> O, dil HCl; s EtOH; i eth            |
| 6124 | 6-Hydroxy-2-naphthalenesulfonic acid                     | 2-Naphthol-6-sulfonic acid             | C <sub>10</sub> H <sub>6</sub> O <sub>4</sub> S                                               | 93-01-6    | 224.234  | lf, cry (w+1)              | 125     |                        |                            |                      | vs H <sub>2</sub> O, EtOH; i eth; s HOAc               |
| 6125 | Hydroxynaphthol blue, trisodium salt                     |                                        | C <sub>20</sub> H <sub>14</sub> N <sub>2</sub> Na <sub>3</sub> O <sub>11</sub> S <sub>3</sub> | 63451-35-4 | 623.495  | dk red cry                 |         |                        |                            |                      |                                                        |
| 6126 | <i>N</i> -(2-Hydroxy-1-naphthyl)acetamide                |                                        | C <sub>12</sub> H <sub>11</sub> NO <sub>2</sub>                                               | 117-93-1   | 201.221  | lf (w, dil al)             | 235 dec | sub                    |                            |                      | vs ace, bz, eth, EtOH                                  |
| 6127 | 1-(1-Hydroxy-2-naphthyl)ethanone                         |                                        | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                                                | 711-79-5   | 186.206  | pr (bz, lig) gm-ye nd (al) | 101     | dec 325                |                            |                      | vs bz, HOAc                                            |
| 6128 | 2-Hydroxy-3-nitrobenzaldehyde                            |                                        | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                                                 | 5274-70-4  | 167.120  | nd (HOAc)                  | 109.5   |                        |                            |                      | vs bz, EtOH                                            |
| 6129 | 2-Hydroxy-5-nitrobenzaldehyde                            |                                        | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                                                 | 97-51-8    | 167.120  | cry (dil HOAc)             | 127.0   |                        |                            |                      | s ace                                                  |
| 6130 | 2-Hydroxy-3-nitrobenzoic acid                            | 3-Nitrosalicylic acid                  | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub>                                                 | 85-38-1    | 183.119  | ye nd (HOAc, w+1)          | 148     |                        |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s ace, bz, chl      |
| 6131 | 2-Hydroxy-5-nitrobenzoic acid                            | 5-Nitrosalicylic acid                  | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub>                                                 | 96-97-9    | 183.119  | nd (w)                     | 229.5   |                        | 1.650 <sup>20</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth, ace, bz; s chl      |
| 6132 | 2-Hydroxy-1,2,3-nonadecanetricarboxylic acid             | Agaricic acid                          | C <sub>22</sub> H <sub>40</sub> O <sub>7</sub>                                                | 666-99-9   | 416.549  | cry pow                    | 142 dec |                        |                            |                      | s H <sub>2</sub> O; sl EtOH, eth; i bz, chl            |
| 6133 | 12-Hydroxyoctadecanoic acid                              | 12-Hydroxysteric acid                  | C <sub>18</sub> H <sub>36</sub> O <sub>3</sub>                                                | 106-14-9   | 300.477  | cry (al)                   | 82      |                        |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl                   |
| 6134 | <i>cis</i> -12-Hydroxy-9-octadecenoic acid, ( <i>R</i> ) | Ricinoleic acid                        | C <sub>18</sub> H <sub>34</sub> O <sub>3</sub>                                                | 141-22-0   | 298.461  | visc liq                   | 5.5     | 227 <sup>10</sup>      | 0.9450 <sup>21</sup>       | 1.4716 <sup>21</sup> | i H <sub>2</sub> O; vs eth, EtOH                       |
| 6135 | 2-Hydroxyoctanoic acid                                   |                                        | C <sub>8</sub> H <sub>16</sub> O <sub>3</sub>                                                 | 617-73-2   | 160.211  | pl                         | 70      | 162 <sup>10</sup>      |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth                 |
| 6136 | 5-Hydroxy-4-octanone                                     | Butyrolin                              | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                                                 | 496-77-5   | 144.212  | liq                        | -10     | 185                    | 0.9107 <sup>16</sup>       | 1.4345 <sup>16</sup> |                                                        |
| 6137 | [2-Hydroxy-4-(octyloxy)phenyl]phenylmethanone            | Octabenzone                            | C <sub>21</sub> H <sub>26</sub> O <sub>3</sub>                                                | 1843-05-6  | 326.429  |                            | 48.5    |                        |                            |                      |                                                        |
| 6138 | 3-Hydroxy-2-oxopropanoic acid                            | Hydroxypyruvic acid                    | C <sub>3</sub> H <sub>4</sub> O <sub>4</sub>                                                  | 1113-60-6  | 104.062  |                            | 81 dec  |                        |                            |                      |                                                        |
| 6139 | 3-Hydroxy-4-oxo-4 <i>H</i> -pyran-2,6-dicarboxylic acid  | Meconic acid                           | C <sub>7</sub> H <sub>4</sub> O <sub>7</sub>                                                  | 497-59-6   | 200.103  | orth pl (w, dil HCl) (+3w) | 120 dec |                        |                            |                      | sl H <sub>2</sub> O, MeOH, ace, eth; s EtOH, bz        |
| 6140 | 2-Hydroxypentanoic acid                                  |                                        | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                                                 | 617-31-2   | 118.131  | hyg pl                     | 34      | sub                    |                            |                      | s H <sub>2</sub> O, EtOH, eth                          |
| 6141 | 5-Hydroxy-2-pentanone                                    |                                        | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                                                 | 1071-73-4  | 102.132  |                            |         | 209; 117 <sup>33</sup> | 1.0071 <sup>20</sup>       | 1.4390 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth                      |

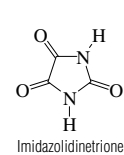
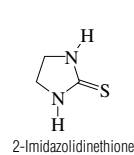
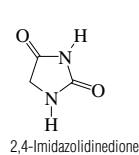
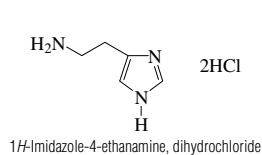
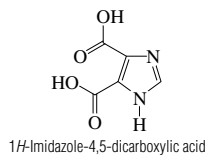
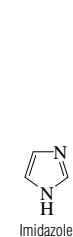
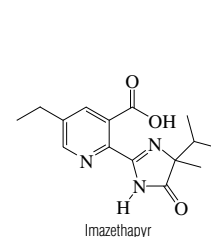
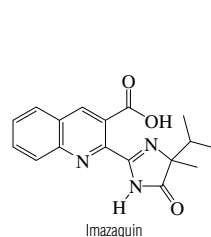
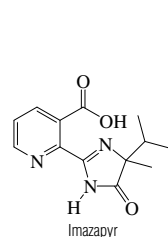
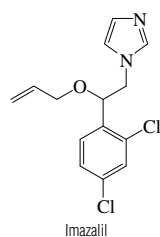
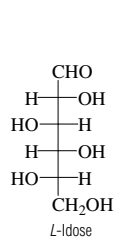
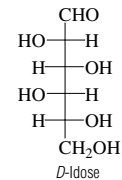
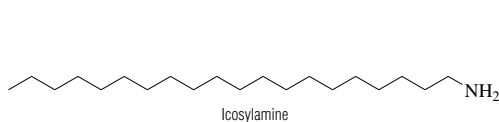
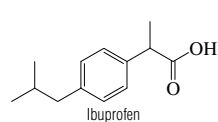
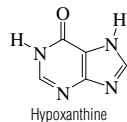
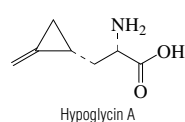
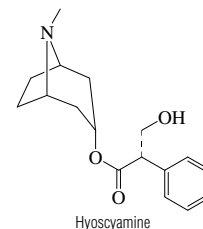
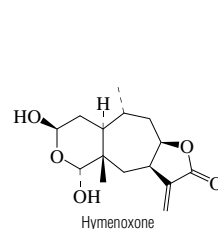
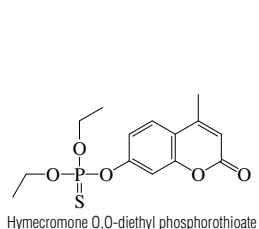
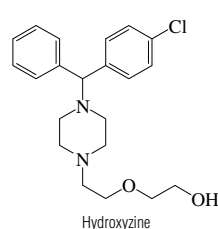
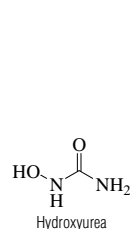
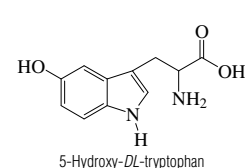
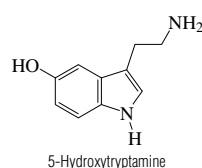
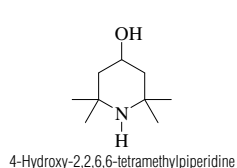
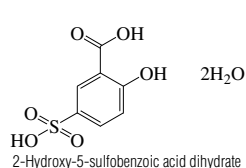
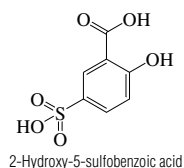
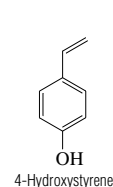
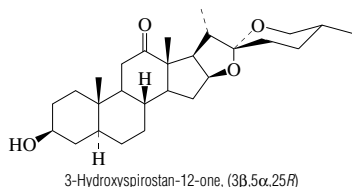
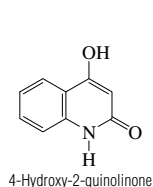
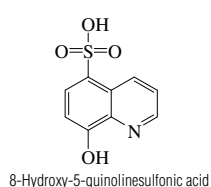
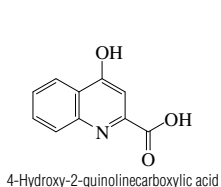
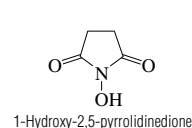
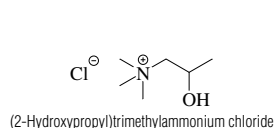
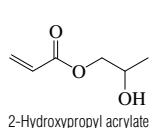
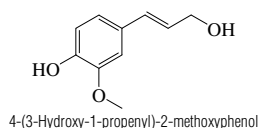
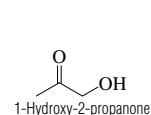
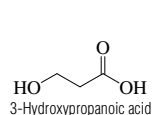
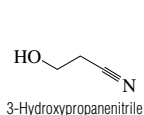
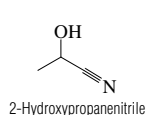
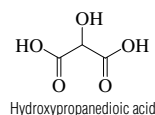
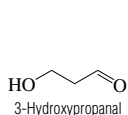


| No.  | Name                                                          | Synonym                                       | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                             | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                      |
|------|---------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------|------------|----------|-------------------------------------------|---------|---------------------------------------|----------------------------|-----------------------|-----------------------------------------------------------------|
| 6142 | 7-Hydroxy-3 <i>H</i> -phenoxazin-3-one                        | Resorufine                                    | C <sub>12</sub> H <sub>7</sub> NO <sub>3</sub>                | 635-78-9   | 213.189  | br nd<br>(PhNO <sub>2</sub> ) pr<br>(HCl) |         |                                       |                            |                       | i H <sub>2</sub> O; sl EtOH; i eth; vs alk                      |
| 6143 | <i>N</i> -(2-Hydroxyphenyl)acetamide                          |                                               | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 614-80-2   | 151.163  | pl (dil al)                               | 209     |                                       |                            |                       | sl H <sub>2</sub> O; vs EtOH, eth, bz; s DMSO                   |
| 6144 | <i>N</i> -(3-Hydroxyphenyl)acetamide                          |                                               | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 621-42-1   | 151.163  | nd (w)                                    | 148.5   |                                       |                            |                       | vs H <sub>2</sub> O; EtOH; sl eth, bz, chl, DMSO                |
| 6145 | <i>N</i> -(4-Hydroxyphenyl)acetamide                          | Acetaminophen                                 | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                 | 103-90-2   | 151.163  | mcl pr (w)                                | 170     |                                       | 1.293 <sup>21</sup>        |                       | i H <sub>2</sub> O; vs EtOH                                     |
| 6146 | 2-[(4-Hydroxyphenyl)azo]benzoic acid                          |                                               | C <sub>13</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub> | 1634-82-8  | 242.229  |                                           | 206     |                                       |                            |                       | sl DMSO                                                         |
| 6147 | 2-Hydroxy- <i>N</i> -phenylbenzamide                          | Salicylanilide                                | C <sub>13</sub> H <sub>11</sub> NO <sub>2</sub>               | 87-17-2    | 213.232  | pr (w, al)                                | 136.5   |                                       |                            |                       | s H <sub>2</sub> O; sl EtOH, eth, bz, chl                       |
| 6148 | <i>N</i> -Hydroxy- <i>N</i> -phenylbenzamide                  |                                               | C <sub>13</sub> H <sub>11</sub> NO <sub>2</sub>               | 304-88-1   | 213.232  |                                           | 120.3   |                                       |                            |                       |                                                                 |
| 6149 | $\alpha$ -Hydroxy- $\alpha$ -phenylbenzeneacetic acid         | Benzilic acid                                 | C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>                | 76-93-7    | 228.243  | mcl nd (w)                                | 150     | dec 180                               |                            |                       | sl H <sub>2</sub> O, ace; vs EtOH, eth; s con sulf              |
| 6150 | 3-Hydroxy-2-phenyl-4 <i>H</i> -1-benzopyran-4-one             |                                               | C <sub>15</sub> H <sub>10</sub> O <sub>3</sub>                | 577-85-5   | 238.238  | pa ye nd (al)                             | 169.5   |                                       |                            |                       | s EtOH                                                          |
| 6151 | <i>N</i> -(4-Hydroxyphenyl)butanamide                         | 4'-Hydroxybutyrilide                          | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>               | 101-91-7   | 179.216  | nd (w)                                    | 139.5   |                                       |                            |                       | vs H <sub>2</sub> O, EtOH                                       |
| 6152 | 4-(4-Hydroxyphenyl)-2-butanone                                |                                               | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 5471-51-2  | 164.201  |                                           | 82.5    |                                       |                            |                       |                                                                 |
| 6153 | 1-(2-Hydroxyphenyl)ethanone                                   |                                               | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                  | 118-93-4   | 136.149  |                                           | 2.5     | 218                                   | 1.1307 <sup>20</sup>       | 1.5584 <sup>20</sup>  | vs eth, EtOH, HOAc                                              |
| 6154 | 1-(3-Hydroxyphenyl)ethanone                                   |                                               | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                  | 121-71-1   | 136.149  | nd or lf                                  | 96      | 296; 153 <sup>5</sup>                 | 1.0992 <sup>109</sup>      | 1.5348 <sup>109</sup> | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl; i lig               |
| 6155 | 1-(4-Hydroxyphenyl)ethanone                                   |                                               | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                  | 99-93-4    | 136.149  | nd (eth, dil al)                          | 109.5   | 147 <sup>3</sup>                      | 1.1090 <sup>109</sup>      | 1.5577 <sup>109</sup> | sl H <sub>2</sub> O, DMSO; vs EtOH, eth                         |
| 6156 | 4-Hydroxyphenyl- $\beta$ - <i>D</i> -glucopyranoside          | Arbutin                                       | C <sub>12</sub> H <sub>16</sub> O <sub>7</sub>                | 497-76-7   | 272.251  | nd (w+1)                                  | 199.5   |                                       |                            |                       | vs H <sub>2</sub> O; s EtOH; sl eth; i bz, chl, CS <sub>2</sub> |
| 6157 | 2-(4-Hydroxyphenyl)- <i>D</i> -glycine                        | Oxfenicine                                    | C <sub>8</sub> H <sub>9</sub> NO <sub>3</sub>                 | 22818-40-2 | 167.162  | cry                                       | 240 dec |                                       |                            |                       |                                                                 |
| 6158 | <i>N</i> -(4-Hydroxyphenyl)glycine                            |                                               | C <sub>8</sub> H <sub>9</sub> NO <sub>3</sub>                 | 122-87-2   | 167.162  | lf (w) pl (w)                             | 246 dec |                                       |                            |                       | sl H <sub>2</sub> O, EtOH; i eth; s AcOEt, chl                  |
| 6159 | 2(2-Hydroxyphenyl)-2(4-hydroxyphenyl)propane                  | 2,4'-Isopropylidenediphenol                   | C <sub>15</sub> H <sub>16</sub> O <sub>2</sub>                | 837-08-1   | 228.287  | cry (bz)                                  | 111     |                                       |                            |                       |                                                                 |
| 6160 | 2-[[2-(2-Hydroxyphenyl)imino]methyl]phenol                    | <i>N</i> -Salicylidene- <i>o</i> -aminophenol | C <sub>13</sub> H <sub>11</sub> NO <sub>2</sub>               | 1761-56-4  | 213.232  |                                           | 185     |                                       |                            |                       |                                                                 |
| 6161 | <i>N</i> -Hydroxy- <i>N</i> -(phenylmethyl)benzenemethanamine |                                               | C <sub>14</sub> H <sub>15</sub> NO                            | 621-07-8   | 213.275  |                                           | 122.5   |                                       |                            |                       | s chl                                                           |
| 6162 | <i>N</i> -(4-Hydroxyphenyl)octadecanamide                     |                                               | C <sub>24</sub> H <sub>41</sub> NO <sub>2</sub>               | 103-99-1   | 375.589  |                                           | 133.8   | 239.5 <sup>10</sup>                   |                            |                       | i H <sub>2</sub> O; sl eth, bz, chl; s ace                      |
| 6163 | 3-(4-Hydroxyphenyl)-2-oxopropanoic acid                       | 4-Hydroxy- $\alpha$ -oxobenzenepropanoic acid | C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                  | 156-39-8   | 180.158  | cry (w)                                   | 220 dec |                                       |                            |                       | s H <sub>2</sub> O; dec alk                                     |
| 6164 | (2-Hydroxyphenyl)phenylmethanone                              |                                               | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                | 117-99-7   | 198.217  | pl (dil al)                               | 40      | 250 <sup>60</sup>                     |                            |                       | i H <sub>2</sub> O; vs EtOH, eth, bz; sl chl, peth              |
| 6165 | 1-(2-Hydroxyphenyl)-3-phenyl-2-propen-1-one                   | 2'-Hydroxychalcone                            | C <sub>15</sub> H <sub>12</sub> O <sub>2</sub>                | 1214-47-7  | 224.255  |                                           | 90      |                                       |                            |                       |                                                                 |
| 6166 | 2-Hydroxy-1-phenyl-1-propanone                                |                                               | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 5650-40-8  | 150.174  | ye oil                                    |         | 251                                   | 1.1085 <sup>18</sup>       | 1.536 <sup>23</sup>   |                                                                 |
| 6167 | 1-(2-Hydroxyphenyl)-1-propanone                               |                                               | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 610-99-1   | 150.174  |                                           |         | 150 <sup>80</sup> , 115 <sup>15</sup> |                            | 1.5501 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth, etc, alk                      |
| 6168 | 1-(4-Hydroxyphenyl)-1-propanone                               | Paroxypropione                                | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 70-70-2    | 150.174  | wh nd or pl (w)                           | 149     |                                       |                            |                       | sl H <sub>2</sub> O, ace; s EtOH, eth, alk                      |
| 6169 | 3-(4-Hydroxyphenyl)-2-propenoic acid                          | <i>p</i> -Coumaric acid                       | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                  | 7400-08-0  | 164.158  | nd                                        | 211.5   |                                       |                            |                       | vs eth, EtOH                                                    |
| 6170 | 3-Hydroxy-2-phenyl-4-quinolinecarboxylic acid                 | Oxycinchophen                                 | C <sub>16</sub> H <sub>11</sub> NO <sub>3</sub>               | 485-89-2   | 265.263  | ye pr (al)                                | 206 dec |                                       |                            |                       | vs bz, EtOH, HOAc                                               |
| 6171 | <i>N</i> -Hydroxypiperidine                                   | 1-Piperidinol                                 | C <sub>6</sub> H <sub>11</sub> NO                             | 4801-58-5  | 101.147  | hyg                                       | 39.3    | 110 <sup>55</sup>                     |                            |                       |                                                                 |
| 6172 | 3-Hydroxypregnan-20-one, (3 $\alpha$ ,5 $\alpha$ )            | Allopregnan-3 $\alpha$ -ol-20-one             | C <sub>21</sub> H <sub>34</sub> O <sub>2</sub>                | 516-54-1   | 318.494  | cry (al)                                  | 177     |                                       |                            |                       |                                                                 |
| 6173 | 3-Hydroxypregnan-20-one, (3 $\beta$ ,5 $\alpha$ )             | Allopregnan-3 $\beta$ -ol-20-one              | C <sub>21</sub> H <sub>34</sub> O <sub>2</sub>                | 516-55-2   | 318.494  |                                           | 189.5   |                                       |                            |                       |                                                                 |
| 6174 | 17-Hydroxypregn-4-ene-3,20-dione                              | 17 $\alpha$ -Hydroxyprogesterone              | C <sub>21</sub> H <sub>30</sub> O <sub>3</sub>                | 68-96-2    | 330.461  |                                           |         |                                       |                            |                       | sl chl                                                          |
| 6175 | 21-Hydroxypregn-4-ene-3,20-dione                              | Deoxycorticosterone                           | C <sub>21</sub> H <sub>30</sub> O <sub>3</sub>                | 64-85-7    | 330.461  | pl (eth)                                  | 141.5   |                                       |                            |                       | sl H <sub>2</sub> O, eth; vs EtOH, ace; s chl                   |
| 6176 | 21-Hydroxypregn-4-ene-3,11,20-trione                          | 11-Dehydrocorticosterone                      | C <sub>21</sub> H <sub>28</sub> O <sub>4</sub>                | 72-23-1    | 344.445  | pr (ace-w, al, ace-eth)                   | 183.5   |                                       |                            |                       | i H <sub>2</sub> O; s EtOH, ace, bz                             |
| 6177 | <i>cis</i> -4-Hydroxy- <i>L</i> -proline                      |                                               | C <sub>5</sub> H <sub>9</sub> NO <sub>3</sub>                 | 618-27-9   | 131.130  | nd (w+1)                                  | 239.5   |                                       |                            |                       | vs H <sub>2</sub> O                                             |
| 6178 | <i>trans</i> -4-Hydroxy- <i>L</i> -proline                    |                                               | C <sub>5</sub> H <sub>9</sub> NO <sub>3</sub>                 | 51-35-4    | 131.130  | lf (dil al) pr (w)                        | 274     |                                       |                            |                       | vs H <sub>2</sub> O; sl EtOH                                    |

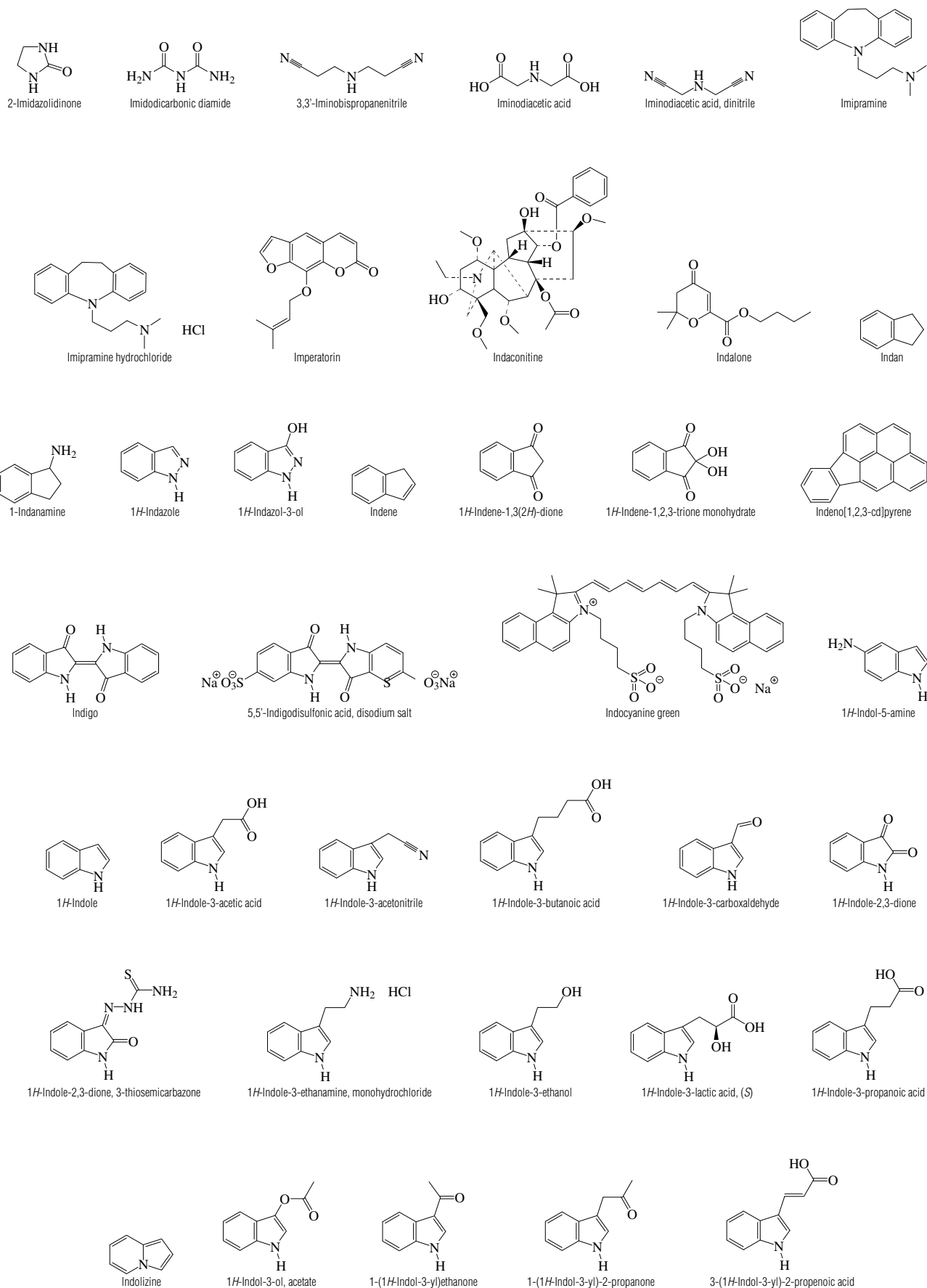




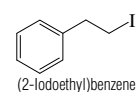
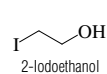
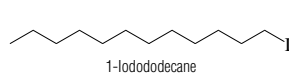
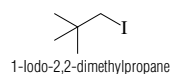
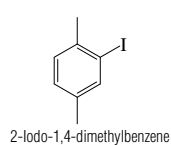
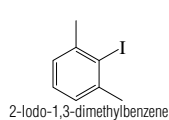
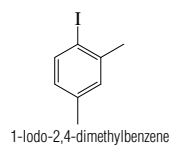
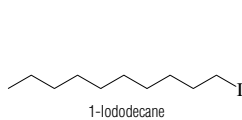
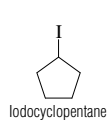
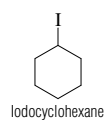
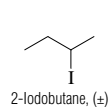
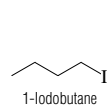
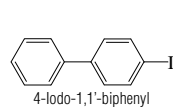
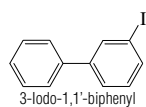
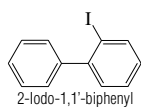
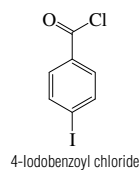
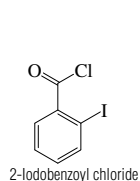
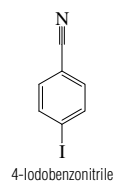
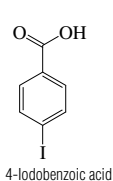
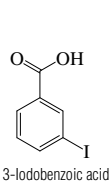
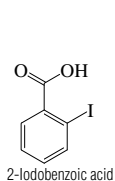
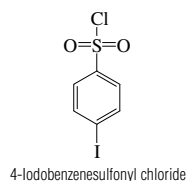
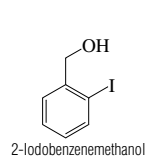
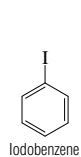
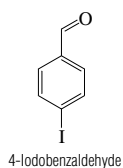
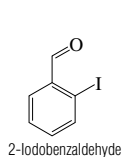
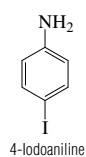
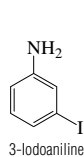
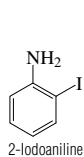
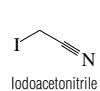
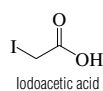
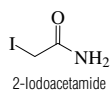
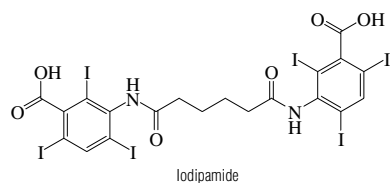
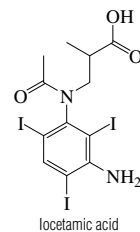
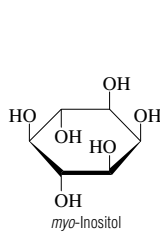
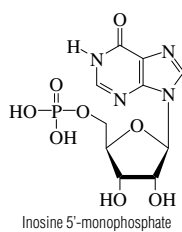
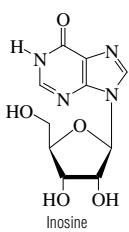
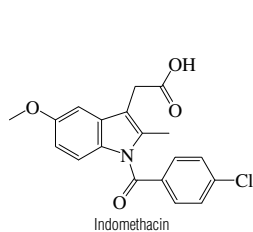
| No.  | Name                                                | Synonym                            | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                       |
|------|-----------------------------------------------------|------------------------------------|------------------------------------------------------------------|------------|----------|---------------------------|---------|-------------------------------------|----------------------------|-----------------------|------------------------------------------------------------------|
| 6179 | 3-Hydroxypropanal                                   | Hydracrolein                       | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                     | 2134-29-4  | 74.079   |                           |         | 90 <sup>18</sup> , 38 <sup>92</sup> |                            |                       | vs ace, eth, EtOH                                                |
| 6180 | Hydroxypropanedioic acid                            | Tartronic acid                     | C <sub>3</sub> H <sub>4</sub> O <sub>5</sub>                     | 80-69-3    | 120.061  | pr (w+1)                  | 157     | sub                                 |                            |                       | s H <sub>2</sub> O, EtOH; sl eth                                 |
| 6181 | 2-Hydroxypropanenitrile                             | Acetaldehyde cyanohydrin           | C <sub>3</sub> H <sub>5</sub> NO                                 | 78-97-7    | 71.078   | liq                       | -40     | 183                                 | 0.9877 <sup>20</sup>       | 1.4058 <sup>18</sup>  | msc H <sub>2</sub> O, EtOH; s eth, chl; i CS <sub>2</sub> , peth |
| 6182 | 3-Hydroxypropanenitrile                             | Hydracrylonitrile                  | C <sub>3</sub> H <sub>5</sub> NO                                 | 109-78-4   | 71.078   | liq                       | -46     | 221                                 | 1.0404 <sup>25</sup>       | 1.4248 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH; sl eth; s chl; i CS <sub>2</sub>     |
| 6183 | 3-Hydroxypropanoic acid                             | Hydracrylic acid                   | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                     | 503-66-2   | 90.078   | syr                       |         | dec                                 |                            | 1.4489 <sup>20</sup>  | vs H <sub>2</sub> O; s EtOH; msc eth                             |
| 6184 | 1-Hydroxy-2-propanone                               | Acetone alcohol                    | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                     | 116-09-6   | 74.079   | hyg liq                   | -17     | 145.5                               | 1.0805 <sup>20</sup>       | 1.4295 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH, eth                                   |
| 6185 | 4-(3-Hydroxy-1-propenyl)-2-methoxyphenol            | Coniferyl alcohol                  | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                   | 458-35-5   | 180.200  | pr (eth-lig)              | 74      | 164 <sup>3</sup>                    |                            |                       | i H <sub>2</sub> O; s EtOH, alk; vs eth                          |
| 6186 | 2-Hydroxypropyl acrylate                            |                                    | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                    | 999-61-1   | 130.141  | liq                       |         | 70 <sup>2</sup>                     |                            |                       |                                                                  |
| 6187 | (2-Hydroxypropyl) trimethylammonium chloride        |                                    | C <sub>6</sub> H <sub>16</sub> ClNO                              | 2382-43-6  | 153.650  | pr (Bu OH)                | 165     | dec                                 |                            |                       | vs H <sub>2</sub> O, EtOH                                        |
| 6188 | 3-Hydroxy-1 <i>H</i> -pyridin-2-one                 |                                    | C <sub>6</sub> H <sub>6</sub> NO <sub>2</sub>                    | 16867-04-2 | 111.100  |                           | 245 dec |                                     |                            |                       |                                                                  |
| 6189 | 1-Hydroxy-2,5-pyrrolidinedione                      | <i>N</i> -Hydroxysuccinimide       | C <sub>4</sub> H <sub>6</sub> NO <sub>3</sub>                    | 6066-82-6  | 115.088  | hyg                       | 96.3    |                                     |                            |                       | sl DMSO                                                          |
| 6190 | 4-Hydroxy-2-quinolinecarboxylic acid                | Kynurenic acid                     | C <sub>10</sub> H <sub>7</sub> NO <sub>3</sub>                   | 492-27-3   | 189.168  | ye nd (+w, dil al)        | 282.5   |                                     |                            |                       | sl H <sub>2</sub> O; s EtOH; i eth; vs alk                       |
| 6191 | 8-Hydroxy-5-quinolinesulfonic acid                  |                                    | C <sub>9</sub> H <sub>7</sub> NO <sub>3</sub> S                  | 84-88-8    | 225.222  | ye lf, nd (+1w) (dil HCl) | 322.5   |                                     |                            |                       | sl H <sub>2</sub> O                                              |
| 6192 | 4-Hydroxy-2-quinolinone                             | 2,4-Quinolinediol                  | C <sub>9</sub> H <sub>7</sub> NO <sub>2</sub>                    | 86-95-3    | 161.158  |                           | 360 dec |                                     |                            |                       | sl EtOH, PhNO <sub>2</sub> , gl HOAc                             |
| 6193 | 3-Hydroxyspirostan-12-one, (3β,5α,25 <i>R</i> )     | Hecogenin                          | C <sub>27</sub> H <sub>42</sub> O <sub>4</sub>                   | 467-55-0   | 430.620  | pl (eth)                  | 266.5   |                                     |                            |                       | vs ace, eth, EtOH                                                |
| 6194 | 4-Hydroxystyrene                                    | 4-Vinylphenol                      | C <sub>8</sub> H <sub>8</sub> O                                  | 2628-17-3  | 120.149  |                           | 73.5    |                                     |                            |                       |                                                                  |
| 6195 | 2-Hydroxy-5-sulfobenzoic acid                       | 5-Sulfosalicylic acid              | C <sub>7</sub> H <sub>6</sub> O <sub>5</sub> S                   | 97-05-2    | 218.184  | hyg nd                    | 120     |                                     |                            |                       | vs H <sub>2</sub> O; vs EtOH, eth                                |
| 6196 | 2-Hydroxy-5-sulfobenzoic acid dihydrate             | 5-Sulfosalicylic acid dihydrate    | C <sub>7</sub> H <sub>10</sub> O <sub>6</sub> S                  | 5965-83-3  | 254.214  | wh cry (w)                |         |                                     |                            |                       | vs H <sub>2</sub> O; vs EtOH, eth                                |
| 6197 | 4-Hydroxy-2,2,6,6-tetramethylpiperidine             | 2,2,6,6-Tetramethyl-4-piperidinol  | C <sub>9</sub> H <sub>19</sub> NO                                | 2403-88-5  | 157.253  |                           | 130     | 213.5                               |                            |                       |                                                                  |
| 6198 | 5-Hydroxytryptamine                                 | 3-(2-Aminoethyl)indol-5-ol         | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O                 | 50-67-9    | 176.214  |                           |         |                                     |                            |                       | s H <sub>2</sub> O                                               |
| 6199 | 5-Hydroxy- <i>DL</i> -tryptophan                    |                                    | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>    | 114-03-4   | 220.224  | rod or nd (al)            | 300 dec |                                     |                            |                       |                                                                  |
| 6200 | Hydroxyurea                                         |                                    | CH <sub>3</sub> N <sub>2</sub> O <sub>2</sub>                    | 127-07-1   | 76.055   | nd (al)                   | 141     | dec                                 |                            |                       | vs H <sub>2</sub> O                                              |
| 6201 | Hydroxyzine                                         |                                    | C <sub>21</sub> H <sub>27</sub> ClN <sub>2</sub> O <sub>2</sub>  | 68-88-2    | 374.904  | oil                       |         | 220 <sup>0.5</sup>                  |                            |                       |                                                                  |
| 6202 | Hymecromone 0,0-diethyl phosphorothioate            |                                    | C <sub>14</sub> H <sub>17</sub> O <sub>3</sub> PS                | 299-45-6   | 328.321  | nd                        | 38      | 210 <sup>1.0</sup> dec              | 1.260 <sup>38</sup>        | 1.5685 <sup>37</sup>  | vs H <sub>2</sub> O; sl peth                                     |
| 6203 | Hymenoxone                                          |                                    | C <sub>15</sub> H <sub>22</sub> O <sub>3</sub>                   | 57377-32-9 | 282.333  | cry                       |         |                                     |                            |                       |                                                                  |
| 6204 | Hyoscyamine                                         |                                    | C <sub>17</sub> H <sub>23</sub> NO <sub>3</sub>                  | 101-31-5   | 289.370  | tetr nd (dil al)          | 108.5   |                                     |                            |                       | sl H <sub>2</sub> O, eth, bz; vs EtOH, chl                       |
| 6205 | Hypoglycin A                                        |                                    | C <sub>7</sub> H <sub>11</sub> NO <sub>2</sub>                   | 156-56-9   | 141.168  | ye pl (Me aq)             | 282     |                                     |                            |                       |                                                                  |
| 6206 | Hypoxanthine                                        |                                    | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O                   | 68-94-0    | 136.112  | oct nd (w)                | 150 dec |                                     |                            |                       | sl H <sub>2</sub> O; s alk, dil acid                             |
| 6207 | Ibuprofen                                           | 2-(4-Isobutylphenyl)propanoic acid | C <sub>13</sub> H <sub>18</sub> O <sub>2</sub>                   | 15687-27-1 | 206.281  | col cry                   | 76      |                                     |                            |                       | sl H <sub>2</sub> O; s os                                        |
| 6208 | Icosylamine                                         | 1-Eicosanamine                     | C <sub>20</sub> H <sub>42</sub> N                                | 10525-37-8 | 297.562  |                           |         | 372.4                               |                            |                       |                                                                  |
| 6209 | <i>D</i> -Idose                                     |                                    | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                    | 5978-95-0  | 180.155  | syr                       |         |                                     |                            |                       | vs H <sub>2</sub> O                                              |
| 6210 | <i>L</i> -Idose                                     |                                    | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                    | 5934-56-5  | 180.155  | syr                       |         |                                     |                            |                       | vs H <sub>2</sub> O                                              |
| 6211 | Imazalil                                            |                                    | C <sub>14</sub> H <sub>14</sub> Cl <sub>2</sub> N <sub>2</sub> O | 35554-44-0 | 297.179  |                           | 50      | dec                                 | 1.243 <sup>23</sup>        |                       |                                                                  |
| 6212 | Imazapyr                                            |                                    | C <sub>13</sub> H <sub>15</sub> N <sub>3</sub> O <sub>3</sub>    | 81334-34-1 | 261.276  |                           | 171     |                                     |                            |                       |                                                                  |
| 6213 | Imazaquin                                           |                                    | C <sub>17</sub> H <sub>17</sub> N <sub>3</sub> O <sub>3</sub>    | 81335-37-7 | 311.335  |                           | 221     |                                     |                            |                       |                                                                  |
| 6214 | Imazethapyr                                         |                                    | C <sub>15</sub> H <sub>19</sub> N <sub>3</sub> O <sub>3</sub>    | 81335-77-5 | 289.330  |                           | 173     |                                     |                            |                       |                                                                  |
| 6215 | Imidazole                                           | 1,3-Diazole                        | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>                     | 288-32-4   | 68.077   | mcl pr (bz)               | 89.5    | 257                                 | 1.0303 <sup>101</sup>      | 1.4801 <sup>101</sup> | vs H <sub>2</sub> O, EtOH; s eth, ace, py; sl bz                 |
| 6216 | 1 <i>H</i> -Imidazole-4,5-dicarboxylic acid         |                                    | C <sub>5</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>      | 570-22-9   | 156.097  | pr                        | 290 dec |                                     | 1.749 <sup>25</sup>        |                       | sl H <sub>2</sub> O, py; i EtOH, eth, bz                         |
| 6217 | 1 <i>H</i> -Imidazole-4-ethanamine, dihydrochloride |                                    | C <sub>5</sub> H <sub>11</sub> Cl <sub>2</sub> N <sub>3</sub>    | 56-92-8    | 184.066  | pl (eth-HOAc), pr (w)     | 251.3   |                                     | 1.43 <sup>20</sup>         |                       | vs H <sub>2</sub> O, MeOH                                        |
| 6218 | 2,4-Imidazolidinedione                              | Hydantoin                          | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>      | 461-72-3   | 100.076  | nd (MeOH), lf (w)         | 220     |                                     |                            |                       | s H <sub>2</sub> O, EtOH, alk; sl eth; i peth                    |
| 6219 | 2-Imidazolidinethione                               | Ethylene thiourea                  | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> S                   | 96-45-7    | 102.158  | nd (al), pr (al)          | 203     |                                     |                            |                       | vs H <sub>2</sub> O; s EtOH; i eth, bz, chl; sl DMSO             |
| 6220 | Imidazolidinetrione                                 | Parabanic acid                     | C <sub>3</sub> H <sub>2</sub> N <sub>2</sub> O <sub>3</sub>      | 120-89-8   | 114.059  | mcl nd (w)                | 244 dec | sub 100                             |                            |                       | s H <sub>2</sub> O; vs EtOH                                      |



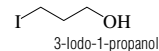
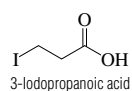
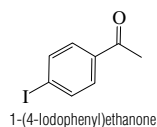
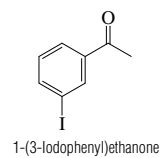
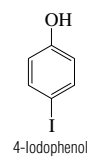
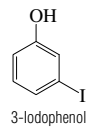
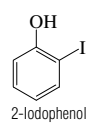
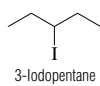
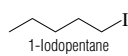
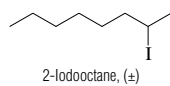
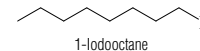
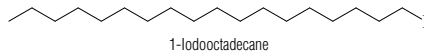
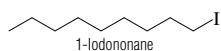
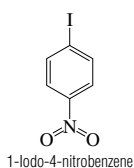
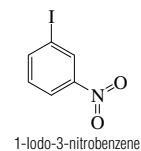
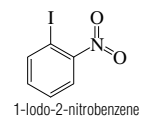
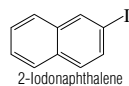
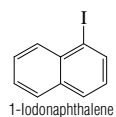
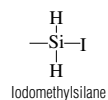
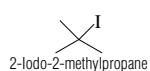
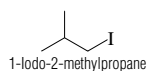
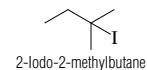
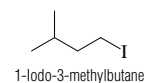
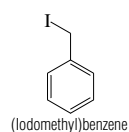
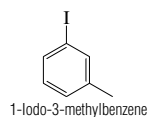
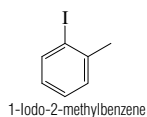
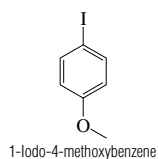
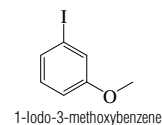
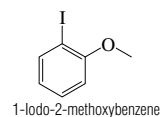
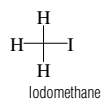
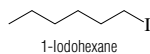
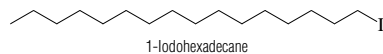
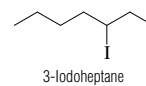
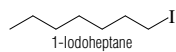
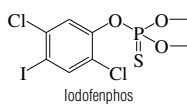
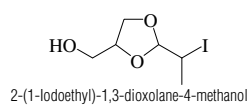
| No.  | Name                                               | Synonym                                       | Mol. Form.                                                                                  | CAS RN     | Mol. Wt. | Physical Form                 | mp/°C   | bp/°C                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|----------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------|------------|----------|-------------------------------|---------|----------------------|----------------------------|----------------------|----------------------------------------------------------|
| 6221 | 2-Imidazolidinone                                  | Ethylene urea                                 | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O                                              | 120-93-4   | 86.092   |                               | 131     |                      |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth, chl                   |
| 6222 | Imidodicarbonic diamide                            | Biuret                                        | C <sub>2</sub> H <sub>4</sub> N <sub>3</sub> O <sub>2</sub>                                 | 108-19-0   | 103.080  | pl (al), nd (w+1)             | 190 dec |                      |                            |                      | sl H <sub>2</sub> O; vs EtOH; l eth                      |
| 6223 | 3,3'-Iminobispropanenitrile                        | Bis(2-cyanoethyl)amine                        | C <sub>6</sub> H <sub>8</sub> N <sub>3</sub>                                                | 111-94-4   | 123.155  |                               | -6      | 162 <sup>5</sup>     | 1.0165 <sup>20</sup>       |                      |                                                          |
| 6224 | Iminodiacetic acid                                 |                                               | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>                                               | 142-73-4   | 133.104  | orth pr                       | 247.5   |                      |                            |                      | sl H <sub>2</sub> O; i EtOH, eth                         |
| 6225 | Iminodiacetic acid, dinitrile                      | 2,2'-Iminobisacetoneitrile                    | C <sub>4</sub> H <sub>5</sub> N <sub>3</sub>                                                | 628-87-5   | 95.103   |                               | 78      |                      |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, bz, chl                |
| 6226 | Imipramine                                         |                                               | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub>                                              | 50-49-7    | 280.407  |                               |         | 160 <sup>0.1</sup>   |                            |                      |                                                          |
| 6227 | Imipramine hydrochloride                           | Tofranil                                      | C <sub>19</sub> H <sub>25</sub> ClN <sub>2</sub>                                            | 113-52-0   | 316.868  |                               | 174.5   |                      |                            |                      | vs H <sub>2</sub> O; s EtOH; sl ace                      |
| 6228 | Imperatorin                                        |                                               | C <sub>16</sub> H <sub>14</sub> O <sub>4</sub>                                              | 482-44-0   | 270.280  | cry (al)                      | 102     |                      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, peth; vs chl       |
| 6229 | Indaconitine                                       |                                               | C <sub>34</sub> H <sub>47</sub> NO <sub>10</sub>                                            | 4491-19-4  | 629.738  | cry                           | 202 dec |                      |                            |                      | vs eth, EtOH, chl                                        |
| 6230 | Indalone                                           | Butopyronoxyl                                 | C <sub>12</sub> H <sub>18</sub> O <sub>4</sub>                                              | 532-34-3   | 226.269  | ye-red liq                    |         | 263                  | 1.057 <sup>20</sup>        | 1.475 <sup>25</sup>  | i H <sub>2</sub> O; vs EtOH, eth, chl                    |
| 6231 | Indan                                              |                                               | C <sub>9</sub> H <sub>10</sub>                                                              | 496-11-7   | 118.175  | liq                           | -51.38  | 177.97               | 0.9639 <sup>20</sup>       | 1.5378 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl chl                |
| 6232 | 1-Indanamine                                       | 1-Aminoindane                                 | C <sub>9</sub> H <sub>11</sub> N                                                            | 34698-41-4 | 133.190  |                               |         | 221; 96 <sup>3</sup> | 1.038 <sup>15</sup>        | 1.5613 <sup>20</sup> | sl H <sub>2</sub> O; s eth, ace, bz                      |
| 6233 | 1 <i>H</i> -Indazole                               | 1 <i>H</i> -Benzopyrazole                     | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                                | 271-44-3   | 118.136  | nd (al, w)                    | 148     | 269                  |                            |                      | s H <sub>2</sub> O, EtOH, eth                            |
| 6234 | 1 <i>H</i> -Indazol-3-ol                           | 1,2-Dihydro-3 <i>H</i> -indazol-3-one         | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O                                              | 7364-25-2  | 134.135  | nd or lf (MeOH) pl or nd (al) | 252.5   |                      |                            |                      | sl H <sub>2</sub> O, eth; s MeOH, EtOH                   |
| 6235 | Indene                                             | Indonaphthene                                 | C <sub>9</sub> H <sub>8</sub>                                                               | 95-13-6    | 116.160  | liq                           | -1.5    | 182                  | 0.9960 <sup>25</sup>       | 1.5768 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace, bz, py; sl chl |
| 6236 | 1 <i>H</i> -Indene-1,3(2 <i>H</i> )-dione          |                                               | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>                                                | 606-23-5   | 146.143  | nd (eth, lig)                 | 131 dec |                      | 1.37 <sup>21</sup>         |                      | sl H <sub>2</sub> O, ctc; vs EtOH; s eth, bz, alk        |
| 6237 | 1 <i>H</i> -Indene-1,2,3-trione monohydrate        | Ninhydrin                                     | C <sub>9</sub> H <sub>6</sub> O <sub>4</sub>                                                | 485-47-2   | 178.142  | pa ye pr (w, al)              | 242 dec |                      |                            |                      | vs H <sub>2</sub> O; s EtOH, alk; sl eth                 |
| 6238 | Indeno[1,2,3- <i>cd</i> ]pyrene                    | 1,10-(1,2-Phenylene)pyrene                    | C <sub>22</sub> H <sub>12</sub>                                                             | 193-39-5   | 276.330  | ye cry (cy)                   | 162     |                      |                            |                      |                                                          |
| 6239 | Indigo                                             |                                               | C <sub>16</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>                               | 482-89-3   | 262.262  | dk bl pow                     | 390 dec | sub 300              |                            |                      |                                                          |
| 6240 | 5,5'-Indigodisulfonic acid, disodium salt          | Indigo Carmine                                | C <sub>16</sub> H <sub>8</sub> N <sub>2</sub> Na <sub>2</sub> O <sub>8</sub> S <sub>2</sub> | 860-22-0   | 466.353  | dk-bl pow                     |         |                      |                            |                      | sl H <sub>2</sub> O, EtOH; i os                          |
| 6241 | Indocyanine green                                  |                                               | C <sub>43</sub> H <sub>47</sub> N <sub>2</sub> NaO <sub>6</sub> S <sub>2</sub>              | 3599-32-4  | 774.962  | grn pow                       | 244 dec |                      |                            |                      |                                                          |
| 6242 | 1 <i>H</i> -Indol-5-amine                          |                                               | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub>                                                | 5192-03-0  | 132.163  |                               | 132     |                      |                            |                      |                                                          |
| 6243 | 1 <i>H</i> -Indole                                 | 2,3-Benzopyrrole                              | C <sub>8</sub> H <sub>7</sub> N                                                             | 120-72-9   | 117.149  | lf (w, peth) cry (eth)        | 52.5    | 253.6                | 1.22 <sup>25</sup>         |                      | s H <sub>2</sub> O, bz; vs EtOH, eth, tol; sl ctc        |
| 6244 | 1 <i>H</i> -Indole-3-acetic acid                   | Indoleacetic acid                             | C <sub>10</sub> H <sub>9</sub> NO <sub>2</sub>                                              | 87-51-4    | 175.184  | lf (bz), pl (chl)             | 168.5   |                      |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, ace, bz; sl chl      |
| 6245 | 1 <i>H</i> -Indole-3-acetonitrile                  |                                               | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                                               | 771-51-7   | 156.184  |                               | 36      | 160 <sup>0.2</sup>   |                            |                      |                                                          |
| 6246 | 1 <i>H</i> -Indole-3-butyric acid                  | Indolebutyric acid                            | C <sub>12</sub> H <sub>13</sub> NO <sub>2</sub>                                             | 133-32-4   | 203.237  |                               | 124.5   |                      |                            |                      | vs bz; s DMSO; l peth                                    |
| 6247 | 1 <i>H</i> -Indole-3-carboxaldehyde                |                                               | C <sub>9</sub> H <sub>7</sub> NO                                                            | 487-89-8   | 145.158  |                               | 197.8   |                      |                            |                      |                                                          |
| 6248 | 1 <i>H</i> -Indole-2,3-dione                       | Isatin                                        | C <sub>8</sub> H <sub>5</sub> NO <sub>2</sub>                                               | 91-56-5    | 147.132  | oran mcl pr                   | 203 dec |                      |                            |                      | s H <sub>2</sub> O, ace, bz; vs EtOH; sl eth             |
| 6249 | 1 <i>H</i> -Indole-2,3-dione, 3-thiosemicarbazone  | Isatin, 3-thiosemicarbazone                   | C <sub>9</sub> H <sub>8</sub> N <sub>4</sub> OS                                             | 487-16-1   | 220.251  |                               | 283     |                      |                            |                      |                                                          |
| 6250 | 1 <i>H</i> -Indole-3-ethanamine, monohydrochloride | Tryptamine hydrochloride                      | C <sub>10</sub> H <sub>13</sub> ClN <sub>2</sub>                                            | 343-94-2   | 196.676  | nd (al-bz or lig)             | 255     |                      |                            |                      | vs ace, EtOH                                             |
| 6251 | 1 <i>H</i> -Indole-3-ethanol                       | Tryptophol                                    | C <sub>10</sub> H <sub>11</sub> NO                                                          | 526-55-6   | 161.200  | pr (bz-peth)                  | 59      | 174 <sup>2</sup>     |                            |                      | vs ace, eth, EtOH, chl                                   |
| 6252 | 1 <i>H</i> -Indole-3-lactic acid, (S)              | α-Hydroxy-1 <i>H</i> -indole-3-propanoic acid | C <sub>11</sub> H <sub>11</sub> NO <sub>3</sub>                                             | 7417-65-4  | 205.210  | cry (peth)                    | 100     |                      |                            |                      |                                                          |
| 6253 | 1 <i>H</i> -Indole-3-propanoic acid                |                                               | C <sub>11</sub> H <sub>11</sub> NO <sub>2</sub>                                             | 830-96-6   | 189.211  |                               | 134.5   |                      |                            |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth, ace, bz         |
| 6254 | Indolizine                                         |                                               | C <sub>8</sub> H <sub>7</sub> N                                                             | 274-40-8   | 117.149  | pl                            | 75      | 205                  |                            |                      | i H <sub>2</sub> O; s EtOH                               |
| 6255 | 1 <i>H</i> -Indol-3-ol, acetate                    |                                               | C <sub>10</sub> H <sub>9</sub> NO <sub>2</sub>                                              | 608-08-2   | 175.184  |                               | 129     |                      |                            |                      |                                                          |
| 6256 | 1-(1 <i>H</i> -Indol-3-yl)ethanone                 |                                               | C <sub>10</sub> H <sub>9</sub> NO                                                           | 703-80-0   | 159.184  | nd (bz)                       | 192.3   | 144 <sup>10</sup>    |                            |                      | vs EtOH                                                  |
| 6257 | 1-(1 <i>H</i> -Indol-3-yl)-2-propanone             | 3-Indolylacetone                              | C <sub>11</sub> H <sub>11</sub> NO                                                          | 1201-26-9  | 173.211  | br orth (bz), nd (aq MeOH)    | 116     |                      |                            |                      |                                                          |
| 6258 | 3-(1 <i>H</i> -Indol-3-yl)-2-propenoic acid        | 3-Indolylacrylic acid                         | C <sub>11</sub> H <sub>9</sub> NO <sub>2</sub>                                              | 1204-06-4  | 187.195  |                               | 185 dec |                      |                            |                      |                                                          |



| No.  | Name                           | Synonym                                                                                      | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form               | mp/°C                         | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                |
|------|--------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|-----------------------------|-------------------------------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------------|
| 6259 | Indomethacin                   |                                                                                              | C <sub>19</sub> H <sub>16</sub> ClNO <sub>4</sub>                            | 53-86-1    | 357.788  |                             | 155 (form a);<br>162 (form b) |                                       |                            |                      |                                                           |
| 6260 | Inosine                        | Hypoxanthine riboside                                                                        | C <sub>10</sub> H <sub>12</sub> N <sub>4</sub> O <sub>5</sub>                | 58-63-9    | 268.226  | pl (w + 2), nd<br>(80% al)  | 218 dec                       |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH                              |
| 6261 | Inosine 5'-monophosphate       | 5'-Inosinic acid                                                                             | C <sub>10</sub> H <sub>13</sub> N <sub>4</sub> O <sub>8</sub> P              | 131-99-7   | 348.206  | visc liq or<br>glass        |                               |                                       |                            |                      | vs H <sub>2</sub> O; sl EtOH,<br>eth                      |
| 6262 | myo-Inositol                   | (1 $\alpha$ ,2 $\alpha$ ,3 $\alpha$ ,4 $\beta$ ,5 $\alpha$ ,6 $\beta$ )-<br>Cyclohexanehexol | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                | 87-89-8    | 180.155  | cry (w)                     | 225                           |                                       | 1.752                      |                      | s H <sub>2</sub> O                                        |
| 6263 | locetamic acid                 |                                                                                              | C <sub>12</sub> H <sub>13</sub> I <sub>3</sub> N <sub>2</sub> O <sub>3</sub> | 16034-77-8 | 613.955  | wh-ye pow                   | 225                           |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>bz, eth, ace              |
| 6264 | Iodipamide                     |                                                                                              | C <sub>20</sub> H <sub>14</sub> I <sub>6</sub> N <sub>2</sub> O <sub>6</sub> | 606-17-7   | 1139.761 |                             | 307 dec                       |                                       |                            |                      | i H <sub>2</sub> O, bz; sl<br>EtOH, eth, ace              |
| 6265 | 2-Iodoacetamide                |                                                                                              | C <sub>2</sub> H <sub>4</sub> IINO                                           | 144-48-9   | 184.963  |                             | 93.0                          |                                       |                            |                      | s H <sub>2</sub> O; sl tfa                                |
| 6266 | Iodoacetic acid                |                                                                                              | C <sub>2</sub> H <sub>3</sub> IO <sub>2</sub>                                | 64-69-7    | 185.948  |                             | 82.5                          | dec                                   |                            |                      | s H <sub>2</sub> O, EtOH,<br>peth; sl eth,<br>chl         |
| 6267 | Iodoacetone                    |                                                                                              | C <sub>3</sub> H <sub>5</sub> IO                                             | 3019-04-3  | 183.975  |                             |                               | 62 <sup>12</sup>                      | 2.17 <sup>15</sup>         |                      | s EtOH                                                    |
| 6268 | Iodoacetoneitrile              |                                                                                              | C <sub>2</sub> H <sub>2</sub> IN                                             | 624-75-9   | 166.948  |                             |                               | 185                                   | 2.307 <sup>25</sup>        | 1.5744 <sup>20</sup> |                                                           |
| 6269 | Iodoacetylene                  |                                                                                              | C <sub>2</sub> HI                                                            | 14545-08-5 | 151.933  |                             |                               | 32                                    |                            |                      |                                                           |
| 6270 | 2-Iodoaniline                  |                                                                                              | C <sub>6</sub> H <sub>6</sub> IN                                             | 615-43-0   | 219.023  | nd (dil al)                 | 60.5                          |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH,<br>eth, ace                 |
| 6271 | 3-Iodoaniline                  |                                                                                              | C <sub>6</sub> H <sub>6</sub> IN                                             | 626-01-7   | 219.023  | lf                          | 33                            | 145 <sup>15</sup>                     |                            | 1.6811 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>chl                        |
| 6272 | 4-Iodoaniline                  |                                                                                              | C <sub>6</sub> H <sub>6</sub> IN                                             | 540-37-4   | 219.023  | nd (w)                      | 67.5                          |                                       |                            |                      | sl H <sub>2</sub> O, peth; s<br>EtOH, eth                 |
| 6273 | 2-Iodobenzaldehyde             |                                                                                              | C <sub>7</sub> H <sub>5</sub> IO                                             | 26260-02-6 | 232.018  |                             | 37                            | 129 <sup>14</sup>                     |                            |                      | sl H <sub>2</sub> O; s ace                                |
| 6274 | 4-Iodobenzaldehyde             |                                                                                              | C <sub>7</sub> H <sub>5</sub> IO                                             | 15164-44-0 | 232.018  |                             | 77.5                          | 265                                   |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>bz                        |
| 6275 | Iodobenzene                    |                                                                                              | C <sub>6</sub> H <sub>5</sub> I                                              | 591-50-4   | 204.008  | liq                         | -31.3                         | 188.4                                 | 1.8308 <sup>20</sup>       | 1.6200 <sup>20</sup> | i H <sub>2</sub> O; s EtOH;<br>msc eth, ace,<br>bz, ctc   |
| 6276 | 2-Iodobenzenemethanol          |                                                                                              | C <sub>7</sub> H <sub>7</sub> IO                                             | 5159-41-1  | 234.034  |                             | 92                            | 148 <sup>32</sup>                     |                            | 1.6349 <sup>20</sup> |                                                           |
| 6277 | 4-Iodobenzenesulfonyl chloride | Pipsyl chloride                                                                              | C <sub>6</sub> H <sub>4</sub> ClIO <sub>2</sub> S                            | 98-61-3    | 302.517  |                             | 85                            |                                       |                            |                      |                                                           |
| 6278 | 2-Iodobenzoic acid             |                                                                                              | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                                | 88-67-5    | 248.018  | nd (w)                      | 163                           | exp 233                               | 2.25 <sup>25</sup>         |                      | sl H <sub>2</sub> O, ace; vs<br>EtOH, eth                 |
| 6279 | 3-Iodobenzoic acid             |                                                                                              | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                                | 618-51-9   | 248.018  | mcl pr (ace)                | 188.3                         | sub                                   |                            |                      | sl H <sub>2</sub> O, eth; vs<br>EtOH                      |
| 6280 | 4-Iodobenzoic acid             |                                                                                              | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                                | 619-58-9   | 248.018  | mcl pr (dil<br>al) lf (sub) | 270                           | sub                                   | 2.184 <sup>20</sup>        |                      | i H <sub>2</sub> O; sl EtOH;<br>s eth, DMSO               |
| 6281 | 4-Iodobenzonitrile             |                                                                                              | C <sub>7</sub> H <sub>4</sub> IN                                             | 3058-39-7  | 229.018  |                             | 127.5                         |                                       |                            |                      |                                                           |
| 6282 | 2-Iodobenzoyl chloride         |                                                                                              | C <sub>7</sub> H <sub>4</sub> ClIO                                           | 609-67-6   | 266.463  |                             | 38.3                          | 159 <sup>27</sup> , 135 <sup>19</sup> |                            |                      |                                                           |
| 6283 | 4-Iodobenzoyl chloride         |                                                                                              | C <sub>7</sub> H <sub>4</sub> ClIO                                           | 1711-02-0  | 266.463  |                             | 65.5                          | 164 <sup>32</sup>                     |                            |                      |                                                           |
| 6284 | 2-Iodo-1,1'-biphenyl           |                                                                                              | C <sub>12</sub> H <sub>9</sub> I                                             | 2113-51-1  | 280.103  |                             |                               | 190 <sup>36</sup> , 169 <sup>17</sup> | 1.5511 <sup>25</sup>       | 1.6620 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz, HOAc              |
| 6285 | 3-Iodo-1,1'-biphenyl           |                                                                                              | C <sub>12</sub> H <sub>9</sub> I                                             | 20442-79-9 | 280.103  |                             | 26.5                          | 188 <sup>16</sup>                     | 1.5967 <sup>25</sup>       |                      |                                                           |
| 6286 | 4-Iodo-1,1'-biphenyl           |                                                                                              | C <sub>12</sub> H <sub>9</sub> I                                             | 1591-31-7  | 280.103  | nd (al,<br>HOAc)            | 113.5                         | 320; 183 <sup>11</sup>                |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, bz, HOAc              |
| 6287 | 1-Iodobutane                   | Butyl iodide                                                                                 | C <sub>4</sub> H <sub>9</sub> I                                              | 542-69-8   | 184.018  | liq                         | -103                          | 130.5                                 | 1.6154 <sup>20</sup>       | 1.5001 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; vs<br>chl           |
| 6288 | 2-Iodobutane, (±)              | (±)-sec-Butyl iodide                                                                         | C <sub>4</sub> H <sub>9</sub> I                                              | 52152-71-3 | 184.018  | liq                         | -104.2                        | 120.1                                 | 1.5920 <sup>20</sup>       | 1.4991 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; vs<br>chl           |
| 6289 | Iodocyclohexane                | Cyclohexyl iodide                                                                            | C <sub>6</sub> H <sub>11</sub> I                                             | 626-62-0   | 210.055  |                             |                               | dec 180; 81 <sup>20</sup>             | 1.6244 <sup>20</sup>       | 1.5477 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz               |
| 6290 | Iodocyclopentane               | Cyclopentyl iodide                                                                           | C <sub>5</sub> H <sub>9</sub> I                                              | 1556-18-9  | 196.029  |                             |                               | 166.5                                 | 1.7096 <sup>20</sup>       | 1.5447 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz;<br>sl ctc                  |
| 6291 | 1-Iododecane                   |                                                                                              | C <sub>10</sub> H <sub>21</sub> I                                            | 2050-77-3  | 268.178  | liq                         | -16.3                         | 263.7; 132 <sup>15</sup>              | 1.2546 <sup>20</sup>       | 1.4858 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ctc                   |
| 6292 | 1-Iodo-2,4-dimethylbenzene     |                                                                                              | C <sub>8</sub> H <sub>9</sub> I                                              | 4214-28-2  | 232.061  |                             |                               | dec 231; 111 <sup>14</sup>            | 1.6282 <sup>16</sup>       | 1.6008 <sup>16</sup> | i H <sub>2</sub> O; s ace, bz                             |
| 6293 | 2-Iodo-1,3-dimethylbenzene     |                                                                                              | C <sub>8</sub> H <sub>9</sub> I                                              | 608-28-6   | 232.061  | oil                         | 11.2                          | 229.5                                 | 1.6158 <sup>20</sup>       | 1.6035 <sup>20</sup> | i H <sub>2</sub> O; s ace, bz                             |
| 6294 | 2-Iodo-1,4-dimethylbenzene     |                                                                                              | C <sub>8</sub> H <sub>9</sub> I                                              | 1122-42-5  | 232.061  |                             |                               | dec 227                               | 1.6168 <sup>17</sup>       | 1.5992 <sup>17</sup> | i H <sub>2</sub> O; s ace, bz                             |
| 6295 | 1-Iodo-2,2-dimethylpropane     |                                                                                              | C <sub>5</sub> H <sub>11</sub> I                                             | 15501-33-4 | 198.045  |                             |                               | dec 128                               | 1.4940 <sup>20</sup>       | 1.4890 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                        |
| 6296 | 1-Iodododecane                 | Lauryl iodide                                                                                | C <sub>12</sub> H <sub>25</sub> I                                            | 4292-19-7  | 296.231  |                             | 0.3                           | 298.2                                 | 1.1999 <sup>20</sup>       | 1.4840 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>MeOH; msc<br>eth, ace, ctc |
| 6297 | Iodoethane                     | Ethyl iodide                                                                                 | C <sub>2</sub> H <sub>5</sub> I                                              | 75-03-6    | 155.965  | liq                         | -111.1                        | 72.3                                  | 1.9357 <sup>20</sup>       | 1.5133 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH; s eth,<br>chl           |
| 6298 | 2-Iodoethanol                  |                                                                                              | C <sub>2</sub> H <sub>5</sub> IO                                             | 624-76-0   | 171.964  |                             |                               | dec 176                               | 2.1967 <sup>20</sup>       | 1.5713 <sup>20</sup> | vs H <sub>2</sub> O, eth,<br>EtOH                         |
| 6299 | Iodoethene                     | Vinyl iodide                                                                                 | C <sub>2</sub> H <sub>3</sub> I                                              | 593-66-8   | 153.949  |                             |                               | 56                                    | 2.037 <sup>20</sup>        | 1.5385 <sup>20</sup> | vs eth, EtOH                                              |
| 6300 | (2-Iodoethyl)benzene           |                                                                                              | C <sub>8</sub> H <sub>9</sub> I                                              | 17376-04-4 | 232.061  | liq                         |                               | 122 <sup>13</sup>                     | 1.603                      | 1.6010 <sup>20</sup> |                                                           |

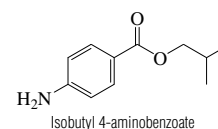
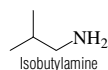
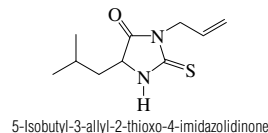
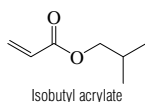
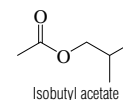
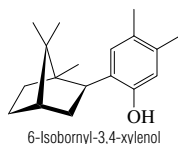
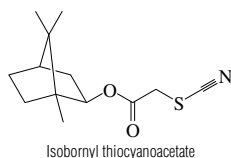
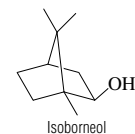
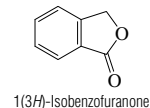
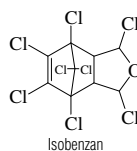
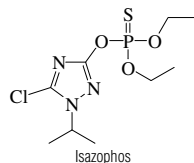
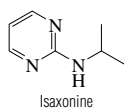
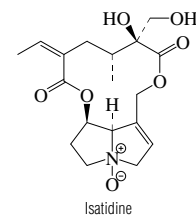
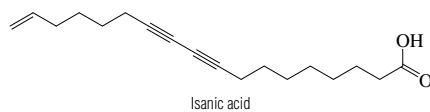
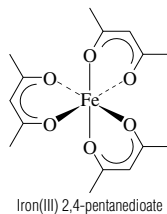
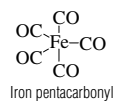
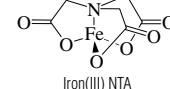
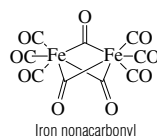
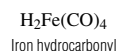
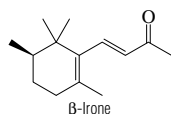
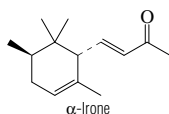
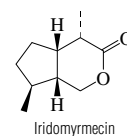
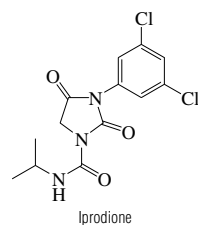
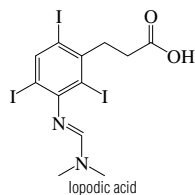
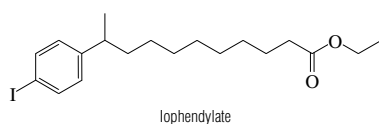
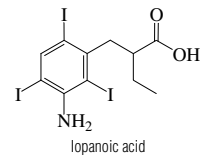
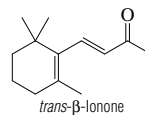
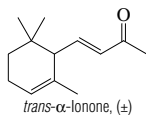
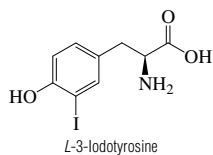
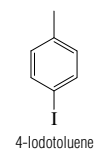
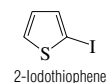
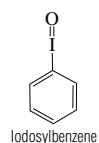
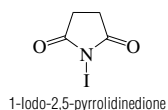
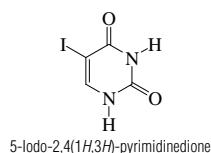
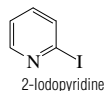


| No.  | Name                                     | Synonym                   | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form              | mp/°C  | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|------------------------------------------|---------------------------|------------------------------------------------------------------|------------|----------|----------------------------|--------|--------------------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 6301 | 2-(1-Iodoethyl)-1,3-dioxolane-4-methanol | Iodinated glycerol        | C <sub>6</sub> H <sub>11</sub> IO <sub>3</sub>                   | 5634-39-9  | 258.053  | pale ye liq                |        |                                      | 1.797                      | 1.547                | s eth, chl, thf, AcOEt                                  |
| 6302 | Iodofenphos                              |                           | C <sub>8</sub> H <sub>8</sub> Cl <sub>2</sub> IO <sub>3</sub> PS | 18181-70-9 | 412.997  | wh cry                     | 76     |                                      |                            |                      | i H <sub>2</sub> O; s ace, xyl; sl EtOH                 |
| 6303 | 1-Iodoheptane                            |                           | C <sub>7</sub> H <sub>15</sub> I                                 | 4282-40-0  | 226.098  | liq                        | -48.2  | 204.0                                | 1.3719 <sup>25</sup>       | 1.4904 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, chl; sl ctc       |
| 6304 | 3-Iodoheptane                            |                           | C <sub>7</sub> H <sub>15</sub> I                                 | 31294-92-5 | 226.098  |                            |        | 89 <sup>30</sup>                     | 1.3676 <sup>20</sup>       |                      |                                                         |
| 6305 | 1-Iodohexadecane                         |                           | C <sub>16</sub> H <sub>33</sub> I                                | 544-77-4   | 352.337  | pa ye liq                  | 24.7   | 357; 212 <sup>15</sup>               | 1.1213 <sup>25</sup>       | 1.4797 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH; s eth, ace; msc bz; vs chl |
| 6306 | 1-Iodohexane                             | Hexyl iodide              | C <sub>6</sub> H <sub>13</sub> I                                 | 638-45-9   | 212.071  | liq                        | -74.2  | 181.3                                | 1.4305 <sup>25</sup>       | 1.4928 <sup>20</sup> | i H <sub>2</sub> O                                      |
| 6307 | Iodomethane                              | Methyl iodide             | CH <sub>3</sub> I                                                | 74-88-4    | 141.939  | liq                        | -66.4  | 42.43                                | 2.2789 <sup>20</sup>       | 1.5308 <sup>20</sup> | sl H <sub>2</sub> O; s ace, bz, chl; msc EtOH, eth      |
| 6308 | 1-Iodo-2-methoxybenzene                  | <i>o</i> -Iodoanisole     | C <sub>7</sub> H <sub>7</sub> IO                                 | 529-28-2   | 234.034  |                            |        | 241; 91 <sup>2</sup>                 | 1.8 <sup>20</sup>          |                      | vs EtOH, eth, ace, bz, chl, lig                         |
| 6309 | 1-Iodo-3-methoxybenzene                  | <i>m</i> -Iodoanisole     | C <sub>7</sub> H <sub>7</sub> IO                                 | 766-85-8   | 234.034  |                            |        | 244.5                                | 1.9650 <sup>20</sup>       |                      | vs EtOH, eth                                            |
| 6310 | 1-Iodo-4-methoxybenzene                  | <i>p</i> -Iodoanisole     | C <sub>7</sub> H <sub>7</sub> IO                                 | 696-62-8   | 234.034  | lf (al), nd (MeOH)         | 53     | 238; 138 <sup>25</sup>               |                            |                      | s EtOH, eth, chl                                        |
| 6311 | 1-Iodo-2-methylbenzene                   |                           | C <sub>7</sub> H <sub>7</sub> I                                  | 615-37-2   | 218.035  |                            |        | 211.5                                | 1.713 <sup>20</sup>        | 1.6079 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                       |
| 6312 | 1-Iodo-3-methylbenzene                   |                           | C <sub>7</sub> H <sub>7</sub> I                                  | 625-95-6   | 218.035  | liq                        | -27.2  | 213                                  | 1.705 <sup>20</sup>        | 1.6053 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                       |
| 6313 | (Iodomethyl)benzene                      |                           | C <sub>7</sub> H <sub>7</sub> I                                  | 620-05-3   | 218.035  | col or ye nd (MeOH)        | 24.5   | 93 <sup>10</sup>                     | 1.7335 <sup>25</sup>       | 1.6334 <sup>25</sup> | vs bz, eth, EtOH                                        |
| 6314 | 1-Iodo-3-methylbutane                    | Isopentyl iodide          | C <sub>6</sub> H <sub>11</sub> I                                 | 541-28-6   | 198.045  |                            |        | 147                                  | 1.5118 <sup>20</sup>       | 1.4939 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth                 |
| 6315 | 2-Iodo-2-methylbutane                    |                           | C <sub>6</sub> H <sub>11</sub> I                                 | 594-38-7   | 198.045  |                            |        | 124.5                                | 1.4937 <sup>20</sup>       | 1.4981 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                       |
| 6316 | 1-Iodo-2-methylpropane                   | Isobutyl iodide           | C <sub>4</sub> H <sub>9</sub> I                                  | 513-38-2   | 184.018  |                            |        | 121.1                                | 1.6035 <sup>20</sup>       | 1.4959 <sup>20</sup> |                                                         |
| 6317 | 2-Iodo-2-methylpropane                   | <i>tert</i> -Butyl iodide | C <sub>4</sub> H <sub>9</sub> I                                  | 558-17-8   | 184.018  | liq                        | -38.2  | 100.1                                | 1.571 <sup>25</sup>        | 1.4918 <sup>20</sup> | msc EtOH, eth                                           |
| 6318 | Iodomethylsilane                         |                           | CH <sub>3</sub> Si                                               | 18089-64-0 | 172.041  | col liq                    | -109.5 | 71.8                                 |                            |                      |                                                         |
| 6319 | 1-Iodonaphthalene                        |                           | C <sub>10</sub> H <sub>7</sub> I                                 | 90-14-2    | 254.067  |                            | 2.1    | 302                                  | 1.7399 <sup>20</sup>       | 1.7026 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, bz, CS <sub>2</sub>  |
| 6320 | 2-Iodonaphthalene                        |                           | C <sub>10</sub> H <sub>7</sub> I                                 | 612-55-5   | 254.067  | lf (dil al)                | 54.5   | 308                                  | 1.6319 <sup>99</sup>       | 1.6662 <sup>99</sup> | i H <sub>2</sub> O; vs EtOH, eth, HOAc                  |
| 6321 | 1-Iodo-2-nitrobenzene                    |                           | C <sub>6</sub> H <sub>4</sub> INO <sub>2</sub>                   | 609-73-4   | 249.006  | ye orth nd (al)            | 54     | 290; 162 <sup>18</sup>               | 1.9186 <sup>75</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                         |
| 6322 | 1-Iodo-3-nitrobenzene                    |                           | C <sub>6</sub> H <sub>4</sub> INO <sub>2</sub>                   | 645-00-1   | 249.006  | mcl pr                     | 38.5   | 280                                  | 1.9477 <sup>50</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                         |
| 6323 | 1-Iodo-4-nitrobenzene                    |                           | C <sub>6</sub> H <sub>4</sub> INO <sub>2</sub>                   | 636-98-6   | 249.006  | ye nd (al)                 | 174.7  | 288                                  | 1.8090 <sup>155</sup>      |                      | i H <sub>2</sub> O; s EtOH, HOAc; sl DMSO               |
| 6324 | 1-Iodononane                             |                           | C <sub>9</sub> H <sub>19</sub> I                                 | 4282-42-2  | 254.151  | col liq                    | -20    | 245.0                                | 1.2836 <sup>25</sup>       | 1.4848 <sup>25</sup> |                                                         |
| 6325 | 1-Iodoctadecane                          |                           | C <sub>18</sub> H <sub>37</sub> I                                | 629-93-6   | 380.391  | lf (lig), nd (ace, al-ace) | 34.0   | 383                                  | 1.0994 <sup>20</sup>       | 1.4810 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH, eth                        |
| 6326 | 1-Iodoctane                              |                           | C <sub>8</sub> H <sub>17</sub> I                                 | 629-27-6   | 240.125  | liq                        | -45.7  | 225.1                                | 1.3298 <sup>20</sup>       | 1.4885 <sup>20</sup> | s EtOH, eth                                             |
| 6327 | 2-Iodoctane, (±)                         | 2-Octyl iodide, (±)       | C <sub>8</sub> H <sub>17</sub> I                                 | 36049-78-2 | 240.125  |                            |        | 210; 95 <sup>16</sup>                | 1.3251 <sup>20</sup>       | 1.4896 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, lig                    |
| 6328 | 1-Iodopentane                            | Pentyl iodide             | C <sub>5</sub> H <sub>11</sub> I                                 | 628-17-1   | 198.045  | liq                        | -85.6  | 157.0                                | 1.5161 <sup>20</sup>       | 1.4959 <sup>20</sup> | s chl                                                   |
| 6329 | 3-Iodopentane                            |                           | C <sub>5</sub> H <sub>11</sub> I                                 | 1809-05-8  | 198.045  |                            |        | 145.5                                | 1.5176 <sup>20</sup>       | 1.4974 <sup>20</sup> | vs ace, bz, eth                                         |
| 6330 | 2-Iodophenol                             |                           | C <sub>6</sub> H <sub>5</sub> IO                                 | 533-58-4   | 220.007  | nd                         | 43     | 186 <sup>160</sup> , 91 <sup>2</sup> | 1.8757 <sup>90</sup>       |                      | s H <sub>2</sub> O; vs EtOH, eth, CS <sub>2</sub>       |
| 6331 | 3-Iodophenol                             |                           | C <sub>6</sub> H <sub>5</sub> IO                                 | 626-02-8   | 220.007  | nd (lig)                   | 118    | 186 <sup>100</sup>                   |                            |                      | sl H <sub>2</sub> O; s EtOH, eth                        |
| 6332 | 4-Iodophenol                             |                           | C <sub>6</sub> H <sub>5</sub> IO                                 | 540-38-5   | 220.007  | nd (w or sub)              | 93.5   | 139 <sup>5</sup> dec                 | 1.8573 <sup>112</sup>      |                      | sl H <sub>2</sub> O; vs EtOH, eth                       |
| 6333 | 1-(3-Iodophenyl)ethanone                 | 3-Iodoacetophenone        | C <sub>8</sub> H <sub>7</sub> IO                                 | 14452-30-3 | 246.045  |                            |        | 129 <sup>8</sup> , 117 <sup>4</sup>  | 1.622 <sup>20</sup>        |                      | s bz                                                    |
| 6334 | 1-(4-Iodophenyl)ethanone                 | 4-Iodoacetophenone        | C <sub>8</sub> H <sub>7</sub> IO                                 | 13329-40-3 | 246.045  |                            | 86     | 153 <sup>18</sup>                    |                            |                      | s EtOH, bz, CS <sub>2</sub> , HOAc; sl lig, eth         |
| 6335 | 1-Iodopropane                            | Propyl iodide             | C <sub>3</sub> H <sub>7</sub> I                                  | 107-08-4   | 169.992  | liq                        | -101.3 | 102.5                                | 1.7489 <sup>20</sup>       | 1.5058 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth                 |
| 6336 | 2-Iodopropane                            | Isopropyl iodide          | C <sub>3</sub> H <sub>7</sub> I                                  | 75-30-9    | 169.992  | liq                        | -90    | 89.5                                 | 1.7042 <sup>20</sup>       | 1.5028 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, bz, chl             |
| 6337 | 3-Iodopropanoic acid                     |                           | C <sub>3</sub> H <sub>5</sub> IO <sub>2</sub>                    | 141-76-4   | 199.975  | lf (w)                     | 85     |                                      |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH; s eth, ace           |
| 6338 | 3-Iodo-1-propanol                        |                           | C <sub>3</sub> H <sub>7</sub> IO                                 | 627-32-7   | 185.991  | visc oil                   |        | 226; 115 <sup>38</sup>               | 1.9976 <sup>20</sup>       | 1.5585 <sup>20</sup> |                                                         |
| 6339 | 3-Iodopropene                            | Allyl iodide              | C <sub>3</sub> H <sub>5</sub> I                                  | 556-56-9   | 167.976  | ye liq                     | -99.3  | 103                                  | 1.848 <sup>12</sup>        | 1.5540 <sup>21</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                    |

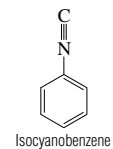
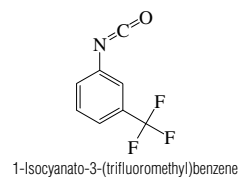
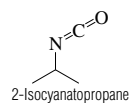
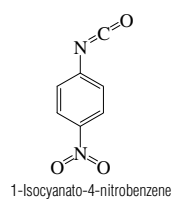
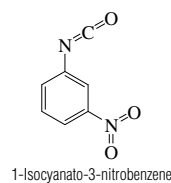
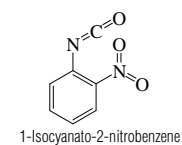
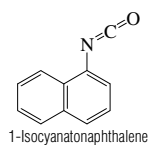
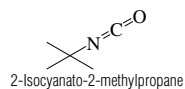
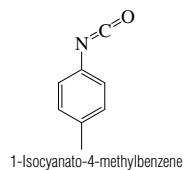
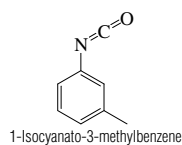
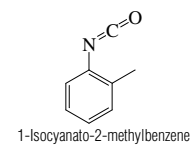
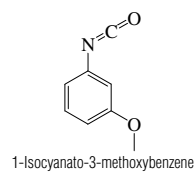
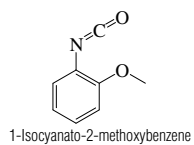
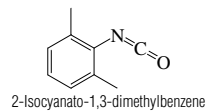
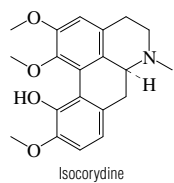
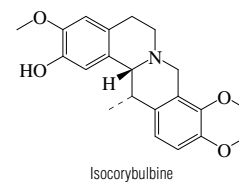
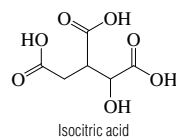
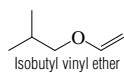
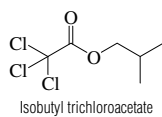
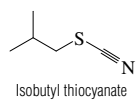
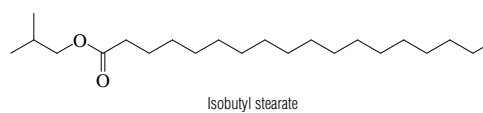
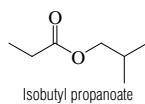
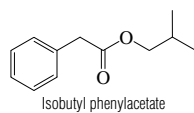
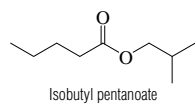
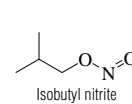
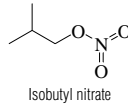
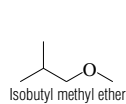
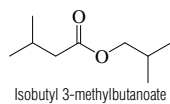
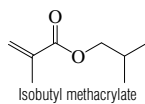
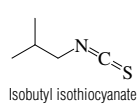
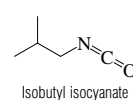
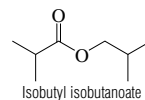
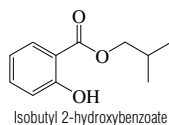
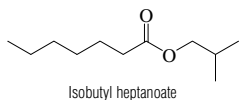
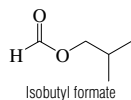
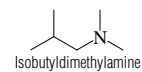
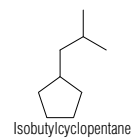
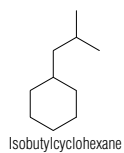
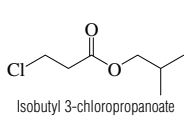
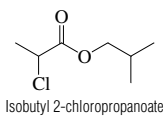
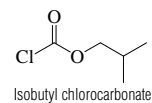
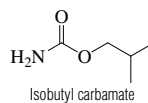
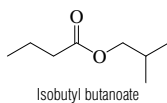
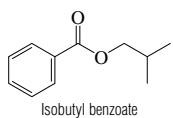
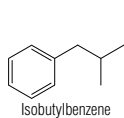




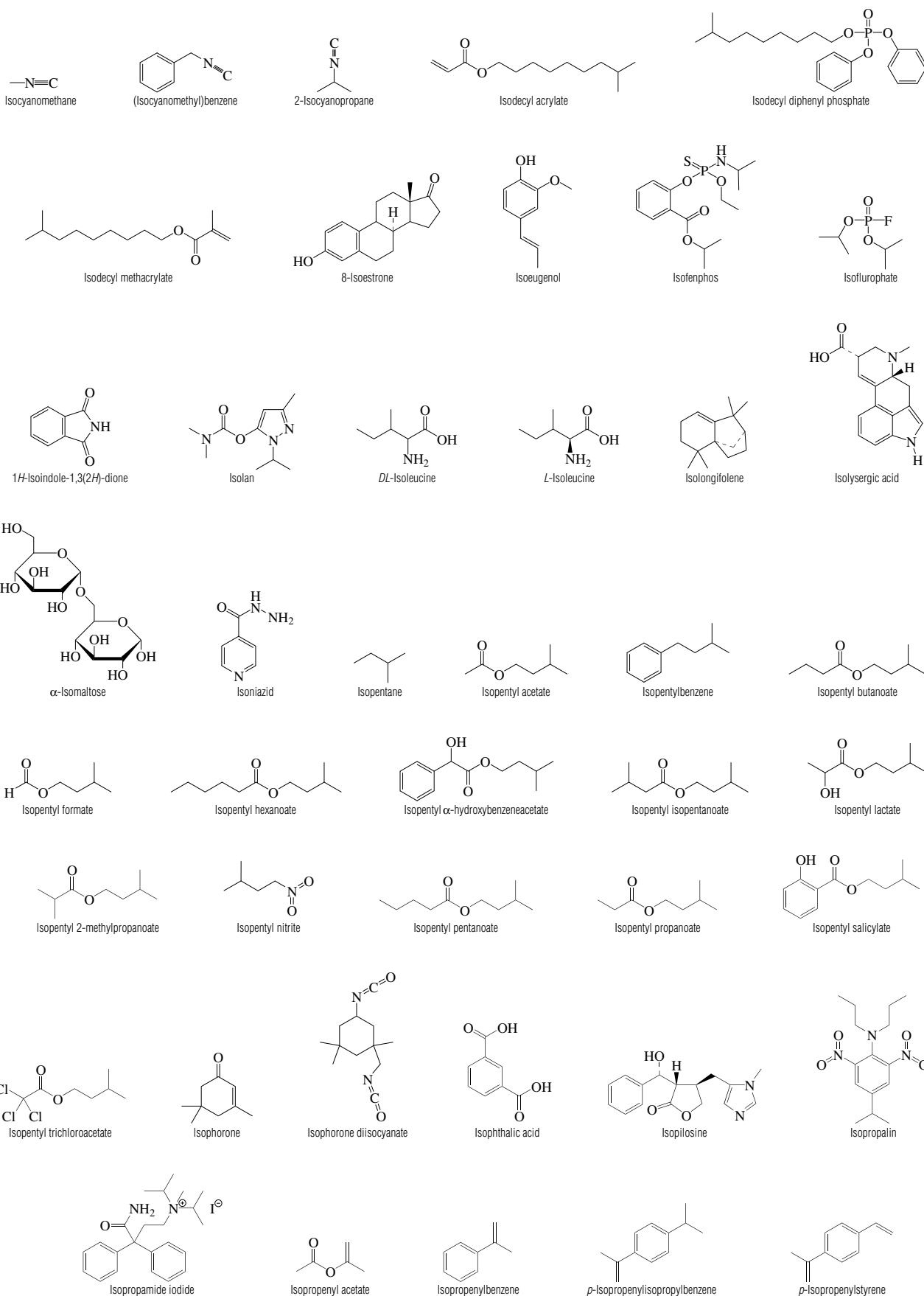
| No.  | Name                                                 | Synonym                                                     | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup>        | n <sub>D</sub>        | Solubility                                                |
|------|------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|--------------------|---------|---------------------------------------|-----------------------------------|-----------------------|-----------------------------------------------------------|
| 6340 | 2-Iodopyridine                                       |                                                             | C <sub>5</sub> H <sub>4</sub> IN                                              | 5029-67-4  | 204.997  |                    |         | 100 <sup>15</sup> , 93 <sup>13</sup>  | 1.928 <sup>25</sup>               | 1.6366 <sup>20</sup>  | s EtOH, eth, ace, bz                                      |
| 6341 | 5-Iodo-2,4-(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione | 5-Iodouracil                                                | C <sub>4</sub> H <sub>3</sub> IN <sub>2</sub> O <sub>2</sub>                  | 696-07-1   | 237.983  |                    | 275 dec |                                       |                                   |                       |                                                           |
| 6342 | 1-Iodo-2,5-pyrrolidinedione                          | <i>N</i> -Iodosuccinimide                                   | C <sub>4</sub> H <sub>4</sub> INO <sub>2</sub>                                | 516-12-1   | 224.985  | cry (ace)          | 200.5   |                                       | 2.245 <sup>25</sup>               |                       | vs H <sub>2</sub> O; s EtOH, ace; sl eth, DMSO            |
| 6343 | Iodosylbenzene                                       |                                                             | C <sub>6</sub> H <sub>5</sub> IO                                              | 536-80-1   | 220.007  | ye pow             | 210 exp |                                       |                                   |                       | s H <sub>2</sub> O, EtOH; i eth, ace, bz, peth            |
| 6344 | 2-Iodothiophene                                      |                                                             | C <sub>4</sub> H <sub>3</sub> IS                                              | 3437-95-4  | 210.036  | liq                | -40     | 181                                   | 2.0595 <sup>25</sup>              | 1.6465 <sup>25</sup>  | vs EtOH, eth; sl chl                                      |
| 6345 | 4-Iodotoluene                                        |                                                             | C <sub>7</sub> H <sub>7</sub> I                                               | 624-31-7   | 218.035  | lf (al)            | 36.5    | 211                                   | 1.678 <sup>20</sup>               |                       | i H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub> ; sl chl |
| 6346 | <i>L</i> -3-Iodotyrosine                             |                                                             | C <sub>9</sub> H <sub>10</sub> INO <sub>3</sub>                               | 70-78-0    | 307.084  | cry (w)            | 205 dec |                                       |                                   |                       |                                                           |
| 6347 | <i>trans</i> -α-Ionone, (±)                          |                                                             | C <sub>13</sub> H <sub>20</sub> O                                             | 30685-95-1 | 192.297  |                    |         | 146 <sup>28</sup>                     | 0.9298 <sup>21</sup>              | 1.5041 <sup>20</sup>  | vs ace, eth, EtOH                                         |
| 6348 | <i>trans</i> -β-Ionone                               |                                                             | C <sub>13</sub> H <sub>20</sub> O                                             | 79-77-6    | 192.297  |                    |         | 124 <sup>10</sup> , 73 <sup>0.1</sup> | 0.945 <sup>20</sup>               | 1.5198 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth; s chl                 |
| 6349 | Iopanoic acid                                        |                                                             | C <sub>11</sub> H <sub>19</sub> INO <sub>2</sub>                              | 96-83-3    | 570.932  | wh solid           | 156     |                                       |                                   |                       | i H <sub>2</sub> O; s dil alk, EtOH                       |
| 6350 | Iophendylate                                         | Ethyl 10-(4-iodophenyl)undecanoate                          | C <sub>19</sub> H <sub>29</sub> IO <sub>2</sub>                               | 99-79-6    | 416.336  | visc liq           |         | 197 <sup>1</sup>                      | 1.25 <sup>20</sup>                | 1.525 <sup>25</sup>   | sl H <sub>2</sub> O; s EtOH, bz, chl                      |
| 6351 | Iopodic acid                                         | Ipodate                                                     | C <sub>12</sub> H <sub>13</sub> IN <sub>2</sub> O <sub>2</sub>                | 5587-89-3  | 597.956  | cry                | 168     |                                       |                                   |                       | i H <sub>2</sub> O; vs EtOH, MeOH, chl, ace               |
| 6352 | Iprodione                                            |                                                             | C <sub>13</sub> H <sub>13</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>3</sub> | 36734-19-7 | 330.166  |                    | 136     |                                       |                                   |                       |                                                           |
| 6353 | Iridomyrmecin                                        | Hexahydro-4,7-dimethylcyclopenta[c]pyran-3(1 <i>H</i> )-one | C <sub>10</sub> H <sub>16</sub> O <sub>2</sub>                                | 485-43-8   | 168.233  | pr                 | 61      | 106 <sup>1.5</sup>                    |                                   | 1.4607 <sup>65</sup>  | sl H <sub>2</sub> O; s eth                                |
| 6354 | α-Irone                                              | 4-(2,5,6,6-Tetramethyl-2-cyclohexen-1-yl)-3-buten-2-one     | C <sub>14</sub> H <sub>22</sub> O                                             | 79-69-6    | 206.324  |                    |         | 90 <sup>0.4</sup>                     | 0.9362 <sup>20</sup>              | 1.5002 <sup>20</sup>  |                                                           |
| 6355 | β-Irone                                              | 4-(2,5,6,6-Tetramethyl-1-cyclohexen-1-yl)-3-buten-2-one     | C <sub>14</sub> H <sub>22</sub> O                                             | 79-70-9    | 206.324  |                    |         | 125 <sup>11</sup>                     | 0.9434 <sup>21</sup>              | 1.5162 <sup>25</sup>  | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl                |
| 6356 | Iron hydrocarbonyl                                   | Hydrogen tetracarbonylferrate(II)                           | C <sub>4</sub> H <sub>2</sub> FeO <sub>4</sub>                                | 17440-90-3 | 169.902  | col liq; unstab    | -70     | dec                                   |                                   |                       | s alk                                                     |
| 6357 | Iron nonacarbonyl                                    | Diiron nonacarbonyl                                         | C <sub>9</sub> Fe <sub>2</sub> O <sub>9</sub>                                 | 15321-51-4 | 363.781  | oran-ye cry        | 100 dec |                                       | 2.85                              |                       |                                                           |
| 6358 | Iron(III) NTA                                        | Nitrilotriacetatoiron(III)                                  | C <sub>6</sub> H <sub>8</sub> FeNO <sub>6</sub>                               | 16448-54-7 | 243.960  | solid              |         |                                       |                                   |                       | s H <sub>2</sub> O                                        |
| 6359 | Iron pentacarbonyl                                   |                                                             | C <sub>5</sub> FeO <sub>5</sub>                                               | 13463-40-6 | 195.896  | col to ye oily liq | -20     | 103                                   | 1.5 <sup>20</sup>                 | 1.453 <sup>22</sup>   | i H <sub>2</sub> O; sl EtOH; s bz, ace, ctc               |
| 6360 | Iron(III) 2,4-pentanedioate                          | Ferric acetylacetonate                                      | C <sub>15</sub> H <sub>21</sub> FeO <sub>6</sub>                              | 14024-18-1 | 353.169  |                    | 179     |                                       | 5.24                              |                       |                                                           |
| 6361 | Isanic acid                                          | 17-Octadecene-9,11-diynoic acid                             | C <sub>18</sub> H <sub>26</sub> O <sub>2</sub>                                | 506-25-2   | 274.398  | cry                | 39.5    |                                       | 0.9309 <sup>45</sup>              | 1.49148 <sup>50</sup> | s ace, EtOH, i-PrOH; sl peth                              |
| 6362 | Isatidine                                            | Retrorsine <i>N</i> -oxide                                  | C <sub>18</sub> H <sub>25</sub> NO <sub>7</sub>                               | 15503-86-3 | 367.395  | cry                | 145     |                                       |                                   |                       |                                                           |
| 6363 | Isaxonine                                            | <i>N</i> -Isopropyl-2-pyrimidineamine                       | C <sub>8</sub> H <sub>11</sub> N <sub>3</sub>                                 | 4214-72-6  | 137.182  |                    | 28      | 93 <sup>12</sup>                      |                                   |                       |                                                           |
| 6364 | Isazophos                                            |                                                             | C <sub>9</sub> H <sub>17</sub> ClN <sub>3</sub> O <sub>3</sub> PS             | 67329-04-8 | 313.741  |                    |         | 170; 100 <sup>0.001</sup>             | 1.22 <sup>20</sup>                |                       |                                                           |
| 6365 | Isobenzan                                            |                                                             | C <sub>9</sub> H <sub>8</sub> Cl <sub>6</sub> O                               | 297-78-9   | 411.751  | cry (hp)           | 121     |                                       |                                   |                       | s eth, bz, xyl, tol                                       |
| 6366 | 1(3 <i>H</i> )-Isobenzofuranone                      |                                                             | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>                                  | 87-41-2    | 134.133  | nd or pl (w)       | 75      | 290                                   | 1.1636 <sup>99</sup>              | 1.536 <sup>99</sup>   | s H <sub>2</sub> O; vs EtOH, eth; sl chl                  |
| 6367 | Isoborneol                                           | 1,7,7-Trimethylbicyclo[2.2.1]heptan-2-ol, <i>exo</i> -(±)   | C <sub>10</sub> H <sub>18</sub> O                                             | 24393-70-2 | 154.249  | tab (peth)         | 212     | sub                                   | 1.10 <sup>20</sup>                |                       | i H <sub>2</sub> O; vs EtOH, eth, chl; sl bz              |
| 6368 | Isobornyl thiocanoacetate                            |                                                             | C <sub>13</sub> H <sub>19</sub> NO <sub>2</sub> S                             | 115-31-1   | 253.361  | ye oily liq        |         | 95 <sup>0.06</sup>                    | 1.1465 <sup>25</sup>              | 1.512 <sup>25</sup>   | i H <sub>2</sub> O; vs EtOH, bz, chl, peth                |
| 6369 | 6-Isobornyl-3,4-xyleneol                             | Xibornol                                                    | C <sub>18</sub> H <sub>26</sub> O                                             | 13741-18-9 | 258.398  | cry                | 95      | 167 <sup>3</sup>                      | 1.0240 <sup>20</sup>              | 1.5382 <sup>20</sup>  |                                                           |
| 6370 | Isobutanal                                           | 2-Methyl-1-propanal                                         | C <sub>4</sub> H <sub>8</sub> O                                               | 78-84-2    | 72.106   | liq                | -65.9   | 64.5                                  | 0.7891 <sup>20</sup>              | 1.3730 <sup>20</sup>  | s H <sub>2</sub> O, eth, ace, chl; sl ctc                 |
| 6371 | Isobutane                                            | 2-Methylpropane                                             | C <sub>4</sub> H <sub>10</sub>                                                | 75-28-5    | 58.122   | col gas            | -159.4  | -11.73                                | 0.5510 <sup>25</sup><br>(p>1 atm) | 1.3518 <sup>-25</sup> | sl H <sub>2</sub> O; s EtOH, eth, chl                     |
| 6372 | Isobutene                                            |                                                             | C <sub>4</sub> H <sub>8</sub>                                                 | 115-11-7   | 56.107   | col gas            | -140.7  | -6.9                                  | 0.589 <sup>25</sup><br>(p>1 atm)  | 1.3926 <sup>-25</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz, sulf              |
| 6373 | Isobutyl acetate                                     |                                                             | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                                 | 110-19-0   | 116.158  | liq                | -98.8   | 116.5                                 | 0.8712 <sup>20</sup>              | 1.3902 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; msc EtOH, eth; s ace            |
| 6374 | Isobutyl acrylate                                    |                                                             | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                                 | 106-63-8   | 128.169  | liq                | -61     | 132                                   | 0.8896 <sup>20</sup>              | 1.4150 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth, MeOH                    |
| 6375 | 5-Isobutyl-3-allyl-2-thioxo-4-imidazolidinone        | Albutoin                                                    | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub> OS                             | 830-89-7   | 212.311  |                    | 210.5   |                                       |                                   |                       |                                                           |
| 6376 | Isobutylamine                                        | 2-Methyl-1-propanamine                                      | C <sub>4</sub> H <sub>11</sub> N                                              | 78-81-9    | 73.137   | liq                | -86.7   | 67.75                                 | 0.724 <sup>25</sup>               | 1.3988 <sup>19</sup>  |                                                           |
| 6377 | Isobutyl 4-aminobenzoate                             | Isobutyl <i>p</i> -aminobenzoate                            | C <sub>11</sub> H <sub>12</sub> NO <sub>2</sub>                               | 94-14-4    | 193.243  |                    | 64.5    |                                       |                                   |                       |                                                           |



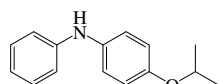
| No.  | Name                                    | Synonym                               | Mol. Form.                                                   | CAS RN      | Mol. Wt. | Physical Form | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|-----------------------------------------|---------------------------------------|--------------------------------------------------------------|-------------|----------|---------------|--------|---------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 6378 | Isobutylbenzene                         |                                       | C <sub>10</sub> H <sub>14</sub>                              | 538-93-2    | 134.218  | liq           | -51.4  | 172.79                                | 0.8532 <sup>20</sup>       | 1.4866 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc  |
| 6379 | Isobutyl benzoate                       |                                       | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>               | 120-50-3    | 178.228  |               |        | 242                                   | 0.9990 <sup>20</sup>       |                      | i H <sub>2</sub> O; msc EtOH, eth; s ace, chl          |
| 6380 | Isobutyl butanoate                      |                                       | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | 539-90-2    | 144.212  |               |        | 156.9                                 | 0.8364 <sup>18</sup>       | 1.4032 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                     |
| 6381 | Isobutyl carbamate                      |                                       | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>               | 543-28-2    | 117.147  | lf            | 67     | 207                                   |                            | 1.4098 <sup>78</sup> | vs eth, EtOH                                           |
| 6382 | Isobutyl chlorocarbonate                |                                       | C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>               | 543-27-1    | 136.577  |               |        | 128.8                                 | 1.0426 <sup>18</sup>       | 1.4071 <sup>18</sup> | s EtOH, bz, chl; msc eth                               |
| 6383 | Isobutyl 2-chloropropanoate             |                                       | C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>              | 114489-96-2 | 164.630  |               |        | 176                                   | 1.0312 <sup>20</sup>       | 1.4247 <sup>20</sup> |                                                        |
| 6384 | Isobutyl 3-chloropropanoate             |                                       | C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>              | 62108-68-3  | 164.630  |               |        | 191.3                                 | 1.0323 <sup>20</sup>       | 1.4295 <sup>20</sup> | vs eth, EtOH                                           |
| 6385 | Isobutylcyclohexane                     |                                       | C <sub>10</sub> H <sub>20</sub>                              | 1678-98-4   | 140.266  | liq           | -95    | 171.3                                 | 0.7952 <sup>20</sup>       | 1.4386 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, chl; vs eth, bz       |
| 6386 | Isobutylcyclopentane                    |                                       | C <sub>9</sub> H <sub>18</sub>                               | 3788-32-7   | 126.239  | liq           | -115.2 | 148                                   | 0.7769 <sup>25</sup>       | 1.4298 <sup>20</sup> |                                                        |
| 6387 | Isobutyldimethylamine                   | <i>N,N</i> ,2-Trimethyl-1-propanamine | C <sub>6</sub> H <sub>15</sub> N                             | 7239-24-9   | 101.190  |               |        | 80.5                                  | 0.7097 <sup>20</sup>       | 1.3907 <sup>20</sup> | vs H <sub>2</sub> O                                    |
| 6388 | Isobutyl formate                        |                                       | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | 542-55-2    | 102.132  | liq           | -95.8  | 98.2                                  | 0.8776 <sup>20</sup>       | 1.3857 <sup>20</sup> | sl H <sub>2</sub> O, chl; msc EtOH, eth; vs ace        |
| 6389 | Isobutyl heptanoate                     | Isobutyl enanthate                    | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>               | 7779-80-8   | 186.292  |               |        | 208                                   | 0.8593 <sup>20</sup>       |                      | vs ace, bz, eth, EtOH                                  |
| 6390 | Isobutyl 2-hydroxybenzoate              | Isobutyl salicylate                   | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>               | 87-19-4     | 194.227  |               | 5.9    | 261                                   | 1.0639 <sup>20</sup>       | 1.5087 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                   |
| 6391 | Isobutyl isobutanoate                   |                                       | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | 97-85-8     | 144.212  | liq           | -80.7  | 148.6                                 | 0.8542 <sup>20</sup>       | 1.3999 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, ace; msc eth         |
| 6392 | Isobutyl isocyanate                     |                                       | C <sub>5</sub> H <sub>9</sub> NO                             | 1873-29-6   | 99.131   |               |        | 106                                   |                            |                      |                                                        |
| 6393 | Isobutyl isothiocyanate                 | 1-Isothiocyanato-2-methylpropane      | C <sub>5</sub> H <sub>9</sub> NS                             | 591-82-2    | 115.197  |               |        | 160                                   | 0.9631 <sup>14</sup>       | 1.5005 <sup>14</sup> |                                                        |
| 6394 | Isobutyl methacrylate                   |                                       | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                | 97-86-9     | 142.196  |               |        | 155                                   | 0.8858 <sup>20</sup>       | 1.4199 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                      |
| 6395 | Isobutyl 3-methylbutanoate              | Isobutyl isovalerate                  | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                | 589-59-3    | 158.238  |               |        | 168.5                                 | 0.853 <sup>20</sup>        | 1.4057 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs ace; s chl       |
| 6396 | Isobutyl methyl ether                   |                                       | C <sub>5</sub> H <sub>12</sub> O                             | 625-44-5    | 88.148   |               |        | 58.6                                  | 0.7311 <sup>20</sup>       |                      | vs eth, EtOH                                           |
| 6397 | Isobutyl nitrate                        |                                       | C <sub>6</sub> H <sub>13</sub> NO <sub>3</sub>               | 543-29-3    | 119.119  |               |        | 123.4                                 | 1.0152 <sup>20</sup>       | 1.4028 <sup>20</sup> |                                                        |
| 6398 | Isobutyl nitrite                        |                                       | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>               | 542-56-3    | 103.120  | col liq       |        | 67                                    | 0.8699 <sup>22</sup>       | 1.3715 <sup>22</sup> | sl H <sub>2</sub> O; s EtOH, eth                       |
| 6399 | Isobutyl pentanoate                     |                                       | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                | 10588-10-0  | 158.238  |               |        | 179                                   | 0.8625 <sup>25</sup>       | 1.4046 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH; s eth, ace               |
| 6400 | Isobutyl phenylacetate                  |                                       | C <sub>12</sub> H <sub>16</sub> O <sub>2</sub>               | 102-13-6    | 192.254  |               |        | 247                                   | 0.999 <sup>18</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth                        |
| 6401 | Isobutyl propanoate                     | Isobutyl propionate                   | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                | 540-42-1    | 130.185  | liq           | -71.4  | 137                                   | 0.888 <sup>0</sup>         | 1.3973 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth; s ace, bz, chl, ctc |
| 6402 | Isobutyl stearate                       |                                       | C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>               | 646-13-9    | 340.583  | wax           | 28.9   | 223 <sup>15</sup>                     | 0.8498 <sup>20</sup>       |                      | vs eth                                                 |
| 6403 | Isobutyl thiocyanate                    |                                       | C <sub>5</sub> H <sub>9</sub> NS                             | 591-84-4    | 115.197  | liq           | -59    | 175.4                                 |                            |                      | vs eth, EtOH                                           |
| 6404 | Isobutyl trichloroacetate               |                                       | C <sub>6</sub> H <sub>9</sub> Cl <sub>3</sub> O <sub>2</sub> | 33560-15-5  | 219.493  |               |        | 188                                   | 1.2636 <sup>20</sup>       | 1.4483 <sup>20</sup> | vs bz, eth, EtOH                                       |
| 6405 | Isobutyl vinyl ether                    |                                       | C <sub>6</sub> H <sub>12</sub> O                             | 109-53-5    | 100.158  | liq           | -112   | 83                                    | 0.7645 <sup>20</sup>       | 1.3966 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, ace, bz; msc eth         |
| 6406 | Isocitric acid                          |                                       | C <sub>6</sub> H <sub>8</sub> O <sub>7</sub>                 | 320-77-4    | 192.124  | ye syr        | 105    |                                       |                            |                      |                                                        |
| 6407 | Isocorybulbine                          |                                       | C <sub>21</sub> H <sub>25</sub> NO <sub>4</sub>              | 22672-74-8  | 355.429  | lf (al)       | 187.5  |                                       | 1.045 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH, chl, acid                  |
| 6408 | Isocorydine                             |                                       | C <sub>20</sub> H <sub>23</sub> NO <sub>4</sub>              | 475-67-2    | 341.402  | pl            | 185    |                                       |                            |                      | vs chl                                                 |
| 6409 | 2-Isocyanato-1,3-dimethylbenzene        | 2,6-Dimethylphenyl isocyanate         | C <sub>8</sub> H <sub>9</sub> NO                             | 28556-81-2  | 147.173  | liq           |        | 100 <sup>13</sup>                     |                            |                      |                                                        |
| 6410 | 1-Isocyanato-2-methoxybenzene           |                                       | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>                | 700-87-8    | 149.148  |               |        | 94 <sup>17</sup>                      |                            |                      |                                                        |
| 6411 | 1-Isocyanato-3-methoxybenzene           |                                       | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>                | 18908-07-1  | 149.148  |               |        | 102 <sup>15</sup>                     |                            |                      |                                                        |
| 6412 | 1-Isocyanato-2-methylbenzene            | 2-Tolyl isocyanate                    | C <sub>8</sub> H <sub>7</sub> NO                             | 614-68-6    | 133.148  |               |        | 185                                   |                            | 1.5282 <sup>20</sup> | i H <sub>2</sub> O; s eth                              |
| 6413 | 1-Isocyanato-3-methylbenzene            | 3-Tolyl isocyanate                    | C <sub>8</sub> H <sub>7</sub> NO                             | 621-29-4    | 133.148  |               |        | 196.5                                 | 1.0330 <sup>20</sup>       |                      | vs bz, eth                                             |
| 6414 | 1-Isocyanato-4-methylbenzene            | 4-Tolyl isocyanate                    | C <sub>8</sub> H <sub>7</sub> NO                             | 622-58-2    | 133.148  |               |        | 187                                   |                            |                      | vs bz, eth                                             |
| 6415 | 2-Isocyanato-2-methylpropane            | <i>tert</i> -Butyl isocyanate         | C <sub>5</sub> H <sub>9</sub> NO                             | 1609-86-5   | 99.131   |               | 85.5   |                                       | 0.8670 <sup>7</sup>        | 1.4061 <sup>20</sup> |                                                        |
| 6416 | 1-Isocyanatonaphthalene                 | 1-Naphthyl isocyanate                 | C <sub>11</sub> H <sub>7</sub> NO                            | 86-84-0     | 169.180  |               |        | 269                                   | 1.1774 <sup>20</sup>       |                      | s eth, bz                                              |
| 6417 | 1-Isocyanato-2-nitrobenzene             | 2-Nitrophenyl isocyanate              | C <sub>7</sub> H <sub>5</sub> N <sub>2</sub> O <sub>3</sub>  | 3320-86-3   | 164.118  | wh nd (peth)  | 41     | 137 <sup>18</sup>                     |                            |                      | vs bz, eth, chl                                        |
| 6418 | 1-Isocyanato-3-nitrobenzene             | 3-Nitrophenyl isocyanate              | C <sub>7</sub> H <sub>5</sub> N <sub>2</sub> O <sub>3</sub>  | 3320-87-4   | 164.118  | wh lf (lig)   | 51     | 130 <sup>11</sup>                     |                            |                      | vs bz, eth, chl                                        |
| 6419 | 1-Isocyanato-4-nitrobenzene             | 4-Nitrophenyl isocyanate              | C <sub>7</sub> H <sub>5</sub> N <sub>2</sub> O <sub>3</sub>  | 100-28-7    | 164.118  | pa ye nd      | 57     | 162 <sup>20</sup> , 137 <sup>11</sup> |                            |                      | vs bz, eth, chl                                        |
| 6420 | 2-Isocyanatopropane                     | Isopropyl isocyanate                  | C <sub>4</sub> H <sub>7</sub> NO                             | 1795-48-8   | 85.105   |               |        | 74.5                                  | 0.866 <sup>25</sup>        | 1.3825 <sup>20</sup> |                                                        |
| 6421 | 1-Isocyanato-3-(trifluoromethyl)benzene | 3-(Trifluoromethyl)phenyl isocyanate  | C <sub>8</sub> H <sub>4</sub> F <sub>3</sub> NO              | 329-01-1    | 187.119  |               |        | 54 <sup>11</sup>                      | 1.3455 <sup>20</sup>       | 1.4690 <sup>20</sup> |                                                        |
| 6422 | Isocyanobenzene                         | Phenyl isocyanide                     | C <sub>7</sub> H <sub>5</sub> N                              | 931-54-4    | 103.122  | unstab liq    |        | 80 <sup>40</sup>                      | 0.98 <sup>15</sup>         |                      |                                                        |



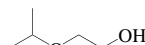
| No.  | Name                                         | Synonym                                                              | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|------|----------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------|------------|----------|----------------------------|---------|---------------------------|----------------------------|----------------------|---------------------------------------------------|
| 6423 | Isocyanomethane                              | Methyl isocyanide                                                    | C <sub>2</sub> H <sub>3</sub> N                               | 593-75-9   | 41.052   |                            | -45     | exp 59.6                  | 0.756 <sup>4</sup>         |                      |                                                   |
| 6424 | (Isocyanomethyl)benzene                      | Benzyl isocyanide                                                    | C <sub>8</sub> H <sub>7</sub> N                               | 10340-91-7 | 117.149  |                            |         | dec 199; 93 <sup>55</sup> | 0.972 <sup>15</sup>        | 1.5193 <sup>20</sup> |                                                   |
| 6425 | 2-Isocyanopropane                            | Isopropyl isocyanide                                                 | C <sub>4</sub> H <sub>7</sub> N                               | 598-45-8   | 69.106   |                            |         | 87                        | 0.7596 <sup>25</sup>       |                      | i H <sub>2</sub> O; msc EtOH, eth                 |
| 6426 | Isodecyl acrylate                            |                                                                      | C <sub>13</sub> H <sub>24</sub> O <sub>2</sub>                | 1330-61-6  | 212.329  |                            | -100    | 158 <sup>50</sup>         | 0.885 <sup>20</sup>        | 1.4416 <sup>20</sup> |                                                   |
| 6427 | Isodecyl diphenyl phosphate                  |                                                                      | C <sub>22</sub> H <sub>31</sub> O <sub>4</sub> P              | 29761-21-5 | 390.452  |                            |         | 249 <sup>10</sup> dec     |                            |                      |                                                   |
| 6428 | Isodecyl methacrylate                        |                                                                      | C <sub>14</sub> H <sub>26</sub> O <sub>2</sub>                | 29964-84-9 | 226.355  |                            |         | 126 <sup>10</sup>         | 0.876 <sup>20</sup>        |                      |                                                   |
| 6429 | 8-Isoestrone                                 |                                                                      | C <sub>18</sub> H <sub>22</sub> O <sub>2</sub>                | 517-06-6   | 270.367  | pr (MeOH)                  | 254     |                           |                            |                      | vs eth, Diox                                      |
| 6430 | Isoeugenol                                   |                                                                      | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 97-54-1    | 164.201  |                            |         | 266                       | 1.080 <sup>25</sup>        | 1.5739 <sup>19</sup> | vs eth, EtOH                                      |
| 6431 | Isofenphos                                   |                                                                      | C <sub>15</sub> H <sub>24</sub> NO <sub>4</sub> PS            | 25311-71-1 | 345.395  |                            | <-12    | 120 <sup>0.01</sup>       | 1.134 <sup>20</sup>        |                      |                                                   |
| 6432 | Isoflurophate                                |                                                                      | C <sub>6</sub> H <sub>14</sub> FO <sub>3</sub> P              | 55-91-4    | 184.145  |                            |         | 62 <sup>9</sup>           | 1.055 <sup>25</sup>        | 1.3830 <sup>25</sup> | sl H <sub>2</sub> O; lig; s eth; vs oils          |
| 6433 | 1 <i>H</i> -Isoindole-1,3(2 <i>H</i> )-dione | Phthalimide                                                          | C <sub>8</sub> H <sub>5</sub> NO <sub>2</sub>                 | 85-41-6    | 147.132  | nd (w), pr (HOAc) if (sub) | 238     |                           |                            |                      | vs bz                                             |
| 6434 | Isolan                                       |                                                                      | C <sub>10</sub> H <sub>17</sub> N <sub>3</sub> O <sub>2</sub> | 119-38-0   | 211.261  | col liq                    |         | 118 <sup>2.5</sup>        | 1.07 <sup>20</sup>         |                      | msc H <sub>2</sub> O; s EtOH, xyl                 |
| 6435 | <i>DL</i> -Isoleucine                        |                                                                      | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                | 443-79-8   | 131.173  |                            | 292 dec |                           |                            |                      |                                                   |
| 6436 | <i>L</i> -Isoleucine                         | 2-Amino-3-methylpentanoic acid                                       | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                | 73-32-5    | 131.173  |                            | 284 dec |                           |                            |                      | s H <sub>2</sub> O; i EtOH                        |
| 6437 | Isolongifolene                               |                                                                      | C <sub>15</sub> H <sub>24</sub>                               | 1135-66-6  | 204.352  | liq                        |         | 82 <sup>0.4</sup>         |                            |                      |                                                   |
| 6438 | Isolysergic acid                             |                                                                      | C <sub>16</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub> | 478-95-5   | 268.310  | cry (w+2)                  | 218 dec |                           |                            |                      | sl H <sub>2</sub> O, EtOH; s py                   |
| 6439 | $\alpha$ -Isomaltose                         | 6- <i>O</i> - $\alpha$ - <i>D</i> -Glucopyranosyl- <i>D</i> -glucose | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>               | 499-40-1   | 342.296  |                            | 120     |                           |                            |                      |                                                   |
| 6440 | Isoniazid                                    | 4-Pyridinecarboxylic acid hydrazide                                  | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O                | 54-85-3    | 137.139  | cry (al)                   | 171.4   |                           |                            |                      | vs H <sub>2</sub> O, EtOH                         |
| 6441 | Isopentane                                   | 2-Methylbutane                                                       | C <sub>5</sub> H <sub>12</sub>                                | 78-78-4    | 72.149   | vol liq or gas             | -159.77 | 27.88                     | 0.6201 <sup>20</sup>       | 1.3537 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                 |
| 6442 | Isopentyl acetate                            |                                                                      | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | 123-92-2   | 130.185  | liq                        | -78.5   | 142.5                     | 0.876 <sup>15</sup>        | 1.4000 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ace, chl    |
| 6443 | Isopentylbenzene                             |                                                                      | C <sub>11</sub> H <sub>16</sub>                               | 2049-94-7  | 148.245  |                            |         | 195                       | 0.856 <sup>20</sup>        | 1.4867 <sup>10</sup> | i H <sub>2</sub> O; s EtOH, eth; vs bz            |
| 6444 | Isopentyl butanoate                          |                                                                      | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                 | 106-27-4   | 158.238  |                            |         | 179                       | 0.865 <sup>19</sup>        | 1.4110 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                  |
| 6445 | Isopentyl formate                            |                                                                      | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 110-45-2   | 116.158  | liq                        | -93.5   | 123.5                     | 0.877 <sup>20</sup>        | 1.3967 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH; msc eth         |
| 6446 | Isopentyl hexanoate                          | Isopentyl caproate                                                   | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                | 2198-61-0  | 186.292  |                            |         | 225.5                     | 0.861 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth                   |
| 6447 | Isopentyl $\alpha$ -hydroxybenzeneacetate    | Isopentyl mandelate                                                  | C <sub>13</sub> H <sub>18</sub> O <sub>3</sub>                | 5421-04-5  | 222.280  | oily liq                   |         | 172 <sup>11</sup>         |                            |                      |                                                   |
| 6448 | Isopentyl isopentanoate                      | Isoamyl isovalerate                                                  | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                | 659-70-1   | 172.265  |                            |         | 190.4                     | 0.8583 <sup>19</sup>       | 1.4130 <sup>19</sup> |                                                   |
| 6449 | Isopentyl lactate                            |                                                                      | C <sub>8</sub> H <sub>16</sub> O <sub>3</sub>                 | 19329-89-6 | 160.211  |                            |         | 202.4                     | 0.9589 <sup>25</sup>       | 1.4240 <sup>25</sup> | vs eth, EtOH                                      |
| 6450 | Isopentyl 2-methylpropanoate                 | Isopentyl isobutyrate                                                | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                 | 2050-01-3  | 158.238  |                            |         | 168.5                     | 0.8627 <sup>20</sup>       |                      | sl H <sub>2</sub> O; s EtOH, eth, ace             |
| 6451 | Isopentyl nitrite                            | Isoamyl nitrite                                                      | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                | 110-46-3   | 117.147  |                            |         | 99.2                      | 0.8828 <sup>20</sup>       | 1.3918 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                |
| 6452 | Isopentyl pentanoate                         |                                                                      | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                | 2050-09-1  | 172.265  |                            |         | 193                       |                            |                      |                                                   |
| 6453 | Isopentyl propanoate                         |                                                                      | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                 | 105-68-0   | 144.212  |                            |         | 160.2                     | 0.8697 <sup>20</sup>       | 1.4069 <sup>20</sup> | vs eth, EtOH                                      |
| 6454 | Isopentyl salicylate                         |                                                                      | C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>                | 87-20-7    | 208.253  |                            |         | 278; 151 <sup>15</sup>    | 1.0535 <sup>20</sup>       | 1.5080 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; s eth, chl; sl ctc   |
| 6455 | Isopentyl trichloroacetate                   |                                                                      | C <sub>7</sub> H <sub>11</sub> Cl <sub>3</sub> O <sub>2</sub> | 57392-55-9 | 233.520  |                            |         | 217                       | 1.2314 <sup>20</sup>       | 1.4521 <sup>20</sup> | vs eth, EtOH                                      |
| 6456 | Isophorone                                   | 3,5,5-Trimethyl-2-cyclohexen-1-one                                   | C <sub>9</sub> H <sub>14</sub> O                              | 78-59-1    | 138.206  | liq                        | -8.1    | 215.2                     | 0.9255 <sup>20</sup>       | 1.4766 <sup>18</sup> |                                                   |
| 6457 | Isophorone diisocyanate                      |                                                                      | C <sub>12</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub> | 4098-71-9  | 222.283  |                            | 60      | 217 <sup>100</sup>        | 1.062 <sup>20</sup>        |                      |                                                   |
| 6458 | Isophthalic acid                             | 1,3-Benzenedicarboxylic acid                                         | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                  | 121-91-5   | 166.132  | nd (w, al)                 | 347     | sub                       |                            |                      | sl H <sub>2</sub> O; s EtOH, HOAc; i eth, bz, lig |
| 6459 | Isopilosine                                  |                                                                      | C <sub>16</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub> | 491-88-3   | 286.325  | pl (al), pr (w, dil al)    | 187     |                           |                            |                      | vs EtOH                                           |
| 6460 | Isopropalin                                  | Benzenamine, 4-(1-methylethyl)-2,6-dinitro- <i>N,N</i> -dipropyl-    | C <sub>15</sub> H <sub>23</sub> N <sub>3</sub> O <sub>4</sub> | 33820-53-0 | 309.362  | red-oran liq               |         |                           |                            |                      | i H <sub>2</sub> O; s os                          |
| 6461 | Isopropamide iodide                          |                                                                      | C <sub>23</sub> H <sub>33</sub> IN <sub>2</sub> O             | 71-81-8    | 480.424  | cry or pow                 | 190     |                           |                            |                      | s H <sub>2</sub> O, EtOH, MeOH; i chl             |
| 6462 | Isopropenyl acetate                          |                                                                      | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                  | 108-22-5   | 100.117  | liq                        | -92.9   | 94                        | 0.9090 <sup>20</sup>       | 1.4033 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, chl, ace; vs eth     |
| 6463 | Isopropenylbenzene                           | $\alpha$ -Methyl styrene                                             | C <sub>9</sub> H <sub>10</sub>                                | 98-83-9    | 118.175  | liq                        | -23.2   | 165.4                     | 0.9106 <sup>20</sup>       | 1.5386 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, ctc |
| 6464 | <i>p</i> -Isopropenylisopropylbenzene        |                                                                      | C <sub>12</sub> H <sub>16</sub>                               | 2388-14-9  | 160.255  | liq                        | -30.6   | 220.8                     | 0.8936 <sup>20</sup>       | 1.5238 <sup>20</sup> | vs ace, bz, eth, EtOH                             |
| 6465 | <i>p</i> -Isopropenylstyrene                 |                                                                      | C <sub>11</sub> H <sub>12</sub>                               | 16262-48-9 | 144.213  | liq                        |         | 242                       | 0.93                       | 1.5684 <sup>20</sup> |                                                   |



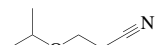
| No.  | Name                                            | Synonym                               | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form | mp/°C  | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|-------------------------------------------------|---------------------------------------|----------------------------------------------------------------|------------|----------|---------------|--------|----------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 6466 | 4-Isopropoxydiphenylamine                       | 4-Isopropoxy- <i>N</i> -phenylaniline | C <sub>15</sub> H <sub>17</sub> NO                             | 101-73-5   | 227.302  |               | 83     |                                        |                            |                      |                                                       |
| 6467 | 2-Isopropoxyethanol                             |                                       | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                  | 109-59-1   | 104.148  |               |        | 145                                    | 0.9030 <sup>20</sup>       | 1.4095 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace                |
| 6468 | 3-Isopropoxypropanenitrile                      | 1-Cyano-2-isopropoxyethane            | C <sub>6</sub> H <sub>11</sub> NO                              | 110-47-4   | 113.157  |               |        | 65 <sup>10</sup>                       |                            |                      | s chl                                                 |
| 6469 | Isopropyl acetate                               |                                       | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                  | 108-21-4   | 102.132  | liq           | -73.4  | 88.7                                   | 0.8718 <sup>20</sup>       | 1.3773 <sup>20</sup> | s H <sub>2</sub> O, EtOH, ace, chl; msc eth           |
| 6470 | Isopropyl acrylate                              | Isopropyl 2-propenoate                | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                  | 689-12-3   | 114.142  | liq           |        | 51 <sup>103</sup>                      |                            |                      |                                                       |
| 6471 | Isopropylamine                                  | 2-Propanamine                         | C <sub>3</sub> H <sub>9</sub> N                                | 75-31-0    | 59.110   | liq           | -95.13 | 31.76                                  | 0.6891 <sup>20</sup>       | 1.3742 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; vs ace; s bz, chl    |
| 6472 | Isopropylamine hydrochloride                    | 2-Propanamine hydrochloride           | C <sub>3</sub> H <sub>10</sub> CIN                             | 15572-56-2 | 95.571   |               | 164    |                                        |                            |                      | s DMSO                                                |
| 6473 | 2-(Isopropylamino)ethanol                       |                                       | C <sub>6</sub> H <sub>13</sub> NO                              | 109-56-8   | 103.163  |               | 128.5  | 173                                    | 0.8970 <sup>20</sup>       | 1.4395 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth                       |
| 6474 | 2-Isopropylaniline                              |                                       | C <sub>9</sub> H <sub>13</sub> N                               | 643-28-7   | 135.206  |               |        | 221; 95 <sup>13</sup>                  | 0.9760 <sup>12</sup>       |                      | i H <sub>2</sub> O; s eth, bz, ctc                    |
| 6475 | 4-Isopropylaniline                              | Cumidine                              | C <sub>9</sub> H <sub>13</sub> N                               | 99-88-7    | 135.206  |               |        | 225                                    | 0.953 <sup>20</sup>        |                      |                                                       |
| 6476 | <i>N</i> -Isopropylaniline                      |                                       | C <sub>9</sub> H <sub>13</sub> N                               | 768-52-5   | 135.206  |               |        | 203                                    | 0.9526 <sup>25</sup>       | 1.5380 <sup>20</sup> | s EtOH, eth, ace, bz                                  |
| 6477 | 4-Isopropylbenzaldehyde                         | Cuminaldehyde                         | C <sub>10</sub> H <sub>12</sub> O                              | 122-03-2   | 148.201  |               |        | 235.5                                  | 0.9755 <sup>20</sup>       | 1.5301 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc               |
| 6478 | Isopropylbenzene                                | Cumene                                | C <sub>9</sub> H <sub>12</sub>                                 | 98-82-8    | 120.191  | liq           | -96.02 | 152.41                                 | 0.8640 <sup>25</sup>       | 1.4915 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 6479 | Isopropylbenzene hydroperoxide                  | Cumene hydroperoxide                  | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                  | 80-15-9    | 152.190  | liq           |        | 153; 84 <sup>8</sup>                   | 1.03 <sup>20</sup>         |                      |                                                       |
| 6480 | 4-Isopropylbenzenemethanol                      | Cumic alcohol                         | C <sub>10</sub> H <sub>14</sub> O                              | 536-60-7   | 150.217  |               | 28     | 249                                    | 0.9818 <sup>20</sup>       | 1.5210 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs bz              |
| 6481 | $\alpha$ -Isopropylbenzenemethanol              | 1-Phenyl-2-methylpropyl alcohol       | C <sub>10</sub> H <sub>14</sub> O                              | 611-69-8   | 150.217  |               |        | 223                                    | 0.9869 <sup>14</sup>       | 1.5193 <sup>14</sup> | i H <sub>2</sub> O; s EtOH, ace                       |
| 6482 | Isopropyl benzoate                              |                                       | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                 | 939-48-0   | 164.201  |               |        | 216                                    | 1.0163 <sup>15</sup>       | 1.4890 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace                  |
| 6483 | 4-Isopropylbenzoic acid                         | Cumic acid                            | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                 | 536-66-3   | 164.201  | tcl pl (al)   | 117.5  | sub                                    | 1.162 <sup>4</sup>         |                      | sl H <sub>2</sub> O; vs EtOH, eth; s peth             |
| 6484 | Isopropyl butanoate                             |                                       | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 638-11-9   | 130.185  |               |        | 130.5                                  | 0.8588 <sup>20</sup>       | 1.3936 <sup>20</sup> | i H <sub>2</sub> O; s EtOH                            |
| 6485 | Isopropyl carbamate                             |                                       | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                 | 1746-77-6  | 103.120  | nd            | 93     | 183                                    | 0.9951 <sup>66</sup>       |                      |                                                       |
| 6486 | Isopropyl chloroacetate                         |                                       | C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>                 | 105-48-6   | 136.577  |               |        | 150.5                                  | 1.0888 <sup>20</sup>       | 1.4382 <sup>20</sup> | vs eth                                                |
| 6487 | Isopropyl chloroformate                         |                                       | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>                 | 108-23-6   | 122.551  |               |        | 105                                    |                            | 1.4013 <sup>30</sup> | vs eth                                                |
| 6488 | Isopropyl 2-chloropropanoate                    |                                       | C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>                | 40058-87-5 | 150.603  |               |        | 151.5                                  | 1.0315 <sup>20</sup>       | 1.4149 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                       |
| 6489 | Isopropylcyclohexane                            |                                       | C <sub>9</sub> H <sub>18</sub>                                 | 696-29-7   | 126.239  | liq           | -89.4  | 154.8                                  | 0.8023 <sup>20</sup>       | 1.4410 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; msc ace, bz         |
| 6490 | 4-Isopropylcyclohexanone                        |                                       | C <sub>9</sub> H <sub>16</sub> O                               | 5432-85-9  | 140.222  |               |        | 214; 139 <sup>100</sup>                | 0.9099 <sup>30</sup>       | 1.4552 <sup>25</sup> |                                                       |
| 6491 | Isopropylcyclopentane                           |                                       | C <sub>8</sub> H <sub>16</sub>                                 | 3875-51-2  | 112.213  | liq           | -111.4 | 126.5                                  | 0.7765 <sup>20</sup>       | 1.4258 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, ace, ctc; s eth, bz     |
| 6492 | Isopropylcyclopropane                           |                                       | C <sub>6</sub> H <sub>12</sub>                                 | 3638-35-5  | 84.159   | liq           | -112.9 | 58.3                                   | 0.6936 <sup>25</sup>       | 1.3865 <sup>20</sup> |                                                       |
| 6493 | Isopropyl (2,4-dichlorophenoxy) acetate         |                                       | C <sub>11</sub> H <sub>12</sub> Cl <sub>2</sub> O <sub>3</sub> | 94-11-1    | 263.117  |               | 5      | 140 <sup>1</sup>                       | 1.26 <sup>25</sup>         | 1.5209 <sup>25</sup> |                                                       |
| 6494 | <i>N</i> -Isopropyl-4,4-diphenylcyclohexanamine | Pramiverin                            | C <sub>21</sub> H <sub>27</sub> N                              | 14334-40-8 | 293.446  |               | 70     | 165 <sup>0.05</sup>                    |                            |                      |                                                       |
| 6495 | Isopropyl dodecanoate                           | Isopropyl laurate                     | C <sub>15</sub> H <sub>30</sub> O <sub>2</sub>                 | 10233-13-3 | 242.398  |               |        | 196 <sup>60</sup> , 105 <sup>0.8</sup> | 0.8536 <sup>20</sup>       | 1.4280 <sup>25</sup> | vs eth, EtOH                                          |
| 6496 | Isopropyl formate                               |                                       | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                   | 625-55-8   | 88.106   |               |        | 68.2                                   | 0.8728 <sup>20</sup>       | 1.3678 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace; s chl     |
| 6497 | Isopropyl 2-furancarboxylate                    | Isopropyl 2-furanoate                 | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                  | 6270-34-4  | 154.163  |               |        | 198.5                                  | 1.0655 <sup>24</sup>       | 1.4682 <sup>24</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz              |
| 6498 | Isopropyl glycidyl ether                        | (1-Methylethoxy)methyloxirane         | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                  | 4016-14-2  | 116.158  |               |        | 137                                    | 0.9186 <sup>20</sup>       |                      | s H <sub>2</sub> O, ace, EtOH                         |
| 6499 | 4-Isopropylheptane                              |                                       | C <sub>10</sub> H <sub>22</sub>                                | 52896-87-4 | 142.282  |               |        | 158.9                                  | 0.7354 <sup>25</sup>       | 1.4153 <sup>20</sup> |                                                       |
| 6500 | Isopropylhydrazine                              |                                       | C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>                  | 2257-52-5  | 74.124   | liq           |        | 107                                    |                            |                      | s H <sub>2</sub> O, bz, EtOH; sl eth                  |
| 6501 | Isopropyl 2-hydroxybenzoate                     | Isopropyl salicylate                  | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                 | 607-85-2   | 180.200  |               |        | 238                                    | 1.0729 <sup>20</sup>       | 1.5065 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                     |
| 6502 | Isopropyl isobutanoate                          | Isopropyl isobutyrate                 | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 617-50-5   | 130.185  |               |        | 120.7                                  | 0.8471 <sup>21</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, ace                  |
| 6503 | Isopropyl lactate                               |                                       | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                  | 617-51-6   | 132.157  |               |        | 167                                    | 0.9980 <sup>20</sup>       | 1.4082 <sup>25</sup> | vs H <sub>2</sub> O, bz, eth, EtOH                    |
| 6504 | Isopropyl methacrylate                          | Isopropyl 2-methyl-2-propenoate       | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                  | 4655-34-9  | 128.169  |               |        | 125                                    | 0.8847 <sup>20</sup>       | 1.4122 <sup>20</sup> | vs ace, bz, eth, EtOH                                 |
| 6505 | Isopropyl methanesulfonate                      |                                       | C <sub>4</sub> H <sub>10</sub> O <sub>3</sub> S                | 926-06-7   | 138.185  |               |        | 82 <sup>6</sup>                        |                            |                      |                                                       |
| 6506 | Isopropylmethylaniline                          | Methylisopropylamine                  | C <sub>2</sub> H <sub>7</sub> N                                | 4747-21-1  | 73.137   |               |        | 50.4                                   |                            |                      |                                                       |



4-Isopropoxydiphenylamine



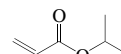
2-Isopropoxyethanol



3-Isopropoxypropanenitrile



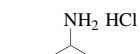
Isopropyl acetate



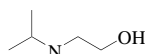
Isopropyl acrylate



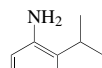
Isopropylamine



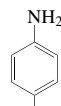
Isopropylamine hydrochloride



2-(Isopropylamino)ethanol



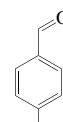
2-Isopropylaniline



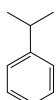
4-Isopropylaniline



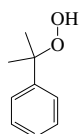
N-Isopropylaniline



4-Isopropylbenzaldehyde



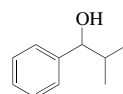
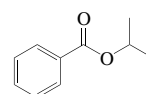
Isopropylbenzene



Isopropylbenzene hydroperoxide



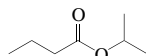
4-Isopropylbenzenemethanol

 $\alpha$ -Isopropylbenzenemethanol

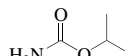
Isopropyl benzoate



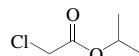
4-Isopropylbenzoic acid



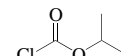
Isopropyl butanoate



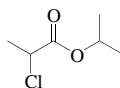
Isopropyl carbamate



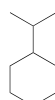
Isopropyl chloroacetate



Isopropyl chloroformate



Isopropyl 2-chloropropanoate



Isopropylcyclohexane



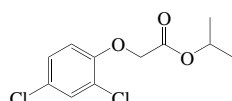
4-Isopropylcyclohexanone



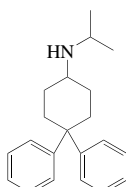
Isopropylcyclopentane



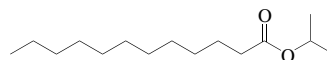
Isopropylcyclopropane



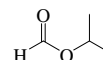
Isopropyl (2,4-dichlorophenoxy)acetate



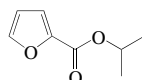
N-Isopropyl-4,4-diphenylcyclohexanamine



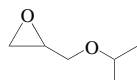
Isopropyl dodecanoate



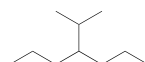
Isopropyl formate



Isopropyl 2-furancarboxylate



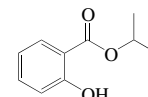
Isopropyl glycidyl ether



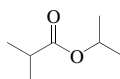
4-Isopropylheptane



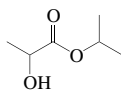
Isopropylhydrazine



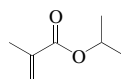
Isopropyl 2-hydroxybenzoate



Isopropyl isobutanoate



Isopropyl lactate



Isopropyl methacrylate



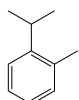
Isopropyl methanesulfonate



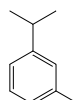
Isopropylmethylaniline



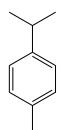
| No.  | Name                                                      | Synonym                                               | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|-----------------------------------------------------------|-------------------------------------------------------|--------------------------------------------------------------|------------|----------|---------------|--------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 6507 | 1-Isopropyl-2-methylbenzene                               | <i>o</i> -Cymene                                      | C <sub>10</sub> H <sub>14</sub>                              | 527-84-4   | 134.218  | liq           | -71.5  | 178.1                                 | 0.8766 <sup>20</sup>       | 1.5006 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 6508 | 1-Isopropyl-3-methylbenzene                               | <i>m</i> -Cymene                                      | C <sub>10</sub> H <sub>14</sub>                              | 535-77-3   | 134.218  | liq           | -63.7  | 175.1                                 | 0.8610 <sup>20</sup>       | 1.4930 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 6509 | 1-Isopropyl-4-methylbenzene                               | <i>p</i> -Cymene                                      | C <sub>10</sub> H <sub>14</sub>                              | 99-87-6    | 134.218  | liq           | -67.94 | 177.1                                 | 0.8573 <sup>20</sup>       | 1.4909 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 6510 | Isopropyl 3-methylbutanoate                               |                                                       | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | 32665-23-9 | 144.212  |               |        | 142; 70 <sup>35</sup>                 | 0.8538 <sup>17</sup>       | 1.3960 <sup>20</sup> | vs ace, eth, EtOH                                     |
| 6511 | 5-Isopropyl-2-methyl-1,3-cyclohexadiene, ( <i>R</i> )     |                                                       | C <sub>10</sub> H <sub>16</sub>                              | 4221-98-1  | 136.234  |               |        | 173                                   | 0.8421 <sup>20</sup>       | 1.4772 <sup>19</sup> |                                                       |
| 6512 | 5-Isopropyl-3-methyl-2-cyclohexen-1-one, (±)              | Homocamfin                                            | C <sub>10</sub> H <sub>16</sub> O                            | 535-86-4   | 152.233  | pa ye         |        | 244; 121 <sup>15</sup>                | 0.9340 <sup>21</sup>       | 1.4865 <sup>21</sup> | vs ace, EtOH                                          |
| 6513 | 6-Isopropyl-3-methyl-2-cyclohexen-1-one, (±)              | (±)-Piperitone                                        | C <sub>10</sub> H <sub>16</sub> O                            | 6091-52-7  | 152.233  | liq           | -19    | 232.5                                 | 0.9331 <sup>20</sup>       | 1.4845 <sup>20</sup> | vs ace, EtOH                                          |
| 6514 | Isopropyl methyl ether                                    | 2-Methoxypropane                                      | C <sub>4</sub> H <sub>10</sub> O                             | 598-53-8   | 74.121   |               |        | 30.77                                 | 0.7237 <sup>15</sup>       | 1.3576 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                    |
| 6515 | 5-Isopropyl-2-methylphenol                                | Carvacrol                                             | C <sub>10</sub> H <sub>14</sub> O                            | 499-75-2   | 150.217  | nd            | 1      | 237.7                                 | 0.9772 <sup>20</sup>       | 1.5230 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc; vs ace         |
| 6516 | 2-Isopropyl-6-methyl-4-pyrimidinol                        |                                                       | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O              | 2814-20-2  | 152.193  | cry           | 173    |                                       |                            |                      |                                                       |
| 6517 | Isopropyl methyl sulfide                                  |                                                       | C <sub>4</sub> H <sub>10</sub> S                             | 1551-21-9  | 90.187   | liq           | -101.5 | 84.8                                  | 0.8291 <sup>20</sup>       | 1.4932 <sup>20</sup> | s EtOH, eth, ace                                      |
| 6518 | 1-Isopropyl-naphthalene                                   |                                                       | C <sub>13</sub> H <sub>14</sub>                              | 6158-45-8  | 170.250  | liq           | -16    | 268                                   | 0.9956 <sup>20</sup>       | 1.5952 <sup>20</sup> |                                                       |
| 6519 | 2-Isopropyl-naphthalene                                   |                                                       | C <sub>13</sub> H <sub>14</sub>                              | 2027-17-0  | 170.250  |               | 14.5   | 268.2                                 | 0.9753 <sup>20</sup>       | 1.5848 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz                |
| 6520 | Isopropyl nitrate                                         |                                                       | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                | 1712-64-7  | 105.093  |               |        | 100                                   | 1.034 <sup>19</sup>        | 1.3912 <sup>16</sup> | s EtOH, eth                                           |
| 6521 | Isopropyl nitrite                                         |                                                       | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | 541-42-4   | 89.094   | pa ye oil     |        | 40                                    | 0.8684 <sup>15</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                       |
| 6522 | 1-Isopropyl-4-nitrobenzene                                |                                                       | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>               | 1817-47-6  | 165.189  | pa ye oil     |        | 122 <sup>9</sup>                      | 1.084 <sup>20</sup>        | 1.5367 <sup>20</sup> | i H <sub>2</sub> O; s ace, bz, lig                    |
| 6523 | <i>N</i> -Isopropyl- <i>N</i> -nitroso-2-propanamine      |                                                       | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O              | 601-77-4   | 130.187  | cry (eth,w)   | 48     | 194.5                                 | 0.9422 <sup>20</sup>       |                      | sl H <sub>2</sub> O; s EtOH, eth, bz                  |
| 6524 | Isopropyl 3-oxobutanoate                                  | Isopropyl acetoacetate                                | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>                | 542-08-5   | 144.168  | liq           | -27.3  | 186                                   | 0.9835 <sup>20</sup>       | 1.4173 <sup>20</sup> | vs eth, EtOH, lig                                     |
| 6525 | Isopropyl palmitate                                       | Isopropyl hexadecanoate                               | C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>               | 142-91-6   | 298.504  |               | 13.5   | 160 <sup>2</sup>                      | 0.8404 <sup>38</sup>       | 1.4364 <sup>25</sup> | vs ace, bz, eth, EtOH                                 |
| 6526 | Isopropyl pentanoate                                      |                                                       | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | 18362-97-5 | 144.212  |               |        |                                       | 0.8579 <sup>20</sup>       | 1.4061 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace                  |
| 6527 | 2-Isopropylphenol                                         |                                                       | C <sub>9</sub> H <sub>12</sub> O                             | 88-69-7    | 136.190  |               | 15.5   | 213.5                                 | 1.012 <sup>20</sup>        | 1.5315 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, bz, ctc             |
| 6528 | 3-Isopropylphenol                                         |                                                       | C <sub>9</sub> H <sub>12</sub> O                             | 618-45-1   | 136.190  |               | 26     | 228                                   |                            | 1.5261 <sup>20</sup> | vs eth                                                |
| 6529 | 4-Isopropylphenol                                         |                                                       | C <sub>9</sub> H <sub>12</sub> O                             | 99-89-8    | 136.190  | nd (peth)     | 62.3   | 230; 110 <sup>10</sup>                | 0.990 <sup>20</sup>        | 1.5228 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, chl                      |
| 6530 | <i>N</i> -Isopropyl- <i>N</i> '-phenyl-1,4-benzenediamine |                                                       | C <sub>15</sub> H <sub>18</sub> N <sub>2</sub>               | 101-72-4   | 226.317  |               | 72.5   | 148 <sup>2</sup>                      |                            |                      |                                                       |
| 6531 | Isopropyl phenylcarbamate                                 | Propham                                               | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>              | 122-42-9   | 179.216  | wh nd (al)    | 90     |                                       | 1.09 <sup>20</sup>         | 1.4989 <sup>31</sup> | vs bz, EtOH                                           |
| 6532 | 1-(4-Isopropylphenyl)ethanone                             |                                                       | C <sub>11</sub> H <sub>14</sub> O                            | 645-13-6   | 162.228  |               |        | 254                                   | 0.9753 <sup>15</sup>       | 1.5235 <sup>20</sup> |                                                       |
| 6533 | Isopropyl propanoate                                      |                                                       | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                | 637-78-5   | 116.158  |               |        | 109.5                                 | 0.8660 <sup>20</sup>       | 1.3872 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                    |
| 6534 | <i>N</i> -Isopropyl-2-propenamide                         |                                                       | C <sub>8</sub> H <sub>13</sub> NO                            | 2210-25-5  | 113.157  |               | 64.5   | 110 <sup>15</sup>                     |                            |                      |                                                       |
| 6535 | Isopropylpropylamine                                      | <i>N</i> -Propyl-2-propanamine                        | C <sub>6</sub> H <sub>15</sub> N                             | 21968-17-2 | 101.190  |               |        | 96.9                                  |                            |                      |                                                       |
| 6536 | Isopropyl propyl sulfide                                  |                                                       | C <sub>6</sub> H <sub>14</sub> S                             | 5008-73-1  | 118.240  |               |        | 132.1                                 | 0.8269 <sup>20</sup>       |                      |                                                       |
| 6537 | 4-Isopropylpyridine                                       |                                                       | C <sub>8</sub> H <sub>11</sub> N                             | 696-30-0   | 121.180  | liq           | -54.9  | 178                                   | 0.9382 <sup>25</sup>       | 1.4962 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace            |
| 6538 | Isopropyl 3-pyridinecarboxylate                           | Isopropyl nicotinate                                  | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>               | 553-60-6   | 165.189  |               |        | 126 <sup>30</sup> , 92.5 <sup>5</sup> | 1.0624 <sup>20</sup>       | 1.4926 <sup>20</sup> |                                                       |
| 6539 | Isopropyl silicate                                        | Tetra(isopropoxy)silane                               | C <sub>12</sub> H <sub>26</sub> O <sub>4</sub> Si            | 1992-48-9  | 264.434  |               |        | 184                                   | 0.8770 <sup>20</sup>       |                      | s ctc, CS <sub>2</sub>                                |
| 6540 | Isopropyl stearate                                        |                                                       | C <sub>21</sub> H <sub>42</sub> O <sub>2</sub>               | 112-10-7   | 326.557  |               | 28     | 207 <sup>6</sup>                      | 0.8403 <sup>38</sup>       |                      | vs ace, eth, EtOH, chl                                |
| 6541 | 4-Isopropylstyrene                                        |                                                       | C <sub>11</sub> H <sub>14</sub>                              | 2055-40-5  | 146.229  | liq           | -44.7  | 204.1                                 | 0.8850 <sup>20</sup>       | 1.5289 <sup>20</sup> | vs ace, bz, eth, EtOH                                 |
| 6542 | Isopropyl tetradecanoate                                  | Isopropyl myristate                                   | C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>               | 110-27-0   | 270.451  |               |        | 193 <sup>20</sup> , 140 <sup>2</sup>  | 0.8532 <sup>20</sup>       | 1.4325 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, chl; vs ace, bz      |
| 6543 | (Isopropylthio)benzene                                    |                                                       | C <sub>8</sub> H <sub>12</sub> S                             | 3019-20-3  | 152.256  |               |        | 208                                   | 0.9852 <sup>20</sup>       | 1.5464 <sup>20</sup> |                                                       |
| 6544 | Isopropyl trichloroacetate                                |                                                       | C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub> O <sub>2</sub> | 3974-99-0  | 205.468  |               |        | 175; 66 <sup>15</sup>                 | 1.2911 <sup>25</sup>       | 1.4428 <sup>20</sup> | vs bz, eth, EtOH                                      |
| 6545 | Isopropylurea                                             |                                                       | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O              | 691-60-1   | 102.134  | nd            |        | 103 <sup>0.1</sup>                    |                            |                      | s H <sub>2</sub> O, EtOH, chl, ace; sl eth            |
| 6546 | Isopropyl vinyl ether                                     | 2-(Ethenyloxy)propane                                 | C <sub>5</sub> H <sub>10</sub> O                             | 926-65-8   | 86.132   | liq           | -140   | 55.5                                  | 0.7534 <sup>20</sup>       | 1.3840 <sup>20</sup> | vs ace, bz, eth, EtOH                                 |
| 6547 | Isoproterenol                                             | 4-[1-Hydroxy-2-[isopropylamino]ethyl]-1,2-benzenediol | C <sub>11</sub> H <sub>17</sub> NO <sub>3</sub>              | 7683-59-2  | 211.258  |               | 170.5  |                                       |                            |                      |                                                       |



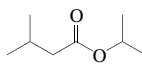
1-Isopropyl-2-methylbenzene



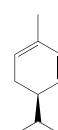
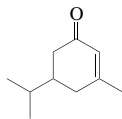
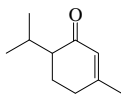
1-Isopropyl-3-methylbenzene



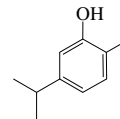
1-Isopropyl-4-methylbenzene



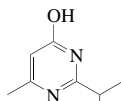
Isopropyl 3-methylbutanoate

5-Isopropyl-2-methyl-1,3-cyclohexadiene, (*R*)5-Isopropyl-3-methyl-2-cyclohexen-1-one, ( $\pm$ )6-Isopropyl-3-methyl-2-cyclohexen-1-one, ( $\pm$ )

Isopropyl methyl ether



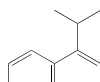
5-Isopropyl-2-methylphenol



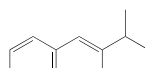
2-Isopropyl-6-methyl-4-pyrimidinol



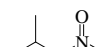
Isopropyl methyl sulfide



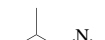
1-Isopropylnaphthalene



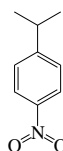
2-Isopropylnaphthalene



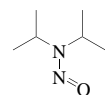
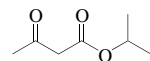
Isopropyl nitrate



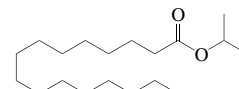
Isopropyl nitrite



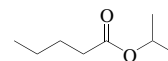
1-Isopropyl-4-nitrobenzene

*N*-Isopropyl-*N*-nitroso-2-propanamine

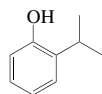
Isopropyl 3-oxobutanoate



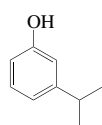
Isopropyl palmitate



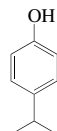
Isopropyl pentanoate



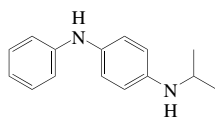
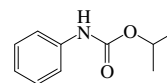
2-Isopropylphenol



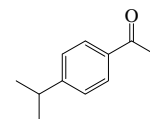
3-Isopropylphenol



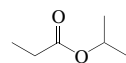
4-Isopropylphenol

*N*-Isopropyl-*N*'-phenyl-1,4-benzenediamine

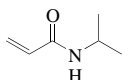
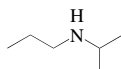
Isopropyl phenylcarbamate



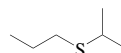
1-(4-Isopropylphenyl)ethanone



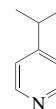
Isopropyl propanoate

*N*-Isopropyl-2-propenamide

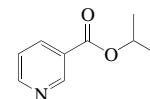
Isopropylpropylamine



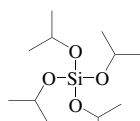
Isopropyl propyl sulfide



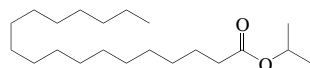
4-Isopropylpyridine



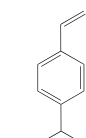
Isopropyl 3-pyridinecarboxylate



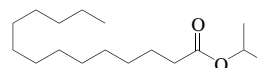
Isopropyl silicate



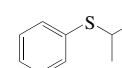
Isopropyl stearate



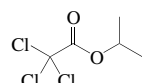
4-Isopropylstyrene



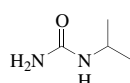
Isopropyl tetradecanoate



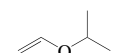
(Isopropylthio)benzene



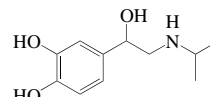
Isopropyl trichloroacetate



Isopropylurea

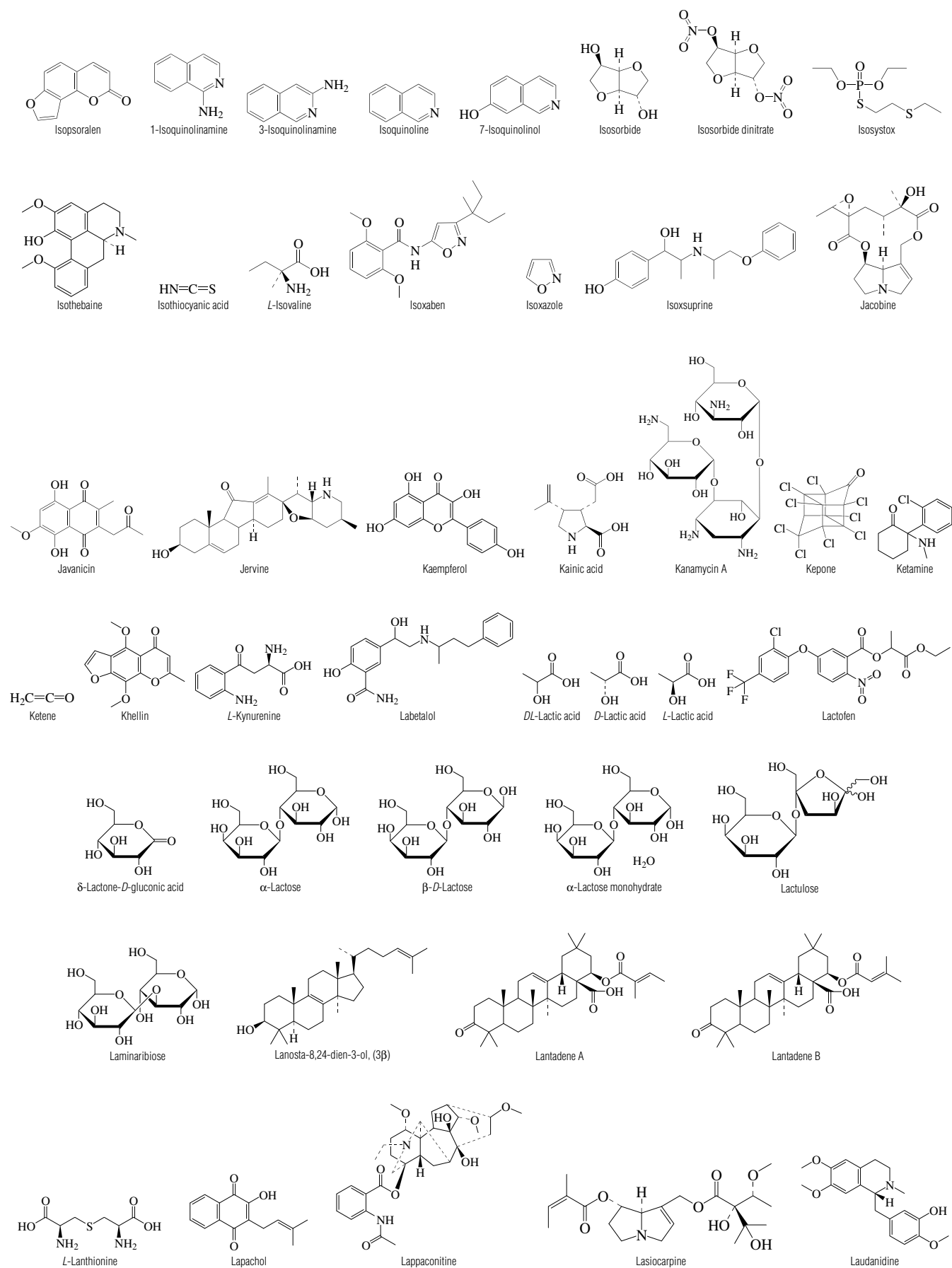


Isopropyl vinyl ether

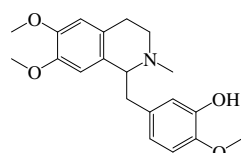


Isoproterenol

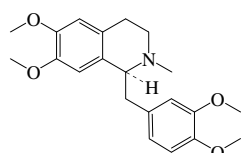
| No.  | Name                         | Synonym                                                                    | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form            | mp/°C   | bp/°C               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|------|------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------|------------|----------|--------------------------|---------|---------------------|----------------------------|----------------------|---------------------------------------------------|
| 6548 | Isopsoralen                  |                                                                            | C <sub>11</sub> H <sub>6</sub> O <sub>3</sub>                    | 523-50-2   | 186.164  |                          | 139     |                     |                            |                      |                                                   |
| 6549 | 1-Isoquinolinamine           |                                                                            | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                     | 1532-84-9  | 144.173  | pl(w)                    | 123     | 164 <sup>8</sup>    |                            |                      | sl H <sub>2</sub> O, eth; vs EtOH                 |
| 6550 | 3-Isoquinolinamine           |                                                                            | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                     | 25475-67-6 | 144.173  |                          | 178.5   |                     |                            |                      |                                                   |
| 6551 | Isoquinoline                 | Benzo[c]pyridine                                                           | C <sub>9</sub> H <sub>7</sub> N                                  | 119-65-3   | 129.159  | hyg pl                   | 26.47   | 243.22              | 1.0910 <sup>90</sup>       | 1.6148 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, chl; msc eth, bz     |
| 6552 | 7-Isoquinolinol              |                                                                            | C <sub>9</sub> H <sub>7</sub> NO                                 | 7651-83-4  | 145.158  |                          | 230     |                     |                            |                      | sl H <sub>2</sub> O, eth; s EtOH                  |
| 6553 | Isosorbide                   |                                                                            | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>                    | 652-67-5   | 146.141  |                          | 63      | 170 <sup>2</sup>    |                            |                      |                                                   |
| 6554 | Isosorbide dinitrate         | 1,4:3,6-Dianhydroglucitol                                                  | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>8</sub>      | 87-33-2    | 236.136  | col cry                  | 52      |                     |                            |                      | vs EtOH, eth, ace                                 |
| 6555 | Isosystox                    | Demeton-S                                                                  | C <sub>8</sub> H <sub>19</sub> O <sub>3</sub> PS <sub>2</sub>    | 126-75-0   | 258.339  | liq                      |         | 133 <sup>2</sup>    | 1.132 <sup>21</sup>        |                      | s H <sub>2</sub> O                                |
| 6556 | Isothebaine                  |                                                                            | C <sub>19</sub> H <sub>21</sub> NO <sub>3</sub>                  | 568-21-8   | 311.375  | orth cry (al)            | 203.5   |                     |                            |                      | i H <sub>2</sub> O; msc EtOH, chl; sl eth; s MeOH |
| 6557 | Is thiocyanic acid           |                                                                            | CHNS                                                             | 3129-90-6  | 59.091   | unstab gas               |         |                     |                            |                      |                                                   |
| 6558 | L-Isovaline                  | 2-Amino-2-methylbutyric acid                                               | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                   | 595-40-4   | 117.147  | nd (w)                   | ≈300    |                     |                            |                      | s EtOH; sl eth                                    |
| 6559 | Isoxaben                     |                                                                            | C <sub>18</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub>    | 82558-50-7 | 332.395  | wh cry                   | 173     |                     |                            |                      | s EtOAc, MeCN, MeOH                               |
| 6560 | Isoxazole                    | 1-Oxa-2-azacyclopentadiene                                                 | C <sub>3</sub> H <sub>3</sub> NO                                 | 288-14-2   | 69.062   |                          |         | 95                  | 1.078 <sup>20</sup>        | 1.4298 <sup>17</sup> | s H <sub>2</sub> O                                |
| 6561 | Isoxsuprine                  |                                                                            | C <sub>18</sub> H <sub>23</sub> NO <sub>3</sub>                  | 395-28-8   | 301.381  | cry                      | 103.0   |                     |                            |                      |                                                   |
| 6562 | Jacobine                     |                                                                            | C <sub>18</sub> H <sub>25</sub> NO <sub>6</sub>                  | 6870-67-3  | 351.395  | pl (EtOH)                | 228     |                     |                            |                      |                                                   |
| 6563 | Javanicin                    |                                                                            | C <sub>15</sub> H <sub>14</sub> O <sub>6</sub>                   | 476-45-9   | 290.268  | red cry (al)             | 208 dec |                     |                            |                      | s alk                                             |
| 6564 | Jervine                      |                                                                            | C <sub>27</sub> H <sub>35</sub> NO <sub>3</sub>                  | 469-59-0   | 425.604  |                          | 243 dec |                     |                            |                      | i H <sub>2</sub> O; s EtOH, ace, chl; sl eth      |
| 6565 | Kaempferol                   |                                                                            | C <sub>15</sub> H <sub>10</sub> O <sub>6</sub>                   | 520-18-3   | 286.236  | ye nd (al, + 1 w)        | 277     |                     |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth, ace; i bz |
| 6566 | Kainic acid                  |                                                                            | C <sub>10</sub> H <sub>15</sub> NO <sub>4</sub>                  | 487-79-6   | 213.231  | cry (EtOH aq)            | 253 dec |                     |                            |                      | s H <sub>2</sub> O; i EtOH                        |
| 6567 | Kanamycin A                  |                                                                            | C <sub>18</sub> H <sub>36</sub> N <sub>6</sub> O <sub>11</sub>   | 59-01-8    | 484.499  | cry (EtOH)               |         |                     |                            |                      |                                                   |
| 6568 | Kepone                       | Chlordecone                                                                | C <sub>10</sub> Cl <sub>10</sub> O                               | 143-50-0   | 490.636  |                          | 350 dec |                     | 1.61 <sup>25</sup>         |                      |                                                   |
| 6569 | Ketamine                     | 2-(2-Chlorophenyl)-2-(methylamino)cyclohexanone, (±)                       | C <sub>13</sub> H <sub>16</sub> ClNO                             | 6740-88-1  | 237.725  | cry (eth-pentane)        | 92.5    |                     |                            |                      |                                                   |
| 6570 | Ketene                       |                                                                            | C <sub>2</sub> H <sub>2</sub> O                                  | 463-51-4   | 42.036   | col gas                  | -151    | -49.8               |                            |                      | sl eth, ace                                       |
| 6571 | Khellin                      | 4,9-Dimethoxy-7-methyl-5 <i>H</i> -furo[3,2- <i>g</i> ][1]benzopyran-5-one | C <sub>14</sub> H <sub>12</sub> O <sub>5</sub>                   | 82-02-0    | 260.242  | eth, al                  | 154 dec | 190 <sup>0.05</sup> |                            |                      | i H <sub>2</sub> O; s EtOH, ace; sl eth, chl      |
| 6572 | L-Kynurenine                 | Benzenebutanoic acid, α,2-diamino-γ-oxo-                                   | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>    | 343-65-7   | 208.213  | lf (+/2w)                | 191 dec |                     |                            |                      | sl H <sub>2</sub> O                               |
| 6573 | Labetalol                    |                                                                            | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub> O <sub>3</sub>    | 36894-69-6 | 328.405  | cry (MeOH)               | 164     |                     |                            |                      |                                                   |
| 6574 | DL-Lactic acid               | 2-Hydroxypropanoic acid, (±)                                               | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                     | 598-82-3   | 90.078   | ye cry                   |         | 122 <sup>15</sup>   | 1.2060 <sup>21</sup>       | 1.4392 <sup>20</sup> | vs H <sub>2</sub> O, EtOH; sl eth                 |
| 6575 | D-Lactic acid                | D-2-Hydroxypropanoic acid                                                  | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                     | 10326-41-7 | 90.078   | pl (chl)                 | 53      | 103 <sup>2</sup>    |                            |                      | vs H <sub>2</sub> O, EtOH                         |
| 6576 | L-Lactic acid                | L-2-Hydroxypropanoic acid                                                  | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                     | 79-33-4    | 90.078   | hyg pr (eth)             | 53      |                     |                            |                      | vs H <sub>2</sub> O, EtOH                         |
| 6577 | Lactofen                     |                                                                            | C <sub>19</sub> H <sub>15</sub> ClF <sub>3</sub> NO <sub>7</sub> | 77501-63-4 | 461.773  | ye pow (bz)              | 93      |                     |                            |                      |                                                   |
| 6578 | δ-Lactone-D-gluconic acid    | δ-D-Gluconolactone                                                         | C <sub>6</sub> H <sub>10</sub> O <sub>6</sub>                    | 90-80-2    | 178.139  | nd (al)                  |         |                     |                            |                      |                                                   |
| 6579 | α-Lactose                    |                                                                            | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                  | 14641-93-1 | 342.296  | wh pow                   | 222.8   |                     |                            |                      | vs H <sub>2</sub> O; sl EtOH; i eth, chl          |
| 6580 | β-D-Lactose                  |                                                                            | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                  | 5965-66-2  | 342.296  |                          | 254     |                     | 1.59 <sup>20</sup>         |                      | vs H <sub>2</sub> O; sl EtOH; i eth, chl          |
| 6581 | α-Lactose monohydrate        |                                                                            | C <sub>12</sub> H <sub>24</sub> O <sub>12</sub>                  | 5989-81-1  | 360.312  | mcl (w)                  | 201 dec |                     | 1.547 <sup>20</sup>        |                      | vs H <sub>2</sub> O; i EtOH, eth, chl, MeOH       |
| 6582 | Lactulose                    | 4-O-β-D-Galactopyranosyl-D-fructose                                        | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                  | 4618-18-2  | 342.296  | hx pl (MeOH)             | 169     |                     |                            |                      | vs H <sub>2</sub> O                               |
| 6583 | Laminaribiose                | 3-O-β-D-Glucopyranosyl-D-glucose                                           | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                  | 34980-39-7 | 342.296  |                          | 205     |                     |                            |                      |                                                   |
| 6584 | Lanosta-8,24-dien-3-ol, (3β) | Lanosterol                                                                 | C <sub>30</sub> H <sub>50</sub> O                                | 79-63-0    | 426.717  | nd (eth), cry (MeOH-ace) | 140.5   |                     |                            |                      | vs eth, EtOH, chl                                 |
| 6585 | Lantadene A                  | Rehmannic acid                                                             | C <sub>35</sub> H <sub>52</sub> O <sub>5</sub>                   | 467-81-2   | 552.785  | cry (MeOH)               | 297     |                     |                            |                      |                                                   |
| 6586 | Lantadene B                  |                                                                            | C <sub>35</sub> H <sub>52</sub> O <sub>5</sub>                   | 467-82-3   | 552.785  | cry (EtOH)               | 302     |                     |                            |                      |                                                   |
| 6587 | L-Lanthionine                | L-Cysteine, S-(2-amino-2-carboxyethyl)-, (R)-                              | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> S   | 922-55-4   | 208.235  | hex pl                   | 294 dec |                     |                            |                      | sl H <sub>2</sub> O                               |
| 6588 | Lapachol                     | 2-Hydroxy-3-(3-methyl-2-butenyl)-1,4-naphthalenedione                      | C <sub>15</sub> H <sub>14</sub> O <sub>3</sub>                   | 84-79-7    | 242.270  | ye pr (eth, bz) pl (al)  | 139.5   |                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl; vs HOAc |
| 6589 | Lappaconitine                |                                                                            | C <sub>32</sub> H <sub>44</sub> N <sub>2</sub> O <sub>8</sub>    | 32854-75-4 | 584.699  | hex pl (al)              | 217.5   |                     |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s bz, chl       |
| 6590 | Lasiocarpine                 |                                                                            | C <sub>21</sub> H <sub>33</sub> NO <sub>7</sub>                  | 303-34-4   | 411.490  | col pl (peth)            | 95.5    |                     |                            |                      | sl H <sub>2</sub> O; s EtOH, bz, eth              |
| 6591 | Laudanidine                  |                                                                            | C <sub>20</sub> H <sub>25</sub> NO <sub>4</sub>                  | 301-21-3   | 343.418  | hex pr (al)              | 184.5   |                     |                            |                      | vs H <sub>2</sub> O, bz                           |



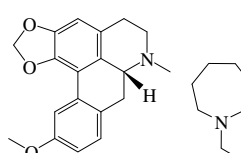
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|------|-----------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------|----------|-------------------------------------------|---------|-----------------------------------------|----------------------------|-----------------------|-------------------------------------------------------|
| 6592 | Laudanine                         |                                                                           | C <sub>20</sub> H <sub>25</sub> NO <sub>4</sub>                                             | 85-64-3    | 343.418  | ye wh pr (dil al, al-chl)                 | 167     |                                         | 1.26 <sup>20</sup>         |                       | sl H <sub>2</sub> O, EtOH, eth; s bz, chl             |
| 6593 | Laudanosine                       |                                                                           | C <sub>21</sub> H <sub>27</sub> NO <sub>4</sub>                                             | 2688-77-9  | 357.444  | nd (peth), pr (al)                        | 89      |                                         |                            |                       | vs ace, eth, EtOH, chl                                |
| 6594 | Laureline                         |                                                                           | C <sub>19</sub> H <sub>19</sub> NO <sub>3</sub>                                             | 81-38-9    | 309.359  | tab (al) cubes (peth)                     | 114     |                                         |                            |                       | i H <sub>2</sub> O; s EtOH, eth, dil acid, con sulf   |
| 6595 | Laurocapram                       | 1-Dodecylhexahydro-2 <i>H</i> -azepin-2-one                               | C <sub>18</sub> H <sub>35</sub> NO                                                          | 59227-89-3 | 281.477  | col liq                                   | -7      | 160 <sup>50</sup>                       | 0.91                       | 1.4701                | i H <sub>2</sub> O                                    |
| 6596 | Lead bis(dimethyldithiocarbamate) |                                                                           | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> PbS <sub>4</sub>                              | 19010-66-3 | 447.6    | pale ye nd                                | 258     |                                         |                            |                       |                                                       |
| 6597 | Ledol                             |                                                                           | C <sub>15</sub> H <sub>26</sub> O                                                           | 577-27-5   | 222.366  | nd (al)                                   | 105     | 292                                     | 0.9078 <sup>100</sup>      | 1.4667 <sup>110</sup> | vs ace, eth, EtOH                                     |
| 6598 | Lenacil                           |                                                                           | C <sub>13</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub>                               | 2164-08-1  | 234.294  |                                           | 290     |                                         | 1.32 <sup>25</sup>         |                       | vs py                                                 |
| 6599 | Leptophos                         |                                                                           | C <sub>13</sub> H <sub>10</sub> BrCl <sub>2</sub> O <sub>2</sub> PS                         | 21609-90-5 | 412.066  | tan waxy solid                            | 71      |                                         | 1.53 <sup>25</sup>         |                       | i H <sub>2</sub> O; vs bz; s ace, 2-PrOH, xyl         |
| 6600 | <i>DL</i> -Leucine                |                                                                           | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                                              | 328-39-2   | 131.173  | lf (w)                                    | 293     | sub                                     | 1.293 <sup>18</sup>        |                       | s H <sub>2</sub> O; sl EtOH; i eth                    |
| 6601 | <i>D</i> -Leucine                 |                                                                           | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                                              | 328-38-1   | 131.173  | pl (al)                                   | 293     | sub                                     |                            |                       | sl H <sub>2</sub> O                                   |
| 6602 | <i>L</i> -Leucine                 | 2-Amino-4-methylpentanoic acid                                            | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                                              | 61-90-5    | 131.173  | hex pl (dil al)                           | 293     | sub                                     | 1.293 <sup>18</sup>        |                       | sl H <sub>2</sub> O; i EtOH, eth                      |
| 6603 | <i>N</i> -Leucylglycine           |                                                                           | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub>                                | 686-50-0   | 188.224  |                                           | 248 dec |                                         |                            |                       | s H <sub>2</sub> O; sl EtOH, eth; i ace, bz, chl      |
| 6604 | Leuprolide                        |                                                                           | C <sub>59</sub> H <sub>84</sub> N <sub>16</sub> O <sub>12</sub>                             | 53714-56-0 | 1209.398 | fluffy solid                              |         |                                         |                            |                       |                                                       |
| 6605 | Leurosine                         |                                                                           | C <sub>46</sub> H <sub>62</sub> N <sub>4</sub> O <sub>9</sub>                               | 23360-92-1 | 808.959  | cry                                       | 203     |                                         |                            |                       |                                                       |
| 6606 | Levallorphan                      | 17-Allylmorphinan-3-ol                                                    | C <sub>19</sub> H <sub>25</sub> NO                                                          | 152-02-3   | 283.408  | cry (EtOH aq)                             | 181     |                                         |                            |                       |                                                       |
| 6607 | Levodopa                          | <i>L</i> -3,4-Dihydroxyphenylalanine                                      | C <sub>9</sub> H <sub>11</sub> NO <sub>4</sub>                                              | 59-92-7    | 197.188  | pl (dil al) pr or nd (w+SO <sub>2</sub> ) | 277 dec |                                         |                            |                       | s H <sub>2</sub> O; i EtOH, eth, ace, bz; s alk, MeOH |
| 6608 | Levopimaric acid                  |                                                                           | C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>                                              | 79-54-9    | 302.451  | orth cry                                  | 150     |                                         |                            |                       |                                                       |
| 6609 | Levorphanol                       | 17-Methylmorphinan-3-ol                                                   | C <sub>17</sub> H <sub>23</sub> NO                                                          | 77-07-6    | 257.371  | cry                                       | 198     |                                         |                            |                       |                                                       |
| 6610 | <i>α</i> -Limonene                | <i>p</i> -Mentha-1,8-diene, ( <i>R</i> )                                  | C <sub>10</sub> H <sub>16</sub>                                                             | 5989-27-5  | 136.234  | oil                                       | -74.0   | 178                                     | 0.8411 <sup>20</sup>       | 1.4730 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s ctc              |
| 6611 | <i>l</i> -Limonene                | <i>p</i> -Mentha-1,8-diene, ( <i>S</i> )                                  | C <sub>10</sub> H <sub>16</sub>                                                             | 5989-54-8  | 136.234  | oil                                       |         | 178; 64.4 <sup>15</sup>                 | 0.843 <sup>20</sup>        | 1.4746 <sup>20</sup>  | i H <sub>2</sub> O; vs eth, EtOH                      |
| 6612 | Linalol                           | 3,7-Dimethyl-1,6-octadien-3-ol, (±)-                                      | C <sub>10</sub> H <sub>18</sub> O                                                           | 22564-99-4 | 154.249  |                                           |         | 198; 86 <sup>13</sup>                   | 0.870 <sup>15</sup>        | 1.4627                |                                                       |
| 6613 | Linalyl acetate                   | 3,7-Dimethyl-1,6-octadien-3-yl acetate                                    | C <sub>12</sub> H <sub>20</sub> O <sub>2</sub>                                              | 115-95-7   | 196.286  | liq                                       |         | 220; 44 <sup>9,2</sup>                  | 0.895 <sup>20</sup>        | 1.4460 <sup>20</sup>  | i H <sub>2</sub> O; misc EtOH, eth                    |
| 6614 | Lincomycin                        |                                                                           | C <sub>18</sub> H <sub>34</sub> N <sub>2</sub> O <sub>6</sub> S                             | 154-21-2   | 406.537  | amor solid                                |         |                                         |                            |                       | sl H <sub>2</sub> O; s EtOH, ace, chl                 |
| 6615 | Linoleic acid                     | <i>cis,cis</i> -9,12-Octadecadienoic acid                                 | C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>                                              | 60-33-3    | 280.446  |                                           | -7      | 229 <sup>16</sup>                       | 0.9022 <sup>20</sup>       | 1.4699 <sup>20</sup>  | vs ace, bz, eth, EtOH                                 |
| 6616 | Linolenic acid                    | <i>cis,cis,cis</i> -9,12,15-Octadecatrienoic acid                         | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub>                                              | 463-40-1   | 278.430  |                                           | -11     | 231 <sup>17</sup> , 129 <sup>9,05</sup> | 0.9164 <sup>20</sup>       | 1.4800 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl bz                |
| 6617 | Linuron                           | <i>N</i> -(3,4-Dichlorophenyl)- <i>N'</i> -methoxy- <i>N'</i> -methylurea | C <sub>9</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub>                | 330-55-2   | 249.093  |                                           | 93      |                                         |                            |                       |                                                       |
| 6618 | Liothyronine                      |                                                                           | C <sub>15</sub> H <sub>12</sub> I <sub>3</sub> NO <sub>4</sub>                              | 6893-02-3  | 650.974  | cry                                       | 236 dec |                                         |                            |                       | i H <sub>2</sub> O, EtOH; s dil alk                   |
| 6619 | Lipoamide                         | 1,2-Dithiolane-3-pentanamide                                              | C <sub>8</sub> H <sub>15</sub> NOS <sub>2</sub>                                             | 940-69-2   | 205.341  | cry                                       | 128     |                                         |                            |                       |                                                       |
| 6620 | <i>α</i> -Lipoic acid             | 1,2-Dithiolane-3-pentanoic acid                                           | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub> S <sub>2</sub>                                | 1077-28-7  | 206.326  | ye pl (cy)                                | 60      | 87 <sup>25</sup>                        |                            |                       | i H <sub>2</sub> O                                    |
| 6621 | Lisinopril                        |                                                                           | C <sub>21</sub> H <sub>35</sub> N <sub>3</sub> O <sub>7</sub>                               | 83915-83-7 | 441.519  | wh cry pow                                | 159     |                                         |                            |                       | i EtOH, chl, ace; sl MeOH                             |
| 6622 | Lithium oxalate                   |                                                                           | C <sub>2</sub> Li <sub>2</sub> O <sub>4</sub>                                               | 30903-87-8 | 101.901  |                                           | dec     |                                         | 2.121 <sup>17</sup>        |                       | s H <sub>2</sub> O; i EtOH, eth                       |
| 6623 | Lobelanidine                      |                                                                           | C <sub>22</sub> H <sub>29</sub> NO <sub>2</sub>                                             | 552-72-7   | 339.471  | sc (al, eth)                              | 150     |                                         |                            |                       | i H <sub>2</sub> O; s EtOH; sl eth; vs ace, bz, py    |
| 6624 | Lobelanine                        |                                                                           | C <sub>22</sub> H <sub>25</sub> NO <sub>2</sub>                                             | 579-21-5   | 335.440  | nd (eth, peth)                            | 99      |                                         |                            |                       | vs ace, bz, EtOH, chl                                 |
| 6625 | Lobeline                          |                                                                           | C <sub>22</sub> H <sub>27</sub> NO <sub>2</sub>                                             | 90-69-7    | 337.455  | nd (al, bz)                               | 130.5   |                                         |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, bz, chl; vs ace     |
| 6626 | Loflucarban                       |                                                                           | C <sub>13</sub> H <sub>6</sub> Cl <sub>2</sub> FN <sub>2</sub> S                            | 790-69-2   | 315.192  |                                           | 163.5   |                                         |                            |                       |                                                       |
| 6627 | Longifolene                       | Kuromatsuene                                                              | C <sub>15</sub> H <sub>24</sub>                                                             | 475-20-7   | 204.352  |                                           |         | 258; 126 <sup>15</sup>                  | 0.9319 <sup>18</sup>       | 1.5040 <sup>20</sup>  | i H <sub>2</sub> O; s bz                              |
| 6628 | Loratadine                        | Claritin                                                                  | C <sub>22</sub> H <sub>23</sub> ClN <sub>2</sub> O <sub>2</sub>                             | 79794-75-5 | 382.883  | cry (MeCN)                                | 132     |                                         |                            |                       |                                                       |
| 6629 | Lovastatin                        | Mevacor                                                                   | C <sub>24</sub> H <sub>36</sub> O <sub>5</sub>                                              | 75330-75-5 | 404.540  | wh cry (ace aq)                           | 174     |                                         |                            |                       | i H <sub>2</sub> O; vs chl; s DMF; sl ace, EtOH       |
| 6630 | Lovozal                           |                                                                           | C <sub>15</sub> H <sub>7</sub> Cl <sub>2</sub> F <sub>3</sub> N <sub>2</sub> O <sub>2</sub> | 14255-88-0 | 375.130  | ye cry                                    | 103     |                                         |                            |                       | s ace, diox                                           |
| 6631 | Loxapine                          |                                                                           | C <sub>18</sub> H <sub>18</sub> ClN <sub>3</sub> O                                          | 1977-10-2  | 327.808  | ye cry (peth)                             | 109.5   |                                         |                            |                       |                                                       |



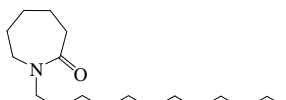
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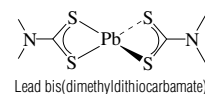
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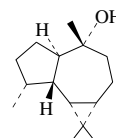
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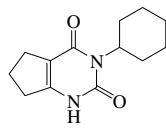
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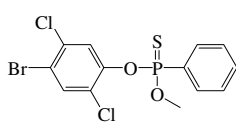
Lead bis(dimethyldithiocarbamate)



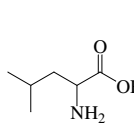
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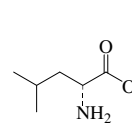
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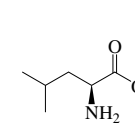
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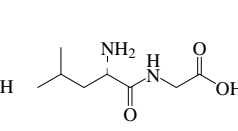
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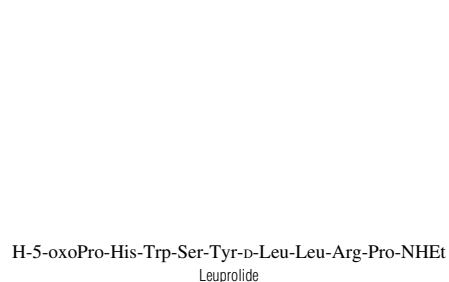
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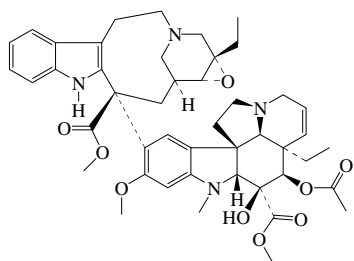
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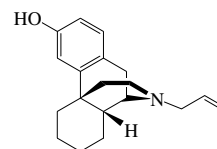
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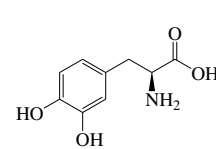
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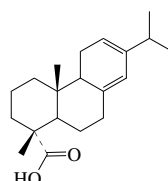
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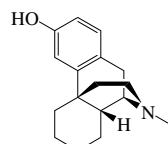
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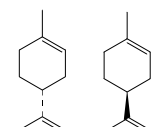
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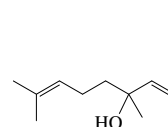
Levopimaric acid



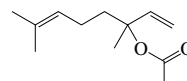
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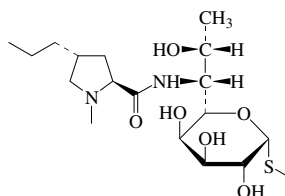
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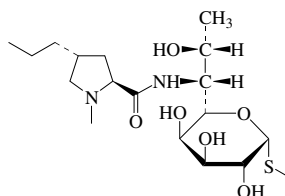
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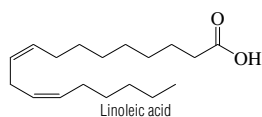
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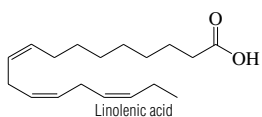
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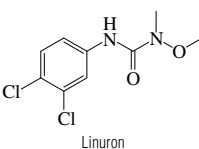
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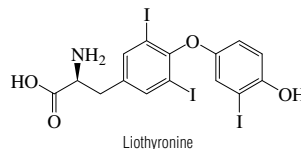
Linoleic acid



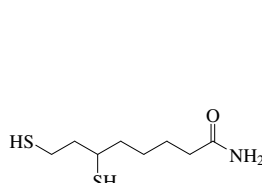
Linolenic acid



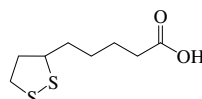
Linuron



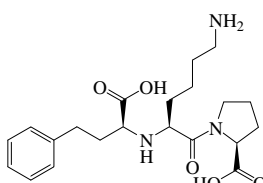
Liothyronine



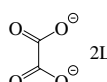
Lipoamide



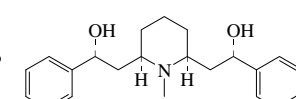
alpha-Lipoic acid



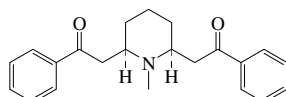
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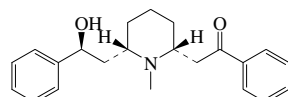
Lithium oxalate



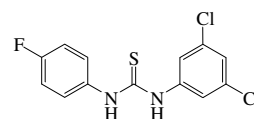
Lobelanidine



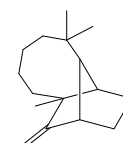
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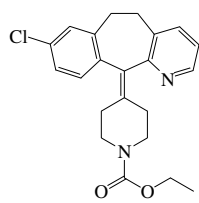
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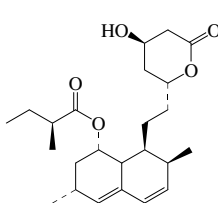
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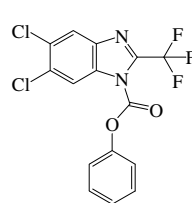
Longifolene



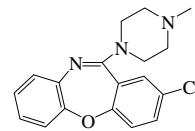
Loratadine



Lovastatin

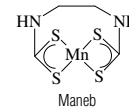
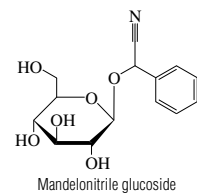
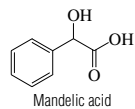
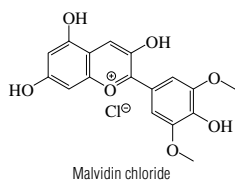
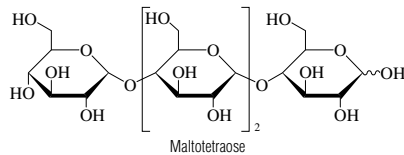
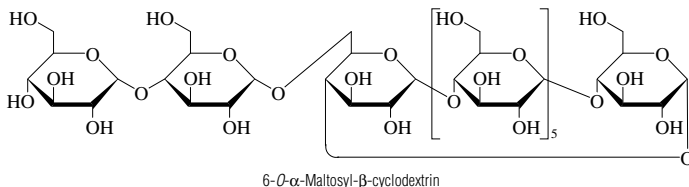
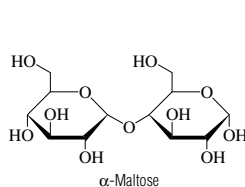
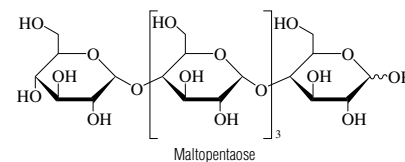
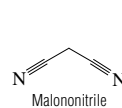
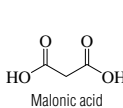
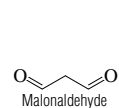
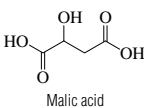
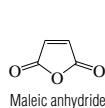
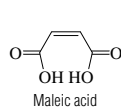
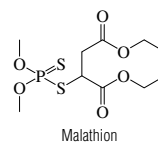
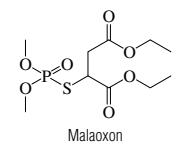
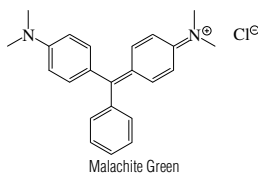
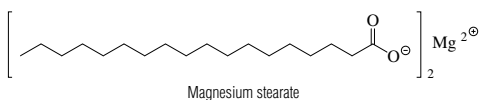
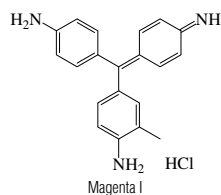
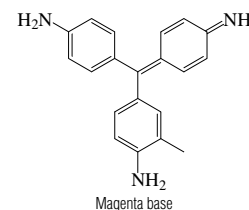
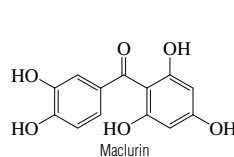
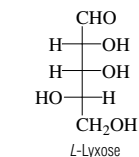
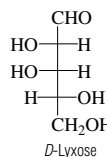
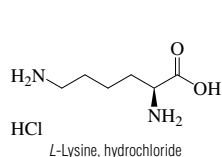
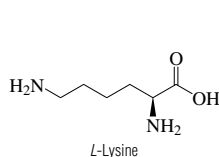
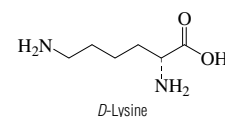
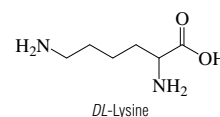
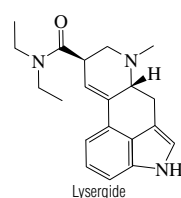
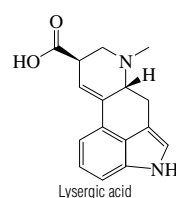
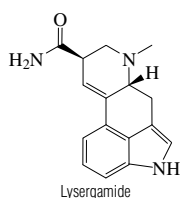
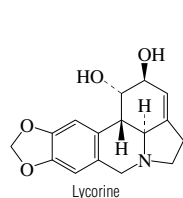
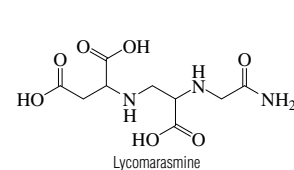
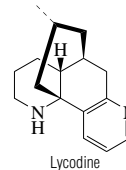
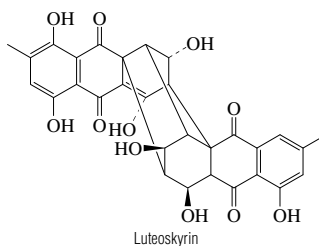
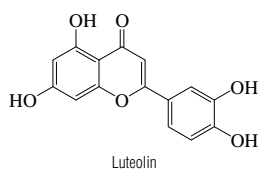
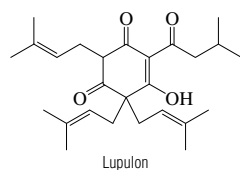
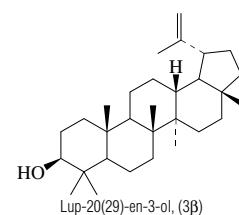
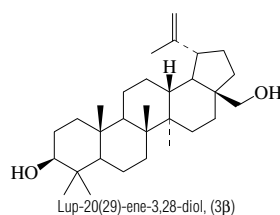
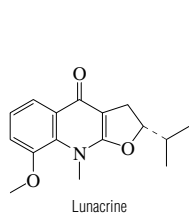
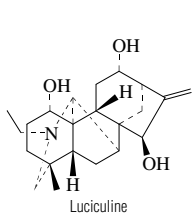
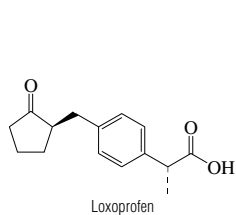


Lovozal



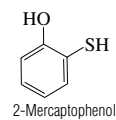
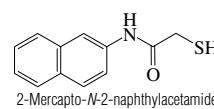
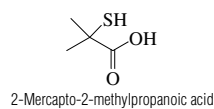
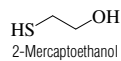
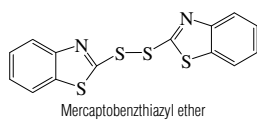
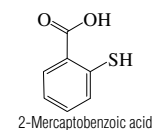
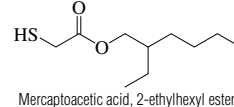
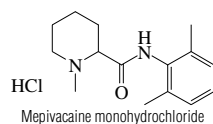
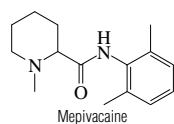
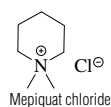
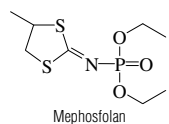
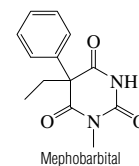
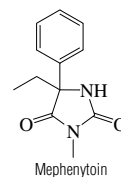
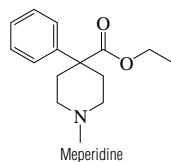
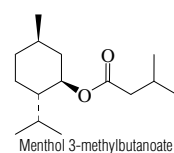
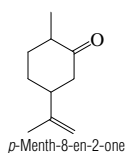
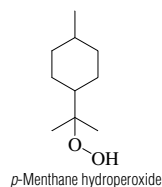
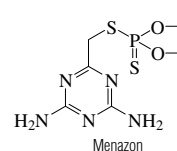
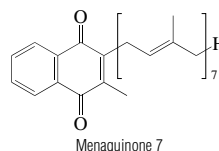
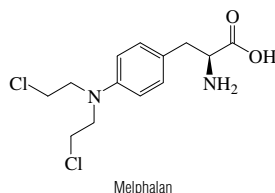
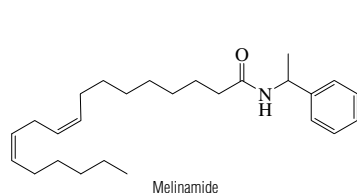
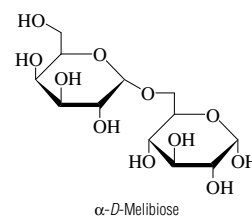
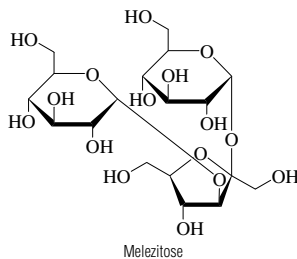
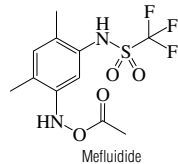
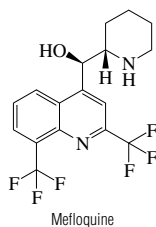
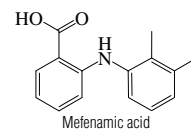
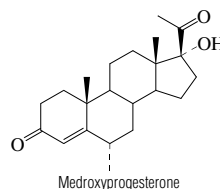
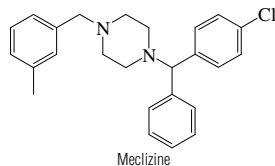
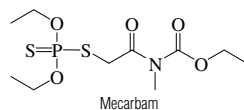
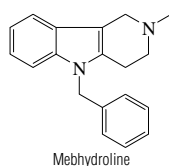
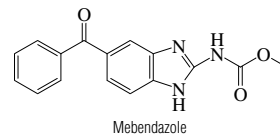
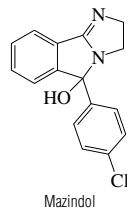
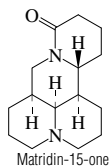
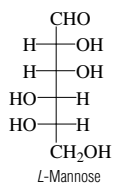
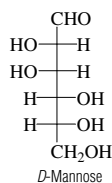
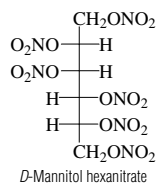
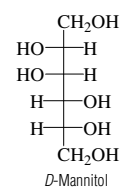
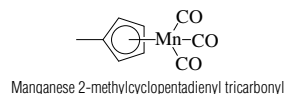
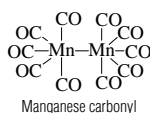
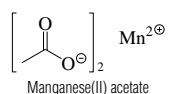
Loxapine

| No.  | Name                                           | Synonym                                                         | Mol. Form.                                                     | CAS RN      | Mol. Wt. | Physical Form            | mp/°C    | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                         |
|------|------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------|-------------|----------|--------------------------|----------|------------------------|----------------------------|-----------------------|----------------------------------------------------|
| 6632 | Loxoprofen                                     | $\alpha$ -Methyl-4-[(2-oxocyclopentyl)methyl]benzeneacetic acid | C <sub>15</sub> H <sub>18</sub> O <sub>3</sub>                 | 68767-14-6  | 246.302  | col oil                  | 110      | 192 <sup>0.3</sup>     |                            |                       |                                                    |
| 6633 | Luciculine                                     | Napelline                                                       | C <sub>22</sub> H <sub>38</sub> NO <sub>3</sub>                | 5008-52-6   | 361.518  | cry (+1w, ace)           | 149      | 165 <sup>0.02</sup>    |                            |                       | vs EtOH                                            |
| 6634 | Lunacrine                                      |                                                                 | C <sub>16</sub> H <sub>18</sub> NO <sub>3</sub>                | 82-40-6     | 273.327  |                          |          |                        |                            |                       | s chl                                              |
| 6635 | Lup-20(29)-ene-3,28-diol, (3 $\beta$ )         | Betulin                                                         | C <sub>30</sub> H <sub>50</sub> O <sub>2</sub>                 | 473-98-3    | 442.717  | nd (al +1)               | 250      | sub 240                |                            |                       | i H <sub>2</sub> O; sl EtOH, bz; s eth, AcOEt, lig |
| 6636 | Lup-20(29)-en-3-ol, (3 $\beta$ )               | Lupeol                                                          | C <sub>30</sub> H <sub>50</sub> O                              | 545-47-1    | 426.717  | nd (al, ace)             | 216      |                        | 0.9457 <sup>218</sup>      | 1.4910 <sup>218</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace, bz, chl     |
| 6637 | Lupulon                                        |                                                                 | C <sub>26</sub> H <sub>38</sub> O <sub>4</sub>                 | 468-28-0    | 414.578  | pr (MeOH)                | 93       |                        |                            |                       | i H <sub>2</sub> O; s EtOH, peth, hx               |
| 6638 | Luteolin                                       |                                                                 | C <sub>15</sub> H <sub>10</sub> O <sub>6</sub>                 | 491-70-3    | 286.236  | ye nd (dil al, + 1 w)    | 329 dec  |                        |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, alk, con sulf    |
| 6639 | Luteoskyrin                                    | 8,8'-Dihydroxyrugulosin                                         | C <sub>30</sub> H <sub>22</sub> O <sub>12</sub>                | 21884-44-6  | 574.489  | ye nd (EtOH)             | 278 dec  |                        |                            |                       |                                                    |
| 6640 | Lycodine                                       |                                                                 | C <sub>18</sub> H <sub>22</sub> N <sub>2</sub>                 | 20316-18-1  | 242.359  | orth pr                  | 99       | 190 <sup>1.0</sup>     |                            |                       | s H <sub>2</sub> O, chl, eth, EtOH; i peth         |
| 6641 | Lycomarasmine                                  |                                                                 | C <sub>9</sub> H <sub>15</sub> N <sub>3</sub> O <sub>7</sub>   | 7611-43-0   | 277.231  |                          | 228 dec  |                        |                            |                       |                                                    |
| 6642 | Lycorine                                       |                                                                 | C <sub>16</sub> H <sub>17</sub> NO <sub>4</sub>                | 476-28-8    | 287.311  | pr (al, py)              | 280      | sub                    |                            |                       | i H <sub>2</sub> O; sl EtOH, eth, chl              |
| 6643 | Lysergamide                                    |                                                                 | C <sub>16</sub> H <sub>17</sub> N <sub>3</sub> O               | 478-94-4    | 267.325  | cry (MeOH), pr (aq, ace) | 137.5    |                        |                            |                       | sl EtOH, ace, os                                   |
| 6644 | Lysergic acid                                  |                                                                 | C <sub>16</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub>  | 82-58-6     | 268.310  | lf or hex sc (w)         | 240 dec  |                        |                            |                       | sl H <sub>2</sub> O, eth, bz; s EtOH, py           |
| 6645 | Lysergide                                      |                                                                 | C <sub>20</sub> H <sub>25</sub> N <sub>3</sub> O               | 50-37-3     | 323.432  |                          | 82       |                        |                            |                       |                                                    |
| 6646 | DL-Lysine                                      | 2,6-Diaminohexanoic acid, ( $\pm$ )                             | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>   | 70-54-2     | 146.187  |                          | 224      |                        |                            |                       | sl H <sub>2</sub> O                                |
| 6647 | D-Lysine                                       | 2,6-Diaminohexanoic acid, (D)                                   | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>   | 923-27-3    | 146.187  |                          | 218 dec  |                        |                            |                       | s H <sub>2</sub> O                                 |
| 6648 | L-Lysine                                       | 2,6-Diaminohexanoic acid, (L)                                   | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>   | 56-87-1     | 146.187  | nd (w, dil al)           | 224 dec  |                        |                            |                       | s H <sub>2</sub> O; i EtOH, eth, ace, bz           |
| 6649 | L-Lysine, hydrochloride                        |                                                                 | C <sub>6</sub> H <sub>15</sub> ClN <sub>2</sub> O <sub>2</sub> | 10098-89-2  | 182.648  |                          | 263 dec  |                        |                            |                       |                                                    |
| 6650 | D-Lyxose                                       |                                                                 | C <sub>6</sub> H <sub>10</sub> O <sub>5</sub>                  | 1114-34-7   | 150.130  |                          | 108      |                        | 1.545 <sup>20</sup>        |                       |                                                    |
| 6651 | L-Lyxose                                       |                                                                 | C <sub>6</sub> H <sub>10</sub> O <sub>5</sub>                  | 1949-78-6   | 150.130  |                          | 110      |                        |                            |                       |                                                    |
| 6652 | Maclurin                                       | (3,4-Dihydroxyphenyl)(2,4,6-trihydroxyphenyl)methanone          | C <sub>13</sub> H <sub>10</sub> O <sub>6</sub>                 | 519-34-6    | 262.214  | ye nd (al)               | 222.5    |                        |                            |                       | vs eth, EtOH                                       |
| 6653 | Magenta base                                   | Rosaniline                                                      | C <sub>20</sub> H <sub>19</sub> N <sub>3</sub>                 | 3248-93-9   | 301.385  | br-red cry               | 186 dec  |                        |                            |                       |                                                    |
| 6654 | Magenta I                                      | Rosaniline hydrochloride                                        | C <sub>20</sub> H <sub>20</sub> ClN <sub>3</sub>               | 632-99-5    | 337.846  | grn cry                  | 200 dec  |                        |                            |                       | sl H <sub>2</sub> O, EtOH; i eth                   |
| 6655 | Magnesium stearate                             | Magnesium octadecanoate                                         | C <sub>36</sub> H <sub>70</sub> MgO <sub>4</sub>               | 557-04-0    | 591.244  | wh pow                   | 132      |                        |                            |                       | i H <sub>2</sub> O; reac acid                      |
| 6656 | Malachite Green                                |                                                                 | C <sub>23</sub> H <sub>25</sub> ClN <sub>2</sub>               | 569-64-2    | 364.911  | grn cry                  |          |                        |                            |                       | vs H <sub>2</sub> O, EtOH, MeOH                    |
| 6657 | Malaoxon                                       | (Dimethoxyphosphinylthio) butanedioic acid                      | C <sub>10</sub> H <sub>15</sub> O <sub>7</sub> PS              | 1634-78-2   | 314.293  | liq                      |          | 132 <sup>0.1</sup>     |                            |                       |                                                    |
| 6658 | Malathion                                      |                                                                 | C <sub>10</sub> H <sub>19</sub> O <sub>6</sub> PS <sub>2</sub> | 121-75-5    | 330.358  | ye-br liq                | 1.4      | 156 <sup>0.7</sup> dec | 1.2076 <sup>20</sup>       | 1.4960 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth, bz               |
| 6659 | Maleic acid                                    | cis-2-Butenedioic acid                                          | C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                   | 110-16-7    | 116.073  | mcl pr (w)               | 139      |                        | 1.590 <sup>20</sup>        |                       | vs H <sub>2</sub> O, EtOH, ace; s eth; i bz, chl   |
| 6660 | Maleic anhydride                               |                                                                 | C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>                   | 108-31-6    | 98.057   | nd (chl, eth)            | 52.56    | 202                    | 1.314 <sup>60</sup>        |                       | s H <sub>2</sub> O; s eth, ace, chl; sl lig        |
| 6661 | Maleonitrile                                   | cis-Butenedinitrile                                             | C <sub>4</sub> H <sub>2</sub> N <sub>2</sub>                   | 928-53-0    | 78.072   | pr (EtOH)                | 31.5     | 111 <sup>20</sup>      |                            |                       |                                                    |
| 6662 | Malic acid                                     | Hydroxybutanedioic acid                                         | C <sub>4</sub> H <sub>6</sub> O <sub>5</sub>                   | 617-48-1    | 134.088  |                          | 132      |                        | 1.601 <sup>20</sup>        |                       | s H <sub>2</sub> O; vs eth, EtOH, MeOH             |
| 6663 | Malonaldehyde                                  | 1,3-Propanedial                                                 | C <sub>3</sub> H <sub>2</sub> O <sub>2</sub>                   | 542-78-9    | 72.063   | hyg nd                   | 73       |                        |                            |                       |                                                    |
| 6664 | Malonic acid                                   |                                                                 | C <sub>3</sub> H <sub>4</sub> O <sub>4</sub>                   | 141-82-2    | 104.062  | tcl (al)                 | 135 dec  | sub                    | 1.619 <sup>10</sup>        |                       | vs H <sub>2</sub> O, py; s EtOH, eth; i bz         |
| 6665 | Malononitrile                                  |                                                                 | C <sub>3</sub> H <sub>2</sub> N <sub>2</sub>                   | 109-77-3    | 66.061   |                          | 32       | 218.5                  | 1.1910 <sup>20</sup>       | 1.4146 <sup>34</sup>  | s H <sub>2</sub> O, ace, bz, chl; vs EtOH, eth     |
| 6666 | Maltopentaose                                  |                                                                 | C <sub>30</sub> H <sub>52</sub> O <sub>26</sub>                | 34620-76-3  | 828.718  | cry (w)                  | 78 (hyd) |                        |                            |                       |                                                    |
| 6667 | $\alpha$ -Maltose                              |                                                                 | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                | 4482-75-1   | 342.296  | nd (al)                  | 162.5    |                        | 1.546 <sup>20</sup>        |                       | vs H <sub>2</sub> O                                |
| 6668 | 6-O- $\alpha$ -Maltosyl- $\beta$ -cyclodextrin |                                                                 | C <sub>54</sub> H <sub>90</sub> O <sub>45</sub>                | 104723-60-6 | 1459.266 | cry (MeOH)               |          |                        |                            |                       |                                                    |
| 6669 | Maltotetraose                                  |                                                                 | C <sub>24</sub> H <sub>46</sub> O <sub>21</sub>                | 34612-38-9  | 666.577  | amorp solid              | 170 dec  |                        |                            |                       |                                                    |
| 6670 | Malvidin chloride                              |                                                                 | C <sub>17</sub> H <sub>15</sub> ClO <sub>7</sub>               | 643-84-5    | 366.750  |                          | >300     |                        |                            |                       | sl H <sub>2</sub> O; s EtOH, MeOH                  |
| 6671 | Mandelic acid                                  | $\alpha$ -Hydroxybenzeneacetic acid                             | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                   | 90-64-2     | 152.148  | orth pl                  | 119      |                        | 1.2890 <sup>20</sup>       |                       | s H <sub>2</sub> O, eth, EtOH, i-PrOH              |
| 6672 | Mandelonitrile glucoside                       |                                                                 | C <sub>14</sub> H <sub>17</sub> NO <sub>6</sub>                | 138-53-4    | 295.288  | wh nd or pl (al)         | 122      |                        |                            |                       | vs H <sub>2</sub> O, EtOH                          |
| 6673 | Maneb                                          | Manganese, [[1,2-ethanediy]bis(carbamodithioato)](2-)-          | C <sub>4</sub> H <sub>6</sub> MnN <sub>2</sub> S <sub>4</sub>  | 12427-38-2  | 265.302  |                          | dec 200  |                        |                            |                       |                                                    |

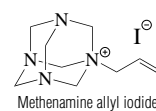
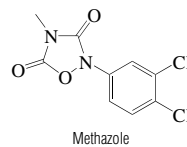
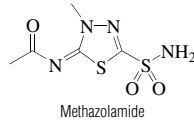
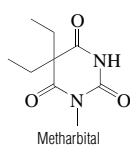
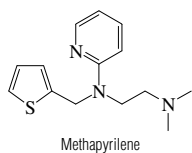
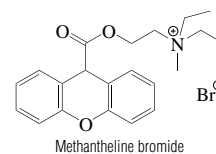
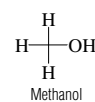
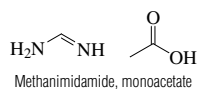
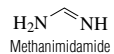
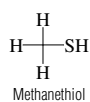
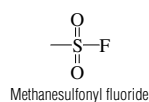
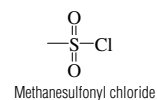
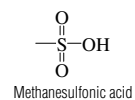
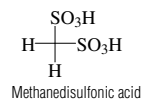
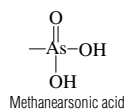
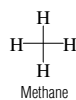
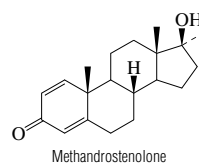
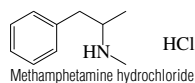
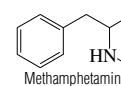
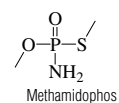
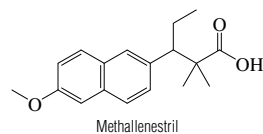
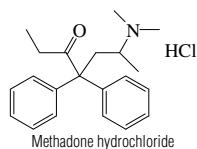
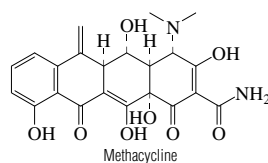
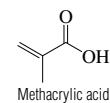
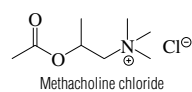
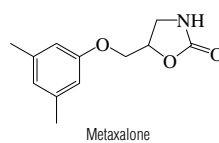
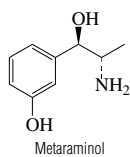
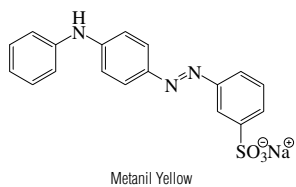
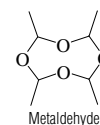
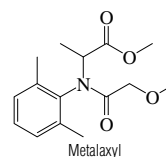
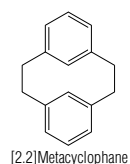
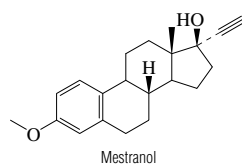
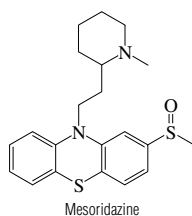
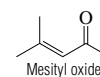
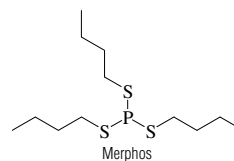
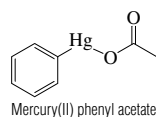
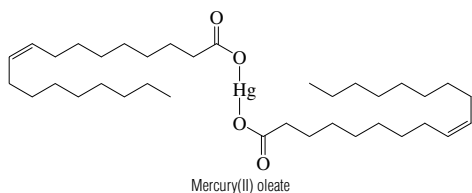
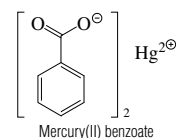
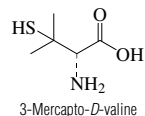
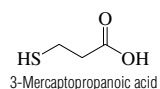
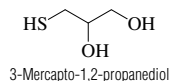
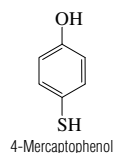




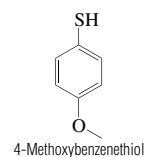
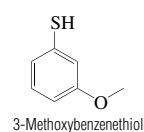
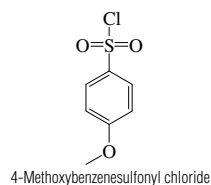
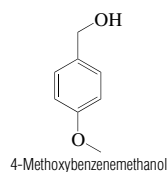
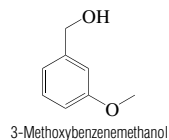
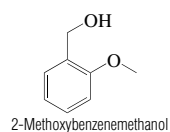
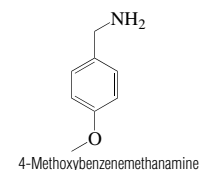
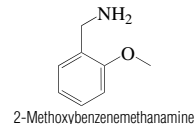
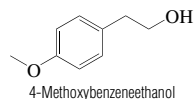
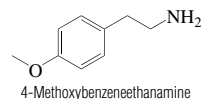
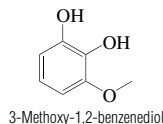
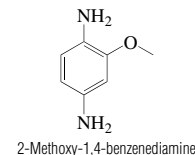
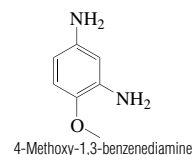
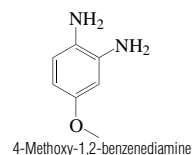
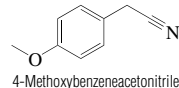
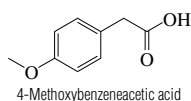
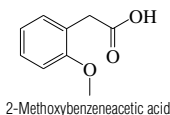
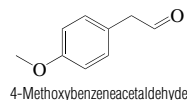
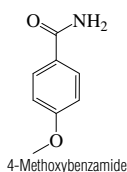
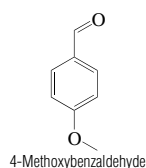
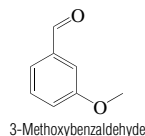
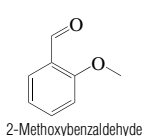
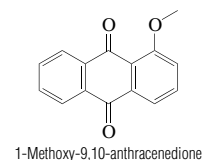
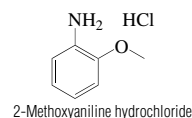
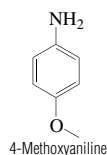
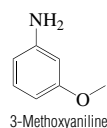
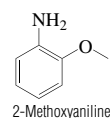
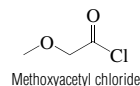
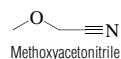
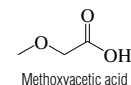
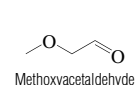
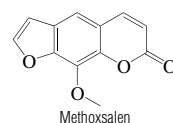
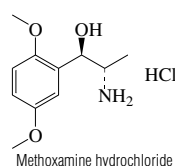
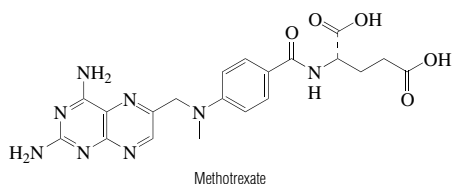
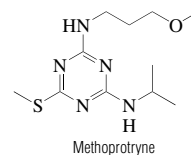
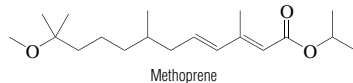
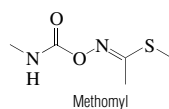
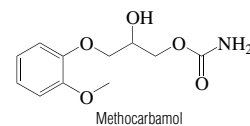
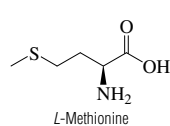
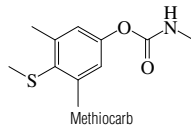
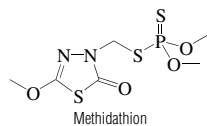
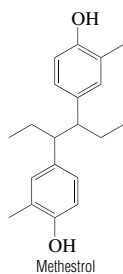
| No.  | Name                                           | Synonym                                                 | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form          | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                         |
|------|------------------------------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------|------------|----------|------------------------|---------|------------------------|----------------------------|----------------------|----------------------------------------------------|
| 6674 | Manganese(II) acetate                          |                                                         | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub> Mn                                | 638-38-0   | 173.027  | red cry (w)            | 210     |                        |                            |                      | s H <sub>2</sub> O, MeOH, HOAc; i ace              |
| 6675 | Manganese carbonyl                             | Dimanganese decacarbonyl                                | C <sub>10</sub> Mn <sub>2</sub> O <sub>10</sub>                                | 10170-69-1 | 389.977  | ye mcl cry             | 154     |                        | 1.75                       |                      | i H <sub>2</sub> O; s os                           |
| 6676 | Manganese cyclopentadienyl tricarbonyl         |                                                         | C <sub>8</sub> H <sub>5</sub> MnO <sub>3</sub>                                 | 12079-65-1 | 204.062  | pale ye cry            | 77.0    | subl                   |                            |                      | s os                                               |
| 6677 | Manganese 2-methylcyclopentadienyl tricarbonyl |                                                         | C <sub>9</sub> H <sub>7</sub> MnO <sub>3</sub>                                 | 12108-13-3 | 218.088  | ye liq                 | 1.5     | 233; 102 <sup>10</sup> | 1.388 <sup>20</sup>        |                      | i H <sub>2</sub> O; misc bz                        |
| 6678 | D-Mannitol                                     | Cordycepic acid                                         | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                                  | 69-65-8    | 182.171  | orth nd or pr (w)      | 168     | 295 <sup>3,5</sup>     | 1.489 <sup>20</sup>        | 1.3330               | vs H <sub>2</sub> O; sl EtOH, py; i eth            |
| 6679 | D-Mannitol hexanitrate                         |                                                         | C <sub>6</sub> H <sub>9</sub> N <sub>6</sub> O <sub>18</sub>                   | 15825-70-4 | 452.157  | nd (al)                | 107     | exp                    | 1.8 <sup>20</sup>          |                      | vs bz, eth, EtOH                                   |
| 6680 | D-Mannose                                      | Seminose                                                | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                  | 3458-28-4  | 180.155  | nd or orth pr (al)     | 132 dec |                        | 1.539 <sup>20</sup>        |                      | vs H <sub>2</sub> O; sl EtOH, MeOH; i eth, bz      |
| 6681 | L-Mannose                                      |                                                         | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                  | 10030-80-5 | 180.155  | cry (al)               | 132     |                        |                            |                      | vs H <sub>2</sub> O                                |
| 6682 | Matridin-15-one                                | Matrine                                                 | C <sub>15</sub> H <sub>24</sub> N <sub>2</sub> O                               | 519-02-8   | 248.364  | α-nd or pl; β-orth pr, |         | 223 <sup>6</sup>       |                            | 1.5286 <sup>25</sup> | s H <sub>2</sub> O, eth, ace; vs EtOH, bz; sl peth |
| 6683 | Mazindol                                       |                                                         | C <sub>16</sub> H <sub>13</sub> ClN <sub>2</sub> O                             | 22232-71-9 | 284.739  | cry (ace/hx)           | 198     |                        |                            |                      | i H <sub>2</sub> O; s EtOH                         |
| 6684 | Mebendazole                                    |                                                         | C <sub>16</sub> H <sub>13</sub> N <sub>3</sub> O <sub>3</sub>                  | 31431-39-7 | 295.292  | cry (HOAc/MeOH)        | 288.5   |                        |                            |                      | i H <sub>2</sub> O, EtOH, eth, chl                 |
| 6685 | Mebhydroline                                   |                                                         | C <sub>19</sub> H <sub>20</sub> N <sub>2</sub>                                 | 524-81-2   | 276.375  | cry                    | 95      | 211 <sup>1</sup>       |                            |                      | i H <sub>2</sub> O; sl eth; vs EtOH, ace, MeOH     |
| 6686 | Mecarbam                                       |                                                         | C <sub>10</sub> H <sub>20</sub> NO <sub>3</sub> PS <sub>2</sub>                | 2595-54-2  | 329.374  | ye oil                 |         | 144 <sup>0.02</sup>    | 1.223 <sup>20</sup>        |                      | sl H <sub>2</sub> O                                |
| 6687 | Meclizine                                      |                                                         | C <sub>25</sub> H <sub>27</sub> ClN <sub>2</sub>                               | 569-65-3   | 390.948  |                        |         | 230                    |                            |                      | s CS <sub>2</sub>                                  |
| 6688 | Medroxyprogesterone                            |                                                         | C <sub>22</sub> H <sub>32</sub> O <sub>3</sub>                                 | 520-85-4   | 344.487  |                        | 214.5   |                        |                            |                      | vs chl                                             |
| 6689 | Mefenamic acid                                 | 2-[(2,3-Dimethylphenyl)amino] benzoic acid              | C <sub>15</sub> H <sub>15</sub> NO <sub>2</sub>                                | 61-68-7    | 241.286  | hyg cry                | 230 dec |                        |                            |                      | s alk; sl eth, chl                                 |
| 6690 | Mefloquine                                     |                                                         | C <sub>17</sub> H <sub>16</sub> F <sub>6</sub> N <sub>2</sub> O                | 53230-10-7 | 378.311  | cry (MeOH aq)          | 178.2   |                        |                            |                      |                                                    |
| 6691 | Mefluidide                                     |                                                         | C <sub>11</sub> H <sub>13</sub> F <sub>3</sub> N <sub>2</sub> O <sub>3</sub> S | 53780-34-0 | 310.292  |                        | 184     |                        |                            |                      |                                                    |
| 6692 | Melezitose                                     |                                                         | C <sub>18</sub> H <sub>32</sub> O <sub>16</sub>                                | 597-12-6   | 504.437  | cry (w+2)              | 153     |                        | 1.5565 <sup>25</sup>       |                      | vs H <sub>2</sub> O                                |
| 6693 | α-D-Melibiose                                  | 6-O-α-D-Galactopyranosyl-D-glucose                      | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                                | 585-99-9   | 342.296  |                        |         |                        |                            |                      | vs H <sub>2</sub> O; sl EtOH; dec acid             |
| 6694 | Melinamide                                     | N-(1-Phenylethyl)-9,12-octadecadieneamide, (Z,Z)-       | C <sub>26</sub> H <sub>41</sub> NO                                             | 14417-88-0 | 383.610  | oil                    | <4      | 202 <sup>0.07</sup>    |                            | 1.5050 <sup>23</sup> |                                                    |
| 6695 | Melphalan                                      | L-Phenylalanine, 4-[bis(2-chloroethyl)amino]-           | C <sub>13</sub> H <sub>18</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub>  | 148-82-3   | 305.200  | nd                     | 183 dec |                        |                            |                      | i H <sub>2</sub> O; s EtOH                         |
| 6696 | Menaquinone 7                                  | Vitamin K <sub>2</sub> (35)                             | C <sub>46</sub> H <sub>64</sub> O <sub>2</sub>                                 | 2124-57-4  | 648.999  | cry                    | 54      |                        |                            |                      |                                                    |
| 6697 | Menazon                                        |                                                         | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub> PS <sub>2</sub>   | 78-57-9    | 281.296  | cry (MeOH)             | 160     |                        |                            |                      | sl H <sub>2</sub> O; s thf                         |
| 6698 | p-Menthane hydroperoxide                       | 1-Methyl-1-(4-methylcyclohexyl)ethyl hydroperoxide      | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                                 | 80-47-7    | 172.265  |                        |         | 259                    | 0.92                       |                      |                                                    |
| 6699 | p-Menth-8-en-2-one                             | 2-Methyl-5-(1-methylethenyl) cyclohexanone              | C <sub>10</sub> H <sub>18</sub> O                                              | 7764-50-3  | 152.233  |                        |         | 223.0                  |                            |                      |                                                    |
| 6700 | Menthol 3-methylbutanoate                      | Menthol, isovalerate                                    | C <sub>15</sub> H <sub>26</sub> O <sub>2</sub>                                 | 16409-46-4 | 240.382  |                        |         | 129 <sup>9</sup>       | 0.908 <sup>15</sup>        | 1.4486 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace                    |
| 6701 | Meperidine                                     | Pethidine                                               | C <sub>15</sub> H <sub>21</sub> NO <sub>2</sub>                                | 57-42-1    | 247.334  |                        | 30      | 155 <sup>5</sup>       |                            |                      |                                                    |
| 6702 | Mephentoin                                     |                                                         | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>                  | 50-12-4    | 218.251  |                        | 136     |                        |                            |                      |                                                    |
| 6703 | Mephobarbital                                  |                                                         | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>                  | 115-38-8   | 246.261  | wh cry (w)             | 176     |                        |                            |                      | sl H <sub>2</sub> O, eth, chl; vs EtOH             |
| 6704 | Mephosfolan                                    |                                                         | C <sub>8</sub> H <sub>16</sub> NO <sub>3</sub> PS <sub>2</sub>                 | 950-10-7   | 269.322  | ye liq                 |         | 120 <sup>0.001</sup>   |                            | 1.5354 <sup>26</sup> | s ace, EtOH, bz                                    |
| 6705 | Mepiquat chloride                              | Piperidinium, 1,1-dimethyl-, chloride                   | C <sub>7</sub> H <sub>16</sub> ClN                                             | 24307-26-4 | 149.662  |                        | 223     |                        |                            |                      |                                                    |
| 6706 | Mepivacaine                                    | N-(2,6-Dimethylphenyl)-1-methyl-2-piperidinecarboxamide | C <sub>15</sub> H <sub>22</sub> N <sub>2</sub> O                               | 96-88-8    | 246.348  | cry (eth)              | 150.5   |                        |                            |                      | s CS <sub>2</sub>                                  |
| 6707 | Mepivacaine monohydrochloride                  | Carbocaine hydrochloride                                | C <sub>15</sub> H <sub>23</sub> ClN <sub>2</sub> O                             | 1722-62-9  | 282.809  | cry                    | 263     |                        |                            |                      | s H <sub>2</sub> O                                 |
| 6708 | Mercaptoacetic acid, 2-ethylhexyl ester        |                                                         | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub> S                               | 7659-86-1  | 204.330  |                        |         | 133.5                  | 0.97 <sup>20</sup>         |                      |                                                    |
| 6709 | 2-Mercaptobenzoic acid                         | o-Thiosalicylic acid                                    | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub> S                                 | 147-93-3   | 154.187  | lf or nd (al, w, HOAc) | 168.5   | sub                    |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl DMSO, lig        |
| 6710 | Mercaptobenzthiazyl ether                      | 2,2'-Dithiobis[benzothiazole]                           | C <sub>14</sub> H <sub>8</sub> N <sub>2</sub> S <sub>4</sub>                   | 120-78-5   | 332.487  | ye nd                  | 180     |                        | 1.50                       |                      | i H <sub>2</sub> O; sl EtOH, bz, ctc, ace          |
| 6711 | 2-Mercaptoethanol                              |                                                         | C <sub>2</sub> H <sub>6</sub> OS                                               | 60-24-2    | 78.133   |                        |         | 158; 55 <sup>13</sup>  | 1.1143 <sup>20</sup>       | 1.4996 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, bz                  |
| 6712 | 2-Mercapto-2-methylpropanoic acid              |                                                         | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S                                 | 4695-31-2  | 120.171  |                        | 47      | 101 <sup>15</sup>      |                            |                      | vs H <sub>2</sub> O                                |
| 6713 | 2-Mercapto-N-2-naphthylacetamide               | Thionalide                                              | C <sub>12</sub> H <sub>11</sub> NOS                                            | 93-42-5    | 217.286  |                        | 111.5   |                        |                            |                      | i H <sub>2</sub> O; vs EtOH, os                    |
| 6714 | 2-Mercaptophenol                               |                                                         | C <sub>6</sub> H <sub>6</sub> OS                                               | 1121-24-0  | 126.176  | oil                    | 5.5     | 217; 89 <sup>9</sup>   | 1.2371 <sup>0</sup>        |                      | vs bz, eth, EtOH                                   |



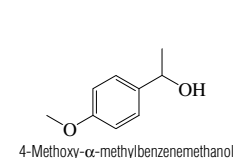
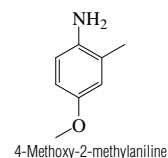
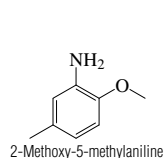
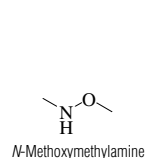
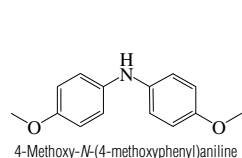
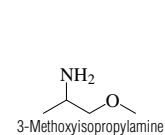
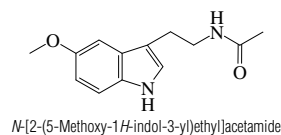
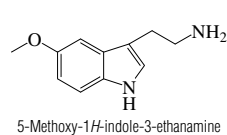
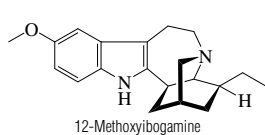
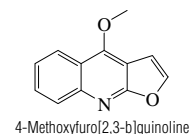
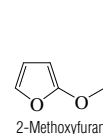
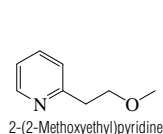
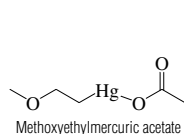
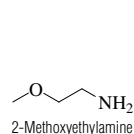
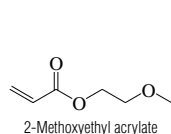
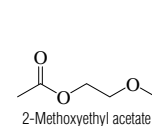
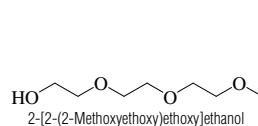
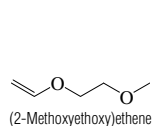
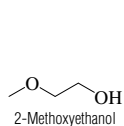
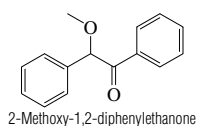
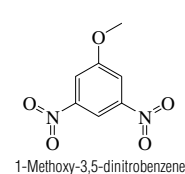
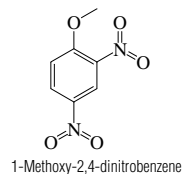
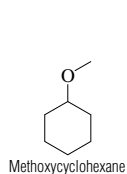
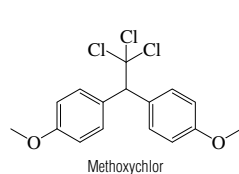
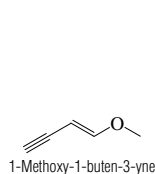
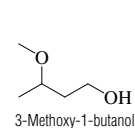
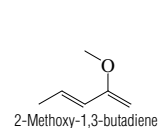
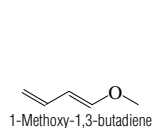
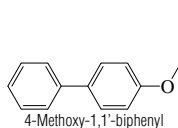
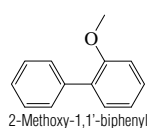
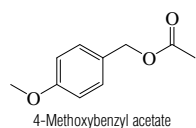
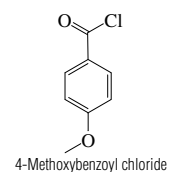
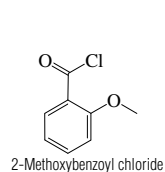
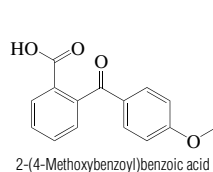
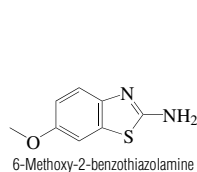
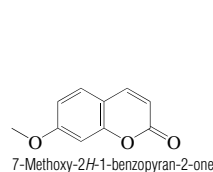
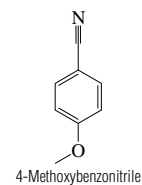
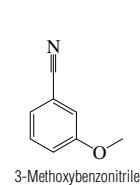
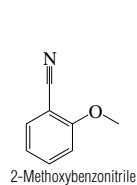
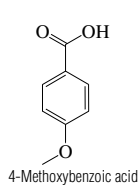
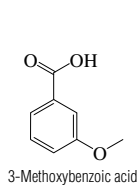
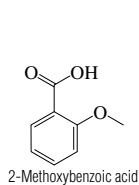
| No.  | Name                          | Synonym                                                                          | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-------------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------|------------|----------|--------------------|---------|----------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 6715 | 4-Mercaptophenol              |                                                                                  | C <sub>6</sub> H <sub>6</sub> OS                                            | 637-89-8   | 126.176  | cry                | 29.5    | 167 <sup>45</sup> , 135 <sup>11</sup>  | 1.1285 <sup>25</sup>       | 1.5101 <sup>25</sup> | s H <sub>2</sub> O, EtOH, alk, con sulf              |
| 6716 | 3-Mercapto-1,2-propanediol    | Thioglycerol                                                                     | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> S                              | 96-27-5    | 108.160  | visc               |         | 100 <sup>1</sup>                       | 1.2455 <sup>20</sup>       | 1.5268 <sup>20</sup> | sl H <sub>2</sub> O, eth, bz, chl; msc EtOH; vs ace  |
| 6717 | 3-Mercaptopropanoic acid      |                                                                                  | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> S                              | 107-96-0   | 106.144  | amor               | 18      | 111 <sup>15</sup> , 86 <sup>3</sup>    | 1.218 <sup>21</sup>        | 1.494 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, eth, ctc                   |
| 6718 | 3-Mercapto-D-valine           | Penicillamine                                                                    | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub> S                            | 52-67-5    | 149.212  |                    | 198.5   |                                        |                            |                      | i EtOH                                               |
| 6719 | Mercury(II) benzoate          | Mercuric benzoate                                                                | C <sub>14</sub> H <sub>10</sub> HgO <sub>4</sub>                            | 583-15-3   | 442.81   | cry pow (w)        | ≈125    |                                        |                            |                      | i EtOH                                               |
| 6720 | Mercury(II) oleate            | Mercuric oleate                                                                  | C <sub>36</sub> H <sub>66</sub> HgO <sub>4</sub>                            | 1191-80-6  | 763.35   | ye-br solid        |         |                                        |                            |                      | i H <sub>2</sub> O; sl EtOH, eth                     |
| 6721 | Mercury(II) phenyl acetate    | Phenylmercuric acetate                                                           | C <sub>8</sub> H <sub>9</sub> HgO <sub>2</sub>                              | 62-38-4    | 336.74   |                    | 153     |                                        |                            |                      | i H <sub>2</sub> O; s chl                            |
| 6722 | Merphos                       | Phosphorotriethous acid, S,S,S-tributyl ester                                    | C <sub>12</sub> H <sub>27</sub> PS <sub>3</sub>                             | 150-50-5   | 298.511  |                    | 100     | 137 <sup>0.7</sup> , 176 <sup>15</sup> | 1.02 <sup>20</sup>         |                      |                                                      |
| 6723 | Mesityl oxide                 | Isobutenyl methyl ketone                                                         | C <sub>6</sub> H <sub>10</sub> O                                            | 141-79-7   | 98.142   | liq                | -59     | 130                                    | 0.8653 <sup>20</sup>       | 1.4440 <sup>20</sup> | s H <sub>2</sub> O, ace; msc EtOH, eth               |
| 6724 | Mesoridazine                  |                                                                                  | C <sub>21</sub> H <sub>26</sub> N <sub>2</sub> OS <sub>2</sub>              | 5588-33-0  | 386.573  | oil                |         |                                        |                            |                      |                                                      |
| 6725 | Mestranol                     |                                                                                  | C <sub>21</sub> H <sub>26</sub> O <sub>2</sub>                              | 72-33-3    | 310.430  | cry                | 151     |                                        |                            |                      | i H <sub>2</sub> O; s diox, eth, EtOH, chl           |
| 6726 | [2.2]Metacyclopentane         | Tricyclo[9.3.1.1]hexadeca-1(15),4,6,8(16),11,13-hexaene                          | C <sub>16</sub> H <sub>16</sub>                                             | 2319-97-3  | 208.298  | orth pr            | 132.5   | 290                                    |                            |                      | sl EtOH; s bz, eth                                   |
| 6727 | Metalaxyl                     |                                                                                  | C <sub>15</sub> H <sub>21</sub> NO <sub>4</sub>                             | 57837-19-1 | 279.333  |                    | 71      |                                        |                            |                      |                                                      |
| 6728 | Metaldehyde                   | Metacetaldehyde (polymer)                                                        | (C <sub>2</sub> H <sub>4</sub> O) <sub>x</sub>                              | 37273-91-9 |          | tetr nd or pr (al) | 246     | sub 115                                |                            |                      | i H <sub>2</sub> O, ace; sl EtOH, eth, bz, chl       |
| 6729 | Metanil Yellow                |                                                                                  | C <sub>18</sub> H <sub>14</sub> N <sub>2</sub> NaO <sub>3</sub> S           | 587-98-4   | 375.377  | br-ye pow          |         |                                        |                            |                      | vs H <sub>2</sub> O, EtOH; s bz, eth; sl ace         |
| 6730 | Metaraminol                   | 2-Amino-1-(3-hydroxyphenyl)-1-propanol, (1 <i>R</i> ,2 <i>S</i> )                | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                              | 54-49-9    | 167.205  | hyg cry (HCl)      |         |                                        |                            |                      | s H <sub>2</sub> O                                   |
| 6731 | Metaxalone                    |                                                                                  | C <sub>12</sub> H <sub>15</sub> NO <sub>3</sub>                             | 1665-48-1  | 221.252  | cry (AcOEt)        | 122     | 223 <sup>1.5</sup>                     |                            |                      |                                                      |
| 6732 | Methacholine chloride         |                                                                                  | C <sub>8</sub> H <sub>18</sub> ClNO <sub>2</sub>                            | 62-51-1    | 195.688  | hyg cry            | 172     |                                        |                            |                      | vs H <sub>2</sub> O, EtOH, chl                       |
| 6733 | Methacrylic acid              | 2-Methylpropenoic acid                                                           | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                | 79-41-4    | 86.090   | pr                 | 16      | 162.5                                  | 1.0153 <sup>20</sup>       | 1.4314 <sup>20</sup> | s H <sub>2</sub> O, chl; msc EtOH, eth               |
| 6734 | Methacycline                  |                                                                                  | C <sub>22</sub> H <sub>22</sub> N <sub>2</sub> O <sub>8</sub>               | 914-00-1   | 442.418  | cry                | 205 dec |                                        |                            |                      |                                                      |
| 6735 | Methadone hydrochloride       | 6-(Dimethylamino)-4,4-diphenyl-3-heptanone hydrochloride                         | C <sub>21</sub> H <sub>28</sub> ClNO                                        | 1095-90-5  | 345.906  | pl (al-eth)        | 235     |                                        |                            |                      | vs H <sub>2</sub> O, EtOH                            |
| 6736 | Methallenestril               |                                                                                  | C <sub>18</sub> H <sub>22</sub> O <sub>3</sub>                              | 517-18-0   | 286.366  | cry (MeOH aq)      | 139     |                                        |                            |                      | s eth                                                |
| 6737 | Methamidophos                 | Phosphoramidothioic acid, O,S-dimethyl ester                                     | C <sub>2</sub> H <sub>6</sub> NO <sub>2</sub> PS                            | 10265-92-6 | 141.130  |                    | 46      |                                        | 1.31 <sup>20</sup>         |                      |                                                      |
| 6738 | Methamphetamine               |                                                                                  | C <sub>10</sub> H <sub>15</sub> N                                           | 537-46-2   | 149.233  |                    |         | 212                                    |                            |                      |                                                      |
| 6739 | Methamphetamine hydrochloride | N,α-Dimethylbenzeneethanamine, hydrochloride, (S)-                               | C <sub>10</sub> H <sub>16</sub> ClN                                         | 51-57-0    | 185.694  |                    | 173.8   |                                        |                            |                      | vs H <sub>2</sub> O, EtOH, chl                       |
| 6740 | Methandrostenolone            |                                                                                  | C <sub>20</sub> H <sub>28</sub> O <sub>2</sub>                              | 72-63-9    | 300.435  |                    | 166     |                                        |                            |                      |                                                      |
| 6741 | Methane                       |                                                                                  | CH <sub>4</sub>                                                             | 74-82-8    | 16.043   | col gas            | -182.47 | -161.48                                | 0.4228 <sup>162</sup>      |                      | sl H <sub>2</sub> O, ace; s EtOH, eth, bz, tol, MeOH |
| 6742 | Methanearsonic acid           |                                                                                  | CH <sub>3</sub> AsO <sub>3</sub>                                            | 124-58-3   | 139.971  |                    | 160.5   |                                        |                            |                      | s H <sub>2</sub> O, EtOH                             |
| 6743 | Methanedisulfonic acid        | Methionic acid                                                                   | CH <sub>3</sub> O <sub>3</sub> S <sub>2</sub>                               | 503-40-2   | 176.169  |                    | 98      |                                        |                            |                      | i H <sub>2</sub> O; s HNO <sub>3</sub>               |
| 6744 | Methanesulfonic acid          | Methylsulfonic acid                                                              | CH <sub>3</sub> O <sub>3</sub> S                                            | 75-75-2    | 96.106   |                    | 20      | 167 <sup>10</sup>                      | 1.4812 <sup>18</sup>       | 1.4317 <sup>18</sup> | s H <sub>2</sub> O                                   |
| 6745 | Methanesulfonyl chloride      |                                                                                  | CH <sub>3</sub> ClO <sub>2</sub> S                                          | 124-63-0   | 114.552  |                    |         | 162; 55 <sup>11</sup>                  | 1.4805 <sup>18</sup>       | 1.4573 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                      |
| 6746 | Methanesulfonyl fluoride      |                                                                                  | CH <sub>3</sub> FO <sub>2</sub> S                                           | 558-25-8   | 98.097   |                    |         | 123.5                                  |                            |                      |                                                      |
| 6747 | Methanethiol                  | Methyl mercaptan                                                                 | CH <sub>3</sub> S                                                           | 74-93-1    | 48.108   | col gas            | -123    | 5.9                                    | 0.8665 <sup>20</sup>       |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth               |
| 6748 | Methanimidamide               | Formamidine                                                                      | CH <sub>3</sub> N <sub>2</sub>                                              | 463-52-5   | 44.056   | pr                 | 81      | dec                                    |                            |                      | vs H <sub>2</sub> O, EtOH                            |
| 6749 | Methanimidamide, monoacetate  | Formamidine acetate                                                              | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                 | 3473-63-0  | 104.108  |                    | 161.5   |                                        |                            |                      | vs H <sub>2</sub> O                                  |
| 6750 | Methanol                      | Methyl alcohol                                                                   | CH <sub>3</sub> O                                                           | 67-56-1    | 32.042   | liq                | -97.53  | 64.6                                   | 0.7914 <sup>20</sup>       | 1.3288 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace; vs bz; s chl   |
| 6751 | Methantheline bromide         |                                                                                  | C <sub>21</sub> H <sub>28</sub> BrNO <sub>3</sub>                           | 53-46-3    | 420.340  | cry (i-PrOH)       | 174.5   |                                        |                            |                      | s H <sub>2</sub> O, EtOH, chl; i eth                 |
| 6752 | Methapyrilene                 |                                                                                  | C <sub>14</sub> H <sub>19</sub> N <sub>3</sub> S                            | 91-80-5    | 261.386  |                    |         | 174 <sup>3</sup>                       |                            | 1.5915 <sup>20</sup> |                                                      |
| 6753 | Metharbital                   | 5,5-Diethyl-1-methyl-2,4,6(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | C <sub>9</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>                | 50-11-3    | 198.218  | nd                 | 150.5   |                                        |                            |                      | s H <sub>2</sub> O; sl chl                           |
| 6754 | Methazolamide                 |                                                                                  | C <sub>5</sub> H <sub>8</sub> N <sub>4</sub> O <sub>3</sub> S <sub>2</sub>  | 554-57-4   | 236.273  | cry (w)            | 213 dec |                                        |                            |                      |                                                      |
| 6755 | Methazole                     |                                                                                  | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>3</sub> | 20354-26-1 | 261.061  |                    | 123     |                                        | 1.24 <sup>25</sup>         |                      |                                                      |
| 6756 | Methenamine allyl iodide      | Allylhexamethylenetetramine iodide                                               | C <sub>5</sub> H <sub>17</sub> IN <sub>4</sub>                              | 36895-62-2 | 308.162  | cry                | 148 dec |                                        |                            |                      | vs H <sub>2</sub> O; i chl, eth                      |



| No.  | Name                              | Synonym                                               | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form         | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|-----------------------------------|-------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|-----------------------|---------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 6757 | Methestrol                        |                                                       | C <sub>20</sub> H <sub>26</sub> O <sub>2</sub>                               | 130-73-4   | 298.419  | cry (dil HOAc)        | 145     |                                       |                            |                      |                                                         |
| 6758 | Methidathion                      |                                                       | C <sub>8</sub> H <sub>11</sub> N <sub>2</sub> O <sub>4</sub> PS <sub>3</sub> | 950-37-8   | 302.330  |                       | 39      |                                       |                            |                      |                                                         |
| 6759 | Methiocarb                        | Phenol, 3,5-dimethyl-4-(methylthio)-, methylcarbamate | C <sub>11</sub> H <sub>13</sub> NO <sub>2</sub> S                            | 2032-65-7  | 225.308  |                       | 120     |                                       |                            |                      |                                                         |
| 6760 | L-Methionine                      |                                                       | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub> S                             | 63-68-3    | 149.212  | hex pl (dil al)       | 281 dec |                                       |                            |                      | s H <sub>2</sub> O; i EtOH, eth, ace, bz, peth; sl HOAc |
| 6761 | Methocarbamol                     | Guaifenesin-1-carbamate                               | C <sub>11</sub> H <sub>15</sub> NO <sub>3</sub>                              | 532-03-6   | 241.241  | cry (bz)              | 93      |                                       |                            |                      | s EtOH                                                  |
| 6762 | Methomyl                          |                                                       | C <sub>6</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> S               | 16752-77-5 | 162.210  |                       | 78      |                                       | 1.2946 <sup>24</sup>       |                      |                                                         |
| 6763 | Methoprene                        |                                                       | C <sub>19</sub> H <sub>34</sub> O <sub>3</sub>                               | 40596-69-8 | 310.471  |                       |         | 100 <sup>0.05</sup>                   | 0.926 <sup>20</sup>        |                      |                                                         |
| 6764 | Methoprotryne                     |                                                       | C <sub>11</sub> H <sub>21</sub> N <sub>3</sub> OS                            | 841-06-5   | 271.383  | cry                   | 69      |                                       |                            |                      | sl H <sub>2</sub> O; s os                               |
| 6765 | Methotrexate                      |                                                       | C <sub>20</sub> H <sub>22</sub> N <sub>6</sub> O <sub>5</sub>                | 59-05-2    | 454.440  | ye cry (w)            | 190 dec |                                       |                            |                      |                                                         |
| 6766 | Methoxamine hydrochloride         |                                                       | C <sub>11</sub> H <sub>18</sub> ClNO <sub>3</sub>                            | 61-16-5    | 247.719  | cry                   | 214     |                                       |                            |                      | vs H <sub>2</sub> O; i eth, bz, chl                     |
| 6767 | Methoxsalen                       | 9-Methoxy-7H-furo[3,2-g][1]benzopyran-7-one           | C <sub>12</sub> H <sub>8</sub> O <sub>4</sub>                                | 298-81-7   | 216.190  | pr (dil al) nd (peth) | 148     |                                       |                            |                      | sl H <sub>2</sub> O, eth, ace, peth; vs EtOH            |
| 6768 | Methoxyacetaldehyde               |                                                       | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                                 | 10312-83-1 | 74.079   |                       |         | 92                                    | 1.005 <sup>25</sup>        | 1.3950 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                     |
| 6769 | Methoxyacetic acid                |                                                       | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                                 | 625-45-6   | 90.078   | hyg                   |         | 203.5                                 | 1.1768 <sup>20</sup>       | 1.4168 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth                           |
| 6770 | Methoxyacetonitrile               |                                                       | C <sub>3</sub> H <sub>5</sub> NO                                             | 1738-36-9  | 71.078   |                       |         | 119                                   | 0.9492 <sup>20</sup>       | 1.3831 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, chl, alk, acid   |
| 6771 | Methoxyacetyl chloride            |                                                       | C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>                               | 38870-89-2 | 108.524  |                       |         | 112.5                                 | 1.1871 <sup>20</sup>       | 1.4199 <sup>20</sup> | s eth, ace, ctc; vs chl                                 |
| 6772 | 2-Methoxyaniline                  | <i>o</i> -Anisidine                                   | C <sub>7</sub> H <sub>9</sub> NO                                             | 90-04-0    | 123.152  |                       | 6.2     | 224                                   | 1.0923 <sup>20</sup>       | 1.5715 <sup>10</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz               |
| 6773 | 3-Methoxyaniline                  | <i>m</i> -Anisidine                                   | C <sub>7</sub> H <sub>9</sub> NO                                             | 536-90-3   | 123.152  | liq                   | -1      | 251                                   | 1.096 <sup>20</sup>        | 1.5794 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, ace, bz          |
| 6774 | 4-Methoxyaniline                  | <i>p</i> -Anisidine                                   | C <sub>7</sub> H <sub>9</sub> NO                                             | 104-94-9   | 123.152  | orth pl               | 57.2    | 243                                   | 1.071 <sup>57</sup>        | 1.5559 <sup>60</sup> | s H <sub>2</sub> O, ace, bz; vs EtOH, eth               |
| 6775 | 2-Methoxyaniline hydrochloride    | <i>o</i> -Anisidine hydrochloride                     | C <sub>7</sub> H <sub>10</sub> ClNO                                          | 134-29-2   | 159.613  | nd                    | 225     |                                       |                            |                      |                                                         |
| 6776 | 1-Methoxy-9,10-anthracenedione    |                                                       | C <sub>15</sub> H <sub>10</sub> O <sub>3</sub>                               | 82-39-3    | 238.238  |                       | 170.3   |                                       |                            |                      | sl EtOH; vs bz, chl                                     |
| 6777 | 2-Methoxybenzaldehyde             |                                                       | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                                 | 135-02-4   | 136.149  | pr                    | 37.5    | 243.5                                 | 1.1326 <sup>20</sup>       | 1.5600 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, ctc; vs eth, ace, chl   |
| 6778 | 3-Methoxybenzaldehyde             |                                                       | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                                 | 591-31-1   | 136.149  |                       |         | 231                                   | 1.1187 <sup>20</sup>       | 1.5530 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz; vs eth, ace, chl        |
| 6779 | 4-Methoxybenzaldehyde             | <i>p</i> -Anisaldehyde                                | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                                 | 123-11-5   | 136.149  |                       | 0       | 248; 134 <sup>12</sup>                | 1.119 <sup>15</sup>        | 1.5730 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs ace, chl; s bz    |
| 6780 | 4-Methoxybenzamide                |                                                       | C <sub>9</sub> H <sub>9</sub> NO <sub>2</sub>                                | 3424-93-9  | 151.163  | nd or tab (w)         | 166.5   | 295                                   |                            |                      | vs H <sub>2</sub> O, EtOH                               |
| 6781 | 4-Methoxybenzeneacetaldehyde      |                                                       | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                                | 5703-26-4  | 150.174  |                       |         | 255.5                                 | 1.096 <sup>20</sup>        | 1.5359 <sup>20</sup> |                                                         |
| 6782 | 2-Methoxybenzeneacetic acid       |                                                       | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                                | 93-25-4    | 166.173  | nd (w)                | 124     | 100 <sup>2</sup>                      |                            |                      | s H <sub>2</sub> O; vs EtOH, eth, ace, bz, chl          |
| 6783 | 4-Methoxybenzeneacetic acid       |                                                       | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                                | 104-01-8   | 166.173  | pl (w)                | 87      | 138 <sup>2</sup>                      |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, bz; sl chl, lig     |
| 6784 | 4-Methoxybenzeneacetonitrile      |                                                       | C <sub>9</sub> H <sub>9</sub> NO                                             | 104-47-2   | 147.173  |                       |         | 286.5                                 | 1.0845 <sup>20</sup>       | 1.5309 <sup>20</sup> | s EtOH, eth, chl                                        |
| 6785 | 4-Methoxy-1,2-benzenediamine      | 4-Methoxy- <i>o</i> -phenylenediamine                 | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> O                              | 102-51-2   | 138.166  | grn pl                | 51      | 200 <sup>21</sup> , 168 <sup>11</sup> |                            |                      | vs eth                                                  |
| 6786 | 4-Methoxy-1,3-benzenediamine      | 4-Methoxy- <i>m</i> -phenylenediamine                 | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> O                              | 615-05-4   | 138.166  | nd (eth)              | 67.5    |                                       |                            |                      | s EtOH, eth; sl DMSO                                    |
| 6787 | 2-Methoxy-1,4-benzenediamine      | 2,5-Diaminoanisole                                    | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> O                              | 5307-02-8  | 138.166  | cry                   | 107     |                                       |                            |                      |                                                         |
| 6788 | 3-Methoxy-1,2-benzenediol         |                                                       | C <sub>7</sub> H <sub>8</sub> O <sub>3</sub>                                 | 934-00-9   | 140.137  | nd                    | 42.8    | 163 <sup>48</sup> , 129 <sup>10</sup> |                            |                      | s chl                                                   |
| 6789 | 4-Methoxybenzenemethanamine       |                                                       | C <sub>9</sub> H <sub>13</sub> NO                                            | 55-81-2    | 151.205  |                       |         | 139 <sup>20</sup>                     |                            | 1.5379 <sup>20</sup> |                                                         |
| 6790 | 4-Methoxybenzeneethanol           |                                                       | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                                | 702-23-8   | 152.190  |                       | 29      | 335                                   |                            |                      |                                                         |
| 6791 | 2-Methoxybenzenemethanamine       |                                                       | C <sub>8</sub> H <sub>11</sub> NO                                            | 6850-57-3  | 137.179  |                       |         | 228                                   | 1.051 <sup>25</sup>        | 1.5475 <sup>20</sup> |                                                         |
| 6792 | 4-Methoxybenzenemethanamine       |                                                       | C <sub>8</sub> H <sub>11</sub> NO                                            | 2393-23-9  | 137.179  |                       |         | 236.5                                 | 1.050 <sup>15</sup>        | 1.5462 <sup>20</sup> | sl H <sub>2</sub> O, EtOH, eth                          |
| 6793 | 2-Methoxybenzenemethanol          |                                                       | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                                | 612-16-8   | 138.164  |                       |         | 249                                   | 1.0386 <sup>25</sup>       | 1.5455 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; msc eth                     |
| 6794 | 3-Methoxybenzenemethanol          |                                                       | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                                | 6971-51-3  | 138.164  |                       | 30      | 252                                   | 1.112 <sup>25</sup>        | 1.5440 <sup>20</sup> |                                                         |
| 6795 | 4-Methoxybenzenemethanol          | Anise alcohol                                         | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                                | 105-13-5   | 138.164  | nd                    | 25      | 259.1                                 | 1.109 <sup>26</sup>        | 1.5420 <sup>25</sup> | s H <sub>2</sub> O, ctc; vs EtOH, eth                   |
| 6796 | 4-Methoxybenzenesulfonyl chloride |                                                       | C <sub>7</sub> H <sub>7</sub> ClO <sub>3</sub> S                             | 98-68-0    | 206.647  | nd or pr (bz)         | 42.5    | 103 <sup>0.25</sup>                   |                            |                      | s EtOH, eth, bz                                         |
| 6797 | 3-Methoxybenzenethiol             |                                                       | C <sub>7</sub> H <sub>8</sub> OS                                             | 15570-12-4 | 140.203  |                       |         | 224.5; 114 <sup>20</sup>              |                            | 1.5874 <sup>20</sup> | s chl                                                   |
| 6798 | 4-Methoxybenzenethiol             |                                                       | C <sub>7</sub> H <sub>8</sub> OS                                             | 696-63-9   | 140.203  |                       |         | 228                                   | 1.1313 <sup>25</sup>       | 1.5801 <sup>25</sup> | s EtOH, eth, bz; sl chl                                 |

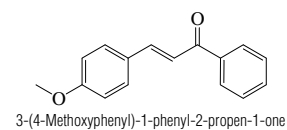
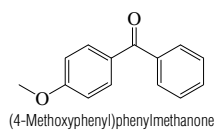
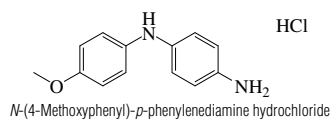
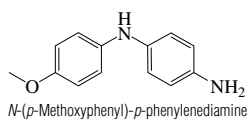
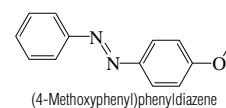
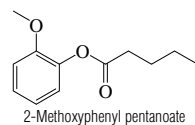
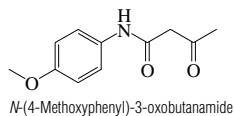
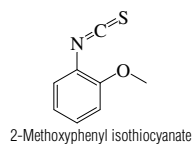
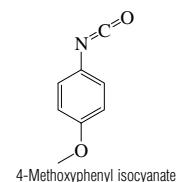
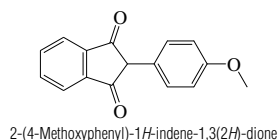
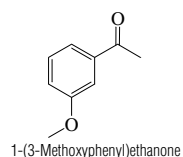
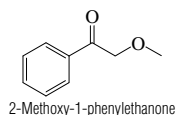
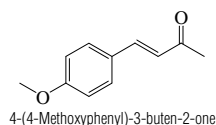
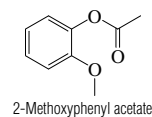
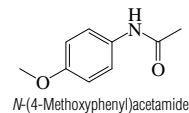
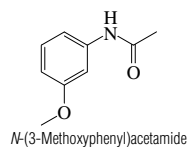
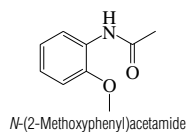
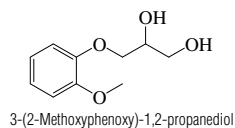
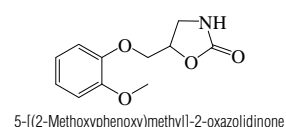
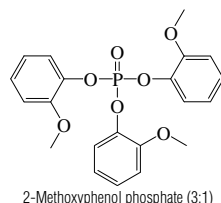
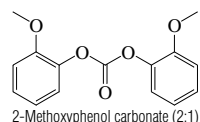
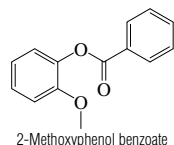
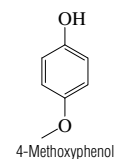
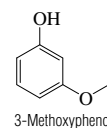
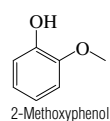
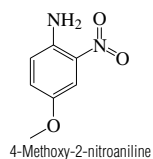
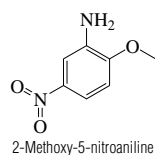
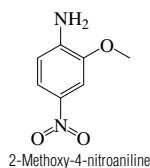
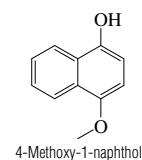
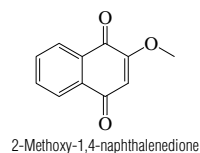
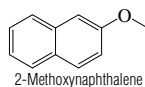
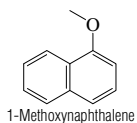
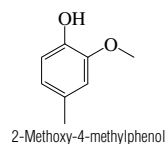
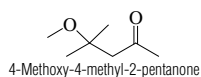
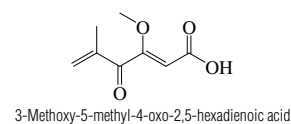
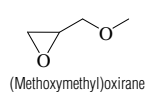
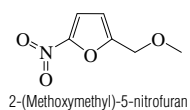
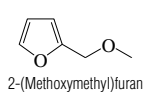
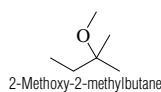


| No.  | Name                                                           | Synonym                                    | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form        | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                            |
|------|----------------------------------------------------------------|--------------------------------------------|----------------------------------------------------------------|------------|----------|----------------------|-------|---------------------------------------|----------------------------|-----------------------|-------------------------------------------------------|
| 6799 | 2-Methoxybenzoic acid                                          |                                            | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                   | 579-75-9   | 152.148  | pl (w)               | 101   | 200                                   |                            |                       | sl H <sub>2</sub> O; vs EtOH, eth, chl; s bz, ctc     |
| 6800 | 3-Methoxybenzoic acid                                          |                                            | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                   | 586-38-9   | 152.148  | nd (w)               | 107   | 170 <sup>10</sup>                     |                            |                       | sl H <sub>2</sub> O, ctc; s EtOH, eth, bz; vs chl     |
| 6801 | 4-Methoxybenzoic acid                                          | <i>p</i> -Anisic acid                      | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                   | 100-09-4   | 152.148  |                      | 185   | 276.5                                 |                            |                       | i H <sub>2</sub> O; vs EtOH, MeOH, eth; s chl         |
| 6802 | 2-Methoxybenzonitrile                                          |                                            | C <sub>8</sub> H <sub>7</sub> NO                               | 6609-56-9  | 133.148  |                      | 24.5  | 255.5                                 | 1.1063 <sup>20</sup>       |                       | s EtOH; vs eth                                        |
| 6803 | 3-Methoxybenzonitrile                                          |                                            | C <sub>8</sub> H <sub>7</sub> NO                               | 1527-89-5  | 133.148  |                      |       | 140 <sup>34</sup> , 111 <sup>13</sup> | 1.089 <sup>25</sup>        | 1.5402 <sup>20</sup>  |                                                       |
| 6804 | 4-Methoxybenzonitrile                                          |                                            | C <sub>8</sub> H <sub>7</sub> NO                               | 874-90-8   | 133.148  | nd (w) lf (al)       | 61.5  | 256.5                                 |                            |                       | i H <sub>2</sub> O; vs EtOH, eth; s bz                |
| 6805 | 7-Methoxy-2 <i>H</i> -1-benzopyran-2-one                       |                                            | C <sub>10</sub> H <sub>8</sub> O <sub>3</sub>                  | 531-59-9   | 176.169  | lf (w, MeOH)         | 118.3 |                                       |                            |                       | sl H <sub>2</sub> O; s EtOH, eth, con sulf, alk       |
| 6806 | 6-Methoxy-2-benzothiazolamine                                  |                                            | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> OS                | 1747-60-0  | 180.227  |                      | 166   |                                       |                            |                       |                                                       |
| 6807 | 2-(4-Methoxybenzoyl)benzoic acid                               | <i>o</i> -( <i>p</i> -Anisoyl)benzoic acid | C <sub>15</sub> H <sub>12</sub> O <sub>4</sub>                 | 1151-15-1  | 256.254  | lf (w), cry (al, to) | 146   |                                       |                            |                       | vs eth, EtOH, tol                                     |
| 6808 | 2-Methoxybenzoyl chloride                                      |                                            | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                 | 21615-34-9 | 170.594  |                      |       | 254                                   |                            |                       |                                                       |
| 6809 | 4-Methoxybenzoyl chloride                                      | <i>p</i> -Anisoyl chloride                 | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                 | 100-07-2   | 170.594  | nd                   | 24.5  | 262.5                                 | 1.261 <sup>20</sup>        | 1.580 <sup>20</sup>   | s eth, ace; vs bz; sl ctc                             |
| 6810 | 4-Methoxybenzyl acetate                                        |                                            | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                 | 104-21-2   | 180.200  |                      | 84    | 270; 150 <sup>23</sup>                | 1.105 <sup>25</sup>        |                       | s ctc                                                 |
| 6811 | 2-Methoxy-1,1'-biphenyl                                        |                                            | C <sub>13</sub> H <sub>12</sub> O                              | 86-26-0    | 184.233  | pr (peth)            | 29    | 274                                   | 1.0233 <sup>99</sup>       | 1.5641 <sup>99</sup>  | s H <sub>2</sub> O; s EtOH, peth; sl ctc              |
| 6812 | 4-Methoxy-1,1'-biphenyl                                        |                                            | C <sub>13</sub> H <sub>12</sub> O                              | 613-37-6   | 184.233  | pl (al)              | 90    | 157 <sup>10</sup>                     | 1.0278 <sup>100</sup>      | 1.5744 <sup>100</sup> | i H <sub>2</sub> O; s EtOH, eth                       |
| 6813 | 1-Methoxy-1,3-butadiene                                        |                                            | C <sub>6</sub> H <sub>8</sub> O                                | 3036-66-6  | 84.117   |                      |       | 91.5                                  | 0.8296 <sup>20</sup>       | 1.4594 <sup>20</sup>  | s H <sub>2</sub> O, EtOH                              |
| 6814 | 2-Methoxy-1,3-butadiene                                        |                                            | C <sub>6</sub> H <sub>8</sub> O                                | 3588-30-5  | 84.117   |                      |       | 75                                    | 0.8272 <sup>20</sup>       | 1.4442 <sup>20</sup>  | vs ace, bz, eth, EtOH                                 |
| 6815 | 3-Methoxy-1-butanol                                            |                                            | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                  | 2517-43-3  | 104.148  |                      |       | 157                                   | 0.923 <sup>23</sup>        | 1.4148 <sup>25</sup>  | vs EtOH, ace; s eth; sl chl                           |
| 6816 | 1-Methoxy-1-buten-3-yne                                        |                                            | C <sub>6</sub> H <sub>8</sub> O                                | 2798-73-4  | 82.101   |                      |       | dec 123; 39 <sup>23</sup>             | 0.906 <sup>20</sup>        | 1.4818 <sup>20</sup>  | i H <sub>2</sub> O; s chl                             |
| 6817 | Methoxychlor                                                   |                                            | C <sub>18</sub> H <sub>15</sub> Cl <sub>3</sub> O <sub>2</sub> | 72-43-5    | 345.648  | cry (dil al)         | 87    |                                       | 1.41 <sup>25</sup>         |                       | i H <sub>2</sub> O; s EtOH, ctc; vs eth, bz           |
| 6818 | Methoxycyclohexane                                             |                                            | C <sub>7</sub> H <sub>14</sub> O                               | 931-56-6   | 114.185  | liq                  | -74.4 | 133                                   | 0.8756 <sup>20</sup>       | 1.4355 <sup>20</sup>  | vs eth, EtOH                                          |
| 6819 | 1-Methoxy-2,4-dinitrobenzene                                   |                                            | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>5</sub>    | 119-27-7   | 198.133  | nd (al or w)         | 94.5  | 206 <sup>12</sup>                     | 1.3364 <sup>131</sup>      | 1.546 <sup>15</sup>   | sl H <sub>2</sub> O; s EtOH, eth, ace, bz; vs py      |
| 6820 | 1-Methoxy-3,5-dinitrobenzene                                   | 3,5-Dinitroanisole                         | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>5</sub>    | 5327-44-6  | 198.133  | nd (al)              | 105.3 |                                       | 1.558 <sup>12</sup>        |                       | vs ace, bz, MeOH                                      |
| 6821 | 2-Methoxy-1,2-diphenylethanone                                 |                                            | C <sub>15</sub> H <sub>14</sub> O <sub>2</sub>                 | 3524-62-7  | 226.271  | nd (lig)             | 49.5  | 188 <sup>15</sup>                     | 1.1278 <sup>14</sup>       |                       | vs bz, eth, EtOH                                      |
| 6822 | 2-Methoxyethanol                                               | Ethylene glycol monomethyl ether           | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                   | 109-86-4   | 76.095   | liq                  | -85.1 | 124.1                                 | 0.9647 <sup>20</sup>       | 1.4024 <sup>20</sup>  | msc H <sub>2</sub> O, eth, bz; vs EtOH; s ace; sl chl |
| 6823 | (2-Methoxyethoxy)ethene                                        |                                            | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                  | 1663-35-0  | 102.132  |                      |       | 107                                   |                            |                       |                                                       |
| 6824 | 2-[2-(2-Methoxyethoxy)ethoxy] ethanol                          | Triethyleneglycol monomethyl ether         | C <sub>7</sub> H <sub>16</sub> O <sub>4</sub>                  | 112-35-6   | 164.200  |                      |       | 246                                   |                            |                       |                                                       |
| 6825 | 2-Methoxyethyl acetate                                         | Ethylene glycol monomethyl ether acetate   | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>                  | 110-49-6   | 118.131  | liq                  | -70   | 143                                   | 1.0074 <sup>19</sup>       | 1.4002 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, eth; sl ctc                 |
| 6826 | 2-Methoxyethyl acrylate                                        | 2-Methoxyethyl 2-propenoate                | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                  | 3121-61-7  | 130.141  |                      |       | 67 <sup>16</sup> , 56 <sup>12</sup>   | 1.012 <sup>20</sup>        |                       |                                                       |
| 6827 | 2-Methoxyethylamine                                            | 1-Amino-2-methoxyethane                    | C <sub>3</sub> H <sub>9</sub> NO                               | 109-85-3   | 75.109   |                      |       | 95                                    |                            |                       | vs H <sub>2</sub> O, EtOH; sl chl                     |
| 6828 | Methoxyethylmercuric acetate                                   |                                            | C <sub>6</sub> H <sub>10</sub> HgO <sub>3</sub>                | 151-38-2   | 318.72   | nd (peth)            | 42    |                                       |                            |                       |                                                       |
| 6829 | 2-(2-Methoxyethyl)pyridine                                     | Metyridine                                 | C <sub>8</sub> H <sub>11</sub> NO                              | 114-91-0   | 137.179  |                      |       | 203; 96 <sup>17</sup>                 | 0.988 <sup>20</sup>        | 1.4975 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH                             |
| 6830 | 2-Methoxyfuran                                                 |                                            | C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                   | 25414-22-6 | 98.101   |                      |       | 110.5                                 | 1.0646 <sup>25</sup>       | 1.4468 <sup>25</sup>  |                                                       |
| 6831 | 4-Methoxyfuro[2,3- <i>b</i> ]quinoline                         | Dictamine                                  | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>   | 484-29-7   | 199.205  | pr (al)              | 133.5 |                                       |                            |                       | sl H <sub>2</sub> O; vs EtOH; s eth, chl, AcOEt       |
| 6832 | 12-Methoxyibogamine                                            | Ibogaïne                                   | C <sub>20</sub> H <sub>26</sub> N <sub>2</sub> O               | 83-74-9    | 310.432  |                      | 148   |                                       |                            |                       | s chl                                                 |
| 6833 | 5-Methoxy-1 <i>H</i> -indole-3-ethanamine                      | 5-Methoxytryptamine                        | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> O               | 608-07-1   | 190.241  | cry (al)             | 121.5 |                                       |                            |                       |                                                       |
| 6834 | <i>N</i> -[2-(5-Methoxy-1 <i>H</i> -indol-3-yl)ethyl]acetamide | Melatonin                                  | C <sub>13</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>  | 73-31-4    | 232.278  | pa ye lf (bz)        | 117   |                                       |                            |                       |                                                       |
| 6835 | 3-Methoxyisopropylamine                                        | 1-Methoxy-2-propanamine                    | C <sub>4</sub> H <sub>11</sub> NO                              | 37143-54-7 | 89.136   |                      |       | 97                                    |                            | 1.4031 <sup>25</sup>  |                                                       |
| 6836 | 4-Methoxy- <i>N</i> -(4-methoxyphenyl) aniline                 | 4,4'-Dimethoxydiphenylamine                | C <sub>14</sub> H <sub>15</sub> NO <sub>2</sub>                | 101-70-2   | 229.275  | lf (EtOH)            | 103   |                                       |                            |                       |                                                       |
| 6837 | <i>N</i> -Methoxymethylamine                                   | <i>N</i> -Methoxymethanamine               | C <sub>2</sub> H <sub>7</sub> NO                               | 1117-97-1  | 61.083   | liq                  |       | 42.4                                  |                            |                       |                                                       |
| 6838 | 2-Methoxy-5-methylaniline                                      | 5-Methyl- <i>o</i> -anisidine              | C <sub>8</sub> H <sub>11</sub> NO                              | 120-71-8   | 137.179  |                      | 53    | 235                                   |                            |                       | sl H <sub>2</sub> O, chl; s EtOH, eth, bz, peth       |
| 6839 | 4-Methoxy-2-methylaniline                                      |                                            | C <sub>8</sub> H <sub>11</sub> NO                              | 102-50-1   | 137.179  | cry (lig)            | 29.5  | 248.5                                 | 1.065 <sup>25</sup>        | 1.5647 <sup>20</sup>  | vs EtOH                                               |
| 6840 | 4-Methoxy- $\alpha$ -methylbenzenemethanol                     |                                            | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                  | 3319-15-1  | 152.190  |                      |       | dec 310; 140 <sup>17</sup>            | 1.0794 <sup>20</sup>       | 1.5310 <sup>25</sup>  | s ctc                                                 |

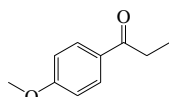




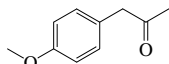
| No.  | Name                                                                  | Synonym                                        | Mol. Form.                                                  | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|-----------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------|------------|----------|----------------------------|---------|---------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 6841 | 2-Methoxy-2-methylbutane                                              | Methyl <i>tert</i> -pentyl ether               | C <sub>8</sub> H <sub>14</sub> O                            | 994-05-8   | 102.174  |                            |         | 86.1                                  | 0.7660 <sup>25</sup>       | 1.3862 <sup>25</sup> | sl H <sub>2</sub> O; vs eth, EtOH                            |
| 6842 | 2-(Methoxymethyl)furan                                                |                                                | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                | 13679-46-4 | 112.127  |                            |         | 132                                   | 1.0163 <sup>20</sup>       | 1.4570 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; vs eth                           |
| 6843 | 2-(Methoxymethyl)-5-nitrofuran                                        |                                                | C <sub>6</sub> H <sub>7</sub> NO <sub>4</sub>               | 586-84-5   | 157.125  |                            |         | 104 <sup>3</sup>                      | 1.281 <sup>20</sup>        | 1.5325 <sup>20</sup> | vs EtOH                                                      |
| 6844 | (Methoxymethyl)oxirane                                                |                                                | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | 930-37-0   | 88.106   |                            |         | 113                                   | 0.9890 <sup>20</sup>       | 1.4320 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                          |
| 6845 | 3-Methoxy-5-methyl-4-oxo-2,5-hexadienoic acid                         | Penicillic acid                                | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>               | 90-65-3    | 170.163  | orth or hex pl (+ 1w)      | 83      |                                       |                            |                      | s H <sub>2</sub> O, ace; vs EtOH, eth, bz; sl peth           |
| 6846 | 4-Methoxy-4-methyl-2-pentanone                                        | Pentoxone                                      | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>               | 107-70-0   | 130.185  |                            |         | 160                                   | 0.8980 <sup>25</sup>       | 1.418 <sup>20</sup>  |                                                              |
| 6847 | 2-Methoxy-4-methylphenol                                              | Creosol                                        | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>               | 93-51-6    | 138.164  | pr                         | 5.5     | 221                                   | 1.098 <sup>20</sup>        | 1.5353 <sup>25</sup> | vs eth, EtOH                                                 |
| 6848 | 1-Methoxynaphthalene                                                  |                                                | C <sub>11</sub> H <sub>10</sub> O                           | 2216-69-5  | 158.196  |                            | <-10    | 269                                   | 1.0963 <sup>14</sup>       | 1.6940 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl; vs CS <sub>2</sub> |
| 6849 | 2-Methoxynaphthalene                                                  |                                                | C <sub>11</sub> H <sub>10</sub> O                           | 93-04-9    | 158.196  | lf (eth), pl (peth)        | 73.5    | 274                                   |                            |                      | vs bz, eth, chl                                              |
| 6850 | 2-Methoxy-1,4-naphthalenedione                                        |                                                | C <sub>11</sub> H <sub>6</sub> O <sub>3</sub>               | 2348-82-5  | 188.180  |                            | 183.0   |                                       |                            |                      |                                                              |
| 6851 | 4-Methoxy-1-naphthol                                                  |                                                | C <sub>11</sub> H <sub>10</sub> O <sub>2</sub>              | 84-85-5    | 174.196  |                            | 129.8   |                                       |                            |                      |                                                              |
| 6852 | 2-Methoxy-4-nitroaniline                                              |                                                | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> | 97-52-9    | 168.150  |                            | 141.0   |                                       |                            |                      | s DMSO                                                       |
| 6853 | 2-Methoxy-5-nitroaniline                                              | 5-Nitro- <i>o</i> -anisidine                   | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> | 99-59-2    | 168.150  |                            | 118     |                                       | 1.2068 <sup>15</sup>       |                      | s H <sub>2</sub> O, eth; vs EtOH, ace, bz; sl lig            |
| 6854 | 4-Methoxy-2-nitroaniline                                              |                                                | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> | 96-96-8    | 168.150  | dk red pr (w or al)        | 129     |                                       |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH                          |
| 6855 | 2-Methoxyphenol                                                       | Guaiacol                                       | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                | 90-05-1    | 124.138  | hex pr                     | 32      | 205                                   | 1.1287 <sup>21</sup>       | 1.5429 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc, chl                   |
| 6856 | 3-Methoxyphenol                                                       |                                                | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                | 150-19-6   | 124.138  |                            | <-17    | 114 <sup>5</sup>                      | 1.131 <sup>25</sup>        | 1.5510 <sup>20</sup> | sl H <sub>2</sub> O, chl; msc EtOH, eth                      |
| 6857 | 4-Methoxyphenol                                                       |                                                | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                | 150-76-5   | 124.138  | pl                         | 57      | 243                                   |                            |                      | s H <sub>2</sub> O, bz, ctc; vs EtOH, eth                    |
| 6858 | 2-Methoxyphenol benzoate                                              | Guaiacol benzoate                              | C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>              | 531-37-3   | 228.243  |                            | 57.5    |                                       |                            |                      | vs eth, chl                                                  |
| 6859 | 2-Methoxyphenol carbonate (2:1)                                       | Guaiacol carbonate                             | C <sub>15</sub> H <sub>14</sub> O <sub>3</sub>              | 553-17-3   | 274.269  | cry (al)                   | 89      |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth; vs chl                   |
| 6860 | 2-Methoxyphenol phosphate (3:1)                                       | Guaiacol phosphate                             | C <sub>21</sub> H <sub>21</sub> O <sub>7</sub> P            | 563-03-1   | 416.362  |                            | 91      | 277 <sup>3</sup>                      |                            |                      | vs ace, tol, chl                                             |
| 6861 | 5-[(2-Methoxyphenoxy)methyl]-2-oxazolidinone                          | Mephenoxalone                                  | C <sub>11</sub> H <sub>13</sub> NO <sub>4</sub>             | 70-07-5    | 223.226  |                            | 144     |                                       |                            |                      |                                                              |
| 6862 | 3-(2-Methoxyphenoxy)-1,2-propanediol                                  | Guaiifenesin                                   | C <sub>10</sub> H <sub>14</sub> O <sub>4</sub>              | 93-14-1    | 198.216  | orth pr (eth, eth-peth)    | 78.5    | 215 <sup>19</sup> , 1270 <sup>2</sup> |                            |                      | s H <sub>2</sub> O, bz, chl; vs EtOH; i peth                 |
| 6863 | <i>N</i> -(2-Methoxyphenyl)acetamide                                  | <i>o</i> -Acetanisidine                        | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>              | 93-26-5    | 165.189  | nd (w)                     | 87.5    | 304                                   |                            |                      | vs H <sub>2</sub> O, EtOH; s eth, ace, HOAc                  |
| 6864 | <i>N</i> -(3-Methoxyphenyl)acetamide                                  | <i>m</i> -Acetanisidine                        | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>              | 588-16-9   | 165.189  | nd or pl (w)               | 81      |                                       |                            |                      | vs H <sub>2</sub> O, EtOH; s eth, ace                        |
| 6865 | <i>N</i> -(4-Methoxyphenyl)acetamide                                  | <i>p</i> -Acetanisidine                        | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>              | 51-66-1    | 165.189  | pl (w)                     | 131     |                                       |                            |                      | vs ace, EtOH, chl                                            |
| 6866 | 2-Methoxyphenyl acetate                                               | 2-Acetoxyanisole                               | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>               | 613-70-7   | 166.173  |                            | 31.5    | 123 <sup>13</sup>                     | 1.1285 <sup>25</sup>       | 1.5101 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth                              |
| 6867 | 4-(4-Methoxyphenyl)-3-buten-2-one                                     |                                                | C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>              | 943-88-4   | 176.212  | lf (al, eth, HOAc)         | 74.0    | 187.5 <sup>19</sup>                   |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s bz, HOAc, sulf           |
| 6868 | 2-Methoxy-1-phenylethanone                                            |                                                | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>               | 4079-52-1  | 150.174  | ye liq                     | 8       | 245; 125 <sup>19</sup>                | 1.0897 <sup>20</sup>       | 1.5393 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, ace                             |
| 6869 | 1-(3-Methoxyphenyl)ethanone                                           |                                                | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>               | 586-37-8   | 150.174  |                            | 95.5    | 240                                   | 1.0343 <sup>19</sup>       | 1.5410 <sup>20</sup> | s H <sub>2</sub> O, EtOH, ace, ctc                           |
| 6870 | 2-(4-Methoxyphenyl)-1 <i>H</i> -indene-1,3(2 <i>H</i> )-dione         | Anisindione                                    | C <sub>16</sub> H <sub>12</sub> O <sub>3</sub>              | 117-37-3   | 252.264  | pa ye cry (HOAc, al)       | 156.5   |                                       |                            |                      |                                                              |
| 6871 | 4-Methoxyphenyl isocyanate                                            |                                                | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>               | 5416-93-3  | 149.148  |                            |         | 110 <sup>10</sup>                     |                            |                      |                                                              |
| 6872 | 2-Methoxyphenyl isothiocyanate                                        | 1-Isothiocyanato-2-methoxybenzene              | C <sub>8</sub> H <sub>7</sub> NOS                           | 3288-04-8  | 165.213  |                            |         | 264; 131 <sup>11</sup>                | 1.1878 <sup>20</sup>       | 1.6458 <sup>20</sup> |                                                              |
| 6873 | <i>N</i> -(4-Methoxyphenyl)-3-oxobutanamide                           |                                                | C <sub>11</sub> H <sub>13</sub> NO <sub>3</sub>             | 5437-98-9  | 207.226  |                            | 117.3   |                                       |                            |                      | s EtOH, chl; sl eth                                          |
| 6874 | 2-Methoxyphenyl pentanoate                                            | Guaiacol valerate                              | C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>              | 531-39-5   | 208.253  |                            |         | 265                                   | 1.05 <sup>25</sup>         |                      | vs bz, eth, EtOH                                             |
| 6875 | (4-Methoxyphenyl)phenyldiazene                                        |                                                | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O            | 2396-60-3  | 212.246  | oran-red pl, lf (al, peth) | 56      | 340                                   | 1.12 <sup>75</sup>         |                      | i H <sub>2</sub> O; s EtOH, eth, ace                         |
| 6876 | <i>N</i> -( <i>p</i> -Methoxyphenyl)- <i>p</i> -phenylenediamine      | <i>N</i> -(4-Methoxyphenyl)-1,4-benzenediamine | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> O            | 101-64-4   | 214.262  | nd                         | 102     | 238 <sup>12</sup>                     |                            |                      | sl H <sub>2</sub> O, peth; vs bz, eth, EtOH                  |
| 6877 | <i>N</i> -(4-Methoxyphenyl)- <i>p</i> -phenylenediamine hydrochloride |                                                | C <sub>13</sub> H <sub>15</sub> ClN <sub>2</sub> O          | 3566-44-7  | 250.723  | cry                        | 245 dec |                                       |                            |                      |                                                              |
| 6878 | (4-Methoxyphenyl)phenylmethanone                                      |                                                | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>              | 611-94-9   | 212.244  | pr (eth)                   | 61.5    | 355; 168 <sup>12</sup>                |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz, HOAc            |
| 6879 | 3-(4-Methoxyphenyl)-1-phenyl-2-propen-1-one                           |                                                | C <sub>16</sub> H <sub>14</sub> O <sub>2</sub>              | 959-33-1   | 238.281  | ye nd (al)                 | 79      | 187 <sup>19</sup>                     |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, ctc, chl, HOAc           |



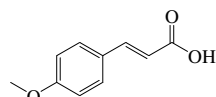
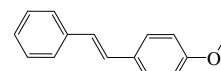
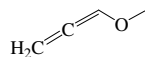
| No.  | Name                                               | Synonym                              | Mol. Form.                                                  | CAS RN     | Mol. Wt. | Physical Form          | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|------|----------------------------------------------------|--------------------------------------|-------------------------------------------------------------|------------|----------|------------------------|---------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------|
| 6880 | 1-(4-Methoxyphenyl)-1-propanone                    | Ethyl 4-methoxyphenyl ketone         | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | 121-97-1   | 164.201  |                        | 25.5    | 266                                   | 1.0798 <sup>16</sup>       |                      | s ctc                                             |
| 6881 | 1-(4-Methoxyphenyl)-2-propanone                    | Anisyl methyl ketone                 | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | 122-84-9   | 164.201  |                        | <-15    | 268                                   | 1.0694 <sup>17</sup>       | 1.5253 <sup>20</sup> | vs eth, EtOH                                      |
| 6882 | <i>trans</i> -3-(4-Methoxyphenyl)-2-propenoic acid | <i>trans</i> -4-Methoxycinnamic acid | C <sub>10</sub> H <sub>10</sub> O <sub>3</sub>              | 943-89-5   | 178.184  |                        | 173.5   |                                       |                            |                      | sl H <sub>2</sub> O, EtOH, bz, DMSO; s ctc, HOAc  |
| 6883 | <i>trans</i> -1-Methoxy-4-(2-phenylvinyl)benzene   |                                      | C <sub>15</sub> H <sub>14</sub> O                           | 1694-19-5  | 210.271  |                        | 136.5   | 142.5 <sup>15</sup>                   |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, ace, bz; s peth |
| 6884 | 1-Methoxy-1,2-propadiene                           | Methoxyallene                        | C <sub>4</sub> H <sub>6</sub> O                             | 13169-00-1 | 70.090   | oil                    |         | 51.5                                  |                            |                      |                                                   |
| 6885 | 3-Methoxy-1-propanamine                            |                                      | C <sub>4</sub> H <sub>11</sub> NO                           | 5332-73-0  | 89.136   |                        |         | 117.5                                 | 0.8727 <sup>20</sup>       | 1.4391 <sup>20</sup> | s H <sub>2</sub> O, ace, bz, ctc, chl, MeOH       |
| 6886 | 3-Methoxy-1,2-propanediol                          | Glycerol 3-methyl ether              | C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>               | 623-39-2   | 106.120  | hyg liq                |         | 220                                   | 1.114 <sup>20</sup>        | 1.442 <sup>25</sup>  | vs H <sub>2</sub> O, EtOH, ace; s eth             |
| 6887 | 3-Methoxypropanenitrile                            |                                      | C <sub>4</sub> H <sub>7</sub> NO                            | 110-67-8   | 85.105   |                        |         | 163                                   | 0.9379 <sup>20</sup>       | 1.4043 <sup>20</sup> | s EtOH, eth, chl                                  |
| 6888 | 2-Methoxy-1-propanol                               |                                      | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>               | 1589-47-5  | 90.121   |                        |         | 130                                   | 0.938 <sup>20</sup>        | 1.4070 <sup>20</sup> |                                                   |
| 6889 | 1-Methoxy-2-propanone                              | Methoxyacetone                       | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | 5878-19-3  | 88.106   |                        |         | 116                                   | 0.957 <sup>25</sup>        | 1.3970 <sup>20</sup> |                                                   |
| 6890 | 2-Methoxy-1-propene                                |                                      | C <sub>4</sub> H <sub>8</sub> O                             | 116-11-0   | 72.106   |                        |         | 38                                    | 0.7372 <sup>20</sup>       |                      |                                                   |
| 6891 | 3-Methoxy-1-propene                                |                                      | C <sub>4</sub> H <sub>8</sub> O                             | 627-40-7   | 72.106   |                        |         | 44                                    | 0.77 <sup>11</sup>         | 1.3778 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace          |
| 6892 | <i>trans</i> -1-Methoxy-4-(1-propenyl)benzene      | Anethole                             | C <sub>10</sub> H <sub>12</sub> O                           | 4180-23-8  | 148.201  | col oily liq           | 22.5    | 235; 81 <sup>2,3</sup>                | 0.9882 <sup>20</sup>       | 1.5615 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ace; vs bz  |
| 6893 | 1-Methoxy-4-(2-propenyl)benzene                    | Estragole                            | C <sub>10</sub> H <sub>12</sub> O                           | 140-67-0   | 148.201  |                        |         | 215.5                                 | 0.965 <sup>25</sup>        | 1.5195 <sup>20</sup> | vs EtOH, chl                                      |
| 6894 | <i>cis</i> -2-Methoxy-4-(1-propenyl)phenol         |                                      | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | 5912-86-7  | 164.201  |                        |         | 134 <sup>13</sup>                     | 1.0837 <sup>20</sup>       | 1.5726 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                  |
| 6895 | <i>trans</i> -2-Methoxy-4-(1-propenyl)phenol       |                                      | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | 5932-68-3  | 164.201  |                        | 33.5    | 141 <sup>13</sup>                     | 1.0852 <sup>20</sup>       | 1.5784 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, chl             |
| 6896 | 1-Methoxy-4-propylbenzene                          |                                      | C <sub>10</sub> H <sub>14</sub> O                           | 104-45-0   | 150.217  |                        |         | 211.5                                 | 0.9472 <sup>20</sup>       | 1.5045 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, ace, bz, chl; vs eth |
| 6897 | 2-Methoxy-4-propylphenol                           |                                      | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>              | 2785-87-7  | 166.217  |                        |         | 121 <sup>10</sup>                     |                            |                      |                                                   |
| 6898 | 3-Methoxy-1-propyne                                |                                      | C <sub>4</sub> H <sub>6</sub> O                             | 627-41-8   | 70.090   |                        |         | 63                                    | 0.83 <sup>12</sup>         | 1.5035 <sup>20</sup> | vs eth, EtOH                                      |
| 6899 | 5-Methoxypsoralen                                  | Bergaptene                           | C <sub>12</sub> H <sub>8</sub> O <sub>4</sub>               | 484-20-8   | 216.190  | nd (EtOH)              | 188     |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH, bz, chl              |
| 6900 | 6-Methoxy-3-pyridinamine                           |                                      | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O              | 6628-77-9  | 124.140  |                        | 30      | 125 <sup>10</sup> , 87 <sup>1</sup>   |                            | 1.5745 <sup>20</sup> |                                                   |
| 6901 | 2-Methoxypyridine                                  |                                      | C <sub>6</sub> H <sub>7</sub> NO                            | 1628-89-3  | 109.126  |                        |         | 142.5                                 | 1.0457 <sup>20</sup>       | 1.5042 <sup>20</sup> |                                                   |
| 6902 | 3-Methoxypyridine                                  |                                      | C <sub>6</sub> H <sub>7</sub> NO                            | 7295-76-3  | 109.126  | liq                    |         | 178.5; 65 <sup>15</sup>               | 1.083                      | 1.5180 <sup>20</sup> |                                                   |
| 6903 | 4-Methoxypyridine                                  |                                      | C <sub>6</sub> H <sub>7</sub> NO                            | 620-08-6   | 109.126  |                        |         | 192; 95 <sup>45</sup>                 |                            |                      | msc H <sub>2</sub> O                              |
| 6904 | 6-Methoxyquinoline                                 |                                      | C <sub>10</sub> H <sub>9</sub> NO                           | 5263-87-6  | 159.184  | hyg lf                 | 26.5    | 306; 153 <sup>12</sup>                | 1.152 <sup>20</sup>        |                      | s EtOH, eth, chl, dil HCl                         |
| 6905 | 6-Methoxy-4-quinolinecarboxylic acid               | Quininic acid                        | C <sub>11</sub> H <sub>9</sub> NO <sub>3</sub>              | 86-68-0    | 203.194  | pa ye pr (dil al)      | 285 dec | sub                                   |                            |                      | sl H <sub>2</sub> O, eth, bz, tfa; i chl; s EtOH  |
| 6906 | 2-Methoxy-1,3,5-trinitrobenzene                    | Methyl picrate                       | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>7</sub> | 606-35-9   | 243.131  | nd (dil MeOH)          | 69      |                                       | 1.4947 <sup>80</sup>       |                      | i H <sub>2</sub> O; vs EtOH, chl, bz; s eth       |
| 6907 | (2-Methoxyvinyl)benzene                            |                                      | C <sub>9</sub> H <sub>10</sub> O                            | 4747-15-3  | 134.174  |                        |         | 211.5                                 | 0.9894 <sup>23</sup>       | 1.5620 <sup>24</sup> |                                                   |
| 6908 | Methscopolamine bromide                            | Scopolamine methobromide             | C <sub>18</sub> H <sub>24</sub> BrNO <sub>4</sub>           | 155-41-9   | 398.293  | cry (EtOH)             | 215 dec |                                       |                            |                      | s H <sub>2</sub> O; sl EtOH                       |
| 6909 | Methyl abietate                                    |                                      | C <sub>21</sub> H <sub>32</sub> O <sub>2</sub>              | 127-25-3   | 316.478  | pa ye lf (liq)         |         | 225 <sup>16</sup>                     | 1.049 <sup>20</sup>        | 1.5344               | i H <sub>2</sub> O; s EtOH, HOAc                  |
| 6910 | <i>N</i> -Methylacetamide                          |                                      | C <sub>3</sub> H <sub>7</sub> NO                            | 79-16-3    | 73.094   |                        | 28      | 205                                   | 0.9371 <sup>25</sup>       | 1.4301 <sup>20</sup> | vs ace, bz, eth, EtOH                             |
| 6911 | 4-Methylacetanilide                                |                                      | C <sub>9</sub> H <sub>11</sub> NO                           | 103-89-9   | 149.189  | mcl cry or nd (dil al) | 152     | 307                                   | 1.2120 <sup>15</sup>       |                      | vs eth, EtOH                                      |
| 6912 | Methyl acetate                                     |                                      | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | 79-20-9    | 74.079   | liq                    | -98.25  | 56.87                                 | 0.9342 <sup>20</sup>       | 1.3614 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                    |
| 6913 | Methyl acetoacetate                                |                                      | C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>                | 105-45-3   | 116.116  |                        | 27.5    | 171.7                                 | 1.0762 <sup>20</sup>       | 1.4184 <sup>20</sup> | vs H <sub>2</sub> O; msc EtOH, eth; s ctc         |
| 6914 | 4-Methylacetophenone                               |                                      | C <sub>9</sub> H <sub>10</sub> O                            | 122-00-9   | 134.174  | nd                     | 28      | 226; 93.5 <sup>7</sup>                | 1.0051 <sup>20</sup>       | 1.5335 <sup>20</sup> | vs bz, eth, EtOH, chl                             |
| 6915 | Methyl 2-(acetyloxy)benzoate                       | Methyl <i>o</i> -acetylsalicylate    | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>              | 580-02-9   | 194.184  | pl (peth)              | 51.5    | 135 <sup>9</sup>                      |                            |                      | vs eth, EtOH, chl                                 |
| 6916 | Methyl acrylate                                    | Methyl propenoate                    | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                | 96-33-3    | 86.090   | liq                    | <-75    | 80.7                                  | 0.9535 <sup>20</sup>       | 1.4040 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, chl    |
| 6917 | 2-Methylacrylonitrile                              | 2-Methylpropenenitrile               | C <sub>4</sub> H <sub>5</sub> N                             | 126-98-7   | 67.090   | liq                    | -35.8   | 90.3                                  | 0.8001 <sup>20</sup>       | 1.4003 <sup>20</sup> | sl H <sub>2</sub> O, chl; msc EtOH, eth, ace, tol |
| 6918 | 2-Methylalanine                                    | $\alpha$ -Aminoisobutyric acid       | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>               | 62-57-7    | 103.120  | mcl pr                 | 335     | sub 280                               |                            |                      | vs H <sub>2</sub> O; sl EtOH; i eth               |
| 6919 | 5-Methyl-3-allyl-2,4-oxazolidinedione              | Aloxidone                            | C <sub>7</sub> H <sub>9</sub> NO <sub>3</sub>               | 526-35-2   | 155.151  |                        |         | 138 <sup>35</sup> , 86 <sup>0,5</sup> |                            | 1.4688 <sup>25</sup> |                                                   |



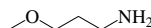
1-(4-Methoxyphenyl)-1-propanone



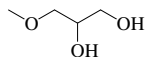
1-(4-Methoxyphenyl)-2-propanone

*trans*-3-(4-Methoxyphenyl)-2-propenoic acid*trans*-1-Methoxy-4-(2-phenylvinyl)benzene

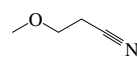
1-Methoxy-1,2-propadiene



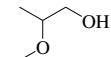
3-Methoxy-1-propanamine



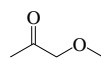
3-Methoxy-1,2-propanediol



3-Methoxypropanenitrile



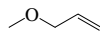
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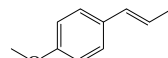
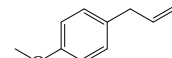
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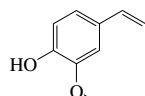
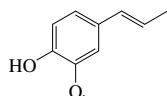
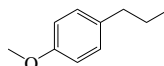
2-Methoxy-1-propene



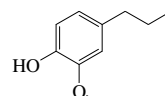
3-Methoxy-1-propene

*trans*-1-Methoxy-4-(1-propenyl)benzene

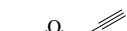
1-Methoxy-4-(2-propenyl)benzene

*cis*-2-Methoxy-4-(1-propenyl)phenol*trans*-2-Methoxy-4-(1-propenyl)phenol

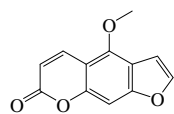
1-Methoxy-4-propylbenzene



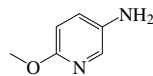
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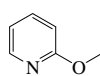
3-Methoxy-1-propyne



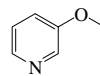
5-Methoxypsoralen



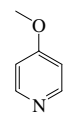
6-Methoxy-3-pyridinamine



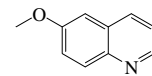
2-Methoxypyridine



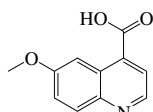
3-Methoxypyridine



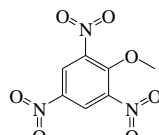
4-Methoxypyridine



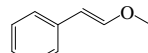
6-Methoxyquinoline



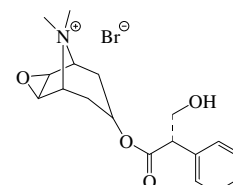
6-Methoxy-4-quinolinecarboxylic acid



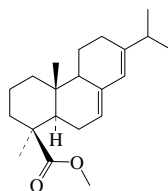
2-Methoxy-1,3,5-trinitrobenzene



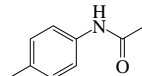
(2-Methoxyvinyl)benzene



Methscopolamine bromide



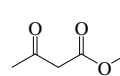
Methyl abietate

*N*-Methylacetamide

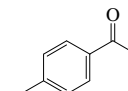
4-Methylacetanilide



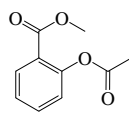
Methyl acetate



Methyl acetoacetate



4-Methylacetophenone



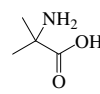
Methyl 2-(acetyloxy)benzoate



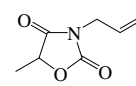
Methyl acrylate



2-Methylacrylonitrile

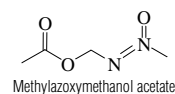
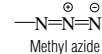
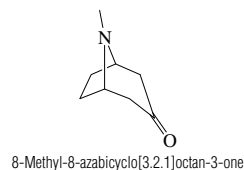
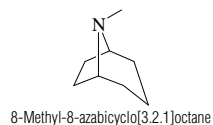
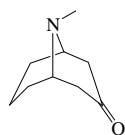
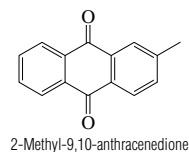
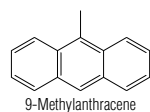
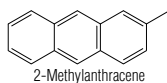
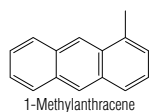
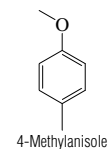
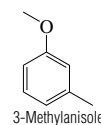
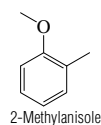
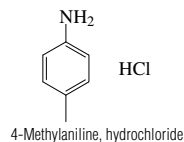
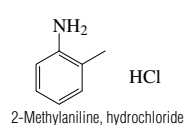
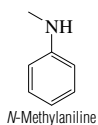
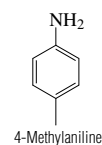
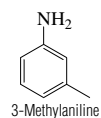
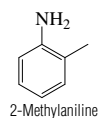
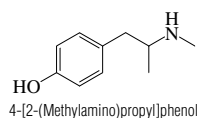
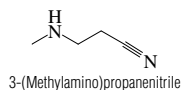
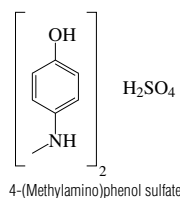
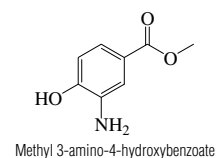
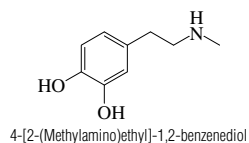
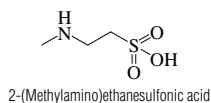
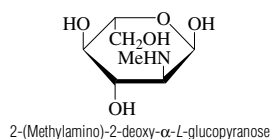
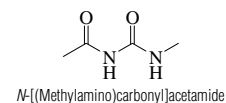
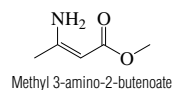
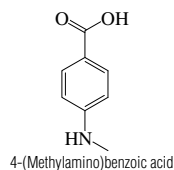
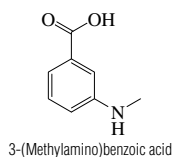
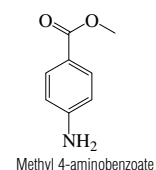
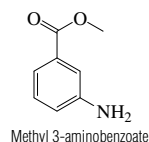
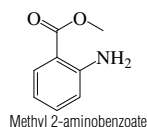
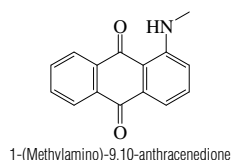
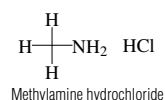
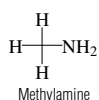


2-Methylalanine

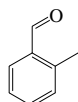


5-Methyl-3-allyl-2,4-oxazolidinedione

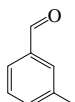
| No.  | Name                                                        | Synonym                                            | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form              | mp/°C  | bp/°C                                | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>        | Solubility                                                   |
|------|-------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------|------------|----------|----------------------------|--------|--------------------------------------|----------------------------------|-----------------------|--------------------------------------------------------------|
| 6920 | Methylamine                                                 | Methanamine                                        | CH <sub>5</sub> N                                               | 74-89-5    | 31.058   | col gas                    | -93.5  | -6.32                                | 0.656 <sup>25</sup><br>(p>1 atm) |                       | vs H <sub>2</sub> O; s EtOH, ace, bz, msc eth                |
| 6921 | Methylamine hydrochloride                                   | Methanamine hydrochloride                          | CH <sub>5</sub> ClN                                             | 593-51-1   | 67.519   | hyg tetr tab (al)          | 227.5  | 227 <sup>15</sup>                    |                                  |                       | s H <sub>2</sub> O, EtOH; i chl, ace                         |
| 6922 | 1-(Methylamino)-9,10-anthracenedione                        |                                                    | C <sub>15</sub> H <sub>11</sub> NO <sub>2</sub>                 | 82-38-2    | 237.254  | ye-red nd                  | 171.0  |                                      |                                  |                       | s EtOH, bz, chl, HOAc                                        |
| 6923 | Methyl 2-aminobenzoate                                      | Methyl anthranilate                                | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                   | 134-20-3   | 151.163  |                            | 24.5   | 256                                  | 1.1682 <sup>10</sup>             | 1.5810                | sl H <sub>2</sub> O; vs EtOH, eth                            |
| 6924 | Methyl 3-aminobenzoate                                      |                                                    | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                   | 4518-10-9  | 151.163  |                            | 39     | 152 <sup>11</sup>                    | 1.232 <sup>20</sup>              |                       | vs EtOH, eth, bz, chl; s lig; sl peth                        |
| 6925 | Methyl 4-aminobenzoate                                      |                                                    | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                   | 619-45-4   | 151.163  | lf or nd (aq MeOH)         | 113.0  |                                      |                                  |                       | s chl                                                        |
| 6926 | 2-(Methylamino)benzoic acid                                 |                                                    | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                   | 119-68-6   | 151.163  | pl (al or lig)             | 180.5  | 80 <sup>01</sup>                     |                                  |                       | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl                   |
| 6927 | 3-(Methylamino)benzoic acid                                 |                                                    | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                   | 51524-84-6 | 151.163  | pl (peth)                  | 127    |                                      |                                  |                       | vs ace, bz, EtOH, chl                                        |
| 6928 | 4-(Methylamino)benzoic acid                                 |                                                    | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                   | 10541-83-0 | 151.163  | nd (bz, w, dil al)         | 168    |                                      |                                  |                       | s H <sub>2</sub> O, bz, AcOEt; vs EtOH, eth; sl tfa          |
| 6929 | Methyl 3-amino-2-butenate                                   |                                                    | C <sub>7</sub> H <sub>9</sub> NO <sub>2</sub>                   | 14205-39-1 | 115.131  |                            |        |                                      |                                  |                       | s chl                                                        |
| 6930 | <i>N</i> -[(Methylamino)carbonyl]acetamide                  |                                                    | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>     | 623-59-6   | 116.119  | tcl (w, al), pr (w)        | 180.5  | dec                                  |                                  |                       | s H <sub>2</sub> O, chl; sl EtOH, eth                        |
| 6931 | 2-(Methylamino)-2-deoxy- $\alpha$ - <i>L</i> -glucopyranose | <i>N</i> -Methyl- $\alpha$ - <i>L</i> -glucosamine | C <sub>7</sub> H <sub>15</sub> NO <sub>5</sub>                  | 42852-95-9 | 193.198  | glass                      |        |                                      |                                  |                       | s MeOH                                                       |
| 6932 | 2-(Methylamino)ethanesulfonic acid                          | <i>N</i> -Methyltaurine                            | C <sub>3</sub> H <sub>9</sub> NO <sub>3</sub> S                 | 107-68-6   | 139.173  |                            | 241.5  |                                      |                                  |                       | vs H <sub>2</sub> O; i EtOH, eth                             |
| 6933 | 4-[2-(Methylamino)ethyl]-1,2-benzenediol                    | Deoxyepinephrine                                   | C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | 501-15-5   | 167.205  |                            | 188.5  |                                      |                                  |                       |                                                              |
| 6934 | Methyl 3-amino-4-hydroxybenzoate                            | Orthocaine                                         | C <sub>8</sub> H <sub>9</sub> NO <sub>3</sub>                   | 536-25-4   | 167.162  | nd (bz or HOAc)            | 143    |                                      |                                  |                       | i H <sub>2</sub> O; vs EtOH; s eth, alk; sl bz               |
| 6935 | 4-(Methylamino)phenol sulfate                               |                                                    | C <sub>14</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> S | 1936-57-8  | 344.383  | cry                        | 260    | dec                                  |                                  |                       | sl EtOH; i eth                                               |
| 6936 | 3-(Methylamino)propanenitrile                               |                                                    | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub>                    | 693-05-0   | 84.120   |                            |        | 102 <sup>49</sup> , 74 <sup>16</sup> | 0.8992 <sup>20</sup>             | 1.4320 <sup>20</sup>  | s H <sub>2</sub> O, ace, bz, chl, MeOH                       |
| 6937 | 4-[2-(Methylamino)propyl]phenol                             | Pholedrine                                         | C <sub>10</sub> H <sub>15</sub> NO                              | 370-14-9   | 165.232  | cry (MeOH)                 | 161    |                                      |                                  |                       | vs eth, EtOH                                                 |
| 6938 | 2-Methylaniline                                             | <i>o</i> -Toluidine                                | C <sub>7</sub> H <sub>9</sub> N                                 | 95-53-4    | 107.153  | liq                        | -14.41 | 200.3                                | 0.9984 <sup>20</sup>             | 1.5725 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth, ctc                      |
| 6939 | 3-Methylaniline                                             | <i>m</i> -Toluidine                                | C <sub>7</sub> H <sub>9</sub> N                                 | 108-44-1   | 107.153  | liq                        | -31.3  | 203.3                                | 0.9889 <sup>20</sup>             | 1.5681 <sup>20</sup>  | vs ace, bz, eth, EtOH                                        |
| 6940 | 4-Methylaniline                                             | <i>p</i> -Toluidine                                | C <sub>7</sub> H <sub>9</sub> N                                 | 106-49-0   | 107.153  | lf (w+1)                   | 43.6   | 200.4                                | 0.9619 <sup>20</sup>             | 1.5534 <sup>45</sup>  | sl H <sub>2</sub> O; vs EtOH, py; s eth, ace, ctc            |
| 6941 | <i>N</i> -Methylaniline                                     |                                                    | C <sub>7</sub> H <sub>9</sub> N                                 | 100-61-8   | 107.153  | liq                        | -57    | 196.2                                | 0.9891 <sup>20</sup>             | 1.5684 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ctc, chl                    |
| 6942 | 2-Methylaniline, hydrochloride                              | <i>o</i> -Toluidine, hydrochloride                 | C <sub>7</sub> H <sub>10</sub> ClN                              | 636-21-5   | 143.614  | mcl pr (w)                 | 215    |                                      |                                  |                       | vs H <sub>2</sub> O, EtOH                                    |
| 6943 | 4-Methylaniline, hydrochloride                              |                                                    | C <sub>7</sub> H <sub>10</sub> ClN                              | 540-23-8   | 143.614  | mcl nd (eth-HOAc)          | 244.5  | 258                                  | 1.1930 <sup>18</sup>             |                       | vs H <sub>2</sub> O, EtOH, HOAc                              |
| 6944 | 2-Methylanisole                                             |                                                    | C <sub>8</sub> H <sub>10</sub> O                                | 578-58-5   | 122.164  | liq                        | -34.1  | 171                                  | 0.985 <sup>25</sup>              | 1.5161 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, ctc                    |
| 6945 | 3-Methylanisole                                             |                                                    | C <sub>8</sub> H <sub>10</sub> O                                | 100-84-5   | 122.164  | liq                        | -47    | 175.5                                | 0.969 <sup>25</sup>              | 1.5130 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, bz; sl ctc             |
| 6946 | 4-Methylanisole                                             |                                                    | C <sub>8</sub> H <sub>10</sub> O                                | 104-93-8   | 122.164  | liq                        | -32    | 175.5                                | 0.969 <sup>25</sup>              | 1.5112 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, chl                         |
| 6947 | 1-Methylantracene                                           |                                                    | C <sub>15</sub> H <sub>12</sub>                                 | 610-48-0   | 192.256  | bl nd (MeOH) lf (al)       | 85.5   | 199.5                                | 1.0471 <sup>99</sup>             | 1.6802 <sup>99</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl, sulf               |
| 6948 | 2-Methylantracene                                           |                                                    | C <sub>15</sub> H <sub>12</sub>                                 | 613-12-7   | 192.256  | grn bl flr lf (sub)        | 209    | sub                                  | 1.80 <sup>0</sup>                |                       | i H <sub>2</sub> O, ace; sl EtOH, eth; s bz, CS <sub>2</sub> |
| 6949 | 9-Methylantracene                                           |                                                    | C <sub>15</sub> H <sub>12</sub>                                 | 779-02-2   | 192.256  | ye nd (dil al) pr (bz, al) | 81.5   | 196 <sup>12</sup>                    | 1.065 <sup>99</sup>              | 1.6959 <sup>99</sup>  | s EtOH, eth, ace, bz, chl                                    |
| 6950 | 2-Methyl-9,10-anthracenedione                               | 2-Methylanthraquinone                              | C <sub>15</sub> H <sub>10</sub> O <sub>2</sub>                  | 84-54-8    | 222.239  | ye nd (al, HOAc)           | 177    | sub                                  |                                  |                       | vs bz, EtOH, HOAc                                            |
| 6951 | Methylarsine                                                |                                                    | CH <sub>3</sub> As                                              | 593-52-2   | 91.973   | col gas                    | -143   | 2                                    |                                  |                       | vs ace, eth, EtOH                                            |
| 6952 | 9-Methyl-9-azabicyclo[3.3.1]nonan-3-one                     | Pseudopelletierine                                 | C <sub>9</sub> H <sub>15</sub> NO                               | 552-70-5   | 153.221  | orth pr (peth)             | 54     | 246                                  | 1.001 <sup>100</sup>             | 1.4760 <sup>100</sup> | vs H <sub>2</sub> O, eth, EtOH                               |
| 6953 | 8-Methyl-8-azabicyclo[3.2.1]octane                          | Tropine                                            | C <sub>8</sub> H <sub>15</sub> N                                | 529-17-9   | 125.212  |                            |        | 166                                  | 0.9251 <sup>15</sup>             |                       |                                                              |
| 6954 | 8-Methyl-8-azabicyclo[3.2.1]octan-3-one                     |                                                    | C <sub>8</sub> H <sub>13</sub> NO                               | 532-24-1   | 139.195  |                            | 43     | 227; 113 <sup>25</sup>               | 1.9872 <sup>100</sup>            | 1.4598 <sup>100</sup> | s EtOH, eth, ace, bz, peth; sl chl                           |
| 6955 | Methyl azide                                                |                                                    | CH <sub>3</sub> N <sub>3</sub>                                  | 624-90-8   | 57.055   |                            |        | exp 20.5                             | 0.869 <sup>15</sup>              |                       |                                                              |
| 6956 | Methylazoxymethanol acetate                                 |                                                    | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>     | 592-62-1   | 132.118  |                            |        | 191; 49 <sup>0,45</sup>              |                                  |                       |                                                              |



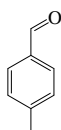
| No.  | Name                                          | Synonym                 | Mol. Form.                                    | CAS RN     | Mol. Wt. | Physical Form           | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                       |
|------|-----------------------------------------------|-------------------------|-----------------------------------------------|------------|----------|-------------------------|-------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------------------|
| 6957 | 2-Methylbenzaldehyde                          | <i>o</i> -Tolualdehyde  | C <sub>8</sub> H <sub>8</sub> O               | 529-20-4   | 120.149  |                         |       | 200; 94 <sup>10</sup>                 | 1.0328 <sup>20</sup>       | 1.5462 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, bz; vs ace                |
| 6958 | 3-Methylbenzaldehyde                          | <i>m</i> -Tolualdehyde  | C <sub>8</sub> H <sub>8</sub> O               | 620-23-5   | 120.149  |                         |       | 199                                   | 1.0189 <sup>21</sup>       | 1.5413 <sup>21</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace; s bz, chl            |
| 6959 | 4-Methylbenzaldehyde                          | <i>p</i> -Tolualdehyde  | C <sub>8</sub> H <sub>8</sub> O               | 104-87-0   | 120.149  |                         |       | 204; 106 <sup>10</sup>                | 1.0194 <sup>17</sup>       | 1.5454 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, ace; vs chl                  |
| 6960 | 2-Methylbenzamide                             | <i>o</i> -Toluamide     | C <sub>8</sub> H <sub>9</sub> NO              | 527-85-5   | 135.163  |                         | 147   |                                       |                            |                      | sl H <sub>2</sub> O, eth, tfa, bz; vs EtOH                       |
| 6961 | 4-Methylbenzamide                             | <i>p</i> -Toluamide     | C <sub>8</sub> H <sub>9</sub> NO              | 619-55-6   | 135.163  |                         | 162.5 |                                       |                            |                      | sl H <sub>2</sub> O, bz, chl; vs EtOH, eth; s tfa                |
| 6962 | <i>N</i> -Methylbenzamide                     |                         | C <sub>8</sub> H <sub>9</sub> NO              | 613-93-4   | 135.163  |                         | 82    | 291; 167 <sup>12</sup>                |                            |                      | s EtOH, ace                                                      |
| 6963 | 7-Methylbenz[a]anthracene                     |                         | C <sub>19</sub> H <sub>14</sub>               | 2541-69-7  | 242.314  | ye pl (al)              | 141   |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, ctc, HOAc, CS <sub>2</sub> |
| 6964 | 8-Methylbenz[a]anthracene                     |                         | C <sub>19</sub> H <sub>14</sub>               | 2381-31-9  | 242.314  | pl (bz-al), nd (bz-lig) | 156.5 | 272 <sup>3</sup> , 160 <sup>0.1</sup> | 1.2310 <sup>0</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, bz, xyl                         |
| 6965 | 9-Methylbenz[a]anthracene                     |                         | C <sub>19</sub> H <sub>14</sub>               | 2381-16-0  | 242.314  | nd (al)                 | 152.5 |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ctc, chl, CS <sub>2</sub> , xyl |
| 6966 | 10-Methylbenz[a]anthracene                    |                         | C <sub>19</sub> H <sub>14</sub>               | 2381-15-9  | 242.314  |                         | 184   |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, HOAc                                 |
| 6967 | 12-Methylbenz[a]anthracene                    |                         | C <sub>19</sub> H <sub>14</sub>               | 2422-79-9  | 242.314  | pl (al)                 | 150.5 |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, CS <sub>2</sub> , HOAc               |
| 6968 | 2-Methylbenzeneacetaldehyde                   |                         | C <sub>9</sub> H <sub>10</sub> O              | 10166-08-2 | 134.174  |                         |       | 221; 92 <sup>10</sup>                 | 1.0241 <sup>10</sup>       |                      | vs eth, EtOH, chl                                                |
| 6969 | 4-Methylbenzeneacetaldehyde                   |                         | C <sub>9</sub> H <sub>10</sub> O              | 104-09-6   | 134.174  |                         | 40    | 221.5                                 | 1.0052 <sup>20</sup>       | 1.5255 <sup>20</sup> | vs eth, EtOH, chl                                                |
| 6970 | $\alpha$ -Methylbenzeneacetaldehyde           |                         | C <sub>9</sub> H <sub>10</sub> O              | 93-53-8    | 134.174  |                         |       | 203.5                                 | 1.0089 <sup>20</sup>       | 1.5176 <sup>20</sup> | vs EtOH                                                          |
| 6971 | 2-Methylbenzeneacetic acid                    |                         | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub> | 644-36-0   | 150.174  | nd (w)                  | 89    |                                       |                            |                      | s H <sub>2</sub> O, chl                                          |
| 6972 | 3-Methylbenzeneacetic acid                    |                         | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub> | 621-36-3   | 150.174  | nd (w)                  | 62    | 121 <sup>26</sup>                     |                            |                      | s H <sub>2</sub> O, chl                                          |
| 6973 | 4-Methylbenzeneacetic acid                    |                         | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub> | 622-47-9   | 150.174  | nd or pl (al, w)        | 93    | 265                                   |                            |                      | vs bz, eth, EtOH                                                 |
| 6974 | $\alpha$ -Methylbenzeneacetic acid, ( $\pm$ ) |                         | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub> | 2328-24-7  | 150.174  |                         | <-20  | 263                                   | 1.1 <sup>0</sup>           | 1.5237 <sup>20</sup> |                                                                  |
| 6975 | 4-Methylbenzeneacetonitrile                   |                         | C <sub>9</sub> H <sub>9</sub> N               | 2947-61-7  | 131.174  |                         | 18    | 242.5                                 | 0.992 <sup>25</sup>        | 1.5190 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc                         |
| 6976 | $\alpha$ -Methylbenzeneacetonitrile           |                         | C <sub>9</sub> H <sub>9</sub> N               | 1823-91-2  | 131.174  |                         |       | 231                                   | 0.9854 <sup>20</sup>       | 1.5095 <sup>25</sup> | vs eth, EtOH                                                     |
| 6977 | 3-Methyl-1,2-benzenediamine                   | Toluene-2,3-diamine     | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> | 2687-25-4  | 122.167  |                         | 63.5  | 255                                   |                            |                      | vs ace, bz, EtOH                                                 |
| 6978 | 4-Methyl-1,2-benzenediamine                   | Toluene-3,4-diamine     | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> | 496-72-0   | 122.167  | pl (lig)                | 89.5  | 265                                   |                            |                      | vs H <sub>2</sub> O; s lig                                       |
| 6979 | 2-Methyl-1,3-benzenediamine                   | Toluene-2,6-diamine     | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> | 823-40-5   | 122.167  | pr (bz, w)              | 106   |                                       |                            |                      | s H <sub>2</sub> O, EtOH, bz                                     |
| 6980 | 2-Methyl-1,4-benzenediamine                   | Toluene-2,5-diamine     | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> | 95-70-5    | 122.167  | pl (bz)                 | 64    | 273.5                                 |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl bz, HOAc                       |
| 6981 | 3-Methyl-1,2-benzenediol                      |                         | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>  | 488-17-5   | 124.138  | lf (bz)                 | 68    | 248                                   |                            |                      | s H <sub>2</sub> O, EtOH, bz, chl                                |
| 6982 | 4-Methyl-1,2-benzenediol                      |                         | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>  | 452-86-8   | 124.138  | lf (bz-lig), pr (bz)    | 65    | 258                                   | 1.1287 <sup>74</sup>       | 1.5425 <sup>74</sup> | s H <sub>2</sub> O, EtOH, eth, ace, chl; sl lig                  |
| 6983 | 2-Methyl-1,3-benzenediol                      |                         | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>  | 608-25-3   | 124.138  | pr (bz)                 | 120   | 265                                   |                            |                      | vs H <sub>2</sub> O, bz, eth, EtOH                               |
| 6984 | 4-Methyl-1,3-benzenediol                      |                         | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>  | 496-73-1   | 124.138  | cry (bz-peth)           | 105   | 270                                   |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl bz, peth                       |
| 6985 | 5-Methyl-1,3-benzenediol                      | Orcinol                 | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>  | 504-15-4   | 124.138  | pr(w+1), lf(chl)        | 107   | 287                                   | 1.290 <sup>4</sup>         |                      | s H <sub>2</sub> O, EtOH, eth, bz; sl lig, peth                  |
| 6986 | 2-Methyl-1,4-benzenediol                      |                         | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>  | 95-71-6    | 124.138  |                         | 125   | 283; 163 <sup>11</sup>                |                            |                      | vs H <sub>2</sub> O, EtOH, eth; s ace; sl bz, lig                |
| 6987 | 4-Methyl-1,2-benzenedithiol                   | Toluene-3,4-dithiol     | C <sub>7</sub> H <sub>8</sub> S <sub>2</sub>  | 496-74-2   | 156.269  |                         | 29    |                                       |                            |                      | s chl                                                            |
| 6988 | $\beta$ -Methylbenzeneethanamine              |                         | C <sub>9</sub> H <sub>13</sub> N              | 582-22-9   | 135.206  |                         |       | 210                                   | 0.9433 <sup>4</sup>        | 1.5255 <sup>20</sup> | vs bz, eth, EtOH                                                 |
| 6989 | <i>N</i> -Methylbenzeneethanamine             |                         | C <sub>9</sub> H <sub>13</sub> N              | 589-08-2   | 135.206  |                         |       | 206                                   | 0.93 <sup>25</sup>         | 1.5162 <sup>20</sup> |                                                                  |
| 6990 | 2-Methylbenzeneethanol                        |                         | C <sub>9</sub> H <sub>12</sub> O              | 19819-98-8 | 136.190  |                         | 1.0   | 243.5                                 | 1.016 <sup>25</sup>        | 1.5355 <sup>20</sup> |                                                                  |
| 6991 | 4-Methylbenzeneethanol                        |                         | C <sub>9</sub> H <sub>12</sub> O              | 699-02-5   | 136.190  |                         |       | 244.5; 94 <sup>6</sup>                | 1.0028 <sup>20</sup>       | 1.5267 <sup>20</sup> |                                                                  |
| 6992 | 2-Methylbenzenemethanamine                    |                         | C <sub>8</sub> H <sub>11</sub> N              | 89-93-0    | 121.180  | liq                     | -30   | 206; 81 <sup>15</sup>                 | 0.9766 <sup>19</sup>       | 1.5436 <sup>19</sup> |                                                                  |
| 6993 | 3-Methylbenzenemethanamine                    |                         | C <sub>8</sub> H <sub>11</sub> N              | 100-81-2   | 121.180  |                         |       | 203.5                                 | 0.966 <sup>25</sup>        | 1.5360 <sup>20</sup> |                                                                  |
| 6994 | 4-Methylbenzenemethanamine                    |                         | C <sub>8</sub> H <sub>11</sub> N              | 104-84-7   | 121.180  |                         | 12.5  | 195                                   | 0.952 <sup>20</sup>        | 1.5340 <sup>20</sup> |                                                                  |
| 6995 | <i>N</i> -Methylbenzenemethanamine            |                         | C <sub>8</sub> H <sub>11</sub> N              | 103-67-3   | 121.180  |                         |       | 180.5                                 | 0.9442 <sup>18</sup>       |                      | vs H <sub>2</sub> O                                              |
| 6996 | $\alpha$ -Methylbenzenemethanol               | 1-Phenylethanol         | C <sub>8</sub> H <sub>10</sub> O              | 98-85-1    | 122.164  |                         | 20    | 205                                   | 1.013 <sup>25</sup>        | 1.5265 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                                 |
| 6997 | 2-Methylbenzenemethanol                       | <i>o</i> -Tolyl alcohol | C <sub>8</sub> H <sub>10</sub> O              | 89-95-2    | 122.164  | nd (peth-eth)           | 38    | 224; 118 <sup>20</sup>                | 1.023 <sup>40</sup>        |                      | vs eth, EtOH, chl                                                |



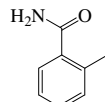
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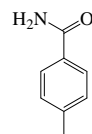
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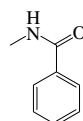
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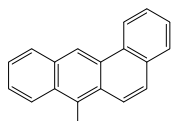
2-Methylbenzamide



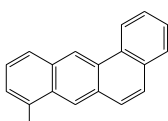
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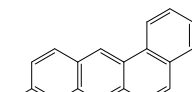
N-Methylbenzamide



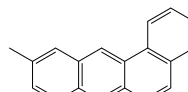
7-Methylbenz[a]anthracene



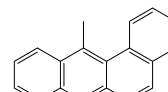
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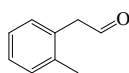
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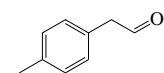
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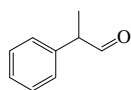
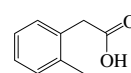
12-Methylbenz[a]anthracene



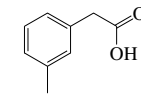
2-Methylbenzeneacetaldehyde



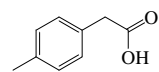
4-Methylbenzeneacetaldehyde

 $\alpha$ -Methylbenzeneacetaldehyde

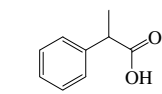
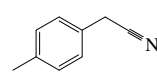
2-Methylbenzeneacetic acid



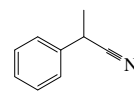
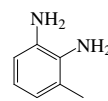
3-Methylbenzeneacetic acid



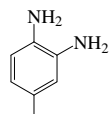
4-Methylbenzeneacetic acid

 $\alpha$ -Methylbenzeneacetic acid, ( $\pm$ )

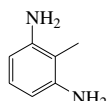
4-Methylbenzeneacetonitrile

 $\alpha$ -Methylbenzeneacetonitrile

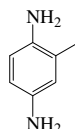
3-Methyl-1,2-benzenediamine



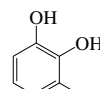
4-Methyl-1,2-benzenediamine



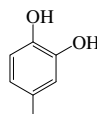
2-Methyl-1,3-benzenediamine



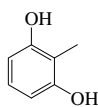
2-Methyl-1,4-benzenediamine



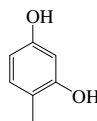
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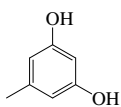
4-Methyl-1,2-benzenediol



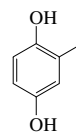
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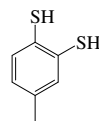
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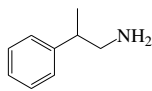
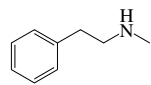
5-Methyl-1,3-benzenediol



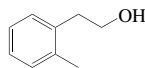
2-Methyl-1,4-benzenediol



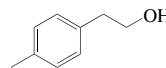
4-Methyl-1,2-benzenedithiol

 $\beta$ -Methylbenzeneethanamine

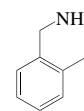
N-Methylbenzeneethanamine



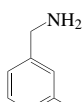
2-Methylbenzeneethanol



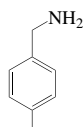
4-Methylbenzeneethanol



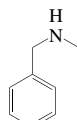
2-Methylbenzenemethanamine



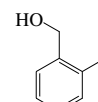
3-Methylbenzenemethanamine



4-Methylbenzenemethanamine



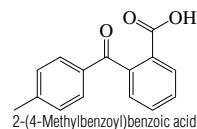
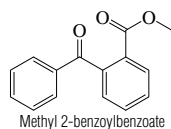
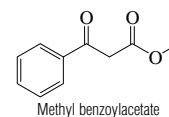
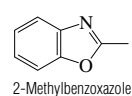
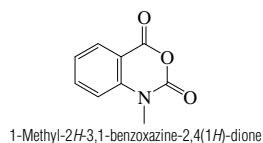
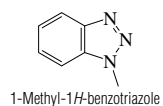
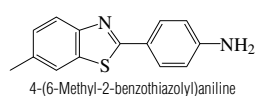
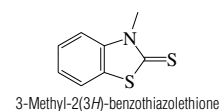
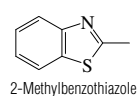
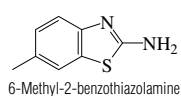
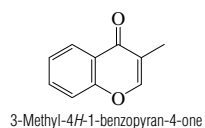
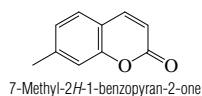
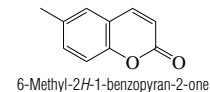
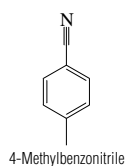
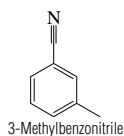
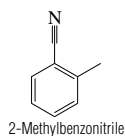
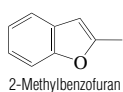
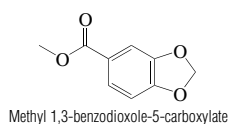
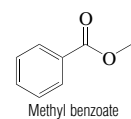
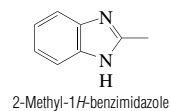
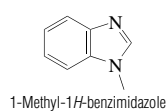
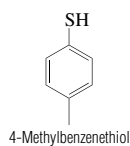
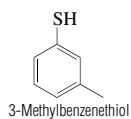
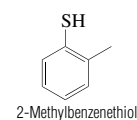
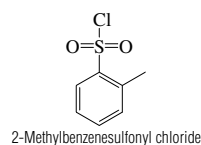
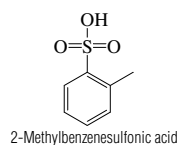
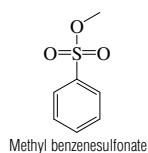
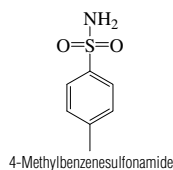
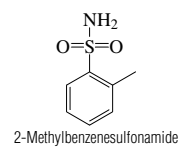
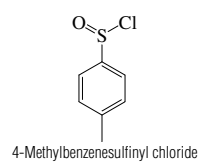
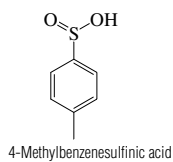
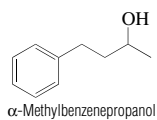
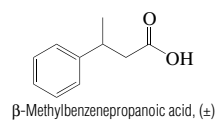
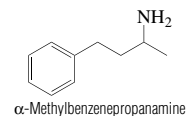
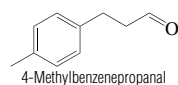
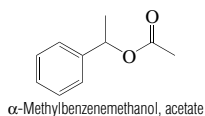
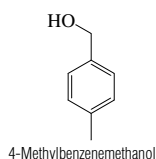
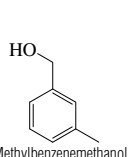
N-Methylbenzenemethanamine

 $\alpha$ -Methylbenzenemethanol

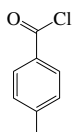
2-Methylbenzenemethanol



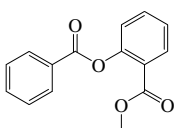
| No.  | Name                                                        | Synonym                            | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form         | mp/°C | bp/°C                      | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                       |
|------|-------------------------------------------------------------|------------------------------------|--------------------------------------------------|------------|----------|-----------------------|-------|----------------------------|----------------------------|----------------------|--------------------------------------------------|
| 6998 | 3-Methylbenzenemethanol                                     | <i>m</i> -Tolyl alcohol            | C <sub>8</sub> H <sub>10</sub> O                 | 587-03-1   | 122.164  |                       | <-20  | 215.5                      | 0.9157 <sup>17</sup>       |                      | sl H <sub>2</sub> O; vs EtOH, eth; s chl         |
| 6999 | 4-Methylbenzenemethanol                                     | <i>p</i> -Tolyl alcohol            | C <sub>8</sub> H <sub>10</sub> O                 | 589-18-4   | 122.164  | nd (lig)              | 61.5  | 217                        | 0.978 <sup>22</sup>        |                      | vs eth, EtOH                                     |
| 7000 | $\alpha$ -Methylbenzenemethanol, acetate                    |                                    | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>   | 93-92-5    | 164.201  | oil                   |       | 109 <sup>18</sup>          |                            |                      |                                                  |
| 7001 | 4-Methylbenzenepropanal                                     |                                    | C <sub>10</sub> H <sub>12</sub> O                | 5406-12-2  | 148.201  |                       |       | 223                        | 0.999 <sup>14</sup>        | 1.525 <sup>14</sup>  |                                                  |
| 7002 | $\alpha$ -Methylbenzenepropanamine                          | 1-Methyl-3-phenylpropylamine       | C <sub>10</sub> H <sub>13</sub> N                | 22374-89-6 | 149.233  |                       | 143   | 223; 101 <sup>14</sup>     | 0.9289 <sup>15</sup>       | 1.5152 <sup>20</sup> | vs EtOH                                          |
| 7003 | $\beta$ -Methylbenzenepropanoic acid, ( $\pm$ )             |                                    | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>   | 772-17-8   | 164.201  |                       | 46.5  | 168 <sup>14</sup>          | 1.0701 <sup>20</sup>       | 1.5155 <sup>20</sup> | sl H <sub>2</sub> O; s peth                      |
| 7004 | $\alpha$ -Methylbenzenepropanol                             |                                    | C <sub>10</sub> H <sub>14</sub> O                | 2344-70-9  | 150.217  |                       |       | 239; 123 <sup>15</sup>     | 0.9899 <sup>16</sup>       | 1.517 <sup>16</sup>  |                                                  |
| 7005 | 4-Methylbenzenesulfonic acid                                | <i>p</i> -Toluenesulfonic acid     | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub> S   | 536-57-2   | 156.203  | orth pl or nd (w)     | 86.5  |                            |                            |                      | s H <sub>2</sub> O; vs EtOH, eth; sl bz          |
| 7006 | 4-Methylbenzenesulfinyl chloride                            |                                    | C <sub>7</sub> H <sub>7</sub> ClOS               | 10439-23-3 | 174.648  | nd                    | 57    | 113 <sup>3,5</sup>         |                            |                      | vs chl                                           |
| 7007 | 2-Methylbenzenesulfonamide                                  |                                    | C <sub>7</sub> H <sub>9</sub> NO <sub>2</sub> S  | 88-19-7    | 171.217  | oct cry (al), pr (w)  | 158.7 | 214 <sup>10</sup>          |                            |                      | sl H <sub>2</sub> O, eth, DMSO; s EtOH           |
| 7008 | 4-Methylbenzenesulfonamide                                  | <i>p</i> -Toluenesulfonamide       | C <sub>7</sub> H <sub>9</sub> NO <sub>2</sub> S  | 70-55-3    | 171.217  | mcl pl (w+2)          | 138   | 214 <sup>10</sup>          |                            |                      | sl H <sub>2</sub> O, eth; s EtOH                 |
| 7009 | Methyl benzenesulfonate                                     |                                    | C <sub>7</sub> H <sub>8</sub> O <sub>3</sub> S   | 80-18-2    | 172.202  |                       | 4.5   | 150 <sup>15</sup>          | 1.2730 <sup>17</sup>       | 1.5151 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth, chl           |
| 7010 | 2-Methylbenzenesulfonic acid                                |                                    | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub> S   | 88-20-0    | 172.202  | hyg pl (w+2)          | 67.5  | 128.8 <sup>25</sup>        |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth               |
| 7011 | 2-Methylbenzenesulfonyl chloride                            | <i>o</i> -Toluenesulfonyl chloride | C <sub>7</sub> H <sub>7</sub> ClO <sub>2</sub> S | 133-59-5   | 190.648  |                       | 10.2  | 154 <sup>36</sup>          | 1.3383 <sup>20</sup>       | 1.5565 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc         |
| 7012 | 2-Methylbenzenethiol                                        |                                    | C <sub>7</sub> H <sub>6</sub> S                  | 137-06-4   | 124.204  |                       | 15    | 195                        | 1.041 <sup>20</sup>        | 1.570 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH; vs eth               |
| 7013 | 3-Methylbenzenethiol                                        |                                    | C <sub>7</sub> H <sub>6</sub> S                  | 108-40-7   | 124.204  | liq                   | -20   | 195                        | 1.044 <sup>20</sup>        | 1.572 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH; msc eth              |
| 7014 | 4-Methylbenzenethiol                                        |                                    | C <sub>7</sub> H <sub>6</sub> S                  | 106-45-6   | 124.204  |                       | 43    | 195                        | 1.0220 <sup>51</sup>       |                      | i H <sub>2</sub> O; s EtOH, chl; vs eth          |
| 7015 | 1-Methyl-1 <i>H</i> -benzimidazole                          |                                    | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub>     | 1632-83-3  | 132.163  | nd (peth), pl (al)    | 66    | 286                        | 1.1254 <sup>20</sup>       | 1.6013 <sup>7</sup>  | s peth                                           |
| 7016 | 2-Methyl-1 <i>H</i> -benzimidazole                          |                                    | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub>     | 615-15-6   | 132.163  | pr or nd (w)          | 177.8 |                            |                            |                      | s H <sub>2</sub> O; sl EtOH, eth; i bz           |
| 7017 | Methyl benzoate                                             |                                    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>     | 93-58-3    | 136.149  | liq                   | -12.4 | 199                        | 1.0837 <sup>25</sup>       | 1.5164 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ctc, MeOH; msc eth   |
| 7018 | Methyl 1,3-benzodioxole-5-carboxylate                       |                                    | C <sub>9</sub> H <sub>6</sub> O <sub>4</sub>     | 326-56-7   | 180.158  | nd or lf (peth)       | 53    | dec 273                    |                            |                      | vs eth, EtOH                                     |
| 7019 | 2-Methylbenzofuran                                          |                                    | C <sub>9</sub> H <sub>8</sub> O                  | 4265-25-2  | 132.159  |                       |       | 197.5                      | 1.0540 <sup>20</sup>       | 1.5495 <sup>22</sup> | vs eth, EtOH                                     |
| 7020 | 2-Methylbenzonitrile                                        | <i>o</i> -Tolunitrile              | C <sub>8</sub> H <sub>7</sub> N                  | 529-19-1   | 117.149  | liq                   | -13.5 | 205                        | 0.9955 <sup>20</sup>       | 1.5279 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl ctc        |
| 7021 | 3-Methylbenzonitrile                                        | <i>m</i> -Tolunitrile              | C <sub>8</sub> H <sub>7</sub> N                  | 620-22-4   | 117.149  | liq                   | -23   | 213                        | 1.0316 <sup>20</sup>       | 1.5252 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; sl ctc        |
| 7022 | 4-Methylbenzonitrile                                        | <i>p</i> -Tolunitrile              | C <sub>8</sub> H <sub>7</sub> N                  | 104-85-8   | 117.149  |                       | 29.5  | 217.0                      | 0.9762 <sup>30</sup>       |                      | i H <sub>2</sub> O; vs EtOH, eth; sl ctc         |
| 7023 | 6-Methyl-2 <i>H</i> -1-benzopyran-2-one                     |                                    | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>    | 92-48-8    | 160.170  |                       | 76.5  | 304; 174 <sup>14</sup>     |                            |                      | vs EtOH, eth, bz; sl chl, peth                   |
| 7024 | 7-Methyl-2 <i>H</i> -1-benzopyran-2-one                     | 7-Methylcoumarin                   | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>    | 2445-83-2  | 160.170  | nd, (pl) (aq al)      | 128   | 171.5 <sup>11</sup>        |                            |                      | sl H <sub>2</sub> O; vs EtOH, HOAc; s eth        |
| 7025 | 3-Methyl-4 <i>H</i> -1-benzopyran-4-one                     | Tricromyl                          | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>    | 85-90-5    | 160.170  |                       |       |                            |                            |                      | s chl                                            |
| 7026 | 6-Methyl-2-benzothiazolamine                                |                                    | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> S   | 2536-91-6  | 164.228  | nd (w) pr (dil al)    | 142   |                            |                            |                      | sl H <sub>2</sub> O; s EtOH                      |
| 7027 | 2-Methylbenzothiazole                                       |                                    | C <sub>8</sub> H <sub>7</sub> NS                 | 120-75-2   | 149.214  |                       | 14    | 238                        | 1.1763 <sup>19</sup>       | 1.6092 <sup>19</sup> | i H <sub>2</sub> O; s EtOH, chl                  |
| 7028 | 3-Methyl-2(3 <i>H</i> )-benzothiazolethione                 |                                    | C <sub>8</sub> H <sub>7</sub> NS <sub>2</sub>    | 2254-94-6  | 181.279  | nd (al), pr (HOAc)    | 90    | 335                        |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; vs bz, chl     |
| 7029 | 4-(6-Methyl-2-benzothiazolyl)aniline                        |                                    | C <sub>14</sub> H <sub>12</sub> N <sub>2</sub> S | 92-36-4    | 240.323  |                       | 194.8 | 434                        |                            |                      | sl EtOH, eth, bz, HOAc                           |
| 7030 | 1-Methyl-1 <i>H</i> -benzotriazole                          |                                    | C <sub>7</sub> H <sub>7</sub> N <sub>3</sub>     | 13351-73-0 | 133.151  | pl (bz-lig)           | 64.5  | 270.5                      |                            |                      | vs bz, EtOH, HOAc                                |
| 7031 | 1-Methyl-2 <i>H</i> -3,1-benzoxazine-2,4(1 <i>H</i> )-dione |                                    | C <sub>8</sub> H <sub>7</sub> NO <sub>3</sub>    | 10328-92-4 | 177.157  |                       | 180   |                            |                            |                      |                                                  |
| 7032 | 2-Methylbenzoxazole                                         |                                    | C <sub>8</sub> H <sub>7</sub> NO                 | 95-21-6    | 133.148  |                       | 9.5   | 200.5                      | 1.1211 <sup>20</sup>       | 1.5497 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth             |
| 7033 | Methyl benzoylacetate                                       |                                    | C <sub>10</sub> H <sub>10</sub> O <sub>3</sub>   | 614-27-7   | 178.184  | pa ye                 |       | dec 265; 151 <sup>12</sup> | 1.158 <sup>29</sup>        | 1.537 <sup>20</sup>  | vs ace, eth, EtOH                                |
| 7034 | Methyl 2-benzoylbenzoate                                    |                                    | C <sub>15</sub> H <sub>12</sub> O <sub>3</sub>   | 606-28-0   | 240.254  | pl or mcl pr (dil al) | 52    | 351                        | 1.1903 <sup>19</sup>       | 1.591 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth; s sulf         |
| 7035 | 2-(4-Methylbenzoyl)benzoic acid                             | 2-( <i>p</i> -Toluoyl)benzoic acid | C <sub>15</sub> H <sub>12</sub> O <sub>3</sub>   | 85-55-2    | 240.254  |                       | 146   |                            |                            |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth, ace, bz |
| 7036 | 2-Methylbenzoyl chloride                                    |                                    | C <sub>8</sub> H <sub>7</sub> ClO                | 933-88-0   | 154.594  |                       |       | 213.5                      |                            | 1.5549 <sup>20</sup> | vs eth, EtOH                                     |
| 7037 | 3-Methylbenzoyl chloride                                    |                                    | C <sub>8</sub> H <sub>7</sub> ClO                | 1711-06-4  | 154.594  | liq                   | -23   | 219.5                      | 1.0265 <sup>21</sup>       | 1.505 <sup>22</sup>  | vs eth, EtOH                                     |



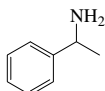
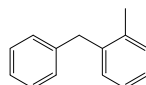
| No.  | Name                                             | Synonym                                  | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form         | mp/°C  | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                         |
|------|--------------------------------------------------|------------------------------------------|--------------------------------------------------|------------|----------|-----------------------|--------|--------------------------------------|----------------------------|----------------------|----------------------------------------------------|
| 7038 | 4-Methylbenzoyl chloride                         |                                          | C <sub>8</sub> H <sub>7</sub> ClO                | 874-60-2   | 154.594  | liq                   | -1.5   | 226                                  | 1.1686 <sup>20</sup>       | 1.5547 <sup>20</sup> | s ctc                                              |
| 7039 | Methyl benzoylsalicylate                         | 2-(Benzoyloxy)benzoic acid, methyl ester | C <sub>15</sub> H <sub>12</sub> O <sub>4</sub>   | 610-60-6   | 256.254  | cry                   | 85     | 385                                  |                            |                      | i H <sub>2</sub> O; s bz, chl, eth, EtOH           |
| 7040 | α-Methylbenzylamine, (±)                         | 1-Amino-1-phenylethane                   | C <sub>8</sub> H <sub>11</sub> N                 | 618-36-0   | 121.180  |                       | 32     | 187                                  | 0.9395 <sup>15</sup>       | 1.5238 <sup>25</sup> | s H <sub>2</sub> O, chl; msc EtOH, eth             |
| 7041 | 1-Methyl-2-benzylbenzene                         |                                          | C <sub>14</sub> H <sub>14</sub>                  | 713-36-0   | 182.261  |                       | 6.6    | 280.5                                | 1.0020 <sup>20</sup>       | 1.5763 <sup>20</sup> |                                                    |
| 7042 | 1-Methyl-4-benzylbenzene                         |                                          | C <sub>14</sub> H <sub>14</sub>                  | 620-83-7   | 182.261  | liq                   | -30    | 286                                  | 0.9976 <sup>20</sup>       | 1.5712 <sup>20</sup> | vs eth, bz, EtOH, chl                              |
| 7043 | α-Methylbenzyl formate                           |                                          | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>    | 7775-38-4  | 150.174  | liq                   |        |                                      |                            |                      |                                                    |
| 7044 | 1-Methyl-2-benzyl-4(1 <i>H</i> )-quinazolinone   | Glycosine                                | C <sub>18</sub> H <sub>14</sub> N <sub>2</sub> O | 6873-15-0  | 250.294  |                       | 161.5  |                                      |                            |                      |                                                    |
| 7045 | 1-Methylbicyclo[3.1.0]hexane                     |                                          | C <sub>7</sub> H <sub>12</sub>                   | 4625-24-5  | 96.170   |                       |        | 93.1                                 |                            |                      |                                                    |
| 7046 | 2-Methylbiphenyl                                 |                                          | C <sub>13</sub> H <sub>12</sub>                  | 643-58-3   | 168.234  | liq                   | -0.2   | 255.3                                | 1.0113 <sup>20</sup>       | 1.5914 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                    |
| 7047 | 3-Methylbiphenyl                                 |                                          | C <sub>13</sub> H <sub>12</sub>                  | 643-93-6   | 168.234  |                       | 2.3    | 272.7                                | 1.0182 <sup>17</sup>       | 1.5972 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc               |
| 7048 | 4-Methylbiphenyl                                 |                                          | C <sub>13</sub> H <sub>12</sub>                  | 644-08-6   | 168.234  | pl (lig, MeOH)        | 49.5   | 267.5                                | 1.015 <sup>27</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth; sl ctc            |
| 7049 | 4-Methyl- <i>N,N</i> -bis(4-methylphenyl)aniline |                                          | C <sub>21</sub> H <sub>21</sub> N                | 1159-53-1  | 287.399  | cry (HOAc)            | 117    |                                      |                            |                      | vs ace, bz, eth, chl                               |
| 7050 | Methyl bromoacetate                              |                                          | C <sub>3</sub> H <sub>5</sub> BrO <sub>2</sub>   | 96-32-2    | 152.975  |                       |        | 132                                  | 1.6350 <sup>20</sup>       | 1.4520 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz           |
| 7051 | Methyl 2-bromobenzoate                           |                                          | C <sub>8</sub> H <sub>7</sub> BrO <sub>2</sub>   | 610-94-6   | 215.045  |                       |        | 244                                  |                            |                      | i H <sub>2</sub> O; s EtOH                         |
| 7052 | Methyl 3-bromobenzoate                           |                                          | C <sub>8</sub> H <sub>7</sub> BrO <sub>2</sub>   | 618-89-3   | 215.045  | pl                    | 32     | 125 <sup>15</sup>                    |                            |                      | sl H <sub>2</sub> O; s EtOH, eth                   |
| 7053 | Methyl 4-bromobenzoate                           |                                          | C <sub>8</sub> H <sub>7</sub> BrO <sub>2</sub>   | 619-42-1   | 215.045  | lf (dil al), nd (eth) | 81     |                                      | 1.689 <sup>25</sup>        |                      | s EtOH, eth, ace, peth; vs bz, chl                 |
| 7054 | Methyl 2-bromobutanoate                          |                                          | C <sub>8</sub> H <sub>9</sub> BrO <sub>2</sub>   | 3196-15-4  | 181.028  |                       |        | 168                                  | 1.4528 <sup>20</sup>       | 1.4029 <sup>25</sup> | vs EtOH                                            |
| 7055 | Methyl 4-bromobutanoate                          |                                          | C <sub>8</sub> H <sub>9</sub> BrO <sub>2</sub>   | 4897-84-1  | 181.028  |                       |        | 186.5                                | 1.4 <sup>25</sup>          | 1.4567 <sup>25</sup> | vs EtOH                                            |
| 7056 | Methyl 4-bromo-2-butenate                        |                                          | C <sub>8</sub> H <sub>9</sub> BrO <sub>2</sub>   | 1117-71-1  | 179.013  |                       |        | 84 <sup>12</sup>                     | 1.490 <sup>19</sup>        | 1.498 <sup>19</sup>  |                                                    |
| 7057 | Methyl 5-bromopentanoate                         |                                          | C <sub>8</sub> H <sub>11</sub> BrO <sub>2</sub>  | 5454-83-1  | 195.054  | liq                   |        | 101 <sup>14</sup>                    | 1.363                      | 1.4630 <sup>20</sup> |                                                    |
| 7058 | Methyl 3-bromopropanoate                         |                                          | C <sub>6</sub> H <sub>9</sub> BrO <sub>2</sub>   | 3395-91-3  | 167.002  |                       |        | 105 <sup>60</sup> , 62 <sup>12</sup> | 1.4123 <sup>18</sup>       | 1.4542 <sup>20</sup> | s EtOH, eth, ace                                   |
| 7059 | 3-Methyl-1,2-butadiene                           |                                          | C <sub>5</sub> H <sub>8</sub>                    | 598-25-4   | 68.118   | liq                   | -113.6 | 40.83                                | 0.6806 <sup>25</sup>       | 1.4203 <sup>20</sup> | vs ace, bz, eth, EtOH                              |
| 7060 | 2-Methyl-1,3-butadiene                           | Isoprene                                 | C <sub>5</sub> H <sub>8</sub>                    | 78-79-5    | 68.118   | liq                   | -145.9 | 34.0                                 | 0.679 <sup>20</sup>        | 1.4219 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz         |
| 7061 | 3-Methylbutanal                                  | Isovaleraldehyde                         | C <sub>5</sub> H <sub>10</sub> O                 | 590-86-3   | 86.132   | liq                   | -51    | 92.5                                 | 0.7977 <sup>20</sup>       | 1.3902 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                   |
| 7062 | 3-Methylbutanamide                               | Isovaleramide                            | C <sub>5</sub> H <sub>11</sub> NO                | 541-46-8   | 101.147  | mcl lf (al)           | 137    | 226                                  |                            |                      | s H <sub>2</sub> O, EtOH, eth; vs peth             |
| 7063 | 3-Methyl-1-butanamine                            | Isopentylamine                           | C <sub>5</sub> H <sub>13</sub> N                 | 107-85-7   | 87.164   |                       |        | 96                                   | 0.7505 <sup>20</sup>       | 1.4083 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace, chl        |
| 7064 | 2-Methyl-2-butanamine                            |                                          | C <sub>5</sub> H <sub>13</sub> N                 | 594-39-8   | 87.164   | liq                   | -105   | 77                                   | 0.731 <sup>25</sup>        | 1.3954 <sup>25</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                |
| 7065 | 3-Methyl-2-butanamine                            |                                          | C <sub>5</sub> H <sub>13</sub> N                 | 598-74-3   | 87.164   | liq                   | -50    | 85.5                                 | 0.7574 <sup>19</sup>       | 1.4096 <sup>18</sup> | vs H <sub>2</sub> O; s EtOH                        |
| 7066 | 3-Methyl-1,3-butanediol                          |                                          | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>    | 2568-33-4  | 104.148  |                       |        | 202.5                                | 0.9448 <sup>20</sup>       | 1.4452 <sup>20</sup> | s H <sub>2</sub> O, EtOH                           |
| 7067 | 2-Methylbutanenitrile                            |                                          | C <sub>5</sub> H <sub>9</sub> N                  | 18936-17-9 | 83.132   |                       |        | 125                                  | 0.7913 <sup>15</sup>       | 1.3933 <sup>20</sup> | vs eth, EtOH                                       |
| 7068 | 3-Methylbutanenitrile                            | Isobutyl cyanide                         | C <sub>5</sub> H <sub>9</sub> N                  | 625-28-5   | 83.132   | liq                   | -101   | 127.5                                | 0.7914 <sup>20</sup>       | 1.3927 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace         |
| 7069 | 2-Methyl-1-butanethiol, (+)                      |                                          | C <sub>5</sub> H <sub>12</sub> S                 | 20089-07-0 | 104.214  | liq                   |        | 119.1                                | 0.8420 <sup>20</sup>       | 1.4440 <sup>20</sup> |                                                    |
| 7070 | 3-Methyl-1-butanethiol                           | Isopentyl mercaptan                      | C <sub>5</sub> H <sub>12</sub> S                 | 541-31-1   | 104.214  | liq                   |        | 116                                  | 0.8350 <sup>20</sup>       | 1.4412 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc           |
| 7071 | 2-Methyl-2-butanethiol                           |                                          | C <sub>5</sub> H <sub>12</sub> S                 | 1679-09-0  | 104.214  | liq                   |        | 99.1                                 | 0.8120 <sup>20</sup>       | 1.4385 <sup>20</sup> |                                                    |
| 7072 | 3-Methyl-2-butanethiol                           |                                          | C <sub>5</sub> H <sub>12</sub> S                 | 2084-18-6  | 104.214  | liq                   | -127.1 | 109.8                                |                            |                      |                                                    |
| 7073 | Methyl butanoate                                 |                                          | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>    | 623-42-7   | 102.132  | liq                   | -85.8  | 102.8                                | 0.8984 <sup>20</sup>       | 1.3878 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth            |
| 7074 | 2-Methylbutanoic acid                            | (±)-2-Methylbutyric acid                 | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>    | 600-07-7   | 102.132  |                       | <-80   | 177                                  | 0.934 <sup>20</sup>        | 1.4051 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s chl          |
| 7075 | 3-Methylbutanoic acid                            | Isovaleric acid                          | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>    | 503-74-2   | 102.132  | liq                   | -29.3  | 176.5                                | 0.931 <sup>20</sup>        | 1.4033 <sup>20</sup> | s H <sub>2</sub> O; msc EtOH, eth, chl             |
| 7076 | 3-Methylbutanoic anhydride                       |                                          | C <sub>10</sub> H <sub>18</sub> O <sub>3</sub>   | 1468-39-9  | 186.248  |                       |        | 215                                  | 0.9327 <sup>20</sup>       | 1.4043 <sup>20</sup> | vs eth                                             |
| 7077 | 2-Methyl-1-butanol, (±)                          |                                          | C <sub>5</sub> H <sub>12</sub> O                 | 34713-94-5 | 88.148   |                       |        | 127.5                                | 0.8152 <sup>25</sup>       | 1.4092 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace         |
| 7078 | 3-Methyl-1-butanol                               | Isopentyl alcohol                        | C <sub>5</sub> H <sub>12</sub> O                 | 123-51-3   | 88.148   | liq                   | -117.2 | 131.1                                | 0.8104 <sup>20</sup>       | 1.4053 <sup>20</sup> | sl H <sub>2</sub> O; vs ace, eth, EtOH             |
| 7079 | 2-Methyl-2-butanol                               | <i>tert</i> -Pentyl alcohol              | C <sub>5</sub> H <sub>12</sub> O                 | 75-85-4    | 88.148   | liq                   | -9.1   | 102.4                                | 0.8096 <sup>20</sup>       | 1.4052 <sup>20</sup> | s H <sub>2</sub> O, bz, chl; msc EtOH, eth; vs ace |



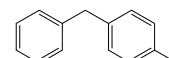
4-Methylbenzoyl chloride



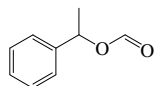
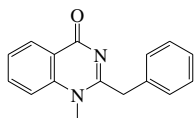
Methyl benzoylsalicylate

 $\alpha$ -Methylbenzylamine, ( $\pm$ )

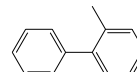
1-Methyl-2-benzylbenzene



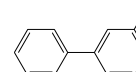
1-Methyl-4-benzylbenzene

 $\alpha$ -Methylbenzyl formate1-Methyl-2-benzyl-4(1*H*)-quinazolinone

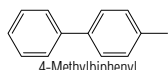
1-Methylbicyclo[3.1.0]hexane



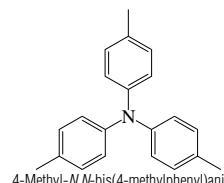
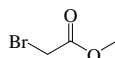
2-Methylbiphenyl



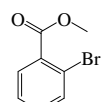
3-Methylbiphenyl



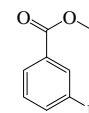
4-Methylbiphenyl

4-Methyl-*N,N*-bis(4-methylphenyl)aniline

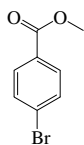
Methyl bromoacetate



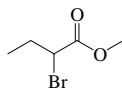
Methyl 2-bromobenzoate



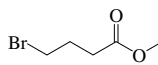
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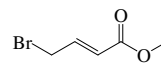
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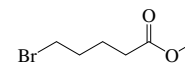
Methyl 2-bromobutanoate



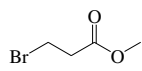
Methyl 4-bromobutanoate



Methyl 4-bromo-2-butenolate



Methyl 5-bromopentanoate



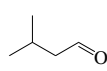
Methyl 3-bromopropanoate



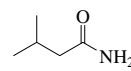
3-Methyl-1,2-butadiene



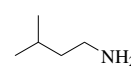
2-Methyl-1,3-butadiene



3-Methylbutanal



3-Methylbutanamide



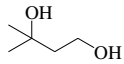
3-Methyl-1-butanamine



2-Methyl-2-butanamine



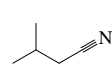
3-Methyl-2-butanamine



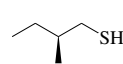
3-Methyl-1,3-butanediol



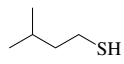
2-Methylbutanenitrile



3-Methylbutanenitrile



2-Methyl-1-butanethiol, (+)



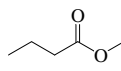
3-Methyl-1-butanethiol



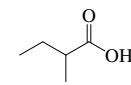
2-Methyl-2-butanethiol



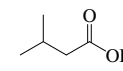
3-Methyl-2-butanethiol



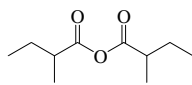
Methyl butanoate



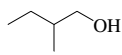
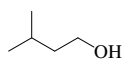
2-Methylbutanoic acid



3-Methylbutanoic acid



3-Methylbutanoic anhydride

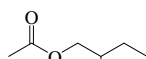
2-Methyl-1-butanol, ( $\pm$ )

3-Methyl-1-butanol



2-Methyl-2-butanol

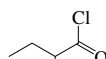
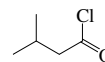
| No.  | Name                                            | Synonym                         | Mol. Form.                                      | CAS RN     | Mol. Wt. | Physical Form                   | mp/°C   | bp/°C                      | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|-------------------------------------------------|---------------------------------|-------------------------------------------------|------------|----------|---------------------------------|---------|----------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 7080 | 3-Methyl-2-butanol, (±)                         |                                 | C <sub>5</sub> H <sub>12</sub> O                | 70116-68-6 | 88.148   |                                 |         | 112.9                      | 0.8180 <sup>20</sup>       | 1.4089 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace; s bz, ctc   |
| 7081 | 2-Methyl-1-butanol acetate                      |                                 | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>   | 624-41-9   | 130.185  |                                 |         | 140                        | 0.8740 <sup>20</sup>       | 1.4040 <sup>20</sup> | vs ace, eth, EtOH                                       |
| 7082 | 3-Methyl-2-butanone                             | Methyl isopropyl ketone         | C <sub>5</sub> H <sub>10</sub> O                | 563-80-4   | 86.132   | liq                             | -93.1   | 94.33                      | 0.8051 <sup>20</sup>       | 1.3880 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace; s ctc       |
| 7083 | 2-Methylbutanoyl chloride, (±)                  |                                 | C <sub>5</sub> H <sub>9</sub> ClO               | 57526-28-0 | 120.577  |                                 |         | 116                        | 0.9917 <sup>20</sup>       | 1.4170 <sup>20</sup> |                                                         |
| 7084 | 3-Methylbutanoyl chloride                       | Isovaleryl chloride             | C <sub>5</sub> H <sub>9</sub> ClO               | 108-12-3   | 120.577  |                                 |         | 114                        | 0.9844 <sup>20</sup>       | 1.4149 <sup>20</sup> | s eth                                                   |
| 7085 | <i>trans</i> -2-Methyl-2-butenal                | Tiglic aldehyde                 | C <sub>5</sub> H <sub>8</sub> O                 | 497-03-0   | 84.117   | liq                             |         | 117; 64 <sup>119</sup>     | 0.8710 <sup>20</sup>       | 1.4475 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH                            |
| 7086 | 3-Methyl-2-butenal                              | Senecialdehyde                  | C <sub>5</sub> H <sub>8</sub> O                 | 107-86-8   | 84.117   |                                 |         | 134                        | 0.8722 <sup>20</sup>       | 1.4528 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth                           |
| 7087 | 2-Methyl-1-butene                               |                                 | C <sub>5</sub> H <sub>10</sub>                  | 563-46-2   | 70.133   | liq                             | -137.53 | 31.2                       | 0.6504 <sup>20</sup>       | 1.3778 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc                |
| 7088 | 3-Methyl-1-butene                               |                                 | C <sub>5</sub> H <sub>10</sub>                  | 563-45-1   | 70.133   | vol liq or gas                  | -168.43 | 20.1                       | 0.6213 <sup>25</sup>       | 1.3643 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz                 |
| 7089 | 2-Methyl-2-butene                               |                                 | C <sub>5</sub> H <sub>10</sub>                  | 513-35-9   | 70.133   | liq                             | -133.72 | 38.56                      | 0.6623 <sup>20</sup>       | 1.3874 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc; vs lig        |
| 7090 | <i>cis</i> -2-Methyl-2-butenedioic acid         | Citraconic acid                 | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>    | 498-23-7   | 130.100  | nd (eth-lig)<br>tcl pr (eth-bz) | 93.5    |                            | 1.617 <sup>25</sup>        |                      | vs H <sub>2</sub> O; sl eth, chl; i bz, CS <sub>2</sub> |
| 7091 | 3-Methyl-2-butenenitrile                        |                                 | C <sub>6</sub> H <sub>9</sub> N                 | 4786-24-7  | 81.117   | liq                             |         | 141                        |                            |                      |                                                         |
| 7092 | Methyl <i>cis</i> -2-butenate                   | Methyl isocrotonate             | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>    | 4358-59-2  | 100.117  |                                 |         | 118                        |                            | 1.4175 <sup>20</sup> |                                                         |
| 7093 | Methyl <i>trans</i> -2-butenate                 | Methyl crotonate                | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>    | 623-43-8   | 100.117  | liq                             | -42     | 121                        | 0.9444 <sup>20</sup>       | 1.4242 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                        |
| 7094 | <i>cis</i> -2-Methyl-2-butenic acid             | Angelic acid                    | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>    | 565-63-9   | 100.117  | mcl pr or nd                    | 45.5    | 185                        | 0.9834 <sup>49</sup>       | 1.4434 <sup>47</sup> | sl H <sub>2</sub> O; s EtOH; vs eth                     |
| 7095 | <i>trans</i> -2-Methyl-2-butenic acid           | Tiglic acid                     | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>    | 80-59-1    | 100.117  | tab (w)                         | 64.5    | 198.5                      | 0.9641 <sup>76</sup>       | 1.4330 <sup>76</sup> | s H <sub>2</sub> O; vs EtOH, eth                        |
| 7096 | 3-Methyl-2-butenic acid                         |                                 | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>    | 541-47-9   | 100.117  |                                 | 69.5    | 197                        | 1.0062 <sup>24</sup>       |                      |                                                         |
| 7097 | 3-Methyl-2-buten-1-ol                           |                                 | C <sub>5</sub> H <sub>10</sub> O                | 556-82-1   | 86.132   |                                 |         | 140                        | 0.848 <sup>25</sup>        | 1.4412 <sup>20</sup> |                                                         |
| 7098 | 3-Methyl-3-buten-1-ol                           |                                 | C <sub>6</sub> H <sub>10</sub> O                | 763-32-6   | 86.132   |                                 |         | 129.9                      |                            |                      |                                                         |
| 7099 | 2-Methyl-3-buten-2-ol                           |                                 | C <sub>6</sub> H <sub>10</sub> O                | 115-18-4   | 86.132   | liq                             | -28     | 97                         | 0.82 <sup>20</sup>         |                      |                                                         |
| 7100 | 3-Methyl-3-buten-2-ol                           |                                 | C <sub>6</sub> H <sub>10</sub> O                | 10473-14-0 | 86.132   |                                 |         | 114                        | 0.8531 <sup>17</sup>       | 1.4288 <sup>17</sup> |                                                         |
| 7101 | 3-Methyl-3-buten-2-one                          | Isopropenyl methyl ketone       | C <sub>6</sub> H <sub>8</sub> O                 | 814-78-8   | 84.117   | liq                             | -54     | 98                         | 0.8527 <sup>20</sup>       | 1.4220 <sup>20</sup> | vs EtOH                                                 |
| 7102 | 3-Methyl-2-butenoyl chloride                    |                                 | C <sub>6</sub> H <sub>9</sub> ClO               | 3350-78-5  | 118.562  |                                 |         | 146                        | 1.065 <sup>25</sup>        | 1.4770 <sup>20</sup> |                                                         |
| 7103 | (3-Methyl-2-butenyl)guanidine                   | Galegine                        | C <sub>6</sub> H <sub>13</sub> N <sub>3</sub>   | 543-83-9   | 127.187  | hyg                             | 62.5    | dec                        |                            |                      | vs H <sub>2</sub> O, EtOH                               |
| 7104 | 2-Methyl-1-buten-3-yne                          | Isopropenylacetylene            | C <sub>6</sub> H <sub>6</sub>                   | 78-80-8    | 66.102   | liq                             | -113    | 32                         | 0.6801 <sup>11</sup>       | 1.4140 <sup>20</sup> | s chl                                                   |
| 7105 | [(3-Methylbutoxy)methyl]benzene                 |                                 | C <sub>12</sub> H <sub>18</sub> O               | 122-73-6   | 178.270  |                                 |         | 236; 118 <sup>19</sup>     | 0.909 <sup>20</sup>        | 1.4792 <sup>20</sup> | vs eth, EtOH                                            |
| 7106 | 1-[2-(3-Methylbutoxy)-2-phenylethyl]pyrrolidine | Amixetrine                      | C <sub>17</sub> H <sub>27</sub> NO              | 24622-72-8 | 261.402  |                                 |         | 121 <sup>2</sup>           |                            | 1.4978 <sup>22</sup> |                                                         |
| 7107 | 2-Methylbutyl acrylate                          |                                 | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>   | 44914-03-6 | 142.196  |                                 |         | 160; 45 <sup>10</sup>      | 0.8936 <sup>20</sup>       | 1.4240 <sup>20</sup> | vs eth, EtOH                                            |
| 7108 | 3-Methylbutyl benzoate                          | Isopentyl benzoate              | C <sub>12</sub> H <sub>16</sub> O <sub>2</sub>  | 94-46-2    | 192.254  |                                 |         | 261                        | 0.993 <sup>15</sup>        |                      | vs EtOH                                                 |
| 7109 | 3-Methylbutyl 2-chloropropanoate                |                                 | C <sub>8</sub> H <sub>15</sub> ClO <sub>2</sub> | 62108-69-4 | 178.657  |                                 |         | 208                        | 1.0050 <sup>20</sup>       | 1.4289 <sup>20</sup> |                                                         |
| 7110 | 3-Methylbutyl 3-chloropropanoate                |                                 | C <sub>8</sub> H <sub>15</sub> ClO <sub>2</sub> | 62108-70-7 | 178.657  |                                 |         | 208; 87 <sup>12</sup>      | 1.0171 <sup>20</sup>       | 1.4343 <sup>20</sup> | vs eth, EtOH                                            |
| 7111 | Methyl <i>tert</i> -butyl ether                 | <i>tert</i> -Butyl methyl ether | C <sub>5</sub> H <sub>12</sub> O                | 1634-04-4  | 88.148   | liq                             | -108.6  | 55.0                       | 0.7353 <sup>25</sup>       | 1.3664 <sup>25</sup> | s H <sub>2</sub> O; vs EtOH, eth                        |
| 7112 | 3-Methylbutyl nitrate                           | Isopentyl nitrate               | C <sub>8</sub> H <sub>17</sub> NO <sub>3</sub>  | 543-87-3   | 133.146  |                                 |         | 148                        | 0.996 <sup>22</sup>        | 1.4122 <sup>21</sup> |                                                         |
| 7113 | 2-Methyl-3-butyne-2-amine                       |                                 | C <sub>6</sub> H <sub>9</sub> N                 | 2978-58-7  | 83.132   |                                 | 18      | 79.5                       | 0.79 <sup>25</sup>         | 1.4235 <sup>20</sup> |                                                         |
| 7114 | 3-Methyl-1-butyne                               |                                 | C <sub>6</sub> H <sub>8</sub>                   | 598-23-2   | 68.118   | vol liq or gas                  | -89.7   | 26.3                       | 0.6660 <sup>20</sup>       | 1.3723 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                       |
| 7115 | 2-Methyl-3-butyne-2-ol                          | 1,1-Dimethylpropargyl alcohol   | C <sub>6</sub> H <sub>8</sub> O                 | 115-19-5   | 84.117   |                                 | 1.5     | 104                        | 0.8618 <sup>20</sup>       | 1.4207 <sup>20</sup> |                                                         |
| 7116 | Methyl carbamate                                |                                 | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>   | 598-55-0   | 75.067   | nd                              | 54      | 177                        | 1.1361 <sup>56</sup>       | 1.4125 <sup>56</sup> | vs H <sub>2</sub> O; vs EtOH, eth                       |
| 7117 | 3-Methyl-9 <i>H</i> -carbazole                  |                                 | C <sub>13</sub> H <sub>11</sub> N               | 4630-20-0  | 181.233  | pl (HOAc)                       | 208.5   | 365                        |                            |                      | vs bz, eth                                              |
| 7118 | 9-Methyl-9 <i>H</i> -carbazole                  |                                 | C <sub>13</sub> H <sub>11</sub> N               | 1484-12-4  | 181.233  | nd, lf (al)                     | 89.34   | 343.64; 195 <sup>12</sup>  |                            |                      | vs eth                                                  |
| 7119 | Methyl chloroacetate                            |                                 | C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>  | 96-34-4    | 108.524  | liq                             | -32.1   | 129.5                      | 1.236 <sup>20</sup>        | 1.4218 <sup>20</sup> | vs ace, bz, eth, EtOH                                   |
| 7120 | Methyl 2-chloroacrylate                         |                                 | C <sub>4</sub> H <sub>5</sub> ClO <sub>2</sub>  | 80-63-7    | 120.535  |                                 |         | 52 <sup>51</sup>           | 1.189 <sup>20</sup>        | 1.4420 <sup>20</sup> | vs eth                                                  |
| 7121 | Methyl 2-chlorobenzoate                         |                                 | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>  | 610-96-8   | 170.594  |                                 |         | 234                        |                            |                      | s EtOH                                                  |
| 7122 | Methyl 3-chlorobenzoate                         |                                 | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>  | 2905-65-9  | 170.594  |                                 | 21      | 229                        |                            |                      |                                                         |
| 7123 | Methyl 4-chlorobenzoate                         |                                 | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>  | 1126-46-1  | 170.594  | nd or mcl pr                    | 43.5    |                            | 1.382 <sup>20</sup>        |                      | vs EtOH                                                 |
| 7124 | Methyl 4-chlorobutanoate                        |                                 | C <sub>6</sub> H <sub>9</sub> ClO <sub>2</sub>  | 3153-37-5  | 136.577  |                                 |         | 174; 55 <sup>4</sup>       | 1.1293 <sup>20</sup>       | 1.4321 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ace                 |
| 7125 | Methyl chlorocarbonate                          |                                 | C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>  | 79-22-1    | 94.497   |                                 |         | 70.5                       | 1.2231 <sup>20</sup>       | 1.3868 <sup>20</sup> | msc EtOH, eth; s bz, ctc, chl                           |
| 7126 | Methyl 5-chloro-2-hydroxybenzoate               |                                 | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>  | 4068-78-4  | 186.593  | nd (al)                         | 50      | dec 249; 120 <sup>12</sup> |                            |                      | vs EtOH                                                 |
| 7127 | Methyl 5-chloro-2-nitrobenzoate                 |                                 | C <sub>8</sub> H <sub>6</sub> ClNO <sub>4</sub> | 51282-49-6 | 215.592  | pl (MeOH)                       | 48.5    |                            | 1.453 <sup>18</sup>        |                      | vs MeOH                                                 |
| 7128 | Methyl chlorooxoacetate                         |                                 | C <sub>3</sub> H <sub>3</sub> ClO <sub>3</sub>  | 5781-53-3  | 122.507  |                                 |         | 119                        | 1.3316 <sup>20</sup>       | 1.4189 <sup>20</sup> |                                                         |
| 7129 | Methyl 2-chloropropanoate                       |                                 | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>  | 17639-93-9 | 122.551  |                                 |         | 132.5                      | 1.0750 <sup>25</sup>       |                      |                                                         |

3-Methyl-2-butanol, ( $\pm$ )

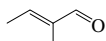
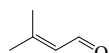
2-Methyl-1-butanol acetate



3-Methyl-2-butanone

2-Methylbutanoyl chloride, ( $\pm$ )

3-Methylbutanoyl chloride

*trans*-2-Methyl-2-butenal

3-Methyl-2-butenal



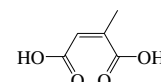
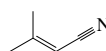
2-Methyl-1-butene



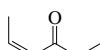
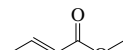
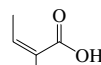
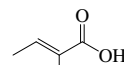
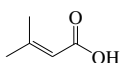
3-Methyl-1-butene



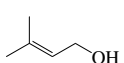
2-Methyl-2-butene

*cis*-2-Methyl-2-butenedioic acid

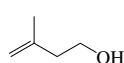
3-Methyl-2-butenenitrile

Methyl *cis*-2-butenateMethyl *trans*-2-butenate*cis*-2-Methyl-2-butenic acid*trans*-2-Methyl-2-butenic acid

3-Methyl-2-butenic acid



3-Methyl-2-buten-1-ol



3-Methyl-3-buten-1-ol



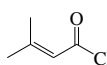
2-Methyl-3-buten-2-ol



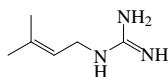
3-Methyl-3-buten-2-ol



3-Methyl-3-buten-2-one



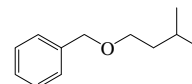
3-Methyl-2-butenoyl chloride



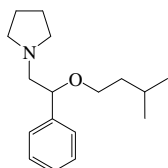
(3-Methyl-2-butenyl)guanidine



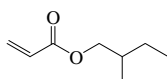
2-Methyl-1-buten-3-yne



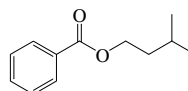
[(3-Methylbutoxy)methyl]benzene



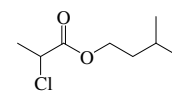
1-[2-(3-Methylbutoxy)-2-phenylethyl]pyrrolidine



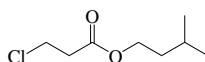
2-Methylbutyl acrylate



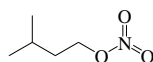
3-Methylbutyl benzoate



3-Methylbutyl 2-chloropropanoate



3-Methylbutyl 3-chloropropanoate

Methyl *tert*-butyl ether

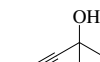
3-Methylbutyl nitrate



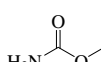
2-Methyl-3-buten-2-amine



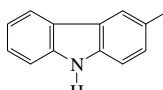
3-Methyl-1-butyne



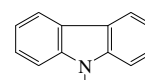
2-Methyl-3-buten-2-ol



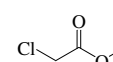
Methyl carbamate



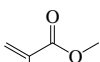
3-Methyl-9H-carbazole



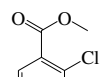
9-Methyl-9H-carbazole



Methyl chloroacetate



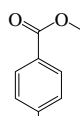
Methyl 2-chloroacrylate



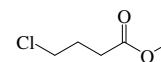
Methyl 2-chlorobenzoate



Methyl 3-chlorobenzoate



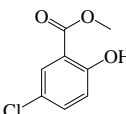
Methyl 4-chlorobenzoate



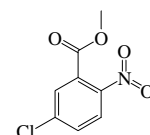
Methyl 4-chlorobutanoate



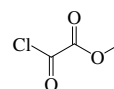
Methyl chlorocarbonate



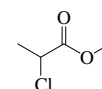
Methyl 5-chloro-2-hydroxybenzoate



Methyl 5-chloro-2-nitrobenzoate

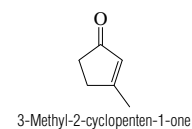
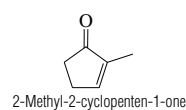
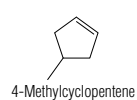
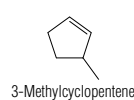
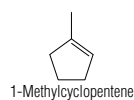
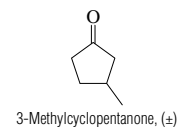
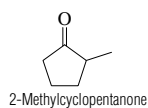
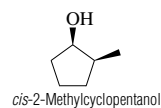
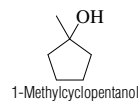
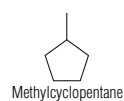
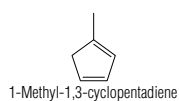
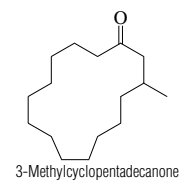
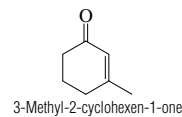
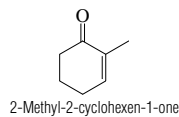
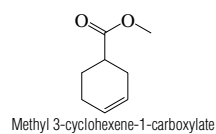
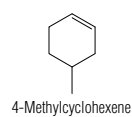
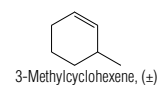
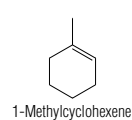
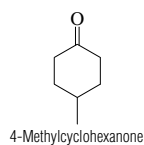
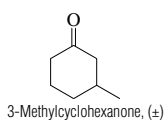
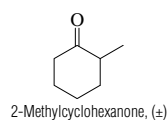
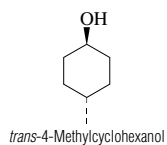
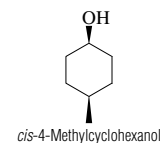
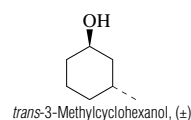
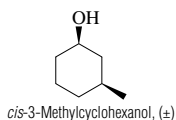
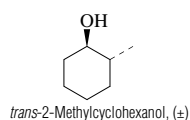
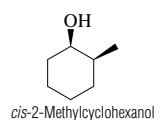
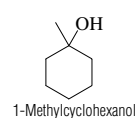
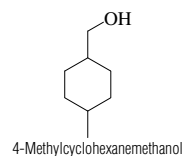
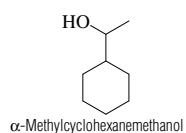
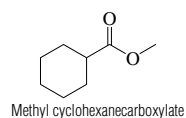
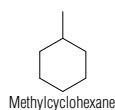
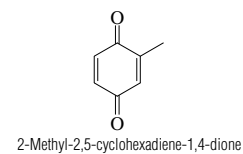
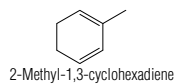
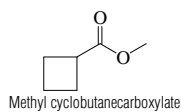
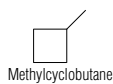
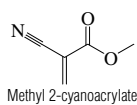
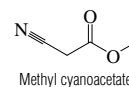
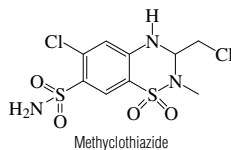
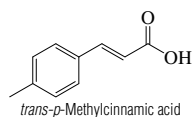
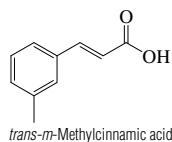
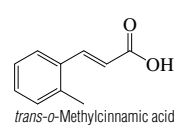
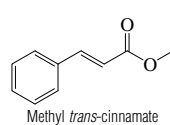
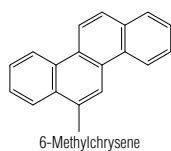
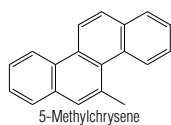
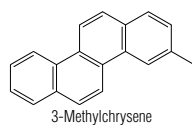


Methyl chlorooxoacetate



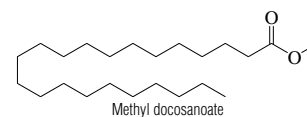
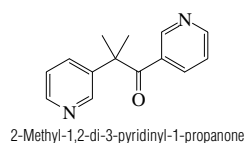
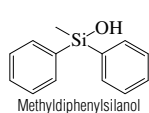
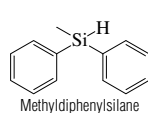
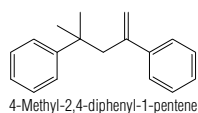
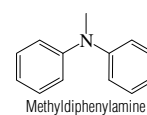
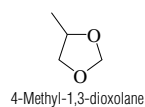
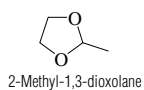
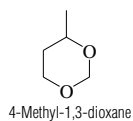
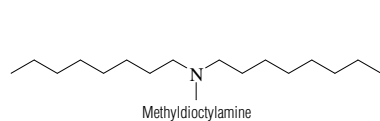
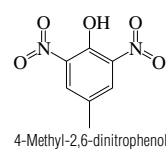
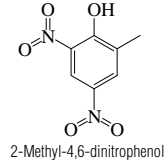
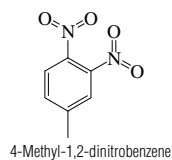
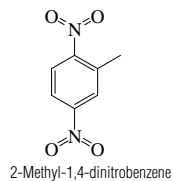
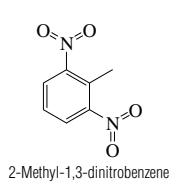
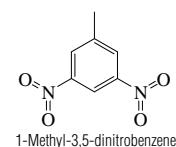
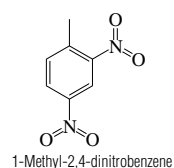
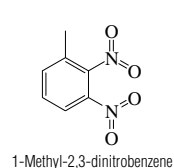
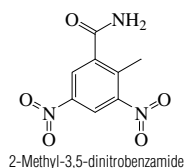
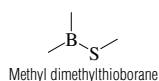
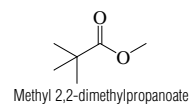
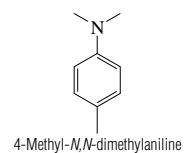
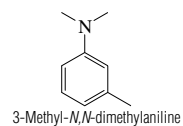
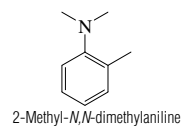
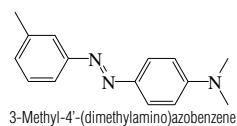
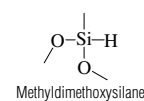
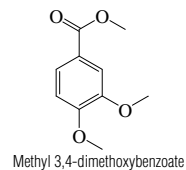
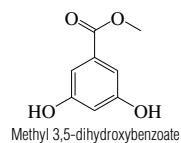
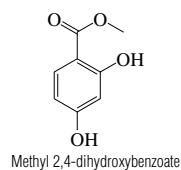
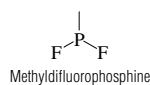
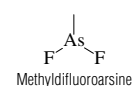
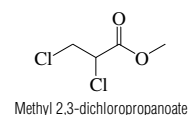
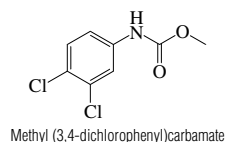
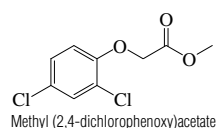
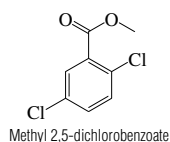
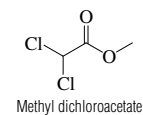
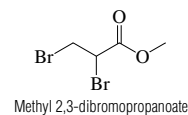
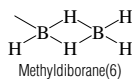
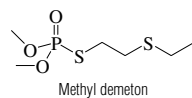
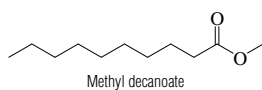
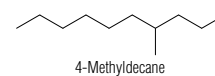
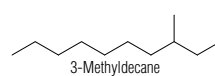
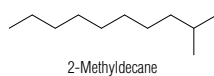
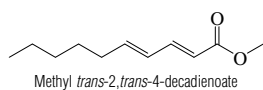
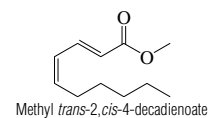
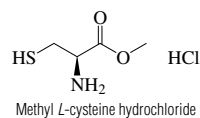
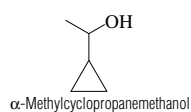
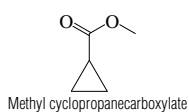
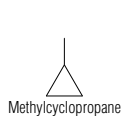
Methyl 2-chloropropanoate

| No.  | Name                                    | Synonym                                    | Mol. Form.                                                                                  | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                           |
|------|-----------------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------------|------------|----------|--------------------|---------|-------------------------|----------------------------|-----------------------|------------------------------------------------------|
| 7130 | 3-Methylchrysene                        |                                            | C <sub>19</sub> H <sub>14</sub>                                                             | 3351-31-3  | 242.314  | lf (bz-peth)       | 173.3   |                         |                            |                       | vs EtOH                                              |
| 7131 | 5-Methylchrysene                        |                                            | C <sub>19</sub> H <sub>14</sub>                                                             | 3697-24-3  | 242.314  |                    | 118.3   |                         |                            |                       | i H <sub>2</sub> O                                   |
| 7132 | 6-Methylchrysene                        |                                            | C <sub>19</sub> H <sub>14</sub>                                                             | 1705-85-7  | 242.314  |                    | 161     |                         |                            |                       |                                                      |
| 7133 | Methyl <i>trans</i> -cinnamate          | Methyl <i>trans</i> -3-phenyl-2-propenoate | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                                              | 1754-62-7  | 162.185  | cry (peth, dil al) | 36.5    | 261.9                   | 1.042 <sup>36</sup>        | 1.5766 <sup>22</sup>  | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz; sl chl  |
| 7134 | <i>trans</i> -o-Methylcinnamic acid     |                                            | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                                              | 2373-76-4  | 162.185  | cry (EtOH)         | 175     |                         |                            |                       |                                                      |
| 7135 | <i>trans</i> -m-Methylcinnamic acid     |                                            | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                                              | 3029-79-6  | 162.185  | cry (w)            | 115     |                         |                            |                       |                                                      |
| 7136 | <i>trans</i> -p-Methylcinnamic acid     |                                            | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                                              | 1866-39-3  | 162.185  |                    | 198.5   |                         |                            |                       |                                                      |
| 7137 | Methylthiazide                          |                                            | C <sub>9</sub> H <sub>11</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 135-07-9   | 360.237  | cry (EtOH aq)      | 225     |                         |                            |                       | i H <sub>2</sub> O, bz, chl; sl MeOH; vs ace, py     |
| 7138 | Methyl cyanate                          |                                            | C <sub>2</sub> H <sub>3</sub> NO                                                            | 1768-34-9  | 57.051   | unstab gas         | -30     | exp                     |                            |                       |                                                      |
| 7139 | Methyl cyanoacetate                     |                                            | C <sub>4</sub> H <sub>5</sub> NO <sub>2</sub>                                               | 105-34-0   | 99.089   | liq                | -22.5   | 200.5                   | 1.1225 <sup>25</sup>       | 1.4176 <sup>20</sup>  | vs eth, EtOH                                         |
| 7140 | Methyl 2-cyanoacrylate                  | Mecrylate                                  | C <sub>5</sub> H <sub>7</sub> NO <sub>2</sub>                                               | 137-05-3   | 111.100  |                    |         | 47 <sup>2</sup>         | 1.1012 <sup>20</sup>       | 1.4430                |                                                      |
| 7141 | Methylcyclobutane                       |                                            | C <sub>5</sub> H <sub>10</sub>                                                              | 598-61-8   | 70.133   | liq                | -161.5  | 36.3                    | 0.6884 <sup>20</sup>       | 1.3866 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s ace, bz, peth   |
| 7142 | Methyl cyclobutanecarboxylate           |                                            | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                                               | 765-85-5   | 114.142  |                    |         | 135.5                   |                            |                       |                                                      |
| 7143 | 2-Methyl-1,3-cyclohexadiene             | 4,5-Dihydrotoluene                         | C <sub>7</sub> H <sub>10</sub>                                                              | 1489-57-2  | 94.154   |                    |         | 107.5                   | 0.8260 <sup>18</sup>       | 1.4662 <sup>18</sup>  |                                                      |
| 7144 | 2-Methyl-2,5-cyclohexadiene-1,4-dione   |                                            | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                                | 553-97-9   | 122.122  | ye pl or nd        | 69      | sub                     | 1.08 <sup>75</sup>         |                       | sl H <sub>2</sub> O; s EtOH, eth                     |
| 7145 | Methylcyclohexane                       |                                            | C <sub>7</sub> H <sub>14</sub>                                                              | 108-87-2   | 98.186   | liq                | -126.6  | 100.93                  | 0.7694 <sup>20</sup>       | 1.4231 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, lig    |
| 7146 | Methyl cyclohexanecarboxylate           |                                            | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                                               | 4630-82-4  | 142.196  |                    |         | 183                     | 0.9954 <sup>15</sup>       | 1.4433 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, chl            |
| 7147 | α-Methylcyclohexanemethanol             |                                            | C <sub>8</sub> H <sub>16</sub> O                                                            | 1193-81-3  | 128.212  |                    |         | 189                     | 0.928 <sup>25</sup>        | 1.4656 <sup>20</sup>  | vs EtOH, eth; sl ctc                                 |
| 7148 | 4-Methylcyclohexanemethanol             |                                            | C <sub>8</sub> H <sub>16</sub> O                                                            | 34885-03-5 | 128.212  |                    |         | 75 <sup>2,5</sup>       | 0.9074 <sup>20</sup>       | 1.4617 <sup>20</sup>  |                                                      |
| 7149 | 1-Methylcyclohexanol                    |                                            | C <sub>7</sub> H <sub>14</sub> O                                                            | 590-67-0   | 114.185  |                    | 25      | 155; 70 <sup>25</sup>   | 0.9194 <sup>20</sup>       | 1.4595 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, bz, chl                  |
| 7150 | <i>cis</i> -2-Methylcyclohexanol        |                                            | C <sub>7</sub> H <sub>14</sub> O                                                            | 615-38-3   | 114.185  |                    | 7       | 165                     | 0.9360 <sup>20</sup>       | 1.4640 <sup>20</sup>  | vs EtOH                                              |
| 7151 | <i>trans</i> -2-Methylcyclohexanol, (±) |                                            | C <sub>7</sub> H <sub>14</sub> O                                                            | 615-39-4   | 114.185  | liq                | -2.0    | 167.5                   | 0.9247 <sup>20</sup>       | 1.4616 <sup>20</sup>  | vs eth, EtOH                                         |
| 7152 | <i>cis</i> -3-Methylcyclohexanol, (±)   |                                            | C <sub>7</sub> H <sub>14</sub> O                                                            | 5454-79-5  | 114.185  | liq                | -5.5    | 168; 94 <sup>12</sup>   | 0.9155 <sup>20</sup>       | 1.4752 <sup>20</sup>  | vs eth, EtOH                                         |
| 7153 | <i>trans</i> -3-Methylcyclohexanol, (±) |                                            | C <sub>7</sub> H <sub>14</sub> O                                                            | 7443-55-2  | 114.185  | liq                | -0.5    | 167; 84 <sup>13</sup>   | 0.9214 <sup>20</sup>       | 1.4580 <sup>20</sup>  | vs eth, EtOH                                         |
| 7154 | <i>cis</i> -4-Methylcyclohexanol        |                                            | C <sub>7</sub> H <sub>14</sub> O                                                            | 7731-28-4  | 114.185  | liq                | -9.2    | 173                     | 0.9170 <sup>20</sup>       | 1.4614 <sup>20</sup>  | vs eth, EtOH                                         |
| 7155 | <i>trans</i> -4-Methylcyclohexanol      |                                            | C <sub>7</sub> H <sub>14</sub> O                                                            | 7731-29-5  | 114.185  |                    |         | 174                     | 0.9118 <sup>21</sup>       | 1.4561 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH; s eth                 |
| 7156 | 2-Methylcyclohexanone, (±)              |                                            | C <sub>7</sub> H <sub>12</sub> O                                                            | 24965-84-2 | 112.169  | liq                | -13.9   | 165                     | 0.9250 <sup>20</sup>       | 1.4483 <sup>25</sup>  | i H <sub>2</sub> O; s EtOH, eth                      |
| 7157 | 3-Methylcyclohexanone, (±)              |                                            | C <sub>7</sub> H <sub>12</sub> O                                                            | 625-96-7   | 112.169  | liq                | -73.5   | 169; 65 <sup>15</sup>   | 0.9136 <sup>20</sup>       | 1.4456 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                      |
| 7158 | 4-Methylcyclohexanone                   |                                            | C <sub>7</sub> H <sub>12</sub> O                                                            | 589-92-4   | 112.169  | liq                | -40.6   | 170                     | 0.9138 <sup>20</sup>       | 1.4451 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl ctc              |
| 7159 | 1-Methylcyclohexene                     |                                            | C <sub>7</sub> H <sub>12</sub>                                                              | 591-49-1   | 96.170   | liq                | -120.4  | 110.3                   | 0.8102 <sup>20</sup>       | 1.4503 <sup>20</sup>  | i H <sub>2</sub> O; s eth, bz, ctc                   |
| 7160 | 3-Methylcyclohexene, (±)                |                                            | C <sub>7</sub> H <sub>12</sub>                                                              | 56688-75-6 | 96.170   | liq                | -115.5  | 104                     | 0.7990 <sup>20</sup>       | 1.4414 <sup>20</sup>  | vs bz, eth, chl, peth                                |
| 7161 | 4-Methylcyclohexene                     |                                            | C <sub>7</sub> H <sub>12</sub>                                                              | 591-47-9   | 96.170   | liq                | -115.5  | 102.7                   | 0.7991 <sup>20</sup>       | 1.4414 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                      |
| 7162 | Methyl 3-cyclohexene-1-carboxylate      |                                            | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                                               | 6493-77-2  | 140.180  |                    |         | 182; 80 <sup>20</sup>   | 1.0130 <sup>20</sup>       | 1.4610 <sup>20</sup>  |                                                      |
| 7163 | 2-Methyl-2-cyclohexen-1-one             |                                            | C <sub>7</sub> H <sub>10</sub> O                                                            | 1121-18-2  | 110.153  |                    |         | 178.5                   | 0.966 <sup>20</sup>        | 1.4833 <sup>20</sup>  | s bz                                                 |
| 7164 | 3-Methyl-2-cyclohexen-1-one             |                                            | C <sub>7</sub> H <sub>10</sub> O                                                            | 1193-18-6  | 110.153  | liq                | -21     | 201                     | 0.9693 <sup>20</sup>       | 1.49475 <sup>20</sup> | msc H <sub>2</sub> O; s bz                           |
| 7165 | 3-Methylcyclopentadecanone              | Muscione                                   | C <sub>16</sub> H <sub>30</sub> O                                                           | 541-91-3   | 238.408  | oily liq           |         | 329; 130 <sup>0,5</sup> | 0.9221 <sup>17</sup>       | 1.4802 <sup>17</sup>  | vs ace, eth, EtOH                                    |
| 7166 | 1-Methyl-1,3-cyclopentadiene            |                                            | C <sub>6</sub> H <sub>8</sub>                                                               | 96-39-9    | 80.128   | liq                |         | 73                      | 0.81 <sup>20</sup>         | 1.4512 <sup>20</sup>  |                                                      |
| 7167 | Methylcyclopentane                      |                                            | C <sub>6</sub> H <sub>12</sub>                                                              | 96-37-7    | 84.159   | liq                | -142.42 | 71.8                    | 0.7486 <sup>20</sup>       | 1.4097 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, lig, ctc |
| 7168 | 1-Methylcyclopentanol                   |                                            | C <sub>6</sub> H <sub>12</sub> O                                                            | 1462-03-9  | 100.158  | nd                 | 36      | 136; 53 <sup>30</sup>   | 0.9044 <sup>23</sup>       | 1.4429 <sup>23</sup>  |                                                      |
| 7169 | <i>cis</i> -2-Methylcyclopentanol       |                                            | C <sub>6</sub> H <sub>12</sub> O                                                            | 25144-05-2 | 100.158  |                    |         | 148.5                   | 0.9379 <sup>16</sup>       | 1.4504 <sup>16</sup>  |                                                      |
| 7170 | 2-Methylcyclopentanone                  |                                            | C <sub>6</sub> H <sub>10</sub> O                                                            | 1120-72-5  | 98.142   | liq                | -75     | 139.5                   | 0.9139 <sup>20</sup>       | 1.4364 <sup>20</sup>  | s H <sub>2</sub> O; vs EtOH, eth, ace                |
| 7171 | 3-Methylcyclopentanone, (±)             |                                            | C <sub>6</sub> H <sub>10</sub> O                                                            | 6195-92-2  | 98.142   | liq                | -58.4   | 144                     | 0.913 <sup>22</sup>        | 1.4329 <sup>20</sup>  | s H <sub>2</sub> O; vs EtOH, eth, ace, HOAc          |
| 7172 | 1-Methylcyclopentene                    |                                            | C <sub>6</sub> H <sub>10</sub>                                                              | 693-89-0   | 82.143   | liq                | -126.5  | 75.5                    | 0.7748 <sup>25</sup>       | 1.4322 <sup>20</sup>  |                                                      |
| 7173 | 3-Methylcyclopentene                    |                                            | C <sub>6</sub> H <sub>10</sub>                                                              | 1120-62-3  | 82.143   |                    |         | 64.9                    | 0.7572 <sup>25</sup>       | 1.4216 <sup>20</sup>  |                                                      |
| 7174 | 4-Methylcyclopentene                    |                                            | C <sub>6</sub> H <sub>10</sub>                                                              | 1759-81-5  | 82.143   | liq                | -160.8  | 65.7                    | 0.7634 <sup>25</sup>       | 1.4209 <sup>20</sup>  |                                                      |
| 7175 | 2-Methyl-2-cyclopenten-1-one            |                                            | C <sub>6</sub> H <sub>8</sub> O                                                             | 1120-73-6  | 96.127   |                    |         | 157                     | 0.9808 <sup>16</sup>       | 1.4762 <sup>15</sup>  |                                                      |
| 7176 | 3-Methyl-2-cyclopenten-1-one            |                                            | C <sub>6</sub> H <sub>8</sub> O                                                             | 2758-18-1  | 96.127   |                    |         | 157.5                   | 0.9712 <sup>20</sup>       | 1.4714 <sup>20</sup>  |                                                      |

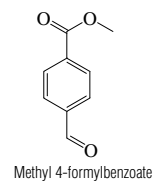
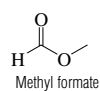
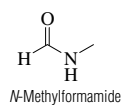
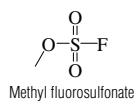
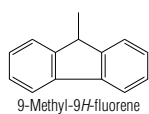
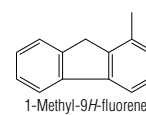
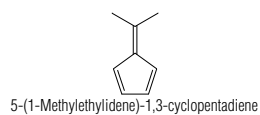
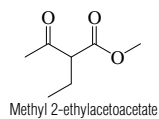
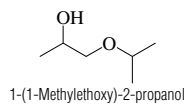
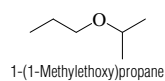
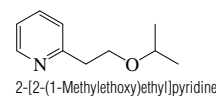
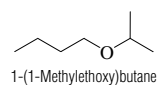
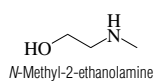
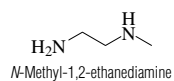
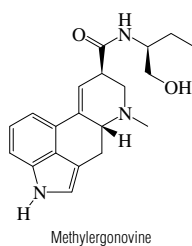
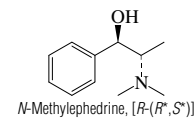
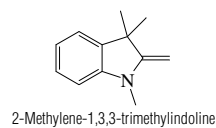
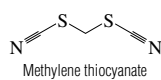
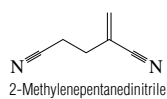
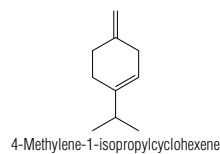
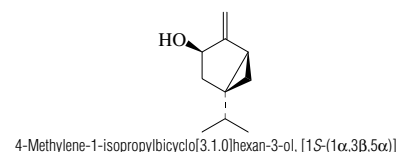
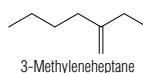
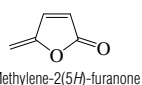
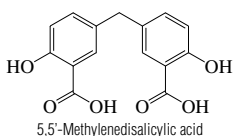
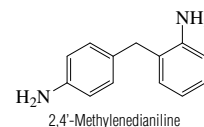
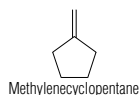
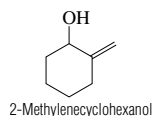
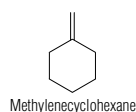
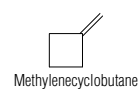
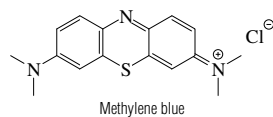
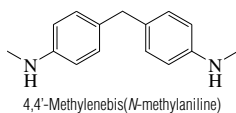
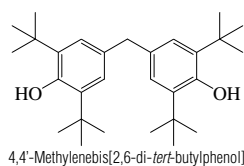
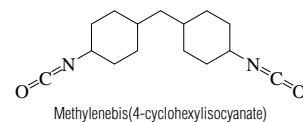
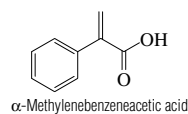
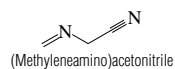
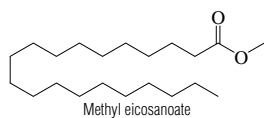
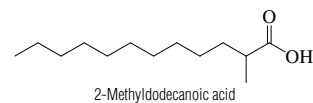
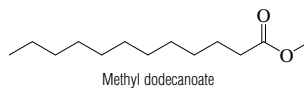
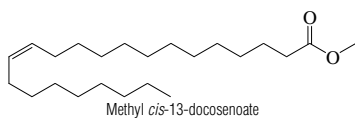




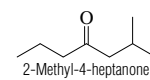
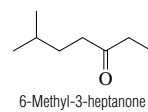
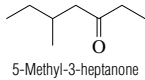
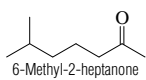
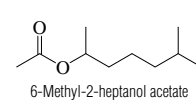
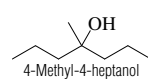
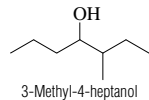
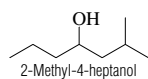
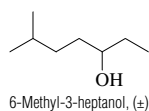
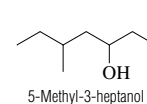
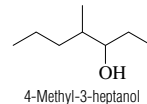
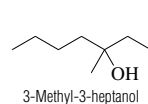
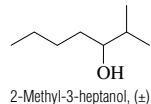
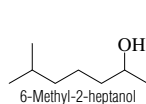
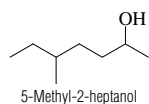
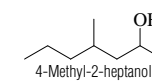
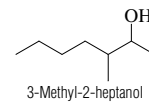
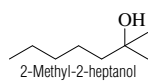
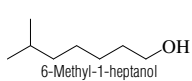
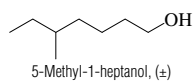
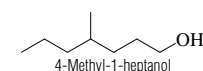
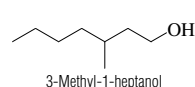
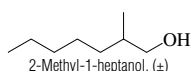
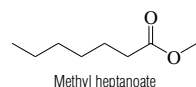
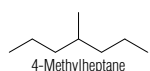
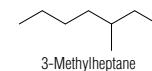
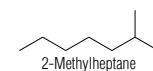
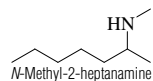
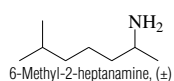
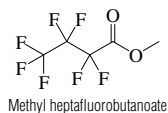
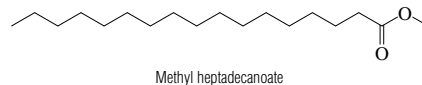
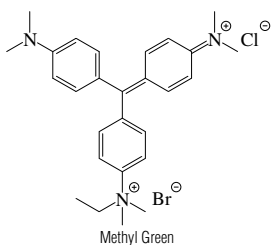
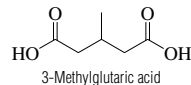
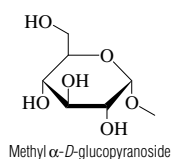
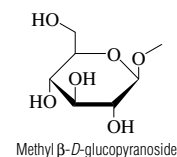
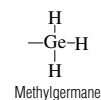
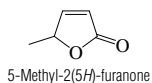
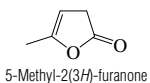
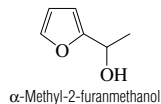
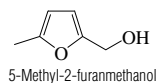
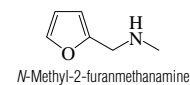
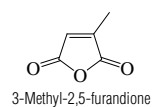
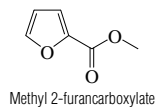
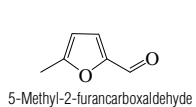
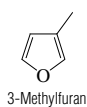
| No.  | Name                                    | Synonym                           | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                      | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|-----------------------------------------|-----------------------------------|---------------------------------------------------------------|------------|----------|------------------------------------|--------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 7177 | Methylcyclopropane                      |                                   | C <sub>4</sub> H <sub>8</sub>                                 | 594-11-6   | 56.107   | col gas                            | -177.6 | 0.7                                   | 0.6912 <sup>20</sup>       |                      | vs eth, EtOH                                               |
| 7178 | Methyl cyclopropanecarboxylate          |                                   | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                  | 2868-37-3  | 100.117  |                                    |        | 114.9                                 | 0.9848 <sup>20</sup>       | 1.4144 <sup>19</sup> | s ace, chl                                                 |
| 7179 | α-Methylcyclopropanemethanol            |                                   | C <sub>6</sub> H <sub>10</sub> O                              | 765-42-4   | 86.132   | liq                                | -32.1  | 123.5                                 | 0.8805 <sup>20</sup>       | 1.4316 <sup>20</sup> |                                                            |
| 7180 | Methyl L-cysteine hydrochloride         |                                   | C <sub>4</sub> H <sub>10</sub> ClNO <sub>2</sub> S            | 18598-63-5 | 171.646  | cry (MeOH)                         | 140.5  |                                       |                            |                      |                                                            |
| 7181 | Methyl trans-2,cis-4-decadienoate       |                                   | C <sub>11</sub> H <sub>18</sub> O <sub>2</sub>                | 4493-42-9  | 182.260  |                                    |        | 71 <sup>0.15</sup>                    | 0.9128 <sup>22</sup>       | 1.4874 <sup>22</sup> |                                                            |
| 7182 | Methyl trans-2,trans-4-decadienoate     |                                   | C <sub>11</sub> H <sub>18</sub> O <sub>2</sub>                | 7328-33-8  | 182.260  |                                    |        | 87 <sup>13</sup> , 70 <sup>0.2</sup>  | 0.9082 <sup>22</sup>       | 1.4918 <sup>22</sup> |                                                            |
| 7183 | 2-Methyldecane                          |                                   | C <sub>11</sub> H <sub>24</sub>                               | 6975-98-0  | 156.309  | liq                                | -48.9  | 189.3                                 | 0.7368 <sup>20</sup>       | 1.4154 <sup>20</sup> |                                                            |
| 7184 | 3-Methyldecane                          |                                   | C <sub>11</sub> H <sub>24</sub>                               | 13151-34-3 | 156.309  | liq                                | -92.9  | 188.1                                 | 0.7422 <sup>20</sup>       | 1.4177 <sup>20</sup> |                                                            |
| 7185 | 4-Methyldecane                          |                                   | C <sub>11</sub> H <sub>24</sub>                               | 2847-72-5  | 156.309  | liq                                | -77.5  | 187                                   |                            | 1.4352 <sup>20</sup> |                                                            |
| 7186 | Methyl decanoate                        |                                   | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                | 110-42-9   | 186.292  | liq                                | -18    | 224                                   | 0.8730 <sup>20</sup>       | 1.4259 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; sl ctc; msc chl          |
| 7187 | Methyl demeton                          |                                   | C <sub>6</sub> H <sub>15</sub> O <sub>3</sub> PS <sub>2</sub> | 8022-00-2  | 230.285  | ye liq                             |        | 89 <sup>0.15</sup> , 118 <sup>1</sup> | 1.20 <sup>20</sup>         | 1.5063 <sup>20</sup> | i H <sub>2</sub> O; s os                                   |
| 7188 | Methyldiborane(6)                       |                                   | CH <sub>6</sub> B <sub>2</sub>                                | 23777-55-1 | 41.697   | unstab gas                         |        |                                       |                            |                      | s eth                                                      |
| 7189 | Methyl 2,3-dibromopropanoate            |                                   | C <sub>4</sub> H <sub>6</sub> Br <sub>2</sub> O <sub>2</sub>  | 1729-67-5  | 245.898  |                                    |        | 206                                   | 1.9333 <sup>20</sup>       | 1.5127 <sup>20</sup> | s EtOH                                                     |
| 7190 | Methyl dichloroacetate                  |                                   | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>  | 116-54-1   | 142.969  | liq                                | -51.9  | 142.9                                 | 1.3774 <sup>20</sup>       | 1.4429 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ctc                            |
| 7191 | Methyl 2,5-dichlorobenzoate             |                                   | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>  | 2905-69-3  | 205.039  | cry                                | 38     |                                       |                            |                      |                                                            |
| 7192 | Methyl (2,4-dichlorophenoxy) acetate    | 2,4-D methyl ester                | C <sub>9</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>3</sub>  | 1928-38-7  | 235.064  |                                    | 119    | 141 <sup>18</sup>                     |                            |                      |                                                            |
| 7193 | Methyl (3,4-dichlorophenyl) carbamate   | Swep                              | C <sub>8</sub> H <sub>7</sub> Cl <sub>2</sub> NO <sub>2</sub> | 1918-18-9  | 220.054  | nd                                 | 114    |                                       |                            |                      |                                                            |
| 7194 | Methyl 2,3-dichloropropanoate           |                                   | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>  | 3674-09-7  | 156.996  |                                    |        | 92 <sup>20</sup> , 63 <sup>10</sup>   | 1.3282 <sup>20</sup>       |                      | vs ace, eth, EtOH                                          |
| 7195 | Methyldifluoroarsine                    |                                   | CH <sub>3</sub> AsF <sub>2</sub>                              | 420-24-6   | 127.954  | liq, fumes in air                  | -29.7  | 76.5                                  | 1.924 <sup>18</sup>        |                      |                                                            |
| 7196 | Methyldifluorophosphine                 | (Difluoro)methylphosphine         | CH <sub>3</sub> F <sub>2</sub> P                              | 753-59-3   | 84.006   | gas                                | -110   | -28                                   |                            |                      |                                                            |
| 7197 | Methyl 2,4-dihydroxybenzoate            |                                   | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                  | 2150-47-2  | 168.148  |                                    | 116.5  |                                       |                            |                      | sl EtOH, ace                                               |
| 7198 | Methyl 3,5-dihydroxybenzoate            |                                   | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                  | 2150-44-9  | 168.148  |                                    | 165    |                                       |                            |                      |                                                            |
| 7199 | Methyl 3,4-dimethoxybenzoate            |                                   | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                | 2150-38-1  | 196.200  | nd (dil al)                        | 60.8   | 283                                   |                            |                      | vs bz, eth, EtOH                                           |
| 7200 | Methyldimethoxysilane                   |                                   | C <sub>3</sub> H <sub>10</sub> O <sub>2</sub> Si              | 16881-77-9 | 106.196  |                                    |        | 61                                    |                            |                      |                                                            |
| 7201 | 3-Methyl-4'-(dimethylamino) azobenzene  |                                   | C <sub>15</sub> H <sub>17</sub> N <sub>3</sub>                | 55-80-1    | 239.316  | oran cry                           | 122    |                                       |                            |                      |                                                            |
| 7202 | 2-Methyl-N,N-dimethylaniline            | N,N-Dimethyl- <i>o</i> -toluidine | C <sub>9</sub> H <sub>13</sub> N                              | 609-72-3   | 135.206  | liq                                | -60    | 194.1                                 | 0.9286 <sup>20</sup>       | 1.5152 <sup>20</sup> | vs eth, EtOH                                               |
| 7203 | 3-Methyl-N,N-dimethylaniline            | N,N-Dimethyl- <i>m</i> -toluidine | C <sub>9</sub> H <sub>13</sub> N                              | 121-72-2   | 135.206  |                                    |        | 212                                   | 0.9410 <sup>20</sup>       | 1.5492 <sup>20</sup> | msc EtOH, eth                                              |
| 7204 | 4-Methyl-N,N-dimethylaniline            | N,N-Dimethyl- <i>p</i> -toluidine | C <sub>9</sub> H <sub>13</sub> N                              | 99-97-8    | 135.206  |                                    |        | 211                                   | 0.9366 <sup>20</sup>       | 1.5366 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc                   |
| 7205 | Methyl 2,2-dimethylpropanoate           | Methyl 2,2-dimethylpropionate     | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 598-98-1   | 116.158  |                                    |        | 101.1                                 | 0.891 <sup>0</sup>         | 1.3905 <sup>20</sup> | vs eth, EtOH                                               |
| 7206 | Methyl dimethylthioborane               | Dimethyl(methylthio)borane        | C <sub>3</sub> H <sub>6</sub> BS                              | 19163-05-4 | 87.979   | liq                                | -84    | 71                                    |                            |                      | vs ace, eth                                                |
| 7207 | 2-Methyl-3,5-dinitrobenzamide           | Dinitolmide                       | C <sub>8</sub> H <sub>7</sub> N <sub>3</sub> O <sub>5</sub>   | 148-01-6   | 225.159  | cry                                | 181    |                                       |                            |                      |                                                            |
| 7208 | 1-Methyl-2,3-dinitrobenzene             | 2,3-Dinitrotoluene                | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>   | 602-01-7   | 182.134  |                                    | 63     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth; sl chl                    |
| 7209 | 1-Methyl-2,4-dinitrobenzene             | 2,4-Dinitrotoluene                | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>   | 121-14-2   | 182.134  | ye nd or mcl pr (CS <sub>2</sub> ) | 70.5   | dec 300                               | 1.3208 <sup>71</sup>       | 1.442                | i H <sub>2</sub> O; s EtOH, eth, chl, bz; vs ace, py       |
| 7210 | 1-Methyl-3,5-dinitrobenzene             | 3,5-Dinitrotoluene                | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>   | 618-85-9   | 182.134  | ye orth nd (HOAc)                  | 93     | sub                                   | 1.2772 <sup>111</sup>      |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl, CS <sub>2</sub> |
| 7211 | 2-Methyl-1,3-dinitrobenzene             | 2,6-Dinitrotoluene                | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>   | 606-20-2   | 182.134  | orth nd (al)                       | 66.0   | 285                                   | 1.2833 <sup>111</sup>      | 1.479                | s EtOH, chl                                                |
| 7212 | 2-Methyl-1,4-dinitrobenzene             | 2,5-Dinitrotoluene                | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>   | 619-15-8   | 182.134  | nd (al)                            | 52.5   |                                       | 1.282 <sup>111</sup>       |                      | s EtOH, bz; vs CS <sub>2</sub>                             |
| 7213 | 4-Methyl-1,2-dinitrobenzene             | 3,4-Dinitrotoluene                | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>   | 610-39-9   | 182.134  | ye nd (CS <sub>2</sub> )           | 59.0   |                                       | 1.2594 <sup>111</sup>      |                      | i H <sub>2</sub> O; s EtOH, CS <sub>2</sub> ; sl chl       |
| 7214 | 2-Methyl-4,6-dinitrophenol              | 4,6-Dinitro- <i>p</i> -cresol     | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>5</sub>   | 534-52-1   | 198.133  | ye pr or nd (al)                   | 86.5   |                                       |                            |                      | sl H <sub>2</sub> O, peth; s EtOH, eth, ace, chl           |
| 7215 | 4-Methyl-2,6-dinitrophenol              | 2,6-Dinitro- <i>p</i> -cresol     | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>5</sub>   | 609-93-8   | 198.133  | ye nd (eth, peth)                  | 85     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz                        |
| 7216 | Methyldioctylamine                      | N-Methyl-N-octyl-1-octanamine     | C <sub>17</sub> H <sub>37</sub> N                             | 4455-26-9  | 255.483  |                                    | -30.1  | 158 <sup>10</sup>                     |                            | 1.4424 <sup>20</sup> |                                                            |
| 7217 | 4-Methyl-1,3-dioxane                    |                                   | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                 | 1120-97-4  | 102.132  | liq                                | -44.5  | 114                                   | 0.9758 <sup>20</sup>       | 1.4159 <sup>20</sup> | sl H <sub>2</sub> O; vs os                                 |
| 7218 | 2-Methyl-1,3-dioxolane                  |                                   | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 497-26-7   | 88.106   |                                    |        | 81.5                                  | 0.9811 <sup>20</sup>       | 1.4035 <sup>17</sup> | vs H <sub>2</sub> O; msc EtOH, eth                         |
| 7219 | 4-Methyl-1,3-dioxolane                  |                                   | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 1072-47-5  | 88.106   | liq                                |        | 85                                    | 0.99 <sup>20</sup>         | 1.3980 <sup>20</sup> |                                                            |
| 7220 | Methyldiphenylamine                     | N-Methyl-N-phenylbenzenamine      | C <sub>13</sub> H <sub>13</sub> N                             | 552-82-9   | 183.249  | liq                                | -7.5   | 293.5                                 | 1.0476 <sup>20</sup>       | 1.6193 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH, MeOH; s ctc                   |
| 7221 | 4-Methyl-2,4-diphenyl-1-pentene         |                                   | C <sub>18</sub> H <sub>20</sub>                               | 6362-80-7  | 236.352  | liq                                |        | 172 <sup>8</sup> , 102 <sup>0.2</sup> | 0.99 <sup>25</sup>         |                      |                                                            |
| 7222 | Methyldiphenylsilane                    |                                   | C <sub>13</sub> H <sub>14</sub> Si                            | 776-76-1   | 198.336  |                                    |        | 93.5 <sup>1</sup>                     | 0.996 <sup>20</sup>        | 1.5694 <sup>20</sup> | s ctc                                                      |
| 7223 | Methyldiphenylsilanol                   |                                   | C <sub>13</sub> H <sub>14</sub> OSi                           | 778-25-6   | 214.335  |                                    | 167    | 184 <sup>24</sup> , 148 <sup>3</sup>  | 1.0840 <sup>25</sup>       |                      | s ctc, CS <sub>2</sub>                                     |
| 7224 | 2-Methyl-1,2-di-3-pyridinyl-1-propanone | Metyrapone                        | C <sub>14</sub> H <sub>14</sub> N <sub>2</sub> O              | 54-36-4    | 226.273  |                                    | 50.5   |                                       |                            |                      |                                                            |
| 7225 | Methyl docosanoate                      | Methyl behenate                   | C <sub>23</sub> H <sub>46</sub> O <sub>2</sub>                | 929-77-1   | 354.610  | nd (ace)                           | 54     |                                       |                            | 1.4339 <sup>60</sup> | vs eth, EtOH                                               |



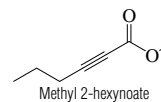
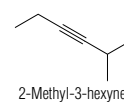
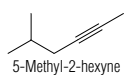
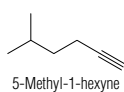
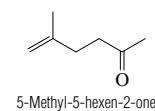
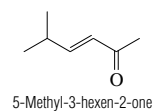
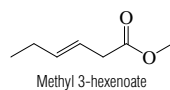
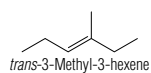
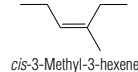
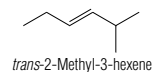
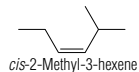
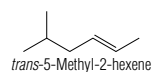
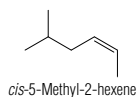
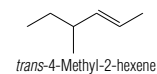
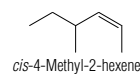
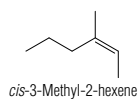
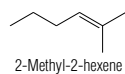
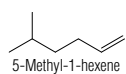
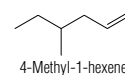
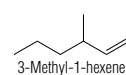
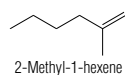
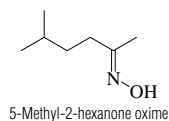
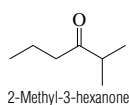
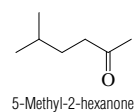
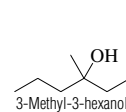
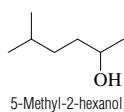
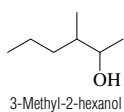
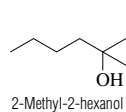
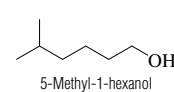
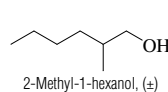
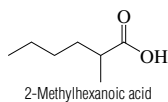
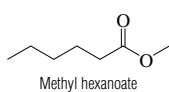
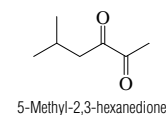
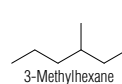
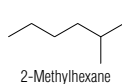
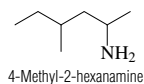
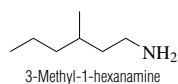
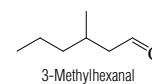
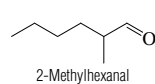
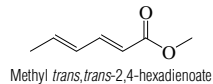
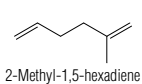
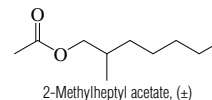
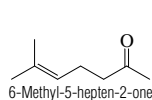
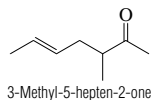
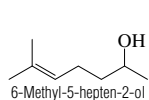
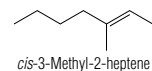
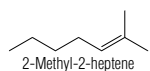
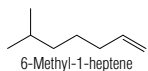
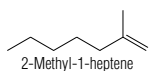
| No.  | Name                                                                      | Synonym                                                | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form               | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|---------------------------------------------------------------------------|--------------------------------------------------------|---------------------------------------------------------------|------------|----------|-----------------------------|--------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 7226 | Methyl <i>cis</i> -13-docosenoate                                         |                                                        | C <sub>23</sub> H <sub>44</sub> O <sub>2</sub>                | 1120-34-9  | 352.594  |                             | -1.2   | 220 <sup>5</sup>                      |                            |                      |                                                            |
| 7227 | Methyl dodecanoate                                                        | Methyl laurate                                         | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                | 111-82-0   | 214.344  |                             | 5.2    | 267                                   | 0.8702 <sup>20</sup>       | 1.4319 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; s chl, ctc     |
| 7228 | 2-Methyldodecanoic acid                                                   |                                                        | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                | 2874-74-0  | 214.344  | pl                          | 22     | 153 <sup>1</sup>                      | 0.890 <sup>18</sup>        |                      |                                                            |
| 7229 | Methyl eicosanoate                                                        | Methyl arachidate                                      | C <sub>21</sub> H <sub>42</sub> O <sub>2</sub>                | 1120-28-1  | 326.557  | lf (MeOH)                   | 54.5   | 215 <sup>10</sup>                     |                            | 1.4317 <sup>60</sup> | vs bz, eth, EtOH, chl                                      |
| 7230 | (Methyleneamino)acetonitrile                                              |                                                        | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>                  | 109-82-0   | 68.077   |                             | 129    |                                       |                            |                      |                                                            |
| 7231 | α-Methylenebenzeneacetic acid                                             | Atropic acid                                           | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                  | 492-38-6   | 148.159  | lf (al), nd (w)             | 106.5  | dec 267                               |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl, CS <sub>2</sub> |
| 7232 | Methylenebis(4-cyclohexylisocyanate)                                      |                                                        | C <sub>15</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub> | 5124-30-1  | 262.348  | liq                         |        |                                       | 1.066                      | 1.4970 <sup>20</sup> |                                                            |
| 7233 | 4,4'-Methylenebis[2,6-di- <i>tert</i> -butylphenol]                       | Bis(3,5-di- <i>tert</i> -butyl-4-hydroxyphenyl)methane | C <sub>29</sub> H <sub>40</sub> O <sub>2</sub>                | 118-82-1   | 424.658  |                             | 154    | 289 <sup>40</sup> , 250 <sup>10</sup> |                            |                      |                                                            |
| 7234 | 4,4'-Methylenebis( <i>N</i> -methylaniline)                               | <i>N,N'</i> -Dimethyl-4,4'-diaminodiphenylmethane      | C <sub>15</sub> H <sub>18</sub> N <sub>2</sub>                | 1807-55-2  | 226.317  |                             |        |                                       |                            |                      | s ctc, CS <sub>2</sub>                                     |
| 7235 | Methylene blue                                                            |                                                        | C <sub>16</sub> H <sub>18</sub> ClN <sub>3</sub> S            | 61-73-4    | 319.852  | dk grn cry or pow (chl-eth) |        |                                       |                            |                      | s H <sub>2</sub> O, EtOH, chl; i eth; sl py                |
| 7236 | Methylenecyclobutane                                                      |                                                        | C <sub>4</sub> H <sub>8</sub>                                 | 1120-56-5  | 68.118   | liq                         | -134.7 | 42.2                                  | 0.7401 <sup>20</sup>       | 1.4210 <sup>20</sup> |                                                            |
| 7237 | Methylenecyclohexane                                                      |                                                        | C <sub>6</sub> H <sub>12</sub>                                | 1192-37-6  | 96.170   | liq                         | -106.7 | 102.5                                 | 0.8074 <sup>20</sup>       | 1.4523 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl                         |
| 7238 | 2-Methylenecyclohexanol                                                   |                                                        | C <sub>7</sub> H <sub>12</sub> O                              | 4065-80-9  | 112.169  |                             |        | 83 <sup>13</sup>                      | 0.955 <sup>20</sup>        | 1.4843 <sup>20</sup> |                                                            |
| 7239 | Methylenecyclopentane                                                     |                                                        | C <sub>6</sub> H <sub>10</sub>                                | 1528-30-9  | 82.143   |                             |        | 75.5                                  | 0.7787 <sup>20</sup>       | 1.4355 <sup>20</sup> | s bz, chl                                                  |
| 7240 | Methylenecyclopropene                                                     |                                                        | C <sub>4</sub> H <sub>4</sub>                                 | 4095-06-1  | 52.075   | solid stab at -196          |        |                                       |                            |                      |                                                            |
| 7241 | 2,4'-Methylenedianiline                                                   | 2,4'-Diaminodiphenylmethane                            | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub>                | 1208-52-2  | 198.263  | lf (bz)                     | 88.5   | 222 <sup>9</sup>                      |                            |                      |                                                            |
| 7242 | 5,5'-Methylenedisalicylic acid                                            |                                                        | C <sub>15</sub> H <sub>12</sub> O <sub>6</sub>                | 122-25-8   | 288.252  | nd (bz)                     | 243.5  |                                       |                            |                      | vs ace, eth, EtOH                                          |
| 7243 | 5-Methylene-2(5 <i>H</i> )-furanone                                       | Protoanemonin                                          | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                  | 108-28-1   | 96.085   | pa ye oil                   |        | 73 <sup>11</sup>                      |                            |                      | sl H <sub>2</sub> O; s chl                                 |
| 7244 | 3-Methyleneheptane                                                        |                                                        | C <sub>8</sub> H <sub>16</sub>                                | 1632-16-2  | 112.213  |                             |        | 120                                   | 0.7270 <sup>20</sup>       | 1.4157 <sup>20</sup> | i H <sub>2</sub> O; vs eth, bz, peth                       |
| 7245 | 4-Methylene-1-isopropylbicyclo[3.1.0]hexan-3-ol, [1 <i>S</i> -(1α,3β,5α)] | 4(10)-Thujene-3-ol                                     | C <sub>10</sub> H <sub>16</sub> O                             | 471-16-9   | 152.233  |                             |        | 208                                   | 0.9488 <sup>19</sup>       | 1.4871 <sup>25</sup> | s eth                                                      |
| 7246 | 4-Methylene-1-isopropylcyclohexene                                        |                                                        | C <sub>10</sub> H <sub>16</sub>                               | 99-84-3    | 136.234  |                             |        | 173.5                                 | 0.838 <sup>22</sup>        | 1.4754 <sup>22</sup> |                                                            |
| 7247 | 2-Methylenepentanedinitrile                                               | 2,4-Dicyano-1-butene                                   | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub>                  | 1572-52-7  | 106.125  |                             |        | 103 <sup>5</sup>                      |                            | 1.4561 <sup>20</sup> | s chl                                                      |
| 7248 | Methylene thiocyanate                                                     | Dithiocyanatomethane                                   | C <sub>3</sub> H <sub>2</sub> N <sub>2</sub> S <sub>2</sub>   | 6317-18-6  | 130.191  | solid                       | 102    |                                       |                            |                      |                                                            |
| 7249 | 2-Methylene-1,3,3-trimethylindoline                                       | Fischer's base                                         | C <sub>12</sub> H <sub>15</sub> N                             | 118-12-7   | 173.254  |                             |        | 244                                   |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                  |
| 7250 | <i>N</i> -Methylephedrine, [ <i>R</i> -( <i>R</i> *, <i>S</i> *)]         | (1 <i>R</i> ,2 <i>S</i> )- <i>N</i> -Methylephedrine   | C <sub>11</sub> H <sub>17</sub> NO                            | 552-79-4   | 179.259  | nd or pl (al, eth)          | 87.5   |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, MeOH                      |
| 7251 | Methylergonovine                                                          | Methylergometrine                                      | C <sub>20</sub> H <sub>25</sub> N <sub>3</sub> O <sub>2</sub> | 113-42-8   | 339.432  | pr (MeOH, ace)              | 172    |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, ace                            |
| 7252 | <i>N</i> -Methyl-1,2-ethanediamine                                        |                                                        | C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>                 | 109-81-9   | 74.124   |                             |        | 115                                   | 0.841 <sup>25</sup>        | 1.4395 <sup>20</sup> |                                                            |
| 7253 | <i>N</i> -Methyl-2-ethanolamine                                           |                                                        | C <sub>3</sub> H <sub>9</sub> NO                              | 109-83-1   | 75.109   |                             |        | 158                                   | 0.937 <sup>20</sup>        | 1.4385 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth                            |
| 7254 | 1-(1-Methylethoxy)butane                                                  | Butyl isopropyl ether                                  | C <sub>7</sub> H <sub>16</sub> O                              | 1860-27-1  | 116.201  |                             |        | 108                                   | 0.7594 <sup>15</sup>       | 1.3870 <sup>15</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, con sulf             |
| 7255 | 2-[2-(1-Methylethoxy)ethyl]pyridine                                       |                                                        | C <sub>10</sub> H <sub>15</sub> NO                            | 70715-19-4 | 165.232  |                             |        | 133 <sup>50</sup>                     | 0.9502 <sup>25</sup>       | 1.4820 <sup>25</sup> | vs H <sub>2</sub> O                                        |
| 7256 | 1-(1-Methylethoxy)propane                                                 |                                                        | C <sub>6</sub> H <sub>14</sub> O                              | 627-08-7   | 102.174  |                             |        | 83                                    | 0.7370 <sup>20</sup>       | 1.376 <sup>21</sup>  | sl H <sub>2</sub> O; vs EtOH; s eth, ace                   |
| 7257 | 1-(1-Methylethoxy)-2-propanol                                             | 1-Isopropoxy-2-propanol                                | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | 3944-36-3  | 118.174  |                             |        | 137.5                                 | 0.879 <sup>20</sup>        | 1.4070 <sup>20</sup> |                                                            |
| 7258 | Methyl 2-ethylacetoacetate                                                |                                                        | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>                 | 51756-08-2 | 144.168  |                             |        | 182                                   | 0.995 <sup>14</sup>        |                      | vs ace, eth, EtOH                                          |
| 7259 | 5-(1-Methylethylidene)-1,3-cyclopentadiene                                |                                                        | C <sub>8</sub> H <sub>10</sub>                                | 2175-91-9  | 106.165  |                             | 1.4    | 155; 49 <sup>11</sup>                 | 0.881 <sup>20</sup>        | 1.5474 <sup>20</sup> |                                                            |
| 7260 | 1-Methyl-9 <i>H</i> -fluorene                                             |                                                        | C <sub>14</sub> H <sub>12</sub>                               | 1730-37-6  | 180.245  |                             | 87     |                                       |                            |                      |                                                            |
| 7261 | 9-Methyl-9 <i>H</i> -fluorene                                             |                                                        | C <sub>14</sub> H <sub>12</sub>                               | 2523-37-7  | 180.245  | pr                          | 46.5   | 155 <sup>15</sup>                     | 1.0263 <sup>66</sup>       | 1.610 <sup>66</sup>  | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl              |
| 7262 | Methyl fluorosulfonate                                                    |                                                        | CH <sub>3</sub> FO <sub>3</sub> S                             | 421-20-5   | 114.096  | col liq                     | -95    | 93                                    | 1.412                      | 1.3326 <sup>20</sup> |                                                            |
| 7263 | <i>N</i> -Methylformamide                                                 |                                                        | C <sub>2</sub> H <sub>5</sub> NO                              | 123-39-7   | 59.067   | liq                         | -3.8   | 199.51                                | 1.011 <sup>19</sup>        | 1.4319 <sup>20</sup> | vs H <sub>2</sub> O, ace, EtOH                             |
| 7264 | Methyl formate                                                            |                                                        | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                  | 107-31-3   | 60.052   | liq                         | -99    | 31.7                                  | 0.9713 <sup>20</sup>       | 1.3419 <sup>20</sup> | vs H <sub>2</sub> O; msc EtOH; s eth, chl, MeOH            |
| 7265 | Methyl 4-formylbenzoate                                                   |                                                        | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                  | 1571-08-0  | 164.158  | nd (w)                      | 63     | 265                                   |                            |                      |                                                            |
| 7266 | 2-Methylfuran                                                             |                                                        | C <sub>5</sub> H <sub>6</sub> O                               | 534-22-5   | 82.101   | liq                         | -91.3  | 64.7                                  | 0.9132 <sup>20</sup>       | 1.4342 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth                      |



| No.  | Name                           | Synonym                   | Mol. Form.                                                  | CAS RN      | Mol. Wt. | Physical Form | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|--------------------------------|---------------------------|-------------------------------------------------------------|-------------|----------|---------------|---------|----------------------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 7267 | 3-Methylfuran                  |                           | C <sub>5</sub> H <sub>6</sub> O                             | 930-27-8    | 82.101   |               |         | 65.5                                   | 0.923 <sup>18</sup>        | 1.4330 <sup>19</sup> | i H <sub>2</sub> O; s EtOH, eth                         |
| 7268 | 5-Methyl-2-furancarboxaldehyde |                           | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                | 620-02-0    | 110.111  |               |         | 187; 89 <sup>26</sup>                  | 1.1072 <sup>18</sup>       | 1.5264 <sup>20</sup> | s H <sub>2</sub> O; vs EtOH; msc eth; sl ctc            |
| 7269 | Methyl 2-furancarboxylate      | Methyl 2-furanoate        | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                | 611-13-2    | 126.110  |               |         | 181.3                                  | 1.1786 <sup>21</sup>       | 1.4860 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl                |
| 7270 | 3-Methyl-2,5-furandione        |                           | C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                | 616-02-4    | 112.084  |               | 7.5     | 213.5                                  | 1.2469 <sup>16</sup>       | 1.4710 <sup>21</sup> | vs ace, eth, EtOH                                       |
| 7271 | N-Methyl-2-furanmethanamine    |                           | C <sub>6</sub> H <sub>9</sub> NO                            | 4753-75-7   | 111.141  |               |         | 149                                    | 0.989 <sup>25</sup>        | 1.4729 <sup>20</sup> |                                                         |
| 7272 | 5-Methyl-2-furanmethanol       |                           | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                | 3857-25-8   | 112.127  |               |         | dec 195; 81 <sup>23</sup>              | 1.0769 <sup>20</sup>       | 1.4853 <sup>20</sup> | vs eth, EtOH                                            |
| 7273 | α-Methyl-2-furanmethanol       |                           | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                | 4208-64-4   | 112.127  |               |         | 162.5                                  | 1.0739 <sup>25</sup>       | 1.4827 <sup>15</sup> |                                                         |
| 7274 | 5-Methyl-2(3H)-furanone        |                           | C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                | 591-12-8    | 98.101   | nd            | 18      | 56 <sup>12</sup>                       | 1.084 <sup>20</sup>        | 1.4476 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, CS <sub>2</sub> ; sl ctc |
| 7275 | 5-Methyl-2(5H)-furanone        |                           | C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                | 591-11-7    | 98.101   |               | <-17    | 209; 98 <sup>15</sup>                  | 1.0810 <sup>20</sup>       | 1.4454 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth                       |
| 7276 | Methylgermane                  |                           | CH <sub>3</sub> Ge                                          | 1449-65-6   | 90.70    | col gas       | -158    | -23                                    |                            |                      |                                                         |
| 7277 | Methyl β-D-glucopyranoside     |                           | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>               | 709-50-2    | 194.182  |               | 109     |                                        |                            |                      | s H <sub>2</sub> O                                      |
| 7278 | Methyl α-D-glucopyranoside     | α-Methylglucoside         | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>               | 97-30-3     | 194.182  | orth nd (al)  | 168     | 200 <sup>0.2</sup>                     | 1.46 <sup>30</sup>         |                      | vs H <sub>2</sub> O                                     |
| 7279 | 3-Methylglutaric acid          | 3-Methylpentanedioic acid | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>               | 626-51-7    | 146.141  |               | 87      | 166 <sup>0.5</sup>                     |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl bz, chl; i lig        |
| 7280 | Methyl Green                   |                           | C <sub>27</sub> H <sub>35</sub> BrClN <sub>3</sub>          | 14855-76-6  | 516.944  | grn pow (al)  |         |                                        |                            |                      | vs H <sub>2</sub> O                                     |
| 7281 | Methyl heptadecanoate          |                           | C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>              | 1731-92-6   | 284.478  | pl (al)       | 30      | 185 <sup>9</sup> , 152 <sup>0.05</sup> |                            |                      | i H <sub>2</sub> O; s EtOH, ace, ctc; vs eth, bz        |
| 7282 | Methyl heptafluorobutanoate    |                           | C <sub>5</sub> H <sub>3</sub> F <sub>7</sub> O <sub>2</sub> | 356-24-1    | 228.066  | liq           | -86     | 80                                     | 1.483 <sup>20</sup>        | 1.295 <sup>20</sup>  | sl H <sub>2</sub> O; s eth, ace                         |
| 7283 | 6-Methyl-2-heptanamine, (±)    | Octodrine                 | C <sub>8</sub> H <sub>19</sub> N                            | 5984-58-7   | 129.244  | visc liq      |         | 155                                    | 0.767 <sup>25</sup>        | 1.4209 <sup>20</sup> |                                                         |
| 7284 | N-Methyl-2-heptanamine         |                           | C <sub>8</sub> H <sub>19</sub> N                            | 540-43-2    | 129.244  |               |         | 155                                    |                            |                      |                                                         |
| 7285 | 2-Methylheptane                |                           | C <sub>8</sub> H <sub>18</sub>                              | 592-27-8    | 114.229  | liq           | -109.02 | 117.66                                 | 0.6980 <sup>20</sup>       | 1.3949 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, ace, bz; s eth, ctc       |
| 7286 | 3-Methylheptane                |                           | C <sub>8</sub> H <sub>18</sub>                              | 589-81-1    | 114.229  | col liq       | -120.48 | 118.9                                  | 0.7017 <sup>25</sup>       | 1.3961 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, chl       |
| 7287 | 4-Methylheptane                |                           | C <sub>8</sub> H <sub>18</sub>                              | 589-53-7    | 114.229  | liq           | -121.0  | 117.72                                 | 0.7046 <sup>20</sup>       | 1.3979 <sup>20</sup> | i H <sub>2</sub> O; s eth; msc EtOH, ace, bz            |
| 7288 | Methyl heptanoate              |                           | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>               | 106-73-0    | 144.212  | liq           | -56     | 174                                    | 0.8815 <sup>20</sup>       | 1.4152 <sup>20</sup> | sl H <sub>2</sub> O, ctc, ace; s EtOH, eth              |
| 7289 | 2-Methyl-1-heptanol, (±)       |                           | C <sub>8</sub> H <sub>18</sub> O                            | 111675-77-5 | 130.228  | col liq       | -112    | 175.6                                  | 0.8022 <sup>20</sup>       | 1.424 <sup>20</sup>  |                                                         |
| 7290 | 3-Methyl-1-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 1070-32-2   | 130.228  | liq           | -90     | 186; 101 <sup>20</sup>                 | 0.824 <sup>24</sup>        | 1.4295 <sup>25</sup> |                                                         |
| 7291 | 4-Methyl-1-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 817-91-4    | 130.228  |               |         | 188                                    | 0.8065 <sup>25</sup>       | 1.4253 <sup>25</sup> | vs EtOH                                                 |
| 7292 | 5-Methyl-1-heptanol, (±)       |                           | C <sub>8</sub> H <sub>18</sub> O                            | 111767-95-4 | 130.228  | col liq       | -104    | 186.6                                  | 0.8153 <sup>25</sup>       | 1.4272 <sup>25</sup> |                                                         |
| 7293 | 6-Methyl-1-heptanol            | Isocetyl alcohol          | C <sub>8</sub> H <sub>18</sub> O                            | 1653-40-3   | 130.228  | liq           | -106    | 188; 95.8 <sup>20</sup>                | 0.8176 <sup>25</sup>       | 1.4251 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth                         |
| 7294 | 2-Methyl-2-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 625-25-2    | 130.228  | liq           | -50.4   | 156                                    | 0.8142 <sup>20</sup>       | 1.4250 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                         |
| 7295 | 3-Methyl-2-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 31367-46-1  | 130.228  |               |         | 166.1                                  | 0.8177 <sup>25</sup>       | 1.4199 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                    |
| 7296 | 4-Methyl-2-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 56298-90-9  | 130.228  | col liq       | -102    | 171.6                                  | 0.8027 <sup>20</sup>       | 1.424 <sup>20</sup>  |                                                         |
| 7297 | 5-Methyl-2-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 54630-50-1  | 130.228  | liq           | -61     | 170                                    | 0.8174 <sup>21</sup>       |                      |                                                         |
| 7298 | 6-Methyl-2-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 4730-22-7   | 130.228  | liq           | -105    | 174                                    | 0.8218 <sup>20</sup>       | 1.4238 <sup>10</sup> |                                                         |
| 7299 | 2-Methyl-3-heptanol, (±)       |                           | C <sub>8</sub> H <sub>18</sub> O                            | 100296-26-2 | 130.228  | liq           | -85     | 167.5                                  | 0.8235 <sup>20</sup>       | 1.4265 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc                   |
| 7300 | 3-Methyl-3-heptanol            | 2-Ethyl-2-hexanol         | C <sub>8</sub> H <sub>18</sub> O                            | 5582-82-1   | 130.228  | liq           | -83     | 163                                    | 0.8282 <sup>20</sup>       | 1.4279 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                    |
| 7301 | 4-Methyl-3-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 14979-39-6  | 130.228  | liq           | -123    | 170                                    | 0.827 <sup>25</sup>        | 1.4300 <sup>20</sup> |                                                         |
| 7302 | 5-Methyl-3-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 18720-65-5  | 130.228  | liq           | -91.2   | 172                                    | 0.8425 <sup>25</sup>       | 1.433 <sup>24</sup>  |                                                         |
| 7303 | 6-Methyl-3-heptanol, (±)       |                           | C <sub>8</sub> H <sub>18</sub> O                            | 100295-85-0 | 130.228  | col liq       | -61     | 169                                    | 0.8220 <sup>20</sup>       | 1.4254 <sup>20</sup> |                                                         |
| 7304 | 2-Methyl-4-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 21570-35-4  | 130.228  | liq           | -81     | 164                                    | 0.8207 <sup>20</sup>       | 1.4203               | vs eth, EtOH                                            |
| 7305 | 3-Methyl-4-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 1838-73-9   | 130.228  | liq           |         | 164.7                                  | 0.8329 <sup>25</sup>       | 1.4211 <sup>25</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc                   |
| 7306 | 4-Methyl-4-heptanol            |                           | C <sub>8</sub> H <sub>18</sub> O                            | 598-01-6    | 130.228  | liq           | -82     | 161                                    | 0.8248 <sup>20</sup>       | 1.4258 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                    |
| 7307 | 6-Methyl-2-heptanol acetate    |                           | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>              | 67952-57-2  | 172.265  |               |         | 187                                    | 0.8474 <sup>20</sup>       | 1.413 <sup>20</sup>  | vs EtOH                                                 |
| 7308 | 6-Methyl-2-heptanone           |                           | C <sub>8</sub> H <sub>16</sub> O                            | 928-68-7    | 128.212  |               |         | 167                                    | 0.8151 <sup>20</sup>       | 1.4162 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth; msc ace, bz, chl     |
| 7309 | 5-Methyl-3-heptanone           |                           | C <sub>8</sub> H <sub>16</sub> O                            | 541-85-5    | 128.212  | liq           |         | 161                                    |                            |                      |                                                         |
| 7310 | 6-Methyl-3-heptanone           |                           | C <sub>8</sub> H <sub>16</sub> O                            | 624-42-0    | 128.212  |               |         | 164                                    | 0.8304 <sup>20</sup>       | 1.4209 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc                |
| 7311 | 2-Methyl-4-heptanone           | Isobutyl propyl ketone    | C <sub>8</sub> H <sub>16</sub> O                            | 626-33-5    | 128.212  |               |         | 154                                    | 0.813 <sup>22</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth                         |

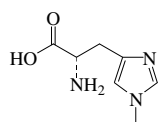


| No.  | Name                                        | Synonym                 | Mol. Form.                                     | CAS RN      | Mol. Wt. | Physical Form | mp/°C  | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|---------------------------------------------|-------------------------|------------------------------------------------|-------------|----------|---------------|--------|-------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 7312 | 2-Methyl-1-heptene                          |                         | C <sub>8</sub> H <sub>16</sub>                 | 15870-10-7  | 112.213  | liq           | -90    | 119.3                               | 0.7104 <sup>25</sup>       | 1.4123 <sup>20</sup> |                                                        |
| 7313 | 6-Methyl-1-heptene                          |                         | C <sub>8</sub> H <sub>16</sub>                 | 5026-76-6   | 112.213  |               |        | 113.2                               | 0.7079 <sup>25</sup>       | 1.4070 <sup>20</sup> |                                                        |
| 7314 | 2-Methyl-2-heptene                          |                         | C <sub>8</sub> H <sub>16</sub>                 | 627-97-4    | 112.213  |               |        | 122.6                               | 0.7200 <sup>25</sup>       | 1.4170 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, ctc, chl                |
| 7315 | <i>cis</i> -3-Methyl-2-heptene              |                         | C <sub>8</sub> H <sub>16</sub>                 | 22768-19-0  | 112.213  |               |        | 122                                 | 0.725 <sup>25</sup>        | 1.419 <sup>20</sup>  |                                                        |
| 7316 | 6-Methyl-5-hepten-2-ol                      |                         | C <sub>8</sub> H <sub>16</sub> O               | 1569-60-4   | 128.212  |               |        | 175                                 | 0.8545 <sup>20</sup>       | 1.4505 <sup>20</sup> |                                                        |
| 7317 | 3-Methyl-5-hepten-2-one                     |                         | C <sub>8</sub> H <sub>14</sub> O               | 38552-72-6  | 126.196  |               |        | 63 <sup>20</sup>                    | 0.8463 <sup>18</sup>       | 1.4345 <sup>18</sup> |                                                        |
| 7318 | 6-Methyl-5-hepten-2-one                     |                         | C <sub>8</sub> H <sub>14</sub> O               | 110-93-0    | 126.196  |               | 173.5  |                                     | 0.8546 <sup>16</sup>       | 1.4445 <sup>20</sup> | vs eth, EtOH                                           |
| 7319 | 2-Methylheptyl acetate, (±)                 |                         | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub> | 74112-36-0  | 172.265  |               |        | 195                                 | 0.8626 <sup>14</sup>       | 1.4146 <sup>20</sup> | vs eth, EtOH                                           |
| 7320 | 2-Methyl-1,5-hexadiene                      |                         | C <sub>7</sub> H <sub>12</sub>                 | 4049-81-4   | 96.170   | liq           | -128.8 | 88.1                                | 0.7153 <sup>25</sup>       | 1.4183 <sup>20</sup> |                                                        |
| 7321 | Methyl <i>trans,trans</i> -2,4-hexadienoate | Methyl sorbate          | C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>  | 689-89-4    | 126.153  | lf            | 15     | 180; 70 <sup>20</sup>               | 0.9777 <sup>20</sup>       | 1.5025 <sup>22</sup> | i H <sub>2</sub> O; s EtOH, eth                        |
| 7322 | 2-Methylhexanal                             |                         | C <sub>7</sub> H <sub>14</sub> O               | 925-54-2    | 114.185  | liq           |        | 141; 132 <sup>60</sup>              |                            |                      |                                                        |
| 7323 | 3-Methylhexanal                             | 3-Methylcaproaldehyde   | C <sub>7</sub> H <sub>14</sub> O               | 19269-28-4  | 114.185  |               |        | 143                                 | 0.8203 <sup>20</sup>       | 1.4122 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                        |
| 7324 | 3-Methyl-1-hexanamine                       |                         | C <sub>7</sub> H <sub>17</sub> N               | 65530-93-0  | 115.217  |               |        | 149; 67 <sup>45</sup>               | 0.772 <sup>26</sup>        | 1.4249 <sup>25</sup> |                                                        |
| 7325 | 4-Methyl-2-hexanamine                       |                         | C <sub>7</sub> H <sub>17</sub> N               | 105-41-9    | 115.217  |               |        | 132.5                               | 0.7655 <sup>20</sup>       | 1.4150 <sup>25</sup> | sl H <sub>2</sub> O; vs EtOH, eth, chl, dil acid       |
| 7326 | 2-Methylhexane                              |                         | C <sub>7</sub> H <sub>16</sub>                 | 591-76-4    | 100.202  | liq           | -118.2 | 90.04                               | 0.6787 <sup>20</sup>       | 1.3848 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; msc eth, ace, bz, lig, chl |
| 7327 | 3-Methylhexane                              |                         | C <sub>7</sub> H <sub>16</sub>                 | 78918-91-9  | 100.202  | liq           | -119.4 | 92                                  | 0.687 <sup>21</sup>        | 1.3854 <sup>25</sup> | i H <sub>2</sub> O; s EtOH; msc eth, ace, bz, lig, chl |
| 7328 | 5-Methyl-2,3-hexanedione                    | 2-Methylhexa-4,5-dione  | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>  | 13706-86-0  | 128.169  |               |        | 138                                 | 0.908 <sup>22</sup>        | 1.4119 <sup>20</sup> |                                                        |
| 7329 | Methyl hexanoate                            | Methyl caproate         | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>  | 106-70-7    | 130.185  | liq           | -71    | 149.5                               | 0.8846 <sup>20</sup>       | 1.4049 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz, ctc       |
| 7330 | 2-Methylhexanoic acid                       |                         | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>  | 4536-23-6   | 130.185  |               |        | 215.5                               | 0.918 <sup>20</sup>        | 1.4193 <sup>20</sup> | vs ace, bz, eth, EtOH                                  |
| 7331 | 2-Methyl-1-hexanol, (±)                     |                         | C <sub>7</sub> H <sub>16</sub> O               | 111768-04-8 | 116.201  |               |        | 164; 71 <sup>15</sup>               | 0.826 <sup>20</sup>        | 1.4226 <sup>20</sup> | vs eth, EtOH                                           |
| 7332 | 5-Methyl-1-hexanol                          |                         | C <sub>7</sub> H <sub>16</sub> O               | 627-98-5    | 116.201  |               |        | 169; 54 <sup>15</sup>               | 0.8192 <sup>24</sup>       | 1.4175 <sup>20</sup> | vs eth, EtOH                                           |
| 7333 | 2-Methyl-2-hexanol                          |                         | C <sub>7</sub> H <sub>16</sub> O               | 625-23-0    | 116.201  |               |        | 143                                 | 0.8119 <sup>20</sup>       | 1.4175 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                     |
| 7334 | 3-Methyl-2-hexanol                          |                         | C <sub>7</sub> H <sub>16</sub> O               | 2313-65-7   | 116.201  |               |        | 151; 80 <sup>32</sup>               | 0.8220 <sup>25</sup>       | 1.4198 <sup>18</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ace                |
| 7335 | 5-Methyl-2-hexanol                          |                         | C <sub>7</sub> H <sub>16</sub> O               | 627-59-8    | 116.201  |               |        | 151; 78 <sup>28</sup>               | 0.814 <sup>20</sup>        | 1.4180 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                       |
| 7336 | 3-Methyl-3-hexanol                          |                         | C <sub>7</sub> H <sub>16</sub> O               | 597-96-6    | 116.201  |               |        | 143                                 | 0.8233 <sup>20</sup>       | 1.4231 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc                  |
| 7337 | 5-Methyl-2-hexanone                         | Methyl isopentyl ketone | C <sub>7</sub> H <sub>14</sub> O               | 110-12-3    | 114.185  |               |        | 144                                 | 0.888 <sup>20</sup>        | 1.4062 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH; vs ace, bz; s ctc       |
| 7338 | 2-Methyl-3-hexanone                         | Propyl isopropyl ketone | C <sub>7</sub> H <sub>14</sub> O               | 7379-12-6   | 114.185  |               |        | 135                                 | 0.8091 <sup>20</sup>       | 1.4042 <sup>20</sup> | s EtOH, eth, chl; vs ace                               |
| 7339 | 5-Methyl-2-hexanone oxime                   |                         | C <sub>7</sub> H <sub>13</sub> NO              | 624-44-2    | 129.200  |               |        | 195.5                               | 0.8881 <sup>20</sup>       | 1.4448 <sup>20</sup> | sl chl                                                 |
| 7340 | 2-Methyl-1-hexene                           |                         | C <sub>7</sub> H <sub>14</sub>                 | 6094-02-6   | 98.186   | liq           | -102.8 | 92                                  | 0.7000 <sup>20</sup>       | 1.4035 <sup>20</sup> |                                                        |
| 7341 | 3-Methyl-1-hexene                           |                         | C <sub>7</sub> H <sub>14</sub>                 | 3404-61-3   | 98.186   |               |        | 83.9                                | 0.6871 <sup>25</sup>       | 1.3965 <sup>20</sup> |                                                        |
| 7342 | 4-Methyl-1-hexene                           |                         | C <sub>7</sub> H <sub>14</sub>                 | 3769-23-1   | 98.186   | liq           | -141.5 | 86.7                                | 0.6942 <sup>25</sup>       | 1.4000 <sup>20</sup> |                                                        |
| 7343 | 5-Methyl-1-hexene                           |                         | C <sub>7</sub> H <sub>14</sub>                 | 3524-73-0   | 98.186   |               |        | 85.3                                | 0.6877 <sup>25</sup>       | 1.3967 <sup>20</sup> |                                                        |
| 7344 | 2-Methyl-2-hexene                           |                         | C <sub>7</sub> H <sub>14</sub>                 | 2738-19-4   | 98.186   | liq           | -130.4 | 95.4                                | 0.7038 <sup>25</sup>       | 1.4106 <sup>20</sup> |                                                        |
| 7345 | <i>cis</i> -3-Methyl-2-hexene               |                         | C <sub>7</sub> H <sub>14</sub>                 | 10574-36-4  | 98.186   | liq           | -118.5 | 95.6                                | 0.712 <sup>20</sup>        | 1.4126 <sup>20</sup> |                                                        |
| 7346 | <i>cis</i> -4-Methyl-2-hexene               |                         | C <sub>7</sub> H <sub>14</sub>                 | 3683-19-0   | 98.186   |               |        | 86.3                                | 0.6952 <sup>25</sup>       | 1.4026 <sup>20</sup> |                                                        |
| 7347 | <i>trans</i> -4-Methyl-2-hexene             |                         | C <sub>7</sub> H <sub>14</sub>                 | 3683-22-5   | 98.186   | liq           | -125.7 | 87.6                                | 0.6925 <sup>25</sup>       | 1.4025 <sup>20</sup> |                                                        |
| 7348 | <i>cis</i> -5-Methyl-2-hexene               |                         | C <sub>7</sub> H <sub>14</sub>                 | 13151-17-2  | 98.186   |               |        | 89.5                                | 0.697 <sup>25</sup>        | 1.404 <sup>20</sup>  |                                                        |
| 7349 | <i>trans</i> -5-Methyl-2-hexene             |                         | C <sub>7</sub> H <sub>14</sub>                 | 7385-82-2   | 98.186   | liq           | -124.3 | 88.1                                | 0.6883 <sup>25</sup>       | 1.4006 <sup>20</sup> |                                                        |
| 7350 | <i>cis</i> -2-Methyl-3-hexene               |                         | C <sub>7</sub> H <sub>14</sub>                 | 15840-60-5  | 98.186   |               |        | 86                                  | 0.690 <sup>25</sup>        | 1.401 <sup>20</sup>  |                                                        |
| 7351 | <i>trans</i> -2-Methyl-3-hexene             |                         | C <sub>7</sub> H <sub>14</sub>                 | 692-24-0    | 98.186   | liq           | -141.6 | 85.9                                | 0.6853 <sup>25</sup>       | 1.4001 <sup>20</sup> |                                                        |
| 7352 | <i>cis</i> -3-Methyl-3-hexene               |                         | C <sub>7</sub> H <sub>14</sub>                 | 4914-89-0   | 98.186   |               |        | 95.4                                | 0.7079 <sup>25</sup>       | 1.4126 <sup>20</sup> |                                                        |
| 7353 | <i>trans</i> -3-Methyl-3-hexene             |                         | C <sub>7</sub> H <sub>14</sub>                 | 3899-36-3   | 98.186   |               |        | 93.5                                | 0.7050 <sup>25</sup>       | 1.4109 <sup>20</sup> |                                                        |
| 7354 | Methyl 3-hexenoate                          |                         | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>  | 2396-78-3   | 128.169  |               |        | 67 <sup>34</sup>                    | 0.9132 <sup>25</sup>       | 1.4240 <sup>23</sup> |                                                        |
| 7355 | 5-Methyl-3-hexen-2-one                      | 2-Oxo-5-methylhex-3-ene | C <sub>7</sub> H <sub>12</sub> O               | 5166-53-0   | 112.169  |               |        | 77 <sup>30</sup> , 65 <sup>13</sup> | 0.8549 <sup>28</sup>       | 1.4395 <sup>22</sup> |                                                        |
| 7356 | 5-Methyl-5-hexen-2-one                      |                         | C <sub>7</sub> H <sub>12</sub> O               | 3240-09-3   | 112.169  |               |        | 150                                 | 0.8460 <sup>20</sup>       | 1.4348 <sup>20</sup> | vs ace, eth, EtOH                                      |
| 7357 | 5-Methyl-1-hexyne                           |                         | C <sub>7</sub> H <sub>12</sub>                 | 2203-80-7   | 96.170   | liq           | -125   | 92                                  | 0.7274 <sup>20</sup>       | 1.4059 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl, peth         |
| 7358 | 5-Methyl-2-hexyne                           |                         | C <sub>7</sub> H <sub>12</sub>                 | 53566-37-3  | 96.170   | liq           | -92.9  | 102.5                               | 0.7378 <sup>20</sup>       | 1.4176 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace, bz, chl, peth          |
| 7359 | 2-Methyl-3-hexyne                           |                         | C <sub>7</sub> H <sub>12</sub>                 | 36566-80-0  | 96.170   | liq           | -116.7 | 95.2                                | 0.7263 <sup>20</sup>       | 1.4120 <sup>20</sup> | vs bz, eth, chl, peth                                  |
| 7360 | Methyl 2-hexynoate                          |                         | C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>  | 18937-79-6  | 126.153  |               |        | 80 <sup>23</sup>                    | 0.9648 <sup>25</sup>       |                      |                                                        |

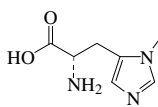




| No.  | Name                                                 | Synonym                                            | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form               | mp/°C  | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|------------------------------------------------------|----------------------------------------------------|--------------------------------------------------------------|------------|----------|-----------------------------|--------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 7361 | <i>L</i> -1-Methylhistidine                          |                                                    | C <sub>7</sub> H <sub>11</sub> N <sub>3</sub> O <sub>2</sub> | 332-80-9   | 169.181  | pl (DMF aq)                 | 249    |                                      |                            |                      |                                                      |
| 7362 | <i>L</i> -3-Methylhistidine                          |                                                    | C <sub>7</sub> H <sub>11</sub> N <sub>3</sub> O <sub>2</sub> | 368-16-1   | 169.181  |                             | 250    |                                      |                            |                      |                                                      |
| 7363 | Methylhydrazine                                      |                                                    | CH <sub>6</sub> N <sub>2</sub>                               | 60-34-4    | 46.072   | liq                         | -52.36 | 87.5                                 |                            | 1.4325 <sup>20</sup> | s H <sub>2</sub> O, eth, ctc;<br>msc EtOH; i lig     |
| 7364 | Methyl hydrazinecarboxylate                          | Methyl carbazate                                   | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>  | 6294-89-9  | 90.081   |                             | 73     | 108 <sup>12</sup>                    |                            |                      | s H <sub>2</sub> O, EtOH; sl<br>bz; i peth           |
| 7365 | Methyl hydrogen succinate                            | Monomethyl succinate                               | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                 | 3878-55-5  | 132.116  |                             | 58     | 151 <sup>20</sup> , 122 <sup>4</sup> |                            |                      | s H <sub>2</sub> O                                   |
| 7366 | Methyl hydroperoxide                                 | Methyl hydrogen peroxide                           | CH <sub>4</sub> O <sub>2</sub>                               | 3031-73-0  | 48.042   | liq                         | -72    | 86; 39 <sup>65</sup>                 | 1.9967 <sup>15</sup>       | 1.3641 <sup>15</sup> | vs H <sub>2</sub> O, bz, eth,<br>EtOH                |
| 7367 | Methyl hydroxyacetate                                |                                                    | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                 | 96-35-5    | 90.078   |                             |        | 149; 52 <sup>17</sup>                | 1.1677 <sup>18</sup>       |                      | s H <sub>2</sub> O; msc<br>EtOH, eth                 |
| 7368 | Methyl 3-hydroxybenzoate                             |                                                    | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | 19438-10-9 | 152.148  | nd (bz-peth)                | 73     | 281; 178 <sup>17</sup>               | 1.1528 <sup>100</sup>      |                      | s EtOH, bz,<br>peth; sl chl                          |
| 7369 | Methyl 4-hydroxybenzoate                             | Methylparaben                                      | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | 99-76-3    | 152.148  | nd (dil al)                 | 131    | dec 275                              |                            |                      | sl H <sub>2</sub> O; vs EtOH,<br>eth, ace; s tfa     |
| 7370 | Methyl α-hydroxydiphenylacetate                      | Methyl diphenylglycolate                           | C <sub>15</sub> H <sub>14</sub> O <sub>3</sub>               | 76-89-1    | 242.270  | mcl or tcl cry<br>(al)      | 75.8   | 187 <sup>13</sup>                    |                            |                      | vs eth, EtOH                                         |
| 7371 | <i>O</i> -Methylhydroxylamine                        | Methoxyamine                                       | CH <sub>3</sub> NO                                           | 67-62-9    | 47.057   |                             |        | 49                                   |                            |                      |                                                      |
| 7372 | <i>O</i> -Methylhydroxylamine hydrochloride          | Methoxyamine hydrochloride                         | CH <sub>6</sub> ClNO                                         | 593-56-6   | 83.518   | pr                          | 150.0  |                                      |                            |                      | vs H <sub>2</sub> O, EtOH                            |
| 7373 | Methyl 4-hydroxy-3-methoxybenzoate                   |                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                | 3943-74-6  | 182.173  | nd (dil al)                 | 64     | 286                                  |                            |                      | s EtOH, peth; sl<br>chl                              |
| 7374 | Methyl 2-hydroxy-3-methylbenzoate                    |                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                | 23287-26-5 | 166.173  |                             | 29     | 235                                  | 1.1683 <sup>25</sup>       | 1.5354 <sup>16</sup> |                                                      |
| 7375 | Methyl 2-hydroxy-5-methylbenzoate                    |                                                    | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                | 22717-57-3 | 166.173  | liq                         | -1     | 244.5                                | 1.1673 <sup>25</sup>       | 1.5351 <sup>15</sup> |                                                      |
| 7376 | Methyl 2-hydroxy-2-methylpropanoate                  | Methyl 2-methylactate                              | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>                | 2110-78-3  | 118.131  |                             |        | 137                                  |                            | 1.4056 <sup>20</sup> | vs H <sub>2</sub> O, EtOH                            |
| 7377 | Methyl 3-hydroxy-2-naphthalenecarboxylate            | Methyl 3-hydroxy-2-naphthoate                      | C <sub>12</sub> H <sub>10</sub> O <sub>3</sub>               | 883-99-8   | 202.205  | paye orth nd<br>(dil MeOH)  | 75.5   | 206                                  |                            |                      | i H <sub>2</sub> O; s EtOH                           |
| 7378 | Methyl α-hydroxyphenylacetate, (±)                   | (±)-Methyl mandelate                               | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                | 4358-87-6  | 166.173  | pl (bz-lig)                 | 58     | dec 250; 144 <sup>20</sup>           | 1.1756 <sup>20</sup>       |                      | vs EtOH, chl                                         |
| 7379 | 1-Methylimidazol                                     |                                                    | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>                 | 616-47-7   | 82.104   | liq                         | -6     | 195.5                                | 1.0325 <sup>20</sup>       | 1.4970 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth,<br>EtOH               |
| 7380 | 2-Methyl-1 <i>H</i> -imidazole                       |                                                    | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>                 | 693-98-1   | 82.104   |                             | 144    | 267                                  |                            |                      | vs H <sub>2</sub> O, EtOH                            |
| 7381 | 4-Methyl-1 <i>H</i> -imidazole                       |                                                    | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>                 | 822-36-6   | 82.104   |                             | 56     | 263                                  | 1.0416 <sup>14</sup>       | 1.5037 <sup>14</sup> | vs H <sub>2</sub> O, EtOH                            |
| 7382 | <i>N</i> -Methyliminodiacetic acid                   | <i>N</i> -(Carboxymethyl)- <i>N</i> -methylglycine | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                | 4408-64-4  | 147.130  | cry (w)                     | 226    |                                      |                            |                      | s H <sub>2</sub> O; i EtOH,<br>eth                   |
| 7383 | 1-Methyl-1 <i>H</i> -indene                          |                                                    | C <sub>10</sub> H <sub>10</sub>                              | 767-59-9   | 130.186  |                             |        | 199; 82 <sup>15</sup>                | 0.970 <sup>25</sup>        | 1.5616 <sup>20</sup> |                                                      |
| 7384 | 2-Methyl-1 <i>H</i> -indene                          |                                                    | C <sub>10</sub> H <sub>10</sub>                              | 2177-47-1  | 130.186  |                             | 80     | 208                                  | 0.974 <sup>25</sup>        | 1.5652 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace,<br>bz                |
| 7385 | 3-Methyl-1 <i>H</i> -indene                          |                                                    | C <sub>10</sub> H <sub>10</sub>                              | 767-60-2   | 130.186  |                             |        | 198                                  | 0.972 <sup>25</sup>        | 1.5621 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace,<br>bz                |
| 7386 | 1-Methyl-1 <i>H</i> -indole                          |                                                    | C <sub>9</sub> H <sub>9</sub> N                              | 603-76-9   | 131.174  |                             |        | 237                                  | 1.0707 <sup>25</sup>       |                      | i H <sub>2</sub> O; s EtOH,<br>eth, bz               |
| 7387 | 2-Methyl-1 <i>H</i> -indole                          |                                                    | C <sub>9</sub> H <sub>9</sub> N                              | 95-20-5    | 131.174  | pl (dil al) nd<br>or lf (w) | 61     | 272                                  | 1.07 <sup>20</sup>         |                      | sl H <sub>2</sub> O; vs EtOH,<br>eth; s ace, bz      |
| 7388 | 3-Methyl-1 <i>H</i> -indole                          | Skatole                                            | C <sub>9</sub> H <sub>9</sub> N                              | 83-34-1    | 131.174  | lf (lig)                    | 97.5   | 266                                  |                            |                      | s H <sub>2</sub> O, EtOH,<br>eth, ace, bz,<br>chl    |
| 7389 | 5-Methyl-1 <i>H</i> -indole                          |                                                    | C <sub>9</sub> H <sub>9</sub> N                              | 614-96-0   | 131.174  |                             | 60     | 267                                  | 1.0202 <sup>78</sup>       |                      | s H <sub>2</sub> O, EtOH,<br>eth, bz, lig            |
| 7390 | 7-Methyl-1 <i>H</i> -indole                          |                                                    | C <sub>9</sub> H <sub>9</sub> N                              | 933-67-5   | 131.174  |                             | 85     | 266                                  | 1.0202 <sup>100</sup>      |                      |                                                      |
| 7391 | Methyl 2-iodobenzoate                                |                                                    | C <sub>8</sub> H <sub>7</sub> I O <sub>2</sub>               | 610-97-9   | 262.045  |                             |        | 280; 146 <sup>16</sup>               |                            | 1.6052 <sup>20</sup> | s EtOH                                               |
| 7392 | Methyl 3-iodobenzoate                                |                                                    | C <sub>8</sub> H <sub>7</sub> I O <sub>2</sub>               | 618-91-7   | 262.045  | nd (dil al)                 | 54.5   | 277; 150 <sup>18</sup>               |                            |                      | i H <sub>2</sub> O, lig; s<br>EtOH; vs eth,<br>ace   |
| 7393 | Methyl 4-iodobenzoate                                |                                                    | C <sub>8</sub> H <sub>7</sub> I O <sub>2</sub>               | 619-44-3   | 262.045  | nd (eth-al)                 | 114.8  | sub                                  | 2.0200 <sup>10</sup>       |                      | s EtOH, eth                                          |
| 7394 | 5-Methyl-1,3-isobenzofurandione                      |                                                    | C <sub>9</sub> H <sub>6</sub> O <sub>3</sub>                 | 19438-61-0 | 162.142  |                             | 93.0   | 295                                  |                            |                      |                                                      |
| 7395 | Methyl isobutanoate                                  |                                                    | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | 547-63-7   | 102.132  | liq                         | -84.7  | 92.5                                 | 0.8906 <sup>20</sup>       | 1.3840 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ace, ctc |
| 7396 | Methyl isocyanate                                    |                                                    | C <sub>2</sub> H <sub>3</sub> NO                             | 624-83-9   | 57.051   | liq                         | -45    | 38.3                                 | 0.9588 <sup>20</sup>       | 1.3694 <sup>20</sup> | vs H <sub>2</sub> O                                  |
| 7397 | 2-Methyl-1 <i>H</i> -isindole-1,3(2 <i>H</i> )-dione |                                                    | C <sub>9</sub> H <sub>7</sub> NO <sub>2</sub>                | 550-44-7   | 161.158  | nd (al), lf<br>(sub)        | 134    | 286                                  |                            |                      | i H <sub>2</sub> O; sl EtOH                          |
| 7398 | Methyl isopentanoate                                 | Methyl isovalerate                                 | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                | 556-24-1   | 116.158  |                             |        | 116.5                                | 0.8808 <sup>20</sup>       | 1.3927 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth, ace             |
| 7399 | 6-Methyl- <i>N</i> -isopentyl-2-heptanamine          | Octamylamine                                       | C <sub>13</sub> H <sub>29</sub> N                            | 502-59-0   | 199.376  |                             |        | 100 <sup>7</sup>                     |                            |                      |                                                      |
| 7400 | 2-Methyl-5-isopropylaniline                          |                                                    | C <sub>10</sub> H <sub>15</sub> N                            | 2051-53-8  | 149.233  | liq                         | -16    | 241                                  | 0.9942 <sup>20</sup>       | 1.5387 <sup>20</sup> | s ctc, CS <sub>2</sub>                               |
| 7401 | α-Methyl-4-isopropylbenzenepropanal                  | 3- <i>p</i> -Cumenyl-2-methylpropionaldehyde       | C <sub>13</sub> H <sub>18</sub> O                            | 103-95-7   | 190.281  |                             |        | 270; 135 <sup>99</sup>               | 0.9459 <sup>20</sup>       | 1.5068 <sup>20</sup> | vs bz, eth, EtOH                                     |
| 7402 | 2-Methyl-5-isopropylbicyclo[3.1.0]hex-2-ene          |                                                    | C <sub>10</sub> H <sub>16</sub>                              | 2867-05-2  | 136.234  |                             |        | 151                                  | 0.8301 <sup>20</sup>       | 1.4515 <sup>20</sup> |                                                      |



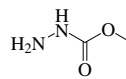
L-1-Methylhistidine



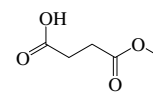
L-3-Methylhistidine



Methylhydrazine



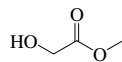
Methyl hydrazinecarboxylate



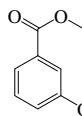
Methyl hydrogen succinate



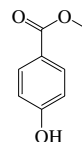
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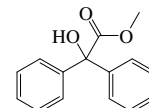
Methyl hydroxyacetate



Methyl 3-hydroxybenzoate



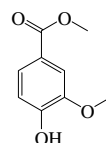
Methyl 4-hydroxybenzoate

Methyl  $\alpha$ -hydroxydiphenylacetate

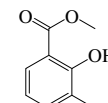
O-Methylhydroxylamine



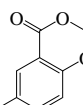
O-Methylhydroxylamine hydrochloride



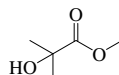
Methyl 4-hydroxy-3-methoxybenzoate



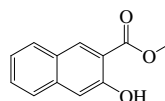
Methyl 2-hydroxy-3-methylbenzoate



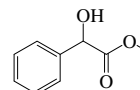
Methyl 2-hydroxy-5-methylbenzoate



Methyl 2-hydroxy-2-methylpropanoate



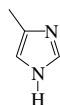
Methyl 3-hydroxy-2-naphthalenecarboxylate

Methyl  $\alpha$ -hydroxyphenylacetate, ( $\pm$ )

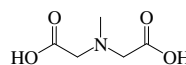
1-Methylimidazole



2-Methyl-1H-imidazole



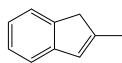
4-Methyl-1H-imidazole



N-Methyliminodiacetic acid



1-Methyl-1H-indene



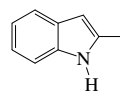
2-Methyl-1H-indene



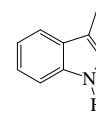
3-Methyl-1H-indene



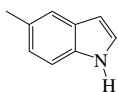
1-Methyl-1H-indole



2-Methyl-1H-indole



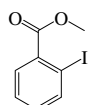
3-Methyl-1H-indole



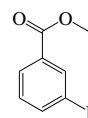
5-Methyl-1H-indole



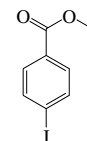
7-Methyl-1H-indole



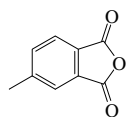
Methyl 2-iodobenzoate



Methyl 3-iodobenzoate



Methyl 4-iodobenzoate



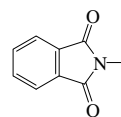
5-Methyl-1,3-isobenzofurandione



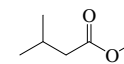
Methyl isobutanoate



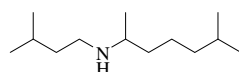
Methyl isocyanate



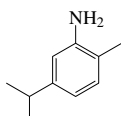
2-Methyl-1H-isindole-1,3(2H)-dione



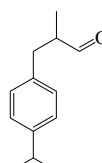
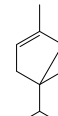
Methyl isopentanoate



6-Methyl-N-isopentyl-2-heptanamine

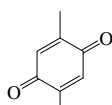


2-Methyl-5-isopropylaniline

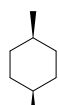
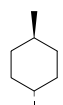
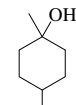
 $\alpha$ -Methyl-4-isopropylbenzenepropanal

2-Methyl-5-isopropylbicyclo[3.1.0]hex-2-ene

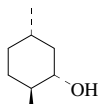
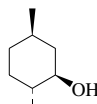
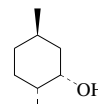
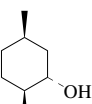
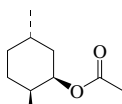
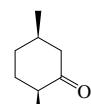
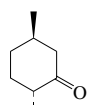
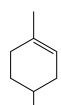
| No.  | Name                                                                                         | Synonym                               | Mol. Form.                                      | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                      |
|------|----------------------------------------------------------------------------------------------|---------------------------------------|-------------------------------------------------|------------|----------|---------------------------|---------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------------------|
| 7403 | 2-Methyl-5-isopropyl-2,5-cyclohexadiene-1,4-dione                                            |                                       | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>  | 490-91-5   | 164.201  |                           | 45.5    | 232                                   |                            |                      | s chl                                                           |
| 7404 | <i>cis</i> -1-Methyl-4-isopropylcyclohexane                                                  |                                       | C <sub>10</sub> H <sub>20</sub>                 | 6069-98-3  | 140.266  | liq                       | -89.9   | 172                                   | 0.8039 <sup>20</sup>       | 1.4431 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz, peth                    |
| 7405 | <i>trans</i> -1-Methyl-4-isopropylcyclohexane                                                | <i>trans</i> - <i>p</i> -Menthane     | C <sub>10</sub> H <sub>20</sub>                 | 1678-82-6  | 140.266  | oil                       | -86.3   | 170.6                                 | 0.7928 <sup>20</sup>       | 1.4366 <sup>20</sup> | vs bz, eth, EtOH, lig                                           |
| 7406 | 1-Methyl-4-isopropylcyclohexanol                                                             |                                       | C <sub>10</sub> H <sub>20</sub> O               | 21129-27-1 | 156.265  |                           |         | 208.5                                 | 0.90 <sup>20</sup>         | 1.4619 <sup>20</sup> |                                                                 |
| 7407 | 5-Methyl-2-isopropylcyclohexanol, [1 <i>S</i> -(1 $\alpha$ ,2 $\beta$ ,5 $\alpha$ )]-        | (+)-Menthol                           | C <sub>10</sub> H <sub>20</sub> O               | 15356-60-2 | 156.265  |                           | 39      | 103 <sup>9</sup>                      |                            |                      | vs ace, bz, eth, EtOH                                           |
| 7408 | 5-Methyl-2-isopropylcyclohexanol, [1 <i>R</i> -(1 $\alpha$ ,2 $\beta$ ,5 $\alpha$ )]-        | (-)-Menthol                           | C <sub>10</sub> H <sub>20</sub> O               | 2216-51-5  | 156.265  | nd (MeOH)                 | 43      | 216                                   | 0.903 <sup>15</sup>        | 1.460 <sup>22</sup>  | sl H <sub>2</sub> O; vs EtOH, eth, ace, bz; s peth              |
| 7409 | 5-Methyl-2-isopropylcyclohexanol, [1 <i>S</i> -(1 $\alpha$ ,2 $\alpha$ ,5 $\beta$ )]-        | (+)-Neomenthol                        | C <sub>10</sub> H <sub>20</sub> O               | 2216-52-6  | 156.265  | oil                       | -22     | 211.7                                 | 0.897 <sup>22</sup>        | 1.4600 <sup>20</sup> | vs ace, EtOH                                                    |
| 7410 | 5-Methyl-2-isopropylcyclohexanol, [1 <i>S</i> -(1 $\alpha$ ,2 $\beta$ ,5 $\beta$ )]-         | (+)-Isomenthol                        | C <sub>10</sub> H <sub>20</sub> O               | 23283-97-8 | 156.265  | nd(dil al)                | 82.5    | 218                                   |                            |                      | vs eth, EtOH                                                    |
| 7411 | 5-Methyl-2-isopropylcyclohexanol acetate, [1 <i>R</i> -(1 $\alpha$ ,2 $\alpha$ ,5 $\beta$ )] |                                       | C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>  | 2623-23-6  | 198.302  |                           |         | 222; 109 <sup>10</sup>                | 0.9244 <sup>20</sup>       | 1.4469 <sup>20</sup> |                                                                 |
| 7412 | <i>cis</i> -5-Methyl-2-isopropylcyclohexanone                                                | Menthone                              | C <sub>10</sub> H <sub>18</sub> O               | 491-07-6   | 154.249  |                           |         | 205; 89 <sup>15</sup>                 | 0.8995 <sup>20</sup>       | 1.4527 <sup>20</sup> |                                                                 |
| 7413 | <i>trans</i> -5-Methyl-2-isopropylcyclohexanone, (2 <i>S</i> )                               | <i>l</i> -Menthone                    | C <sub>10</sub> H <sub>18</sub> O               | 14073-97-3 | 154.249  | liq                       | -6      | 207                                   | 0.8954 <sup>20</sup>       | 1.4505 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, bz, CS <sub>2</sub> ; s ace |
| 7414 | 1-Methyl-4-isopropylcyclohexene                                                              |                                       | C <sub>10</sub> H <sub>18</sub>                 | 5502-88-5  | 138.250  |                           |         | 174.5                                 | 0.8457 <sup>15</sup>       | 1.4735 <sup>20</sup> |                                                                 |
| 7415 | 3-Methyl-6-isopropyl-2-cyclohexen-1-ol                                                       |                                       | C <sub>10</sub> H <sub>18</sub> O               | 491-04-3   | 154.249  |                           |         | 97 <sup>15.5</sup>                    | 0.9119 <sup>25</sup>       | 1.4729 <sup>25</sup> |                                                                 |
| 7416 | 4-Methyl-1-isopropyl-3-cyclohexen-1-ol                                                       |                                       | C <sub>10</sub> H <sub>18</sub> O               | 562-74-3   | 154.249  |                           |         | 209                                   | 0.926 <sup>20</sup>        | 1.4785 <sup>19</sup> |                                                                 |
| 7417 | 5-Methyl-2-isopropylcyclohexyl ethoxyacetate, (1 $\alpha$ ,2 $\beta$ ,5 $\alpha$ )           |                                       | C <sub>14</sub> H <sub>26</sub> O <sub>3</sub>  | 579-94-2   | 242.354  |                           |         | 155 <sup>20</sup> , 144 <sup>14</sup> | 0.9545 <sup>20</sup>       |                      | vs eth, EtOH, chl                                               |
| 7418 | 1-Methyl-4-isopropyl-2-nitrobenzene                                                          |                                       | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub> | 943-15-7   | 179.216  |                           |         | 126 <sup>10</sup>                     | 1.0744 <sup>20</sup>       | 1.5301 <sup>20</sup> | vs eth, EtOH                                                    |
| 7419 | 1-Methyl-4-isopropyl-7-oxabicyclo[2.2.1]heptane                                              |                                       | C <sub>10</sub> H <sub>18</sub> O               | 470-67-7   | 154.249  |                           | 1       | 173.5                                 | 0.8997 <sup>20</sup>       | 1.4562 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s bz, lig                   |
| 7420 | 1-Methyl-7-isopropylphenanthrene                                                             | Retene                                | C <sub>18</sub> H <sub>18</sub>                 | 483-65-8   | 234.336  |                           | 101     | 390                                   | 1.035 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, bz, CS <sub>2</sub> , HOAc     |
| 7421 | 4-Methyl-2-isopropylphenol                                                                   |                                       | C <sub>10</sub> H <sub>14</sub> O               | 4427-56-9  | 150.217  | nd (HOAc)                 | 36.5    | 228.5                                 | 0.9910 <sup>20</sup>       | 1.5275 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, bz, chl                            |
| 7422 | 5-Methyl-2-isopropylphenyl acetate                                                           | Thymol, acetate                       | C <sub>12</sub> H <sub>16</sub> O <sub>2</sub>  | 528-79-0   | 192.254  |                           |         | 245                                   | 1.009 <sup>9</sup>         |                      | vs bz, eth, EtOH, chl                                           |
| 7423 | 1-Methylisoquinoline                                                                         | Isoquinaldine                         | C <sub>10</sub> H <sub>9</sub> N                | 1721-93-3  | 143.185  |                           | 10      | 248                                   | 1.0777 <sup>20</sup>       | 1.6095 <sup>20</sup> | sl H <sub>2</sub> O; s eth, ace, bz                             |
| 7424 | 3-Methylisoquinoline                                                                         |                                       | C <sub>10</sub> H <sub>9</sub> N                | 1125-80-0  | 143.185  | cry (eth)                 | 68      | 249                                   |                            |                      | sl H <sub>2</sub> O, chl; s eth, ace                            |
| 7425 | Methyl isothiocyanate                                                                        |                                       | C <sub>2</sub> H <sub>3</sub> NS                | 556-61-6   | 73.117   |                           | 36      | 119                                   | 1.0691 <sup>37</sup>       | 1.5258               | sl H <sub>2</sub> O; msc EtOH; vs eth                           |
| 7426 | 5-Methyl-3-isoxazoline                                                                       |                                       | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O  | 1072-67-9  | 98.103   |                           | 62      |                                       |                            |                      |                                                                 |
| 7427 | 4-Methylisoxazole                                                                            |                                       | C <sub>4</sub> H <sub>5</sub> NO                | 6454-84-8  | 83.089   | liq                       |         | 127                                   |                            |                      |                                                                 |
| 7428 | 5-Methylisoxazole                                                                            |                                       | C <sub>4</sub> H <sub>5</sub> NO                | 5765-44-6  | 83.089   |                           |         | 122                                   | 1.023 <sup>20</sup>        | 1.4386 <sup>20</sup> | s DMSO                                                          |
| 7429 | Methyl lactate, ( $\pm$ )                                                                    | Methyl 2-hydroxypropanoate, ( $\pm$ ) | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>    | 2155-30-8  | 104.105  | oil                       |         | 144.8                                 | 1.0928 <sup>20</sup>       | 1.4141 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                                  |
| 7430 | Methyl linoleate                                                                             |                                       | C <sub>19</sub> H <sub>34</sub> O <sub>2</sub>  | 112-63-0   | 294.472  |                           | -35     | 215 <sup>20</sup>                     | 0.8886 <sup>10</sup>       | 1.4638 <sup>20</sup> | vs eth, EtOH                                                    |
| 7431 | Methyl linolenate                                                                            |                                       | C <sub>19</sub> H <sub>32</sub> O <sub>2</sub>  | 301-00-8   | 292.456  |                           | -45.5   | 207 <sup>14</sup> , 182 <sup>3</sup>  | 0.895 <sup>25</sup>        | 1.4709 <sup>20</sup> |                                                                 |
| 7432 | Methyl magnesium bromide                                                                     | Bromomethylmagnesium                  | CH <sub>3</sub> BrMg                            | 75-16-1    | 119.244  |                           |         |                                       |                            |                      | s eth, thf; i hx, bz                                            |
| 7433 | Methylmagnesium chloride                                                                     | Chloromethylmagnesium                 | CH <sub>3</sub> ClMg                            | 676-58-4   | 74.793   | stab in thf soln          |         |                                       |                            |                      | i peth, bz                                                      |
| 7434 | Methylmalonic acid                                                                           |                                       | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>    | 516-05-2   | 118.089  | nd (bz-AcOEt) pr (eth-bz) | 135 dec |                                       | 1.455 <sup>20</sup>        |                      | vs H <sub>2</sub> O, EtOH, eth; sl bz, tfa; s AcOEt             |
| 7435 | Methyl mercaptoacetate                                                                       |                                       | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> S  | 2365-48-2  | 106.144  |                           |         | 42 <sup>10</sup>                      |                            | 1.4657 <sup>20</sup> | vs eth, EtOH                                                    |
| 7436 | Methyl 3-mercaptopropanoate                                                                  |                                       | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S  | 2935-90-2  | 120.171  |                           |         | 54 <sup>14</sup>                      | 1.085 <sup>25</sup>        | 1.4640 <sup>20</sup> |                                                                 |
| 7437 | Methylmercuric dicyanamide                                                                   | 1-Cyano-3-(methylmercurio) guanidine  | C <sub>3</sub> H <sub>6</sub> HgN <sub>4</sub>  | 502-39-6   | 298.70   |                           | 157     |                                       |                            |                      |                                                                 |
| 7438 | Methyl methacrylate                                                                          |                                       | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>    | 80-62-6    | 100.117  | liq                       | -47.55  | 100.5                                 | 0.9377 <sup>25</sup>       | 1.4142 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, ace; s chl                  |
| 7439 | Methyl methanesulfonate                                                                      |                                       | C <sub>2</sub> H <sub>6</sub> O <sub>3</sub> S  | 66-27-3    | 110.132  |                           | 20      | 202.5                                 | 1.2943 <sup>20</sup>       | 1.4138 <sup>20</sup> |                                                                 |
| 7440 | Methyl methoxyacetate                                                                        |                                       | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>    | 6290-49-9  | 104.105  |                           |         | 131                                   | 1.0511 <sup>20</sup>       | 1.3962 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth, ace                          |



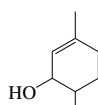
2-Methyl-5-isopropyl-2,5-cyclohexadiene-1,4-dione

*cis*-1-Methyl-4-isopropylcyclohexane*trans*-1-Methyl-4-isopropylcyclohexane

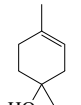
1-Methyl-4-isopropylcyclohexanol

5-Methyl-2-isopropylcyclohexanol, [1*S*-(1 $\alpha$ ,2 $\beta$ ,5 $\alpha$ )]-5-Methyl-2-isopropylcyclohexanol, [1*R*-(1 $\alpha$ ,2 $\beta$ ,5 $\alpha$ )]-5-Methyl-2-isopropylcyclohexanol, [1*S*-(1 $\alpha$ ,2 $\alpha$ ,5 $\beta$ )]-5-Methyl-2-isopropylcyclohexanol, [1*S*-(1 $\alpha$ ,2 $\beta$ ,5 $\beta$ )]-5-Methyl-2-isopropylcyclohexanol acetate, [1*R*-(1 $\alpha$ ,2 $\alpha$ ,5 $\beta$ )]*cis*-5-Methyl-2-isopropylcyclohexanone*trans*-5-Methyl-2-isopropylcyclohexanone, (2*S*)

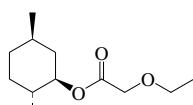
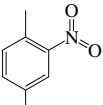
1-Methyl-4-isopropylcyclohexene



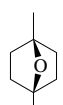
3-Methyl-6-isopropyl-2-cyclohexen-1-ol



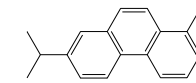
4-Methyl-1-isopropyl-3-cyclohexen-1-ol

5-Methyl-2-isopropylcyclohexyl ethoxyacetate, (1 $\alpha$ ,2 $\beta$ ,5 $\alpha$ )

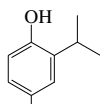
1-Methyl-4-isopropyl-2-nitrobenzene



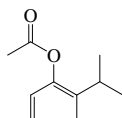
1-Methyl-4-isopropyl-7-oxabicyclo[2.2.1]heptane



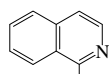
1-Methyl-7-isopropylphenanthrene



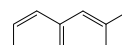
4-Methyl-2-isopropylphenol



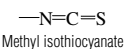
5-Methyl-2-isopropylphenyl acetate



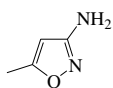
1-Methylisoquinoline



3-Methylisoquinoline



Methyl isothiocyanate



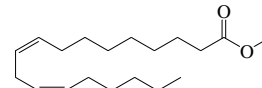
5-Methyl-3-isoxazolamine



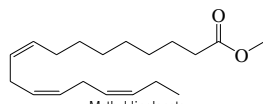
4-Methylisoxazole



5-Methylisoxazole

Methyl lactate, ( $\pm$ )

Methyl linoleate



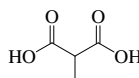
Methyl linolenate



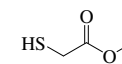
Methyl magnesium bromide



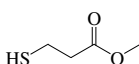
Methylmagnesium chloride



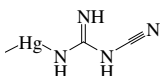
Methylmalonic acid



Methyl mercaptoacetate



Methyl 3-mercaptopropanoate



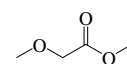
Methylmercuric dicyanamide



Methyl methacrylate

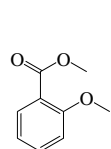


Methyl methanesulfonate

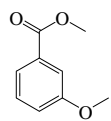


Methyl methoxyacetate

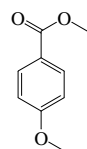
| No.  | Name                                                                     | Synonym                              | Mol. Form.                                                  | CAS RN     | Mol. Wt. | Physical Form              | mp/°C  | bp/°C                                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|------|--------------------------------------------------------------------------|--------------------------------------|-------------------------------------------------------------|------------|----------|----------------------------|--------|-----------------------------------------|----------------------------|----------------------|---------------------------------------------------|
| 7441 | Methyl 2-methoxybenzoate                                                 |                                      | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>               | 606-45-1   | 166.173  |                            |        | 246.5                                   | 1.1571 <sup>19</sup>       | 1.534 <sup>19</sup>  | i H <sub>2</sub> O; s EtOH                        |
| 7442 | Methyl 3-methoxybenzoate                                                 |                                      | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>               | 5368-81-0  | 166.173  |                            |        | 248                                     | 1.1310 <sup>20</sup>       | 1.5224 <sup>20</sup> | i H <sub>2</sub> O; s EtOH                        |
| 7443 | Methyl 4-methoxybenzoate                                                 |                                      | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>               | 121-98-2   | 166.173  | lf (al or eth)             | 49     | 244                                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl              |
| 7444 | Methyl 3-methoxy-2-(methylamino)benzoate                                 | Damascenine                          | C <sub>10</sub> H <sub>13</sub> NO <sub>3</sub>             | 483-64-7   | 195.215  | pr (al)                    | 28     | 271; 147 <sup>10</sup>                  |                            |                      | vs bz, eth, EtOH, lig                             |
| 7445 | Methyl 3-methoxypropanoate                                               |                                      | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>               | 3852-09-3  | 118.131  |                            |        | 142.8                                   | 1.0139 <sup>15</sup>       | 1.4030 <sup>20</sup> |                                                   |
| 7446 | Methyl 2-methylacetoacetate                                              |                                      | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>               | 17094-21-2 | 130.141  |                            |        | 177.4                                   | 1.0217 <sup>25</sup>       | 1.416 <sup>24</sup>  | vs eth, EtOH                                      |
| 7447 | Methyl 2-(methylamino)benzoate                                           |                                      | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>              | 85-91-6    | 165.189  | cry (peth)                 | 19     | 255                                     | 1.120 <sup>15</sup>        | 1.5839 <sup>15</sup> | i H <sub>2</sub> O; s EtOH, eth                   |
| 7448 | Methyl 2-methylbenzoate                                                  |                                      | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>               | 89-71-4    | 150.174  |                            | <-50   | 215                                     | 1.068 <sup>20</sup>        |                      | i H <sub>2</sub> O; msc EtOH, eth                 |
| 7449 | Methyl 3-methylbenzoate                                                  |                                      | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>               | 99-36-5    | 150.174  |                            |        | 221                                     | 1.061 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH; sl ctc                |
| 7450 | Methyl 4-methylbenzoate                                                  |                                      | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>               | 99-75-2    | 150.174  | cry (aq MeOH, peth)        | 33.2   | 220                                     |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                  |
| 7451 | Methyl 2-methyl-2-butenolate, ( <i>E</i> )                               |                                      | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>               | 6622-76-0  | 114.142  |                            |        | 139                                     | 0.9349 <sup>12</sup>       | 1.4370 <sup>20</sup> |                                                   |
| 7452 | Methyl 3-methyl-2-butenolate                                             |                                      | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>               | 924-50-5   | 114.142  |                            | 114    | 136.5                                   | 0.9337 <sup>20</sup>       | 1.432 <sup>20</sup>  |                                                   |
| 7453 | 3-Methyl-4-methylenehexane                                               |                                      | C <sub>9</sub> H <sub>16</sub>                              | 3404-67-9  | 112.213  |                            |        | 112.5                                   | 0.725 <sup>25</sup>        | 1.414 <sup>20</sup>  |                                                   |
| 7454 | 2-Methyl-5-(1-methylethenyl)cyclohexanone, ( <i>2R-trans</i> )           |                                      | C <sub>10</sub> H <sub>16</sub> O                           | 5524-05-0  | 152.233  |                            |        | 221.5                                   | 0.928 <sup>19</sup>        | 1.4724               | vs ace, eth                                       |
| 7455 | 5-Methyl-2-(1-methylethylidene)cyclohexanone                             |                                      | C <sub>10</sub> H <sub>16</sub> O                           | 15932-80-6 | 152.233  |                            |        | 93 <sup>10</sup>                        | 0.9367 <sup>20</sup>       | 1.4869 <sup>20</sup> |                                                   |
| 7456 | 3-Methyl-6-(1-methylethylidene)-2-cyclohexen-1-one                       | Piperitenone                         | C <sub>10</sub> H <sub>14</sub> O                           | 491-09-8   | 150.217  |                            |        | 120 <sup>14</sup>                       | 0.9774 <sup>20</sup>       | 1.5294 <sup>20</sup> | vs EtOH, eth                                      |
| 7457 | 1-Methyl-4-(5-methyl-1-methylene-4-hexenyl)cyclohexene, ( <i>S</i> )     |                                      | C <sub>15</sub> H <sub>24</sub>                             | 495-61-4   | 204.352  |                            |        | 129 <sup>10</sup>                       | 0.8673 <sup>20</sup>       | 1.4880 <sup>20</sup> |                                                   |
| 7458 | <i>N</i> -Methyl- <i>N</i> -(2-methylphenyl)acetamide                    |                                      | C <sub>10</sub> H <sub>13</sub> NO                          | 573-26-2   | 163.216  |                            | 55.5   | 260                                     |                            |                      | s EtOH, chl                                       |
| 7459 | 4-Methyl- <i>N</i> -(4-methylphenyl)aniline                              |                                      | C <sub>14</sub> H <sub>15</sub> N                           | 620-93-9   | 197.276  | nd (peth)                  | 79.8   | 330.5                                   |                            |                      | vs eth, peth                                      |
| 7460 | 2-Methyl-3-(2-methylphenyl)-4(3 <i>H</i> )-quinazolinone                 | Methaqualone                         | C <sub>16</sub> H <sub>14</sub> N <sub>2</sub> O            | 72-44-6    | 250.294  |                            | 120    |                                         |                            |                      | vs eth, EtOH, chl                                 |
| 7461 | Methyl 3-(methylthio)propanoate                                          | 2-Methoxycarbonylthyl methyl sulfide | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub> S             | 13532-18-8 | 134.197  |                            |        | 75 <sup>13</sup> , 69 <sup>11</sup>     | 1.077 <sup>25</sup>        | 1.4650 <sup>20</sup> |                                                   |
| 7462 | 1-Methyl-4-(1-methylvinyl)benzene                                        |                                      | C <sub>10</sub> H <sub>12</sub>                             | 1195-32-0  | 132.202  | liq                        | -20    | 185.3                                   | 0.8936 <sup>23</sup>       | 1.5283 <sup>23</sup> |                                                   |
| 7463 | 1-Methyl-4-(1-methylvinyl)cyclohexanol                                   | β-Terpineol                          | C <sub>10</sub> H <sub>18</sub> O                           | 138-87-4   | 154.249  | nd                         | 32.5   | 210; 90 <sup>10</sup>                   | 0.917 <sup>20</sup>        | 1.4747 <sup>20</sup> |                                                   |
| 7464 | 5-Methyl-2-(1-methylvinyl)cyclohexanol, [1 <i>R</i> -(1α,2β,5α)]         |                                      | C <sub>10</sub> H <sub>18</sub> O                           | 89-79-2    | 154.249  |                            | 78     | 93 <sup>14</sup>                        | 0.911 <sup>20</sup>        | 1.4723 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                  |
| 7465 | 5-Methyl-2-(1-methylvinyl)cyclohexanol acetate, [1 <i>R</i> -(1α,2β,5α)] |                                      | C <sub>12</sub> H <sub>20</sub> O <sub>2</sub>              | 57576-09-7 | 196.286  |                            | 85     | 113 <sup>8</sup>                        | 0.925 <sup>25</sup>        | 1.4566 <sup>20</sup> |                                                   |
| 7466 | <i>trans</i> -5-Methyl-2-(1-methylvinyl)cyclohexanone                    |                                      | C <sub>10</sub> H <sub>16</sub> O                           | 29606-79-9 | 152.233  |                            |        | 100 <sup>18</sup>                       | 0.9198 <sup>20</sup>       | 1.4675 <sup>20</sup> |                                                   |
| 7467 | 2-Methyl-5-(1-methylvinyl)-2-cyclohexen-1-ol                             |                                      | C <sub>10</sub> H <sub>16</sub> O                           | 99-48-9    | 152.233  |                            |        | 228                                     | 0.9484 <sup>25</sup>       | 1.4942 <sup>25</sup> |                                                   |
| 7468 | 4-Methylmorpholine                                                       |                                      | C <sub>5</sub> H <sub>11</sub> NO                           | 109-02-4   | 101.147  | liq                        | -64.40 | 116                                     | 0.9051 <sup>20</sup>       | 1.4332 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth                     |
| 7469 | α-Methyl-4-morpholineethanol                                             |                                      | C <sub>7</sub> H <sub>15</sub> NO <sub>2</sub>              | 2109-66-2  | 145.200  |                            |        | 121 <sup>18</sup> , 93 <sup>13</sup>    | 1.0174 <sup>20</sup>       | 1.4638 <sup>20</sup> | vs H <sub>2</sub> O, ace, bz, EtOH                |
| 7470 | 1-Methylnaphthalene                                                      |                                      | C <sub>11</sub> H <sub>10</sub>                             | 90-12-0    | 142.197  | liq                        | -30.43 | 244.7                                   | 1.0202 <sup>20</sup>       | 1.6170 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz            |
| 7471 | 2-Methylnaphthalene                                                      |                                      | C <sub>11</sub> H <sub>10</sub>                             | 91-57-6    | 142.197  | mcl (al)                   | 34.6   | 241.1                                   | 1.0058 <sup>20</sup>       | 1.6015 <sup>40</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz, chl       |
| 7472 | Methyl 1-naphthalenecarboxylate                                          | Methyl 1-naphthoate                  | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>              | 2459-24-7  | 186.206  |                            | 59.5   | 168 <sup>20</sup> , 101 <sup>0.04</sup> | 1.1290 <sup>20</sup>       | 1.6086 <sup>20</sup> | vs bz, EtOH                                       |
| 7473 | Methyl 2-naphthalenecarboxylate                                          | Methyl 2-naphthoate                  | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>              | 2459-25-8  | 186.206  | lf (MeOH)                  | 77     | 290                                     |                            |                      | vs bz, eth, EtOH, chl                             |
| 7474 | 2-Methyl-1,4-naphthalenediol diacetate                                   | Menadiol diacetate                   | C <sub>15</sub> H <sub>14</sub> O <sub>4</sub>              | 573-20-6   | 258.270  | pr (al)                    | 113    |                                         |                            |                      | vs EtOH                                           |
| 7475 | 2-Methyl-1,4-naphthalenedione                                            | Menadione                            | C <sub>11</sub> H <sub>6</sub> O <sub>2</sub>               | 58-27-5    | 172.181  | ye nd (al, peth)           | 107    |                                         |                            |                      | i H <sub>2</sub> O; sl EtOH, HOAc; s eth, bz, chl |
| 7476 | Methyl-1-naphthylamine                                                   | <i>N</i> -Methyl-1-naphthalenamine   | C <sub>11</sub> H <sub>11</sub> N                           | 2216-68-4  | 157.212  | oil                        | 174    | 294.5                                   |                            | 1.6722 <sup>20</sup> | vs eth, EtOH                                      |
| 7477 | Methyl nitrate                                                           |                                      | CH <sub>3</sub> NO <sub>3</sub>                             | 598-58-3   | 77.040   | exp gas                    | -83.0  | exp 64.6                                | 1.2075 <sup>20</sup>       | 1.3748 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                  |
| 7478 | Methyl nitrite                                                           |                                      | CH <sub>3</sub> NO <sub>2</sub>                             | 624-91-9   | 61.041   | ye gas                     | -16    | -12                                     | 0.991 <sup>15</sup>        |                      | s EtOH, eth                                       |
| 7479 | Methyl nitroacetate                                                      |                                      | C <sub>3</sub> H <sub>5</sub> NO <sub>4</sub>               | 2483-57-0  | 119.077  |                            |        | 107 <sup>28</sup>                       | 1.320 <sup>0</sup>         |                      |                                                   |
| 7480 | 2-Methyl-3-nitroaniline                                                  |                                      | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> | 603-83-8   | 152.151  | ye orth nd (w), ye lf (al) | 92     | 305                                     | 1.3780 <sup>15</sup>       |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl         |



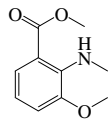
Methyl 2-methoxybenzoate



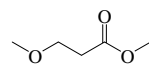
Methyl 3-methoxybenzoate



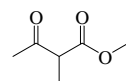
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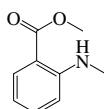
Methyl 3-methoxy-2-(methylamino)benzoate



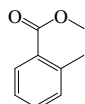
Methyl 3-methoxypropanoate



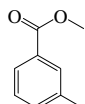
Methyl 2-methylacetoacetate



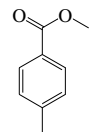
Methyl 2-(methylamino)benzoate



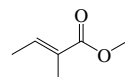
Methyl 2-methylbenzoate



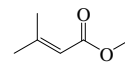
Methyl 3-methylbenzoate



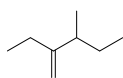
Methyl 4-methylbenzoate



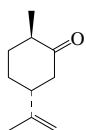
Methyl 2-methyl-2-butenate, (E)



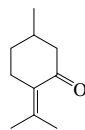
Methyl 3-methyl-2-butenate



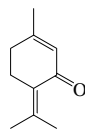
3-Methyl-4-methylenehexane



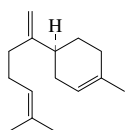
2-Methyl-5-(1-methylethenyl)cyclohexanone, (2R-trans)



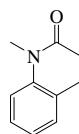
5-Methyl-2-(1-methylethylidene)cyclohexanone



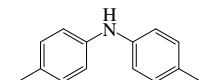
3-Methyl-6-(1-methylethylidene)-2-cyclohexen-1-one



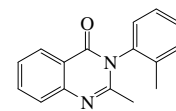
1-Methyl-4-(5-methyl-1-methylene-4-hexenyl)cyclohexene, (S)



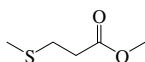
N-Methyl-N-(2-methylphenyl)acetamide



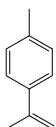
4-Methyl-N-(4-methylphenyl)aniline



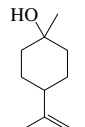
2-Methyl-3-(2-methylphenyl)-4(3H)-quinazolinone



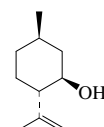
Methyl 3-(methylthio)propanoate



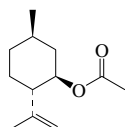
1-Methyl-4-(1-methylvinyl)benzene



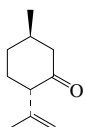
1-Methyl-4-(1-methylvinyl)cyclohexanol



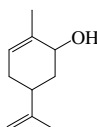
5-Methyl-2-(1-methylvinyl)cyclohexanol, [1R-(1α,2β,5α)]



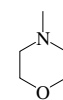
5-Methyl-2-(1-methylvinyl)cyclohexanol acetate, [1R-(1α,2β,5α)]



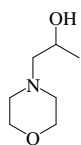
trans-5-Methyl-2-(1-methylvinyl)cyclohexanone



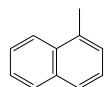
2-Methyl-5-(1-methylvinyl)-2-cyclohexen-1-ol



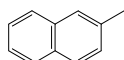
4-Methylmorpholine



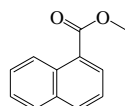
α-Methyl-4-morpholineethanol



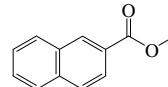
1-Methylnaphthalene



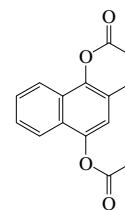
2-Methylnaphthalene



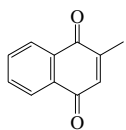
Methyl 1-naphthalenecarboxylate



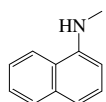
Methyl 2-naphthalenecarboxylate



2-Methyl-1,4-naphthalenediol diacetate



2-Methyl-1,4-naphthalenedione



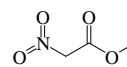
Methyl-1-naphthylamine



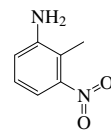
Methyl nitrate



Methyl nitrite

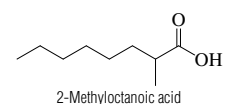
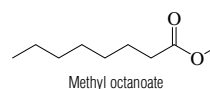
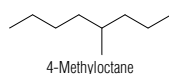
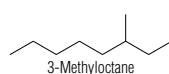
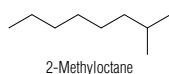
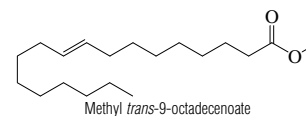
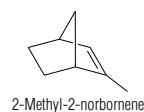
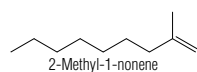
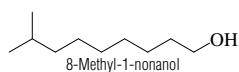
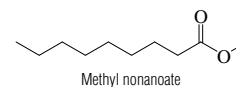
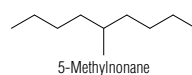
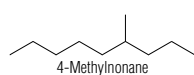
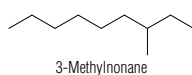
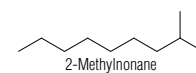
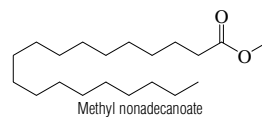
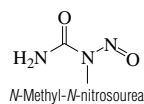
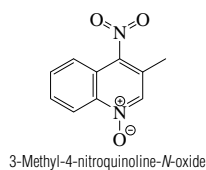
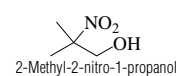
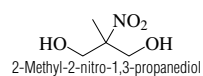
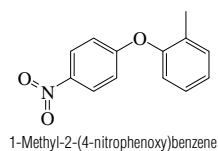
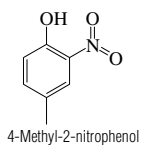
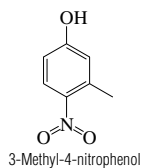
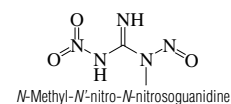
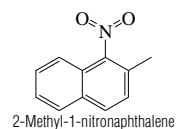
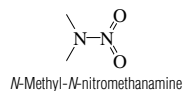
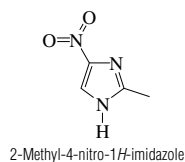
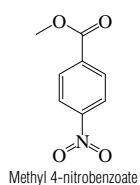
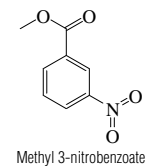
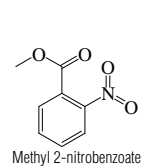
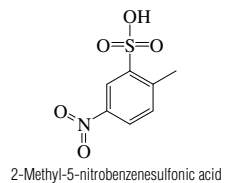
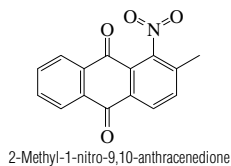
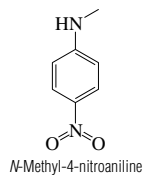
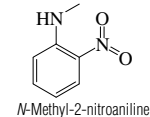
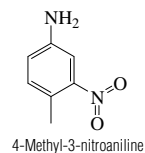
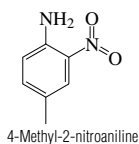
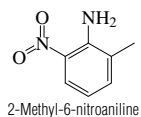
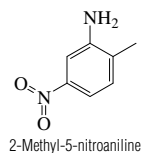
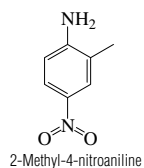


Methyl nitroacetate



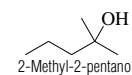
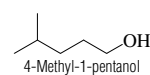
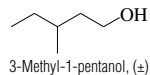
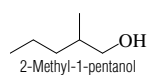
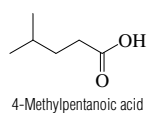
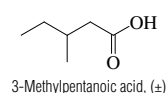
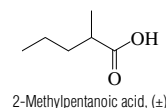
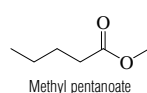
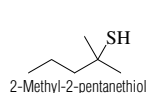
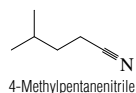
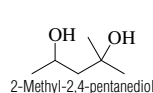
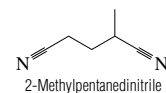
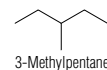
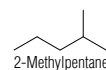
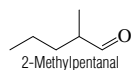
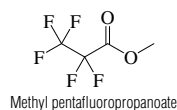
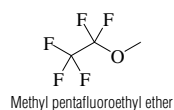
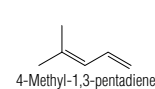
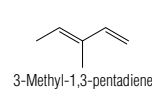
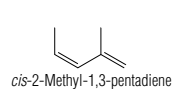
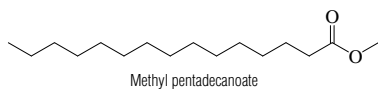
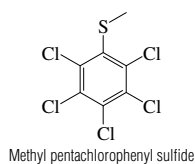
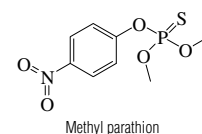
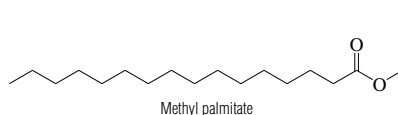
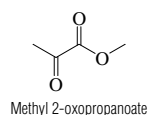
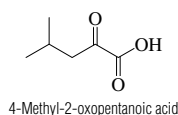
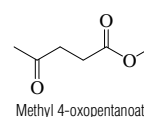
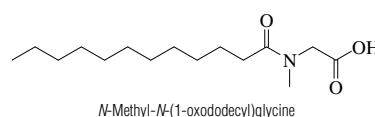
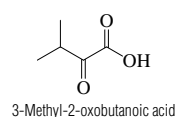
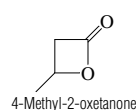
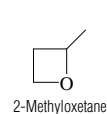
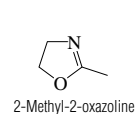
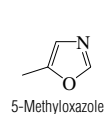
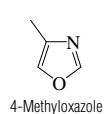
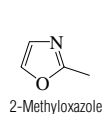
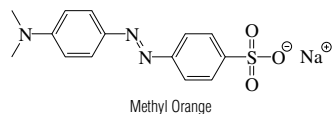
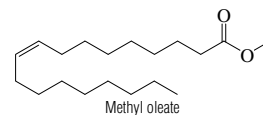
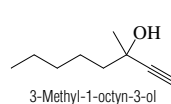
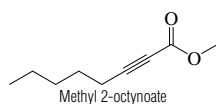
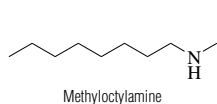
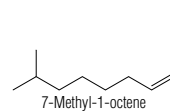
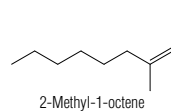
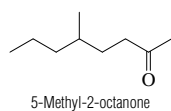
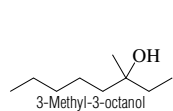
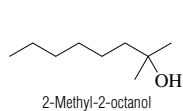
2-Methyl-3-nitroaniline

| No.  | Name                                                           | Synonym                                 | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                     |
|------|----------------------------------------------------------------|-----------------------------------------|--------------------------------------------------------------|------------|----------|-------------------------|---------|-------------------------------------|----------------------------|----------------------|----------------------------------------------------------------|
| 7481 | 2-Methyl-4-nitroaniline                                        |                                         | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>  | 99-52-5    | 152.151  |                         | 133.5   |                                     | 1.1586 <sup>140</sup>      |                      | sl H <sub>2</sub> O; DMSO; s EtOH, bz, HOAc                    |
| 7482 | 2-Methyl-5-nitroaniline                                        |                                         | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>  | 99-55-8    | 152.151  |                         | 105.5   |                                     |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, chl                 |
| 7483 | 2-Methyl-6-nitroaniline                                        |                                         | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>  | 570-24-1   | 152.151  |                         | 96      |                                     | 1.1900 <sup>100</sup>      |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                      |
| 7484 | 4-Methyl-2-nitroaniline                                        |                                         | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>  | 89-62-3    | 152.151  |                         | 116.3   |                                     | 1.16 <sup>121</sup>        |                      | sl H <sub>2</sub> O; s EtOH, chl                               |
| 7485 | 4-Methyl-3-nitroaniline                                        |                                         | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>  | 119-32-4   | 152.151  |                         | 79.8    |                                     |                            |                      | sl H <sub>2</sub> O; CS <sub>2</sub> ; s EtOH, eth, bz         |
| 7486 | <i>N</i> -Methyl-2-nitroaniline                                |                                         | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>  | 612-28-2   | 152.151  | red or orange (peth)    | 38      | 158 <sup>18</sup>                   |                            |                      | sl H <sub>2</sub> O; lig; s EtOH, eth, ace, bz                 |
| 7487 | <i>N</i> -Methyl-4-nitroaniline                                |                                         | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>  | 100-15-2   | 152.151  | br-ye pr (al) cry (eth) | 152     | dec                                 | 1.201 <sup>155</sup>       |                      | i H <sub>2</sub> O; s EtOH, bz, chl; sl eth, lig               |
| 7488 | 2-Methyl-1-nitro-9,10-anthracenedione                          |                                         | C <sub>13</sub> H <sub>9</sub> N <sub>2</sub> O <sub>4</sub> | 129-15-7   | 267.237  | pa ye nd (HOAc)         | 273.0   |                                     |                            |                      | i H <sub>2</sub> O; EtOH; sl eth, bz, chl; s PhNO <sub>2</sub> |
| 7489 | 2-Methyl-5-nitrobenzenesulfonic acid                           |                                         | C <sub>7</sub> H <sub>7</sub> NO <sub>5</sub> S              | 121-03-9   | 217.200  |                         | 135.8   |                                     |                            |                      | vs H <sub>2</sub> O; EtOH, eth, chl                            |
| 7490 | Methyl 2-nitrobenzoate                                         |                                         | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                | 606-27-9   | 181.147  | liq                     | -13     | 275                                 | 1.2855 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl; i lig                |
| 7491 | Methyl 3-nitrobenzoate                                         |                                         | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                | 618-95-1   | 181.147  |                         | 78      | 279 <sup>60</sup>                   |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, MeOH                         |
| 7492 | Methyl 4-nitrobenzoate                                         |                                         | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                | 619-50-1   | 181.147  |                         | 96      |                                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl                           |
| 7493 | 2-Methyl-4-nitro-1 <i>H</i> -imidazole                         |                                         | C <sub>4</sub> H <sub>6</sub> N <sub>3</sub> O <sub>2</sub>  | 696-23-1   | 127.102  |                         | 253     |                                     |                            |                      |                                                                |
| 7494 | <i>N</i> -Methyl- <i>N</i> -nitromethanamine                   |                                         | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>  | 4164-28-7  | 90.081   | nd(eth)                 | 58      | 187                                 | 1.1090 <sup>72</sup>       | 1.4462 <sup>72</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                            |
| 7495 | 2-Methyl-1-nitronaphthalene                                    |                                         | C <sub>11</sub> H <sub>9</sub> NO <sub>2</sub>               | 881-03-8   | 187.195  | ye pr or nd (al)        | 81.5    | 188 <sup>20</sup>                   |                            |                      | i H <sub>2</sub> O; s EtOH; vs ace                             |
| 7496 | <i>N</i> -Methyl- <i>N'</i> -nitro- <i>N</i> -nitrosoguanidine |                                         | C <sub>2</sub> H <sub>5</sub> N <sub>5</sub> O <sub>3</sub>  | 70-25-7    | 147.093  |                         |         |                                     |                            |                      | s DMSO                                                         |
| 7497 | 3-Methyl-4-nitrophenol                                         |                                         | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                | 2581-34-2  | 153.136  | nd or pr (w)            | 129     |                                     |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl                      |
| 7498 | 4-Methyl-2-nitrophenol                                         |                                         | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                | 119-33-5   | 153.136  | ye nd (al, w)           | 36.5    | 125 <sup>22</sup>                   | 1.2399 <sup>20</sup>       | 1.5744 <sup>40</sup> | vs ace, bz, eth, EtOH                                          |
| 7499 | 1-Methyl-2-(4-nitrophenoxy) benzene                            | 2-Methylphenyl 4-nitrophenyl ether      | C <sub>13</sub> H <sub>11</sub> NO <sub>3</sub>              | 2444-29-3  | 229.231  | ye cry (peth)           |         | 220 <sup>27</sup>                   |                            |                      | vs bz, eth, EtOH                                               |
| 7500 | 2-Methyl-2-nitro-1,3-propanediol                               |                                         | C <sub>4</sub> H <sub>9</sub> NO <sub>4</sub>                | 77-49-6    | 135.119  | mcl                     | 150.1   | dec                                 |                            |                      | vs H <sub>2</sub> O, EtOH; sl DMSO                             |
| 7501 | 2-Methyl-2-nitro-1-propanol                                    |                                         | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | 76-39-1    | 119.119  | nd or pl (MeOH)         | 89.5    | 94 <sup>10</sup>                    |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s chl                       |
| 7502 | 3-Methyl-4-nitroquinoline- <i>N</i> -oxide                     |                                         | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> | 14073-00-8 | 204.182  | cry (MeOH)              | 179     |                                     |                            |                      |                                                                |
| 7503 | <i>N</i> -Methyl- <i>N</i> -nitrosoaniline                     |                                         | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O               | 614-00-6   | 136.151  | ye cry                  | 14.7    | dec 225; 121 <sup>13</sup>          | 1.1240 <sup>20</sup>       | 1.5769 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                                |
| 7504 | <i>N</i> -Methyl- <i>N</i> -nitrosoourea                       | <i>N</i> -Nitroso- <i>N</i> -methylurea | C <sub>2</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>  | 684-93-5   | 103.080  | col or ye pl (eth)      | 123 dec |                                     |                            |                      | sl H <sub>2</sub> O; EtOH, eth                                 |
| 7505 | Methyl nonadecanoate                                           |                                         | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>               | 1731-94-8  | 312.531  |                         | 41.3    | 190 <sup>4</sup>                    |                            |                      |                                                                |
| 7506 | 2-Methylnonane                                                 |                                         | C <sub>10</sub> H <sub>22</sub>                              | 871-83-0   | 142.282  | liq                     | -74.6   | 167.1                               | 0.7281 <sup>20</sup>       | 1.4099 <sup>30</sup> | i H <sub>2</sub> O; s eth, bz, chl                             |
| 7507 | 3-Methylnonane                                                 |                                         | C <sub>10</sub> H <sub>22</sub>                              | 5911-04-6  | 142.282  | liq                     | -84.8   | 167.9                               | 0.7354 <sup>20</sup>       | 1.4125 <sup>20</sup> | vs bz, eth, chl                                                |
| 7508 | 4-Methylnonane                                                 |                                         | C <sub>10</sub> H <sub>22</sub>                              | 17301-94-9 | 142.282  | liq                     | -99     | 165.7                               | 0.7323 <sup>20</sup>       | 1.4123 <sup>20</sup> | vs bz, eth, chl                                                |
| 7509 | 5-Methylnonane                                                 |                                         | C <sub>10</sub> H <sub>22</sub>                              | 15869-85-9 | 142.282  | liq                     | -87.7   | 165.1                               | 0.7326 <sup>20</sup>       | 1.4116 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl                             |
| 7510 | Methyl nonanoate                                               |                                         | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>               | 1731-84-6  | 172.265  |                         |         | 213.5                               | 0.8799 <sup>15</sup>       | 1.4214 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                        |
| 7511 | 8-Methyl-1-nonanol                                             |                                         | C <sub>10</sub> H <sub>22</sub> O                            | 55505-26-5 | 158.281  |                         |         | 108 <sup>10</sup>                   |                            |                      |                                                                |
| 7512 | 2-Methyl-1-nonene                                              |                                         | C <sub>10</sub> H <sub>20</sub>                              | 2980-71-4  | 140.266  | liq                     | -64.2   | 168.4                               | 0.7412 <sup>25</sup>       | 1.4241 <sup>20</sup> |                                                                |
| 7513 | 2-Methyl-2-norbornene                                          | 2-Methylbicyclo[2.2.1]hept-2-ene        | C <sub>8</sub> H <sub>12</sub>                               | 694-92-8   | 108.181  | liq                     |         | 122                                 |                            |                      |                                                                |
| 7514 | Methyl <i>trans</i> -9-octadecenoate                           |                                         | C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>               | 1937-62-8  | 296.488  | liq                     | 13.5    | 218 <sup>24</sup>                   | 0.8730 <sup>20</sup>       | 1.4513 <sup>20</sup> | vs eth, EtOH                                                   |
| 7515 | 2-Methyloctane                                                 |                                         | C <sub>9</sub> H <sub>20</sub>                               | 3221-61-2  | 128.255  | liq                     | -80.3   | 143.2                               | 0.7095 <sup>25</sup>       | 1.4031 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc; vs peth               |
| 7516 | 3-Methyloctane                                                 |                                         | C <sub>9</sub> H <sub>20</sub>                               | 2216-33-3  | 128.255  | liq                     | -107.6  | 144.2                               | 0.717 <sup>25</sup>        | 1.4040 <sup>25</sup> |                                                                |
| 7517 | 4-Methyloctane                                                 |                                         | C <sub>9</sub> H <sub>20</sub>                               | 2216-34-4  | 128.255  | liq                     | -113.3  | 142.4                               | 0.716 <sup>25</sup>        | 1.4039 <sup>25</sup> | i H <sub>2</sub> O                                             |
| 7518 | Methyl octanoate                                               | Methyl caprylate                        | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                | 111-11-5   | 158.238  | liq                     | -40     | 192.9                               | 0.8775 <sup>20</sup>       | 1.4170 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; sl ctc                       |
| 7519 | 2-Methyloctanoic acid                                          |                                         | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                | 3004-93-1  | 158.238  |                         |         | 138 <sup>14</sup> , 88 <sup>4</sup> |                            | 1.4281 <sup>25</sup> |                                                                |

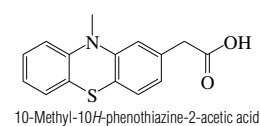
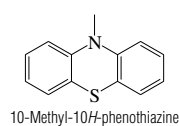
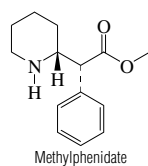
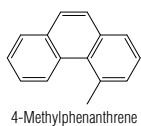
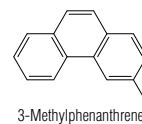
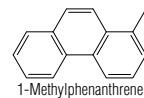
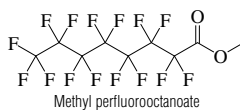
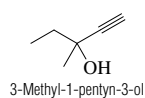
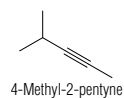
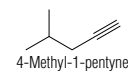
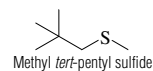
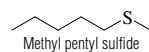
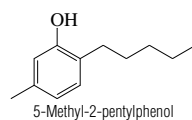
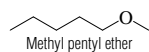
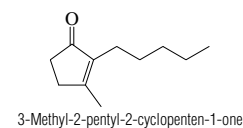
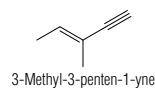
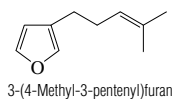
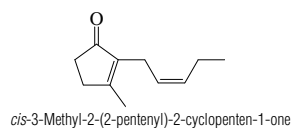
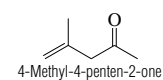
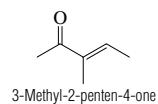
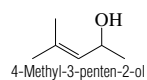
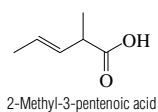
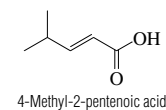
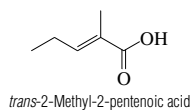
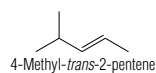
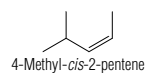
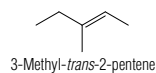
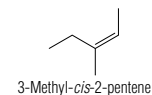
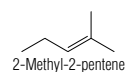
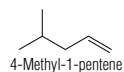
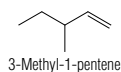
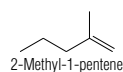
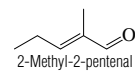
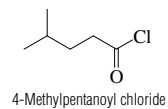
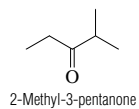
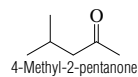
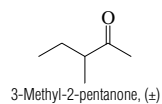
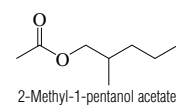
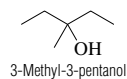
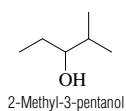
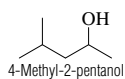
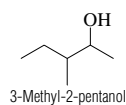




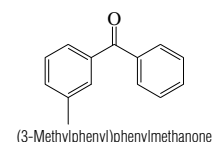
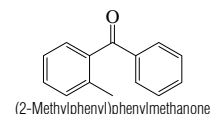
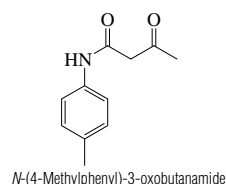
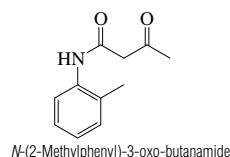
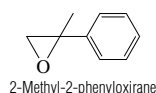
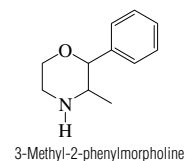
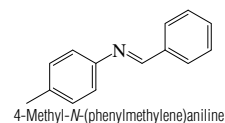
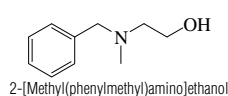
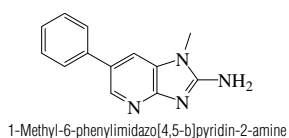
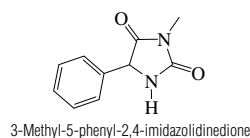
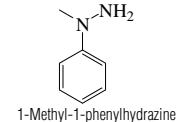
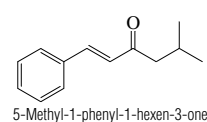
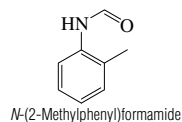
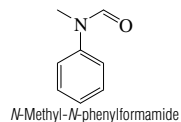
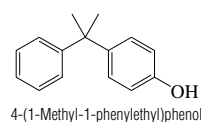
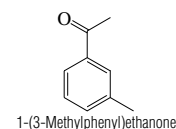
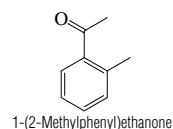
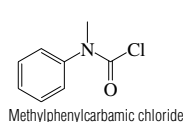
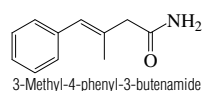
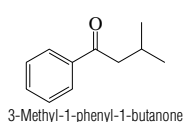
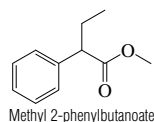
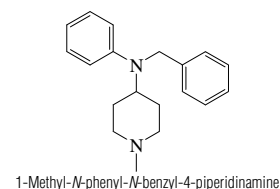
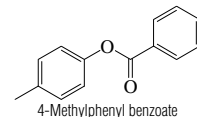
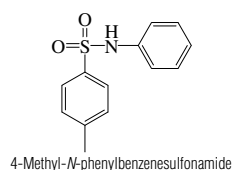
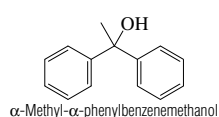
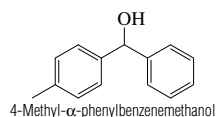
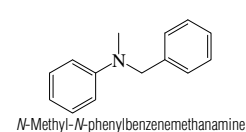
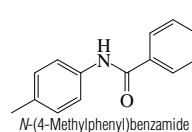
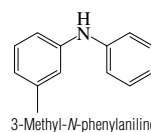
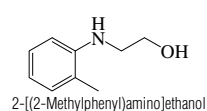
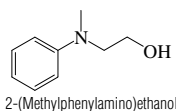
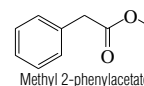
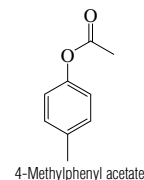
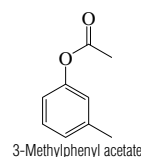
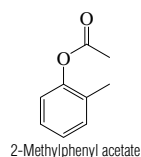
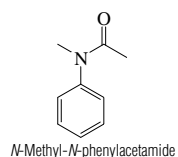
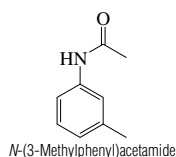
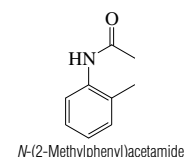
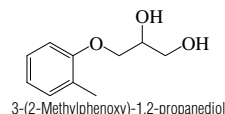
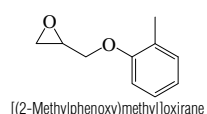
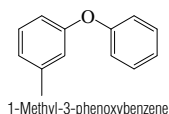
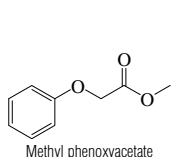
| No.  | Name                                              | Synonym                                           | Mol. Form.                                                        | CAS RN     | Mol. Wt. | Physical Form         | mp/°C   | bp/°C                              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|---------------------------------------------------|---------------------------------------------------|-------------------------------------------------------------------|------------|----------|-----------------------|---------|------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 7520 | 2-Methyl-2-octanol                                |                                                   | C <sub>9</sub> H <sub>20</sub> O                                  | 628-44-4   | 144.254  |                       |         | 178                                | 0.8210 <sup>20</sup>       | 1.4280 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                       |
| 7521 | 3-Methyl-3-octanol                                |                                                   | C <sub>9</sub> H <sub>20</sub> O                                  | 5340-36-3  | 144.254  |                       |         | 83 <sup>18</sup> , 36 <sup>3</sup> | 0.8108 <sup>25</sup>       | 1.4257 <sup>25</sup> |                                                       |
| 7522 | 5-Methyl-2-octanone                               |                                                   | C <sub>9</sub> H <sub>18</sub> O                                  | 58654-67-4 | 142.238  |                       |         | 101 <sup>50</sup>                  |                            |                      |                                                       |
| 7523 | 2-Methyl-1-octene                                 |                                                   | C <sub>9</sub> H <sub>18</sub>                                    | 4588-18-5  | 126.239  | liq                   | -77.8   | 144.8                              | 0.7343 <sup>20</sup>       | 1.4184 <sup>20</sup> |                                                       |
| 7524 | 7-Methyl-1-octene                                 |                                                   | C <sub>9</sub> H <sub>18</sub>                                    | 13151-06-9 | 126.239  | liq                   |         | 138.9                              |                            |                      |                                                       |
| 7525 | Methyloctylamine                                  | <i>N</i> -Methyl-1-octanamine                     | C <sub>9</sub> H <sub>21</sub> N                                  | 2439-54-5  | 143.270  |                       |         | 68 <sup>8</sup>                    |                            |                      |                                                       |
| 7526 | Methyl 2-octynoate                                |                                                   | C <sub>9</sub> H <sub>14</sub> O <sub>2</sub>                     | 111-12-6   | 154.206  |                       |         | 217; 107 <sup>20</sup>             | 0.926 <sup>20</sup>        | 1.4464 <sup>20</sup> |                                                       |
| 7527 | 3-Methyl-1-octyn-3-ol                             |                                                   | C <sub>9</sub> H <sub>16</sub> O                                  | 23580-51-0 | 140.222  |                       |         | 174; 75 <sup>10</sup>              | 0.8547 <sup>20</sup>       | 1.443 <sup>10</sup>  |                                                       |
| 7528 | Methyl oleate                                     |                                                   | C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>                    | 112-62-9   | 296.488  |                       | -19.9   | 218.5 <sup>20</sup>                | 0.8739 <sup>20</sup>       | 1.4522 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl              |
| 7529 | Methyl Orange                                     | Sodium <i>p</i> -dimethylaminoazobenzenesulfonate | C <sub>14</sub> H <sub>14</sub> N <sub>3</sub> NaO <sub>3</sub> S | 547-58-0   | 327.334  | oran, ye pl or sc (w) | dec     |                                    |                            |                      | sl H <sub>2</sub> O, EtOH, py; i eth                  |
| 7530 | 2-Methyloxazole                                   |                                                   | C <sub>4</sub> H <sub>5</sub> NO                                  | 23012-10-4 | 83.089   | liq                   |         | 87.5                               |                            |                      |                                                       |
| 7531 | 4-Methyloxazole                                   |                                                   | C <sub>4</sub> H <sub>5</sub> NO                                  | 693-93-6   | 83.089   |                       |         | 88                                 | 1.015 <sup>25</sup>        | 1.4317 <sup>20</sup> |                                                       |
| 7532 | 5-Methyloxazole                                   |                                                   | C <sub>4</sub> H <sub>5</sub> NO                                  | 66333-88-8 | 83.089   | liq                   |         | 88                                 |                            |                      |                                                       |
| 7533 | 2-Methyl-2-oxazoline                              |                                                   | C <sub>4</sub> H <sub>7</sub> NO                                  | 1120-64-5  | 85.105   |                       |         | 111                                | 1.005 <sup>25</sup>        | 1.4340 <sup>20</sup> |                                                       |
| 7534 | 2-Methyloxetane                                   |                                                   | C <sub>4</sub> H <sub>8</sub> O                                   | 2167-39-7  | 72.106   | hyg                   |         | 59                                 | 0.841 <sup>25</sup>        | 1.3885 <sup>20</sup> |                                                       |
| 7535 | 4-Methyl-2-oxetanone                              | 3-Hydroxybutyric acid lactone                     | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                      | 3068-88-0  | 86.090   |                       |         | 86 <sup>90</sup> , 57 <sup>9</sup> | 1.0555 <sup>20</sup>       |                      |                                                       |
| 7536 | Methyloxirane                                     | 1,2-Propylene oxide                               | C <sub>3</sub> H <sub>6</sub> O                                   | 16033-71-9 | 58.079   | liq                   | -111.9  | 35                                 | 0.859 <sup>0</sup>         | 1.3660 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; s chl                 |
| 7537 | 3-Methyl-2-oxobutanoic acid                       |                                                   | C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>                      | 759-05-7   | 116.116  |                       | 31.5    | 170.5                              | 0.9968 <sup>20</sup>       | 1.3850 <sup>18</sup> | s H <sub>2</sub> O, EtOH, eth                         |
| 7538 | <i>N</i> -Methyl- <i>N</i> -(1-oxododecyl)glycine | <i>N</i> -Dodecanoylsarcosine                     | C <sub>15</sub> H <sub>29</sub> NO <sub>3</sub>                   | 97-78-9    | 271.396  |                       | 44.5    |                                    |                            |                      | s chl                                                 |
| 7539 | Methyl 4-oxopentanoate                            | Methyl levulinate                                 | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                     | 624-45-3   | 130.141  |                       |         | 196                                | 1.0511 <sup>20</sup>       | 1.4233 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, ace, bz, ctc; msc eth    |
| 7540 | 4-Methyl-2-oxopentanoic acid                      |                                                   | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                     | 816-66-0   | 130.141  | liq                   | 10      | 84 <sup>15</sup>                   |                            |                      |                                                       |
| 7541 | Methyl 2-oxopropanoate                            | Methyl pyruvate                                   | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                      | 600-22-6   | 102.089  |                       |         | 135.5                              | 1.154 <sup>0</sup>         | 1.4046 <sup>25</sup> | sl H <sub>2</sub> O; s ace; msc EtOH, eth             |
| 7542 | Methyl palmitate                                  | Methyl hexadecanoate                              | C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>                    | 112-39-0   | 270.451  |                       | 30      | 417; 148 <sup>2</sup>              | 0.8247 <sup>75</sup>       |                      | i H <sub>2</sub> O; vs EtOH, ace, bz; s eth           |
| 7543 | Methyl parathion                                  |                                                   | C <sub>9</sub> H <sub>10</sub> NO <sub>3</sub> PS                 | 298-00-0   | 263.208  | cry                   | 38      |                                    | 1.358 <sup>20</sup>        | 1.5367 <sup>25</sup> | i H <sub>2</sub> O; s os                              |
| 7544 | Methyl pentachlorophenyl sulfide                  | <i>S</i> -Methyl pentachlorobenzenethiol          | C <sub>7</sub> H <sub>5</sub> Cl <sub>5</sub> S                   | 1825-19-0  | 296.429  | cry (EtOH)            | 95.5    |                                    |                            |                      |                                                       |
| 7545 | Methyl pentadecanoate                             |                                                   | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                    | 7132-64-1  | 256.424  | nd (dil al)           | 18.5    | 153.5                              | 0.8618 <sup>25</sup>       | 1.4390 <sup>25</sup> | s EtOH, eth                                           |
| 7546 | <i>cis</i> -2-Methyl-1,3-pentadiene               |                                                   | C <sub>6</sub> H <sub>10</sub>                                    | 1501-60-6  | 82.143   | liq                   | -117.6  | 75.8                               | 0.714 <sup>25</sup>        | 1.446 <sup>20</sup>  |                                                       |
| 7547 | 3-Methyl-1,3-pentadiene                           |                                                   | C <sub>6</sub> H <sub>10</sub>                                    | 4549-74-0  | 82.143   |                       |         | 77                                 | 0.730 <sup>25</sup>        | 1.452 <sup>20</sup>  |                                                       |
| 7548 | 4-Methyl-1,3-pentadiene                           | 1,1-Dimethyl-1,3-butadiene                        | C <sub>6</sub> H <sub>10</sub>                                    | 926-56-7   | 82.143   |                       |         | 76.5                               | 0.7181 <sup>20</sup>       | 1.4532 <sup>20</sup> |                                                       |
| 7549 | Methyl pentafluoroethyl ether                     | 1-Methoxyperfluoroethane                          | C <sub>3</sub> H <sub>3</sub> F <sub>5</sub> O                    | 22410-44-2 | 150.047  | col gas               |         | 5.59                               |                            |                      |                                                       |
| 7550 | Methyl pentafluoropropanoate                      |                                                   | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O <sub>2</sub>       | 378-75-6   | 178.058  |                       |         | 59.5                               | 1.390 <sup>25</sup>        | 1.2869 <sup>25</sup> |                                                       |
| 7551 | 2-Methylpentanal                                  | 2-Methylvaleraldehyde                             | C <sub>6</sub> H <sub>12</sub> O                                  | 123-15-9   | 100.158  |                       |         | 117                                |                            |                      | s H <sub>2</sub> O; s eth, ace; sl ctc                |
| 7552 | 2-Methylpentane                                   | Isohexane                                         | C <sub>6</sub> H <sub>14</sub>                                    | 107-83-5   | 86.175   | liq                   | -153.6  | 60.26                              | 0.650 <sup>25</sup>        | 1.3715 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; msc ace, bz, chl     |
| 7553 | 3-Methylpentane                                   |                                                   | C <sub>6</sub> H <sub>14</sub>                                    | 96-14-0    | 86.175   | liq                   | -162.90 | 63.27                              | 0.6598 <sup>25</sup>       | 1.3765 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ctc; msc eth, ace, bz, hp |
| 7554 | 2-Methylpentanedinitrile                          | 2-Methylglutaronitrile                            | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                      | 4553-62-2  | 108.141  | liq                   | -45     | 270; 134 <sup>13</sup>             | 0.950                      | 1.4340 <sup>20</sup> | s H <sub>2</sub> O                                    |
| 7555 | 2-Methyl-2,4-pentanediol                          | Hexylene glycol                                   | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                     | 107-41-5   | 118.174  | liq                   | -50     | 197.1                              | 0.923 <sup>15</sup>        | 1.4276 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth; sl ctc                 |
| 7556 | 4-Methylpentanenitrile                            | Isopentyl cyanide                                 | C <sub>6</sub> H <sub>11</sub> N                                  | 542-54-1   | 97.158   | liq                   | -51     | 156.5                              | 0.8030 <sup>20</sup>       | 1.4059 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; msc eth; sl ctc           |
| 7557 | 2-Methyl-2-pentanethiol                           |                                                   | C <sub>6</sub> H <sub>14</sub> S                                  | 1633-97-2  | 118.240  | liq                   |         | 125.0; 36 <sup>30</sup>            |                            |                      |                                                       |
| 7558 | Methyl pentanoate                                 | Methyl valerate                                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                     | 624-24-8   | 116.158  |                       |         | 127.4                              | 0.8947 <sup>20</sup>       | 1.4003 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth; s ace        |
| 7559 | 2-Methylpentanoic acid, (±)                       |                                                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                     | 22160-39-0 | 116.158  |                       |         | 195.6                              | 0.9230 <sup>20</sup>       | 1.413 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, eth; sl ctc                 |
| 7560 | 3-Methylpentanoic acid, (±)                       |                                                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                     | 22160-40-3 | 116.158  | liq                   | -41.6   | 197.5                              | 0.9262 <sup>20</sup>       | 1.4159 <sup>20</sup> | vs eth, EtOH                                          |
| 7561 | 4-Methylpentanoic acid                            |                                                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                     | 646-07-1   | 116.158  | liq                   | -33     | 200.5                              | 0.9225 <sup>20</sup>       | 1.4144 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, chl                 |
| 7562 | 2-Methyl-1-pentanol                               |                                                   | C <sub>6</sub> H <sub>14</sub> O                                  | 105-30-6   | 102.174  |                       |         | 149                                | 0.8263 <sup>20</sup>       | 1.4182 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, ctc            |
| 7563 | 3-Methyl-1-pentanol, (±)                          |                                                   | C <sub>6</sub> H <sub>14</sub> O                                  | 20281-83-8 | 102.174  |                       |         | 153                                | 0.8242 <sup>20</sup>       | 1.4112 <sup>23</sup> | i H <sub>2</sub> O; s EtOH, eth                       |
| 7564 | 4-Methyl-1-pentanol                               | Isohexyl alcohol                                  | C <sub>6</sub> H <sub>14</sub> O                                  | 626-89-1   | 102.174  |                       |         | 151.9                              | 0.8131 <sup>20</sup>       | 1.4134 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth                       |
| 7565 | 2-Methyl-2-pentanol                               |                                                   | C <sub>6</sub> H <sub>14</sub> O                                  | 590-36-3   | 102.174  | liq                   | -103    | 121.1                              | 0.8350 <sup>16</sup>       | 1.4100 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                      |



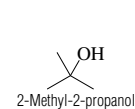
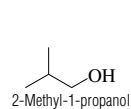
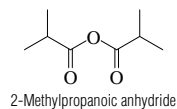
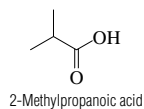
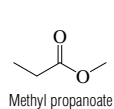
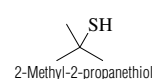
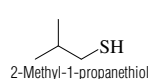
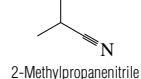
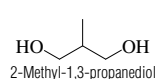
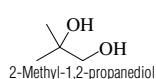
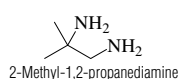
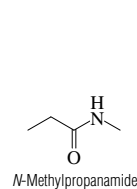
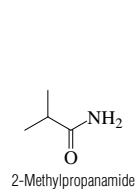
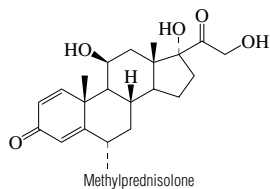
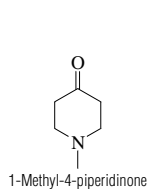
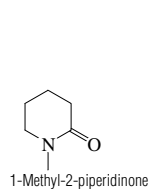
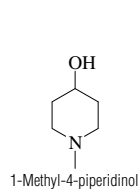
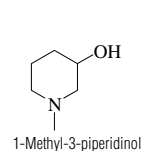
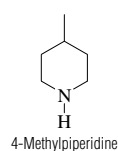
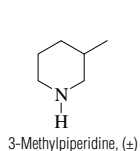
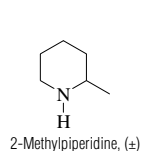
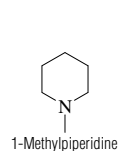
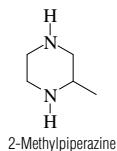
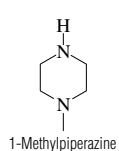
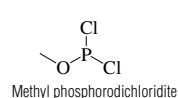
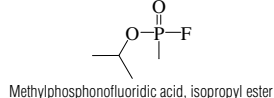
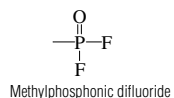
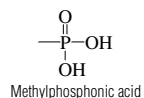
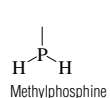
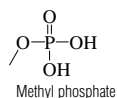
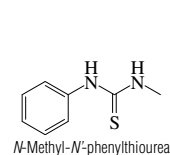
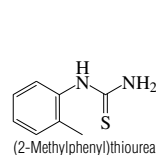
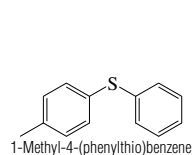
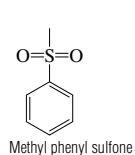
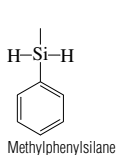
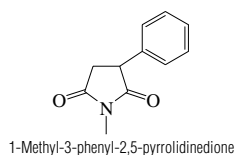
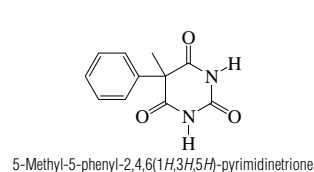
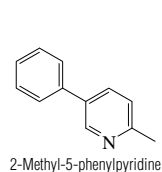
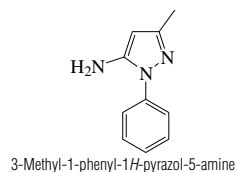
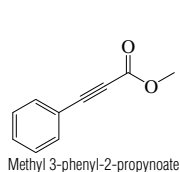
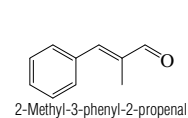
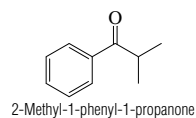
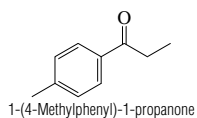
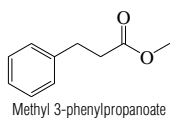
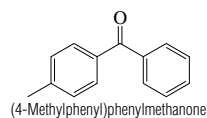
| No.  | Name                                                    | Synonym                              | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form   | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|---------------------------------------------------------|--------------------------------------|--------------------------------------------------------------|------------|----------|-----------------|--------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 7566 | 3-Methyl-2-pentanol                                     |                                      | C <sub>6</sub> H <sub>14</sub> O                             | 565-60-6   | 102.174  |                 |        | 134.3                                 | 0.8307 <sup>20</sup>       | 1.4182 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                      |
| 7567 | 4-Methyl-2-pentanol                                     |                                      | C <sub>6</sub> H <sub>14</sub> O                             | 108-11-2   | 102.174  | liq             | -90    | 131.6                                 | 0.8075 <sup>20</sup>       | 1.4100 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth                 |
| 7568 | 2-Methyl-3-pentanol                                     |                                      | C <sub>6</sub> H <sub>14</sub> O                             | 565-67-3   | 102.174  |                 |        | 126.5                                 | 0.8243 <sup>20</sup>       | 1.4175 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                    |
| 7569 | 3-Methyl-3-pentanol                                     |                                      | C <sub>6</sub> H <sub>14</sub> O                             | 77-74-7    | 102.174  | liq             | -23.6  | 122.4                                 | 0.8286 <sup>20</sup>       | 1.4186 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth               |
| 7570 | 2-Methyl-1-pentanol acetate                             |                                      | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | 7789-99-3  | 144.212  |                 |        | 163                                   | 0.870 <sup>25</sup>        |                      | vs eth, EtOH                                          |
| 7571 | 3-Methyl-2-pentanone, (±)                               | (±)- <i>sec</i> -Butyl methyl ketone | C <sub>6</sub> H <sub>12</sub> O                             | 55156-16-6 | 100.158  |                 |        | 117.5                                 | 0.8130 <sup>20</sup>       | 1.4002 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s chl             |
| 7572 | 4-Methyl-2-pentanone                                    | Isobutyl methyl ketone               | C <sub>6</sub> H <sub>12</sub> O                             | 108-10-1   | 100.158  | liq             | -84    | 116.5                                 | 0.7965 <sup>25</sup>       | 1.3962 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, ace, bz; s chl    |
| 7573 | 2-Methyl-3-pentanone                                    | Ethyl isopropyl ketone               | C <sub>6</sub> H <sub>12</sub> O                             | 565-69-5   | 100.158  |                 |        | 113.5                                 | 0.814 <sup>18</sup>        | 1.3975 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, bz; msc eth, ace; s chl |
| 7574 | 4-Methylpentanoyl chloride                              |                                      | C <sub>6</sub> H <sub>11</sub> ClO                           | 38136-29-7 | 134.603  |                 |        | 143                                   | 0.9725 <sup>20</sup>       |                      |                                                       |
| 7575 | 2-Methyl-2-pentenal                                     |                                      | C <sub>6</sub> H <sub>10</sub> O                             | 623-36-9   | 98.142   |                 |        | 136.5                                 | 0.8581 <sup>20</sup>       | 1.4488 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, MeOH             |
| 7576 | 2-Methyl-1-pentene                                      |                                      | C <sub>6</sub> H <sub>12</sub>                               | 763-29-1   | 84.159   | liq             | -135.7 | 62.1                                  | 0.6799 <sup>20</sup>       | 1.3920 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, chl; sl ctc           |
| 7577 | 3-Methyl-1-pentene                                      |                                      | C <sub>6</sub> H <sub>12</sub>                               | 760-20-3   | 84.159   | liq             | -153   | 54.2                                  | 0.6675 <sup>20</sup>       | 1.3841 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, chl, peth             |
| 7578 | 4-Methyl-1-pentene                                      |                                      | C <sub>6</sub> H <sub>12</sub>                               | 691-37-2   | 84.159   | liq             | -153.6 | 53.9                                  | 0.6642 <sup>20</sup>       | 1.3828 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, chl, peth             |
| 7579 | 2-Methyl-2-pentene                                      |                                      | C <sub>6</sub> H <sub>12</sub>                               | 625-27-4   | 84.159   | liq             | -135   | 67.3                                  | 0.6863 <sup>20</sup>       | 1.4004 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, ctc, chl              |
| 7580 | 3-Methyl- <i>cis</i> -2-pentene                         |                                      | C <sub>6</sub> H <sub>12</sub>                               | 922-62-3   | 84.159   | liq             | -134.8 | 67.7                                  | 0.6886 <sup>25</sup>       | 1.4016 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, chl, peth             |
| 7581 | 3-Methyl- <i>trans</i> -2-pentene                       |                                      | C <sub>6</sub> H <sub>12</sub>                               | 616-12-6   | 84.159   | liq             | -138.5 | 70.4                                  | 0.6930 <sup>25</sup>       | 1.4045 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, ctc, chl, peth        |
| 7582 | 4-Methyl- <i>cis</i> -2-pentene                         |                                      | C <sub>6</sub> H <sub>12</sub>                               | 691-38-3   | 84.159   | liq             | -134.8 | 56.3                                  | 0.6690 <sup>20</sup>       | 1.3800 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, chl, peth             |
| 7583 | 4-Methyl- <i>trans</i> -2-pentene                       |                                      | C <sub>6</sub> H <sub>12</sub>                               | 674-76-0   | 84.159   | liq             | -140.8 | 58.6                                  | 0.6686 <sup>20</sup>       | 1.3889 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, chl; sl ctc           |
| 7584 | <i>trans</i> -2-Methyl-2-pentenoic acid                 |                                      | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                | 16957-70-3 | 114.142  | pr              | 24.4   | 214; 112 <sup>12</sup>                | 0.9751 <sup>20</sup>       | 1.4513 <sup>20</sup> | sl H <sub>2</sub> O; s eth, chl, CS <sub>2</sub>      |
| 7585 | 4-Methyl-2-pentenoic acid                               | 4,4-Dimethyl-2-butenic acid          | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                | 10321-71-8 | 114.142  |                 | 35     | 217                                   | 0.9529 <sup>21</sup>       | 1.4489 <sup>21</sup> | vs ace, eth, EtOH                                     |
| 7586 | 2-Methyl-3-pentenoic acid                               |                                      | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                | 37674-63-8 | 114.142  |                 |        | 199                                   | 0.966 <sup>15</sup>        | 1.4402 <sup>25</sup> |                                                       |
| 7587 | 4-Methyl-3-penten-2-ol                                  |                                      | C <sub>6</sub> H <sub>12</sub> O                             | 4325-82-0  | 100.158  |                 |        | 134                                   | 0.840 <sup>15</sup>        | 1.9377 <sup>15</sup> |                                                       |
| 7588 | 3-Methyl-2-penten-4-one                                 |                                      | C <sub>6</sub> H <sub>10</sub> O                             | 565-62-8   | 98.142   |                 |        | 138                                   |                            | 1.4508 <sup>20</sup> |                                                       |
| 7589 | 4-Methyl-4-penten-2-one                                 |                                      | C <sub>6</sub> H <sub>10</sub> O                             | 3744-02-3  | 98.142   | liq             | -72.6  | 124.2                                 | 0.8411 <sup>20</sup>       |                      |                                                       |
| 7590 | <i>cis</i> -3-Methyl-2-(2-pentenyl)-2-cyclopenten-1-one | Jasmone                              | C <sub>11</sub> H <sub>16</sub> O                            | 488-10-8   | 164.244  | ye oil          |        | 258; 134 <sup>12</sup>                | 0.9437 <sup>22</sup>       | 1.4979 <sup>22</sup> | sl H <sub>2</sub> O; s EtOH, eth, ctc, lig            |
| 7591 | 3-(4-Methyl-3-pentenyl)furan                            |                                      | C <sub>10</sub> H <sub>14</sub> O                            | 539-52-6   | 150.217  |                 |        | 185.5                                 | 0.9017 <sup>20</sup>       | 1.4705 <sup>21</sup> |                                                       |
| 7592 | 3-Methyl-3-penten-1-yne                                 |                                      | C <sub>6</sub> H <sub>8</sub>                                | 1574-33-0  | 80.128   |                 |        | 66.5                                  | 0.739 <sup>20</sup>        | 1.4332 <sup>20</sup> | s eth, bz                                             |
| 7593 | 3-Methyl-2-pentyl-2-cyclopenten-1-one                   |                                      | C <sub>11</sub> H <sub>16</sub> O                            | 1128-08-1  | 166.260  |                 |        | 143 <sup>22</sup> , 116 <sup>12</sup> | 0.9165 <sup>18</sup>       | 1.4767 <sup>20</sup> |                                                       |
| 7594 | Methyl pentyl ether                                     |                                      | C <sub>6</sub> H <sub>14</sub> O                             | 628-80-8   | 102.174  |                 |        | 99                                    | 0.759 <sup>22</sup>        | 1.3862 <sup>22</sup> | vs ace, eth, EtOH                                     |
| 7595 | 5-Methyl-2-pentylphenol                                 | 6-Pentyl- <i>m</i> -cresol           | C <sub>12</sub> H <sub>16</sub> O                            | 1300-94-3  | 178.270  |                 | 24     | 138 <sup>15</sup>                     |                            |                      | vs ace, eth, EtOH                                     |
| 7596 | Methyl pentyl sulfide                                   |                                      | C <sub>6</sub> H <sub>14</sub> S                             | 1741-83-9  | 118.240  | liq             | -94    | 145.1                                 | 0.8431 <sup>20</sup>       | 1.4506 <sup>20</sup> | s EtOH, eth, ace, bz, chl                             |
| 7597 | Methyl <i>tert</i> -pentyl sulfide                      | 2-Methyl-2-(methylthio)butane        | C <sub>6</sub> H <sub>14</sub> S                             | 13286-92-5 | 118.240  | liq             |        | 150                                   | 0.84                       | 1.4570 <sup>20</sup> |                                                       |
| 7598 | 4-Methyl-1-pentyne                                      |                                      | C <sub>6</sub> H <sub>10</sub>                               | 7154-75-8  | 82.143   | liq             | -104.6 | 61.2                                  | 0.7000 <sup>25</sup>       | 1.3936 <sup>20</sup> | i H <sub>2</sub> O; s bz, chl                         |
| 7599 | 4-Methyl-2-pentyne                                      |                                      | C <sub>6</sub> H <sub>10</sub>                               | 21020-27-9 | 82.143   | liq             | -110.3 | 73.1                                  | 0.7112 <sup>25</sup>       | 1.4057 <sup>20</sup> | vs bz, chl                                            |
| 7600 | 3-Methyl-1-pentyn-3-ol                                  | Meparfynol                           | C <sub>6</sub> H <sub>10</sub> O                             | 77-75-8    | 98.142   |                 | 30.5   | 120.5                                 | 0.8688 <sup>20</sup>       | 1.4310 <sup>20</sup> |                                                       |
| 7601 | Methyl perfluorooctanoate                               |                                      | C <sub>9</sub> H <sub>3</sub> F <sub>15</sub> O <sub>2</sub> | 376-27-2   | 428.095  |                 |        | 158                                   | 1.684 <sup>20</sup>        | 1.304 <sup>27</sup>  |                                                       |
| 7602 | 1-Methylphenanthrene                                    |                                      | C <sub>15</sub> H <sub>12</sub>                              | 832-69-9   | 192.256  | lf, pl (dil al) | 123    | 354                                   |                            |                      | i H <sub>2</sub> O; s EtOH                            |
| 7603 | 3-Methylphenanthrene                                    |                                      | C <sub>15</sub> H <sub>12</sub>                              | 832-71-3   | 192.256  | pr or nd (al)   | 65     | 350; 145 <sup>6</sup>                 |                            |                      | i H <sub>2</sub> O; s EtOH, ace; sl chl               |
| 7604 | 4-Methylphenanthrene                                    |                                      | C <sub>15</sub> H <sub>12</sub>                              | 832-64-4   | 192.256  | pl (90% al)     | 53.5   | 177 <sup>10</sup>                     |                            |                      | i H <sub>2</sub> O; s EtOH, ctc                       |
| 7605 | Methylphenidate                                         |                                      | C <sub>14</sub> H <sub>19</sub> NO <sub>2</sub>              | 113-45-1   | 233.307  |                 |        | 136 <sup>0.6</sup>                    |                            |                      | i H <sub>2</sub> O, peth; s chl, EtOH, eth, AcOEt     |
| 7606 | 10-Methyl-10 <i>H</i> -phenothiazine                    |                                      | C <sub>13</sub> H <sub>11</sub> NS                           | 1207-72-3  | 213.298  |                 | 101    |                                       |                            |                      |                                                       |
| 7607 | 10-Methyl-10 <i>H</i> -phenothiazine-2-acetic acid      | Metiazinic acid                      | C <sub>15</sub> H <sub>13</sub> NO <sub>2</sub> S            | 13993-65-2 | 271.335  |                 | 144    |                                       |                            |                      | s chl                                                 |



| No.  | Name                                                          | Synonym                     | Mol. Form.                                                    | CAS RN      | Mol. Wt. | Physical Form                                 | mp/°C  | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                      |
|------|---------------------------------------------------------------|-----------------------------|---------------------------------------------------------------|-------------|----------|-----------------------------------------------|--------|----------------------------------------|----------------------------|----------------------|-------------------------------------------------|
| 7608 | Methyl phenoxyacetate                                         |                             | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | 2065-23-8   | 166.173  |                                               |        | 245                                    | 1.1493 <sup>20</sup>       | 1.5155 <sup>20</sup> | vs eth, EtOH                                    |
| 7609 | 1-Methyl-3-phenoxybenzene                                     |                             | C <sub>13</sub> H <sub>12</sub> O                             | 3586-14-9   | 184.233  |                                               |        | 272                                    | 1.051 <sup>25</sup>        | 1.5727 <sup>20</sup> |                                                 |
| 7610 | [(2-Methylphenoxy)methyl]oxirane                              |                             | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 2210-79-9   | 164.201  |                                               |        | 123 <sup>2</sup>                       | 1.0884 <sup>20</sup>       |                      |                                                 |
| 7611 | 3-(2-Methylphenoxy)-1,2-propanediol                           | Mephesisin                  | C <sub>10</sub> H <sub>14</sub> O <sub>3</sub>                | 59-47-2     | 182.216  |                                               | 70 dec |                                        |                            |                      | sl H <sub>2</sub> O, eth; s EtOH                |
| 7612 | <i>N</i> -(2-Methylphenyl)acetamide                           |                             | C <sub>9</sub> H <sub>11</sub> NO                             | 120-66-1    | 149.189  | nd (al)                                       | 110    | 296                                    | 1.168 <sup>15</sup>        |                      | sl H <sub>2</sub> O, bz; s EtOH, eth, ace, HOAc |
| 7613 | <i>N</i> -(3-Methylphenyl)acetamide                           |                             | C <sub>9</sub> H <sub>11</sub> NO                             | 537-92-8    | 149.189  | nd (w)                                        | 65.5   | 303                                    | 1.141 <sup>15</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth; s chl        |
| 7614 | <i>N</i> -Methyl- <i>N</i> -phenylacetamide                   | <i>N</i> -Methylacetanilide | C <sub>9</sub> H <sub>11</sub> NO                             | 579-10-2    | 149.189  | nd (eth), pr (al)                             | 103    | 256                                    | 1.0036 <sup>105</sup>      | 1.576                | s H <sub>2</sub> O, EtOH, eth, chl, lig         |
| 7615 | 2-Methylphenyl acetate                                        | <i>o</i> -Cresyl acetate    | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 533-18-6    | 150.174  |                                               |        | 208                                    | 1.0533 <sup>15</sup>       | 1.5002 <sup>20</sup> | vs eth, EtOH                                    |
| 7616 | 3-Methylphenyl acetate                                        | <i>m</i> -Cresyl acetate    | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 122-46-3    | 150.174  |                                               | 12     | 212                                    | 1.043 <sup>20</sup>        | 1.4978 <sup>20</sup> | vs bz, eth, EtOH                                |
| 7617 | 4-Methylphenyl acetate                                        | <i>p</i> -Cresyl acetate    | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 140-39-6    | 150.174  |                                               |        | 212.5                                  | 1.0512 <sup>17</sup>       | 1.5163 <sup>22</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, chl      |
| 7618 | Methyl 2-phenylacetate                                        |                             | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 101-41-7    | 150.174  |                                               |        | 216.5                                  | 1.0622 <sup>16</sup>       | 1.5075 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace, ctc   |
| 7619 | 2-(Methylphenylamino)ethanol                                  |                             | C <sub>9</sub> H <sub>13</sub> NO                             | 93-90-3     | 151.205  |                                               |        | 218 <sup>110</sup> , 150 <sup>14</sup> | 1.0143 <sup>9</sup>        |                      | s H <sub>2</sub> O; vs EtOH, eth, ace, bz       |
| 7620 | 2-[(2-Methylphenyl)amino]ethanol                              |                             | C <sub>9</sub> H <sub>13</sub> NO                             | 136-80-1    | 151.205  |                                               |        | 285.5                                  | 1.0794 <sup>20</sup>       | 1.5675 <sup>20</sup> | vs eth, EtOH                                    |
| 7621 | 3-Methyl- <i>N</i> -phenylaniline                             |                             | C <sub>13</sub> H <sub>13</sub> N                             | 1205-64-7   | 183.249  |                                               | 30     | 316; 183 <sup>17</sup>                 |                            | 1.635 <sup>20</sup>  | vs bz, eth, EtOH                                |
| 7622 | <i>N</i> -(4-Methylphenyl)benzamide                           |                             | C <sub>14</sub> H <sub>13</sub> NO                            | 582-78-5    | 211.259  | orth nd (al)                                  | 158    |                                        | 1.202 <sup>15</sup>        |                      | vs eth, EtOH                                    |
| 7623 | <i>N</i> -Methyl- <i>N</i> -phenylbenzenemethanamine          |                             | C <sub>14</sub> H <sub>15</sub> N                             | 614-30-2    | 197.276  |                                               |        |                                        |                            |                      | s ctc                                           |
| 7624 | 4-Methyl- $\alpha$ -phenylbenzenemethanol                     |                             | C <sub>14</sub> H <sub>14</sub> O                             | 1517-63-1   | 198.260  |                                               | 52     |                                        |                            |                      |                                                 |
| 7625 | $\alpha$ -Methyl- $\alpha$ -phenylbenzenemethanol             |                             | C <sub>14</sub> H <sub>14</sub> O                             | 599-67-7    | 198.260  |                                               |        | 285; 190 <sup>12</sup>                 | 1.1059 <sup>15</sup>       |                      |                                                 |
| 7626 | 4-Methyl- <i>N</i> -phenylbenzenesulfonamide                  |                             | C <sub>13</sub> H <sub>13</sub> NO <sub>2</sub> S             | 68-34-8     | 247.313  | ( $\alpha$ ) tcl, ( $\beta$ ) mcl pr (al, bz) | 103.5  |                                        |                            |                      | i H <sub>2</sub> O; vs EtOH; s bz, HOAc         |
| 7627 | 4-Methylphenyl benzoate                                       |                             | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>                | 614-34-6    | 212.244  | pl (eth-al)                                   | 71.5   | 316                                    |                            |                      | vs eth, EtOH                                    |
| 7628 | 1-Methyl- <i>N</i> -phenyl- <i>N</i> -benzyl-4-piperidinamine | Bamipine                    | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub>                | 4945-47-5   | 280.407  | cry (MeOH)                                    | 115    |                                        |                            |                      |                                                 |
| 7629 | Methyl 2-phenylbutanoate                                      |                             | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                | 2294-71-5   | 178.228  | nd (dil al)                                   | 77.5   | 228                                    |                            |                      | vs eth, EtOH                                    |
| 7630 | 3-Methyl-1-phenyl-1-butanone                                  |                             | C <sub>11</sub> H <sub>14</sub> O                             | 582-62-7    | 162.228  |                                               |        | 236.5                                  | 0.9701 <sup>16</sup>       | 1.5139 <sup>15</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs ace       |
| 7631 | 3-Methyl-4-phenyl-3-butenamide                                | $\beta$ -Benzalbutyramide   | C <sub>11</sub> H <sub>13</sub> NO                            | 7236-47-7   | 175.227  |                                               | 133    |                                        |                            |                      |                                                 |
| 7632 | Methylphenylcarbamic chloride                                 |                             | C <sub>8</sub> H <sub>9</sub> ClNO                            | 4285-42-1   | 169.609  | pl (al)                                       | 88.5   | 280                                    |                            |                      | vs eth, EtOH                                    |
| 7633 | 1-(2-Methylphenyl)ethanone                                    |                             | C <sub>9</sub> H <sub>10</sub> O                              | 577-16-2    | 134.174  |                                               |        | 214                                    | 1.026 <sup>20</sup>        | 1.5276 <sup>20</sup> |                                                 |
| 7634 | 1-(3-Methylphenyl)ethanone                                    |                             | C <sub>9</sub> H <sub>10</sub> O                              | 585-74-0    | 134.174  |                                               |        | 220                                    | 1.0165 <sup>9</sup>        | 1.533 <sup>15</sup>  | s EtOH, eth, ace; sl ctc                        |
| 7635 | 4-(1-Methyl-1-phenylethyl)phenol                              |                             | C <sub>15</sub> H <sub>16</sub> O                             | 599-64-4    | 212.287  | pr (peth)                                     | 74.5   | 335                                    |                            |                      |                                                 |
| 7636 | <i>N</i> -Methyl- <i>N</i> -phenylformamide                   |                             | C <sub>8</sub> H <sub>9</sub> NO                              | 93-61-8     | 135.163  |                                               | 14.5   | 243                                    | 1.0948 <sup>20</sup>       | 1.5589 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, ace           |
| 7637 | <i>N</i> -(2-Methylphenyl)formamide                           |                             | C <sub>8</sub> H <sub>9</sub> NO                              | 94-69-9     | 135.163  | lf (al)                                       | 62     | 288                                    | 1.086 <sup>55</sup>        |                      | s H <sub>2</sub> O; vs EtOH                     |
| 7638 | 5-Methyl-1-phenyl-1-hexen-3-one                               |                             | C <sub>13</sub> H <sub>16</sub> O                             | 2892-18-4   | 188.265  | cry                                           | 43     | 154 <sup>25</sup>                      | 0.9509 <sup>46</sup>       | 1.5523 <sup>25</sup> | sl H <sub>2</sub> O; s EtOH, bz, chl            |
| 7639 | 1-Methyl-1-phenylhydrazine                                    |                             | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                 | 618-40-6    | 122.167  |                                               |        | 228; 131 <sup>35</sup>                 | 1.0404 <sup>20</sup>       | 1.5691 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, bz, chl     |
| 7640 | 3-Methyl-5-phenyl-2,4-imidazolidinedione                      | 3-Methyl-5-phenylhydantoin  | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | 6846-11-3   | 190.198  |                                               | 164.5  |                                        |                            |                      | s chl                                           |
| 7641 | 1-Methyl-6-phenylimidazo[4,5-b]pyridin-2-amine                | PhIP                        | C <sub>13</sub> H <sub>12</sub> N <sub>4</sub>                | 105650-23-5 | 224.261  | solid                                         | 327    |                                        |                            |                      |                                                 |
| 7642 | 2-[Methyl(phenylmethyl)amino]ethanol                          |                             | C <sub>10</sub> H <sub>15</sub> NO                            | 101-98-4    | 165.232  |                                               |        | 134 <sup>14</sup>                      |                            |                      |                                                 |
| 7643 | 4-Methyl- <i>N</i> -(phenylmethylene)aniline                  |                             | C <sub>14</sub> H <sub>13</sub> N                             | 2272-45-9   | 195.260  | ye cry                                        | 35     | 318; 178 <sup>11</sup>                 |                            |                      | vs ace                                          |
| 7644 | 3-Methyl-2-phenylmorpholine                                   | Phenmetrazine               | C <sub>11</sub> H <sub>15</sub> NO                            | 134-49-6    | 177.243  |                                               |        | 139 <sup>12</sup> , 104 <sup>1</sup>   |                            |                      |                                                 |
| 7645 | 2-Methyl-2-phenyloxirane                                      |                             | C <sub>9</sub> H <sub>10</sub> O                              | 2085-88-3   | 134.174  |                                               |        | 84 <sup>17</sup>                       | 1.0228 <sup>20</sup>       | 1.5232 <sup>20</sup> |                                                 |
| 7646 | <i>N</i> -(2-Methylphenyl)-3-oxobutanamide                    |                             | C <sub>11</sub> H <sub>13</sub> NO <sub>2</sub>               | 93-68-5     | 191.227  | pr (AcOEt)                                    | 107.5  |                                        |                            |                      | vs bz, EtOH                                     |
| 7647 | <i>N</i> -(4-Methylphenyl)-3-oxobutanamide                    |                             | C <sub>11</sub> H <sub>13</sub> NO <sub>2</sub>               | 2415-85-2   | 191.227  | pr (AcOEt)                                    | 95     |                                        |                            |                      | sl H <sub>2</sub> O, lig; s EtOH, bz            |
| 7648 | (2-Methylphenyl)phenylmethanone                               |                             | C <sub>14</sub> H <sub>12</sub> O                             | 131-58-8    | 196.244  |                                               | <-18   | 308; 128 <sup>12</sup>                 | 1.1098 <sup>20</sup>       |                      | i H <sub>2</sub> O; vs EtOH                     |
| 7649 | (3-Methylphenyl)phenylmethanone                               |                             | C <sub>14</sub> H <sub>12</sub> O                             | 643-65-2    | 196.244  | oil                                           | 2      | 317; 170 <sup>9</sup>                  | 1.095 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl, HOAc  |



| No.  | Name                                                                          | Synonym                      | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form  | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                      |
|------|-------------------------------------------------------------------------------|------------------------------|---------------------------------------------------------------|------------|----------|----------------|--------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------------------|
| 7650 | (4-Methylphenyl)<br>phenylmethanone                                           |                              | C <sub>14</sub> H <sub>12</sub> O                             | 134-84-9   | 196.244  | mcl pr         | 59.5   | 228 <sup>70</sup>                     | 0.9926 <sup>9</sup>        |                      | i H <sub>2</sub> O; sl EtOH,<br>lig; s eth, bz,<br>chl          |
| 7651 | Methyl 3-phenylpropanoate                                                     | Methyl dihydrocinnamate      | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 103-25-3   | 164.201  |                |        | 238.5; 91 <sup>4</sup>                | 1.0455 <sup>25</sup>       |                      | i H <sub>2</sub> O; s EtOH,<br>eth, bz, AcOEt                   |
| 7652 | 1-(4-Methylphenyl)-1-propanone                                                |                              | C <sub>10</sub> H <sub>12</sub> O                             | 5337-93-9  | 148.201  |                | 7.2    | 236                                   | 0.9926 <sup>20</sup>       | 1.5278 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz,<br>CS <sub>2</sub> |
| 7653 | 2-Methyl-1-phenyl-1-propanone                                                 |                              | C <sub>10</sub> H <sub>12</sub> O                             | 611-70-1   | 148.201  | liq            | -0.7   | 220                                   | 0.9863 <sup>11</sup>       | 1.5172 <sup>20</sup> | vs eth, EtOH                                                    |
| 7654 | 2-Methyl-3-phenyl-2-propenal                                                  |                              | C <sub>10</sub> H <sub>10</sub> O                             | 101-39-3   | 146.185  |                |        | 248; 150 <sup>100</sup>               | 1.0407 <sup>17</sup>       | 1.6057 <sup>17</sup> |                                                                 |
| 7655 | Methyl 3-phenyl-2-propynoate                                                  |                              | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                 | 4891-38-7  | 160.170  |                | 26     | 158 <sup>48</sup> , 132 <sup>16</sup> | 1.0830 <sup>25</sup>       | 1.5618 <sup>25</sup> |                                                                 |
| 7656 | 3-Methyl-1-phenyl-1 <i>H</i> -pyrazol-5-amine                                 |                              | C <sub>10</sub> H <sub>11</sub> N <sub>3</sub>                | 1131-18-6  | 173.214  |                | 116    | 333                                   |                            |                      | s H <sub>2</sub> O, EtOH,<br>chl; sl bz                         |
| 7657 | 2-Methyl-5-phenylpyridine                                                     |                              | C <sub>12</sub> H <sub>11</sub> N                             | 3256-88-0  | 169.222  |                |        | 189 <sup>50</sup>                     | 1.0590 <sup>25</sup>       | 1.6055 <sup>25</sup> |                                                                 |
| 7658 | 5-Methyl-5-phenyl-2,4,6(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | Phenylmethylbarbituric acid  | C <sub>11</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub> | 76-94-8    | 218.208  | cry            | 220    |                                       |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth, alk                         |
| 7659 | 1-Methyl-3-phenyl-2,5-pyrrolidinedione                                        | Phensuximide                 | C <sub>11</sub> H <sub>11</sub> NO <sub>2</sub>               | 86-34-0    | 189.211  | cry (hot al)   | 72     |                                       |                            |                      | vs EtOH, MeOH                                                   |
| 7660 | Methylphenylsilane                                                            |                              | C <sub>7</sub> H <sub>10</sub> Si                             | 766-08-5   | 122.240  |                |        | 140                                   | 0.8895 <sup>20</sup>       | 1.5058 <sup>20</sup> |                                                                 |
| 7661 | Methyl phenyl sulfone                                                         |                              | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub> S                | 3112-85-4  | 156.203  |                | 88     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH,<br>bz, chl; sl ctc                  |
| 7662 | 1-Methyl-4-(phenylthio)benzene                                                |                              | C <sub>13</sub> H <sub>12</sub> S                             | 3699-01-2  | 200.299  |                | 15.7   | 317                                   | 1.0986 <sup>25</sup>       | 1.6225 <sup>25</sup> | i H <sub>2</sub> O; s ace, bz                                   |
| 7663 | (2-Methylphenyl)thiourea                                                      | <i>o</i> -Tolylthiourea      | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> S               | 614-78-8   | 166.243  | nd (dil al, w) | 162    |                                       |                            |                      | vs H <sub>2</sub> O, EtOH; sl<br>eth                            |
| 7664 | <i>N</i> -Methyl- <i>N'</i> -phenylthiourea                                   |                              | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> S               | 2724-69-8  | 166.243  | ta, pl         | 112.5  |                                       |                            |                      | vs EtOH                                                         |
| 7665 | Methyl phosphate                                                              | Methyl dihydrogen phosphate  | CH <sub>3</sub> O <sub>4</sub> P                              | 812-00-0   | 112.022  | oil            |        |                                       |                            |                      |                                                                 |
| 7666 | Methylphosphine                                                               |                              | CH <sub>3</sub> P                                             | 593-54-4   | 48.025   | col gas        |        | -16                                   |                            |                      | vs eth                                                          |
| 7667 | Methylphosphonic acid                                                         |                              | CH <sub>3</sub> O <sub>3</sub> P                              | 993-13-5   | 96.023   | hyg pl         | 108.5  | dec                                   |                            |                      | vs H <sub>2</sub> O, EtOH,<br>eth; i bz, peth                   |
| 7668 | Methylphosphonic difluoride                                                   |                              | CH <sub>3</sub> F <sub>2</sub> OP                             | 676-99-3   | 100.005  | liq            |        | 98; 22 <sup>27</sup>                  | 1.3314 <sup>20</sup>       |                      |                                                                 |
| 7669 | Methylphosphonofluoridic acid, isopropyl ester                                | Sarin                        | C <sub>6</sub> H <sub>10</sub> FO <sub>2</sub> P              | 107-44-8   | 140.093  | liq            | -57    | 147                                   | 1.10 <sup>20</sup>         |                      | dec H <sub>2</sub> O                                            |
| 7670 | Methyl phosphorodichloridite                                                  | Methyl dichlorophosphite     | CH <sub>3</sub> Cl <sub>2</sub> OP                            | 3279-26-3  | 132.914  | hyg liq        | -91    | 93                                    | 1.406                      | 1.4740 <sup>20</sup> |                                                                 |
| 7671 | 1-Methylpiperazine                                                            |                              | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>                 | 109-01-3   | 100.162  |                |        | 138                                   |                            | 1.4378 <sup>20</sup> | vs H <sub>2</sub> O, eth,<br>EtOH                               |
| 7672 | 2-Methylpiperazine                                                            |                              | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>                 | 109-07-9   | 100.162  | hyg lf (al)    | 62     | 153                                   |                            |                      | vs H <sub>2</sub> O; s EtOH,<br>eth, bz, chl                    |
| 7673 | 1-Methylpiperidine                                                            |                              | C <sub>6</sub> H <sub>13</sub> N                              | 626-67-5   | 99.174   | liq            | -102.7 | 107                                   | 0.8159 <sup>20</sup>       | 1.4355 <sup>20</sup> | vs H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ctc                 |
| 7674 | 2-Methylpiperidine, (±)                                                       |                              | C <sub>6</sub> H <sub>13</sub> N                              | 3000-79-1  | 99.174   | liq            | -2.5   | 118                                   | 0.8436 <sup>24</sup>       | 1.4459 <sup>20</sup> | vs H <sub>2</sub> O; s EtOH,<br>eth; sl chl; i dil<br>KOH       |
| 7675 | 3-Methylpiperidine, (±)                                                       |                              | C <sub>6</sub> H <sub>13</sub> N                              | 53152-98-0 | 99.174   | liq            | -24    | 125.5                                 | 0.8446 <sup>26</sup>       | 1.4470 <sup>20</sup> | vs H <sub>2</sub> O; sl chl                                     |
| 7676 | 4-Methylpiperidine                                                            |                              | C <sub>6</sub> H <sub>13</sub> N                              | 626-58-4   | 99.174   |                |        | 130                                   | 0.8674 <sup>25</sup>       | 1.4458 <sup>20</sup> | vs H <sub>2</sub> O; sl chl                                     |
| 7677 | 1-Methyl-3-piperidinol                                                        |                              | C <sub>6</sub> H <sub>13</sub> NO                             | 3554-74-3  | 115.173  |                |        | 93 <sup>26</sup> , 77 <sup>11</sup>   | 0.9635 <sup>16</sup>       | 1.4735 <sup>20</sup> |                                                                 |
| 7678 | 1-Methyl-4-piperidinol                                                        |                              | C <sub>6</sub> H <sub>13</sub> NO                             | 106-52-5   | 115.173  |                | 29     | 200                                   |                            | 1.4775 <sup>20</sup> |                                                                 |
| 7679 | 1-Methyl-2-piperidinone                                                       |                              | C <sub>6</sub> H <sub>11</sub> NO                             | 931-20-4   | 113.157  |                |        | 221; 105 <sup>12</sup>                | 1.0263 <sup>25</sup>       | 1.4820 <sup>20</sup> |                                                                 |
| 7680 | 1-Methyl-4-piperidinone                                                       |                              | C <sub>6</sub> H <sub>11</sub> NO                             | 1445-73-4  | 113.157  |                |        | 85 <sup>46</sup> , 57 <sup>11</sup>   | 0.971 <sup>25</sup>        | 1.4580 <sup>25</sup> |                                                                 |
| 7681 | Methylprednisolone                                                            |                              | C <sub>22</sub> H <sub>30</sub> O <sub>5</sub>                | 83-43-2    | 374.470  | cry            | 232    |                                       |                            |                      |                                                                 |
| 7682 | 2-Methylpropanamide                                                           |                              | C <sub>4</sub> H <sub>9</sub> NO                              | 563-83-7   | 87.120   |                | 129.0  | 217                                   | 1.013 <sup>20</sup>        |                      | s chl                                                           |
| 7683 | <i>N</i> -Methylpropanamide                                                   |                              | C <sub>4</sub> H <sub>9</sub> NO                              | 1187-58-2  | 87.120   | liq            | -30.9  | 148                                   | 0.9305 <sup>25</sup>       | 1.4345 <sup>25</sup> |                                                                 |
| 7684 | 2-Methyl-1,2-propanediamine                                                   |                              | C <sub>4</sub> H <sub>12</sub> N <sub>2</sub>                 | 811-93-8   | 88.151   |                |        | 123                                   | 0.841 <sup>25</sup>        | 1.4410 <sup>20</sup> | s ctc                                                           |
| 7685 | 2-Methyl-1,2-propanediol                                                      |                              | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 558-43-0   | 90.121   |                |        | 176                                   | 1.0024 <sup>20</sup>       | 1.4350 <sup>20</sup> | vs H <sub>2</sub> O, eth,<br>EtOH                               |
| 7686 | 2-Methyl-1,3-propanediol                                                      |                              | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                 | 2163-42-0  | 90.121   | liq            | -91    | 211.6; 124 <sup>20</sup>              | 1.015 <sup>20</sup>        | 1.4450 <sup>20</sup> |                                                                 |
| 7687 | 2-Methylpropanenitrile                                                        | Isobutyronitrile             | C <sub>4</sub> H <sub>7</sub> N                               | 78-82-0    | 69.106   | liq            | -71.5  | 103.9                                 | 0.7704 <sup>20</sup>       | 1.3720 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH,<br>eth, ace, chl                  |
| 7688 | 2-Methyl-1-propanethiol                                                       | Isobutyl mercaptan           | C <sub>4</sub> H <sub>10</sub> S                              | 513-44-0   | 90.187   |                | <-70   | 88.5                                  | 0.8357 <sup>20</sup>       | 1.4387 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH,<br>eth, ace; s ctc                |
| 7689 | 2-Methyl-2-propanethiol                                                       | <i>tert</i> -Butyl mercaptan | C <sub>4</sub> H <sub>10</sub> S                              | 75-66-1    | 90.187   | liq            | -0.5   | 64.2                                  | 0.7943 <sup>25</sup>       | 1.4232 <sup>20</sup> | i H <sub>2</sub> O; s ctc, hp                                   |
| 7690 | Methyl propanoate                                                             | Methyl propionate            | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 554-12-1   | 88.106   | liq            | -87.5  | 79.8                                  | 0.9150 <sup>20</sup>       | 1.3775 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ace, ctc            |
| 7691 | 2-Methylpropanoic acid                                                        | Isobutyric acid              | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 79-31-2    | 88.106   | liq            | -46    | 154.45                                | 0.9681 <sup>20</sup>       | 1.3930 <sup>20</sup> | vs H <sub>2</sub> O; msc<br>EtOH, eth; sl<br>ctc                |
| 7692 | 2-Methylpropanoic anhydride                                                   | Isobutyric anhydride         | C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>                 | 97-72-3    | 158.195  | liq            | -53.5  | 183; 89 <sup>32</sup>                 | 0.9535 <sup>20</sup>       | 1.4061 <sup>19</sup> | msc eth; s chl                                                  |
| 7693 | 2-Methyl-1-propanol                                                           | Isobutyl alcohol             | C <sub>4</sub> H <sub>10</sub> O                              | 78-83-1    | 74.121   | liq            | -101.9 | 107.89                                | 0.8018 <sup>20</sup>       | 1.3955 <sup>20</sup> | s H <sub>2</sub> O, EtOH,<br>eth, ace, ctc                      |
| 7694 | 2-Methyl-2-propanol                                                           | <i>tert</i> -Butyl alcohol   | C <sub>4</sub> H <sub>10</sub> O                              | 75-65-0    | 74.121   |                | 25.69  | 82.4                                  | 0.7887 <sup>20</sup>       | 1.3878 <sup>20</sup> | msc H <sub>2</sub> O, EtOH,<br>eth; s chl                       |





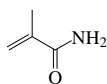
| No.  | Name                                                     | Synonym                        | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form  | mp/°C  | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|----------------------------------------------------------|--------------------------------|--------------------------------------------------------------|------------|----------|----------------|--------|---------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 7695 | 2-Methylpropanoyl chloride                               | Isobutyric acid chloride       | C <sub>4</sub> H <sub>7</sub> ClO                            | 79-30-1    | 106.551  | liq            | -90    | 92                        |                            | 1.4079 <sup>20</sup> | s eth                                                    |
| 7696 | 2-Methylpropenal                                         | Methacrolein                   | C <sub>4</sub> H <sub>6</sub> O                              | 78-85-3    | 70.090   |                |        | 68.4                      | 0.840 <sup>25</sup>        | 1.4144 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth                          |
| 7697 | 2-Methyl-2-propenamide                                   |                                | C <sub>5</sub> H <sub>7</sub> NO                             | 79-39-0    | 85.105   | cry (bz)       | 110.5  |                           |                            |                      | sl eth, chl; s EtOH, CH <sub>2</sub> Cl <sub>2</sub>     |
| 7698 | <i>N</i> -Methyl-2-propen-1-amine                        |                                | C <sub>5</sub> H <sub>9</sub> N                              | 627-37-2   | 71.121   |                |        | 64                        |                            | 1.4065 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                      |
| 7699 | 2-Methyl-2-propene-1,1-diol diacetate                    | Methacrolein diacetate         | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                | 10476-95-6 | 172.179  |                |        | 191                       |                            | 1.4241 <sup>20</sup> |                                                          |
| 7700 | 2-Methyl-1-propene, tetramer                             |                                | C <sub>16</sub> H <sub>32</sub>                              | 15220-85-6 | 224.425  | liq            | -98    | 244; 109 <sup>15</sup>    | 0.7944 <sup>20</sup>       | 1.4482 <sup>20</sup> |                                                          |
| 7701 | 2-Methyl-2-propenoic anhydride                           | Methacrylic acid anhydride     | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                | 760-93-0   | 154.163  |                |        | 89 <sup>5</sup>           |                            | 1.4540 <sup>20</sup> | msc EtOH, eth                                            |
| 7702 | 2-Methyl-2-propenol                                      | Methallyl alcohol              | C <sub>4</sub> H <sub>8</sub> O                              | 513-42-8   | 72.106   |                |        | 114.5                     | 0.8515 <sup>20</sup>       | 1.4255 <sup>20</sup> | vs H <sub>2</sub> O; msc EtOH, eth                       |
| 7703 | 2-Methyl-2-propenoyl chloride                            | Methacrylic acid chloride      | C <sub>5</sub> H <sub>7</sub> ClO                            | 920-46-7   | 104.535  | liq            | -60    | 96                        | 1.0871 <sup>20</sup>       | 1.4435 <sup>20</sup> | s eth, ace, chl                                          |
| 7704 | <i>cis</i> -(1-Methyl-1-propenyl)benzene                 |                                | C <sub>10</sub> H <sub>12</sub>                              | 767-99-7   | 132.202  |                |        | 194.7; 177 <sup>500</sup> | 0.9191 <sup>25</sup>       | 1.5402 <sup>25</sup> | i H <sub>2</sub> O; s bz, chl                            |
| 7705 | <i>trans</i> -(1-Methyl-1-propenyl)benzene               |                                | C <sub>10</sub> H <sub>12</sub>                              | 768-00-3   | 132.202  | liq            | -23.5  | 194.7                     | 0.9138 <sup>25</sup>       | 1.5425 <sup>20</sup> | i H <sub>2</sub> O; s bz, chl                            |
| 7706 | (2-Methyl-1-propenyl)benzene                             |                                | C <sub>10</sub> H <sub>12</sub>                              | 768-49-0   | 132.202  | liq            | -48.0  | 183; 99 <sup>43</sup>     | 0.900 <sup>20</sup>        | 1.5388 <sup>20</sup> |                                                          |
| 7707 | 4-(2-Methylpropenyl)morpholine                           | 1-Morpholinoisobutene          | C <sub>8</sub> H <sub>15</sub> NO                            | 2403-55-6  | 141.211  |                | 120    | 89 <sup>20</sup>          |                            | 1.4663 <sup>20</sup> |                                                          |
| 7708 | 2-(2-Methylpropoxy)ethanol                               |                                | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                | 4439-24-1  | 118.174  |                |        | 160                       | 0.8900 <sup>20</sup>       | 1.4143 <sup>20</sup> |                                                          |
| 7709 | Methylpropylamine                                        | <i>N</i> -Methyl-1-propanamine | C <sub>4</sub> H <sub>11</sub> N                             | 627-35-0   | 73.137   |                |        | 63                        | 0.7204 <sup>17</sup>       |                      |                                                          |
| 7710 | 1-Methyl-2-propylbenzene                                 |                                | C <sub>10</sub> H <sub>14</sub>                              | 1074-17-5  | 134.218  | liq            | -60.3  | 185                       | 0.8697 <sup>25</sup>       | 1.4996 <sup>20</sup> |                                                          |
| 7711 | 1-Methyl-3-propylbenzene                                 |                                | C <sub>10</sub> H <sub>14</sub>                              | 1074-43-7  | 134.218  | liq            | -82.5  | 182                       | 0.8569 <sup>25</sup>       | 1.4935 <sup>20</sup> |                                                          |
| 7712 | 1-Methyl-4-propylbenzene                                 |                                | C <sub>10</sub> H <sub>14</sub>                              | 1074-55-1  | 134.218  | liq            | -63.6  | 183.4                     | 0.8544 <sup>25</sup>       | 1.4922 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                          |
| 7713 | <i>cis</i> -1-Methyl-2-propylcyclopentane                |                                | C <sub>9</sub> H <sub>18</sub>                               | 932-43-4   | 126.239  | liq            | -104   | 152.6                     | 0.7881 <sup>25</sup>       | 1.4343 <sup>20</sup> |                                                          |
| 7714 | <i>trans</i> -1-Methyl-2-propylcyclopentane              |                                | C <sub>9</sub> H <sub>18</sub>                               | 932-44-5   | 126.239  | liq            | -123   | 146.4                     | 0.7735 <sup>25</sup>       | 1.4274 <sup>20</sup> |                                                          |
| 7715 | Methyl propyl disulfide                                  |                                | C <sub>4</sub> H <sub>10</sub> S <sub>2</sub>                | 2179-60-4  | 122.252  | liq            |        | 70 <sup>43</sup>          | 0.980                      | 1.5080 <sup>20</sup> |                                                          |
| 7716 | Methyl propyl ether                                      | 1-Methoxypropane               | C <sub>4</sub> H <sub>10</sub> O                             | 557-17-5   | 74.121   |                |        | 39.1                      | 0.7356 <sup>13</sup>       | 1.3579 <sup>25</sup> | s H <sub>2</sub> O, ace; msc EtOH, eth                   |
| 7717 | 1-Methyl-2-propylpiperidine, (S)                         | Methylconiine                  | C <sub>9</sub> H <sub>19</sub> N                             | 35305-13-6 | 141.254  |                |        | 174                       | 0.8326 <sup>22</sup>       | 1.4538 <sup>12</sup> | vs ace, EtOH                                             |
| 7718 | 2-Methyl-2-propyl-1,3-propanediol                        |                                | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>                | 78-26-2    | 132.201  | cry (hx)       | 62.5   | 234; 121 <sup>10</sup>    |                            |                      | s H <sub>2</sub> O, hx; sl chl                           |
| 7719 | 2-Methyl-2-propyl-1,3-propanediol dicarbamate            | Meprobamate                    | C <sub>9</sub> H <sub>18</sub> N <sub>2</sub> O <sub>4</sub> | 57-53-4    | 218.250  | cry (w)        | 105    |                           |                            |                      | vs bz, eth, EtOH                                         |
| 7720 | Methyl propyl sulfide                                    |                                | C <sub>4</sub> H <sub>10</sub> S                             | 3877-15-4  | 90.187   | liq            | -113   | 95.6                      | 0.8424 <sup>20</sup>       | 1.4442 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ace                       |
| 7721 | <i>N</i> -Methyl-2-propyn-1-amine                        |                                | C <sub>4</sub> H <sub>7</sub> N                              | 35161-71-8 | 69.106   |                |        | 83                        | 0.819 <sup>25</sup>        | 1.4332 <sup>20</sup> |                                                          |
| 7722 | <i>N</i> -Methyl- <i>N</i> -2-propynylbenzenemethanamine | Pargyline                      | C <sub>11</sub> H <sub>13</sub> N                            | 555-57-7   | 159.228  |                |        | 96 <sup>11</sup>          | 0.944 <sup>25</sup>        | 1.5213 <sup>20</sup> |                                                          |
| 7723 | 3-Methylpyrazinamine                                     | 2-Amino-3-methylpyrazine       | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub>                 | 19838-08-5 | 109.130  | nd (hx/AcOEt)  | 174    |                           |                            |                      |                                                          |
| 7724 | 2-Methylpyrazine                                         |                                | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                 | 109-08-0   | 94.115   | liq            | -29    | 137                       | 1.03 <sup>20</sup>         | 1.5042 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace; sl ctc           |
| 7725 | 1-Methyl-1 <i>H</i> -pyrazole                            |                                | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>                 | 930-36-9   | 82.104   |                |        | 127                       | 0.9929 <sup>13</sup>       | 1.4787 <sup>13</sup> |                                                          |
| 7726 | 3-Methyl-1 <i>H</i> -pyrazole                            |                                | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>                 | 1453-58-3  | 82.104   |                | 36.5   | 204; 108 <sup>25</sup>    | 1.0203 <sup>16</sup>       | 1.4915 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth                          |
| 7727 | 4-Methyl-1 <i>H</i> -pyrazole                            | Formepizole                    | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>                 | 7554-65-6  | 82.104   |                |        | 206; 95 <sup>13</sup>     | 1.015 <sup>20</sup>        |                      |                                                          |
| 7728 | 3-Methyl-2-pyrazolin-5-one                               |                                | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O               | 108-26-9   | 98.103   |                | 215    |                           |                            |                      | vs H <sub>2</sub> O; sl EtOH                             |
| 7729 | 1-Methylpyrene                                           |                                | C <sub>17</sub> H <sub>12</sub>                              | 2381-21-7  | 216.277  |                | 71.3   | 410                       |                            |                      |                                                          |
| 7730 | 2-Methylpyrene                                           |                                | C <sub>17</sub> H <sub>12</sub>                              | 3442-78-2  | 216.277  | fl (EtOH)      | 143    | 409.8                     |                            |                      |                                                          |
| 7731 | 3-Methylpyridazine                                       | 3-Methyl-1,2-diazine           | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                 | 1632-76-4  | 94.115   |                | 184    | 214                       | 1.0450 <sup>26</sup>       | 1.5145 <sup>20</sup> |                                                          |
| 7732 | 3-Methyl-2-pyridinamine                                  | 2-Amino-3-picoline             | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 1603-40-3  | 108.141  | hyg            | 33.5   | 222; 95 <sup>9</sup>      |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, ace, bz, ctc; sl lig   |
| 7733 | 4-Methyl-2-pyridinamine                                  | 2-Amino-4-picoline             | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 695-34-1   | 108.141  | lf or pl (lig) | 100    | 116 <sup>11</sup>         |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, ace, bz; i lig; sl chl |
| 7734 | 5-Methyl-2-pyridinamine                                  |                                | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 1603-41-4  | 108.141  |                | 76.5   | 227                       |                            |                      |                                                          |
| 7735 | 6-Methyl-2-pyridinamine                                  | 2-Amino-6-picoline             | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 1824-81-3  | 108.141  | hyg (lig)      | 41     | 208.5                     |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, ace, bz, lig           |
| 7736 | <i>N</i> -Methyl-2-pyridinamine                          |                                | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 4597-87-9  | 108.141  |                | 15     | 200.5                     | 1.048 <sup>29</sup>        |                      | s H <sub>2</sub> O, bz; vs EtOH, eth, HOAc               |
| 7737 | <i>N</i> -Methyl-4-pyridinamine                          |                                | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 1121-58-0  | 108.141  | pl (eth)       | 118.8  |                           |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH                      |
| 7738 | 2-Methylpyridine                                         | 2-Picoline                     | C <sub>6</sub> H <sub>7</sub> N                              | 109-06-8   | 93.127   | liq            | -66.68 | 129.38                    | 0.9443 <sup>20</sup>       | 1.4957 <sup>20</sup> | vs H <sub>2</sub> O, ace; msc EtOH, eth; s ctc           |



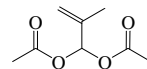
2-Methylpropanoyl chloride



2-Methylpropenal



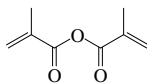
2-Methyl-2-propenamide

*N*-Methyl-2-propen-1-amine

2-Methyl-2-propene-1,1-diol diacetate



2-Methyl-1-propene, tetramer



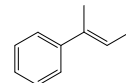
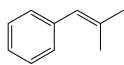
2-Methyl-2-propenoic anhydride



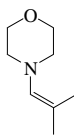
2-Methyl-2-propenol



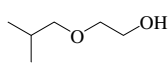
2-Methyl-2-propenoyl chloride

*cis*-(1-Methyl-1-propenyl)benzene*trans*-(1-Methyl-1-propenyl)benzene

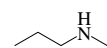
(2-Methyl-1-propenyl)benzene



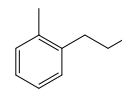
4-(2-Methylpropenyl)morpholine



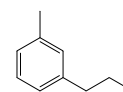
2-(2-Methylpropoxy)ethanol



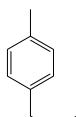
Methylpropylamine



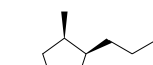
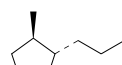
1-Methyl-2-propylbenzene



1-Methyl-3-propylbenzene



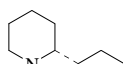
1-Methyl-4-propylbenzene

*cis*-1-Methyl-2-propylcyclopentane*trans*-1-Methyl-2-propylcyclopentane

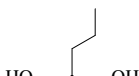
Methyl propyl disulfide



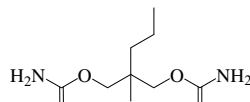
Methyl propyl ether



1-Methyl-2-propylpiperidine, (S)



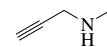
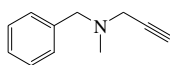
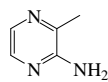
2-Methyl-2-propyl-1,3-propanediol



2-Methyl-2-propyl-1,3-propanediol dicarbamate



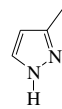
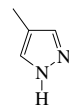
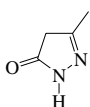
Methyl propyl sulfide

*N*-Methyl-2-propyn-1-amine*N*-Methyl-*N*-2-propynylbenzenemethanamine

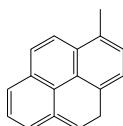
3-Methylpyrazinamine



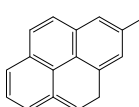
2-Methylpyrazine

1-Methyl-1*H*-pyrazole3-Methyl-1*H*-pyrazole4-Methyl-1*H*-pyrazole

3-Methyl-2-pyrazolin-5-one



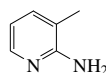
1-Methylpyrene



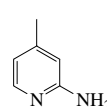
2-Methylpyrene



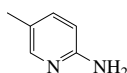
3-Methylpyridazine



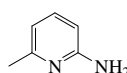
3-Methyl-2-pyridinamine



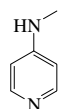
4-Methyl-2-pyridinamine



5-Methyl-2-pyridinamine



6-Methyl-2-pyridinamine

*N*-Methyl-2-pyridinamine*N*-Methyl-4-pyridinamine

2-Methylpyridine

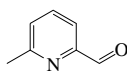
| No.  | Name                                                  | Synonym                                         | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                |
|------|-------------------------------------------------------|-------------------------------------------------|---------------------------------------------------------------|------------|----------|-------------------------|---------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------------|
| 7739 | 3-Methylpyridine                                      | 3-Picoline                                      | C <sub>6</sub> H <sub>7</sub> N                               | 108-99-6   | 93.127   | liq                     | -18.14  | 144.14                                | 0.9566 <sup>20</sup>       | 1.5040 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; vs ace; s ctc            |
| 7740 | 4-Methylpyridine                                      | 4-Picoline                                      | C <sub>6</sub> H <sub>7</sub> N                               | 108-89-4   | 93.127   |                         | 3.67    | 145.36                                | 0.9548 <sup>20</sup>       | 1.5037 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace, ctc               |
| 7741 | 6-Methyl-2-pyridinecarboxaldehyde                     |                                                 | C <sub>7</sub> H <sub>7</sub> NO                              | 1122-72-1  | 121.137  |                         | 32      | 77 <sup>12</sup>                      |                            |                      |                                                           |
| 7742 | Methyl 3-pyridinecarboxylate                          | Methyl nicotinate                               | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                 | 93-60-7    | 137.137  | cry                     | 42.5    | 204                                   |                            |                      | s H <sub>2</sub> O, EtOH, bz                              |
| 7743 | Methyl 4-pyridinecarboxylate                          | Methyl isonicotinate                            | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                 | 2459-09-8  | 137.137  |                         | 16.1    | 208                                   | 1.1599 <sup>20</sup>       | 1.5135 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, bz                 |
| 7744 | 2-Methylpyridine-1-oxide                              |                                                 | C <sub>6</sub> H <sub>7</sub> NO                              | 931-19-1   | 109.126  |                         | 49      | 260                                   |                            |                      |                                                           |
| 7745 | 3-Methylpyridine-1-oxide                              |                                                 | C <sub>6</sub> H <sub>7</sub> NO                              | 1003-73-2  | 109.126  |                         | 39      | 148 <sup>15</sup>                     |                            |                      | s chl                                                     |
| 7746 | 4-Methylpyridine-1-oxide                              |                                                 | C <sub>6</sub> H <sub>7</sub> NO                              | 1003-67-4  | 109.126  |                         | 185.8   |                                       |                            |                      |                                                           |
| 7747 | 1-Methyl-2(1 <i>H</i> )-pyridinone                    |                                                 | C <sub>6</sub> H <sub>7</sub> NO                              | 694-85-9   | 109.126  | nd                      | 31      | 250                                   | 1.1120 <sup>20</sup>       |                      | msc H <sub>2</sub> O; sl peth, lig                        |
| 7748 | 1-(6-Methyl-3-pyridinyl)ethanone                      |                                                 | C <sub>8</sub> H <sub>9</sub> NO                              | 36357-38-7 | 135.163  |                         | 17.6    | 144 <sup>50</sup>                     | 1.0168 <sup>25</sup>       | 1.5302 <sup>25</sup> | vs H <sub>2</sub> O                                       |
| 7749 | 4-Methyl-2-pyrimidinamine                             |                                                 | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub>                  | 108-52-1   | 109.130  | pl (w), nd (sub)        | 160.3   | sub                                   |                            |                      | s H <sub>2</sub> O, EtOH; sl chl                          |
| 7750 | 2-Methylpyrimidine                                    | 2-Methyl-1,3-diazine                            | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                  | 5053-43-0  | 94.115   | liq                     | -4      | 138                                   |                            |                      | msc H <sub>2</sub> O                                      |
| 7751 | 4-Methylpyrimidine                                    | 4-Methyl-1,3-diazine                            | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                  | 3438-46-8  | 94.115   |                         | 32      | 142                                   | 1.030 <sup>16</sup>        | 1.500 <sup>20</sup>  | msc H <sub>2</sub> O                                      |
| 7752 | 5-Methylpyrimidine                                    | 5-Methyl-1,3-diazine                            | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                  | 2036-41-1  | 94.115   |                         | 30.5    | 153                                   |                            |                      | vs H <sub>2</sub> O                                       |
| 7753 | 6-Methyl-2,4(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione | 6-Methyluracil                                  | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>   | 626-48-2   | 126.114  | oct pr or nd (w, al)    | 275 dec |                                       |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, tfa; vs NH <sub>3</sub> |
| 7754 | 1-Methylpyrrole                                       |                                                 | C <sub>5</sub> H <sub>7</sub> N                               | 96-54-8    | 81.117   | liq                     | -56.32  | 112.81                                | 0.9145 <sup>15</sup>       | 1.4875 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                         |
| 7755 | 2-Methylpyrrole                                       |                                                 | C <sub>5</sub> H <sub>7</sub> N                               | 636-41-9   | 81.117   | liq                     | -35.6   | 147.6                                 | 0.9446 <sup>15</sup>       | 1.5035 <sup>16</sup> | i H <sub>2</sub> O; msc EtOH, eth                         |
| 7756 | 3-Methylpyrrole                                       |                                                 | C <sub>5</sub> H <sub>7</sub> N                               | 616-43-3   | 81.117   | liq                     | -48.4   | 142.9; 45 <sup>11</sup>               |                            | 1.4970 <sup>20</sup> | msc EtOH, eth                                             |
| 7757 | <i>N</i> -Methylpyrrolidine                           |                                                 | C <sub>5</sub> H <sub>11</sub> N                              | 120-94-5   | 85.148   |                         |         | 81                                    | 0.8188 <sup>20</sup>       | 1.4247 <sup>20</sup> | vs H <sub>2</sub> O, eth                                  |
| 7758 | 1-Methyl-2,5-pyrrolidinedione                         |                                                 | C <sub>5</sub> H <sub>7</sub> NO <sub>2</sub>                 | 1121-07-9  | 113.116  | nd (eth-peth, al, ace)  | 71      | 234                                   |                            |                      | s H <sub>2</sub> O, EtOH; vs eth                          |
| 7759 | <i>N</i> -Methyl-2-pyrrolidinethione                  |                                                 | C <sub>5</sub> H <sub>9</sub> NS                              | 10441-57-3 | 115.197  | oil                     |         | 100 <sup>0.08</sup>                   |                            |                      |                                                           |
| 7760 | 5-Methyl-2-pyrrolidinone                              |                                                 | C <sub>5</sub> H <sub>9</sub> NO                              | 108-27-0   | 99.131   |                         | 43      | 248                                   | 1.0458 <sup>20</sup>       |                      |                                                           |
| 7761 | 1-(1-Methyl-2-pyrrolidinyl)-2-propanone, ( <i>R</i> ) | Hygrine                                         | C <sub>8</sub> H <sub>15</sub> NO                             | 496-49-1   | 141.211  |                         |         | 76.5 <sup>11</sup>                    |                            | 1.4555 <sup>20</sup> | vs EtOH, chl                                              |
| 7762 | 3-(1-Methyl-2-pyrrolidinyl)pyridine, (±)              |                                                 | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub>                | 22083-74-5 | 162.231  |                         |         | 244                                   | 1.0082 <sup>20</sup>       | 1.5289 <sup>20</sup> | msc H <sub>2</sub> O; vs EtOH, eth, chl; s lig            |
| 7763 | <i>N</i> -Methyl-2-pyrrolidinone                      |                                                 | C <sub>5</sub> H <sub>9</sub> NO                              | 872-50-4   | 99.131   | liq                     | -23.09  | 202                                   | 1.0230 <sup>25</sup>       | 1.4684 <sup>20</sup> | vs H <sub>2</sub> O; s eth, ace, chl                      |
| 7764 | 1-(1-Methyl-1 <i>H</i> -pyrrol-2-yl)ethanone          |                                                 | C <sub>7</sub> H <sub>9</sub> NO                              | 932-16-1   | 123.152  |                         |         | 201 <sup>252</sup> , 93 <sup>22</sup> | 1.0445 <sup>15</sup>       | 1.5403 <sup>15</sup> | s EtOH, bz, chl                                           |
| 7765 | 6-Methyl-8-quinolinamine                              | 8-Amino-6-methylquinoline                       | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub>                | 68420-93-9 | 158.199  | nd                      | 73      | sub                                   |                            |                      | vs ace, bz, eth, EtOH                                     |
| 7766 | 2-Methylquinoline                                     | Quinaldine                                      | C <sub>10</sub> H <sub>9</sub> N                              | 91-63-4    | 143.185  | col oily liq            | -0.8    | 246.5                                 | 1.06 <sup>25</sup>         | 1.6116 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, ctc, chl           |
| 7767 | 3-Methylquinoline                                     |                                                 | C <sub>10</sub> H <sub>9</sub> N                              | 612-58-8   | 143.185  | pr                      | 16.5    | 259.8                                 | 1.0673 <sup>20</sup>       | 1.6171 <sup>20</sup> | vs ace, eth, EtOH                                         |
| 7768 | 4-Methylquinoline                                     | Lepidine                                        | C <sub>10</sub> H <sub>9</sub> N                              | 491-35-0   | 143.185  | col oily liq            | 9.5     | 262                                   | 1.083 <sup>20</sup>        | 1.6200 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace; i alk              |
| 7769 | 5-Methylquinoline                                     |                                                 | C <sub>10</sub> H <sub>9</sub> N                              | 7661-55-4  | 143.185  | col cry                 | 19      | 262.7                                 | 1.0832 <sup>20</sup>       | 1.6219 <sup>20</sup> | sl H <sub>2</sub> O; s ace; msc EtOH, eth                 |
| 7770 | 6-Methylquinoline                                     |                                                 | C <sub>10</sub> H <sub>9</sub> N                              | 91-62-3    | 143.185  | col oily liq            | -22     | 258.6                                 | 1.0654 <sup>20</sup>       | 1.6157 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace                     |
| 7771 | 7-Methylquinoline                                     | <i>m</i> -Toluquinoline                         | C <sub>10</sub> H <sub>9</sub> N                              | 612-60-2   | 143.185  | ye cry                  | 39      | 257.6                                 | 1.0609 <sup>20</sup>       | 1.6150 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace                     |
| 7772 | 8-Methylquinoline                                     |                                                 | C <sub>10</sub> H <sub>9</sub> N                              | 611-32-5   | 143.185  | col liq                 | -80     | 247.5                                 | 1.0719 <sup>20</sup>       | 1.6164 <sup>20</sup> | sl H <sub>2</sub> O; s ace; msc EtOH, eth                 |
| 7773 | 2-Methyl-8-quinolinol                                 |                                                 | C <sub>10</sub> H <sub>9</sub> NO                             | 826-81-3   | 159.184  |                         | 73.8    | 267                                   |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz, ctc                  |
| 7774 | 1-Methyl-2(1 <i>H</i> )-quinolinone                   |                                                 | C <sub>10</sub> H <sub>9</sub> NO                             | 606-43-9   | 159.184  | nd (lig)                | 74      | 325                                   |                            |                      | sl H <sub>2</sub> O, lig; s EtOH, eth, ace; vs bz         |
| 7775 | 1-Methyl-4(1 <i>H</i> )-quinolinone                   | Echinopsine                                     | C <sub>10</sub> H <sub>9</sub> NO                             | 83-54-5    | 159.184  | α-nd (bz); β-cry (al)   |         |                                       |                            |                      | s H <sub>2</sub> O; vs EtOH, bz, chl; sl eth              |
| 7776 | 2-Methylquinoxaline                                   |                                                 | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                  | 7251-61-8  | 144.173  | ye cry                  | 180.5   | 244                                   |                            |                      | msc H <sub>2</sub> O, eth, ace, bz; vs EtOH; s ctc        |
| 7777 | Methyl Red                                            | Benzoic acid, 2-[[4-(dimethylamino)phenyl]azo]- | C <sub>15</sub> H <sub>15</sub> N <sub>3</sub> O <sub>2</sub> | 493-52-7   | 269.299  | viol or red pr (to, bz) | 183     |                                       |                            |                      | sl H <sub>2</sub> O, lig; s EtOH; vs ace, bz, chl         |
| 7778 | Methyl β- <i>D</i> -ribofuranoside                    |                                                 | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                 | 7473-45-2  | 164.156  |                         | 80      |                                       |                            |                      |                                                           |



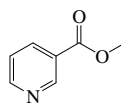
3-Methylpyridine



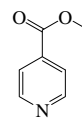
4-Methylpyridine



6-Methyl-2-pyridinecarboxaldehyde



Methyl 3-pyridinecarboxylate



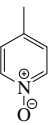
Methyl 4-pyridinecarboxylate



2-Methylpyridine-1-oxide



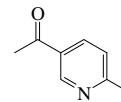
3-Methylpyridine-1-oxide



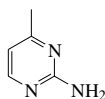
4-Methylpyridine-1-oxide



1-Methyl-2(1H)-pyridinone



1-(6-Methyl-3-pyridinyl)ethanone



4-Methyl-2-pyrimidinamine



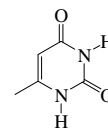
2-Methylpyrimidine



4-Methylpyrimidine



5-Methylpyrimidine



6-Methyl-2,4(1H,3H)-pyrimidinedione



1-Methylpyrrole



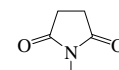
2-Methylpyrrole



3-Methylpyrrole



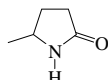
N-Methylpyrrolidine



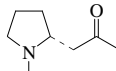
1-Methyl-2,5-pyrrolidinedione



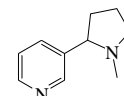
N-Methyl-2-pyrrolidinethione



5-Methyl-2-pyrrolidinone



1-(1-Methyl-2-pyrrolidinyl)-2-propanone, (R)



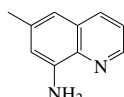
3-(1-Methyl-2-pyrrolidinyl)pyridine, (±)



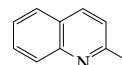
N-Methyl-2-pyrrolidinone



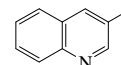
1-(1-Methyl-1H-pyrrol-2-yl)ethanone



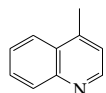
6-Methyl-8-quinolinamine



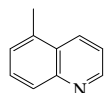
2-Methylquinoline



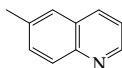
3-Methylquinoline



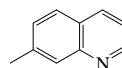
4-Methylquinoline



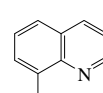
5-Methylquinoline



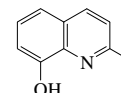
6-Methylquinoline



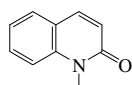
7-Methylquinoline



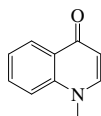
8-Methylquinoline



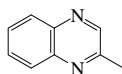
2-Methyl-8-quinolinol



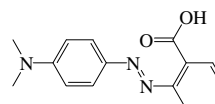
1-Methyl-2(1H)-quinolinone



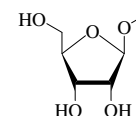
1-Methyl-4(1H)-quinolinone



2-Methylquinoxaline

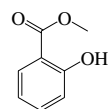


Methyl Red



Methyl β-D-ribofuranoside

| No.  | Name                                                | Synonym                                     | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form     | mp/°C  | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-----------------------------------------------------|---------------------------------------------|---------------------------------------------------------------|------------|----------|-------------------|--------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 7779 | Methyl salicylate                                   | Methyl 2-hydroxybenzoate                    | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                  | 119-36-8   | 152.148  | liq               | -8     | 222.9                                 | 1.181 <sup>25</sup>        | 1.535 <sup>20</sup>  | sl H <sub>2</sub> O; vs eth, EtOH, chl               |
| 7780 | Methylsilane                                        |                                             | CH <sub>4</sub> Si                                            | 992-94-9   | 46.145   | col gas           | -156.5 | -57.5                                 |                            |                      |                                                      |
| 7781 | Methyl silyl ether                                  |                                             | CH <sub>3</sub> OSi                                           | 2171-96-2  | 62.144   | col gas           | -98.5  | -21; -87 <sup>10</sup>                |                            |                      |                                                      |
| 7782 | Methylstannane                                      |                                             | CH <sub>3</sub> Sn                                            | 1631-78-3  | 136.769  | col gas           |        | 0                                     |                            |                      | dec H <sub>2</sub> O                                 |
| 7783 | Methyl stearate                                     |                                             | C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>                | 112-61-8   | 298.504  |                   | 39.1   | 443; 215 <sup>15</sup>                | 0.8498 <sup>40</sup>       | 1.4367 <sup>40</sup> | vs eth, chl                                          |
| 7784 | 2-Methylstyrene                                     |                                             | C <sub>9</sub> H <sub>10</sub>                                | 611-15-4   | 118.175  | liq               | -68.5  | 169.8                                 | 0.9077 <sup>25</sup>       | 1.5437 <sup>20</sup> | i H <sub>2</sub> O; s bz, chl                        |
| 7785 | 3-Methylstyrene                                     |                                             | C <sub>9</sub> H <sub>10</sub>                                | 100-80-1   | 118.175  | liq               | -86.3  | 164                                   | 0.9076 <sup>25</sup>       | 1.5411 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz                  |
| 7786 | 4-Methylstyrene                                     |                                             | C <sub>9</sub> H <sub>10</sub>                                | 622-97-9   | 118.175  | liq               | -34.1  | 172.8                                 | 0.9173 <sup>25</sup>       | 1.5420               | i H <sub>2</sub> O; s bz                             |
| 7787 | Methylsuccinic acid                                 |                                             | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                  | 636-60-2   | 132.116  | pr                | 115    | dec                                   | 1.4200 <sup>9</sup>        | 1.4303               | vs H <sub>2</sub> O, EtOH, MeOH; s eth; sl chl       |
| 7788 | Methyl sulfate                                      |                                             | CH <sub>3</sub> O <sub>3</sub> S                              | 75-93-4    | 112.106  |                   | <-30   | dec 135                               |                            |                      | vs H <sub>2</sub> O, eth, EtOH                       |
| 7789 | (Methylsulfinyl)benzene                             |                                             | C <sub>7</sub> H <sub>8</sub> OS                              | 1193-82-4  | 140.203  |                   | 32.0   | 263.5; 140 <sup>13</sup>              |                            | 1.5885 <sup>20</sup> |                                                      |
| 7790 | 1-(Methylsulfinyl)decane                            | Decyl methyl sulfoxide                      | C <sub>11</sub> H <sub>24</sub> OS                            | 3079-28-5  | 204.373  | cry               | 52.5   |                                       |                            |                      |                                                      |
| 7791 | 3-Methyl sulfolane                                  |                                             | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> S               | 872-93-5   | 134.197  |                   | 1      | 276                                   | 1.188 <sup>25</sup>        | 1.4772 <sup>20</sup> |                                                      |
| 7792 | (Methylsulfonyl)ethene                              |                                             | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub> S                | 3680-02-2  | 106.144  |                   |        | 122 <sup>24</sup>                     | 1.2117 <sup>20</sup>       | 1.4636 <sup>20</sup> | s eth, ace                                           |
| 7793 | Methyl terephthalate                                | Methyl 1,4-benzenedicarboxylate             | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                  | 1679-64-7  | 180.158  | nd (w)            | 222    | subl ≈ 230                            |                            |                      |                                                      |
| 7794 | 17-Methyltestosterone                               | 17-Hydroxy-17-methylandro-4-en-3-one, (17β) | C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>                | 58-18-4    | 302.451  |                   | 163.5  |                                       |                            |                      | vs eth, EtOH                                         |
| 7795 | Methyl tetradecanoate                               |                                             | C <sub>15</sub> H <sub>30</sub> O <sub>2</sub>                | 124-10-7   | 242.398  |                   | 19     | 295; 155 <sup>7</sup>                 | 0.8671 <sup>20</sup>       | 1.425 <sup>45</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, chl, ctc |
| 7796 | 5- <i>N</i> -Methyl-5,6,7,8-tetrahydrofolic acid    |                                             | C <sub>20</sub> H <sub>28</sub> N <sub>2</sub> O <sub>6</sub> | 134-35-0   | 459.456  | cry (w)           |        |                                       |                            |                      |                                                      |
| 7797 | 2-Methyltetrahydrofuran                             |                                             | C <sub>5</sub> H <sub>10</sub> O                              | 96-47-9    | 86.132   |                   |        | 78                                    | 0.8552 <sup>20</sup>       | 1.4059 <sup>21</sup> | s H <sub>2</sub> O; vs EtOH, eth, ace, bz; sl ctc    |
| 7798 | <i>N</i> -Methyl- <i>N</i> ,2,4,6-tetranitroaniline | Tetryl                                      | C <sub>7</sub> H <sub>5</sub> N <sub>5</sub> O <sub>8</sub>   | 479-45-8   | 287.144  | ye pr (al)        | 131.5  | exp 180                               | 1.57 <sup>10</sup>         |                      | i H <sub>2</sub> O; sl EtOH, eth, chl; s ace, bz, py |
| 7799 | 4-Methyl-2-thiazolamine                             | 2-Amino-4-methylthiazole                    | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> S                | 1603-91-4  | 114.169  |                   | 45.5   | 125 <sup>20</sup> , 70 <sup>0.4</sup> |                            |                      | vs H <sub>2</sub> O, EtOH, eth                       |
| 7800 | 2-Methylthiazole                                    |                                             | C <sub>4</sub> H <sub>5</sub> NS                              | 3581-87-1  | 99.155   |                   |        | 128                                   |                            | 1.510                | msc H <sub>2</sub> O; s EtOH, ace                    |
| 7801 | 4-Methylthiazole                                    |                                             | C <sub>4</sub> H <sub>5</sub> NS                              | 693-95-8   | 99.155   |                   |        | 133.3                                 | 1.112 <sup>25</sup>        |                      | s H <sub>2</sub> O, EtOH, eth                        |
| 7802 | 4-Methyl-5-thiazoleethanol                          |                                             | C <sub>6</sub> H <sub>9</sub> NOS                             | 137-00-8   | 143.206  | col to pa ye      |        | 135 <sup>7</sup>                      | 1.196 <sup>24</sup>        |                      | vs H <sub>2</sub> O; s EtOH, eth, bz, chl            |
| 7803 | 4-Methyl-2(3 <i>H</i> )-thiazolethione              |                                             | C <sub>4</sub> H <sub>4</sub> NS <sub>2</sub>                 | 5685-06-3  | 131.220  | ye cry (dil al)   | 89.3   | 188 <sup>3</sup>                      |                            |                      | vs EtOH                                              |
| 7804 | Methylthiirane                                      |                                             | C <sub>3</sub> H <sub>6</sub> S                               | 1072-43-1  | 74.145   | liq               | -91    | 72.5                                  | 0.941 <sup>20</sup>        | 1.472 <sup>20</sup>  | s chl                                                |
| 7805 | (Methylthio)acetic acid                             |                                             | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> S                | 2444-37-3  | 106.144  |                   | 13.0   | 130 <sup>27</sup>                     | 1.221 <sup>20</sup>        | 1.495 <sup>20</sup>  |                                                      |
| 7806 | 2-(Methylthio)aniline                               |                                             | C <sub>7</sub> H <sub>9</sub> NS                              | 2987-53-3  | 139.218  |                   |        | 234                                   | 1.111 <sup>25</sup>        | 1.6239 <sup>20</sup> |                                                      |
| 7807 | 4-(Methylthio)aniline                               |                                             | C <sub>7</sub> H <sub>9</sub> NS                              | 104-96-1   | 139.218  |                   |        | 272.5                                 | 1.1379 <sup>20</sup>       | 1.6395 <sup>20</sup> | s EtOH, eth, ace, bz                                 |
| 7808 | (Methylthio)benzene                                 | Methyl phenyl sulfide                       | C <sub>7</sub> H <sub>8</sub> S                               | 100-68-5   | 124.204  |                   |        | 194.3                                 | 1.0579 <sup>20</sup>       | 1.5868 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; vs ace                   |
| 7809 | 2-(Methylthio)benzothiazole                         |                                             | C <sub>8</sub> H <sub>7</sub> NS <sub>2</sub>                 | 615-22-5   | 181.279  | pr (dil al)       | 52     | 174 <sup>22</sup>                     |                            |                      | s EtOH, chl                                          |
| 7810 | Methyl thiocyanate                                  |                                             | C <sub>2</sub> H <sub>3</sub> NS                              | 556-64-9   | 73.117   | col liq           | -2.5   | 132.9                                 | 1.0678 <sup>25</sup>       | 1.4669 <sup>25</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ctc            |
| 7811 | 2-(Methylthio)ethanol                               |                                             | C <sub>3</sub> H <sub>8</sub> OS                              | 5271-38-5  | 92.160   |                   |        | 70 <sup>20</sup>                      | 1.063 <sup>20</sup>        | 1.4861 <sup>30</sup> | vs H <sub>2</sub> O, eth, EtOH                       |
| 7812 | (Methylthio)ethene                                  |                                             | C <sub>3</sub> H <sub>6</sub> S                               | 1822-74-8  | 74.145   |                   |        | 69.5                                  | 0.9026 <sup>20</sup>       | 1.4837 <sup>20</sup> | s eth, ace, chl                                      |
| 7813 | [(Methylthio)methyl]benzene                         |                                             | C <sub>8</sub> H <sub>10</sub> S                              | 766-92-7   | 138.230  | liq               | -30    | 210; 120 <sup>48</sup>                | 1.0274 <sup>20</sup>       | 1.5620 <sup>20</sup> |                                                      |
| 7814 | 4-(Methylthio)-2-oxobutanoic acid                   |                                             | C <sub>6</sub> H <sub>8</sub> O <sub>3</sub> S                | 583-92-6   | 148.181  | oil               |        |                                       |                            |                      |                                                      |
| 7815 | 2-Methylthiophene                                   |                                             | C <sub>5</sub> H <sub>6</sub> S                               | 554-14-3   | 98.167   | liq               | -63.4  | 112.6                                 | 1.0193 <sup>20</sup>       | 1.5203 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, hp, ctc  |
| 7816 | 3-Methylthiophene                                   |                                             | C <sub>5</sub> H <sub>6</sub> S                               | 616-44-4   | 98.167   | liq               | -69    | 115.5                                 | 1.0218 <sup>20</sup>       | 1.5204 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; vs chl   |
| 7817 | 5-Methyl-2-thiophenecarboxaldehyde                  |                                             | C <sub>6</sub> H <sub>6</sub> OS                              | 13679-70-4 | 126.176  |                   |        | 114 <sup>25</sup>                     |                            | 1.5825 <sup>20</sup> | s chl                                                |
| 7818 | 4-(Methylthio)phenol                                |                                             | C <sub>7</sub> H <sub>8</sub> OS                              | 1073-72-9  | 140.203  |                   | 84     | 154 <sup>20</sup> , 113 <sup>6</sup>  |                            |                      |                                                      |
| 7819 | 3-(Methylthio)propanal                              |                                             | C <sub>6</sub> H <sub>8</sub> OS                              | 3268-49-3  | 104.171  |                   |        | 62 <sup>11</sup>                      |                            |                      |                                                      |
| 7820 | 3-(Methylthio)propanoic acid                        | <i>S</i> -Methylpropiothetin                | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub> S               | 646-01-5   | 120.171  | ye oil or fl (hx) | 21     | 132 <sup>13</sup>                     |                            |                      |                                                      |
| 7821 | 3-(Methylthio)-1-propene                            |                                             | C <sub>4</sub> H <sub>6</sub> S                               | 10152-76-8 | 88.172   |                   |        | 92                                    | 0.8767 <sup>20</sup>       | 1.4714 <sup>20</sup> |                                                      |
| 7822 | <i>N</i> -Methylthiosemicarbazide                   | <i>N</i> -Methylhydrazinecarbothioamide     | C <sub>2</sub> H <sub>4</sub> N <sub>3</sub> S                | 6610-29-3  | 105.162  |                   | 136.5  |                                       |                            |                      | s H <sub>2</sub> O, EtOH, DMSO; i eth, bz, lig       |



Methyl salicylate



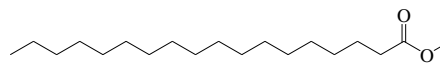
Methylsilane



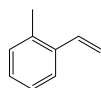
Methyl silyl ether



Methylstannane



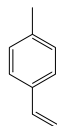
Methyl stearate



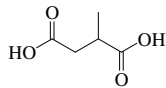
2-Methylstyrene



3-Methylstyrene



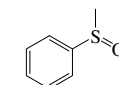
4-Methylstyrene



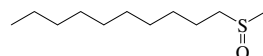
Methylsuccinic acid



Methyl sulfate



(Methylsulfinyl)benzene



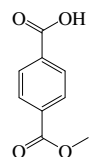
1-(Methylsulfinyl)decane



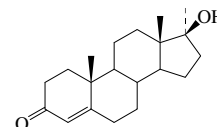
3-Methyl sulfolane



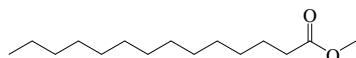
(Methylsulfonyl)ethene



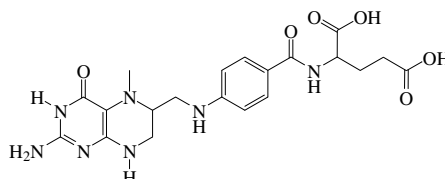
Methyl terephthalate



17-Methyltestosterone



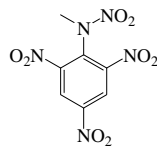
Methyl tetradecanoate



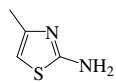
5-N-Methyl-5,6,7,8-tetrahydrofolic acid



2-Methyltetrahydrofuran



N-Methyl-N,2,4,6-tetranitroaniline



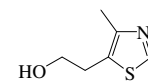
4-Methyl-2-thiazolamine



2-Methylthiazole



4-Methylthiazole



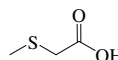
4-Methyl-5-thiazoleethanol



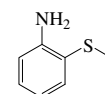
4-Methyl-2(3H)-thiazolethione



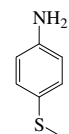
Methylthiirane



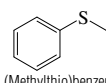
(Methylthio)acetic acid



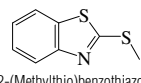
2-(Methylthio)aniline



4-(Methylthio)aniline



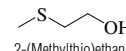
(Methylthio)benzene



2-(Methylthio)benzothiazole



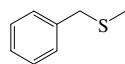
Methyl thiocyanate



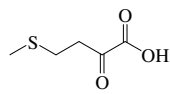
2-(Methylthio)ethanol



(Methylthio)ethene



[(Methylthio)methyl]benzene



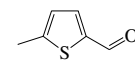
4-(Methylthio)-2-oxobutanoic acid



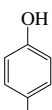
2-Methylthiophene



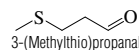
3-Methylthiophene



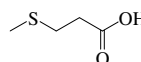
5-Methyl-2-thiophenecarboxaldehyde



4-(Methylthio)phenol



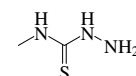
3-(Methylthio)propanal



3-(Methylthio)propanoic acid

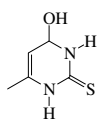


3-(Methylthio)-1-propene



N-Methylthiosemicarbazide

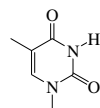
| No.  | Name                                                               | Synonym                                                   | Mol. Form.                                                                       | CAS RN     | Mol. Wt. | Physical Form       | mp/°C                             | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|--------------------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------------------------|------------|----------|---------------------|-----------------------------------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 7823 | Methylthiouracil                                                   |                                                           | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> OS                                  | 56-04-2    | 142.179  |                     | 330 dec                           | sub                                   |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, MeOH, bz                    |
| 7824 | Methylthiourea                                                     |                                                           | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> S                                   | 598-52-7   | 90.147   | pr (EtOH)           | 121                               |                                       |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth; s ace                      |
| 7825 | 1-Methylthymine                                                    | 1,5-Dimethyl-2,4(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                      | 4160-72-9  | 140.140  | nd (w)              | 295                               |                                       |                            |                      | s H <sub>2</sub> O                                            |
| 7826 | Methylthymol blue, sodium salt                                     |                                                           | C <sub>37</sub> H <sub>40</sub> N <sub>2</sub> O <sub>13</sub> Na <sub>3</sub> S | 1945-77-3  | 844.743  | bl-viol cry         |                                   |                                       |                            |                      | s H <sub>2</sub> O                                            |
| 7827 | Methyl 4-toluenesulfonate                                          |                                                           | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub> S                                  | 80-48-8    | 186.228  |                     | 28.5                              | 292; 186 <sup>22</sup>                | 1.2087 <sup>40</sup>       |                      | i H <sub>2</sub> O; vs EtOH, bz; s eth, ctc; sl lig           |
| 7828 | Methyltriacetoxysilane                                             | Methylsilanetriol, triacetate                             | C <sub>7</sub> H <sub>12</sub> O <sub>5</sub> Si                                 | 4253-34-3  | 220.252  |                     | 40.5                              | 111 <sup>17</sup>                     | 1.1750 <sup>20</sup>       | 1.4083 <sup>20</sup> |                                                               |
| 7829 | 6-Methyl-1,2,4-triazine-3,5(2 <i>H</i> ,4 <i>H</i> )-dione         | 6-Azathymine                                              | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                      | 932-53-6   | 127.102  | cry (w)             | 211                               |                                       |                            |                      | s H <sub>2</sub> O, EtOH, ace                                 |
| 7830 | 5-Methyl-[1,2,4]triazolo[1,5- <i>a</i> ]pyrimidin-7-ol             |                                                           | C <sub>6</sub> H <sub>6</sub> N <sub>4</sub> O                                   | 2503-56-2  | 150.138  |                     | >245                              |                                       |                            |                      |                                                               |
| 7831 | Methyl trichloroacetate                                            |                                                           | C <sub>3</sub> H <sub>3</sub> Cl <sub>3</sub> O <sub>2</sub>                     | 598-99-2   | 177.414  | liq                 | -17.5                             | 153.8                                 | 1.4874 <sup>20</sup>       | 1.4572 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ctc                       |
| 7832 | Methyltrichlorosilane                                              |                                                           | CH <sub>3</sub> Cl <sub>3</sub> Si                                               | 75-79-6    | 149.480  | liq                 | -90                               | 65.6                                  | 1.273 <sup>20</sup>        | 1.4106 <sup>20</sup> | dec H <sub>2</sub> O, EtOH                                    |
| 7833 | Methyl tridecanoate                                                |                                                           | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                                   | 1731-88-0  | 228.371  |                     | 6.5                               | 92 <sup>1</sup>                       |                            | 1.4405 <sup>20</sup> | msc EtOH; s ctc                                               |
| 7834 | Methyltriethyllead                                                 | Triethylmethylplumbane                                    | C <sub>7</sub> H <sub>18</sub> Pb                                                | 1762-28-3  | 309.4    | col liq             |                                   | 70 <sup>16</sup>                      |                            | 1.71 <sup>20</sup>   |                                                               |
| 7835 | Methyl trifluoroacetate                                            |                                                           | C <sub>3</sub> H <sub>3</sub> F <sub>3</sub> O <sub>2</sub>                      | 431-47-0   | 128.050  |                     |                                   | 43.0                                  |                            | 1.28 <sup>20</sup>   |                                                               |
| 7836 | Methyl trifluoromethyl ether                                       |                                                           | C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O                                   | 421-14-7   | 100.039  | col gas             | -149                              | -23.66                                |                            |                      |                                                               |
| 7837 | Methyl 3,4,5-trihydroxybenzoate                                    |                                                           | C <sub>8</sub> H <sub>8</sub> O <sub>5</sub>                                     | 99-24-1    | 184.147  | mcl pr (MeOH)       | 202                               |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, MeOH                            |
| 7838 | Methyl 3,4,5-trimethoxybenzoate                                    |                                                           | C <sub>11</sub> H <sub>14</sub> O <sub>5</sub>                                   | 1916-07-0  | 226.226  |                     | 83                                | 274.5                                 |                            |                      |                                                               |
| 7839 | Methyltriphenoxysilane                                             |                                                           | C <sub>19</sub> H <sub>16</sub> O <sub>3</sub> Si                                | 3439-97-2  | 322.430  |                     |                                   | 269 <sup>100</sup> , 179 <sup>2</sup> | 1.135 <sup>20</sup>        | 1.5599 <sup>20</sup> |                                                               |
| 7840 | Methyl trithion                                                    |                                                           | C <sub>6</sub> H <sub>12</sub> ClO <sub>2</sub> PS <sub>3</sub>                  | 953-17-3   | 314.812  | ye liq              | -18                               |                                       |                            |                      | sl H <sub>2</sub> O; misc os                                  |
| 7841 | <i>N</i> -Methyl- <i>L</i> -tryptophan                             | <i>L</i> -Abrine                                          | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>                    | 526-31-8   | 218.251  | pr (w)              | 295 dec                           |                                       |                            |                      | sl H <sub>2</sub> O, MeOH; i eth; s alk                       |
| 7842 | <i>N</i> -Methyl- <i>L</i> -tyrosine                               | Surinamine                                                | C <sub>10</sub> H <sub>13</sub> NO <sub>3</sub>                                  | 537-49-5   | 195.215  | nd                  | 293                               |                                       |                            |                      |                                                               |
| 7843 | $\alpha$ -Methyl- <i>DL</i> -tyrosine, methyl ester, hydrochloride |                                                           | C <sub>11</sub> H <sub>16</sub> ClNO <sub>3</sub>                                | 7361-31-1  | 245.703  |                     | 190 dec                           |                                       |                            |                      | s H <sub>2</sub> O                                            |
| 7844 | 2-Methylundecanal                                                  |                                                           | C <sub>12</sub> H <sub>24</sub> O                                                | 110-41-8   | 184.318  |                     |                                   | 119 <sup>16</sup> , 114 <sup>10</sup> | 0.832 <sup>15</sup>        | 1.4321 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                              |
| 7845 | 2-Methylundecane                                                   |                                                           | C <sub>12</sub> H <sub>26</sub>                                                  | 7045-71-8  | 170.334  | liq                 | -45.6                             | 210.2                                 |                            | 1.4191 <sup>20</sup> |                                                               |
| 7846 | 3-Methylundecane                                                   |                                                           | C <sub>12</sub> H <sub>26</sub>                                                  | 1002-43-3  | 170.334  | col liq             | -58.0                             | 211.2                                 | 0.7485 <sup>25</sup>       | 1.4208 <sup>25</sup> |                                                               |
| 7847 | Methyl undecanoate                                                 |                                                           | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                                   | 1731-86-8  | 200.318  |                     |                                   | 123 <sup>10</sup>                     |                            |                      |                                                               |
| 7848 | 2-Methyl-1-undecanol                                               |                                                           | C <sub>12</sub> H <sub>26</sub> O                                                | 10522-26-6 | 186.333  |                     |                                   | 129 <sup>12</sup>                     | 0.8300 <sup>15</sup>       | 1.4382 <sup>20</sup> | vs eth, EtOH                                                  |
| 7849 | Methyl 10-undecenoate                                              |                                                           | C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>                                   | 111-81-9   | 198.302  | liq                 | -27.5                             | 248                                   | 0.889 <sup>15</sup>        | 1.4393 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, HOAc; sl ctc                 |
| 7850 | <i>N</i> -Methylurea                                               |                                                           | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O                                   | 598-50-5   | 74.081   | orth pr (w, al)     | 104.9                             | dec                                   | 1.2040 <sup>0</sup>        |                      | vs H <sub>2</sub> O, EtOH; i eth, bz; s CS <sub>2</sub> , lig |
| 7851 | 5-Methyluridine                                                    | Thymine riboside                                          | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O <sub>5</sub>                    | 1463-10-1  | 258.227  | cry (EtOH)          | 184                               |                                       |                            |                      |                                                               |
| 7852 | 3-Methyl- <i>L</i> -valine                                         | <i>L</i> - <i>tert</i> -Leucine                           | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                                   | 20859-02-3 | 131.173  |                     | 248 dec                           |                                       |                            |                      |                                                               |
| 7853 | 2-(1-Methylvinyl)aniline                                           |                                                           | C <sub>9</sub> H <sub>11</sub> N                                                 | 52562-19-3 | 133.190  |                     |                                   | 115 <sup>20</sup> , 95 <sup>13</sup>  | 0.977 <sup>25</sup>        | 1.5722 <sup>20</sup> |                                                               |
| 7854 | 1-Methyl-4-vinylcyclohexene                                        |                                                           | C <sub>9</sub> H <sub>14</sub>                                                   | 17699-86-4 | 122.207  | liq                 |                                   | 152                                   | 0.85                       | 1.4701 <sup>20</sup> |                                                               |
| 7855 | 4-(1-Methylvinyl)-1-cyclohexene-1-carboxaldehyde, ( <i>R</i> )     | <i>d</i> -Perillaldehyde                                  | C <sub>10</sub> H <sub>14</sub> O                                                | 5503-12-8  | 150.217  | oil                 |                                   | 238; 99 <sup>7</sup>                  | 0.953 <sup>20</sup>        | 1.5058 <sup>20</sup> | s ctc                                                         |
| 7856 | 4-(1-Methylvinyl)-1-cyclohexene-1-carboxaldehyde, ( <i>S</i> )     | <i>l</i> -Perillaldehyde                                  | C <sub>10</sub> H <sub>14</sub> O                                                | 18031-40-8 | 150.217  | oil                 |                                   | 104 <sup>10</sup>                     | 0.9645 <sup>20</sup>       | 1.5072 <sup>20</sup> |                                                               |
| 7857 | 4-(1-Methylvinyl)-1-cyclohexene-1-methanol                         |                                                           | C <sub>10</sub> H <sub>16</sub> O                                                | 536-59-4   | 152.233  |                     |                                   | 244; 12.5 <sup>12</sup>               | 0.9690 <sup>20</sup>       | 1.5005 <sup>20</sup> |                                                               |
| 7858 | (1-Methylvinyl)cyclopropane                                        |                                                           | C <sub>6</sub> H <sub>10</sub>                                                   | 4663-22-3  | 82.143   | liq                 | -102.3                            | 70                                    | 0.751 <sup>20</sup>        | 1.4252 <sup>20</sup> |                                                               |
| 7859 | Methyl vinyl ether                                                 |                                                           | C <sub>3</sub> H <sub>6</sub> O                                                  | 107-25-5   | 58.079   | col gas             | -122                              | 5.5                                   | 0.7725 <sup>0</sup>        | 1.3730 <sup>0</sup>  | sl H <sub>2</sub> O; vs EtOH, eth, ace, bz                    |
| 7860 | Methyl Violet                                                      | C.I. Basic Violet 1                                       | C <sub>24</sub> H <sub>28</sub> ClN <sub>3</sub>                                 | 8004-87-3  | 393.952  | bl-viol pow         | 137 dec                           |                                       |                            |                      | s H <sub>2</sub> O, EtOH                                      |
| 7861 | Methysergide                                                       |                                                           | C <sub>21</sub> H <sub>27</sub> N <sub>3</sub> O <sub>2</sub>                    | 361-37-5   | 353.458  | cry                 | 195                               |                                       |                            |                      |                                                               |
| 7862 | Methysticin                                                        |                                                           | C <sub>15</sub> H <sub>14</sub> O <sub>5</sub>                                   | 495-85-2   | 274.269  | nd (MeOH), pr (ace) | 137                               |                                       |                            |                      |                                                               |
| 7863 | Metobromuron                                                       | 3-( <i>p</i> -Bromophenyl)-1-methoxy-1-methylurea         | C <sub>9</sub> H <sub>11</sub> BrN <sub>2</sub> O <sub>2</sub>                   | 3060-89-7  | 259.099  |                     | 95                                |                                       | 1.60 <sup>20</sup>         |                      |                                                               |
| 7864 | Metolachlor                                                        |                                                           | C <sub>15</sub> H <sub>22</sub> ClNO <sub>2</sub>                                | 51218-45-2 | 283.795  |                     |                                   | 100 <sup>0.001</sup>                  | 1.12 <sup>20</sup>         |                      |                                                               |
| 7865 | Metolazone                                                         |                                                           | C <sub>16</sub> H <sub>16</sub> ClN <sub>3</sub> O <sub>3</sub> S                | 17560-51-9 | 365.834  | cry (EtOH)          | 254                               |                                       |                            |                      |                                                               |
| 7866 | Metoprolol tartrate                                                |                                                           | C <sub>34</sub> H <sub>56</sub> N <sub>2</sub> O <sub>12</sub>                   | 56392-17-7 | 684.815  | cry                 | 121                               |                                       |                            |                      |                                                               |
| 7867 | Metribuzin                                                         |                                                           | C <sub>8</sub> H <sub>14</sub> N <sub>4</sub> OS                                 | 21087-64-9 | 214.288  |                     | 126                               |                                       | 1.31 <sup>20</sup>         |                      |                                                               |
| 7868 | Metronidazole                                                      | 2-Methyl-5-nitro-1 <i>H</i> -imidazole-1-ethanol          | C <sub>6</sub> H <sub>9</sub> N <sub>3</sub> O <sub>3</sub>                      | 443-48-1   | 171.153  |                     | 160.5                             |                                       |                            |                      |                                                               |
| 7869 | Metsulfuron-methyl                                                 |                                                           | C <sub>14</sub> H <sub>15</sub> N <sub>3</sub> O <sub>6</sub> S                  | 74223-64-6 | 381.364  | wh cry              | 163                               |                                       |                            |                      | sl H <sub>2</sub> O                                           |
| 7870 | Mevinphos                                                          |                                                           | C <sub>7</sub> H <sub>13</sub> O <sub>6</sub> P                                  | 7786-34-7  | 224.148  |                     | 21 ( <i>E</i> ), 6.9 ( <i>Z</i> ) | 101 <sup>0.3</sup>                    |                            |                      |                                                               |
| 7871 | Mexacarbate                                                        | 4-(Dimethylamino)-3,5-xylol methylcarbamate               | C <sub>12</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub>                    | 315-18-4   | 222.283  | cry                 | 85                                |                                       |                            |                      | vs EtOH, bz, ace                                              |



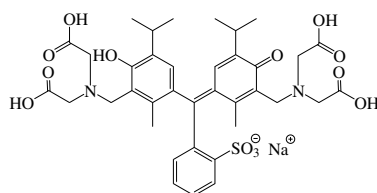
Methylthiouracil



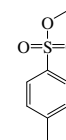
Methylthiourea



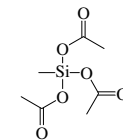
1-Methylthymine



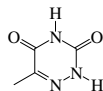
Methylthymol blue, sodium salt



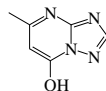
Methyl 4-toluenesulfonate



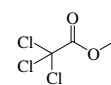
Methyltriacetoxysilane



6-Methyl-1,2,4-triazine-3,5-dione



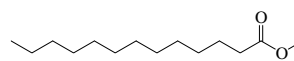
5-Methyl-[1,2,4]triazolo[1,5-a]pyrimidin-7-ol



Methyl trichloroacetate



Methyltrichlorosilane



Methyl tridecanoate



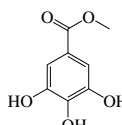
Methyltriethyllead



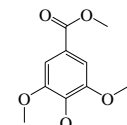
Methyl trifluoroacetate



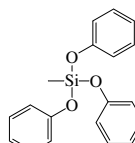
Methyl trifluoromethyl ether



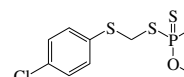
Methyl 3,4,5-trihydroxybenzoate



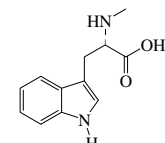
Methyl 3,4,5-trimethoxybenzoate



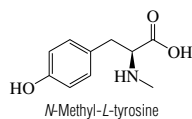
Methyltriphenoxysilane



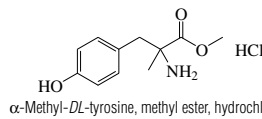
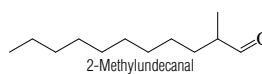
Methyl trithion



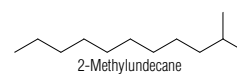
N-Methyl-L-tryptophan



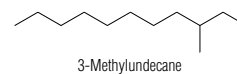
N-Methyl-L-tyrosine

 $\alpha$ -Methyl-DL-tyrosine, methyl ester, hydrochloride

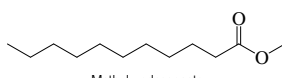
2-Methylundecanal



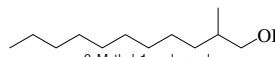
2-Methylundecane



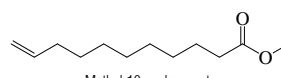
3-Methylundecane



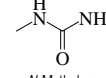
Methyl undecanoate



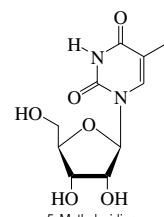
2-Methyl-1-undecanol



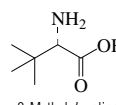
Methyl 10-undecenoate



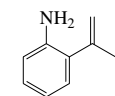
N-Methylurea



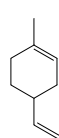
5-Methyluridine



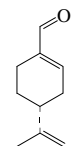
3-Methyl-L-valine



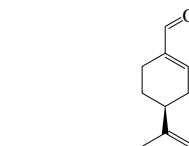
2-(1-Methylvinyl)aniline



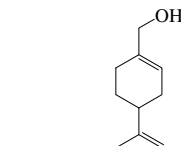
1-Methyl-4-vinylcyclohexene



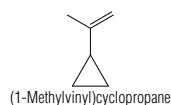
4-(1-Methylvinyl)-1-cyclohexene-1-carboxaldehyde, (R)



4-(1-Methylvinyl)-1-cyclohexene-1-carboxaldehyde, (S)



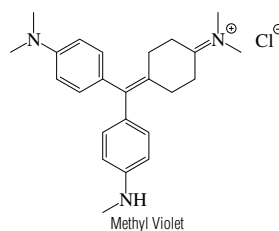
4-(1-Methylvinyl)-1-cyclohexene-1-methanol



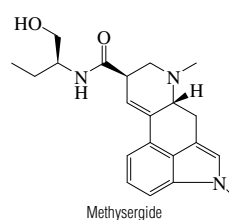
(1-Methylvinyl)cyclopropane



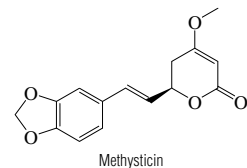
Methyl vinyl ether



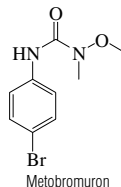
Methyl Violet



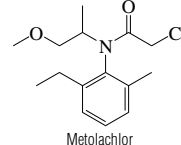
Methysergide



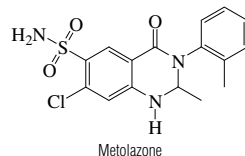
Methysticin



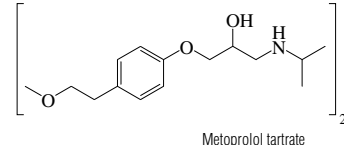
Metobromuron



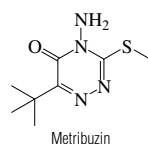
Metolachlor



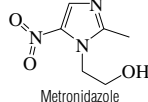
Metolazone



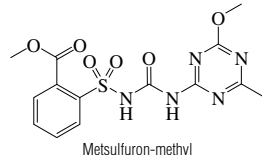
Metoprolol tartrate



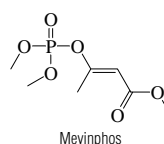
Metribuzin



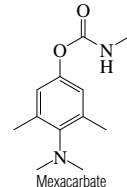
Metronidazole



Metsulfuron-methyl



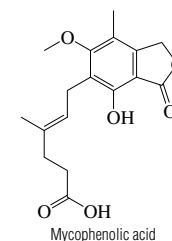
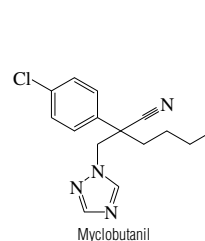
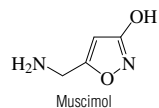
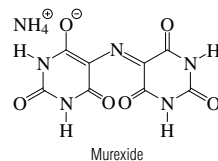
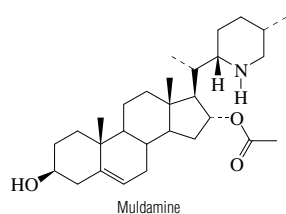
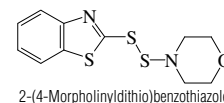
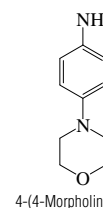
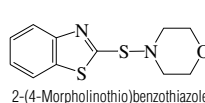
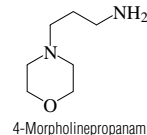
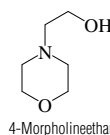
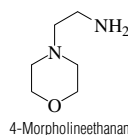
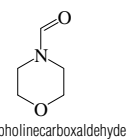
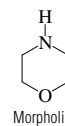
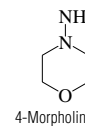
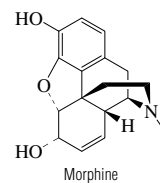
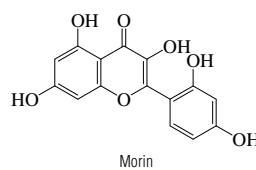
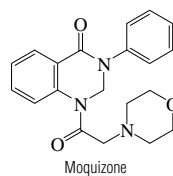
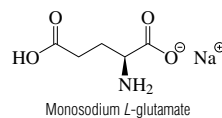
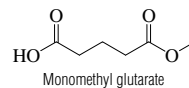
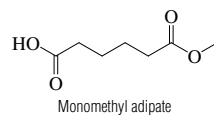
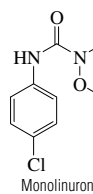
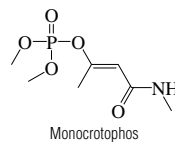
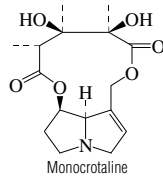
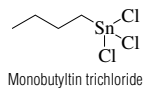
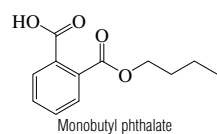
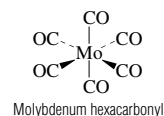
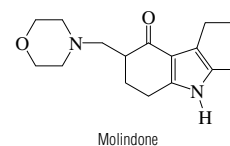
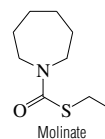
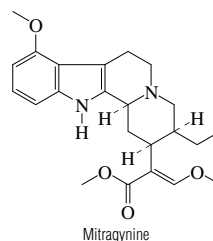
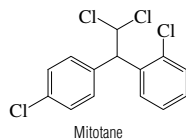
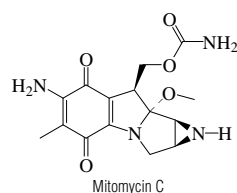
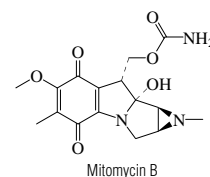
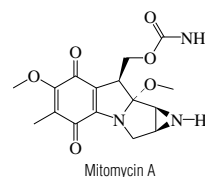
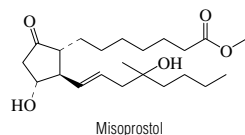
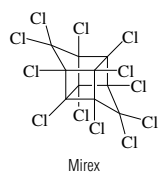
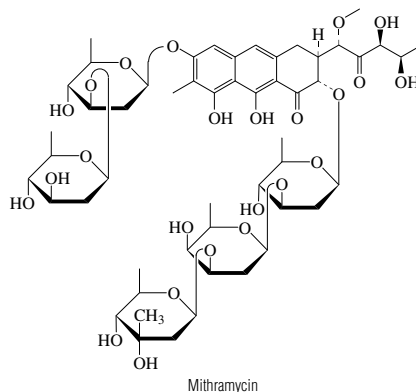
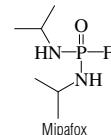
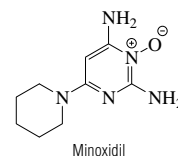
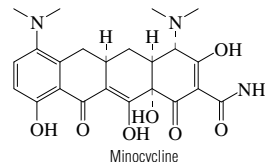
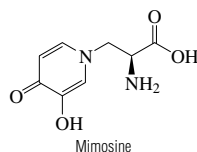
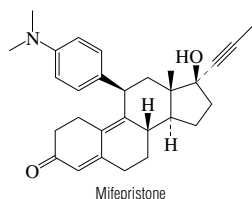
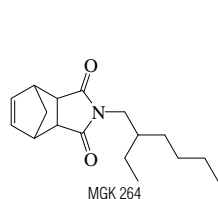
Mevinphos



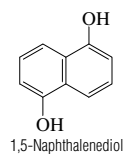
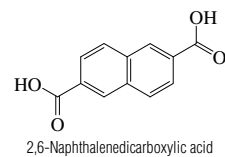
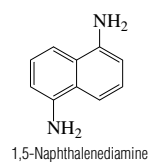
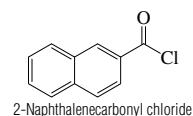
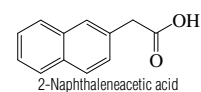
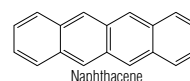
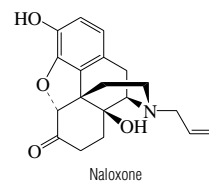
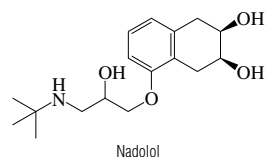
Mexacarbate



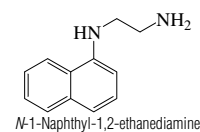
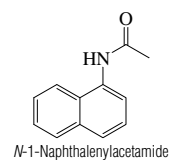
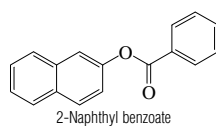
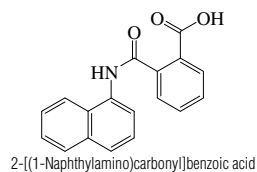
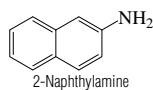
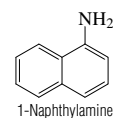
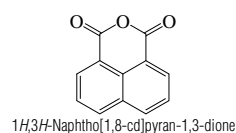
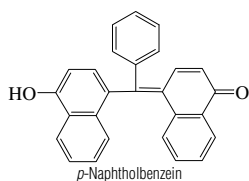
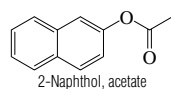
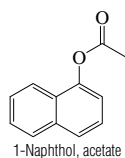
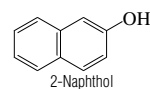
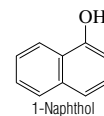
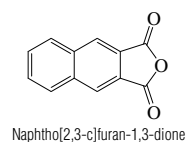
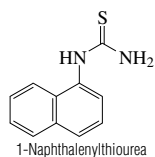
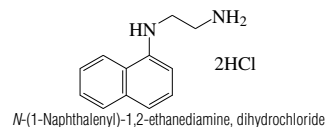
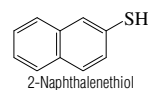
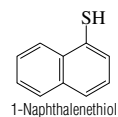
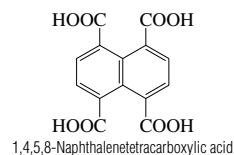
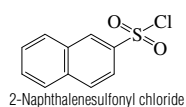
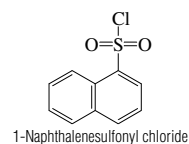
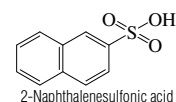
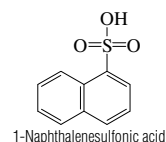
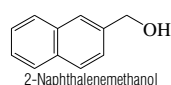
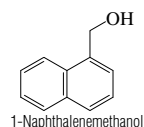
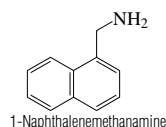
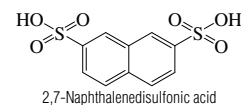
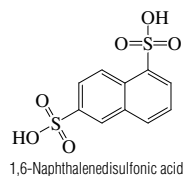
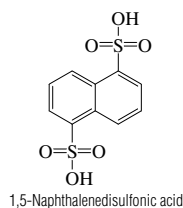
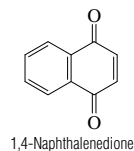
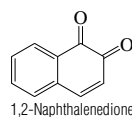
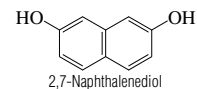
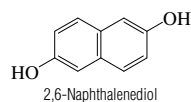
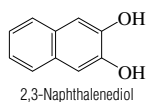
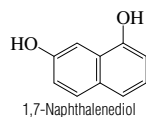
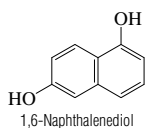
| No.  | Name                                   | Synonym                                                             | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form               | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                      |
|------|----------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------|------------|----------|-----------------------------|---------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------------------|
| 7872 | MGK 264                                |                                                                     | C <sub>17</sub> H <sub>25</sub> NO <sub>2</sub>                | 113-48-4   | 275.387  |                             | <-20    | 157                                   | 1.04                       |                      |                                                                 |
| 7873 | Mifepristone                           | RU-486                                                              | C <sub>29</sub> H <sub>35</sub> NO <sub>2</sub>                | 84371-65-3 | 429.594  | cry                         | 150     |                                       |                            |                      |                                                                 |
| 7874 | Mimosine                               |                                                                     | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub>   | 500-44-7   | 198.176  | tab (w)                     | 228 dec |                                       |                            |                      | sl H <sub>2</sub> O; i EtOH, eth, ace, bz; s dil alk            |
| 7875 | Minocycline                            |                                                                     | C <sub>23</sub> H <sub>27</sub> N <sub>3</sub> O <sub>7</sub>  | 10118-90-8 | 457.476  | ye-oran amorp solid         |         |                                       |                            |                      |                                                                 |
| 7876 | Minoxidil                              |                                                                     | C <sub>9</sub> H <sub>15</sub> N <sub>5</sub> O                | 38304-91-5 | 209.248  | cry                         | 248     |                                       |                            |                      | i ace, bz, chl, sl; EtOH, MeOH                                  |
| 7877 | Mipafox                                | Bis(isopropylamido) fluorophosphate                                 | C <sub>6</sub> H <sub>16</sub> FN <sub>2</sub> OP              | 371-86-8   | 182.175  | cry (peth)                  | 65      | 125 <sup>2</sup>                      |                            |                      | sl H <sub>2</sub> O                                             |
| 7878 | Mirex                                  | Hexachloropentadiene dimer                                          | C <sub>10</sub> Cl <sub>12</sub>                               | 2385-85-5  | 545.543  | cry (bz)                    | 485 dec |                                       |                            |                      | vs bz, diox                                                     |
| 7879 | Misoprostol                            |                                                                     | C <sub>22</sub> H <sub>38</sub> O <sub>5</sub>                 | 59122-46-2 | 382.534  | ye oil                      |         |                                       |                            |                      | s H <sub>2</sub> O                                              |
| 7880 | Mithramycin                            | Plicamycin                                                          | C <sub>52</sub> H <sub>76</sub> O <sub>24</sub>                | 18378-89-7 | 1085.145 | ye cry (ace)                | 182     |                                       |                            |                      | s H <sub>2</sub> O, EtOH, AcOEt; sl bz, eth                     |
| 7881 | Mitomycin A                            |                                                                     | C <sub>16</sub> H <sub>19</sub> N <sub>3</sub> O <sub>6</sub>  | 4055-39-4  | 349.338  | purp nd                     | 160 dec |                                       |                            |                      |                                                                 |
| 7882 | Mitomycin B                            |                                                                     | C <sub>16</sub> H <sub>19</sub> N <sub>3</sub> O <sub>6</sub>  | 4055-40-7  | 349.338  | purp-bl nd                  | dec     |                                       |                            |                      |                                                                 |
| 7883 | Mitomycin C                            |                                                                     | C <sub>15</sub> H <sub>18</sub> N <sub>4</sub> O <sub>5</sub>  | 50-07-7    | 334.328  | bl-viol cry                 | 360     |                                       |                            |                      | s H <sub>2</sub> O, MeOH, ace                                   |
| 7884 | Mitotane                               |                                                                     | C <sub>14</sub> H <sub>10</sub> Cl <sub>4</sub>                | 53-19-0    | 320.041  |                             | 77      |                                       |                            |                      |                                                                 |
| 7885 | Mitragynine                            | 9-Methoxycorynantheidine                                            | C <sub>23</sub> H <sub>30</sub> N <sub>2</sub> O <sub>4</sub>  | 4098-40-2  | 398.495  | wh amorp pow                | 104     | 235 <sup>5</sup>                      |                            |                      | s EtOH, chl, HOAc                                               |
| 7886 | Molinate                               | Ethyl 1-hexamethyleneiminecarbothiolate                             | C <sub>9</sub> H <sub>17</sub> NOS                             | 2212-67-1  | 187.302  |                             |         | 202 <sup>10</sup>                     | 1.063 <sup>20</sup>        |                      |                                                                 |
| 7887 | Molindone                              |                                                                     | C <sub>16</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>  | 7416-34-4  | 276.374  | cry                         | 180     |                                       |                            |                      |                                                                 |
| 7888 | Molybdenum hexacarbonyl                |                                                                     | C <sub>6</sub> MoO <sub>6</sub>                                | 13939-06-5 | 264.00   |                             | dec 150 |                                       |                            |                      | s os                                                            |
| 7889 | Monobutyl phthalate                    | 1,2-Benzenedicarboxylic acid, monobutyl ester                       | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                 | 131-70-4   | 222.237  | pl (ace, al)                | 73.5    |                                       |                            |                      | vs EtOH, chl                                                    |
| 7890 | Monobutyltin trichloride               |                                                                     | C <sub>4</sub> H <sub>9</sub> Cl <sub>3</sub> Sn               | 1118-46-3  | 282.183  | hyg liq                     | -63     | 93 <sup>10</sup>                      | 0.85 <sup>20</sup>         |                      | s bz, CH <sub>2</sub> Cl <sub>2</sub>                           |
| 7891 | Monocrotaline                          |                                                                     | C <sub>16</sub> H <sub>23</sub> NO <sub>6</sub>                | 315-22-0   | 325.357  | wh pr (EtOH)                | 198 dec |                                       |                            |                      |                                                                 |
| 7892 | Monocrotophos                          |                                                                     | C <sub>7</sub> H <sub>14</sub> NO <sub>3</sub> P               | 6923-22-4  | 223.164  |                             | 55      | 125 <sup>0.0005</sup>                 | 1.33 <sup>20</sup>         |                      |                                                                 |
| 7893 | Monolinuron                            | <i>N</i> -(4-Chlorophenyl)- <i>N</i> -methoxy- <i>N</i> -methylurea | C <sub>9</sub> H <sub>11</sub> ClN <sub>2</sub> O <sub>2</sub> | 1746-81-2  | 214.648  | solid                       | 77      |                                       |                            |                      |                                                                 |
| 7894 | Monomethyl adipate                     |                                                                     | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                  | 627-91-8   | 160.168  | lf (Me <sub>3</sub> N-MeOH) | 9       | 158 <sup>10</sup>                     | 1.0623 <sup>20</sup>       | 1.4283 <sup>20</sup> | s EtOH                                                          |
| 7895 | Monomethyl glutarate                   |                                                                     | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub>                  | 1501-27-5  | 146.141  |                             |         | 158 <sup>27</sup> , 150 <sup>10</sup> | 1.169 <sup>25</sup>        | 1.4381 <sup>20</sup> |                                                                 |
| 7896 | Monosodium <i>L</i> -glutamate         |                                                                     | C <sub>5</sub> H <sub>9</sub> NNaO <sub>4</sub>                | 142-47-2   | 169.113  |                             |         |                                       |                            |                      | s H <sub>2</sub> O                                              |
| 7897 | Moquizone                              |                                                                     | C <sub>20</sub> H <sub>21</sub> N <sub>3</sub> O <sub>3</sub>  | 19395-58-5 | 351.399  |                             | 136     |                                       |                            |                      | s chl                                                           |
| 7898 | Morin                                  |                                                                     | C <sub>15</sub> H <sub>10</sub> O <sub>7</sub>                 | 480-16-0   | 302.236  | pa ye nd (+1 w, dil al)     | 303.5   |                                       |                            |                      | sl H <sub>2</sub> O, eth; vs EtOH; s bz, alk; i CS <sub>2</sub> |
| 7899 | Morphine                               |                                                                     | C <sub>17</sub> H <sub>19</sub> NO <sub>3</sub>                | 57-27-2    | 285.338  | pr                          | 255     | sub 190                               |                            |                      | i H <sub>2</sub> O, eth, ace; s MeOH, py; sl EtOH               |
| 7900 | 4-Morpholinamine                       |                                                                     | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O                | 4319-49-7  | 102.134  |                             |         | 166                                   | 1.059 <sup>25</sup>        | 1.4772 <sup>20</sup> |                                                                 |
| 7901 | Morpholine                             | Tetrahydro-1,4-oxazine                                              | C <sub>4</sub> H <sub>9</sub> NO                               | 110-91-8   | 87.120   | hyg liq                     | -4.8    | 128                                   | 1.0005 <sup>20</sup>       | 1.4548 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth, ace, bz; sl chl              |
| 7902 | 4-Morpholinecarboxaldehyde             |                                                                     | C <sub>5</sub> H <sub>9</sub> NO <sub>2</sub>                  | 4394-85-8  | 115.131  |                             | 21      | 239                                   | 1.1520 <sup>20</sup>       | 1.4845 <sup>20</sup> |                                                                 |
| 7903 | 4-Morpholineethanamine                 |                                                                     | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O                | 2038-03-1  | 130.187  |                             | 25.6    | 205                                   | 0.9897 <sup>20</sup>       | 1.4715 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, bz, lig; s ace                      |
| 7904 | 4-Morpholineethanol                    |                                                                     | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                 | 622-40-2   | 131.173  | liq                         | -0.8    | 227                                   | 1.0710 <sup>20</sup>       | 1.4763 <sup>20</sup> | s H <sub>2</sub> O, EtOH; sl ctc                                |
| 7905 | 4-Morpholinepropanamine                | 4-(3-Aminopropyl)morpholine                                         | C <sub>7</sub> H <sub>16</sub> N <sub>2</sub> O                | 123-00-2   | 144.214  | liq                         | -15     | 220; 134 <sup>50</sup>                | 0.9854 <sup>20</sup>       | 1.4762 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, bz, lig; s ace; sl ctc              |
| 7906 | 2-(4-Morpholiniothio) benzothiazole    | 4-(2-Benzothiazolythio) morpholine                                  | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> OS <sub>2</sub> | 102-77-2   | 252.355  | cry (EtOH)                  | 85      |                                       |                            |                      |                                                                 |
| 7907 | 4-(4-Morpholinyl)aniline               |                                                                     | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O               | 2524-67-6  | 178.230  |                             | 131.6   |                                       |                            |                      |                                                                 |
| 7908 | 2-(4-Morpholinylidithio) benzothiazole |                                                                     | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> OS <sub>3</sub> | 95-32-9    | 284.420  |                             | 135     |                                       |                            |                      |                                                                 |
| 7909 | Muldamine                              |                                                                     | C <sub>29</sub> H <sub>47</sub> NO <sub>3</sub>                | 36069-45-1 | 457.688  |                             | 210     |                                       |                            |                      |                                                                 |
| 7910 | Murexide                               | 5,5'-Nitrilobarbituric acid, ammonium salt                          | C <sub>8</sub> H <sub>10</sub> N <sub>6</sub> O <sub>7</sub>   | 3051-09-0  | 302.201  |                             |         |                                       |                            |                      | sl H <sub>2</sub> O; i EtOH, eth; s alk                         |
| 7911 | Muscimol                               | 5-(Aminomethyl)-3(2 <i>H</i> )-isoxazolone                          | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>    | 2763-96-4  | 114.103  | cry (EtOH)                  | 175 dec |                                       |                            |                      |                                                                 |
| 7912 | Myclobutanil                           |                                                                     | C <sub>15</sub> H <sub>17</sub> ClN <sub>4</sub>               | 88671-89-0 | 288.776  | ye cry                      | 65      | 205 <sup>1.0</sup>                    |                            |                      | i H <sub>2</sub> O, peth; s EtOH                                |
| 7913 | Mycophenolic acid                      |                                                                     | C <sub>17</sub> H <sub>20</sub> O <sub>6</sub>                 | 24280-93-1 | 320.337  | nd (w)                      | 141     |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, chl; sl bz, tol               |



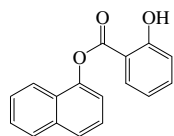
| No.  | Name                                             | Synonym                                                      | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form               | mp/°C    | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|--------------------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------|------------|----------|-----------------------------|----------|---------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 7914 | β-Myrcene                                        | 7-Methyl-3-methylene-1,6-octadiene                           | C <sub>10</sub> H <sub>16</sub>                                                | 123-35-3   | 136.234  |                             |          | 167                                   | 0.8013 <sup>15</sup>       | 1.4722 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl, HOAc               |
| 7915 | Myristicin                                       |                                                              | C <sub>11</sub> H <sub>12</sub> O <sub>3</sub>                                 | 607-91-0   | 192.211  |                             | <-20     | 276.5                                 | 1.1416 <sup>20</sup>       | 1.5403 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH; s eth, bz                       |
| 7916 | Nabam                                            | Sodium ethylenebisdithiocarbamic acid                        | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> Na <sub>2</sub> S <sub>4</sub>    | 142-59-6   | 256.344  | cry (w)                     |          |                                       |                            |                      | s H <sub>2</sub> O                                           |
| 7917 | Nadolol                                          |                                                              | C <sub>17</sub> H <sub>27</sub> NO <sub>4</sub>                                | 42200-33-9 | 309.401  | cry (bz)                    | ≈130     |                                       |                            |                      | s EtOH; sl chl; i ace, eth, hx                               |
| 7918 | Naled                                            | 1,2-Dibromo-2,2-dichloroethylphosphoric acid, dimethyl ester | C <sub>4</sub> H <sub>7</sub> Br <sub>2</sub> Cl <sub>2</sub> O <sub>4</sub> P | 300-76-5   | 380.784  |                             | 27       | 110 <sup>0.5</sup>                    | 1.96 <sup>20</sup>         |                      |                                                              |
| 7919 | Nalidixic acid                                   |                                                              | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>                  | 389-08-2   | 232.234  |                             | 229.5    |                                       |                            |                      | sl EtOH, eth; s chl                                          |
| 7920 | Nalmefene                                        |                                                              | C <sub>21</sub> H <sub>25</sub> NO <sub>3</sub>                                | 55096-26-9 | 339.429  | cry (AcOEt)                 | 189      |                                       |                            |                      |                                                              |
| 7921 | Nalorphine                                       | Acetorphan                                                   | C <sub>19</sub> H <sub>21</sub> NO <sub>3</sub>                                | 62-67-9    | 311.375  | cry (eth)                   | 208      |                                       |                            |                      | sl H <sub>2</sub> O; s alk, ace, EtOH                        |
| 7922 | Naloxone                                         |                                                              | C <sub>19</sub> H <sub>21</sub> NO <sub>4</sub>                                | 465-65-6   | 327.375  | cry (AcOEt)                 | 178      |                                       |                            |                      | i peth; s chl                                                |
| 7923 | Naltrexone                                       |                                                              | C <sub>20</sub> H <sub>23</sub> NO <sub>4</sub>                                | 16590-41-3 | 341.402  | cry (ace)                   | 169      |                                       |                            |                      |                                                              |
| 7924 | Nandrolone                                       | 17-Hydroxyestr-4-en-3-one                                    | C <sub>18</sub> H <sub>26</sub> O <sub>2</sub>                                 | 434-22-0   | 274.398  | cry                         | 112      |                                       |                            |                      | s EtOH, eth, chl                                             |
| 7925 | Naphazoline hydrochloride                        |                                                              | C <sub>14</sub> H <sub>14</sub> ClN <sub>2</sub>                               | 550-99-2   | 245.727  |                             |          |                                       |                            |                      | sl H <sub>2</sub> O                                          |
| 7926 | Naphthacene                                      | 2,3-Benzanthracene                                           | C <sub>18</sub> H <sub>12</sub>                                                | 92-24-0    | 228.288  | oran-ye lf (bz, xyl)        | 357      | sub                                   |                            |                      | i H <sub>2</sub> O; sl bz; s con sulf                        |
| 7927 | 5,12-Naphthacenedione                            |                                                              | C <sub>18</sub> H <sub>10</sub> O <sub>2</sub>                                 | 1090-13-7  | 258.271  |                             | 285 dec  |                                       |                            |                      | sl ace, bz, gl HOAc                                          |
| 7928 | Naphthalene                                      |                                                              | C <sub>10</sub> H <sub>8</sub>                                                 | 91-20-3    | 128.171  | mcl pl (al)                 | 80.26    | 217.9                                 | 1.0253 <sup>20</sup>       | 1.5898 <sup>25</sup> | i H <sub>2</sub> O; s EtOH; vs eth, ace, bz, CS <sub>2</sub> |
| 7929 | 1-Naphthaleneacetamide                           |                                                              | C <sub>12</sub> H <sub>11</sub> NO                                             | 86-86-2    | 185.221  | nd(w, al)                   |          | sub 180                               |                            |                      | i H <sub>2</sub> O; s eth, bz, CS <sub>2</sub> , HOAc        |
| 7930 | 1-Naphthaleneacetic acid                         | 1-Naphthylacetic acid                                        | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                                 | 86-87-3    | 186.206  | nd (w)                      | 133      | dec                                   |                            |                      | sl H <sub>2</sub> O, EtOH; vs eth, ace, chl; s bz            |
| 7931 | 2-Naphthaleneacetic acid                         | 2-Naphthylacetic acid                                        | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                                 | 581-96-4   | 186.206  | lf(w) cry (bz)              | 143      |                                       |                            |                      | vs eth, lig, chl                                             |
| 7932 | 1-Naphthaleneacetonitrile                        |                                                              | C <sub>12</sub> H <sub>9</sub> N                                               | 132-75-2   | 167.206  |                             | 32.5     | 192 <sup>18</sup> , 163 <sup>12</sup> |                            | 1.6192 <sup>20</sup> | s EtOH                                                       |
| 7933 | 1-Naphthalenecarbonitrile                        |                                                              | C <sub>11</sub> H <sub>7</sub> N                                               | 86-53-3    | 153.181  | nd (lig)                    | 37.5     | 299                                   | 1.1080 <sup>25</sup>       | 1.6298 <sup>18</sup> | i H <sub>2</sub> O; vs EtOH, eth; s lig                      |
| 7934 | 2-Naphthalenecarbonitrile                        |                                                              | C <sub>11</sub> H <sub>7</sub> N                                               | 613-46-7   | 153.181  | lf (lig)                    | 66       | 306.5                                 | 1.0755 <sup>60</sup>       |                      | sl H <sub>2</sub> O, chl; s EtOH, eth, lig                   |
| 7935 | 1-Naphthalenecarbonyl chloride                   |                                                              | C <sub>11</sub> H <sub>7</sub> ClO                                             | 879-18-5   | 190.626  |                             | 20       | 297.5                                 |                            |                      |                                                              |
| 7936 | 2-Naphthalenecarbonyl chloride                   |                                                              | C <sub>11</sub> H <sub>7</sub> ClO                                             | 2243-83-6  | 190.626  | cry (peth)                  | 51       | 305                                   |                            |                      | vs bz, eth, chl                                              |
| 7937 | 1-Naphthalenecarboxaldehyde                      |                                                              | C <sub>11</sub> H <sub>8</sub> O                                               | 66-77-3    | 156.181  | pa ye                       | 33.5     | 292                                   | 1.1503 <sup>20</sup>       | 1.6507 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, sulf               |
| 7938 | 2-Naphthalenecarboxaldehyde                      |                                                              | C <sub>11</sub> H <sub>8</sub> O                                               | 66-99-9    | 156.181  | lf (w)                      | 62       | 160 <sup>19</sup>                     | 1.0775 <sup>99</sup>       | 1.6211 <sup>99</sup> | sl H <sub>2</sub> O; vs EtOH, eth; s ace                     |
| 7939 | 1-Naphthalenecarboxylic acid                     | 1-Naphthoic acid                                             | C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                                  | 86-55-5    | 172.181  | nd (HOAc-w, w, al)          | 161      | >300                                  | 1.398 <sup>25</sup>        | 1.46                 | i H <sub>2</sub> O; vs eth, EtOH, chl                        |
| 7940 | 2-Naphthalenecarboxylic acid                     | 2-Naphthoic acid                                             | C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                                  | 93-09-4    | 172.181  | nd (lig, chl, sub) pl (ace) | 185.5    | >300                                  | 1.077 <sup>100</sup>       |                      | sl H <sub>2</sub> O, DMSO, lig; s EtOH, eth, chl             |
| 7941 | 1,5-Naphthalenediamine                           | 1,5-Diaminonaphthalene                                       | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub>                                 | 2243-62-1  | 158.199  | pr (eth, al, w)             | 190      | sub                                   | 1.4 <sup>25</sup>          |                      | s H <sub>2</sub> O, EtOH, eth; vs chl                        |
| 7942 | 1,8-Naphthalenediamine                           | 1,8-Diaminonaphthalene                                       | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub>                                 | 479-27-6   | 158.199  |                             | 66.5     | 205 <sup>12</sup>                     | 1.1265 <sup>90</sup>       | 1.6828 <sup>99</sup> | vs eth, EtOH                                                 |
| 7943 | 2,3-Naphthalenediamine                           | 2,3-Diaminonaphthalene                                       | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub>                                 | 771-97-1   | 158.199  | lf (eth, w)                 | 199      |                                       | 1.0968 <sup>26</sup>       | 1.6392 <sup>26</sup> | sl H <sub>2</sub> O, DMSO; vs EtOH; s eth                    |
| 7944 | 1,8-Naphthalenedicarboxylic acid                 | Naphthalic acid                                              | C <sub>12</sub> H <sub>6</sub> O <sub>4</sub>                                  | 518-05-8   | 216.190  |                             | 260      |                                       |                            |                      | i H <sub>2</sub> O; sl EtOH, eth                             |
| 7945 | 2,3-Naphthalenedicarboxylic acid                 |                                                              | C <sub>12</sub> H <sub>6</sub> O <sub>4</sub>                                  | 2169-87-1  | 216.190  | pr (HOAc, w, sub)           | 244.5    |                                       |                            |                      | i H <sub>2</sub> O, bz, chl; sl EtOH, eth, DMSO              |
| 7946 | 2,6-Naphthalenedicarboxylic acid                 |                                                              | C <sub>12</sub> H <sub>6</sub> O <sub>4</sub>                                  | 1141-38-4  | 216.190  | nd (al or sub)              | >300 dec |                                       |                            |                      | vs EtOH                                                      |
| 7947 | 2,6-Naphthalenedicarboxylic acid, dimethyl ester |                                                              | C <sub>14</sub> H <sub>12</sub> O <sub>4</sub>                                 | 840-65-3   | 244.243  |                             | 190.0    |                                       |                            |                      |                                                              |
| 7948 | 1,5-Naphthalene diisocyanate                     | 1,5-Diisocyanatonaphthalene                                  | C <sub>12</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                   | 3173-72-6  | 210.188  | cry                         | 127      | 183 <sup>10</sup>                     |                            |                      |                                                              |
| 7949 | 1,3-Naphthalenediol                              | Naphthoresorcinol                                            | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                                  | 132-86-5   | 160.170  | lf (w)                      | 123.5    |                                       |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl ace, bz, lig               |
| 7950 | 1,4-Naphthalenediol                              |                                                              | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                                  | 571-60-8   | 160.170  | mcl nd (bz, w)              | 192      |                                       |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl ace; i bz                  |
| 7951 | 1,5-Naphthalenediol                              |                                                              | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                                  | 83-56-7    | 160.170  | pr (w), nd (sub)            | 262 dec  | sub                                   |                            |                      | sl H <sub>2</sub> O, EtOH; vs eth, ace; i bz; s HOAc         |



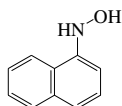
| No.  | Name                                                   | Synonym                                    | Mol. Form.                                                     | CAS RN    | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|--------------------------------------------------------|--------------------------------------------|----------------------------------------------------------------|-----------|----------|------------------------------|---------|----------------------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 7952 | 1,6-Naphthalenediol                                    |                                            | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                  | 575-44-0  | 160.170  | pr (bz)                      | 138     | sub                                    |                            |                      | sl H <sub>2</sub> O; EtOH; s eth, ace, bz, DMSO               |
| 7953 | 1,7-Naphthalenediol                                    |                                            | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                  | 575-38-2  | 160.170  | nd (bz or sub)               | 180.5   | sub                                    |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz, HOAc                 |
| 7954 | 2,3-Naphthalenediol                                    |                                            | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                  | 92-44-4   | 160.170  | lf (w)                       | 163.5   |                                        |                            |                      | s H <sub>2</sub> O, EtOH, eth, ace, bz, lig, HOAc             |
| 7955 | 2,6-Naphthalenediol                                    |                                            | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                  | 581-43-1  | 160.170  | orth pl (w)                  | 220     | sub                                    |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, eth, ace; i lig              |
| 7956 | 2,7-Naphthalenediol                                    |                                            | C <sub>10</sub> H <sub>8</sub> O <sub>2</sub>                  | 582-17-2  | 160.170  | nd, (w, dil al), pl (dil al) | 193     | sub                                    |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl; sl ace; i lig         |
| 7957 | 1,2-Naphthalenedione                                   | 1,2-Naphthoquinone                         | C <sub>10</sub> H <sub>6</sub> O <sub>2</sub>                  | 524-42-5  | 158.154  | ye-red nd (eth) oran lf (bz) | 146     |                                        | 1.450 <sup>25</sup>        |                      | s H <sub>2</sub> O, EtOH, eth, sulf; sl lig                   |
| 7958 | 1,4-Naphthalenedione                                   | 1,4-Naphthoquinone                         | C <sub>10</sub> H <sub>6</sub> O <sub>2</sub>                  | 130-15-4  | 158.154  | bt ye nd (al, peth) ye (sub) | 128.5   | sub                                    |                            |                      | sl H <sub>2</sub> O; vs EtOH; s eth, bz, chl, CS <sub>2</sub> |
| 7959 | 1,5-Naphthalenedisulfonic acid                         | Armstrong's acid                           | C <sub>10</sub> H <sub>6</sub> O <sub>6</sub> S <sub>2</sub>   | 81-04-9   | 288.297  | pl (+4w, dil HOAc)           | 242 dec |                                        | 1.493 <sup>25</sup>        |                      | vs H <sub>2</sub> O; s EtOH; i eth                            |
| 7960 | 1,6-Naphthalenedisulfonic acid                         | Naphthalene-1,6-disulfonic acid            | C <sub>10</sub> H <sub>6</sub> O <sub>6</sub> S <sub>2</sub>   | 525-37-1  | 288.297  | oran pr (+4w, HOAc or w)     | 125 dec |                                        |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth                            |
| 7961 | 2,7-Naphthalenedisulfonic acid                         | Naphthalene-2,7-disulfonic acid            | C <sub>10</sub> H <sub>6</sub> O <sub>6</sub> S <sub>2</sub>   | 92-41-1   | 288.297  | hyg nd (conc HCl)            | 199     |                                        |                            |                      | s H <sub>2</sub> O; sl con HCl                                |
| 7962 | 1-Naphthalenemethanamine                               |                                            | C <sub>11</sub> H <sub>11</sub> N                              | 118-31-0  | 157.212  |                              |         | 292                                    | 1.0958 <sup>20</sup>       |                      | s EtOH, eth, sulf, CS <sub>2</sub>                            |
| 7963 | 1-Naphthalenemethanol                                  |                                            | C <sub>11</sub> H <sub>10</sub> O                              | 4780-79-4 | 158.196  | nd (w, al), cry (bz-lig)     | 64      | 304; 163 <sup>12</sup>                 | 1.1039 <sup>80</sup>       |                      | sl H <sub>2</sub> O; vs EtOH, eth                             |
| 7964 | 2-Naphthalenemethanol                                  |                                            | C <sub>11</sub> H <sub>10</sub> O                              | 1592-38-7 | 158.196  | lf                           | 81.3    | 178 <sup>12</sup>                      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth                              |
| 7965 | 1-Naphthalenesulfonic acid                             | α-Naphthylsulfonic acid                    | C <sub>10</sub> H <sub>6</sub> O <sub>3</sub> S                | 85-47-2   | 208.234  | pr (+2 w, dil HCl)           | 140     |                                        |                            |                      | s H <sub>2</sub> O, EtOH; sl eth                              |
| 7966 | 2-Naphthalenesulfonic acid                             | β-Naphthylsulfonic acid                    | C <sub>10</sub> H <sub>6</sub> O <sub>3</sub> S                | 120-18-3  | 208.234  | hyg pl (+1w), cry (+3w, HCl) | 91      | dec                                    | 1.441 <sup>25</sup>        |                      | vs H <sub>2</sub> O, EtOH; s eth; sl bz                       |
| 7967 | 1-Naphthalenesulfonyl chloride                         |                                            | C <sub>10</sub> H <sub>7</sub> ClO <sub>2</sub> S              | 85-46-1   | 226.680  | lf (eth)                     | 68      | 209 <sup>20</sup> , 147 <sup>0.9</sup> |                            |                      | vs bz, eth, EtOH                                              |
| 7968 | 2-Naphthalenesulfonyl chloride                         |                                            | C <sub>10</sub> H <sub>7</sub> ClO <sub>2</sub> S              | 93-11-8   | 226.680  | pow or lf (bz-peth)          | 81      | 201 <sup>13</sup> , 148 <sup>0.5</sup> |                            |                      | i H <sub>2</sub> O; s EtOH, bz, chl; sl peth; vs eth          |
| 7969 | 1,4,5,8-Naphthalenetetracarboxylic acid                |                                            | C <sub>14</sub> H <sub>6</sub> O <sub>8</sub>                  | 128-97-2  | 304.209  | lf or nd (w, dil HCl)        | 320     |                                        |                            |                      | sl H <sub>2</sub> O, bz, chl, EtOH; vs ace                    |
| 7970 | 1-Naphthalenethiol                                     | 1-Naphthyl mercaptan                       | C <sub>10</sub> H <sub>8</sub> S                               | 529-36-2  | 160.236  |                              |         | dec 285; 161 <sup>20</sup>             | 1.1607 <sup>20</sup>       | 1.6802 <sup>20</sup> | sl H <sub>2</sub> O, dil alk; vs EtOH, eth                    |
| 7971 | 2-Naphthalenethiol                                     | 2-Naphthyl mercaptan                       | C <sub>10</sub> H <sub>8</sub> S                               | 91-60-1   | 160.236  | pl (al)                      | 81      | 288                                    | 1.550 <sup>25</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth, lig                        |
| 7972 | N-(1-Naphthalenyl)-1,2-ethanediamine, dihydrochloride  |                                            | C <sub>12</sub> H <sub>16</sub> Cl <sub>2</sub> N <sub>2</sub> | 1465-25-4 | 259.174  | hex pr                       | 189     |                                        |                            |                      | vs H <sub>2</sub> O, EtOH                                     |
| 7973 | 1-Naphthalenylthiourea                                 | ANTU                                       | C <sub>11</sub> H <sub>10</sub> N <sub>2</sub> S               | 86-88-4   | 202.275  | pr (al)                      | 198     |                                        |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, ace                         |
| 7974 | Naphtho[2,3-c]furan-1,3-dione                          | 2,3-Naphthalenedicarboxylic acid anhydride | C <sub>12</sub> H <sub>6</sub> O <sub>3</sub>                  | 716-39-2  | 198.174  |                              | 246     |                                        |                            |                      | sl EtOH, chl; s eth, bz                                       |
| 7975 | 1-Naphthol                                             | 1-Naphthalenol                             | C <sub>10</sub> H <sub>8</sub> O                               | 90-15-3   | 144.170  | ye nd (w)                    | 95.0    | 288; 184 <sup>40</sup>                 | 1.0989 <sup>99</sup>       | 1.6224 <sup>99</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ace, bz; sl ctc           |
| 7976 | 2-Naphthol                                             | 2-Naphthalenol                             | C <sub>10</sub> H <sub>8</sub> O                               | 135-19-3  | 144.170  | mcl lf (w)                   | 121.5   | 285                                    | 1.28 <sup>20</sup>         |                      | i H <sub>2</sub> O; vs EtOH, eth; s bz, chl; sl lig           |
| 7977 | 1-Naphthol, acetate                                    | 1-Naphthyl acetate                         | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                 | 830-81-9  | 186.206  | nd or pl (al)                | 49      | 114 <sup>1</sup>                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth                               |
| 7978 | 2-Naphthol, acetate                                    | 2-Naphthyl acetate                         | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                 | 1523-11-1 | 186.206  | nd (al)                      | 71.0    | 132 <sup>2</sup>                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl                          |
| 7979 | p-Naphtholbenzein                                      |                                            | C <sub>27</sub> H <sub>18</sub> O <sub>2</sub>                 | 145-50-6  | 374.431  |                              | 123     |                                        |                            |                      |                                                               |
| 7980 | 1 <i>H</i> ,3 <i>H</i> -Naphtho[1,8-cd]pyran-1,3-dione |                                            | C <sub>12</sub> H <sub>6</sub> O <sub>3</sub>                  | 81-84-5   | 198.174  |                              | 275.0   |                                        |                            |                      | i H <sub>2</sub> O, eth, bz; sl EtOH; s HOAc                  |
| 7981 | 1-Naphthylamine                                        | α-Naphthylamine                            | C <sub>10</sub> H <sub>9</sub> N                               | 134-32-7  | 143.185  |                              | 49.2    | 300.7                                  | 1.0228 <sup>20</sup>       | 1.6140 <sup>20</sup> | s chl                                                         |
| 7982 | 2-Naphthylamine                                        | β-Naphthylamine                            | C <sub>10</sub> H <sub>9</sub> N                               | 91-59-8   | 143.185  |                              | 113     | 306.2                                  | 1.6414 <sup>98</sup>       | 1.6493 <sup>98</sup> | s H <sub>2</sub> O, EtOH, eth                                 |
| 7983 | 2-[(1-Naphthylamino)carbonyl] benzoic acid             | Naptalam                                   | C <sub>18</sub> H <sub>13</sub> NO <sub>3</sub>                | 132-66-1  | 291.301  |                              | 185     |                                        | 1.4 <sup>20</sup>          |                      | i H <sub>2</sub> O; sl EtOH, ace, bz, tfa                     |
| 7984 | 2-Naphthyl benzoate                                    | 2-Naphthalenol benzoate                    | C <sub>17</sub> H <sub>12</sub> O <sub>2</sub>                 | 93-44-7   | 248.276  | nd or pr (al)                | 107     |                                        |                            |                      | i H <sub>2</sub> O; s EtOH; sl eth, HOAc                      |
| 7985 | N-1-Naphthalenylacetamide                              |                                            | C <sub>12</sub> H <sub>11</sub> NO                             | 575-36-0  | 185.221  |                              | 160     |                                        |                            |                      | s H <sub>2</sub> O, EtOH; sl eth                              |
| 7986 | N-1-Naphthyl-1,2-ethanediamine                         | N-(1-Naphthyl)ethylenediamine              | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub>                 | 551-09-7  | 186.252  | visc lig                     |         | 204 <sup>9</sup>                       | 1.114 <sup>25</sup>        | 1.6648 <sup>25</sup> |                                                               |



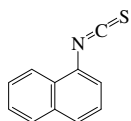
| No.  | Name                                   | Synonym                                                     | Mol. Form.                                                                    | CAS RN      | Mol. Wt. | Physical Form                          | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup>        | n <sub>D</sub>       | Solubility                                         |
|------|----------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------------------------|-------------|----------|----------------------------------------|---------|------------------------|-----------------------------------|----------------------|----------------------------------------------------|
| 7987 | 1-Naphthyl 2-hydroxybenzoate           | 1-Naphthyl salicylate                                       | C <sub>17</sub> H <sub>12</sub> O <sub>3</sub>                                | 550-97-0    | 264.275  |                                        | 83      |                        |                                   |                      | vs eth                                             |
| 7988 | 1-Naphthylhydroxylamine                | <i>N</i> -Hydroxyl-1-naphthalenamine                        | C <sub>10</sub> H <sub>9</sub> NO                                             | 607-30-7    | 159.184  |                                        | 79      |                        |                                   |                      |                                                    |
| 7989 | 1-Naphthyl isothiocyanate              | 1-Isothiocyanatonaphthalene                                 | C <sub>11</sub> H <sub>7</sub> NS                                             | 551-06-4    | 185.246  | wh nd (al)                             | 58      |                        |                                   |                      | vs bz, eth, EtOH, chl                              |
| 7990 | <i>N</i> -2-Naphthyl-2-naphthalenamine | β,β'-Dinaphthylamine                                        | C <sub>20</sub> H <sub>15</sub> N                                             | 532-18-3    | 269.340  | lf(bz)                                 | 172.2   | 471                    |                                   |                      | i H <sub>2</sub> O; sl EtOH, bz, DMSO; s eth, HOAc |
| 7991 | (2-Naphthoxy)acetic acid               | 2-Naphthoxyacetic acid                                      | C <sub>12</sub> H <sub>10</sub> O <sub>3</sub>                                | 120-23-0    | 202.205  | pr(w)                                  | 156     |                        |                                   |                      | s H <sub>2</sub> O, EtOH, eth; sl DMSO             |
| 7992 | 1-Naphthyl phosphate                   | 1-Naphthalenol, dihydrogen phosphate                        | C <sub>10</sub> H <sub>9</sub> O <sub>4</sub> P                               | 1136-89-6   | 224.149  | cry                                    | 160     |                        |                                   |                      |                                                    |
| 7993 | 2-Naphthyl salicylate                  | 2-Naphthyl 2-hydroxybenzoate                                | C <sub>17</sub> H <sub>12</sub> O <sub>3</sub>                                | 613-78-5    | 264.275  | cry (al)                               | 95.5    |                        | 1.11 <sup>116</sup>               |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz             |
| 7994 | 1,5-Naphthyridine                      | 1,5-Diazanaphthalene                                        | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                                  | 254-79-5    | 130.147  | ye nd (peth)                           | 75      | 112 <sup>12</sup>      | 1.2100 <sup>20</sup>              |                      |                                                    |
| 7995 | 1,6-Naphthyridine                      |                                                             | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                                  | 253-72-5    | 130.147  |                                        | 29.5    |                        |                                   |                      |                                                    |
| 7996 | Napropamide                            | Propanamide, <i>N,N</i> -diethyl-2-(1-naphthalenyloxy)-     | C <sub>17</sub> H <sub>21</sub> NO <sub>2</sub>                               | 15299-99-7  | 271.355  |                                        | 75      |                        |                                   |                      |                                                    |
| 7997 | Naproxen                               | 6-Methoxy-α-methyl-2-naphthaleneacetic acid                 | C <sub>14</sub> H <sub>14</sub> O <sub>3</sub>                                | 22204-53-1  | 230.259  | cry (ace/hx)                           | 155     |                        |                                   |                      | i H <sub>2</sub> O; sl eth; s MeOH, chl            |
| 7998 | Narceine                               |                                                             | C <sub>23</sub> H <sub>27</sub> NO <sub>8</sub>                               | 131-28-2    | 445.462  |                                        | 138     |                        |                                   |                      | i H <sub>2</sub> O                                 |
| 7999 | Narcobarbital                          |                                                             | C <sub>11</sub> H <sub>15</sub> BrN <sub>2</sub> O <sub>3</sub>               | 125-55-3    | 303.152  |                                        | 115     |                        |                                   |                      | sl H <sub>2</sub> O; s EtOH, py                    |
| 8000 | Naringenin                             |                                                             | C <sub>15</sub> H <sub>12</sub> O <sub>5</sub>                                | 480-41-1    | 272.253  | nd (dil al)                            | 251     |                        |                                   |                      | vs bz, eth, EtOH                                   |
| 8001 | Naringin                               |                                                             | C <sub>27</sub> H <sub>32</sub> O <sub>14</sub>                               | 10236-47-2  | 580.535  | nd (w+8)                               |         |                        |                                   |                      | sl H <sub>2</sub> O, EtOH; i eth, bz, chl; s HOAc  |
| 8002 | Nealbarbital                           |                                                             | C <sub>12</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub>                 | 561-83-1    | 238.282  |                                        | 156     |                        |                                   |                      | vs ace, eth, EtOH                                  |
| 8003 | Nellite                                | Diamidafos                                                  | C <sub>8</sub> H <sub>13</sub> N <sub>2</sub> O <sub>2</sub> P                | 1754-58-1   | 200.175  | cry (ctc)                              | 103.5   |                        |                                   |                      | sl AcOEt, bz                                       |
| 8004 | Neobietic acid                         | 8(14),13(15)-Abietadien-18-oic acid                         | C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>                                | 471-77-2    | 302.451  | cry (EtOH aq)                          | 173     |                        |                                   |                      |                                                    |
| 8005 | Neobornylamine                         |                                                             | C <sub>10</sub> H <sub>19</sub> N                                             | 2223-67-8   | 153.265  | pow                                    | 184     |                        |                                   |                      | vs ace, eth                                        |
| 8006 | Neopentane                             | 2,2-Dimethylpropane                                         | C <sub>5</sub> H <sub>12</sub>                                                | 463-82-1    | 72.149   | col gas                                | -16.4   | 9.48                   | 0.5852 <sup>25</sup><br>(p>1 atm) | 1.3476 <sup>6</sup>  | i H <sub>2</sub> O; s EtOH, eth, ctc               |
| 8007 | Neopine                                |                                                             | C <sub>18</sub> H <sub>21</sub> NO <sub>3</sub>                               | 467-14-1    | 299.365  | nd (peth)                              | 127.5   |                        |                                   |                      | s H <sub>2</sub> O, EtOH, eth, bz; vs chl; sl lig  |
| 8008 | Neostigmine bromide                    |                                                             | C <sub>12</sub> H <sub>19</sub> BrN <sub>2</sub> O <sub>2</sub>               | 114-80-7    | 303.195  | cry (al-eth)                           | 167 dec |                        |                                   |                      | vs H <sub>2</sub> O; s EtOH                        |
| 8009 | Nepetalactone                          |                                                             | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                                | 490-10-8    | 166.217  |                                        |         | 71 <sup>0.05</sup>     | 1.0663 <sup>25</sup>              | 1.4859 <sup>25</sup> | vs EtOH; s eth, ace, HOAc                          |
| 8010 | <i>cis</i> -Nerolidol                  |                                                             | C <sub>15</sub> H <sub>26</sub> O                                             | 142-50-7    | 222.366  |                                        |         | 276; 70 <sup>0.1</sup> | 0.8778 <sup>20</sup>              | 1.4898 <sup>20</sup> | vs EtOH; s eth, ace, HOAc                          |
| 8011 | Neurine                                |                                                             | C <sub>5</sub> H <sub>13</sub> NO                                             | 463-88-7    | 103.163  | syr                                    |         |                        |                                   |                      | vs H <sub>2</sub> O, eth, EtOH                     |
| 8012 | Neutral Red                            |                                                             | C <sub>15</sub> H <sub>17</sub> ClN <sub>4</sub>                              | 553-24-2    | 288.776  | grn pow                                |         |                        |                                   |                      | s H <sub>2</sub> O, ethylene glycol, EtOH; i xyl   |
| 8013 | Nialamide                              |                                                             | C <sub>16</sub> H <sub>18</sub> N <sub>4</sub> O <sub>2</sub>                 | 51-12-7     | 298.340  |                                        | 151.6   |                        |                                   |                      |                                                    |
| 8014 | Nickel(II) acetate                     |                                                             | C <sub>4</sub> H <sub>8</sub> NiO <sub>4</sub>                                | 373-02-4    | 176.782  |                                        |         |                        |                                   |                      | vs H <sub>2</sub> O; s EtOH                        |
| 8015 | Nickel bis(dibutylthiocarbamate)       |                                                             | C <sub>18</sub> H <sub>38</sub> N <sub>2</sub> NiS <sub>4</sub>               | 13927-77-0  | 467.445  | grn cry (bz/ EtOH)                     | 91      |                        |                                   |                      | s bz, ace                                          |
| 8016 | Nickel bis(2,4-pentanedioate)          | Nickel acetylacetonate                                      | C <sub>10</sub> H <sub>14</sub> NiO <sub>4</sub>                              | 3264-82-2   | 256.909  | grn orth cry                           | 230     | 227 <sup>11</sup>      |                                   |                      | s H <sub>2</sub> O, bz, chl, EtOH; i eth           |
| 8017 | Nickel carbonyl                        | Nickel tetracarbonyl                                        | C <sub>4</sub> NiO <sub>4</sub>                                               | 13463-39-3  | 170.734  | col liq                                | -19.3   | 43 (exp 60)            | 1.31 <sup>25</sup>                |                      |                                                    |
| 8018 | Nickelocene                            | Bis(η <sup>5</sup> -2,4-cyclopentadien-1-yl)nickel          | C <sub>10</sub> H <sub>10</sub> Ni                                            | 1271-28-9   | 188.879  |                                        | 172     |                        |                                   |                      |                                                    |
| 8019 | Niclosamide                            |                                                             | C <sub>13</sub> H <sub>8</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>4</sub>  | 50-65-7     | 327.120  |                                        | 227     |                        |                                   |                      |                                                    |
| 8020 | Nicofibrate                            |                                                             | C <sub>16</sub> H <sub>16</sub> ClNO <sub>3</sub>                             | 31980-29-7  | 305.756  |                                        | 49      | 180 <sup>0.4</sup>     |                                   |                      |                                                    |
| 8021 | Nicosulfuron                           |                                                             | C <sub>15</sub> H <sub>18</sub> N <sub>6</sub> O <sub>5</sub> S               | 111991-09-4 | 410.405  |                                        | 172     |                        |                                   |                      |                                                    |
| 8022 | Nicotelline                            | 3,2':4',3"-Terpyridine                                      | C <sub>15</sub> H <sub>11</sub> N <sub>3</sub>                                | 494-04-2    | 233.268  | prismatic nd                           | 148     | >300                   |                                   |                      | sl H <sub>2</sub> O, eth; s bz, chl, EtOH          |
| 8023 | Nicotinamide hypoxanthine dinucleotide | Nicotinic acid adenine dinucleotide                         | C <sub>21</sub> H <sub>26</sub> N <sub>6</sub> O <sub>15</sub> P <sub>2</sub> | 1851-07-6   | 664.410  | pow                                    |         |                        |                                   |                      |                                                    |
| 8024 | β-Nicotinamide mononucleotide          | NMN                                                         | C <sub>11</sub> H <sub>15</sub> N <sub>2</sub> O <sub>6</sub> P               | 1094-61-7   | 334.219  | amor pow                               |         |                        |                                   |                      | vs H <sub>2</sub> O; i ace                         |
| 8025 | <i>L</i> -Nicotine                     | 3-(1-Methyl-2-pyrrolidinyl)pyridine, ( <i>S</i> )-          | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub>                                | 54-11-5     | 162.231  | hyg liq                                | -79     | 247; 125 <sup>18</sup> | 1.0097 <sup>20</sup>              | 1.5282 <sup>20</sup> | msc H <sub>2</sub> O; vs EtOH, eth, chl; s lig     |
| 8026 | Nifurthiazole                          |                                                             | C <sub>8</sub> H <sub>8</sub> N <sub>4</sub> O <sub>4</sub> S                 | 3570-75-0   | 254.224  | cry                                    | 215 dec |                        |                                   |                      |                                                    |
| 8027 | Nitratin                               | 4-(Methylsulfonyl)-2,6-dinitro- <i>N,N</i> -dipropylaniline | C <sub>13</sub> H <sub>19</sub> N <sub>3</sub> O <sub>6</sub> S               | 4726-14-1   | 345.371  |                                        | 150     |                        |                                   |                      |                                                    |
| 8028 | Nitrilic acid                          | 2,5-Dihydroxy-3,6-dinitro-2,5-cyclohexadiene-1,4-dione      | C <sub>6</sub> H <sub>2</sub> N <sub>2</sub> O <sub>8</sub>                   | 479-22-1    | 230.088  | gold-ye pl (+w, dil HNO <sub>3</sub> ) | 170 dec |                        |                                   |                      | vs H <sub>2</sub> O, EtOH; i eth                   |
| 8029 | Nitrpyrin                              | Pyridine, 2-chloro-6-(trichloromethyl)-                     | C <sub>6</sub> H <sub>5</sub> Cl <sub>4</sub> N                               | 1929-82-4   | 230.907  |                                        | 63      | 136 <sup>11</sup>      |                                   |                      |                                                    |



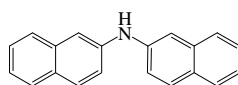
1-Naphthyl 2-hydroxybenzoate



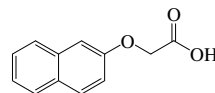
1-Naphthylhydroxylamine



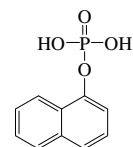
1-Naphthyl isothiocyanate



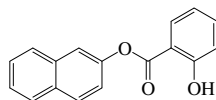
N-2-Naphthyl-2-naphthalenamine



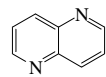
(2-Naphthoxy)acetic acid



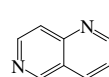
1-Naphthyl phosphate



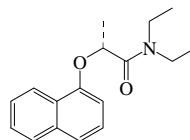
2-Naphthyl salicylate



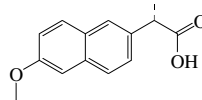
1,5-Naphthyridine



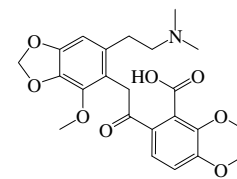
1,6-Naphthyridine



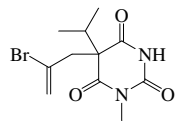
Napropamide



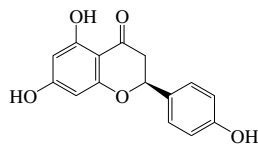
Naproxen



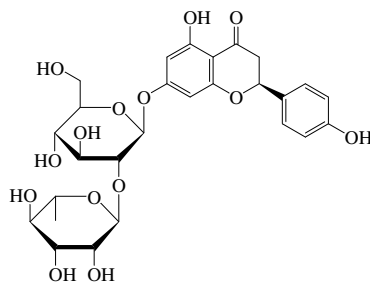
Narceine



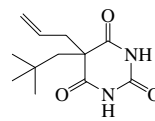
Narcobarbital



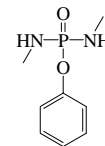
Naringenin



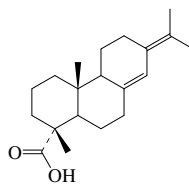
Naringin



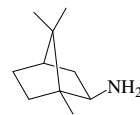
Neobarbital



Nellite



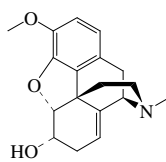
Neobiatic acid



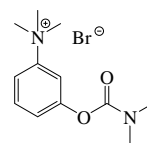
Neobornylamine



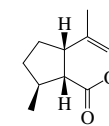
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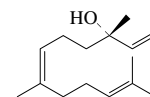
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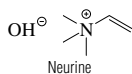
Neostigmine bromide



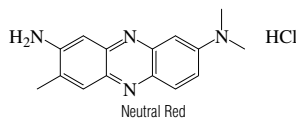
Nepetalactone



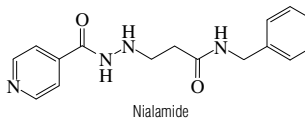
cis-Nerolidol



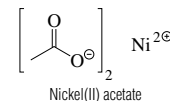
Neurine



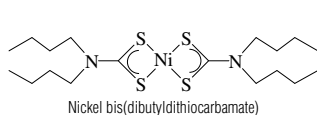
Neutral Red



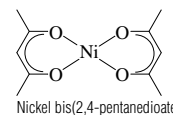
Nialamide



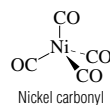
Nickel(II) acetate



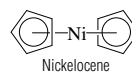
Nickel bis(dibutylthiocarbamate)



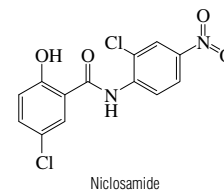
Nickel bis(2,4-pentanedioate)



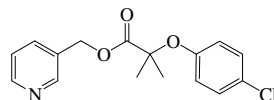
Nickel carbonyl



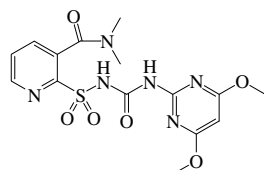
Nickelocene



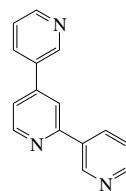
Niclosamide



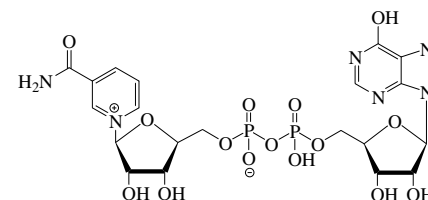
Nicotifibrate



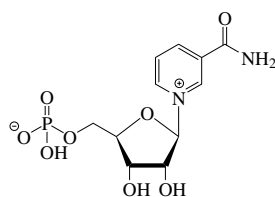
Nicosulfuron



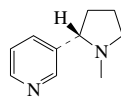
Nicotelline



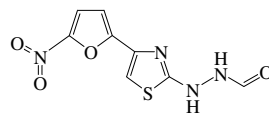
Nicotinamide hypoxanthine dinucleotide



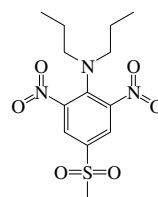
beta-Nicotinamide mononucleotide



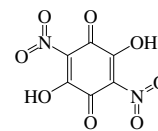
L-Nicotine



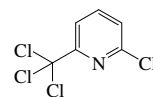
Nifurthiazole



Nitalin



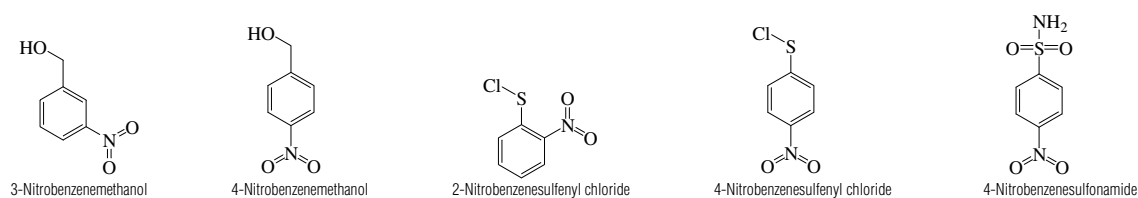
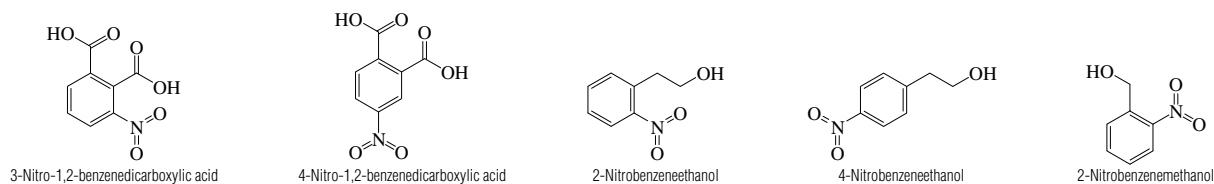
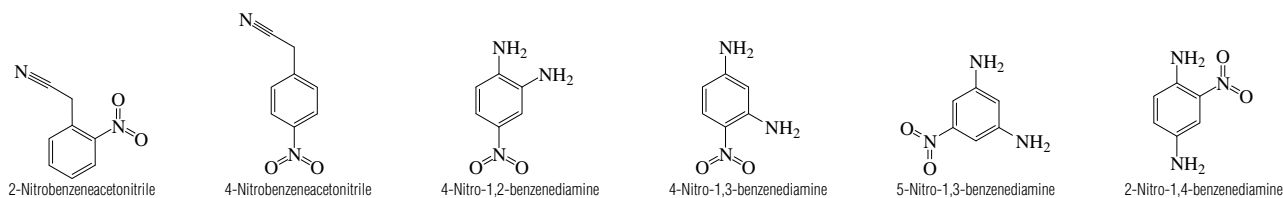
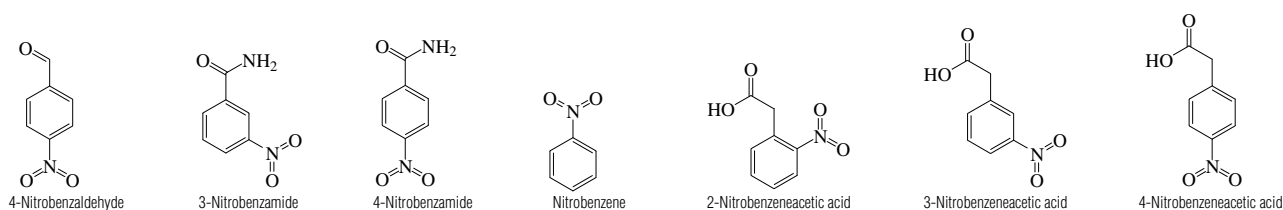
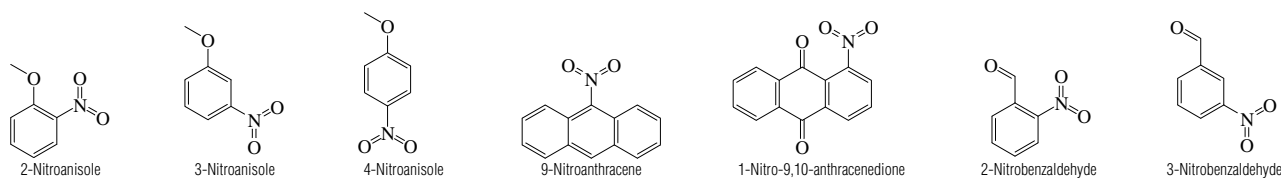
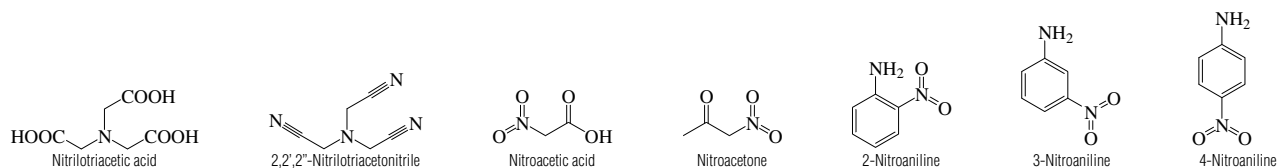
Nitranilic acid



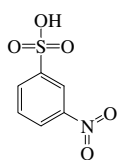
Nitrapyrin



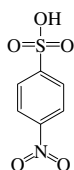
| No.  | Name                                 | Synonym                               | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                     | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                        |
|------|--------------------------------------|---------------------------------------|---------------------------------------------------------------|------------|----------|-----------------------------------|---------|--------------------------------------|----------------------------|----------------------|-------------------------------------------------------------------|
| 8030 | Nitilotriacetic acid                 | <i>N,N</i> -Bis(carboxymethyl)glycine | C <sub>6</sub> H <sub>9</sub> NO <sub>6</sub>                 | 139-13-9   | 191.138  | pr cry (w)                        | 242 dec |                                      |                            |                      | sl H <sub>2</sub> O, DMSO;<br>s EtOH                              |
| 8031 | 2,2',2''-Nitilotriacetoneitrile      | Tricyanotrimethylamine                | C <sub>6</sub> H <sub>6</sub> N <sub>4</sub>                  | 7327-60-8  | 134.139  | nd (EtOH)                         | 125.5   |                                      |                            |                      |                                                                   |
| 8032 | Nitroacetic acid                     |                                       | C <sub>2</sub> H <sub>3</sub> NO <sub>4</sub>                 | 625-75-2   | 105.050  | nd (chl)                          | 92 dec  |                                      |                            |                      | vs bz, eth, EtOH,<br>chl                                          |
| 8033 | Nitroacetone                         |                                       | C <sub>3</sub> H <sub>5</sub> NO <sub>3</sub>                 | 10230-68-9 | 103.077  | pl, nd (eth,<br>bz)               | 50.3    | 103 <sup>24</sup>                    |                            |                      | vs bz, eth, EtOH                                                  |
| 8034 | 2-Nitroaniline                       |                                       | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 88-74-4    | 138.124  |                                   | 71.0    | 284                                  | 0.9015 <sup>25</sup>       |                      | sl H <sub>2</sub> O; s EtOH;<br>vs eth, ace, bz,<br>chl           |
| 8035 | 3-Nitroaniline                       |                                       | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 99-09-2    | 138.124  |                                   | 113.4   | dec 306                              | 0.9011 <sup>25</sup>       |                      | sl H <sub>2</sub> O, bz; s<br>EtOH, eth, ace;<br>vs MeOH          |
| 8036 | 4-Nitroaniline                       |                                       | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 100-01-6   | 138.124  | pa ye mcl nd<br>(w)               | 147.5   | 332                                  | 1.424 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH,<br>eth, ace; sl bz,<br>DMSO           |
| 8037 | 2-Nitroanisole                       | 1-Methoxy-2-nitrobenzene              | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                 | 91-23-6    | 153.136  |                                   | 10.5    | 277; 144 <sup>4</sup>                | 1.2540 <sup>20</sup>       | 1.5161 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ctc                    |
| 8038 | 3-Nitroanisole                       | 1-Methoxy-3-nitrobenzene              | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                 | 555-03-3   | 153.136  | nd (al), pl<br>(bz-lig)           | 38.5    | 258                                  | 1.373 <sup>18</sup>        |                      | i H <sub>2</sub> O; s EtOH;<br>vs eth                             |
| 8039 | 4-Nitroanisole                       | 1-Methoxy-4-nitrobenzene              | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                 | 100-17-4   | 153.136  | pr (al), nd<br>(dil al)           | 54      | 274                                  | 1.2192 <sup>60</sup>       | 1.5070 <sup>60</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth; s ctc; sl<br>peth            |
| 8040 | 9-Nitroanthracene                    |                                       | C <sub>14</sub> H <sub>9</sub> NO <sub>2</sub>                | 602-60-8   | 223.227  | ye nd (al) pr<br>(HOAc or<br>xyl) | 146     | 275 <sup>17</sup>                    |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>chl; vs ace,<br>CS <sub>2</sub>   |
| 8041 | 1-Nitro-9,10-anthracenedione         |                                       | C <sub>14</sub> H <sub>7</sub> NO <sub>4</sub>                | 82-34-8    | 253.211  | nd (HOAc)<br>ye pr (ace)          | 231.5   | 270 <sup>7</sup>                     |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>eth; s ace, bz                    |
| 8042 | 2-Nitrobenzaldehyde                  |                                       | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub>                 | 552-89-6   | 151.120  | ye nd (w)                         | 43.5    | 153 <sup>23</sup>                    | 1.2844 <sup>20</sup>       |                      | sl H <sub>2</sub> O, chl; vs<br>EtOH, eth, ace,<br>bz             |
| 8043 | 3-Nitrobenzaldehyde                  |                                       | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub>                 | 99-61-6    | 151.120  | lt ye nd (w)                      | 58.5    | 164 <sup>23</sup>                    | 1.2792 <sup>20</sup>       |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, chl; vs<br>ace, bz           |
| 8044 | 4-Nitrobenzaldehyde                  |                                       | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub>                 | 555-16-8   | 151.120  | lf, pr (w)                        | 107     | sub                                  | 1.496 <sup>25</sup>        |                      | sl H <sub>2</sub> O, lig; vs<br>EtOH; s bz,<br>chl, HOAc          |
| 8045 | 3-Nitrobenzamide                     |                                       | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>3</sub>   | 645-09-0   | 166.134  |                                   | 142.7   | 312.5                                |                            |                      | s H <sub>2</sub> O, EtOH, eth                                     |
| 8046 | 4-Nitrobenzamide                     |                                       | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>3</sub>   | 619-80-7   | 166.134  | nd (w)                            | 200.7   |                                      |                            |                      | i H <sub>2</sub> O; s EtOH,<br>eth                                |
| 8047 | Nitrobenzene                         |                                       | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                 | 98-95-3    | 123.110  |                                   | 5.7     | 210.8                                | 1.2037 <sup>20</sup>       | 1.5562 <sup>20</sup> | sl H <sub>2</sub> O, ctc; vs<br>EtOH, eth, ace,<br>bz             |
| 8048 | 2-Nitrobenzeneacetic acid            | <i>o</i> -Nitrophenylacetic acid      | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                 | 3740-52-1  | 181.147  | nd (w, pl (dil<br>al)             | 141.5   |                                      |                            |                      | s H <sub>2</sub> O, EtOH                                          |
| 8049 | 3-Nitrobenzeneacetic acid            | <i>m</i> -Nitrophenylacetic acid      | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                 | 1877-73-2  | 181.147  | nd (w)                            | 122     |                                      |                            |                      | vs EtOH                                                           |
| 8050 | 4-Nitrobenzeneacetic acid            | <i>p</i> -Nitrophenylacetic acid      | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                 | 104-03-0   | 181.147  | pa ye nd (w)                      | 154     |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, bz                           |
| 8051 | 2-Nitrobenzeneacetonitrile           | 2-Nitrobenzyl cyanide                 | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 610-66-2   | 162.146  | nd (dil al), pr<br>(HOAc, al)     | 84      | 178 <sup>12</sup> , 138 <sup>1</sup> |                            |                      | vs ace, bz, eth,<br>EtOH                                          |
| 8052 | 4-Nitrobenzeneacetonitrile           | 4-Nitrobenzyl cyanide                 | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 555-21-5   | 162.146  | pr (al)                           | 117     | 196 <sup>12</sup>                    |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, bz, chl                      |
| 8053 | 4-Nitro-1,2-benzenediamine           | 4-Nitro- <i>o</i> -phenylenediamine   | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>   | 99-56-9    | 153.139  | dk red nd (dil<br>al)             | 199.5   |                                      |                            |                      | s acid                                                            |
| 8054 | 4-Nitro-1,3-benzenediamine           |                                       | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>   | 5131-58-8  | 153.139  | oran pr (w)                       | 161     |                                      |                            |                      |                                                                   |
| 8055 | 5-Nitro-1,3-benzenediamine           |                                       | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>   | 5042-55-7  | 153.139  | red cry (w)                       | 143     |                                      |                            |                      |                                                                   |
| 8056 | 2-Nitro-1,4-benzenediamine           |                                       | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>   | 5307-14-2  | 153.139  |                                   | 140.0   |                                      |                            |                      |                                                                   |
| 8057 | 3-Nitro-1,2-benzenedicarboxylic acid |                                       | C <sub>8</sub> H <sub>5</sub> NO <sub>6</sub>                 | 603-11-2   | 211.129  | pa ye pr (w)                      | 218     |                                      |                            |                      | sl H <sub>2</sub> O, ace; s<br>EtOH; i bz,<br>peth, chl           |
| 8058 | 4-Nitro-1,2-benzenedicarboxylic acid |                                       | C <sub>8</sub> H <sub>5</sub> NO <sub>6</sub>                 | 610-27-5   | 211.129  | pa ye nd (w,<br>eth)              | 164.8   |                                      |                            |                      | s H <sub>2</sub> O, EtOH; i<br>bz, chl, CS <sub>2</sub> ,<br>peth |
| 8059 | 2-Nitrobenzeneethanol                |                                       | C <sub>8</sub> H <sub>9</sub> NO <sub>3</sub>                 | 15121-84-3 | 167.162  |                                   | 1.0     | 267                                  | 1.19 <sup>25</sup>         | 1.5637 <sup>20</sup> |                                                                   |
| 8060 | 4-Nitrobenzeneethanol                |                                       | C <sub>8</sub> H <sub>9</sub> NO <sub>3</sub>                 | 100-27-6   | 167.162  |                                   | 63      | 148 <sup>2</sup>                     |                            |                      |                                                                   |
| 8061 | 2-Nitrobenzenemethanol               | 2-Nitrobenzyl alcohol                 | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                 | 612-25-9   | 153.136  | nd (w)                            | 74      | 270; 168 <sup>20</sup>               |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth                               |
| 8062 | 3-Nitrobenzenemethanol               | 3-Nitrobenzyl alcohol                 | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                 | 619-25-0   | 153.136  | orth nd (w)                       | 30.5    | 177 <sup>3</sup>                     | 1.296 <sup>19</sup>        |                      | s H <sub>2</sub> O, EtOH,<br>eth; sl chl                          |
| 8063 | 4-Nitrobenzenemethanol               | 4-Nitrobenzyl alcohol                 | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                 | 619-73-8   | 153.136  | nd (w)                            | 96.5    | dec 255; 185 <sup>12</sup>           |                            |                      | sl H <sub>2</sub> O, ace; s<br>EtOH, eth                          |
| 8064 | 2-Nitrobenzenesulfonyl chloride      |                                       | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub> S             | 7669-54-7  | 189.620  | ye nd (bz)                        | 75      |                                      |                            |                      | vs eth, bz, chl                                                   |
| 8065 | 4-Nitrobenzenesulfonyl chloride      |                                       | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub> S             | 937-32-6   | 189.620  | ye lf (peth)                      | 52      | 125 <sup>0.1</sup>                   |                            |                      | vs bz                                                             |
| 8066 | 4-Nitrobenzenesulfonamide            |                                       | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> S | 6325-93-5  | 202.188  |                                   | 180 dec |                                      |                            |                      |                                                                   |



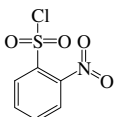
| No.  | Name                                            | Synonym                                    | Mol. Form.                                                      | CAS RN    | Mol. Wt. | Physical Form         | mp/°C    | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                        |
|------|-------------------------------------------------|--------------------------------------------|-----------------------------------------------------------------|-----------|----------|-----------------------|----------|----------------------------------------|----------------------------|----------------------|---------------------------------------------------|
| 8067 | 3-Nitrobenzenesulfonic acid                     |                                            | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub> S                 | 98-47-5   | 203.173  | pl                    | 48       |                                        |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth, bz            |
| 8068 | 4-Nitrobenzenesulfonic acid                     |                                            | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub> S                 | 138-42-1  | 203.173  |                       | 95       |                                        |                            |                      | vs H <sub>2</sub> O                               |
| 8069 | 2-Nitrobenzenesulfonyl chloride                 |                                            | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub> S               | 1694-92-4 | 221.619  | pr (lig, eth-peth)    | 68.5     |                                        |                            |                      | s eth; sl peth                                    |
| 8070 | 3-Nitrobenzenesulfonyl chloride                 |                                            | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub> S               | 121-51-7  | 221.619  | mcl pr (eth) nd (lig) | 64       |                                        |                            |                      | i H <sub>2</sub> O; s EtOH                        |
| 8071 | 4-Nitrobenzenesulfonyl chloride                 |                                            | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub> S               | 98-74-8   | 221.619  | mcl pr (peth)         | 79.5     | 143 <sup>1.5</sup>                     |                            |                      | s peth                                            |
| 8072 | 5-Nitro-1 <i>H</i> -benzimidazole               |                                            | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>     | 94-52-0   | 163.134  | nd (w)                | 207.8    |                                        |                            |                      | i H <sub>2</sub> O, eth, bz, chl; s acid; vs EtOH |
| 8073 | 2-Nitrobenzoic acid                             |                                            | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                   | 552-16-9  | 167.120  | tcl nd (w)            | 147.5    |                                        | 1.575 <sup>20</sup>        |                      | s H <sub>2</sub> O, eth; vs EtOH, ace; sl bz, lig |
| 8074 | 3-Nitrobenzoic acid                             |                                            | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                   | 121-92-6  | 167.120  | mcl pr (w)            | 141.1    |                                        | 1.494 <sup>20</sup>        |                      | sl H <sub>2</sub> O, bz; vs EtOH, eth, ace; s chl |
| 8075 | 4-Nitrobenzoic acid                             |                                            | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                   | 62-23-7   | 167.120  | mcl lf (w)            | 242      | sub                                    | 1.610 <sup>20</sup>        |                      | vs ace, eth, EtOH, chl, MeOH                      |
| 8076 | 3-Nitrobenzoic acid, hydrazide                  |                                            | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>3</sub>     | 618-94-0  | 181.149  |                       | 153.5    |                                        |                            |                      | sl H <sub>2</sub> O, EtOH; i eth, bz, chl         |
| 8077 | 4-Nitrobenzoic acid, hydrazide                  |                                            | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>3</sub>     | 636-97-5  | 181.149  |                       | 215.5    |                                        |                            |                      | sl H <sub>2</sub> O, EtOH; i eth, bz, chl         |
| 8078 | 3-Nitrobenzonitrile                             |                                            | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>     | 619-24-9  | 148.119  |                       | 118      | 165 <sup>16</sup>                      |                            |                      | s H <sub>2</sub> O, EtOH, bz; vs eth, ace; i peth |
| 8079 | 4-Nitrobenzonitrile                             |                                            | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>     | 619-72-7  | 148.119  |                       | 150.0    |                                        |                            |                      | sl H <sub>2</sub> O, EtOH, eth; s chl, HOAc       |
| 8080 | 5-Nitro-1 <i>H</i> -benzotriazole               |                                            | C <sub>6</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub>     | 2338-12-7 | 164.122  |                       | 217      |                                        |                            |                      |                                                   |
| 8081 | 2-Nitrobenzoyl chloride                         |                                            | C <sub>7</sub> H <sub>4</sub> ClNO <sub>2</sub>                 | 610-14-0  | 185.565  |                       | 20       |                                        |                            |                      | vs eth; sl ctc                                    |
| 8082 | 3-Nitrobenzoyl chloride                         |                                            | C <sub>7</sub> H <sub>4</sub> ClNO <sub>2</sub>                 | 121-90-4  | 185.565  |                       | 36       | 276.5                                  |                            |                      | vs eth                                            |
| 8083 | 4-Nitrobenzoyl chloride                         |                                            | C <sub>7</sub> H <sub>4</sub> ClNO <sub>2</sub>                 | 122-04-3  | 185.565  | ye nd (lig)           | 75       | 203 <sup>105</sup> , 151 <sup>15</sup> |                            |                      | s eth                                             |
| 8084 | 2-Nitrobiphenyl                                 | 2-Nitro-1,1'-biphenyl                      | C <sub>12</sub> H <sub>9</sub> NO <sub>2</sub>                  | 86-00-0   | 199.205  | pl (al, MeOH)         | 37.2     | 320                                    | 1.44 <sup>25</sup>         |                      | i H <sub>2</sub> O; s EtOH, eth, chl              |
| 8085 | 3-Nitrobiphenyl                                 | 3-Nitro-1,1'-biphenyl                      | C <sub>12</sub> H <sub>9</sub> NO <sub>2</sub>                  | 2113-58-8 | 199.205  | ye pl or nd (dil al)  | 62       | 227 <sup>35</sup> , 143 <sup>9</sup>   |                            |                      | i H <sub>2</sub> O; s EtOH, eth, HOAc, lig        |
| 8086 | 4-Nitrobiphenyl                                 | 4-Nitro-1,1'-biphenyl                      | C <sub>12</sub> H <sub>9</sub> NO <sub>2</sub>                  | 92-93-3   | 199.205  | ye nd (al)            | 114      | 340                                    |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, chl, HOAc |
| 8087 | 2-Nitro-1,1-bis( <i>p</i> -chlorophenyl)propane |                                            | C <sub>15</sub> H <sub>13</sub> Cl <sub>2</sub> NO <sub>2</sub> | 117-27-1  | 310.176  | cry                   | 81       | 180 <sup>0.16</sup>                    |                            |                      |                                                   |
| 8088 | 1-Nitrobutane                                   |                                            | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                   | 627-05-4  | 103.120  |                       |          | 153                                    | 0.970 <sup>25</sup>        | 1.4303 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s alk         |
| 8089 | 2-Nitro-1-butanol                               |                                            | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                   | 609-31-4  | 119.119  |                       | -47      | 105 <sup>10</sup>                      | 1.1332 <sup>25</sup>       | 1.4390 <sup>20</sup> | s H <sub>2</sub> O, ace; msc EtOH, eth; sl ctc    |
| 8090 | 3-Nitro-2-butanol                               |                                            | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                   | 6270-16-2 | 119.119  |                       |          | 91 <sup>9</sup> , 55 <sup>0.5</sup>    | 1.1260 <sup>20</sup>       | 1.4414 <sup>20</sup> |                                                   |
| 8091 | 6-Nitrochrysene                                 |                                            | C <sub>18</sub> H <sub>11</sub> NO <sub>2</sub>                 | 7496-02-8 | 273.286  | ye nd (bz)            | ≈215 dec |                                        |                            |                      |                                                   |
| 8092 | Nitrocyclohexane                                |                                            | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                  | 1122-60-7 | 129.157  | liq                   | -34      | 205; 95 <sup>22</sup>                  | 1.0610 <sup>20</sup>       | 1.4612 <sup>19</sup> | i H <sub>2</sub> O; s EtOH, lig                   |
| 8093 | 1-Nitrodecane                                   |                                            | C <sub>10</sub> H <sub>21</sub> NO <sub>2</sub>                 | 4609-87-4 | 187.280  |                       |          | 86 <sup>1</sup>                        |                            | 1.4337 <sup>20</sup> |                                                   |
| 8094 | <i>N</i> -Nitrodiethylamine                     | <i>N</i> -Ethyl- <i>N</i> -nitroethanamine | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>    | 7119-92-8 | 118.134  |                       |          | 206.5                                  | 1.057 <sup>15</sup>        |                      | vs eth, EtOH                                      |
| 8095 | Nitroethane                                     |                                            | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                   | 79-24-3   | 75.067   | liq                   | -89.5    | 114.0                                  | 1.0448 <sup>25</sup>       | 1.3917 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ace, chl    |
| 8096 | 2-Nitroethanol                                  |                                            | C <sub>2</sub> H <sub>5</sub> NO <sub>3</sub>                   | 625-48-9  | 91.066   | liq                   | -80      | 194; 102 <sup>10</sup>                 | 1.270 <sup>15</sup>        | 1.4438 <sup>19</sup> | msc H <sub>2</sub> O, EtOH, eth; i bz             |
| 8097 | Nitroethene                                     |                                            | C <sub>2</sub> H <sub>3</sub> NO <sub>2</sub>                   | 3638-64-0 | 73.051   | liq                   | -55.5    | 98.5                                   | 1.2212 <sup>14</sup>       | 1.4282 <sup>20</sup> | vs EtOH, eth, ace, bz, chl                        |
| 8098 | (2-Nitroethyl)benzene                           |                                            | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                   | 6125-24-2 | 151.163  | liq                   | -23      | 250; 137 <sup>16</sup>                 | 1.126 <sup>24</sup>        | 1.5407 <sup>19</sup> |                                                   |
| 8099 | Nitrofen                                        | 2,4-Dichloro-1-(4-nitrophenoxy)benzene     | C <sub>12</sub> H <sub>7</sub> Cl <sub>2</sub> NO <sub>3</sub>  | 1836-75-5 | 284.095  |                       | 70       |                                        |                            |                      |                                                   |
| 8100 | 2-Nitro-9 <i>H</i> -fluorene                    |                                            | C <sub>13</sub> H <sub>9</sub> NO <sub>2</sub>                  | 607-57-8  | 211.216  | nd (50% HOAc ace)     | 159.3    |                                        |                            |                      | i H <sub>2</sub> O; s ace, bz                     |
| 8101 | 2-Nitro-9 <i>H</i> -fluoren-9-one               |                                            | C <sub>13</sub> H <sub>7</sub> NO <sub>3</sub>                  | 3096-52-4 | 225.200  | ye nd or lf (HOAc)    | 224.3    | sub                                    |                            |                      | sl EtOH; s ace, sulf, HOAc                        |
| 8102 | 5-Nitro-2-furaldehyde diacetate                 |                                            | C <sub>9</sub> H <sub>9</sub> NO <sub>7</sub>                   | 92-55-7   | 243.170  |                       | 92.0     |                                        |                            |                      | s chl                                             |
| 8103 | 2-Nitrofuran                                    |                                            | C <sub>4</sub> H <sub>3</sub> NO <sub>3</sub>                   | 609-39-2  | 113.072  | ye mcl cry (peth)     | 30       | 134 <sup>123</sup> , 84 <sup>13</sup>  |                            |                      | s H <sub>2</sub> O, EtOH, eth                     |
| 8104 | 5-Nitro-2-furancarboxaldehyde                   |                                            | C <sub>6</sub> H <sub>3</sub> NO <sub>4</sub>                   | 698-63-5  | 141.083  | pa ye (peth)          | 35.5     | 130 <sup>10</sup>                      |                            |                      | sl H <sub>2</sub> O; s peth                       |



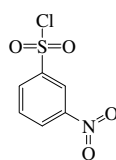
3-Nitrobenzenesulfonic acid



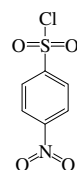
4-Nitrobenzenesulfonic acid



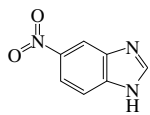
2-Nitrobenzenesulfonyl chloride



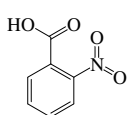
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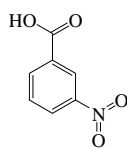
4-Nitrobenzenesulfonyl chloride



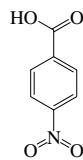
5-Nitro-1H-benzimidazole



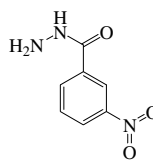
2-Nitrobenzoic acid



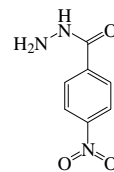
3-Nitrobenzoic acid



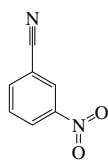
4-Nitrobenzoic acid



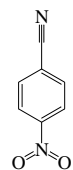
3-Nitrobenzoic acid, hydrazide



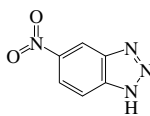
4-Nitrobenzoic acid, hydrazide



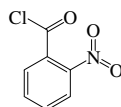
3-Nitrobenzonitrile



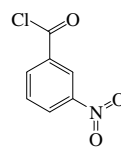
4-Nitrobenzonitrile



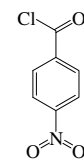
5-Nitro-1H-benzotriazole



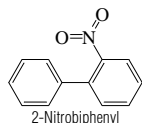
2-Nitrobenzoyl chloride



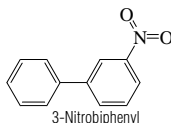
3-Nitrobenzoyl chloride



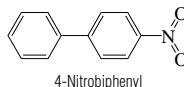
4-Nitrobenzoyl chloride



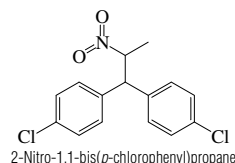
2-Nitrobiphenyl



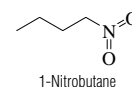
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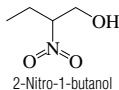
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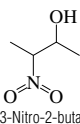
2-Nitro-1,1-bis(p-chlorophenyl)propane



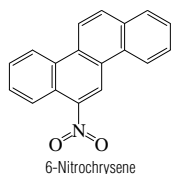
1-Nitrobutane



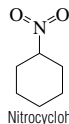
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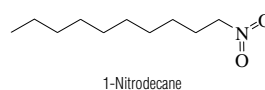
3-Nitro-2-butanol



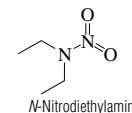
6-Nitrochrysene



Nitrocyclohexane



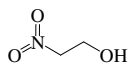
1-Nitrodecane



N-Nitrodiethylamine



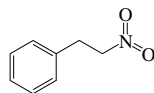
Nitroethane



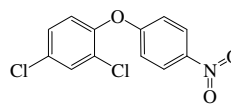
2-Nitroethanol



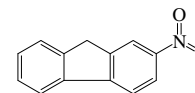
Nitroethene



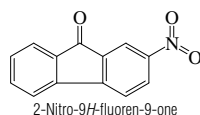
(2-Nitroethyl)benzene



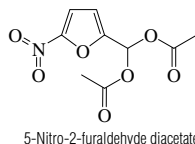
Nitrofen



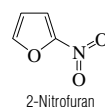
2-Nitro-9H-fluorene



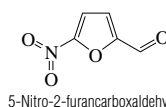
2-Nitro-9H-fluoren-9-one



5-Nitro-2-furaldehyde diacetate

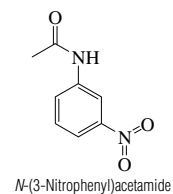
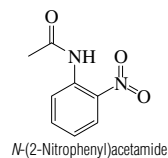
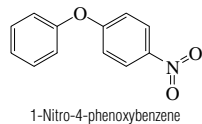
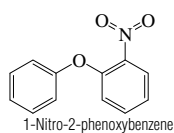
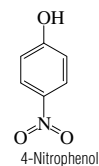
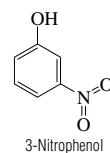
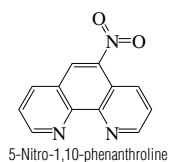
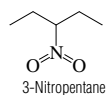
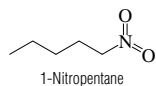
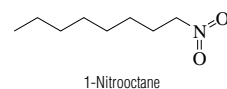
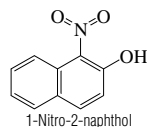
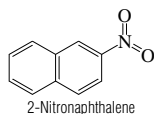
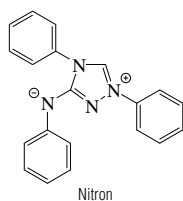
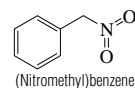
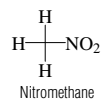
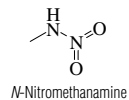
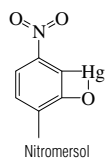
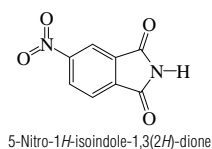
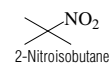
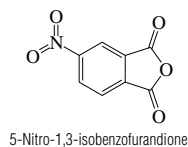
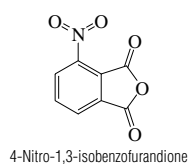
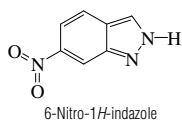
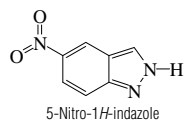
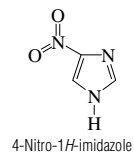
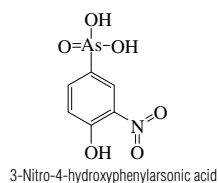
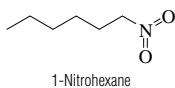
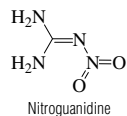
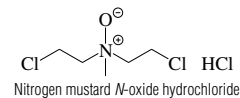
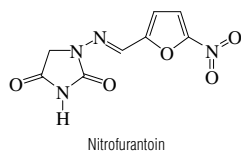
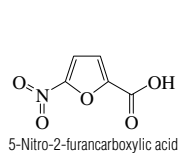


2-Nitrofuran

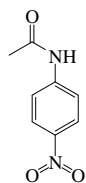
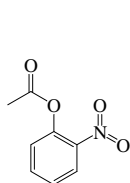


5-Nitro-2-furancarboxaldehyde

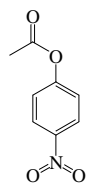
| No.  | Name                                                 | Synonym                                              | Mol. Form.                                                   | CAS RN    | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------|-----------|----------|----------------------------|---------|--------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 8105 | 5-Nitro-2-furancarboxylic acid                       |                                                      | C <sub>5</sub> H <sub>3</sub> NO <sub>5</sub>                | 645-12-5  | 157.082  | pa ye pl (w)               | 186     | sub                                  |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl ace, bz; i chl     |
| 8106 | Nitrofurantoin                                       |                                                      | C <sub>8</sub> H <sub>8</sub> N <sub>4</sub> O <sub>5</sub>  | 67-20-9   | 238.158  |                            | 263     |                                      |                            |                      |                                                      |
| 8107 | Nitrofurazone                                        | 2-[(5-Nitro-2-furanyl)methylene]hydrazinecarboxamide | C <sub>6</sub> H <sub>6</sub> N <sub>4</sub> O <sub>4</sub>  | 59-87-0   | 198.137  | pa ye nd                   | 238 dec |                                      |                            |                      | i H <sub>2</sub> O, eth; sl EtOH, DMSO; s alk        |
| 8108 | Nitrogen mustard <i>N</i> -oxide hydrochloride       | Mechlorethamine oxide hydrochloride                  | C <sub>5</sub> H <sub>12</sub> Cl <sub>3</sub> NO            | 302-70-5  | 208.514  | pr (ace)                   | 110     |                                      |                            |                      | s H <sub>2</sub> O                                   |
| 8109 | Nitroguanidine                                       |                                                      | CH <sub>4</sub> N <sub>4</sub> O <sub>2</sub>                | 556-88-7  | 104.069  | nd or pr (w)               | 239 dec |                                      |                            |                      | sl H <sub>2</sub> O, EtOH; i eth; vs alk             |
| 8110 | 1-Nitrohexane                                        |                                                      | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>               | 646-14-0  | 131.173  |                            |         | 193; 84 <sup>21</sup>                | 0.9396 <sup>20</sup>       | 1.4270 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, alk        |
| 8111 | 3-Nitro-4-hydroxyphenylarsonic acid                  | Roxarsone                                            | C <sub>6</sub> H <sub>6</sub> AsNO <sub>6</sub>              | 121-19-7  | 263.037  | ye nd or pl (w)            | 300     |                                      |                            |                      | sl hot H <sub>2</sub> O; i eth, EtOAc; vs MeOH, EtOH |
| 8112 | 2-Nitro-1 <i>H</i> -imidazole                        | Azomycin                                             | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub> O <sub>2</sub>  | 527-73-1  | 113.075  | cry (MeOH)                 | 287 dec |                                      |                            |                      |                                                      |
| 8113 | 4-Nitro-1 <i>H</i> -imidazole                        |                                                      | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub> O <sub>2</sub>  | 3034-38-6 | 113.075  |                            | 303 dec |                                      |                            |                      |                                                      |
| 8114 | 5-Nitro-1 <i>H</i> -indazole                         |                                                      | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>  | 5401-94-5 | 163.134  | ye nd or col nd (al)       | 208     |                                      |                            |                      | s EtOH, eth, bz; vs ace, HOAc; i lig                 |
| 8115 | 6-Nitro-1 <i>H</i> -indazole                         |                                                      | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>  | 7597-18-4 | 163.134  | nd (w, al, ace)            | 181 dec |                                      |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz; vs ace; i lig     |
| 8116 | 4-Nitro-1,3-isobenzofurandione                       |                                                      | C <sub>8</sub> H <sub>3</sub> NO <sub>5</sub>                | 641-70-3  | 193.114  | nd (ace, al)               | 164     |                                      |                            |                      | i H <sub>2</sub> O; s EtOH, ace, HOAc; sl bz         |
| 8117 | 5-Nitro-1,3-isobenzofurandione                       |                                                      | C <sub>8</sub> H <sub>3</sub> NO <sub>5</sub>                | 5466-84-2 | 193.114  |                            | 120.3   | 196 <sup>8</sup>                     |                            |                      | i H <sub>2</sub> O, peth; s EtOH, ace; sl eth        |
| 8118 | 2-Nitroisobutane                                     |                                                      | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 594-70-7  | 103.120  |                            | 26.23   | 127.16                               | 0.9501 <sup>28</sup>       | 1.4015 <sup>20</sup> | msc EtOH, eth, ace, bz; vs chl; i alk                |
| 8119 | 5-Nitro-1 <i>H</i> -isoindole-1,3(2 <i>H</i> )-dione |                                                      | C <sub>8</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>  | 89-40-7   | 192.129  | col nd (w), ye lf (al-ace) | 202     |                                      |                            |                      | vs ace                                               |
| 8120 | Nitromersol                                          |                                                      | C <sub>7</sub> H <sub>5</sub> HgNO <sub>3</sub>              | 133-58-4  | 351.71   |                            |         |                                      |                            |                      | i H <sub>2</sub> O; sl ace, EtOH; s alk              |
| 8121 | <i>N</i> -Nitromethanamine                           |                                                      | CH <sub>4</sub> N <sub>2</sub> O <sub>2</sub>                | 598-57-2  | 76.055   |                            | 38      | 82 <sup>10</sup>                     | 1.2433 <sup>49</sup>       | 1.4616 <sup>49</sup> | vs H <sub>2</sub> O, EtOH, bz, chl; s eth; sl peth   |
| 8122 | Nitromethane                                         |                                                      | CH <sub>3</sub> NO <sub>2</sub>                              | 75-52-5   | 61.041   | liq                        | -28.38  | 101.19                               | 1.1371 <sup>20</sup>       | 1.3817 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ace, ctc, alk         |
| 8123 | (Nitromethyl)benzene                                 |                                                      | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                | 622-42-4  | 137.137  | ye liq                     |         | 226; 135 <sup>25</sup>               | 1.1596 <sup>20</sup>       | 1.5323 <sup>20</sup> | vs ace, eth                                          |
| 8124 | Nitron                                               |                                                      | C <sub>20</sub> H <sub>16</sub> N <sub>4</sub>               | 2218-94-2 | 312.368  | ye lf (al), nd (chl)       | 189 dec |                                      |                            |                      | vs ace, bz, EtOH, chl                                |
| 8125 | 1-Nitronaphthalene                                   |                                                      | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>               | 86-57-7   | 173.169  | ye nd (al)                 | 61      | 180 <sup>14</sup>                    | 1.332 <sup>20</sup>        |                      | i H <sub>2</sub> O; vs EtOH, eth, bz, chl, py        |
| 8126 | 2-Nitronaphthalene                                   |                                                      | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>               | 581-89-5  | 173.169  | ye orth nd or pl (al)      | 79      | 314; 165 <sup>15</sup>               |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                     |
| 8127 | 1-Nitro-2-naphthol                                   |                                                      | C <sub>10</sub> H <sub>7</sub> NO <sub>3</sub>               | 550-60-7  | 189.168  | ye nd, lf or pr (al)       | 104     | 115 <sup>0.05</sup>                  |                            |                      | s H <sub>2</sub> O, EtOH; vs eth; sl chl             |
| 8128 | 1-Nitrooctane                                        |                                                      | C <sub>8</sub> H <sub>17</sub> NO <sub>2</sub>               | 629-37-8  | 159.227  |                            | 15      | 208.5                                | 0.9346 <sup>20</sup>       | 1.4322 <sup>20</sup> |                                                      |
| 8129 | 1-Nitropentane                                       |                                                      | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>               | 628-05-7  | 117.147  |                            |         | 172.5                                | 0.9525 <sup>20</sup>       | 1.4175 <sup>20</sup> | s EtOH, eth, bz                                      |
| 8130 | 3-Nitropentane                                       |                                                      | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>               | 551-88-2  | 117.147  |                            |         | 154                                  | 0.957 <sup>0</sup>         |                      | vs ace, eth, EtOH                                    |
| 8131 | 5-Nitro-1,10-phenanthroline                          |                                                      | C <sub>12</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub> | 4199-88-6 | 225.203  |                            | 202.3   |                                      |                            |                      |                                                      |
| 8132 | 2-Nitrophenol                                        |                                                      | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                | 88-75-5   | 139.109  | ye nd or pr (eth, al)      | 44.8    | 216                                  | 1.2942 <sup>40</sup>       | 1.5723 <sup>30</sup> | sl H <sub>2</sub> O; vs EtOH, eth, ace, bz, py       |
| 8133 | 3-Nitrophenol                                        |                                                      | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                | 554-84-7  | 139.109  | ye mcl (eth, aq HCl)       | 96.8    | 194 <sup>70</sup>                    | 1.2797 <sup>100</sup>      |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth, ace, bz     |
| 8134 | 4-Nitrophenol                                        |                                                      | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                | 100-02-7  | 139.109  | ye mcl pr (to)             | 113.6   |                                      | 1.479 <sup>20</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth, ace; s tol, py    |
| 8135 | 1-Nitro-2-phenoxybenzene                             |                                                      | C <sub>12</sub> H <sub>9</sub> NO <sub>3</sub>               | 2216-12-8 | 215.204  | ye liq                     | <-20    | 235 <sup>60</sup> , 184 <sup>8</sup> | 1.2539 <sup>22</sup>       | 1.575 <sup>20</sup>  | vs bz, eth, EtOH, chl                                |
| 8136 | 1-Nitro-4-phenoxybenzene                             |                                                      | C <sub>12</sub> H <sub>9</sub> NO <sub>3</sub>               | 620-88-2  | 215.204  | pl (peth), MeOH)           | 61      | 320; 225 <sup>30</sup>               |                            |                      | i H <sub>2</sub> O; sl EtOH, ctc; s eth, bz          |
| 8137 | <i>N</i> -(2-Nitrophenyl)acetamide                   |                                                      | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>  | 552-32-9  | 180.161  |                            | 94      | 100 <sup>0.1</sup>                   | 1.419 <sup>15</sup>        |                      | s H <sub>2</sub> O, EtOH, bz, chl, lig; vs eth       |
| 8138 | <i>N</i> -(3-Nitrophenyl)acetamide                   |                                                      | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>  | 122-28-1  | 180.161  | wh lf (al)                 | 155     | 100 <sup>0.0074</sup>                |                            |                      | s H <sub>2</sub> O, EtOH, chl; i eth; sl tfa         |



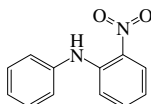
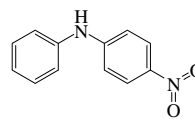
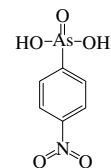
| No.  | Name                                                                | Synonym                             | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form             | mp/°C                       | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                |
|------|---------------------------------------------------------------------|-------------------------------------|---------------------------------------------------------------|------------|----------|---------------------------|-----------------------------|----------------------------------------|----------------------------|----------------------|-----------------------------------------------------------|
| 8139 | <i>N</i> -(4-Nitrophenyl)acetamide                                  |                                     | C <sub>8</sub> H <sub>9</sub> N <sub>3</sub> O <sub>3</sub>   | 104-04-1   | 180.161  | ye pr (w)                 | 216                         | 100 <sup>0.008</sup>                   |                            |                      | sl H <sub>2</sub> O, eth, chl;<br>s EtOH, tfa, alk        |
| 8140 | 2-Nitrophenyl acetate                                               |                                     | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                 | 610-69-5   | 181.147  | nd or pr (liq)            | 40.5                        | dec 253; 141 <sup>11</sup>             |                            |                      | s H <sub>2</sub> O; vs EtOH,<br>eth, ace, bz; sl<br>lig   |
| 8141 | 4-Nitrophenyl acetate                                               |                                     | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                 | 830-03-5   | 181.147  | lf (dil al)               | 82.3                        |                                        |                            |                      | vs H <sub>2</sub> O, bz; s<br>EtOH, chl, lig              |
| 8142 | 2-Nitro- <i>N</i> -phenylaniline                                    |                                     | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | 119-75-5   | 214.219  |                           | 75.5                        | 215 <sup>15</sup>                      | 1.3660 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH; sl<br>ctc                     |
| 8143 | 4-Nitro- <i>N</i> -phenylaniline                                    |                                     | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | 836-30-6   | 214.219  |                           | 135.3                       | 211 <sup>30</sup>                      |                            |                      | i H <sub>2</sub> O; vs EtOH;<br>sl ace; s con<br>sulf     |
| 8144 | (4-Nitrophenyl)arsonic acid                                         | Nitarsonic                          | C <sub>6</sub> H <sub>5</sub> AsNO <sub>3</sub>               | 98-72-6    | 247.038  | lf or nd (w)              | >310 dec                    |                                        |                            |                      | sl H <sub>2</sub> O, EtOH,<br>DMSO                        |
| 8145 | 4-[(4-Nitrophenyl)azo]-1,3-benzenediol                              | Magneson                            | C <sub>12</sub> H <sub>9</sub> N <sub>3</sub> O <sub>4</sub>  | 74-39-5    | 259.217  | red pow (al<br>or MeOH)   | 200                         |                                        |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>bz, HOAc, tol             |
| 8146 | 1-[(4-Nitrophenyl)azo]-2-naphthol                                   |                                     | C <sub>16</sub> H <sub>11</sub> N <sub>3</sub> O <sub>3</sub> | 6410-10-2  | 293.276  | br-oran pl (to<br>or bz)  | 257                         |                                        |                            |                      | vs bz, EtOH                                               |
| 8147 | (3-Nitrophenyl)boronic acid                                         |                                     | C <sub>6</sub> H <sub>5</sub> BN <sub>2</sub> O <sub>4</sub>  | 13331-27-6 | 166.928  |                           | 274.5                       |                                        |                            |                      |                                                           |
| 8148 | 1-(2-Nitrophenyl)ethanone                                           | 2-Nitroacetophenone                 | C <sub>8</sub> H <sub>7</sub> NO <sub>3</sub>                 | 577-59-3   | 165.147  |                           | 28.5                        | 178 <sup>32</sup> , 158 <sup>16</sup>  | 1.2370 <sup>25</sup>       | 1.5468 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth, chl                  |
| 8149 | 1-(3-Nitrophenyl)ethanone                                           | 3-Nitroacetophenone                 | C <sub>8</sub> H <sub>7</sub> NO <sub>3</sub>                 | 121-89-1   | 165.147  | nd (al)                   | 81                          | 202; 167 <sup>18</sup>                 |                            |                      | vs H <sub>2</sub> O, bz; sl<br>EtOH, chl                  |
| 8150 | 1-(4-Nitrophenyl)ethanone                                           | 4-Nitroacetophenone                 | C <sub>8</sub> H <sub>7</sub> NO <sub>3</sub>                 | 100-19-6   | 165.147  | ye pr (al)                | 81.8                        | 165 <sup>5</sup>                       |                            |                      | vs eth, EtOH                                              |
| 8151 | 2-Nitro-1-phenylethanone                                            |                                     | C <sub>8</sub> H <sub>7</sub> NO <sub>3</sub>                 | 614-21-1   | 165.147  |                           | 106                         | 158 <sup>16</sup> , 142 <sup>10</sup>  |                            | 1.5468 <sup>30</sup> | vs eth, EtOH                                              |
| 8152 | (4-Nitrophenyl)hydrazine                                            |                                     | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>   | 100-16-3   | 153.139  | oran-red lf or<br>nd (al) | 158 dec                     |                                        |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, bz, chl,<br>AcOEt    |
| 8153 | (4-Nitrophenyl)phenylmethanone                                      |                                     | C <sub>13</sub> H <sub>9</sub> NO <sub>3</sub>                | 1144-74-7  | 227.215  | nd or lf (al)             | 138                         |                                        | 1.406 <sup>9</sup>         |                      | vs bz                                                     |
| 8154 | 3-(4-Nitrophenyl)-1-phenyl-2-propen-1-one                           | Nitrochalcone                       | C <sub>15</sub> H <sub>11</sub> NO <sub>3</sub>               | 1222-98-6  | 253.253  | pa ye nd (al)<br>pl (bz)  | 164                         |                                        |                            |                      | s EtOH, chl; i<br>eth, lig                                |
| 8155 | 4-Nitrophenyl phosphate                                             | 4-Nitrophenyl dihydrogen phosphate  | C <sub>6</sub> H <sub>5</sub> NO <sub>6</sub> P               | 330-13-2   | 219.089  | ye-wh nd                  | 155                         |                                        |                            |                      | i cold H <sub>2</sub> O; s<br>EtOH, chl, bz               |
| 8156 | 3-(2-Nitrophenyl)propanoic acid                                     | 2-Nitrobenzenepropanoic acid        | C <sub>9</sub> H <sub>9</sub> NO <sub>4</sub>                 | 2001-32-3  | 195.172  | ye cry                    | 115                         |                                        |                            |                      |                                                           |
| 8157 | 3-(4-Nitrophenyl)propanoic acid                                     | 4-Nitrobenzenepropanoic acid        | C <sub>9</sub> H <sub>9</sub> NO <sub>4</sub>                 | 16642-79-8 | 195.172  | nd (w)                    | 163                         |                                        |                            |                      |                                                           |
| 8158 | 3-(4-Nitrophenyl)-2-propenal                                        | 4-Nitrocinnamaldehyde               | C <sub>9</sub> H <sub>7</sub> NO <sub>3</sub>                 | 1734-79-8  | 177.157  | nd (w, al)                | 141.5                       |                                        |                            |                      | s H <sub>2</sub> O, eth, ace,<br>bz; vs EtOH              |
| 8159 | 3-(2-Nitrophenyl)-2-propynoic acid                                  | <i>o</i> -Nitrophenylpropionic acid | C <sub>9</sub> H <sub>7</sub> NO <sub>4</sub>                 | 530-85-8   | 191.141  |                           | ≈157 dec;<br>may<br>explode |                                        |                            |                      | sl H <sub>2</sub> O; vs EtOH,<br>eth; i CS <sub>2</sub> O |
| 8160 | 1-Nitro-4-(phenylthio)benzene                                       |                                     | C <sub>12</sub> H <sub>9</sub> NO <sub>2</sub> S              | 952-97-6   | 231.270  | pa ye mcl pr<br>(liq)     | 56                          | 288 <sup>100</sup> , 240 <sup>25</sup> |                            |                      | vs eth, EtOH                                              |
| 8161 | (4-Nitrophenyl)urea                                                 | <i>p</i> -Nitrophenylurea           | C <sub>7</sub> H <sub>7</sub> N <sub>3</sub> O <sub>3</sub>   | 556-10-5   | 181.149  | pr (al), nd<br>(dil al)   | 238                         |                                        |                            |                      | vs H <sub>2</sub> O, EtOH                                 |
| 8162 | <i>N</i> -Nitropiperidine                                           |                                     | C <sub>6</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>  | 7119-94-0  | 130.145  | liq                       | -5.5                        | 245; 121 <sup>20</sup>                 | 1.1519 <sup>26</sup>       | 1.4954 <sup>26</sup> |                                                           |
| 8163 | 1-Nitropropane                                                      |                                     | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                 | 108-03-2   | 89.094   | liq                       | -108                        | 131.1                                  | 0.9961 <sup>25</sup>       | 1.4018 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth; s<br>chl           |
| 8164 | 2-Nitropropane                                                      |                                     | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                 | 79-46-9    | 89.094   | liq                       | -91.3                       | 120.2                                  | 0.9821 <sup>25</sup>       | 1.3944 <sup>20</sup> | sl H <sub>2</sub> O; s chl                                |
| 8165 | 3-Nitropropanoic acid                                               |                                     | C <sub>3</sub> H <sub>5</sub> NO <sub>4</sub>                 | 504-88-1   | 119.077  |                           | 62                          |                                        | 1.59 <sup>20</sup>         |                      | vs H <sub>2</sub> O, EtOH,<br>eth; s chl; i lig           |
| 8166 | 2-Nitro-1-propanol                                                  |                                     | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                 | 2902-96-7  | 105.093  |                           |                             | 120 <sup>32</sup> , 100 <sup>12</sup>  | 1.1841 <sup>25</sup>       | 1.4379 <sup>20</sup> | s H <sub>2</sub> O, EtOH,<br>eth; sl chl                  |
| 8167 | 1-Nitro-1-propene                                                   |                                     | C <sub>3</sub> H <sub>5</sub> NO <sub>2</sub>                 | 3156-70-5  | 87.078   |                           |                             | 60 <sup>34</sup> , 37 <sup>10</sup>    | 1.0661 <sup>20</sup>       | 1.4527 <sup>20</sup> | s eth, ace, chl                                           |
| 8168 | 2-Nitro-1-propene                                                   |                                     | C <sub>3</sub> H <sub>5</sub> NO <sub>2</sub>                 | 4749-28-4  | 87.078   | ye-grn liq                |                             | 52 <sup>20</sup> , 32 <sup>30</sup>    | 1.0559 <sup>25</sup>       | 1.4358 <sup>20</sup> | s eth, ace, chl                                           |
| 8169 | 5-Nitro-2-propoxyaniline                                            |                                     | C <sub>9</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>  | 553-79-7   | 196.202  | oran (PROH-<br>peth)      | 49                          |                                        |                            |                      | vs EtOH                                                   |
| 8170 | <i>N</i> -(5-Nitro-2-propoxyphenyl)acetamide                        | 5'-Nitro-2'-propoxyacetanilide      | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> O <sub>4</sub> | 553-20-8   | 238.240  | cry (PROH)                | 102.5                       |                                        |                            |                      |                                                           |
| 8171 | 1-Nitropyrene                                                       |                                     | C <sub>16</sub> H <sub>9</sub> NO <sub>2</sub>                | 5522-43-0  | 247.248  | ye nd<br>(MeCN)           | 152                         |                                        |                            |                      |                                                           |
| 8172 | 5-Nitro-2-pyridinamine                                              |                                     | C <sub>5</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>   | 4214-76-0  | 139.113  | ye lf (dil al)            | 188                         |                                        |                            |                      | sl H <sub>2</sub> O, eth, bz,<br>lig; s EtOH              |
| 8173 | 4-Nitropyridine                                                     |                                     | C <sub>5</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>   | 1122-61-8  | 124.098  | pl (aq al)                | 50                          |                                        |                            |                      |                                                           |
| 8174 | 4-Nitropyridine 1-oxide                                             |                                     | C <sub>5</sub> H <sub>4</sub> N <sub>2</sub> O <sub>3</sub>   | 1124-33-0  | 140.097  |                           | 160.5                       |                                        |                            |                      |                                                           |
| 8175 | 5-Nitropyrimidinamine                                               |                                     | C <sub>4</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub>   | 3073-77-6  | 140.101  | nd (al)                   | 236.5                       |                                        |                            |                      | sl H <sub>2</sub> O, DMSO;<br>s EtOH, ace; i<br>eth, bz   |
| 8176 | 5-Nitro-2,4,6(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione              | 5-Nitrouacil                        | C <sub>4</sub> H <sub>3</sub> N <sub>3</sub> O <sub>4</sub>   | 611-08-5   | 157.085  | gold nd (al)              | >300 exp                    |                                        |                            |                      | sl H <sub>2</sub> O; s EtOH                               |
| 8177 | 5-Nitro-2,4,6(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | 5-Nitrobarbituric acid              | C <sub>4</sub> H <sub>3</sub> N <sub>3</sub> O <sub>5</sub>   | 480-68-2   | 173.084  | pr, lf (w+3)              | 180.5                       |                                        |                            |                      | s H <sub>2</sub> O, EtOH; i<br>eth                        |
| 8178 | 5-Nitroquinoline                                                    |                                     | C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | 607-34-1   | 174.156  | pl (w, al) nd<br>(+w)     | 74                          | sub                                    |                            |                      | sl H <sub>2</sub> O, chl; s<br>EtOH, bz                   |

*N*-(4-Nitrophenyl)acetamide

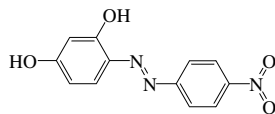
2-Nitrophenyl acetate



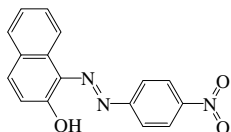
4-Nitrophenyl acetate

2-Nitro-*N*-phenylaniline4-Nitro-*N*-phenylaniline

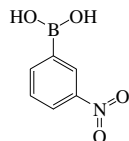
(4-Nitrophenyl)arsonic acid



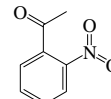
4-[(4-Nitrophenyl)azo]-1,3-benzenediol



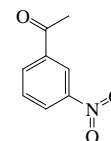
1-[(4-Nitrophenyl)azo]-2-naphthol



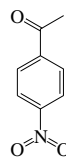
(3-Nitrophenyl)boronic acid



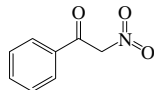
1-(2-Nitrophenyl)ethanone



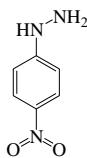
1-(3-Nitrophenyl)ethanone



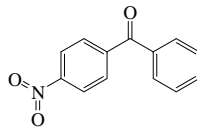
1-(4-Nitrophenyl)ethanone



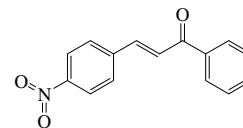
2-Nitro-1-phenylethanone



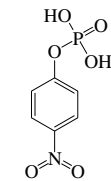
(4-Nitrophenyl)hydrazine



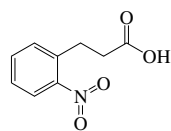
(4-Nitrophenyl)phenylmethanone



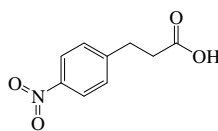
3-(4-Nitrophenyl)-1-phenyl-2-propen-1-one



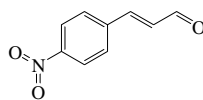
4-Nitrophenyl phosphate



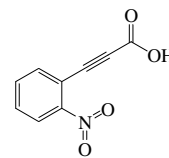
3-(2-Nitrophenyl)propanoic acid



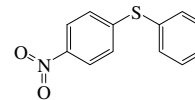
3-(4-Nitrophenyl)propanoic acid



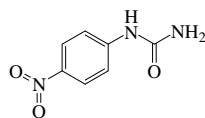
3-(4-Nitrophenyl)-2-propenal



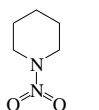
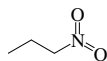
3-(2-Nitrophenyl)-2-propynoic acid



1-Nitro-4-(phenylthio)benzene



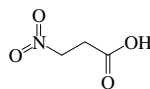
(4-Nitrophenyl)urea

*N*-Nitropiperidine

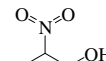
1-Nitropropane



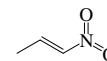
2-Nitropropane



3-Nitropropanoic acid



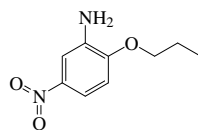
2-Nitro-1-propanol



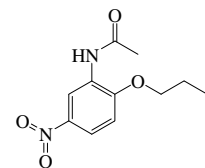
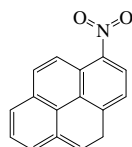
1-Nitro-1-propene



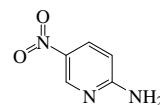
2-Nitro-1-propene



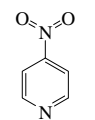
5-Nitro-2-propoxyaniline

*N*-(5-Nitro-2-propoxyphenyl)acetamide

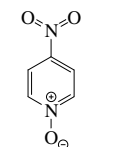
1-Nitropyrene



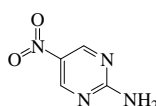
5-Nitro-2-pyridinamine



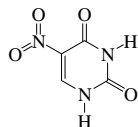
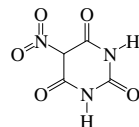
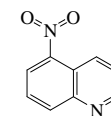
4-Nitropyridine



4-Nitropyridine 1-oxide



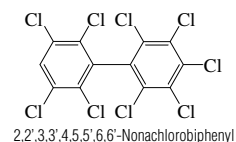
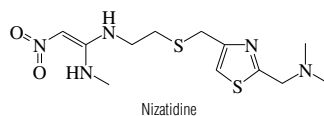
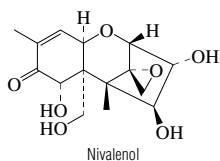
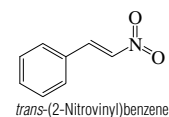
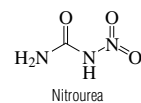
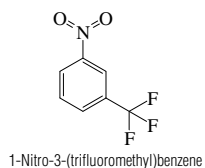
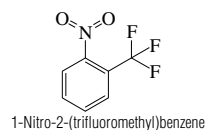
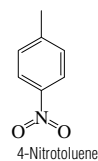
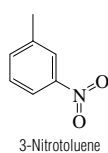
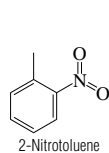
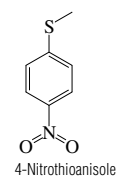
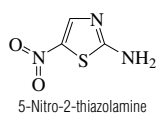
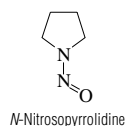
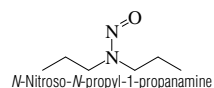
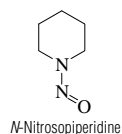
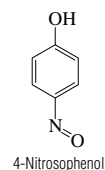
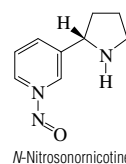
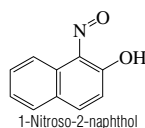
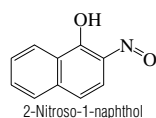
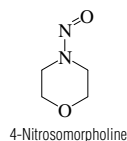
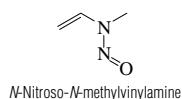
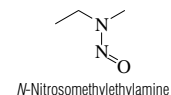
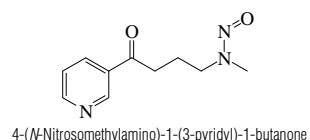
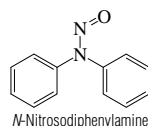
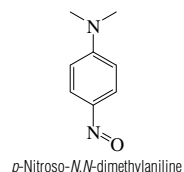
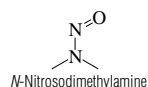
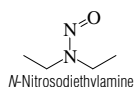
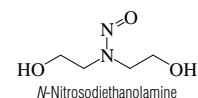
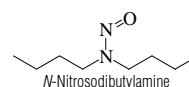
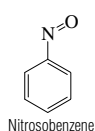
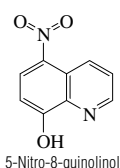
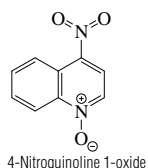
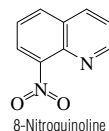
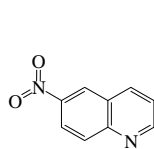
5-Nitropyrimidinamine

5-Nitro-2,4(1*H*,3*H*)-pyrimidinedione5-Nitro-2,4,6(1*H*,3*H*,5*H*)-pyrimidinetrione

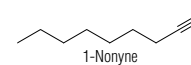
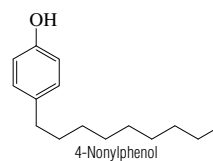
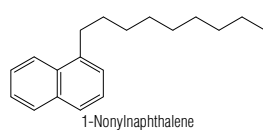
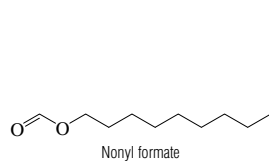
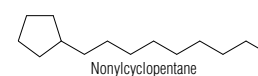
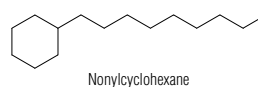
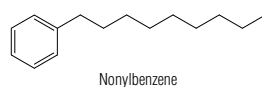
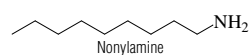
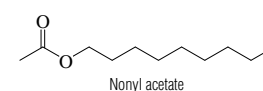
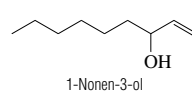
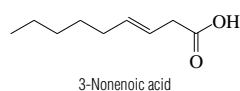
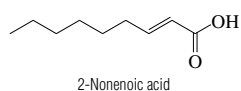
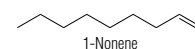
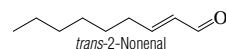
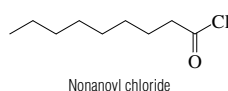
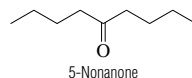
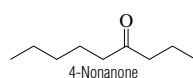
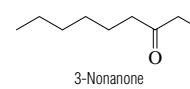
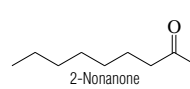
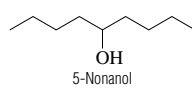
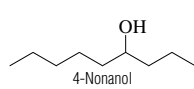
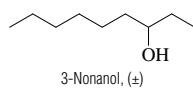
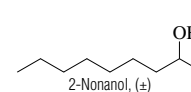
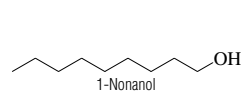
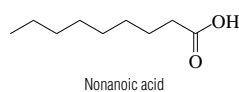
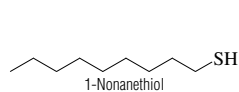
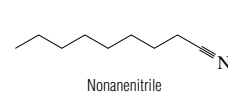
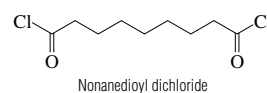
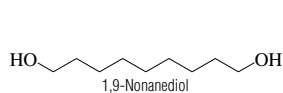
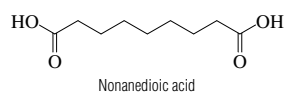
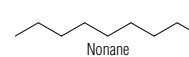
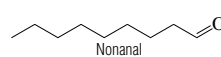
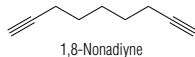
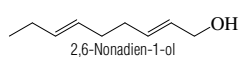
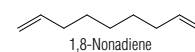
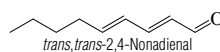
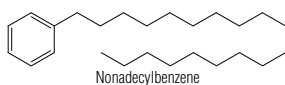
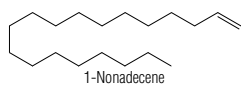
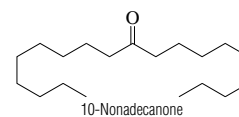
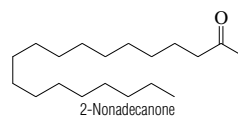
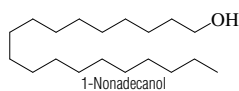
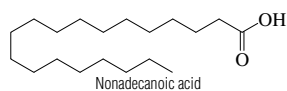
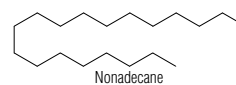
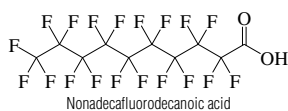
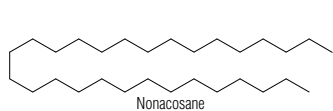
5-Nitroquinoline



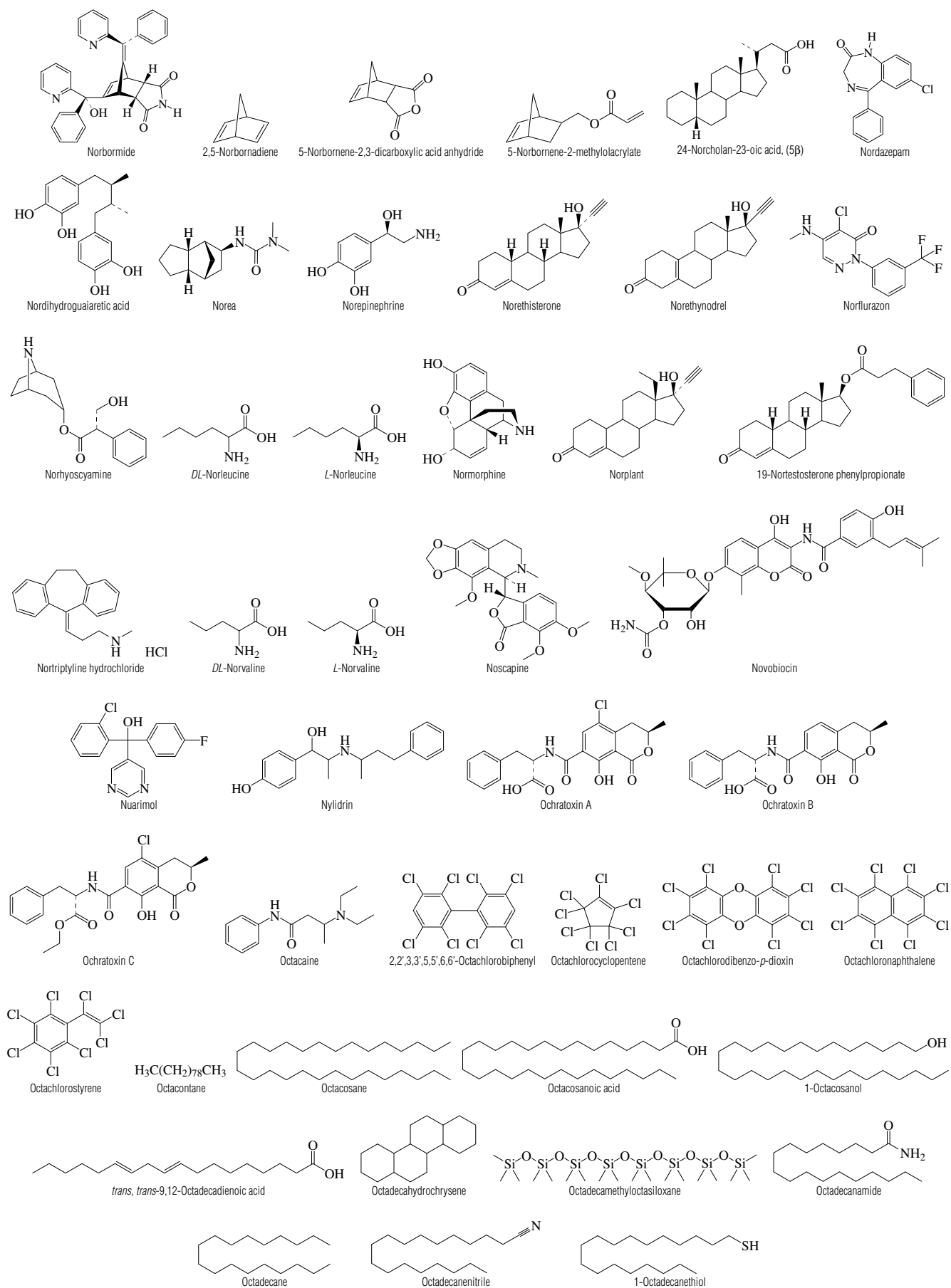
| No.  | Name                                                       | Synonym                                                              | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|-------------------------|---------|--------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 8179 | 6-Nitroquinoline                                           |                                                                      | C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                  | 613-50-3   | 174.156  | ye pl (HCl-HOAc)        | 153.5   | 170 <sup>0.2</sup>       |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, chl; vs bz                  |
| 8180 | 8-Nitroquinoline                                           |                                                                      | C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                  | 607-35-2   | 174.156  | mcl pr (al)             | 91.5    |                          |                            |                      | sl H <sub>2</sub> O, chl; s EtOH, eth, bz, acid               |
| 8181 | 4-Nitroquinoline 1-oxide                                   |                                                                      | C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> O <sub>3</sub>                  | 56-57-5    | 190.155  | ye nd, pl (ace)         | 154     |                          |                            |                      |                                                               |
| 8182 | 5-Nitro-8-quinolinol                                       | Nitroxoline                                                          | C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> O <sub>3</sub>                  | 4008-48-4  | 190.155  |                         | 180     |                          |                            |                      |                                                               |
| 8183 | Nitrosobenzene                                             |                                                                      | C <sub>6</sub> H <sub>5</sub> NO                                             | 586-96-9   | 107.110  | orth or mcl (al-eth)    | 67      | 58 <sup>18</sup>         |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz, lig                      |
| 8184 | <i>N</i> -Nitrosodibutylamine                              | Dibutylnitrosamine                                                   | C <sub>8</sub> H <sub>18</sub> N <sub>2</sub> O                              | 924-16-3   | 158.241  |                         |         | 105 <sup>8</sup>         |                            |                      |                                                               |
| 8185 | <i>N</i> -Nitrosodiethanolamine                            | 2,2'-(Nitrosoimino)ethanol                                           | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>                 | 1116-54-7  | 134.133  | wh-ye oil               |         | 125 <sup>0.01</sup>      |                            | 1.4849 <sup>20</sup> |                                                               |
| 8186 | <i>N</i> -Nitrosodiethylamine                              | Diethylnitrosamine                                                   | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O                              | 55-18-5    | 102.134  | ye oil                  |         | 176.9                    | 0.9422 <sup>20</sup>       | 1.4386 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth; sl chl                         |
| 8187 | <i>N</i> -Nitrosodimethylamine                             | Dimethylnitrosamine                                                  | C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O                               | 62-75-9    | 74.081   | ye liq                  |         | 152                      | 1.0048 <sup>20</sup>       | 1.4368 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; s chl                         |
| 8188 | <i>p</i> -Nitroso- <i>N,N</i> -dimethylaniline             |                                                                      | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O                              | 138-89-6   | 150.177  | grn pl (eth)            | 92.5    |                          | 1.145 <sup>20</sup>        |                      | sl H <sub>2</sub> O; s EtOH, eth, chl, HCONH <sub>2</sub>     |
| 8189 | <i>N</i> -Nitrosodiphenylamine                             | <i>N,N</i> -Diphenylnitrosamine                                      | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O                             | 86-30-6    | 198.219  | ye pl(lig)              | 66.5    |                          |                            |                      | i H <sub>2</sub> O; sl EtOH, chl; s bz                        |
| 8190 | 4-( <i>N</i> -Nitrosomethylamino)-1-(3-pyridyl)-1-butanone | Ketone, 3-pyridyl-3-( <i>N</i> -methyl- <i>N</i> -nitrosamino)propyl | C <sub>10</sub> H <sub>13</sub> N <sub>3</sub> O <sub>2</sub>                | 64091-91-4 | 207.229  |                         | 63      |                          |                            |                      | sl H <sub>2</sub> O                                           |
| 8191 | <i>N</i> -Nitrosomethylethylamine                          |                                                                      | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O                               | 10595-95-6 | 88.108   | ye liq                  |         | 67 <sup>40</sup>         |                            |                      |                                                               |
| 8192 | <i>N</i> -Nitroso- <i>N</i> -methylvinylamine              | <i>N</i> -Methyl- <i>N</i> -nitrosoethenamine                        | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O                               | 4549-40-0  | 86.092   | ye liq                  |         | 47                       |                            |                      | sl H <sub>2</sub> O                                           |
| 8193 | 4-Nitrosomorpholine                                        | <i>N</i> -Nitrosomorpholine                                          | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                  | 59-89-2    | 116.119  |                         | 29      | 225; 140 <sup>25</sup>   |                            |                      | s H <sub>2</sub> O                                            |
| 8194 | 2-Nitroso-1-naphthol                                       |                                                                      | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>                               | 132-53-6   | 173.169  |                         | 157 dec |                          |                            |                      | sl H <sub>2</sub> O, eth, bz, chl; s EtOH, ace, HOAc          |
| 8195 | 1-Nitroso-2-naphthol                                       | 1-Nitroso-β-naphthol                                                 | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>                               | 131-91-9   | 173.169  | ye-br nd (peth)         | 109.5   |                          |                            |                      | vs bz, eth                                                    |
| 8196 | <i>N</i> -Nitrosornicotine                                 | <i>N</i> -Nitroso-3-(2-pyrrolidinyl)pyridine                         | C <sub>9</sub> H <sub>11</sub> N <sub>3</sub> O                              | 16543-55-8 | 177.202  |                         |         | 155 <sup>0.2</sup>       |                            |                      |                                                               |
| 8197 | 4-Nitrosophenol                                            |                                                                      | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                                | 104-91-6   | 123.110  | pa ye orth nd (ace, bz) | 144 dec |                          |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, dil alk            |
| 8198 | 4-Nitroso- <i>N</i> -phenylaniline                         | <i>p</i> -Nitrosodiphenylamine                                       | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O                             | 156-10-5   | 198.219  |                         | 143     |                          |                            |                      | sl H <sub>2</sub> O, lig; vs EtOH, eth, bz                    |
| 8199 | <i>N</i> -Nitrosopiperidine                                | 1-Nitrosopiperidine                                                  | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O                              | 100-75-4   | 114.145  | pa ye                   |         | 219; 109 <sup>20</sup>   | 1.0631 <sup>18</sup>       | 1.4933 <sup>18</sup> | s H <sub>2</sub> O, HCl                                       |
| 8200 | <i>N</i> -Nitroso- <i>N</i> -propyl-1-propanamine          | <i>N</i> -Nitrosodipropylamine                                       | C <sub>8</sub> H <sub>14</sub> N <sub>2</sub> O                              | 621-64-7   | 130.187  | gold                    |         | 206; 113 <sup>40</sup>   | 0.9163 <sup>20</sup>       | 1.4437 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                            |
| 8201 | <i>N</i> -Nitrosopyrrolidine                               |                                                                      | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O                               | 930-55-2   | 100.119  |                         |         | 214                      | 1.085 <sup>25</sup>        | 1.4880 <sup>25</sup> |                                                               |
| 8202 | 5-Nitro-2-thiazolamine                                     | 2-Amino-5-nitrothiazole                                              | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub> O <sub>2</sub> S                | 121-66-4   | 145.140  | oran-ye pow             | 202 dec |                          |                            |                      |                                                               |
| 8203 | <i>N</i> -(5-Nitro-2-thiazolyl)acetamide                   | Aminitroazole                                                        | C <sub>5</sub> H <sub>5</sub> N <sub>3</sub> O <sub>3</sub> S                | 140-40-9   | 187.177  | nd (al), pl (HOAc)      | 264.5   |                          |                            |                      | s alk                                                         |
| 8204 | 4-Nitrothioanisole                                         |                                                                      | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub> S                              | 701-57-5   | 169.202  |                         | 72      | 137 <sup>2</sup>         | 1.2391 <sup>80</sup>       | 1.6401 <sup>20</sup> | i H <sub>2</sub> O; s ace, bz                                 |
| 8205 | 2-Nitrothiophene                                           |                                                                      | C <sub>4</sub> H <sub>3</sub> NO <sub>2</sub> S                              | 609-40-5   | 129.138  | lt ye mcl nd (peth)     | 46.5    | 224.5                    | 1.3644 <sup>43</sup>       |                      | i H <sub>2</sub> O; vs EtOH; s alk; sl peth                   |
| 8206 | 2-Nitrotoluene                                             |                                                                      | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                | 88-72-2    | 137.137  | liq                     | -10.4   | 222                      | 1.1611 <sup>19</sup>       | 1.5450 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc                      |
| 8207 | 3-Nitrotoluene                                             |                                                                      | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                | 99-08-1    | 137.137  | pa ye                   | 15.5    | 232                      | 1.1581 <sup>20</sup>       | 1.5466 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, ctc; msc eth                  |
| 8208 | 4-Nitrotoluene                                             |                                                                      | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                | 99-99-0    | 137.137  | orth cry (al, eth)      | 51.63   | 238.3                    | 1.1038 <sup>75</sup>       |                      | i H <sub>2</sub> O; s EtOH; vs eth, ace, bz, chl              |
| 8209 | 1-Nitro-2-(trifluoromethyl)benzene                         |                                                                      | C <sub>7</sub> H <sub>4</sub> F <sub>3</sub> NO <sub>2</sub>                 | 384-22-5   | 191.108  | cry (al)                | 32.5    | 217; 105 <sup>20</sup>   |                            |                      | i H <sub>2</sub> O; vs EtOH, HOAc, bz; sl ctc                 |
| 8210 | 1-Nitro-3-(trifluoromethyl)benzene                         |                                                                      | C <sub>7</sub> H <sub>4</sub> F <sub>3</sub> NO <sub>2</sub>                 | 98-46-4    | 191.108  | liq                     | -2.4    | 202.8; 103 <sup>40</sup> | 1.4357 <sup>15</sup>       | 1.4719 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                       |
| 8211 | Nitrourea                                                  |                                                                      | CH <sub>3</sub> N <sub>3</sub> O <sub>3</sub>                                | 556-89-8   | 105.053  | pl (al-peth)            | 158 dec |                          |                            |                      | vs ace, EtOH                                                  |
| 8212 | <i>trans</i> -(2-Nitrovinyl)benzene                        |                                                                      | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>                                | 5153-67-3  | 149.148  | ye pr (peth, al)        | 60      | 255                      |                            |                      | i H <sub>2</sub> O; s EtOH, ace; vs eth, chl, CS <sub>2</sub> |
| 8213 | Nivalenol                                                  |                                                                      | C <sub>15</sub> H <sub>26</sub> O <sub>7</sub>                               | 23282-20-4 | 312.316  | cry (MeOH)              | 224 dec |                          |                            |                      | sl H <sub>2</sub> O; s EtOH, MeOH                             |
| 8214 | Nizatidine                                                 |                                                                      | C <sub>12</sub> H <sub>21</sub> N <sub>5</sub> O <sub>2</sub> S <sub>2</sub> | 76963-41-2 | 331.458  | cry (EtOH/AcOEt)        | 131     |                          |                            |                      | sl H <sub>2</sub> O; s MeOH; vs chl; i bz, eth                |
| 8215 | 2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl                   |                                                                      | C <sub>12</sub> HCl <sub>9</sub>                                             | 52663-77-1 | 464.213  | cry                     | 180.5   |                          |                            |                      | i H <sub>2</sub> O                                            |
| 8216 | Nonacontane                                                |                                                                      | C <sub>90</sub> H <sub>182</sub>                                             | 7667-51-8  | 1264.408 |                         |         | 612 <sup>200</sup>       |                            |                      |                                                               |



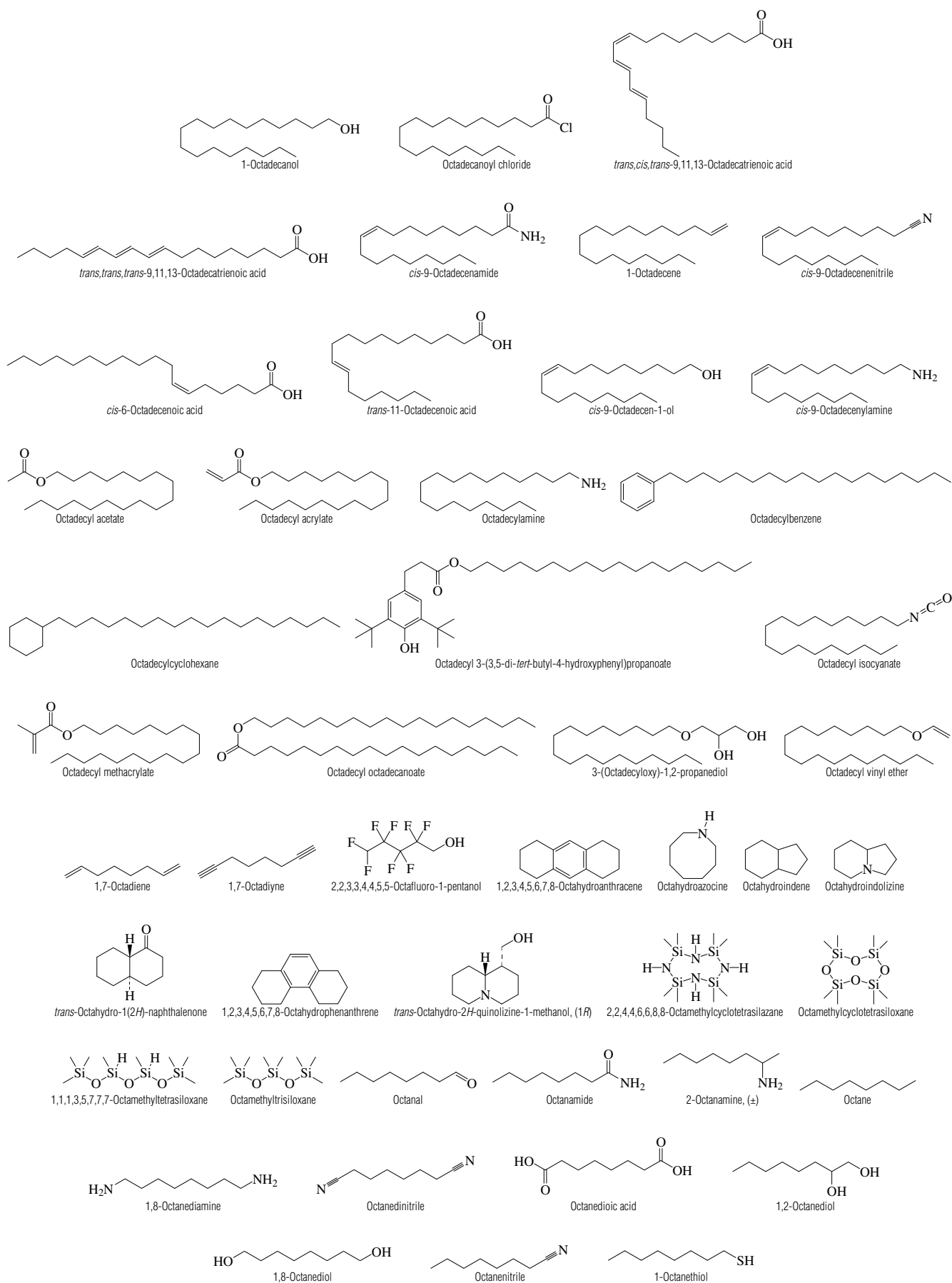
| No.  | Name                        | Synonym              | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form   | mp/°C  | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                          |
|------|-----------------------------|----------------------|---------------------------------------------------------------|------------|----------|-----------------|--------|----------------------------------------|----------------------------|-----------------------|-----------------------------------------------------|
| 8217 | Nonacosane                  |                      | C <sub>29</sub> H <sub>60</sub>                               | 630-03-5   | 408.786  | orth cry (peth) | 63.7   | 440.8                                  | 0.8083 <sup>20</sup>       | 1.4529 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth, ace; s bz; sl chl |
| 8218 | Nonadecafluorodecanoic acid |                      | C <sub>10</sub> HF <sub>19</sub> O <sub>2</sub>               | 335-76-2   | 514.084  |                 |        | 219.4                                  |                            |                       |                                                     |
| 8219 | Nonadecane                  |                      | C <sub>19</sub> H <sub>40</sub>                               | 629-92-5   | 268.521  | wax             | 32.0   | 329.9                                  | 0.7855 <sup>20</sup>       | 1.4409 <sup>20</sup>  | i H <sub>2</sub> O; sl EtOH; s eth, ace, ctc        |
| 8220 | Nonadecanoic acid           |                      | C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>                | 646-30-0   | 298.504  | lf (al)         | 69.4   | 297 <sup>100</sup> , 228 <sup>10</sup> | 0.8468 <sup>70</sup>       |                       | i H <sub>2</sub> O; vs EtOH, eth, bz, chl, lig      |
| 8221 | 1-Nonadecanol               |                      | C <sub>19</sub> H <sub>40</sub> O                             | 1454-84-8  | 284.520  | cry (ace)       | 61.7   | 345; 166 <sup>0.3</sup>                |                            | 1.4328 <sup>75</sup>  | s eth, ace                                          |
| 8222 | 2-Nonadecanone              |                      | C <sub>19</sub> H <sub>38</sub> O                             | 629-66-3   | 282.504  | pr (al)         | 57     | 266 <sup>110</sup> , 165 <sup>2</sup>  | 0.8108 <sup>86</sup>       |                       | i H <sub>2</sub> O; sl EtOH; s ace, bz; vs eth, ctc |
| 8223 | 10-Nonadecanone             |                      | C <sub>19</sub> H <sub>38</sub> O                             | 504-57-4   | 282.504  | lf(al)          | 65.5   | >350; 156 <sup>1.1</sup>               |                            |                       | i H <sub>2</sub> O; sl EtOH; s eth, ace, lig; vs bz |
| 8224 | 1-Nonadecene                |                      | C <sub>19</sub> H <sub>38</sub>                               | 18435-45-5 | 266.505  |                 | 23.4   | 329.0                                  | 0.7886 <sup>25</sup>       | 1.4445 <sup>25</sup>  |                                                     |
| 8225 | Nonadecylbenzene            |                      | C <sub>25</sub> H <sub>44</sub>                               | 29136-19-4 | 344.617  |                 | 40     | 419                                    | 0.8545 <sup>20</sup>       | 1.4807 <sup>20</sup>  |                                                     |
| 8226 | trans,trans-2,4-Nonadienal  |                      | C <sub>9</sub> H <sub>14</sub> O                              | 5910-87-2  | 138.206  |                 |        | 98 <sup>10</sup>                       | 0.862 <sup>25</sup>        | 1.5207 <sup>20</sup>  |                                                     |
| 8227 | 1,8-Nonadiene               |                      | C <sub>9</sub> H <sub>16</sub>                                | 4900-30-5  | 124.223  |                 |        | 142.5                                  | 0.7511 <sup>20</sup>       | 1.4302 <sup>20</sup>  |                                                     |
| 8228 | 2,6-Nonadien-1-ol           |                      | C <sub>9</sub> H <sub>16</sub> O                              | 7786-44-9  | 140.222  |                 |        | 108 <sup>24</sup> , 98 <sup>11</sup>   | 0.8604 <sup>25</sup>       | 1.4598 <sup>25</sup>  |                                                     |
| 8229 | 1,8-Nonadiyne               |                      | C <sub>9</sub> H <sub>12</sub>                                | 2396-65-8  | 120.191  | liq             | -27.3  | 162                                    | 0.8158 <sup>20</sup>       | 1.4490 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ace                      |
| 8230 | Nonanal                     | Nonaldehyde          | C <sub>9</sub> H <sub>18</sub> O                              | 124-19-6   | 142.238  |                 | -19.3  | 191                                    | 0.8264 <sup>22</sup>       | 1.4273 <sup>20</sup>  | s eth, chl                                          |
| 8231 | Nonane                      |                      | C <sub>9</sub> H <sub>20</sub>                                | 111-84-2   | 128.255  | liq             | -53.46 | 150.82                                 | 0.7192 <sup>20</sup>       | 1.4058 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth; msc ace, bz, hp   |
| 8232 | Nonanedioic acid            | Azelaic acid         | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                 | 123-99-9   | 188.221  | lf or nd        | 106.5  | 357.1; 287 <sup>100</sup>              | 1.225 <sup>25</sup>        | 1.4303 <sup>111</sup> | sl H <sub>2</sub> O, eth, bz, DMSO; s EtOH          |
| 8233 | 1,9-Nonanediol              |                      | C <sub>9</sub> H <sub>20</sub> O <sub>2</sub>                 | 3937-56-2  | 160.254  | cry (bz)        | 45.8   | 173 <sup>20</sup> , 150 <sup>3</sup>   |                            |                       | sl H <sub>2</sub> O; vs EtOH, eth; s bz; i lig      |
| 8234 | Nonanedioyl dichloride      |                      | C <sub>9</sub> H <sub>14</sub> Cl <sub>2</sub> O <sub>2</sub> | 123-98-8   | 225.112  |                 |        | 166 <sup>18</sup>                      | 1.143                      | 1.4680 <sup>20</sup>  | s eth; vs bz                                        |
| 8235 | Nonanenitrile               |                      | C <sub>9</sub> H <sub>17</sub> N                              | 2243-27-8  | 139.238  | liq             | -34.2  | 224.4                                  | 0.8178 <sup>20</sup>       | 1.4255 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl ctc             |
| 8236 | 1-Nonanethiol               | Nonyl mercaptan      | C <sub>9</sub> H <sub>20</sub> S                              | 1455-21-6  | 160.320  | liq             | -20.1  | 220                                    | 0.842 <sup>25</sup>        | 1.4548 <sup>20</sup>  |                                                     |
| 8237 | Nonanoic acid               | Pelargonic acid      | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                 | 112-05-0   | 158.238  |                 | 12.4   | 254.5                                  | 0.9052 <sup>20</sup>       | 1.4343 <sup>19</sup>  | i H <sub>2</sub> O; s EtOH, eth, chl                |
| 8238 | 1-Nonanol                   | Nonyl alcohol        | C <sub>9</sub> H <sub>20</sub> O                              | 143-08-8   | 144.254  | liq             | -5     | 213.37                                 | 0.8280 <sup>20</sup>       | 1.4333 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth; sl ctc             |
| 8239 | 2-Nonanol, (±)              |                      | C <sub>9</sub> H <sub>20</sub> O                              | 74683-66-2 | 144.254  | liq             | -35    | 193.5                                  | 0.8471 <sup>20</sup>       | 1.4353 <sup>20</sup>  | i H <sub>2</sub> O; vs eth, EtOH                    |
| 8240 | 3-Nonanol, (±)              |                      | C <sub>9</sub> H <sub>20</sub> O                              | 74742-08-8 | 144.254  |                 | 22     | 195; 93 <sup>18</sup>                  | 0.8250 <sup>20</sup>       | 1.4289 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                     |
| 8241 | 4-Nonanol                   |                      | C <sub>9</sub> H <sub>20</sub> O                              | 52708-03-9 | 144.254  |                 |        | 192.5; 94 <sup>18</sup>                | 0.8282 <sup>20</sup>       | 1.4197 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth                     |
| 8242 | 5-Nonanol                   | Dibutylcarbinol      | C <sub>9</sub> H <sub>20</sub> O                              | 623-93-8   | 144.254  |                 | 5.6    | 193; 97 <sup>20</sup>                  | 0.8220 <sup>20</sup>       | 1.4289 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH                          |
| 8243 | 2-Nonanone                  | Heptyl methyl ketone | C <sub>9</sub> H <sub>18</sub> O                              | 821-55-6   | 142.238  | liq             | -7.5   | 195.3                                  | 0.8208 <sup>20</sup>       | 1.4210 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz; vs ace, chl    |
| 8244 | 3-Nonanone                  | Ethyl hexyl ketone   | C <sub>9</sub> H <sub>18</sub> O                              | 925-78-0   | 142.238  | liq             | -8     | 190; 86 <sup>20</sup>                  | 0.8241 <sup>20</sup>       | 1.4208 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz, chl; vs ace    |
| 8245 | 4-Nonanone                  | Pentyl propyl ketone | C <sub>9</sub> H <sub>18</sub> O                              | 4485-09-0  | 142.238  |                 |        | 187.5                                  | 0.8190 <sup>25</sup>       | 1.4189 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, chl; vs ace        |
| 8246 | 5-Nonanone                  | Dibutyl ketone       | C <sub>9</sub> H <sub>18</sub> O                              | 502-56-7   | 142.238  | liq             | -3.8   | 188.45                                 | 0.8217 <sup>20</sup>       | 1.4195 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH; vs eth, chl             |
| 8247 | Nonanoyl chloride           |                      | C <sub>9</sub> H <sub>17</sub> ClO                            | 764-85-2   | 176.683  | liq             | -60.5  | 215.3                                  | 0.9463 <sup>15</sup>       |                       | s eth, ace                                          |
| 8248 | trans-2-Nonenal             |                      | C <sub>9</sub> H <sub>16</sub> O                              | 18829-56-6 | 140.222  | liq             |        | 101 <sup>16</sup> , 89 <sup>12</sup>   | 0.846                      | 1.4531 <sup>20</sup>  |                                                     |
| 8249 | 1-Nonene                    |                      | C <sub>9</sub> H <sub>18</sub>                                | 124-11-8   | 126.239  | liq             | -81.3  | 146.9                                  | 0.7253 <sup>25</sup>       | 1.4257 <sup>20</sup>  |                                                     |
| 8250 | 2-Nonenoic acid             |                      | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>                 | 3760-11-0  | 156.222  |                 |        | 173 <sup>20</sup> , 136 <sup>5</sup>   |                            |                       |                                                     |
| 8251 | 3-Nonenoic acid             |                      | C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>                 | 4124-88-3  | 156.222  |                 | -4.4   | 156 <sup>16</sup> , 106 <sup>1</sup>   | 0.9254 <sup>20</sup>       | 1.4454 <sup>25</sup>  |                                                     |
| 8252 | 1-Nonen-3-ol                | 1-Vinylheptanol      | C <sub>9</sub> H <sub>18</sub> O                              | 21964-44-3 | 142.238  |                 |        | 193.5                                  | 0.824 <sup>21</sup>        | 1.4382 <sup>15</sup>  |                                                     |
| 8253 | Nonyl acetate               |                      | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                | 143-13-5   | 186.292  | liq             | -26    | 210                                    | 0.8785 <sup>15</sup>       | 1.426 <sup>20</sup>   |                                                     |
| 8254 | Nonylamine                  | 1-Nonanamine         | C <sub>9</sub> H <sub>21</sub> N                              | 112-20-9   | 143.270  | liq             | -1     | 202.2                                  | 0.7886 <sup>20</sup>       | 1.4336 <sup>20</sup>  | sl H <sub>2</sub> O, chl; s EtOH, eth               |
| 8255 | Nonylbenzene                |                      | C <sub>15</sub> H <sub>24</sub>                               | 1081-77-2  | 204.352  | liq             | -24    | 280.5                                  | 0.8584 <sup>20</sup>       | 1.4816 <sup>20</sup>  |                                                     |
| 8256 | Nonylcyclohexane            |                      | C <sub>15</sub> H <sub>30</sub>                               | 2883-02-5  | 210.399  | liq             | -10    | 282                                    | 0.8163 <sup>20</sup>       | 1.4519 <sup>20</sup>  |                                                     |
| 8257 | Nonylcyclopentane           |                      | C <sub>14</sub> H <sub>28</sub>                               | 2882-98-6  | 196.372  | liq             | -29    | 262                                    | 0.8081 <sup>20</sup>       | 1.4467 <sup>20</sup>  | vs ace, bz, eth, EtOH                               |
| 8258 | Nonyl formate               |                      | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                | 5451-92-3  | 172.265  | liq             | -33    | 214                                    | 0.86                       | 1.4216 <sup>20</sup>  |                                                     |
| 8259 | 1-Nonylnaphthalene          |                      | C <sub>19</sub> H <sub>26</sub>                               | 26438-26-6 | 254.409  |                 | 8      | 366                                    | 0.9371 <sup>20</sup>       | 1.5477 <sup>20</sup>  |                                                     |
| 8260 | 4-Nonylphenol               |                      | C <sub>15</sub> H <sub>24</sub> O                             | 104-40-5   | 220.351  | visc ye liq     | 42     | ≈295; 180 <sup>10</sup>                | 0.950 <sup>20</sup>        | 1.513 <sup>20</sup>   | i H <sub>2</sub> O; s bz, ctc, hp                   |
| 8261 | 1-Nonyne                    | Heptylacetylene      | C <sub>9</sub> H <sub>16</sub>                                | 3452-09-3  | 124.223  | liq             | -50    | 150.8                                  | 0.7658 <sup>20</sup>       | 1.4217 <sup>20</sup>  | i H <sub>2</sub> O; s eth, bz, ctc                  |



| No.  | Name                                         | Synonym                                                  | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                |
|------|----------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------|------------|----------|---------------------------|---------|---------------------------------------|----------------------------|-----------------------|-----------------------------------------------------------|
| 8262 | Norbormide                                   |                                                          | C <sub>33</sub> H <sub>25</sub> N <sub>3</sub> O <sub>3</sub>    | 991-42-4   | 511.570  | cry (eth)                 | 194     |                                       |                            |                       |                                                           |
| 8263 | 2,5-Norbornadiene                            | Bicyclo[2.2.1]hepta-2,5-diene                            | C <sub>7</sub> H <sub>8</sub>                                    | 121-46-0   | 92.139   | liq                       | -19.1   | 89.5                                  | 0.9064 <sup>20</sup>       | 1.4702 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz;<br>msc tol   |
| 8264 | 5-Norbornene-2,3-dicarboxylic acid anhydride |                                                          | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                     | 826-62-0   | 164.158  |                           | 166     |                                       |                            |                       |                                                           |
| 8265 | 5-Norbornene-2-methylolacrylate              |                                                          | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                   | 95-39-6    | 178.228  | col liq                   |         | 104                                   | 1.029 <sup>25</sup>        |                       | s os                                                      |
| 8266 | 24-Norcholan-23-oic acid, (5β)               | Norcholan acid                                           | C <sub>23</sub> H <sub>36</sub> O <sub>2</sub>                   | 511-18-2   | 346.547  | nd(HOAc)                  | 177     |                                       |                            |                       |                                                           |
| 8267 | Nordazepam                                   | 7-Chloro-1,3-dihydro-5-phenyl-2H-1,4-benzodiazepin-2-one | C <sub>15</sub> H <sub>11</sub> ClN <sub>2</sub> O               | 1088-11-5  | 270.713  |                           | 216.5   |                                       |                            |                       |                                                           |
| 8268 | Nordihydroguaiaretic acid                    |                                                          | C <sub>18</sub> H <sub>22</sub> O <sub>4</sub>                   | 500-38-9   | 302.366  | nd(w, al, HOAc)           | 185.5   |                                       |                            |                       | sl H <sub>2</sub> O; s EtOH,<br>eth, ace, alk; i<br>bz    |
| 8269 | Norea                                        |                                                          | C <sub>13</sub> H <sub>22</sub> N <sub>2</sub> O                 | 18530-56-8 | 222.326  |                           | 177     |                                       |                            |                       |                                                           |
| 8270 | Norepinephrine                               | Noradrenaline                                            | C <sub>8</sub> H <sub>11</sub> NO <sub>3</sub>                   | 51-41-2    | 169.178  |                           | 217 dec |                                       |                            |                       | sl H <sub>2</sub> O, EtOH,<br>eth; vs alk, dil<br>HCl     |
| 8271 | Norethisterone                               | 19-Norpregn-4-en-20-yn-3-one, 17-hydroxy-, (17 α)-       | C <sub>20</sub> H <sub>26</sub> O <sub>2</sub>                   | 68-22-4    | 298.419  | cry                       | 204     |                                       |                            |                       |                                                           |
| 8272 | Norethynodrel                                |                                                          | C <sub>20</sub> H <sub>26</sub> O <sub>2</sub>                   | 68-23-5    | 298.419  | cry (MeOH)                | 170     |                                       |                            |                       |                                                           |
| 8273 | Norflurazon                                  |                                                          | C <sub>12</sub> H <sub>5</sub> ClF <sub>3</sub> N <sub>3</sub> O | 27314-13-2 | 303.666  |                           | 184     |                                       |                            |                       |                                                           |
| 8274 | Norhyscymine                                 |                                                          | C <sub>16</sub> H <sub>21</sub> NO <sub>3</sub>                  | 537-29-1   | 275.343  | nd                        | 140.5   |                                       |                            |                       | vs EtOH, chl                                              |
| 8275 | DL-Norleucine                                | 2-Aminohexanoic acid, (DL)                               | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                   | 616-06-8   | 131.173  | lf(w)                     | 327 dec |                                       | 1.172 <sup>25</sup>        |                       | s H <sub>2</sub> O; sl EtOH;<br>i eth                     |
| 8276 | L-Norleucine                                 | 2-Aminohexanoic acid, (L)                                | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                   | 327-57-1   | 131.173  |                           | 301 dec |                                       |                            |                       | sl H <sub>2</sub> O                                       |
| 8277 | Normorphine                                  |                                                          | C <sub>16</sub> H <sub>17</sub> NO <sub>3</sub>                  | 466-97-7   | 271.311  |                           | 273     |                                       |                            |                       |                                                           |
| 8278 | Norplant                                     | Norgestrel, (-)                                          | C <sub>21</sub> H <sub>28</sub> O <sub>2</sub>                   | 797-63-7   | 312.446  | cry (MeOH)                | 206     |                                       |                            |                       |                                                           |
| 8279 | 19-Nortestosterone phenylpropionate          | Nandrolone phenpropionate                                | C <sub>27</sub> H <sub>34</sub> O <sub>3</sub>                   | 62-90-8    | 406.557  | cry                       | 95      |                                       |                            |                       |                                                           |
| 8280 | Nortriptyline hydrochloride                  |                                                          | C <sub>19</sub> H <sub>22</sub> ClN                              | 894-71-3   | 299.838  | cry (eth)                 | 214     |                                       |                            |                       | s H <sub>2</sub> O, EtOH; i<br>bz, eth, ace               |
| 8281 | DL-Norvaline                                 | 2-Aminopentanoic acid, (±)                               | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                   | 760-78-1   | 117.147  | lf(al, w)                 | 303     | sub                                   |                            |                       | s H <sub>2</sub> O; i EtOH,<br>eth, chl,<br>AcOEt, lig    |
| 8282 | L-Norvaline                                  | 2-Aminopentanoic acid, (S)                               | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                   | 6600-40-4  | 117.147  | cry (dil al)              | 307     |                                       |                            |                       | s H <sub>2</sub> O                                        |
| 8283 | Noscapine                                    |                                                          | C <sub>22</sub> H <sub>23</sub> NO <sub>7</sub>                  | 128-62-1   | 413.421  | pr or nd (al)             | 176     |                                       |                            |                       | i H <sub>2</sub> O; s EtOH,<br>bz, chl; sl eth;<br>vs ace |
| 8284 | Novobiocin                                   | Streptonivicin                                           | C <sub>31</sub> H <sub>38</sub> N <sub>2</sub> O <sub>11</sub>   | 303-81-1   | 612.624  | wh-ye orth<br>cry         | 154     |                                       | 1.3448                     |                       | i H <sub>2</sub> O; s EtOH,<br>EtOAc, ace, py             |
| 8285 | Nuarimol                                     |                                                          | C <sub>17</sub> H <sub>12</sub> ClFN <sub>2</sub> O              | 63284-71-9 | 314.740  |                           | 126     |                                       |                            |                       |                                                           |
| 8286 | Nylidrin                                     | Buphenine                                                | C <sub>19</sub> H <sub>25</sub> NO <sub>2</sub>                  | 447-41-6   | 299.408  | cry (MeOH)                | 111     |                                       |                            |                       |                                                           |
| 8287 | Ochratoxin A                                 |                                                          | C <sub>20</sub> H <sub>16</sub> ClNO <sub>6</sub>                | 303-47-9   | 403.813  | cry (xyl)                 | 169     |                                       |                            |                       |                                                           |
| 8288 | Ochratoxin B                                 |                                                          | C <sub>20</sub> H <sub>16</sub> NO <sub>6</sub>                  | 4825-86-9  | 369.368  | cry (MeOH)                | 221     |                                       |                            |                       |                                                           |
| 8289 | Ochratoxin C                                 |                                                          | C <sub>22</sub> H <sub>22</sub> ClNO <sub>6</sub>                | 4865-85-4  | 431.866  | amorp solid               |         |                                       |                            |                       |                                                           |
| 8290 | Octacaine                                    | 3-(Diethylamino)-N-phenylbutanamide                      | C <sub>14</sub> H <sub>22</sub> N <sub>2</sub> O                 | 13912-77-1 | 234.337  | cry                       | 47      | 200 <sup>1</sup>                      |                            |                       | vs EtOH, bz, eth                                          |
| 8291 | 2,2',3,3',5,5',6,6'-Octachlorobiphenyl       |                                                          | C <sub>12</sub> H <sub>2</sub> Cl <sub>8</sub>                   | 2136-99-4  | 429.768  | cry                       | 161     |                                       |                            |                       | i H <sub>2</sub> O                                        |
| 8292 | Octachlorocyclopentene                       | Perchlorocyclopentene                                    | C <sub>5</sub> Cl <sub>8</sub>                                   | 706-78-5   | 343.678  | nd                        | 40      | 283                                   | 1.8200 <sup>50</sup>       | 1.5660 <sup>50</sup>  | i H <sub>2</sub> O; vs EtOH                               |
| 8293 | Octachlorodibenzo-p-dioxin                   |                                                          | C <sub>12</sub> Cl <sub>8</sub> O <sub>2</sub>                   | 3268-87-9  | 459.751  | nd                        | 331     |                                       |                            |                       |                                                           |
| 8294 | Octachloronaphthalene                        | Perchloronaphthalene                                     | C <sub>10</sub> Cl <sub>8</sub>                                  | 2234-13-1  | 403.731  | nd (bz-CCl <sub>4</sub> ) | 197.5   | 441 <sup>7</sup> , 248 <sup>0.5</sup> |                            |                       | sl EtOH; vs bz,<br>chl, lig                               |
| 8295 | Octachlorostyrene                            | Perchlorostyrene                                         | C <sub>8</sub> Cl <sub>8</sub>                                   | 29082-74-4 | 379.710  | cry (ace/<br>EtOH)        | 99      |                                       |                            |                       |                                                           |
| 8296 | Octacontane                                  |                                                          | C <sub>80</sub> H <sub>162</sub>                                 | 7667-88-1  | 1124.142 |                           | 112     | 672                                   |                            |                       |                                                           |
| 8297 | Octacosane                                   |                                                          | C <sub>28</sub> H <sub>58</sub>                                  | 630-02-4   | 394.761  | mcl or orth<br>(bz-al)    | 61.1    | 431.6                                 | 0.8067 <sup>20</sup>       | 1.4330 <sup>70</sup>  | i H <sub>2</sub> O; msc ace;<br>s bz, chl                 |
| 8298 | Octacosanoic acid                            | Montanic acid                                            | C <sub>28</sub> H <sub>56</sub> O <sub>2</sub>                   | 506-48-9   | 424.744  |                           | 90.9    |                                       | 0.8191 <sup>100</sup>      | 1.4313 <sup>100</sup> | vs bz, chl                                                |
| 8299 | 1-Octacosanol                                | Montanyl alcohol                                         | C <sub>28</sub> H <sub>58</sub> O                                | 557-61-9   | 410.760  | cry (ace,<br>peth)        | 83.4    | 200 <sup>1</sup>                      |                            |                       | i H <sub>2</sub> O; s CS <sub>2</sub>                     |
| 8300 | trans, trans-9,12-Octadecadienoic acid       | Linolelaidic acid                                        | C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>                   | 506-21-8   | 280.446  | cry (MeOH)                | 28.5    | 181 <sup>0.8</sup>                    |                            |                       | sl H <sub>2</sub> O; s ace, hx                            |
| 8301 | Octadecahydrochrysene                        |                                                          | C <sub>18</sub> H <sub>30</sub>                                  | 2090-14-4  | 246.431  |                           | 115     | 353                                   |                            |                       | vs EtOH                                                   |
| 8302 | Octadecamethyloctasiloxane                   |                                                          | C <sub>18</sub> H <sub>54</sub> O <sub>8</sub> Si <sub>8</sub>   | 556-69-4   | 607.302  |                           | -63     | 186 <sup>20</sup> , 153 <sup>5</sup>  | 0.913 <sup>25</sup>        | 1.3970 <sup>20</sup>  | vs bz, peth, lig                                          |
| 8303 | Octadecanamide                               |                                                          | C <sub>18</sub> H <sub>37</sub> NO                               | 124-26-5   | 283.493  | lf (al)                   | 109     | 250 <sup>12</sup>                     |                            |                       | vs eth, chl                                               |
| 8304 | Octadecane                                   |                                                          | C <sub>18</sub> H <sub>38</sub>                                  | 593-45-3   | 254.495  | nd (al, eth-<br>MeOH)     | 28.2    | 316.3                                 | 0.7768 <sup>28</sup>       | 1.4390 <sup>20</sup>  | i H <sub>2</sub> O; sl EtOH;<br>s eth, ace, chl,<br>lig   |
| 8305 | Octadecanenitrile                            |                                                          | C <sub>18</sub> H <sub>35</sub> N                                | 638-65-3   | 265.478  |                           | 41      | 362                                   | 0.8325 <sup>20</sup>       | 1.4389 <sup>45</sup>  | i H <sub>2</sub> O; s EtOH;<br>vs eth, ace, chl           |
| 8306 | 1-Octadecanethiol                            | Stearyl mercaptan                                        | C <sub>18</sub> H <sub>36</sub> S                                | 2885-00-9  | 286.560  |                           | 30      | 207 <sup>11</sup>                     | 0.8475 <sup>20</sup>       | 1.4645 <sup>20</sup>  | vs eth                                                    |

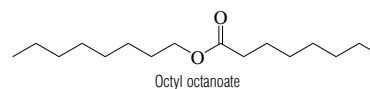
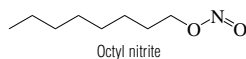
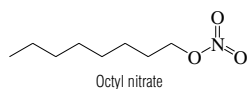
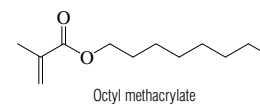
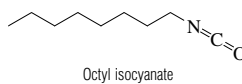
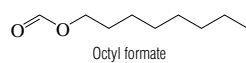
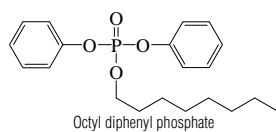
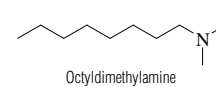
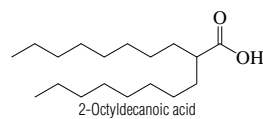
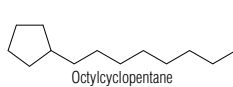
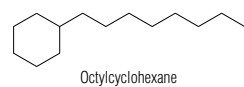
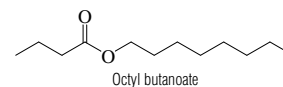
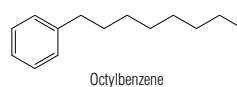
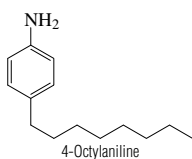
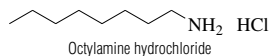
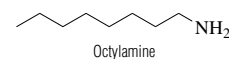
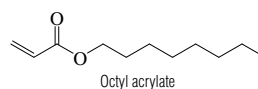
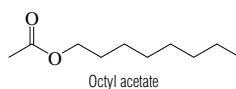
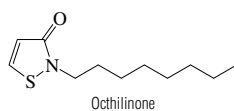
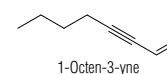
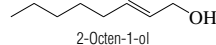
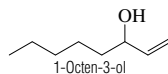
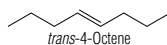
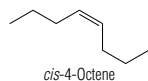
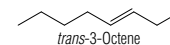
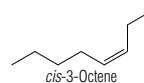
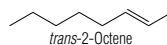
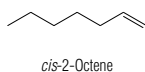
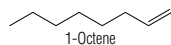
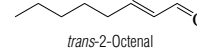
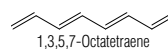
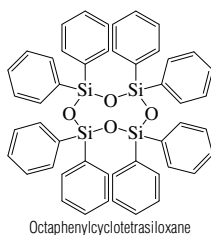
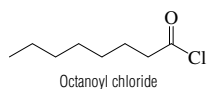
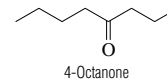
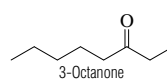
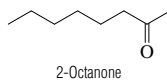
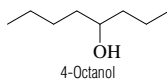
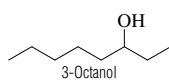
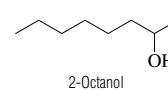
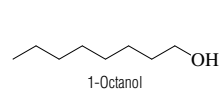
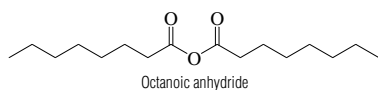
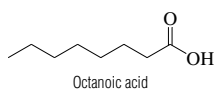


| No.  | Name                                                                      | Synonym                        | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form    | mp/°C  | bp/°C                                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|---------------------------------------------------------------------------|--------------------------------|---------------------------------------------------------------|------------|----------|------------------|--------|-----------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 8307 | 1-Octadecanol                                                             | Stearyl alcohol                | C <sub>18</sub> H <sub>38</sub> O                             | 112-92-5   | 270.494  | lf (al)          | 57.9   | 335; 210.5 <sup>15</sup>                | 0.8124 <sup>59</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth; sl ace, bz           |
| 8308 | Octadecanoyl chloride                                                     |                                | C <sub>18</sub> H <sub>35</sub> ClO                           | 112-76-5   | 302.923  |                  | 23     | 215 <sup>15</sup>                       | 0.8969 <sup>9</sup>        | 1.4523 <sup>24</sup> | sl EtOH                                               |
| 8309 | <i>cis,trans,trans</i> -9,11,13-Octadecatrienoic acid                     | α-Eleostearic acid             | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub>                | 506-23-0   | 278.430  | nd (al)          | 49     | 235 <sup>12</sup> dec, 170 <sup>1</sup> | 0.9028 <sup>50</sup>       | 1.5112 <sup>50</sup> | vs eth, EtOH                                          |
| 8310 | <i>trans,trans,trans</i> -9,11,13-Octadecatrienoic acid                   | <i>trans</i> -Eleostearic acid | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub>                | 544-73-0   | 278.430  | lf (al)          | 71.5   | 188 <sup>1</sup>                        | 0.8839 <sup>90</sup>       | 1.5000 <sup>80</sup> | vs EtOH                                               |
| 8311 | <i>cis</i> -9-Octadecenamide                                              |                                | C <sub>19</sub> H <sub>35</sub> NO                            | 301-02-0   | 281.477  |                  | 76     |                                         |                            |                      | vs eth                                                |
| 8312 | 1-Octadecene                                                              |                                | C <sub>18</sub> H <sub>36</sub>                               | 112-88-9   | 252.479  |                  | 17.5   | 179 <sup>15</sup> , 145 <sup>8</sup>    | 0.7891 <sup>20</sup>       | 1.4448 <sup>20</sup> | i H <sub>2</sub> O; s ace, ctc                        |
| 8313 | <i>cis</i> -9-Octadecenitrile                                             |                                | C <sub>18</sub> H <sub>33</sub> N                             | 112-91-4   | 263.462  |                  | -1     | dec 332                                 | 0.847 <sup>17</sup>        | 1.4566 <sup>20</sup> | vs EtOH                                               |
| 8314 | <i>cis</i> -6-Octadecenoic acid                                           | Petroselinic acid              | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>                | 593-39-5   | 282.462  | lf               | 29.8   | 238 <sup>18</sup>                       | 0.8700 <sup>40</sup>       | 1.4533 <sup>40</sup> | s eth; sl hp, MeOH                                    |
| 8315 | <i>trans</i> -11-Octadecenoic acid                                        | Vaccenic acid                  | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>                | 693-72-1   | 282.462  |                  | 44     |                                         |                            | 1.4499 <sup>90</sup> | s ace                                                 |
| 8316 | <i>cis</i> -9-Octadecen-1-ol                                              | Oleyl alcohol                  | C <sub>18</sub> H <sub>36</sub> O                             | 143-28-2   | 268.478  |                  | 6.5    | 207 <sup>15</sup>                       | 0.8489 <sup>20</sup>       | 1.4606 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc               |
| 8317 | <i>cis</i> -9-Octadecenylamine                                            | Oleylamine                     | C <sub>18</sub> H <sub>37</sub> N                             | 112-90-3   | 267.494  | oil              | 25     | 147 <sup>2</sup>                        |                            |                      |                                                       |
| 8318 | Octadecyl acetate                                                         |                                | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>                | 822-23-1   | 312.531  |                  | 34.5   | 208 <sup>9</sup>                        | 0.8510 <sup>90</sup>       |                      | vs EtOH                                               |
| 8319 | Octadecyl acrylate                                                        | Stearyl 2-propenoate           | C <sub>21</sub> H <sub>40</sub> O <sub>2</sub>                | 4813-57-4  | 324.542  |                  |        |                                         |                            |                      | s ctc, CS <sub>2</sub>                                |
| 8320 | Octadecylamine                                                            | 1-Octadecanamine               | C <sub>18</sub> H <sub>39</sub> N                             | 124-30-1   | 269.510  | cry (w)          | 52.9   | 346.8                                   | 0.8618 <sup>20</sup>       | 1.4522 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz; sl ace           |
| 8321 | Octadecylbenzene                                                          |                                | C <sub>24</sub> H <sub>42</sub>                               | 4445-07-2  | 330.590  |                  | 36     | 400                                     | 0.85 <sup>36</sup>         | 1.479 <sup>36</sup>  |                                                       |
| 8322 | Octadecylcyclohexane                                                      |                                | C <sub>24</sub> H <sub>48</sub>                               | 4445-06-1  | 336.638  |                  | 41.6   | 409; 175 <sup>1</sup>                   | 0.8300 <sup>20</sup>       | 1.4610 <sup>20</sup> |                                                       |
| 8323 | Octadecyl 3-(3,5-di- <i>tert</i> -butyl-4-hydroxyphenyl)propanoate        | Irganox 1076                   | C <sub>35</sub> H <sub>62</sub> O <sub>3</sub>                | 2082-79-3  | 530.865  | cry (MeOH/AcOEt) | 50     |                                         |                            |                      |                                                       |
| 8324 | Octadecyl isocyanate                                                      | 1-Isocyanatooctadecane         | C <sub>19</sub> H <sub>37</sub> NO                            | 112-96-9   | 295.503  |                  | 15.5   | 172 <sup>5</sup>                        |                            |                      |                                                       |
| 8325 | Octadecyl methacrylate                                                    | Stearyl methacrylate           | C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>                | 32360-05-7 | 338.567  |                  |        | 195 <sup>6</sup>                        | 0.880 <sup>25</sup>        | 1.429 <sup>25</sup>  |                                                       |
| 8326 | Octadecyl octadecanoate                                                   | Octadecyl stearate             | C <sub>36</sub> H <sub>72</sub> O <sub>2</sub>                | 2778-96-3  | 536.956  | cry (EtOH)       | 60     |                                         |                            |                      |                                                       |
| 8327 | 3-(Octadecyloxy)-1,2-propanediol                                          | Batyl alcohol                  | C <sub>21</sub> H <sub>44</sub> O <sub>3</sub>                | 544-62-7   | 344.572  |                  | 70.5   | 217 <sup>2</sup>                        |                            |                      | vs eth                                                |
| 8328 | Octadecyl vinyl ether                                                     | 1-(Ethenyloxy)octadecane       | C <sub>20</sub> H <sub>40</sub> O                             | 930-02-9   | 296.531  |                  | 30     | 182 <sup>3</sup>                        | 0.8138 <sup>40</sup>       |                      | sl chl                                                |
| 8329 | 1,7-Octadiene                                                             |                                | C <sub>8</sub> H <sub>14</sub>                                | 3710-30-3  | 110.197  |                  |        | 115.5                                   | 0.734 <sup>20</sup>        | 1.4245 <sup>20</sup> |                                                       |
| 8330 | 1,7-Octadiyne                                                             |                                | C <sub>8</sub> H <sub>10</sub>                                | 871-84-1   | 106.165  |                  |        | 135.5; 59 <sup>35</sup>                 | 0.8169 <sup>21</sup>       | 1.4521 <sup>18</sup> | s eth                                                 |
| 8331 | 2,2,3,3,4,4,5,5-Octafluoro-1-pentanol                                     |                                | C <sub>8</sub> H <sub>4</sub> F <sub>8</sub> O                | 355-80-6   | 232.072  |                  |        | 140.5                                   | 1.6647 <sup>20</sup>       | 1.3178 <sup>20</sup> |                                                       |
| 8332 | 1,2,3,4,5,6,7,8-Octahydroanthracene                                       |                                | C <sub>14</sub> H <sub>18</sub>                               | 1079-71-6  | 186.293  | pl (al)          | 78     | 294                                     | 0.9703 <sup>90</sup>       | 1.5372 <sup>80</sup> | i H <sub>2</sub> O; s EtOH, HOAc; vs bz; sl ctc       |
| 8333 | Octahydroazocine                                                          |                                | C <sub>7</sub> H <sub>15</sub> N                              | 1121-92-2  | 113.201  |                  | 29     | 52 <sup>15</sup>                        | 0.896 <sup>25</sup>        | 1.4720 <sup>20</sup> |                                                       |
| 8334 | Octahydroindene                                                           |                                | C <sub>9</sub> H <sub>16</sub>                                | 496-10-6   | 124.223  | liq              | -53    | 167                                     | 0.876 <sup>25</sup>        | 1.4702 <sup>20</sup> |                                                       |
| 8335 | Octahydroindolizine                                                       |                                | C <sub>9</sub> H <sub>15</sub> N                              | 13618-93-4 | 125.212  |                  |        | 75 <sup>43</sup>                        | 0.9074 <sup>10</sup>       | 1.4748               | vs eth, EtOH                                          |
| 8336 | <i>trans</i> -Octahydro-1(2 <i>H</i> )-naphthalenone                      |                                | C <sub>10</sub> H <sub>16</sub> O                             | 21370-71-8 | 152.233  |                  | 33     | 122 <sup>20</sup>                       | 0.986 <sup>20</sup>        | 1.4849 <sup>21</sup> |                                                       |
| 8337 | 1,2,3,4,5,6,7,8-Octahydrophenanthrene                                     |                                | C <sub>14</sub> H <sub>18</sub>                               | 5325-97-3  | 186.293  |                  | 16.7   | 295                                     | 1.026 <sup>20</sup>        | 1.5569 <sup>17</sup> | i H <sub>2</sub> O; s ace, bz, CS <sub>2</sub> , HOAc |
| 8338 | <i>trans</i> -Octahydro-2 <i>H</i> -quinolizine-1-methanol, (1 <i>R</i> ) | Lupinine                       | C <sub>10</sub> H <sub>19</sub> NO                            | 486-70-4   | 169.264  | orth (peth)      | 70     | 270                                     |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl; sl peth       |
| 8339 | 2,2,4,4,6,6,8,8-Octamethylcyclotetrasilazane                              |                                | C <sub>8</sub> H <sub>28</sub> N <sub>4</sub> Si <sub>4</sub> | 1020-84-4  | 292.677  |                  | 97     |                                         |                            |                      |                                                       |
| 8340 | Octamethylcyclotetrasiloxane                                              |                                | C <sub>8</sub> H <sub>24</sub> O <sub>4</sub> Si <sub>4</sub> | 556-67-2   | 296.617  |                  | 17.5   | 175.8                                   | 0.9561 <sup>20</sup>       | 1.3968 <sup>20</sup> | i H <sub>2</sub> O; s ctc                             |
| 8341 | 1,1,1,3,5,7,7,7-Octamethyltetrasiloxane                                   |                                | C <sub>8</sub> H <sub>26</sub> O <sub>5</sub> Si <sub>4</sub> | 16066-09-4 | 282.632  |                  |        | 170                                     | 0.8559 <sup>20</sup>       | 1.3854 <sup>20</sup> |                                                       |
| 8342 | Octamethyltrisiloxane                                                     |                                | C <sub>8</sub> H <sub>24</sub> O <sub>2</sub> Si <sub>3</sub> | 107-51-7   | 236.533  | liq              | -80    | 153; 51 <sup>17</sup>                   | 0.8200 <sup>20</sup>       | 1.3840 <sup>20</sup> | sl EtOH; s bz, peth                                   |
| 8343 | Octanal                                                                   | Caprylic aldehyde              | C <sub>8</sub> H <sub>16</sub> O                              | 124-13-0   | 128.212  |                  |        | 171                                     | 0.8211 <sup>20</sup>       | 1.4217 <sup>20</sup> | vs ace, bz, eth, EtOH                                 |
| 8344 | Octanamide                                                                |                                | C <sub>8</sub> H <sub>17</sub> NO                             | 629-01-6   | 143.227  | lf, pl           | 108    | 239                                     | 0.8450 <sup>110</sup>      |                      | sl H <sub>2</sub> O, bz, chl; vs EtOH; s eth, ace     |
| 8345 | 2-Octanamine, (±)                                                         |                                | C <sub>8</sub> H <sub>19</sub> N                              | 44855-57-4 | 129.244  |                  | 97     | 164                                     | 0.7744 <sup>20</sup>       | 1.4232 <sup>25</sup> | vs eth, EtOH                                          |
| 8346 | Octane                                                                    |                                | C <sub>8</sub> H <sub>18</sub>                                | 111-65-9   | 114.229  | liq              | -56.82 | 125.67                                  | 0.6986 <sup>25</sup>       | 1.3944 <sup>25</sup> | i H <sub>2</sub> O; s eth; msc EtOH, ace, bz          |
| 8347 | 1,8-Octanediamine                                                         |                                | C <sub>8</sub> H <sub>20</sub> N <sub>2</sub>                 | 373-44-4   | 144.258  | pl               | 51.64  | 225.6                                   |                            |                      | vs H <sub>2</sub> O, eth, EtOH                        |
| 8348 | Octanedinitrile                                                           | Suberonitrile                  | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                 | 629-40-3   | 136.194  |                  | -1.8   | 185 <sup>15</sup>                       | 0.954 <sup>25</sup>        | 1.4436 <sup>20</sup> |                                                       |
| 8349 | Octanedioic acid                                                          | Suberic acid                   | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                 | 505-48-6   | 174.195  | lo nd or pl (w)  | 144    | 345.5; 219 <sup>20</sup>                |                            |                      | i H <sub>2</sub> O; msc eth, bz; sl DMSO              |
| 8350 | 1,2-Octanediol                                                            |                                | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                 | 1117-86-8  | 146.228  |                  | 30     | 131 <sup>10</sup> , 104 <sup>9,2</sup>  |                            |                      |                                                       |
| 8351 | 1,8-Octanediol                                                            |                                | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                 | 629-41-4   | 146.228  | nd (bz-liq), pr  | 63     | 172 <sup>20</sup>                       |                            |                      | sl H <sub>2</sub> O, eth, chl, lig; vs EtOH; s bz     |
| 8352 | Octanenitrile                                                             | Caprylnitrile                  | C <sub>8</sub> H <sub>15</sub> N                              | 124-12-9   | 125.212  | liq              | -45.6  | 205.25                                  | 0.8136 <sup>20</sup>       | 1.4203 <sup>20</sup> | vs eth                                                |
| 8353 | 1-Octanethiol                                                             | Octyl mercaptan                | C <sub>8</sub> H <sub>18</sub> S                              | 111-88-6   | 146.294  | liq              | -49.2  | 199.1                                   | 0.8433 <sup>20</sup>       | 1.4540 <sup>20</sup> | s EtOH; sl ctc                                        |

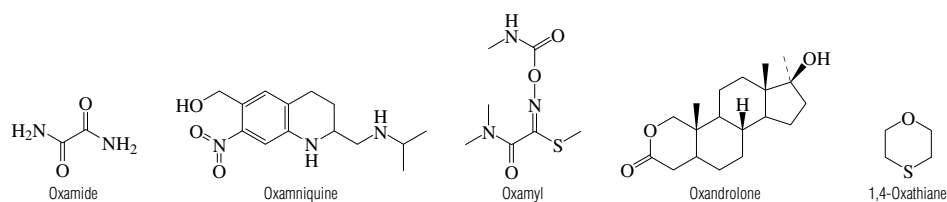
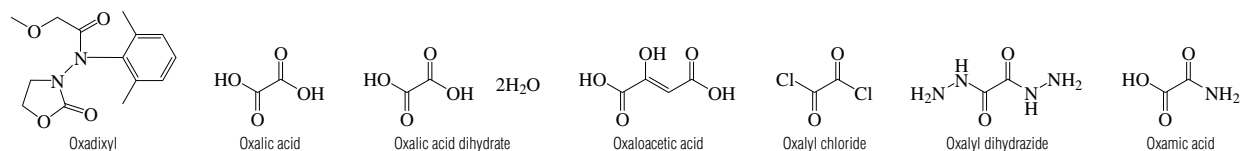
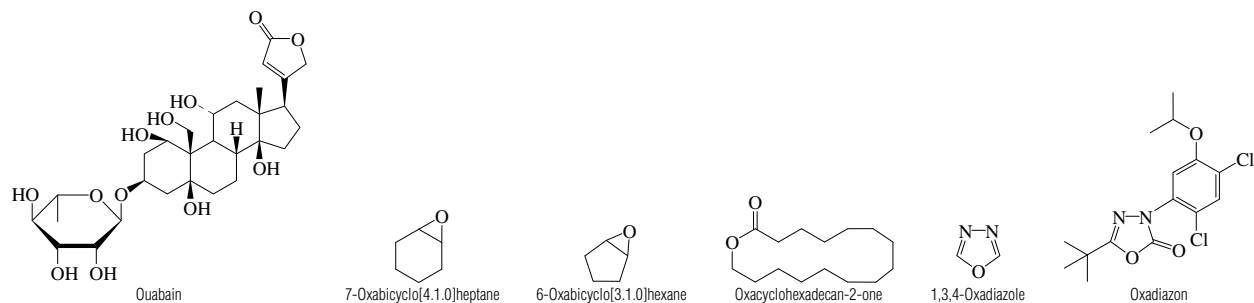
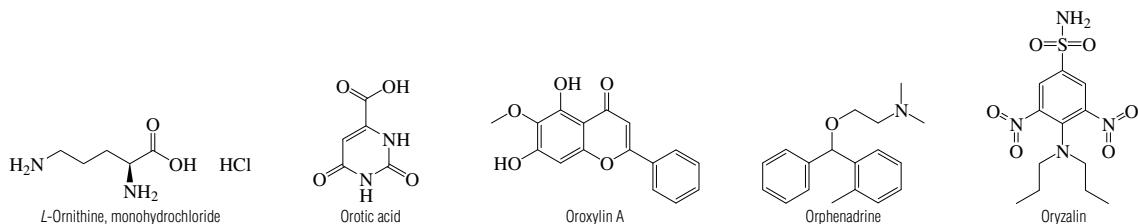
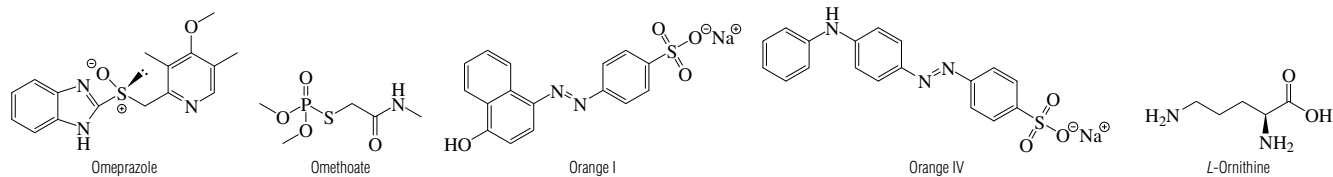
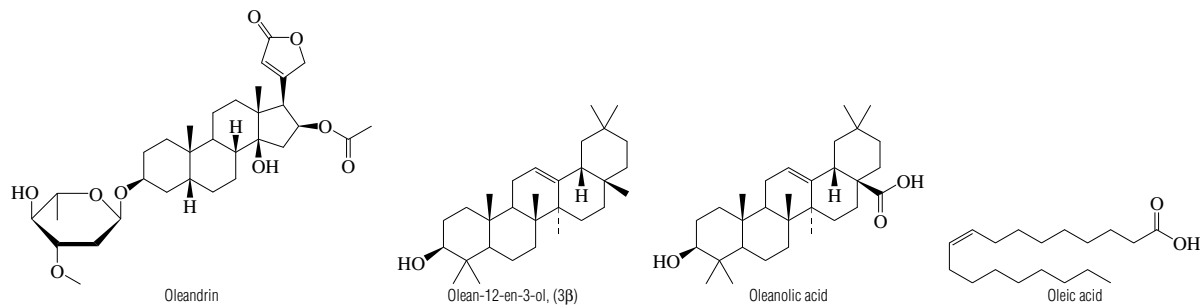
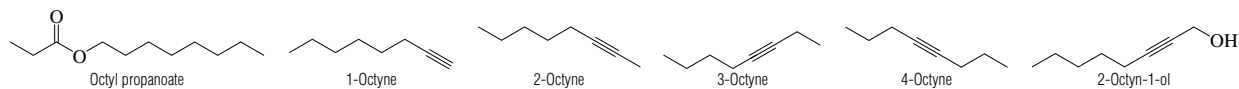
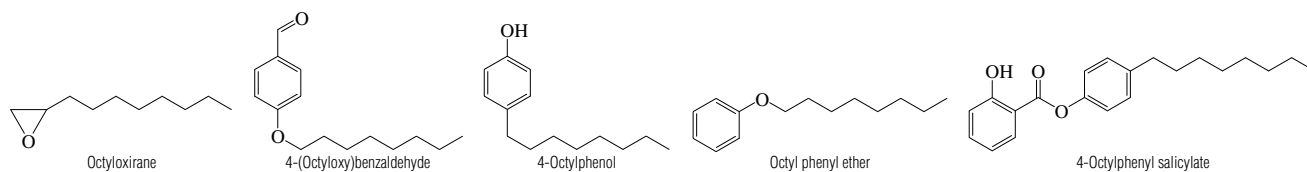




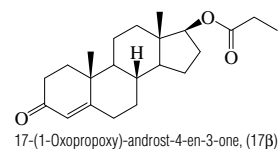
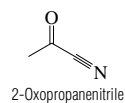
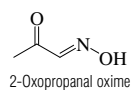
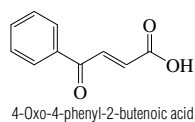
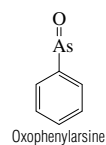
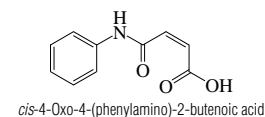
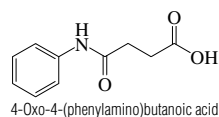
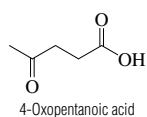
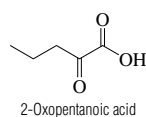
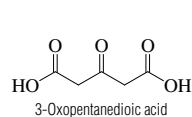
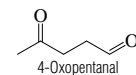
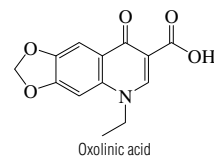
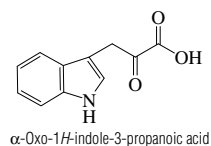
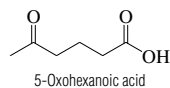
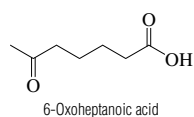
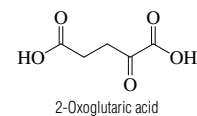
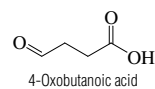
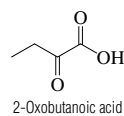
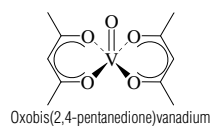
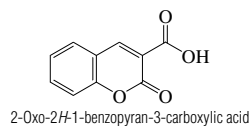
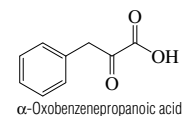
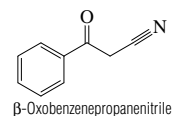
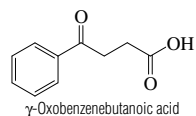
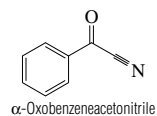
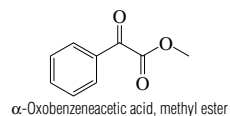
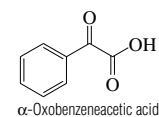
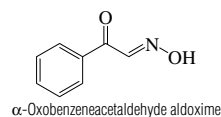
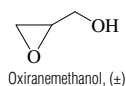
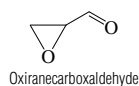
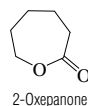
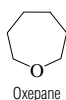
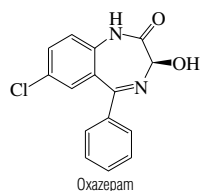
| No.  | Name                         | Synonym                     | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form    | mp/°C  | bp/°C                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|------------------------------|-----------------------------|----------------------------------------------------------------|------------|----------|------------------|--------|-------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 8354 | Octanoic acid                | Caprylic acid               | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                  | 124-07-2   | 144.212  |                  | 16.5   | 239                     | 0.9073 <sup>25</sup>       | 1.4285 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, chl, CH <sub>3</sub> CN |
| 8355 | Octanoic anhydride           |                             | C <sub>16</sub> H <sub>30</sub> O <sub>3</sub>                 | 623-66-5   | 270.407  | liq              | -1     | 282.5                   | 0.9065 <sup>18</sup>       | 1.4358 <sup>18</sup> | vs ace, eth, EtOH                                      |
| 8356 | 1-Octanol                    | Capryl alcohol              | C <sub>8</sub> H <sub>18</sub> O                               | 111-87-5   | 130.228  | liq              | -14.8  | 195.16                  | 0.8262 <sup>25</sup>       | 1.4295 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc               |
| 8357 | 2-Octanol                    | (±)-sec-Caprylic alcohol    | C <sub>8</sub> H <sub>18</sub> O                               | 4128-31-8  | 130.228  | liq              | -31.6  | 179.3                   | 0.8193 <sup>20</sup>       | 1.4203 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace                  |
| 8358 | 3-Octanol                    |                             | C <sub>8</sub> H <sub>18</sub> O                               | 589-98-0   | 130.228  | liq              | -45    | 171                     | 0.8258 <sup>20</sup>       |                      |                                                        |
| 8359 | 4-Octanol                    |                             | C <sub>8</sub> H <sub>18</sub> O                               | 74778-22-6 | 130.228  | liq              | -40.7  | 176.3                   | 0.8186 <sup>20</sup>       | 1.4248 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH                       |
| 8360 | 2-Octanone                   | Hexyl methyl ketone         | C <sub>8</sub> H <sub>16</sub> O                               | 111-13-7   | 128.212  | liq              | -16    | 172.5                   | 0.820 <sup>20</sup>        | 1.4151 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                     |
| 8361 | 3-Octanone                   | Ethyl pentyl ketone         | C <sub>8</sub> H <sub>16</sub> O                               | 106-68-3   | 128.212  |                  |        | 167.5                   | 0.822 <sup>25</sup>        | 1.4150 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                      |
| 8362 | 4-Octanone                   | Butyl propyl ketone         | C <sub>8</sub> H <sub>16</sub> O                               | 589-63-9   | 128.212  |                  |        | 163                     | 0.8146 <sup>25</sup>       | 1.4173 <sup>14</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ctc               |
| 8363 | Octanoyl chloride            |                             | C <sub>8</sub> H <sub>15</sub> ClO                             | 111-64-8   | 162.657  | liq              | -63    | 195.6                   | 0.9535 <sup>15</sup>       | 1.4335 <sup>20</sup> | s eth                                                  |
| 8364 | Octaphenylcyclotetrasiloxane |                             | C <sub>48</sub> H <sub>40</sub> O <sub>4</sub> Si <sub>4</sub> | 546-56-5   | 793.172  | nd (bz-al, HOAc) | 200.5  | 330 <sup>1</sup>        |                            |                      | i H <sub>2</sub> O; sl EtOH; s bz, chl, HOAc           |
| 8365 | 1,3,5,7-Octatetraene         |                             | C <sub>8</sub> H <sub>10</sub>                                 | 1482-91-3  | 106.165  | cry (bz)         | 50     | sub                     |                            |                      | s peth, HOAc                                           |
| 8366 | trans-2-Octenal              |                             | C <sub>8</sub> H <sub>14</sub> O                               | 2548-87-0  | 126.196  | liq              |        | 85 <sup>19</sup>        | 0.846                      | 1.4500 <sup>20</sup> |                                                        |
| 8367 | 1-Octene                     | Caprylene                   | C <sub>8</sub> H <sub>16</sub>                                 | 111-66-0   | 112.213  | liq              | -101.7 | 121.29                  | 0.7149 <sup>20</sup>       | 1.4087 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH; s eth, ace; sl ctc       |
| 8368 | cis-2-Octene                 |                             | C <sub>8</sub> H <sub>16</sub>                                 | 7642-04-8  | 112.213  | liq              | -100.2 | 125.6                   | 0.7243 <sup>20</sup>       | 1.4150 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl          |
| 8369 | trans-2-Octene               |                             | C <sub>8</sub> H <sub>16</sub>                                 | 13389-42-9 | 112.213  | liq              | -87.7  | 125                     | 0.7199 <sup>20</sup>       | 1.4132 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz; vs chl       |
| 8370 | cis-3-Octene                 |                             | C <sub>8</sub> H <sub>16</sub>                                 | 14850-22-7 | 112.213  | liq              | -126   | 122.9                   | 0.7159 <sup>20</sup>       | 1.4135 <sup>20</sup> | vs ace, bz, eth, EtOH                                  |
| 8371 | trans-3-Octene               |                             | C <sub>8</sub> H <sub>16</sub>                                 | 14919-01-8 | 112.213  | liq              | -110   | 123.3                   | 0.7152 <sup>20</sup>       | 1.4126 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, lig, ctc     |
| 8372 | cis-4-Octene                 |                             | C <sub>8</sub> H <sub>16</sub>                                 | 7642-15-1  | 112.213  | liq              | -118.7 | 122.5                   | 0.7212 <sup>20</sup>       | 1.4148 <sup>20</sup> | vs ace, bz, eth, EtOH                                  |
| 8373 | trans-4-Octene               |                             | C <sub>8</sub> H <sub>16</sub>                                 | 14850-23-8 | 112.213  | liq              | -93.8  | 122.3                   | 0.7141 <sup>20</sup>       | 1.4114 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, lig; sl ctc  |
| 8374 | 1-Octen-3-ol                 |                             | C <sub>8</sub> H <sub>16</sub> O                               | 3391-86-4  | 128.212  |                  |        | 174; 69 <sup>12</sup>   | 0.8395 <sup>13</sup>       | 1.4391 <sup>12</sup> |                                                        |
| 8375 | 2-Octen-1-ol                 |                             | C <sub>8</sub> H <sub>16</sub> O                               | 22104-78-5 | 128.212  |                  |        | 88 <sup>11</sup>        | 0.850 <sup>20</sup>        | 1.4470 <sup>20</sup> |                                                        |
| 8376 | 1-Octen-3-yne                |                             | C <sub>8</sub> H <sub>12</sub>                                 | 17679-92-4 | 108.181  |                  |        | 134; 62 <sup>20</sup>   | 0.7749 <sup>20</sup>       | 1.4592 <sup>20</sup> | vs eth                                                 |
| 8377 | Octhilinone                  | 2-Octyl-3(2H)-isothiazolone | C <sub>11</sub> H <sub>15</sub> NOS                            | 26530-20-1 | 213.340  |                  |        | 120 <sup>0.01</sup>     |                            |                      |                                                        |
| 8378 | Octyl acetate                |                             | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | 112-14-1   | 172.265  | liq              | -38.5  | 210                     | 0.8705 <sup>20</sup>       | 1.4150 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                |
| 8379 | Octyl acrylate               | Octyl 2-propenoate          | C <sub>11</sub> H <sub>20</sub> O <sub>2</sub>                 | 2499-59-4  | 184.276  |                  |        | 229; 57 <sup>0.05</sup> | 0.8810 <sup>20</sup>       |                      |                                                        |
| 8380 | Octylamine                   | 1-Octanamine                | C <sub>8</sub> H <sub>19</sub> N                               | 111-86-4   | 129.244  |                  | 0      | 179.6                   | 0.7826 <sup>20</sup>       | 1.4292 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth; s ctc               |
| 8381 | Octylamine hydrochloride     | 1-Octanamine hydrochloride  | C <sub>8</sub> H <sub>20</sub> ClN                             | 142-95-0   | 165.705  |                  | 196.5  |                         |                            |                      | s H <sub>2</sub> O                                     |
| 8382 | 4-Octylaniline               |                             | C <sub>14</sub> H <sub>23</sub> N                              | 16245-79-7 | 205.340  |                  | 20     | 310; 138 <sup>5</sup>   | 0.9128 <sup>20</sup>       |                      | vs eth                                                 |
| 8383 | Octylbenzene                 |                             | C <sub>14</sub> H <sub>22</sub>                                | 2189-60-8  | 190.325  | liq              | -36    | 264                     | 0.8562 <sup>20</sup>       | 1.4845 <sup>20</sup> | i H <sub>2</sub> O; msc eth, bz                        |
| 8384 | Octyl butanoate              |                             | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                 | 110-39-4   | 200.318  | liq              | -55.6  | 244.1                   | 0.8629 <sup>20</sup>       | 1.4267 <sup>15</sup> | vs EtOH                                                |
| 8385 | Octylcyclohexane             |                             | C <sub>14</sub> H <sub>28</sub>                                | 1795-15-9  | 196.372  | liq              | -20    | 264                     | 0.8138 <sup>20</sup>       | 1.4503 <sup>20</sup> |                                                        |
| 8386 | Octylcyclopentane            |                             | C <sub>13</sub> H <sub>26</sub>                                | 1795-20-6  | 182.345  | liq              | -44    | 243                     | 0.8048 <sup>20</sup>       | 1.4446 <sup>20</sup> |                                                        |
| 8387 | 2-Octyldecanoic acid         |                             | C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>                 | 619-39-6   | 284.478  | nd or lf (al)    | 38.5   | 215 <sup>13</sup>       | 0.8447 <sup>70</sup>       |                      | vs eth, EtOH                                           |
| 8388 | Octyldimethylamine           | N,N-Dimethyl-1-octanamine   | C <sub>10</sub> H <sub>23</sub> N                              | 7378-99-6  | 157.297  |                  |        | 194                     |                            |                      |                                                        |
| 8389 | Octyl diphenyl phosphate     |                             | C <sub>20</sub> H <sub>27</sub> O <sub>4</sub> P               | 115-88-8   | 362.399  |                  |        |                         | 1.09 <sup>25</sup>         |                      |                                                        |
| 8390 | Octyl formate                |                             | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                  | 112-32-3   | 158.238  | liq              | -39.1  | 198.8                   | 0.8744 <sup>20</sup>       | 1.4208 <sup>15</sup> | i H <sub>2</sub> O; s EtOH; msc eth; sl ctc            |
| 8391 | Octyl isocyanate             |                             | C <sub>9</sub> H <sub>17</sub> NO                              | 3158-26-7  | 155.237  |                  |        | 78 <sup>6</sup>         |                            |                      |                                                        |
| 8392 | Octyl methacrylate           |                             | C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>                 | 2157-01-9  | 198.302  |                  |        | 239.5                   |                            |                      |                                                        |
| 8393 | Octyl nitrate                |                             | C <sub>8</sub> H <sub>17</sub> NO <sub>3</sub>                 | 629-39-0   | 175.226  |                  |        | 110 <sup>20</sup>       | 0.975 <sup>0</sup>         |                      | sl H <sub>2</sub> O; s EtOH, eth                       |
| 8394 | Octyl nitrite                |                             | C <sub>8</sub> H <sub>17</sub> NO <sub>2</sub>                 | 629-46-9   | 159.227  |                  |        | 174.5                   | 0.862 <sup>17</sup>        | 1.4127 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth                      |
| 8395 | Octyl octanoate              |                             | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                 | 2306-88-9  | 256.424  | liq              | -18.1  | 306.8                   | 0.8554 <sup>20</sup>       | 1.4352 <sup>20</sup> | vs ace, eth, EtOH                                      |



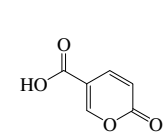
| No.  | Name                           | Synonym                                                  | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form      | mp/°C     | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|------|--------------------------------|----------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|--------------------|-----------|--------------------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 8396 | Octyloxirane                   |                                                          | C <sub>10</sub> H <sub>20</sub> O                                             | 2404-44-6  | 156.265  | liq                |           | 128 <sup>95</sup> , 97 <sup>30</sup> |                            |                      |                                                          |
| 8397 | 4-(Octyloxy)benzaldehyde       |                                                          | C <sub>18</sub> H <sub>28</sub> O <sub>2</sub>                                | 24083-13-4 | 234.335  |                    |           | 131 <sup>10,5</sup>                  |                            |                      |                                                          |
| 8398 | 4-Octylphenol                  |                                                          | C <sub>14</sub> H <sub>22</sub> O                                             | 1806-26-4  | 206.324  |                    | 43.0      | 169 <sup>10</sup> , 150 <sup>4</sup> |                            |                      |                                                          |
| 8399 | Octyl phenyl ether             | (Octyloxy)benzene                                        | C <sub>14</sub> H <sub>22</sub> O                                             | 1818-07-1  | 206.324  |                    | 8         | 285                                  | 0.9131 <sup>15</sup>       | 1.4875 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                          |
| 8400 | 4-Octylphenyl salicylate       | 2-Hydroxybenzoic acid, 4-octylphenyl ester               | C <sub>21</sub> H <sub>26</sub> O <sub>3</sub>                                | 2512-56-3  | 326.429  | wh cry             | 73        |                                      |                            |                      |                                                          |
| 8401 | Octyl propanoate               |                                                          | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                                | 142-60-9   | 186.292  | liq                | -42.6     | 228                                  | 0.8663 <sup>20</sup>       | 1.4221 <sup>15</sup> | i H <sub>2</sub> O; s EtOH, eth, bz; sl ctc              |
| 8402 | 1-Octyne                       | Hexylacetylene                                           | C <sub>8</sub> H <sub>14</sub>                                                | 629-05-0   | 110.197  | liq                | -79.3     | 126.3                                | 0.7461 <sup>20</sup>       | 1.4159 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                          |
| 8403 | 2-Octyne                       | Methylpentylacetylene                                    | C <sub>8</sub> H <sub>14</sub>                                                | 2809-67-8  | 110.197  | liq                | -61.6     | 137.6                                | 0.7596 <sup>20</sup>       | 1.4278 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                          |
| 8404 | 3-Octyne                       |                                                          | C <sub>8</sub> H <sub>14</sub>                                                | 15232-76-5 | 110.197  | liq                | -103.9    | 133.1                                | 0.7529 <sup>20</sup>       | 1.4250 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                          |
| 8405 | 4-Octyne                       | Dipropylacetylene                                        | C <sub>8</sub> H <sub>14</sub>                                                | 1942-45-6  | 110.197  | liq                | -101      | 131.6                                | 0.7509 <sup>20</sup>       | 1.4248 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                          |
| 8406 | 2-Octyn-1-ol                   | 2-Octynol                                                | C <sub>8</sub> H <sub>14</sub> O                                              | 20739-58-6 | 126.196  |                    | -18       | 98 <sup>15</sup>                     | 0.8805 <sup>20</sup>       | 1.4556 <sup>20</sup> | vs eth                                                   |
| 8407 | Oleandrin                      |                                                          | C <sub>32</sub> H <sub>48</sub> O <sub>9</sub>                                | 465-16-7   | 576.718  | cry (EtOH)         | 250 dec   |                                      |                            |                      | i H <sub>2</sub> O; s EtOH, chl                          |
| 8408 | Olean-12-en-3-ol, (3β)         | β-Amyrin                                                 | C <sub>30</sub> H <sub>50</sub> O                                             | 559-70-6   | 426.717  | nd (lig or al)     | 197       | 260 <sup>65</sup>                    |                            |                      | i H <sub>2</sub> O; sl EtOH, chl, lig; s eth, bz         |
| 8409 | Oleanolic acid                 |                                                          | C <sub>30</sub> H <sub>48</sub> O <sub>3</sub>                                | 508-02-1   | 456.700  | nd or pr (al)      | 310 dec   | sub 280                              |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, ace; vs py, HOAc       |
| 8410 | Oleic acid                     | cis-9-Octadecenoic acid                                  | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>                                | 112-80-1   | 282.462  |                    | 13.4      | 360; 286 <sup>100</sup>              | 0.8935 <sup>20</sup>       | 1.4582 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, chl, ctc     |
| 8411 | Omeprazole                     |                                                          | C <sub>17</sub> H <sub>15</sub> N <sub>3</sub> O <sub>2</sub> S               | 73590-58-6 | 345.416  | cry (MeCN)         | 156       |                                      |                            |                      |                                                          |
| 8412 | Omethoate                      |                                                          | C <sub>8</sub> H <sub>12</sub> NO <sub>4</sub> PS                             | 1113-02-6  | 213.192  | oil                | ≈135 dec  |                                      | 1.32 <sup>20</sup>         | 1.4987 <sup>20</sup> | msc H <sub>2</sub> O; i hx                               |
| 8413 | Orange I                       | 1-Naphthol Orange                                        | C <sub>16</sub> H <sub>11</sub> N <sub>2</sub> NaO <sub>4</sub> S             | 523-44-4   | 350.324  | red-br pow         |           |                                      |                            |                      | s H <sub>2</sub> O; sl EtOH; i bz                        |
| 8414 | Orange IV                      | Tropaeolin OO                                            | C <sub>18</sub> H <sub>14</sub> N <sub>3</sub> NaO <sub>3</sub> S             | 554-73-4   | 375.377  | ye pow             |           |                                      |                            |                      | s H <sub>2</sub> O                                       |
| 8415 | Orcein                         |                                                          |                                                                               | 1400-62-0  |          | br-red pow         |           |                                      |                            |                      |                                                          |
| 8416 | L-Ornithine                    | 2,5-Diaminopentanoic acid, (S)                           | C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                  | 70-26-8    | 132.161  | micro cry (al-eth) | 140       |                                      |                            |                      | vs H <sub>2</sub> O, EtOH                                |
| 8417 | L-Ornithine, monohydrochloride |                                                          | C <sub>5</sub> H <sub>13</sub> ClN <sub>2</sub> O <sub>2</sub>                | 3184-13-2  | 168.622  | nd                 | 215       |                                      |                            |                      | vs H <sub>2</sub> O                                      |
| 8418 | Orotic acid                    | 1,2,3,6-Tetrahydro-2,6-dioxo-4-pyrimidinecarboxylic acid | C <sub>5</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>                   | 65-86-1    | 156.097  | cry (w)            | 345.5     |                                      |                            |                      | sl H <sub>2</sub> O; i os                                |
| 8419 | Oroxilin A                     | 5,7-Dihydroxy-6-methoxy-2-phenyl-4H-1-benzopyran-4-one   | C <sub>16</sub> H <sub>12</sub> O <sub>5</sub>                                | 480-11-5   | 284.263  | ye nd (al)         | 231.5     |                                      |                            |                      | vs ace, eth, EtOH                                        |
| 8420 | Orphenadrine                   |                                                          | C <sub>18</sub> H <sub>22</sub> NO                                            | 83-98-7    | 269.382  |                    |           | 195 <sup>12</sup>                    |                            |                      |                                                          |
| 8421 | Oryzalin                       | Benzenesulfonamide, 4-(dipropylamino)-3,5-dinitro-       | C <sub>12</sub> H <sub>18</sub> N <sub>4</sub> O <sub>6</sub> S               | 19044-88-3 | 346.359  |                    | 141       |                                      |                            |                      |                                                          |
| 8422 | Ouabain                        |                                                          | C <sub>29</sub> H <sub>44</sub> O <sub>12</sub>                               | 630-60-4   | 584.652  | hyg pl (+9w)       | 200       |                                      |                            |                      | sl H <sub>2</sub> O; vs EtOH                             |
| 8423 | 7-Oxabicyclo[4.1.0]heptane     |                                                          | C <sub>6</sub> H <sub>10</sub> O                                              | 286-20-4   | 98.142   |                    | <-10      | 131.5                                | 0.9663 <sup>20</sup>       | 1.4519 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace, bz; s chl; sl ctc |
| 8424 | 6-Oxabicyclo[3.1.0]hexane      |                                                          | C <sub>6</sub> H <sub>8</sub> O                                               | 285-67-6   | 84.117   |                    |           | 102                                  | 0.964 <sup>25</sup>        | 1.4336 <sup>20</sup> |                                                          |
| 8425 | Oxacyclohexadecan-2-one        | Exaltolide                                               | C <sub>15</sub> H <sub>28</sub> O <sub>2</sub>                                | 106-02-5   | 240.382  | thick oil          |           | 176 <sup>15</sup>                    | 0.9549 <sup>20</sup>       | 1.4708 <sup>20</sup> |                                                          |
| 8426 | 1,3,4-Oxadiazole               | 1-Oxa-3,4-diazacyclopentadiene                           | C <sub>2</sub> H <sub>2</sub> N <sub>2</sub> O                                | 288-99-3   | 70.049   |                    |           | 150                                  |                            | 1.4300 <sup>25</sup> |                                                          |
| 8427 | Oxadiazon                      |                                                          | C <sub>15</sub> H <sub>18</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>3</sub> | 19666-30-9 | 345.221  |                    | 90        |                                      |                            |                      |                                                          |
| 8428 | Oxadixyl                       |                                                          | C <sub>14</sub> H <sub>18</sub> N <sub>2</sub> O <sub>4</sub>                 | 77732-09-3 | 278.304  |                    | 104       |                                      |                            |                      |                                                          |
| 8429 | Oxalic acid                    |                                                          | C <sub>2</sub> H <sub>2</sub> O <sub>4</sub>                                  | 144-62-7   | 90.035   | orth pym or oct    | 189.5 dec | sub 157                              | 1.900 <sup>17</sup>        |                      | s H <sub>2</sub> O; vs EtOH; sl eth; i bz, chl, peth     |
| 8430 | Oxalic acid dihydrate          |                                                          | C <sub>2</sub> H <sub>2</sub> O <sub>6</sub>                                  | 6153-56-6  | 126.065  | mcl tab or pr      | 101.5     |                                      | 1.653 <sup>18</sup>        |                      | s H <sub>2</sub> O, EtOH; sl eth                         |
| 8431 | Oxaloacetic acid               | Oxalacetic acid                                          | C <sub>4</sub> H <sub>4</sub> O <sub>5</sub>                                  | 328-42-7   | 132.072  |                    | 161 dec   |                                      |                            |                      |                                                          |
| 8432 | Oxalyl chloride                | Oxalyl dichloride                                        | C <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>                                 | 79-37-8    | 126.926  | liq                | -16       | 63.5                                 | 1.4785 <sup>20</sup>       | 1.4316 <sup>20</sup> | s eth                                                    |
| 8433 | Oxalyl dihydrazide             |                                                          | C <sub>2</sub> H <sub>6</sub> N <sub>4</sub> O <sub>2</sub>                   | 996-98-5   | 118.095  | nd (w)             | 244.0     |                                      | 1.458 <sup>22</sup>        |                      | s H <sub>2</sub> O; sl EtOH, eth, bz, chl                |
| 8434 | Oxamic acid                    |                                                          | C <sub>2</sub> H <sub>3</sub> NO <sub>3</sub>                                 | 471-47-6   | 89.050   | cry (w)            | 210 dec   |                                      |                            |                      | sl H <sub>2</sub> O; i EtOH, eth                         |
| 8435 | Oxamide                        |                                                          | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>                   | 471-46-5   | 88.065   | nd (w)             | 350 dec   |                                      | 1.667 <sup>20</sup>        |                      | sl H <sub>2</sub> O, EtOH; i eth                         |
| 8436 | Oxamniquine                    |                                                          | C <sub>14</sub> H <sub>21</sub> N <sub>3</sub> O <sub>3</sub>                 | 21738-42-1 | 279.335  | ye-oran cry        | 149       |                                      |                            |                      | s ace, chl, MeOH                                         |
| 8437 | Oxamyl                         |                                                          | C <sub>7</sub> H <sub>13</sub> N <sub>3</sub> O <sub>2</sub> S                | 23135-22-0 | 219.261  |                    | 109       | dec                                  | 0.97 <sup>25</sup>         |                      |                                                          |
| 8438 | Oxandrolone                    |                                                          | C <sub>19</sub> H <sub>30</sub> O <sub>3</sub>                                | 53-39-4    | 306.439  |                    | 236       |                                      |                            |                      |                                                          |
| 8439 | 1,4-Oxathiane                  |                                                          | C <sub>2</sub> H <sub>6</sub> OS                                              | 15980-15-1 | 104.171  | liq                | -17       | 147                                  | 1.1174 <sup>20</sup>       |                      | sl H <sub>2</sub> O                                      |



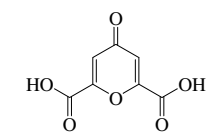
| No.  | Name                                        | Synonym                    | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form                       | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                  |
|------|---------------------------------------------|----------------------------|-----------------------------------------------------------------|------------|----------|-------------------------------------|---------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------------------|
| 8440 | Oxazepam                                    |                            | C <sub>15</sub> H <sub>11</sub> ClN <sub>2</sub> O <sub>2</sub> | 604-75-1   | 286.713  | cry (EtOH)                          | 205.5   |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, chl, diox                       |
| 8441 | Oxazole                                     |                            | C <sub>3</sub> H <sub>3</sub> NO                                | 288-42-6   | 69.062   |                                     |         | 69.5                                  |                            | 1.4285 <sup>17</sup> |                                                             |
| 8442 | Oxepane                                     |                            | C <sub>6</sub> H <sub>12</sub> O                                | 592-90-5   | 100.158  |                                     |         | 119                                   | 0.89 <sup>25</sup>         | 1.4400 <sup>20</sup> |                                                             |
| 8443 | 2-Oxepanone                                 | Caprolactone               | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                   | 502-44-3   | 114.142  | liq                                 | -1.0    | 215                                   | 1.0761 <sup>20</sup>       | 1.4611 <sup>20</sup> | s EtOH, eth, ace                                            |
| 8444 | Oxetane                                     | Trimethylene oxide         | C <sub>3</sub> H <sub>6</sub> O                                 | 503-30-0   | 58.079   | liq                                 | -97     | 47.6                                  | 0.8930 <sup>25</sup>       | 1.3961 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; s eth; vs ace                   |
| 8445 | 2-Oxetanone                                 | β-Propiolactone            | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                    | 57-57-8    | 72.063   | liq                                 | -33.4   | 162                                   | 1.1460 <sup>20</sup>       | 1.4105 <sup>20</sup> | msc eth; s chl                                              |
| 8446 | 3-Oxetanone                                 |                            | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                    | 6704-31-0  | 72.063   | unstab liq                          |         | 106                                   | 1.137                      |                      |                                                             |
| 8447 | Oxirane                                     | Ethylene oxide             | C <sub>2</sub> H <sub>4</sub> O                                 | 75-21-8    | 44.052   | vol liq or gas                      | -112.5  | 10.6                                  | 0.8821 <sup>10</sup>       | 1.3597 <sup>7</sup>  | s H <sub>2</sub> O, EtOH, eth, ace, bz                      |
| 8448 | Oxiranecarboxaldehyde                       | Glycidaldehyde             | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                    | 765-34-4   | 72.063   | liq                                 | -62     | 112.5                                 | 1.1403 <sup>20</sup>       | 1.4265 <sup>20</sup> |                                                             |
| 8449 | Oxiranemethanol, (±)                        | Glycidol                   | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                    | 61915-27-3 | 74.079   |                                     | -45     | dec 167; 66 <sup>2,5</sup>            | 1.1143 <sup>25</sup>       | 1.4287 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth, EtOH; s bz, chl              |
| 8450 | α-Oxobenzeneacetaldehyde aldoxime           | Isonitrosoacetophenone     | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>                   | 532-54-7   | 149.148  |                                     | 129     |                                       |                            |                      | sl H <sub>2</sub> O; s chl                                  |
| 8451 | α-Oxobenzeneacetic acid                     |                            | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                    | 611-73-4   | 150.132  | pr (CCl <sub>4</sub> )              | 66      | 163 <sup>15</sup>                     |                            |                      | vs H <sub>2</sub> O; s EtOH, eth; sl ctc; i CS <sub>2</sub> |
| 8452 | α-Oxobenzeneacetic acid, methyl ester       |                            | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                    | 15206-55-0 | 164.158  |                                     |         | 247                                   |                            | 1.5268 <sup>20</sup> |                                                             |
| 8453 | α-Oxobenzeneacetoneitrile                   |                            | C <sub>8</sub> H <sub>5</sub> NO                                | 613-90-1   | 131.132  |                                     | 32.5    | 206                                   |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; sl chl                    |
| 8454 | γ-Oxobenzenebutanoic acid                   |                            | C <sub>10</sub> H <sub>10</sub> O <sub>3</sub>                  | 2051-95-8  | 178.184  | lf (dil al)                         | 116.5   |                                       |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl, CS <sub>2</sub>     |
| 8455 | β-Oxobenzenepropanenitrile                  | Benzoylacetoneitrile       | C <sub>9</sub> H <sub>7</sub> NO                                | 614-16-4   | 145.158  |                                     | 80.5    | 160 <sup>10</sup>                     |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl, alk, aq KCN      |
| 8456 | α-Oxobenzenepropanoic acid                  | 3-Phenylpyruvic acid       | C <sub>9</sub> H <sub>8</sub> O <sub>3</sub>                    | 156-06-9   | 164.158  | lf (bz, chl)                        | 157.5   |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz, chl; i lig         |
| 8457 | 2-Oxo-2H-1-benzopyran-3-carboxylic acid     | Coumarin-3-carboxylic acid | C <sub>9</sub> H <sub>6</sub> O <sub>3</sub>                    | 531-81-7   | 162.142  | nd (w, bz)                          | 190 dec |                                       |                            |                      | vs EtOH                                                     |
| 8458 | Oxobis(2,4-pentanedione) vanadium           | Vanadyl acetylacetonate    | C <sub>10</sub> H <sub>14</sub> O <sub>5</sub> V                | 3153-26-2  | 265.157  | bl cry                              | 258     | 174 <sup>0,2</sup>                    |                            |                      | i H <sub>2</sub> O; s EtOH, MeOH, bz, chl                   |
| 8459 | 2-Oxobutanoic acid                          |                            | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                    | 600-18-0   | 102.089  |                                     | 33      | 81 <sup>16</sup>                      | 1.200 <sup>17</sup>        | 1.3972 <sup>20</sup> | vs H <sub>2</sub> O, EtOH; sl eth                           |
| 8460 | 4-Oxobutanoic acid                          |                            | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                    | 692-29-5   | 102.089  | oil                                 |         | 135 <sup>14</sup>                     |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz                           |
| 8461 | 2-Oxoglutaric acid                          | α-Ketoglutaric acid        | C <sub>5</sub> H <sub>6</sub> O <sub>5</sub>                    | 328-50-7   | 146.099  | cry (ace-bz)                        | 115.5   |                                       |                            |                      | vs H <sub>2</sub> O, EtOH, eth; s ace                       |
| 8462 | 6-Oxoheptanoic acid                         |                            | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>                   | 3128-07-2  | 144.168  |                                     | 40.2    | 251 <sup>280</sup> , 135 <sup>1</sup> |                            | 1.4306 <sup>25</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                         |
| 8463 | 5-Oxohexanoic acid                          |                            | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                   | 3128-06-1  | 130.141  |                                     | 13.5    | 274.5                                 | 1.09 <sup>25</sup>         | 1.4451 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth; sl ctc                       |
| 8464 | α-Oxo-1H-indole-3-propanoic acid            | Indole-3-pyruvic acid      | C <sub>11</sub> H <sub>9</sub> NO <sub>3</sub>                  | 392-12-1   | 203.194  | gray cry                            | 211     |                                       |                            |                      |                                                             |
| 8465 | Oxolinic acid                               |                            | C <sub>13</sub> H <sub>11</sub> NO <sub>5</sub>                 | 14698-29-4 | 261.230  | cry (DMF)                           | 313 dec |                                       |                            |                      |                                                             |
| 8466 | 4-Oxopentanal                               |                            | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                    | 626-96-0   | 100.117  |                                     | <-21    | dec 187                               | 1.0134 <sup>21</sup>       | 1.4257 <sup>22</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                         |
| 8467 | 3-Oxopentanedioic acid                      | Acetonedicarboxylic acid   | C <sub>5</sub> H <sub>6</sub> O <sub>5</sub>                    | 542-05-2   | 146.099  | nd (AcOEt)                          | 138 dec |                                       |                            |                      | s H <sub>2</sub> O, EtOH; sl eth; i bz, chl, lig            |
| 8468 | 2-Oxopentanoic acid                         |                            | C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>                    | 1821-02-9  | 116.116  |                                     | 6.5     | 179                                   | 1.0970 <sup>14</sup>       |                      | sl H <sub>2</sub> O; s eth, bz, chl, lig, CS <sub>2</sub>   |
| 8469 | 4-Oxopentanoic acid                         | Levulinic acid             | C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>                    | 123-76-2   | 116.116  | lf or pl                            | 33      | dec 245                               | 1.1335 <sup>20</sup>       | 1.4396 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, eth; s chl                       |
| 8470 | 4-Oxo-4-(phenylamino)butanoic acid          | Succinilic acid            | C <sub>10</sub> H <sub>11</sub> NO <sub>3</sub>                 | 102-14-7   | 193.199  | nd (w)                              | 148.5   |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH; vs eth                         |
| 8471 | cis-4-Oxo-4-(phenylamino)-2-butenic acid    | Maleanilic acid            | C <sub>10</sub> H <sub>9</sub> NO <sub>3</sub>                  | 555-59-9   | 191.183  | mcl ye cry                          | 192 dec |                                       | 1.418 <sup>30</sup>        |                      |                                                             |
| 8472 | Oxophenylarsine                             | Phenylarsine oxide         | C <sub>6</sub> H <sub>5</sub> AsO                               | 637-03-6   | 168.025  | cry (bz-eth) or (chl-eth)           | 145     |                                       |                            |                      | i H <sub>2</sub> O, eth; sl EtOH; vs bz, chl                |
| 8473 | 4-Oxo-4-phenyl-2-butenic acid               |                            | C <sub>10</sub> H <sub>8</sub> O <sub>3</sub>                   | 583-06-2   | 176.169  | nd or pr (tol)                      | 99      |                                       |                            |                      | sl H <sub>2</sub> O, chl, lig; s EtOH, eth, tol             |
| 8474 | 2-Oxopropanal oxime                         | Isonitrosoacetone          | C <sub>3</sub> H <sub>5</sub> NO <sub>2</sub>                   | 306-44-5   | 87.078   | nd(CCl <sub>4</sub> ) lf (eth-peth) | 69      | sub                                   | 1.0744 <sup>67</sup>       |                      | s H <sub>2</sub> O, eth; sl bz, ctc, chl                    |
| 8475 | 2-Oxopropanenitrile                         |                            | C <sub>3</sub> H <sub>3</sub> NO                                | 631-57-2   | 69.062   |                                     |         | 92.3                                  | 0.9745 <sup>20</sup>       | 1.3764 <sup>20</sup> | s eth, ace, CH <sub>3</sub> CN                              |
| 8476 | 17-(1-Oxopropoxy)-androst-4-en-3-one, (17β) | Testosterone-17-propionate | C <sub>22</sub> H <sub>32</sub> O <sub>3</sub>                  | 57-85-2    | 344.487  |                                     | 120     |                                       |                            |                      | vs eth, py, EtOH                                            |



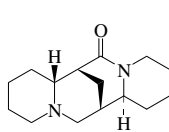
| No.  | Name                                   | Synonym                                 | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form                        | mp/°C   | bp/°C               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                            |
|------|----------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------|------------|----------|--------------------------------------|---------|---------------------|----------------------------|----------------------|-----------------------------------------------------------------------|
| 8477 | 2-Oxo-2H-pyran-5-carboxylic acid       | Coumalic acid                           | C <sub>6</sub> H <sub>4</sub> O <sub>4</sub>                                   | 500-05-0   | 140.094  | pr (MeOH)                            | 207 dec | 218 <sup>120</sup>  |                            |                      | sl H <sub>2</sub> O, eth, ace;<br>i bz, chl; s<br>EtOH, HOAc          |
| 8478 | 4-Oxo-4H-pyran-2,6-dicarboxylic acid   | Chelidonic acid                         | C <sub>7</sub> H <sub>4</sub> O <sub>6</sub>                                   | 99-32-1    | 184.103  | rose mcl nd<br>(al-w,+1w)            | 262     |                     |                            |                      | sl H <sub>2</sub> O, EtOH                                             |
| 8479 | 17-Oxosparteine                        |                                         | C <sub>15</sub> H <sub>24</sub> N <sub>2</sub> O                               | 489-72-5   | 248.364  | ye to col hyg<br>nd (peth)           | 84      | 209 <sup>12</sup>   |                            |                      | vs H <sub>2</sub> O, EtOH,<br>eth; s chl                              |
| 8480 | 4,4'-Oxybis(benzenesulfonyl chloride)  | Diphenyl ether 4,4'-disulfonyl chloride | C <sub>12</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>5</sub> S <sub>2</sub>   | 121-63-1   | 367.225  | cry (peth)                           | 128     |                     |                            |                      |                                                                       |
| 8481 | 4,4'-Oxybis(benzenesulfonyl hydrazide) |                                         | C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>5</sub> S <sub>2</sub>   | 80-51-3    | 358.393  | cry (H <sub>2</sub> O)               | 164 dec |                     |                            |                      |                                                                       |
| 8482 | Oxybutynin                             |                                         | C <sub>22</sub> H <sub>31</sub> NO <sub>3</sub>                                | 5633-20-5  | 357.486  | cry                                  | 114     |                     |                            |                      |                                                                       |
| 8483 | Oxycarboxin                            | Carboxin S,S-dioxide                    | C <sub>12</sub> H <sub>13</sub> NO <sub>4</sub> S                              | 5259-88-1  | 267.301  | pr (EtOH)                            | 129     |                     |                            |                      | sl H <sub>2</sub> O; s bz,<br>EtOH; vs ace                            |
| 8484 | Oxychlordane                           |                                         | C <sub>10</sub> H <sub>6</sub> Cl <sub>8</sub> O                               | 27304-13-8 | 423.762  | cry (pentane)                        | 100     |                     |                            |                      |                                                                       |
| 8485 | Oxycodone                              | Dihydro-14-hydroxycodeinone             | C <sub>18</sub> H <sub>21</sub> NO <sub>4</sub>                                | 76-42-6    | 315.365  | rods (EtOH)                          | 219     |                     |                            |                      | i H <sub>2</sub> O, eth; s<br>EtOH, chl                               |
| 8486 | Oxydemeton-methyl                      |                                         | C <sub>6</sub> H <sub>15</sub> O <sub>4</sub> PS <sub>2</sub>                  | 301-12-2   | 246.284  |                                      | <-20    | 106 <sup>0.01</sup> | 1.289 <sup>20</sup>        |                      |                                                                       |
| 8487 | 10,10'-Oxydiphenoxarsine               | 10,10'-Oxybis[10H-phenoxarsine]         | C <sub>24</sub> H <sub>16</sub> As <sub>2</sub> O <sub>3</sub>                 | 58-36-6    | 502.225  | col mcl cry                          | 185     |                     | 1.41                       |                      | i H <sub>2</sub> O; s EtOH,<br>chl; i CH <sub>2</sub> Cl <sub>2</sub> |
| 8488 | Oxyfluorfen                            |                                         | C <sub>15</sub> H <sub>11</sub> ClF <sub>3</sub> NO <sub>4</sub>               | 42874-03-3 | 361.701  |                                      | 84      | dec 358             | 1.35 <sup>73</sup>         |                      |                                                                       |
| 8489 | Oxymetazoline                          |                                         | C <sub>16</sub> H <sub>24</sub> N <sub>2</sub> O                               | 1491-59-4  | 260.374  | cry (bz)                             | 182     |                     |                            |                      | i eth, chl                                                            |
| 8490 | Oxymetholone                           |                                         | C <sub>21</sub> H <sub>32</sub> O <sub>3</sub>                                 | 434-07-1   | 332.477  | cry                                  | 179     |                     |                            |                      |                                                                       |
| 8491 | Oxymethurea                            |                                         | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>                    | 140-95-4   | 120.107  | pr(al)                               | 126     | 149 <sup>25</sup>   |                            |                      | s H <sub>2</sub> O, EtOH,<br>MeOH; i eth; sl<br>DMSO                  |
| 8492 | Oxyphenbutazone                        |                                         | C <sub>19</sub> H <sub>20</sub> N <sub>2</sub> O <sub>3</sub>                  | 129-20-4   | 324.373  | cry (eth/<br>peth)                   | 124     |                     |                            |                      | s EtOH, MeOH,<br>chl, bz, eth                                         |
| 8493 | Oxyphenonium bromide                   |                                         | C <sub>21</sub> H <sub>18</sub> BrNO <sub>3</sub>                              | 50-10-2    | 428.404  |                                      | 191.5   |                     |                            |                      | vs H <sub>2</sub> O; sl EtOH                                          |
| 8494 | Oxytetracycline                        |                                         | C <sub>22</sub> H <sub>24</sub> N <sub>2</sub> O <sub>3</sub>                  | 79-57-2    | 460.434  |                                      | 184.5   |                     | 1.634 <sup>20</sup>        |                      |                                                                       |
| 8495 | Oxytocin                               |                                         | C <sub>43</sub> H <sub>66</sub> N <sub>12</sub> O <sub>12</sub> S <sub>2</sub> | 50-56-6    | 1007.187 | wh pow                               |         |                     |                            |                      | s H <sub>2</sub> O, BuOH                                              |
| 8496 | Paclobutrazol                          |                                         | C <sub>15</sub> H <sub>26</sub> ClN <sub>3</sub> O                             | 76738-62-0 | 293.792  | wh cry                               | 166     |                     | 1.22                       |                      | i H <sub>2</sub> O; vs ace,<br>MeOH; s xyl,<br>hx                     |
| 8497 | Palustric acid                         |                                         | C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>                                 | 1945-53-5  | 302.451  | cry (MeOH)                           | 164.5   |                     |                            |                      |                                                                       |
| 8498 | Pamoic acid                            |                                         | C <sub>23</sub> H <sub>16</sub> O <sub>6</sub>                                 | 130-85-8   | 388.369  |                                      | 315     |                     |                            |                      |                                                                       |
| 8499 | Pancuronium dibromide                  |                                         | C <sub>35</sub> H <sub>46</sub> Br <sub>2</sub> N <sub>2</sub> O <sub>4</sub>  | 15500-66-0 | 732.670  | cry                                  | 215     |                     |                            |                      | sl chl                                                                |
| 8500 | Panose                                 | 4-α-Isomaltosylglucose                  | C <sub>18</sub> H <sub>32</sub> O <sub>16</sub>                                | 33401-87-5 | 504.437  |                                      | 223 dec |                     |                            |                      |                                                                       |
| 8501 | Panthesin                              |                                         | C <sub>18</sub> H <sub>32</sub> N <sub>2</sub> O <sub>5</sub> S                | 135-44-4   | 388.522  | pa ye pow<br>(al)                    | 158     |                     |                            |                      | vs H <sub>2</sub> O, EtOH                                             |
| 8502 | Pantolactone                           |                                         | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                                  | 599-04-2   | 130.141  |                                      | 92      |                     |                            |                      |                                                                       |
| 8503 | Pantothenic acid                       |                                         | C <sub>9</sub> H <sub>17</sub> NO <sub>5</sub>                                 | 79-83-4    | 219.235  | ye visc oil                          |         |                     |                            |                      | vs H <sub>2</sub> O, bz, eth                                          |
| 8504 | Papaveraldine                          |                                         | C <sub>20</sub> H <sub>19</sub> NO <sub>5</sub>                                | 522-57-6   | 353.369  | nd (al),cry<br>(bz, peth)            | 210.5   |                     |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>eth; s bz, chl                        |
| 8505 | Papaverine                             |                                         | C <sub>20</sub> H <sub>21</sub> NO <sub>4</sub>                                | 58-74-2    | 339.386  | wh pr (al-<br>eth), nd<br>(chl-peth) | 147.5   | sub 135             | 1.337 <sup>20</sup>        | 1.625                | sl H <sub>2</sub> O; vs EtOH,<br>chl; s ace, bz,<br>py                |
| 8506 | Papaverine hydrochloride               | Cerespan                                | C <sub>20</sub> H <sub>22</sub> ClNO <sub>4</sub>                              | 61-25-6    | 375.847  | wh mcl pr<br>(w)                     | 224.5   |                     |                            |                      | vs H <sub>2</sub> O, EtOH                                             |
| 8507 | Paraformaldehyde                       |                                         | (CH <sub>2</sub> O) <sub>x</sub>                                               | 30525-89-4 | 30.026   |                                      | 164 dec |                     |                            |                      |                                                                       |
| 8508 | Paraldehyde                            | 2,4,6-Trimethyl-1,3,5-trioxane          | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                                  | 123-63-7   | 132.157  |                                      | 12.6    | 124.3               | 0.9943 <sup>20</sup>       | 1.4049 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth, chl                            |
| 8509 | Paramethadione                         |                                         | C <sub>7</sub> H <sub>11</sub> NO <sub>3</sub>                                 | 115-67-3   | 157.167  | liq                                  |         |                     | 1.121 <sup>25</sup>        | 1.449 <sup>25</sup>  | sl H <sub>2</sub> O; s EtOH,<br>chl, bz, eth                          |
| 8510 | Paraoxon                               | O,O-Diethyl O-(4-nitrophenyl) phosphate | C <sub>10</sub> H <sub>14</sub> NO <sub>6</sub> P                              | 311-45-5   | 275.195  | oily liq                             |         | 161 <sup>0.5</sup>  | 1.2683 <sup>25</sup>       | 1.5096               | s eth                                                                 |
| 8511 | Paraquat                               |                                         | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub>                                 | 4685-14-7  | 186.252  | cation                               |         |                     |                            |                      |                                                                       |
| 8512 | Pararosaniline hydrochloride           | Basic fuchsin                           | C <sub>19</sub> H <sub>18</sub> ClN <sub>3</sub>                               | 569-61-9   | 323.819  | pale viol pow                        | 269 dec |                     |                            |                      |                                                                       |
| 8513 | Parasorbic acid                        |                                         | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                                   | 10048-32-5 | 112.127  | oily lig                             |         | 100 <sup>15</sup>   | 1.079 <sup>18</sup>        | 1.4736 <sup>20</sup> | vs H <sub>2</sub> O, eth,<br>EtOH                                     |
| 8514 | Parathion                              |                                         | C <sub>10</sub> H <sub>14</sub> NO <sub>3</sub> PS                             | 56-38-2    | 291.261  | ye liq                               | 6.1     | 375                 | 1.2681 <sup>20</sup>       | 1.5370 <sup>25</sup> | i H <sub>2</sub> O; s eth, ace;<br>sl ctc; vs EtOH,<br>AcOEt          |
| 8515 | Patchouli alcohol                      |                                         | C <sub>15</sub> H <sub>26</sub> O                                              | 5986-55-0  | 222.366  |                                      | 56      |                     | 0.9906 <sup>55</sup>       | 1.5029 <sup>65</sup> | i H <sub>2</sub> O; s EtOH,<br>eth                                    |
| 8516 | Pebulate                               |                                         | C <sub>10</sub> H <sub>21</sub> NOS                                            | 1114-71-2  | 203.345  |                                      |         | 142 <sup>20</sup>   | 0.9458 <sup>20</sup>       | 1.4752 <sup>20</sup> | vs ace, bz,<br>MeOH                                                   |
| 8517 | Pelargonidin chloride                  |                                         | C <sub>15</sub> H <sub>11</sub> ClO <sub>5</sub>                               | 134-04-3   | 306.698  | red br hyg<br>(anh) pr or<br>pl      | >350    |                     |                            |                      | s H <sub>2</sub> O; vs EtOH;<br>sl chl, MeOH                          |
| 8518 | Pellotine                              |                                         | C <sub>13</sub> H <sub>19</sub> NO <sub>3</sub>                                | 83-14-7    | 237.295  | pl (al, peth)                        | 111.5   |                     |                            |                      | vs ace, eth,<br>EtOH, peth                                            |
| 8519 | Pemoline                               | 2-Amino-5-phenyl-4(5H)-oxazolone        | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                    | 2152-34-3  | 176.172  | cry                                  | 256 dec |                     |                            |                      | i H <sub>2</sub> O, eth, ace;<br>sl hot EtOH                          |



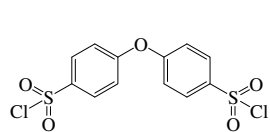
2-Oxo-2H-pyran-5-carboxylic acid



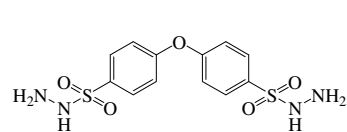
4-Oxo-4H-pyran-2,6-dicarboxylic acid



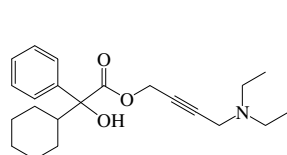
17-Oxosparteine



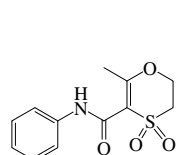
4,4'-Oxybis(benzenesulfonyl chloride)



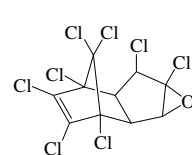
4,4'-Oxybis(benzenesulfonyl hydrazide)



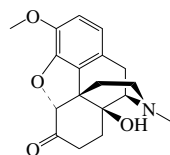
Oxybutynin



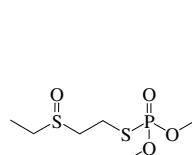
Oxycarboxin



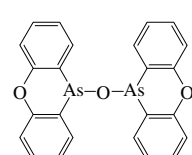
Oxychlordane



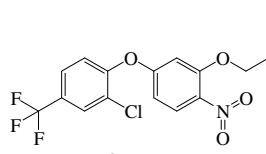
Oxycodone



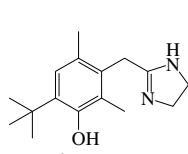
Oxydemeton-methyl



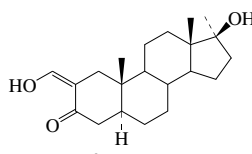
10,10'-Oxydiphenoxarsine



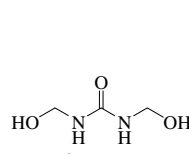
Oxyfluorfen



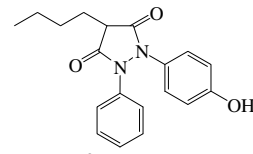
Oxymetazoline



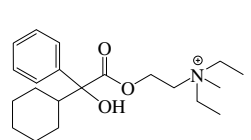
Oxymetholone



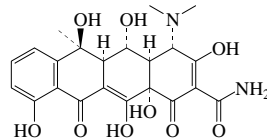
Oxymethurea



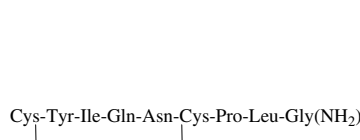
Oxyphenbutazone



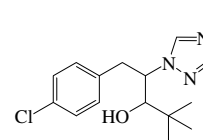
Oxypheonium bromide



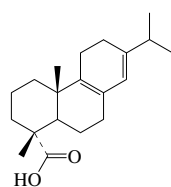
Oxytetracycline



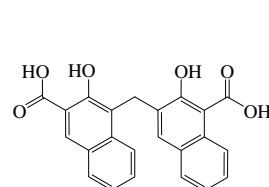
Oxytocin



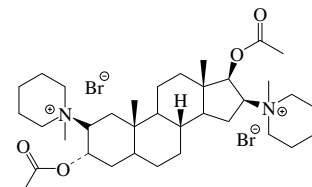
Paclobutrazol



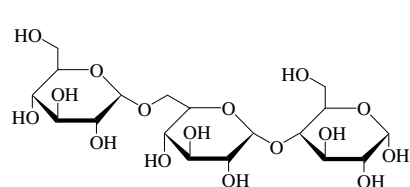
Palustric acid



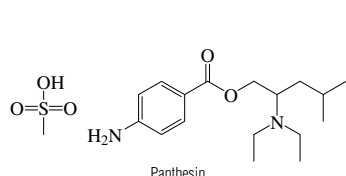
Pamoic acid



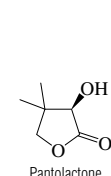
Pancuronium dibromide



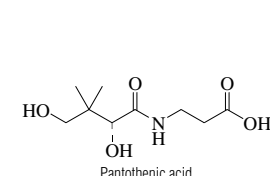
Panose



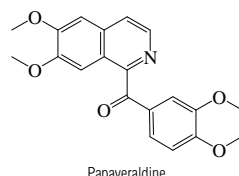
Panthesin



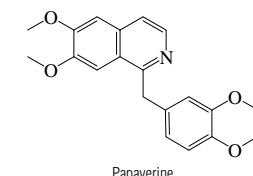
Pantolactone



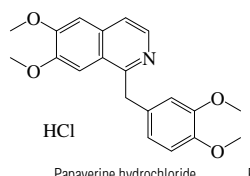
Pantoic acid



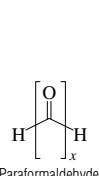
Papaveralidine



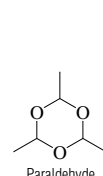
Papaverine



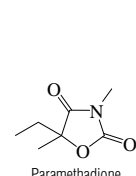
Papaverine hydrochloride



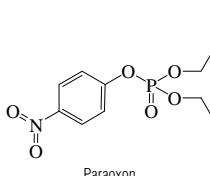
Paraformaldehyde



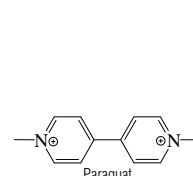
Paraldehyde



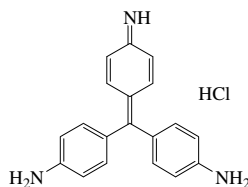
Paramethadione



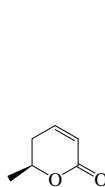
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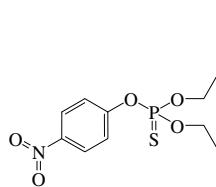
Paraquat



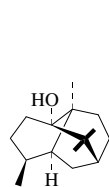
Pararosaniline hydrochloride



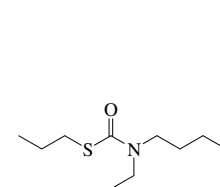
Parasorbic acid



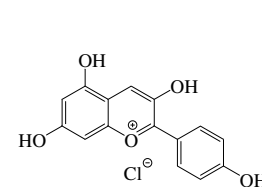
Parathion



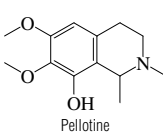
Patchouli alcohol



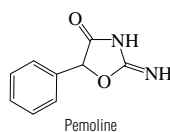
Pebulate



Pelargonidin chloride



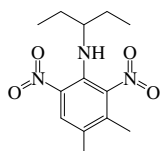
Pellotine



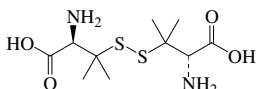
Pemoline



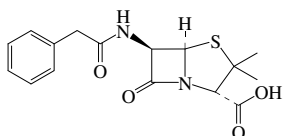
| No.  | Name                                                    | Synonym                                                   | Mol. Form.                                                                  | CAS RN     | Mol. Wt. | Physical Form                      | mp/°C    | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                       |
|------|---------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------------------------|------------|----------|------------------------------------|----------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------------------|
| 8520 | Pendimethalin                                           | <i>N</i> -(1-Ethylpropyl)-3,4-dimethyl-2,6-dinitroaniline | C <sub>13</sub> H <sub>19</sub> N <sub>3</sub> O <sub>4</sub>               | 40487-42-1 | 281.308  |                                    | 56       | dec                                   | 1.19 <sup>25</sup>         |                      |                                                                  |
| 8521 | Penicillamine cysteine disulfide                        |                                                           | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 18840-45-4 | 268.354  |                                    | 195      |                                       |                            |                      |                                                                  |
| 8522 | Penicillin G                                            | Benzylpenicillinic acid                                   | C <sub>18</sub> H <sub>18</sub> N <sub>2</sub> O <sub>4</sub> S             | 61-33-6    | 334.390  | amor wh<br>pow                     |          |                                       |                            |                      | sl H <sub>2</sub> O; s MeOH,<br>EtOH, eth, chl,<br>bz, ace       |
| 8523 | Penicillin G procaine                                   |                                                           | C <sub>29</sub> H <sub>38</sub> N <sub>4</sub> O <sub>6</sub> S             | 54-35-3    | 570.700  |                                    | 108 dec  |                                       | 1.2555 <sup>25</sup>       |                      | s H <sub>2</sub> O, EtOH, chl                                    |
| 8524 | Penicillin V                                            | Phenoxymethylpenicillin                                   | C <sub>16</sub> H <sub>18</sub> N <sub>2</sub> O <sub>5</sub> S             | 87-08-1    | 350.389  | cry                                | 124 dec  |                                       |                            |                      | sl H <sub>2</sub> O; s os                                        |
| 8525 | 1,2,3,4,5-Pentabromo-6-chlorocyclohexane                |                                                           | C <sub>6</sub> H <sub>6</sub> Br <sub>5</sub> Cl                            | 87-84-3    | 513.085  | cry                                | 204      |                                       |                            |                      |                                                                  |
| 8526 | Pentabromomethylbenzene                                 |                                                           | C <sub>7</sub> H <sub>5</sub> Br <sub>5</sub>                               | 87-83-2    | 486.619  |                                    | 288      |                                       | 2.97 <sup>17</sup>         |                      | i H <sub>2</sub> O; sl EtOH,<br>HOAc; s bz                       |
| 8527 | Pentabromophenol                                        |                                                           | C <sub>6</sub> HBr <sub>5</sub> O                                           | 608-71-9   | 488.591  | mcl pr<br>(HOAc) nd<br>(al)        | 229.5    | sub                                   |                            |                      | i H <sub>2</sub> O; s EtOH,<br>bz, HOAc; sl<br>eth               |
| 8528 | 1,1,1,3,3-Pentabromo-2-propanone                        | Pentabromoacetone                                         | C <sub>3</sub> HBr <sub>5</sub> O                                           | 79-49-2    | 452.559  | nd (w, al) pr<br>(eth)             | 79.5     | sub                                   |                            |                      | i H <sub>2</sub> O; vs EtOH,<br>eth, ace, chl                    |
| 8529 | Pentac                                                  | Dienochlor                                                | C <sub>10</sub> Cl <sub>10</sub>                                            | 2227-17-0  | 474.637  | tan cry (peth)                     | 122      |                                       |                            |                      |                                                                  |
| 8530 | Pentacene                                               | Benzo[b]naphthacene                                       | C <sub>22</sub> H <sub>14</sub>                                             | 135-48-8   | 278.346  | ye grn nd or<br>lf (xyl)           | >300 dec |                                       |                            |                      | i H <sub>2</sub> O; sl bz; s<br>PhNO <sub>2</sub>                |
| 8531 | 2,3,4,5,6-Pentachloroaniline                            |                                                           | C <sub>6</sub> H <sub>2</sub> Cl <sub>5</sub> N                             | 527-20-8   | 265.352  | nd (al)                            | 233.0    |                                       |                            |                      | vs eth, EtOH, lig                                                |
| 8532 | 2,3,4,5,6-Pentachloroanisole                            | Methyl pentachlorophenyl ether                            | C <sub>7</sub> H <sub>3</sub> Cl <sub>5</sub> O                             | 1825-21-4  | 280.363  | nd MeOH                            | 108.5    |                                       |                            |                      |                                                                  |
| 8533 | Pentachlorobenzene                                      |                                                           | C <sub>6</sub> HCl <sub>5</sub>                                             | 608-93-5   | 250.337  | nd (al)                            | 86       | 277                                   | 1.8342 <sup>16</sup>       |                      | i H <sub>2</sub> O, EtOH; sl<br>eth, bz, chl,<br>CS <sub>2</sub> |
| 8534 | Pentachlorobenzenethiol                                 | Pentachlorophenyl mercaptan                               | C <sub>6</sub> HCl <sub>5</sub> S                                           | 133-49-3   | 282.402  |                                    | 231.5    |                                       |                            |                      |                                                                  |
| 8535 | 2,3,4,5,6-Pentachlorobiphenyl                           |                                                           | C <sub>12</sub> H <sub>2</sub> Cl <sub>5</sub>                              | 18259-05-7 | 326.433  | nd (peth)                          | 123.5    |                                       |                            |                      | i H <sub>2</sub> O                                               |
| 8536 | 2,2',4,5,5'-Pentachlorobiphenyl                         |                                                           | C <sub>12</sub> H <sub>5</sub> Cl <sub>5</sub>                              | 37680-73-2 | 326.433  | cry (EtOH)                         | 78.5     |                                       |                            |                      | i H <sub>2</sub> O                                               |
| 8537 | 1,2,3,4,7-Pentachlorodibenzo- <i>p</i> -dioxin          |                                                           | C <sub>12</sub> H <sub>3</sub> Cl <sub>5</sub> O <sub>2</sub>               | 39227-61-7 | 356.416  | cry (bz/<br>MeOH)                  | 195      |                                       |                            |                      |                                                                  |
| 8538 | Pentachloroethane                                       | Refrigerant 120                                           | C <sub>2</sub> HCl <sub>5</sub>                                             | 76-01-7    | 202.294  | liq                                | -28.78   | 162.0                                 | 1.6796 <sup>20</sup>       | 1.5025 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                             |
| 8539 | Pentachlorofluoroethane                                 |                                                           | C <sub>2</sub> Cl <sub>5</sub> F                                            | 354-56-3   | 220.284  | col liq                            | 101.3    | 138                                   | 1.74 <sup>25</sup>         |                      | i H <sub>2</sub> O; s EtOH,<br>eth                               |
| 8540 | Pentachloronitrobenzene                                 | Quintozone                                                | C <sub>6</sub> Cl <sub>5</sub> NO <sub>2</sub>                              | 82-68-8    | 295.335  | cry (al)                           | 144      | dec 328                               | 1.718 <sup>25</sup>        |                      | i H <sub>2</sub> O; sl EtOH;<br>s bz, chl                        |
| 8541 | Pentachlorophenol                                       |                                                           | C <sub>6</sub> HCl <sub>5</sub> O                                           | 87-86-5    | 266.336  | mcl pr (al +<br>1w) nd (bz)        | 174      | dec 310                               | 1.978 <sup>22</sup>        |                      | i H <sub>2</sub> O; sl lig; vs<br>EtOH, eth; s bz                |
| 8542 | 1,1,2,2,3-Pentachloropropane                            |                                                           | C <sub>3</sub> H <sub>2</sub> Cl <sub>5</sub>                               | 16714-68-4 | 216.321  |                                    |          | 181 <sup>500</sup>                    | 1.633 <sup>25</sup>        | 1.5098 <sup>25</sup> |                                                                  |
| 8543 | 1,1,2,3,3-Pentachloro-1-propene                         |                                                           | C <sub>3</sub> HCl <sub>5</sub>                                             | 1600-37-9  | 214.305  |                                    |          | 185                                   | 1.6317 <sup>94</sup>       | 1.5313 <sup>20</sup> | vs eth                                                           |
| 8544 | Pentachloropyridine                                     |                                                           | C <sub>5</sub> Cl <sub>5</sub> N                                            | 2176-62-7  | 251.326  |                                    | 125.5    | 280                                   |                            |                      | vs bz, EtOH, lig                                                 |
| 8545 | 2,3,4,5,6-Pentachlorotoluene                            |                                                           | C <sub>7</sub> H <sub>3</sub> Cl <sub>5</sub>                               | 877-11-2   | 264.364  | nd (bz, peth)                      | 224.8    | 301                                   |                            |                      | sl EtOH, eth,<br>CS <sub>2</sub> ; s bz, tol,<br>peth            |
| 8546 | Pentacontane                                            |                                                           | C <sub>50</sub> H <sub>102</sub>                                            | 6596-40-3  | 703.345  |                                    | 92.1     | 575.0                                 |                            |                      |                                                                  |
| 8547 | Pentacosane                                             |                                                           | C <sub>25</sub> H <sub>52</sub>                                             | 629-99-2   | 352.681  |                                    | 53.93    | 401.9; 282 <sup>40</sup>              | 0.8012 <sup>20</sup>       | 1.4491 <sup>20</sup> | s bz, chl                                                        |
| 8548 | 1 <i>H</i> -Pentadecafluoroheptane                      |                                                           | C <sub>7</sub> HF <sub>15</sub>                                             | 375-83-7   | 370.059  |                                    |          | 96.0                                  | 1.725 <sup>25</sup>        | 1.2690 <sup>25</sup> |                                                                  |
| 8549 | Pentadecafluorooctanoic acid                            |                                                           | C <sub>8</sub> HF <sub>15</sub> O <sub>2</sub>                              | 335-67-1   | 414.069  |                                    | 54.3     | 192.4                                 |                            |                      |                                                                  |
| 8550 | 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-Pentadecafluoro-1-octanol | 1,1-Dihydroperfluorooctanol                               | C <sub>8</sub> H <sub>3</sub> F <sub>15</sub> O                             | 307-30-2   | 400.085  | waxy solid                         | 47       | 164; 68 <sup>8</sup>                  |                            |                      |                                                                  |
| 8551 | Pentadecanal                                            |                                                           | C <sub>15</sub> H <sub>30</sub> O                                           | 2765-11-9  | 226.398  | nd                                 | 24.5     | 185 <sup>25</sup>                     |                            |                      | vs ace, eth,<br>EtOH                                             |
| 8552 | Pentadecane                                             |                                                           | C <sub>15</sub> H <sub>32</sub>                                             | 629-62-9   | 212.415  |                                    | 9.95     | 270.6                                 | 0.7685 <sup>20</sup>       | 1.4315 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH,<br>eth                              |
| 8553 | Pentadecanoic acid                                      | Pentadecylic acid                                         | C <sub>15</sub> H <sub>30</sub> O <sub>2</sub>                              | 1002-84-2  | 242.398  | pl (dil al,<br>HOAc) cry<br>(peth) | 52.3     | 257 <sup>100</sup> , 158 <sup>1</sup> | 0.8423 <sup>80</sup>       | 1.4254 <sup>80</sup> | i H <sub>2</sub> O; vs EtOH,<br>ace; s eth; sl<br>tta            |
| 8554 | 1-Pentadecanol                                          |                                                           | C <sub>15</sub> H <sub>32</sub> O                                           | 629-76-5   | 228.414  |                                    | 43.9     | 300                                   | 0.8347 <sup>25</sup>       |                      | i H <sub>2</sub> O                                               |
| 8555 | 2-Pentadecanone                                         |                                                           | C <sub>15</sub> H <sub>30</sub> O                                           | 2345-28-0  | 226.398  |                                    | 39.5     | 294                                   | 0.8182 <sup>39</sup>       |                      |                                                                  |
| 8556 | 8-Pentadecanone                                         |                                                           | C <sub>15</sub> H <sub>30</sub> O                                           | 818-23-5   | 226.398  | cry (al)                           | 43       | 291                                   | 0.8180 <sup>39</sup>       |                      | s EtOH, eth, bz,<br>ctc, chl                                     |
| 8557 | 1-Pentadecene                                           |                                                           | C <sub>15</sub> H <sub>30</sub>                                             | 13360-61-7 | 210.399  | liq                                | -1.4     | 268.2                                 | 0.7764 <sup>20</sup>       | 1.4389 <sup>20</sup> | i H <sub>2</sub> O; s ace                                        |
| 8558 | Pentadecylamine                                         | Pentadecanamine                                           | C <sub>15</sub> H <sub>33</sub> N                                           | 2570-26-5  | 227.430  |                                    | 37.3     | 307.6                                 | 0.8104 <sup>20</sup>       | 1.4480 <sup>20</sup> | vs eth, EtOH                                                     |
| 8559 | Pentadecylbenzene                                       |                                                           | C <sub>21</sub> H <sub>36</sub>                                             | 2131-18-2  | 288.511  |                                    | 22       | 373                                   | 0.8548 <sup>20</sup>       | 1.4815 <sup>20</sup> |                                                                  |
| 8560 | 3-Pentadecyl-1,2-benzenediol                            | 3-Pentadecylcatechol                                      | C <sub>21</sub> H <sub>36</sub> O <sub>2</sub>                              | 492-89-7   | 320.510  | nd (to, peth)                      | 59.5     |                                       |                            |                      | vs bz, eth, EtOH                                                 |
| 8561 | Pentadecylcyclohexane                                   |                                                           | C <sub>21</sub> H <sub>42</sub>                                             | 6006-95-7  | 294.558  |                                    | 29       | 373                                   | 0.8267 <sup>20</sup>       | 1.4588 <sup>20</sup> |                                                                  |
| 8562 | 3-Pentadecylphenol                                      |                                                           | C <sub>21</sub> H <sub>36</sub> O                                           | 501-24-6   | 304.510  | nd (peth)                          | 53.5     | 230 <sup>8</sup> , 197 <sup>15</sup>  |                            |                      | vs ace, bz, EtOH                                                 |
| 8563 | 1-Pentadecyne                                           |                                                           | C <sub>15</sub> H <sub>28</sub>                                             | 765-13-9   | 208.383  |                                    | 10       | 268                                   | 0.7928 <sup>20</sup>       | 1.4419 <sup>20</sup> | vs ace                                                           |
| 8564 | 1,2-Pentadiene                                          | Ethylallene                                               | C <sub>5</sub> H <sub>8</sub>                                               | 591-95-7   | 68.118   | liq                                | -137.3   | 44.9                                  | 0.6926 <sup>20</sup>       | 1.4209 <sup>20</sup> | msc EtOH, eth,<br>ace, bz, ctc, hp                               |
| 8565 | <i>cis</i> -1,3-Pentadiene                              | <i>cis</i> -Piperylene                                    | C <sub>5</sub> H <sub>8</sub>                                               | 1574-41-0  | 68.118   | liq                                | -140.8   | 44.1                                  | 0.6910 <sup>20</sup>       | 1.4363 <sup>20</sup> | msc EtOH, eth,<br>ace, bz, ctc, hp                               |
| 8566 | <i>trans</i> -1,3-Pentadiene                            | <i>trans</i> -Piperylene                                  | C <sub>5</sub> H <sub>8</sub>                                               | 2004-70-8  | 68.118   | liq                                | -87.4    | 42                                    | 0.6710 <sup>25</sup>       | 1.4301 <sup>20</sup> |                                                                  |



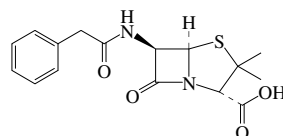
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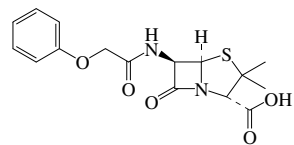
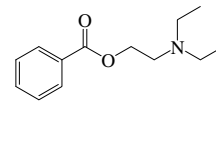
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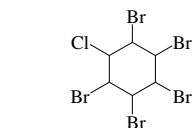
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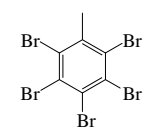
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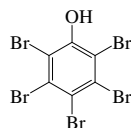
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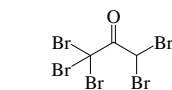
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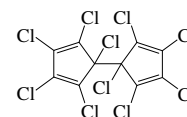
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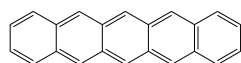
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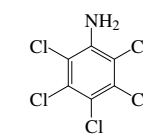
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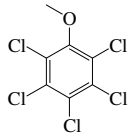
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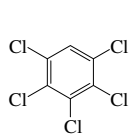
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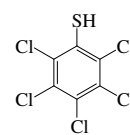
2,3,4,5,6-Pentachloroaniline



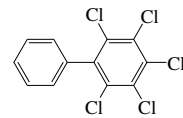
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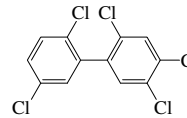
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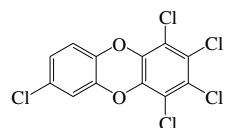
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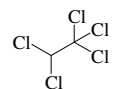
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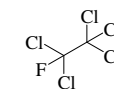
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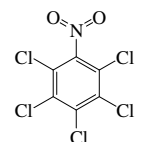
1,2,3,4,7-Pentachlorodibenzo-p-dioxin



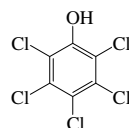
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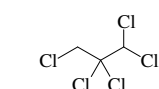
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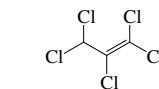
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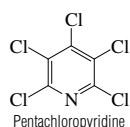
Pentachlorophenol



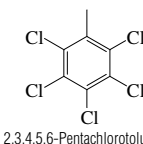
1,1,2,2,3-Pentachloropropane



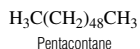
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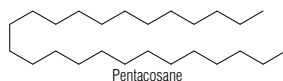
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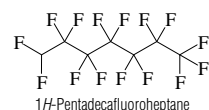
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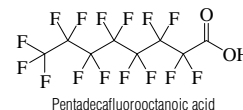
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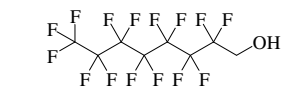
Pentacosane



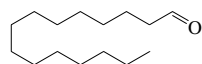
1H-Pentadecafluoroheptane



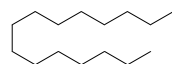
Pentadecafluorooctanoic acid



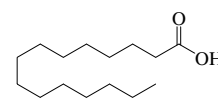
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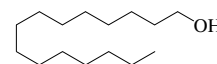
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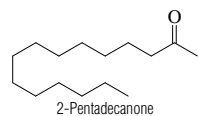
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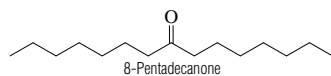
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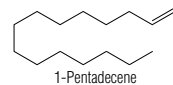
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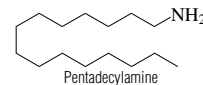
2-Pentadecanone



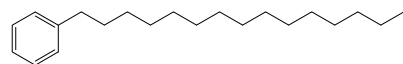
8-Pentadecanone



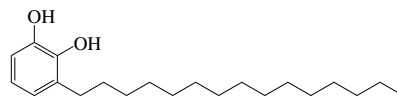
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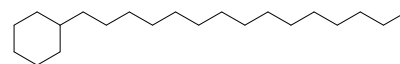
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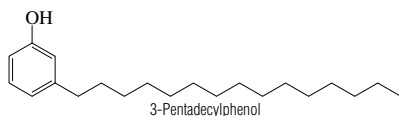
Pentadecylbenzene



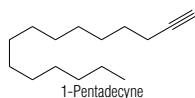
3-Pentadecyl-1,2-benzenediol



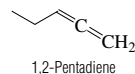
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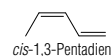
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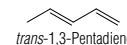
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1,2-Pentadiene



cis-1,3-Pentadiene



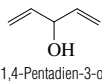
trans-1,3-Pentadiene

| No.  | Name                                                    | Synonym                                              | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form          | mp/°C   | bp/°C                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                              |
|------|---------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------|------------|----------|------------------------|---------|--------------------------|----------------------------|-----------------------|---------------------------------------------------------|
| 8567 | 1,4-Pentadiene                                          |                                                      | C <sub>5</sub> H <sub>8</sub>                                   | 591-93-5   | 68.118   | vol liq or gas         | -148.2  | 26                       | 0.6608 <sup>20</sup>       | 1.3888 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth, ace, bz               |
| 8568 | 2,3-Pentadiene                                          | 1,3-Dimethylallene                                   | C <sub>5</sub> H <sub>8</sub>                                   | 591-96-8   | 68.118   | liq                    | -125.6  | 48.2                     | 0.6950 <sup>20</sup>       | 1.4284 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, hp, ctc     |
| 8569 | 1,4-Pentadien-3-ol                                      |                                                      | C <sub>5</sub> H <sub>8</sub> O                                 | 922-65-6   | 84.117   |                        |         | 115.5                    | 0.860 <sup>23</sup>        | 1.4400 <sup>17</sup>  |                                                         |
| 8570 | 1,3-Pentadiyne                                          | Methyldiacetylene                                    | C <sub>5</sub> H <sub>4</sub>                                   | 4911-55-1  | 64.086   | liq                    | -38.5   | 55                       | 0.7909 <sup>20</sup>       | 1.4431 <sup>21</sup>  | i H <sub>2</sub> O; s eth, bz, chl                      |
| 8571 | Pentaerythritol                                         |                                                      | C <sub>5</sub> H <sub>12</sub> O <sub>4</sub>                   | 115-77-5   | 136.147  | cry (dil HCl)          | 258     | sub                      |                            | 1.548                 | s H <sub>2</sub> O; i eth, bz                           |
| 8572 | Pentaerythritol tetraacetate                            | 2,2-Bis[(acetyloxy)methyl]-1,3-propanediol diacetate | C <sub>13</sub> H <sub>20</sub> O <sub>8</sub>                  | 597-71-7   | 304.293  | tetr nd (w, bz)        | 83.5    |                          | 1.273 <sup>18</sup>        |                       | s H <sub>2</sub> O; vs EtOH, eth                        |
| 8573 | Pentaerythritol tetrakis(2-mercaptoacetate)             |                                                      | C <sub>13</sub> H <sub>20</sub> O <sub>8</sub> S <sub>4</sub>   | 10193-99-4 | 432.553  | liq                    |         | 250 <sup>1</sup>         | 1.385 <sup>25</sup>        | 1.5470 <sup>20</sup>  |                                                         |
| 8574 | Pentaerythritol tetramethacrylate                       | Tetramethylolmethane tetramethacrylate               | C <sub>21</sub> H <sub>28</sub> O <sub>8</sub>                  | 3253-41-6  | 408.442  |                        | 53.5    |                          |                            |                       |                                                         |
| 8575 | Pentaerythritol tetranitrate                            |                                                      | C <sub>5</sub> H <sub>8</sub> N <sub>4</sub> O <sub>12</sub>    | 78-11-5    | 316.138  | tetr (ace) pr (ace-al) | 140.5   |                          | 1.773 <sup>20</sup>        |                       | sl H <sub>2</sub> O, EtOH, eth; vs ace; s bz, py        |
| 8576 | Pentaethylbenzene                                       |                                                      | C <sub>16</sub> H <sub>26</sub>                                 | 605-01-6   | 218.377  |                        | <-20    | 277                      | 0.8971 <sup>19</sup>       | 1.5127 <sup>20</sup>  |                                                         |
| 8577 | Pentaethyl tantalate                                    | Ethanol, tantalum(5+) salt                           | C <sub>10</sub> H <sub>25</sub> O <sub>5</sub> Ta               | 6074-84-6  | 406.251  |                        |         | 151 <sup>1</sup>         |                            |                       |                                                         |
| 8578 | 2,3,4,5,6-Pentafluoroaniline                            |                                                      | C <sub>6</sub> H <sub>2</sub> F <sub>5</sub> N                  | 771-60-8   | 183.079  |                        | 34      | 153.5                    |                            |                       |                                                         |
| 8579 | Pentafluorobenzaldehyde                                 |                                                      | C <sub>7</sub> HF <sub>5</sub> O                                | 653-37-2   | 196.074  |                        | 20      | 167                      |                            | 1.4506 <sup>20</sup>  |                                                         |
| 8580 | Pentafluorobenzene                                      |                                                      | C <sub>6</sub> HF <sub>5</sub>                                  | 363-72-4   | 168.064  | liq                    | -47.4   | 85.74                    | 1.514 <sup>25</sup>        | 1.3905 <sup>20</sup>  |                                                         |
| 8581 | Pentafluorobenzenethiol                                 |                                                      | C <sub>6</sub> HF <sub>5</sub> S                                | 771-62-0   | 200.129  | liq                    | -24     | 143                      | 1.501 <sup>25</sup>        | 1.4645 <sup>20</sup>  |                                                         |
| 8582 | Pentafluorobenzoic acid                                 |                                                      | C <sub>7</sub> HF <sub>5</sub> O <sub>2</sub>                   | 602-94-8   | 212.074  |                        | 101     | 220                      |                            |                       |                                                         |
| 8583 | Pentafluorobenzonitrile                                 |                                                      | C <sub>7</sub> F <sub>5</sub> N                                 | 773-82-0   | 193.074  |                        | 1.2     | 162                      | 1.563 <sup>20</sup>        | 1.4402 <sup>25</sup>  |                                                         |
| 8584 | Pentafluoroethane                                       |                                                      | C <sub>2</sub> HF <sub>5</sub>                                  | 354-33-6   | 120.021  | col gas                | -100.6  | -48.1                    |                            |                       |                                                         |
| 8585 | Pentafluoriodobenzene                                   |                                                      | C <sub>6</sub> F <sub>5</sub> I                                 | 827-15-6   | 293.960  | liq                    | -29     | 166                      | 2.212 <sup>20</sup>        | 1.4950 <sup>25</sup>  |                                                         |
| 8586 | Pentafluoromethoxybenzene                               | Methyl pentafluorophenyl ether                       | C <sub>7</sub> H <sub>2</sub> F <sub>6</sub> O                  | 389-40-2   | 198.090  | liq                    | -37     | 138.5                    | 1.493 <sup>20</sup>        | 1.4087 <sup>20</sup>  |                                                         |
| 8587 | Pentafluorophenol                                       |                                                      | C <sub>6</sub> HF <sub>5</sub> O                                | 771-61-9   | 184.063  |                        | 37.5    | 145.6                    |                            | 1.4263 <sup>20</sup>  |                                                         |
| 8588 | 1,1,1,2,2-Pentafluoropropane                            | Refrigerant 245cb                                    | C <sub>3</sub> H <sub>2</sub> F <sub>5</sub>                    | 1814-88-6  | 134.048  | col gas                |         | -17.4                    |                            |                       |                                                         |
| 8589 | 2,2,3,3,3-Pentafluoro-1-propanol                        |                                                      | C <sub>3</sub> H <sub>2</sub> F <sub>5</sub> O                  | 422-05-9   | 150.047  |                        |         | 26 <sup>20</sup>         |                            |                       |                                                         |
| 8590 | 2,3,4,5,6-Pentafluorotoluene                            |                                                      | C <sub>7</sub> H <sub>2</sub> F <sub>5</sub>                    | 771-56-2   | 182.091  | liq                    | -29.78  | 117.5                    | 1.440 <sup>20</sup>        | 1.4016 <sup>25</sup>  |                                                         |
| 8591 | 1,1,2,4,4-Pentafluoro-3-(trifluoromethyl)-1,3-butadiene |                                                      | C <sub>5</sub> F <sub>8</sub>                                   | 384-04-3   | 212.041  |                        |         | 39                       | 1.527 <sup>0</sup>         | 1.3000 <sup>0</sup>   | vs ace, bz, eth                                         |
| 8592 | Pentagastrin                                            |                                                      | C <sub>37</sub> H <sub>49</sub> N <sub>7</sub> O <sub>9</sub> S | 5534-95-2  | 767.892  | col nd                 | 230 dec |                          |                            |                       | i H <sub>2</sub> O, bz, EtOH, eth                       |
| 8593 | <i>trans</i> -3,3',4',5,7-Pentahydroxyflavanone, (±)    | Taxifolin                                            | C <sub>15</sub> H <sub>12</sub> O <sub>7</sub>                  | 480-18-2   | 304.252  |                        | 227 dec |                          |                            |                       | s chl                                                   |
| 8594 | Pentamethonium bromide                                  |                                                      | C <sub>11</sub> H <sub>28</sub> Br <sub>2</sub> N <sub>2</sub>  | 541-20-8   | 348.161  |                        | 301     |                          |                            |                       | sl H <sub>2</sub> O                                     |
| 8595 | Pentamethylbenzene                                      |                                                      | C <sub>11</sub> H <sub>16</sub>                                 | 700-12-9   | 148.245  | pr (al)                | 54.5    | 232                      | 0.917 <sup>20</sup>        | 1.527 <sup>20</sup>   | i H <sub>2</sub> O; vs EtOH, bz; s chl                  |
| 8596 | 2,4,6,8,10-Pentamethylcyclopentasiloxane                |                                                      | C <sub>5</sub> H <sub>20</sub> O <sub>5</sub> Si <sub>5</sub>   | 6166-86-5  | 300.638  | liq                    | -108    | 169                      | 0.9985 <sup>20</sup>       | 1.3912 <sup>20</sup>  |                                                         |
| 8597 | 2,2,4,6,6-Pentamethylheptane                            |                                                      | C <sub>12</sub> H <sub>26</sub>                                 | 13475-82-6 | 170.334  | liq                    | -67     | 177.8                    | 0.7463 <sup>20</sup>       | 1.4440 <sup>20</sup>  |                                                         |
| 8598 | 2,2,4,6,6-Pentamethyl-3-heptene                         |                                                      | C <sub>12</sub> H <sub>24</sub>                                 | 123-48-8   | 168.319  | liq                    |         | 180.5                    |                            |                       |                                                         |
| 8599 | 2,2,3,3,4-Pentamethylpentane                            |                                                      | C <sub>10</sub> H <sub>22</sub>                                 | 16747-44-7 | 142.282  | liq                    | -36.4   | 166.1                    | 0.7767 <sup>25</sup>       | 1.4361 <sup>20</sup>  |                                                         |
| 8600 | 2,2,3,4,4-Pentamethylpentane                            |                                                      | C <sub>10</sub> H <sub>22</sub>                                 | 16747-45-8 | 142.282  | liq                    | -38.7   | 159.3                    | 0.7636 <sup>25</sup>       | 1.4307 <sup>20</sup>  |                                                         |
| 8601 | Pentamethylphenol                                       |                                                      | C <sub>11</sub> H <sub>16</sub> O                               | 2819-86-5  | 164.244  | nd (al, peth, ace)     | 128     | 267                      |                            |                       | i H <sub>2</sub> O; s EtOH                              |
| 8602 | 1,2,2,6,6-Pentamethylpiperidine                         | Pempidine                                            | C <sub>10</sub> H <sub>21</sub> N                               | 79-55-0    | 155.281  |                        |         | 147                      | 0.8580 <sup>0</sup>        | 1.4550 <sup>21</sup>  |                                                         |
| 8603 | Pentamethylsilanamine                                   |                                                      | C <sub>5</sub> H <sub>15</sub> NSi                              | 2083-91-2  | 117.266  |                        |         | 86                       | 0.7400 <sup>20</sup>       | 1.4379 <sup>24</sup>  |                                                         |
| 8604 | Pentanal                                                | Valeraldehyde                                        | C <sub>5</sub> H <sub>10</sub> O                                | 110-62-3   | 86.132   | liq                    | -91.5   | 103                      | 0.8095 <sup>20</sup>       | 1.3944 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth                        |
| 8605 | Pentanamide                                             |                                                      | C <sub>5</sub> H <sub>11</sub> NO                               | 626-97-1   | 101.147  | mcl pl (peth, al)      | 106     | 225                      | 0.8735 <sup>110</sup>      | 1.4183 <sup>110</sup> | vs H <sub>2</sub> O, EtOH, eth; sl chl                  |
| 8606 | 3-Pentanamine                                           |                                                      | C <sub>5</sub> H <sub>13</sub> N                                | 616-24-0   | 87.164   |                        |         | 89                       | 0.7487 <sup>20</sup>       | 1.4063 <sup>20</sup>  | s EtOH; sl chl                                          |
| 8607 | Pentane                                                 |                                                      | C <sub>5</sub> H <sub>12</sub>                                  | 109-66-0   | 72.149   | liq                    | -129.67 | 36.06                    | 0.6262 <sup>20</sup>       | 1.3575 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth, ace, bz, chl; s ctc |
| 8608 | Pentanedial                                             | Glutaraldehyde                                       | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                    | 111-30-8   | 100.117  |                        |         | dec 188                  |                            |                       | msc H <sub>2</sub> O, EtOH; s bz                        |
| 8609 | 1,5-Pentanediamine                                      | Cadaverine                                           | C <sub>5</sub> H <sub>14</sub> N <sub>2</sub>                   | 462-94-2   | 102.178  |                        | 11.83   | 179                      | 0.873 <sup>25</sup>        | 1.463 <sup>20</sup>   | s H <sub>2</sub> O, EtOH; sl eth                        |
| 8610 | Pentanedinitrile                                        | Glutaronitrile                                       | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                    | 544-13-8   | 94.115   | liq                    | -29     | 286                      | 0.9911 <sup>15</sup>       | 1.4295 <sup>20</sup>  | vs EtOH, chl                                            |
| 8611 | 1,2-Pentanediol, (±)                                    |                                                      | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                   | 91049-43-3 | 104.148  |                        |         | 209                      | 0.9723 <sup>20</sup>       | 1.4397 <sup>19</sup>  |                                                         |
| 8612 | 1,4-Pentanediol                                         |                                                      | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                   | 626-95-9   | 104.148  |                        |         | 202; 125 <sup>10</sup>   | 0.9883 <sup>20</sup>       | 1.4452 <sup>23</sup>  | vs H <sub>2</sub> O, EtOH, chl                          |
| 8613 | 1,5-Pentanediol                                         | Pentamethylene glycol                                | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                   | 111-29-5   | 104.148  | liq                    | -18     | 239                      | 0.9914 <sup>20</sup>       | 1.4494 <sup>20</sup>  | s H <sub>2</sub> O, EtOH; sl eth, bz                    |
| 8614 | 2,3-Pentanediol                                         |                                                      | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                   | 42027-23-6 | 104.148  |                        |         | 187.5; 100 <sup>17</sup> | 0.9798 <sup>19</sup>       | 1.4412 <sup>25</sup>  | s H <sub>2</sub> O, EtOH; sl eth                        |
| 8615 | 2,4-Pentanediol                                         | 2,4-Amylene glycol                                   | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                   | 625-69-4   | 104.148  |                        |         | 199; 97 <sup>13</sup>    | 0.9635 <sup>20</sup>       | 1.4349 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH                               |

1,4-Pentadiene



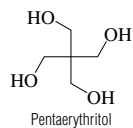
2,3-Pentadiene



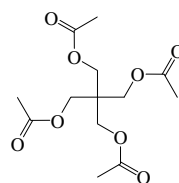
1,4-Pentadien-3-ol



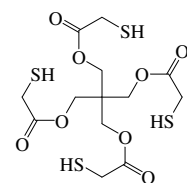
1,3-Pentadiyne



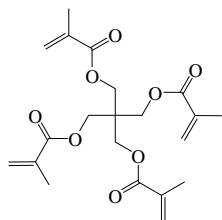
Pentaerythritol



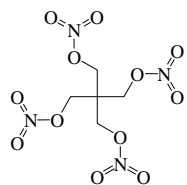
Pentaerythritol tetraacetate



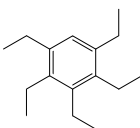
Pentaerythritol tetrakis(2-mercaptoacetate)



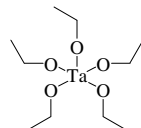
Pentaerythritol tetramethacrylate



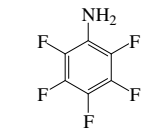
Pentaerythritol tetranitrate



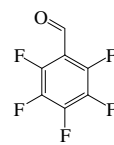
Pentaethylbenzene



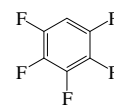
Pentaethyl tantalate



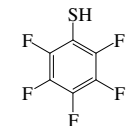
2,3,4,5,6-Pentafluoroaniline



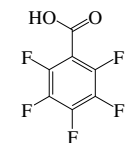
Pentafluorobenzaldehyde



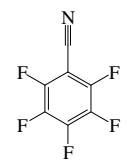
Pentafluorobenzene



Pentafluorobenzenethiol



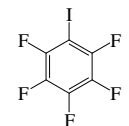
Pentafluorobenzoic acid



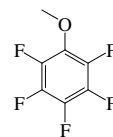
Pentafluorobenzonitrile



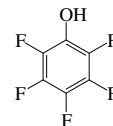
Pentafluoroethane



Pentafluoriodobenzene



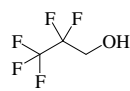
Pentafluoromethoxybenzene



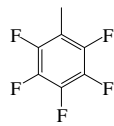
Pentafluorophenol



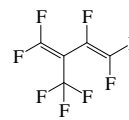
1,1,1,2,2-Pentafluoropropane



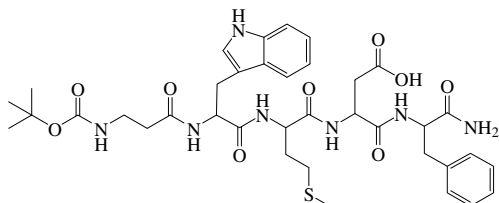
2,2,3,3,3-Pentafluoro-1-propanol



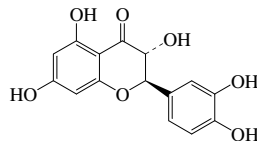
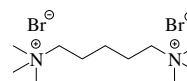
2,3,4,5,6-Pentafluorotoluene



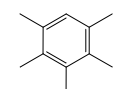
1,1,2,4,4-Pentafluoro-3-(trifluoromethyl)-1,3-butadiene



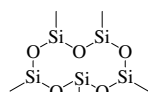
Pentagastrin

*trans*-3,3',4',5,7-Pentahydroxyflavanone, (±)

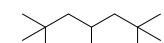
Pentamethonium bromide



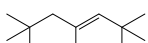
Pentamethylbenzene



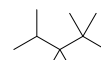
2,4,6,8,10-Pentamethylcyclopentasiloxane



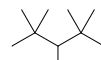
2,2,4,6,6-Pentamethylheptane



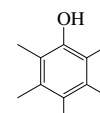
2,2,4,6,6-Pentamethyl-3-heptene



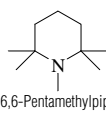
2,2,3,3,4-Pentamethylpentane



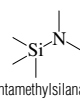
2,2,3,4,4-Pentamethylpentane



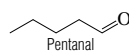
Pentamethylphenol



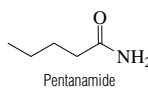
1,2,2,6,6-Pentamethylpiperidine



Pentamethylsilamine



Pentanal



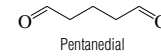
Pentanamide



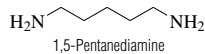
3-Pentanamine



Pentane



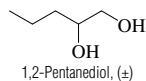
Pentanedial



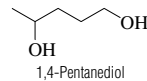
1,5-Pentanediamine



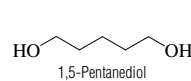
Pentanedinitrile



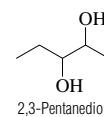
1,2-Pentandiol, (±)



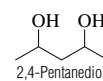
1,4-Pentandiol



1,5-Pentandiol

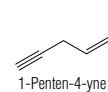
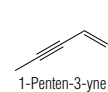
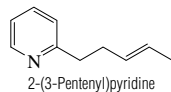
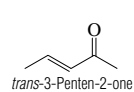
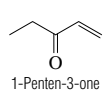
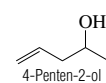
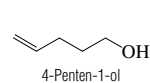
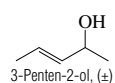
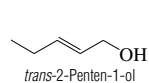
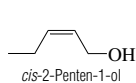
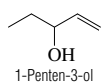
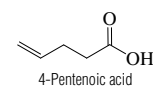
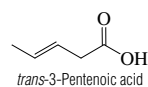
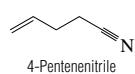
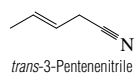
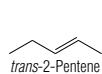
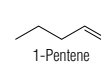
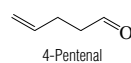
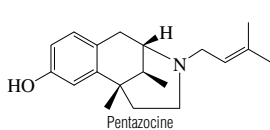
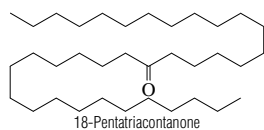
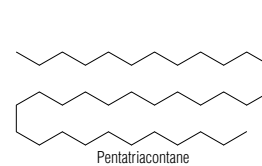
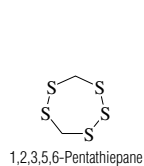
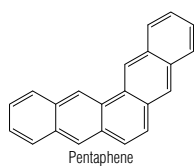
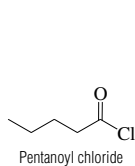
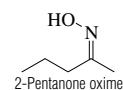
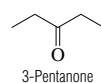
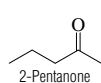
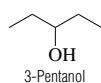
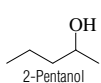
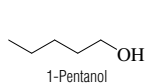
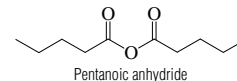
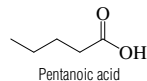
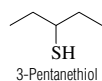
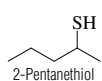
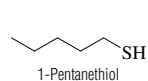
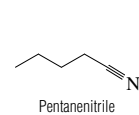
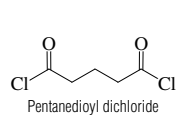
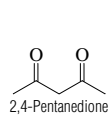
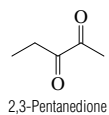
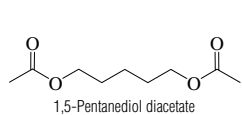


2,3-Pentandiol

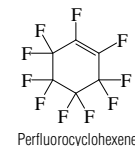
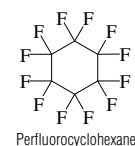
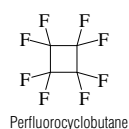
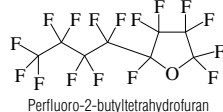
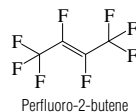
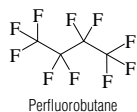
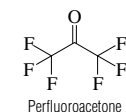
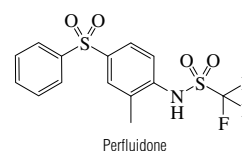
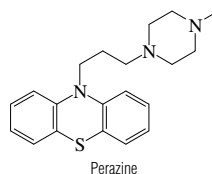
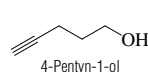
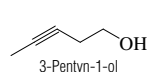
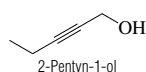
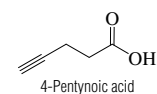
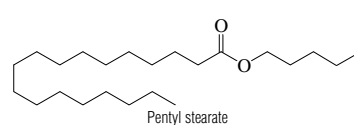
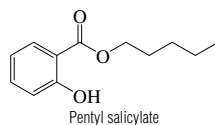
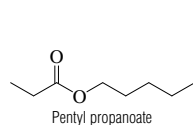
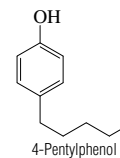
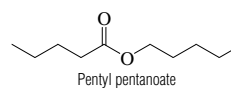
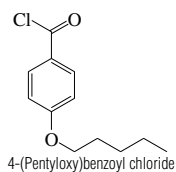
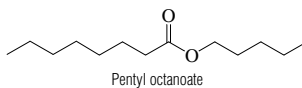
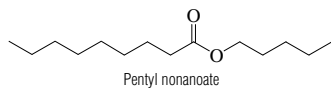
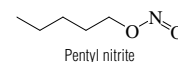
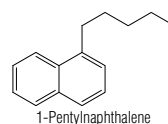
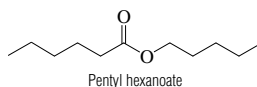
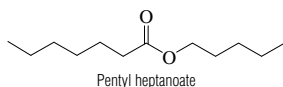
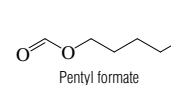
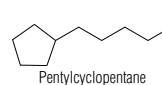
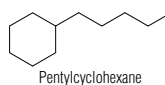
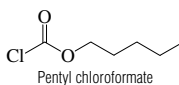
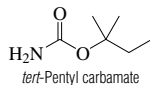
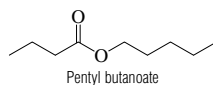
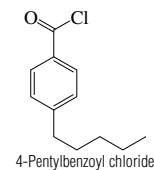
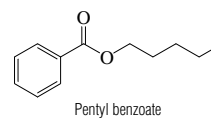
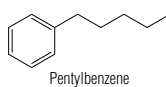
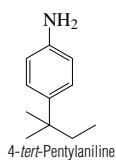
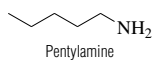
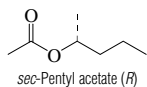
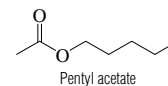
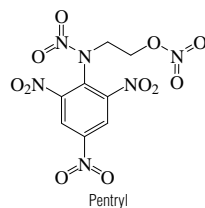
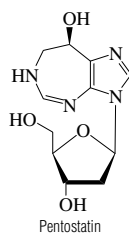
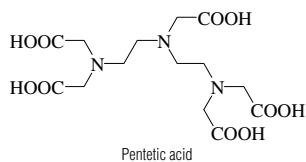
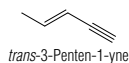
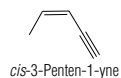


2,4-Pentandiol

| No.  | Name                      | Synonym                    | Mol. Form.                                                   | CAS RN     | Mol. Wt. | Physical Form    | mp/°C   | bp/°C                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|---------------------------|----------------------------|--------------------------------------------------------------|------------|----------|------------------|---------|-------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 8616 | 1,5-Pentanediol diacetate | Pentamethylene acetate     | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                | 6963-44-6  | 188.221  |                  | 2       | 241; 123 <sup>3</sup>   | 1.0296 <sup>20</sup>       | 1.4261 <sup>19</sup> |                                                            |
| 8617 | 2,3-Pentanedione          | Acetylpropionyl            | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | 600-14-6   | 100.117  | dk ye liq        |         | 108                     | 0.9565 <sup>19</sup>       | 1.4014 <sup>19</sup> | s H <sub>2</sub> O; msc<br>EtOH, eth, ace                  |
| 8618 | 2,4-Pentanedione          | Acetylacetone              | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | 123-54-6   | 100.117  | liq              | -23     | 138                     | 0.9721 <sup>25</sup>       | 1.4494 <sup>20</sup> | vs H <sub>2</sub> O; msc<br>EtOH, eth, ace,<br>chl         |
| 8619 | Pentanedioyl dichloride   |                            | C <sub>5</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub> | 2873-74-7  | 169.006  |                  |         | 217                     | 1.324 <sup>20</sup>        | 1.4728 <sup>20</sup> | s eth; sl chl                                              |
| 8620 | Pentanenitrile            | Valeronitrile              | C <sub>5</sub> H <sub>9</sub> N                              | 110-59-8   | 83.132   | liq              | -96.2   | 141.3                   | 0.8008 <sup>20</sup>       | 1.3971 <sup>20</sup> | s eth, ace, bz; sl<br>ctc                                  |
| 8621 | 1-Pentanethiol            | Pentyl mercaptan           | C <sub>5</sub> H <sub>12</sub> S                             | 110-66-7   | 104.214  | liq              | -75.65  | 126.6                   | 0.850 <sup>20</sup>        | 1.4469 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                       |
| 8622 | 2-Pentanethiol            | sec-Pentyl mercaptan       | C <sub>5</sub> H <sub>12</sub> S                             | 2084-19-7  | 104.214  | liq              | -169    | 112.9                   | 0.8327 <sup>20</sup>       | 1.4412 <sup>20</sup> | s EtOH, liq                                                |
| 8623 | 3-Pentanethiol            | 3-Pentyl mercaptan         | C <sub>5</sub> H <sub>12</sub> S                             | 616-31-9   | 104.214  | liq              | -110.8  | 105                     | 0.8410 <sup>20</sup>       | 1.4447 <sup>20</sup> | s EtOH; sl<br>DMSO                                         |
| 8624 | Pentanoic acid            | Valeric acid               | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | 109-52-4   | 102.132  | liq              | -33.6   | 186.1                   | 0.9339 <sup>25</sup>       | 1.4085 <sup>20</sup> | s H <sub>2</sub> O, EtOH,<br>eth; sl ctc                   |
| 8625 | Pentanoic anhydride       |                            | C <sub>10</sub> H <sub>16</sub> O <sub>3</sub>               | 2082-59-9  | 186.248  | liq              | -56.1   | 227                     | 0.924 <sup>20</sup>        | 1.4171 <sup>26</sup> | vs eth, EtOH                                               |
| 8626 | 1-Pentanol                | Amyl alcohol               | C <sub>5</sub> H <sub>12</sub> O                             | 71-41-0    | 88.148   | liq              | -77.6   | 137.98                  | 0.8144 <sup>20</sup>       | 1.4101 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth; s<br>ace, chl       |
| 8627 | 2-Pentanol                | sec-Amyl alcohol           | C <sub>5</sub> H <sub>12</sub> O                             | 6032-29-7  | 88.148   | liq              | -73     | 119.3                   | 0.8094 <sup>20</sup>       | 1.4053 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth, ctc, chl              |
| 8628 | 3-Pentanol                | Diethyl carbinol           | C <sub>5</sub> H <sub>12</sub> O                             | 584-02-1   | 88.148   | liq              | -69     | 116.25                  | 0.8203 <sup>20</sup>       | 1.4104 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth, ace, ctc              |
| 8629 | 2-Pentanone               | Methyl propyl ketone       | C <sub>5</sub> H <sub>10</sub> O                             | 107-87-9   | 86.132   | liq              | -76.8   | 102.26                  | 0.809 <sup>20</sup>        | 1.3895 <sup>20</sup> | sl H <sub>2</sub> O, ctc; msc<br>EtOH, eth                 |
| 8630 | 3-Pentanone               | Diethyl ketone             | C <sub>5</sub> H <sub>10</sub> O                             | 96-22-0    | 86.132   | liq              | -39     | 101.7                   | 0.8098 <sup>25</sup>       | 1.3905 <sup>25</sup> | s H <sub>2</sub> O, ctc; msc<br>EtOH, eth                  |
| 8631 | 2-Pentanone oxime         | Methyl propyl ketone oxime | C <sub>5</sub> H <sub>11</sub> NO                            | 623-40-5   | 101.147  |                  |         | 168                     | 0.9095 <sup>20</sup>       | 1.4450 <sup>20</sup> | vs H <sub>2</sub> O, eth,<br>EtOH                          |
| 8632 | Pentanoyl chloride        | Valeroyl chloride          | C <sub>5</sub> H <sub>9</sub> ClO                            | 638-29-9   | 120.577  | liq              | -110    | 109                     | 1.0155 <sup>15</sup>       | 1.4200 <sup>20</sup> |                                                            |
| 8633 | Pentaphene                | 2,3,6,7-Dibenzphenanthrene | C <sub>22</sub> H <sub>14</sub>                              | 222-93-5   | 278.346  | ye grn li(xyl)   | 257     |                         |                            |                      | i H <sub>2</sub> O; sl EtOH,<br>xyl, eth; s bz             |
| 8634 | 1,2,3,5,6-Pentathiepane   | Lenthionine                | C <sub>5</sub> H <sub>6</sub> S <sub>5</sub>                 | 292-46-6   | 188.378  |                  | 60.5    |                         |                            |                      |                                                            |
| 8635 | Pentatriacontane          |                            | C <sub>35</sub> H <sub>72</sub>                              | 630-07-9   | 492.947  | cry (al)         | 74.6    | 490                     | 0.8157 <sup>20</sup>       | 1.4568 <sup>20</sup> | i H <sub>2</sub> O; sl eth; s<br>ace                       |
| 8636 | 18-Pentatriacontanone     |                            | C <sub>35</sub> H <sub>70</sub> O                            | 504-53-0   | 506.930  | lf (lig)         | 89.0    | 270 <sup>0.1</sup>      | 0.793 <sup>95</sup>        |                      | i H <sub>2</sub> O; sl EtOH,<br>eth, ace, bz,<br>lig, chl  |
| 8637 | Pentazocine               |                            | C <sub>19</sub> H <sub>27</sub> NO                           | 359-83-1   | 285.423  | cry (MeOH<br>aq) | 147     |                         |                            |                      |                                                            |
| 8638 | 4-Pentalenal              |                            | C <sub>9</sub> H <sub>8</sub> O                              | 2100-17-6  | 84.117   |                  |         | 99                      | 0.852 <sup>20</sup>        | 1.4191 <sup>20</sup> | i H <sub>2</sub> O; s eth, ace                             |
| 8639 | 1-Pentene                 | α-Amylene                  | C <sub>5</sub> H <sub>10</sub>                               | 109-67-1   | 70.133   | vol liq or gas   | -165.12 | 29.96                   | 0.6405 <sup>20</sup>       | 1.3715 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>bz; sl ctc      |
| 8640 | cis-2-Pentene             | cis-β-Amylene              | C <sub>5</sub> H <sub>10</sub>                               | 627-20-3   | 70.133   | liq              | -151.36 | 36.93                   | 0.6556 <sup>20</sup>       | 1.3830 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>bz, dil sulf    |
| 8641 | trans-2-Pentene           | trans-β-Amylene            | C <sub>5</sub> H <sub>10</sub>                               | 646-04-8   | 70.133   | liq              | -140.21 | 36.34                   | 0.6431 <sup>25</sup>       | 1.3793 <sup>20</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth; s<br>bz; vs dil sulf |
| 8642 | trans-3-Pentenitrile      |                            | C <sub>5</sub> H <sub>7</sub> N                              | 16529-66-1 | 81.117   | liq              |         | 144                     | 0.837                      | 1.4220 <sup>20</sup> |                                                            |
| 8643 | 4-Pentenitrile            |                            | C <sub>5</sub> H <sub>7</sub> N                              | 592-51-8   | 81.117   |                  |         | 140                     | 0.8239 <sup>24</sup>       | 1.4213 <sup>14</sup> | i H <sub>2</sub> O; msc<br>EtOH, eth                       |
| 8644 | trans-3-Pentenoic acid    |                            | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | 1617-32-9  | 100.117  |                  |         | 193.2                   | 0.989 <sup>19</sup>        |                      |                                                            |
| 8645 | 4-Pentenoic acid          | Allylacetic acid           | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | 591-80-0   | 100.117  | liq              | -22.5   | 188.5                   | 0.9809 <sup>20</sup>       | 1.4281 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH,<br>eth                       |
| 8646 | 1-Penten-3-ol             |                            | C <sub>5</sub> H <sub>10</sub> O                             | 616-25-1   | 86.132   |                  |         | 115                     | 0.839 <sup>20</sup>        | 1.4239 <sup>20</sup> | sl H <sub>2</sub> O; msc<br>EtOH, eth                      |
| 8647 | cis-2-Penten-1-ol         |                            | C <sub>5</sub> H <sub>10</sub> O                             | 1576-95-0  | 86.132   |                  |         | 138                     | 0.8529 <sup>20</sup>       | 1.4354 <sup>20</sup> | s EtOH, eth, ace                                           |
| 8648 | trans-2-Penten-1-ol       |                            | C <sub>5</sub> H <sub>10</sub> O                             | 1576-96-1  | 86.132   |                  |         | 138                     | 0.8471 <sup>20</sup>       | 1.4341 <sup>20</sup> | s EtOH, eth, ace                                           |
| 8649 | 3-Penten-2-ol, (±)        |                            | C <sub>5</sub> H <sub>10</sub> O                             | 42569-16-4 | 86.132   |                  |         | 121.6; 65 <sup>70</sup> | 0.8328 <sup>25</sup>       | 1.4280 <sup>20</sup> | vs ace, eth,<br>EtOH                                       |
| 8650 | 4-Penten-1-ol             |                            | C <sub>5</sub> H <sub>10</sub> O                             | 821-09-0   | 86.132   |                  |         | 141                     | 0.8457 <sup>20</sup>       | 1.4309 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s eth                            |
| 8651 | 4-Penten-2-ol             |                            | C <sub>5</sub> H <sub>10</sub> O                             | 625-31-0   | 86.132   |                  |         | 116                     | 0.8367 <sup>20</sup>       | 1.4225 <sup>20</sup> | vs H <sub>2</sub> O; msc<br>EtOH, eth                      |
| 8652 | 1-Penten-3-one            | Ethyl vinyl ketone         | C <sub>5</sub> H <sub>8</sub> O                              | 1629-58-9  | 84.117   |                  |         | 103; 44 <sup>90</sup>   | 0.8468 <sup>20</sup>       | 1.4195 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace, bz,<br>chl        |
| 8653 | trans-3-Penten-2-one      |                            | C <sub>5</sub> H <sub>8</sub> O                              | 3102-33-8  | 84.117   |                  |         | 122                     | 0.8624 <sup>20</sup>       | 1.4350 <sup>20</sup> | s H <sub>2</sub> O, eth, ace,<br>ctc                       |
| 8654 | 2-(3-Pentenyl)pyridine    |                            | C <sub>10</sub> H <sub>13</sub> N                            | 2057-43-4  | 147.217  |                  |         | 216; 93 <sup>12</sup>   | 0.9234 <sup>25</sup>       | 1.5076 <sup>25</sup> |                                                            |
| 8655 | 1-Penten-3-yne            | Methylvinylacetylene       | C <sub>5</sub> H <sub>6</sub>                                | 646-05-9   | 66.102   |                  |         | 59.5                    | 0.7401 <sup>20</sup>       | 1.4496 <sup>20</sup> | vs bz, eth                                                 |
| 8656 | 1-Penten-4-yne            |                            | C <sub>5</sub> H <sub>6</sub>                                | 871-28-3   | 66.102   |                  |         | 42.5                    | 0.738 <sup>16</sup>        | 1.4125 <sup>16</sup> | i H <sub>2</sub> O; s eth, bz                              |

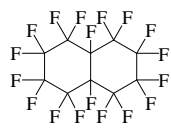


| No.  | Name                                    | Synonym                                                           | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form    | mp/°C               | bp/°C                                 | den/<br>g cm <sup>-3</sup>    | n <sub>D</sub>       | Solubility                                              |
|------|-----------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|------------------|---------------------|---------------------------------------|-------------------------------|----------------------|---------------------------------------------------------|
| 8657 | <i>cis</i> -3-Penten-1-yne              |                                                                   | C <sub>5</sub> H <sub>6</sub>                                                | 1574-40-9  | 66.102   |                  |                     | 44.6                                  |                               |                      |                                                         |
| 8658 | <i>trans</i> -3-Penten-1-yne            |                                                                   | C <sub>5</sub> H <sub>6</sub>                                                | 2004-69-5  | 66.102   |                  |                     | 52.2                                  |                               |                      |                                                         |
| 8659 | Pentetic acid                           | Diethylenetriaminepentaacetic acid                                | C <sub>14</sub> H <sub>23</sub> N <sub>3</sub> O <sub>10</sub>               | 67-43-6    | 393.347  | cry (w)          | 219                 |                                       |                               |                      | s H <sub>2</sub> O, alk                                 |
| 8660 | Pentostatin                             |                                                                   | C <sub>11</sub> H <sub>18</sub> N <sub>4</sub> O <sub>4</sub>                | 53910-25-1 | 268.270  | wh cry (MeOH aq) | 222                 |                                       |                               |                      |                                                         |
| 8661 | Pentryl                                 | 2-(N,2,4,6-Tetranitroanilino) ethanol                             | C <sub>8</sub> H <sub>6</sub> N <sub>6</sub> O <sub>11</sub>                 | 4481-55-4  | 362.167  | wh-ye cry        | 129                 |                                       | 1.82                          |                      | i H <sub>2</sub> O, ctc; s chl; vs eth, bz              |
| 8662 | Pentyl acetate                          | Amyl acetate                                                      | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                                | 628-63-7   | 130.185  | liq              | -70.8               | 149.2                                 | 0.8756 <sup>20</sup>          | 1.4023 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ctc               |
| 8663 | <i>sec</i> -Pentyl acetate ( <i>R</i> ) | <i>sec</i> -Amyl acetate ( <i>R</i> )                             | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                                | 54638-10-7 | 130.185  |                  |                     | 142                                   | 0.8803 <sup>18</sup>          | 1.4012 <sup>20</sup> | vs eth, EtOH                                            |
| 8664 | Pentylamine                             | Amylamine                                                         | C <sub>6</sub> H <sub>13</sub> N                                             | 110-58-7   | 87.164   | liq              | -55                 | 104.3                                 | 0.7544 <sup>20</sup>          | 1.448 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH, eth; vs ace, bz; sl chl     |
| 8665 | 4- <i>tert</i> -Pentylaniline           |                                                                   | C <sub>11</sub> H <sub>17</sub> N                                            | 2049-92-5  | 163.260  |                  |                     | 260.5                                 |                               |                      |                                                         |
| 8666 | Pentylbenzene                           | Amylbenzene                                                       | C <sub>11</sub> H <sub>16</sub>                                              | 538-68-1   | 148.245  | liq              | -75                 | 205.4                                 | 0.8585 <sup>20</sup>          | 1.4878 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc   |
| 8667 | Pentyl benzoate                         |                                                                   | C <sub>12</sub> H <sub>16</sub> O <sub>2</sub>                               | 2049-96-9  | 192.254  |                  |                     | 137 <sup>15</sup>                     |                               |                      |                                                         |
| 8668 | 4-Pentylbenzoyl chloride                |                                                                   | C <sub>12</sub> H <sub>15</sub> ClO                                          | 49763-65-7 | 210.699  |                  |                     | 144 <sup>10</sup> , 121 <sup>8</sup>  | 1.036 <sup>25</sup>           | 1.5300 <sup>20</sup> |                                                         |
| 8669 | Pentyl butanoate                        | Amyl butyrate                                                     | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                                | 540-18-1   | 158.238  | liq              | -73.2               | 186.4                                 | 0.8713 <sup>15</sup>          | 1.4123 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                        |
| 8670 | <i>tert</i> -Pentyl carbamate           | <i>tert</i> -Amyl carbamate                                       | C <sub>8</sub> H <sub>13</sub> NO <sub>2</sub>                               | 590-60-3   | 131.173  | nd (dil al)      | 86                  |                                       |                               |                      | vs ace, bz                                              |
| 8671 | Pentyl chloroformate                    |                                                                   | C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>                              | 638-41-5   | 150.603  |                  |                     | 61 <sup>15</sup>                      |                               | 1.4181 <sup>18</sup> | s eth                                                   |
| 8672 | Pentylcyclohexane                       |                                                                   | C <sub>11</sub> H <sub>22</sub>                                              | 4292-92-6  | 154.293  | liq              | -57.5               | 203.7                                 | 0.8037 <sup>20</sup>          | 1.4437 <sup>20</sup> | vs ace, bz, eth, EtOH                                   |
| 8673 | Pentylcyclopentane                      |                                                                   | C <sub>10</sub> H <sub>20</sub>                                              | 3741-00-2  | 140.266  | liq              | -83                 | 180                                   | 0.7912 <sup>20</sup>          | 1.4356 <sup>20</sup> | i H <sub>2</sub> O; vs ace, bz, eth, EtOH               |
| 8674 | Pentyl formate                          | Amyl formate                                                      | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                                | 638-49-3   | 116.158  | liq              | -73.5               | 130.4                                 | 0.8853 <sup>20</sup>          | 1.3992 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                      |
| 8675 | Pentyl heptanoate                       | Amyl enanthate                                                    | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                               | 7493-82-5  | 200.318  | liq              | -50                 | 245.4                                 | 0.8623 <sup>20</sup>          | 1.4263 <sup>15</sup> | vs ace, bz, eth, EtOH                                   |
| 8676 | Pentyl hexanoate                        | Amyl caproate                                                     | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                               | 540-07-8   | 186.292  | liq              | -47                 | 226                                   | 0.8612 <sup>25</sup>          | 1.4202 <sup>25</sup> | s EtOH, eth, ace; sl ctc                                |
| 8677 | 1-Pentyl naphthalene                    |                                                                   | C <sub>15</sub> H <sub>18</sub>                                              | 86-89-5    | 198.304  | liq              | -22                 | 307                                   | 0.9656 <sup>20</sup>          | 1.5725 <sup>20</sup> |                                                         |
| 8678 | Pentyl nitrite                          | Amyl nitrite                                                      | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                               | 463-04-7   | 117.147  |                  |                     | 104.5                                 | 0.8817 <sup>20</sup>          | 1.3851 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                      |
| 8679 | Pentyl nonanoate                        | Pentyl pelargonate                                                | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                               | 61531-45-1 | 228.371  |                  | -27                 | 131 <sup>20</sup>                     | 0.8506 <sup>25</sup>          | 1.4318 <sup>20</sup> |                                                         |
| 8680 | Pentyl octanoate                        | Amyl octanoate                                                    | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                               | 638-25-5   | 214.344  | liq              | -34.8               | 260.2                                 | 0.8613 <sup>20</sup>          | 1.4262 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, ace                    |
| 8681 | 4-(Pentyloxy)benzoyl chloride           |                                                                   | C <sub>12</sub> H <sub>15</sub> ClO <sub>2</sub>                             | 36823-84-4 | 226.699  |                  |                     | 198 <sup>30</sup> , 182 <sup>25</sup> | 1.087 <sup>25</sup>           | 1.5434 <sup>20</sup> |                                                         |
| 8682 | Pentyl pentanoate                       |                                                                   | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                               | 2173-56-0  | 172.265  | liq              | -78.8               | 203.7                                 | 0.8638 <sup>20</sup>          | 1.4164 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                      |
| 8683 | 4-Pentylphenol                          |                                                                   | C <sub>11</sub> H <sub>16</sub> O                                            | 14938-35-3 | 164.244  |                  | 23                  | 250.5                                 | 0.960 <sup>20</sup>           | 1.5272 <sup>25</sup> | vs eth, EtOH                                            |
| 8684 | Pentyl propanoate                       |                                                                   | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                                | 624-54-4   | 144.212  | liq              | -73.1               | 168.6                                 | 0.8761 <sup>25</sup>          | 1.4096 <sup>15</sup> | i H <sub>2</sub> O; msc EtOH, eth; s bz; sl ctc         |
| 8685 | Pentyl salicylate                       |                                                                   | C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>                               | 2050-08-0  | 208.253  |                  |                     | 270                                   | 1.064 <sup>15</sup>           | 1.506 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth                      |
| 8686 | Pentyl stearate                         |                                                                   | C <sub>23</sub> H <sub>46</sub> O <sub>2</sub>                               | 6382-13-4  | 354.610  | pl               | 30                  |                                       |                               | 1.4342 <sup>20</sup> | vs eth, EtOH                                            |
| 8687 | 1-Pentyne                               | Propylacetylene                                                   | C <sub>5</sub> H <sub>8</sub>                                                | 627-19-0   | 68.118   | liq              | -90                 | 40.1                                  | 0.6901 <sup>20</sup>          | 1.3852 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth; s bz, chl; sl ctc |
| 8688 | 2-Pentyne                               |                                                                   | C <sub>5</sub> H <sub>8</sub>                                                | 627-21-4   | 68.118   | liq              | -109.3              | 56.1                                  | 0.7058 <sup>25</sup>          | 1.4039 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth; s bz, chl         |
| 8689 | 4-Pentynoic acid                        | Propargylacetic acid                                              | C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                                 | 6089-09-4  | 98.101   |                  | 57.7                | 110 <sup>30</sup> , 102 <sup>17</sup> |                               |                      | vs eth, EtOH                                            |
| 8690 | 2-Pentyn-1-ol                           |                                                                   | C <sub>5</sub> H <sub>8</sub> O                                              | 6261-22-9  | 84.117   | liq              | -49.7               | 154; 61 <sup>15</sup>                 | 0.909 <sup>20</sup>           | 1.4518 <sup>17</sup> |                                                         |
| 8691 | 3-Pentyn-1-ol                           |                                                                   | C <sub>5</sub> H <sub>8</sub> O                                              | 10229-10-4 | 84.117   |                  |                     | 154                                   | 0.9002 <sup>20</sup>          | 1.4454 <sup>20</sup> |                                                         |
| 8692 | 4-Pentyn-1-ol                           |                                                                   | C <sub>5</sub> H <sub>8</sub> O                                              | 5390-04-5  | 84.117   |                  |                     | 154                                   | 0.913 <sup>20</sup>           | 1.4414 <sup>20</sup> |                                                         |
| 8693 | Perazine                                | 10-[3-(4-Methyl-1-piperazinyl) propyl]-10 <i>H</i> -phenothiazine | C <sub>20</sub> H <sub>25</sub> N <sub>3</sub> S                             | 84-97-9    | 339.498  | cry              | 52                  | 165 <sup>0.001</sup>                  |                               |                      |                                                         |
| 8694 | Perfluoridone                           |                                                                   | C <sub>4</sub> H <sub>12</sub> F <sub>3</sub> NO <sub>4</sub> S <sub>2</sub> | 37924-13-3 | 379.375  |                  | 143                 |                                       |                               |                      |                                                         |
| 8695 | Perfluoroacetone                        | Hexafluoroacetone                                                 | C <sub>2</sub> F <sub>6</sub> O                                              | 684-16-2   | 166.021  | col gas          | -125.45             | -27.4                                 |                               |                      |                                                         |
| 8696 | Perfluorobutane                         | Decafluorobutane                                                  | C <sub>4</sub> F <sub>10</sub>                                               | 355-25-9   | 238.027  | col gas          | -129.1              | -1.9                                  | 1.6484 <sup>25</sup>          |                      | s bz, chl                                               |
| 8697 | Perfluoro-2-butene                      |                                                                   | C <sub>4</sub> F <sub>8</sub>                                                | 360-89-4   | 200.030  | col gas          | -129                | 1.5                                   | 1.5297 <sup>25</sup>          |                      |                                                         |
| 8698 | Perfluoro-2-butyltetrahydrofuran        |                                                                   | C <sub>8</sub> F <sub>16</sub> O                                             | 335-36-4   | 416.059  |                  |                     | 102.6                                 |                               |                      |                                                         |
| 8699 | Perfluorocyclobutane                    | Octafluorocyclobutane                                             | C <sub>4</sub> F <sub>8</sub>                                                | 115-25-3   | 200.030  | col gas          | -40.19              | -5.91                                 | 1.500 <sup>25</sup> (p>1 atm) |                      | i H <sub>2</sub> O; s eth                               |
| 8700 | Perfluorocyclohexane                    |                                                                   | C <sub>6</sub> F <sub>12</sub>                                               | 355-68-0   | 300.045  |                  | 62.5 (triple point) | 52.8 sp                               |                               |                      |                                                         |
| 8701 | Perfluorocyclohexene                    |                                                                   | C <sub>6</sub> F <sub>10</sub>                                               | 355-75-9   | 262.048  |                  |                     | 52.0                                  | 1.6650 <sup>25</sup>          | 1.293 <sup>20</sup>  |                                                         |

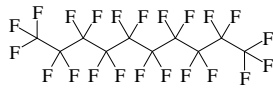




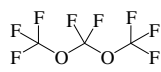
| No.  | Name                                      | Synonym                                                                   | Mol. Form.                                                       | CAS RN      | Mol. Wt. | Physical Form                  | mp/°C     | bp/°C               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                     |
|------|-------------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------|-------------|----------|--------------------------------|-----------|---------------------|----------------------------|----------------------|----------------------------------------------------------------|
| 8702 | Perfluorodecalin                          |                                                                           | C <sub>10</sub> F <sub>18</sub>                                  | 306-94-5    | 462.078  | liq                            | -10       | 142.02              | 1.9305 <sup>25</sup>       |                      |                                                                |
| 8703 | Perfluorodecane                           |                                                                           | C <sub>10</sub> F <sub>22</sub>                                  | 307-45-9    | 538.072  |                                |           | 144.2               |                            |                      | i H <sub>2</sub> O                                             |
| 8704 | Perfluorodimethoxymethane                 |                                                                           | C <sub>2</sub> F <sub>8</sub> O <sub>2</sub>                     | 53772-78-4  | 220.018  | col gas                        | -161      | -10                 |                            |                      |                                                                |
| 8705 | Perfluoro-2,3-dimethylbutane              |                                                                           | C <sub>6</sub> F <sub>14</sub>                                   | 354-96-1    | 338.042  | liq                            | -15       | 59.8                |                            |                      |                                                                |
| 8706 | Perfluoroethyl ethyl ether                |                                                                           | C <sub>4</sub> H <sub>4</sub> F <sub>8</sub> O                   | 22052-81-9  | 164.074  | vol liq or gas                 |           | 28.11               |                            |                      |                                                                |
| 8707 | Perfluoroethyl 2,2,2-trifluoroethyl ether |                                                                           | C <sub>4</sub> H <sub>2</sub> F <sub>8</sub> O                   | 156053-88-2 | 218.045  | vol liq or gas                 |           | 27.89               |                            |                      |                                                                |
| 8708 | Perfluoroheptane                          |                                                                           | C <sub>7</sub> F <sub>16</sub>                                   | 335-57-9    | 388.049  | liq                            | -51.2     | 82.5                | 1.7333 <sup>20</sup>       | 1.2618 <sup>20</sup> | i H <sub>2</sub> O; vs ace, eth, EtOH, chl                     |
| 8709 | Perfluoro-1-heptene                       |                                                                           | C <sub>7</sub> F <sub>14</sub>                                   | 355-63-5    | 350.053  |                                |           | 81.0                |                            |                      |                                                                |
| 8710 | Perfluorohexane                           |                                                                           | C <sub>6</sub> F <sub>14</sub>                                   | 355-42-0    | 338.042  | liq                            | -88.2     | 57.14               | 1.6910 <sup>20</sup>       | 1.2515 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl                             |
| 8711 | Perfluoro-1-hexene                        |                                                                           | C <sub>6</sub> F <sub>12</sub>                                   | 755-25-9    | 300.045  |                                |           | 57.0                |                            |                      | vs chl                                                         |
| 8712 | Perfluoroisobutane                        |                                                                           | C <sub>4</sub> F <sub>10</sub>                                   | 354-92-7    | 238.027  | col gas                        |           | 0                   |                            |                      |                                                                |
| 8713 | Perfluoroisobutene                        | Perfluoroisobutylene                                                      | C <sub>4</sub> F <sub>8</sub>                                    | 382-21-8    | 200.030  | col gas                        | -130      | 7                   | 1.5922 <sup>0</sup>        |                      |                                                                |
| 8714 | Perfluoroisopropyl methyl ether           |                                                                           | C <sub>7</sub> H <sub>3</sub> F <sub>7</sub> O                   | 22052-84-2  | 200.055  | vol liq or gas                 |           | 29.34               | 1.4205 <sup>20</sup>       |                      |                                                                |
| 8715 | Perfluoromethylcyclohexane                |                                                                           | C <sub>7</sub> F <sub>14</sub>                                   | 355-02-2    | 350.053  | liq                            | -44.7     | 76.3                | 1.7878 <sup>25</sup>       | 1.285 <sup>17</sup>  | s ace, bz, ctc, tol, AcOEt                                     |
| 8716 | Perfluoro-2-methylpentane                 |                                                                           | C <sub>6</sub> F <sub>14</sub>                                   | 355-04-4    | 338.042  |                                |           | 57.6                | 1.7326 <sup>20</sup>       | 1.2564 <sup>22</sup> | i H <sub>2</sub> O; s bz                                       |
| 8717 | Perfluoro-3-methylpentane                 |                                                                           | C <sub>6</sub> F <sub>14</sub>                                   | 865-71-4    | 338.042  | liq                            | -115      | 58.4                |                            |                      | s bz                                                           |
| 8718 | Perfluoronaphthalene                      |                                                                           | C <sub>10</sub> F <sub>8</sub>                                   | 313-72-4    | 272.094  |                                | 87.5      | 209                 |                            |                      |                                                                |
| 8719 | Perfluorononane                           |                                                                           | C <sub>9</sub> F <sub>20</sub>                                   | 375-96-2    | 488.064  |                                |           | 117.61              | 1.8001 <sup>20</sup>       |                      |                                                                |
| 8720 | Perfluorooctane                           |                                                                           | C <sub>8</sub> F <sub>18</sub>                                   | 307-34-6    | 438.057  |                                |           | 105.9               | 1.73 <sup>20</sup>         | 1.282 <sup>20</sup>  | i H <sub>2</sub> O                                             |
| 8721 | Perfluorooctylsulfonate fluoride          |                                                                           | C <sub>8</sub> F <sub>18</sub> O <sub>2</sub> S                  | 307-35-7    | 502.121  | liq                            |           | 154                 |                            |                      |                                                                |
| 8722 | Perfluorooxetane                          |                                                                           | C <sub>3</sub> F <sub>6</sub> O                                  | 425-82-1    | 166.021  | col gas                        | -117      | -28.4               |                            |                      |                                                                |
| 8723 | Perfluoropentane                          |                                                                           | C <sub>5</sub> F <sub>12</sub>                                   | 678-26-2    | 288.035  | vol liq or gas                 | -10       | 29.2                |                            |                      | i H <sub>2</sub> O                                             |
| 8724 | Perfluoropropane                          |                                                                           | C <sub>3</sub> F <sub>8</sub>                                    | 76-19-7     | 188.019  | col gas                        | -147.70   | -36.6               |                            |                      | i H <sub>2</sub> O                                             |
| 8725 | Perfluoropropene                          |                                                                           | C <sub>3</sub> F <sub>6</sub>                                    | 116-15-4    | 150.022  | col gas                        | -156.5    | -29.6               |                            | 1.583 <sup>-40</sup> | i H <sub>2</sub> O                                             |
| 8726 | Perfluoropropyl methyl ether              |                                                                           | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O                   | 375-03-1    | 200.055  |                                |           | 34.23               | 1.4092 <sup>20</sup>       |                      |                                                                |
| 8727 | Perfluoropyridine                         | Pentafluoropyridine                                                       | C <sub>5</sub> F <sub>5</sub> N                                  | 700-16-3    | 169.053  |                                |           | 83.7                |                            |                      |                                                                |
| 8728 | Perfluorotoluene                          |                                                                           | C <sub>7</sub> F <sub>8</sub>                                    | 434-64-0    | 236.062  | liq                            | -65.49    | 103.55              | 1.6616 <sup>25</sup>       | 1.3670 <sup>20</sup> |                                                                |
| 8729 | Perfluorotripropylamine                   |                                                                           | C <sub>9</sub> F <sub>21</sub> N                                 | 338-83-0    | 521.069  |                                |           | 130                 | 1.822 <sup>4</sup>         | 1.279 <sup>25</sup>  |                                                                |
| 8730 | 1 <i>H</i> -Perimidine                    |                                                                           | C <sub>11</sub> H <sub>6</sub> N <sub>2</sub>                    | 204-02-4    | 168.195  | grn cry (dil al)               | 223.0     |                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz; sl DMSO              |
| 8731 | Permethrin                                |                                                                           | C <sub>21</sub> H <sub>20</sub> Cl <sub>2</sub> O <sub>3</sub>   | 52645-53-1  | 391.288  | cry or ye liq                  | 34        | 200 <sup>0.01</sup> | 1.23 <sup>20</sup>         |                      | i H <sub>2</sub> O; s os                                       |
| 8732 | Peroxyacetic acid                         | Ethaneperoxoic acid                                                       | C <sub>2</sub> H <sub>4</sub> O <sub>3</sub>                     | 79-21-0     | 76.051   | liq                            | -0.2      | 110                 | 1.226 <sup>15</sup>        | 1.3974 <sup>20</sup> | vs H <sub>2</sub> O, eth, sulf; s EtOH                         |
| 8733 | Peroxypropanoic acid                      | Propaneperoxoic acid                                                      | C <sub>3</sub> H <sub>4</sub> O <sub>3</sub>                     | 4212-43-5   | 90.078   |                                |           | exp 119.7           |                            | 1.4148 <sup>15</sup> |                                                                |
| 8734 | Perphenazine                              |                                                                           | C <sub>21</sub> H <sub>26</sub> ClN <sub>3</sub> OS              | 58-39-9     | 403.968  |                                | 97        |                     |                            |                      |                                                                |
| 8735 | Perthane                                  | Ethane, 1,1-dichloro-2,2-bis( <i>p</i> -ethylphenyl)-                     | C <sub>18</sub> H <sub>20</sub> Cl <sub>2</sub>                  | 72-56-0     | 307.258  |                                | 56        |                     |                            |                      |                                                                |
| 8736 | Perylene                                  | Dibenz[de,kl]anthracene                                                   | C <sub>20</sub> H <sub>12</sub>                                  | 198-55-0    | 252.309  | gold-br, ye pl (bz, HOAc)      | 277.76    |                     | 1.35 <sup>25</sup>         |                      | i H <sub>2</sub> O; sl EtOH, eth; vs ace, chl; s bz            |
| 8737 | Peucedanin                                | 3-Methoxy-2-isopropyl-7 <i>H</i> -furo[3,2- <i>g</i> ][1]benzopyran-7-one | C <sub>15</sub> H <sub>14</sub> O <sub>4</sub>                   | 133-26-6    | 258.270  | pr or pl (bz-peth)             | 85        | 278 <sup>17</sup>   |                            |                      | sl H <sub>2</sub> O; bz; s EtOH, eth; vs chl, CS <sub>2</sub>  |
| 8738 | Phalloidin                                |                                                                           | C <sub>35</sub> H <sub>48</sub> N <sub>8</sub> O <sub>11</sub> S | 17466-45-4  | 788.868  | nd (w)                         | 281 (hyd) |                     |                            |                      | s EtOH, MeOH, py                                               |
| 8739 | Phalloin                                  |                                                                           | C <sub>35</sub> H <sub>48</sub> N <sub>8</sub> O <sub>10</sub> S | 28227-92-1  | 772.869  | cry (w)                        | 250 dec   |                     |                            |                      |                                                                |
| 8740 | α-Phellandrene                            | 2-Methyl-5-(1-methylethyl)-1,3-cyclohexadiene                             | C <sub>10</sub> H <sub>16</sub>                                  | 99-83-2     | 136.234  |                                | 238       | 174.9               | 0.8410 <sup>20</sup>       | 1.471 <sup>25</sup>  | i H <sub>2</sub> O; s eth                                      |
| 8741 | β-Phellandrene                            | <i>p</i> -Mentha-1(7),2-diene                                             | C <sub>10</sub> H <sub>16</sub>                                  | 555-10-2    | 136.234  |                                |           | 171.5               | 0.8520 <sup>20</sup>       | 1.4788 <sup>20</sup> | i H <sub>2</sub> O, EtOH; s eth                                |
| 8742 | 9-Phenanthrenamine                        |                                                                           | C <sub>14</sub> H <sub>11</sub> N                                | 947-73-9    | 193.244  | lt ye cry (al)                 | 138.3     | sub                 |                            |                      | sl eth, bz, chl                                                |
| 8743 | Phenanthrene                              |                                                                           | C <sub>14</sub> H <sub>10</sub>                                  | 85-01-8     | 178.229  | mcl pl (al), lf (sub)          | 99.24     | 340                 | 0.9800 <sup>4</sup>        | 1.5943               | i H <sub>2</sub> O; s EtOH, eth, ace, bz, CS <sub>2</sub>      |
| 8744 | 9,10-Phenanthrene-1,10-dione              | Phenanthrenequinone                                                       | C <sub>14</sub> H <sub>6</sub> O <sub>2</sub>                    | 84-11-7     | 208.213  | oran nd (to) oran-red pl (sub) | 209       |                     | 1.405 <sup>22</sup>        |                      | i H <sub>2</sub> O; sl EtOH, bz; s eth                         |
| 8745 | Phenanthridine                            |                                                                           | C <sub>13</sub> H <sub>9</sub> N                                 | 229-87-8    | 179.217  | nd (dil al)                    | 107.4     | 348.9               |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz, CS <sub>2</sub> ; s ace |
| 8746 | 1,7-Phenanthroline                        |                                                                           | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>                    | 230-46-6    | 180.205  | pl (anh), nd (w+2)             | 78        | 360                 |                            |                      | s H <sub>2</sub> O; vs EtOH; i eth, bz, lig                    |
| 8747 | 1,10-Phenanthroline                       | <i>o</i> -Phenanthroline                                                  | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>                    | 66-71-7     | 180.205  | wh nd (bz) cry (w+1)           | 117       | >300                |                            |                      | vs H <sub>2</sub> O; s EtOH, ace, bz; i peth                   |
| 8748 | 4,7-Phenanthroline                        |                                                                           | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>                    | 230-07-9    | 180.205  | nd (w)                         | 177       | sub 100             |                            |                      | s H <sub>2</sub> O, lig; vs EtOH; sl eth, bz, CS <sub>2</sub>  |



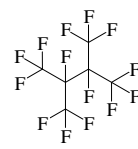
Perfluorodecalin



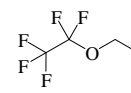
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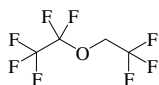
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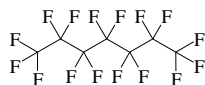
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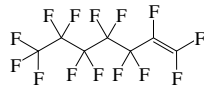
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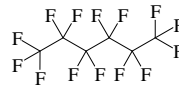
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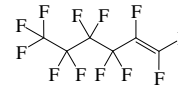
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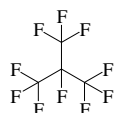
Perfluoro-1-heptene



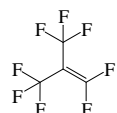
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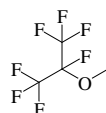
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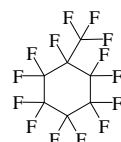
Perfluoroisobutane



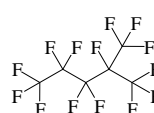
Perfluoroisobutene



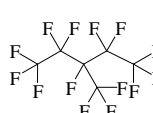
Perfluoroisopropyl methyl ether



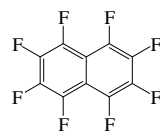
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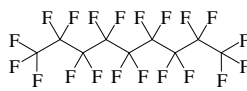
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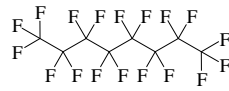
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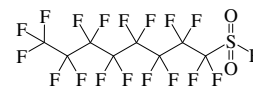
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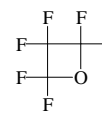
Perfluorononane



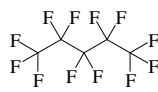
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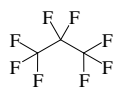
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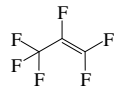
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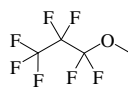
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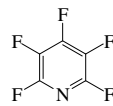
Perfluoropropane



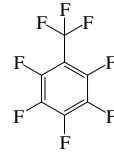
Perfluoropropene



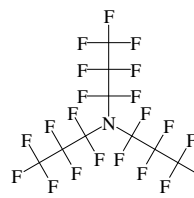
Perfluoropropyl methyl ether



Perfluoropyridine



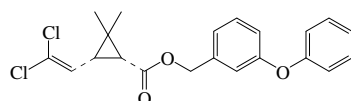
Perfluorotoluene



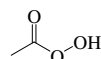
Perfluorotripropylamine



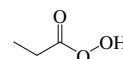
1H-Perimidine



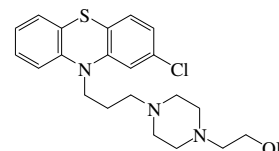
Permethrin



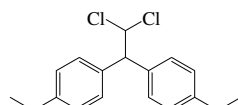
Peroxyacetic acid



Peroxypropanoic acid



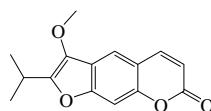
Perphenazine



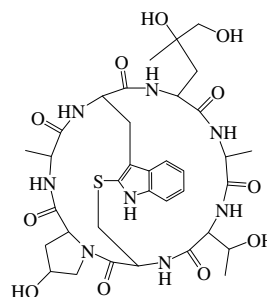
Perthane



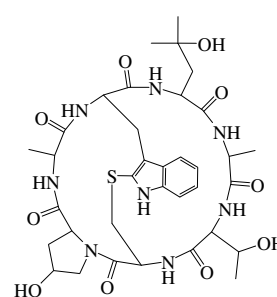
Perylene



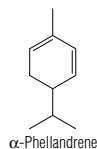
Peucedanin



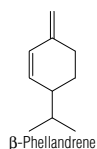
Phalloidin



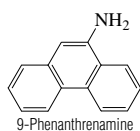
Phalloin



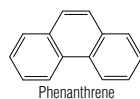
α-Phellandrene



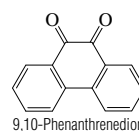
β-Phellandrene



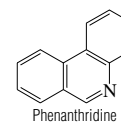
9-Phenanthrenamine



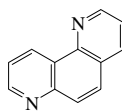
Phenanthrene



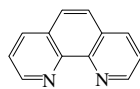
9,10-Phenanthrene-9,10-dione



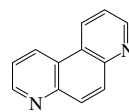
Phenanthridine



1,7-Phenanthroline

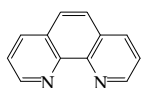


1,10-Phenanthroline

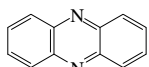


4,7-Phenanthroline

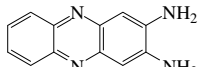
| No.  | Name                                   | Synonym                                                                       | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form                | mp/°C | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|----------------------------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------|------------|----------|------------------------------|-------|----------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 8749 | 1,10-Phenanthroline monohydrate        | <i>o</i> -Phenanthroline monohydrate                                          | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O                 | 5144-89-8  | 198.219  | wh cry pow                   | 93    |                                        |                            |                      | s EtOH, ace; sl bz                                    |
| 8750 | Phenazine                              | Dibenzopyrazine                                                               | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>                    | 92-82-0    | 180.205  | ye-red nd (HOAc)             | 176.5 |                                        |                            |                      | sl H <sub>2</sub> O, eth; s bz, EtOH                  |
| 8751 | 2,3-Phenazinediamine                   | 2,3-Diaminophenazine                                                          | C <sub>12</sub> H <sub>10</sub> N <sub>4</sub>                   | 655-86-7   | 210.234  | ye nd                        | 264   | sub                                    |                            |                      | vs bz, EtOH                                           |
| 8752 | 1-Phenazinol                           | Hemipyocyanine                                                                | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub> O                  | 528-71-2   | 196.204  | ye nd (bz, dil MeOH)         | 158   | sub                                    |                            |                      | sl H <sub>2</sub> O, EtOH; s bz, py, dil alk          |
| 8753 | Phenazopyridine                        | 2,6-Diamino-3-phenylazopyridine                                               | C <sub>11</sub> H <sub>11</sub> N <sub>5</sub>                   | 94-78-0    | 213.239  | red cry                      | 139   |                                        |                            |                      |                                                       |
| 8754 | Phenazopyridine hydrochloride          | 3-(Phenylazo)-2,6-pyridinediamine, monohydrochloride                          | C <sub>11</sub> H <sub>12</sub> ClN <sub>5</sub>                 | 136-40-3   | 249.700  | ye-red cry                   |       |                                        |                            |                      | sl H <sub>2</sub> O, EtOH; i bz, ace; s HOAc          |
| 8755 | Phencarbamide                          |                                                                               | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub> OS                | 3735-90-8  | 328.471  |                              | 48.5  | 121 <sup>0.01</sup>                    |                            |                      | vs eth, chl, MeOH, peth                               |
| 8756 | Phendimetrazine                        | 3,4-Dimethyl-2-phenylmorpholine                                               | C <sub>12</sub> H <sub>17</sub> NO                               | 634-03-7   | 191.269  |                              |       | 134 <sup>12</sup> , 78 <sup>0.35</sup> |                            |                      |                                                       |
| 8757 | Phenethicillin potassium               |                                                                               | C <sub>17</sub> H <sub>19</sub> KN <sub>2</sub> O <sub>5</sub> S | 132-93-4   | 402.506  | cry (ace)                    | 235   |                                        |                            |                      | s H <sub>2</sub> O                                    |
| 8758 | Phenicin                               |                                                                               | C <sub>14</sub> H <sub>10</sub> O <sub>6</sub>                   | 128-68-7   | 274.225  | ye-br (al)                   | 230.5 |                                        |                            |                      | sl H <sub>2</sub> O; vs EtOH, chl, HOAc               |
| 8759 | Phenindamine                           |                                                                               | C <sub>19</sub> H <sub>19</sub> N                                | 82-88-2    | 261.361  | cry                          | 91    |                                        | 1.17                       |                      |                                                       |
| 8760 | Phenmedipham                           |                                                                               | C <sub>18</sub> H <sub>18</sub> N <sub>2</sub> O <sub>4</sub>    | 13684-63-4 | 300.309  |                              | 143   |                                        |                            |                      |                                                       |
| 8761 | Phenobarbital                          | 5-Ethyl-5-phenyl-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>    | 50-06-6    | 232.234  | pl (w)                       | 174   |                                        |                            |                      | i H <sub>2</sub> O, bz; s EtOH, eth; sl DMSO          |
| 8762 | Phenol                                 | Hydroxybenzene                                                                | C <sub>6</sub> H <sub>6</sub> O                                  | 108-95-2   | 94.111   |                              | 40.89 | 181.87                                 | 1.0545 <sup>45</sup>       | 1.5408 <sup>41</sup> | s H <sub>2</sub> O, EtOH; vs eth; msc ace, bz         |
| 8763 | Phenolphthalein                        | 3,3-Bis(4-hydroxyphenyl)-1(3 <i>H</i> )-isobenzofuranone                      | C <sub>20</sub> H <sub>14</sub> O <sub>4</sub>                   | 77-09-8    | 318.323  | wh orth nd                   | 262.5 |                                        | 1.277 <sup>32</sup>        |                      | i H <sub>2</sub> O, bz; vs EtOH, ace; s eth, chl      |
| 8764 | Phenolphthalin                         | 2-[Bis(4-hydroxyphenyl)methyl] benzoic acid                                   | C <sub>20</sub> H <sub>16</sub> O <sub>4</sub>                   | 81-90-3    | 320.339  | nd (w)                       | 230.5 |                                        |                            |                      | vs eth, EtOH                                          |
| 8765 | Phenolphthalol                         |                                                                               | C <sub>20</sub> H <sub>16</sub> O <sub>3</sub>                   | 81-92-5    | 306.355  | cry (dil al)                 | 201.5 |                                        |                            |                      |                                                       |
| 8766 | Phenol Red                             | Phenolsulfonphthalein                                                         | C <sub>19</sub> H <sub>14</sub> O <sub>3</sub> S                 | 143-74-8   | 354.376  | dk red nd or pl              | >300  |                                        |                            |                      | sl H <sub>2</sub> O, EtOH, ace, bz; i eth, chl        |
| 8767 | 10 <i>H</i> -Phenothiazine             | Thiodiphenylamine                                                             | C <sub>12</sub> H <sub>9</sub> NS                                | 92-84-2    | 199.271  | ye pr (al) ye lf or pl (tol) | 187.5 | 371                                    |                            |                      | vs ace, bz, eth, EtOH                                 |
| 8768 | Phenothrin                             |                                                                               | C <sub>23</sub> H <sub>26</sub> O <sub>3</sub>                   | 26002-80-2 | 350.450  | col liq                      |       |                                        | 1.061 <sup>25</sup>        | 1.5483 <sup>25</sup> | i H <sub>2</sub> O; s ace, xyl                        |
| 8769 | 10 <i>H</i> -Phenoxazine               |                                                                               | C <sub>12</sub> H <sub>9</sub> NO                                | 135-67-1   | 183.205  | lf (dil al, bz)              | 156   | dec                                    |                            |                      | vs bz, eth, EtOH                                      |
| 8770 | Phenoxyacetic acid                     |                                                                               | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                     | 122-59-8   | 152.148  | nd or pl (w)                 | 98.5  | dec 285                                |                            |                      | s H <sub>2</sub> O; vs EtOH, eth, bz, CS <sub>2</sub> |
| 8771 | Phenoxyacetyl chloride                 |                                                                               | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                   | 701-99-5   | 170.594  |                              |       | 225.5                                  |                            |                      | s eth                                                 |
| 8772 | Phenoxyacetylene                       |                                                                               | C <sub>8</sub> H <sub>6</sub> O                                  | 4279-76-9  | 118.133  |                              | -36   | 61 <sup>25</sup>                       | 1.0614 <sup>20</sup>       | 1.5125 <sup>20</sup> | vs eth, EtOH                                          |
| 8773 | 2-Phenoxyaniline                       |                                                                               | C <sub>12</sub> H <sub>11</sub> NO                               | 2688-84-8  | 185.221  | cry (lig)                    | 45.8  | 308; 172 <sup>14</sup>                 |                            |                      | s EtOH; s eth, ace, bz                                |
| 8774 | 3-Phenoxyaniline                       |                                                                               | C <sub>12</sub> H <sub>11</sub> NO                               | 3586-12-7  | 185.221  | pr (lig)                     | 37    | 315; 180 <sup>10</sup>                 | 1.1583 <sup>25</sup>       |                      | s EtOH, eth, ace, bz; sl lig                          |
| 8775 | 4-Phenoxyaniline                       |                                                                               | C <sub>12</sub> H <sub>11</sub> NO                               | 139-59-3   | 185.221  | nd (w), cry (dil al)         | 85.5  |                                        |                            |                      | s H <sub>2</sub> O; vs EtOH, eth; sl lig              |
| 8776 | 3-Phenoxybenzaldehyde                  |                                                                               | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                   | 39515-51-0 | 198.217  |                              | 14.0  | 169 <sup>11</sup> , 140 <sup>0.1</sup> | 1.147 <sup>25</sup>        | 1.5954 <sup>20</sup> |                                                       |
| 8777 | Phenoxybenzamine                       |                                                                               | C <sub>18</sub> H <sub>22</sub> ClNO                             | 59-96-1    | 303.827  |                              | 39    |                                        |                            |                      | s bz                                                  |
| 8778 | Phenoxybenzamine hydrochloride         |                                                                               | C <sub>18</sub> H <sub>23</sub> Cl <sub>2</sub> NO               | 63-92-3    | 340.288  |                              | 139   |                                        |                            |                      | sl H <sub>2</sub> O; s EtOH                           |
| 8779 | 2-Phenoxybenzoic acid                  |                                                                               | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                   | 2243-42-7  | 214.216  | lf (dil al)                  | 113   | 355                                    | 1.1553 <sup>50</sup>       |                      | i H <sub>2</sub> O; vs EtOH, eth; s chl               |
| 8780 | 3-Phenoxybenzoic acid                  |                                                                               | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                   | 3739-38-6  | 214.216  | nd (aq al)                   | 145.8 |                                        |                            |                      | i H <sub>2</sub> O; s EtOH, eth                       |
| 8781 | 4-Phenoxybenzoic acid                  |                                                                               | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                   | 2215-77-2  | 214.216  | pr (chl)                     | 161   |                                        |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, chl                 |
| 8782 | 2-Phenoxyethanol                       |                                                                               | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                    | 122-99-6   | 138.164  | oil                          | 14    | 245                                    | 1.102 <sup>22</sup>        | 1.534 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, chl, alk             |
| 8783 | 2-Phenoxyethyl acrylate                | Phenyl Cellosolve acrylate                                                    | C <sub>11</sub> H <sub>12</sub> O <sub>3</sub>                   | 48145-04-6 | 192.211  |                              |       | 110 <sup>2</sup>                       | 1.090 <sup>25</sup>        |                      | vs ace, eth, chl                                      |
| 8784 | 2-Phenoxyethyl butanoate               |                                                                               | C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>                   | 23511-70-8 | 208.253  |                              |       | 251; 88 <sup>2</sup>                   | 1.0388 <sup>21</sup>       |                      | vs ace, eth, EtOH                                     |
| 8785 | 3-Phenoxyphenol                        |                                                                               | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                   | 713-68-8   | 186.206  |                              |       | 175 <sup>7</sup>                       |                            |                      |                                                       |
| 8786 | 4-Phenoxyphenol                        |                                                                               | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                   | 831-82-3   | 186.206  |                              | 84.0  |                                        |                            |                      |                                                       |
| 8787 | 2-(3-Phenoxyphenyl)propanoic acid, (±) | Fenoprofen                                                                    | C <sub>15</sub> H <sub>14</sub> O <sub>3</sub>                   | 31879-05-7 | 242.270  | visc oil                     |       | 170 <sup>0.11</sup>                    |                            | 1.5742 <sup>25</sup> |                                                       |
| 8788 | 3-Phenoxy-1,2-propanediol              | Phenylglyceryl ether                                                          | C <sub>9</sub> H <sub>12</sub> O <sub>3</sub>                    | 538-43-2   | 168.189  | nd (eth, peth)               | 67.5  | 200 <sup>22</sup>                      | 1.225 <sup>20</sup>        |                      | vs H <sub>2</sub> O, bz, eth, EtOH                    |
| 8789 | 2-Phenoxypropanoic acid                |                                                                               | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                    | 940-31-8   | 166.173  | nd (w)                       | 115.5 | 266; 105 <sup>5</sup>                  | 1.1865 <sup>20</sup>       | 1.5184 <sup>20</sup> |                                                       |
| 8790 | 2-Phenoxy-1-propanol                   |                                                                               | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                    | 4169-04-4  | 152.190  |                              |       | 244                                    | 0.9801 <sup>25</sup>       | 1.4760 <sup>25</sup> | s EtOH, eth                                           |
| 8791 | 1-Phenoxy-2-propanol                   |                                                                               | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                    | 770-35-4   | 152.190  |                              |       | 233; 134 <sup>20</sup>                 | 1.0622 <sup>20</sup>       | 1.5232 <sup>20</sup> |                                                       |
| 8792 | 1-Phenoxy-2-propanone                  | Phenoxyacetone                                                                | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                    | 621-87-4   | 150.174  |                              |       | 229.5                                  | 1.0903 <sup>20</sup>       | 1.5228 <sup>20</sup> | s eth, ace                                            |



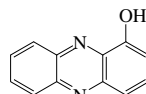
H<sub>2</sub>O  
1,10-Phenanthroline monohydrate



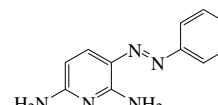
Phenazine



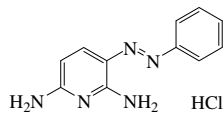
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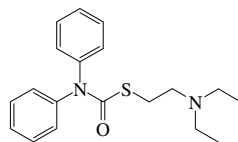
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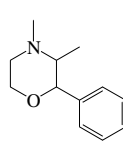
Phenazopyridine



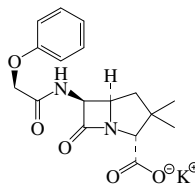
Phenazopyridine hydrochloride



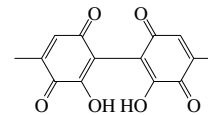
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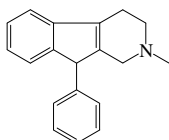
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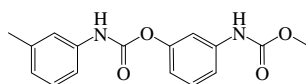
Phenethicillin potassium



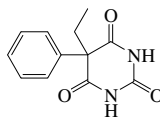
Phenicin



Phenindamine



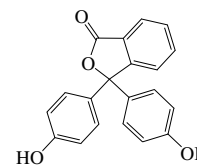
Phenmedipham



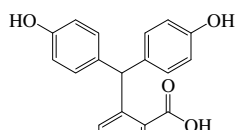
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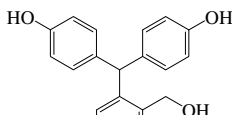
Phenol



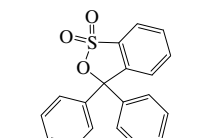
Phenolphthalein



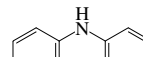
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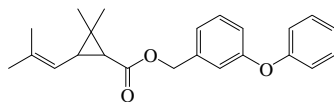
Phenolphthalol



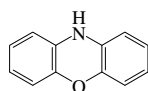
Phenol Red



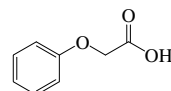
10H-Phenothiazine



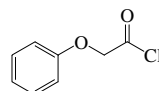
Phenothrin



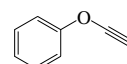
10H-Phenoxazine



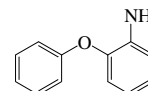
Phenoxyacetic acid



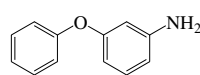
Phenoxyacetyl chloride



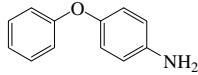
Phenoxyacetylene



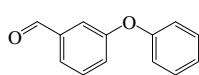
2-Phenoxyaniline



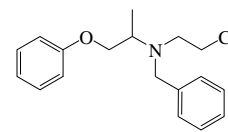
3-Phenoxyaniline



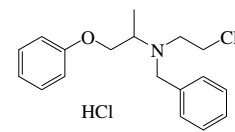
4-Phenoxyaniline



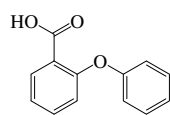
3-Phenoxybenzaldehyde



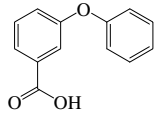
Phenoxybenzamine



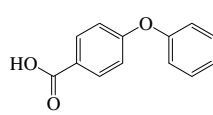
Phenoxybenzamine hydrochloride



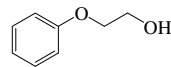
2-Phenoxybenzoic acid



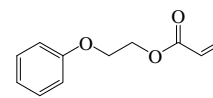
3-Phenoxybenzoic acid



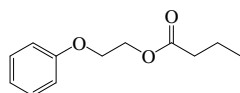
4-Phenoxybenzoic acid



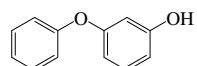
2-Phenoxyethanol



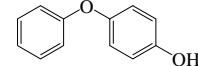
2-Phenoxyethyl acrylate



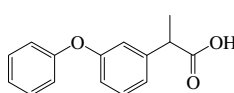
2-Phenoxyethyl butanoate



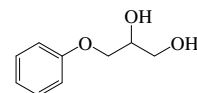
3-Phenoxyphenol



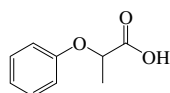
4-Phenoxyphenol



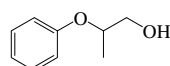
2-(3-Phenoxyphenyl)propanoic acid, (±)



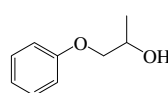
3-Phenoxy-1,2-propanediol



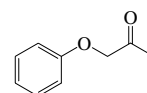
2-Phenoxypropanoic acid



2-Phenoxy-1-propanol

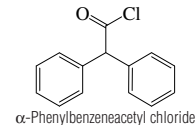
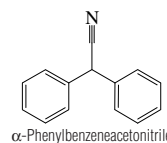
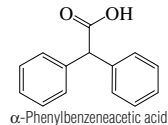
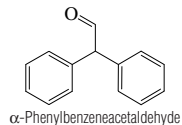
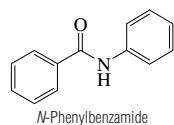
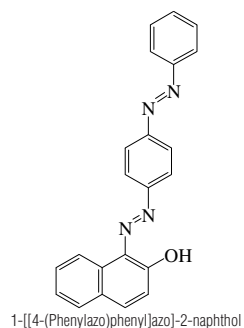
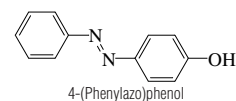
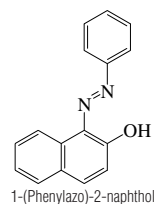
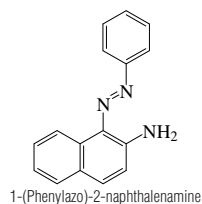
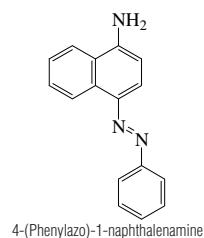
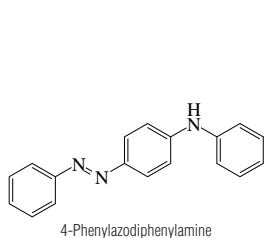
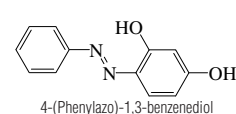
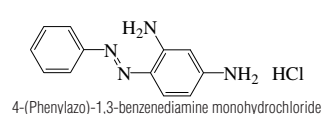
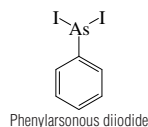
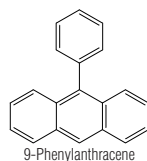
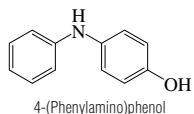
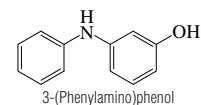
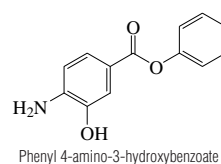
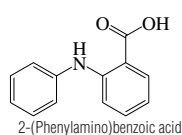
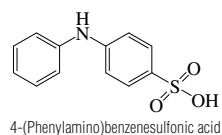
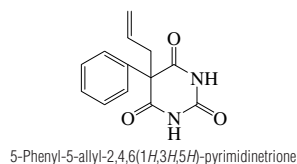
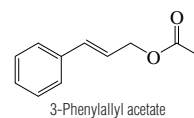
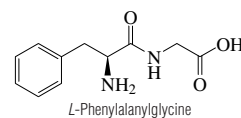
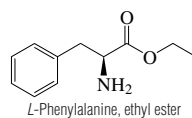
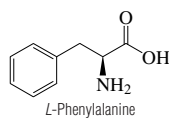
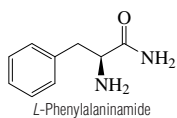
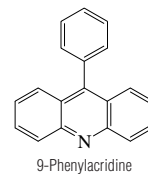
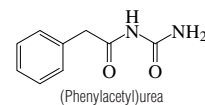
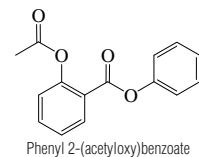
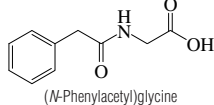
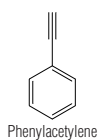
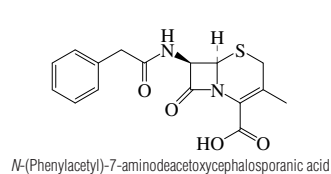
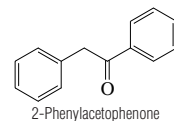
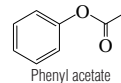
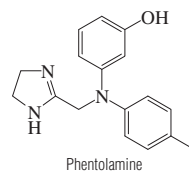
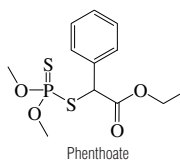
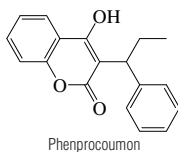
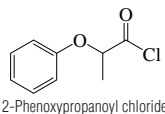


1-Phenoxy-2-propanol

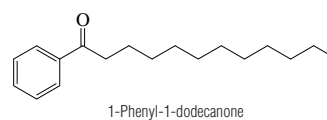
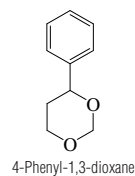
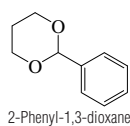
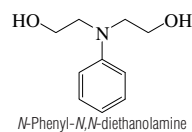
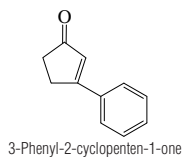
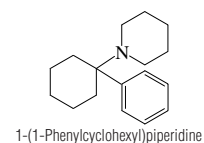
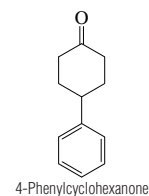
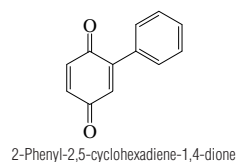
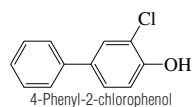
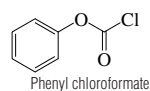
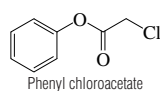
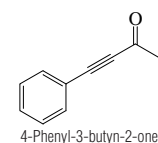
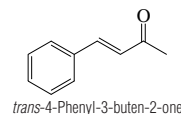
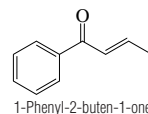
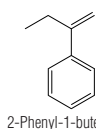
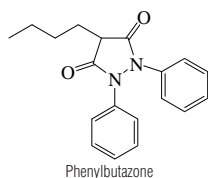
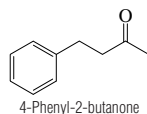
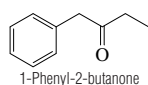
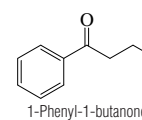
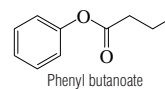
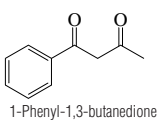
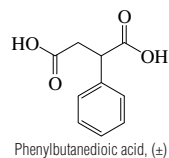
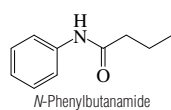
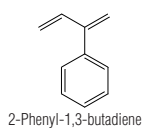
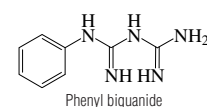
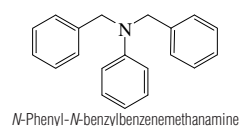
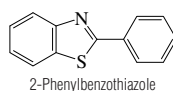
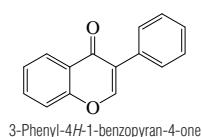
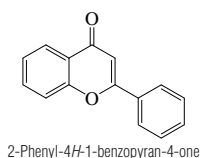
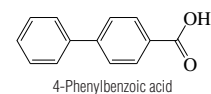
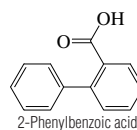
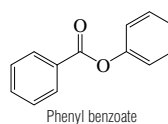
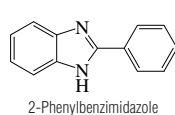
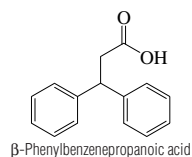
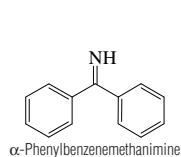
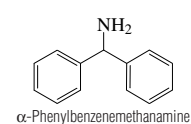
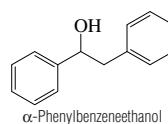
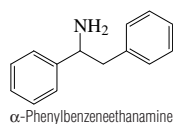
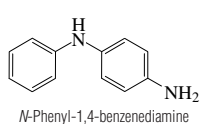
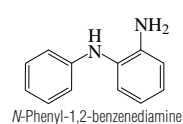
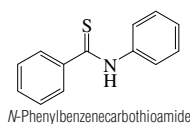


1-Phenoxy-2-propanone

| No.  | Name                                                                          | Synonym                                            | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                |
|------|-------------------------------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------|------------|----------|---------------------------|---------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------------|
| 8793 | 2-Phenoxypropanoyl chloride                                                   |                                                    | C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>                  | 122-35-0   | 184.619  |                           |         | 147; 116 <sup>10</sup>                | 1.1865 <sup>20</sup>       | 1.5178 <sup>20</sup> | s eth                                                     |
| 8794 | Phenprocoumon                                                                 | 3-( $\alpha$ -Ethylbenzyl)-4-hydroxycoumarin       | C <sub>18</sub> H <sub>16</sub> O <sub>3</sub>                  | 435-97-2   | 280.318  | pr (MeOH aq)              | 179     |                                       |                            |                      |                                                           |
| 8795 | Phenthoate                                                                    |                                                    | C <sub>12</sub> H <sub>17</sub> O <sub>4</sub> PS <sub>2</sub>  | 2597-03-7  | 320.364  | ye oil                    |         | 123 <sup>0.01</sup>                   |                            |                      | sl H <sub>2</sub> O; s hx                                 |
| 8796 | Phentolamine                                                                  |                                                    | C <sub>17</sub> H <sub>19</sub> N <sub>3</sub> O                | 50-60-2    | 281.352  |                           | 175     |                                       |                            |                      |                                                           |
| 8797 | Phenyl acetate                                                                |                                                    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                    | 122-79-2   | 136.149  |                           |         | 196; 75 <sup>a</sup>                  | 1.0780 <sup>20</sup>       | 1.5035 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, chl; s ctc            |
| 8798 | 2-Phenylacetophenone                                                          |                                                    | C <sub>14</sub> H <sub>12</sub> O                               | 451-40-1   | 196.244  | pl (al)                   | 60      | 320                                   | 1.201 <sup>0</sup>         |                      | sl H <sub>2</sub> O; s EtOH, eth, ctc, chl                |
| 8799 | <i>N</i> -(Phenylacetyl)-7-aminodeacetoxycephalosporanic acid                 | 7-Phenylacetamidodeacetoxycephalosporanic acid     | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub> S | 27255-72-7 | 332.374  | cry (2-PrOH/peth)         | 200     |                                       |                            |                      |                                                           |
| 8800 | Phenylacetylene                                                               | Ethynylbenzene                                     | C <sub>8</sub> H <sub>6</sub>                                   | 536-74-3   | 102.134  | liq                       | -44.8   | 143                                   | 0.9300 <sup>20</sup>       | 1.5470 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s ace; sl chl          |
| 8801 | ( <i>N</i> -Phenylacetyl)glycine                                              | Phenaceturic acid                                  | C <sub>10</sub> H <sub>11</sub> NO <sub>3</sub>                 | 500-98-1   | 193.199  | lf (EtOH)                 | 143     |                                       |                            |                      |                                                           |
| 8802 | Phenyl 2-(acetyloxy)benzoate                                                  | Phenyl acetylsalicylate                            | C <sub>15</sub> H <sub>12</sub> O <sub>4</sub>                  | 134-55-4   | 256.254  |                           | 96      |                                       |                            |                      |                                                           |
| 8803 | (Phenylacetyl)urea                                                            | Phenacemide                                        | C <sub>9</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>    | 63-98-9    | 178.187  | cry (al)                  | 215     |                                       |                            |                      | vs bz, eth, EtOH                                          |
| 8804 | 9-Phenylacridine                                                              |                                                    | C <sub>19</sub> H <sub>13</sub> N                               | 602-56-2   | 255.313  | ye nd, lf (al)            | 184     | 404                                   |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth; vs bz                 |
| 8805 | <i>L</i> -Phenylalaninamide                                                   | $\alpha$ -Aminobenzenepropanamide, ( <i>S</i> )-   | C <sub>9</sub> H <sub>12</sub> N <sub>2</sub> O                 | 5241-58-7  | 164.203  |                           | 82      |                                       |                            |                      |                                                           |
| 8806 | <i>L</i> -Phenylalanine                                                       | $\alpha$ -Aminobenzenepropanoic acid, ( <i>S</i> ) | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                  | 63-91-2    | 165.189  | pr (w)                    | 283 dec |                                       |                            |                      | sl H <sub>2</sub> O; i EtOH, eth, bz, acid                |
| 8807 | <i>L</i> -Phenylalanine, ethyl ester                                          | Ethyl 2-amino-3-phenylpropionate                   | C <sub>11</sub> H <sub>15</sub> NO <sub>2</sub>                 | 3081-24-1  | 193.243  |                           | 136     | 148 <sup>13</sup>                     | 1.065 <sup>15</sup>        |                      | sl H <sub>2</sub> O                                       |
| 8808 | <i>L</i> -Phenylalanylglycine                                                 |                                                    | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>   | 721-90-4   | 222.240  |                           | 262 dec |                                       |                            |                      | s H <sub>2</sub> O                                        |
| 8809 | 3-Phenylallyl acetate                                                         |                                                    | C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>                  | 103-54-8   | 176.212  |                           |         | 123 <sup>5</sup>                      |                            |                      |                                                           |
| 8810 | 5-Phenyl-5-allyl-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-pyrimidinetrione | Phenallymal                                        | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>   | 115-43-5   | 244.245  |                           | 156.5   |                                       |                            |                      | sl H <sub>2</sub> O; bz, DMSO; vs EtOH, eth; i lig        |
| 8811 | 4-(Phenylamino)benzenesulfonic acid                                           | <i>N</i> -Phenylsulfanilic acid                    | C <sub>12</sub> H <sub>11</sub> NO <sub>3</sub> S               | 101-57-5   | 249.285  | pl (al-eth)               | 206     |                                       |                            |                      | vs H <sub>2</sub> O, EtOH                                 |
| 8812 | 2-(Phenylamino)benzoic acid                                                   | <i>N</i> -Phenylanthranilic acid                   | C <sub>13</sub> H <sub>11</sub> NO <sub>2</sub>                 | 91-40-7    | 213.232  | lf (al)                   | 183.5   |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH; sl eth, bz                   |
| 8813 | Phenyl 4-amino-3-hydroxybenzoate                                              | Phenyl <i>p</i> -aminosalicylate                   | C <sub>13</sub> H <sub>11</sub> NO <sub>3</sub>                 | 133-11-9   | 229.231  |                           | 153     |                                       |                            |                      |                                                           |
| 8814 | 3-(Phenylamino)phenol                                                         |                                                    | C <sub>12</sub> H <sub>11</sub> NO                              | 101-18-8   | 185.221  | lf (w)                    | 81.5    | 340                                   |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, ace; s bz, acid        |
| 8815 | 4-(Phenylamino)phenol                                                         |                                                    | C <sub>12</sub> H <sub>11</sub> NO                              | 122-37-2   | 185.221  | lf (w)                    | 73      | 330                                   |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl; s acid        |
| 8816 | 9-Phenylanthracene                                                            |                                                    | C <sub>20</sub> H <sub>14</sub>                                 | 602-55-1   | 254.325  | bl lf (al) (HOAc)         | 156     | 417                                   |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl, CS <sub>2</sub> |
| 8817 | Phenylarsonous diiodide                                                       |                                                    | C <sub>6</sub> H <sub>5</sub> AsI <sub>2</sub>                  | 6380-34-3  | 405.835  |                           | 15      | 205 <sup>14</sup> , 185 <sup>10</sup> | 1.6264 <sup>15</sup>       |                      |                                                           |
| 8818 | 4-(Phenylazo)-1,3-benzenediamine monohydrochloride                            | Chrysoidine hydrochloride                          | C <sub>12</sub> H <sub>13</sub> ClN <sub>4</sub>                | 532-82-1   | 248.711  | red-br cry pow            | 118.5   |                                       |                            |                      | vs ace                                                    |
| 8819 | 4-(Phenylazo)-1,3-benzenediol                                                 |                                                    | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>   | 2051-85-6  | 214.219  | dk red nd (dil al)        | 170     |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, bz, HOAc                |
| 8820 | 4-Phenylazodiphenylamine                                                      | <i>N</i> -Phenyl-4-(phenylazo)benzenamine          | C <sub>18</sub> H <sub>15</sub> N <sub>3</sub>                  | 101-75-7   | 273.332  | ye pl or pr               | 84.0    |                                       |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, lig                     |
| 8821 | 4-(Phenylazo)-1-naphthalenamine                                               | $\alpha$ -Naphthyl Red                             | C <sub>16</sub> H <sub>13</sub> N <sub>3</sub>                  | 131-22-6   | 247.294  | red-viol cry (EtOH)       | 123     |                                       |                            |                      | s EtOH, dil HCl, bz                                       |
| 8822 | 1-(Phenylazo)-2-naphthalenamine                                               | Yellow AB                                          | C <sub>16</sub> H <sub>13</sub> N <sub>3</sub>                  | 85-84-7    | 247.294  | red pl (al)               | 103     |                                       |                            |                      | vs EtOH, HOAc                                             |
| 8823 | 1-(Phenylazo)-2-naphthol                                                      | Sudan I                                            | C <sub>16</sub> H <sub>12</sub> N <sub>2</sub> O                | 842-07-9   | 248.278  | ye cry                    | 132     |                                       |                            |                      |                                                           |
| 8824 | 4-(Phenylazo)phenol                                                           |                                                    | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O                | 1689-82-3  | 198.219  | ye lf (bz) oran pr (al)   | 155     | 225 <sup>20</sup> dec                 |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; s bz, con sulf          |
| 8825 | 1-[[4-(Phenylazo)phenyl]azo]-2-naphthol                                       | Sudan III                                          | C <sub>22</sub> H <sub>16</sub> N <sub>4</sub> O                | 85-86-9    | 352.388  | br lf (grn lustre) (HOAc) | 195     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, xyl, chl        |
| 8826 | <i>N</i> -Phenylbenzamide                                                     | Benzanilide                                        | C <sub>13</sub> H <sub>11</sub> NO                              | 93-98-1    | 197.232  | lf (al)                   | 163     | sub 117                               | 1.315 <sup>25</sup>        |                      | i H <sub>2</sub> O; sl EtOH, eth, HOAc                    |
| 8827 | $\alpha$ -Phenylbenzeneacetaldehyde                                           |                                                    | C <sub>14</sub> H <sub>12</sub> O                               | 947-91-1   | 196.244  |                           |         | dec 315; 157 <sup>7</sup>             | 1.1061 <sup>21</sup>       | 1.5920 <sup>21</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz                      |
| 8828 | $\alpha$ -Phenylbenzeneacetic acid                                            | Diphenylacetic acid                                | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>                  | 117-34-0   | 212.244  | nd (w), lf (al)           | 147.29  | 194 <sup>25</sup>                     | 1.257 <sup>15</sup>        |                      | sl H <sub>2</sub> O; vs EtOH; s eth, chl                  |
| 8829 | $\alpha$ -Phenylbenzeneacetonitrile                                           |                                                    | C <sub>14</sub> H <sub>11</sub> N                               | 86-29-3    | 193.244  | pr (eth), lf (dil al)     | 74.3    | 184 <sup>16</sup>                     |                            |                      | s EtOH, chl; vs eth; sl lig                               |
| 8830 | $\alpha$ -Phenylbenzeneacetyl chloride                                        |                                                    | C <sub>14</sub> H <sub>11</sub> ClO                             | 1871-76-7  | 230.689  |                           | 56.5    | 170 <sup>16</sup>                     |                            |                      | s lig                                                     |

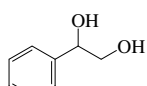


| No.  | Name                                                 | Synonym                                     | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form               | mp/°C | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|------------------------------------------------------|---------------------------------------------|---------------------------------------------------------------|------------|----------|-----------------------------|-------|-------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 8831 | <i>N</i> -Phenylbenzenecarbothioamide                |                                             | C <sub>13</sub> H <sub>11</sub> NS                            | 636-04-4   | 213.298  | ye pl or pr (al)            | 102   | dec                                 |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, bz, chl; sl lig  |
| 8832 | <i>N</i> -Phenyl-1,2-benzenediamine                  |                                             | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                | 534-85-0   | 184.236  | nd(w)                       | 79.5  | 313                                 |                            |                      | sl H <sub>2</sub> O; lig; s ace, bz, chl             |
| 8833 | <i>N</i> -Phenyl-1,4-benzenediamine                  | <i>p</i> -Aminodiphenylamine                | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                | 101-54-2   | 184.236  | nd(al)                      | 66    | 354                                 |                            |                      | sl H <sub>2</sub> O; chl; vs EtOH; s eth, lig        |
| 8834 | $\alpha$ -Phenylbenzeneethanamine                    |                                             | C <sub>14</sub> H <sub>15</sub> N                             | 25611-78-3 | 197.276  |                             |       | 311; 175 <sup>15</sup>              | 1.031 <sup>15</sup>        |                      | vs eth, EtOH                                         |
| 8835 | $\alpha$ -Phenylbenzeneethanol                       |                                             | C <sub>14</sub> H <sub>16</sub> O                             | 614-29-9   | 198.260  | nd (peth-bz)                | 67    | 177 <sup>15</sup>                   | 1.0360 <sup>70</sup>       |                      |                                                      |
| 8836 | $\alpha$ -Phenylbenzenemethanamine                   | Benzhydramine                               | C <sub>13</sub> H <sub>13</sub> N                             | 91-00-9    | 183.249  | hex pl                      | 34    | 304; 176 <sup>23</sup>              | 1.0633 <sup>20</sup>       | 1.5963               | sl H <sub>2</sub> O; s ace                           |
| 8837 | $\alpha$ -Phenylbenzenemethanimine                   |                                             | C <sub>13</sub> H <sub>11</sub> N                             | 1013-88-3  | 181.233  |                             |       | 282                                 | 1.0847 <sup>19</sup>       | 1.6191 <sup>19</sup> | vs eth                                               |
| 8838 | $\beta$ -Phenylbenzenepropanoic acid                 |                                             | C <sub>15</sub> H <sub>14</sub> O <sub>2</sub>                | 606-83-7   | 226.271  | nd (dil al)                 | 156.0 |                                     |                            |                      | sl H <sub>2</sub> O; vs EtOH; s eth, ace             |
| 8839 | 2-Phenylbenzimidazole                                | Phenizidole                                 | C <sub>13</sub> H <sub>10</sub> N <sub>2</sub>                | 716-79-0   | 194.231  | pl (HOAc) (al-w) nd (bz, w) | 293   |                                     |                            |                      | sl H <sub>2</sub> O; bz; s EtOH, chl, HOAc           |
| 8840 | Phenyl benzoate                                      |                                             | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                | 93-99-2    | 198.217  | mcl pr (eth-al)             | 71    | 314                                 | 1.235 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, chl                 |
| 8841 | 2-Phenylbenzoic acid                                 |                                             | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                | 947-84-2   | 198.217  | lf (dil al)                 | 114.3 | 343.5                               |                            |                      | i H <sub>2</sub> O; vs EtOH, bz, HOAc                |
| 8842 | 4-Phenylbenzoic acid                                 |                                             | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                | 92-92-2    | 198.217  | nd (bz, al)                 | 228   | sub                                 |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz                  |
| 8843 | 2-Phenyl-4 <i>H</i> -1-benzopyran-4-one              | Flavone                                     | C <sub>15</sub> H <sub>10</sub> O <sub>2</sub>                | 525-82-6   | 222.239  | nd (lig), cry (30% al)      | 100   |                                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz             |
| 8844 | 3-Phenyl-4 <i>H</i> -1-benzopyran-4-one              | Isoflavone                                  | C <sub>15</sub> H <sub>10</sub> O <sub>2</sub>                | 574-12-9   | 222.239  |                             | 148   |                                     |                            |                      |                                                      |
| 8845 | 2-Phenylbenzothiazole                                |                                             | C <sub>13</sub> H <sub>9</sub> NS                             | 883-93-2   | 211.282  | nd (dil al)                 | 115   | 371                                 |                            |                      | i H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub>     |
| 8846 | <i>N</i> -Phenyl- <i>N</i> -benzylbenzenemethanamine |                                             | C <sub>20</sub> H <sub>19</sub> N                             | 91-73-6    | 273.372  |                             | 69    | 226 <sup>10</sup>                   | 1.0444 <sup>80</sup>       | 1.6065 <sup>80</sup> | i H <sub>2</sub> O; sl EtOH, HOAc; s eth, bz         |
| 8847 | Phenyl biguanide                                     | <i>N</i> -Phenylimidodicarbonimidic diamide | C <sub>8</sub> H <sub>11</sub> N <sub>5</sub>                 | 102-02-3   | 177.207  |                             | 143   |                                     |                            |                      |                                                      |
| 8848 | 2-Phenyl-1,3-butadiene                               |                                             | C <sub>10</sub> H <sub>10</sub>                               | 2288-18-8  | 130.186  |                             |       | 60 <sup>17</sup>                    | 0.925 <sup>20</sup>        | 1.5489 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl                   |
| 8849 | <i>N</i> -Phenylbutanamide                           |                                             | C <sub>10</sub> H <sub>13</sub> NO                            | 1129-50-6  | 163.216  | mcl pr (al, bz, eth)        | 97    | 189 <sup>15</sup>                   | 1.134 <sup>25</sup>        |                      | i H <sub>2</sub> O; vs EtOH, eth; sl chl             |
| 8850 | Phenylbutanedioic acid, (±)                          |                                             | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                | 10424-29-0 | 194.184  | lf or nd (w)                | 168   | dec                                 |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth, ace; i bz    |
| 8851 | 1-Phenyl-1,3-butanedione                             |                                             | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                | 93-91-4    | 162.185  | pr                          | 56    | 261.5                               | 1.0599 <sup>74</sup>       | 1.5678 <sup>78</sup> | i H <sub>2</sub> O; s eth; sl chl                    |
| 8852 | Phenyl butanoate                                     | Phenyl butyrate                             | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 4346-18-3  | 164.201  |                             |       | 225                                 | 1.0382 <sup>15</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                      |
| 8853 | 1-Phenyl-1-butanone                                  |                                             | C <sub>10</sub> H <sub>12</sub> O                             | 495-40-9   | 148.201  |                             | 12    | 228.5                               | 0.988 <sup>20</sup>        | 1.5203 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; vs ace; s ctc     |
| 8854 | 1-Phenyl-2-butanone                                  |                                             | C <sub>10</sub> H <sub>12</sub> O                             | 1007-32-5  | 148.201  |                             |       | 228; 111 <sup>16</sup>              | 0.9877 <sup>20</sup>       |                      | i H <sub>2</sub> O; s EtOH, ctc; msc eth; vs ace     |
| 8855 | 4-Phenyl-2-butanone                                  |                                             | C <sub>10</sub> H <sub>12</sub> O                             | 2550-26-7  | 148.201  | liq                         | -13   | 233.5                               | 0.9849 <sup>22</sup>       | 1.511 <sup>22</sup>  | i H <sub>2</sub> O; s EtOH, eth, ctc; vs ace         |
| 8856 | Phenylbutazone                                       |                                             | C <sub>19</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub> | 50-33-9    | 308.374  |                             | 105   |                                     |                            |                      |                                                      |
| 8857 | 2-Phenyl-1-butene                                    | $\alpha$ -Ethylstyrene                      | C <sub>10</sub> H <sub>12</sub>                               | 2039-93-2  | 132.202  |                             |       | 182                                 | 0.887 <sup>25</sup>        | 1.5288 <sup>20</sup> |                                                      |
| 8858 | 1-Phenyl-2-buten-1-one                               |                                             | C <sub>10</sub> H <sub>10</sub> O                             | 495-41-0   | 146.185  |                             | 20.5  | 111 <sup>9</sup>                    | 1.025 <sup>15</sup>        | 1.5626 <sup>18</sup> |                                                      |
| 8859 | <i>trans</i> -4-Phenyl-3-buten-2-one                 | Benzilideneacetone                          | C <sub>10</sub> H <sub>10</sub> O                             | 1896-62-4  | 146.185  | pl                          | 41.5  | 261                                 | 1.0097 <sup>45</sup>       | 1.5836 <sup>45</sup> | i H <sub>2</sub> O; vs EtOH; s eth, ace, bz; sl peth |
| 8860 | 4-Phenyl-3-buten-2-one                               |                                             | C <sub>10</sub> H <sub>10</sub> O                             | 1817-57-8  | 144.170  |                             | 4.5   | 79 <sup>2</sup>                     | 1.0215 <sup>20</sup>       | 1.5762 <sup>20</sup> |                                                      |
| 8861 | Phenyl chloroacetate                                 |                                             | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                | 620-73-5   | 170.594  | nd or pl (al)               | 44.5  | 232.5                               | 1.2202 <sup>44</sup>       | 1.5146 <sup>44</sup> | i H <sub>2</sub> O; vs EtOH, eth                     |
| 8862 | Phenyl chloroformate                                 |                                             | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                | 1885-14-9  | 156.567  |                             |       | 71 <sup>9</sup>                     |                            |                      |                                                      |
| 8863 | 4-Phenyl-2-chlorophenol                              | 3-Chloro-(1,1'-biphenyl)-4-ol               | C <sub>12</sub> H <sub>9</sub> ClO                            | 92-04-6    | 204.651  | wh-ye cry                   | 77    | 161 <sup>7</sup>                    |                            |                      |                                                      |
| 8864 | 2-Phenyl-2,5-cyclohexadiene-1,4-dione                |                                             | C <sub>12</sub> H <sub>8</sub> O <sub>2</sub>                 | 363-03-1   | 184.191  | ye lf (peth, al)            | 114   |                                     |                            |                      | sl H <sub>2</sub> O; s EtOH, bz, peth; vs chl        |
| 8865 | 4-Phenylcyclohexanone                                |                                             | C <sub>12</sub> H <sub>14</sub> O                             | 4894-75-1  | 174.238  | cry (peth)                  | 79    | 158 <sup>12</sup>                   |                            |                      |                                                      |
| 8866 | 1-(1-Phenylcyclohexyl)piperidine                     | Phencyclidine                               | C <sub>17</sub> H <sub>25</sub> N                             | 77-10-1    | 243.388  |                             | 46.5  | 136 <sup>1.0</sup>                  |                            |                      |                                                      |
| 8867 | 3-Phenyl-2-cyclopenten-1-one                         |                                             | C <sub>11</sub> H <sub>10</sub> O                             | 3810-26-2  | 158.196  | liq                         | -23   | 234.2                               | 0.9711 <sup>20</sup>       | 1.5440 <sup>20</sup> | s EtOH, ace, chl; sl eth                             |
| 8868 | <i>N</i> -Phenyl- <i>N,N</i> -diethanolamine         |                                             | C <sub>10</sub> H <sub>15</sub> NO <sub>2</sub>               | 120-07-0   | 181.232  |                             | 57    | 200 <sup>10</sup>                   | 1.201 <sup>60</sup>        |                      | vs ace, bz, eth, EtOH                                |
| 8869 | 2-Phenyl-1,3-dioxane                                 |                                             | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 772-01-0   | 164.201  | nd (peth)                   | 41    | 253                                 | 1.6053 <sup>60</sup>       |                      | vs EtOH, eth                                         |
| 8870 | 4-Phenyl-1,3-dioxane                                 |                                             | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 772-00-9   | 164.201  |                             |       | 247                                 | 1.1038 <sup>20</sup>       | 1.5306 <sup>18</sup> | i H <sub>2</sub> O; s os                             |
| 8871 | 1-Phenyl-1-dodecanone                                |                                             | C <sub>18</sub> H <sub>36</sub> O                             | 1674-38-0  | 260.414  |                             | 47    | 201 <sup>9</sup> , 181 <sup>5</sup> | 0.8794 <sup>18</sup>       | 1.4700 <sup>18</sup> | i H <sub>2</sub> O; s ace; sl ctc                    |

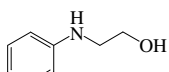




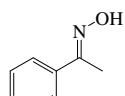
| No.  | Name                                                                    | Synonym                                 | Mol. Form.                                                  | CAS RN     | Mol. Wt. | Physical Form    | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|-------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------------------------|------------|----------|------------------|---------|-------------------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 8872 | 1-Phenyl-1,2-ethanediol                                                 | Styrene glycol                          | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>               | 93-56-1    | 138.164  | nd (lig)         | 67.5    | 273                                 |                            |                      | vs H <sub>2</sub> O, eth, bz, EtOH; sl lig                 |
| 8873 | <i>N</i> -Phenylethanolamine                                            |                                         | C <sub>8</sub> H <sub>11</sub> NO                           | 122-98-5   | 137.179  |                  |         | 279.5; 150 <sup>10</sup>            | 1.0945 <sup>20</sup>       | 1.5760 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth, chl                     |
| 8874 | 1-Phenylethanone oxime                                                  |                                         | C <sub>8</sub> H <sub>9</sub> NO                            | 613-91-2   | 135.163  | nd (w)           | 60      | 245                                 | 1.0515 <sup>78</sup>       |                      | sl H <sub>2</sub> O; vs EtOH, eth, ace, bz; s ctc          |
| 8875 | 2-Phenylethyl acetate                                                   |                                         | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | 103-45-7   | 164.201  | liq              | -31.1   | 232.6                               | 1.0883 <sup>20</sup>       | 1.5171 <sup>20</sup> | vs eth, EtOH                                               |
| 8876 | 1-Phenylethyl hydroperoxide                                             |                                         | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>               | 3071-32-7  | 138.164  | liq              |         | 50 <sup>0.01</sup>                  |                            |                      |                                                            |
| 8877 | <i>N</i> -(2-Phenylethyl)imidodocarbonimidic diamide, monohydrochloride | Phenformin hydrochloride                | C <sub>10</sub> H <sub>16</sub> ClN <sub>5</sub>            | 834-28-6   | 241.721  | cry              | 177.3   |                                     |                            |                      | s H <sub>2</sub> O                                         |
| 8878 | 2-Phenylethyl 2-methylpropanoate                                        | Benzylcarbinol isobutyrate              | C <sub>12</sub> H <sub>16</sub> O <sub>2</sub>              | 103-48-0   | 192.254  |                  |         | 250; 123 <sup>15</sup>              | 0.9950 <sup>15</sup>       | 1.4871 <sup>20</sup> |                                                            |
| 8879 | 2-Phenylethyl phenylacetate                                             |                                         | C <sub>16</sub> H <sub>16</sub> O <sub>2</sub>              | 102-20-5   | 240.297  |                  | 26.5    | 177 <sup>4.5</sup>                  | 1.077 <sup>25</sup>        |                      | vs EtOH                                                    |
| 8880 | 2-Phenylethyl propanoate                                                | Phenethyl propionate                    | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>              | 122-70-3   | 178.228  | liq              |         | 244                                 | 1.02 <sup>25</sup>         | 1.4950 <sup>20</sup> |                                                            |
| 8881 | 2-(2-Phenylethyl)pyridine                                               |                                         | C <sub>13</sub> H <sub>13</sub> N                           | 2116-62-3  | 183.249  | liq              | -1.5    | 289                                 | 1.0465 <sup>0</sup>        |                      |                                                            |
| 8882 | <i>N</i> -Phenylformamide                                               | Formanilide                             | C <sub>8</sub> H <sub>9</sub> NO                            | 103-70-8   | 121.137  | mcl pr (lig-xyl) | 46      | 271                                 | 1.1186 <sup>50</sup>       |                      | s H <sub>2</sub> O, eth, bz; vs EtOH                       |
| 8883 | Phenyl formate                                                          |                                         | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                | 1864-94-4  | 122.122  | liq              |         | 178; 82 <sup>15</sup>               |                            |                      |                                                            |
| 8884 | 2-Phenylfuran                                                           |                                         | C <sub>10</sub> H <sub>8</sub> O                            | 17113-33-6 | 144.170  |                  |         | 108 <sup>18</sup> , 82 <sup>5</sup> | 1.083 <sup>20</sup>        | 1.5920 <sup>20</sup> | vs ace, bz                                                 |
| 8885 | Phenyl α-D-glucopyranoside                                              |                                         | C <sub>12</sub> H <sub>16</sub> O <sub>6</sub>              | 4630-62-0  | 256.251  |                  | 174     |                                     |                            |                      |                                                            |
| 8886 | Phenyl glycidyl ether                                                   |                                         | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>               | 122-60-1   | 150.174  |                  |         | 243                                 | 1.1109 <sup>21</sup>       | 1.5307 <sup>21</sup> |                                                            |
| 8887 | <i>N</i> -Phenylglycine                                                 | Phenylaminoacetic acid                  | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>               | 103-01-5   | 151.163  |                  | 127.5   |                                     |                            |                      | vs H <sub>2</sub> O, EtOH                                  |
| 8888 | 1-Phenyl-1-heptanone                                                    |                                         | C <sub>13</sub> H <sub>18</sub> O                           | 1671-75-6  | 190.281  | lf               | 16.4    | 283.3                               | 0.9516 <sup>20</sup>       | 1.5060 <sup>20</sup> | vs ace, eth, EtOH                                          |
| 8889 | 1-Phenyl-1-hexanone                                                     |                                         | C <sub>12</sub> H <sub>16</sub> O                           | 942-92-7   | 176.254  | fl               | 27      | 265                                 | 0.9576 <sup>20</sup>       | 1.5027 <sup>25</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth, ace                 |
| 8890 | Phenylhydrazine                                                         |                                         | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                | 100-63-0   | 108.141  | mcl pr or pl     | 20.6    | 243.5                               | 1.0986 <sup>20</sup>       | 1.6084 <sup>10</sup> | s H <sub>2</sub> O; msc EtOH, eth, bz; vs ace              |
| 8891 | 2-Phenylhydrazinecarboxamide                                            | Phenicarbazide                          | C <sub>7</sub> H <sub>8</sub> N <sub>3</sub> O              | 103-03-7   | 151.165  |                  | 172     |                                     |                            |                      | sl H <sub>2</sub> O, eth, bz, lig; s EtOH, ace             |
| 8892 | <i>N</i> -Phenylhydrazinecarboxamide                                    | 4-Phenylsemicarbazide                   | C <sub>7</sub> H <sub>8</sub> N <sub>3</sub> O              | 537-47-3   | 151.165  | nd (bz), pl (w)  | 128     |                                     |                            |                      | sl H <sub>2</sub> O; vs EtOH, chl; i eth                   |
| 8893 | Phenylhydrazine monohydrochloride                                       |                                         | C <sub>6</sub> H <sub>8</sub> ClN <sub>2</sub>              | 59-88-1    | 144.601  | lf (al)          | 244 dec | sub                                 |                            |                      | vs H <sub>2</sub> O, EtOH                                  |
| 8894 | Phenylhydroxylamine                                                     | <i>N</i> -Hydroxybenzenamine            | C <sub>6</sub> H <sub>7</sub> NO                            | 100-65-2   | 109.126  | nd (w, bz, peth) | 83.5    |                                     |                            |                      | vs bz, eth, EtOH, chl                                      |
| 8895 | Phenyl 1-hydroxy-2-naphthalenecarboxylate                               |                                         | C <sub>17</sub> H <sub>12</sub> O <sub>3</sub>              | 132-54-7   | 264.275  |                  | 96      |                                     |                            |                      | vs bz, EtOH                                                |
| 8896 | 1-Phenyl-1 <i>H</i> -imidazole                                          |                                         | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub>                | 7164-98-9  | 144.173  |                  | 13      | 276                                 | 1.1397 <sup>15</sup>       | 1.6025 <sup>25</sup> | i H <sub>2</sub> O; vs eth, ace, chl                       |
| 8897 | 2-Phenyl-1 <i>H</i> -imidazole                                          |                                         | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub>                | 670-96-2   | 144.173  | lf (bz)          | 149.3   | 340                                 |                            |                      | vs EtOH                                                    |
| 8898 | 5-Phenyl-2,4-imidazolidinedione                                         | 5-Phenylhydantoin                       | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> | 89-24-7    | 176.172  |                  | 184.5   |                                     |                            |                      |                                                            |
| 8899 | Phenylimidocarbonyl chloride                                            |                                         | C <sub>7</sub> H <sub>5</sub> Cl <sub>2</sub> N             | 622-44-6   | 174.028  | liq              |         | 210; 105 <sup>30</sup>              | 1.28 <sup>15</sup>         |                      |                                                            |
| 8900 | 2-[(Phenylimino)methyl]phenol                                           |                                         | C <sub>13</sub> H <sub>11</sub> NO                          | 779-84-0   | 197.232  |                  | 49.5    |                                     | 1.087 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH                                 |
| 8901 | 4-[(Phenylimino)methyl]phenol                                           | <i>N</i> -(4-Hydroxybenzylidene)aniline | C <sub>13</sub> H <sub>11</sub> NO                          | 1689-73-2  | 197.232  |                  | 196.0   |                                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth; sl bz, chl                |
| 8902 | 1-Phenyl-1 <i>H</i> -indene                                             |                                         | C <sub>15</sub> H <sub>12</sub>                             | 1961-96-2  | 192.256  | oil              |         | 158 <sup>7</sup>                    |                            |                      |                                                            |
| 8903 | 2-Phenyl-1 <i>H</i> -indene-1,3(2 <i>H</i> )-dione                      | Phenindione                             | C <sub>15</sub> H <sub>10</sub> O <sub>2</sub>              | 83-12-5    | 222.239  | lf (al, bz)      | 150     |                                     |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, MeOH, chl        |
| 8904 | 2-Phenyl-1 <i>H</i> -indole                                             |                                         | C <sub>14</sub> H <sub>11</sub> N                           | 948-65-2   | 193.244  |                  | 190.5   | 250 <sup>10</sup>                   |                            |                      | sl H <sub>2</sub> O; s eth, bz, chl, HOAc, CS <sub>2</sub> |
| 8905 | Phenyl iodine diacetate                                                 | Iodobenzene diacetate                   | C <sub>10</sub> H <sub>11</sub> IO <sub>4</sub>             | 3240-34-4  | 322.096  | cry              | 161     |                                     |                            |                      |                                                            |
| 8906 | Phenyl isocyanate                                                       |                                         | C <sub>7</sub> H <sub>5</sub> NO                            | 103-71-9   | 119.121  |                  |         | 163; 55 <sup>13</sup>               | 1.0956 <sup>20</sup>       | 1.5368 <sup>20</sup> | vs eth; sl chl                                             |
| 8907 | 2-Phenyl-1 <i>H</i> -isoindole-1,3(2 <i>H</i> )-dione                   |                                         | C <sub>14</sub> H <sub>9</sub> NO <sub>2</sub>              | 520-03-6   | 223.227  | wh nd (al)       | 210     | sub                                 |                            |                      | i H <sub>2</sub> O; sl EtOH; msc chl                       |
| 8908 | Phenyl isopropyl ether                                                  | Isopropoxybenzene                       | C <sub>9</sub> H <sub>12</sub> O                            | 2741-16-4  | 136.190  | liq              | -33     | 176.8                               | 0.9408 <sup>25</sup>       | 1.4975 <sup>20</sup> | s H <sub>2</sub> O, EtOH, ace, bz                          |
| 8909 | Phenyl isothiocyanate                                                   |                                         | C <sub>7</sub> H <sub>5</sub> NS                            | 103-72-0   | 135.187  | liq              | -21     | 221                                 | 1.1303 <sup>20</sup>       | 1.6492 <sup>23</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                       |
| 8910 | 3-Phenyl-2-isoxazolin-5-one                                             |                                         | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>               | 1076-59-1  | 161.158  |                  | 151     |                                     |                            |                      | sl chl                                                     |
| 8911 | Phenyl laurate                                                          | Phenyl dodecanoate                      | C <sub>18</sub> H <sub>28</sub> O <sub>2</sub>              | 4228-00-6  | 276.414  | lf (al)          | 24.5    | 210 <sup>15</sup>                   | 0.9354 <sup>30</sup>       |                      | vs ace, eth, EtOH                                          |
| 8912 | Phenylmagnesium chloride                                                | Chlorophenylmagnesium                   | C <sub>6</sub> H <sub>5</sub> ClMg                          | 100-59-4   | 136.862  | cry              |         |                                     |                            |                      | reac H <sub>2</sub> O; s thf, eth                          |
| 8913 | Phenylmercuric chloride                                                 | Chlorophenylmercury                     | C <sub>6</sub> H <sub>5</sub> ClHg                          | 100-56-1   | 313.15   | pl (bz)          | 251     |                                     |                            |                      | i H <sub>2</sub> O; sl EtOH, bz                            |
| 8914 | Phenylmercuric nitrate                                                  |                                         | C <sub>6</sub> H <sub>5</sub> HgNO <sub>3</sub>             | 55-68-5    | 339.70   |                  | ≈181    |                                     |                            |                      |                                                            |
| 8915 | 4-(Phenylmethoxy)benzaldehyde                                           |                                         | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>              | 4397-53-9  | 212.244  |                  | 73      | 217 <sup>13</sup>                   |                            |                      |                                                            |



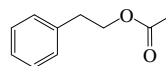
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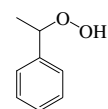
N-Phenylethanolamine



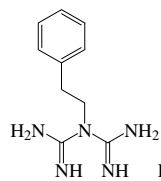
1-Phenylethanone oxime



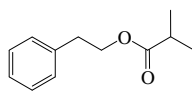
2-Phenylethyl acetate



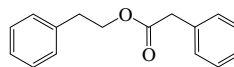
1-Phenylethyl hydroperoxide



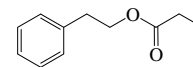
N-(2-Phenylethyl)imidodicarbonimidic diamide, monohydrochloride



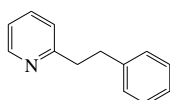
2-Phenylethyl 2-methylpropanoate



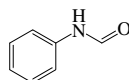
2-Phenylethyl phenylacetate



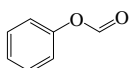
2-Phenylethyl propanoate



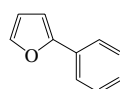
2-(2-Phenylethyl)pyridine



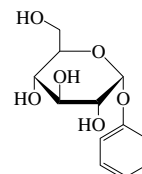
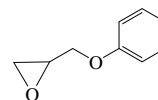
N-Phenylformamide



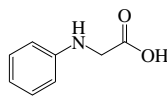
Phenyl formate



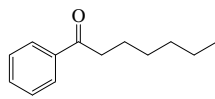
2-Phenylfuran

Phenyl  $\alpha$ -D-glucopyranoside

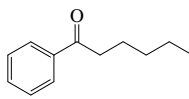
Phenyl glycidyl ether



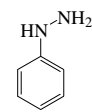
N-Phenylglycine



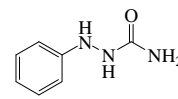
1-Phenyl-1-heptanone



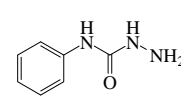
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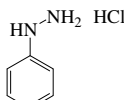
Phenylhydrazine



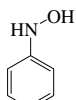
2-Phenylhydrazinecarboxamide



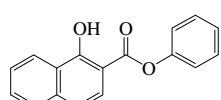
N-Phenylhydrazinecarboxamide



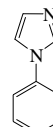
Phenylhydrazine monohydrochloride



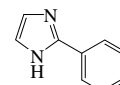
Phenylhydroxylamine



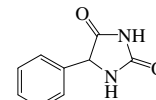
Phenyl 1-hydroxy-2-naphthalenecarboxylate



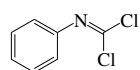
1-Phenyl-1H-imidazole



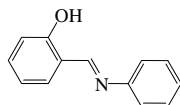
2-Phenyl-1H-imidazole



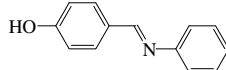
5-Phenyl-2,4-imidazolidinedione



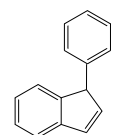
Phenylimidocarbonyl chloride



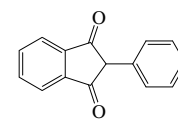
2-[(Phenylimino)methyl]phenol



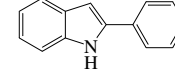
4-[(Phenylimino)methyl]phenol



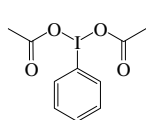
1-Phenyl-1H-indene



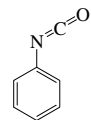
2-Phenyl-1H-indene-1,3(2H)-dione



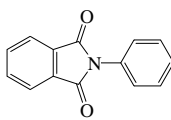
2-Phenyl-1H-indole



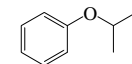
Phenyl iodine diacetate



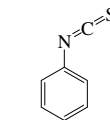
Phenyl isocyanate



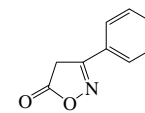
2-Phenyl-1H-indole-1,3(2H)-dione



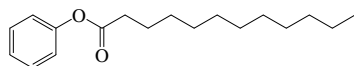
Phenyl isopropyl ether



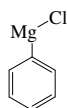
Phenyl isothiocyanate



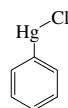
3-Phenyl-2-isoxazolin-5-one



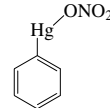
Phenyl laurate



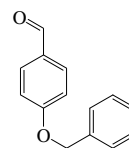
Phenylmagnesium chloride



Phenylmercuric chloride

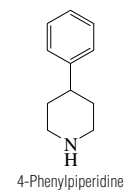
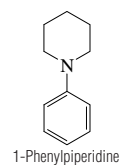
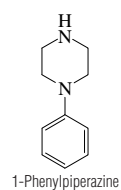
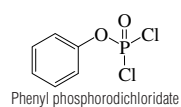
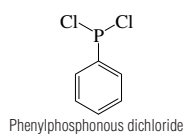
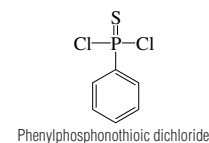
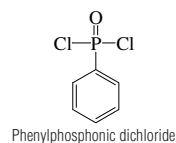
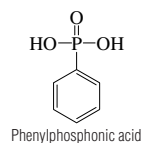
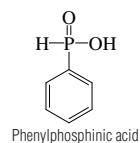
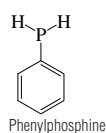
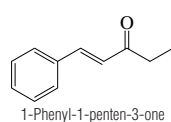
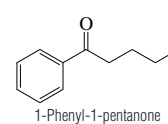
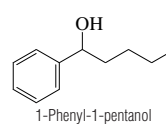
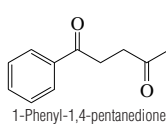
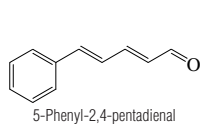
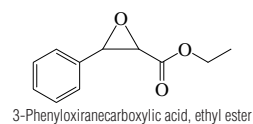
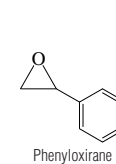
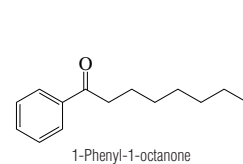
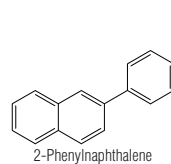
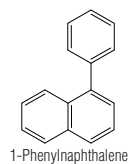
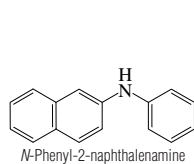
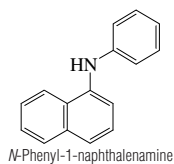
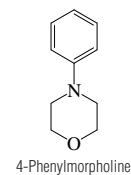
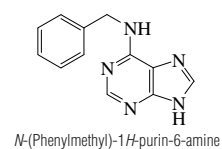
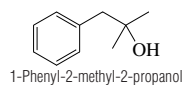
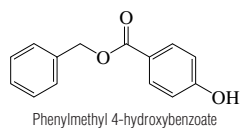
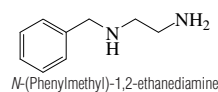
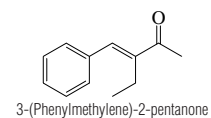
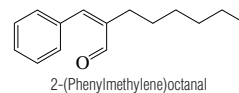
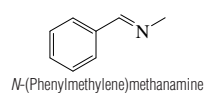
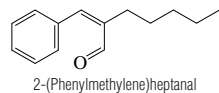
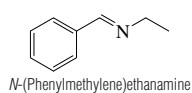
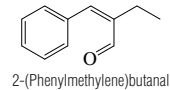
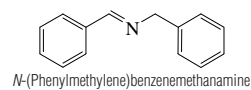
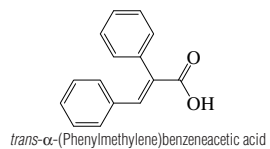
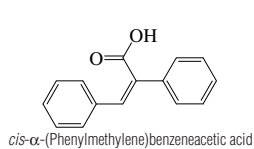
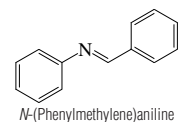
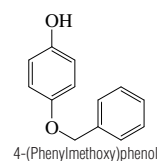
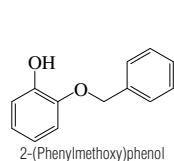
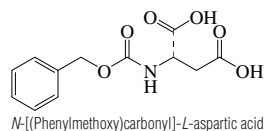
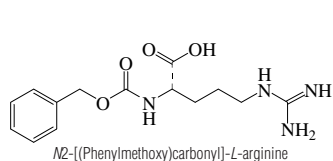


Phenylmercuric nitrate

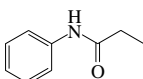


4-(Phenylmethoxy)benzaldehyde

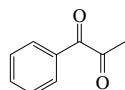
| No.  | Name                                                         | Synonym                                      | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form                           | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                |
|------|--------------------------------------------------------------|----------------------------------------------|----------------------------------------------------------------|------------|----------|-----------------------------------------|-------|---------------------------------------|----------------------------|----------------------|-----------------------------------------------------------|
| 8916 | <i>N</i> 2-[(Phenylmethoxy)carbonyl]- <i>L</i> -arginine     |                                              | C <sub>14</sub> H <sub>20</sub> N <sub>4</sub> O <sub>4</sub>  | 1234-35-1  | 308.334  |                                         | 174   |                                       |                            |                      |                                                           |
| 8917 | <i>N</i> -[(Phenylmethoxy)carbonyl]- <i>L</i> -aspartic acid |                                              | C <sub>12</sub> H <sub>13</sub> NO <sub>6</sub>                | 1152-61-0  | 267.234  |                                         | 117.0 |                                       |                            |                      |                                                           |
| 8918 | 2-(Phenylmethoxy)phenol                                      |                                              | C <sub>13</sub> H <sub>12</sub> O <sub>2</sub>                 | 6272-38-4  | 200.233  |                                         |       | 205 <sup>20</sup> , 173 <sup>13</sup> | 1.154 <sup>22</sup>        | 1.5906 <sup>18</sup> | vs eth, EtOH                                              |
| 8919 | 4-(Phenylmethoxy)phenol                                      | Monobenzene                                  | C <sub>13</sub> H <sub>12</sub> O <sub>2</sub>                 | 103-16-2   | 200.233  | pl (w)                                  | 122   |                                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, bz, eth; s ace              |
| 8920 | <i>N</i> -(Phenylmethylene)aniline                           | Benzylideneaniline                           | C <sub>13</sub> H <sub>11</sub> N                              | 538-51-2   | 181.233  | pa ye nd (CS <sub>2</sub> ) pl (dil al) | 54    | 310                                   | 1.038 <sup>55</sup>        | 1.600 <sup>100</sup> | i H <sub>2</sub> O; s EtOH, eth, NH <sub>3</sub> ; sl chl |
| 8921 | <i>cis</i> - $\alpha$ -(Phenylmethylene)benzeneacetic acid   | <i>cis</i> - $\alpha$ -Phenylcinnamic acid   | C <sub>15</sub> H <sub>12</sub> O <sub>2</sub>                 | 91-47-4    | 224.255  | silky needles                           | 174   |                                       |                            |                      | s H <sub>2</sub> O, EtOH, MeOH, eth, bz                   |
| 8922 | <i>trans</i> - $\alpha$ -(Phenylmethylene)benzeneacetic acid | <i>trans</i> - $\alpha$ -Phenylcinnamic acid | C <sub>15</sub> H <sub>12</sub> O <sub>2</sub>                 | 91-48-5    | 224.255  | prisms                                  | 138   |                                       |                            |                      | vs H <sub>2</sub> O; s EtOH, MeOH, eth, bz                |
| 8923 | <i>N</i> -(Phenylmethylene)benzenemethanamine                |                                              | C <sub>14</sub> H <sub>13</sub> N                              | 780-25-6   | 195.260  |                                         |       | 205 <sup>20</sup>                     |                            |                      |                                                           |
| 8924 | 2-(Phenylmethylene)butanal                                   |                                              | C <sub>11</sub> H <sub>12</sub> O                              | 28467-92-7 | 160.212  |                                         | 18    | 243; 157 <sup>5</sup>                 | 1.0201 <sup>22</sup>       | 1.578 <sup>20</sup>  |                                                           |
| 8925 | <i>N</i> -(Phenylmethylene)ethanamine                        |                                              | C <sub>9</sub> H <sub>11</sub> N                               | 6852-54-6  | 133.190  |                                         |       | 195                                   | 0.937 <sup>20</sup>        | 1.5378 <sup>15</sup> | i H <sub>2</sub> O; s EtOH, eth                           |
| 8926 | 2-(Phenylmethylene)heptanal                                  |                                              | C <sub>14</sub> H <sub>18</sub> O                              | 122-40-7   | 202.292  | ye oil                                  | 80    | 174 <sup>20</sup>                     | 0.9711 <sup>20</sup>       | 1.5381 <sup>20</sup> | i H <sub>2</sub> O; s ace, ctc                            |
| 8927 | <i>N</i> -(Phenylmethylene)methanamine                       | Benzylidenemethylamine                       | C <sub>8</sub> H <sub>9</sub> N                                | 622-29-7   | 119.164  |                                         |       | 185; 92 <sup>34</sup>                 | 0.9671 <sup>14</sup>       | 1.5526 <sup>20</sup> | s EtOH, eth, ace, chl                                     |
| 8928 | 2-(Phenylmethylene)octanal                                   | 2-Hexyl-3-phenyl-2-propenal                  | C <sub>15</sub> H <sub>20</sub> O                              | 101-86-0   | 216.319  | liq                                     | 4     | 252; 169 <sup>20</sup>                |                            |                      |                                                           |
| 8929 | 3-(Phenylmethylene)-2-pentanone                              | Methyl $\alpha$ -ethylstyryl ketone          | C <sub>12</sub> H <sub>14</sub> O                              | 3437-89-6  | 174.238  |                                         |       | 137 <sup>12</sup>                     | 1.0005 <sup>22</sup>       | 1.5650 <sup>22</sup> |                                                           |
| 8930 | <i>N</i> -(Phenylmethyl)-1,2-ethanediamine                   |                                              | C <sub>9</sub> H <sub>14</sub> N <sub>2</sub>                  | 4152-09-4  | 150.220  |                                         |       | 130 <sup>11</sup>                     |                            |                      |                                                           |
| 8931 | Phenylmethyl 4-hydroxybenzoate                               |                                              | C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>                 | 94-18-8    | 228.243  |                                         |       |                                       |                            |                      | sl chl                                                    |
| 8932 | 1-Phenyl-2-methyl-2-propanol                                 |                                              | C <sub>10</sub> H <sub>14</sub> O                              | 100-86-7   | 150.217  | nd                                      | 24    | 215                                   | 0.9787 <sup>16</sup>       | 1.5173 <sup>16</sup> |                                                           |
| 8933 | <i>N</i> -(Phenylmethyl)-1 <i>H</i> -purin-6-amine           |                                              | C <sub>12</sub> H <sub>11</sub> N <sub>5</sub>                 | 1214-39-7  | 225.249  |                                         | 232.8 |                                       |                            |                      |                                                           |
| 8934 | 4-Phenylmorpholine                                           |                                              | C <sub>10</sub> H <sub>13</sub> NO                             | 92-53-5    | 163.216  | cry (al-eth)                            | 58.3  |                                       |                            |                      | i H <sub>2</sub> O, EtOH; vs eth                          |
| 8935 | <i>N</i> -Phenyl-1-naphthalenamine                           | 1-Naphthylphenylamine                        | C <sub>16</sub> H <sub>13</sub> N                              | 90-30-2    | 219.281  |                                         | 61    |                                       |                            |                      | sl H <sub>2</sub> O, ctc; s EtOH, eth, bz, HOAc           |
| 8936 | <i>N</i> -Phenyl-2-naphthalenamine                           | <i>N</i> -Phenyl- $\beta$ -naphthylamine     | C <sub>16</sub> H <sub>13</sub> N                              | 135-88-6   | 219.281  |                                         | 108   | 395.5                                 |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz, HOAc; sl chl         |
| 8937 | 1-Phenyl-naphthalene                                         |                                              | C <sub>16</sub> H <sub>12</sub>                                | 605-02-7   | 204.266  | cry                                     | 45    | 334                                   | 1.096 <sup>20</sup>        | 1.6664 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz, HOAc; s ctc         |
| 8938 | 2-Phenyl-naphthalene                                         |                                              | C <sub>16</sub> H <sub>12</sub>                                | 612-94-2   | 204.266  | lf (al)                                 | 103.5 | 345.5                                 | 1.2180 <sup>20</sup>       |                      | s EtOH, bz, chl, HOAc; vs eth                             |
| 8939 | 1-Phenyl-1-octanone                                          |                                              | C <sub>14</sub> H <sub>20</sub> O                              | 1674-37-9  | 204.308  |                                         | 22.8  | 285; 164 <sup>15</sup>                | 0.9360 <sup>30</sup>       |                      | s EtOH, eth                                               |
| 8940 | Phenyloxirane                                                | Styrene-7,8-oxide                            | C <sub>8</sub> H <sub>8</sub> O                                | 96-09-3    | 120.149  | colorless liq                           | -35.6 | 194.1                                 | 1.0490 <sup>25</sup>       | 1.5342 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                      |
| 8941 | 3-Phenyloxiranecarboxylic acid, ethyl ester                  |                                              | C <sub>11</sub> H <sub>12</sub> O <sub>3</sub>                 | 121-39-1   | 192.211  |                                         |       | 136 <sup>5</sup>                      |                            |                      |                                                           |
| 8942 | 5-Phenyl-2,4-pentadienal                                     |                                              | C <sub>11</sub> H <sub>10</sub> O                              | 13466-40-5 | 158.196  |                                         | 42.5  | 160 <sup>3</sup> , 133 <sup>10</sup>  |                            |                      | i H <sub>2</sub> O; msc EtOH, bz; vs eth                  |
| 8943 | 1-Phenyl-1,4-pentanedione                                    |                                              | C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>                 | 583-05-1   | 176.212  | ye oil                                  |       | 162 <sup>12</sup>                     |                            | 1.5250 <sup>30</sup> | vs ace                                                    |
| 8944 | 1-Phenyl-1-pentanol                                          |                                              | C <sub>11</sub> H <sub>16</sub> O                              | 583-03-9   | 164.244  |                                         |       | 141 <sup>25</sup> , 102 <sup>3</sup>  | 0.9655 <sup>20</sup>       | 1.4086 <sup>25</sup> | vs ace, eth, EtOH                                         |
| 8945 | 1-Phenyl-1-pentanone                                         |                                              | C <sub>11</sub> H <sub>14</sub> O                              | 1009-14-9  | 162.228  | liq                                     | -9.4  | 245                                   | 0.986 <sup>20</sup>        | 1.5158 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; sl ctc                  |
| 8946 | 1-Phenyl-1-penten-3-one                                      |                                              | C <sub>11</sub> H <sub>12</sub> O                              | 3152-68-9  | 160.212  | lf (lig)                                | 38.5  | 142 <sup>12</sup>                     | 0.8697 <sup>20</sup>       | 1.5684 <sup>20</sup> | sl H <sub>2</sub> O, chl; vs EtOH, eth, bz                |
| 8947 | Phenylphosphine                                              | Monophenylphosphine                          | C <sub>6</sub> H <sub>7</sub> P                                | 638-21-1   | 110.094  |                                         |       | 160.5                                 | 1.001 <sup>15</sup>        | 1.5796 <sup>20</sup> |                                                           |
| 8948 | Phenylphosphinic acid                                        | Benzenephosphinic acid                       | C <sub>6</sub> H <sub>7</sub> O <sub>2</sub> P                 | 1779-48-2  | 142.093  |                                         | 83.8  |                                       |                            |                      | s H <sub>2</sub> O; vs EtOH; sl eth, chl                  |
| 8949 | Phenylphosphonic acid                                        | Benzenephosphonic acid                       | C <sub>6</sub> H <sub>7</sub> O <sub>3</sub> P                 | 1571-33-1  | 158.092  | lf (w)                                  | 160   |                                       |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, ace; i bz               |
| 8950 | Phenylphosphonic dichloride                                  |                                              | C <sub>6</sub> H <sub>5</sub> Cl <sub>2</sub> OP               | 824-72-6   | 194.983  |                                         | 1     | 258                                   | 1.197 <sup>25</sup>        | 1.5581 <sup>25</sup> | sl DMSO                                                   |
| 8951 | Phenylphosphonothioic dichloride                             | Dichlorophenylphosphine sulfide              | C <sub>6</sub> H <sub>5</sub> Cl <sub>2</sub> PS               | 3497-00-5  | 211.049  |                                         |       | 205 <sup>130</sup>                    | 1.376 <sup>13</sup>        |                      |                                                           |
| 8952 | Phenylphosphonous dichloride                                 | Dichlorophenylphosphine                      | C <sub>6</sub> H <sub>5</sub> Cl <sub>2</sub> P                | 644-97-3   | 178.984  | liq                                     | -51   | 225; 142 <sup>57</sup>                | 1.356 <sup>20</sup>        | 1.6030 <sup>20</sup> | vs bz                                                     |
| 8953 | Phenyl phosphorodichloridate                                 | Phenyl dichlorophosphate                     | C <sub>6</sub> H <sub>5</sub> Cl <sub>2</sub> O <sub>2</sub> P | 770-12-7   | 210.983  | hyg liq                                 |       | 242; 100 <sup>5</sup>                 | 1.412 <sup>20</sup>        | 1.5230 <sup>20</sup> |                                                           |
| 8954 | 1-Phenylpiperazine                                           |                                              | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub>                 | 92-54-6    | 162.231  | pa ye oil                               |       | 286.5; 161 <sup>15</sup>              | 1.0621 <sup>20</sup>       | 1.5875 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl                  |
| 8955 | 1-Phenylpiperidine                                           |                                              | C <sub>11</sub> H <sub>15</sub> N                              | 4096-20-2  | 161.244  |                                         | 4.7   | 258                                   | 0.9944 <sup>25</sup>       | 1.5598 <sup>25</sup> | vs EtOH, eth, bz, chl                                     |
| 8956 | 4-Phenylpiperidine                                           |                                              | C <sub>11</sub> H <sub>15</sub> N                              | 771-99-3   | 161.244  |                                         | 60.5  | 257                                   | 0.9996 <sup>16</sup>       |                      | s chl                                                     |



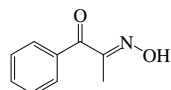
| No.  | Name                                         | Synonym                        | Mol. Form.                                      | CAS RN     | Mol. Wt. | Physical Form         | mp/°C | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|----------------------------------------------|--------------------------------|-------------------------------------------------|------------|----------|-----------------------|-------|---------------------------------------|----------------------------|----------------------|------------------------------------------------------|
| 8957 | <i>N</i> -Phenylpropanamide                  |                                | C <sub>9</sub> H <sub>11</sub> NO               | 620-71-3   | 149.189  | pl (eth, al, bz)      | 105.5 | 222.2                                 | 1.175 <sup>25</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth                    |
| 8958 | 1-Phenyl-1,2-propanedione                    |                                | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>    | 579-07-7   | 148.159  | ye oil                | <20   | 222; 102 <sup>12</sup>                | 1.1006 <sup>20</sup>       | 1.537 <sup>10</sup>  | s H <sub>2</sub> O, EtOH, eth                        |
| 8959 | 1-Phenyl-1,2-propanedione, 2-oxime           |                                | C <sub>9</sub> H <sub>9</sub> NO <sub>2</sub>   | 119-51-7   | 163.173  | wh nd (w)             | 115   |                                       |                            |                      |                                                      |
| 8960 | Phenyl propanoate                            |                                | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>   | 637-27-4   | 150.174  | pr                    | 20    | 211                                   | 1.0436 <sup>25</sup>       | 1.4980 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz               |
| 8961 | 2-Phenyl-1-propanol                          |                                | C <sub>9</sub> H <sub>12</sub> O                | 1123-85-9  | 136.190  |                       |       | 121 <sup>26</sup> , 105 <sup>11</sup> | 0.975 <sup>25</sup>        | 1.5582 <sup>2</sup>  | i H <sub>2</sub> O; s EtOH                           |
| 8962 | 1-Phenyl-2-propanol                          |                                | C <sub>9</sub> H <sub>12</sub> O                | 698-87-3   | 136.190  |                       |       | 125 <sup>25</sup> , 120 <sup>20</sup> | 0.991 <sup>20</sup>        | 1.5190 <sup>20</sup> |                                                      |
| 8963 | Phenylpropanolamine hydrochloride            |                                | C <sub>9</sub> H <sub>14</sub> ClNO             | 154-41-6   | 187.666  |                       | 194   |                                       |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth, bz, chl          |
| 8964 | 1-Phenyl-1-propanone                         | Propiophenone                  | C <sub>9</sub> H <sub>10</sub> O                | 93-55-0    | 134.174  |                       | 18.6  | 217.5                                 | 1.0096 <sup>20</sup>       | 1.5269 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                 |
| 8965 | 1-Phenyl-2-propanone                         | Phenylacetone                  | C <sub>9</sub> H <sub>10</sub> O                | 103-79-7   | 134.174  | liq                   | -15   | 216.5                                 | 1.0157 <sup>20</sup>       | 1.5168 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; msc bz, xyl; s chl |
| 8966 | <i>cis</i> -3-Phenyl-2-propenenitrile        |                                | C <sub>9</sub> H <sub>7</sub> N                 | 24840-05-9 | 129.159  | liq                   | -4.4  | 249; 139 <sup>30</sup>                | 1.0289 <sup>20</sup>       | 1.5843 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; vs bz                    |
| 8967 | <i>trans</i> -3-Phenyl-2-propenenitrile      |                                | C <sub>9</sub> H <sub>7</sub> N                 | 1885-38-7  | 129.159  |                       | 22    | 263.8                                 | 1.0304 <sup>20</sup>       | 1.6013 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, ctc                 |
| 8968 | 3-Phenyl-2-propenoic anhydride               | Cinnamic anhydride             | C <sub>18</sub> H <sub>14</sub> O <sub>3</sub>  | 538-56-7   | 278.302  | nd (bz or al) pt (al) | 136   |                                       |                            |                      | vs bz                                                |
| 8969 | <i>cis</i> -3-Phenyl-2-propen-1-ol           |                                | C <sub>9</sub> H <sub>10</sub> O                | 4510-34-3  | 134.174  | wh nd (eth-peth)      | 34    | 257.5                                 | 1.0440 <sup>20</sup>       | 1.5819 <sup>20</sup> | vs eth, EtOH                                         |
| 8970 | <i>trans</i> -3-Phenyl-2-propen-1-ol         |                                | C <sub>9</sub> H <sub>10</sub> O                | 4407-36-7  | 134.174  | wh nd (eth-peth)      | 34    | 257.5                                 | 1.0440 <sup>20</sup>       | 1.5819 <sup>20</sup> | sl H <sub>2</sub> O, chl; vs EtOH, eth               |
| 8971 | <i>trans</i> -3-Phenyl-2-propen-1-ol acetate | <i>trans</i> -Cinnamyl acetate | C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>  | 21040-45-9 | 176.212  |                       |       | 265; 145 <sup>15</sup>                | 1.0567 <sup>20</sup>       | 1.5425 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl        |
| 8972 | <i>trans</i> -3-Phenyl-2-propenoyl chloride  | Cinnamoyl chloride             | C <sub>9</sub> H <sub>7</sub> ClO               | 17082-09-6 | 166.604  | ye cry                | 37.5  | 257.5                                 | 1.1617 <sup>45</sup>       | 1.614 <sup>42</sup>  | i H <sub>2</sub> O; s EtOH, ctc, lig                 |
| 8973 | 3-Phenylpropyl acetate                       | Benzenepropanol, acetate       | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>  | 122-72-5   | 178.228  | col liq               | -40   | 69 <sup>1</sup>                       |                            |                      |                                                      |
| 8974 | 1-Phenyl-2-propylamine, (±)                  | Amphetamine                    | C <sub>9</sub> H <sub>13</sub> N                | 300-62-9   | 135.206  | oil                   |       | 203                                   | 0.9306 <sup>25</sup>       | 1.518 <sup>26</sup>  | sl H <sub>2</sub> O, eth; s chl, EtOH                |
| 8975 | 1-Phenyl-2-propylamine, (S)                  | Dexamphetamine                 | C <sub>9</sub> H <sub>13</sub> N                | 51-64-9    | 135.206  | oil                   | 27.5  | 203.5; 80 <sup>12</sup>               | 0.949 <sup>15</sup>        | 1.4704 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                     |
| 8976 | Phenyl propyl ether                          | Propoxybenzene                 | C <sub>9</sub> H <sub>12</sub> O                | 622-85-5   | 136.190  | liq                   | -27   | 189.9                                 | 0.9474 <sup>20</sup>       | 1.5014 <sup>20</sup> | s EtOH, eth                                          |
| 8977 | 4-(3-Phenylpropyl)pyridine                   |                                | C <sub>14</sub> H <sub>15</sub> N               | 2057-49-0  | 197.276  |                       |       | 322; 150 <sup>5</sup>                 | 1.024 <sup>25</sup>        | 1.5616 <sup>25</sup> | vs bz, eth, py, EtOH                                 |
| 8978 | 3-Phenyl-2-propynal                          |                                | C <sub>9</sub> H <sub>8</sub> O                 | 2579-22-8  | 130.143  |                       |       | 127 <sup>28</sup> , 104 <sup>11</sup> | 1.0622 <sup>20</sup>       | 1.6079 <sup>12</sup> |                                                      |
| 8979 | 3-Phenyl-2-propynoic acid                    | Phenylacetylenecarboxylic acid | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>    | 637-44-5   | 146.143  | nd (w)                | 137.5 |                                       | 1.28 <sup>20</sup>         |                      | sl H <sub>2</sub> O; vs EtOH, eth                    |
| 8980 | 3-Phenyl-2-propyn-1-ol                       |                                | C <sub>9</sub> H <sub>8</sub> O                 | 1504-58-1  | 132.159  |                       |       | 137 <sup>15</sup>                     | 1.078 <sup>20</sup>        | 1.5873 <sup>28</sup> | s eth, ace, bz                                       |
| 8981 | 6-Phenyl-2,4,7-pteridinetriamine             | Triamterene                    | C <sub>12</sub> H <sub>11</sub> N <sub>7</sub>  | 396-01-0   | 253.262  | ye pl (BuOH)          | 316   |                                       |                            |                      | i eth; sl EtOH, chl                                  |
| 8982 | 1-Phenyl-3-pyrazolidinone                    |                                | C <sub>9</sub> H <sub>10</sub> N <sub>2</sub> O | 92-43-3    | 162.187  |                       | 126   |                                       |                            |                      | i eth, lig                                           |
| 8983 | 2-Phenylpyridine                             |                                | C <sub>11</sub> H <sub>9</sub> N                | 1008-89-5  | 155.196  |                       |       | 271                                   | 1.0833 <sup>25</sup>       | 1.6210 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth                   |
| 8984 | 3-Phenylpyridine                             |                                | C <sub>11</sub> H <sub>9</sub> N                | 1008-88-4  | 155.196  | pa ye oil             | 164   | 272                                   |                            | 1.6123 <sup>25</sup> | sl H <sub>2</sub> O; s EtOH, eth                     |
| 8985 | 4-Phenylpyridine                             |                                | C <sub>11</sub> H <sub>9</sub> N                | 939-23-1   | 155.196  | pl (w)                | 77.5  | 281                                   |                            |                      | s H <sub>2</sub> O, EtOH, eth                        |
| 8986 | Phenyl-2-pyridinylmethanone                  |                                | C <sub>12</sub> H <sub>9</sub> NO               | 91-02-1    | 183.205  |                       | 42    | 317                                   | 1.1556 <sup>20</sup>       |                      | s chl                                                |
| 8987 | Phenyl-4-pyridinylmethanone                  |                                | C <sub>12</sub> H <sub>9</sub> NO               | 14548-46-0 | 183.205  | nd (peth), pl (w)     | 72    | 315; 170 <sup>10</sup>                |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz                 |
| 8988 | 1-Phenyl-1 <i>H</i> -pyrrole                 |                                | C <sub>10</sub> H <sub>9</sub> N                | 635-90-5   | 143.185  | pl (sub), red in air  | 62    | 234                                   |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz; vs peth    |
| 8989 | 2-Phenyl-1 <i>H</i> -pyrrole                 |                                | C <sub>10</sub> H <sub>9</sub> N                | 3042-22-6  | 143.185  | pl (al, sub)          | 129   | 272                                   |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, bz, chl; sl lig    |
| 8990 | 1-Phenyl-1 <i>H</i> -pyrrole-2,5-dione       | <i>N</i> -Phenylmaleimide      | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>  | 941-69-5   | 173.169  | ye nd (bz-lig)        | 90.5  | 162 <sup>12</sup>                     |                            |                      | vs bz, eth, EtOH                                     |
| 8991 | 1-Phenylpyrrolidine                          |                                | C <sub>10</sub> H <sub>13</sub> N               | 4096-21-3  | 147.217  |                       | 11    | 119 <sup>12</sup> , 102 <sup>5</sup>  | 1.018 <sup>20</sup>        | 1.5813 <sup>20</sup> | s eth                                                |
| 8992 | 1-Phenyl-2,5-pyrrolidinedione                | Succinanyl                     | C <sub>10</sub> H <sub>9</sub> NO <sub>2</sub>  | 83-25-0    | 175.184  | mcl pr or nd (w, al)  | 156   | 400                                   | 1.356 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth                      |
| 8993 | 2-Phenylquinoline                            |                                | C <sub>15</sub> H <sub>11</sub> N               | 612-96-4   | 205.255  | nd (dil al)           | 86    | 363; 194 <sup>6</sup>                 |                            |                      | sl H <sub>2</sub> O, peth; vs EtOH, eth, ace, bz     |
| 8994 | 2-Phenyl-4-quinolinecarboxylic acid          | Cinchophen                     | C <sub>16</sub> H <sub>11</sub> NO <sub>2</sub> | 132-60-5   | 249.264  | nd                    | 214.5 |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, alk; sl ace, bz     |
| 8995 | Phenyl salicylate                            |                                | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>  | 118-55-8   | 214.216  |                       | 43    | 173 <sup>12</sup>                     | 1.2614 <sup>30</sup>       |                      | i H <sub>2</sub> O; vs EtOH, ace, bz; s eth, HOAc    |
| 8996 | Phenylsilane                                 |                                | C <sub>6</sub> H <sub>6</sub> Si                | 694-53-1   | 108.214  |                       |       | 119                                   | 0.8681 <sup>20</sup>       | 1.5125 <sup>20</sup> | i H <sub>2</sub> O                                   |



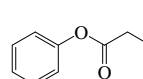
N-Phenylpropanamide



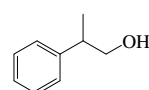
1-Phenyl-1,2-propanedione



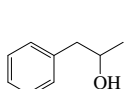
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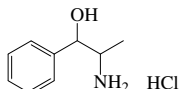
Phenyl propanoate



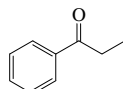
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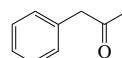
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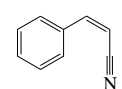
Phenylpropanolamine hydrochloride



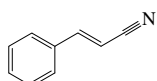
1-Phenyl-1-propanone



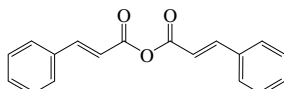
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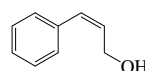
cis-3-Phenyl-2-propenenitrile



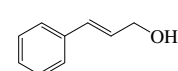
trans-3-Phenyl-2-propenenitrile



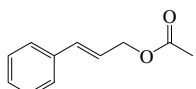
3-Phenyl-2-propenoic anhydride



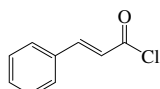
cis-3-Phenyl-2-propen-1-ol



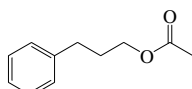
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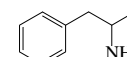
trans-3-Phenyl-2-propen-1-ol acetate



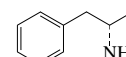
trans-3-Phenyl-2-propenoyl chloride



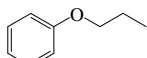
3-Phenylpropyl acetate



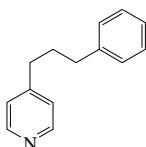
1-Phenyl-2-propylamine, (±)



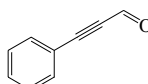
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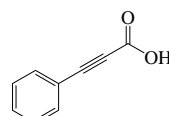
Phenyl propyl ether



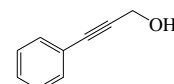
4-(3-Phenylpropyl)pyridine



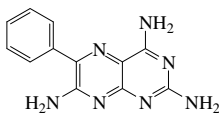
3-Phenyl-2-propynal



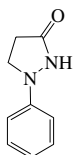
3-Phenyl-2-propynoic acid



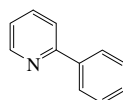
3-Phenyl-2-propyn-1-ol



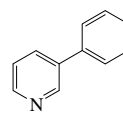
6-Phenyl-2,4,7-pteridinetriamine



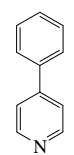
1-Phenyl-3-pyrazolidinone



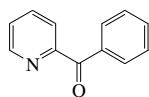
2-Phenylpyridine



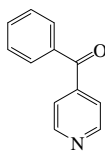
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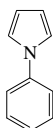
4-Phenylpyridine



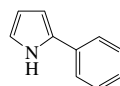
Phenyl-2-pyridinylmethanone



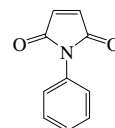
Phenyl-4-pyridinylmethanone



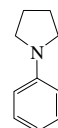
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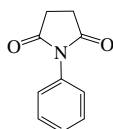
2-Phenyl-1H-pyrrole



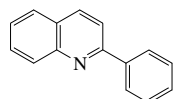
1-Phenyl-1H-pyrrole-2,5-dione



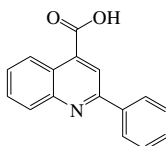
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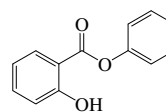
1-Phenyl-2,5-pyrrolidinedione



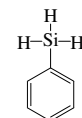
2-Phenylquinoline



2-Phenyl-4-quinolinecarboxylic acid

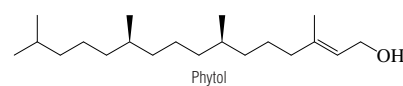
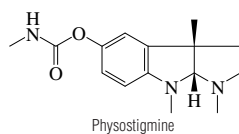
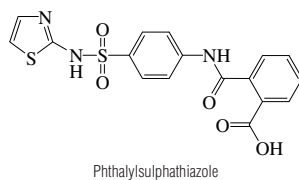
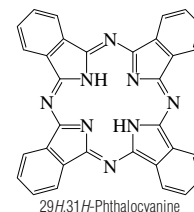
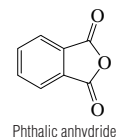
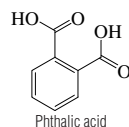
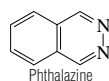
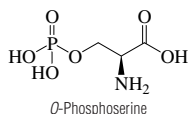
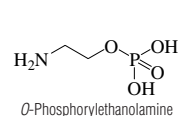
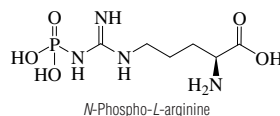
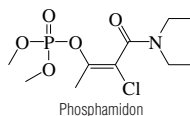
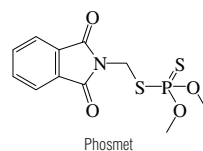
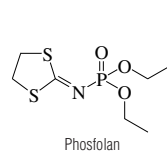
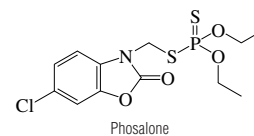
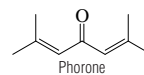
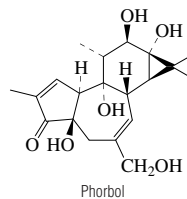
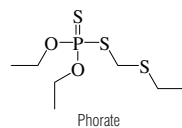
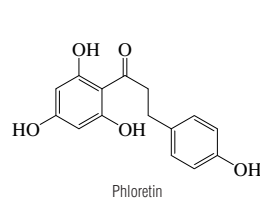
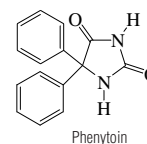
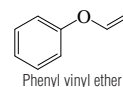
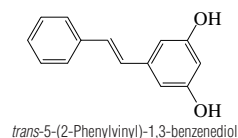
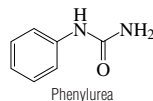
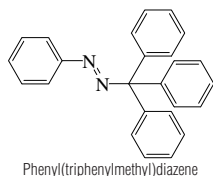
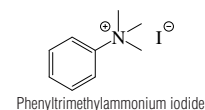
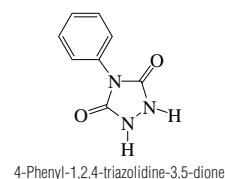
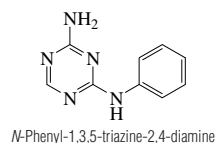
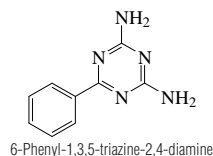
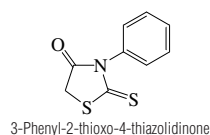
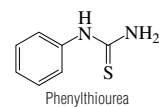
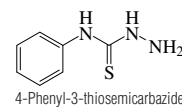
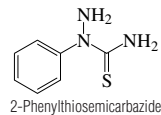
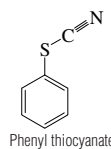
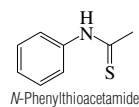
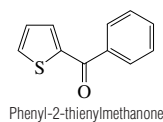
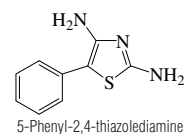
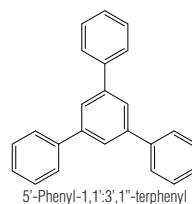
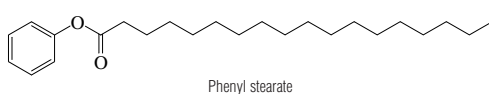
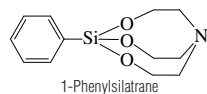


Phenyl salicylate



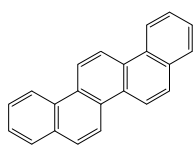
Phenylsilane

| No.  | Name                                            | Synonym                                                                                     | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|-------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|----------------------------|---------|----------------------|----------------------------|----------------------|------------------------------------------------------|
| 8997 | 1-Phenylsilatrane                               |                                                                                             | C <sub>12</sub> H <sub>17</sub> NO <sub>3</sub> Si                           | 2097-19-0  | 251.354  | pr or nd (ace)             | 209     |                      |                            |                      |                                                      |
| 8998 | Phenyl stearate                                 |                                                                                             | C <sub>24</sub> H <sub>40</sub> O <sub>2</sub>                               | 637-55-8   | 360.574  |                            | 52      | 267 <sup>15</sup>    |                            |                      | i H <sub>2</sub> O; s EtOH, eth                      |
| 8999 | 5'-Phenyl-1,1':3',1''-terphenyl                 |                                                                                             | C <sub>24</sub> H <sub>18</sub>                                              | 612-71-5   | 306.400  | orth nd (al or HOAc)       | 176     | 462                  | 1.199 <sup>30</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, HOAc; vs bz; sl chl |
| 9000 | 5-Phenyl-2,4-thiazolidine                       | Amiphenazole                                                                                | C <sub>9</sub> H <sub>9</sub> N <sub>3</sub> S                               | 490-55-1   | 191.252  | fl (dil al) br in air      | 163 dec |                      |                            |                      |                                                      |
| 9001 | Phenyl-2-thienylmethanone                       |                                                                                             | C <sub>11</sub> H <sub>8</sub> OS                                            | 135-00-2   | 188.246  | nd (dil al)                | 56.5    | 300                  | 1.1890 <sup>54</sup>       | 1.6181 <sup>54</sup> | i H <sub>2</sub> O; s EtOH, eth                      |
| 9002 | <i>N</i> -Phenylthioacetamide                   | Thioacetanilide                                                                             | C <sub>8</sub> H <sub>9</sub> NS                                             | 637-53-6   | 151.229  | nd (w)                     | 75.5    | dec                  |                            |                      |                                                      |
| 9003 | Phenyl thiocyanate                              |                                                                                             | C <sub>7</sub> H <sub>5</sub> NS                                             | 5285-87-0  | 135.187  |                            |         | 232.5                | 1.153 <sup>18</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth                      |
| 9004 | 2-Phenylthiosemicarbazide                       | 2-Phenylhydrazinecarbothioamide                                                             | C <sub>7</sub> H <sub>9</sub> N <sub>3</sub> S                               | 645-48-7   | 167.231  | pr (al)                    | 200 dec |                      |                            |                      |                                                      |
| 9005 | 4-Phenyl-3-thiosemicarbazide                    | <i>N</i> -Phenylhydrazinecarbothioamide                                                     | C <sub>7</sub> H <sub>9</sub> N <sub>3</sub> S                               | 5351-69-9  | 167.231  | pl (al)                    | 140 dec |                      |                            |                      | i EtOH, lig; sl bz                                   |
| 9006 | Phenylthiourea                                  |                                                                                             | C <sub>7</sub> H <sub>9</sub> N <sub>2</sub> S                               | 103-85-5   | 152.217  | nd (w), pr (al)            | 154     |                      |                            |                      | sl H <sub>2</sub> O; s EtOH, NaOH                    |
| 9007 | 3-Phenyl-2-thioxo-4-thiazolidinone              | 3-Phenylrhodanine                                                                           | C <sub>9</sub> H <sub>7</sub> NOS <sub>2</sub>                               | 1457-46-1  | 209.288  | ye pr (HOAc) nd or pr (al) | 194.5   |                      |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s ace, chl, HOAc   |
| 9008 | 6-Phenyl-1,3,5-triazine-2,4-diamine             | Benzoguanamine                                                                              | C <sub>9</sub> H <sub>9</sub> N <sub>5</sub>                                 | 91-76-9    | 187.201  | nd, pl (al)                | 226.5   |                      |                            |                      | s EtOH, eth; sl tfa                                  |
| 9009 | <i>N</i> -Phenyl-1,3,5-triazine-2,4-diamine     | Amanozine                                                                                   | C <sub>9</sub> H <sub>9</sub> N <sub>5</sub>                                 | 537-17-7   | 187.201  | cry (diox, 50% al)         | 235.5   |                      |                            |                      |                                                      |
| 9010 | 4-Phenyl-1,2,4-triazolidine-3,5-dione           |                                                                                             | C <sub>8</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>                  | 15988-11-1 | 177.161  |                            | 205.5   |                      |                            |                      |                                                      |
| 9011 | Phenyltrimethylammonium iodide                  |                                                                                             | C <sub>9</sub> H <sub>14</sub> IN                                            | 98-04-4    | 263.118  | lf (al)                    | 224     |                      |                            |                      | vs H <sub>2</sub> O; s EtOH, HOAc; sl ace; i chl     |
| 9012 | Phenyl(triphenylmethyl)diazene                  |                                                                                             | C <sub>25</sub> H <sub>20</sub> N <sub>2</sub>                               | 981-18-0   | 348.440  |                            | 111 dec |                      |                            |                      |                                                      |
| 9013 | Phenylurea                                      |                                                                                             | C <sub>7</sub> H <sub>9</sub> N <sub>2</sub> O                               | 64-10-8    | 136.151  | mcl pr (w, al)             | 147     | 238                  | 1.302 <sup>25</sup>        |                      | sl H <sub>2</sub> O, eth, DMSO; s EtOH, AcOEt        |
| 9014 | <i>trans</i> -5-(2-Phenylvinyl)-1,3-benzenediol | Pinosylvin                                                                                  | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>                               | 22139-77-1 | 212.244  | nd (HOAc)                  | 156     |                      |                            |                      | vs ace, bz, chl, HOAc                                |
| 9015 | Phenyl vinyl ether                              |                                                                                             | C <sub>8</sub> H <sub>8</sub> O                                              | 766-94-9   | 120.149  |                            |         | 155.5                | 0.9770 <sup>20</sup>       | 1.5224 <sup>20</sup> | i H <sub>2</sub> O; vs eth                           |
| 9016 | Phenytol                                        | 5,5-Diphenyl-2,4-imidazolidinedione                                                         | C <sub>15</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                | 57-41-0    | 252.268  | nd (al)                    | 286     |                      |                            |                      | i H <sub>2</sub> O; s EtOH, ace; sl eth, bz          |
| 9017 | Phloretin                                       |                                                                                             | C <sub>15</sub> H <sub>14</sub> O <sub>5</sub>                               | 60-82-2    | 274.269  | nd (dil al), cry (ace)     | 263 dec |                      |                            |                      | sl H <sub>2</sub> O, chl; msc EtOH, bz; i eth; s ace |
| 9018 | Phorate                                         |                                                                                             | C <sub>7</sub> H <sub>17</sub> O <sub>2</sub> PS <sub>3</sub>                | 298-02-2   | 260.378  |                            | <-15    | 119 <sup>0.8</sup>   | 1.16 <sup>25</sup>         |                      |                                                      |
| 9019 | Phorbol                                         |                                                                                             | C <sub>20</sub> H <sub>26</sub> O <sub>6</sub>                               | 17673-25-5 | 364.432  | cry (EtOH)                 | 250 dec |                      |                            |                      | s H <sub>2</sub> O, ace                              |
| 9020 | Phorone                                         |                                                                                             | C <sub>9</sub> H <sub>14</sub> O                                             | 504-20-1   | 138.206  | ye-grn pr                  | 28      | 197.5                | 0.8850 <sup>20</sup>       | 1.4998 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, ctc           |
| 9021 | Phosalone                                       |                                                                                             | C <sub>12</sub> H <sub>15</sub> ClNO <sub>4</sub> PS <sub>2</sub>            | 2310-17-0  | 367.808  |                            | 46      |                      |                            |                      |                                                      |
| 9022 | Phosfolan                                       |                                                                                             | C <sub>7</sub> H <sub>14</sub> NO <sub>3</sub> PS <sub>2</sub>               | 947-02-4   | 255.295  |                            | 36.5    | 117 <sup>0.001</sup> |                            |                      | vs H <sub>2</sub> O, bz, ace; sl eth; s hx           |
| 9023 | Phosmet                                         |                                                                                             | C <sub>11</sub> H <sub>12</sub> NO <sub>4</sub> PS <sub>2</sub>              | 732-11-6   | 317.321  |                            | 72      | dec                  |                            |                      |                                                      |
| 9024 | Phosphamidon                                    |                                                                                             | C <sub>10</sub> H <sub>15</sub> ClNO <sub>3</sub> P                          | 13171-21-6 | 299.689  | oil                        | -45     | 162 <sup>1.5</sup>   | 1.2132 <sup>25</sup>       | 1.4718 <sup>25</sup> | msc H <sub>2</sub> O; s hx                           |
| 9025 | <i>N</i> -Phospho- <i>L</i> -arginine           |                                                                                             | C <sub>6</sub> H <sub>15</sub> N <sub>4</sub> O <sub>5</sub> P               | 1189-11-3  | 254.181  | cry (ace aq)               | 177     |                      |                            |                      |                                                      |
| 9026 | <i>O</i> -Phosphorylethanolamine                | Ethanolamine <i>O</i> -phosphate                                                            | C <sub>2</sub> H <sub>5</sub> NO <sub>4</sub> P                              | 1071-23-4  | 141.063  | cry (EtOH aq)              | 242     |                      |                            |                      |                                                      |
| 9027 | <i>O</i> -Phosphoserine                         |                                                                                             | C <sub>3</sub> H <sub>8</sub> NO <sub>5</sub> P                              | 407-41-0   | 185.073  | cry                        | 166 dec |                      |                            |                      |                                                      |
| 9028 | Phthalazine                                     | 2,3-Benzodiazine                                                                            | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                                 | 253-52-1   | 130.147  |                            | 90.5    | 316                  |                            |                      | s H <sub>2</sub> O, EtOH, bz; sl eth; i lig          |
| 9029 | Phthalic acid                                   | 1,2-Benzenedicarboxylic acid                                                                | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                                 | 88-99-3    | 166.132  | pl (w)                     | 230 dec | dec                  | 2.18 <sup>191</sup>        |                      | sl H <sub>2</sub> O, eth; i chl; s EtOH              |
| 9030 | Phthalic anhydride                              |                                                                                             | C <sub>8</sub> H <sub>4</sub> O <sub>3</sub>                                 | 85-44-9    | 148.116  | wh nd (al, bz)             | 130.8   | 295                  | 1.527 <sup>4</sup>         |                      | sl H <sub>2</sub> O, eth; s EtOH, ace, bz            |
| 9031 | 29 <i>H</i> ,31 <i>H</i> -Phthalocyanine        |                                                                                             | C <sub>32</sub> H <sub>18</sub> N <sub>6</sub>                               | 574-93-6   | 514.539  | grsh-bl mcl (quinoline)    |         | sub 550              |                            |                      | i H <sub>2</sub> O, EtOH, eth; s PhNH <sub>2</sub>   |
| 9032 | Phthalylsulphathiazole                          |                                                                                             | C <sub>17</sub> H <sub>13</sub> N <sub>3</sub> O <sub>5</sub> S <sub>2</sub> | 85-73-4    | 403.432  |                            | 273     |                      |                            |                      | i H <sub>2</sub> O, eth, chl; sl EtOH; s acid, alk   |
| 9033 | Physostigmine                                   |                                                                                             | C <sub>15</sub> H <sub>21</sub> N <sub>3</sub> O <sub>2</sub>                | 57-47-6    | 275.347  | orth pr (eth, bz)          | 105.5   |                      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, bz, chl            |
| 9034 | Phytol                                          | 3,7,11,15-Tetramethyl-2-hexadecen-1-ol, [ <i>R</i> -( <i>P</i> *, <i>R</i> *-( <i>E</i> ))] | C <sub>20</sub> H <sub>40</sub> O                                            | 150-86-7   | 296.531  | oily liq                   |         | 203 <sup>10</sup>    | 0.8497 <sup>25</sup>       | 1.4595 <sup>25</sup> |                                                      |

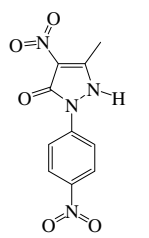




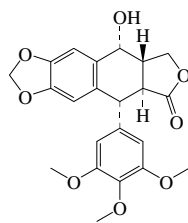
| No.  | Name                                 | Synonym                              | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form                     | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|--------------------------------------|--------------------------------------|-------------------------------------------------------------------------------|------------|----------|-----------------------------------|---------|-------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 9035 | Picene                               | Benzo[a]chrysene                     | C <sub>22</sub> H <sub>14</sub>                                               | 213-46-7   | 278.346  | lf, pl (xyl, py, sub)             | 368     | 519                                 |                            |                      | i H <sub>2</sub> O; sl EtOH, bz, chl; s con sulf      |
| 9036 | Picolonic acid                       |                                      | C <sub>10</sub> H <sub>8</sub> N <sub>4</sub> O <sub>5</sub>                  | 550-74-3   | 264.195  | ye nd (al)                        | 116     | dec                                 |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, MeOH                |
| 9037 | Picropodophyllin                     |                                      | C <sub>22</sub> H <sub>22</sub> O <sub>8</sub>                                | 477-47-4   | 414.405  | col nd (al, bz)                   | 228     |                                     |                            |                      | vs ace, bz, eth, EtOH                                 |
| 9038 | Picrotoxin                           |                                      | C <sub>30</sub> H <sub>34</sub> O <sub>13</sub>                               | 124-87-8   | 602.583  | orth lf                           | 203.5   |                                     |                            |                      | vs py, EtOH                                           |
| 9039 | Pilocarpine                          |                                      | C <sub>11</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>                 | 92-13-7    | 208.257  | nd                                | 34      | 260 <sup>5</sup>                    |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, bz; vs chl; i peth  |
| 9040 | Pilocarpine, monohydrochloride       |                                      | C <sub>11</sub> H <sub>17</sub> ClN <sub>2</sub> O <sub>2</sub>               | 54-71-7    | 244.718  | hyg cry                           | 204.5   |                                     |                            |                      | vs H <sub>2</sub> O, EtOH                             |
| 9041 | Pilocarpine, mononitrate             |                                      | C <sub>11</sub> H <sub>17</sub> N <sub>3</sub> O <sub>5</sub>                 | 148-72-1   | 271.270  | wh pow or cry (al)                | 178     |                                     |                            |                      | vs H <sub>2</sub> O                                   |
| 9042 | Pilosine                             |                                      | C <sub>16</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub>                 | 13640-28-3 | 286.325  | nd (al)                           | 179     |                                     |                            |                      |                                                       |
| 9043 | Pimaric acid                         | Dextropimaric acid                   | C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>                                | 127-27-5   | 302.451  | orth (ace) pr (al)                | 218.5   | 282 <sup>18</sup>                   |                            |                      | vs eth, py, EtOH                                      |
| 9044 | Pinane                               | 2,6,6-Trimethylbicyclo[3.1.1]heptane | C <sub>10</sub> H <sub>18</sub>                                               | 473-55-2   | 138.250  | oil                               | -53     | 169                                 | 0.8467 <sup>21</sup>       | 1.4605 <sup>21</sup> |                                                       |
| 9045 | <i>trans</i> -2-Pinanol              | Pinene hydrate                       | C <sub>10</sub> H <sub>18</sub> O                                             | 35408-04-9 | 154.249  |                                   | 60      | 81 <sup>10</sup>                    |                            |                      |                                                       |
| 9046 | Pindolol                             |                                      | C <sub>14</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub>                 | 13523-86-9 | 248.321  | cry (EtOH)                        | 172     |                                     |                            |                      |                                                       |
| 9047 | α-Pinene                             | 2-Pinene                             | C <sub>10</sub> H <sub>16</sub>                                               | 80-56-8    | 136.234  | liq                               | -64     | 156.2                               | 0.8539 <sup>25</sup>       | 1.4632 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, eth, chl                |
| 9048 | β-Pinene                             | Nopinene                             | C <sub>10</sub> H <sub>16</sub>                                               | 127-91-3   | 136.234  | liq                               | -61.5   | 166                                 | 0.860 <sup>25</sup>        | 1.4768 <sup>25</sup> | i H <sub>2</sub> O; s bz, EtOH, eth, chl              |
| 9049 | Piperazine                           | Diethylenediamine                    | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub>                                 | 110-85-0   | 86.135   | hyg pl or lf (al)                 | 106     | 148.6                               |                            | 1.446 <sup>113</sup> | vs H <sub>2</sub> O; s EtOH, chl; i eth               |
| 9050 | 1-Piperazinecarboxaldehyde           |                                      | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O                               | 7755-92-2  | 114.145  |                                   |         | 95 <sup>0.5</sup>                   |                            | 1.5094 <sup>20</sup> |                                                       |
| 9051 | 1,4-Piperazinediethanol              |                                      | C <sub>8</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub>                  | 122-96-3   | 174.241  |                                   | 135     | 217 <sup>30</sup>                   |                            |                      |                                                       |
| 9052 | Piperazine dihydrochloride           | Diethylenediamine dihydrochloride    | C <sub>4</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>2</sub>                 | 142-64-3   | 159.057  |                                   |         |                                     |                            |                      | sl H <sub>2</sub> O; i EtOH                           |
| 9053 | 2,5-Piperazinedione                  |                                      | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                   | 106-57-0   | 114.103  | tab or pl (w)                     | 312 dec | sub 260                             |                            |                      | sl H <sub>2</sub> O, EtOH; s HCl                      |
| 9054 | 1,4-Piperazinedipropylamine          | 1,4-Bis(3-aminopropyl)piperazine     | C <sub>10</sub> H <sub>24</sub> N <sub>4</sub>                                | 7209-38-3  | 200.325  |                                   | 15      | 151 <sup>2</sup>                    | 0.973 <sup>25</sup>        | 1.5015 <sup>20</sup> |                                                       |
| 9055 | 1-Piperazineethanamine               | 1-(2-Aminoethyl)piperazine           | C <sub>6</sub> H <sub>15</sub> N <sub>3</sub>                                 | 140-31-8   | 129.203  |                                   |         | 220                                 | 0.985 <sup>25</sup>        | 1.4983 <sup>20</sup> |                                                       |
| 9056 | 1-Piperazineethanol                  |                                      | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O                               | 103-76-4   | 130.187  |                                   |         | 246                                 | 1.061 <sup>25</sup>        | 1.5065 <sup>20</sup> |                                                       |
| 9057 | 1-Piperidinamine                     |                                      | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>                                 | 2213-43-6  | 100.162  |                                   |         | 147                                 | 0.928 <sup>25</sup>        | 1.4750 <sup>20</sup> |                                                       |
| 9058 | Piperidine                           | Azacyclohexane                       | C <sub>5</sub> H <sub>11</sub> N                                              | 110-89-4   | 85.148   | liq                               | -11.02  | 106.22                              | 0.8606 <sup>20</sup>       | 1.4530 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; s eth, ace, bz, chl       |
| 9059 | 1-Piperidinecarboxaldehyde           |                                      | C <sub>6</sub> H <sub>11</sub> NO                                             | 2591-86-8  | 113.157  | liq                               | -30.8   | 222.5                               | 1.0158 <sup>25</sup>       | 1.4805 <sup>25</sup> | msc H <sub>2</sub> O, EtOH, eth, bz, chl, lig         |
| 9060 | 4-Piperidinecarboxamide              |                                      | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O                               | 39546-32-2 | 128.171  |                                   | 138.5   |                                     |                            |                      |                                                       |
| 9061 | 2-Piperidinecarboxylic acid, (S)     | L-Pipecolic acid                     | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                                | 3105-95-1  | 129.157  | nd (MeOH/eth)                     | 260     |                                     |                            |                      |                                                       |
| 9062 | 3-Piperidinecarboxylic acid          | Nipecotic acid                       | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                                | 498-95-3   | 129.157  |                                   | 261 dec |                                     |                            |                      | vs H <sub>2</sub> O                                   |
| 9063 | 4-Piperidinecarboxylic acid          | Isonipecotic acid                    | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                                | 498-94-2   | 129.157  | nd                                | 336     |                                     |                            |                      |                                                       |
| 9064 | 1-Piperidineethanol                  |                                      | C <sub>7</sub> H <sub>15</sub> NO                                             | 3040-44-6  | 129.200  |                                   | 17.9    | 202; 90 <sup>12</sup>               | 0.9703 <sup>25</sup>       | 1.4749 <sup>20</sup> | msc H <sub>2</sub> O; vs EtOH                         |
| 9065 | 2-Piperidineethanol                  | 2-(2-Hydroxyethyl)piperidine         | C <sub>7</sub> H <sub>15</sub> NO                                             | 1484-84-0  | 129.200  |                                   | 69      | 202; 145 <sup>36</sup>              | 1.01 <sup>27</sup>         |                      | vs H <sub>2</sub> O                                   |
| 9066 | 4-Piperidineethanol                  | 4-(2-Hydroxyethyl)piperidine         | C <sub>7</sub> H <sub>15</sub> NO                                             | 622-26-4   | 129.200  | syr                               | 132.5   | 227.5                               | 1.0059 <sup>15</sup>       | 1.4907 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                        |
| 9067 | Piperidine, hydrochloride            | Piperidinium chloride                | C <sub>5</sub> H <sub>12</sub> ClN                                            | 6091-44-7  | 121.609  |                                   | 142 dec |                                     |                            |                      | vs H <sub>2</sub> O, chl                              |
| 9068 | 4-Piperidinemethanamine              | 4-(Aminomethyl)piperidine            | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                                 | 7144-05-0  | 114.188  |                                   | 25      | 200; 31 <sup>10</sup>               |                            | 1.4900 <sup>20</sup> |                                                       |
| 9069 | 2-Piperidinemethanol                 |                                      | C <sub>6</sub> H <sub>13</sub> NO                                             | 3433-37-2  | 115.173  |                                   | 69      | 104 <sup>10</sup> , 80 <sup>1</sup> |                            |                      | sl chl                                                |
| 9070 | 3-Piperidinemethanol                 |                                      | C <sub>6</sub> H <sub>13</sub> NO                                             | 4606-65-9  | 115.173  |                                   | 61      | 106 <sup>3.5</sup>                  | 1.0263 <sup>20</sup>       | 1.4964 <sup>20</sup> | sl chl                                                |
| 9071 | 1-Piperidinepropanenitrile           |                                      | C <sub>8</sub> H <sub>14</sub> N <sub>2</sub>                                 | 3088-41-3  | 138.210  |                                   | -6.8    | 145 <sup>50</sup>                   | 0.9403 <sup>25</sup>       | 1.4676 <sup>25</sup> |                                                       |
| 9072 | 2-Piperidinone                       |                                      | C <sub>5</sub> H <sub>9</sub> NO                                              | 675-20-7   | 99.131   | hyg                               | 39.5    | 256                                 |                            |                      | vs H <sub>2</sub> O, EtOH, eth; s dil acid; i con alk |
| 9073 | 2-(1-Piperidinylmethyl)cyclohexanone | Pimeclone                            | C <sub>12</sub> H <sub>21</sub> NO                                            | 534-84-9   | 195.301  |                                   |         | 119 <sup>14</sup>                   |                            |                      |                                                       |
| 9074 | 1-(2-Piperidinyl)-2-propanone, (±)   |                                      | C <sub>8</sub> H <sub>15</sub> NO                                             | 539-00-4   | 141.211  | oil                               |         | 91 <sup>14</sup>                    | 0.9624 <sup>20</sup>       | 1.4683 <sup>20</sup> | vs EtOH, chl                                          |
| 9075 | 3-(2-Piperidinyl)pyridine, (S)       | Anabasine                            | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub>                                | 494-52-0   | 162.231  | liq                               | 9       | 276; 146 <sup>14</sup>              | 1.0455 <sup>20</sup>       | 1.5430 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth, bz                 |
| 9076 | Piperine                             |                                      | C <sub>17</sub> H <sub>19</sub> NO <sub>3</sub>                               | 94-62-2    | 285.338  | pr (AcOEt) pl or mcl pr (al), cry | 131.5   |                                     |                            |                      | i H <sub>2</sub> O; s EtOH, bz, py; sl eth; vs chl    |
| 9077 | Piperonyl butoxide                   |                                      | C <sub>19</sub> H <sub>30</sub> O <sub>5</sub>                                | 51-03-6    | 338.438  |                                   |         | 180 <sup>1</sup>                    | 1.05 <sup>25</sup>         |                      |                                                       |
| 9078 | Piperonyl sulfoxide                  | Isosafrole octyl sulfoxide           | C <sub>18</sub> H <sub>26</sub> O <sub>3</sub> S                              | 120-62-7   | 324.478  | ye-br liq                         |         | dec                                 |                            | 1.530 <sup>25</sup>  | sl H <sub>2</sub> O; misc os                          |
| 9079 | Pipobroman                           |                                      | C <sub>10</sub> H <sub>16</sub> Br <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 54-91-1    | 356.054  |                                   | 106     |                                     |                            |                      |                                                       |
| 9080 | Piprotal                             | Tropital                             | C <sub>24</sub> H <sub>40</sub> O <sub>8</sub>                                | 5281-13-0  | 456.570  | liq                               |         | 215 <sup>0.04</sup>                 |                            |                      |                                                       |



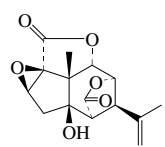
Picene



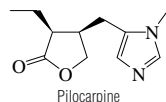
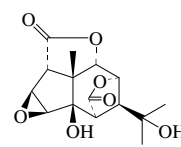
Picrolonic acid



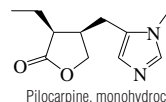
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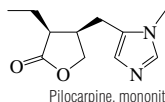
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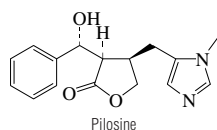
Pilocarpine



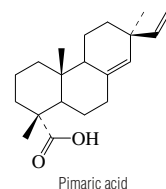
Pilocarpine, monohydrochloride



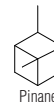
Pilocarpine, mononitrate



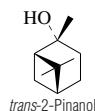
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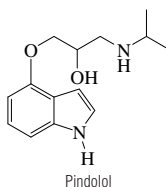
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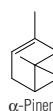
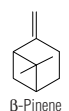
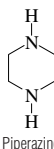
Pinane



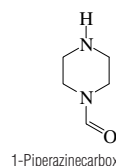
trans-2-Pinanol



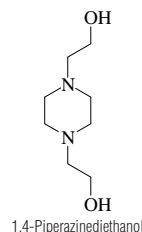
Pindolol

 $\alpha$ -Pinene $\beta$ -Pinene

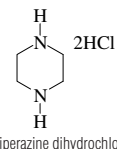
Piperazine



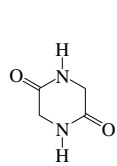
1-Piperazinecarboxaldehyde



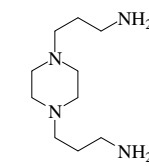
1,4-Piperazinediethanol



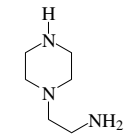
Piperazine dihydrochloride



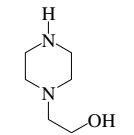
2,5-Piperazinedione



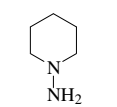
1,4-Piperazinedipropanamine



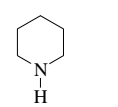
1-Piperazineethanamine



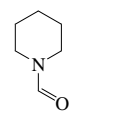
1-Piperazineethanol



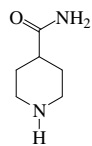
1-Piperidinamine



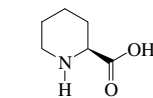
Piperidine



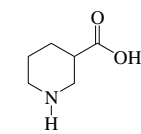
1-Piperidinecarboxaldehyde



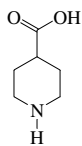
4-Piperidinecarboxamide



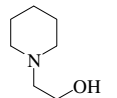
2-Piperidinecarboxylic acid, (S)



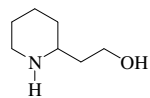
3-Piperidinecarboxylic acid



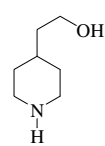
4-Piperidinecarboxylic acid



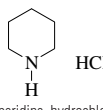
1-Piperidineethanol



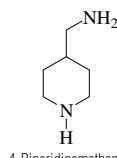
2-Piperidineethanol



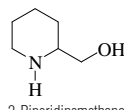
4-Piperidineethanol



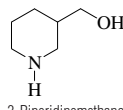
Piperidine, hydrochloride



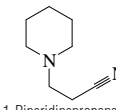
4-Piperidinemethanamine



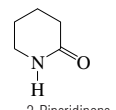
2-Piperidinemethanol



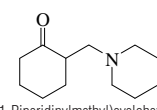
3-Piperidinemethanol



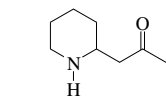
1-Piperidinepropanenitrile



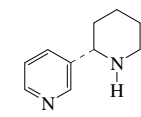
2-Piperidinone



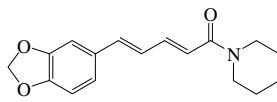
2-(1-Piperidinylmethyl)cyclohexanone



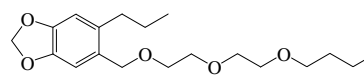
1-(2-Piperidinyl)-2-propanone, (±)



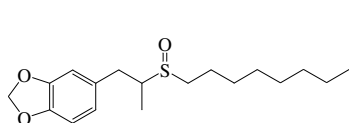
3-(2-Piperidinyl)pyridine, (S)



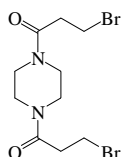
Piperine



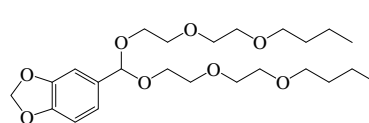
Piperonyl butoxide



Piperonyl sulfide

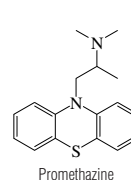
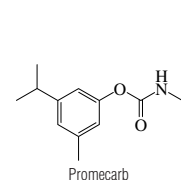
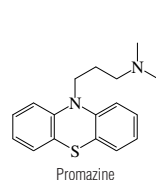
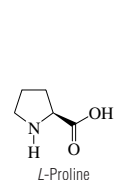
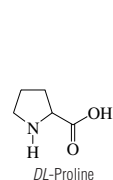
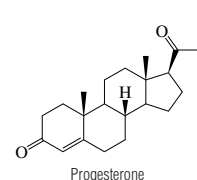
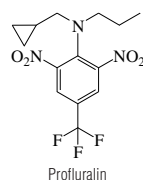
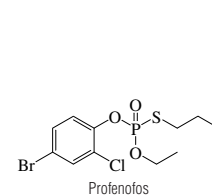
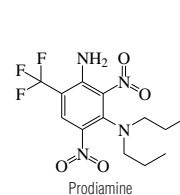
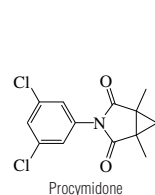
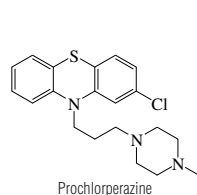
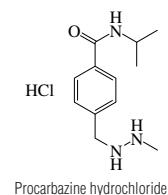
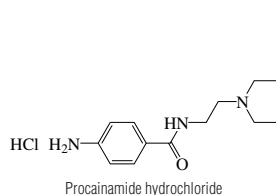
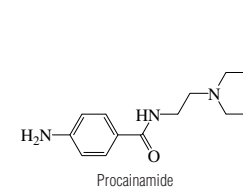
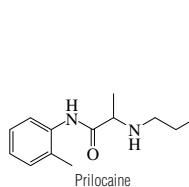
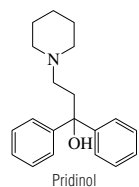
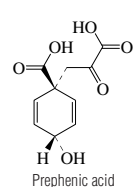
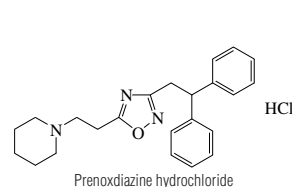
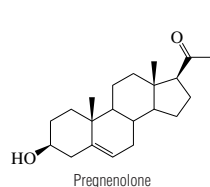
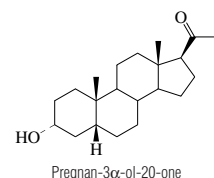
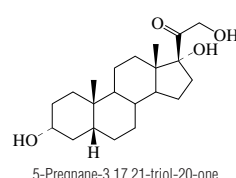
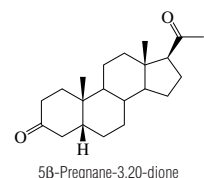
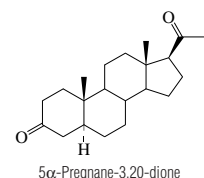
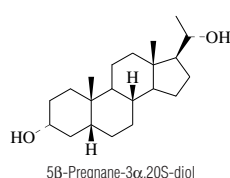
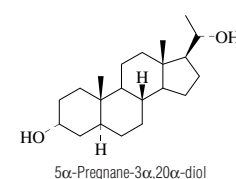
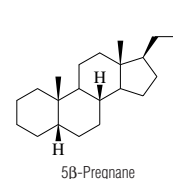
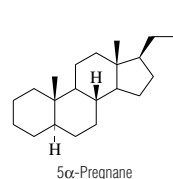
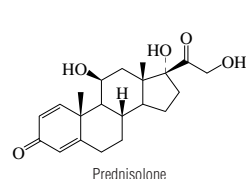
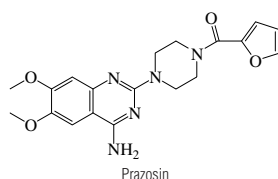
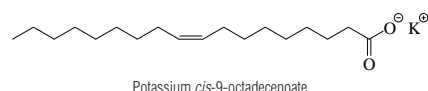
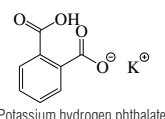
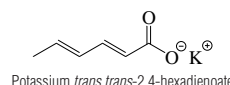
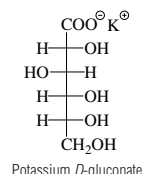
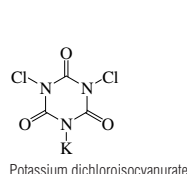
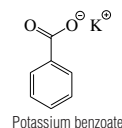
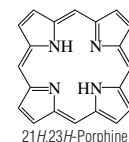
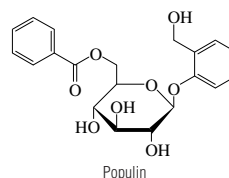
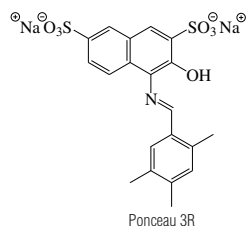
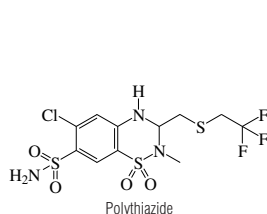
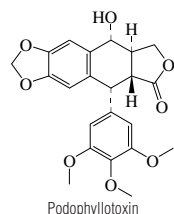
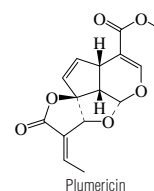
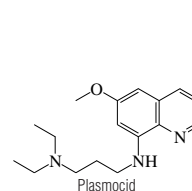
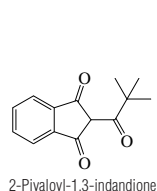
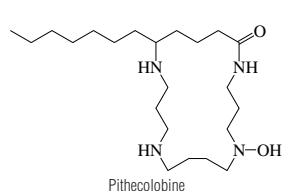
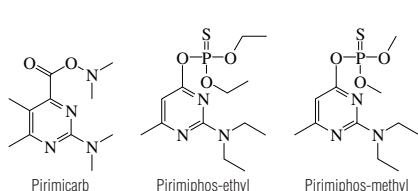


Pipobroman

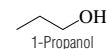
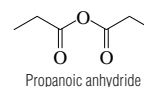
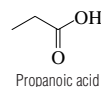
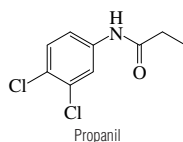
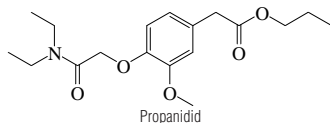
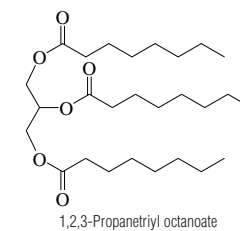
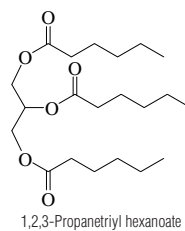
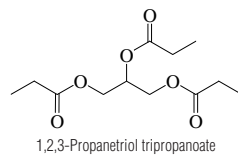
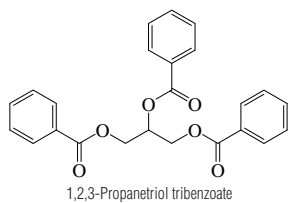
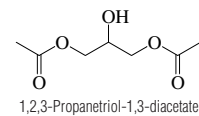
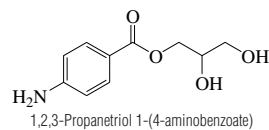
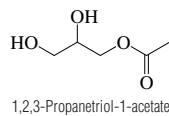
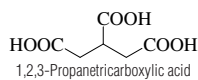
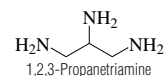
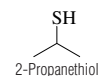
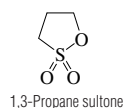
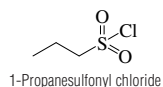
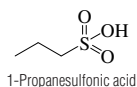
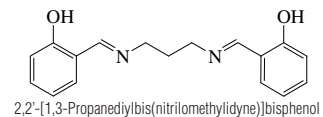
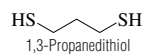
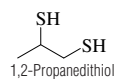
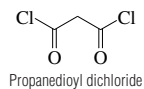
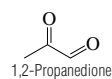
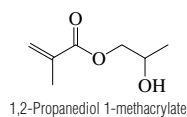
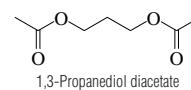
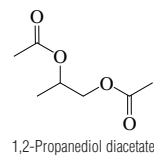
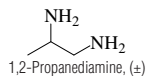
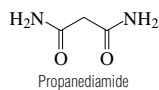
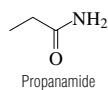
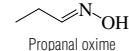
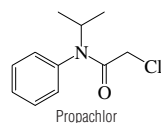
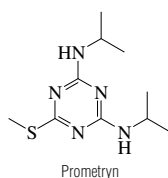
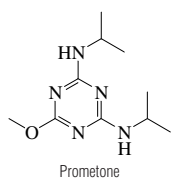
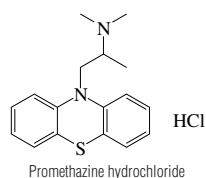


Piprotal

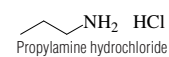
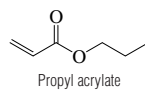
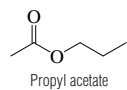
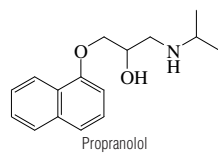
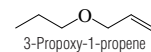
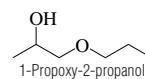
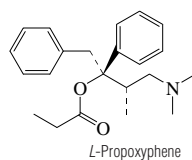
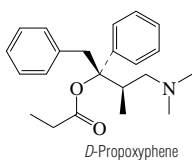
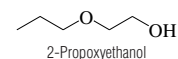
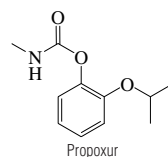
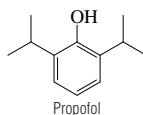
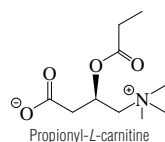
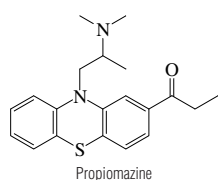
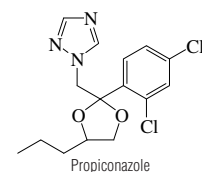
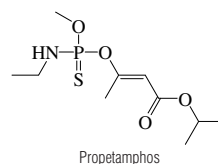
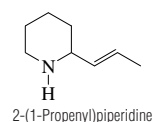
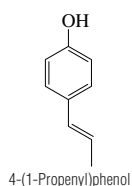
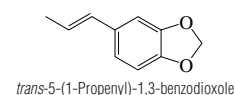
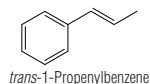
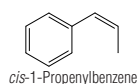
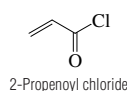
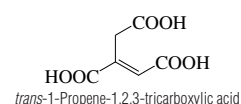
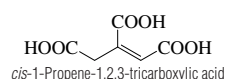
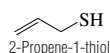
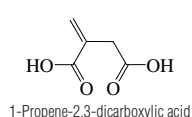
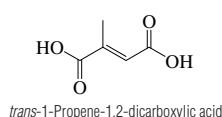
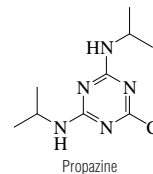
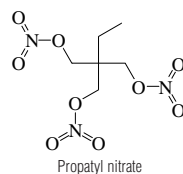
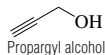
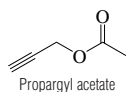
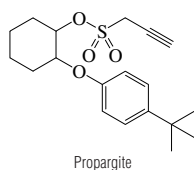
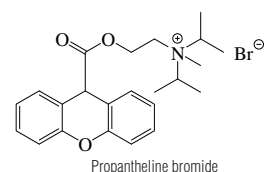
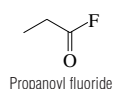
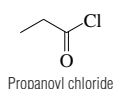
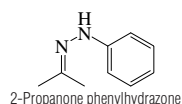
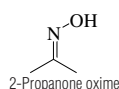
| No.  | Name                                   | Synonym                                              | Mol. Form.                                                                                    | CAS RN     | Mol. Wt. | Physical Form             | mp/°C    | bp/°C                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                           |
|------|----------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------|----------|---------------------------|----------|----------------------|----------------------------|----------------------|------------------------------------------------------|
| 9081 | Pirimicarb                             |                                                      | C <sub>11</sub> H <sub>18</sub> N <sub>4</sub> O <sub>2</sub>                                 | 23103-98-2 | 238.287  |                           | 90.5     |                      |                            |                      |                                                      |
| 9082 | Pirimiphos-ethyl                       |                                                      | C <sub>13</sub> H <sub>24</sub> N <sub>3</sub> O <sub>3</sub> PS                              | 23505-41-1 | 333.387  |                           |          | dec >130             | 1.14 <sup>20</sup>         |                      |                                                      |
| 9083 | Pirimiphos-methyl                      |                                                      | C <sub>11</sub> H <sub>20</sub> N <sub>3</sub> O <sub>3</sub> PS                              | 29232-93-7 | 305.334  |                           | 15       | dec                  | 1.17 <sup>20</sup>         |                      |                                                      |
| 9084 | Pithecolobine                          |                                                      | C <sub>22</sub> H <sub>46</sub> N <sub>4</sub> O <sub>2</sub>                                 | 22368-82-7 | 398.626  | cry                       | 68       | 230 <sup>0.007</sup> |                            |                      | s H <sub>2</sub> O, chl, eth, EtOH, peth             |
| 9085 | 2-Pivaloyl-1,3-indandione              | Pindone                                              | C <sub>14</sub> H <sub>14</sub> O <sub>3</sub>                                                | 83-26-1    | 230.259  | ye cry                    | 109      |                      |                            |                      |                                                      |
| 9086 | Plasmocid                              |                                                      | C <sub>17</sub> H <sub>26</sub> N <sub>3</sub> O                                              | 551-01-9   | 287.400  |                           |          | 182 <sup>1.0</sup>   | 1.0569 <sup>24</sup>       | 1.5855 <sup>24</sup> |                                                      |
| 9087 | Plumericin                             |                                                      | C <sub>15</sub> H <sub>14</sub> O <sub>6</sub>                                                | 77-16-7    | 290.268  |                           |          |                      |                            |                      | s chl                                                |
| 9088 | Podophyllotoxin                        |                                                      | C <sub>22</sub> H <sub>22</sub> O <sub>8</sub>                                                | 518-28-5   | 414.405  |                           | 183      |                      |                            |                      | sl H <sub>2</sub> O; vs EtOH; i eth; s ace, bz, HOAc |
| 9089 | Polythiazide                           |                                                      | C <sub>11</sub> H <sub>13</sub> ClF <sub>3</sub> N <sub>3</sub> O <sub>4</sub> S <sub>3</sub> | 346-18-9   | 439.882  |                           | 214      |                      |                            |                      |                                                      |
| 9090 | Ponceau 3R                             | C.I. Food Red 6                                      | C <sub>19</sub> H <sub>16</sub> N <sub>2</sub> Na <sub>2</sub> O <sub>7</sub> S <sub>2</sub>  | 3564-09-8  | 494.449  | dk red pow                |          |                      |                            |                      | s H <sub>2</sub> O; sl EtOH                          |
| 9091 | Populin                                |                                                      | C <sub>20</sub> H <sub>22</sub> O <sub>3</sub>                                                | 99-17-2    | 390.384  | nd (w+2), pr (al)         | 180      |                      |                            |                      |                                                      |
| 9092 | 21H,23H-Porphine                       |                                                      | C <sub>20</sub> H <sub>14</sub> N <sub>4</sub>                                                | 101-60-0   | 310.352  | red or oran lf (chl-MeOH) | 360      | sub 300              | 1.336 <sup>25</sup>        |                      | i H <sub>2</sub> O, eth, ace, bz; sl EtOH; s diox    |
| 9093 | Potassium benzoate                     |                                                      | C <sub>7</sub> H <sub>5</sub> KO <sub>2</sub>                                                 | 582-25-2   | 160.212  | hyg cry                   |          |                      |                            |                      |                                                      |
| 9094 | Potassium dichloroisocyanurate         | Troclosene potassium                                 | C <sub>3</sub> Cl <sub>2</sub> KN <sub>3</sub> O <sub>3</sub>                                 | 2244-21-5  | 236.054  | hyg cry                   | 250 dec  |                      |                            |                      |                                                      |
| 9095 | Potassium D-gluconate                  |                                                      | C <sub>6</sub> H <sub>11</sub> KO <sub>7</sub>                                                | 299-27-4   | 234.245  | ye-wh cry                 | 183 dec  |                      |                            |                      | vs H <sub>2</sub> O; i EtOH, eth, bz, chl            |
| 9096 | Potassium trans,trans-2,4-hexadienoate | Potassium sorbate                                    | C <sub>8</sub> H <sub>7</sub> KO <sub>2</sub>                                                 | 24634-61-5 | 150.217  |                           | >270 dec |                      | 1.361 <sup>25</sup>        |                      | vs H <sub>2</sub> O; s EtOH                          |
| 9097 | Potassium hydrogen phthalate           | Potassium biphthalate                                | C <sub>8</sub> H <sub>5</sub> KO <sub>4</sub>                                                 | 877-24-7   | 204.222  |                           |          |                      | 1.636 <sup>25</sup>        |                      | s H <sub>2</sub> O; sl EtOH                          |
| 9098 | Potassium cis-9-octadecenoate          | Potassium oleate                                     | C <sub>18</sub> H <sub>33</sub> KO <sub>2</sub>                                               | 143-18-0   | 320.552  | ye-br solid               |          |                      |                            |                      | s H <sub>2</sub> O, EtOH                             |
| 9099 | Prazosin                               |                                                      | C <sub>19</sub> H <sub>21</sub> N <sub>5</sub> O <sub>4</sub>                                 | 19216-56-9 | 383.402  | cry                       | 279      |                      |                            |                      |                                                      |
| 9100 | Prednisolone                           |                                                      | C <sub>21</sub> H <sub>28</sub> O <sub>5</sub>                                                | 50-24-8    | 360.444  |                           | 235      |                      |                            |                      |                                                      |
| 9101 | 5α-Pregnane                            | Allopregnane                                         | C <sub>21</sub> H <sub>36</sub>                                                               | 641-85-0   | 288.511  |                           | 84.5     |                      |                            |                      |                                                      |
| 9102 | 5β-Pregnane                            | 17β-Ethyletiocholane                                 | C <sub>21</sub> H <sub>36</sub>                                                               | 481-26-5   | 288.511  | mcl sc or pl (MeOH)       | 83.5     |                      | 1.032 <sup>15</sup>        |                      | i H <sub>2</sub> O; s chl, MeOH                      |
| 9103 | 5α-Pregnane-3α,20α-diol                | Allopregnane-3α,20α-diol                             | C <sub>21</sub> H <sub>36</sub> O <sub>2</sub>                                                | 566-58-5   | 320.510  | cry (MeOH)                | 244      |                      |                            |                      |                                                      |
| 9104 | 5β-Pregnane-3α,20S-diol                | Pregnenediol                                         | C <sub>21</sub> H <sub>36</sub> O <sub>2</sub>                                                | 80-92-2    | 320.510  | pl (ace)                  | 243.5    |                      | 1.15 <sup>25</sup>         |                      | sl EtOH, eth; s ace                                  |
| 9105 | 5α-Pregnane-3,20-dione                 | 3,20-Allopregnenedione                               | C <sub>21</sub> H <sub>32</sub> O <sub>2</sub>                                                | 566-65-4   | 316.478  | cry                       | 200      |                      |                            |                      |                                                      |
| 9106 | 5β-Pregnane-3,20-dione                 |                                                      | C <sub>21</sub> H <sub>32</sub> O <sub>2</sub>                                                | 128-23-4   | 316.478  | nd (dil al) cry (dil ace) | 123      |                      |                            |                      | i H <sub>2</sub> O; vs EtOH; s eth, ace              |
| 9107 | 5-Pregnane-3,17,21-triol-20-one        | 3,17,21-Trihydroxypregnan-20-one, (3α,5β)            | C <sub>21</sub> H <sub>34</sub> O <sub>4</sub>                                                | 68-60-0    | 350.493  | cry (EtOAc)               | 226      |                      |                            |                      |                                                      |
| 9108 | Pregnan-3α-ol-20-one                   |                                                      | C <sub>21</sub> H <sub>34</sub> O <sub>2</sub>                                                | 128-20-1   | 318.494  | nd (bz), cry (dil al)     | 149.5    |                      |                            |                      | vs EtOH                                              |
| 9109 | Pregnenolone                           |                                                      | C <sub>21</sub> H <sub>32</sub> O <sub>2</sub>                                                | 145-13-1   | 316.478  | nd (dil al)               | 192      |                      |                            |                      |                                                      |
| 9110 | Prenoxdiazine hydrochloride            |                                                      | C <sub>23</sub> H <sub>28</sub> ClN <sub>3</sub> O                                            | 982-43-4   | 397.940  |                           | 186.5    |                      |                            |                      |                                                      |
| 9111 | Prephenic acid                         |                                                      | C <sub>10</sub> H <sub>10</sub> O <sub>6</sub>                                                | 126-49-8   | 226.182  | free acid unstab          |          |                      |                            |                      |                                                      |
| 9112 | Pridinol                               | 1,1-Diphenyl-3-(1-piperidiny)-1-propanol             | C <sub>20</sub> H <sub>25</sub> NO                                                            | 511-45-5   | 295.419  | cry                       | 120      |                      |                            |                      | s ace                                                |
| 9113 | Prilocaine                             | N-(2-Methylphenyl)-2-(propylamino)propanamide        | C <sub>13</sub> H <sub>20</sub> N <sub>2</sub> O                                              | 721-50-6   | 220.310  | nd                        | 38       | 160 <sup>1</sup>     |                            | 1.5299 <sup>20</sup> |                                                      |
| 9114 | Procainamide                           | 4-Amino-N-[2-(diethylamino)ethyl]benzamide           | C <sub>13</sub> H <sub>21</sub> N <sub>3</sub> O                                              | 51-06-9    | 235.325  |                           | 47       | 212 <sup>2</sup>     |                            |                      |                                                      |
| 9115 | Procainamide hydrochloride             |                                                      | C <sub>13</sub> H <sub>22</sub> ClN <sub>3</sub> O                                            | 614-39-1   | 271.786  |                           | 166      |                      |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth, bz; sl chl       |
| 9116 | Procarbazine hydrochloride             |                                                      | C <sub>12</sub> H <sub>20</sub> ClN <sub>3</sub> O                                            | 366-70-1   | 257.759  | cry (MeOH)                | 225      |                      |                            |                      |                                                      |
| 9117 | Prochlorperazine                       |                                                      | C <sub>20</sub> H <sub>24</sub> ClN <sub>3</sub> S                                            | 58-38-8    | 373.943  |                           | 228      |                      |                            |                      |                                                      |
| 9118 | Procymidone                            |                                                      | C <sub>13</sub> H <sub>11</sub> Cl <sub>2</sub> NO <sub>2</sub>                               | 32809-16-8 | 284.138  |                           | 166      |                      | 1.452 <sup>25</sup>        |                      |                                                      |
| 9119 | Prodiamine                             |                                                      | C <sub>13</sub> H <sub>17</sub> F <sub>3</sub> N <sub>4</sub> O <sub>4</sub>                  | 29091-21-2 | 350.294  |                           | 124      |                      | 1.47 <sup>25</sup>         |                      |                                                      |
| 9120 | Profenofos                             |                                                      | C <sub>11</sub> H <sub>15</sub> BrClO <sub>3</sub> PS                                         | 41198-08-7 | 373.631  |                           |          | 110 <sup>0.001</sup> | 1.455 <sup>20</sup>        |                      |                                                      |
| 9121 | Profluralin                            |                                                      | C <sub>14</sub> H <sub>16</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub>                  | 26399-36-0 | 347.290  |                           | 34       |                      |                            |                      |                                                      |
| 9122 | Progesterone                           | Pregn-4-ene-3,20-dione                               | C <sub>21</sub> H <sub>30</sub> O <sub>2</sub>                                                | 57-83-0    | 314.462  | pr                        | 129      |                      | 1.166 <sup>23</sup>        |                      | i H <sub>2</sub> O; s EtOH, diox, ace                |
| 9123 | DL-Proline                             |                                                      | C <sub>5</sub> H <sub>9</sub> NO <sub>2</sub>                                                 | 609-36-9   | 115.131  | hyg nd (al-eth) cry (+w)  | 205 dec  |                      |                            |                      | vs H <sub>2</sub> O, EtOH                            |
| 9124 | L-Proline                              | 2-Pyrrolidinecarboxylic acid                         | C <sub>5</sub> H <sub>9</sub> NO <sub>2</sub>                                                 | 147-85-3   | 115.131  | nd (al-eth) pr (w)        | 221 dec  |                      |                            |                      | vs H <sub>2</sub> O; sl EtOH, ace, bz; i eth, PrOH   |
| 9125 | Promazine                              |                                                      | C <sub>17</sub> H <sub>20</sub> N <sub>2</sub> S                                              | 58-40-2    | 284.419  |                           |          | 206 <sup>0.3</sup>   |                            |                      |                                                      |
| 9126 | Promecarb                              | Phenol, 3-methyl-5-(1-methylethyl)-, methylcarbamate | C <sub>12</sub> H <sub>17</sub> NO <sub>2</sub>                                               | 2631-37-0  | 207.269  |                           | 87       | 117 <sup>0.01</sup>  |                            |                      |                                                      |
| 9127 | Promethazine                           | N,N,α-Trimethyl-10H-phenothiazine-10-ethanamine      | C <sub>17</sub> H <sub>20</sub> N <sub>2</sub> S                                              | 60-87-7    | 284.419  |                           | 60       | 191 <sup>0.5</sup>   |                            |                      | i H <sub>2</sub> O; vs dil HCl                       |



| No.  | Name                                                  | Synonym                                                            | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form  | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>        | Solubility                                           |
|------|-------------------------------------------------------|--------------------------------------------------------------------|---------------------------------------------------------------|------------|----------|----------------|---------|---------------------------------------|----------------------------------|-----------------------|------------------------------------------------------|
| 9128 | Promethazine hydrochloride                            | Diprazin                                                           | C <sub>17</sub> H <sub>21</sub> ClN <sub>2</sub> S            | 58-33-3    | 320.880  |                | 231     |                                       |                                  |                       | vs H <sub>2</sub> O, EtOH, chl                       |
| 9129 | Prometone                                             |                                                                    | C <sub>10</sub> H <sub>19</sub> N <sub>3</sub> O              | 1610-18-0  | 225.291  | solid          | 91.5    |                                       |                                  |                       |                                                      |
| 9130 | Prometryn                                             | <i>N,N'</i> -Diisopropyl-6-(methylthio)-1,3,5-triazine-2,4-diamine | C <sub>10</sub> H <sub>19</sub> N <sub>3</sub> S              | 7287-19-6  | 241.357  |                | 119     |                                       | 1.157 <sup>20</sup>              |                       |                                                      |
| 9131 | Propachlor                                            | Acetamide, 2-chloro- <i>N</i> -(1-methylethyl)- <i>N</i> -phenyl-  | C <sub>11</sub> H <sub>14</sub> ClNO                          | 1918-16-7  | 211.688  |                | 77      | 110 <sup>0.03</sup>                   | 1.242 <sup>25</sup>              |                       |                                                      |
| 9132 | Propanal                                              | Propionaldehyde                                                    | C <sub>3</sub> H <sub>6</sub> O                               | 123-38-6   | 58.079   | liq            | -80     | 48                                    | 0.8657 <sup>25</sup>             | 1.3636 <sup>20</sup>  | s H <sub>2</sub> O; msc EtOH, eth                    |
| 9133 | Propanal oxime                                        |                                                                    | C <sub>3</sub> H <sub>7</sub> NO                              | 627-39-4   | 73.094   |                | 40      | 131.5                                 | 0.9258 <sup>20</sup>             | 1.4287 <sup>20</sup>  |                                                      |
| 9134 | Propanamide                                           | Propionamide                                                       | C <sub>3</sub> H <sub>7</sub> NO                              | 79-05-0    | 73.094   | rhomb, pl (bz) | 81.3    | 213                                   | 0.9262 <sup>10</sup>             | 1.4180 <sup>110</sup> | vs H <sub>2</sub> O, EtOH, eth, chl                  |
| 9135 | Propane                                               |                                                                    | C <sub>3</sub> H <sub>8</sub>                                 | 74-98-6    | 44.096   | col gas        | -187.63 | -42.1                                 | 0.493 <sup>25</sup><br>(p>1 atm) |                       | s H <sub>2</sub> O, EtOH; vs eth, bz; sl ace         |
| 9136 | Propanediamide                                        |                                                                    | C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>   | 108-13-4   | 102.092  | mcl pr(w)      | 170.8   |                                       |                                  |                       | s H <sub>2</sub> O; i EtOH, eth, bz; sl DMSO         |
| 9137 | 1,2-Propanediamine, (±)                               | Propylenediamine                                                   | C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>                 | 10424-38-1 | 74.124   | hyg            |         | 119.5                                 | 0.878 <sup>15</sup>              | 1.4460 <sup>20</sup>  | vs H <sub>2</sub> O; i eth; vs chl                   |
| 9138 | 1,3-Propanediamine                                    | 1,3-Diaminopropane                                                 | C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>                 | 109-76-2   | 74.124   | liq            | -10.8   | 139.8                                 | 0.884 <sup>25</sup>              | 1.4600 <sup>20</sup>  | s H <sub>2</sub> O; msc EtOH, eth                    |
| 9139 | 1,2-Propanediol diacetate                             |                                                                    | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | 623-84-7   | 160.168  |                |         | 190.5                                 | 1.059 <sup>20</sup>              | 1.4173 <sup>20</sup>  | vs H <sub>2</sub> O; s EtOH, eth                     |
| 9140 | 1,3-Propanediol diacetate                             |                                                                    | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | 628-66-0   | 160.168  |                |         | 209.5                                 | 1.070 <sup>14</sup>              | 1.4192                | vs H <sub>2</sub> O; s EtOH                          |
| 9141 | 1,2-Propanediol 1-methacrylate                        | 2-Hydroxypropyl methacrylate                                       | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>                 | 923-26-2   | 144.168  |                |         | 90 <sup>3</sup> , 57 <sup>0.5</sup>   | 1.066 <sup>25</sup>              | 1.4458 <sup>20</sup>  |                                                      |
| 9142 | 1,2-Propanedione                                      | Pyrvaldehyde                                                       | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                  | 78-98-8    | 72.063   | ye hyg liq     |         | 72                                    | 1.0455 <sup>20</sup>             | 1.4002 <sup>18</sup>  | s EtOH, eth, bz                                      |
| 9143 | Propanediol dichloride                                |                                                                    | C <sub>3</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>  | 1663-67-8  | 140.953  |                |         | 57 <sup>28</sup>                      | 1.4509 <sup>20</sup>             | 1.4639 <sup>20</sup>  | s eth, AcOEt                                         |
| 9144 | 1,2-Propanedithiol                                    |                                                                    | C <sub>3</sub> H <sub>6</sub> S <sub>2</sub>                  | 814-67-5   | 108.226  |                |         | 152                                   | 1.08 <sup>20</sup>               | 1.532 <sup>20</sup>   | s chl                                                |
| 9145 | 1,3-Propanedithiol                                    | Trimethylene dimercaptan                                           | C <sub>3</sub> H <sub>6</sub> S <sub>2</sub>                  | 109-80-8   | 108.226  | liq            | -79     | 172.9                                 | 1.0772 <sup>20</sup>             | 1.5392 <sup>20</sup>  | sl H <sub>2</sub> O, ctc; msc EtOH, eth, bz          |
| 9146 | 2,2'-[1,3-Propanediylbis(nitrimethylidyn e)]bisphenol | Disalicylidene-1,3-propanediamine                                  | C <sub>17</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub> | 120-70-7   | 282.337  |                | 54.3    |                                       |                                  |                       |                                                      |
| 9147 | Propanenitrile                                        | Ethyl cyanide                                                      | C <sub>3</sub> H <sub>5</sub> N                               | 107-12-0   | 55.079   | liq            | -92.78  | 97.14                                 | 0.7818 <sup>20</sup>             | 1.3655 <sup>20</sup>  | vs H <sub>2</sub> O; s EtOH, eth, ace, bz, ctc       |
| 9148 | 1-Propanesulfonic acid                                |                                                                    | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub> S                | 5284-66-2  | 124.159  |                | 8       | 136 <sup>1</sup>                      | 1.2516 <sup>25</sup>             |                       |                                                      |
| 9149 | 1-Propanesulfonyl chloride                            |                                                                    | C <sub>3</sub> H <sub>7</sub> ClO <sub>2</sub> S              | 10147-36-1 | 142.605  |                |         | dec 180; 77 <sup>12</sup>             | 1.267 <sup>20</sup>              | 1.452 <sup>20</sup>   |                                                      |
| 9150 | 1,3-Propane sultone                                   | 1,2-Oxathiolane, 2,2-dioxide                                       | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub> S                | 1120-71-4  | 122.143  |                |         |                                       |                                  |                       | s chl                                                |
| 9151 | 1-Propanethiol                                        | Propyl mercaptan                                                   | C <sub>3</sub> H <sub>6</sub> S                               | 107-03-9   | 76.161   | liq            | -113.13 | 67.8                                  | 0.8411 <sup>20</sup>             | 1.4380 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth, ace, bz            |
| 9152 | 2-Propanethiol                                        | Isopropyl mercaptan                                                | C <sub>3</sub> H <sub>6</sub> S                               | 75-33-2    | 76.161   | liq            | -130.5  | 52.6                                  | 0.8143 <sup>20</sup>             | 1.4255 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth; vs ace; s chl    |
| 9153 | 1,2,3-Propanetriamine                                 | 1,2,3-Triaminopropane                                              | C <sub>3</sub> H <sub>11</sub> N <sub>3</sub>                 | 21291-99-6 | 89.139   | visc oil       |         | 190; 92 <sup>9</sup>                  |                                  |                       | s H <sub>2</sub> O                                   |
| 9154 | 1,2,3-Propanetricarboxylic acid                       | Tricarballic acid                                                  | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                  | 99-14-9    | 176.124  | orth (eth)     | 166     |                                       |                                  |                       | vs H <sub>2</sub> O, EtOH; sl eth                    |
| 9155 | 1,2,3-Propanetriol-1-acetate                          |                                                                    | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                 | 106-61-6   | 134.131  |                |         | 158 <sup>165</sup> , 129 <sup>3</sup> | 1.2060 <sup>20</sup>             | 1.4157 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH                            |
| 9156 | 1,2,3-Propanetriol 1-(4-aminobenzoate)                | Glyceryl <i>p</i> -aminobenzoate                                   | C <sub>10</sub> H <sub>13</sub> NO <sub>4</sub>               | 136-44-7   | 211.215  |                |         |                                       |                                  |                       | i H <sub>2</sub> O; s EtOH                           |
| 9157 | 1,2,3-Propanetriol-1,3-diacetate                      | 1,3-Diacetin                                                       | C <sub>7</sub> H <sub>12</sub> O <sub>5</sub>                 | 105-70-4   | 176.167  | hyg liq        |         | 260; 149 <sup>12</sup>                | 1.179 <sup>15</sup>              | 1.4395 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH; sl eth; i CS <sub>2</sub> |
| 9158 | 1,2,3-Propanetriol tribenzoate                        |                                                                    | C <sub>24</sub> H <sub>26</sub> O <sub>6</sub>                | 614-33-5   | 404.412  | nd (MeOH)      | 76      |                                       | 1.228 <sup>12</sup>              |                       | i H <sub>2</sub> O; s EtOH; vs eth, ace, bz, chl     |
| 9159 | 1,2,3-Propanetriol tripropanoate                      |                                                                    | C <sub>12</sub> H <sub>20</sub> O <sub>6</sub>                | 139-45-7   | 260.283  |                |         | 175 <sup>20</sup> , 157 <sup>13</sup> | 1.108 <sup>15</sup>              | 1.4318 <sup>19</sup>  | i H <sub>2</sub> O; s EtOH, chl; vs eth              |
| 9160 | 1,2,3-Propanetriyl hexanoate                          |                                                                    | C <sub>21</sub> H <sub>38</sub> O <sub>6</sub>                | 621-70-5   | 386.523  |                | -60     | >200                                  | 0.9867 <sup>20</sup>             | 1.4427 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, bz; vs ace        |
| 9161 | 1,2,3-Propanetriyl octanoate                          |                                                                    | C <sub>27</sub> H <sub>50</sub> O <sub>6</sub>                | 538-23-8   | 470.682  |                | 10      | 233                                   | 0.9540 <sup>20</sup>             | 1.4482 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH; vs eth, bz, chl, liq   |
| 9162 | Propanidid                                            |                                                                    | C <sub>18</sub> H <sub>27</sub> NO <sub>5</sub>               | 1421-14-3  | 337.411  |                |         | 211 <sup>0.7</sup>                    |                                  |                       | i H <sub>2</sub> O; s EtOH, chl                      |
| 9163 | Propanil                                              | Propanamide, <i>N</i> -(3,4-dichlorophenyl)-                       | C <sub>9</sub> H <sub>6</sub> Cl <sub>2</sub> NO              | 709-98-8   | 218.079  |                | 92      |                                       | 1.25 <sup>25</sup>               |                       |                                                      |
| 9164 | Propanoic acid                                        | Propionic acid                                                     | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                  | 79-09-4    | 74.079   | liq            | -20.5   | 141.15                                | 0.9882 <sup>25</sup>             | 1.3809 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH; s eth; sl chl            |
| 9165 | Propanoic anhydride                                   | Propionic anhydride                                                | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                 | 123-62-6   | 130.141  | liq            | -45     | 170; 67.5 <sup>18</sup>               | 1.0110 <sup>20</sup>             | 1.4038 <sup>20</sup>  | msc eth; sl ctc                                      |
| 9166 | 1-Propanol                                            | Propyl alcohol                                                     | C <sub>3</sub> H <sub>8</sub> O                               | 71-23-8    | 60.095   | liq            | -124.39 | 97.2                                  | 0.7997 <sup>25</sup>             | 1.3850 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH, eth; s ace, chl; vs bz   |

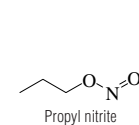
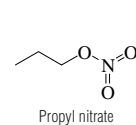
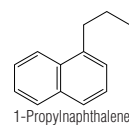
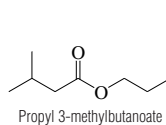
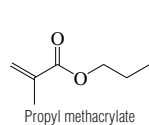
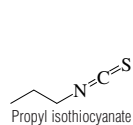
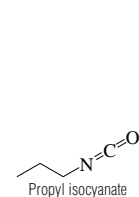
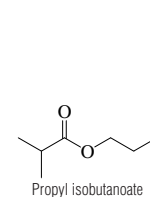
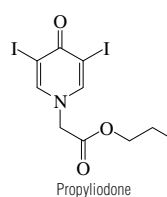
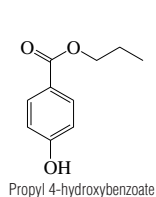
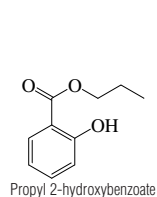
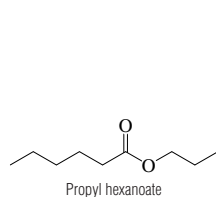
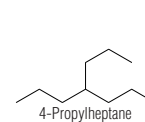
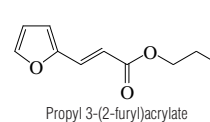
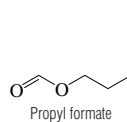
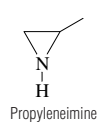
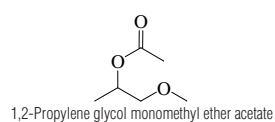
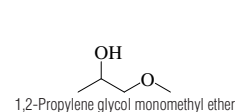
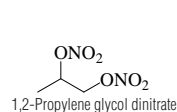
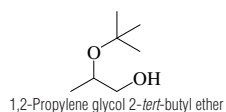
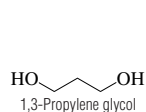
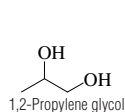
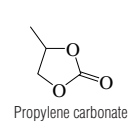
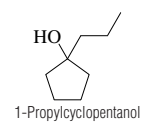
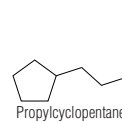
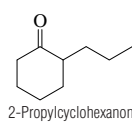
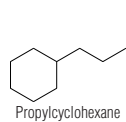
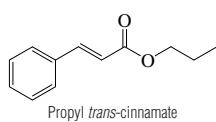
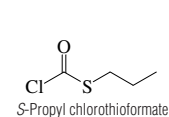
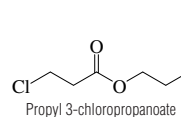
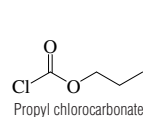
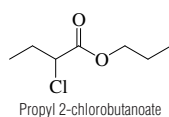
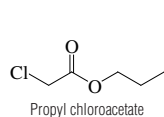
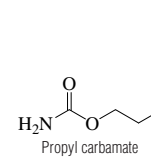
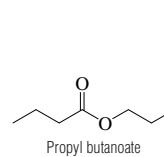
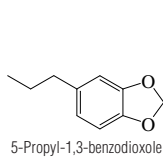
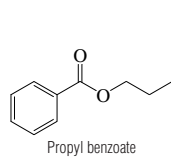
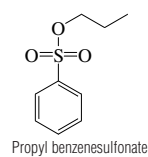
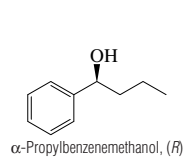
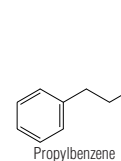
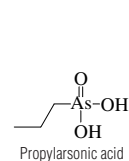
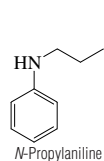
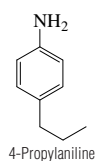
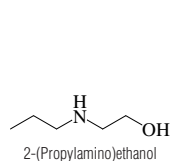
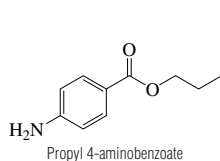


| No.  | Name                                             | Synonym                                                       | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>        | Solubility                                                     |
|------|--------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|----------------------------|---------|------------------------|----------------------------------|-----------------------|----------------------------------------------------------------|
| 9167 | 2-Propanol                                       | Isopropyl alcohol                                             | C <sub>3</sub> H <sub>8</sub> O                                               | 67-63-0    | 60.095   | liq                        | -87.9   | 82.3                   | 0.7809 <sup>25</sup>             | 1.3776 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH, eth; s ace, chl; vs bz             |
| 9168 | 2-Propanone oxime                                | Acetoxime                                                     | C <sub>3</sub> H <sub>7</sub> NO                                              | 127-06-0   | 73.094   | pr (al)                    | 61      | 136; 61 <sup>20</sup>  | 0.9113 <sup>62</sup>             | 1.4156 <sup>20</sup>  | s H <sub>2</sub> O, EtOH, eth, chl, lig                        |
| 9169 | 2-Propanone phenylhydrazone                      | Acetone, phenylhydrazone                                      | C <sub>9</sub> H <sub>9</sub> N <sub>2</sub>                                  | 103-02-6   | 148.204  | orth                       | 42      | 163 <sup>50</sup>      |                                  |                       | s EtOH, eth, dil acid                                          |
| 9170 | Propanoyl chloride                               | Propionyl chloride                                            | C <sub>3</sub> H <sub>5</sub> ClO                                             | 79-03-8    | 92.524   | liq                        | -94     | 80                     | 1.0646 <sup>20</sup>             | 1.4032 <sup>20</sup>  | s eth                                                          |
| 9171 | Propanoyl fluoride                               | Propionyl fluoride                                            | C <sub>3</sub> H <sub>5</sub> FO                                              | 430-71-7   | 76.069   |                            |         | 44                     | 0.972 <sup>15</sup>              | 1.329 <sup>13</sup>   |                                                                |
| 9172 | Propantheline bromide                            |                                                               | C <sub>23</sub> H <sub>30</sub> BrNO <sub>3</sub>                             | 50-34-0    | 448.393  | cry                        | 160     |                        |                                  |                       | vs H <sub>2</sub> O, EtOH, chl; i eth, bz                      |
| 9173 | Propargite                                       |                                                               | C <sub>19</sub> H <sub>26</sub> O <sub>4</sub> S                              | 2312-35-8  | 350.472  |                            |         |                        | 1.10 <sup>25</sup>               |                       |                                                                |
| 9174 | Propargyl acetate                                |                                                               | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                                  | 627-09-8   | 98.101   |                            |         | 121.5                  | 0.9982 <sup>20</sup>             | 1.4187 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth                               |
| 9175 | Propargyl alcohol                                | 3-Hydroxy-1-propyne                                           | C <sub>3</sub> H <sub>4</sub> O                                               | 107-19-7   | 56.063   | liq                        | -51.8   | 113.6                  | 0.9478 <sup>20</sup>             | 1.4322 <sup>20</sup>  | s H <sub>2</sub> O, chl; msc EtOH, eth                         |
| 9176 | Propatyl nitrate                                 | 2-Ethyl-2-[(nitrooxy)methyl]-1,3-propanediol, dinitrate       | C <sub>6</sub> H <sub>11</sub> N <sub>3</sub> O <sub>9</sub>                  | 2921-92-8  | 269.166  | wh pow                     | 52      |                        | 1.49                             |                       | i H <sub>2</sub> O; s EtOH, ace                                |
| 9177 | Propazine                                        | 6-Chloro- <i>N,N'</i> -diisopropyl-1,3,5-triazine-2,4-diamine | C <sub>9</sub> H <sub>16</sub> ClN <sub>5</sub>                               | 139-40-2   | 229.710  |                            | 213     |                        | 1.162 <sup>20</sup>              |                       |                                                                |
| 9178 | Propene                                          | Propylene                                                     | C <sub>3</sub> H <sub>6</sub>                                                 | 115-07-1   | 42.080   | col gas                    | -185.24 | -47.69                 | 0.505 <sup>25</sup><br>(p>1 atm) | 1.3567 <sup>-70</sup> | sl H <sub>2</sub> O; vs EtOH, HOAc                             |
| 9179 | <i>trans</i> -1-Propene-1,2-dicarboxylic acid    | Mesaconic acid                                                | C <sub>5</sub> H <sub>6</sub> O <sub>4</sub>                                  | 498-24-8   | 130.100  | orth nd or<br>mcl pr (eth) | 204.5   | sub                    | 1.466 <sup>20</sup>              |                       | sl H <sub>2</sub> O, bz, CS <sub>2</sub> ; vs EtOH; s eth, tfa |
| 9180 | 1-Propene-2,3-dicarboxylic acid                  | Itaconic acid                                                 | C <sub>5</sub> H <sub>6</sub> O <sub>4</sub>                                  | 97-65-4    | 130.100  | rhomb (bz)                 | 175     | dec                    | 1.632 <sup>25</sup>              |                       | s H <sub>2</sub> O, EtOH, ace; sl eth, bz, peth                |
| 9181 | 2-Propene-1-thiol                                |                                                               | C <sub>3</sub> H <sub>6</sub> S                                               | 870-23-5   | 74.145   |                            |         | 65                     | 0.925 <sup>23</sup>              | 1.4832 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s chl                       |
| 9182 | <i>cis</i> -1-Propene-1,2,3-tricarboxylic acid   | <i>cis</i> -Aconitic acid                                     | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                                  | 585-84-2   | 174.108  | nd (w)                     | 125     |                        |                                  |                       | s H <sub>2</sub> O; sl eth                                     |
| 9183 | <i>trans</i> -1-Propene-1,2,3-tricarboxylic acid | <i>trans</i> -Aconitic acid                                   | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                                  | 4023-65-8  | 174.108  | lf (w) nd (w, eth)         | 196 dec |                        |                                  |                       | vs H <sub>2</sub> O, EtOH                                      |
| 9184 | 1-Propen-1-one                                   | Methylketene                                                  | C <sub>3</sub> H <sub>4</sub> O                                               | 6004-44-0  | 56.063   | col gas                    | -80     | -23                    |                                  |                       | vs eth                                                         |
| 9185 | 2-Propenoyl chloride                             | Acrylic acid chloride                                         | C <sub>3</sub> H <sub>3</sub> ClO                                             | 814-68-6   | 90.508   |                            |         | 75.5                   | 1.1136 <sup>20</sup>             | 1.4343 <sup>20</sup>  | vs chl                                                         |
| 9186 | <i>cis</i> -1-Propenylbenzene                    |                                                               | C <sub>9</sub> H <sub>10</sub>                                                | 766-90-5   | 118.175  | liq                        | -61.6   | 167.5                  | 0.9088 <sup>20</sup>             | 1.5420 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc          |
| 9187 | <i>trans</i> -1-Propenylbenzene                  |                                                               | C <sub>9</sub> H <sub>10</sub>                                                | 873-66-5   | 118.175  | liq                        | -29.3   | 178.3                  | 0.9023 <sup>25</sup>             | 1.5506 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz                     |
| 9188 | <i>trans</i> -5-(1-Propenyl)-1,3-benzodioxole    |                                                               | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                                | 4043-71-4  | 162.185  |                            | 6.8     | 253                    | 1.1224 <sup>20</sup>             | 1.5782 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; vs ace; s chl               |
| 9189 | 4-(1-Propenyl)phenol                             | <i>p</i> -Anol                                                | C <sub>9</sub> H <sub>10</sub> O                                              | 539-12-8   | 134.174  | lf                         | 94      | dec 250                |                                  |                       | sl H <sub>2</sub> O; vs DMF                                    |
| 9190 | 2-(1-Propenyl)piperidine                         | $\beta$ -Coniceine                                            | C <sub>8</sub> H <sub>13</sub> N                                              | 538-90-9   | 125.212  |                            | 8       | 168                    | 0.8716 <sup>15</sup>             |                       |                                                                |
| 9191 | Propetamphos                                     |                                                               | C <sub>10</sub> H <sub>20</sub> NO <sub>4</sub> PS                            | 31218-83-4 | 281.309  |                            |         | 88 <sup>0.005</sup>    | 1.1294 <sup>20</sup>             |                       |                                                                |
| 9192 | Propiconazole                                    |                                                               | C <sub>15</sub> H <sub>17</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>2</sub> | 60207-90-1 | 342.221  |                            |         | 180 <sup>0.1</sup>     | 1.27 <sup>20</sup>               |                       |                                                                |
| 9193 | Propiomazine                                     |                                                               | C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> OS                             | 362-29-8   | 340.482  |                            |         | 240 <sup>0.5</sup>     |                                  |                       |                                                                |
| 9194 | Propionyl- <i>L</i> -carnitine                   | Carnitine, <i>O</i> -propanoyl                                | C <sub>10</sub> H <sub>19</sub> NO <sub>4</sub>                               | 20064-19-1 | 217.263  | hyg pr (2-PrOH)            | 147 dec |                        |                                  |                       |                                                                |
| 9195 | Propofol                                         |                                                               | C <sub>12</sub> H <sub>18</sub> O                                             | 2078-54-8  | 178.270  |                            | 19      | 256; 136 <sup>30</sup> | 0.955 <sup>20</sup>              | 1.5140 <sup>20</sup>  |                                                                |
| 9196 | Propoxur                                         | Phenol, 2-(1-methylethoxy)-, methylcarbamate                  | C <sub>11</sub> H <sub>15</sub> NO <sub>3</sub>                               | 114-26-1   | 209.242  |                            | 87      | dec                    | 1.12 <sup>20</sup>               |                       |                                                                |
| 9197 | 2-Propoxyethanol                                 | Ethylene glycol monopropyl ether                              | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                                 | 2807-30-9  | 104.148  |                            |         | 149.8                  | 0.9112 <sup>20</sup>             | 1.4133 <sup>20</sup>  | s H <sub>2</sub> O; vs EtOH, eth                               |
| 9198 | <i>D</i> -Propoxyphene                           | Dextropropoxyphene                                            | C <sub>22</sub> H <sub>29</sub> NO <sub>2</sub>                               | 469-62-5   | 339.471  | cry (peth)                 | 75.5    |                        |                                  |                       |                                                                |
| 9199 | <i>L</i> -Propoxyphene                           | Levopropoxyphene                                              | C <sub>22</sub> H <sub>29</sub> NO <sub>2</sub>                               | 2338-37-6  | 339.471  | cry (peth)                 | 75.5    |                        |                                  |                       |                                                                |
| 9200 | 1-Propoxy-2-propanol                             | 1,2-Propylene glycol 1-propyl ether                           | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                                 | 1569-01-3  | 118.174  |                            |         | 150                    | 0.8886 <sup>20</sup>             | 1.4130 <sup>20</sup>  |                                                                |
| 9201 | 3-Propoxy-1-propene                              |                                                               | C <sub>6</sub> H <sub>12</sub> O                                              | 1471-03-0  | 100.158  |                            |         | 91                     | 0.7764 <sup>20</sup>             | 1.3919 <sup>20</sup>  | vs ace, eth, EtOH                                              |
| 9202 | Propranolol                                      |                                                               | C <sub>16</sub> H <sub>21</sub> NO <sub>2</sub>                               | 525-66-6   | 259.344  | cry (cyhex)                | 96      |                        |                                  |                       |                                                                |
| 9203 | Propyl acetate                                   |                                                               | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                                 | 109-60-4   | 102.132  | liq                        | -93     | 101.3                  | 0.8820 <sup>25</sup>             | 1.3828 <sup>25</sup>  | sl H <sub>2</sub> O; msc EtOH, eth; s ctc                      |
| 9204 | Propyl acrylate                                  | 2-Propenoic acid, propyl ester                                | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                                 | 925-60-0   | 114.142  |                            |         | 122; 63 <sup>100</sup> |                                  |                       |                                                                |
| 9205 | Propylamine                                      | 1-Propanamine                                                 | C <sub>3</sub> H <sub>9</sub> N                                               | 107-10-8   | 59.110   | liq                        | -84.75  | 47.22                  | 0.7173 <sup>20</sup>             | 1.3870 <sup>20</sup>  | msc H <sub>2</sub> O; vs EtOH, ace; s bz, chl; sl ctc          |
| 9206 | Propylamine hydrochloride                        | 1-Propanamine hydrochloride                                   | C <sub>3</sub> H <sub>10</sub> ClN                                            | 556-53-6   | 95.571   |                            | 163.5   |                        |                                  |                       | s DMSO                                                         |

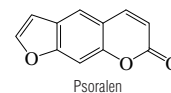
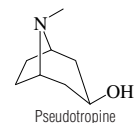
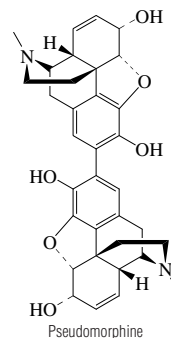
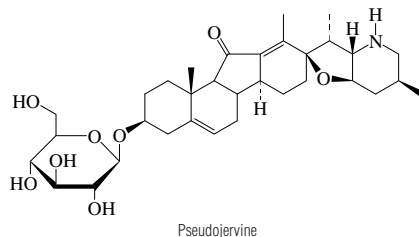
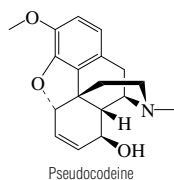
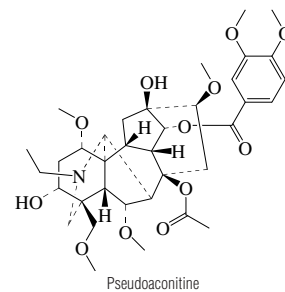
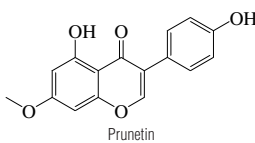
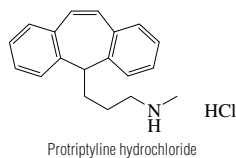
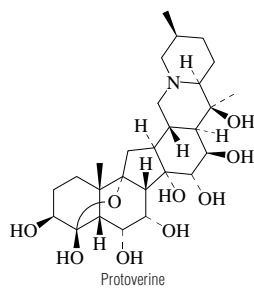
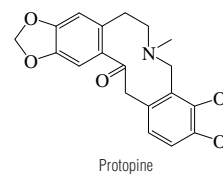
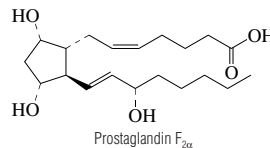
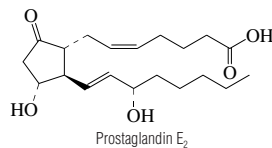
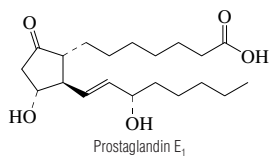
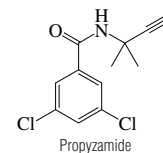
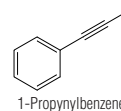
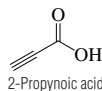
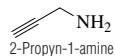
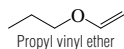
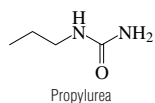
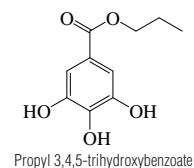
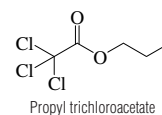
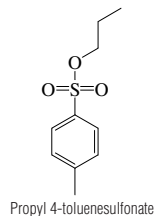
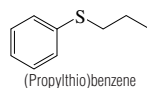
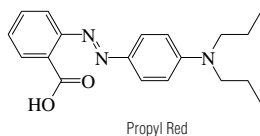
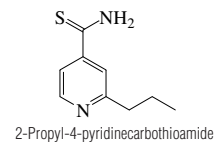
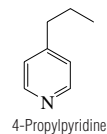
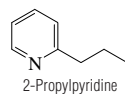
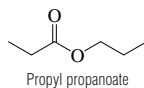
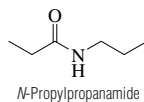
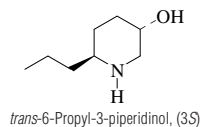
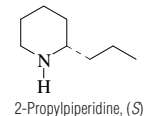
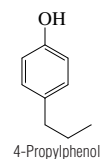
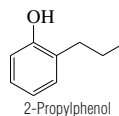
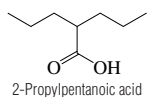
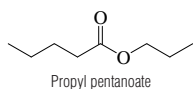
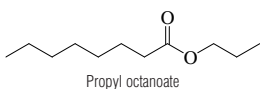




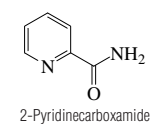
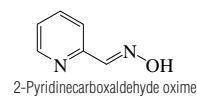
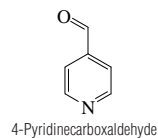
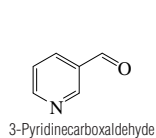
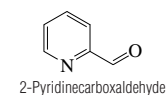
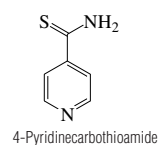
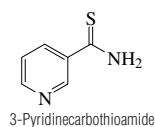
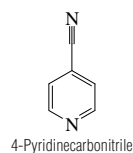
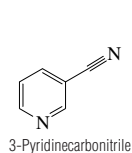
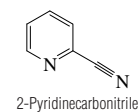
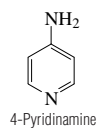
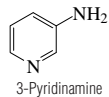
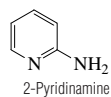
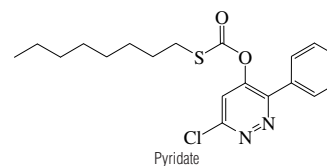
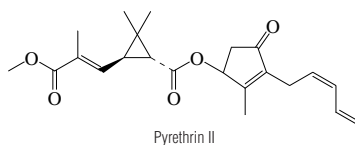
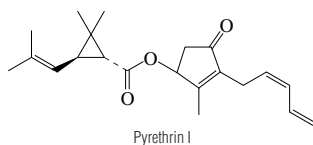
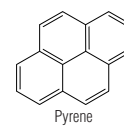
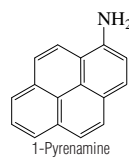
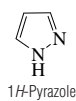
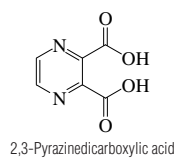
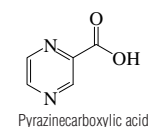
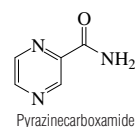
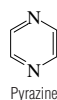
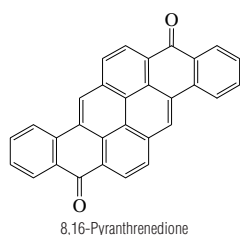
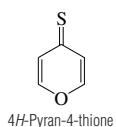
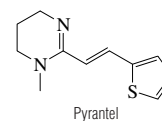
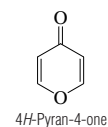
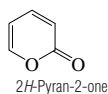
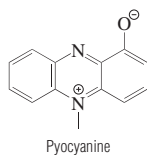
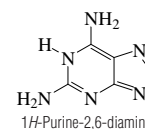
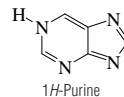
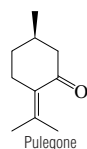
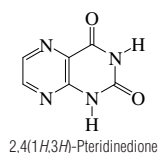
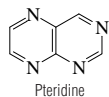
| No.  | Name                                             | Synonym                                    | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form   | mp/°C  | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                            |
|------|--------------------------------------------------|--------------------------------------------|----------------------------------------------------------------|------------|----------|-----------------|--------|-------------------------------------|----------------------------|-----------------------|-------------------------------------------------------|
| 9207 | Propyl 4-aminobenzoate                           | Risocaine                                  | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>                | 94-12-2    | 179.216  | pr              | 75     |                                     |                            |                       | vs bz, eth, EtOH, chl                                 |
| 9208 | 2-(Propylamino)ethanol                           |                                            | C <sub>8</sub> H <sub>13</sub> NO                              | 16369-21-4 | 103.163  |                 |        | 182                                 | 0.9005 <sup>20</sup>       | 1.4428 <sup>20</sup>  |                                                       |
| 9209 | 4-Propylaniline                                  |                                            | C <sub>9</sub> H <sub>13</sub> N                               | 2696-84-6  | 135.206  |                 |        | 227                                 |                            |                       |                                                       |
| 9210 | <i>N</i> -Propylaniline                          |                                            | C <sub>9</sub> H <sub>13</sub> N                               | 622-80-0   | 135.206  |                 |        | 222; 98 <sup>11</sup>               | 0.9443 <sup>20</sup>       | 1.5428 <sup>20</sup>  | vs eth, EtOH                                          |
| 9211 | Propylarsonic acid                               | 1-Propanearsonic acid                      | C <sub>3</sub> H <sub>9</sub> AsO <sub>3</sub>                 | 107-34-6   | 168.023  | nd (al), pl (w) | 134.5  |                                     |                            |                       | vs H <sub>2</sub> O, EtOH; i eth                      |
| 9212 | Propylbenzene                                    | Isocumene                                  | C <sub>9</sub> H <sub>12</sub>                                 | 103-65-1   | 120.191  | liq             | -99.6  | 159.24                              | 0.8593 <sup>25</sup>       | 1.4895 <sup>25</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 9213 | $\alpha$ -Propylbenzenemethanol, ( <i>R</i> )    |                                            | C <sub>10</sub> H <sub>14</sub> O                              | 22144-60-1 | 150.217  |                 | 16     | 232                                 | 0.9740 <sup>20</sup>       | 1.5139 <sup>20</sup>  | vs eth, EtOH                                          |
| 9214 | Propyl benzenesulfonate                          |                                            | C <sub>9</sub> H <sub>12</sub> O <sub>3</sub> S                | 80-42-2    | 200.254  |                 |        | 162 <sup>15</sup>                   | 1.1804 <sup>17</sup>       | 1.5035 <sup>25</sup>  | sl H <sub>2</sub> O; s EtOH; vs eth, chl              |
| 9215 | Propyl benzoate                                  |                                            | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                 | 2315-68-6  | 164.201  | liq             | -51.6  | 211                                 | 1.0230 <sup>20</sup>       | 1.5000 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth                     |
| 9216 | 5-Propyl-1,3-benzodioxole                        | Dihydrosafrole                             | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                 | 94-58-6    | 164.201  |                 |        | 228                                 |                            |                       | s ctc                                                 |
| 9217 | Propyl butanoate                                 |                                            | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 105-66-8   | 130.185  | liq             | -95.2  | 143.0                               | 0.8730 <sup>20</sup>       | 1.4001 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth                    |
| 9218 | Propyl carbamate                                 |                                            | C <sub>6</sub> H <sub>9</sub> NO <sub>2</sub>                  | 627-12-3   | 103.120  | pr              | 60     | 196                                 |                            |                       | vs ace, eth, EtOH                                     |
| 9219 | Propyl chloroacetate                             |                                            | C <sub>6</sub> H <sub>9</sub> ClO <sub>2</sub>                 | 5396-24-7  | 136.577  |                 |        | 161                                 | 1.104 <sup>20</sup>        | 1.4261 <sup>20</sup>  | vs eth                                                |
| 9220 | Propyl 2-chlorobutanoate                         |                                            | C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>                | 62108-71-8 | 164.630  |                 |        | 183                                 | 1.0252 <sup>20</sup>       |                       |                                                       |
| 9221 | Propyl chlorocarbonate                           |                                            | C <sub>6</sub> H <sub>7</sub> ClO <sub>2</sub>                 | 109-61-5   | 122.551  |                 |        | 115.2                               | 1.0901 <sup>20</sup>       | 1.4035 <sup>20</sup>  | msc EtOH, eth                                         |
| 9222 | Propyl 3-chloropropanoate                        |                                            | C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>                | 62108-66-1 | 150.603  |                 |        | 180                                 | 1.0656 <sup>20</sup>       | 1.4290 <sup>20</sup>  | vs eth, EtOH                                          |
| 9223 | <i>S</i> -Propyl chlorothioformate               | <i>S</i> -Propyl carbonochloridothioate    | C <sub>3</sub> H <sub>7</sub> ClOS                             | 13889-92-4 | 138.616  | liq             |        | 59 <sup>26</sup>                    |                            |                       |                                                       |
| 9224 | Propyl <i>trans</i> -cinnamate                   | Propyl <i>trans</i> -3-phenyl-2-propenoate | C <sub>12</sub> H <sub>14</sub> O <sub>2</sub>                 | 74513-58-9 | 190.238  |                 |        | 285                                 | 1.0433 <sup>30</sup>       |                       | i H <sub>2</sub> O                                    |
| 9225 | Propylcyclohexane                                |                                            | C <sub>9</sub> H <sub>18</sub>                                 | 1678-92-8  | 126.239  | liq             | -94.9  | 156                                 | 0.7936 <sup>20</sup>       | 1.4370 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, ace, ctc; s eth, bz     |
| 9226 | 2-Propylcyclohexanone                            |                                            | C <sub>9</sub> H <sub>16</sub> O                               | 94-65-5    | 140.222  |                 |        | 197                                 | 0.927 <sup>20</sup>        | 1.4538 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, ace; vs eth, bz           |
| 9227 | Propylcyclopentane                               |                                            | C <sub>8</sub> H <sub>16</sub>                                 | 2040-96-2  | 112.213  | liq             | -117.3 | 131                                 | 0.7763 <sup>20</sup>       | 1.4266 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace; s bz; vs ctc  |
| 9228 | 1-Propylcyclopentanol                            |                                            | C <sub>8</sub> H <sub>16</sub> O                               | 1604-02-0  | 128.212  | liq             | -37.5  | 173.5                               | 0.9040 <sup>25</sup>       | 1.4502 <sup>25</sup>  |                                                       |
| 9229 | Propylene carbonate                              | 4-Methyl-1,3-dioxolan-2-one                | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                   | 108-32-7   | 102.089  | liq             | -48.8  | 242                                 | 1.2047 <sup>20</sup>       | 1.4189 <sup>20</sup>  | vs H <sub>2</sub> O, EtOH, eth, ace, bz               |
| 9230 | 1,2-Propylene glycol                             | 1,2-Propanediol                            | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                   | 57-55-6    | 76.095   | liq             | -60    | 187.6                               | 1.0361 <sup>20</sup>       | 1.4324 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH; s eth, bz, chl            |
| 9231 | 1,3-Propylene glycol                             | Trimethylene glycol                        | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                   | 504-63-2   | 76.095   | liq             | -27.7  | 214.4                               | 1.0538 <sup>20</sup>       | 1.4398 <sup>20</sup>  | msc H <sub>2</sub> O, EtOH; vs eth; sl bz             |
| 9232 | 1,2-Propylene glycol 2- <i>tert</i> -butyl ether | 2-(1,1-Dimethylethoxy)-1-propanol          | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>                  | 94023-15-1 | 132.201  | liq             |        | 152                                 | 0.87                       |                       |                                                       |
| 9233 | 1,2-Propylene glycol dinitrate                   |                                            | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>6</sub>    | 6423-43-4  | 166.089  | liq             | exp    | 92 <sup>10</sup>                    |                            |                       |                                                       |
| 9234 | 1,2-Propylene glycol monomethyl ether            | 1-Methoxy-2-propanol                       | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                  | 107-98-2   | 90.121   |                 |        | 119                                 | 0.9620 <sup>20</sup>       | 1.4034 <sup>20</sup>  |                                                       |
| 9235 | 1,2-Propylene glycol monomethyl ether acetate    | 2-Acetoxy-1-methoxypropane                 | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                  | 108-65-6   | 132.157  | liq             |        | 147                                 |                            |                       |                                                       |
| 9236 | Propyleneimine                                   | 2-Methylaziridine                          | C <sub>3</sub> H <sub>5</sub> N                                | 75-55-8    | 57.095   |                 |        | 67                                  | 0.812 <sup>16</sup>        |                       |                                                       |
| 9237 | Propyl formate                                   |                                            | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                   | 110-74-7   | 88.106   | liq             | -92.9  | 80.9                                | 0.9073 <sup>20</sup>       | 1.377 <sup>20</sup>   | sl H <sub>2</sub> O, ctc; msc EtOH, eth               |
| 9238 | Propyl 3-(2-furyl)acrylate                       |                                            | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                 | 623-22-3   | 180.200  |                 |        | 113 <sup>16</sup> , 92 <sup>3</sup> | 1.0744 <sup>20</sup>       | 1.5392 <sup>24</sup>  | vs bz, eth, EtOH                                      |
| 9239 | 4-Propylheptane                                  |                                            | C <sub>10</sub> H <sub>22</sub>                                | 3178-29-8  | 142.282  |                 |        | 157.5                               | 0.7321 <sup>25</sup>       | 1.4135 <sup>20</sup>  |                                                       |
| 9240 | Propyl hexanoate                                 |                                            | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                  | 626-77-7   | 158.238  | liq             | -68.7  | 187                                 | 0.8672 <sup>20</sup>       | 1.4170 <sup>20</sup>  | vs eth, EtOH                                          |
| 9241 | Propyl 2-hydroxybenzoate                         |                                            | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                 | 607-90-9   | 180.200  |                 | 97     | 239                                 | 1.0979 <sup>20</sup>       | 1.5161 <sup>20</sup>  | s ctc, CS <sub>2</sub>                                |
| 9242 | Propyl 4-hydroxybenzoate                         | Propylparaben                              | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                 | 94-13-3    | 180.200  | pr (eth)        | 97     |                                     | 1.0630 <sup>102</sup>      | 1.5050 <sup>102</sup> | i H <sub>2</sub> O; s EtOH, eth; sl chl               |
| 9243 | Propyliodone                                     |                                            | C <sub>10</sub> H <sub>11</sub> I <sub>2</sub> NO <sub>3</sub> | 587-61-1   | 447.008  |                 | 186    |                                     |                            |                       |                                                       |
| 9244 | Propyl isobutanoate                              |                                            | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 644-49-5   | 130.185  |                 |        | 135.4                               | 0.8843 <sup>30</sup>       | 1.3955 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, ace; vs eth              |
| 9245 | Propyl isocyanate                                | 1-Isocyanatopropane                        | C <sub>4</sub> H <sub>7</sub> NO                               | 110-78-1   | 85.105   |                 |        | 83.5                                | 0.908 <sup>25</sup>        | 1.3970 <sup>20</sup>  |                                                       |
| 9246 | Propyl isothiocyanate                            | 1-Isothiocyanatopropane                    | C <sub>4</sub> H <sub>7</sub> NS                               | 628-30-8   | 101.171  |                 |        | 153                                 | 0.9781 <sup>16</sup>       | 1.5085 <sup>16</sup>  | sl H <sub>2</sub> O; msc EtOH, eth                    |
| 9247 | Propyl methacrylate                              |                                            | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                  | 2210-28-8  | 128.169  |                 |        | 141                                 | 0.9022 <sup>20</sup>       | 1.4190 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth                     |
| 9248 | Propyl 3-methylbutanoate                         | Propyl isopentanoate                       | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                  | 557-00-6   | 144.212  |                 |        | 155.9                               | 0.8617 <sup>20</sup>       | 1.4031 <sup>20</sup>  | vs eth, EtOH                                          |
| 9249 | 1-Propylnaphthalene                              |                                            | C <sub>13</sub> H <sub>14</sub>                                | 2765-18-6  | 170.250  | liq             | -8.6   | 274.5                               | 0.9897 <sup>20</sup>       | 1.5923 <sup>20</sup>  |                                                       |
| 9250 | Propyl nitrate                                   |                                            | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                  | 627-13-4   | 105.093  |                 |        | 110                                 | 1.0538 <sup>20</sup>       | 1.3973 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth, ctc                 |
| 9251 | Propyl nitrite                                   |                                            | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                  | 543-67-9   | 89.094   | liq             |        | 48                                  | 0.886 <sup>20</sup>        | 1.3604 <sup>20</sup>  | sl H <sub>2</sub> O; s EtOH, eth                      |



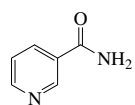
| No.  | Name                               | Synonym                                            | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form                        | mp/°C   | bp/°C                     | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>       | Solubility                                                      |
|------|------------------------------------|----------------------------------------------------|---------------------------------------------------------------|------------|----------|--------------------------------------|---------|---------------------------|----------------------------------|----------------------|-----------------------------------------------------------------|
| 9252 | Propyl octanoate                   |                                                    | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                | 624-13-5   | 186.292  | liq                                  | -46.2   | 226.4                     | 0.8659 <sup>20</sup>             | 1.4191 <sup>25</sup> | vs ace, eth, EtOH                                               |
| 9253 | Propyl pentanoate                  |                                                    | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                 | 141-06-0   | 144.212  | liq                                  | -70.7   | 167.5                     | 0.8699 <sup>20</sup>             | 1.4065 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                            |
| 9254 | 2-Propylpentanoic acid             | Valproic acid                                      | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                 | 99-66-1    | 144.212  | col liq                              |         | 221; 120 <sup>14</sup>    | 0.904 <sup>25</sup>              | 1.425 <sup>25</sup>  | sl H <sub>2</sub> O                                             |
| 9255 | 2-Propylphenol                     |                                                    | C <sub>9</sub> H <sub>12</sub> O                              | 644-35-9   | 136.190  |                                      | 7       | 220                       | 1.015 <sup>20</sup>              |                      | vs eth, EtOH                                                    |
| 9256 | 4-Propylphenol                     |                                                    | C <sub>9</sub> H <sub>12</sub> O                              | 645-56-7   | 136.190  |                                      | 22      | 232.6                     | 1.009 <sup>20</sup>              | 1.5379 <sup>25</sup> | sl H <sub>2</sub> O, ctc; s EtOH                                |
| 9257 | 2-Propylpiperidine, (S)            | Coniine                                            | C <sub>8</sub> H <sub>17</sub> N                              | 458-88-8   | 127.228  | liq                                  | -1.0    | 166.5                     | 0.8440 <sup>20</sup>             | 1.4512 <sup>22</sup> | sl H <sub>2</sub> O, chl; msc EtOH; vs eth; s bz                |
| 9258 | trans-6-Propyl-3-piperidinol, (3S) | Pseudoconhydrine                                   | C <sub>8</sub> H <sub>17</sub> NO                             | 140-55-6   | 143.227  | hyg nd (eth)                         | 106     | 236                       |                                  |                      | vs H <sub>2</sub> O, eth, EtOH                                  |
| 9259 | N-Propylpropanamide                |                                                    | C <sub>6</sub> H <sub>13</sub> NO                             | 3217-86-5  | 115.173  |                                      | 154     | 215; 108 <sup>9</sup>     | 0.8985 <sup>25</sup>             |                      | sl H <sub>2</sub> O, eth                                        |
| 9260 | Propyl propanoate                  | Propyl propionate                                  | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 106-36-5   | 116.158  | liq                                  | -75.9   | 122.5                     | 0.8755 <sup>25</sup>             | 1.3909 <sup>25</sup> | sl H <sub>2</sub> O, ctc; msc EtOH, eth; s ace                  |
| 9261 | 2-Propylpyridine                   |                                                    | C <sub>8</sub> H <sub>11</sub> N                              | 622-39-9   | 121.180  |                                      | 1.0     | 167                       | 0.9119 <sup>20</sup>             | 1.4925 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; vs ace                      |
| 9262 | 4-Propylpyridine                   |                                                    | C <sub>8</sub> H <sub>11</sub> N                              | 1122-81-2  | 121.180  |                                      |         | 185                       | 0.9381 <sup>15</sup>             | 1.4966 <sup>20</sup> | vs eth, EtOH                                                    |
| 9263 | 2-Propyl-4-pyridinecarbothioamide  | Protionamide                                       | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> S               | 14222-60-7 | 180.269  |                                      | 136.7   |                           |                                  |                      |                                                                 |
| 9264 | Propyl Red                         | Benzoic acid, 2-[[4-(dipropylamino)phenyl]azo]-    | C <sub>19</sub> H <sub>23</sub> N <sub>3</sub> O <sub>2</sub> | 2641-01-2  | 325.405  | viol-bl or purp red cry (al)         |         |                           |                                  |                      | s EtOH, KOH                                                     |
| 9265 | (Propylthio)benzene                |                                                    | C <sub>8</sub> H <sub>12</sub> S                              | 874-79-3   | 152.256  | liq                                  | -45     | 220                       | 0.9995 <sup>20</sup>             | 1.5571 <sup>20</sup> |                                                                 |
| 9266 | Propyl 4-toluenesulfonate          |                                                    | C <sub>10</sub> H <sub>14</sub> O <sub>3</sub> S              | 599-91-7   | 214.281  |                                      | <-20    | 189 <sup>9</sup>          | 1.144 <sup>20</sup>              | 1.4998 <sup>20</sup> |                                                                 |
| 9267 | Propyl trichloroacetate            |                                                    | C <sub>6</sub> H <sub>7</sub> Cl <sub>3</sub> O <sub>2</sub>  | 13313-91-2 | 205.468  |                                      |         | 187                       | 1.3221 <sup>20</sup>             | 1.4501 <sup>20</sup> | vs eth, EtOH                                                    |
| 9268 | Propyl 3,4,5-trihydroxybenzoate    | Propyl gallate                                     | C <sub>10</sub> H <sub>12</sub> O <sub>5</sub>                | 121-79-9   | 212.199  | nd (w)                               | 130     |                           |                                  |                      | sl H <sub>2</sub> O                                             |
| 9269 | Propylurea                         |                                                    | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O               | 627-06-5   | 102.134  | pr (al)                              | 108.5   |                           |                                  |                      | sl H <sub>2</sub> O, DMSO; s EtOH                               |
| 9270 | Propyl vinyl ether                 | 1-(Ethenyloxy)propane                              | C <sub>5</sub> H <sub>10</sub> O                              | 764-47-6   | 86.132   |                                      |         | 65                        | 0.7674 <sup>20</sup>             | 1.3908 <sup>20</sup> |                                                                 |
| 9271 | 2-Propynal                         | Propargyl aldehyde                                 | C <sub>3</sub> H <sub>2</sub> O                               | 624-67-9   | 54.047   |                                      |         | 60                        | 0.9152 <sup>20</sup>             | 1.4033 <sup>25</sup> | msc H <sub>2</sub> O; s EtOH, eth, ace, bz, tol                 |
| 9272 | 2-Propyn-1-amine                   |                                                    | C <sub>3</sub> H <sub>3</sub> N                               | 2450-71-7  | 55.079   |                                      |         | 83                        | 0.803 <sup>25</sup>              | 1.4480 <sup>20</sup> |                                                                 |
| 9273 | Propyne                            | Methylacetylene                                    | C <sub>3</sub> H <sub>4</sub>                                 | 74-99-7    | 40.064   | col gas                              | -102.7  | -23.2                     | 0.607 <sup>25</sup><br>(p>1 atm) | 1.3863 <sup>40</sup> | sl H <sub>2</sub> O; vs EtOH; s bz, chl                         |
| 9274 | 2-Propynoic acid                   | Propiolic acid                                     | C <sub>3</sub> H <sub>2</sub> O <sub>2</sub>                  | 471-25-0   | 70.047   | cry (CS <sub>2</sub> )               | 9       | dec 144; 72 <sup>50</sup> | 1.1380 <sup>20</sup>             | 1.4306 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH, chl                             |
| 9275 | 1-Propynylbenzene                  |                                                    | C <sub>8</sub> H <sub>8</sub>                                 | 673-32-5   | 116.160  |                                      |         | 183                       | 0.942 <sup>15</sup>              | 1.563 <sup>15</sup>  |                                                                 |
| 9276 | Propyzamide                        | N-(1,1-Dimethyl-2-propynyl)-3,5-dichlorobenzamide  | C <sub>12</sub> H <sub>11</sub> Cl <sub>2</sub> NO            | 23950-58-5 | 256.127  |                                      | 155     |                           |                                  |                      |                                                                 |
| 9277 | Prostaglandin E <sub>1</sub>       | 11,15-Dihydroxy-9-oxo-13-prostenoic acid           | C <sub>20</sub> H <sub>34</sub> O <sub>5</sub>                | 745-65-3   | 354.481  | cry (EtOAc)                          | 115     |                           |                                  |                      | s H <sub>2</sub> O                                              |
| 9278 | Prostaglandin E <sub>2</sub>       | 11,15-Dihydroxy-9-oxo-5,13-prostadienoic acid      | C <sub>20</sub> H <sub>32</sub> O <sub>5</sub>                | 363-24-6   | 352.465  | col cry                              | 67      |                           |                                  |                      | s H <sub>2</sub> O, thf                                         |
| 9279 | Prostaglandin F <sub>2α</sub>      | 9,11,15-Trihydroxyprosta-5,13-dienoic acid         | C <sub>20</sub> H <sub>34</sub> O <sub>5</sub>                | 551-11-1   | 354.481  | oil or solid                         | ≈30     |                           |                                  |                      | sl H <sub>2</sub> O; s EtOH, MeOH, chl, AcOEt                   |
| 9280 | Protopine                          | Fumarine                                           | C <sub>20</sub> H <sub>19</sub> NO <sub>5</sub>               | 130-86-9   | 353.369  | mcl pr (al-chl)                      | 208     |                           |                                  |                      | i H <sub>2</sub> O; sl EtOH, eth, bz, peth; s chl               |
| 9281 | Protoverine                        |                                                    | C <sub>27</sub> H <sub>43</sub> NO <sub>9</sub>               | 76-45-9    | 525.632  | nd (MeOH)                            | 221     |                           |                                  |                      | i H <sub>2</sub> O; s EtOH, bz, aq acid, MeOH                   |
| 9282 | Protriptyline hydrochloride        | Triptil                                            | C <sub>19</sub> H <sub>22</sub> ClN                           | 1225-55-4  | 299.838  | cry (2-PrOH/eth)                     | 170     |                           |                                  |                      |                                                                 |
| 9283 | Prunetin                           |                                                    | C <sub>16</sub> H <sub>12</sub> O <sub>5</sub>                | 552-59-0   | 284.263  |                                      | 239.5   |                           |                                  |                      |                                                                 |
| 9284 | Pseudoaconitine                    |                                                    | C <sub>36</sub> H <sub>51</sub> NO <sub>12</sub>              | 127-29-7   | 689.790  | tcl (MeOH)                           | 214     |                           |                                  |                      | vs eth, EtOH                                                    |
| 9285 | Pseudocodeine                      |                                                    | C <sub>18</sub> H <sub>21</sub> NO <sub>3</sub>               | 466-96-6   | 299.365  | wh nd                                | 181.5   |                           | 1.290 <sup>80</sup>              | 1.574                |                                                                 |
| 9286 | Pseudojervine                      |                                                    | C <sub>33</sub> H <sub>49</sub> NO <sub>8</sub>               | 36069-05-3 | 587.744  | wh nd or hex cry                     | 304 dec |                           |                                  |                      | i H <sub>2</sub> O, eth, bz, chl, tol, peth; s EtOH             |
| 9287 | Pseudomorphine                     |                                                    | C <sub>34</sub> H <sub>38</sub> N <sub>2</sub> O <sub>6</sub> | 125-24-6   | 568.659  | cry (aq NH <sub>3</sub> + 3 w)       | 282.5   |                           |                                  |                      | i H <sub>2</sub> O, EtOH, eth, chl, sulf; s py, NH <sub>3</sub> |
| 9288 | Pseudotropine                      | 8-Methyl-8-azabicyclo[3.2.1]octan-3-ol, <i>exo</i> | C <sub>8</sub> H <sub>15</sub> NO                             | 135-97-7   | 141.211  | orth cry (eth), orth bipym (peth-bz) | 109     | 241                       |                                  |                      | vs H <sub>2</sub> O, EtOH; sl eth; s bz, chl                    |
| 9289 | Psoralen                           |                                                    | C <sub>11</sub> H <sub>6</sub> O <sub>3</sub>                 | 66-97-7    | 186.164  | nd (w, EtOH)                         | 171     |                           |                                  |                      |                                                                 |



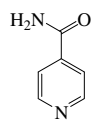
| No.  | Name                                        | Synonym                              | Mol. Form.                                                        | CAS RN     | Mol. Wt. | Physical Form                            | mp/°C   | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|------|---------------------------------------------|--------------------------------------|-------------------------------------------------------------------|------------|----------|------------------------------------------|---------|---------------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 9290 | Pteridine                                   | Pyrazino[2,3-d]pyrimidine            | C <sub>6</sub> H <sub>6</sub> N <sub>4</sub>                      | 91-18-9    | 132.123  | ye pl (bz, sub)                          | 139.5   | sub 125                   |                            |                      | vs H <sub>2</sub> O; s EtOH; sl eth, bz                       |
| 9291 | 2,4(1 <i>H</i> ,3 <i>H</i> )-Pteridinedione | Lumazine                             | C <sub>6</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub>       | 487-21-8   | 164.122  | ye-oran nd (w)                           | 348.5   |                           |                            |                      | vs HOAc                                                       |
| 9292 | Pulegone                                    |                                      | C <sub>10</sub> H <sub>16</sub> O                                 | 89-82-7    | 152.233  |                                          |         | 224                       | 0.9346 <sup>45</sup>       | 1.4894 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, chl; s ctc                 |
| 9293 | 1 <i>H</i> -Purine                          | 6 <i>H</i> -Imidazo[4,5-d]pyrimidine | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub>                      | 120-73-0   | 120.113  |                                          | 216.5   |                           |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth, chl; s ace                 |
| 9294 | 1 <i>H</i> -Purine-2,6-diamine              | 2,6-Diaminopurine                    | C <sub>5</sub> H <sub>6</sub> N <sub>6</sub>                      | 1904-98-9  | 150.142  | cry (dil al)                             | 302     |                           |                            |                      |                                                               |
| 9295 | Pyocyanine                                  |                                      | C <sub>13</sub> H <sub>10</sub> N <sub>2</sub> O                  | 85-66-5    | 210.230  | dk bl nd (w + 1) (chl-peth)              | 133 dec |                           |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, ace; i eth; vs chl           |
| 9296 | 4 <i>H</i> -Pyran                           | 1,4-Pyran                            | C <sub>5</sub> H <sub>6</sub> O                                   | 289-65-6   | 82.101   | unstab oil                               |         | 80                        |                            | 1.4559 <sup>20</sup> | s EtOH, eth, bz                                               |
| 9297 | 2 <i>H</i> -Pyran-2-one                     |                                      | C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                      | 504-31-4   | 96.085   |                                          | 8.5     | 207.5                     | 1.200 <sup>20</sup>        | 1.5270 <sup>25</sup> | msc H <sub>2</sub> O; vs ace                                  |
| 9298 | 4 <i>H</i> -Pyran-4-one                     |                                      | C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                      | 108-97-4   | 96.085   |                                          | 32.5    | 212.5                     | 1.190 <sup>25</sup>        | 1.5238               | vs H <sub>2</sub> O, chl, eth; s EtOH, bz; sl CS <sub>2</sub> |
| 9299 | Pyrantel                                    |                                      | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> S                  | 15686-83-6 | 206.307  | cry (MeOH)                               | 178     |                           |                            |                      |                                                               |
| 9300 | 4 <i>H</i> -Pyran-4-thione                  |                                      | C <sub>5</sub> H <sub>4</sub> OS                                  | 1120-93-0  | 112.150  |                                          | 49      |                           |                            |                      | s H <sub>2</sub> O                                            |
| 9301 | 8,16-Pyranthrene-dione                      |                                      | C <sub>30</sub> H <sub>14</sub> O <sub>2</sub>                    | 128-70-1   | 406.431  | red-ye or red-br nd (PhNO <sub>2</sub> ) | dec     | sub                       |                            |                      |                                                               |
| 9302 | Pyrazine                                    | 1,4-Diazine                          | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                      | 290-37-9   | 80.088   | pr (w)                                   | 51.0    | 115                       | 1.0311 <sup>61</sup>       | 1.4953 <sup>61</sup> | s H <sub>2</sub> O, EtOH, eth, ace; sl ctc                    |
| 9303 | Pyrazinecarboxamide                         | Pyrazinamide                         | C <sub>5</sub> H <sub>5</sub> N <sub>2</sub> O                    | 98-96-4    | 123.113  | wh nd (w, al)                            | 192     | sub                       |                            |                      | s H <sub>2</sub> O, EtOH                                      |
| 9304 | Pyrazinecarboxylic acid                     | Pyrazinoic acid                      | C <sub>5</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>       | 98-97-5    | 124.098  | wh nd (w)                                | 225 dec | sub                       |                            |                      |                                                               |
| 9305 | 2,3-Pyrazinedicarboxylic acid               | 2,3-Dicarboxypyrazine                | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>       | 89-01-0    | 168.107  | pr (w+2)                                 | 193 dec |                           |                            |                      | vs H <sub>2</sub> O; sl EtOH, eth, bz; s ace, MeOH            |
| 9306 | 1 <i>H</i> -Pyrazole                        | 1,2-Diazole                          | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>                      | 288-13-1   | 68.077   | nd or pr (lig)                           | 70.7    | 187                       |                            | 1.4203               | s H <sub>2</sub> O, EtOH, eth, bz; sl chl                     |
| 9307 | 1-Pyrenamine                                |                                      | C <sub>16</sub> H <sub>11</sub> N                                 | 1606-67-3  | 217.265  | ye nd (hx) lf (dil al)                   | 117.5   |                           |                            |                      | s EtOH, ace, hx, acid; sl chl                                 |
| 9308 | Pyrene                                      | Benzo[def]phenanthrene               | C <sub>16</sub> H <sub>10</sub>                                   | 129-00-0   | 202.250  | pa ye pl (to, sub)                       | 150.62  | 404                       | 1.271 <sup>23</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, bz, to; sl ctc               |
| 9309 | Pyrethrin I                                 |                                      | C <sub>21</sub> H <sub>28</sub> O <sub>3</sub>                    | 121-21-1   | 328.445  | visc liq                                 |         | 170 <sup>0.1</sup> dec    | 1.5192 <sup>18</sup>       | 1.5192 <sup>18</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc, peth                    |
| 9310 | Pyrethrin II                                |                                      | C <sub>22</sub> H <sub>28</sub> O <sub>3</sub>                    | 121-29-9   | 372.454  | visc liq                                 |         | 200 <sup>0.1</sup> dec    |                            | 1.5258 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc, peth                    |
| 9311 | Pyridate                                    |                                      | C <sub>19</sub> H <sub>23</sub> ClN <sub>2</sub> O <sub>2</sub> S | 55512-33-9 | 378.916  | br oil                                   | 27      | 220 <sup>0.1</sup>        | 1.555 <sup>20</sup>        | 1.568 <sup>20</sup>  | i H <sub>2</sub> O                                            |
| 9312 | Pyridazine                                  | 1,2-Diazabenzene                     | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                      | 289-80-5   | 80.088   | liq                                      | -8      | 208                       | 1.1035 <sup>23</sup>       | 1.5218 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; vs eth, ace, bz; i peth           |
| 9313 | 2-Pyridinamine                              | 2-Aminopyridine                      | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                      | 504-29-0   | 94.115   | lf (lig)                                 | 57.5    | 105 <sup>20</sup>         |                            |                      | s EtOH, eth, ace, bz; sl chl                                  |
| 9314 | 3-Pyridinamine                              | 3-Aminopyridine                      | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                      | 462-08-8   | 94.115   | lf (bz-lig)                              | 64.5    | 252                       |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl lig                         |
| 9315 | 4-Pyridinamine                              | 4-Aminopyridine                      | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                      | 504-24-5   | 94.115   | nd (bz)                                  | 158.5   | 273                       |                            |                      | s H <sub>2</sub> O, eth, bz; vs EtOH; sl lig                  |
| 9316 | Pyridine                                    | Azine                                | C <sub>5</sub> H <sub>5</sub> N                                   | 110-86-1   | 79.101   | liq                                      | -41.70  | 115.23                    | 0.9819 <sup>20</sup>       | 1.5095 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, bz, chl                 |
| 9317 | 2-Pyridinecarbonitrile                      |                                      | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub>                      | 100-70-9   | 104.109  | nd or pr (eth)                           | 29      | 224.5                     | 1.0810 <sup>25</sup>       | 1.5242 <sup>25</sup> | s H <sub>2</sub> O, chl; vs EtOH, eth, bz; sl ctc             |
| 9318 | 3-Pyridinecarbonitrile                      |                                      | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub>                      | 100-54-9   | 104.109  | nd (lig), peth-eth                       | 51      | 206.9; 170 <sup>300</sup> | 1.1590 <sup>25</sup>       |                      | vs H <sub>2</sub> O, EtOH, eth, bz; s chl; sl lig             |
| 9319 | 4-Pyridinecarbonitrile                      |                                      | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub>                      | 100-48-1   | 104.109  | nd(lig-eth)                              | 83      | 186                       |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, chl; sl lig                |
| 9320 | 3-Pyridinecarbothioamide                    |                                      | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> S                    | 4621-66-3  | 138.190  |                                          | 192     |                           |                            |                      |                                                               |
| 9321 | 4-Pyridinecarbothioamide                    |                                      | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> S                    | 2196-13-6  | 138.190  |                                          | 198 dec |                           |                            |                      |                                                               |
| 9322 | 2-Pyridinecarboxaldehyde                    |                                      | C <sub>6</sub> H <sub>5</sub> NO                                  | 1121-60-4  | 107.110  |                                          |         | 180; 62 <sup>13</sup>     | 1.1181 <sup>25</sup>       | 1.5389 <sup>18</sup> | s H <sub>2</sub> O, EtOH, eth, AcOEt; sl ctc                  |
| 9323 | 3-Pyridinecarboxaldehyde                    | Nicotinaldehyde                      | C <sub>6</sub> H <sub>5</sub> NO                                  | 500-22-1   | 107.110  |                                          |         | 92 <sup>23</sup>          | 1.1394 <sup>25</sup>       |                      | s H <sub>2</sub> O, EtOH, ace, chl; sl eth, peth              |
| 9324 | 4-Pyridinecarboxaldehyde                    |                                      | C <sub>6</sub> H <sub>5</sub> NO                                  | 872-85-5   | 107.110  |                                          |         | 77 <sup>12</sup>          |                            | 1.5423 <sup>20</sup> | s H <sub>2</sub> O, eth, ctc                                  |
| 9325 | 2-Pyridinecarboxaldehyde oxime              |                                      | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O                    | 873-69-8   | 122.124  |                                          | 112.5   |                           |                            |                      |                                                               |
| 9326 | 2-Pyridinecarboxamide                       |                                      | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O                    | 1452-77-3  | 122.124  | mcl pr (w)                               | 108.3   |                           |                            |                      | sl H <sub>2</sub> O, chl; s EtOH, bz                          |



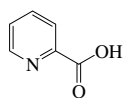
| No.  | Name                                         | Synonym                       | Mol. Form.                                       | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|----------------------------------------------|-------------------------------|--------------------------------------------------|------------|----------|--------------------|---------|-----------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 9327 | 3-Pyridinecarboxamide                        | Niacinamide                   | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O   | 98-92-0    | 122.124  | wh pw, nd (bz)     | 130     | 157 <sup>0.0005</sup>                   | 1.400 <sup>25</sup>        | 1.466                | vs H <sub>2</sub> O, EtOH, glycerol; sl chl                  |
| 9328 | 4-Pyridinecarboxamide                        |                               | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O   | 1453-82-3  | 122.124  |                    | 157.5   |                                         |                            |                      |                                                              |
| 9329 | 2-Pyridinecarboxylic acid                    | Picolinic acid                | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>    | 98-98-6    | 123.110  | nd (w, al, bz)     | 136.5   | sub                                     |                            |                      | sl H <sub>2</sub> O, bz; s EtOH; i eth, chl, CS <sub>2</sub> |
| 9330 | 3-Pyridinecarboxylic acid                    | Nicotinic acid                | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>    | 59-67-6    | 123.110  | nd (al, w)         | 236.6   | sub                                     | 1.473 <sup>25</sup>        |                      | sl H <sub>2</sub> O, EtOH, eth                               |
| 9331 | 4-Pyridinecarboxylic acid                    | Isonicotinic acid             | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>    | 55-22-1    | 123.110  | nd(w)              | 315     | sub 260                                 |                            |                      | sl H <sub>2</sub> O, EtOH, eth, bz                           |
| 9332 | 3-Pyridinecarboxylic acid 1-oxide            | Oxiniac acid                  | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>    | 2398-81-4  | 139.109  | nd                 | 254 dec |                                         |                            |                      | vs H <sub>2</sub> O, MeOH                                    |
| 9333 | 4-Pyridinecarboxylic acid 1-oxide            |                               | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>    | 13602-12-5 | 139.109  |                    | 273 dec |                                         |                            |                      |                                                              |
| 9334 | 2,3-Pyridinediamine                          |                               | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub>     | 452-58-4   | 109.130  | lf or pl (dil al)  | 120.8   | 149 <sup>5</sup>                        |                            |                      | s H <sub>2</sub> O, EtOH, bz                                 |
| 9335 | 2,5-Pyridinediamine                          | 2,5-Diaminopyridine           | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub>     | 4318-76-7  | 109.130  | nd                 | 110.3   | 182 <sup>12</sup>                       |                            |                      | vs H <sub>2</sub> O, EtOH                                    |
| 9336 | 2,6-Pyridinediamine                          |                               | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub>     | 141-86-6   | 109.130  |                    | 121.5   | 285; 148 <sup>5</sup>                   |                            |                      | sl H <sub>2</sub> O, ace                                     |
| 9337 | 3,4-Pyridinediamine                          |                               | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub>     | 54-96-6    | 109.130  | nd or lf           | 219.3   |                                         |                            |                      |                                                              |
| 9338 | 2,3-Pyridinedicarboxylic acid                | Quinolinic acid               | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>    | 89-00-9    | 167.120  | mcl pr (w)         | 228.5   |                                         |                            |                      | sl H <sub>2</sub> O, tfa; i EtOH, eth, bz                    |
| 9339 | 2,4-Pyridinedicarboxylic acid                | Lutidinic acid                | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>    | 499-80-9   | 167.120  | lf (w+1)           | 249     |                                         | 0.942 <sup>25</sup>        |                      | sl H <sub>2</sub> O; s EtOH; i eth, bz, CS <sub>2</sub>      |
| 9340 | 2,5-Pyridinedicarboxylic acid                | Isocinchomeronic acid         | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>    | 100-26-5   | 167.120  | lf or pr (dil HCl) | 254     |                                         |                            |                      | s H <sub>2</sub> O, HCl; sl EtOH; i eth, bz                  |
| 9341 | 2,6-Pyridinedicarboxylic acid                | Dipicolinic acid              | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>    | 499-83-2   | 167.120  | nd (w+3/2)         | 252     |                                         |                            |                      | sl H <sub>2</sub> O, EtOH, HOAc                              |
| 9342 | 3,4-Pyridinedicarboxylic acid                | Cinchomeronic acid            | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>    | 490-11-9   | 167.120  | cry (w)            | 256     | sub                                     |                            |                      | sl H <sub>2</sub> O, EtOH, bz; i eth, i chl                  |
| 9343 | 3,5-Pyridinedicarboxylic acid                | Dinicotinic acid              | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>    | 499-81-0   | 167.120  | cry (w)            | 324     | sub                                     |                            |                      | i H <sub>2</sub> O; sl eth, HOAc; s DMSO, HCl                |
| 9344 | 2,3-Pyridinedicarboxylic acid anhydride      | Furo[3,4-b]pyridine-5,7-dione | C <sub>7</sub> H <sub>3</sub> NO <sub>3</sub>    | 699-98-9   | 149.104  |                    | 138     |                                         |                            |                      |                                                              |
| 9345 | 2-Pyridineethanamine                         |                               | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>    | 2706-56-1  | 122.167  |                    |         | 213; 131 <sup>50</sup>                  | 1.0220 <sup>25</sup>       | 1.5335 <sup>25</sup> |                                                              |
| 9346 | 4-Pyridineethanamine                         |                               | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>    | 13258-63-4 | 122.167  |                    |         | 121 <sup>10</sup>                       | 1.0302 <sup>25</sup>       | 1.5381 <sup>25</sup> | vs H <sub>2</sub> O                                          |
| 9347 | 2-Pyridineethanol                            |                               | C <sub>7</sub> H <sub>9</sub> NO                 | 103-74-2   | 123.152  |                    | -7.8    | 190 <sup>200</sup> , 170 <sup>100</sup> | 1.091 <sup>25</sup>        | 1.5366 <sup>20</sup> | vs H <sub>2</sub> O, EtOH, chl; sl eth                       |
| 9348 | Pyridine hydrochloride                       |                               | C <sub>5</sub> H <sub>6</sub> ClN                | 628-13-7   | 115.562  | hyg pl or sc (al)  | 146     | 222                                     |                            |                      | vs H <sub>2</sub> O, EtOH, chl                               |
| 9349 | 2-Pyridinemethanamine                        |                               | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>     | 3731-51-9  | 108.141  |                    |         | 203; 91 <sup>17</sup>                   | 1.0525 <sup>25</sup>       | 1.5431 <sup>25</sup> | vs H <sub>2</sub> O                                          |
| 9350 | 3-Pyridinemethanamine                        |                               | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>     | 3731-52-0  | 108.141  | liq                | -21.1   | 226                                     | 1.064 <sup>20</sup>        | 1.552 <sup>20</sup>  | vs H <sub>2</sub> O, eth, EtOH                               |
| 9351 | 4-Pyridinemethanamine                        |                               | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>     | 3731-53-1  | 108.141  | liq                | -7.6    | 230; 103 <sup>11</sup>                  | 1.072 <sup>20</sup>        | 1.5495 <sup>25</sup> | vs H <sub>2</sub> O                                          |
| 9352 | 2-Pyridinemethanol                           |                               | C <sub>6</sub> H <sub>7</sub> NO                 | 586-98-1   | 109.126  |                    |         | 112 <sup>16</sup> , 102.5 <sup>8</sup>  | 1.1317 <sup>20</sup>       | 1.5444 <sup>20</sup> | msc H <sub>2</sub> O; vs EtOH, eth, ace, bz                  |
| 9353 | 3-Pyridinemethanol                           | Nicotinyl alcohol             | C <sub>6</sub> H <sub>7</sub> NO                 | 100-55-0   | 109.126  | liq                | -6.5    | 266                                     | 1.131 <sup>20</sup>        | 1.5455 <sup>20</sup> | vs H <sub>2</sub> O, eth                                     |
| 9354 | 4-Pyridinemethanol                           | 4-Picolyl alcohol             | C <sub>6</sub> H <sub>7</sub> NO                 | 586-95-8   | 109.126  |                    | 53      | 141 <sup>12</sup>                       |                            |                      | s chl                                                        |
| 9355 | Pyridine-1-oxide                             | Pyridine <i>N</i> -oxide      | C <sub>5</sub> H <sub>5</sub> NO                 | 694-59-7   | 95.100   |                    | 65.5    | 146 <sup>13</sup>                       |                            |                      |                                                              |
| 9356 | 2-Pyridinepropanol                           |                               | C <sub>8</sub> H <sub>11</sub> NO                | 2859-68-9  | 137.179  |                    | 34      | 260.2; 116 <sup>4</sup>                 | 1.060 <sup>25</sup>        | 1.5298 <sup>20</sup> | vs H <sub>2</sub> O                                          |
| 9357 | 3-Pyridinepropanol                           |                               | C <sub>8</sub> H <sub>11</sub> NO                | 2859-67-8  | 137.179  |                    |         | 284; 130 <sup>3</sup>                   | 1.063 <sup>25</sup>        | 1.5313 <sup>20</sup> | vs H <sub>2</sub> O                                          |
| 9358 | 3-Pyridinesulfonic acid                      | 3-Pyridylsulfonic acid        | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub> S  | 636-73-7   | 159.164  | orth               | 357 dec |                                         | 1.713 <sup>25</sup>        |                      | vs H <sub>2</sub> O; sl EtOH; i eth                          |
| 9359 | 2-Pyridinethiol, 1-oxide                     |                               | C <sub>6</sub> H <sub>5</sub> NOS                | 1121-31-9  | 127.165  |                    | 70.5    |                                         |                            |                      |                                                              |
| 9360 | 2(1 <i>H</i> )-Pyridinethione                |                               | C <sub>6</sub> H <sub>5</sub> NS                 | 2637-34-5  | 111.166  |                    | 130.0   |                                         |                            |                      | s H <sub>2</sub> O, EtOH, bz, chl                            |
| 9361 | 2-Pyridinol                                  |                               | C <sub>5</sub> H <sub>5</sub> NO                 | 72762-00-6 | 95.100   | nd (bz)            | 107.8   |                                         | 1.3910 <sup>20</sup>       |                      | vs H <sub>2</sub> O, bz, EtOH                                |
| 9362 | 3-Pyridinol                                  |                               | C <sub>5</sub> H <sub>5</sub> NO                 | 109-00-2   | 95.100   | nd (bz)            | 129     |                                         |                            |                      | s H <sub>2</sub> O, EtOH; sl eth, chl                        |
| 9363 | 4-Pyridinol                                  |                               | C <sub>5</sub> H <sub>5</sub> NO                 | 626-64-2   | 95.100   | pr or nd (w+1)     | 149.8   | >350; 257 <sup>10</sup>                 |                            |                      | s H <sub>2</sub> O, EtOH; i eth, bz                          |
| 9364 | 2(1 <i>H</i> )-Pyridinone                    |                               | C <sub>5</sub> H <sub>5</sub> NO                 | 142-08-5   | 95.100   | nd (bz)            | 107.8   | 280                                     | 1.3910 <sup>20</sup>       |                      | s H <sub>2</sub> O, EtOH, bz, chl; sl eth, DMSO              |
| 9365 | 2(1 <i>H</i> )-Pyridinone hydrazone          | 2-Pyridinylhydrazine          | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub>     | 4930-98-7  | 109.130  |                    | 46.6    | 185 <sup>140</sup> , 90 <sup>1</sup>    |                            |                      | s chl                                                        |
| 9366 | α-[(2-Pyridinylamino)methyl]benzenem ethanol | Phenyramidol                  | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> O | 553-69-5   | 214.262  | cry (dil MeOH)     | 83.5    |                                         |                            |                      |                                                              |
| 9367 | 1-(2-Pyridinyl)ethanone                      |                               | C <sub>7</sub> H <sub>7</sub> NO                 | 1122-62-9  | 121.137  | ye in air          |         | 192                                     | 1.077 <sup>25</sup>        | 1.5203 <sup>20</sup> | s EtOH, eth, HOAc; sl ctc                                    |
| 9368 | 1-(3-Pyridinyl)ethanone                      | Methyl pyridyl ketone         | C <sub>7</sub> H <sub>7</sub> NO                 | 350-03-8   | 121.137  |                    | 13.5    | 220                                     |                            | 1.5341 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, acid                          |
| 9369 | 1-(4-Pyridinyl)ethanone                      |                               | C <sub>7</sub> H <sub>7</sub> NO                 | 1122-54-9  | 121.137  |                    | 16      | 212                                     | 1.097 <sup>25</sup>        | 1.5282 <sup>25</sup> | sl EtOH, eth, acid                                           |



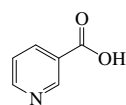
3-Pyridinecarboxamide



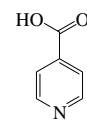
4-Pyridinecarboxamide



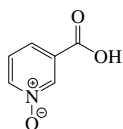
2-Pyridinecarboxylic acid



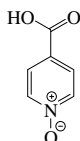
3-Pyridinecarboxylic acid



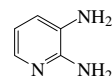
4-Pyridinecarboxylic acid



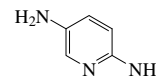
3-Pyridinecarboxylic acid 1-oxide



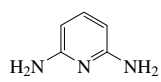
4-Pyridinecarboxylic acid 1-oxide



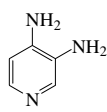
2,3-Pyridinediamine



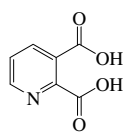
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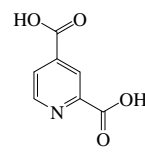
2,6-Pyridinediamine



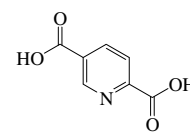
3,4-Pyridinediamine



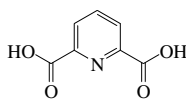
2,3-Pyridinedicarboxylic acid



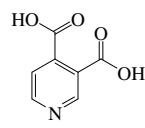
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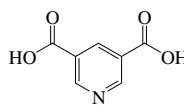
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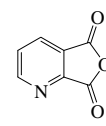
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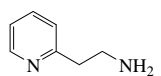
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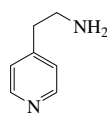
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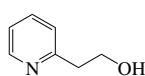
2,3-Pyridinedicarboxylic acid anhydride



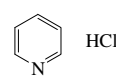
2-Pyridineethanamine



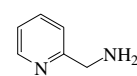
4-Pyridineethanamine



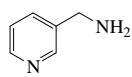
2-Pyridineethanol



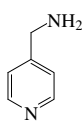
Pyridine hydrochloride



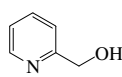
2-Pyridinemethanamine



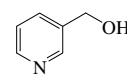
3-Pyridinemethanamine



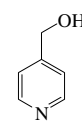
4-Pyridinemethanamine



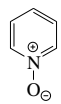
2-Pyridinemethanol



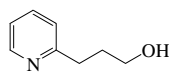
3-Pyridinemethanol



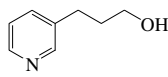
4-Pyridinemethanol



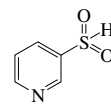
Pyridine-1-oxide



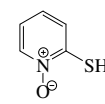
2-Pyridinepropanol



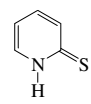
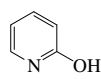
3-Pyridinepropanol



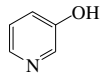
3-Pyridinesulfonic acid



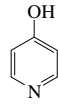
2-Pyridinethiol, 1-oxide

2(1*H*)-Pyridinethione

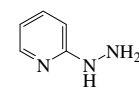
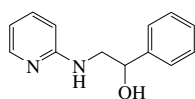
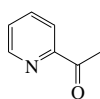
2-Pyridinol



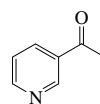
3-Pyridinol



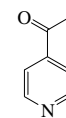
4-Pyridinol

2(1*H*)-Pyridinone2(1*H*)-Pyridinone hydrazone $\alpha$ -[(2-Pyridinylamino)methyl]benzenemethanol

1-(2-Pyridinyl)ethanone



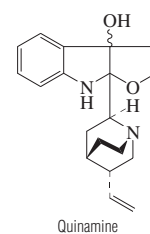
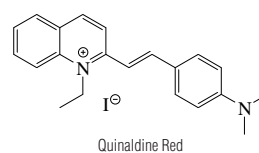
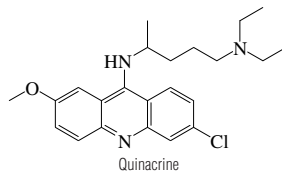
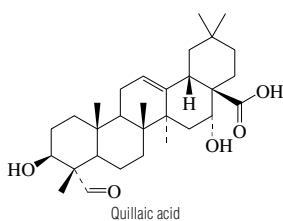
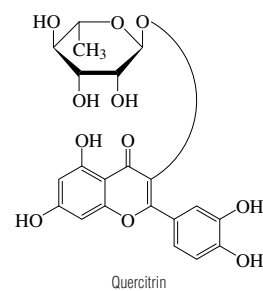
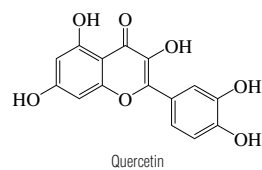
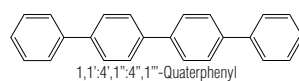
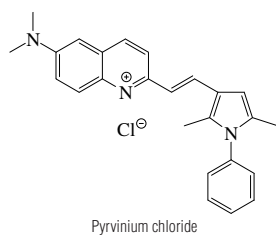
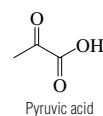
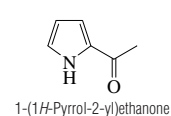
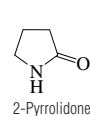
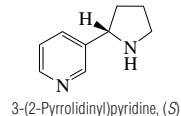
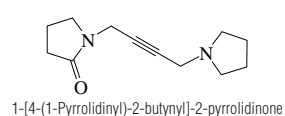
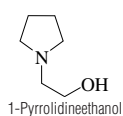
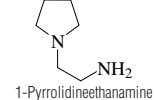
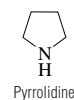
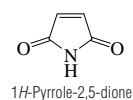
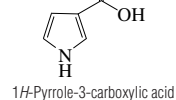
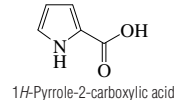
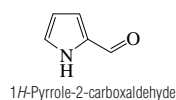
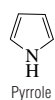
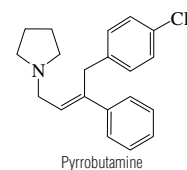
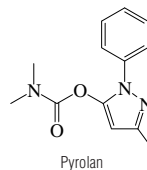
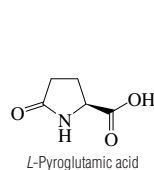
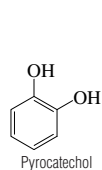
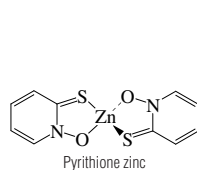
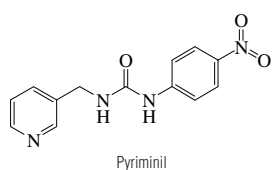
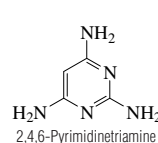
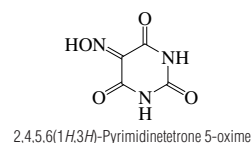
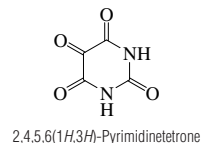
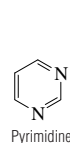
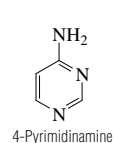
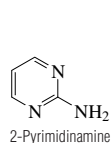
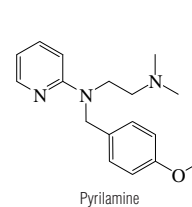
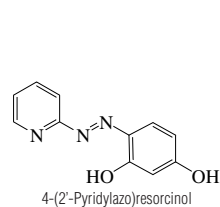
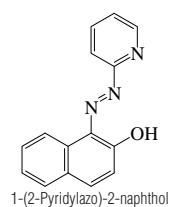
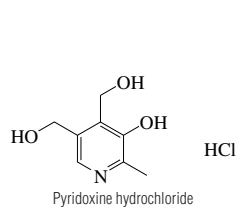
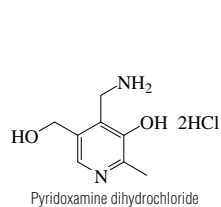
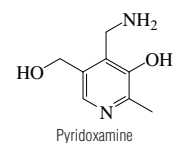
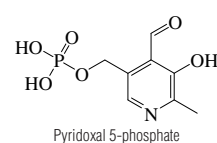
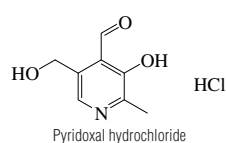
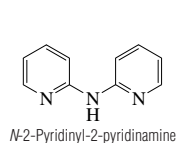
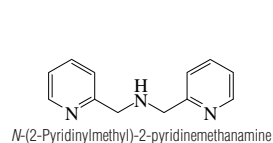
1-(3-Pyridinyl)ethanone



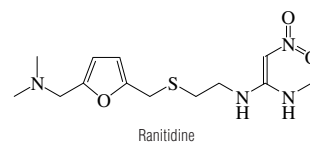
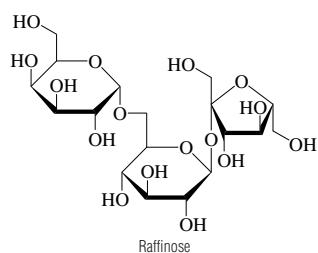
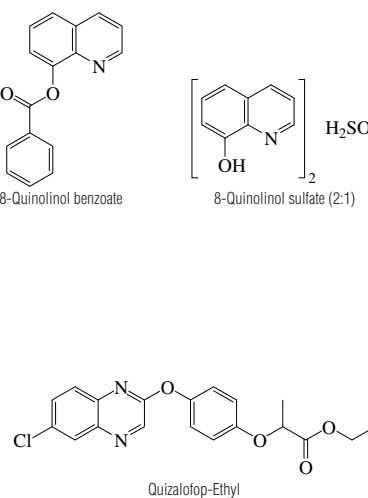
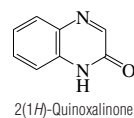
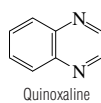
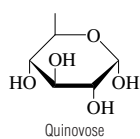
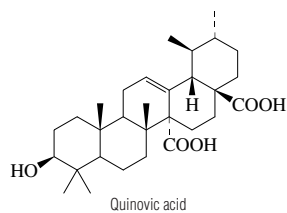
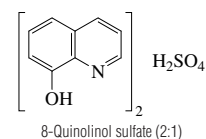
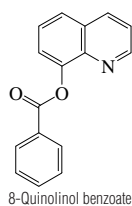
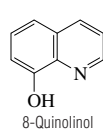
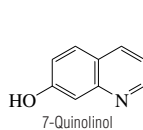
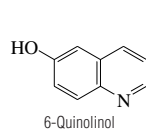
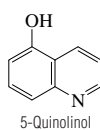
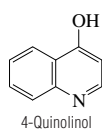
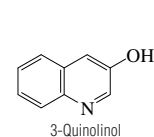
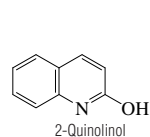
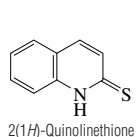
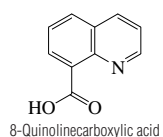
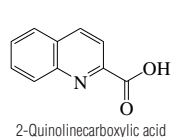
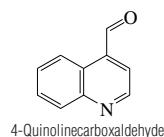
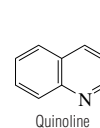
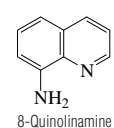
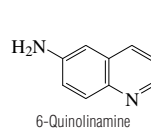
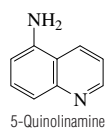
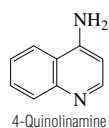
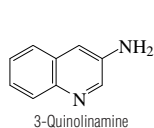
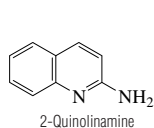
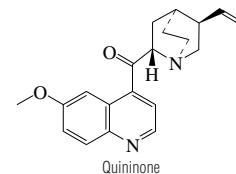
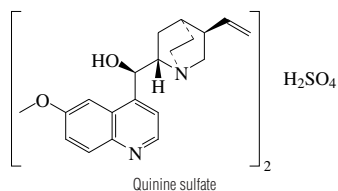
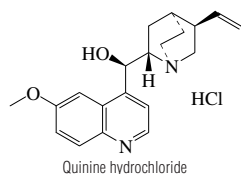
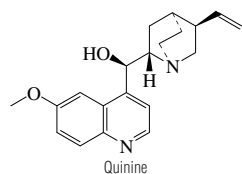
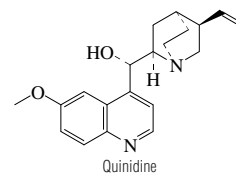
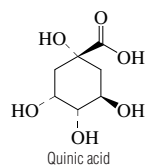
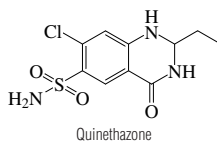
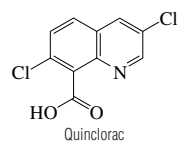
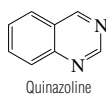
1-(4-Pyridinyl)ethanone



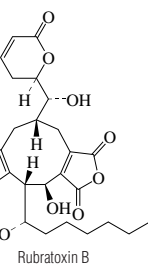
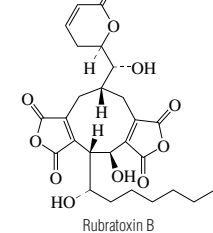
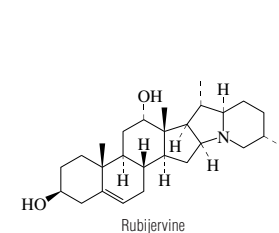
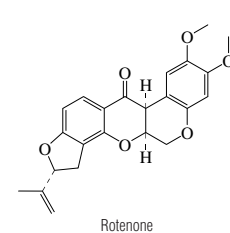
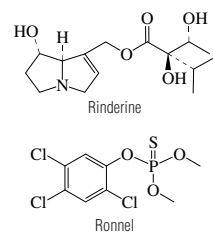
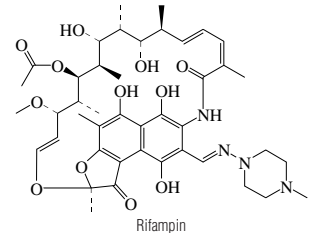
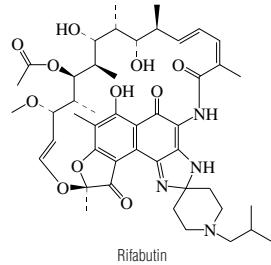
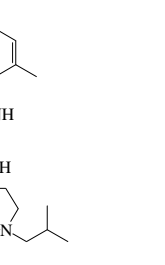
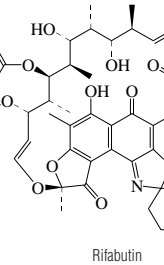
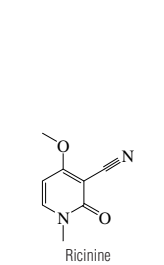
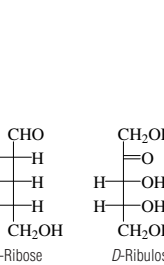
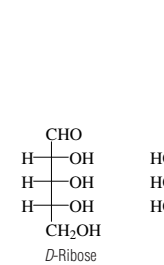
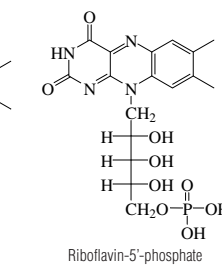
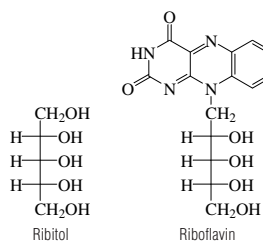
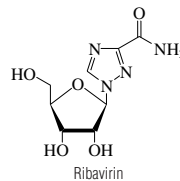
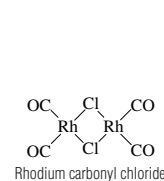
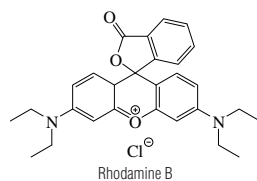
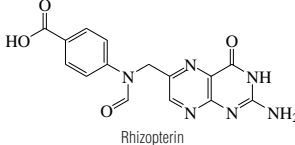
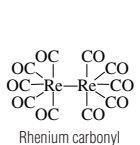
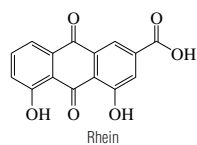
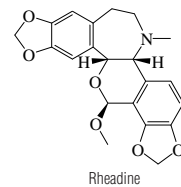
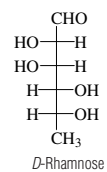
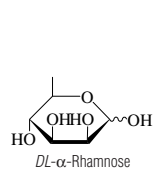
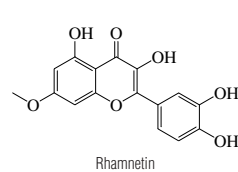
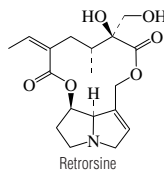
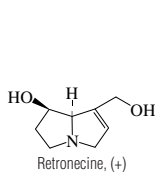
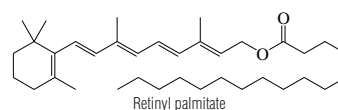
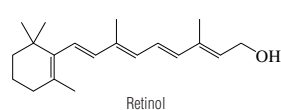
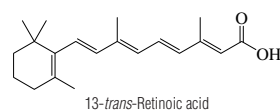
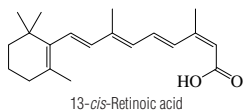
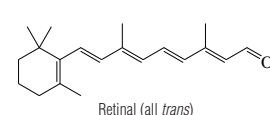
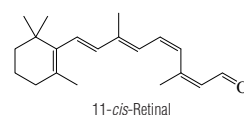
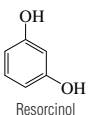
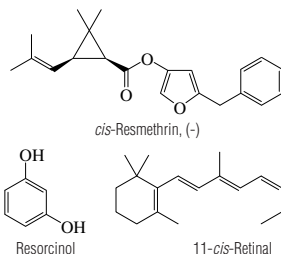
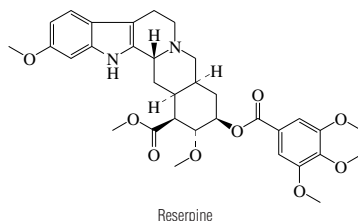
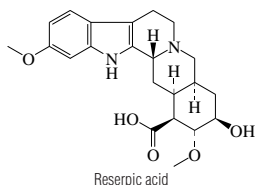
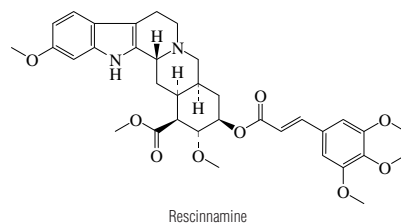
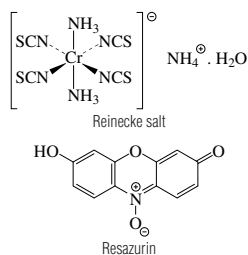
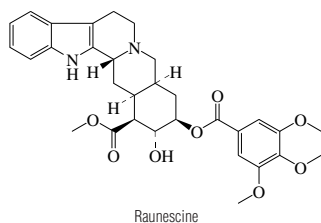
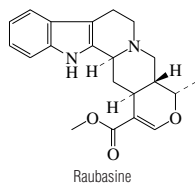
| No.  | Name                                                     | Synonym                                                 | Mol. Form.                                                                     | CAS RN     | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                         |
|------|----------------------------------------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------|------------|----------|------------------------------|---------|--------------------------------------|----------------------------|----------------------|--------------------------------------------------------------------|
| 9370 | <i>N</i> -(2-Pyridinylmethyl)-2-pyridinemethanamine      |                                                         | C <sub>12</sub> H <sub>13</sub> N <sub>3</sub>                                 | 1539-42-0  | 199.251  |                              |         | 200 <sup>10</sup> , 139 <sup>1</sup> | 1.1074 <sup>25</sup>       | 1.5757 <sup>25</sup> |                                                                    |
| 9371 | <i>N</i> -2-Pyridinyl-2-pyridinamine                     |                                                         | C <sub>10</sub> H <sub>9</sub> N <sub>3</sub>                                  | 1202-34-2  | 171.198  |                              | 90.5    | 307.5                                |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth, ace, bz                    |
| 9372 | Pyridoxal hydrochloride                                  | Vitamin B6                                              | C <sub>8</sub> H <sub>10</sub> ClNO <sub>3</sub>                               | 65-22-5    | 203.623  | orth                         | 165 dec |                                      |                            |                      | vs H <sub>2</sub> O; sl EtOH                                       |
| 9373 | Pyridoxal 5-phosphate                                    | Pyridoxal 5-(dihydrogen phosphate)                      | C <sub>8</sub> H <sub>10</sub> NO <sub>6</sub> P                               | 54-47-7    | 247.142  | wh-ye pow or cry             | 141     |                                      |                            |                      |                                                                    |
| 9374 | Pyridoxamine                                             | 4-(Aminomethyl)-5-hydroxy-6-methyl-3-pyridinemethanol   | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                   | 85-87-0    | 168.193  | cry                          | 198     |                                      |                            |                      | s EtOH, acid                                                       |
| 9375 | Pyridoxamine dihydrochloride                             |                                                         | C <sub>8</sub> H <sub>14</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub>   | 524-36-7   | 241.115  | pl (al)                      | 226 dec |                                      |                            |                      | vs H <sub>2</sub> O; sl EtOH                                       |
| 9376 | Pyridoxine hydrochloride                                 | 5-Hydroxy-6-methyl-3,4-pyridinedimethanol hydrochloride | C <sub>8</sub> H <sub>12</sub> ClNO <sub>3</sub>                               | 58-56-0    | 205.639  | pl (al, ace)                 | 207     | sub                                  |                            |                      | vs H <sub>2</sub> O                                                |
| 9377 | 1-(2-Pyridylazo)-2-naphthol                              | PAN                                                     | C <sub>15</sub> H <sub>11</sub> N <sub>3</sub> O                               | 85-85-8    | 249.267  | red-br cry                   | 130     |                                      |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl                               |
| 9378 | 4-(2'-Pyridylazo)resorcinol                              | PAR                                                     | C <sub>11</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                   | 1141-59-9  | 215.208  | red-br cry                   | 187 dec |                                      |                            |                      |                                                                    |
| 9379 | Pyrilamine                                               |                                                         | C <sub>17</sub> H <sub>23</sub> N <sub>3</sub> O                               | 91-84-9    | 285.384  |                              |         | 201 <sup>5</sup>                     |                            |                      |                                                                    |
| 9380 | 2-Pyrimidinamine                                         |                                                         | C <sub>4</sub> H <sub>6</sub> N <sub>3</sub>                                   | 109-12-6   | 95.103   | nd (AcOEt)                   | 127.5   | sub                                  |                            |                      | s H <sub>2</sub> O; sl chl                                         |
| 9381 | 4-Pyrimidinamine                                         |                                                         | C <sub>4</sub> H <sub>6</sub> N <sub>3</sub>                                   | 591-54-8   | 95.103   | pl (AcOEt)                   | 151.5   |                                      |                            |                      | vs H <sub>2</sub> O, EtOH                                          |
| 9382 | Pyrimidine                                               | 1,3-Diazine                                             | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                                   | 289-95-2   | 80.088   |                              | 22      | 123.8                                |                            | 1.4998 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH                                       |
| 9383 | 2,4,5,6(1 <i>H</i> ,3 <i>H</i> )-Pyrimidinetrone         | Alloxan                                                 | C <sub>4</sub> H <sub>2</sub> N <sub>2</sub> O <sub>4</sub>                    | 50-71-5    | 142.070  |                              | 256 dec | sub                                  |                            |                      | vs H <sub>2</sub> O; s EtOH, ace, bz, HOAc                         |
| 9384 | 2,4,5,6(1 <i>H</i> ,3 <i>H</i> )-Pyrimidinetrone 5-oxime | Violuric acid                                           | C <sub>4</sub> H <sub>3</sub> N <sub>3</sub> O <sub>4</sub>                    | 87-39-8    | 157.085  | pa ye orth                   | 203 dec |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH                                        |
| 9385 | 2,4,6-Pyrimidinetrifluoride                              |                                                         | C <sub>4</sub> H <sub>2</sub> N <sub>2</sub> F <sub>6</sub>                    | 1004-38-2  | 125.133  |                              | 248 dec |                                      |                            |                      |                                                                    |
| 9386 | Pyriminil                                                |                                                         | C <sub>13</sub> H <sub>12</sub> N <sub>4</sub> O <sub>3</sub>                  | 53558-25-1 | 272.259  | solid                        | 224 dec |                                      |                            |                      |                                                                    |
| 9387 | Pyrrhione zinc                                           |                                                         | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> S <sub>2</sub> Zn | 13463-41-7 | 317.722  | wh solid                     | 262     |                                      |                            |                      | s chl, DMSO, DMF                                                   |
| 9388 | Pyrocatechol                                             | 1,2-Benzenediol                                         | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                                   | 120-80-9   | 110.111  | cry                          | 104.6   | 245                                  | 1.344 <sup>20</sup>        | 1.604 <sup>25</sup>  | vs H <sub>2</sub> O, bz, eth, EtOH                                 |
| 9389 | <i>L</i> -Pyroglutamic acid                              | 5-Oxo- <i>L</i> -proline                                | C <sub>5</sub> H <sub>7</sub> NO <sub>3</sub>                                  | 98-79-3    | 129.115  |                              | 162     |                                      |                            |                      | s DMSO                                                             |
| 9390 | Pyrolan                                                  |                                                         | C <sub>13</sub> H <sub>15</sub> N <sub>3</sub> O <sub>2</sub>                  | 87-47-8    | 245.277  |                              | 50      | 161 <sup>0.2</sup>                   |                            |                      | s ctc, CS <sub>2</sub>                                             |
| 9391 | Pyrrbutamine                                             | 1-[4-(4-Chlorophenyl)-3-phenyl-2-butenyl]pyrrolidine    | C <sub>20</sub> H <sub>22</sub> ClN                                            | 91-82-7    | 311.849  | cry                          | 49      | 192 <sup>0.3</sup>                   |                            |                      |                                                                    |
| 9392 | Pyrrole                                                  | Imidole                                                 | C <sub>4</sub> H <sub>5</sub> N                                                | 109-97-7   | 67.090   | liq                          | -23.39  | 129.79                               | 0.9698 <sup>20</sup>       | 1.5085 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz, chl                     |
| 9393 | 1 <i>H</i> -Pyrrole-2-carboxaldehyde                     |                                                         | C <sub>5</sub> H <sub>5</sub> NO                                               | 1003-29-8  | 95.100   | orth pr (peth)               | 46.5    | 218                                  |                            | 1.5939 <sup>16</sup> | sl chl, lig                                                        |
| 9394 | 1 <i>H</i> -Pyrrole-2-carboxylic acid                    |                                                         | C <sub>5</sub> H <sub>5</sub> NO <sub>2</sub>                                  | 634-97-9   | 111.100  | lf (w)                       | 208 dec |                                      |                            |                      | s H <sub>2</sub> O, EtOH, eth                                      |
| 9395 | 1 <i>H</i> -Pyrrole-3-carboxylic acid                    | 3-Pyrrolicarboxylic acid                                | C <sub>5</sub> H <sub>5</sub> NO <sub>2</sub>                                  | 931-03-3   | 111.100  | nd (lig)                     | 161.5   |                                      |                            |                      |                                                                    |
| 9396 | 1 <i>H</i> -Pyrrole-2,5-dione                            |                                                         | C <sub>4</sub> H <sub>3</sub> NO <sub>2</sub>                                  | 541-59-3   | 97.073   | pl (bz)                      | 94      | sub                                  | 1.2493 <sup>106</sup>      |                      | s H <sub>2</sub> O, EtOH, eth                                      |
| 9397 | Pyrrolidine                                              | Azacyclopentane                                         | C <sub>4</sub> H <sub>9</sub> N                                                | 123-75-1   | 71.121   | col liq                      | -57.79  | 86.56                                | 0.8586 <sup>20</sup>       | 1.4431 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth; sl bz, chl                      |
| 9398 | 1-Pyrrolidineethanamine                                  |                                                         | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                                  | 7154-73-6  | 114.188  |                              |         | 166; 68 <sup>23</sup>                | 0.901 <sup>25</sup>        | 1.4687 <sup>20</sup> |                                                                    |
| 9399 | 1-Pyrrolidineethanol                                     |                                                         | C <sub>6</sub> H <sub>13</sub> NO                                              | 2955-88-6  | 115.173  |                              |         | 187; 80 <sup>13</sup>                | 0.9750 <sup>20</sup>       | 1.4713 <sup>20</sup> |                                                                    |
| 9400 | 1-[4-(1-Pyrrolidinyl)-2-butenyl]-2-pyrrolidinone         | Oxotremorine                                            | C <sub>12</sub> H <sub>18</sub> N <sub>2</sub> O                               | 70-22-4    | 206.283  | pa ye liq                    |         | 124 <sup>0.1</sup>                   | 0.991 <sup>25</sup>        | 1.5160 <sup>20</sup> |                                                                    |
| 9401 | 3-(2-Pyrrolidinyl)pyridine, (S)                          | Normicotine                                             | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                                  | 494-97-3   | 148.204  | hyg                          |         | 270                                  | 1.0737 <sup>19</sup>       | 1.5378 <sup>18</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                                |
| 9402 | 2-Pyrrolidone                                            | γ-Butyrolactam                                          | C <sub>4</sub> H <sub>7</sub> NO                                               | 616-45-5   | 85.105   | cry (peth)                   | 25      | 251; 133 <sup>12</sup>               | 1.120 <sup>20</sup>        | 1.4806 <sup>30</sup> | vs H <sub>2</sub> O, EtOH, eth, bz, chl, CS <sub>2</sub>           |
| 9403 | 1-(1 <i>H</i> -Pyrrol-2-yl)ethanone                      |                                                         | C <sub>6</sub> H <sub>7</sub> NO                                               | 1072-83-9  | 109.126  | mcl nd (w)                   | 90      | 220                                  |                            |                      | s H <sub>2</sub> O, EtOH, eth                                      |
| 9404 | Pyruvic acid                                             |                                                         | C <sub>3</sub> H <sub>4</sub> O <sub>3</sub>                                   | 127-17-3   | 88.062   |                              | 13.8    | dec 165; 54 <sup>10</sup>            | 1.2272 <sup>20</sup>       | 1.4280 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; s ace                             |
| 9405 | Pyrvinium chloride                                       |                                                         | C <sub>26</sub> H <sub>28</sub> ClN <sub>3</sub>                               | 548-84-5   | 417.973  | red pow (w)                  | 250 dec |                                      |                            |                      |                                                                    |
| 9406 | 1,1':4,1'':4'',1'''-Quaterphenyl                         |                                                         | C <sub>24</sub> H <sub>18</sub>                                                | 135-70-6   | 306.400  |                              | 320     | 428 <sup>18</sup>                    |                            |                      | i H <sub>2</sub> O, EtOH, eth, chl; s bz, PhNO <sub>2</sub> , HOAc |
| 9407 | Quercetin                                                |                                                         | C <sub>15</sub> H <sub>10</sub> O <sub>7</sub>                                 | 117-39-5   | 302.236  | ye nd (dil al, + 2 w)        | 316.5   | sub                                  |                            |                      | sl H <sub>2</sub> O, eth, MeOH; s EtOH, ace, py                    |
| 9408 | Quercitrin                                               | Quercetin-3- <i>L</i> -rhamnoside                       | C <sub>21</sub> H <sub>20</sub> O <sub>11</sub>                                | 522-12-3   | 448.377  | pa ye nd or pl (+2w, dil al) | 170     |                                      |                            |                      | i H <sub>2</sub> O, eth; s EtOH, HOAc, MeOH, alk                   |
| 9409 | Quillaic acid                                            |                                                         | C <sub>30</sub> H <sub>46</sub> O <sub>5</sub>                                 | 631-01-6   | 486.683  | nd (dil al)                  | 294     |                                      |                            |                      | vs ace, eth, py, EtOH                                              |
| 9410 | Quinacrine                                               | Mepacrine                                               | C <sub>23</sub> H <sub>30</sub> ClN <sub>3</sub> O                             | 83-89-6    | 399.956  | ye oil                       | 87      |                                      |                            |                      |                                                                    |
| 9411 | Quinaldine Red                                           |                                                         | C <sub>21</sub> H <sub>23</sub> IN <sub>2</sub>                                | 117-92-0   | 430.325  | dk red pow                   |         |                                      |                            |                      | s H <sub>2</sub> O; vs EtOH                                        |
| 9412 | Quinamine                                                |                                                         | C <sub>19</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>                  | 464-85-7   | 312.406  | pr (bz), nd (80% al)         | 185.5   |                                      |                            |                      | i H <sub>2</sub> O; vs EtOH, bz; s eth, ace                        |



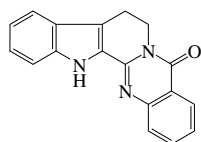
| No.  | Name                          | Synonym                                                               | Mol. Form.                                                        | CAS RN     | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                           |
|------|-------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------|------------|----------|------------------------------|---------|------------------------|----------------------------|----------------------|----------------------------------------------------------------------|
| 9413 | Quinazoline                   | 1,3-Benzodiazine                                                      | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                      | 253-82-7   | 130.147  | ye pl (peth)                 | 48      | 241                    |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, ace, bz; sl chl                    |
| 9414 | Quinclorac                    | 3,7-Dichloroquinoline-8-carboxylic acid                               | C <sub>10</sub> H <sub>5</sub> Cl <sub>2</sub> NO <sub>2</sub>    | 84087-01-4 | 242.059  |                              | 274     |                        | 1.75                       |                      |                                                                      |
| 9415 | Quinethazone                  |                                                                       | C <sub>10</sub> H <sub>12</sub> ClN <sub>3</sub> O <sub>3</sub> S | 73-49-4    | 289.738  |                              |         |                        |                            |                      | s tfa                                                                |
| 9416 | Quinic acid                   |                                                                       | C <sub>7</sub> H <sub>12</sub> O <sub>6</sub>                     | 77-95-2    | 192.166  |                              | 162.5   |                        | 1.64 <sup>25</sup>         |                      | vs H <sub>2</sub> O, EtOH, HOAc                                      |
| 9417 | Quinidine                     |                                                                       | C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>     | 56-54-2    | 324.417  | cry (+2.5w, dil al)          | 174     |                        |                            |                      | sl H <sub>2</sub> O, eth; s EtOH, bz; vs chl; i peth                 |
| 9418 | Quinine                       | 6'-Methoxycinchonan-9-ol, (8 $\alpha$ ,9 <i>R</i> )                   | C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>     | 130-95-0   | 324.417  |                              | 57      |                        |                            | 1.625 <sup>15</sup>  | sl H <sub>2</sub> O, ace; vs EtOH, py; s eth, chl                    |
| 9419 | Quinine hydrochloride         | 6'-Methoxycinchonan-9-ol monohydrochloride, (8 $\alpha$ ,9 <i>R</i> ) | C <sub>20</sub> H <sub>25</sub> ClN <sub>2</sub> O <sub>2</sub>   | 130-89-2   | 360.878  | silky efflor nd (w)          | 159     |                        |                            |                      | vs H <sub>2</sub> O, EtOH, chl                                       |
| 9420 | Quinine sulfate               |                                                                       | C <sub>40</sub> H <sub>50</sub> N <sub>4</sub> O <sub>8</sub> S   | 804-63-7   | 746.912  | silky nd (w)                 | 235.2   |                        |                            |                      | vs EtOH                                                              |
| 9421 | Quinone                       |                                                                       | C <sub>20</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>     | 84-31-1    | 322.401  | nd, lf (eth)                 | 108     |                        |                            |                      | vs bz, eth, EtOH                                                     |
| 9422 | 2-Quinolinamine               | 2-Aminoquinoline                                                      | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                      | 580-22-3   | 144.173  | lf (w)                       | 131.5   | sub                    |                            |                      | vs H <sub>2</sub> O; s EtOH, eth, ace, chl; sl bz                    |
| 9423 | 3-Quinolinamine               | 3-Aminoquinoline                                                      | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                      | 580-17-6   | 144.173  | orth (w, dil al)             | 94      |                        |                            |                      | vs eth, EtOH, chl                                                    |
| 9424 | 4-Quinolinamine               | 4-Aminoquinoline                                                      | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                      | 578-68-7   | 144.173  | nd (bz, dil al)              | 154.8   | 180 <sup>12</sup>      |                            |                      | s H <sub>2</sub> O, bz, chl; vs EtOH, eth                            |
| 9425 | 5-Quinolinamine               | 5-Aminoquinoline                                                      | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                      | 611-34-7   | 144.173  | ye nd (al) lf (eth)          | 110     | 310; 184 <sup>10</sup> |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s bz; i lig                       |
| 9426 | 6-Quinolinamine               | 6-Aminoquinoline                                                      | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                      | 580-15-4   | 144.173  | cry (w+2), pr (eth)          | 114     | 187 <sup>12</sup>      |                            |                      | sl H <sub>2</sub> O, eth; s NH <sub>3</sub> , EtOH                   |
| 9427 | 8-Quinolinamine               | 8-Aminoquinoline                                                      | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                      | 578-66-5   | 144.173  | pa ye nd (sub) cry (al, lig) | 70      | 157 <sup>19</sup>      |                            |                      | vs H <sub>2</sub> O, EtOH                                            |
| 9428 | Quinoline                     | 1-Azanaphthalene                                                      | C <sub>9</sub> H <sub>7</sub> N                                   | 91-22-5    | 129.159  | liq                          | -14.78  | 237.16                 | 1.0977 <sup>15</sup>       | 1.6268 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, ace, bz, CS <sub>2</sub> ; s ctc |
| 9429 | 4-Quinolinecarboxaldehyde     | Cinchoninaldehyde                                                     | C <sub>10</sub> H <sub>7</sub> NO                                 | 4363-93-3  | 157.169  | nd (to-peth)                 | 51      | 122 <sup>4</sup>       |                            |                      | vs eth, tol                                                          |
| 9430 | 2-Quinolinecarboxylic acid    | Quinaldic acid                                                        | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>                    | 93-10-7    | 173.169  |                              | 156     |                        |                            |                      | s H <sub>2</sub> O; vs bz                                            |
| 9431 | 8-Quinolinecarboxylic acid    | 8-Carboxyquinoline                                                    | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>                    | 86-59-9    | 173.169  | nd (w)                       | 187     | sub                    |                            |                      | vs EtOH                                                              |
| 9432 | 2(1 <i>H</i> )-Quinolinetione |                                                                       | C <sub>9</sub> H <sub>7</sub> NS                                  | 2637-37-8  | 161.224  |                              | 187     |                        |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, bz; sl DMSO                        |
| 9433 | 2-Quinolinol                  | 2-Hydroxyquinoline                                                    | C <sub>9</sub> H <sub>7</sub> NO                                  | 59-31-4    | 145.158  | pr (MeOH)                    | 199.5   | sub                    |                            |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth; s dil HCl                   |
| 9434 | 3-Quinolinol                  | 3-Hydroxyquinoline                                                    | C <sub>9</sub> H <sub>7</sub> NO                                  | 580-18-7   | 145.158  | cry (bz, dil al)             | 201.3   |                        |                            |                      | i H <sub>2</sub> O; s EtOH; sl eth, chl; vs bz                       |
| 9435 | 4-Quinolinol                  | 4-Hydroxyquinoline                                                    | C <sub>9</sub> H <sub>7</sub> NO                                  | 611-36-9   | 145.158  | nd (w+3)                     | 210     |                        |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth, bz, peth                          |
| 9436 | 5-Quinolinol                  | 5-Hydroxyquinoline                                                    | C <sub>9</sub> H <sub>7</sub> NO                                  | 578-67-6   | 145.158  | nd (al), pl                  | 226 dec | sub                    |                            |                      | s H <sub>2</sub> O, bz, chl; sl EtOH; vs MeOH; i lig                 |
| 9437 | 6-Quinolinol                  | 6-Hydroxyquinoline                                                    | C <sub>9</sub> H <sub>7</sub> NO                                  | 580-16-5   | 145.158  | pr (al, eth)                 | 195     | 360                    |                            |                      | i H <sub>2</sub> O, bz, chl; sl EtOH, eth; s alk                     |
| 9438 | 7-Quinolinol                  | 7-Hydroxyquinoline                                                    | C <sub>9</sub> H <sub>7</sub> NO                                  | 580-20-1   | 145.158  | pr (al), nd (dil al-eth)     | 239     | sub                    |                            |                      | vs EtOH                                                              |
| 9439 | 8-Quinolinol                  | 8-Hydroxyquinoline                                                    | C <sub>9</sub> H <sub>7</sub> NO                                  | 148-24-3   | 145.158  | nd (dil al)                  | 75.5    | 267                    | 1.034 <sup>20</sup>        |                      | i H <sub>2</sub> O, eth; vs EtOH, bz, chl; s ace                     |
| 9440 | 8-Quinolinol benzoate         | Benzoxiquine                                                          | C <sub>16</sub> H <sub>11</sub> NO <sub>2</sub>                   | 86-75-9    | 249.264  |                              |         |                        |                            |                      | sl chl                                                               |
| 9441 | 8-Quinolinol sulfate (2:1)    | 8-Hydroxyquinoline sulfate                                            | C <sub>18</sub> H <sub>16</sub> N <sub>2</sub> O <sub>6</sub> S   | 134-31-6   | 388.934  |                              | 177.5   |                        |                            |                      | vs H <sub>2</sub> O; s EtOH; i eth                                   |
| 9442 | Quinovic acid                 |                                                                       | C <sub>30</sub> H <sub>46</sub> O <sub>5</sub>                    | 465-74-7   | 486.683  | pl or nd                     | 298 dec |                        |                            |                      |                                                                      |
| 9443 | Quinovose                     |                                                                       | C <sub>9</sub> H <sub>12</sub> O <sub>5</sub>                     | 7658-08-4  | 164.156  | cry (AcOEt)                  | 139.5   |                        |                            |                      | vs H <sub>2</sub> O, EtOH                                            |
| 9444 | Quinoxaline                   | 1,4-Benzodiazine                                                      | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                      | 91-19-0    | 130.147  | cry (peth)                   | 28      | 229.5                  | 1.1334 <sup>48</sup>       | 1.6231 <sup>48</sup> | s H <sub>2</sub> O; msc EtOH, eth, ace, bz; sl chl                   |
| 9445 | 2(1 <i>H</i> )-Quinoxalinone  |                                                                       | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub> O                    | 1196-57-2  | 146.146  | lf (al)                      | 271     | sub 200                |                            |                      |                                                                      |
| 9446 | Quizalofop-Ethyl              |                                                                       | C <sub>19</sub> H <sub>17</sub> ClN <sub>2</sub> O <sub>4</sub>   | 76578-14-8 | 372.802  | wh cry                       | 93      | 220 <sup>0.2</sup>     |                            |                      | i H <sub>2</sub> O; s bz, EtOH, ace, xyl                             |
| 9447 | Radiciin                      |                                                                       | C <sub>12</sub> H <sub>12</sub> O <sub>5</sub>                    | 10088-95-6 | 236.220  |                              | 221.5   |                        |                            |                      | sl chl                                                               |
| 9448 | Raffinose                     |                                                                       | C <sub>18</sub> H <sub>32</sub> O <sub>16</sub>                   | 512-69-6   | 504.437  |                              | 80      |                        | 1.465 <sup>25</sup>        |                      | s H <sub>2</sub> O, py; vs MeOH; sl EtOH; i eth                      |
| 9449 | Ranitidine                    |                                                                       | C <sub>13</sub> H <sub>22</sub> N <sub>4</sub> O <sub>3</sub> S   | 66357-35-5 | 314.404  | solid                        | 69.5    |                        |                            |                      |                                                                      |



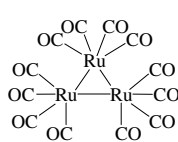
| No.  | Name                            | Synonym                                                     | Mol. Form.                                                      | CAS RN      | Mol. Wt. | Physical Form                | mp/°C   | bp/°C                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                       |
|------|---------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------|-------------|----------|------------------------------|---------|--------------------------|----------------------------|----------------------|------------------------------------------------------------------|
| 9450 | Raubasine                       |                                                             | C <sub>21</sub> H <sub>24</sub> N <sub>2</sub> O <sub>3</sub>   | 483-04-5    | 352.427  |                              | 258 dec |                          |                            |                      | i H <sub>2</sub> O; s MeOH                                       |
| 9451 | Raunescine                      |                                                             | C <sub>31</sub> H <sub>36</sub> N <sub>2</sub> O <sub>8</sub>   | 117-73-7    | 564.626  |                              | 165     |                          |                            |                      | i H <sub>2</sub> O; s EtOH, chl, HOAc                            |
| 9452 | Reinecke salt                   |                                                             | C <sub>4</sub> H <sub>12</sub> CrN <sub>7</sub> OS <sub>4</sub> | 13573-16-5  | 354.440  | red cry (w)                  | 270 dec |                          |                            |                      | s H <sub>2</sub> O, EtOH, ace; i bz                              |
| 9453 | Resazurin                       | 7-Hydroxy-3 <i>H</i> -phenoxazin-3-one, 10-oxide            | C <sub>12</sub> H <sub>7</sub> NO <sub>4</sub>                  | 550-82-3    | 229.189  | dk red to gr pr or pl (HOAc) |         | sub                      |                            |                      | i H <sub>2</sub> O; eth; sl EtOH, HOAc; s alk                    |
| 9454 | Rescinnamine                    |                                                             | C <sub>35</sub> H <sub>42</sub> N <sub>2</sub> O <sub>9</sub>   | 24815-24-5  | 634.716  | nd (bz)                      | 238.5   |                          |                            |                      | i H <sub>2</sub> O; sl EtOH; s ace, chl, AcOEt                   |
| 9455 | Reserpine                       |                                                             | C <sub>22</sub> H <sub>28</sub> N <sub>2</sub> O <sub>5</sub>   | 83-60-3     | 400.467  | cry (MeOH)                   | 242     |                          |                            |                      |                                                                  |
| 9456 | Reserpine                       |                                                             | C <sub>33</sub> H <sub>40</sub> N <sub>2</sub> O <sub>9</sub>   | 50-55-5     | 608.679  | lo pr (dil ace)              | 264.5   |                          |                            |                      | sl H <sub>2</sub> O, eth, ace; s EtOH, bz, AcOEt                 |
| 9457 | <i>cis</i> -Resmethrin, (-)     |                                                             | C <sub>22</sub> H <sub>26</sub> O <sub>3</sub>                  | 10453-86-8  | 338.439  |                              | 75      |                          |                            |                      |                                                                  |
| 9458 | Resorcinol                      | 1,3-Benzenediol                                             | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                    | 108-46-3    | 110.111  | nd (bz), pl (w)              | 109.4   | 276.5; 178 <sup>16</sup> | 1.278 <sup>20</sup>        | 1.578 <sup>25</sup>  | vs H <sub>2</sub> O, ctc; s EtOH, eth; sl bz, chl                |
| 9459 | 11- <i>cis</i> -Retinal         | Vitamin A <sub>1</sub> aldehyde                             | C <sub>20</sub> H <sub>28</sub> O                               | 564-87-4    | 284.435  | cry                          |         |                          |                            |                      |                                                                  |
| 9460 | Retinal (all <i>trans</i> )     |                                                             | C <sub>20</sub> H <sub>28</sub> O                               | 116-31-4    | 284.435  | oran cry                     | 64      |                          |                            |                      | i H <sub>2</sub> O; s EtOH, chl, cy, peth                        |
| 9461 | 13- <i>cis</i> -Retinoic acid   | Accutane                                                    | C <sub>20</sub> H <sub>28</sub> O <sub>2</sub>                  | 4759-48-2   | 300.435  | cry (EtOH)                   | 189     |                          |                            |                      |                                                                  |
| 9462 | 13- <i>trans</i> -Retinoic acid |                                                             | C <sub>20</sub> H <sub>28</sub> O <sub>2</sub>                  | 302-79-4    | 300.435  | cry (MeOH)                   | 181.5   |                          |                            |                      |                                                                  |
| 9463 | Retinol                         | Vitamin A                                                   | C <sub>20</sub> H <sub>30</sub> O                               | 68-26-8     | 286.451  | ye pr (peth)                 | 63.5    | 137 <sup>0.000001</sup>  |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz                         |
| 9464 | Retinyl palmitate               | Retinol, hexadecanoate                                      | C <sub>36</sub> H <sub>60</sub> O <sub>2</sub>                  | 79-81-2     | 524.860  |                              | 28      |                          |                            |                      |                                                                  |
| 9465 | Retronecine, (+)                |                                                             | C <sub>8</sub> H <sub>13</sub> NO <sub>2</sub>                  | 480-85-3    | 155.195  | cry (ace)                    | 121     |                          |                            |                      | s H <sub>2</sub> O, EtOH; sl eth                                 |
| 9466 | Retrorsine                      |                                                             | C <sub>18</sub> H <sub>25</sub> NO <sub>6</sub>                 | 480-54-6    | 351.395  | cry (AcOEt)                  | 212     |                          |                            |                      | sl H <sub>2</sub> O, ace; s EtOH, chl; i eth                     |
| 9467 | Rhamnetin                       |                                                             | C <sub>16</sub> H <sub>12</sub> O <sub>7</sub>                  | 90-19-7     | 316.262  | ye nd (al)                   | 295     |                          |                            |                      | sl H <sub>2</sub> O; s EtOH, ace, PhOH; vs dil alk               |
| 9468 | <i>DL</i> -α-Rhamnose           |                                                             | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                   | 116908-82-8 | 164.156  | cry (w)                      | 151     |                          |                            |                      | vs H <sub>2</sub> O, EtOH                                        |
| 9469 | <i>D</i> -Rhamnose              | 6-Deoxy- <i>D</i> -mannose                                  | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                   | 634-74-2    | 164.156  |                              |         |                          |                            |                      | s H <sub>2</sub> O                                               |
| 9470 | Rheadine                        |                                                             | C <sub>21</sub> H <sub>21</sub> NO <sub>6</sub>                 | 2718-25-4   | 383.395  | nd (chl, eth, al)            | 257     | sub                      |                            |                      |                                                                  |
| 9471 | Rhein                           |                                                             | C <sub>15</sub> H <sub>8</sub> O <sub>6</sub>                   | 478-43-3    | 284.221  | ye or oran nd (MeOH, py)     | 321     | sub                      |                            |                      | sl H <sub>2</sub> O, EtOH, eth, ace, bz; vs py                   |
| 9472 | Rhenium carbonyl                | Dirhenium decacarbonyl                                      | C <sub>10</sub> O <sub>10</sub> Re <sub>2</sub>                 | 14285-68-8  | 652.515  | ye-wh cry                    | 170 dec |                          | 2.87                       |                      | s os                                                             |
| 9473 | Rhizopterin                     |                                                             | C <sub>15</sub> H <sub>12</sub> N <sub>6</sub> O <sub>4</sub>   | 119-20-0    | 340.294  | lt ye pl (w)                 | >300    |                          |                            |                      | i H <sub>2</sub> O, EtOH, eth; s aq alk, aq NH <sub>3</sub> , py |
| 9474 | Rhodamine B                     |                                                             | C <sub>28</sub> H <sub>32</sub> ClN <sub>2</sub> O <sub>3</sub> | 81-88-9     | 480.018  |                              | 165     |                          |                            |                      | s H <sub>2</sub> O, EtOH, eth, bz, xyl                           |
| 9475 | Rhodium carbonyl chloride       | Dirhodium tetracarbonyl dichloride                          | C <sub>4</sub> Cl <sub>2</sub> O <sub>4</sub> Rh <sub>2</sub>   | 14523-22-9  | 388.758  | red-oran cry                 | 124     |                          |                            |                      | s os                                                             |
| 9476 | Ribavirin                       | Tribavirin                                                  | C <sub>8</sub> H <sub>12</sub> N <sub>4</sub> O <sub>5</sub>    | 36791-04-5  | 244.205  | col cry (EtOH)               | 175     |                          |                            |                      | s H <sub>2</sub> O                                               |
| 9477 | Ribitol                         | Adonitol                                                    | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                   | 488-81-3    | 152.146  | pr (w), nd (al)              | 104     |                          |                            |                      | s H <sub>2</sub> O, EtOH; i eth, lig                             |
| 9478 | Riboflavin                      |                                                             | C <sub>17</sub> H <sub>20</sub> N <sub>4</sub> O <sub>6</sub>   | 83-88-5     | 376.364  | ye or oran-ye nd (w)         | 280 dec |                          |                            |                      | i H <sub>2</sub> O, eth, ace, chl; sl EtOH                       |
| 9479 | Riboflavin-5'-phosphate         |                                                             | C <sub>17</sub> H <sub>20</sub> N <sub>4</sub> O <sub>9</sub> P | 146-17-8    | 455.336  | ye cry (w)                   |         |                          |                            |                      |                                                                  |
| 9480 | <i>D</i> -Ribose                |                                                             | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                   | 50-69-1     | 150.130  | pl (al)                      | 88      |                          |                            |                      | s H <sub>2</sub> O; sl EtOH                                      |
| 9481 | <i>L</i> -Ribose                |                                                             | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                   | 24259-59-4  | 150.130  |                              | 81      |                          |                            |                      |                                                                  |
| 9482 | <i>D</i> -Ribulose              | <i>erythro</i> -2-Pentulose                                 | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                   | 488-84-6    | 150.130  | syrup                        |         |                          |                            |                      | vs H <sub>2</sub> O                                              |
| 9483 | Ricinine                        | 1,2-Dihydro-4-methoxy-1-methyl-2-oxo-3-pyridinecarbonitrile | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>     | 524-40-3    | 164.162  | pr or lf (w, al)             | 201.5   | sub 170                  |                            |                      | s H <sub>2</sub> O, chl; sl EtOH, bz; vs py; i peth              |
| 9484 | Rifabutin                       |                                                             | C <sub>46</sub> H <sub>62</sub> N <sub>4</sub> O <sub>11</sub>  | 72559-06-9  | 847.004  | viol-red cry                 |         |                          |                            |                      | i H <sub>2</sub> O; vs chl; s MeOH; sl EtOH                      |
| 9485 | Rifampin                        |                                                             | C <sub>43</sub> H <sub>58</sub> N <sub>4</sub> O <sub>12</sub>  | 13292-46-1  | 822.941  | red-oran pl (ace)            | 185 dec |                          |                            |                      |                                                                  |
| 9486 | Rinderine                       | Echinatine-3'-epimer                                        | C <sub>15</sub> H <sub>25</sub> NO <sub>5</sub>                 | 6029-84-1   | 299.364  | cry (ace)                    | 100.5   |                          |                            |                      |                                                                  |
| 9487 | Ronnel                          |                                                             | C <sub>8</sub> H <sub>8</sub> Cl <sub>3</sub> O <sub>3</sub> PS | 299-84-3    | 321.546  |                              | 41      | 152 <sup>0.4</sup>       | 1.44 <sup>32</sup>         | 1.5335 <sup>35</sup> |                                                                  |
| 9488 | Rotenone                        |                                                             | C <sub>23</sub> H <sub>22</sub> O <sub>6</sub>                  | 83-79-4     | 394.417  | nd or lf (al, aq-ace)        | 176     | 215 <sup>0.5</sup>       |                            |                      | i H <sub>2</sub> O; s EtOH, ace, bz; sl eth; vs chl              |
| 9489 | Rubijervine                     |                                                             | C <sub>27</sub> H <sub>43</sub> NO <sub>2</sub>                 | 79-58-3     | 413.636  | nd (+1w, dil al)             | 242     |                          |                            |                      | vs bz, EtOH, chl                                                 |
| 9490 | Rubratoxin B                    |                                                             | C <sub>26</sub> H <sub>30</sub> O <sub>11</sub>                 | 21794-01-4  | 518.509  | cry (MeCN)                   | 169 dec |                          |                            |                      |                                                                  |



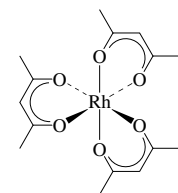
| No.  | Name                             | Synonym                                                  | Mol. Form.                                                                                    | CAS RN     | Mol. Wt. | Physical Form                | mp/°C        | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|------|----------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------|----------|------------------------------|--------------|---------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 9491 | Rutecarpine                      |                                                          | C <sub>18</sub> H <sub>13</sub> N <sub>3</sub> O                                              | 84-26-4    | 287.315  | ye nd (al, AcOEt)            | 259.5        |                           |                            |                      | sl EtOH, ace, bz                                    |
| 9492 | Ruthenium dodecacarbonyl         | Triruthenium dodecacarbonyl                              | C <sub>12</sub> O <sub>12</sub> Ru <sub>3</sub>                                               | 15243-33-1 | 639.33   | oran cry                     | dec 150      |                           |                            |                      |                                                     |
| 9493 | Ruthenium(III) 2,4-pentanedioate | Ruthenium(III) acetylacetonate                           | C <sub>15</sub> H <sub>21</sub> O <sub>6</sub> Ru                                             | 14284-93-6 | 398.39   |                              | 230          |                           |                            |                      |                                                     |
| 9494 | Rutinoside                       |                                                          | C <sub>12</sub> H <sub>22</sub> O <sub>10</sub>                                               | 90-74-4    | 326.297  | hyg pow (al, eth)            | 190 dec      |                           |                            |                      | vs H <sub>2</sub> O, EtOH                           |
| 9495 | Sabadine                         |                                                          | C <sub>29</sub> H <sub>47</sub> NO <sub>8</sub>                                               | 124-80-1   | 537.685  | nd (eth)                     | 258          |                           |                            |                      | vs ace, EtOH                                        |
| 9496 | Saccharin                        |                                                          | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub> S                                               | 81-07-2    | 183.185  | nd (ace) pr (al), lf (w)     | 228 dec      | sub                       | 0.828 <sup>25</sup>        |                      | sl H <sub>2</sub> O, bz, eth, chl; s ace, EtOH      |
| 9497 | Saccharin sodium                 | 1,2-Benzisothiazolin-3-one, 1,1-dioxide, sodium salt     | C <sub>7</sub> H <sub>4</sub> NNaO <sub>3</sub> S                                             | 128-44-9   | 205.168  | wh cry                       | 229          |                           |                            |                      | s H <sub>2</sub> O                                  |
| 9498 | Safranal                         | 2,6,6-Trimethyl-1,3-cyclohexadiene-1-carboxaldehyde      | C <sub>10</sub> H <sub>14</sub> O                                                             | 116-26-7   | 150.217  |                              |              | 70 <sup>1</sup>           | 0.9734 <sup>19</sup>       | 1.5281 <sup>19</sup> | vs EtOH, peth                                       |
| 9499 | Safrole                          | 5-(2-Propenyl)-1,3-benzodioxole                          | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                                                | 94-59-7    | 162.185  | mcl                          | 11.2         | 234.5                     | 1.1000 <sup>20</sup>       | 1.5381 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth, chl           |
| 9500 | Salcomine                        | <i>N,N'</i> -Bis(salicylidene)ethylenediamine cobalt(II) | C <sub>16</sub> H <sub>14</sub> CoN <sub>2</sub> O <sub>2</sub>                               | 14167-18-1 | 325.227  | red cry (DMF)                |              |                           |                            |                      | s bz, chl, py                                       |
| 9501 | Salicylaldehyde                  | 2-Hydroxybenzaldehyde                                    | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                                  | 90-02-8    | 122.122  | liq                          | -7           | 197                       | 1.1674 <sup>20</sup>       | 1.5740 <sup>20</sup> | sl H <sub>2</sub> O, chl; msc EtOH; vs ace, bz      |
| 9502 | Salicylaldoxime                  |                                                          | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                                 | 94-67-7    | 137.137  |                              | 57           |                           |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz; s chl; i lig |
| 9503 | Salsoline                        |                                                          | C <sub>11</sub> H <sub>15</sub> NO <sub>2</sub>                                               | 89-31-6    | 193.243  | pow or cry (al)              | 221.5        |                           |                            |                      | sl H <sub>2</sub> O, EtOH; i eth, peth; s chl, alk  |
| 9504 | Salvarsan dihydrochloride        | Arsphenamine                                             | C <sub>12</sub> H <sub>14</sub> As <sub>2</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 139-93-5   | 439.001  | ye hyg pow                   | 190 dec      |                           |                            |                      | vs H <sub>2</sub> O                                 |
| 9505 | Sanguinarine                     |                                                          | C <sub>20</sub> H <sub>15</sub> NO <sub>5</sub>                                               | 2447-54-3  | 349.337  | cry (eth, al)                | 266          |                           |                            |                      | vs ace, bz, eth, EtOH                               |
| 9506 | α-Santalol                       |                                                          | C <sub>15</sub> H <sub>24</sub> O                                                             | 115-71-9   | 220.351  |                              |              | 301.5                     | 0.9679 <sup>20</sup>       | 1.5023 <sup>20</sup> | i H <sub>2</sub> O; s EtOH                          |
| 9507 | β-Santalol                       |                                                          | C <sub>15</sub> H <sub>24</sub> O                                                             | 77-42-9    | 220.351  |                              |              | 167 <sup>10</sup>         | 0.9750 <sup>20</sup>       | 1.5115 <sup>20</sup> |                                                     |
| 9508 | Santonin acid                    |                                                          | C <sub>15</sub> H <sub>20</sub> O <sub>4</sub>                                                | 510-35-0   | 264.318  | cry                          | 171          | 285 <sup>15</sup>         |                            |                      | sl H <sub>2</sub> O; s chl, eth, HOAc, EtOH         |
| 9509 | α-Santonin                       |                                                          | C <sub>15</sub> H <sub>18</sub> O <sub>3</sub>                                                | 481-06-1   | 246.302  | orth (w, eth)                | 175          |                           | 1.590 <sup>25</sup>        |                      | sl H <sub>2</sub> O, EtOH, eth; s bz, chl; i peth   |
| 9510 | Sarcosine                        | <i>N</i> -Methylglycine                                  | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                                                 | 107-97-1   | 89.094   | cry (al)                     | 212 dec      |                           |                            |                      | s H <sub>2</sub> O                                  |
| 9511 | Sarmentogenin                    |                                                          | C <sub>23</sub> H <sub>34</sub> O <sub>5</sub>                                                | 76-28-8    | 390.513  | pr (95% al, MeOH-eth)        | 280          |                           |                            |                      | i H <sub>2</sub> O, eth, bz; s EtOH; sl ace, chl    |
| 9512 | Sarpagan-17-al                   | Vellosimine                                              | C <sub>19</sub> H <sub>20</sub> N <sub>2</sub> O                                              | 6874-98-2  | 292.374  | cry (MeOH)                   | 305.5        | sub 180                   |                            |                      |                                                     |
| 9513 | Sarpagan-10,17-diol              | Sarpagine                                                | C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>                                 | 482-68-8   | 310.390  | nd                           | 320          |                           |                            |                      | i H <sub>2</sub> O; s EtOH                          |
| 9514 | Saxitoxin dihydrochloride        |                                                          | C <sub>10</sub> H <sub>15</sub> Cl <sub>2</sub> N <sub>7</sub> O <sub>4</sub>                 | 35554-08-6 | 372.209  | hyg wh solid                 |              |                           |                            |                      | vs H <sub>2</sub> O, MeOH, EtOH                     |
| 9515 | Scarlet red                      |                                                          | C <sub>24</sub> H <sub>20</sub> N <sub>4</sub> O                                              | 85-83-6    | 380.442  | dk br pow or nd              | 185; dec 260 |                           |                            |                      | i H <sub>2</sub> O; sl ace, bz; vs chl, peth        |
| 9516 | Schradan                         |                                                          | C <sub>8</sub> H <sub>24</sub> N <sub>4</sub> O <sub>3</sub> P <sub>2</sub>                   | 152-16-9   | 286.250  |                              | 17           | 154 <sup>2,0</sup>        | 1.09 <sup>25</sup>         | 1.462 <sup>25</sup>  | vs H <sub>2</sub> O, EtOH, chl                      |
| 9517 | Scilliroside                     |                                                          | C <sub>32</sub> H <sub>44</sub> O <sub>12</sub>                                               | 507-60-8   | 620.684  | lo pr (dil MeOH)             | 169          | dec                       |                            |                      | sl H <sub>2</sub> O, ace, chl; vs EtOH, diox; i eth |
| 9518 | Scopolamine                      |                                                          | C <sub>17</sub> H <sub>21</sub> NO <sub>4</sub>                                               | 51-34-3    | 303.354  | visc liq                     |              |                           |                            |                      | vs hot H <sub>2</sub> O, EtOH, ace; sl bz           |
| 9519 | Scopoline                        |                                                          | C <sub>8</sub> H <sub>13</sub> NO <sub>2</sub>                                                | 487-27-4   | 155.195  | hyg nd (lig, eth, chl, peth) | 108.5        | 248                       | 1.0891 <sup>134</sup>      |                      | s H <sub>2</sub> O                                  |
| 9520 | Sebacic acid                     | Decanedioic acid                                         | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                                                | 111-20-6   | 202.248  | lf                           | 130.9        | 353.9; 295 <sup>100</sup> | 1.2705 <sup>20</sup>       | 1.422 <sup>133</sup> | sl H <sub>2</sub> O; s EtOH, eth; i bz              |
| 9521 | Selenium methionine              | Selenomethionine                                         | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub> Se                                             | 1464-42-2  | 196.11   | hex pl (MeOH aq)             | 265 dec      |                           |                            |                      |                                                     |
| 9522 | Selenoformaldehyde               |                                                          | CH <sub>2</sub> Se                                                                            | 6596-50-5  | 92.99    | unstab gas                   |              |                           |                            |                      |                                                     |
| 9523 | Selenourea                       | Carbamimidoseleonic acid                                 | CH <sub>3</sub> N <sub>2</sub> Se                                                             | 630-10-4   | 123.02   | pr or nd (w)                 |              | dec 200                   |                            |                      | vs H <sub>2</sub> O                                 |
| 9524 | Semicarbazide hydrochloride      |                                                          | CH <sub>2</sub> ClN <sub>3</sub> O                                                            | 563-41-7   | 111.531  | pr (dil al)                  | 176 dec      |                           |                            |                      | vs H <sub>2</sub> O                                 |
| 9525 | Senecionine                      |                                                          | C <sub>18</sub> H <sub>25</sub> NO <sub>5</sub>                                               | 130-01-8   | 335.396  | pl                           | 232          |                           |                            |                      | i H <sub>2</sub> O; sl EtOH, eth; s chl             |
| 9526 | Seneciphylline                   |                                                          | C <sub>18</sub> H <sub>23</sub> NO <sub>5</sub>                                               | 480-81-9   | 333.380  | pl (AcOEt)                   | 217 dec      |                           |                            |                      | s chl; sl EtOH, ace; i eth                          |
| 9527 | Senkirkin                        |                                                          | C <sub>19</sub> H <sub>27</sub> NO <sub>6</sub>                                               | 2318-18-5  | 365.420  | pl (ace)                     | 197          |                           |                            |                      |                                                     |
| 9528 | <i>L</i> -Sepsippterin           | 6-Lactoyl-7,8-dihydropterin                              | C <sub>9</sub> H <sub>11</sub> N <sub>5</sub> O <sub>3</sub>                                  | 17094-01-8 | 237.215  | ye pow or cry                |              |                           |                            |                      |                                                     |



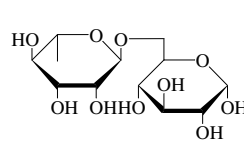
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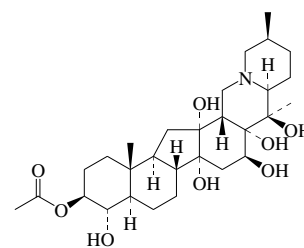
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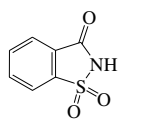
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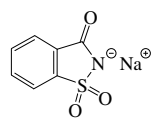
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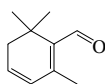
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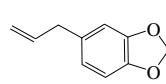
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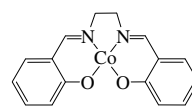
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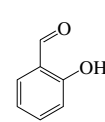
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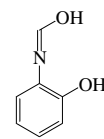
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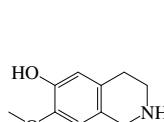
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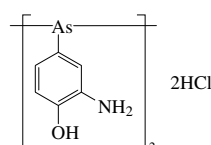
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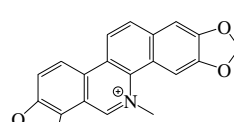
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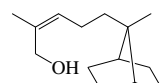
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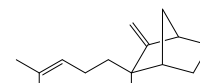
Salvarsan dihydrochloride



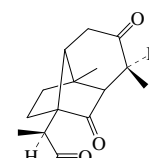
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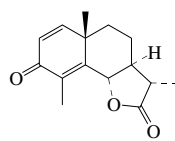
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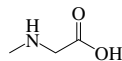
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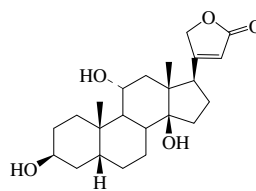
Santonic acid



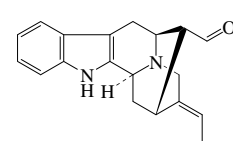
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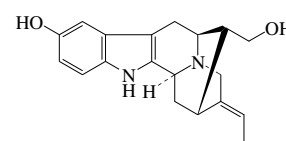
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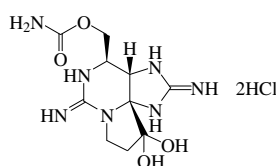
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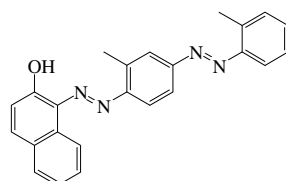
Sarpagan-17-al



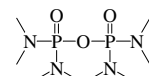
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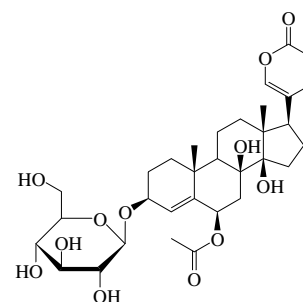
Saxitoxin dihydrochloride



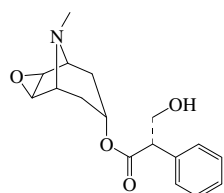
Scarlet red



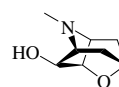
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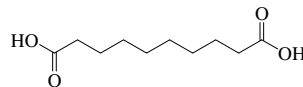
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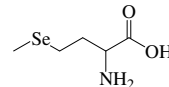
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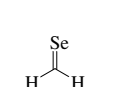
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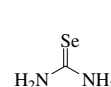
Sebacic acid



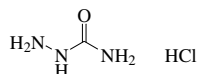
Selenium methionine



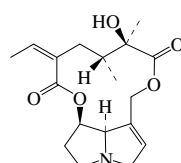
Selenoformaldehyde



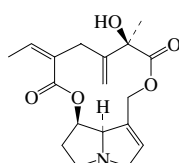
Selenourea



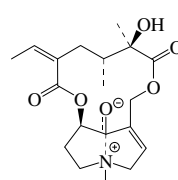
Semicarbazide hydrochloride



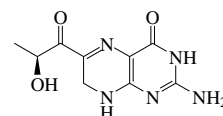
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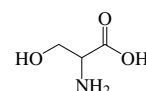
Seneciophylline



Senkirkirin



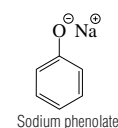
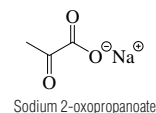
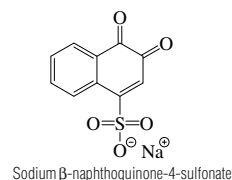
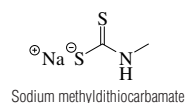
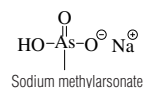
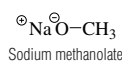
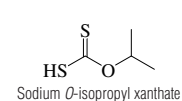
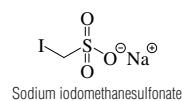
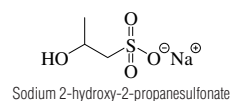
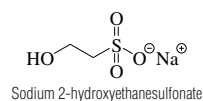
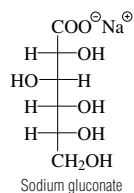
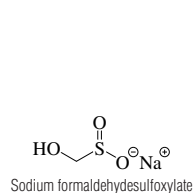
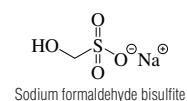
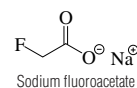
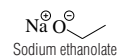
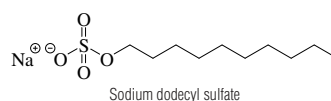
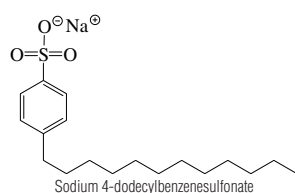
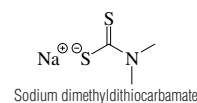
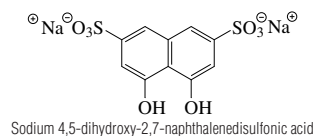
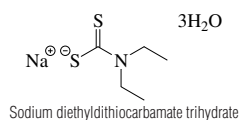
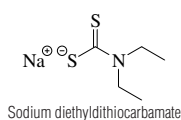
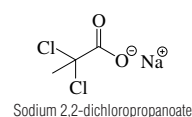
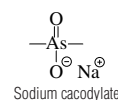
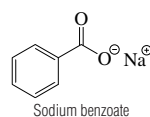
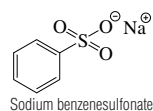
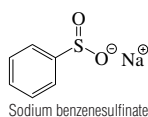
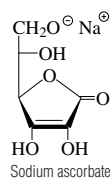
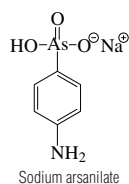
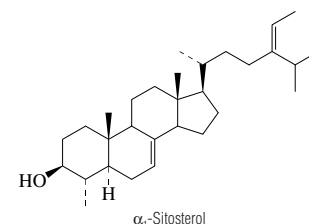
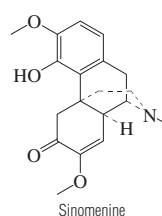
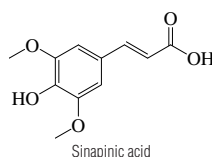
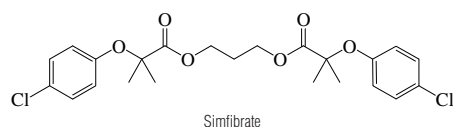
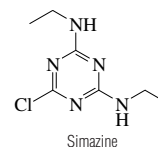
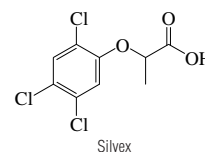
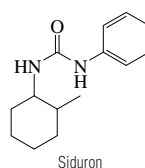
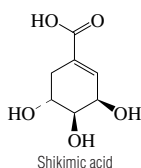
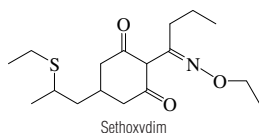
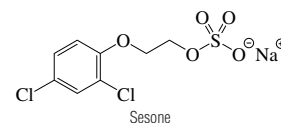
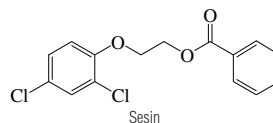
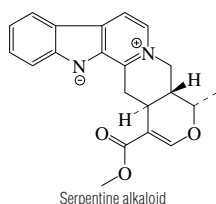
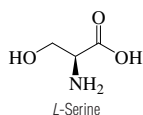
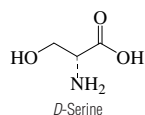
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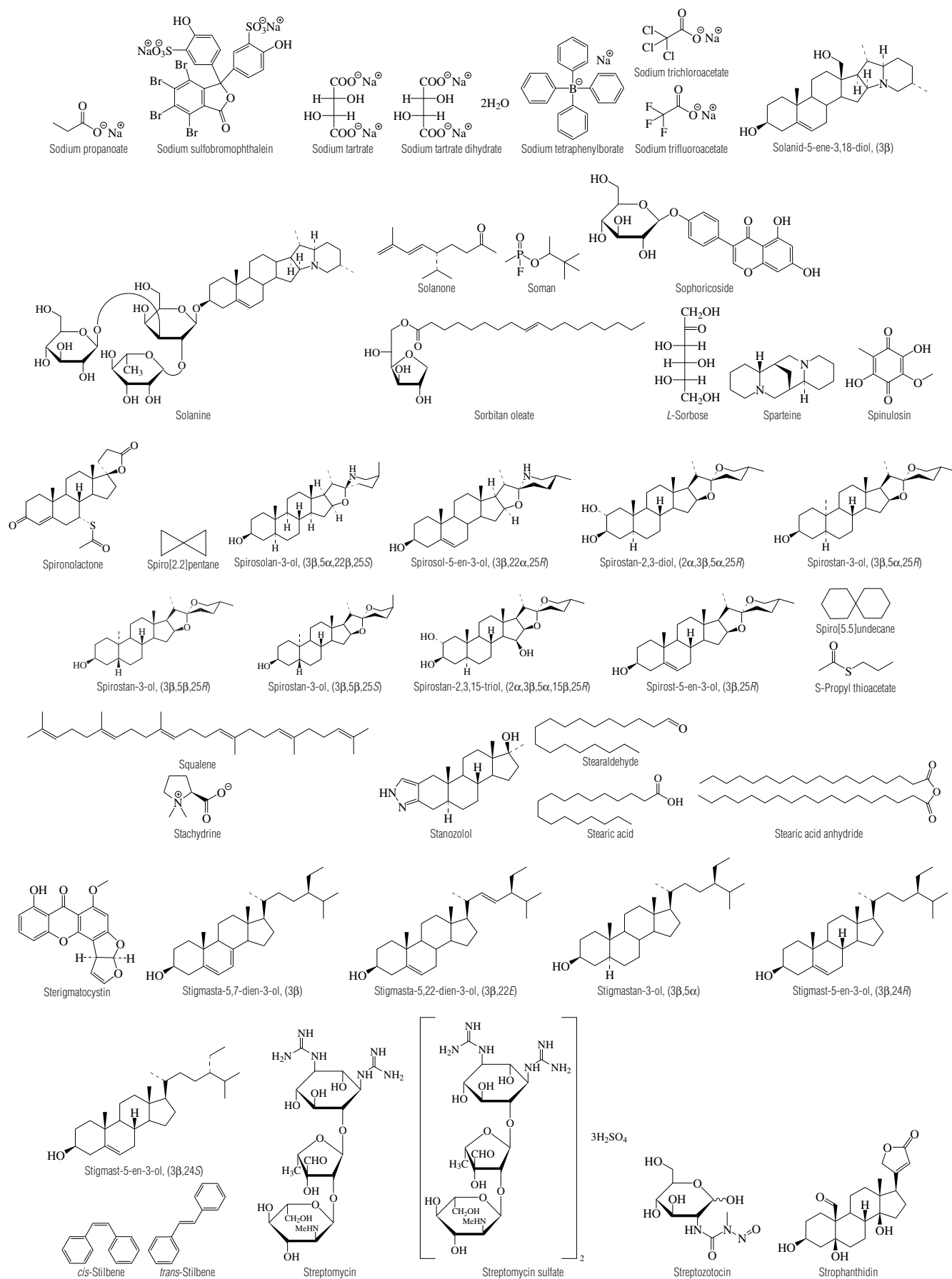
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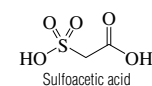
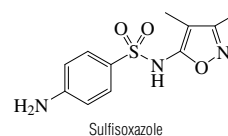
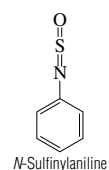
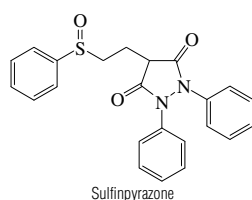
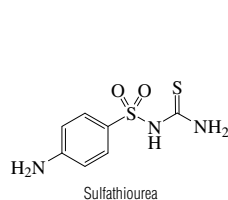
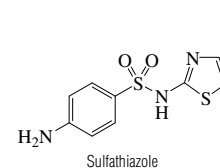
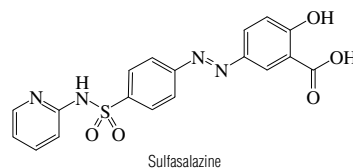
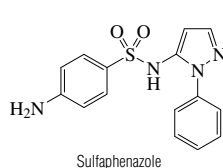
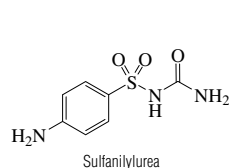
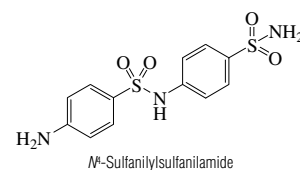
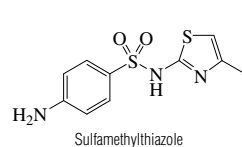
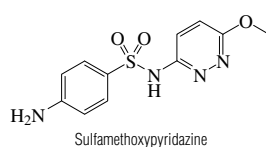
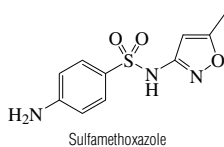
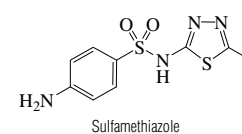
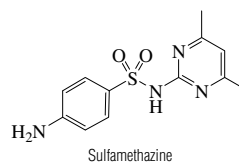
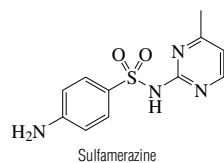
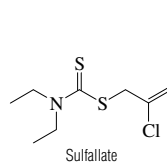
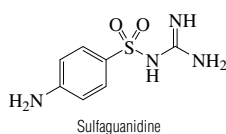
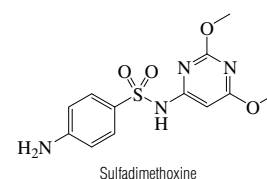
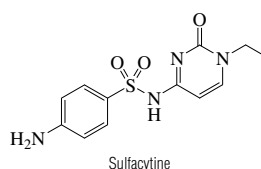
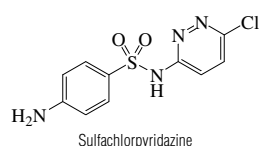
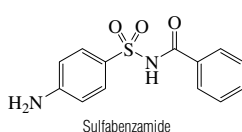
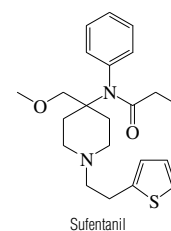
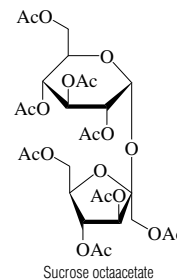
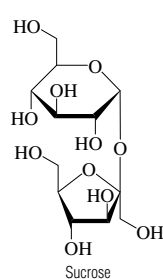
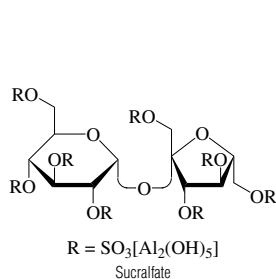
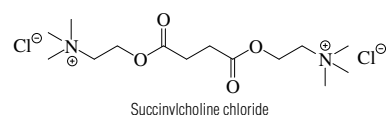
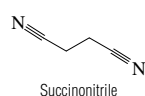
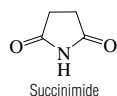
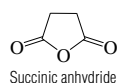
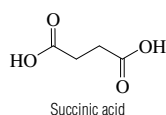
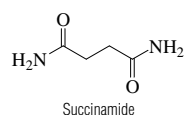
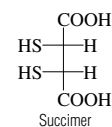
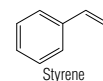
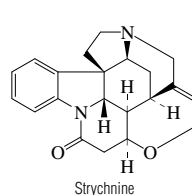
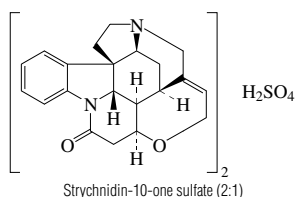
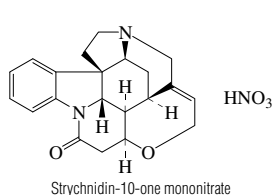
| No.  | Name                                                | Synonym                                                     | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form    | mp/°C     | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub> | Solubility                                         |
|------|-----------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|------------------|-----------|------------------------|----------------------------|----------------|----------------------------------------------------|
| 9529 | <i>DL</i> -Serine                                   |                                                             | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                                | 302-84-1   | 105.093  | mcl pr or lf (w) | 246 dec   |                        | 1.603 <sup>22</sup>        |                | s H <sub>2</sub> O; i EtOH, eth, bz, HOAc          |
| 9530 | <i>D</i> -Serine                                    |                                                             | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                                | 312-84-5   | 105.093  | nd or hex pr (w) | 229 dec   | dec                    |                            |                | vs H <sub>2</sub> O; i EtOH, eth, bz, HOAc         |
| 9531 | <i>L</i> -Serine                                    | 2-Amino-3-hydroxypropanoic acid, (S)                        | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                                | 56-45-1    | 105.093  | hex pl or pr (w) | 228 dec   | sub 150                | 1.6 <sup>22</sup>          |                | s H <sub>2</sub> O; i EtOH, eth, bz, HOAc          |
| 9532 | Serpentine alkaloid                                 |                                                             | C <sub>21</sub> H <sub>20</sub> N <sub>2</sub> O <sub>3</sub>                | 18786-24-8 | 348.395  |                  | 175       |                        |                            |                | i H <sub>2</sub> O; s EtOH, eth, ace               |
| 9533 | Sesin                                               | 2,4-Dichlorophenoxyethyl benzoate                           | C <sub>15</sub> H <sub>12</sub> Cl <sub>2</sub> O <sub>3</sub>               | 94-83-7    | 311.160  | cry              | 66        | 185 <sup>1.5</sup>     |                            |                |                                                    |
| 9534 | Sesone                                              | Sodium 2-(2,4-dichlorophenoxy)ethyl sulfate                 | C <sub>8</sub> H <sub>7</sub> Cl <sub>2</sub> NaO <sub>5</sub> S             | 136-78-7   | 309.100  |                  | 245 dec   |                        |                            |                |                                                    |
| 9535 | Sethoxydim                                          |                                                             | C <sub>17</sub> H <sub>29</sub> NO <sub>3</sub> S                            | 74051-80-2 | 327.482  |                  |           | >90 <sup>0.00003</sup> | 1.043 <sup>25</sup>        |                |                                                    |
| 9536 | Shikimic acid                                       |                                                             | C <sub>7</sub> H <sub>10</sub> O <sub>5</sub>                                | 138-59-0   | 174.151  | nd               | 184       | subl                   |                            |                | sl EtOH; i eth, bz, chl                            |
| 9537 | Siduron                                             |                                                             | C <sub>14</sub> H <sub>20</sub> N <sub>2</sub> O                             | 1982-49-6  | 232.321  | cry solid        | 135       |                        |                            |                | s EtOH, DMF, CH <sub>2</sub> Cl <sub>2</sub>       |
| 9538 | Silvex                                              | Propanoic acid, 2-(2,4,5-trichlorophenoxy)-                 | C <sub>9</sub> H <sub>7</sub> Cl <sub>3</sub> O <sub>3</sub>                 | 93-72-1    | 269.509  |                  | 181.6     |                        |                            |                |                                                    |
| 9539 | Simazine                                            | 1,3,5-Triazine-2,4-diamine, 6-chloro- <i>N,N'</i> -diethyl- | C <sub>7</sub> H <sub>12</sub> ClN <sub>5</sub>                              | 122-34-9   | 201.657  |                  | 226       |                        | 1.302 <sup>20</sup>        |                |                                                    |
| 9540 | Simfibrate                                          |                                                             | C <sub>23</sub> H <sub>26</sub> Cl <sub>2</sub> O <sub>6</sub>               | 14929-11-4 | 469.354  | cry              | 52        | 225 <sup>0.15</sup>    |                            |                |                                                    |
| 9541 | Sinapinic acid                                      | 3-(4-Hydroxy-3,5-dimethoxyphenyl)-2-propenoic acid          | C <sub>11</sub> H <sub>12</sub> O <sub>5</sub>                               | 530-59-6   | 224.210  | wh pow           |           |                        |                            |                | i H <sub>2</sub> O; s MeOH, ace                    |
| 9542 | Sinomenine                                          |                                                             | C <sub>19</sub> H <sub>23</sub> NO <sub>4</sub>                              | 115-53-7   | 329.391  | nd (bz)          | 162       |                        |                            |                | sl H <sub>2</sub> O, eth, bz; s EtOH, ace, dil alk |
| 9543 | α <sub>1</sub> -Sitosterol                          | 4-Methylstigmasta-7,24(28)-dien-3-ol, (3β,4α,5α,24Z)        | C <sub>30</sub> H <sub>50</sub> O                                            | 474-40-8   | 426.717  | nd (al)          | 166       |                        |                            |                | vs EtOH, chl                                       |
| 9544 | Sodium arsanilate                                   | Sodium (4-aminophenyl)arsonate                              | C <sub>6</sub> H <sub>7</sub> AsNNaO <sub>3</sub>                            | 127-85-5   | 239.037  | wh cry           |           |                        |                            |                | s H <sub>2</sub> O                                 |
| 9545 | Sodium ascorbate                                    |                                                             | C <sub>6</sub> H <sub>7</sub> NaO <sub>6</sub>                               | 134-03-2   | 198.106  | cry              | 218 dec   |                        |                            |                |                                                    |
| 9546 | Sodium benzenesulfinate                             |                                                             | C <sub>6</sub> H <sub>5</sub> NaO <sub>2</sub> S                             | 873-55-2   | 164.158  | cry              | 300       |                        |                            |                |                                                    |
| 9547 | Sodium benzenesulfonate                             | Monosodium benzenesulfonate                                 | C <sub>6</sub> H <sub>5</sub> NaO <sub>3</sub> S                             | 515-42-4   | 180.157  |                  | >300      |                        |                            |                | s H <sub>2</sub> O; sl EtOH                        |
| 9548 | Sodium benzoate                                     |                                                             | C <sub>7</sub> H <sub>5</sub> NaO <sub>2</sub>                               | 532-32-1   | 144.104  |                  | >300      |                        |                            |                | s H <sub>2</sub> O                                 |
| 9549 | Sodium cacodylate                                   | Sodium dimethylarsonate                                     | C <sub>2</sub> H <sub>6</sub> AsNaO <sub>2</sub>                             | 124-65-2   | 159.980  | gran cry         | 60 (hyd)  |                        |                            |                | vs H <sub>2</sub> O; s EtOH                        |
| 9550 | Sodium 2,2-dichloropropanoate                       |                                                             | C <sub>3</sub> H <sub>3</sub> Cl <sub>2</sub> NaO <sub>2</sub>               | 127-20-8   | 164.951  | hyg pow          | 166 dec   |                        |                            |                |                                                    |
| 9551 | Sodium diethyldithiocarbamate                       | Dithiocarb sodium                                           | C <sub>5</sub> H <sub>10</sub> NNaS <sub>2</sub>                             | 148-18-5   | 171.260  | cry (EtOH)       | 95        |                        |                            |                | s H <sub>2</sub> O, EtOH, MeOH, ace; i eth, bz     |
| 9552 | Sodium diethyldithiocarbamate trihydrate            | Diethyldithiocarbamate sodium salt trihydrate               | C <sub>5</sub> H <sub>16</sub> NNaO <sub>3</sub> S <sub>2</sub>              | 20624-25-3 | 225.306  | orth cry (ace)   | 95        |                        |                            |                | vs H <sub>2</sub> O; s EtOH, ace; i bz, eth        |
| 9553 | Sodium 4,5-dihydroxy-2,7-naphthalenedisulfonic acid | Chromotropic acid disodium salt                             | C <sub>10</sub> H <sub>6</sub> Na <sub>2</sub> O <sub>6</sub> S <sub>2</sub> | 129-96-4   | 364.260  | wh nd or lf (w)  |           |                        |                            |                | vs H <sub>2</sub> O                                |
| 9554 | Sodium dimethyldithiocarbamate                      |                                                             | C <sub>3</sub> H <sub>7</sub> NNaS <sub>2</sub>                              | 128-04-1   | 144.215  | col cry (w)      | 121 (hyd) |                        |                            |                |                                                    |
| 9555 | Sodium 4-dodecylbenzenesulfonate                    |                                                             | C <sub>18</sub> H <sub>29</sub> NaO <sub>3</sub> S                           | 2211-98-5  | 348.476  | cry              | 144       |                        |                            |                |                                                    |
| 9556 | Sodium dodecyl sulfate                              | Sodium lauryl sulfate                                       | C <sub>12</sub> H <sub>25</sub> NaO <sub>4</sub> S                           | 151-21-3   | 288.379  | wh pow           | 205       |                        |                            |                |                                                    |
| 9557 | Sodium ethanolate                                   | Sodium ethoxide                                             | C <sub>2</sub> H <sub>5</sub> NaO                                            | 141-52-6   | 68.050   | hyg wh pow       | 260 dec   |                        |                            |                | reac H <sub>2</sub> O; s EtOH                      |
| 9558 | Sodium fluoroacetate                                |                                                             | C <sub>2</sub> H <sub>2</sub> FNaO <sub>2</sub>                              | 62-74-8    | 100.024  | wh mcl cry       | 200       |                        |                            |                | i ace, chl; sl EtOH, MeOH                          |
| 9559 | Sodium formaldehyde bisulfite                       | Sodium hydroxymethanesulfonate                              | CH <sub>3</sub> NaO <sub>4</sub> S                                           | 870-72-4   | 134.088  | cry (EtOH aq)    |           |                        |                            |                |                                                    |
| 9560 | Sodium formaldehydesulfoxylate                      | Sodium hydroxymethanesulfinate                              | CH <sub>3</sub> NaO <sub>3</sub> S                                           | 149-44-0   | 118.088  | cry (w)          | 63 (hyd)  |                        |                            |                | s H <sub>2</sub> O; i EtOH, bz, eth                |
| 9561 | Sodium gluconate                                    |                                                             | C <sub>6</sub> H <sub>11</sub> NaO <sub>7</sub>                              | 527-07-1   | 218.137  |                  |           |                        |                            |                | s H <sub>2</sub> O                                 |
| 9562 | Sodium 2-hydroxyethanesulfonate                     | Monosodium 2-hydroxyethanesulfonate                         | C <sub>2</sub> H <sub>5</sub> NaO <sub>4</sub> S                             | 1562-00-1  | 148.114  |                  |           |                        |                            |                | s H <sub>2</sub> O                                 |
| 9563 | Sodium 2-hydroxy-2-propanesulfonate                 | Monosodium 2-hydroxy-2-propanesulfonate                     | C <sub>3</sub> H <sub>7</sub> NaO <sub>4</sub> S                             | 540-92-1   | 162.141  | cry              |           |                        |                            |                | s H <sub>2</sub> O; sl EtOH                        |
| 9564 | Sodium iodomethanesulfonate                         | Methiodal sodium                                            | CH <sub>3</sub> INaO <sub>3</sub> S                                          | 126-31-8   | 243.984  | cry              |           |                        |                            |                | sl EtOH, ace, bz                                   |
| 9565 | Sodium <i>O</i> -isopropyl xanthate                 |                                                             | C <sub>4</sub> H <sub>7</sub> NaOS <sub>2</sub>                              | 140-93-2   | 158.218  | hyg wh-ye pow    | 150 dec   |                        |                            |                |                                                    |
| 9566 | Sodium methanolate                                  | Sodium methoxide                                            | CH <sub>3</sub> NaO                                                          | 124-41-4   | 54.024   | wh hyg tetr cry  | 300       |                        |                            |                | reac H <sub>2</sub> O; s MeOH, EtOH                |
| 9567 | Sodium methylarsonate                               |                                                             | CH <sub>3</sub> AsNaO <sub>3</sub>                                           | 2163-80-6  | 161.953  | cry (w)          | 115       |                        |                            |                | vs H <sub>2</sub> O; s MeOH; i os                  |
| 9568 | Sodium methyldithiocarbamate                        | Metham sodium                                               | C <sub>2</sub> H <sub>5</sub> NNaS <sub>2</sub>                              | 137-42-8   | 129.180  | cry (w)          |           |                        |                            |                | vs H <sub>2</sub> O                                |
| 9569 | Sodium β-naphthoquinone-4-sulfonate                 | Sodium 3,4-dihydro-3,4-dioxo-1-naphthalenesulfonate         | C <sub>10</sub> H <sub>5</sub> NaO <sub>5</sub> S                            | 521-24-4   | 260.199  |                  | 287 dec   |                        |                            |                |                                                    |
| 9570 | Sodium 2-oxopropanoate                              |                                                             | C <sub>3</sub> H <sub>3</sub> NaO <sub>3</sub>                               | 113-24-6   | 110.044  |                  |           |                        |                            |                | s H <sub>2</sub> O; sl abs EtOH                    |



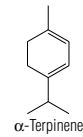
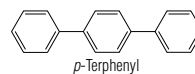
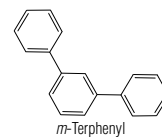
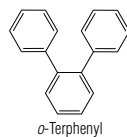
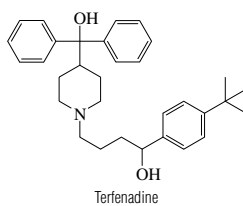
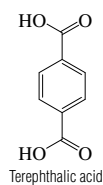
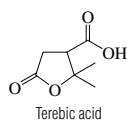
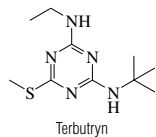
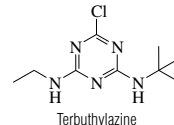
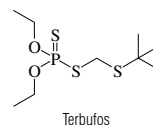
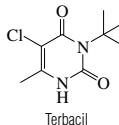
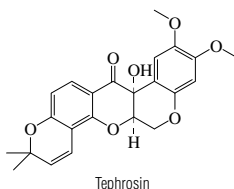
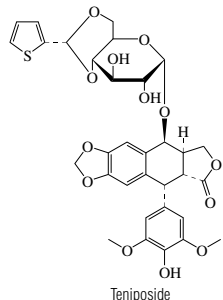
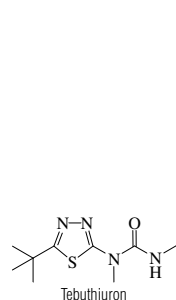
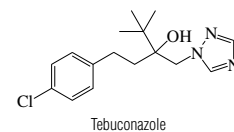
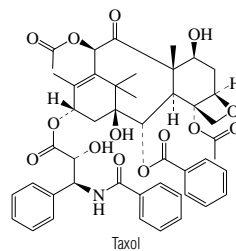
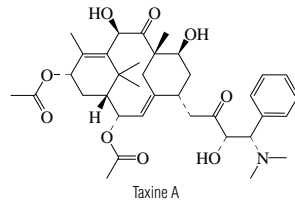
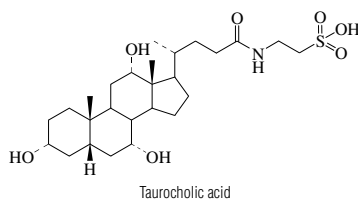
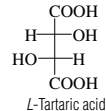
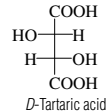
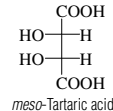
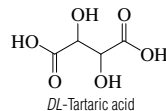
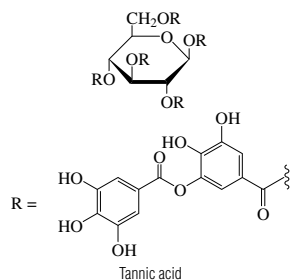
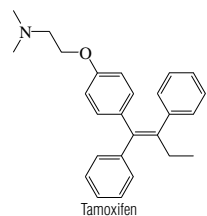
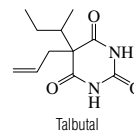
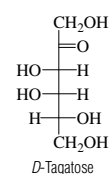
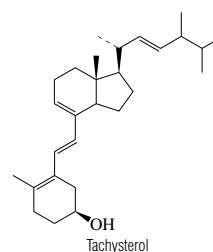
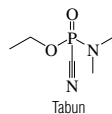
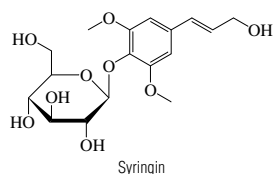
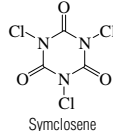
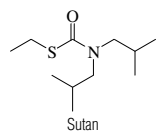
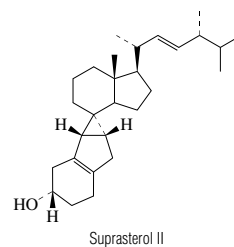
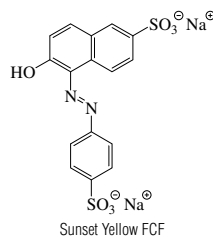
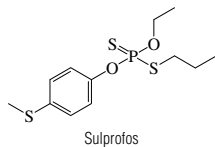
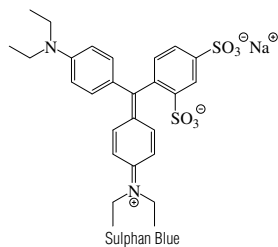
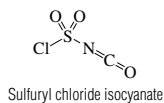
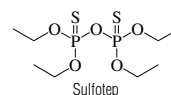
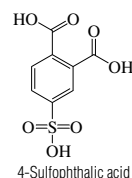
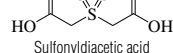
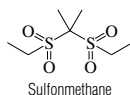
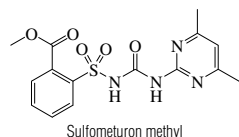
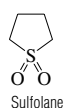
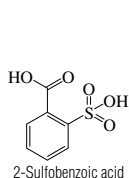
| No.  | Name                                       | Synonym                                       | Mol. Form.                                                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C    | bp/°C                      | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|------|--------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------------------------------------|------------|----------|----------------------------|----------|----------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 9571 | Sodium phenolate                           | Sodium phenoxide                              | C <sub>6</sub> H <sub>5</sub> NaO                                                             | 139-02-6   | 116.093  | hyg cry                    | 384      |                            |                            |                      | vs H <sub>2</sub> O; s EtOH, thf                             |
| 9572 | Sodium propanoate                          |                                               | C <sub>3</sub> H <sub>5</sub> NaO <sub>2</sub>                                                | 137-40-6   | 96.061   |                            |          |                            |                            |                      | sl H <sub>2</sub> O                                          |
| 9573 | Sodium sulfobromophthalein                 | Sulfobromophthalein sodium                    | C <sub>20</sub> H <sub>6</sub> Br <sub>4</sub> Na <sub>2</sub> O <sub>10</sub> S <sub>2</sub> | 71-67-0    | 837.998  | hyg cry                    |          |                            |                            |                      | s H <sub>2</sub> O; i EtOH, ace                              |
| 9574 | Sodium tartrate                            |                                               | C <sub>4</sub> H <sub>4</sub> Na <sub>2</sub> O <sub>6</sub>                                  | 868-18-8   | 194.051  |                            |          |                            |                            |                      | s H <sub>2</sub> O                                           |
| 9575 | Sodium tartrate dihydrate                  |                                               | C <sub>4</sub> H <sub>6</sub> Na <sub>2</sub> O <sub>8</sub>                                  | 6106-24-7  | 230.082  |                            |          |                            | 1.545 <sup>25</sup>        |                      | s H <sub>2</sub> O; i EtOH                                   |
| 9576 | Sodium tetraphenylborate                   |                                               | C <sub>24</sub> H <sub>20</sub> BNa                                                           | 143-66-8   | 342.217  | nd                         | 300      |                            |                            |                      | s H <sub>2</sub> O, EtOH, ace; sl eth, chl; i peth           |
| 9577 | Sodium trichloroacetate                    |                                               | C <sub>2</sub> Cl <sub>3</sub> NaO <sub>2</sub>                                               | 650-51-1   | 185.369  | ye-wh pow                  | 300      |                            |                            |                      | s H <sub>2</sub> O, EtOH                                     |
| 9578 | Sodium trifluoroacetate                    |                                               | C <sub>2</sub> F <sub>3</sub> NaO <sub>2</sub>                                                | 2923-18-4  | 136.005  | cry                        | 207 dec  |                            |                            |                      |                                                              |
| 9579 | Solanid-5-ene-3,18-diol, (3β)              | Isorubijervine                                | C <sub>27</sub> H <sub>43</sub> NO <sub>2</sub>                                               | 468-45-1   | 413.636  | pr(al)                     | 242.5    |                            |                            |                      | vs bz, chl                                                   |
| 9580 | Solanine                                   |                                               | C <sub>45</sub> H <sub>73</sub> NO <sub>15</sub>                                              | 20562-02-1 | 868.060  | nd (EtOH aq)               | 286 dec  |                            |                            |                      | i H <sub>2</sub> O, eth, chl; s hot EtOH                     |
| 9581 | Solanone                                   |                                               | C <sub>13</sub> H <sub>22</sub> O                                                             | 1937-54-8  | 194.313  |                            |          | 60 <sup>1</sup>            | 0.870 <sup>20</sup>        | 1.4755 <sup>20</sup> |                                                              |
| 9582 | Soman                                      |                                               | C <sub>7</sub> H <sub>16</sub> FO <sub>4</sub> P                                              | 96-64-0    | 182.173  | liq                        |          |                            |                            |                      |                                                              |
| 9583 | Sophoricoside                              |                                               | C <sub>21</sub> H <sub>20</sub> O <sub>10</sub>                                               | 152-95-4   | 432.378  |                            | 274      |                            |                            |                      |                                                              |
| 9584 | Sorbitan oleate                            |                                               | C <sub>24</sub> H <sub>44</sub> O <sub>6</sub>                                                | 1338-43-8  | 428.602  | ye oil                     |          |                            | 0.986                      | 1.4800 <sup>20</sup> | i H <sub>2</sub> O; s EtOH                                   |
| 9585 | L-Sorbose                                  | L-Sorbinose                                   | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                                 | 87-79-6    | 180.155  | orth (al)                  | 165      |                            | 1.612 <sup>17</sup>        |                      | s H <sub>2</sub> O; sl EtOH, eth, MeOH                       |
| 9586 | Sparteine                                  |                                               | C <sub>15</sub> H <sub>26</sub> N <sub>2</sub>                                                | 90-39-1    | 234.380  |                            | 30.5     | 325; 173 <sup>8</sup>      | 1.0196 <sup>20</sup>       | 1.5312 <sup>20</sup> | vs eth, EtOH, chl                                            |
| 9587 | Spinulosin                                 |                                               | C <sub>8</sub> H <sub>8</sub> O <sub>5</sub>                                                  | 85-23-4    | 184.147  | red-bl                     | 202.5    | sub 120                    |                            |                      | sl H <sub>2</sub> O; s alk                                   |
| 9588 | Spironolactone                             |                                               | C <sub>24</sub> H <sub>32</sub> O <sub>4</sub> S                                              | 52-01-7    | 416.574  |                            |          | 134                        |                            |                      |                                                              |
| 9589 | Spiro[2.2]pentane                          |                                               | C <sub>5</sub> H <sub>8</sub>                                                                 | 157-40-4   | 68.118   | liq                        | -107.0   | 39                         | 0.7266 <sup>20</sup>       | 1.4120 <sup>20</sup> |                                                              |
| 9590 | Spirosolan-3-ol, (3β,5α,22β,25S)           | Tomatidine                                    | C <sub>27</sub> H <sub>45</sub> NO <sub>2</sub>                                               | 77-59-8    | 415.652  | pl                         | 210.5    |                            |                            |                      | s EtOH, eth                                                  |
| 9591 | Spirosol-5-en-3-ol, (3β,22α,25R)           | Solasodine                                    | C <sub>27</sub> H <sub>45</sub> NO <sub>2</sub>                                               | 126-17-0   | 413.636  | hex pl (sub)               | 202      |                            |                            |                      | s EtOH, ace, bz, diox, py; sl eth; vs chl                    |
| 9592 | Spirostan-2,3-diol, (2α,3β,5α,25R)         | Gitogenin                                     | C <sub>27</sub> H <sub>44</sub> O <sub>4</sub>                                                | 511-96-6   | 432.636  | lf (bz), nd (eth)          | 271.5    |                            |                            |                      | i H <sub>2</sub> O; s EtOH, chl; sl eth                      |
| 9593 | Spirostan-3-ol, (3β,5α,25R)                | Tigogenin                                     | C <sub>27</sub> H <sub>44</sub> O <sub>3</sub>                                                | 77-60-1    | 416.636  | lf (al +1w) pr (ace)       | 205.5    |                            |                            |                      | s EtOH, eth, ace, ctc, MeOH, peth                            |
| 9594 | Spirostan-3-ol, (3β,5β,25R)                | Smilagenin                                    | C <sub>27</sub> H <sub>44</sub> O <sub>3</sub>                                                | 126-18-1   | 416.636  | nd (ace)                   | 185      |                            |                            |                      | vs ace, bz, EtOH                                             |
| 9595 | Spirostan-3-ol, (3β,5β,25S)                | Sarsasapogenin                                | C <sub>27</sub> H <sub>44</sub> O <sub>3</sub>                                                | 126-19-2   | 416.636  | lo pr, nd (ace)            | 200.5    |                            |                            |                      | s EtOH, ace, bz, chl                                         |
| 9596 | Spirostan-2,3,15-triol, (2α,3β,5α,15β,25R) | Digitogenin                                   | C <sub>27</sub> H <sub>44</sub> O <sub>5</sub>                                                | 511-34-2   | 448.635  | nd (al)                    | 281.5    |                            |                            |                      | vs chl                                                       |
| 9597 | Spirost-5-en-3-ol, (3β,25R)                | Diosgenin                                     | C <sub>27</sub> H <sub>42</sub> O <sub>3</sub>                                                | 512-04-9   | 414.620  | cry (ace)                  | 205.5    |                            |                            |                      | vs EtOH                                                      |
| 9598 | Spiro[5.5]undecane                         |                                               | C <sub>11</sub> H <sub>20</sub>                                                               | 180-43-8   | 152.277  |                            |          | 208                        | 0.8783 <sup>20</sup>       | 1.4731               |                                                              |
| 9599 | S-Propyl thioacetate                       |                                               | C <sub>5</sub> H <sub>10</sub> OS                                                             | 2307-10-0  | 118.197  |                            |          | 137.9                      | 0.9535 <sup>25</sup>       |                      |                                                              |
| 9600 | Squalene                                   |                                               | C <sub>30</sub> H <sub>50</sub>                                                               | 111-02-4   | 410.718  | oil                        | -4.8     | 421.3; 280 <sup>17</sup>   | 0.8584 <sup>20</sup>       | 1.4990 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH; s eth, ace, ctc                 |
| 9601 | Stachydrine                                |                                               | C <sub>7</sub> H <sub>13</sub> NO <sub>2</sub>                                                | 471-87-4   | 143.184  | cry (w+1)                  | 235      |                            |                            |                      | vs H <sub>2</sub> O, EtOH                                    |
| 9602 | Stanozolol                                 |                                               | C <sub>21</sub> H <sub>32</sub> N <sub>2</sub> O                                              | 10418-03-8 | 328.491  | cry (EtOH)                 | ≈236     |                            |                            |                      |                                                              |
| 9603 | Stearaldehyde                              |                                               | C <sub>18</sub> H <sub>36</sub> O                                                             | 638-66-4   | 268.478  | nd (peth)                  |          | 261                        |                            |                      |                                                              |
| 9604 | Stearic acid                               | Octadecanoic acid                             | C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>                                                | 57-11-4    | 284.478  | mcl lf (al)                | 69.3     | dec 350; 232 <sup>15</sup> | 0.9408 <sup>20</sup>       | 1.4299 <sup>80</sup> | i H <sub>2</sub> O; sl EtOH, bz; s ace, chl, CS <sub>2</sub> |
| 9605 | Stearic acid anhydride                     | Octadecanoic anhydride                        | C <sub>36</sub> H <sub>70</sub> O <sub>3</sub>                                                | 638-08-4   | 550.939  |                            | 72       |                            | 0.8365 <sup>82</sup>       | 1.4362 <sup>80</sup> | i H <sub>2</sub> O, EtOH; sl eth, bz                         |
| 9606 | Sterigmatocystin                           |                                               | C <sub>18</sub> H <sub>12</sub> O <sub>6</sub>                                                | 10048-13-2 | 324.284  | ye nd                      | 246 dec  |                            |                            |                      |                                                              |
| 9607 | Stigmasta-5,7-dien-3-ol, (3β)              | 7-Dehydrositosterol                           | C <sub>29</sub> H <sub>48</sub> O                                                             | 521-04-0   | 412.690  |                            | 144.5    |                            |                            |                      | vs bz, eth, EtOH                                             |
| 9608 | Stigmasta-5,22-dien-3-ol, (3β,22E)         | Stigmasterol                                  | C <sub>29</sub> H <sub>48</sub> O                                                             | 83-48-7    | 412.690  |                            | 170      |                            |                            |                      | vs bz, eth, EtOH                                             |
| 9609 | Stigmastan-3-ol, (3β,5α)                   |                                               | C <sub>29</sub> H <sub>50</sub> O                                                             | 83-45-4    | 416.722  |                            | 144      |                            |                            |                      |                                                              |
| 9610 | Stigmast-5-en-3-ol, (3β,24R)               | β-Sitosterol                                  | C <sub>29</sub> H <sub>50</sub> O                                                             | 83-46-5    | 414.706  | pl (al)                    | 137      |                            |                            |                      | s EtOH, eth, HOAc                                            |
| 9611 | Stigmast-5-en-3-ol, (3β,24S)               | γ-Sitosterol                                  | C <sub>29</sub> H <sub>50</sub> O                                                             | 83-47-6    | 414.706  | cry (EtOH)                 | 148      |                            |                            |                      | s EtOH                                                       |
| 9612 | cis-Stilbene                               | cis-1,2-Diphenylethene                        | C <sub>14</sub> H <sub>12</sub>                                                               | 645-49-8   | 180.245  |                            | -5       | 141 <sup>12</sup>          | 1.0143 <sup>20</sup>       | 1.6130 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, peth, chl          |
| 9613 | trans-Stilbene                             | trans-1,2-Diphenylethene                      | C <sub>14</sub> H <sub>12</sub>                                                               | 103-30-0   | 180.245  | cry (al)                   | 124.2    | 307; 166 <sup>12</sup>     | 0.9707 <sup>20</sup>       | 1.6264 <sup>17</sup> | i H <sub>2</sub> O; sl EtOH, chl; vs eth, bz                 |
| 9614 | Streptomycin                               | N-Methyl-L-glucosamidinostreptosidostrep tide | C <sub>21</sub> H <sub>39</sub> N <sub>7</sub> O <sub>12</sub>                                | 57-92-1    | 581.575  | hyg pow                    |          |                            |                            |                      | s H <sub>2</sub> O                                           |
| 9615 | Streptomycin sulfate                       |                                               | C <sub>42</sub> H <sub>84</sub> N <sub>14</sub> O <sub>36</sub> S <sub>3</sub>                | 3810-74-0  | 1457.383 | pow                        | ≈230 dec |                            |                            |                      |                                                              |
| 9616 | Streptozotocin                             |                                               | C <sub>8</sub> H <sub>15</sub> N <sub>3</sub> O <sub>7</sub>                                  | 18883-66-4 | 265.221  | pl                         | 115 dec  |                            |                            |                      | s H <sub>2</sub> O, EtOH                                     |
| 9617 | Strophanthidin                             |                                               | C <sub>23</sub> H <sub>32</sub> O <sub>6</sub>                                                | 66-28-4    | 404.496  | orth tab (MeOH-w) lf (w+2) | 173 dec  |                            |                            |                      | i H <sub>2</sub> O, eth; s EtOH, ace, bz, HOAc, chl          |



| No.  | Name                             | Synonym                                                      | Mol. Form.                                                                      | CAS RN     | Mol. Wt. | Physical Form                     | mp/°C                       | bp/°C            | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|----------------------------------|--------------------------------------------------------------|---------------------------------------------------------------------------------|------------|----------|-----------------------------------|-----------------------------|------------------|----------------------------|----------------------|------------------------------------------------------------|
| 9618 | Strychnidin-10-one mononitrate   | Strychnine nitrate                                           | C <sub>21</sub> H <sub>23</sub> N <sub>3</sub> O <sub>5</sub>                   | 66-32-0    | 397.425  | nd (w)                            | 295                         |                  | 1.627 <sup>25</sup>        |                      | vs H <sub>2</sub> O, MeOH;<br>sl bz; s chl,<br>EtOH        |
| 9619 | Strychnidin-10-one sulfate (2:1) | Strychnine sulfate                                           | C <sub>42</sub> H <sub>46</sub> N <sub>4</sub> O <sub>8</sub> S                 | 60-41-3    | 766.901  |                                   | 200 dec                     |                  |                            |                      | s H <sub>2</sub> O, EtOH,<br>MeOH; i eth; sl<br>chl        |
| 9620 | Strychnine                       |                                                              | C <sub>21</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>                   | 57-24-9    | 334.412  | orth pr (al)                      | 287                         | 270 <sup>5</sup> | 1.36 <sup>20</sup>         |                      | sl H <sub>2</sub> O, EtOH,<br>ace, bz; i eth; s<br>chl     |
| 9621 | Styrene                          | Vinylbenzene                                                 | C <sub>8</sub> H <sub>8</sub>                                                   | 100-42-5   | 104.150  | liq                               | -30.65                      | 145              | 0.9016 <sup>25</sup>       | 1.5440 <sup>25</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, ace; msc<br>bz; sl ctc |
| 9622 | Succimer                         | 2,3-Dimercaptobutanedioic acid,<br>(R*,S*)                   | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub> S <sub>2</sub>                     | 304-55-2   | 182.219  | wh cry<br>(MeOH)                  | 193                         |                  |                            |                      |                                                            |
| 9623 | Succinamide                      |                                                              | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                     | 110-14-5   | 116.119  | orth nd (w)                       | 268 dec                     | sub 125          |                            |                      | s H <sub>2</sub> O                                         |
| 9624 | Succinic acid                    |                                                              | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                                    | 110-15-6   | 118.089  | tcl or mcl pr                     | 187.9                       | dec 235          | 1.572 <sup>25</sup>        | 1.450                | sl H <sub>2</sub> O, DMSO;<br>s EtOH, eth,<br>ace; i bz    |
| 9625 | Succinic anhydride               |                                                              | C <sub>4</sub> H <sub>4</sub> O <sub>3</sub>                                    | 108-30-5   | 100.073  | nd (al), orth<br>pym (chl)        | 119                         | 261              | 1.2 <sup>20</sup>          |                      | i H <sub>2</sub> O; s EtOH,<br>chl; sl eth                 |
| 9626 | Succinimide                      |                                                              | C <sub>4</sub> H <sub>5</sub> NO <sub>2</sub>                                   | 123-56-8   | 99.089   | pl (+1w, al)<br>orth (ace)        | 126.5                       | dec 287          | 1.418 <sup>25</sup>        |                      | s H <sub>2</sub> O; sl EtOH,<br>eth, ace                   |
| 9627 | Succinonitrile                   | Butanedinitrile                                              | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                                    | 110-61-2   | 80.088   |                                   | 57.98                       | 266              | 0.9867 <sup>60</sup>       | 1.4173 <sup>60</sup> | vs H <sub>2</sub> O; s EtOH,<br>ace, bz, chl; sl<br>eth    |
| 9628 | Succinylcholine chloride         | Suxamethonium chloride                                       | C <sub>14</sub> H <sub>30</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>4</sub>   | 71-27-2    | 361.305  | cry (w)                           | 190                         |                  |                            |                      | sl EtOH, bz, chl;<br>i eth                                 |
| 9629 | Succinylsulphathiazole           |                                                              | C <sub>13</sub> H <sub>13</sub> N <sub>3</sub> O <sub>3</sub> S <sub>2</sub>    | 116-43-8   | 355.389  | cry                               | 193.5                       |                  |                            |                      | i H <sub>2</sub> O, eth, chl;<br>sl EtOH, ace; s<br>alk    |
| 9630 | Sucralfate                       |                                                              | C <sub>12</sub> H <sub>54</sub> Al <sub>16</sub> O <sub>75</sub> S <sub>8</sub> | 54182-58-0 | 2086.737 | wh amorp<br>pow                   |                             |                  |                            |                      | i H <sub>2</sub> O, EtOH,<br>chl; s dil HCl,<br>alk        |
| 9631 | Sucrose                          |                                                              | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                                 | 57-50-1    | 342.296  | mcl                               | 185.5                       |                  | 1.5805 <sup>17</sup>       | 1.5376               | s H <sub>2</sub> O, py; sl<br>EtOH; i eth                  |
| 9632 | Sucrose monohexadecanoate        | Sucrose palmitate                                            | C <sub>28</sub> H <sub>52</sub> O <sub>12</sub>                                 | 26446-38-8 | 580.706  | cry                               | 61                          |                  |                            |                      | s H <sub>2</sub> O                                         |
| 9633 | Sucrose octaacetate              |                                                              | C <sub>28</sub> H <sub>36</sub> O <sub>19</sub>                                 | 126-14-7   | 678.591  | nd (al)                           | 86.5                        | 250 <sup>1</sup> | 1.27 <sup>16</sup>         | 1.4660               | sl H <sub>2</sub> O; s EtOH,<br>eth, ace, bz,<br>chl       |
| 9634 | Sufentanil                       |                                                              | C <sub>22</sub> H <sub>30</sub> N <sub>2</sub> O <sub>2</sub> S                 | 56030-54-7 | 386.550  | cry (peth)                        | 96.6                        |                  |                            |                      |                                                            |
| 9635 | Sulfabenzamide                   | N-[(4-Aminophenyl)sulfonyl]<br>benzamide                     | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub> S                 | 127-71-9   | 276.310  | hex pr (60%<br>al)                | 181.5                       |                  |                            |                      |                                                            |
| 9636 | Sulfachlorpyridazine             |                                                              | C <sub>10</sub> H <sub>9</sub> ClN <sub>4</sub> O <sub>3</sub> S                | 80-32-0    | 284.722  |                                   | 187                         |                  |                            |                      |                                                            |
| 9637 | Sulfacytine                      |                                                              | C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>3</sub> S                 | 17784-12-2 | 294.329  | cry (MeOH/<br>BuOH)               | 167                         |                  |                            |                      | i H <sub>2</sub> O; s alk                                  |
| 9638 | Sulfadimethoxine                 |                                                              | C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>4</sub> S                 | 122-11-2   | 310.329  |                                   | 203.5                       |                  |                            |                      |                                                            |
| 9639 | Sulfaguanidine                   |                                                              | C <sub>7</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub> S                  | 57-67-0    | 214.245  | nd (w)                            | 191.5                       |                  |                            |                      |                                                            |
| 9640 | Sulfallate                       | Carbamodithioic acid, diethyl-,<br>2-chloro-2-propenyl ester | C <sub>8</sub> H <sub>14</sub> ClNS <sub>2</sub>                                | 95-06-7    | 223.787  |                                   |                             | 129 <sup>1</sup> | 1.088                      |                      |                                                            |
| 9641 | Sulfamerazine                    |                                                              | C <sub>11</sub> H <sub>12</sub> N <sub>4</sub> O <sub>2</sub> S                 | 127-79-7   | 264.304  | cry                               | 236                         |                  |                            |                      | sl H <sub>2</sub> O, EtOH,<br>ace, DMSO; i<br>eth, chl     |
| 9642 | Sulfamethazine                   |                                                              | C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub> S                 | 57-68-1    | 278.330  | pa ye (w+1/<br>2) cry<br>(diox-w) | 198.5                       |                  |                            |                      | s H <sub>2</sub> O, acid, alk;<br>sl DMSO                  |
| 9643 | Sulfamethiazole                  |                                                              | C <sub>9</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub> S <sub>2</sub>     | 144-82-1   | 270.331  | cry (w)                           | 210                         |                  |                            |                      | sl hot H <sub>2</sub> O                                    |
| 9644 | Sulfamethoxazole                 |                                                              | C <sub>10</sub> H <sub>11</sub> N <sub>3</sub> O <sub>3</sub> S                 | 723-46-6   | 253.277  | ye-wh pow                         | 171                         |                  |                            |                      | i eth                                                      |
| 9645 | Sulfamethoxypyridazine           |                                                              | C <sub>11</sub> H <sub>12</sub> N <sub>4</sub> O <sub>3</sub> S                 | 80-35-3    | 280.303  |                                   | 182.5                       |                  |                            |                      |                                                            |
| 9646 | Sulfamethylthiazole              |                                                              | C <sub>10</sub> H <sub>11</sub> N <sub>3</sub> O <sub>2</sub> S <sub>2</sub>    | 515-59-3   | 269.343  |                                   | 237                         |                  |                            |                      | vs EtOH                                                    |
| 9647 | N-Sulfanilylsulfanilamide        | 4-Amino-N-[4-(aminosulfonyl)<br>phenyl]benzenesulfonamide    | C <sub>12</sub> H <sub>13</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub>    | 547-52-4   | 327.379  |                                   | 137                         |                  |                            |                      | sl H <sub>2</sub> O; s EtOH,<br>eth, ace; i chl,<br>peth   |
| 9648 | Sulfanilylurea                   |                                                              | C <sub>7</sub> H <sub>9</sub> N <sub>3</sub> O <sub>3</sub> S                   | 547-44-4   | 215.229  | cry (w)                           | 147 dec                     |                  |                            |                      |                                                            |
| 9649 | Sulfaphenazole                   |                                                              | C <sub>15</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub> S                 | 526-08-9   | 314.363  | cry (EtOH)                        | 181                         |                  |                            |                      | sl EtOH, MeOH,<br>gl HOAc                                  |
| 9650 | Sulfasalazine                    |                                                              | C <sub>18</sub> H <sub>14</sub> N <sub>4</sub> O <sub>5</sub> S                 | 599-79-1   | 398.393  |                                   | 220 dec                     |                  |                            |                      |                                                            |
| 9651 | Sulfathiazole                    | 4-Amino-N-2-<br>thiazolylbenzenesulfonamide                  | C <sub>9</sub> H <sub>8</sub> N <sub>3</sub> O <sub>2</sub> S <sub>2</sub>      | 72-14-0    | 255.316  | br pl, rods or<br>pow (45%<br>al) | 175(form a);<br>202(form b) |                  |                            |                      | sl H <sub>2</sub> O, EtOH,<br>DMSO                         |
| 9652 | Sulfathiourea                    |                                                              | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> S <sub>2</sub>      | 515-49-1   | 231.295  |                                   | 182                         |                  |                            |                      | i H <sub>2</sub> O; sl EtOH                                |
| 9653 | Sulfipyrazone                    |                                                              | C <sub>23</sub> H <sub>20</sub> N <sub>2</sub> O <sub>3</sub> S                 | 57-96-5    | 404.481  |                                   | 137                         |                  |                            |                      |                                                            |
| 9654 | N-Sulfinylaniline                |                                                              | C <sub>8</sub> H <sub>9</sub> NOS                                               | 1122-83-4  | 139.175  |                                   |                             | 200              | 1.236 <sup>25</sup>        | 1.6270 <sup>20</sup> |                                                            |
| 9655 | Sulfisoxazole                    |                                                              | C <sub>11</sub> H <sub>13</sub> N <sub>3</sub> O <sub>3</sub> S                 | 127-69-5   | 267.304  | ye-wh pow                         | 191                         |                  |                            |                      | sl H <sub>2</sub> O                                        |
| 9656 | Sulfoacetic acid                 |                                                              | C <sub>2</sub> H <sub>4</sub> O <sub>5</sub> S                                  | 123-43-3   | 140.115  | hyg tab<br>(w+1)                  | 85                          | dec 245          |                            |                      | vs H <sub>2</sub> O, ace,<br>EtOH                          |

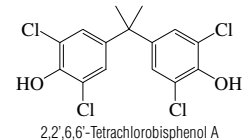
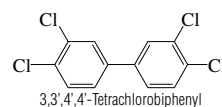
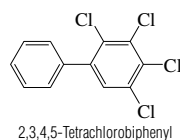
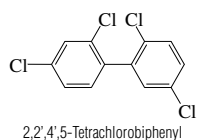
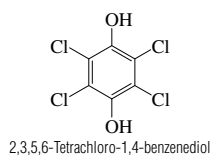
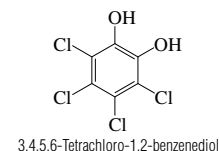
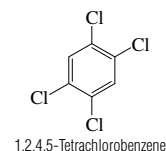
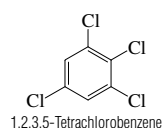
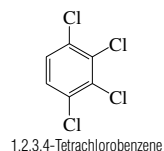
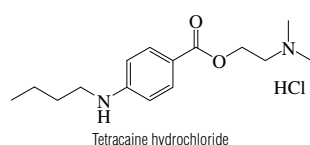
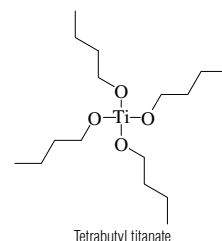
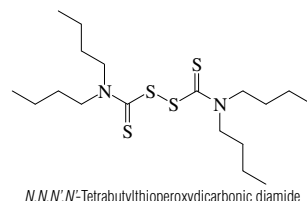
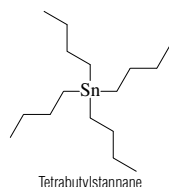
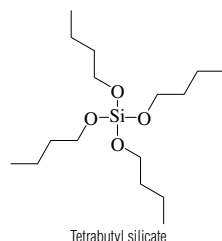
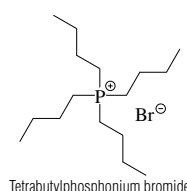
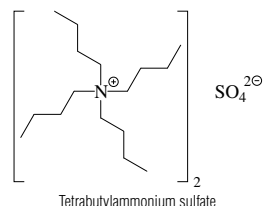
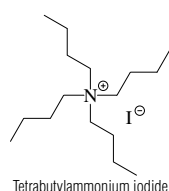
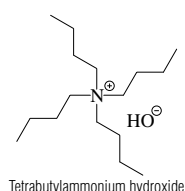
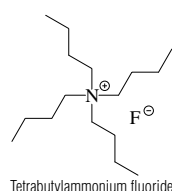
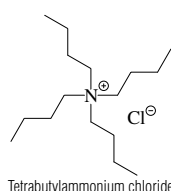
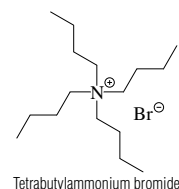
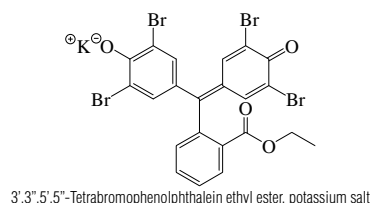
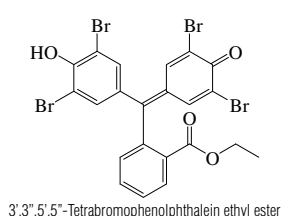
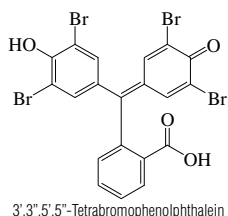
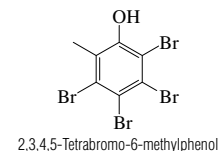
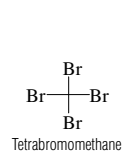
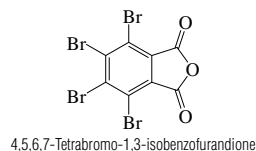
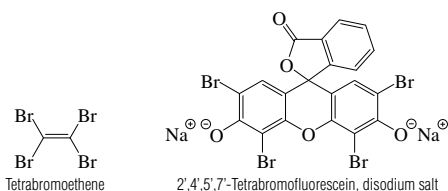
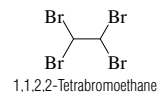
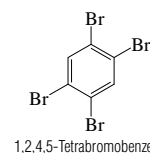
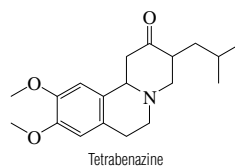
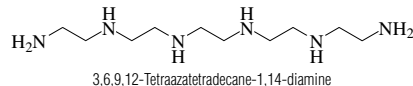
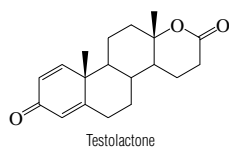
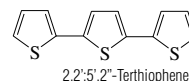
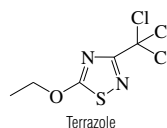
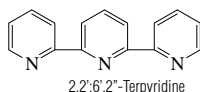
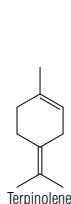
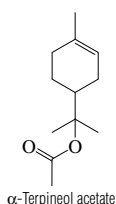
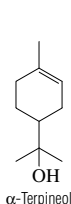
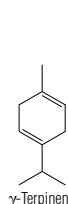


| No.  | Name                         | Synonym                                                                               | Mol. Form.                                                                                   | CAS RN      | Mol. Wt. | Physical Form      | mp/°C     | bp/°C                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|------|------------------------------|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-------------|----------|--------------------|-----------|----------------------|----------------------------|----------------------|---------------------------------------------------------|
| 9657 | 2-Sulfobenzoic acid          |                                                                                       | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub> S                                               | 632-25-7    | 202.185  | nd (w+3)           | 141       |                      |                            |                      | vs H <sub>2</sub> O, EtOH                               |
| 9658 | Sulfolane                    | Tetrahydrothiophene, 1-1-dioxide                                                      | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S                                               | 126-33-0    | 120.171  |                    | 27.6      | 287.3                | 1.2723 <sup>18</sup>       | 1.4833 <sup>18</sup> | s chl                                                   |
| 9659 | Sulfometuron methyl          |                                                                                       | C <sub>13</sub> H <sub>16</sub> N <sub>4</sub> O <sub>3</sub> S                              | 74222-97-2  | 364.377  | wh solid           | 202       |                      |                            |                      |                                                         |
| 9660 | Sulfonmethane                | 2,2-Bis(ethylsulfonyl)propane                                                         | C <sub>7</sub> H <sub>16</sub> O <sub>4</sub> S <sub>2</sub>                                 | 115-24-2    | 228.330  | mcl (w), pr (al)   | 125.8     | dec 300              |                            |                      | vs bz, EtOH, chl                                        |
| 9661 | Sulfonyldiacetic acid        |                                                                                       | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub> S                                               | 123-45-5    | 182.152  |                    | 187       |                      |                            |                      | vs H <sub>2</sub> O, EtOH; s eth, sulf                  |
| 9662 | 4-Sulphthalic acid           | 4-Sulfo-1,2-benzenedicarboxylic acid                                                  | C <sub>8</sub> H <sub>6</sub> O <sub>7</sub> S                                               | 89-08-7     | 246.195  | cry                | 139       |                      |                            |                      |                                                         |
| 9663 | Sulfotep                     |                                                                                       | C <sub>8</sub> H <sub>20</sub> O <sub>3</sub> P <sub>2</sub> S <sub>2</sub>                  | 3689-24-5   | 322.320  |                    |           | 137 <sup>2</sup>     | 1.196 <sup>25</sup>        | 1.4753 <sup>25</sup> | i H <sub>2</sub> O; s EtOH                              |
| 9664 | Sulfuryl chloride isocyanate |                                                                                       | CCINO <sub>2</sub> S                                                                         | 1189-71-5   | 141.534  | liq                | -44       | 107                  | 1.626 <sup>25</sup>        | 1.4467 <sup>20</sup> |                                                         |
| 9665 | Sulphan Blue                 |                                                                                       | C <sub>27</sub> H <sub>31</sub> N <sub>3</sub> NaO <sub>6</sub> S <sub>2</sub>               | 129-17-9    | 566.664  | viol pow           |           |                      |                            |                      | s EtOH                                                  |
| 9666 | Sulprofos                    |                                                                                       | C <sub>12</sub> H <sub>19</sub> O <sub>2</sub> PS <sub>3</sub>                               | 35400-43-2  | 322.447  |                    |           | 156 <sup>0.1</sup>   | 1.20 <sup>20</sup>         | 1.5859               | sl H <sub>2</sub> O                                     |
| 9667 | Sunset Yellow FCF            | C.I. Food Yellow 3                                                                    | C <sub>19</sub> H <sub>10</sub> N <sub>2</sub> Na <sub>2</sub> O <sub>7</sub> S <sub>2</sub> | 2783-94-0   | 452.369  | cry                | >300      |                      |                            |                      | s H <sub>2</sub> O; sl EtOH                             |
| 9668 | Suprasterol II               |                                                                                       | C <sub>28</sub> H <sub>44</sub> O                                                            | 562-71-0    | 396.648  | pr                 | 110       | 190 <sup>0.005</sup> |                            |                      | s MeOH                                                  |
| 9669 | Sutan                        | Carbamothioic acid, bis(2-methylpropyl)-, S-ethyl ester                               | C <sub>11</sub> H <sub>23</sub> NOS                                                          | 2008-41-5   | 217.372  |                    |           | 138 <sup>21</sup>    | 0.9402 <sup>25</sup>       |                      |                                                         |
| 9670 | Symclosene                   | 1,3,5-Trichloro-1,3,5-triazine-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-trione     | C <sub>3</sub> Cl <sub>3</sub> N <sub>3</sub> O <sub>3</sub>                                 | 87-90-1     | 232.409  |                    | 246.7 dec |                      |                            |                      |                                                         |
| 9671 | Syringin                     |                                                                                       | C <sub>17</sub> H <sub>24</sub> O <sub>3</sub>                                               | 118-34-3    | 372.368  | cry (w), nd (al)   | 192       |                      |                            |                      | vs EtOH                                                 |
| 9672 | Tabun                        | Dimethylphosphoramidocyanidic acid, ethyl ester                                       | C <sub>5</sub> H <sub>11</sub> N <sub>2</sub> O <sub>2</sub> P                               | 77-81-6     | 162.127  | liq                | -50       | 240                  | 1.077                      | 1.4250 <sup>20</sup> | msc H <sub>2</sub> O                                    |
| 9673 | Tachysterol                  | 9,10-Secoergosta-5(10),6,8,22-tetraen-3-ol, (3 <i>β</i> ,6 <i>E</i> ,22 <i>E</i> )-   | C <sub>28</sub> H <sub>44</sub> O                                                            | 115-61-7    | 396.648  |                    |           |                      |                            |                      | i H <sub>2</sub> O, MeOH; s EtOH, eth, ace, bz          |
| 9674 | D-Tagatose                   |                                                                                       | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                                                | 87-81-0     | 180.155  | cry (dil al)       | 134.5     |                      |                            |                      | vs H <sub>2</sub> O                                     |
| 9675 | Talbutal                     |                                                                                       | C <sub>11</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub>                                | 115-44-6    | 224.256  | cry                | 109       |                      |                            |                      | i H <sub>2</sub> O, peth; s EtOH, ace, eth, chl         |
| 9676 | Tamoxifen                    |                                                                                       | C <sub>26</sub> H <sub>28</sub> NO                                                           | 10540-29-1  | 371.514  | cry (peth)         | 97        |                      |                            |                      |                                                         |
| 9677 | Tannic acid                  | Tannin                                                                                | C <sub>76</sub> H <sub>52</sub> O <sub>46</sub>                                              | 1401-55-4   | 1701.198 | ye-br amorp pow    | ≈210 dec  |                      |                            |                      | vs EtOH, ace; i bz, chl, eth, ctc                       |
| 9678 | DL-Tartaric acid             | 2,3-Dihydroxybutanedioic acid, ( <i>R</i> *, <i>R</i> *)-(±)-                         | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                                                 | 133-37-9    | 150.087  | mcl pr (w, al +1w) | 206       |                      | 1.788 <sup>25</sup>        |                      | s H <sub>2</sub> O, EtOH; sl eth; i bz                  |
| 9679 | meso-Tartaric acid           |                                                                                       | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                                                 | 147-73-9    | 150.087  | tcl pl (w)         | 147       |                      | 1.666 <sup>20</sup>        |                      | vs H <sub>2</sub> O, EtOH                               |
| 9680 | D-Tartaric acid              | 2,3-Dihydroxybutanedioic acid, [ <i>S</i> -( <i>R</i> *, <i>R</i> *)]-                | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                                                 | 147-71-7    | 150.087  | mcl, orth pr (w+1) | 172.5     |                      | 1.7598 <sup>20</sup>       | 1.4955 <sup>20</sup> | sl DMSO                                                 |
| 9681 | L-Tartaric acid              | 2,3-Dihydroxybutanedioic acid, [ <i>R</i> -( <i>R</i> *, <i>R</i> *)]-                | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                                                 | 87-69-4     | 150.087  |                    | 169       |                      |                            |                      |                                                         |
| 9682 | Taurocholic acid             | Cholaic acid                                                                          | C <sub>26</sub> H <sub>45</sub> NO <sub>7</sub> S                                            | 81-24-3     | 515.703  | pr (al-eth)        | 125 dec   |                      |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth, AcOEt                |
| 9683 | Taxine A                     |                                                                                       | C <sub>35</sub> H <sub>47</sub> NO <sub>10</sub>                                             | 1361-49-5   | 641.749  | cry (ace)          | 205       |                      |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl                    |
| 9684 | Taxol                        | Paclitaxel                                                                            | C <sub>47</sub> H <sub>51</sub> NO <sub>14</sub>                                             | 33069-62-4  | 853.907  | nd (MeOH aq)       | 214 dec   |                      |                            |                      |                                                         |
| 9685 | Tebuconazole                 |                                                                                       | C <sub>16</sub> H <sub>23</sub> ClN <sub>3</sub> O                                           | 107534-96-3 | 308.826  |                    | 102.4     |                      |                            |                      |                                                         |
| 9686 | Tebuthiuron                  |                                                                                       | C <sub>9</sub> H <sub>16</sub> N <sub>4</sub> OS                                             | 34014-18-1  | 228.314  |                    | 163 dec   |                      |                            |                      |                                                         |
| 9687 | Teniposide                   |                                                                                       | C <sub>32</sub> H <sub>32</sub> O <sub>13</sub> S                                            | 29767-20-2  | 656.653  | cry (EtOH)         | 244       |                      |                            |                      |                                                         |
| 9688 | Tephrosin                    |                                                                                       | C <sub>23</sub> H <sub>22</sub> O <sub>7</sub>                                               | 76-80-2     | 410.417  | pr (chl-MeOH)      | 198       |                      |                            |                      | vs ace, eth, chl                                        |
| 9689 | Terbacil                     | 5-Chloro-3- <i>tert</i> -butyl-6-methyl-2,4-(1 <i>H</i> ,3 <i>H</i> )-pyrimidinedione | C <sub>9</sub> H <sub>13</sub> ClN <sub>2</sub> O <sub>2</sub>                               | 5902-51-2   | 216.664  |                    | 176       | sub 175              | 1.34 <sup>25</sup>         |                      |                                                         |
| 9690 | Terbufos                     |                                                                                       | C <sub>9</sub> H <sub>21</sub> O <sub>2</sub> PS <sub>3</sub>                                | 13071-79-9  | 288.431  |                    | -29.2     | 69 <sup>0.01</sup>   | 1.105 <sup>24</sup>        |                      |                                                         |
| 9691 | Terbutylazine                | 6-Chloro- <i>N-tert</i> -butyl- <i>N'</i> -ethyl-1,3,5-triazine-2,4-diamine           | C <sub>9</sub> H <sub>16</sub> ClN <sub>5</sub>                                              | 5915-41-3   | 229.710  |                    | 178       |                      | 1.188 <sup>20</sup>        |                      |                                                         |
| 9692 | Terbutryn                    |                                                                                       | C <sub>10</sub> H <sub>19</sub> N <sub>3</sub> S                                             | 886-50-0    | 241.357  |                    | 104       | 157 <sup>0.06</sup>  | 1.115 <sup>20</sup>        |                      |                                                         |
| 9693 | Terebic acid                 | Tetrahydro-2,2-dimethyl-5-oxo-3-furancarboxylic acid                                  | C <sub>7</sub> H <sub>10</sub> O <sub>4</sub>                                                | 79-91-4     | 158.152  | cry                | 175       |                      | 0.815                      |                      | sl H <sub>2</sub> O; s EtOH                             |
| 9694 | Terephthalic acid            | 1,4-Benzenedicarboxylic acid                                                          | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                                                 | 100-21-0    | 166.132  | nd (sub)           |           | sub 300              |                            |                      | i H <sub>2</sub> O, EtOH, eth, chl, HOAc; sl ctc        |
| 9695 | Terfenadine                  | Seldane                                                                               | C <sub>32</sub> H <sub>41</sub> NO <sub>2</sub>                                              | 50679-08-8  | 471.674  |                    | 147       |                      |                            |                      | i H <sub>2</sub> O; s EtOH; sl hx                       |
| 9696 | <i>o</i> -Terphenyl          |                                                                                       | C <sub>18</sub> H <sub>14</sub>                                                              | 84-15-1     | 230.304  | mcl pr (MeOH)      | 56.20     | 332                  |                            |                      | i H <sub>2</sub> O; s ace, bz, chl, MeOH                |
| 9697 | <i>m</i> -Terphenyl          |                                                                                       | C <sub>18</sub> H <sub>14</sub>                                                              | 92-06-8     | 230.304  | ye nd (al)         | 87        | 363                  | 1.199 <sup>20</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, bz, HOAc; sl chl       |
| 9698 | <i>p</i> -Terphenyl          |                                                                                       | C <sub>18</sub> H <sub>14</sub>                                                              | 92-94-4     | 230.304  |                    | 213.9     | 376                  |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, CS <sub>2</sub> |
| 9699 | α-Terpinene                  | 4-Isopropyl-1-methyl-1,3-cyclohexadiene                                               | C <sub>10</sub> H <sub>16</sub>                                                              | 99-86-5     | 136.234  |                    |           | 174                  | 0.8375 <sup>19</sup>       | 1.477 <sup>19</sup>  | i H <sub>2</sub> O; msc EtOH, eth                       |

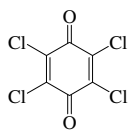




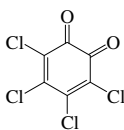
| No.  | Name                                                                | Synonym                                          | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                                   |
|------|---------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|----------------------------|-------|----------------------------------------|----------------------------|-----------------------|--------------------------------------------------------------|
| 9700 | γ-Terpinene                                                         |                                                  | C <sub>10</sub> H <sub>16</sub>                                               | 99-85-4    | 136.234  |                            |       | 183                                    | 0.849 <sup>20</sup>        | 1.4765 <sup>14</sup>  |                                                              |
| 9701 | α-Terpineol                                                         |                                                  | C <sub>10</sub> H <sub>18</sub> O                                             | 2438-12-2  | 154.249  | cry (peth)                 | 40.5  | 220                                    | 0.9337 <sup>20</sup>       | 1.4831 <sup>20</sup>  | sl H <sub>2</sub> O; vs ace, bz, eth, EtOH                   |
| 9702 | α-Terpineol acetate                                                 |                                                  | C <sub>12</sub> H <sub>20</sub> O <sub>2</sub>                                | 80-26-2    | 196.286  |                            |       | 140 <sup>40</sup> , 105 <sup>11</sup>  | 0.9659 <sup>21</sup>       | 1.4689 <sup>21</sup>  | i H <sub>2</sub> O; s EtOH, eth, bz                          |
| 9703 | Terpinolene                                                         | p-Mentha-1,4(8)-diene                            | C <sub>10</sub> H <sub>16</sub>                                               | 586-62-9   | 136.234  |                            |       | 186                                    | 0.8632 <sup>15</sup>       | 1.4883 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s bz, etc                 |
| 9704 | 2,2':6',2''-Terpyridine                                             |                                                  | C <sub>15</sub> H <sub>11</sub> N <sub>3</sub>                                | 1148-79-4  | 233.268  |                            | 88.0  | 370                                    |                            |                       |                                                              |
| 9705 | Terrazole                                                           | 1,2,4-Thiadiazole, 5-ethoxy-3-(trichloromethyl)- | C <sub>6</sub> H <sub>5</sub> Cl <sub>3</sub> N <sub>2</sub> OS               | 2593-15-9  | 247.530  |                            | 19.9  | 95 <sup>1</sup>                        | 1.503 <sup>25</sup>        |                       |                                                              |
| 9706 | 2,2':5',2''-Terthiophene                                            | α-Terthienyl                                     | C <sub>12</sub> H <sub>8</sub> S <sub>3</sub>                                 | 1081-34-1  | 248.387  | ye-oran pl (MeOH)          | 93    |                                        |                            |                       | i H <sub>2</sub> O; sl EtOH; s bz, eth, ace, peth            |
| 9707 | Testolactone                                                        |                                                  | C <sub>19</sub> H <sub>24</sub> O <sub>3</sub>                                | 968-93-4   | 300.392  | cry (ace)                  | 218   |                                        |                            |                       |                                                              |
| 9708 | 3,6,9,12-Tetraazatetradecane-1,14-diamine                           | Pentaethylenehexamine                            | C <sub>10</sub> H <sub>28</sub> N <sub>6</sub>                                | 4067-16-7  | 232.369  | liq                        |       |                                        | 0.950                      | 1.5096 <sup>20</sup>  |                                                              |
| 9709 | Tetrabenazine                                                       |                                                  | C <sub>19</sub> H <sub>27</sub> NO <sub>3</sub>                               | 58-46-8    | 317.422  |                            | 128   |                                        |                            |                       | s chl                                                        |
| 9710 | 1,2,4,5-Tetrabromobenzene                                           |                                                  | C <sub>6</sub> H <sub>2</sub> Br <sub>4</sub>                                 | 636-28-2   | 393.696  | mcl pr (CS <sub>2</sub> )  | 182   | 3.1 <sup>20</sup>                      | 3.072 <sup>20</sup>        |                       | i H <sub>2</sub> O; vs eth                                   |
| 9711 | 1,1,2,2-Tetrabromoethane                                            | Acetylene tetrabromide                           | C <sub>2</sub> H <sub>2</sub> Br <sub>4</sub>                                 | 79-27-6    | 345.653  | ye visc liq                | 0     | 243.5; 151 <sup>54</sup>               | 2.9655 <sup>20</sup>       | 1.6353 <sup>20</sup>  | i H <sub>2</sub> O; msc EtOH, eth; s ace, bz; sl etc         |
| 9712 | Tetrabromoethene                                                    | Tetrabromoethylene                               | C <sub>2</sub> Br <sub>4</sub>                                                | 79-28-7    | 343.637  | pl (dil al), nd (al)       | 56.5  | 226                                    |                            |                       | i H <sub>2</sub> O; s EtOH, eth, ace; vs chl                 |
| 9713 | 2',4',5',7'-Tetrabromofluorescein, disodium salt                    | Eosine YS                                        | C <sub>20</sub> H <sub>6</sub> Br <sub>4</sub> Na <sub>2</sub> O <sub>5</sub> | 17372-87-1 | 691.855  | ye-red cry                 | 295.5 |                                        |                            |                       | vs EtOH                                                      |
| 9714 | 4,5,6,7-Tetrabromo-1,3-isobenzofurandione                           |                                                  | C <sub>8</sub> Br <sub>4</sub> O <sub>3</sub>                                 | 632-79-1   | 463.700  | nd (xyl, HOAc)             | 280   |                                        |                            |                       | i H <sub>2</sub> O, EtOH; sl bz; s PhNO <sub>2</sub>         |
| 9715 | Tetrabromomethane                                                   | Carbon tetrabromide                              | CBr <sub>4</sub>                                                              | 558-13-4   | 331.627  | mcl tab (dil al)           | 92.3  | 189.5                                  | 2.9608 <sup>100</sup>      | 1.5942 <sup>100</sup> | i H <sub>2</sub> O; s EtOH, eth, chl; vs CS <sub>2</sub>     |
| 9716 | 2,3,4,5-Tetrabromo-6-methylphenol                                   | 3,4,5,6-Tetrabromo-o-cresol                      | C <sub>7</sub> H <sub>4</sub> Br <sub>4</sub> O                               | 576-55-6   | 423.722  | ye nd (chl, HOAc)          | 208   | dec                                    |                            |                       | i H <sub>2</sub> O; s EtOH, eth, bz, chl; sl lig, HOAc       |
| 9717 | 3',3'',5',5''-Tetrabromophenolphthalein                             |                                                  | C <sub>20</sub> H <sub>10</sub> Br <sub>4</sub> O <sub>4</sub>                | 76-62-0    | 633.907  | nd (al, eth)               | 296   |                                        |                            |                       | i H <sub>2</sub> O; sl EtOH; vs eth; s alk, HOAc             |
| 9718 | 3',3'',5',5''-Tetrabromophenolphthalein ethyl ester                 |                                                  | C <sub>22</sub> H <sub>14</sub> Br <sub>4</sub> O <sub>4</sub>                | 1176-74-5  | 661.960  | ye cry (bz)                | 210   |                                        |                            |                       |                                                              |
| 9719 | 3',3'',5',5''-Tetrabromophenolphthalein ethyl ester, potassium salt |                                                  | C <sub>22</sub> H <sub>13</sub> Br <sub>4</sub> KO <sub>4</sub>               | 62637-91-6 | 700.050  |                            | 210   |                                        |                            |                       |                                                              |
| 9720 | Tetrabutylammonium bromide                                          | TMAB                                             | C <sub>16</sub> H <sub>36</sub> BrN                                           | 1643-19-2  | 322.368  |                            | 99    |                                        |                            |                       | s chl                                                        |
| 9721 | Tetrabutylammonium chloride                                         |                                                  | C <sub>16</sub> H <sub>36</sub> ClN                                           | 1112-67-0  | 277.917  | cry                        | 74    |                                        |                            |                       |                                                              |
| 9722 | Tetrabutylammonium fluoride                                         |                                                  | C <sub>16</sub> H <sub>36</sub> FN                                            | 429-41-4   | 261.462  | cry (w)                    | 37    |                                        |                            |                       |                                                              |
| 9723 | Tetrabutylammonium hydroxide                                        |                                                  | C <sub>16</sub> H <sub>37</sub> NO                                            | 2052-49-5  | 259.471  | stab in soln               |       |                                        |                            |                       | s H <sub>2</sub> O, MeOH                                     |
| 9724 | Tetrabutylammonium iodide                                           |                                                  | C <sub>16</sub> H <sub>36</sub> IN                                            | 311-28-4   | 369.368  | lf (w, bz)                 | 148   |                                        |                            |                       | sl H <sub>2</sub> O, chl; vs EtOH                            |
| 9725 | Tetrabutylammonium sulfate                                          |                                                  | C <sub>32</sub> H <sub>72</sub> N <sub>2</sub> O <sub>4</sub> S               | 32503-27-8 | 580.990  |                            | 170   |                                        |                            |                       | sl chl                                                       |
| 9726 | Tetrabutylphosphonium bromide                                       |                                                  | C <sub>16</sub> H <sub>36</sub> BrP                                           | 3115-68-2  | 339.335  | cry (ace/eth)              | 102   |                                        |                            |                       |                                                              |
| 9727 | Tetrabutyl silicate                                                 | Silicic acid, tetrabutyl ester                   | C <sub>16</sub> H <sub>36</sub> O <sub>4</sub> Si                             | 4766-57-8  | 320.541  |                            |       | 256; 120 <sup>3</sup>                  | 0.8990 <sup>20</sup>       | 1.4128 <sup>20</sup>  |                                                              |
| 9728 | Tetrabutylstannane                                                  |                                                  | C <sub>16</sub> H <sub>36</sub> Sn                                            | 1461-25-2  | 347.167  | liq                        | -97   | 145 <sup>10</sup> , 95 <sup>0,28</sup> | 1.06 <sup>20</sup>         |                       |                                                              |
| 9729 | N,N,N',N'-Tetrabutylthioperoxydicarbonic diamide                    | Bis(dibutylthiocarbonyl) disulfide               | C <sub>18</sub> H <sub>36</sub> N <sub>2</sub> S <sub>4</sub>                 | 1634-02-2  | 408.752  |                            | 39.5  |                                        | 1.03 <sup>20</sup>         |                       | i H <sub>2</sub> O; sl EtOH; s eth                           |
| 9730 | Tetrabutyl titanate                                                 | Titanium(IV) butoxide                            | C <sub>16</sub> H <sub>36</sub> O <sub>4</sub> Ti                             | 5593-70-4  | 340.322  |                            |       | 292.4                                  |                            |                       |                                                              |
| 9731 | Tetracaine hydrochloride                                            |                                                  | C <sub>15</sub> H <sub>25</sub> ClN <sub>2</sub> O <sub>2</sub>               | 136-47-0   | 300.825  |                            | 147   |                                        |                            |                       |                                                              |
| 9732 | 1,2,3,4-Tetrachlorobenzene                                          |                                                  | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>                                 | 634-66-2   | 215.892  | nd (al)                    | 47.5  | 254                                    |                            |                       | i H <sub>2</sub> O; sl EtOH; vs eth, CS <sub>2</sub>         |
| 9733 | 1,2,3,5-Tetrachlorobenzene                                          |                                                  | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>                                 | 634-90-2   | 215.892  | nd (al)                    | 54.5  | 246                                    |                            |                       | i H <sub>2</sub> O                                           |
| 9734 | 1,2,4,5-Tetrachlorobenzene                                          |                                                  | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>                                 | 95-94-3    | 215.892  | nd, mcl pr (eth, al or bz) | 139.5 | 244.5                                  | 1.858 <sup>22</sup>        |                       | i H <sub>2</sub> O; sl EtOH; s eth, bz, chl, CS <sub>2</sub> |
| 9735 | 3,4,5,6-Tetrachloro-1,2-benzenediol                                 |                                                  | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub> O <sub>2</sub>                  | 1198-55-6  | 247.891  | cry (dil al, bz)           | 194   |                                        |                            |                       | sl H <sub>2</sub> O                                          |
| 9736 | 2,3,5,6-Tetrachloro-1,4-benzenediol                                 |                                                  | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub> O <sub>2</sub>                  | 87-87-6    | 247.891  | nd (HOAc)                  |       | sub                                    |                            |                       | i H <sub>2</sub> O, bz, etc; vs EtOH, eth; sl HOAc           |
| 9737 | 2,2',4',5-Tetrachlorobiphenyl                                       |                                                  | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub>                                | 41464-40-8 | 291.988  | cry (MeOH)                 | 66.5  |                                        |                            |                       | i H <sub>2</sub> O                                           |
| 9738 | 2,3,4,5-Tetrachlorobiphenyl                                         |                                                  | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub>                                | 33284-53-6 | 291.988  | cry                        | 92.2  |                                        |                            |                       | i H <sub>2</sub> O                                           |
| 9739 | 3,3',4',4'-Tetrachlorobiphenyl                                      |                                                  | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub>                                | 32598-13-3 | 291.988  | cry (EtOH)                 | 180   |                                        |                            |                       |                                                              |
| 9740 | 2,2',6,6'-Tetrachlorobisphenol A                                    |                                                  | C <sub>15</sub> H <sub>12</sub> Cl <sub>4</sub> O <sub>2</sub>                | 79-95-8    | 366.067  | cry (HOAc)                 | 136   |                                        |                            |                       |                                                              |



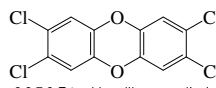
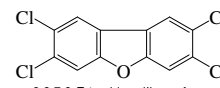
| No.  | Name                                                  | Synonym                                                         | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form                | mp/°C  | bp/°C                    | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                         |
|------|-------------------------------------------------------|-----------------------------------------------------------------|------------------------------------------------------------------|------------|----------|------------------------------|--------|--------------------------|----------------------------|----------------------|----------------------------------------------------|
| 9741 | 2,3,5,6-Tetrachloro-2,5-cyclohexadiene-1,4-dione      | Chloranil                                                       | C <sub>6</sub> Cl <sub>4</sub> O <sub>2</sub>                    | 118-75-2   | 245.875  | ye mcl, pr (bz) ye lf (HOAc) | 290    | sub                      |                            |                      | i H <sub>2</sub> O; liq; sl EtOH, chl; s eth       |
| 9742 | 3,4,5,6-Tetrachloro-3,5-cyclohexadiene-1,2-dione      |                                                                 | C <sub>6</sub> Cl <sub>4</sub> O <sub>2</sub>                    | 2435-53-2  | 245.875  |                              | 130.5  |                          |                            |                      |                                                    |
| 9743 | 2,3,7,8-Tetrachlorodibenzo- <i>p</i> -dioxin          | Dioxin                                                          | C <sub>12</sub> H <sub>4</sub> Cl <sub>4</sub> O <sub>2</sub>    | 1746-01-6  | 321.971  | nd                           | 295    |                          |                            |                      |                                                    |
| 9744 | 2,3,7,8-Tetrachlorodibenzofuran                       |                                                                 | C <sub>12</sub> H <sub>4</sub> Cl <sub>4</sub> O                 | 51207-31-9 | 305.971  | cry                          | 227    |                          |                            |                      |                                                    |
| 9745 | 1,1,1,2-Tetrachloro-2,2-difluoroethane                |                                                                 | C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>                    | 76-11-9    | 203.830  |                              | 41.0   | 92.8                     | 1.649 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, eth, chl               |
| 9746 | 1,1,2,2-Tetrachloro-1,2-difluoroethane                |                                                                 | C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>                    | 76-12-0    | 203.830  |                              | 24.8   | 92.8                     | 1.5951 <sup>50</sup>       | 1.4130 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, chl               |
| 9747 | 1,2,3,4-Tetrachloro-5,5-dimethoxy-1,3-cyclopentadiene |                                                                 | C <sub>7</sub> H <sub>6</sub> Cl <sub>4</sub> O <sub>2</sub>     | 2207-27-4  | 263.934  |                              |        | 109                      | 1.501 <sup>25</sup>        | 1.5282 <sup>20</sup> |                                                    |
| 9748 | 1,2,3,4-Tetrachloro-5,6-dimethylbenzene               |                                                                 | C <sub>8</sub> H <sub>6</sub> Cl <sub>4</sub>                    | 877-08-7   | 243.946  |                              | 228    |                          |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz                |
| 9749 | 1,2,3,5-Tetrachloro-4,6-dimethylbenzene               |                                                                 | C <sub>8</sub> H <sub>6</sub> Cl <sub>4</sub>                    | 877-09-8   | 243.946  |                              | 223    |                          | 1.703 <sup>25</sup>        |                      | i H <sub>2</sub> O, EtOH, eth, bz, chl             |
| 9750 | 1,1,2,2-Tetrachloro-1,2-dimethyldisilane              |                                                                 | C <sub>2</sub> H <sub>6</sub> Cl <sub>4</sub> Si <sub>2</sub>    | 4518-98-3  | 228.052  |                              |        | 154                      |                            |                      |                                                    |
| 9751 | 1,1,1,2-Tetrachloroethane                             |                                                                 | C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                    | 630-20-6   | 167.849  | liq                          | -70.2  | 130.2                    | 1.5406 <sup>20</sup>       | 1.4821 <sup>20</sup> | sl H <sub>2</sub> O; s ace, bz, chl; msc EtOH, eth |
| 9752 | 1,1,2,2-Tetrachloroethane                             | Acetylene tetrachloride                                         | C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                    | 79-34-5    | 167.849  | liq                          | -42.4  | 145.2                    | 1.5953 <sup>20</sup>       | 1.4940 <sup>20</sup> | sl H <sub>2</sub> O; s ace, bz, chl; msc EtOH, eth |
| 9753 | Tetrachloroethene                                     | Perchloroethylene                                               | C <sub>2</sub> Cl <sub>4</sub>                                   | 127-18-4   | 165.833  | liq                          | -22.3  | 121.3                    | 1.6230 <sup>20</sup>       | 1.5059 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, bz              |
| 9754 | 1,1,1,2-Tetrachloro-2-fluoroethane                    |                                                                 | C <sub>2</sub> HCl <sub>3</sub> F                                | 354-11-0   | 185.839  | liq                          | -95.3  | 117.1                    |                            |                      |                                                    |
| 9755 | 1,1,2,2-Tetrachloro-1-fluoroethane                    |                                                                 | C <sub>2</sub> HCl <sub>3</sub> F                                | 354-14-3   | 185.839  | liq                          | -82.6  | 116.7                    | 1.5497 <sup>17</sup>       | 1.4390 <sup>20</sup> |                                                    |
| 9756 | Tetrachloromethane                                    | Carbon tetrachloride                                            | CCl <sub>4</sub>                                                 | 56-23-5    | 153.823  | liq                          | -22.62 | 76.8                     | 1.5940 <sup>20</sup>       | 1.4601 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace; msc eth, bz, chl  |
| 9757 | 2,3,5,6-Tetrachloro-4-methoxyphenol                   | Drosophilin A                                                   | C <sub>7</sub> H <sub>4</sub> Cl <sub>4</sub> O <sub>2</sub>     | 484-67-3   | 261.918  |                              | 116    |                          |                            |                      |                                                    |
| 9758 | 2,3,4,6-Tetrachloro-5-methylphenol                    |                                                                 | C <sub>7</sub> H <sub>4</sub> Cl <sub>4</sub> O                  | 10460-33-0 | 245.918  | nd (peth)                    | 189.5  |                          |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, KOH      |
| 9759 | 1,2,3,4-Tetrachloronaphthalene                        |                                                                 | C <sub>10</sub> H <sub>4</sub> Cl <sub>4</sub>                   | 20020-02-4 | 265.951  |                              | 199    |                          |                            |                      |                                                    |
| 9760 | 1,2,3,4-Tetrachloro-5-nitrobenzene                    |                                                                 | C <sub>6</sub> HCl <sub>4</sub> NO <sub>2</sub>                  | 879-39-0   | 260.890  |                              | 66     |                          |                            |                      |                                                    |
| 9761 | 1,2,4,5-Tetrachloro-3-nitrobenzene                    |                                                                 | C <sub>6</sub> HCl <sub>4</sub> NO <sub>2</sub>                  | 117-18-0   | 260.890  |                              | 99.5   | 304                      | 1.744 <sup>25</sup>        |                      | i H <sub>2</sub> O; s EtOH, bz, chl                |
| 9762 | 2,3,4,5-Tetrachlorophenol                             |                                                                 | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub> O                  | 4901-51-3  | 231.891  | nd (peth, sub)               | 116.5  | sub                      |                            |                      | vs EtOH                                            |
| 9763 | 2,3,4,6-Tetrachlorophenol                             |                                                                 | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub> O                  | 58-90-2    | 231.891  | nd (lig)                     | 70     | 150 <sup>15</sup>        |                            |                      | i H <sub>2</sub> O; s EtOH, bz, chl, HOAc; vs NaOH |
| 9764 | 2,3,5,6-Tetrachlorophenol                             |                                                                 | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub> O                  | 935-95-5   | 231.891  | lf (lig)                     | 115    |                          |                            |                      | sl H <sub>2</sub> O; vs bz; s lig                  |
| 9765 | Tetrachlorophthalic anhydride                         |                                                                 | C <sub>6</sub> Cl <sub>4</sub> O <sub>3</sub>                    | 117-08-8   | 285.896  |                              | 254.5  | sub                      | 1.49 <sup>275</sup>        |                      | sl eth                                             |
| 9766 | 1,1,1,2-Tetrachloropropane                            |                                                                 | C <sub>3</sub> H <sub>4</sub> Cl <sub>4</sub>                    | 812-03-3   | 181.876  | liq                          | -64    | 152.5                    | 1.473 <sup>20</sup>        | 1.4867 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; s eth, chl            |
| 9767 | 1,1,1,3-Tetrachloropropane                            |                                                                 | C <sub>3</sub> H <sub>4</sub> Cl <sub>4</sub>                    | 1070-78-6  | 181.876  |                              |        | 157                      | 1.4509 <sup>20</sup>       | 1.4825 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, bz, chl          |
| 9768 | 1,1,2,3-Tetrachloropropane                            |                                                                 | C <sub>3</sub> H <sub>4</sub> Cl <sub>4</sub>                    | 18495-30-2 | 181.876  |                              |        | 179.5                    | 1.513 <sup>17</sup>        | 1.5037 <sup>17</sup> | i H <sub>2</sub> O; s EtOH, chl; vs eth            |
| 9769 | 1,2,2,3-Tetrachloropropane                            |                                                                 | C <sub>3</sub> H <sub>4</sub> Cl <sub>4</sub>                    | 13116-53-5 | 181.876  |                              |        | 165                      | 1.500 <sup>18</sup>        | 1.4940 <sup>18</sup> | i H <sub>2</sub> O; vs EtOH, eth; s chl            |
| 9770 | 1,1,2,3-Tetrachloropropene                            |                                                                 | C <sub>3</sub> H <sub>2</sub> Cl <sub>4</sub>                    | 10436-39-2 | 179.860  | liq                          |        | 167.2; 59 <sup>17</sup>  | 1.55 <sup>20</sup>         |                      |                                                    |
| 9771 | 2,3,5,6-Tetrachloropyridine                           |                                                                 | C <sub>5</sub> HCl <sub>4</sub> N                                | 2402-79-1  | 216.881  | cry (aq al)                  | 90.5   | 250.5                    |                            |                      | vs eth, EtOH, peth                                 |
| 9772 | Tetrachloropyrimidine                                 |                                                                 | C <sub>4</sub> Cl <sub>4</sub> N <sub>2</sub>                    | 1780-40-1  | 217.868  |                              | 69.0   |                          |                            |                      |                                                    |
| 9773 | 3,3',4',5'-Tetrachlorosalicylanilide                  | 3,5-Dichloro- <i>N</i> -(3,4-dichlorophenyl)-2-hydroxybenzamide | C <sub>13</sub> H <sub>7</sub> Cl <sub>4</sub> NO <sub>2</sub>   | 1154-59-2  | 351.013  |                              | 161    |                          |                            |                      |                                                    |
| 9774 | 2,3,5,6-Tetrachloroterphthaloyl dichloride            |                                                                 | C <sub>8</sub> Cl <sub>6</sub> O <sub>2</sub>                    | 719-32-4   | 340.803  | cry (ctc)                    | 146.5  |                          |                            |                      |                                                    |
| 9775 | Tetrachlorothiophene                                  |                                                                 | C <sub>4</sub> Cl <sub>4</sub> S                                 | 6012-97-1  | 221.920  | nd (dil al)                  | 30.5   | 233.4                    | 1.7036 <sup>30</sup>       | 1.5915 <sup>30</sup> | i H <sub>2</sub> O; vs EtOH; msc eth               |
| 9776 | Tetrachlorovinphos                                    |                                                                 | C <sub>10</sub> H <sub>9</sub> Cl <sub>4</sub> O <sub>4</sub> P  | 961-11-5   | 365.961  |                              | 97     |                          |                            |                      |                                                    |
| 9777 | Tetracontane                                          |                                                                 | C <sub>40</sub> H <sub>82</sub>                                  | 4181-95-7  | 563.079  |                              | 81.5   | 522; 400 <sup>50</sup>   | 0.8171 <sup>25</sup>       | 1.4572 <sup>25</sup> |                                                    |
| 9778 | Tetracosamethylundecasiloxane                         | Tetracosamethylhendecasiloxane                                  | C <sub>24</sub> H <sub>72</sub> O <sub>10</sub> Si <sub>11</sub> | 107-53-9   | 829.764  |                              |        | 322.8; 202 <sup>47</sup> | 0.9247 <sup>25</sup>       | 1.3994 <sup>20</sup> | vs bz                                              |
| 9779 | Tetracosane                                           |                                                                 | C <sub>24</sub> H <sub>50</sub>                                  | 646-31-1   | 338.654  | cry (eth)                    | 50.4   | 391.3                    | 0.7991 <sup>20</sup>       | 1.4283 <sup>70</sup> | i H <sub>2</sub> O; sl EtOH; vs eth                |



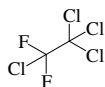
2,3,5,6-Tetrachloro-2,5-cyclohexadiene-1,4-dione



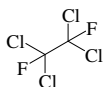
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2,3,7,8-Tetrachlorodibenzo-*p*-dioxin

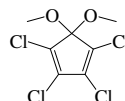
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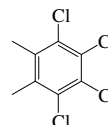
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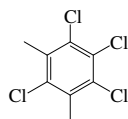
1,1,2,2-Tetrachloro-1,2-difluoroethane



1,2,3,4-Tetrachloro-5,5-dimethoxy-1,3-cyclopentadiene



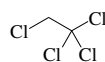
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1,2,3,5-Tetrachloro-4,6-dimethylbenzene



1,1,2,2-Tetrachloro-1,2-dimethyldisilane



1,1,1,2-Tetrachloroethane



1,1,2,2-Tetrachloroethane



Tetrachloroethene



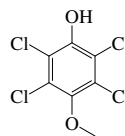
1,1,1,2-Tetrachloro-2-fluoroethane



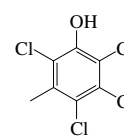
1,1,2,2-Tetrachloro-1-fluoroethane



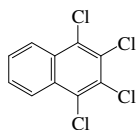
Tetrachloromethane



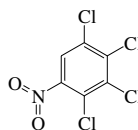
2,3,5,6-Tetrachloro-4-methoxyphenol



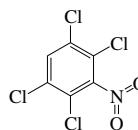
2,3,4,6-Tetrachloro-5-methylphenol



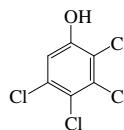
1,2,3,4-Tetrachloronaphthalene



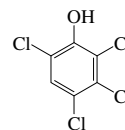
1,2,3,4-Tetrachloro-5-nitrobenzene



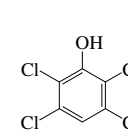
1,2,4,5-Tetrachloro-3-nitrobenzene



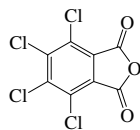
2,3,4,5-Tetrachlorophenol



2,3,4,6-Tetrachlorophenol



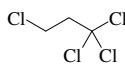
2,3,5,6-Tetrachlorophenol



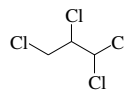
Tetrachlorophthalic anhydride



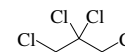
1,1,1,2-Tetrachloropropane



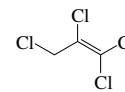
1,1,1,3-Tetrachloropropane



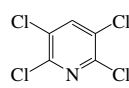
1,1,2,3-Tetrachloropropane



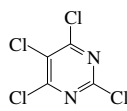
1,2,2,3-Tetrachloropropane



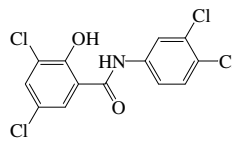
1,1,2,3-Tetrachloropropene



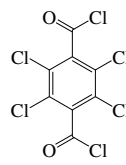
2,3,5,6-Tetrachloropyridine



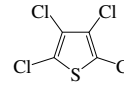
Tetrachloropyrimidine



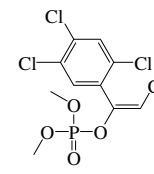
3,3',4',5-Tetrachlorosalicylanilide



2,3,5,6-Tetrachloroterphthaloyl dichloride



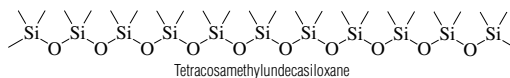
Tetrachlorothiophene



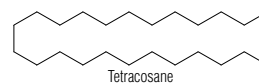
Tetrachlorovinphos



Tetracontane

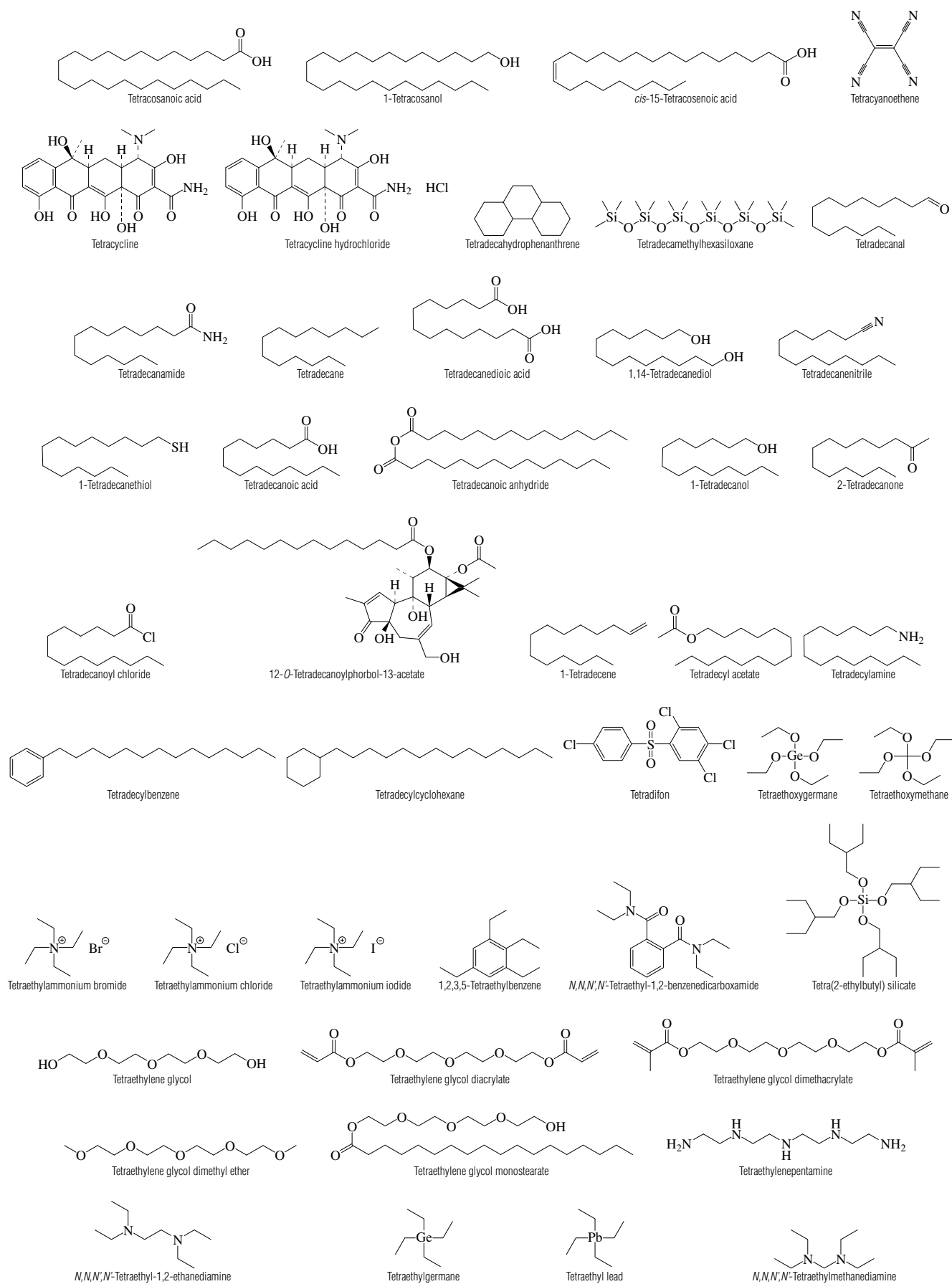


Tetraacosamethylundecasiloxane

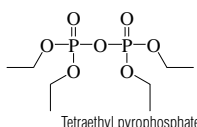


Tetracosane

| No.  | Name                                                  | Synonym                                             | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form | mp/°C   | bp/°C                                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                          |
|------|-------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------|------------|----------|---------------|---------|----------------------------------------|----------------------------|-----------------------|-----------------------------------------------------|
| 9780 | Tetracosanoic acid                                    | Lignoceric acid                                     | C <sub>24</sub> H <sub>48</sub> O <sub>2</sub>                  | 557-59-5   | 368.637  |               | 87.5    | 272 <sup>10</sup>                      | 0.8207 <sup>100</sup>      | 1.4287 <sup>100</sup> | vs bz, eth                                          |
| 9781 | 1-Tetracosanol                                        |                                                     | C <sub>24</sub> H <sub>50</sub> O                               | 506-51-4   | 354.653  |               | 77      | 210 <sup>0.4</sup>                     |                            |                       |                                                     |
| 9782 | <i>cis</i> -15-Tetracosenoic acid                     | Nervonic acid                                       | C <sub>24</sub> H <sub>46</sub> O <sub>2</sub>                  | 506-37-6   | 366.621  |               | 43      |                                        |                            |                       |                                                     |
| 9783 | Tetracyanoethene                                      | Tetracyanoethylene                                  | C <sub>6</sub> N <sub>4</sub>                                   | 670-54-2   | 128.091  |               | 199     | 223                                    | 1.348 <sup>25</sup>        | 1.560 <sup>25</sup>   | sl eth, bz, ctc, chl; s ace                         |
| 9784 | Tetracycline                                          |                                                     | C <sub>22</sub> H <sub>24</sub> N <sub>2</sub> O <sub>6</sub>   | 60-54-8    | 444.434  | cry (+3w)     | 172 dec |                                        |                            |                       |                                                     |
| 9785 | Tetracycline hydrochloride                            |                                                     | C <sub>22</sub> H <sub>25</sub> ClN <sub>2</sub> O <sub>6</sub> | 64-75-5    | 480.895  |               | 214     |                                        |                            |                       |                                                     |
| 9786 | Tetradecahydrophenanthrene                            |                                                     | C <sub>14</sub> H <sub>24</sub>                                 | 5743-97-5  | 192.341  | liq           | -3      | 270; 87 <sup>2</sup>                   | 0.944 <sup>20</sup>        | 1.5011 <sup>20</sup>  | i H <sub>2</sub> O; s eth, ace, bz                  |
| 9787 | Tetradecamethylhexasiloxane                           |                                                     | C <sub>14</sub> H <sub>42</sub> O <sub>5</sub> Si <sub>6</sub>  | 107-52-8   | 458.993  | liq           | -59     | 245.5                                  | 0.8910 <sup>20</sup>       | 1.3948 <sup>20</sup>  | vs bz                                               |
| 9788 | Tetradecanal                                          |                                                     | C <sub>14</sub> H <sub>28</sub> O                               | 124-25-4   | 212.371  | lf            | 30      |                                        |                            |                       | i H <sub>2</sub> O; s EtOH, eth, ace                |
| 9789 | Tetradecanamide                                       |                                                     | C <sub>14</sub> H <sub>29</sub> NO                              | 638-58-4   | 227.386  | lf (ace)      | 104     | 217 <sup>12</sup>                      |                            |                       | vs EtOH                                             |
| 9790 | Tetradecane                                           |                                                     | C <sub>14</sub> H <sub>30</sub>                                 | 629-59-4   | 198.388  |               | 5.82    | 253.58                                 | 0.7596 <sup>20</sup>       | 1.4290 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth; s ctc             |
| 9791 | Tetradecanedioic acid                                 |                                                     | C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>                  | 821-38-5   | 258.354  |               | 125.5   |                                        |                            |                       |                                                     |
| 9792 | 1,14-Tetradecanediol                                  |                                                     | C <sub>14</sub> H <sub>30</sub> O <sub>2</sub>                  | 19812-64-7 | 230.387  | nd (bz)       | 85.8    | 200 <sup>9</sup>                       |                            |                       | vs eth, EtOH                                        |
| 9793 | Tetradecanenitrile                                    | Myristonitrile                                      | C <sub>14</sub> H <sub>27</sub> N                               | 629-63-0   | 209.371  |               | 19      | 226 <sup>100</sup> , 119 <sup>1</sup>  | 0.8281 <sup>19</sup>       | 1.4392 <sup>23</sup>  | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; sl ctc  |
| 9794 | 1-Tetradecanethiol                                    |                                                     | C <sub>14</sub> H <sub>30</sub> S                               | 2079-95-0  | 230.453  |               | 7       | 310; 178 <sup>22</sup>                 | 0.8641 <sup>20</sup>       | 1.4597 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth, ctc                |
| 9795 | Tetradecanoic acid                                    | Myristic acid                                       | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                  | 544-63-8   | 228.371  | lf (eth)      | 54.2    | 250 <sup>100</sup>                     | 0.8622 <sup>54</sup>       | 1.4723 <sup>70</sup>  | i H <sub>2</sub> O; s EtOH, ace, chl; sl eth; vs bz |
| 9796 | Tetradecanoic anhydride                               |                                                     | C <sub>28</sub> H <sub>54</sub> O <sub>3</sub>                  | 626-29-9   | 438.727  | lf (peth)     | 53.4    |                                        | 0.8502 <sup>70</sup>       | 1.4335 <sup>70</sup>  | vs eth, EtOH                                        |
| 9797 | 1-Tetradecanol                                        | Tetradecyl alcohol                                  | C <sub>14</sub> H <sub>30</sub> O                               | 112-72-1   | 214.387  | lf            | 38.2    | 287                                    | 0.8236 <sup>38</sup>       |                       | i H <sub>2</sub> O; vs EtOH, eth, ace, bz, chl      |
| 9798 | 2-Tetradecanone                                       | Dodecyl methyl ketone                               | C <sub>14</sub> H <sub>28</sub> O                               | 2345-27-9  | 212.371  | cry (dil al)  | 33.5    | 205 <sup>100</sup> , 134 <sup>13</sup> |                            |                       | i H <sub>2</sub> O; s EtOH, ace                     |
| 9799 | Tetradecanoyl chloride                                | Myristoyl chloride                                  | C <sub>14</sub> H <sub>27</sub> ClO                             | 112-64-1   | 246.816  |               | -1      | 171 <sup>16</sup>                      | 0.9078 <sup>25</sup>       |                       | s eth                                               |
| 9800 | 12- <i>O</i> -Tetradecanoylphorbol-13-acetate         | Cocarcinogen A1                                     | C <sub>36</sub> H <sub>56</sub> O <sub>8</sub>                  | 16561-29-8 | 616.825  | oil           |         |                                        |                            |                       |                                                     |
| 9801 | 1-Tetradecene                                         |                                                     | C <sub>14</sub> H <sub>28</sub>                                 | 1120-36-1  | 196.372  | liq           | -12     | 233                                    | 0.7745 <sup>25</sup>       | 1.4351 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth; s bz; sl ctc      |
| 9802 | Tetradecyl acetate                                    | 1-Tetradecanol, acetate                             | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                  | 638-59-5   | 256.424  |               |         | 173 <sup>10</sup>                      |                            |                       |                                                     |
| 9803 | Tetradecylamine                                       | 1-Tetradecanamine                                   | C <sub>14</sub> H <sub>31</sub> N                               | 2016-42-4  | 213.403  |               | 83.1    | 291.2                                  | 0.8079 <sup>20</sup>       | 1.4463 <sup>20</sup>  | i H <sub>2</sub> O; vs EtOH, eth, bz, chl; s ace    |
| 9804 | Tetradecylbenzene                                     |                                                     | C <sub>20</sub> H <sub>34</sub>                                 | 1459-10-5  | 274.484  |               | 16      | 359                                    | 0.8549 <sup>20</sup>       | 1.4818 <sup>20</sup>  |                                                     |
| 9805 | Tetradecylcyclohexane                                 |                                                     | C <sub>20</sub> H <sub>40</sub>                                 | 1795-18-2  | 280.532  |               | 24      | 360                                    | 0.8254 <sup>20</sup>       | 1.4579 <sup>20</sup>  |                                                     |
| 9806 | Tetradifon                                            | 1,2,4-Trichloro-5-[(4-chlorophenyl)sulfonyl]benzene | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub> O <sub>2</sub> S | 116-29-0   | 356.052  |               | 146     |                                        | 1.151 <sup>20</sup>        |                       |                                                     |
| 9807 | Tetraethoxygermane                                    | Ethanol, germanium(4+) salt                         | C <sub>8</sub> H <sub>20</sub> GeO <sub>4</sub>                 | 14165-55-0 | 252.88   |               |         | 139 <sup>200</sup>                     |                            |                       |                                                     |
| 9808 | Tetraethoxymethane                                    | Tetraethyl orthocarbonate                           | C <sub>8</sub> H <sub>20</sub> O <sub>4</sub>                   | 78-09-1    | 192.253  |               |         | 159.5                                  | 0.9186 <sup>20</sup>       | 1.3905 <sup>25</sup>  | msc EtOH, eth; s ctc                                |
| 9809 | Tetraethylammonium bromide                            |                                                     | C <sub>8</sub> H <sub>20</sub> BrN                              | 71-91-0    | 210.156  | hyg (al)      | 286 dec |                                        | 1.3970 <sup>20</sup>       |                       | vs H <sub>2</sub> O, EtOH, chl, MeOH                |
| 9810 | Tetraethylammonium chloride                           |                                                     | C <sub>8</sub> H <sub>20</sub> ClN                              | 56-34-8    | 165.705  | hyg cry       |         |                                        |                            |                       | vs H <sub>2</sub> O, EtOH, ace, chl                 |
| 9811 | Tetraethylammonium iodide                             |                                                     | C <sub>8</sub> H <sub>20</sub> IN                               | 68-05-3    | 257.156  | cry (w)       | 300 dec |                                        |                            |                       | s H <sub>2</sub> O                                  |
| 9812 | 1,2,3,5-Tetraethylbenzene                             |                                                     | C <sub>14</sub> H <sub>22</sub>                                 | 38842-05-6 | 190.325  |               |         | 249.0                                  |                            |                       |                                                     |
| 9813 | <i>N,N,N',N'</i> -Tetraethyl-1,2-benzenedicarboxamide | <i>N,N,N',N'</i> -Tetraethylphthalamide             | C <sub>18</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>   | 83-81-8    | 276.374  |               | 36      | 204 <sup>16</sup>                      |                            |                       |                                                     |
| 9814 | Tetra(2-ethylbutyl) silicate                          | Silicic acid, tetrakis(2-ethylbutyl) ester          | C <sub>24</sub> H <sub>52</sub> O <sub>4</sub> Si               | 78-13-7    | 432.754  | liq           |         |                                        | 0.8920 <sup>20</sup>       | 1.4307 <sup>20</sup>  | i H <sub>2</sub> O; sl EtOH, ctc; s eth, bz         |
| 9815 | Tetraethylene glycol                                  | 3,6,9-Trioxaundecane-1,11-diol                      | C <sub>8</sub> H <sub>18</sub> O <sub>5</sub>                   | 112-60-7   | 194.226  | liq           | -6.2    | 328                                    | 1.1285 <sup>15</sup>       | 1.4577 <sup>20</sup>  | vs H <sub>2</sub> O; s EtOH, eth, ctc, diox         |
| 9816 | Tetraethylene glycol diacrylate                       |                                                     | C <sub>14</sub> H <sub>22</sub> O <sub>7</sub>                  | 17831-71-9 | 302.321  |               |         |                                        | 1.125 <sup>25</sup>        |                       |                                                     |
| 9817 | Tetraethylene glycol dimethacrylate                   |                                                     | C <sub>16</sub> H <sub>26</sub> O <sub>7</sub>                  | 109-17-1   | 330.373  |               |         | 220 <sup>1</sup>                       |                            | 1.4610 <sup>25</sup>  |                                                     |
| 9818 | Tetraethylene glycol dimethyl ether                   |                                                     | C <sub>10</sub> H <sub>22</sub> O <sub>3</sub>                  | 143-24-8   | 222.279  |               |         | 275.3                                  | 1.0114 <sup>20</sup>       |                       | msc H <sub>2</sub> O; s EtOH, eth, ctc              |
| 9819 | Tetraethylene glycol monostearate                     |                                                     | C <sub>26</sub> H <sub>52</sub> O <sub>6</sub>                  | 106-07-0   | 460.687  |               | 40      | 328                                    | 1.1285 <sup>15</sup>       | 1.4593 <sup>20</sup>  |                                                     |
| 9820 | Tetraethylenepentamine                                |                                                     | C <sub>8</sub> H <sub>23</sub> N <sub>5</sub>                   | 112-57-2   | 189.303  |               |         | 341.5                                  |                            | 1.5042 <sup>20</sup>  | s H <sub>2</sub> O                                  |
| 9821 | <i>N,N,N',N'</i> -Tetraethyl-1,2-ethanediamine        |                                                     | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub>                  | 150-77-6   | 172.311  |               |         | 192                                    | 0.808 <sup>25</sup>        | 1.4343 <sup>20</sup>  |                                                     |
| 9822 | Tetraethylgermane                                     |                                                     | C <sub>8</sub> H <sub>20</sub> Ge                               | 597-63-7   | 188.89   |               |         | 164.5                                  | 1.199                      |                       |                                                     |
| 9823 | Tetraethyl lead                                       |                                                     | C <sub>8</sub> H <sub>20</sub> Pb                               | 78-00-2    | 323.4    |               |         | dec 200                                | 1.653 <sup>20</sup>        | 1.5198 <sup>20</sup>  | i H <sub>2</sub> O; s bz; sl EtOH                   |
| 9824 | <i>N,N,N',N'</i> -Tetraethylmethanediamine            |                                                     | C <sub>8</sub> H <sub>22</sub> N <sub>2</sub>                   | 102-53-4   | 158.284  |               |         | 165.8                                  | 0.8000 <sup>20</sup>       | 1.4420 <sup>25</sup>  |                                                     |



| No.  | Name                                                                          | Synonym                                        | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|------|-------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------|------------|----------|----------------------------|---------|--------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 9825 | Tetraethyl pyrophosphate                                                      |                                                | C <sub>8</sub> H <sub>20</sub> O <sub>7</sub> P <sub>2</sub>  | 107-49-3   | 290.188  |                            | 170 dec | 155 <sup>3</sup>                     | 1.1847 <sup>20</sup>       | 1.4180 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth, ace, xyl, chl; sl ctc |
| 9826 | Tetraethylsilane                                                              |                                                | C <sub>8</sub> H <sub>20</sub> Si                             | 631-36-7   | 144.331  |                            |         | 154.7                                | 0.7658 <sup>20</sup>       | 1.4268 <sup>20</sup> | i H <sub>2</sub> O                                     |
| 9827 | Tetraethylstannane                                                            | Tin tetraethyl                                 | C <sub>8</sub> H <sub>20</sub> Sn                             | 597-64-8   | 234.955  | liq                        | -112    | 181; 64 <sup>12</sup>                | 1.187 <sup>25</sup>        | 1.4730 <sup>20</sup> |                                                        |
| 9828 | Tetraethylthiocarbonic diamide                                                | Sulfiram                                       | C <sub>10</sub> H <sub>20</sub> N <sub>2</sub> S <sub>3</sub> | 95-05-6    | 264.474  |                            |         | 232 <sup>3</sup>                     | 1.12 <sup>20</sup>         |                      | s chl                                                  |
| 9829 | Tetraethylurea                                                                |                                                | C <sub>8</sub> H <sub>20</sub> N <sub>2</sub> O               | 1187-03-7  | 172.267  |                            |         | 209                                  | 0.919 <sup>20</sup>        | 1.4474 <sup>20</sup> | i H <sub>2</sub> O, alk, acid                          |
| 9830 | 1,2,3,4-Tetrafluorobenzene                                                    |                                                | C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>                  | 551-62-2   | 150.074  |                            |         | 94.3                                 |                            | 1.4054 <sup>20</sup> |                                                        |
| 9831 | 1,2,3,5-Tetrafluorobenzene                                                    |                                                | C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>                  | 2367-82-0  | 150.074  | liq                        | -46.25  | 84.4                                 | 1.319 <sup>25</sup>        | 1.4035 <sup>20</sup> |                                                        |
| 9832 | 1,2,4,5-Tetrafluorobenzene                                                    |                                                | C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>                  | 327-54-8   | 150.074  |                            | 3.88    | 90.2                                 | 1.4255 <sup>20</sup>       | 1.4075 <sup>20</sup> |                                                        |
| 9833 | 3,3,4,4-Tetrafluorodihydro-2,5-furandione                                     |                                                | C <sub>4</sub> F <sub>4</sub> O <sub>3</sub>                  | 699-30-9   | 172.035  |                            |         | 54.5                                 | 1.6209 <sup>20</sup>       | 1.3240 <sup>20</sup> |                                                        |
| 9834 | 1,1,2,2-Tetrafluoro-1,2-dinitroethane                                         |                                                | C <sub>2</sub> F <sub>4</sub> N <sub>2</sub> O <sub>4</sub>   | 356-16-1   | 192.026  | liq                        | -41.5   | 58.5                                 | 1.6024 <sup>25</sup>       | 1.3265 <sup>25</sup> | i H <sub>2</sub> O; s ace                              |
| 9835 | 1,1,1,2-Tetrafluoroethane                                                     |                                                | C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>                  | 811-97-2   | 102.031  | col gas                    | -103.3  | -26.5                                | 1.2072 <sup>25</sup>       |                      | i H <sub>2</sub> O; s eth                              |
| 9836 | 1,1,2,2-Tetrafluoroethane                                                     |                                                | C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>                  | 359-35-3   | 102.031  | col gas                    | -89     | -19.9                                |                            |                      |                                                        |
| 9837 | Tetrafluoroethene                                                             | Tetrafluoroethylene                            | C <sub>2</sub> F <sub>4</sub>                                 | 116-14-3   | 100.015  | col gas                    | -131.15 | -75.9                                | 1.519 <sup>-76</sup>       |                      | i H <sub>2</sub> O                                     |
| 9838 | 1,2,2,2-Tetrafluoroethyl difluoromethyl ether                                 | Refrigerant 236me                              | C <sub>2</sub> H <sub>2</sub> F <sub>6</sub> O                | 57041-67-5 | 168.037  | vol liq or gas             |         | 23.35                                | 1.4540 <sup>23</sup>       |                      |                                                        |
| 9839 | Tetrafluoromethane                                                            | Carbon tetrafluoride                           | CF <sub>4</sub>                                               | 75-73-0    | 88.005   | col gas                    | -183.60 | -128.0                               | 3.034 <sup>25</sup>        |                      | i H <sub>2</sub> O; s bz, chl                          |
| 9840 | 2,2,3,3-Tetrafluoro-1-propanol                                                |                                                | C <sub>3</sub> H <sub>4</sub> F <sub>4</sub> O                | 76-37-9    | 132.057  | liq                        | -15     | 109.5                                | 1.4853 <sup>20</sup>       | 1.3197 <sup>20</sup> | s EtOH, ace, chl                                       |
| 9841 | 6,7,8,9-Tetrahydro-5 <i>H</i> -benzocyclohepten-5-one                         |                                                | C <sub>11</sub> H <sub>12</sub> O                             | 826-73-3   | 160.212  |                            |         | 175 <sup>40</sup> , 124 <sup>7</sup> | 1.080 <sup>20</sup>        | 1.5698 <sup>20</sup> | s EtOH                                                 |
| 9842 | 2,3,6,7-Tetrahydro-1 <i>H</i> ,5 <i>H</i> -benzo[ <i>ij</i> ]quinolizine      | Julolidine                                     | C <sub>12</sub> H <sub>13</sub> N                             | 479-59-4   | 173.254  |                            | 40      | dec 280; 155 <sup>17</sup>           | 1.003 <sup>20</sup>        | 1.568 <sup>25</sup>  |                                                        |
| 9843 | 1,2,3,6-Tetrahydro-2,3'-bipyridine ( <i>S</i> )                               | Anatabine                                      | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub>                | 581-49-7   | 160.215  |                            |         | 145 <sup>10</sup>                    | 1.091 <sup>19</sup>        | 1.5676 <sup>20</sup> | msc H <sub>2</sub> O; s EtOH, eth, bz                  |
| 9844 | 2,3,4,9-Tetrahydro-1 <i>H</i> -carbazole                                      |                                                | C <sub>12</sub> H <sub>13</sub> N                             | 942-01-8   | 171.238  | lf (dil al)                | 120     | 327.5                                |                            |                      | i H <sub>2</sub> O; s EtOH; vs eth, bz, MeOH           |
| 9845 | Tetrahydrocortisone                                                           |                                                | C <sub>21</sub> H <sub>32</sub> O <sub>5</sub>                | 53-05-4    | 364.476  | cry (EtOAc)                | 190     |                                      |                            |                      |                                                        |
| 9846 | 1,2,3,4-Tetrahydro-6,7-dimethoxy-1,2-dimethylisoquinoline, (±)                | Carnegine                                      | C <sub>13</sub> H <sub>19</sub> NO <sub>2</sub>               | 490-53-9   | 221.296  | pa br syr                  |         | 170 <sup>1</sup>                     |                            |                      | vs H <sub>2</sub> O, eth, EtOH                         |
| 9847 | Tetrahydro-2,5-dimethoxyfuran                                                 |                                                | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                 | 696-59-3   | 132.157  |                            |         | 145.7                                | 1.02 <sup>25</sup>         | 1.4180 <sup>20</sup> |                                                        |
| 9848 | 4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran                                     |                                                | C <sub>10</sub> H <sub>14</sub> O                             | 494-90-6   | 150.217  |                            | 86      | 80 <sup>18</sup>                     | 0.972 <sup>15</sup>        |                      |                                                        |
| 9849 | 1,2,3,4-Tetrahydro-1,5-dimethylnaphthalene                                    |                                                | C <sub>12</sub> H <sub>16</sub>                               | 21564-91-0 | 160.255  |                            |         | 239                                  | 0.941 <sup>20</sup>        | 1.526 <sup>20</sup>  |                                                        |
| 9850 | Tetrahydro-2,2-dimethyl-5-oxo-3-furanacetic acid                              | Terpenylic acid                                | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                 | 26754-48-3 | 172.179  | lf or pr (w+1)             | 90      |                                      |                            |                      | vs H <sub>2</sub> O                                    |
| 9851 | <i>cis</i> -Tetrahydro-2,5-dimethylthiophene                                  |                                                | C <sub>6</sub> H <sub>12</sub> S                              | 5161-13-7  | 116.224  | liq                        | -89     | 142.3                                | 0.9222 <sup>20</sup>       | 1.4799 <sup>20</sup> | vs ace, bz, eth, EtOH                                  |
| 9852 | 1,2,3,4-Tetrahydro-9 <i>H</i> -fluoren-9-one                                  | Phentydrone                                    | C <sub>13</sub> H <sub>12</sub> O                             | 634-19-5   | 184.233  | lt ye nd or pr (pentane)   | 81.5    | 139 <sup>0.05</sup>                  |                            |                      |                                                        |
| 9853 | 5,6,7,8-Tetrahydrofolic acid                                                  |                                                | C <sub>19</sub> H <sub>23</sub> N <sub>7</sub> O <sub>5</sub> | 135-16-0   | 445.429  | pow                        |         |                                      |                            |                      | s H <sub>2</sub> O                                     |
| 9854 | Tetrahydrofuran                                                               | Tetramethylene oxide                           | C <sub>4</sub> H <sub>8</sub> O                               | 109-99-9   | 72.106   | liq                        | -108.44 | 65                                   | 0.8833 <sup>25</sup>       | 1.4050 <sup>25</sup> | s H <sub>2</sub> O, chl; vs EtOH, eth, ace, bz         |
| 9855 | Tetrahydro-2-furanmethanamine                                                 | Tetrahydrofurfurylamine                        | C <sub>5</sub> H <sub>11</sub> NO                             | 4795-29-3  | 101.147  |                            |         | 153                                  | 0.9752 <sup>20</sup>       | 1.4551 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                         |
| 9856 | Tetrahydro-2-furanmethanol propanoate                                         |                                                | C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>                 | 637-65-0   | 158.195  |                            |         | 205.5                                | 1.044 <sup>20</sup>        |                      | vs eth, EtOH, chl                                      |
| 9857 | Tetrahydro-3-furanol                                                          |                                                | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                  | 453-20-3   | 88.106   |                            |         | 181                                  | 1.09 <sup>25</sup>         | 1.4500 <sup>20</sup> |                                                        |
| 9858 | Tetrahydrofurfuryl acetate                                                    |                                                | C <sub>7</sub> H <sub>12</sub> O <sub>3</sub>                 | 637-64-9   | 144.168  |                            |         | 193; 89 <sup>18</sup>                | 1.0624 <sup>20</sup>       | 1.4350 <sup>25</sup> | vs H <sub>2</sub> O, eth, EtOH, chl                    |
| 9859 | Tetrahydrofurfuryl acrylate                                                   |                                                | C <sub>8</sub> H <sub>12</sub> O <sub>3</sub>                 | 2399-48-6  | 156.179  |                            | <-60    | 96 <sup>6</sup>                      | 1.061 <sup>20</sup>        |                      |                                                        |
| 9860 | Tetrahydrofurfuryl alcohol                                                    | Tetrahydro-2-furancarbinol                     | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                 | 97-99-4    | 102.132  |                            | <-80    | 178                                  | 1.0524 <sup>20</sup>       | 1.4520 <sup>20</sup> | vs ace, eth                                            |
| 9861 | Tetrahydrofurfuryl methacrylate                                               |                                                | C <sub>9</sub> H <sub>14</sub> O <sub>3</sub>                 | 2455-24-5  | 170.205  |                            |         | 265; 81 <sup>4</sup>                 | 1.040 <sup>25</sup>        | 1.4554 <sup>25</sup> |                                                        |
| 9862 | Tetrahydroimidazo[4,5- <i>d</i> ]imidazole-2,5(1 <i>H</i> ,3 <i>H</i> )-dione | Acetyleneurea                                  | C <sub>4</sub> H <sub>6</sub> N <sub>4</sub> O <sub>2</sub>   | 496-46-8   | 142.117  | nd or pr (w)               | 300 dec |                                      |                            |                      | sl H <sub>2</sub> O; i EtOH, HOAc; s eth, HCl, alk     |
| 9863 | <i>cis</i> -3a,4,7,7a-Tetrahydro-1,3-isobenzofurandione                       | 4-Cyclohexene-1,2-dicarboxylic acid, anhydride | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                  | 935-79-5   | 152.148  | cry (peth)                 | 103.5   |                                      |                            |                      | s EtOH, ace, chl, bz; sl peth                          |
| 9864 | 4,5,6,7-Tetrahydro-1,3-isobenzofurandione                                     | 1-Cyclohexene-1,2-dicarboxylic acid, anhydride | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                  | 2426-02-0  | 152.148  | pl (EtOH)                  | 74      |                                      | 1.2 <sup>105</sup>         |                      | s EtOH, ace, chl; vs eth                               |
| 9865 | 1,2,3,4-Tetrahydroisoquinoline                                                |                                                | C <sub>9</sub> H <sub>11</sub> N                              | 91-21-4    | 133.190  |                            | <-15    | 232.5                                | 1.0642 <sup>24</sup>       | 1.5668 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, bz, acid, xyl              |
| 9866 | 3,4,5,6-Tetrahydro-7-methoxy-2 <i>H</i> -azepine                              |                                                | C <sub>7</sub> H <sub>13</sub> NO                             | 2525-16-8  | 127.184  | liq                        |         | 49 <sup>16</sup> , 66 <sup>24</sup>  | 0.887                      | 1.4630 <sup>20</sup> |                                                        |
| 9867 | 1,2,3,4-Tetrahydro-6-methoxyquinoline                                         |                                                | C <sub>10</sub> H <sub>13</sub> NO                            | 120-15-0   | 163.216  | pr (peth, al) orth pym (w) | 42.5    | 284; 128 <sup>1</sup>                |                            | 1.5718 <sup>20</sup> | s chl                                                  |
| 9868 | 1,2,3,4-Tetrahydro-1-methylnaphthalene                                        |                                                | C <sub>11</sub> H <sub>14</sub>                               | 1559-81-5  | 146.229  |                            |         | 220.6                                | 0.9583 <sup>20</sup>       | 1.5353 <sup>20</sup> |                                                        |



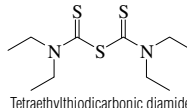
Tetraethyl pyrophosphate



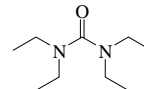
Tetraethylsilane



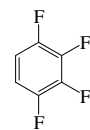
Tetraethylstannane



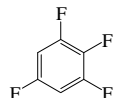
Tetraethylthiodicarbonyl diamide



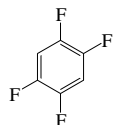
Tetraethylurea



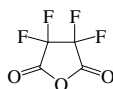
1,2,3,4-Tetrafluorobenzene



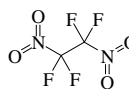
1,2,3,5-Tetrafluorobenzene



1,2,4,5-Tetrafluorobenzene



3,3,4,4-Tetrafluorodihydro-2,5-furandione



1,1,2-Tetrafluoro-1,2-dinitroethane



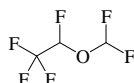
1,1,1,2-Tetrafluoroethane



1,1,2,2-Tetrafluoroethane



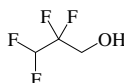
Tetrafluoroethene



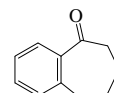
1,2,2,2-Tetrafluoroethyl difluoromethyl ether



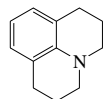
Tetrafluoromethane



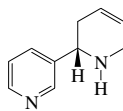
2,2,3,3-Tetrafluoro-1-propanol



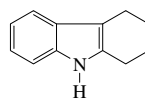
6,7,8,9-Tetrahydro-5H-benzocyclohept-5-one



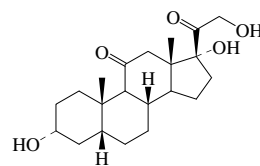
2,3,6,7-Tetrahydro-1H,5H-benzo[ij]quinolizine



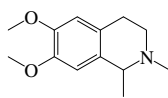
1,2,3,6-Tetrahydro-2,3'-bipyridine, (S)



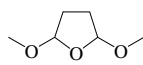
2,3,4,9-Tetrahydro-1H-carbazole



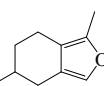
Tetrahydrocortisone



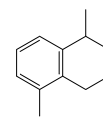
1,2,3,4-Tetrahydro-6,7-dimethoxy-1,2-dimethylisoquinoline, (±)



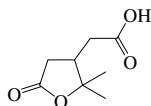
Tetrahydro-2,5-dimethoxyfuran



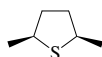
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran



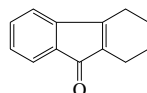
1,2,3,4-Tetrahydro-1,5-dimethylnaphthalene



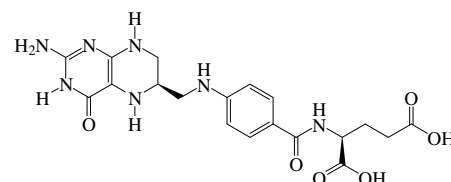
Tetrahydro-2,2-dimethyl-5-oxo-3-furanacetic acid



cis-Tetrahydro-2,5-dimethylthiophene



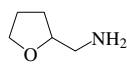
1,2,3,4-Tetrahydro-9H-fluoren-9-one



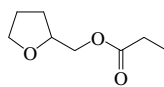
5,6,7,8-Tetrahydrofolic acid



Tetrahydrofuran



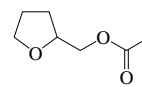
Tetrahydro-2-furanmethanamine



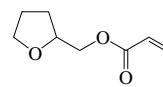
Tetrahydro-2-furanmethanol propanoate



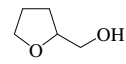
Tetrahydro-3-furanol



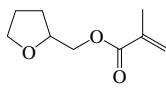
Tetrahydrofurfuryl acetate



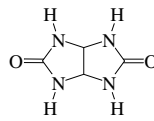
Tetrahydrofurfuryl acrylate



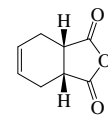
Tetrahydrofurfuryl alcohol



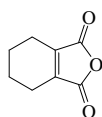
Tetrahydrofurfuryl methacrylate



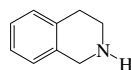
Tetrahydroimidazo[4,5-d]imidazole-2,5-(1H,3H)-dione



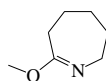
cis-3a,4,7,7a-Tetrahydro-1,3-isobenzofurandione



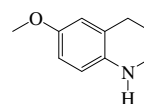
4,5,6,7-Tetrahydro-1,3-isobenzofurandione



1,2,3,4-Tetrahydroisoquinoline



3,4,5,6-Tetrahydro-7-methoxy-2H-azepine



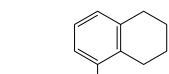
1,2,3,4-Tetrahydro-6-methoxyquinoline



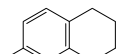
1,2,3,4-Tetrahydro-1-methylnaphthalene



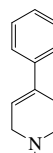
| No.  | Name                                                            | Synonym                                                        | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                 |
|------|-----------------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------|------------|----------|---------------------------|---------|------------------------|----------------------------|----------------------|------------------------------------------------------------|
| 9869 | 1,2,3,4-Tetrahydro-5-methylnaphthalene                          |                                                                | C <sub>11</sub> H <sub>14</sub>                               | 2809-64-5  | 146.229  | liq                       | -23     | 234                    | 0.9720 <sup>20</sup>       | 1.5439 <sup>20</sup> |                                                            |
| 9870 | 1,2,3,4-Tetrahydro-6-methylnaphthalene                          |                                                                | C <sub>11</sub> H <sub>14</sub>                               | 1680-51-9  | 146.229  | liq                       | -40     | 229                    | 0.9537 <sup>20</sup>       | 1.5357 <sup>20</sup> |                                                            |
| 9871 | 1,2,3,6-Tetrahydro-1-methyl-4-phenylpyridine                    | MPTP                                                           | C <sub>12</sub> H <sub>13</sub> N                             | 28289-54-5 | 173.254  | cry                       | 41      | 87 <sup>0.8</sup>      |                            |                      |                                                            |
| 9872 | Tetrahydro-3-methyl-2H-thiopyran                                |                                                                | C <sub>6</sub> H <sub>12</sub> S                              | 5258-50-4  | 116.224  | liq                       | -60     | 158                    | 0.9473 <sup>20</sup>       | 1.4922 <sup>20</sup> |                                                            |
| 9873 | 5,6,7,8-Tetrahydro-1-naphthalenamine                            |                                                                | C <sub>10</sub> H <sub>13</sub> N                             | 2217-41-6  | 147.217  |                           | 38      | 279                    | 1.0625 <sup>16</sup>       | 1.5900 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, acid                     |
| 9874 | 1,2,3,4-Tetrahydronaphthalene                                   | Tetralin                                                       | C <sub>10</sub> H <sub>12</sub>                               | 119-64-2   | 132.202  | liq                       | -35.7   | 207.6                  | 0.9645 <sup>25</sup>       | 1.5413 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s chl, PhNH <sub>2</sub> |
| 9875 | 1,2,3,4-Tetrahydro-1-naphthol                                   | 1,2,3,4-Tetrahydro- $\alpha$ -naphthol                         | C <sub>10</sub> H <sub>12</sub> O                             | 529-33-9   | 148.201  |                           | 34.5    | 255; 103 <sup>2</sup>  | 1.0996 <sup>20</sup>       | 1.5638 <sup>20</sup> |                                                            |
| 9876 | 5,6,7,8-Tetrahydro-1-naphthol                                   | 5,6,7,8-Tetrahydro- $\alpha$ -naphthol                         | C <sub>10</sub> H <sub>12</sub> O                             | 529-35-1   | 148.201  |                           | 70      | 266; 143 <sup>11</sup> | 1.0556 <sup>75</sup>       |                      |                                                            |
| 9877 | 1,2,3,4-Tetrahydro-2-naphthol                                   | Tetralol                                                       | C <sub>10</sub> H <sub>12</sub> O                             | 530-91-6   | 148.201  |                           | 15.5    | 140 <sup>12</sup>      |                            |                      |                                                            |
| 9878 | 5,6,7,8-Tetrahydro-2-naphthol                                   | 5,6,7,8-Tetrahydro- $\beta$ -naphthol                          | C <sub>10</sub> H <sub>12</sub> O                             | 1125-78-6  | 148.201  |                           | 57      | 275.5                  | 1.0552 <sup>85</sup>       |                      |                                                            |
| 9879 | Tetrahydro-6-pentyl-2H-pyran-2-one                              | 5-Hydroxydecanoic acid lactone                                 | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>                | 705-86-2   | 170.249  | liq                       | -27     | 121 <sup>3</sup>       |                            |                      |                                                            |
| 9880 | 1,2,3,4-Tetrahydrophenanthrene                                  |                                                                | C <sub>14</sub> H <sub>14</sub>                               | 1013-08-7  | 182.261  | lf (MeOH)                 | 33.5    | 173 <sup>11</sup>      | 1.0601 <sup>40</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, HOAc, chl, lig   |
| 9881 | 1,2,3,6-Tetrahydrophthalimide                                   |                                                                | C <sub>8</sub> H <sub>6</sub> NO <sub>2</sub>                 | 85-40-5    | 151.163  | cry (EtOH)                | 137     |                        |                            |                      |                                                            |
| 9882 | Tetrahydro-6-propyl-2H-pyran-2-one                              | 5-Hydroxyoctanoic acid lactone                                 | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                 | 698-76-0   | 142.196  | liq                       | -13     | 126 <sup>15</sup>      |                            |                      |                                                            |
| 9883 | 2,3,4,5-Tetrahydro-6-propylpyridine                             | $\gamma$ -Coniceine                                            | C <sub>8</sub> H <sub>13</sub> N                              | 1604-01-9  | 125.212  |                           |         | 174                    | 0.8753 <sup>15</sup>       | 1.4661 <sup>16</sup> |                                                            |
| 9884 | Tetrahydropyran                                                 | Oxane                                                          | C <sub>5</sub> H <sub>10</sub> O                              | 142-68-7   | 86.132   | liq                       | -49.1   | 88                     | 0.8814 <sup>20</sup>       | 1.4200 <sup>20</sup> | s EtOH, eth, bz, ctc                                       |
| 9885 | Tetrahydro-2H-pyran-2-methanol                                  |                                                                | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                 | 100-72-1   | 116.158  |                           |         | 185                    | 1.027 <sup>25</sup>        | 1.458 <sup>20</sup>  |                                                            |
| 9886 | Tetrahydro-2H-pyran-2-one                                       |                                                                | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                  | 542-28-9   | 100.117  | liq                       | -12.5   | 219                    | 1.1082 <sup>20</sup>       | 1.4503 <sup>20</sup> | s H <sub>2</sub> O; msc EtOH, eth; sl ctc                  |
| 9887 | Tetrahydro-4H-pyran-4-one                                       |                                                                | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                  | 29943-42-8 | 100.117  |                           |         | 166.5                  | 1.084 <sup>25</sup>        | 1.4520 <sup>20</sup> |                                                            |
| 9888 | 1,2,5,6-Tetrahydropyridine                                      | $\Delta^3$ -Piperidine                                         | C <sub>5</sub> H <sub>9</sub> N                               | 694-05-3   | 83.132   | liq                       | -48     | 108                    | 0.911 <sup>25</sup>        | 1.4800 <sup>20</sup> | s chl                                                      |
| 9889 | 1,2,5,6-Tetrahydro-3-pyridinecarboxylic acid                    | Guvacine                                                       | C <sub>6</sub> H <sub>9</sub> NO <sub>2</sub>                 | 498-96-4   | 127.141  | pr (w), rods (+1w dil al) | 295 dec |                        |                            |                      | vs H <sub>2</sub> O                                        |
| 9890 | 3,4,5,6-Tetrahydro-2(1H)-pyrimidinethione                       | Hexahydropyrimidine-2-thione                                   | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> S                | 2055-46-1  | 116.185  |                           | 211     |                        | 1.33 <sup>20</sup>         |                      |                                                            |
| 9891 | 1,2,3,4-Tetrahydroquinoline                                     |                                                                | C <sub>8</sub> H <sub>11</sub> N                              | 635-46-1   | 133.190  | nd                        | 20      | 251                    | 1.0588 <sup>20</sup>       | 1.6062 <sup>19</sup> | s H <sub>2</sub> O, chl; msc EtOH, eth                     |
| 9892 | 5,6,7,8-Tetrahydroquinoline                                     | 2,3-Cyclohexenopyridine                                        | C <sub>8</sub> H <sub>11</sub> N                              | 10500-57-9 | 133.190  |                           |         | 222                    | 1.0304 <sup>13</sup>       | 1.5435 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace, bz                  |
| 9893 | 1,2,3,4-Tetrahydroquinoxaline                                   |                                                                | C <sub>8</sub> H <sub>10</sub> N <sub>2</sub>                 | 3476-89-9  | 134.178  | lf (w, eth, peth)         | 99      | 289                    |                            |                      | s H <sub>2</sub> O, chl; vs EtOH, eth, bz; sl peth         |
| 9894 | 6,7,8,9-Tetrahydro-5H-tetrazolo[1,5-a]azepine                   | Pentylentetrazole                                              | C <sub>6</sub> H <sub>10</sub> N <sub>4</sub>                 | 54-95-5    | 138.170  | cry (bz-lig)              | 59.5    | 194 <sup>12</sup>      |                            |                      | vs H <sub>2</sub> O, EtOH, ace; s eth, bz; sl chl          |
| 9895 | Tetrahydrothiophene                                             | Thiacyclopentane                                               | C <sub>4</sub> H <sub>8</sub> S                               | 110-01-0   | 88.172   | liq                       | -96.2   | 121.1                  | 0.9987 <sup>20</sup>       | 1.4871 <sup>18</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; s chl          |
| 9896 | 1,2,3,4-Tetrahydro-1,1,6-trimethylnaphthalene                   |                                                                | C <sub>13</sub> H <sub>18</sub>                               | 475-03-6   | 174.282  |                           |         | 240; 90 <sup>4</sup>   | 0.9303 <sup>20</sup>       | 1.5257 <sup>20</sup> | s EtOH, eth, bz, chl                                       |
| 9897 | 1,2,5,8-Tetrahydroxy-9,10-anthracenedione                       | Quinalizarin                                                   | C <sub>14</sub> H <sub>6</sub> O <sub>6</sub>                 | 81-61-8    | 272.210  | oran nd                   | >275    |                        |                            |                      | sl H <sub>2</sub> O, ace, bz, EtOH, eth                    |
| 9898 | 2,3,4,6-Tetrahydroxy-5H-benzocyclohepten-5-one                  | Purpurogallin                                                  | C <sub>11</sub> H <sub>8</sub> O <sub>5</sub>                 | 569-77-7   | 220.179  | red nd (gl HOAc)          | 274 dec |                        |                            |                      |                                                            |
| 9899 | 2,2',4,4'-Tetrahydroxybenzophenone                              |                                                                | C <sub>13</sub> H <sub>10</sub> O <sub>5</sub>                | 131-55-5   | 246.215  | ye nd (w+1)               | 197     |                        |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH                        |
| 9900 | 2,3,5,6-Tetrahydroxy-2,5-cyclohexadiene-1,4-dione               | Tetroquinone                                                   | C <sub>6</sub> H <sub>4</sub> O <sub>6</sub>                  | 319-89-1   | 172.092  | bl-blk cry                |         |                        |                            |                      | sl H <sub>2</sub> O, eth, ctc; vs EtOH                     |
| 9901 | 11,17,20,21-Tetrahydroxypregn-4-en-3-one, (11 $\beta$ ,20 $R$ ) | 4-Pregnene-11 $\beta$ ,17 $\alpha$ ,20 $\beta$ ,21-tetrol-3-on | C <sub>21</sub> H <sub>32</sub> O <sub>5</sub>                | 116-58-5   | 364.476  | cry (aq ace)              | 125 dec |                        |                            |                      | vs ace, EtOH                                               |
| 9902 | N,N,N',N'-Tetra(2-hydroxypropyl)ethylenediamine                 | ENTPROL                                                        | C <sub>14</sub> H <sub>32</sub> N <sub>2</sub> O <sub>4</sub> | 102-60-3   | 292.415  |                           |         |                        | 1.030 <sup>25</sup>        | 1.478 <sup>25</sup>  | sl chl                                                     |
| 9903 | Tetraiodoethene                                                 | Tetraiodoethylene                                              | C <sub>2</sub> I <sub>4</sub>                                 | 513-92-8   | 531.639  | ye lf, pr (eth)           | 187     | sub                    | 2.983 <sup>20</sup>        |                      | vs bz, chl                                                 |
| 9904 | 4,5,6,7-Tetraiodo-1,3-isobenzofuran-dione                       |                                                                | C <sub>8</sub> I <sub>4</sub> O <sub>3</sub>                  | 632-80-4   | 651.702  | ye pr, nd (HOAc) nd (sub) | 327.5   | sub                    |                            |                      | i H <sub>2</sub> O, EtOH, bz; sl HOAc                      |
| 9905 | Tetraiodomethane                                                | Carbon tetraiodide                                             | Cl <sub>4</sub>                                               | 507-25-5   | 519.629  | red lf (bz, chl)          | 171     | 135 <sup>1.5</sup>     | 4.23 <sup>20</sup>         |                      | vs py, chl                                                 |
| 9906 | 2,3,4,5-Tetraiodo-1H-pyrrole                                    | Iodopyrrole                                                    | C <sub>4</sub> HI <sub>4</sub> N                              | 87-58-1    | 570.676  | ye nd (al)                | 150 dec |                        |                            |                      | vs ace, eth, chl                                           |
| 9907 | Tetraisobutyl titanate                                          | 2-Methyl-1-propanol, titanium(4+) salt                         | C <sub>16</sub> H <sub>36</sub> O <sub>4</sub> Ti             | 7425-80-1  | 340.322  |                           |         | 256 <sup>500</sup>     | 0.960 <sup>50</sup>        |                      | dec H <sub>2</sub> O                                       |



1,2,3,4-Tetrahydro-5-methylnaphthalene



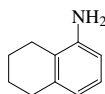
1,2,3,4-Tetrahydro-6-methylnaphthalene



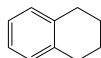
1,2,3,6-Tetrahydro-1-methyl-4-phenylpyridine



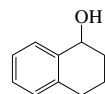
Tetrahydro-3-methyl-2H-thiopyran



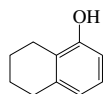
5,6,7,8-Tetrahydro-1-naphthalenamine



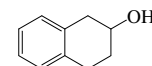
1,2,3,4-Tetrahydronaphthalene



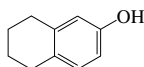
1,2,3,4-Tetrahydro-1-naphthol



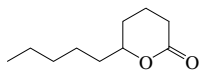
5,6,7,8-Tetrahydro-1-naphthol



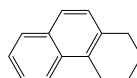
1,2,3,4-Tetrahydro-2-naphthol



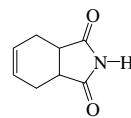
5,6,7,8-Tetrahydro-2-naphthol



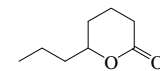
Tetrahydro-6-pentyl-2H-pyran-2-one



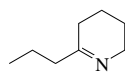
1,2,3,4-Tetrahydrophenanthrene



1,2,3,6-Tetrahydrophthalimide



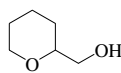
Tetrahydro-6-propyl-2H-pyran-2-one



2,3,4,5-Tetrahydro-6-propylpyridine



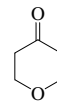
Tetrahydropyran



Tetrahydro-2H-pyran-2-methanol



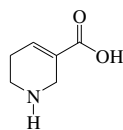
Tetrahydro-2H-pyran-2-one



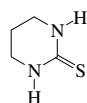
Tetrahydro-4H-pyran-4-one



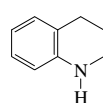
1,2,5,6-Tetrahydropyridine



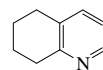
1,2,5,6-Tetrahydro-3-pyridinecarboxylic acid



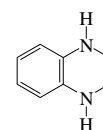
3,4,5,6-Tetrahydro-2(1H)-pyrimidinethione



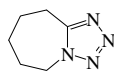
1,2,3,4-Tetrahydroquinoline



5,6,7,8-Tetrahydroquinoline



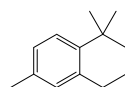
1,2,3,4-Tetrahydroquinoxaline



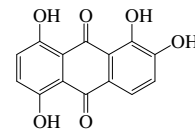
6,7,8,9-Tetrahydro-5H-tetrazolo[1,5-a]azepine



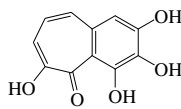
Tetrahydrothiophene



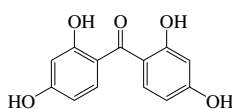
1,2,3,4-Tetrahydro-1,1,6-trimethylnaphthalene



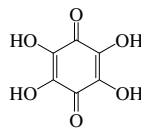
1,2,5,8-Tetrahydroxy-9,10-anthracenedione



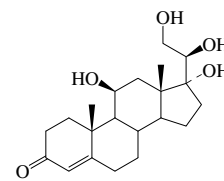
2,3,4,6-Tetrahydroxy-5H-benzocyclohept-5-ene



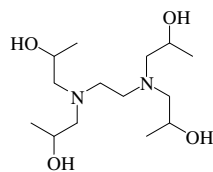
2,2',4,4'-Tetrahydroxybenzophenone



2,3,5,6-Tetrahydroxy-2,5-cyclohexadiene-1,4-dione



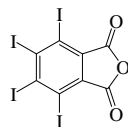
11,17,20,21-Tetrahydroxypregn-4-en-3-one, (11β,20R)



N,N,N',N'-Tetra(2-hydroxypropyl)ethylenediamine



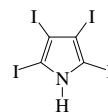
Tetraiodoethene



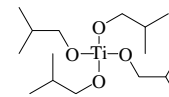
4,5,6,7-Tetraiodo-1,3-isobenzofurandione



Tetraiodomethane

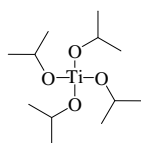


2,3,4,5-Tetraiodo-1H-pyrrole

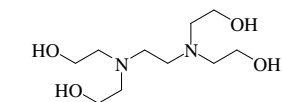
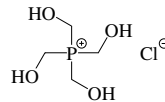


Tetraisobutyl titanate

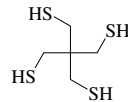
| No.  | Name                                                                 | Synonym                                 | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form         | mp/°C    | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|------|----------------------------------------------------------------------|-----------------------------------------|---------------------------------------------------------------|------------|----------|-----------------------|----------|------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 9908 | Tetraisopropyl titanate                                              | 2-Propanol, titanium(4+) salt           | C <sub>12</sub> H <sub>28</sub> O <sub>4</sub> Ti             | 546-68-9   | 284.215  |                       |          | 227.5                  | 0.9711 <sup>20</sup>       |                      | dec H <sub>2</sub> O; s EtOH, eth, bz, chl            |
| 9909 | <i>N,N,N',N'</i> -Tetrakis(2-hydroxyethyl)-1,2-ethanediamine         |                                         | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub> | 140-07-8   | 236.309  |                       |          |                        |                            |                      | sl H <sub>2</sub> O, EtOH                             |
| 9910 | Tetrakis(hydroxymethyl)phosphonium chloride                          |                                         | C <sub>4</sub> H <sub>12</sub> ClO <sub>4</sub> P             | 124-64-1   | 190.562  |                       | 152.5    |                        |                            |                      | s H <sub>2</sub> O                                    |
| 9911 | Tetrakis(methylthio)methane                                          |                                         | C <sub>8</sub> H <sub>12</sub> S <sub>4</sub>                 | 6156-25-8  | 200.409  |                       |          |                        |                            |                      | s chl                                                 |
| 9912 | 1-Tetralone                                                          |                                         | C <sub>10</sub> H <sub>10</sub> O                             | 529-34-0   | 146.185  |                       | 8        | 115 <sup>6</sup>       | 1.0988 <sup>16</sup>       | 1.5672 <sup>20</sup> |                                                       |
| 9913 | Tetramethoxymethane                                                  |                                         | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                 | 1850-14-2  | 136.147  | liq                   | -2.5     | 114                    | 1.023 <sup>25</sup>        | 1.3845 <sup>20</sup> |                                                       |
| 9914 | 1,1,3,3-Tetramethoxypropane                                          |                                         | C <sub>7</sub> H <sub>16</sub> O <sub>4</sub>                 | 102-52-3   | 164.200  |                       |          | 183; 66 <sup>12</sup>  | 0.997 <sup>25</sup>        | 1.4081 <sup>20</sup> |                                                       |
| 9915 | Tetramethrin                                                         |                                         | C <sub>19</sub> H <sub>28</sub> NO <sub>4</sub>               | 7696-12-0  | 331.407  | wh cry                | ≈65-80   |                        | 1.108 <sup>20</sup>        | 1.5175 <sup>21</sup> |                                                       |
| 9916 | <i>N,N,N',N'</i> -Tetramethyl-3,6-acridinediamine, monohydrochloride | Acridine Orange                         | C <sub>17</sub> H <sub>20</sub> ClN <sub>3</sub>              | 65-61-2    | 301.814  | oran-ye soln          |          |                        |                            |                      | s H <sub>2</sub> O, EtOH                              |
| 9917 | Tetramethylammonium bromide                                          |                                         | C <sub>4</sub> H <sub>12</sub> BrN                            | 64-20-0    | 154.049  | hyg bipym             | 230 dec  |                        | 1.56 <sup>25</sup>         |                      | vs H <sub>2</sub> O; sl EtOH; i eth, bz, chl; s MeOH  |
| 9918 | Tetramethylammonium chloride                                         |                                         | C <sub>4</sub> H <sub>12</sub> ClN                            | 75-57-0    | 109.598  | hyg bipym (dil al)    | 420 dec  |                        | 1.169 <sup>20</sup>        |                      | s H <sub>2</sub> O; sl EtOH; i eth, bz, chl; vs MeOH  |
| 9919 | Tetramethylammonium iodide                                           |                                         | C <sub>4</sub> H <sub>12</sub> IN                             | 75-58-1    | 201.049  |                       | >230 dec |                        | 1.829 <sup>25</sup>        |                      | sl H <sub>2</sub> O, alk, EtOH, ace; i eth, chl       |
| 9920 | <i>N,N</i> ,2,6-Tetramethylaniline                                   |                                         | C <sub>10</sub> H <sub>12</sub> N                             | 769-06-2   | 149.233  | liq                   | -36      | 196; 88 <sup>20</sup>  | 0.9147 <sup>20</sup>       |                      |                                                       |
| 9921 | 1,2,3,4-Tetramethylbenzene                                           |                                         | C <sub>10</sub> H <sub>14</sub>                               | 488-23-3   | 134.218  | liq                   | -6.2     | 205                    | 0.9052 <sup>20</sup>       | 1.5203 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 9922 | 1,2,3,5-Tetramethylbenzene                                           | Isodurene                               | C <sub>10</sub> H <sub>14</sub>                               | 527-53-7   | 134.218  | liq                   | -23.7    | 198                    | 0.8903 <sup>20</sup>       | 1.5130 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 9923 | 1,2,4,5-Tetramethylbenzene                                           | Durene                                  | C <sub>10</sub> H <sub>14</sub>                               | 95-93-2    | 134.218  |                       | 79.3     | 196.8                  | 0.8380 <sup>81</sup>       | 1.4790 <sup>81</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc |
| 9924 | <i>N,N,N',N'</i> -Tetramethyl-1,2-benzenediamine                     |                                         | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub>                | 704-01-8   | 164.247  |                       | 8.9      | 215.5                  | 0.9560 <sup>20</sup>       |                      |                                                       |
| 9925 | <i>N,N,N',N'</i> -Tetramethyl-1,4-benzenediamine                     | Tetramethyl- <i>p</i> -phenylenediamine | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub>                | 100-22-1   | 164.247  | lf (dil al or lig)    | 51       | 260                    |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz, chl            |
| 9926 | 2,3,5,6-Tetramethyl-1,4-benzenediol                                  | Durohydroquinone                        | C <sub>10</sub> H <sub>14</sub> O <sub>2</sub>                | 527-18-4   | 166.217  | nd (al)               | 233      |                        |                            |                      | s EtOH; sl eth                                        |
| 9927 | Tetramethyl 1,2,4,5-benzenetetra-carboxylate                         |                                         | C <sub>14</sub> H <sub>14</sub> O <sub>8</sub>                | 635-10-9   | 310.256  | nd (al)               | 144      | sub                    |                            |                      | vs EtOH                                               |
| 9928 | 3,3',5,5'-Tetramethyl-[1,1'-biphenyl]-4,4'-diamine                   |                                         | C <sub>16</sub> H <sub>20</sub> N <sub>2</sub>                | 54827-17-7 | 240.343  |                       | 168.5    |                        |                            |                      |                                                       |
| 9929 | <i>N,N,N',N'</i> -Tetramethyl-[1,1'-biphenyl]-4,4'-diamine           |                                         | C <sub>16</sub> H <sub>20</sub> N <sub>2</sub>                | 366-29-0   | 240.343  |                       | 196.0    |                        |                            |                      |                                                       |
| 9930 | 3,3',5,5'-Tetramethyl-[1,1'-biphenyl]-4,4'-diol                      |                                         | C <sub>16</sub> H <sub>18</sub> O <sub>2</sub>                | 2417-04-1  | 242.313  | pa ye nd or pr (HOAc) | 221.8    | sub                    |                            |                      | sl EtOH, bz, gl HOAc, tol; i lig                      |
| 9931 | 2,2,3,3-Tetramethylbutane                                            |                                         | C <sub>8</sub> H <sub>18</sub>                                | 594-82-1   | 114.229  | lf (eth)              | 100.7    | 106.45                 | 0.8242 <sup>20</sup>       | 1.4695 <sup>20</sup> | i H <sub>2</sub> O; s eth, chl                        |
| 9932 | <i>N,N,N',N'</i> -Tetramethyl-1,4-butanediamine                      |                                         | C <sub>8</sub> H <sub>20</sub> N <sub>2</sub>                 | 111-51-3   | 144.258  |                       |          | 168                    | 0.7942 <sup>15</sup>       | 1.4621 <sup>25</sup> | msc H <sub>2</sub> O; s EtOH, eth                     |
| 9933 | 4-(1,1,3,3-Tetramethylbutyl)phenol                                   |                                         | C <sub>14</sub> H <sub>22</sub> O                             | 140-66-9   | 206.324  |                       | 85.8     | 279                    |                            |                      |                                                       |
| 9934 | 2,2,4,4-Tetramethyl-1,3-cyclobutanedione                             |                                         | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                 | 933-52-8   | 140.180  |                       |          |                        |                            |                      | s chl                                                 |
| 9935 | 2,3,5,6-Tetramethyl-2,5-cyclohexadiene-1,4-dione                     | Duroquinone                             | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                | 527-17-3   | 164.201  | ye nd (al or lig)     | 111.5    |                        |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, sulf, chl   |
| 9936 | 1,2,3,4-Tetramethylcyclohexane                                       |                                         | C <sub>10</sub> H <sub>20</sub>                               | 3726-45-2  | 140.266  |                       |          |                        | 0.8219 <sup>20</sup>       | 1.4531 <sup>20</sup> |                                                       |
| 9937 | 1,1,3,3-Tetramethylcyclopentane                                      |                                         | C <sub>9</sub> H <sub>18</sub>                                | 50876-33-0 | 126.239  | liq                   | -88.4    | 118                    | 0.7469 <sup>25</sup>       | 1.4125 <sup>20</sup> |                                                       |
| 9938 | 1,1,2,2-Tetramethylcyclopropane                                      |                                         | C <sub>7</sub> H <sub>14</sub>                                | 4127-47-3  | 98.186   | liq                   | -81      | 76                     |                            |                      |                                                       |
| 9939 | 2,4,6,8-Tetramethylcyclotetrasiloxane                                |                                         | C <sub>4</sub> H <sub>16</sub> O <sub>4</sub> Si <sub>4</sub> | 2370-88-9  | 240.510  | liq                   | -65      | 134.5                  | 0.9912 <sup>20</sup>       | 1.3870 <sup>20</sup> | i H <sub>2</sub> O                                    |
| 9940 | 2,4,7,9-Tetramethyl-5-decylene-4,7-diol                              |                                         | C <sub>14</sub> H <sub>26</sub> O <sub>2</sub>                | 126-86-3   | 226.355  |                       | 47       | 165 <sup>40</sup>      |                            |                      |                                                       |
| 9941 | <i>N,N,N',N'</i> -Tetramethyl-4,4'-diaminobenzophenone               | Michler's ketone                        | C <sub>17</sub> H <sub>20</sub> N <sub>2</sub> O              | 90-94-8    | 268.353  | lf (al), nd (bz)      | 179      | dec 360                |                            |                      | i H <sub>2</sub> O, eth; sl EtOH; vs bz; s chl        |
| 9942 | Tetramethyldiarsine                                                  | Cacodyl                                 | C <sub>4</sub> H <sub>12</sub> As <sub>2</sub>                | 471-35-2   | 209.981  | liq                   | -6       | 165                    | 1.447 <sup>15</sup>        |                      | vs eth, EtOH                                          |
| 9943 | 1,1,3,3-Tetramethyl-1,3-diphenyldisiloxane                           |                                         | C <sub>16</sub> H <sub>22</sub> OSi <sub>2</sub>              | 56-33-7    | 286.516  | liq                   | -80      | 292; 156 <sup>13</sup> | 0.9763 <sup>20</sup>       | 1.5176 <sup>20</sup> | s ctc                                                 |
| 9944 | 1,1,3,3-Tetramethyldisiloxane                                        |                                         | C <sub>4</sub> H <sub>14</sub> OSi <sub>2</sub>               | 3277-26-7  | 134.324  |                       |          | 71                     | 0.756 <sup>20</sup>        | 1.3700 <sup>20</sup> |                                                       |
| 9945 | 1,1,3,3-Tetramethyl-1,3-disiloxanediol                               |                                         | C <sub>4</sub> H <sub>14</sub> O <sub>3</sub> Si <sub>2</sub> | 1118-15-6  | 166.323  |                       | 66       |                        | 1.095 <sup>25</sup>        |                      |                                                       |



Tetraisopropyl titanate

*N,N,N',N'*-Tetrakis(2-hydroxyethyl)-1,2-ethanediamine

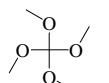
Tetrakis(hydroxymethyl)phosphonium chloride



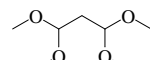
Tetrakis(methylthio)methane



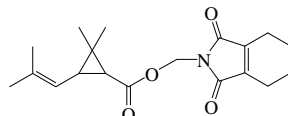
1-Tetralone



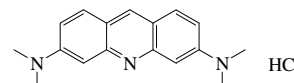
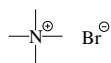
Tetramethoxymethane



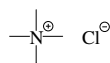
1,1,3,3-Tetramethoxypropane



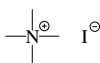
Tetramethrin

*N,N,N',N'*-Tetramethyl-3,6-acridinediamine, monohydrochloride

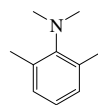
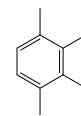
Tetramethylammonium bromide



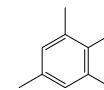
Tetramethylammonium chloride



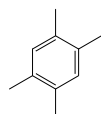
Tetramethylammonium iodide

*N,N*,2,6-Tetramethylaniline

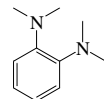
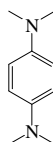
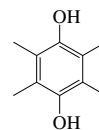
1,2,3,4-Tetramethylbenzene



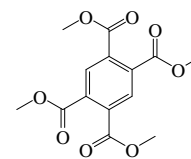
1,2,3,5-Tetramethylbenzene



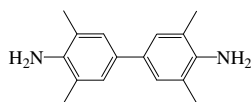
1,2,4,5-Tetramethylbenzene

*N,N,N',N'*-Tetramethyl-1,2-benzenediamine*N,N,N',N'*-Tetramethyl-1,4-benzenediamine

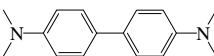
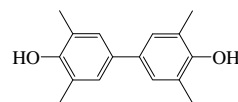
2,3,5,6-Tetramethyl-1,4-benzenediol



Tetramethyl 1,2,4,5-benzenetetracarboxylate



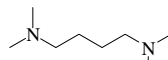
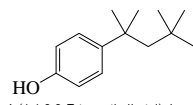
3,3',5,5'-Tetramethyl-[1,1'-biphenyl]-4,4'-diamine

*N,N,N',N'*-Tetramethyl-1,1'-biphenyl-4,4'-diamine

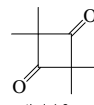
3,3',5,5'-Tetramethyl-[1,1'-biphenyl]-4,4'-diol



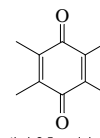
2,2,3,3-Tetramethylbutane

*N,N,N',N'*-Tetramethyl-1,4-butanediamine

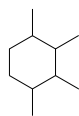
4-(1,1,3,3-Tetramethylbutyl)phenol



2,2,4,4-Tetramethyl-1,3-cyclobutanedione



2,3,5,6-Tetramethyl-2,5-cyclohexadiene-1,4-dione



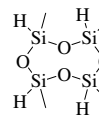
1,2,3,4-Tetramethylcyclohexane



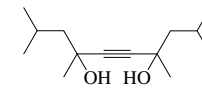
1,1,3,3-Tetramethylcyclopentane



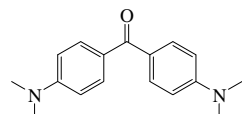
1,1,2,2-Tetramethylcyclopropane



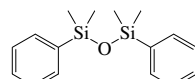
2,4,6,8-Tetramethylcyclotetrasiloxane



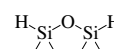
2,4,7,9-Tetramethyl-5-decyne-4,7-diol

*N,N,N',N'*-Tetramethyl-4,4'-diaminobenzophenone

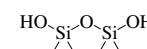
Tetramethyldiarsine



1,1,3,3-Tetramethyl-1,3-diphenyldisiloxane

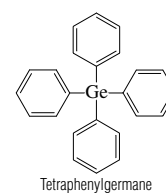
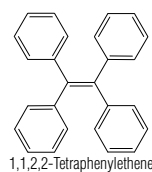
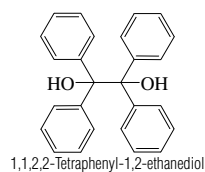
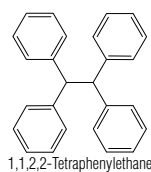
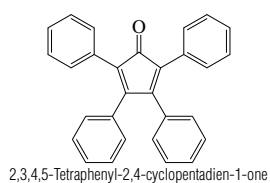
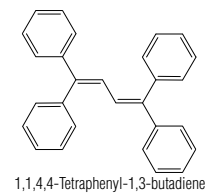
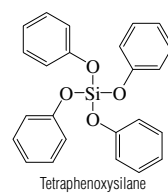
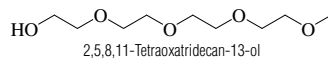
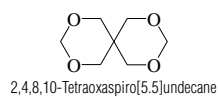
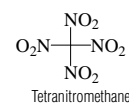
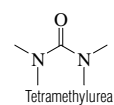
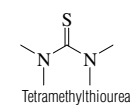
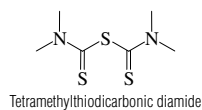
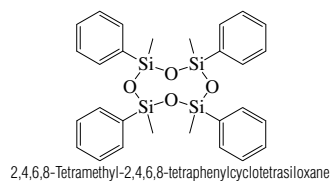
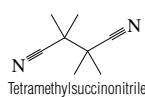
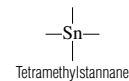
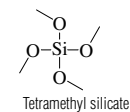
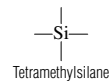
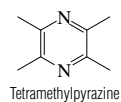
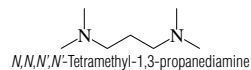
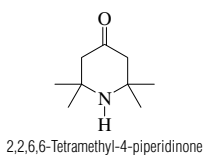
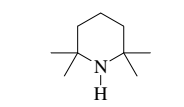
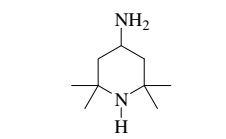
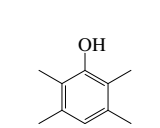
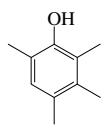
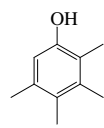
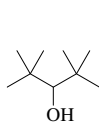
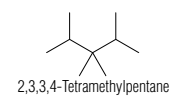
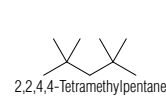
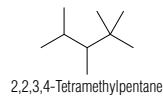
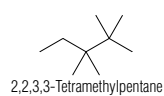
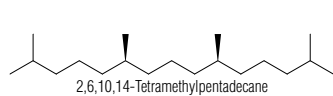
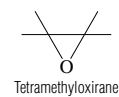
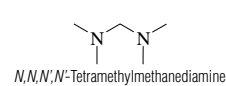
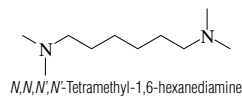
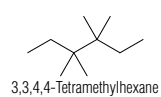
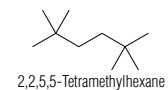
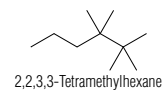
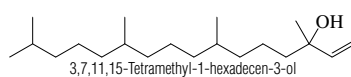
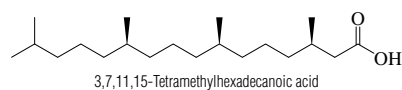
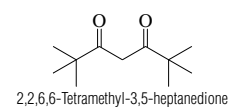
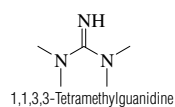
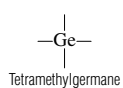
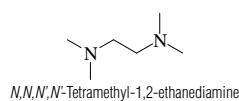


1,1,3,3-Tetramethyldisiloxane

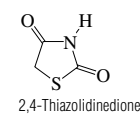
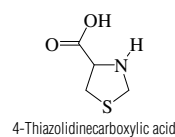
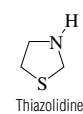
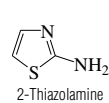
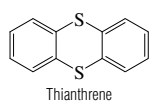
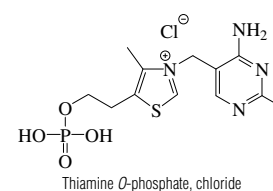
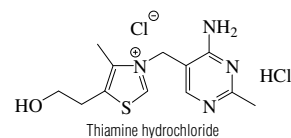
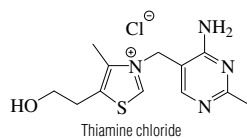
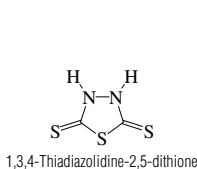
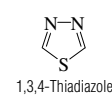
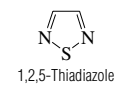
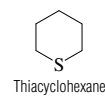
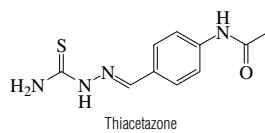
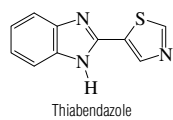
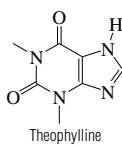
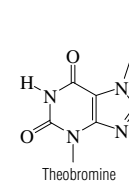
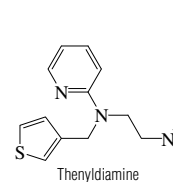
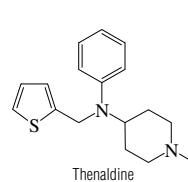
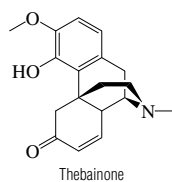
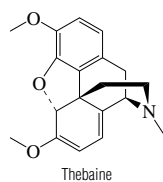
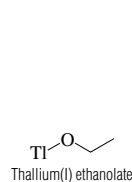
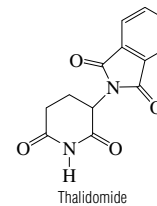
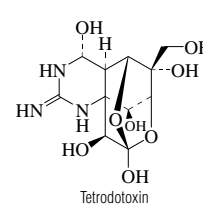
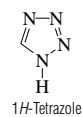
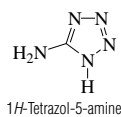
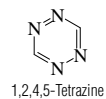
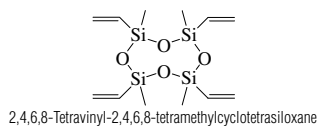
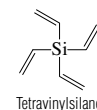
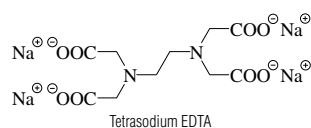
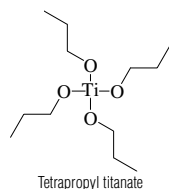
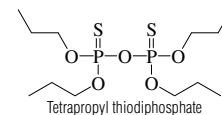
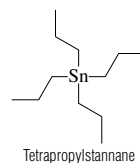
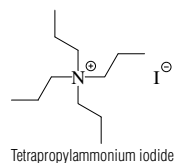
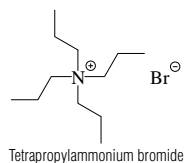
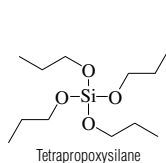
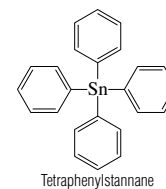
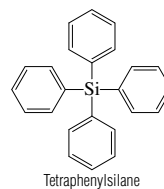
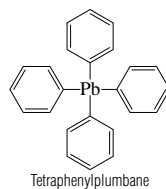
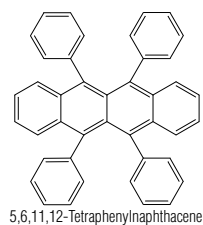
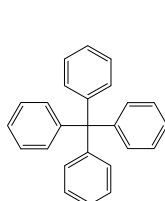


1,1,3,3-Tetramethyl-1,3-disiloxanediol

| No.  | Name                                                      | Synonym                       | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form                  | mp/°C  | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                     |
|------|-----------------------------------------------------------|-------------------------------|----------------------------------------------------------------|------------|----------|--------------------------------|--------|-------------------------------------|----------------------------|----------------------|----------------------------------------------------------------|
| 9946 | <i>N,N,N',N'</i> -Tetramethyl-1,2-ethanediamine           | 1,2-Dimethylaminoethane       | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                  | 110-18-9   | 116.204  | liq                            | -55    | 121                                 | 0.777 <sup>25</sup>        | 1.4179 <sup>20</sup> |                                                                |
| 9947 | Tetramethylgermane                                        | Germanium tetramethyl         | C <sub>4</sub> H <sub>12</sub> Ge                              | 865-52-1   | 132.78   |                                |        | 32 <sup>500</sup>                   | 1.006                      |                      |                                                                |
| 9948 | 1,1,3,3-Tetramethylguanidine                              |                               | C <sub>6</sub> H <sub>13</sub> N <sub>3</sub>                  | 80-70-6    | 115.177  |                                |        |                                     |                            |                      | s ctc                                                          |
| 9949 | 2,2,6,6-Tetramethyl-3,5-heptanedione                      | Dipivaloylmethane             | C <sub>11</sub> H <sub>20</sub> O <sub>2</sub>                 | 1118-71-4  | 184.276  |                                |        | 93 <sup>25</sup> , 72 <sup>6</sup>  | 0.883 <sup>25</sup>        | 1.4589 <sup>20</sup> | sl ctc                                                         |
| 9950 | 3,7,11,15-Tetramethylhexadecanoic acid                    | Phytanic acid                 | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>                 | 14721-66-5 | 312.531  |                                | -65    |                                     |                            |                      |                                                                |
| 9951 | 3,7,11,15-Tetramethyl-1-hexadecen-3-ol                    | Isophytol                     | C <sub>20</sub> H <sub>40</sub> O                              | 505-32-8   | 296.531  | oil                            |        | 108 <sup>0.01</sup>                 | 0.8519 <sup>20</sup>       | 1.4571 <sup>20</sup> | vs bz, eth, EtOH                                               |
| 9952 | 2,2,3,3-Tetramethylhexane                                 |                               | C <sub>10</sub> H <sub>22</sub>                                | 13475-81-5 | 142.282  | liq                            | -54    | 160.3                               | 0.7609 <sup>25</sup>       | 1.4282 <sup>20</sup> |                                                                |
| 9953 | 2,2,5,5-Tetramethylhexane                                 |                               | C <sub>10</sub> H <sub>22</sub>                                | 1071-81-4  | 142.282  | liq                            | -12.6  | 137.4                               | 0.7148 <sup>25</sup>       | 1.4055 <sup>20</sup> |                                                                |
| 9954 | 3,3,4,4-Tetramethylhexane                                 |                               | C <sub>10</sub> H <sub>22</sub>                                | 5171-84-6  | 142.282  |                                |        | 170.0                               | 0.7789 <sup>25</sup>       | 1.4368 <sup>20</sup> |                                                                |
| 9955 | <i>N,N,N',N'</i> -Tetramethyl-1,6-hexanediamine           |                               | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub>                 | 111-18-2   | 172.311  |                                |        | 209.5                               | 0.806 <sup>25</sup>        | 1.4359 <sup>20</sup> |                                                                |
| 9956 | Tetramethyl lead                                          |                               | C <sub>4</sub> H <sub>12</sub> Pb                              | 75-74-1    | 267.3    | liq                            | -30.2  | 110                                 | 1.995 <sup>20</sup>        |                      |                                                                |
| 9957 | <i>N,N,N',N'</i> -Tetramethylmethanediamine               |                               | C <sub>5</sub> H <sub>14</sub> N <sub>2</sub>                  | 51-80-9    | 102.178  |                                |        | 83                                  | 0.7491 <sup>18</sup>       |                      | s H <sub>2</sub> O                                             |
| 9958 | Tetramethyloxirane                                        |                               | C <sub>3</sub> H <sub>6</sub> O                                | 5076-20-0  | 100.158  |                                |        | 90.4                                | 0.8156 <sup>16</sup>       | 1.3984 <sup>16</sup> | s H <sub>2</sub> O                                             |
| 9959 | 2,6,10,14-Tetramethylpentadecane                          | Pristane                      | C <sub>19</sub> H <sub>40</sub>                                | 1921-70-6  | 268.521  |                                |        | 296                                 | 0.7791 <sup>25</sup>       | 1.4370 <sup>25</sup> | vs bz, eth, chl, peth                                          |
| 9960 | 2,2,3,3-Tetramethylpentane                                |                               | C <sub>9</sub> H <sub>20</sub>                                 | 7154-79-2  | 128.255  | liq                            | -9.75  | 140.2                               | 0.7530 <sup>25</sup>       | 1.4236 <sup>20</sup> |                                                                |
| 9961 | 2,2,3,4-Tetramethylpentane                                |                               | C <sub>9</sub> H <sub>20</sub>                                 | 1186-53-4  | 128.255  | liq                            | -121.0 | 133.0                               | 0.7389 <sup>20</sup>       | 1.4147 <sup>20</sup> |                                                                |
| 9962 | 2,2,4,4-Tetramethylpentane                                | Di- <i>tert</i> -butylmethane | C <sub>9</sub> H <sub>20</sub>                                 | 1070-87-7  | 128.255  | liq                            | -66.54 | 122.29                              | 0.7195 <sup>20</sup>       | 1.4069 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, bz                                |
| 9963 | 2,3,3,4-Tetramethylpentane                                |                               | C <sub>9</sub> H <sub>20</sub>                                 | 16747-38-9 | 128.255  | liq                            | -102.1 | 141.5                               | 0.7547 <sup>20</sup>       | 1.4222 <sup>20</sup> |                                                                |
| 9964 | 2,2,4,4-Tetramethyl-3-pentanol                            |                               | C <sub>9</sub> H <sub>20</sub> O                               | 14609-79-1 | 144.254  |                                | 52     | 165.5                               |                            |                      |                                                                |
| 9965 | 2,3,4,5-Tetramethylphenol                                 | Prehnitenol                   | C <sub>10</sub> H <sub>14</sub> O                              | 488-70-0   | 150.217  | nd (lig, aq al)                | 85.3   | 266                                 |                            |                      | sl H <sub>2</sub> O, lig; vs EtOH, eth                         |
| 9966 | 2,3,4,6-Tetramethylphenol                                 |                               | C <sub>10</sub> H <sub>14</sub> O                              | 3238-38-8  | 150.217  | cry (peth)                     | 80.5   | 240                                 |                            |                      | s EtOH                                                         |
| 9967 | 2,3,5,6-Tetramethylphenol                                 |                               | C <sub>10</sub> H <sub>14</sub> O                              | 527-35-5   | 150.217  | nd (lig), pr (al)              | 118.5  | 247                                 |                            |                      | s chl, peth, HOAc                                              |
| 9968 | 2,2,6,6-Tetramethyl-4-piperidinamine                      |                               | C <sub>9</sub> H <sub>20</sub> N <sub>2</sub>                  | 36768-62-4 | 156.268  |                                | 17     | 188.5                               | 0.912 <sup>25</sup>        | 1.4706 <sup>20</sup> |                                                                |
| 9969 | 2,2,6,6-Tetramethylpiperidine                             | Norpempidine                  | C <sub>9</sub> H <sub>19</sub> N                               | 768-66-1   | 141.254  |                                | 28     | 156                                 | 0.8367 <sup>16</sup>       | 1.4455 <sup>20</sup> | vs eth                                                         |
| 9970 | 2,2,6,6-Tetramethyl-4-piperidinone                        |                               | C <sub>9</sub> H <sub>17</sub> NO                              | 826-36-8   | 155.237  | orth pl (eth-w) nd (eth)       | 36     | 205                                 |                            |                      | s H <sub>2</sub> O, EtOH, eth; sl chl                          |
| 9971 | <i>N,N,N',N'</i> -Tetramethyl-1,3-propanediamine          |                               | C <sub>7</sub> H <sub>18</sub> N <sub>2</sub>                  | 110-95-2   | 130.231  |                                |        | 144                                 | 0.7837 <sup>18</sup>       |                      | msc H <sub>2</sub> O, EtOH, eth                                |
| 9972 | Tetramethylpyrazine                                       |                               | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                  | 1124-11-4  | 136.194  | cry (w)                        | 86     | 190                                 |                            |                      |                                                                |
| 9973 | Tetramethylsilane                                         | TMS                           | C <sub>4</sub> H <sub>12</sub> Si                              | 75-76-3    | 88.224   | vol liq or gas                 | -99.06 | 26.6                                | 0.648 <sup>19</sup>        | 1.3587 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; i sulf                       |
| 9974 | Tetramethyl silicate                                      | Methyl silicate               | C <sub>4</sub> H <sub>12</sub> O <sub>2</sub> Si               | 681-84-5   | 152.222  | liq                            | -1.0   | 121                                 | 1.0232 <sup>20</sup>       | 1.3683 <sup>20</sup> | vs EtOH                                                        |
| 9975 | Tetramethylstannane                                       |                               | C <sub>4</sub> H <sub>12</sub> Sn                              | 594-27-4   | 178.848  | liq                            | -55.1  | 78                                  | 1.314 <sup>25</sup>        | 1.4386               | i H <sub>2</sub> O; s ctc, CS <sub>2</sub>                     |
| 9976 | Tetramethylsuccinonitrile                                 | Tetramethylbutanedinitrile    | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                  | 3333-52-6  | 136.194  | mcl pl, lf, pr (dil al)        | 170.5  |                                     | 1.070 <sup>25</sup>        |                      | s EtOH                                                         |
| 9977 | 2,4,6,8-Tetramethyl-2,4,6,8-tetraphenylcyclotetrasiloxane |                               | C <sub>28</sub> H <sub>32</sub> O <sub>4</sub> Si <sub>4</sub> | 77-63-4    | 544.894  | cry (HOAc)                     | 99     | 237 <sup>115</sup>                  | 1.1183 <sup>20</sup>       | 1.5461 <sup>20</sup> | i H <sub>2</sub> O; msc ace, hp                                |
| 9978 | Tetramethylthiodicarbonyl diamide                         |                               | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> S <sub>3</sub>   | 97-74-5    | 208.367  |                                | 109.5  |                                     | 1.37 <sup>25</sup>         |                      | i H <sub>2</sub> O; s EtOH, ace, bz, chl; sl eth               |
| 9979 | Tetramethylthiourea                                       |                               | C <sub>3</sub> H <sub>12</sub> N <sub>2</sub> S                | 2782-91-4  | 132.227  |                                | 79.3   | 245                                 |                            |                      | s H <sub>2</sub> O, EtOH, chl; sl eth                          |
| 9980 | Tetramethylurea                                           |                               | C <sub>3</sub> H <sub>12</sub> N <sub>2</sub> O                | 632-22-4   | 116.161  | liq                            | -0.6   | 176.5                               | 0.9687 <sup>20</sup>       | 1.4496 <sup>23</sup> | sl EtOH, eth, ctc                                              |
| 9981 | Tetranitromethane                                         |                               | CN <sub>4</sub> O <sub>8</sub>                                 | 509-14-8   | 196.033  |                                | 13.8   | 126.1                               | 1.6380 <sup>20</sup>       | 1.4384 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                                |
| 9982 | 2,4,8,10-Tetraoxaspiro[5.5]undecane                       |                               | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                  | 126-54-5   | 160.168  |                                | 48.3   | 147 <sup>23</sup> , 68 <sup>1</sup> |                            |                      | vs H <sub>2</sub> O, ace, eth, EtOH                            |
| 9983 | 2,5,8,11-Tetraoxatridecan-13-ol                           |                               | C <sub>9</sub> H <sub>20</sub> O <sub>5</sub>                  | 23783-42-8 | 208.252  |                                |        | 164 <sup>11</sup>                   | 0.987 <sup>25</sup>        | 1.4453 <sup>20</sup> |                                                                |
| 9984 | Tetraphenoxysilane                                        |                               | C <sub>24</sub> H <sub>20</sub> O <sub>2</sub> Si              | 1174-72-7  | 400.500  |                                | 49     | 417; 236 <sup>1</sup>               | 1.1412 <sup>60</sup>       |                      |                                                                |
| 9985 | 1,1,4,4-Tetraphenyl-1,3-butadiene                         |                               | C <sub>28</sub> H <sub>22</sub>                                | 1450-63-1  | 358.475  |                                | 203.5  |                                     |                            |                      | s EtOH, bz, chl, HOAc                                          |
| 9986 | 2,3,4,5-Tetraphenyl-2,4-cyclopentadien-1-one              |                               | C <sub>29</sub> H <sub>20</sub> O                              | 479-33-4   | 384.468  | blk-viol lf (HOAc, xyl)        | 222.3  |                                     |                            |                      | s EtOH, bz, xyl, HOAc                                          |
| 9987 | 1,1,2,2-Tetraphenylethane                                 |                               | C <sub>26</sub> H <sub>22</sub>                                | 632-50-8   | 334.453  | cry (bz), orth nd (chl)        | 214.5  | 360                                 |                            |                      | sl EtOH; s bz, HOAc                                            |
| 9988 | 1,1,2,2-Tetraphenyl-1,2-ethanediol                        | Benzopinacol                  | C <sub>26</sub> H <sub>22</sub> O <sub>2</sub>                 | 464-72-2   | 366.452  | pr (bz), cry (ace)             | 182    |                                     |                            |                      | i H <sub>2</sub> O, peth; sl EtOH; s eth, ace, CS <sub>2</sub> |
| 9989 | 1,1,2,2-Tetraphenylethane                                 |                               | C <sub>26</sub> H <sub>20</sub>                                | 632-51-9   | 332.437  | mcl or orth (bz-eth or chl-al) | 225    | 420                                 | 1.155 <sup>0</sup>         |                      | i H <sub>2</sub> O; sl EtOH, chl, eth; vs bz                   |
| 9990 | Tetraphenylgermane                                        | Germanium tetraphenyl         | C <sub>24</sub> H <sub>20</sub> Ge                             | 1048-05-1  | 381.06   |                                | 229.0  |                                     |                            |                      |                                                                |

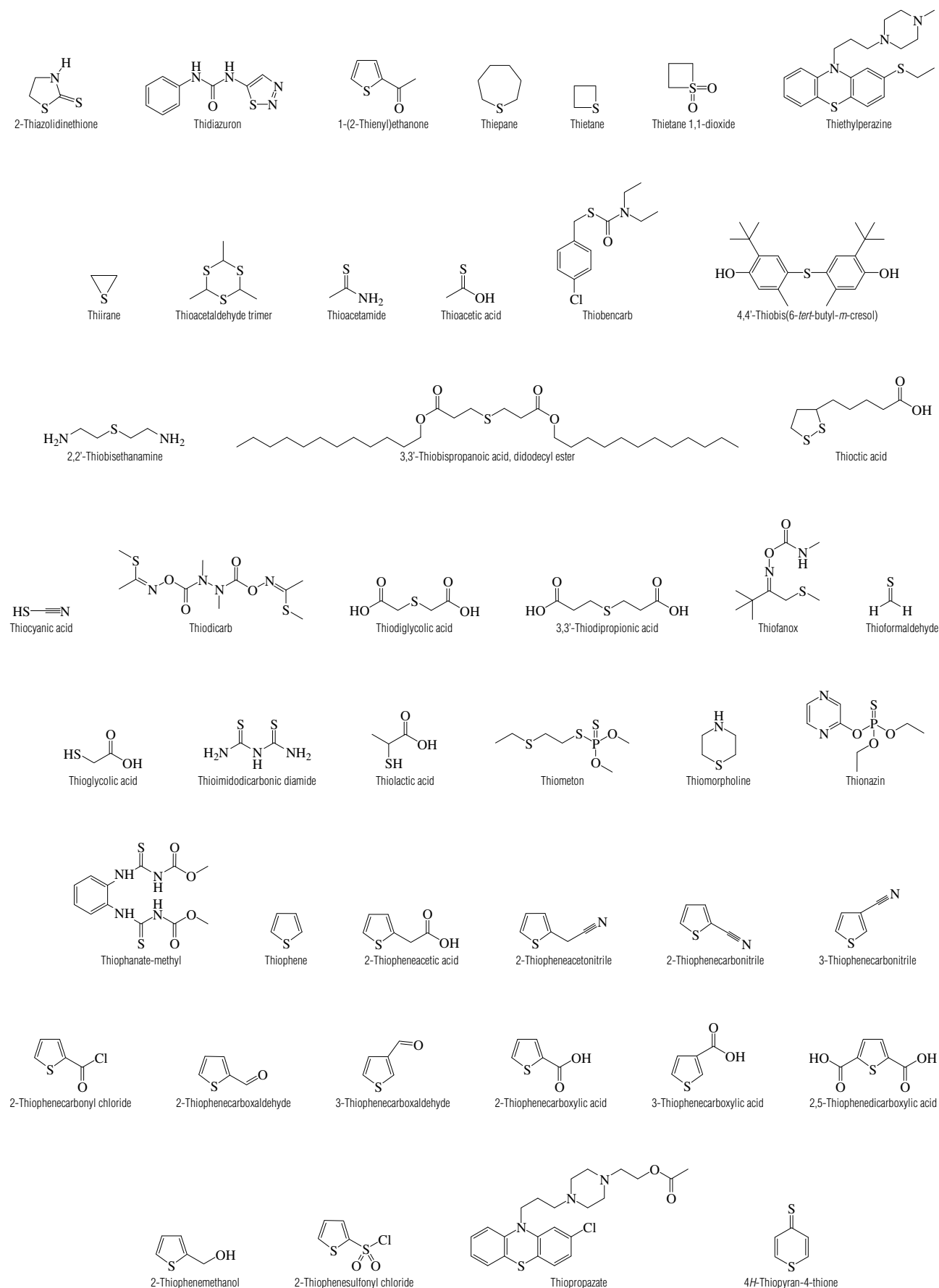


| No.   | Name                                                     | Synonym                                                                  | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form         | mp/°C           | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|-------|----------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|-----------------------|-----------------|------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 9991  | Tetraphenylmethane                                       |                                                                          | C <sub>25</sub> H <sub>20</sub>                                               | 630-76-2   | 320.427  | orth nd (bz, sub)     | 282             | 431                    |                            |                      | i H <sub>2</sub> O, EtOH, eth, lig, HOAc; s bz, tol     |
| 9992  | 5,6,11,12-Tetraphenyl-naphthacene                        | Rubrene                                                                  | C <sub>42</sub> H <sub>28</sub>                                               | 517-51-1   | 532.671  | oran-red (bz-lig)     | 332.5           |                        |                            |                      | i H <sub>2</sub> O; sl EtOH, eth, ace, py; s bz         |
| 9993  | Tetraphenylplumbane                                      |                                                                          | C <sub>24</sub> H <sub>20</sub> Pb                                            | 595-89-1   | 515.6    |                       | 228.3           | 126 <sup>13</sup>      | 1.5298 <sup>20</sup>       |                      | s chl                                                   |
| 9994  | Tetraphenylsilane                                        |                                                                          | C <sub>24</sub> H <sub>20</sub> Si                                            | 1048-08-4  | 336.502  |                       | 236.5           | 228 <sup>3</sup>       | 1.078 <sup>20</sup>        |                      | s ctc, CS <sub>2</sub>                                  |
| 9995  | Tetraphenylstannane                                      |                                                                          | C <sub>24</sub> H <sub>20</sub> Sn                                            | 595-90-4   | 427.126  |                       | 228             | 420                    |                            |                      | sl chl                                                  |
| 9996  | Tetrapropoxysilane                                       |                                                                          | C <sub>12</sub> H <sub>26</sub> O <sub>4</sub> Si                             | 682-01-9   | 264.434  |                       |                 | 226                    | 0.9158 <sup>20</sup>       | 1.4012 <sup>20</sup> | s ctc, CS <sub>2</sub>                                  |
| 9997  | Tetrapropylammonium bromide                              | <i>N,N,N</i> -Tripropyl-1-propanaminium bromide                          | C <sub>12</sub> H <sub>28</sub> BrN                                           | 1941-30-6  | 266.261  |                       | 252             |                        |                            |                      | vs H <sub>2</sub> O, chl                                |
| 9998  | Tetrapropylammonium iodide                               |                                                                          | C <sub>12</sub> H <sub>28</sub> IN                                            | 631-40-3   | 313.261  | orth bipym            | 280 dec         |                        | 1.3138 <sup>25</sup>       |                      | vs H <sub>2</sub> O, chl; s EtOH, HOAc; sl eth          |
| 9999  | Tetrapropylstannane                                      |                                                                          | C <sub>12</sub> H <sub>28</sub> Sn                                            | 2176-98-9  | 291.060  | liq                   | -109.1          | 228                    | 1.1065 <sup>20</sup>       | 1.4745 <sup>20</sup> |                                                         |
| 10000 | Tetrapropyl thiophosphate                                | Aspon                                                                    | C <sub>12</sub> H <sub>26</sub> O <sub>9</sub> P <sub>2</sub> S <sub>2</sub>  | 3244-90-4  | 378.425  | amber liq             |                 | 104 <sup>0.1</sup>     | 1.12 <sup>25</sup>         | 1.4710 <sup>21</sup> | sl H <sub>2</sub> O, peth                               |
| 10001 | Tetrapropyl titanate                                     | 1-Propanol, titanium(4+) salt                                            | C <sub>12</sub> H <sub>26</sub> O <sub>4</sub> Ti                             | 3087-37-4  | 284.215  |                       |                 | 206 <sup>100</sup>     |                            |                      | sl EtOH                                                 |
| 10002 | Tetrasodium EDTA                                         | Edetate sodium                                                           | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> Na <sub>4</sub> O <sub>8</sub> | 64-02-8    | 380.169  | amorp pow             | 300 (dihydrate) |                        |                            |                      |                                                         |
| 10003 | Tetratetracontane                                        |                                                                          | C <sub>44</sub> H <sub>90</sub>                                               | 7098-22-8  | 619.186  |                       | 85.6            |                        |                            |                      |                                                         |
| 10004 | Tetra triacontane                                        |                                                                          | C <sub>34</sub> H <sub>70</sub>                                               | 14167-59-0 | 478.920  | pl (eth)              | 72.5            | 285.4 <sup>3</sup>     | 0.7728 <sup>90</sup>       | 1.4296 <sup>90</sup> |                                                         |
| 10005 | Tetravinylsilane                                         |                                                                          | C <sub>8</sub> H <sub>12</sub> Si                                             | 1112-55-6  | 136.267  |                       |                 | 130.2                  | 0.7999 <sup>20</sup>       | 1.4625 <sup>20</sup> |                                                         |
| 10006 | 2,4,6,8-Tetravinyl-2,4,6,8-tetramethylcyclotetrasiloxane |                                                                          | C <sub>12</sub> H <sub>24</sub> O <sub>4</sub> Si <sub>4</sub>                | 2554-06-5  | 344.659  | liq                   | -43.5           | 224; 111 <sup>12</sup> | 0.9875 <sup>20</sup>       |                      | s ctc, CS <sub>2</sub>                                  |
| 10007 | 1,2,4,5-Tetrazine                                        | <i>sym</i> -Tetrazine                                                    | C <sub>2</sub> H <sub>2</sub> N <sub>4</sub>                                  | 290-96-0   | 82.064   | dk red pr             | 99              | sub                    |                            |                      | s H <sub>2</sub> O, EtOH, eth, sulf                     |
| 10008 | 1 <i>H</i> -Tetrazol-5-amine                             |                                                                          | CH <sub>3</sub> N <sub>5</sub>                                                | 4418-61-5  | 85.069   |                       | 204 dec         |                        |                            |                      |                                                         |
| 10009 | 1 <i>H</i> -Tetrazole                                    |                                                                          | CH <sub>2</sub> N <sub>4</sub>                                                | 288-94-8   | 70.054   | pl (al)               | 157.3           | sub                    | 1.4060 <sup>20</sup>       |                      | sl H <sub>2</sub> O                                     |
| 10010 | Tetrodotoxin                                             |                                                                          | C <sub>11</sub> H <sub>17</sub> N <sub>3</sub> O <sub>8</sub>                 | 4368-28-9  | 319.268  | cry                   | 225 dec         |                        |                            |                      | sl H <sub>2</sub> O, eth, EtOH; s dil HOAc              |
| 10011 | Thalidomide                                              | 2-(2,6-Dioxo-3-piperidiny)-1 <i>H</i> -isoindole-1,3(2 <i>H</i> )-dione  | C <sub>13</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub>                 | 50-35-1    | 258.229  | nd                    | 270             |                        |                            |                      | vs py, diox                                             |
| 10012 | Thallium(I) ethanolate                                   | Thalious ethoxide                                                        | C <sub>2</sub> H <sub>5</sub> OTl                                             | 20398-06-5 | 249.443  | cloudy liq            | -3              | dec 130                | 3.49                       |                      | dec H <sub>2</sub> O                                    |
| 10013 | Thebaine                                                 |                                                                          | C <sub>19</sub> H <sub>21</sub> NO <sub>3</sub>                               | 115-37-7   | 311.375  | pl (eth), pr (dil al) | 193             | sub 91                 | 1.305 <sup>20</sup>        |                      | i H <sub>2</sub> O; vs EtOH, chl; sl eth; s bz          |
| 10014 | Thebainone                                               |                                                                          | C <sub>18</sub> H <sub>21</sub> NO <sub>3</sub>                               | 467-98-1   | 299.365  | nd or pr (al)         | 151.5           |                        |                            |                      | sl H <sub>2</sub> O, EtOH, eth; s ace, bz, AcOEt        |
| 10015 | Thenaldine                                               | 1-Methyl- <i>N</i> -phenyl- <i>N</i> -(2-thienylmethyl)-4-piperidinamine | C <sub>17</sub> H <sub>22</sub> N <sub>2</sub> S                              | 86-12-4    | 286.435  |                       | 96              | 159 <sup>0.02</sup>    |                            |                      |                                                         |
| 10016 | Thenyl diamine                                           |                                                                          | C <sub>14</sub> H <sub>19</sub> N <sub>3</sub> S                              | 91-79-2    | 261.386  |                       |                 | 170 <sup>1</sup>       |                            | 1.5915 <sup>20</sup> |                                                         |
| 10017 | Theobromine                                              |                                                                          | C <sub>7</sub> H <sub>8</sub> N <sub>4</sub> O <sub>2</sub>                   | 83-67-0    | 180.165  | orth or mcl nd (w)    | 357             | sub 290                |                            |                      | sl H <sub>2</sub> O, EtOH; i eth, bz, ctc, lig, chl     |
| 10018 | Theophylline                                             | 3,7-Dihydro-1,3-dimethyl-1 <i>H</i> -purine-2,6-dione                    | C <sub>7</sub> H <sub>8</sub> N <sub>4</sub> O <sub>2</sub>                   | 58-55-9    | 180.165  | nd or pl (w+1)        | 273             |                        |                            |                      | s H <sub>2</sub> O; sl EtOH, eth, chl                   |
| 10019 | Thiabendazole                                            | 1 <i>H</i> -Benzimidazole, 2-(4-thiazolyl)-                              | C <sub>10</sub> H <sub>7</sub> N <sub>3</sub> S                               | 148-79-8   | 201.248  |                       |                 | sub 305                |                            |                      |                                                         |
| 10020 | Thiacetazone                                             |                                                                          | C <sub>10</sub> H <sub>12</sub> N <sub>4</sub> OS                             | 104-06-3   | 236.293  |                       | 225 dec         |                        |                            |                      | i H <sub>2</sub> O, os, CS <sub>2</sub>                 |
| 10021 | Thiacyclohexane                                          |                                                                          | C <sub>6</sub> H <sub>10</sub> S                                              | 1613-51-0  | 102.198  |                       | 19              | 141.8                  | 0.9861 <sup>20</sup>       | 1.5067 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz                |
| 10022 | 1,2,5-Thiadiazole                                        | Piazthiole                                                               | C <sub>2</sub> H <sub>2</sub> N <sub>2</sub> S                                | 288-39-1   | 86.115   | liq                   | -50.1           | 94                     | 1.268 <sup>25</sup>        | 1.5150 <sup>25</sup> |                                                         |
| 10023 | 1,3,4-Thiadiazole                                        |                                                                          | C <sub>2</sub> H <sub>2</sub> N <sub>2</sub> S                                | 289-06-5   | 86.115   | cry (sub)             | 42.5            | 204                    |                            |                      |                                                         |
| 10024 | 1,3,4-Thiadiazolidine-2,5-dithione                       |                                                                          | C <sub>2</sub> H <sub>2</sub> N <sub>2</sub> S <sub>3</sub>                   | 1072-71-5  | 150.245  | ye cry (MeOH)         | 168             |                        |                            |                      | s H <sub>2</sub> O                                      |
| 10025 | Thiamine chloride                                        |                                                                          | C <sub>12</sub> H <sub>17</sub> ClN <sub>4</sub> OS                           | 59-43-8    | 300.807  | cry                   | 164             |                        |                            |                      | s H <sub>2</sub> O                                      |
| 10026 | Thiamine hydrochloride                                   |                                                                          | C <sub>12</sub> H <sub>18</sub> Cl <sub>2</sub> N <sub>4</sub> OS             | 67-03-8    | 337.268  | mcl pl                | 248 dec         |                        |                            |                      | vs H <sub>2</sub> O; sl EtOH; i eth, bz, chl            |
| 10027 | Thiamine <i>O</i> -phosphate, chloride                   |                                                                          | C <sub>12</sub> H <sub>18</sub> ClN <sub>4</sub> O <sub>4</sub> PS            | 532-40-1   | 380.787  |                       | 200             |                        |                            |                      |                                                         |
| 10028 | Thianthrene                                              |                                                                          | C <sub>12</sub> H <sub>6</sub> S <sub>2</sub>                                 | 92-85-3    | 216.322  | mcl pr or pl (al)     | 159.3           | 365                    | 1.4420 <sup>20</sup>       |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, CS <sub>2</sub> |
| 10029 | 2-Thiazolamine                                           | 2-Aminothiazole                                                          | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> S                                | 96-50-4    | 100.142  | ye pl (al)            | 93              | 140 <sup>11</sup>      |                            |                      | sl H <sub>2</sub> O, EtOH, eth, chl; vs dil HCl         |
| 10030 | Thiazole                                                 |                                                                          | C <sub>3</sub> H <sub>3</sub> NS                                              | 288-47-1   | 85.128   |                       | -33.62          | 118                    | 1.1998 <sup>17</sup>       | 1.5969 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth, ace                   |
| 10031 | Thiazolidine                                             |                                                                          | C <sub>3</sub> H <sub>7</sub> NS                                              | 504-78-9   | 89.160   |                       |                 | 164.5                  | 1.131 <sup>25</sup>        | 1.551 <sup>20</sup>  | misc H <sub>2</sub> O; s EtOH, ctc; vs eth, ace         |
| 10032 | 4-Thiazolidinecarboxylic acid                            | Timonacic                                                                | C <sub>4</sub> H <sub>7</sub> NO <sub>2</sub> S                               | 444-27-9   | 133.170  | cry (w)               | 196.5           |                        |                            |                      | vs H <sub>2</sub> O                                     |
| 10033 | 2,4-Thiazolidinedione                                    |                                                                          | C <sub>3</sub> H <sub>3</sub> NO <sub>2</sub> S                               | 2295-31-0  | 117.127  | pl (w), pr (al)       | 128             | 179 <sup>19</sup>      |                            |                      | vs eth                                                  |

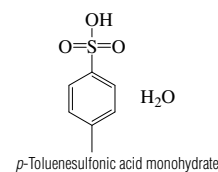
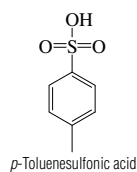
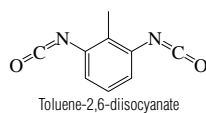
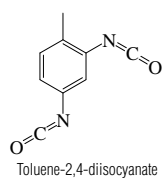
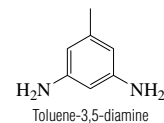
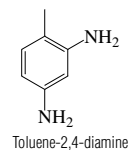
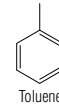
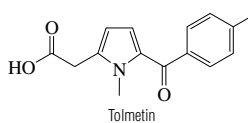
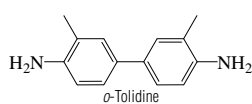
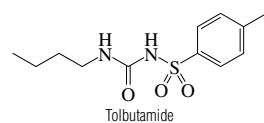
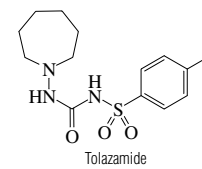
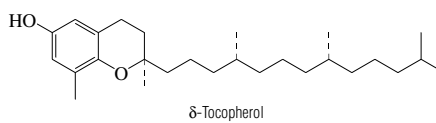
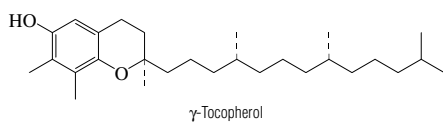
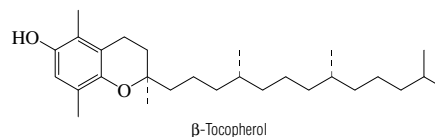
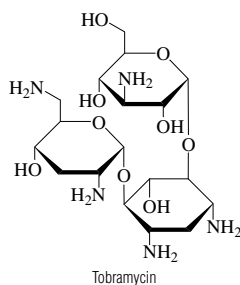
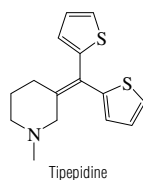
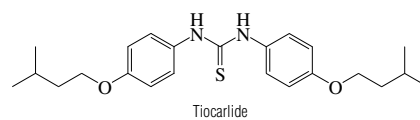
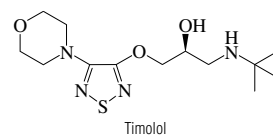
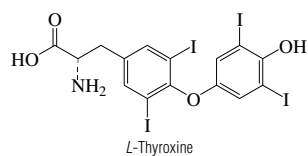
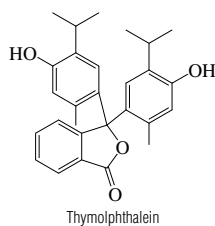
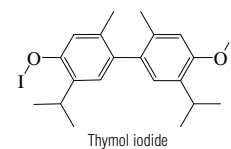
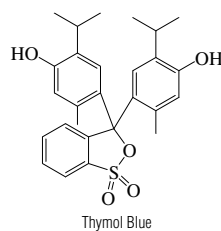
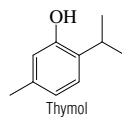
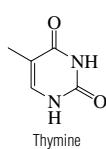
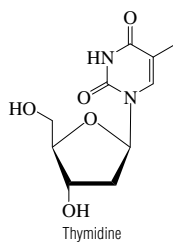
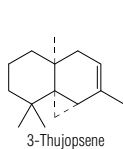
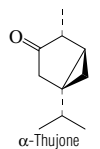
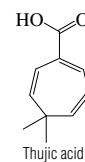
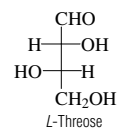
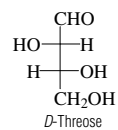
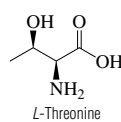
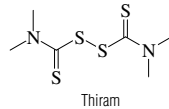
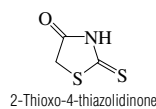
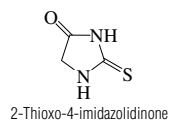
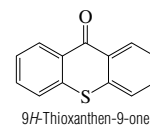
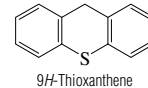
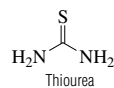
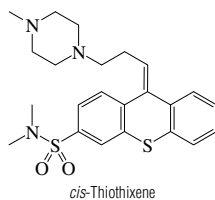
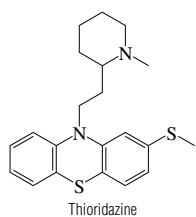
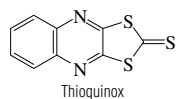




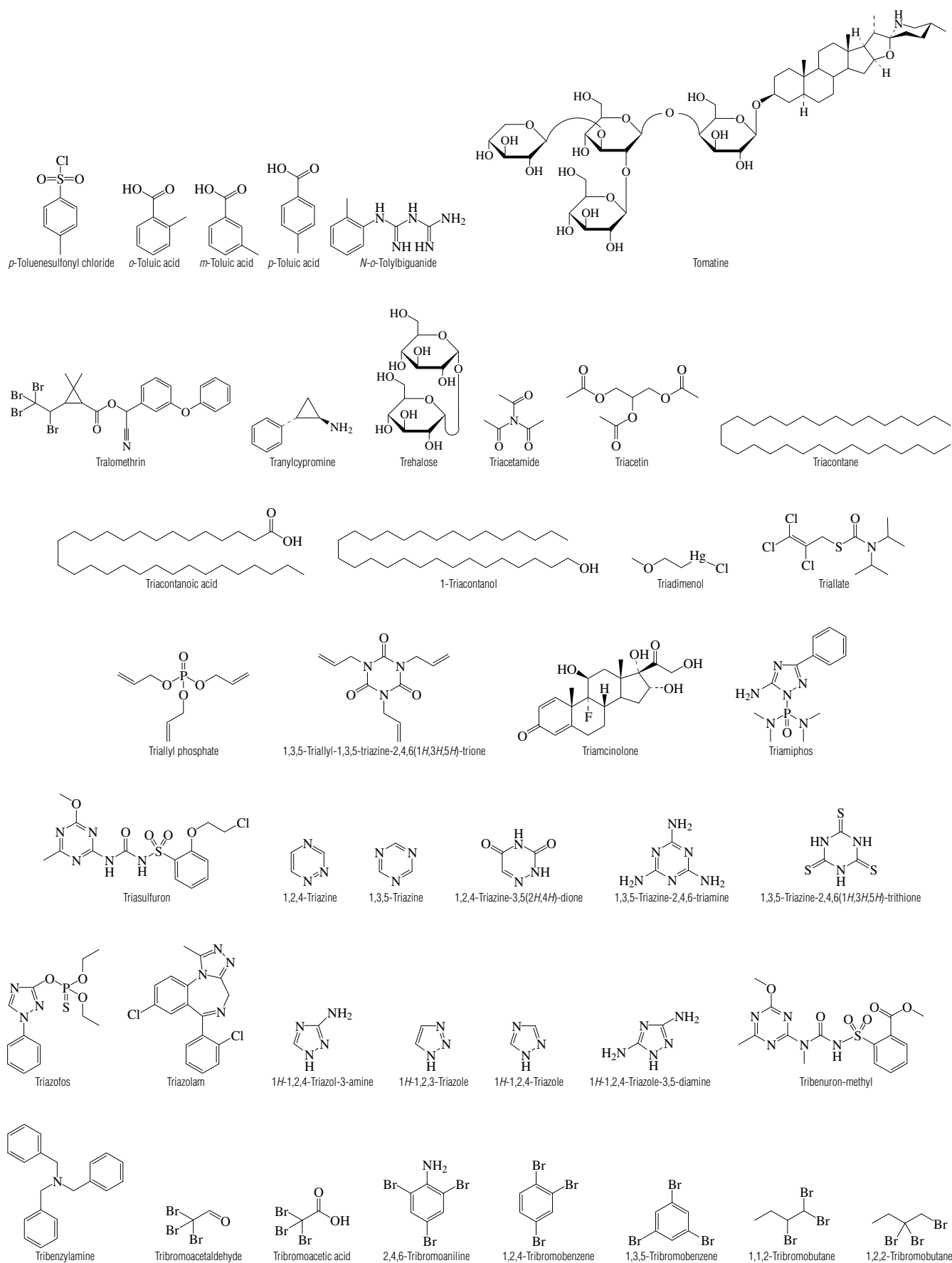
| No.   | Name                                                  | Synonym                                                             | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form        | mp/°C   | bp/°C                                   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|-------|-------------------------------------------------------|---------------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|----------------------|---------|-----------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 10034 | 2-Thiazolidinethione                                  |                                                                     | C <sub>3</sub> H <sub>5</sub> NS <sub>2</sub>                                | 96-53-7    | 119.209  | nd (w, MeOH)         | 107.3   |                                         |                            |                      | s H <sub>2</sub> O, bz, chl; sl EtOH; i eth, CS <sub>2</sub> |
| 10035 | Thidiazuron                                           | <i>N</i> -Phenyl- <i>N'</i> -1,2,3-thiadiazol-5-yl-urea             | C <sub>9</sub> H <sub>8</sub> N <sub>4</sub> OS                              | 51707-55-2 | 220.251  |                      | 211 dec |                                         |                            |                      |                                                              |
| 10036 | 1-(2-Thienyl)ethanone                                 |                                                                     | C <sub>8</sub> H <sub>6</sub> OS                                             | 88-15-3    | 126.176  |                      | 10.5    | 213.5                                   | 1.1679 <sup>20</sup>       | 1.5667 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ctc                    |
| 10037 | Thiepane                                              | Hexamethylene sulfide                                               | C <sub>6</sub> H <sub>12</sub> S                                             | 4753-80-4  | 116.224  | liq                  | 0.5     | 173.5                                   | 0.991 <sup>20</sup>        | 1.5044 <sup>18</sup> | i H <sub>2</sub> O; s eth, ace, chl                          |
| 10038 | Thietane                                              | Trimethylene sulfide                                                | C <sub>3</sub> H <sub>6</sub> S                                              | 287-27-4   | 74.145   | liq                  | -73.24  | 95.0                                    | 1.0200 <sup>20</sup>       | 1.5102 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, bz; s ace                       |
| 10039 | Thietane 1,1-dioxide                                  | Trimethylene sulfone                                                | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> S                               | 5687-92-3  | 106.144  |                      | 75.5    | 91.2 <sup>14</sup>                      |                            | 1.5156 <sup>20</sup> | s H <sub>2</sub> O, EtOH; sl eth, peth                       |
| 10040 | Thiethylperazine                                      |                                                                     | C <sub>22</sub> H <sub>20</sub> N <sub>2</sub> S <sub>2</sub>                | 1420-55-9  | 399.615  | cry                  | 63      | 227 <sup>0.01</sup>                     |                            |                      | sl ace                                                       |
| 10041 | Thiirane                                              | Ethylene sulfide                                                    | C <sub>2</sub> H <sub>4</sub> S                                              | 420-12-2   | 60.118   |                      | -109    | dec 57                                  | 1.0130 <sup>20</sup>       | 1.4935 <sup>20</sup> | sl EtOH, eth; s ace, chl                                     |
| 10042 | Thioacetaldehyde trimer                               | 2,4,6-Trimethyl-1,3,5-trithiane                                     | C <sub>6</sub> H <sub>12</sub> S <sub>3</sub>                                | 2765-04-0  | 180.354  | α-mcl pl; β-nd (ace) | 101     | 246.5                                   |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace; vs bz, chl             |
| 10043 | Thioacetamide                                         | Ethanethioamide                                                     | C <sub>2</sub> H <sub>5</sub> NS                                             | 62-55-5    | 75.133   |                      | 115.5   |                                         |                            |                      | vs H <sub>2</sub> O, EtOH; sl eth, bz; s DMSO                |
| 10044 | Thioacetic acid                                       |                                                                     | C <sub>2</sub> H <sub>4</sub> OS                                             | 507-09-5   | 76.117   | ye fuming liq        | <-17    | 93; 26 <sup>35</sup>                    | 1.064 <sup>20</sup>        | 1.4648 <sup>20</sup> | s H <sub>2</sub> O, chl; vs EtOH, ace; msc eth               |
| 10045 | Thiobencarb                                           |                                                                     | C <sub>12</sub> H <sub>16</sub> ClNOS                                        | 28249-77-6 | 257.779  |                      | 1.7     | 127 <sup>0.008</sup>                    | 1.16 <sup>20</sup>         |                      |                                                              |
| 10046 | 4,4'-Thiobis(6- <i>tert</i> -butyl- <i>m</i> -cresol) | Bis(5- <i>tert</i> -butyl-4-hydroxy-2-methylphenyl) sulfide         | C <sub>22</sub> H <sub>30</sub> O <sub>2</sub> S                             | 96-69-5    | 358.537  | cry                  | 163     |                                         |                            |                      |                                                              |
| 10047 | 2,2'-Thiobisethanamine                                | Bis(2-aminoethyl) sulfide                                           | C <sub>4</sub> H <sub>12</sub> N <sub>2</sub> S                              | 871-76-1   | 120.216  | ye cry               |         | 232; 119 <sup>17</sup>                  |                            |                      |                                                              |
| 10048 | 3,3'-Thiobispropanoic acid, didodecyl ester           | Didodecyl thiobispropanoate                                         | C <sub>30</sub> H <sub>58</sub> O <sub>4</sub> S                             | 123-28-4   | 514.845  |                      | 39      |                                         |                            |                      |                                                              |
| 10049 | Thioctic acid                                         | 1,2-Dithiolane-3-pentanoic acid                                     | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub> S <sub>2</sub>                 | 62-46-4    | 206.326  | ye nd                | 61      | 162                                     |                            |                      | i H <sub>2</sub> O                                           |
| 10050 | Thiocyanic acid                                       |                                                                     | CHNS                                                                         | 463-56-9   | 59.091   |                      | dec 0   |                                         |                            |                      | vs H <sub>2</sub> O; s os                                    |
| 10051 | Thiodicarb                                            |                                                                     | C <sub>10</sub> H <sub>18</sub> N <sub>4</sub> O <sub>4</sub> S <sub>3</sub> | 59669-26-0 | 354.470  |                      | 173     |                                         | 1.4 <sup>20</sup>          |                      |                                                              |
| 10052 | Thiodiglycolic acid                                   | Thiodiacetic acid                                                   | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub> S                               | 123-93-3   | 150.154  | cry (w)              | 129     |                                         |                            |                      | sl H <sub>2</sub> O; vs EtOH; s bz                           |
| 10053 | 3,3'-Thiodipropionic acid                             |                                                                     | C <sub>8</sub> H <sub>10</sub> O <sub>4</sub> S                              | 111-17-1   | 178.206  | cry wh pow           | 129     |                                         |                            |                      | vs H <sub>2</sub> O, EtOH                                    |
| 10054 | Thiofanox                                             |                                                                     | C <sub>9</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub> S               | 39196-18-4 | 218.316  |                      | 57      |                                         |                            |                      |                                                              |
| 10055 | Thioformaldehyde                                      | Methanethial                                                        | CH <sub>2</sub> S                                                            | 865-36-1   | 46.092   | unstab gas           |         |                                         |                            |                      |                                                              |
| 10056 | Thioglycolic acid                                     |                                                                     | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> S                               | 68-11-1    | 92.117   |                      | -16.5   | 120 <sup>20</sup>                       | 1.3253 <sup>20</sup>       | 1.5080 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, eth; sl chl                      |
| 10057 | Thioimidodicarbonic diamide                           | 2,4-Dithiobiuret                                                    | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> S <sub>2</sub>                  | 541-53-7   | 135.211  | mcl cry              | 181 dec |                                         |                            |                      | vs ace                                                       |
| 10058 | Thiolactic acid                                       |                                                                     | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> S                               | 71563-86-5 | 106.144  |                      | 12      | 106 <sup>15</sup>                       | 1.1938 <sup>20</sup>       | 1.4810 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth; sl chl                        |
| 10059 | Thiometon                                             |                                                                     | C <sub>8</sub> H <sub>15</sub> O <sub>2</sub> PS <sub>3</sub>                | 640-15-3   | 246.351  | oil                  |         | 110 <sup>0.1</sup> , 77 <sup>0.01</sup> | 1.209 <sup>20</sup>        |                      | sl H <sub>2</sub> O; s os                                    |
| 10060 | Thiomorpholine                                        | Thiamorpholine                                                      | C <sub>4</sub> H <sub>9</sub> NS                                             | 123-90-0   | 103.186  |                      |         | 175; 110 <sup>100</sup>                 | 1.0882 <sup>20</sup>       | 1.5386 <sup>20</sup> | vs H <sub>2</sub> O, ace, eth, EtOH                          |
| 10061 | Thionazin                                             | Phosphorothioic acid, <i>O,O</i> -diethyl <i>O</i> -pyrazinyl ester | C <sub>8</sub> H <sub>13</sub> N <sub>2</sub> O <sub>3</sub> PS              | 297-97-2   | 248.239  | liq                  | -0.9    | 80                                      |                            |                      |                                                              |
| 10062 | Thiophanate-methyl                                    |                                                                     | C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>4</sub> S <sub>2</sub> | 23564-05-8 | 342.394  |                      | 172 dec |                                         |                            |                      |                                                              |
| 10063 | Thiophene                                             | Thiofuran                                                           | C <sub>4</sub> H <sub>4</sub> S                                              | 110-02-1   | 84.140   | liq                  | -38.21  | 84.0                                    | 1.0649 <sup>20</sup>       | 1.5289 <sup>20</sup> | msc EtOH, eth, ace, bz, ctc, dio, py; sl chl                 |
| 10064 | 2-Thiopheneacetic acid                                |                                                                     | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub> S                               | 1918-77-0  | 142.176  | cry (w)              | 76      |                                         |                            |                      | vs H <sub>2</sub> O, eth, EtOH                               |
| 10065 | 2-Thiopheneacetonitrile                               |                                                                     | C <sub>6</sub> H <sub>5</sub> NS                                             | 20893-30-5 | 123.176  |                      |         | 120 <sup>23</sup>                       | 1.155 <sup>25</sup>        | 1.5425 <sup>20</sup> |                                                              |
| 10066 | 2-Thiophenecarbonitrile                               | 2-Cyanothiophene                                                    | C <sub>5</sub> H <sub>3</sub> NS                                             | 1003-31-2  | 109.150  |                      |         | 192                                     | 1.172 <sup>25</sup>        | 1.5629 <sup>20</sup> | s chl                                                        |
| 10067 | 3-Thiophenecarbonitrile                               | 3-Cyanothiophene                                                    | C <sub>5</sub> H <sub>3</sub> NS                                             | 1641-09-4  | 109.150  | oil                  |         | 204; 85 <sup>15</sup>                   |                            |                      |                                                              |
| 10068 | 2-Thiophenecarbonyl chloride                          |                                                                     | C <sub>6</sub> H <sub>4</sub> ClOS                                           | 5271-67-0  | 146.595  |                      |         | 280                                     |                            |                      |                                                              |
| 10069 | 2-Thiophenecarboxaldehyde                             |                                                                     | C <sub>6</sub> H <sub>4</sub> OS                                             | 98-03-3    | 112.150  | pa ye liq            |         | 197; 85 <sup>16</sup>                   | 1.2127 <sup>21</sup>       | 1.5920 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; s eth; sl chl                   |
| 10070 | 3-Thiophenecarboxaldehyde                             | 3-Formylthiophene                                                   | C <sub>6</sub> H <sub>4</sub> OS                                             | 498-62-4   | 112.150  |                      |         | 86.7 <sup>20</sup>                      |                            | 1.5855 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                             |
| 10071 | 2-Thiophenecarboxylic acid                            | 2-Carboxythiophene                                                  | C <sub>6</sub> H <sub>4</sub> O <sub>2</sub> S                               | 527-72-0   | 128.150  | nd (w)               | 129.5   | dec 260                                 |                            |                      | vs H <sub>2</sub> O, EtOH, eth; s chl; sl peth               |
| 10072 | 3-Thiophenecarboxylic acid                            | 3-Thenoic acid                                                      | C <sub>6</sub> H <sub>4</sub> O <sub>2</sub> S                               | 88-13-1    | 128.150  |                      | 138     |                                         |                            |                      | s H <sub>2</sub> O                                           |
| 10073 | 2,5-Thiophenedicarboxylic acid                        | 2,5-Dicarboxythiophene                                              | C <sub>6</sub> H <sub>4</sub> O <sub>4</sub> S                               | 4282-31-9  | 172.159  |                      | 359     | sub 150                                 |                            |                      | sl H <sub>2</sub> O; s EtOH, eth                             |
| 10074 | 2-Thiophenemethanol                                   |                                                                     | C <sub>6</sub> H <sub>6</sub> OS                                             | 636-72-6   | 114.166  |                      |         | 207; 86 <sup>10</sup>                   | 1.2053 <sup>16</sup>       | 1.5280 <sup>20</sup> | s EtOH, ace                                                  |
| 10075 | 2-Thiophenesulfonyl chloride                          |                                                                     | C <sub>6</sub> H <sub>4</sub> ClO <sub>2</sub> S <sub>2</sub>                | 16629-19-9 | 182.649  |                      | 28      | 100 <sup>6</sup>                        |                            |                      | s eth                                                        |
| 10076 | Thiopropazate                                         |                                                                     | C <sub>23</sub> H <sub>28</sub> ClN <sub>3</sub> O <sub>2</sub> S            | 84-06-0    | 446.005  |                      |         | 216 <sup>0.1</sup>                      |                            |                      |                                                              |
| 10077 | 4 <i>H</i> -Thiopyran-4-thione                        |                                                                     | C <sub>5</sub> H <sub>4</sub> S <sub>2</sub>                                 | 1120-94-1  | 128.216  |                      | 47      |                                         |                            |                      |                                                              |



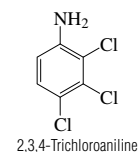
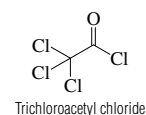
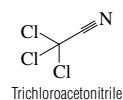
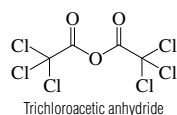
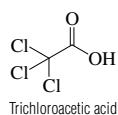
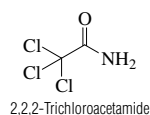
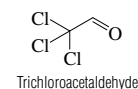
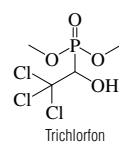
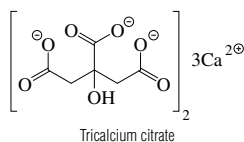
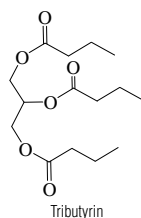
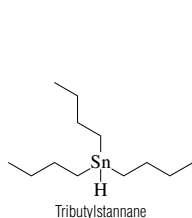
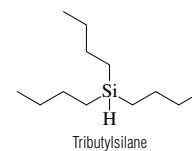
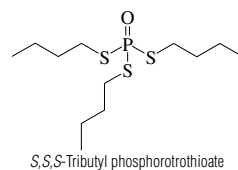
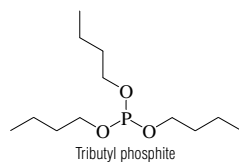
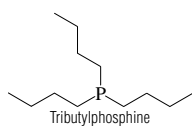
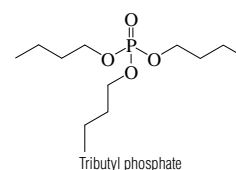
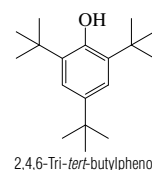
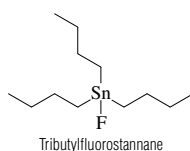
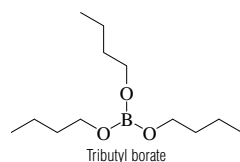
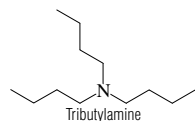
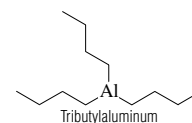
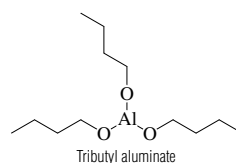
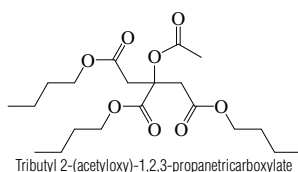
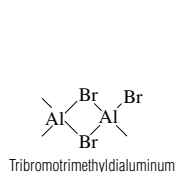
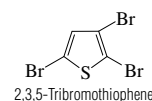
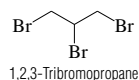
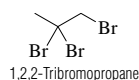
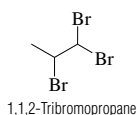
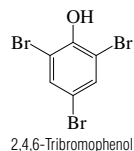
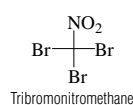
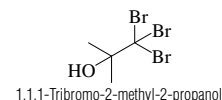
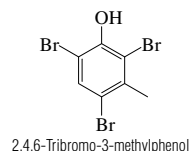
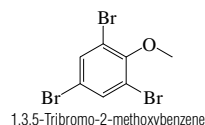
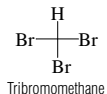
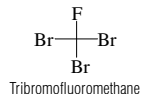
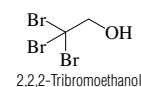
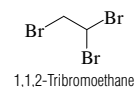
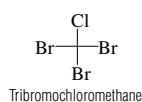
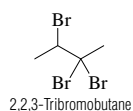
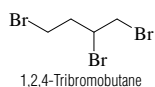
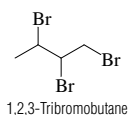
| No.   | Name                                       | Synonym                                                                | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form             | mp/°C   | bp/°C                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                    |
|-------|--------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------|------------|----------|---------------------------|---------|----------------------|----------------------------|----------------------|---------------------------------------------------------------|
| 10078 | Thioquinox                                 |                                                                        | C <sub>9</sub> H <sub>4</sub> N <sub>2</sub> S <sub>3</sub>                  | 93-75-4    | 236.336  | br-ye pow                 | 180     |                      |                            |                      | i H <sub>2</sub> O; sl ace, EtOH, peth                        |
| 10079 | Thiordazine                                |                                                                        | C <sub>12</sub> H <sub>26</sub> N <sub>2</sub> S <sub>2</sub>                | 50-52-2    | 262.477  | cry                       | 73      | 230 <sup>0.02</sup>  |                            |                      | sl ace                                                        |
| 10080 | <i>cis</i> -Thiothixene                    |                                                                        | C <sub>23</sub> H <sub>28</sub> N <sub>2</sub> O <sub>2</sub> S <sub>2</sub> | 3313-26-6  | 443.625  | cry                       | 148     |                      |                            |                      |                                                               |
| 10081 | Thiourea                                   | Thiocarbamide                                                          | CH <sub>4</sub> N <sub>2</sub> S                                             | 62-56-6    | 76.121   | orth (al)                 | 178     |                      | 1.405 <sup>25</sup>        |                      | s H <sub>2</sub> O, EtOH; i eth                               |
| 10082 | 9 <i>H</i> -Thioxanthene                   | Dibenzothiapyran                                                       | C <sub>13</sub> H <sub>10</sub> S                                            | 261-31-4   | 198.283  | nd (al-chl)               | 128.5   | 341                  |                            |                      | s chl                                                         |
| 10083 | 9 <i>H</i> -Thioxanthene-9-one             | Thioxanthone                                                           | C <sub>13</sub> H <sub>8</sub> OS                                            | 492-22-8   | 212.267  | ye nd (chl)               | 209     | 373                  |                            |                      | i H <sub>2</sub> O, peth; sl EtOH; s bz, chl, CS <sub>2</sub> |
| 10084 | 2-Thioxo-4-imidazolidinone                 | 2-Thiohydantoin                                                        | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> OS                              | 503-87-7   | 116.141  | wh nd (w)                 | 230 dec |                      |                            |                      | vs H <sub>2</sub> O, EtOH; s eth, alk                         |
| 10085 | 2-Thioxo-4-thiazolidinone                  | Rhodanine                                                              | C <sub>3</sub> H <sub>3</sub> NOS <sub>2</sub>                               | 141-84-4   | 133.192  | lt ye pr (al, w)          | 170     |                      | 0.868 <sup>25</sup>        |                      | sl H <sub>2</sub> O, DMSO; vs EtOH, eth                       |
| 10086 | Thiram                                     |                                                                        | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> S <sub>4</sub>                 | 137-26-8   | 240.432  | wh or ye mcl (chl-al)     | 155.6   | 129 <sup>20</sup>    |                            |                      | vs chl                                                        |
| 10087 | <i>L</i> -Threonine                        | 2-Amino-3-hydroxybutanoic acid, [ <i>R</i> -( <i>R</i> *, <i>S</i> *)] | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                                | 72-19-5    | 119.119  |                           | 256 dec |                      |                            |                      | s H <sub>2</sub> O; i EtOH, eth, chl                          |
| 10088 | <i>D</i> -Threose                          |                                                                        | C <sub>4</sub> H <sub>8</sub> O <sub>4</sub>                                 | 95-43-2    | 120.105  | hyg-syr or nd (w)         | 129     |                      |                            |                      | vs H <sub>2</sub> O                                           |
| 10089 | <i>L</i> -Threose                          |                                                                        | C <sub>4</sub> H <sub>8</sub> O <sub>4</sub>                                 | 95-44-3    | 120.105  |                           |         |                      |                            |                      |                                                               |
| 10090 | Thujic acid                                | 5,5-Dimethyl-1,3,6-cycloheptatriene-1-carboxylic acid                  | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                               | 499-89-8   | 164.201  | cry (peth)                | 88.5    |                      |                            |                      |                                                               |
| 10091 | α-Thujone                                  | 4-Methyl-1-(1-methylethyl)-bicyclo[3.1.0]hexan-3-one, (/)              | C <sub>10</sub> H <sub>16</sub> O                                            | 546-80-5   | 152.233  |                           |         | 201.2                | 0.9109 <sup>25</sup>       | 1.4490 <sup>15</sup> | i H <sub>2</sub> O; s EtOH                                    |
| 10092 | 3-Thujopsene                               | Widdrene                                                               | C <sub>15</sub> H <sub>24</sub>                                              | 470-40-6   | 204.352  | liq                       |         | 122 <sup>12</sup>    | 0.932 <sup>24</sup>        | 1.5031 <sup>25</sup> |                                                               |
| 10093 | Thymidine                                  | Thymine 2-desoxyriboside                                               | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O <sub>5</sub>                | 50-89-5    | 242.228  | nd (AcOEt)                | 186.5   |                      |                            |                      | s H <sub>2</sub> O, EtOH, ace, py, HOAc; sl chl               |
| 10094 | Thymine                                    |                                                                        | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                  | 65-71-4    | 126.114  |                           | 316     |                      |                            |                      | sl H <sub>2</sub> O, EtOH, eth, DMSO                          |
| 10095 | Thymol                                     | 2-Isopropyl-5-methylphenol                                             | C <sub>10</sub> H <sub>14</sub> O                                            | 89-83-8    | 150.217  |                           | 49.5    | 232.5                | 0.970 <sup>25</sup>        | 1.5227 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, chl, AcOEt                  |
| 10096 | Thymol Blue                                |                                                                        | C <sub>27</sub> H <sub>30</sub> O <sub>5</sub> S                             | 76-61-9    | 466.589  | grn-red (al, eth)         | 222 dec |                      |                            |                      | sl H <sub>2</sub> O, ace, bz; s EtOH, HOAc, PhNH <sub>2</sub> |
| 10097 | Thymol iodide                              |                                                                        | C <sub>20</sub> H <sub>24</sub> I <sub>2</sub> O <sub>2</sub>                | 552-22-7   | 550.213  | amorp                     |         |                      |                            |                      | i H <sub>2</sub> O; s eth; vs EtOH                            |
| 10098 | Thymolphthalein                            |                                                                        | C <sub>28</sub> H <sub>30</sub> O <sub>4</sub>                               | 125-20-2   | 430.536  | pr or nd (al)             | 253     |                      |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace; sl DMSO                 |
| 10099 | <i>L</i> -Thyroxine                        |                                                                        | C <sub>15</sub> H <sub>11</sub> I <sub>4</sub> NO <sub>4</sub>               | 51-48-9    | 776.871  | nd                        | 235     |                      |                            |                      | sl H <sub>2</sub> O; i EtOH, bz                               |
| 10100 | Timolol                                    |                                                                        | C <sub>13</sub> H <sub>24</sub> N <sub>4</sub> O <sub>3</sub> S              | 26839-75-8 | 316.420  | oil                       |         |                      |                            |                      |                                                               |
| 10101 | Tiocardide                                 |                                                                        | C <sub>23</sub> H <sub>32</sub> N <sub>2</sub> O <sub>2</sub> S              | 910-86-1   | 400.577  |                           | 146     |                      |                            |                      |                                                               |
| 10102 | Tipecidine                                 | 3-(Di-2-thienylmethylene)-1-methylpiperidine                           | C <sub>15</sub> H <sub>17</sub> NS <sub>2</sub>                              | 5169-78-8  | 275.433  | ye cry                    | 65      | 181 <sup>4.5</sup>   |                            |                      |                                                               |
| 10103 | Tobramycin                                 |                                                                        | C <sub>18</sub> H <sub>37</sub> N <sub>5</sub> O <sub>9</sub>                | 32986-56-4 | 467.516  | cry                       |         |                      |                            |                      | s H <sub>2</sub> O                                            |
| 10104 | β-Tocopherol                               | 5,8-Dimethyltolcol                                                     | C <sub>28</sub> H <sub>48</sub> O <sub>2</sub>                               | 148-03-8   | 416.680  | pa ye visc oil            |         | 205 <sup>0.1</sup>   |                            |                      | vs ace, eth, EtOH, chl                                        |
| 10105 | γ-Tocopherol                               | 7,8-Dimethyltolcol                                                     | C <sub>28</sub> H <sub>48</sub> O <sub>2</sub>                               | 7616-22-0  | 416.680  | pa ye visc oil            | -1.5    | 205 <sup>0.1</sup>   |                            |                      | i H <sub>2</sub> O; msc EtOH, eth, ace, chl                   |
| 10106 | δ-Tocopherol                               | 8-Methyltolcol                                                         | C <sub>27</sub> H <sub>46</sub> O <sub>2</sub>                               | 119-13-1   | 402.653  | pa ye visc oil            |         | 150 <sup>0.001</sup> |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, ace, chl                    |
| 10107 | Tolazamide                                 |                                                                        | C <sub>14</sub> H <sub>21</sub> N <sub>3</sub> O <sub>3</sub> S              | 1156-19-0  | 311.400  | cry                       | 172     |                      |                            |                      |                                                               |
| 10108 | Tolbutamide                                | <i>N</i> -[(Butylamino)carbonyl]-4-methylbenzenesulfonamide            | C <sub>12</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub> S              | 64-77-7    | 270.347  | orth cry                  | 128.5   |                      | 1.245 <sup>25</sup>        |                      | sl H <sub>2</sub> O; s EtOH, eth, chl                         |
| 10109 | α-Tolidine                                 | 3,3'-Dimethylbenzidine                                                 | C <sub>14</sub> H <sub>16</sub> N <sub>2</sub>                               | 119-93-7   | 212.290  | wh-red lf (EtOH aq)       | 131     |                      |                            |                      | sl H <sub>2</sub> O, chl; vs EtOH, eth                        |
| 10110 | Tolmetin                                   |                                                                        | C <sub>15</sub> H <sub>15</sub> NO <sub>3</sub>                              | 26171-23-3 | 257.285  | cry (MeCN)                | 156 dec |                      |                            |                      |                                                               |
| 10111 | Toluene                                    | Methylbenzene                                                          | C <sub>7</sub> H <sub>8</sub>                                                | 108-88-3   | 92.139   | liq                       | -94.95  | 110.63               | 0.8623 <sup>25</sup>       | 1.4941 <sup>25</sup> | i H <sub>2</sub> O, msc EtOH, eth; s ace, CS <sub>2</sub>     |
| 10112 | Toluene-2,4-diamine                        | 4-Methyl-1,3-benzenediamine                                            | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                                | 95-80-7    | 122.167  | nd (w), cry (al)          | 99      | 292                  |                            |                      | vs H <sub>2</sub> O, EtOH, eth, bz; s chl                     |
| 10113 | Toluene-3,5-diamine                        | 5-Methyl-1,3-benzenediamine                                            | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                                | 108-71-4   | 122.167  | oil                       |         | 284                  |                            |                      |                                                               |
| 10114 | Toluene-2,4-diisocyanate                   |                                                                        | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                  | 584-84-9   | 174.156  |                           | 20.5    | 251                  | 1.2244 <sup>20</sup>       |                      | vs ace, bz, eth                                               |
| 10115 | Toluene-2,6-diisocyanate                   |                                                                        | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                  | 91-08-7    | 174.156  |                           | 18.3    |                      |                            |                      | dec H <sub>2</sub> O; s ace, bz                               |
| 10116 | <i>p</i> -Toluenesulfonic acid             |                                                                        | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub> S                               | 104-15-4   | 172.202  | hyg pl (w+1) mcl lf or pl | 104.5   | 140 <sup>20</sup>    |                            |                      | vs H <sub>2</sub> O; s EtOH, eth                              |
| 10117 | <i>p</i> -Toluenesulfonic acid monohydrate | 4-Methylbenzenesulfonic acid, monohydrate                              | C <sub>7</sub> H <sub>10</sub> O <sub>4</sub> S                              | 6192-52-5  | 190.217  |                           | 105.3   |                      |                            |                      | s H <sub>2</sub> O                                            |



| No.   | Name                                                                             | Synonym                                               | Mol. Form.                                                        | CAS RN      | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                             |
|-------|----------------------------------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------------------|-------------|----------|--------------------|---------|---------------------------------------|----------------------------|-----------------------|--------------------------------------------------------|
| 10118 | <i>p</i> -Toluenesulfonyl chloride                                               |                                                       | C <sub>7</sub> H <sub>7</sub> ClO <sub>2</sub> S                  | 98-59-9     | 190.648  | tcl (eth, peth)    | 71      | 145 <sup>15</sup>                     |                            |                       | i H <sub>2</sub> O; s EtOH, eth, chl; vs bz            |
| 10119 | <i>o</i> -Toluic acid                                                            |                                                       | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                      | 118-90-1    | 136.149  | pr or nd (w)       | 103.5   | 259                                   | 1.062 <sup>115</sup>       | 1.512 <sup>115</sup>  | i H <sub>2</sub> O; vs EtOH, eth; s chl                |
| 10120 | <i>m</i> -Toluic acid                                                            |                                                       | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                      | 99-04-7     | 136.149  |                    | 109.9   |                                       | 1.054 <sup>112</sup>       | 1.509                 | sl H <sub>2</sub> O, chl; vs EtOH, eth                 |
| 10121 | <i>p</i> -Toluic acid                                                            |                                                       | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                      | 99-94-5     | 136.149  |                    | 179.6   |                                       |                            |                       | i H <sub>2</sub> O; vs EtOH, eth, MeOH; sl tfa         |
| 10122 | <i>N</i> - <i>o</i> -Tolylbiguanide                                              | <i>N</i> -(2-Methylphenyl)imidodicarbonimidic diamide | C <sub>9</sub> H <sub>13</sub> N <sub>5</sub>                     | 93-69-6     | 191.233  | nd or pl (w+1)     | 145.0   |                                       |                            |                       | sl H <sub>2</sub> O; vs EtOH, ace; i bz, chl, eth      |
| 10123 | Tomatine                                                                         |                                                       | C <sub>50</sub> H <sub>83</sub> NO <sub>21</sub>                  | 17406-45-0  | 1034.188 | nd (MeOH)          | 270     |                                       |                            |                       | vs EtOH, diox                                          |
| 10124 | Tralomethrin                                                                     |                                                       | C <sub>22</sub> H <sub>19</sub> Br <sub>4</sub> NO <sub>3</sub>   | 66841-25-6  | 665.007  | oran-ye solid      |         |                                       |                            |                       |                                                        |
| 10125 | Tranlylcypromine                                                                 | 2-Phenylcyclopropylamine                              | C <sub>9</sub> H <sub>11</sub> N                                  | 155-09-9    | 133.190  | cry                | 44      | 127 <sup>32</sup>                     |                            |                       |                                                        |
| 10126 | Trehalose                                                                        |                                                       | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                   | 99-20-7     | 342.296  | orth cry           | 203     |                                       | 1.58 <sup>24</sup>         |                       | vs H <sub>2</sub> O; s EtOH; i eth, bz                 |
| 10127 | Triacetamide                                                                     |                                                       | C <sub>6</sub> H <sub>9</sub> NO <sub>3</sub>                     | 641-06-5    | 143.140  | nd (eth)           | 79      |                                       |                            |                       | vs eth                                                 |
| 10128 | Triacetin                                                                        | Glycerol triacetate                                   | C <sub>9</sub> H <sub>14</sub> O <sub>6</sub>                     | 102-76-1    | 218.203  | col oily liq       | -78     | 259                                   | 1.1583 <sup>20</sup>       | 1.4301 <sup>20</sup>  | sl H <sub>2</sub> O; msc EtOH, eth, bz; vs ace         |
| 10129 | Triacontane                                                                      |                                                       | C <sub>30</sub> H <sub>62</sub>                                   | 638-68-6    | 422.813  | orth (eth, bz)     | 65.1    | 452.0                                 | 0.8097 <sup>20</sup>       | 1.4352 <sup>70</sup>  | i H <sub>2</sub> O; sl EtOH; s eth; vs bz              |
| 10130 | Triacantanolic acid                                                              |                                                       | C <sub>30</sub> H <sub>60</sub> O <sub>2</sub>                    | 506-50-3    | 452.796  | sc, nd (al, ace)   | 93.6    |                                       |                            | 1.4323 <sup>100</sup> | vs bz, CS <sub>2</sub> , chl                           |
| 10131 | 1-Triacontanol                                                                   | Myrcyl alcohol                                        | C <sub>30</sub> H <sub>62</sub> O                                 | 593-50-0    | 438.812  | nd (eth), pl (bz)  | 88      |                                       | 0.777 <sup>95</sup>        |                       | vs bz, eth, EtOH                                       |
| 10132 | Triadimenol                                                                      | Mercury, chloro(2-methoxyethyl)-                      | C <sub>3</sub> H <sub>7</sub> ClHgO                               | 123-88-6    | 295.13   | cry                | 115     |                                       |                            |                       | i H <sub>2</sub> O; s EtOH, ace                        |
| 10133 | Triallate                                                                        |                                                       | C <sub>10</sub> H <sub>16</sub> Cl <sub>3</sub> NOS               | 2303-17-5   | 304.664  |                    | 29      | 117 <sup>0.0003</sup>                 | 1.273 <sup>25</sup>        |                       |                                                        |
| 10134 | Triallyl phosphate                                                               |                                                       | C <sub>9</sub> H <sub>15</sub> O <sub>4</sub> P                   | 1623-19-4   | 218.186  |                    | -50     | 108 <sup>7</sup>                      | 1.0815 <sup>20</sup>       |                       | sl chl                                                 |
| 10135 | 1,3,5-Triallyl-1,3,5-triazine-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-trione |                                                       | C <sub>12</sub> H <sub>15</sub> N <sub>3</sub> O <sub>3</sub>     | 1025-15-6   | 249.265  |                    | 20.5    | 149 <sup>4</sup> , 105 <sup>0.5</sup> | 1.1590 <sup>20</sup>       |                       |                                                        |
| 10136 | Triamcinolone                                                                    | Fluoxiprednisolone                                    | C <sub>21</sub> H <sub>27</sub> FO <sub>6</sub>                   | 124-94-7    | 394.433  | cry                | 270     |                                       |                            |                       |                                                        |
| 10137 | Triamphos                                                                        |                                                       | C <sub>12</sub> H <sub>19</sub> N <sub>6</sub> OP                 | 1031-47-6   | 294.292  | cry (EtOH aq)      | 167     |                                       |                            |                       | sl H <sub>2</sub> O; s os                              |
| 10138 | Triasulfuron                                                                     |                                                       | C <sub>14</sub> H <sub>16</sub> ClN <sub>5</sub> O <sub>5</sub> S | 82097-50-5  | 401.826  |                    | 186     |                                       |                            |                       |                                                        |
| 10139 | 1,2,4-Triazine                                                                   |                                                       | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub>                      | 290-38-0    | 81.076   | pa ye oil          | 16.5    | 157                                   |                            | 1.5149 <sup>25</sup>  |                                                        |
| 10140 | 1,3,5-Triazine                                                                   |                                                       | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub>                      | 290-87-9    | 81.076   |                    | 80.3    | 114                                   | 1.38 <sup>25</sup>         |                       | s EtOH, eth                                            |
| 10141 | 1,2,4-Triazine-3,5-(2 <i>H</i> ,4 <i>H</i> )-dione                               |                                                       | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub> O <sub>2</sub>       | 461-89-2    | 113.075  |                    | 276.8   |                                       |                            |                       |                                                        |
| 10142 | 1,3,5-Triazine-2,4,6-triamine                                                    | Melamine                                              | C <sub>3</sub> H <sub>6</sub> N <sub>6</sub>                      | 108-78-1    | 126.120  | mcl pr (w)         | 345 dec | sub                                   | 1.573 <sup>16</sup>        | 1.872 <sup>20</sup>   | sl H <sub>2</sub> O, EtOH; i eth                       |
| 10143 | 1,3,5-Triazine-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-trithione             | Trithiocyanuric acid                                  | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub> S <sub>3</sub>       | 638-16-4    | 177.271  | ye pr              | >300    | 100 <sup>22</sup>                     |                            |                       |                                                        |
| 10144 | Triazofos                                                                        |                                                       | C <sub>12</sub> H <sub>16</sub> N <sub>3</sub> O <sub>3</sub> PS  | 24017-47-8  | 313.312  | ye-br oil          | 5       |                                       | 1.2514 <sup>20</sup>       |                       | i H <sub>2</sub> O; s os                               |
| 10145 | Triazolam                                                                        |                                                       | C <sub>17</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>4</sub>    | 28911-01-5  | 343.210  | tan cry (2-PrOH)   | 234     |                                       |                            |                       |                                                        |
| 10146 | 1 <i>H</i> -1,2,4-Triazol-3-amine                                                | Amitrole                                              | C <sub>2</sub> H <sub>4</sub> N <sub>4</sub>                      | 61-82-5     | 84.080   | cry (w, al)        | 159     |                                       |                            |                       | vs H <sub>2</sub> O, EtOH; i eth, ace; s chl; sl AcOEt |
| 10147 | 1 <i>H</i> -1,2,3-Triazole                                                       |                                                       | C <sub>2</sub> H <sub>3</sub> N <sub>3</sub>                      | 288-36-8    | 69.065   | hyg cry            | 23      | 204                                   | 1.1861 <sup>25</sup>       | 1.4854 <sup>25</sup>  | s H <sub>2</sub> O; s eth, ace; i lig                  |
| 10148 | 1 <i>H</i> -1,2,4-Triazole                                                       | Pyrrrodiazole                                         | C <sub>2</sub> H <sub>3</sub> N <sub>3</sub>                      | 288-88-0    | 69.065   | nd (bz/EtOH)       | 120.5   | 260 dec                               |                            |                       | s H <sub>2</sub> O, EtOH                               |
| 10149 | 1 <i>H</i> -1,2,4-Triazole-3,5-diamine                                           |                                                       | C <sub>2</sub> H <sub>5</sub> N <sub>5</sub>                      | 1455-77-2   | 99.095   |                    | 211.5   |                                       |                            |                       | s H <sub>2</sub> O, EtOH; i eth, bz                    |
| 10150 | Tribenuron-methyl                                                                |                                                       | C <sub>15</sub> H <sub>17</sub> N <sub>5</sub> O <sub>6</sub> S   | 101200-48-0 | 395.391  | solid              | 141     |                                       |                            |                       |                                                        |
| 10151 | Tribenzylamine                                                                   | <i>N,N</i> -Bis(phenylmethyl)benzenemethanamine       | C <sub>21</sub> H <sub>21</sub> N                                 | 620-40-6    | 287.399  | pl (eth), mcl (al) | 91.5    | 385                                   | 0.9912 <sup>95</sup>       |                       | sl H <sub>2</sub> O, EtOH; s eth, ctc                  |
| 10152 | Tribromoacetaldehyde                                                             | Bromal                                                | C <sub>2</sub> HBr <sub>3</sub> O                                 | 115-17-3    | 280.740  |                    |         | 174                                   | 2.6649 <sup>25</sup>       | 1.5939 <sup>20</sup>  | vs ace, eth, EtOH                                      |
| 10153 | Tribromoacetic acid                                                              |                                                       | C <sub>2</sub> HBr <sub>3</sub> O <sub>2</sub>                    | 75-96-7     | 296.740  | mcl                | 132     | dec 245                               |                            |                       | s H <sub>2</sub> O, EtOH, eth                          |
| 10154 | 2,4,6-Tribromoaniline                                                            |                                                       | C <sub>6</sub> H <sub>3</sub> Br <sub>3</sub> N                   | 147-82-0    | 329.815  | nd (al, bz)        | 122     | 300                                   | 2.35 <sup>20</sup>         |                       | i H <sub>2</sub> O; sl EtOH; s eth, chl                |
| 10155 | 1,2,4-Tribromobenzene                                                            |                                                       | C <sub>6</sub> H <sub>3</sub> Br <sub>3</sub>                     | 615-54-3    | 314.800  |                    | 44.5    | 275                                   |                            |                       | i H <sub>2</sub> O; s EtOH; vs eth, ace; sl bz         |
| 10156 | 1,3,5-Tribromobenzene                                                            |                                                       | C <sub>6</sub> H <sub>3</sub> Br <sub>3</sub>                     | 626-39-1    | 314.800  | nd or pr (al)      | 122.8   | 271                                   |                            |                       | i H <sub>2</sub> O; sl EtOH; s eth, bz, chl            |
| 10157 | 1,1,2-Tribromobutane                                                             |                                                       | C <sub>4</sub> H <sub>7</sub> Br <sub>3</sub>                     | 3675-68-1   | 294.811  |                    |         | 216.2                                 | 2.1835 <sup>20</sup>       | 1.5626 <sup>17</sup>  | vs eth, EtOH, chl                                      |
| 10158 | 1,2,2-Tribromobutane                                                             |                                                       | C <sub>4</sub> H <sub>7</sub> Br <sub>3</sub>                     | 3675-69-2   | 294.811  |                    |         | 213.8                                 | 2.1692 <sup>20</sup>       | 1.568 <sup>20</sup>   | vs eth, EtOH, chl                                      |

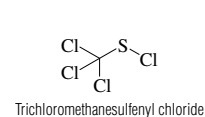
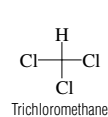
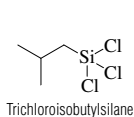
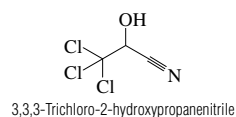
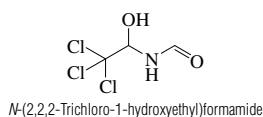
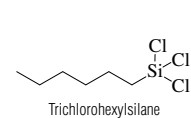
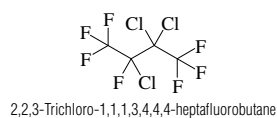
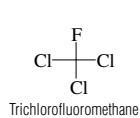
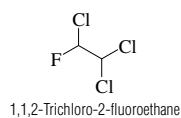
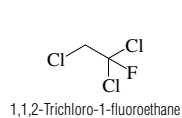
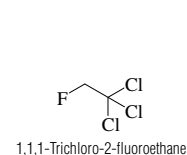
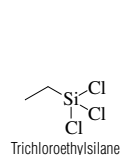
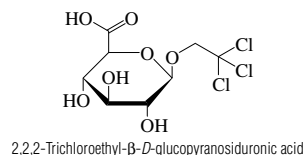
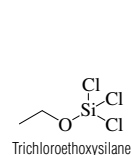
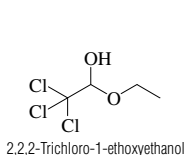
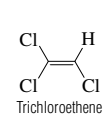
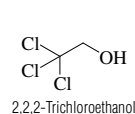
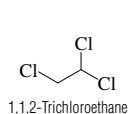
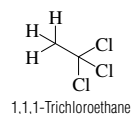
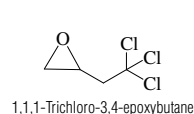
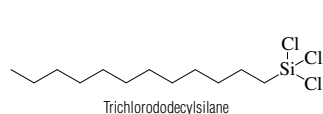
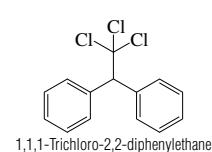
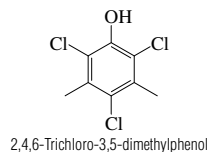
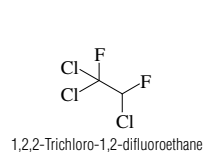
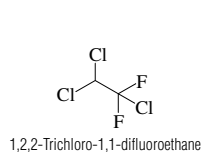
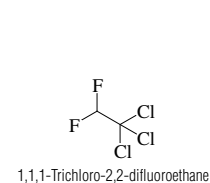
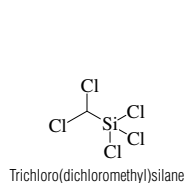
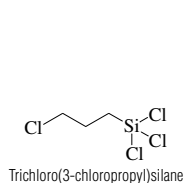
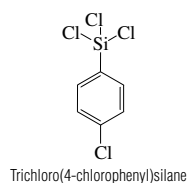
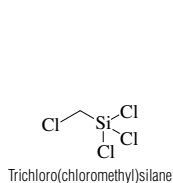
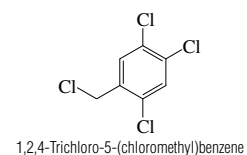
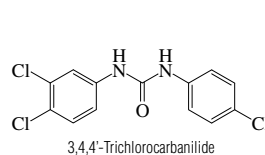
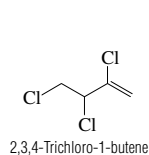
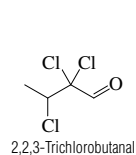
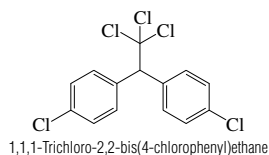
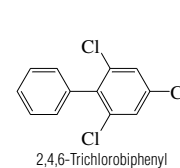
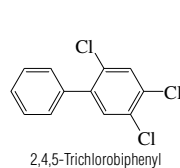
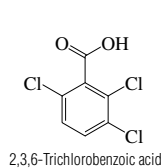
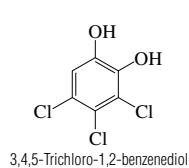
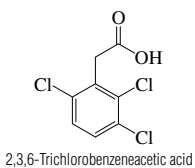
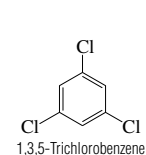
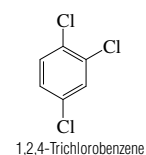
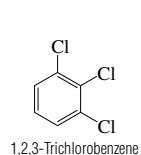
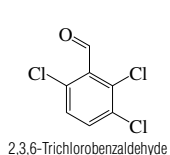
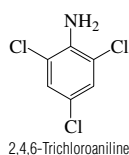
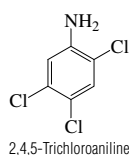


| No.   | Name                                               | Synonym                                    | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form         | mp/°C          | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                              |
|-------|----------------------------------------------------|--------------------------------------------|-----------------------------------------------------------------|------------|----------|-----------------------|----------------|---------------------------------------|----------------------------|----------------------|---------------------------------------------------------|
| 10159 | 1,2,3-Tribromobutane                               |                                            | C <sub>4</sub> H <sub>7</sub> Br <sub>3</sub>                   | 632-05-3   | 294.811  | liq                   | -19            | 220                                   | 2.1907 <sup>20</sup>       | 1.5680 <sup>20</sup> | vs eth, EtOH, chl                                       |
| 10160 | 1,2,4-Tribromobutane                               |                                            | C <sub>4</sub> H <sub>7</sub> Br <sub>3</sub>                   | 38300-67-3 | 294.811  | liq                   | -18            | 215                                   | 2.170 <sup>20</sup>        | 1.5608 <sup>20</sup> | vs eth, EtOH, chl                                       |
| 10161 | 2,2,3-Tribromobutane                               |                                            | C <sub>4</sub> H <sub>7</sub> Br <sub>3</sub>                   | 62127-47-3 | 294.811  |                       | 0.9            | 206                                   | 2.1723 <sup>20</sup>       | 1.5602 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl; sl ctc            |
| 10162 | Tribromochloromethane                              |                                            | CBr <sub>3</sub> Cl                                             | 594-15-0   | 287.176  | lf (eth)              | 55             | 158.5                                 | 2.71 <sup>15</sup>         |                      | vs eth                                                  |
| 10163 | 1,1,2-Tribromoethane                               |                                            | C <sub>2</sub> H <sub>3</sub> Br <sub>3</sub>                   | 78-74-0    | 266.757  | liq                   | -29.3          | 188.93                                | 2.6210 <sup>20</sup>       | 1.5933 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, ctc                |
| 10164 | 2,2,2-Tribromoethanol                              |                                            | C <sub>2</sub> H <sub>3</sub> Br <sub>3</sub> O                 | 75-80-9    | 282.756  | nd or pr (peth)       | 81             | 92 <sup>10</sup>                      |                            |                      | vs bz, eth, EtOH                                        |
| 10165 | Tribromoethene                                     |                                            | C <sub>2</sub> HBr <sub>3</sub>                                 | 598-16-3   | 264.741  |                       |                | 164                                   | 2.708 <sup>20</sup>        | 1.6045 <sup>16</sup> | sl H <sub>2</sub> O; vs EtOH; s eth, ace, chl           |
| 10166 | Tribromofluoromethane                              |                                            | CBr <sub>3</sub> F                                              | 353-54-8   | 270.721  | liq                   | -73.6          | 108                                   |                            |                      | i H <sub>2</sub> O; s EtOH                              |
| 10167 | Tribromomethane                                    | Bromoform                                  | CHBr <sub>3</sub>                                               | 75-25-2    | 252.731  |                       | 8.69           | 149.1                                 | 2.8788 <sup>25</sup>       | 1.5948 <sup>25</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s bz, lig, chl      |
| 10168 | 1,3,5-Tribromo-2-methoxybenzene                    |                                            | C <sub>7</sub> H <sub>5</sub> Br <sub>3</sub> O                 | 607-99-8   | 344.826  | nd (al)               | 88             | 298                                   | 2.491 <sup>25</sup>        |                      | sl H <sub>2</sub> O, EtOH; vs ace, bz; s ctc            |
| 10169 | 2,4,6-Tribromo-3-methylphenol                      | 2,4,6-Tribromo- <i>m</i> -cresol           | C <sub>7</sub> H <sub>5</sub> Br <sub>3</sub> O                 | 4619-74-3  | 344.826  |                       | 84             |                                       |                            |                      | s EtOH, eth, bz, HOAc; sl chl, peth                     |
| 10170 | 1,1,1-Tribromo-2-methyl-2-propanol                 | 1,1,1-Tribromo- <i>tert</i> -butyl alcohol | C <sub>4</sub> H <sub>9</sub> Br <sub>3</sub> O                 | 76-08-4    | 310.810  | nd (lig) cry (dil al) | 169            | sub                                   |                            |                      | sl H <sub>2</sub> O, chl; s EtOH, eth                   |
| 10171 | Tribromonitromethane                               |                                            | CBr <sub>3</sub> NO <sub>2</sub>                                | 464-10-8   | 297.729  | pr                    | 10             | 127 <sup>18</sup>                     | 2.811 <sup>12</sup>        | 1.5790 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; vs ace, bz             |
| 10172 | 2,4,6-Tribromophenol                               |                                            | C <sub>6</sub> H <sub>3</sub> Br <sub>3</sub> O                 | 118-79-6   | 330.799  | nd (al), pr (bz)      | 95.5           | 286                                   | 2.55 <sup>20</sup>         |                      | i H <sub>2</sub> O; vs EtOH; s eth, bz, HOAc, chl       |
| 10173 | 1,1,2-Tribromopropane                              |                                            | C <sub>3</sub> H <sub>5</sub> Br <sub>3</sub>                   | 14602-62-1 | 280.784  |                       |                | 200.5                                 | 2.3547 <sup>20</sup>       | 1.5790 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, chl, HOAc; vs eth           |
| 10174 | 1,2,2-Tribromopropane                              |                                            | C <sub>3</sub> H <sub>5</sub> Br <sub>3</sub>                   | 14476-30-3 | 280.784  |                       |                | 190.5                                 | 2.2984 <sup>20</sup>       | 1.5670 <sup>20</sup> | vs eth, EtOH, chl                                       |
| 10175 | 1,2,3-Tribromopropane                              |                                            | C <sub>3</sub> H <sub>5</sub> Br <sub>3</sub>                   | 96-11-7    | 280.784  |                       | 16.9           | 222.1                                 | 2.4208 <sup>20</sup>       | 1.5862 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; sl ctc                |
| 10176 | 2,3,5-Tribromothiophene                            |                                            | C <sub>4</sub> HBr <sub>3</sub> S                               | 3141-24-0  | 320.828  | nd (al)               | 29             | 260                                   |                            |                      | s chl                                                   |
| 10177 | Tribromotrimethyldialuminum                        | Methyl aluminum sesquibromide              | C <sub>3</sub> H <sub>9</sub> Al <sub>2</sub> Br <sub>3</sub>   | 12263-85-3 | 338.778  | hyg col liq           |                | 110 <sup>50</sup>                     |                            |                      |                                                         |
| 10178 | Tributyl 2-(acetyloxy)-1,2,3-propanetricarboxylate |                                            | C <sub>20</sub> H <sub>34</sub> O <sub>8</sub>                  | 77-90-7    | 402.479  |                       |                | 173 <sup>1</sup>                      |                            |                      | sl chl                                                  |
| 10179 | Tributyl aluminate                                 | 1-Butanol, aluminum salt                   | C <sub>12</sub> H <sub>27</sub> AlO <sub>3</sub>                | 3085-30-1  | 246.322  |                       |                | 260 <sup>5</sup>                      |                            |                      |                                                         |
| 10180 | Tributylaluminum                                   |                                            | C <sub>12</sub> H <sub>27</sub> Al                              | 1116-70-7  | 198.324  |                       |                | 102 <sup>2</sup>                      |                            |                      |                                                         |
| 10181 | Tributylamine                                      | <i>N,N</i> -Dibutyl-1-butanamine           | C <sub>12</sub> H <sub>27</sub> N                               | 102-82-9   | 185.349  | liq                   | -70            | 216.5                                 | 0.7770 <sup>20</sup>       | 1.4299 <sup>20</sup> | sl H <sub>2</sub> O, ctc; vs EtOH, eth; s ace, bz       |
| 10182 | Tributyl borate                                    |                                            | C <sub>12</sub> H <sub>27</sub> BO <sub>3</sub>                 | 688-74-4   | 230.151  | oil                   | <-70           | 234                                   | 0.8567 <sup>20</sup>       | 1.4106 <sup>18</sup> | s EtOH, bz; vs eth, MeOH                                |
| 10183 | Tributylfluorostannane                             | Tributyltin fluoride                       | C <sub>12</sub> H <sub>27</sub> FSn                             | 1983-10-4  | 309.050  | nd                    | ≈260           | sub >200                              |                            |                      |                                                         |
| 10184 | 2,4,6-Tri- <i>tert</i> -butylphenol                |                                            | C <sub>18</sub> H <sub>30</sub> O                               | 732-26-3   | 262.430  | cry (al, peth)        | 131            | 278                                   | 0.864 <sup>27</sup>        |                      | i H <sub>2</sub> O, alk; s EtOH, ace, ctc               |
| 10185 | Tributyl phosphate                                 |                                            | C <sub>12</sub> H <sub>27</sub> O <sub>4</sub> P                | 126-73-8   | 266.313  |                       |                | 289                                   | 0.9727 <sup>25</sup>       | 1.4224 <sup>25</sup> | s H <sub>2</sub> O, eth, bz, CS <sub>2</sub> ; msc EtOH |
| 10186 | Tributylphosphine                                  |                                            | C <sub>12</sub> H <sub>27</sub> P                               | 998-40-3   | 202.316  |                       |                | 240; 150 <sup>50</sup>                | 0.812 <sup>25</sup>        | 1.4619 <sup>20</sup> |                                                         |
| 10187 | Tributyl phosphite                                 | Tributoxyphosphine                         | C <sub>12</sub> H <sub>27</sub> O <sub>3</sub> P                | 102-85-2   | 250.314  |                       |                | 137 <sup>26</sup> , 122 <sup>12</sup> | 0.9259 <sup>20</sup>       | 1.4321 <sup>19</sup> | s EtOH; sl ctc; vs eth                                  |
| 10188 | <i>S,S,S</i> -Tributyl phosphorothioate            | <i>S,S,S</i> -Tributyl trithiophosphate    | C <sub>12</sub> H <sub>27</sub> OPS <sub>3</sub>                | 78-48-8    | 314.510  |                       | <-25           | 150 <sup>0,3</sup>                    | 1.057 <sup>20</sup>        |                      |                                                         |
| 10189 | Tributylsilane                                     |                                            | C <sub>12</sub> H <sub>26</sub> Si                              | 998-41-4   | 200.436  |                       |                | 221                                   | 0.7794 <sup>20</sup>       | 1.4380 <sup>20</sup> |                                                         |
| 10190 | Tributylstannane                                   | Tributyltin hydride                        | C <sub>12</sub> H <sub>26</sub> Sn                              | 688-73-3   | 291.060  | liq                   |                | 113 <sup>8</sup> , 76 <sup>0,7</sup>  | 1.103 <sup>20</sup>        |                      |                                                         |
| 10191 | Tributyryl                                         | Butanoic acid, 1,2,3-propanetriyl ester    | C <sub>15</sub> H <sub>26</sub> O <sub>6</sub>                  | 60-01-5    | 302.363  | liq                   | -75            | 307.5                                 | 1.0350 <sup>20</sup>       | 1.4359 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, ace, bz; sl ctc; vs eth     |
| 10192 | Tricalcium citrate                                 | Calcium citrate                            | C <sub>12</sub> H <sub>10</sub> Ca <sub>3</sub> O <sub>14</sub> | 813-94-5   | 498.433  | cry (w)               | ≈100 dec (hyd) |                                       |                            |                      | sl H <sub>2</sub> O; i EtOH                             |
| 10193 | Trichlorfon                                        |                                            | C <sub>4</sub> H <sub>8</sub> Cl <sub>3</sub> O <sub>4</sub> P  | 52-68-6    | 257.437  |                       | 77             | 100 <sup>0,1</sup>                    | 1.73 <sup>20</sup>         |                      |                                                         |
| 10194 | Trichloroacetaldehyde                              | Chloral                                    | C <sub>2</sub> HCl <sub>3</sub> O                               | 75-87-6    | 147.387  | liq                   | -57.5          | 97.8                                  | 1.512 <sup>20</sup>        | 1.4580 <sup>20</sup> | vs H <sub>2</sub> O; s EtOH, eth                        |
| 10195 | 2,2,2-Trichloroacetamide                           |                                            | C <sub>2</sub> H <sub>2</sub> Cl <sub>3</sub> NO                | 594-65-0   | 162.402  |                       | 142            | 240                                   |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth                       |
| 10196 | Trichloroacetic acid                               |                                            | C <sub>2</sub> HCl <sub>3</sub> O <sub>2</sub>                  | 76-03-9    | 163.387  | hyg cry               | 59.2           | 196.5                                 | 1.6126 <sup>64</sup>       | 1.4603 <sup>61</sup> | vs H <sub>2</sub> O; s EtOH, eth; sl ctc                |
| 10197 | Trichloroacetic anhydride                          |                                            | C <sub>4</sub> Cl <sub>6</sub> O <sub>3</sub>                   | 4124-31-6  | 308.759  |                       |                | dec 223; 139 <sup>60</sup>            | 1.6908 <sup>20</sup>       |                      | vs eth, HOAc                                            |
| 10198 | Trichloroacetoneitrile                             |                                            | C <sub>2</sub> Cl <sub>3</sub> N                                | 545-06-2   | 144.387  | liq                   | -42            | 85.7                                  | 1.4403 <sup>25</sup>       | 1.4409 <sup>20</sup> | i H <sub>2</sub> O                                      |
| 10199 | Trichloroacetyl chloride                           |                                            | C <sub>2</sub> Cl <sub>3</sub> O                                | 76-02-8    | 181.832  |                       |                | 117.9                                 | 1.6202 <sup>20</sup>       | 1.4695 <sup>20</sup> | msc eth                                                 |
| 10200 | 2,3,4-Trichloroaniline                             |                                            | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> N                 | 634-67-3   | 196.462  | nd (lig)              | 73             | 292                                   |                            |                      | vs EtOH                                                 |

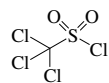




| No.   | Name                                               | Synonym                               | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form                 | mp/°C                       | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|-------|----------------------------------------------------|---------------------------------------|-----------------------------------------------------------------|------------|----------|-------------------------------|-----------------------------|-------------------------------------|----------------------------|----------------------|----------------------------------------------------------|
| 10201 | 2,4,5-Trichloroaniline                             |                                       | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> N                 | 636-30-6   | 196.462  | nd (lig)                      | 96.5                        | 270                                 |                            |                      | s EtOH, eth; vs CS <sub>2</sub> ; sl lig                 |
| 10202 | 2,4,6-Trichloroaniline                             |                                       | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> N                 | 634-93-5   | 196.462  | cry (al), nd (lig or peth)    | 78.5                        | 262                                 |                            |                      | i H <sub>2</sub> O; s EtOH, eth, chl; vs CS <sub>2</sub> |
| 10203 | 2,3,6-Trichlorobenzaldehyde                        |                                       | C <sub>7</sub> H <sub>3</sub> Cl <sub>3</sub> O                 | 4659-47-6  | 209.457  | nd (lig)                      | 87.3                        |                                     |                            |                      | vs ace, bz, eth                                          |
| 10204 | 1,2,3-Trichlorobenzene                             |                                       | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>                   | 87-61-6    | 181.447  | pl (al)                       | 51.3                        | 218.5                               | 1.4533 <sup>25</sup>       |                      | i H <sub>2</sub> O; sl EtOH, chl; vs eth, bz             |
| 10205 | 1,2,4-Trichlorobenzene                             |                                       | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>                   | 120-82-1   | 181.447  | orth                          | 16.92                       | 213.5                               | 1.459 <sup>25</sup>        | 1.5717 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH, chl; vs eth                 |
| 10206 | 1,3,5-Trichlorobenzene                             |                                       | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>                   | 108-70-3   | 181.447  | nd                            | 62.8                        | 208                                 |                            |                      | i H <sub>2</sub> O; sl EtOH; vs eth, bz; s chl           |
| 10207 | 2,3,6-Trichlorobenzeneacetic acid                  | Chlorfenac                            | C <sub>8</sub> H <sub>5</sub> Cl <sub>3</sub> O <sub>2</sub>    | 85-34-7    | 239.484  |                               | 161                         |                                     |                            |                      |                                                          |
| 10208 | 3,4,5-Trichloro-1,2-benzenediol                    |                                       | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O <sub>2</sub>    | 56961-20-7 | 213.446  | (i) pr (HOAc)<br>(ii) pr (bz) | 115(form a);<br>134(form b) |                                     |                            |                      | sl H <sub>2</sub> O; vs eth, EtOH, HOAc                  |
| 10209 | 2,3,6-Trichlorobenzoic acid                        |                                       | C <sub>7</sub> H <sub>3</sub> Cl <sub>3</sub> O <sub>2</sub>    | 50-31-7    | 225.457  |                               | 124.5                       |                                     |                            |                      | sl H <sub>2</sub> O; s eth                               |
| 10210 | 2,4,5-Trichlorobiphenyl                            |                                       | C <sub>12</sub> H <sub>7</sub> Cl <sub>3</sub>                  | 15862-07-4 | 257.543  | cry                           | 78.5                        |                                     |                            |                      | i H <sub>2</sub> O                                       |
| 10211 | 2,4,6-Trichlorobiphenyl                            |                                       | C <sub>12</sub> H <sub>7</sub> Cl <sub>3</sub>                  | 35693-92-6 | 257.543  | cry (EtOH aq)                 | 62.5                        | 172 <sup>15</sup>                   |                            |                      | i H <sub>2</sub> O                                       |
| 10212 | 1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane      | Dichlorodiphenyltrichloroethane (DDT) | C <sub>14</sub> H <sub>9</sub> Cl <sub>5</sub>                  | 50-29-3    | 354.486  | nd (al)                       | 108.5                       | 260; 186 <sup>0.05</sup>            |                            |                      | i H <sub>2</sub> O; sl EtOH; vs eth, ace, bz, py         |
| 10213 | 2,2,3-Trichlorobutanal                             | 2,2,3-Trichlorobutyraldehyde          | C <sub>4</sub> H <sub>5</sub> Cl <sub>3</sub> O                 | 76-36-8    | 175.441  |                               |                             | 164                                 | 1.3956 <sup>20</sup>       | 1.4755 <sup>20</sup> | vs H <sub>2</sub> O, eth, EtOH                           |
| 10214 | 2,3,4-Trichloro-1-butene                           |                                       | C <sub>4</sub> H <sub>5</sub> Cl <sub>3</sub>                   | 2431-50-7  | 159.442  |                               |                             | 60 <sup>20</sup> , 40 <sup>10</sup> | 1.3430 <sup>20</sup>       | 1.4944 <sup>20</sup> | vs ace, chl                                              |
| 10215 | 3,4,4'-Trichlorocarbaniide                         | Triclocarban                          | C <sub>13</sub> H <sub>9</sub> Cl <sub>3</sub> N <sub>2</sub> O | 101-20-2   | 315.581  | fine pl                       | 256                         |                                     |                            |                      |                                                          |
| 10216 | 1,2,4-Trichloro-5-(chloromethyl)benzene            |                                       | C <sub>7</sub> H <sub>4</sub> Cl <sub>4</sub>                   | 3955-26-8  | 229.919  |                               |                             | 273                                 | 1.547 <sup>20</sup>        |                      | vs ace, eth, EtOH                                        |
| 10217 | Trichloro(chloromethyl)silane                      | (Chloromethyl)trichlorosilane         | CH <sub>2</sub> Cl <sub>3</sub> Si                              | 1558-25-4  | 183.925  |                               |                             | 118                                 | 1.4650 <sup>20</sup>       | 1.4555 <sup>20</sup> |                                                          |
| 10218 | Trichloro(4-chlorophenyl)silane                    |                                       | C <sub>6</sub> H <sub>4</sub> Cl <sub>4</sub> Si                | 825-94-5   | 245.994  |                               |                             | 233; 116 <sup>20</sup>              | 1.4062 <sup>20</sup>       | 1.5418 <sup>20</sup> |                                                          |
| 10219 | Trichloro(3-chloropropyl)silane                    |                                       | C <sub>6</sub> H <sub>8</sub> Cl <sub>4</sub> Si                | 2550-06-3  | 211.978  |                               |                             | 181.5                               | 1.3590 <sup>20</sup>       | 1.4668 <sup>20</sup> |                                                          |
| 10220 | Trichloro(dichloromethyl)silane                    | (Dichloromethyl)trichlorosilane       | CHCl <sub>2</sub> Si                                            | 1558-24-3  | 218.370  |                               |                             | 145                                 | 1.5518 <sup>20</sup>       | 1.4714 <sup>20</sup> |                                                          |
| 10221 | 1,1,1-Trichloro-2,2-difluoroethane                 |                                       | C <sub>2</sub> HCl <sub>3</sub> F <sub>2</sub>                  | 354-12-1   | 169.385  |                               |                             | 73                                  |                            |                      |                                                          |
| 10222 | 1,2,2-Trichloro-1,1-difluoroethane                 |                                       | C <sub>2</sub> HClF <sub>3</sub>                                | 354-21-2   | 169.385  |                               | -140                        | 71.9                                | 1.5447 <sup>20</sup>       | 1.3889 <sup>20</sup> |                                                          |
| 10223 | 1,2,2-Trichloro-1,2-difluoroethane                 |                                       | C <sub>2</sub> HCl <sub>3</sub> F <sub>2</sub>                  | 354-15-4   | 169.385  |                               | -174                        | 72.5                                |                            |                      |                                                          |
| 10224 | 2,4,6-Trichloro-3,5-dimethylphenol                 |                                       | C <sub>8</sub> H <sub>7</sub> Cl <sub>3</sub> O                 | 6972-47-0  | 225.500  | ye nd (peth)                  | 175                         |                                     |                            |                      | i H <sub>2</sub> O; s chl; vs peth                       |
| 10225 | 1,1,1-Trichloro-2,2-diphenylethane                 |                                       | C <sub>14</sub> H <sub>11</sub> Cl <sub>3</sub>                 | 2971-22-4  | 285.596  |                               | 65                          |                                     |                            |                      | s EtOH; sl chl                                           |
| 10226 | Trichlorododecylsilane                             | Dodecyltrichlorosilane                | C <sub>12</sub> H <sub>25</sub> Cl <sub>3</sub> Si              | 4484-72-4  | 303.772  |                               |                             | 155 <sup>10</sup>                   |                            | 1.4581 <sup>20</sup> |                                                          |
| 10227 | 1,1,1-Trichloro-3,4-epoxybutane                    | (2,2,2-Trichloroethyl)oxirane         | C <sub>4</sub> H <sub>5</sub> Cl <sub>3</sub> O                 | 3083-25-8  | 175.441  | liq                           |                             | 110 <sup>100</sup>                  |                            |                      |                                                          |
| 10228 | 1,1,1-Trichloroethane                              | Methyl chloroform                     | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                   | 71-55-6    | 133.404  | liq                           | -30.01                      | 74.09                               | 1.3390 <sup>20</sup>       | 1.4379 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, chl; msc eth                |
| 10229 | 1,1,2-Trichloroethane                              | Vinyl trichloride                     | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                   | 79-00-5    | 133.404  | liq                           | -36.3                       | 113.8                               | 1.4397 <sup>20</sup>       | 1.4714 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                     |
| 10230 | 2,2,2-Trichloroethanol                             |                                       | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> O                 | 115-20-8   | 149.403  | hyg orth tab or pl            | 19                          | 152; 52 <sup>11</sup>               |                            | 1.4861 <sup>20</sup> | sl H <sub>2</sub> O, etc; msc EtOH, eth; s alk           |
| 10231 | Trichloroethene                                    | Trichloroethylene                     | C <sub>2</sub> HCl <sub>3</sub>                                 | 79-01-6    | 131.388  | liq                           | -84.7                       | 87.21                               | 1.4642 <sup>20</sup>       | 1.4773 <sup>20</sup> | sl H <sub>2</sub> O, etc; msc EtOH, eth; s ace           |
| 10232 | 2,2,2-Trichloro-1-ethoxyethanol                    | Chloral alcoholate                    | C <sub>4</sub> H <sub>7</sub> Cl <sub>3</sub> O <sub>2</sub>    | 515-83-3   | 193.457  |                               | 56.5                        | 115.5                               | 1.143 <sup>40</sup>        |                      | s H <sub>2</sub> O, EtOH, eth                            |
| 10233 | Trichloroethoxysilane                              |                                       | C <sub>2</sub> H <sub>5</sub> Cl <sub>3</sub> OSi               | 1825-82-7  | 179.505  | liq                           | -135                        | 101.9                               | 1.2274 <sup>20</sup>       | 1.4045 <sup>20</sup> | vs EtOH                                                  |
| 10234 | 2,2,2-Trichloroethyl-β-D-glucopyranosiduronic acid | Urochloralic acid                     | C <sub>8</sub> H <sub>11</sub> Cl <sub>3</sub> O <sub>7</sub>   | 97-25-6    | 325.528  | nd                            | 142                         |                                     |                            |                      | vs H <sub>2</sub> O, EtOH                                |
| 10235 | Trichloroethylsilane                               | Ethyltrichlorosilane                  | C <sub>2</sub> H <sub>5</sub> Cl <sub>3</sub> Si                | 115-21-9   | 163.506  | liq                           | -105.6                      | 100.5                               | 1.2373 <sup>20</sup>       | 1.4256 <sup>20</sup> | s etc                                                    |
| 10236 | 1,1,1-Trichloro-2-fluoroethane                     | Refrigerant 131b                      | C <sub>2</sub> H <sub>2</sub> Cl <sub>3</sub> F                 | 2366-36-1  | 151.394  | liq                           |                             | 86.5                                |                            |                      |                                                          |
| 10237 | 1,1,2-Trichloro-1-fluoroethane                     | Refrigerant 131a                      | C <sub>2</sub> H <sub>2</sub> Cl <sub>3</sub> F                 | 811-95-0   | 151.394  |                               | -104.7                      | 88.0                                | 1.492 <sup>20</sup>        |                      |                                                          |
| 10238 | 1,1,2-Trichloro-2-fluoroethane                     |                                       | C <sub>2</sub> H <sub>2</sub> Cl <sub>3</sub> F                 | 359-28-4   | 151.394  |                               |                             | 102.4                               | 1.5393 <sup>20</sup>       | 1.4390 <sup>20</sup> | i H <sub>2</sub> O                                       |
| 10239 | Trichlorofluoromethane                             | Refrigerant 11                        | CCl <sub>3</sub> F                                              | 75-69-4    | 137.368  | vol liq or gas                | -110.44                     | 23.7                                |                            |                      | i H <sub>2</sub> O                                       |
| 10240 | 2,2,3-Trichloro-1,1,1,3,4,4,4-heptafluorobutane    |                                       | C <sub>4</sub> Cl <sub>3</sub> F <sub>7</sub>                   | 335-44-4   | 287.391  |                               | 2.0                         | 98                                  | 1.7484 <sup>20</sup>       | 1.3530 <sup>20</sup> |                                                          |
| 10241 | Trichlorohexylsilane                               | Hexyltrichlorosilane                  | C <sub>6</sub> H <sub>13</sub> Cl <sub>3</sub> Si               | 928-65-4   | 219.612  |                               |                             | 190                                 | 1.1100 <sup>20</sup>       |                      | dec H <sub>2</sub> O                                     |
| 10242 | N-(2,2,2-Trichloro-1-hydroxyethyl)formamide        | Chloral formamide                     | C <sub>3</sub> H <sub>4</sub> Cl <sub>3</sub> NO <sub>2</sub>   | 515-82-2   | 192.429  | cry                           | 120                         |                                     |                            |                      | vs ace, eth, EtOH                                        |
| 10243 | 3,3,3-Trichloro-2-hydroxypropanenitrile            | Chlorocyanohydrin                     | C <sub>3</sub> H <sub>2</sub> Cl <sub>3</sub> NO                | 513-96-2   | 174.413  | pl (w)                        | 61                          | dec 217                             |                            |                      | vs H <sub>2</sub> O, eth, EtOH                           |
| 10244 | Trichloroisobutylsilane                            |                                       | C <sub>4</sub> H <sub>9</sub> Cl <sub>3</sub> Si                | 18169-57-8 | 191.559  |                               |                             | 143.3                               | 1.154 <sup>20</sup>        |                      | dec H <sub>2</sub> O                                     |
| 10245 | Trichloromethane                                   | Chloroform                            | CHCl <sub>3</sub>                                               | 67-66-3    | 119.378  | liq                           | -63.41                      | 61.17                               | 1.4788 <sup>25</sup>       | 1.4459 <sup>20</sup> | sl H <sub>2</sub> O; msc EtOH, eth, bz; s ace, etc       |
| 10246 | Trichloromethanesulfonyl chloride                  | Perchloromethyl mercaptan             | CCl <sub>3</sub> S                                              | 594-42-3   | 185.888  | ye oil                        |                             | 149                                 | 1.6947 <sup>20</sup>       | 1.5484 <sup>20</sup> | s eth                                                    |



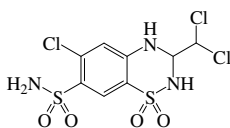
| No.   | Name                                                   | Synonym                                     | Mol. Form.                                                                                 | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C                     | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|-------|--------------------------------------------------------|---------------------------------------------|--------------------------------------------------------------------------------------------|------------|----------|--------------------|---------|---------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 10247 | Trichloromethanesulfonyl chloride                      |                                             | CCl <sub>3</sub> O <sub>2</sub> S                                                          | 2547-61-7  | 217.887  | cry (al-w)         | 140.5   | 170                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub>             |
| 10248 | Trichloromethanethiol                                  | Trichloromethyl mercaptan                   | CHCl <sub>3</sub> S                                                                        | 75-70-7    | 151.443  | oran oil           |         | 125 <sup>15</sup>         |                            |                      |                                                              |
| 10249 | Trichloromethiazide                                    |                                             | C <sub>7</sub> H <sub>6</sub> Cl <sub>3</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 133-67-5   | 380.657  |                    | 270 dec |                           |                            |                      | sl H <sub>2</sub> O; s EtOH                                  |
| 10250 | 1,2,4-Trichloro-5-methoxybenzene                       |                                             | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub> O                                            | 6130-75-2  | 211.473  | nd (dil al)        | 77.5    | 254                       |                            |                      | vs EtOH, ace                                                 |
| 10251 | 1,3,5-Trichloro-2-methoxybenzene                       | 2,4,6-Trichloroanisole                      | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub> O                                            | 87-40-1    | 211.473  | mcl nd (al)        | 61.5    | 241                       | 1.640 <sup>25</sup>        |                      | s EtOH, bz, chl; vs ace                                      |
| 10252 | 1,2,4-Trichloro-5-methylbenzene                        | 2,4,5-Trichlorotoluene                      | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub>                                              | 6639-30-1  | 195.474  | nd or lf (al)      | 82.4    | 231                       |                            |                      | i H <sub>2</sub> O; s EtOH, ace                              |
| 10253 | (Trichloromethyl)benzene                               | Benzotrichloride                            | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub>                                              | 98-07-7    | 195.474  | liq                | -4.42   | 221                       | 1.3723 <sup>20</sup>       | 1.5580 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz                          |
| 10254 | (Trichloromethyl)oxirane                               |                                             | C <sub>3</sub> H <sub>2</sub> Cl <sub>3</sub> O                                            | 3083-23-6  | 161.414  |                    |         | 149; 44 <sup>13</sup>     | 1.495 <sup>20</sup>        | 1.4737 <sup>25</sup> | vs eth; s chl                                                |
| 10255 | 2,3,4-Trichloro-6-methylphenol                         | 4,5,6-Trichloro- <i>o</i> -cresol           | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub> O                                            | 551-78-0   | 211.473  | nd (peth)          | 77      |                           |                            |                      |                                                              |
| 10256 | 2,3,6-Trichloro-4-methylphenol                         | 2,3,6-Trichloro- <i>p</i> -cresol           | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub> O                                            | 551-77-9   | 211.473  | nd (HOAc, peth)    | 66.5    |                           |                            |                      | vs EtOH                                                      |
| 10257 | 2,4,6-Trichloro-3-methylphenol                         | 2,4,6-Trichloro- <i>m</i> -cresol           | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub> O                                            | 551-76-8   | 211.473  | nd or pl (w, peth) | 46      | 265                       |                            |                      | i H <sub>2</sub> O; vs EtOH, MeOH, chl                       |
| 10258 | 1,1,1-Trichloro-2-methyl-2-propanol                    | 1,1,1-Trichloro- <i>tert</i> -butyl alcohol | C <sub>4</sub> H <sub>7</sub> Cl <sub>3</sub> O                                            | 57-15-8    | 177.457  | hyg nd (w + 1)     | 97      | 167                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz, lig, chl           |
| 10259 | Trichloronate                                          |                                             | C <sub>10</sub> H <sub>12</sub> Cl <sub>3</sub> O <sub>2</sub> PS                          | 327-98-0   | 333.599  | ye liq             |         | 108 <sup>0.01</sup>       | 1.365 <sup>20</sup>        |                      |                                                              |
| 10260 | 1,2,4-Trichloro-5-nitrobenzene                         |                                             | C <sub>6</sub> H <sub>2</sub> Cl <sub>3</sub> NO <sub>2</sub>                              | 89-69-0    | 226.445  | pr (al), nd (al)   | 57.5    | 288                       | 1.790 <sup>23</sup>        |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, chl, CS <sub>2</sub> |
| 10261 | Trichloronitromethane                                  | Chloropicrin                                | CCl <sub>3</sub> NO <sub>2</sub>                                                           | 76-06-2    | 164.376  | liq                | -64     | 112                       | 1.6558 <sup>20</sup>       | 1.4611 <sup>20</sup> | s H <sub>2</sub> O; msc EtOH, ace, bz, MeOH, HOAc            |
| 10262 | 3,4,6-Trichloro-2-nitrophenol                          |                                             | C <sub>6</sub> H <sub>2</sub> Cl <sub>3</sub> NO <sub>3</sub>                              | 82-62-2    | 242.444  | pa ye cry (peth)   | 92.5    |                           |                            |                      |                                                              |
| 10263 | Trichlorooctadecylsilane                               | Octadecyltrichlorosilane                    | C <sub>18</sub> H <sub>37</sub> Cl <sub>3</sub> Si                                         | 112-04-9   | 387.932  |                    |         | 223 <sup>10</sup>         | 0.984 <sup>25</sup>        | 1.4602 <sup>20</sup> |                                                              |
| 10264 | Trichlorooctylsilane                                   | Octyltrichlorosilane                        | C <sub>8</sub> H <sub>17</sub> Cl <sub>3</sub> Si                                          | 5283-66-9  | 247.666  |                    |         | 232                       |                            | 1.4480 <sup>20</sup> | dec H <sub>2</sub> O, EtOH; s ctc                            |
| 10265 | 1,2,3-Trichloro-1,1,2,3,3-pentafluoropropane           |                                             | C <sub>3</sub> Cl <sub>3</sub> F <sub>5</sub>                                              | 76-17-5    | 237.383  | liq                | -72     | 73.7                      | 1.6631 <sup>20</sup>       | 1.3512 <sup>20</sup> |                                                              |
| 10266 | Trichloropentylsilane                                  | Amyltrichlorosilane                         | C <sub>5</sub> H <sub>11</sub> Cl <sub>3</sub> Si                                          | 107-72-2   | 205.586  |                    |         | 172; 60.5 <sup>15</sup>   | 1.1330 <sup>20</sup>       | 1.4503 <sup>20</sup> |                                                              |
| 10267 | 2,3,4-Trichlorophenol                                  |                                             | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O                                            | 15950-66-0 | 197.446  | nd (bz, lig, sub)  | 83.5    | sub                       |                            |                      | s EtOH, eth, bz, alk, HOAc                                   |
| 10268 | 2,3,5-Trichlorophenol                                  |                                             | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O                                            | 933-78-8   | 197.446  | nd (al)            | 62      | 248 <sup>250</sup>        |                            |                      | vs eth, EtOH                                                 |
| 10269 | 2,3,6-Trichlorophenol                                  |                                             | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O                                            | 933-75-5   | 197.446  | nd (dil al, lig)   | 58      |                           |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz; s HOAc                |
| 10270 | 2,4,5-Trichlorophenol                                  |                                             | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O                                            | 95-95-4    | 197.446  | nd (al, peth)      | 69      | 247                       |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz; s HOAc                |
| 10271 | 2,4,6-Trichlorophenol                                  |                                             | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O                                            | 88-06-2    | 197.446  | orth nd (HOAc)     | 69      | 246                       | 1.4901 <sup>75</sup>       |                      | sl H <sub>2</sub> O; s EtOH, eth, HOAc                       |
| 10272 | 3,4,5-Trichlorophenol                                  |                                             | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O                                            | 609-19-8   | 197.446  | nd (lig)           | 101     | 275                       |                            |                      | sl H <sub>2</sub> O, lig; s eth                              |
| 10273 | 2,4,5-Trichlorophenoxyacetic acid                      | 2,4,5-T                                     | C <sub>8</sub> H <sub>3</sub> Cl <sub>3</sub> O <sub>3</sub>                               | 93-76-5    | 255.483  | cry (bz)           | 153     | dec                       |                            |                      | i H <sub>2</sub> O; s EtOH; vs bz                            |
| 10274 | 2-(2,4,5-Trichlorophenoxy)ethyl 2,2-dichloropropanoate | Pentanate                                   | C <sub>11</sub> H <sub>9</sub> Cl <sub>5</sub> O <sub>3</sub>                              | 136-25-4   | 366.452  |                    | 49      | 162 <sup>0.5</sup>        | 1.55 <sup>50</sup>         |                      | i H <sub>2</sub> O; s EtOH, ace, xyl                         |
| 10275 | Trichloro(2-phenylethyl)silane                         |                                             | C <sub>8</sub> H <sub>9</sub> Cl <sub>3</sub> Si                                           | 940-41-0   | 239.602  |                    |         | 242; 98 <sup>5</sup>      | 1.2397 <sup>20</sup>       | 1.5185 <sup>20</sup> |                                                              |
| 10276 | (2,4,6-Trichlorophenyl)hydrazine                       |                                             | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> N <sub>2</sub>                               | 5329-12-4  | 211.476  | cry (bz)           | 143     |                           |                            |                      | s H <sub>2</sub> O, bz                                       |
| 10277 | Trichlorophenylsilane                                  |                                             | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub> Si                                           | 98-13-5    | 211.549  |                    |         | 201                       | 1.321 <sup>20</sup>        | 1.5230 <sup>20</sup> | s ctc, chl, CS <sub>2</sub>                                  |
| 10278 | 1,1,2-Trichloropropane                                 |                                             | C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>                                              | 598-77-6   | 147.431  |                    |         | 132.0; 117 <sup>500</sup> | 1.372 <sup>15</sup>        |                      | i H <sub>2</sub> O; s EtOH, chl; vs eth; sl ctc              |
| 10279 | 1,1,3-Trichloropropane                                 |                                             | C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>                                              | 20395-25-9 | 147.431  | liq                | -59     | 145.5                     | 1.3557 <sup>20</sup>       | 1.4718 <sup>20</sup> | vs eth, EtOH, chl                                            |
| 10280 | 1,2,2-Trichloropropane                                 |                                             | C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>                                              | 3175-23-3  | 147.431  |                    |         | 124                       | 1.318 <sup>25</sup>        | 1.4609 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; vs chl                      |
| 10281 | 1,2,3-Trichloropropane                                 |                                             | C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>                                              | 96-18-4    | 147.431  | liq                | -14.7   | 157                       | 1.3889 <sup>20</sup>       | 1.4852 <sup>20</sup> | sl H <sub>2</sub> O, ctc; s EtOH, eth; vs chl                |
| 10282 | 1,1,1-Trichloro-2-propanol                             |                                             | C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub> O                                            | 76-00-6    | 163.430  |                    | 50.5    | 163; 54 <sup>12</sup>     |                            |                      | vs ace, bz, eth, EtOH                                        |
| 10283 | 1,1,1-Trichloro-2-propanone                            | 1,1,1-Trichloroacetone                      | C <sub>3</sub> H <sub>3</sub> Cl <sub>3</sub> O                                            | 918-00-3   | 161.414  |                    |         | 149; 28 <sup>10</sup>     | 1.435 <sup>20</sup>        | 1.4635 <sup>17</sup> | i H <sub>2</sub> O; vs EtOH, eth                             |
| 10284 | 1,2,3-Trichloro-1-propene                              |                                             | C <sub>3</sub> H <sub>3</sub> Cl <sub>3</sub>                                              | 96-19-5    | 145.415  |                    |         | 142                       | 1.412 <sup>20</sup>        | 1.5030 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz, chl                  |
| 10285 | 3,3,3-Trichloro-1-propene                              |                                             | C <sub>3</sub> H <sub>3</sub> Cl <sub>3</sub>                                              | 2233-00-3  | 145.415  | liq                | -30     | 114.5                     | 1.367 <sup>20</sup>        | 1.4827 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, bz, chl                     |
| 10286 | 2,3,3-Trichloro-2-propenoyl chloride                   |                                             | C <sub>3</sub> Cl <sub>4</sub> O                                                           | 815-58-7   | 193.843  |                    |         | 158                       |                            | 1.5271 <sup>18</sup> | vs bz                                                        |
| 10287 | Trichloropropylsilane                                  | Propyltrichlorosilane                       | C <sub>3</sub> H <sub>7</sub> Cl <sub>3</sub> Si                                           | 141-57-1   | 177.533  |                    |         | 123.5                     | 1.195 <sup>20</sup>        | 1.4310 <sup>20</sup> |                                                              |



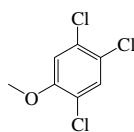
Trichloromethanesulfonyl chloride



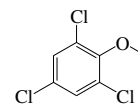
Trichloromethanethiol



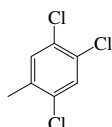
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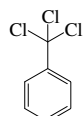
1,2,4-Trichloro-5-methoxybenzene



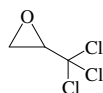
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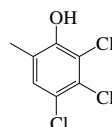
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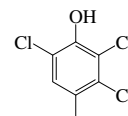
(Trichloromethyl)benzene



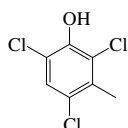
(Trichloromethyl)oxirane



2,3,4-Trichloro-6-methylphenol



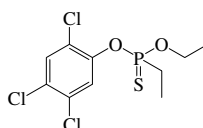
2,3,6-Trichloro-4-methylphenol



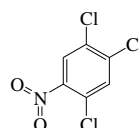
2,4,6-Trichloro-3-methylphenol



1,1,1-Trichloro-2-methyl-2-propanol



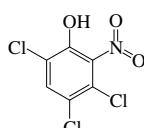
Trichloronate



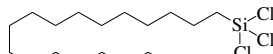
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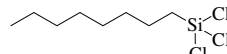
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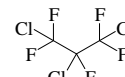
3,4,6-Trichloro-2-nitrophenol



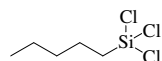
Trichlorooctadecylsilane



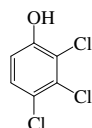
Trichlorooctylsilane



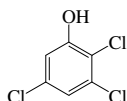
1,2,3-Trichloro-1,1,2,3,3-pentafluoropropane



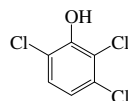
Trichloropentylsilane



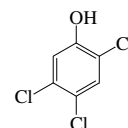
2,3,4-Trichlorophenol



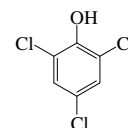
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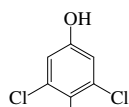
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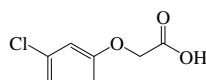
2,4,5-Trichlorophenol



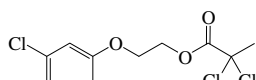
2,4,6-Trichlorophenol



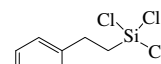
3,4,5-Trichlorophenol



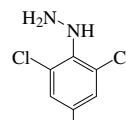
2,4,5-Trichlorophenoxyacetic acid



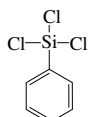
2-(2,4,5-Trichlorophenoxy)ethyl 2,2-dichloropropanoate



Trichloro(2-phenylethyl)silane



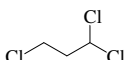
(2,4,6-Trichlorophenyl)hydrazine



Trichlorophenylsilane



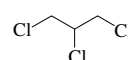
1,1,2-Trichloropropane



1,1,3-Trichloropropane



1,2,2-Trichloropropane



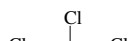
1,2,3-Trichloropropane



1,1,1-Trichloro-2-propanol



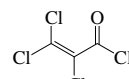
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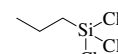
1,2,3-Trichloro-1-propene



3,3,3-Trichloro-1-propene

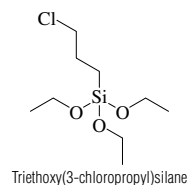
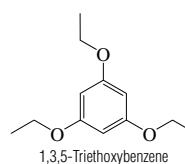
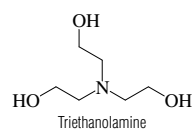
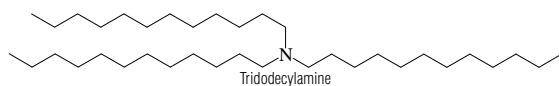
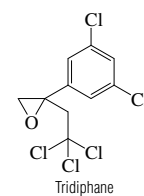
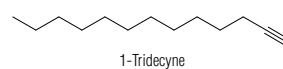
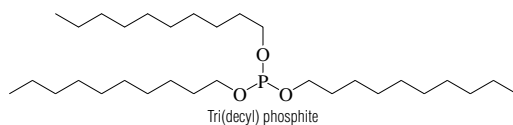
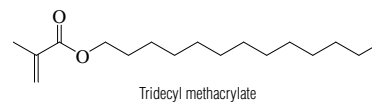
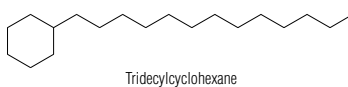
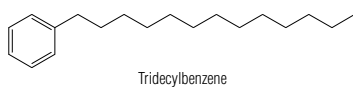
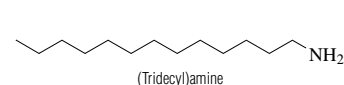
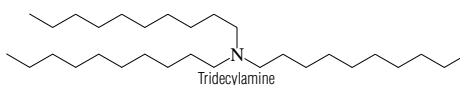
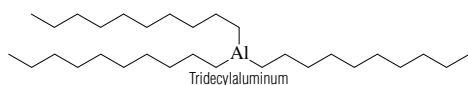
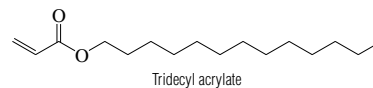
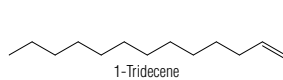
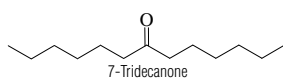
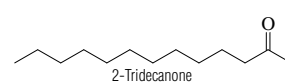
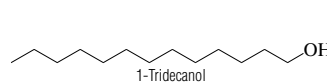
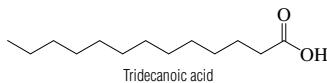
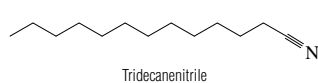
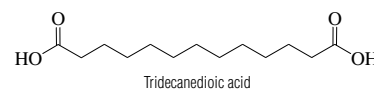
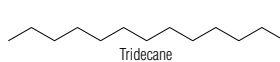
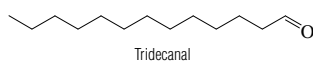
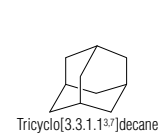
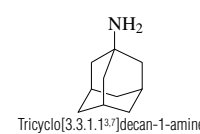
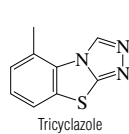
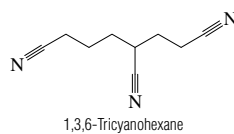
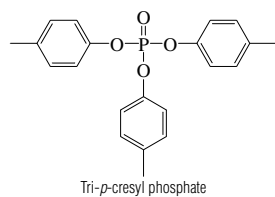
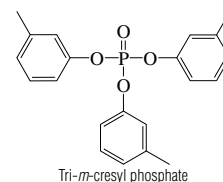
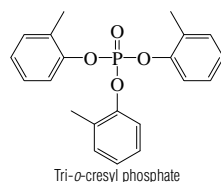
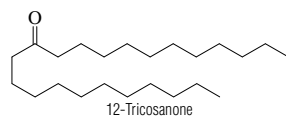
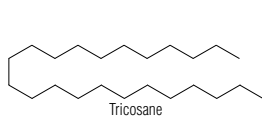
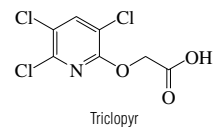
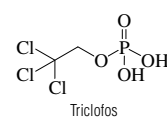
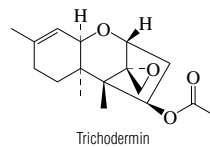
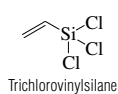
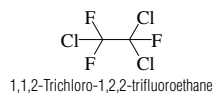
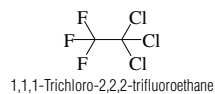
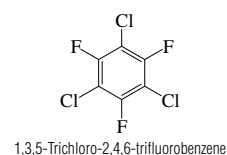
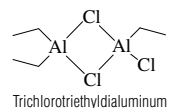
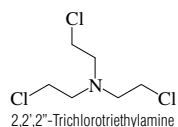
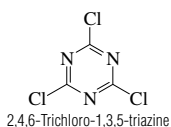
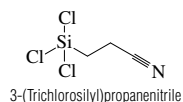
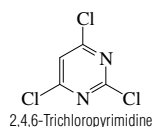


2,3,3-Trichloro-2-propenoyl chloride

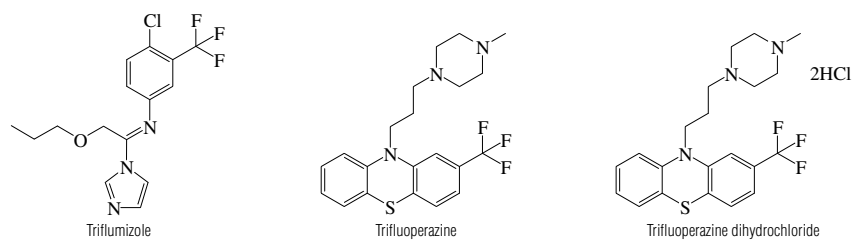
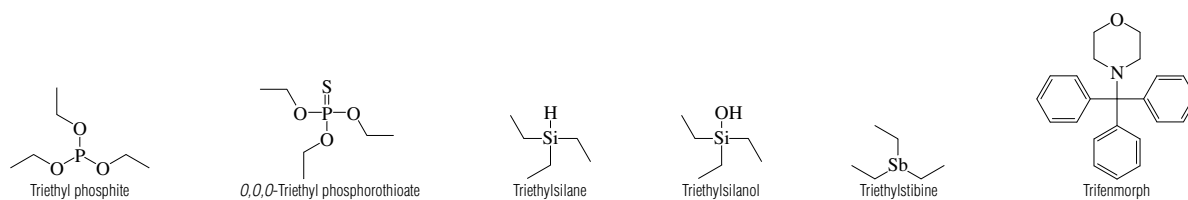
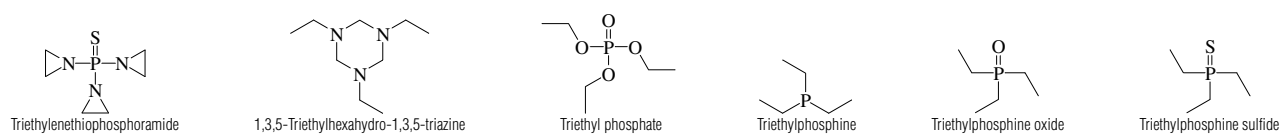
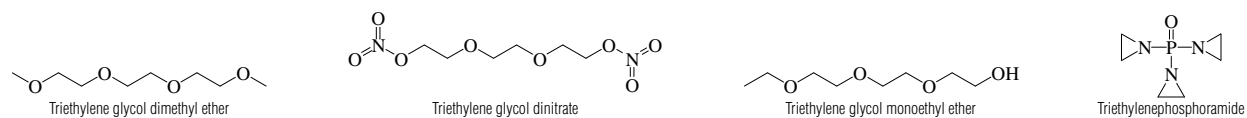
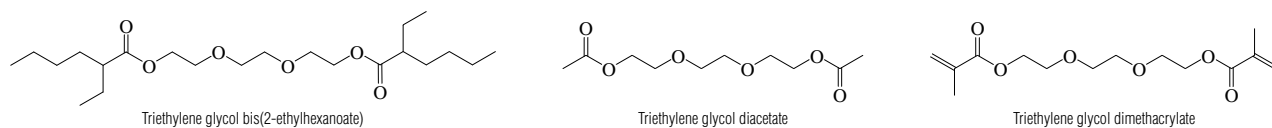
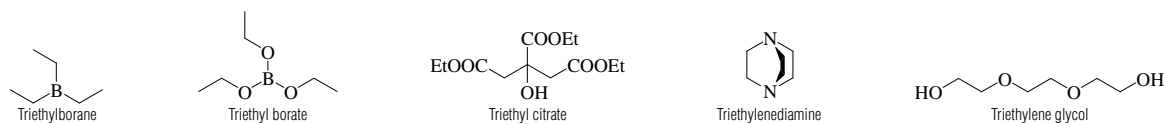
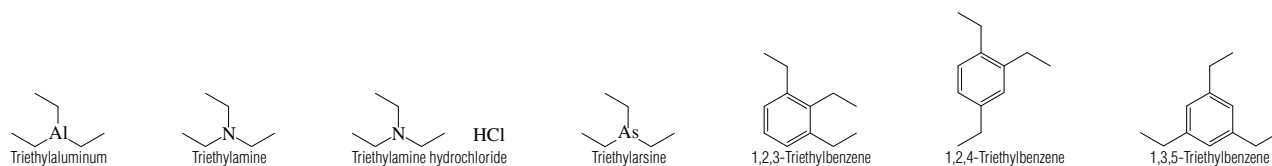
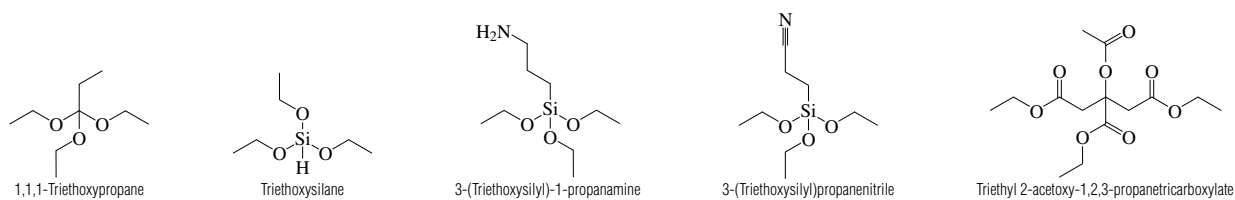
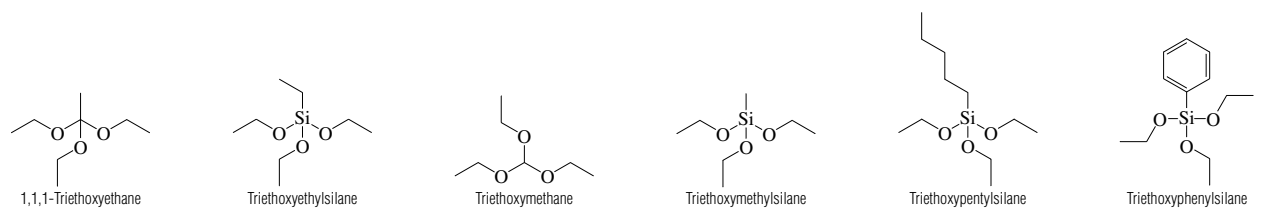


Trichloropropylsilane

| No.   | Name                                           | Synonym                                                     | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form      | mp/°C  | bp/°C                                        | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                         |
|-------|------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------|------------|----------|--------------------|--------|----------------------------------------------|----------------------------|----------------------|----------------------------------------------------|
| 10288 | 2,4,6-Trichloropyrimidine                      |                                                             | C <sub>4</sub> HCl <sub>3</sub> N <sub>2</sub>                 | 3764-01-0  | 183.423  |                    | 22.5   | 212.5                                        |                            | 1.5700 <sup>20</sup> |                                                    |
| 10289 | 3-(Trichlorosilyl)propanenitrile               |                                                             | C <sub>3</sub> H <sub>2</sub> Cl <sub>3</sub> NSi              | 1071-22-3  | 188.516  |                    |        | 109 <sup>30</sup>                            |                            |                      |                                                    |
| 10290 | 2,4,6-Trichloro-1,3,5-triazine                 | Cyanuric acid trichloride                                   | C <sub>3</sub> Cl <sub>3</sub> N <sub>3</sub>                  | 108-77-0   | 184.411  | cry (eth, bz)      | 154    | 192                                          |                            |                      | vs EtOH                                            |
| 10291 | 2,2',2''-Trichlorotriethylamine                |                                                             | C <sub>6</sub> H <sub>12</sub> Cl <sub>3</sub> N               | 555-77-1   | 204.525  | pa ye              | -2.0   | 143 <sup>15</sup>                            |                            |                      | vs bz, eth, EtOH                                   |
| 10292 | Trichlorotriethylaluminum                      | Ethylaluminum sesquichloride                                | C <sub>6</sub> H <sub>9</sub> Al <sub>2</sub> Cl <sub>3</sub>  | 12075-68-2 | 247.505  | ye liq             |        | 115.5 <sup>50</sup> ,<br>36.2 <sup>0,2</sup> |                            |                      |                                                    |
| 10293 | 1,3,5-Trichloro-2,4,6-trifluorobenzene         |                                                             | C <sub>6</sub> Cl <sub>3</sub> F <sub>3</sub>                  | 319-88-0   | 235.418  |                    |        | 198.4                                        |                            |                      |                                                    |
| 10294 | 1,1,1-Trichloro-2,2,2-trifluoroethane          |                                                             | C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>                  | 354-58-5   | 187.375  |                    | 14.37  | 45.5                                         | 1.5790 <sup>20</sup>       | 1.3610 <sup>38</sup> | i H <sub>2</sub> O; s EtOH, eth, chl               |
| 10295 | 1,1,2-Trichloro-1,2,2-trifluoroethane          |                                                             | C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>                  | 76-13-1    | 187.375  | liq                | -36.22 | 47.7                                         | 1.5635 <sup>25</sup>       | 1.3557 <sup>25</sup> | i H <sub>2</sub> O; s EtOH; msc eth, bz            |
| 10296 | Trichlorovinylsilane                           | Vinyltrichlorosilane                                        | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> Si               | 75-94-5    | 161.490  | liq                | -95    | 91.5                                         | 1.2426 <sup>20</sup>       | 1.4295 <sup>20</sup> | vs chl                                             |
| 10297 | Trichodermin                                   | 12,13-Epoxytrichothec-9-en-4-ol acetate                     | C <sub>17</sub> H <sub>24</sub> O <sub>4</sub>                 | 4682-50-2  | 292.371  | cry                | 59     | 111 <sup>0,05</sup>                          |                            |                      | sl H <sub>2</sub> O; s EtOH, chl                   |
| 10298 | Triclofos                                      | 2,2,2-Trichloroethanol dihydrogen phosphate                 | C <sub>2</sub> H <sub>4</sub> Cl <sub>3</sub> O <sub>4</sub> P | 306-52-5   | 229.383  | cry (bz)           | 120.5  |                                              |                            |                      |                                                    |
| 10299 | Triclopyr                                      | Acetic acid, [(3,5,6-trichloro-2-pyridinyl)oxy]-            | C <sub>7</sub> H <sub>4</sub> Cl <sub>3</sub> NO <sub>3</sub>  | 55335-06-3 | 256.471  |                    | 149    | dec 290                                      |                            |                      |                                                    |
| 10300 | Tricosane                                      |                                                             | C <sub>23</sub> H <sub>48</sub>                                | 638-67-5   | 324.627  | lf (eth-al)        | 47.76  | 380                                          | 0.7785 <sup>48</sup>       | 1.4468 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH; s eth, ctc            |
| 10301 | 12-Tricosanone                                 | Diundecyl ketone                                            | C <sub>23</sub> H <sub>46</sub> O                              | 540-09-0   | 338.610  | lf (al)            | 70.2   |                                              | 0.8086 <sup>69</sup>       | 1.4283 <sup>80</sup> | vs bz, eth, chl                                    |
| 10302 | Tri- <i>o</i> -cresyl phosphate                | Tri- <i>o</i> -tolyl phosphate                              | C <sub>21</sub> H <sub>21</sub> O <sub>4</sub> P               | 78-30-8    | 368.363  | col or pa ye       | 11     | 410                                          | 1.1955 <sup>20</sup>       | 1.5575 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ctc, tol; s HOAc |
| 10303 | Tri- <i>m</i> -cresyl phosphate                | Tri- <i>m</i> -tolyl phosphate                              | C <sub>21</sub> H <sub>21</sub> O <sub>4</sub> P               | 563-04-2   | 368.363  | wax                | 25.5   | 260 <sup>15</sup>                            | 1.150 <sup>25</sup>        | 1.5575 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH; s eth; vs ctc, tol    |
| 10304 | Tri- <i>p</i> -cresyl phosphate                | Tri- <i>p</i> -tolyl phosphate                              | C <sub>21</sub> H <sub>21</sub> O <sub>4</sub> P               | 78-32-0    | 368.363  | nd (al), tab (eth) | 77.5   | 224 <sup>35</sup>                            | 1.247 <sup>25</sup>        |                      | s EtOH, eth, bz, chl, HOAc                         |
| 10305 | 1,3,6-Tricyanohexane                           |                                                             | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub>                   | 1772-25-4  | 161.203  | br liq             |        | 257 <sup>2</sup>                             | 1.040                      | 1.4660 <sup>20</sup> |                                                    |
| 10306 | Tricyclazole                                   | 1,2,4-Triazolo[3,4-b]benzothiazole, 5-methyl-               | C <sub>9</sub> H <sub>7</sub> N <sub>3</sub> S                 | 41814-78-2 | 189.237  |                    | 187    |                                              |                            |                      |                                                    |
| 10307 | Tricyclene                                     | 1,7,7-Trimethyltricyclo[2.2.1.0 <sup>2,6</sup> ]heptane     | C <sub>10</sub> H <sub>16</sub>                                | 508-32-7   | 136.234  | cry (al)           | 67.5   | 152.5                                        | 0.8668 <sup>80</sup>       | 1.4296 <sup>80</sup> |                                                    |
| 10308 | Tricyclo[3.3.1.1 <sup>3,7</sup> ]decan-1-amine | Amantadine                                                  | C <sub>10</sub> H <sub>17</sub> N                              | 768-94-5   | 151.249  |                    | 180    |                                              |                            |                      | sl H <sub>2</sub> O                                |
| 10309 | Tricyclo[3.3.1.1 <sup>3,7</sup> ]decane        | Adamantane                                                  | C <sub>10</sub> H <sub>16</sub>                                | 281-23-2   | 136.234  | nd (sub)           | 268    | sub                                          | 1.07 <sup>25</sup>         | 1.568                | s bz, ctc                                          |
| 10310 | Tridecanal                                     |                                                             | C <sub>13</sub> H <sub>26</sub> O                              | 10486-19-8 | 198.344  |                    | 14     | 156 <sup>13</sup>                            | 0.8356 <sup>18</sup>       | 1.4384 <sup>18</sup> | i H <sub>2</sub> O; s EtOH                         |
| 10311 | Tridecane                                      |                                                             | C <sub>13</sub> H <sub>28</sub>                                | 629-50-5   | 184.361  | liq                | -5.4   | 235.47                                       | 0.7564 <sup>20</sup>       | 1.4256 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s ctc            |
| 10312 | Tridecanedioic acid                            |                                                             | C <sub>13</sub> H <sub>24</sub> O <sub>4</sub>                 | 505-52-2   | 244.328  |                    | 114    |                                              |                            |                      | sl H <sub>2</sub> O, bz, tfa; s EtOH, eth, chl     |
| 10313 | Tridecanenitrile                               |                                                             | C <sub>13</sub> H <sub>25</sub> N                              | 629-60-7   | 195.345  |                    | 9.7    | 293                                          | 0.8257 <sup>20</sup>       | 1.4378 <sup>20</sup> | vs EtOH, eth                                       |
| 10314 | Tridecanoic acid                               | Tridecyclic acid                                            | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                 | 638-53-9   | 214.344  | cry (peth ace)     | 41.5   | 236 <sup>100</sup> , 140 <sup>1</sup>        | 0.8458 <sup>80</sup>       | 1.4286 <sup>80</sup> | i H <sub>2</sub> O; vs EtOH, eth, HOAc; s ace      |
| 10315 | 1-Tridecanol                                   | Tridecyl alcohol                                            | C <sub>13</sub> H <sub>28</sub> O                              | 112-70-9   | 200.360  | cry (al)           | 31.7   | 274; 152 <sup>14</sup>                       | 0.8223 <sup>31</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                    |
| 10316 | 2-Tridecanone                                  | Methyl undecyl ketone                                       | C <sub>13</sub> H <sub>26</sub> O                              | 593-08-8   | 198.344  |                    | 30.5   | 263                                          | 0.8217 <sup>30</sup>       | 1.4318 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace, bz, chl     |
| 10317 | 7-Tridecanone                                  | Dihexyl ketone                                              | C <sub>13</sub> H <sub>26</sub> O                              | 462-18-0   | 198.344  | lf (al)            | 33     | 261                                          | 0.825 <sup>30</sup>        |                      | s EtOH, chl, lig; vs eth                           |
| 10318 | 1-Tridecene                                    |                                                             | C <sub>13</sub> H <sub>26</sub>                                | 2437-56-1  | 182.345  | liq                | -13    | 232.8                                        | 0.7658 <sup>20</sup>       | 1.4340 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth; s bz             |
| 10319 | Tridecyl acrylate                              |                                                             | C <sub>16</sub> H <sub>30</sub> O <sub>2</sub>                 | 3076-04-8  | 254.408  | liq                |        | 150 <sup>10</sup>                            | 0.88 <sup>20</sup>         |                      |                                                    |
| 10320 | Tridecylaluminum                               |                                                             | C <sub>30</sub> H <sub>63</sub> Al                             | 1726-66-5  | 450.803  | hyg visc liq       | -38    |                                              |                            |                      |                                                    |
| 10321 | Tridecylamine                                  | <i>N,N</i> -Didecyl-1-decanamine                            | C <sub>30</sub> H <sub>63</sub> N                              | 1070-01-5  | 437.828  |                    |        | 406                                          |                            |                      |                                                    |
| 10322 | (Tridecyl)amine                                | 1-Tridecanamine                                             | C <sub>13</sub> H <sub>29</sub> N                              | 2869-34-3  | 199.376  |                    | 27.4   | 275.8                                        | 0.8049 <sup>20</sup>       | 1.4443 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                   |
| 10323 | Tridecylbenzene                                | 1-Phenyltridecane                                           | C <sub>19</sub> H <sub>32</sub>                                | 123-02-4   | 260.457  |                    | 10     | 346                                          | 0.8550 <sup>20</sup>       | 1.4821 <sup>20</sup> |                                                    |
| 10324 | Tridecylcyclohexane                            |                                                             | C <sub>19</sub> H <sub>38</sub>                                | 6006-33-3  | 266.505  |                    | 18.5   | 346                                          | 0.8239 <sup>20</sup>       | 1.4570 <sup>20</sup> |                                                    |
| 10325 | Tridecyl methacrylate                          |                                                             | C <sub>17</sub> H <sub>32</sub> O <sub>2</sub>                 | 2495-25-2  | 268.435  |                    |        | 118 <sup>1</sup>                             | 0.881 <sup>20</sup>        | 1.448 <sup>25</sup>  |                                                    |
| 10326 | Tri(decyl) phosphite                           |                                                             | C <sub>30</sub> H <sub>63</sub> O <sub>3</sub> P               | 2929-86-4  | 502.793  | liq                |        | 255 <sup>3</sup> , 180 <sup>0,1</sup>        |                            |                      |                                                    |
| 10327 | 1-Tridecyne                                    |                                                             | C <sub>13</sub> H <sub>24</sub>                                | 26186-02-7 | 180.330  |                    | 2.5    | 234; 94 <sup>25</sup>                        | 0.7842 <sup>20</sup>       | 1.4309 <sup>20</sup> | vs bz, eth                                         |
| 10328 | Tridipane                                      | 2-(3,5-Dichlorophenyl)-2-(2,2,2-trichloroethyl)oxirane, (±) | C <sub>10</sub> H <sub>7</sub> Cl <sub>5</sub> O               | 58138-08-2 | 320.427  |                    | 42.8   |                                              |                            |                      |                                                    |
| 10329 | Tridodecylamine                                | <i>N,N</i> -Didodecyl-1-dodecanamine                        | C <sub>36</sub> H <sub>79</sub> N                              | 102-87-4   | 521.988  |                    | 16.4   | 220 <sup>0,03</sup>                          |                            |                      |                                                    |
| 10330 | Triethanolamine                                | Tris(2-hydroxyethyl)amine                                   | C <sub>6</sub> H <sub>15</sub> NO <sub>3</sub>                 | 102-71-6   | 149.188  | hyg cry            | 20.5   | 335.4                                        | 1.1242 <sup>20</sup>       | 1.4852 <sup>20</sup> | msc H <sub>2</sub> O, EtOH; sl eth, bz; s chl      |
| 10331 | 1,3,5-Triethoxybenzene                         |                                                             | C <sub>12</sub> H <sub>10</sub> O <sub>3</sub>                 | 2437-88-9  | 210.269  | cry (al, dil al)   | 43.5   | 170 <sup>24</sup>                            |                            |                      | vs eth, EtOH                                       |
| 10332 | Triethoxy(3-chloropropyl)silane                | (3-Chloropropyl)triethoxysilane                             | C <sub>9</sub> H <sub>21</sub> ClO <sub>3</sub> Si             | 5089-70-3  | 240.800  | col gas            |        | -149                                         |                            |                      |                                                    |

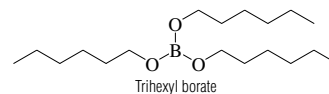
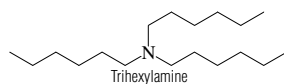
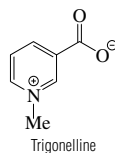
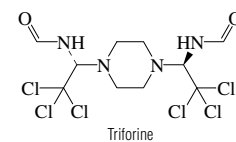
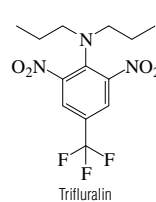
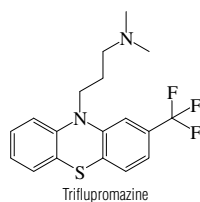
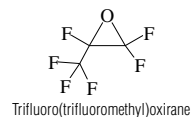
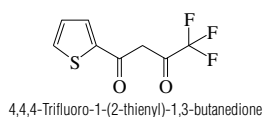
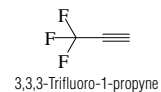
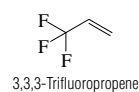
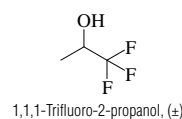
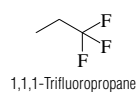
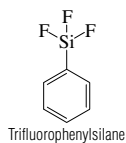
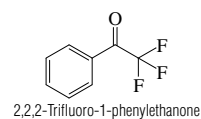
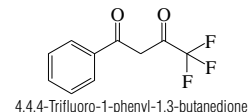
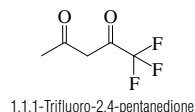
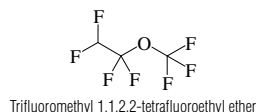
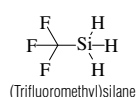
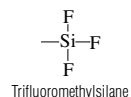
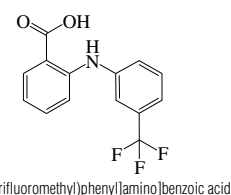
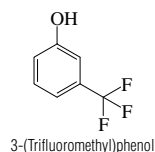
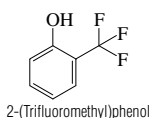
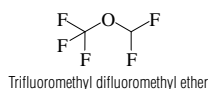
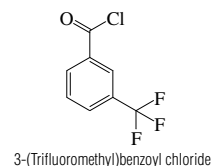
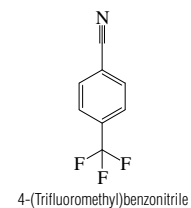
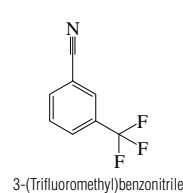
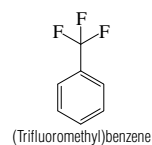
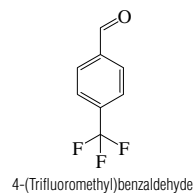
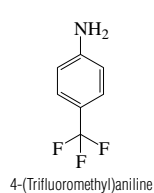
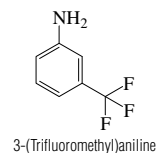
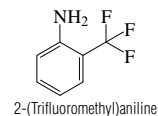
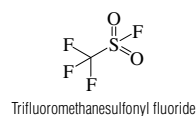
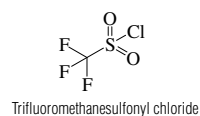
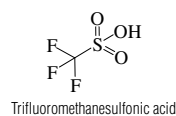
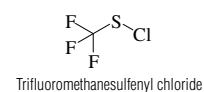
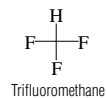
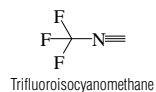
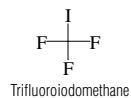
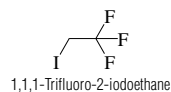
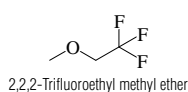
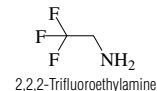
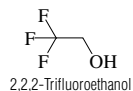
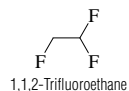
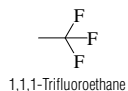
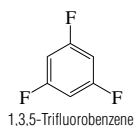
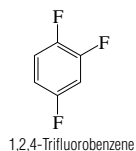
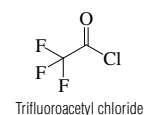
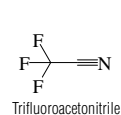
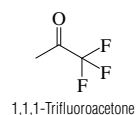
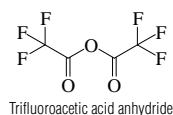
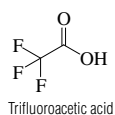
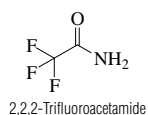


| No.   | Name                                           | Synonym                                               | Mol. Form.                                                                      | CAS RN     | Mol. Wt. | Physical Form | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                          |
|-------|------------------------------------------------|-------------------------------------------------------|---------------------------------------------------------------------------------|------------|----------|---------------|---------|--------------------------------------|----------------------------|----------------------|-----------------------------------------------------|
| 10333 | 1,1,1-Triethoxyethane                          |                                                       | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>                                   | 78-39-7    | 162.227  |               |         | 145                                  | 0.8847 <sup>25</sup>       | 1.3980 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ctc, chl         |
| 10334 | Triethoxyethylsilane                           |                                                       | C <sub>8</sub> H <sub>20</sub> O <sub>3</sub> Si                                | 78-07-9    | 192.329  |               |         | 158.5                                | 0.8963 <sup>20</sup>       | 1.3955 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth; s chl            |
| 10335 | Triethoxymethane                               |                                                       | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>                                   | 122-51-0   | 148.200  |               |         | 143; 60 <sup>20</sup>                | 0.8909 <sup>20</sup>       | 1.3922 <sup>20</sup> | s EtOH, eth                                         |
| 10336 | Triethoxymethylsilane                          |                                                       | C <sub>7</sub> H <sub>18</sub> O <sub>3</sub> Si                                | 2031-67-6  | 178.302  |               |         | 142                                  | 0.8948 <sup>25</sup>       | 1.3832 <sup>20</sup> |                                                     |
| 10337 | Triethoxypentylsilane                          |                                                       | C <sub>11</sub> H <sub>26</sub> O <sub>3</sub> Si                               | 2761-24-2  | 234.408  |               |         | 100 <sup>30</sup> , 95 <sup>13</sup> | 0.8862 <sup>20</sup>       | 1.4059 <sup>20</sup> |                                                     |
| 10338 | Triethoxyphenylsilane                          |                                                       | C <sub>12</sub> H <sub>20</sub> O <sub>3</sub> Si                               | 780-69-8   | 240.371  |               |         | 232; 113 <sup>10</sup>               | 0.996 <sup>25</sup>        | 1.4604 <sup>20</sup> |                                                     |
| 10339 | 1,1,1-Triethoxypropane                         |                                                       | C <sub>9</sub> H <sub>20</sub> O <sub>3</sub>                                   | 115-80-0   | 176.253  |               |         | 171                                  |                            | 1.4000 <sup>25</sup> | vs eth, EtOH                                        |
| 10340 | Triethoxysilane                                |                                                       | C <sub>6</sub> H <sub>16</sub> O <sub>3</sub> Si                                | 998-30-1   | 164.275  |               |         | 133.5                                | 0.8745 <sup>20</sup>       |                      |                                                     |
| 10341 | 3-(Triethoxysilyl)-1-propanamine               |                                                       | C <sub>9</sub> H <sub>23</sub> NO <sub>3</sub> Si                               | 919-30-2   | 221.370  |               |         | 119 <sup>29</sup>                    | 0.9506 <sup>20</sup>       | 1.4225 <sup>20</sup> |                                                     |
| 10342 | 3-(Triethoxysilyl)propanenitrile               |                                                       | C <sub>9</sub> H <sub>19</sub> NO <sub>3</sub> Si                               | 919-31-3   | 217.338  | liq           |         | 109 <sup>10</sup>                    | 0.974 <sup>20</sup>        |                      |                                                     |
| 10343 | Triethyl 2-acetoxy-1,2,3-propanetricarboxylate | Triethyl acetyl/citrate                               | C <sub>14</sub> H <sub>22</sub> O <sub>8</sub>                                  | 77-89-4    | 318.320  |               |         | 214 <sup>40</sup>                    | 1.135 <sup>25</sup>        | 1.4380               |                                                     |
| 10344 | Triethylaluminum                               | Hexaethylaluminum                                     | C <sub>6</sub> H <sub>15</sub> Al                                               | 97-93-8    | 114.165  | col hyg liq   | -46     | 194; 100 <sup>13</sup>               | 0.832 <sup>25</sup>        |                      |                                                     |
| 10345 | Triethylamine                                  | <i>N,N</i> -Diethylethanamine                         | C <sub>6</sub> H <sub>15</sub> N                                                | 121-44-8   | 101.190  | liq           | -114.7  | 89                                   | 0.7275 <sup>20</sup>       | 1.4010 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ctc; vs ace, bz, chl |
| 10346 | Triethylamine hydrochloride                    | <i>N,N</i> -Diethylethanamine hydrochloride           | C <sub>6</sub> H <sub>16</sub> ClN                                              | 554-68-7   | 137.651  | hex (al)      | 260 dec | sub 245                              | 1.0689 <sup>21</sup>       |                      | vs H <sub>2</sub> O, EtOH, chl                      |
| 10347 | Triethylarsine                                 |                                                       | C <sub>6</sub> H <sub>15</sub> As                                               | 617-75-4   | 162.105  |               |         | 138.5                                | 1.150 <sup>20</sup>        | 1.467 <sup>20</sup>  | vs ace, eth, EtOH                                   |
| 10348 | 1,2,3-Triethylbenzene                          |                                                       | C <sub>12</sub> H <sub>18</sub>                                                 | 42205-08-3 | 162.271  | col liq       | -26     | 172                                  |                            |                      |                                                     |
| 10349 | 1,2,4-Triethylbenzene                          |                                                       | C <sub>12</sub> H <sub>18</sub>                                                 | 877-44-1   | 162.271  |               |         | 218; 99 <sup>15</sup>                | 0.8738 <sup>20</sup>       | 1.5024 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth                     |
| 10350 | 1,3,5-Triethylbenzene                          |                                                       | C <sub>12</sub> H <sub>18</sub>                                                 | 102-25-0   | 162.271  | liq           | -66.5   | 215.9                                | 0.8631 <sup>20</sup>       | 1.4969 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                    |
| 10351 | Triethylborane                                 |                                                       | C <sub>6</sub> H <sub>15</sub> B                                                | 97-94-9    | 97.994   | liq           | -93     | 95                                   | 0.70 <sup>23</sup>         | 1.3971               | s EtOH, eth                                         |
| 10352 | Triethyl borate                                | Boric acid, triethyl ester                            | C <sub>6</sub> H <sub>15</sub> BO <sub>3</sub>                                  | 150-46-9   | 145.992  | liq           | -84.8   | 120                                  | 0.8546 <sup>20</sup>       | 1.3749 <sup>20</sup> | msc EtOH, eth                                       |
| 10353 | Triethyl citrate                               |                                                       | C <sub>12</sub> H <sub>20</sub> O <sub>7</sub>                                  | 77-93-0    | 276.283  |               |         | 294                                  | 1.1369 <sup>20</sup>       | 1.4455 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc             |
| 10354 | Triethylenediamine                             |                                                       | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>                                   | 280-57-9   | 112.172  |               | 159     |                                      |                            |                      | s chl                                               |
| 10355 | Triethylene glycol                             | Triglycol                                             | C <sub>6</sub> H <sub>14</sub> O <sub>4</sub>                                   | 112-27-6   | 150.173  | hyg liq       | -7      | 285                                  | 1.1274 <sup>15</sup>       | 1.4531 <sup>20</sup> | msc H <sub>2</sub> O, EtOH, bz; sl eth, chl; i peth |
| 10356 | Triethylene glycol bis(2-ethylhexanoate)       |                                                       | C <sub>22</sub> H <sub>42</sub> O <sub>6</sub>                                  | 94-28-0    | 402.564  |               |         |                                      |                            |                      | s chl                                               |
| 10357 | Triethylene glycol diacetate                   |                                                       | C <sub>10</sub> H <sub>18</sub> O <sub>6</sub>                                  | 111-21-7   | 234.246  | liq           | -50     | 286                                  | 1.1153 <sup>20</sup>       |                      | vs H <sub>2</sub> O, eth, EtOH                      |
| 10358 | Triethylene glycol dimethacrylate              |                                                       | C <sub>14</sub> H <sub>22</sub> O <sub>6</sub>                                  | 109-16-0   | 286.321  |               |         | 170 <sup>5</sup>                     | 1.092 <sup>20</sup>        | 1.4595 <sup>25</sup> | vs ace, eth, EtOH, peth                             |
| 10359 | Triethylene glycol dimethyl ether              | Triglyme                                              | C <sub>8</sub> H <sub>18</sub> O <sub>4</sub>                                   | 112-49-2   | 178.227  | liq           | -45     | 216                                  | 0.986 <sup>20</sup>        | 1.4224 <sup>20</sup> | vs H <sub>2</sub> O, bz                             |
| 10360 | Triethylene glycol dinitrate                   | Ethanol, 2,2'-[1,2-ethanediy]bis(oxy)]bis-, dinitrate | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>8</sub>                    | 111-22-8   | 240.167  |               |         | 82 <sup>20,03</sup>                  |                            |                      |                                                     |
| 10361 | Triethylene glycol monoethyl ether             | 2-[2-(2-Ethoxyethoxy)ethoxy] ethanol                  | C <sub>8</sub> H <sub>18</sub> O <sub>4</sub>                                   | 112-50-5   | 178.227  |               |         | 256                                  | 1.0209 <sup>20</sup>       |                      |                                                     |
| 10362 | Triethylenephosphoramidate                     | Tris(1-aziridinyl)phosphine, oxide                    | C <sub>6</sub> H <sub>12</sub> N <sub>3</sub> OP                                | 545-55-1   | 173.152  | cry           | 41      | 91 <sup>23</sup>                     |                            |                      | vs H <sub>2</sub> O, EtOH, eth, ace                 |
| 10363 | Triethylenethiophosphoramidate                 | Thiotepa                                              | C <sub>6</sub> H <sub>12</sub> N <sub>3</sub> PS                                | 52-24-4    | 189.218  | cry           | 51.5    |                                      |                            |                      | vs H <sub>2</sub> O; s bz, chl, eth, EtOH           |
| 10364 | 1,3,5-Triethylhexahydro-1,3,5-triazine         |                                                       | C <sub>9</sub> H <sub>21</sub> N <sub>3</sub>                                   | 7779-27-3  | 171.283  |               |         | 78 <sup>6</sup>                      |                            | 1.4580 <sup>25</sup> |                                                     |
| 10365 | Triethyl phosphate                             | Ethyl phosphate                                       | C <sub>6</sub> H <sub>15</sub> O <sub>4</sub> P                                 | 78-40-0    | 182.154  | liq           | -56.4   | 215.5                                | 1.0695 <sup>20</sup>       | 1.4053 <sup>20</sup> | s H <sub>2</sub> O, eth, bz; vs EtOH; sl chl        |
| 10366 | Triethylphosphine                              |                                                       | C <sub>6</sub> H <sub>15</sub> P                                                | 554-70-1   | 118.157  | liq           | -88     | 129                                  | 0.8006 <sup>19</sup>       | 1.458 <sup>15</sup>  | i H <sub>2</sub> O; msc EtOH, eth                   |
| 10367 | Triethylphosphine oxide                        |                                                       | C <sub>6</sub> H <sub>15</sub> OP                                               | 597-50-2   | 134.156  | wh hyg nd     | 48      | 243                                  |                            |                      | vs H <sub>2</sub> O, eth, EtOH                      |
| 10368 | Triethylphosphine sulfide                      |                                                       | C <sub>6</sub> H <sub>15</sub> PS                                               | 597-51-3   | 150.222  | cry (al)      | 94      |                                      |                            |                      | s H <sub>2</sub> O; sl ctc                          |
| 10369 | Triethyl phosphite                             | Triethoxyphosphine                                    | C <sub>6</sub> H <sub>15</sub> O <sub>3</sub> P                                 | 122-52-1   | 166.155  |               |         | 157.9                                | 0.9629 <sup>20</sup>       | 1.4127 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                    |
| 10370 | <i>O,O,O</i> -Triethyl phosphorothioate        | <i>O,O,O</i> -Triethyl thiophosphate                  | C <sub>6</sub> H <sub>15</sub> O <sub>3</sub> PS                                | 126-68-1   | 198.220  |               |         | 217; 100 <sup>16</sup>               | 1.0768 <sup>20</sup>       | 1.4480 <sup>20</sup> |                                                     |
| 10371 | Triethylsilane                                 |                                                       | C <sub>6</sub> H <sub>16</sub> Si                                               | 617-86-7   | 116.277  | liq           | -156.9  | 109                                  | 0.7302 <sup>20</sup>       | 1.447 <sup>20</sup>  | i H <sub>2</sub> O, sulf                            |
| 10372 | Triethylsilanol                                |                                                       | C <sub>6</sub> H <sub>16</sub> OSi                                              | 597-52-4   | 132.276  |               |         | 154                                  | 0.8647 <sup>20</sup>       | 1.4329 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                   |
| 10373 | Triethylstibine                                |                                                       | C <sub>6</sub> H <sub>15</sub> Sb                                               | 617-85-6   | 208.943  | liq           | -98     | 161.4                                | 1.3224 <sup>15</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth                     |
| 10374 | Trifenmorph                                    | 4-(Triphenylmethyl)morpholine                         | C <sub>23</sub> H <sub>23</sub> NO                                              | 1420-06-0  | 329.435  | cry (EtOH)    | 176     |                                      |                            |                      | i H <sub>2</sub> O; s chl, ctc                      |
| 10375 | Trifluorizole                                  |                                                       | C <sub>15</sub> H <sub>15</sub> ClF <sub>3</sub> N <sub>3</sub> O               | 68694-11-1 | 345.747  |               | 63.5    |                                      |                            |                      |                                                     |
| 10376 | Trifluoperazine                                |                                                       | C <sub>21</sub> H <sub>24</sub> F <sub>3</sub> N <sub>3</sub> S                 | 117-89-5   | 407.496  | cry           |         | 206 <sup>0,7</sup>                   |                            |                      |                                                     |
| 10377 | Trifluoperazine dihydrochloride                | Stelazine                                             | C <sub>21</sub> H <sub>26</sub> Cl <sub>2</sub> F <sub>3</sub> N <sub>3</sub> S | 440-17-5   | 480.417  |               | 241.5   |                                      |                            |                      |                                                     |

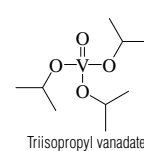
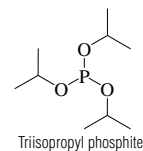
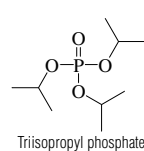
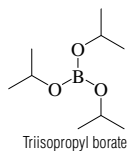
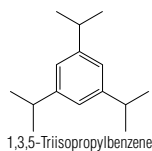
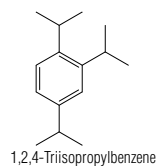
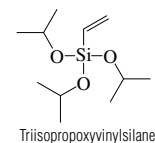
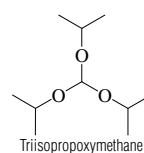
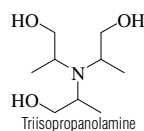
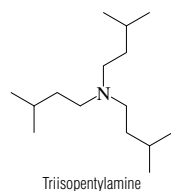
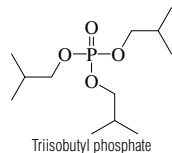
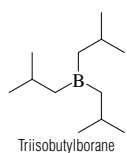
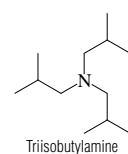
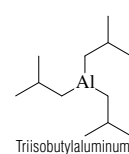
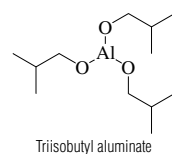
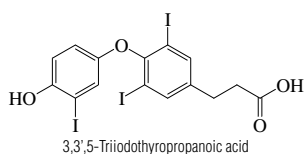
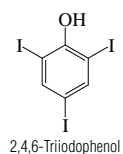
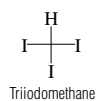
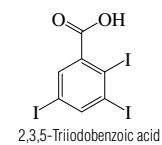
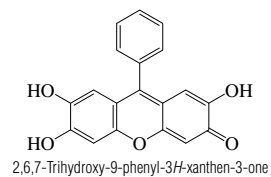
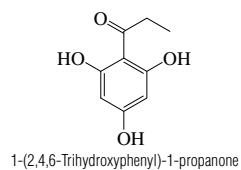
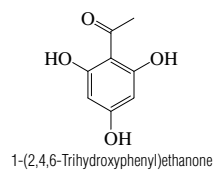
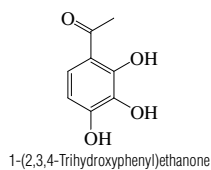
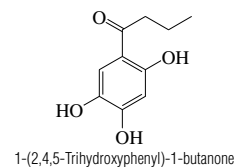
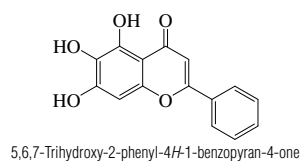
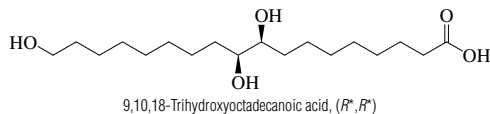
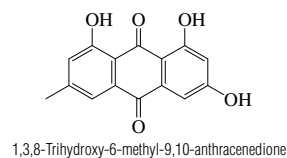
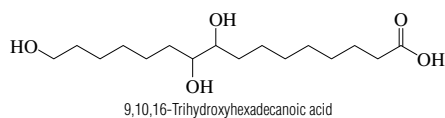
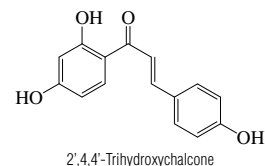
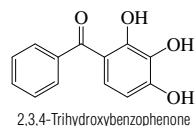
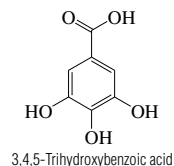
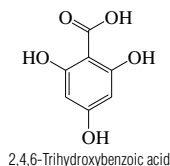
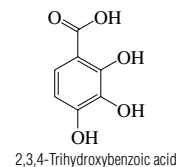
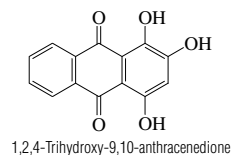
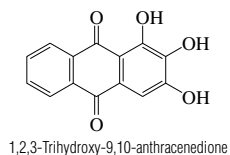
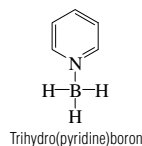
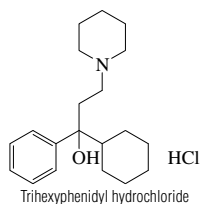




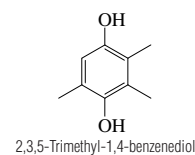
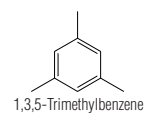
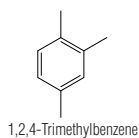
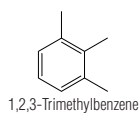
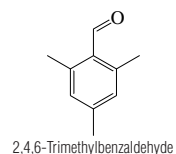
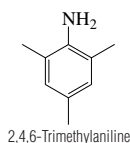
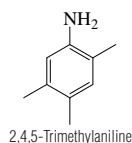
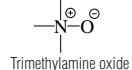
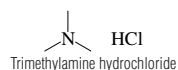
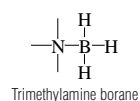
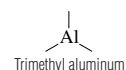
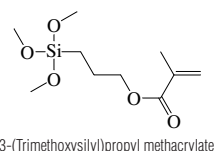
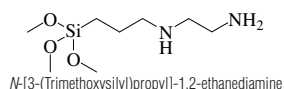
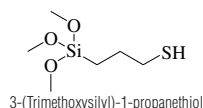
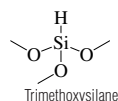
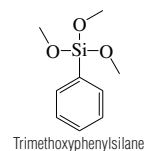
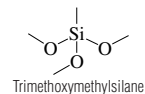
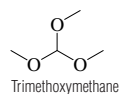
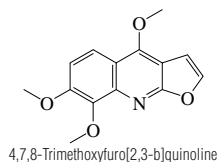
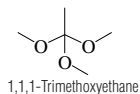
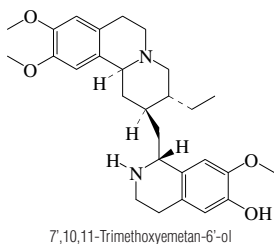
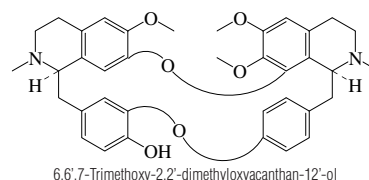
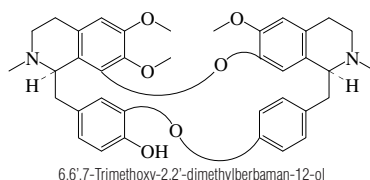
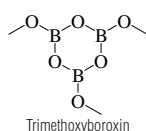
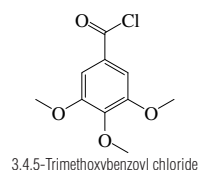
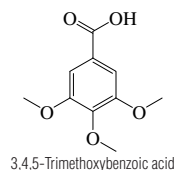
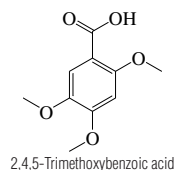
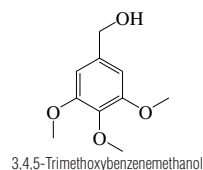
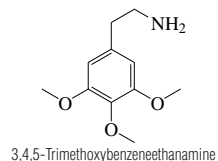
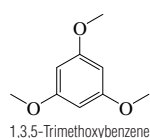
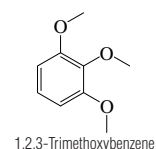
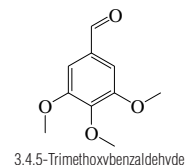
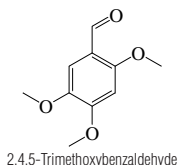
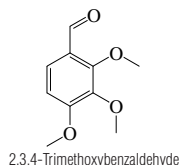
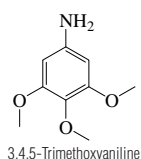
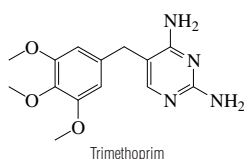
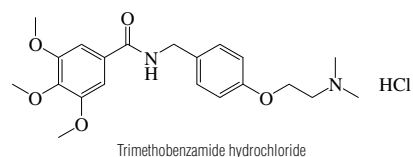
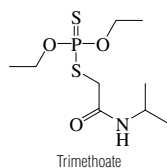
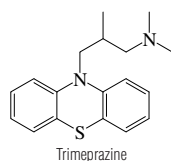
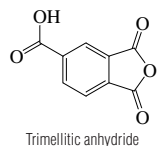
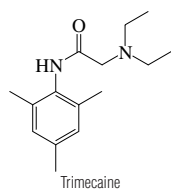
| No.   | Name                                             | Synonym                                                      | Mol. Form.                                                                    | CAS RN     | Mol. Wt. | Physical Form    | mp/°C   | bp/°C                 | den/<br>g cm <sup>-3</sup>       | n <sub>D</sub>       | Solubility                                   |
|-------|--------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------------|------------|----------|------------------|---------|-----------------------|----------------------------------|----------------------|----------------------------------------------|
| 10378 | 2,2,2-Trifluoroacetamide                         |                                                              | C <sub>2</sub> H <sub>2</sub> F <sub>3</sub> NO                               | 354-38-1   | 113.038  |                  | 73.8    | 162.5                 |                                  |                      |                                              |
| 10379 | Trifluoroacetic acid                             |                                                              | C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>                                 | 76-05-1    | 114.023  | liq              | -15.2   | 73                    | 1.5351 <sup>25</sup>             |                      | s H <sub>2</sub> O, EtOH, eth, ace           |
| 10380 | Trifluoroacetic acid anhydride                   |                                                              | C <sub>2</sub> F <sub>6</sub> O <sub>3</sub>                                  | 407-25-0   | 210.031  | liq              | -65     | 39.5                  | 1.490 <sup>25</sup>              | 1.269 <sup>25</sup>  |                                              |
| 10381 | 1,1,1-Trifluoroacetone                           | Methyl trifluoromethyl ketone                                | C <sub>3</sub> H <sub>2</sub> F <sub>3</sub> O                                | 421-50-1   | 112.050  | vol liq or gas   |         | 21.5                  | 1.252 <sup>25</sup>              |                      |                                              |
| 10382 | Trifluoroacetonitrile                            |                                                              | C <sub>2</sub> F <sub>3</sub> N                                               | 353-85-5   | 95.023   | col gas          |         | -68.8                 |                                  |                      |                                              |
| 10383 | Trifluoroacetyl chloride                         |                                                              | C <sub>2</sub> ClF <sub>3</sub> O                                             | 354-32-5   | 132.468  | col gas          | -146    | -18                   |                                  |                      |                                              |
| 10384 | 1,2,4-Trifluorobenzene                           |                                                              | C <sub>6</sub> H <sub>3</sub> F <sub>3</sub>                                  | 367-23-7   | 132.083  |                  |         | 90                    | 1.264 <sup>25</sup>              | 1.4171 <sup>20</sup> |                                              |
| 10385 | 1,3,5-Trifluorobenzene                           |                                                              | C <sub>6</sub> H <sub>3</sub> F <sub>3</sub>                                  | 372-38-3   | 132.083  | liq              | -5.5    | 75.5                  | 1.277 <sup>25</sup>              | 1.4140 <sup>20</sup> |                                              |
| 10386 | 1,1,1-Trifluoroethane                            | Methyl fluoroform                                            | C <sub>2</sub> H <sub>2</sub> F <sub>3</sub>                                  | 420-46-2   | 84.040   | col gas          | -111.3  | -47.25                |                                  |                      | s eth, chl                                   |
| 10387 | 1,1,2-Trifluoroethane                            |                                                              | C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>                                  | 430-66-0   | 84.040   | col gas          | -84     | 3.7                   |                                  |                      |                                              |
| 10388 | 2,2,2-Trifluoroethanol                           |                                                              | C <sub>2</sub> H <sub>2</sub> F <sub>3</sub> O                                | 75-89-8    | 100.039  | liq              | -43.5   | 74                    | 1.3842 <sup>20</sup>             | 1.2907 <sup>22</sup> | vs EtOH; s eth, ace, bz, chl                 |
| 10389 | Trifluoroethene                                  | Trifluoroethylene                                            | C <sub>2</sub> HF <sub>3</sub>                                                | 359-11-5   | 82.024   | col gas          |         | -51                   | 1.26 <sup>70</sup>               |                      | i H <sub>2</sub> O; sl EtOH; s eth           |
| 10390 | 2,2,2-Trifluoroethylamine                        | 2,2,2-Trifluoroethanamine                                    | C <sub>2</sub> H <sub>4</sub> F <sub>3</sub> N                                | 753-90-2   | 99.055   |                  |         | 36                    | 1.245 <sup>25</sup>              |                      |                                              |
| 10391 | 2,2,2-Trifluoroethyl methyl ether                |                                                              | C <sub>3</sub> H <sub>5</sub> F <sub>3</sub> O                                | 460-43-5   | 114.066  |                  |         | 31.62                 |                                  |                      |                                              |
| 10392 | 1,1,1-Trifluoro-2-iodoethane                     |                                                              | C <sub>2</sub> H <sub>2</sub> F <sub>3</sub> I                                | 353-83-3   | 209.936  |                  |         | 54.5                  | 2.13 <sup>25</sup>               | 1.4009 <sup>20</sup> |                                              |
| 10393 | Trifluoroiodomethane                             |                                                              | CF <sub>3</sub> I                                                             | 2314-97-8  | 195.910  | col gas          |         | -22.5                 | 2.3607 <sup>32</sup>             | 1.3790 <sup>32</sup> |                                              |
| 10394 | Trifluoroisocyanomethane                         | Trifluoromethyl isocyanide                                   | C <sub>2</sub> F <sub>3</sub> N                                               | 19480-01-4 | 95.023   | col gas          |         | -80                   |                                  |                      |                                              |
| 10395 | Trifluoromethane                                 | Fluoroform                                                   | CHF <sub>3</sub>                                                              | 75-46-7    | 70.014   | col gas          | -155.2  | -82.1                 | 0.673 <sup>25</sup><br>(p>1 atm) |                      | s H <sub>2</sub> O, ace, bz; vs EtOH; sl chl |
| 10396 | Trifluoromethanesulfonyl chloride                |                                                              | CClF <sub>3</sub> S                                                           | 421-17-0   | 136.524  | col gas          |         | -0.7                  |                                  |                      | i H <sub>2</sub> O                           |
| 10397 | Trifluoromethanesulfonic acid                    |                                                              | CHF <sub>3</sub> O <sub>3</sub> S                                             | 1493-13-6  | 150.077  | hyg liq          | 45      | 162                   |                                  |                      | vs eth                                       |
| 10398 | Trifluoromethanesulfonyl chloride                |                                                              | CClF <sub>3</sub> O <sub>2</sub> S                                            | 421-83-0   | 168.523  |                  |         | 162; 62 <sup>18</sup> |                                  | 1.3344 <sup>20</sup> | i H <sub>2</sub> O                           |
| 10399 | Trifluoromethanesulfonyl fluoride                |                                                              | CF <sub>3</sub> O <sub>2</sub> S                                              | 335-05-7   | 152.069  | col gas          |         | -21.7                 |                                  |                      |                                              |
| 10400 | 2-(Trifluoromethyl)aniline                       |                                                              | C <sub>7</sub> H <sub>6</sub> F <sub>3</sub> N                                | 88-17-5    | 161.125  |                  | 35.5    | 68 <sup>15</sup>      | 1.282 <sup>25</sup>              | 1.4810 <sup>20</sup> |                                              |
| 10401 | 3-(Trifluoromethyl)aniline                       |                                                              | C <sub>7</sub> H <sub>6</sub> F <sub>3</sub> N                                | 98-16-8    | 161.125  |                  | 5.5     | 187; 74 <sup>10</sup> | 1.3047 <sup>12</sup>             | 1.4787 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth             |
| 10402 | 4-(Trifluoromethyl)aniline                       |                                                              | C <sub>7</sub> H <sub>6</sub> F <sub>3</sub> N                                | 455-14-1   | 161.125  |                  | 38      | 117.5 <sup>60</sup>   | 1.283 <sup>27</sup>              | 1.4815 <sup>25</sup> |                                              |
| 10403 | 4-(Trifluoromethyl)benzaldehyde                  |                                                              | C <sub>8</sub> H <sub>5</sub> F <sub>3</sub> O                                | 455-19-6   | 174.120  |                  |         | 80 <sup>25</sup>      |                                  | 1.4630 <sup>20</sup> |                                              |
| 10404 | (Trifluoromethyl)benzene                         | Benzotrifluoride                                             | C <sub>7</sub> H <sub>5</sub> F <sub>3</sub>                                  | 98-08-8    | 146.110  | liq              | -28.95  | 102.1                 | 1.1884 <sup>20</sup>             | 1.4146 <sup>20</sup> | msc EtOH, eth, ace, bz, ctc                  |
| 10405 | 3-(Trifluoromethyl)benzonitrile                  |                                                              | C <sub>8</sub> H <sub>4</sub> F <sub>3</sub> N                                | 368-77-4   | 171.120  |                  | 14.5    | 189                   | 1.2813 <sup>20</sup>             | 1.4508 <sup>20</sup> |                                              |
| 10406 | 4-(Trifluoromethyl)benzonitrile                  |                                                              | C <sub>8</sub> H <sub>4</sub> F <sub>3</sub> N                                | 455-18-5   | 171.120  |                  | 37.5    |                       |                                  |                      |                                              |
| 10407 | 3-(Trifluoromethyl)benzoyl chloride              |                                                              | C <sub>8</sub> H <sub>4</sub> ClF <sub>3</sub> O                              | 2251-65-2  | 208.565  | oil              |         | 186; 80 <sup>16</sup> | 1.383                            | 1.4770 <sup>20</sup> |                                              |
| 10408 | Trifluoromethyl difluoromethyl ether             |                                                              | C <sub>2</sub> HF <sub>3</sub> O                                              | 3822-68-2  | 136.020  | col gas          | -157    | -38                   |                                  |                      |                                              |
| 10409 | 2-(Trifluoromethyl)phenol                        |                                                              | C <sub>7</sub> H <sub>5</sub> F <sub>3</sub> O                                | 444-30-4   | 162.109  |                  | 45.5    | 147.5                 |                                  |                      |                                              |
| 10410 | 3-(Trifluoromethyl)phenol                        |                                                              | C <sub>7</sub> H <sub>5</sub> F <sub>3</sub> O                                | 98-17-9    | 162.109  | liq              | -0.9    | 178                   | 1.3418 <sup>25</sup>             |                      |                                              |
| 10411 | 2-[[3-(Trifluoromethyl)phenyl]amino]benzoic acid | Flufenamic acid                                              | C <sub>14</sub> H <sub>10</sub> F <sub>3</sub> NO <sub>2</sub>                | 530-78-9   | 281.230  |                  | 133.5   |                       |                                  |                      | s DMSO                                       |
| 10412 | Trifluoromethylsilane                            |                                                              | CH <sub>3</sub> F <sub>3</sub> Si                                             | 373-74-0   | 100.116  | col gas          | -73     | -30                   |                                  |                      |                                              |
| 10413 | (Trifluoromethyl)silane                          |                                                              | CH <sub>3</sub> F <sub>3</sub> Si                                             | 10112-11-5 | 100.116  | col gas          | -124    | -38.3                 |                                  |                      |                                              |
| 10414 | Trifluoromethyl 1,1,2,2-tetrafluoroethyl ether   |                                                              | C <sub>3</sub> HF <sub>7</sub> O                                              | 2356-61-8  | 186.028  | col gas          | -141    | -3                    |                                  |                      |                                              |
| 10415 | 1,1,1-Trifluoro-2,4-pentanedione                 | 1,1,1-Trifluoroacetylacetone                                 | C <sub>5</sub> H <sub>2</sub> F <sub>3</sub> O <sub>2</sub>                   | 367-57-7   | 154.088  | liq              |         | 107                   |                                  |                      | s os                                         |
| 10416 | 4,4,4-Trifluoro-1-phenyl-1,3-butanedione         |                                                              | C <sub>10</sub> H <sub>7</sub> F <sub>3</sub> O <sub>2</sub>                  | 326-06-7   | 216.157  | cry              | 39      | 224                   |                                  |                      | i H <sub>2</sub> O; s EtOH, ace              |
| 10417 | 2,2,2-Trifluoro-1-phenylethanone                 |                                                              | C <sub>8</sub> H <sub>5</sub> F <sub>3</sub> O                                | 434-45-7   | 174.120  | liq              | -40     | 153                   | 1.279 <sup>20</sup>              | 1.4583 <sup>20</sup> |                                              |
| 10418 | Trifluorophenylsilane                            |                                                              | C <sub>6</sub> H <sub>4</sub> F <sub>3</sub> Si                               | 368-47-8   | 162.185  | liq              | -18     | 101.5                 | 1.2169 <sup>20</sup>             | 1.4110 <sup>20</sup> | vs bz, EtOH                                  |
| 10419 | 1,1,1-Trifluoropropane                           |                                                              | C <sub>3</sub> H <sub>2</sub> F <sub>3</sub>                                  | 421-07-8   | 98.067   | col gas          |         | -13                   |                                  |                      |                                              |
| 10420 | 1,1,1-Trifluoro-2-propanol, (±)                  |                                                              | C <sub>3</sub> H <sub>5</sub> F <sub>3</sub> O                                | 17556-48-8 | 114.066  | liq              | -52     | 78                    | 1.2632 <sup>25</sup>             | 1.3130 <sup>25</sup> | vs EtOH, eth; s ace, bz; sl ctc              |
| 10421 | 3,3,3-Trifluoropropene                           |                                                              | C <sub>3</sub> H <sub>2</sub> F <sub>3</sub>                                  | 677-21-4   | 96.051   | col gas          |         | -17                   |                                  |                      |                                              |
| 10422 | 3,3,3-Trifluoro-1-propyne                        | (Trifluoromethyl)acetylene                                   | C <sub>2</sub> HF <sub>3</sub>                                                | 661-54-1   | 94.035   | col gas          |         | -48.3                 |                                  |                      |                                              |
| 10423 | 4,4,4-Trifluoro-1-(2-thienyl)-1,3-butanedione    | Thenoyltrifluoroacetone                                      | C <sub>8</sub> H <sub>5</sub> F <sub>3</sub> O <sub>2</sub> S                 | 326-91-0   | 222.185  |                  | 42.8    | 97 <sup>9</sup>       |                                  |                      |                                              |
| 10424 | Trifluoro(trifluoromethyl)oxirane                | Perfluoropropylene oxide                                     | C <sub>3</sub> F <sub>6</sub> O                                               | 428-59-1   | 166.021  | gas              |         | -27.4                 |                                  |                      |                                              |
| 10425 | Trifluoromazine                                  | Fluopromazine                                                | C <sub>18</sub> H <sub>15</sub> F <sub>3</sub> N <sub>2</sub> S               | 146-54-3   | 352.417  | visc oil         |         | 176 <sup>9,7</sup>    |                                  | 1.5780 <sup>23</sup> |                                              |
| 10426 | Trifluralin                                      | 2,6-Dinitro- <i>N,N</i> -dipropyl-4-(trifluoromethyl)aniline | C <sub>13</sub> H <sub>16</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub>  | 1582-09-8  | 335.279  |                  | 49      | 140 <sup>4,2</sup>    |                                  |                      |                                              |
| 10427 | Triforine                                        |                                                              | C <sub>10</sub> H <sub>14</sub> Cl <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | 26644-46-2 | 434.962  |                  | 155 dec |                       |                                  |                      |                                              |
| 10428 | Trigonelline                                     |                                                              | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                 | 535-83-1   | 137.137  | pr (aq, al, +1w) |         |                       |                                  |                      | vs H <sub>2</sub> O                          |
| 10429 | Trihexylamine                                    | <i>N,N</i> -Dihexyl-1-hexanamine                             | C <sub>18</sub> H <sub>39</sub> N                                             | 102-86-3   | 269.510  |                  |         | 261.7                 | 0.7976 <sup>21</sup>             |                      | i H <sub>2</sub> O; vs EtOH, eth; s acid     |
| 10430 | Trihexyl borate                                  |                                                              | C <sub>18</sub> H <sub>39</sub> BO <sub>3</sub>                               | 5337-36-0  | 314.312  |                  |         | 143 <sup>2</sup>      |                                  |                      | sl ctc                                       |



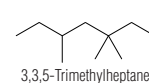
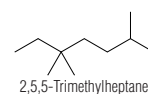
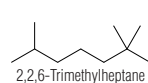
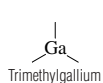
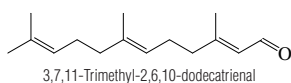
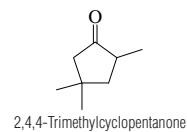
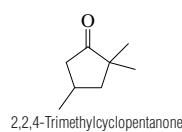
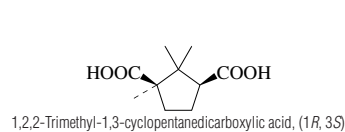
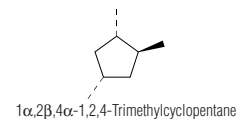
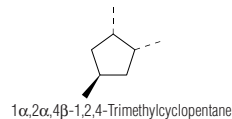
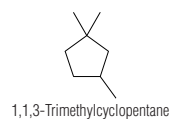
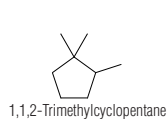
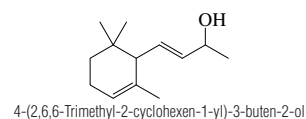
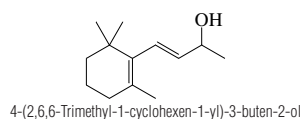
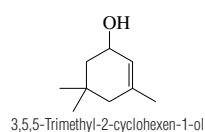
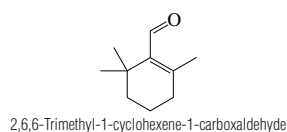
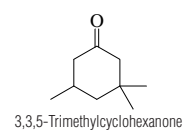
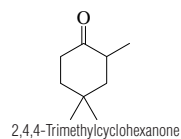
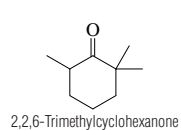
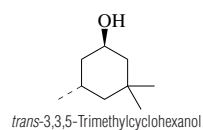
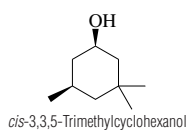
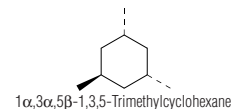
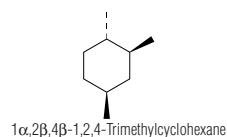
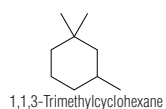
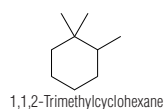
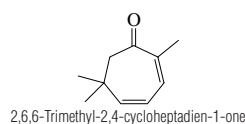
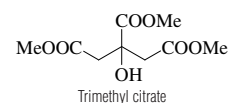
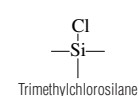
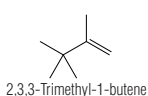
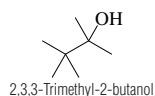
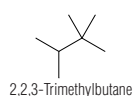
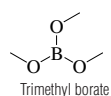
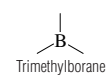
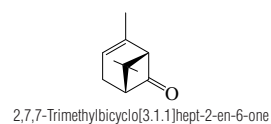
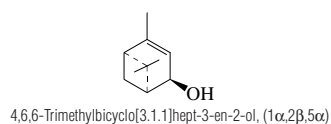
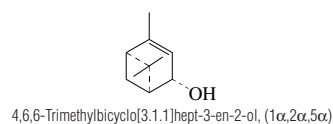
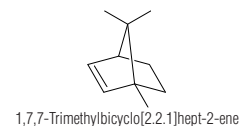
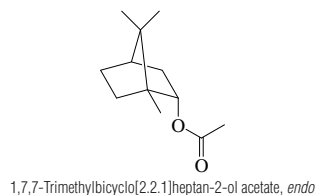
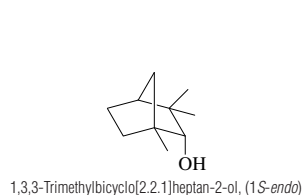
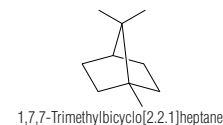
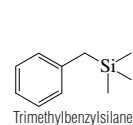
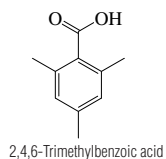
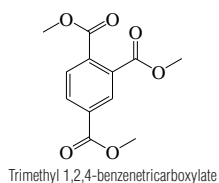
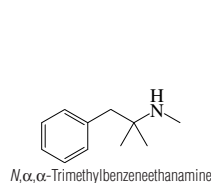
| No.   | Name                                                           | Synonym                                                                   | Mol. Form.                                                    | CAS RN     | Mol. Wt. | Physical Form               | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                   |
|-------|----------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------|------------|----------|-----------------------------|---------|-------------------------------------|----------------------------|----------------------|--------------------------------------------------------------|
| 10431 | Trihexyphenidyl hydrochloride                                  | $\alpha$ -Cyclohexyl- $\alpha$ -phenyl-1-piperidinepropanol hydrochloride | C <sub>20</sub> H <sub>32</sub> ClNO                          | 52-49-3    | 337.927  |                             | 258.5   |                                     |                            |                      |                                                              |
| 10432 | Trihydro(pyridine)boron                                        | Borane pyridine                                                           | C <sub>5</sub> H <sub>6</sub> BN                              | 110-51-0   | 92.936   |                             | 10.5    |                                     | 0.920 <sup>20</sup>        | 1.5280 <sup>25</sup> | i H <sub>2</sub> O; dec acid                                 |
| 10433 | 1,2,3-Trihydroxy-9,10-anthracenedione                          | Anthragallol                                                              | C <sub>14</sub> H <sub>8</sub> O <sub>5</sub>                 | 602-64-2   | 256.211  | ye nd (dil al)              | 313     | sub 290                             |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, HOAc, CS <sub>2</sub>      |
| 10434 | 1,2,4-Trihydroxy-9,10-anthracenedione                          | Purpurin                                                                  | C <sub>14</sub> H <sub>8</sub> O <sub>5</sub>                 | 81-54-9    | 256.211  | oran red or oran-ye nd (al) | 259     | sub                                 |                            |                      | sl H <sub>2</sub> O; vs EtOH, bz, HOAc; s eth                |
| 10435 | 2,3,4-Trihydroxybenzoic acid                                   |                                                                           | C <sub>7</sub> H <sub>6</sub> O <sub>5</sub>                  | 610-02-6   | 170.120  | nd (+w)                     | 221     | sub                                 |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace; i bz, CS <sub>2</sub> |
| 10436 | 2,4,6-Trihydroxybenzoic acid                                   |                                                                           | C <sub>7</sub> H <sub>6</sub> O <sub>5</sub>                  | 83-30-7    | 170.120  | cry (w+1)                   | 100 dec |                                     |                            |                      | sl H <sub>2</sub> O; s EtOH; vs eth; i bz                    |
| 10437 | 3,4,5-Trihydroxybenzoic acid                                   | Gallic acid                                                               | C <sub>7</sub> H <sub>6</sub> O <sub>5</sub>                  | 149-91-7   | 170.120  | pr (w+1)                    | 253 dec |                                     | 1.694 <sup>6</sup>         |                      | sl H <sub>2</sub> O, eth; vs EtOH; s ace; i bz, chl          |
| 10438 | 2,3,4-Trihydroxybenzophenone                                   | Alizarin Yellow A                                                         | C <sub>13</sub> H <sub>10</sub> O <sub>4</sub>                | 1143-72-2  | 230.216  | ye nd (dil al)              | 140.5   |                                     |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, eth, ace, HOAc              |
| 10439 | 2',4',4''-Trihydroxychalcone                                   | Isoliquiritigenin                                                         | C <sub>15</sub> H <sub>12</sub> O <sub>4</sub>                | 961-29-5   | 256.254  | ye nd (EtOH-w)              | 200     |                                     |                            |                      |                                                              |
| 10440 | 9,10,16-Trihydroxyhexadecanoic acid                            | Aleuritic acid                                                            | C <sub>16</sub> H <sub>32</sub> O <sub>5</sub>                | 6949-98-0  | 304.422  | lf (dil al), nd (w)         | 102     |                                     |                            |                      | sl H <sub>2</sub> O                                          |
| 10441 | 1,3,8-Trihydroxy-6-methyl-9,10-anthracenedione                 | Emodin                                                                    | C <sub>15</sub> H <sub>10</sub> O <sub>5</sub>                | 518-82-1   | 270.237  | oran-red mcl nd (HOAc)      | 257     | sub                                 |                            |                      | vs eth, EtOH                                                 |
| 10442 | 9,10,18-Trihydroxyoctadecanoic acid, ( <i>R</i> *, <i>R</i> *) | Phloionolic acid                                                          | C <sub>18</sub> H <sub>36</sub> O <sub>5</sub>                | 583-86-8   | 332.476  | cry (dil al)                | 101.5   |                                     |                            |                      |                                                              |
| 10443 | 5,6,7-Trihydroxy-2-phenyl-4 <i>H</i> -1-benzopyran-4-one       | Baicalein                                                                 | C <sub>15</sub> H <sub>10</sub> O <sub>5</sub>                | 491-67-8   | 270.237  | ye pr (al)                  | 264 dec |                                     |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, eth, ace, HOAc              |
| 10444 | 1-(2,4,5-Trihydroxyphenyl)-1-butanone                          |                                                                           | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                | 1421-63-2  | 196.200  |                             | 153.8   |                                     |                            |                      |                                                              |
| 10445 | 1-(2,3,4-Trihydroxyphenyl) ethanone                            | Gallacetophenone                                                          | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                  | 528-21-2   | 168.148  |                             | 173     |                                     |                            |                      | s H <sub>2</sub> O, eth; vs EtOH, ace; sl bz, chl            |
| 10446 | 1-(2,4,6-Trihydroxyphenyl) ethanone                            | 2',4',6'-Trihydroxyacetophenone                                           | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                  | 480-66-0   | 168.148  |                             | 221.0   |                                     |                            |                      | sl H <sub>2</sub> O, chl, bz; vs EtOH, eth, ace              |
| 10447 | 1-(2,4,6-Trihydroxyphenyl)-1-propanone                         | Flopropione                                                               | C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>                 | 2295-58-1  | 182.173  | nd (w, +1w)                 | 175.5   |                                     |                            |                      | vs eth, EtOH                                                 |
| 10448 | 2,6,7-Trihydroxy-9-phenyl-3 <i>H</i> -xanthen-3-one            | Phenylfluorone                                                            | C <sub>19</sub> H <sub>12</sub> O <sub>5</sub>                | 975-17-7   | 320.295  | oran red (al-HCl)           | >300    |                                     |                            |                      |                                                              |
| 10449 | 2,3,5-Triiodobenzoic acid                                      |                                                                           | C <sub>7</sub> H <sub>3</sub> I <sub>3</sub> O <sub>2</sub>   | 88-82-4    | 499.811  | pr (al)                     | 225     |                                     |                            |                      | i H <sub>2</sub> O; vs EtOH, eth; sl bz                      |
| 10450 | Triiodomethane                                                 | Iodoform                                                                  | CHI <sub>3</sub>                                              | 75-47-8    | 393.732  | ye cry                      | 121.2   | 218                                 | 4.008 <sup>25</sup>        |                      | i H <sub>2</sub> O, bz; s EtOH, eth, ace; sl DMSO            |
| 10451 | 2,4,6-Triiodophenol                                            |                                                                           | C <sub>6</sub> H <sub>3</sub> I <sub>3</sub> O                | 609-23-4   | 471.800  | nd (dil al)                 | 159.8   | sub                                 |                            |                      | i H <sub>2</sub> O; sl EtOH; s eth, ace                      |
| 10452 | 3,3',5-Triiodothyropropanoic acid                              |                                                                           | C <sub>15</sub> H <sub>11</sub> I <sub>3</sub> O <sub>4</sub> | 51-26-3    | 635.959  | cry (EtOH)                  | 200     |                                     |                            |                      | sl EtOH                                                      |
| 10453 | Triisobutyl aluminate                                          | 2-Methyl-1-propanol, aluminum salt                                        | C <sub>12</sub> H <sub>27</sub> AlO <sub>3</sub>              | 3453-79-0  | 246.322  |                             |         | 275 <sup>50</sup>                   |                            |                      |                                                              |
| 10454 | Triisobutylaluminum                                            |                                                                           | C <sub>12</sub> H <sub>27</sub> Al                            | 100-99-2   | 198.324  | liq                         | 6       | 86 <sup>10</sup>                    |                            |                      |                                                              |
| 10455 | Triisobutylamine                                               | 2-Methyl- <i>N,N</i> -bis(2-methylpropyl)-1-propanamine                   | C <sub>12</sub> H <sub>27</sub> N                             | 1116-40-1  | 185.349  | liq                         | -21.8   | 191.5                               | 0.7684 <sup>20</sup>       | 1.4252 <sup>17</sup> | vs eth, EtOH                                                 |
| 10456 | Triisobutylborane                                              |                                                                           | C <sub>12</sub> H <sub>27</sub> B                             | 1116-39-8  | 182.153  |                             |         | 188; 86 <sup>20</sup>               | 0.7380 <sup>25</sup>       | 1.4188 <sup>23</sup> | vs bz, eth, EtOH                                             |
| 10457 | Triisobutyl phosphate                                          |                                                                           | C <sub>12</sub> H <sub>27</sub> O <sub>4</sub> P              | 126-71-6   | 266.313  |                             |         | 264                                 | 0.9681 <sup>20</sup>       | 1.4193 <sup>20</sup> | vs H <sub>2</sub> O, bz, eth, EtOH                           |
| 10458 | Triisopentylamine                                              | 3-Methyl- <i>N,N</i> -bis(3-methylbutyl)-1-butanamine                     | C <sub>15</sub> H <sub>33</sub> N                             | 645-41-0   | 227.430  |                             |         | 235                                 | 0.7848 <sup>20</sup>       | 1.4331 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth, bz, ctc                |
| 10459 | Triisopropanolamine                                            |                                                                           | C <sub>9</sub> H <sub>21</sub> NO <sub>3</sub>                | 122-20-3   | 191.268  |                             | 45      | 175 <sup>10</sup>                   | 1.0 <sup>20</sup>          |                      | s H <sub>2</sub> O, EtOH; sl chl                             |
| 10460 | Triisopropoxymethane                                           | Isopropyl orthoformate                                                    | C <sub>10</sub> H <sub>22</sub> O <sub>3</sub>                | 4447-60-3  | 190.280  |                             |         | 167                                 | 0.8621 <sup>20</sup>       | 1.4000 <sup>20</sup> | vs eth, EtOH                                                 |
| 10461 | Triisopropoxylvinsilane                                        |                                                                           | C <sub>11</sub> H <sub>26</sub> O <sub>3</sub> Si             | 18023-33-1 | 232.393  |                             |         | 179.5; 77 <sup>20</sup>             | 0.8627 <sup>25</sup>       | 1.3981 <sup>20</sup> | s ctc                                                        |
| 10462 | 1,2,4-Triisopropylbenzene                                      |                                                                           | C <sub>15</sub> H <sub>24</sub>                               | 948-32-3   | 204.352  |                             |         | 244                                 | 0.8574 <sup>25</sup>       | 1.4896 <sup>25</sup> |                                                              |
| 10463 | 1,3,5-Triisopropylbenzene                                      |                                                                           | C <sub>15</sub> H <sub>24</sub>                               | 717-74-8   | 204.352  | liq                         | -7.4    | 238                                 | 0.8545 <sup>20</sup>       | 1.4882 <sup>20</sup> | s ace, bz, chl                                               |
| 10464 | Triisopropyl borate                                            |                                                                           | C <sub>9</sub> H <sub>21</sub> BO <sub>3</sub>                | 5419-55-6  | 188.072  |                             |         | 140; 75 <sup>16</sup>               | 0.8251 <sup>20</sup>       | 1.3777 <sup>20</sup> | vs EtOH, eth, bz, PrOH                                       |
| 10465 | Triisopropyl phosphate                                         |                                                                           | C <sub>9</sub> H <sub>21</sub> O <sub>4</sub> P               | 513-02-0   | 224.234  |                             |         | 219                                 | 0.9867 <sup>20</sup>       | 1.4057 <sup>20</sup> | vs EtOH                                                      |
| 10466 | Triisopropyl phosphite                                         |                                                                           | C <sub>9</sub> H <sub>21</sub> O <sub>3</sub> P               | 116-17-6   | 208.235  |                             |         | 74 <sup>20</sup> , 60 <sup>10</sup> | 0.9063 <sup>20</sup>       | 1.4085 <sup>25</sup> | s EtOH, eth, chl                                             |
| 10467 | Triisopropyl vanadate                                          | Vanadium, oxotris(2-propanolato)-, (T-4)-                                 | C <sub>9</sub> H <sub>21</sub> O <sub>4</sub> V               | 5588-84-1  | 244.203  |                             |         | 104 <sup>10</sup>                   |                            |                      |                                                              |



| No.   | Name                                                    | Synonym                                                           | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                                 | den/<br>g cm <sup>-3</sup>    | n <sub>D</sub>       | Solubility                                                     |
|-------|---------------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------|------------|----------|-------------------------|---------|---------------------------------------|-------------------------------|----------------------|----------------------------------------------------------------|
| 10468 | Trimecaine                                              | 2-Diethylamino-2',4',6'-trimethylacetanilide                      | C <sub>15</sub> H <sub>24</sub> N <sub>2</sub> O                | 616-68-2   | 248.364  | cry                     | 44      | 187 <sup>6</sup>                      |                               |                      |                                                                |
| 10469 | Trimellitic anhydride                                   |                                                                   | C <sub>9</sub> H <sub>4</sub> O <sub>5</sub>                    | 552-30-7   | 192.125  |                         | 162     | 241 <sup>14</sup>                     |                               |                      |                                                                |
| 10470 | Trimeprazine                                            | <i>N,N</i> ,β-Trimethyl-10 <i>H</i> -phenothiazine-10-propanamine | C <sub>18</sub> H <sub>22</sub> N <sub>2</sub> S                | 84-96-8    | 298.446  | cry                     | 68      | 162 <sup>20,3</sup>                   |                               |                      |                                                                |
| 10471 | Trimethoate                                             |                                                                   | C <sub>9</sub> H <sub>20</sub> NO <sub>3</sub> PS <sub>2</sub>  | 2275-18-5  | 285.364  | solid                   | 28.5    | 135 <sup>0,1</sup>                    |                               |                      | sl H <sub>2</sub> O                                            |
| 10472 | Trimethobenzamide hydrochloride                         |                                                                   | C <sub>21</sub> H <sub>25</sub> ClN <sub>2</sub> O <sub>5</sub> | 554-92-7   | 424.918  | cry                     | 188     |                                       |                               |                      | vs H <sub>2</sub> O                                            |
| 10473 | Trimethoprim                                            |                                                                   | C <sub>14</sub> H <sub>18</sub> N <sub>4</sub> O <sub>3</sub>   | 738-70-5   | 290.318  | ye cry                  | 201     |                                       |                               |                      | sl chl, MeOH; i eth, bz                                        |
| 10474 | 3,4,5-Trimethoxyaniline                                 |                                                                   | C <sub>9</sub> H <sub>13</sub> NO <sub>3</sub>                  | 24313-88-0 | 183.204  |                         | 112.8   |                                       |                               |                      |                                                                |
| 10475 | 2,3,4-Trimethoxybenzaldehyde                            |                                                                   | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                  | 2103-57-3  | 196.200  |                         |         | 122 <sup>0,5</sup>                    |                               | 1.5547 <sup>20</sup> |                                                                |
| 10476 | 2,4,5-Trimethoxybenzaldehyde                            |                                                                   | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                  | 4460-86-0  | 196.200  |                         | 114     |                                       |                               |                      | s H <sub>2</sub> O, eth, chl, lig                              |
| 10477 | 3,4,5-Trimethoxybenzaldehyde                            |                                                                   | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                  | 86-81-7    | 196.200  |                         | 72.5    | 148 <sup>5</sup>                      |                               |                      | s chl                                                          |
| 10478 | 1,2,3-Trimethoxybenzene                                 |                                                                   | C <sub>9</sub> H <sub>12</sub> O <sub>3</sub>                   | 634-36-6   | 168.189  | orth nd (al)            | 48.5    | 235                                   | 1.1009 <sup>45</sup>          |                      | i H <sub>2</sub> O; s EtOH, eth, bz                            |
| 10479 | 1,3,5-Trimethoxybenzene                                 |                                                                   | C <sub>9</sub> H <sub>12</sub> O <sub>3</sub>                   | 621-23-8   | 168.189  | pr (al), lf (peth)      | 54.5    | 255.5                                 |                               |                      | i H <sub>2</sub> O; s EtOH, eth, bz                            |
| 10480 | 3,4,5-Trimethoxybenzeneethanamine                       | Mescaline                                                         | C <sub>11</sub> H <sub>17</sub> NO <sub>3</sub>                 | 54-04-6    | 211.258  | cry                     | 35.5    | 180 <sup>12</sup>                     |                               |                      | s H <sub>2</sub> O, EtOH, bz, chl; i eth, peth                 |
| 10481 | 3,4,5-Trimethoxybenzenemethanol                         | 3,4,5-Trimethoxybenzyl alcohol                                    | C <sub>10</sub> H <sub>14</sub> O <sub>4</sub>                  | 3840-31-1  | 198.216  |                         | 3       | 228 <sup>25</sup>                     | 1.1427 <sup>20</sup>          | 1.5439 <sup>20</sup> |                                                                |
| 10482 | 2,4,5-Trimethoxybenzoic acid                            |                                                                   | C <sub>10</sub> H <sub>12</sub> O <sub>5</sub>                  | 490-64-2   | 212.199  | nd (al or bz-peth)      | 145     | 300                                   |                               |                      | vs H <sub>2</sub> O, bz, EtOH, peth                            |
| 10483 | 3,4,5-Trimethoxybenzoic acid                            |                                                                   | C <sub>10</sub> H <sub>12</sub> O <sub>5</sub>                  | 118-41-2   | 212.199  | mcl nd (w)              | 172.3   | 226 <sup>10</sup>                     |                               |                      | sl H <sub>2</sub> O; vs EtOH, eth, chl                         |
| 10484 | 3,4,5-Trimethoxybenzoyl chloride                        |                                                                   | C <sub>10</sub> H <sub>11</sub> ClO <sub>4</sub>                | 4521-61-3  | 230.645  |                         | 82      | 185 <sup>18</sup>                     |                               |                      |                                                                |
| 10485 | Trimethoxyboroxin                                       |                                                                   | C <sub>3</sub> H <sub>3</sub> B <sub>3</sub> O <sub>6</sub>     | 102-24-9   | 173.532  |                         |         |                                       |                               | 1.40 <sup>25</sup>   |                                                                |
| 10486 | 6,6',7'-Trimethoxy-2,2'-dimethylberbaman-12-ol          | Berbamine                                                         | C <sub>37</sub> H <sub>40</sub> N <sub>2</sub> O <sub>6</sub>   | 478-61-5   | 608.723  | lf (+2w, al) cry (peth) | 198.5   |                                       |                               |                      | sl H <sub>2</sub> O; s EtOH, eth, chl, peth                    |
| 10487 | 6,6',7'-Trimethoxy-2,2'-dimethoxyacanthan-12'-ol        | Oxyacanthine                                                      | C <sub>37</sub> H <sub>40</sub> N <sub>2</sub> O <sub>6</sub>   | 548-40-3   | 608.723  | nd (al, eth)            | 216.5   |                                       |                               |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl; i lig                |
| 10488 | 7',10,11-Trimethoxyemetan-6'-ol                         | Cephaeline                                                        | C <sub>28</sub> H <sub>38</sub> N <sub>2</sub> O <sub>4</sub>   | 483-17-0   | 466.613  | nd (eth)                | 115.5   |                                       |                               |                      | vs ace, EtOH, MeOH, chl                                        |
| 10489 | 1,1,1-Trimethoxyethane                                  |                                                                   | C <sub>3</sub> H <sub>12</sub> O <sub>3</sub>                   | 1445-45-0  | 120.147  |                         |         | 108                                   | 0.9438 <sup>25</sup>          | 1.3859 <sup>25</sup> | vs eth, EtOH                                                   |
| 10490 | 4,7,8-Trimethoxyfuro[2,3-b]quinoline                    | Skimmianine                                                       | C <sub>14</sub> H <sub>13</sub> NO <sub>4</sub>                 | 83-95-4    | 259.258  | pym (al)                | 177     |                                       |                               |                      | i H <sub>2</sub> O, peth; s EtOH, chl; sl eth, CS <sub>2</sub> |
| 10491 | Trimethoxymethane                                       |                                                                   | C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>                   | 149-73-5   | 106.120  |                         | 15      | 104                                   | 0.9676 <sup>20</sup>          | 1.3793 <sup>20</sup> | s EtOH, eth                                                    |
| 10492 | Trimethoxymethylsilane                                  |                                                                   | C <sub>2</sub> H <sub>12</sub> O <sub>2</sub> Si                | 1185-55-3  | 136.222  |                         |         | 102.5                                 | 0.9548 <sup>20</sup>          | 1.3696 <sup>20</sup> | s chl                                                          |
| 10493 | Trimethoxyphenylsilane                                  |                                                                   | C <sub>9</sub> H <sub>14</sub> O <sub>3</sub> Si                | 2996-92-1  | 198.291  |                         |         | 130 <sup>45</sup> , 110 <sup>20</sup> | 1.064 <sup>20</sup>           | 1.4734 <sup>20</sup> | s ctc, CS <sub>2</sub>                                         |
| 10494 | Trimethoxysilane                                        |                                                                   | C <sub>3</sub> H <sub>10</sub> O <sub>3</sub> Si                | 2487-90-3  | 122.195  |                         |         | 32 <sup>100</sup>                     |                               |                      |                                                                |
| 10495 | 3-(Trimethoxysilyl)-1-propanethiol                      | (3-Mercaptopropyl) trimethoxysilane                               | C <sub>6</sub> H <sub>16</sub> O <sub>3</sub> SSi               | 4420-74-0  | 196.340  |                         |         | 128 <sup>50</sup> , 93 <sup>10</sup>  | 1.015 <sup>25</sup>           | 1.4420 <sup>25</sup> |                                                                |
| 10496 | <i>N</i> -[3-(Trimethoxysilyl)propyl]-1,2-ethanediamine |                                                                   | C <sub>8</sub> H <sub>22</sub> N <sub>2</sub> O <sub>3</sub> Si | 1760-24-3  | 222.358  |                         |         | 140.5 <sup>15</sup>                   | 1.01 <sup>25</sup>            | 1.4416 <sup>25</sup> |                                                                |
| 10497 | 3-(Trimethoxysilyl)propyl methacrylate                  |                                                                   | C <sub>10</sub> H <sub>20</sub> O <sub>5</sub> Si               | 2530-85-0  | 248.349  | liq                     |         | 107 <sup>5</sup> , 95 <sup>1</sup>    |                               |                      |                                                                |
| 10498 | Trimethyl aluminum                                      |                                                                   | C <sub>3</sub> H <sub>9</sub> Al                                | 75-24-1    | 72.085   |                         | 15.4    | 130; 20 <sup>9</sup>                  | 0.752 <sup>20</sup>           |                      |                                                                |
| 10499 | Trimethylamine                                          | <i>N,N</i> -Dimethylmethanamine                                   | C <sub>3</sub> H <sub>9</sub> N                                 | 75-50-3    | 59.110   | col gas                 | -117.1  | 2.87                                  | 0.627 <sup>25</sup> (p>1 atm) | 1.3631 <sup>0</sup>  | vs H <sub>2</sub> O, chl, tol; s EtOH, eth, bz                 |
| 10500 | Trimethylamine borane                                   | <i>N,N</i> -Dimethylmethanamine borane                            | C <sub>3</sub> H <sub>12</sub> BN                               | 75-22-9    | 72.945   |                         | 94      | 172                                   | 0.792 <sup>25</sup>           |                      | vs eth, EtOH                                                   |
| 10501 | Trimethylamine hydrochloride                            | <i>N,N</i> -Dimethylmethanamine hydrochloride                     | C <sub>3</sub> H <sub>10</sub> ClN                              | 593-81-7   | 95.571   | mcl hyg nd (al)         | 277.5   | sub 200                               |                               |                      | vs H <sub>2</sub> O, EtOH, chl                                 |
| 10502 | Trimethylamine oxide                                    | <i>N,N</i> -Dimethylmethanamine oxide                             | C <sub>3</sub> H <sub>9</sub> NO                                | 1184-78-7  | 75.109   | hyg nd (w+2)            | 256     |                                       |                               |                      | vs H <sub>2</sub> O, EtOH                                      |
| 10503 | 2,4,5-Trimethylaniline                                  |                                                                   | C <sub>9</sub> H <sub>13</sub> N                                | 137-17-7   | 135.206  | nd (w)                  | 68      | 234.5                                 | 0.957 <sup>25</sup>           |                      | vs EtOH                                                        |
| 10504 | 2,4,6-Trimethylaniline                                  | Mesitylamine                                                      | C <sub>9</sub> H <sub>13</sub> N                                | 88-05-1    | 135.206  | liq                     | -2.5    | 232.5                                 | 0.9633 <sup>25</sup>          | 1.5495 <sup>20</sup> | sl ctc                                                         |
| 10505 | Trimethylarsine                                         |                                                                   | C <sub>3</sub> H <sub>9</sub> As                                | 593-88-4   | 120.025  | liq                     | -87.3   | 52                                    | 1.144 <sup>15</sup>           |                      | vs bz, eth, EtOH                                               |
| 10506 | 2,4,6-Trimethylbenzaldehyde                             |                                                                   | C <sub>10</sub> H <sub>12</sub> O                               | 487-68-3   | 148.201  |                         | 14      | 238.5                                 | 1.0154 <sup>25</sup>          |                      | i H <sub>2</sub> O; s EtOH, eth, ace, bz                       |
| 10507 | 1,2,3-Trimethylbenzene                                  | Hemimellitene                                                     | C <sub>9</sub> H <sub>12</sub>                                  | 526-73-8   | 120.191  | liq                     | -25.4   | 176.12                                | 0.8944 <sup>20</sup>          | 1.5139 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc          |
| 10508 | 1,2,4-Trimethylbenzene                                  | Pseudocumene                                                      | C <sub>9</sub> H <sub>12</sub>                                  | 95-63-6    | 120.191  | liq                     | -43.77  | 169.38                                | 0.8758 <sup>20</sup>          | 1.5048 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc          |
| 10509 | 1,3,5-Trimethylbenzene                                  | Mesitylene                                                        | C <sub>9</sub> H <sub>12</sub>                                  | 108-67-8   | 120.191  | liq                     | -44.72  | 164.74                                | 0.8615 <sup>25</sup>          | 1.4994 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc          |
| 10510 | 2,3,5-Trimethyl-1,4-benzenediol                         |                                                                   | C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                   | 700-13-0   | 152.190  | nd (w)                  | 169 dec |                                       |                               |                      | sl H <sub>2</sub> O; vs EtOH, eth, bz                          |

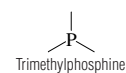
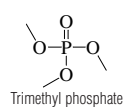
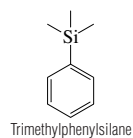
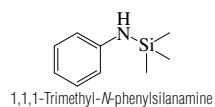
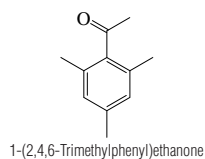
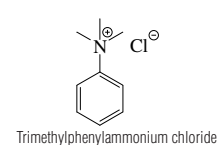
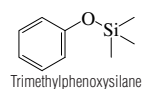
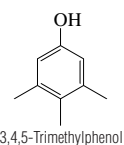
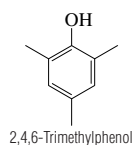
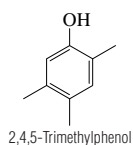
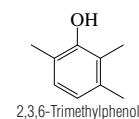
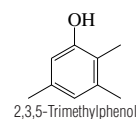
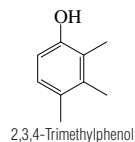
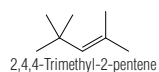
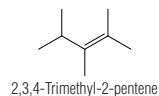
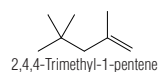
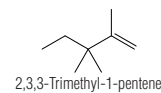
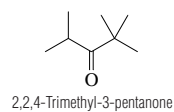
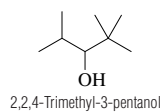
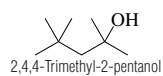
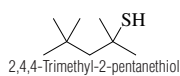
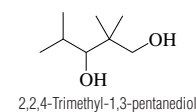
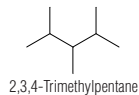
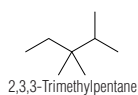
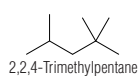
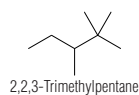
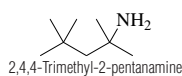
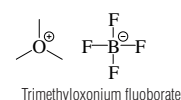
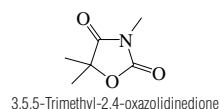
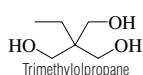
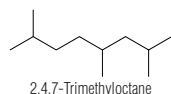
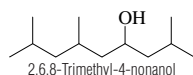
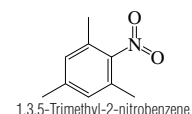
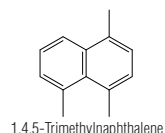
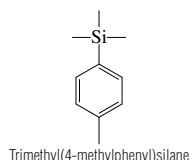
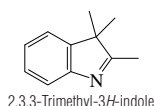
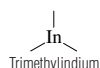
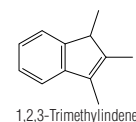
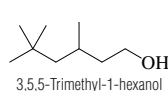
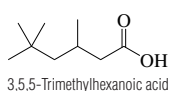
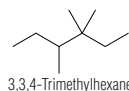
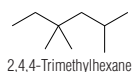
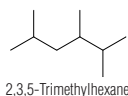
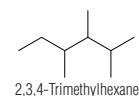
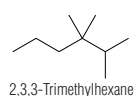
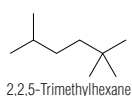
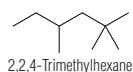
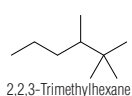
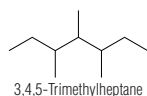


| No.   | Name                                                                               | Synonym                                  | Mol. Form.                                     | CAS RN     | Mol. Wt. | Physical Form        | mp/°C  | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                             |
|-------|------------------------------------------------------------------------------------|------------------------------------------|------------------------------------------------|------------|----------|----------------------|--------|--------------------------------------|----------------------------|----------------------|--------------------------------------------------------|
| 10511 | <i>N</i> , $\alpha$ , $\alpha$ -Trimethylbenzeneethanamine                         | Mephentermine                            | C <sub>11</sub> H <sub>17</sub> N              | 100-92-5   | 163.260  | liq                  |        | 95 <sup>9</sup>                      |                            |                      | i H <sub>2</sub> O; s eth; vs EtOH                     |
| 10512 | Trimethyl 1,2,4-benzenetricarboxylate                                              | Trimethyl trimellitate                   | C <sub>12</sub> H <sub>12</sub> O <sub>6</sub> | 2459-10-1  | 252.219  | visc oil             | -13    | 194 <sup>12</sup>                    | 1.261                      | 1.5230 <sup>20</sup> |                                                        |
| 10513 | 2,4,6-Trimethylbenzoic acid                                                        |                                          | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> | 480-63-7   | 164.201  | pr (liq)             | 156.5  |                                      |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, ace, chl             |
| 10514 | Trimethylbenzylsilane                                                              |                                          | C <sub>10</sub> H <sub>16</sub> Si             | 770-09-2   | 164.320  |                      |        | 190.5                                | 0.8933 <sup>20</sup>       | 1.4941 <sup>20</sup> |                                                        |
| 10515 | 1,7,7-Trimethylbicyclo[2.2.1]heptane                                               |                                          | C <sub>10</sub> H <sub>18</sub>                | 464-15-3   | 138.250  | hex pl(al), pr(MeOH) |        | 161                                  |                            |                      | i H <sub>2</sub> O; s EtOH, eth, AcOEt, MeOH           |
| 10516 | 1,3,3-Trimethylbicyclo[2.2.1]heptan-2-ol, (1 <i>S</i> -endo)                       | $\alpha$ -Fenchyl alcohol, ( <i>l</i> )  | C <sub>10</sub> H <sub>18</sub> O              | 512-13-0   | 154.249  | pr                   | 48     | 94 <sup>20</sup>                     | 0.9034 <sup>84</sup>       |                      |                                                        |
| 10517 | 1,7,7-Trimethylbicyclo[2.2.1]heptan-2-ol acetate, endo                             | Bornyl acetate                           | C <sub>12</sub> H <sub>20</sub> O <sub>2</sub> | 76-49-3    | 196.286  |                      | 29     | 221                                  |                            |                      |                                                        |
| 10518 | 1,7,7-Trimethylbicyclo[2.2.1]hept-2-ene                                            |                                          | C <sub>10</sub> H <sub>16</sub>                | 464-17-5   | 136.234  | cry (al)             | 113    | 146                                  |                            |                      | vs bz, eth, EtOH                                       |
| 10519 | 4,6,6-Trimethylbicyclo[3.1.1]hept-3-en-2-ol, (1 $\alpha$ ,2 $\alpha$ ,5 $\alpha$ ) |                                          | C <sub>10</sub> H <sub>16</sub> O              | 1820-09-3  | 152.233  |                      | 24     | 92 <sup>10</sup>                     | 0.9657 <sup>25</sup>       | 1.4908 <sup>25</sup> |                                                        |
| 10520 | 4,6,6-Trimethylbicyclo[3.1.1]hept-3-en-2-ol, (1 $\alpha$ ,2 $\beta$ ,5 $\alpha$ )  |                                          | C <sub>10</sub> H <sub>16</sub> O              | 1845-30-3  | 152.233  |                      | 15.5   | 90 <sup>10</sup>                     | 0.9684 <sup>25</sup>       | 1.4912 <sup>25</sup> |                                                        |
| 10521 | 2,7,7-Trimethylbicyclo[3.1.1]hept-2-en-6-one                                       | Chrysanthenone                           | C <sub>10</sub> H <sub>14</sub> O              | 473-06-3   | 150.217  |                      |        | 88 <sup>12</sup>                     |                            | 1.4720 <sup>22</sup> | vs EtOH                                                |
| 10522 | Trimethylborane                                                                    |                                          | C <sub>3</sub> H <sub>9</sub> B                | 593-90-8   | 55.914   | col gas              | -161.5 | -20.2                                |                            |                      |                                                        |
| 10523 | Trimethyl borate                                                                   |                                          | C <sub>3</sub> H <sub>9</sub> BO <sub>3</sub>  | 121-43-7   | 103.912  | liq                  | -29.3  | 67.5                                 | 0.915 <sup>25</sup>        | 1.3568 <sup>20</sup> | vs eth, MeOH                                           |
| 10524 | 2,2,3-Trimethylbutane                                                              | Triptane                                 | C <sub>7</sub> H <sub>16</sub>                 | 464-06-2   | 100.202  | liq                  | -24.6  | 80.86                                | 0.6901 <sup>20</sup>       | 1.3864 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; vs ace, bz, peth, ctc |
| 10525 | 2,3,3-Trimethyl-2-butanol                                                          |                                          | C <sub>7</sub> H <sub>16</sub> O               | 594-83-2   | 116.201  | cry (dil al +1/2w)   | 17     | 131                                  | 0.8380 <sup>25</sup>       | 1.4233 <sup>22</sup> | sl H <sub>2</sub> O; vs ace, eth, EtOH                 |
| 10526 | 2,3,3-Trimethyl-1-butene                                                           |                                          | C <sub>7</sub> H <sub>14</sub>                 | 594-56-9   | 98.186   | liq                  | -109.9 | 77.9                                 | 0.7050 <sup>20</sup>       | 1.4025 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, chl, MeOH               |
| 10527 | Trimethylchlorosilane                                                              |                                          | C <sub>3</sub> H <sub>9</sub> ClSi             | 75-77-4    | 108.642  | liq                  | -40    | 60                                   | 0.856 <sup>25</sup>        | 1.3870 <sup>20</sup> |                                                        |
| 10528 | Trimethyl citrate                                                                  |                                          | C <sub>9</sub> H <sub>14</sub> O <sub>7</sub>  | 1587-20-8  | 234.203  | tcl                  | 79.3   | 285; 176 <sup>16</sup>               |                            |                      | vs eth, EtOH                                           |
| 10529 | 2,6,6-Trimethyl-2,4-cycloheptadien-1-one                                           | Eucarvone                                | C <sub>10</sub> H <sub>14</sub> O              | 503-93-5   | 150.217  |                      |        | 210; 105 <sup>22</sup>               | 0.9490 <sup>20</sup>       | 1.5087 <sup>20</sup> | s eth, ace                                             |
| 10530 | 1,1,2-Trimethylcyclohexane                                                         |                                          | C <sub>9</sub> H <sub>18</sub>                 | 7094-26-0  | 126.239  | liq                  | -29    | 145.2                                | 0.7963 <sup>25</sup>       | 1.4382 <sup>20</sup> |                                                        |
| 10531 | 1,1,3-Trimethylcyclohexane                                                         |                                          | C <sub>9</sub> H <sub>18</sub>                 | 3073-66-3  | 126.239  | liq                  | -65.7  | 136.6                                | 0.7749 <sup>25</sup>       | 1.4295 <sup>20</sup> | i H <sub>2</sub> O                                     |
| 10532 | 1 $\alpha$ ,2 $\beta$ ,4 $\beta$ -1,2,4-Trimethylcyclohexane                       |                                          | C <sub>9</sub> H <sub>18</sub>                 | 7667-60-9  | 126.239  | liq                  | -83.5  | 142.9                                | 0.7870 <sup>25</sup>       | 1.4341 <sup>20</sup> |                                                        |
| 10533 | 1 $\alpha$ ,3 $\alpha$ ,5 $\beta$ -1,3,5-Trimethylcyclohexane                      | <i>trans</i> -1,3,5-Trimethylcyclohexane | C <sub>9</sub> H <sub>18</sub>                 | 1795-26-2  | 126.239  | liq                  | -107.4 | 140.5                                | 0.7794 <sup>20</sup>       | 1.4307 <sup>20</sup> | vs bz, eth, lig                                        |
| 10534 | <i>cis</i> -3,3,5-Trimethylcyclohexanol                                            |                                          | C <sub>9</sub> H <sub>18</sub> O               | 933-48-2   | 142.238  |                      | 37.3   | 202; 92 <sup>12</sup>                | 0.9006 <sup>16</sup>       | 1.4550 <sup>16</sup> | i H <sub>2</sub> O; s EtOH, eth, chl                   |
| 10535 | <i>trans</i> -3,3,5-Trimethylcyclohexanol                                          |                                          | C <sub>9</sub> H <sub>18</sub> O               | 767-54-4   | 142.238  | cry (eth)            | 55.8   | 189.2                                | 0.8631 <sup>60</sup>       |                      | i H <sub>2</sub> O; s EtOH, eth, chl                   |
| 10536 | 2,2,6-Trimethylcyclohexanone                                                       |                                          | C <sub>9</sub> H <sub>16</sub> O               | 2408-37-9  | 140.222  | liq                  | -31.8  | 178.5                                | 0.9043 <sup>18</sup>       | 1.4470 <sup>20</sup> |                                                        |
| 10537 | 2,4,4-Trimethylcyclohexanone                                                       |                                          | C <sub>9</sub> H <sub>16</sub> O               | 2230-70-8  | 140.222  |                      |        | 191                                  | 0.902 <sup>20</sup>        | 1.4493 <sup>20</sup> |                                                        |
| 10538 | 3,3,5-Trimethylcyclohexanone                                                       | Dihydroisophorone                        | C <sub>9</sub> H <sub>16</sub> O               | 873-94-9   | 140.222  | ye oil               |        | 189                                  | 0.8919 <sup>19</sup>       | 1.4454 <sup>15</sup> |                                                        |
| 10539 | 2,6,6-Trimethyl-1-cyclohexene-1-carboxaldehyde                                     | $\beta$ -Cyclocitral                     | C <sub>10</sub> H <sub>16</sub> O              | 432-25-7   | 152.233  |                      |        | 112 <sup>29</sup> , 97 <sup>15</sup> | 0.959 <sup>15</sup>        | 1.4971 <sup>15</sup> |                                                        |
| 10540 | 3,5,5-Trimethyl-2-cyclohexen-1-ol                                                  | Isophorol                                | C <sub>9</sub> H <sub>16</sub> O               | 470-99-5   | 140.222  |                      |        | 69 <sup>5</sup>                      | 0.914 <sup>20</sup>        | 1.4717 <sup>20</sup> |                                                        |
| 10541 | 4-(2,6,6-Trimethyl-1-cyclohexen-1-yl)-3-buten-2-ol                                 | $\beta$ -Ionol                           | C <sub>13</sub> H <sub>22</sub> O              | 22029-76-1 | 194.313  |                      |        | 130 <sup>14</sup>                    | 0.9243 <sup>20</sup>       | 1.4969 <sup>20</sup> | s EtOH, eth, ace                                       |
| 10542 | 4-(2,6,6-Trimethyl-2-cyclohexen-1-yl)-3-buten-2-ol                                 | $\alpha$ -Ionol                          | C <sub>13</sub> H <sub>22</sub> O              | 25312-34-9 | 194.313  | oil                  |        | 127 <sup>14</sup>                    | 0.9189 <sup>20</sup>       | 1.4735 <sup>20</sup> |                                                        |
| 10543 | 1,1,2-Trimethylcyclopentane                                                        |                                          | C <sub>8</sub> H <sub>16</sub>                 | 4259-00-1  | 112.213  | liq                  | -21.6  | 114; 53 <sup>100</sup>               | 0.7660 <sup>20</sup>       | 1.4199 <sup>20</sup> |                                                        |
| 10544 | 1,1,3-Trimethylcyclopentane                                                        |                                          | C <sub>8</sub> H <sub>16</sub>                 | 4516-69-2  | 112.213  | liq                  | -142.4 | 104.9                                | 0.7439 <sup>25</sup>       | 1.4112 <sup>20</sup> | i H <sub>2</sub> O                                     |
| 10545 | 1 $\alpha$ ,2 $\alpha$ ,4 $\beta$ -1,2,4-Trimethylcyclopentane                     |                                          | C <sub>8</sub> H <sub>16</sub>                 | 4850-28-6  | 112.213  | liq                  | -132.6 | 116.7                                | 0.7592 <sup>25</sup>       | 1.4186 <sup>20</sup> |                                                        |
| 10546 | 1 $\alpha$ ,2 $\beta$ ,4 $\alpha$ -1,2,4-Trimethylcyclopentane                     |                                          | C <sub>8</sub> H <sub>16</sub>                 | 16883-48-0 | 112.213  | liq                  | -130.8 | 109.3                                | 0.7430 <sup>25</sup>       | 1.4106 <sup>20</sup> |                                                        |
| 10547 | 1,2,2-Trimethyl-1,3-cyclopentanedicarboxylic acid, (1 <i>R</i> , 3 <i>S</i> )      | (+)-Camphoric acid                       | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub> | 124-83-4   | 200.232  | pr, lf (w)           | 187    |                                      | 1.186 <sup>20</sup>        |                      | sl H <sub>2</sub> O; vs EtOH, eth; s ace; i bz, chl    |
| 10548 | 2,2,4-Trimethylcyclopentanone                                                      |                                          | C <sub>8</sub> H <sub>14</sub> O               | 28056-54-4 | 126.196  | liq                  | -40.6  | 158                                  | 0.877 <sup>25</sup>        | 1.4300 <sup>20</sup> |                                                        |
| 10549 | 2,4,4-Trimethylcyclopentanone                                                      |                                          | C <sub>8</sub> H <sub>14</sub> O               | 4694-12-6  | 126.196  | liq                  | -25.6  | 160.5                                | 0.8785 <sup>18</sup>       | 1.433 <sup>18</sup>  |                                                        |
| 10550 | 1,1,2-Trimethylcyclopropane                                                        |                                          | C <sub>6</sub> H <sub>12</sub>                 | 4127-45-1  | 84.159   | liq                  | -138.2 | 54                                   | 0.6897 <sup>25</sup>       | 1.3864 <sup>20</sup> |                                                        |
| 10551 | 3,7,11-Trimethyl-2,6,10-dodecatrienal                                              |                                          | C <sub>15</sub> H <sub>24</sub> O              | 19317-11-4 | 220.351  |                      |        | 172 <sup>14</sup>                    | 0.893 <sup>18</sup>        | 1.4995               |                                                        |
| 10552 | Trimethylgallium                                                                   |                                          | C <sub>3</sub> H <sub>9</sub> Ga               | 1445-79-0  | 114.826  |                      |        | 55.7                                 |                            |                      | dec H <sub>2</sub> O (exp)                             |
| 10553 | 2,2,6-Trimethylheptane                                                             |                                          | C <sub>10</sub> H <sub>22</sub>                | 1190-83-6  | 142.282  | liq                  | -105   | 148.9                                | 0.7200 <sup>25</sup>       | 1.4078 <sup>20</sup> |                                                        |
| 10554 | 2,5,5-Trimethylheptane                                                             |                                          | C <sub>10</sub> H <sub>22</sub>                | 1189-99-7  | 142.282  |                      |        | 152.8                                | 0.7362 <sup>25</sup>       | 1.4149 <sup>20</sup> |                                                        |
| 10555 | 3,3,5-Trimethylheptane                                                             |                                          | C <sub>10</sub> H <sub>22</sub>                | 7154-80-5  | 142.282  |                      |        | 155.7                                | 0.7248 <sup>20</sup>       | 1.4170 <sup>20</sup> | i H <sub>2</sub> O; s bz, ctc, chl                     |

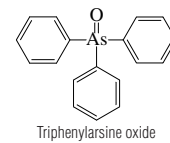
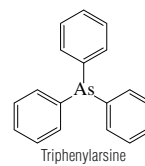
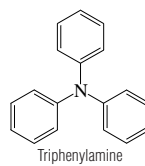
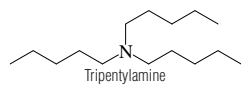
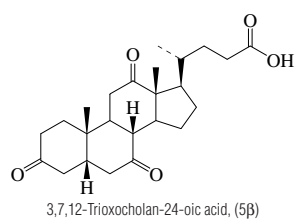
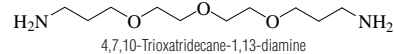
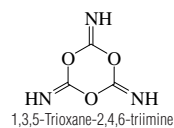
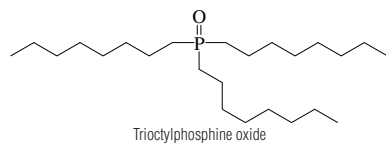
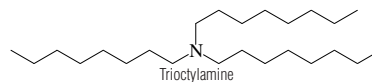
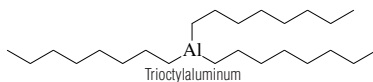
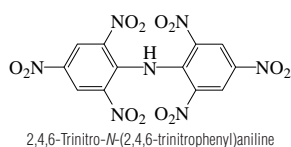
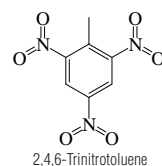
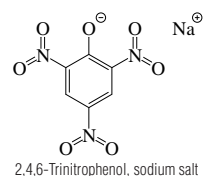
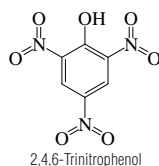
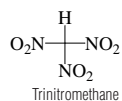
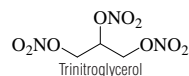
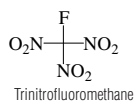
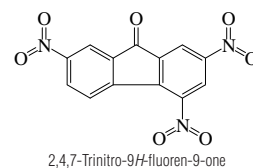
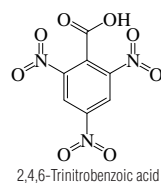
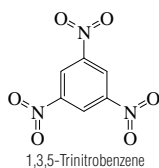
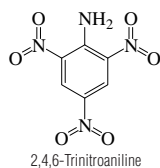
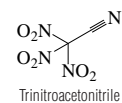
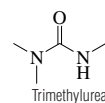
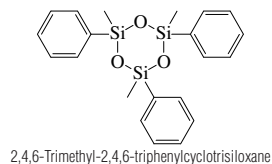
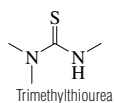
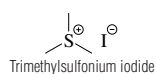
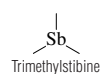
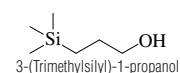
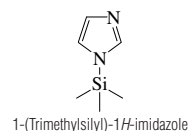
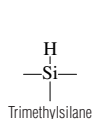
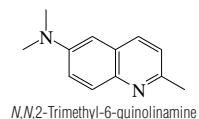
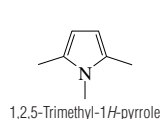
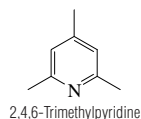
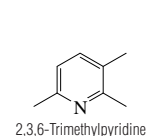
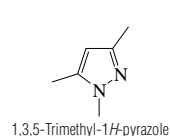
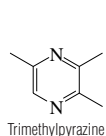
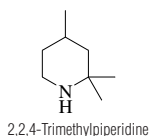
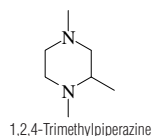
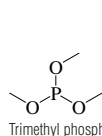




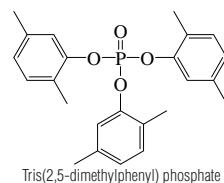
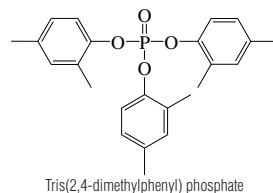
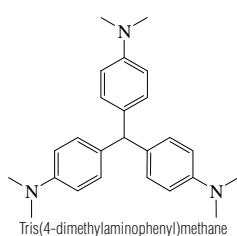
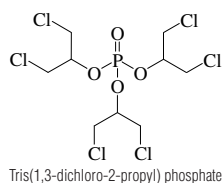
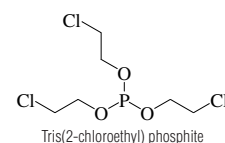
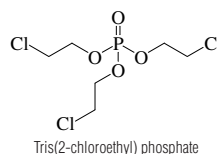
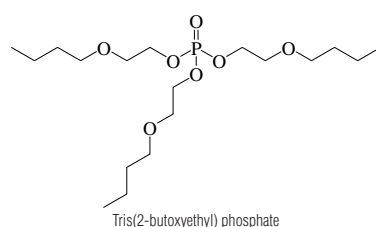
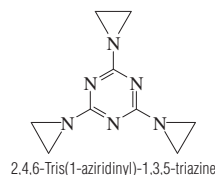
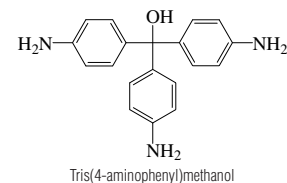
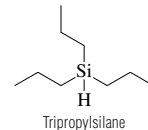
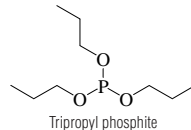
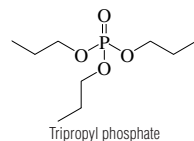
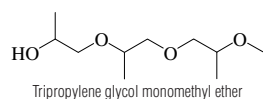
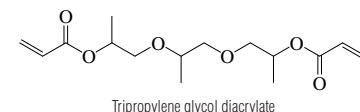
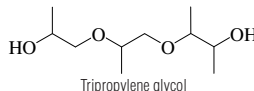
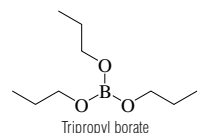
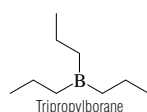
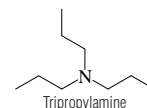
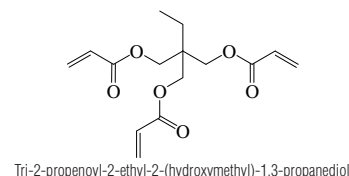
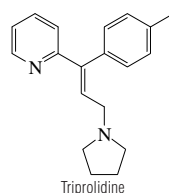
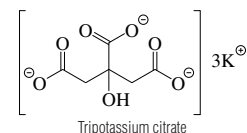
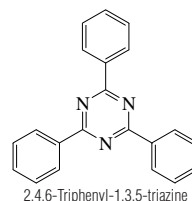
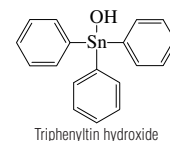
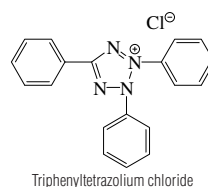
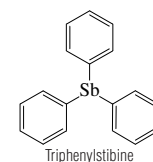
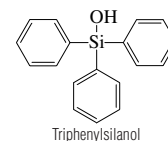
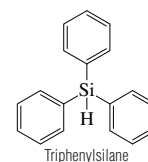
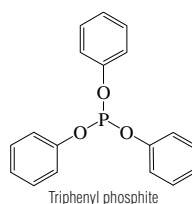
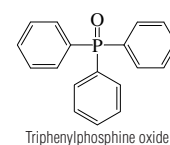
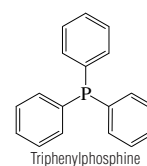
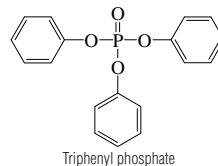
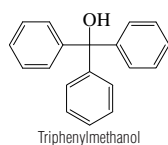
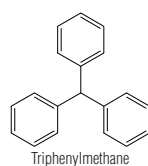
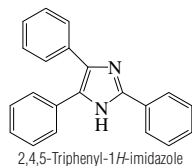
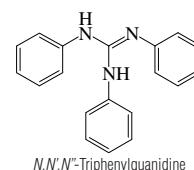
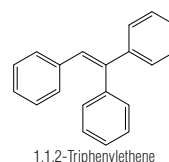
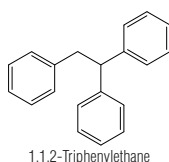
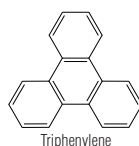
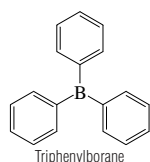
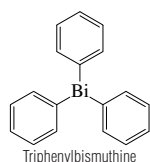
| No.   | Name                                 | Synonym                          | Mol. Form.                                      | CAS RN     | Mol. Wt. | Physical Form   | mp/°C   | bp/°C                               | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                            |
|-------|--------------------------------------|----------------------------------|-------------------------------------------------|------------|----------|-----------------|---------|-------------------------------------|----------------------------|----------------------|-------------------------------------------------------|
| 10556 | 3,4,5-Trimethylheptane               |                                  | C <sub>10</sub> H <sub>22</sub>                 | 20278-89-1 | 142.282  |                 |         | 162.5                               | 0.7519 <sup>25</sup>       | 1.4229 <sup>20</sup> |                                                       |
| 10557 | 2,2,3-Trimethylhexane                |                                  | C <sub>9</sub> H <sub>20</sub>                  | 16747-25-4 | 128.255  |                 |         | 133.6                               | 0.7257 <sup>25</sup>       | 1.4106 <sup>20</sup> |                                                       |
| 10558 | 2,2,4-Trimethylhexane                |                                  | C <sub>9</sub> H <sub>20</sub>                  | 16747-26-5 | 128.255  | liq             | -120    | 126.5                               | 0.711 <sup>20</sup>        | 1.4033 <sup>20</sup> |                                                       |
| 10559 | 2,2,5-Trimethylhexane                |                                  | C <sub>9</sub> H <sub>20</sub>                  | 3522-94-9  | 128.255  | liq             | -105.7  | 124.09                              | 0.7072 <sup>20</sup>       | 1.3997 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth, ace, bz; s ctc      |
| 10560 | 2,3,3-Trimethylhexane                |                                  | C <sub>9</sub> H <sub>20</sub>                  | 16747-28-7 | 128.255  | liq             | -116.8  | 137.7                               | 0.7345 <sup>25</sup>       | 1.4141 <sup>20</sup> |                                                       |
| 10561 | 2,3,4-Trimethylhexane                |                                  | C <sub>9</sub> H <sub>20</sub>                  | 921-47-1   | 128.255  |                 |         | 139.1                               | 0.7354 <sup>25</sup>       | 1.4144 <sup>20</sup> |                                                       |
| 10562 | 2,3,5-Trimethylhexane                |                                  | C <sub>9</sub> H <sub>20</sub>                  | 1069-53-0  | 128.255  | liq             | -127.9  | 131.4                               | 0.7218 <sup>20</sup>       | 1.4051 <sup>20</sup> |                                                       |
| 10563 | 2,4,4-Trimethylhexane                |                                  | C <sub>9</sub> H <sub>20</sub>                  | 16747-30-1 | 128.255  | liq             | -113.4  | 130.7                               | 0.7201 <sup>25</sup>       | 1.4074 <sup>20</sup> |                                                       |
| 10564 | 3,3,4-Trimethylhexane                |                                  | C <sub>9</sub> H <sub>20</sub>                  | 16747-31-2 | 128.255  | liq             | -101.2  | 140.5                               | 0.7414 <sup>25</sup>       | 1.4178 <sup>20</sup> |                                                       |
| 10565 | 3,5,5-Trimethylhexanoic acid         | Isononanoic acid                 | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | 3302-10-1  | 158.238  | liq             |         | 121 <sup>10</sup> , 85 <sup>4</sup> |                            |                      |                                                       |
| 10566 | 3,5,5-Trimethyl-1-hexanol            |                                  | C <sub>9</sub> H <sub>20</sub> O                | 3452-97-9  | 144.254  |                 |         | 194                                 | 0.8236 <sup>25</sup>       | 1.4300 <sup>25</sup> |                                                       |
| 10567 | 1,2,3-Trimethylindene                |                                  | C <sub>12</sub> H <sub>14</sub>                 | 4773-83-5  | 158.239  | liq             |         | 100.5 <sup>10</sup>                 | 0.9714 <sup>20</sup>       | 1.5521 <sup>20</sup> |                                                       |
| 10568 | Trimethylindium                      | Indium trimethyl                 | C <sub>3</sub> H <sub>9</sub> In                | 3385-78-2  | 159.921  |                 |         | 135.7                               | 1.568 <sup>19</sup>        |                      |                                                       |
| 10569 | 2,3,3-Trimethyl-3H-indole            |                                  | C <sub>11</sub> H <sub>13</sub> N               | 1640-39-7  | 159.228  |                 |         | 107 <sup>11</sup>                   |                            |                      |                                                       |
| 10570 | Trimethyl(4-methylphenyl)silane      |                                  | C <sub>10</sub> H <sub>16</sub> Si              | 3728-43-6  | 164.320  |                 | 38      | 192; 73 <sup>10</sup>               | 0.8666 <sup>20</sup>       | 1.4900 <sup>20</sup> |                                                       |
| 10571 | 1,4,5-Trimethylnaphthalene           |                                  | C <sub>13</sub> H <sub>14</sub>                 | 2131-41-1  | 170.250  | lf (MeOH)       | 63      | 145 <sup>12</sup>                   |                            |                      | i H <sub>2</sub> O                                    |
| 10572 | 1,3,5-Trimethyl-2-nitrobenzene       |                                  | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>  | 603-71-4   | 165.189  | orth pr (al)    | 44      | 255                                 | 1.51 <sup>25</sup>         |                      | vs EtOH                                               |
| 10573 | 2,6,8-Trimethyl-4-nonanol            |                                  | C <sub>12</sub> H <sub>26</sub> O               | 123-17-1   | 186.333  |                 |         | 225.4                               | 0.8178 <sup>20</sup>       |                      | sl ctc                                                |
| 10574 | 2,4,7-Trimethyloctane                |                                  | C <sub>11</sub> H <sub>24</sub>                 | 62016-38-0 | 156.309  |                 |         | 168.1                               |                            |                      |                                                       |
| 10575 | Trimethylolpropane                   |                                  | C <sub>9</sub> H <sub>14</sub> O <sub>3</sub>   | 77-99-6    | 134.173  | wh pow or pl    | 58      | 160 <sup>5</sup>                    |                            |                      | vs H <sub>2</sub> O, EtOH                             |
| 10576 | 3,5,5-Trimethyl-2,4-oxazolidinedione | Trimethadione                    | C <sub>6</sub> H <sub>8</sub> NO <sub>3</sub>   | 127-48-0   | 143.140  |                 | 46      | 79 <sup>5</sup>                     |                            |                      | s H <sub>2</sub> O; vs EtOH, eth, ace, bz; i peth     |
| 10577 | Trimethyloxonium fluoborate          |                                  | C <sub>3</sub> H <sub>9</sub> BF <sub>4</sub> O | 420-37-1   | 147.907  | hyg nd          | 148 dec |                                     |                            |                      | vs ace, chl                                           |
| 10578 | 2,4,4-Trimethyl-2-pentanamine        |                                  | C <sub>8</sub> H <sub>19</sub> N                | 107-45-9   | 129.244  |                 |         |                                     |                            |                      | s chl                                                 |
| 10579 | 2,2,3-Trimethylpentane               |                                  | C <sub>8</sub> H <sub>18</sub>                  | 564-02-3   | 114.229  | liq             | -112.2  | 110                                 | 0.7161 <sup>20</sup>       | 1.4030 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, hp; s bz      |
| 10580 | 2,2,4-Trimethylpentane               | Isooctane                        | C <sub>8</sub> H <sub>18</sub>                  | 540-84-1   | 114.229  | liq             | -107.3  | 99.22                               | 0.6878 <sup>25</sup>       | 1.3884 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, ace, hp; s eth, ctc     |
| 10581 | 2,3,3-Trimethylpentane               |                                  | C <sub>8</sub> H <sub>18</sub>                  | 560-21-4   | 114.229  | liq             | -100.9  | 114.8                               | 0.7262 <sup>20</sup>       | 1.4075 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth, ace, bz, hp     |
| 10582 | 2,3,4-Trimethylpentane               |                                  | C <sub>8</sub> H <sub>18</sub>                  | 565-75-3   | 114.229  | liq             | -109.2  | 113.5                               | 0.7191 <sup>20</sup>       | 1.4042 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH; msc eth, ace, bz; sl ctc |
| 10583 | 2,2,4-Trimethyl-1,3-pentanediol      |                                  | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>   | 144-19-4   | 146.228  | pl (bz)         | 51.5    | 235; 81 <sup>1</sup>                | 0.9361 <sup>15</sup>       | 1.4513 <sup>15</sup> | sl H <sub>2</sub> O; vs EtOH, eth; s bz, chl          |
| 10584 | 2,4,4-Trimethyl-2-pentanethiol       |                                  | C <sub>8</sub> H <sub>18</sub> S                | 141-59-3   | 146.294  | liq             |         | 76 <sup>20</sup>                    |                            |                      |                                                       |
| 10585 | 2,4,4-Trimethyl-2-pentanol           |                                  | C <sub>8</sub> H <sub>18</sub> O                | 690-37-9   | 130.228  | liq             | -20     | 147.5                               | 0.8225 <sup>20</sup>       | 1.4284 <sup>20</sup> | i H <sub>2</sub> O; sl EtOH; s eth                    |
| 10586 | 2,2,4-Trimethyl-3-pentanol           |                                  | C <sub>8</sub> H <sub>18</sub> O                | 5162-48-1  | 130.228  | liq             | -13     | 150.5                               | 0.8297 <sup>20</sup>       | 1.4288 <sup>20</sup> |                                                       |
| 10587 | 2,2,4-Trimethyl-3-pentanone          | tert-Butyl isopropyl ketone      | C <sub>8</sub> H <sub>16</sub> O                | 5857-36-3  | 128.212  |                 |         | 135.1                               | 0.8065 <sup>20</sup>       | 1.4060               | i H <sub>2</sub> O; s eth, ace                        |
| 10588 | 2,3,3-Trimethyl-1-pentene            |                                  | C <sub>8</sub> H <sub>16</sub>                  | 560-23-6   | 112.213  | liq             | -69     | 108.3                               | 0.7308 <sup>25</sup>       | 1.4174 <sup>20</sup> |                                                       |
| 10589 | 2,4,4-Trimethyl-1-pentene            |                                  | C <sub>8</sub> H <sub>16</sub>                  | 107-39-1   | 112.213  | liq             | -93.5   | 101.4                               | 0.7150 <sup>20</sup>       | 1.4086 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, ctc, chl, lig          |
| 10590 | 2,3,4-Trimethyl-2-pentene            |                                  | C <sub>8</sub> H <sub>16</sub>                  | 565-77-5   | 112.213  | liq             | -113.4  | 116.5                               | 0.7434 <sup>20</sup>       | 1.4274 <sup>20</sup> |                                                       |
| 10591 | 2,4,4-Trimethyl-2-pentene            |                                  | C <sub>8</sub> H <sub>16</sub>                  | 107-40-4   | 112.213  | liq             | -106.3  | 104.9                               | 0.7218 <sup>20</sup>       | 1.4160 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz, ctc, chl; vs lig       |
| 10592 | 2,3,4-Trimethylphenol                |                                  | C <sub>9</sub> H <sub>12</sub> O                | 526-85-2   | 136.190  | nd (peth)       | 81      | 236                                 |                            |                      | vs bz, eth, EtOH                                      |
| 10593 | 2,3,5-Trimethylphenol                |                                  | C <sub>9</sub> H <sub>12</sub> O                | 697-82-5   | 136.190  |                 | 94.5    | 233                                 |                            |                      |                                                       |
| 10594 | 2,3,6-Trimethylphenol                |                                  | C <sub>9</sub> H <sub>12</sub> O                | 2416-94-6  | 136.190  |                 | 63      |                                     |                            |                      |                                                       |
| 10595 | 2,4,5-Trimethylphenol                |                                  | C <sub>9</sub> H <sub>12</sub> O                | 496-78-6   | 136.190  | nd (lig)        | 72      | 232                                 |                            |                      | i H <sub>2</sub> O; vs EtOH, eth                      |
| 10596 | 2,4,6-Trimethylphenol                |                                  | C <sub>9</sub> H <sub>12</sub> O                | 527-60-6   | 136.190  | nd (peth, MeOH) | 73      | 220                                 |                            |                      | vs eth, EtOH                                          |
| 10597 | 3,4,5-Trimethylphenol                |                                  | C <sub>9</sub> H <sub>12</sub> O                | 527-54-8   | 136.190  | nd (peth)       | 108     | 248.5                               |                            |                      |                                                       |
| 10598 | Trimethylphenoxysilane               |                                  | C <sub>9</sub> H <sub>14</sub> OSi              | 1529-17-5  | 166.292  | liq             | -55     | 119                                 | 0.8681 <sup>20</sup>       | 1.5125 <sup>20</sup> |                                                       |
| 10599 | Trimethylphenylammonium chloride     | Phenyltrimethylammonium chloride | C <sub>9</sub> H <sub>14</sub> CIN              | 138-24-9   | 171.667  |                 |         |                                     |                            |                      | vs H <sub>2</sub> O, EtOH                             |
| 10600 | 1-(2,4,6-Trimethylphenyl)ethanone    |                                  | C <sub>11</sub> H <sub>14</sub> O               | 1667-01-2  | 162.228  |                 |         | 241; 120 <sup>12</sup>              | 0.9754 <sup>20</sup>       | 1.5175 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, ctc         |
| 10601 | 1,1,1-Trimethyl-N-phenylsilanamine   | Phenyl(trimethylsilyl)amine      | C <sub>9</sub> H <sub>15</sub> NSi              | 3768-55-6  | 165.308  |                 |         | 206                                 | 0.940 <sup>20</sup>        |                      |                                                       |
| 10602 | Trimethylphenylsilane                |                                  | C <sub>9</sub> H <sub>14</sub> Si               | 768-32-1   | 150.293  |                 |         | 169.5                               | 0.8722 <sup>20</sup>       | 1.4907 <sup>20</sup> | s ctc, CS <sub>2</sub>                                |
| 10603 | Trimethyl phosphate                  | Methyl phosphate                 | C <sub>3</sub> H <sub>9</sub> O <sub>4</sub> P  | 512-56-1   | 140.074  | liq             | -46     | 197.2                               | 1.2144 <sup>20</sup>       | 1.3967 <sup>20</sup> | vs H <sub>2</sub> O; sl EtOH; s eth                   |
| 10604 | Trimethylphosphine                   |                                  | C <sub>3</sub> H <sub>9</sub> P                 | 594-09-2   | 76.077   | liq             | -85     | 37.5                                |                            |                      | i H <sub>2</sub> O; s eth                             |



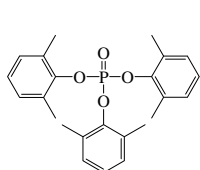
| No.   | Name                                                    | Synonym                              | Mol. Form.                                                     | CAS RN      | Mol. Wt. | Physical Form               | mp/°C   | bp/°C                       | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                     |
|-------|---------------------------------------------------------|--------------------------------------|----------------------------------------------------------------|-------------|----------|-----------------------------|---------|-----------------------------|----------------------------|----------------------|----------------------------------------------------------------|
| 10605 | Trimethyl phosphite                                     |                                      | C <sub>3</sub> H <sub>9</sub> O <sub>3</sub> P                 | 121-45-9    | 124.075  |                             |         | 111.5                       | 1.0518 <sup>20</sup>       | 1.4095 <sup>20</sup> | vs EtOH, eth; sl ctc                                           |
| 10606 | 1,2,4-Trimethylpiperazine                               |                                      | C <sub>7</sub> H <sub>16</sub> N <sub>2</sub>                  | 120-85-4    | 128.215  |                             |         | 149.5                       |                            | 1.4433 <sup>20</sup> | s ctc                                                          |
| 10607 | 2,2,4-Trimethylpiperidine                               |                                      | C <sub>9</sub> H <sub>17</sub> N                               | 101257-71-0 | 127.228  |                             |         | 148                         | 0.832 <sup>15</sup>        | 1.4458 <sup>20</sup> | vs eth, EtOH                                                   |
| 10608 | Trimethylpyrazine                                       |                                      | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                  | 14667-55-1  | 122.167  |                             |         | 87 <sup>25</sup>            |                            |                      |                                                                |
| 10609 | 1,3,5-Trimethyl-1 <i>H</i> -pyrazole                    |                                      | C <sub>6</sub> H <sub>10</sub> N <sub>2</sub>                  | 1072-91-9   | 110.156  |                             | 37      | 170                         | 0.9269 <sup>40</sup>       | 1.4589 <sup>57</sup> |                                                                |
| 10610 | 2,3,6-Trimethylpyridine                                 | 2,3,6-Collidine                      | C <sub>8</sub> H <sub>11</sub> N                               | 1462-84-6   | 121.180  |                             |         | 171.6                       | 0.9220 <sup>25</sup>       | 1.5053 <sup>20</sup> | s H <sub>2</sub> O, EtOH, eth, ace, bz                         |
| 10611 | 2,4,6-Trimethylpyridine                                 | 2,4,6-Collidine                      | C <sub>8</sub> H <sub>11</sub> N                               | 108-75-8    | 121.180  | liq                         | -46     | 170.6                       | 0.9166 <sup>22</sup>       | 1.4959 <sup>25</sup> | s H <sub>2</sub> O, EtOH, eth, ace, ctc                        |
| 10612 | 1,2,5-Trimethyl-1 <i>H</i> -pyrrole                     |                                      | C <sub>7</sub> H <sub>11</sub> N                               | 930-87-0    | 109.169  |                             |         | 171                         | 0.807 <sup>25</sup>        | 1.4969 <sup>20</sup> |                                                                |
| 10613 | <i>N,N</i> ,2-Trimethyl-6-quinolinamine                 |                                      | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub>                 | 92-99-9     | 186.252  | ye pr (HOAc, AcOEt)         | 101     | 319                         |                            |                      | s ctc, CS <sub>2</sub>                                         |
| 10614 | Trimethylsilane                                         |                                      | C <sub>3</sub> H <sub>10</sub> Si                              | 993-07-7    | 74.197   | col gas                     | -135.9  | 6.7                         |                            |                      |                                                                |
| 10615 | 1-(Trimethylsilyl)-1 <i>H</i> -imidazole                |                                      | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> Si               | 18156-74-6  | 140.258  |                             |         |                             |                            |                      | s chl                                                          |
| 10616 | 3-(Trimethylsilyl)-1-propanol                           |                                      | C <sub>6</sub> H <sub>16</sub> OSi                             | 2917-47-7   | 132.276  |                             |         | 141; 82 <sup>24</sup>       | 0.822 <sup>25</sup>        | 1.4298 <sup>20</sup> |                                                                |
| 10617 | Trimethylstibine                                        |                                      | C <sub>3</sub> H <sub>9</sub> Sb                               | 594-10-5    | 166.863  | liq                         | -62     | 80.6                        | 1.523 <sup>15</sup>        | 1.42 <sup>15</sup>   | i H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub>               |
| 10618 | Trimethylsulfonium iodide                               |                                      | C <sub>3</sub> H <sub>9</sub> I <sup>+</sup> S <sup>-</sup>    | 2181-42-2   | 204.072  | cry (eth)                   | 211 dec |                             |                            |                      |                                                                |
| 10619 | Trimethylthiourea                                       |                                      | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> S                | 2489-77-2   | 118.200  | pr (bz-lig)                 | 87.5    |                             |                            |                      | vs bz, EtOH, chl                                               |
| 10620 | 2,4,6-Trimethyl-2,4,6-triphenylcyclotrisiloxane         |                                      | C <sub>21</sub> H <sub>24</sub> O <sub>3</sub> Si <sub>3</sub> | 546-45-2    | 408.671  |                             | 100     | 190 <sup>1.5</sup>          | 1.1062 <sup>20</sup>       | 1.5397 <sup>20</sup> |                                                                |
| 10621 | Trimethylurea                                           |                                      | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O                | 632-14-4    | 102.134  | pr (eth)                    | 75.5    | 232.5                       | 1.1900 <sup>20</sup>       |                      | s H <sub>2</sub> O, EtOH; sl eth, bz                           |
| 10622 | Trinitroacetone                                         |                                      | C <sub>2</sub> N <sub>4</sub> O <sub>6</sub>                   | 630-72-8    | 176.044  | wax                         | 41.5    | exp 220                     |                            |                      | vs eth                                                         |
| 10623 | 2,4,6-Trinitroaniline                                   |                                      | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>6</sub>    | 489-98-5    | 228.119  | dk ye pr (HOAc)             | 193.5   | exp                         | 1.762 <sup>10</sup>        |                      | i H <sub>2</sub> O; sl EtOH, eth; s ace, bz, AcOEt             |
| 10624 | 1,3,5-Trinitrobenzene                                   | <i>sym</i> -Trinitrobenzene          | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>6</sub>    | 99-35-4     | 213.104  | orth pl (bz) lf (w)         | 122.9   | 315                         | 1.4775 <sup>152</sup>      |                      | sl H <sub>2</sub> O, EtOH, eth; vs ace; s bz, py               |
| 10625 | 2,4,6-Trinitro-1,3-benzenediol                          | Styphnic acid                        | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>8</sub>    | 82-71-3     | 245.103  | hex ye cry (dil al)         | 175.5   | sub                         |                            |                      | vs eth, EtOH                                                   |
| 10626 | 2,4,6-Trinitrobenzoic acid                              |                                      | C <sub>7</sub> H <sub>3</sub> N <sub>3</sub> O <sub>8</sub>    | 129-66-8    | 257.114  | orth (w)                    | 228 dec |                             |                            |                      | sl H <sub>2</sub> O, bz; vs EtOH; s eth, ace                   |
| 10627 | 2,4,7-Trinitro-9 <i>H</i> -fluoren-9-one                |                                      | C <sub>13</sub> H <sub>5</sub> N <sub>3</sub> O <sub>7</sub>   | 129-79-3    | 315.195  | pa ye nd (bz, HOAc)         | 175.8   |                             |                            |                      | sl H <sub>2</sub> O; vs ace, bz, chl                           |
| 10628 | Trinitrofluoromethane                                   | Fluorotrinitromethane                | CFN <sub>3</sub> O <sub>6</sub>                                | 1840-42-2   | 169.025  |                             |         | 86.3                        | 1.59 <sup>20</sup>         |                      |                                                                |
| 10629 | Trinitroglycerol                                        | Nitroglycerin                        | C <sub>3</sub> H <sub>5</sub> N <sub>3</sub> O <sub>9</sub>    | 55-63-0     | 227.087  | pa ye tcl or orth           | 13.5    | exp 218; 93 <sup>0.31</sup> | 1.5931 <sup>20</sup>       | 1.4786 <sup>12</sup> | sl H <sub>2</sub> O; s EtOH, bz; msc eth; vs ace, chl          |
| 10630 | Trinitromethane                                         |                                      | CHN <sub>3</sub> O <sub>6</sub>                                | 517-25-9    | 151.035  |                             | 15      | exp                         | 1.479 <sup>20</sup>        | 1.4451 <sup>24</sup> | vs ace, EtOH                                                   |
| 10631 | 2,4,6-Trinitrophenol                                    | Picric acid                          | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>7</sub>    | 88-89-1     | 229.104  | ye lf (w), pr (eth) pl (al) | 122.5   | exp 300                     |                            | 1.763                | sl H <sub>2</sub> O; s EtOH, eth, bz, chl; vs ace              |
| 10632 | 2,4,6-Trinitrophenol, sodium salt                       | Sodium picrate                       | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> NaO <sub>7</sub>  | 3324-58-1   | 251.086  | nd (w)                      | 270.4   |                             |                            |                      |                                                                |
| 10633 | 2,4,6-Trinitrotoluene                                   | 2-Methyl-1,3,5-trinitrobenzene       | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>6</sub>    | 118-96-7    | 227.131  | orth (al)                   | 80.5    | exp 240                     | 1.654 <sup>25</sup>        |                      | i H <sub>2</sub> O; sl EtOH; s eth; vs ace, bz                 |
| 10634 | 2,4,6-Trinitro- <i>N</i> -(2,4,6-trinitrophenyl)aniline | Dipicrylamine                        | C <sub>12</sub> H <sub>5</sub> N <sub>7</sub> O <sub>12</sub>  | 131-73-7    | 439.208  | pa ye pr(HOAc)              | 244 dec |                             |                            |                      | i H <sub>2</sub> O, EtOH, bz, ctc; sl eth, ace; vs py          |
| 10635 | Trioctylaluminum                                        |                                      | C <sub>24</sub> H <sub>51</sub> Al                             | 1070-00-4   | 366.644  | hyg visc liq                | -62     |                             | 0.701                      |                      |                                                                |
| 10636 | Trioctylamine                                           | <i>N,N</i> -Dioctyl-1-octanamine     | C <sub>24</sub> H <sub>51</sub> N                              | 1116-76-3   | 353.669  | liq                         | -34.6   | 366                         | 0.8110 <sup>20</sup>       | 1.4510 <sup>19</sup> |                                                                |
| 10637 | Trioctylphosphine oxide                                 | TOPO                                 | C <sub>24</sub> H <sub>51</sub> OP                             | 78-50-2     | 386.635  |                             | 52      | 201 <sup>2</sup>            |                            |                      |                                                                |
| 10638 | 1,3,5-Trioxane                                          | Formaldehyde, trimer                 | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                   | 110-88-3    | 90.078   | orth nd (eth)               | 60.29   | 114.5                       | 1.17 <sup>85</sup>         |                      | vs H <sub>2</sub> O; s EtOH, eth, bz, CS <sub>2</sub> ; i peth |
| 10639 | 1,3,5-Trioxane-2,4,6-trimine                            | Cyameline                            | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub> O <sub>3</sub>    | 462-02-2    | 129.074  | amor pow                    | dec     | dec                         | 1.127 <sup>15</sup>        |                      | vs eth, EtOH                                                   |
| 10640 | 4,7,10-Trioxatridecane-1,13-diamine                     | Diethyleneglycol diaminopropyl ether | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub> O <sub>3</sub>  | 4246-51-9   | 220.309  | liq                         |         | 147 <sup>4</sup>            | 1.005                      | 1.4640 <sup>20</sup> |                                                                |
| 10641 | 3,7,12-Trioxocholan-24-oic acid, (5β)                   | Dehydrocholic acid                   | C <sub>24</sub> H <sub>34</sub> O <sub>5</sub>                 | 81-23-2     | 402.524  |                             | 237     |                             |                            |                      | i H <sub>2</sub> O, eth; sl EtOH, bz; s ace, AcOEt             |
| 10642 | Triptylamine                                            | <i>N,N</i> -Dipentyl-1-pentanamine   | C <sub>15</sub> H <sub>33</sub> N                              | 621-77-2    | 227.430  |                             |         | 242.5                       | 0.7907 <sup>20</sup>       | 1.4366 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, acid                          |
| 10643 | Triphenylamine                                          | <i>N,N</i> -Diphenylbenzenamine      | C <sub>18</sub> H <sub>15</sub> N                              | 603-34-9    | 245.319  | mcl (MeOH, bz)              | 126.5   | 365                         | 1.18 <sup>25</sup>         |                      | i H <sub>2</sub> O; sl EtOH; s eth, bz, MeOH                   |
| 10644 | Triphenylarsine                                         |                                      | C <sub>18</sub> H <sub>15</sub> As                             | 603-32-7    | 306.234  |                             | 61      | 360                         | 1.2634 <sup>18</sup>       | 1.6888 <sup>21</sup> | i H <sub>2</sub> O; sl EtOH; vs eth, bz; s chl                 |
| 10645 | Triphenylarsine oxide                                   |                                      | C <sub>18</sub> H <sub>15</sub> AsO                            | 1153-05-5   | 322.233  |                             | 192     | 324.0                       |                            |                      |                                                                |



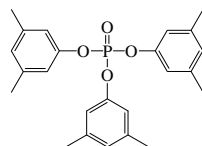
| No.   | Name                                                      | Synonym                                                    | Mol. Form.                                                      | CAS RN     | Mol. Wt. | Physical Form               | mp/°C   | bp/°C                  | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                  |
|-------|-----------------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------|------------|----------|-----------------------------|---------|------------------------|----------------------------|----------------------|-------------------------------------------------------------|
| 10646 | Triphenylbismuthine                                       |                                                            | C <sub>18</sub> H <sub>15</sub> Bi                              | 603-33-8   | 440.292  |                             | 77.6    | 242 <sup>14</sup>      | 1.715 <sup>75</sup>        | 1.7040 <sup>75</sup> | sl EtOH, chl; s eth, ace, bz, CS <sub>2</sub>               |
| 10647 | Triphenylborane                                           |                                                            | C <sub>18</sub> H <sub>15</sub> B                               | 960-71-4   | 242.123  | wh cry                      | 142     |                        |                            |                      | i H <sub>2</sub> O; sl eth; s bz, lig                       |
| 10648 | Triphenylene                                              | Benzo[1]phenanthrene                                       | C <sub>18</sub> H <sub>12</sub>                                 | 217-59-4   | 228.288  | nd (al, chl, bz)            | 197.8   | 425                    |                            |                      | i H <sub>2</sub> O; s EtOH, HOAc; vs bz, chl                |
| 10649 | 1,1,2-Triphenylethane                                     |                                                            | C <sub>20</sub> H <sub>18</sub>                                 | 1520-42-9  | 258.357  | mcl lf (dil al), nd (al)    | 57      |                        |                            |                      | i H <sub>2</sub> O; vs EtOH, eth, bz; sl MeOH               |
| 10650 | 1,1,2-Triphenylethene                                     |                                                            | C <sub>20</sub> H <sub>16</sub>                                 | 58-72-0    | 256.341  | lf (al)                     | 72.5    | 220 <sup>14</sup>      | 1.0373 <sup>78</sup>       | 1.6292 <sup>78</sup> | i H <sub>2</sub> O; s EtOH, chl, MeOH; vs eth               |
| 10651 | <i>N,N,N'</i> -Triphenylguanidine                         |                                                            | C <sub>19</sub> H <sub>17</sub> N <sub>3</sub>                  | 101-01-9   | 287.358  | nd or pr (al)               | 146.5   | dec                    | 1.163 <sup>20</sup>        |                      | sl H <sub>2</sub> O; s EtOH                                 |
| 10652 | 2,4,5-Triphenyl-1 <i>H</i> -imidazole                     |                                                            | C <sub>21</sub> H <sub>16</sub> N <sub>2</sub>                  | 484-47-9   | 296.365  | nd (al)                     | 275     | sub                    |                            |                      | i H <sub>2</sub> O; s EtOH, eth                             |
| 10653 | Triphenylmethane                                          |                                                            | C <sub>19</sub> H <sub>16</sub>                                 | 519-73-3   | 244.330  | orth (al)                   | 93.4    | 359; 200 <sup>10</sup> | 1.014 <sup>99</sup>        | 1.5839 <sup>99</sup> | i H <sub>2</sub> O; sl EtOH; vs eth, py, chl; s bz          |
| 10654 | Triphenylmethanol                                         |                                                            | C <sub>19</sub> H <sub>16</sub> O                               | 76-84-6    | 260.329  | pl (al), trg (bz)           | 164.2   | 380                    | 1.199 <sup>0</sup>         |                      | i H <sub>2</sub> O, peth; vs EtOH, eth; s ace, bz           |
| 10655 | Triphenyl phosphate                                       |                                                            | C <sub>18</sub> H <sub>15</sub> O <sub>4</sub> P                | 115-86-6   | 326.283  | cry (lig), pr (al) nd (eth) | 50.5    | 245 <sup>11</sup>      | 1.2055 <sup>50</sup>       |                      | i H <sub>2</sub> O; s EtOH; vs eth, bz, ctc, chl            |
| 10656 | Triphenylphosphine                                        |                                                            | C <sub>18</sub> H <sub>15</sub> P                               | 603-35-0   | 262.286  |                             | 80      | 188 <sup>1</sup>       | 1.0749 <sup>80</sup>       | 1.6358 <sup>80</sup> | i H <sub>2</sub> O; s EtOH, bz, chl; vs eth                 |
| 10657 | Triphenylphosphine oxide                                  |                                                            | C <sub>18</sub> H <sub>15</sub> OP                              | 791-28-6   | 278.285  | pr                          | 156.5   | >360                   | 1.2124 <sup>23</sup>       |                      | sl H <sub>2</sub> O, eth, chl; vs EtOH, bz                  |
| 10658 | Triphenyl phosphite                                       |                                                            | C <sub>18</sub> H <sub>15</sub> O <sub>3</sub> P                | 101-02-0   | 310.284  |                             | 25      | 360                    | 1.1842 <sup>20</sup>       | 1.5900 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH                                 |
| 10659 | Triphenylsilane                                           |                                                            | C <sub>19</sub> H <sub>16</sub> Si                              | 789-25-3   | 260.406  |                             |         |                        |                            |                      | s ctc, CS <sub>2</sub>                                      |
| 10660 | Triphenylsilanol                                          |                                                            | C <sub>18</sub> H <sub>16</sub> OSi                             | 791-31-1   | 276.405  |                             | 154.8   |                        | 1.1777 <sup>20</sup>       |                      | s ctc, CS <sub>2</sub>                                      |
| 10661 | Triphenylstibine                                          |                                                            | C <sub>18</sub> H <sub>15</sub> Sb                              | 603-36-1   | 353.072  | pr (peth)                   | 53.5    | >360                   | 1.4343 <sup>25</sup>       | 1.6948 <sup>42</sup> | i H <sub>2</sub> O; s EtOH; vs eth, ace, bz, chl            |
| 10662 | Triphenyltetrazolium chloride                             |                                                            | C <sub>19</sub> H <sub>15</sub> ClN <sub>4</sub>                | 298-96-4   | 334.802  | nd (al, chl)                | 243 dec |                        |                            |                      | s H <sub>2</sub> O, EtOH, ace, chl; i eth                   |
| 10663 | Triphenyltin hydroxide                                    | Stannane, hydroxytriphenyl-                                | C <sub>18</sub> H <sub>16</sub> OSn                             | 76-87-9    | 367.029  |                             | 119     |                        | 1.54 <sup>20</sup>         |                      |                                                             |
| 10664 | 2,4,6-Triphenyl-1,3,5-triazine                            |                                                            | C <sub>21</sub> H <sub>16</sub> N <sub>3</sub>                  | 493-77-6   | 309.364  |                             | 257     |                        |                            |                      |                                                             |
| 10665 | Tripotassium citrate                                      | Potassium citrate                                          | C <sub>6</sub> H <sub>5</sub> K <sub>3</sub> O <sub>7</sub>     | 866-84-2   | 306.395  | wh cry (w)                  | 275 dec |                        |                            |                      | vs H <sub>2</sub> O; i EtOH                                 |
| 10666 | Tripolidine                                               |                                                            | C <sub>19</sub> H <sub>22</sub> N <sub>2</sub>                  | 486-12-4   | 278.391  | cry (peth)                  | 60      |                        |                            |                      |                                                             |
| 10667 | Tri-2-propenoyl-2-ethyl-2-(hydroxymethyl)-1,3-propanediol | Trimethylolpropane triacrylate                             | C <sub>15</sub> H <sub>20</sub> O <sub>6</sub>                  | 15625-89-5 | 296.316  |                             |         | >200 <sup>1</sup>      |                            | 1.4735 <sup>20</sup> |                                                             |
| 10668 | Tripropylamine                                            | <i>N,N</i> -Dipropyl-1-propanamine                         | C <sub>9</sub> H <sub>21</sub> N                                | 102-69-2   | 143.270  | liq                         | -93.5   | 156                    | 0.7558 <sup>20</sup>       | 1.4181 <sup>20</sup> | vs eth, EtOH                                                |
| 10669 | Tripropylborane                                           |                                                            | C <sub>9</sub> H <sub>21</sub> B                                | 1116-61-6  | 140.074  | liq                         | -56     | 159                    | 0.7204 <sup>25</sup>       | 1.4135 <sup>22</sup> |                                                             |
| 10670 | Tripropyl borate                                          | Boric acid, tripropyl ester                                | C <sub>9</sub> H <sub>21</sub> BO <sub>3</sub>                  | 688-71-1   | 188.072  |                             |         | 179.5                  | 0.8576 <sup>20</sup>       | 1.3948 <sup>20</sup> | vs EtOH; msc eth; s PrOH                                    |
| 10671 | Tripropylene glycol                                       | [(1-Methyl-1,2-ethanediyl) bis(oxy)]bispropanol            | C <sub>9</sub> H <sub>20</sub> O <sub>4</sub>                   | 24800-44-0 | 192.253  | liq                         |         | 268; 115 <sup>2</sup>  | 1.02 <sup>20</sup>         | 1.4440 <sup>20</sup> |                                                             |
| 10672 | Tripropylene glycol diacrylate                            |                                                            | C <sub>15</sub> H <sub>24</sub> O <sub>6</sub>                  | 42978-66-5 | 300.348  |                             |         | >120 <sup>1</sup>      |                            |                      |                                                             |
| 10673 | Tripropylene glycol monomethyl ether                      | 1-[2-(2-Methoxy-1-methylethoxy)-1-methylethoxy]-2-propanol | C <sub>10</sub> H <sub>22</sub> O <sub>4</sub>                  | 20324-33-8 | 206.280  |                             |         | 241.3                  |                            |                      |                                                             |
| 10674 | Tripropyl phosphate                                       |                                                            | C <sub>9</sub> H <sub>21</sub> O <sub>4</sub> P                 | 513-08-6   | 224.234  |                             |         | 252                    | 1.0121 <sup>20</sup>       | 1.4165 <sup>20</sup> | sl H <sub>2</sub> O, chl; s EtOH, eth, tol, CS <sub>2</sub> |
| 10675 | Tripropyl phosphite                                       | Tripropoxyphosphine                                        | C <sub>9</sub> H <sub>21</sub> O <sub>3</sub> P                 | 923-99-9   | 208.235  |                             |         | 206.5                  | 0.9417 <sup>20</sup>       | 1.4282 <sup>20</sup> | vs eth, EtOH                                                |
| 10676 | Tripropylsilane                                           |                                                            | C <sub>9</sub> H <sub>22</sub> Si                               | 998-29-8   | 158.357  |                             |         | 172                    | 0.7723 <sup>9</sup>        | 1.4280 <sup>20</sup> | i H <sub>2</sub> O                                          |
| 10677 | Tris(4-aminophenyl)methanol                               | C.I. Basic Red 9                                           | C <sub>19</sub> H <sub>18</sub> N <sub>3</sub> O                | 467-62-9   | 305.373  | purp cry                    | 205     |                        |                            |                      |                                                             |
| 10678 | 2,4,6-Tris(1-aziridinyl)-1,3,5-triazine                   | Triethylenemelamine                                        | C <sub>6</sub> H <sub>12</sub> N <sub>6</sub>                   | 51-18-3    | 204.231  | cry pow                     | 139 dec |                        |                            |                      | s H <sub>2</sub> O                                          |
| 10679 | Tris(2-butoxyethyl) phosphate                             |                                                            | C <sub>18</sub> H <sub>38</sub> O <sub>7</sub> P                | 78-51-3    | 398.473  | liq                         |         | 255 <sup>10</sup>      | 1.02 <sup>25</sup>         |                      | i H <sub>2</sub> O                                          |
| 10680 | Tris(2-chloroethyl) phosphate                             |                                                            | C <sub>6</sub> H <sub>12</sub> Cl <sub>3</sub> O <sub>4</sub> P | 115-96-8   | 285.489  |                             |         | 330; 194 <sup>10</sup> | 1.39 <sup>25</sup>         | 1.4721 <sup>20</sup> | s ctc                                                       |
| 10681 | Tris(2-chloroethyl) phosphite                             |                                                            | C <sub>6</sub> H <sub>12</sub> Cl <sub>3</sub> O <sub>3</sub> P | 140-08-9   | 269.490  |                             |         | 120 <sup>3</sup>       | 1.3443 <sup>26</sup>       | 1.4868 <sup>20</sup> |                                                             |
| 10682 | Tris(1,3-dichloro-2-propyl) phosphate                     | Fyrol FR-2                                                 | C <sub>9</sub> H <sub>15</sub> Cl <sub>6</sub> O <sub>4</sub> P | 13674-87-8 | 430.904  | visc liq                    |         | 236 <sup>5</sup>       |                            | 1.5022 <sup>20</sup> | i H <sub>2</sub> O                                          |
| 10683 | Tris(4-dimethylaminophenyl) methane                       | Paraleucaniline                                            | C <sub>25</sub> H <sub>31</sub> N <sub>3</sub>                  | 603-48-5   | 373.534  | lf (al), nd (bz)            | 176.5   |                        |                            |                      | vs bz, eth, chl                                             |
| 10684 | Tris(2,4-dimethylphenyl) phosphate                        | 2,4-Xylenol, phosphate (3:1)                               | C <sub>24</sub> H <sub>27</sub> O <sub>4</sub> P                | 3862-12-2  | 410.442  |                             |         | 233.5                  | 1.142 <sup>38</sup>        | 1.5550 <sup>20</sup> | i H <sub>2</sub> O; s bz, chl, hx                           |
| 10685 | Tris(2,5-dimethylphenyl) phosphate                        | 2,5-Xylenol, phosphate (3:1)                               | C <sub>24</sub> H <sub>27</sub> O <sub>4</sub> P                | 19074-59-0 | 410.442  |                             | 79.8    | 262 <sup>8</sup>       | 1.197 <sup>25</sup>        |                      | i H <sub>2</sub> O; sl EtOH, hx; s eth, bz, ctc             |



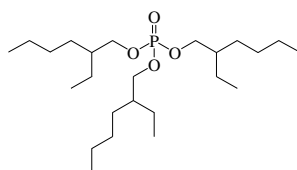
| No.   | Name                                                              | Synonym                                                  | Mol. Form.                                                                                    | CAS RN     | Mol. Wt. | Physical Form            | mp/°C     | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>        | Solubility                                    |
|-------|-------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------|----------|--------------------------|-----------|--------------------------------------|----------------------------|-----------------------|-----------------------------------------------|
| 10686 | Tris(2,6-dimethylphenyl)phosphate                                 | 2,6-Xylenol, phosphate (3:1)                             | C <sub>24</sub> H <sub>27</sub> O <sub>4</sub> P                                              | 121-06-2   | 410.442  | wax                      | 137.8     | 263 <sup>6</sup>                     |                            |                       | i H <sub>2</sub> O; sl EtOH, hx; s bz         |
| 10687 | Tris(3,5-dimethylphenyl)phosphate                                 |                                                          | C <sub>24</sub> H <sub>27</sub> O <sub>4</sub> P                                              | 25653-16-1 | 410.442  |                          | 46.2      | 290 <sup>10</sup>                    |                            |                       | i H <sub>2</sub> O; sl EtOH, chl, hx; s HOAc  |
| 10688 | Tris(2-ethylhexyl) phosphate                                      |                                                          | C <sub>24</sub> H <sub>51</sub> O <sub>4</sub> P                                              | 78-42-2    | 434.633  | liq                      |           | 215 <sup>5</sup>                     | 0.99 <sup>20</sup>         |                       |                                               |
| 10689 | Tris(ethylthio)methane                                            | Triethyl orthothioformate                                | C <sub>7</sub> H <sub>16</sub> S <sub>3</sub>                                                 | 6267-24-9  | 196.397  |                          |           | dec 235; 127 <sup>12</sup>           | 1.053 <sup>20</sup>        | 1.5410 <sup>15</sup>  | vs eth, EtOH                                  |
| 10690 | 1,3,5-Tris(2-hydroxyethyl)isocyanuric acid                        |                                                          | C <sub>9</sub> H <sub>15</sub> N <sub>3</sub> O <sub>6</sub>                                  | 839-90-7   | 261.231  | cry                      | 136       |                                      |                            |                       |                                               |
| 10691 | 1,1,1-Tris(hydroxymethyl)ethane trinitrate                        | 2-Methyl-2-[(nitrooxy)methyl]-1,3-propanediol, dinitrate | C <sub>6</sub> H <sub>9</sub> N <sub>3</sub> O <sub>9</sub>                                   | 3032-55-1  | 255.140  |                          |           | 83 <sup>0.05</sup>                   |                            |                       |                                               |
| 10692 | <i>N,N',N''</i> -Tris(hydroxymethyl)melamine                      | Trimethylolmelamine                                      | C <sub>6</sub> H <sub>12</sub> N <sub>6</sub> O <sub>3</sub>                                  | 1017-56-7  | 216.197  | cry                      | 148       |                                      |                            |                       |                                               |
| 10693 | Tris(hydroxymethyl)methylamine                                    | 2-Amino-2-(hydroxymethyl)-1,3-propanediol                | C <sub>4</sub> H <sub>11</sub> NO <sub>3</sub>                                                | 77-86-1    | 121.135  |                          | 171.5     | 219 <sup>10</sup>                    |                            |                       | vs H <sub>2</sub> O; s MeOH                   |
| 10694 | Tris(methoxyethoxy)vinylsilane                                    |                                                          | C <sub>11</sub> H <sub>24</sub> O <sub>6</sub> Si                                             | 1067-53-4  | 280.391  |                          |           |                                      |                            |                       | s ctc                                         |
| 10695 | Tris(4-methoxyphenyl)chloroethene                                 | Chlorotrianisene                                         | C <sub>23</sub> H <sub>21</sub> ClO <sub>3</sub>                                              | 569-57-3   | 380.864  |                          | 115       |                                      |                            |                       |                                               |
| 10696 | Tris(2-methylphenyl)phosphine                                     |                                                          | C <sub>21</sub> H <sub>21</sub> P                                                             | 6163-58-2  | 304.366  |                          | 127.0     |                                      |                            |                       |                                               |
| 10697 | Tris(3-methylphenyl)phosphine                                     |                                                          | C <sub>21</sub> H <sub>21</sub> P                                                             | 6224-63-1  | 304.366  |                          | 101.0     |                                      |                            |                       |                                               |
| 10698 | Tris(4-methylphenyl)phosphine                                     |                                                          | C <sub>21</sub> H <sub>21</sub> P                                                             | 1038-95-5  | 304.366  |                          | 147.0     |                                      |                            |                       |                                               |
| 10699 | Tris(2-methyl-2-propenyl)-2-ethyl-2-hydroxymethyl-1,3-propanediol | 1,1,1-Trimethylolpropane trimethacrylate                 | C <sub>18</sub> H <sub>26</sub> O <sub>6</sub>                                                | 3290-92-4  | 338.395  |                          |           | >200 <sup>1</sup>                    |                            | 1.470 <sup>25</sup>   |                                               |
| 10700 | Trisodium citrate                                                 | Sodium citrate                                           | C <sub>6</sub> H <sub>5</sub> Na <sub>3</sub> O <sub>7</sub>                                  | 68-04-2    | 258.069  | wh cry (w)               | 300       |                                      |                            |                       | vs H <sub>2</sub> O; i EtOH                   |
| 10701 | Trisodium <i>N</i> -hydroxyethylethylenediaminetriacetate         | Versen-OI                                                | C <sub>10</sub> H <sub>15</sub> N <sub>2</sub> Na <sub>3</sub> O <sub>7</sub>                 | 139-89-9   | 344.204  |                          | 288 (hyd) |                                      |                            |                       |                                               |
| 10702 | Tris(perfluorobutyl)amine                                         | Trinonafluorobutylamine                                  | C <sub>12</sub> F <sub>27</sub> N                                                             | 311-89-7   | 671.092  |                          |           | 178                                  | 1.884 <sup>25</sup>        | 1.291 <sup>25</sup>   | s ace                                         |
| 10703 | 2,4,6-Tris(2-pyridinyl)-1,3,5-triazine                            | 2,4,6-Tripiridyl-s-triazine                              | C <sub>18</sub> H <sub>12</sub> N <sub>6</sub>                                                | 3682-35-7  | 312.328  |                          | 210       |                                      |                            |                       |                                               |
| 10704 | Tris( <i>o</i> -tolyl) phosphite                                  |                                                          | C <sub>21</sub> H <sub>21</sub> O <sub>3</sub> P                                              | 2622-08-4  | 352.364  |                          | 11        | 238 <sup>11</sup> , 197 <sup>2</sup> | 1.1423 <sup>20</sup>       | 1.5740 <sup>28</sup>  | s eth; sl chl                                 |
| 10705 | Tris( <i>p</i> -tolyl) phosphite                                  |                                                          | C <sub>21</sub> H <sub>21</sub> O <sub>3</sub> P                                              | 620-42-8   | 352.364  | pa ye                    | 52        | 252 <sup>10</sup>                    | 1.1280 <sup>25</sup>       | 1.5703 <sup>28</sup>  | vs eth                                        |
| 10706 | Tris(triphenylphosphine) rhodium carbonyl hydride                 | Carbonylhydrotris(triphenylphosphine)rhodium             | C <sub>55</sub> H <sub>46</sub> OP <sub>3</sub> Rh                                            | 17185-29-4 | 918.781  | ye cry                   | 121       |                                      | 1.33                       |                       | sl bz, chl                                    |
| 10707 | 1,3,5-Trithiane                                                   |                                                          | C <sub>3</sub> H <sub>6</sub> S <sub>3</sub>                                                  | 291-21-4   | 138.275  | hex (bz), pr (w) nd (al) | 220       | sub                                  | 1.6374 <sup>24</sup>       |                       | sl H <sub>2</sub> O, EtOH, eth; s bz          |
| 10708 | Trithiocarbonic acid                                              |                                                          | CH <sub>2</sub> S <sub>3</sub>                                                                | 594-08-1   | 110.222  | red oil                  | -26.9     | 57.8                                 | 1.476 <sup>25</sup>        | 1.8225 <sup>20</sup>  | dec H <sub>2</sub> O, EtOH; vs tol, chl       |
| 10709 | Tritriacontane                                                    |                                                          | C <sub>33</sub> H <sub>68</sub>                                                               | 630-05-7   | 464.893  |                          | 71.2      |                                      |                            |                       |                                               |
| 10710 | Tropacocaine                                                      |                                                          | C <sub>15</sub> H <sub>19</sub> NO <sub>2</sub>                                               | 537-26-8   | 245.318  | pl or tab                | 49        | dec                                  | 1.0426 <sup>100</sup>      | 1.5080 <sup>100</sup> | vs bz, eth, EtOH, peth                        |
| 10711 | Tropine                                                           | 8-Methyl-8-azabicyclo[3.2.1]octan-3-ol, <i>endo</i>      | C <sub>8</sub> H <sub>15</sub> NO                                                             | 120-29-6   | 141.211  | hyg pl (eth)             | 64        | 233                                  | 1.016 <sup>100</sup>       | 1.4811 <sup>100</sup> | vs H <sub>2</sub> O, eth, EtOH                |
| 10712 | Trypan blue                                                       |                                                          | C <sub>34</sub> H <sub>24</sub> N <sub>6</sub> Na <sub>4</sub> O <sub>14</sub> S <sub>4</sub> | 72-57-1    | 960.805  | dk bl cry                | 300       |                                      |                            |                       | s H <sub>2</sub> O, acid; i EtOH              |
| 10713 | Tryptamine                                                        |                                                          | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub>                                                | 61-54-1    | 160.215  | nd (al-bz, lig)          | 118       | 137 <sup>0.15</sup>                  |                            |                       | i H <sub>2</sub> O, eth, bz, chl; s EtOH, ace |
| 10714 | <i>L</i> -Tryptophan                                              | $\alpha$ -Aminoindole-3-propionic acid, ( <i>l</i> )     | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                                 | 73-22-3    | 204.225  | lf or pl (dil al)        | 289 dec   |                                      |                            |                       | sl H <sub>2</sub> O, HOAc; s EtOH; i eth, chl |
| 10715 | Tsuduranine                                                       |                                                          | C <sub>18</sub> H <sub>19</sub> NO <sub>3</sub>                                               | 517-97-5   | 297.349  | nd (eth)                 | 204       |                                      |                            |                       | vs ace, eth, EtOH                             |
| 10716 | T-2 Toxin                                                         | Mycotoxin T2                                             | C <sub>24</sub> H <sub>34</sub> O <sub>3</sub>                                                | 21259-20-1 | 466.522  | nd                       | 151       |                                      |                            |                       | sl H <sub>2</sub> O, peth; s EtOH, chl, DMSO  |
| 10717 | Tubocurarine dichloride                                           |                                                          | C <sub>37</sub> H <sub>42</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>6</sub>                 | 57-94-3    | 681.644  | hyg cry                  | 275 dec   |                                      |                            |                       | s MeOH; i py, bz, ace, eth                    |
| 10718 | Tungsten carbonyl                                                 | Tungsten hexacarbonyl                                    | C <sub>6</sub> O <sub>6</sub> W                                                               | 14040-11-0 | 351.90   | wh cry                   | dec 170   | sub                                  | 2.65                       |                       | i H <sub>2</sub> O; s os                      |
| 10719 | Turanose                                                          |                                                          | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                                               | 547-25-1   | 342.296  | pr (w-al, MeOH)          | 168       |                                      |                            |                       | vs H <sub>2</sub> O; s EtOH, MeOH             |
| 10720 | Tybamate                                                          |                                                          | C <sub>13</sub> H <sub>26</sub> N <sub>2</sub> O <sub>4</sub>                                 | 4268-36-4  | 274.356  | cry                      | 50        | 151 <sup>0.06</sup>                  |                            |                       |                                               |
| 10721 | <i>L</i> -Tyrosine                                                | 4-Hydroxy- <i>L</i> -phenylalanine                       | C <sub>9</sub> H <sub>11</sub> NO <sub>3</sub>                                                | 60-18-4    | 181.188  | nd (w)                   | 343 dec   | sub                                  |                            |                       | sl H <sub>2</sub> O, HOAc; i EtOH, eth        |
| 10722 | Tyrosineamide                                                     |                                                          | C <sub>9</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                                  | 4985-46-0  | 180.203  | pl or pl (al)            | 153.5     |                                      |                            |                       | vs H <sub>2</sub> O, EtOH                     |
| 10723 | <i>L</i> -Tyrosine, ethyl ester                                   |                                                          | C <sub>11</sub> H <sub>15</sub> NO <sub>3</sub>                                               | 949-67-7   | 209.242  | pr (AcOEt)               | 108.5     |                                      |                            |                       | vs bz, EtOH, AcOEt                            |
| 10724 | <i>L</i> -Tyrosine, methyl ester, hydrochloride                   |                                                          | C <sub>10</sub> H <sub>14</sub> ClNO <sub>3</sub>                                             | 3417-91-2  | 231.676  |                          | 191.0     |                                      |                            |                       | s H <sub>2</sub> O                            |
| 10725 | 1,10-Undecadiyne                                                  |                                                          | C <sub>11</sub> H <sub>16</sub>                                                               | 4117-15-1  | 148.245  |                          | -17       | 83 <sup>12</sup>                     | 0.8182 <sup>21</sup>       | 1.453 <sup>21</sup>   | vs ace, bz                                    |
| 10726 | Undecafluorocyclohexane                                           |                                                          | C <sub>6</sub> HF <sub>11</sub>                                                               | 308-24-7   | 282.054  |                          |           | 62.0                                 |                            |                       |                                               |
| 10727 | Undecanal                                                         |                                                          | C <sub>11</sub> H <sub>22</sub> O                                                             | 112-44-7   | 170.292  |                          | -2.0      | 117 <sup>18</sup>                    | 0.8251 <sup>23</sup>       | 1.4520 <sup>20</sup>  | i H <sub>2</sub> O; s EtOH, eth               |



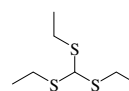
Tris(2,6-dimethylphenyl) phosphate



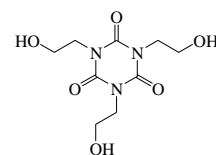
Tris(3,5-dimethylphenyl) phosphate



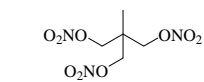
Tris(2-ethylhexyl) phosphate



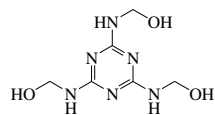
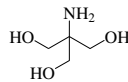
Tris(ethylthio)methane



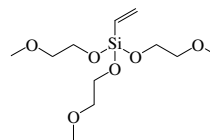
1,3,5-Tris(2-hydroxyethyl) isocyanuric acid



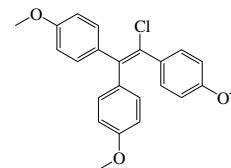
1,1,1-Tris(hydroxymethyl)ethane trinitrate

*N,N',N''*-Tris(hydroxymethyl)melamine

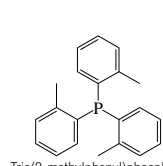
Tris(hydroxymethyl)methylamine



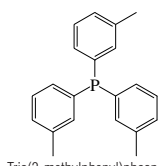
Tris(methoxyethoxy)vinylsilane



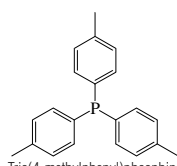
Tris(4-methoxyphenyl)chloroethene



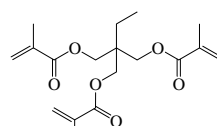
Tris(2-methylphenyl)phosphine



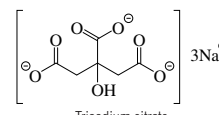
Tris(3-methylphenyl)phosphine



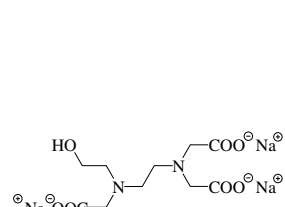
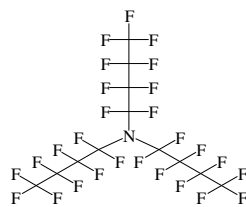
Tris(4-methylphenyl)phosphine



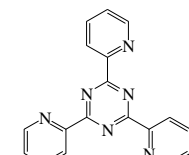
Tris(2-methyl-2-propenyl)-2-ethyl-2-hydroxymethyl-1,3-propanediol



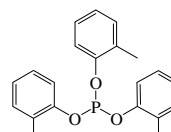
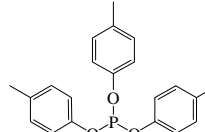
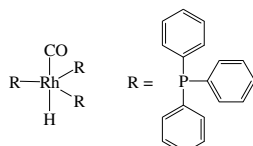
Trisodium citrate

Trisodium *N*-hydroxyethylethylenediaminetriacetate

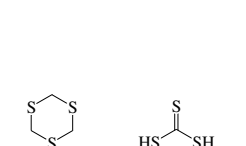
Tris(perfluorobutyl)amine



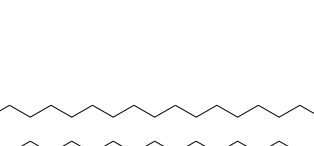
2,4,6-Tris(2-pyridinyl)-1,3,5-triazine

Tris(*o*-tolyl) phosphiteTris(*p*-tolyl) phosphite

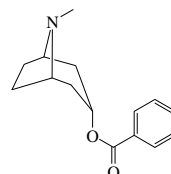
Tris(triphenylphosphine) rhodium carbonyl hydride



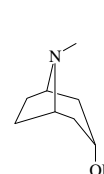
1,3,5-Trithiane



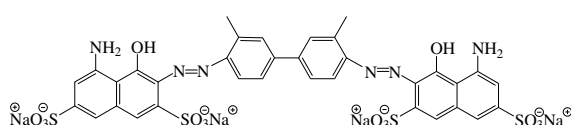
Trithiocarbonic acid



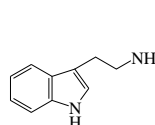
Tropacocaine



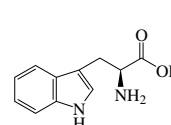
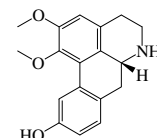
Tropine



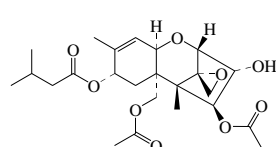
Trypan blue



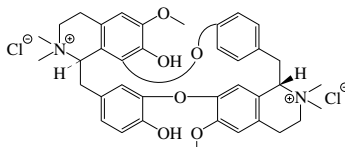
Tryptamine

*L*-Tryptophan

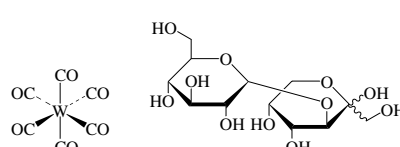
Tsuduranine



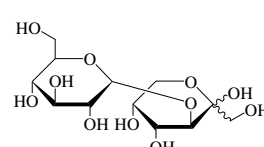
T-2 Toxin



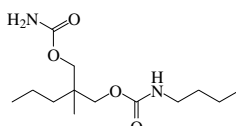
Tubocurarine dichloride



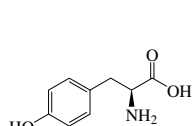
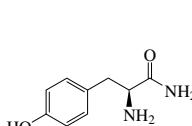
Tungsten carbonyl



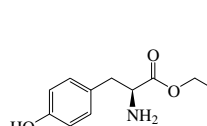
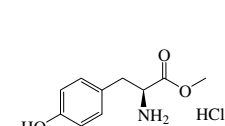
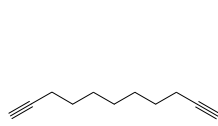
Turanose



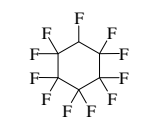
Tybamate

*L*-Tyrosine

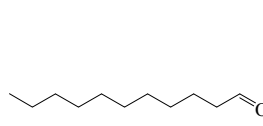
Tyrosineamide

*L*-Tyrosine, ethyl ester*L*-Tyrosine, methyl ester, hydrochloride

1,10-Undecadiyne



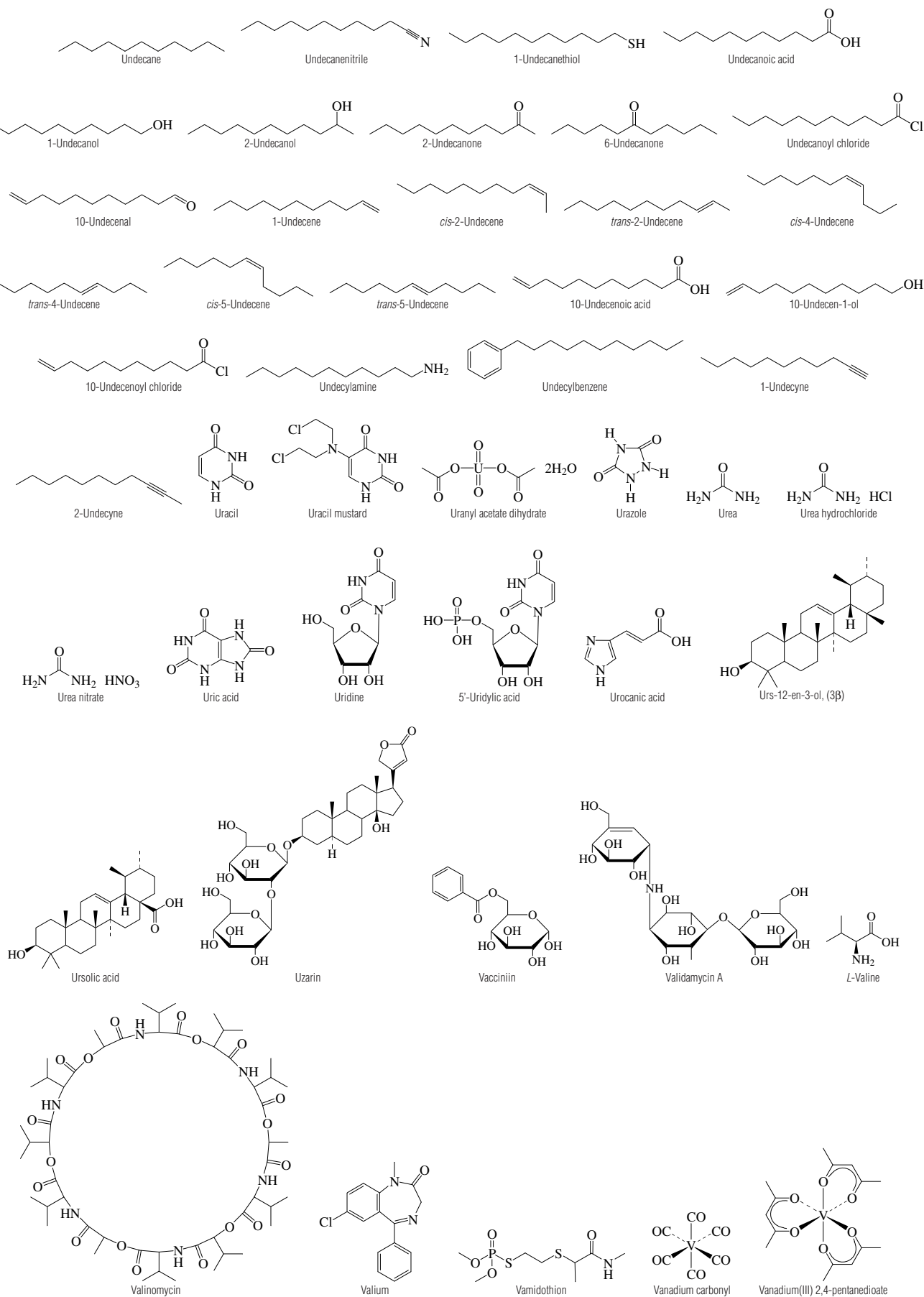
Undecafluorocyclohexane



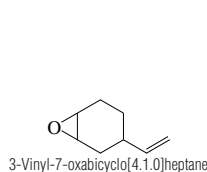
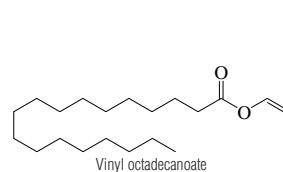
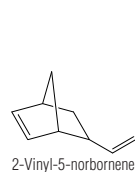
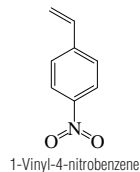
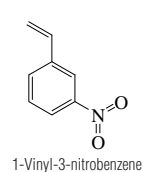
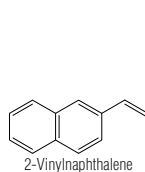
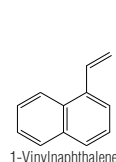
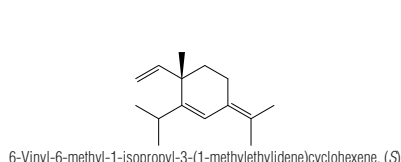
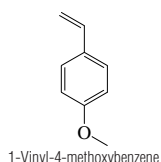
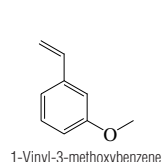
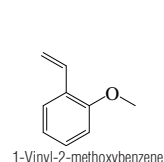
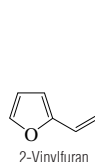
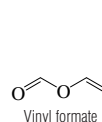
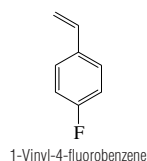
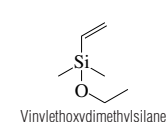
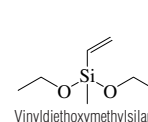
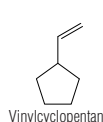
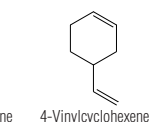
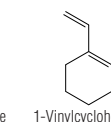
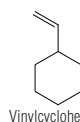
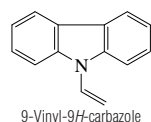
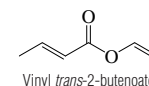
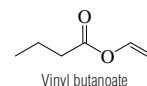
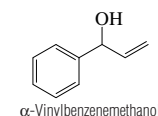
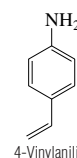
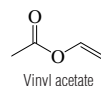
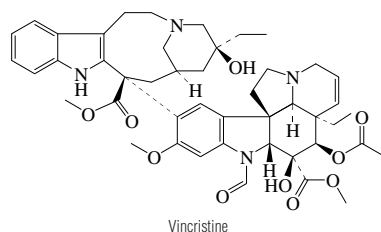
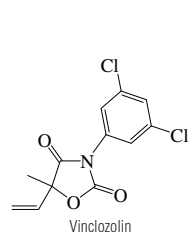
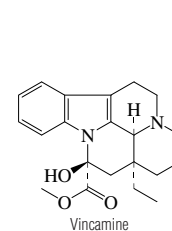
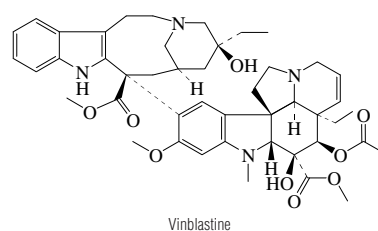
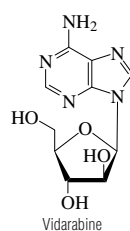
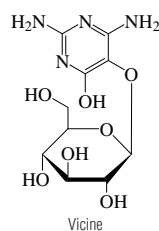
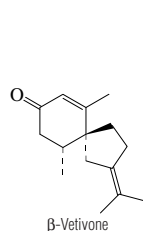
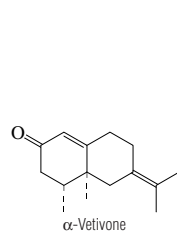
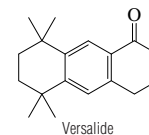
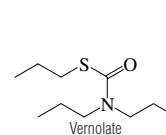
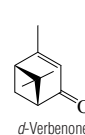
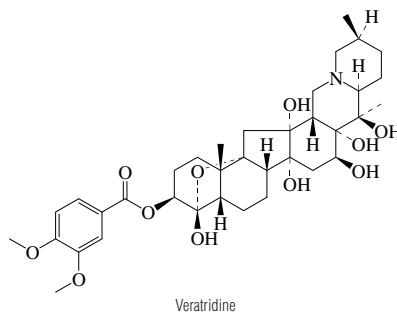
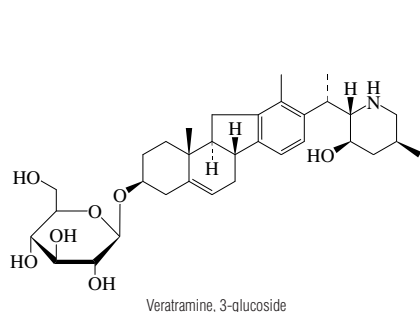
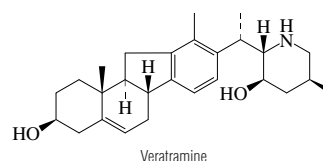
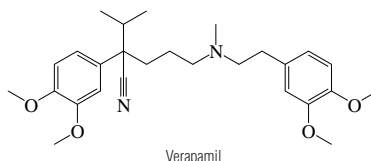
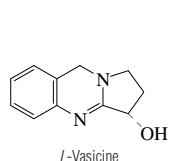
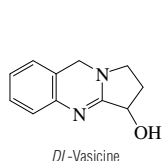
Undecanal



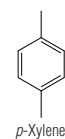
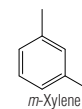
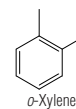
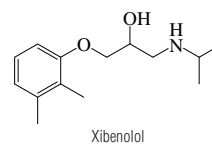
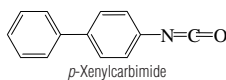
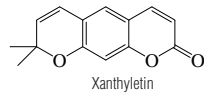
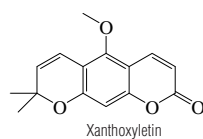
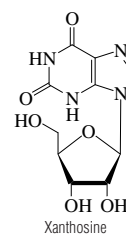
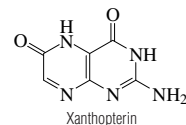
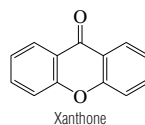
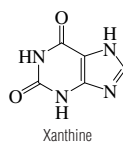
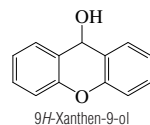
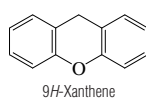
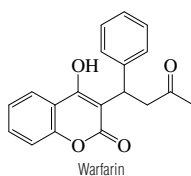
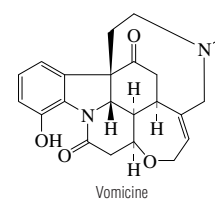
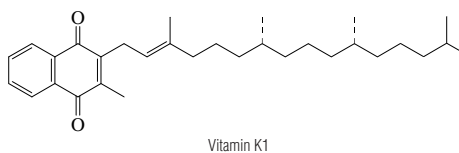
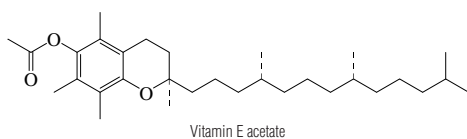
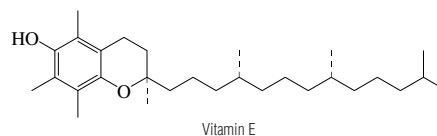
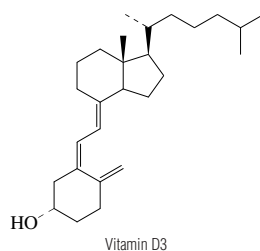
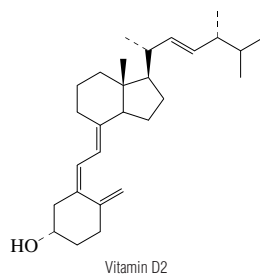
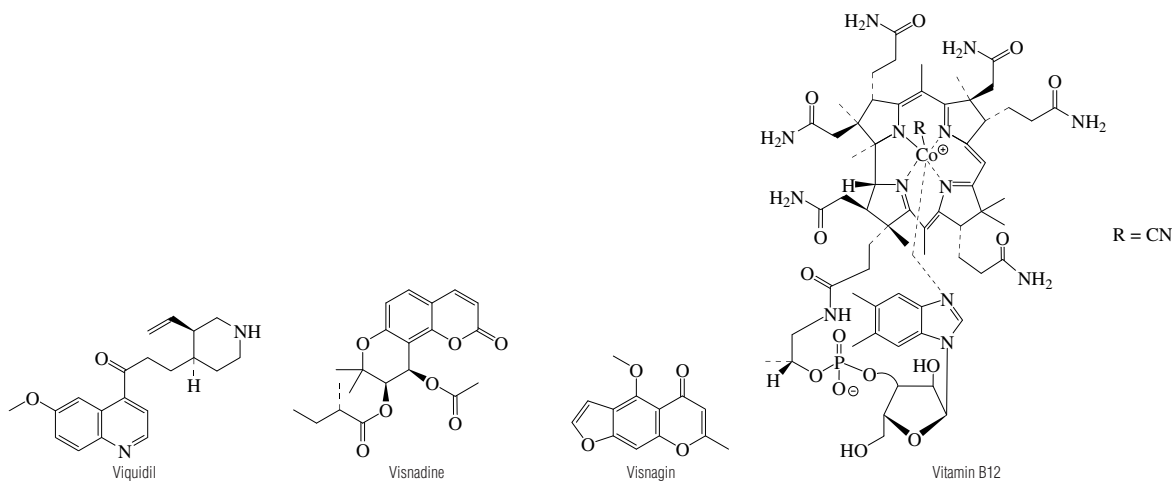
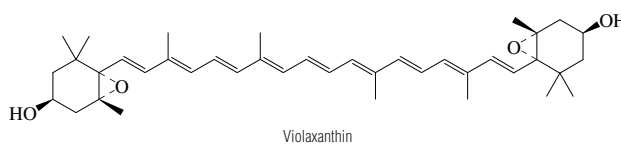
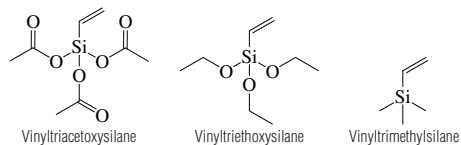
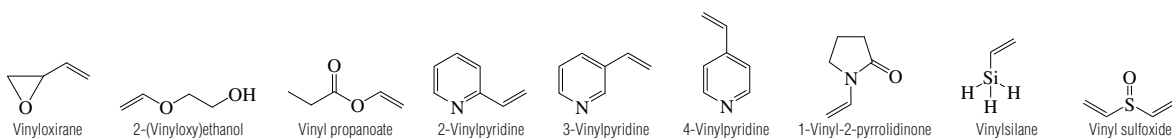
| No.   | Name                            | Synonym                       | Mol. Form.                                                                   | CAS RN     | Mol. Wt. | Physical Form      | mp/°C   | bp/°C              | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                               |
|-------|---------------------------------|-------------------------------|------------------------------------------------------------------------------|------------|----------|--------------------|---------|--------------------|----------------------------|----------------------|----------------------------------------------------------|
| 10728 | Undecane                        | Henecane                      | C <sub>11</sub> H <sub>24</sub>                                              | 1120-21-4  | 156.309  | liq                | -25.5   | 195.9              | 0.7402 <sup>20</sup>       | 1.4164 <sup>20</sup> | i H <sub>2</sub> O; msc EtOH, eth                        |
| 10729 | Undecanenitrile                 | Decyl cyanide                 | C <sub>11</sub> H <sub>21</sub> N                                            | 2244-07-7  | 167.292  |                    |         | 253                | 0.8254 <sup>30</sup>       | 1.4293 <sup>30</sup> | i H <sub>2</sub> O; s EtOH, eth, ctc                     |
| 10730 | 1-Undecanethiol                 | Undecyl mercaptan             | C <sub>11</sub> H <sub>24</sub> S                                            | 5332-52-5  | 188.374  | liq                | -1.5    | 257.4              | 0.8448 <sup>20</sup>       | 1.4585 <sup>20</sup> |                                                          |
| 10731 | Undecanoic acid                 |                               | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                               | 112-37-8   | 186.292  | cry (ace)          | 28.6    | 280                | 0.8907 <sup>20</sup>       | 1.4294 <sup>45</sup> | i H <sub>2</sub> O; vs EtOH, ace; s eth; msc bz          |
| 10732 | 1-Undecanol                     | Undecyl alcohol               | C <sub>11</sub> H <sub>24</sub> O                                            | 112-42-5   | 172.308  |                    | 15.9    | 245                | 0.8298 <sup>20</sup>       | 1.4392 <sup>20</sup> | i H <sub>2</sub> O; s EtOH; vs eth                       |
| 10733 | 2-Undecanol                     | sec-Undecyl alcohol           | C <sub>11</sub> H <sub>24</sub> O                                            | 1653-30-1  | 172.308  | col liq            | 0       | 229.7              | 0.8234 <sup>25</sup>       | 1.4352 <sup>25</sup> |                                                          |
| 10734 | 2-Undecanone                    | Methyl nonyl ketone           | C <sub>11</sub> H <sub>22</sub> O                                            | 112-12-9   | 170.292  |                    | 15      | 231.5              | 0.8250 <sup>20</sup>       | 1.4291 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, chl            |
| 10735 | 6-Undecanone                    | Butyl hexyl ketone            | C <sub>11</sub> H <sub>22</sub> O                                            | 927-49-1   | 170.292  |                    | 14.5    | 228                | 0.8308 <sup>20</sup>       | 1.4270 <sup>20</sup> | i H <sub>2</sub> O; vs EtOH, eth                         |
| 10736 | Undecanoyl chloride             |                               | C <sub>11</sub> H <sub>21</sub> ClO                                          | 17746-05-3 | 204.737  |                    |         |                    |                            |                      | sl ctc                                                   |
| 10737 | 10-Undecenal                    |                               | C <sub>11</sub> H <sub>20</sub> O                                            | 112-45-8   | 168.276  |                    |         |                    |                            |                      | sl ctc                                                   |
| 10738 | 1-Undecene                      |                               | C <sub>11</sub> H <sub>22</sub>                                              | 821-95-4   | 154.293  | liq                | -49.2   | 192.7              | 0.7503 <sup>20</sup>       | 1.4261 <sup>20</sup> | i H <sub>2</sub> O; s eth, chl, lig                      |
| 10739 | cis-2-Undecene                  |                               | C <sub>11</sub> H <sub>22</sub>                                              | 821-96-5   | 154.293  | liq                | -66.5   | 196.1              | 0.7576 <sup>20</sup>       |                      |                                                          |
| 10740 | trans-2-Undecene                |                               | C <sub>11</sub> H <sub>22</sub>                                              | 693-61-8   | 154.293  | liq                | -48.3   | 192.5              | 0.7528 <sup>20</sup>       | 1.4292 <sup>20</sup> |                                                          |
| 10741 | cis-4-Undecene                  |                               | C <sub>11</sub> H <sub>22</sub>                                              | 821-98-7   | 154.293  | liq                | -97     | 192.6              | 0.7541 <sup>20</sup>       | 1.4302 <sup>20</sup> |                                                          |
| 10742 | trans-4-Undecene                |                               | C <sub>11</sub> H <sub>22</sub>                                              | 693-62-9   | 154.293  | liq                | -63.7   | 193                | 0.7508 <sup>20</sup>       | 1.4285 <sup>20</sup> |                                                          |
| 10743 | cis-5-Undecene                  |                               | C <sub>11</sub> H <sub>22</sub>                                              | 764-96-5   | 154.293  | liq                | -106.5  | 192.3              | 0.7537 <sup>20</sup>       | 1.4302 <sup>20</sup> |                                                          |
| 10744 | trans-5-Undecene                |                               | C <sub>11</sub> H <sub>22</sub>                                              | 764-97-6   | 154.293  | liq                | -61.1   | 192                | 0.7497 <sup>20</sup>       | 1.4285 <sup>20</sup> | vs eth, chl, lig                                         |
| 10745 | 10-Undecenoic acid              | Undecylenic acid              | C <sub>11</sub> H <sub>20</sub> O <sub>2</sub>                               | 112-38-9   | 184.276  | cry                | 24.5    | 275                | 0.9072 <sup>24</sup>       | 1.4486 <sup>24</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                  |
| 10746 | 10-Undecen-1-ol                 |                               | C <sub>11</sub> H <sub>22</sub> O                                            | 112-43-6   | 170.292  | liq                | -1.0    | 250                | 0.8495 <sup>15</sup>       | 1.4500 <sup>20</sup> | i H <sub>2</sub> O; s EtOH, eth; sl ctc                  |
| 10747 | 10-Undecenyl chloride           |                               | C <sub>11</sub> H <sub>19</sub> ClO                                          | 38460-95-6 | 202.721  |                    |         | 127 <sup>13</sup>  | 0.944 <sup>20</sup>        | 1.454 <sup>20</sup>  |                                                          |
| 10748 | Undecylamine                    | 1-Undecanamine                | C <sub>11</sub> H <sub>25</sub> N                                            | 7307-55-3  | 171.324  | cry (eth, al)      | 17      | 242                | 0.7979 <sup>20</sup>       | 1.4398 <sup>20</sup> | s H <sub>2</sub> O, EtOH; i eth; sl ctc                  |
| 10749 | Undecylbenzene                  |                               | C <sub>17</sub> H <sub>28</sub>                                              | 6742-54-7  | 232.404  | liq                | -5      | 316                | 0.8553 <sup>20</sup>       | 1.4828 <sup>20</sup> |                                                          |
| 10750 | 1-Undecyne                      |                               | C <sub>11</sub> H <sub>20</sub>                                              | 2243-98-3  | 152.277  | liq                | -25     | 196                | 0.7728 <sup>20</sup>       | 1.4306 <sup>20</sup> | vs ace, bz, eth, EtOH                                    |
| 10751 | 2-Undecyne                      |                               | C <sub>11</sub> H <sub>20</sub>                                              | 60212-29-5 | 152.277  | liq                | -30.1   | 204.2              | 0.7827 <sup>20</sup>       | 1.4391 <sup>20</sup> |                                                          |
| 10752 | Uracil                          |                               | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>                  | 66-22-8    | 112.087  | nd (w)             | 338     |                    |                            |                      | sl H <sub>2</sub> O; vs EtOH, eth; s dil NH <sub>3</sub> |
| 10753 | Uracil mustard                  |                               | C <sub>8</sub> H <sub>11</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>2</sub> | 66-75-1    | 252.098  |                    | 206 dec |                    |                            |                      | sl H <sub>2</sub> O                                      |
| 10754 | Uranyl acetate dihydrate        |                               | C <sub>2</sub> H <sub>10</sub> O <sub>8</sub> U                              | 6159-44-0  | 424.146  | ye cry (HOAc)      | 80 dec  |                    | 2.89                       |                      | sl EtOH                                                  |
| 10755 | Urazole                         |                               | C <sub>2</sub> H <sub>3</sub> N <sub>3</sub> O <sub>2</sub>                  | 3232-84-6  | 101.064  | lf (w)             | 249 dec |                    |                            |                      |                                                          |
| 10756 | Urea                            | Carbamide                     | CH <sub>4</sub> N <sub>2</sub> O                                             | 57-13-6    | 60.055   | tetr pr (al)       | 133.3   | dec                | 1.3230 <sup>20</sup>       | 1.484                | vs H <sub>2</sub> O, EtOH; i eth, bz; s HOAc, py         |
| 10757 | Urea hydrochloride              |                               | CH <sub>5</sub> ClN <sub>2</sub> O                                           | 506-89-8   | 96.516   |                    | 145 dec |                    |                            |                      | s H <sub>2</sub> O                                       |
| 10758 | Urea nitrate                    |                               | CH <sub>5</sub> N <sub>3</sub> O <sub>4</sub>                                | 124-47-0   | 123.069  | mcl lf (w)         | 152 dec |                    | 1.690 <sup>20</sup>        |                      | vs EtOH                                                  |
| 10759 | Uric acid                       |                               | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>3</sub>                  | 69-93-2    | 168.111  | orth pr or pl      | dec     | dec                | 1.89 <sup>25</sup>         |                      | i H <sub>2</sub> O, EtOH, eth; s alk, glycerol; sl acid  |
| 10760 | Uridine                         | 1-β-D-Ribofuranosyluracil     | C <sub>9</sub> H <sub>12</sub> N <sub>2</sub> O <sub>6</sub>                 | 58-96-8    | 244.200  | nd (aq al)         | 165     |                    |                            |                      | s H <sub>2</sub> O, EtOH, py                             |
| 10761 | 5'-Uridylic acid                | Uridine 5'-phosphoric acid    | C <sub>9</sub> H <sub>13</sub> N <sub>2</sub> O <sub>8</sub> P               | 58-97-9    | 324.180  | pr (MeOH)          | 202 dec |                    |                            |                      | vs H <sub>2</sub> O; s MeOH                              |
| 10762 | Urocanic acid                   | Imidazole-4-acrylic acid      | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                  | 104-98-3   | 138.124  |                    | 227     |                    |                            |                      | s H <sub>2</sub> O, ace; i EtOH, eth                     |
| 10763 | Urs-12-en-3-ol, (3β)            | α-Amyrin                      | C <sub>30</sub> H <sub>50</sub> O                                            | 638-95-9   | 426.717  | nd (al)            | 186     | 243 <sup>0.5</sup> |                            |                      | s EtOH, eth, bz, chl, HOAc; sl peth                      |
| 10764 | Ursolic acid                    |                               | C <sub>30</sub> H <sub>48</sub> O <sub>3</sub>                               | 77-52-1    | 456.700  | pl (al)            | 284     |                    |                            |                      | vs ace, eth, chl                                         |
| 10765 | Uzarin                          |                               | C <sub>35</sub> H <sub>54</sub> O <sub>14</sub>                              | 20231-81-6 | 698.796  | pr                 | 269     |                    |                            |                      |                                                          |
| 10766 | Vacciniin                       | D-Glucose, 6-benzoate         | C <sub>13</sub> H <sub>16</sub> O <sub>7</sub>                               | 14200-76-1 | 284.262  | amor (aq ace, +1w) | 122     |                    |                            |                      | vs H <sub>2</sub> O, ace, EtOH, eth                      |
| 10767 | Validamycin A                   |                               | C <sub>20</sub> H <sub>35</sub> NO <sub>13</sub>                             | 37248-47-8 | 497.491  | amorp pow          | 95 dec  |                    |                            |                      |                                                          |
| 10768 | L-Valine                        | 2-Aminoisovaleric acid        | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                               | 72-18-4    | 117.147  | lf (w-al)          | 315     | sub                | 1.23 <sup>25</sup>         |                      | s H <sub>2</sub> O                                       |
| 10769 | Valinomycin                     |                               | C <sub>54</sub> H <sub>90</sub> N <sub>6</sub> O <sub>18</sub>               | 2001-95-8  | 1111.322 | cry                | 187     |                    |                            |                      |                                                          |
| 10770 | Valium                          |                               | C <sub>16</sub> H <sub>13</sub> ClN <sub>2</sub> O                           | 439-14-5   | 284.739  |                    | 132     |                    |                            |                      |                                                          |
| 10771 | Vamidothion                     |                               | C <sub>8</sub> H <sub>18</sub> NO <sub>4</sub> PS <sub>2</sub>               | 2275-23-2  | 287.337  | oil                |         |                    |                            |                      | i peth; s os                                             |
| 10772 | Vanadium carbonyl               | Vanadium hexacarbonyl         | C <sub>6</sub> O <sub>6</sub> V                                              | 14024-00-1 | 219.002  | bl-grn cry         | dec 60  | sub                |                            |                      |                                                          |
| 10773 | Vanadium(III) 2,4-pentanedioate | Vanadium(III) acetylacetonate | C <sub>15</sub> H <sub>21</sub> O <sub>6</sub> V                             | 13476-99-8 | 348.266  | brn cry            | ≈185    | sub                | ≈1.0                       |                      | s MeOH, ace, bz, chl                                     |



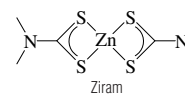
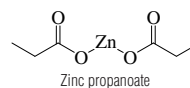
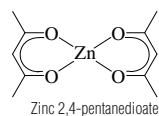
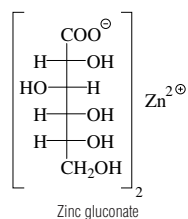
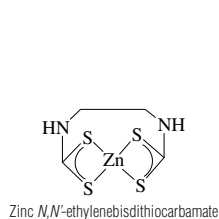
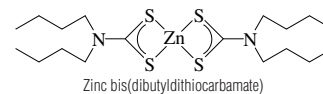
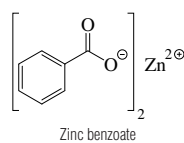
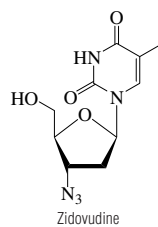
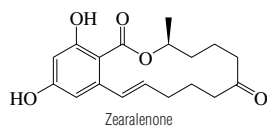
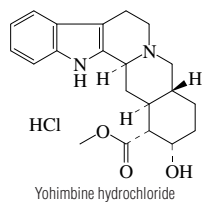
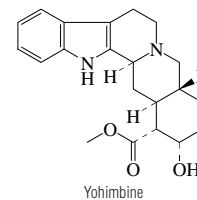
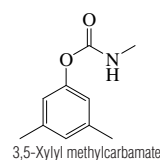
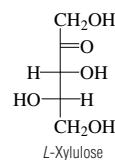
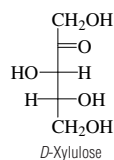
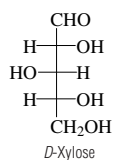
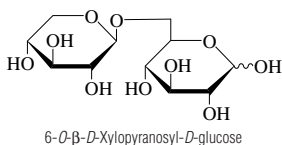
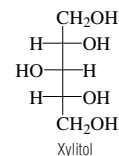
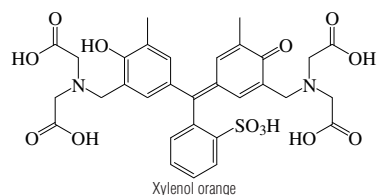
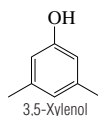
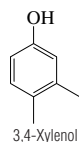
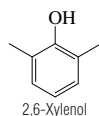
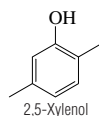
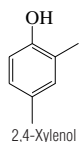
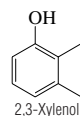
| No.   | Name                                                                         | Synonym                                                                                    | Mol. Form.                                                     | CAS RN     | Mol. Wt. | Physical Form           | mp/°C   | bp/°C                                | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                |
|-------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------|------------|----------|-------------------------|---------|--------------------------------------|----------------------------|----------------------|-----------------------------------------------------------|
| 10774 | <i>DL</i> -Vasicine                                                          | <i>DL</i> -Peganine                                                                        | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O               | 6159-56-4  | 188.225  | nd (al)                 | 210.8   |                                      |                            |                      | sl H <sub>2</sub> O; eth, bz;<br>s EtOH, ace,<br>chl      |
| 10775 | <i>L</i> -Vasicine                                                           | <i>L</i> -Peganine                                                                         | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O               | 6159-55-3  | 188.225  | nd (al)                 | 211.5   |                                      |                            |                      | sl H <sub>2</sub> O; eth, bz;<br>s EtOH, ace,<br>chl      |
| 10776 | Verapamil                                                                    |                                                                                            | C <sub>27</sub> H <sub>38</sub> N <sub>2</sub> O <sub>4</sub>  | 52-53-9    | 454.602  | ye oil                  |         | 245 <sup>0.01</sup>                  |                            | 1.5448 <sup>25</sup> | i H <sub>2</sub> O; vs EtOH,<br>ace; sl bz, hx            |
| 10777 | Veratramine                                                                  |                                                                                            | C <sub>27</sub> H <sub>39</sub> NO <sub>2</sub>                | 60-70-8    | 409.605  | nd                      | 206     |                                      |                            |                      | s EtOH, bz, chl,<br>dil acid; i dil<br>alk                |
| 10778 | Veratramine, 3-glucoside                                                     |                                                                                            | C <sub>33</sub> H <sub>49</sub> NO <sub>7</sub>                | 475-00-3   | 571.745  | nd (aq.<br>MeOH)        | 242 dec |                                      |                            |                      |                                                           |
| 10779 | Veratridine                                                                  |                                                                                            | C <sub>36</sub> H <sub>51</sub> NO <sub>11</sub>               | 71-62-5    | 673.790  | ye amorp<br>pow         | 180     |                                      |                            |                      | i H <sub>2</sub> O; sl eth                                |
| 10780 | <i>d</i> -Verbenone                                                          |                                                                                            | C <sub>10</sub> H <sub>14</sub> O                              | 18309-32-5 | 150.217  |                         | 9.8     | 227.5                                | 0.9978 <sup>20</sup>       | 1.4993 <sup>18</sup> | s H <sub>2</sub> O, EtOH,<br>ace, bz                      |
| 10781 | Vernolate                                                                    | Carbamothioic acid, dipropyl-,<br><i>S</i> -propyl ester                                   | C <sub>10</sub> H <sub>21</sub> NOS                            | 1929-77-7  | 203.345  |                         |         | 150 <sup>30</sup>                    | 0.952 <sup>20</sup>        |                      |                                                           |
| 10782 | Versalide                                                                    |                                                                                            | C <sub>18</sub> H <sub>26</sub> O                              | 88-29-9    | 258.398  | cry                     | 46.5    | 130 <sup>2</sup>                     |                            |                      | s EtOH                                                    |
| 10783 | $\alpha$ -Vetivone                                                           | Isonootkatone                                                                              | C <sub>15</sub> H <sub>22</sub> O                              | 15764-04-2 | 218.335  | cry (peth)              | 51.5    | 144 <sup>2</sup>                     | 1.0035 <sup>20</sup>       | 1.5370 <sup>20</sup> | vs ace                                                    |
| 10784 | $\beta$ -Vetivone                                                            |                                                                                            | C <sub>15</sub> H <sub>22</sub> O                              | 18444-79-6 | 218.335  | cry (peth)              | 44.5    | 141 <sup>2</sup>                     | 1.0001 <sup>20</sup>       | 1.5309 <sup>20</sup> | s ace                                                     |
| 10785 | Vicine                                                                       | 2,6-Diamino-5-( $\beta$ - <i>D</i> -<br>glucopyranosyloxy)-4(1 <i>H</i> )-<br>pyrimidinone | C <sub>10</sub> H <sub>16</sub> N <sub>4</sub> O <sub>7</sub>  | 152-93-2   | 304.257  | nd (w, dil al,<br>+1 w) | 240 dec |                                      |                            |                      | sl H <sub>2</sub> O, EtOH; vs<br>acid, alk                |
| 10786 | Vidarabine                                                                   | $\beta$ - <i>D</i> -9-Arabinofuranosyladenine                                              | C <sub>10</sub> H <sub>15</sub> N <sub>5</sub> O <sub>5</sub>  | 5536-17-4  | 285.257  | nd (w)                  | 257     |                                      |                            |                      |                                                           |
| 10787 | Vinblastine                                                                  |                                                                                            | C <sub>46</sub> H <sub>58</sub> N <sub>4</sub> O <sub>9</sub>  | 865-21-4   | 810.975  | nd (MeOH)               | 216     |                                      |                            |                      | i H <sub>2</sub> O; s EtOH,<br>ace, chl, AcOEt            |
| 10788 | Vincamine                                                                    |                                                                                            | C <sub>21</sub> H <sub>26</sub> N <sub>2</sub> O <sub>3</sub>  | 1617-90-9  | 354.442  |                         | 231.5   |                                      |                            |                      |                                                           |
| 10789 | Vinclozolin                                                                  |                                                                                            | C <sub>12</sub> H <sub>9</sub> Cl <sub>2</sub> NO <sub>3</sub> | 50471-44-8 | 286.110  |                         | 108     | 131 <sup>0.05</sup>                  | 1.51                       |                      |                                                           |
| 10790 | Vincristine                                                                  |                                                                                            | C <sub>46</sub> H <sub>56</sub> N <sub>4</sub> O <sub>10</sub> | 57-22-7    | 824.958  |                         | 219     |                                      |                            |                      |                                                           |
| 10791 | Vinyl acetate                                                                |                                                                                            | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                   | 108-05-4   | 86.090   | liq                     | -93.2   | 72.8                                 | 0.9256 <sup>25</sup>       | 1.3926 <sup>25</sup> | sl H <sub>2</sub> O; msc<br>EtOH; s eth,<br>ace, bz, chl  |
| 10792 | 4-Vinylaniline                                                               |                                                                                            | C <sub>8</sub> H <sub>9</sub> N                                | 1520-21-4  | 119.164  |                         | 23.5    | 116 <sup>9</sup>                     | 1.010 <sup>20</sup>        | 1.6250 <sup>22</sup> | s ace, bz                                                 |
| 10793 | $\alpha$ -Vinylbenzenemethanol                                               | 1-Phenylallyl alcohol                                                                      | C <sub>9</sub> H <sub>10</sub> O                               | 4393-06-0  | 134.174  |                         |         |                                      | 1.0249 <sup>21</sup>       | 1.5406 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH,<br>eth, bz, chl              |
| 10794 | Vinyl butanoate                                                              |                                                                                            | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                  | 123-20-6   | 114.142  |                         |         | 116.7; 64 <sup>130</sup>             | 0.9006 <sup>20</sup>       |                      |                                                           |
| 10795 | Vinyl <i>trans</i> -2-butenate                                               | Vinyl crotonate                                                                            | C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                   | 3234-54-6  | 112.127  |                         |         |                                      |                            |                      | s ctc                                                     |
| 10796 | 9-Vinyl-9 <i>H</i> -carbazole                                                |                                                                                            | C <sub>14</sub> H <sub>11</sub> N                              | 1484-13-5  | 193.244  | cry (al)                | 66      |                                      |                            |                      | i H <sub>2</sub> O; sl EtOH;<br>vs eth                    |
| 10797 | Vinylcyclohexane                                                             |                                                                                            | C <sub>8</sub> H <sub>14</sub>                                 | 695-12-5   | 110.197  |                         |         | 128                                  | 0.8166 <sup>19</sup>       | 1.455 <sup>19</sup>  |                                                           |
| 10798 | 1-Vinylcyclohexene                                                           |                                                                                            | C <sub>8</sub> H <sub>12</sub>                                 | 2622-21-1  | 108.181  |                         |         | 145                                  | 0.8623 <sup>15</sup>       | 1.4915 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz;<br>vs MeOH                 |
| 10799 | 4-Vinylcyclohexene                                                           |                                                                                            | C <sub>8</sub> H <sub>12</sub>                                 | 100-40-3   | 108.181  | liq                     | -108.9  | 128                                  | 0.8299 <sup>20</sup>       | 1.4639 <sup>20</sup> | i H <sub>2</sub> O; s eth, bz,<br>peth                    |
| 10800 | Vinylcyclopentane                                                            |                                                                                            | C <sub>7</sub> H <sub>12</sub>                                 | 3742-34-5  | 96.170   | liq                     | -126.5  | 97                                   | 0.7834 <sup>20</sup>       | 1.4360 <sup>20</sup> |                                                           |
| 10801 | Vinyldiethoxymethylsilane                                                    |                                                                                            | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub> Si               | 5507-44-8  | 160.287  |                         |         | 133                                  | 0.8620 <sup>20</sup>       | 1.4001 <sup>20</sup> |                                                           |
| 10802 | Vinylethoxydimethylsilane                                                    |                                                                                            | C <sub>8</sub> H <sub>14</sub> OSi                             | 5356-83-2  | 130.260  |                         |         | 99                                   | 0.790 <sup>20</sup>        | 1.3983 <sup>20</sup> |                                                           |
| 10803 | 1-Vinyl-4-fluorobenzene                                                      |                                                                                            | C <sub>8</sub> H <sub>7</sub> F                                | 405-99-2   | 122.140  |                         | -34.5   | 67.4 <sup>50</sup> , 30 <sup>4</sup> | 1.0220 <sup>20</sup>       | 1.5150 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz                    |
| 10804 | Vinyl formate                                                                |                                                                                            | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                   | 692-45-5   | 72.063   | visc liq                | -78     | 46                                   | 0.965 <sup>20</sup>        | 1.3842 <sup>20</sup> |                                                           |
| 10805 | 2-Vinylfuran                                                                 |                                                                                            | C <sub>6</sub> H <sub>6</sub> O                                | 1487-18-9  | 94.111   | liq                     | -94     | 99.5                                 | 0.9445 <sup>19</sup>       | 1.4992 <sup>19</sup> |                                                           |
| 10806 | 1-Vinyl-2-methoxybenzene                                                     |                                                                                            | C <sub>9</sub> H <sub>10</sub> O                               | 612-15-7   | 134.174  | nd                      | 29      | 197; 83 <sup>12</sup>                | 1.0049 <sup>17</sup>       | 1.5388 <sup>20</sup> | vs ace, bz, eth,<br>EtOH                                  |
| 10807 | 1-Vinyl-3-methoxybenzene                                                     |                                                                                            | C <sub>9</sub> H <sub>10</sub> O                               | 626-20-0   | 134.174  |                         |         | 91 <sup>15</sup> , 70 <sup>5</sup>   | 0.9919 <sup>20</sup>       | 1.5586 <sup>23</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz                    |
| 10808 | 1-Vinyl-4-methoxybenzene                                                     |                                                                                            | C <sub>9</sub> H <sub>10</sub> O                               | 637-69-4   | 134.174  |                         | 2.0     | 205; 91 <sup>13</sup>                | 1.0001 <sup>13</sup>       | 1.5642 <sup>13</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz; sl ctc            |
| 10809 | 6-Vinyl-6-methyl-1-isopropyl-3-(1-methylethylidene)cyclohexene, ( <i>S</i> ) |                                                                                            | C <sub>15</sub> H <sub>24</sub>                                | 5951-67-7  | 204.352  |                         |         | 125 <sup>8</sup>                     | 0.8782 <sup>20</sup>       | 1.5130 <sup>26</sup> | vs ace, bz                                                |
| 10810 | 1-Vinylnaphthalene                                                           |                                                                                            | C <sub>12</sub> H <sub>10</sub>                                | 826-74-4   | 154.207  |                         |         | 124 <sup>15</sup>                    | 1.0656 <sup>20</sup>       | 1.644 <sup>20</sup>  |                                                           |
| 10811 | 2-Vinylnaphthalene                                                           |                                                                                            | C <sub>12</sub> H <sub>10</sub>                                | 827-54-3   | 154.207  |                         | 66      | 135 <sup>18</sup> , 95 <sup>2</sup>  |                            |                      | i H <sub>2</sub> O; s EtOH,<br>ace, bz                    |
| 10812 | 1-Vinyl-3-nitrobenzene                                                       |                                                                                            | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>                  | 586-39-0   | 149.148  |                         | -10     | 120 <sup>11</sup>                    | 1.1552 <sup>32</sup>       | 1.5836 <sup>20</sup> | i H <sub>2</sub> O; s EtOH,<br>eth, bz, chl,<br>lig, HOAc |
| 10813 | 1-Vinyl-4-nitrobenzene                                                       |                                                                                            | C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>                  | 100-13-0   | 149.148  | pr (liq)                | 29      | dec                                  |                            |                      | vs EtOH, eth; s<br>chl, HOAc, lig                         |
| 10814 | 2-Vinyl-5-norbornene                                                         | 5-Vinylbicyclo[2.2.1]hept-2-ene                                                            | C <sub>9</sub> H <sub>12</sub>                                 | 3048-64-4  | 120.191  | liq                     | -80     | 139                                  | 0.841                      | 1.4810 <sup>20</sup> |                                                           |
| 10815 | Vinyl octadecanoate                                                          | Vinyl stearate                                                                             | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub>                 | 111-63-7   | 310.515  |                         | 29      | 167 <sup>2</sup>                     | 0.8517 <sup>20</sup>       |                      | sl chl                                                    |
| 10816 | 3-Vinyl-7-oxabicyclo[4.1.0]heptane                                           |                                                                                            | C <sub>8</sub> H <sub>12</sub> O                               | 106-86-5   | 124.180  |                         | <-100   | 169; 70 <sup>20</sup>                | 0.9581 <sup>20</sup>       | 1.4700 <sup>20</sup> |                                                           |



| No.   | Name                     | Synonym                                                                                 | Mol. Form.                                                          | CAS RN     | Mol. Wt. | Physical Form                  | mp/°C    | bp/°C                                 | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                                  |
|-------|--------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------|------------|----------|--------------------------------|----------|---------------------------------------|----------------------------|----------------------|-------------------------------------------------------------|
| 10817 | Vinyloxirane             |                                                                                         | C <sub>2</sub> H <sub>4</sub> O                                     | 930-22-3   | 70.090   |                                |          | 68                                    | 0.9006 <sup>25</sup>       | 1.4168 <sup>20</sup> | s EtOH, eth, bz                                             |
| 10818 | 2-(Vinyloxy)ethanol      | Ethylene glycol monovinyl ether                                                         | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                        | 764-48-7   | 88.106   |                                |          | 141.6                                 | 0.9821 <sup>20</sup>       | 1.4564 <sup>17</sup> | s H <sub>2</sub> O, EtOH, eth, bz; i lig                    |
| 10819 | Vinyl propanoate         | Vinyl propionate                                                                        | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                        | 105-38-4   | 100.117  |                                |          | 91.2                                  |                            |                      |                                                             |
| 10820 | 2-Vinylpyridine          |                                                                                         | C <sub>7</sub> H <sub>7</sub> N                                     | 100-69-6   | 105.138  |                                |          | 159.5                                 | 0.9983 <sup>20</sup>       | 1.5495 <sup>20</sup> | sl H <sub>2</sub> O; vs EtOH, eth, ace, chl                 |
| 10821 | 3-Vinylpyridine          |                                                                                         | C <sub>7</sub> H <sub>7</sub> N                                     | 1121-55-7  | 105.138  |                                |          | 162                                   | 0.9879 <sup>20</sup>       | 1.5530 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth                            |
| 10822 | 4-Vinylpyridine          |                                                                                         | C <sub>7</sub> H <sub>7</sub> N                                     | 100-43-6   | 105.138  | red to dk-br                   |          | 121 <sup>150</sup> , 79 <sup>33</sup> | 0.9879 <sup>20</sup>       | 1.5449 <sup>20</sup> | s H <sub>2</sub> O, EtOH, chl; sl eth                       |
| 10823 | 1-Vinyl-2-pyrrolidinone  |                                                                                         | C <sub>6</sub> H <sub>9</sub> NO                                    | 88-12-0    | 111.141  |                                | 13.5     | 193 <sup>400</sup> , 93 <sup>11</sup> | 1.04 <sup>20</sup>         |                      |                                                             |
| 10824 | Vinylsilane              |                                                                                         | C <sub>2</sub> H <sub>4</sub> Si                                    | 7291-09-0  | 58.155   | col gas                        | -171.6   | -22.8                                 |                            |                      |                                                             |
| 10825 | Vinyl sulfoxide          |                                                                                         | C <sub>4</sub> H <sub>6</sub> OS                                    | 1115-15-7  | 102.155  | liq                            |          | 86 <sup>18</sup>                      |                            |                      |                                                             |
| 10826 | Vinyltriacetoxysilane    | Vinylsilanetriol, triacetate                                                            | C <sub>8</sub> H <sub>12</sub> O <sub>6</sub> Si                    | 4130-08-9  | 232.263  |                                |          | 115 <sup>10</sup>                     | 1.169 <sup>20</sup>        | 1.4226 <sup>20</sup> |                                                             |
| 10827 | Vinyltriethoxysilane     |                                                                                         | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub> Si                    | 78-08-0    | 190.313  |                                |          | 160; 62 <sup>20</sup>                 | 0.901 <sup>20</sup>        | 1.3960 <sup>25</sup> | s chl                                                       |
| 10828 | Vinyltrimethylsilane     |                                                                                         | C <sub>8</sub> H <sub>12</sub> Si                                   | 754-05-2   | 100.235  |                                |          | 55                                    | 0.65 <sup>20</sup>         | 1.3914 <sup>20</sup> | i H <sub>2</sub> O                                          |
| 10829 | Violaxanthin             |                                                                                         | C <sub>40</sub> H <sub>56</sub> O <sub>4</sub>                      | 126-29-4   | 600.871  | red pr (MeOH, al-eth)          | 208      |                                       |                            |                      | s EtOH, eth, CS <sub>2</sub> ; i peth                       |
| 10830 | Viquidil                 |                                                                                         | C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>       | 84-55-9    | 324.417  | red ye amor                    | 60       |                                       |                            |                      | vs eth, EtOH, chl                                           |
| 10831 | Visnadine                |                                                                                         | C <sub>21</sub> H <sub>24</sub> O <sub>7</sub>                      | 477-32-7   | 388.412  | nd                             | 85.5     |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, eth                             |
| 10832 | Visnagin                 | 4-Methoxy-7-methyl-5 <i>H</i> -furo[3,2- <i>g</i> ][1]benzopyran-5-one                  | C <sub>13</sub> H <sub>10</sub> O <sub>4</sub>                      | 82-57-5    | 230.216  | nd (w, MeOH)                   | 144.5    |                                       |                            |                      | sl H <sub>2</sub> O, EtOH; vs chl                           |
| 10833 | Vitamin B12              | Cyanocobalamin                                                                          | C <sub>63</sub> H <sub>88</sub> CoN <sub>14</sub> O <sub>14</sub> P | 68-19-9    | 1355.365 |                                | >300     |                                       |                            |                      |                                                             |
| 10834 | Vitamin D2               |                                                                                         | C <sub>28</sub> H <sub>44</sub> O                                   | 50-14-6    | 396.648  | pr (ace)                       | 116.5    | sub                                   |                            |                      | i H <sub>2</sub> O; s EtOH, eth, ace, chl                   |
| 10835 | Vitamin D3               | 9,10-Secocholesta-5,7,10(19)-trien-3-ol, (3 <i>β</i> ,5,7 <i>E</i> )-                   | C <sub>27</sub> H <sub>44</sub> O                                   | 67-97-0    | 384.637  |                                | 84.5     |                                       |                            |                      | i H <sub>2</sub> O; s os                                    |
| 10836 | Vitamin E                | α-Tocopherol                                                                            | C <sub>29</sub> H <sub>50</sub> O <sub>2</sub>                      | 59-02-9    | 430.706  | pale ye oil                    | 3.0      | 210 <sup>0.1</sup>                    | 0.950 <sup>25</sup>        | 1.5045 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, chl                   |
| 10837 | Vitamin E acetate        |                                                                                         | C <sub>31</sub> H <sub>52</sub> O <sub>3</sub>                      | 58-95-7    | 472.743  |                                | -27.5    | 184 <sup>0.01</sup>                   | 0.9533 <sup>21</sup>       | 1.497 <sup>20</sup>  | i H <sub>2</sub> O; sl EtOH; s eth, ace, chl                |
| 10838 | Vitamin K1               |                                                                                         | C <sub>31</sub> H <sub>46</sub> O <sub>2</sub>                      | 84-80-0    | 450.696  |                                | -20      | 142 <sup>0.001</sup>                  | 0.964 <sup>25</sup>        | 1.5250 <sup>25</sup> | i H <sub>2</sub> O; s EtOH, eth, ace, bz, peth, chl         |
| 10839 | Vomicine                 | 4-Hydroxy-19-methyl-16,19-secostrychnidine-10,16-dione                                  | C <sub>22</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub>       | 125-15-5   | 380.437  | nd (80% al) pr (ace)           | 282      |                                       |                            |                      | sl EtOH, eth, ace; vs chl; s AcOEt                          |
| 10840 | Warfarin                 | Coumadin                                                                                | C <sub>19</sub> H <sub>16</sub> O <sub>4</sub>                      | 81-81-2    | 308.328  | cry (al)                       | 161      |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, ace, diox                       |
| 10841 | 9 <i>H</i> -Xanthene     | 10 <i>H</i> -9-Oxaanthracene                                                            | C <sub>13</sub> H <sub>10</sub> O                                   | 92-83-1    | 182.217  | ye lf (al)                     | 100.5    | 311                                   |                            |                      | i H <sub>2</sub> O; sl EtOH, ctc; s eth, bz, chl            |
| 10842 | 9 <i>H</i> -Xanthen-9-ol |                                                                                         | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                      | 90-46-0    | 198.217  | nd (aq al)                     | 125      |                                       |                            |                      | sl H <sub>2</sub> O; s EtOH, eth, chl                       |
| 10843 | Xanthine                 |                                                                                         | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub>         | 69-89-6    | 152.112  | ye pl (w)                      | dec      | sub                                   |                            |                      | i H <sub>2</sub> O                                          |
| 10844 | Xanthone                 |                                                                                         | C <sub>13</sub> H <sub>8</sub> O <sub>2</sub>                       | 90-47-1    | 196.202  | nd (al)                        | 174      | 351; 146 <sup>3</sup>                 |                            |                      | i H <sub>2</sub> O; s EtOH, eth, bz, chl; sl peth           |
| 10845 | Xanthopterin             |                                                                                         | C <sub>6</sub> H <sub>15</sub> N <sub>5</sub> O <sub>2</sub>        | 119-44-8   | 179.137  | hyg ye amor or oran pow (HOAc) | >410 dec | 99 <sup>18</sup>                      | 1.559 <sup>25</sup>        |                      | i H <sub>2</sub> O; sl EtOH, eth; vs acid, alk              |
| 10846 | Xanthosine               |                                                                                         | C <sub>10</sub> H <sub>12</sub> N <sub>4</sub> O <sub>6</sub>       | 146-80-5   | 284.225  | pr cry (w)                     |          |                                       |                            |                      | sl cold H <sub>2</sub> O; vs hot H <sub>2</sub> O; dec acid |
| 10847 | Xanthoxyletin            |                                                                                         | C <sub>15</sub> H <sub>14</sub> O <sub>4</sub>                      | 84-99-1    | 258.270  | pr (MeOH, peth)                | 133      |                                       |                            |                      | i H <sub>2</sub> O; s EtOH, ace; sl eth; vs bz, alk         |
| 10848 | Xanthyletin              | 8,8-Dimethyl-2 <i>H</i> ,8 <i>H</i> -benzo[1,2- <i>b</i> :5,4- <i>b'</i> ]dipyran-2-one | C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>                      | 553-19-5   | 228.243  | pr (MeOH)                      | 131.5    | 142 <sup>0.1</sup>                    |                            |                      | s EtOH, peth                                                |
| 10849 | <i>p</i> -Xenylcarbimide | 4-Isocyanato-1,1'-biphenyl                                                              | C <sub>13</sub> H <sub>9</sub> NO                                   | 92-95-5    | 195.216  | nd                             | 56       | dec 283                               |                            |                      | vs eth                                                      |
| 10850 | Xibenolol                |                                                                                         | C <sub>15</sub> H <sub>25</sub> NO <sub>2</sub>                     | 81584-06-7 | 251.366  | cry                            | 57       | 135 <sup>0.7</sup>                    |                            |                      | s EtOH                                                      |
| 10851 | <i>o</i> -Xylene         | 1,2-Dimethylbenzene                                                                     | C <sub>8</sub> H <sub>10</sub>                                      | 95-47-6    | 106.165  | liq                            | -25.2    | 144.5                                 | 0.8755 <sup>25</sup>       | 1.5018 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz, peth, ctc       |
| 10852 | <i>m</i> -Xylene         | 1,3-Dimethylbenzene                                                                     | C <sub>8</sub> H <sub>10</sub>                                      | 108-38-3   | 106.165  | liq                            | -47.8    | 139.07                                | 0.8598 <sup>25</sup>       | 1.4944 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; s chl           |
| 10853 | <i>p</i> -Xylene         | 1,4-Dimethylbenzene                                                                     | C <sub>8</sub> H <sub>10</sub>                                      | 106-42-3   | 106.165  | mcl pr (al)                    | 13.25    | 138.23                                | 0.8565 <sup>25</sup>       | 1.4929 <sup>25</sup> | i H <sub>2</sub> O; msc EtOH, eth, ace, bz; s chl           |



| No.   | Name                                                       | Synonym                                               | Mol. Form.                                                       | CAS RN     | Mol. Wt. | Physical Form              | mp/°C   | bp/°C   | den/<br>g cm <sup>-3</sup> | n <sub>D</sub>       | Solubility                                |
|-------|------------------------------------------------------------|-------------------------------------------------------|------------------------------------------------------------------|------------|----------|----------------------------|---------|---------|----------------------------|----------------------|-------------------------------------------|
| 10854 | 2,3-Xylenol                                                | 2,3-Dimethylphenol                                    | C <sub>8</sub> H <sub>10</sub> O                                 | 526-75-0   | 122.164  | nd (w, dil al)             | 72.5    | 216.9   |                            | 1.5420 <sup>20</sup> | sl H <sub>2</sub> O; s EtOH, eth          |
| 10855 | 2,4-Xylenol                                                | 2,4-Dimethylphenol                                    | C <sub>8</sub> H <sub>10</sub> O                                 | 105-67-9   | 122.164  | nd (w)                     | 24.5    | 210.98  | 0.9650 <sup>20</sup>       | 1.5420 <sup>14</sup> | sl H <sub>2</sub> O; msc EtOH, eth; s ctc |
| 10856 | 2,5-Xylenol                                                | 2,5-Dimethylphenol                                    | C <sub>8</sub> H <sub>10</sub> O                                 | 95-87-4    | 122.164  | nd (w), pr (al-eth)        | 74.8    | 211.1   |                            |                      | s H <sub>2</sub> O, EtOH; vs eth; sl chl  |
| 10857 | 2,6-Xylenol                                                | 2,6-Dimethylphenol                                    | C <sub>8</sub> H <sub>10</sub> O                                 | 576-26-1   | 122.164  | lf or nd (al)              | 45.8    | 201.07  |                            |                      | s H <sub>2</sub> O, EtOH, eth, ctc        |
| 10858 | 3,4-Xylenol                                                | 3,4-Dimethylphenol                                    | C <sub>8</sub> H <sub>10</sub> O                                 | 95-65-8    | 122.164  |                            | 65.1    | 227     | 0.9830 <sup>20</sup>       |                      | sl H <sub>2</sub> O; s EtOH, ctc; msc eth |
| 10859 | 3,5-Xylenol                                                | 3,5-Dimethylphenol                                    | C <sub>8</sub> H <sub>10</sub> O                                 | 108-68-9   | 122.164  | nd (w, peth)               | 63.4    | 221.74  | 0.9680 <sup>20</sup>       |                      | s H <sub>2</sub> O, EtOH, ctc             |
| 10860 | Xylenol orange                                             |                                                       | C <sub>31</sub> H <sub>32</sub> N <sub>2</sub> O <sub>13</sub> S | 1611-35-4  | 672.656  | dk red cry                 | 286 dec |         |                            |                      | s H <sub>2</sub> O                        |
| 10861 | Xylitol                                                    | Xylite                                                | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                    | 87-99-0    | 152.146  | mcl (al)                   | 93.5    | 216     |                            |                      | vs H <sub>2</sub> O, py, EtOH             |
| 10862 | 6- <i>O</i> -β- <i>D</i> -Xylopyranosyl- <i>D</i> -glucose | Primeverose                                           | C <sub>11</sub> H <sub>20</sub> O <sub>10</sub>                  | 26531-85-1 | 312.271  | cry (MeOH)                 | 210     |         |                            |                      | vs H <sub>2</sub> O, MeOH                 |
| 10863 | <i>D</i> -Xylose                                           |                                                       | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                    | 58-86-6    | 150.130  | mcl nd                     | 90.5    |         | 1.525 <sup>20</sup>        |                      | vs H <sub>2</sub> O; s EtOH; sl eth       |
| 10864 | <i>D</i> -Xylulose                                         | <i>D</i> -threo-2-Pentulose                           | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                    | 551-84-8   | 150.130  | visc liq                   |         |         |                            |                      | s H <sub>2</sub> O                        |
| 10865 | <i>L</i> -Xylulose                                         | <i>L</i> -threo-2-Pentulose                           | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                    | 527-50-4   | 150.130  | syrup                      |         |         |                            |                      | vs H <sub>2</sub> O                       |
| 10866 | 3,5-Xylyl methylcarbamate                                  | 3,5-Dimethylphenyl methylcarbamate                    | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>                  | 2655-14-3  | 179.216  | cry                        | 99      |         |                            |                      | sl H <sub>2</sub> O; s os                 |
| 10867 | Yohimbine                                                  |                                                       | C <sub>21</sub> H <sub>26</sub> N <sub>2</sub> O <sub>3</sub>    | 146-48-5   | 354.442  | nd (dil al)                | 241     | sub 160 |                            |                      | sl H <sub>2</sub> O, bz; s EtOH, eth, chl |
| 10868 | Yohimbine hydrochloride                                    | Tosanpin                                              | C <sub>21</sub> H <sub>27</sub> ClN <sub>2</sub> O <sub>3</sub>  | 65-19-0    | 390.903  | orth nd or pl (w, dil HCl) | 302     |         |                            |                      | vs H <sub>2</sub> O                       |
| 10869 | Zearalenone                                                |                                                       | C <sub>18</sub> H <sub>22</sub> O <sub>5</sub>                   | 17924-92-4 | 318.365  | cry                        | 164     |         |                            |                      | i H <sub>2</sub> O; s alk, bz, EtOH, eth  |
| 10870 | Zidovudine                                                 | 3'-Azido-3'-deoxythymidine                            | C <sub>10</sub> H <sub>13</sub> N <sub>5</sub> O <sub>4</sub>    | 30516-87-1 | 267.242  | cry (w)                    | 121     |         |                            |                      |                                           |
| 10871 | Zinc benzoate                                              |                                                       | C <sub>14</sub> H <sub>10</sub> O <sub>4</sub> Zn                | 553-72-0   | 307.636  |                            |         |         |                            |                      | sl H <sub>2</sub> O                       |
| 10872 | Zinc bis(dibutylthiocarbamate)                             |                                                       | C <sub>18</sub> H <sub>36</sub> N <sub>2</sub> S <sub>4</sub> Zn | 136-23-2   | 474.161  | cry                        | 138     |         |                            |                      |                                           |
| 10873 | Zinc <i>N,N'</i> -ethylenebisdithiocarbamate               | Zineb                                                 | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> S <sub>4</sub> Zn   | 12122-67-7 | 275.773  |                            | 157 dec |         |                            |                      |                                           |
| 10874 | Zinc gluconate                                             |                                                       | C <sub>12</sub> H <sub>22</sub> O <sub>14</sub> Zn               | 4468-02-4  | 455.704  | pow                        |         |         |                            |                      |                                           |
| 10875 | Zinc 2,4-pentanedioate                                     | Zinc acetylacetonate                                  | C <sub>10</sub> H <sub>14</sub> O <sub>4</sub> Zn                | 14024-63-6 | 263.625  |                            |         |         |                            |                      | s DMSO                                    |
| 10876 | Zinc propanoate                                            |                                                       | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub> Zn                 | 557-28-8   | 211.550  | hyg pl or nd               |         |         |                            |                      | sl EtOH                                   |
| 10877 | Ziram                                                      | Zinc, bis(dimethylcarbamo-<br>dithioato-S,S)-, (T-4)- | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> S <sub>4</sub> Zn  | 137-30-4   | 305.841  | cry                        | 250     |         | 1.66 <sup>25</sup>         |                      | i H <sub>2</sub> O; sl bz; s chl          |





## DIAMAGNETIC SUSCEPTIBILITY OF SELECTED ORGANIC COMPOUNDS

When a material is placed in a magnetic field  $H$ , a magnetization  $M$  is induced in the material which is related to  $H$  by  $M = \kappa H$ , where  $\kappa$  is called the volume susceptibility. Since  $H$  and  $M$  have the same dimensions,  $\kappa$  is dimensionless. A more useful parameter is the molar susceptibility  $\chi_m$ , defined by

$$\chi_m = \kappa V_m = \kappa M/\rho$$

where  $V_m$  is the molar volume of the substance,  $M$  the molar mass, and  $\rho$  the mass density. When the cgs system is used, the customary unit for  $\chi_m$  is  $\text{cm}^3 \text{mol}^{-1}$ ; the corresponding SI unit is  $\text{m}^3 \text{mol}^{-1}$ . Substances with no unpaired electrons are called diamagnetic; they have negative values of  $\chi_m$ .

This table gives values of the diamagnetic susceptibility for about 400 common organic compounds. All values refer to room temperature and atmospheric pressure and to the physical form

that is stable under these conditions. Substances are arranged by molecular formula in Hill order. A more extensive table may be found in Reference 1.

In keeping with customary practice, the molar susceptibility is given here in units appropriate to the cgs system. These values should be multiplied by  $4\pi$  to obtain values for use in SI equations (where the magnetic field strength  $H$  has units of  $\text{A m}^{-1}$ ).

### References

1. *Landolt-Börnstein, Numerical Data and Functional Relationships in Science and Technology, New Series*, II/16, *Diamagnetic Susceptibility*, Gupta, R. R., Ed., Springer-Verlag, Heidelberg, 1986.
2. Barter, C., Meisenheimer, R. G., and Stevenson, D. P., *J. Phys. Chem.* 64, 1312, 1960.
3. Broersma, S., *J. Chem. Phys.* 17, 873, 1949.

| Molecular formula               | Compound                | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Molecular formula                  | Compound                           | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|---------------------------------|-------------------------|-------------------------------------------------|------------------------------------|------------------------------------|-------------------------------------------------|
| $\text{CBrCl}_3$                | Bromotrichloromethane   | 73.2                                            | $\text{CN}_4\text{O}_8$            | Tetranitromethane                  | 43.0                                            |
| $\text{CBr}_4$                  | Tetrabromomethane       | 93.7                                            | $\text{C}_2\text{ClF}_3$           | Chlorotrifluoroethylene            | 49.1                                            |
| $\text{CClF}_3$                 | Chlorotrifluoromethane  | 45.3                                            | $\text{C}_2\text{Cl}_4$            | Tetrachloroethylene                | 81.6                                            |
| $\text{CClN}$                   | Cyanogen chloride       | 32.4                                            | $\text{C}_2\text{Cl}_6$            | Hexachloroethane                   | 112.8                                           |
| $\text{CCl}_2\text{F}_2$        | Dichlorodifluoromethane | 52.2                                            | $\text{C}_2\text{HCl}_3$           | Trichloroethylene                  | 65.8                                            |
| $\text{CCl}_2\text{O}$          | Carbonyl chloride       | 47.9                                            | $\text{C}_2\text{HCl}_3\text{O}$   | Trichloroacetaldehyde              | 73.0                                            |
| $\text{CCl}_3\text{F}$          | Trichlorofluoromethane  | 58.7                                            | $\text{C}_2\text{HCl}_3\text{O}$   | Dichloroacetyl chloride            | 69.0                                            |
| $\text{CCl}_3\text{NO}_2$       | Trichloronitromethane   | 75.3                                            | $\text{C}_2\text{HCl}_3\text{O}_2$ | Trichloroacetic acid               | 73.0                                            |
| $\text{CCl}_4$                  | Tetrachloromethane      | 66.8                                            | $\text{C}_2\text{HCl}_5$           | Pentachloroethane                  | 99.1                                            |
| $\text{CHBrCl}_2$               | Bromodichloromethane    | 66.3                                            | $\text{C}_2\text{HF}_3\text{O}_2$  | Trifluoroacetic acid               | 43.3                                            |
| $\text{CHBr}_3$                 | Tribromomethane         | 82.6                                            | $\text{C}_2\text{H}_2$             | Acetylene                          | 20.8                                            |
| $\text{CHCl}_3$                 | Trichloromethane        | 58.9                                            | $\text{C}_2\text{H}_2\text{Br}_4$  | 1,1,2,2-Tetrabromoethane           | 123.4                                           |
| $\text{CHI}_3$                  | Triiodomethane          | 117.1                                           | $\text{C}_2\text{H}_2\text{Cl}_2$  | 1,1-Dichloroethylene               | 49.2                                            |
| $\text{CH}_2\text{BrCl}$        | Bromochloromethane      | 55.1                                            | $\text{C}_2\text{H}_2\text{Cl}_2$  | <i>cis</i> -1,2-Dichloroethylene   | 51.0                                            |
| $\text{CH}_2\text{Br}_2$        | Dibromomethane          | 65.1                                            | $\text{C}_2\text{H}_2\text{Cl}_2$  | <i>trans</i> -1,2-Dichloroethylene | 48.9                                            |
| $\text{CH}_2\text{Cl}_2$        | Dichloromethane         | 46.6                                            | $\text{C}_2\text{H}_2\text{Cl}_4$  | 1,1,2,2-Tetrachloroethane          | 89.8                                            |
| $\text{CH}_2\text{I}_2$         | Diiodomethane           | 93.1                                            | $\text{C}_2\text{H}_3\text{Cl}$    | Chloroethylene                     | 35.9                                            |
| $\text{CH}_2\text{N}_2$         | Cyanamide               | 24.8                                            | $\text{C}_2\text{H}_3\text{ClO}$   | Acetyl chloride                    | 39.3                                            |
| $\text{CH}_2\text{O}$           | Formaldehyde            | 18.6                                            | $\text{C}_2\text{H}_3\text{N}$     | Acetonitrile                       | 27.8                                            |
| $\text{CH}_2\text{O}_2$         | Formic acid             | 19.9                                            | $\text{C}_2\text{H}_4$             | Ethylene                           | 18.8                                            |
| $\text{CH}_3\text{Br}$          | Bromomethane            | 42.8                                            | $\text{C}_2\text{H}_4\text{Br}_2$  | 1,2-Dibromoethane                  | 78.9                                            |
| $\text{CH}_3\text{Cl}$          | Chloromethane           | 32.0                                            | $\text{C}_2\text{H}_4\text{Cl}_2$  | 1,1-Dichloroethane                 | 57.4                                            |
| $\text{CH}_3\text{F}$           | Fluoromethane           | 17.8                                            | $\text{C}_2\text{H}_4\text{Cl}_2$  | 1,2-Dichloroethane                 | 59.6                                            |
| $\text{CH}_3\text{I}$           | Iodomethane             | 57.2                                            | $\text{C}_2\text{H}_4\text{O}$     | Acetaldehyde                       | 22.2                                            |
| $\text{CH}_3\text{NO}$          | Formamide               | 23.0                                            | $\text{C}_2\text{H}_4\text{O}$     | Ethylene oxide                     | 30.5                                            |
| $\text{CH}_3\text{NO}_2$        | Nitromethane            | 21.0                                            | $\text{C}_2\text{H}_4\text{O}_2$   | Acetic acid                        | 31.8                                            |
| $\text{CH}_4$                   | Methane                 | 17.4                                            | $\text{C}_2\text{H}_4\text{O}_2$   | Methyl formate                     | 31.1                                            |
| $\text{CH}_4\text{N}_2\text{O}$ | Urea                    | 33.5                                            | $\text{C}_2\text{H}_5\text{Br}$    | Bromoethane                        | 78.8                                            |
| $\text{CH}_4\text{O}$           | Methanol                | 21.4                                            | $\text{C}_2\text{H}_5\text{Cl}$    | Chloroethane                       | 69.9                                            |
| $\text{CH}_5\text{N}$           | Methylamine             | 27.0                                            | $\text{C}_2\text{H}_5\text{I}$     | Iodoethane                         | 69.1                                            |
| $\text{Cl}_4$                   | Tetraiodomethane        | 136                                             | $\text{C}_2\text{H}_5\text{NO}$    | Acetamide                          | 33.9                                            |

| Molecular formula                 | Compound             | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Molecular formula                   | Compound                | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|-----------------------------------|----------------------|-------------------------------------------------|-------------------------------------|-------------------------|-------------------------------------------------|
| $\text{C}_2\text{H}_5\text{NO}_2$ | Nitroethane          | 35.4                                            | $\text{C}_4\text{H}_6$              | 1,2-Butadiene           | 35.6                                            |
| $\text{C}_2\text{H}_5\text{NO}_2$ | Glycine              | 39.6                                            | $\text{C}_4\text{H}_6$              | 1,3-Butadiene           | 32.1                                            |
| $\text{C}_2\text{H}_6$            | Ethane               | 26.8                                            | $\text{C}_4\text{H}_6\text{O}_2$    | Vinyl acetate           | 46.4                                            |
| $\text{C}_2\text{H}_6\text{O}$    | Ethanol              | 33.7                                            | $\text{C}_4\text{H}_6\text{O}_3$    | Acetic anhydride        | 52.8                                            |
| $\text{C}_2\text{H}_6\text{O}$    | Dimethyl ether       | 26.3                                            | $\text{C}_4\text{H}_6\text{O}_4$    | Succinic acid           | 58.0                                            |
| $\text{C}_2\text{H}_6\text{O}_2$  | Ethylene glycol      | 38.9                                            | $\text{C}_4\text{H}_6\text{O}_4$    | Dimethyl oxalate        | 55.7                                            |
| $\text{C}_2\text{H}_6\text{S}$    | Ethanethiol          | 47.0                                            | $\text{C}_4\text{H}_7\text{N}$      | Butanenitrile           | 50.4                                            |
| $\text{C}_2\text{H}_6\text{S}$    | Dimethyl sulfide     | 44.9                                            | $\text{C}_4\text{H}_8$              | 1-Butene                | 41.0                                            |
| $\text{C}_2\text{H}_8\text{N}_2$  | 1,2-Ethanediamine    | 46.5                                            | $\text{C}_4\text{H}_8$              | <i>cis</i> -2-Butene    | 42.6                                            |
| $\text{C}_2\text{N}_2$            | Cyanogen             | 21.6                                            | $\text{C}_4\text{H}_8$              | <i>trans</i> -2-Butene  | 43.3                                            |
| $\text{C}_3\text{H}_4$            | Allene               | 25.3                                            | $\text{C}_4\text{H}_8$              | Isobutene               | 40.8                                            |
| $\text{C}_3\text{H}_4\text{O}_2$  | Vinyl formate        | 34.7                                            | $\text{C}_4\text{H}_8$              | Cyclobutane             | 40.0                                            |
| $\text{C}_3\text{H}_5\text{Br}$   | 3-Bromopropene       | 58.6                                            | $\text{C}_4\text{H}_8\text{O}$      | Ethyl vinyl ether       | 47.9                                            |
| $\text{C}_3\text{H}_5\text{Cl}$   | 2-Chloropropene      | 47.8                                            | $\text{C}_4\text{H}_8\text{O}$      | 1,2-Epoxybutane         | 54.8                                            |
| $\text{C}_3\text{H}_5\text{Cl}$   | 3-Chloropropene      | 47.8                                            | $\text{C}_4\text{H}_8\text{O}$      | Butanal                 | 45.9                                            |
| $\text{C}_3\text{H}_5\text{N}$    | Propanenitrile       | 38.6                                            | $\text{C}_4\text{H}_8\text{O}$      | 2-Butanone              | 45.6                                            |
| $\text{C}_3\text{H}_6$            | Propene              | 30.7                                            | $\text{C}_4\text{H}_8\text{O}_2$    | Butanoic acid           | 55.2                                            |
| $\text{C}_3\text{H}_6$            | Cyclopropane         | 39.2                                            | $\text{C}_4\text{H}_8\text{O}_2$    | 2-Methylpropanoic acid  | 56.1                                            |
| $\text{C}_3\text{H}_6\text{O}$    | Allyl alcohol        | 36.7                                            | $\text{C}_4\text{H}_8\text{O}_2$    | Propyl formate          | 55.0                                            |
| $\text{C}_3\text{H}_6\text{O}$    | Propanal             | 34.2                                            | $\text{C}_4\text{H}_8\text{O}_2$    | Ethyl acetate           | 54.1                                            |
| $\text{C}_3\text{H}_6\text{O}$    | Acetone              | 33.8                                            | $\text{C}_4\text{H}_8\text{O}_2$    | Methyl propanoate       | 54.5                                            |
| $\text{C}_3\text{H}_6\text{O}$    | Methyloxirane        | 42.5                                            | $\text{C}_4\text{H}_8\text{O}_2$    | 1,4-Dioxane             | 52.2                                            |
| $\text{C}_3\text{H}_6\text{O}_2$  | Propanoic acid       | 43.2                                            | $\text{C}_4\text{H}_9\text{Br}$     | 1-Bromobutane           | 77.1                                            |
| $\text{C}_3\text{H}_6\text{O}_2$  | Ethyl formate        | 42.4                                            | $\text{C}_4\text{H}_9\text{Br}$     | 1-Bromo-2-methylpropane | 79.9                                            |
| $\text{C}_3\text{H}_7\text{Br}$   | 1-Bromopropane       | 65.6                                            | $\text{C}_4\text{H}_9\text{Cl}$     | 1-Chlorobutane          | 67.1                                            |
| $\text{C}_3\text{H}_7\text{Br}$   | 2-Bromopropane       | 65.1                                            | $\text{C}_4\text{H}_9\text{Cl}$     | 2-Chlorobutane          | 67.4                                            |
| $\text{C}_3\text{H}_7\text{Cl}$   | 1-Chloropropane      | 56.0                                            | $\text{C}_4\text{H}_9\text{I}$      | 1-Iodobutane            | 93.6                                            |
| $\text{C}_3\text{H}_7\text{I}$    | 1-Iodopropane        | 84.3                                            | $\text{C}_4\text{H}_9\text{N}$      | Pyrrolidine             | 54.8                                            |
| $\text{C}_3\text{H}_7\text{N}$    | Allylamine           | 40.1                                            | $\text{C}_4\text{H}_9\text{NO}$     | Morpholine              | 55.0                                            |
| $\text{C}_3\text{H}_7\text{NO}_2$ | 1-Nitropropane       | 45.0                                            | $\text{C}_4\text{H}_{10}$           | Butane                  | 50.3                                            |
| $\text{C}_3\text{H}_7\text{NO}_2$ | 2-Nitropropane       | 45.4                                            | $\text{C}_4\text{H}_{10}$           | Isobutane               | 50.5                                            |
| $\text{C}_3\text{H}_7\text{NO}_2$ | Ethyl carbamate      | 57.0                                            | $\text{C}_4\text{H}_{10}\text{O}$   | 1-Butanol               | 56.4                                            |
| $\text{C}_3\text{H}_8$            | Propane              | 38.6                                            | $\text{C}_4\text{H}_{10}\text{O}$   | 2-Butanol               | 57.6                                            |
| $\text{C}_3\text{H}_8\text{O}$    | 1-Propanol           | 44.8                                            | $\text{C}_4\text{H}_{10}\text{O}$   | 2-Methyl-1-propanol     | 57.6                                            |
| $\text{C}_3\text{H}_8\text{O}$    | 2-Propanol           | 45.7                                            | $\text{C}_4\text{H}_{10}\text{O}$   | 2-Methyl-2-propanol     | 56.6                                            |
| $\text{C}_3\text{H}_8\text{O}_2$  | 1,3-Propylene glycol | 50.2                                            | $\text{C}_4\text{H}_{10}\text{O}$   | Diethyl ether           | 55.5                                            |
| $\text{C}_3\text{H}_8\text{O}_2$  | Dimethoxymethane     | 47.3                                            | $\text{C}_4\text{H}_{10}\text{O}_2$ | 1,3-Butanediol          | 61.8                                            |
| $\text{C}_3\text{H}_8\text{O}_3$  | Glycerol             | 57.1                                            | $\text{C}_4\text{H}_{10}\text{O}_2$ | 1,4-Butanediol          | 61.8                                            |
| $\text{C}_4\text{H}_2\text{O}_3$  | Maleic anhydride     | 35.8                                            | $\text{C}_4\text{H}_{10}\text{S}$   | 1-Butanethiol           | 70.2                                            |
| $\text{C}_4\text{H}_4\text{N}_2$  | Pyrazine             | 37.8                                            | $\text{C}_4\text{H}_{11}\text{N}$   | Butylamine              | 58.9                                            |
| $\text{C}_4\text{H}_4\text{N}_2$  | Pyrimidine           | 43.1                                            | $\text{C}_4\text{H}_{11}\text{N}$   | Isobutylamine           | 59.8                                            |
| $\text{C}_4\text{H}_4\text{O}$    | Furan                | 43.1                                            | $\text{C}_4\text{H}_{11}\text{N}$   | Diethylamine            | 56.8                                            |
| $\text{C}_4\text{H}_4\text{O}_3$  | Succinic anhydride   | 47.5                                            | $\text{C}_5\text{H}_4\text{O}_2$    | Furfural                | 47.2                                            |
| $\text{C}_4\text{H}_4\text{O}_4$  | Maleic acid          | 49.6                                            | $\text{C}_5\text{H}_5\text{N}$      | Pyridine                | 48.7                                            |
| $\text{C}_4\text{H}_4\text{O}_4$  | Fumaric acid         | 49.1                                            | $\text{C}_5\text{H}_6\text{O}_2$    | Furfuryl alcohol        | 61.0                                            |
| $\text{C}_4\text{H}_4\text{S}$    | Thiophene            | 57.3                                            | $\text{C}_5\text{H}_7\text{NO}_2$   | Ethyl cyanoacetate      | 67.3                                            |
| $\text{C}_4\text{H}_5\text{N}$    | Pyrrole              | 48.6                                            | $\text{C}_5\text{H}_8$              | 2-Methyl-1,3-butadiene  | 46.0                                            |

| Molecular formula                   | Compound                   | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Molecular formula                          | Compound                   | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|-------------------------------------|----------------------------|-------------------------------------------------|--------------------------------------------|----------------------------|-------------------------------------------------|
| $\text{C}_5\text{H}_8\text{O}$      | Cyclopentanone             | 51.6                                            | $\text{C}_6\text{H}_6\text{ClN}$           | <i>o</i> -Chloroaniline    | 79.5                                            |
| $\text{C}_5\text{H}_8\text{O}_2$    | Methyl methacrylate        | 57.3                                            | $\text{C}_6\text{H}_6\text{ClN}$           | <i>m</i> -Chloroaniline    | 76.6                                            |
| $\text{C}_5\text{H}_8\text{O}_2$    | 2,4-Pentanedione           | 54.9                                            | $\text{C}_6\text{H}_6\text{ClN}$           | <i>p</i> -Chloroaniline    | 76.7                                            |
| $\text{C}_5\text{H}_{10}$           | 1-Pentene                  | 54.6                                            | $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | <i>o</i> -Nitroaniline     | 67.4                                            |
| $\text{C}_5\text{H}_{10}$           | 2-Methyl-2-butene          | 54.7                                            | $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | <i>m</i> -Nitroaniline     | 69.7                                            |
| $\text{C}_5\text{H}_{10}$           | Cyclopentane               | 56.2                                            | $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | <i>p</i> -Nitroaniline     | 68.0                                            |
| $\text{C}_5\text{H}_{10}\text{O}$   | Cyclopentanol              | 64.0                                            | $\text{C}_6\text{H}_6\text{O}$             | Phenol                     | 60.6                                            |
| $\text{C}_5\text{H}_{10}\text{O}$   | Pentanal                   | 57.5                                            | $\text{C}_6\text{H}_6\text{O}_2$           | <i>p</i> -Hydroquinone     | 64.7                                            |
| $\text{C}_5\text{H}_{10}\text{O}$   | 2-Pentanone                | 57.5                                            | $\text{C}_6\text{H}_6\text{O}_2$           | Pyrocatechol               | 68.2                                            |
| $\text{C}_5\text{H}_{10}\text{O}$   | 3-Pentanone                | 57.7                                            | $\text{C}_6\text{H}_6\text{O}_2$           | Resorcinol                 | 67.2                                            |
| $\text{C}_5\text{H}_{10}\text{O}_2$ | Pentanoic acid             | 66.5                                            | $\text{C}_6\text{H}_7\text{N}$             | Aniline                    | 62.4                                            |
| $\text{C}_5\text{H}_{10}\text{O}_2$ | 3-Methylbutanoic acid      | 67.7                                            | $\text{C}_6\text{H}_7\text{N}$             | 4-Methylpyridine           | 59.8                                            |
| $\text{C}_5\text{H}_{10}\text{O}_2$ | Butyl formate              | 65.8                                            | $\text{C}_6\text{H}_8$                     | 1,4-Cyclohexadiene         | 48.7                                            |
| $\text{C}_5\text{H}_{10}\text{O}_2$ | Isobutyl formate           | 66.8                                            | $\text{C}_6\text{H}_8\text{N}_2$           | <i>o</i> -Phenylenediamine | 72.5                                            |
| $\text{C}_5\text{H}_{10}\text{O}_2$ | Propyl acetate             | 65.9                                            | $\text{C}_6\text{H}_8\text{N}_2$           | <i>m</i> -Phenylenediamine | 70.4                                            |
| $\text{C}_5\text{H}_{10}\text{O}_2$ | Isopropyl acetate          | 67.0                                            | $\text{C}_6\text{H}_8\text{N}_2$           | <i>p</i> -Phenylenediamine | 70.7                                            |
| $\text{C}_5\text{H}_{10}\text{O}_2$ | Ethyl propanoate           | 66.3                                            | $\text{C}_6\text{H}_{10}$                  | 1,5-Hexadiene              | 55.1                                            |
| $\text{C}_5\text{H}_{10}\text{O}_2$ | Tetrahydrofurfuryl alcohol | 69.4                                            | $\text{C}_6\text{H}_{10}$                  | 1-Hexyne                   | 64.5                                            |
| $\text{C}_5\text{H}_{10}\text{O}_3$ | Diethyl carbonate          | 75.4                                            | $\text{C}_6\text{H}_{10}$                  | Cyclohexene                | 58.0                                            |
| $\text{C}_5\text{H}_{11}\text{N}$   | Piperidine                 | 64.2                                            | $\text{C}_6\text{H}_{10}\text{O}$          | Cyclohexanone              | 62.0                                            |
| $\text{C}_5\text{H}_{12}$           | Pentane                    | 61.5                                            | $\text{C}_6\text{H}_{10}\text{O}_3$        | Ethyl acetoacetate         | 71.7                                            |
| $\text{C}_5\text{H}_{12}$           | Isopentane                 | 63.0                                            | $\text{C}_6\text{H}_{10}\text{O}_4$        | Diethyl oxalate            | 81.7                                            |
| $\text{C}_5\text{H}_{12}$           | Neopentane                 | 63.0                                            | $\text{C}_6\text{H}_{12}$                  | 1-Hexene                   | 66.4                                            |
| $\text{C}_5\text{H}_{12}\text{O}$   | 1-Pentanol                 | 67.0                                            | $\text{C}_6\text{H}_{12}$                  | 2,3-Dimethyl-2-butene      | 65.9                                            |
| $\text{C}_5\text{H}_{12}\text{O}$   | 2-Pentanol                 | 69.1                                            | $\text{C}_6\text{H}_{12}$                  | Cyclohexane                | 68                                              |
| $\text{C}_5\text{H}_{12}\text{O}_2$ | 1,5-Pentanediol            | 73.5                                            | $\text{C}_6\text{H}_{12}$                  | Methylcyclopentane         | 70.2                                            |
| $\text{C}_5\text{H}_{13}\text{N}$   | Pentylamine                | 69.3                                            | $\text{C}_6\text{H}_{12}\text{O}$          | Hexanal                    | 69.4                                            |
| $\text{C}_6\text{Cl}_6$             | Hexachlorobenzene          | 147.0                                           | $\text{C}_6\text{H}_{12}\text{O}$          | 2-Hexanone                 | 69.2                                            |
| $\text{C}_6\text{H}_4\text{ClNO}_2$ | 1-Chloro-2-nitrobenzene    | 75.5                                            | $\text{C}_6\text{H}_{12}\text{O}$          | 3-Hexanone                 | 69.0                                            |
| $\text{C}_6\text{H}_4\text{ClNO}_2$ | 1-Chloro-3-nitrobenzene    | 77.2                                            | $\text{C}_6\text{H}_{12}\text{O}$          | 4-Methyl-2-pentanone       | 69.7                                            |
| $\text{C}_6\text{H}_4\text{ClNO}_2$ | 1-Chloro-4-nitrobenzene    | 74.7                                            | $\text{C}_6\text{H}_{12}\text{O}$          | Cyclohexanol               | 73.4                                            |
| $\text{C}_6\text{H}_4\text{Cl}_2$   | <i>o</i> -Dichlorobenzene  | 84.4                                            | $\text{C}_6\text{H}_{12}\text{O}_2$        | Hexanoic acid              | 78.1                                            |
| $\text{C}_6\text{H}_4\text{Cl}_2$   | <i>m</i> -Dichlorobenzene  | 84.1                                            | $\text{C}_6\text{H}_{12}\text{O}_2$        | Isopentyl formate          | 78.4                                            |
| $\text{C}_6\text{H}_4\text{Cl}_2$   | <i>p</i> -Dichlorobenzene  | 81.7                                            | $\text{C}_6\text{H}_{12}\text{O}_2$        | Isobutyl acetate           | 78.7                                            |
| $\text{C}_6\text{H}_4\text{O}_2$    | <i>p</i> -Benzoquinone     | 36                                              | $\text{C}_6\text{H}_{12}\text{O}_2$        | Propyl propanoate          | 77.7                                            |
| $\text{C}_6\text{H}_5\text{Br}$     | Bromobenzene               | 78.4                                            | $\text{C}_6\text{H}_{12}\text{O}_3$        | Paraldehyde                | 86.1                                            |
| $\text{C}_6\text{H}_5\text{Cl}$     | Chlorobenzene              | 69.5                                            | $\text{C}_6\text{H}_{14}$                  | Hexane                     | 74.1                                            |
| $\text{C}_6\text{H}_5\text{ClO}$    | <i>o</i> -Chlorophenol     | 77.3                                            | $\text{C}_6\text{H}_{14}$                  | 2-Methylpentane            | 75.3                                            |
| $\text{C}_6\text{H}_5\text{ClO}$    | <i>m</i> -Chlorophenol     | 77.6                                            | $\text{C}_6\text{H}_{14}$                  | 3-Methylpentane            | 75.5                                            |
| $\text{C}_6\text{H}_5\text{ClO}$    | <i>p</i> -Chlorophenol     | 77.7                                            | $\text{C}_6\text{H}_{14}$                  | 2,2-Dimethylbutane         | 76.2                                            |
| $\text{C}_6\text{H}_5\text{F}$      | Fluorobenzene              | 58.4                                            | $\text{C}_6\text{H}_{14}$                  | 2,3-Dimethylbutane         | 76.2                                            |
| $\text{C}_6\text{H}_5\text{I}$      | Iodobenzene                | 92.0                                            | $\text{C}_6\text{H}_{14}\text{O}$          | 1-Hexanol                  | 79.5                                            |
| $\text{C}_6\text{H}_5\text{NO}_2$   | Nitrobenzene               | 61.9                                            | $\text{C}_6\text{H}_{14}\text{O}$          | 4-Methyl-2-pentanol        | 80.4                                            |
| $\text{C}_6\text{H}_5\text{NO}_3$   | <i>o</i> -Nitrophenol      | 68.9                                            | $\text{C}_6\text{H}_{14}\text{O}$          | Dipropyl ether             | 79.4                                            |
| $\text{C}_6\text{H}_5\text{NO}_3$   | <i>m</i> -Nitrophenol      | 65.9                                            | $\text{C}_6\text{H}_{14}\text{O}_2$        | 1,6-Hexanediol             | 84.3                                            |
| $\text{C}_6\text{H}_5\text{NO}_3$   | <i>p</i> -Nitrophenol      | 66.9                                            | $\text{C}_6\text{H}_{14}\text{O}_2$        | 1,1-Diethoxyethane         | 81.4                                            |
| $\text{C}_6\text{H}_6$              | Benzene                    | 54.8                                            | $\text{C}_6\text{H}_{14}\text{O}_6$        | <i>D</i> -Glucitol         | 107.8                                           |

| Molecular formula                   | Compound                                           | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Molecular formula                   | Compound                    | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|-------------------------------------|----------------------------------------------------|-------------------------------------------------|-------------------------------------|-----------------------------|-------------------------------------------------|
| $\text{C}_6\text{H}_{15}\text{N}$   | Triethylamine                                      | 83.3                                            | $\text{C}_7\text{H}_{16}$           | 3,3-Dimethylpentane         | 89.5                                            |
| $\text{C}_7\text{H}_5\text{N}$      | Benzonitrile                                       | 65.2                                            | $\text{C}_7\text{H}_{16}\text{O}$   | 1-Heptanol                  | 91.7                                            |
| $\text{C}_7\text{H}_6\text{O}$      | Benzaldehyde                                       | 60.7                                            | $\text{C}_7\text{H}_{16}\text{O}$   | 4-Heptanol                  | 92.1                                            |
| $\text{C}_7\text{H}_6\text{O}_2$    | Salicylaldehyde                                    | 66.8                                            | $\text{C}_8\text{H}_4\text{O}_3$    | Phthalic anhydride          | 66.7                                            |
| $\text{C}_7\text{H}_6\text{O}_3$    | Salicylic acid                                     | 75                                              | $\text{C}_8\text{H}_6\text{O}_4$    | Phthalic acid               | 83.6                                            |
| $\text{C}_7\text{H}_7\text{Br}$     | <i>p</i> -Bromotoluene                             | 88.7                                            | $\text{C}_8\text{H}_6\text{O}_4$    | Isophthalic acid            | 84.6                                            |
| $\text{C}_7\text{H}_7\text{Cl}$     | <i>o</i> -Chlorotoluene                            | 82.4                                            | $\text{C}_8\text{H}_6\text{O}_4$    | Terephthalic acid           | 83.5                                            |
| $\text{C}_7\text{H}_7\text{Cl}$     | <i>m</i> -Chlorotoluene                            | 79.7                                            | $\text{C}_8\text{H}_7\text{N}$      | Benzeneacetonitrile         | 76.9                                            |
| $\text{C}_7\text{H}_7\text{Cl}$     | <i>p</i> -Chlorotoluene                            | 80.3                                            | $\text{C}_8\text{H}_7\text{N}$      | Indole                      | 85.0                                            |
| $\text{C}_7\text{H}_7\text{Cl}$     | (Chloromethyl)benzene                              | 81.6                                            | $\text{C}_8\text{H}_8$              | Styrene                     | 68.2                                            |
| $\text{C}_7\text{H}_7\text{NO}$     | Benzamide                                          | 72.0                                            | $\text{C}_8\text{H}_8\text{O}$      | Acetophenone                | 72.5                                            |
| $\text{C}_7\text{H}_7\text{NO}_2$   | <i>o</i> -Nitrotoluene                             | 72.2                                            | $\text{C}_8\text{H}_8\text{O}_2$    | <i>o</i> -Toluic acid       | 84.3                                            |
| $\text{C}_7\text{H}_7\text{NO}_2$   | <i>m</i> -Nitrotoluene                             | 72.7                                            | $\text{C}_8\text{H}_8\text{O}_2$    | <i>m</i> -Toluic acid       | 83.0                                            |
| $\text{C}_7\text{H}_7\text{NO}_2$   | <i>p</i> -Nitrotoluene                             | 73.3                                            | $\text{C}_8\text{H}_8\text{O}_2$    | <i>p</i> -Toluic acid       | 82.4                                            |
| $\text{C}_7\text{H}_8$              | Toluene                                            | 65.6                                            | $\text{C}_8\text{H}_8\text{O}_2$    | Benzeneacetic acid          | 82.4                                            |
| $\text{C}_7\text{H}_8\text{O}$      | <i>o</i> -Cresol                                   | 73.3                                            | $\text{C}_8\text{H}_8\text{O}_2$    | Methyl benzoate             | 81.6                                            |
| $\text{C}_7\text{H}_8\text{O}$      | <i>m</i> -Cresol                                   | 72.2                                            | $\text{C}_8\text{H}_8\text{O}_3$    | Methyl salicylate           | 86.6                                            |
| $\text{C}_7\text{H}_8\text{O}$      | <i>p</i> -Cresol                                   | 72.4                                            | $\text{C}_8\text{H}_{10}$           | Ethylbenzene                | 77.3                                            |
| $\text{C}_7\text{H}_8\text{O}$      | Benzyl alcohol                                     | 71.8                                            | $\text{C}_8\text{H}_{10}$           | <i>o</i> -Xylene            | 77.7                                            |
| $\text{C}_7\text{H}_8\text{O}$      | Anisole                                            | 72.2                                            | $\text{C}_8\text{H}_{10}$           | <i>m</i> -Xylene            | 76.4                                            |
| $\text{C}_7\text{H}_9\text{N}$      | <i>o</i> -Methylaniline                            | 74.9                                            | $\text{C}_8\text{H}_{10}$           | <i>p</i> -Xylene            | 77.0                                            |
| $\text{C}_7\text{H}_9\text{N}$      | <i>m</i> -Methylaniline                            | 74.6                                            | $\text{C}_8\text{H}_{10}\text{O}$   | Phenetole                   | 84.5                                            |
| $\text{C}_7\text{H}_9\text{N}$      | <i>p</i> -Methylaniline                            | 72.5                                            | $\text{C}_8\text{H}_{11}\text{N}$   | <i>N</i> -Ethylaniline      | 85.6                                            |
| $\text{C}_7\text{H}_9\text{N}$      | <i>N</i> -Methylaniline                            | 74.1                                            | $\text{C}_8\text{H}_{11}\text{N}$   | <i>N,N</i> -Dimethylaniline | 85.1                                            |
| $\text{C}_7\text{H}_9\text{N}$      | 2,4-Dimethylpyridine                               | 71.3                                            | $\text{C}_8\text{H}_{11}\text{N}$   | 2,4,6-Trimethylpyridine     | 83.1                                            |
| $\text{C}_7\text{H}_9\text{N}$      | 2,6-Dimethylpyridine                               | 72.5                                            | $\text{C}_8\text{H}_{14}\text{O}_4$ | Ethyl succinate             | 105.0                                           |
| $\text{C}_7\text{H}_9\text{NO}$     | <i>o</i> -Methoxyaniline<br>[ <i>o</i> -Anisidine] | 79.1                                            | $\text{C}_8\text{H}_{16}$           | 1-Octene                    | 88.8                                            |
| $\text{C}_7\text{H}_{12}\text{O}_4$ | Diethyl malonate                                   | 92.6                                            | $\text{C}_8\text{H}_{16}$           | Cyclooctane                 | 85.3                                            |
| $\text{C}_7\text{H}_{14}$           | 1-Heptene                                          | 77.8                                            | $\text{C}_8\text{H}_{16}\text{O}_2$ | Octanoic acid               | 99.5                                            |
| $\text{C}_7\text{H}_{14}$           | Cycloheptane                                       | 73.9                                            | $\text{C}_8\text{H}_{16}\text{O}_2$ | Hexyl acetate               | 100.9                                           |
| $\text{C}_7\text{H}_{14}$           | Methylcyclohexane                                  | 78.9                                            | $\text{C}_8\text{H}_{17}\text{Cl}$  | 1-Chlorooctane              | 114.9                                           |
| $\text{C}_7\text{H}_{14}\text{O}$   | 1-Heptanal                                         | 81.0                                            | $\text{C}_8\text{H}_{18}$           | Octane                      | 96.6                                            |
| $\text{C}_7\text{H}_{14}\text{O}$   | 2-Heptanone                                        | 80.5                                            | $\text{C}_8\text{H}_{18}$           | 4-Methylheptane             | 97.3                                            |
| $\text{C}_7\text{H}_{14}\text{O}$   | 3-Heptanone                                        | 80.7                                            | $\text{C}_8\text{H}_{18}$           | 3-Ethylhexane               | 97.8                                            |
| $\text{C}_7\text{H}_{14}\text{O}$   | 4-Heptanone                                        | 80.5                                            | $\text{C}_8\text{H}_{18}$           | 3,4-Dimethylhexane          | 99.1                                            |
| $\text{C}_7\text{H}_{14}\text{O}$   | 2,4-Dimethyl-3-pentanone                           | 81.1                                            | $\text{C}_8\text{H}_{18}$           | 2,2,4-Trimethylpentane      | 99.1                                            |
| $\text{C}_7\text{H}_{14}\text{O}_2$ | Heptanoic acid                                     | 89.0                                            | $\text{C}_8\text{H}_{18}$           | 2,3,4-Trimethylpentane      | 99.8                                            |
| $\text{C}_7\text{H}_{14}\text{O}_2$ | Pentyl acetate                                     | 88.9                                            | $\text{C}_8\text{H}_{18}\text{O}$   | 1-Octanol                   | 101.6                                           |
| $\text{C}_7\text{H}_{14}\text{O}_2$ | Isopentyl acetate                                  | 89.4                                            | $\text{C}_8\text{H}_{19}\text{N}$   | Dibutylamine                | 103.7                                           |
| $\text{C}_7\text{H}_{14}\text{O}_2$ | Butyl propanoate                                   | 89.1                                            | $\text{C}_9\text{H}_7\text{N}$      | Quinoline                   | 86.1                                            |
| $\text{C}_7\text{H}_{14}\text{O}_2$ | Ethyl 3-methylbutanoate                            | 91.1                                            | $\text{C}_9\text{H}_7\text{N}$      | Isoquinoline                | 83.9                                            |
| $\text{C}_7\text{H}_{16}$           | Heptane                                            | 85.2                                            | $\text{C}_9\text{H}_8$              | Indene                      | 83                                              |
| $\text{C}_7\text{H}_{16}$           | 3-Ethylpentane                                     | 86.2                                            | $\text{C}_9\text{H}_{10}$           | Isopropenylbenzene          | 80.0                                            |
| $\text{C}_7\text{H}_{16}$           | 2,2-Dimethylpentane                                | 87.0                                            | $\text{C}_9\text{H}_{10}\text{O}_2$ | Ethyl benzoate              | 93.8                                            |
| $\text{C}_7\text{H}_{16}$           | 2,3-Dimethylpentane                                | 87.5                                            | $\text{C}_9\text{H}_{10}\text{O}_2$ | Benzyl acetate              | 93.2                                            |
| $\text{C}_7\text{H}_{16}$           | 2,4-Dimethylpentane                                | 87.5                                            | $\text{C}_9\text{H}_{12}$           | Propylbenzene               | 89.1                                            |

| Molecular formula                              | Compound                               | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Molecular formula                              | Compound                                        | $-\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|------------------------------------------------|----------------------------------------|-------------------------------------------------|------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| C <sub>9</sub> H <sub>12</sub>                 | Isopropylbenzene<br>[Cumene]           | 89.5                                            | C <sub>12</sub> H <sub>9</sub> N               | Carbazole                                       | 119.9                                           |
| C <sub>9</sub> H <sub>12</sub>                 | 1,3,5-Trimethylbenzene<br>[Mesitylene] | 92.3                                            | C <sub>12</sub> H <sub>10</sub>                | Acenaphthene                                    | 109.9                                           |
| C <sub>9</sub> H <sub>18</sub>                 | 1-Nonene                               | 100.1                                           | C <sub>12</sub> H <sub>10</sub>                | Biphenyl                                        | 103.3                                           |
| C <sub>9</sub> H <sub>18</sub> O               | 2,6-Dimethyl-4-heptanone               | 104.3                                           | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> | Azobenzene                                      | 106.8                                           |
| C <sub>9</sub> H <sub>20</sub>                 | Nonane                                 | 108.1                                           | C <sub>12</sub> H <sub>11</sub> N              | Diphenylamine                                   | 108.4                                           |
| C <sub>10</sub> H <sub>7</sub> Br              | 1-Bromonaphthalene                     | 123.6                                           | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub> | Diethyl phthalate                               | 127.5                                           |
| C <sub>10</sub> H <sub>7</sub> Cl              | 1-Chloronaphthalene                    | 107.6                                           | C <sub>12</sub> H <sub>18</sub>                | Hexamethylbenzene                               | 122.5                                           |
| C <sub>10</sub> H <sub>8</sub>                 | Naphthalene                            | 91.6                                            | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub> | Dodecanoic acid                                 | 113.0                                           |
| C <sub>10</sub> H <sub>8</sub>                 | Azulene                                | 123.7                                           | C <sub>13</sub> H <sub>9</sub> N               | Acridine                                        | 118.8                                           |
| C <sub>10</sub> H <sub>8</sub> O               | 1-Naphthol                             | 96.2                                            | C <sub>13</sub> H <sub>10</sub> O              | Benzophenone                                    | 109.6                                           |
| C <sub>10</sub> H <sub>8</sub> O               | 2-Naphthol                             | 96.8                                            | C <sub>13</sub> H <sub>12</sub>                | Diphenylmethane                                 | 116.0                                           |
| C <sub>10</sub> H <sub>9</sub> N               | 1-Naphthalenamine                      | 92.5                                            | C <sub>13</sub> H <sub>28</sub>                | Tridecane                                       | 153.7                                           |
| C <sub>10</sub> H <sub>9</sub> N               | 2-Naphthalenamine                      | 98.0                                            | C <sub>14</sub> H <sub>8</sub> O <sub>2</sub>  | 9,10-Anthracenedione                            | 113.0                                           |
| C <sub>10</sub> H <sub>10</sub> O <sub>2</sub> | Safrole                                | 97.5                                            | C <sub>14</sub> H <sub>10</sub>                | Anthracene                                      | 129.8                                           |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub> | Dimethyl terephthalate                 | 101.6                                           | C <sub>14</sub> H <sub>10</sub>                | Phenanthrene                                    | 127.6                                           |
| C <sub>10</sub> H <sub>14</sub>                | Butylbenzene                           | 100.7                                           | C <sub>14</sub> H <sub>10</sub>                | Diphenylacetylene                               | 116                                             |
| C <sub>10</sub> H <sub>14</sub>                | <i>tert</i> -Butylbenzene              | 101.8                                           | C <sub>14</sub> H <sub>10</sub> O <sub>2</sub> | Benzil                                          | 106.8                                           |
| C <sub>10</sub> H <sub>14</sub>                | Isobutylbenzene                        | 101.7                                           | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub> | Benzyl benzoate                                 | 132.2                                           |
| C <sub>10</sub> H <sub>14</sub>                | <i>p</i> -Cymene                       | 102.8                                           | C <sub>14</sub> H <sub>14</sub>                | 1,2-Diphenylethane                              | 127.8                                           |
| C <sub>10</sub> H <sub>14</sub>                | 1,2,4,5-Tetramethylbenzene             | 101.2                                           | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub> | Tetradecanoic acid<br>[Myristic acid]           | 176.0                                           |
| C <sub>10</sub> H <sub>14</sub> O              | <i>p-tert</i> -Butylphenol             | 108.0                                           | C <sub>14</sub> H <sub>30</sub>                | Tetradecane                                     | 166.2                                           |
| C <sub>10</sub> H <sub>15</sub> N              | <i>N,N</i> -Diethylaniline             | 107.9                                           | C <sub>16</sub> H <sub>10</sub>                | Pyrene                                          | 147                                             |
| C <sub>10</sub> H <sub>16</sub>                | <i>d</i> -Limonene                     | 98.0                                            | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub> | Hexadecanoic acid<br>[Palmitic acid]            | 198.6                                           |
| C <sub>10</sub> H <sub>16</sub>                | $\alpha$ -Pinene                       | 100.7                                           | C <sub>16</sub> H <sub>34</sub>                | Hexadecane                                      | 187.6                                           |
| C <sub>10</sub> H <sub>16</sub>                | $\beta$ -Pinene                        | 101.9                                           | C <sub>16</sub> H <sub>34</sub> O              | 1-Hexadecanol                                   | 183.5                                           |
| C <sub>10</sub> H <sub>16</sub> O              | Camphor, (+)                           | 103.0                                           | C <sub>18</sub> H <sub>12</sub>                | Chrysene                                        | 148.0                                           |
| C <sub>10</sub> H <sub>18</sub>                | <i>cis</i> -Decahydronaphthalene       | 107.0                                           | C <sub>18</sub> H <sub>14</sub>                | <i>o</i> -Terphenyl                             | 150.4                                           |
| C <sub>10</sub> H <sub>18</sub>                | <i>trans</i> -Decahydronaphthalene     | 107.6                                           | C <sub>18</sub> H <sub>14</sub>                | <i>m</i> -Terphenyl                             | 155.5                                           |
| C <sub>10</sub> H <sub>22</sub>                | Decane                                 | 119.5                                           | C <sub>18</sub> H <sub>14</sub>                | <i>p</i> -Terphenyl                             | 156.0                                           |
| C <sub>11</sub> H <sub>10</sub>                | 1-Methylnaphthalene                    | 102.9                                           | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub> | <i>cis</i> -9-Octadecenoic acid<br>[Oleic acid] | 208.5                                           |
| C <sub>11</sub> H <sub>10</sub>                | 2-Methylnaphthalene                    | 102.7                                           | C <sub>18</sub> H <sub>36</sub> O <sub>2</sub> | Octadecanoic acid<br>[Stearic acid]             | 220.8                                           |
| C <sub>11</sub> H <sub>24</sub>                | Undecane                               | 131.8                                           | C <sub>20</sub> H <sub>12</sub>                | Perylene                                        | 167.5                                           |
| C <sub>12</sub> H <sub>8</sub>                 | Acenaphthylene                         | 111.6                                           |                                                |                                                 |                                                 |

# THE ELEMENTS

C. R. Hammond

One of the most striking facts about the elements is their unequal distribution and occurrence in nature. Present knowledge of the chemical composition of the universe, obtained from the study of the spectra of stars and nebulae, indicates that hydrogen is by far the most abundant element and may account for more than 90% of the atoms or about 75% of the mass of the universe. Helium atoms make up most of the remainder. All of the other elements together contribute only slightly to the total mass.

The chemical composition of the universe is undergoing continuous change. Hydrogen is being converted into helium, and helium is being changed into heavier elements. As time goes on, the ratio of heavier elements increases relative to hydrogen. Presumably, the process is not reversible.

Burbidge, Burbidge, Fowler, and Hoyle, and more recently, Peebles, Penzias, and others have studied the synthesis of elements in stars. To explain all of the features of the nuclear abundance curve — obtained by studies of the composition of the earth, meteorites, stars, etc. — it is necessary to postulate that the elements were originally formed by at least eight different processes: (1) hydrogen burning, (2) helium burning, (3)  $\chi$  process, (4)  $e$  process, (5)  $s$  process, (6)  $r$  process, (7)  $p$  process, and (8) the X process. The X process is thought to account for the existence of light nuclei such as D, Li, Be, and B. Common metals such as Fe, Cr, Ni, Cu, Ti, Zn, etc. were likely produced early in the history of our galaxy. It is also probable that most of the heavy elements on Earth and elsewhere in the universe were originally formed in supernovae, or in the hot interior of stars.

Studies of the solar spectrum have led to the identification of 67 elements in the sun's atmosphere; however, all elements cannot be identified with the same degree of certainty. Other elements may be present in the sun, although they have not yet been detected spectroscopically. The element helium was discovered on the sun before it was found on Earth. Some elements such as scandium are relatively more plentiful in the sun and stars than here on Earth.

Minerals in lunar rocks brought back from the moon on the Apollo missions consist predominantly of *plagioclase*  $\{(Ca,Na)(Al,Si)O_4O_8\}$  and *pyroxene*  $\{(Ca,Mg,Fe)_2Si_2O_6\}$  — two minerals common in terrestrial volcanic rock. No new elements have been found on the moon that cannot be accounted for on Earth; however, three minerals, *armalcolite*  $\{(Fe,Mg)Ti_2O_5\}$ , *pyroxferroite*  $\{CaFe_6(SiO_3)_7\}$ , and *tranquillityite*  $\{Fe_8(Zr,Y)Ti_3Si_3O_{21}\}$ , are new. The oldest known terrestrial rocks are about 4 billion years old. One rock, known as the "Genesis Rock," brought back from the Apollo 15 Mission, is about 4.15 billion years old. This is only about one-half billion years younger than the supposed age of the moon and solar system. Lunar rocks appear to be relatively enriched in refractory elements such as chromium, titanium, zirconium, and the rare earths, and impoverished in volatile elements such as the alkali metals, in chlorine, and in noble metals such as nickel, platinum, and gold.

Even older than the "Genesis Rock" are *carbonaceous chondrites*, a type of meteorite that has fallen to Earth and has been studied. These are some of the most primitive objects of the solar system yet found. The grains making up these objects probably condensed directly out the gaseous nebula from which the sun and planets were born. Most of the condensation of the grains probably was completed within 50,000 years of the time the disk of the nebula was first formed — about 4.6 billion years ago. It is now thought that this type of meteorite may contain a small percentage

of presolar dust grains. The relative abundances of the elements of these meteorites are about the same as the abundances found in the solar chromosphere.

The X-ray fluorescent spectrometer sent with the Viking I spacecraft to Mars shows that the Martian soil contains about 12 to 16% iron, 14 to 15% silicon, 3 to 8% calcium, 2 to 7% aluminum, and one-half to 2% titanium. The gas chromatograph — mass spectrometer on Viking II found no trace of organic compounds.

F. W. Clarke and others have carefully studied the composition of rocks making up the crust of the earth. Oxygen accounts for about 47% of the crust, by weight, while silicon comprises about 28% and aluminum about 8%. These elements, plus iron, calcium, sodium, potassium, and magnesium, account for about 99% of the composition of the crust.

Many elements such as tin, copper, zinc, lead, mercury, silver, platinum, antimony, arsenic, and gold, which are so essential to our needs and civilization, are among some of the rarest elements in the earth's crust. These are made available to us only by the processes of concentration in ore bodies. Some of the so-called *rare-earth* elements have been found to be much more plentiful than originally thought and are about as abundant as uranium, mercury, lead, or bismuth. The least abundant rare-earth or *lanthanide* element, thulium, is now believed to be more plentiful on earth than silver, cadmium, gold, or iodine, for example. Rubidium, the 16th most abundant element, is more plentiful than chlorine while its compounds are little known in chemistry and commerce.

It is now thought that at least 24 elements are essential to living matter. The four most abundant in the human body are hydrogen, oxygen, carbon, and nitrogen. The seven next most common, in order of abundance, are calcium, phosphorus, chlorine, potassium, sulfur, sodium, and magnesium. Iron, copper, zinc, silicon, iodine, cobalt, manganese, molybdenum, fluorine, tin, chromium, selenium, and vanadium are needed and play a role in living matter. Boron is also thought essential for some plants, and it is possible that aluminum, nickel, and germanium may turn out to be necessary.

Ninety-one elements occur naturally on earth. Minute traces of plutonium-244 have been discovered in rocks mined in Southern California. This discovery supports the theory that heavy elements were produced during creation of the solar system. While technetium and promethium have not yet been found naturally on earth, they have been found to be present in stars. Technetium has been identified in the spectra of certain "late" type stars, and promethium lines have been identified in the spectra of a faintly visible star HR465 in Andromeda. Promethium must have been made near the star's surface for no known isotope of this element has a half-life longer than 17.7 years.

It has been suggested that californium is present in certain stellar explosions known as supernovae; however, this has not been proved. At present no elements are found elsewhere in the universe that cannot be accounted for here on earth.

All atomic mass numbers from 1 to 238 are found naturally on earth except for masses 5 and 8. About 285 relatively stable and 67 naturally radioactive isotopes occur on earth totaling 352. In addition, the neutron, technetium, promethium, and the transuranic elements (lying beyond uranium) have now been produced artificially. In June 1999, scientists at the Lawrence Berkeley National Laboratory reported that they had found evidence of an isotope of Element 118 and its immediate decay



products of Elements 116, 114, and 112. This sequence of events tended to reinforce the theory that was predicted since the 1970s that an “island of stability” existed for nuclei with approximately 114 protons and 184 neutrons. This “island” refers to nuclei in which the decay lasts for a period of time instead of a decay that occurs instantaneously. However, on July 27, 2001, researchers at LBNL reported that their laboratory and the facilities at the GSI Laboratory in Germany and at Japanese laboratories failed to confirm the results of their earlier experiments where the fusion of a krypton atom with a lead target resulted in Element 118, with chains of decay leading to Elements 116, 114, and 112, and on down to Element 106. Therefore, the discovery was reported to be spurious. However, with the announcement it was said that different experiments at the Livermore Laboratory and Joint Institute for Nuclear Research in Dubna, Russia indicated that Element 116 had since been created directly. (See also under Elements 116 and 118.)

Laboratory processes have now extended the radioactive element mass numbers beyond 238 to about 280. Each element from atomic numbers 1 to 110 is known to have at least one radioactive isotope. As of December 2001, about 3286 isotopes and isomers were thought to be known and recognized. Many stable and radioactive isotopes are now produced and distributed by the Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A., to customers licensed by the U.S. Department of Energy.

The nucleus of an atom is characterized by the number of protons it contains, denoted by  $Z$ , and by the number of neutrons,  $N$ . Isotopes of an element have the same value of  $Z$ , but different values of  $N$ . The *mass number*  $A$ , is the sum of  $Z$  and  $N$ . For example, Uranium-238 has a mass number of 238, and contains 92 protons and 146 neutrons.

There is evidence that the definition of chemical elements must be broadened to include the electron. Several compounds known as *electrides* have recently been made of alkaline metal elements and electrons. A relatively stable combination of a positron and electron, known as *positronium*, has also been studied.

The well-known proton, neutron, and electron are now thought to be members of a group that includes other fundamental particles that have been discovered or hypothesized by physicists. These very elemental particles, of which all matter is made, are now thought to belong to one of two families: namely, **quarks** or **leptons**. Each of these two families consists of six particles. Also, there are four different force carriers that lead to interactions between particles. The six members or “flavors” of the quark family are called **up**, **charm**, **top**, **down**, **strange**, and **bottom**. The force carriers for the quarks are the **gluon** and the **photon**. The six members of the lepton family are the **e neutrino**, the **mu neutrino**, the **tau neutrino**, the **electron**, the **muon particle**, and the **tau particle**. The force carriers for these are the **w boson** and the **z boson**. Furthermore, it appears that each of these particles has an anti-particle that has an opposite electrical charge from the above particles.

Quarks are not found individually, but are found with other quarks arranged to form composites known as **hadrons**. There are two basic types of hadrons: **baryons**, composed of three quarks, and **mesons**, composed of a quark and an anti-quark. Examples of baryons are the neutron and the proton. Neutrons are made of two down quarks and one up quark. Protons are made of two up quarks and one down quark. An example of the meson is the **pion**. This particle is made of an up quark and a down anti-quark. Such particles are unstable and tend to decay rapidly. The anti-particle of the proton is the anti-proton. The exception to the rule is the electron, whose anti-particle is the **positron**.

In recent years a search has been made for a hypothetical particle known as the **Higgs particle** or **Higgs boson**, suggested in 1966 by Peter Higgs of the University of Edinburgh, which could possibly explain why the carriers of the “electro-weak” field ( $w$  and  $z$  bosons) have mass. The Higgs particle is thought to be responsible possibly for the mass of objects throughout the universe.

Many physicists now hold that all matter and energy in the universe are controlled by four fundamental forces: the **electromagnetic force**, **gravity**, a **weak nuclear force**, and a **strong nuclear force**. The **gluon** binds quarks together by carrying the strong nuclear force. Each of these natural forces is passed back and forth among the basic particles of matter by the force carriers mentioned above. The electromagnetic force is carried by the photon, the weak nuclear force by the **intermediate vector boson**, and the gravity by the **graviton**.

For more complete information on these fundamental particles, please consult recent articles and books on nuclear or particle physics.

The available evidence leads to the conclusion that elements 89 (actinium) through 103 (lawrencium) are chemically similar to the rare-earth or lanthanide elements (elements 57 to 71, inclusive). These elements therefore have been named *actinides* after the first member of this series. Those elements beyond uranium that have been produced artificially have the following names and symbols: neptunium, 93 (Np); plutonium, 94 (Pu); americium, 95 (Am); curium, 96 (Cm); berkelium, 97 (Bk); californium, 98 (Cf); einsteinium, 99 (Es); fermium, 100 (Fm); mendelevium, 101 (Md); nobelium, 102 (No); lawrencium, 103 (Lr); rutherfordium, 104 (Rf); dubnium, 105 (Db); seaborgium, 106 (Sg); bohrium, 107 (Bh); hassium, 108 (Hs); meitnerium, 109 (Mt); darmstadtium, 110 (Ds); and roentgenium, 111 (Rg). As of 2005, evidence has been reported for elements 112, 113, 114, 115, 116, and 118, but these elements have not been officially recognized or named. IUPAC recommends that until the existence of a new element is proven to their satisfaction, the elements are to have names and symbols derived according to these precise and simple rules: The name is based on the digits in the element’s atomic number. Each digit is replaced with these expressions, with the end using the usual -ium suffix as follows: **0 nil, 1 un, 2 bi, 3 tri, 4 quad, 5 pent, 6 hex, 7 sept, 8 oct, 9 enn**. Double letter i’s are not used, as for example Ununbium, but would be Ununbium. The symbol used would be the first letter of the three main syllables. For example, Element 126 would be Unbihexium, with the symbol Ubh. (See J. Chatt, *Pure Appl. Chem.* 51, 381, 1979; W. H. Koppenol, *Pure Appl. Chem.* 74, 787, 2002.)

There are many claims in the literature of the existence of various allotropic modifications of the elements, some of which are based on doubtful or incomplete evidence. Also, the physical properties of an element may change drastically by the presence of small amounts of impurities. With new methods of purification, which are now able to produce elements with 99.9999% purity, it has been necessary to restudy the properties of the elements. For example, the melting point of thorium changes by several hundred degrees by the presence of a small percentage of  $\text{ThO}_2$  as an impurity. Ordinary commercial tungsten is brittle and can be worked only with difficulty. Pure tungsten, however, can be cut with a hacksaw, forged, spun, drawn, or extruded. In general, the value of a physical property given here applies to the pure element, when it is known.

Many of the chemical elements and their compounds are toxic and should be handled with due respect and care. In recent years there has been greatly increased knowledge and awareness of the health hazards associated with chemicals, radioactive materials,

and other agents. Anyone working with the elements and certain of their compounds should become thoroughly familiar with the proper safeguards to be taken. Information on specific hazards and recommended exposure limits may also be found in Section 16. Reference should also be made to publications such as the following:

1. *Code of Federal Regulations, Title 29, Labor*. With additions found in issues of the *Federal Register*.
2. *Code of Federal Regulations, Title 10, Energy*. With additions found in issues of the *Federal Register*. (Published by the U.S. Government Printing Office. Supt. of Documents.)
3. *Occupational Safety and Health Reporter* (latest edition with amendments and corrections), Bureau of National Affairs, Washington, D.C.
4. *Atomic Energy Law Reporter*, Commerce Clearing House, Chicago, IL.
5. *Nuclear Regulation Reporter*, Commerce Clearing House, Chicago, IL.
6. *TLVs® Threshold Limit Values for Chemical Substances and Physical Agents* is issued annually by the American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.
7. *The Sigma Aldrich Library of Regulatory and Safety Data*. Vol. 3, Robert E. Lenga and Kristine L. Volonpal, Sigma Chemical Co. and Aldrich Chemical Co., Inc. 1993.
8. *Hazardous Chemicals Desk Reference*, Richard J. Lewis, Sr., 4th ed., John Wiley & Sons, New York, 1997.
9. *Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens*, 3rd ed., Noyes Publications, 2001/2.
10. *Sax's Dangerous Properties of Industrial Materials*, Richard J. Lewis and N. Irving Sax, John Wiley & Sons, New York, 1999.
11. *World Wide Limits for Toxic and Hazardous Chemicals in Air, Water, and Soil*, Marshall Sittig, Noyes Publishers.

The prices of elements as indicated in this article are intended to be only a rough guide. Prices may vary, over time, widely with supplier, quantity, and purity.

The density of gases is given in grams per liter at 0°C and a pressure of 1 atm.

**Actinium** — (Gr. *aktis*, *aktinos*, beam or ray), Ac; at. wt. (227); at. no. 89; m.p. 1050°C, b.p. 3198°C; sp. gr. 10.07 (calc.). Discovered by Andre Debierne in 1899 and independently by F. Giesel in 1902. Occurs naturally in association with uranium minerals. Thirty-four isotopes and isomers are now recognized. All are radioactive. Actinium-227, a decay product of uranium-235, is an alpha and beta emitter with a 21.77-year half-life. Its principal decay products are thorium-227 (18.72-day half-life), radium-223 (11.4-day half-life), and a number of short-lived products including radon, bismuth, polonium, and lead isotopes. In equilibrium with its decay products, it is a powerful source of alpha rays. Actinium metal has been prepared by the reduction of actinium fluoride with lithium vapor at about 1100 to 1300°C. The chemical behavior of actinium is similar to that of the rare earths, particularly lanthanum. Purified actinium comes into equilibrium with its decay products at the end of 185 days, and then decays according to its 21.77-year half-life. It is about 150 times as active as radium, making it of value in the production of neutrons. Actinium-225, with a purity of 99%, is available from the Oak Ridge National

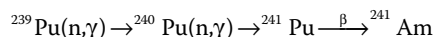
Laboratory to holders of a permit for about \$500/millicurie, plus packing charges.

**Aluminum** — (L. *alumen*, *alum*), Al; at. wt. 26.9815386(8); at. no. 13; m.p. 660.32°C; b.p. 2519°C; sp. gr. 2.6989 (20°C); valence 3. The ancient Greeks and Romans used *alum* in medicine as an astringent, and as a mordant in dyeing. In 1761 de Morveau proposed the name *alumine* for the base in alum, and Lavoisier, in 1787, thought this to be the oxide of a still undiscovered metal. Wohler is generally credited with having isolated the metal in 1827, although an impure form was prepared by Oersted two years earlier. In 1807, Davy proposed the name *aluminium* for the metal, undiscovered at that time, and later agreed to change it to *aluminum*. Shortly thereafter, the name *aluminium* was adopted to conform with the "ium" ending of most elements, and this spelling is now in use elsewhere in the world. *Aluminium* was also the accepted spelling in the U.S. until 1925, at which time the American Chemical Society officially decided to use the name *aluminum* thereafter in their publications. The method of obtaining aluminum metal by the electrolysis of alumina dissolved in *cryolite* was discovered in 1886 by Hall in the U.S. and at about the same time by Heroult in France. *Cryolite*, a natural ore found in Greenland, is no longer widely used in commercial production, but has been replaced by an artificial mixture of sodium, aluminum, and calcium fluorides. *Bauxite*, an impure hydrated oxide ore, is found in large deposits in Jamaica, Australia, Suriname, Guyana, Russia, Arkansas, and elsewhere. The Bayer process is most commonly used today to refine bauxite so it can be accommodated in the Hall-Heroult refining process used to make most aluminum. Aluminum can now be produced from clay, but the process is not economically feasible at present. Aluminum is the most abundant metal to be found in the Earth's crust (8.1%), but is never found free in nature. In addition to the minerals mentioned above, it is found in feldspars, granite, and in many other common minerals. Twenty-two isotopes and isomers are known. Natural aluminum is made of one isotope, <sup>27</sup>Al. Pure aluminum, a silvery-white metal, possesses many desirable characteristics. It is light, nontoxic, has a pleasing appearance, can easily be formed, machined, or cast, has a high thermal conductivity, and has excellent corrosion resistance. It is nonmagnetic and nonsparking, stands second among metals in the scale of malleability, and sixth in ductility. It is extensively used for kitchen utensils, outside building decoration, and in thousands of industrial applications where a strong, light, easily constructed material is needed. Although its electrical conductivity is only about 60% that of copper, it is used in electrical transmission lines because of its light weight. Pure aluminum is soft and lacks strength, but it can be alloyed with small amounts of copper, magnesium, silicon, manganese, and other elements to impart a variety of useful properties. These alloys are of vital importance in the construction of modern aircraft and rockets. Aluminum, evaporated in a vacuum, forms a highly reflective coating for both visible light and radiant heat. These coatings soon form a thin layer of the protective oxide and do not deteriorate as do silver coatings. They have found application in coatings for telescope mirrors, in making decorative paper, packages, toys, and in many other uses. The compounds of greatest importance are aluminum oxide, the sulfate, and the soluble sulfate with potassium (alum). The oxide, alumina, occurs naturally as ruby, sapphire, corundum, and emery, and is used in glassmaking and refractories. Synthetic ruby and sapphire have found application in the construction of lasers



for producing coherent light. In 1852, the price of aluminum was about \$1200/kg, and just before Hall's discovery in 1886, about \$25/kg. The price rapidly dropped to 60¢ and has been as low as 33¢/kg. The price in December 2001 was about 64¢/lb or \$1.40/kg.

**Americium** — (the Americas), Am; at. wt. 243; at. no. 95; m.p. 1176°C; b.p. 2011°C; sp. gr. 12; valence 2, 3, 4, 5, or 6. Americium was the fourth transuranium element to be discovered; the isotope  $^{241}\text{Am}$  was identified by Seaborg, James, Morgan, and Ghiorso late in 1944 at the wartime Metallurgical Laboratory of the University of Chicago as the result of successive neutron capture reactions by plutonium isotopes in a nuclear reactor:



Since the isotope  $^{241}\text{Am}$  can be prepared in relatively pure form by extraction as a decay product over a period of years from strongly neutron-bombarded plutonium,  $^{241}\text{Pu}$ , this isotope is used for much of the chemical investigation of this element. Better suited is the isotope  $^{243}\text{Am}$  due to its longer half-life ( $7.37 \times 10^3$  years as compared to 432.2 years for  $^{241}\text{Am}$ ). A mixture of the isotopes  $^{241}\text{Am}$ ,  $^{242}\text{Am}$ , and  $^{243}\text{Am}$  can be prepared by intense neutron irradiation of  $^{241}\text{Am}$  according to the reactions  $^{241}\text{Am}(n,\gamma) \rightarrow ^{242}\text{Am}(n,\gamma) \rightarrow ^{243}\text{Am}$ . Nearly isotopically pure,  $^{243}\text{Am}$  can be prepared by a sequence of neutron bombardments and chemical separations as follows: neutron bombardment of  $^{241}\text{Am}$  yields  $^{242}\text{Pu}$  by the reactions  $^{241}\text{Am}(n,\gamma) \rightarrow ^{242}\text{Am} \rightarrow ^{242}\text{Pu}$ , after chemical separation the  $^{242}\text{Pu}$  can be transformed to  $^{243}\text{Am}$  via the reactions  $^{242}\text{Pu}(n,\gamma) \rightarrow ^{243}\text{Pu} \rightarrow ^{243}\text{Am}$ , and the  $^{243}\text{Am}$  can be chemically separated. Fairly pure  $^{242}\text{Pu}$  can be prepared more simply by very intense neutron irradiation of  $^{239}\text{Pu}$  as the result of successive neutron-capture reactions. Seventeen radioactive isotopes and isomers are now recognized. Americium metal has been prepared by reducing the trifluoride with barium vapor at 1000 to 1200°C or the dioxide by lanthanum metal. The luster of freshly prepared americium metal is white and more silvery than plutonium or neptunium prepared in the same manner. It appears to be more malleable than uranium or neptunium and tarnishes slowly in dry air at room temperature. Americium is thought to exist in two forms: an alpha form which has a double hexagonal close-packed structure and a loose-packed cubic beta form. Americium must be handled with great care to avoid personal contamination. As little as 0.03  $\mu\text{Ci}$  of  $^{241}\text{Am}$  is the maximum permissible total body burden. The alpha activity from  $^{241}\text{Am}$  is about three times that of radium. When gram quantities of  $^{241}\text{Am}$  are handled, the intense gamma activity makes exposure a serious problem. Americium dioxide,  $\text{AmO}_2$ , is the most important oxide.  $\text{AmF}_3$ ,  $\text{AmF}_4$ ,  $\text{AmCl}_3$ ,  $\text{AmBr}_3$ ,  $\text{AmI}_3$ , and other compounds have been prepared. The isotope  $^{241}\text{Am}$  has been used as a portable source for gamma radiography. It has also been used as a radioactive glass thickness gage for the flat glass industry, and as a source of ionization for smoke detectors. Americium-243 (99%) is available from the Oak Ridge National Laboratory at a cost of about \$750/g plus packing charges.

**Antimony** — (Gr. *anti* plus *monos* - a metal not found alone), Sb; at. wt. 121.760(1); at. no. 51; m.p. 630.63°C; b.p. 1587°C; sp. gr. 6.68 (20°C); valence 0, -3, +3, or +5. Antimony was recognized in compounds by the ancients and was known as a metal at the beginning of the 17th century and possibly much earlier.

It is not abundant, but is found in over 100 mineral species. It is sometimes found native, but more frequently as the sulfide, *stibnite* ( $\text{Sb}_2\text{S}_3$ ); it is also found as antimonides of the heavy metals, and as oxides. It is extracted from the sulfide by roasting to the oxide, which is reduced by salt and scrap iron; from its oxides it is also prepared by reduction with carbon. Two allotropic forms of antimony exist: the normal stable, metallic form, and the amorphous gray form. The so-called explosive antimony is an ill-defined material always containing an appreciable amount of halogen; therefore, it no longer warrants consideration as a separate allotrope. The yellow form, obtained by oxidation of *stibine*,  $\text{SbH}_3$ , is probably impure, and is not a distinct form. Natural antimony is made of two stable isotopes,  $^{121}\text{Sb}$  and  $^{123}\text{Sb}$ . Forty-five other radioactive isotopes and isomers are now recognized. Metallic antimony is an extremely brittle metal of a flaky, crystalline texture. It is bluish white and has a metallic luster. It is not acted on by air at room temperature, but burns brilliantly when heated with the formation of white fumes of  $\text{Sb}_2\text{O}_3$ . It is a poor conductor of heat and electricity, and has a hardness of 3 to 3.5. Antimony, available commercially with a purity of 99.999 + %, is finding use in semiconductor technology for making infrared detectors, diodes, and Hall-effect devices. Commercial-grade antimony is widely used in alloys with percentages ranging from 1 to 20. It greatly increases the hardness and mechanical strength of lead. Batteries, antifriction alloys, type metal, small arms and tracer bullets, cable sheathing, and minor products use about half the metal produced. Compounds taking up the other half are oxides, sulfides, sodium antimonate, and antimony trichloride. These are used in manufacturing flame-proofing compounds, paints, ceramic enamels, glass, and pottery. Tartar emetic (hydrated potassium antimonyl tartrate) has been used in medicine. Antimony and many of its compounds are toxic. Antimony costs about \$1.30/kg for the commercial metal or about \$12/g (99.999%).

**Argon** — (Gr. *argos*, inactive), Ar; at. wt. 39.948(1); at. no. 18; m.p. -189.36°C; b.p. -185.85°C;  $t_c$  -122.28°C; density 1.7837 g/L. Its presence in air was suspected by Cavendish in 1785, discovered by Lord Rayleigh and Sir William Ramsay in 1894. The gas is prepared by fractionation of liquid air, the atmosphere containing 0.94% argon. The atmosphere of Mars contains 1.6% of  $^{40}\text{Ar}$  and 5 p.p.m. of  $^{36}\text{Ar}$ . Argon is two and one half times as soluble in water as nitrogen, having about the same solubility as oxygen. It is recognized by the characteristic lines in the red end of the spectrum. It is used in electric light bulbs and in fluorescent tubes at a pressure of about 400 Pa, and in filling photo tubes, glow tubes, etc. Argon is also used as an inert gas shield for arc welding and cutting, as a blanket for the production of titanium and other reactive elements, and as a protective atmosphere for growing silicon and germanium crystals. Argon is colorless and odorless, both as a gas and liquid. It is available in high-purity form. Commercial argon is available at a cost of about 3¢ per cubic foot. Argon is considered to be a very inert gas and is not known to form true chemical compounds, as do krypton, xenon, and radon. However, it does form a hydrate having a dissociation pressure of 105 atm at 0°C. Ion molecules such as  $(\text{ArKr})^+$ ,  $(\text{ArXe})^+$ ,  $(\text{NeAr})^+$  have been observed spectroscopically. Argon also forms a clathrate with  $\beta$ -hydroquinone. This clathrate is stable and can be stored for a considerable time, but a true chemical bond does not exist. Van der Waals' forces act to hold the argon. In August 2000, researchers at the University of Helsinki, Finland reported they made a new argon compound  $\text{HArF}$

by shining UV light on frozen argon that contained a small amount of HF. Naturally occurring argon is a mixture of three isotopes. Seventeen other radioactive isotopes are now known to exist. Commercial argon is priced at about \$70/300 cu. ft. or 8.5 cu. meters.

**Arsenic** — (L. *arsenicum*, Gr. *arsenikon*, yellow orpiment, identified with *arsenikos*, male, from the belief that metals were different sexes; Arabic, *Az-zernikh*, the orpiment from Persian *zerni-zar*, gold), As; at. wt. 74.92160(2); at. no. 33; valence -3, 0, +3 or +5. Elemental arsenic occurs in two solid modifications: yellow, and gray or metallic, with specific gravities of 1.97, and 5.75, respectively. Gray arsenic, the ordinary stable form, has a triple point of 817°C and sublimates at 616°C and has a critical temperature of 1400°C. Several other allotropic forms of arsenic are reported in the literature. It is believed that Albertus Magnus obtained the element in 1250 A.D. In 1649 Schroeder published two methods of preparing the element. It is found native, in the sulfides *realgar* and *orpiment*, as arsenides and sulfarsenides of heavy metals, as the oxide, and as arsenates. *Mispickel*, arsenopyrite, (FeSAs) is the most common mineral, from which on heating the arsenic sublimates leaving ferrous sulfide. The element is a steel gray, very brittle, crystalline, semimetallic solid; it tarnishes in air, and when heated is rapidly oxidized to arsenous oxide (As<sub>2</sub>O<sub>3</sub>) with the odor of garlic. Arsenic and its compounds are poisonous. Exposure to arsenic and its compounds should not exceed 0.01 mg/m<sup>3</sup> as elemental As during an 8-h work day. Arsenic is also used in bronzing, pyrotechny, and for hardening and improving the sphericity of shot. The most important compounds are white arsenic (As<sub>2</sub>O<sub>3</sub>), the sulfide, Paris green 3Cu(AsO<sub>2</sub>)<sub>2</sub>·Cu(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>2</sub>, calcium arsenate, and lead arsenate; the last three have been used as agricultural insecticides and poisons. Marsh's test makes use of the formation and ready decomposition of arsine (AsH<sub>3</sub>). Arsenic is available in high-purity form. It is finding increasing uses as a doping agent in solid-state devices such as transistors. Gallium arsenide is used as a laser material to convert electricity directly into coherent light. Natural arsenic is made of one isotope <sup>75</sup>As. Thirty other radioactive isotopes and isomers are known. Arsenic (99%) costs about \$75/50g. Purified arsenic (99.9995%) costs about \$50/g.

**Astatine** — (Gr. *astatos*, unstable), At; at. wt. (210); at. no. 85; m.p. 302°C; valence probably 1, 3, 5, or 7. Synthesized in 1940 by D. R. Corson, K. R. MacKenzie, and E. Segre at the University of California by bombarding bismuth with alpha particles. The longest-lived isotope, <sup>210</sup>At, has a half-life of only 8.1 hours. Thirty-six other isotopes and isomers are now known. Minute quantities of <sup>215</sup>At, <sup>218</sup>At, and <sup>219</sup>At exist in equilibrium in nature with naturally occurring uranium and thorium isotopes, and traces of <sup>217</sup>At are in equilibrium with <sup>233</sup>U and <sup>239</sup>Np resulting from interaction of thorium and uranium with naturally produced neutrons. The total amount of astatine present in the Earth's crust, however, is probably less than 1 oz. Astatine can be produced by bombarding bismuth with energetic alpha particles to obtain the relatively long-lived <sup>209-211</sup>At, which can be distilled from the target by heating it in air. Only about 0.05 µg of astatine has been prepared to date. The "time of flight" mass spectrometer has been used to confirm that this highly radioactive halogen behaves chemically very much like other halogens, particularly iodine. The interhalogen compounds AtI, AtBr, and AtCl are known to form, but it is not yet known if astatine forms diatomic astatine mol-

ecules. HAt and CH<sub>3</sub>At (methyl astatide) have been detected. Astatine is said to be more metallic than iodine, and, like iodine, it probably accumulates in the thyroid gland.

**Barium** — (Gr. *barys*, heavy), Ba; at. wt. 137.327(7), at. no. 56; m.p. 727°C; b.p. 1897°C; sp. gr. 3.62 (20°C); valence 2. Baryta was distinguished from lime by Scheele in 1774; the element was discovered by Sir Humphrey Davy in 1808. It is found only in combination with other elements, chiefly in *barite* or *heavy spar* (sulfate) and *witherite* (carbonate) and is prepared by electrolysis of the chloride. Large deposits of barite are found in China, Germany, India, Morocco, and in the U.S. Barium is a metallic element, soft, and when pure is silvery white like lead; it belongs to the alkaline earth group, resembling calcium chemically. The metal oxidizes very easily and should be kept under petroleum or other suitable oxygen-free liquids to exclude air. It is decomposed by water or alcohol. The metal is used as a "getter" in vacuum tubes. The most important compounds are the peroxide (BaO<sub>2</sub>), chloride, sulfate, carbonate, nitrate, and chlorate. Lithopone, a pigment containing barium sulfate and zinc sulfide, has good covering power, and does not darken in the presence of sulfides. The sulfate, as permanent white or *blanc fixe*, is also used in paint, in X-ray diagnostic work, and in glassmaking. *Barite* is extensively used as a weighting agent in oilwell drilling fluids, and also in making rubber. The carbonate has been used as a rat poison, while the nitrate and chlorate give green colors in pyrotechny. The impure sulfide phosphoresces after exposure to the light. The compounds and the metal are not expensive. Barium metal (99.2 + % pure) costs about \$3/g. All barium compounds that are water or acid soluble are poisonous. Naturally occurring barium is a mixture of seven stable isotopes. Thirty-six other radioactive isotopes and isomers are known to exist.

**Berkelium** — (*Berkeley*, home of the University of California), Bk; at. wt. (247); at. no. 97; m.p. 996°C; valence 3 or 4; sp. gr. 14 (est.). Berkelium, the eighth member of the actinide transition series, was discovered in December 1949 by Thompson, Ghiorso, and Seaborg, and was the fifth transuranium element synthesized. It was produced by cyclotron bombardment of milligram amounts of <sup>241</sup>Am with helium ions at Berkeley, California. The first isotope produced had a mass number of 243 and decayed with a half-life of 4.5 hours. Thirteen isotopes are now known and have been synthesized. The existence of <sup>249</sup>Bk, with a half-life of 320 days, makes it feasible to isolate berkelium in weighable amounts so that its properties can be investigated with macroscopic quantities. One of the first visible amounts of a pure berkelium compound, berkelium chloride, was produced in 1962. It weighed 3 billionth of a gram. Berkelium probably has not yet been prepared in elemental form, but it is expected to be a silvery metal, easily soluble in dilute mineral acids, and readily oxidized by air or oxygen at elevated temperatures to form the oxide. X-ray diffraction methods have been used to identify the following compounds: BkO<sub>2</sub>, BkO<sub>3</sub>, BkF<sub>3</sub>, BkCl, and BkOCl. As with other actinide elements, berkelium tends to accumulate in the skeletal system. The maximum permissible body burden of <sup>249</sup>Bk in the human skeleton is about 0.0004 µg. Because of its rarity, berkelium presently has no commercial or technological use. Berkelium most likely resembles terbium with respect to chemical properties. Berkelium-249 is available from O.R.N.L. at a cost of \$185/µg plus packing charges.

**Beryllium** — (Gr. *beryllos*, *beryl*; also called Glucinium or Glucinum, Gr. *glykys*, sweet), Be; at. wt. 9.012182(3); at. no. 4; m.p. 1287°C; b.p. 2471°C; sp. gr. 1.848 (20°C); valence 2. Discovered as the oxide by Vauquelin in beryl and in emeralds in 1798. The metal was isolated in 1828 by Wohler and by Bussy independently by the action of potassium on beryllium chloride. Beryllium is found in some 30 mineral species, the most important of which are *bertrandite*, *beryl*, *chrysoberyl*, and *phenacite*. *Aquamarine* and *emerald* are precious forms of *beryl*. Beryllium minerals are found in the U.S., Brazil, Russia, Kazakhstan, and elsewhere. Colombia is known for its emeralds. *Beryl* ( $3\text{BeO} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$ ) and *bertrandite* ( $4\text{BeO} \cdot 2\text{SiO}_2 \cdot \text{H}_2\text{O}$ ) are the most important commercial sources of the element and its compounds. Most of the metal is now prepared by reducing beryllium fluoride with magnesium metal. Beryllium metal did not become readily available to industry until 1957. The metal, steel gray in color, has many desirable properties. It is one of the lightest of all metals, and has one of the highest melting points of the light metals. Its modulus of elasticity is about one third greater than that of steel. It resists attack by concentrated nitric acid, has excellent thermal conductivity, and is nonmagnetic. It has a high permeability to X-rays, and when bombarded by alpha particles, as from radium or polonium, neutrons are produced in the ratio of about 30 neutrons/million alpha particles. At ordinary temperatures beryllium resists oxidation in air, although its ability to scratch glass is probably due to the formation of a thin layer of the oxide. Beryllium is used as an alloying agent in producing beryllium copper, which is extensively used for springs, electrical contacts, spot-welding electrodes, and nonsparking tools. It has found application as a structural material for high-speed aircraft, missiles, spacecraft, and communication satellites. It is being used in the windshield frame, brake discs, support beams, and other structural components of the space shuttle. Because beryllium is relatively transparent to X-rays, ultra-thin Be-foil is finding use in X-ray lithography for reproduction of microminiature integrated circuits. Natural beryllium is made of  $^9\text{Be}$  and is stable. Eight other radioactive isotopes are known.

Beryllium is used in nuclear reactors as a reflector or moderator for it has a low thermal neutron absorption cross section. It is used in gyroscopes, computer parts, and instruments where lightness, stiffness, and dimensional stability are required. The oxide has a very high melting point and is also used in nuclear work and ceramic applications. Beryllium and its salts are toxic and should be handled with the greatest of care. Beryllium and its compounds should not be tasted to verify the sweetish nature of beryllium (as did early experimenters). The metal, its alloys, and its salts can be handled safely if certain work codes are observed, but no attempt should be made to work with beryllium before becoming familiar with proper safeguards. Beryllium metal is available at a cost of about \$5/g (99.5% pure).

**Bismuth** — (Ger. *Weisse Masse*, white mass; later *Wisuth* and *Bisemutum*), Bi; at. wt. 208.98040(1); at. no. 83; m.p. 271.4°C; b.p. 1564°C; sp. gr. 9.79 (20°C); valence 3 or 5. In early times bismuth was confused with tin and lead. Claude Geoffroy the Younger showed it to be distinct from lead in 1753. It is a white crystalline, brittle metal with a pinkish tinge. It occurs native. The most important ores are *bismuthinite* or bismuth glance ( $\text{Bi}_2\text{S}_3$ ) and *bismite* ( $\text{Bi}_2\text{O}_3$ ). Peru, Japan, Mexico, Bolivia, and Canada are major bismuth producers. Much of the bismuth produced in the U.S. is obtained as a by-product in refining

lead, copper, tin, silver, and gold ores. Bismuth is the most diamagnetic of all metals, and the thermal conductivity is lower than any metal, except mercury. It has a high electrical resistance, and has the highest Hall effect of any metal (i.e., greatest increase in electrical resistance when placed in a magnetic field). "Bismanol" is a permanent magnet of high coercive force, made of MnBi, by the U.S. Naval Surface Weapons Center. Bismuth expands 3.32% on solidification. This property makes bismuth alloys particularly suited to the making of sharp castings of objects subject to damage by high temperatures. With other metals such as tin, cadmium, etc., bismuth forms low-melting alloys that are extensively used for safety devices in fire detection and extinguishing systems. Bismuth is used in producing malleable irons and is finding use as a catalyst for making acrylic fibers. When bismuth is heated in air it burns with a blue flame, forming yellow fumes of the oxide. The metal is also used as a thermocouple material, and has found application as a carrier for  $\text{U}^{235}$  or  $\text{U}^{233}$  fuel in atomic reactors. Its soluble salts are characterized by forming insoluble basic salts on the addition of water, a property sometimes used in detection work. Bismuth oxychloride is used extensively in cosmetics. Bismuth subnitrate and subcarbonate are used in medicine. Natural bismuth contains only one isotope  $^{209}\text{Bi}$ . Forty-four isotopes and isomers of bismuth are known. Bismuth metal (99.5%) costs about \$250/kg.

**Bohrium** — (Named after Niels Bohr [1885–1962], Danish atomic and nuclear physicist.) Bh; at. wt. [264]. at. no. 107. Bohrium is expected to have chemical properties similar to rhenium. This element was synthesized and unambiguously identified in 1981 using the Universal Linear Accelerator (UNILAC) at the Gesellschaft für Schwerionenforschung (G.S.I.) in Darmstadt, Germany. The discovery team was led by Armbruster and Münzenberg. The reaction producing the element was proposed and applied earlier by a Dubna Group led by Oganessian in 1976. A target of  $^{209}\text{Bi}$  was bombarded by a beam of  $^{54}\text{Cr}$  ions. In 1983 experiments at Dubna using the 157-inch cyclotron, produced  $^{262}107$  by the reaction  $^{209}\text{Bi} + ^{54}\text{Cr}$ . The alpha decay of  $^{246}\text{Cf}$ , the sixth member in the decay chain of  $^{262}107$ , served to establish a 1-neutron reaction channel. The IUPAC adopted the name **Bohrium** with the symbol Bh for Element 107 in August 1997. Five isotopes of bohrium are now recognized. One isotope of bohrium appears to have a relatively long life of 15 seconds. Work on this relatively long-lived isotope has been performed with the 88-inch cyclotron at the Lawrence-Berkeley National Laboratory.

**Boron** — (Ar. *Buraq*, Pers. *Burah*), B; at. wt. 10.811(7); at. no. 5; m.p. 2075°C; b.p. 4000°C; sp. gr. of crystals 2.34, of amorphous variety 2.37; valence 3. Boron compounds have been known for thousands of years, but the element was not discovered until 1808 by Sir Humphry Davy and by Gay-Lussac and Thenard. The element is not found free in nature, but occurs as orthoboric acid usually in certain volcanic spring waters and as borates in *borax* and *colemanite*. *Ulexite*, another boron mineral, is interesting as it is nature's own version of "fiber optics." Important sources of boron are the ores *rasorite* (*kernite*) and *tincal* (*borax ore*). Both of these ores are found in the Mojave Desert. *Tincal* is the most important source of boron from the Mojave. Extensive *borax* deposits are also found in Turkey. Boron exists naturally as 19.9%  $^{10}\text{B}$  isotope and 80.1%  $^{11}\text{B}$  isotope. Ten other isotopes of boron are known. High-purity crystalline boron may be prepared by the vapor phase reduction of boron trichloride or tribromide with hydrogen on



electrically heated filaments. The impure, or amorphous, boron, a brownish-black powder, can be obtained by heating the trioxide with magnesium powder. Boron of 99.9999% purity has been produced and is available commercially. Elemental boron has an energy band gap of 1.50 to 1.56 eV, which is higher than that of either silicon or germanium. It has interesting optical characteristics, transmitting portions of the infrared, and is a poor conductor of electricity at room temperature, but a good conductor at high temperature. Amorphous boron is used in pyrotechnic flares to provide a distinctive green color, and in rockets as an igniter. By far the most commercially important boron compound in terms of dollar sales is  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$ . This pentahydrate is used in very large quantities in the manufacture of insulation fiberglass and sodium perborate bleach. Boric acid is also an important boron compound with major markets in textile fiberglass and in cellulose insulation as a flame retardant. Next in order of importance is borax ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ) which is used principally in laundry products. Use of borax as a mild antiseptic is minor in terms of dollars and tons. Boron compounds are also extensively used in the manufacture of borosilicate glasses. The isotope boron-10 is used as a control for nuclear reactors, as a shield for nuclear radiation, and in instruments used for detecting neutrons. Boron nitride has remarkable properties and can be used to make a material as hard as diamond. The nitride also behaves like an electrical insulator but conducts heat like a metal. It also has lubricating properties similar to graphite. The hydrides are easily oxidized with considerable energy liberation, and have been studied for use as rocket fuels. Demand is increasing for boron filaments, a high-strength, lightweight material chiefly employed for advanced aerospace structures. Boron is similar to carbon in that it has a capacity to form stable covalently bonded molecular networks. Carboranes, metalboranes, phosphacarboranes, and other families comprise thousands of compounds. Crystalline boron (99.5%) costs about \$6/g. Amorphous boron (94–96%) costs about \$1.50/g. Elemental boron and the borates are not considered to be toxic, and they do not require special care in handling. However, some of the more exotic boron hydrogen compounds are definitely toxic and do require care.

**Bromine** — (Gr. *bromos*, stench), Br; at. wt. 79.904(1); at. no. 35; m.p.  $-7.2^\circ\text{C}$ ; b.p.  $58.8^\circ\text{C}$ ;  $t_c$   $315^\circ\text{C}$ ; density of gas 7.59 g/l, liquid 3.12 ( $20^\circ\text{C}$ ); valence 1, 3, 5, or 7. Discovered by Balard in 1826, but not prepared in quantity until 1860. A member of the halogen group of elements, it is obtained from natural brines from wells in Michigan and Arkansas. Little bromine is extracted today from seawater, which contains only about 85 ppm. Bromine is the only liquid nonmetallic element. It is a heavy, mobile, reddish-brown liquid, volatilizing readily at room temperature to a red vapor with a strong disagreeable odor, resembling chlorine, and having a very irritating effect on the eyes and throat; it is readily soluble in water or carbon disulfide, forming a red solution, is less active than chlorine but more so than iodine; it unites readily with many elements and has a bleaching action; when spilled on the skin it produces painful sores. It presents a serious health hazard, and maximum safety precautions should be taken when handling it. Much of the bromine output in the U.S. was used in the production of ethylene dibromide, a lead scavenger used in making gasoline antiknock compounds. Lead in gasoline, however, has been drastically reduced, due to environmental considerations. This will greatly affect future production of bromine. Bromine is also used in making fumigants,

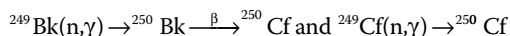
flameproofing agents, water purification compounds, dyes, medicinals, sanitizers, inorganic bromides for photography, etc. Organic bromides are also important. Natural bromine is made of two isotopes,  $^{79}\text{Br}$  and  $^{81}\text{Br}$ . Thirty-four isotopes and isomers are known. Bromine (99.8%) costs about \$70/kg.

**Cadmium** — (L. *cadmia*; Gr. *kadmeia* - ancient name for calamine, zinc carbonate), Cd; at. wt. 112.411(8); at. no. 48; m.p.  $321.07^\circ\text{C}$ ; b.p.  $767^\circ\text{C}$ ; sp. gr. 8.69 ( $20^\circ\text{C}$ ); valence 2. Discovered by Stromeyer in 1817 from an impurity in zinc carbonate. Cadmium most often occurs in small quantities associated with zinc ores, such as *sphalerite* ( $\text{ZnS}$ ). *Greenockite* ( $\text{CdS}$ ) is the only mineral of any consequence bearing cadmium. Almost all cadmium is obtained as a by-product in the treatment of zinc, copper, and lead ores. It is a soft, bluish-white metal which is easily cut with a knife. It is similar in many respects to zinc. It is a component of some of the lowest melting alloys; it is used in bearing alloys with low coefficients of friction and great resistance to fatigue; it is used extensively in electroplating, which accounts for about 60% of its use. It is also used in many types of solder, for standard E.M.F. cells, for Ni-Cd batteries, and as a barrier to control atomic fission. The market for Ni-Cd batteries is expected to grow significantly. Cadmium compounds are used in black and white television phosphors and in blue and green phosphors for color TV tubes. It forms a number of salts, of which the sulfate is most common; the sulfide is used as a yellow pigment. Cadmium and solutions of its compounds are toxic. Failure to appreciate the toxic properties of cadmium may cause workers to be unwittingly exposed to dangerous fumes. Some silver solders, for example, contain cadmium and should be handled with care. Serious toxicity problems have been found from long-term exposure and work with cadmium plating baths. Cadmium is present in certain phosphate rocks. This has raised concerns that the long-term use of certain phosphate fertilizers might pose a health hazard from levels of cadmium that might enter the food chain. In 1927 the International Conference on Weights and Measures redefined the meter in terms of the wavelength of the red cadmium spectral line (i.e.,  $1\text{ m} = 1,553,164.13$  wavelengths). This definition has been changed (see under Krypton). The current price of cadmium is about 50¢/g (99.5%). It is available in high purity form for about \$550/kg. Natural cadmium is made of eight isotopes. Thirty-four other isotopes and isomers are now known and recognized.

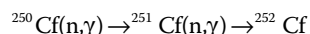
**Calcium** — (L. *calx*, lime), Ca; at. wt. 40.078(4); at. no. 20; m.p.  $842^\circ\text{C}$ ; b.p.  $1484^\circ\text{C}$ ; sp. gr. 1.54 ( $20^\circ\text{C}$ ); valence 2. Though lime was prepared by the Romans in the first century under the name *calx*, the metal was not discovered until 1808. After learning that Berzelius and Pontin prepared calcium amalgam by electrolyzing lime in mercury, Davy was able to isolate the impure metal. Calcium is a metallic element, fifth in abundance in the Earth's crust, of which it forms more than 3%. It is an essential constituent of leaves, bones, teeth, and shells. Never found in nature uncombined, it occurs abundantly as *limestone* ( $\text{CaCO}_3$ ), *gypsum* ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ), and *fluorite* ( $\text{CaF}_2$ ); *apatite* is the fluorophosphate or chlorophosphate of calcium. The metal has a silvery color, is rather hard, and is prepared by electrolysis of the fused chloride to which calcium fluoride is added to lower the melting point. Chemically it is one of the alkaline earth elements; it readily forms a white coating of oxide in air, reacts with water, burns with a yellow-red flame, largely forming the oxide. The metal is used as a reducing agent in preparing other metals such as thorium,

uranium, zirconium, etc., and is used as a deoxidizer, desulfurizer, and inclusion modifier for various ferrous and nonferrous alloys. It is also used as an alloying agent for aluminum, beryllium, copper, lead, and magnesium alloys, and serves as a "getter" for residual gases in vacuum tubes. Its natural and prepared compounds are widely used. Quicklime ( $\text{CaO}$ ), made by heating limestone and changed into slaked lime by the careful addition of water, is the great cheap base of the chemical industry with countless uses. Mixed with sand it hardens as mortar and plaster by taking up carbon dioxide from the air. Calcium from limestone is an important element in Portland cement. The solubility of the carbonate in water containing carbon dioxide causes the formation of caves with stalactites and stalagmites and is responsible for hardness in water. Other important compounds are the carbide ( $\text{CaC}_2$ ), chloride ( $\text{CaCl}_2$ ), cyanamide ( $\text{CaCN}_2$ ), hypochlorite ( $\text{Ca(OCl)}_2$ ), nitrate ( $\text{Ca(NO}_3)_2$ ), and sulfide ( $\text{CaS}$ ). Calcium sulfide is phosphorescent after being exposed to light. Natural calcium contains six isotopes. Sixteen other radioactive isotopes are known. Metallic calcium (99.5%) costs about \$200/kg.

**Californium** — (State and University of California), Cf; at. wt. (251); m.p.  $900^\circ\text{C}$ ; sp. gr. 15.1; at. no. 98. Californium, the sixth transuranium element to be discovered, was produced by Thompson, Street, Ghioirso, and Seaborg in 1950 by bombarding microgram quantities of  $^{242}\text{Cm}$  with 35 MeV helium ions in the Berkeley 60-inch cyclotron. Californium (III) is the only ion stable in aqueous solutions, all attempts to reduce or oxidize californium (III) having failed. The isotope  $^{249}\text{Cf}$  results from the beta decay of  $^{249}\text{Bk}$  while the heavier isotopes are produced by intense neutron irradiation by the reactions:



followed by



The existence of the isotopes  $^{249}\text{Cf}$ ,  $^{250}\text{Cf}$ ,  $^{251}\text{Cf}$ , and  $^{252}\text{Cf}$  makes it feasible to isolate californium in weighable amounts so that its properties can be investigated with macroscopic quantities. Californium-252 is a very strong neutron emitter. One microgram releases 170 million neutrons per minute, which presents biological hazards. Proper safeguards should be used in handling californium. Twenty isotopes of californium are now recognized.  $^{249}\text{Cf}$  and  $^{252}\text{Cf}$  have half-lives of 351 years and 900 years, respectively. In 1960 a few tenths of a microgram of californium trichloride,  $\text{CfCl}_3$ , californium oxychloride,  $\text{CfOCl}$ , and californium oxide,  $\text{Cf}_2\text{O}_3$ , were first prepared. Reduction of californium to its metallic state has not yet been accomplished. Because californium is a very efficient source of neutrons, many new uses are expected for it. It has already found use in neutron moisture gages and in well-logging (the determination of water and oil-bearing layers). It is also being used as a portable neutron source for discovery of metals such as gold or silver by on-the-spot activation analysis.  $^{252}\text{Cf}$  is now being offered for sale by the Oak Ridge National Laboratory (O.R.N.L.) at a cost of \$60/ $\mu\text{g}$  and  $^{249}\text{Cf}$  at a cost of \$185/ $\mu\text{g}$  plus packing charges. It has been suggested that californium may be produced in certain stellar explosions, called *supernovae*, for the radioactive decay of  $^{254}\text{Cf}$  (55-day half-life) agrees with the characteristics of the light curves of such explosions observed through telescopes. This suggestion, however, is

questioned. Californium is expected to have chemical properties similar to dysprosium.

**Carbon** — (L. *carbo*, charcoal), C; at. wt. 12.0107(8); at. no. 6; sublimes at  $3825^\circ\text{C}$ ; triple point (graphite-liquid-gas),  $4489^\circ\text{C}$ ; sp. gr. amorphous 1.8 to 2.1, graphite 1.9 to 2.3, diamond 3.15 to 3.53 (depending on variety); gem diamond  $3.513 (25^\circ\text{C})$ ; valence 2, 3, or 4. Carbon, an element of prehistoric discovery, is very widely distributed in nature. It is found in abundance in the sun, stars, comets, and atmospheres of most planets. Carbon in the form of microscopic diamonds is found in some meteorites. Natural diamonds are found in *kimberlite* or *lamproite* of ancient formations called "pipes," such as found in South Africa, Arkansas, and elsewhere. Diamonds are now also being recovered from the ocean floor off the Cape of Good Hope. About 30% of all industrial diamonds used in the U.S. are now made synthetically. The energy of the sun and stars can be attributed at least in part to the well-known carbon-nitrogen cycle. Carbon is found free in nature in three allotropic forms: amorphous, graphite, and diamond. Graphite is one of the softest known materials while diamond is one of the hardest. Graphite exists in two forms: alpha and beta. These have identical physical properties, except for their crystal structure. Naturally occurring graphites are reported to contain as much as 30% of the rhombohedral (beta) form, whereas synthetic materials contain only the alpha form. The hexagonal alpha type can be converted to the beta by mechanical treatment, and the beta form reverts to the alpha on heating it above  $1000^\circ\text{C}$ . Of recent interest is the discovery of all-carbon molecules, known as "buckyballs" or fullerenes, which have a number of unusual properties. These interesting molecules, consisting of 60 or 70 carbon atoms linked together, seem capable of withstanding great pressure and trapping foreign atoms inside their network of carbon. They are said to be capable of magnetism and superconductivity and have potential as a nonlinear optical material. Buckyball films are reported to remain superconductive at temperatures as high as 45 K. In combination, carbon is found as carbon dioxide in the atmosphere of the Earth and dissolved in all natural waters. It is a component of great rock masses in the form of carbonates of calcium (limestone), magnesium, and iron. Coal, petroleum, and natural gas are chiefly hydrocarbons. Carbon is unique among the elements in the vast number and variety of compounds it can form. With hydrogen, oxygen, nitrogen, and other elements, it forms a very large number of compounds, carbon atom often being linked to carbon atom. There are close to ten million known carbon compounds, many thousands of which are vital to organic and life processes. Without carbon, the basis for life would be impossible. While it has been thought that silicon might take the place of carbon in forming a host of similar compounds, it is now not possible to form stable compounds with very long chains of silicon atoms. The atmosphere of Mars contains 96.2%  $\text{CO}_2$ . Some of the most important compounds of carbon are carbon dioxide ( $\text{CO}_2$ ), carbon monoxide ( $\text{CO}$ ), carbon disulfide ( $\text{CS}_2$ ), chloroform ( $\text{CHCl}_3$ ), carbon tetrachloride ( $\text{CCl}_4$ ), methane ( $\text{CH}_4$ ), ethylene ( $\text{C}_2\text{H}_4$ ), acetylene ( $\text{C}_2\text{H}_2$ ), benzene ( $\text{C}_6\text{H}_6$ ), ethyl alcohol ( $\text{C}_2\text{H}_5\text{OH}$ ), acetic acid ( $\text{CH}_3\text{COOH}$ ), and their derivatives. Carbon has fifteen isotopes. Natural carbon consists of 98.89%  $^{12}\text{C}$  and 1.11%  $^{13}\text{C}$ . In 1961 the International Union of Pure and Applied Chemistry adopted the isotope carbon-12 as the basis for atomic weights. Carbon-14, an isotope with a half-life of 5715 years, has been widely used to date such materials as wood, archeological specimens, etc. A new brittle form of car-

bon, known as “glassy carbon,” has been developed. It can be obtained with high purity. It has a high resistance to corrosion, has good thermal stability, and is structurally impermeable to both gases and liquids. It has a randomized structure, making it useful in ultra-high technology applications, such as crystal growing, crucibles for high-temperature use, etc. Glassy carbon is available at a cost of about \$35/10g. Fullerene powder is available at a cost of about \$55/10mg (99% $C_{10}$ ). Diamond powder (99.9%) costs about \$40/g.

**Cerium** — (named for the asteroid *Ceres*, which was discovered in 1801 only 2 years before the element), Ce; at. wt. 140.116(1); at. no. 58; m.p. 799°C; b.p. 3443°C; sp. gr. 6.770 (25°C); valence 3 or 4. Discovered in 1803 by Klaproth and by Berzelius and Hisinger; metal prepared by Hillebrand and Norton in 1875. Cerium is the most abundant of the metals of the so-called rare earths. It is found in a number of minerals including *allanite* (also known as *orthite*), *monazite*, *bastnasite*, *cerite*, and *samaraskite*. Monazite and bastnasite are presently the two most important sources of cerium. Large deposits of monazite found on the beaches of Travancore, India, in river sands in Brazil, and deposits of *allanite* in the western United States, and *bastnasite* in Southern California will supply cerium, thorium, and the other rare-earth metals for many years to come. Metallic cerium is prepared by metallothermic reduction techniques, such as by reducing cerous fluoride with calcium, or by electrolysis of molten cerous chloride or other cerous halides. The metallothermic technique is used to produce high-purity cerium. Cerium is especially interesting because of its variable electronic structure. The energy of the inner 4f level is nearly the same as that of the outer or valence electrons, and only small amounts of energy are required to change the relative occupancy of these electronic levels. This gives rise to dual valency states. For example, a volume change of about 10% occurs when cerium is subjected to high pressures or low temperatures. It appears that the valence changes from about 3 to 4 when it is cooled or compressed. The low temperature behavior of cerium is complex. Four allotropic modifications are thought to exist: cerium at room temperature and at atmospheric pressure is known as  $\gamma$  cerium. Upon cooling to  $-16^{\circ}\text{C}$ ,  $\gamma$  cerium changes to  $\beta$  cerium. The remaining  $\gamma$  cerium starts to change to  $\alpha$  cerium when cooled to  $-172^{\circ}\text{C}$ , and the transformation is complete at  $-269^{\circ}\text{C}$ .  $\alpha$  Cerium has a density of 8.16;  $\delta$  cerium exists above  $726^{\circ}\text{C}$ . At atmospheric pressure, liquid cerium is more dense than its solid form at the melting point. Cerium is an iron-gray lustrous metal. It is malleable, and oxidizes very readily at room temperature, especially in moist air. Except for europium, cerium is the most reactive of the “rare-earth” metals. It slowly decomposes in cold water, and rapidly in hot water. Alkali solutions and dilute and concentrated acids attack the metal rapidly. The pure metal is likely to ignite if scratched with a knife. Ceric salts are orange red or yellowish; cerous salts are usually white. Cerium is a component of misch metal, which is extensively used in the manufacture of pyrophoric alloys for cigarette lighters, etc. Natural cerium is stable and contains four isotopes. Thirty-two other radioactive isotopes and isomers are known. While cerium is not radioactive, the impure commercial grade may contain traces of thorium, which is radioactive. The oxide is an important constituent of incandescent gas mantles and it is emerging as a hydrocarbon catalyst in “self-cleaning” ovens. In this application it can be incorporated into oven walls to prevent the collection of cooking residues. As ceric sulfate it finds extensive use as a volumetric oxidizing agent in quan-

titative analysis. Cerium compounds are used in the manufacture of glass, both as a component and as a decolorizer. The oxide is finding increased use as a glass polishing agent instead of rouge, for it is much faster than rouge in polishing glass surfaces. Cerium compounds are finding use in automobile exhaust catalysts. Cerium is also finding use in making permanent magnets. Cerium, with other rare earths, is used in carbon-arc lighting, especially in the motion picture industry. It is also finding use as an important catalyst in petroleum refining and in metallurgical and nuclear applications. In small lots, cerium costs about \$5/g (99.9%).

**Cesium** — (*L. caesius*, sky blue), Cs; at. wt. 132.9054519(2); at. no. 55; m.p.  $28.44^{\circ}\text{C}$ ; b.p.  $671^{\circ}\text{C}$ ; sp. gr. 1.873 ( $20^{\circ}\text{C}$ ); valence 1. Cesium was discovered spectroscopically by Bunsen and Kirchhoff in 1860 in mineral water from Durkheim. Cesium, an alkali metal, occurs in *lepidolite*, *pollucite* (a hydrated silicate of aluminum and cesium), and in other sources. One of the world's richest sources of cesium is located at Bernic Lake, Manitoba. The deposits are estimated to contain 300,000 tons of pollucite, averaging 20% cesium. It can be isolated by electrolysis of the fused cyanide and by a number of other methods. Very pure, gas-free cesium can be prepared by thermal decomposition of cesium azide. The metal is characterized by a spectrum containing two bright lines in the blue along with several others in the red, yellow, and green. It is silvery white, soft, and ductile. It is the most electropositive and most alkaline element. Cesium, gallium, and mercury are the only three metals that are liquid at room temperature. Cesium reacts explosively with cold water, and reacts with ice at temperatures above  $-116^{\circ}\text{C}$ . Cesium hydroxide, the strongest base known, attacks glass. Because of its great affinity for oxygen the metal is used as a “getter” in electron tubes. It is also used in photoelectric cells, as well as a catalyst in the hydrogenation of certain organic compounds. The metal has recently found application in ion propulsion systems. Cesium is used in atomic clocks, which are accurate to 5 s in 300 years. A second of time is now defined as being the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyper-fine levels of the ground state of the cesium-133 atom. Its chief compounds are the chloride and the nitrate. Cesium has 52 isotopes and isomers with masses ranging from 112 to 148. The present price of cesium is about \$50/g (99.98%) sealed in a glass ampoule.

**Chlorine** — (*Gr. chloros*, greenish yellow), Cl; at. wt. 35.453(2); at. no. 17; m.p.  $-101.5^{\circ}\text{C}$ ; b.p.  $-34.04^{\circ}\text{C}$ ;  $t_c$   $143.8^{\circ}\text{C}$ ; density 3.214 g/L; sp. gr. 1.56 ( $-33.6^{\circ}\text{C}$ ); valence 1, 3, 5, or 7. Discovered in 1774 by Scheele, who thought it contained oxygen; named in 1810 by Davy, who insisted it was an element. In nature it is found in the combined state only, chiefly with sodium as common salt (NaCl), *carnallite* ( $\text{KMgCl}_3 \cdot 6\text{H}_2\text{O}$ ), and *sylvite* (KCl). It is a member of the halogen (salt-forming) group of elements and is obtained from chlorides by the action of oxidizing agents and more often by electrolysis; it is a greenish-yellow gas, combining directly with nearly all elements. At  $10^{\circ}\text{C}$  one volume of water dissolves 3.10 volumes of chlorine, at  $30^{\circ}\text{C}$  only 1.77 volumes. Chlorine is widely used in making many everyday products. It is used for producing safe drinking water the world over. Even the smallest water supplies are now usually chlorinated. It is also extensively used in the production of paper products, dyestuffs, textiles, petroleum products, medicines, antiseptics, insecticides, foodstuffs, solvents, paints, plastics, and many other consumer products. Most of the chlorine produced is used in the manufacture of chlorinat-



ed compounds for sanitation, pulp bleaching, disinfectants, and textile processing. Further use is in the manufacture of chlorates, chloroform, carbon tetrachloride, and in the extraction of bromine. Organic chemistry demands much from chlorine, both as an oxidizing agent and in substitution, since it often brings desired properties in an organic compound when substituted for hydrogen, as in one form of synthetic rubber. Chlorine is a respiratory irritant. The gas irritates the mucous membranes and the liquid burns the skin. As little as 3.5 ppm can be detected as an odor, and 1000 ppm is likely to be fatal after a few deep breaths. It was used as a war gas in 1915. Natural chlorine contains two isotopes. Twenty other isotopes and isomers are known.

**Chromium** — (Gr. *chroma*, color), Cr; at. wt. 51.9961(6); at. no. 24; m.p. 1907°C; b.p. 2671°C; sp. gr. 7.15 (20°C); valence chiefly 2, 3, or 6. Discovered in 1797 by Vauquelin, who prepared the metal the next year, chromium is a steel-gray, lustrous, hard metal that takes a high polish. The principal ore is *chromite* ( $\text{FeCr}_2\text{O}_4$ ), which is found in Zimbabwe, Russia, South Africa, Turkey, Iran, Albania, Finland, Democratic Republic of Madagascar, the Philippines, and elsewhere. The U.S. has no appreciable chromite ore reserves. The metal is usually produced by reducing the oxide with aluminum. Chromium is used to harden steel, to manufacture stainless steel, and to form many useful alloys. Much is used in plating to produce a hard, beautiful surface and to prevent corrosion. Chromium is used to give glass an emerald green color. It finds wide use as a catalyst. All compounds of chromium are colored; the most important are the chromates of sodium and potassium ( $\text{K}_2\text{CrO}_4$ ) and the dichromates ( $\text{K}_2\text{Cr}_2\text{O}_7$ ) and the potassium and ammonium chrome alums, as  $\text{KCr}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ . The dichromates are used as oxidizing agents in quantitative analysis, also in tanning leather. Other compounds are of industrial value; lead chromate is chrome yellow, a valued pigment. Chromium compounds are used in the textile industry as mordants, and by the aircraft and other industries for anodizing aluminum. The refractory industry has found chromite useful for forming bricks and shapes, as it has a high melting point, moderate thermal expansion, and stability of crystalline structure. Chromium is an essential trace element for human health. Many chromium compounds, however, are acutely or chronically toxic, and some are carcinogenic. They should be handled with proper safeguards. Natural chromium contains four isotopes. Twenty other isotopes are known. Chromium metal (99.95%) costs about \$1000/kg. Commercial grade chromium (99%) costs about \$75/kg.

**Cobalt** — (*Kobald*, from the German, goblin or evil spirit, *cobalos*, Greek, mine), Co; at. wt. 58.933195(5); at. no. 27; m.p. 1495°C; b.p. 2927°C; sp. gr. 8.9 (20°C); valence 2 or 3. Discovered by Brandt about 1735. Cobalt occurs in the mineral *cobaltite*, *smaltite*, and *erythrite*, and is often associated with nickel, silver, lead, copper, and iron ores, from which it is most frequently obtained as a by-product. It is also present in meteorites. Important ore deposits are found in Congo-Kinshasa, Australia, Zambia, Russia, Canada, and elsewhere. The U.S. Geological Survey has announced that the bottom of the north central Pacific Ocean may have cobalt-rich deposits at relatively shallow depths in waters close to the Hawaiian Islands and other U.S. Pacific territories. Cobalt is a brittle, hard metal, closely resembling iron and nickel in appearance. It has a magnetic permeability of about two thirds that of iron. Cobalt tends to exist as a mixture of two allotropes over a wide temperature

range; the  $\beta$ -form predominates below 400°C, and the  $\alpha$  above that temperature. The transformation is sluggish and accounts in part for the wide variation in reported data on physical properties of cobalt. It is alloyed with iron, nickel and other metals to make Alnico, an alloy of unusual magnetic strength with many important uses. Stellite alloys, containing cobalt, chromium, and tungsten, are used for high-speed, heavy-duty, high-temperature cutting tools, and for dies. Cobalt is also used in other magnet steels and stainless steels, and in alloys used in jet turbines and gas turbine generators. The metal is used in electroplating because of its appearance, hardness, and resistance to oxidation. The salts have been used for centuries for the production of brilliant and permanent blue colors in porcelain, glass, pottery, tiles, and enamels. It is the principal ingredient in Sevre's and Thenard's blue. A solution of the chloride ( $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ ) is used as sympathetic ink. The cobalt amines are of interest; the oxide and the nitrate are important. Cobalt carefully used in the form of the chloride, sulfate, acetate, or nitrate has been found effective in correcting a certain mineral deficiency disease in animals. Soils should contain 0.13 to 0.30 ppm of cobalt for proper animal nutrition. Cobalt is found in Vitamin B-12, which is essential for human nutrition. Cobalt of 99.9+% purity is priced at about \$250/kg. Cobalt-60, an artificial isotope, is an important gamma ray source, and is extensively used as a tracer and a radiotherapeutic agent. Single compact sources of Cobalt-60 vary from about \$1 to \$10/curie, depending on quantity and specific activity. Thirty isotopes and isomers of cobalt are known.

**Columbium** — See Niobium.

**Copper** — (L. *cuprum*, from the island of Cyprus), Cu; at. wt. 63.546(3); at. no. 29; f.p. 1084.62 °C; b.p. 2562°C; sp. gr. 8.96 (20°C); valence 1 or 2. The discovery of copper dates from prehistoric times. It is said to have been mined for more than 5000 years. It is one of man's most important metals. Copper is reddish colored, takes on a bright metallic luster, and is malleable, ductile, and a good conductor of heat and electricity (second only to silver in electrical conductivity). The electrical industry is one of the greatest users of copper. Copper occasionally occurs native, and is found in many minerals such as *cuprite*, *malachite*, *azurite*, *chalcopyrite*, and *bornite*. Large copper ore deposits are found in the U.S., Chile, Zambia, Zaire, Peru, and Canada. The most important copper ores are the sulfides, oxides, and carbonates. From these, copper is obtained by smelting, leaching, and by electrolysis. Its alloys, brass and bronze, long used, are still very important; all American coins are now copper alloys; monel and gun metals also contain copper. The most important compounds are the oxide and the sulfate, blue vitriol; the latter has wide use as an agricultural poison and as an algicide in water purification. Copper compounds such as Fehling's solution are widely used in analytical chemistry in tests for sugar. High-purity copper (99.999 + %) is readily available commercially. The price of commercial copper has fluctuated widely. The price of copper in December 2001 was about \$1.50/kg. Natural copper contains two isotopes. Twenty-six other radioactive isotopes and isomers are known.

**Curium** — (Pierre and Marie Curie), Cm; at. wt. (247); at. no. 96; m.p. 1345°C; sp. gr. 13.51 (calc.); valence 3 and 4. Although curium follows americium in the periodic system, it was actually known before americium and was the third transuranium element to be discovered. It was identified by Seaborg, James,

and Ghiorso in 1944 at the wartime Metallurgical Laboratory in Chicago as a result of helium-ion bombardment of  $^{239}\text{Pu}$  in the Berkeley, California, 60-inch cyclotron. Visible amounts (30  $\mu\text{g}$ ) of  $^{242}\text{Cm}$ , in the form of the hydroxide, were first isolated by Werner and Perlman of the University of California in 1947. In 1950, Crane, Wallmann, and Cunningham found that the magnetic susceptibility of microgram samples of  $\text{CmF}_3$  was of the same magnitude as that of  $\text{GdF}_3$ . This provided direct experimental evidence for assigning an electronic configuration to  $\text{Cm}^{+3}$ . In 1951, the same workers prepared curium in its elemental form for the first time. Sixteen isotopes of curium are now known. The most stable,  $^{247}\text{Cm}$ , with a half-life of 16 million years, is so short compared to the Earth's age that any primordial curium must have disappeared long ago from the natural scene. Minute amounts of curium probably exist in natural deposits of uranium, as a result of a sequence of neutron captures and  $\beta$  decays sustained by the very low flux of neutrons naturally present in uranium ores. The presence of natural curium, however, has never been detected.  $^{242}\text{Cm}$  and  $^{244}\text{Cm}$  are available in multigram quantities.  $^{248}\text{Cm}$  has been produced only in milligram amounts. Curium is similar in some regards to gadolinium, its rare-earth homolog, but it has a more complex crystal structure. Curium is silver in color, is chemically reactive, and is more electropositive than aluminum.  $\text{CmO}_2$ ,  $\text{Cm}_2\text{O}_3$ ,  $\text{CmF}_3$ ,  $\text{CmF}_4$ ,  $\text{CmCl}_3$ ,  $\text{CmBr}_3$ , and  $\text{CmI}_3$  have been prepared. Most compounds of trivalent curium are faintly yellow in color.  $^{242}\text{Cm}$  generates about three watts of thermal energy per gram. This compares to one-half watt per gram of  $^{238}\text{Pu}$ . This suggests use for curium as a power source.  $^{244}\text{Cm}$  is now offered for sale by the O.R.N.L. at \$185/mg plus packing charges.  $^{248}\text{Cm}$  is available at a cost of \$160/ $\mu\text{g}$ , plus packing charges, from the O.R.N.L. Curium absorbed into the body accumulates in the bones, and is therefore very toxic as its radiation destroys the red-cell forming mechanism. The maximum permissible total body burden of  $^{244}\text{Cm}$  (soluble) in a human being is 0.3  $\mu\text{Ci}$  (microcurie).

**Darmstadtium** — (Darmstadt, city in Germany), Ds. In 1987 Oganessian et al., at Dubna, claimed discovery of this element. Their experiments indicated the spontaneous fissioning nuclide  $^{272}110$  with a half-life of 10 ms. More recently a group led by Armbruster at G.S.I. in Darmstadt, Germany, reported evidence of  $^{269}110$ , which was produced by bombarding lead for many days with more than  $10^{18}$  nickel atoms. A detector searched each collision for Element 110's distinct decay sequence. On November 9, 1994, evidence of 110 was detected. In 2003 IUPAC approved the name darmstadtium, symbol Ds, for Element 110. Seven isotopes of Element 110 are now recognized.

**Deuterium** — an isotope of hydrogen — see Hydrogen.

**Dubnium** — (named after the Joint Institute of Nuclear Research in Dubna, Russia). Db; at. wt. [262]; at. no. 105. In 1967 G. N. Flerov reported that a Soviet team working at the Joint Institute for Nuclear Research at Dubna may have produced a few atoms of  $^{260}105$  and  $^{261}105$  by bombarding  $^{243}\text{Am}$  with  $^{22}\text{Ne}$ . Their evidence was based on time-coincidence measurements of alpha energies. More recently, it was reported that early in 1970 Dubna scientists synthesized Element 105 and that by the end of April 1970 "had investigated all the types of decay of the new element and had determined its chemical properties." In late April 1970, it was announced that Ghiorso, Nurmia, Harris, K. A. Y. Eskola, and P. L. Eskola, working at the University of California at Berkeley, had positively identi-

fied Element 105. The discovery was made by bombarding a target of  $^{249}\text{Cf}$  with a beam of 84 MeV nitrogen nuclei in the Heavy Ion Linear Accelerator (HILAC). When a  $^{15}\text{N}$  nucleus is absorbed by a  $^{249}\text{Cf}$  nucleus, four neutrons are emitted and a new atom of  $^{260}105$  with a half-life of 1.6 s is formed. While the first atoms of Element 105 are said to have been detected conclusively on March 5, 1970, there is evidence that Element 105 had been formed in Berkeley experiments a year earlier by the method described. Ghiorso and his associates have attempted to confirm Soviet findings by more sophisticated methods without success.

In October 1971, it was announced that two new isotopes of Element 105 were synthesized with the heavy ion linear accelerator by A. Ghiorso and co-workers at Berkeley. Element  $^{261}105$  was produced both by bombarding  $^{250}\text{Cf}$  with  $^{15}\text{N}$  and by bombarding  $^{249}\text{Bk}$  with  $^{16}\text{O}$ . The isotope emits 8.93-MeV  $\alpha$  particles and decays to  $^{257}\text{Lr}$  with a half-life of about 1.8 s. Element  $^{262}105$  was produced by bombarding  $^{249}\text{Bk}$  with  $^{18}\text{O}$ . It emits 8.45 MeV  $\alpha$  particles and decays to  $^{258}\text{Lr}$  with a half-life of about 40 s. Nine isotopes of Dubnium are now recognized. Soon after the discovery the names *Hahnium* and *Joliotium*, named after Otto Hahn and Jean-Frederic Joliot and Mme. Joliot-Curie, were suggested as names for Element 105. The IUPAC in August 1997 finally resolved the issue, naming Element 105 Dubnium with the symbol Db. Dubnium is thought to have properties similar to tantalum.

**Dysprosium** — (Gr. *dysprositos*, hard to get at), Dy; at. wt. 160.500(1); at. no. 66; m.p. 1412°C; b.p. 2567°C; sp. gr. 8.551 (25°C); valence 3. Dysprosium was discovered in 1886 by Lecoq de Boisbaudran, but not isolated. Neither the oxide nor the metal was available in relatively pure form until the development of ion-exchange separation and metallographic reduction techniques by Spedding and associates about 1950. Dysprosium occurs along with other so-called rare-earth or lanthanide elements in a variety of minerals such as *xenotime*, *fergusonite*, *gadolinite*, *euxenite*, *polycrase*, and *blomstrandine*. The most important sources, however, are from *monazite* and *bastnasite*. Dysprosium can be prepared by reduction of the trifluoride with calcium. The element has a metallic, bright silver luster. It is relatively stable in air at room temperature, and is readily attacked and dissolved, with the evolution of hydrogen, by dilute and concentrated mineral acids. The metal is soft enough to be cut with a knife and can be machined without sparking if overheating is avoided. Small amounts of impurities can greatly affect its physical properties. While dysprosium has not yet found many applications, its thermal neutron absorption cross-section and high melting point suggest metallurgical uses in nuclear control applications and for alloying with special stainless steels. A dysprosium oxide-nickel cermet has found use in cooling nuclear reactor rods. This cermet absorbs neutrons readily without swelling or contracting under prolonged neutron bombardment. In combination with vanadium and other rare earths, dysprosium has been used in making laser materials. Dysprosium-cadmium chalcogenides, as sources of infrared radiation, have been used for studying chemical reactions. The cost of dysprosium metal has dropped in recent years since the development of ion-exchange and solvent extraction techniques, and the discovery of large ore bodies. Thirty-two isotopes and isomers are now known. The metal costs about \$6/g (99.9% purity).

**Einsteinium** — (Albert Einstein [1879–1955]), Es; at. wt. (252); m.p. 860°C (est.); at. no. 99. Einsteinium, the seventh transura-



nic element of the actinide series to be discovered, was identified by Ghiorso and co-workers at Berkeley in December 1952 in debris from the first large thermonuclear explosion, which took place in the Pacific in November 1952. The isotope produced was the 20-day  $^{253}\text{Es}$  isotope. In 1961, a sufficient amount of einsteinium was produced to permit separation of a macroscopic amount of  $^{253}\text{Es}$ . This sample weighed about 0.01  $\mu\text{g}$ . A special magnetic-type balance was used in making this determination.  $^{253}\text{Es}$  so produced was used to produce mendelevium. About 3  $\mu\text{g}$  of einsteinium has been produced at Oak Ridge National Laboratories by irradiating for several years kilogram quantities of  $^{239}\text{Pu}$  in a reactor to produce  $^{242}\text{Pu}$ . This was then fabricated into pellets of plutonium oxide and aluminum powder, and loaded into target rods for an initial 1-year irradiation at the Savannah River Plant, followed by irradiation in a HFIR (High Flux Isotopic Reactor). After 4 months in the HFIR the targets were removed for chemical separation of the einsteinium from californium. Nineteen isotopes and isomers of einsteinium are now recognized.  $^{254}\text{Es}$  has the longest half-life (276 days). Tracer studies using  $^{253}\text{Es}$  show that einsteinium has chemical properties typical of a heavy trivalent, actinide element. Einsteinium is extremely radioactive. Great care must be taken when handling it.

**Element 112** — In late February 1996, Sigurd Hofmann and his collaborators at GSI Darmstadt announced their discovery of Element 112, having 112 protons and 165 neutrons, with an atomic mass of 277. This element was made by bombarding a lead target with high-energy zinc ions. A single nucleus of Element 112 was detected, which decayed after less than 0.001 sec by emitting an  $\alpha$  particle, consisting of two protons and two neutrons. This created Element  $110_{273}$ , which in turn decayed by emitting an  $\alpha$  particle to form a new isotope of Element 108 and so on. Evidence indicates that nuclei with 162 neutrons are held together more strongly than nuclei with a smaller or larger number of neutrons. This suggests a narrow “peninsula” of relatively stable isotopes around Element 114. GSI scientists are experimenting to bombard targets with ions heavier than zinc to produce Elements 113 and 114. A name has not yet been suggested for Element 112, although the IUPAC suggested the temporary name of ununbium, with the symbol of Uub, when the element was discovered. Element 112 is expected to have properties similar to mercury.

**Element 113** — (Ununtrium) See Element 115.

**Element 114** — (Ununquadium) Symbol Uuq. Element 114 is the first new element to be discovered since 1996. This element was found by a Russian–American team, including Livermore researchers, by bombarding a sheet of plutonium with a rare form of calcium hoping to make the atoms stick together in a new element. Radiation showed that the new element broke into smaller pieces. Data of radiation collected at the Russian Joint Institute for Nuclear Research in November and December 1998 were analyzed in January 1999. It was found that some of the heavy atoms created when 114 decayed lived up to 30 seconds, which was longer than ever seen before for such a heavy element. This isotope decayed into a previously unknown isotope of Element 112, which itself lasted 15 minutes. That isotope, in turn, decayed to a previously undiscovered isotope of Element 108, which survived 17 minutes. Isotopes of these and those with longer life-times have been predicted for some time by theorists. It appears that these isotopes are on the edge of the “island of stability,” and that some

of the isotopes in this region might last long enough for studies of their nuclear behavior and for a chemical evaluation to be made. No name has yet been suggested for Element 114; however, the temporary name of ununquadium with symbol Uuq may be used.

**Element 115**— (Ununpentium) On February 2, 2004, it was reported that Element 115 had been discovered at the Joint Institute for Nuclear Research (JINR) in Dubna, Russia. Four atoms of this element were produced by JINR physicists and collaborators from the Lawrence Livermore (California) Laboratory using a 248-MeV beam of calcium-48 ions striking a target of americium-243 atoms. The nuclei of these atoms are said to have a life of 90 milliseconds. The relatively long lifetime of Element 115 suggests that these experiments might be getting closer to the “island of stability” long sought to exist by some nuclear physicists. These atoms were thought to decay first to Element 113 by the emission of an alpha particle, then decay further to Element 111 by alpha emission again, and then by three more alpha decay processes to Element 105 (dubnium), which after a long delay from the time of the initial interaction, fissioned. This experiment entailed separating four atoms from trillions of other atoms. A gas-filled separator, employing chemistry, was important in this experiment. Names for Elements 115, Element 113, and Element 111 have not yet been chosen.

**Element 116** — (Ununhexium) Symbol Uuh. As of January 2004 it is questionable if this element has been discovered.

**Element 117** — (Ununseptium) Symbol Uus. As of January 2004, this element remains undiscovered.

**Element 118** — (Ununoctium) Symbol Uuo. In June 1999 it was announced that Elements 118 and 116 had been discovered at the Lawrence Berkeley National Laboratory. A lead target was bombarded for more than 10 days with roughly 1 quintillion krypton ions. The team reported that three atoms of Element 118 were made, which quickly decayed into Elements 116, 114, and elements of lower atomic mass. It was said that the isotopes of Element 118 lasted only about 200 milliseconds, while the isotope of Element 116 lasted only 1.2 milliseconds. It was hoped that these elements might be members of “an island of stability,” which had long been sought. At that time it was hoped that a target of bismuth might be bombarded with krypton ions to make Element 119, which, in turn, would decay into Elements 117, 115, and 113.

On July 27, 2001 researchers at the Lawrence Berkeley Laboratory announced that their discovery of Element 118 was being retracted because workers at the GSI Laboratory in Germany and at Japanese laboratories failed to confirm their results. However, it was reported that different experiments at the Livermore Laboratory and Joint Institute from Nuclear Research in Dubna, Russia indicated that Element 116 had since been created.

Researchers at the Australian National Laboratory suggest that super-heavy elements may be more difficult to make than previously thought. Their data suggest the best way to encourage fusion in making super-heavy elements is to combine the lightest projectiles possible with the heaviest possible targets. This would minimize a so-called “quasi-fission process” in which a projectile nucleus steals protons and neutrons from a target nucleus. In this process the two nuclei are said to fly apart without ever having actually combined.

**Erbium** — (*Ytterby*, a town in Sweden), Er; at. wt. 167.259(3); at. no. 68; m.p. 1529°C; b.p. 2868°C; sp. gr. 9.066 (25°C); valence 3, Erbium, one of the so-called rare-earth elements of the lanthanide series, is found in the minerals mentioned under dysprosium above. In 1842 Mosander separated "yttria," found in the mineral *gadolinite*, into three fractions which he called *yttria*, *erbia*, and *terbia*. The names *erbia* and *terbia* became confused in this early period. After 1860, Mosander's *terbia* was known as *erbia*, and after 1877, the earlier known *erbia* became *terbia*. The *erbia* of this period was later shown to consist of five oxides, now known as *erbia*, *scandia*, *holmia*, *thulia* and *ytterbia*. By 1905 Urbain and James independently succeeded in isolating fairly pure  $\text{Er}_2\text{O}_3$ . Klemm and Bommer first produced reasonably pure erbium metal in 1934 by reducing the anhydrous chloride with potassium vapor. The pure metal is soft and malleable and has a bright, silvery, metallic luster. As with other rare-earth metals, its properties depend to a certain extent on the impurities present. The metal is fairly stable in air and does not oxidize as rapidly as some of the other rare-earth metals. Naturally occurring erbium is a mixture of six isotopes, all of which are stable. Twenty-seven radioactive isotopes of erbium are also recognized. Recent production techniques, using ion-exchange reactions, have resulted in much lower prices of the rare-earth metals and their compounds in recent years. The cost of 99.9% erbium metal is about \$21/g. Erbium is finding nuclear and metallurgical uses. Added to vanadium, for example, erbium lowers the hardness and improves workability. Most of the rare-earth oxides have sharp absorption bands in the visible, ultraviolet, and near infrared. This property, associated with the electronic structure, gives beautiful pastel colors to many of the rare-earth salts. Erbium oxide gives a pink color and has been used as a colorant in glasses and porcelain enamel glazes.

**Europium** — (Europe), Eu; at. wt. 151.964(1); at. no. 63; m.p. 822°C; b.p. 1596°C; sp. gr. 5.244 (25°C); valence 2 or 3. In 1890 Boisbaudran obtained basic fractions from samarium-gadolinium concentrates that had spark spectral lines not accounted for by samarium or gadolinium. These lines subsequently have been shown to belong to europium. The discovery of europium is generally credited to Demarcay, who separated the rare earth in reasonably pure form in 1901. The pure metal was not isolated until recent years. Europium is now prepared by mixing  $\text{Eu}_2\text{O}_3$  with a 10% excess of lanthanum metal and heating the mixture in a tantalum crucible under high vacuum. The element is collected as a silvery-white metallic deposit on the walls of the crucible. As with other rare-earth metals, except for lanthanum, europium ignites in air at about 150 to 180°C. Europium is about as hard as lead and is quite ductile. It is the most reactive of the rare-earth metals, quickly oxidizing in air. It resembles calcium in its reaction with water. *Bastnasite* and *monazite* are the principal ores containing europium. Europium has been identified spectroscopically in the sun and certain stars. Europium isotopes are good neutron absorbers and are being studied for use in nuclear control applications. Europium oxide is now widely used as a phosphor activator and europium-activated yttrium vanadate is in commercial use as the red phosphor in color TV tubes. Europium-doped plastic has been used as a laser material. With the development of ion-exchange techniques and special processes, the cost of the metal has been greatly reduced in recent years. Natural europium contains two stable isotopes. Thirty-five other radioactive isotopes and isomers are known. Europium

is one of the rarest and most costly of the rare-earth metals. It is priced at about \$60/g (99.9% pure).

**Fermium** — (Enrico Fermi [1901–1954], nuclear physicist), Fm; at. wt. [257]; at. no. 100; m.p. 1527°C. Fermium, the eighth transuranium element of the actinide series to be discovered, was identified by Ghiorso and co-workers in 1952 in the debris from a thermonuclear explosion in the Pacific in work involving the University of California Radiation Laboratory, the Argonne National Laboratory, and the Los Alamos Scientific Laboratory. The isotope produced was the 20-hour  $^{255}\text{Fm}$ . During 1953 and early 1954, while discovery of elements 99 and 100 was withheld from publication for security reasons, a group from the Nobel Institute of Physics in Stockholm bombarded  $^{238}\text{U}$  with  $^{16}\text{O}$  ions, and isolated a 30-min  $\alpha$ -emitter, which they ascribed to  $^{250}\text{100}$ , without claiming discovery of the element. This isotope has since been identified positively, and the 30-min half-life confirmed. The chemical properties of fermium have been studied solely with tracer amounts, and in normal aqueous media only the (III) oxidation state appears to exist. The isotope  $^{254}\text{Fm}$  and heavier isotopes can be produced by intense neutron irradiation of lower elements such as plutonium by a process of successive neutron capture interspersed with beta decays until these mass numbers and atomic numbers are reached. Twenty isotopes and isomers of fermium are known to exist.  $^{257}\text{Fm}$ , with a half-life of about 100.5 days, is the longest lived.  $^{250}\text{Fm}$ , with a half-life of 30 min, has been shown to be a product of decay of Element  $^{254}\text{102}$ . It was by chemical identification of  $^{250}\text{Fm}$  that production of Element 102 (nobelium) was confirmed. Fermium would probably have chemical properties resembling erbium.

**Fluorine** — (L. and F. *fluere*, flow, or flux), F; at. wt. 18.9984032(5); at. no. 9; m.p. -219.67°C (1 atm); b.p. -188.12°C (1 atm);  $t_c$  -129.02°C; density 1.696 g/L (0°C, 1 atm); liq. den. at b.p. 1.50 g/cm<sup>3</sup>; valence 1. In 1529, Georgius Agricola described the use of fluorspar as a flux, and as early as 1670 Schwandhard found that glass was etched when exposed to fluorspar treated with acid. Scheele and many later investigators, including Davy, Gay-Lussac, Lavoisier, and Thenard, experimented with hydrofluoric acid, some experiments ending in tragedy. The element was finally isolated in 1886 by Moisson after nearly 74 years of continuous effort. Fluorine occurs chiefly in *fluorspar* ( $\text{CaF}_2$ ) and *cryolite* ( $\text{Na}_3\text{AlF}_6$ ), and is in *topaz* and other minerals. It is a member of the halogen family of elements, and is obtained by electrolyzing a solution of potassium hydrogen fluoride in anhydrous hydrogen fluoride in a vessel of metal or transparent fluorspar. Modern commercial production methods are essentially variations on the procedures first used by Moisson. Fluorine is the most electronegative and reactive of all elements. It is a pale yellow, corrosive gas, which reacts with practically all organic and inorganic substances. Finely divided metals, glass, ceramics, carbon, and even water burn in fluorine with a bright flame. Until World War II, there was no commercial production of elemental fluorine. The atom bomb project and nuclear energy applications, however, made it necessary to produce large quantities. Safe handling techniques have now been developed and it is possible at present to transport liquid fluorine by the ton. Fluorine and its compounds are used in producing uranium (from the hexafluoride) and more than 100 commercial fluorochemicals, including many well-known high-temperature plastics. Hydrofluoric acid is extensively used for etching the glass of light bulbs, etc. Fluorochlorohydrocarbons have been extensively used in air

conditioning and refrigeration. However, in recent years the U.S. and other countries have been phasing out ozone-depleting substances, such as the fluorochlorohydrocarbons that have been used in these applications. It has been suggested that fluorine might be substituted for hydrogen wherever it occurs in organic compounds, which could lead to an astronomical number of new fluorine compounds. The presence of fluorine as a soluble fluoride in drinking water to the extent of 2 ppm may cause mottled enamel in teeth, when used by children acquiring permanent teeth; in smaller amounts, however, fluorides are said to be beneficial and used in water supplies to prevent dental cavities. Elemental fluorine has been studied as a rocket propellant as it has an exceptionally high specific impulse value. Compounds of fluorine with rare gases have now been confirmed. Fluorides of xenon, radon, and krypton are among those known. Elemental fluorine and the fluoride ion are highly toxic. The free element has a characteristic pungent odor, detectable in concentrations as low as 20 ppb, which is below the safe working level. The recommended maximum allowable concentration for a daily 8-hour time-weighted exposure is 1 ppm. Fluorine is known to have fourteen isotopes.

**Francium** — (France), Fr; at. no. 87; at. wt. [223]; m.p. 27°C; valence 1. Discovered in 1939 by Mlle. Marguerite Perey of the Curie Institute, Paris. Francium, the heaviest known member of the alkali metal series, occurs as a result of an alpha disintegration of actinium. It can also be made artificially by bombarding thorium with protons. While it occurs naturally in uranium minerals, there is probably less than an ounce of francium at any time in the total crust of the earth. It has the highest equivalent weight of any element, and is the most unstable of the first 101 elements of the periodic system. Thirty-six isotopes and isomers of francium are recognized. The longest lived  $^{223}\text{Fr}$  (Ac, K), a daughter of  $^{227}\text{Ac}$ , has a half-life of 21.8 min. This is the only isotope of francium occurring in nature. Because all known isotopes of francium are highly unstable, knowledge of the chemical properties of this element comes from radiochemical techniques. No weighable quantity of the element has been prepared or isolated. The chemical properties of francium most closely resemble cesium. In 1996, researchers Orozco, Sprouse, and co-workers at the State University of New York, Stony Brook, reported that they had produced francium atoms by bombarding  $^{18}\text{O}$  atoms at a gold target heated almost to its melting point. Collisions between gold and oxygen nuclei created atoms of francium-210 which had 87 protons and 123 neutrons. This team reported they had generated about 1 million francium-210 ions per second and held 1000 or more atoms at a time for about 20 secs in a magnetic trap they had devised before the atoms decayed or escaped. Enough francium was trapped so that a videocamera could capture the light given off by the atoms as they fluoresced. A cluster of about 10,000 francium atoms appeared as a glowing sphere about 1 mm in diameter. It is thought that the francium atoms could serve as miniature laboratories for probing interactions between electrons and quarks.

**Gadolinium** — (*gadolinite*, a mineral named for Gadolin, a Finnish chemist), Gd; at. wt. 157.25(3); at. no. 64; m.p. 1313°C; b.p. 3273°C; sp. gr. 7.901 (25°C); valence 3. Gadolinia, the oxide of gadolinium, was separated by Marignac in 1880 and Lecoq de Boisbaudran independently isolated the element from Mosander's "yttria" in 1886. The element was named for the mineral *gadolinite* from which this rare earth was originally

obtained. Gadolinium is found in several other minerals, including *monazite* and *bastnasite*, which are of commercial importance. The element has been isolated only in recent years. With the development of ion-exchange and solvent extraction techniques, the availability and price of gadolinium and the other rare-earth metals have greatly improved. Thirty-one isotopes and isomers of gadolinium are now recognized; seven are stable and occur naturally. The metal can be prepared by the reduction of the anhydrous fluoride with metallic calcium. As with other related rare-earth metals, it is silvery white, has a metallic luster, and is malleable and ductile. At room temperature, gadolinium crystallizes in the hexagonal, close-packed  $\alpha$  form. Upon heating to 1235°C,  $\alpha$  gadolinium transforms into the  $\beta$  form, which has a body-centered cubic structure. The metal is relatively stable in dry air, but in moist air it tarnishes with the formation of a loosely adhering oxide film which splits off and exposes more surface to oxidation. The metal reacts slowly with water and is soluble in dilute acid. Gadolinium has the highest thermal neutron capture cross-section of any known element (49,000 barns). Natural gadolinium is a mixture of seven isotopes. Two of these,  $^{155}\text{Gd}$  and  $^{157}\text{Gd}$ , have excellent capture characteristics, but they are present naturally in low concentrations. As a result, gadolinium has a very fast burnout rate and has limited use as a nuclear control rod material. It has been used in making gadolinium yttrium garnets, which have microwave applications. Compounds of gadolinium are used in making phosphors for color TV tubes. The metal has unusual superconductive properties. As little as 1% gadolinium has been found to improve the workability and resistance of iron, chromium, and related alloys to high temperatures and oxidation. Gadolinium ethyl sulfate has extremely low noise characteristics and may find use in duplicating the performance of amplifiers, such as the maser. The metal is ferromagnetic. Gadolinium is unique for its high magnetic moment and for its special Curie temperature (above which ferromagnetism vanishes) lying just at room temperature. This suggests uses as a magnetic component that senses hot and cold. The price of the metal is about \$5/g (99.9% purity).

**Gallium** — (L. *Gallia*, France), Ga; at. wt. 69.723(1); at. no. 31; m.p. 29.76°C; b.p. 2204°C; sp. gr. 5.904 (29.6°C) solid; sp. gr. 6.095 (29.6°C) liquid; valence 2 or 3. Predicted and described by Mendeleev as ekaaluminum, and discovered spectroscopically by Lecoq de Boisbaudran in 1875, who in the same year obtained the free metal by electrolysis of a solution of the hydroxide in KOH, Gallium is often found as a trace element in *diaspore*, *sphalerite*, *germanite*, *bauxite*, and *coal*. Some flue dusts from burning coal have been shown to contain as much as 1.5% gallium. It is the only metal, except for mercury, cesium, and rubidium, which can be liquid near room temperatures; this makes possible its use in high-temperature thermometers. It has one of the longest liquid ranges of any metal and has a low vapor pressure even at high temperatures. There is a strong tendency for gallium to supercool below its freezing point. Therefore, seeding may be necessary to initiate solidification. Ultra-pure gallium has a beautiful, silvery appearance, and the solid metal exhibits a conchoidal fracture similar to glass. The metal expands 3.1% on solidifying; therefore, it should not be stored in glass or metal containers, as they may break as the metal solidifies. Gallium wets glass or porcelain, and forms a brilliant mirror when it is painted on glass. It is widely used in doping semiconductors and producing solid-state devices such as transistors. High-purity gallium is attacked slowly only by



mineral acids. Magnesium gallate containing divalent impurities such as  $\text{Mn}^{+2}$  is finding use in commercial ultraviolet activated powder phosphors. Gallium nitride has been used to produce blue light-emitting diodes such as those used in CD and DVD readers. Gallium has found application in the Gallex Detector Experiment located in the Gran Sasso Underground Laboratory in Italy. This underground facility has been built by the Italian Istituto Nazionale di Fisica Nucleare in the middle of a highway tunnel through the Abruzzese mountains, about 150 km east of Rome. In this experiment, 30.3 tons of gallium in the form of 110 tons of  $\text{GaCl}_3\text{-HCl}$  solution are being used to detect solar neutrinos. The production of  $^{71}\text{Ge}$  from gallium is being measured. Gallium arsenide is capable of converting electricity directly into coherent light. Gallium readily alloys with most metals, and has been used as a component in low melting alloys. Its toxicity appears to be of a low order, but it should be handled with care until more data are forthcoming. Natural gallium contains two stable isotopes. Twenty-six other isotopes, one of which is an isomer, are known. The metal can be supplied in ultrapure form (99.9999+%). The cost is about \$5/g (99.999%).

**Germanium** — (L. *Germania*, Germany), Ge; at. wt. 72.64(2); at. no. 32; m.p. 938.25°C; b.p. 2833°C; sp. gr. 5.323 (25°C); valence 2 and 4. Predicted by Mendeleev in 1871 as ekasilicon, and discovered by Winkler in 1886. The metal is found in *argyrodite*, a sulfide of germanium and silver; in *germanite*, which contains 8% of the element; in zinc ores; in coal; and in other minerals. The element is frequently obtained commercially from flue dusts of smelters processing zinc ores, and has been recovered from the by-products of combustion of certain coals. Its presence in coal insures a large reserve of the element in the years to come. Germanium can be separated from other metals by fractional distillation of its volatile tetrachloride. The tetrachloride may then be hydrolyzed to give  $\text{GeO}_2$ ; the dioxide can be reduced with hydrogen to give the metal. Recently developed zone-refining techniques permit the production of germanium of ultra-high purity. The element is a gray-white metalloid, and in its pure state is crystalline and brittle, retaining its luster in air at room temperature. It is a very important semiconductor material. Zone-refining techniques have led to production of crystalline germanium for semiconductor use with an impurity of only one part in  $10^{10}$ . Doped with arsenic, gallium, or other elements, it is used as a transistor element in thousands of electronic applications. Its application in fiber optics and infrared optical systems now provides the largest use for germanium. Germanium is also finding many other applications including use as an alloying agent, as a phosphor in fluorescent lamps, and as a catalyst. Germanium and germanium oxide are transparent to the infrared and are used in infrared spectrometers and other optical equipment, including extremely sensitive infrared detectors. Germanium oxide's high index of refraction and dispersion make it useful as a component of glasses used in wide-angle camera lenses and microscope objectives. The field of organogermanium chemistry is becoming increasingly important. Certain germanium compounds have a low mammalian toxicity, but a marked activity against certain bacteria, which makes them of interest as chemotherapeutic agents. The cost of germanium is about \$10/g (99.999% purity). Thirty isotopes and isomers are known, five of which occur naturally.

**Gold** — (Sanskrit *Ival*; Anglo-Saxon *gold*), Au (L. *aurum*, gold); at. wt. 196.966569(4); at. no. 79; m.p. 1064.18°C; b.p. 2856°C;

sp. gr. ~19.3 (20°C); valence 1 or 3. Known and highly valued from earliest times, gold is found in nature as the free metal and in tellurides; it is very widely distributed and is almost always associated with quartz or pyrite. It occurs in veins and alluvial deposits, and is often separated from rocks and other minerals by sluicing and panning operations. About 25% of the world's gold output comes from South Africa, and about two thirds of the total U.S. production now comes from South Dakota and Nevada. The metal is recovered from its ores by cyaniding, amalgamating, and smelting processes. Refining is also frequently done by electrolysis. Gold occurs in sea water to the extent of 0.1 to 2 mg/ton, depending on the location where the sample is taken. As yet, no method has been found for recovering gold from sea water profitably. It is estimated that all the gold in the world, so far refined, could be placed in a single cube 60 ft on a side. Of all the elements, gold in its pure state is undoubtedly the most beautiful. It is metallic, having a yellow color when in a mass, but when finely divided it may be black, ruby, or purple. The Purple of Cassius is a delicate test for auric gold. It is the most malleable and ductile metal; 1 oz. of gold can be beaten out to 300 ft<sup>2</sup>. It is a soft metal and is usually alloyed to give it more strength. It is a good conductor of heat and electricity, and is unaffected by air and most reagents. It is used in coinage and is a standard for monetary systems in many countries. It is also extensively used for jewelry, decoration, dental work, and for plating. It is used for coating certain space satellites, as it is a good reflector of infrared and is inert. Gold, like other precious metals, is measured in troy weight; when alloyed with other metals, the term *carat* is used to express the amount of gold present, 24 carats being pure gold. For many years the value of gold was set by the U.S. at \$20.67/troy ounce; in 1934 this value was fixed by law at \$35.00/troy ounce, 9/10th fine. On March 17, 1968, because of a gold crisis, a two-tiered pricing system was established whereby gold was still used to settle international accounts at the old \$35.00/troy ounce price while the price of gold on the private market would be allowed to fluctuate. Since this time, the price of gold on the free market has fluctuated widely. The price of gold on the free market reached a price of \$620/troy oz. in January 1980. More recently, the U.K. and other nations, including the I.M.F. have sold or threatened to sell a sizeable portion of their gold reserves. This has caused wide fluctuations in the price of gold. Because this has damaged the economy of some countries, a moratorium for a few years has been declared. This has tended to stabilize temporarily the price of gold. The most common gold compounds are auric chloride ( $\text{AuCl}_3$ ) and chlorauric acid ( $\text{HAuCl}_4$ ), the latter being used in photography for toning the silver image. Gold has forty-eight recognized isotopes and isomers;  $^{198}\text{Au}$ , with a half-life of 2.7 days, is used for treating cancer and other diseases. Disodium aurothiomalate is administered intramuscularly as a treatment for arthritis. A mixture of one part nitric acid with three of hydrochloric acid is called *aqua regia* (because it dissolved gold, the King of Metals). Gold is available commercially with a purity of 99.999+%. For many years the temperature assigned to the freezing point of gold has been 1063.0°C; this has served as a calibration point for the International Temperature Scales (ITS-27 and ITS-48) and the International Practical Temperature Scale (IPTS-48). In 1968, a new International Practical Temperature Scale (IPTS-68) was adopted, which demanded that the freezing point of gold be changed to 1064.43°C. In 1990 a new International Temperature Scale (ITS-90) was adopted bringing the t.p.

(triple point) of  $\text{H}_2\text{O}$  ( $t_{90}$  (°C)) to 0.01°C and the freezing point of gold to 1064.18°C. The specific gravity of gold has been found to vary considerably depending on temperature, how the metal is precipitated, and cold-worked. As of December 2001, gold was priced at about \$275/troy oz. (\$8.50/g).

**Hafnium** — (*Hafnia*, Latin name for Copenhagen), Hf; at. wt. 178.49(2); at. no. 72; m.p. 2233°C; b.p. 4603°C; sp. gr. 13.31 (20°C); valence 4. Hafnium was thought to be present in various minerals and concentrations many years prior to its discovery, in 1923, credited to D. Coster and G. von Hevesey. On the basis of the Bohr theory, the new element was expected to be associated with zirconium. It was finally identified in *zircon* from Norway, by means of X-ray spectroscopic analysis. It was named in honor of the city in which the discovery was made. Most zirconium minerals contain 1 to 5% hafnium. It was originally separated from zirconium by repeated recrystallization of the double ammonium or potassium fluorides by von Hevesey and Jantzen. Metallic hafnium was first prepared by van Arkel and deBoer by passing the vapor of the tetraiodide over a heated tungsten filament. Almost all hafnium metal now produced is made by reducing the tetrachloride with magnesium or with sodium (Kroll Process). Hafnium is a ductile metal with a brilliant silver luster. Its properties are considerably influenced by the impurities of zirconium present. Of all the elements, zirconium and hafnium are two of the most difficult to separate. Their chemistry is almost identical; however, the density of zirconium is about half that of hafnium. Very pure hafnium has been produced, with zirconium being the major impurity. Natural hafnium contains six isotopes, one of which is slightly radioactive. Hafnium has a total of 41 recognized isotopes and isomers. Because hafnium has a good absorption cross section for thermal neutrons (almost 600 times that of zirconium), has excellent mechanical properties, and is extremely corrosion resistant, it is used for reactor control rods. Such rods are used in nuclear submarines. Hafnium has been successfully alloyed with iron, titanium, niobium, tantalum, and other metals. Hafnium carbide is the most refractory binary composition known, and the nitride is the most refractory of all known metal nitrides (m.p. 3310°C). Hafnium is used in gas-filled and incandescent lamps, and is an efficient "getter" for scavenging oxygen and nitrogen. Finely divided hafnium is pyrophoric and can ignite spontaneously in air. Care should be taken when machining the metal or when handling hot sponge hafnium. At 700°C hafnium rapidly absorbs hydrogen to form the composition  $\text{HfH}_{1.86}$ . Hafnium is resistant to concentrated alkalis, but at elevated temperatures reacts with oxygen, nitrogen, carbon, boron, sulfur, and silicon. Halogens react directly to form tetrahalides. The price of the metal is about \$2/g. The yearly demand for hafnium in the U.S. is now in excess of 50,000 kg.

**Hahnium** — A name previously used for Element 105, now named *dubnium*.

**Hassium** — (named for the German state, Hesse) Hs; at. wt. [277]; at. no. 108. This element was first synthesized and identified in 1964 by the same G.S.I. Darmstadt Group who first identified *Bohrium* and *Meitnerium*. Presumably this element has chemical properties similar to osmium. Isotope  $^{265}\text{108}$  was produced using a beam of  $^{58}\text{Fe}$  projectiles, produced by the Universal Linear Accelerator (UNILAC) to bombard a  $^{208}\text{Pb}$  target. Discovery of *Bohrium* and *Meitnerium* was made using detection of isotopes with odd proton and neutron numbers.

Elements having even atomic numbers have been thought to be less stable against spontaneous fission than odd elements. The production of  $^{265}\text{108}$  in the same reaction as was used at G.S.I. was confirmed at Dubna with detection of the seventh member of the decay chain  $^{253}\text{Es}$ . Isotopes of *Hassium* are believed to decay by spontaneous fission, explaining why 109 was produced before 108. Isotope  $^{265}\text{108}$  and  $^{266}\text{108}$  are thought to decay to  $^{261}\text{106}$ , which in turn decay to  $^{257}\text{104}$  and  $^{253}\text{102}$ . The IUPAC adopted the name *Hassium* after the German state of Hesse in September 1997. In June 2001 it was announced that hassium is now the heaviest element to have its chemical properties analyzed. A research team at the UNILAC heavy-ion accelerator in Darmstadt, Germany built an instrument to detect and analyze hassium. Atoms of curium-248 were collided with atoms of magnesium-26, producing about 6 atoms of hassium with a half-life of 9 sec. This was sufficiently long to obtain data showing that hassium atoms react with oxygen to form hassium oxide molecules. These condensed at a temperature consistent with the behavior of Group 8 elements. This experiment appears to confirm hassium's location under osmium in the periodic table.

**Helium** — (Gr. *helios*, the sun), He; at. wt. 4.002602(2); at. no. 2; b.p. — 268.93°C;  $t_c$  — 267.96°C; density 0.1785 g/L (0°C, 1 atm); liquid density 0.125 g/mL at. b.p.; valence usually 0. Evidence of the existence of helium was first obtained by Janssen during the solar eclipse of 1868 when he detected a new line in the solar spectrum; Lockyer and Frankland suggested the name *helium* for the new element; in 1895, Ramsay discovered helium in the uranium mineral *cleveite*, and it was independently discovered in *cleveite* by the Swedish chemists Cleve and Langlet about the same time. Rutherford and Royds in 1907 demonstrated that  $\alpha$  particles are helium nuclei. Except for hydrogen, helium is the most abundant element found throughout the universe. Helium is extracted from natural gas; all natural gas contains at least trace quantities of helium. It has been detected spectroscopically in great abundance, especially in the hotter stars, and it is an important component in both the proton-proton reaction and the carbon cycle, which account for the energy of the sun and stars. The fusion of hydrogen into helium provides the energy of the hydrogen bomb. The helium content of the atmosphere is about 1 part in 200,000. It is present in various radioactive minerals as a decay product. Much of the world's supply of helium is obtained from wells in Texas, Colorado, and Kansas. The only other known helium extraction plants, outside the United States, in 1999 were in Poland, Russia, China, Algeria, and India. The cost of helium has fallen from \$2500/ft<sup>3</sup> in 1915 to about 2.5¢/cu.ft. (.028 cu meters) in 1999. Helium has the lowest melting point of any element and has found wide use in cryogenic research, as its boiling point is close to absolute zero. Its use in the study of superconductivity is vital. Using liquid helium, Kurti and co-workers, and others, have succeeded in obtaining temperatures of a few microkelvins by the adiabatic demagnetization of copper nuclei, starting from about 0.01 K. Liquid helium ( $\text{He}^4$ ) exists in two forms:  $\text{He}^4\text{I}$  and  $\text{He}^4\text{II}$ , with a sharp transition point at 2.174 K (3.83 cm Hg).  $\text{He}^4\text{I}$  (above this temperature) is a normal liquid, but  $\text{He}^4\text{II}$  (below it) is unlike any other known substance. It expands on cooling; its conductivity for heat is enormous; and neither its heat conduction nor viscosity obeys normal rules. It has other peculiar properties. Helium is the only liquid that cannot be solidified by lowering the temperature. It remains liquid down to absolute zero at ordinary pressures, but it can readily be solidified by increasing

the pressure. Solid  $^3\text{He}$  and  $^4\text{He}$  are unusual in that both can readily be changed in volume by more than 30% by application of pressure. The specific heat of helium gas is unusually high. The density of helium vapor at the normal boiling point is also very high, with the vapor expanding greatly when heated to room temperature. Containers filled with helium gas at 5 to 10 K should be treated as though they contained liquid helium due to the large increase in pressure resulting from warming the gas to room temperature. While helium normally has a 0 valence, it seems to have a weak tendency to combine with certain other elements. Means of preparing helium difluoride have been studied, and species such as  $\text{HeNe}$  and the molecular ions  $\text{He}^+$  and  $\text{He}^{++}$  have been investigated. Helium is widely used as an inert gas shield for arc welding; as a protective gas in growing silicon and germanium crystals, and in titanium and zirconium production; as a cooling medium for nuclear reactors, and as a gas for supersonic wind tunnels. A mixture of helium and oxygen is used as an artificial atmosphere for divers and others working under pressure. Different ratios of  $\text{He}/\text{O}_2$  are used for different depths at which the diver is operating. Helium is extensively used for filling balloons as it is a much safer gas than hydrogen. One of the recent largest uses for helium has been for pressurizing liquid fuel rockets. A Saturn booster such as used on the Apollo lunar missions required about 13 million  $\text{ft}^3$  of helium for a firing, plus more for checkouts. Liquid helium's use in magnetic resonance imaging (MRI) continues to increase as the medical profession accepts and develops new uses for the equipment. This equipment is providing accurate diagnoses of problems where exploratory surgery has previously been required to determine problems. Another medical application that is being developed uses MRI to determine by blood analysis whether a patient has any form of cancer. Lifting gas applications are increasing. Various companies in addition to Goodyear, are now using "blimps" for advertising. The Navy and the Air Force are investigating the use of airships to provide early warning systems to detect low-flying cruise missiles. The Drug Enforcement Agency has used radar-equipped blimps to detect drug smugglers along the southern border of the U.S. In addition, NASA is currently using helium-filled balloons to sample the atmosphere in Antarctica to determine what is depleting the ozone layer that protects Earth from harmful U.V. radiation. Research on and development of materials which become superconductive at temperatures well above the boiling point of helium could have a major impact on the demand for helium. Less costly refrigerants having boiling points considerably higher could replace the present need to cool such superconductive materials to the boiling point of helium. Natural helium contains two stable isotopes  $^3\text{He}$  and  $^4\text{He}$ .  $^3\text{He}$  is present in very small quantities. Six other isotopes of helium are now recognized.

**Holmium** — (L. *Holmia*, for Stockholm), Ho; at. wt. 164.93032(2); at. no. 67; m.p.  $1472^\circ\text{C}$ ; b.p.  $2700^\circ\text{C}$ ; sp. gr. 8.795 ( $25^\circ\text{C}$ ); valence + 3. The spectral absorption bands of holmium were noticed in 1878 by the Swiss chemists Delafontaine and Soret, who announced the existence of an "Element X." Cleve, of Sweden, later independently discovered the element while working on erbia earth. The element is named after Cleve's native city. Pure holmia, the yellow oxide, was prepared by Homberg in 1911. Holmium occurs in *gadolinite*, *monazite*, and in other rare-earth minerals. It is commercially obtained from monazite, occurring in that mineral to the extent of about 0.05%. It has been isolated by the reduction of its anhydrous chloride or fluoride with calcium metal. Pure holmium has a metallic

to bright silver luster. It is relatively soft and malleable, and is stable in dry air at room temperature, but rapidly oxidizes in moist air and at elevated temperatures. The metal has unusual magnetic properties. Few uses have yet been found for the element. The element, as with other rare earths, seems to have a low acute toxic rating. Natural holmium consists of one isotope  $^{165}\text{Ho}$ , which is not radioactive. Holmium has 49 other isotopes known, all of which are radioactive. The price of 99.9% holmium metal is about \$20/g.

**Hydrogen** — (Gr. *hydro*, water, and *genes*, forming), H; at. wt. 1.00794(7); at. no. 1; m.p.  $-259.1^\circ\text{C}$ ; b.p.  $-252.76^\circ\text{C}$ ;  $t_c$   $-240.18^\circ\text{C}$ ; density 0.08988 g/L; density (liquid) 0.0708 g/mL ( $-253^\circ\text{C}$ ); density (solid) 0.0706 g/mL ( $-262^\circ\text{C}$ ); valence 1. Hydrogen was prepared many years before it was recognized as a distinct substance by Cavendish in 1766. It was named by Lavoisier. Hydrogen is the most abundant of all elements in the universe, and it is thought that the heavier elements were, and still are, being built from hydrogen and helium. It has been estimated that hydrogen makes up more than 90% of all the atoms or three quarters of the mass of the universe. It is found in the sun and most stars, and plays an important part in the proton-proton reaction and carbon-nitrogen cycle, which accounts for the energy of the sun and stars. It is thought that hydrogen is a major component of the planet Jupiter and that at some depth in the planet's interior the pressure is so great that solid molecular hydrogen is converted into solid metallic hydrogen. In 1973, it was reported that a group of Russian experimenters may have produced metallic hydrogen at a pressure of 2.8 Mbar. At the transition the density changed from 1.08 to 1.3  $\text{g}/\text{cm}^3$ . Earlier, in 1972, a Livermore (California) group also reported on a similar experiment in which they observed a pressure-volume point centered at 2 Mbar. It has been predicted that metallic hydrogen may be metastable; others have predicted it would be a superconductor at room temperature. On Earth, hydrogen occurs chiefly in combination with oxygen in water, but it is also present in organic matter such as living plants, petroleum, coal, etc. It is present as the free element in the atmosphere, but only to the extent of less than 1 ppm by volume. It is the lightest of all gases, and combines with other elements, sometimes explosively, to form compounds. Great quantities of hydrogen are required commercially for the fixation of nitrogen from the air in the Haber ammonia process and for the hydrogenation of fats and oils. It is also used in large quantities in methanol production, in hydrodealkylation, hydrocracking, and hydrodesulfurization. It is also used as a rocket fuel, for welding, for production of hydrochloric acid, for the reduction of metallic ores, and for filling balloons. The lifting power of 1  $\text{ft}^3$  of hydrogen gas is about 0.076 lb at  $0^\circ\text{C}$ , 760 mm pressure. Production of hydrogen in the U.S. alone now amounts to about 3 billion cubic feet per year. It is prepared by the action of steam on heated carbon, by decomposition of certain hydrocarbons with heat, by the electrolysis of water, or by the displacement from acids by certain metals. It is also produced by the action of sodium or potassium hydroxide on aluminum. Liquid hydrogen is important in cryogenics and in the study of superconductivity, as its melting point is only a  $20^\circ\text{C}$  above absolute zero. Hydrogen consists of three isotopes, most of which is  $^1\text{H}$ . The ordinary isotope of hydrogen, H, is known as *protium*. In 1932, Urey announced the discovery of a stable isotope, deuterium ( $^2\text{H}$  or D) with an atomic weight of 2. Deuterium is present in natural hydrogen to the extent of 0.015%. Two years later an unstable isotope, tritium ( $^3\text{H}$ ), with an atomic weight of 3 was discovered. Tritium has a half-life



of about 12.32 years. Tritium atoms are also present in natural hydrogen but in a much smaller proportion. Tritium is readily produced in nuclear reactors and is used in the production of the hydrogen bomb. It is also used as a radioactive agent in making luminous paints, and as a tracer. On August 27, 2001 Russian, French, and Japanese physicists working at the Joint Institute for Nuclear Research near Moscow reported they had made "super-heavy hydrogen," which had a nucleus with one proton and four neutrons. Using an accelerator, they used a beam of helium-6 nuclei to strike a hydrogen target, which resulted in the occasional production of a hydrogen-5 nucleus plus a helium-2 nucleus. These unstable particles quickly disintegrated. This resulted in two protons from the He-2, a triton, and two neutrons from the H-5 breakup. Deuterium gas is readily available, without permit, at about \$1/l. Heavy water, deuterium oxide ( $D_2O$ ), which is used as a moderator to slow down neutrons, is available without permit at a cost of 6¢ to \$1/g, depending on quantity and purity. About 1000 tons (4,400,000 kg) of deuterium oxide (heavy water) are now in use at the Sudbury (Ontario) Neutrino Observatory. This observatory is taking data to provide new revolutionary insight into the properties of neutrinos and into the core of the sun. The heavy water is on loan from Atomic Energy of Canada, Ltd. (AECL). The observatory and detectors are located 6800 ft (2072 m) deep in the Creighton mine of the International Nickel Co., near Sudbury. The heavy water is contained in an acrylic vessel, 12 m in diameter. Neutrinos react with the heavy water to produce Cherenkov radiation. This light is then detected with 9600 photomultiplier tubes surrounding the vessel. The detector laboratory is immensely clean to reduce background radiation, which otherwise hides the very weak signals from neutrinos. Quite apart from isotopes, it has been shown that hydrogen gas under ordinary conditions is a mixture of two kinds of molecules, known as *ortho*- and *para*-hydrogen, which differ from one another by the spins of their electrons and nuclei. Normal hydrogen at room temperature contains 25% of the *para* form and 75% of the *ortho* form. The *ortho* form cannot be prepared in the pure state. Since the two forms differ in energy, the physical properties also differ. The melting and boiling points of *parahydrogen* are about 0.1°C lower than those of normal hydrogen. Consideration is being given to an entire economy based on solar- and nuclear-generated hydrogen. Located in remote regions, power plants would electrolyze sea water; the hydrogen produced would travel to distant cities by pipelines. Pollution-free hydrogen could replace natural gas, gasoline, etc., and could serve as a reducing agent in metallurgy, chemical processing, refining, etc. It could also be used to convert trash into methane and ethylene. Public acceptance, high capital investment, and the high present cost of hydrogen with respect to current fuels are but a few of the problems facing establishment of such an economy. Hydrogen is being investigated as a substitute for deep-sea diving applications below 300 m. Hydrogen is readily available from air product suppliers.

**Indium** — (from the brilliant indigo line in its spectrum), In; at. wt. 114.818(3); at. no. 49; m.p. 156.60°C; b.p. 2072°C; sp. gr. 7.31 (20°C); valence 1, 2, or 3. Discovered by Reich and Richter, who later isolated the metal. Indium is most frequently associated with zinc materials, and it is from these that most commercial indium is now obtained; however, it is also found in iron, lead, and copper ores. Until 1924, a gram or so constituted the world's supply of this element in isolated form. It is probably about as abundant as silver. About 4 million troy ounces of

indium are now produced annually in the Free World. Canada is presently producing more than 1,000,000 troy ounces annually. The present cost of indium is about \$2 to \$10/g, depending on quantity and purity. It is available in ultrapure form. Indium is a very soft, silvery-white metal with a brilliant luster. The pure metal gives a high-pitched "cry" when bent. It wets glass, as does gallium. It has found application in making low-melting alloys; an alloy of 24% indium–76% gallium is liquid at room temperature. Indium is used in making bearing alloys, germanium transistors, rectifiers, thermistors, liquid crystal displays, high definition television, batteries, and photoconductors. It can be plated onto metal and evaporated onto glass, forming a mirror as good as that made with silver but with more resistance to atmospheric corrosion. There is evidence that indium has a low order of toxicity; however, care should be taken until further information is available. Seventy isotopes and isomers are now recognized (more than any other element). Natural indium contains two isotopes. One is stable. The other,  $^{115}\text{In}$ , comprising 95.71% of natural indium is slightly radioactive with a very long half-life.

**Iodine** — (Gr. *iodes*, violet), I; at. wt. 126.90447(3); at. no. 53; m.p. 113.7°C; b.p. 184.4°C;  $t_c$  546°C; density of the gas 11.27 g/L; sp. gr. solid 4.93 (20°C); valence 1, 3, 5, or 7. Discovered by Courtois in 1811. Iodine, a halogen, occurs sparingly in the form of iodides in sea water from which it is assimilated by seaweeds, in Chilean saltpeter and nitrate-bearing earth, known as *caliche* in brines from old sea deposits, and in brackish waters from oil and salt wells. Ultrapure iodine can be obtained from the reaction of potassium iodide with copper sulfate. Several other methods of isolating the element are known. Iodine is a bluish-black, lustrous solid, volatilizing at ordinary temperatures into a blue-violet gas with an irritating odor; it forms compounds with many elements, but is less active than the other halogens, which displace it from iodides. Iodine exhibits some metallic-like properties. It dissolves readily in chloroform, carbon tetrachloride, or carbon disulfide to form beautiful purple solutions. It is only slightly soluble in water. Iodine compounds are important in organic chemistry and very useful in medicine. Forty-two isotopes and isomers are recognized. Only one stable isotope,  $^{127}\text{I}$ , is found in nature. The artificial radioisotope  $^{131}\text{I}$ , with a half-life of 8 days, has been used in treating the thyroid gland. The most common compounds are the iodides of sodium and potassium (KI) and the iodates ( $\text{KIO}_3$ ). Lack of iodine is the cause of goiter. Iodides and thyroxine, which contains iodine, are used internally in medicine, and a solution of KI and iodine in alcohol is used for external wounds. Potassium iodide finds use in photography. The deep blue color with starch solution is characteristic of the free element. Care should be taken in handling and using iodine, as contact with the skin can cause lesions; iodine vapor is intensely irritating to the eyes and mucous membranes. Elemental iodine costs about 25 to 75¢/g depending on purity and quantity.

**Iridium** — (L. *iris*, rainbow), Ir; at. wt. 192.217(3); at. no. 77; m.p. 2446°C; b.p. 4428°C; sp. gr. 22.562 (20°C); valence 3 or 4. Discovered in 1803 by Tennant in the residue left when crude platinum is dissolved by aqua regia. The name iridium is appropriate, for its salts are highly colored. Iridium, a metal of the platinum family, is white, similar to platinum, but with a slight yellowish cast. It is very hard and brittle, making it very hard to machine, form, or work. It is the most corrosion-resistant metal known, and was used in making the standard meter

bar of Paris, which is a 90% platinum–10% iridium alloy. This meter bar was replaced in 1960 as a fundamental unit of length (see under Krypton). Iridium is not attacked by any of the acids nor by aqua regia, but is attacked by molten salts, such as NaCl and NaCN. Iridium occurs uncombined in nature with platinum and other metals of this family in alluvial deposits. It is recovered as a by-product from the nickel mining industry. The largest reserves and production of the platinum group of metals, which includes iridium, is in South Africa, followed by Russia and Canada. The U.S. has only one active mine, located at Nye, MT. The presence of iridium has recently been used in examining the Cretaceous-Tertiary (K-T) boundary. Meteorites contain small amounts of iridium. Because iridium is found widely distributed at the K-T boundary, it has been suggested that a large meteorite or asteroid collided with the Earth, killing the dinosaurs, and creating a large dust cloud and crater. Searches for such a crater point to one in the Yucatan, known as Chicxulub. Iridium has found use in making crucibles and apparatus for use at high temperatures. It is also used for electrical contacts. Its principal use is as a hardening agent for platinum. With osmium, it forms an alloy that is used for tipping pens and compass bearings. The specific gravity of iridium is only very slightly lower than that of osmium, which has been generally credited as being the heaviest known element. Calculations of the densities of iridium and osmium from the space lattices give values of 22.65 and 22.61 g/cm<sup>3</sup>, respectively. These values may be more reliable than actual physical measurements. At present, therefore, we know that either iridium or osmium is the densest known element, but the data do not yet allow selection between the two. Natural iridium contains two stable isotopes. Forty-five other isotopes, all radioactive, are now recognized. Iridium (99.9%) costs about \$100/g.

**Iron** — (Anglo-Saxon, *iron*), Fe (L. *ferrum*); at. wt. 55.845(2); at. no. 26; m.p. 1538°C; b.p. 2861°C; sp. gr. 7.874 (20°C); valence 2, 3, 4, or 6. The use of iron is prehistoric. Genesis mentions that Tubal-Cain, seven generations from Adam, was “an instructor of every artificer in brass and iron.” A remarkable iron pillar, dating to about A.D. 400, remains standing today in Delhi, India. This solid shaft of wrought iron is about 7½ m high by 40 cm in diameter. Corrosion to the pillar has been minimal although it has been exposed to the weather since its erection. Iron is a relatively abundant element in the universe. It is found in the sun and many types of stars in considerable quantity. It has been suggested that the iron we have here on Earth may have originated in a supernova. Iron is a very difficult element to produce in ordinary nuclear reactions, such as would take place in the sun. Iron is found native as a principal component of a class of iron–nickel meteorites known as *siderites*, and is a minor constituent of the other two classes of meteorites. The core of the Earth, 2150 miles in radius, is thought to be largely composed of iron with about 10% occluded hydrogen. The metal is the fourth most abundant element, by weight, making up the crust of the Earth. The most common ore is *hematite* (Fe<sub>2</sub>O<sub>3</sub>). Magnetite (Fe<sub>3</sub>O<sub>4</sub>) is frequently seen as *black sands* along beaches and banks of streams. *Lodestone* is another form of magnetite. *Taconite* is becoming increasingly important as a commercial ore. Iron is a vital constituent of plant and animal life, and appears in hemoglobin. The pure metal is not often encountered in commerce, but is usually alloyed with carbon or other metals. The pure metal is very reactive chemically, and rapidly corrodes, especially in moist air or at elevated temperatures. It has four allotropic forms,

or ferrites, known as  $\alpha$ ,  $\beta$ ,  $\gamma$ , and  $\delta$ , with transition points at 700, 928, and 1530°C. The  $\alpha$  form is magnetic, but when transformed into the  $\beta$  form, the magnetism disappears although the lattice remains unchanged. The relations of these forms are peculiar. Pig iron is an alloy containing about 3% carbon with varying amounts of S, Si, Mn, and P. It is hard, brittle, fairly fusible, and is used to produce other alloys, including steel. Wrought iron contains only a few tenths of a percent of carbon, is tough, malleable, less fusible, and usually has a “fibrous” structure. Carbon steel is an alloy of iron with carbon, with small amounts of Mn, S, P, and Si. Alloy steels are carbon steels with other additives such as nickel, chromium, vanadium, etc. Iron is the cheapest and most abundant, useful, and important of all metals. Natural iron contains four isotopes. Twenty-six other isotopes and isomers, all radioactive, are now recognized.

**Krypton** — (Gr. *kryptos*, hidden), Kr; at. wt. 83.798(2); at. no. 36; m.p. –157.36°C; b.p. –153.34 ± 0.10°C;  $t_c$  –63.67°C; density 3.733 g/L (0°C); valence usually 0. Discovered in 1898 by Ramsay and Travers in the residue left after liquid air had nearly boiled away, krypton is present in the air to the extent of about 1 ppm. The atmosphere of Mars has been found to contain 0.3 ppm of krypton. It is one of the “noble” gases. It is characterized by its brilliant green and orange spectral lines. Naturally occurring krypton contains six stable isotopes. Thirty other unstable isotopes and isomers are now recognized. The spectral lines of krypton are easily produced and some are very sharp. In 1960 it was internationally agreed that the fundamental unit of length, the meter, should be defined in terms of the orange-red spectral line of <sup>86</sup>Kr. This replaced the standard meter of Paris, which was defined in terms of a bar made of a platinum–iridium alloy. In October 1983 the meter was again redefined by the International Bureau of Weights and Measures as being the length of path traveled by light in a vacuum during a time interval of 1/299,792,458 of a second. Solid krypton is a white crystalline substance with a face-centered cubic structure that is common to all the rare gases. While krypton is generally thought of as a noble gas that normally does not combine with other elements, the existence of some krypton compounds has been established. Krypton difluoride has been prepared in gram quantities and can be made by several methods. A higher fluoride of krypton and a salt of an oxyacid of krypton also have been prepared. Molecule-ions of ArKr<sup>+</sup> and KrH<sup>+</sup> have been identified and investigated, and evidence is provided for the formation of KrXe or KrXe<sup>+</sup>. Krypton clathrates have been prepared with hydroquinone and phenol. <sup>85</sup>Kr has found recent application in chemical analysis. By imbedding the isotope in various solids, *kryptonates* are formed. The activity of these kryptonates is sensitive to chemical reactions at the surface. Estimates of the concentration of reactants are therefore made possible. Krypton is used in certain photographic flash lamps for high-speed photography. Uses thus far have been limited because of its high cost. Krypton gas presently costs about \$690/100 L.

**Kurchatovium** — See Rutherfordium.

**Lanthanum** — (Gr. *lanthanein*, to lie hidden), La; at. wt. 138.90547(7); at. no. 57; m.p. 920°C; b.p. 3464°C; sp. gr. 6.145 (25°C); valence 3. Mosander in 1839 extracted a new earth *lanthana*, from impure cerium nitrate, and recognized the new element. Lanthanum is found in rare-earth minerals such as *cerite*, *monazite*, *allanite*, and *bastnasite*. Monazite and bastnasite are principal ores in which lanthanum occurs



in percentages up to 25 and 38%, respectively. Misch metal, used in making lighter flints, contains about 25% lanthanum. Lanthanum was isolated in relatively pure form in 1923. Ion-exchange and solvent extraction techniques have led to much easier isolation of the so-called "rare-earth" elements. The availability of lanthanum and other rare earths has improved greatly in recent years. The metal can be produced by reducing the anhydrous fluoride with calcium. Lanthanum is silvery white, malleable, ductile, and soft enough to be cut with a knife. It is one of the most reactive of the rare-earth metals. It oxidizes rapidly when exposed to air. Cold water attacks lanthanum slowly, and hot water attacks it much more rapidly. The metal reacts directly with elemental carbon, nitrogen, boron, selenium, silicon, phosphorus, sulfur, and with halogens. At 310°C, lanthanum changes from a hexagonal to a face-centered cubic structure, and at 865°C it again transforms into a body-centered cubic structure. Natural lanthanum is a mixture of two isotopes, one of which is stable and one of which is radioactive with a very long half-life. Thirty other radioactive isotopes are recognized. Rare-earth compounds containing lanthanum are extensively used in carbon lighting applications, especially by the motion picture industry for studio lighting and projection. This application consumes about 25% of the rare-earth compounds produced.  $\text{La}_2\text{O}_3$  improves the alkali resistance of glass, and is used in making special optical glasses. Small amounts of lanthanum, as an additive, can be used to produce nodular cast iron. There is current interest in hydrogen sponge alloys containing lanthanum. These alloys take up to 400 times their own volume of hydrogen gas, and the process is reversible. Heat energy is released every time they do so; therefore these alloys have possibilities in energy conservation systems. Lanthanum and its compounds have a low to moderate acute toxicity rating; therefore, care should be taken in handling them. The metal costs about \$2/g (99.9%).

**Lawrencium** — (Ernest O. Lawrence [1901–1958], inventor of the cyclotron), Lr; at. no. 103; at. mass no. [262]; valence + 3(?). This member of the 5f transition elements (actinide series) was discovered in March 1961 by A. Ghiorso, T. Sikkeland, A. E. Larsh, and R. M. Latimer. A 3- $\mu\text{g}$  californium target, consisting of a mixture of isotopes of mass number 249, 250, 251, and 252, was bombarded with either  $^{10}\text{B}$  or  $^{11}\text{B}$ . The electrically charged transmutation nuclei recoiled with an atmosphere of helium and were collected on a thin copper conveyor tape which was then moved to place collected atoms in front of a series of solid-state detectors. The isotope of element 103 produced in this way decayed by emitting an 8.6-MeV alpha particle with a half-life of 8 s. In 1967, Flerov and associates of the Dubna Laboratory reported their inability to detect an alpha emitter with a half-life of 8 s which was assigned by the Berkeley group to  $^{257}\text{103}$ . This assignment has been changed to  $^{258}\text{Lr}$  or  $^{259}\text{Lr}$ . In 1965, the Dubna workers found a longer-lived lawrencium isotope,  $^{256}\text{Lr}$ , with a half-life of 35 s. In 1968, Ghiorso and associates at Berkeley were able to use a few atoms of this isotope to study the oxidation behavior of lawrencium. Using solvent extraction techniques and working very rapidly, they extracted lawrencium ions from a buffered aqueous solution into an organic solvent, completing each extraction in about 30 s. It was found that lawrencium behaves differently from dipositive nobelium and more like the tripositive elements earlier in the actinide series. Ten isotopes of lawrencium are now recognized.

**Lead** — (Anglo-Saxon *lead*), Pb (L. *plumbum*); at. wt. 207.2(1); at. no. 82; m.p. 327.46°C; b.p. 1749°C; sp. gr. 11.35 (20°C); valence 2 or 4. Long known, mentioned in Exodus. The alchemists believed lead to be the oldest metal and associated it with the planet Saturn. Native lead occurs in nature, but it is rare. Lead is obtained chiefly from *galena* ( $\text{PbS}$ ) by a roasting process. *Anglesite* ( $\text{PbSO}_4$ ), *cerussite* ( $\text{PbCO}_3$ ), and *minim* ( $\text{Pb}_3\text{O}_4$ ) are other common lead minerals. Lead is a bluish-white metal of bright luster, is very soft, highly malleable, ductile, and a poor conductor of electricity. It is very resistant to corrosion; lead pipes bearing the insignia of Roman emperors, used as drains from the baths, are still in service. It is used in containers for corrosive liquids (such as sulfuric acid) and may be toughened by the addition of a small percentage of antimony or other metals. Natural lead is a mixture of four stable isotopes:  $^{204}\text{Pb}$  (1.4%),  $^{206}\text{Pb}$  (24.1%),  $^{207}\text{Pb}$  (22.1%), and  $^{208}\text{Pb}$  (52.4%). Lead isotopes are the end products of each of the three series of naturally occurring radioactive elements:  $^{206}\text{Pb}$  for the uranium series,  $^{207}\text{Pb}$  for the actinium series, and  $^{208}\text{Pb}$  for the thorium series. Forty-three other isotopes of lead, all of which are radioactive, are recognized. Its alloys include solder, type metal, and various antifriction metals. Great quantities of lead, both as the metal and as the dioxide, are used in storage batteries. Lead is also used for cable covering, plumbing, and ammunition. The metal is very effective as a sound absorber, is used as a radiation shield around X-ray equipment and nuclear reactors, and is used to absorb vibration. Lead, alloyed with tin, is used in making organ pipes. White lead, the basic carbonate, sublimed white lead ( $\text{PbSO}_4$ ), chrome yellow ( $\text{PbCrO}_4$ ), red lead ( $\text{Pb}_3\text{O}_4$ ), and other lead compounds are used extensively in paints, although in recent years the use of lead in paints has been drastically curtailed to eliminate or reduce health hazards. Lead oxide is used in producing fine "crystal glass" and "flint glass" of a high index of refraction for achromatic lenses. The nitrate and the acetate are soluble salts. Lead salts such as lead arsenate have been used as insecticides, but their use in recent years has been practically eliminated in favor of less harmful organic compounds. Care must be used in handling lead as it is a cumulative poison. Environmental concern with lead poisoning led to elimination of lead tetraethyl in gasoline. The U.S. Occupational Safety and Health Administration (OSHA) has recommended that industries limit airborne lead to 50  $\mu\text{g}/\text{cu. meter}$ . Lead is priced at about 90¢/kg (99.9%).

**Lithium** — (Gr. *lithos*, stone), Li; at. wt. 6.941(2); at. no. 3; m.p. 180.5°C; b.p. 1342°C; sp. gr. 0.534 (20°C); valence 1. Discovered by Arfvedson in 1817. Lithium is the lightest of all metals, with a density only about half that of water. It does not occur free in nature; combined it is found in small amounts in nearly all igneous rocks and in the waters of many mineral springs. *Lepidolite*, *spodumene*, *petalite*, and *amblygonite* are the more important minerals containing it. Lithium is presently being recovered from brines of Seale Lake, in California, and from Nevada, Chile, and Argentina. Large deposits of spodumene are found in North Carolina. The metal is produced electrolytically from the fused chloride. Lithium is silvery in appearance, much like Na and K, other members of the alkali metal series. It reacts with water, but not as vigorously as sodium. Lithium imparts a beautiful crimson color to a flame, but when the metal burns strongly the flame is a dazzling white. Since World War II, the production of lithium metal and its compounds has increased greatly. Because the metal has the highest specific heat of any solid element, it has found use in heat transfer applications; however, it is corrosive and re-

quires special handling. The metal has been used as an alloying agent, is of interest in synthesis of organic compounds, and has nuclear applications. It ranks as a leading contender as a battery anode material because it has a high electrochemical potential. Lithium is used in special glasses and ceramics. The glass for the 200-inch telescope at Mt. Palomar contains lithium as a minor ingredient. Lithium chloride is one of the most hygroscopic materials known, and it, as well as lithium bromide, is used in air conditioning and industrial drying systems. Lithium stearate is used as an all-purpose and high-temperature lubricant. Other lithium compounds are used in dry cells and storage batteries. Seven isotopes of lithium are recognized. Natural lithium contains two isotopes. The metal is priced at about \$1.50/g (99.9%).

**Lutetium** — (Lutetia, ancient name for Paris, sometimes called *cassiopeium* by the Germans), Lu; at. wt. 174.967(1); at. no. 71; m.p. 1663°C; b.p. 3402°C; sp. gr. 9.841 (25°C); valence 3. In 1907, Urbain described a process by which Marignac's ytterbium (1879) could be separated into the two elements, ytterbium (neoytterbium) and lutetium. These elements were identical with "aldebaranum" and "cassiopeium," independently discovered by von Welsbach about the same time. Charles James of the University of New Hampshire also independently prepared the very pure oxide, *lutecia*, at this time. The spelling of the element was changed from *lutecium* to *lutetium* in 1949. Lutetium occurs in very small amounts in nearly all minerals containing yttrium, and is present in *monazite* to the extent of about 0.003%, which is a commercial source. The pure metal has been isolated only in recent years and is one of the most difficult to prepare. It can be prepared by the reduction of anhydrous  $\text{LuCl}_3$  or  $\text{LuF}_3$  by an alkali or alkaline earth metal. The metal is silvery white and relatively stable in air. While new techniques, including ion-exchange reactions, have been developed to separate the various rare-earth elements, lutetium is still the most costly of all rare earths. It is priced at about \$100/g (99.9%).  $^{176}\text{Lu}$  occurs naturally (97.41%) with  $^{175}\text{Lu}$  (2.59%), which is radioactive with a very long half-life of about  $4 \times 10^{10}$  years. Lutetium has 50 isotopes and isomers that are now recognized. Stable lutetium nuclides, which emit pure beta radiation after thermal neutron activation, can be used as catalysts in cracking, alkylation, hydrogenation, and polymerization. Virtually no other commercial uses have been found yet for lutetium. While lutetium, like other rare-earth metals, is thought to have a low toxicity rating, it should be handled with care until more information is available.

**Magnesium** — (*Magnesia*, district in Thessaly) Mg; at. wt. 24.3050(6); at. no. 12; m.p. 650°C; b.p. 1090°C; sp. gr. 1.738 (20°C); valence 2. Compounds of magnesium have long been known. Black recognized magnesium as an element in 1755. It was isolated by Davy in 1808, and prepared in coherent form by Bussy in 1831. Magnesium is the eighth most abundant element in the Earth's crust. It does not occur uncombined, but is found in large deposits in the form of *magnesite*, *dolomite*, and other minerals. The metal is now principally obtained in the U.S. by electrolysis of fused magnesium chloride derived from brines, wells, and sea water. Magnesium is a light, silvery-white, and fairly tough metal. It tarnishes slightly in air, and finely divided magnesium readily ignites upon heating in air and burns with a dazzling white flame. It is used in flashlight photography, flares, and pyrotechnics, including incendiary bombs. It is one third lighter than aluminum, and in alloys is essential for airplane and missile

construction. The metal improves the mechanical, fabrication, and welding characteristics of aluminum when used as an alloying agent. Magnesium is used in producing nodular graphite in cast iron, and is used as an additive to conventional propellants. It is also used as a reducing agent in the production of pure uranium and other metals from their salts. The hydroxide (*milk of magnesia*), chloride, sulfate (*Epsom salts*), and citrate are used in medicine. Dead-burned magnesite is employed for refractory purposes such as brick and liners in furnaces and converters. Calcined magnesia is also used for water treatment and in the manufacture of rubber, paper, etc. Organic magnesium compounds (Grignard's reagents) are important. Magnesium is an important element in both plant and animal life. Chlorophylls are magnesium-centered porphyrins. The adult daily requirement of magnesium is about 300 mg/day, but this is affected by various factors. Great care should be taken in handling magnesium metal, especially in the finely divided state, as serious fires can occur. Water should not be used on burning magnesium or on magnesium fires. Natural magnesium contains three isotopes. Twelve other isotopes are recognized. Magnesium metal costs about \$100/kg (99.8%).

**Manganese** — (L. *magnes*, magnet, from magnetic properties of pyrolusite; It. *manganese*, corrupt form of *magnesia*), Mn; at. wt. 54.938045(5); at. no. 25; m.p. 1246°C; b.p. 2061°C; sp. gr. 7.21 to 7.44, depending on allotropic form; valence 1, 2, 3, 4, 6, or 7. Recognized by Scheele, Bergman, and others as an element and isolated by Gahn in 1774 by reduction of the dioxide with carbon. Manganese minerals are widely distributed; oxides, silicates, and carbonates are the most common. The discovery of large quantities of manganese nodules on the floor of the oceans holds promise as a source of manganese. These nodules contain about 24% manganese together with many other elements in lesser abundance. Most manganese today is obtained from ores found in Ukraine, Brazil, Australia, Republic of So. Africa, Gabon, China, and India. *Pyrolusite* ( $\text{MnO}_2$ ) and *rhodochrosite* ( $\text{MnCO}_3$ ) are among the most common manganese minerals. The metal is obtained by reduction of the oxide with sodium, magnesium, aluminum, or by electrolysis. It is gray-white, resembling iron, but is harder and very brittle. The metal is reactive chemically, and decomposes in cold water slowly. Manganese is used to form many important alloys. In steel, manganese improves the rolling and forging qualities, strength, toughness, stiffness, wear resistance, hardness, and hardenability. With aluminum and antimony, especially with small amounts of copper, it forms highly ferromagnetic alloys. Manganese metal is ferromagnetic only after special treatment. The pure metal exists in four allotropic forms. The alpha form is stable at ordinary temperature; gamma manganese, which changes to alpha at ordinary temperatures, is soft, easily cut, and capable of being bent. The dioxide (pyrolusite) is used as a depolarizer in dry cells, and is used to "decolorize" glass that is colored green by impurities of iron. Manganese by itself colors glass an amethyst color, and is responsible for the color of true amethyst. The dioxide is also used in the preparation of oxygen and chlorine, and in drying black paints. The permanganate is a powerful oxidizing agent and is used in quantitative analysis and in medicine. Manganese is widely distributed throughout the animal kingdom. It is an important trace element and may be essential for utilization of vitamin  $\text{B}_{12}$ . Twenty-seven isotopes and isomers are known. Manganese metal (99.95%) is priced at about \$800/kg. Metal of 99.6% purity is priced at about \$80/kg.

**Meitnerium** — (Lise Meitner [1878–1968], Austrian–Swedish physicist and mathematician), Mt; at. wt. [268]; at. no. 109. On August 29, 1992, Element 109 was made and identified by physicists at the Heavy Ion Research Laboratory (G.S.I.), Darmstadt, Germany, by bombarding a target of  $^{209}\text{Bi}$  with accelerated nuclei of  $^{58}\text{Fe}$ . The production of Element 109 has been extremely small. It took a week of target bombardment ( $10^{11}$  nuclear encounters) to produce a single atom of 109. Oganessian and his team at Dubna in 1994 repeated the Darmstadt experiment using a tenfold irradiation dose. One fission event from seven alpha decays of 109 was observed, thus indirectly confirming the existence of isotope  $^{266}\text{109}$ . In August 1997, the IUPAC adopted the name *meitnerium* for this element, honoring L. Meitner. Four isotopes of *meitnerium* are now recognized.

**Mendelevium** — (Dmitri Mendeleev [1834–1907]), Md; at. wt. (258); at. no. 101; m.p.  $827^\circ\text{C}$ ; valence +2, +3. Mendelevium, the ninth transuranium element of the actinide series to be discovered, was first identified by Ghiorso, Harvey, Choppin, Thompson, and Seaborg early in 1955 as a result of the bombardment of the isotope  $^{253}\text{Es}$  with helium ions in the Berkeley 60-inch cyclotron. The isotope produced was  $^{256}\text{Md}$ , which has a half-life of 78 min. This first identification was notable in that  $^{256}\text{Md}$  was synthesized on a one-atom-at-a-time basis. Nineteen isotopes and isomers are now recognized.  $^{258}\text{Md}$  has a half-life of 51.5 days. This isotope has been produced by the bombardment of an isotope of einsteinium with ions of helium. It now appears possible that eventually enough  $^{258}\text{Md}$  can be made so that some of its physical properties can be determined.  $^{256}\text{Md}$  has been used to elucidate some of the chemical properties of mendelevium in aqueous solution. Experiments seem to show that the element possesses a moderately stable dipositive (II) oxidation state in addition to the tripositive (III) oxidation state, which is characteristic of actinide elements.

**Mercury** — (Planet *Mercury*), Hg (*hydrargyrum*, liquid silver); at. wt. 200.59(2); at. no. 80; t.p.  $-38.83^\circ\text{C}$ ; b.p.  $356.62^\circ\text{C}$ ;  $t_c$   $1477^\circ\text{C}$ ; sp. gr. 13.546 ( $20^\circ\text{C}$ ); valence 1 or 2. Known to ancient Chinese and Hindus; found in Egyptian tombs of 1500 B.C. Mercury is the only common metal liquid at ordinary temperatures. It only rarely occurs free in nature. The chief ore is *cinnabar* ( $\text{HgS}$ ). Spain and China produce about 75% of the world's supply of the metal. The commercial unit for handling mercury is the "flask," which weighs 76 lb (34.46 kg). The metal is obtained by heating cinnabar in a current of air and by condensing the vapor. It is a heavy, silvery-white metal; a rather poor conductor of heat, as compared with other metals, and a fair conductor of electricity. It easily forms alloys with many metals, such as gold, silver, and tin, which are called *amalgams*. Its ease in amalgamating with gold is made use of in the recovery of gold from its ores. The metal is widely used in laboratory work for making thermometers, barometers, diffusion pumps, and many other instruments. It is used in making mercury-vapor lamps and advertising signs, etc. and is used in mercury switches and other electrical apparatus. Other uses are in making pesticides, mercury cells for caustic soda and chlorine production, dental preparations, antifouling paint, batteries, and catalysts. The most important salts are mercuric chloride  $\text{HgCl}_2$  (corrosive sublimate — a violent poison), mercurous chloride  $\text{Hg}_2\text{Cl}_2$  (calomel, occasionally still used in medicine), mercury fulminate ( $\text{Hg}(\text{ONC})_2$ ), a detonator widely used in explosives, and mercuric sulfide ( $\text{HgS}$ , vermillion, a high-grade paint pigment). Organic mercury compounds are im-

portant. It has been found that an electrical discharge causes mercury vapor to combine with neon, argon, krypton, and xenon. These products, held together with van der Waals' forces, correspond to  $\text{HgNe}$ ,  $\text{HgAr}$ ,  $\text{HgKr}$ , and  $\text{HgXe}$ . Mercury is a virulent poison and is readily absorbed through the respiratory tract, the gastrointestinal tract, or through unbroken skin. It acts as a cumulative poison and dangerous levels are readily attained in air. Air saturated with mercury vapor at  $20^\circ\text{C}$  contains a concentration that exceeds the toxic limit many times. The danger increases at higher temperatures. *It is therefore important that mercury be handled with care.* Containers of mercury should be securely covered and spillage should be avoided. If it is necessary to heat mercury or mercury compounds, it should be done in a well-ventilated hood. Methyl mercury is a dangerous pollutant and is now widely found in water and streams. The triple point of mercury,  $-38.8344^\circ\text{C}$ , is a fixed point on the International Temperature Scale (ITS-90). Mercury (99.98%) is priced at about \$110/kg. Native mercury contains seven isotopes. Thirty-six other isotopes and isomers are known.

**Molybdenum** — (Gr. *molybdos*, lead), Mo; at. wt. 95.94(2); at. no. 42; m.p.  $2623^\circ\text{C}$ ; b.p.  $4639^\circ\text{C}$ ; sp. gr. 10.22 ( $20^\circ\text{C}$ ); valence 2, 3, 4?, 5?, or 6. Before Scheele recognized molybdenite as a distinct ore of a new element in 1778, it was confused with graphite and lead ore. The metal was prepared in an impure form in 1782 by Hjelm. Molybdenum does not occur native, but is obtained principally from *molybdenite* ( $\text{MoS}_2$ ). *Wulfenite* ( $\text{PbMoO}_4$ ) and *powellite* ( $\text{Ca}(\text{MoW})\text{O}_4$ ) are also minor commercial ores. Molybdenum is also recovered as a by-product of copper and tungsten mining operations. The U.S., Canada, Chile, and China produce most of the world's molybdenum ores. The metal is prepared from the powder made by the hydrogen reduction of purified molybdic trioxide or ammonium molybdate. The metal is silvery white, very hard, but is softer and more ductile than tungsten. It has a high elastic modulus, and only tungsten and tantalum, of the more readily available metals, have higher melting points. It is a valuable alloying agent, as it contributes to the hardenability and toughness of quenched and tempered steels. It also improves the strength of steel at high temperatures. It is used in certain nickel-based alloys, such as the Hastelloys® which are heat-resistant and corrosion-resistant to chemical solutions. Molybdenum oxidizes at elevated temperatures. The metal has found recent application as electrodes for electrically heated glass furnaces and forehearths. It is also used in nuclear energy applications and for missile and aircraft parts. Molybdenum is valuable as a catalyst in the refining of petroleum. It has found application as a filament material in electronic and electrical applications. Molybdenum is an essential trace element in plant nutrition. Some lands are barren for lack of this element in the soil. Molybdenum sulfide is useful as a lubricant, especially at high temperatures where oils would decompose. Almost all ultra-high strength steels with minimum yield points up to 300,000 lb/in.<sup>2</sup> contain molybdenum in amounts from 0.25 to 8%. Natural molybdenum contains seven isotopes. Thirty other isotopes and isomers are known, all of which are radioactive. Molybdenum metal costs about \$1/g (99.999% purity). Molybdenum metal (99.9%) costs about \$160/kg.

**Neodymium** — (Gr. *neos*, new, and *didymos*, twin), Nd; at. wt. 144.242(3); at. no. 60; m.p.  $1016^\circ\text{C}$ ; b.p.  $3074^\circ\text{C}$ ; sp. gr. 7.008 ( $25^\circ\text{C}$ ); valence 3. In 1841 Mosander extracted from *cerite* a new rose-colored oxide, which he believed contained a new



element. He named the element *didymium*, as it was *an inseparable twin brother of lanthanum*. In 1885 von Welsbach separated didymium into two new elemental components, *neodymia* and *praseodymia*, by repeated fractionation of ammonium didymium nitrate. While the free metal is in *misch metal*, long known and used as a pyrophoric alloy for light flints, the element was not isolated in relatively pure form until 1925. Neodymium is present in misch metal to the extent of about 18%. It is present in the minerals *monazite* and *bastnasite*, which are principal sources of rare-earth metals. The element may be obtained by separating neodymium salts from other rare earths by ion-exchange or solvent extraction techniques, and by reducing anhydrous halides such as  $\text{NdF}_3$  with calcium metal. Other separation techniques are possible. The metal has a bright silvery metallic luster. Neodymium is one of the more reactive rare-earth metals and quickly tarnishes in air, forming an oxide that splits off and exposes metal to oxidation. The metal, therefore, should be kept under light mineral oil or sealed in a plastic material. Neodymium exists in two allotropic forms, with a transformation from a double hexagonal to a body-centered cubic structure taking place at  $863^\circ\text{C}$ . Natural neodymium is a mixture of seven isotopes, one of which has a very long half-life. Twenty-seven other radioactive isotopes and isomers are recognized. Didymium, of which neodymium is a component, is used for coloring glass to make welder's goggles. By itself, neodymium colors glass delicate shades ranging from pure violet through wine-red and warm gray. Light transmitted through such glass shows unusually sharp absorption bands. The glass has been used in astronomical work to produce sharp bands by which spectral lines may be calibrated. Glass containing neodymium can be used as a laser material to produce coherent light. Neodymium salts are also used as a colorant for enamels. The element is also being used with iron and boron to produce extremely strong magnets. These are the most compact magnets commercially available. The price of the metal is about \$4/g. Neodymium has a low-to-moderate acute toxic rating. As with other rare earths, neodymium should be handled with care.

**Neon** — (Gr. *neos*, new), Ne; at. wt. 20.1797(6); at. no. 10; t.p.  $-248.609^\circ\text{C}$ ; b.p.  $-246.053^\circ\text{C}$ ;  $t_c$   $-228.7^\circ\text{C}$ ; density of gas 0.89990 g/L (1 atm,  $0^\circ\text{C}$ ); density of liquid at b.p. 1.204 g/cm<sup>3</sup>; valence 0. Discovered by Ramsay and Travers in 1898. Neon is a rare gaseous element present in the atmosphere to the extent of 1 part in 65,000 of air. It is obtained by liquefaction of air and separated from the other gases by fractional distillation. Natural neon is a mixture of three isotopes. Fourteen other unstable isotopes are known. It is very inert element; however, it is said to form a compound with fluorine. It is still questionable if true compounds of neon exist, but evidence is mounting in favor of their existence. The following ions are known from optical and mass spectrometric studies:  $\text{Ne}^+$ ,  $(\text{NeAr})^+$ ,  $(\text{NeH})^+$ , and  $(\text{HeNe}^+)$ . Neon also forms an unstable hydrate. In a vacuum discharge tube, neon glows reddish orange. Of all the rare gases, the discharge of neon is the most intense at ordinary voltages and currents. Neon is used in making the common neon advertising signs, which accounts for its largest use. It is also used to make high-voltage indicators, lightning arrestors, wave meter tubes, and TV tubes. Neon and helium are used in making gas lasers. Liquid neon is now commercially available and is finding important application as an economical cryogenic refrigerant. It has over 40 times more refrigerating capacity per unit volume than liquid helium and more than three times that of liquid hydrogen. It

is compact, inert, and is less expensive than helium when it meets refrigeration requirements. Neon costs about \$800/80 cu. ft. (2265 l).

**Neptunium** — (Planet *Neptune*), Np; at. wt. (237); at. no. 93; m.p.  $644^\circ\text{C}$ ; sp. gr. 20.25 ( $20^\circ\text{C}$ ); valence 3, 4, 5, and 6. Neptunium was the first synthetic transuranium element of the actinide series discovered; the isotope  $^{239}\text{Np}$  was produced by McMillan and Abelson in 1940 at Berkeley, California, as the result of bombarding uranium with cyclotron-produced neutrons. The isotope  $^{237}\text{Np}$  (half-life of  $2.14 \times 10^6$  years) is currently obtained in gram quantities as a by-product from nuclear reactors in the production of plutonium. Twenty-three isotopes and isomers of neptunium are now recognized. Trace quantities of the element are actually found in nature due to transmutation reactions in uranium ores produced by the neutrons which are present. Neptunium is prepared by the reduction of  $\text{NpF}_3$  with barium or lithium vapor at about  $1200^\circ\text{C}$ . Neptunium metal has a silvery appearance, is chemically reactive, and exists in at least three structural modifications:  $\alpha$ -neptunium, orthorhombic, density 20.25 g/cm<sup>3</sup>,  $\beta$ -neptunium (above  $280^\circ\text{C}$ ), tetragonal, density ( $313^\circ\text{C}$ ) 19.36 g/cm<sup>3</sup>,  $\gamma$ -neptunium (above  $577^\circ\text{C}$ ), cubic, density ( $600^\circ\text{C}$ ) 18.0 g/cm<sup>3</sup>. Neptunium has four ionic oxidation states in solution:  $\text{Np}^{+3}$  (pale purple), analogous to the rare earth ion  $\text{Pm}^{+3}$ ,  $\text{Np}^{+4}$  (yellow green);  $\text{NpO}^+$  (green blue); and  $\text{NpO}^{++}$  (pale pink). These latter oxygenated species are in contrast to the rare earths that exhibit only simple ions of the (II), (III), and (IV) oxidation states in aqueous solution. The element forms tri- and tetrahalides such as  $\text{NpF}_3$ ,  $\text{NpF}_4$ ,  $\text{NpCl}_3$ ,  $\text{NpBr}_3$ ,  $\text{NpI}_3$ , and oxides of various compositions such as are found in the uranium-oxygen system, including  $\text{Np}_3\text{O}_8$  and  $\text{NpO}_2$ .

**Nickel** — (Ger. *Nickel*, Satan or Old Nick's and from *kupfernickel*, Old Nick's copper), Ni; at. wt. 58.6934(2); at. no. 28; m.p.  $1455^\circ\text{C}$ ; b.p.  $2913^\circ\text{C}$ ; sp. gr. 8.902 ( $25^\circ\text{C}$ ); valence 0, 1, 2, 3. Discovered by Cronstedt in 1751 in *kupfernickel* (*niccolite*). Nickel is found as a constituent in most meteorites and often serves as one of the criteria for distinguishing a meteorite from other minerals. Iron meteorites, or *siderites*, may contain iron alloyed with from 5 to nearly 20% nickel. Nickel is obtained commercially from *pentlandite* and *pyrrhotite* of the Sudbury region of Ontario, a district that produces much of the world's nickel. It is now thought that the Sudbury deposit is the result of an ancient meteorite impact. Large deposits of nickel, cobalt, and copper have recently been developed at Voisey's Bay, Labrador. Other deposits of nickel are found in Russia, New Caledonia, Australia, Cuba, Indonesia, and elsewhere. Nickel is silvery white and takes on a high polish. It is hard, malleable, ductile, somewhat ferromagnetic, and a fair conductor of heat and electricity. It belongs to the iron-cobalt group of metals and is chiefly valuable for the alloys it forms. It is extensively used for making stainless steel and other corrosion-resistant alloys such as Invar®, Monel®, Inconel®, and the Hastelloys®. Tubing made of a copper-nickel alloy is extensively used in making desalination plants for converting sea water into fresh water. Nickel is also now used extensively in coinage and in making nickel steel for armor plate and burglar-proof vaults, and is a component in Nichrome®, Permalloy®, and constantan. Nickel added to glass gives a green color. Nickel plating is often used to provide a protective coating for other metals, and finely divided nickel is a catalyst for hydrogenating vegetable oils. It is also used in ceramics, in the manufacture of Alnico magnets, and in batteries. The sulfate and the

oxides are important compounds. Natural nickel is a mixture of five stable isotopes; twenty-five other unstable isotopes are known. Nickel sulfide fume and dust, as well as other nickel compounds, are carcinogens. Nickel metal (99.9%) is priced at about \$2/g or less in larger quantities.

**Niobium** — (*Niobe*, daughter of Tantalus), Nb; or Columbium (*Columbia*, name for America); at. wt. 92.90638(2); at. no. 41; m.p. 2477°C; b.p. 4744°C, sp. gr. 8.57 (20°C); valence 2, 3, 4?, 5. Discovered in 1801 by Hatchett in an ore sent to England more than a century before by John Winthrop the Younger, first governor of Connecticut. The metal was first prepared in 1864 by Blomstrand, who reduced the chloride by heating it in a hydrogen atmosphere. The name *niobium* was adopted by the International Union of Pure and Applied Chemistry in 1950 after 100 years of controversy. Most leading chemical societies and government organizations refer to it by this name. Some metallurgists and commercial producers, however, still refer to the metal as “columbium.” The element is found in *niobite* (or *columbite*), *niobite-tantalite*, *pyrochlore*, and *euxenite*. Large deposits of niobium have been found associated with *carbonatites* (carbon-silicate rocks), as a constituent of *pyrochlore*. Extensive ore reserves are found in Canada, Brazil, Congo-Kinshasa, Rwanda, and Australia. The metal can be isolated from tantalum, and prepared in several ways. It is a shiny, white, soft, and ductile metal, and takes on a bluish cast when exposed to air at room temperatures for a long time. The metal starts to oxidize in air at 200°C, and when processed at even moderate temperatures must be placed in a protective atmosphere. It is used in arc-welding rods for stabilized grades of stainless steel. Thousands of pounds of niobium have been used in advanced air frame systems such as were used in the Gemini space program. It has also found use in super-alloys for applications such as jet engine components, rocket sub-assemblies, and heat-resisting equipment. The element has superconductive properties; superconductive magnets have been made with Nb-Zr wire, which retains its superconductivity in strong magnetic fields. Natural niobium is composed of only one isotope, <sup>93</sup>Nb. Forty-seven other isotopes and isomers of niobium are now recognized. Niobium metal (99.9% pure) is priced at about 50¢/g.

**Nitrogen** — (L. *nitrum*, Gr. *nitron*, native soda; genes, *forming*, N; at. wt. 14.0067(2); at. no. 7; m.p. -210.00°C; b.p. -195.798°C; *t<sub>c</sub>* -146.94°C; density 1.2506 g/L; sp. gr. liquid 0.808 (-195.8°C), solid 1.026 (-252°C); valence 3 or 5. Discovered by Daniel Rutherford in 1772, but Scheele, Cavendish, Priestley, and others about the same time studied “burnt or dephlogisticated air,” as air without oxygen was then called. Nitrogen makes up 78% of the air, by volume. The atmosphere of Mars, by comparison, is 2.6% nitrogen. The estimated amount of this element in our atmosphere is more than 4000 trillion tons. From this inexhaustible source it can be obtained by liquefaction and fractional distillation. Nitrogen molecules give the orange-red, blue-green, blue-violet, and deep violet shades to the aurora. The element is so inert that Lavoisier named it *azote*, meaning without life, yet its compounds are so active as to be most important in foods, poisons, fertilizers, and explosives. Nitrogen can be also easily prepared by heating a water solution of ammonium nitrite. Nitrogen, as a gas, is colorless, odorless, and a generally inert element. As a liquid it is also colorless and odorless, and is similar in appearance to water. Two allotropic forms of solid nitrogen exist, with the transition from the  $\alpha$  to the  $\beta$  form taking place at -237°C. When nitrogen is heated, it

combines directly with magnesium, lithium, or calcium; when mixed with oxygen and subjected to electric sparks, it forms first nitric oxide (NO) and then the dioxide (NO<sub>2</sub>); when heated under pressure with a catalyst with hydrogen, ammonia is formed (Haber process). The ammonia thus formed is of the utmost importance as it is used in fertilizers, and it can be oxidized to nitric acid (Ostwald process). The ammonia industry is the largest consumer of nitrogen. Large amounts of gas are also used by the electronics industry, which uses the gas as a blanketing medium during production of such components as transistors, diodes, etc. Large quantities of nitrogen are used in annealing stainless steel and other steel mill products. The drug industry also uses large quantities. Nitrogen is used as a refrigerant both for the immersion freezing of food products and for transportation of foods. Liquid nitrogen is also used in missile work as a purge for components, insulators for space chambers, etc., and by the oil industry to build up great pressures in wells to force crude oil upward. Sodium and potassium nitrates are formed by the decomposition of organic matter with compounds of the metals present. In certain dry areas of the world these saltpeters are found in quantity. Ammonia, nitric acid, the nitrates, the five oxides (N<sub>2</sub>O, NO, N<sub>2</sub>O<sub>3</sub>, NO<sub>2</sub>, and N<sub>2</sub>O<sub>5</sub>), TNT, the cyanides, etc. are but a few of the important compounds. Nitrogen gas prices vary from 2¢ to \$2.75 per 100 ft<sup>3</sup> (2.83 cu. meters), depending on purity, etc. Production of elemental nitrogen in the U.S. is more than 9 million short tons per year. Natural nitrogen contains two isotopes, <sup>14</sup>N and <sup>15</sup>N. Ten other isotopes are known.

**Nobelium** — (Alfred Nobel [1833–1896], inventor of dynamite), No; at. wt. [259]; at. no. 102; valence +2, +3. Nobelium was unambiguously discovered and identified in April 1958 at Berkeley by A. Ghiorso, T. Sikkeland, J. R. Walton, and G. T. Seaborg, who used a new double-recoil technique. A heavy-ion linear accelerator (HILAC) was used to bombard a thin target of curium (95% <sup>244</sup>Cm and 4.5% <sup>246</sup>Cm) with <sup>12</sup>C ions to produce <sup>102</sup><sup>254</sup> according to the <sup>246</sup>Cm (<sup>12</sup>C, 4*n*) reaction. Earlier in 1957 workers of the U.S., Britain, and Sweden announced the discovery of an isotope of Element 102 with a 10-min half-life at 8.5 MeV, as a result of bombarding <sup>244</sup>Cm with <sup>13</sup>C nuclei. On the basis of this experiment the name *nobelium* was assigned and accepted by the Commission on Atomic Weights of the International Union of Pure and Applied Chemistry. The acceptance of the name was premature, for both Russian and American efforts now completely rule out the possibility of any isotope of Element 102 having a half-life of 10 min in the vicinity of 8.5 MeV. Early work in 1957 on the search for this element, in Russia at the Kurchatov Institute, was marred by the assignment of 8.9 ± 0.4 MeV alpha radiation with a half-life of 2 to 40 sec, which was too indefinite to support claim to discovery. Confirmatory experiments at Berkeley in 1966 have shown the existence of <sup>254</sup>102 with a 55-s half-life, <sup>252</sup>102 with a 2.3-s half-life, and <sup>257</sup>102 with a 25-s half-life. Twelve isotopes are now recognized, one of which — <sup>255</sup>102 — has a half-life of 3.1 min. In view of the discoverer's traditional right to name an element, the Berkeley group, in 1967, suggested that the hastily given name *nobelium*, along with the symbol No, be retained.

**Osmium** — (Gr. *osme*, a smell), Os; at. wt. 190.23(3); at. no. 76; m.p. 3033°C; b.p. 5012°C; sp. gr. 22.587; valence 0 to +8, more usually +3, +4, +6, and +8. Discovered in 1803 by Tennant in the residue left when crude platinum is dissolved by *aqua regia*. Osmium occurs in *iridosmine* and in platinum-bearing

river sands of the Urals, North America, and South America. It is also found in the nickel-bearing ores of the Sudbury, Ontario, region along with other platinum metals. While the quantity of platinum metals in these ores is very small, the large tonnages of nickel ores processed make commercial recovery possible. The metal is lustrous, bluish white, extremely hard, and brittle even at high temperatures. It has the highest melting point and the lowest vapor pressure of the platinum group. The metal is very difficult to fabricate, but the powder can be sintered in a hydrogen atmosphere at a temperature of 2000°C. The solid metal is not affected by air at room temperature, but the powdered or spongy metal slowly gives off osmium tetroxide, which is a powerful oxidizing agent and has a strong smell. The tetroxide is highly toxic, and boils at 130°C (760 mm). Concentrations in air as low as  $10^{-7}$  g/m<sup>3</sup> can cause lung congestion, skin damage, or eye damage. The tetroxide has been used to detect fingerprints and to stain fatty tissue for microscope slides. The metal is almost entirely used to produce very hard alloys, with other metals of the platinum group, for fountain pen tips, instrument pivots, phonograph needles, and electrical contacts. The price of 99.9% pure osmium powder — the form usually supplied commercially — is about \$100/g, depending on quantity and supplier. Natural osmium contains seven isotopes, one of which, <sup>186</sup>Os, is radioactive with a very long half-life. Thirty-four other isotopes and isomers are known, all of which are radioactive. The measured densities of iridium and osmium seem to indicate that osmium is slightly more dense than iridium, so osmium has generally been credited with being the heaviest known element. Calculations of the density from the space lattice, which may be more reliable for these elements than actual measurements, however, give a density of 22.65 for iridium compared to 22.61 for osmium. At present, therefore, we know either iridium or osmium is the heaviest element, but the data do not allow selection between the two.

**Oxygen** — (Gr. *oxys*, sharp, acid, and *genes*, forming; acid former), O; at. wt. 15.9994(3); at. no. 8; t.p. -218.79°C; *t*<sub>c</sub> -118.56°C; valence 2. For many centuries, workers occasionally realized air was composed of more than one component. The behavior of oxygen and nitrogen as components of air led to the advancement of the phlogiston theory of combustion, which captured the minds of chemists for a century. Oxygen was prepared by several workers, including Bayen and Borch, but they did not know how to collect it, did not study its properties, and did not recognize it as an elementary substance. Priestley is generally credited with its discovery, although Scheele also discovered it independently. Oxygen is the third most abundant element found in the sun, and it plays a part in the carbon-nitrogen cycle, one process thought to give the sun and stars their energy. Oxygen under excited conditions is responsible for the bright red and yellow-green colors of the aurora. Oxygen, as a gaseous element, forms 21% of the atmosphere by volume from which it can be obtained by liquefaction and fractional distillation. The atmosphere of Mars contains about 0.15% oxygen. The element and its compounds make up 49.2%, by weight, of the Earth's crust. About two thirds of the human body and nine tenths of water is oxygen. In the laboratory it can be prepared by the electrolysis of water or by heating potassium chlorate with manganese dioxide as a catalyst. The gas is colorless, odorless, and tasteless. The liquid and solid forms are a pale blue color and are strongly paramagnetic. Ozone (O<sub>3</sub>), a highly active compound, is formed by the action of an

electrical discharge or ultraviolet light on oxygen. Ozone's presence in the atmosphere (amounting to the equivalent of a layer 3 mm thick at ordinary pressures and temperatures) is of vital importance in preventing harmful ultraviolet rays of the sun from reaching the Earth's surface. There has been recent concern that pollutants in the atmosphere may have a detrimental effect on this ozone layer. Ozone is toxic and exposure should not exceed 0.2 mg/m<sup>3</sup> (8-hour time-weighted average — 40-hour work week). Undiluted ozone has a bluish color. Liquid ozone is bluish black, and solid ozone is violet-black. Oxygen is very reactive and capable of combining with most elements. It is a component of hundreds of thousands of organic compounds. It is essential for respiration of all plants and animals and for practically all combustion. In hospitals it is frequently used to aid respiration of patients. Its atomic weight was used as a standard of comparison for each of the other elements until 1961 when the International Union of Pure and Applied Chemistry adopted carbon 12 as the new basis. Oxygen has thirteen recognized isotopes. Natural oxygen is a mixture of three isotopes. Oxygen 18 occurs naturally, is stable, and is available commercially. Water (H<sub>2</sub>O with 1.5% <sup>18</sup>O) is also available. Commercial oxygen consumption in the U.S. is estimated to be 20 million short tons per year and the demand is expected to increase substantially in the next few years. Oxygen enrichment of steel blast furnaces accounts for the greatest use of the gas. Large quantities are also used in making synthesis gas for ammonia and methanol, ethylene oxide, and for oxy-acetylene welding. Air separation plants produce about 99% of the gas, electrolysis plants about 1%. The gas costs 5¢/ft<sup>3</sup> (\$1.75/cu. meter) in small quantities.

**Palladium** — (named after the asteroid *Pallas*, discovered about the same time; Gr. *Pallas*, goddess of wisdom), Pd; at. wt. 106.42(1) at. no. 46; m.p. 1554.8°C; b.p. 2963°C; sp. gr. 12.02 (20°C); valence 2, 3, or 4. Discovered in 1803 by Wollaston. Palladium is found along with platinum and other metals of the platinum group in deposits of Russia, South Africa, Canada (Ontario), and elsewhere. Natural palladium contains six stable isotopes. Twenty-nine other isotopes are recognized, all of which are radioactive. It is frequently found associated with the nickel-copper deposits such as those found in Ontario. Its separation from the platinum metals depends upon the type of ore in which it is found. It is a steel-white metal, does not tarnish in air, and is the least dense and lowest melting of the platinum group of metals. When annealed, it is soft and ductile; cold working greatly increases its strength and hardness. Palladium is attacked by nitric and sulfuric acid. At room temperatures the metal has the unusual property of absorbing up to 900 times its own volume of hydrogen, possibly forming Pd<sub>2</sub>H. It is not yet clear if this a true compound. Hydrogen readily diffuses through heated palladium and this provides a means of purifying the gas. Finely divided palladium is a good catalyst and is used for hydrogenation and dehydrogenation reactions. It is alloyed and used in jewelry trades. White gold is an alloy of gold decolorized by the addition of palladium. Like gold, palladium can be beaten into leaf as thin as 1/250,000 in. The metal is used in dentistry, watchmaking, and in making surgical instruments and electrical contacts. Palladium recently has been substituted for higher priced platinum in catalytic converters by some automobile companies. This has caused a large increase in the cost of palladium. The prices of the two metals are now, in 2002, about the same. Palladium, however, is less resistant to poisoning



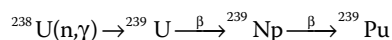
by sulfur and lead than platinum, but it may prove useful in controlling emissions from diesel vehicles. The metal sells for about \$350/tr. oz. (\$11/g).

**Phosphorus** — (Gr. *phosphoros*, light bearing; ancient name for the planet Venus when appearing before sunrise), P; at. wt. 30.973762(2); at. no. 15; m.p. (white) 44.15°C; b.p. 280.5°C; sp. gr. (white) 1.82, (red) 2.16, (black) 2.25 to 2.69; valence 3 or 5. Discovered in 1669 by Brand, who prepared it from urine. Phosphorus exists in four or more allotropic forms: white (or yellow), red, and black (or violet). White phosphorus has two modifications:  $\alpha$  and  $\beta$  with a transition temperature at  $-3.8^\circ\text{C}$ . Never found free in nature, it is widely distributed in combination with minerals. Twenty-one isotopes of phosphorus are recognized. *Phosphate* rock, which contains the mineral *apatite*, an impure tricalcium phosphate, is an important source of the element. Large deposits are found in the Russia, China, Morocco, and in Florida, Tennessee, Utah, Idaho, and elsewhere. Phosphorus is an essential ingredient of all cell protoplasm, nervous tissue, and bones. Ordinary phosphorus is a waxy white solid; when pure it is colorless and transparent. It is insoluble in water, but soluble in carbon disulfide. It takes fire spontaneously in air, burning to the pentoxide. It is very poisonous, 50 mg constituting an approximate fatal dose. Exposure to white phosphorus should not exceed  $0.1\text{ mg/m}^3$  (8-hour time-weighted average — 40-hour work week). White phosphorus should be kept under water, as it is dangerously reactive in air, and it should be handled with forceps, as contact with the skin may cause severe burns. When exposed to sunlight or when heated in its own vapor to  $250^\circ\text{C}$ , it is converted to the red variety, which does not phosphoresce in air as does the white variety. This form does not ignite spontaneously and it is not as dangerous as white phosphorus. It should, however, be handled with care as it does convert to the white form at some temperatures and it emits highly toxic fumes of the oxides of phosphorus when heated. The red modification is fairly stable, sublimates with a vapor pressure of 1 atm at  $417^\circ\text{C}$ , and is used in the manufacture of safety matches, pyrotechnics, pesticides, incendiary shells, smoke bombs, tracer bullets, etc. White phosphorus may be made by several methods. By one process, tricalcium phosphate, the essential ingredient of phosphate rock, is heated in the presence of carbon and silica in an electric furnace or fuel-fired furnace. Elementary phosphorus is liberated as vapor and may be collected under water. If desired, the phosphorus vapor and carbon monoxide produced by the reaction can be oxidized at once in the presence of moisture to produce phosphoric acid, an important compound in making super-phosphate fertilizers. In recent years, concentrated phosphoric acids, which may contain as much as 70 to 75%  $\text{P}_2\text{O}_5$  content, have become of great importance to agriculture and farm production. World-wide demand for fertilizers has caused record phosphate production. Phosphates are used in the production of special glasses, such as those used for sodium lamps. Bone-ash, calcium phosphate, is also used to produce fine chinaware and to produce monocalcium phosphate used in baking powder. Phosphorus is also important in the production of steels, phosphor bronze, and many other products. Trisodium phosphate is important as a cleaning agent, as a water softener, and for preventing boiler scale and corrosion of pipes and boiler tubes. Organic compounds of phosphorus are important. Amorphous (red) phosphorus costs about \$70/kg (99%).

**Platinum** — (It. *platina*, silver), Pt; at. wt. 195.084(9); at. no. 78; m.p.  $1768.2^\circ\text{C}$ ; b.p.  $3825^\circ\text{C}$ ; sp. gr. 21.45 ( $20^\circ\text{C}$ ); valence 1?, 2, 3, or 4. Discovered in South America by Ulloa in 1735 and by Wood in 1741. The metal was used by pre-Columbian Indians. Platinum occurs native, accompanied by small quantities of iridium, osmium, palladium, ruthenium, and rhodium, all belonging to the same group of metals. These are found in the alluvial deposits of the Ural mountains and in Columbia. *Sperrylite* ( $\text{PtAs}_2$ ), occurring with the nickel-bearing deposits of Sudbury, Ontario, is a source of a considerable amount of metal. The large production of nickel offsets there being only one part of the platinum metals in two million parts of ore. The largest supplier of the platinum group of metals is now South Africa, followed by Russia and Canada. Platinum is a beautiful silvery-white metal, when pure, and is malleable and ductile. It has a coefficient of expansion almost equal to that of soda-lime-silica glass, and is therefore used to make sealed electrodes in glass systems. The metal does not oxidize in air at any temperature, but is corroded by halogens, cyanides, sulfur, and caustic alkalis. It is insoluble in hydrochloric and nitric acid, but dissolves when they are mixed as *aqua regia*, forming chloroplatinic acid ( $\text{H}_2\text{PtCl}_6$ ), an important compound. Natural platinum contains six isotopes, one of which,  $^{190}\text{Pt}$ , is radioactive with a long half-life. Thirty-seven other radioactive isotopes and isomers are recognized. The metal is used extensively in jewelry, wire, and vessels for laboratory use, and in many valuable instruments including thermocouple elements. It is also used for electrical contacts, corrosion-resistant apparatus, and in dentistry. Platinum-cobalt alloys have magnetic properties. One such alloy made of 76.7% Pt and 23.3% Co, by weight, is an extremely powerful magnet that offers a B-H (max) almost twice that of Alnico V. Platinum resistance wires are used for constructing high-temperature electric furnaces. The metal is used for coating missile nose cones, jet engine fuel nozzles, etc., which must perform reliably for long periods of time at high temperatures. The metal, like palladium, absorbs large volumes of hydrogen, retaining it at ordinary temperatures but giving it up at red heat. In the finely divided state platinum is an excellent catalyst, having long been used in the contact process for producing sulfuric acid. It is also used as a catalyst in cracking petroleum products. There is also much current interest in the use of platinum as a catalyst in fuel cells and in its use as antipollution devices for automobiles. Platinum anodes are extensively used in cathodic protection systems for large ships and ocean-going vessels, pipelines, steel piers, etc. Pure platinum wire will glow red hot when placed in the vapor of methyl alcohol. It acts here as a catalyst, converting the alcohol to formaldehyde. This phenomenon has been used commercially to produce cigarette lighters and hand warmers. Hydrogen and oxygen explode in the presence of platinum. The price of platinum has varied widely; more than a century ago it was used to adulterate gold. It was nearly eight times as valuable as gold in 1920. The price in January 2002 was about \$430/troy oz. (\$15/g), higher than the price of gold.

**Plutonium** — (planet *Pluto*), Pu; at. wt. (244); at. no. 94; sp. gr. ( $\alpha$  modification) 19.84 ( $25^\circ\text{C}$ ); m.p.  $640^\circ\text{C}$ ; b.p.  $3228^\circ\text{C}$ ; valence 3, 4, 5, or 6. Plutonium was the second transuranium element of the actinide series to be discovered. The isotope  $^{238}\text{Pu}$  was produced in 1940 by Seaborg, McMillan, Kennedy, and Wahl by deuteron bombardment of uranium in the 60-inch cyclotron at Berkeley, California. Plutonium also exists

in trace quantities in naturally occurring uranium ores. It is formed in much the same manner as neptunium, by irradiation of natural uranium with the neutrons that are present. By far of greatest importance is the isotope  $\text{Pu}^{239}$ , with a half-life of 24,100 years, produced in extensive quantities in nuclear reactors from natural uranium:



Nineteen isotopes of plutonium are now known. Plutonium has assumed the position of dominant importance among the transuranium elements because of its successful use as an explosive ingredient in nuclear weapons and the place it holds as a key material in the development of industrial use of nuclear power. One kilogram is equivalent to about 22 million kilowatt hours of heat energy. The complete detonation of a kilogram of plutonium produces an explosion equal to about 20,000 tons of chemical explosive. Its importance depends on the nuclear property of being readily fissionable with neutrons and its availability in quantity. The world's nuclear-power reactors are now producing about 20,000 kg of plutonium/yr. By 1982 it was estimated that about 300,000 kg had accumulated. The various nuclear applications of plutonium are well known.  $^{238}\text{Pu}$  has been used in the Apollo lunar missions to power seismic and other equipment on the lunar surface. As with neptunium and uranium, plutonium metal can be prepared by reduction of the trifluoride with alkaline-earth metals. The metal has a silvery appearance and takes on a yellow tarnish when slightly oxidized. It is chemically reactive. A relatively large piece of plutonium is warm to the touch because of the energy given off in alpha decay. Larger pieces will produce enough heat to boil water. The metal readily dissolves in concentrated hydrochloric acid, hydroiodic acid, or perchloric acid with formation of the  $\text{Pu}^{+3}$  ion. The metal exhibits six allotropic modifications having various crystalline structures. The densities of these vary from 16.00 to 19.86 g/cm<sup>3</sup>. Plutonium also exhibits four ionic valence states in aqueous solutions:  $\text{Pu}^{+3}$  (blue lavender),  $\text{Pu}^{+4}$  (yellow brown),  $\text{PuO}^{+}$  (pink?), and  $\text{PuO}^{+2}$  (pink orange). The ion  $\text{PuO}^{+}$  is unstable in aqueous solutions, disproportionating into  $\text{Pu}^{+4}$  and  $\text{PuO}^{+2}$ . The  $\text{Pu}^{+4}$  thus formed, however, oxidizes the  $\text{PuO}^{+}$  into  $\text{PuO}^{+2}$ , itself being reduced to  $\text{Pu}^{+3}$ , giving finally  $\text{Pu}^{+3}$  and  $\text{PuO}^{+2}$ . Plutonium forms binary compounds with oxygen:  $\text{PuO}$ ,  $\text{PuO}_2$ , and intermediate oxides of variable composition; with the halides:  $\text{PuF}_3$ ,  $\text{PuF}_4$ ,  $\text{PuCl}_3$ ,  $\text{PuBr}_3$ ,  $\text{PuI}_3$ ; with carbon, nitrogen, and silicon:  $\text{PuC}$ ,  $\text{PuN}$ ,  $\text{PuSi}_2$ . Oxyhalides are also well known:  $\text{PuOCl}$ ,  $\text{PuOBr}$ ,  $\text{PuOI}$ . Because of the high rate of emission of alpha particles and the element being specifically absorbed by bone marrow, plutonium, as well as all of the other transuranium elements except neptunium, are radiological poisons and must be handled with very special equipment and precautions. Plutonium is a very dangerous radiological hazard. Precautions must also be taken to prevent the unintentional formation of a critical mass. Plutonium in liquid solution is more likely to become critical than solid plutonium. The shape of the mass must also be considered where criticality is concerned. Plutonium-239 is available to authorized users from the O.R.N.L. at a cost of about \$4.80/mg (99.9%) plus packing costs.

**Polonium** — (Poland, native country of Mme. Curie [1867–1934]), Po; at. wt. (209); at. no. 84; m.p. 254°C; b.p. 962°C; sp. gr. 9.20; valence -2, 0, +2, +3(?), +4, and +6. Polonium was the first element discovered by Mme. Curie in 1898, while seeking

the cause of radioactivity of pitchblende from Joachimsthal, Bohemia. The electroscope showed it separating with bismuth. Polonium is also called Radium F. Polonium is a very rare natural element. Uranium ores contain only about 100 µg of the element per ton. Its abundance is only about 0.2% of that of radium. In 1934, it was found that when natural bismuth ( $^{209}\text{Bi}$ ) was bombarded by neutrons,  $^{210}\text{Bi}$ , the parent of polonium, was obtained. Milligram amounts of polonium may now be prepared this way, by using the high neutron fluxes of nuclear reactors. Polonium-210 is a low-melting, fairly volatile metal, 50% of which is vaporized in air in 45 hours at 55°C. It is an alpha emitter with a half-life of 138.39 days. A milligram emits as many alpha particles as 5 g of radium. The energy released by its decay is so large (140 W/g) that a capsule containing about half a gram reaches a temperature above 500°C. The capsule also presents a contact gamma-ray dose rate of 0.012 Gy/h. A few curies (1 curie =  $3.7 \times 10^{10}$  Bq) of polonium exhibit a blue glow, caused by excitation of the surrounding gas. Because almost all alpha radiation is stopped within the solid source and its container, giving up its energy, polonium has attracted attention for uses as a lightweight heat source for thermoelectric power in space satellites. Thirty-eight isotopes and isomers of polonium are known, with atomic masses ranging from 192 to 218. All are radioactive. Polonium-210 is the most readily available. Isotopes of mass 209 (half-life 102 years) and mass 208 (half-life 2.9 years) can be prepared by alpha, proton, or deuteron bombardment of lead or bismuth in a cyclotron, but these are expensive to produce. Metallic polonium has been prepared from polonium hydroxide and some other polonium compounds in the presence of concentrated aqueous or anhydrous liquid ammonia. Two allotropic modifications are known to exist. Polonium is readily dissolved in dilute acids, but is only slightly soluble in alkalis. Polonium salts of organic acids char rapidly; halide amines are reduced to the metal. Polonium can be mixed or alloyed with beryllium to provide a source of neutrons. It has been used in devices for eliminating static charges in textile mills, etc.; however, beta sources are more commonly used and are less dangerous. It is also used on brushes for removing dust from photographic films. The polonium for these is carefully sealed and controlled, minimizing hazards to the user. Polonium-210 is very dangerous to handle in even milligram or microgram amounts, and special equipment and strict control are necessary. Damage arises from the complete absorption of the energy of the alpha particle into tissue. The maximum permissible body burden for ingested polonium is only 0.03 µCi, which represents a particle weighing only  $6.8 \times 10^{-12}$  g. Weight for weight it is about  $2.5 \times 10^{11}$  times as toxic as hydrocyanic acid. The maximum allowable concentration for soluble polonium compounds in air is about  $2 \times 10^{11}$  µCi/cm<sup>3</sup>. Polonium-209 is available on special order from the Oak Ridge National Laboratory at a cost of \$3600/µCi plus packing costs.

**Potassium** — (English, *potash* — pot ashes; *L. kalium*, Arab. *qali*, alkali), K; at. wt. 39.0983(1); at. no. 19; m.p. 63.5°C; b.p. 759°C; sp. gr. 0.89; valence 1. Discovered in 1807 by Davy, who obtained it from caustic potash (KOH); this was the first metal isolated by electrolysis. The metal is the seventh most abundant and makes up about 2.4% by weight of the Earth's crust. Most potassium minerals are insoluble and the metal is obtained from them only with great difficulty. Certain minerals, however, such as *sylvite*, *carnallite*, *langbeinite*, and *polyhalite* are found in ancient lake and sea beds and form rather extensive deposits from which potassium and its salts can readily be obtained.



Potash is mined in Germany, New Mexico, California, Utah, and elsewhere. Large deposits of potash, found at a depth of some 1000 m in Saskatchewan, promise to be important in coming years. Potassium is also found in the ocean, but is present only in relatively small amounts compared to sodium. The greatest demand for potash has been in its use for fertilizers. Potassium is an essential constituent for plant growth and it is found in most soils. Potassium is never found free in nature, but is obtained by electrolysis of the hydroxide, much in the same manner as prepared by Davy. Thermal methods also are commonly used to produce potassium (such as by reduction of potassium compounds with  $\text{CaC}_2$ , C, Si, or Na). It is one of the most reactive and electropositive of metals. Except for lithium, it is the lightest known metal. It is soft, easily cut with a knife, and is silvery in appearance immediately after a fresh surface is exposed. It rapidly oxidizes in air and should be preserved in a mineral oil. As with other metals of the alkali group, it decomposes in water with the evolution of hydrogen. It catches fire spontaneously on water. Potassium and its salts impart a violet color to flames. Twenty-one isotopes, one of which is an isomer, of potassium are known. Ordinary potassium is composed of three isotopes, one of which is  $^{40}\text{K}$  (0.0117%), a radioactive isotope with a half-life of  $1.26 \times 10^9$  years. The radioactivity presents no appreciable hazard. An alloy of sodium and potassium (NaK) is used as a heat-transfer medium. Many potassium salts are of utmost importance, including the hydroxide, nitrate, carbonate, chloride, chlorate, bromide, iodide, cyanide, sulfate, chromate, and dichromate. Metallic potassium is available commercially for about \$1200/kg (98% purity) or \$75/g (99.95% purity).

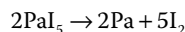
**Praseodymium** — (Gr. *prasios*, green, and *didymos*, twin), Pr; at. wt. 140.90765(2); at. no. 59; m.p. 931°C; b.p. 3520°C; sp. gr. 6.773; valence 3. In 1841 Mosander extracted the rare earth *didymia* from *lanthana*; in 1879, Lecoq de Boisbaudran isolated a new earth, *samarium*, from didymia obtained from the mineral *samaraskite*. Six years later, in 1885, von Welsbach separated didymia into two others, *praseodymia* and *neodymia*, which gave salts of different colors. As with other rare earths, compounds of these elements in solution have distinctive sharp spectral absorption bands or lines, some of which are only a few Angstroms wide. The element occurs along with other rare-earth elements in a variety of minerals. *Monazite* and *bastnasite* are the two principal commercial sources of the rare-earth metals. Ion-exchange and solvent extraction techniques have led to much easier isolation of the rare earths and the cost has dropped greatly. Thirty-seven isotopes and isomers are now recognized. Praseodymium can be prepared by several methods, such as by calcium reduction of the anhydrous chloride or fluoride. Misch metal, used in making cigarette lighters, contains about 5% praseodymium metal. Praseodymium is soft, silvery, malleable, and ductile. It was prepared in relatively pure form in 1931. It is somewhat more resistant to corrosion in air than europium, lanthanum, cerium, or neodymium, but it does develop a green oxide coating that splits off when exposed to air. As with other rare-earth metals it should be kept under a light mineral oil or sealed in plastic. The rare-earth oxides, including  $\text{Pr}_2\text{O}_3$ , are among the most refractory substances known. Along with other rare earths, it is widely used as a core material for carbon arcs used by the motion picture industry for studio lighting and projection. Salts of praseodymium are used to color glasses and enamels; when mixed with certain other materials, praseodymium produces an intense and unusually clean yellow color

in glass. Didymium glass, of which praseodymium is a component, is a colorant for welder's goggles. The metal (99.9% pure) is priced at about \$4/g.

**Promethium** — (*Prometheus*, who, according to mythology, stole fire from heaven), Pm; at. no. 61; at. wt. (145); m.p. 1042°C; b.p. 3000°C (est.); sp. gr. 7.264 (25°C); valence 3. In 1902 Branner predicted the existence of an element between neodymium and samarium, and this was confirmed by Moseley in 1914. Unsuccessful searches were made for this predicted element over two decades, and various investigators proposed the names "illinium," "florentium," and "cyclonium" for this element. In 1941, workers at Ohio State University irradiated neodymium and praseodymium with neutrons, deuterons, and alpha particles, resp., and produced several new radioactivities, which most likely were those of Element 61. Wu and Segre, and Bethe, in 1942, confirmed the formation; however, chemical proof of the production of Element 61 was lacking because of the difficulty in separating the rare earths from each other at that time. In 1945, Marininsky, Glendenin, and Coryell made the first chemical identification by using ion-exchange chromatography. Their work was done by fission of uranium and by neutron bombardment of neodymium. These investigators named the newly discovered element. Searches for the element on Earth have been fruitless, and it now appears that promethium is completely missing from the Earth's crust. Promethium, however, has been reported to be in the spectrum of the star HR<sup>465</sup> in Andromeda. It must be formed near the star's surface, for no known isotope of promethium has a half-life longer than 17.7 years. Thirty-five isotopes and isomers of promethium, with atomic masses from 130 to 158 are now known. Promethium-145, with a half-life of 17.7 years, is the most useful. Promethium-145 has a specific activity of 940 Ci/g. It is a soft beta emitter; although no gamma rays are emitted, X-radiation can be generated when beta particles impinge on elements of a high atomic number, and great care must be taken in handling it. Promethium salts luminesce in the dark with a pale blue or greenish glow, due to their high radioactivity. Ion-exchange methods led to the preparation of about 10 g of promethium from atomic reactor fuel processing wastes in early 1963. Little is yet generally known about the properties of metallic promethium. Two allotropic modifications exist. The element has applications as a beta source for thickness gages, and it can be absorbed by a phosphor to produce light. Light produced in this manner can be used for signs or signals that require dependable operation; it can be used as a nuclear-powered battery by capturing light in photocells that convert it into electric current. Such a battery, using  $^{147}\text{Pm}$ , would have a useful life of about 5 years. It is being used for fluorescent lighting starters and coatings for self-luminous watch dials. Promethium shows promise as a portable X-ray source, and it may become useful as a heat source to provide auxiliary power for space probes and satellites. More than 30 promethium compounds have been prepared. Most are colored.

**Protactinium** — (Gr. *protos*, first), Pa; at. wt. 231.03588(2); at. no. 91; m.p. 1572°C; sp. gr. 15.37 (calc.); valence 4 or 5. The first isotope of Element 91 to be discovered was  $^{234}\text{Pa}$ , also known as  $\text{UX}_2$ , a short-lived member of the naturally occurring  $^{238}\text{U}$  decay series. It was identified by K. Fajans and O. H. Gohring in 1913 and they named the new element *brevium*. When the longer-lived isotope  $^{231}\text{Pa}$  was identified by Hahn and Meitner

in 1918, the name protoactinium was adopted as being more consistent with the characteristics of the most abundant isotope. Soddy, Cranson, and Fleck were also active in this work. The name *protoactinium* was shortened to *protactinium* in 1949. In 1927, Grosse prepared 2 mg of a white powder, which was shown to be  $\text{Pa}_2\text{O}_5$ . Later, in 1934, from 0.1 g of pure  $\text{Pa}_2\text{O}_5$  he isolated the element by two methods, one of which was by converting the oxide to an iodide and "cracking" it in a high vacuum by an electrically heated filament by the reaction



Protactinium has a bright metallic luster that it retains for some time in air. The element occurs in *pitchblende* to the extent of about 1 part  $^{231}\text{Pa}$  to 10 million of ore. Ores from Congo-Kinshasa have about 3 ppm. Protactinium has twenty-eight isotopes and isomers, the most common of which is  $^{231}\text{Pa}$  with a half-life of 32,500 years. A number of protactinium compounds are known, some of which are colored. The element is superconductive below 1.4 K. The element is a dangerous toxic material and requires precautions similar to those used when handling plutonium. In 1959 and 1961, it was announced that the Great Britain Atomic Energy Authority extracted by a 12-stage process 125 g of 99.9% protactinium, the world's only stock of the metal for many years to come. The extraction was made from 60 tons of waste material at a cost of about \$500,000. Protactinium is one of the rarest and most expensive naturally occurring elements.

**Radium** — (L. *radius*, ray), Ra; at. wt. (226); at. no. 88; m.p.  $696^\circ\text{C}$ ; sp. gr. 5; valence 2. Radium was discovered in 1898 by M. and Mme. Curie in the *pitchblende* or *uraninite* of North Bohemia (Czech Republic), where it occurs. There is about 1 g of radium in 7 tons of pitchblende. The element was isolated in 1911 by Mme. Curie and Debierne by the electrolysis of a solution of pure radium chloride, employing a mercury cathode; on distillation in an atmosphere of hydrogen this amalgam yielded the pure metal. Originally, radium was obtained from the rich pitchblende ore found at Joachimsthal, Bohemia. The *carnotite* sands of Colorado furnish some radium, but richer ores are found in the Republic of Congo-Kinshasa and the Great Bear Lake region of Canada. Radium is present in all uranium minerals, and could be extracted, if desired, from the extensive wastes of uranium processing. Large uranium deposits are located in Ontario, New Mexico, Utah, Australia, and elsewhere. Radium is obtained commercially as the bromide or chloride; it is doubtful if any appreciable stock of the isolated element now exists. The pure metal is brilliant white when freshly prepared, but blackens on exposure to air, probably due to formation of the nitride. It exhibits luminescence, as do its salts; it decomposes in water and is somewhat more volatile than barium. It is a member of the alkaline-earth group of metals. Radium imparts a carmine red color to a flame. Radium emits alpha, beta, and gamma rays and when mixed with beryllium produce neutrons. One gram of  $^{226}\text{Ra}$  undergoes  $3.7 \times 10^{10}$  disintegrations per s. The *curie* (Ci) is defined as that amount of radioactivity which has the same disintegration rate as 1 g of  $^{226}\text{Ra}$ . Thirty-six isotopes are now known; radium 226, the common isotope, has a half-life of 1599 years. One gram of radium produces about 0.0001 mL (stp) of emanation, or radon gas, per day. This is pumped from the radium and sealed in minute tubes, which are used in the treatment of cancer and other diseases. One gram of radium yields about 4186 kJ per year. Radium is used in producing self-luminous

paints, neutron sources, and in medicine for the treatment of cancer. Some of the more recently discovered radioisotopes, such as  $^{60}\text{Co}$ , are now being used in place of radium. Some of these sources are much more powerful, and others are safer to use. Radium loses about 1% of its activity in 25 years, being transformed into elements of lower atomic weight. Lead is a final product of disintegration. Stored radium should be ventilated to prevent build-up of radon. Inhalation, injection, or body exposure to radium can cause cancer and other body disorders. The maximum permissible burden in the total body for  $^{226}\text{Ra}$  is 7400 becquerel.

**Radon** — (from *radium*; called *niton* at first, L. *nitens*, shining), Rn; at. wt. (222); at. no. 86; m.p.  $-71^\circ\text{C}$ ; b.p.  $-61.7^\circ\text{C}$ ;  $t_c$   $104^\circ\text{C}$ ; density of gas 9.73 g/L; sp. gr. liquid 4.4 at  $-62^\circ\text{C}$ , solid 4; valence usually 0. The element was discovered in 1900 by Dorn, who called it *radium emanation*. In 1908 Ramsay and Gray, who named it *niton*, isolated the element and determined its density, finding it to be the heaviest known gas. It is essentially inert and occupies the last place in the zero group of gases in the Periodic Table. Since 1923, it has been called radon. Thirty-seven isotopes and isomers are known. Radon-222, coming from radium, has a half-life of 3.823 days and is an alpha emitter; Radon-220, emanating naturally from thorium and called *thoron*, has a half-life of 55.6 s and is also an alpha emitter. Radon-219 emanates from actinium and is called *actinon*. It has a half-life of 3.9 s and is also an alpha emitter. It is estimated that every square mile of soil to a depth of 6 inches contains about 1 g of radium, which releases radon in tiny amounts to the atmosphere. Radon is present in some spring waters, such as those at Hot Springs, Arkansas. On the average, one part of radon is present to  $1 \times 10^{21}$  part of air. At ordinary temperatures radon is a colorless gas; when cooled below the freezing point, radon exhibits a brilliant phosphorescence which becomes yellow as the temperature is lowered and orange-red at the temperature of liquid air. It has been reported that fluorine reacts with radon, forming radon fluoride. Radon clathrates have also been reported. Radon is still produced for therapeutic use by a few hospitals by pumping it from a radium source and sealing it in minute tubes, called seeds or needles, for application to patients. This practice has now been largely discontinued as hospitals can order the seeds directly from suppliers, who make up the seeds with the desired activity for the day of use. Care must be taken in handling radon, as with other radioactive materials. The main hazard is from inhalation of the element and its solid daughters, which are collected on dust in the air. Good ventilation should be provided where radium, thorium, or actinium is stored to prevent build-up of this element. Radon build-up is a health consideration in uranium mines. Recently radon build-up in homes has been a concern. Many deaths from lung cancer are caused by radon exposure. In the U.S. it is recommended that remedial action be taken if the air from radon in homes exceeds 4 pCi/L.

**Rhenium** — (L. *Rhenus*, Rhine), Re; at. wt. 186.207(1); at. no. 75; m.p.  $3185^\circ\text{C}$ ; b.p.  $5596^\circ\text{C}$ ; sp. gr. 20.8 ( $20^\circ\text{C}$ ); valence  $-1, +1, 2, 3, 4, 5, 6, 7$ . Discovery of rhenium is generally attributed to Noddack, Tacke, and Berg, who announced in 1925 they had detected the element in platinum ores and *columbite*. They also found the element in *gadolinite* and *molybdenite*. By working up 660 kg of molybdenite they were able in 1928 to extract 1 g of rhenium. The price in 1928 was \$10,000/g. Rhenium does not occur free in nature or as a compound in a distinct mineral

species. It is, however, widely spread throughout the Earth's crust to the extent of about 0.001 ppm. Commercial rhenium in the U.S. today is obtained from molybdenite roaster-flue dusts obtained from copper-sulfide ores mined in the vicinity of Miami, Arizona, and elsewhere in Arizona and Utah. Some molybdenites contain from 0.002 to 0.2% rhenium. It is estimated that in 1999 about 16,000 kg of rhenium was being produced. The total estimated world reserves of rhenium is 11,000,000 kg. Natural rhenium is a mixture of two isotopes, one of which has a very long half-life. Thirty-nine other unstable isotopes are recognized. Rhenium metal is prepared by reducing ammonium perrhenate with hydrogen at elevated temperatures. The element is silvery white with a metallic luster; its density is exceeded by that of only platinum, iridium, and osmium, and its melting point is exceeded by that of only tungsten and carbon. It has other useful properties. The usual commercial form of the element is a powder, but it can be consolidated by pressing and resistance-sintering in a vacuum or hydrogen atmosphere. This produces a compact shape in excess of 90% of the density of the metal. Annealed rhenium is very ductile, and can be bent, coiled, or rolled. Rhenium is used as an additive to tungsten and molybdenum-based alloys to impart useful properties. It is widely used for filaments for mass spectrographs and ion gages. Rhenium-molybdenum alloys are superconductive at 10 K. Rhenium is also used as an electrical contact material as it has good wear resistance and withstands arc corrosion. Thermocouples made of Re-W are used for measuring temperatures up to 2200°C, and rhenium wire has been used in photoflash lamps for photography. Rhenium catalysts are exceptionally resistant to poisoning from nitrogen, sulfur, and phosphorus, and are used for hydrogenation of fine chemicals, hydrocracking, reforming, and disproportionation of olefins. Rhenium has recently become especially important as a catalyst for petroleum refining and in making super-alloys for jet engines. Rhenium costs about \$16/g (99.99% pure). Little is known of its toxicity; therefore, it should be handled with care until more data are available.

**Rhodium** — (Gr. *rhodon*, rose), Rh; at. wt. 102.90550(2); at. no. 45; m.p. 1964°C; b.p. 3695°C; sp. gr. 12.41 (20°C); valence 2, 3, 4, 5, and 6. Wollaston discovered rhodium in 1803-4 in crude platinum ore he presumably obtained from South America. Rhodium occurs native with other platinum metals in river sands of the Urals and in North and South America. It is also found with other platinum metals in the copper-nickel sulfide ores of the Sudbury, Ontario region. Although the quantity occurring here is very small, the large tonnages of nickel processed make the recovery commercially feasible. The annual world production of rhodium in 1999 was only about 9000 kg. The metal is silvery white and at red heat slowly changes in air to the sesquioxide. At higher temperatures it converts back to the element. Rhodium has a higher melting point and lower density than platinum. Its major use is as an alloying agent to harden platinum and palladium. Such alloys are used for furnace windings, thermocouple elements, bushings for glass fiber production, electrodes for aircraft spark plugs, and laboratory crucibles. It is useful as an electrical contact material as it has a low electrical resistance, a low and stable contact resistance, and is highly resistant to corrosion. Plated rhodium, produced by electroplating or evaporation, is exceptionally hard and is used for optical instruments. It has a high reflectance and is hard and durable. Rhodium is also used for jewelry, for decoration, and as a catalyst. Fifty-two isotopes

and isomers are now known. Rhodium metal (powder) costs about \$180/g (99.9%).

**Roentgenium** — (Wilhelm Roentgen, discoverer of X-rays), Rg. On December 20, 1994, scientists at GSI Darmstadt, Germany announced they had detected three atoms of a new element with 111 protons and 161 neutrons. This element was made by bombarding  $^{83}\text{Bi}$  with  $^{28}\text{Ni}$ . Signals of Element 111 appeared for less than 0.002 s, then decayed into lighter elements including Element  $^{268}109$  and Element  $^{264}107$ . These isotopes had not previously been observed. In 2004 IUPAC approved the name roentgenium for Element 111. Roentgenium is expected to have properties similar to gold.

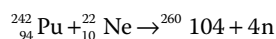
**Rubidium** — (L. *rubidus*, deepest red), Rb; at. wt. 85.4678(3); at. no. 37; m.p. 39.30°C; b.p. 688°C; sp. gr. (solid) 1.532 (20°C), (liquid) 1.475 (39°C); valence 1, 2, 3, 4. Discovered in 1861 by Bunsen and Kirchhoff in the mineral *lepidolite* by use of the spectroscope. The element is much more abundant than was thought several years ago. It is now considered to be the 16th most abundant element in the Earth's crust. Rubidium occurs in *pollucite*, *carnallite*, *leucite*, and *zinnwaldite*, which contains traces up to 1%, in the form of the oxide. It is found in lepidolite to the extent of about 1.5%, and is recovered commercially from this source. Potassium minerals, such as those found at Searles Lake, California, and potassium chloride recovered from brines in Michigan also contain the element and are commercial sources. It is also found along with cesium in the extensive deposits of *pollucite* at Bernic Lake, Manitoba. Rubidium can be liquid at room temperature. It is a soft, silvery-white metallic element of the alkali group and is the second most electropositive and alkaline element. It ignites spontaneously in air and reacts violently in water, setting fire to the liberated hydrogen. As with other alkali metals, it forms amalgams with mercury and it alloys with gold, cesium, sodium, and potassium. It colors a flame yellowish violet. Rubidium metal can be prepared by reducing rubidium chloride with calcium, and by a number of other methods. It must be kept under a dry mineral oil or in a vacuum or inert atmosphere. Thirty-five isotopes and isomers of rubidium are known. Naturally occurring rubidium is made of two isotopes,  $^{85}\text{Rb}$  and  $^{87}\text{Rb}$ . Rubidium-87 is present to the extent of 27.83% in natural rubidium and is a beta emitter with a half-life of  $4.9 \times 10^{10}$  years. Ordinary rubidium is sufficiently radioactive to expose a photographic film in about 30 to 60 days. Rubidium forms four oxides:  $\text{Rb}_2\text{O}$ ,  $\text{Rb}_2\text{O}_2$ ,  $\text{Rb}_2\text{O}_3$ ,  $\text{Rb}_2\text{O}_4$ . Because rubidium can be easily ionized, it has been considered for use in "ion engines" for space vehicles; however, cesium is somewhat more efficient for this purpose. It is also proposed for use as a working fluid for vapor turbines and for use in a thermoelectric generator using the magnetohydrodynamic principle where rubidium ions are formed by heat at high temperature and passed through a magnetic field. These conduct electricity and act like an armature of a generator thereby generating an electric current. Rubidium is used as a getter in vacuum tubes and as a photocell component. It has been used in making special glasses.  $\text{RbAg}_4\text{I}_5$  is important, as it has the highest room-temperature conductivity of any known ionic crystal. At 20°C its conductivity is about the same as dilute sulfuric acid. This suggests use in thin film batteries and other applications. The present cost in small quantities is about \$50/g (99.8% pure).

**Ruthenium** — (L. *Ruthenia*, Russia), Ru; at. wt. 101.07(2); at. no. 44, m.p. 2334°C; b.p. 4150°C; sp. gr. 12.1 (20°C); valence 0, 1, 2, 3, 4, 5, 6, 7, 8. Berzelius and Osann in 1827 examined the



residues left after dissolving crude platinum from the Ural mountains in *aqua regia*. While Berzelius found no unusual metals, Osann thought he found three new metals, one of which he named ruthenium. In 1844 Klaus, generally recognized as the discoverer, showed that Osann's ruthenium oxide was very impure and that it contained a new metal. Klaus obtained 6 g of ruthenium from the portion of crude platinum that is insoluble in *aqua regia*. A member of the platinum group, ruthenium occurs native with other members of the group of ores found in the Ural mountains and in North and South America. It is also found along with other platinum metals in small but commercial quantities in *pentlandite* of the Sudbury, Ontario, nickel-mining region, and in *pyroxinite* deposits of South Africa. Natural ruthenium contains seven isotopes. Twenty-eight other isotopes and isomers are known, all of which are radioactive. The metal is isolated commercially by a complex chemical process, the final stage of which is the hydrogen reduction of ammonium ruthenium chloride, which yields a powder. The powder is consolidated by powder metallurgy techniques or by argon-arc welding. Ruthenium is a hard, white metal and has four crystal modifications. It does not tarnish at room temperatures, but oxidizes in air at about 800°C. The metal is not attacked by hot or cold acids or *aqua regia*, but when potassium chlorate is added to the solution, it oxidizes explosively. It is attacked by halogens, hydroxides, etc. Ruthenium can be plated by electrodeposition or by thermal decomposition methods. The metal is one of the most effective hardeners for platinum and palladium, and is alloyed with these metals to make electrical contacts for severe wear resistance. A ruthenium-molybdenum alloy is said to be superconductive at 10.6 K. The corrosion resistance of titanium is improved a hundredfold by addition of 0.1% ruthenium. It is a versatile catalyst. Hydrogen sulfide can be split catalytically by light using an aqueous suspension of CdS particles loaded with ruthenium dioxide. It is thought this may have application to removal of H<sub>2</sub>S in oil refining and other industrial processes. Compounds in at least eight oxidation states have been found, but of these, the +2, +3, and +4 states are the most common. Ruthenium tetroxide, like osmium tetroxide, is highly toxic. In addition, it may explode. Ruthenium compounds show a marked resemblance to those of osmium. The metal is priced at about \$25/g (99.95% pure).

**Rutherfordium** — (Ernest Rutherford [1871–1937], New Zealand, Canadian, and British physicist); Rf; at. wt. [261]; at. no. 104. In 1964, workers of the Joint Nuclear Research Institute at Dubna (Russia) bombarded plutonium with accelerated 113 to 115 MeV neon ions. By measuring fission tracks in a special glass with a microscope, they detected an isotope that decays by spontaneous fission. They suggested that this isotope, which has a half-life of  $0.3 \pm 0.1$  s, might be <sup>260</sup>104, produced by the following reaction:



Element 104, the first *transactinide* element, is expected to have chemical properties similar to those of hafnium. It would, for example, form a relatively volatile compound with chlorine (a tetrachloride). The Soviet scientists have performed experiments aimed at chemical identification, and have attempted to show that the 0.3-s activity is more volatile than that of the relatively nonvolatile actinide trichlorides. This experiment does not fulfill the test of chemically separating the new element from all others, but it provides important evidence for

evaluation. New data, reportedly issued by Soviet scientists, have reduced the half-life of the isotope they worked with from 0.3 to 0.15 s. The Dubna scientists suggest the name *kurchatovium* and symbol *Ku* for Element 104, in honor of Igor Vasilevich Kurchatov (1903–1960), late Head of Soviet Nuclear Research. The Dubna Group also has proposed the name *dubnium* for Element 104. In 1969, Ghiorso, Nurmia, Harris, K. A. Y. Eskola, and P. I. Eskola of the University of California at Berkeley reported they had positively identified two, and possibly three, isotopes of Element 104. The group also indicated that after repeated attempts so far they have been unable to produce isotope <sup>260</sup>104 reported by the Dubna groups in 1964. The discoveries at Berkeley were made by bombarding a target of <sup>249</sup>Cf with <sup>12</sup>C nuclei of 71 MeV, and <sup>13</sup>C nuclei of 69 MeV. The combination of <sup>12</sup>C with <sup>249</sup>Cf followed by instant emission of four neutrons produced Element <sup>257</sup>104. This isotope has a half-life of 4 to 5 s, decaying by emitting an alpha particle into <sup>253</sup>No, with a half-life of 105 s. The same reaction, except with the emission of three neutrons, was thought to have produced <sup>258</sup>104 with a half-life of about 1/100 s. Element <sup>259</sup>104 is formed by the merging of a <sup>13</sup>C nuclei with <sup>249</sup>Cf, followed by emission of three neutrons. This isotope has a half-life of 3 to 4 s, and decays by emitting an alpha particle into <sup>255</sup>No, which has a half-life of 185 s. Thousands of atoms of <sup>257</sup>104 and <sup>259</sup>104 have been detected. The Berkeley group believes its identification of <sup>258</sup>104 was correct. Eleven isotopes of Element 104 have now been identified. The Berkeley group proposed the name *rutherfordium* (symbol Rf) for the new element, in honor of Ernest Rutherford. This name was formally adapted by IUPAC in August 1997.

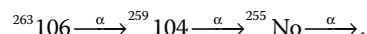
**Samarium** — (*Samarските*, a mineral), Sm; at. wt. 150.36(3); at. no. 62; m.p. 1072°C; b.p. 1794°C; sp. gr (α) 7.520 (25°C); valence 2 or 3. Discovered spectroscopically by its sharp absorption lines in 1879 by Lecoq de Boisbaudran in the mineral *samarските*, named in honor of a Russian mine official, Col. Samarski. Samarium is found along with other members of the rare-earth-elements in many minerals, including *monazite* and *bastnasite*, which are commercial sources. The largest producer of rare-earth minerals is now China, followed by the U.S., India, and Russia. It occurs in monazite to the extent of 2.8%. While *misch metal* containing about 1% of samarium metal has long been used, samarium has not been isolated in relatively pure form until recently. Ion-exchange and solvent extraction techniques have recently simplified separation of the rare earths from one another; more recently, electrochemical deposition, using an electrolytic solution of lithium citrate and a mercury electrode, is said to be a simple, fast, and highly specific way to separate the rare earths. Samarium metal can be produced by reducing the oxide with barium or lanthanum. Samarium has a bright silver luster and is reasonably stable in air. Three crystal modifications of the metal exist, with transformations at 734 and 922°C. The metal ignites in air at about 150°C. Thirty-three isotopes and isomers of samarium are now recognized. Natural samarium is a mixture of seven isotopes, three of which are unstable but have long half-lives. Samarium, along with other rare earths, is used for carbon-arc lighting for the motion picture industry. The sulfide has excellent high-temperature stability and good thermoelectric efficiencies up to 1100°C. SmCo<sub>5</sub> has been used in making a new permanent magnet material with the highest resistance to demagnetization of any known material. It is said to have an intrinsic coercive force as high as 2200 kA/m. Samarium oxide has been used in optical glass to absorb the infrared.

Samarium is used to dope calcium fluoride crystals for use in optical masers or lasers. Compounds of the metal act as sensitizers for phosphors excited in the infrared; the oxide exhibits catalytic properties in the dehydration and dehydrogenation of ethyl alcohol. It is used in infrared absorbing glass and as a neutron absorber in nuclear reactors. The metal is priced at about \$3.50/g (99.9%). Little is known of the toxicity of samarium; therefore, it should be handled carefully.

**Scandium** — (L. *Scandia*, Scandinavia), Sc; at. wt. 44.955912(6); at. no. 21; m.p. 1541°C; b.p. 2836°C; sp. gr. 2.989 (25°C); valence 3. On the basis of the Periodic System, Mendeleev predicted the existence of *ekaboron*, which would have an atomic weight between 40 of calcium and 48 of titanium. The element was discovered by Nilson in 1878 in the minerals *euxenite* and *gadolinite*, which had not yet been found anywhere except in Scandinavia. By processing 10 kg of euxenite and other residues of rare-earth minerals, Nilson was able to prepare about 2 g of scandium oxide of high purity. Cleve later pointed out that Nilson's scandium was identical with Mendeleev's *ekaboron*. Scandium is apparently a much more abundant element in the sun and certain stars than here on Earth. It is about the 23rd most abundant element in the sun, compared to the 50th most abundant on Earth. It is widely distributed on Earth, occurring in very minute quantities in over 800 mineral species. The blue color of beryl (aquamarine variety) is said to be due to scandium. It occurs as a principal component in the rare mineral *thortveitite*, found in Scandinavia and Malagasy. It is also found in the residues remaining after the extraction of tungsten from Zinnwald *wolframite*, and in *wiikite* and *bazzite*. Most scandium is presently being recovered from *thortveitite* or is extracted as a by-product from uranium mill tailings. Metallic scandium was first prepared in 1937 by Fischer, Brunger, and Grieneisen, who electrolyzed a eutectic melt of potassium, lithium, and scandium chlorides at 700 to 800°C. Tungsten wire and a pool of molten zinc served as the electrodes in a graphite crucible. Pure scandium is now produced by reducing scandium fluoride with calcium metal. The production of the first pound of 99% pure scandium metal was announced in 1960. Scandium is a silver-white metal that develops a slightly yellowish or pinkish cast upon exposure to air. It is relatively soft, and resembles yttrium and the rare-earth metals more than it resembles aluminum or titanium. It is a very light metal and has a much higher melting point than aluminum, making it of interest to designers of spacecraft. Scandium is not attacked by a 1:1 mixture of conc. HNO<sub>3</sub> and 48% HF. Scandium reacts rapidly with many acids. Twenty-three isotopes and isomers of scandium are recognized. The metal is expensive, costing about \$200/g with a purity of about 99.9%. About 20 kg of scandium (as Sc<sub>2</sub>O<sub>3</sub>) are now being used yearly in the U.S. to produce high-intensity lights, and the radioactive isotope <sup>46</sup>Sc is used as a tracing agent in refinery crackers for crude oil, etc. Scandium iodide added to mercury vapor lamps produces a highly efficient light source resembling sunlight, which is important for indoor or night-time color TV. Little is yet known about the toxicity of scandium; therefore, it should be handled with care.

**Seaborgium** — (Glenn T. Seaborg [1912–1999], American chemist and nuclear physicist). Sg; at. wt. [266]; at no. 106. The discovery of *Seaborgium*, Element 106, took place in 1974 almost simultaneously at the Lawrence-Berkeley Laboratory and at the Joint Institute for Nuclear Research at Dubna, Russia. The Berkeley Group, under direction of Ghiorso, used the Super-

Heavy Ion Linear Accelerator (Super HILAC) as a source of heavy <sup>18</sup>O ions to bombard a 259-μg target of <sup>249</sup>Cf. This resulted in the production and positive identification of <sup>263</sup>106, which decayed with a half-life of 0.9 ± 0.2 s by the emission of alpha particles as follows:



The Dubna Team, directed by Flerov and Organessian, produced heavy ions of <sup>54</sup>Cr with their 310-cm heavy-ion cyclotron to bombard <sup>207</sup>Pb and <sup>208</sup>Pb and found a product that decayed with a half-life of 7 ms. They assigned <sup>259</sup>106 to this isotope. It is now thought seven isotopes of *Seaborgium* have been identified. Two of the isotopes are believed to have half-lives of about 30 s. *Seaborgium* most likely would have properties resembling tungsten. The IUPAC adopted the name *Seaborgium* in August 1997. Normally the naming of an element is not given until after the death of the person for which the element is named; however, in this case, it was named while Dr. Seaborg was still alive.

**Selenium** — (Gr. *Selene*, moon), Se; at. wt. 78.96(3); at. no. 34; m.p. (gray) 221°C; b.p. (gray) 685°C; sp. gr. (gray) 4.79, (vitreous) 4.28; valence -2, +4, or +6. Discovered by Berzelius in 1817, who found it associated with tellurium, named for the Earth. Selenium is found in a few rare minerals, such as *crooksite* and *clausthalite*. In years past it has been obtained from flue dusts remaining from processing copper sulfide ores, but the anode muds from electrolytic copper refineries now provide the source of most of the world's selenium. Selenium is recovered by roasting the muds with soda or sulfuric acid, or by smelting them with soda and niter. Selenium exists in several allotropic forms. Three are generally recognized, but as many as six have been claimed. Selenium can be prepared with either an amorphous or crystalline structure. The color of amorphous selenium is either red, in powder form, or black, in vitreous form. Crystalline monoclinic selenium is a deep red; crystalline hexagonal selenium, the most stable variety, is a metallic gray. Natural selenium contains six stable isotopes. Twenty-nine other isotopes and isomers have been characterized. The element is a member of the sulfur family and resembles sulfur both in its various forms and in its compounds. Selenium exhibits both photovoltaic action, where light is converted directly into electricity, and photoconductive action, where the electrical resistance decreases with increased illumination. These properties make selenium useful in the production of photocells and exposure meters for photographic use, as well as solar cells. Selenium is also able to convert a.c. electricity to d.c., and is extensively used in rectifiers. Below its melting point, selenium is a p-type semiconductor and is finding many uses in electronic and solid-state applications. It is used in xerography for reproducing and copying documents, letters, etc., but recently its use in this application has been decreasing in favor of certain organic compounds. It is used by the glass industry to decolorize glass and to make ruby-colored glasses and enamels. It is also used as a photographic toner, and as an additive to stainless steel. Elemental selenium has been said to be practically nontoxic and is considered to be an essential trace element; however, hydrogen selenide and other selenium compounds are extremely toxic, and resemble arsenic in their physiological reactions. Hydrogen selenide in a concentration of 1.5 ppm is intolerable to man. Selenium occurs in some soils in amounts sufficient to produce serious effects on animals feeding on plants, such as locoweed, grown

in such soils. Selenium (99.5%) is priced at about \$250/kg. It is also available in high-purity form at a cost of about \$350/kg (99.999%).

**Silicon** — (L. *silex*, *silicis*, flint), Si; at. wt. 28.0855(3); at. no. 14; m.p. 1414°C; b.p. 3265°C; sp. gr. 2.33 (25°C); valence 4. Davy in 1800 thought silica to be a compound and not an element; later in 1811, Gay Lussac and Thenard probably prepared impure amorphous silicon by heating potassium with silicon tetrafluoride. Berzelius, generally credited with the discovery, in 1824 succeeded in preparing amorphous silicon by the same general method as used earlier, but he purified the product by removing the fluosilicates by repeated washings. Deville in 1854 first prepared crystalline silicon, the second allotropic form of the element. Silicon is present in the sun and stars and is a principal component of a class of meteorites known as "aerolites." It is also a component of *tektites*, a natural glass of uncertain origin. Natural silicon contains three isotopes. Twenty-four other radioactive isotopes are recognized. Silicon makes up 25.7% of the Earth's crust, by weight, and is the second most abundant element, being exceeded only by oxygen. Silicon is not found free in nature, but occurs chiefly as the oxide and as silicates. *Sand, quartz, rock crystal, amethyst, agate, flint, jasper, and opal* are some of the forms in which the oxide appears. *Granite, hornblende, asbestos, feldspar, clay mica*, etc. are but a few of the numerous silicate minerals. Silicon is prepared commercially by heating silica and carbon in an electric furnace, using carbon electrodes. Several other methods can be used for preparing the element. Amorphous silicon can be prepared as a brown powder, which can be easily melted or vaporized. Crystalline silicon has a metallic luster and grayish color. The Czochralski process is commonly used to produce single crystals of silicon used for solid-state or semiconductor devices. Hyperpure silicon can be prepared by the thermal decomposition of ultra-pure trichlorosilane in a hydrogen atmosphere, and by a vacuum float zone process. This product can be doped with boron, gallium, phosphorus, or arsenic to produce silicon for use in transistors, solar cells, rectifiers, and other solid-state devices that are used extensively in the electronics and space-age industries. Hydrogenated amorphous silicon has shown promise in producing economical cells for converting solar energy into electricity. Silicon is a relatively inert element, but it is attacked by halogens and dilute alkali. Most acids, except hydrofluoric, do not affect it. Silicones are important products of silicon. They may be prepared by hydrolyzing a silicon organic chloride, such as dimethyl silicon chloride. Hydrolysis and condensation of various substituted chlorosilanes can be used to produce a very great number of polymeric products, or silicones, ranging from liquids to hard, glasslike solids with many useful properties. Elemental silicon transmits more than 95% of all wavelengths of infrared, from 1.3 to 6.7  $\mu\text{m}$ . Silicon is one of man's most useful elements. In the form of sand and clay it is used to make concrete and brick; it is a useful refractory material for high-temperature work, and in the form of silicates it is used in making enamels, pottery, etc. Silica, as sand, is a principal ingredient of glass, one of the most inexpensive of materials with excellent mechanical, optical, thermal, and electrical properties. Glass can be made in a very great variety of shapes, and is used as containers, window glass, insulators, and thousands of other uses. Silicon tetrachloride can be used to iridize glass. Silicon is important in plant and animal life. Diatoms in both fresh and salt water extract silica from the water to build up their cell walls. Silica is present in ashes of plants and in the human

skeleton. Silicon is an important ingredient in steel; silicon carbide is one of the most important abrasives and has been used in lasers to produce coherent light of 4560 Å. A remarkable material, first discovered in 1930, is *Aerogel*, which is now used by NASA in their space missions to collect cometary and interplanet dust. *Aerogel* is a highly insulative material that has the lowest density of any known solid. One form of *Aerogel* is 99.9% air and 0.1%  $\text{SiO}_2$  by volume. It is 1000 times less dense than glass. It has been called "blue smoke" or "solid smoke." A block of *Aerogel* as large as a person may weigh less than a pound and yet support the weight of 1000 lbs (455 kg). This material is expected to trap cometary particles traveling at speeds of 32 km/sec. *Aerogel* is said to be non-toxic and non-inflammable. It has high thermal insulating qualities that could be used in home insulation. Its light weight may have aircraft applications. Regular grade silicon (99.5%) costs about \$160/kg. Silicon (99.9999%) pure costs about \$200/kg; hyperpure silicon is available at a higher cost. Miners, stonecutters, and other engaged in work where siliceous dust is breathed in large quantities often develop a serious lung disease known as *silicosis*.

**Silver** — (Anglo-Saxon, *Seolfur siolfur*), Ag (L. *argentum*), at. wt. 107.8682(2); at. no. 47; m.p. 961.78°C; b.p. 2162°C; sp. gr. 10.50 (20°C); valence 1, 2. Silver has been known since ancient times. It is mentioned in Genesis. Slag dumps in Asia Minor and on islands in the Aegean Sea indicate that man learned to separate silver from lead as early as 3000 B.C. Silver occurs native and in ores such as *argentite* ( $\text{Ag}_2\text{S}$ ) and *horn silver* ( $\text{AgCl}$ ); lead, lead-zinc, copper, gold, and copper-nickel ores are principal sources. Mexico, Canada, Peru, and the U.S. are the principal silver producers in the western hemisphere. Silver is also recovered during electrolytic refining of copper. Commercial fine silver contains at least 99.9% silver. Purities of 99.999+% are available commercially. Pure silver has a brilliant white metallic luster. It is a little harder than gold and is very ductile and malleable, being exceeded only by gold and perhaps palladium. Pure silver has the highest electrical and thermal conductivity of all metals, and possesses the lowest contact resistance. It is stable in pure air and water, but tarnishes when exposed to ozone, hydrogen sulfide, or air containing sulfur. The alloys of silver are important. Sterling silver is used for jewelry, silverware, etc. where appearance is paramount. This alloy contains 92.5% silver, the remainder being copper or some other metal. Silver is of utmost importance in photography, about 30% of the U.S. industrial consumption going into this application. It is used for dental alloys. Silver is used in making solder and brazing alloys, electrical contacts, and high capacity silver-zinc and silver-cadmium batteries. Silver paints are used for making printed circuits. It is used in mirror production and may be deposited on glass or metals by chemical deposition, electrodeposition, or by evaporation. When freshly deposited, it is the best reflector of visible light known, but is rapidly tarnishes and loses much of its reflectance. It is a poor reflector of ultraviolet. Silver fulminate ( $\text{Ag}_2\text{C}_2\text{N}_2\text{O}_2$ ), a powerful explosive, is sometimes formed during the silvering process. Silver iodide is used in seeding clouds to produce rain. Silver chloride has interesting optical properties as it can be made transparent; it also is a cement for glass. Silver nitrate, or *lunar caustic*, the most important silver compound, is used extensively in photography. While silver itself is not considered to be toxic, most of its salts are poisonous. Natural silver contains two stable isotopes. Fifty-six other radioactive isotopes and isomers are



known. Silver compounds can be absorbed in the circulatory system and reduced silver deposited in the various tissues of the body. A condition, known as *argyria*, results with a greyish pigmentation of the skin and mucous membranes. Silver has germicidal effects and kills many lower organisms effectively without harm to higher animals. Silver for centuries has been used traditionally for coinage by many countries of the world. In recent times, however, consumption of silver has at times greatly exceeded the output. In 1939, the price of silver was fixed by the U.S. Treasury at 71¢/troy oz., and at 90.5¢/troy oz. in 1946. In November 1961 the U.S. Treasury suspended sales of nonmonetized silver, and the price stabilized for a time at about \$1.29, the melt-down value of silver U.S. coins. The Coinage Act of 1965 authorized a change in the metallic composition of the three U.S. subsidiary denominations to clad or composite type coins. This was the first change in U.S. coinage since the monetary system was established in 1792. Clad dimes and quarters are made of an outer layer of 75% Cu and 25% Ni bonded to a central core of pure Cu. The composition of the one- and five-cent pieces remains unchanged. One-cent coins are 95% Cu and 5% Zn. Five-cent coins are 75% Cu and 25% Ni. Old silver dollars are 90% Ag and 10% Cu. Earlier subsidiary coins of 90% Ag and 10% Cu officially were to circulate alongside the clad coins; however, in practice they have largely disappeared (Gresham's Law), as the value of the silver is now greater than their exchange value. Silver coins of other countries have largely been replaced with coins made of other metals. On June 24, 1968, the U.S. Government ceased to redeem U.S. Silver Certificates with silver. Since that time, the price of silver has fluctuated widely. As of January 2002, the price of silver was about \$4.10/troy oz. (13¢/g); however the price has fluctuated considerably due to market instability. The price of silver in 2001 was only about four times the cost of the metal about 150 years ago. This has largely been caused by Central Banks disposing of some of their silver reserves and the development of more productive mines with better refining methods. Also, silver has been displaced by other metals or processes, such as digital photography.

**Sodium** — (English, *soda*; Medieval Latin, *sodanum*, headache remedy), Na (L. *natrium*); at. wt. 22.98976928(2); at. no. 11; m.p. 97.80°C; b.p. 883°C; sp. gr. 0.971 (20°C); valence 1. Long recognized in compounds, sodium was first isolated by Davy in 1807 by electrolysis of caustic soda. Sodium is present in fair abundance in the sun and stars. The D lines of sodium are among the most prominent in the solar spectrum. Sodium is the sixth most abundant element on earth, comprising about 2.6% of the Earth's crust; it is the most abundant of the alkali group of metals of which it is a member. The most common compound is sodium chloride, but it occurs in many other minerals, such as *soda niter*, *cryolite*, *amphibole*, *zeolite*, *sodalite*, etc. It is a very reactive element and is never found free in nature. It is now obtained commercially by the electrolysis of absolutely dry fused sodium chloride. This method is much cheaper than that of electrolyzing sodium hydroxide, as was used several years ago. Sodium is a soft, bright, silvery metal that floats on water, decomposing it with the evolution of hydrogen and the formation of the hydroxide. It may or may not ignite spontaneously on water, depending on the amount of oxide and metal exposed to the water. It normally does not ignite in air at temperatures below 115°C. Sodium should be handled with respect, as it can be dangerous when improperly handled. Metallic sodium is vital in the manufacture of sodamide and esters, and in the preparation of organic

compounds. The metal may be used to improve the structure of certain alloys, to descale metal, to purify molten metals, and as a heat transfer agent. An alloy of sodium with potassium, NaK, is also an important heat transfer agent. Sodium compounds are important to the paper, glass, soap, textile, petroleum, chemical, and metal industries. Soap is generally a sodium salt of certain fatty acids. The importance of common salt to animal nutrition has been recognized since prehistoric times. Among the many compounds that are of the greatest industrial importance are common salt (NaCl), soda ash (Na<sub>2</sub>CO<sub>3</sub>), baking soda (NaHCO<sub>3</sub>), caustic soda (NaOH), Chile saltpeter (NaNO<sub>3</sub>), di- and tri-sodium phosphates, sodium thiosulfate (hypo, Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> · 5H<sub>2</sub>O), and borax (Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> · 10H<sub>2</sub>O). Seventeen isotopes of sodium are recognized. Metallic sodium is priced at about \$575/kg (99.95%). On a volume basis, it is the cheapest of all metals. Sodium metal should be handled with great care. It should be kept in an inert atmosphere and contact with water and other substances with which sodium reacts should be avoided.

**Strontium** — (*Strontian*, town in Scotland), Sr; at. wt. 87.62(1); at. no. 38; m.p. 777°C; b.p. 1382°C; sp. gr. 2.64; valence 2. Isolated by Davey by electrolysis in 1808; however, Adair Crawford in 1790 recognized a new mineral (strontianite) as differing from other barium minerals (baryta). Strontium is found chiefly as *celestite* (SrSO<sub>4</sub>) and *strontianite* (SrCO<sub>3</sub>). *Celestite* is found in Mexico, Turkey, Iran, Spain, Algeria, and in the U.K. The U.S. has no active *celestite* mines. The metal can be prepared by electrolysis of the fused chloride mixed with potassium chloride, or is made by reducing strontium oxide with aluminum in a vacuum at a temperature at which strontium distills off. Three allotropic forms of the metal exist, with transition points at 235 and 540°C. Strontium is softer than calcium and decomposes water more vigorously. It does not absorb nitrogen below 380°C. It should be kept under mineral oil to prevent oxidation. Freshly cut strontium has a silvery appearance, but rapidly turns a yellowish color with the formation of the oxide. The finely divided metal ignites spontaneously in air. Volatile strontium salts impart a beautiful crimson color to flames, and these salts are used in pyrotechnics and in the production of flares. Natural strontium is a mixture of four stable isotopes. Thirty-two other unstable isotopes and isomers are known to exist. Of greatest importance is <sup>90</sup>Sr with a half-life of 29 years. It is a product of nuclear fallout and presents a health problem. This isotope is one of the best long-lived high-energy beta emitters known, and is used in SNAP (Systems for Nuclear Auxiliary Power) devices. These devices hold promise for use in space vehicles, remote weather stations, navigational buoys, etc., where a lightweight, long-lived, nuclear-electric power source is needed. The major use for strontium at present is in producing glass for color television picture tubes. All color TV and cathode ray tubes sold in the U.S. are required by law to contain strontium in the face plate glass to block X-ray emission. Strontium also improves the brilliance of the glass and the quality of the picture. It has also found use in producing ferrite magnets and in refining zinc. Strontium titanate is an interesting optical material as it has an extremely high refractive index and an optical dispersion greater than that of diamond. It has been used as a gemstone, but it is very soft. It does not occur naturally. Strontium metal (99% pure) costs about \$220/kg.

**Sulfur** — (Sanskrit, *sulvere*; L. *sulphurium*), S; at. wt. 32.065(5); at. no. 16; m.p. 115.21°C; b.p. 444.61°C; *t<sub>c</sub>* 1041°C; sp. gr. (rhombohedral) 2.07, (monoclinic) 2.00 (20°C); valence 2, 4, or 6. Known to the

ancients; referred to in Genesis as *brimstone*. Sulfur is found in meteorites. A dark area near the crater Aristarchus on the moon has been studied by R. W. Wood with ultraviolet light. This study suggests strongly that it is a sulfur deposit. Sulfur occurs native in the vicinity of volcanoes and hot springs. It is widely distributed in nature as *iron pyrites, galena, sphalerite, cinnabar, stibnite, gypsum, Epsom salts, celestite, barite*, etc. Sulfur is commercially recovered from wells sunk into the salt domes along the Gulf Coast of the U.S. It is obtained from these wells by the Frasch process, which forces heated water into the wells to melt the sulfur, which is then brought to the surface. Sulfur also occurs in natural gas and petroleum crudes and must be removed from these products. Formerly this was done chemically, which wasted the sulfur. New processes now permit recovery, and these sources promise to be very important. Large amounts of sulfur are being recovered from Alberta gas fields. Sulfur is a pale yellow, odorless, brittle solid that is insoluble in water but soluble in carbon disulfide. In every state, whether gas, liquid or solid, elemental sulfur occurs in more than one allotropic form or modification; these present a confusing multitude of forms whose relations are not yet fully understood. Amorphous or "plastic" sulfur is obtained by fast cooling of the crystalline form. X-ray studies indicate that amorphous sulfur may have a helical structure with eight atoms per spiral. Crystalline sulfur seems to be made of rings, each containing eight sulfur atoms that fit together to give a normal X-ray pattern. Twenty-one isotopes of sulfur are now recognized. Four occur in natural sulfur, none of which is radioactive. A finely divided form of sulfur, known as *flowers of sulfur*, is obtained by sublimation. Sulfur readily forms sulfides with many elements. Sulfur is a component of black gunpowder, and is used in the vulcanization of natural rubber and a fungicide. It is also used extensively in making phosphatic fertilizers. A tremendous tonnage is used to produce sulfuric acid, the most important manufactured chemical. It is used in making sulfite paper and other papers, as a fumigant, and in the bleaching of dried fruits. The element is a good electrical insulator. Organic compounds containing sulfur are very important. Calcium sulfate, ammonium sulfate, carbon disulfide, sulfur dioxide, and hydrogen sulfide are but a few of the many other important compounds of sulfur. Sulfur is essential to life. It is a minor constituent of fats, body fluids, and skeletal minerals. Carbon disulfide, hydrogen sulfide, and sulfur dioxide should be handled carefully. Hydrogen sulfide in small concentrations can be metabolized, but in higher concentrations it can quickly cause death by respiratory paralysis. It is insidious in that it quickly deadens the sense of smell. Sulfur dioxide is a dangerous component in atmospheric pollution. Sulfur (99.999%) costs about \$575/kg.

**Tantalum** — (Gr. *Tantalos*, mythological character, father of *Niobe*), Ta; at. wt. 180.94788(2); at. no. 73; m.p. 3017°C; b.p. 5458°C; sp. gr. 16.4; valence 2?, 3, 4?, or 5. Discovered in 1802 by Ekeberg, but many chemists thought niobium and tantalum were identical elements until Rose, in 1844, and Marignac, in 1866, showed that niobic and tantalic acids were two different acids. The early investigators only isolated the impure metal. The first relatively pure ductile tantalum was produced by von Bolton in 1903. Tantalum occurs principally in the mineral *columbite-tantalite* (Fe, Mn)(Nb, Ta)<sub>2</sub>O<sub>6</sub>. Tantalum ores are found in Australia, Brazil, Rwanda, Zimbabwe, Congo-Kinshasa, Nigeria, and Canada. Separation of tantalum from niobium requires several complicated steps. Several methods are used to commercially produce the element, including

electrolysis of molten potassium fluorotantalate, reduction of potassium fluorotantalate with sodium, or reacting tantalum carbide with tantalum oxide. Thirty-four isotopes and isomers of tantalum are known to exist. Natural tantalum contains two isotopes, one of which is radioactive with a very long half-life. Tantalum is a gray, heavy, and very hard metal. When pure, it is ductile and can be drawn into fine wire, which is used as a filament for evaporating metals such as aluminum. Tantalum is almost completely immune to chemical attack at temperatures below 150°C, and is attacked only by hydrofluoric acid, acidic solutions containing the fluoride ion, and free sulfur trioxide. Alkalis attack it only slowly. At high temperatures, tantalum becomes much more reactive. The element has a melting point exceeded only by tungsten and rhenium. Tantalum is used to make a variety of alloys with desirable properties such as high melting point, high strength, good ductility, etc. Scientists at Los Alamos have produced a tantalum carbide graphite composite material that is said to be one of the hardest materials ever made. The compound has a melting point of 3738°C. Tantalum has good "gettering" ability at high temperatures, and tantalum oxide films are stable and have good rectifying and dielectric properties. Tantalum is used to make electrolytic capacitors and vacuum furnace parts, which account for about 60% of its use. The metal is also widely used to fabricate chemical process equipment, nuclear reactors, and aircraft and missile parts. Tantalum is completely immune to body liquids and is a nonirritating metal. It has, therefore, found wide use in making surgical appliances. Tantalum oxide is used to make special glass with a high index of refraction for camera lenses. The metal has many other uses. The price of (99.9%) tantalum is about \$2/g.

**Technetium** — (Gr. *technetos*, artificial), Tc; at. wt. (98); at. no. 43; m.p. 2157°C; b.p. 4265°C; sp. gr. 11.50 (calc.); valence 0, +2, +4, +5, +6, and +7. Element 43 was predicted on the basis of the periodic table, and was erroneously reported as having been discovered in 1925, at which time it was named *masurium*. The element was actually discovered by Perrier and Segre in Italy in 1937. It was found in a sample of molybdenum that was bombarded by deuterons in the Berkeley cyclotron, and which E. Lawrence sent to these investigators. Technetium was the first element to be produced artificially. Since its discovery, searches for the element in terrestrial materials have been made without success. If it does exist, the concentration must be very small. Technetium has been found in the spectrum of S-, M-, and N-type stars, and its presence in stellar matter is leading to new theories of the production of heavy elements in the stars. Forty-three isotopes and isomers of technetium, with mass numbers ranging from 86 to 113, are known. <sup>97</sup>Tc has a half-life of  $2.6 \times 10^6$  years. <sup>98</sup>Tc has a half-life of  $4.2 \times 10^6$  years. The isomeric isotope <sup>95m</sup>Tc, with a half-life of 61 days, is useful for tracer work, as it produces energetic gamma rays. Technetium metal has been produced in kilogram quantities. The metal was first prepared by passing hydrogen gas at 1100°C over Tc<sub>2</sub>S<sub>7</sub>. It is now conveniently prepared by the reduction of ammonium pertechnetate with hydrogen. Technetium is a silvery-gray metal that tarnishes slowly in moist air. Until 1960, technetium was available only in small amounts and the price was as high as \$2800/g, but the price is now of the order of \$100/g. The chemistry of technetium is similar to that of rhenium. Technetium dissolves in nitric acid, aqua regia, and concentrated sulfuric acid, but is not soluble in hydrochloric acid of any strength. The element is a remarkable corrosion inhibitor for steel. It is reported that



mild carbon steels may be effectively protected by as little as 55 ppm of  $\text{KTCO}_4$  in aerated distilled water at temperatures up to 250°C. This corrosion protection is limited to closed systems, since technetium is radioactive and must be confined.  $^{99}\text{Tc}$  has a specific activity of  $6.2 \times 10^8$  Bq/g. Activity of this level must not be allowed to spread.  $^{99}\text{Tc}$  is a contamination hazard and should be handled in a glove box. The metal is an excellent superconductor at 11K and below.

**Tellurium** — (L. *tellus*, earth), Te; at. wt. 127.60(3); at. no. 52; m.p. 449.51°C; b.p. 988°C; sp. gr. 6.23 (20°C); valence -2, 4, or 6. Discovered by Muller von Reichenstein in 1782; named by Klaproth, who isolated it in 1798. Tellurium is occasionally found native, but is more often found as the telluride of gold (*calaverite*), and combined with other metals. It is recovered commercially from the anode muds produced during the electrolytic refining of blister copper. The U.S., Canada, Peru, and Japan are the largest producers of the element. Crystalline tellurium has a silvery-white appearance, and when pure exhibits a metallic luster. It is brittle and easily pulverized. Amorphous tellurium is formed by precipitating tellurium from a solution of telluric or tellurous acid. Whether this form is truly amorphous, or made of minute crystals, is open to question. Tellurium is a p-type semiconductor, and shows greater conductivity in certain directions, depending on alignment of the atoms. Its conductivity increases slightly with exposure to light. It can be doped with silver, copper, gold, tin, or other elements. In air, tellurium burns with a greenish-blue flame, forming the dioxide. Molten tellurium corrodes iron, copper, and stainless steel. Tellurium and its compounds are probably toxic and should be handled with care. Workmen exposed to as little as 0.01 mg/m<sup>3</sup> of air, or less, develop "tellurium breath," which has a garlic-like odor. Forty-two isotopes and isomers of tellurium are known, with atomic masses ranging from 106 to 138. Natural tellurium consists of eight isotopes, two of which are radioactive with very long half-lives. Tellurium improves the machinability of copper and stainless steel, and its addition to lead decreases the corrosive action of sulfuric acid on lead and improves its strength and hardness. Tellurium catalysts are used in the oxidation of organic compounds and are used in hydrogenation and halogenation reactions. Tellurium is also used in electronic and semiconductor devices. It is also used as a basic ingredient in blasting caps, and is added to cast iron for chill control. Tellurium is used in ceramics. Bismuth telluride has been used in thermoelectric devices. Tellurium costs about 50¢/g, with a purity of about 99.5%. The metal with a purity of 99.9999% costs about \$5/g.

**Terbium** — (*Ytterby*, village in Sweden), Tb; at. wt. 158.92534(2); at. no. 65; m.p. 1356°C; b.p. 3230°C; sp. gr. 8.230; valence 3, 4. Discovered by Mosander in 1843. Terbium is a member of the lanthanide or "rare earth" group of elements. It is found in *cerite*, *gadolinite*, and other minerals along with other rare earths. It is recovered commercially from *monazite* in which it is present to the extent of 0.03%, from *xenotime*, and from *euxenite*, a complex oxide containing 1% or more of terbium. Terbium has been isolated only in recent years with the development of ion-exchange techniques for separating the rare-earth elements. As with other rare earths, it can be produced by reducing the anhydrous chloride or fluoride with calcium metal in a tantalum crucible. Calcium and tantalum impurities can be removed by vacuum remelting. Other methods of isolation are possible. Terbium is reasonably stable in air. It is

a silver-gray metal, and is malleable, ductile, and soft enough to be cut with a knife. Two crystal modifications exist, with a transformation temperature of 1289°C. Forty-two isotopes and isomers are recognized. The oxide is a chocolate or dark maroon color. Sodium terbium borate is used as a laser material and emits coherent light at 0.546  $\mu\text{m}$ . Terbium is used to dope calcium fluoride, calcium tungstate, and strontium molybdate, used in solid-state devices. The oxide has potential application as an activator for green phosphors used in color TV tubes. It can be used with  $\text{ZrO}_2$  as a crystal stabilizer of fuel cells that operate at elevated temperature. Few other uses have been found. The element is priced at about \$40/g (99.9%). Little is known of the toxicity of terbium. It should be handled with care as with other lanthanide elements.

**Thallium** — (Gr. *thallos*, a green shoot or twig), Tl; at. wt. 204.3833(2); at. no. 81; m.p. 304°C; b.p. 1473°C; sp. gr. 11.85 (20°C); valence 1, or 3. Thallium was discovered spectroscopically in 1861 by Crookes. The element was named after the beautiful green spectral line, which identified the element. The metal was isolated both by Crookes and Lamy in 1862 about the same time. Thallium occurs in *crooksite*, *lorandite*, and *hutchinsonite*. It is also present in *pyrites* and is recovered from the roasting of this ore in connection with the production of sulfuric acid. It is also obtained from the smelting of lead and zinc ores. Extraction is somewhat complex and depends on the source of the thallium. Manganese nodules, found on the ocean floor, contain thallium. When freshly exposed to air, thallium exhibits a metallic luster, but soon develops a bluish-gray tinge, resembling lead in appearance. A heavy oxide builds up on thallium if left in air, and in the presence of water the hydroxide is formed. The metal is very soft and malleable. It can be cut with a knife. Forty-seven isotopes of thallium, with atomic masses ranging from 179 to 210 are recognized. Natural thallium is a mixture of two isotopes. The element and its compounds are toxic and should be handled carefully. Contact of the metal with skin is dangerous, and when melting the metal adequate ventilation should be provided. Thallium is suspected of carcinogenic potential for man. Thallium sulfate has been widely employed as a rodenticide and ant killer. It is odorless and tasteless, giving no warning of its presence. Its use, however, has been prohibited in the U.S. since 1975 as a household insecticide and rodenticide. The electrical conductivity of thallium sulfide changes with exposure to infrared light, and this compound is used in photocells. Thallium bromide-iodide crystals have been used as infrared optical materials. Thallium has been used, with sulfur or selenium and arsenic, to produce low melting glasses which become fluid between 125 and 150°C. These glasses have properties at room temperatures similar to ordinary glasses and are said to be durable and insoluble in water. Thallium oxide has been used to produce glasses with a high index of refraction. Thallium has been used in treating ringworm and other skin infections; however, its use has been limited because of the narrow margin between toxicity and therapeutic benefits. A mercury-thallium alloy, which forms a eutectic at 8.5% thallium, is reported to freeze at -60°C, some 20° below the freezing point of mercury. Thallium metal (99.999%) costs about \$2/g.

**Thorium** — (*Thor*, Scandinavian god of war), Th; at. wt. 232.03806(2); at. no. 90; m.p. 1750°C; b.p. 4788°C; sp. gr. 11.72; valence +2(?), +3(?), +4. Discovered by Berzelius in 1828. Thorium occurs in *thorite* ( $\text{ThSiO}_4$ ) and in *thorianite*

( $\text{ThO}_2 + \text{UO}_2$ ). Large deposits of thorium minerals have been reported in New England and elsewhere, but these have not yet been exploited. Thorium is now thought to be about three times as abundant as uranium and about as abundant as lead or molybdenum. The metal is a source of nuclear power. There is probably more energy available for use from thorium in the minerals of the Earth's crust than from both uranium and fossil fuels. Any sizable demand for thorium as a nuclear fuel is still several years in the future. Work has been done in developing thorium cycle converter-reactor systems. Several prototypes, including the HTGR (high-temperature gas-cooled reactor) and MSRE (molten salt converter reactor experiment), have operated. While the HTGR reactors are efficient, they are not expected to become important commercially for many years because of certain operating difficulties. Thorium is recovered commercially from the mineral *monazite*, which contains from 3 to 9%  $\text{ThO}_2$  along with rare-earth minerals. Much of the internal heat the Earth produces has been attributed to thorium and uranium. Several methods are available for producing thorium metal: it can be obtained by reducing thorium oxide with calcium, by electrolysis of anhydrous thorium chloride in a fused mixture of sodium and potassium chlorides, by calcium reduction of thorium tetrachloride mixed with anhydrous zinc chloride, and by reduction of thorium tetrachloride with an alkali metal. Thorium was originally assigned a position in Group IV of the periodic table. Because of its atomic weight, valence, etc., it is now considered to be the second member of the *actinide* series of elements. When pure, thorium is a silvery-white metal which is air stable and retains its luster for several months. When contaminated with the oxide, thorium slowly tarnishes in air, becoming gray and finally black. The physical properties of thorium are greatly influenced by the degree of contamination with the oxide. The purest specimens often contain several tenths of a percent of the oxide. High-purity thorium has been made. Pure thorium is soft, very ductile, and can be cold-rolled, swaged, and drawn. Thorium is dimorphic, changing at  $1400^\circ\text{C}$  from a cubic to a body-centered cubic structure. Thorium oxide has a melting point of  $3300^\circ\text{C}$ , which is the highest of all oxides. Only a few elements, such as tungsten, and a few compounds, such as tantalum carbide, have higher melting points. Thorium is slowly attacked by water, but does not dissolve readily in most common acids, except hydrochloric. Powdered thorium metal is often pyrophoric and should be carefully handled. When heated in air, thorium turnings ignite and burn brilliantly with a white light. The principal use of thorium has been in the preparation of the Welsbach mantle, used for portable gas lights. These mantles, consisting of thorium oxide with about 1% cerium oxide and other ingredients, glow with a dazzling light when heated in a gas flame. Thorium is an important alloying element in magnesium, imparting high strength and creep resistance at elevated temperatures. Because thorium has a low work-function and high electron emission, it is used to coat tungsten wire used in electronic equipment. The oxide is also used to control the grain size of tungsten used for electric lamps; it is also used for high-temperature laboratory crucibles. Glasses containing thorium oxide have a high refractive index and low dispersion. Consequently, they find application in high quality lenses for cameras and scientific instruments. Thorium oxide has also found use as a catalyst in the conversion of ammonia to nitric acid, in petroleum cracking, and in producing sulfuric acid. Thorium has not found many uses due to its radioactive nature

and its handling and disposal problems. Thirty isotopes of thorium are known with atomic masses ranging from 210 to 237. All are unstable.  $^{232}\text{Th}$  occurs naturally and has a half-life of  $1.4 \times 10^{10}$  years. It is an alpha emitter.  $^{232}\text{Th}$  goes through six alpha and four beta decay steps before becoming the stable isotope  $^{208}\text{Pb}$ .  $^{232}\text{Th}$  is sufficiently radioactive to expose a photographic plate in a few hours. Thorium disintegrates with the production of "thoron" ( $^{220}\text{Rn}$ ), which is an alpha emitter and presents a radiation hazard. Good ventilation of areas where thorium is stored or handled is therefore essential. Thorium metal (99.8%) costs about \$25/g.

**Thulium** — (*Thule*, the earliest name for Scandinavia), Tm; at. wt. 168.93421(2); at. no. 69; m.p.  $1545^\circ\text{C}$ ; b.p.  $1950^\circ\text{C}$ ; sp. gr. 9.321 ( $25^\circ\text{C}$ ); valence 3. Discovered in 1879 by Cleve. Thulium occurs in small quantities along with other rare earths in a number of minerals. It is obtained commercially from *monazite*, which contains about 0.007% of the element. Thulium is the least abundant of the rare-earth elements, but with new sources recently discovered, it is now considered to be about as rare as silver, gold, or cadmium. Ion-exchange and solvent extraction techniques have recently permitted much easier separation of the rare earths, with much lower costs. Only a few years ago, thulium metal was not obtainable at any cost; in 1996 the oxide cost \$20/g. Thulium metal powder now costs \$70/g (99.9%). Thulium can be isolated by reduction of the oxide with lanthanum metal or by calcium reduction of the anhydrous fluoride. The pure metal has a bright, silvery luster. It is reasonably stable in air, but the metal should be protected from moisture in a closed container. The element is silver-gray, soft, malleable, and ductile, and can be cut with a knife. Forty-one isotopes and isomers are known, with atomic masses ranging from 146 to 176. Natural thulium, which is 100%  $^{169}\text{Tm}$ , is stable. Because of the relatively high price of the metal, thulium has not yet found many practical applications.  $^{169}\text{Tm}$  bombarded in a nuclear reactor can be used as a radiation source in portable X-ray equipment.  $^{171}\text{Tm}$  is potentially useful as an energy source. Natural thulium also has possible use in *ferrites* (ceramic magnetic materials) used in microwave equipment. As with other lanthanides, thulium has a low-to-moderate acute toxicity rating. It should be handled with care.

**Tin** — (Anglo-Saxon, *tin*), Sn (L. *stannum*); at. wt. 118.710(7); at. no. 50; m.p.  $231.93^\circ\text{C}$ ; b.p.  $2602^\circ\text{C}$ ; sp. gr. (gray) 5.77, (white) 7.29; valence 2, 4. Known to the ancients. Tin is found chiefly in *cassiterite* ( $\text{SnO}_2$ ). Most of the world's supply comes from China, Indonesia, Peru, Brazil, and Bolivia. The U.S. produces almost none, although occurrences have been found in Alaska and Colorado. Tin is obtained by reducing the ore with coal in a reverberatory furnace. Ordinary tin is composed of ten stable isotopes; thirty-six unstable isotopes and isomers are also known. Ordinary tin is a silver-white metal, is malleable, somewhat ductile, and has a highly crystalline structure. Due to the breaking of these crystals, a "tin cry" is heard when a bar is bent. The element has two allotropic forms at normal pressure. On warming, gray, or  $\alpha$  tin, with a cubic structure, changes at  $13.2^\circ\text{C}$  into white, or  $\beta$  tin, the ordinary form of the metal. White tin has a tetragonal structure. When tin is cooled below  $13.2^\circ\text{C}$ , it changes slowly from white to gray. This change is affected by impurities such as aluminum and zinc, and can be prevented by small additions of antimony or bismuth. This change from the  $\alpha$  to  $\beta$  form is called the tin pest. Tin-lead alloys are used to make organ pipes. There are few if any uses

for gray tin. Tin takes a high polish and is used to coat other metals to prevent corrosion or other chemical action. Such tin plate over steel is used in the so-called tin can for preserving food. Alloys of tin are very important. Soft solder, type metal, fusible metal, pewter, bronze, bell metal, Babbitt metal, white metal, die casting alloy, and phosphor bronze are some of the important alloys using tin. Tin resists distilled sea and soft tap water, but is attacked by strong acids, alkalis, and acid salts. Oxygen in solution accelerates the attack. When heated in air, tin forms  $\text{SnO}_2$ , which is feebly acid, forming stannate salts with basic oxides. The most important salt is the chloride ( $\text{SnCl}_2 \cdot \text{H}_2\text{O}$ ), which is used as a reducing agent and as a mordant in calico printing. Tin salts sprayed onto glass are used to produce electrically conductive coatings. These have been used for panel lighting and for frost-free windshields. Most window glass is now made by floating molten glass on molten tin (float glass) to produce a flat surface (Pilkington process). Of recent interest is a crystalline tin–niobium alloy that is superconductive at very low temperatures. This promises to be important in the construction of superconductive magnets that generate enormous field strengths but use practically no power. Such magnets, made of tin–niobium wire, weigh but a few pounds and produce magnetic fields that, when started with a small battery, are comparable to that of a 100 ton electromagnet operated continuously with a large power supply. The small amount of tin found in canned foods is quite harmless. The agreed limit of tin content in U.S. foods is 300 mg/kg. The trialkyl and triaryl tin compounds are used as biocides and must be handled carefully. Over the past 25 years the price of commercial tin has varied from 50¢/lb (\$1.10/kg) to about \$6/kg. Tin (99.99% pure) costs about \$260/kg.

**Titanium** — (L. *Titans*, the first sons of the Earth, myth.), Ti; at. wt. 47.867(1); at. no. 22; m.p. 1668°C; b.p. 3287°C; sp. gr. 4.51; valence 2, 3, or 4. Discovered by Gregor in 1791; named by Klaproth in 1795. Impure titanium was prepared by Nilson and Pettersson in 1887; however, the pure metal (99.9%) was not made until 1910 by Hunter by heating  $\text{TiCl}_4$  with sodium in a steel bomb. Titanium is present in meteorites and in the sun. Rocks obtained during the Apollo 17 lunar mission showed presence of 12.1%  $\text{TiO}_2$ . Analyses of rocks obtained during earlier Apollo missions show lower percentages. Titanium oxide bands are prominent in the spectra of M-type stars. The element is the ninth most abundant in the crust of the Earth. Titanium is almost always present in igneous rocks and in the sediments derived from them. It occurs in the minerals *rutile*, *ilmenite*, and *sphene*, and is present in titanates and in many iron ores. Deposits of ilmenite and rutile are found in Florida, California, Tennessee, and New York. Australia, Norway, Malaysia, India, and China are also large suppliers of titanium minerals. Titanium is present in the ash of coal, in plants, and in the human body. The metal was a laboratory curiosity until Kroll, in 1946, showed that titanium could be produced commercially by reducing titanium tetrachloride with magnesium. This method is largely used for producing the metal today. The metal can be purified by decomposing the iodide. Titanium, when pure, is a lustrous, white metal. It has a low density, good strength, is easily fabricated, and has excellent corrosion resistance. It is ductile only when it is free of oxygen. The metal burns in air and is the only element that burns in nitrogen. Titanium is resistant to dilute sulfuric and hydrochloric acid, most organic acids, moist chlorine gas, and chloride solutions. Natural titanium consists of five isotopes with atomic masses from 46 to 50. All are stable. Eighteen

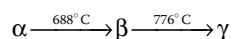
other unstable isotopes are known. The metal is dimorphic. The hexagonal  $\alpha$  form changes to the cubic  $\beta$  form very slowly at about 880°C. The metal combines with oxygen at red heat, and with chlorine at 550°C. Titanium is important as an alloying agent with aluminum, molybdenum, manganese, iron, and other metals. Alloys of titanium are principally used for aircraft and missiles where lightweight strength and ability to withstand extremes of temperature are important. Titanium is as strong as steel, but 45% lighter. It is 60% heavier than aluminum, but twice as strong. Titanium has potential use in desalination plants for converting sea water into fresh water. The metal has excellent resistance to sea water and is used for propeller shafts, rigging, and other parts of ships exposed to salt water. A titanium anode coated with platinum has been used to provide cathodic protection from corrosion by salt water. Titanium metal is considered to be physiologically inert; however, titanium powder may be a carcinogenic hazard. When pure, titanium dioxide is relatively clear and has an extremely high index of refraction with an optical dispersion higher than diamond. It is produced artificially for use as a gemstone, but it is relatively soft. Star sapphires and rubies exhibit their asterism as a result of the presence of  $\text{TiO}_2$ . Titanium dioxide is extensively used for both house paint and artist's paint, as it is permanent and has good covering power. Titanium oxide pigment accounts for the largest use of the element. Titanium paint is an excellent reflector of infrared, and is extensively used in solar observatories where heat causes poor seeing conditions. Titanium tetrachloride is used to iridize glass. This compound fumes strongly in air and has been used to produce smoke screens. The price of titanium metal (99.9%) is about \$1100/kg.

**Tungsten** — (Swedish, *tung sten*, heavy stone); also known as *wolfram* (from *wolframite*, said to be named from *wolf rahm* or *spumi lupi*, because the ore interfered with the smelting of tin and was supposed to devour the tin), W; at. wt. 183.84(1); at. no. 74; m.p. 3422°C; b.p. 5555°C; sp. gr. 19.3 (20°C); valence 2, 3, 4, 5, or 6. In 1779 Peter Woulfe examined the mineral now known as *wolframite* and concluded it must contain a new substance. Scheele, in 1781, found that a new acid could be made from *tung sten* (a name first applied about 1758 to a mineral now known as *scheelite*). Scheele and Berman suggested the possibility of obtaining a new metal by reducing this acid. The de Elhuyar brothers found an acid in *wolframite* in 1783 that was identical to the acid of *tungsten* (tungstic acid) of Scheele, and in that year they succeeded in obtaining the element by reduction of this acid with charcoal. Tungsten occurs in *wolframite*,  $(\text{Fe}, \text{Mn})\text{WO}_4$ ; *scheelite*,  $\text{CaWO}_4$ ; *huebnerite*,  $\text{MnWO}_4$ ; and *ferberite*,  $\text{FeWO}_4$ . Important deposits of tungsten occur in California, Colorado, Bolivia, Russia, and Portugal. China is reported to have about 75% of the world's tungsten resources. Natural tungsten contains five stable isotopes. Thirty-two other unstable isotopes and isomers are recognized. The metal is obtained commercially by reducing tungsten oxide with hydrogen or carbon. Pure tungsten is a steel-gray to tin-white metal. Very pure tungsten can be cut with a hacksaw, and can be forged, spun, drawn, and extruded. The impure metal is brittle and can be worked only with difficulty. Tungsten has the highest melting point of all metals, and at temperatures over 1650°C has the highest tensile strength. The metal oxidizes in air and must be protected at elevated temperatures. It has excellent corrosion resistance and is attacked only slightly by most mineral acids. The thermal expansion is about the same as borosilicate glass, which makes the metal useful for glass-



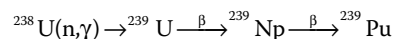
to-metal seals. Tungsten and its alloys are used extensively for filaments for electric lamps, electron and television tubes, and for metal evaporation work; for electrical contact points for automobile distributors; X-ray targets; windings and heating elements for electrical furnaces; and for numerous spacecraft and high-temperature applications. High-speed tool steels, Hastelloy®, Stellite®, and many other alloys contain tungsten. Tungsten carbide is of great importance to the metal-working, mining, and petroleum industries. Calcium and magnesium tungstates are widely used in fluorescent lighting; other salts of tungsten are used in the chemical and tanning industries. Tungsten disulfide is a dry, high-temperature lubricant, stable to 500°C. Tungsten bronzes and other tungsten compounds are used in paints. Zirconium tungstate has found recent applications (see under Zirconium). Tungsten powder (99.999%) costs about \$2900/kg.

**Uranium** — (Planet *Uranus*), U; at. wt. 238.02891(3); at. no. 92; m.p. 1135°C; b.p. 4131°C; sp. gr. 19.1; valence 2, 3, 4, 5, or 6. Yellow-colored glass, containing more than 1% uranium oxide and dating back to 79 A.D., has been found near Naples, Italy. Klaproth recognized an unknown element in *pitchblende* and attempted to isolate the metal in 1789. The metal apparently was first isolated in 1841 by Peligot, who reduced the anhydrous chloride with potassium. Uranium is not as rare as it was once thought. It is now considered to be more plentiful than mercury, antimony, silver, or cadmium, and is about as abundant as molybdenum or arsenic. It occurs in numerous minerals such as *pitchblende*, *uraninite*, *carnotite*, *autunite*, *uranophane*, *davidite*, and *tobernite*. It is also found in *phosphate rock*, *lignite*, *monazite sands*, and can be recovered commercially from these sources. Large deposits of uranium occur in Utah, Colorado, New Mexico, Canada, and elsewhere. Uranium can be made by reducing uranium halides with alkali or alkaline earth metals or by reducing uranium oxides by calcium, aluminum, or carbon at high temperatures. The metal can also be produced by electrolysis of  $KUF_5$  or  $UF_4$ , dissolved in a molten mixture of  $CaCl_2$  and  $NaCl$ . High-purity uranium can be prepared by the thermal decomposition of uranium halides on a hot filament. Uranium exhibits three crystallographic modifications as follows:

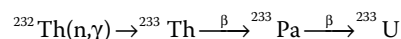


Uranium is a heavy, silvery-white metal that is pyrophoric when finely divided. It is a little softer than steel, and is attacked by cold water in a finely divided state. It is malleable, ductile, and slightly paramagnetic. In air, the metal becomes coated with a layer of oxide. Acids dissolve the metal, but it is unaffected by alkalis. Uranium has twenty-three isotopes, one of which is an isomer and all of which are radioactive. Naturally occurring uranium contains 99.2745% by weight  $^{238}U$ , 0.720%  $^{235}U$ , and 0.0055%  $^{234}U$ . Studies show that the percentage weight of  $^{235}U$  in natural uranium varies by as much as 0.1%, depending on the source. The U.S.D.O.E. has adopted the value of 0.711 as being their “official” percentage of  $^{235}U$  in natural uranium. Natural uranium is sufficiently radioactive to expose a photographic plate in an hour or so. Much of the internal heat of the Earth is thought to be attributable to the presence of uranium and thorium.  $^{238}U$ , with a half-life of  $4.46 \times 10^9$  years, has been used to estimate the age of igneous rocks. The origin of uranium, the highest member of the naturally occurring elements — except perhaps for traces of nep-

tunium or plutonium — is not clearly understood, although it has been thought that uranium might be a decay product of elements of higher atomic weight, which may have once been present on Earth or elsewhere in the universe. These original elements may have been formed as a result of a primordial “creation,” known as “the big bang,” in a supernova, or in some other stellar processes. The fact that recent studies show that most trans-uranic elements are extremely rare with very short half-lives indicates that it may be necessary to find some alternative explanation for the very large quantities of radioactive uranium we find on Earth. Studies of meteorites from other parts of the solar system show a relatively low radioactive content, compared to terrestrial rocks. Uranium is of great importance as a nuclear fuel.  $^{238}U$  can be converted into fissionable plutonium by the following reactions:



This nuclear conversion can be brought about in “breeder” reactors where it is possible to produce more new fissionable material than the fissionable material used in maintaining the chain reaction.  $^{235}U$  is of even greater importance, for it is the key to the utilization of uranium.  $^{235}U$ , while occurring in natural uranium to the extent of only 0.72%, is so fissionable with slow neutrons that a self-sustaining fission chain reaction can be made to occur in a reactor constructed from natural uranium and a suitable moderator, such as heavy water or graphite, alone.  $^{235}U$  can be concentrated by gaseous diffusion and other physical processes, if desired, and used directly as a nuclear fuel, instead of natural uranium, or used as an explosive. Natural uranium, slightly enriched with  $^{235}U$  by a small percentage, is used to fuel nuclear power reactors for the generation of electricity. Natural thorium can be irradiated with neutrons as follows to produce the important isotope  $^{233}U$ .



While thorium itself is not fissionable,  $^{233}U$  is, and in this way may be used as a nuclear fuel. One pound of completely fissioned uranium has the fuel value of over 1500 tons of coal. The uses of nuclear fuels to generate electrical power, to make isotopes for peaceful purposes, and to make explosives are well known. The estimated world-wide production of the 437 nuclear power reactors in operation in 1998 amounted to about 352,000 megawatt hours. In 1998 the U.S. had about 107 commercial reactors with an output of about 100,000 megawatt-hours. Some nuclear-powered electric generating plants have recently been closed because of safety concerns. There are also serious problems with nuclear waste disposal that have not been completely resolved. Uranium in the U.S. is controlled by the U.S. Nuclear Regulatory Commission, under the Department of Energy. Uses are being found for the large quantities of “depleted” uranium now available, where uranium-235 has been lowered to about 0.2%. Depleted uranium has been used for inertial guidance devices, gyrocompasses, counterweights for aircraft control surfaces, ballast for missile reentry vehicles, and as a shielding material for tanks, etc. Concerns, however, have been raised over its low radioactive properties. Uranium metal is used for X-ray targets for production of high-energy X-rays. The nitrate has been used as photographic toner, and the acetate is used in analytical chemistry. Crystals of uranium nitrate are triboluminescent. Uranium salts have also been used for producing yellow “vase-

line" glass and glazes. Uranium and its compounds are highly toxic, both from a chemical and radiological standpoint. Finely divided uranium metal, being pyrophoric, presents a fire hazard. The maximum permissible total body burden of natural uranium (based on radiotoxicity) is 0.2  $\mu\text{Ci}$  for soluble compounds. Recently, the natural presence of uranium and thorium in many soils has become of concern to homeowners because of the generation of radon and its daughters (see under Radon). Uranium metal is available commercially at a cost of about \$6/g (99.7%) in air-tight glass under argon.

**Vanadium** — (Scandinavian goddess, *Vanadis*), V; at. wt. 50.9415(1); at. no. 23; m.p. 1910°C; b.p. 3407°C; sp. gr. 6.0 (18.7°C); valence 2, 3, 4, or 5. Vanadium was first discovered by del Rio in 1801. Unfortunately, a French chemist incorrectly declared that del Rio's new element was only impure chromium; del Rio thought himself to be mistaken and accepted the French chemist's statement. The element was re-discovered in 1830 by Sefstrom, who named the element in honor of the Scandinavian goddess *Vanadis* because of its beautiful multicolored compounds. It was isolated in nearly pure form by Roscoe, in 1867, who reduced the chloride with hydrogen. Vanadium of 99.3 to 99.8% purity was not produced until 1927. Vanadium is found in about 65 different minerals among which *carnotite*, *roscoelite*, *vanadinite*, and *patronite* are important sources of the metal. Vanadium is also found in phosphate rock and certain iron ores, and is present in some crude oils in the form of organic complexes. It is also found in small percentages in meteorites. Commercial production from petroleum ash holds promise as an important source of the element. China, South Africa, and Russia supply much of the world's vanadium ores. High-purity ductile vanadium can be obtained by reduction of vanadium trichloride with magnesium or with magnesium-sodium mixtures. Much of the vanadium metal being produced is now made by calcium reduction of  $\text{V}_2\text{O}_5$  in a pressure vessel, an adaptation of a process developed by McKechnie and Seybolt. Natural vanadium is a mixture of two isotopes,  $^{50}\text{V}$  (0.25%) and  $^{51}\text{V}$  (99.75%).  $^{50}\text{V}$  is slightly radioactive, having a long half-life. Twenty other unstable isotopes are recognized. Pure vanadium is a bright white metal, and is soft and ductile. It has good corrosion resistance to alkalis, sulfuric and hydrochloric acid, and salt water, but the metal oxidizes readily above 660°C. The metal has good structural strength and a low-fission neutron cross section, making it useful in nuclear applications. Vanadium is used in producing rust-resistant, spring, and high-speed tool steels. It is an important carbide stabilizer in making steels. About 80% of the vanadium now produced is used as ferrovanadium or as a steel additive. Vanadium foil is used as a bonding agent in cladding titanium to steel. Vanadium pentoxide is used in ceramics and as a catalyst. It is also used in producing a superconductive magnet with a field of 175,000 gauss. Vanadium and its compounds are toxic and should be handled with care. Ductile vanadium is commercially available. Vanadium metal (99.7%) costs about \$3/g.

**Wolfram** — see Tungsten.

**Xenon** — (Gr. *xenon*, stranger), Xe; at. wt. 131.293(6); at. no. 54; m.p. -111.74°C; b.p. -108.09°C;  $t_c$  16.58°C; density (gas)  $5.887 \pm 0.009$  g/L, sp. gr (liquid) 2.95 (-109°C); valence usually 0. Discovered by Ramsay and Travers in 1898 in the residue left after evaporating liquid air components. Xenon is a member of the so-called noble or "inert" gases. It is present

in the atmosphere to the extent of about one part in twenty million. Xenon is present in the Martian atmosphere to the extent of 0.08 ppm. The element is found in the gases evolved from certain mineral springs, and is commercially obtained by extraction from liquid air. Natural xenon is composed of nine stable isotopes. In addition to these, thirty-five unstable isotopes and isomers have been characterized. Before 1962, it had generally been assumed that xenon and other noble gases were unable to form compounds. However, it is now known that xenon, as well as other members of the zero valence elements, do form compounds. Among the compounds of xenon now reported are xenon hydrate, sodium perxenate, xenon deuterate, difluoride, tetrafluoride, hexafluoride, and  $\text{XePtF}_6$  and  $\text{XeRhF}_6$ . Xenon trioxide, which is highly explosive, has been prepared. More than 80 xenon compounds have been made with xenon chemically bonded to fluorine and oxygen. Some xenon compounds are colored. Metallic xenon has been produced, using several hundred kilobars of pressure. Xenon in a vacuum tube produces a beautiful blue glow when excited by an electrical discharge. The gas is used in making electron tubes, stroboscopic lamps, bactericidal lamps, and lamps used to excite ruby lasers for generating coherent light. Xenon is used in the atomic energy field in bubble chambers, probes, and other applications where its high molecular weight is of value. The perxenates are used in analytical chemistry as oxidizing agents.  $^{133}\text{Xe}$  and  $^{135}\text{Xe}$  are produced by neutron irradiation in air-cooled nuclear reactors.  $^{133}\text{Xe}$  has useful applications as a radioisotope. The element is available in sealed glass containers for about \$20/L of gas at standard pressure. Xenon is not toxic, but its compounds are highly toxic because of their strong oxidizing characteristics.

**Ytterbium** — (*Ytterby*, village in Sweden), Yb; at. wt. 173.04(3); at. no. 70; m.p. 824°C; b.p. 1196°C; sp. gr ( $\alpha$ ) 6.903 ( $\beta$ ) 6.966; valence 2, 3. Marignac in 1878 discovered a new component, which he called *ytterbia*, in the Earth then known as *erbia*. In 1907, Urbain separated ytterbia into two components, which he called *neoytterbia* and *lutecia*. The elements in these earths are now known as *ytterbium* and *lutetium*, respectively. These elements are identical with *aldebaranium* and *cassiopeium*, discovered independently and at about the same time by von Welsbach. Ytterbium occurs along with other rare earths in a number of rare minerals. It is commercially recovered principally from *monazite sand*, which contains about 0.03%. Ion-exchange and solvent extraction techniques developed in recent years have greatly simplified the separation of the rare earths from one another. The element was first prepared by Klemm and Bonner in 1937 by reducing ytterbium trichloride with potassium. Their metal was mixed, however, with KCl. Daane, Dennison, and Spedding prepared a much purer form in 1953 from which the chemical and physical properties of the element could be determined. Ytterbium has a bright silvery luster, is soft, malleable, and quite ductile. While the element is fairly stable, it should be kept in closed containers to protect it from air and moisture. Ytterbium is readily attacked and dissolved by dilute and concentrated mineral acids and reacts slowly with water. Ytterbium has three allotropic forms with transformation points at -13° and 795°C. The beta form is a room-temperature, face-centered, cubic modification, while the high-temperature gamma form is a body-centered cubic form. Another body-centered cubic phase has recently been found to be stable at high pressures at room temperatures. The beta form ordinarily has metallic-type conductivity, but becomes a semiconductor when the pressure is increased above 16,000 atm. The electri-

cal resistance increases tenfold as the pressure is increased to 39,000 atm and drops to about 80% of its standard temperature-pressure resistivity at a pressure of 40,000 atm. Natural ytterbium is a mixture of seven stable isotopes. Twenty-six other unstable isotopes and isomers are known. Ytterbium metal has possible use in improving the grain refinement, strength, and other mechanical properties of stainless steel. One isotope is reported to have been used as a radiation source as a substitute for a portable X-ray machine where electricity is unavailable. Few other uses have been found. Ytterbium metal is available with a purity of about 99.9% for about \$10/g. Ytterbium has a low acute toxicity rating.

**Yttrium** — (*Ytterby*, village in Sweden near Vauxholm), Y; at. wt. 88.90585(2); at. no. 39; m.p. 1522°C; b.p. 3345°C; sp. gr. 4.469 (25°C); valence 3. *Yttria*, which is an earth containing yttrium, was discovered by Gadolin in 1794. *Ytterby* is the site of a quarry which yielded many unusually minerals containing rare earths and other elements. This small town, near Stockholm, bears the honor of giving names to *erbium*, *terbium*, and *ytterbium* as well as *yttrium*. In 1843 Mosander showed that yttria could be resolved into the oxides (or earths) of three elements. The name yttria was reserved for the most basic one; the others were named *erbia* and *terbia*. Yttrium occurs in nearly all of the rare-earth minerals. Analysis of lunar rock samples obtained during the Apollo missions show a relatively high yttrium content. It is recovered commercially from *monazite sand*, which contains about 3%, and from *bastnasite*, which contains about 0.2%. Wohler obtained the impure element in 1828 by reduction of the anhydrous chloride with potassium. The metal is now produced commercially by reduction of the fluoride with calcium metal. It can also be prepared by other techniques. Yttrium has a silver-metallic luster and is relatively stable in air. Turnings of the metal, however, ignite in air if their temperature exceeds 400°C, and finely divided yttrium is very unstable in air. Yttrium oxide is one of the most important compounds of yttrium and accounts for the largest use. It is widely used in making YVO<sub>4</sub> europium, and Y<sub>2</sub>O<sub>3</sub> europium phosphors to give the red color in color television tubes. Many hundreds of thousands of pounds are now used in this application. Yttrium oxide also is used to produce yttrium iron garnets, which are very effective microwave filters. Yttrium iron, aluminum, and gadolinium garnets, with formulas such as Y<sub>3</sub>Fe<sub>5</sub>O<sub>12</sub> and Y<sub>3</sub>Al<sub>5</sub>O<sub>12</sub>, have interesting magnetic properties. Yttrium iron garnet is also exceptionally efficient as both a transmitter and transducer of acoustic energy. Yttrium aluminum garnet, with a hardness of 8.5, is also finding use as a gemstone (simulated diamond). Small amounts of yttrium (0.1 to 0.2%) can be used to reduce the grain size in chromium, molybdenum, zirconium, and titanium, and to increase strength of aluminum and magnesium alloys. Alloys with other useful properties can be obtained by using yttrium as an additive. The metal can be used as a deoxidizer for vanadium and other nonferrous metals. The metal has a low cross section for nuclear capture. <sup>90</sup>Y, one of the isotopes of yttrium, exists in equilibrium with its parent <sup>90</sup>Sr, a product of atomic explosions. Yttrium has been considered for use as a nodulizer for producing nodular cast iron, in which the graphite forms compact nodules instead of the usual flakes. Such iron has increased ductility. Yttrium is also finding application in laser systems and as a catalyst for ethylene polymerization. It also has potential use in ceramic and glass formulas, as the oxide has a high melting point and imparts shock resistance and low expansion characteristics to glass. Natural yttrium contains

but one isotope, <sup>89</sup>Y. Forty-three other unstable isotopes and isomers have been characterized. Yttrium metal of 99.9% purity is commercially available at a cost of about \$5/g.

**Zinc** — (Ger. *Zink*, of obscure origin), Zn; at. wt. 65.409(4); at. no. 30; m.p. 419.53°C; b.p. 907°C; sp. gr. 7.134 (25°C); valence 2. Centuries before zinc was recognized as a distinct element, zinc ores were used for making brass. Tubal-Cain, seven generations from Adam, is mentioned as being an "instructor in every artificer in brass and iron." An alloy containing 87% zinc has been found in prehistoric ruins in Transylvania. Metallic zinc was produced in the 13th century A.D. in India by reducing calamine with organic substances such as wool. The metal was rediscovered in Europe by Marggraf in 1746, who showed that it could be obtained by reducing *calamine* with charcoal. The principal ores of zinc are *sphalerite* or *blende* (sulfide), *smithsonite* (carbonate), *calamine* (silicate), and *franklinite* (zinc, manganese, iron oxide). Canada, Japan, Belgium, Germany, and the Netherlands are suppliers of zinc ores. Zinc is also mined in Alaska, Tennessee, Missouri, and elsewhere in the U.S. Zinc can be obtained by roasting its ores to form the oxide and by reduction of the oxide with coal or carbon, with subsequent distillation of the metal. Other methods of extraction are possible. Naturally occurring zinc contains five stable isotopes. Twenty-five other unstable isotopes and isomers are recognized. Zinc is a bluish-white, lustrous metal. It is brittle at ordinary temperatures but malleable at 100 to 150°C. It is a fair conductor of electricity, and burns in air at high red heat with evolution of white clouds of the oxide. The metal is employed to form numerous alloys with other metals. Brass, nickel silver, typewriter metal, commercial bronze, spring brass, German silver, soft solder, and aluminum solder are some of the more important alloys. Large quantities of zinc are used to produce die castings, used extensively by the automotive, electrical, and hardware industries. An alloy called *Prestal*®, consisting of 78% zinc and 22% aluminum, is reported to be almost as strong as steel but as easy to mold as plastic. It is said to be so plastic that it can be molded into form by relatively inexpensive die casts made of ceramics and cement. It exhibits superplasticity. Zinc is also extensively used to galvanize other metals such as iron to prevent corrosion. Neither zinc nor zirconium is ferromagnetic; but ZrZn<sub>2</sub> exhibits ferromagnetism at temperatures below 35 K. Zinc oxide is a unique and very useful material to modern civilization. It is widely used in the manufacture of paints, rubber products, cosmetics, pharmaceuticals, floor coverings, plastics, printing inks, soap, storage batteries, textiles, electrical equipment, and other products. It has unusual electrical, thermal, optical, and solid-state properties that have not yet been fully investigated. Lithopone, a mixture of zinc sulfide and barium sulfate, is an important pigment. Zinc sulfide is used in making luminous dials, X-ray and TV screens, and fluorescent lights. The chloride and chromate are also important compounds. Zinc is an essential element in the growth of human beings and animals. Tests show that zinc-deficient animals require 50% more food to gain the same weight as an animal supplied with sufficient zinc. Zinc is not considered to be toxic, but when freshly formed ZnO is inhaled a disorder known as the *oxide shakes* or *zinc chills* sometimes occurs. It is recommended that where zinc oxide is encountered good ventilation be provided. The commercial price of zinc in January 2002 was roughly 40¢/lb (\$90/kg). Zinc metal with a purity of 99.9999% is priced at about \$5/g.



**Zirconium** — (Syriac, *zargun*, color of gold), Zr; at. wt. 91.224(2); at. no. 40; m.p. 1855°C; b.p. 4409°C; sp. gr. 6.52 (20°C); valence +2, +3, and +4. The name *zircon* may have originated from the Syriac word *zargono*, which describes the color of certain gemstones now known as *zircon*, *jargon*, *hyacinth*, *jacinth*, or *ligure*. This mineral, or its variations, is mentioned in biblical writings. These minerals were not known to contain this element until Klaproth, in 1789, analyzed a *jargon* from Sri Lanka and found a new earth, which Werner named zircon (*silex circonius*), and Klaproth called *Zirkonerde* (*zirconia*). The impure metal was first isolated by Berzelius in 1824 by heating a mixture of potassium and potassium zirconium fluoride in a small iron tube. Pure zirconium was first prepared in 1914. Very pure zirconium was first produced in 1925 by van Arkel and de Boer by an iodide decomposition process they developed. Zirconium is found in abundance in S-type stars, and has been identified in the sun and meteorites. Analyses of lunar rock samples obtained during the various Apollo missions to the moon show a surprisingly high zirconium oxide content, compared with terrestrial rocks. Naturally occurring zirconium contains five isotopes. Thirty-one other radioactive isotopes and isomers are known to exist. *Zircon*,  $\text{ZrSiO}_4$ , the principal ore, is found in deposits in Florida, South Carolina, Australia, South Africa, and elsewhere. *Baddeleyite*, found in Brazil, is an important zirconium mineral. It is principally pure  $\text{ZrO}_2$  in crystalline form having a hafnium content of about 1%. Zirconium also occurs in some 30 other recognized mineral species. Zirconium is produced commercially by reduction of the chloride with magnesium (the Kroll Process), and by other methods. It is a grayish-white lustrous metal. When finely divided, the metal may ignite spontaneously in air, especially at elevated temperatures. The solid metal is much more difficult to ignite. The inherent toxicity of zirconium compounds is low. Hafnium is invariably found in zirconium ores, and the separation is difficult. Commercial-grade zirconium contains

from 1 to 3% hafnium. Zirconium has a low absorption cross section for neutrons, and is therefore used for nuclear energy applications, such as for cladding fuel elements. Commercial nuclear power generation now takes more than 90% of zirconium metal production. Reactors of the size now being made may use as much as a half-million lineal feet of zirconium alloy tubing. Reactor-grade zirconium is essentially free of hafnium. *Zircaloy*® is an important alloy developed specifically for nuclear applications. Zirconium is exceptionally resistant to corrosion by many common acids and alkalis, by sea water, and by other agents. It is used extensively by the chemical industry where corrosive agents are employed. Zirconium is used as a getter in vacuum tubes, as an alloying agent in steel, in surgical appliances, photoflash bulbs, explosive primers, rayon spinnerets, lamp filaments, etc. It is used in poison ivy lotions in the form of the carbonate as it combines with *urushiol*. With niobium, zirconium is superconductive at low temperatures and is used to make superconductive magnets. Alloyed with zinc, zirconium becomes magnetic at temperatures below 35 K. Zirconium oxide (zircon) has a high index of refraction and is used as a gem material. The impure oxide, *zirconia*, is used for laboratory crucibles that will withstand heat shock, for linings of metallurgical furnaces, and by the glass and ceramic industries as a refractory material. Its use as a refractory material accounts for a large share of all zirconium consumed. Zirconium tungstate is an unusual material that shrinks, rather than expands, when heated. A few other compounds are known to possess this property, but they tend to shrink in one direction, while they stretch out in others in order to maintain an overall volume. Zirconium tungstate shrinks in all directions over a wide temperature range of from near absolute zero to +777°C. It is being considered for use in composite materials where thermal expansion may be a problem. Zirconium of about 99.5% purity is available at a cost of about \$2000/kg or about \$4/g.

## PHYSICAL CONSTANTS OF INORGANIC COMPOUNDS

The compounds in this table were selected on the basis of their laboratory and industrial importance, as well as their value in illustrating trends in the variation of physical properties with position in the periodic table. An effort has been made to include the most frequently encountered inorganic substances; a limited number of organometallics are also covered. Many, if not most, of the compounds that are solids at ambient temperature can exist in more than one crystalline modification. In the absence of other information, the data given here can be assumed to apply to the most stable or common crystalline form. In many cases, however, two or more forms are of practical importance, and separate entries will be found in the table.

Compounds are arranged primarily in alphabetical order by the most commonly used name. However, adjustments are made in many instances so as to bring closely related compounds together. For example, hydrides of elements such as boron, silicon, and germanium are grouped together immediately following the entry for the parent element, since they would otherwise be scattered throughout the table. Likewise, the oxoacids of an element are given in one group whenever a strict alphabetical order would separate them (e.g., sulfuric acid and fluorosulfuric acid). The Formula Index following the table provides another means of locating a compound. There is also an index to CAS Registry Numbers.

The following data fields appear in the table:

- **Name:** Systematic name for the substance. The valence state of a metallic element is indicated by a Roman numeral, e.g., copper in the +1 state is written as copper(I) rather than cuprous, iron in the +3 state is iron(III) rather than ferric.
- **Formula:** The simplest descriptive formula is given, but this does not necessarily specify the actual structure of the compound. For example, aluminum chloride is designated as  $\text{AlCl}_3$ , even though a more accurate representation of the structure in the solid phase (and, under some conditions, in the gas phase) is  $\text{Al}_2\text{Cl}_6$ . A few exceptions are made, such as the use of  $\text{Hg}_2^{+2}$  for the mercury(I) ion.
- **CAS Registry Number:** Chemical Abstracts Service Registry Number. An asterisk\* following the CAS RN for a hydrate indicates that the number refers to the anhydrous compound. In most cases the generic CAS RN for the compound is given rather than the number for a specific crystalline form or mineral.
- **Mol. Weight:** Molecular weight (relative molar mass) as calculated with the 2005 IUPAC Recommended Atomic Weights. The number of decimal places corresponds to the number of places in the atomic weight of the least accurately known element (e.g., one place for lead compounds, two places for compounds of selenium, germanium, etc.); a maximum of three places is given. For compounds of

radioactive elements for which IUPAC makes no recommendation, the mass number of the isotope with longest half-life is used.

- **Physical Form:** The crystal system is given, when available, for compounds that are solid at room temperature, together with color and other descriptive features. Abbreviations are listed below.
- **mp:** Normal melting point in °C. The notation tp indicates the temperature where solid, liquid, and gas are in equilibrium at a pressure greater than one atmosphere (i.e., the normal melting point does not exist). When available, the triple point pressure is listed.
- **bp:** Normal boiling point in °C (referred to 101.325 kPa or 760 mmHg pressure). The notation sp following the number indicates the temperature where the pressure of the vapor in equilibrium with the solid reaches 101.325 kPa. See Reference 8, p. 23, for further discussion of sublimation points and triple points. A notation "sublimes" without a temperature being given indicates that there is a perceptible sublimation pressure above the solid at ambient temperatures.
- **Density:** Density values for solids and liquids are always in units of grams per cubic centimeter and can be assumed to refer to temperatures near room temperature unless otherwise stated. Values for gases are the calculated ideal gas densities in grams per liter at 25 °C and 101.325 kPa; the unit is always specified for a gas value.
- **Aqueous Solubility:** Solubility is expressed as the number of grams of the compound (excluding any water of hydration) that will dissolve in 100 grams of water. The temperature in °C is given as a superscript. Solubility at other temperatures can be found for many compounds in the table "Aqueous Solubility of Inorganic Compounds at Various Temperatures" in Section 8.
- **Qualitative Solubility:** Qualitative information on the solubility in other solvents (and in water, if quantitative data are unavailable) is given here. The abbreviations are:

i insoluble  
sl slightly soluble  
s soluble  
vs very soluble  
reac reacts with the solvent

Data were taken from a wide variety of reliable sources, including monographs, treatises, review articles, evaluated compilations and databases, and in many cases the primary literature. Some of the most useful references for the properties covered here are listed below.

### List of Abbreviations

Ac - acetyl  
ace - acetone  
acid - acid solutions  
alk - alkaline solutions  
amorp - amorphous  
anh - anhydrous  
aq - aqueous

blk - black  
brn - brown  
bz - benzene  
chl - chloroform  
col - colorless  
conc - concentrated  
cry - crystals, crystalline

cub - cubic  
cyhex - cyclohexane  
dec - decomposes  
dil - dilute  
diox - dioxane  
eth - ethyl ether  
EtOH - ethanol

exp - explodes, explosive  
extrap - extrapolated  
flam - flammable  
gl - glass, glassy  
grn - green  
hc - hydrocarbon solvents  
hex - hexagonal, hexane



|                              |                                |                                 |                                           |
|------------------------------|--------------------------------|---------------------------------|-------------------------------------------|
| <b>hp</b> - heptane          | <b>orth</b> - orthorhombic     | <b>s</b> - soluble in           | <b>tp</b> - triple point                  |
| <b>HT</b> - high temperature | <b>os</b> - organic solvents   | <b>silv</b> - silvery           | <b>trans</b> - transition, transformation |
| <b>hyd</b> - hydrate         | <b>peth</b> - petroleum ether  | <b>sl</b> - slightly soluble in | <b>tricl</b> - triclinic                  |
| <b>hyg</b> - hygroscopic     | <b>pow</b> - powder            | <b>soln</b> - solution          | <b>trig</b> - trigonal                    |
| <b>i</b> - insoluble in      | <b>prec</b> - precipitate      | <b>sp</b> - sublimation point   | <b>unstab</b> - unstable                  |
| <b>liq</b> - liquid          | <b>pur</b> - purple            | <b>stab</b> - stable            | <b>viol</b> - violet                      |
| <b>LT</b> - low temperature  | <b>py</b> - pyridine           | <b>subl</b> - sublimes          | <b>visc</b> - viscous                     |
| <b>MeOH</b> - methanol       | <b>reac</b> - reacts with      | <b>temp</b> - temperature       | <b>vs</b> - very soluble in               |
| <b>monocl</b> - monoclinic   | <b>refrac</b> - refractory     | <b>tetr</b> - tetragonal        | <b>wh</b> - white                         |
| <b>octahed</b> - octahedral  | <b>rhom</b> - rhombohedral     | <b>thf</b> - tetrahydrofuran    | <b>xyl</b> - xylene                       |
| <b>oran</b> - orange         | <b>r.t.</b> - room temperature | <b>tol</b> - toluene            | <b>yel</b> - yellow                       |

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| No. | Name                                    | Formula                                                                | CAS Reg No. | Mol. weight | Physical form          | mp/°C  | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility           |
|-----|-----------------------------------------|------------------------------------------------------------------------|-------------|-------------|------------------------|--------|----------|----------------------------|-------------------------------------|----------------------------------|
| 1   | Actinium                                | Ac                                                                     | 7440-34-8   | 227         | silv metal; cub        | 1050   | 3198     | 10                         |                                     |                                  |
| 2   | Actinium bromide                        | AcBr <sub>3</sub>                                                      | 33689-81-5  | 467         | wh hex cry             |        | 800 subl | 5.85                       |                                     | s H <sub>2</sub> O               |
| 3   | Actinium chloride                       | AcCl <sub>3</sub>                                                      | 22986-54-5  | 333         | wh hex cry             |        | 960 subl | 4.81                       |                                     |                                  |
| 4   | Actinium fluoride                       | AcF <sub>3</sub>                                                       | 33689-80-4  | 284         | wh hex cry             |        |          | 7.88                       |                                     | i H <sub>2</sub> O               |
| 5   | Actinium iodide                         | AcI <sub>3</sub>                                                       | 33689-82-6  | 608         | wh cry                 |        |          |                            |                                     | s H <sub>2</sub> O               |
| 6   | Actinium oxide                          | Ac <sub>2</sub> O <sub>3</sub>                                         | 12002-61-8  | 502         | wh hex cry             | 1977   |          | 9.19                       |                                     | i H <sub>2</sub> O               |
| 7   | Aluminum                                | Al                                                                     | 7429-90-5   | 26.982      | silv-wh metal; cub cry | 660.32 | 2519     | 2.70                       |                                     | i H <sub>2</sub> O; s acid, alk  |
| 8   | Aluminum acetate                        | Al(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub>         | 139-12-8    | 204.113     | wh hyg solid           | dec    |          |                            |                                     | s H <sub>2</sub> O; sl ace       |
| 9   | Aluminum diacetate                      | Al(OH)(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>     | 142-03-0    | 162.078     | wh amorp powder        |        |          |                            |                                     | i H <sub>2</sub> O               |
| 10  | Aluminum ammonium sulfate               | AlNH <sub>4</sub> (SO <sub>4</sub> ) <sub>2</sub>                      | 7784-25-0   | 237.146     | wh powder              |        |          |                            |                                     | sl H <sub>2</sub> O; i EtOH      |
| 11  | Aluminum ammonium sulfate dodecahydrate | AlNH <sub>4</sub> (SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O | 7784-26-1   | 453.329     | col cry or powder      | 94.5   | >280 dec | 1.65                       |                                     | s H <sub>2</sub> O; i EtOH       |
| 12  | Aluminum antimonide                     | AlSb                                                                   | 25152-52-7  | 148.742     | brn cub cry            | 1065   |          | 4.26                       |                                     |                                  |
| 13  | Aluminum arsenide                       | AlAs                                                                   | 22831-42-1  | 101.903     | oran cub cry; hyg      | 1740   |          | 3.76                       |                                     |                                  |
| 14  | Aluminum borate                         | 2Al <sub>2</sub> O <sub>3</sub> · B <sub>2</sub> O <sub>3</sub>        | 11121-16-7  | 273.543     | needles                | ≈1050  |          |                            |                                     | i H <sub>2</sub> O               |
| 15  | Aluminum borohydride                    | Al(BH <sub>4</sub> ) <sub>3</sub>                                      | 16962-07-5  | 71.510      | flam liq               | -64.5  | 44.5     |                            |                                     | reac H <sub>2</sub> O            |
| 16  | Aluminum bromate nonahydrate            | Al(BrO <sub>3</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                 | 11126-81-1* | 572.826     | wh hyg cry             | 62     | >100 dec |                            |                                     | s H <sub>2</sub> O               |
| 17  | Aluminum bromide                        | AlBr <sub>3</sub>                                                      | 7727-15-3   | 266.694     | wh-yel monocl cry; hyg | 97.5   | 255      | 3.2                        |                                     | reac H <sub>2</sub> O; s bz, tol |

| No. | Name                                    | Formula                                                                          | CAS Reg No. | Mol. weight | Physical form              | mp/°C                  | bp/°C             | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                    |
|-----|-----------------------------------------|----------------------------------------------------------------------------------|-------------|-------------|----------------------------|------------------------|-------------------|----------------------------|-------------------------------------|-------------------------------------------|
| 18  | Aluminum bromide hexahydrate            | AlBr <sub>3</sub> · 6H <sub>2</sub> O                                            | 7784-11-4   | 374.785     | col-yel hyg cry            | 93                     |                   | 2.54                       |                                     | s H <sub>2</sub> O, EtOH, CS <sub>2</sub> |
| 19  | Aluminum carbide                        | Al <sub>4</sub> C <sub>3</sub>                                                   | 1299-86-1   | 143.958     | yel hex cry                | 2100                   | >2200 dec         | 2.36                       |                                     | reac H <sub>2</sub> O                     |
| 20  | Aluminum chlorate nonahydrate           | Al(ClO <sub>3</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                           | 15477-33-5  | 439.473     | hyg cry                    |                        |                   |                            |                                     | vs H <sub>2</sub> O; s EtOH               |
| 21  | Aluminum chloride                       | AlCl <sub>3</sub>                                                                | 7446-70-0   | 133.341     | wh hex cry or powder; hyg  | 192.6                  | 180 sp            | 2.48                       | 45.1 <sup>25</sup>                  | s bz, ctc, chl                            |
| 22  | Aluminum chloride hexahydrate           | AlCl <sub>3</sub> · 6H <sub>2</sub> O                                            | 7784-13-6   | 241.432     | col hyg cry                | 100 dec                |                   | 2.398                      | 45.1 <sup>25</sup>                  | s EtOH, eth                               |
| 23  | Dichloromethylaluminum                  | AlCl <sub>2</sub> CH <sub>3</sub>                                                | 917-65-7    | 112.923     | cry                        | 72.7                   | 95 <sup>100</sup> |                            |                                     | s bz, eth, hc                             |
| 24  | Chlorodiethylaluminum                   | AlCl(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>                                | 96-10-6     | 120.557     | col liq                    | -74                    |                   | 0.96                       |                                     | reac H <sub>2</sub> O                     |
| 25  | Chlorodiisobutylaluminum                | AlCl(C <sub>4</sub> H <sub>9</sub> ) <sub>2</sub>                                | 1779-25-5   | 176.664     | hyg col liq                | -40                    |                   | 0.95                       |                                     | s eth, hx                                 |
| 26  | Aluminum diboride                       | AlB <sub>2</sub>                                                                 | 12041-50-8  | 48.604      | powder                     | >920 dec               |                   | 3.19                       |                                     | s dil HCl                                 |
| 27  | Aluminum dodecaboride                   | AlB <sub>12</sub>                                                                | 12041-54-2  | 156.714     | yel-brn prisms             | 2070                   |                   | 2.55                       |                                     | s hot HNO <sub>3</sub> ; i acid, alk      |
| 28  | Aluminum ethanolate                     | Al(C <sub>2</sub> H <sub>5</sub> O) <sub>3</sub>                                 | 555-75-9    | 162.163     | liq, condenses to wh solid | 140                    |                   |                            |                                     | reac H <sub>2</sub> O; sl xyl             |
| 29  | Aluminum fluoride                       | AlF <sub>3</sub>                                                                 | 7784-18-1   | 83.977      | wh hex cry                 | 2250 tp (220 MPa)      | 1276 sp           | 3.10                       | 0.50 <sup>25</sup>                  |                                           |
| 30  | Aluminum fluoride monohydrate           | AlF <sub>3</sub> · H <sub>2</sub> O                                              | 32287-65-3  | 101.992     | orth cry                   |                        |                   | 2.17                       | 0.50 <sup>25</sup>                  |                                           |
| 31  | Aluminum fluoride trihydrate            | AlF <sub>3</sub> · 3H <sub>2</sub> O                                             | 15098-87-0  | 138.023     | wh hyg cry                 |                        |                   | 1.914                      | 0.50 <sup>25</sup>                  |                                           |
| 32  | Aluminum hexafluorosilicate nonahydrate | Al <sub>2</sub> (SiF <sub>6</sub> ) <sub>3</sub> · 9H <sub>2</sub> O             | 17099-70-6  | 642.329     | hex prisms                 | >500 dec               |                   |                            |                                     | s H <sub>2</sub> O                        |
| 33  | Aluminum hydride                        | AlH <sub>3</sub>                                                                 | 7784-21-6   | 30.006      | col hex cry                | >150 dec               |                   |                            |                                     | reac H <sub>2</sub> O                     |
| 34  | Aluminum hydroxide                      | Al(OH) <sub>3</sub>                                                              | 21645-51-2  | 78.004      | wh amorp powder            |                        |                   | 2.42                       |                                     | i H <sub>2</sub> O; s alk, acid           |
| 35  | Aluminum hydroxychloride                | Al <sub>2</sub> (OH) <sub>2</sub> Cl · 2H <sub>2</sub> O                         | 1327-41-9   | 210.483     | gl solid                   |                        |                   |                            |                                     | s H <sub>2</sub> O                        |
| 36  | Aluminum iodide                         | AlI <sub>3</sub>                                                                 | 7784-23-8   | 407.695     | wh leaflets                | 188.28                 | 382               | 3.98                       |                                     | reac H <sub>2</sub> O                     |
| 37  | Aluminum iodide hexahydrate             | AlI <sub>3</sub> · 6H <sub>2</sub> O                                             | 10090-53-6  | 515.786     | yel hyg cry powder         |                        |                   |                            |                                     | vs H <sub>2</sub> O; s EtOH, eth          |
| 38  | Aluminum lactate                        | Al(C <sub>3</sub> H <sub>5</sub> O <sub>3</sub> ) <sub>3</sub>                   | 18917-91-4  | 294.192     | powder                     |                        |                   |                            |                                     | vs H <sub>2</sub> O                       |
| 39  | Aluminum molybdate                      | Al <sub>2</sub> (MoO <sub>4</sub> ) <sub>3</sub>                                 | 15123-80-5  | 533.78      | wh pow                     | ≈950                   |                   |                            |                                     |                                           |
| 40  | Aluminum nitrate                        | Al(NO <sub>3</sub> ) <sub>3</sub>                                                | 13473-90-0  | 212.997     | wh hyg solid               | dec                    |                   |                            | 68.9 <sup>25</sup>                  | vs EtOH; sl ace                           |
| 41  | Aluminum nitrate nonahydrate            | Al(NO <sub>3</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                            | 7784-27-2   | 375.134     | wh hyg monocl cry          | 73                     | 135 dec           | 1.72                       | 68.9 <sup>25</sup>                  | vs EtOH; i pyr                            |
| 42  | Aluminum nitride                        | AlN                                                                              | 24304-00-5  | 40.989      | blue-wh hex cry            | 3000                   |                   | 3.255                      |                                     | reac H <sub>2</sub> O                     |
| 43  | Aluminum oleate                         | Al(C <sub>18</sub> H <sub>33</sub> O <sub>2</sub> ) <sub>3</sub>                 | 688-37-9    | 871.342     | yel solid                  |                        |                   |                            |                                     | i H <sub>2</sub> O; s EtOH, bz            |
| 44  | Aluminum oxalate monohydrate            | Al <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> · H <sub>2</sub> O | 814-87-9    | 336.035     | wh pow                     |                        |                   |                            |                                     | i H <sub>2</sub> O, EtOH; s acid          |
| 45  | Aluminum oxide (α)                      | Al <sub>2</sub> O <sub>3</sub>                                                   | 1344-28-1   | 101.961     | wh powder; hex             | 2054                   | 2977              | 3.99                       |                                     | i H <sub>2</sub> O, os; sl alk            |
| 46  | Aluminum oxide (γ)                      | Al <sub>2</sub> O <sub>3</sub>                                                   | 1344-28-1   | 101.961     | soft wh pow                | trans to corundum 1200 |                   | 3.97                       |                                     | i H <sub>2</sub> O; s acid; sl alk        |
| 47  | Aluminum oxyhydroxide (boehmite)        | AlO(OH)                                                                          | 1318-23-6   | 59.989      | wh orth cry                | trans to diasphore 227 |                   | 3.07                       |                                     | i H <sub>2</sub> O; s hot acid, alk       |
| 48  | Aluminum oxyhydroxide (diaspore)        | AlO(OH)                                                                          | 14457-84-2  | 59.989      | orth cry                   | dec 450                |                   | 3.38                       |                                     | i H <sub>2</sub> O; s acid, alk           |
| 49  | Aluminum palmitate                      | Al(C <sub>15</sub> H <sub>31</sub> COO) <sub>3</sub>                             | 555-35-1    | 793.230     | wh-yel powder              |                        |                   |                            |                                     | i H <sub>2</sub> O, EtOH; s peth          |
| 50  | Aluminum 2,4-pentanedioate              | Al(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub>                          | 13963-57-0  | 324.306     | pale yel prisms            | 194.6                  | 315               | 1.27                       |                                     | i H <sub>2</sub> O; s bz, EtOH; sl hex    |
| 51  | Aluminum perchlorate                    | Al(ClO <sub>4</sub> ) <sub>3</sub>                                               | 14452-39-2  | 325.334     | wh hyg cry                 |                        |                   |                            | 55 <sup>0</sup>                     | s H <sub>2</sub> O, eth; i ctc            |
| 52  | Aluminum perchlorate nonahydrate        | Al(ClO <sub>4</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                           | 14452-39-2  | 487.471     | wh hyg cry                 | 82 dec                 |                   | 2.0                        | 182.4 <sup>0</sup>                  |                                           |
| 53  | Aluminum phosphate                      | AlPO <sub>4</sub>                                                                | 7784-30-7   | 121.953     | wh rhomb plates            | >1460                  |                   | 2.56                       |                                     | i H <sub>2</sub> O; sl acid               |
| 54  | Aluminum phosphate dihydrate            | AlPO <sub>4</sub> · 2H <sub>2</sub> O                                            | 13477-75-3  | 157.984     | wh rhom cry                | dec 1500               |                   | 2.54                       |                                     | i H <sub>2</sub> O                        |
| 55  | Aluminum phosphate trihydroxide         | Al <sub>2</sub> (OH) <sub>3</sub> PO <sub>4</sub>                                | 12004-29-4  | 199.957     | wh or yel monocl cry       |                        |                   | 2.7                        |                                     |                                           |
| 56  | Aluminum metaphosphate                  | Al(PO <sub>3</sub> ) <sub>3</sub>                                                | 32823-06-6  | 263.898     | col powder; tetr           | ≈1525                  |                   | 2.78                       |                                     | i H <sub>2</sub> O                        |
| 57  | Aluminum hypophosphite                  | Al(H <sub>2</sub> PO <sub>2</sub> ) <sub>3</sub>                                 | 7784-22-7   | 221.948     | cry powder                 | 220 dec                |                   |                            |                                     | i H <sub>2</sub> O; s alk, acid           |
| 58  | Aluminum phosphide                      | AlP                                                                              | 20859-73-8  | 57.956      | grn or yel cub cry         | 2550                   |                   | 2.40                       |                                     | reac H <sub>2</sub> O                     |
| 59  | Aluminum selenide                       | Al <sub>2</sub> Se <sub>3</sub>                                                  | 1302-82-5   | 290.84      | yel-brown powder           | 960                    |                   | 3.437                      |                                     | reac H <sub>2</sub> O                     |
| 60  | Aluminum silicate (andalusite)          | Al <sub>2</sub> SiO <sub>5</sub>                                                 | 12183-80-1  | 162.046     | gray-grn cry               |                        |                   | 3.145                      |                                     |                                           |
| 61  | Aluminum silicate (kyanite)             | Al <sub>2</sub> SiO <sub>5</sub>                                                 | 1302-76-7   | 162.046     | blue or gray tricl cry     | dec 1000               |                   | 3.68                       |                                     |                                           |
| 62  | Aluminum silicate (mullite)             | 3Al <sub>2</sub> O <sub>3</sub> · 2SiO <sub>2</sub>                              | 1302-93-8   | 426.052     | col orth cry               | 1750                   |                   | 3.17                       |                                     | i H <sub>2</sub> O, acid, HF              |
| 63  | Aluminum silicate (sillimanite)         | Al <sub>2</sub> SiO <sub>5</sub>                                                 | 12141-45-6  | 162.046     | wh orth cry                | 1816                   |                   | 3.25                       |                                     |                                           |
| 64  | Aluminum silicate dihydrate             | Al <sub>2</sub> O <sub>3</sub> · 2SiO <sub>2</sub> · 2H <sub>2</sub> O           | 1332-58-7   | 258.161     | wh-yel powder; tricl       |                        |                   | 2.59                       |                                     | i H <sub>2</sub> O, acid, alk             |
| 65  | Aluminum stearate                       | Al(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>3</sub>                 | 637-12-7    | 877.390     | wh powder                  | 115                    |                   | 1.070                      |                                     | i H <sub>2</sub> O, EtOH, eth; s alk      |
| 66  | Aluminum monostearate                   | Al(OH)(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> )                          | 7047-84-9   | 344.467     | yel-wh pow                 | 155                    |                   | 1.02                       |                                     | i H <sub>2</sub> O                        |
| 67  | Aluminum distearate                     | Al(OH)(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>2</sub>             | 300-92-5    | 610.928     | wh pow                     | 145                    |                   |                            |                                     | i H <sub>2</sub> O                        |
| 68  | Aluminum sulfate                        | Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                  | 10043-01-3  | 342.151     | wh cry                     | 1040 dec               |                   |                            | 38.5 <sup>25</sup>                  | i EtOH                                    |
| 69  | Aluminum sulfate octadecahydrate        | Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 18H <sub>2</sub> O             | 7784-31-8   | 666.426     | col monocl cry             | 86 dec                 |                   | 1.69                       | 38.5 <sup>25</sup>                  |                                           |
| 70  | Aluminum sulfide                        | Al <sub>2</sub> S <sub>3</sub>                                                   | 1302-81-4   | 150.158     | yel-gray powder            | 1100                   |                   | 2.02                       |                                     |                                           |
| 71  | Aluminum telluride                      | Al <sub>2</sub> Te <sub>3</sub>                                                  | 12043-29-7  | 436.76      | gray-blk hex cry           | ≈895                   |                   | 4.5                        |                                     |                                           |

| No. | Name                                        | Formula                                                                               | CAS Reg No. | Mol. weight | Physical form            | mp/°C          | bp/°C  | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                   |
|-----|---------------------------------------------|---------------------------------------------------------------------------------------|-------------|-------------|--------------------------|----------------|--------|----------------------------|-------------------------------------|------------------------------------------|
| 72  | Aluminum thiocyanate                        | Al(SCN) <sub>3</sub>                                                                  | 538-17-0    | 201.229     | yel powder               |                |        |                            |                                     | s H <sub>2</sub> O; i EtOH, eth          |
| 73  | Aluminum titanate                           | Al <sub>2</sub> TiO <sub>5</sub>                                                      | 12004-39-6  | 181.827     | refrac solid             | 1860           |        |                            |                                     |                                          |
| 74  | Aluminum zirconium                          | Al <sub>2</sub> Zr                                                                    | 12004-50-1  | 145.187     | metallic solid           | 1645           |        |                            |                                     |                                          |
| 75  | Americium                                   | Am                                                                                    | 7440-35-9   | 243         | silv metal; hex or cub   | 1176           | 2011   | 12                         |                                     | s acid                                   |
| 76  | Americium(III) oxide                        | Am <sub>2</sub> O <sub>3</sub>                                                        | 12254-64-7  | 534         | tan hex cry              |                |        | 11.77                      |                                     | s acid                                   |
| 77  | Americium(III) bromide                      | AmBr <sub>3</sub>                                                                     | 14933-38-1  | 483         | wh orth cry              |                |        | 6.85                       |                                     | s H <sub>2</sub> O                       |
| 78  | Americium(III) chloride                     | AmCl <sub>3</sub>                                                                     | 13464-46-5  | 349         | pink hex cry             | 500            |        | 5.87                       |                                     |                                          |
| 79  | Americium(III) fluoride                     | AmF <sub>3</sub>                                                                      | 13708-80-0  | 300         | pink hex cry             | 1393           |        | 9.53                       |                                     |                                          |
| 80  | Americium(III) iodide                       | AmI <sub>3</sub>                                                                      | 13813-47-3  | 624         | yel ortho cry            | ≈950           |        | 6.9                        |                                     |                                          |
| 81  | Americium(IV) fluoride                      | AmF <sub>4</sub>                                                                      | 15947-41-8  | 319         | tan monocl cry           |                |        | 7.23                       |                                     |                                          |
| 82  | Americium(IV) oxide                         | AmO <sub>2</sub>                                                                      | 12005-67-3  | 275         | blk cub cry              | >1000 dec      |        | 11.68                      |                                     | s acid                                   |
| 83  | Ammonia                                     | NH <sub>3</sub>                                                                       | 7664-41-7   | 17.031      | col gas                  | -77.73         | -33.33 | 0.696 g/L                  |                                     | vs H <sub>2</sub> O; s EtOH, eth         |
| 84  | Ammonium acetate                            | NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                          | 631-61-8    | 77.083      | wh hyg cry               | 114            |        | 1.073                      | 148 <sup>4</sup>                    | s EtOH; sl ace                           |
| 85  | Ammonium azide                              | NH <sub>4</sub> N <sub>3</sub>                                                        | 12164-94-2  | 60.059      | orth cry; flam           | 160            | exp    | 1.346                      | 20.2 <sup>30</sup>                  |                                          |
| 86  | Ammonium benzoate                           | NH <sub>4</sub> C <sub>6</sub> H <sub>5</sub> O <sub>2</sub>                          | 1863-63-4   | 139.152     | wh cry or powder         | 198            |        | 1.26                       |                                     | s H <sub>2</sub> O; sl EtOH              |
| 87  | Ammonium bromate                            | NH <sub>4</sub> BrO <sub>3</sub>                                                      | 13843-59-9  | 145.941     | col hex cry              | exp            |        |                            |                                     | vs H <sub>2</sub> O                      |
| 88  | Ammonium bromide                            | NH <sub>4</sub> Br                                                                    | 12124-97-9  | 97.943      | wh hyg tetr cry          | 542 dec        | 396 sp | 2.429                      | 78.3 <sup>25</sup>                  | s EtOH, ace; sl eth                      |
| 89  | Ammonium caprylate                          | NH <sub>4</sub> C <sub>8</sub> H <sub>15</sub> O <sub>2</sub>                         | 5972-76-9   | 161.243     | hyg monocl cry           | ≈75            |        |                            |                                     | reac H <sub>2</sub> O; s EtOH; i chl, bz |
| 90  | Ammonium carbamate                          | NH <sub>4</sub> COONH <sub>2</sub>                                                    | 1111-78-0   | 78.071      | cry powder               |                |        |                            |                                     | vs H <sub>2</sub> O; s EtOH              |
| 91  | Ammonium carbonate                          | (NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>                                       | 506-87-6    | 96.086      | col cry powder           | 58 dec         |        |                            | 100 <sup>15</sup>                   |                                          |
| 92  | Ammonium chlorate                           | NH <sub>4</sub> ClO <sub>3</sub>                                                      | 10192-29-7  | 101.490     | wh cry                   | 102 exp        |        | 1.80                       | 28.7 <sup>9</sup>                   |                                          |
| 93  | Ammonium chloride                           | NH <sub>4</sub> Cl                                                                    | 12125-02-9  | 53.492      | col cub cry              | 520.1 tp (dec) | 338 sp | 1.519                      | 39.5 <sup>25</sup>                  |                                          |
| 94  | Ammonium chromate                           | (NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub>                                      | 7788-98-9   | 152.071     | yel cry                  | 185 dec        |        | 1.90                       | 37 <sup>25</sup>                    | sl ace, MeOH; i EtOH                     |
| 95  | Ammonium chromic sulfate dodecahydrate      | NH <sub>4</sub> Cr(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O                | 10022-47-6  | 478.343     | blue-viol cry            | 94 dec         |        | 1.72                       |                                     | s H <sub>2</sub> O; sl EtOH              |
| 96  | Ammonium cobalt(II) phosphate               | CoNH <sub>4</sub> PO <sub>4</sub>                                                     | 14590-13-7  | 171.943     | red-viol powder (hyd)    |                |        |                            |                                     | i H <sub>2</sub> O; s acid               |
| 97  | Ammonium cobalt(II) phosphate monohydrate   | CoNH <sub>4</sub> PO <sub>4</sub> · H <sub>2</sub> O                                  | 16827-96-6  | 189.959     | red-purp orth plates     | dec 450        |        |                            |                                     | s acid                                   |
| 98  | Ammonium cobalt(II) sulfate hexahydrate     | (NH <sub>4</sub> ) <sub>2</sub> Co(SO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O | 13586-38-4  | 395.227     | red monocl prisms        |                |        | 1.90                       |                                     | s H <sub>2</sub> O; i EtOH               |
| 99  | Ammonium copper(II) chloride                | CuCl <sub>2</sub> · 2NH <sub>4</sub> Cl                                               | 10060-13-6* | 241.435     | yel hyg orth cry         |                |        |                            |                                     | s H <sub>2</sub> O                       |
| 100 | Ammonium copper(II) chloride dihydrate      | CuCl <sub>2</sub> · 2NH <sub>4</sub> Cl · 2H <sub>2</sub> O                           | 10060-13-6  | 277.465     | blue-grn tetr cry        | 110 dec        |        | 1.993                      |                                     | s H <sub>2</sub> O, EtOH                 |
| 101 | Ammonium cyanide                            | NH <sub>4</sub> CN                                                                    | 12211-52-8  | 44.056      | col tetr cry             | dec            |        | 1.10                       |                                     | vs H <sub>2</sub> O                      |
| 102 | Ammonium dichromate                         | (NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>                        | 7789-09-5   | 252.065     | oran-red monocl cry; hyg | 180 dec        |        | 2.155                      | 35.6 <sup>20</sup>                  |                                          |
| 103 | Ammonium dihydrogen arsenate                | NH <sub>4</sub> H <sub>2</sub> AsO <sub>4</sub>                                       | 13462-93-6  | 158.975     | tetr cry                 | 300 dec        |        | 2.311                      | 52.7 <sup>25</sup>                  |                                          |
| 104 | Ammonium dihydrogen phosphate               | NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>                                        | 7722-76-1   | 115.026     | wh tetr cry              | 190            |        | 1.80                       | 40.4 <sup>25</sup>                  | sl EtOH; i ace                           |
| 105 | Ammonium <i>O,O</i> -diethyldithiophosphate | (C <sub>2</sub> H <sub>5</sub> O) <sub>2</sub> P(S)SNH <sub>4</sub>                   | 1068-22-0   | 203.264     | cry                      | 165            |        |                            |                                     |                                          |
| 106 | Ammonium dithiocarbamate                    | NH <sub>4</sub> NH <sub>2</sub> CSS                                                   | 513-74-6    | 110.202     | yel ortho cry            | 99 dec         |        | 1.45                       |                                     | s H <sub>2</sub> O                       |
| 107 | Ammonium ferricyanide trihydrate            | (NH <sub>4</sub> ) <sub>3</sub> Fe(CN) <sub>6</sub> · 3H <sub>2</sub> O               | 14221-48-8* | 320.110     | red cry                  |                |        |                            |                                     | s H <sub>2</sub> O; i EtOH               |
| 108 | Ammonium ferrocyanide trihydrate            | (NH <sub>4</sub> ) <sub>4</sub> Fe(CN) <sub>6</sub> · 3H <sub>2</sub> O               | 14481-29-9* | 338.149     | yel cry                  | dec            |        |                            |                                     | s H <sub>2</sub> O; i EtOH               |
| 109 | Ammonium fluoride                           | NH <sub>4</sub> F                                                                     | 12125-01-8  | 37.037      | wh hex cry; hyg          | 238            |        | 1.015                      | 83.5 <sup>25</sup>                  | sl EtOH                                  |
| 110 | Ammonium fluorosulfonate                    | NH <sub>4</sub> SO <sub>3</sub> F                                                     | 13446-08-7  | 117.100     | col needles              | 245            |        |                            |                                     | s H <sub>2</sub> O, EtOH, MeOH           |
| 111 | Ammonium formate                            | NH <sub>4</sub> CHO <sub>2</sub>                                                      | 540-69-2    | 63.057      | hyg cry                  | 116            |        | 1.27                       | 143 <sup>20</sup>                   | s EtOH                                   |
| 112 | Ammonium heptafluorotantalate               | (NH <sub>4</sub> ) <sub>7</sub> TaF <sub>7</sub>                                      | 12022-02-5  | 350.014     | hyg cry                  |                |        |                            |                                     |                                          |
| 113 | Ammonium hexabromoosmate(IV)                | (NH <sub>4</sub> ) <sub>2</sub> OsBr <sub>6</sub>                                     | 24598-62-7  | 705.73      | small blk cubes          |                |        |                            |                                     | sl H <sub>2</sub> O; s glycerol; i EtOH  |
| 114 | Ammonium hexabromoplatinate(IV)             | (NH <sub>4</sub> ) <sub>2</sub> PtBr <sub>6</sub>                                     | 17363-02-9  | 710.585     | powder                   | 145 dec        |        |                            | 0.59 <sup>20</sup>                  |                                          |
| 115 | Ammonium hexachloroiridate(III)             | (NH <sub>4</sub> ) <sub>3</sub> IrCl <sub>6</sub>                                     | 15752-05-3  | 459.050     | grn pow                  |                |        |                            |                                     |                                          |
| 116 | Ammonium hexachloroiridate(IV)              | (NH <sub>4</sub> ) <sub>3</sub> IrCl <sub>6</sub>                                     | 16940-92-4  | 441.012     | blk cry powder           | dec            |        | 2.856                      | 1.09 <sup>25</sup>                  |                                          |
| 117 | Ammonium hexachloroosmate(IV)               | (NH <sub>4</sub> ) <sub>2</sub> OsCl <sub>6</sub>                                     | 12125-08-5  | 439.03      | red cry or powder        |                | subl   | 2.93                       |                                     | s H <sub>2</sub> O, EtOH                 |
| 118 | Ammonium hexachloropalladate(IV)            | (NH <sub>4</sub> ) <sub>2</sub> PdCl <sub>6</sub>                                     | 19168-23-1  | 355.22      | red-brn hyg cry          | dec            |        | 2.418                      |                                     |                                          |
| 119 | Ammonium hexachloroplatinate(IV)            | (NH <sub>4</sub> ) <sub>2</sub> PtCl <sub>6</sub>                                     | 16919-58-7  | 443.879     | red-oran cub cry         | 380 dec        |        | 3.065                      | 0.5 <sup>20</sup>                   | i EtOH                                   |
| 120 | Ammonium hexachlororuthenate(IV)            | (NH <sub>4</sub> ) <sub>2</sub> RuCl <sub>6</sub>                                     | 18746-63-9  | 349.87      | red cry                  |                |        |                            |                                     |                                          |
| 121 | Ammonium hexafluoroaluminate                | (NH <sub>4</sub> ) <sub>3</sub> AlF <sub>6</sub>                                      | 7784-19-2   | 195.087     | cub cry                  |                |        | 1.78                       |                                     | s H <sub>2</sub> O                       |
| 122 | Ammonium hexafluorogallate                  | (NH <sub>4</sub> ) <sub>3</sub> GaF <sub>6</sub>                                      | 14639-94-2  | 237.828     | col cub cry              | >200 dec       |        | 2.10                       |                                     |                                          |
| 123 | Ammonium hexafluorogermanate                | (NH <sub>4</sub> ) <sub>3</sub> GeF <sub>6</sub>                                      | 16962-47-3  | 222.71      | wh cry                   | 380            | subl   | 2.564                      |                                     | s H <sub>2</sub> O; i EtOH               |
| 124 | Ammonium hexafluorophosphate                | NH <sub>4</sub> PF <sub>6</sub>                                                       | 16941-11-0  | 163.003     | wh cub cry               | 58 dec         |        | 2.180                      |                                     | vs H <sub>2</sub> O; s ace, EtOH, MeOH   |
| 125 | Ammonium hexafluorosilicate                 | (NH <sub>4</sub> ) <sub>2</sub> SiF <sub>6</sub>                                      | 16919-19-0  | 178.153     | wh cub or trig cry       | dec            |        | 2.011                      | 22.7 <sup>25</sup>                  | i EtOH, ace                              |
| 126 | Ammonium hexafluorotitanate                 | (NH <sub>4</sub> ) <sub>2</sub> TiF <sub>6</sub>                                      | 16962-40-6  | 197.934     | wh solid                 |                |        |                            |                                     | s H <sub>2</sub> O                       |

| No. | Name                                         | Formula                                                                                             | CAS Reg No. | Mol. weight | Physical form           | mp/°C    | bp/°C       | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                           |
|-----|----------------------------------------------|-----------------------------------------------------------------------------------------------------|-------------|-------------|-------------------------|----------|-------------|----------------------------|-------------------------------------|--------------------------------------------------|
| 127 | Ammonium hexafluorozirconate(IV)             | (NH <sub>4</sub> ) <sub>2</sub> ZrF <sub>6</sub>                                                    | 16919-31-6  | 241.291     | wh hex cry              |          |             | 1.154                      |                                     | s H <sub>2</sub> O                               |
| 128 | Ammonium hydrogen arsenate                   | (NH <sub>4</sub> ) <sub>2</sub> HAsO <sub>4</sub>                                                   | 7784-44-3   | 176.004     | wh powder               |          |             | 1.99                       |                                     | s H <sub>2</sub> O                               |
| 129 | Ammonium hydrogen carbonate                  | NH <sub>4</sub> HCO <sub>3</sub>                                                                    | 1066-33-7   | 79.056      | col or wh prisms        | 107 dec  |             | 1.586                      | 24.8 <sup>25</sup>                  | i EtOH, bz                                       |
| 130 | Ammonium hydrogen citrate                    | (NH <sub>4</sub> ) <sub>3</sub> HC <sub>6</sub> H <sub>5</sub> O <sub>7</sub>                       | 3012-65-5   | 226.184     | col cry                 |          |             | 1.48                       |                                     | vs H <sub>2</sub> O; sl EtOH                     |
| 131 | Ammonium hydrogen fluoride                   | NH <sub>4</sub> HF <sub>2</sub>                                                                     | 1341-49-7   | 57.044      | wh orth cry             | 125      | 240 dec     | 1.50                       | 60.2 <sup>20</sup>                  |                                                  |
| 132 | Ammonium hydrogen malate                     | NH <sub>4</sub> C <sub>4</sub> H <sub>5</sub> O <sub>5</sub>                                        | 5972-71-4   | 151.118     | orth cry                | 160      |             | 1.15                       |                                     | s H <sub>2</sub> O; sl EtOH                      |
| 133 | Ammonium hydrogen oxalate monohydrate        | NH <sub>4</sub> HC <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> O                                   | 5972-72-5*  | 125.081     | col rhomb cry           | dec      |             | 1.56                       |                                     | sl H <sub>2</sub> O, EtOH                        |
| 134 | Ammonium hydrogen phosphate                  | (NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>                                                    | 7783-28-0   | 132.055     | wh cry                  | 155 dec  |             | 1.619                      | 69.5 <sup>25</sup>                  | i EtOH, ace                                      |
| 135 | Ammonium hydrogen phosphite monohydrate      | (NH <sub>4</sub> ) <sub>2</sub> HPO <sub>3</sub> · H <sub>2</sub> O                                 | 51503-61-8  | 134.071     | hyg cry                 |          |             |                            |                                     | s H <sub>2</sub> O                               |
| 136 | Ammonium hydrogen selenate                   | NH <sub>4</sub> HSeO <sub>4</sub>                                                                   | 10294-60-7  | 162.01      | rhomb cry               | dec      |             | 2.162                      |                                     |                                                  |
| 137 | Ammonium hydrogen sulfate                    | NH <sub>4</sub> HSO <sub>4</sub>                                                                    | 7803-63-6   | 115.110     | wh hyg cry              | 147      |             | 1.78                       | 100 <sup>20</sup>                   | i EtOH, ace, py                                  |
| 138 | Ammonium hydrogen sulfide                    | NH <sub>4</sub> HS                                                                                  | 12124-99-1  | 51.112      | wh tetr or orth cry     | dec      |             | 1.17                       | 128 <sup>0</sup>                    | sl ace; i bz, eth                                |
| 139 | Ammonium hydrogen sulfite                    | NH <sub>4</sub> HSO <sub>3</sub>                                                                    | 10192-30-0  | 99.110      | col cry                 | dec      |             | 2.03                       | 71.8 <sup>0</sup>                   |                                                  |
| 140 | Ammonium hydrogen tartrate                   | NH <sub>4</sub> HC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                                       | 3095-65-6   | 167.117     | wh cry                  |          |             | 1.68                       |                                     | sl H <sub>2</sub> O; s alk; i EtOH               |
| 141 | Ammonium hydroxide                           | NH <sub>4</sub> OH                                                                                  | 1336-21-6   | 35.046      | exists only in soln     |          |             |                            |                                     |                                                  |
| 142 | Ammonium hypophosphite                       | NH <sub>4</sub> H <sub>2</sub> PO <sub>2</sub>                                                      | 7803-65-8   | 83.028      | wh hyg cry              | dec      |             |                            |                                     | vs H <sub>2</sub> O; sl EtOH; i ace              |
| 143 | Ammonium iodate                              | NH <sub>4</sub> IO <sub>3</sub>                                                                     | 13446-09-8  | 192.941     | wh powder               | 150      |             | 3.3                        | 3.84 <sup>25</sup>                  |                                                  |
| 144 | Ammonium iodide                              | NH <sub>4</sub> I                                                                                   | 12027-06-4  | 144.943     | wh tetr cry; hyg        | 551 dec  | 405 sp      | 2.514                      | 178 <sup>25</sup>                   | sl EtOH, MeOH                                    |
| 145 | Ammonium iron(II) sulfate hexahydrate        | (NH <sub>4</sub> ) <sub>2</sub> Fe(SO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O               | 7783-85-9   | 392.139     | blue-grn monocl cry     | ≈100 dec |             | 1.86                       |                                     | s H <sub>2</sub> O; i EtOH                       |
| 146 | Ammonium iron(III) chromate                  | NH <sub>4</sub> Fe(CrO <sub>4</sub> ) <sub>2</sub>                                                  | 7789-08-4   | 305.871     | red powder              |          |             |                            |                                     | i H <sub>2</sub> O                               |
| 147 | Ammonium iron(III) oxalate trihydrate        | (NH <sub>4</sub> ) <sub>3</sub> Fe(C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> · 3H <sub>2</sub> O | 13268-42-3  | 428.063     | grn monocl cry; hyg     | ≈160 dec |             | 1.780                      |                                     | vs H <sub>2</sub> O; i EtOH                      |
| 148 | Ammonium iron(III) sulfate dodecahydrate     | NH <sub>4</sub> Fe(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O                              | 7783-83-7   | 482.192     | col to viol cry         | ≈37      |             | 1.71                       |                                     | vs H <sub>2</sub> O; i EtOH                      |
| 149 | Ammonium lactate                             | NH <sub>4</sub> C <sub>3</sub> H <sub>5</sub> O <sub>3</sub>                                        | 52003-58-4  | 107.108     | col cry                 | 92       |             |                            |                                     | s H <sub>2</sub> O, EtOH; sl MeOH; i ace, eth    |
| 150 | Ammonium magnesium chloride hexahydrate      | NH <sub>4</sub> MgCl <sub>3</sub> · 6H <sub>2</sub> O                                               | 39733-35-2  | 256.794     | hyg cry                 | dec 100  |             | 1.46                       | 17 <sup>20</sup>                    | s H <sub>2</sub> O                               |
| 151 | Ammonium mercuric chloride dihydrate         | (NH <sub>4</sub> ) <sub>2</sub> HgCl <sub>4</sub> · 2H <sub>2</sub> O                               | 33445-15-7* | 414.51      | powder                  |          |             |                            |                                     | s H <sub>2</sub> O; sl EtOH                      |
| 152 | Ammonium metatungstate hexahydrate           | (NH <sub>4</sub> ) <sub>6</sub> W <sub>12</sub> O <sub>42</sub> · 6H <sub>2</sub> O                 | 12028-48-7  | 1887.19     | wh cry                  |          |             |                            |                                     | s H <sub>2</sub> O; i EtOH                       |
| 153 | Ammonium metavanadate                        | NH <sub>4</sub> VO <sub>3</sub>                                                                     | 7803-55-6   | 116.979     | wh-yel cry              | 200 dec  |             | 2.326                      | 4.8 <sup>20</sup>                   |                                                  |
| 154 | Ammonium molybdate(VI) tetrahydrate          | (NH <sub>4</sub> ) <sub>6</sub> Mo <sub>7</sub> O <sub>24</sub> · 4H <sub>2</sub> O                 | 12054-85-2  | 1235.86     | col or grn-yel cry      | 90 dec   |             | 2.498                      | 43                                  | i EtOH                                           |
| 155 | Ammonium dimolybdate                         | (NH <sub>4</sub> ) <sub>2</sub> Mo <sub>2</sub> O <sub>7</sub>                                      | 27546-07-2  | 339.95      | cry                     |          |             |                            |                                     | s H <sub>2</sub> O                               |
| 156 | Ammonium molybdophosphate                    | (NH <sub>4</sub> ) <sub>3</sub> PO <sub>4</sub> · 12MoO <sub>3</sub>                                | 12026-66-3  | 1876.35     | grn or yel cry          | dec      |             |                            | 0.02 <sup>20</sup>                  | sl H <sub>2</sub> O; s alk                       |
| 157 | Ammonium nitrate                             | NH <sub>4</sub> NO <sub>3</sub>                                                                     | 6484-52-2   | 80.043      | wh hyg cry; orth        | 169.7    | dec 200-260 | 1.72                       | 213 <sup>25</sup>                   | sl MeOH                                          |
| 158 | Ammonium nitrite                             | NH <sub>4</sub> NO <sub>2</sub>                                                                     | 13446-48-5  | 64.044      | wh-yel cry              | 60 exp   |             | 1.69                       | 221 <sup>25</sup>                   | i eth                                            |
| 159 | Ammonium nitroferricyanide                   | (NH <sub>4</sub> ) <sub>5</sub> Fe(CN) <sub>5</sub> NO                                              | 14402-70-1  | 252.016     | red-brn cry             |          |             |                            |                                     | s H <sub>2</sub> O, EtOH                         |
| 160 | Ammonium oleate                              | NH <sub>4</sub> C <sub>18</sub> H <sub>33</sub> O <sub>2</sub>                                      | 544-60-5    | 299.493     | yel-brn paste           | 21       |             |                            |                                     | s H <sub>2</sub> O; sl ace                       |
| 161 | Ammonium oxalate                             | (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                                       | 1113-38-8   | 124.096     | col sol                 |          |             | 1.5                        | 5.20 <sup>25</sup>                  |                                                  |
| 162 | Ammonium oxalate monohydrate                 | (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> O                    | 6009-70-7   | 142.110     | wh orth cry             | dec      |             | 1.50                       | 5.20 <sup>25</sup>                  | sl EtOH                                          |
| 163 | Ammonium palmitate                           | NH <sub>4</sub> C <sub>15</sub> H <sub>31</sub> CO <sub>2</sub>                                     | 593-26-0    | 273.455     | yel-wh powder           | 22       |             |                            |                                     | s H <sub>2</sub> O; sl bz, xyl; i ace, EtOH, etc |
| 164 | Ammonium pentaborate tetrahydrate            | NH <sub>4</sub> B <sub>5</sub> O <sub>8</sub> · 4H <sub>2</sub> O                                   | 12007-89-5  | 272.150     | wh cry                  |          |             |                            | 7.03 <sup>18</sup>                  |                                                  |
| 165 | Ammonium pentachlororhodate(III) monohydrate | (NH <sub>4</sub> ) <sub>2</sub> RhCl <sub>5</sub> · H <sub>2</sub> O                                | 63771-33-5  | 334.262     | red cry                 | dec 210  |             |                            |                                     |                                                  |
| 166 | Ammonium pentachlorozincate                  | (NH <sub>4</sub> ) <sub>2</sub> ZnCl <sub>5</sub>                                                   | 14639-98-6  | 296.789     | hyg orth cry            |          |             | 1.81                       |                                     | vs H <sub>2</sub> O                              |
| 167 | Ammonium perchlorate                         | NH <sub>4</sub> ClO <sub>4</sub>                                                                    | 7790-98-9   | 117.490     | wh orth cry             | dec, exp |             | 1.95                       | 24.5 <sup>25</sup>                  | s MeOH; sl EtOH, ace; i eth                      |
| 168 | Ammonium permanganate                        | NH <sub>4</sub> MnO <sub>4</sub>                                                                    | 13446-10-1  | 136.975     | purp rhomb cry          | 70 dec   |             | 2.22                       | 7.9 <sup>15</sup>                   |                                                  |
| 169 | Ammonium peroxydisulfate                     | (NH <sub>4</sub> ) <sub>2</sub> S <sub>2</sub> O <sub>8</sub>                                       | 7727-54-0   | 228.202     | monocl cry or wh powder | dec      |             | 1.982                      | 83.5 <sup>25</sup>                  |                                                  |
| 170 | Ammonium perrhenate                          | NH <sub>4</sub> ReO <sub>4</sub>                                                                    | 13598-65-7  | 268.244     | col powder              |          |             | 3.97                       | 6.23 <sup>20</sup>                  |                                                  |
| 171 | Ammonium phosphate trihydrate                | (NH <sub>4</sub> ) <sub>3</sub> PO <sub>4</sub> · 3H <sub>2</sub> O                                 | 10361-65-6* | 203.133     | wh prisms               |          |             |                            | 25.0 <sup>25</sup>                  | i ace                                            |
| 172 | Ammonium phosphomolybdate monohydrate        | (NH <sub>4</sub> ) <sub>3</sub> PO <sub>4</sub> · 12MoO <sub>3</sub> · H <sub>2</sub> O             | 54723-94-3  | 1894.36     | yel cry or powder       | dec      |             |                            | 0.02                                |                                                  |
| 173 | Ammonium phosphotungstate dihydrate          | (NH <sub>4</sub> ) <sub>3</sub> PO <sub>4</sub> · 12WO <sub>3</sub> · 2H <sub>2</sub> O             | 1311-90-6   | 2967.18     | cry powder              |          |             |                            |                                     | sl H <sub>2</sub> O                              |
| 174 | Ammonium picrate                             | NH <sub>4</sub> C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>7</sub>                         | 131-74-8    | 246.135     | yel orth cry            | exp      |             | 1.72                       |                                     | sl H <sub>2</sub> O                              |
| 175 | Ammonium polysulfide                         | (NH <sub>4</sub> ) <sub>2</sub> S <sub>x</sub>                                                      | 9080-17-5   |             | yel unstab soln         |          |             |                            |                                     | reac acids                                       |
| 176 | Ammonium salicylate                          | NH <sub>4</sub> C <sub>7</sub> H <sub>5</sub> O <sub>3</sub>                                        | 528-94-9    | 155.151     | wh cry powder           |          |             |                            |                                     | vs H <sub>2</sub> O; s EtOH                      |

| No. | Name                                                     | Formula                                                                                             | CAS Reg No. | Mol. weight | Physical form              | mp/°C        | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                       |
|-----|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-------------|-------------|----------------------------|--------------|---------|----------------------------|-------------------------------------|----------------------------------------------|
| 177 | Ammonium selenate                                        | (NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub>                                                    | 7783-21-3   | 179.04      | wh monocl cry              | dec          |         | 2.194                      | 117 <sup>25</sup>                   | i EtOH, ace                                  |
| 178 | Ammonium selenite                                        | (NH <sub>4</sub> ) <sub>2</sub> SeO <sub>3</sub>                                                    | 7783-19-9   | 163.04      | wh or red hyg cry          | dec          |         |                            | 121 <sup>25</sup>                   |                                              |
| 179 | Ammonium stearate                                        | NH <sub>4</sub> C <sub>18</sub> H <sub>35</sub> O <sub>2</sub>                                      | 1002-89-7   | 301.509     | yel-wh powder              | 22           |         | 0.89                       |                                     | sl H <sub>2</sub> O, bz; s EtOH, MeOH; i ace |
| 180 | Ammonium sulfamate                                       | NH <sub>4</sub> NH <sub>2</sub> SO <sub>3</sub>                                                     | 7773-06-0   | 114.124     | wh hyg cry                 | 131          | 160 dec |                            |                                     | vs H <sub>2</sub> O; sl EtOH                 |
| 181 | Ammonium sulfate                                         | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>                                                     | 7783-20-2   | 132.140     | wh or brn orth cry         | 280 dec      |         | 1.77                       | 76.4 <sup>25</sup>                  | i EtOH, ace                                  |
| 182 | Ammonium sulfide                                         | (NH <sub>4</sub> ) <sub>2</sub> S                                                                   | 12135-76-1  | 68.142      | yel-oran cry               | ≈0 dec       |         |                            |                                     | s H <sub>2</sub> O, EtOH, alk                |
| 183 | Ammonium sulfite                                         | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>3</sub>                                                     | 17026-44-7  | 116.140     | wh hyg cry                 |              |         |                            | 64.2 <sup>25</sup>                  |                                              |
| 184 | Ammonium sulfite monohydrate                             | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>3</sub> · H <sub>2</sub> O                                  | 7783-11-1   | 134.155     | col cry                    | dec          |         | 1.41                       | 64.2 <sup>25</sup>                  | i EtOH, ace                                  |
| 185 | Ammonium tartrate                                        | (NH <sub>4</sub> ) <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                        | 3164-29-2   | 184.147     | wh cry                     | dec          |         | 1.601                      |                                     | s H <sub>2</sub> O                           |
| 186 | Ammonium tellurate                                       | (NH <sub>4</sub> ) <sub>2</sub> TeO <sub>4</sub>                                                    | 13453-06-0  | 227.68      | wh powder                  | dec          |         | 3.024                      |                                     |                                              |
| 187 | Ammonium tetraborate tetrahydrate                        | (NH <sub>4</sub> ) <sub>2</sub> B <sub>4</sub> O <sub>7</sub> · 4H <sub>2</sub> O                   | 12228-87-4  | 263.377     | wh tetr cry                | dec 87       |         |                            |                                     | vs H <sub>2</sub> O; s HNO <sub>3</sub>      |
| 188 | Ammonium tetrachloroaluminate                            | NH <sub>4</sub> AlCl <sub>4</sub>                                                                   | 7784-14-7   | 186.833     | wh hyg solid               | 304          |         |                            |                                     | s H <sub>2</sub> O, eth                      |
| 189 | Ammonium tetrachloropalladate(II)                        | (NH <sub>4</sub> ) <sub>2</sub> PdCl <sub>4</sub>                                                   | 13820-40-1  | 284.31      | grn cry or red-brn pow     |              |         |                            |                                     | s H <sub>2</sub> O                           |
| 190 | Ammonium tetrachloroplatinate(II)                        | (NH <sub>4</sub> ) <sub>2</sub> PtCl <sub>4</sub>                                                   | 13820-41-2  | 372.973     | red cry                    | dec          |         | 2.936                      |                                     | s H <sub>2</sub> O; i EtOH                   |
| 191 | Ammonium tetrachlorozincate                              | (NH <sub>4</sub> ) <sub>2</sub> ZnCl <sub>4</sub>                                                   | 14639-97-5  | 243.298     | wh orth plates; hyg        | 150 dec      |         | 1.879                      |                                     | vs H <sub>2</sub> O                          |
| 192 | Ammonium tetrafluoroantimonate                           | NH <sub>4</sub> SbF <sub>4</sub>                                                                    | 14972-90-8  | 215.793     | col cry                    |              |         |                            |                                     | s H <sub>2</sub> O                           |
| 193 | Ammonium tetrafluoroborate                               | NH <sub>4</sub> BF <sub>4</sub>                                                                     | 13826-83-0  | 104.844     | wh powder; orth            | 487 dec      |         | 1.871                      | 25 <sup>20</sup>                    |                                              |
| 194 | Ammonium tetrathiocyanodiammonochromate(III) monohydrate | NH <sub>4</sub> [Cr(NH <sub>2</sub> ) <sub>2</sub> (SCN) <sub>4</sub> ] · H <sub>2</sub> O          | 13573-16-5  | 354.440     | red cry                    | 270 dec      |         |                            |                                     | s H <sub>2</sub> O, EtOH, ace; i bz          |
| 195 | Ammonium tetrathiomolybdate                              | (NH <sub>4</sub> ) <sub>2</sub> MoS <sub>4</sub>                                                    | 15060-55-6  | 260.28      | red cry                    | 100 dec      |         |                            |                                     | vs H <sub>2</sub> O                          |
| 196 | Ammonium tetrathiotungstate                              | (NH <sub>4</sub> ) <sub>2</sub> WS <sub>4</sub>                                                     | 13862-78-7  | 348.18      | oran cry                   | dec          |         | 2.71                       |                                     | s H <sub>2</sub> O                           |
| 197 | Ammonium tetrathiovanadate                               | (NH <sub>4</sub> ) <sub>2</sub> VS <sub>4</sub>                                                     | 14693-56-2  | 233.317     | dark viol cry              |              |         |                            |                                     |                                              |
| 198 | Ammonium thiocyanate                                     | NH <sub>4</sub> SCN                                                                                 | 1762-95-4   | 76.121      | col hyg cry                | ≈149         | dec     | 1.30                       | 181 <sup>25</sup>                   | vs EtOH; s ace; i chl                        |
| 199 | Ammonium thiosulfate                                     | (NH <sub>4</sub> ) <sub>2</sub> S <sub>2</sub> O <sub>3</sub>                                       | 7783-18-8   | 148.205     | wh cry                     | 150 dec      |         | 1.678                      |                                     | vs H <sub>2</sub> O; i EtOH, eth             |
| 200 | Ammonium titanium oxalate monohydrate                    | (NH <sub>4</sub> ) <sub>2</sub> TiO(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> · H <sub>2</sub> O | 10580-03-7  | 293.996     | hyg cry                    |              |         |                            |                                     | vs H <sub>2</sub> O                          |
| 201 | Ammonium tungstate(VI)                                   | (NH <sub>4</sub> ) <sub>10</sub> W <sub>12</sub> O <sub>41</sub>                                    | 11120-25-5  | 3042.44     | cry powder                 |              |         | 2.3                        |                                     | s H <sub>2</sub> O; i EtOH                   |
| 202 | Ammonium tungstate(VI) pentahydrate                      | (NH <sub>4</sub> ) <sub>10</sub> W <sub>12</sub> O <sub>41</sub> · 5H <sub>2</sub> O                | 1311-93-9   | 3132.52     | cry pow or plates          |              |         | 2.3                        |                                     | vs H <sub>2</sub> O; i EtOH                  |
| 203 | Ammonium uranate(VI)                                     | (NH <sub>4</sub> ) <sub>2</sub> U <sub>2</sub> O <sub>7</sub>                                       | 7783-22-4   | 624.131     | red-yel amorp powder       |              |         |                            |                                     | i H <sub>2</sub> O, alk; s acid              |
| 204 | Ammonium uranium fluoride                                | UO <sub>2</sub> (NH <sub>4</sub> ) <sub>3</sub> F <sub>5</sub>                                      | 18433-40-4  | 419.135     | grn-yel monocl cry         |              |         |                            |                                     | s H <sub>2</sub> O; i EtOH                   |
| 205 | Ammonium valerate                                        | NH <sub>4</sub> C <sub>4</sub> H <sub>9</sub> CO <sub>2</sub>                                       | 42739-38-8  | 119.163     | hyg cry                    | 108          |         |                            |                                     | vs H <sub>2</sub> O, EtOH; s eth             |
| 206 | Antimony (gray)                                          | Sb                                                                                                  | 7440-36-0   | 121.760     | silv metal; hex            | 630.628      | 1587    | 6.68                       |                                     | i dil acid                                   |
| 207 | Antimony (black)                                         | Sb                                                                                                  | 7440-36-0   | 121.760     | blk amorp solid            | trans gray 0 |         |                            |                                     |                                              |
| 208 | Stibine                                                  | SbH <sub>3</sub>                                                                                    | 7803-52-3   | 124.784     | col gas; flam              | -88          | -17     | 5.100 g/L                  |                                     | sl H <sub>2</sub> O; s EtOH                  |
| 209 | Trimethylstibine                                         | Sb(CH <sub>3</sub> ) <sub>3</sub>                                                                   | 594-10-5    | 166.863     | col flam liq               | -62          | 81      | 1.52                       |                                     |                                              |
| 210 | Pentamethylstibine                                       | Sb(CH <sub>3</sub> ) <sub>5</sub>                                                                   | 15120-50-0  | 196.933     | col hyg liq                | -19          | 127     |                            |                                     | reac H <sub>2</sub> O                        |
| 211 | Tetramethyldistibine                                     | [Sb(CH <sub>3</sub> ) <sub>2</sub> ] <sub>2</sub>                                                   | 41422-43-9  | 303.658     | yel flam liq or red solid  | 17           |         |                            |                                     |                                              |
| 212 | Antimony arsenide                                        | SbAs                                                                                                | 12322-34-8  | 196.682     | hex cry                    | ≈680         |         | 6.0                        |                                     |                                              |
| 213 | Antimony potassium tartrate trihydrate                   | K <sub>2</sub> (SbC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ) <sub>2</sub> · 3H <sub>2</sub> O   | 28300-74-5  | 667.873     | col cry                    |              |         | 2.6                        |                                     | sl H <sub>2</sub> O                          |
| 214 | Antimony(III) acetate                                    | Sb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub>                                      | 3643-76-3   | 298.891     | wh pow                     |              |         |                            |                                     |                                              |
| 215 | Antimony(III) bromide                                    | SbBr <sub>3</sub>                                                                                   | 7789-61-9   | 361.472     | yel orth cry; hyg          | 97           | 288     | 4.35                       |                                     | reac H <sub>2</sub> O; s ace, bz, chl        |
| 216 | Antimony(III) chloride                                   | SbCl <sub>3</sub>                                                                                   | 10025-91-9  | 228.119     | col orth cry; hyg          | 73.4         | 220.3   | 3.14                       | 987 <sup>25</sup>                   | s acid, EtOH, bz, ace                        |
| 217 | Antimony(III) fluoride                                   | SbF <sub>3</sub>                                                                                    | 7783-56-4   | 178.755     | wh orth cry; hyg           | 287          | 376     | 4.38                       | 492 <sup>25</sup>                   |                                              |
| 218 | Antimony(III) iodide                                     | SbI <sub>3</sub>                                                                                    | 7790-44-5   | 502.473     | red rhomb cry              | 171          | 400     | 4.92                       |                                     | reac H <sub>2</sub> O; s EtOH, ace; i ctc    |
| 219 | Antimony(III) iodide sulfide                             | SbI <sub>2</sub> S                                                                                  | 13816-38-1  | 280.729     | dark red prisms or needles | 400          |         |                            |                                     |                                              |
| 220 | Antimony(III) oxide (senarmontite)                       | Sb <sub>2</sub> O <sub>3</sub>                                                                      | 1309-64-4   | 291.518     | col cub cry                | 570 trans    | 1425    | 5.58                       |                                     | sl H <sub>2</sub> O; i os                    |
| 221 | Antimony(III) oxide (valentinite)                        | Sb <sub>2</sub> O <sub>3</sub>                                                                      | 1309-64-4   | 291.518     | wh orth cry                | 655          | 1425    | 5.7                        |                                     | sl H <sub>2</sub> O; i os                    |
| 222 | Antimony(III) oxychloride                                | SbOCl                                                                                               | 7791-08-4   | 173.212     | wh momo cry                | 170 dec      |         |                            |                                     | reac H <sub>2</sub> O; i EtOH, eth           |
| 223 | Antimony(III) phosphate                                  | SbPO <sub>4</sub>                                                                                   | 12036-46-3  | 216.731     | cry pow                    |              |         |                            |                                     | reac H <sub>2</sub> O                        |
| 224 | Antimony(III) potassium oxalate trihydrate               | K <sub>3</sub> Sb(C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> · 3H <sub>2</sub> O                  | 5965-33-3*  | 557.158     | cry pow                    |              |         |                            |                                     | s H <sub>2</sub> O                           |
| 225 | Antimony(III) selenide                                   | Sb <sub>2</sub> Se <sub>3</sub>                                                                     | 1315-05-5   | 480.40      | grn orth cry               | 611          |         | 5.81                       |                                     | sl H <sub>2</sub> O                          |
| 226 | Antimony(III) sulfate                                    | Sb <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                                     | 7446-32-4   | 531.708     | wh cry powder; hyg         | dec          |         | 3.62                       |                                     | sl H <sub>2</sub> O                          |
| 227 | Antimony(III) sulfide                                    | Sb <sub>2</sub> S <sub>3</sub>                                                                      | 1345-04-6   | 339.715     | gray-blk orth cry          | 550          |         | 4.562                      |                                     | i H <sub>2</sub> O; s conc HCl               |
| 228 | Antimony(III) telluride                                  | Sb <sub>2</sub> Te <sub>3</sub>                                                                     | 1327-50-0   | 626.32      | gray cry                   | 620          |         | 6.5                        |                                     |                                              |

| No. | Name                            | Formula                                                                           | CAS Reg No. | Mol. weight | Physical form            | mp/°C                       | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                       |
|-----|---------------------------------|-----------------------------------------------------------------------------------|-------------|-------------|--------------------------|-----------------------------|----------|----------------------------|-------------------------------------|----------------------------------------------|
| 229 | Antimony(III,V) oxide           | Sb <sub>2</sub> O <sub>4</sub>                                                    | 1332-81-6   | 307.518     | yel orth cry             |                             |          | 6.64                       |                                     |                                              |
| 230 | Antimony(V) chloride            | SbCl <sub>5</sub>                                                                 | 7647-18-9   | 299.025     | col or yel liq           | 4                           | 140 dec  | 2.34                       |                                     | reac H <sub>2</sub> O; s chl, ctc            |
| 231 | Antimony(V) fluoride            | SbF <sub>5</sub>                                                                  | 7783-70-2   | 216.752     | hyg visc liq             | 8.3                         | 141      | 3.10                       |                                     | reac H <sub>2</sub> O                        |
| 232 | Antimony(V) dichlorotrifluoride | SbCl <sub>2</sub> F <sub>3</sub>                                                  | 7791-16-4   | 249.661     | visc liq                 |                             |          |                            |                                     | reac H <sub>2</sub> O                        |
| 233 | Antimony(V) oxide               | Sb <sub>2</sub> O <sub>3</sub>                                                    | 1314-60-9   | 323.517     | yel powder; cub          | dec                         |          | 3.78                       | 0.3 <sup>20</sup>                   |                                              |
| 234 | Antimony(V) sulfide             | Sb <sub>2</sub> S <sub>3</sub>                                                    | 1315-04-4   | 403.845     | oran-yel powder          | 75 dec                      |          | 4.120                      |                                     | i H <sub>2</sub> O; s acid, alk              |
| 235 | Argon                           | Ar                                                                                | 7440-37-1   | 39.948      | col gas                  | -189.36 tp (69 kPa)         | -185.847 | 1.633 g/L                  |                                     | sl H <sub>2</sub> O                          |
| 236 | Arsenic (gray)                  | As                                                                                | 7440-38-2   | 74.922      | gray metal; rhomb        | 817 tp (3.70 MPa)           | 616 sp   | 5.75                       |                                     | i H <sub>2</sub> O                           |
| 237 | Arsenic (black)                 | As                                                                                | 7440-38-2   | 74.922      | blk amorp solid          | trans gray As 270           |          | 4.9                        |                                     |                                              |
| 238 | Arsenic (yellow)                | As                                                                                | 7440-38-2   | 74.922      | soft yel cub cry         | trans gray As 358           |          | 1.97                       |                                     | s CS <sub>2</sub>                            |
| 239 | Arsine                          | AsH <sub>3</sub>                                                                  | 7784-42-1   | 77.946      | col gas                  | -116                        | -62.5    | 3.186 g/L                  |                                     | sl H <sub>2</sub> O                          |
| 240 | Diarsine                        | As <sub>2</sub> H <sub>4</sub>                                                    | 15942-63-9  | 153.875     | unstab liq               |                             | ≈100     |                            |                                     |                                              |
| 241 | Arsenic acid                    | H <sub>3</sub> AsO <sub>4</sub>                                                   | 7778-39-4   | 141.944     | exists only in soln      |                             |          |                            |                                     |                                              |
| 242 | Arsenic acid hemihydrate        | H <sub>3</sub> AsO <sub>4</sub> · 0.5H <sub>2</sub> O                             | 7778-39-4*  | 150.951     | wh hyg cry               | 36.1                        |          | 2.5                        |                                     | vs H <sub>2</sub> O, EtOH                    |
| 243 | Arsenious acid                  | H <sub>3</sub> AsO <sub>3</sub>                                                   | 13464-58-9  | 125.944     | exists only in soln      |                             |          |                            |                                     |                                              |
| 244 | Arsenic diiodide                | As <sub>2</sub> I <sub>4</sub>                                                    | 13770-56-4  | 657.461     | red cry                  | 137                         |          |                            |                                     | reac H <sub>2</sub> O; s os                  |
| 245 | Arsenic hemiselenide            | As <sub>2</sub> Se                                                                | 1303-35-1   | 228.80      | blk cry                  |                             |          |                            |                                     | i H <sub>2</sub> O, os; dec acid, alk        |
| 246 | Arsenic sulfide                 | As <sub>2</sub> S <sub>4</sub>                                                    | 12279-90-2  | 427.946     | red monoc cry            | 320                         | 565      | 3.5                        |                                     | i H <sub>2</sub> O; sl bz; s alk             |
| 247 | Arsenic(III) bromide            | AsBr <sub>3</sub>                                                                 | 7784-33-0   | 314.634     | col or yel orth cry; hyg | 31.1                        | 221      | 3.40                       |                                     | reac H <sub>2</sub> O; s hc, ctc; vs eth, bz |
| 248 | Arsenic(III) chloride           | AsCl <sub>3</sub>                                                                 | 7784-34-1   | 181.281     | col liq                  | -16                         | 130      | 2.150                      |                                     | reac H <sub>2</sub> O; s chl, ctc, eth       |
| 249 | Arsenic(III) ethoxide           | As(C <sub>2</sub> H <sub>5</sub> O) <sub>3</sub>                                  | 3141-12-6   | 210.103     | liq                      |                             | 166      | 1.21                       |                                     |                                              |
| 250 | Arsenic(III) fluoride           | AsF <sub>3</sub>                                                                  | 7784-35-2   | 131.917     | col liq                  | -5.9                        | 57.13    | 2.7                        |                                     | reac H <sub>2</sub> O; s EtOH, eth, bz       |
| 251 | Arsenic(III) iodide             | AsI <sub>3</sub>                                                                  | 7784-45-4   | 455.635     | red hex cry              | 141                         | 424      | 4.73                       |                                     | sl H <sub>2</sub> O, EtOH, eth; s bz, tol    |
| 252 | Arsenic(III) oxide (arsenolite) | As <sub>2</sub> O <sub>3</sub>                                                    | 1327-53-3   | 197.841     | wh cub cry               | 274                         | 460      | 3.86                       | 2.05 <sup>25</sup>                  |                                              |
| 253 | Arsenic(III) oxide (claudetite) | As <sub>2</sub> O <sub>3</sub>                                                    | 1327-53-3   | 197.841     | wh monoc cry             | 314                         | 460      | 3.74                       | 2.05 <sup>25</sup>                  | s dil acid, alk; i EtOH                      |
| 254 | Arsenic(III) selenide           | As <sub>2</sub> Se <sub>3</sub>                                                   | 1303-36-2   | 386.72      | brn-blk solid            | 260                         |          | 4.75                       |                                     | i H <sub>2</sub> O; s alk                    |
| 255 | Arsenic(III) sulfide            | As <sub>2</sub> S <sub>3</sub>                                                    | 1303-33-9   | 246.038     | yel-oran monoc cry       | 312                         | 707      | 3.46                       |                                     | i H <sub>2</sub> O; s alk                    |
| 256 | Arsenic(III) telluride          | As <sub>2</sub> Te <sub>3</sub>                                                   | 12044-54-1  | 532.64      | blk monoc cry            | 621                         |          | 6.50                       |                                     |                                              |
| 257 | Arsenic(V) chloride             | AsCl <sub>5</sub>                                                                 | 22441-45-8  | 252.187     | stab at low temp         | ≈-50 dec                    |          |                            |                                     |                                              |
| 258 | Arsenic(V) fluoride             | AsF <sub>5</sub>                                                                  | 7784-36-3   | 169.914     | col gas                  | -79.8                       | -52.8    | 6.945 g/L                  |                                     | reac H <sub>2</sub> O; s EtOH, bz, eth       |
| 259 | Arsenic(V) oxide                | As <sub>2</sub> O <sub>5</sub>                                                    | 1303-28-2   | 229.840     | wh amorp powder          | 315                         |          | 4.32                       | 65.8 <sup>20</sup>                  | vs EtOH                                      |
| 260 | Arsenic(V) selenide             | As <sub>2</sub> Se <sub>5</sub>                                                   | 1303-37-3   | 544.64      | blk solid                | dec                         |          |                            |                                     | i H <sub>2</sub> O, EtOH, eth; s alk         |
| 261 | Arsenic(V) sulfide              | As <sub>2</sub> S <sub>5</sub>                                                    | 1303-34-0   | 310.168     | brn-yel amorp solid      | dec                         |          |                            |                                     | i H <sub>2</sub> O; s alk                    |
| 262 | Astatine                        | At                                                                                | 7440-68-8   | 210         | cry                      | 302                         |          |                            |                                     | s HNO <sub>3</sub> , os                      |
| 263 | Barium                          | Ba                                                                                | 7440-39-3   | 137.327     | silv-yel metal; cub      | 727                         | 1897     | 3.62                       |                                     | reac H <sub>2</sub> O; sl EtOH               |
| 264 | Barium acetate                  | Ba(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                    | 543-80-6    | 255.416     | wh powder                |                             |          | 2.47                       | 79.2 <sup>25</sup>                  |                                              |
| 265 | Barium acetate monohydrate      | Ba(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O | 5908-64-5   | 273.431     | wh cry                   | 110 dec                     |          | 2.19                       | 79.2 <sup>25</sup>                  | sl EtOH                                      |
| 266 | Barium aluminate                | BaAl <sub>2</sub> O <sub>4</sub>                                                  | 12004-04-5  | 255.288     | hex cry                  | 1827                        |          |                            |                                     |                                              |
| 267 | Barium aluminide                | BaAl <sub>2</sub>                                                                 | 12672-79-6  | 245.253     | metallic solid           | 1097                        |          |                            |                                     |                                              |
| 268 | Barium azide                    | Ba(N <sub>3</sub> ) <sub>2</sub>                                                  | 18810-58-7  | 221.367     | monoc cry; exp           | ≈120 dec                    |          | 2.936                      | 17.3 <sup>20</sup>                  | sl EtOH; i eth                               |
| 269 | Barium bismuthate               | BaBiO <sub>3</sub>                                                                | 12785-50-1  | 394.305     | bronze cry               | 1040 dec                    |          |                            |                                     |                                              |
| 270 | Barium bromate                  | Ba(BrO <sub>3</sub> ) <sub>2</sub>                                                | 13967-90-3  | 393.131     | col monoc cry            |                             |          |                            | 0.79 <sup>25</sup>                  | s ace                                        |
| 271 | Barium bromate monohydrate      | Ba(BrO <sub>3</sub> ) <sub>2</sub> · H <sub>2</sub> O                             | 10326-26-8  | 411.147     | wh monoc cry             | 260 dec                     |          | 3.99                       | 0.831 <sup>25</sup>                 | i EtOH                                       |
| 272 | Barium bromide                  | BaBr <sub>2</sub>                                                                 | 10553-31-8  | 297.135     | wh orth cry              | 857                         | 1835     | 4.781                      | 100 <sup>25</sup>                   |                                              |
| 273 | Barium bromide dihydrate        | BaBr <sub>2</sub> · 2H <sub>2</sub> O                                             | 7791-28-8   | 333.166     | wh cry                   | 75 dec                      |          | 3.7                        | 100 <sup>25</sup>                   | s MeOH; i EtOH, ace, diox                    |
| 274 | Barium calcium tungstate        | Ba <sub>2</sub> CaWO <sub>6</sub>                                                 | 15552-14-4  | 594.57      | cub cry                  | 1420                        |          |                            |                                     |                                              |
| 275 | Barium carbide                  | BaC <sub>2</sub>                                                                  | 50813-65-5  | 161.348     | gray tetr cry            | dec                         |          | 3.74                       |                                     | reac H <sub>2</sub> O                        |
| 276 | Barium carbonate                | BaCO <sub>3</sub>                                                                 | 513-77-9    | 197.336     | wh orth cry              | 1380 dec; 1555 (high pres.) |          | 4.308                      | 0.0014 <sup>20</sup>                | s acid                                       |
| 277 | Barium chlorate                 | Ba(ClO <sub>3</sub> ) <sub>2</sub>                                                | 13477-00-4  | 304.229     | wh cry                   | 414                         |          |                            | 37.9 <sup>25</sup>                  | sl EtOH, ace                                 |
| 278 | Barium chlorate monohydrate     | Ba(ClO <sub>3</sub> ) <sub>2</sub> · H <sub>2</sub> O                             | 10294-38-9  | 322.245     | wh monoc cry             | 120 dec                     |          | 3.179                      | 37.9 <sup>25</sup>                  | s acid; sl EtOH, ace                         |
| 279 | Barium chloride                 | BaCl <sub>2</sub>                                                                 | 10361-37-2  | 208.233     | wh orth cry; hyg         | 961                         | 1560     | 3.9                        | 37.0 <sup>25</sup>                  |                                              |
| 280 | Barium chloride dihydrate       | BaCl <sub>2</sub> · 2H <sub>2</sub> O                                             | 10326-27-9  | 244.264     | wh monoc cry             | ≈120 dec                    |          | 3.097                      | 37.0 <sup>25</sup>                  | i EtOH                                       |
| 281 | Barium chloride fluoride        | BaClF                                                                             | 13718-55-3  | 191.778     | wh cry                   |                             |          |                            |                                     |                                              |
| 282 | Barium chromate(V)              | Ba <sub>3</sub> (CrO <sub>4</sub> ) <sub>2</sub>                                  | 12345-14-1  | 643.968     | grn-blk hex cry          |                             |          | 5.25                       |                                     | s H <sub>2</sub> O                           |



| No. | Name                                 | Formula                                                                                         | CAS Reg No. | Mol. weight | Physical form                | mp/°C     | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility             |
|-----|--------------------------------------|-------------------------------------------------------------------------------------------------|-------------|-------------|------------------------------|-----------|-------|----------------------------|-------------------------------------|------------------------------------|
| 283 | Barium chromate(VI)                  | BaCrO <sub>4</sub>                                                                              | 10294-40-3  | 253.321     | yel orth cry                 | 1380      |       | 4.50                       | 0.00026 <sup>20</sup>               | reac acid                          |
| 284 | Barium citrate monohydrate           | Ba <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sub>2</sub> · H <sub>2</sub> O | 512-25-4*   | 808.195     | gray-wh cry                  |           |       |                            |                                     | s H <sub>2</sub> O, acid           |
| 285 | Barium copper yttrium oxide          | BaCuY <sub>2</sub> O <sub>5</sub>                                                               | 82642-06-6  | 458.682     | grn cry; not superconductor  |           |       |                            |                                     |                                    |
| 286 | Barium copper yttrium oxide          | Ba <sub>2</sub> Cu <sub>3</sub> YO <sub>7</sub>                                                 | 109064-29-1 | 666.194     | blk solid; HT superconductor |           |       |                            |                                     |                                    |
| 287 | Barium copper yttrium oxide          | Ba <sub>2</sub> Cu <sub>4</sub> YO <sub>8</sub>                                                 | 114104-80-2 | 745.739     | HT superconductor            |           |       |                            |                                     |                                    |
| 288 | Barium copper yttrium oxide          | Ba <sub>4</sub> Cu <sub>4</sub> Y <sub>2</sub> O <sub>15</sub>                                  | 124365-83-9 | 1411.933    | HT superconductor            |           |       |                            |                                     |                                    |
| 289 | Barium cyanide                       | Ba(CN) <sub>2</sub>                                                                             | 542-62-1    | 189.361     | wh cry powder                |           |       |                            |                                     | vs H <sub>2</sub> O; s EtOH        |
| 290 | Barium dichromate dihydrate          | BaCr <sub>2</sub> O <sub>7</sub> · 2H <sub>2</sub> O                                            | 10031-16-0  | 389.346     | brn-red needles              | dec       |       |                            |                                     | reac H <sub>2</sub> O              |
| 291 | Barium disilicate                    | BaSi <sub>2</sub> O <sub>5</sub>                                                                | 12650-28-1  | 273.495     | wh orth cry                  | 1420      |       | 3.70                       |                                     |                                    |
| 292 | Barium dithionate dihydrate          | BaS <sub>2</sub> O <sub>6</sub> · 2H <sub>2</sub> O                                             | 13845-17-5  | 333.484     | wh cry                       | 140 dec   |       | 4.54                       | 22.1 <sup>20</sup>                  | sl EtOH                            |
| 293 | Barium ferrite                       | BaFe <sub>12</sub> O <sub>19</sub>                                                              | 11138-11-7  | 1111.456    | magnetic solid               |           |       |                            |                                     |                                    |
| 294 | Barium ferrocyanide hexahydrate      | Ba <sub>2</sub> Fe(CN) <sub>6</sub> · 6H <sub>2</sub> O                                         | 13821-06-2* | 594.694     | yel monocl cry               | 80 dec    |       |                            |                                     | i H <sub>2</sub> O, EtOH           |
| 295 | Barium fluoride                      | BaF <sub>2</sub>                                                                                | 7787-32-8   | 175.324     | wh cub cry                   | 1368      | 2260  | 4.893                      | 0.161 <sup>25</sup>                 |                                    |
| 296 | Barium formate                       | Ba(CHO <sub>2</sub> ) <sub>2</sub>                                                              | 541-43-5    | 227.362     | cry                          |           |       | 3.21                       |                                     | s H <sub>2</sub> O; i EtOH         |
| 297 | Barium hexaboride                    | BaB <sub>6</sub>                                                                                | 12046-08-1  | 202.193     | blk cub cry                  | 2070      |       | 4.36                       |                                     | i H <sub>2</sub> O; s acid; i EtOH |
| 298 | Barium hexafluorogermanate           | BaGeF <sub>6</sub>                                                                              |             | 323.96      | wh cry                       | ≈665      |       | 4.56                       |                                     |                                    |
| 299 | Barium hexafluorosilicate            | BaSiF <sub>6</sub>                                                                              | 17125-80-3  | 279.403     | wh orth needles              | 300 dec   |       | 4.29                       |                                     | i H <sub>2</sub> O, EtOH; sl acid  |
| 300 | Barium hydride                       | BaH <sub>2</sub>                                                                                | 13477-09-3  | 139.343     | gray orth cry                | 1200      |       | 4.16                       |                                     | reac H <sub>2</sub> O              |
| 301 | Barium hydrogen phosphate            | BaHPO <sub>4</sub>                                                                              | 10048-98-3  | 233.306     | wh cry powder                | 400 dec   |       | 4.16                       | 0.015 <sup>20</sup>                 | s dil acid                         |
| 302 | Barium hydrosulfide                  | Ba(HS) <sub>2</sub>                                                                             | 25417-81-6  | 203.473     | yel hyg cry                  |           |       |                            |                                     | s H <sub>2</sub> O                 |
| 303 | Barium hydrosulfide tetrahydrate     | Ba(HS) <sub>2</sub> · 4H <sub>2</sub> O                                                         | 12230-74-9  | 275.534     | yel rhomb cry                | 50 dec    |       |                            |                                     | s H <sub>2</sub> O                 |
| 304 | Barium hydroxide                     | Ba(OH) <sub>2</sub>                                                                             | 17194-00-2  | 171.342     | wh powder                    | 408       |       |                            | 4.91 <sup>25</sup>                  |                                    |
| 305 | Barium hydroxide monohydrate         | Ba(OH) <sub>2</sub> · H <sub>2</sub> O                                                          | 22326-55-2  | 189.357     | wh powder                    |           |       | 3.743                      | 4.91 <sup>25</sup>                  | s acid                             |
| 306 | Barium hydroxide octahydrate         | Ba(OH) <sub>2</sub> · 8H <sub>2</sub> O                                                         | 12230-71-6  | 315.464     | wh monocl cry                | 78 dec    |       | 2.18                       | 4.91 <sup>25</sup>                  |                                    |
| 307 | Barium hypophosphite monohydrate     | Ba(H <sub>2</sub> PO <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                             | 14871-79-5* | 285.320     | monocl plates                |           |       | 2.90                       |                                     | s H <sub>2</sub> O; i EtOH         |
| 308 | Barium iodate                        | Ba(IO <sub>3</sub> ) <sub>2</sub>                                                               | 10567-69-8  | 487.132     | wh cry powder                | 476 dec   |       | 5.23                       | 0.0396 <sup>25</sup>                |                                    |
| 309 | Barium iodate monohydrate            | Ba(IO <sub>3</sub> ) <sub>2</sub> · H <sub>2</sub> O                                            | 7787-34-0   | 505.148     | cry                          | 130 dec   |       | 5.00                       | 0.0396 <sup>25</sup>                | s acid; i EtOH                     |
| 310 | Barium iodide                        | BaI <sub>2</sub>                                                                                | 13718-50-8  | 391.136     | wh orth cry                  | 711       |       | 5.15                       | 221 <sup>25</sup>                   |                                    |
| 311 | Barium iodide dihydrate              | BaI <sub>2</sub> · 2H <sub>2</sub> O                                                            | 7787-33-9   | 427.167     | col cry                      | 740 dec   |       | 5.0                        | 221 <sup>25</sup>                   | s EtOH, ace                        |
| 312 | Barium manganate(VI)                 | BaMnO <sub>4</sub>                                                                              | 7787-35-1   | 256.263     | grn-gray hyg cry             |           |       | 4.85                       | 0.00041 <sup>20</sup>               |                                    |
| 313 | Barium metaborate monohydrate        | Ba(BO <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                                            | 26124-86-7  | 240.962     | wh powder                    | >900      |       | 3.3                        |                                     | sl H <sub>2</sub> O                |
| 314 | Barium metaborate dihydrate          | Ba(BO <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O                                           | 23436-05-7  | 258.977     | wh prec                      | dec       |       |                            | 1.3 <sup>25</sup>                   | sl H <sub>2</sub> O                |
| 315 | Barium metaphosphate                 | Ba(PO <sub>3</sub> ) <sub>2</sub>                                                               | 13466-20-1  | 295.271     | wh powder                    | 1560      |       |                            |                                     | i H <sub>2</sub> O; sl acid        |
| 316 | Barium metasilicate                  | BaSiO <sub>3</sub>                                                                              | 13255-26-0  | 213.411     | col rhomb powder             | 1605      |       | 4.40                       |                                     | i H <sub>2</sub> O; s acid         |
| 317 | Barium molybdate                     | BaMoO <sub>4</sub>                                                                              | 7787-37-3   | 297.27      | wh powder                    | 1450      |       | 4.975                      | 0.0021 <sup>20</sup>                |                                    |
| 318 | Barium niobate                       | Ba(NbO <sub>3</sub> ) <sub>2</sub>                                                              | 12009-14-2  | 419.136     | yel orth cry                 | 1455      |       | 5.44                       |                                     | i H <sub>2</sub> O                 |
| 319 | Barium nitrate                       | Ba(NO <sub>3</sub> ) <sub>2</sub>                                                               | 10022-31-8  | 261.336     | wh cub cry                   | 590       |       | 3.24                       | 10.3 <sup>25</sup>                  | sl EtOH, ace                       |
| 320 | Barium nitride                       | Ba <sub>3</sub> N <sub>2</sub>                                                                  | 12047-79-9  | 439.994     | yel-brn cry                  | >500 dec  |       | 4.78                       |                                     | reac H <sub>2</sub> O              |
| 321 | Barium nitrite                       | Ba(NO <sub>2</sub> ) <sub>2</sub>                                                               | 13465-94-6  | 229.338     | col hex cry                  | 267       |       | 3.234                      | 79.5 <sup>25</sup>                  |                                    |
| 322 | Barium nitrite monohydrate           | Ba(NO <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                                            | 7787-38-4   | 247.353     | yel-wh hex cry               | 217 dec   |       | 3.18                       | 79.5 <sup>25</sup>                  | i EtOH                             |
| 323 | Barium orthovanadate                 | Ba <sub>2</sub> (VO <sub>4</sub> ) <sub>3</sub>                                                 | 39416-30-3  | 641.859     | hex cry                      | 707       |       | 5.14                       |                                     |                                    |
| 324 | Barium oxalate                       | BaC <sub>2</sub> O <sub>4</sub>                                                                 | 516-02-9    | 225.346     | wh powder                    | 400 dec   |       | 2.658                      | 0.0075                              |                                    |
| 325 | Barium oxalate monohydrate           | BaC <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> O                                              | 13463-22-4  | 243.361     | wh cry powder                |           |       | 2.66                       | 0.0075 <sup>20</sup>                | s acid                             |
| 326 | Barium oxide                         | BaO                                                                                             | 1304-28-5   | 153.326     | wh-yel powder; cub and hex   | 1973      |       | 5.72(cub)                  | 1.5 <sup>20</sup>                   | s dil acid, EtOH; i ace            |
| 327 | Barium 2,4-pentanedioate octahydrate | Ba(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub> · 8H <sub>2</sub> O                     | 12084-29-6* | 479.665     | col hyg cry                  | 320 (anh) |       |                            |                                     |                                    |
| 328 | Barium perchlorate                   | Ba(ClO <sub>4</sub> ) <sub>2</sub>                                                              | 13465-95-7  | 336.228     | col hex cry                  | 505       |       | 3.20                       | 312 <sup>25</sup>                   | vs EtOH                            |
| 329 | Barium perchlorate trihydrate        | Ba(ClO <sub>4</sub> ) <sub>2</sub> · 3H <sub>2</sub> O                                          | 10294-39-0  | 390.274     | col cry                      |           |       | 2.74                       | 312 <sup>25</sup>                   | s MeOH; sl EtOH, ace; i eth        |
| 330 | Barium permanganate                  | Ba(MnO <sub>4</sub> ) <sub>2</sub>                                                              | 7787-36-2   | 375.198     | brn-viol cry                 | 200 dec   |       | 3.77                       | 62.5 <sup>20</sup>                  | reac EtOH                          |
| 331 | Barium peroxide                      | BaO <sub>2</sub>                                                                                | 1304-29-6   | 169.326     | gray-wh tetr cry             | 450 dec   |       | 4.96                       | 0.091 <sup>20</sup>                 | reac dil acid                      |
| 332 | Barium plumbate                      | BaPbO <sub>3</sub>                                                                              | 12047-25-5  | 392.5       | orth cry                     |           |       |                            |                                     |                                    |
| 333 | Barium potassium chromate            | BaK <sub>2</sub> (CrO <sub>4</sub> ) <sub>2</sub>                                               | 27133-66-0  | 447.511     | yel hex cry                  |           |       | 3.63                       |                                     | vs H <sub>2</sub> O                |
| 334 | Barium pyrophosphate                 | Ba <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                                                   | 13466-21-2  | 448.597     | wh powder                    | 1430      |       | 3.9                        | 0.0088 <sup>20</sup>                | s acid                             |
| 335 | Barium selenate                      | BaSeO <sub>4</sub>                                                                              | 7787-41-9   | 280.29      | wh rhomb cry                 | dec       |       | 4.75                       | 0.015 <sup>20</sup>                 |                                    |
| 336 | Barium selenide                      | BaSe                                                                                            | 1304-39-8   | 216.29      | cub cry powder               | 1780      |       | 5.02                       |                                     | reac H <sub>2</sub> O              |
| 337 | Barium selenite                      | BaSeO <sub>3</sub>                                                                              | 13718-59-7  | 264.29      | solid                        |           |       |                            |                                     | i H <sub>2</sub> O                 |
| 338 | Barium silicide                      | BaSi <sub>2</sub>                                                                               | 1304-40-1   | 193.498     | gray lumps                   | 1180      |       |                            |                                     | reac H <sub>2</sub> O              |
| 339 | Barium sodium niobate                | Ba <sub>2</sub> Na(NbO <sub>3</sub> ) <sub>5</sub>                                              | 12323-03-4  | 1002.167    | wh orth cry                  | 1437      |       | 5.40                       |                                     | i H <sub>2</sub> O                 |
| 340 | Barium stannate                      | BaSnO <sub>3</sub>                                                                              | 12009-18-6  | 304.035     | cub cry                      |           |       | 7.24                       |                                     | sl H <sub>2</sub> O                |
| 341 | Barium stannate trihydrate           | BaSnO <sub>3</sub> · 3H <sub>2</sub> O                                                          | 12009-18-6* | 358.081     | wh cry powder                |           |       |                            |                                     | sl H <sub>2</sub> O; s acid        |

| No. | Name                                                | Formula                                                                       | CAS Reg No. | Mol. weight | Physical form              | mp/°C        | bp/°C  | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility            |
|-----|-----------------------------------------------------|-------------------------------------------------------------------------------|-------------|-------------|----------------------------|--------------|--------|----------------------------|-------------------------------------|-----------------------------------|
| 342 | Barium stearate                                     | Ba(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>2</sub>              | 6865-35-6   | 704.266     | wh powder                  | 160          |        | 1.145                      |                                     | i H <sub>2</sub> O, EtOH          |
| 343 | Barium strontium niobate                            | BaSr(NbO <sub>3</sub> ) <sub>4</sub>                                          | 37185-09-4  | 788.57      | pale yel solid             |              |        |                            |                                     |                                   |
| 344 | Barium strontium tungstate                          | Ba <sub>2</sub> SrWO <sub>6</sub>                                             | 14871-56-8  | 642.11      | hyg pow                    | 1400         |        |                            |                                     |                                   |
| 345 | Barium sulfate                                      | BaSO <sub>4</sub>                                                             | 7727-43-7   | 233.390     | wh orth cry                | 1580         |        | 4.49                       | 0.00031 <sup>20</sup>               | i EtOH                            |
| 346 | Barium sulfide                                      | BaS                                                                           | 21109-95-5  | 169.392     | col cub cry or gray powder | 2227         |        | 4.3                        | 8.94 <sup>25</sup>                  |                                   |
| 347 | Barium sulfite                                      | BaSO <sub>3</sub>                                                             | 7787-39-5   | 217.390     | wh monocl cry              | dec          |        | 4.44                       | 0.0011 <sup>25</sup>                | i EtOH                            |
| 348 | Barium tartrate                                     | BaC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                                | 5908-81-6   | 285.398     | wh cry                     |              |        | 2.98                       |                                     | s H <sub>2</sub> O; i EtOH        |
| 349 | Barium tetracyanoplatinate(II) tetrahydrate         | BaPt(CN) <sub>4</sub> · 4H <sub>2</sub> O                                     | 13755-32-3  | 508.543     | yel powder or cry          |              |        | 2.076                      |                                     | sl H <sub>2</sub> O; i EtOH       |
| 350 | Barium tetraiodomercurate(II)                       | BaHgI <sub>4</sub>                                                            | 10048-99-4  | 845.54      | yel-red hyg cry            |              |        |                            |                                     | vs H <sub>2</sub> O, EtOH         |
| 351 | Barium thiocyanate                                  | Ba(SCN) <sub>2</sub>                                                          | 2092-17-3   | 253.491     | hyg cry                    |              |        |                            | 167 <sup>25</sup>                   | s ace, MeOH, EtOH                 |
| 352 | Barium thiocyanate dihydrate                        | Ba(SCN) <sub>2</sub> · 2H <sub>2</sub> O                                      | 2092-17-3*  | 289.522     | hyg wh cry                 |              |        |                            | 167 <sup>25</sup>                   | s EtOH                            |
| 353 | Barium thiocyanate trihydrate                       | Ba(SCN) <sub>2</sub> · 3H <sub>2</sub> O                                      | 68016-36-4  | 307.537     | wh needles; hyg            |              |        | 2.286                      | 167 <sup>25</sup>                   | s EtOH                            |
| 354 | Barium thiosulfate                                  | BaS <sub>2</sub> O <sub>3</sub>                                               | 35112-53-9  | 249.455     | wh cry powder              | 220 dec      |        |                            | 0.2 <sup>20</sup>                   | i EtOH                            |
| 355 | Barium thiosulfate monohydrate                      | BaS <sub>2</sub> O <sub>3</sub> · H <sub>2</sub> O                            | 7787-40-8   | 267.471     | wh cry powder              | dec          |        | 3.5                        | 0.2                                 | i EtOH                            |
| 356 | Barium titanate (BaTiO <sub>3</sub> )               | BaTiO <sub>3</sub>                                                            | 12047-27-7  | 233.192     | wh tet cry                 | 1625         |        | 6.02                       |                                     | i H <sub>2</sub> O                |
| 357 | Barium titanate (BaTi <sub>2</sub> O <sub>7</sub> ) | BaTi <sub>2</sub> O <sub>7</sub>                                              | 12009-27-7  | 313.058     | wh solid                   |              |        |                            |                                     |                                   |
| 358 | Barium titanate (BaTi <sub>4</sub> O <sub>9</sub> ) | BaTi <sub>4</sub> O <sub>9</sub>                                              | 12009-31-3  | 472.790     | wh solid                   |              |        |                            |                                     |                                   |
| 359 | Barium titanium silicate                            | BaTi(SiO <sub>3</sub> ) <sub>3</sub>                                          | 15491-35-7  | 413.446     | rhomb blue-pur cry         |              |        |                            |                                     |                                   |
| 360 | Barium tungstate                                    | BaWO <sub>4</sub>                                                             | 7787-42-0   | 385.17      | wh tet cry                 | 1475         | 1730   | 5.04                       | 0.0016 <sup>20</sup>                |                                   |
| 361 | Barium uranium oxide                                | Ba <sub>2</sub> U <sub>2</sub> O <sub>7</sub>                                 | 10380-31-1  | 725.381     | oran-yel powder            |              |        |                            |                                     | i H <sub>2</sub> O; s acid        |
| 362 | Barium yttrium tungsten oxide                       | Ba <sub>3</sub> Y <sub>2</sub> WO <sub>9</sub>                                | 37265-86-4  | 1006.53     | cub cry                    | 1470         |        |                            |                                     |                                   |
| 363 | Barium zirconate                                    | BaZrO <sub>3</sub>                                                            | 12009-21-1  | 276.549     | gray-wh cub cry            | 2500         |        | 5.52                       |                                     | i H <sub>2</sub> O, alk; sl acid  |
| 364 | Barium zirconium silicate                           | BaO · ZrO <sub>2</sub> · SiO <sub>2</sub>                                     |             | 336.634     | wh pow                     |              |        |                            |                                     |                                   |
| 365 | Berkelium (α form)                                  | Bk                                                                            | 7440-40-6   | 247         | hex cry                    | trans to 930 |        | 14.78                      |                                     |                                   |
| 366 | Berkelium (β form)                                  | Bk                                                                            | 7440-40-6   | 247         | cub cry                    | 986          |        | 13.25                      |                                     |                                   |
| 367 | Beryllium                                           | Be                                                                            | 7440-41-7   | 9.012       | hex cry                    | 1287         | 2471   | 1.85                       |                                     | s acid, alk                       |
| 368 | Beryllium acetate                                   | Be(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                | 543-81-7    | 127.101     | wh cry                     | 60 dec       |        |                            |                                     | i H <sub>2</sub> O, EtOH          |
| 369 | Beryllium basic acetate                             | Be <sub>2</sub> O(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>6</sub> | 1332-52-1   | 406.312     | wh cry                     | 285          | 330    | 1.25                       |                                     | i H <sub>2</sub> O; s eth, os     |
| 370 | Beryllium aluminate                                 | BeAl <sub>2</sub> O <sub>4</sub>                                              | 12004-06-7  | 126.973     | orth cry                   |              |        | 3.65                       |                                     |                                   |
| 371 | Beryllium aluminum metasilicate                     | Be <sub>3</sub> Al <sub>2</sub> (SiO <sub>3</sub> ) <sub>6</sub>              | 1302-52-9   | 537.502     | col or grn-yel cry; hex    |              |        | 2.64                       |                                     |                                   |
| 372 | Beryllium boride (BeB <sub>2</sub> )                | BeB <sub>2</sub>                                                              | 12228-40-9  | 30.634      | refrac solid               | >1970        |        |                            |                                     |                                   |
| 373 | Beryllium boride (BeB <sub>6</sub> )                | BeB <sub>6</sub>                                                              | 12429-94-6  | 73.878      | red solid                  | 2070         |        |                            |                                     |                                   |
| 374 | Beryllium boride (Be <sub>2</sub> B)                | Be <sub>2</sub> B                                                             | 12536-51-5  | 28.835      | pink cry                   | 1520         |        |                            |                                     |                                   |
| 375 | Beryllium boride (Be <sub>3</sub> B)                | Be <sub>3</sub> B                                                             | 12536-52-6  | 46.860      | refrac solid               | 1160         |        |                            |                                     |                                   |
| 376 | Beryllium borohydride                               | Be(BH <sub>4</sub> ) <sub>2</sub>                                             | 17440-85-6  | 36.682      | solid                      | 125 dec      | subl   |                            |                                     | reac H <sub>2</sub> O             |
| 377 | Beryllium bromide                                   | BeBr <sub>2</sub>                                                             | 7787-46-4   | 168.820     | orth cry; hyg              | 508          | 473 sp | 3.465                      |                                     | vs H <sub>2</sub> O; s EtOH, pyr  |
| 378 | Beryllium carbide                                   | Be <sub>2</sub> C                                                             | 506-66-1    | 30.035      | red cub cry                | 2127         |        | 1.90                       |                                     | reac H <sub>2</sub> O             |
| 379 | Beryllium carbonate tetrahydrate                    | BeCO <sub>3</sub> · 4H <sub>2</sub> O                                         | 60883-64-9  | 93.085      | wh solid                   | 100 dec      |        |                            | 0.36 <sup>9</sup>                   |                                   |
| 380 | Beryllium basic carbonate                           | Be <sub>2</sub> (OH) <sub>2</sub> (CO <sub>3</sub> ) <sub>2</sub>             | 66104-24-3  | 181.069     | wh powder                  |              |        |                            |                                     | i H <sub>2</sub> O; s acid, alk   |
| 381 | Beryllium chloride                                  | BeCl <sub>2</sub>                                                             | 7787-47-5   | 79.918      | wh-yel orth cry; hyg       | 415          | 482    | 1.90                       | 71.5 <sup>25</sup>                  | s EtOH, eth, py; i bz, tol        |
| 382 | Beryllium fluoride                                  | BeF <sub>2</sub>                                                              | 7787-49-7   | 47.009      | tetr cry or gl; hyg        | 552          | 1283   | 2.1                        |                                     | vs H <sub>2</sub> O; sl EtOH      |
| 383 | Beryllium formate                                   | Be(CHO <sub>2</sub> ) <sub>2</sub>                                            | 1111-71-3   | 99.047      | powder                     | >250 dec     |        |                            |                                     | reac H <sub>2</sub> O; i os       |
| 384 | Beryllium hydride                                   | BeH <sub>2</sub>                                                              | 7787-52-2   | 11.028      | wh amorp solid             | 250 dec      |        | 0.65                       |                                     | reac H <sub>2</sub> O; i eth, tol |
| 385 | Beryllium hydrogen phosphate                        | BeHPO <sub>4</sub>                                                            | 13598-15-7  | 104.991     | cry                        |              |        |                            |                                     | i H <sub>2</sub> O                |
| 386 | Beryllium hydroxide (α)                             | Be(OH) <sub>2</sub>                                                           | 13327-32-7  | 43.027      | wh powder or cry           | ≈200 dec     |        | 1.92                       |                                     | sl H <sub>2</sub> O, alk; s acid  |
| 387 | Beryllium hydroxide (β)                             | Be(OH) <sub>2</sub>                                                           | 13327-32-7  | 43.027      | col tet cry                | dec 138      |        |                            |                                     | i H <sub>2</sub> O; s, acid, alk  |
| 388 | Beryllium iodide                                    | BeI <sub>2</sub>                                                              | 7787-53-3   | 262.821     | hyg needles                | 480          | 590    | 4.32                       |                                     | reac H <sub>2</sub> O; s EtOH     |
| 389 | Beryllium nitrate trihydrate                        | Be(NO <sub>3</sub> ) <sub>2</sub> · 3H <sub>2</sub> O                         | 13597-99-4  | 187.068     | yel-wh hyg cry             | ≈30          | dec    |                            | 107 <sup>20</sup>                   | s EtOH                            |
| 390 | Beryllium nitride                                   | Be <sub>3</sub> N <sub>2</sub>                                                | 1304-54-7   | 55.050      | gray refrac cry; cub       | 2200         |        | 2.71                       |                                     | reac acid, alk                    |
| 391 | Beryllium oxalate trihydrate                        | BeC <sub>2</sub> O <sub>4</sub> · 3H <sub>2</sub> O                           | 15771-43-4  | 151.077     | rhomb cry                  | dec 320      |        |                            |                                     | vs H <sub>2</sub> O               |
| 392 | Beryllium oxide                                     | BeO                                                                           | 1304-56-9   | 25.011      | wh hex cry                 | 2578         |        | 3.01                       |                                     | i H <sub>2</sub> O; sl acid, alk  |
| 393 | Beryllium 2,4-pentanedioate                         | Be(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>                       | 10210-64-7  | 207.228     | monocl cry powder          | 108          | 270    | 1.168                      |                                     | i H <sub>2</sub> O; vs EtOH, eth  |
| 394 | Beryllium perchlorate tetrahydrate                  | Be(ClO <sub>4</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                        | 7787-48-6   | 279.975     | hyg cry                    | 250 dec      |        |                            | 198 <sup>25</sup>                   |                                   |
| 395 | Beryllium selenate tetrahydrate                     | BeSeO <sub>4</sub> · 4H <sub>2</sub> O                                        | 10039-31-3  | 224.03      | orth cry                   | 100 dec      |        | 2.03                       |                                     | vs H <sub>2</sub> O               |
| 396 | Beryllium sulfate                                   | BeSO <sub>4</sub>                                                             | 13510-49-1  | 105.075     | col tet cry; hyg           | 1127         |        | 2.5                        | 41.3 <sup>25</sup>                  |                                   |
| 397 | Beryllium sulfate dihydrate                         | BeSO <sub>4</sub> · 2H <sub>2</sub> O                                         | 14215-00-0  | 141.105     | col cry                    | dec 92       |        |                            |                                     |                                   |
| 398 | Beryllium sulfate tetrahydrate                      | BeSO <sub>4</sub> · 4H <sub>2</sub> O                                         | 7787-56-6   | 177.136     | col tet cry                | ≈100 dec     |        | 1.71                       | 41.3 <sup>25</sup>                  | i EtOH                            |
| 399 | Beryllium sulfide                                   | BeS                                                                           | 13598-22-6  | 41.077      | col cub cry                | dec          |        | 2.36                       |                                     | reac hot H <sub>2</sub> O         |
| 400 | Bismuth                                             | Bi                                                                            | 7440-69-9   | 208.980     | gray-wh soft metal         | 271.406      | 1564   | 9.79                       |                                     | s acid                            |
| 401 | Bismuth acetate                                     | Bi(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub>                | 22306-37-2  | 386.111     | col tablets                | 250          |        |                            |                                     | i H <sub>2</sub> O                |
| 402 | Bismuth subacetate                                  | BiOC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                               | 5142-76-7   | 284.023     | thin cry plates            |              |        |                            |                                     | i H <sub>2</sub> O; s dil acid    |
| 403 | Bismuth antimonide                                  | BiSb                                                                          | 12323-19-2  | 330.740     | cry                        | 475          |        |                            |                                     |                                   |



| No. | Name                                 | Formula                                                              | CAS Reg No. | Mol. weight | Physical form            | mp/°C     | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                 |
|-----|--------------------------------------|----------------------------------------------------------------------|-------------|-------------|--------------------------|-----------|---------|----------------------------|-------------------------------------|--------------------------------------------------------|
| 404 | Bismuth arsenate                     | BiAsO <sub>4</sub>                                                   | 13702-38-0  | 347.900     | wh monocl cry            |           |         | 7.14                       |                                     | i H <sub>2</sub> O; sl conc HNO <sub>3</sub>           |
| 405 | Bismuth basic carbonate              | (BiO) <sub>2</sub> CO <sub>3</sub>                                   | 5892-10-4   | 509.969     | wh powder                |           |         | 6.86                       |                                     | i H <sub>2</sub> O; s acid                             |
| 406 | Bismuth basic dichromate             | Bi <sub>2</sub> O <sub>3</sub> · 2CrO <sub>3</sub>                   |             | 665.948     | red-oran amorp pow       |           |         |                            |                                     | i H <sub>2</sub> O; s acid, alk                        |
| 407 | Bismuth citrate                      | BiC <sub>6</sub> H <sub>5</sub> O <sub>7</sub>                       | 813-93-4    | 398.080     | wh powder                |           |         | 3.458                      |                                     | i H <sub>2</sub> O; sl EtOH                            |
| 408 | Bismuth hydride                      | BiH <sub>3</sub>                                                     | 18288-22-7  | 212.004     | col gas; unstab          | -67       | ≈17     | 8.665 g/L                  |                                     |                                                        |
| 409 | Bismuth hydroxide                    | Bi(OH) <sub>3</sub>                                                  | 10361-43-0  | 260.002     | wh-yel amorp powder      |           |         | 4.962                      |                                     | i H <sub>2</sub> O; s acid                             |
| 410 | Bismuth germanium oxide              | 2Bi <sub>2</sub> O <sub>3</sub> · 3GeO <sub>2</sub>                  | 12233-56-6  | 1245.84     | wh pow                   | 1044      |         |                            |                                     |                                                        |
| 411 | Bismuth hexafluoro-2,4-pentanedioate | Bi(CF <sub>3</sub> COCHCOCF <sub>3</sub> ) <sub>3</sub>              | 142617-56-9 | 830.132     | powder                   | 96        |         |                            |                                     |                                                        |
| 412 | Bismuth molybdate                    | Bi <sub>2</sub> MoO <sub>6</sub>                                     | 13565-96-3  | 609.90      | yel solid                |           |         | 9.32                       |                                     |                                                        |
| 413 | Bismuth molybdate                    | Bi <sub>2</sub> (MoO <sub>4</sub> ) <sub>3</sub>                     | 51898-99-8  | 897.77      | monocl cry               |           |         | 5.95                       |                                     |                                                        |
| 414 | Bismuth nitrate pentahydrate         | Bi(NO <sub>3</sub> ) <sub>3</sub> · 5H <sub>2</sub> O                | 10035-06-0  | 485.071     | col tricr cry; hyg       | ≈75 dec   |         | 2.83                       |                                     | reac H <sub>2</sub> O; s ace; i EtOH                   |
| 415 | Bismuth subnitrate                   | Bi <sub>5</sub> O(OH) <sub>9</sub> (NO <sub>3</sub> ) <sub>4</sub>   | 1304-85-4   | 1461.987    | hyg cry powder           | 260 dec   |         | 4.928                      |                                     | i H <sub>2</sub> O, EtOH; s dil acid                   |
| 416 | Bismuth oleate                       | Bi(C <sub>18</sub> H <sub>33</sub> O <sub>2</sub> ) <sub>3</sub>     | 52951-38-9  | 1053.340    | soft yel-brn solid       |           |         |                            |                                     | i H <sub>2</sub> O; s eth; sl bz                       |
| 417 | Bismuth oxalate                      | Bi <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub>        | 6591-55-5   | 682.018     | wh powder                |           |         |                            |                                     | i H <sub>2</sub> O, EtOH; s dil acid                   |
| 418 | Bismuth oxide                        | Bi <sub>2</sub> O <sub>3</sub>                                       | 1304-76-3   | 465.959     | yel monocl cry or powder | 825       | 1890    | 8.9                        |                                     | i H <sub>2</sub> O; s acid                             |
| 419 | Bismuth tetroxide                    | Bi <sub>2</sub> O <sub>4</sub>                                       | 12048-50-9  | 481.959     | red-oran powder          | 305       |         | 5.6                        |                                     | reac H <sub>2</sub> O                                  |
| 420 | Bismuth oxybromide                   | BiOBr                                                                | 7787-57-7   | 304.883     | col tetr cry             | 560 dec   |         | 8.08                       |                                     | i H <sub>2</sub> O, EtOH; s acid                       |
| 421 | Bismuth oxychloride                  | BiOCl                                                                | 7787-59-9   | 260.432     | wh tetr cry              | 575 dec   |         | 7.72                       |                                     | i H <sub>2</sub> O                                     |
| 422 | Bismuth oxyiodide                    | BiOI                                                                 | 7787-63-5   | 351.883     | red tetr cry             | 300 dec   |         | 7.92                       |                                     | i H <sub>2</sub> O, EtOH, chl; s HCl                   |
| 423 | Bismuth oxynitrate                   | BiONO <sub>3</sub>                                                   | 10361-46-3  | 286.985     | wh powder                | 260 dec   |         | 4.93                       |                                     | i H <sub>2</sub> O, EtOH; s acid                       |
| 424 | Bismuth phosphate                    | BiPO <sub>4</sub>                                                    | 10049-01-1  | 303.951     | monocl cry               |           |         | 6.32                       |                                     | sl H <sub>2</sub> O, dil acid; i EtOH                  |
| 425 | Bismuth potassium iodide             | BiKI <sub>7</sub>                                                    | 41944-01-8  | 1253.704    | red cry                  |           |         |                            |                                     | reac H <sub>2</sub> O; s alk iodide soln               |
| 426 | Bismuth selenide                     | Bi <sub>2</sub> Se <sub>3</sub>                                      | 12068-69-8  | 654.84      | blk hex cry              | 710 dec   |         | 7.5                        |                                     | i H <sub>2</sub> O                                     |
| 427 | Bismuth stannate pentahydrate        | Bi <sub>2</sub> (SnO <sub>3</sub> ) <sub>3</sub> · 5H <sub>2</sub> O | 12777-45-6  | 1008.162    | wh cry                   |           |         |                            |                                     | i H <sub>2</sub> O                                     |
| 428 | Bismuth sulfate                      | Bi <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                      | 7787-68-0   | 706.149     | wh needles or powder     | 405 dec   |         | 5.08                       |                                     | reac H <sub>2</sub> O, EtOH                            |
| 429 | Bismuth sulfide                      | Bi <sub>2</sub> S <sub>3</sub>                                       | 1345-07-9   | 514.156     | blk-brn orth cry         | 850       |         | 6.78                       |                                     | i H <sub>2</sub> O; s acid                             |
| 430 | Bismuth telluride                    | Bi <sub>2</sub> Te <sub>3</sub>                                      | 1304-82-1   | 800.76      | gray hex plates          | 580       |         | 7.74                       |                                     | i H <sub>2</sub> O; s EtOH                             |
| 431 | Bismuth tribromide                   | BiBr <sub>3</sub>                                                    | 7787-58-8   | 448.692     | yel cub cry              | 219       | 462     | 5.72                       |                                     | reac H <sub>2</sub> O; s dil acid, ace; i EtOH         |
| 432 | Bismuth trichloride                  | BiCl <sub>3</sub>                                                    | 7787-60-2   | 315.339     | col or yel cub cry; hyg  | 234       | 441     | 4.75                       |                                     | reac H <sub>2</sub> O; s acid, EtOH, ace               |
| 433 | Bismuth trifluoride                  | BiF <sub>3</sub>                                                     | 7787-61-3   | 265.975     | wh-gray cub cry          | 727       | 900     | 8.3                        |                                     | i H <sub>2</sub> O                                     |
| 434 | Bismuth pentafluoride                | BiF <sub>5</sub>                                                     | 7787-62-4   | 303.972     | wh tetr needles; hyg     | 151.4     | 230     | 5.55                       |                                     | reac H <sub>2</sub> O                                  |
| 435 | Bismuth triiodide                    | BiI <sub>3</sub>                                                     | 7787-64-6   | 589.693     | blk-brn hex cry          | 408.6     | 542     | 5.778                      | 0.00078 <sup>20</sup>               | s EtOH                                                 |
| 436 | Bismuth trimethyl                    | Bi(CH <sub>3</sub> ) <sub>3</sub>                                    | 593-91-9    | 254.083     | col flam liq             | -86       | 110     | 2.3                        |                                     |                                                        |
| 437 | Bismuth titanate                     | Bi <sub>2</sub> (TiO <sub>4</sub> ) <sub>3</sub>                     | 12048-51-0  | 1171.516    | wh orth cry              |           |         | 7.85                       |                                     |                                                        |
| 438 | Bismuth tungstate                    | Bi <sub>2</sub> (WO <sub>4</sub> ) <sub>3</sub>                      | 13595-87-4  | 1161.47     | wh powder                |           |         |                            |                                     |                                                        |
| 439 | Bismuth vanadate                     | BiVO <sub>4</sub>                                                    | 14059-33-7  | 323.920     | orth cry                 | trans 500 |         | 6.25                       |                                     | i H <sub>2</sub> O; s acid                             |
| 440 | Bismuth zirconate                    | 2Bi <sub>2</sub> O <sub>3</sub> · 3ZrO <sub>2</sub>                  | 37306-42-6  | 1301.587    | wh pow                   |           |         |                            |                                     |                                                        |
| 441 | Boron                                | B                                                                    | 7440-42-8   | 10.811      | blk rhomb cry            | 2075      | 4000    | 2.34                       |                                     | i H <sub>2</sub> O                                     |
| 442 | Diborane                             | B <sub>2</sub> H <sub>6</sub>                                        | 19287-45-7  | 27.670      | col gas; flam            | -164.85   | -92.49  | 1.131 g/L                  |                                     | reac H <sub>2</sub> O                                  |
| 443 | Tetraborane(10)                      | B <sub>4</sub> H <sub>10</sub>                                       | 18283-93-7  | 53.323      | unstab col gas           | -120      | 18      | 2.180 g/L                  |                                     | reac H <sub>2</sub> O                                  |
| 444 | Pentaborane(9)                       | B <sub>5</sub> H <sub>9</sub>                                        | 19624-22-7  | 63.126      | flam col liq             | -46.74    | 60.10   | 0.60                       |                                     | reac hot H <sub>2</sub> O                              |
| 445 | Pentaborane(11)                      | B <sub>5</sub> H <sub>11</sub>                                       | 18433-84-6  | 65.142      | col liq; unstab          | -122      | 65      |                            |                                     | reac H <sub>2</sub> O                                  |
| 446 | Hexaborane(10)                       | B <sub>6</sub> H <sub>10</sub>                                       | 23777-80-2  | 74.945      | col liq                  | -62.3     | 108 dec | 0.67                       |                                     | reac hot H <sub>2</sub> O                              |
| 447 | Hexaborane(12)                       | B <sub>6</sub> H <sub>12</sub>                                       | 12008-19-4  | 76.961      | col liq                  | -82.3     | ≈85     |                            |                                     | reac H <sub>2</sub> O                                  |
| 448 | Nonaborane(15)                       | B <sub>9</sub> H <sub>15</sub>                                       | 19465-30-6  | 112.418     | col liq                  | 2.7       |         |                            |                                     |                                                        |
| 449 | Decaborane(14)                       | B <sub>10</sub> H <sub>14</sub>                                      | 17702-41-9  | 122.221     | wh orth cry              | 98.78     | 213     | 0.94                       |                                     | sl H <sub>2</sub> O; s EtOH, bz, CS <sub>2</sub> , ctc |
| 450 | Decaborane(16)                       | B <sub>10</sub> H <sub>16</sub>                                      | 71595-75-0  | 124.237     | col cry                  | ≈81       | dec 170 | subl                       |                                     |                                                        |
| 451 | Dodecaborane(16)                     | B <sub>12</sub> H <sub>16</sub>                                      | 89711-39-7  | 145.859     | col cry                  | 65        |         |                            |                                     | s bz, hx                                               |
| 452 | Tridecaborane(19)                    | B <sub>13</sub> H <sub>19</sub>                                      | 43093-20-5  | 159.694     | yel cry                  | 44        |         |                            |                                     | s hx, CH <sub>2</sub> Cl <sub>2</sub>                  |
| 453 | Tetradecaborane(18)                  | B <sub>14</sub> H <sub>18</sub>                                      | 55606-55-8  | 169.497     | visc yel oil             |           | dec 100 |                            |                                     | s cyhex, CS <sub>2</sub>                               |
| 454 | Hexadecaborane(20)                   | B <sub>16</sub> H <sub>20</sub>                                      | 28265-11-4  | 193.135     | col cry                  | ≈110      |         |                            |                                     | s ctc, cyhex, thf                                      |
| 455 | Octadecaborane(22)                   | B <sub>18</sub> H <sub>22</sub>                                      | 11071-61-7  | 216.773     | yel cry                  | 180       |         |                            |                                     | s os                                                   |
| 456 | Tetrabromodiborane                   | B <sub>2</sub> Br <sub>4</sub>                                       | 14355-29-4  | 341.238     | col liq                  | ≈1        | dec 20  |                            |                                     |                                                        |
| 457 | Tetrachlorodiborane                  | B <sub>2</sub> Cl <sub>4</sub>                                       | 13701-67-2  | 163.434     | col liq; flam            | -92.6     | 66.5    |                            |                                     | reac H <sub>2</sub> O                                  |

| No. | Name                                  | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form             | mp/°C     | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                        |
|-----|---------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|---------------------------|-----------|---------|----------------------------|-------------------------------------|-----------------------------------------------|
| 458 | Tetrafluorodiborane                   | B <sub>2</sub> F <sub>4</sub>                                                      | 13965-73-6  | 97.616      | col gas; flam             | -56       | -34.0   | 3.990 g/L                  |                                     | reac H <sub>2</sub> O                         |
| 459 | Borane carbonyl                       | BH <sub>3</sub> CO                                                                 | 13205-44-2  | 41.845      | col gas                   | -137      | -64     | 1.710 g/L                  |                                     | reac H <sub>2</sub> O                         |
| 460 | Borazine                              | B <sub>3</sub> N <sub>3</sub> H <sub>6</sub>                                       | 6569-51-3   | 80.501      | col liq                   | -58       | 53      | 0.824                      |                                     | reac H <sub>2</sub> O                         |
| 461 | Boric acid                            | H <sub>3</sub> BO <sub>3</sub>                                                     | 10043-35-3  | 61.833      | col tricr cry             | 170.9     |         | 1.5                        | 5.80 <sup>25</sup>                  | sl EtOH                                       |
| 462 | Metaboric acid (α form)               | HBO <sub>2</sub>                                                                   | 13460-50-9  | 43.818      | col orth cry; hyg         | 176       |         | 1.784                      |                                     | s H <sub>2</sub> O                            |
| 463 | Metaboric acid (β form)               | HBO <sub>2</sub>                                                                   | 13460-50-9  | 43.818      | col monocl cry; hyg       | 201       |         | 2.045                      |                                     | s H <sub>2</sub> O                            |
| 464 | Metaboric acid (γ form)               | HBO <sub>2</sub>                                                                   | 13460-50-9  | 43.818      | col cub cry               | 236       |         | 2.487                      |                                     | s H <sub>2</sub> O                            |
| 465 | Tetrafluoroboric acid                 | HF <sub>4</sub> B                                                                  | 16872-11-0  | 87.813      | col liq                   |           | 130 dec | ≈1.8                       |                                     | vs H <sub>2</sub> O, EtOH                     |
| 466 | Boron arsenide                        | BA <sub>s</sub>                                                                    | 12005-69-5  | 85.733      | brn cub cry               | 1100 dec  |         | 5.22                       |                                     |                                               |
| 467 | Boron carbide                         | B <sub>4</sub> C                                                                   | 12069-32-8  | 55.255      | hard blk cry              | 2350      | >3500   | 2.50                       |                                     | i H <sub>2</sub> O, acid                      |
| 468 | Boron nitride                         | BN                                                                                 | 10043-11-5  | 24.818      | wh powder; hex or cub cry | 2967      |         | 2.18                       |                                     | i H <sub>2</sub> O, acid                      |
| 469 | Boron oxide                           | B <sub>2</sub> O <sub>3</sub>                                                      | 1303-86-2   | 69.620      | col gl or hex cry; hyg    | 450       |         | 2.55                       | 2.2 <sup>20</sup>                   | s EtOH                                        |
| 470 | Boron phosphide                       | BP                                                                                 | 20205-91-8  | 41.785      | red cub cry or powder     | 1125 dec  |         |                            |                                     | reac H <sub>2</sub> O, acid                   |
| 471 | Boron silicide                        | B <sub>6</sub> Si                                                                  | 12008-29-6  | 92.952      | blk cry                   | 1980      |         |                            |                                     |                                               |
| 472 | Boron sulfide                         | B <sub>2</sub> S <sub>3</sub>                                                      | 12007-33-9  | 117.817     | yel amorp solid           | 563       |         | ≈1.7                       |                                     |                                               |
| 473 | Boron tribromide                      | BB <sub>3</sub>                                                                    | 10294-33-4  | 250.523     | col liq; hyg              | -46       | 91.3    | 2.6                        |                                     | reac H <sub>2</sub> O, EtOH                   |
| 474 | Boron trichloride                     | BCl <sub>3</sub>                                                                   | 10294-34-5  | 117.170     | col liq or gas            | -107.3    | 12.5    | 4.789 g/L                  |                                     | reac H <sub>2</sub> O, EtOH                   |
| 475 | Boron trifluoride                     | BF <sub>3</sub>                                                                    | 7637-07-2   | 67.806      | col gas                   | -126.8    | -99.9   | 2.772 g/L                  |                                     | s H <sub>2</sub> O                            |
| 476 | Boron trifluoride etherate            | BF <sub>3</sub> (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O                    | 109-63-7    | 141.927     | liq                       | -60.4     | 125.5   | 1.125 <sup>25</sup>        |                                     | reac H <sub>2</sub> O; vs eth, EtOH           |
| 477 | Boron triiodide                       | BI <sub>3</sub>                                                                    | 13517-10-7  | 391.524     | wh needles                | 49.7      | 209.5   | 3.35                       |                                     | i H <sub>2</sub> O                            |
| 478 | Bromine                               | Br <sub>2</sub>                                                                    | 7726-95-6   | 159.808     | red liq                   | -7.2      | 58.8    | 3.1028                     |                                     | sl H <sub>2</sub> O                           |
| 479 | Bromic acid                           | HBrO <sub>3</sub>                                                                  | 7789-31-3   | 128.910     | stab only in aq soln      |           |         |                            |                                     | s H <sub>2</sub> O                            |
| 480 | Hypobromous acid                      | HOBr                                                                               | 13517-11-8  | 96.911      | exists aq soln            |           |         |                            |                                     | s H <sub>2</sub> O                            |
| 481 | Bromine dioxide                       | BrO <sub>2</sub>                                                                   | 21255-83-4  | 111.903     | unstab yel cry            | ≈0 dec    |         |                            |                                     |                                               |
| 482 | Bromine monoxide                      | Br <sub>2</sub> O                                                                  | 21308-80-5  | 175.807     | unstab brn solid          | -17.5 dec |         |                            |                                     |                                               |
| 483 | Dibromine trioxide                    | Br <sub>2</sub> O <sub>3</sub>                                                     | 53809-75-9  | 207.806     | oran needles (LT)         | dec -40   |         |                            |                                     |                                               |
| 484 | Dibromine pentoxide                   | Br <sub>2</sub> O <sub>5</sub>                                                     | 58572-43-3  | 239.805     | col cry (low temp)        | -20 dec   |         |                            |                                     |                                               |
| 485 | Bromine azide                         | BrN <sub>3</sub>                                                                   | 13973-87-0  | 121.924     | red cry; exp              | ≈45       | exp     |                            |                                     |                                               |
| 486 | Bromine chloride                      | BrCl                                                                               | 13863-41-7  | 115.357     | dark red liq (<5°C)       | -66       | 5 dec   |                            |                                     | reac H <sub>2</sub> O; s eth, CS <sub>2</sub> |
| 487 | Bromine fluoride                      | BrF                                                                                | 13863-59-7  | 98.902      | unstab red-brn gas        | ≈-33      | ≈20 dec | 4.043 g/L                  |                                     |                                               |
| 488 | Bromine trifluoride                   | BrF <sub>3</sub>                                                                   | 7787-71-5   | 136.899     | col hyg liq               | 8.77      | 125.8   | 2.803                      |                                     | reac H <sub>2</sub> O                         |
| 489 | Bromine pentafluoride                 | BrF <sub>5</sub>                                                                   | 7789-30-2   | 174.896     | col liq                   | -60.5     | 41.3    | 2.460                      |                                     | reac H <sub>2</sub> O (exp)                   |
| 490 | Bromosyl trifluoride                  | BrOF <sub>3</sub>                                                                  | 61519-37-7  | 152.898     | col liq                   | -5        | dec >20 |                            |                                     | reac H <sub>2</sub> O                         |
| 491 | Bromyl fluoride                       | BrO <sub>2</sub> F                                                                 | 22585-64-4  | 130.901     | col liq                   | -9        | dec 55  |                            |                                     | reac H <sub>2</sub> O                         |
| 492 | Perbromyl fluoride                    | BrO <sub>3</sub> F                                                                 | 37265-91-1  | 146.900     | col gas                   | -110      | dec 20  |                            |                                     | reac H <sub>2</sub> O                         |
| 493 | Cadmium                               | Cd                                                                                 | 7440-43-9   | 112.411     | silv-wh metal             | 321.069   | 767     | 8.69                       |                                     | i H <sub>2</sub> O; reac acid                 |
| 494 | Cadmium acetate                       | Cd(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                     | 543-90-8    | 230.500     | col cry                   | 255       |         | 2.34                       |                                     | s H <sub>2</sub> O, EtOH                      |
| 495 | Cadmium acetate dihydrate             | Cd(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O | 5743-04-4   | 266.529     | wh cry                    | 130 dec   |         | 2.01                       |                                     | vs H <sub>2</sub> O; s EtOH                   |
| 496 | Cadmium antimonide                    | CdSb                                                                               | 12014-29-8  | 234.171     | orth cry                  | 456       |         | 6.92                       |                                     |                                               |
| 497 | Cadmium arsenide                      | CdAs <sub>2</sub>                                                                  | 12006-15-4  | 487.076     | gray tetr cry             | 721       |         | 6.25                       |                                     |                                               |
| 498 | Cadmium azide                         | Cd(N <sub>3</sub> ) <sub>2</sub>                                                   | 14215-29-3  | 196.451     | yel-wh orth cry; exp      | exp       |         | 3.24                       |                                     |                                               |
| 499 | Cadmium borotungstate octadecahydrate | Cd <sub>3</sub> (BW <sub>12</sub> O <sub>40</sub> ) · 18H <sub>2</sub> O           | 1306-26-9   | 3743.20     | yel cry                   |           |         |                            |                                     | vs H <sub>2</sub> O                           |
| 500 | Cadmium bromide                       | CdBr <sub>2</sub>                                                                  | 7789-42-6   | 272.219     | wh-yel hex cry; hyg       | 568       | 863     | 5.19                       | 115 <sup>25</sup>                   | sl ace, eth                                   |
| 501 | Cadmium bromide tetrahydrate          | CdBr <sub>2</sub> · 4H <sub>2</sub> O                                              | 13464-92-1  | 344.281     | wh-yel cry                |           |         |                            | 115 <sup>25</sup>                   | s ace, EtOH                                   |
| 502 | Cadmium carbonate                     | CdCO <sub>3</sub>                                                                  | 513-78-0    | 172.420     | wh hex cry                | 500 dec   |         | 5.026                      |                                     | i H <sub>2</sub> O; s acid                    |
| 503 | Cadmium chlorate dihydrate            | Cd(ClO <sub>3</sub> ) <sub>2</sub> · 2H <sub>2</sub> O                             | 22750-54-5* | 315.344     | col hyg cry               | 80 dec    |         | 2.28                       | 2.64 <sup>9</sup>                   |                                               |
| 504 | Cadmium chloride                      | CdCl <sub>2</sub>                                                                  | 10108-64-2  | 183.317     | rhomb cry; hyg            | 568       | 964     | 4.08                       | 120 <sup>25</sup>                   | s ace; sl EtOH; i eth                         |
| 505 | Cadmium chloride monohydrate          | CdCl <sub>2</sub> · H <sub>2</sub> O                                               | 34330-64-8  | 201.332     | wh cry                    |           |         |                            | 120 <sup>25</sup>                   |                                               |
| 506 | Cadmium chloride hemipentahydrate     | CdCl <sub>2</sub> · 2.5H <sub>2</sub> O                                            | 7790-78-5   | 228.354     | wh rhomb leaflets         |           |         | 3.327                      | 120 <sup>25</sup>                   | s ace                                         |
| 507 | Cadmium chromate                      | CdCrO <sub>4</sub>                                                                 | 14312-00-6  | 228.405     | yel orth cry              |           |         | 4.5                        |                                     | i H <sub>2</sub> O                            |
| 508 | Cadmium cyanide                       | Cd(CN) <sub>2</sub>                                                                | 542-83-6    | 164.445     | wh cub cry                |           |         | 2.23                       | 1.7 <sup>15</sup>                   |                                               |
| 509 | Cadmium dichromate monohydrate        | CdCr <sub>2</sub> O <sub>7</sub> · H <sub>2</sub> O                                | 69239-51-6  | 346.414     | oran solid                |           |         |                            |                                     | s H <sub>2</sub> O                            |
| 510 | Cadmium 2-ethylhexanoate              | Cd(C <sub>8</sub> H <sub>15</sub> O <sub>2</sub> ) <sub>2</sub>                    | 2420-98-6   | 398.818     | powder                    |           |         |                            |                                     |                                               |
| 511 | Cadmium fluoride                      | CdF <sub>2</sub>                                                                   | 7790-79-6   | 150.408     | cub cry                   | 1075      | 1750    | 6.33                       | 4.36 <sup>25</sup>                  | s acid; i EtOH                                |
| 512 | Cadmium hydroxide                     | Cd(OH) <sub>2</sub>                                                                | 21041-95-2  | 146.426     | wh trig or hex cry        | 130 dec   |         | 4.79                       | 0.00015 <sup>20</sup>               | s dil acid                                    |
| 513 | Cadmium iodate                        | Cd(IO <sub>3</sub> ) <sub>2</sub>                                                  | 7790-81-0   | 462.216     | wh powder                 |           |         | 6.48                       | 0.091 <sup>25</sup>                 | s HNO <sub>3</sub>                            |

| No. | Name                            | Formula                                                                                          | CAS Reg No. | Mol. weight | Physical form             | mp/°C             | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                         |
|-----|---------------------------------|--------------------------------------------------------------------------------------------------|-------------|-------------|---------------------------|-------------------|----------|----------------------------|-------------------------------------|------------------------------------------------|
| 514 | Cadmium iodide                  | CdI <sub>2</sub>                                                                                 | 7790-80-9   | 366.220     | col hex flakes            | 388               | 744      | 5.64                       | 86.2 <sup>25</sup>                  | vs H <sub>2</sub> O; s EtOH, eth, ace          |
| 515 | Cadmium metasilicate            | CdSiO <sub>3</sub>                                                                               | 13477-19-5  | 188.495     | grn monoc cry             | 1252              |          | 5.10                       |                                     |                                                |
| 516 | Cadmium molybdate               | CdMoO <sub>4</sub>                                                                               | 13972-68-4  | 272.35      | col tetr cry              | ≈900 dec          |          | 5.4                        |                                     | i H <sub>2</sub> O; s acid                     |
| 517 | Cadmium niobate                 | Cd <sub>2</sub> Nb <sub>2</sub> O <sub>7</sub>                                                   | 12187-14-3  | 522.631     | cub cry                   | ≈1410             |          | 6.28                       |                                     | i H <sub>2</sub> O                             |
| 518 | Cadmium nitrate                 | Cd(NO <sub>3</sub> ) <sub>2</sub>                                                                | 10325-94-7  | 236.420     | wh cub cry; hyg           | 360               |          | 3.6                        | 156 <sup>25</sup>                   | s EtOH                                         |
| 519 | Cadmium nitrate tetrahydrate    | Cd(NO <sub>3</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                                            | 10022-68-1  | 308.482     | col orth cry; hyg         | 59.5              |          | 2.45                       | 156 <sup>25</sup>                   | s EtOH, ace                                    |
| 520 | Cadmium oxalate                 | CdC <sub>2</sub> O <sub>4</sub>                                                                  | 814-88-0    | 200.430     | wh solid                  |                   |          | 3.32                       | 0.0060 <sup>25</sup>                |                                                |
| 521 | Cadmium oxalate trihydrate      | CdC <sub>2</sub> O <sub>4</sub> · 3H <sub>2</sub> O                                              | 20712-42-9  | 254.476     | wh amorp powder           | 340 dec           |          |                            | 0.0060 <sup>25</sup>                | i EtOH; s dil acid                             |
| 522 | Cadmium oxide                   | CdO                                                                                              | 1306-19-0   | 128.410     | brn cub cry               |                   | 1559 sp  | 8.15                       |                                     | i H <sub>2</sub> O; s dil acid                 |
| 523 | Cadmium 2,4-pentanedioate       | Cd(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>                                          | 14689-45-3  | 310.627     | wh solid or red cry       | 235               |          |                            |                                     |                                                |
| 524 | Cadmium perchlorate hexahydrate | Cd(ClO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                           | 10326-28-0  | 419.404     | wh hex cry                |                   |          | 2.37                       | 191.5 <sup>25</sup>                 |                                                |
| 525 | Cadmium phosphate               | Cd <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>                                                  | 13477-17-3  | 527.176     | powder                    | ≈1500             |          |                            |                                     | i H <sub>2</sub> O                             |
| 526 | Cadmium phosphide               | Cd <sub>3</sub> P <sub>2</sub>                                                                   | 12014-28-7  | 399.181     | grn tetr needles          | 700               |          | 5.96                       |                                     | s dil HCl                                      |
| 527 | Cadmium selenate dihydrate      | CdSeO <sub>4</sub> · 2H <sub>2</sub> O                                                           | 10060-09-0  | 291.40      | orth cry                  | 100 dec           |          | 3.62                       | 70.5 <sup>25</sup>                  |                                                |
| 528 | Cadmium selenide                | CdSe                                                                                             | 1306-24-7   | 191.37      | wh cub cry                | 1240              |          | 5.81                       |                                     | i H <sub>2</sub> O                             |
| 529 | Cadmium selenite                | CdSeO <sub>3</sub>                                                                               | 13814-59-0  | 239.37      | col prisms                |                   |          |                            |                                     |                                                |
| 530 | Cadmium stearate                | Cd(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>2</sub>                                 | 22223-93-0  | 679.350     | wh cry pow                | 134               |          | 1.21                       |                                     |                                                |
| 531 | Cadmium succinate               | CdC <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                                                   | 141-00-4    | 228.484     | wh pow or needles         |                   |          |                            | 0.37 <sup>40</sup>                  | sl H <sub>2</sub> O; i EtOH                    |
| 532 | Cadmium sulfate                 | CdSO <sub>4</sub>                                                                                | 10124-36-4  | 208.474     | col orth cry              | 1000              |          | 4.69                       | 76.7 <sup>25</sup>                  | i EtOH                                         |
| 533 | Cadmium sulfate monohydrate     | CdSO <sub>4</sub> · H <sub>2</sub> O                                                             | 7790-84-3   | 226.489     | monoc cry                 | 105               |          | 3.79                       | 76.7 <sup>25</sup>                  |                                                |
| 534 | Cadmium sulfate octahydrate     | CdSO <sub>4</sub> · 8H <sub>2</sub> O                                                            | 15244-35-6  | 352.596     | col monoc cry             | 40 dec            |          | 3.08                       | 76.7 <sup>25</sup>                  |                                                |
| 535 | Cadmium sulfide                 | CdS                                                                                              | 1306-23-6   | 144.476     | yel-oran hex cry          | ≈1480             |          | 4.826                      |                                     | i H <sub>2</sub> O; s acid                     |
| 536 | Cadmium sulfite                 | CdSO <sub>3</sub>                                                                                | 13477-23-1  | 192.474     | col prisms                | dec ≈400          |          |                            | 0.05 <sup>20</sup>                  | sl H <sub>2</sub> O                            |
| 537 | Cadmium telluride               | CdTe                                                                                             | 1306-25-8   | 240.01      | brn-blk cub cry           | 1042              |          | 6.2                        |                                     | i H <sub>2</sub> O, dil acid                   |
| 538 | Cadmium tellurite               | CdTeO <sub>3</sub>                                                                               | 15851-44-2  | 288.01      | col monoc cry             | 695               | dec 1050 |                            |                                     |                                                |
| 539 | Cadmium tetrafluoroborate       | Cd(BF <sub>4</sub> ) <sub>2</sub>                                                                | 14486-19-2  | 286.020     | col hyg liq               |                   |          | 1.6                        |                                     | vs H <sub>2</sub> O, EtOH                      |
| 540 | Cadmium titanate                | CdTiO <sub>3</sub>                                                                               | 12014-14-1  | 208.276     | orth cry                  |                   |          | 6.5                        |                                     |                                                |
| 541 | Cadmium tungstate               | CdWO <sub>4</sub>                                                                                | 7790-85-4   | 360.25      | wh monoc cry              |                   |          | 8.0                        |                                     | i H <sub>2</sub> O, acid; s NH <sub>4</sub> OH |
| 542 | Calcium                         | Ca                                                                                               | 7440-70-2   | 40.078      | silv-wh metal             | 842               | 1484     | 1.54                       |                                     | reac H <sub>2</sub> O; i bz                    |
| 543 | Calcium acetate                 | Ca(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                                   | 62-54-4     | 158.167     | wh hyg cry                | 160 dec           |          | 1.50                       |                                     | s H <sub>2</sub> O; sl EtOH                    |
| 544 | Calcium acetate monohydrate     | Ca(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                | 5743-26-0   | 176.182     | wh needles or powder      | ≈150 dec          |          |                            |                                     | s H <sub>2</sub> O; sl EtOH                    |
| 545 | Calcium acetate dihydrate       | Ca(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O               | 14977-17-4  | 194.196     | long col needles          |                   |          |                            |                                     | s H <sub>2</sub> O                             |
| 546 | Calcium aluminate               | CaAl <sub>2</sub> O <sub>4</sub>                                                                 | 12042-68-1  | 158.039     | wh monoc cry              | 1605              |          | 2.98                       |                                     | reac H <sub>2</sub> O                          |
| 547 | Calcium aluminate (β form)      | Ca <sub>2</sub> Al <sub>2</sub> O <sub>5</sub>                                                   | 12042-78-3  | 270.193     | wh cub cry; refr          | 1535              |          | 3.04                       |                                     | i H <sub>2</sub> O                             |
| 548 | Calcium arsenate                | Ca <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub>                                                 | 7778-44-1   | 398.072     | wh powder                 | dec               |          | 3.6                        | 0.0036 <sup>20</sup>                | s dil acid                                     |
| 549 | Calcium arsenite (1:1)          | CaAsO <sub>3</sub>                                                                               | 52740-16-6  | 162.998     | wh powder                 |                   |          |                            |                                     | sl H <sub>2</sub> O; s acid                    |
| 550 | Calcium borate hexahydrate      | CaB <sub>3</sub> O <sub>7</sub> · 6H <sub>2</sub> O                                              | 13701-64-9* | 303.409     | wh cry pow                | 1162 (anh)        |          |                            |                                     |                                                |
| 551 | Calcium boride                  | CaB <sub>6</sub>                                                                                 | 12007-99-7  | 104.944     | refrac solid              | 2235              |          | 2.49                       |                                     |                                                |
| 552 | Calcium bromate                 | Ca(BrO <sub>3</sub> ) <sub>2</sub>                                                               | 10102-75-7  | 295.882     | wh pow                    | 180               |          |                            |                                     |                                                |
| 553 | Calcium bromate monohydrate     | Ca(BrO <sub>3</sub> ) <sub>2</sub> · H <sub>2</sub> O                                            | 10102-75-7* | 313.898     | wh monoc cry              | dec 180           |          | 3.33                       |                                     | vs H <sub>2</sub> O                            |
| 554 | Calcium bromide                 | CaBr <sub>2</sub>                                                                                | 7789-41-5   | 199.886     | rhom cry; hyg             | 742               | 1815     | 3.38                       | 156 <sup>25</sup>                   | s EtOH, ace                                    |
| 555 | Calcium bromide dihydrate       | CaBr <sub>2</sub> · 2H <sub>2</sub> O                                                            | 22208-73-7  | 235.917     | wh cry pow                |                   |          |                            |                                     | vs H <sub>2</sub> O                            |
| 556 | Calcium bromide hexahydrate     | CaBr <sub>2</sub> · 6H <sub>2</sub> O                                                            | 13477-28-6  | 307.977     | wh hyg powder             | 38 dec            |          | 2.29                       | 156 <sup>25</sup>                   |                                                |
| 557 | Calcium carbide                 | CaC <sub>2</sub>                                                                                 | 75-20-7     | 64.099      | gray-blk orth cry         | 2300              |          | 2.22                       |                                     | reac H <sub>2</sub> O                          |
| 558 | Calcium carbonate (aragonite)   | CaCO <sub>3</sub>                                                                                | 471-34-1    | 100.087     | wh orth cry or powder     | trans calcite 450 |          | 2.930                      | 0.00066 <sup>20</sup>               | s dil acid                                     |
| 559 | Calcium carbonate (calcite)     | CaCO <sub>3</sub>                                                                                | 471-34-1    | 100.087     | wh hex cry or powder      | dec 700-900       |          | 2.710                      | 0.00066 <sup>20</sup>               | s dil acid                                     |
| 560 | Calcium carbonate (vaterite)    | CaCO <sub>3</sub>                                                                                | 471-34-1    | 100.087     | col hex cry               |                   |          | 2.653                      | 0.0011 <sup>25</sup>                | s dil acid                                     |
| 561 | Calcium chlorate                | Ca(ClO <sub>3</sub> ) <sub>2</sub>                                                               | 10137-74-3  | 206.980     | wh cry                    | 340               |          |                            | 197 <sup>25</sup>                   |                                                |
| 562 | Calcium chlorate dihydrate      | Ca(ClO <sub>3</sub> ) <sub>2</sub> · 2H <sub>2</sub> O                                           | 10035-05-9  | 243.011     | wh monoc cry; hyg         | 100 dec           |          | 2.711                      | 197 <sup>25</sup>                   | s EtOH                                         |
| 563 | Calcium chloride                | CaCl <sub>2</sub>                                                                                | 10043-52-4  | 110.984     | wh cub cry or powder; hyg | 775               | 1935     | 2.15                       | 81.3 <sup>25</sup>                  | vs EtOH                                        |
| 564 | Calcium chloride monohydrate    | CaCl <sub>2</sub> · H <sub>2</sub> O                                                             | 13477-29-7  | 128.999     | wh hyg cry                | 260 dec           |          | 2.24                       | 81.3 <sup>25</sup>                  | s EtOH                                         |
| 565 | Calcium chloride dihydrate      | CaCl <sub>2</sub> · 2H <sub>2</sub> O                                                            | 10035-04-8  | 147.015     | hyg flakes or powder      | 175 dec           |          | 1.85                       | 81.3 <sup>25</sup>                  | vs EtOH                                        |
| 566 | Calcium chloride tetrahydrate   | CaCl <sub>2</sub> · 4H <sub>2</sub> O                                                            | 25094-02-4  | 183.046     | col tric cry              |                   |          | 1.83                       |                                     |                                                |
| 567 | Calcium chloride hexahydrate    | CaCl <sub>2</sub> · 6H <sub>2</sub> O                                                            | 7774-34-7   | 219.075     | wh hex cry; hyg           | 30 dec            |          | 1.71                       | 81.3 <sup>25</sup>                  |                                                |
| 568 | Calcium chlorite                | Ca(ClO <sub>2</sub> ) <sub>2</sub>                                                               | 14674-72-7  | 174.982     | wh cub cry                |                   |          | 2.71                       |                                     | reac H <sub>2</sub> O                          |
| 569 | Calcium chromate                | CaCrO <sub>4</sub>                                                                               | 13765-19-0  | 156.072     | yel cry                   | 1000 dec          |          |                            |                                     | sl H <sub>2</sub> O; i EtOH, ace               |
| 570 | Calcium chromate dihydrate      | CaCrO <sub>4</sub> · 2H <sub>2</sub> O                                                           | 10060-08-9  | 192.102     | yel orth cry              | dec 200           |          | 2.50                       | 13.2 <sup>20</sup>                  | s dil acids                                    |
| 571 | Calcium citrate tetrahydrate    | Ca <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sub>2</sub> · 4H <sub>2</sub> O | 5785-44-4   | 570.494     | wh needles or pow         | dec 100           |          |                            | 0.096 <sup>23</sup>                 | i eth                                          |
| 572 | Calcium cyanamide               | CaCN <sub>2</sub>                                                                                | 156-62-7    | 80.102      | col hex cry               | ≈1340             | subl     | 2.29                       |                                     | reac H <sub>2</sub> O                          |
| 573 | Calcium cyanide                 | Ca(CN) <sub>2</sub>                                                                              | 592-01-8    | 92.112      | wh rhomb cry; hyg         |                   |          |                            |                                     | s H <sub>2</sub> O, EtOH                       |

| No. | Name                                     | Formula                                                             | CAS Reg No. | Mol. weight | Physical form            | mp/°C         | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                       |
|-----|------------------------------------------|---------------------------------------------------------------------|-------------|-------------|--------------------------|---------------|-------|----------------------------|-------------------------------------|----------------------------------------------|
| 574 | Calcium dichromate trihydrate            | CaCr <sub>2</sub> O <sub>7</sub> · 3H <sub>2</sub> O                | 14307-33-6* | 310.112     | red-oran cry             | 100 dec       |       | 2.37                       |                                     | vs H <sub>2</sub> O; reac EtOH; i eth, ctc   |
| 575 | Calcium dihydrogen phosphate monohydrate | Ca(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> · H <sub>2</sub> O | 10031-30-8  | 252.068     | col tricl plates         | 100 dec       |       | 2.220                      |                                     | sl H <sub>2</sub> O; s dil acid              |
| 576 | Calcium 2-ethylhexanoate                 | Ca(C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> ) <sub>2</sub>     | 136-51-6    | 326.485     | powder                   |               |       |                            |                                     |                                              |
| 577 | Calcium ferrocyanide dodecahydrate       | Ca <sub>2</sub> Fe(CN) <sub>6</sub> · 12H <sub>2</sub> O            |             | 508.289     | yel tricl cry            | dec           |       | 1.68                       | 87 <sup>25</sup>                    | vs H <sub>2</sub> O; i EtOH                  |
| 578 | Calcium fluoride                         | CaF <sub>2</sub>                                                    | 7789-75-5   | 78.075      | wh cub cry or powder     | 1418          | 2500  | 3.18                       | 0.0016 <sup>25</sup>                | sl acid                                      |
| 579 | Calcium fluorophosphate                  | Ca <sub>3</sub> (PO <sub>3</sub> ) <sub>2</sub> F                   | 12015-73-5  | 504.302     | col hex cry              | 1650          |       | 3.201                      |                                     | i H <sub>2</sub> O                           |
| 580 | Calcium fluorophosphate dihydrate        | CaPO <sub>3</sub> F · 2H <sub>2</sub> O                             | 37809-19-1  | 174.079     | col monocl cry           |               |       |                            | 0.42 <sup>27</sup>                  | i os                                         |
| 581 | Calcium formate                          | Ca(CHO <sub>2</sub> ) <sub>2</sub>                                  | 544-17-2    | 130.113     | orth cry                 | 300 dec       |       | 2.02                       | 16.6 <sup>20</sup>                  | i EtOH                                       |
| 582 | Calcium hexaborate pentahydrate          | 2CaO · 3B <sub>2</sub> O <sub>3</sub> · 5H <sub>2</sub> O           | 12291-65-5  | 411.091     | col monocl cry           | dec 375 (exp) |       | 2.42                       | 1 <sup>25</sup>                     | sl acid                                      |
| 583 | Calcium hexafluoro-2,4-pentanedioate     | Ca(CF <sub>3</sub> COCHCOCF <sub>3</sub> ) <sub>2</sub>             | 121012-90-6 | 454.180     | powder                   | 135           |       |                            |                                     |                                              |
| 584 | Calcium hexafluorosilicate dihydrate     | CaSiF <sub>6</sub> · 2H <sub>2</sub> O                              | 16925-39-6  | 218.185     | col tetr cry             |               |       | 2.25                       | 0.52 <sup>20</sup>                  | i ace; reac hot H <sub>2</sub> O             |
| 585 | Calcium hydride                          | CaH <sub>2</sub>                                                    | 7789-78-8   | 42.094      | gray orth cry or powder  | 1000          |       | 1.7                        |                                     | reac H <sub>2</sub> O, EtOH                  |
| 586 | Calcium hydrogen phosphate               | CaHPO <sub>4</sub>                                                  | 7757-93-9   | 136.057     | wh tricl cry             | dec           |       | 2.92                       | 0.02 <sup>25</sup>                  | i EtOH                                       |
| 587 | Calcium hydrogen phosphate dihydrate     | CaHPO <sub>4</sub> · 2H <sub>2</sub> O                              | 7789-77-7   | 172.088     | monocl cry               | ≈100 dec      |       | 2.31                       | 0.02 <sup>25</sup>                  | i EtOH; s dil acid                           |
| 588 | Calcium hydrogen sulfite                 | CaH <sub>2</sub> (SO <sub>3</sub> ) <sub>2</sub>                    | 13780-03-5  | 202.220     |                          |               |       | 1.06                       |                                     | s H <sub>2</sub> O                           |
| 589 | Calcium hydrosulfide hexahydrate         | Ca(HS) <sub>2</sub> · 6H <sub>2</sub> O                             |             | 214.315     | col cry                  | dec           |       |                            |                                     | s H <sub>2</sub> O, EtOH                     |
| 590 | Calcium hydroxide                        | Ca(OH) <sub>2</sub>                                                 | 1305-62-0   | 74.093      | soft hex cry             |               |       | ≈2.2                       | 0.160 <sup>20</sup>                 | s acid                                       |
| 591 | Calcium hydroxide phosphate              | Ca <sub>3</sub> (OH)(PO <sub>4</sub> ) <sub>3</sub>                 | 12167-74-7  | 502.311     | col hex cry              | dec >900      |       | 3.155                      |                                     | i H <sub>2</sub> O                           |
| 592 | Calcium hypochlorite                     | Ca(OCl) <sub>2</sub>                                                | 7778-54-3   | 142.983     | powder                   | 100           |       | 2.350                      |                                     |                                              |
| 593 | Calcium hypophosphite                    | Ca(H <sub>2</sub> PO <sub>2</sub> ) <sub>2</sub>                    | 7789-79-9   | 170.055     | wh monocl cry            | 300 dec       |       |                            |                                     | s H <sub>2</sub> O; i EtOH                   |
| 594 | Calcium iodate                           | Ca(IO <sub>3</sub> ) <sub>2</sub>                                   | 7789-80-2   | 389.883     | wh monocl cry            |               |       | 4.52                       | 0.306 <sup>25</sup>                 | s HNO <sub>3</sub> ; i EtOH                  |
| 595 | Calcium iodide                           | CaI <sub>2</sub>                                                    | 10102-68-8  | 293.887     | hyg hex cry              | 783           | 1100  | 3.96                       | 215 <sup>25</sup>                   | s MeOH, EtOH, ace; i eth                     |
| 596 | Calcium iodide hexahydrate               | CaI <sub>2</sub> · 6H <sub>2</sub> O                                | 71626-98-7  | 401.978     | wh hex needles or powder | 42 dec        |       | 2.55                       | 215 <sup>25</sup>                   | vs EtOH                                      |
| 597 | Calcium metaborate                       | Ca(BO <sub>2</sub> ) <sub>2</sub>                                   | 13701-64-9  | 125.698     | powder                   |               |       |                            | 0.13 <sup>20</sup>                  |                                              |
| 598 | Calcium metasilicate                     | CaSiO <sub>3</sub>                                                  | 1344-95-2   | 116.162     | wh monocl cry            | 1540          |       | 2.92                       |                                     | i H <sub>2</sub> O                           |
| 599 | Calcium molybdate                        | CaMoO <sub>4</sub>                                                  | 7789-82-4   | 200.02      | wh tetr cry              | 1520          |       | 4.35                       | 0.0011 <sup>20</sup>                | i EtOH; s conc acid                          |
| 600 | Calcium nitrate                          | Ca(NO <sub>3</sub> ) <sub>2</sub>                                   | 10124-37-5  | 164.087     | wh cub cry; hyg          | 561           |       | 2.5                        | 144 <sup>25</sup>                   | s EtOH, MeOH, ace                            |
| 601 | Calcium nitrate tetrahydrate             | Ca(NO <sub>3</sub> ) <sub>2</sub> · 4H <sub>2</sub> O               | 13477-34-4  | 236.149     | wh cry                   | ≈40 dec       |       | 1.82                       | 144 <sup>25</sup>                   | s EtOH, ace                                  |
| 602 | Calcium nitride                          | Ca <sub>3</sub> N <sub>2</sub>                                      | 12013-82-0  | 148.247     | red-brn cub cry          | 1195          |       | 2.67                       |                                     | s H <sub>2</sub> O, acid; i EtOH             |
| 603 | Calcium nitrite                          | Ca(NO <sub>2</sub> ) <sub>2</sub>                                   | 13780-06-8  | 132.089     | wh-yel hex cry; hyg      | 392           |       | 2.23                       | 94.6 <sup>25</sup>                  | sl EtOH                                      |
| 604 | Calcium nitrite monohydrate              | Ca(NO <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                | 10031-34-2  | 150.104     | col or yel cry           | dec 100       |       |                            |                                     | vs H <sub>2</sub> O; sl EtOH                 |
| 605 | Calcium oleate                           | Ca(C <sub>18</sub> H <sub>33</sub> O <sub>2</sub> ) <sub>2</sub>    | 142-17-6    | 602.985     | pale yel solid           | dec 140       |       |                            | 0.04 <sup>25</sup>                  | sl H <sub>2</sub> O; s bz; i EtOH, ace, eth  |
| 606 | Calcium oxalate                          | CaC <sub>2</sub> O <sub>4</sub>                                     | 563-72-4    | 128.097     | wh cry powder            |               |       | 2.2                        | 0.00061 <sup>20</sup>               |                                              |
| 607 | Calcium oxalate monohydrate              | CaC <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> O                  | 5794-28-5   | 146.112     | cub cry                  | 200 dec       |       | 2.2                        | 0.00061 <sup>20</sup>               | s dil acid                                   |
| 608 | Calcium oxide                            | CaO                                                                 | 1305-78-8   | 56.077      | gray-wh cub cry          | 2613          |       | 3.34                       |                                     | reac H <sub>2</sub> O; s acid                |
| 609 | Calcium oxide silicate                   | Ca <sub>3</sub> OSiO <sub>4</sub>                                   | 12168-85-3  | 228.317     | refrac solid             | 2150          |       |                            |                                     |                                              |
| 610 | Calcium palmitate                        | Ca(C <sub>16</sub> H <sub>31</sub> O <sub>2</sub> ) <sub>2</sub>    | 542-42-7    | 550.910     | wh-yel pow               | dec 155       |       |                            |                                     | i H <sub>2</sub> O, EtOH, eth, ace; sl bz    |
| 611 | Calcium perborate heptahydrate           | Ca(BO <sub>2</sub> ) <sub>2</sub> · 7H <sub>2</sub> O               |             | 283.803     | gray-wh pow              |               |       |                            |                                     | s H <sub>2</sub> O, acid                     |
| 612 | Calcium 2,4-pentanedioate                | Ca(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>             | 19372-44-2  | 238.294     | cry                      | dec 175       |       |                            |                                     |                                              |
| 613 | Calcium perchlorate                      | Ca(ClO <sub>4</sub> ) <sub>2</sub>                                  | 13477-36-6  | 238.979     | wh cry                   | 270 dec       |       | 2.65                       | 188 <sup>25</sup>                   | s EtOH, MeOH                                 |
| 614 | Calcium perchlorate tetrahydrate         | Ca(ClO <sub>4</sub> ) <sub>2</sub> · 4H <sub>2</sub> O              | 15627-86-8  | 311.041     | wh cry                   |               |       |                            |                                     | vs H <sub>2</sub> O                          |
| 615 | Calcium permanganate                     | Ca(MnO <sub>4</sub> ) <sub>2</sub>                                  | 10118-76-0  | 277.949     | purp hyg cry             |               |       | 2.4                        | 331 <sup>20</sup>                   | reac EtOH                                    |
| 616 | Calcium peroxide                         | CaO <sub>2</sub>                                                    | 1305-79-9   | 72.077      | wh-yel tetr cry; hyg     | ≈200 dec      |       | 2.9                        |                                     | sl H <sub>2</sub> O; s acid                  |
| 617 | Calcium phosphate                        | Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>                     | 7758-87-4   | 310.177     | wh amorp powder          | 1670          |       | 3.14                       | 0.00012 <sup>20</sup>               | i EtOH; s dil acid                           |
| 618 | Calcium phosphide                        | Ca <sub>3</sub> P <sub>2</sub>                                      | 1305-99-3   | 182.182     | red-brn hyg cry          | ≈1600         |       | 2.51                       |                                     | reac H <sub>2</sub> O; i EtOH, eth           |
| 619 | Calcium phosphonate monohydrate          | CaHPO <sub>3</sub> · H <sub>2</sub> O                               | 25232-60-4  | 138.073     | col monocl cry           | dec 150       |       |                            |                                     | sl H <sub>2</sub> O; i EtOH                  |
| 620 | Calcium plumbate                         | Ca <sub>3</sub> PbO <sub>4</sub>                                    | 12013-69-3  | 351.4       | oran-brn orth cry        | dec           |       | 5.71                       |                                     | i H <sub>2</sub> O; s acid                   |
| 621 | Calcium propanoate                       | Ca(C <sub>3</sub> H <sub>5</sub> O <sub>2</sub> ) <sub>2</sub>      | 4075-81-4   | 186.219     | monocl cry, powder       |               |       |                            |                                     | s H <sub>2</sub> O; sl MeOH, EtOH; i ace, bz |
| 622 | Calcium pyrophosphate                    | Ca <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                       | 7790-76-3   | 254.099     | wh powder                | 1353          |       | 3.09                       |                                     | i H <sub>2</sub> O; s dil acid               |
| 623 | Calcium selenate dihydrate               | CaSeO <sub>4</sub> · 2H <sub>2</sub> O                              | 7790-74-1   | 219.07      | wh monocl cry            |               |       | 2.75                       | 8.3 <sup>18</sup>                   |                                              |
| 624 | Calcium selenide                         | CaSe                                                                | 1305-84-6   | 119.04      | wh-brn cub cry           | 1400 dec      |       | 3.8                        |                                     | reac H <sub>2</sub> O                        |
| 625 | Calcium silicide (CaSi)                  | CaSi                                                                | 12013-55-7  | 68.164      | orth cry                 | 1324          |       | 2.39                       |                                     |                                              |

| No. | Name                                      | Formula                                                                               | CAS Reg No. | Mol. weight | Physical form          | mp/°C              | bp/°C      | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                     |
|-----|-------------------------------------------|---------------------------------------------------------------------------------------|-------------|-------------|------------------------|--------------------|------------|----------------------------|-------------------------------------|------------------------------------------------------------|
| 626 | Calcium silicide (CaSi <sub>2</sub> )     | CaSi <sub>2</sub>                                                                     | 12013-56-8  | 96.249      | gray hex cry           | 1040               |            | 2.50                       |                                     | i cold H <sub>2</sub> O; reac hot H <sub>2</sub> O; s acid |
| 627 | Calcium stannate trihydrate               | CaSnO <sub>3</sub> · 3H <sub>2</sub> O                                                | 12013-46-6* | 260.832     | wh cry pow             | dec ~350           |            |                            |                                     | i H <sub>2</sub> O                                         |
| 628 | Calcium stearate                          | Ca(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>2</sub>                      | 1592-23-0   | 607.017     | granular powder        | 180                |            |                            |                                     | i H <sub>2</sub> O, EtOH                                   |
| 629 | Calcium succinate trihydrate              | CaC <sub>4</sub> H <sub>4</sub> O <sub>4</sub> · 3H <sub>2</sub> O                    | 140-99-8    | 210.196     | needles                |                    |            |                            |                                     | sl H <sub>2</sub> O; s dil acid; i EtOH                    |
| 630 | Calcium sulfate                           | CaSO <sub>4</sub>                                                                     | 7778-18-9   | 136.141     | orth cry               | 1460               |            | 2.96                       | 0.205 <sup>25</sup>                 |                                                            |
| 631 | Calcium sulfate hemihydrate               | CaSO <sub>4</sub> · 0.5H <sub>2</sub> O                                               | 10034-76-1  | 145.149     | wh powder              |                    |            |                            | 0.205 <sup>25</sup>                 |                                                            |
| 632 | Calcium sulfate dihydrate                 | CaSO <sub>4</sub> · 2H <sub>2</sub> O                                                 | 10101-41-4  | 172.171     | monocl cry or powder   | 150 dec            |            | 2.32                       | 0.205 <sup>20</sup>                 | i os                                                       |
| 633 | Calcium sulfide                           | CaS                                                                                   | 20548-54-3  | 72.143      | wh-yel cub cry; hyg    | 2524               |            | 2.59                       |                                     | sl H <sub>2</sub> O; i EtOH                                |
| 634 | Calcium sulfite dihydrate                 | CaSO <sub>3</sub> · 2H <sub>2</sub> O                                                 | 10257-55-3  | 156.172     | wh powder              |                    |            |                            | 0.0070 <sup>25</sup>                | sl EtOH; s acid                                            |
| 635 | Calcium tartrate tetrahydrate             | CaC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> · 4H <sub>2</sub> O                    | 3164-34-9*  | 260.210     | wh pow                 |                    |            |                            | 0.04 <sup>10</sup>                  | s dil acid; sl EtOH                                        |
| 636 | Calcium telluride                         | CaTe                                                                                  | 12013-57-9  | 167.68      | wh cub cry             | 1600 dec           |            | 4.87                       |                                     |                                                            |
| 637 | Calcium tetrahydroaluminate               | Ca(AlH <sub>4</sub> ) <sub>2</sub>                                                    | 16941-10-9  | 102.105     | gray powder; flam      |                    |            |                            |                                     | reac H <sub>2</sub> O; s thf; i eth, bz                    |
| 638 | Calcium thiocyanate tetrahydrate          | Ca(SCN) <sub>2</sub> · 4H <sub>2</sub> O                                              | 2092-16-2   | 228.304     | hyg cry                | 160 dec            |            |                            |                                     | vs H <sub>2</sub> O; s EtOH, ace                           |
| 639 | Calcium thiosulfate hexahydrate           | CaS <sub>2</sub> O <sub>3</sub> · 6H <sub>2</sub> O                                   | 10124-41-1  | 260.298     | tricl cry              | 45 dec             |            | 1.87                       |                                     | s H <sub>2</sub> O; i EtOH                                 |
| 640 | Calcium titanate                          | CaTiO <sub>3</sub>                                                                    | 12049-50-2  | 135.943     | cub cry                | 1980               |            | 3.98                       |                                     |                                                            |
| 641 | Calcium tungstate                         | CaWO <sub>4</sub>                                                                     | 7790-75-2   | 287.92      | wh tetr cry            | 1620               |            | 6.06                       | 0.2 <sup>18</sup>                   | s hot acid                                                 |
| 642 | Calcium zirconate                         | CaZrO <sub>3</sub>                                                                    | 12013-47-7  | 179.300     | powder                 | 2550               |            |                            |                                     |                                                            |
| 643 | Californium                               | Cf                                                                                    | 7440-71-3   | 251         | hex or cub metal       | 900                |            | 15.1                       |                                     |                                                            |
| 644 | Carbon (diamond)                          | C                                                                                     | 7782-40-3   | 12.011      | col cub cry            | 4440 (12.4 GPa)    |            | 3.513                      |                                     | i H <sub>2</sub> O                                         |
| 645 | Carbon (graphite)                         | C                                                                                     | 7782-42-5   | 12.011      | soft blk hex cry       | 4489 tp (10.3 MPa) | 3825 sp    | 2.2                        |                                     | i H <sub>2</sub> O                                         |
| 646 | Carbon black                              | C                                                                                     | 1333-86-4   | 12.011      | fine blk pow           |                    |            |                            |                                     | i H <sub>2</sub> O                                         |
| 647 | Carbon (fullerene-C <sub>60</sub> )       | C <sub>60</sub>                                                                       | 99685-96-8  | 720.642     | yel needles or plates  | >280               |            |                            |                                     | s os                                                       |
| 648 | Carbon (fullerene-C <sub>70</sub> )       | C <sub>70</sub>                                                                       | 115383-22-7 | 840.749     | red-brn solid          | >280               |            |                            |                                     | s bz, tol                                                  |
| 649 | Fullerene fluoride                        | C <sub>60</sub> F <sub>60</sub>                                                       | 134929-59-2 | 1860.546    | col plates             | 287                |            |                            |                                     | vs ace; s thf; i chl                                       |
| 650 | Carbon monoxide                           | CO                                                                                    | 630-08-0    | 28.010      | col gas                | -205.02            | -191.5     | 1.145 g/L                  |                                     | sl H <sub>2</sub> O; s chl, EtOH                           |
| 651 | Carbon dioxide                            | CO <sub>2</sub>                                                                       | 124-38-9    | 44.010      | col gas                | -56.558 tp         | -78.464 sp | 1.799 g/L                  |                                     | s H <sub>2</sub> O                                         |
| 652 | Carbon suboxide                           | C <sub>3</sub> O <sub>2</sub>                                                         | 504-64-3    | 68.031      | col gas                | -112.5             | 6.8        | 2.781 g/L                  |                                     | reac H <sub>2</sub> O                                      |
| 653 | Carbon disulfide                          | CS <sub>2</sub>                                                                       | 75-15-0     | 76.141      | col or yel liq         | -112.1             | 46         | 1.2632 <sup>20</sup>       |                                     | i H <sub>2</sub> O; vs EtOH, bz, os                        |
| 654 | Carbon subsulfide                         | C <sub>3</sub> S <sub>2</sub>                                                         | 627-34-9    | 100.162     | red liq                | -1                 | 90 dec     | 1.27                       |                                     | reac H <sub>2</sub> O                                      |
| 655 | Carbon diselenide                         | CSe <sub>2</sub>                                                                      | 506-80-9    | 169.93      | yel liq                | -43.7              | 125.5      | 2.6823 <sup>20</sup>       |                                     | i H <sub>2</sub> O; vs ctc, tol                            |
| 656 | Carbon oxysulfide                         | COS                                                                                   | 463-58-1    | 60.075      | col gas                | -138.8             | -50        | 2.456 g/L                  |                                     | s H <sub>2</sub> O, EtOH                                   |
| 657 | Carbon oxyselenide                        | COSe                                                                                  | 1603-84-5   | 106.97      | col gas; unstab        | -124.4             | -21.7      | 4.372 g/L                  |                                     | reac H <sub>2</sub> O                                      |
| 658 | Carbon sulfide selenide                   | CSSe                                                                                  | 5951-19-9   | 123.04      | yel liq                | -85                | 84.5       | 1.99                       |                                     | i H <sub>2</sub> O                                         |
| 659 | Carbon sulfide telluride                  | CSTe                                                                                  | 10340-06-4  | 171.68      | red-yel liq; unstab    | -54                | 20 dec     |                            |                                     | reac H <sub>2</sub> O                                      |
| 660 | Carbonyl bromide                          | COBr <sub>2</sub>                                                                     | 593-95-3    | 187.818     | col liq                |                    | 64.5       | 2.5                        |                                     | reac H <sub>2</sub> O                                      |
| 661 | Carbonyl chloride                         | COCl <sub>2</sub>                                                                     | 75-44-5     | 98.916      | col gas                | -127.78            | 8          | 4.043 g/L                  |                                     | sl H <sub>2</sub> O; s bz, tol                             |
| 662 | Carbonyl fluoride                         | COF <sub>2</sub>                                                                      | 353-50-4    | 66.007      | col gas                | -111.26            | -84.57     | 2.698 g/L                  |                                     | reac H <sub>2</sub> O                                      |
| 663 | Cyanogen                                  | C <sub>2</sub> N <sub>2</sub>                                                         | 460-19-5    | 52.034      | col gas                | -27.83             | -21.1      | 2.127 g/L                  |                                     | sl H <sub>2</sub> O, eth; s EtOH                           |
| 664 | Cyanogen azide                            | N <sub>3</sub> CN                                                                     | 764-05-6    | 68.038      | col oily liq           | exp                |            |                            |                                     |                                                            |
| 665 | Cyanogen bromide                          | BrCN                                                                                  | 506-68-3    | 105.922     | wh hyg needles         | 52                 | 61.5       | 2.015                      |                                     | s H <sub>2</sub> O, EtOH, eth                              |
| 666 | Cyanogen chloride                         | ClCN                                                                                  | 506-77-4    | 61.471      | col vol liq or gas     | -6.55              | 13         | 2.513 g/L                  |                                     | s H <sub>2</sub> O, EtOH, eth                              |
| 667 | Cyanogen fluoride                         | FCN                                                                                   | 1495-50-7   | 45.016      | col gas                | -82                | -46        | 1.840 g/L                  |                                     |                                                            |
| 668 | Cyanogen iodide                           | ICN                                                                                   | 506-78-5    | 152.922     | col needles            | 146.7              |            | 2.84                       |                                     | s H <sub>2</sub> O, EtOH, eth                              |
| 669 | Cerium                                    | Ce                                                                                    | 7440-45-1   | 140.116     | silv metal; cub or hex | 799                | 3443       | 6.770                      |                                     | s dil acid                                                 |
| 670 | Cerium boride                             | CeB <sub>6</sub>                                                                      | 12008-02-5  | 204.982     | blue refrac solid; hex | 2550               |            | 4.87                       |                                     | i H <sub>2</sub> O, HCl                                    |
| 671 | Cerium carbide                            | CeC <sub>2</sub>                                                                      | 12012-32-7  | 164.137     | red hex cry            | 2250               |            | 5.47                       |                                     | reac H <sub>2</sub> O                                      |
| 672 | Cerium carbide                            | Ce <sub>3</sub> C <sub>3</sub>                                                        | 12115-63-8  | 316.264     | yel-brn cub cry        | 1505               |            | 6.9                        |                                     |                                                            |
| 673 | Cerium nitride                            | CeN                                                                                   | 25764-08-3  | 154.123     | refrac cub cry         | 2557               |            | 7.89                       |                                     |                                                            |
| 674 | Cerium silicide                           | CeSi <sub>2</sub>                                                                     | 12014-85-6  | 196.287     | tetr cry               | 1420               |            | 5.31                       |                                     | i H <sub>2</sub> O                                         |
| 675 | Cerium(II) hydride                        | CeH <sub>2</sub>                                                                      | 13569-50-1  | 142.132     | cub cry                |                    |            | 5.45                       |                                     | reac H <sub>2</sub> O                                      |
| 676 | Cerium(II) iodide                         | CeI <sub>2</sub>                                                                      | 19139-47-0  | 393.925     | bronze cry             | 808                |            |                            |                                     |                                                            |
| 677 | Cerium(II) sulfide                        | CeS                                                                                   | 12014-82-3  | 172.181     | yel cub cry            | 2445               |            | 5.9                        |                                     |                                                            |
| 678 | Cerium(III) acetate sesquihydrate         | Ce(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · 1.5H <sub>2</sub> O  | 17829-82-2  |             | col cry                | dec 115            |            |                            | 26 <sup>15</sup>                    | s H <sub>2</sub> O                                         |
| 679 | Cerium(III) ammonium nitrate tetrahydrate | (NH <sub>4</sub> ) <sub>2</sub> Ce(NO <sub>3</sub> ) <sub>6</sub> · 4H <sub>2</sub> O | 13083-04-0  | 558.279     | col monocl cry         | 74                 |            |                            |                                     | vs H <sub>2</sub> O                                        |
| 680 | Cerium(III) ammonium sulfate tetrahydrate | NH <sub>4</sub> Ce(SO <sub>4</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                 | 21995-38-0* | 422.341     | monocl cry             |                    |            |                            |                                     | s H <sub>2</sub> O                                         |
| 681 | Cerium(III) bromide                       | CeBr <sub>3</sub>                                                                     | 14457-87-5  | 379.828     | wh hex cry; hyg        | 732                | 1457       |                            |                                     | s H <sub>2</sub> O                                         |

| No. | Name                                     | Formula                                                                               | CAS Reg No. | Mol. weight | Physical form                  | mp/°C      | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                           |
|-----|------------------------------------------|---------------------------------------------------------------------------------------|-------------|-------------|--------------------------------|------------|-------|----------------------------|-------------------------------------|--------------------------------------------------|
| 682 | Cerium(III) bromide heptahydrate         | CeBr <sub>3</sub> · 7H <sub>2</sub> O                                                 | 7789-56-2   | 505.935     | col hyg needles                | 732        |       |                            |                                     | s H <sub>2</sub> O, EtOH                         |
| 683 | Cerium(III) carbonate                    | Ce <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub>                                       | 537-01-9    | 460.259     | wh pow                         | dec 500    |       |                            |                                     | i H <sub>2</sub> O; s acid                       |
| 684 | Cerium(III) carbonate pentahydrate       | Ce <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub> · 5H <sub>2</sub> O                   | 72520-94-6  | 550.335     | wh powder                      |            |       |                            |                                     | i H <sub>2</sub> O; s dil acid                   |
| 685 | Cerium(III) chloride                     | CeCl <sub>3</sub>                                                                     | 7790-86-5   | 246.475     | wh hex cry                     | 807        |       | 3.97                       |                                     | s H <sub>2</sub> O, EtOH                         |
| 686 | Cerium(III) chloride heptahydrate        | CeCl <sub>3</sub> · 7H <sub>2</sub> O                                                 | 18618-55-8  | 372.582     | yel orth cry; hyg              | 90 dec     |       |                            |                                     | vs H <sub>2</sub> O, EtOH                        |
| 687 | Cerium(III) fluoride                     | CeF <sub>3</sub>                                                                      | 7758-88-5   | 197.111     | wh hex cry; hyg                | 1430       | 2180  | 6.157                      |                                     | i H <sub>2</sub> O                               |
| 688 | Cerium(III) hydride                      | CeH <sub>3</sub>                                                                      | 13864-02-3  | 143.140     | blk pow or blue-blk cry        | dec (flam) |       |                            |                                     | reac H <sub>2</sub> O                            |
| 689 | Cerium(III) hydroxide                    | Ce(OH) <sub>3</sub>                                                                   | 15785-09-8  | 191.138     | wh solid                       |            |       |                            |                                     | i H <sub>2</sub> O; s acid                       |
| 690 | Cerium(III) iodide                       | CeI <sub>3</sub>                                                                      | 7790-87-6   | 520.829     | yel orth cry; hyg              | 760        |       |                            |                                     | s H <sub>2</sub> O                               |
| 691 | Cerium(III) iodide nonahydrate           | CeI <sub>3</sub> · 9H <sub>2</sub> O                                                  | 7790-87-6*  | 682.967     | wh-red cry                     |            |       |                            |                                     | vs H <sub>2</sub> O; s EtOH                      |
| 692 | Cerium(III) nitrate hexahydrate          | Ce(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                 | 10108-73-3* | 434.222     | col-red cry                    | 150 dec    |       |                            | 176 <sup>25</sup>                   | s ace                                            |
| 693 | Cerium(III) oxalate nonahydrate          | Ce(C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                   | 13266-83-6  | 706.426     | wh pow                         | dec        |       |                            |                                     | i H <sub>2</sub> O, EtOH; s acid                 |
| 694 | Cerium(III) oxide                        | Ce <sub>2</sub> O <sub>3</sub>                                                        | 1345-13-7   | 328.230     | yel-grn cub cry                | 2210       | 3730  | 6.2                        |                                     | i H <sub>2</sub> O; s acid                       |
| 695 | Cerium(III) 2,4-pentanedioate trihydrate | Ce(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub> · 3H <sub>2</sub> O           | 15653-01-7  | 491.486     | yel hyg cry                    | ≈150       |       |                            |                                     | vs EtOH                                          |
| 696 | Cerium(III) perchlorate hexahydrate      | Ce(ClO <sub>4</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                | 36907-38-7  | 546.559     | hyg col cry                    | dec 200    |       |                            |                                     | s H <sub>2</sub> O, EtOH                         |
| 697 | Cerium(III) selenate                     | Ce <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub>                                      |             | 709.11      | rhomb cry                      |            |       | 4.46                       |                                     | s H <sub>2</sub> O                               |
| 698 | Cerium(III) sulfate                      | Ce <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                       | 13454-94-9  | 568.420     | col hyg cry                    | 920 dec    |       |                            |                                     | s H <sub>2</sub> O                               |
| 699 | Cerium(III) sulfate octahydrate          | Ce <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                   | 13454-94-9  | 712.542     | wh orth cry                    | ≈250 dec   |       | 2.87                       |                                     | s H <sub>2</sub> O                               |
| 700 | Cerium(III) sulfide                      | Ce <sub>2</sub> S <sub>3</sub>                                                        | 12014-93-6  | 376.427     | red cub cry                    | 2450       |       | 5.02                       |                                     | i H <sub>2</sub> O                               |
| 701 | Cerium(III) tungstate                    | Ce <sub>2</sub> (WO <sub>4</sub> ) <sub>3</sub>                                       | 13454-74-5  | 1023.75     | yel tetr cry                   | 1089       |       | 6.77                       |                                     | i H <sub>2</sub> O                               |
| 702 | Cerium(IV) ammonium nitrate              | (NH <sub>4</sub> ) <sub>2</sub> Ce(NO <sub>3</sub> ) <sub>6</sub>                     | 16774-21-3  | 548.223     | red-oran cry                   |            |       |                            |                                     | vs H <sub>2</sub> O                              |
| 703 | Cerium(IV) ammonium sulfate dihydrate    | (NH <sub>4</sub> ) <sub>4</sub> Ce(SO <sub>4</sub> ) <sub>4</sub> · 2H <sub>2</sub> O | 10378-47-9  | 632.551     | cry pow                        | dec 450    |       |                            |                                     |                                                  |
| 704 | Cerium(IV) fluoride                      | CeF <sub>4</sub>                                                                      | 10060-10-3  | 216.110     | wh hyg powder                  | ≈600 dec   |       | 4.77                       |                                     | i H <sub>2</sub> O                               |
| 705 | Cerium(IV) hydroxide                     | Ce(OH) <sub>4</sub>                                                                   | 12014-56-1  | 208.146     | yel-wh pow                     |            |       |                            |                                     | i H <sub>2</sub> O; s conc acid                  |
| 706 | Cerium(IV) oxide                         | CeO <sub>2</sub>                                                                      | 1306-38-3   | 172.115     | wh-yel powder; cub             | 2480       |       | 7.216                      |                                     | i H <sub>2</sub> O, dil acid                     |
| 707 | Cerium(IV) sulfate tetrahydrate          | Ce(SO <sub>4</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                                 | 10294-42-5  | 404.303     | yel-oran orth cry              | 180 dec    |       | 3.91                       | 9.66 <sup>20</sup>                  |                                                  |
| 708 | Cesium                                   | Cs                                                                                    | 7440-46-2   | 132.905     | silv-wh metal                  | 28.5       | 671   | 1.873                      |                                     | reac H <sub>2</sub> O                            |
| 709 | Cesium acetate                           | CsC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                                        | 3396-11-0   | 191.949     | hyg lumps                      | 194        |       |                            | 10 <sup>11</sup>                    |                                                  |
| 710 | Cesium aluminum sulfate dodecahydrate    | CsAl(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O                              | 7784-17-0   | 568.196     | col cub cry                    | 117 dec    |       | 1.97                       |                                     | s H <sub>2</sub> O; i EtOH                       |
| 711 | Cesium amide                             | CsNH <sub>2</sub>                                                                     | 22205-57-8  | 148.928     | wh tetr cry                    |            |       | 3.70                       |                                     |                                                  |
| 712 | Cesium azide                             | CsN <sub>3</sub>                                                                      | 22750-57-8  | 174.925     | hyg tetr cry; exp              | 326        |       | ≈3.5                       | 22 <sup>40</sup>                    |                                                  |
| 713 | Cesium bromate                           | CsBrO <sub>3</sub>                                                                    | 13454-75-6  | 260.807     | col hex cry                    |            |       | 4.11                       | 3.83 <sup>25</sup>                  |                                                  |
| 714 | Cesium bromide                           | CsBr                                                                                  | 7787-69-1   | 212.809     | wh cub cry; hyg                | 636        | ≈1300 | 4.43                       | 123 <sup>25</sup>                   | s EtOH; i ace                                    |
| 715 | Cesium carbonate                         | Cs <sub>2</sub> CO <sub>3</sub>                                                       | 534-17-8    | 325.820     | wh monocl cry; hyg             | 793        |       | 4.24                       | 261 <sup>15</sup>                   | s EtOH, eth                                      |
| 716 | Cesium chlorate                          | CsClO <sub>3</sub>                                                                    | 13763-67-2  | 216.356     | col hex cry                    | 342        |       | 3.57                       | 7.78 <sup>25</sup>                  | sl H <sub>2</sub> O                              |
| 717 | Cesium chloride                          | CsCl                                                                                  | 7647-17-8   | 168.358     | wh cub cry; hyg                | 646        | 1297  | 3.988                      | 191 <sup>25</sup>                   | s EtOH                                           |
| 718 | Cesium chromate(IV)                      | Cs <sub>2</sub> CrO <sub>4</sub>                                                      | 56320-90-2  | 647.616     | yel hex cry                    | 982        |       | 4.24                       |                                     | vs H <sub>2</sub> O                              |
| 719 | Cesium cyanide                           | CsCN                                                                                  | 21159-32-0  | 158.923     | wh cub cry; hyg                | 350        |       | 3.34                       |                                     | vs H <sub>2</sub> O                              |
| 720 | Cesium dibromiodate                      | CsIBr <sub>2</sub>                                                                    | 18278-82-5  | 419.617     | dark oran cry                  | dec        |       |                            |                                     | s H <sub>2</sub> O                               |
| 721 | Cesium fluoride                          | CsF                                                                                   | 13400-13-0  | 151.903     | wh cub cry; hyg                | 703        |       | 4.64                       | 573 <sup>25</sup>                   | s MeOH; i diox, py                               |
| 722 | Cesium fluoroborate                      | CsBF <sub>4</sub>                                                                     | 18909-69-8  | 219.710     | wh orth cry                    | 555 dec    |       | 3.2                        | 1.6 <sup>17</sup>                   | sl H <sub>2</sub> O                              |
| 723 | Cesium formate                           | CsCHO <sub>2</sub>                                                                    | 3495-36-1   | 177.923     | wh cry                         |            |       | 1.017                      |                                     | vs H <sub>2</sub> O                              |
| 724 | Cesium hexafluorogermanate               | Cs <sub>2</sub> GeF <sub>6</sub>                                                      |             | 452.44      | wh cry                         | ≈675       |       | 4.10                       |                                     | sl cold H <sub>2</sub> O; s hot H <sub>2</sub> O |
| 725 | Cesium hydride                           | CsH                                                                                   | 58724-12-2  | 133.913     | wh cub cry; flam               | 528        |       | 3.42                       |                                     | reac H <sub>2</sub> O                            |
| 726 | Cesium hydrogen carbonate                | CsHCO <sub>3</sub>                                                                    | 15519-28-5  | 193.922     | rhomb cry                      | 175 dec    |       |                            | 209 <sup>15</sup>                   | s EtOH                                           |
| 727 | Cesium hydrogen fluoride                 | CsHF <sub>2</sub>                                                                     | 12280-52-3  | 171.910     | tetr cry                       | 170        |       | 3.86                       |                                     |                                                  |
| 728 | Cesium hydrogen sulfate                  | CsHSO <sub>4</sub>                                                                    | 7789-16-4   | 229.976     | col rhomb prisms               | dec        |       | 3.352                      |                                     | s H <sub>2</sub> O                               |
| 729 | Cesium hydroxide                         | CsOH                                                                                  | 21351-79-1  | 149.912     | wh-yel hyg cry                 | 342.3      |       | 3.68                       | 300 <sup>30</sup>                   | s EtOH                                           |
| 730 | Cesium iodate                            | CsIO <sub>3</sub>                                                                     | 13454-81-4  | 307.807     | wh monocl cry                  |            |       | 4.85                       | 2.6 <sup>25</sup>                   |                                                  |
| 731 | Cesium iodide                            | CsI                                                                                   | 7789-17-5   | 259.809     | col cub cry; hyg               | 632        | ≈1280 | 4.51                       | 84.8 <sup>25</sup>                  | s EtOH, MeOH, ace                                |
| 732 | Cesium metaborate                        | CsBO <sub>2</sub>                                                                     | 92141-86-1  | 175.715     | cub cry                        | 732        |       | ≈3.7                       |                                     |                                                  |
| 733 | Cesium molybdate                         | Cs <sub>2</sub> MoO <sub>4</sub>                                                      | 13597-64-3  | 425.75      | wh cry                         | 956.3      |       |                            | 67 <sup>18</sup>                    | s H <sub>2</sub> O                               |
| 734 | Cesium nitrate                           | CsNO <sub>3</sub>                                                                     | 7789-18-6   | 194.910     | wh hex or cub cry              | 409        |       | 3.66                       | 27.9 <sup>25</sup>                  | s ace; sl EtOH                                   |
| 735 | Cesium nitrite                           | CsNO <sub>2</sub>                                                                     | 13454-83-6  | 178.911     | yel cry                        | 406        |       |                            |                                     | s H <sub>2</sub> O                               |
| 736 | Cesium oxide                             | Cs <sub>2</sub> O                                                                     | 20281-00-9  | 281.810     | yel-oran hex cry               | 495        |       | 4.65                       |                                     | vs H <sub>2</sub> O                              |
| 737 | Cesium superoxide                        | CSO <sub>2</sub>                                                                      | 12018-61-0  | 164.904     | yel tetr cry                   | 432        |       | 3.77                       |                                     | reac H <sub>2</sub> O                            |
| 738 | Cesium trioxide                          | Cs <sub>2</sub> O <sub>3</sub>                                                        | 12134-22-4  | 313.809     | brn cry                        | ≈400       |       | 4.25                       |                                     | reac H <sub>2</sub> O                            |
| 739 | Cesium perchlorate                       | CsClO <sub>4</sub>                                                                    | 13454-84-7  | 232.356     | wh orth cry; hyg               | ≈600 dec   |       | 3.327                      | 2.00 <sup>25</sup>                  |                                                  |
| 740 | Cesium periodate                         | CsIO <sub>4</sub>                                                                     | 13478-04-1  | 323.807     | wh rhomb prisms                |            |       | 4.26                       | 2.2 <sup>15</sup>                   |                                                  |
| 741 | Cesium sulfate                           | Cs <sub>2</sub> SO <sub>4</sub>                                                       | 10294-54-9  | 361.874     | wh orth cry or hex prisms; hyg | 1005       |       | 4.24                       | 182 <sup>25</sup>                   | i EtOH, ace, py                                  |



| No. | Name                                              | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form                   | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                  |
|-----|---------------------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|---------------------------------|----------|----------|----------------------------|-------------------------------------|-----------------------------------------|
| 742 | Cesium sulfide                                    | Cs <sub>2</sub> S                                                                  | 12214-16-3  | 297.876     | yel orth hyg cry                | 520      |          |                            |                                     | vs H <sub>2</sub> O                     |
| 743 | Cesium trifluoroacetate                           | Cs(C <sub>2</sub> F <sub>3</sub> O <sub>2</sub> )                                  | 21907-50-6  | 245.920     | hyg solid                       | 115      |          |                            |                                     | vs H <sub>2</sub> O                     |
| 744 | Chlorine                                          | Cl <sub>2</sub>                                                                    | 7782-50-5   | 70.906      | grn-yel gas                     | -101.5   | -34.04   | 2.898 g/L                  |                                     | sl H <sub>2</sub> O                     |
| 745 | Hypochlorous acid                                 | HOCl                                                                               | 7790-92-3   | 52.460      | grn-yel; stable only in aq soln |          |          |                            |                                     | s H <sub>2</sub> O                      |
| 746 | Chloric acid                                      | HClO <sub>3</sub>                                                                  | 7790-93-4   | 84.459      | exists only in aq soln          |          |          |                            |                                     | vs H <sub>2</sub> O                     |
| 747 | Perchloric acid                                   | HClO <sub>4</sub>                                                                  | 7601-90-3   | 100.459     | col hyg liq                     | -112     | ≈90 dec  | 1.77                       |                                     | s H <sub>2</sub> O                      |
| 748 | Chlorine monoxide                                 | Cl <sub>2</sub> O                                                                  | 7791-21-1   | 86.905      | yel-brn gas                     | -120.6   | 2.2      | 3.552 g/L                  |                                     | vs H <sub>2</sub> O                     |
| 749 | Chlorine dioxide                                  | ClO <sub>2</sub>                                                                   | 10049-04-4  | 67.452      | oran-grn gas                    | -59      | 11       | 2.757 g/L                  |                                     | sl H <sub>2</sub> O                     |
| 750 | Dichlorine trioxide                               | Cl <sub>2</sub> O <sub>3</sub>                                                     | 17496-59-2  | 118.904     | dark brn solid                  | exp <25  |          |                            |                                     |                                         |
| 751 | Dichlorine hexoxide                               | Cl <sub>2</sub> O <sub>6</sub>                                                     | 12442-63-6  | 166.902     | red liq                         | 3.5      | ≈200     |                            |                                     | reac H <sub>2</sub> O                   |
| 752 | Dichlorine heptoxide                              | Cl <sub>2</sub> O <sub>7</sub>                                                     | 10294-48-1  | 182.902     | col oily liq; exp               | -91.5    | 82       | 1.9                        |                                     | reac H <sub>2</sub> O                   |
| 753 | Chlorine fluoride                                 | ClF                                                                                | 7790-89-8   | 54.451      | col gas                         | -155.6   | -101.1   | 2.226 g/L                  |                                     | reac H <sub>2</sub> O                   |
| 754 | Chlorine trifluoride                              | ClF <sub>3</sub>                                                                   | 7790-91-2   | 92.448      | gas                             | -76.34   | 11.75    | 3.779 g/L                  |                                     | reac H <sub>2</sub> O                   |
| 755 | Chlorine pentafluoride                            | ClF <sub>5</sub>                                                                   | 13637-63-3  | 130.445     | col gas                         | -103     | -13.1    | 5.332 g/L                  |                                     |                                         |
| 756 | Chlorosyl trifluoride                             | ClOF <sub>3</sub>                                                                  | 30708-80-6  | 108.447     | col liq                         | -42      | 27       |                            |                                     | reac H <sub>2</sub> O                   |
| 757 | Chloryl fluoride                                  | ClO <sub>2</sub> F                                                                 | 13637-83-7  | 86.450      | col gas                         | -115     | -6       | 3.534 g/L                  |                                     | reac H <sub>2</sub> O                   |
| 758 | Chloryl trifluoride                               | ClO <sub>2</sub> F <sub>3</sub>                                                    | 38680-84-1  | 124.447     | col gas                         | -81.2    | -21.6    | 5.087 g/L                  |                                     | reac H <sub>2</sub> O                   |
| 759 | Perchloryl fluoride                               | ClO <sub>3</sub> F                                                                 | 7616-94-6   | 102.449     | col gas                         | -147     | -46.75   | 4.187 g/L                  |                                     |                                         |
| 760 | Chlorine perchlorate                              | ClOClO <sub>3</sub>                                                                | 27218-16-2  | 134.904     | unstab yel liq                  | -117     | ≈45 dec  | 1.81 <sup>o</sup>          |                                     |                                         |
| 761 | Chromium                                          | Cr                                                                                 | 7440-47-3   | 51.996      | blue-wh metal; cub              | 1907     | 2671     | 7.15                       |                                     | reac dil acid                           |
| 762 | Chromic acid                                      | H <sub>2</sub> CrO <sub>4</sub>                                                    | 7738-94-5   | 118.010     | aq soln only                    |          |          |                            |                                     | s H <sub>2</sub> O                      |
| 763 | Chromium antimonide                               | CrSb                                                                               | 12053-12-2  | 173.756     | hex cry                         | 1110     |          | 7.11                       |                                     |                                         |
| 764 | Chromium arsenide                                 | Cr <sub>2</sub> As                                                                 | 12254-85-2  | 178.914     | tetr cry                        |          |          | 7.04                       |                                     |                                         |
| 765 | Chromium boride (CrB)                             | CrB                                                                                | 12006-79-0  | 62.807      | refrac orth cry                 | 2100     |          | 6.1                        |                                     |                                         |
| 766 | Chromium boride (CrB <sub>2</sub> )               | CrB <sub>2</sub>                                                                   | 12007-16-8  | 73.618      | refrac solid; hex               | 2200     |          | 5.22                       |                                     |                                         |
| 767 | Chromium boride (Cr <sub>2</sub> B)               | Cr <sub>2</sub> B                                                                  | 12006-80-3  | 114.803     | refrac solid                    | 1875     |          |                            |                                     |                                         |
| 768 | Chromium boride (Cr <sub>3</sub> B <sub>2</sub> ) | Cr <sub>3</sub> B <sub>2</sub>                                                     | 12007-38-4  | 292.414     | tetr cry                        | 1900     |          | 6.10                       |                                     |                                         |
| 769 | Chromium carbide                                  | Cr <sub>4</sub> C <sub>3</sub>                                                     | 12012-35-0  | 180.009     | gray orth cry                   | 1895     |          | 6.68                       |                                     |                                         |
| 770 | Chromium carbonyl                                 | Cr(CO) <sub>5</sub>                                                                | 13007-92-6  | 220.056     | col orth cry                    | 130 dec  | subl     | 1.77                       |                                     | i H <sub>2</sub> O, EtOH; s eth, chl    |
| 771 | Chromium nitride (CrN)                            | CrN                                                                                | 24094-93-7  | 66.003      | gray cub cry                    | 1080 dec |          | 5.9                        |                                     |                                         |
| 772 | Chromium nitride (Cr <sub>2</sub> N)              | Cr <sub>2</sub> N                                                                  | 12053-27-9  | 117.999     | hex cry                         | 1650     |          | 6.8                        |                                     |                                         |
| 773 | Chromium phosphide                                | CrP                                                                                | 26342-61-0  | 82.970      | orth cry                        |          |          | 5.25                       |                                     |                                         |
| 774 | Chromium selenide                                 | CrSe                                                                               | 12053-13-3  | 130.96      | hex cry                         | ≈1500    |          | 6.1                        |                                     |                                         |
| 775 | Chromium silicide (CrSi <sub>2</sub> )            | CrSi <sub>2</sub>                                                                  | 12018-09-6  | 108.167     | gray hex cry                    | 1490     |          | 4.91                       |                                     |                                         |
| 776 | Chromium silicide (Cr <sub>3</sub> Si)            | Cr <sub>3</sub> Si                                                                 | 12018-36-9  | 184.074     | cub cry                         | 1770     |          | 6.4                        |                                     |                                         |
| 777 | Chromium(II) acetate monohydrate                  | Cr(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O  | 628-52-4*   | 188.100     | red monocl cry                  |          |          | 1.79                       |                                     | sl H <sub>2</sub> O                     |
| 778 | Chromium(II) bromide                              | CrBr <sub>2</sub>                                                                  | 10049-25-9  | 211.804     | wh monocl cry; aq soln blue     | 842      |          | 4.236                      |                                     | s H <sub>2</sub> O, EtOH                |
| 779 | Chromium(II) chloride                             | CrCl <sub>2</sub>                                                                  | 10049-05-5  | 122.902     | wh hyg needles; aq soln blue    | 824      | 1120     | 2.88                       |                                     | s H <sub>2</sub> O                      |
| 780 | Chromium(II) chloride tetrahydrate                | Cr(H <sub>2</sub> O) <sub>4</sub> Cl <sub>2</sub> · 4H <sub>2</sub> O              | 13931-94-7  | 267.024     | blue hyg cry                    | 51 dec   |          |                            |                                     | s H <sub>2</sub> O                      |
| 781 | Chromium(II) fluoride                             | CrF <sub>2</sub>                                                                   | 10049-10-2  | 89.993      | blue-grn monocl cry             | 894      |          | 3.79                       |                                     | sl H <sub>2</sub> O; i EtOH             |
| 782 | Chromium(II) formate monohydrate                  | Cr(CHOO) <sub>2</sub> · H <sub>2</sub> O                                           | 4493-37-2   | 160.046     | red needles                     |          |          |                            |                                     | s H <sub>2</sub> O                      |
| 783 | Chromium(II) iodide                               | CrI <sub>2</sub>                                                                   | 13478-28-9  | 305.805     | red-brn cry; hyg                | 867      |          | 5.1                        |                                     | s H <sub>2</sub> O                      |
| 784 | Chromium(II) oxalate monohydrate                  | CrC <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> O                                 | 814-90-4*   | 158.030     | yel-grn powder                  |          |          | 2.468                      |                                     | sl H <sub>2</sub> O                     |
| 785 | Chromium(II) sulfate pentahydrate                 | CrSO <sub>4</sub> · 5H <sub>2</sub> O                                              | 13825-86-0  | 238.135     | blue cry                        |          |          |                            | 21 <sup>o</sup>                     | s dil acid; sl EtOH; i ace              |
| 786 | Chromium(II,III) oxide                            | Cr <sub>3</sub> O <sub>4</sub>                                                     | 12018-34-7  | 219.986     | cub cry                         |          |          | 6.1                        |                                     |                                         |
| 787 | Chromium(III) acetate                             | Cr(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub>                     | 1066-30-4   | 229.127     | blue-grn pwd                    |          |          |                            |                                     | sl H <sub>2</sub> O                     |
| 788 | Chromium(III) acetate monohydrate                 | Cr(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · H <sub>2</sub> O  | 25013-82-5  | 247.143     | gray-grn pow                    |          |          |                            |                                     | sl H <sub>2</sub> O; i EtOH             |
| 789 | Chromium(III) acetate hexahydrate                 | Cr(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · 6H <sub>2</sub> O | 1066-30-4*  | 337.220     | blue needles                    |          |          |                            |                                     | s H <sub>2</sub> O                      |
| 790 | Chromium(III) acetate hydroxide                   | Cr(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> (OH)                | 39430-51-8  | 187.092     | viol cry pow                    |          |          |                            |                                     | vs H <sub>2</sub> O                     |
| 791 | Chromium(III) bromide                             | CrBr <sub>3</sub>                                                                  | 10031-25-1  | 291.708     | dark grn hex cry                | 812      |          | 4.68                       |                                     | s hot H <sub>2</sub> O, bz              |
| 792 | Chromium(III) bromide hexahydrate (α)             | CrBr <sub>3</sub> (H <sub>2</sub> O) <sub>4</sub> · 2H <sub>2</sub> O              | 18721-05-6  | 399.799     | grn hyg cry                     |          |          |                            |                                     | s H <sub>2</sub> O, EtOH                |
| 793 | Chromium(III) bromide hexahydrate (β)             | Cr(H <sub>2</sub> O) <sub>6</sub> Br <sub>3</sub>                                  | 10031-25-1* | 399.799     | viol hyg cry                    |          |          |                            |                                     | s H <sub>2</sub> O; i EtOH, eth         |
| 794 | Chromium(III) chloride                            | CrCl <sub>3</sub>                                                                  | 10025-73-7  | 158.355     | red-viol cry                    | 1152     | 1300 dec | 2.76                       |                                     | sl H <sub>2</sub> O                     |
| 795 | Chromium(III) chloride hexahydrate                | [CrCl <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ]Cl · 2H <sub>2</sub> O         | 10060-12-5  | 266.446     | grn monocl cry; hyg             |          |          |                            |                                     | s H <sub>2</sub> O, EtOH; sl ace; i eth |
| 796 | Chromium(III) fluoride                            | CrF <sub>3</sub>                                                                   | 7788-97-8   | 108.991     | grn needles                     | 1425     |          | 3.8                        |                                     | i H <sub>2</sub> O, EtOH                |
| 797 | Chromium(III) fluoride trihydrate                 | CrF <sub>3</sub> · 3H <sub>2</sub> O                                               | 16671-27-5  | 163.037     | grn hex cry                     |          |          | 2.2                        |                                     | sl H <sub>2</sub> O                     |
| 798 | Chromium(III) hydroxide sulfate                   | Cr(OH)SO <sub>4</sub>                                                              | 12336-95-7  | 165.066     | grn cry                         |          |          |                            |                                     |                                         |
| 799 | Chromium(III) fluoride nonahydrate                | Cr(H <sub>2</sub> O) <sub>9</sub> F <sub>3</sub> · 3H <sub>2</sub> O               | 102430-09-1 | 271.129     | rhomb viol cry                  |          |          |                            |                                     | sl H <sub>2</sub> O                     |

| No. | Name                                          | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form                 | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                           |
|-----|-----------------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|-------------------------------|----------|----------|----------------------------|-------------------------------------|--------------------------------------------------|
| 800 | Chromium(III) hydroxide trihydrate            | Cr(OH) <sub>3</sub> · 3H <sub>2</sub> O                                            | 1308-14-1   | 157.063     | blue-grn powder               |          |          |                            |                                     | i H <sub>2</sub> O; s acid                       |
| 801 | Chromium(III) iodide                          | CrI <sub>3</sub>                                                                   | 13569-75-0  | 432.709     | dark grn hex cry              | 500 dec  |          | 5.32                       |                                     | sl H <sub>2</sub> O                              |
| 802 | Chromium(III) nitrate                         | Cr(NO <sub>3</sub> ) <sub>3</sub>                                                  | 13548-38-4  | 238.011     | grn hyg powder                | >60 dec  |          |                            |                                     | vs H <sub>2</sub> O                              |
| 803 | Chromium(III) nitrate nonahydrate             | Cr(NO <sub>3</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                              | 7789-02-8   | 400.148     | grn-blk monocl cry            | 66.3     | >100 dec | 1.80                       |                                     | vs H <sub>2</sub> O                              |
| 804 | Chromium(III) oxide                           | Cr <sub>2</sub> O <sub>3</sub>                                                     | 1308-38-9   | 151.990     | grn hex cry                   | 2320     | ≈3000    | 5.22                       |                                     | i H <sub>2</sub> O; EtOH; sl acid, alk           |
| 805 | Chromium(III) 2,4-pentanedioate               | Cr(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub>                            | 21679-31-2  | 349.320     | red monocl cry                | 208      | 345      | 1.34                       |                                     | i H <sub>2</sub> O; s bz                         |
| 806 | Chromium(III) perchlorate                     | Cr(ClO <sub>4</sub> ) <sub>3</sub>                                                 | 27535-70-2  | 350.348     | grn-blue cry                  |          |          |                            | 58 <sup>25</sup>                    | vs H <sub>2</sub> O                              |
| 807 | Chromium(III) phosphate                       | CrPO <sub>4</sub>                                                                  | 7789-04-0   | 146.967     | blue orth cry                 | >1800    |          | 4.6                        |                                     | i H <sub>2</sub> O, acid, aqua regia             |
| 808 | Chromium(III) phosphate hemiheptahydrate      | CrPO <sub>4</sub> · 3.5H <sub>2</sub> O                                            | 84359-31-9  | 210.021     | blue-grn powder               |          |          | 2.15                       |                                     | i H <sub>2</sub> O; s acid                       |
| 809 | Chromium(III) phosphate hexahydrate           | CrPO <sub>4</sub> · 6H <sub>2</sub> O                                              | 84359-31-9  | 255.059     | viol cry                      | >500 dec |          | 2.121                      |                                     | i H <sub>2</sub> O; s acid, alk                  |
| 810 | Chromium(III) potassium oxalate trihydrate    | K <sub>3</sub> Cr(C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> · 3H <sub>2</sub> O | 15275-09-9  | 487.394     | blue-grn monocl cry           |          |          |                            |                                     | s H <sub>2</sub> O                               |
| 811 | Chromium(III) potassium sulfate dodecahydrate | K <sub>2</sub> Cr(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O              | 7788-99-0   | 499.403     | viol-blk cub cry              | 89 dec   |          | 1.83                       |                                     | s H <sub>2</sub> O; i EtOH                       |
| 812 | Chromium(III) sulfate                         | Cr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                    | 10101-53-8  | 392.180     | red pow                       | dec >700 |          | 3.1                        | 64 <sup>25</sup>                    | s H <sub>2</sub> O; vs acid                      |
| 813 | Chromium(III) sulfate octadecahydrate         | Cr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 18H <sub>2</sub> O               | 10101-53-8* | 716.455     | viol cry                      | dec 115  |          | 1.7                        |                                     | reac H <sub>2</sub> O                            |
| 814 | Chromium(III) sulfide                         | Cr <sub>2</sub> S <sub>3</sub>                                                     | 12018-22-3  | 200.187     | brn-blk hex cry               |          |          | 3.8                        |                                     |                                                  |
| 815 | Chromium(III) telluride                       | Cr <sub>2</sub> Te <sub>3</sub>                                                    | 12053-39-3  | 486.79      | hex cry                       | ≈1300    |          | 7.0                        |                                     |                                                  |
| 816 | Chromium(IV) chloride                         | CrCl <sub>4</sub>                                                                  | 15597-88-3  | 193.808     | gas, stable at HT             |          | >600 dec | 7.922 g/L                  |                                     |                                                  |
| 817 | Chromium(IV) fluoride                         | CrF <sub>4</sub>                                                                   | 10049-11-3  | 127.990     | grn cry                       | 277      |          | 2.89                       |                                     | reac H <sub>2</sub> O                            |
| 818 | Chromium(IV) oxide                            | CrO <sub>2</sub>                                                                   | 12018-01-8  | 83.995      | brn-blk tetr powder           | ≈400 dec |          | 4.89                       |                                     | i H <sub>2</sub> O; s acid                       |
| 819 | Chromium(V) fluoride                          | CrF <sub>5</sub>                                                                   | 14884-42-5  | 146.988     | red orth cry                  | 34       | 117      |                            |                                     | reac H <sub>2</sub> O                            |
| 820 | Chromium(V) oxide                             | Cr <sub>2</sub> O <sub>5</sub>                                                     | 12218-36-9  | 183.989     | blk needles                   | dec 200  |          |                            |                                     |                                                  |
| 821 | Chromium(VI) fluoride                         | CrF <sub>6</sub>                                                                   | 13843-28-2  | 165.986     | yel solid; stable at low temp | -100 dec |          |                            |                                     |                                                  |
| 822 | Chromium(VI) oxide                            | CrO <sub>3</sub>                                                                   | 1333-82-0   | 99.994      | red orth cry                  | 197      | ≈250 dec | 2.7                        | 169 <sup>25</sup>                   |                                                  |
| 823 | Chromium(VI) tetrafluoride oxide              | CrOF <sub>4</sub>                                                                  | 23276-90-6  | 143.989     | dark red solid                | 55       |          |                            |                                     | reac H <sub>2</sub> O, ace, dmsO                 |
| 824 | Chromium(VI) dichloride dioxide               | CrO <sub>2</sub> Cl <sub>2</sub>                                                   | 14977-61-8  | 154.901     | red liq                       | -96.5    | 117      | 1.91                       |                                     | reac H <sub>2</sub> O; s ctc, chl, bz            |
| 825 | Chromium(VI) difluoride dioxide               | CrO <sub>2</sub> F <sub>2</sub>                                                    | 7788-96-7   | 121.992     | red-viol cry                  | 30       | subl     |                            |                                     | reac H <sub>2</sub> O                            |
| 826 | Cobalt                                        | Co                                                                                 | 7440-48-4   | 58.933      | gray metal; hex or cub        | 1495     | 2927     | 8.86                       |                                     | s dil acid                                       |
| 827 | Cobaltocene                                   | Co(C <sub>5</sub> H <sub>5</sub> ) <sub>2</sub>                                    | 1277-43-6   | 189.119     | blk-purp cry                  | 173      |          |                            |                                     |                                                  |
| 828 | Cobalt antimonide                             | CoSb                                                                               | 12052-42-5  | 180.693     | hex cry                       | 1202     |          | 8.8                        |                                     |                                                  |
| 829 | Cobalt arsenic sulfide                        | CoAsS                                                                              | 12254-82-9  | 165.920     | silv-wh solid                 |          |          | ≈6.1                       |                                     |                                                  |
| 830 | Cobalt arsenide (CoAs)                        | CoAs                                                                               | 27016-73-5  | 133.855     | orth cry                      | 1180     |          | 8.22                       |                                     |                                                  |
| 831 | Cobalt arsenide (CoAs <sub>2</sub> )          | CoAs <sub>2</sub>                                                                  | 12044-42-7  | 208.776     | monocl cry                    |          |          | 7.2                        |                                     |                                                  |
| 832 | Cobalt arsenide (CoAs <sub>3</sub> )          | CoAs <sub>3</sub>                                                                  | 12256-04-1  | 283.698     | cub cry                       | 942      |          | 6.84                       |                                     |                                                  |
| 833 | Cobalt boride (CoB)                           | CoB                                                                                | 12006-77-8  | 69.744      | refrac solid                  | 1460     |          | 7.25                       |                                     | reac H <sub>2</sub> O, HNO <sub>3</sub>          |
| 834 | Cobalt boride (Co <sub>2</sub> B)             | Co <sub>2</sub> B                                                                  | 12045-01-1  | 128.677     | refrac solid                  | 1280     |          | 8.1                        |                                     |                                                  |
| 835 | Cobalt carbonyl                               | Co <sub>2</sub> (CO) <sub>8</sub>                                                  | 10210-68-1  | 341.947     | oran cry                      | 51 dec   |          | 1.78                       |                                     | i H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub> |
| 836 | Cobalt disulfide                              | CoS <sub>2</sub>                                                                   | 12013-10-4  | 123.063     | cub cry                       |          |          | 4.3                        |                                     |                                                  |
| 837 | Cobalt dodecacarbonyl                         | Co <sub>4</sub> (CO) <sub>12</sub>                                                 | 17786-31-1  | 571.854     | blk cry                       | 60 dec   |          | 2.09                       |                                     |                                                  |
| 838 | Cobalt phosphide                              | Co <sub>3</sub> P                                                                  | 12134-02-0  | 148.840     | gray needles                  | 1386     |          | 6.4                        |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>           |
| 839 | Cobalt silicide                               | CoSi <sub>2</sub>                                                                  | 12017-12-8  | 115.104     | gray cub cry                  | 1326     |          | 4.9                        |                                     | s hot HCl                                        |
| 840 | Cobalt(II) acetate                            | Co(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                     | 71-48-7     | 177.022     | pink cry                      |          |          |                            |                                     | vs H <sub>2</sub> O; s EtOH                      |
| 841 | Cobalt(II) acetate tetrahydrate               | Co(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 4H <sub>2</sub> O | 6147-53-1   | 249.082     | red monocl cry                |          |          | 1.705                      |                                     | s H <sub>2</sub> O, EtOH, dil acid               |
| 842 | Cobalt(II) aluminate                          | CoAl <sub>2</sub> O <sub>4</sub>                                                   | 13820-62-7  | 176.894     | blue cub cry                  |          |          | 4.37                       |                                     | i H <sub>2</sub> O                               |
| 843 | Cobalt(II) arsenate octahydrate               | Co <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub> · 8H <sub>2</sub> O               | 24719-19-5  | 598.760     | red monocl needles            | 400 dec  | 1000 dec | 3.0                        |                                     | i H <sub>2</sub> O; s dil acid                   |
| 844 | Cobalt(II) bromate hexahydrate                | Co(BrO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                             | 13476-01-2  | 422.829     | viol cry                      |          |          | ≈2.5                       |                                     | vs H <sub>2</sub> O                              |
| 845 | Cobalt(II) bromide                            | CoBr <sub>2</sub>                                                                  | 7789-43-7   | 218.741     | grn hex cry; hyg              | 678      |          | 4.91                       | 113.2 <sup>20</sup>                 | s MeOH, EtOH, ace                                |
| 846 | Cobalt(II) bromide hexahydrate                | CoBr <sub>2</sub> · 6H <sub>2</sub> O                                              | 13762-12-4  | 326.832     | red hyg cry                   | 47 dec   | 100 dec  | 2.46                       | 113.2                               |                                                  |
| 847 | Cobalt(II) carbonate                          | CoCO <sub>3</sub>                                                                  | 513-79-1    | 118.942     | pink rhomb cry                | dec 280  |          | 4.2                        | 0.00014 <sup>20</sup>               | i EtOH                                           |
| 848 | Cobalt(II) basic carbonate                    | 2CoCO <sub>3</sub> · 3Co(OH) <sub>2</sub> · H <sub>2</sub> O                       | 7542-09-8   | 534.743     | red-viol cry                  | dec      |          |                            |                                     | i H <sub>2</sub> O; s acid                       |
| 849 | Cobalt(II) chlorate hexahydrate               | Co(ClO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                             |             | 333.927     | dark red hyg cry              | dec 61   |          |                            |                                     | s H <sub>2</sub> O                               |
| 850 | Cobalt(II) chloride                           | CoCl <sub>2</sub>                                                                  | 7646-79-9   | 129.839     | blue hyg leaflets             | 737      | 1049     | 3.36                       | 56.2 <sup>25</sup>                  | s EtOH, eth, ace, py                             |
| 851 | Cobalt(II) chloride dihydrate                 | CoCl <sub>2</sub> · 2H <sub>2</sub> O                                              | 16544-92-6  | 165.870     | viol-blue cry                 |          |          | 2.477                      | 56.2 <sup>25</sup>                  |                                                  |



| No. | Name                                      | Formula                                                                                          | CAS Reg No. | Mol. weight | Physical form       | mp/°C    | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                        |
|-----|-------------------------------------------|--------------------------------------------------------------------------------------------------|-------------|-------------|---------------------|----------|-------|----------------------------|-------------------------------------|-----------------------------------------------|
| 852 | Cobalt(II) chloride hexahydrate           | CoCl <sub>2</sub> · 6H <sub>2</sub> O                                                            | 7791-13-1   | 237.930     | pink-red monocl cry | 87 dec   |       | 1.924                      | 56.2 <sup>25</sup>                  | s EtOH, ace, eth                              |
| 853 | Cobalt(II) chromate                       | CoCrO <sub>4</sub>                                                                               | 24613-38-5  | 174.927     | yel-brn orth cry    |          |       | ≈4.0                       |                                     | i H <sub>2</sub> O; s acid                    |
| 854 | Cobalt(II) chromite                       | CoCr <sub>2</sub> O <sub>4</sub>                                                                 | 13455-25-9  | 226.923     | blue-grn cub cry    |          |       | 5.14                       |                                     | i H <sub>2</sub> O, conc acid                 |
| 855 | Cobalt(II) citrate dihydrate              | Co <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sub>2</sub> · 2H <sub>2</sub> O | 18727-04-3  | 265.170     | rose red cry        | dec 150  |       |                            | 0.8 <sup>15</sup>                   |                                               |
| 856 | Cobalt(II) cyanide                        | Co(CN) <sub>2</sub>                                                                              | 542-84-7    | 110.967     | blue hyg cry        |          |       | 1.872                      |                                     | i H <sub>2</sub> O                            |
| 857 | Cobalt(II) cyanide dihydrate              | Co(CN) <sub>2</sub> · 2H <sub>2</sub> O                                                          | 20427-11-6  | 146.998     | pink-brn needles    |          |       |                            |                                     | i H <sub>2</sub> O, acid                      |
| 858 | Cobalt(II) diiron tetroxide               | CoFe <sub>2</sub> O <sub>4</sub>                                                                 | 12052-28-7  | 234.621     | blk solid           |          |       |                            |                                     | s hot HCl                                     |
| 859 | Cobalt(II) ferricyanide                   | Co <sub>3</sub> [Fe(CN) <sub>6</sub> ] <sub>2</sub>                                              | 14049-81-1  | 600.698     | red needles         |          |       |                            |                                     | i H <sub>2</sub> O, HCl; s NH <sub>4</sub> OH |
| 860 | Cobalt(II) fluoride                       | CoF <sub>2</sub>                                                                                 | 10026-17-2  | 96.930      | red tetr cry        | 1127     | ≈1400 | 4.46                       | 1.4 <sup>25</sup>                   | s acid                                        |
| 861 | Cobalt(II) fluoride tetrahydrate          | CoF <sub>2</sub> · 4H <sub>2</sub> O                                                             | 13817-37-3  | 168.992     | red orth cry        | dec      |       | 2.22                       | 1.4 <sup>25</sup>                   |                                               |
| 862 | Cobalt(II) formate dihydrate              | Co(CHO <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O                                           | 6424-20-0   | 184.998     | red cry powder      | 140 dec  |       | 2.13                       | 5.03 <sup>20</sup>                  | i EtOH                                        |
| 863 | Cobalt(II) hexafluoro-2,4-pentanedioate   | Co(CF <sub>3</sub> COCHCOCF <sub>3</sub> ) <sub>2</sub>                                          | 19648-83-0  | 473.035     | powder              | 197      |       |                            |                                     |                                               |
| 864 | Cobalt(II) hexafluorosilicate hexahydrate | CoSiF <sub>6</sub> · 6H <sub>2</sub> O                                                           | 12021-68-0  | 309.100     | pale red cry        |          |       | 2.087                      | 76.8 <sup>22</sup>                  |                                               |
| 865 | Cobalt(II) hydroxide                      | Co(OH) <sub>2</sub>                                                                              | 21041-93-0  | 92.948      | blue-grn cry        | ≈160 dec |       | 3.60                       |                                     | sl H <sub>2</sub> O; s acid                   |
| 866 | Cobalt(II) hydroxide monohydrate          | Co(OH) <sub>2</sub> · H <sub>2</sub> O                                                           | 35340-84-2  | 110.963     | blue solid          | 136 dec  |       |                            |                                     |                                               |
| 867 | Cobalt(II) iodate                         | Co(IO <sub>3</sub> ) <sub>2</sub>                                                                | 13455-28-2  | 408.738     | blk-viol needles    | 200 dec  |       | 5.09                       | 0.46 <sup>20</sup>                  |                                               |
| 868 | Cobalt(II) iodide                         | CoI <sub>2</sub>                                                                                 | 15238-00-3  | 312.742     | blk hex cry; hyg    | 520      |       | 5.60                       | 203 <sup>25</sup>                   |                                               |
| 869 | Cobalt(II) iodide dihydrate               | CoI <sub>2</sub> · 2H <sub>2</sub> O                                                             | 13455-29-3  | 348.773     | hyg grn cry         | dec 100  |       |                            |                                     |                                               |
| 870 | Cobalt(II) iodide hexahydrate             | CoI <sub>2</sub> · 6H <sub>2</sub> O                                                             | 15238-00-3* | 420.833     | red hex prisms      | 130 dec  |       | 2.90                       | 203 <sup>25</sup>                   | s EtOH, eth, ace                              |
| 871 | Cobalt(II) molybdate                      | CoMoO <sub>4</sub>                                                                               | 13762-14-6  | 218.87      | blk monocl cry      | 1040     |       | 4.7                        |                                     |                                               |
| 872 | Cobalt(II) molybdate monohydrate          | CoMoO <sub>4</sub> · H <sub>2</sub> O                                                            | 18601-87-1  | 236.89      | blk pow             |          |       |                            |                                     |                                               |
| 873 | Cobalt(II) nitrate                        | Co(NO <sub>3</sub> ) <sub>2</sub>                                                                | 10141-05-6  | 182.942     | pale red powder     | 100 dec  |       | 2.49                       | 103 <sup>25</sup>                   |                                               |
| 874 | Cobalt(II) nitrate hexahydrate            | Co(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                            | 10026-22-9  | 291.034     | red monocl cry; hyg | ≈55      |       | 1.88                       | 103 <sup>25</sup>                   | s EtOH                                        |
| 875 | Cobalt(II) nitrite                        | Co(NO <sub>2</sub> ) <sub>2</sub>                                                                | 18488-96-5  | 150.944     |                     |          |       |                            | 0.49 <sup>25</sup>                  |                                               |
| 876 | Cobalt(II) oleate                         | Co(C <sub>18</sub> H <sub>33</sub> O <sub>2</sub> ) <sub>2</sub>                                 | 14666-94-5  | 621.840     | brn amorp pow       |          |       |                            |                                     | i H <sub>2</sub> O; s EtOH, eth               |
| 877 | Cobalt(II) orthosilicate                  | Co <sub>2</sub> SiO <sub>4</sub>                                                                 | 12017-08-2  | 209.950     | red-viol orth cry   | 1345     |       | 4.63                       |                                     | i H <sub>2</sub> O; s dil HCl                 |
| 878 | Cobalt(II) oxalate                        | CoC <sub>2</sub> O <sub>4</sub>                                                                  | 814-89-1    | 146.952     | pink powder         | 250 dec  |       | 3.02                       | 0.0037 <sup>20</sup>                | s acid, NH <sub>4</sub> OH                    |
| 879 | Cobalt(II) oxalate dihydrate              | CoC <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O                                              | 5965-38-8   | 182.982     | pink needles        | dec      |       |                            | 0.0037                              | sl acid; s NH <sub>4</sub> OH                 |
| 880 | Cobalt(II) oxide                          | CoO                                                                                              | 1307-96-6   | 74.932      | gray cub cry        | 1830     |       | 6.44                       |                                     | i H <sub>2</sub> O; s acid                    |
| 881 | Cobalt(II) 2,4-pentanedioate              | Co(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>                                          | 14024-48-7  | 257.149     | bl-viol cry         | 167      |       |                            |                                     |                                               |
| 882 | Cobalt(II) perchlorate                    | Co(ClO <sub>4</sub> ) <sub>2</sub>                                                               | 13455-31-7  | 257.834     | red needles         |          |       | 3.33                       | 113 <sup>25</sup>                   | i EtOH, ace                                   |
| 883 | Cobalt(II) perchlorate hexahydrate        | Co(ClO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                           | 13478-33-6  | 365.926     | dark red cry        | dec 170  |       | 3.33                       |                                     | vs H <sub>2</sub> O                           |
| 884 | Cobalt(II) phosphate octahydrate          | Co <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> · 8H <sub>2</sub> O                              | 10294-50-5  | 510.865     | pink amorp powder   |          |       | 2.77                       |                                     | i H <sub>2</sub> O; s acid                    |
| 885 | Cobalt(II) potassium sulfate hexahydrate  | CoK <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                             | 10026-20-7  | 437.347     | red monocl cry      | 75 dec   |       | 2.22                       |                                     | vs H <sub>2</sub> O                           |
| 886 | Cobalt(II) selenate pentahydrate          | CoSeO <sub>4</sub> · 5H <sub>2</sub> O                                                           | 14590-19-3  | 291.97      | red tricr cry       | dec      |       | 2.51                       | 55 <sup>15</sup>                    |                                               |
| 887 | Cobalt(II) selenide                       | CoSe                                                                                             | 1307-99-9   | 137.89      | yel hex cry         | 1055     |       | 7.65                       |                                     | i H <sub>2</sub> O, alk; s aqua regia         |
| 888 | Cobalt(II) selenite dihydrate             | CoSeO <sub>3</sub> · 2H <sub>2</sub> O                                                           | 19034-13-0  | 221.92      | blue-red powder     |          |       |                            |                                     | i H <sub>2</sub> O                            |
| 889 | Cobalt(II) stannate                       | Co <sub>2</sub> SnO <sub>4</sub>                                                                 | 12139-93-4  | 300.574     | grn-blue cub cry    |          |       | 6.30                       |                                     | i H <sub>2</sub> O; s alk                     |
| 890 | Cobalt(II) stearate                       | Co(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>2</sub>                                 | 1002-88-6   | 625.872     | purp solid          | 74       |       | 1.13                       |                                     |                                               |
| 891 | Cobalt(II) sulfate                        | CoSO <sub>4</sub>                                                                                | 10124-43-3  | 154.996     | red orth cry        | >700     |       | 3.71                       | 38.3 <sup>25</sup>                  |                                               |
| 892 | Cobalt(II) sulfate monohydrate            | CoSO <sub>4</sub> · H <sub>2</sub> O                                                             | 13455-34-0  | 173.011     | red monocl cry      |          |       | 3.08                       | 38.3 <sup>25</sup>                  |                                               |
| 893 | Cobalt(II) sulfate heptahydrate           | CoSO <sub>4</sub> · 7H <sub>2</sub> O                                                            | 10026-24-1  | 281.102     | pink monocl cry     | 41 dec   |       | 2.03                       | 38.3 <sup>25</sup>                  | sl EtOH, MeOH                                 |
| 894 | Cobalt(II) sulfide                        | CoS                                                                                              | 1317-42-6   | 90.998      | blk amorp powder    | 1117     |       | 5.45                       |                                     | i H <sub>2</sub> O; s acid                    |
| 895 | Cobalt(II) telluride                      | CoTe                                                                                             | 12017-13-9  | 186.53      | hex cry             |          |       | ≈8.8                       |                                     |                                               |
| 896 | Cobalt(II) thiocyanate                    | Co(SCN) <sub>2</sub>                                                                             | 3017-60-5   | 175.097     | yel-brn powder      |          |       |                            | 103 <sup>25</sup>                   | s EtOH, MeOH, ace, eth                        |
| 897 | Cobalt(II) thiocyanate trihydrate         | Co(SCN) <sub>2</sub> · 3H <sub>2</sub> O                                                         | 97126-35-7  | 229.143     | viol rhomb cry      |          |       |                            | 103 <sup>25</sup>                   | s EtOH, eth, ace                              |
| 898 | Cobalt(II) titanate                       | CoTiO <sub>3</sub>                                                                               | 12017-01-5  | 154.798     | grn rhomb cry       |          |       | 5.0                        |                                     |                                               |
| 899 | Cobalt(II) tungstate                      | CoWO <sub>4</sub>                                                                                | 12640-47-0  | 306.77      | blue monocl cry     |          |       | ≈7.8                       |                                     | i H <sub>2</sub> O; s hot conc acid           |
| 900 | Cobalt(II,III) oxide                      | Co <sub>2</sub> O <sub>4</sub>                                                                   | 1308-06-1   | 240.798     | blk cub cry         | 900 dec  |       | 6.11                       |                                     | i H <sub>2</sub> O; s acid, alk               |
| 901 | Cobalt(III) acetate                       | Co(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub>                                   | 917-69-1    | 236.064     | grn hyg cry         | 100 dec  |       |                            |                                     | s H <sub>2</sub> O, EtOH                      |
| 902 | Cobalt(III) ammonium tetranitrodiammine   | NH <sub>4</sub> [Co(NH <sub>3</sub> ) <sub>2</sub> (NO <sub>2</sub> ) <sub>4</sub> ]             | 13600-89-0  | 295.054     | red-brn orth cry    |          |       | 1.97                       |                                     | s H <sub>2</sub> O                            |
| 903 | Cobalt(III) fluoride                      | CoF <sub>3</sub>                                                                                 | 10026-18-3  | 115.928     | brn hex cry         | 927      |       | 3.88                       |                                     | reac H <sub>2</sub> O; s EtOH, eth, bz        |
| 904 | Cobalt(III) fluoride dihydrate            | Co <sub>2</sub> F <sub>6</sub> · 2H <sub>2</sub> O                                               | 54496-71-8  | 267.887     | red rhomb cry       |          |       | 2.19                       |                                     | s H <sub>2</sub> O; i EtOH                    |
| 905 | Cobalt(III) hexammine chloride            | Co(NH <sub>3</sub> ) <sub>6</sub> Cl <sub>3</sub>                                                | 10534-89-1  | 267.475     | red monocl cry      |          |       | 1.71                       |                                     | s H <sub>2</sub> O; i EtOH                    |
| 906 | Cobalt(III) hydroxide                     | Co(OH) <sub>3</sub>                                                                              | 1307-86-4   | 109.955     | brn powder          | dec      |       | ≈4                         |                                     | i H <sub>2</sub> O; s acid                    |
| 907 | Cobalt(III) nitrate                       | Co(NO <sub>3</sub> ) <sub>3</sub>                                                                | 15520-84-0  | 244.948     | grn cub cry; hyg    |          |       | ≈3.0                       |                                     | s H <sub>2</sub> O; reac os                   |
| 908 | Cobalt(III) oxide                         | Co <sub>2</sub> O <sub>3</sub>                                                                   | 1308-04-9   | 165.864     | gray-blk powder     | 895 dec  |       | 5.18                       |                                     | i H <sub>2</sub> O; s conc acid               |

| No. | Name                                        | Formula                                                                                              | CAS Reg No. | Mol. weight | Physical form             | mp/°C           | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                    |
|-----|---------------------------------------------|------------------------------------------------------------------------------------------------------|-------------|-------------|---------------------------|-----------------|----------|----------------------------|-------------------------------------|-----------------------------------------------------------|
| 909 | Cobalt(III) oxide monohydrate               | Co <sub>2</sub> O <sub>3</sub> · H <sub>2</sub> O                                                    | 12016-80-7  | 183.880     | brn-blk hex cry           | 150 dec         |          |                            |                                     | i H <sub>2</sub> O; s acid                                |
| 910 | Cobalt(III) 2,4-pentanedioate               | Co(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub>                                              | 21679-46-9  | 356.257     | dark grn cry              | 213             |          |                            |                                     | s bz, ace                                                 |
| 911 | Cobalt(III) potassium nitrite sesquihydrate | CoK <sub>3</sub> (NO <sub>2</sub> ) <sub>6</sub> · 1.5H <sub>2</sub> O                               | 13782-01-9* | 479.284     | yel cub cry               |                 |          | 2.6                        |                                     | sl H <sub>2</sub> O; reac acid; i EtOH                    |
| 912 | Cobalt(III) sulfide                         | Co <sub>2</sub> S <sub>3</sub>                                                                       | 1332-71-4   | 214.061     | blk cub cry               |                 |          | 4.8                        |                                     | reac acid                                                 |
| 913 | Cobalt(III) titanate                        | Co <sub>2</sub> TiO <sub>4</sub>                                                                     | 12017-38-8  | 229.731     | grn-blk cub cry           |                 |          | 5.1                        |                                     | s conc HCl                                                |
| 914 | Copper                                      | Cu                                                                                                   | 7440-50-8   | 63.546      | red metal; cub            | 1084.62         | 2562     | 8.96                       |                                     | sl dil acid                                               |
| 915 | Copper arsenide                             | Cu <sub>3</sub> As                                                                                   | 12005-75-3  | 265.560     | dark gray solid           | 827             |          |                            |                                     |                                                           |
| 916 | Copper nitride                              | Cu <sub>3</sub> N                                                                                    | 1308-80-1   | 204.645     | cub cry                   | 300 dec         |          | 5.84                       |                                     |                                                           |
| 917 | Copper phosphide                            | Cu <sub>3</sub> P <sub>2</sub>                                                                       | 12019-11-3  | 125.494     | monocl cry                | ≈900            |          | 4.20                       |                                     |                                                           |
| 918 | Copper silicide                             | Cu <sub>3</sub> Si                                                                                   | 12159-07-8  | 345.816     | solid                     | 825             |          |                            |                                     |                                                           |
| 919 | Copper(I) acetate                           | CuC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                                                       | 598-54-9    | 122.590     | col cry                   | dec             | subl     |                            |                                     | reac H <sub>2</sub> O                                     |
| 920 | Copper(I) acetylides                        | Cu <sub>2</sub> C <sub>2</sub>                                                                       | 1117-94-8   | 151.113     | red amorp powder; exp     |                 |          |                            |                                     |                                                           |
| 921 | Copper(I) azide                             | CuN <sub>3</sub>                                                                                     | 14336-80-2  | 105.566     | tetr cry; exp             |                 |          |                            |                                     |                                                           |
| 922 | Copper(I) bromide                           | CuBr                                                                                                 | 7787-70-4   | 143.450     | wh cub cry; hyg           | 483             | 1345     | 4.98                       | 0.0012 <sup>20</sup>                | i ace                                                     |
| 923 | Copper(I) chloride                          | CuCl                                                                                                 | 7758-89-6   | 98.999      | wh cub cry                | 423             | 1490     | 4.14                       | 0.0047 <sup>20</sup>                | i EtOH, ace                                               |
| 924 | Copper(I) cyanide                           | CuCN                                                                                                 | 544-92-3    | 89.564      | wh powder or grn orth cry | 474             | dec      | 2.9                        |                                     | i H <sub>2</sub> O, EtOH; s KCN soln                      |
| 925 | Copper(I) fluoride                          | CuF                                                                                                  | 13478-41-6  | 82.544      | cub cry                   |                 |          | 7.1                        |                                     |                                                           |
| 926 | Copper(I) hydride                           | CuH                                                                                                  | 13517-00-5  | 64.554      | red-brn solid             | 60 dec          |          |                            |                                     |                                                           |
| 927 | Copper(I) iodide                            | CuI                                                                                                  | 7681-65-4   | 190.450     | wh cub cry                | 591             | ≈1290    | 5.67                       | 0.000020 <sup>20</sup>              | i dil acid                                                |
| 928 | Copper(I) mercury iodide                    | Cu <sub>2</sub> HgI <sub>4</sub>                                                                     | 13876-85-2  | 835.30      | red cry powder            | trans ≈60 (brn) |          |                            |                                     | i H <sub>2</sub> O, EtOH                                  |
| 929 | Copper(I) oxide                             | Cu <sub>2</sub> O                                                                                    | 1317-39-1   | 143.091     | red-brn cub cry           | 1244            | 1800 dec | 6.0                        |                                     | i H <sub>2</sub> O                                        |
| 930 | Copper(I) selenide                          | Cu <sub>2</sub> Se                                                                                   | 20405-64-5  | 206.05      | blue-blk tetr cry         | 1113            |          | 6.84                       |                                     | i H <sub>2</sub> O; s acid                                |
| 931 | Copper(I) sulfide                           | Cu <sub>2</sub> S                                                                                    | 22205-45-4  | 159.157     | blue-blk orth cry         | 1129            |          | 5.6                        |                                     | i H <sub>2</sub> O; sl acid                               |
| 932 | Copper(I) sulfite hemihydrate               | Cu <sub>2</sub> SO <sub>3</sub> · 0.5H <sub>2</sub> O                                                | 13982-53-1* | 216.164     | wh-yel hex cry            |                 |          |                            |                                     | sl H <sub>2</sub> O; s acid, alk; i EtOH, eth             |
| 933 | Copper(I) sulfite monohydrate               | Cu <sub>2</sub> SO <sub>3</sub> · H <sub>2</sub> O                                                   | 35788-00-2  | 225.171     | cry                       |                 |          | 3.83                       |                                     | sl H <sub>2</sub> O; s HCl                                |
| 934 | Copper(I) telluride                         | Cu <sub>2</sub> Te                                                                                   | 12019-52-2  | 254.69      | blue hex cry              | 1127            |          | 4.6                        |                                     |                                                           |
| 935 | Copper(I) thiocyanate                       | CuSCN                                                                                                | 1111-67-7   | 121.629     | wh-yel amorp powder       | 1084            |          | 2.85                       |                                     | i H <sub>2</sub> O, dil acid, EtOH, ace; s eth            |
| 936 | Copper(II) sulfite dihydrate                | Cu <sub>2</sub> SO <sub>3</sub> · CuSO <sub>3</sub> · 2H <sub>2</sub> O                              | 13814-81-8  | 386.795     | red prisms or powder      |                 |          |                            |                                     | i H <sub>2</sub> O, EtOH; s HCl                           |
| 937 | Copper(II) acetate                          | Cu(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                                       | 142-71-2    | 181.635     | blue-grn hyg powder       |                 |          |                            |                                     |                                                           |
| 938 | Copper(II) acetate monohydrate              | Cu(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                    | 6046-93-1   | 199.650     | grn monocl cry            | 115             | 240 dec  | 1.88                       |                                     | s H <sub>2</sub> O, EtOH; sl eth                          |
| 939 | Copper(II) acetate metaarsenite             | Cu(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 3Cu(AsO <sub>2</sub> ) <sub>2</sub> | 12002-03-8  | 1013.795    | grn cry powder            |                 |          |                            |                                     | i H <sub>2</sub> O; reac acid                             |
| 940 | Copper(II) basic acetate                    | Cu(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · CuO · 6H <sub>2</sub> O             | 52503-64-7  | 369.271     | blue-grn cry or powder    |                 |          |                            |                                     | sl H <sub>2</sub> O, EtOH; s dil acid, NH <sub>4</sub> OH |
| 941 | Copper(II) acetylides                       | CuC <sub>2</sub>                                                                                     | 12540-13-5  | 87.567      | brn-blk solid; exp        | exp 100         |          |                            |                                     |                                                           |
| 942 | Copper(II) arsenate                         | Cu <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub>                                                     | 7778-41-8   | 468.476     | blue-grn cry              |                 |          |                            |                                     | i H <sub>2</sub> O, EtOH; s dil acid                      |
| 943 | Copper(II) arsenite                         | CuHAsO <sub>3</sub>                                                                                  | 10290-12-7  | 187.474     | yel-grn powder            |                 |          |                            |                                     | i H <sub>2</sub> O, EtOH; s acid                          |
| 944 | Copper(II) azide                            | Cu(N <sub>3</sub> ) <sub>2</sub>                                                                     | 14215-30-6  | 147.586     | brn orth cry; exp         |                 |          | ≈2.6                       |                                     |                                                           |
| 945 | Copper(II) borate                           | Cu(BO <sub>2</sub> ) <sub>2</sub>                                                                    | 39290-85-2  | 149.166     | blue-grn powder           |                 |          | 3.859                      |                                     | i H <sub>2</sub> O; s acid                                |
| 946 | Copper(II) bromide                          | CuBr <sub>2</sub>                                                                                    | 7789-45-9   | 223.354     | blk monocl cry; hyg       | 498             | 900      | 4.710                      | 126 <sup>25</sup>                   | vs H <sub>2</sub> O; s EtOH, ace; i bz, eth               |
| 947 | Copper(II) butanoate monohydrate            | Cu(C <sub>4</sub> H <sub>7</sub> O <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                    | 540-16-9    | 255.756     | grn monocl plates         |                 |          |                            |                                     | s H <sub>2</sub> O, diox, bz; sl EtOH                     |
| 948 | Copper(II) carbonate                        | CuCO <sub>3</sub>                                                                                    | 1184-64-1   | 123.555     | cry                       |                 |          |                            |                                     | i H <sub>2</sub> O                                        |
| 949 | Copper(II) carbonate hydroxide              | CuCO <sub>3</sub> · Cu(OH) <sub>2</sub>                                                              | 12069-69-1  | 221.116     | grn monocl cry            | 200 dec         |          | 4.0                        |                                     | i H <sub>2</sub> O, EtOH; s dil acid                      |
| 950 | Copper(II) chlorate hexahydrate             | Cu(ClO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                               | 14721-21-2  | 338.540     | blue-grn hyg cry          | 65              | 100 dec  |                            | 164 <sup>18</sup>                   | vs EtOH                                                   |
| 951 | Copper(II) chloride                         | CuCl <sub>2</sub>                                                                                    | 7447-39-4   | 134.452     | yel-brn monocl cry; hyg   | 598             | 993      | 3.4                        | 75.7 <sup>25</sup>                  | s EtOH, ace                                               |
| 952 | Copper(II) chloride dihydrate               | CuCl <sub>2</sub> · 2H <sub>2</sub> O                                                                | 10125-13-0  | 170.483     | grn-blue orth cry; hyg    | 100 dec         |          | 2.51                       | 75.7 <sup>20</sup>                  | vs EtOH, MeOH; s ace; i eth                               |
| 953 | Copper(II) chloride hydroxide               | Cu <sub>2</sub> (OH) <sub>3</sub> Cl                                                                 | 1332-65-6   | 213.567     | pale grn cry              |                 |          |                            |                                     | i H <sub>2</sub> O; s acid                                |
| 954 | Copper(II) chromate                         | CuCrO <sub>4</sub>                                                                                   | 13548-42-0  | 179.540     | red-brn cry               |                 |          |                            |                                     | i H <sub>2</sub> O; s EtOH                                |
| 955 | Copper(II) basic chromate                   | CuCrO <sub>4</sub> · 2Cu(OH) <sub>2</sub>                                                            | 12433-14-6  | 374.661     | brn pow                   | dec 260         |          |                            |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>                    |
| 956 | Copper(II) chromite                         | CuCr <sub>2</sub> O <sub>4</sub>                                                                     | 12018-10-9  | 231.536     | gray-blk tetr cry         |                 |          | 5.4                        |                                     | i H <sub>2</sub> O, dil acid                              |
| 957 | Copper(II) citrate hemipentahydrate         | Cu <sub>3</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> · 2.5H <sub>2</sub> O                   | 10402-15-0  | 360.221     | blue-grn cry              | 100 dec         |          |                            |                                     | sl H <sub>2</sub> O; s dil acid                           |
| 958 | Copper(II) cyanide                          | Cu(CN) <sub>2</sub>                                                                                  | 14763-77-0  | 115.580     | grn powder                |                 |          |                            |                                     | i H <sub>2</sub> O; s acid, alk                           |
| 959 | Copper(II) cyclohexanecarboxylate           | Cu(C <sub>6</sub> H <sub>11</sub> O <sub>2</sub> ) <sub>2</sub>                                      | 2218-80-6   | 402.028     | powder                    | 126 dec         |          |                            |                                     |                                                           |
| 960 | Copper(II) dichromate dihydrate             | CuCr <sub>2</sub> O <sub>7</sub> · 2H <sub>2</sub> O                                                 | 13675-47-3  | 315.565     | red-brn tricl cry         |                 |          | 2.286                      |                                     | vs H <sub>2</sub> O                                       |
| 961 | Copper(II) ethanolate                       | Cu(C <sub>2</sub> H <sub>5</sub> O) <sub>2</sub>                                                     | 2850-65-9   | 153.667     | blue hyg solid            | 120 dec         |          |                            |                                     | i os                                                      |
| 962 | Copper(II) ethylacetoacetate                | Cu(C <sub>8</sub> H <sub>9</sub> CO <sub>2</sub> CHCOCH <sub>3</sub> ) <sub>2</sub>                  | 14284-06-1  | 321.813     | grn cry                   | 192             |          |                            |                                     | s EtOH, chl                                               |

| No.  | Name                                         | Formula                                                             | CAS Reg No. | Mol. weight | Physical form                    | mp/°C      | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                          |
|------|----------------------------------------------|---------------------------------------------------------------------|-------------|-------------|----------------------------------|------------|---------|----------------------------|-------------------------------------|-----------------------------------------------------------------|
| 963  | Copper(II) 2-ethylhexanoate                  | Cu(C <sub>8</sub> H <sub>15</sub> O <sub>2</sub> ) <sub>2</sub>     | 149-11-1    | 349.953     | powder                           | 252 dec    |         |                            |                                     |                                                                 |
| 964  | Copper(II) ferrate                           | CuFe <sub>2</sub> O <sub>4</sub>                                    | 12018-79-0  | 239.234     | blk cry                          |            |         |                            |                                     |                                                                 |
| 965  | Copper(II) ferrocyanide                      | Cu <sub>2</sub> Fe(CN) <sub>6</sub>                                 | 13601-13-3  | 339.041     | red-br cub cry or powder         |            |         | 2.2                        |                                     | i H <sub>2</sub> O, acid, os                                    |
| 966  | Copper(II) ferrous sulfide                   | CuFeS <sub>2</sub>                                                  | 1308-56-1   | 183.521     | yel tetr cry                     | 950        |         | 4.2                        |                                     | i H <sub>2</sub> O, HCl; s HNO <sub>3</sub>                     |
| 967  | Copper(II) fluoride                          | CuF <sub>2</sub>                                                    | 7789-19-7   | 101.543     | wh monocl cry                    | 836        | 1676    | 4.23                       | 0.075 <sup>25</sup>                 |                                                                 |
| 968  | Copper(II) fluoride dihydrate                | CuF <sub>2</sub> · 2H <sub>2</sub> O                                | 13454-88-1  | 137.574     | blue monocl cry                  | 130 dec    |         | 2.934                      | 0.075 <sup>25</sup>                 |                                                                 |
| 969  | Copper(II) formate                           | Cu(CHO <sub>2</sub> ) <sub>2</sub>                                  | 544-19-4    | 153.581     | blue cry                         |            |         |                            | 12.5 <sup>20</sup>                  | i os                                                            |
| 970  | Copper(II) formate tetrahydrate              | Cu(CHO <sub>2</sub> ) <sub>2</sub> · 4H <sub>2</sub> O              | 5893-61-8   | 225.641     | blue monocl cry                  |            |         |                            | 12.5                                | sl EtOH; i os                                                   |
| 971  | Copper(II) gluconate                         | Cu(C <sub>12</sub> H <sub>22</sub> O <sub>14</sub> ) <sub>2</sub>   | 527-09-3    | 453.841     | bl-grn cry                       | 156        |         |                            |                                     | sl EtOH; i os                                                   |
| 972  | Copper(II) hexafluoro-2,4-pentanedioate      | Cu(CF <sub>3</sub> COCHCOCF <sub>3</sub> ) <sub>2</sub>             | 14781-45-4  | 477.648     | cry                              | 98         | 220 dec |                            |                                     | s MeOH, ace, tol                                                |
| 973  | Copper(II) hexafluorosilicate tetrahydrate   | CuSiF <sub>6</sub> · 4H <sub>2</sub> O                              | 12062-24-7  | 277.684     | blue monocl cry                  | dec        |         | 2.56                       | 99.7 <sup>17</sup>                  | sl EtOH                                                         |
| 974  | Copper(II) hydroxide                         | Cu(OH) <sub>2</sub>                                                 | 20427-59-2  | 97.561      | blue-grn powder                  |            |         | 3.37                       |                                     | i H <sub>2</sub> O; s acid, conc alk                            |
| 975  | Copper(II) iodate                            | Cu(IO <sub>3</sub> ) <sub>2</sub>                                   | 13454-89-2  | 413.351     | grn monocl cry                   | dec        |         | 5.241                      | 0.15 <sup>20</sup>                  | s dil acid                                                      |
| 976  | Copper(II) iodate monohydrate                | Cu(IO <sub>3</sub> ) <sub>2</sub> · H <sub>2</sub> O                | 13454-90-5  | 431.367     | blue tricl cry                   | 248 dec    |         | 4.872                      | 0.15 <sup>20</sup>                  | s dil H <sub>2</sub> SO <sub>4</sub>                            |
| 977  | Copper(II) molybdate                         | CuMoO <sub>4</sub>                                                  | 13767-34-5  | 223.48      | grn cry                          | ≈500       |         | 3.4                        | 0.038                               |                                                                 |
| 978  | Copper(II) nitrate                           | Cu(NO <sub>3</sub> ) <sub>2</sub>                                   | 3251-23-8   | 187.555     | blue-grn orth cry; hyg           | 255        | subl    |                            | 145 <sup>25</sup>                   | s diox; reac eth                                                |
| 979  | Copper(II) nitrate trihydrate                | Cu(NO <sub>3</sub> ) <sub>2</sub> · 3H <sub>2</sub> O               | 10031-43-3  | 241.602     | blue rhomb cry                   | 114        | 170 dec | 2.32                       | 145 <sup>25</sup>                   | vs EtOH                                                         |
| 980  | Copper(II) nitrate hexahydrate               | Cu(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O               | 13478-38-1  | 295.647     | blue rhomb cry; hyg              |            |         | 2.07                       | 145 <sup>25</sup>                   | s EtOH                                                          |
| 981  | Copper(II) oleate                            | Cu(C <sub>18</sub> H <sub>33</sub> O <sub>2</sub> ) <sub>2</sub>    | 1120-44-1   | 626.453     | blue-grn solid                   |            |         |                            |                                     | i H <sub>2</sub> O; sl EtOH; s eth                              |
| 982  | Copper(II) oxalate                           | CuC <sub>2</sub> O <sub>4</sub>                                     | 814-91-5    | 151.565     | blue-wh powder                   | 310 dec    |         |                            | 0.0026 <sup>20</sup>                | i EtOH, eth; s NH <sub>4</sub> OH                               |
| 983  | Copper(II) oxalate hemihydrate               | CuC <sub>2</sub> O <sub>4</sub> · 0.5H <sub>2</sub> O               | 814-91-5*   | 144.573     | blue-wh cry                      | 200 dec    |         |                            | 0.0026 <sup>20</sup>                | s NH <sub>4</sub> OH                                            |
| 984  | Copper(II) oxide                             | CuO                                                                 | 1317-38-0   | 79.545      | blk powder or monocl cry         | 1227       |         | 6.31                       |                                     | i H <sub>2</sub> O, EtOH; s dil acid                            |
| 985  | Copper(II) 2,4-pentanedioate                 | Cu(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>             | 13395-16-9  | 261.762     | blue powder                      | 284 dec    | subl    |                            |                                     | sl H <sub>2</sub> O; s chl                                      |
| 986  | Copper(II) oxychloride hemiheptahydrate      | CuCl <sub>2</sub> · 3CuO · 3.5H <sub>2</sub> O                      | 1332-40-7   |             | blue-grn pow                     | dec 140    |         |                            |                                     | i H <sub>2</sub> O; s acid, NH <sub>4</sub> OH                  |
| 987  | Copper(II) perchlorate                       | Cu(ClO <sub>4</sub> ) <sub>2</sub>                                  | 13770-18-8  | 262.447     | grn hyg cry                      | 130 dec    |         |                            | 146 <sup>30</sup>                   | s eth, diox; i bz, ctc                                          |
| 988  | Copper(II) perchlorate hexahydrate           | Cu(ClO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O              | 10294-46-9  | 370.539     | blue monocl cry; hyg             | 82         | 120 dec | 2.22                       | 146 <sup>30</sup>                   | vs EtOH, HOAc, ace; sl eth                                      |
| 989  | Copper(II) phosphate                         | Cu <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>                     | 7798-23-4   | 380.581     | blue-grn tricl cry               |            |         |                            |                                     | i H <sub>2</sub> O; s acid, NH <sub>4</sub> OH                  |
| 990  | Copper(II) phosphate trihydrate              | Cu <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> · 3H <sub>2</sub> O | 10031-48-8  | 434.627     | blue-grn orth cry                |            |         |                            |                                     | i H <sub>2</sub> O; s acid, NH <sub>4</sub> OH                  |
| 991  | Copper(II) phthalocyanine                    | CuC <sub>32</sub> H <sub>16</sub> N <sub>8</sub>                    | 147-14-8    | 576.069     | bl-purp cry                      |            |         |                            |                                     | i H <sub>2</sub> O, EtOH; s conc H <sub>2</sub> SO <sub>4</sub> |
| 992  | Copper(II) selenate pentahydrate             | CuSeO <sub>4</sub> · 5H <sub>2</sub> O                              | 10031-45-5  | 296.58      | blue tricl cry                   | 80 dec     |         | 2.56                       | 27.4 <sup>25</sup>                  | s acid, NH <sub>4</sub> OH; sl ace; i EtOH                      |
| 993  | Copper(II) selenide                          | CuSe                                                                | 1317-41-5   | 142.51      | blue-blk needles or plates       | 550 dec    |         | 5.99                       |                                     | reac acid                                                       |
| 994  | Copper(II) selenite dihydrate                | CuSeO <sub>3</sub> · 2H <sub>2</sub> O                              | 15168-20-4  | 226.54      | blue orth cry                    |            |         | 3.31                       |                                     | i H <sub>2</sub> O; s acid, NH <sub>4</sub> OH                  |
| 995  | Copper(II) silicate dihydrate                | CuSiO <sub>3</sub> · 2H <sub>2</sub> O                              | 26318-99-0  | 175.661     | grn-blue orth cry                |            |         |                            |                                     |                                                                 |
| 996  | Copper(II) stannate                          | CuSnO <sub>3</sub>                                                  | 12019-07-7  | 230.254     | blue pow                         |            |         |                            |                                     |                                                                 |
| 997  | Copper(II) stearate                          | Cu(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>2</sub>    | 660-60-6    | 630.485     | blue-grn amorp powder            | ≈250       |         |                            |                                     | i H <sub>2</sub> O, EtOH, eth; s py                             |
| 998  | Copper(II) sulfate                           | CuSO <sub>4</sub>                                                   | 7758-98-7   | 159.609     | wh-grn amorp powder or rhomb cry | 560 dec    |         | 3.60                       | 22.0 <sup>25</sup>                  | i EtOH                                                          |
| 999  | Copper(II) sulfate pentahydrate              | CuSO <sub>4</sub> · 5H <sub>2</sub> O                               | 7758-99-8   | 249.685     | blue tricl cry                   | 110 dec    |         | 2.286                      | 22.0 <sup>25</sup>                  | s MeOH; sl EtOH                                                 |
| 1000 | Copper(II) sulfate, basic                    | Cu <sub>2</sub> (OH) <sub>4</sub> SO <sub>4</sub>                   | 1332-14-5   | 354.730     | grn rhomb cry                    |            |         | 3.88                       |                                     | i H <sub>2</sub> O                                              |
| 1001 | Copper(II) sulfide                           | CuS                                                                 | 1317-40-4   | 95.611      | blk hex cry                      | trans 507  |         | 4.76                       |                                     | i H <sub>2</sub> O, EtOH, dil acid, alk                         |
| 1002 | Copper(II) tartrate trihydrate               | CuC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> · 3H <sub>2</sub> O  | 815-82-7    | 265.663     | blue-grn powder                  |            |         |                            |                                     | sl H <sub>2</sub> O; s acid, alk                                |
| 1003 | Copper(II) telluride                         | CuTe                                                                | 12019-23-7  | 191.15      | yel orth cry                     | trans ≈400 |         | 7.09                       |                                     |                                                                 |
| 1004 | Copper(II) tellurite                         | CuTeO <sub>3</sub>                                                  | 13812-58-3  | 239.14      | blk glassy solid                 |            |         |                            |                                     | i H <sub>2</sub> O                                              |
| 1005 | Copper(II) tetrafluoroborate                 | Cu(BF <sub>4</sub> ) <sub>2</sub>                                   | 14735-84-3  | 237.155     | solid                            |            |         |                            |                                     | s H <sub>2</sub> O                                              |
| 1006 | Copper(II) titanate                          | CuTiO <sub>3</sub>                                                  | 12019-08-8  | 159.411     | gray pow                         |            |         |                            |                                     |                                                                 |
| 1007 | Copper(II) 1,1,1-trifluoro-2,4-pentanedioate | Cu(CF <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>             | 14324-82-4  | 369.705     | blue-purp cry                    | 197        | dec 260 |                            |                                     | s EtOH, tol                                                     |
| 1008 | Copper(II) tungstate                         | CuWO <sub>4</sub>                                                   | 13587-35-4  | 311.38      | yel-brn powder                   |            |         | 7.5                        |                                     |                                                                 |
| 1009 | Copper(II) tungstate dihydrate               | CuWO <sub>4</sub> · 2H <sub>2</sub> O                               | 13587-35-4* | 347.41      | grn powder                       |            |         |                            |                                     | i H <sub>2</sub> O; sl HOAc; reac conc acid                     |
| 1010 | Copper(II) vanadate                          | Cu(VO <sub>3</sub> ) <sub>2</sub>                                   | 12789-09-2  | 261.425     | powder                           |            |         |                            |                                     |                                                                 |

| No.  | Name                                   | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form          | mp/°C   | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility      |
|------|----------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|------------------------|---------|-------|----------------------------|-------------------------------------|-----------------------------|
| 1011 | Curium                                 | Cm                                                                                 | 7440-51-9   | 247         | silv metal; hex or cub | 1345    | ≈3100 | 13.51                      |                                     |                             |
| 1012 | Dysprosium                             | Dy                                                                                 | 7429-91-6   | 162.500     | silv metal; hex        | 1412    | 2567  | 8.55                       |                                     | s dil acid                  |
| 1013 | Dysprosium boride                      | DyB <sub>4</sub>                                                                   | 12310-43-9  | 205.744     | tetr cry               | 2500    |       | 6.98                       |                                     |                             |
| 1014 | Dysprosium nitride                     | DyN                                                                                | 12019-88-4  | 176.507     | cub cry                |         |       | 9.93                       |                                     |                             |
| 1015 | Dysprosium silicide                    | DySi <sub>2</sub>                                                                  | 12133-07-2  | 218.671     | orth cry               | 1550    |       | 5.2                        |                                     |                             |
| 1016 | Dysprosium(II) bromide                 | DyBr <sub>2</sub>                                                                  | 83229-05-4  | 322.308     | blk solid              |         |       |                            |                                     |                             |
| 1017 | Dysprosium(II) chloride                | DyCl <sub>2</sub>                                                                  | 13767-31-2  | 233.406     | blk cry                | 721 dec |       |                            |                                     | reac H <sub>2</sub> O       |
| 1018 | Dysprosium(II) iodide                  | DyI <sub>2</sub>                                                                   | 36377-94-3  | 416.309     | purp cry               | 659     |       |                            |                                     | reac H <sub>2</sub> O       |
| 1019 | Dysprosium(III) acetate tetrahydrate   | Dy(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · 4H <sub>2</sub> O | 15280-55-4  | 411.693     | yel needles            | dec 120 |       |                            |                                     | s H <sub>2</sub> O; sl EtOH |
| 1020 | Dysprosium(III) bromide                | DyBr <sub>3</sub>                                                                  | 14456-48-5  | 402.212     | wh hyg cry             | 879     |       |                            |                                     | s H <sub>2</sub> O          |
| 1021 | Dysprosium(III) carbonate tetrahydrate | Dy <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub> · 4H <sub>2</sub> O                | 38245-35-1  | 577.088     | wh cry pow             |         |       |                            |                                     | i H <sub>2</sub> O          |
| 1022 | Dysprosium(III) chloride               | DyCl <sub>3</sub>                                                                  | 10025-74-8  | 268.859     | wh or yel cry          | 718     | 1530  | 3.67                       |                                     | s H <sub>2</sub> O, MeOH    |
| 1023 | Dysprosium(III) chloride hexahydrate   | DyCl <sub>3</sub> · 6H <sub>2</sub> O                                              | 15059-52-6  | 376.950     | bright yel cry         | dec 162 |       |                            |                                     |                             |
| 1024 | Dysprosium(III) fluoride               | DyF <sub>3</sub>                                                                   | 13569-80-7  | 219.495     | grn cry                | 1157    |       |                            |                                     |                             |
| 1025 | Dysprosium(III) hydride                | DyH <sub>3</sub>                                                                   | 13537-09-2  | 165.524     | hex cry                |         |       | 7.1                        |                                     |                             |
| 1026 | Dysprosium(III) hydroxide              | Dy(OH) <sub>3</sub>                                                                | 1308-85-6   | 213.522     | yel or wh needles      | 205 dec |       |                            |                                     | i H <sub>2</sub> O          |
| 1027 | Dysprosium(III) iodide                 | DyI <sub>3</sub>                                                                   | 15474-63-2  | 543.213     | grn cry                | 978     |       |                            |                                     |                             |
| 1028 | Dysprosium(III) nitrate pentahydrate   | Dy(NO <sub>3</sub> ) <sub>3</sub> · 5H <sub>2</sub> O                              | 10143-38-1* | 438.591     | yel cry                | 88.6    |       |                            | 208.4 <sup>25</sup>                 |                             |
| 1029 | Dysprosium(III) oxide                  | Dy <sub>2</sub> O <sub>3</sub>                                                     | 1308-87-8   | 372.998     | wh cub cry             | 2228    | 3900  | 7.81                       |                                     | s acid                      |
| 1030 | Dysprosium(III) sulfate octahydrate    | Dy <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                | 10031-50-2  | 757.310     | pale yel cry           | 110     |       |                            |                                     | sl H <sub>2</sub> O         |
| 1031 | Dysprosium(III) sulfide                | Dy <sub>2</sub> S <sub>3</sub>                                                     | 12133-10-7  | 421.195     | red-brn monocl cry     |         |       | 6.08                       |                                     |                             |
| 1032 | Dysprosium(III) telluride              | Dy <sub>2</sub> Te <sub>3</sub>                                                    | 12159-43-2  | 707.80      | solid                  | ≈1550   |       |                            |                                     |                             |
| 1033 | Einsteinium                            | Es                                                                                 | 7429-92-7   | 252         | metal; cub             | 860     |       |                            |                                     |                             |
| 1034 | Erbium                                 | Er                                                                                 | 7440-52-0   | 167.259     | silv metal; hex        | 1529    | 2868  | 9.07                       |                                     | i H <sub>2</sub> O; s acid  |
| 1035 | Erbium boride                          | ErB <sub>4</sub>                                                                   | 12310-44-0  | 210.503     | tetr cry               | 2450    |       | 7.0                        |                                     |                             |
| 1036 | Erbium acetate tetrahydrate            | Er(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · 4H <sub>2</sub> O | 15280-57-6  | 416.452     | pink or wh cry         |         |       | 2.11                       |                                     | s H <sub>2</sub> O          |
| 1037 | Erbium bromide                         | ErBr <sub>3</sub>                                                                  | 13536-73-7  | 406.971     | viol hyg cry           | 950     | ≈1460 |                            |                                     | s H <sub>2</sub> O, thf     |
| 1038 | Erbium bromide hexahydrate             | ErBr <sub>3</sub> · 6H <sub>2</sub> O                                              | 14890-44-9  | 515.062     | pink cry               |         |       |                            |                                     | s H <sub>2</sub> O          |
| 1039 | Erbium chloride                        | ErCl <sub>3</sub>                                                                  | 10138-41-7  | 273.618     | viol monocl cry; hyg   | 776     |       | 4.1                        |                                     | s H <sub>2</sub> O          |
| 1040 | Erbium chloride hexahydrate            | ErCl <sub>3</sub> · 6H <sub>2</sub> O                                              | 10025-75-9  | 381.709     | pink hyg cry           | dec     |       |                            |                                     | s H <sub>2</sub> O; sl EtOH |
| 1041 | Erbium fluoride                        | ErF <sub>3</sub>                                                                   | 13760-83-3  | 224.254     | pink orth cry          | 1146    |       | 7.8                        |                                     | i H <sub>2</sub> O          |
| 1042 | Erbium hydride                         | ErH <sub>3</sub>                                                                   | 13550-53-3  | 170.283     | hex cry                |         |       | ≈7.6                       |                                     |                             |
| 1043 | Erbium hydroxide                       | Er(OH) <sub>3</sub>                                                                | 14646-16-3  | 218.281     | pink solid             |         |       |                            |                                     | i H <sub>2</sub> O          |
| 1044 | Erbium iodide                          | ErI <sub>3</sub>                                                                   | 13813-42-8  | 547.972     | viol hex cry; hyg      | 1014    |       | ≈5.5                       |                                     | s H <sub>2</sub> O          |
| 1045 | Erbium nitrate pentahydrate            | Er(NO <sub>3</sub> ) <sub>3</sub> · 5H <sub>2</sub> O                              | 10168-80-6* | 443.350     | red cry                | 130 dec |       |                            | 240.8 <sup>25</sup>                 | s EtOH, ace                 |
| 1046 | Erbium nitride                         | ErN                                                                                | 12020-21-2  | 181.266     | cub cry                |         |       | 10.6                       |                                     |                             |
| 1047 | Erbium oxide                           | Er <sub>2</sub> O <sub>3</sub>                                                     | 12061-16-4  | 382.516     | pink powder            | 2344    | 3920  | 8.64                       |                                     | i H <sub>2</sub> O; s acid  |
| 1048 | Erbium silicide                        | ErSi <sub>2</sub>                                                                  | 12020-28-9  | 223.430     | orth cry               |         |       | 7.26                       |                                     |                             |
| 1049 | Erbium sulfate                         | Er <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                    | 13478-49-4  | 622.706     | hyg powder             | dec     |       | 3.68                       | 13 <sup>20</sup>                    |                             |
| 1050 | Erbium sulfate octahydrate             | Er <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                | 10031-52-4  | 766.828     | pink monocl cry        | dec     |       | 3.20                       | 13 <sup>20</sup>                    |                             |
| 1051 | Erbium sulfide                         | Er <sub>2</sub> S <sub>3</sub>                                                     | 12159-66-9  | 430.713     | red-brn monocl cry     | 1730    |       | 6.07                       |                                     |                             |
| 1052 | Erbium telluride                       | Er <sub>2</sub> Te <sub>3</sub>                                                    | 12020-39-2  | 717.32      | orth cry               | 1213    |       | 7.11                       |                                     |                             |
| 1053 | Europium                               | Eu                                                                                 | 7440-53-1   | 151.964     | soft silv metal; cub   | 822     | 1529  | 5.24                       |                                     | reac H <sub>2</sub> O       |
| 1054 | Europium boride                        | EuB <sub>6</sub>                                                                   | 12008-05-8  | 216.830     | cub cry                | ≈2600   |       | 4.91                       |                                     |                             |
| 1055 | Europium nitride                       | EuN                                                                                | 12020-58-5  | 165.971     | cub cry                |         |       | 8.7                        |                                     |                             |
| 1056 | Europium silicide                      | EuSi <sub>2</sub>                                                                  | 12434-24-1  | 208.135     | tetr cry               | 1500    |       | 5.46                       |                                     |                             |
| 1057 | Europium(II) bromide                   | EuBr <sub>2</sub>                                                                  | 13780-48-8  | 311.772     | wh cry                 | 683     |       |                            |                                     | s H <sub>2</sub> O          |
| 1058 | Europium(II) chloride                  | EuCl <sub>2</sub>                                                                  | 13769-20-5  | 222.870     | wh orth cry            | 731     |       | 4.9                        |                                     | s H <sub>2</sub> O          |
| 1059 | Europium(II) fluoride                  | EuF <sub>2</sub>                                                                   | 14077-39-5  | 189.961     | grn-yel cub cry        | ≈1380   |       | 6.5                        |                                     |                             |
| 1060 | Europium(II) iodide                    | EuI <sub>2</sub>                                                                   | 22015-35-6  | 405.773     | grn cry                | 580     |       |                            |                                     | s H <sub>2</sub> O          |
| 1061 | Europium(II) selenide                  | EuSe                                                                               | 12020-66-5  | 230.92      | brn cub cry            |         |       | 6.45                       |                                     |                             |
| 1062 | Europium(II) sulfate                   | EuSO <sub>4</sub>                                                                  | 10031-54-6  | 248.027     | col orth cry           |         |       | 4.99                       |                                     | i H <sub>2</sub> O          |
| 1063 | Europium(II) sulfide                   | EuS                                                                                | 12020-65-4  | 184.029     | cub cry                |         |       | 5.7                        |                                     |                             |
| 1064 | Europium(II) telluride                 | EuTe                                                                               | 12020-69-8  | 279.56      | blk cub cry            | 1526    |       | 6.48                       |                                     |                             |
| 1065 | Europium(III) bromide                  | EuBr <sub>3</sub>                                                                  | 13759-88-1  | 391.676     | gray cry               | dec     |       |                            |                                     | s H <sub>2</sub> O          |
| 1066 | Europium(III) chloride                 | EuCl <sub>3</sub>                                                                  | 10025-76-0  | 258.323     | grn-yel needles        | 623     |       | 4.89                       |                                     |                             |
| 1067 | Europium(III) chloride hexahydrate     | EuCl <sub>3</sub> · 6H <sub>2</sub> O                                              | 13759-92-7  | 366.414     | wh-yel hyg cry         | 850     |       | 4.89                       |                                     | s H <sub>2</sub> O          |
| 1068 | Europium(III) fluoride                 | EuF <sub>3</sub>                                                                   | 13765-25-8  | 208.959     | wh hyg cry             | 1276    |       |                            |                                     | i H <sub>2</sub> O          |
| 1069 | Europium(III) iodide                   | EuI <sub>3</sub>                                                                   | 13759-90-5  | 532.677     | col cry; unstab        | ≈875    |       |                            |                                     |                             |
| 1070 | Europium(III) nitrate hexahydrate      | Eu(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                              | 10031-53-5  | 446.070     | wh-pink hyg cry        | 85 dec  |       |                            | 193 <sup>25</sup>                   |                             |
| 1071 | Europium(III) oxalate                  | Eu <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub>                      | 3269-12-3   | 567.985     | wh solid               |         |       |                            |                                     | i H <sub>2</sub> O; s acid  |

| No.  | Name                                  | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form              | mp/°C      | bp/°C        | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                  |
|------|---------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|----------------------------|------------|--------------|----------------------------|-------------------------------------|-----------------------------------------|
| 1072 | Europium(III) oxide                   | Eu <sub>2</sub> O <sub>3</sub>                                                     | 1308-96-9   | 351.926     | pink powder                | 2291       | 3790         | 7.42                       |                                     | i H <sub>2</sub> O; s acid              |
| 1073 | Europium(III) perchlorate hexahydrate | Eu(ClO <sub>4</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                             | 36907-40-1  | 558.407     | wh or pink cry             |            |              |                            |                                     | s H <sub>2</sub> O, EtOH                |
| 1074 | Europium(III) sulfate                 | Eu <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                    | 13537-15-0  | 592.116     | pale pink cry              |            |              | 4.99                       | 2.1 <sup>20</sup>                   |                                         |
| 1075 | Europium(III) sulfate octahydrate     | Eu <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                | 10031-52-4  | 736.238     | pink cry                   | 375 dec    |              |                            | 2.1 <sup>20</sup>                   |                                         |
| 1076 | Fermium                               | Fm                                                                                 | 7440-72-4   | 257         | metal                      | 1527       |              |                            |                                     |                                         |
| 1077 | Fluorine                              | F <sub>2</sub>                                                                     | 7782-41-4   | 37.997      | pale yel gas               | -219.67 tp | -188.12      | 1.553 g/L                  |                                     | reac H <sub>2</sub> O                   |
| 1078 | Fluorine monoxide                     | F <sub>2</sub> O                                                                   | 7783-41-7   | 53.996      | col gas                    | -223.8     | -144.3       | 2.207 g/L                  |                                     | sl H <sub>2</sub> O                     |
| 1079 | Difluorine dioxide                    | F <sub>2</sub> O <sub>2</sub>                                                      | 7783-44-0   | 69.996      | red-oran solid, unstab gas | -163.5     | -57 (extrap) | 2.861 g/L                  |                                     |                                         |
| 1080 | Fluorine tetroxide                    | F <sub>2</sub> O <sub>4</sub>                                                      | 107782-11-6 | 101.995     | red-brn solid              | -191       | dec -185     |                            |                                     |                                         |
| 1081 | Fluorine nitrate                      | FN O <sub>3</sub>                                                                  | 7789-26-6   | 81.003      | col gas                    | -175       | -46          | 3.311 g/L                  |                                     | reac H <sub>2</sub> O, EtOH, eth; s ace |
| 1082 | Fluorine perchlorate                  | FOClO <sub>3</sub>                                                                 | 10049-03-3  | 118.449     | col gas; exp               | -167.3     | -16          | 4.841 g/L                  |                                     | reac H <sub>2</sub> O                   |
| 1083 | Francium                              | Fr                                                                                 | 7440-73-5   | 223.000     | short-lived alkali metal   | 27         |              |                            |                                     |                                         |
| 1084 | Gadolinium                            | Gd                                                                                 | 7440-54-2   | 157.25      | silv metal; hex            | 1313       | 3273         | 7.90                       |                                     | s dil acid                              |
| 1085 | Gadolinium boride                     | GdB <sub>6</sub>                                                                   | 12008-06-9  | 222.12      | blk-brn cub cry            | 2510       |              | 5.31                       |                                     |                                         |
| 1086 | Gadolinium nitride                    | GdN                                                                                | 25764-15-2  | 171.26      | cub cry                    |            |              | 9.10                       |                                     |                                         |
| 1087 | Gadolinium silicide                   | GdSi <sub>2</sub>                                                                  | 12134-75-7  | 213.42      | orth cry                   | 1540       |              | 5.9                        |                                     |                                         |
| 1088 | Gadolinium(II) iodide                 | GdI <sub>2</sub>                                                                   | 13814-72-7  | 411.06      | bronze cry                 | 831        |              |                            |                                     |                                         |
| 1089 | Gadolinium(II) selenide               | GdSe                                                                               | 12024-81-6  | 236.21      | cub cry                    | 2170       |              | 8.1                        |                                     |                                         |
| 1090 | Gadolinium(III) acetate tetrahydrate  | Gd(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · 4H <sub>2</sub> O | 15280-53-2  | 406.44      | wh tricr cry               | dec        |              | 1.61                       |                                     | s H <sub>2</sub> O                      |
| 1091 | Gadolinium(III) bromide               | GdBr <sub>3</sub>                                                                  | 13818-75-2  | 396.96      | wh monocry cry; hyg        | 770        |              | 4.56                       |                                     |                                         |
| 1092 | Gadolinium(III) chloride              | GdCl <sub>3</sub>                                                                  | 10138-52-0  | 263.61      | wh monocry cry; hyg        | 602        |              | 4.52                       |                                     | s H <sub>2</sub> O                      |
| 1093 | Gadolinium(III) chloride hexahydrate  | GdCl <sub>3</sub> · 6H <sub>2</sub> O                                              | 19423-81-5  | 371.70      | col hyg cry                |            |              | 2.424                      |                                     | s H <sub>2</sub> O                      |
| 1094 | Gadolinium(III) fluoride              | GdF <sub>3</sub>                                                                   | 13765-26-9  | 214.25      | wh cry                     | 1232       |              |                            |                                     |                                         |
| 1095 | Gadolinium(III) iodide                | GdI <sub>3</sub>                                                                   | 13572-98-0  | 537.96      | yel cry                    | 930        |              |                            |                                     |                                         |
| 1096 | Gadolinium(III) nitrate pentahydrate  | Gd(NO <sub>3</sub> ) <sub>3</sub> · 5H <sub>2</sub> O                              | 52788-53-1  | 433.34      | wh cry                     | 92 dec     |              | 2.41                       | 190 <sup>25</sup>                   |                                         |
| 1097 | Gadolinium(III) nitrate hexahydrate   | Gd(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                              | 19598-90-4  | 451.36      | hyg tricr cry              | 91 dec     |              | 2.33                       | 190 <sup>25</sup>                   | s EtOH                                  |
| 1098 | Gadolinium(III) oxalate decahydrate   | Gd <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> · 10H <sub>2</sub> O | 22992-15-0  | 758.71      | wh monocry pow             | dec 110    |              |                            |                                     | i H <sub>2</sub> O; sl acid             |
| 1099 | Gadolinium(III) oxide                 | Gd <sub>2</sub> O <sub>3</sub>                                                     | 12064-62-9  | 362.50      | wh hyg powder              | 2339       | 3900         | 7.41                       |                                     | i H <sub>2</sub> O; s acid              |
| 1100 | Gadolinium(III) sulfate               | Gd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                    | 13628-54-1  | 602.69      | col cry                    | 500 dec    |              | 4.1                        | 2.60 <sup>20</sup>                  | sl H <sub>2</sub> O                     |
| 1101 | Gadolinium(III) sulfate octahydrate   | Gd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                | 13450-87-8  | 746.81      | col monocry cry            | 400 dec    |              | 4.14                       | 2.3 <sup>20</sup>                   | sl H <sub>2</sub> O                     |
| 1102 | Gadolinium(III) sulfide               | Gd <sub>2</sub> S <sub>3</sub>                                                     | 12134-77-9  | 410.70      | yel cub cry                |            |              | 6.1                        |                                     |                                         |
| 1103 | Gadolinium(III) telluride             | Gd <sub>2</sub> Te <sub>3</sub>                                                    | 12160-99-5  | 697.30      | orth cry                   | 1255       |              | 7.7                        |                                     |                                         |
| 1104 | Gallium                               | Ga                                                                                 | 7440-55-3   | 69.723      | silv liq or gray orth cry  | 29.7666 tp | 2204         | 5.91                       |                                     | reac alk                                |
| 1105 | Gallium antimonide                    | GaSb                                                                               | 12064-03-8  | 191.483     | brn cub cry                | 712        |              | 5.6137                     |                                     |                                         |
| 1106 | Gallium arsenide                      | GaAs                                                                               | 1303-00-0   | 144.645     | gray cub cry               | 1238       |              | 5.3176                     |                                     |                                         |
| 1107 | Gallium nitride                       | GaN                                                                                | 25617-97-4  | 83.730      | gray hex cry               | >2500      |              | 6.1                        |                                     |                                         |
| 1108 | Gallium phosphide                     | GaP                                                                                | 12063-98-8  | 100.697     | yel cub cry                | 1457       |              | 4.138                      |                                     |                                         |
| 1109 | Gallium suboxide                      | Ga <sub>2</sub> O                                                                  | 12024-20-3  | 155.445     | brn powder                 | >660       | >800 dec     | 4.77                       |                                     |                                         |
| 1110 | Gallium(II) chloride                  | GaCl <sub>2</sub>                                                                  | 24597-12-4  | 140.629     | wh orth cry                | 172.4      | 535          | 2.74                       |                                     |                                         |
| 1111 | Gallium(II) selenide                  | GaSe                                                                               | 12024-11-2  | 148.68      | hex cry                    | 960        |              | 5.03                       |                                     |                                         |
| 1112 | Gallium(II) sulfide                   | GaS                                                                                | 12024-10-1  | 101.788     | hex cry                    | 965        |              | 3.86                       |                                     |                                         |
| 1113 | Gallium(II) telluride                 | GaTe                                                                               | 12024-14-5  | 197.32      | monocry cry                | 824        |              | 5.44                       |                                     |                                         |
| 1114 | Gallium(III) bromide                  | GaBr <sub>3</sub>                                                                  | 13450-88-9  | 309.435     | wh orth cry                | 123        | 279          | 3.69                       |                                     |                                         |
| 1115 | Gallium(III) chloride                 | GaCl <sub>3</sub>                                                                  | 13450-90-3  | 176.082     | col needles or gl solid    | 77.9       | 201          | 2.47                       |                                     |                                         |
| 1116 | Gallium(III) fluoride                 | GaF <sub>3</sub>                                                                   | 7783-51-9   | 126.718     | wh powder or col needles   | >1000      |              | 4.47                       |                                     | i H <sub>2</sub> O                      |
| 1117 | Gallium(III) fluoride trihydrate      | GaF <sub>3</sub> · 3H <sub>2</sub> O                                               | 22886-66-4  | 180.764     | wh cry                     | >140 dec   |              |                            |                                     | sl H <sub>2</sub> O                     |
| 1118 | Gallium(III) hydride                  | GaH <sub>3</sub>                                                                   | 13572-93-5  | 72.747      | visc liq                   | -15        | ≈0 dec       |                            |                                     |                                         |
| 1119 | Gallium(III) hydroxide                | Ga(OH) <sub>3</sub>                                                                | 12023-99-3  | 120.745     | unstab prec                |            |              |                            |                                     |                                         |
| 1120 | Gallium(III) iodide                   | GaI <sub>3</sub>                                                                   | 13450-91-4  | 450.436     | monocry cry                | 212        | 340          | 4.5                        |                                     |                                         |
| 1121 | Gallium(III) nitrate                  | Ga(NO <sub>3</sub> ) <sub>3</sub>                                                  | 13494-90-1  | 255.738     | wh cry powder              |            |              |                            |                                     | s H <sub>2</sub> O, EtOH, eth           |
| 1122 | Gallium(III) oxide                    | Ga <sub>2</sub> O <sub>3</sub>                                                     | 12024-21-4  | 187.444     | wh cry                     | 1807       |              | ≈6.0                       |                                     | s hot acid                              |
| 1123 | Gallium(III) oxide hydroxide          | GaOOH                                                                              | 20665-52-5  | 102.730     | orth cry                   |            |              | 5.23                       |                                     |                                         |
| 1124 | Gallium(III) 2,4-pentanedioate        | Ga(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub>                            | 14405-43-7  | 367.047     | wh powder                  | 193        | subl         | 1.42                       |                                     |                                         |
| 1125 | Gallium(III) perchlorate hexahydrate  | Ga(ClO <sub>4</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                             | 17835-81-3  | 476.166     | cry                        | dec 175    |              |                            |                                     |                                         |
| 1126 | Gallium(III) selenide                 | Ga <sub>2</sub> Se <sub>3</sub>                                                    | 12024-24-7  | 376.33      | cub cry                    | 937        |              | 4.92                       |                                     |                                         |
| 1127 | Gallium(III) sulfate                  | Ga <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                    | 13494-91-2  | 427.634     | hex cry                    |            |              |                            |                                     |                                         |
| 1128 | Gallium(III) sulfate octadecahydrate  | Ga <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 18H <sub>2</sub> O               | 13780-42-2  | 751.909     | octahed cry                |            |              |                            |                                     | s H <sub>2</sub> O, EtOH                |
| 1129 | Gallium(III) sulfide                  | Ga <sub>2</sub> S <sub>3</sub>                                                     | 12024-22-5  | 235.641     | monocry cry                | 1090       |              | 3.7                        |                                     |                                         |

| No.  | Name                                | Formula                                           | CAS Reg No. | Mol. weight | Physical form               | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                      |
|------|-------------------------------------|---------------------------------------------------|-------------|-------------|-----------------------------|----------|----------|----------------------------|-------------------------------------|---------------------------------------------|
| 1130 | Gallium(III) telluride              | Ga <sub>2</sub> Te <sub>3</sub>                   | 12024-27-0  | 522.25      | cub cry                     | 790      |          | 5.57                       |                                     |                                             |
| 1131 | Germanium                           | Ge                                                | 7440-56-4   | 72.64       | gray-wh cub cry             | 938.25   | 2833     | 5.3234                     |                                     | i H <sub>2</sub> O, dil acid, alk           |
| 1132 | Germane                             | GeH <sub>4</sub>                                  | 7782-65-2   | 76.67       | col gas; flam               | -165     | -88.1    | 3.133 g/L                  |                                     | i H <sub>2</sub> O                          |
| 1133 | Digermane                           | Ge <sub>2</sub> H <sub>6</sub>                    | 13818-89-8  | 151.33      | col liq; flam               | -109     | 29       | 1.98 <sup>-109</sup>       |                                     |                                             |
| 1134 | Trigermane                          | Ge <sub>3</sub> H <sub>8</sub>                    | 14691-44-2  | 225.98      | col liq                     | -105.6   | 110.5    | 2.20 <sup>-105</sup>       |                                     | i H <sub>2</sub> O                          |
| 1135 | Tetragermane                        | Ge <sub>4</sub> H <sub>10</sub>                   | 14691-47-5  | 300.64      | col liq                     |          | 176.9    |                            |                                     | i H <sub>2</sub> O                          |
| 1136 | Pentagermane                        | Ge <sub>5</sub> H <sub>12</sub>                   | 15587-39-0  | 375.30      | col liq                     |          | 234      |                            |                                     | i H <sub>2</sub> O                          |
| 1137 | Bromogermane                        | GeH <sub>3</sub> Br                               | 13569-43-2  | 155.57      | col liq                     | -32      | 52       | 2.34                       |                                     | reac H <sub>2</sub> O                       |
| 1138 | Chlorogermane                       | GeH <sub>3</sub> Cl                               | 13637-65-5  | 111.12      | col liq                     | -52      | 28       | 1.75                       |                                     | reac H <sub>2</sub> O                       |
| 1139 | Chlorotrifluorogermane              | GeF <sub>3</sub> Cl                               | 14188-40-0  | 165.09      | gas                         | -66.2    | -20.3    | 6.747 g/L                  |                                     |                                             |
| 1140 | Dibromogermane                      | GeH <sub>2</sub> Br <sub>2</sub>                  | 13769-36-3  | 234.46      | col liq                     | -15      | 89       | 2.80                       |                                     | reac H <sub>2</sub> O                       |
| 1141 | Dichlorogermane                     | GeH <sub>2</sub> Cl <sub>2</sub>                  | 15230-48-5  | 145.56      | col liq                     | -68      | 69.5     | 1.90                       |                                     | reac H <sub>2</sub> O                       |
| 1142 | Dichlorodifluorogermane             | GeF <sub>2</sub> Cl <sub>2</sub>                  | 24422-21-7  | 181.54      | col gas                     | -51.8    | -2.8     | 7.419 g/L                  |                                     |                                             |
| 1143 | Dichlorodimethylgermane             | Ge(CH <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> | 1529-48-2   | 173.62      | liq                         | -22      | 124      | 1.49                       |                                     |                                             |
| 1144 | Fluorogermane                       | GeH <sub>3</sub> F                                | 13537-30-9  | 94.66       | col gas                     |          |          | 3.868 g/L                  |                                     | reac H <sub>2</sub> O                       |
| 1145 | Iodogermane                         | GeH <sub>3</sub> I                                | 13573-02-9  | 202.57      | liq                         | -15      | ≈90      |                            |                                     | reac H <sub>2</sub> O                       |
| 1146 | Methylgermane                       | GeH <sub>3</sub> CH <sub>3</sub>                  | 1449-65-6   | 90.70       | col gas                     | -158     | -23      | 3.706 g/L                  |                                     |                                             |
| 1147 | Tribromogermane                     | GeHBr <sub>3</sub>                                | 14779-70-5  | 313.36      | col liq                     | -25      | dec      |                            |                                     | reac H <sub>2</sub> O                       |
| 1148 | Trichlorogermane                    | GeHCl <sub>3</sub>                                | 1184-65-2   | 180.01      | liq                         | -71      | 75.3     | 1.93                       |                                     | reac H <sub>2</sub> O                       |
| 1149 | Trichlorofluorogermane              | GeCl <sub>3</sub> F                               | 24422-20-6  | 198.00      | liq                         | -49.8    | 37.5     |                            |                                     |                                             |
| 1150 | Germanium(II) bromide               | GeBr <sub>2</sub>                                 | 24415-00-7  | 232.45      | yel monoc cry               | 122      | 150 dec  |                            |                                     | reac H <sub>2</sub> O                       |
| 1151 | Germanium(II) chloride              | GeCl <sub>2</sub>                                 | 10060-11-4  | 143.55      | wh-yel hyg powder           | dec      |          |                            |                                     | reac H <sub>2</sub> O; s eth, bz            |
| 1152 | Germanium(II) fluoride              | GeF <sub>2</sub>                                  | 13940-63-1  | 110.64      | wh orth cry; hyg            | 110      | 130 dec  | 3.64                       |                                     | reac H <sub>2</sub> O                       |
| 1153 | Germanium(II) iodide                | GeI <sub>2</sub>                                  | 13573-08-5  | 326.45      | oran-yel hex cry            | 428      | 550 dec  | 5.4                        |                                     | reac H <sub>2</sub> O                       |
| 1154 | Germanium(II) oxide                 | GeO                                               | 20619-16-3  | 88.64       | blk solid                   | 700 dec  |          |                            |                                     |                                             |
| 1155 | Germanium(II) selenide              | GeSe                                              | 12065-10-0  | 151.60      | gray orth cry or brn powder | 675      |          | 5.6                        |                                     |                                             |
| 1156 | Germanium(II) sulfide               | GeS                                               | 12025-32-0  | 104.71      | gray orth cry               | 658      |          | 4.1                        |                                     |                                             |
| 1157 | Germanium(II) telluride             | GeTe                                              | 12025-39-7  | 200.24      | cub cry                     | 724      |          | 6.16                       |                                     | i H <sub>2</sub> O; s conc HNO <sub>3</sub> |
| 1158 | Germanium(IV) bromide               | GeBr <sub>4</sub>                                 | 13450-92-5  | 392.26      | wh cry                      | 26.1     | 186.35   | 3.132                      |                                     | reac H <sub>2</sub> O                       |
| 1159 | Germanium(IV) chloride              | GeCl <sub>4</sub>                                 | 10038-98-9  | 214.45      | col liq                     | -51.50   | 86.55    | 1.88                       |                                     | reac H <sub>2</sub> O; s bz, eth, EtOH, ctc |
| 1160 | Germanium(IV) fluoride              | GeF <sub>4</sub>                                  | 7783-58-6   | 148.63      | col gas                     | -15 tp   | -36.5 sp | 6.074 g/L                  |                                     | reac H <sub>2</sub> O                       |
| 1161 | Germanium(IV) iodide                | GeI <sub>4</sub>                                  | 13450-95-8  | 580.26      | red-oran cub cry            | 146      | 348      | 4.322                      |                                     | reac H <sub>2</sub> O                       |
| 1162 | Germanium(IV) nitride               | Ge <sub>3</sub> N <sub>4</sub>                    | 12065-36-0  | 273.95      | orth cry                    | 900 dec  |          |                            |                                     | i H <sub>2</sub> O, acid, aqua regia        |
| 1163 | Germanium(IV) oxide                 | GeO <sub>2</sub>                                  | 1310-53-8   | 104.64      | wh hex cry                  | 1116     |          | 4.25                       |                                     | i H <sub>2</sub> O                          |
| 1164 | Germanium(IV) selenide              | GeSe <sub>2</sub>                                 | 12065-11-1  | 230.56      | yel-oran orth cry           | 707 dec  |          | 4.56                       |                                     |                                             |
| 1165 | Germanium(IV) sulfide               | GeS <sub>2</sub>                                  | 12025-34-2  | 136.77      | blk orth cry                | 530      |          | 3.01                       |                                     |                                             |
| 1166 | Gold                                | Au                                                | 7440-57-5   | 196.967     | soft yel metal              | 1064.18  | 2856     | 19.3                       |                                     | s aqua regia                                |
| 1167 | Bromoaauric(III) acid pentahydrate  | HAuBr <sub>4</sub> · 5H <sub>2</sub> O            | 17083-68-0  | 607.667     | red-brn hyg cry             | 27       |          |                            |                                     | s H <sub>2</sub> O, EtOH                    |
| 1168 | Chloroaauric(III) acid tetrahydrate | HAuCl <sub>4</sub> · 4H <sub>2</sub> O            | 16903-35-8  | 411.848     | yel monoc cry; hyg          |          |          | ≈3.9                       |                                     | vs H <sub>2</sub> O, EtOH; s eth            |
| 1169 | Gold(I) bromide                     | AuBr                                              | 10294-27-6  | 276.871     | yel-gray tetr cry           | 165 dec  |          | 8.20                       |                                     | i H <sub>2</sub> O                          |
| 1170 | Gold(I) chloride                    | AuCl                                              | 10294-29-8  | 232.420     | yel orth cry                | 289 dec  |          | 7.6                        | 0.000031 <sup>20</sup>              |                                             |
| 1171 | Gold(I) cyanide                     | AuCN                                              | 506-65-0    | 222.985     | yel hex cry                 | dec      |          | 7.2                        |                                     | i H <sub>2</sub> O, EtOH, eth, dil acid     |
| 1172 | Gold(I) iodide                      | AuI                                               | 10294-31-2  | 323.871     | yel-grn powder; tetr        | 120 dec  |          | 8.25                       |                                     | i H <sub>2</sub> O; s CN soln               |
| 1173 | Gold(I) sulfide                     | Au <sub>2</sub> S                                 | 1303-60-2   | 425.998     | brn-blk cub cry; unstab     | 240 dec  |          | ≈11                        |                                     | i H <sub>2</sub> O, acid; s aqua regia      |
| 1174 | Gold(III) bromide                   | AuBr <sub>3</sub>                                 | 10294-28-7  | 436.679     | red-br monoc cry            | ≈160 dec |          |                            |                                     | s H <sub>2</sub> O, EtOH                    |
| 1175 | Gold(III) chloride                  | AuCl <sub>3</sub>                                 | 13453-07-1  | 303.326     | red monoc cry               | >160 dec |          | 4.7                        | 68 <sup>20</sup>                    |                                             |
| 1176 | Gold(III) cyanide trihydrate        | Au(CN) <sub>3</sub> · 3H <sub>2</sub> O           | 535-37-5*   | 329.065     | wh hyg cry                  | 50 dec   |          |                            |                                     | vs H <sub>2</sub> O; sl EtOH                |
| 1177 | Gold(III) fluoride                  | AuF <sub>3</sub>                                  | 14720-21-9  | 253.962     | oran-yel hex cry            | >300     | subl     | 6.75                       |                                     |                                             |
| 1178 | Gold(III) hydroxide                 | Au(OH) <sub>3</sub>                               | 1303-52-2   | 247.989     | brn powder                  | ≈100 dec |          |                            |                                     | i H <sub>2</sub> O; s acid                  |
| 1179 | Gold(III) iodide                    | AuI <sub>3</sub>                                  | 31032-13-0  | 577.680     | unstab grn powder           | 20 dec   |          |                            |                                     |                                             |
| 1180 | Gold(III) oxide                     | Au <sub>2</sub> O <sub>3</sub>                    | 1303-58-8   | 441.931     | brn powder                  | ≈150 dec |          |                            |                                     | i H <sub>2</sub> O; s acid                  |
| 1181 | Gold(III) selenate                  | Au <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub>  | 10294-32-3  | 822.81      | yel cry                     |          |          |                            |                                     | i H <sub>2</sub> O; s acid                  |
| 1182 | Gold(III) selenide                  | Au <sub>2</sub> Se <sub>3</sub>                   | 1303-62-4   | 630.81      | blk amorp solid             | dec      |          | 4.65                       |                                     | s aqua regia                                |
| 1183 | Gold(III) sulfide                   | Au <sub>2</sub> S <sub>3</sub>                    | 1303-61-3   | 490.128     | unstab blk powder           | 200 dec  |          |                            |                                     |                                             |
| 1184 | Hafnium                             | Hf                                                | 7440-58-6   | 178.49      | gray metal; hex             | 2233     | 4603     | 13.3                       |                                     | s HF                                        |
| 1185 | Hafnium boride                      | HfB <sub>2</sub>                                  | 12007-23-7  | 200.11      | gray hex cry                | 3100     |          | 10.5                       |                                     |                                             |
| 1186 | Hafnium carbide                     | HfC                                               | 12069-85-1  | 190.50      | refrac cub cry              | ≈3000    |          | 12.2                       |                                     |                                             |
| 1187 | Hafnium hydride                     | HfH <sub>2</sub>                                  | 12770-26-2  | 180.51      | refrac tetr cry             |          |          | 11.4                       |                                     |                                             |
| 1188 | Hafnium nitride                     | HfN                                               | 25817-87-2  | 192.50      | yel-brn cub cry             | 3310     |          | 13.8                       |                                     |                                             |
| 1189 | Hafnium phosphide                   | HfP                                               | 12325-59-6  | 209.46      | hex cry                     |          |          | 9.78                       |                                     |                                             |



| No.  | Name                                   | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form             | mp/°C       | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                   |
|------|----------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|---------------------------|-------------|----------|----------------------------|-------------------------------------|------------------------------------------|
| 1190 | Hafnium silicide                       | HfSi <sub>2</sub>                                                                  | 12401-56-8  | 234.66      | gray orth cry             | ≈1700       |          | 7.6                        |                                     |                                          |
| 1191 | Hafnocene dichloride                   | Hf(C <sub>5</sub> H <sub>5</sub> ) <sub>2</sub> Cl <sub>2</sub>                    | 12116-66-4  | 379.58      | col hyg cry               | 235         |          |                            |                                     | s bz, chl; sl thf, eth; i hex            |
| 1192 | Hafnium(II) bromide                    | HfBr <sub>2</sub>                                                                  | 13782-95-1  | 338.30      | blue-blk cry              | dec 400     |          |                            |                                     |                                          |
| 1193 | Hafnium(II) chloride                   | HfCl <sub>2</sub>                                                                  | 13782-92-8  | 249.40      | blk solid                 | dec 400     |          |                            |                                     |                                          |
| 1194 | Hafnium(III) bromide                   | HfBr <sub>3</sub>                                                                  | 13782-96-2  | 418.20      | blue-blk cry              | dec 350     |          |                            |                                     |                                          |
| 1195 | Hafnium(III) chloride                  | HfCl <sub>3</sub>                                                                  | 13782-93-9  | 284.85      | blk solid                 | dec         |          |                            |                                     |                                          |
| 1196 | Hafnium(III) iodide                    | HfI <sub>3</sub>                                                                   | 13779-73-2  | 559.20      | blk cry                   | dec         |          |                            |                                     |                                          |
| 1197 | Hafnium(IV) bromide                    | HfBr <sub>4</sub>                                                                  | 13777-22-5  | 498.11      | wh cub cry                | 424 tp      | 323 sp   | 4.90                       |                                     | reac H <sub>2</sub> O                    |
| 1198 | Hafnium(IV) chloride                   | HfCl <sub>4</sub>                                                                  | 13499-05-3  | 320.30      | wh monocl cry             | 432 tp      | 317 sp   |                            |                                     | reac H <sub>2</sub> O                    |
| 1199 | Hafnium(IV) fluoride                   | HfF <sub>4</sub>                                                                   | 13709-52-9  | 254.48      | wh monocl cry             | 1025        | 970 sp   | 7.1                        |                                     | reac H <sub>2</sub> O                    |
| 1200 | Hafnium(IV) iodide                     | HfI <sub>4</sub>                                                                   | 13777-23-6  | 686.11      | yel-oran cub cry          | 449 tp      | 394 sp   | 5.6                        |                                     | reac H <sub>2</sub> O                    |
| 1201 | Hafnium(IV) oxide                      | HfO <sub>2</sub>                                                                   | 12055-23-1  | 210.49      | wh cub cry                | 2800        | ≈5400    | 9.68                       |                                     | i H <sub>2</sub> O                       |
| 1202 | Hafnium(IV) oxychloride octahydrate    | HfOCl <sub>2</sub> · 8H <sub>2</sub> O                                             | 14456-34-9  | 409.52      | wh tetr cry               | dec         |          |                            |                                     | s H <sub>2</sub> O                       |
| 1203 | Hafnium(IV) selenide                   | HfSe <sub>2</sub>                                                                  | 12162-21-9  | 336.41      | brn hex cry               |             |          | 7.46                       |                                     |                                          |
| 1204 | Hafnium(IV) silicate                   | HfSiO <sub>4</sub>                                                                 | 13870-13-8  | 270.57      | tetr cry                  | 2758        |          | 7.0                        |                                     |                                          |
| 1205 | Hafnium(IV) sulfate                    | Hf(SO <sub>4</sub> ) <sub>2</sub>                                                  | 15823-43-5  | 370.62      | wh cry                    | >500 dec    |          |                            |                                     |                                          |
| 1206 | Hafnium(IV) sulfide                    | HfS <sub>2</sub>                                                                   | 18855-94-2  | 242.62      | purp-brn hex cry          |             |          | 6.03                       |                                     |                                          |
| 1207 | Hafnium(IV) titanate                   | HfTiO <sub>4</sub>                                                                 | 12055-24-2  | 290.36      | wh pow                    | 1980 dec    |          |                            |                                     |                                          |
| 1208 | Helium                                 | He                                                                                 | 7440-59-7   | 4.003       | col gas                   |             | -268.93  | 0.164 g/L                  |                                     | sl H <sub>2</sub> O; i EtOH              |
| 1209 | Holmium                                | Ho                                                                                 | 7440-60-0   | 164.930     | silv metal; hex           | 1472        | 2700     | 8.80                       |                                     | s dil acid                               |
| 1210 | Holmium acetate                        | Ho(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub>                     | 25519-09-9  | 342.062     | yel cry                   | dec 327     |          |                            |                                     | s H <sub>2</sub> O                       |
| 1211 | Holmium bromide                        | HoBr <sub>3</sub>                                                                  | 13825-76-8  | 404.642     | yel hyg cry               | 919         | 1470     |                            |                                     |                                          |
| 1212 | Holmium chloride                       | HoCl <sub>3</sub>                                                                  | 10138-62-2  | 271.289     | yel monocl cry; hyg       | 720         | 1500     | 3.7                        |                                     | s H <sub>2</sub> O                       |
| 1213 | Holmium chloride hexahydrate           | HoCl <sub>3</sub> · 6H <sub>2</sub> O                                              | 14914-84-2  | 379.381     | hyg yel cry               | 160 dec     |          |                            |                                     | s H <sub>2</sub> O                       |
| 1214 | Holmium fluoride                       | HoF <sub>3</sub>                                                                   | 13760-78-6  | 221.925     | pink-yel orth cry; hyg    | 1143        | >2200    | 7.664                      |                                     | s H <sub>2</sub> O                       |
| 1215 | Holmium iodide                         | HoI <sub>3</sub>                                                                   | 13813-41-7  | 545.643     | yel hex cry               | 994         |          | 5.4                        |                                     |                                          |
| 1216 | Holmium nitrate pentahydrate           | Ho(NO <sub>3</sub> ) <sub>3</sub> · 5H <sub>2</sub> O                              | 14483-18-2  | 441.022     | hyg oran cry              |             |          |                            |                                     | s H <sub>2</sub> O, EtOH, ace            |
| 1217 | Holmium nitride                        | HoN                                                                                | 12029-81-1  | 178.937     | cub cry                   |             |          | 10.6                       |                                     |                                          |
| 1218 | Holmium oxalate decahydrate            | Ho <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> · 10H <sub>2</sub> O | 28965-57-3  | 774.070     | yel solid                 | dec 40      |          |                            |                                     |                                          |
| 1219 | Holmium oxide                          | Ho <sub>2</sub> O <sub>3</sub>                                                     | 12055-62-8  | 377.859     | yel cub cry               | 2330        | 3900     | 8.41                       |                                     | s acid                                   |
| 1220 | Holmium silicide                       | HoSi <sub>2</sub>                                                                  | 12136-24-2  | 221.101     | hex cry                   |             |          | 7.1                        |                                     |                                          |
| 1221 | Holmium sulfide                        | Ho <sub>2</sub> S <sub>3</sub>                                                     | 12162-59-3  | 426.056     | yel-oran monocl cry       |             |          | 5.92                       |                                     |                                          |
| 1222 | Hydrazine                              | N <sub>2</sub> H <sub>4</sub>                                                      | 302-01-2    | 32.045      | col oily liq              | 1.54        | 113.55   | 1.0036                     |                                     | vs H <sub>2</sub> O, EtOH, MeOH          |
| 1223 | Hydrazine acetate                      | N <sub>2</sub> H <sub>4</sub> · CH <sub>3</sub> COOH                               | 13255-48-6  | 92.097      | cry                       | 100         |          |                            |                                     |                                          |
| 1224 | Hydrazine azide                        | N <sub>2</sub> H <sub>4</sub> · HN <sub>3</sub>                                    | 14662-04-5  | 75.074      | hyg wh prism              | 75 exp      |          |                            |                                     | vs H <sub>2</sub> O                      |
| 1225 | Hydrazine monohydrate                  | N <sub>2</sub> H <sub>4</sub> · H <sub>2</sub> O                                   | 7803-57-8   | 50.060      | fuming liq                | -51.7       | 119      | 1.030                      |                                     | vs H <sub>2</sub> O, EtOH; i chl, eth    |
| 1226 | Hydrazine hydrobromide                 | N <sub>2</sub> H <sub>4</sub> · HBr                                                | 13775-80-9  | 112.957     | wh monocl cry flakes      | 84          | ≈190 dec | 2.3                        |                                     | s H <sub>2</sub> O, EtOH                 |
| 1227 | Hydrazine hydrochloride                | N <sub>2</sub> H <sub>4</sub> · HCl                                                | 2644-70-4   | 68.506      | wh orth cry               | 89          | 240 dec  | 1.5                        |                                     | s H <sub>2</sub> O; i os                 |
| 1228 | Hydrazine dihydrochloride              | N <sub>2</sub> H <sub>4</sub> · 2HCl                                               | 5341-61-7   | 104.967     | wh orth cry               | 198 dec     |          | 1.42                       |                                     | s H <sub>2</sub> O; sl EtOH              |
| 1229 | Hydrazine hydroiodide                  | N <sub>2</sub> H <sub>4</sub> · HI                                                 | 10039-55-1  | 159.957     | hyg cry                   | 125         |          |                            |                                     | s H <sub>2</sub> O                       |
| 1230 | Hydrazine nitrate                      | N <sub>2</sub> H <sub>4</sub> · HNO <sub>3</sub>                                   | 13464-97-6  | 95.058      | monocl cry; exp           | 70          |          |                            |                                     | vs H <sub>2</sub> O                      |
| 1231 | Hydrazine dinitrate                    | N <sub>2</sub> H <sub>4</sub> · 2HNO <sub>3</sub>                                  | 13464-98-7  | 158.071     | needles                   | 104 dec     |          |                            | 20 <sup>35</sup>                    | s H <sub>2</sub> O                       |
| 1232 | Hydrazine perchlorate hemihydrate      | N <sub>2</sub> H <sub>4</sub> · HClO <sub>4</sub> · 0.5H <sub>2</sub> O            | 13762-65-7  |             | solid                     | 137         | exp      | 1.94                       |                                     | reac H <sub>2</sub> O, s EtOH; i eth, bz |
| 1233 | Hydrazine sulfate                      | N <sub>2</sub> H <sub>4</sub> · H <sub>2</sub> SO <sub>4</sub>                     | 10034-93-2  | 130.124     | col orth cry              | 254         |          | 1.378                      |                                     | sl H <sub>2</sub> O; i EtOH              |
| 1234 | Dihydrazine sulfate                    | (N <sub>2</sub> H <sub>4</sub> ) <sub>2</sub> · H <sub>2</sub> SO <sub>4</sub>     | 13464-80-7  | 162.169     | hyg wh cry flakes         | 104         | dec >180 |                            | 200 <sup>25</sup>                   | vs H <sub>2</sub> O; i os                |
| 1235 | Hydrazoic acid                         | HN <sub>3</sub>                                                                    | 7782-79-8   | 43.028      | col liq; exp              | -80         | 35.7     |                            |                                     | s H <sub>2</sub> O                       |
| 1236 | Hydroxylamine                          | H <sub>2</sub> NOH                                                                 | 7803-49-8   | 33.030      | wh orth flakes or needles | 33.1        | 58       | 1.21                       |                                     | vs H <sub>2</sub> O, MeOH                |
| 1237 | Hydroxylamine hydrobromide             | H <sub>2</sub> NOH · HBr                                                           | 41591-55-3  | 113.942     | monocl cry                |             |          | 2.35                       |                                     | s H <sub>2</sub> O                       |
| 1238 | Hydroxylamine hydrochloride            | H <sub>2</sub> NOH · HCl                                                           | 5470-11-1   | 69.491      | col monocl cry            | 159 dec     | exp      | 1.68                       | 94 <sup>25</sup>                    | vs H <sub>2</sub> O                      |
| 1239 | Hydroxylamine perchlorate              | H <sub>2</sub> NOH · HClO <sub>4</sub>                                             |             | 133.489     | orth cry                  | 88          | dec 120  |                            |                                     |                                          |
| 1240 | Hydroxylamine sulfate                  | 2(H <sub>2</sub> NOH) · H <sub>2</sub> SO <sub>4</sub>                             | 10039-54-0  | 164.138     | cry                       | 170         |          |                            |                                     | vs H <sub>2</sub> O                      |
| 1241 | Hydrogen                               | H <sub>2</sub>                                                                     | 1333-74-0   | 2.016       | col gas; flam             | -259.198 tp | -252.762 | 0.082 g/L                  |                                     | sl H <sub>2</sub> O                      |
| 1242 | Hydrogen-d <sub>2</sub>                | D <sub>2</sub>                                                                     | 7782-39-0   | 4.028       | col gas                   | -254.42     | -249.48  | 0.164 g/L                  |                                     |                                          |
| 1243 | Hydrogen-t <sub>2</sub>                | T <sub>2</sub>                                                                     | 10028-17-8  | 6.032       | col gas                   | -252.53     | -248.11  | 0.246 g/L                  |                                     |                                          |
| 1244 | Hydrogen-d <sub>1</sub>                | HD                                                                                 | 13983-20-5  | 3.022       | col gas                   | -256.55     | -251.02  | 0.123 g/L                  |                                     |                                          |
| 1245 | Hydrogen-t <sub>1</sub>                | HT                                                                                 | 14885-60-0  | 4.024       | col gas                   | -254.7      | -249.6   |                            |                                     |                                          |
| 1246 | Hydrogen-d <sub>1</sub> t <sub>1</sub> | DT                                                                                 | 14885-61-1  | 5.030       | col gas                   | -253.5      | -238.9   |                            |                                     |                                          |
| 1247 | Hydrogen bromide                       | HBr                                                                                | 10035-10-6  | 80.912      | col gas                   | -86.80      | -66.38   | 3.307 g/L                  |                                     | vs H <sub>2</sub> O; s EtOH              |
| 1248 | Hydrogen bromide-d                     | DBr                                                                                | 13536-59-9  | 81.918      | col gas                   | -87.54      | -66.9    |                            |                                     | s H <sub>2</sub> O                       |

| No.  | Name                                | Formula                                                | CAS Reg No. | Mol. weight | Physical form                 | mp/°C           | bp/°C     | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility            |
|------|-------------------------------------|--------------------------------------------------------|-------------|-------------|-------------------------------|-----------------|-----------|----------------------------|-------------------------------------|-----------------------------------|
| 1249 | Hydrogen chloride                   | HCl                                                    | 7647-01-0   | 36.461      | col gas                       | -114.17         | -85       | 1.490 g/L                  |                                     | vs H <sub>2</sub> O               |
| 1250 | Hydrogen chloride dihydrate         | HCl · 2H <sub>2</sub> O                                | 13465-05-9  | 72.492      | col liq                       | -17.7           |           | 1.46                       |                                     |                                   |
| 1251 | Hydrogen chloride- <i>d</i>         | DCl                                                    | 7698-05-7   | 37.467      | col gas                       | -114.72         | -84.4     |                            |                                     | s H <sub>2</sub> O                |
| 1252 | Hydrogen cyanide                    | HCN                                                    | 74-90-8     | 27.026      | col liq or gas                | -13.29          | 26        | 0.6876 <sup>20</sup>       |                                     | vs H <sub>2</sub> O, EtOH; sl eth |
| 1253 | Hydrogen fluoride                   | HF                                                     | 7664-39-3   | 20.006      | col gas                       | -83.36          | 20        | 0.818 g/L                  |                                     | vs H <sub>2</sub> O, EtOH; sl eth |
| 1254 | Hydrogen iodide                     | HI                                                     | 10034-85-2  | 127.912     | col or yel gas                | -50.76          | -35.55    | 5.228 g/L                  |                                     | vs H <sub>2</sub> O; s os         |
| 1255 | Hydrogen iodide- <i>d</i>           | DI                                                     | 14104-45-1  | 128.918     | col gas                       | -51.93          | -36.2     |                            |                                     | s H <sub>2</sub> O                |
| 1256 | Hydrogen peroxide                   | H <sub>2</sub> O <sub>2</sub>                          | 7722-84-1   | 34.015      | col liq                       | -0.43           | 150.2     | 1.44                       |                                     | vs H <sub>2</sub> O               |
| 1257 | Hydrogen selenide                   | H <sub>2</sub> Se                                      | 7783-07-5   | 80.98       | col gas; flam                 | -65.73          | -41.25    | 3.310 g/L                  |                                     | s H <sub>2</sub> O                |
| 1258 | Hydrogen sulfide                    | H <sub>2</sub> S                                       | 7783-06-4   | 34.081      | col gas; flam                 | -85.5           | -59.55    | 1.393 g/L                  |                                     | s H <sub>2</sub> O                |
| 1259 | Hydrogen disulfide                  | H <sub>2</sub> S <sub>2</sub>                          | 13465-07-1  | 66.146      | col liq                       |                 | 70.7      | 1.334                      |                                     |                                   |
| 1260 | Hydrogen telluride                  | H <sub>2</sub> Te                                      | 7783-09-7   | 129.62      | col gas                       | -49             | -2        | 5.298 g/L                  |                                     | s H <sub>2</sub> O, EtOH, alk     |
| 1261 | Indium                              | In                                                     | 7440-74-6   | 114.818     | soft wh metal                 | 156.60          | 2072      | 7.31                       |                                     | s acid                            |
| 1262 | Indium antimonide                   | InSb                                                   | 1312-41-0   | 236.578     | blk cub cry                   | 524             |           | 5.7747                     |                                     |                                   |
| 1263 | Indium arsenide                     | InAs                                                   | 1303-11-3   | 189.740     | gray cub cry                  | 942             |           | 5.67                       |                                     | i acid                            |
| 1264 | Indium nitride                      | InN                                                    | 25617-98-5  | 128.825     | brn hex cry                   | 1100            |           | 6.88                       |                                     |                                   |
| 1265 | Indium phosphide                    | InP                                                    | 22398-80-7  | 145.792     | blk cub cry                   | 1062            |           | 4.81                       |                                     | sl acid                           |
| 1266 | Indium(I) bromide                   | InBr                                                   | 14280-53-6  | 194.722     | oran-red orth cry             | 285             | 656       | 4.96                       |                                     | reac H <sub>2</sub> O             |
| 1267 | Indium(I) chloride                  | InCl                                                   | 13465-10-6  | 150.271     | yel cub cry                   | 225             | 608       | 4.19                       |                                     | reac H <sub>2</sub> O             |
| 1268 | Indium(I) iodide                    | InI                                                    | 13966-94-4  | 241.722     | orth cry                      | 364.4           | 712       | 5.32                       |                                     |                                   |
| 1269 | Indium(II) bromide                  | InBr <sub>2</sub>                                      | 21264-43-7  | 274.626     | orth cry                      |                 |           | 4.22                       |                                     | reac H <sub>2</sub> O             |
| 1270 | Indium(II) chloride                 | InCl <sub>2</sub>                                      | 13465-11-7  | 185.724     | col orth cry                  | 235             |           | 3.64                       |                                     | reac H <sub>2</sub> O             |
| 1271 | Indium(II) sulfide                  | InS                                                    | 12030-14-7  | 146.883     | red-brn orth cry              | 692             |           | 5.2                        |                                     |                                   |
| 1272 | Indium(III) bromide                 | InBr <sub>3</sub>                                      | 13465-09-3  | 354.530     | hyg yel-wh monocl cry         | 420             |           | 4.74                       | 414 <sup>20</sup>                   |                                   |
| 1273 | Indium(III) chloride                | InCl <sub>3</sub>                                      | 10025-82-8  | 221.177     | yel monocl cry; hyg           | 583             |           | 4.0                        | 195.1 <sup>22</sup>                 | s EtOH                            |
| 1274 | Indium(III) chloride tetrahydrate   | InCl <sub>3</sub> · 4H <sub>2</sub> O                  | 22519-64-8  | 293.239     | wh cry                        |                 |           |                            |                                     | s H <sub>2</sub> O                |
| 1275 | Indium(III) fluoride                | InF <sub>3</sub>                                       | 7783-52-0   | 171.813     | wh hex cry; hyg               | 1172            | >1200     | 4.39                       |                                     | sl H <sub>2</sub> O; s dil acid   |
| 1276 | Indium(III) fluoride trihydrate     | InF <sub>3</sub> · 3H <sub>2</sub> O                   | 14166-78-0  | 225.859     | wh cry                        | 100 dec         |           |                            |                                     | s H <sub>2</sub> O                |
| 1277 | Indium(III) hydroxide               | In(OH) <sub>3</sub>                                    | 20661-21-6  | 165.840     | cub cry                       |                 |           | 4.4                        |                                     |                                   |
| 1278 | Indium(III) iodide                  | InI <sub>3</sub>                                       | 13510-35-5  | 495.531     | yel-red monocl cry; hyg       | 207             |           | 4.69                       | 1308 <sup>22</sup>                  |                                   |
| 1279 | Indium(III) nitrate trihydrate      | In(NO <sub>3</sub> ) <sub>3</sub> · 3H <sub>2</sub> O  | 13770-61-1  | 354.879     | col cry                       | dec 100         |           |                            |                                     |                                   |
| 1280 | Indium(III) oxide                   | In <sub>2</sub> O <sub>3</sub>                         | 1312-43-2   | 277.634     | yel cub cry                   | 1912            |           | 7.18                       |                                     | i H <sub>2</sub> O; s hot acid    |
| 1281 | Indium(III) perchlorate octahydrate | In(ClO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O | 13465-15-1  | 557.292     | wh cry                        | ≈80             | 200 dec   |                            |                                     |                                   |
| 1282 | Indium(III) phosphate               | InPO <sub>4</sub>                                      | 14693-82-4  | 209.789     | wh orth cry                   |                 |           | 4.9                        |                                     | i H <sub>2</sub> O                |
| 1283 | Indium(III) selenide                | In <sub>2</sub> Se <sub>3</sub>                        | 1312-42-1   | 466.52      | blk hex cry                   | 660             |           | 5.8                        |                                     |                                   |
| 1284 | Indium(III) sulfate                 | In <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>        | 13464-82-9  | 517.824     | hyg wh powder                 |                 |           | 3.44                       | 117 <sup>20</sup>                   |                                   |
| 1285 | Indium(III) sulfide                 | In <sub>2</sub> S <sub>3</sub>                         | 12030-24-9  | 325.831     | oran cub cry                  | 1050            |           | 4.45                       |                                     |                                   |
| 1286 | Indium(III) telluride               | In <sub>2</sub> Te <sub>3</sub>                        | 1312-45-4   | 612.44      | blk cub cry                   | 667             |           | 5.75                       |                                     |                                   |
| 1287 | Iodine                              | I <sub>2</sub>                                         | 7553-56-2   | 253.809     | blue-blk plates               | 113.7           | 184.4     | 4.933                      | 0.03 <sup>20</sup>                  | s bz, EtOH, eth, ctc, chl         |
| 1288 | Iodic acid                          | HIO <sub>3</sub>                                       | 7782-68-5   | 175.910     | col orth cry                  | 110 dec         |           | 4.63                       | 308 <sup>25</sup>                   | i EtOH, eth                       |
| 1289 | Periodic acid dihydrate             | HIO <sub>4</sub> · 2H <sub>2</sub> O                   | 10450-60-9  | 227.940     | monocl hyg cry                | 122 dec         |           |                            |                                     | s H <sub>2</sub> O, EtOH; sl eth  |
| 1290 | Iodine tetroxide                    | I <sub>2</sub> O <sub>4</sub>                          | 12399-08-5  | 317.807     | yel cry                       | 130             | dec >85   | 4.2                        |                                     | sl H <sub>2</sub> O               |
| 1291 | Iodine pentoxide                    | I <sub>2</sub> O <sub>5</sub>                          | 12029-98-0  | 333.806     | hyg wh cry                    | ≈300 dec        |           | 4.98                       | 253.4 <sup>20</sup>                 | i EtOH, eth, CS <sub>2</sub>      |
| 1292 | Iodine hexoxide                     | I <sub>2</sub> O <sub>6</sub>                          | 65355-99-9  | 349.805     | yel solid                     | dec 150         |           |                            |                                     | reac H <sub>2</sub> O             |
| 1293 | Iodine nonaoxide                    | I <sub>2</sub> O <sub>9</sub>                          | 73560-00-6  | 651.613     | hyg yel powder                | 75 dec          |           |                            |                                     |                                   |
| 1294 | Iodine bromide                      | IBr                                                    | 7789-33-5   | 206.808     | blk orth cry                  | 40              | 116 dec   | 4.3                        |                                     | s H <sub>2</sub> O, EtOH, eth     |
| 1295 | Iodine chloride                     | ICl                                                    | 7790-99-0   | 162.357     | red cry or oily liq           | 27.38           | 94.4 dec  | 3.24                       |                                     | reac H <sub>2</sub> O; s EtOH     |
| 1296 | Iodine trichloride                  | ICl <sub>3</sub>                                       | 865-44-1    | 233.263     | yel tricl cry; hyg            | 101 tp (16 atm) | 64 sp dec | 3.2                        |                                     | reac H <sub>2</sub> O; s EtOH, bz |
| 1297 | Iodine fluoride                     | IF                                                     | 13873-84-2  | 145.902     | wh pow (-78°C)                | -14 dec         |           |                            |                                     |                                   |
| 1298 | Iodine trifluoride                  | IF <sub>3</sub>                                        | 22520-96-3  | 183.899     | yel solid, stable at low temp | -28 dec         |           |                            |                                     |                                   |
| 1299 | Iodine pentafluoride                | IF <sub>5</sub>                                        | 7783-66-6   | 221.896     | yel liq                       | 9.43            | 100.5     | 3.19                       |                                     | reac H <sub>2</sub> O             |
| 1300 | Iodine heptafluoride                | IF <sub>7</sub>                                        | 16921-96-3  | 259.893     | col gas                       | 6.5 tp          | 4.8 sp    | 10.62 g/L                  |                                     | s H <sub>2</sub> O                |
| 1301 | Iodosyl trifluoride                 | IOF <sub>3</sub>                                       | 19058-78-7  | 199.898     | hyg col needles               | dec >110        |           |                            |                                     | reac H <sub>2</sub> O             |
| 1302 | Iodosyl pentafluoride               | IOF <sub>5</sub>                                       | 16056-61-4  | 237.895     | col liq                       | 4.5             |           |                            |                                     |                                   |
| 1303 | Iodyl trifluoride                   | IO <sub>2</sub> F <sub>3</sub>                         | 25402-50-0  | 215.898     | yel solid                     | 41              | subl      |                            |                                     |                                   |
| 1304 | Periodyl fluoride                   | IO <sub>3</sub> F                                      | 30708-86-2  | 193.900     | col cry                       | dec >100        |           |                            |                                     |                                   |
| 1305 | Iridium                             | Ir                                                     | 7439-88-5   | 192.217     | silv-wh metal; cub            | 2446            | 4428      | 22.562 <sup>20</sup>       |                                     | s aqua regia                      |
| 1306 | Iridium carbonyl                    | Ir <sub>4</sub> (CO) <sub>12</sub>                     | 11065-24-0  | 1104.989    | yel cry                       | 210 dec         |           |                            |                                     |                                   |
| 1307 | Iridium(III) bromide                | IrBr <sub>3</sub>                                      | 10049-24-8  | 431.929     | red-brn monocl cry            |                 |           | 6.82                       |                                     | i H <sub>2</sub> O, acid, alk     |



| No.  | Name                               | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form             | mp/°C    | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                    |
|------|------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|---------------------------|----------|---------|----------------------------|-------------------------------------|-----------------------------------------------------------|
| 1308 | Iridium(III) bromide tetrahydrate  | IrBr <sub>3</sub> · 4H <sub>2</sub> O                                              | 10049-24-8* | 503.991     | grn-brn cry               |          |         |                            |                                     | s H <sub>2</sub> O; i EtOH                                |
| 1309 | Iridium(III) chloride              | IrCl <sub>3</sub>                                                                  | 10025-83-9  | 298.576     | brn monocl cry            | 763 dec  |         | 5.30                       |                                     | i H <sub>2</sub> O, acid, alk                             |
| 1310 | Iridium(III) fluoride              | IrF <sub>3</sub>                                                                   | 23370-59-4  | 249.212     | blk hex cry               | 250 dec  |         | ≈8.0                       |                                     | i H <sub>2</sub> O, dil acid                              |
| 1311 | Iridium(III) iodide                | IrI <sub>3</sub>                                                                   | 7790-41-2   | 572.930     | dark brn monocl cry       |          |         | ≈7.4                       |                                     | i H <sub>2</sub> O, acid, bz, chl; s alk                  |
| 1312 | Iridium(III) oxide                 | Ir <sub>2</sub> O <sub>3</sub>                                                     | 1312-46-5   | 432.432     | blue-blk cry              | 1000 dec |         |                            |                                     | i H <sub>2</sub> O; sl hot HCl                            |
| 1313 | Iridium(III) 2,4-pentanedioate     | Ir(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub>                            | 15635-87-7  | 489.541     | oran-yel cry              | 270      | subl    |                            |                                     | sl H <sub>2</sub> O; s tol, chl, acē, MeOH                |
| 1314 | Iridium(III) sulfide               | Ir <sub>2</sub> S <sub>3</sub>                                                     | 12136-42-4  | 480.629     | orth cry                  |          |         | 10.2                       |                                     |                                                           |
| 1315 | Iridium(IV) chloride               | IrCl <sub>4</sub>                                                                  | 10025-97-5  | 334.029     | brn hyg solid             | ≈700 dec |         |                            |                                     | s H <sub>2</sub> O, EtOH                                  |
| 1316 | Iridium(IV) oxide                  | IrO <sub>2</sub>                                                                   | 12030-49-8  | 224.216     | brn tetr cry              | 1100 dec |         | 11.7                       |                                     |                                                           |
| 1317 | Iridium(IV) sulfide                | IrS <sub>2</sub>                                                                   | 12030-51-2  | 256.347     | orth cry                  |          |         | 9.3                        |                                     |                                                           |
| 1318 | Iridium(VI) fluoride               | IrF <sub>6</sub>                                                                   | 7783-75-7   | 306.207     | yel cub cry; hyg          | 44       | 53.6    | 4.8                        |                                     | reac H <sub>2</sub> O                                     |
| 1319 | Iron                               | Fe                                                                                 | 7439-89-6   | 55.845      | silv-wh or gray met       | 1538     | 2861    | 7.87                       |                                     | s dil acid                                                |
| 1320 | Ferrocene                          | Fe(C <sub>5</sub> H <sub>5</sub> ) <sub>2</sub>                                    | 102-54-5    | 186.031     | oran needles              | 172.5    | 249     |                            |                                     | i H <sub>2</sub> O; s EtOH, eth, bz, dil HNO <sub>3</sub> |
| 1321 | Tetracarbonyldihydroiron           | Fe(CO) <sub>4</sub> H <sub>2</sub>                                                 | 12002-28-7  | 169.902     | col liq, stab low temp    | -70      | dec -20 |                            |                                     | s alk                                                     |
| 1322 | Iron pentacarbonyl                 | Fe(CO) <sub>5</sub>                                                                | 13463-40-6  | 195.896     | yel oily liq; flam        | -20.5    | 103     | 1.46                       |                                     | i H <sub>2</sub> O; s eth, bz, ace                        |
| 1323 | Iron nonacarbonyl                  | Fe <sub>3</sub> (CO) <sub>9</sub>                                                  | 15321-51-4  | 363.781     | oran-yel cry              | 100 dec  |         | 2.85                       |                                     |                                                           |
| 1324 | Iron dodecacarbonyl                | Fe <sub>3</sub> (CO) <sub>12</sub>                                                 | 12088-65-2  | 503.656     | dark grn cry              | 140      |         | 2.00                       |                                     |                                                           |
| 1325 | Iron arsenide                      | FeAs                                                                               | 12044-16-5  | 130.767     | gray orth cry             | 1030     |         | 7.85                       |                                     |                                                           |
| 1326 | Iron boride (FeB)                  | FeB                                                                                | 12006-84-7  | 66.656      | refrac solid; orth        | 1658     |         | ≈7                         |                                     |                                                           |
| 1327 | Iron boride (Fe <sub>3</sub> B)    | Fe <sub>3</sub> B                                                                  | 12006-86-9  | 122.501     | refrac solid; tetr        | 1389     |         | 7.3                        |                                     |                                                           |
| 1328 | Iron carbide                       | Fe <sub>3</sub> C                                                                  | 12011-67-5  | 179.546     | gray cub cry              | 1227     |         | 7.694                      |                                     |                                                           |
| 1329 | Iron phosphide (FeP)               | FeP                                                                                | 26508-33-8  | 86.819      | rhomb cry                 |          |         | 6.07                       |                                     |                                                           |
| 1330 | Iron phosphide (Fe <sub>3</sub> P) | Fe <sub>3</sub> P                                                                  | 1310-43-6   | 142.664     | gray hex needles          | 1370     |         | 6.8                        |                                     | i H <sub>2</sub> O, dil acid, alk                         |
| 1331 | Iron phosphide (Fe <sub>5</sub> P) | Fe <sub>5</sub> P                                                                  | 12023-53-9  | 198.509     | gray solid                | 1100     |         | 6.74                       |                                     | i H <sub>2</sub> O                                        |
| 1332 | Iron disulfide                     | FeS <sub>2</sub>                                                                   | 1317-66-4   | 119.975     | blk cub cry               | >600 dec |         | 5.02                       |                                     | i H <sub>2</sub> O                                        |
| 1333 | Iron silicide                      | FeSi                                                                               | 12022-95-6  | 83.931      | gray cub cry              | 1410     |         | 6.1                        |                                     |                                                           |
| 1334 | Iron disilicide                    | FeSi <sub>2</sub>                                                                  | 12022-99-0  | 112.016     | gray tetr cry             | 1220     |         | 4.74                       |                                     |                                                           |
| 1335 | Iron(II) acetate                   | Fe(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                     | 3094-87-9   | 173.934     | wh cry                    | 190 dec  |         |                            |                                     | s H <sub>2</sub> O                                        |
| 1336 | Iron(II) acetate tetrahydrate      | Fe(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 4H <sub>2</sub> O | 3094-87-9*  | 245.994     | grn cry                   | dec      |         |                            |                                     | s H <sub>2</sub> O, EtOH                                  |
| 1337 | Iron(II) aluminate                 | Fe(AlO <sub>2</sub> ) <sub>2</sub>                                                 | 12068-49-4  | 173.806     | blk cub cry               |          |         | 4.3                        |                                     |                                                           |
| 1338 | Iron(II) arsenate                  | Fe <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub>                                   | 10102-50-8  | 445.373     | grn powder                |          |         |                            |                                     | i H <sub>2</sub> O                                        |
| 1339 | Iron(II) arsenate hexahydrate      | Fe <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O               | 10102-50-8* | 553.465     | grn amorp powder          | dec      |         |                            |                                     | i H <sub>2</sub> O; s acid                                |
| 1340 | Iron(II) bromide                   | FeBr <sub>2</sub>                                                                  | 7789-46-0   | 215.653     | yel-brn hex cry; hyg      | 691      | dec     | 4.636                      | 120 <sup>25</sup>                   | vs EtOH                                                   |
| 1341 | Iron(II) bromide hexahydrate       | FeBr <sub>2</sub> · 6H <sub>2</sub> O                                              | 13463-12-2  | 323.744     | grn hyg cry               | 27 dec   |         | 4.64                       | 120 <sup>25</sup>                   | s EtOH                                                    |
| 1342 | Iron(II) carbonate                 | FeCO <sub>3</sub>                                                                  | 563-71-3    | 115.854     | gray-brn hex cry          |          |         | 3.944                      | 0.000062 <sup>20</sup>              |                                                           |
| 1343 | Iron(II) chloride                  | FeCl <sub>2</sub>                                                                  | 7758-94-3   | 126.751     | wh hex cry; hyg           | 677      | 1023    | 3.16                       | 65.0 <sup>25</sup>                  | vs EtOH, ace; sl bz                                       |
| 1344 | Iron(II) chloride dihydrate        | FeCl <sub>2</sub> · 2H <sub>2</sub> O                                              | 16399-77-2  | 162.782     | wh-grn monocl cry         | 120 dec  |         | 2.39                       | 65.0 <sup>25</sup>                  |                                                           |
| 1345 | Iron(II) chloride tetrahydrate     | FeCl <sub>2</sub> · 4H <sub>2</sub> O                                              | 13478-10-9  | 198.813     | grn monocl cry            | 105 dec  |         | 1.93                       | 65.0 <sup>25</sup>                  | s EtOH                                                    |
| 1346 | Iron(II) chromite                  | FeCr <sub>2</sub> O <sub>4</sub>                                                   | 1308-31-2   | 223.835     | blk cub cry               |          |         | 5.0                        |                                     |                                                           |
| 1347 | Iron(II) fluoride                  | FeF <sub>2</sub>                                                                   | 7789-28-8   | 93.842      | wh tetr cry               | 1100     |         | 4.09                       |                                     | sl H <sub>2</sub> O; s dil HF; i EtOH, eth                |
| 1348 | Iron(II) fluoride tetrahydrate     | FeF <sub>2</sub> · 4H <sub>2</sub> O                                               | 13940-89-1  | 165.904     | col hex cry               |          |         | 2.20                       |                                     |                                                           |
| 1349 | Iron(II) hydroxide                 | Fe(OH) <sub>2</sub>                                                                | 18624-44-7  | 89.860      | wh-grn hex cry            |          |         | 3.4                        | 0.000052 <sup>20</sup>              |                                                           |
| 1350 | Iron(II) iodide                    | FeI <sub>2</sub>                                                                   | 7783-86-0   | 309.654     | red-viol hex cry; hyg     | 594      |         | 5.3                        |                                     | s H <sub>2</sub> O, EtOH, eth                             |
| 1351 | Iron(II) iodide tetrahydrate       | FeI <sub>2</sub> · 4H <sub>2</sub> O                                               | 7783-86-0*  | 381.716     | blk hyg leaflets          | 90 dec   |         | 2.87                       |                                     | s H <sub>2</sub> O, EtOH                                  |
| 1352 | Iron(II) molybdate                 | FeMoO <sub>4</sub>                                                                 | 13718-70-2  | 215.78      | brn-yel monocl cry        | 1115     |         | 5.6                        |                                     | i H <sub>2</sub> O                                        |
| 1353 | Iron(II) nitrate                   | Fe(NO <sub>3</sub> ) <sub>2</sub>                                                  | 14013-86-6  | 179.854     | grn solid                 |          |         |                            | 87.5 <sup>25</sup>                  |                                                           |
| 1354 | Iron(II) nitrate hexahydrate       | Fe(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                              | 14013-86-6* | 287.946     | grn solid                 | 60 dec   |         |                            | 87.5 <sup>25</sup>                  |                                                           |
| 1355 | Iron(II) orthosilicate             | Fe <sub>2</sub> SiO <sub>4</sub>                                                   | 10179-73-4  | 203.774     | brn orth cry              |          |         | 4.30                       |                                     |                                                           |
| 1356 | Iron(II) oxalate dihydrate         | FeC <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O                                | 6047-25-2   | 179.894     | yel cry                   | 150 dec  |         | 2.28                       | 0.078 <sup>25</sup>                 | s acid                                                    |
| 1357 | Iron(II) oxide                     | FeO                                                                                | 1345-25-1   | 71.844      | blk cub cry               | 1377     |         | 6.0                        |                                     | i H <sub>2</sub> O, alk; s acid                           |
| 1358 | Iron(II) 2,4-pentanedioate         | Fe(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>                            | 14024-17-0  | 254.061     | oran-brn cry              | 170      | subl    |                            |                                     | sl bz, tol                                                |
| 1359 | Iron(II) perchlorate               | Fe(ClO <sub>4</sub> ) <sub>2</sub>                                                 | 13933-23-8  | 254.746     | grn-wh hyg needles        | >100 dec |         |                            | 210 <sup>25</sup>                   |                                                           |
| 1360 | Iron(II) phosphate octahydrate     | Fe <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> · 8H <sub>2</sub> O                | 14940-41-1  | 501.600     | gray-blue monocl cry; hyg |          |         | 2.58                       |                                     | i H <sub>2</sub> O; s acid                                |
| 1361 | Iron(II) selenide                  | FeSe                                                                               | 1310-32-3   | 134.81      | blk hex cry               |          |         | 6.7                        |                                     | i H <sub>2</sub> O                                        |
| 1362 | Iron(II) sulfate                   | FeSO <sub>4</sub>                                                                  | 7720-78-7   | 151.908     | wh orth cry; hyg          |          |         | 3.65                       | 29.5 <sup>25</sup>                  |                                                           |
| 1363 | Iron(II) sulfate monohydrate       | FeSO <sub>4</sub> · H <sub>2</sub> O                                               | 17375-41-6  | 169.923     | wh-yel monocl cry         | 300 dec  |         | 3.0                        | 29.5 <sup>25</sup>                  |                                                           |

| No.  | Name                                  | Formula                                                                                        | CAS Reg No. | Mol. weight | Physical form               | mp/°C                 | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                    |
|------|---------------------------------------|------------------------------------------------------------------------------------------------|-------------|-------------|-----------------------------|-----------------------|---------|----------------------------|-------------------------------------|-------------------------------------------|
| 1364 | Iron(II) sulfate heptahydrate         | FeSO <sub>4</sub> · 7H <sub>2</sub> O                                                          | 7782-63-0   | 278.014     | blue-grn monocl cry         | ≈60 dec               |         | 1.895                      | 29.5 <sup>25</sup>                  | i EtOH                                    |
| 1365 | Iron(II) sulfide                      | FeS                                                                                            | 1317-37-9   | 87.910      | col hex or tetr cry; hyg    | 1188                  | dec     | 4.7                        |                                     | i H <sub>2</sub> O; reac acid             |
| 1366 | Iron(II) tantalate                    | Fe(TaO <sub>3</sub> ) <sub>2</sub>                                                             | 12140-41-9  | 513.737     | brn tetr cry                |                       |         | 7.33                       |                                     |                                           |
| 1367 | Iron(II) tartrate                     | FeC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                                                 |             | 203.916     | wh cry                      |                       |         |                            | 0.88                                | vs acid; s NH <sub>3</sub> OH             |
| 1368 | Iron(II) telluride                    | FeTe                                                                                           | 12125-63-2  | 183.45      | tetr cry                    | 914                   |         | 6.8                        |                                     |                                           |
| 1369 | Iron(II) thiocyanate trihydrate       | Fe(SCN) <sub>2</sub> · 3H <sub>2</sub> O                                                       | 6010-09-9   | 226.055     | grn monocl cry              |                       |         |                            |                                     | s H <sub>2</sub> O, EtOH, eth             |
| 1370 | Iron(II) titanate                     | FeTiO <sub>3</sub>                                                                             | 12168-52-4  | 151.710     | blk rhomb cry               | ≈1470                 |         | 4.72                       |                                     |                                           |
| 1371 | Iron(II) tungstate                    | FeWO <sub>4</sub>                                                                              | 13870-24-1  | 303.68      | monocl cry                  |                       |         | 7.51                       |                                     |                                           |
| 1372 | Iron(II,III) oxide                    | Fe <sub>3</sub> O <sub>4</sub>                                                                 | 1317-61-9   | 231.533     | blk cub cry or amorp powder | 1597                  |         | 5.17                       |                                     | i H <sub>2</sub> O; s acid                |
| 1373 | Iron(III) acetate, basic              | FeOH(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                               | 10450-55-2  | 190.941     | brn-red amorp powder        |                       |         |                            |                                     | i H <sub>2</sub> O; s EtOH, acid          |
| 1374 | Iron(III) ammonium citrate            | Fe(NH <sub>4</sub> ) <sub>2</sub> (C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sub>2</sub> | 1185-57-5   | 488.160     | red or brn pow; hyg         |                       |         |                            |                                     | s H <sub>2</sub> O; i EtOH                |
| 1375 | Iron(III) arsenate dihydrate          | FeAsO <sub>4</sub> · 2H <sub>2</sub> O                                                         | 10102-49-5  | 230.795     | grn-brn powder              | dec                   |         | 3.18                       |                                     | i H <sub>2</sub> O; s dil acid            |
| 1376 | Iron(III) bromide                     | FeBr <sub>3</sub>                                                                              | 10031-26-2  | 295.557     | dark red hex cry; hyg       | dec                   |         | 4.5                        | 455 <sup>25</sup>                   | s EtOH, eth                               |
| 1377 | Iron(III) chloride                    | FeCl <sub>3</sub>                                                                              | 7705-08-0   | 162.204     | grn hex cry; hyg            | 307.6                 | ≈316    | 2.90                       | 91.2 <sup>25</sup>                  | s EtOH, eth, ace                          |
| 1378 | Iron(III) chloride hexahydrate        | FeCl <sub>3</sub> · 6H <sub>2</sub> O                                                          | 10025-77-1  | 270.295     | yel-oran monocl cry; hyg    | 37 dec                |         | 1.82                       | 91.2 <sup>25</sup>                  | s EtOH, eth, ace                          |
| 1379 | Iron(III) chromate                    | Fe <sub>2</sub> (CrO <sub>4</sub> ) <sub>3</sub>                                               | 10294-52-7  | 459.671     | yel powder                  |                       |         |                            |                                     | i H <sub>2</sub> O, EtOH; s acid          |
| 1380 | Iron(III) citrate pentahydrate        | FeC <sub>6</sub> H <sub>5</sub> O <sub>7</sub> · 5H <sub>2</sub> O                             | 3522-50-7   | 335.021     | red-brn cry                 |                       |         |                            |                                     | s H <sub>2</sub> O; i EtOH                |
| 1381 | Iron(III) dichromate                  | Fe <sub>2</sub> (Cr <sub>2</sub> O <sub>7</sub> ) <sub>3</sub>                                 | 10294-53-8  | 759.654     | red-brn solid               |                       |         |                            |                                     | s H <sub>2</sub> O, acid                  |
| 1382 | Iron(III) ferrocyanide                | Fe <sub>3</sub> [Fe(CN) <sub>6</sub> ] <sub>3</sub>                                            | 14038-43-8  | 859.229     | dark blue powder            |                       |         | 1.80                       |                                     | i H <sub>2</sub> O, dil acid, os          |
| 1383 | Iron(III) fluoride                    | FeF <sub>3</sub>                                                                               | 7783-50-8   | 112.840     | grn hex cry                 | >1000                 |         | 3.87                       | 5.92 <sup>25</sup>                  | i EtOH, eth, bz                           |
| 1384 | Iron(III) fluoride trihydrate         | FeF <sub>3</sub> · 3H <sub>2</sub> O                                                           | 15469-38-2  | 166.886     | yel-brn tetr cry            |                       |         | 2.3                        | 5.92 <sup>25</sup>                  |                                           |
| 1385 | Iron(III) formate                     | Fe(CHO <sub>2</sub> ) <sub>3</sub>                                                             | 555-76-0    | 190.897     | red-yel cry powder          |                       |         |                            |                                     | s H <sub>2</sub> O; sl EtOH               |
| 1386 | Iron(III) hydroxide                   | Fe(OH) <sub>3</sub>                                                                            | 1309-33-7   | 106.867     | yel monocl cry              |                       |         | 3.12                       |                                     |                                           |
| 1387 | Iron(III) hydroxide oxide             | FeO(OH)                                                                                        | 20344-49-4  | 88.852      | red-brn orth cry            |                       |         | 4.26                       |                                     | i H <sub>2</sub> O; s acid                |
| 1388 | Iron(III) metavanadate                | Fe(VO <sub>3</sub> ) <sub>3</sub>                                                              | 65842-03-7  | 352.665     | gray-brn powder             |                       |         |                            |                                     | i H <sub>2</sub> O, EtOH; s acid          |
| 1389 | Iron(III) nitrate                     | Fe(NO <sub>3</sub> ) <sub>3</sub>                                                              | 10421-48-4  | 241.860     | cry                         |                       |         |                            | 82.5 <sup>20</sup>                  |                                           |
| 1390 | Iron(III) nitrate hexahydrate         | Fe(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                          | 13476-08-9  | 349.951     | viol cub cry                | 35 dec                |         |                            | 82.5 <sup>20</sup>                  |                                           |
| 1391 | Iron(III) nitrate nonahydrate         | Fe(NO <sub>3</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                                          | 7782-61-8   | 403.997     | viol-gray hyg cry           | 47 dec                |         | 1.68                       | 82.5 <sup>20</sup>                  | vs EtOH, ace                              |
| 1392 | Iron(III) oxalate                     | Fe <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub>                                  | 19469-07-9  | 375.747     | yel amorp powder            | 100 dec               |         |                            |                                     | s H <sub>2</sub> O, acid; i alk           |
| 1393 | Iron(III) oxide                       | Fe <sub>2</sub> O <sub>3</sub>                                                                 | 1309-37-1   | 159.688     | red-brn hex cry             | 1539                  |         | 5.25                       |                                     | i H <sub>2</sub> O; s acid                |
| 1394 | Iron(III) 2,4-pentanedioate           | Fe(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub>                                        | 14024-18-1  | 353.169     | red-oran cry                | 179                   |         | 5.24                       |                                     | sl H <sub>2</sub> O; s os                 |
| 1395 | Iron(III) perchlorate hexahydrate     | Fe(ClO <sub>4</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                         | 32963-81-8  | 462.288     | viol cry                    |                       |         |                            |                                     |                                           |
| 1396 | Iron(III) phosphate dihydrate         | FePO <sub>4</sub> · 2H <sub>2</sub> O                                                          | 10045-86-0  | 186.847     | gray-wh orth cry            |                       |         | 2.87                       |                                     | i H <sub>2</sub> O; s HCl                 |
| 1397 | Iron(III) pyrophosphate nonahydrate   | Fe <sub>4</sub> (P <sub>2</sub> O <sub>7</sub> ) <sub>3</sub> · 9H <sub>2</sub> O              | 10058-44-3  | 907.348     | yel powder                  |                       |         |                            |                                     | i H <sub>2</sub> O; s acid                |
| 1398 | Iron(III) hypophosphite               | Fe(H <sub>2</sub> PO <sub>2</sub> ) <sub>3</sub>                                               | 7783-84-8   | 250.811     | wh-gray powder              |                       |         |                            |                                     | i H <sub>2</sub> O                        |
| 1399 | Iron(III) sodium pyrophosphate        | FeNaP <sub>2</sub> O <sub>7</sub>                                                              | 10045-87-1  | 252.778     | wh powder                   |                       |         | 1.5                        |                                     | i H <sub>2</sub> O; s HCl                 |
| 1400 | Iron(III) sulfate                     | Fe <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                                | 10028-22-5  | 399.878     | gray-wh rhomb cry; hyg      |                       |         | 3.10                       | 440 <sup>20</sup>                   | sl EtOH; i ace                            |
| 1401 | Iron(III) sulfate nonahydrate         | Fe <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                            | 13520-56-4  | 562.015     | yel hex cry                 | 400 dec               |         | 2.1                        | 440 <sup>20</sup>                   |                                           |
| 1402 | Iron(III) thiocyanate                 | Fe(SCN) <sub>3</sub>                                                                           | 4119-52-2   | 230.092     | red-viol hyg cry            | dec                   |         |                            |                                     | s H <sub>2</sub> O, EtOH, ace; i tol, chl |
| 1403 | Krypton                               | Kr                                                                                             | 7439-90-9   | 83.798      | col gas                     | -157.38 tp (73.2 kPa) | -153.34 | 3.425 g/L                  |                                     | sl H <sub>2</sub> O                       |
| 1404 | Krypton difluoride                    | KrF <sub>2</sub>                                                                               | 13773-81-4  | 121.795     | col tetr cry                | ≈25 dec               |         | 3.24                       |                                     | reac H <sub>2</sub> O                     |
| 1405 | Krypton fluoride hexafluoroantimonate | KrFSbF <sub>11</sub>                                                                           | 39578-36-4  | 555.299     | wh solid                    | dec 45                |         |                            |                                     |                                           |
| 1406 | Lanthanum                             | La                                                                                             | 7439-91-0   | 138.905     | silv metal; hex             | 920                   | 3464    | 6.15                       |                                     | s dil acid                                |
| 1407 | Lanthanum aluminum oxide              | LaAlO <sub>3</sub>                                                                             | 12003-65-5  | 213.885     | wh rhom cry                 | trans cub 500         |         |                            |                                     |                                           |
| 1408 | Lanthanum boride                      | LaB <sub>6</sub>                                                                               | 12008-21-8  | 203.771     | blk cub cry; refrac         | 2715                  |         | 4.76                       |                                     |                                           |
| 1409 | Lanthanum bromate nonahydrate         | LaBrO <sub>3</sub> · 9H <sub>2</sub> O                                                         |             | 684.749     | hex cry                     | dec 100               |         | 5.06                       |                                     | vs H <sub>2</sub> O                       |
| 1410 | Lanthanum bromide                     | LaBr <sub>3</sub>                                                                              | 13536-79-3  | 378.617     | wh hex cry; hyg             | 788                   |         | 5.1                        |                                     | s H <sub>2</sub> O                        |
| 1411 | Lanthanum carbide                     | LaC <sub>2</sub>                                                                               | 12071-15-7  | 162.926     | tetr cry                    | 2360                  |         | 5.29                       |                                     |                                           |
| 1412 | Lanthanum carbonate octahydrate       | La <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                            | 6487-39-4   | 601.960     | wh cry powder               |                       |         | 2.6                        |                                     | i H <sub>2</sub> O; s dil acid            |
| 1413 | Lanthanum chloride                    | LaCl <sub>3</sub>                                                                              | 10099-58-8  | 245.264     | wh hex cry; hyg             | 858                   |         | 3.84                       | 95.7 <sup>25</sup>                  |                                           |
| 1414 | Lanthanum chloride heptahydrate       | LaCl <sub>3</sub> · 7H <sub>2</sub> O                                                          | 20211-76-1  | 371.371     | wh tricl cry; hyg           | 91 dec                |         |                            | 95.7 <sup>25</sup>                  | s EtOH                                    |
| 1415 | Lanthanum fluoride                    | LaF <sub>3</sub>                                                                               | 13709-38-1  | 195.900     | wh hex cry; hyg             | 1493                  |         | 5.9                        |                                     | i H <sub>2</sub> O, acid                  |
| 1416 | Lanthanum hydride                     | LaH <sub>3</sub>                                                                               | 13864-01-2  | 141.929     | blk cub cry                 |                       |         | 5.36                       |                                     |                                           |
| 1417 | Lanthanum hydroxide                   | La(OH) <sub>3</sub>                                                                            | 14507-19-8  | 189.927     | wh amorp solid              | dec                   |         |                            | 0.000020 <sup>20</sup>              |                                           |
| 1418 | Lanthanum iodate                      | La(IO <sub>3</sub> ) <sub>3</sub>                                                              | 13870-19-4  | 663.614     | col cry                     |                       |         |                            | 1.7                                 |                                           |
| 1419 | Lanthanum iodide                      | LaI <sub>3</sub>                                                                               | 13813-22-4  | 519.619     | wh orth cry; hyg            | 778                   |         | 5.6                        |                                     | s H <sub>2</sub> O                        |
| 1420 | Lanthanum nitrate hexahydrate         | La(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                          | 10277-43-7  | 433.011     | wh hyg tricl cry            | ≈40 dec               |         |                            | 200 <sup>25</sup>                   | vs EtOH; s ace                            |

| No.  | Name                                  | Formula                                                                                          | CAS Reg No. | Mol. weight | Physical form             | mp/°C                 | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                           |
|------|---------------------------------------|--------------------------------------------------------------------------------------------------|-------------|-------------|---------------------------|-----------------------|---------|----------------------------|-------------------------------------|--------------------------------------------------|
| 1421 | Lanthanum nitride                     | LaN                                                                                              | 25764-10-7  | 152.912     | cub cry                   |                       |         | 6.73                       |                                     |                                                  |
| 1422 | Lanthanum oxide                       | La <sub>2</sub> O <sub>3</sub>                                                                   | 1312-81-8   | 325.809     | wh amorp powder           | 2304                  | 3620    | 6.51                       |                                     | i H <sub>2</sub> O; s dil acid                   |
| 1423 | Lanthanum perchlorate hexahydrate     | La(ClO <sub>4</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                           | 36907-37-6  | 475.021     | hyg col cry               | dec 100               |         |                            |                                     | vs H <sub>2</sub> O; s EtOH                      |
| 1424 | Lanthanum silicide                    | LaSi <sub>2</sub>                                                                                | 12056-90-5  | 195.076     | gray tetr cry             | 1520                  |         | 5.0                        |                                     |                                                  |
| 1425 | Lanthanum sulfate                     | La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                                  | 10099-60-2  | 565.999     | hyg wh pow                | 1150                  |         |                            |                                     | sl H <sub>2</sub> O                              |
| 1426 | Lanthanum sulfate octahydrate         | La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                              | 57804-25-8  | 702.058     | col cry                   | dec                   |         | 2.82                       |                                     | sl H <sub>2</sub> O                              |
| 1427 | Lanthanum sulfate nonahydrate         | La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                              | 10294-62-9  | 728.136     | hex cry                   |                       |         | 2.82                       | 2.7 <sup>20</sup>                   | i EtOH                                           |
| 1428 | Lanthanum monosulfide                 | LaS                                                                                              | 12031-30-0  | 170.970     | yel cub cry               | 2300                  |         | 5.61                       |                                     |                                                  |
| 1429 | Lanthanum sulfide                     | La <sub>2</sub> S <sub>3</sub>                                                                   | 12031-49-1  | 374.006     | red cub cry               | 2110                  |         | 4.9                        |                                     |                                                  |
| 1430 | Lawrencium                            | Lr                                                                                               | 22537-19-5  | 262         | metal                     | 1627                  |         |                            |                                     |                                                  |
| 1431 | Lead                                  | Pb                                                                                               | 7439-92-1   | 207.2       | soft silv-gray metal; cub | 327.462               | 1749    | 11.3                       |                                     | s conc acid                                      |
| 1432 | Plumbane                              | PbH <sub>4</sub>                                                                                 | 15875-18-0  | 211.2       | unstab col gas            |                       | -13     |                            |                                     |                                                  |
| 1433 | Lead(II) acetate                      | Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                                   | 301-04-2    | 325.3       | wh cry                    | 280                   | dec     | 3.25                       | 44.3 <sup>20</sup>                  |                                                  |
| 1434 | Lead(II) acetate trihydrate           | Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 3H <sub>2</sub> O               | 6080-56-4   | 427.3       | col cry                   | 75 dec                |         | 2.55                       |                                     | vs H <sub>2</sub> O; sl EtOH                     |
| 1435 | Lead(II) acetate, basic               | Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 2Pb(OH) <sub>2</sub>            | 1335-32-6   | 807.7       | wh powder                 | dec                   |         |                            | 6.3 <sup>0</sup>                    |                                                  |
| 1436 | Lead(II) antimonate                   | Pb <sub>2</sub> (SbO <sub>4</sub> ) <sub>3</sub>                                                 | 13510-89-9  | 993.1       | oran-yel powder           |                       |         | 6.58                       |                                     | i H <sub>2</sub> O, dil acid                     |
| 1437 | Lead(II) arsenate                     | Pb <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub>                                                 | 3687-31-8   | 899.4       | wh cry                    | 1042 dec              |         | 5.8                        |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>           |
| 1438 | Lead(II) arsenite                     | Pb(AsO <sub>2</sub> ) <sub>2</sub>                                                               | 10031-13-7  | 421.0       | wh powder                 |                       |         | 5.85                       |                                     | i H <sub>2</sub> O; s dil HNO <sub>3</sub>       |
| 1439 | Lead(II) azide                        | Pb(N <sub>3</sub> ) <sub>2</sub>                                                                 | 13424-46-9  | 291.2       | col orth needles; exp     | exp ≈350              |         | 4.7                        | 0.023 <sup>18</sup>                 | vs HOAc                                          |
| 1440 | Lead(II) borate monohydrate           | Pb(BO <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                                             | 10214-39-8  | 310.8       | wh powder                 | 500 dec               |         | 5.6                        |                                     | i H <sub>2</sub> O; s dil HNO <sub>3</sub>       |
| 1441 | Lead(II) bromate monohydrate          | Pb(BrO <sub>3</sub> ) <sub>2</sub> · H <sub>2</sub> O                                            | 10031-21-7  | 481.0       | col cry                   | ≈180 dec              |         | 5.53                       | 1.33 <sup>20</sup>                  |                                                  |
| 1442 | Lead(II) bromide                      | PbBr <sub>2</sub>                                                                                | 10031-22-8  | 367.0       | wh orth cry               | 371                   | 892     | 6.69                       | 0.975 <sup>25</sup>                 | i EtOH                                           |
| 1443 | Lead(II) butanoate                    | Pb(C <sub>4</sub> H <sub>7</sub> O <sub>2</sub> ) <sub>2</sub>                                   | 819-73-8    | 381.4       | col solid                 | ≈90                   |         |                            |                                     | i H <sub>2</sub> O; s dil HNO <sub>3</sub>       |
| 1444 | Lead(II) carbonate                    | PbCO <sub>3</sub>                                                                                | 598-63-0    | 267.2       | col orth cry              | ≈315 dec              |         | 6.582                      |                                     | i H <sub>2</sub> O                               |
| 1445 | Lead(II) carbonate, basic             | Pb(OH) <sub>2</sub> · 2PbCO <sub>3</sub>                                                         | 1319-46-6   | 775.6       | wh hex cry                | 400 dec               |         | ≈6.5                       |                                     | i H <sub>2</sub> O, EtOH; s acid                 |
| 1446 | Lead(II) chlorate                     | Pb(ClO <sub>3</sub> ) <sub>2</sub>                                                               | 10294-47-0  | 374.1       | col hyg cry               | 230 dec               |         | 3.9                        | 144 <sup>18</sup>                   | vs EtOH                                          |
| 1447 | Lead(II) chloride                     | PbCl <sub>2</sub>                                                                                | 7758-95-4   | 278.1       | wh orth needles or powder | 501                   | 951     | 5.98                       | 1.08 <sup>25</sup>                  | s alk                                            |
| 1448 | Lead(II) chloride fluoride            | PbClF                                                                                            | 13847-57-9  | 261.7       | tetr cry                  |                       |         | 7.05                       | 0.035 <sup>20</sup>                 |                                                  |
| 1449 | Lead(II) chlorite                     | Pb(ClO <sub>2</sub> ) <sub>2</sub>                                                               | 13453-57-1  | 342.1       | yel monocl cry            | dec 126               |         |                            | 0.2 <sup>25</sup>                   | sl H <sub>2</sub> O; s alk                       |
| 1450 | Lead(II) chromate                     | PbCrO <sub>4</sub>                                                                               | 7758-97-6   | 323.2       | yel-oran monocl cry       | 844                   |         | 6.12                       | 0.000017 <sup>20</sup>              | s alk, dil acid                                  |
| 1451 | Lead(II) chromate(VI) oxide           | PbCrO <sub>4</sub> · PbO                                                                         | 18454-12-1  | 546.4       | red powder                |                       |         |                            |                                     | i H <sub>2</sub> O                               |
| 1452 | Lead(II) citrate trihydrate           | Pb <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sub>2</sub> · 3H <sub>2</sub> O | 512-26-5    | 1053.8      | wh cry powder             |                       |         |                            |                                     | s H <sub>2</sub> O; sl EtOH                      |
| 1453 | Lead(II) cyanide                      | Pb(CN) <sub>2</sub>                                                                              | 592-05-2    | 259.2       | wh-yel powder             |                       |         |                            |                                     | sl H <sub>2</sub> O; reac acid                   |
| 1454 | Lead(II) 2-ethylhexanoate             | Pb(C <sub>8</sub> H <sub>15</sub> CO <sub>2</sub> ) <sub>2</sub>                                 | 301-08-6    | 493.6       | visc liq                  |                       |         | 1.56                       |                                     |                                                  |
| 1455 | Lead(II) fluoride                     | PbF <sub>2</sub>                                                                                 | 7783-46-2   | 245.2       | wh orth cry               | 830                   | 1293    | 8.44                       | 0.0670 <sup>25</sup>                |                                                  |
| 1456 | Lead(II) fluoroborate                 | Pb(BF <sub>4</sub> ) <sub>2</sub>                                                                | 13814-96-5  | 380.8       | stab only in aq soln      |                       |         |                            |                                     | s H <sub>2</sub> O                               |
| 1457 | Lead(II) formate                      | Pb(CHO <sub>2</sub> ) <sub>2</sub>                                                               | 811-54-1    | 297.2       | wh prisms or needles      | 190 dec               |         | 4.63                       | 1.6 <sup>16</sup>                   | i EtOH                                           |
| 1458 | Lead(II) hexafluoro-2,4-pentanedioate | Pb(CF <sub>3</sub> COCHCOCF <sub>3</sub> ) <sub>2</sub>                                          | 19648-88-5  | 621.3       | cry                       | 155                   | 210     |                            |                                     |                                                  |
| 1459 | Lead(II) hydrogen arsenate            | PbHAsO <sub>4</sub>                                                                              | 7784-40-9   | 347.1       | wh monocl cry             | 280 dec               |         | 5.943                      |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub> , alk     |
| 1460 | Lead(II) hydrogen phosphate           | PbHPO <sub>4</sub>                                                                               | 15845-52-0  | 303.2       | wh monocl cry             | dec                   |         | 5.66                       |                                     |                                                  |
| 1461 | Lead(II) hydroxide                    | Pb(OH) <sub>2</sub>                                                                              | 19783-14-3  | 241.2       | wh powder                 | 145 dec               |         | 5.69                       | 0.00012 <sup>20</sup>               | s acid                                           |
| 1462 | Lead(II) iodate                       | Pb(IO <sub>3</sub> ) <sub>2</sub>                                                                | 25659-31-8  | 557.0       | wh orth cry               |                       |         | 6.50                       | 0.0025 <sup>25</sup>                |                                                  |
| 1463 | Lead(II) iodide                       | PbI <sub>2</sub>                                                                                 | 10101-63-0  | 461.0       | yel hex cry or powder     | 410                   | 872 dec | 6.16                       | 0.076 <sup>25</sup>                 | i EtOH                                           |
| 1464 | Lead(II) lactate                      | Pb(C <sub>3</sub> H <sub>5</sub> O <sub>3</sub> ) <sub>2</sub>                                   | 18917-82-3  | 385.3       | wh cry powder             |                       |         |                            |                                     | s H <sub>2</sub> O, hot EtOH                     |
| 1465 | Lead(II) molybdate                    | PbMoO <sub>4</sub>                                                                               | 10190-55-3  | 367.1       | yel tetr cry              | ≈1060                 |         | 6.7                        |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub> , NaOH    |
| 1466 | Lead(II) niobate                      | Pb(NbO <sub>3</sub> ) <sub>2</sub>                                                               | 12034-88-7  | 489.0       | rhomb or tetr cry         | 1343                  |         | 6.6                        |                                     | i H <sub>2</sub> O                               |
| 1467 | Lead(II) nitrate                      | Pb(NO <sub>3</sub> ) <sub>2</sub>                                                                | 10099-74-8  | 331.2       | col cub cry               | 470                   |         | 4.53                       | 59.7 <sup>25</sup>                  | sl EtOH                                          |
| 1468 | Lead(II) oleate                       | Pb(C <sub>18</sub> H <sub>33</sub> O <sub>2</sub> ) <sub>2</sub>                                 | 1120-46-3   | 770.1       | wax-like solid            |                       |         |                            |                                     | i H <sub>2</sub> O; s EtOH, bz, eth              |
| 1469 | Lead(II) oxalate                      | PbC <sub>2</sub> O <sub>4</sub>                                                                  | 814-93-7    | 295.2       | wh powder                 | 300 dec               |         | 5.28                       | 0.00025 <sup>20</sup>               | s dil HNO <sub>3</sub>                           |
| 1470 | Lead(II) oxide (litharge)             | PbO                                                                                              | 1317-36-8   | 223.2       | red tetr cry              | trans to massicot 489 |         | 9.35                       |                                     | i H <sub>2</sub> O, EtOH; s dil HNO <sub>3</sub> |
| 1471 | Lead(II) oxide (massicot)             | PbO                                                                                              | 1317-36-8   | 223.2       | yel orth cry              | 887                   |         | 9.64                       |                                     | i H <sub>2</sub> O, EtOH; s dil HNO <sub>3</sub> |
| 1472 | Lead(II) oxide hydrate                | 3PbO · H <sub>2</sub> O                                                                          | 1311-11-1   | 687.6       | wh powder                 |                       |         | 7.41                       |                                     | i H <sub>2</sub> O; s dil acid                   |
| 1473 | Lead(II) 2,4-pentanedioate            | Pb(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>                                          | 15282-88-9  | 405.4       | cry                       | 143                   |         |                            |                                     |                                                  |
| 1474 | Lead(II) perchlorate                  | Pb(ClO <sub>4</sub> ) <sub>2</sub>                                                               | 13453-62-8  | 406.1       | wh cry                    |                       |         |                            | 441 <sup>25</sup>                   |                                                  |
| 1475 | Lead(II) perchlorate trihydrate       | Pb(ClO <sub>4</sub> ) <sub>2</sub> · 3H <sub>2</sub> O                                           | 13637-76-8  | 460.1       | wh cry                    | 100 dec               |         | 2.6                        | 441 <sup>25</sup>                   | s EtOH                                           |

| No.  | Name                                  | Formula                                                                          | CAS Reg No. | Mol. weight | Physical form                      | mp/°C        | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                    |
|------|---------------------------------------|----------------------------------------------------------------------------------|-------------|-------------|------------------------------------|--------------|----------|----------------------------|-------------------------------------|-------------------------------------------|
| 1476 | Lead(II) phosphate                    | Pb <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>                                  | 7446-27-7   | 811.5       | wh hex cry                         | 1014         |          | 7.01                       |                                     | i H <sub>2</sub> O, EtOH                  |
| 1477 | Lead(II) hypophosphite                | Pb(H <sub>2</sub> PO <sub>2</sub> ) <sub>2</sub>                                 | 10294-58-3  | 337.2       | hyg cry powder                     | dec          |          |                            |                                     | sl H <sub>2</sub> O; i EtOH               |
| 1478 | Lead(II) metasilicate                 | PbSiO <sub>3</sub>                                                               | 10099-76-0  | 283.3       | wh monocl cry powder               | 764          |          | 6.49                       |                                     | i H <sub>2</sub> O, os                    |
| 1479 | Lead(II) orthosilicate                | Pb <sub>2</sub> SiO <sub>4</sub>                                                 | 13566-17-1  | 506.5       | monocl cry                         | 743          |          | 7.60                       |                                     |                                           |
| 1480 | Lead(II) hexafluorosilicate dihydrate | PbSiF <sub>6</sub> · 2H <sub>2</sub> O                                           | 1310-03-8   | 385.3       | col cry                            | dec          |          |                            |                                     | vs H <sub>2</sub> O                       |
| 1481 | Lead(II) selenate                     | PbSeO <sub>4</sub>                                                               | 7446-15-3   | 350.2       | orth cry                           |              |          | 6.37                       | 0.013 <sup>25</sup>                 | s conc acid                               |
| 1482 | Lead(II) selenide                     | PbSe                                                                             | 12069-00-0  | 286.2       | gray cub cry                       | 1078         |          | 8.1                        |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>    |
| 1483 | Lead(II) selenite                     | PbSeO <sub>3</sub>                                                               | 7488-51-9   | 334.2       | wh monocl cry                      | ≈500         |          | 7.0                        |                                     | i H <sub>2</sub> O                        |
| 1484 | Lead(II) sodium thiosulfate           | Na <sub>4</sub> Pb(S <sub>2</sub> O <sub>3</sub> ) <sub>3</sub>                  | 10101-94-7  | 635.5       | wh cry                             |              |          |                            |                                     | sl H <sub>2</sub> O                       |
| 1485 | Lead(II) stearate                     | Pb(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>2</sub>                 | 1072-35-1   | 774.1       | wh powder                          | ≈100         |          | 1.4                        |                                     | i H <sub>2</sub> O; s hot EtOH            |
| 1486 | Lead(II) sulfate                      | PbSO <sub>4</sub>                                                                | 7446-14-2   | 303.3       | orth cry                           | 1087         |          | 6.29                       | 0.0044 <sup>25</sup>                | i acid; sl alk                            |
| 1487 | Lead(II) sulfide                      | PbS                                                                              | 1314-87-0   | 239.3       | blk powder or silv cub cry         | 1113         |          | 7.60                       |                                     | i H <sub>2</sub> O; s acid                |
| 1488 | Lead(II) sulfite                      | PbSO <sub>3</sub>                                                                | 7446-10-8   | 287.3       | wh powder                          | dec          |          |                            |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>    |
| 1489 | Lead(II) tantalate                    | Pb(TaO <sub>3</sub> ) <sub>2</sub>                                               | 12065-68-8  | 665.1       | orth cry                           |              |          | 7.9                        |                                     | i H <sub>2</sub> O                        |
| 1490 | Lead(II) telluride                    | PbTe                                                                             | 1314-91-6   | 334.8       | gray cub cry                       | 924          |          | 8.164                      |                                     | i H <sub>2</sub> O, acid                  |
| 1491 | Lead(II) thiocyanate                  | Pb(SCN) <sub>2</sub>                                                             | 592-87-0    | 323.4       | wh-yel powder                      |              |          | 3.82                       | 0.05 <sup>20</sup>                  |                                           |
| 1492 | Lead(II) thiosulfate                  | PbS <sub>2</sub> O <sub>3</sub>                                                  | 13478-50-7  | 319.3       | wh cry                             | dec          |          | 5.18                       |                                     | i H <sub>2</sub> O; s acid                |
| 1493 | Lead(II) titanate                     | PbTiO <sub>3</sub>                                                               | 12060-00-3  | 303.1       | yel tetr cry                       |              |          | 7.9                        |                                     | i H <sub>2</sub> O; reac HCl              |
| 1494 | Lead(II) tungstate (stolzite)         | PbWO <sub>4</sub>                                                                | 7759-01-5   | 455.0       | yel tetr cry                       | 1130         |          | 8.24                       | 0.03 <sup>20</sup>                  | s alk                                     |
| 1495 | Lead(II) tungstate (raspite)          | PbWO <sub>4</sub>                                                                | 7759-01-5   | 455.0       | monocl cry                         | trans 400    |          | 8.46                       | 0.03 <sup>20</sup>                  | s alk                                     |
| 1496 | Lead(II) metavanadate                 | Pb(VO <sub>3</sub> ) <sub>2</sub>                                                | 10099-79-3  | 405.1       | yel powder                         |              |          |                            |                                     | i H <sub>2</sub> O; reac HNO <sub>3</sub> |
| 1497 | Lead(II) zirconate                    | PbZrO <sub>3</sub>                                                               | 12060-01-4  | 346.4       | col orth cry                       |              |          | ≈8                         |                                     | i H <sub>2</sub> O, alk; s acid           |
| 1498 | Lead(II,IV) oxide                     | Pb <sub>3</sub> O <sub>4</sub>                                                   | 1314-27-8   | 462.4       | blk monocl cry or red amorp powder | 530 dec      |          | 10.05                      |                                     | i H <sub>2</sub> O; s alk; reac conc HCl  |
| 1499 | Lead(II,IV) oxide                     | Pb <sub>3</sub> O <sub>4</sub>                                                   | 1314-41-6   | 685.6       | red tetr cry                       | 830          |          | 8.92                       |                                     | i H <sub>2</sub> O, EtOH; s hot HCl       |
| 1500 | Lead(IV) acetate                      | Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>4</sub>                   | 546-67-8    | 443.4       | col monocl cry                     | ≈175         |          | 2.23                       |                                     | reac H <sub>2</sub> O, EtOH; s bz, chl    |
| 1501 | Lead(IV) bromide                      | PbBr <sub>4</sub>                                                                | 13701-91-2  | 526.8       | unstab liq                         |              |          |                            |                                     |                                           |
| 1502 | Lead(IV) chloride                     | PbCl <sub>4</sub>                                                                | 13463-30-4  | 349.0       | yel oily liq                       | -15          | ≈50 dec  |                            |                                     |                                           |
| 1503 | Lead(IV) fluoride                     | PbF <sub>4</sub>                                                                 | 7783-59-7   | 283.2       | wh tetr cry; hyg                   | ≈600         |          | 6.7                        |                                     |                                           |
| 1504 | Lead(IV) oxide                        | PbO <sub>2</sub>                                                                 | 1309-60-0   | 239.2       | red tetr cry or brn powder         | 290 dec      |          | 9.64                       |                                     |                                           |
| 1505 | Lithium                               | Li                                                                               | 7439-93-2   | 6.941       | soft silv-wh metal                 | 180.50       | 1342     | 0.534                      |                                     | reac H <sub>2</sub> O                     |
| 1506 | Lithium acetate                       | LiC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                                   | 546-89-4    | 65.985      | cry                                | 286          |          |                            | 45.0 <sup>25</sup>                  | vs EtOH                                   |
| 1507 | Lithium acetate dihydrate             | LiC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> · 2H <sub>2</sub> O               | 6108-17-4   | 102.016     | wh rhomb cry                       | 58 dec       |          | 1.3                        | 45.0 <sup>25</sup>                  | s EtOH                                    |
| 1508 | Lithium aluminum hydride              | LiAlH <sub>4</sub>                                                               | 16853-85-3  | 37.955      | gray-wh monocl cry                 | >125 dec     |          | 0.917                      |                                     | reac H <sub>2</sub> O, EtOH; s eth, thf   |
| 1509 | Lithium aluminum silicate             | LiAlSi <sub>2</sub> O <sub>6</sub>                                               | 12068-40-5  | 186.090     | wh monocl cry                      | 1430         |          | 3.188                      |                                     |                                           |
| 1510 | Lithium amide                         | LiNH <sub>2</sub>                                                                | 7782-89-0   | 22.964      | tetr cry                           | 380          |          | 1.18                       |                                     | reac H <sub>2</sub> O                     |
| 1511 | Lithium arsenate                      | Li <sub>3</sub> AsO <sub>4</sub>                                                 | 13478-14-3  | 159.743     | col orth cry                       |              |          | 3.07                       |                                     | sl H <sub>2</sub> O; s HOAc               |
| 1512 | Lithium azide                         | LiN <sub>3</sub>                                                                 | 19597-69-4  | 48.961      | hyg monocl cry; exp                |              |          | 1.83                       |                                     | vs H <sub>2</sub> O                       |
| 1513 | Lithium borohydride                   | LiBH <sub>4</sub>                                                                | 16949-15-8  | 21.784      | wh-gray orth cry or powder         | 268          | 380 dec  | 0.66                       |                                     | s alk, eth, thf                           |
| 1514 | Lithium bromate                       | LiBrO <sub>3</sub>                                                               | 13550-28-2  | 134.843     | hyg col orth cry                   | 260          |          |                            | 65.4 <sup>25</sup>                  | vs H <sub>2</sub> O                       |
| 1515 | Lithium bromide                       | LiBr                                                                             | 7550-35-8   | 86.845      | wh cub cry; hyg                    | 550          | ≈1300    | 3.464                      | 181 <sup>25</sup>                   | s EtOH, eth                               |
| 1516 | Lithium bromide monohydrate           | LiBr · H <sub>2</sub> O                                                          | 23303-71-1  | 104.860     | wh orth cry                        | trans cub 33 |          | 3.46                       | 145 <sup>4</sup>                    | vs H <sub>2</sub> O                       |
| 1517 | Lithium carbide                       | Li <sub>2</sub> C <sub>2</sub>                                                   | 1070-75-3   | 37.903      | wh hyg cry                         |              |          | 1.65                       |                                     | reac H <sub>2</sub> O; i os               |
| 1518 | Lithium carbonate                     | Li <sub>2</sub> CO <sub>3</sub>                                                  | 554-13-2    | 73.891      | wh monocl cry                      | 732          | 1300 dec | 2.11                       | 1.30 <sup>25</sup>                  | s acid; i EtOH                            |
| 1519 | Lithium chlorate                      | LiClO <sub>3</sub>                                                               | 13453-71-9  | 90.392      | col hyg rhom needles               | 127.6        | 300 dec  | 1.119                      | 459 <sup>25</sup>                   | vs EtOH; sl ace                           |
| 1520 | Lithium chloride                      | LiCl                                                                             | 7447-41-8   | 42.394      | wh cub cry or powder; hyg          | 610          | 1383     | 2.07                       | 84.5 <sup>25</sup>                  | s EtOH, ace, py                           |
| 1521 | Lithium chloride monohydrate          | LiCl · H <sub>2</sub> O                                                          | 16712-20-2  | 60.409      | hyg wh tetr cry                    | dec 98       |          | 1.78                       | 45.9 <sup>25</sup>                  | vs H <sub>2</sub> O                       |
| 1522 | Lithium chromate dihydrate            | Li <sub>2</sub> CrO <sub>4</sub> · 2H <sub>2</sub> O                             | 7789-01-7   | 165.906     | yel orth cry; hyg                  | 75 dec       |          | 2.15                       |                                     | vs H <sub>2</sub> O; s EtOH               |
| 1523 | Lithium citrate tetrahydrate          | Li <sub>3</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> · 4H <sub>2</sub> O | 6680-58-6   | 281.983     | wh cry                             | 210 (anh)    |          |                            | 75 <sup>25</sup>                    | vs H <sub>2</sub> O; sl EtOH              |
| 1524 | Lithium cobaltite                     | LiCoO <sub>2</sub>                                                               | 12190-79-3  | 97.873      | dark gray pow                      |              |          |                            |                                     | i H <sub>2</sub> O                        |
| 1525 | Lithium cyanide                       | LiCN                                                                             | 2408-36-8   | 32.959      | wh orth cry                        | 160          |          |                            |                                     |                                           |
| 1526 | Lithium hydride-d                     | LiD                                                                              | 13587-16-1  | 8.955       | hyg wh cry                         | 680          |          | 0.82                       |                                     | reac H <sub>2</sub> O                     |
| 1527 | Lithium dichromate dihydrate          | Li <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> · 2H <sub>2</sub> O               | 10022-48-7  | 265.901     | yel-red hyg cry                    | 130 dec      |          | 2.34                       |                                     | vs H <sub>2</sub> O                       |
| 1528 | Lithium dihydrogen phosphate          | LiH <sub>2</sub> PO <sub>4</sub>                                                 | 13453-80-0  | 103.928     | col hyg cry                        | >100         |          | 2.461                      | 126 <sup>9</sup>                    |                                           |
| 1529 | Lithium diisopropylamide              | LiN(C <sub>3</sub> H <sub>7</sub> ) <sub>2</sub>                                 | 4111-54-0   | 107.123     | hyg col cry                        | dec          |          |                            |                                     | s eth; i hc                               |
| 1530 | Lithium ferrosilicon                  | LiFeSi                                                                           | 64082-35-5  | 90.872      | dark brittle cry                   |              |          |                            |                                     | reac H <sub>2</sub> O                     |

| No.  | Name                                     | Formula                                                           | CAS Reg No. | Mol. weight | Physical form               | mp/°C   | bp/°C     | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                 |
|------|------------------------------------------|-------------------------------------------------------------------|-------------|-------------|-----------------------------|---------|-----------|----------------------------|-------------------------------------|----------------------------------------|
| 1531 | Lithium fluoride                         | LiF                                                               | 7789-24-4   | 25.939      | wh cub cry or powder        | 848.2   | 1673      | 2.640                      | 0.134 <sup>25</sup>                 | s acid                                 |
| 1532 | Lithium formate monohydrate              | Li(CHO <sub>2</sub> ) · H <sub>2</sub> O                          | 6108-23-2   | 69.974      | col-wh cry                  |         |           | 1.46                       |                                     | s H <sub>2</sub> O                     |
| 1533 | Lithium hexafluoroantimonate             | LiSbF <sub>6</sub>                                                | 18424-17-4  | 242.691     | hyg pow                     | dec     |           |                            |                                     |                                        |
| 1534 | Lithium hexafluoroarsenate               | LiAsF <sub>6</sub>                                                | 29935-35-1  | 310.672     | rhomb wh cry; hyg           |         |           |                            |                                     |                                        |
| 1535 | Lithium hexafluorophosphate              | LiPF <sub>6</sub>                                                 | 21324-40-3  | 151.905     | wh pow                      |         |           |                            |                                     |                                        |
| 1536 | Lithium hexafluorosilicate               | Li <sub>2</sub> SiF <sub>6</sub>                                  | 17347-95-4  | 155.958     | col hex cry                 | dec 350 |           |                            |                                     | sl ace                                 |
| 1537 | Lithium hexafluorostannate               | Li <sub>2</sub> SnF <sub>6</sub>                                  | 17029-16-2  | 246.582     | wh pow                      |         |           |                            |                                     |                                        |
| 1538 | Lithium hydride                          | LiH                                                               | 7580-67-8   | 7.949       | gray cub cry or powder; hyg | 692     |           | 0.78                       |                                     | reac H <sub>2</sub> O, EtOH            |
| 1539 | Lithium hydrogen carbonate               | LiHCO <sub>3</sub>                                                | 5006-97-3   | 67.958      | wh pow                      |         |           |                            |                                     | sl H <sub>2</sub> O                    |
| 1540 | Lithium hydroxide                        | LiOH                                                              | 1310-65-2   | 23.948      | col tetra cry               | 473     | 1626      | 1.45                       | 12.5 <sup>25</sup>                  | sl EtOH                                |
| 1541 | Lithium hydroxide monohydrate            | LiOH · H <sub>2</sub> O                                           | 1310-66-3   | 41.964      | wh monoc cry or powder      |         |           | 1.51                       | 12.5 <sup>25</sup>                  | sl EtOH                                |
| 1542 | Lithium hypochlorite                     | LiOCl                                                             | 13840-33-0  | 58.393      | wh pow                      |         |           |                            |                                     | vs H <sub>2</sub> O                    |
| 1543 | Lithium iodate                           | LiIO <sub>3</sub>                                                 | 13765-03-2  | 181.843     | wh hyg hex cry              | 450     |           | 4.502                      | 77.9 <sup>25</sup>                  | i EtOH                                 |
| 1544 | Lithium iodide                           | LiI                                                               | 10377-51-2  | 133.845     | wh cub cry; hyg             | 469     | 1171      | 4.06                       | 165 <sup>25</sup>                   |                                        |
| 1545 | Lithium iodide trihydrate                | LiI · 3H <sub>2</sub> O                                           | 7790-22-9   | 187.891     | wh hyg cry                  | 73      |           | 2.38                       | 165 <sup>25</sup>                   | vs EtOH, ace                           |
| 1546 | Lithium manganate                        | Li <sub>2</sub> MnO <sub>3</sub>                                  | 12163-00-7  | 116.818     | red-brn monoc cry           |         |           | 3.90                       |                                     | i H <sub>2</sub> O                     |
| 1547 | Lithium metaborate                       | LiBO <sub>2</sub>                                                 | 13453-69-5  | 49.751      | wh monoc cry; hyg           | 844     |           | 2.18                       | 2.6 <sup>20</sup>                   | sl H <sub>2</sub> O; s EtOH            |
| 1548 | Lithium metaborate dihydrate             | LiBO <sub>2</sub> · 2H <sub>2</sub> O                             | 15293-74-0  | 85.782      | wh cry pow                  |         |           | 1.8                        |                                     | s H <sub>2</sub> O                     |
| 1549 | Lithium metaphosphate                    | LiPO <sub>3</sub>                                                 | 13762-75-9  | 85.913      | wh cry or gl solid          |         |           | 1.8                        |                                     | i H <sub>2</sub> O                     |
| 1550 | Lithium metasilicate                     | Li <sub>2</sub> SiO <sub>3</sub>                                  | 10102-24-6  | 89.966      | wh orth needles             | 1201    |           | 2.52                       |                                     | i cold H <sub>2</sub> O; reac dil acid |
| 1551 | Lithium molybdate                        | Li <sub>2</sub> MoO <sub>4</sub>                                  | 13568-40-6  | 173.82      | hyg wh cry                  | 702     |           | 2.66                       | 44.8 <sup>25</sup>                  | s H <sub>2</sub> O                     |
| 1552 | Lithium niobate                          | LiNbO <sub>3</sub>                                                | 12031-63-9  | 147.845     | wh hex cry                  | 1240    |           | 4.30                       |                                     |                                        |
| 1553 | Lithium nitrate                          | LiNO <sub>3</sub>                                                 | 7790-69-4   | 68.946      | col hex cry; hyg            | 253     |           | 2.38                       | 102 <sup>25</sup>                   | s EtOH                                 |
| 1554 | Lithium nitride                          | Li <sub>3</sub> N                                                 | 26134-62-3  | 34.830      | red hex cry                 | 813     |           | 1.27                       |                                     | reac H <sub>2</sub> O                  |
| 1555 | Lithium nitrite                          | LiNO <sub>2</sub>                                                 | 13568-33-7  | 52.947      | wh hyg cry                  | 222     |           |                            |                                     | vs H <sub>2</sub> O                    |
| 1556 | Lithium nitrite monohydrate              | LiNO <sub>2</sub> · H <sub>2</sub> O                              | 13568-33-7* | 70.962      | col needles                 | >100    |           | 1.615                      | 139.5 <sup>25</sup>                 | vs H <sub>2</sub> O, EtOH              |
| 1557 | Lithium orthosilicate                    | LiSiO <sub>4</sub>                                                | 13453-84-4  | 99.025      | wh rhomb cry                | 1256    |           | 2.39                       |                                     |                                        |
| 1558 | Lithium oxalate                          | Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                     | 30903-87-8  | 101.901     | col cry                     | dec     |           | 2.121 <sup>17</sup>        |                                     | s H <sub>2</sub> O; i EtOH, eth        |
| 1559 | Lithium phosphate                        | Li <sub>3</sub> PO <sub>4</sub>                                   | 10377-52-3  | 115.794     | wh orth cry                 | 1205    |           | 2.46                       | 0.027 <sup>25</sup>                 |                                        |
| 1560 | Lithium oxide                            | Li <sub>2</sub> O                                                 | 12057-24-8  | 29.881      | wh cub cry                  | 1438    |           | 2.013                      |                                     |                                        |
| 1561 | Lithium perchlorate                      | LiClO <sub>4</sub>                                                | 7791-03-9   | 106.392     | wh orth cry or powder       | 236     | 430 dec   | 2.428                      | 58.7 <sup>25</sup>                  | s EtOH, ace, eth                       |
| 1562 | Lithium perchlorate trihydrate           | LiClO <sub>4</sub> · 3H <sub>2</sub> O                            | 13453-78-6  | 160.438     | wh hex cry                  | 95 dec  |           | 1.84                       |                                     | vs H <sub>2</sub> O, EtOH, ace; i eth  |
| 1563 | Lithium peroxide                         | Li <sub>2</sub> O <sub>2</sub>                                    | 12031-80-0  | 45.881      | wh hex cry                  |         |           | 2.31                       |                                     | s H <sub>2</sub> O; i EtOH             |
| 1564 | Lithium selenate monohydrate             | Li <sub>2</sub> SeO <sub>4</sub> · H <sub>2</sub> O               | 7790-71-8   | 174.86      | monoc cry                   |         |           | 2.56                       |                                     | vs H <sub>2</sub> O                    |
| 1565 | Lithium selenite monohydrate             | Li <sub>2</sub> SeO <sub>3</sub> · H <sub>2</sub> O               | 15593-51-8  | 158.86      | hyg cry                     |         |           |                            |                                     |                                        |
| 1566 | Lithium stearate                         | LiC <sub>18</sub> H <sub>35</sub> O <sub>2</sub>                  | 4485-12-5   | 290.411     | cry                         | ≈220    |           |                            |                                     |                                        |
| 1567 | Lithium sulfate                          | Li <sub>2</sub> SO <sub>4</sub>                                   | 10377-48-7  | 109.945     | wh monoc cry; hyg           | 860     |           | 2.21                       | 34.2 <sup>25</sup>                  |                                        |
| 1568 | Lithium sulfate monohydrate              | Li <sub>2</sub> SO <sub>4</sub> · H <sub>2</sub> O                | 10102-25-7  | 127.960     | col cry                     | 130 dec |           | 2.06                       | 34.2 <sup>25</sup>                  | sl EtOH                                |
| 1569 | Lithium sulfide                          | Li <sub>2</sub> S                                                 | 12136-58-2  | 45.947      | wh cub cry; hyg             | 1372    |           | 1.64                       |                                     |                                        |
| 1570 | Lithium tantalate                        | LiTaO <sub>3</sub>                                                | 12031-66-2  | 235.887     | wh pow                      | 1650    |           |                            |                                     |                                        |
| 1571 | Lithium tetraborate                      | Li <sub>2</sub> B <sub>4</sub> O <sub>7</sub>                     | 12007-60-2  | 169.122     | wh tetra cry                | 917     |           | 2.9 <sup>20</sup>          |                                     | sl H <sub>2</sub> O                    |
| 1572 | Lithium tetraborate pentahydrate         | Li <sub>2</sub> B <sub>4</sub> O <sub>7</sub> · 5H <sub>2</sub> O | 1303-94-2   | 259.198     | wh cry pow                  | dec 200 |           |                            |                                     | vs H <sub>2</sub> O; i EtOH            |
| 1573 | Lithium tetracyanoplatinate pentahydrate | Li <sub>2</sub> Pt(CN) <sub>4</sub> · 5H <sub>2</sub> O           | 14402-73-4  | 403.112     | grn-yel cry                 |         |           |                            |                                     | sl H <sub>2</sub> O                    |
| 1574 | Lithium tetrafluoroborate                | LiBF <sub>4</sub>                                                 | 14283-07-9  | 93.746      | hyg wh pow                  | dec     |           |                            |                                     | vs H <sub>2</sub> O                    |
| 1575 | Lithium thiocyanate                      | LiSCN                                                             | 556-65-0    | 65.024      | wh hyg cry                  |         |           |                            | 120 <sup>25</sup>                   |                                        |
| 1576 | Lithium titanate                         | Li <sub>2</sub> TiO <sub>3</sub>                                  | 12031-82-2  | 109.747     | wh pow                      | 1325    |           |                            |                                     | i H <sub>2</sub> O                     |
| 1577 | Lithium tungstate                        | Li <sub>2</sub> WO <sub>4</sub>                                   | 13568-45-1  | 261.72      | wh trig pow                 | 740     |           | 3.71                       |                                     | s H <sub>2</sub> O                     |
| 1578 | Lithium vanadate                         | LiVO <sub>3</sub>                                                 | 15060-59-0  | 105.881     | yel pow                     |         | subl 1400 |                            |                                     |                                        |
| 1579 | Lithium zirconate                        | Li <sub>2</sub> ZrO <sub>3</sub>                                  | 12031-83-3  | 153.104     | wh solid                    |         |           |                            |                                     |                                        |
| 1580 | Lutetium                                 | Lu                                                                | 7439-94-3   | 174.967     | silv metal; hex             | 1663    | 3402      | 9.84                       |                                     | s dil acid                             |
| 1581 | Lutetium boride                          | LuB <sub>4</sub>                                                  | 12688-52-7  | 218.211     | tetra cry                   | 2600    |           | ≈7.0                       |                                     |                                        |
| 1582 | Lutetium bromide                         | LuBr <sub>3</sub>                                                 | 14456-53-2  | 414.679     | wh hyg cry                  | 1025    |           |                            |                                     | vs H <sub>2</sub> O                    |
| 1583 | Lutetium chloride                        | LuCl <sub>3</sub>                                                 | 10099-66-8  | 281.326     | wh monoc cry; hyg           | 925     |           | 3.98                       |                                     | s H <sub>2</sub> O                     |
| 1584 | Lutetium chloride hexahydrate            | LuCl <sub>3</sub> · 6H <sub>2</sub> O                             | 15230-79-2  | 389.417     | col cry                     | dec 150 |           |                            |                                     | s H <sub>2</sub> O, EtOH               |
| 1585 | Lutetium fluoride                        | LuF <sub>3</sub>                                                  | 13760-81-1  | 231.962     | orth cry                    | 1182    | 2200      | 8.3                        |                                     | i H <sub>2</sub> O                     |
| 1586 | Lutetium iodide                          | LuI <sub>3</sub>                                                  | 13813-45-1  | 555.680     | brn hex cry; hyg            | 1050    |           | ≈5.6                       |                                     | vs H <sub>2</sub> O                    |
| 1587 | Lutetium iron oxide                      | Lu <sub>2</sub> Fe <sub>6</sub> O <sub>12</sub>                   | 12023-71-1  | 996.119     | cry                         |         |           |                            |                                     |                                        |
| 1588 | Lutetium nitrate                         | Lu(NO <sub>3</sub> ) <sub>3</sub>                                 | 10099-67-9  | 360.982     | hyg col solid               |         |           |                            |                                     | s H <sub>2</sub> O, EtOH               |

| No.  | Name                                       | Formula                                                                                           | CAS Reg No. | Mol. weight | Physical form        | mp/°C         | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                      |
|------|--------------------------------------------|---------------------------------------------------------------------------------------------------|-------------|-------------|----------------------|---------------|-------|----------------------------|-------------------------------------|---------------------------------------------|
| 1589 | Lutetium nitride                           | LuN                                                                                               | 12125-25-6  | 188.974     | cub cry              |               |       | 11.6                       |                                     |                                             |
| 1590 | Lutetium oxide                             | Lu <sub>2</sub> O <sub>3</sub>                                                                    | 12032-20-1  | 397.932     | wh cub cry or powder | 2427          | 3980  | 9.41                       |                                     |                                             |
| 1591 | Lutetium perchlorate hexahydrate           | Lu(ClO <sub>4</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                            | 14646-29-8  | 581.410     | col cry              | dec 350 (anh) |       |                            |                                     | s H <sub>2</sub> O, MeOH                    |
| 1592 | Lutetium sulfate                           | Lu <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                                   | 14986-89-1  | 638.122     | wh pow               | dec >850      |       |                            |                                     | vs H <sub>2</sub> O                         |
| 1593 | Lutetium sulfate octahydrate               | Lu <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                               | 13473-77-3  | 782.244     | col cry              |               |       |                            | 42.3 <sup>20</sup>                  | s H <sub>2</sub> O                          |
| 1594 | Lutetium sulfide                           | Lu <sub>2</sub> S <sub>3</sub>                                                                    | 12163-20-1  | 446.129     | gray rhomb cry       | 1750 dec      |       | 6.26                       |                                     |                                             |
| 1595 | Lutetium telluride                         | Lu <sub>2</sub> Te <sub>3</sub>                                                                   | 12163-22-3  | 732.73      | orth cry             |               |       | 7.8                        |                                     |                                             |
| 1596 | Magnesium                                  | Mg                                                                                                | 7439-95-4   | 24.305      | silv-wh metal        | 650           | 1090  | 1.74                       |                                     | s dil acid                                  |
| 1597 | Magnesium acetate                          | Mg(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                                    | 142-72-3    | 142.394     | wh orth/monocl cry   | 323 dec       |       | 1.50                       | 65.6 <sup>25</sup>                  |                                             |
| 1598 | Magnesium acetate monohydrate              | Mg(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                 | 60582-92-5  | 160.409     | orth cry             |               |       | 1.55                       |                                     |                                             |
| 1599 | Magnesium acetate tetrahydrate             | Mg(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                | 16674-78-5  | 214.454     | col monocl cry; hyg  | 80 dec        |       | 1.45                       | 65.6 <sup>25</sup>                  | vs EtOH                                     |
| 1600 | Magnesium aluminate                        | Mg(AlO <sub>2</sub> ) <sub>2</sub>                                                                | 12068-51-8  | 142.266     | col cub cry          | 2105          |       | 3.55                       |                                     | i H <sub>2</sub> O                          |
| 1601 | Magnesium aluminum silicate                | Mg <sub>2</sub> Al <sub>2</sub> (AlSi <sub>5</sub> O <sub>18</sub> )                              | 1302-88-1   | 584.953     | blue cry             |               |       | 2.6                        |                                     |                                             |
| 1602 | Magnesium amide                            | Mg(NH <sub>2</sub> ) <sub>2</sub>                                                                 | 7803-54-5   | 56.350      | wh powder; flam      | dec           |       | 1.39                       |                                     | reac H <sub>2</sub> O                       |
| 1603 | Magnesium ammonium phosphate hexahydrate   | MgNH <sub>4</sub> PO <sub>4</sub> · 6H <sub>2</sub> O                                             | 13478-16-5  | 245.407     | wh pow               | dec           |       | 1.71                       |                                     | i H <sub>2</sub> O, EtOH; s acid            |
| 1604 | Magnesium antimonide                       | Mg <sub>3</sub> Sb <sub>2</sub>                                                                   | 12057-75-9  | 316.435     | hex cry              | 1245          |       | 3.99                       |                                     |                                             |
| 1605 | Magnesium arsenide                         | Mg <sub>3</sub> As <sub>2</sub>                                                                   | 12044-49-4  | 222.758     | solid                | ≈1200         |       | 3.15                       |                                     | i H <sub>2</sub> O                          |
| 1606 | Magnesium diboride                         | MgB <sub>2</sub>                                                                                  | 12007-25-9  | 45.927      | hex cry              | 800 dec       |       | 2.57                       |                                     |                                             |
| 1607 | Magnesium hexaboride                       | MgB <sub>6</sub>                                                                                  | 12008-22-9  | 89.171      | refrac solid         | 1100 dec      |       |                            |                                     | i H <sub>2</sub> O                          |
| 1608 | Magnesium dodecaboride                     | MgB <sub>12</sub>                                                                                 | 12230-32-9  | 154.037     | refrac solid         | 1300 dec      |       |                            |                                     |                                             |
| 1609 | Magnesium bromate hexahydrate              | Mg(BrO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                            | 7789-36-8   | 388.201     | col cub cry          | 200 dec       |       | 2.29                       | 98 <sup>25</sup>                    |                                             |
| 1610 | Magnesium bromide                          | MgBr <sub>2</sub>                                                                                 | 7789-48-2   | 184.113     | wh hex cry; hyg      | 711           |       | 3.72                       | 102 <sup>25</sup>                   |                                             |
| 1611 | Magnesium bromide hexahydrate              | MgBr <sub>2</sub> · 6H <sub>2</sub> O                                                             | 13446-53-2  | 292.204     | col monocl cry       | 165 dec       |       | 2.0                        | 102 <sup>25</sup>                   | s EtOH                                      |
| 1612 | Magnesium carbonate                        | MgCO <sub>3</sub>                                                                                 | 546-93-0    | 84.314      | wh hex cry           | 990           |       | 3.010                      | 0.18 <sup>20</sup>                  | i EtOH; s acid                              |
| 1613 | Magnesium carbonate dihydrate              | MgCO <sub>3</sub> · 2H <sub>2</sub> O                                                             | 5145-48-2   | 120.345     | col tricr cry        |               |       | 2.8                        |                                     | i H <sub>2</sub> O, ace, NH <sub>4</sub> OH |
| 1614 | Magnesium carbonate trihydrate             | MgCO <sub>3</sub> · 3H <sub>2</sub> O                                                             | 14457-83-1  | 138.360     | col monocl cry       | 165           |       | 1.8                        | 0.18 <sup>16</sup>                  |                                             |
| 1615 | Magnesium carbonate pentahydrate           | MgCO <sub>3</sub> · 5H <sub>2</sub> O                                                             | 61042-72-6  | 174.390     | wh monocl cry        | dec >400      |       | 3.04                       | 0.38 <sup>16</sup>                  |                                             |
| 1616 | Magnesium carbonate hydroxide tetrahydrate | 4MgCO <sub>3</sub> · Mg(OH) <sub>2</sub> · 4H <sub>2</sub> O                                      | 39409-82-0  | 467.636     | wh monocl cry        |               |       | 2.3                        |                                     |                                             |
| 1617 | Magnesium carbonate hydroxide pentahydrate | 4MgCO <sub>3</sub> · Mg(OH) <sub>2</sub> · 5H <sub>2</sub> O                                      | 56378-72-4  | 485.652     | wh pow               | dec 700       |       |                            |                                     | i H <sub>2</sub> O; s dil acid; i EtOH      |
| 1618 | Magnesium carbonate dihydroxide trihydrate | MgCO <sub>3</sub> · Mg(OH) <sub>2</sub> · 3H <sub>2</sub> O                                       | 12143-96-3  | 196.680     | wh monocl cry        | dec           |       | 2.04                       |                                     |                                             |
| 1619 | Magnesium chlorate hexahydrate             | Mg(ClO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                            | 13446-19-0  | 299.299     | wh hyg cry           | ≈35 dec       |       | 1.80                       | 142 <sup>25</sup>                   | sl EtOH                                     |
| 1620 | Magnesium chloride                         | MgCl <sub>2</sub>                                                                                 | 7786-30-3   | 95.211      | wh hex leaflets; hyg | 714           | 1412  | 2.325                      | 56.0 <sup>25</sup>                  |                                             |
| 1621 | Magnesium chloride hexahydrate             | MgCl <sub>2</sub> · 6H <sub>2</sub> O                                                             | 7791-18-6   | 203.302     | wh hyg cry           | ≈100 dec      |       | 1.56                       | 56.0 <sup>25</sup>                  | s EtOH                                      |
| 1622 | Magnesium chromate heptahydrate            | MgCrO <sub>4</sub> · 7H <sub>2</sub> O                                                            | 13423-61-5* | 266.405     | yel rhom cry         |               |       | 1.695                      | 54.8 <sup>25</sup>                  |                                             |
| 1623 | Magnesium chromite                         | MgCr <sub>2</sub> O <sub>4</sub>                                                                  | 12053-26-8  | 192.295     | deep grn cry         | 2390          |       | 4.4                        |                                     |                                             |
| 1624 | Magnesium citrate                          | Mg <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sub>2</sub>                      | 3344-18-1   | 451.114     | wh cry               |               |       |                            |                                     | sl H <sub>2</sub> O                         |
| 1625 | Magnesium citrate tetradecahydrate         | Mg <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sub>2</sub> · 14H <sub>2</sub> O | 3344-18-1*  | 703.328     | wh cry pow           |               |       |                            |                                     | sl H <sub>2</sub> O; s acid                 |
| 1626 | Magnesium fluoride                         | MgF <sub>2</sub>                                                                                  | 7783-40-6   | 62.302      | wh tetr cry          | 1263          | 2227  | 3.148                      | 0.013 <sup>25</sup>                 |                                             |
| 1627 | Magnesium formate dihydrate                | Mg(CHO <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O                                            | 6150-82-9   | 150.370     | wh cry               | dec           |       |                            |                                     | s H <sub>2</sub> O; i EtOH                  |
| 1628 | Magnesium germanate                        | Mg <sub>2</sub> GeO <sub>4</sub>                                                                  | 12025-13-7  | 185.25      | wh prec              |               |       |                            |                                     | i H <sub>2</sub> O                          |
| 1629 | Magnesium germanide                        | Mg <sub>2</sub> Ge                                                                                | 1310-52-7   | 121.25      | cub cry              | 1117          |       | 3.09                       |                                     |                                             |
| 1630 | Magnesium hydride                          | MgH <sub>2</sub>                                                                                  | 7693-27-8   | 26.321      | wh tetr cry          | 327           |       | 1.45                       |                                     | reac H <sub>2</sub> O                       |
| 1631 | Magnesium hydrogen phosphate trihydrate    | MgHPO <sub>4</sub> · 3H <sub>2</sub> O                                                            | 7757-86-0   | 174.331     | wh powder            | 550 dec       |       | 2.13                       |                                     | sl H <sub>2</sub> O; s dil acid             |
| 1632 | Magnesium hydroxide                        | Mg(OH) <sub>2</sub>                                                                               | 1309-42-8   | 58.320      | wh hex cry           | 350           |       | 2.37                       | 0.00069 <sup>20</sup>               | s dil acid                                  |
| 1633 | Magnesium iodate tetrahydrate              | Mg(IO <sub>3</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                                             | 7790-32-1*  | 446.172     | col monocl cry       | 210 dec       |       | 3.3                        | 11.1 <sup>25</sup>                  |                                             |
| 1634 | Magnesium iodide                           | MgI <sub>2</sub>                                                                                  | 10377-58-9  | 278.114     | wh hex cry; hyg      | 634           |       | 4.43                       | 146 <sup>25</sup>                   |                                             |
| 1635 | Magnesium iodide hexahydrate               | MgI <sub>2</sub> · 6H <sub>2</sub> O                                                              | 66778-21-0  | 386.205     | wh monocl cry        |               |       | 2.35                       |                                     |                                             |
| 1636 | Magnesium iodide octahydrate               | MgI <sub>2</sub> · 8H <sub>2</sub> O                                                              | 7790-31-0   | 422.236     | wh orth cry; hyg     | 41 dec        |       | 2.10                       | 146 <sup>25</sup>                   | s EtOH                                      |
| 1637 | Magnesium metaborate octahydrate           | Mg(BO <sub>2</sub> ) <sub>2</sub> · 8H <sub>2</sub> O                                             | 13703-82-7* | 254.047     | wh pow               | 988 (anh)     |       |                            |                                     | sl H <sub>2</sub> O                         |
| 1638 | Magnesium metasilicate                     | MgSiO <sub>3</sub>                                                                                | 13776-74-4  | 100.389     | wh monocl cry        | ≈1550 dec     |       | 3.19                       |                                     | i H <sub>2</sub> O; sl HF                   |
| 1639 | Magnesium metatitanate                     | MgTiO <sub>3</sub>                                                                                | 12032-30-3  | 120.170     | col hex cry          | 1565          |       | 3.85                       |                                     |                                             |
| 1640 | Magnesium molybdate                        | MgMoO <sub>4</sub>                                                                                | 12013-21-7  | 184.24      | wh pow               | ≈1060         |       | 2.2                        | 15.9 <sup>25</sup>                  | s H <sub>2</sub> O                          |
| 1641 | Magnesium nitrate                          | Mg(NO <sub>3</sub> ) <sub>2</sub>                                                                 | 10377-60-3  | 148.314     | wh cub cry           |               |       | ≈2.3                       | 71.2 <sup>25</sup>                  |                                             |
| 1642 | Magnesium nitrate dihydrate                | Mg(NO <sub>3</sub> ) <sub>2</sub> · 2H <sub>2</sub> O                                             | 15750-45-5  | 184.345     | wh cry               | ≈100 dec      |       | 1.45                       | 71.2 <sup>25</sup>                  | s EtOH                                      |
| 1643 | Magnesium nitrate hexahydrate              | Mg(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                             | 13446-18-9  | 256.406     | col monocl cry; hyg  | ≈95 dec       |       | 1.46                       | 71.2 <sup>25</sup>                  | s EtOH                                      |
| 1644 | Magnesium nitride                          | Mg <sub>3</sub> N <sub>2</sub>                                                                    | 12057-71-5  | 100.928     | yel cub cry          | ≈1500 dec     |       | 2.71                       |                                     |                                             |
| 1645 | Magnesium nitrite trihydrate               | Mg(NO <sub>2</sub> ) <sub>2</sub> · 3H <sub>2</sub> O                                             | 15070-34-5  | 170.362     | wh hyg prisms        | 100 dec       |       |                            | 129.9 <sup>25</sup>                 | s EtOH                                      |



| No.  | Name                                         | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form       | mp/°C    | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility           |
|------|----------------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|---------------------|----------|-------|----------------------------|-------------------------------------|----------------------------------|
| 1646 | Magnesium orthosilicate                      | Mg <sub>2</sub> SiO <sub>4</sub>                                                   | 26686-77-1  | 140.694     | wh orth cry         | 1897     |       | 3.21                       |                                     | i H <sub>2</sub> O               |
| 1647 | Magnesium orthotitanate                      | Mg <sub>2</sub> TiO <sub>4</sub>                                                   | 12032-52-9  | 160.475     | wh cub cry          | 1840     |       | 3.53                       |                                     |                                  |
| 1648 | Magnesium oxalate                            | MgC <sub>2</sub> O <sub>4</sub>                                                    | 547-66-0    | 112.324     | wh powder           |          |       |                            | 0.038 <sup>25</sup>                 |                                  |
| 1649 | Magnesium oxalate dihydrate                  | MgC <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O                                | 6150-88-5   | 148.354     | wh powder           |          |       |                            | 0.038 <sup>25</sup>                 | i EtOH; s dil acid               |
| 1650 | Magnesium oxide                              | MgO                                                                                | 1309-48-4   | 40.304      | wh cub cry          | 2825     | 3600  | 3.6                        |                                     | sl H <sub>2</sub> O; i EtOH      |
| 1651 | Magnesium perborate heptahydrate             | Mg(BO <sub>3</sub> ) <sub>2</sub> · 7H <sub>2</sub> O                              | 14635-87-1  | 268.030     | wh pow              |          |       |                            |                                     | sl H <sub>2</sub> O              |
| 1652 | Magnesium perchlorate                        | Mg(ClO <sub>4</sub> ) <sub>2</sub>                                                 | 10034-81-8  | 223.206     | wh hyg powder       | 250 dec  |       | 2.2                        | 100 <sup>25</sup>                   |                                  |
| 1653 | Magnesium perchlorate hexahydrate            | Mg(ClO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                             | 13446-19-0  | 331.298     | wh hyg cry          | 190 dec  |       | 1.98                       | 100 <sup>25</sup>                   | s EtOH                           |
| 1654 | Magnesium permanganate hexahydrate           | Mg(MnO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                             | 10377-62-5  | 370.268     | blue-blk cry        | dec      |       | 2.18                       |                                     | s H <sub>2</sub> O               |
| 1655 | Magnesium peroxide                           | MgO <sub>2</sub>                                                                   | 1335-26-8   | 56.304      | wh cub cry          | 100 dec  |       | ≈3.0                       |                                     | i H <sub>2</sub> O; s dil acid   |
| 1656 | Magnesium phosphate pentahydrate             | Mg <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> · 5H <sub>2</sub> O                | 7757-87-1*  | 352.934     | wh cry              | 400 dec  |       |                            | 0.00009 <sup>20</sup>               | s dil acid                       |
| 1657 | Magnesium phosphate octahydrate              | Mg <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> · 8H <sub>2</sub> O                | 13446-23-6  | 406.980     | wh monocl cry       |          |       | 2.17                       | 0.00009 <sup>20</sup>               | s acid                           |
| 1658 | Magnesium pyrophosphate                      | Mg <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                                      | 13446-24-7  | 222.553     | col monocl plates   | 1395     |       | 2.56                       |                                     |                                  |
| 1659 | Magnesium pyrophosphate trihydrate           | Mg <sub>2</sub> P <sub>2</sub> O <sub>7</sub> · 3H <sub>2</sub> O                  | 10102-34-8  | 276.600     | wh powder           | 100 dec  |       | 2.56                       |                                     | i H <sub>2</sub> O; s acid       |
| 1660 | Magnesium phosphide                          | Mg <sub>3</sub> P <sub>2</sub>                                                     | 12057-74-8  | 134.863     | yel cub cry         |          |       | 2.06                       |                                     | reac H <sub>2</sub> O            |
| 1661 | Magnesium selenate hexahydrate               | MgSeO <sub>4</sub> · 6H <sub>2</sub> O                                             | 13446-28-1  | 275.35      | wh monocl cry       |          |       | 1.928                      | 55.5 <sup>25</sup>                  |                                  |
| 1662 | Magnesium selenide                           | MgSe                                                                               | 1313-04-8   | 103.27      | brn cub cry         |          |       | 4.2                        |                                     | reac H <sub>2</sub> O            |
| 1663 | Magnesium selenite hexahydrate               | MgSeO <sub>3</sub> · 6H <sub>2</sub> O                                             | 15593-61-0  | 259.36      | col hex cry         |          |       | 2.09                       |                                     | i H <sub>2</sub> O; s dil acid   |
| 1664 | Magnesium hexafluorosilicate hexahydrate     | MgSiF <sub>6</sub> · 6H <sub>2</sub> O                                             | 60950-56-3  | 274.472     | wh cry              | 120 dec  |       | 1.79                       | 39.3 <sup>18</sup>                  | i EtOH                           |
| 1665 | Magnesium silicide                           | Mg <sub>2</sub> Si                                                                 | 22831-39-6  | 76.696      | gray cub cry        | 1102     |       | 1.99                       |                                     | reac H <sub>2</sub> O            |
| 1666 | Magnesium stannide                           | Mg <sub>2</sub> Sn                                                                 | 1313-08-2   | 167.320     | blue cub cry        | 771      |       | 3.60                       |                                     | s H <sub>2</sub> O, dil HCl      |
| 1667 | Magnesium sulfate                            | MgSO <sub>4</sub>                                                                  | 7487-88-9   | 120.368     | col orth cry        | 1137     |       | 2.66                       | 35.7 <sup>25</sup>                  |                                  |
| 1668 | Magnesium sulfate monohydrate                | MgSO <sub>4</sub> · H <sub>2</sub> O                                               | 14168-73-1  | 138.383     | col monocl cry      | 150 dec  |       | 2.57                       | 35.7 <sup>25</sup>                  |                                  |
| 1669 | Magnesium sulfate heptahydrate               | MgSO <sub>4</sub> · 7H <sub>2</sub> O                                              | 10034-99-8  | 246.474     | col orth cry        | 150 dec  |       | 1.67                       | 35.7 <sup>25</sup>                  | sl EtOH                          |
| 1670 | Magnesium sulfide                            | MgS                                                                                | 12032-36-9  | 56.370      | red-brn cub cry     | 2226     |       | 2.68                       |                                     | reac H <sub>2</sub> O            |
| 1671 | Magnesium sulfite trihydrate                 | MgSO <sub>3</sub> · 3H <sub>2</sub> O                                              | 19086-20-5  | 158.414     | col orth cry        |          |       | 2.12                       | 0.79 <sup>25</sup>                  |                                  |
| 1672 | Magnesium sulfite hexahydrate                | MgSO <sub>3</sub> · 6H <sub>2</sub> O                                              | 13446-29-2  | 212.460     | wh hex cry          | 200 dec  |       | 1.72                       | 0.79 <sup>25</sup>                  | i EtOH                           |
| 1673 | Magnesium tetrahydrogen phosphate dihydrate  | Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> · 2H <sub>2</sub> O               | 15609-80-0  | 254.311     | wh hyg cry          | dec 90   |       |                            |                                     | s H <sub>2</sub> O; i EtOH       |
| 1674 | Magnesium thiocyanate tetrahydrate           | Mg(SCN) <sub>2</sub> · 4H <sub>2</sub> O                                           | 306-61-6    | 212.531     | wh hyg cry          |          |       |                            |                                     | vs H <sub>2</sub> O, EtOH        |
| 1675 | Magnesium thiosulfate hexahydrate            | MgS <sub>2</sub> O <sub>3</sub> · 6H <sub>2</sub> O                                | 13446-30-5  | 244.525     | col cry             | 170 dec  |       | 1.82                       | 93 <sup>25</sup>                    | i EtOH                           |
| 1676 | Magnesium trisilicate                        | Mg <sub>2</sub> Si <sub>3</sub> O <sub>8</sub>                                     | 14987-04-3  | 260.862     | wh powder           |          |       |                            |                                     | i H <sub>2</sub> O, EtOH         |
| 1677 | Magnesium tungstate                          | MgWO <sub>4</sub>                                                                  | 13573-11-0  | 272.14      | wh monocl cry       |          |       | 6.89                       | 0.016 <sup>20</sup>                 | i EtOH                           |
| 1678 | Magnesium vanadate                           | Mg <sub>2</sub> V <sub>2</sub> O <sub>7</sub>                                      | 13568-63-3  | 262.489     | tricl cry           |          |       | 3.1                        |                                     |                                  |
| 1679 | Magnesium zirconate                          | MgZrO <sub>3</sub>                                                                 | 12032-31-4  | 163.527     | col cry             | 2060     |       | 4.23                       |                                     |                                  |
| 1680 | Magnesium zirconium silicate                 | MgO · ZrO <sub>2</sub> · SiO <sub>2</sub>                                          | 52110-05-1  | 223.612     | wh solid            |          |       |                            |                                     | i H <sub>2</sub> O, alk; sl acid |
| 1681 | Manganese                                    | Mn                                                                                 | 7439-96-5   | 54.938      | hard gray metal     | 1246     | 2061  | 7.3                        |                                     | s dil acids                      |
| 1682 | Manganocene                                  | Mn(C <sub>2</sub> H <sub>2</sub> ) <sub>2</sub>                                    | 1271-27-8   | 185.124     | yel-brn cry         | 173      |       |                            |                                     | s py, thf; sl bz                 |
| 1683 | Manganese antimonide (MnSb)                  | MnSb                                                                               | 12032-82-5  | 176.698     | hex cry             | 840      |       | 6.9                        |                                     |                                  |
| 1684 | Manganese antimonide (Mn <sub>2</sub> Sb)    | Mn <sub>2</sub> Sb                                                                 | 12032-97-2  | 231.636     | tetr cry            | 948      |       | 7.0                        |                                     |                                  |
| 1685 | Manganese boride (MnB)                       | MnB                                                                                | 12045-15-7  | 65.749      | orth cry            | 1890     |       | 6.45                       |                                     |                                  |
| 1686 | Manganese boride (MnB <sub>2</sub> )         | MnB <sub>2</sub>                                                                   | 12228-50-1  | 76.560      | hex cry             | 1827     |       | 5.3                        |                                     |                                  |
| 1687 | Manganese boride (Mn <sub>2</sub> B)         | Mn <sub>2</sub> B                                                                  | 12045-16-8  | 120.687     | red-brn tetr cry    | 1580     |       | 7.20                       |                                     |                                  |
| 1688 | Manganese carbide                            | Mn <sub>3</sub> C                                                                  | 12266-65-8  | 176.825     | refrac solid        | 1520     |       | 6.89                       |                                     |                                  |
| 1689 | Manganese carbonyl                           | Mn <sub>5</sub> (CO) <sub>10</sub>                                                 | 10170-69-1  | 389.977     | yel monocl cry      | 154      |       | 1.75                       |                                     | i H <sub>2</sub> O; s os         |
| 1690 | Manganese pentacarbonyl bromide              | Mn(CO) <sub>5</sub> Br                                                             | 14516-54-2  | 274.893     | oran-yel cry        |          |       |                            |                                     | s os                             |
| 1691 | Manganese phosphide (MnP)                    | MnP                                                                                | 12032-78-9  | 85.912      | orth cry            | 1147     |       | 5.49                       |                                     |                                  |
| 1692 | Manganese phosphide (Mn <sub>2</sub> P)      | Mn <sub>2</sub> P                                                                  | 12333-54-9  | 140.850     | hex cry             | 1327     |       | 6.0                        |                                     |                                  |
| 1693 | Manganese silicide                           | MnSi <sub>2</sub>                                                                  | 12032-86-9  | 111.109     | gray solid          | 1152 dec |       |                            |                                     |                                  |
| 1694 | Manganese(II) acetate tetrahydrate           | Mn(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 4H <sub>2</sub> O | 6156-78-1   | 245.087     | red monocl cry      | 80       |       | 1.59                       |                                     | s H <sub>2</sub> O, EtOH         |
| 1695 | Manganese(II) bromide                        | MnBr <sub>2</sub>                                                                  | 13446-03-2  | 214.746     | pink hex cry        | 698      |       | 4.385                      | 151 <sup>25</sup>                   |                                  |
| 1696 | Manganese(II) bromide tetrahydrate           | MnBr <sub>2</sub> · 4H <sub>2</sub> O                                              | 10031-20-6  | 286.808     | red hyg cry         | 64 dec   |       |                            | 151 <sup>25</sup>                   |                                  |
| 1697 | Manganese(II) carbonate                      | MnCO <sub>3</sub>                                                                  | 598-62-9    | 114.947     | pink hex cry        | >200 dec |       | 3.70                       | 0.00008 <sup>20</sup>               | s dil acid                       |
| 1698 | Manganese(II) chloride                       | MnCl <sub>2</sub>                                                                  | 7773-01-5   | 125.844     | pink trig cry; hyg  | 650      | 1190  | 2.977                      | 77.3 <sup>25</sup>                  | s py, EtOH; i eth                |
| 1699 | Manganese(II) chloride tetrahydrate          | MnCl <sub>2</sub> · 4H <sub>2</sub> O                                              | 13446-34-9  | 197.906     | red monocl cry; hyg | 87.5     |       | 1.913                      | 77.3 <sup>25</sup>                  | s EtOH; i eth                    |
| 1700 | Manganese(II) dihydrogen phosphate dihydrate | Mn(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> · 2H <sub>2</sub> O               | 18718-07-5  | 284.944     | col hyg cry         |          |       |                            |                                     | s H <sub>2</sub> O; i EtOH       |
| 1701 | Manganese(II) fluoride                       | MnF <sub>2</sub>                                                                   | 7782-64-1   | 92.935      | red tetr cry        | 900      |       | 3.98                       | 1.02 <sup>25</sup>                  | i EtOH                           |
| 1702 | Manganese(II) hydroxide                      | Mn(OH) <sub>2</sub>                                                                | 18933-05-6  | 88.953      | pink hex cry        | dec      |       | 3.26                       | 0.00034 <sup>20</sup>               |                                  |
| 1703 | Manganese(II) hypophosphite monohydrate      | Mn(H <sub>2</sub> PO <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O                | 10043-84-2  | 202.931     | pink cry            | >250     |       |                            | 15 <sup>20</sup>                    | s H <sub>2</sub> O               |

| No.  | Name                                  | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form          | mp/°C    | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                           |
|------|---------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|------------------------|----------|---------|----------------------------|-------------------------------------|--------------------------------------------------|
| 1704 | Manganese(II) iodide                  | MnI <sub>2</sub>                                                                   | 7790-33-2   | 308.747     | wh hex cry; hyg        | 638      |         | 5.04                       |                                     | s H <sub>2</sub> O, EtOH                         |
| 1705 | Manganese(II) iodide tetrahydrate     | MnI <sub>2</sub> · 4H <sub>2</sub> O                                               | 7790-33-2*  | 380.809     | red cry                |          |         |                            |                                     | vs H <sub>2</sub> O; s EtOH                      |
| 1706 | Manganese(II) metasilicate            | MnSiO <sub>3</sub>                                                                 | 7759-00-4   | 131.022     | red orth cry           | 1291     |         | 3.48                       |                                     | i H <sub>2</sub> O                               |
| 1707 | Manganese(II) molybdate               | MnMoO <sub>4</sub>                                                                 | 14013-15-1  | 214.88      | yel monoc cry          |          |         | 4.05                       |                                     |                                                  |
| 1708 | Manganese(II) nitrate                 | Mn(NO <sub>3</sub> ) <sub>2</sub>                                                  | 10377-93-2  | 178.947     | col orth cry; hyg      |          |         | 2.2                        | 161 <sup>25</sup>                   | s diox, thf                                      |
| 1709 | Manganese(II) nitrate tetrahydrate    | Mn(NO <sub>3</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                              | 20694-39-7  | 251.009     | pink hyg cry           | 37.1 dec |         | 2.13                       | 161 <sup>25</sup>                   | s EtOH                                           |
| 1710 | Manganese(II) nitrate hexahydrate     | Mn(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                              | 10377-66-9  | 287.039     | rose monoc cry         | 28 dec   |         | 1.8                        | 161 <sup>25</sup>                   | vs EtOH                                          |
| 1711 | Manganese(II) orthosilicate           | Mn <sub>2</sub> SiO <sub>4</sub>                                                   | 13568-32-6  | 201.960     | orth cry               |          |         | 4.11                       |                                     | i H <sub>2</sub> O                               |
| 1712 | Manganese(II) oxalate dihydrate       | MnC <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O                                | 6556-16-7   | 178.987     | wh cry powder          | 150 dec  |         | 2.45                       | 0.032 <sup>20</sup>                 | s acid                                           |
| 1713 | Manganese(II) oxide                   | MnO                                                                                | 1344-43-0   | 70.937      | grn cub cry or powder  | 1842     |         | 5.37                       |                                     | i H <sub>2</sub> O; s acid                       |
| 1714 | Manganese(II) perchlorate hexahydrate | Mn(ClO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                             | 15364-94-0  | 361.931     | pink hex cry           |          |         | 2.10                       |                                     |                                                  |
| 1715 | Manganese(II) pyrophosphate           | Mn <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                                      | 53731-35-4  | 283.819     | wh monoc cry           | 1196     |         | 3.71                       |                                     | i H <sub>2</sub> O                               |
| 1716 | Manganese(II) selenide                | MnSe                                                                               | 1313-22-0   | 133.90      | gray cub cry           | 1460     |         | 5.45                       |                                     | i H <sub>2</sub> O                               |
| 1717 | Manganese(II) sulfate                 | MnSO <sub>4</sub>                                                                  | 7785-87-7   | 151.001     | wh orth cry            | 700      | 850 dec | 3.25                       | 63.7 <sup>25</sup>                  |                                                  |
| 1718 | Manganese(II) sulfate monohydrate     | MnSO <sub>4</sub> · H <sub>2</sub> O                                               | 10034-96-5  | 169.016     | red monoc cry          |          |         | 2.95                       | 63.7 <sup>25</sup>                  | i EtOH                                           |
| 1719 | Manganese(II) sulfate tetrahydrate    | MnSO <sub>4</sub> · 4H <sub>2</sub> O                                              | 10101-68-5  | 223.062     | red monoc cry          | 38 dec   |         | 2.26                       | 63.7 <sup>25</sup>                  | i EtOH                                           |
| 1720 | Manganese(II) sulfide (α form)        | MnS                                                                                | 18820-29-6  | 87.003      | grn cub cry            | 1610     |         | 4.0                        |                                     | i H <sub>2</sub> O; s dil acid                   |
| 1721 | Manganese(II) sulfide (β form)        | MnS                                                                                | 18820-29-6  | 87.003      | red cub cry            |          |         | 3.3                        |                                     | i H <sub>2</sub> O; s dil acid                   |
| 1722 | Manganese(II) sulfide (γ form)        | MnS                                                                                | 18820-29-6  | 87.003      | red hex cry            |          |         | ≈3.3                       |                                     | i H <sub>2</sub> O; s dil acid                   |
| 1723 | Manganese(II) telluride               | MnTe                                                                               | 12032-88-1  | 182.54      | hex cry                | ≈1150    |         | 6.0                        |                                     |                                                  |
| 1724 | Manganese(II) tetraborate octahydrate | MnB <sub>4</sub> O <sub>7</sub> · 8H <sub>2</sub> O                                | 12228-91-0  | 354.300     | red solid              |          |         |                            |                                     | i H <sub>2</sub> O, EtOH; s dil acid             |
| 1725 | Manganese(II) titanate                | MnTiO <sub>3</sub>                                                                 | 12032-74-5  | 150.803     | red hex cry            | 1360     |         | 4.55                       |                                     |                                                  |
| 1726 | Manganese(II) tungstate               | MnWO <sub>4</sub>                                                                  | 13918-22-4  | 302.78      | wh monoc cry           |          |         | 7.2                        | 0.0054 <sup>20</sup>                |                                                  |
| 1727 | Manganese(II,III) oxide               | Mn <sub>3</sub> O <sub>4</sub>                                                     | 1317-35-7   | 228.812     | brn tetr cry           | 1567     |         | 4.84                       |                                     | i H <sub>2</sub> O; s HCl                        |
| 1728 | Manganese(III) acetate dihydrate      | Mn(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · 2H <sub>2</sub> O | 19513-05-4  | 268.100     | brn cry                |          |         |                            |                                     | s eth, HOAc                                      |
| 1729 | Manganese(III) fluoride               | MnF <sub>3</sub>                                                                   | 7783-53-1   | 111.933     | red monoc cry; hyg     | >600 dec |         | 3.54                       |                                     | reac H <sub>2</sub> O                            |
| 1730 | Manganese(III) hydroxide              | MnO(OH)                                                                            | 1332-63-4   | 87.945      | blk monoc cry          | 250 dec  |         | ≈4.3                       |                                     | i H <sub>2</sub> O                               |
| 1731 | Manganese(III) oxide                  | Mn <sub>2</sub> O <sub>3</sub>                                                     | 1317-34-6   | 157.874     | blk cub cry            | 1080 dec |         | ≈5.0                       |                                     | i H <sub>2</sub> O                               |
| 1732 | Manganese(IV) oxide                   | MnO <sub>2</sub>                                                                   | 1313-13-9   | 86.937      | blk tetr cry           | 535 dec  |         | 5.08                       |                                     | i H <sub>2</sub> O, HNO <sub>3</sub>             |
| 1733 | Manganese(VII) oxide                  | Mn <sub>2</sub> O <sub>7</sub>                                                     | 12057-92-0  | 221.872     | grn oil; exp           | 5.9      | 95 exp  | 2.40                       |                                     | vs H <sub>2</sub> O                              |
| 1734 | Mendelevium                           | Md                                                                                 | 7440-11-1   | 258         | metal                  | 827      |         |                            |                                     |                                                  |
| 1735 | Mercury                               | Hg                                                                                 | 7439-97-6   | 200.59      | heavy silv liq         | -38.8290 | 356.62  | 13.5336                    |                                     | i H <sub>2</sub> O                               |
| 1736 | Dimethyl mercury                      | Hg(CH <sub>3</sub> ) <sub>2</sub>                                                  | 593-74-8    | 230.66      | liq                    |          | 93      | 3.17                       |                                     | i H <sub>2</sub> O; vs EtOH, eth                 |
| 1737 | Mercury(I) acetate                    | Hg <sub>2</sub> (C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>       | 631-60-7    | 519.27      | col scales             | dec      |         |                            |                                     | sl H <sub>2</sub> O; i EtOH, eth                 |
| 1738 | Mercury(I) bromate                    | Hg <sub>2</sub> (BrO <sub>3</sub> ) <sub>2</sub>                                   | 13465-33-3  | 656.98      | col cry                | dec      |         |                            |                                     | i H <sub>2</sub> O; sl acid                      |
| 1739 | Mercury(I) bromide                    | Hg <sub>2</sub> Br <sub>2</sub>                                                    | 15385-58-7  | 560.99      | wh tetr cry or powder  | 345 dec  |         | 7.307                      |                                     | i H <sub>2</sub> O, EtOH, eth                    |
| 1740 | Mercury(I) carbonate                  | Hg <sub>2</sub> CO <sub>3</sub>                                                    | 6824-78-8   | 461.19      | yel-brn cry            | 130 dec  |         |                            | 0.0000045                           | i EtOH                                           |
| 1741 | Mercury(I) chlorate                   | Hg <sub>2</sub> (ClO <sub>3</sub> ) <sub>2</sub>                                   | 10294-44-7  | 568.08      | wh rhom cry            | ≈250 dec |         | 6.409                      |                                     | sl H <sub>2</sub> O; s EtOH                      |
| 1742 | Mercury(I) chloride                   | Hg <sub>2</sub> Cl <sub>2</sub>                                                    | 10112-91-1  | 472.09      | wh tetr cry            | 525 tp   | 383 sp  | 7.16                       | 0.0004 <sup>25</sup>                | i EtOH, eth                                      |
| 1743 | Mercury(I) chromate                   | Hg <sub>2</sub> CrO <sub>4</sub>                                                   | 13465-34-4  | 517.17      | brn-red solid          |          |         |                            |                                     | i H <sub>2</sub> O EtOH; s conc HNO <sub>3</sub> |
| 1744 | Mercury(I) fluoride                   | Hg <sub>2</sub> F <sub>2</sub>                                                     | 13967-25-4  | 439.18      | yel cub cry            | 570 dec  | subl    | 8.73                       |                                     | reac H <sub>2</sub> O                            |
| 1745 | Mercury(I) iodate                     | Hg <sub>2</sub> (IO <sub>3</sub> ) <sub>2</sub>                                    | 13465-35-5  | 750.99      | yel-wh pow             | dec 175  |         |                            | 0.0032 <sup>20</sup>                |                                                  |
| 1746 | Mercury(I) iodide                     | Hg <sub>2</sub> I <sub>2</sub>                                                     | 15385-57-6  | 654.99      | yel amorp powder       | 290      |         | 7.70                       |                                     | i H <sub>2</sub> O, EtOH, eth                    |
| 1747 | Mercury(I) nitrate                    | Hg <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>                                    | 10415-75-5  | 525.19      | cry                    |          |         |                            |                                     | sl H <sub>2</sub> O                              |
| 1748 | Mercury(I) nitrate dihydrate          | Hg <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> · 2H <sub>2</sub> O                | 14836-60-3  | 561.22      | col cry                | 70 dec   |         | 4.8                        |                                     | sl H <sub>2</sub> O                              |
| 1749 | Mercury(I) nitrite                    | Hg <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub>                                    | 13492-25-6  | 493.19      | yel cry                | 100 dec  |         | 7.3                        |                                     | reac H <sub>2</sub> O                            |
| 1750 | Mercury(I) oxalate                    | Hg <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                                      | 2949-11-3   | 489.20      | cry                    |          |         |                            |                                     | i H <sub>2</sub> O; sl HNO <sub>3</sub>          |
| 1751 | Mercury(I) oxide                      | Hg <sub>2</sub> O                                                                  | 15829-53-5  | 417.18      | prob mixture of HgO+Hg | 100 dec  |         | 9.8                        |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>           |
| 1752 | Mercury(I) perchlorate tetrahydrate   | Hg <sub>2</sub> (ClO <sub>4</sub> ) <sub>2</sub> · 4H <sub>2</sub> O               | 65202-12-2  | 672.14      | cry                    | 64       |         |                            | 442 <sup>25</sup>                   |                                                  |
| 1753 | Mercury(I) sulfate                    | Hg <sub>2</sub> SO <sub>4</sub>                                                    | 7783-36-0   | 497.24      | wh-yel cry powder      |          |         | 7.56                       | 0.051 <sup>25</sup>                 | s dil HNO <sub>3</sub>                           |
| 1754 | Mercury(I) sulfide                    | Hg <sub>2</sub> S                                                                  | 51595-71-2  | 433.25      | unstab blk pow         | dec      |         |                            |                                     | i H <sub>2</sub> O                               |
| 1755 | Mercury(I) thiocyanate                | Hg <sub>2</sub> (SCN) <sub>2</sub>                                                 | 13465-37-7  | 517.34      | col powder             | dec      |         |                            | 0.03 <sup>25</sup>                  | s HCl, KCNS                                      |
| 1756 | Mercury(I) tungstate                  | Hg <sub>2</sub> WO <sub>4</sub>                                                    | 38705-19-0  | 649.02      | yel amorp solid        | dec      |         |                            |                                     | i H <sub>2</sub> O, EtOH                         |
| 1757 | Mercury(II) acetate                   | Hg(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                     | 1600-27-7   | 318.68      | wh-yel cry or powder   | 179 dec  |         | 3.28                       | 25 <sup>10</sup>                    | s EtOH                                           |
| 1758 | Mercury(II) amide chloride            | Hg(NH <sub>2</sub> )Cl                                                             | 10124-48-8  | 252.07      | wh solid               |          | subl    | 5.38                       |                                     | i H <sub>2</sub> O, EtOH; s warm acid            |
| 1759 | Mercury(II) benzoate monohydrate      | Hg(C <sub>6</sub> H <sub>5</sub> O <sub>2</sub> ) <sub>2</sub> · H <sub>2</sub> O  | 32839-04-6  | 460.83      | wh cry                 | 165      |         |                            | 1.2 <sup>15</sup>                   | sl EtOH                                          |
| 1760 | Mercury(II) bromate                   | Hg(BrO <sub>3</sub> ) <sub>2</sub>                                                 | 26522-91-8  | 456.39      | cry                    | 130 dec  |         |                            | 0.15                                | s acid                                           |
| 1761 | Mercury(II) bromide                   | HgBr <sub>2</sub>                                                                  | 7789-47-1   | 360.40      | wh rhomb cry or powder | 241      | 318     | 6.05                       | 0.61 <sup>25</sup>                  | sl chl; s EtOH, MeOH                             |
| 1762 | Mercury(II) chlorate                  | Hg(ClO <sub>3</sub> ) <sub>2</sub>                                                 | 13465-30-0  | 367.49      | wh needles             | dec      |         | 4.998                      | 25                                  |                                                  |



| No.  | Name                                                | Formula                                                         | CAS Reg No. | Mol. weight | Physical form           | mp/°C                | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                          |
|------|-----------------------------------------------------|-----------------------------------------------------------------|-------------|-------------|-------------------------|----------------------|---------|----------------------------|-------------------------------------|-------------------------------------------------|
| 1763 | Mercury(II) chloride                                | HgCl <sub>2</sub>                                               | 7487-94-7   | 271.50      | wh orth cry             | 277                  | 304     | 5.6                        | 7.31 <sup>25</sup>                  | sl bz; s EtOH, MeOH, ace, eth                   |
| 1764 | Mercury(II) chromate                                | HgCrO <sub>4</sub>                                              | 13444-75-2  | 316.58      | red monocl cry          |                      |         | 6.06                       |                                     | sl H <sub>2</sub> O                             |
| 1765 | Mercury(II) cyanide                                 | Hg(CN) <sub>2</sub>                                             | 592-04-1    | 252.62      | col tetr cry            | 320 dec              |         | 4.00                       | 11.4 <sup>25</sup>                  | s EtOH; sl eth                                  |
| 1766 | Mercury(II) dichromate                              | HgCr <sub>2</sub> O <sub>7</sub>                                | 7789-10-8   | 416.58      | red cry powder          |                      |         |                            |                                     | i H <sub>2</sub> O; s acid                      |
| 1767 | Mercury(II) fluoride                                | HgF <sub>2</sub>                                                | 7783-39-3   | 238.59      | wh cub cry; hyg         | 645 dec              |         | 8.95                       |                                     | reac H <sub>2</sub> O                           |
| 1768 | Mercury(II) fulminate                               | Hg(CNO) <sub>2</sub>                                            | 628-86-4    | 284.62      | gray cry                | exp                  |         | 4.42                       |                                     | sl H <sub>2</sub> O; s EtOH, NH <sub>4</sub> OH |
| 1769 | Mercury(II) hydrogen arsenate                       | HgHAsO <sub>4</sub>                                             | 7784-37-4   | 340.52      | yel powder              |                      |         |                            |                                     | i H <sub>2</sub> O; s acid                      |
| 1770 | Mercury(II) iodate                                  | Hg(IO <sub>3</sub> ) <sub>2</sub>                               | 7783-32-6   | 550.40      | wh powder               | 175 dec              |         |                            |                                     | i H <sub>2</sub> O                              |
| 1771 | Mercury(II) iodide (yellow)                         | HgI <sub>2</sub>                                                | 7774-29-0   | 454.40      | yel tetr cry or powder  | 256                  | 351     | 6.28                       | 0.0055 <sup>25</sup>                | sl EtOH, ace, eth                               |
| 1772 | Mercury(II) iodide (red)                            | HgI <sub>2</sub>                                                | 7774-29-0   | 454.40      | red pow                 | trans to yel 127     |         |                            | 0.006 <sup>25</sup>                 | sl EtOH, ace, eth, chl                          |
| 1773 | Mercury(II) nitrate                                 | Hg(NO <sub>3</sub> ) <sub>2</sub>                               | 10045-94-0  | 324.60      | col hyg cry             | 79                   |         | 4.3                        |                                     | s H <sub>2</sub> O; i EtOH                      |
| 1774 | Mercury(II) nitrate monohydrate                     | Hg(NO <sub>3</sub> ) <sub>2</sub> · H <sub>2</sub> O            | 7783-34-8   | 342.62      | wh-yel hyg cry          |                      |         | 4.3                        |                                     | s H <sub>2</sub> O, dil acid                    |
| 1775 | Mercury(II) nitrate dihydrate                       | Hg(NO <sub>3</sub> ) <sub>2</sub> · 2H <sub>2</sub> O           | 22852-67-1  | 360.63      | monocl cry              |                      |         | 4.78                       |                                     | s H <sub>2</sub> O                              |
| 1776 | Mercury(II) oxalate                                 | HgC <sub>2</sub> O <sub>4</sub>                                 | 3444-13-1   | 288.61      | powder                  | 165 dec              |         |                            |                                     | i H <sub>2</sub> O                              |
| 1777 | Mercury(II) oxide                                   | HgO                                                             | 21908-53-2  | 216.59      | red or yel orth cry     | 500 dec              |         | 11.14                      |                                     | i H <sub>2</sub> O, EtOH; s dil acid            |
| 1778 | Mercury(II) oxide sulfate                           | (Hg <sub>2</sub> O <sub>2</sub> )SO <sub>4</sub>                | 1312-03-4   | 729.83      | yel powder              |                      |         |                            |                                     | i H <sub>2</sub> O; s acid                      |
| 1779 | Mercury(II) oxycyanide                              | Hg(CN) <sub>2</sub> · HgO                                       | 1335-31-5   | 469.21      | wh orth cry             | exp                  |         | 4.44                       | 11.4 <sup>25</sup>                  |                                                 |
| 1780 | Mercury(II) perchlorate trihydrate                  | Hg(ClO <sub>4</sub> ) <sub>2</sub> · 3H <sub>2</sub> O          | 7616-83-3   | 453.54      | cry                     |                      |         |                            |                                     |                                                 |
| 1781 | Mercury(II) phosphate                               | Hg <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>                 | 7782-66-3   | 791.71      | wh-yel powder           |                      |         |                            |                                     | i H <sub>2</sub> O, EtOH; s acid                |
| 1782 | Mercury(II) selenide                                | HgSe                                                            | 20601-83-6  | 279.55      | gray cub cry            |                      | subl    | 8.21                       |                                     | i H <sub>2</sub> O                              |
| 1783 | Mercury(II) sulfate                                 | HgSO <sub>4</sub>                                               | 7783-35-9   | 296.65      | wh monocl cry           |                      |         | 6.47                       |                                     | reac H <sub>2</sub> O                           |
| 1784 | Mercury(II) sulfide (black)                         | HgS                                                             | 1344-48-5   | 232.66      | blk cub cry or powder   | 850                  |         | 7.70                       |                                     | i H <sub>2</sub> O; s acid, EtOH                |
| 1785 | Mercury(II) sulfide (red)                           | HgS                                                             | 1344-48-5   | 232.66      | red hex cry             | trans to blk HgS 344 |         | 8.17                       |                                     | i H <sub>2</sub> O, acid; s aqua regia          |
| 1786 | Mercury(II) telluride                               | HgTe                                                            | 12068-90-5  | 328.19      | gray cub cry            | 673                  |         | 8.63                       |                                     |                                                 |
| 1787 | Mercury(II) thiocyanate                             | Hg(SCN) <sub>2</sub>                                            | 592-85-8    | 316.75      | monocl cry              | ~165 dec             |         | 3.71                       | 0.070 <sup>25</sup>                 | s dil HCl                                       |
| 1788 | Mercury(II) tungstate                               | HgWO <sub>4</sub>                                               | 37913-38-5  | 448.43      | yel cry                 | dec                  |         |                            |                                     | i H <sub>2</sub> O, EtOH                        |
| 1789 | Molybdenum                                          | Mo                                                              | 7439-98-7   | 95.94       | gray-blk metal; cub     | 2623                 | 4639    | 10.2                       |                                     | i H <sub>2</sub> O, dil acid, alk               |
| 1790 | Molybdophosphoric acid                              | H <sub>3</sub> P(Mo <sub>3</sub> O <sub>10</sub> ) <sub>4</sub> | 51429-74-4  | 1825.25     | bright yel cry          |                      |         |                            |                                     |                                                 |
| 1791 | Molybdenum boride (Mo <sub>2</sub> B)               | Mo <sub>2</sub> B                                               | 12006-99-4  | 202.69      | refrac tetr cry         | 2000                 |         | 9.2                        |                                     |                                                 |
| 1792 | Molybdenum boride (Mo <sub>2</sub> B <sub>3</sub> ) | Mo <sub>2</sub> B <sub>3</sub>                                  | 12007-97-5  | 245.94      | refrac hex cry          | 1600                 |         | ~7.2                       |                                     |                                                 |
| 1793 | Molybdenum carbide (MoC)                            | MoC                                                             | 12011-97-1  | 107.95      | refrac solid; cub       | 2577                 |         |                            |                                     |                                                 |
| 1794 | Molybdenum carbide (Mo <sub>2</sub> C)              | Mo <sub>2</sub> C                                               | 12069-89-5  | 203.89      | gray orth cry           | 2687                 |         | 9.18                       |                                     |                                                 |
| 1795 | Molybdenum carbonyl                                 | Mo(CO) <sub>6</sub>                                             | 13939-06-5  | 264.00      | wh orth cry             | 148                  | 155 dec | 1.96                       |                                     | i H <sub>2</sub> O; s bz; sl eth                |
| 1796 | Molybdenum nitride (MoN)                            | MoN                                                             | 12033-19-1  | 109.95      | hex cry                 | 1750                 |         | 9.20                       |                                     |                                                 |
| 1797 | Molybdenum nitride (Mo <sub>2</sub> N)              | Mo <sub>2</sub> N                                               | 12033-31-7  | 205.89      | gray cub cry            | 790 dec              |         | 9.46                       |                                     |                                                 |
| 1798 | Molybdenum phosphide                                | MoP                                                             | 12163-69-8  | 126.91      | blk hex cry             |                      |         | 7.34                       |                                     |                                                 |
| 1799 | Molybdenum silicide (MoSi <sub>2</sub> )            | MoSi <sub>2</sub>                                               | 12136-78-6  | 152.11      | gray tetr cry           | ~1900                |         | 6.2                        |                                     | i H <sub>2</sub> O; s HF                        |
| 1800 | Molybdenum(II) bromide                              | MoBr <sub>2</sub>                                               | 13446-56-5  | 255.75      | yel-red cry             | dec 700              |         | 4.88                       |                                     | i H <sub>2</sub> O, EtOH                        |
| 1801 | Molybdenum(II) chloride                             | MoCl <sub>2</sub>                                               | 13478-17-6  | 166.85      | yel cry                 | dec 500              |         | 3.71                       |                                     | i H <sub>2</sub> O                              |
| 1802 | Molybdenum(II) iodide                               | MoI <sub>2</sub>                                                | 14055-74-4  | 349.75      | blk hyg cry             | 700                  |         | 5.28                       |                                     | i H <sub>2</sub> O                              |
| 1803 | Molybdenum(III) bromide                             | MoBr <sub>3</sub>                                               | 13446-57-6  | 335.65      | grn hex cry             | dec 500              |         | 4.89                       |                                     | i H <sub>2</sub> O, EtOH                        |
| 1804 | Molybdenum(III) chloride                            | MoCl <sub>3</sub>                                               | 13478-18-7  | 202.30      | dark red monocl cry     | dec 400              |         | 3.74                       |                                     | i H <sub>2</sub> O, os                          |
| 1805 | Molybdenum(III) fluoride                            | MoF <sub>3</sub>                                                | 20193-58-2  | 152.94      | yel-brn hex cry         | >600                 |         | 4.64                       |                                     | i H <sub>2</sub> O                              |
| 1806 | Molybdenum(III) iodide                              | MoI <sub>3</sub>                                                | 14055-75-5  | 476.65      | blk solid               | 927                  |         |                            |                                     | i H <sub>2</sub> O                              |
| 1807 | Molybdenum(III) oxide                               | Mo <sub>2</sub> O <sub>3</sub>                                  | 1313-29-7   | 239.88      | gray-blk powder         |                      |         |                            |                                     | i H <sub>2</sub> O; sl acid                     |
| 1808 | Molybdenum(IV) bromide                              | MoBr <sub>4</sub>                                               | 13520-59-7  | 415.56      | blk cry                 | dec 110              |         |                            |                                     | reac H <sub>2</sub> O                           |
| 1809 | Molybdenum(IV) chloride                             | MoCl <sub>4</sub>                                               | 13320-71-3  | 237.75      | blk cry                 | 317                  |         |                            |                                     | reac H <sub>2</sub> O, sl chl; i eth, bz        |
| 1810 | Molybdenum(IV) fluoride                             | MoF <sub>4</sub>                                                | 23412-45-5  | 171.93      | grn cry                 | dec                  |         |                            |                                     | reac H <sub>2</sub> O                           |
| 1811 | Molybdenum(IV) iodide                               | MoI <sub>4</sub>                                                | 14055-76-6  | 603.56      | blk cry                 | dec 100              |         |                            |                                     | i H <sub>2</sub> O                              |
| 1812 | Molybdenum(IV) oxide                                | MoO <sub>3</sub>                                                | 18868-43-4  | 127.94      | brn-viol tetr cry       | ~1800 dec            |         | 6.47                       |                                     | i H <sub>2</sub> O, acid, alk                   |
| 1813 | Molybdenum(IV) selenide                             | MoSe <sub>2</sub>                                               | 12058-18-3  | 253.86      | gray hex cry            | >1200                |         | 6.90                       |                                     |                                                 |
| 1814 | Molybdenum(IV) sulfide                              | MoS <sub>2</sub>                                                | 1317-33-5   | 160.07      | blk powder or hex cry   | 1750                 |         | 5.06                       |                                     | i H <sub>2</sub> O; s conc acid                 |
| 1815 | Molybdenum(IV) telluride                            | MoTe <sub>2</sub>                                               | 12058-20-7  | 351.14      | gray hex cry            |                      |         | 7.7                        |                                     |                                                 |
| 1816 | Molybdenum(V) chloride                              | MoCl <sub>5</sub>                                               | 10241-05-1  | 273.21      | grn-blk monocl cry; hyg | 194                  | 268     | 2.93                       |                                     | reac H <sub>2</sub> O; s EtOH, eth              |
| 1817 | Molybdenum(V) fluoride                              | MoF <sub>5</sub>                                                | 13819-84-6  | 190.93      | yel monocl cry          | 67                   | 213.6   | 3.5                        |                                     | reac H <sub>2</sub> O                           |
| 1818 | Molybdenum(V) oxytrichloride                        | MoOCl <sub>3</sub>                                              | 13814-74-9  | 218.30      | blk monocl cry          | 310                  | subl    |                            |                                     | reac H <sub>2</sub> O                           |
| 1819 | Molybdenum(VI) acid monohydrate                     | H <sub>2</sub> MoO <sub>4</sub> · H <sub>2</sub> O              | 7782-91-4   | 179.97      | wh powder               |                      |         | 3.1                        |                                     | sl H <sub>2</sub> O; s alk                      |

| No.  | Name                                     | Formula                                                                               | CAS Reg No. | Mol. weight | Physical form              | mp/°C                | bp/°C          | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                |
|------|------------------------------------------|---------------------------------------------------------------------------------------|-------------|-------------|----------------------------|----------------------|----------------|----------------------------|-------------------------------------|-------------------------------------------------------|
| 1820 | Molybdenum(VI) dioxydichloride           | MoO <sub>2</sub> Cl <sub>2</sub>                                                      | 13637-68-8  | 198.85      | yel-oran solid             | 176                  | 250            | 3.31                       |                                     | reac H <sub>2</sub> O                                 |
| 1821 | Molybdenum(VI) dioxydifluoride           | MoO <sub>2</sub> F <sub>2</sub>                                                       | 13824-57-2  | 165.94      | pale lilac cry             | subl 270             |                | 3.5                        |                                     | i MeCN, chl; sl HF                                    |
| 1822 | Molybdenum(VI) fluoride                  | MoF <sub>6</sub>                                                                      | 7783-77-9   | 209.93      | wh cub cry or col liq; hyg | 17.5                 | 34.0           | 2.54                       |                                     | reac H <sub>2</sub> O; vs hex, ctc                    |
| 1823 | Molybdenum(VI) metaphosphate             | Mo(PO <sub>3</sub> ) <sub>6</sub>                                                     | 133863-98-6 | 569.77      | yel powder                 |                      |                | 3.28                       |                                     | i H <sub>2</sub> O, acid                              |
| 1824 | Molybdenum(VI) oxide                     | MoO <sub>3</sub>                                                                      | 1313-27-5   | 143.94      | wh-yel rhomb cry           | 802                  | 1155           | 4.70                       | 0.14 <sup>20</sup>                  | sl H <sub>2</sub> O; s alk, acid                      |
| 1825 | Molybdenum(VI) oxytetrachloride          | MoOCl <sub>4</sub>                                                                    | 13814-75-0  | 253.75      | grn hyg powder             | 105                  | 159            |                            |                                     |                                                       |
| 1826 | Molybdenum(VI) oxytetrafluoride          | MoOF <sub>4</sub>                                                                     | 14459-59-7  | 187.93      | volatile solid             | 97.2                 | 186.0          |                            |                                     |                                                       |
| 1827 | Molybdenum(VI) sulfide                   | MoS <sub>3</sub>                                                                      | 12033-29-3  | 192.14      | blk solid                  | 350 dec              |                |                            |                                     | i H <sub>2</sub> O, os                                |
| 1828 | Neodymium                                | Nd                                                                                    | 7440-00-8   | 144.242     | silv metal; hex            | 1016                 | 3074           | 7.01                       |                                     |                                                       |
| 1829 | Neodymium boride                         | NdB <sub>6</sub>                                                                      | 12008-23-0  | 209.108     | blk cub cry                | 2610                 |                | 4.93                       |                                     |                                                       |
| 1830 | Neodymium nitride                        | NdN                                                                                   | 25764-11-8  | 158.249     | blk cub cry                |                      |                | 7.69                       |                                     |                                                       |
| 1831 | Neodymium(II) acetate                    | Nd(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                        | 6192-13-8   | 321.373     | red-purp cry               |                      |                |                            |                                     | s H <sub>2</sub> O                                    |
| 1832 | Neodymium(II) chloride                   | NdCl <sub>2</sub>                                                                     | 25469-93-6  | 215.148     | grn hyg solid              | 841                  |                |                            |                                     |                                                       |
| 1833 | Neodymium(III) bromate nonahydrate       | Nd(BrO <sub>3</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                                | 15162-92-2  | 690.086     | red hex cry                | 66 dec               |                |                            |                                     |                                                       |
| 1834 | Neodymium(III) bromide                   | NdBr <sub>3</sub>                                                                     | 13536-80-6  | 383.954     | viol orth cry; hyg         | 682                  | 1540           | 5.3                        |                                     | s H <sub>2</sub> O                                    |
| 1835 | Neodymium(III) chloride                  | NdCl <sub>3</sub>                                                                     | 10024-93-8  | 250.601     | viol hex cry               | 759                  | 1600           | 4.13                       | 100 <sup>25</sup>                   | vs EtOH; i eth, chl                                   |
| 1836 | Neodymium(III) chloride hexahydrate      | NdCl <sub>3</sub> · 6H <sub>2</sub> O                                                 | 13477-89-9  | 358.692     | purp cry                   | 124 dec              |                | 2.3                        | 100 <sup>25</sup>                   | s EtOH                                                |
| 1837 | Neodymium(III) fluoride                  | NdF <sub>3</sub>                                                                      | 13709-42-7  | 201.237     | viol hex cry; hyg          | 1377                 | 2300           | 6.51                       |                                     | i H <sub>2</sub> O                                    |
| 1838 | Neodymium(III) hydroxide                 | Nd(OH) <sub>3</sub>                                                                   | 16469-17-3  | 195.264     | blue solid                 | dec 210              |                |                            |                                     | i H <sub>2</sub> O                                    |
| 1839 | Neodymium(III) iodide                    | NdI <sub>3</sub>                                                                      | 13813-24-6  | 524.955     | grn orth cry; hyg          | 787                  |                | 5.85                       |                                     | s H <sub>2</sub> O                                    |
| 1840 | Neodymium(III) nitrate                   | Nd(NO <sub>3</sub> ) <sub>3</sub>                                                     | 10045-95-1  | 330.257     | viol hyg. cry              |                      |                |                            | 152 <sup>25</sup>                   | s EtOH                                                |
| 1841 | Neodymium(III) nitrate hexahydrate       | Nd(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                 | 14517-29-4  | 438.348     | purp hyg cry               |                      |                |                            | 152 <sup>25</sup>                   | s EtOH, ace                                           |
| 1842 | Neodymium(III) oxide                     | Nd <sub>2</sub> O <sub>3</sub>                                                        | 1313-97-9   | 336.482     | blue hex cry; hyg          | 2233                 | 3760           | 7.24                       |                                     | i H <sub>2</sub> O; s dil acid                        |
| 1843 | Neodymium(III) sulfate                   | Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                                       | 13477-91-3  | 576.672     | pink needles               | ≈700 dec             |                |                            | 7.1 <sup>20</sup>                   |                                                       |
| 1844 | Neodymium(III) sulfate octahydrate       | Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                   | 13477-91-3  | 720.794     | red cry                    | 350 dec              |                | 2.85                       |                                     | sl H <sub>2</sub> O                                   |
| 1845 | Neodymium(III) sulfide                   | Nd <sub>2</sub> S <sub>3</sub>                                                        | 12035-32-4  | 384.679     | orth cry                   | 2207                 |                | 5.46                       |                                     |                                                       |
| 1846 | Neodymium(III) telluride                 | Nd <sub>2</sub> Te <sub>3</sub>                                                       | 12035-35-7  | 671.28      | gray orth cry              | 1377                 |                | 7.0                        |                                     |                                                       |
| 1847 | Neodymium(III) tris(cyclopentadienyl)    | Nd(C <sub>5</sub> H <sub>5</sub> ) <sub>3</sub>                                       | 1273-98-9   | 339.522     | red-blue cry               | 380                  |                |                            |                                     | s thf                                                 |
| 1848 | Neon                                     | Ne                                                                                    | 7440-01-9   | 20.180      | col gas                    | -248.609 tp (43 kPa) | -246.053       | 0.825 g/L                  |                                     | sl H <sub>2</sub> O                                   |
| 1849 | Neptunium                                | Np                                                                                    | 7439-99-8   | 237         | silv metal                 | 644                  |                | 20.2                       |                                     | s HCl                                                 |
| 1850 | Neptunium(IV) oxide                      | NpO <sub>2</sub>                                                                      | 12035-79-9  | 269         | grn cub cry                | 2547                 |                | 11.1                       |                                     |                                                       |
| 1851 | Nickel                                   | Ni                                                                                    | 7440-02-0   | 58.693      | wh metal; cub              | 1455                 | 2913           | 8.90                       |                                     | i H <sub>2</sub> O; sl dil acid                       |
| 1852 | Nickelocene                              | Ni(C <sub>2</sub> H <sub>2</sub> ) <sub>2</sub>                                       | 1271-28-9   | 188.879     | grn cry                    | 173                  |                |                            |                                     |                                                       |
| 1853 | Nickel aluminide (NiAl)                  | NiAl                                                                                  | 12003-78-0  | 85.675      | metallic solid             | 1638                 |                |                            |                                     |                                                       |
| 1854 | Nickel antimonide                        | NiSb                                                                                  | 12035-52-8  | 180.453     | hex cry                    | 1147                 |                | 8.74                       |                                     |                                                       |
| 1855 | Nickel arsenide                          | NiAs                                                                                  | 27016-75-7  | 133.615     | hex cry                    | 967                  |                | 7.77                       |                                     |                                                       |
| 1856 | Nickel boride (NiB)                      | NiB                                                                                   | 12007-00-0  | 69.504      | grn refrac solid           | 1035                 |                | 7.13                       |                                     |                                                       |
| 1857 | Nickel boride (Ni <sub>2</sub> B)        | Ni <sub>2</sub> B                                                                     | 12007-01-1  | 128.198     | refrac solid               | 1125                 |                | 7.90                       |                                     |                                                       |
| 1858 | Nickel boride (Ni <sub>3</sub> B)        | Ni <sub>3</sub> B                                                                     | 12007-02-2  | 186.891     | refrac solid               | 1166                 |                | 8.17                       |                                     |                                                       |
| 1859 | Nickel carbonyl                          | Ni(CO) <sub>4</sub>                                                                   | 13463-39-3  | 170.734     | col liq                    | -19.3                | 42.1 (exp ≈60) | 1.31                       |                                     | i H <sub>2</sub> O; s EtOH, bz, ace, ctc              |
| 1860 | Nickel phosphide                         | Ni <sub>2</sub> P                                                                     | 12035-64-2  | 148.361     | hex cry                    | 1100                 |                | 7.33                       |                                     |                                                       |
| 1861 | Nickel silicide (NiSi <sub>2</sub> )     | NiSi <sub>2</sub>                                                                     | 12201-89-7  | 114.864     | cub cry                    | 993                  |                | 4.83                       |                                     |                                                       |
| 1862 | Nickel silicide (Ni <sub>2</sub> Si)     | Ni <sub>2</sub> Si                                                                    | 12059-14-2  | 145.473     | orth cry                   | 1255                 |                | 7.40                       |                                     |                                                       |
| 1863 | Nickel subsulfide                        | Ni <sub>3</sub> S <sub>2</sub>                                                        | 12035-72-2  | 240.210     | yel hex cry                | 789                  |                | 5.87                       |                                     |                                                       |
| 1864 | Nickel(II) acetate tetrahydrate          | Ni(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 4H <sub>2</sub> O    | 6018-89-9   | 248.842     | grn monoc cry              | 250 dec              |                | 1.74                       | 16 <sup>20</sup>                    | s H <sub>2</sub> O, EtOH                              |
| 1865 | Nickel(II) ammonium chloride hexahydrate | NH <sub>4</sub> NiCl <sub>3</sub> · 6H <sub>2</sub> O                                 | 16122-03-5* | 291.182     | grn hyg cry                |                      |                | 1.65                       |                                     | s H <sub>2</sub> O                                    |
| 1866 | Nickel(II) ammonium sulfate              | Ni(NH <sub>4</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub>                     | 15699-18-0  | 286.895     | blue-grn cry               | dec 250              |                |                            |                                     | sl H <sub>2</sub> O                                   |
| 1867 | Nickel(II) ammonium sulfate hexahydrate  | Ni(NH <sub>4</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O | 7785-20-8   | 394.987     | blue-grn cry               | dec 130              |                | 1.92                       | 6.5 <sup>20</sup>                   | s H <sub>2</sub> O; i EtOH                            |
| 1868 | Nickel(II) arsenate octahydrate          | Ni <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub> · 8H <sub>2</sub> O                  | 7784-48-7   | 598.040     | yel-grn powder             | dec                  |                | 4.98                       |                                     | i H <sub>2</sub> O; s acid                            |
| 1869 | Nickel(II) bromide                       | NiBr <sub>2</sub>                                                                     | 13462-88-9  | 218.501     | yel hex cry; hyg           | 963                  | subl           | 5.10                       | 131 <sup>20</sup>                   |                                                       |
| 1870 | Nickel(II) bromide trihydrate            | NiBr <sub>2</sub> · 3H <sub>2</sub> O                                                 | 13462-88-9* | 272.547     | yel-grn hyg cry            | 200 dec              |                |                            |                                     | vs H <sub>2</sub> O; s EtOH, eth                      |
| 1871 | Nickel(II) carbonate                     | NiCO <sub>3</sub>                                                                     | 3333-67-3   | 118.702     | grn rhomb cry              |                      |                | 4.389                      | 0.0043 <sup>20</sup>                | s dil acid                                            |
| 1872 | Nickel(II) chlorate hexahydrate          | Ni(ClO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                | 13477-94-6  | 333.687     | grn cub cry                | dec 80               |                | 2.07                       |                                     | vs H <sub>2</sub> O                                   |
| 1873 | Nickel(II) chloride                      | NiCl <sub>2</sub>                                                                     | 7718-54-9   | 129.599     | yel hex cry; hyg           | 1031                 | 985 sp         | 3.51                       | 67.5 <sup>25</sup>                  | s EtOH                                                |
| 1874 | Nickel(II) chloride hexahydrate          | NiCl <sub>2</sub> · 6H <sub>2</sub> O                                                 | 7791-20-0   | 237.690     | grn monoc cry              |                      |                |                            | 67.5 <sup>25</sup>                  | s EtOH                                                |
| 1875 | Nickel(II) chromate                      | NiCrO <sub>4</sub>                                                                    | 14721-18-7  | 174.687     | red solid                  |                      |                |                            |                                     | sl H <sub>2</sub> O                                   |
| 1876 | Nickel(II) cyanide tetrahydrate          | Ni(CN) <sub>2</sub> · 4H <sub>2</sub> O                                               | 13477-95-7  | 182.789     | grn plates                 | 200 dec              |                |                            |                                     | i H <sub>2</sub> O; sl dil acid; s NH <sub>4</sub> OH |
| 1877 | Nickel(II) fluoride                      | NiF <sub>2</sub>                                                                      | 10028-18-9  | 96.690      | yel tetr cry               | 1380                 |                | 4.7                        | 2.56 <sup>25</sup>                  | i EtOH, eth                                           |
| 1878 | Nickel(II) fluoride tetrahydrate         | NiF <sub>2</sub> · 4H <sub>2</sub> O                                                  | 13940-83-5  | 168.752     | grn pow                    |                      |                |                            |                                     | sl H <sub>2</sub> O                                   |

| No.  | Name                                | Formula                                                             | CAS Reg No. | Mol. weight | Physical form         | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                          |
|------|-------------------------------------|---------------------------------------------------------------------|-------------|-------------|-----------------------|----------|----------|----------------------------|-------------------------------------|-------------------------------------------------|
| 1879 | Nickel(II) hydroxide                | Ni(OH) <sub>2</sub>                                                 | 12054-48-7  | 92.708      | grn hex cry           | 230 dec  |          | 4.1                        | 0.00015 <sup>20</sup>               |                                                 |
| 1880 | Nickel(II) hydroxide monohydrate    | Ni(OH) <sub>2</sub> · H <sub>2</sub> O                              | 36897-37-7  | 110.723     | grn powder            |          |          |                            | 0.00015 <sup>20</sup>               | s dil acid                                      |
| 1881 | Nickel(II) iodate                   | Ni(IO <sub>3</sub> ) <sub>2</sub>                                   | 13477-98-0  | 408.498     | yel needles           |          |          | 5.07                       | 1.1 <sup>30</sup>                   | sl H <sub>2</sub> O                             |
| 1882 | Nickel(II) iodate tetrahydrate      | Ni(IO <sub>3</sub> ) <sub>2</sub> · 4H <sub>2</sub> O               | 13477-99-1  | 480.560     | yel hex cry           | dec 100  |          | 5.07                       |                                     | sl H <sub>2</sub> O                             |
| 1883 | Nickel(II) iodide                   | NiI <sub>2</sub>                                                    | 13462-90-3  | 312.502     | blk hex cry; hyg      | 800      | subl     | 5.22                       | 154 <sup>25</sup>                   | vs EtOH                                         |
| 1884 | Nickel(II) iodide hexahydrate       | NiI <sub>2</sub> · 6H <sub>2</sub> O                                | 7790-34-3   | 420.593     | grn monocl cry; hyg   |          |          |                            | 154 <sup>25</sup>                   |                                                 |
| 1885 | Nickel(II) nitrate                  | Ni(NO <sub>3</sub> ) <sub>2</sub>                                   | 13138-45-9  | 182.702     | grn cry               |          |          |                            | 99.2 <sup>25</sup>                  | s EtOH                                          |
| 1886 | Nickel(II) nitrate hexahydrate      | Ni(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O               | 13478-00-7  | 290.794     | grn monocl cry; hyg   | 56 dec   |          | 2.05                       | 99.2 <sup>25</sup>                  | s EtOH                                          |
| 1887 | Nickel(II) oxalate dihydrate        | NiC <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O                 | 6018-94-6   | 182.742     | grn-wh solid          | dec 150  |          |                            | 0.0012 <sup>25</sup>                | i H <sub>2</sub> O; s acid, NH <sub>4</sub> OH  |
| 1888 | Nickel(II) oxide                    | NiO                                                                 | 1313-99-1   | 74.692      | grn cub cry           | 1957     |          | 6.72                       |                                     | i H <sub>2</sub> O; s acid                      |
| 1889 | Nickel(II) perchlorate hexahydrate  | Ni(ClO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O              | 13637-71-3* | 365.686     | grn hex needles       | 140      |          |                            | 158.8 <sup>25</sup>                 | s EtOH, ace                                     |
| 1890 | Nickel(II) phosphate octahydrate    | Ni <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> · 8H <sub>2</sub> O | 10381-36-9* | 510.145     | grn plates            |          |          |                            |                                     | s acid                                          |
| 1891 | Nickel(II) selenate hexahydrate     | NiSeO <sub>4</sub> · 6H <sub>2</sub> O                              | 15060-62-5* | 309.74      | grn tetr cry          |          |          | 2.314                      | 35.5 <sup>20</sup>                  |                                                 |
| 1892 | Nickel(II) selenide                 | NiSe                                                                | 1314-05-2   | 137.65      | yel-grn hex cry       | 980      |          | 7.2                        |                                     |                                                 |
| 1893 | Nickel(II) stannate dihydrate       | NiSnO <sub>3</sub> · 2H <sub>2</sub> O                              | 12035-38-0  | 261.432     | grn pow               | dec 120  |          |                            |                                     |                                                 |
| 1894 | Nickel(II) sulfate                  | NiSO <sub>4</sub>                                                   | 7786-81-4   | 154.756     | grn-yel orth cry      | 840 dec  |          | 4.01                       | 40.4 <sup>25</sup>                  |                                                 |
| 1895 | Nickel(II) sulfate hexahydrate      | NiSO <sub>4</sub> · 6H <sub>2</sub> O                               | 10101-97-0  | 262.847     | blue-grn tetr cry     | ≈100 dec |          | 2.07                       | 40.4 <sup>25</sup>                  | sl EtOH                                         |
| 1896 | Nickel(II) sulfate heptahydrate     | NiSO <sub>4</sub> · 7H <sub>2</sub> O                               | 10101-98-1  | 280.862     | grn orth cry          |          |          | 1.98                       | 40.4 <sup>25</sup>                  | s EtOH                                          |
| 1897 | Nickel(II) sulfide                  | NiS                                                                 | 16812-54-7  | 90.758      | yel hex cry           | 976      |          | 5.5                        |                                     | i H <sub>2</sub> O                              |
| 1898 | Nickel(II) thiocyanate              | Ni(SCN) <sub>2</sub>                                                | 13689-92-4  | 174.857     | grn pwd               |          |          |                            | 55.0 <sup>25</sup>                  |                                                 |
| 1899 | Nickel(II) titanate                 | NiTiO <sub>3</sub>                                                  | 12035-39-1  | 154.558     | brn hex cry           |          |          | 5.0                        |                                     |                                                 |
| 1900 | Nickel(II,III) sulfide              | Ni <sub>3</sub> S <sub>4</sub>                                      | 12137-12-1  | 304.340     | cub cry               | 995      |          | 4.77                       |                                     |                                                 |
| 1901 | Nickel(III) oxide                   | Ni <sub>2</sub> O <sub>3</sub>                                      | 1314-06-3   | 165.385     | gray-blk cub cry      | ≈600 dec |          |                            |                                     | i H <sub>2</sub> O; s hot acid                  |
| 1902 | Niobium                             | Nb                                                                  | 7440-03-1   | 92.906      | gray metal; cub       | 2477     | 4744     | 8.57                       |                                     | i acid                                          |
| 1903 | Niobocene dichloride                | Nb(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> Cl <sub>2</sub>     | 12793-14-5  | 293.998     | hyg blk cry           |          |          |                            |                                     | sl tol                                          |
| 1904 | Niobium boride (NbB)                | NbB                                                                 | 12045-19-1  | 103.717     | gray orth cry         | 2270     |          | 7.5                        |                                     |                                                 |
| 1905 | Niobium boride (NbB <sub>2</sub> )  | NbB <sub>2</sub>                                                    | 12007-29-3  | 114.528     | gray hex cry          | 3050     |          | 6.97                       |                                     |                                                 |
| 1906 | Niobium carbide (NbC)               | NbC                                                                 | 12069-94-2  | 104.917     | gray cub cry          | 3608     | 4300     | 7.82                       |                                     | i H <sub>2</sub> O, acid                        |
| 1907 | Niobium carbide (Nb <sub>2</sub> C) | Nb <sub>2</sub> C                                                   | 12011-99-3  | 197.824     | refrac hex cry        | 3080     |          | 7.8                        |                                     | i H <sub>2</sub> O                              |
| 1908 | Niobium nitride                     | NbN                                                                 | 24621-21-4  | 106.913     | gray cry; cub         | 2300     |          | 8.47                       |                                     | i HCl, acid                                     |
| 1909 | Niobium phosphide                   | NbP                                                                 | 12034-66-1  | 123.880     | tetr cry              |          |          | 6.5                        |                                     |                                                 |
| 1910 | Niobium silicide                    | NbSi <sub>2</sub>                                                   | 12034-80-9  | 149.077     | gray hex cry          | 1950     |          | 5.7                        |                                     |                                                 |
| 1911 | Niobium(II) oxide                   | NbO                                                                 | 12034-57-0  | 108.905     | gray cub cry          | 1937     |          | 7.30                       |                                     |                                                 |
| 1912 | Niobium(III) bromide                | NbBr <sub>3</sub>                                                   | 15752-41-7  | 332.618     | dark brn solid        |          | subl 400 |                            |                                     |                                                 |
| 1913 | Niobium(III) chloride               | NbCl <sub>3</sub>                                                   | 13569-59-0  | 199.265     | blk solid             |          |          |                            |                                     |                                                 |
| 1914 | Niobium(III) fluoride               | NbF <sub>3</sub>                                                    | 15195-53-6  | 149.901     | blue cub cry          |          |          | 4.2                        |                                     |                                                 |
| 1915 | Niobium(III) iodide                 | NbI <sub>3</sub>                                                    | 13870-20-7  | 473.619     | blk solid             | dec 510  |          |                            |                                     |                                                 |
| 1916 | Niobium(IV) bromide                 | NbBr <sub>4</sub>                                                   | 13842-75-6  | 412.522     | dark brn cry          |          | subl 300 | 4.72                       |                                     | reac H <sub>2</sub> O                           |
| 1917 | Niobium(IV) chloride                | NbCl <sub>4</sub>                                                   | 13569-70-5  | 234.718     | viol-blk monocl cry   | dec 800  | 275 subl | 3.2                        |                                     | reac H <sub>2</sub> O                           |
| 1918 | Niobium(IV) fluoride                | NbF <sub>4</sub>                                                    | 13842-88-1  | 168.900     | blk tetr cry; hyg     | >350 dec |          | 4.01                       |                                     |                                                 |
| 1919 | Niobium(IV) iodide                  | NbI <sub>4</sub>                                                    | 13870-21-8  | 600.524     | gray orth cry         | 503      |          | 5.6                        |                                     | reac H <sub>2</sub> O                           |
| 1920 | Niobium(IV) oxide                   | NbO <sub>2</sub>                                                    | 12034-59-2  | 124.905     | wh tetr cry or powder | 1901     |          | 5.9                        |                                     |                                                 |
| 1921 | Niobium(IV) selenide                | NbSe <sub>2</sub>                                                   | 12034-77-4  | 250.83      | gray hex cry          | >1300    |          | 6.3                        |                                     |                                                 |
| 1922 | Niobium(IV) sulfide                 | NbS <sub>2</sub>                                                    | 12136-97-9  | 157.036     | blk rhomb cry         |          |          | 4.4                        |                                     |                                                 |
| 1923 | Niobium(IV) telluride               | NbTe <sub>2</sub>                                                   | 12034-83-2  | 348.11      | hex cry               |          |          | 7.6                        |                                     |                                                 |
| 1924 | Niobium(V) bromide                  | NbBr <sub>5</sub>                                                   | 13478-45-0  | 492.426     | oran orth cry         | 265.2    | 361.6    | 4.36                       |                                     | s H <sub>2</sub> O, EtOH                        |
| 1925 | Niobium(V) chloride                 | NbCl <sub>5</sub>                                                   | 10026-12-7  | 270.171     | yel monocl cry; hyg   | 205.8    | 247.4    | 2.78                       |                                     | reac H <sub>2</sub> O; s HCl, ctc               |
| 1926 | Niobium(V) dioxyfluoride            | NbO <sub>2</sub> F                                                  | 15195-33-2  | 143.903     | wh cub cry            |          |          | 4.0                        |                                     |                                                 |
| 1927 | Niobium(V) ethoxide                 | Nb(OC <sub>2</sub> H <sub>5</sub> ) <sub>5</sub>                    | 3236-82-6   | 318.209     | col hyg liq           | 5        | 203      | 1.258                      |                                     | reac H <sub>2</sub> O; s peth                   |
| 1928 | Niobium(V) fluoride                 | NbF <sub>5</sub>                                                    | 7783-68-8   | 187.898     | col monocl cry; hyg   | 80       | 234      | 2.70                       |                                     | reac H <sub>2</sub> O; sl CS <sub>2</sub> , chl |
| 1929 | Niobium(V) iodide                   | NbI <sub>5</sub>                                                    | 13779-92-5  | 727.428     | yel-blk monocl cry    | 327      |          | 5.32                       |                                     | reac H <sub>2</sub> O                           |
| 1930 | Niobium(V) oxide                    | Nb <sub>2</sub> O <sub>5</sub>                                      | 1313-96-8   | 265.810     | wh orth cry           | 1500     |          | 4.47                       |                                     | i H <sub>2</sub> O; s HF                        |
| 1931 | Niobium(V) oxybromide               | NbOBr <sub>3</sub>                                                  | 14459-75-7  | 348.617     | yel-brn cry           | ≈320 dec | subl     |                            |                                     |                                                 |
| 1932 | Niobium(V) oxychloride              | NbOCl <sub>3</sub>                                                  | 13597-20-1  | 215.264     | wh tetr cry           |          | subl     | 3.72                       |                                     |                                                 |
| 1933 | Nitrogen                            | N <sub>2</sub>                                                      | 7727-37-9   | 28.013      | col gas               | -210.0   | -195.798 | 1.145 g/L                  |                                     | sl H <sub>2</sub> O; i EtOH                     |
| 1934 | Nitramide                           | NO <sub>2</sub> NH <sub>2</sub>                                     | 7782-94-7   | 62.028      | unstab wh cry         | 72 dec   |          |                            |                                     | s H <sub>2</sub> O, EtOH, ace, eth; i chl       |
| 1935 | Nitric acid                         | HNO <sub>3</sub>                                                    | 7697-37-2   | 63.013      | col liq; hyg          | -41.6    | 83       | 1.5129 <sup>20</sup>       |                                     | vs H <sub>2</sub> O                             |
| 1936 | Nitrous acid                        | HNO <sub>2</sub>                                                    | 7782-77-6   | 47.014      | stab only in soln     |          |          |                            |                                     |                                                 |
| 1937 | Nitrous oxide                       | N <sub>2</sub> O                                                    | 10024-97-2  | 44.012      | col gas               | -90.8    | -88.48   | 1.799 g/L                  |                                     | sl H <sub>2</sub> O; s EtOH, eth                |
| 1938 | Nitric oxide                        | NO                                                                  | 10102-43-9  | 30.006      | col gas               | -163.6   | -151.74  | 1.226 g/L                  |                                     | sl H <sub>2</sub> O                             |

| No.  | Name                                | Formula                                                        | CAS Reg No. | Mol. weight | Physical form                                     | mp/°C    | bp/°C                             | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                |
|------|-------------------------------------|----------------------------------------------------------------|-------------|-------------|---------------------------------------------------|----------|-----------------------------------|----------------------------|-------------------------------------|-------------------------------------------------------|
| 1939 | Nitrogen dioxide                    | NO <sub>2</sub>                                                | 10102-44-0  | 46.006      | brn gas; equil with N <sub>2</sub> O <sub>4</sub> |          | see N <sub>2</sub> O <sub>4</sub> | 1.880 g/L                  |                                     | reac H <sub>2</sub> O                                 |
| 1940 | Nitrogen trioxide                   | N <sub>2</sub> O <sub>3</sub>                                  | 10544-73-7  | 76.011      | blue solid or liq (low temp)                      | -101.1   | ≈3 dec                            | 1.4 <sup>2</sup>           |                                     | reac H <sub>2</sub> O                                 |
| 1941 | Nitrogen tetroxide                  | N <sub>2</sub> O <sub>4</sub>                                  | 10544-72-6  | 92.011      | col liq; equil with NO <sub>2</sub>               | -9.3     | 21.15                             | 1.45 <sup>20</sup>         |                                     | reac H <sub>2</sub> O                                 |
| 1942 | Nitrogen pentoxide                  | N <sub>2</sub> O <sub>5</sub>                                  | 10102-03-1  | 108.010     | col hex cry                                       |          | 33 sp                             | 2.0                        |                                     | s chl; sl ctc                                         |
| 1943 | Nitrogen tribromide                 | NBr <sub>3</sub>                                               | 15162-90-0  | 253.719     | unstab solid                                      | exp -100 |                                   |                            |                                     |                                                       |
| 1944 | Nitrogen trichloride                | NCI <sub>3</sub>                                               | 10025-85-1  | 120.366     | yel oily liq; exp                                 | -40      | 71                                | 1.653                      |                                     | i H <sub>2</sub> O; s CS <sub>2</sub> , bz, ctc       |
| 1945 | Nitrogen trifluoride                | NF <sub>3</sub>                                                | 7783-54-2   | 71.002      | col gas                                           | -206.79  | -128.75                           | 2.902 g/L                  |                                     | i H <sub>2</sub> O                                    |
| 1946 | Nitrogen triiodide                  | NI <sub>3</sub>                                                | 13444-85-4  | 394.720     | unstab blk cry; exp                               |          |                                   |                            |                                     |                                                       |
| 1947 | Nitrogen chloride difluoride        | NCIF <sub>2</sub>                                              | 13637-87-1  | 87.457      | col gas                                           | -195     | -67                               | 3.575 g/L                  |                                     |                                                       |
| 1948 | Chloramine                          | NH <sub>2</sub> Cl                                             | 10599-90-3  | 51.476      | yel liq                                           | -66      |                                   |                            |                                     | s H <sub>2</sub> O, EtOH, eth; sl bz, ctc             |
| 1949 | Fluoramine                          | NHF                                                            | 15861-05-9  | 35.021      | unstab gas                                        | ≈-110    |                                   | 1.431 g/L                  |                                     |                                                       |
| 1950 | Difluoramine                        | NHF <sub>2</sub>                                               | 10405-27-3  | 53.012      | col gas                                           | -116     | -23                               | 2.167 g/L                  |                                     |                                                       |
| 1951 | cis-Difluorodiazine                 | N <sub>2</sub> F <sub>2</sub>                                  | 13812-43-6  | 66.010      | col gas                                           | <-195    | -105.75                           | 2.698 g/L                  |                                     |                                                       |
| 1952 | trans-Difluorodiazine               | N <sub>2</sub> F <sub>2</sub>                                  | 13776-62-0  | 66.010      | col gas                                           | -172     | -111.45                           | 2.698 g/L                  |                                     |                                                       |
| 1953 | Tetrafluorohydrazine                | N <sub>2</sub> F <sub>4</sub>                                  | 10036-47-2  | 104.007     | col gas                                           | -164.5   | -74                               | 4.251 g/L                  |                                     |                                                       |
| 1954 | Nitrosyl bromide                    | NOBr                                                           | 13444-87-6  | 109.910     | red gas                                           | -56      | ≈0                                | 4.492 g/L                  |                                     | reac H <sub>2</sub> O                                 |
| 1955 | Nitrosyl chloride                   | NOCl                                                           | 2696-92-6   | 65.459      | yel gas                                           | -59.6    | -5.5                              | 2.676 g/L                  |                                     | reac H <sub>2</sub> O                                 |
| 1956 | Nitrosyl fluoride                   | NOF                                                            | 7789-25-5   | 49.004      | col gas                                           | -132.5   | -59.9                             | 2.003 g/L                  |                                     |                                                       |
| 1957 | Trifluoramine oxide                 | NOF <sub>3</sub>                                               | 13847-65-9  | 87.001      | col gas                                           | -161     | -87.5                             | 3.556 g/L                  |                                     |                                                       |
| 1958 | Nitryl chloride                     | NO <sub>2</sub> Cl                                             | 13444-90-1  | 81.459      | col gas                                           | -145     | -15                               | 3.330 g/L                  |                                     |                                                       |
| 1959 | Nitryl fluoride                     | NO <sub>2</sub> F                                              | 10022-50-1  | 65.004      | col gas                                           | -166     | -72.4                             | 2.657 g/L                  |                                     | reac H <sub>2</sub> O                                 |
| 1960 | Nitrogen selenide                   | N <sub>4</sub> Se <sub>4</sub>                                 | 12033-88-4  | 371.87      | red monocl cry; hyg                               | exp      |                                   | 4.2                        |                                     | i H <sub>2</sub> O, eth, EtOH; sl bz, CS <sub>2</sub> |
| 1961 | Nobelium                            | No                                                             | 10028-14-5  | 259.000     | metal                                             | 827      |                                   |                            |                                     |                                                       |
| 1962 | Osmium                              | Os                                                             | 7440-04-2   | 190.23      | blue-wh metal; hex                                | 3033     | 5012                              | 22.587 <sup>20</sup>       |                                     | s aqua regia                                          |
| 1963 | Osmocene                            | Os(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>                | 1273-81-0   | 320.42      | col cry                                           | 229      |                                   |                            |                                     |                                                       |
| 1964 | Osmium carbonyl                     | Os <sub>5</sub> (CO) <sub>12</sub>                             | 15696-40-9  | 906.81      | yel cry                                           | 224      |                                   | 3.48                       |                                     |                                                       |
| 1965 | Osmium pentacarbonyl                | Os(CO) <sub>5</sub>                                            | 16406-49-8  | 330.28      | col liq                                           | -15      | dec 100                           |                            |                                     | s os                                                  |
| 1966 | Osmium nonacarbonyl                 | Os <sub>9</sub> (CO) <sub>9</sub>                              | 28411-13-4  | 632.55      | oran-yel cry                                      | 65 dec   |                                   |                            |                                     | s hc                                                  |
| 1967 | Osmium(II) chloride                 | OsCl <sub>2</sub>                                              | 13444-92-3  | 261.14      | hyg brn solid                                     | dec >450 |                                   |                            |                                     | s EtOH, eth                                           |
| 1968 | Osmium(III) bromide                 | OsBr <sub>3</sub>                                              | 59201-51-3  | 429.94      | dark gray cry                                     | 340 dec  |                                   |                            |                                     | i H <sub>2</sub> O, os, acid                          |
| 1969 | Osmium(III) chloride                | OsCl <sub>3</sub>                                              | 13444-93-4  | 296.59      | gray cub cry                                      | 450 dec  |                                   |                            |                                     | i H <sub>2</sub> O, os; s conc acid                   |
| 1970 | Osmium(IV) chloride                 | OsCl <sub>4</sub>                                              | 10026-01-4  | 332.04      | red-blk orth cry                                  | 323 dec  |                                   | 4.38                       |                                     | reac H <sub>2</sub> O; i os                           |
| 1971 | Osmium(IV) fluoride                 | OsF <sub>4</sub>                                               | 54120-05-7  | 266.22      | yel cry                                           | 230      |                                   |                            |                                     | reac H <sub>2</sub> O                                 |
| 1972 | Osmium(IV) oxide                    | OsO <sub>2</sub>                                               | 12036-02-1  | 222.23      | yel-brn tetr cry                                  | dec 500  |                                   | 11.4                       |                                     | i H <sub>2</sub> O, acid                              |
| 1973 | Osmium(V) fluoride                  | OsF <sub>5</sub>                                               | 31576-40-6  | 285.22      | hyg blue-grn cry                                  | 70       | 233                               |                            |                                     | reac H <sub>2</sub> O                                 |
| 1974 | Osmium(VI) fluoride                 | OsF <sub>6</sub>                                               | 13768-38-2  | 304.22      | yel cub cry                                       | 33.4     | 47.5                              | 4.1                        |                                     | reac H <sub>2</sub> O                                 |
| 1975 | Osmium(VI) tetrachloride oxide      | OsOCl <sub>4</sub>                                             | 36509-15-6  | 348.04      | dark brn hyg cry                                  | 32       | 200                               |                            |                                     | reac H <sub>2</sub> O; s hc                           |
| 1976 | Osmium(VIII) oxide                  | OsO <sub>4</sub>                                               | 20816-12-0  | 254.23      | yel monocl cry                                    | 40.6     | 131.2                             | 5.1                        | 6.44 <sup>20</sup>                  | sl H <sub>2</sub> O; s ctc, bz, EtOH, eth             |
| 1977 | Oxygen                              | O <sub>2</sub>                                                 | 7782-44-7   | 31.999      | col gas                                           | -218.79  | -182.953                          | 1.308 g/L                  |                                     | sl H <sub>2</sub> O, EtOH, os                         |
| 1978 | Ozone                               | O <sub>3</sub>                                                 | 10028-15-6  | 47.998      | blue gas                                          | -193     | -111.35                           | 1.962 g/L                  |                                     | sl H <sub>2</sub> O                                   |
| 1979 | Palladium                           | Pd                                                             | 7440-05-3   | 106.42      | silv-wh metal; cub                                | 1554.8   | 2963                              | 12.0                       |                                     | s aqua regia                                          |
| 1980 | Palladium(II) acetate               | Pd(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> | 3375-31-3   | 224.51      | oran-brn cry                                      | 205 dec  |                                   |                            |                                     | i H <sub>2</sub> O; s MeCN, eth, ace                  |
| 1981 | Palladium(II) bromide               | PdBr <sub>2</sub>                                              | 13444-94-5  | 266.23      | red-blk monocl cry; hyg                           | 250 dec  |                                   | ≈5.2                       |                                     | i H <sub>2</sub> O                                    |
| 1982 | Palladium(II) chloride              | PdCl <sub>2</sub>                                              | 7647-10-1   | 177.33      | red rhomb cry; hyg                                | 679      |                                   | 4.0                        |                                     | s H <sub>2</sub> O, EtOH, ace                         |
| 1983 | Palladium(II) chloride dihydrate    | PdCl <sub>2</sub> · 2H <sub>2</sub> O                          | 7647-10-1*  | 213.36      | brn cry                                           |          |                                   |                            |                                     | s H <sub>2</sub> O, EtOH, ace                         |
| 1984 | Palladium(II) cyanide               | Pd(CN) <sub>2</sub>                                            | 2035-66-7   | 158.45      | yel solid                                         | dec      |                                   |                            |                                     |                                                       |
| 1985 | Palladium(II) fluoride              | PdF <sub>2</sub>                                               | 13444-96-7  | 144.42      | viol tetr cry; hyg                                | 952      |                                   | 5.76                       |                                     | reac H <sub>2</sub> O                                 |
| 1986 | Palladium(II) iodide                | PdI <sub>2</sub>                                               | 7790-38-7   | 360.23      | blk cry                                           | 360 dec  |                                   | 6.0                        |                                     | i H <sub>2</sub> O, EtOH, eth                         |
| 1987 | Palladium(II) nitrate               | Pd(NO <sub>3</sub> ) <sub>2</sub>                              | 10102-05-3  | 230.43      | brn hyg cry                                       | dec      |                                   |                            |                                     | sl H <sub>2</sub> O; s dil HNO <sub>3</sub>           |
| 1988 | Palladium(II) oxide                 | PdO                                                            | 1314-08-5   | 122.42      | grn-blk tetr cry                                  | 750 dec  |                                   | 8.3                        |                                     | i H <sub>2</sub> O, acid; sl aqua regia               |
| 1989 | Palladium(II) 2,4-pentanedioate     | Pd(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>        | 14024-61-4  | 304.64      | oran-yel cry                                      | 205 dec  |                                   |                            |                                     | s bz, chl                                             |
| 1990 | Palladium(II) sulfate dihydrate     | PdSO <sub>4</sub> · 2H <sub>2</sub> O                          | 13566-03-5  | 238.51      | grn-brn cry                                       | dec      |                                   |                            |                                     |                                                       |
| 1991 | Palladium(II) sulfide               | PdS                                                            | 12125-22-3  | 138.49      | gray tetr cry                                     |          |                                   | 6.7                        |                                     |                                                       |
| 1992 | cis-Dichlorodiamminepalladium(II)   | Pd(NH <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub>              | 15684-18-1  | 211.39      | yel pow                                           |          |                                   |                            | 0.025 <sup>25</sup>                 |                                                       |
| 1993 | trans-Dichlorodiamminepalladium(II) | Pd(NH <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub>              | 13782-33-7  | 211.39      | yel solid                                         |          |                                   | 2.50                       |                                     |                                                       |

| No.  | Name                                                | Formula                                         | CAS Reg No. | Mol. weight | Physical form               | mp/°C    | bp/°C            | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                  |
|------|-----------------------------------------------------|-------------------------------------------------|-------------|-------------|-----------------------------|----------|------------------|----------------------------|-------------------------------------|---------------------------------------------------------|
| 1994 | Phosphorus (white)                                  | P                                               | 7723-14-0   | 30.974      | col waxlike cub cry         | 44.15    | 280.5            | 1.823                      |                                     | i H <sub>2</sub> O; sl bz, EtOH, chl; s CS <sub>2</sub> |
| 1995 | Phosphorus (red)                                    | P                                               | 7723-14-0   | 30.974      | red-viol amorp powder       | 579.2    | 431 sp           | 2.16                       |                                     | i H <sub>2</sub> O, os                                  |
| 1996 | Phosphorus (black)                                  | P                                               | 7723-14-0   | 30.974      | blk orth cry or amorp solid | 610      |                  | 2.69                       |                                     | i os                                                    |
| 1997 | Phosphine                                           | PH <sub>3</sub>                                 | 7803-51-2   | 33.998      | col gas; flam               | -133.8   | -87.75           | 1.390 g/L                  |                                     | i H <sub>2</sub> O; sl EtOH, eth                        |
| 1998 | Diphosphine                                         | P <sub>2</sub> H <sub>4</sub>                   | 13445-50-6  | 65.980      | col liq                     | -99      | 63.5 dec         |                            |                                     | reac H <sub>2</sub> O                                   |
| 1999 | Diphosphorus tetrachloride                          | P <sub>2</sub> Cl <sub>4</sub>                  | 13497-91-1  | 203.760     | col oily liq                | -28      | ≈180 dec         |                            |                                     |                                                         |
| 2000 | Diphosphorus tetrafluoride                          | P <sub>2</sub> F <sub>4</sub>                   | 13824-74-3  | 137.942     | col gas                     | -86.5    | -6.2             | 5.638 g/L                  |                                     |                                                         |
| 2001 | Diphosphorus tetraiodide                            | P <sub>2</sub> I <sub>4</sub>                   | 13455-00-0  | 569.566     | red tricl needles           | 125.5    | dec              | 3.89                       |                                     |                                                         |
| 2002 | Phosphonium chloride                                | PH <sub>4</sub> Cl                              | 24567-53-1  | 70.459      | gas                         |          | -27 sp           | 2.880 g/L                  |                                     | reac H <sub>2</sub> O                                   |
| 2003 | Phosphonium iodide                                  | PH <sub>4</sub> I                               | 12125-09-6  | 161.910     | col tetr cry                | 18.5     | 62.5             | 2.86                       |                                     | reac H <sub>2</sub> O, EtOH                             |
| 2004 | Phosphoric acid                                     | H <sub>3</sub> PO <sub>4</sub>                  | 7664-38-2   | 97.995      | col visc liq                | 42.4     | 407              |                            | 548 <sup>20</sup>                   | s EtOH                                                  |
| 2005 | Phosphotungstic acid                                | H <sub>3</sub> PW <sub>12</sub> O <sub>40</sub> | 12067-99-1  | 2880.05     | wh-yel cry                  | 89       |                  |                            |                                     | vs H <sub>2</sub> O; s EtOH, eth                        |
| 2006 | Phosphonic acid                                     | H <sub>3</sub> PO <sub>3</sub>                  | 13598-36-2  | 81.996      | wh hyg cry                  | 74.4     | 200              | 1.65                       | 309 <sup>9</sup>                    | vs EtOH                                                 |
| 2007 | Phosphinic acid                                     | HPH <sub>2</sub> O <sub>2</sub>                 | 6303-21-5   | 65.997      | hyg cry or col oily liq     | 26.5     | 130              | 1.49                       |                                     | vs H <sub>2</sub> O, EtOH, eth                          |
| 2008 | Metaphosphoric acid                                 | HPO <sub>3</sub>                                | 37267-86-0  | 79.980      | gl solid; hyg               |          |                  |                            |                                     | sl H <sub>2</sub> O; s EtOH                             |
| 2009 | Hypophosphoric acid                                 | H <sub>4</sub> P <sub>2</sub> O <sub>6</sub>    | 7803-60-3   | 161.976     | col orth cry                | 73 dec   |                  |                            |                                     | vs H <sub>2</sub> O                                     |
| 2010 | Diphosphoric acid                                   | H <sub>4</sub> P <sub>2</sub> O <sub>7</sub>    | 2466-09-3   | 177.975     | wh cry                      | 71.5     |                  |                            | 709 <sup>23</sup>                   |                                                         |
| 2011 | Difluorophosphoric acid                             | HPO <sub>2</sub> F <sub>2</sub>                 | 13779-41-4  | 101.978     | col liq                     | ≈-94     | 110 dec          | 1.583                      |                                     | reac H <sub>2</sub> O                                   |
| 2012 | Hexafluorophosphoric acid                           | HPF <sub>6</sub>                                | 16940-81-1  | 145.972     | col oily liq                | 25 dec   |                  |                            |                                     | reac H <sub>2</sub> O                                   |
| 2013 | Fluorophosphonic acid                               | H <sub>2</sub> PFO <sub>3</sub>                 | 13537-32-1  | 99.986      | col visc liq                | <-70     |                  | 1.82                       |                                     | vs H <sub>2</sub> O                                     |
| 2014 | Phosphorus nitride (P <sub>3</sub> N <sub>2</sub> ) | P <sub>3</sub> N <sub>5</sub>                   | 12136-91-3  | 162.955     | yel-brn solid               | 800 dec  |                  |                            |                                     | i H <sub>2</sub> O; s os                                |
| 2015 | Phosphorus sesquisulfide                            | P <sub>4</sub> S <sub>3</sub>                   | 1314-85-8   | 220.090     | yel-grn orth cry            | 173      | 407              | 2.03                       |                                     | i H <sub>2</sub> O; s bz; vs CS <sub>2</sub>            |
| 2016 | Phosphorus heptasulfide                             | P <sub>4</sub> S <sub>7</sub>                   | 12037-82-0  | 348.350     | pale yel monocl cry         | 308      | 523              | 2.19                       |                                     | sl CS <sub>2</sub>                                      |
| 2017 | Phosphonitric chloride trimer                       | (PNCl <sub>2</sub> ) <sub>3</sub>               | 940-71-6    | 347.659     | wh hyg cry                  | 128.8    |                  | 1.98                       |                                     | reac H <sub>2</sub> O                                   |
| 2018 | Phosphorus(III) bromide                             | PBr <sub>3</sub>                                | 7789-60-8   | 270.686     | col liq                     | -41.5    | 173.2            | 2.8                        |                                     | reac H <sub>2</sub> O, EtOH; s ace, CS <sub>2</sub>     |
| 2019 | Phosphorus(III) dibromide fluoride                  | PBr <sub>2</sub> F                              | 15597-39-4  | 209.780     | col liq                     | -115     | 78.5             |                            |                                     |                                                         |
| 2020 | Phosphorus(III) bromide difluoride                  | PBrF <sub>2</sub>                               | 15597-40-7  | 148.875     | col gas                     | -133.8   | -16.1            | 6.085 g/L                  |                                     |                                                         |
| 2021 | Phosphorus(III) chloride                            | PCl <sub>3</sub>                                | 7719-12-2   | 137.333     | col liq                     | -93      | 76               | 1.574                      |                                     | reac H <sub>2</sub> O, EtOH; s bz, chl, eth             |
| 2022 | Phosphorus(III) dichloride fluoride                 | PCl <sub>2</sub> F                              | 15597-63-4  | 120.878     | col gas                     | -144     | 13.85            | 4.941 g/L                  |                                     |                                                         |
| 2023 | Phosphorus(III) chloride difluoride                 | PClF <sub>2</sub>                               | 14335-40-1  | 104.424     | col gas                     | -164.8   | -47.3            | 4.268 g/L                  |                                     |                                                         |
| 2024 | Phosphorus(III) fluoride                            | PF <sub>3</sub>                                 | 7783-55-3   | 87.969      | col gas                     | -151.5   | -101.8           | 3.596 g/L                  |                                     | reac H <sub>2</sub> O                                   |
| 2025 | Phosphorus(III) iodide                              | PI <sub>3</sub>                                 | 13455-01-1  | 411.687     | red-oran hex cry; hyg       | 61.2     | 227 dec          | 4.18                       |                                     | reac H <sub>2</sub> O; s EtOH                           |
| 2026 | Phosphorus(III) oxide                               | P <sub>2</sub> O <sub>3</sub>                   | 1314-24-5   | 109.946     | col monocl cry or liq       | 23.8     | 173              | 2.13                       |                                     | reac H <sub>2</sub> O                                   |
| 2027 | Tetraphosphorus(III) hexoxide                       | P <sub>4</sub> O <sub>6</sub>                   | 12440-00-5  | 219.891     | soft wh cry                 | 23.8     | 175.4            |                            |                                     |                                                         |
| 2028 | Phosphorus(III) selenide                            | P <sub>2</sub> Se <sub>3</sub>                  | 1314-86-9   | 298.83      | oran-red cry                | 245      | ≈380             | 1.31                       |                                     | reac H <sub>2</sub> O; s bz, ctc, CS <sub>2</sub> , ace |
| 2029 | Phosphorus(III) sulfide                             | P <sub>2</sub> S <sub>3</sub>                   | 12165-69-4  | 158.143     | yel solid                   | 290      | 490              |                            |                                     | reac H <sub>2</sub> O; s EtOH, eth, CS <sub>2</sub>     |
| 2030 | Phosphorus(V) bromide                               | PBr <sub>5</sub>                                | 7789-69-7   | 430.494     | yel orth cry; hyg           | ≈100 dec |                  | 3.61                       |                                     | reac H <sub>2</sub> O, EtOH; s CS <sub>2</sub> , ctc    |
| 2031 | Phosphorus(V) tetrabromide fluoride                 | PBr <sub>4</sub> F                              |             | 369.588     | pale yel cry                | 87 dec   |                  |                            |                                     |                                                         |
| 2032 | Phosphorus(V) dibromide trifluoride                 | PBr <sub>2</sub> F <sub>3</sub>                 | 13445-58-4  | 247.777     | yel-red liq                 | -20      | 15 dec           |                            |                                     |                                                         |
| 2033 | Phosphorus(V) chloride                              | PCl <sub>5</sub>                                | 10026-13-8  | 208.239     | wh-yel tetr cry; hyg        | 167 tp   | 160 sp           | 2.1                        |                                     | reac H <sub>2</sub> O; s CS <sub>2</sub> , ctc          |
| 2034 | Phosphorus(V) tetrachloride fluoride                | PCl <sub>4</sub> F                              | 13498-11-8  | 191.784     | col liq                     | -59      | 30 dec           |                            |                                     |                                                         |
| 2035 | Phosphorus(V) trichloride difluoride                | PCl <sub>3</sub> F <sub>2</sub>                 | 13537-23-0  | 175.330     | col liq                     | -63      |                  |                            |                                     |                                                         |
| 2036 | Phosphorus(V) dichloride trifluoride                | PCl <sub>2</sub> F <sub>3</sub>                 | 13454-99-4  | 158.875     | col gas                     | -125     | 7.1              | 6.494 g/L                  |                                     |                                                         |
| 2037 | Phosphorus(V) chloride tetrafluoride                | PClF <sub>4</sub>                               | 13498-11-8  | 142.421     | col gas                     | -132     | -43.4            | 5.821 g/L                  |                                     |                                                         |
| 2038 | Phosphorus(V) fluoride                              | PF <sub>5</sub>                                 | 7647-19-0   | 125.966     | col gas                     | -93.8    | -84.6            | 5.149 g/L                  |                                     | reac H <sub>2</sub> O                                   |
| 2039 | Phosphorus(V) oxide                                 | P <sub>2</sub> O <sub>5</sub>                   | 1314-56-3   | 141.945     | wh orth cry; hyg            | 562      | 605              | 2.30                       |                                     | reac H <sub>2</sub> O, EtOH                             |
| 2040 | Phosphorus(V) selenide                              | P <sub>2</sub> Se <sub>5</sub>                  | 1314-82-5   | 456.75      | blk-purp amorp solid        |          |                  |                            |                                     | reac hot H <sub>2</sub> O, ctc; i CS <sub>2</sub>       |
| 2041 | Phosphorus(V) sulfide                               | P <sub>2</sub> S <sub>5</sub>                   | 1314-80-3   | 222.273     | grn-yel hyg cry             | 285      | 515              | 2.03                       |                                     | reac H <sub>2</sub> O; s CS <sub>2</sub>                |
| 2042 | Phosphonic difluoride                               | POF <sub>2</sub> H                              | 14939-34-5  | 85.978      | volatile liq                | >-120    | ≈60 (gas unstab) |                            |                                     |                                                         |

| No.  | Name                                 | Formula                                              | CAS Reg No. | Mol. weight | Physical form           | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                 |
|------|--------------------------------------|------------------------------------------------------|-------------|-------------|-------------------------|----------|----------|----------------------------|-------------------------------------|--------------------------------------------------------|
| 2043 | Phosphoryl bromide                   | POBr <sub>3</sub>                                    | 7789-59-5   | 286.685     | faint oran plates       | 55       | 191.7    | 2.822                      |                                     | reac H <sub>2</sub> O; s bz, eth, chl                  |
| 2044 | Phosphoryl dibromide chloride        | POBr <sub>2</sub> Cl                                 | 13550-31-7  | 242.234     | yel solid               | 31       | 165      |                            |                                     |                                                        |
| 2045 | Phosphoryl dibromide fluoride        | POBr <sub>2</sub> F                                  | 14014-19-8  | 225.779     | col liq                 | -117.2   | 110.1    |                            |                                     |                                                        |
| 2046 | Phosphoryl bromide dichloride        | POBrCl <sub>2</sub>                                  | 13455-03-3  | 197.783     | col liq                 | 11       | 136.5    | 2.104 <sup>14</sup>        |                                     |                                                        |
| 2047 | Phosphoryl bromide difluoride        | POBrF <sub>2</sub>                                   | 14014-18-7  | 164.874     | col liq                 | -84.8    | 31.6     |                            |                                     |                                                        |
| 2048 | Phosphoryl bromide chloride fluoride | POBrClF                                              | 14518-81-1  | 181.328     | col liq                 |          | 79       |                            |                                     |                                                        |
| 2049 | Phosphoryl chloride                  | POCl <sub>3</sub>                                    | 10025-87-3  | 153.332     | col liq                 | 1.18     | 105.5    | 1.645                      |                                     | reac H <sub>2</sub> O, EtOH                            |
| 2050 | Phosphoryl dichloride fluoride       | POCl <sub>2</sub> F                                  | 13769-76-1  | 136.877     | col liq                 | -80.1    | 52.9     |                            |                                     |                                                        |
| 2051 | Phosphoryl chloride difluoride       | POClF <sub>2</sub>                                   | 13769-75-0  | 120.423     | col gas                 | -96.4    | 3.1      | 4.922 g/L                  |                                     |                                                        |
| 2052 | Phosphoryl fluoride                  | POF <sub>3</sub>                                     | 13478-20-1  | 103.968     | col gas                 | -39.1 tp | -39.7 sp | 4.250 g/L                  |                                     | reac H <sub>2</sub> O                                  |
| 2053 | Phosphoryl iodide                    | POI <sub>3</sub>                                     | 13455-04-4  | 427.686     | viol cry                | 53       |          |                            |                                     |                                                        |
| 2054 | Phosphorothioc tribromide            | PSBr <sub>3</sub>                                    | 3931-89-3   | 302.751     | yel cry                 | 37.8     | 212 dec  | 2.85                       |                                     |                                                        |
| 2055 | Phosphorothioc dibromide fluoride    | PSBr <sub>2</sub> F                                  | 13706-10-0  | 241.845     | yel liq                 | -75.2    | 125.3    |                            |                                     |                                                        |
| 2056 | Phosphorothioc bromide difluoride    | PSBrF <sub>2</sub>                                   | 13706-09-7  | 180.940     | yel liq                 | -136.9   | 35.5     |                            |                                     |                                                        |
| 2057 | Phosphorothioc trichloride           | PSCl <sub>3</sub>                                    | 3982-91-0   | 169.398     | fuming liq              | -36.2    | 125      | 1.635                      |                                     | reac H <sub>2</sub> O; s bz, etc, chl, CS <sub>2</sub> |
| 2058 | Phosphorothioc dichloride fluoride   | PSCl <sub>2</sub> F                                  | 155698-29-6 | 152.943     | col liq                 | -96.0    | 64.7     |                            |                                     |                                                        |
| 2059 | Phosphorothioc chloride difluoride   | PSClF <sub>2</sub>                                   | 2524-02-9   | 136.489     | col gas                 | -155.2   | 6.3      | 5.579 g/L                  |                                     |                                                        |
| 2060 | Phosphorothioc trifluoride           | PSF <sub>3</sub>                                     | 2404-52-6   | 120.034     | col gas                 | -148.8   | -52.25   | 4.906 g/L                  |                                     |                                                        |
| 2061 | Phosphorothioc triiodide             | PSI <sub>3</sub>                                     | 63972-04-3  | 443.752     | yel cry                 | 48       | dec      |                            |                                     |                                                        |
| 2062 | Platinum                             | Pt                                                   | 7440-06-4   | 195.084     | silv-gray metal; cub    | 1768.2   | 3825     | 21.5                       |                                     | i acid; s aqua regia                                   |
| 2063 | Hexachloroplatinic acid              | H <sub>2</sub> PtCl <sub>6</sub>                     | 16941-12-1  | 409.818     | hyg yel-brn cry         | 60       |          |                            |                                     | s H <sub>2</sub> O, EtOH                               |
| 2064 | Hydrogen hexahydroxyplatinate(IV)    | H <sub>2</sub> Pt(OH) <sub>6</sub>                   | 51850-20-5  | 299.144     | yel needles             | dec 100  |          |                            |                                     | s H <sub>2</sub> O, acid, dil alk                      |
| 2065 | Platinum(II) bromide                 | PtBr <sub>2</sub>                                    | 13455-12-4  | 354.892     | red-brn powder          | 250 dec  |          | 6.65                       |                                     | i H <sub>2</sub> O                                     |
| 2066 | Platinum(II) chloride                | PtCl <sub>2</sub>                                    | 10025-65-7  | 265.990     | grn hex cry             | 581 dec  |          | 6.0                        |                                     | i H <sub>2</sub> O, EtOH, eth; s HCl                   |
| 2067 | Platinum(II) cyanide                 | Pt(CN) <sub>2</sub>                                  | 592-06-3    | 247.118     | pale yel cry            |          |          |                            |                                     | i H <sub>2</sub> O, acid, alk                          |
| 2068 | Platinum(II) iodide                  | PtI <sub>2</sub>                                     | 7790-39-8   | 448.893     | blk powder              | 325 dec  |          | 6.4                        |                                     | i H <sub>2</sub> O                                     |
| 2069 | Platinum(II) oxide                   | PtO                                                  | 12035-82-4  | 211.083     | blk tetr cry            | 325 dec  |          | 14.1                       |                                     | i H <sub>2</sub> O, EtOH; s aqua regia                 |
| 2070 | Platinum(II) sulfide                 | PtS                                                  | 12038-20-9  | 227.149     | tetr cry                |          |          | 10.25                      |                                     |                                                        |
| 2071 | Platinum(III) bromide                | PtBr <sub>3</sub>                                    | 25985-07-3  | 434.796     | grn-blk cry             | 200 dec  |          |                            |                                     |                                                        |
| 2072 | Platinum(III) chloride               | PtCl <sub>3</sub>                                    | 25909-39-1  | 301.443     | grn-blk cry             | 435 dec  |          | 5.26                       |                                     |                                                        |
| 2073 | Platinum(IV) bromide                 | PtBr <sub>4</sub>                                    | 68938-92-1  | 514.700     | brn-blk cry             | 180 dec  |          |                            | 0.41 <sup>20</sup>                  | sl EtOH, eth                                           |
| 2074 | Platinum(IV) chloride                | PtCl <sub>4</sub>                                    | 37773-49-2  | 336.896     | red-brn cub cry         | 327 dec  |          | 4.30                       | 142 <sup>25</sup>                   |                                                        |
| 2075 | Platinum(IV) chloride pentahydrate   | PtCl <sub>4</sub> · 5H <sub>2</sub> O                | 13454-96-1  | 426.972     | red cry                 |          |          | 2.43                       |                                     | s H <sub>2</sub> O, EtOH                               |
| 2076 | Platinum(IV) fluoride                | PtF <sub>4</sub>                                     | 13455-15-7  | 271.078     | red cry                 | 600      |          |                            |                                     |                                                        |
| 2077 | Platinum(IV) iodide                  | PtI <sub>4</sub>                                     | 7790-46-7   | 702.702     | brn-blk powder          | 130 dec  |          |                            |                                     | s H <sub>2</sub> O                                     |
| 2078 | Platinum(IV) oxide                   | PtO <sub>2</sub>                                     | 1314-15-4   | 227.083     | blk hex cry             | 450      |          | 11.8                       |                                     | i H <sub>2</sub> O; s conc acid, dil alk               |
| 2079 | Platinum(IV) sulfide                 | PtS <sub>2</sub>                                     | 12038-21-0  | 259.214     | hex cry                 |          |          | 7.85                       |                                     |                                                        |
| 2080 | Platinum(VI) fluoride                | PtF <sub>6</sub>                                     | 13693-05-5  | 309.074     | red cub cry             | 61.3     | 69.1     | ≈4.0                       |                                     |                                                        |
| 2081 | cis-Diamminedichloroplatinum         | Pt(NH <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub>    | 15663-27-1  | 300.051     | yel solid               | 270 dec  |          |                            | 0.253 <sup>25</sup>                 |                                                        |
| 2082 | trans-Diamminedichloroplatinum       | Pt(NH <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub>    | 14913-33-8  | 300.051     | pale yel solid          | 270 dec  |          |                            | 0.036 <sup>25</sup>                 | s DMF, DMSO                                            |
| 2083 | Hexachloroplatinic acid hexahydrate  | H <sub>2</sub> PtCl <sub>6</sub> · 6H <sub>2</sub> O | 16941-12-1  | 517.909     | brn-yel hyg cry         | 60       |          | 2.43                       | 140 <sup>18</sup>                   | vs EtOH                                                |
| 2084 | Platinum silicide                    | PtSi                                                 | 12137-83-6  | 223.170     | orth cry                | 1229     |          | 12.4                       |                                     |                                                        |
| 2085 | Plutonium                            | Pu                                                   | 7440-07-5   | 244         | silv-wh metal; monocl   | 640      | 3228     | 19.7                       |                                     |                                                        |
| 2086 | Plutonium nitride                    | PuN                                                  | 12033-54-4  | 258         | gray cub cry            | 2550     |          | 14.4                       |                                     |                                                        |
| 2087 | Plutonium(II) oxide                  | PuO                                                  | 12035-83-5  | 260         | cub cry                 |          |          | 14.0                       |                                     |                                                        |
| 2088 | Plutonium(III) bromide               | PuBr <sub>3</sub>                                    | 15752-46-2  | 484         | grn orth cry            | 681      |          | 6.75                       |                                     | s H <sub>2</sub> O                                     |
| 2089 | Plutonium(III) chloride              | PuCl <sub>3</sub>                                    | 13569-62-5  | 350         | grn hex cry             | 760      |          | 5.71                       |                                     | s H <sub>2</sub> O                                     |
| 2090 | Plutonium(III) fluoride              | PuF <sub>3</sub>                                     | 13842-83-6  | 301         | purp hex cry            | 1396     |          | 9.33                       |                                     | i H <sub>2</sub> O; sl acid                            |
| 2091 | Plutonium(III) iodide                | PuI <sub>3</sub>                                     | 13813-46-2  | 625         | grn orth cry; hyg       | 777      |          | 6.92                       |                                     | s H <sub>2</sub> O                                     |
| 2092 | Plutonium(III) oxide                 | Pu <sub>2</sub> O <sub>3</sub>                       | 12036-34-9  | 536         | blk cub cry             | 2085     |          | 10.5                       |                                     |                                                        |
| 2093 | Plutonium(IV) fluoride               | PuF <sub>4</sub>                                     | 13709-56-3  | 320         | red-brn monocl cry      | 1037     |          | 7.1                        |                                     |                                                        |
| 2094 | Plutonium(IV) oxide                  | PuO <sub>2</sub>                                     | 12059-95-9  | 276         | yel-brn cub cry         | 2390     |          | 11.5                       |                                     |                                                        |
| 2095 | Plutonium(VI) fluoride               | PuF <sub>6</sub>                                     | 13693-06-6  | 358         | red-brn orth cry        | 51.6     |          | 5.08                       |                                     |                                                        |
| 2096 | Polonium                             | Po                                                   | 7440-08-6   | 209         | silv metal; cub         | 254      | 962      | 9.20                       |                                     |                                                        |
| 2097 | Polonium(IV) chloride                | PoCl <sub>4</sub>                                    | 10026-02-5  | 351         | yel hyg cry             | ≈300     | 390      |                            |                                     | s H <sub>2</sub> O, EtOH, ace                          |
| 2098 | Polonium(IV) oxide                   | PoO <sub>2</sub>                                     | 7446-06-2   | 241         | yel cub cry             | 500 dec  |          | 8.9                        |                                     |                                                        |
| 2099 | Potassium                            | K                                                    | 7440-09-7   | 39.098      | soft silv-wh metal; cub | 63.5     | 759      | 0.89                       |                                     | reac H <sub>2</sub> O                                  |
| 2100 | Potassium acetate                    | KC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>        | 127-08-2    | 98.142      | wh hyg cry              | 309      |          | 1.57                       | 269 <sup>25</sup>                   | s EtOH; i eth                                          |



| No.  | Name                                      | Formula                                                                        | CAS Reg No. | Mol. weight | Physical form          | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                  |
|------|-------------------------------------------|--------------------------------------------------------------------------------|-------------|-------------|------------------------|----------|----------|----------------------------|-------------------------------------|-----------------------------------------|
| 2101 | Potassium aluminate trihydrate            | K <sub>2</sub> Al <sub>2</sub> O <sub>4</sub> · 3H <sub>2</sub> O              | 12003-63-3* | 250.204     | wh orth cry            |          |          | 2.13                       |                                     | vs H <sub>2</sub> O; i EtOH             |
| 2102 | Potassium aluminum silicate               | KAlSi <sub>3</sub> O <sub>8</sub>                                              | 1327-44-2   | 278.332     | col monocl cry         |          |          | 2.56                       |                                     | i H <sub>2</sub> O                      |
| 2103 | Potassium aluminum sulfate                | KAl(SO <sub>4</sub> ) <sub>2</sub>                                             | 10043-67-1  | 258.205     | wh hyg powder          |          |          |                            | 5.9 <sup>20</sup>                   |                                         |
| 2104 | Potassium aluminum sulfate dodecahydrate  | KAl(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O                        | 7784-24-9   | 474.389     | col cry                | ≈100 dec |          | 1.72                       | 5.9 <sup>20</sup>                   |                                         |
| 2105 | Potassium amide                           | KNH <sub>2</sub>                                                               | 17242-52-3  | 55.121      | wh/yel-grn hyg cry     | 335      |          |                            |                                     | reac H <sub>2</sub> O, EtOH             |
| 2106 | Potassium arsenate                        | K <sub>3</sub> AsO <sub>4</sub>                                                | 13464-36-3  | 256.215     | col cry                |          |          | 2.8                        | 125 <sup>25</sup>                   |                                         |
| 2107 | Potassium arsenite                        | KAsO <sub>2</sub>                                                              | 13464-35-2  | 146.019     | wh hyg powder          |          |          |                            |                                     | s H <sub>2</sub> O; sl EtOH             |
| 2108 | Potassium azide                           | KN <sub>3</sub>                                                                | 20762-60-1  | 81.118      | tetr cry; exp          |          |          | 2.04                       | 49.7 <sup>17</sup>                  |                                         |
| 2109 | Potassium borohydride                     | KBH <sub>4</sub>                                                               | 13762-51-1  | 53.941      | wh cub cry             | ≈500 dec |          | 1.11                       |                                     | s H <sub>2</sub> O                      |
| 2110 | Potassium bromate                         | KBrO <sub>3</sub>                                                              | 7758-01-2   | 167.000     | wh hex cry             | 434 dec  |          | 3.27                       | 8.17 <sup>25</sup>                  | i EtOH                                  |
| 2111 | Potassium bromide                         | KBr                                                                            | 7758-02-3   | 119.002     | col cub cry; hyg       | 734      | 1435     | 2.74                       | 67.8 <sup>25</sup>                  | sl EtOH                                 |
| 2112 | Potassium carbonate                       | K <sub>2</sub> CO <sub>3</sub>                                                 | 584-08-7    | 138.206     | wh monocl cry; hyg     | 899      | dec      | 2.29                       | 111 <sup>25</sup>                   | i EtOH                                  |
| 2113 | Potassium carbonate sesquihydrate         | K <sub>2</sub> CO <sub>3</sub> · 1.5H <sub>2</sub> O                           | 6381-79-9   | 165.229     | granular cry           |          |          |                            | 111 <sup>20</sup>                   |                                         |
| 2114 | Potassium chlorate                        | KClO <sub>3</sub>                                                              | 3811-04-9   | 122.549     | wh monocl cry          | 357      | dec      | 2.34                       | 8.61 <sup>25</sup>                  |                                         |
| 2115 | Potassium chloride                        | KCl                                                                            | 7447-40-7   | 74.551      | wh cub cry             | 771      |          | 1.988                      | 35.5 <sup>25</sup>                  | i eth, ace                              |
| 2116 | Potassium chlorochromate                  | KCrO <sub>3</sub> Cl                                                           | 16037-50-6  | 174.545     | oran cry               |          |          | 2.5                        |                                     | reac H <sub>2</sub> O; s ace, acid      |
| 2117 | Potassium chromate                        | K <sub>2</sub> CrO <sub>4</sub>                                                | 7789-00-6   | 194.191     | yel orth cry           | 974      |          | 2.73                       | 65.0 <sup>25</sup>                  |                                         |
| 2118 | Potassium citrate monohydrate             | K <sub>3</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> · H <sub>2</sub> O | 6100-05-6   | 324.410     | col hyg cry            | 180 dec  |          | 1.98                       | 172 <sup>20</sup>                   | vs H <sub>2</sub> O; sl EtOH            |
| 2119 | Potassium cobalt(II) selenate hexahydrate | K <sub>2</sub> Co(SeO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O          | 28041-86-3  | 531.14      | red monocl cry         |          |          | 2.51                       |                                     |                                         |
| 2120 | Potassium cyanate                         | KCNO                                                                           | 590-28-3    | 81.115      | wh tetr cry            | ≈700 dec |          | 2.05                       | 75 <sup>25</sup>                    | sl EtOH                                 |
| 2121 | Potassium cyanide                         | KCN                                                                            | 151-50-8    | 65.116      | wh cub cry; hyg        | 622      |          | 1.55                       | 69.9 <sup>20</sup>                  | sl EtOH                                 |
| 2122 | Potassium cyanoaurite                     | KAu(CN) <sub>2</sub>                                                           | 13967-50-5  | 288.099     | col cry                |          |          | 3.45                       | 14 <sup>20</sup>                    | s H <sub>2</sub> O; sl EtOH; i eth, ace |
| 2123 | Potassium dichromate                      | K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>                                  | 7778-50-9   | 294.185     | oran-red tricl cry     | 398      | ≈500 dec | 2.68                       | 15.1 <sup>25</sup>                  |                                         |
| 2124 | Potassium dihydrogen arsenate             | KH <sub>2</sub> AsO <sub>4</sub>                                               | 7784-41-0   | 180.034     | col cry                | 288      |          | 2.87                       | 19 <sup>6</sup>                     | i EtOH                                  |
| 2125 | Potassium dihydrogen phosphate            | KH <sub>2</sub> PO <sub>4</sub>                                                | 7778-77-0   | 136.085     | wh tetr cry            | 253 dec  |          | 2.34                       | 25.0 <sup>25</sup>                  | sl EtOH                                 |
| 2126 | Potassium dihydrogen phosphonate          | KH <sub>2</sub> PO <sub>3</sub>                                                | 13977-65-6  | 120.086     | col monocl hyg cry     |          |          |                            |                                     |                                         |
| 2127 | Potassium dithionate                      | K <sub>2</sub> S <sub>2</sub> O <sub>6</sub>                                   | 13455-20-4  | 238.323     | col hex cry            | dec      |          | 2.27                       |                                     | sl H <sub>2</sub> O; i EtOH             |
| 2128 | Potassium ferricyanide                    | K <sub>3</sub> Fe(CN) <sub>6</sub>                                             | 13746-66-2  | 329.244     | red cry                | dec      |          | 1.89                       | 48.8 <sup>25</sup>                  |                                         |
| 2129 | Potassium ferrocyanide trihydrate         | K <sub>4</sub> Fe(CN) <sub>6</sub> · 3H <sub>2</sub> O                         | 14459-95-1  | 422.388     | yel monocl cry         | 60 dec   |          | 1.85                       | 36.0 <sup>25</sup>                  | i EtOH, eth                             |
| 2130 | Potassium fluoride                        | KF                                                                             | 7789-23-3   | 58.096      | wh cub cry             | 858      | 1502     | 2.48                       | 102 <sup>25</sup>                   |                                         |
| 2131 | Potassium fluoride dihydrate              | KF · 2H <sub>2</sub> O                                                         | 13455-21-5  | 94.127      | monocl cry             | 41 dec   |          | 2.5                        | 102 <sup>25</sup>                   |                                         |
| 2132 | Potassium fluoroborate                    | KBF <sub>4</sub>                                                               | 14075-53-7  | 125.903     | col orth cry           | 530      |          | 2.505                      | 0.55 <sup>25</sup>                  | sl EtOH                                 |
| 2133 | Potassium fluorotantalate                 | K <sub>2</sub> TaF <sub>7</sub>                                                | 16924-00-8  | 392.134     | col cry                | 730      |          | 5.24                       | 0.5 <sup>0</sup>                    |                                         |
| 2134 | Potassium formate                         | KCHO <sub>2</sub>                                                              | 590-29-4    | 84.116      | col hyg cry            | 167      |          | 1.91                       | 331 <sup>18</sup>                   |                                         |
| 2135 | Potassium hexachloroosmate(IV)            | K <sub>2</sub> OsCl <sub>6</sub>                                               | 16871-60-6  | 481.15      | red cub cry            |          |          |                            |                                     | vs H <sub>2</sub> O; sl EtOH            |
| 2136 | Potassium hexachloroplatinate             | K <sub>2</sub> PtCl <sub>6</sub>                                               | 16921-30-5  | 485.999     | yel-oran cub cry       | 250 dec  |          | 3.50                       | 0.77 <sup>20</sup>                  | i EtOH                                  |
| 2137 | Potassium hexacyanocobaltate              | K <sub>3</sub> Co(CN) <sub>6</sub>                                             | 13963-58-1  | 332.332     | yel monocl cry         | dec      |          | 1.91                       |                                     | vs H <sub>2</sub> O; i EtOH             |
| 2138 | Potassium hexafluoromanganate(IV)         | K <sub>2</sub> MnF <sub>6</sub>                                                | 16962-31-5  | 247.125     | yel hex cry            |          |          |                            |                                     | reac H <sub>2</sub> O                   |
| 2139 | Potassium hexafluorosilicate              | K <sub>2</sub> SiF <sub>6</sub>                                                | 16871-90-2  | 220.273     | wh cry                 | dec      |          | 2.27                       | 0.084 <sup>20</sup>                 | i EtOH                                  |
| 2140 | Potassium hexafluorozirconate(IV)         | K <sub>2</sub> ZrF <sub>6</sub>                                                | 16923-95-8  | 283.411     | col monocl cry         |          |          | 3.48                       | 0.78 <sup>2</sup>                   |                                         |
| 2141 | Potassium hydride                         | KH                                                                             | 7693-26-7   | 40.106      | cub cry                | 619      |          | 1.43                       |                                     | reac H <sub>2</sub> O                   |
| 2142 | Potassium hydrogen arsenate               | K <sub>2</sub> HAsO <sub>4</sub>                                               | 21093-83-4  | 218.125     | col monocl prisms      | 300 dec  |          |                            | 18.7 <sup>8</sup>                   | i EtOH                                  |
| 2143 | Potassium hydrogen carbonate              | KHCO <sub>3</sub>                                                              | 298-14-6    | 100.115     | col monocl cry         | ≈100 dec |          | 2.17                       | 36.2 <sup>25</sup>                  | i EtOH                                  |
| 2144 | Potassium hydrogen fluoride               | KHF <sub>2</sub>                                                               | 7789-29-9   | 78.103      | col tetr cry           | 238.8    |          | 2.37                       | 39.2 <sup>20</sup>                  | i EtOH                                  |
| 2145 | Potassium hydrogen iodate                 | KH(IO <sub>3</sub> ) <sub>2</sub>                                              | 13455-24-8  | 389.911     | col cry                | dec      |          |                            | 1.3 <sup>15</sup>                   | sl H <sub>2</sub> O; i EtOH             |
| 2146 | Potassium hydrogen oxalate hemihydrate    | KHC <sub>2</sub> O <sub>4</sub> · 0.5H <sub>2</sub> O                          | 127-95-7    |             | wh cry                 | dec      |          | 2.09                       | 2.5 <sup>20</sup>                   | sl EtOH                                 |
| 2147 | Potassium hydrogen phosphate              | K <sub>2</sub> HPO <sub>4</sub>                                                | 7758-11-4   | 174.176     | wh hyg cry             | dec      |          |                            | 168 <sup>25</sup>                   | s EtOH                                  |
| 2148 | Potassium hydrogen phosphite              | K <sub>2</sub> HPO <sub>3</sub>                                                | 13492-26-7  | 158.177     | wh hyg powder          | dec      |          |                            | 170 <sup>20</sup>                   | i EtOH                                  |
| 2149 | Potassium hydrogen selenite               | KHSeO <sub>3</sub>                                                             | 7782-70-9   | 167.06      | hyg orth cry           | >100 dec |          |                            |                                     | s H <sub>2</sub> O; sl EtOH             |
| 2150 | Potassium hydrogen sulfate                | KHSO <sub>4</sub>                                                              | 7646-93-7   | 136.169     | wh monocl cry; hyg     | ≈200     |          | 2.32                       | 50.6 <sup>25</sup>                  |                                         |
| 2151 | Potassium hydrogen sulfide                | KHS                                                                            | 1310-61-8   | 72.171      | wh hex cry; hyg        | ≈450     |          | 1.69                       |                                     | s H <sub>2</sub> O, EtOH                |
| 2152 | Potassium hydrogen sulfide hemihydrate    | KHS · 0.5H <sub>2</sub> O                                                      | 1310-61-8*  | 81.179      | wh-yel hyg cry         | ≈175     |          | 1.7                        |                                     | vs H <sub>2</sub> O, EtOH               |
| 2153 | Potassium hydrogen sulfite                | KHSO <sub>3</sub>                                                              | 7773-03-7   | 120.169     | wh cry powder          | 190 dec  |          |                            | 49 <sup>20</sup>                    | i EtOH                                  |
| 2154 | Potassium hydrogen tartrate               | KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                                 | 868-14-4    | 188.177     | wh cry                 |          |          | 1.98                       | 0.57 <sup>20</sup>                  | s acid, alk; i EtOH                     |
| 2155 | Potassium hydroxide                       | KOH                                                                            | 1310-58-3   | 56.105      | wh rhomb cry; hyg      | 406      | 1327     | 2.044                      | 121 <sup>25</sup>                   | s EtOH; s MeOH                          |
| 2156 | Potassium hypochlorite                    | KOCl                                                                           | 7778-66-7   | 90.550      | exists only in aq soln |          |          |                            |                                     |                                         |
| 2157 | Potassium phosphinate                     | KH <sub>2</sub> PO <sub>2</sub>                                                | 7782-87-8   | 104.087     | wh hyg cry             | dec      |          |                            |                                     | vs H <sub>2</sub> O; s EtOH             |

| No.  | Name                                         | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form          | mp/°C    | bp/°C      | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                 |
|------|----------------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|------------------------|----------|------------|----------------------------|-------------------------------------|--------------------------------------------------------|
| 2158 | Potassium iodate                             | KIO <sub>3</sub>                                                                   | 7758-05-6   | 214.001     | wh monocl cry          | 560 dec  |            | 3.89                       | 9.22 <sup>25</sup>                  |                                                        |
| 2159 | Potassium iodide                             | KI                                                                                 | 7681-11-0   | 166.003     | col cub cry            | 681      | 1323       | 3.12                       | 148 <sup>25</sup>                   | sl EtOH                                                |
| 2160 | Potassium iron(III) oxalate trihydrate       | K <sub>3</sub> Fe(C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> · 3H <sub>2</sub> O |             | 491.243     | grn monocl cry         | 100      | 230 dec    | 2.133                      | 4.7 <sup>0</sup>                    | i EtOH                                                 |
| 2161 | Potassium manganate                          | K <sub>2</sub> MnO <sub>4</sub>                                                    | 10294-64-1  | 197.133     | grn cry                | 190 dec  |            |                            |                                     | s H <sub>2</sub> O; reac HCl                           |
| 2162 | Potassium metaarsenate                       | KAsO <sub>3</sub>                                                                  | 19197-73-0  | 162.018     | wh solid               | 660      |            |                            |                                     |                                                        |
| 2163 | Potassium metabisulfite                      | K <sub>2</sub> S <sub>2</sub> O <sub>5</sub>                                       | 16731-55-8  | 222.324     | wh powder              | ≈150 dec |            | 2.3                        | 49.5 <sup>25</sup>                  | reac acid; i EtOH                                      |
| 2164 | Potassium metaborate                         | KBO <sub>2</sub>                                                                   | 13709-94-9  | 81.908      | wh hex cry             | 947      |            | ≈2.3                       |                                     |                                                        |
| 2165 | Potassium molybdate                          | K <sub>2</sub> MoO <sub>4</sub>                                                    | 13446-49-6  | 238.14      | wh hyg cry             | 919      |            | 2.3                        | 183 <sup>25</sup>                   | i EtOH                                                 |
| 2166 | Potassium niobate                            | KNbO <sub>3</sub>                                                                  | 12030-85-2  | 180.002     | wh rhomb cry           | ≈1100    |            | 4.64                       |                                     | i H <sub>2</sub> O                                     |
| 2167 | Potassium nitrate                            | KNO <sub>3</sub>                                                                   | 7757-79-1   | 101.103     | col orth cry or powder | 334      | 400 dec    | 2.105                      | 38.3 <sup>25</sup>                  | i EtOH                                                 |
| 2168 | Potassium nitrite                            | KNO <sub>2</sub>                                                                   | 7758-09-0   | 85.104      | wh hyg cry             | 438      | 537 exp    | 1.915                      | 312 <sup>25</sup>                   | sl EtOH                                                |
| 2169 | Potassium oxalate                            | K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                                       | 583-52-8    | 166.216     | wh pwd                 |          |            |                            |                                     | sl H <sub>2</sub> O                                    |
| 2170 | Potassium oxalate monohydrate                | K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> O                    | 6487-48-5   | 184.231     | col cry                | 160 dec  |            | 2.13                       | 36.4 <sup>20</sup>                  |                                                        |
| 2171 | Potassium oxide                              | K <sub>2</sub> O                                                                   | 12136-45-7  | 94.196      | gray cub cry           | 740      |            | 2.35                       |                                     | s H <sub>2</sub> O, EtOH, eth                          |
| 2172 | Potassium perbromate                         | KBrO <sub>4</sub>                                                                  | 22207-96-1  | 183.000     | wh cry                 | 275 dec  |            |                            | 4.21 <sup>25</sup>                  |                                                        |
| 2173 | Potassium percarbonate monohydrate           | K <sub>2</sub> C <sub>2</sub> O <sub>6</sub> · H <sub>2</sub> O                    | 589-97-9    | 216.230     | oran or blue pow       |          |            |                            | 6.5 <sup>20</sup>                   |                                                        |
| 2174 | Potassium perchlorate                        | KClO <sub>4</sub>                                                                  | 7778-74-7   | 138.549     | col orth cry; hyg      | 525      |            | 2.52                       | 2.08 <sup>25</sup>                  |                                                        |
| 2175 | Potassium periodate                          | KIO <sub>4</sub>                                                                   | 7790-21-8   | 230.001     | col tetr cry           | 582      | exp        | 3.618                      | 0.51 <sup>25</sup>                  |                                                        |
| 2176 | Potassium permanganate                       | KMnO <sub>4</sub>                                                                  | 7722-64-7   | 158.034     | purp orth cry          | dec      |            | 2.7                        | 7.60 <sup>25</sup>                  | reac EtOH                                              |
| 2177 | Potassium peroxide                           | K <sub>2</sub> O <sub>2</sub>                                                      | 17014-71-0  | 110.196     | yel amorp solid        | 490      |            |                            |                                     | reac H <sub>2</sub> O                                  |
| 2178 | Potassium persulfate                         | K <sub>2</sub> S <sub>2</sub> O <sub>8</sub>                                       | 7727-21-1   | 270.322     | col cry                | ≈100 dec |            | 2.48                       | 4.7 <sup>20</sup>                   |                                                        |
| 2179 | Potassium phosphate                          | K <sub>3</sub> PO <sub>4</sub>                                                     | 7778-53-2   | 212.266     | wh orth cry; hyg       | 1340     |            | 2.564                      | 106 <sup>25</sup>                   | i EtOH                                                 |
| 2180 | Potassium pyrophosphate                      | K <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                                       | 7320-34-5   |             | wh cry                 | dec 1300 |            |                            |                                     | s H <sub>2</sub>                                       |
| 2181 | Potassium pyrophosphate trihydrate           | K <sub>4</sub> P <sub>2</sub> O <sub>7</sub> · 3H <sub>2</sub> O                   | 7790-67-2   | 384.383     | col hyg cry            | dec 300  |            | 2.33                       |                                     | vs H <sub>2</sub> O; i EtOH                            |
| 2182 | Potassium pyrosulfate                        | K <sub>2</sub> S <sub>2</sub> O <sub>7</sub>                                       | 7790-62-7   | 254.323     | col needles            | ≈325     |            | 2.28                       |                                     | s H <sub>2</sub> O                                     |
| 2183 | Potassium selenate                           | K <sub>2</sub> SeO <sub>4</sub>                                                    | 7790-59-2   | 221.16      | wh powder              |          |            | 3.07                       | 114 <sup>25</sup>                   |                                                        |
| 2184 | Potassium selenide                           | K <sub>2</sub> Se                                                                  | 1312-74-9   | 157.16      | red cub cry; hyg       | 800      |            | 2.29                       |                                     | s H <sub>2</sub> O                                     |
| 2185 | Potassium selenite                           | K <sub>2</sub> SeO <sub>3</sub>                                                    | 10431-47-7  | 205.16      | wh hyg cry             | 875 dec  |            |                            | 217 <sup>25</sup>                   | sl EtOH                                                |
| 2186 | Potassium silver cyanide                     | KAg(CN) <sub>2</sub>                                                               | 506-61-6    | 199.000     | wh cry                 |          |            |                            |                                     | s H <sub>2</sub> O                                     |
| 2187 | Potassium sodium tartrate tetrahydrate       | KNaC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> · 4H <sub>2</sub> O                | 6381-59-5   | 282.220     | wh cry                 | ≈70 dec  | anh at 130 | 1.79                       |                                     | vs H <sub>2</sub> O; i EtOH                            |
| 2188 | Potassium stannate trihydrate                | K <sub>2</sub> SnO <sub>3</sub> · 3H <sub>2</sub> O                                | 12142-33-5* | 298.951     | col cry                |          |            | 3.20                       |                                     | vs H <sub>2</sub> O; i EtOH                            |
| 2189 | Potassium stearate                           | KC <sub>18</sub> H <sub>35</sub> O <sub>2</sub>                                    | 593-29-3    | 322.568     | wh pow                 |          |            |                            |                                     | sl cold H <sub>2</sub> O; s hot H <sub>2</sub> O, EtOH |
| 2190 | Potassium sulfate                            | K <sub>2</sub> SO <sub>4</sub>                                                     | 7778-80-5   | 174.260     | wh orth cry            | 1069     |            | 2.66                       | 12.0 <sup>25</sup>                  | i EtOH                                                 |
| 2191 | Potassium sulfide                            | K <sub>2</sub> S                                                                   | 1312-73-8   | 110.262     | red-yel cub cry; hyg   | 948      |            | 1.74                       |                                     | s H <sub>2</sub> O, EtOH; i eth                        |
| 2192 | Potassium sulfide pentahydrate               | K <sub>2</sub> S · 5H <sub>2</sub> O                                               | 37248-34-3  | 200.338     | col rhomb cry          | 60       |            |                            |                                     | vs H <sub>2</sub> O, EtOH; i eth                       |
| 2193 | Potassium sulfite                            | K <sub>2</sub> SO <sub>3</sub>                                                     | 10117-38-1  | 158.260     | col hex cry            |          |            |                            | 106 <sup>25</sup>                   | sl EtOH                                                |
| 2194 | Potassium sulfite dihydrate                  | K <sub>2</sub> SO <sub>3</sub> · 2H <sub>2</sub> O                                 | 7790-56-9   | 194.291     | wh monocl cry          | dec      |            |                            | 107 <sup>20</sup>                   | sl EtOH; dec dil acid                                  |
| 2195 | Potassium superoxide                         | KO <sub>2</sub>                                                                    | 12030-88-5  | 71.097      | yel tetr cry; hyg      | 380      |            | 2.16                       |                                     | reac H <sub>2</sub> O                                  |
| 2196 | Potassium tellurate(VI) trihydrate           | K <sub>2</sub> TeO <sub>4</sub> · 3H <sub>2</sub> O                                | 15571-91-2* | 323.84      | wh cry powder          |          |            |                            |                                     | s H <sub>2</sub> O                                     |
| 2197 | Potassium tellurite                          | K <sub>2</sub> TeO <sub>3</sub>                                                    | 7790-58-1   | 253.80      | wh hyg cry             | ≈460 dec |            |                            |                                     | vs H <sub>2</sub> O                                    |
| 2198 | Potassium tetraborate pentahydrate           | K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> · 5H <sub>2</sub> O                   | 1332-77-0   | 323.513     | wh cry powder          |          |            |                            | 16.5 <sup>30</sup>                  | sl EtOH                                                |
| 2199 | Potassium tetrachloroaurate dihydrate        | KAuCl <sub>4</sub> · 2H <sub>2</sub> O                                             | 13682-61-6  | 413.908     | yel monocl cry         |          |            |                            |                                     | s H <sub>2</sub> O, EtOH, eth                          |
| 2200 | Potassium tetrachloroplatinate               | K <sub>2</sub> PtCl <sub>4</sub>                                                   | 10025-99-7  | 415.093     | pink-red tetr cry      | 500 dec  |            | 3.38                       |                                     | s H <sub>2</sub> O; i EtOH                             |
| 2201 | Potassium tetracyanocadmte                   | K <sub>2</sub> Cd(CN) <sub>4</sub>                                                 | 14402-75-6  | 294.678     | cub cry                | ≈450     |            | 1.85                       | 25 <sup>20</sup>                    | sl EtOH                                                |
| 2202 | Potassium tetracyanonickelate monohydrate    | K <sub>2</sub> [Ni(CN) <sub>4</sub> ] · H <sub>2</sub> O                           | 14220-17-8* | 258.975     | red-oran cry           | dec 100  |            |                            |                                     |                                                        |
| 2203 | Potassium tetracyanoplatinate(II) trihydrate | K <sub>2</sub> Pt(CN) <sub>4</sub> · 3H <sub>2</sub> O                             | 562-76-5*   | 431.397     | col rhomb prisms       |          |            |                            |                                     | s H <sub>2</sub> O                                     |
| 2204 | Potassium tetracyanozincate                  | K <sub>2</sub> Zn(CN) <sub>4</sub>                                                 | 14244-62-3  | 247.676     | cry pow                |          |            |                            |                                     | vs H <sub>2</sub> O                                    |
| 2205 | Potassium tetraiodomercurate(II)             | K <sub>2</sub> HgI <sub>4</sub>                                                    | 7783-33-7   | 786.40      | yel hyg cry            |          |            | 4.29                       |                                     | vs H <sub>2</sub> O; s EtOH, eth, ace                  |
| 2206 | Potassium thiocyanate                        | KSCN                                                                               | 333-20-0    | 97.181      | col tetr cry; hyg      | 173      | 500 dec    | 1.88                       | 238 <sup>25</sup>                   | s EtOH                                                 |
| 2207 | Potassium thiosulfate                        | K <sub>2</sub> S <sub>2</sub> O <sub>3</sub>                                       | 10294-66-3  | 190.325     | col hyg cry            |          |            |                            | 165 <sup>25</sup>                   | i EtOH                                                 |
| 2208 | Potassium titanate                           | K <sub>2</sub> TiO <sub>3</sub>                                                    | 12030-97-6  | 174.062     | wh orth cry            | 1515     |            | 3.1                        |                                     | reac H <sub>2</sub> O                                  |
| 2209 | Potassium triiodide monohydrate              | KI <sub>3</sub> · H <sub>2</sub> O                                                 | 7790-42-3   | 437.827     | brn monocl cry; hyg    | 225 dec  |            | 3.5                        |                                     | s H <sub>2</sub> O; reac EtOH, eth                     |
| 2210 | Potassium triiodozincate                     | KZnI <sub>3</sub>                                                                  | 7790-43-4   | 485.221     | hyg cry                |          |            |                            |                                     | vs H <sub>2</sub> O                                    |
| 2211 | Potassium thiocarbonate                      | K <sub>2</sub> CS <sub>3</sub>                                                     | 26750-66-3  | 186.403     | yel-red hyg cry        |          |            |                            |                                     | vs H <sub>2</sub> O                                    |
| 2212 | Potassium tungstate                          | K <sub>2</sub> WO <sub>4</sub>                                                     | 7790-60-5   | 326.04      | hyg cry                | 921      |            | 3.12                       |                                     | vs H <sub>2</sub> O; i EtOH                            |
| 2213 | Potassium uranate                            | K <sub>2</sub> U <sub>2</sub> O <sub>7</sub>                                       | 7790-63-8   | 666.251     | oran cub cry           |          |            | 6.12                       |                                     | i H <sub>2</sub> O; s acid                             |



| No.  | Name                                      | Formula                                                                              | CAS Reg No. | Mol. weight | Physical form            | mp/°C         | bp/°C     | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility     |
|------|-------------------------------------------|--------------------------------------------------------------------------------------|-------------|-------------|--------------------------|---------------|-----------|----------------------------|-------------------------------------|----------------------------|
| 2214 | Potassium uranyl nitrate                  | K(UO <sub>2</sub> )(NO <sub>3</sub> ) <sub>3</sub>                                   | 18078-40-5  | 495.140     | grn-yel cry pow          |               |           |                            |                                     | vs H <sub>2</sub> O        |
| 2215 | Potassium uranyl sulfate dihydrate        | K <sub>4</sub> (UO <sub>2</sub> )(SO <sub>4</sub> ) <sub>2</sub> · 2H <sub>2</sub> O | 27709-53-1  | 576.381     | grn-yel cry pow          | dec 120       |           | 3.36                       |                                     | vs H <sub>2</sub> O        |
| 2216 | Potassium zinc sulfate hexahydrate        | K <sub>2</sub> Zn(SO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                 | 13932-17-7  | 443.823     | cry                      |               |           |                            |                                     | s H <sub>2</sub> O         |
| 2217 | Potassium zirconium sulfate trihydrate    | K <sub>4</sub> Zr(SO <sub>4</sub> ) <sub>4</sub> · 3H <sub>2</sub> O                 | 53608-79-0  | 685.914     | wh cry pow               |               |           |                            |                                     | sl H <sub>2</sub> O        |
| 2218 | Praseodymium                              | Pr                                                                                   | 7440-10-0   | 140.908     | silv metal; hex          | 931           | 3520      | 6.77                       |                                     |                            |
| 2219 | Praseodymium boride                       | PrB <sub>6</sub>                                                                     | 12008-27-4  | 205.774     | blk cub cry              | 2610          |           | 4.84                       |                                     |                            |
| 2220 | Praseodymium nitride                      | PrN                                                                                  | 25764-09-4  | 154.915     | cub cry                  |               |           | 7.46                       |                                     |                            |
| 2221 | Praseodymium silicide                     | PrSi <sub>2</sub>                                                                    | 12066-83-0  | 197.079     | tetr cry                 | 1712          |           | 5.46                       |                                     |                            |
| 2222 | Praseodymium(II) iodide                   | PrI <sub>2</sub>                                                                     | 65530-47-4  | 394.717     | bronze solid             | 758           |           |                            |                                     |                            |
| 2223 | Praseodymium(III) bromate                 | Pr(BrO <sub>3</sub> ) <sub>3</sub>                                                   | 15162-93-3  | 524.615     | grn cry                  |               |           |                            |                                     | vs H <sub>2</sub> O        |
| 2224 | Praseodymium(III) bromide                 | PrBr <sub>3</sub>                                                                    | 13536-53-3  | 380.620     | grn hex cry; hyg         | 693           |           | 5.28                       |                                     | s H <sub>2</sub> O         |
| 2225 | Praseodymium(III) carbonate octahydrate   | Pr <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                  | 14948-62-0  | 605.964     | grn silky plates         | dec 420 (anh) |           |                            |                                     | i H <sub>2</sub> O; s acid |
| 2226 | Praseodymium(III) chloride                | PrCl <sub>3</sub>                                                                    | 10361-79-2  | 247.267     | grn hex needles; hyg     | 786           |           | 4.0                        | 96.1 <sup>25</sup>                  | s EtOH                     |
| 2227 | Praseodymium(III) chloride heptahydrate   | PrCl <sub>3</sub> · 7H <sub>2</sub> O                                                | 10025-90-8  | 373.374     | grn cry                  | 110 dec       |           |                            | 96.1 <sup>25</sup>                  | s EtOH                     |
| 2228 | Praseodymium(III) fluoride                | PrF <sub>3</sub>                                                                     | 13709-46-1  | 197.903     | grn hex cry              | 1399          |           | 6.3                        |                                     |                            |
| 2229 | Praseodymium(III) hydroxide               | Pr(OH) <sub>3</sub>                                                                  | 16469-16-2  | 191.930     | grn solid                | dec 220       |           | 3.7                        |                                     | i H <sub>2</sub> O         |
| 2230 | Praseodymium(III) iodide                  | PrI <sub>3</sub>                                                                     | 13813-23-5  | 521.621     | orth hyg cry             | 738           |           | ≈5.8                       |                                     | s H <sub>2</sub> O         |
| 2231 | Praseodymium(III) nitrate                 | Pr(NO <sub>3</sub> ) <sub>3</sub>                                                    | 10361-80-5  | 326.923     | pale grn hyg cry         |               |           |                            | 165 <sup>26</sup>                   | s EtOH                     |
| 2232 | Praseodymium(III) nitrate hexahydrate     | Pr(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                                | 15878-77-0  | 435.014     | grn needles              |               |           |                            | 165 <sup>26</sup>                   | s EtOH, ace                |
| 2233 | Praseodymium(III) oxide                   | Pr <sub>2</sub> O <sub>3</sub>                                                       | 12036-32-7  | 329.813     | wh hex cry               | 2183          | 3760      | 6.9                        |                                     |                            |
| 2234 | Praseodymium(III) perchlorate hexahydrate | Pr(ClO <sub>4</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                               | 13498-07-2* | 547.351     | hyg grn cry              | dec 200       |           |                            |                                     | s H <sub>2</sub> O, EtOH   |
| 2235 | Praseodymium(III) sulfate octahydrate     | Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                  | 13510-41-3  | 714.125     | grn monocl cry           |               |           | 2.83                       | 17 <sup>20</sup>                    | s H <sub>2</sub> O         |
| 2236 | Praseodymium(III) sulfide                 | Pr <sub>2</sub> S <sub>3</sub>                                                       | 12038-13-0  | 378.010     | cub cry                  | 1765          |           | 5.1                        |                                     |                            |
| 2237 | Praseodymium(III) telluride               | Pr <sub>2</sub> Te <sub>3</sub>                                                      | 12038-12-9  | 664.62      | cub cry                  | 1500          |           | ≈7.0                       |                                     |                            |
| 2238 | Praseodymium(IV) fluoride                 | PrF <sub>4</sub>                                                                     | 15192-24-2  | 216.902     | yel-wh solid             | dec 90        |           |                            |                                     |                            |
| 2239 | Promethium                                | Pm                                                                                   | 7440-12-2   | 145         | silv metal; hex          | 1042          | 3000      | 7.26                       |                                     |                            |
| 2240 | Promethium(III) bromide                   | PmBr <sub>3</sub>                                                                    | 14325-78-1  | 385         | red cry                  | 625           |           |                            |                                     | s H <sub>2</sub> O         |
| 2241 | Promethium(III) chloride                  | PmCl <sub>3</sub>                                                                    | 13779-10-7  | 251         | pale blue hyg cry        | 655           |           |                            |                                     | s H <sub>2</sub> O         |
| 2242 | Promethium(III) fluoride                  | PmF <sub>3</sub>                                                                     | 13709-45-0  | 202         | pink solid               | 1338          |           |                            |                                     | s H <sub>2</sub> O         |
| 2243 | Promethium(III) iodide                    | PmI <sub>3</sub>                                                                     | 13818-73-0  | 526         | red solid                | 695           |           |                            |                                     |                            |
| 2244 | Protactinium                              | Pa                                                                                   | 7440-13-3   | 231.036     | shiny metal; tetr or cub | 1572          |           | 15.4                       |                                     |                            |
| 2245 | Protactinium(V) chloride                  | PaCl <sub>5</sub>                                                                    | 13760-41-3  | 408.301     | yel monocl cry           | 306           |           | 3.74                       |                                     |                            |
| 2246 | Radium                                    | Ra                                                                                   | 7440-14-4   | 226         | wh metal; cub            | 696           |           | 5                          |                                     |                            |
| 2247 | Radium bromide                            | RaBr <sub>2</sub>                                                                    | 10031-23-9  | 386         | wh orth cry              | 728           |           | 5.79                       | 70.6 <sup>20</sup>                  | s EtOH                     |
| 2248 | Radium carbonate                          | RaCO <sub>3</sub>                                                                    | 7116-98-5   | 286         | wh orth cry              |               |           |                            |                                     | i H <sub>2</sub> O         |
| 2249 | Radium chloride                           | RaCl <sub>2</sub>                                                                    | 10025-66-8  | 297         | wh orth cry              | 1000          |           | 4.9                        | 24.5 <sup>20</sup>                  | s EtOH                     |
| 2250 | Radium fluoride                           | RaF <sub>2</sub>                                                                     | 20610-49-5  | 264         | wh cub cry               |               |           | 6.7                        |                                     |                            |
| 2251 | Radium nitrate                            | Ra(NO <sub>3</sub> ) <sub>2</sub>                                                    | 10213-12-4  | 350         | cry                      |               |           |                            | 13.9                                |                            |
| 2252 | Radium sulfate                            | RaSO <sub>4</sub>                                                                    | 7446-16-4   | 322         | wh cry                   |               |           |                            |                                     | i H <sub>2</sub> O, acid   |
| 2253 | Radon                                     | Rn                                                                                   | 10043-92-2  | 222         | col gas                  | -71           | -61.7     | 9.074 g/L                  |                                     | sl H <sub>2</sub> O        |
| 2254 | Rhenium                                   | Re                                                                                   | 7440-15-5   | 186.207     | silv-gray metal          | 3185          | 5596      | 20.8                       |                                     | i HCl                      |
| 2255 | Perrhenic acid                            | HReO <sub>4</sub>                                                                    | 13768-11-1  | 251.213     | exists only in soln      |               |           |                            |                                     | vs H <sub>2</sub> O, os    |
| 2256 | Rhenium carbonyl                          | Re <sub>2</sub> (CO) <sub>10</sub>                                                   | 14285-68-8  | 652.515     | yel-wh cry               | 170 dec       |           | 2.87                       |                                     | s os                       |
| 2257 | Rhenium pentacarbonyl bromide             | Re(CO) <sub>5</sub> Br                                                               | 14220-21-4  | 406.162     | wh cry                   | 90            |           |                            |                                     |                            |
| 2258 | Rhenium pentacarbonyl chloride            | Re(CO) <sub>5</sub> Cl                                                               | 14099-01-5  | 361.711     | wh cry                   |               | subl 140  |                            |                                     |                            |
| 2259 | Rhenium(III) bromide                      | ReBr <sub>3</sub>                                                                    | 13569-49-8  | 425.919     | red-brn monocl cry       |               | 500 subl  | 6.10                       |                                     | s ace, MeOH, EtOH          |
| 2260 | Rhenium(III) chloride                     | ReCl <sub>3</sub>                                                                    | 13569-63-6  | 292.566     | red-blk hyg cry          | 500 dec       |           | 4.81                       |                                     | s H <sub>2</sub> O         |
| 2261 | Rhenium(III) iodide                       | ReI <sub>3</sub>                                                                     | 15622-42-1  | 566.920     | blk solid                | dec           |           |                            |                                     |                            |
| 2262 | Rhenium(IV) chloride                      | ReCl <sub>4</sub>                                                                    | 13569-71-6  | 328.019     | purp-blk cry; hyg        | 300 dec       |           | 4.9                        |                                     |                            |
| 2263 | Rhenium(IV) fluoride                      | ReF <sub>4</sub>                                                                     | 15192-42-4  | 262.201     | blue tetr cry            |               | >300 subl | 7.49                       |                                     |                            |
| 2264 | Rhenium(IV) oxide                         | ReO <sub>2</sub>                                                                     | 12036-09-8  | 218.206     | gray orth cry            | 900 dec       |           | 11.4                       |                                     |                            |
| 2265 | Rhenium(IV) selenide                      | ReSe <sub>2</sub>                                                                    | 12038-64-1  | 344.13      | tricl cry                |               |           |                            |                                     |                            |
| 2266 | Rhenium(IV) silicide                      | ReSi <sub>2</sub>                                                                    | 12038-66-3  | 242.378     | refrac solid             | 2000          |           |                            |                                     |                            |
| 2267 | Rhenium(IV) sulfide                       | ReS <sub>2</sub>                                                                     | 12038-63-0  | 250.337     | tricl cry                |               |           | 7.6                        |                                     |                            |
| 2268 | Rhenium(IV) telluride                     | ReTe <sub>2</sub>                                                                    | 12067-00-4  | 441.41      | orth cry                 |               |           | 8.50                       |                                     |                            |
| 2269 | Rhenium(V) bromide                        | ReBr <sub>5</sub>                                                                    | 30937-53-2  | 585.727     | brn solid                | 110 dec       |           |                            |                                     |                            |
| 2270 | Rhenium(V) chloride                       | ReCl <sub>5</sub>                                                                    | 39368-69-9  | 363.472     | brn-blk solid            | 220           |           | 4.9                        |                                     | reac H <sub>2</sub> O      |
| 2271 | Rhenium(V) fluoride                       | ReF <sub>5</sub>                                                                     | 30937-52-1  | 281.199     | yel-grn solid            | 48            | 221.3     |                            |                                     |                            |
| 2272 | Rhenium(V) oxide                          | Re <sub>2</sub> O <sub>5</sub>                                                       | 12165-05-8  | 452.411     | blue-blk tetr cry        |               |           | ≈7                         |                                     |                            |

| No.  | Name                                    | Formula                                                  | CAS Reg No. | Mol. weight | Physical form               | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                  |
|------|-----------------------------------------|----------------------------------------------------------|-------------|-------------|-----------------------------|----------|----------|----------------------------|-------------------------------------|-----------------------------------------|
| 2273 | Rhenium(VI) chloride                    | ReCl <sub>6</sub>                                        | 31234-26-1  | 398.925     | red-grn solid               | 29       |          |                            |                                     |                                         |
| 2274 | Rhenium(VI) dioxidydifluoride           | ReO <sub>2</sub> F <sub>2</sub>                          | 81155-18-2  | 256.203     | col cry                     | 156      |          |                            |                                     |                                         |
| 2275 | Rhenium(VI) fluoride                    | ReF <sub>6</sub>                                         | 10049-17-9  | 300.197     | yel liq or cub cry          | 18.5     | 33.8     | 4.06(cry)                  |                                     | s HNO <sub>3</sub>                      |
| 2276 | Rhenium(VI) oxide                       | ReO <sub>3</sub>                                         | 1314-28-9   | 234.205     | red cub cry                 | 400 dec  |          | 6.9                        |                                     | i H <sub>2</sub> O, acid, alk           |
| 2277 | Rhenium(VI) oxytetrafluoride            | ReOCl <sub>4</sub>                                       | 13814-76-1  | 344.018     | brn cry                     | 29.3     | 223      |                            |                                     | reac H <sub>2</sub> O                   |
| 2278 | Rhenium(VI) oxytetrafluoride            | ReOF <sub>4</sub>                                        | 17026-29-8  | 278.200     | blue solid                  | 108      | 171.7    |                            |                                     |                                         |
| 2279 | Rhenium(VII) fluoride                   | ReF <sub>7</sub>                                         | 17029-21-9  | 319.196     | yel cub cry                 | 48.3     | 73.7     | 4.32                       |                                     |                                         |
| 2280 | Rhenium(VII) oxide                      | Re <sub>2</sub> O <sub>7</sub>                           | 1314-68-7   | 484.410     | yel hyg cry                 | 327      | 360      | 6.10                       |                                     | s H <sub>2</sub> O, EtOH, eth, diox, py |
| 2281 | Rhenium(VII) trioxychloride             | ReO <sub>3</sub> Cl                                      | 7791-09-5   | 269.658     | col liq                     | 4.5      | 128      | 3.87                       |                                     | reac H <sub>2</sub> O                   |
| 2282 | Rhenium(VII) trioxylfluoride            | ReO <sub>3</sub> F                                       | 42246-24-2  | 253.203     | yel solid                   | 147      | 164      |                            |                                     |                                         |
| 2283 | Rhenium(VII) dioxyltrifluoride          | ReO <sub>2</sub> F <sub>3</sub>                          | 57246-89-6  | 275.201     | yel solid                   | 90       | 185.4    |                            |                                     | reac H <sub>2</sub> O                   |
| 2284 | Rhenium(VII) oxypentafluoride           | ReOF <sub>5</sub>                                        | 23377-53-9  | 297.198     | cream solid                 | 43.8     | 73.0     |                            |                                     |                                         |
| 2285 | Rhenium(VII) sulfide                    | Re <sub>2</sub> S <sub>7</sub>                           | 12038-67-4  | 596.869     | brn-blk tetr cry            |          |          | 4.87                       |                                     | i H <sub>2</sub> O                      |
| 2286 | Rhodium                                 | Rh                                                       | 7440-16-6   | 102.906     | silv-wh metal; cub          | 1964     | 3695     | 12.4                       |                                     | i acid, sl aqua regia                   |
| 2287 | Rhodium carbonyl                        | Rh <sub>4</sub> (CO) <sub>16</sub>                       | 28407-51-4  | 1065.594    | red-brn cry                 | 220 dec  |          |                            |                                     |                                         |
| 2288 | Rhodium carbonyl chloride               | [Rh(CO) <sub>2</sub> Cl] <sub>2</sub>                    | 14523-22-9  | 388.758     | red-oran cry                | 124      |          |                            |                                     | s os                                    |
| 2289 | Rhodium dodecacarbonyl                  | Rh <sub>12</sub> (CO) <sub>12</sub>                      | 19584-30-6  | 747.743     | red hyg cry                 | 150 dec  |          | 2.52                       |                                     | reac H <sub>2</sub> O                   |
| 2290 | Rhodium(III) bromide                    | RhBr <sub>3</sub>                                        | 15608-29-4  | 342.618     | dark brn plates             | 800 dec  |          | 5.56                       |                                     | s H <sub>2</sub> O; i acid, os          |
| 2291 | Rhodium(III) chloride                   | RhCl <sub>3</sub>                                        | 10049-07-7  | 209.265     | red monocl cry              |          | 717      | 5.38                       |                                     | i H <sub>2</sub> O; s alk               |
| 2292 | Rhodium(III) fluoride                   | RhF <sub>3</sub>                                         | 60804-25-3  | 159.901     | red hex cry                 |          |          | 5.4                        |                                     |                                         |
| 2293 | Rhodium(III) iodide                     | RhI <sub>3</sub>                                         | 15492-38-3  | 483.619     | blk monocl cry; hyg         |          |          | 6.4                        |                                     |                                         |
| 2294 | Rhodium(III) nitrate                    | Rh(NO <sub>3</sub> ) <sub>3</sub>                        | 10139-58-9  | 288.921     | hyg brn solid               | 600 dec  |          |                            |                                     | i H <sub>2</sub> O                      |
| 2295 | Rhodium(III) nitrate dihydrate          | Rh(NO <sub>3</sub> ) <sub>3</sub> · 2H <sub>2</sub> O    | 13465-43-5  | 324.951     | blk solid                   | dec      |          |                            |                                     | i H <sub>2</sub> O; s aqua regia        |
| 2296 | Rhodium(III) oxide                      | Rh <sub>2</sub> O <sub>3</sub>                           | 12036-35-0  | 253.809     | gray hex cry                | 1100 dec |          | 8.2                        |                                     |                                         |
| 2297 | Rhodium(III) oxide pentahydrate         | Rh <sub>2</sub> O <sub>3</sub> · 5H <sub>2</sub> O       | 39373-27-8  | 309.010     | yel pow                     | dec      |          |                            |                                     | sl H <sub>2</sub> O; s acid             |
| 2298 | Rhodium(III) sulfate                    | Rh <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>          | 10489-46-0  | 493.999     | red-yel solid               | >500 dec |          |                            |                                     |                                         |
| 2299 | Rhodium(IV) oxide                       | RhO <sub>2</sub>                                         | 12137-27-8  | 134.905     | blk tetr cry                |          |          | 7.2                        |                                     |                                         |
| 2300 | Rhodium(IV) oxide dihydrate             | RhO <sub>2</sub> · 2H <sub>2</sub> O                     | 12137-27-8  | 170.936     | grn solid                   | dec      |          | 8.20                       |                                     | i H <sub>2</sub> O, sol HCl, alk        |
| 2301 | Rhodium(VI) fluoride                    | RhF <sub>6</sub>                                         | 13693-07-7  | 216.896     | blk cub cry                 | ≈70      |          | 3.1                        |                                     |                                         |
| 2302 | Rubidium                                | Rb                                                       | 7440-17-7   | 85.468      | soft silv metal; cub        | 39.30    | 688      | 1.53                       |                                     | reac H <sub>2</sub> O                   |
| 2303 | Rubidium acetate                        | RbC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>           | 563-67-7    | 144.512     | wh hyg cry                  | 246      |          |                            |                                     | vs H <sub>2</sub> O                     |
| 2304 | Rubidium aluminum sulfate               | RbAl(SO <sub>4</sub> ) <sub>2</sub>                      | 13530-57-9  | 304.575     | hex cry                     |          |          | ≈3.1                       | 1.60 <sup>20</sup>                  | i EtOH                                  |
| 2305 | Rubidium aluminum sulfate dodecahydrate | RbAl(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O | 7784-29-4   | 520.759     | col cub cry                 | ≈100 dec |          | ≈1.9                       |                                     | s H <sub>2</sub> O; i EtOH              |
| 2306 | Rubidium azide                          | RbN <sub>3</sub>                                         | 22756-36-1  | 127.488     | tetr cry; exp               | 317      |          | 2.79                       | 107 <sup>16</sup>                   |                                         |
| 2307 | Rubidium bromate                        | RbBrO <sub>3</sub>                                       | 13446-70-3  | 213.370     | cub cry                     | 430      |          | 3.68                       | 2.95 <sup>25</sup>                  |                                         |
| 2308 | Rubidium bromide                        | RbBr                                                     | 7789-39-1   | 165.372     | wh cub cry; hyg             | 692      | 1340     | 3.35                       | 116 <sup>25</sup>                   |                                         |
| 2309 | Rubidium carbonate                      | Rb <sub>2</sub> CO <sub>3</sub>                          | 584-09-8    | 230.945     | col monocl cry; hyg         | 837      |          |                            | 223 <sup>20</sup>                   |                                         |
| 2310 | Rubidium chlorate                       | RbClO <sub>3</sub>                                       | 13446-71-4  | 168.919     | col cry                     | 324      | dec 480  | 3.19                       | 6.63 <sup>25</sup>                  | sl H <sub>2</sub> O                     |
| 2311 | Rubidium chloride                       | RbCl                                                     | 7791-11-9   | 120.921     | wh cub cry; hyg             | 724      | 1390     | 2.76                       | 93.9 <sup>25</sup>                  | sl EtOH                                 |
| 2312 | Rubidium chromate                       | Rb <sub>2</sub> CrO <sub>4</sub>                         | 13446-72-5  | 286.930     | yel rhom cry                |          |          | 3.518                      | 76.2 <sup>25</sup>                  |                                         |
| 2313 | Rubidium dichromate                     | Rb <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>           | 13446-73-6  | 386.924     | red tricl or yel monocl cry |          |          | 3.1                        |                                     | s H <sub>2</sub> O                      |
| 2314 | Rubidium cyanide                        | RbCN                                                     | 19073-56-4  | 111.486     | wh cub cry                  |          |          | 2.3                        |                                     | s H <sub>2</sub> O; i EtOH, eth         |
| 2315 | Rubidium fluoride                       | RbF                                                      | 13446-74-7  | 104.466     | wh cub cry; hyg             | 795      | 1410     | 3.2                        | 300 <sup>20</sup>                   | i EtOH                                  |
| 2316 | Rubidium fluoroborate                   | RbBF <sub>4</sub>                                        | 18909-68-7  | 172.273     | orth cry                    | 612 dec  |          | 2.82                       |                                     | sl H <sub>2</sub> O                     |
| 2317 | Rubidium formate                        | RbCHO <sub>2</sub>                                       | 3495-35-0   | 130.486     | wh hyg cry                  | dec      |          |                            |                                     |                                         |
| 2318 | Rubidium hexafluorogermanate            | Rb <sub>2</sub> GeF <sub>6</sub>                         | 16962-48-4  | 357.57      | wh cry                      | 696      |          |                            |                                     | s H <sub>2</sub> O                      |
| 2319 | Rubidium hydride                        | RbH                                                      | 13446-75-8  | 86.476      | wh cub cry; flam            | ≈170 dec |          | 2.60                       |                                     | reac H <sub>2</sub> O                   |
| 2320 | Rubidium hydrogen carbonate             | RbHCO <sub>3</sub>                                       | 19088-74-5  | 146.485     | wh rhomb cry                | 175 dec  |          |                            | 116 <sup>20</sup>                   |                                         |
| 2321 | Rubidium hydrogen fluoride              | RbHF <sub>2</sub>                                        | 12280-64-7  | 124.473     | tetr cry                    | 188      |          | 3.3                        |                                     |                                         |
| 2322 | Rubidium hydrogen sulfate               | RbHSO <sub>4</sub>                                       | 15587-72-1  | 182.539     | col monocl cry              | 208      |          | 2.9                        |                                     | s H <sub>2</sub> O                      |
| 2323 | Rubidium hydroxide                      | RbOH                                                     | 1310-82-3   | 102.475     | gray-wh orth cry; hyg       | 385      |          | 3.2                        | 173 <sup>30</sup>                   | s EtOH                                  |
| 2324 | Rubidium iodate                         | RbIO <sub>3</sub>                                        | 13446-76-9  | 260.370     | monocl or cub cry           | dec      |          | 4.33                       | 2.44 <sup>25</sup>                  | vs HCl                                  |
| 2325 | Rubidium iodide                         | RbI                                                      | 7790-29-6   | 212.372     | wh cub cry                  | 656      | 1300     | 3.55                       | 165 <sup>25</sup>                   | s EtOH                                  |
| 2326 | Rubidium molybdate                      | Rb <sub>2</sub> MoO <sub>4</sub>                         | 13718-22-4  | 330.87      | wh cry                      | 958      |          |                            |                                     | s H <sub>2</sub> O                      |
| 2327 | Rubidium nitrate                        | RbNO <sub>3</sub>                                        | 13126-12-0  | 147.473     | wh hex cry; hyg             | 310      |          | 3.11                       | 65.0 <sup>25</sup>                  | vs H <sub>2</sub> O                     |
| 2328 | Rubidium nitrite                        | RbNO <sub>2</sub>                                        | 13825-25-7  | 131.474     | wh cry                      | 422      |          |                            |                                     | vs H <sub>2</sub> O                     |
| 2329 | Rubidium oxide                          | Rb <sub>2</sub> O                                        | 18088-11-4  | 186.935     | yel-brn cub cry; hyg        | 400 dec  |          | 4.0                        |                                     | reac H <sub>2</sub> O                   |
| 2330 | Rubidium perchlorate                    | RbClO <sub>4</sub>                                       | 13510-42-4  | 184.919     | wh hyg cry                  | 550      | dec >550 | 2.9                        | 1.5 <sup>25</sup>                   |                                         |
| 2331 | Rubidium permanganate                   | RbMnO <sub>4</sub>                                       | 13465-49-1  | 204.404     | dark purp cry               | 300 dec  |          | 3.24                       |                                     | sl H <sub>2</sub> O                     |
| 2332 | Rubidium peroxide                       | Rb <sub>2</sub> O <sub>2</sub>                           | 23611-30-5  | 202.935     | wh orth cry                 | 570      |          | 3.8                        |                                     | reac H <sub>2</sub> O                   |
| 2333 | Rubidium selenide                       | Rb <sub>2</sub> Se                                       | 31052-43-4  | 249.90      | wh cub cry                  | 733      |          | 3.22                       |                                     | reac H <sub>2</sub> O                   |

| No.  | Name                                    | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form             | mp/°C              | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                  |
|------|-----------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|---------------------------|--------------------|---------|----------------------------|-------------------------------------|-----------------------------------------|
| 2334 | Rubidium sulfate                        | Rb <sub>2</sub> SO <sub>4</sub>                                                    | 7488-54-2   | 266.999     | wh orth cry               | 1066               |         | 3.61                       | 50.8 <sup>25</sup>                  |                                         |
| 2335 | Rubidium sulfide                        | Rb <sub>2</sub> S                                                                  | 31083-74-6  | 203.001     | wh cub cry                | 425                |         | 2.91                       |                                     | s H <sub>2</sub> O                      |
| 2336 | Rubidium superoxide                     | RbO <sub>2</sub>                                                                   | 12137-25-6  | 117.467     | tetr cry                  | 412                |         | ≈3.0                       |                                     |                                         |
| 2337 | Ruthenium                               | Ru                                                                                 | 7440-18-8   | 101.07      | silv-wh metal; hex        | 2333               | 4150    | 12.1                       |                                     | i acid, aqua regia                      |
| 2338 | Ruthenium dodecacarbonyl                | Ru <sub>3</sub> (CO) <sub>12</sub>                                                 | 15243-33-1  | 639.33      | oran cry                  | 150 dec            |         |                            |                                     |                                         |
| 2339 | Ruthenium pentacarbonyl                 | Ru(CO) <sub>5</sub>                                                                | 16406-48-7  | 241.12      | col liq                   | -22                | dec 50  |                            |                                     | i H <sub>2</sub> O; s EtOH, bz, chl, hc |
| 2340 | Ruthenium nonacarbonyl                  | Ru <sub>9</sub> (CO) <sub>9</sub>                                                  | 63128-11-0  | 454.23      | stab below -40            |                    |         |                            |                                     | s hex                                   |
| 2341 | Ruthenium nitrosyl chloride monohydrate | Ru(NO)Cl <sub>3</sub> · H <sub>2</sub> O                                           | 18902-42-6  | 255.45      | hyg red cry               |                    |         |                            |                                     |                                         |
| 2342 | Hexaammineruthenium(III) chloride       | Ru(NH <sub>3</sub> ) <sub>6</sub> Cl <sub>3</sub>                                  | 14282-91-8  | 309.61      | col monocl cry            |                    |         |                            |                                     | s H <sub>2</sub> O                      |
| 2343 | Ruthenium(III) bromide                  | RuBr <sub>3</sub>                                                                  | 14014-88-1  | 340.78      | brn hex cry               | dec 500            |         | 5.3                        |                                     | i H <sub>2</sub> O, acid, EtOH          |
| 2344 | Ruthenium(III) chloride                 | RuCl <sub>3</sub>                                                                  | 10049-08-8  | 207.43      | blk-brn hex cry           | ≈500 dec           |         | 3.1                        |                                     | i H <sub>2</sub> O; sl EtOH             |
| 2345 | Ruthenium(III) fluoride                 | RuF <sub>3</sub>                                                                   | 51621-05-7  | 158.07      | brn rhomb cry             | ≈600 dec           |         | 5.36                       |                                     | i H <sub>2</sub> O, dil acid            |
| 2346 | Ruthenium(III) iodide                   | RuI <sub>3</sub>                                                                   | 13896-65-6  | 481.78      | blk hex cry               | dec 300            |         | 6.0                        |                                     | sl H <sub>2</sub> O                     |
| 2347 | Ruthenium(III) 2,4-pentanedioate        | Ru(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub>                            | 14284-93-6  | 398.39      | red-brn cry               | 230                |         |                            |                                     |                                         |
| 2348 | Ruthenium(IV) fluoride                  | RuF <sub>4</sub>                                                                   | 71500-16-8  | 177.06      | yel-red cry               |                    |         |                            |                                     | reac H <sub>2</sub> O                   |
| 2349 | Ruthenium(IV) oxide                     | RuO <sub>2</sub>                                                                   | 12036-10-1  | 133.07      | gray-blk tetr cry         | dec 1300           |         | 7.05                       |                                     | i H <sub>2</sub> O, acid                |
| 2350 | Ruthenium(V) fluoride                   | RuF <sub>5</sub>                                                                   | 14521-18-7  | 196.06      | grn monocl cry            | 86.5               | 227     | 3.90                       |                                     |                                         |
| 2351 | Ruthenium(VI) fluoride                  | RuF <sub>6</sub>                                                                   | 13693-08-8  | 215.06      | dark brn orth cry         | 54                 | 200 dec | 3.54                       |                                     | reac H <sub>2</sub> O                   |
| 2352 | Ruthenium(VIII) oxide                   | RuO <sub>4</sub>                                                                   | 20427-56-9  | 165.07      | yel monocl prisms         | 25.4               | 40      | 3.29                       | 2.03 <sup>20</sup>                  | sl H <sub>2</sub> O; vs ctc; reac EtOH  |
| 2353 | Samarium                                | Sm                                                                                 | 7440-19-9   | 150.36      | silv metal; rhomb         | 1072               | 1794    | 7.52                       |                                     |                                         |
| 2354 | Samarium boride                         | SmB <sub>6</sub>                                                                   | 12008-30-9  | 215.23      | refrac solid              | 2580               |         | 5.07                       |                                     |                                         |
| 2355 | Samarium silicide                       | SmSi <sub>2</sub>                                                                  | 12300-22-0  | 206.53      | orth cry                  |                    |         | 5.14                       |                                     |                                         |
| 2356 | Samarium(II) bromide                    | SmBr <sub>2</sub>                                                                  | 50801-97-3  | 310.17      | brn cry                   | 669                |         |                            |                                     | reac H <sub>2</sub> O                   |
| 2357 | Samarium(II) chloride                   | SmCl <sub>2</sub>                                                                  | 13874-75-4  | 221.27      | brn cry                   | 855                |         | 3.69                       |                                     | reac H <sub>2</sub> O                   |
| 2358 | Samarium(II) fluoride                   | SmF <sub>2</sub>                                                                   | 15192-17-3  | 188.36      | purp cry                  |                    |         |                            |                                     | reac H <sub>2</sub> O                   |
| 2359 | Samarium(II) iodide                     | SmI <sub>2</sub>                                                                   | 32248-43-4  | 404.17      | grn cry                   | 520                |         |                            |                                     | reac H <sub>2</sub> O                   |
| 2360 | Samarium(III) acetate trihydrate        | Sm(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · 3H <sub>2</sub> O | 17829-86-6  | 381.54      | hyg yel-wh solid          |                    |         | 1.94                       |                                     | s H <sub>2</sub> O                      |
| 2361 | Samarium(III) bromate nonahydrate       | Sm(BrO <sub>3</sub> ) <sub>3</sub> · 9H <sub>2</sub> O                             | 63427-22-5  | 696.20      | pink hex cry              | 75 dec             |         |                            |                                     | vs H <sub>2</sub> O; sl EtOH            |
| 2362 | Samarium(III) bromide                   | SmBr <sub>3</sub>                                                                  | 13759-87-0  | 390.07      | yel cry                   | 640                |         |                            |                                     | reac H <sub>2</sub> O                   |
| 2363 | Samarium(III) carbonate                 | Sm <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub>                                    | 5895-47-6   | 480.75      | wh-yel pow                | dec >500           |         |                            |                                     |                                         |
| 2364 | Samarium(III) chloride                  | SmCl <sub>3</sub>                                                                  | 10361-82-7  | 256.72      | yel cry                   | 682                |         | 4.46                       | 93.8 <sup>25</sup>                  |                                         |
| 2365 | Samarium(III) chloride hexahydrate      | SmCl <sub>3</sub> · 6H <sub>2</sub> O                                              | 13465-55-9  | 364.81      | yel cry                   | dec                |         | 2.38                       | 93.8 <sup>25</sup>                  |                                         |
| 2366 | Samarium(III) fluoride                  | SmF <sub>3</sub>                                                                   | 13765-24-7  | 207.36      | wh cry                    | 1306               |         |                            |                                     | reac H <sub>2</sub> O                   |
| 2367 | Samarium(III) iodide                    | SmI <sub>3</sub>                                                                   | 13813-25-7  | 531.07      | oran cry                  | 850                |         |                            |                                     | reac H <sub>2</sub> O                   |
| 2368 | Samarium(III) nitrate                   | Sm(NO <sub>3</sub> ) <sub>3</sub>                                                  | 10361-83-8  | 336.38      | yel-wh hyg solid          |                    |         |                            | 144 <sup>25</sup>                   | s EtOH                                  |
| 2369 | Samarium(III) nitrate hexahydrate       | Sm(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                              | 13759-83-6  | 444.47      | pale yel cry              | 78                 |         |                            |                                     | s H <sub>2</sub> O, MeOH, ace           |
| 2370 | Samarium(III) oxide                     | Sm <sub>2</sub> O <sub>3</sub>                                                     | 12060-58-1  | 348.72      | yel-wh cub cry            | 2269               | 3780    | 7.6                        |                                     |                                         |
| 2371 | Samarium(III) sulfate octahydrate       | Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                | 13465-58-2  | 733.03      | yel cry                   |                    |         | 2.93                       | 2.67 <sup>20</sup>                  |                                         |
| 2372 | Samarium(III) sulfide                   | Sm <sub>2</sub> S <sub>3</sub>                                                     | 12067-22-0  | 396.92      | gray-brn cub cry          | 1720               |         | 5.87                       |                                     |                                         |
| 2373 | Samarium(III) telluride                 | Sm <sub>2</sub> Te <sub>3</sub>                                                    | 12040-00-5  | 683.52      | orth cry                  |                    |         | 7.31                       |                                     |                                         |
| 2374 | Scandium                                | Sc                                                                                 | 7440-20-2   | 44.956      | silv metal; hex           | 1541               | 2836    | 2.99                       |                                     |                                         |
| 2375 | Scandium boride                         | ScB <sub>2</sub>                                                                   | 12007-34-0  | 66.578      | refrac solid              | 2250               |         | 3.17                       |                                     |                                         |
| 2376 | Scandium bromide                        | ScBr <sub>3</sub>                                                                  | 13465-59-3  | 284.668     | wh hyg cry                | 969                |         | 9.33                       |                                     | s H <sub>2</sub> O                      |
| 2377 | Scandium chloride                       | ScCl <sub>3</sub>                                                                  | 10361-84-9  | 151.315     | wh hyg cry                | 967                |         | 2.4                        |                                     | s H <sub>2</sub> O; i EtOH              |
| 2378 | Scandium fluoride                       | ScF <sub>3</sub>                                                                   | 13709-47-2  | 101.951     | wh powder                 | 1552               |         |                            |                                     | sl H <sub>2</sub> O                     |
| 2379 | Scandium hydroxide                      | Sc(OH) <sub>3</sub>                                                                | 17674-34-9  | 95.978      | col amorp solid           |                    |         |                            |                                     | i H <sub>2</sub> O; s dil acid          |
| 2380 | Scandium iodide                         | ScI <sub>3</sub>                                                                   | 14474-33-0  | 425.669     | hyg yel cry               | 953                | subl    |                            |                                     | s H <sub>2</sub> O, EtOH, CCD           |
| 2381 | Scandium nitrate                        | Sc(NO <sub>3</sub> ) <sub>3</sub>                                                  | 13465-60-6  | 230.971     | wh cry                    |                    |         |                            | 169 <sup>25</sup>                   | s EtOH                                  |
| 2382 | Scandium oxide                          | Sc <sub>2</sub> O <sub>3</sub>                                                     | 12060-08-1  | 137.910     | wh cub cry                | 2489               |         | 3.864                      |                                     | s conc acid                             |
| 2383 | Scandium sulfate pentahydrate           | Sc <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 5H <sub>2</sub> O                | 15292-44-1  | 468.176     | col cry                   | dec 110            |         |                            |                                     | vs H <sub>2</sub> O                     |
| 2384 | Scandium sulfide                        | Sc <sub>2</sub> S <sub>3</sub>                                                     | 12166-29-9  | 186.107     | yel orth cry              | 1775               |         | 2.91                       |                                     |                                         |
| 2385 | Scandium telluride                      | Sc <sub>2</sub> Te <sub>3</sub>                                                    | 12166-44-8  | 472.71      | blk hex cry               |                    |         | 5.29                       |                                     |                                         |
| 2386 | Selenium (gray)                         | Se                                                                                 | 7782-49-2   | 78.96       | gray metallic cry; hex    | 220.8              | 685     | 4.809                      |                                     | i H <sub>2</sub> O, CS <sub>2</sub>     |
| 2387 | Selenium (α form)                       | Se                                                                                 | 7782-49-2   | 78.96       | red monocl cry            | trans gray Se >120 | 685     | 4.39                       |                                     | i H <sub>2</sub> O, EtOH; sl eth        |
| 2388 | Selenium (vitreous)                     | Se                                                                                 | 7782-49-2   | 78.96       | blk amorp solid           | trans gray Se 180  | 685     | 4.28                       |                                     | i H <sub>2</sub> O; sl CS <sub>2</sub>  |
| 2389 | Selenic acid                            | H <sub>2</sub> SeO <sub>4</sub>                                                    | 7783-08-6   | 144.97      | wh hyg solid              | 58                 | 260 dec | 2.95                       |                                     | vs H <sub>2</sub> O; reac EtOH          |
| 2390 | Pentafluoroorthoselenic acid            | HOSeF <sub>5</sub>                                                                 | 38989-47-8  | 190.96      | col solid                 | 38                 | 47      |                            |                                     |                                         |
| 2391 | Selenous acid                           | H <sub>2</sub> SeO <sub>3</sub>                                                    | 7783-00-8   | 128.97      | wh hyg cry                | 70 dec             |         | 3.0                        |                                     | vs H <sub>2</sub> O; s EtOH             |
| 2392 | Selenium dioxide                        | SeO <sub>2</sub>                                                                   | 7446-08-4   | 110.96      | wh tetr needles or powder | 340 tp             | 315 sp  | 3.95                       | 264 <sup>22</sup>                   | s EtOH, MeOH; sl ace                    |
| 2393 | Selenium trioxide                       | SeO <sub>3</sub>                                                                   | 13768-86-0  | 126.96      | wh tetr cry; hyg          | 118                | subl    | 3.44                       |                                     | s H <sub>2</sub> O, os                  |

| No.  | Name                                               | Formula                           | CAS Reg No. | Mol. weight | Physical form               | mp/°C               | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                  |
|------|----------------------------------------------------|-----------------------------------|-------------|-------------|-----------------------------|---------------------|----------|----------------------------|-------------------------------------|---------------------------------------------------------|
| 2394 | Selenium bromide                                   | SeBr <sub>2</sub>                 | 7789-52-8   | 317.73      | red liq                     | 5                   | 225 dec  | 3.60                       |                                     | reac H <sub>2</sub> O; s CS <sub>2</sub> , chl          |
| 2395 | Selenium chloride                                  | SeCl <sub>2</sub>                 | 10025-68-0  | 228.83      | yel-brn oily liq            | -85                 | 127 dec  | 2.774                      |                                     | reac H <sub>2</sub> O; s CS <sub>2</sub> , bz, ctc, chl |
| 2396 | Selenium tetrabromide                              | SeBr <sub>4</sub>                 | 7789-65-3   | 398.58      | oran-red cry                | 123                 |          |                            |                                     | reac H <sub>2</sub> O; s CS <sub>2</sub> , chl          |
| 2397 | Selenium tetrachloride                             | SeCl <sub>4</sub>                 | 10026-03-6  | 220.77      | wh-yel cry                  | 305 tp              | 191.4 sp | 2.6                        |                                     | reac H <sub>2</sub> O                                   |
| 2398 | Selenium tetrafluoride                             | SeF <sub>4</sub>                  | 13465-66-2  | 154.95      | col liq                     | -9.5                | 101.6    | 2.75                       |                                     | reac H <sub>2</sub> O; vs EtOH, eth                     |
| 2399 | Selenium hexafluoride                              | SeF <sub>6</sub>                  | 7783-79-1   | 192.95      | col gas                     | -34.6 tp            | -46.6 sp | 7.887 g/L                  |                                     | i H <sub>2</sub> O                                      |
| 2400 | Selenium chloride pentafluoride                    | SeF <sub>5</sub> Cl               | 34979-62-9  | 209.41      | col gas                     | -19                 | 4.5      |                            |                                     |                                                         |
| 2401 | Selenium oxybromide                                | SeOBr <sub>2</sub>                | 7789-51-7   | 254.77      | red-yel solid               | 41.6                | 220 dec  | 3.38                       |                                     | reac H <sub>2</sub> O; s CS <sub>2</sub> , bz, ctc      |
| 2402 | Selenium oxychloride                               | SeOCl <sub>2</sub>                | 7791-23-3   | 165.87      | col or yel liq              | 8.5                 | 177      | 2.44                       |                                     | reac H <sub>2</sub> O; s ctc, chl, bz, tol              |
| 2403 | Selenium oxyfluoride                               | SeOF <sub>2</sub>                 | 7783-43-9   | 132.96      | col liq                     | 15                  | 125      | 2.8                        |                                     | reac H <sub>2</sub> O                                   |
| 2404 | Selenium oxytetrafluoride                          | SeOF <sub>4</sub>                 | 53319-44-1  | 170.95      | unstab col liq              | 12                  | 65       |                            |                                     |                                                         |
| 2405 | Selenium dioxide difluoride                        | SeO <sub>2</sub> F <sub>2</sub>   | 14984-81-7  | 148.96      | col gas                     | -99.5               | -8.4     | 6.089 g/L                  |                                     | reac H <sub>2</sub> O                                   |
| 2406 | Selenium monosulfide                               | SeS                               | 7446-34-6   | 111.03      |                             |                     |          |                            |                                     |                                                         |
| 2407 | Selenium disulfide                                 | SeS <sub>2</sub>                  | 7488-56-4   | 143.09      | red-yel cry                 | 100                 |          |                            |                                     | i H <sub>2</sub> O; s acid                              |
| 2408 | Selenium sulfide (Se <sub>2</sub> S <sub>3</sub> ) | Se <sub>2</sub> S <sub>3</sub>    | 75926-26-0  | 350.31      | oran needles                | 121.5               |          | 2.44                       |                                     | s CS <sub>2</sub> ; sl bz                               |
| 2409 | Selenium sulfide (Se <sub>4</sub> S <sub>4</sub> ) | Se <sub>4</sub> S <sub>4</sub>    | 75926-28-2  | 444.10      | red cry                     | 113 dec             |          | 3.29                       |                                     | s bz; sl CS <sub>2</sub>                                |
| 2410 | Selenium sulfide (Se <sub>8</sub> S <sub>8</sub> ) | Se <sub>8</sub> S <sub>8</sub>    | 75926-30-6  | 537.89      | oran cry                    | 121.5               |          |                            |                                     | s CS <sub>2</sub>                                       |
| 2411 | Silicon                                            | Si                                | 7440-21-3   | 28.086      | gray cry or brn amorp solid | 1414                | 3265     | 2.3296                     |                                     | i H <sub>2</sub> O, acid; s alk                         |
| 2412 | Silane                                             | SiH <sub>4</sub>                  | 7803-62-5   | 32.118      | col gas; flam               | -185                | -111.9   | 1.313 g/L                  |                                     | reac H <sub>2</sub> O; i EtOH, bz                       |
| 2413 | Disilane                                           | Si <sub>2</sub> H <sub>6</sub>    | 1590-87-0   | 62.219      | col gas; flam               | -129.4              | -14.8    | 2.543 g/L                  |                                     | reac H <sub>2</sub> O, ctc, chl; s EtOH, bz             |
| 2414 | Trisilane                                          | Si <sub>3</sub> H <sub>8</sub>    | 7783-26-8   | 92.321      | flam col liq                | -117.4              | 52.9     | 0.739                      |                                     | reac H <sub>2</sub> O                                   |
| 2415 | Tetrasilane                                        | Si <sub>4</sub> H <sub>10</sub>   | 7783-29-1   | 122.421     | col liq; flam               | -89.9               | 108.1    | 0.792                      |                                     | reac H <sub>2</sub> O                                   |
| 2416 | 2-Silyltrisilane                                   | Si <sub>4</sub> H <sub>10</sub>   | 13597-87-0  | 122.421     | col liq                     | -99.4               | 101.7    | 0.792                      |                                     | reac H <sub>2</sub> O                                   |
| 2417 | Cyclopentasilane                                   | Si <sub>5</sub> H <sub>10</sub>   | 289-22-5    | 150.507     | col liq                     | -10.5               | 194.3    | 0.963                      |                                     | reac H <sub>2</sub> O                                   |
| 2418 | Pentasilane                                        | Si <sub>5</sub> H <sub>12</sub>   | 14868-53-2  | 152.523     | col liq                     | -72.8               | 153.2    | 0.827                      |                                     | reac H <sub>2</sub> O                                   |
| 2419 | 2-Silyltetrasilane                                 | Si <sub>6</sub> H <sub>12</sub>   | 14868-54-3  | 152.523     | col liq                     | -109.9              | 146.2    | 0.820                      |                                     | reac H <sub>2</sub> O                                   |
| 2420 | 2,2-Disilyltetrasilane                             | Si <sub>6</sub> H <sub>12</sub>   | 15947-57-6  | 152.523     | col liq                     | -57.8               | 134.3    | 0.815                      |                                     | reac H <sub>2</sub> O                                   |
| 2421 | Cyclohexasilane                                    | Si <sub>6</sub> H <sub>12</sub>   | 291-59-8    | 180.608     | col liq                     | 16.5                | 226      |                            |                                     | reac H <sub>2</sub> O                                   |
| 2422 | Hexasilane                                         | Si <sub>6</sub> H <sub>14</sub>   | 14693-61-9  | 182.624     | col liq                     | -44.7               | 193.6    | 0.847                      |                                     | reac H <sub>2</sub> O                                   |
| 2423 | 2-Silylpentasilane                                 | Si <sub>6</sub> H <sub>14</sub>   | 14868-55-4  | 182.624     | col liq                     | -78.4               | 185.2    | 0.840                      |                                     |                                                         |
| 2424 | 3-Silylpentasilane                                 | Si <sub>6</sub> H <sub>14</sub>   | 52988-75-7  | 182.624     | col liq                     | -69                 | 179.5    | 0.843                      |                                     | reac H <sub>2</sub> O                                   |
| 2425 | Heptasilane                                        | Si <sub>7</sub> H <sub>16</sub>   | 14693-65-3  | 212.726     | col liq                     | -30.1               | 226.8    | 0.859                      |                                     | reac H <sub>2</sub> O                                   |
| 2426 | Bromosilane                                        | SiH <sub>3</sub> Br               | 13465-73-1  | 111.014     | col gas                     | -94                 | 1.9      | 4.538 g/L                  |                                     |                                                         |
| 2427 | Dibromosilane                                      | SiH <sub>2</sub> Br <sub>2</sub>  | 13768-94-0  | 189.910     | liq                         | -70.1               | 66       |                            |                                     |                                                         |
| 2428 | Tribromosilane                                     | SiHBr <sub>3</sub>                | 7789-57-3   | 268.806     | flam liq                    | -73                 | 109      | 2.7                        |                                     | reac H <sub>2</sub> O                                   |
| 2429 | Tetrabromosilane                                   | SiBr <sub>4</sub>                 | 7789-66-4   | 347.702     | col fuming liq              | 5.39                | 154      | 2.8                        |                                     | reac H <sub>2</sub> O                                   |
| 2430 | Bromotrichlorosilane                               | SiBrCl <sub>3</sub>               | 13465-74-2  | 214.349     | col liq                     | -62                 | 80.3     | 1.826                      |                                     | reac H <sub>2</sub> O                                   |
| 2431 | Dibromodichlorosilane                              | SiBr <sub>2</sub> Cl <sub>2</sub> | 13465-75-3  | 258.800     | col liq                     | -45.5               | 104      | 2.172                      |                                     | reac H <sub>2</sub> O                                   |
| 2432 | Tribromochlorosilane                               | SiBr <sub>3</sub> Cl              | 13465-76-4  | 303.251     | col liq                     | -20.8               | 127      | 2.497                      |                                     | reac H <sub>2</sub> O                                   |
| 2433 | Hexabromosilane                                    | Si <sub>6</sub> Br <sub>6</sub>   | 13517-13-0  | 535.595     | col cry                     | 95                  | 265      |                            |                                     |                                                         |
| 2434 | Octabromotrisilane                                 | Si <sub>3</sub> Br <sub>8</sub>   | 54804-32-9  | 723.489     | col liq                     | 46                  |          |                            |                                     |                                                         |
| 2435 | Chlorosilane                                       | SiH <sub>3</sub> Cl               | 13465-78-6  | 66.563      | col gas                     | -118                | -30.4    | 2.721 g/L                  |                                     |                                                         |
| 2436 | Dichlorosilane                                     | SiH <sub>2</sub> Cl <sub>2</sub>  | 4109-96-0   | 101.008     | col gas; flam               | -122                | 8.3      | 4.129 g/L                  |                                     | reac H <sub>2</sub> O                                   |
| 2437 | Trichlorosilane                                    | SiHCl <sub>3</sub>                | 10025-78-2  | 135.453     | fuming liq                  | -128.2              | 33       | 1.331                      |                                     | reac H <sub>2</sub> O                                   |
| 2438 | Tetrachlorosilane                                  | SiCl <sub>4</sub>                 | 10026-04-7  | 169.898     | col fuming liq              | -68.74              | 57.65    | 1.5                        |                                     | reac H <sub>2</sub> O                                   |
| 2439 | Chlorotrifluorosilane                              | SiClF <sub>3</sub>                | 14049-36-6  | 120.534     | col gas                     | -138                | -70.0    | 4.927 g/L                  |                                     | reac H <sub>2</sub> O                                   |
| 2440 | Dichlorodifluorosilane                             | SiCl <sub>2</sub> F <sub>2</sub>  | 18356-71-3  | 136.989     | col gas                     | -44                 | -32      | 5.599 g/L                  |                                     | reac H <sub>2</sub> O                                   |
| 2441 | Trichlorofluorosilane                              | SiCl <sub>3</sub> F               | 14965-52-7  | 153.443     | col gas                     |                     | 12.25    | 6.272 g/L                  |                                     |                                                         |
| 2442 | Trichloriodosilane                                 | SiCl <sub>3</sub> I               | 13465-85-5  | 261.349     | col liq                     | -60                 | 113.5    |                            |                                     | reac H <sub>2</sub> O                                   |
| 2443 | Hexachlorodisilane                                 | Si <sub>2</sub> Cl <sub>6</sub>   | 13465-77-5  | 268.889     | col liq                     | 2.5                 | 146      |                            |                                     | reac H <sub>2</sub> O                                   |
| 2444 | Octachlorotrisilane                                | Si <sub>3</sub> Cl <sub>8</sub>   | 13596-23-1  | 367.881     | col liq                     | -67                 | 216      |                            |                                     |                                                         |
| 2445 | Fluorosilane                                       | SiH <sub>3</sub> F                | 13537-33-2  | 50.108      | col gas                     |                     | -98.6    | 2.048 g/L                  |                                     |                                                         |
| 2446 | Difluorosilane                                     | SiH <sub>2</sub> F <sub>2</sub>   | 13824-36-7  | 68.099      | col gas                     | -122                | -77.8    | 2.783 g/L                  |                                     |                                                         |
| 2447 | Trifluorosilane                                    | SiHF <sub>3</sub>                 | 13465-71-9  | 86.089      | col gas                     | -131                | -95      | 3.519 g/L                  |                                     |                                                         |
| 2448 | Tetrafluorosilane                                  | SiF <sub>4</sub>                  | 7783-61-1   | 104.080     | col gas                     | -90.2               | -86      | 4.254 g/L                  |                                     | reac H <sub>2</sub> O                                   |
| 2449 | Hexafluorodisilane                                 | Si <sub>2</sub> F <sub>6</sub>    | 13830-68-7  | 170.161     | col gas                     | -18.7 tp @ 780 mmHg | -19.1 sp |                            |                                     | reac H <sub>2</sub> O                                   |
| 2450 | Octafluorotrisilane                                | Si <sub>3</sub> F <sub>8</sub>    | 14521-14-3  | 236.244     | col liq                     | -1.2                | 42       |                            |                                     |                                                         |
| 2451 | Decafluorotetrasilane                              | Si <sub>4</sub> F <sub>10</sub>   | 14521-15-4  | 302.326     | col cry                     | 68                  | 85.1     |                            |                                     |                                                         |
| 2452 | Iodosilane                                         | SiH <sub>3</sub> I                | 13598-42-0  | 158.014     | col liq                     | -57                 | 45.6     |                            |                                     |                                                         |

| No.  | Name                                              | Formula                                                                         | CAS Reg No. | Mol. weight | Physical form             | mp/°C                    | bp/°C   | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                      |
|------|---------------------------------------------------|---------------------------------------------------------------------------------|-------------|-------------|---------------------------|--------------------------|---------|----------------------------|-------------------------------------|-------------------------------------------------------------|
| 2453 | Diiodosilane                                      | SiH <sub>2</sub> I <sub>2</sub>                                                 | 13760-02-6  | 283.911     | col liq                   | -1                       | 150     |                            |                                     |                                                             |
| 2454 | Triiodosilane                                     | SiH <sub>3</sub> I <sub>3</sub>                                                 | 13465-72-0  | 409.807     | liq                       | 8                        | 220 dec |                            |                                     |                                                             |
| 2455 | Tetraiodosilane                                   | SiI <sub>4</sub>                                                                | 13465-84-4  | 535.704     | wh powder                 | 120.5                    | 287.35  | 4.1                        |                                     |                                                             |
| 2456 | Hexaiododisilane                                  | Si <sub>2</sub> I <sub>6</sub>                                                  | 13510-43-5  | 817.598     | pale yel cry              | 250                      |         |                            |                                     |                                                             |
| 2457 | Disiloxane                                        | (SiH <sub>3</sub> ) <sub>2</sub> O                                              | 13597-73-4  | 78.218      | gas                       | -144                     | -15.2   | 3.197 g/L                  |                                     |                                                             |
| 2458 | Hexachlorodisiloxane                              | (SiCl <sub>3</sub> ) <sub>2</sub> O                                             | 14986-21-1  | 284.888     | liq                       | -28                      | 137     |                            |                                     |                                                             |
| 2459 | Methylsilane                                      | SiH <sub>3</sub> CH <sub>3</sub>                                                | 992-94-9    | 46.145      | col gas                   | -156.5                   | -57.5   |                            |                                     |                                                             |
| 2460 | Metasilicic acid                                  | H <sub>2</sub> SiO <sub>3</sub>                                                 | 7699-41-4   | 78.100      | wh amorp powder           |                          |         |                            |                                     | i H <sub>2</sub> O; s HF                                    |
| 2461 | Orthosilicic acid                                 | H <sub>4</sub> SiO <sub>4</sub>                                                 | 10193-36-9  | 96.116      | exists only in soln       |                          |         |                            |                                     |                                                             |
| 2462 | Fluorosilicic acid                                | H <sub>2</sub> SiF <sub>6</sub>                                                 | 16961-83-4  | 144.092     | stab only in aq soln      |                          |         |                            |                                     | s H <sub>2</sub> O                                          |
| 2463 | Silicon carbide (hexagonal)                       | SiC                                                                             | 409-21-2    | 40.097      | hard grn-black hex cry    | 2830                     |         | 3.16                       |                                     | i H <sub>2</sub> O, EtOH                                    |
| 2464 | Silicon nitride (Si <sub>3</sub> N <sub>4</sub> ) | Si <sub>3</sub> N <sub>4</sub>                                                  | 12033-89-5  | 140.284     | gray refrac solid; hex    | 1900                     |         | 3.17                       |                                     |                                                             |
| 2465 | Silicon monoxide                                  | SiO                                                                             | 10097-28-6  | 44.085      | blk cub cry, stable >1200 |                          |         | 2.18                       |                                     |                                                             |
| 2466 | Silicon dioxide (α-quartz)                        | SiO <sub>2</sub>                                                                | 14808-60-7  | 60.085      | col hex cry               | trans to beta quartz 573 | 2950    | 2.648                      |                                     | i H <sub>2</sub> O, acid; s HF                              |
| 2467 | Silicon dioxide (β-quartz)                        | SiO <sub>2</sub>                                                                | 14808-60-7  | 60.085      | col hex cry               | trans to tridymite 867   | 2950    | 2.533 <sup>600</sup>       |                                     | i H <sub>2</sub> O, acid; s HF                              |
| 2468 | Silicon dioxide (tridymite)                       | SiO <sub>2</sub>                                                                | 15468-32-3  | 60.085      | col hex cry               | trans cristobalite 1470  | 2950    | 2.265                      |                                     | i H <sub>2</sub> O, acid; s HF                              |
| 2469 | Silicon dioxide (cristobalite)                    | SiO <sub>2</sub>                                                                | 14464-46-1  | 60.085      | col hex cry               | 1722                     | 2950    | 2.334                      |                                     | i H <sub>2</sub> O, acid; s HF                              |
| 2470 | Silicon dioxide (vitreous)                        | SiO <sub>2</sub>                                                                | 60676-86-0  | 60.085      | col amorp solid           | 1713                     | 2950    | 2.196                      |                                     | i H <sub>2</sub> O, acid; s HF                              |
| 2471 | Silicon monosulfide                               | SiS                                                                             | 12504-41-5  | 60.151      | yel-red hyg powder        | 1090                     | 940     | 1.85                       |                                     | reac H <sub>2</sub> O                                       |
| 2472 | Silicon disulfide                                 | SiS <sub>2</sub>                                                                | 13759-10-9  | 92.216      | wh rhomb cry              | 1090                     | subl    | 2.04                       |                                     | reac H <sub>2</sub> O, EtOH; i bz                           |
| 2473 | Silicon tetraacetate                              | Si(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>4</sub>                  | 562-90-3    | 264.262     | wh hyg cry                | 110                      |         |                            |                                     | reac H <sub>2</sub> O; s ace, bz                            |
| 2474 | Silicon tetraboride                               | SiB <sub>4</sub>                                                                | 12007-81-7  | 71.330      | gray refrac solid         | 1870 dec                 |         | 2.4                        |                                     |                                                             |
| 2475 | Silicotungstic acid                               | H <sub>2</sub> SiO <sub>4</sub> · (W <sub>3</sub> O <sub>9</sub> ) <sub>4</sub> | 12520-88-6  | 2878.17     | hyg yel cry               |                          |         |                            |                                     | vs H <sub>2</sub> O, EtOH                                   |
| 2476 | Silver                                            | Ag                                                                              | 7440-22-4   | 107.868     | silv metal; cub           | 961.78                   | 2162    | 10.5                       |                                     |                                                             |
| 2477 | Silver azide                                      | AgN <sub>3</sub>                                                                | 13863-88-2  | 149.888     | orth cry; exp             | exp ≈250                 |         | 4.9                        | 0.00081 <sup>20</sup>               |                                                             |
| 2478 | Silver subfluoride                                | Ag <sub>2</sub> F                                                               | 1302-01-8   | 234.734     | yel hex cry               | 100 dec                  |         | 8.6                        |                                     | reac H <sub>2</sub> O                                       |
| 2479 | Silver(I) acetate                                 | AgC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                                  | 563-63-3    | 166.912     | wh needles or powder      | dec                      |         | 3.26                       | 1.04 <sup>20</sup>                  |                                                             |
| 2480 | Silver(I) acetylide                               | Ag <sub>2</sub> C <sub>2</sub>                                                  | 7659-31-6   | 239.757     | wh powder; exp            |                          |         |                            |                                     |                                                             |
| 2481 | Silver(I) acetylide (AgC <sub>2</sub> H)          | AgC <sub>2</sub> H                                                              | 13092-75-6  | 132.897     | wh powder; exp            |                          |         |                            |                                     |                                                             |
| 2482 | Silver(I) arsenate                                | Ag <sub>3</sub> AsO <sub>4</sub>                                                | 13510-44-6  | 462.524     | red cub cry               | dec                      |         | 6.657                      | 0.00085                             | s NH <sub>4</sub> OH                                        |
| 2483 | Silver(I) benzoate                                | Ag(C <sub>6</sub> H <sub>5</sub> CO <sub>2</sub> )                              | 532-31-0    | 228.982     | powder                    |                          |         |                            | 30 <sup>20</sup>                    |                                                             |
| 2484 | Silver(I) bromate                                 | AgBrO <sub>3</sub>                                                              | 7783-89-3   | 235.770     | wh tetra cry              | 360 dec                  |         | 5.21                       | 0.193 <sup>25</sup>                 |                                                             |
| 2485 | Silver(I) bromide                                 | AgBr                                                                            | 7785-23-1   | 187.772     | yel cub cry               | 430                      | 1502    | 6.47                       | 0.000014 <sup>25</sup>              | i H <sub>2</sub> O, acid, EtOH                              |
| 2486 | Silver(I) carbonate                               | Ag <sub>2</sub> CO <sub>3</sub>                                                 | 534-16-7    | 275.745     | yel monocl cry            | 218                      |         | 6.077                      | 0.0036 <sup>20</sup>                | s acid                                                      |
| 2487 | Silver(I) chlorate                                | AgClO <sub>3</sub>                                                              | 7783-92-8   | 191.319     | wh tetra cry              | 230                      | 270 dec | 4.430                      | 17.6 <sup>25</sup>                  | sl EtOH                                                     |
| 2488 | Silver(I) chloride                                | AgCl                                                                            | 7783-90-6   | 143.321     | wh cub cry                | 455                      | 1547    | 5.56                       | 0.00019 <sup>25</sup>               |                                                             |
| 2489 | Silver(I) chlorite                                | AgClO <sub>2</sub>                                                              | 7783-91-7   | 175.320     | yel cry                   | 105 exp                  |         |                            | 0.55 <sup>25</sup>                  |                                                             |
| 2490 | Silver(I) chromate                                | Ag <sub>2</sub> CrO <sub>4</sub>                                                | 7784-01-2   | 331.730     | brn-red monocl cry        |                          |         | 5.625                      | 0.000014 <sup>9</sup>               |                                                             |
| 2491 | Silver(I) citrate                                 | Ag <sub>3</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub>                    | 126-45-4    | 512.705     | wh cry powder             |                          |         |                            |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>                      |
| 2492 | Silver(I) cyanide                                 | AgCN                                                                            | 506-64-9    | 133.886     | wh-gray hex cry           | 320 dec                  |         | 3.95                       | 0.0000011                           | i EtOH, dil acid                                            |
| 2493 | Silver(I) dichromate                              | Ag <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>                                  | 7784-02-3   | 431.724     | red cry                   |                          |         | 4.770                      |                                     | sl H <sub>2</sub> O                                         |
| 2494 | Silver(I) diethyldithiocarbamate                  | Ag(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> NCS <sub>2</sub>                | 1470-61-7   | 256.138     | powder                    | 173                      |         |                            |                                     | s py                                                        |
| 2495 | Silver(I) fluoride                                | AgF                                                                             | 7775-41-9   | 126.866     | yel-brn cub cry; hyg      | 435                      | 1159    | 5.852                      | 172 <sup>20</sup>                   |                                                             |
| 2496 | Silver(I) hexafluoroantimonate                    | AgSbF <sub>6</sub>                                                              | 26042-64-8  | 343.618     | powder                    |                          |         |                            |                                     |                                                             |
| 2497 | Silver(I) hexafluoroarsenate                      | AgAsF <sub>6</sub>                                                              | 12005-82-2  | 296.780     | powder                    |                          |         |                            |                                     |                                                             |
| 2498 | Silver(I) hexafluorophosphate                     | AgPF <sub>6</sub>                                                               | 26042-63-7  | 252.832     | powder                    | 102 dec                  |         |                            |                                     |                                                             |
| 2499 | Silver(I) hydrogen fluoride                       | AgHF <sub>2</sub>                                                               | 12249-52-4  | 146.873     | hyg cry                   | dec                      |         |                            |                                     |                                                             |
| 2500 | Silver(I) iodate                                  | AgIO <sub>3</sub>                                                               | 7783-97-3   | 282.770     | wh orth cry               | >200                     |         | 5.53                       | 0.053 <sup>25</sup>                 |                                                             |
| 2501 | Silver(I) iodide                                  | AgI                                                                             | 7783-96-2   | 234.772     | yel powder; hex           | 558                      | 1506    | 5.68                       | 0.000003                            | i acid                                                      |
| 2502 | Silver(I) lactate monohydrate                     | AgC <sub>2</sub> H <sub>3</sub> O <sub>3</sub> · H <sub>2</sub> O               | 128-00-7    | 214.954     | gray cry powder           |                          |         |                            |                                     | sl H <sub>2</sub> O, EtOH                                   |
| 2503 | Silver(I) metaphosphate                           | AgPO <sub>3</sub>                                                               | 13465-96-8  | 186.840     | grn glass                 | 490                      |         | 6.37                       |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub> , NH <sub>4</sub> OH |
| 2504 | Silver(I) molybdate                               | Ag <sub>2</sub> MoO <sub>4</sub>                                                | 13765-74-7  | 375.67      | yel cub cry               | 483                      |         | 6.18                       |                                     | sl H <sub>2</sub> O                                         |
| 2505 | Silver(I) nitrate                                 | AgNO <sub>3</sub>                                                               | 7761-88-8   | 169.873     | col rhomb cry             | 210                      | 440 dec | 4.35                       | 234 <sup>25</sup>                   | sl EtOH, ace                                                |
| 2506 | Silver(I) nitrite                                 | AgNO <sub>2</sub>                                                               | 7783-99-5   | 153.874     | yel needles               | 140 dec                  |         | 4.453                      | 0.415 <sup>25</sup>                 | i EtOH; reac acid                                           |
| 2507 | Silver(I) oxalate                                 | Ag <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                                   | 533-51-7    | 303.755     | wh cry powder             | exp 140                  |         | 5.03                       | 0.0043 <sup>20</sup>                |                                                             |

| No.  | Name                                               | Formula                                                                          | CAS Reg No. | Mol. weight | Physical form              | mp/°C                | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                         |
|------|----------------------------------------------------|----------------------------------------------------------------------------------|-------------|-------------|----------------------------|----------------------|----------|----------------------------|-------------------------------------|------------------------------------------------|
| 2508 | Silver(I) oxide                                    | Ag <sub>2</sub> O                                                                | 20667-12-3  | 231.735     | brn-blk cub cry            | ≈200 dec             |          | 7.2                        | 0.0025                              | i EtOH; s acid, alk                            |
| 2509 | Silver(I) perchlorate                              | AgClO <sub>4</sub>                                                               | 7783-93-9   | 207.319     | col cub cry; hyg           | 486 dec              |          | 2.806                      | 558 <sup>25</sup>                   | s bz, py, os                                   |
| 2510 | Silver(I) perchlorate monohydrate                  | AgClO <sub>4</sub> · H <sub>2</sub> O                                            | 14242-05-8  | 225.334     | hyg wh cry                 | 43 dec               |          |                            | 558 <sup>25</sup>                   |                                                |
| 2511 | Silver(I) permanganate                             | AgMnO <sub>4</sub>                                                               | 7783-98-4   | 226.804     | viol monocl cry            | dec                  |          | 4.49                       | 0.91 <sup>18</sup>                  | reac EtOH                                      |
| 2512 | Silver(I) phosphate                                | Ag <sub>3</sub> PO <sub>4</sub>                                                  | 7784-09-0   | 418.576     | yel powder                 | 849                  |          | 6.37                       | 0.0064                              | sl dil acid                                    |
| 2513 | Silver(I) picrate monohydrate                      | AgC <sub>6</sub> H <sub>2</sub> N <sub>3</sub> O <sub>7</sub> · H <sub>2</sub> O | 146-84-9    | 353.979     | yel cry                    |                      |          |                            |                                     | sl H <sub>2</sub> O, EtOH; i chl, eth          |
| 2514 | Silver(I) selenate                                 | Ag <sub>2</sub> SeO <sub>4</sub>                                                 | 7784-07-8   | 358.69      | orth cry                   |                      |          | 5.72                       | 0.118 <sup>20</sup>                 |                                                |
| 2515 | Silver(I) selenide                                 | Ag <sub>2</sub> Se                                                               | 1302-09-6   | 294.70      | gray hex needles           | 880                  |          | 8.216                      |                                     | i H <sub>2</sub> O                             |
| 2516 | Silver(I) selenite                                 | Ag <sub>2</sub> SeO <sub>3</sub>                                                 | 7784-05-6   | 342.69      | needles                    | 530                  | >550 dec | 5.930                      |                                     | sl H <sub>2</sub> O; s acid                    |
| 2517 | Silver(I) sulfate                                  | Ag <sub>2</sub> SO <sub>4</sub>                                                  | 10294-26-5  | 311.799     | col cry or powder          | 660                  |          | 5.45                       | 0.84 <sup>25</sup>                  |                                                |
| 2518 | Silver(I) sulfide                                  | Ag <sub>2</sub> S                                                                | 21548-73-2  | 247.801     | gray-blk orth powder       | 825 (high press.)    |          | 7.23                       |                                     | i H <sub>2</sub> O; s acid                     |
| 2519 | Silver(I) sulfite                                  | Ag <sub>2</sub> SO <sub>3</sub>                                                  | 13465-98-0  | 295.799     | wh cry                     | 100 dec              |          |                            | 0.00046 <sup>20</sup>               | s acid, NH <sub>4</sub> OH                     |
| 2520 | Silver(I) telluride                                | Ag <sub>2</sub> Te                                                               | 12002-99-2  | 343.34      | blk orth cry               | 955                  |          | 8.4                        |                                     |                                                |
| 2521 | Silver(I) tetraiodomercurate(II)                   | Ag <sub>2</sub> HgI <sub>4</sub>                                                 | 7784-03-4   | 923.94      | yel tetr cry               | trans to red cub ≈40 |          | 6.1                        |                                     | i H <sub>2</sub> O, dil acid                   |
| 2522 | Silver(I) thiocyanate                              | AgSCN                                                                            | 1701-93-5   | 165.951     | wh powder                  | dec                  |          |                            |                                     | i H <sub>2</sub> O                             |
| 2523 | Silver(I) thiosulfate                              | Ag <sub>2</sub> S <sub>2</sub> O <sub>3</sub>                                    | 23149-52-2  | 327.864     | wh cry                     | dec                  |          |                            |                                     | sl H <sub>2</sub> O; s NH <sub>4</sub> OH      |
| 2524 | Silver(II) oxide                                   | AgO                                                                              | 1301-96-8   | 123.867     | gray powder; monocl or cub | >100 dec             |          | 7.5                        | 0.0027 <sup>25</sup>                | s alk; reac acid                               |
| 2525 | Silver(II) tungstate                               | Ag <sub>2</sub> WO <sub>4</sub>                                                  | 13465-93-5  | 463.57      | yel cry                    | 620                  |          |                            | 0.015                               | s HNO <sub>3</sub> , NH <sub>4</sub> OH        |
| 2526 | Silver(II) fluoride                                | AgF <sub>2</sub>                                                                 | 7783-95-1   | 145.865     | wh or gray hyg cry         | 690                  |          | 4.58                       |                                     | reac H <sub>2</sub> O                          |
| 2527 | Silver(II) oxide (Ag <sub>2</sub> O <sub>2</sub> ) | Ag <sub>2</sub> O <sub>2</sub>                                                   | 25455-73-6  | 247.735     | gray-blk cub cry           | >100                 |          | 7.44                       |                                     | i H <sub>2</sub> O; s acid, NH <sub>4</sub> OH |
| 2528 | Sodium                                             | Na                                                                               | 7440-23-5   | 22.990      | soft silv met; cub         | 97.794               | 882.940  | 0.97                       |                                     | reac H <sub>2</sub> O                          |
| 2529 | Sodium acetate                                     | NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                                   | 127-09-3    | 82.034      | col cry                    | 328.2                |          | 1.528                      | 50.4 <sup>25</sup>                  |                                                |
| 2530 | Sodium acetate trihydrate                          | NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> · 3H <sub>2</sub> O               | 6131-90-4   | 136.079     | col cry                    | 58 dec               |          | 1.45                       | 50.4 <sup>25</sup>                  | sl EtOH                                        |
| 2531 | Sodium aluminate                                   | NaAlO <sub>2</sub>                                                               | 1302-42-7   | 81.971      | wh orth cry; hyg           | 1650                 |          | 4.63                       |                                     | vs H <sub>2</sub> O; i EtOH                    |
| 2532 | Sodium aluminum hydride                            | NaAlH <sub>4</sub>                                                               | 13770-96-2  | 54.004      | wh hyg solid               | 174 dec              |          | 1.24                       |                                     | i eth; s thf                                   |
| 2533 | Sodium aluminum sulfate dodecahydrate              | NaAl(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O                         | 10102-71-3  | 458.281     | col cry                    | ≈60                  |          | 1.61                       | 39.7 <sup>20</sup>                  | i EtOH                                         |
| 2534 | Sodium amide                                       | NaNH <sub>2</sub>                                                                | 7782-92-5   | 39.013      | wh-grn orth cry            | 210                  | 500 dec  | 1.39                       |                                     | reac H <sub>2</sub> O                          |
| 2535 | Sodium ammonium phosphate tetrahydrate             | NaNH <sub>4</sub> HPO <sub>4</sub> · 4H <sub>2</sub> O                           | 13011-54-6  | 209.069     | monocl cry                 | ≈80 dec              |          | 1.54                       |                                     | s H <sub>2</sub> O; i EtOH                     |
| 2536 | Sodium arsenate dodecahydrate                      | Na <sub>3</sub> AsO <sub>4</sub> · 12H <sub>2</sub> O                            | 7778-43-0   | 424.072     | col monocl prism           | 86 dec               |          |                            |                                     | s H <sub>2</sub> O; sl EtOH; i eth             |
| 2537 | Sodium arsenite                                    | NaAsO <sub>2</sub>                                                               | 7784-46-5   | 129.911     | wh-gray hyg powder         |                      |          | 1.87                       |                                     | vs H <sub>2</sub> O; i EtOH                    |
| 2538 | Sodium azide                                       | NaN <sub>3</sub>                                                                 | 26628-22-8  | 65.010      | col hex cry                | 300 dec              |          | 1.846                      | 40.8 <sup>20</sup>                  | sl EtOH; i eth                                 |
| 2539 | Sodium borohydride                                 | NaBH <sub>4</sub>                                                                | 16940-66-2  | 37.833      | wh cub cry; hyg            | ≈400 dec             |          | 1.07                       | 55 <sup>20</sup>                    | reac EtOH                                      |
| 2540 | Sodium bromate                                     | NaBrO <sub>3</sub>                                                               | 7789-38-0   | 150.892     | col cub cry                | 381                  |          | 3.34                       | 39.4 <sup>25</sup>                  | i EtOH                                         |
| 2541 | Sodium bromide                                     | NaBr                                                                             | 7647-15-6   | 102.894     | wh cub cry                 | 747                  | 1390     | 3.200                      | 94.6 <sup>25</sup>                  | s EtOH                                         |
| 2542 | Sodium bromide dihydrate                           | NaBr · 2H <sub>2</sub> O                                                         | 13466-08-5  | 138.925     | wh cry                     | 36 dec               |          | 2.18                       | 94.6 <sup>25</sup>                  | sl EtOH                                        |
| 2543 | Sodium carbonate                                   | Na <sub>2</sub> CO <sub>3</sub>                                                  | 497-19-8    | 105.989     | wh hyg powder              | 856                  |          | 2.54                       | 30.7 <sup>25</sup>                  | i EtOH                                         |
| 2544 | Sodium carbonate monohydrate                       | Na <sub>2</sub> CO <sub>3</sub> · H <sub>2</sub> O                               | 5968-11-6   | 124.005     | col orth cry               | 100 dec              |          | 2.25                       | 30.7 <sup>25</sup>                  | i EtOH                                         |
| 2545 | Sodium carbonate decahydrate                       | Na <sub>2</sub> CO <sub>3</sub> · 10H <sub>2</sub> O                             | 6132-02-1   | 286.142     | col cry                    | 34 dec               |          | 1.46                       | 30.7 <sup>25</sup>                  | i EtOH                                         |
| 2546 | Sodium chlorate                                    | NaClO <sub>3</sub>                                                               | 7775-09-9   | 106.441     | col cub cry                | 248                  | dec 630  | 2.5                        | 100 <sup>25</sup>                   | sl EtOH                                        |
| 2547 | Sodium chloride                                    | NaCl                                                                             | 7647-14-5   | 58.443      | col cub cry                | 800.7                | 1465     | 2.17                       | 36.0 <sup>25</sup>                  | sl EtOH                                        |
| 2548 | Sodium chlorite                                    | NaClO <sub>2</sub>                                                               | 7758-19-2   | 90.442      | wh hyg cry                 | ≈180 dec             |          |                            | 64 <sup>17</sup>                    |                                                |
| 2549 | Sodium chromate                                    | Na <sub>2</sub> CrO <sub>4</sub>                                                 | 7775-11-3   | 161.974     | yel orth cry               | 794                  |          | 2.72                       | 87.6 <sup>25</sup>                  | sl EtOH                                        |
| 2550 | Sodium chromate tetrahydrate                       | Na <sub>2</sub> CrO <sub>4</sub> · 4H <sub>2</sub> O                             | 10034-82-9  | 234.035     | yel hyg cry                | dec                  |          |                            | 87.6 <sup>25</sup>                  | sl EtOH                                        |
| 2551 | Sodium citrate dihydrate                           | Na <sub>3</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> · 2H <sub>2</sub> O | 6132-04-3   | 294.099     | wh cry                     | 150 dec              |          |                            |                                     | vs H <sub>2</sub> O; i EtOH, eth               |
| 2552 | Sodium citrate pentahydrate                        | Na <sub>3</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> · 5H <sub>2</sub> O | 6858-44-2   | 348.145     | hyg col cry                | dec 150              |          | 1.86                       | 92 <sup>25</sup>                    | vs H <sub>2</sub> O; sl EtOH; i eth            |
| 2553 | Sodium cyanate                                     | NaCNO                                                                            | 917-61-3    | 65.007      | col needles                | 550                  |          | 1.89                       |                                     | s H <sub>2</sub> O; sl EtOH; i eth             |
| 2554 | Sodium cyanide                                     | NaCN                                                                             | 143-33-9    | 49.008      | wh cub cry; hyg            | 562                  |          | 1.6                        | 58.2 <sup>20</sup>                  | sl EtOH                                        |
| 2555 | Sodium cyanoborohydride                            | NaBH <sub>3</sub> CN                                                             | 25895-60-7  | 62.843      | wh hyg powder              | 240 dec              |          | 1.12                       |                                     | vs H <sub>2</sub> O; s thf; sl EtOH; i bz, eth |
| 2556 | Sodium dichromate                                  | Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>                                   | 10588-01-9  | 261.968     | red hyg cry                | 357                  | 400 dec  |                            | 187 <sup>25</sup>                   |                                                |
| 2557 | Sodium dichromate dihydrate                        | Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> · 2H <sub>2</sub> O               | 7789-12-0   | 297.999     | oran-red monocl cry        | 85 dec               |          | 2.35                       |                                     | vs H <sub>2</sub> O; S HOAc                    |
| 2558 | Sodium dihydrogen phosphate                        | NaH <sub>2</sub> PO <sub>4</sub>                                                 | 7558-80-7   | 119.977     | col monocl cry             | 200 dec              |          |                            | 94.9 <sup>25</sup>                  |                                                |
| 2559 | Sodium dihydrogen phosphate monohydrate            | NaH <sub>2</sub> PO <sub>4</sub> · H <sub>2</sub> O                              | 10049-21-5  | 137.993     | wh hyg cry                 | 100 dec              |          |                            | 94.9 <sup>25</sup>                  | i EtOH                                         |
| 2560 | Sodium dihydrogen phosphate dihydrate              | NaH <sub>2</sub> PO <sub>4</sub> · 2H <sub>2</sub> O                             | 13472-35-0  | 156.008     | col orth cry               | 60 dec               |          | 1.91                       | 94.9 <sup>25</sup>                  | i EtOH                                         |
| 2561 | Sodium dihydrogen hypophosphate hexahydrate        | Na <sub>2</sub> H <sub>2</sub> P <sub>2</sub> O <sub>6</sub> · 6H <sub>2</sub> O | 7782-95-8   | 314.031     | monocl plates              | 110 dec              |          | 1.849                      | 2.0 <sup>25</sup>                   | i EtOH                                         |



| No.  | Name                                       | Formula                                                                             | CAS Reg No. | Mol. weight | Physical form                 | mp/°C        | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                     |
|------|--------------------------------------------|-------------------------------------------------------------------------------------|-------------|-------------|-------------------------------|--------------|----------|----------------------------|-------------------------------------|------------------------------------------------------------|
| 2562 | Sodium dihydrogen pyrophosphate            | Na <sub>2</sub> H <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                        | 7758-16-9   | 221.939     | wh powder                     | 220 dec      |          | ≈1.9                       |                                     | s H <sub>2</sub> O                                         |
| 2563 | Sodium dithionate                          | Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub>                                       | 7775-14-6   | 174.108     | gray-wh powder                | 52 dec       |          |                            | 24.1 <sup>20</sup>                  | sl EtOH                                                    |
| 2564 | Sodium dithionate dihydrate                | Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O                   | 7631-94-9*  | 242.137     | col orth cry                  | 110 dec      |          | 2.19                       | 15.1 <sup>20</sup>                  | i EtOH                                                     |
| 2565 | Sodium ethanolate                          | NaC <sub>2</sub> H <sub>5</sub> O                                                   | 141-52-6    | 68.050      | wh-yel hyg powder             | 260 dec      |          |                            |                                     | reac H <sub>2</sub> O; s EtOH                              |
| 2566 | Sodium ferricyanide monohydrate            | Na <sub>3</sub> Fe(CN) <sub>6</sub> · H <sub>2</sub> O                              | 14217-21-1* | 298.933     | red hyg cry                   |              |          |                            |                                     | s H <sub>2</sub> O; i EtOH                                 |
| 2567 | Sodium ferrocyanide decahydrate            | Na <sub>4</sub> Fe(CN) <sub>6</sub> · 10H <sub>2</sub> O                            | 13601-19-9  | 484.061     | yel monocl cry                | ≈50 dec      |          | 1.46                       | 20 <sup>20</sup>                    | i os                                                       |
| 2568 | Sodium fluoride                            | NaF                                                                                 | 7681-49-4   | 41.988      | col cub or tetra cry          | 996          | 1704     | 2.78                       | 4.13 <sup>25</sup>                  | i EtOH                                                     |
| 2569 | Sodium fluorophosphate                     | Na <sub>2</sub> PO <sub>3</sub> F                                                   | 10163-15-2  | 143.950     | powder                        |              |          |                            |                                     |                                                            |
| 2570 | Sodium formate                             | NaCHO <sub>2</sub>                                                                  | 141-53-7    | 68.008      | wh hyg cry                    | 257.3        | dec      | 1.92                       | 94.9 <sup>25</sup>                  | sl EtOH                                                    |
| 2571 | Sodium germanate                           | Na <sub>2</sub> GeO <sub>3</sub>                                                    | 12025-19-3  | 166.62      | wh monocl hyg cry             | 1083         |          | 3.31                       |                                     |                                                            |
| 2572 | Sodium gold cyanide                        | NaAu(CN) <sub>2</sub>                                                               | 15280-09-8  | 271.991     | wh-yel cry pow                |              |          |                            |                                     | s H <sub>2</sub> O, NH <sub>4</sub> OH                     |
| 2573 | Sodium gold thiosulfate dihydrate          | Na <sub>2</sub> Au(S <sub>2</sub> O <sub>3</sub> ) <sub>2</sub> · 5H <sub>2</sub> O | 10233-88-2  | 526.223     | wh needles or prisms          | dec 150      |          | 3.09                       |                                     | vs H <sub>2</sub> O; i EtOH                                |
| 2574 | Sodium hexabromoplatinate(IV) hexahydrate  | Na <sub>2</sub> PtBr <sub>6</sub> · 6H <sub>2</sub> O                               | 39277-13-9  | 828.579     | cry                           |              |          |                            |                                     |                                                            |
| 2575 | Sodium hexachloroiridate(IV) hexahydrate   | Na <sub>2</sub> IrCl <sub>6</sub> · 6H <sub>2</sub> O                               | 19567-78-3  | 559.006     | cry                           | 600 dec      |          |                            |                                     |                                                            |
| 2576 | Sodium hexachloroplatinate(IV)             | Na <sub>2</sub> PtCl <sub>6</sub>                                                   | 16923-58-3  | 453.782     | yel hyg cry                   |              |          |                            | 53 <sup>16</sup>                    | s EtOH                                                     |
| 2577 | Sodium hexachloroplatinate(IV) hexahydrate | Na <sub>2</sub> PtCl <sub>6</sub> · 6H <sub>2</sub> O                               | 16923-58-3  | 561.873     | yel cry                       | 110 dec      |          | 2.50                       | 53 <sup>16</sup>                    | s EtOH; i eth                                              |
| 2578 | Sodium hexafluoroaluminate                 | Na <sub>3</sub> AlF <sub>6</sub>                                                    | 13775-53-6  | 209.941     | col monocl cry; trans cub 560 | 1013         |          | 2.97                       |                                     | i H <sub>2</sub> O                                         |
| 2579 | Sodium hexafluoroantimonate                | NaSbF <sub>6</sub>                                                                  | 16925-25-0  | 258.740     | wh cub cry                    |              |          | 3.375                      | 129 <sup>20</sup>                   | s EtOH, ace                                                |
| 2580 | Sodium hexafluorophosphate monohydrate     | NaPF <sub>6</sub> · H <sub>2</sub> O                                                | 20644-15-9  | 185.969     | col orth cry                  |              |          | 2.369                      | 103 <sup>9</sup>                    | s EtOH, MeOH, ace                                          |
| 2581 | Sodium hexafluorosilicate                  | Na <sub>2</sub> SiF <sub>6</sub>                                                    | 16893-85-9  | 188.056     | wh hex cry                    | 847          |          | 2.7                        | 0.67 <sup>20</sup>                  | i EtOH                                                     |
| 2582 | Sodium hexanitrocobaltate(III)             | Na <sub>3</sub> Co(NO <sub>2</sub> ) <sub>6</sub>                                   | 14649-73-1  | 403.935     | yel-brn cry powder            |              |          |                            |                                     | vs H <sub>2</sub> O; sl EtOH                               |
| 2583 | Sodium hydride                             | NaH                                                                                 | 7646-69-7   | 23.998      | silv cub cry; flam            | 425 dec      |          | 1.39                       |                                     | reac H <sub>2</sub> O, EtOH                                |
| 2584 | Sodium hydrogen arsenate                   | Na <sub>2</sub> HAsO <sub>4</sub>                                                   | 7778-43-0   | 185.908     | wh powder                     | ≈195 dec     |          |                            | 51 <sup>20</sup>                    | sl EtOH                                                    |
| 2585 | Sodium hydrogen arsenate heptahydrate      | Na <sub>2</sub> HAsO <sub>4</sub> · 7H <sub>2</sub> O                               | 10048-95-0  | 312.014     | wh monocl cry                 | ≈50 dec      |          | 1.87                       | 51 <sup>20</sup>                    | sl EtOH                                                    |
| 2586 | Sodium hydrogen carbonate                  | NaHCO <sub>3</sub>                                                                  | 144-55-8    | 84.007      | wh monocl cry                 | ≈50 dec      |          | 2.20                       | 10.3 <sup>25</sup>                  | i EtOH                                                     |
| 2587 | Sodium hydrogen fluoride                   | NaHF <sub>2</sub>                                                                   | 1333-83-1   | 61.995      | wh hex cry                    | >160 dec     |          | 2.08                       | 3.25 <sup>20</sup>                  |                                                            |
| 2588 | Sodium hydrogen phosphate                  | Na <sub>2</sub> HPO <sub>4</sub>                                                    | 7558-79-4   | 141.959     | wh hyg powder                 |              |          | 1.7                        | 11.8 <sup>25</sup>                  |                                                            |
| 2589 | Sodium hydrogen phosphate heptahydrate     | Na <sub>2</sub> HPO <sub>4</sub> · 7H <sub>2</sub> O                                | 7782-85-6   | 268.066     | col cry                       |              |          | ≈1.7                       | 11.8 <sup>25</sup>                  | i EtOH                                                     |
| 2590 | Sodium hydrogen phosphate dodecahydrate    | Na <sub>2</sub> HPO <sub>4</sub> · 12H <sub>2</sub> O                               | 10039-32-4  | 358.143     | col cry                       | ≈35 dec      |          | ≈1.5                       | 11.8 <sup>25</sup>                  | i EtOH                                                     |
| 2591 | Sodium hydrogen sulfate                    | NaHSO <sub>4</sub>                                                                  | 7681-38-1   | 120.061     | wh hyg cry                    | ≈315         |          | 2.43                       | 28.5 <sup>25</sup>                  |                                                            |
| 2592 | Sodium hydrogen sulfate monohydrate        | NaHSO <sub>4</sub> · H <sub>2</sub> O                                               | 10034-88-5  | 138.076     | wh monocl cry                 |              |          | 2.10                       | 28.5 <sup>25</sup>                  | reac EtOH                                                  |
| 2593 | Sodium hydrogen sulfide                    | NaHS                                                                                | 16721-80-5  | 56.063      | col rhomb cry                 | 350          |          | 1.79                       |                                     | s H <sub>2</sub> O, EtOH, eth                              |
| 2594 | Sodium hydrogen sulfide dihydrate          | NaHS · 2H <sub>2</sub> O                                                            | 16721-80-5  | 92.094      | yel hyg needles               | 55 dec       |          |                            |                                     | vs H <sub>2</sub> O, EtOH, eth                             |
| 2595 | Sodium hydrogen sulfite                    | NaHSO <sub>3</sub>                                                                  | 7631-90-5   | 104.061     | wh cry                        |              |          | 1.48                       |                                     | s H <sub>2</sub> O; sl EtOH                                |
| 2596 | Sodium hydroxide                           | NaOH                                                                                | 1310-73-2   | 39.997      | wh orth cry; hyg              | 323          | 1388     | 2.13                       | 100 <sup>25</sup>                   | s EtOH, MeOH                                               |
| 2597 | Sodium hypochlorite                        | NaClO                                                                               | 7681-52-9   | 74.442      | stab in aq soln               | anh form exp |          |                            | 79.9 <sup>25</sup>                  |                                                            |
| 2598 | Sodium hypochlorite pentahydrate           | NaOCl · 5H <sub>2</sub> O                                                           | 10022-70-5  | 164.518     | pale grn orth cry             | 18           |          | 1.6                        |                                     | s H <sub>2</sub> O                                         |
| 2599 | Sodium iodate                              | NaIO <sub>3</sub>                                                                   | 7681-55-2   | 197.892     | wh orth cry                   | 422          |          | 4.28                       | 9.47 <sup>25</sup>                  | i EtOH                                                     |
| 2600 | Sodium iodide                              | NaI                                                                                 | 7681-82-5   | 149.894     | wh cub cry; hyg               | 661          | 1304     | 3.67                       | 184 <sup>25</sup>                   | s EtOH, ace                                                |
| 2601 | Sodium iodide dihydrate                    | NaI · 2H <sub>2</sub> O                                                             | 13517-06-1  | 185.925     | hyg col monocl cry            | 69 dec       |          | 2.45                       | 318 <sup>9</sup>                    | vs H <sub>2</sub> O                                        |
| 2602 | Sodium bismuthate                          | NaBiO <sub>3</sub>                                                                  | 12232-99-4  | 279.968     | yel-brn hyg cry               |              |          |                            |                                     | i cold H <sub>2</sub> O, reac acid                         |
| 2603 | Sodium metabisulfite                       | Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>                                       | 7681-57-4   | 190.107     | wh cry                        |              |          |                            | 66.7 <sup>25</sup>                  | sl EtOH                                                    |
| 2604 | Sodium metaborate                          | NaBO <sub>2</sub>                                                                   | 7775-19-1   | 65.800      | wh hex cry                    | 966          | 1434     | 2.46                       |                                     | s H <sub>2</sub> O                                         |
| 2605 | Sodium metasilicate                        | Na <sub>2</sub> SiO <sub>3</sub>                                                    | 6834-92-0   | 122.064     | wh amorp solid; hyg           | 1089         |          | 2.61                       |                                     | s cold H <sub>2</sub> O; reac hot H <sub>2</sub> O; i EtOH |
| 2606 | Sodium metasilicate pentahydrate           | Na <sub>2</sub> SiO <sub>3</sub> · 5H <sub>2</sub> O                                | 13517-24-3  | 212.140     | wh pow                        | 72 dec       |          |                            |                                     | s H <sub>2</sub> O                                         |
| 2607 | Sodium molybdate                           | Na <sub>2</sub> MoO <sub>4</sub>                                                    | 7631-95-0   | 205.92      | col cub cry                   | 687          |          | ≈3.5                       | 65.0 <sup>25</sup>                  |                                                            |
| 2608 | Sodium molybdate dihydrate                 | Na <sub>2</sub> MoO <sub>4</sub> · 2H <sub>2</sub> O                                | 10102-40-6  | 241.95      | cry powder                    | 100 dec      |          | ≈3.5                       | 65.0 <sup>25</sup>                  |                                                            |
| 2609 | Sodium molybdophosphate                    | Na <sub>3</sub> PO <sub>4</sub> · 12MoO <sub>3</sub>                                | 1313-30-0   | 1891.20     | hyg solid                     |              |          | 2.83                       |                                     | vs H <sub>2</sub> O, EtOH                                  |
| 2610 | Sodium niobate                             | NaNbO <sub>3</sub>                                                                  | 12034-09-2  | 163.894     | rhomb cry                     | 1422         |          | 4.55                       |                                     | i H <sub>2</sub> O                                         |
| 2611 | Sodium nitrate                             | NaNO <sub>3</sub>                                                                   | 7631-99-4   | 84.995      | col hex cry; hyg              | 306.5        |          | 2.261                      | 91.2 <sup>25</sup>                  | sl EtOH, MeOH                                              |
| 2612 | Sodium nitrite                             | NaNO <sub>2</sub>                                                                   | 7632-00-0   | 68.996      | wh orth cry; hyg              | 284          | >320 dec | 2.17                       | 84.8 <sup>25</sup>                  | sl EtOH; reac acid                                         |
| 2613 | Sodium nitroferrocyanide dihydrate         | Na <sub>2</sub> [Fe(CN) <sub>5</sub> NO] · 2H <sub>2</sub> O                        | 13755-38-9  | 297.949     | red cry                       |              |          | 1.72                       | 40 <sup>16</sup>                    | sl EtOH                                                    |
| 2614 | Sodium orthovanadate                       | Na <sub>3</sub> VO <sub>4</sub>                                                     | 13721-39-6  | 183.909     | col hex prisms                | 860          |          |                            |                                     | s H <sub>2</sub> O; i EtOH                                 |
| 2615 | Sodium oxalate                             | Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                                       | 62-76-0     | 133.999     | wh powder                     | ≈250 dec     |          | 2.34                       | 3.61 <sup>25</sup>                  | i EtOH                                                     |

| No.  | Name                                         | Formula                                                                          | CAS Reg No. | Mol. weight | Physical form         | mp/°C    | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                             |
|------|----------------------------------------------|----------------------------------------------------------------------------------|-------------|-------------|-----------------------|----------|-------|----------------------------|-------------------------------------|----------------------------------------------------|
| 2616 | Sodium oxide                                 | Na <sub>2</sub> O                                                                | 1313-59-3   | 61.979      | wh amorp powder       | 1134     |       | 2.27                       |                                     | reac H <sub>2</sub> O                              |
| 2617 | Sodium perborate tetrahydrate                | NaBO <sub>3</sub> · 4H <sub>2</sub> O                                            | 7632-04-4   | 153.861     | wh cry                | 60 dec   |       |                            |                                     | reac H <sub>2</sub> O                              |
| 2618 | Sodium perchlorate                           | NaClO <sub>4</sub>                                                               | 7601-89-0   | 122.441     | wh orth cry; hyg      | 482 dec  |       | 2.52                       | 205 <sup>25</sup>                   |                                                    |
| 2619 | Sodium perchlorate monohydrate               | NaClO <sub>4</sub> · H <sub>2</sub> O                                            | 7791-07-3   | 140.456     | wh hyg cry            | ≈130 dec |       | 2.02                       | 205 <sup>25</sup>                   |                                                    |
| 2620 | Sodium periodate                             | NaIO <sub>4</sub>                                                                | 7790-28-5   | 213.892     | wh tetra cry          | ≈300 dec |       | 3.86                       | 14.4 <sup>25</sup>                  | s acid                                             |
| 2621 | Sodium periodate trihydrate                  | NaIO <sub>4</sub> · 3H <sub>2</sub> O                                            | 13472-31-6  | 267.938     | wh hex cry            | 175 dec  |       | 3.22                       | 14.4 <sup>25</sup>                  |                                                    |
| 2622 | Sodium permanganate trihydrate               | NaMnO <sub>4</sub> · 3H <sub>2</sub> O                                           | 10101-50-5* | 195.972     | red-blk hyg cry       | 170 dec  |       | 2.47                       | 144 <sup>20</sup>                   | reac EtOH                                          |
| 2623 | Sodium peroxide                              | Na <sub>2</sub> O <sub>2</sub>                                                   | 1313-60-6   | 77.979      | yel hyg powder        | 675      |       | 2.805                      |                                     | reac H <sub>2</sub> O                              |
| 2624 | Sodium perrhenate                            | NaReO <sub>4</sub>                                                               | 13472-33-8  | 273.195     | cry                   | 300      |       | 5.39                       |                                     |                                                    |
| 2625 | Sodium persulfate                            | Na <sub>2</sub> S <sub>2</sub> O <sub>8</sub>                                    | 7775-27-1   | 238.105     | wh hyg cry            |          |       |                            |                                     | vs H <sub>2</sub> O; reac EtOH                     |
| 2626 | Sodium phosphate                             | Na <sub>3</sub> PO <sub>4</sub>                                                  | 7601-54-9   | 163.940     | col cry               | 1583     |       | 2.54                       | 14.5 <sup>25</sup>                  | s H <sub>2</sub> O                                 |
| 2627 | Sodium phosphate dodecahydrate               | Na <sub>3</sub> PO <sub>4</sub> · 12H <sub>2</sub> O                             | 10101-89-0  | 380.124     | col hex cry           | ≈75      |       | 1.62                       | 14.4 <sup>25</sup>                  | i EtOH                                             |
| 2628 | Sodium phosphate, chlorinated                | Na <sub>3</sub> PO <sub>4</sub> · NaOCl                                          | 56802-99-4  | 238.383     | wh cry                |          |       |                            | 25 <sup>25</sup>                    |                                                    |
| 2629 | Sodium phosphide                             | Na <sub>3</sub> P                                                                | 12058-85-4  | 99.943      | red solid             | >650     |       |                            |                                     | reac H <sub>2</sub> O                              |
| 2630 | Sodium phosphinate                           | NaH <sub>2</sub> PO <sub>2</sub>                                                 | 7681-53-0   | 87.979      | wh cry                |          |       |                            | 100 <sup>25</sup>                   |                                                    |
| 2631 | Sodium phosphinate monohydrate               | NaH <sub>2</sub> PO <sub>2</sub> · H <sub>2</sub> O                              | 10039-56-2  | 105.994     | col hyg cry           | 310 dec  |       |                            | 100 <sup>25</sup>                   | s EtOH                                             |
| 2632 | Sodium phosphonate pentahydrate              | Na <sub>2</sub> HPO <sub>3</sub> · 5H <sub>2</sub> O                             | 13517-23-2  | 216.036     | wh hex plates         | dec 200  |       |                            | 429 <sup>20</sup>                   | vs H <sub>2</sub> O; i EtOH                        |
| 2633 | Sodium pyrophosphate                         | Na <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                                    | 7722-88-5   | 265.902     | col cry               | 988      |       | 2.53                       | 7.09 <sup>25</sup>                  |                                                    |
| 2634 | Sodium selenate                              | Na <sub>2</sub> SeO <sub>4</sub>                                                 | 13410-01-0  | 188.94      | col orth cry          |          |       |                            | 58.5 <sup>25</sup>                  |                                                    |
| 2635 | Sodium selenate decahydrate                  | Na <sub>2</sub> SeO <sub>4</sub> · 10H <sub>2</sub> O                            | 10102-23-5  | 369.09      | wh cry                |          |       | 1.61                       | 58.5 <sup>25</sup>                  |                                                    |
| 2636 | Sodium selenide                              | Na <sub>2</sub> Se                                                               | 1313-85-5   | 124.94      | amorp solid           | >875     |       | 2.62                       |                                     | reac H <sub>2</sub> O                              |
| 2637 | Sodium selenite                              | Na <sub>2</sub> SeO <sub>3</sub>                                                 | 10102-18-8  | 172.94      | wh tetra cry          |          |       |                            | 89.8 <sup>25</sup>                  | i EtOH                                             |
| 2638 | Sodium selenite pentahydrate                 | Na <sub>2</sub> SeO <sub>3</sub> · 5H <sub>2</sub> O                             | 26970-82-1  | 184.054     | wh tetra cry          | dec      |       |                            |                                     | s H <sub>2</sub> O; i EtOH                         |
| 2639 | Sodium stannate trihydrate                   | Na <sub>2</sub> SnO <sub>3</sub> · 3H <sub>2</sub> O                             | 12209-98-2  | 266.734     | col hex cry           | dec 140  |       |                            | 61 <sup>15</sup>                    | vs H <sub>2</sub> O; i EtOH, ace                   |
| 2640 | Sodium stearate                              | NaC <sub>18</sub> H <sub>35</sub> O <sub>2</sub>                                 | 822-16-2    | 306.460     | wh powder             |          |       |                            |                                     | sl H <sub>2</sub> O, EtOH; vs hot H <sub>2</sub> O |
| 2641 | Sodium succinate hexahydrate                 | Na <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> · 6H <sub>2</sub> O | 150-90-3    | 270.144     | cry powder            | 120 dec  |       |                            | 20                                  | i EtOH                                             |
| 2642 | Sodium sulfate                               | Na <sub>2</sub> SO <sub>4</sub>                                                  | 7757-82-6   | 142.043     | wh orth cry or powder | 884      |       | 2.7                        | 28.1 <sup>25</sup>                  | i EtOH                                             |
| 2643 | Sodium sulfate heptahydrate                  | Na <sub>2</sub> SO <sub>4</sub> · 7H <sub>2</sub> O                              | 13472-39-4  | 204.152     | wh cry                | dec      |       |                            |                                     | vs H <sub>2</sub> O                                |
| 2644 | Sodium sulfate decahydrate                   | Na <sub>2</sub> SO <sub>4</sub> · 10H <sub>2</sub> O                             | 7727-73-3   | 322.196     | col monocl cry        | 32 dec   |       | 1.46                       | 28.1 <sup>25</sup>                  | i EtOH                                             |
| 2645 | Sodium sulfide                               | Na <sub>2</sub> S                                                                | 1313-82-2   | 78.045      | wh cub cry; hyg       | 1172     |       | 1.856                      | 20.6 <sup>25</sup>                  | sl EtOH; i eth                                     |
| 2646 | Sodium sulfide pentahydrate                  | Na <sub>2</sub> S · 5H <sub>2</sub> O                                            | 1313-83-3   | 168.121     | col orth cry          | 120 dec  |       | 1.58                       | 20.6 <sup>25</sup>                  | s EtOH; i eth                                      |
| 2647 | Sodium sulfide nonahydrate                   | Na <sub>2</sub> S · 9H <sub>2</sub> O                                            | 1313-84-4   | 240.183     | wh-yel hyg cry        | ≈50 dec  |       | 1.43                       | 20.6 <sup>25</sup>                  | sl EtOH; i eth                                     |
| 2648 | Sodium sulfite                               | Na <sub>2</sub> SO <sub>3</sub>                                                  | 7757-83-7   | 126.043     | wh hex cry            | 911      |       | 2.63                       | 30.7 <sup>25</sup>                  | i EtOH                                             |
| 2649 | Sodium sulfite heptahydrate                  | Na <sub>2</sub> SO <sub>3</sub> · 7H <sub>2</sub> O                              | 10102-15-5  | 252.150     | wh monocl cry; unstab |          |       | 1.56                       | 30.7 <sup>25</sup>                  | sl EtOH                                            |
| 2650 | Sodium superoxide                            | NaO <sub>2</sub>                                                                 | 12034-12-7  | 54.989      | yel cub cry           | 552      |       | 2.2                        |                                     | reac H <sub>2</sub> O                              |
| 2651 | Sodium tartrate dihydrate                    | Na <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> · 2H <sub>2</sub> O | 6106-24-7   | 230.082     |                       |          |       | 1.545                      |                                     | s H <sub>2</sub> O; i EtOH                         |
| 2652 | Sodium tellurate                             | Na <sub>2</sub> TeO <sub>4</sub>                                                 | 10101-83-4  | 237.58      | wh powder             |          |       |                            | 0.8                                 |                                                    |
| 2653 | Sodium tellurite                             | Na <sub>2</sub> TeO <sub>3</sub>                                                 | 10102-20-2  | 221.58      | wh rhomb prisms       |          |       |                            |                                     | sl H <sub>2</sub> O                                |
| 2654 | Sodium tetraborate                           | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub>                                    | 1330-43-4   | 201.220     | col gl solid; hyg     | 743      | 1575  | 2.4                        | 3.17 <sup>25</sup>                  | sl MeOH                                            |
| 2655 | Sodium tetraborate tetrahydrate              | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> · 4H <sub>2</sub> O                | 12045-87-3  | 273.281     | wh monocl cry         |          |       | 1.95                       | 3.17 <sup>25</sup>                  |                                                    |
| 2656 | Sodium tetraborate pentahydrate              | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> · 5H <sub>2</sub> O                | 12045-88-4  | 291.296     | hex cry               | dec      |       | 1.88                       | 3.17 <sup>25</sup>                  |                                                    |
| 2657 | Sodium tetraborate decahydrate               | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> · 10H <sub>2</sub> O               | 1303-96-4   | 381.373     | wh monocl cry         | 75 dec   |       | 1.73                       | 3.17 <sup>25</sup>                  | i EtOH                                             |
| 2658 | Sodium tetrachloroaluminate                  | NaAlCl <sub>4</sub>                                                              | 7784-16-9   | 191.784     | orth cry              |          |       | 2.01                       |                                     | s H <sub>2</sub> O                                 |
| 2659 | Sodium tetrachloroaurate(III) dihydrate      | NaAuCl <sub>4</sub> · 2H <sub>2</sub> O                                          | 13874-02-7  | 397.800     | oran-yel rhom cry     | 100 dec  |       |                            | 150 <sup>10</sup>                   | s EtOH, eth                                        |
| 2660 | Sodium tetrachloropalladate(II) trihydrate   | Na <sub>2</sub> PdCl <sub>4</sub> · 3H <sub>2</sub> O                            | 13820-53-6  | 348.26      | brn-red hyg cry       |          |       |                            |                                     | vs H <sub>2</sub> O; s EtOH                        |
| 2661 | Sodium tetrachloroplatinate(II) tetrahydrate | Na <sub>2</sub> PtCl <sub>4</sub> · 4H <sub>2</sub> O                            | 10026-00-3  | 454.938     | red prisms            | 100      |       |                            |                                     | s H <sub>2</sub> O, EtOH                           |
| 2662 | Sodium tetrafluoroboroyl fluoride            | Na <sub>2</sub> BF <sub>4</sub>                                                  | 13871-27-7  | 130.986     | orth cry              | 575      |       | 2.47                       |                                     | sl H <sub>2</sub> O                                |
| 2663 | Sodium tetrafluoroborate                     | NaBF <sub>4</sub>                                                                | 13755-29-8  | 109.795     | wh orth prisms        | 384      |       | 2.47                       | 108 <sup>20</sup>                   | sl EtOH                                            |
| 2664 | Sodium thioantimonate nonahydrate            | Na <sub>3</sub> SbS <sub>4</sub> · 9H <sub>2</sub> O                             | 10101-91-4  | 481.127     | yel cry               | dec 108  |       | 1.8                        | 28 <sup>20</sup>                    | i EtOH                                             |
| 2665 | Sodium thiocyanate                           | NaSCN                                                                            | 540-72-7    | 81.073      | col hyg cry           | 287      |       |                            | 151 <sup>25</sup>                   |                                                    |
| 2666 | Sodium thiophosphate dodecahydrate           | Na <sub>2</sub> PO <sub>3</sub> S · 12H <sub>2</sub> O                           | 10101-88-9  | 396.190     | hex hyg leaflets      | 60       |       |                            |                                     | vs hot H <sub>2</sub> O                            |
| 2667 | Sodium thiosulfate                           | Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>                                    | 7772-98-7   | 158.108     | col monocl cry        | 100 dec  |       | 1.69                       | 76.4 <sup>25</sup>                  | i EtOH                                             |
| 2668 | Sodium thiosulfate pentahydrate              | Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 5H <sub>2</sub> O                | 10102-17-7  | 248.184     | col cry               | ≈50 dec  |       | 1.69                       | 76.4 <sup>25</sup>                  | i EtOH                                             |
| 2669 | Sodium trimetaphosphate                      | Na <sub>3</sub> (PO <sub>3</sub> ) <sub>3</sub>                                  | 7785-84-4   | 305.885     | wh cry                |          |       | 2.49                       | 22                                  |                                                    |
| 2670 | Sodium trimetaphosphate hexahydrate          | Na <sub>3</sub> (PO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O              | 7785-84-4   | 413.976     | tricl-rhom hyg prisms | 53       |       | 1.786                      | 22                                  | i EtOH                                             |
| 2671 | Sodium tripolyphosphate                      | Na <sub>5</sub> P <sub>3</sub> O <sub>10</sub>                                   | 7758-29-4   | 367.864     | wh hyg powder         | 622      |       |                            | 20 <sup>25</sup>                    |                                                    |
| 2672 | Sodium tungstate                             | Na <sub>2</sub> WO <sub>4</sub>                                                  | 13472-45-2  | 293.82      | wh rhom cry           | 695      |       | 4.18                       | 74.2 <sup>25</sup>                  |                                                    |
| 2673 | Sodium tungstate dihydrate                   | Na <sub>2</sub> WO <sub>4</sub> · 2H <sub>2</sub> O                              | 10213-10-2  | 329.85      | wh orth cry           | 100 dec  |       | 3.25                       | 74.2 <sup>25</sup>                  | i EtOH                                             |
| 2674 | Sodium uranate(VI) monohydrate               | Na <sub>2</sub> U <sub>2</sub> O <sub>7</sub> · H <sub>2</sub> O                 | 13721-34-1  | 652.049     | yel powder            |          |       |                            |                                     | i H <sub>2</sub> O; s acid                         |



| No.  | Name                                    | Formula                                                        | CAS Reg No. | Mol. weight | Physical form                       | mp/°C                  | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                                  |
|------|-----------------------------------------|----------------------------------------------------------------|-------------|-------------|-------------------------------------|------------------------|----------|----------------------------|-------------------------------------|---------------------------------------------------------|
| 2675 | Sodium vanadate(V)                      | NaVO <sub>3</sub>                                              | 13718-26-8  | 121.930     | col monocl prisms                   | 630                    |          |                            | 21 <sup>25</sup>                    |                                                         |
| 2676 | Sodium vanadate(V) tetrahydrate         | NaVO <sub>3</sub> · 4H <sub>2</sub> O                          | 13718-26-8  | 193.992     | yel-wh cry powder                   |                        |          |                            | 21 <sup>25</sup>                    |                                                         |
| 2677 | Strontium                               | Sr                                                             | 7440-24-6   | 87.62       | silv-wh metal; cub                  | 777                    | 1382     | 2.64                       |                                     | reac H <sub>2</sub> O; s EtOH                           |
| 2678 | Strontium acetate                       | Sr(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> | 543-94-2    | 205.71      | col hyg cry                         | dec                    |          | 2.1                        | 40 <sup>25</sup>                    | vs H <sub>2</sub> O                                     |
| 2679 | Strontium arsenite tetrahydrate         | Sr(AsO <sub>2</sub> ) <sub>2</sub> · 4H <sub>2</sub> O         | 10378-48-0  | 373.52      | wh powder                           |                        |          |                            |                                     | sl H <sub>2</sub> O, EtOH; sol dil acid                 |
| 2680 | Strontium bromate monohydrate           | Sr(BrO <sub>3</sub> ) <sub>2</sub> · H <sub>2</sub> O          | 14519-18-7  | 361.44      | yel hyg monocl cry                  | 120 dec                |          | 3.773                      | 39.0 <sup>25</sup>                  |                                                         |
| 2681 | Strontium bromide                       | SrBr <sub>2</sub>                                              | 10476-81-0  | 247.43      | wh tetr cry                         | 657                    |          | 4.216                      | 107 <sup>25</sup>                   |                                                         |
| 2682 | Strontium bromide hexahydrate           | SrBr <sub>2</sub> · 6H <sub>2</sub> O                          | 7789-53-9   | 355.52      | col hyg cry                         | 88 dec                 |          |                            | 107 <sup>25</sup>                   | s EtOH; i eth                                           |
| 2683 | Strontium carbide                       | SrC <sub>2</sub>                                               | 12071-29-3  | 111.64      | blk tetr cry                        | >1700                  |          | 3.19                       |                                     | i H <sub>2</sub> O                                      |
| 2684 | Strontium carbonate                     | SrCO <sub>3</sub>                                              | 1633-05-2   | 147.63      | wh orth cry; hyg                    | 1494                   |          | 3.785                      | 0.00034 <sup>20</sup>               | s dil acid                                              |
| 2685 | Strontium chlorate                      | Sr(ClO <sub>3</sub> ) <sub>2</sub>                             | 7791-10-8   | 254.52      | col cry                             | 120 dec                |          | 3.15                       | 176 <sup>25</sup>                   | sl EtOH                                                 |
| 2686 | Strontium chloride                      | SrCl <sub>2</sub>                                              | 10476-85-4  | 158.53      | wh cub cry; hyg                     | 874                    | 1250     | 3.052                      | 54.7 <sup>25</sup>                  |                                                         |
| 2687 | Strontium chloride hexahydrate          | SrCl <sub>2</sub> · 6H <sub>2</sub> O                          | 10025-70-4  | 266.62      | col hyg cry                         | 100 dec                |          | 1.96                       | 54.7 <sup>25</sup>                  | s EtOH                                                  |
| 2688 | Strontium chromate                      | SrCrO <sub>4</sub>                                             | 7789-06-2   | 203.61      | yel monocl cry                      | dec                    |          | 3.9                        | 0.106 <sup>20</sup>                 | s dil acid                                              |
| 2689 | Strontium cyanide dihydrate             | Sr(CN) <sub>2</sub> · 4H <sub>2</sub> O                        | 52870-08-3  | 211.72      | wh hyg cry                          | dec                    |          |                            |                                     | vs H <sub>2</sub> O                                     |
| 2690 | Strontium ferrocyanide pentadecahydrate | SrFe(CN) <sub>6</sub> · 15H <sub>2</sub> O                     | 14654-44-5  | 569.80      | yel monocl cry                      |                        |          |                            | 50                                  |                                                         |
| 2691 | Strontium fluoride                      | SrF <sub>2</sub>                                               | 7783-48-4   | 125.62      | wh cub cry or powder                | 1477                   | 2460     | 4.24                       | 0.021 <sup>25</sup>                 | s dil acid                                              |
| 2692 | Strontium formate                       | Sr(CHO <sub>2</sub> ) <sub>2</sub>                             | 592-89-2    | 177.66      | wh cry                              | 71.9                   |          | 2.693                      | 9.1 <sup>0</sup>                    |                                                         |
| 2693 | Strontium formate dihydrate             | Sr(CHO <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O         | 6160-34-5   | 213.69      | col rhom cry                        | 100 dec                |          | 2.25                       | 9.1 <sup>37</sup>                   | i EtOH, eth                                             |
| 2694 | Strontium hexaboride                    | SrB <sub>6</sub>                                               | 12046-54-7  | 152.49      | blk cub cry                         | 2235                   |          | 3.39                       |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>                  |
| 2695 | Strontium hydride                       | SrH <sub>2</sub>                                               | 13598-33-9  | 89.64       | orth cry                            | 1050                   |          | 3.26                       |                                     | reac H <sub>2</sub> O                                   |
| 2696 | Strontium hydroxide                     | Sr(OH) <sub>2</sub>                                            | 18480-07-4  | 121.64      | col orth cry; hyg                   | 535                    | 710 dec  | 3.625                      | 2.25 <sup>25</sup>                  |                                                         |
| 2697 | Strontium iodate                        | Sr(IO <sub>3</sub> ) <sub>2</sub>                              | 13470-01-4  | 437.43      | tricl cry                           |                        |          | 5.045                      | 0.165 <sup>25</sup>                 |                                                         |
| 2698 | Strontium iodide                        | SrI <sub>2</sub>                                               | 10476-86-5  | 341.43      | wh hyg cry                          | 538                    | 1773 dec | 4.55                       | 177 <sup>25</sup>                   |                                                         |
| 2699 | Strontium iodide hexahydrate            | SrI <sub>2</sub> · 6H <sub>2</sub> O                           | 73796-25-5  | 449.52      | wh-yel hex cry; hyg                 | 120 dec                |          | 4.4                        | 177 <sup>25</sup>                   | s EtOH                                                  |
| 2700 | Strontium molybdate                     | SrMoO <sub>4</sub>                                             | 13470-04-7  | 247.56      | wh cry pow                          | 1040                   |          | 4.54                       |                                     | i H <sub>2</sub> O                                      |
| 2701 | Strontium niobate                       | SrNb <sub>2</sub> O <sub>6</sub>                               | 12034-89-8  | 369.43      | monocl cry                          | 1225                   |          | 5.11                       |                                     | i H <sub>2</sub> O                                      |
| 2702 | Strontium nitrate                       | Sr(NO <sub>3</sub> ) <sub>2</sub>                              | 10042-76-9  | 211.63      | wh cub cry                          | 570                    |          | 2.99                       | 80.2 <sup>25</sup>                  | sl EtOH, ace                                            |
| 2703 | Strontium nitride                       | Sr <sub>3</sub> N <sub>2</sub>                                 | 12033-82-8  | 290.87      | refrac solid                        | 1200                   |          |                            |                                     | reac H <sub>2</sub> O; s HCl                            |
| 2704 | Strontium nitrite                       | Sr(NO <sub>2</sub> ) <sub>2</sub>                              | 13470-06-9  | 179.63      | wh-yel hyg needles                  | 240 dec                |          | 2.8                        | 72.1 <sup>30</sup>                  | s H <sub>2</sub> O                                      |
| 2705 | Strontium orthosilicate                 | Sr <sub>2</sub> SiO <sub>4</sub>                               | 13597-55-2  | 267.32      | orth cry                            |                        |          | 4.5                        |                                     |                                                         |
| 2706 | Strontium oxalate monohydrate           | SrC <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> O             | 814-95-9    | 193.65      | cry pow                             | dec 150                |          |                            | 0.00005 <sup>20</sup>               | sl dil acid                                             |
| 2707 | Strontium oxide                         | SrO                                                            | 1314-11-0   | 103.62      | col cub cry                         | 2531                   |          | 5.1                        |                                     | reac H <sub>2</sub> O                                   |
| 2708 | Strontium perchlorate                   | Sr(ClO <sub>4</sub> ) <sub>2</sub>                             | 13450-97-0  | 286.52      | col hyg cry                         |                        |          |                            | 306 <sup>25</sup>                   | s EtOH, MeOH                                            |
| 2709 | Strontium permanganate trihydrate       | Sr(MnO <sub>4</sub> ) <sub>2</sub> · 3H <sub>2</sub> O         | 14446-13-0  | 379.54      | purp cub cry                        | 175 dec                |          | 2.75                       | 250 <sup>18</sup>                   |                                                         |
| 2710 | Strontium peroxide                      | SrO <sub>2</sub>                                               | 1314-18-7   | 119.62      | wh tetr cry; unstab                 | 215 dec                |          | 4.78                       |                                     | reac H <sub>2</sub> O                                   |
| 2711 | Strontium phosphate                     | Sr <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>                | 7446-28-8   | 452.80      | wh powder                           |                        |          |                            | 0.000011 <sup>20</sup>              | s acid                                                  |
| 2712 | Strontium selenate                      | SrSeO <sub>4</sub>                                             | 7446-21-1   | 230.58      | orth cry                            |                        |          | 4.25                       | 0.115 <sup>20</sup>                 | s hot HCl                                               |
| 2713 | Strontium selenide                      | SrSe                                                           | 1315-07-7   | 166.58      | wh cub cry                          | 1600                   |          | 4.54                       |                                     |                                                         |
| 2714 | Strontium silicide                      | SrSi <sub>2</sub>                                              | 12138-28-2  | 143.79      | silv-gray cub cry                   | 1100                   |          | 3.35                       |                                     |                                                         |
| 2715 | Strontium sulfate                       | SrSO <sub>4</sub>                                              | 7759-02-6   | 183.68      | wh orth cry                         | 1606                   |          | 3.96                       | 0.0135 <sup>25</sup>                | i EtOH; sl acid                                         |
| 2716 | Strontium sulfide                       | SrS                                                            | 1314-96-1   | 119.69      | gray cub cry                        | 2226                   |          | 3.70                       |                                     | sl H <sub>2</sub> O; s acid                             |
| 2717 | Strontium sulfite                       | SrSO <sub>3</sub>                                              | 13451-02-0  | 167.68      | col cry                             | dec                    |          |                            | 0.0015 <sup>25</sup>                | s H <sub>2</sub> SO <sub>4</sub> , HCl                  |
| 2718 | Strontium telluride                     | SrTe                                                           | 12040-08-3  | 215.22      | wh cub cry                          |                        |          | 4.83                       |                                     |                                                         |
| 2719 | Strontium thiosulfate pentahydrate      | SrS <sub>2</sub> O <sub>3</sub> · 5H <sub>2</sub> O            | 15123-90-7  | 289.82      | monocl needles                      | 100 dec                |          | 2.17                       | 36.3 <sup>25</sup>                  | i EtOH                                                  |
| 2720 | Strontium titanate                      | SrTiO <sub>3</sub>                                             | 12060-59-2  | 183.49      | wh cub cry                          | 2080                   |          | 5.1                        |                                     | i H <sub>2</sub> O                                      |
| 2721 | Strontium tungstate                     | SrWO <sub>4</sub>                                              | 13451-05-3  | 335.46      | col tetr cry                        | dec                    |          | 6.187                      | 0.14 <sup>15</sup>                  | i EtOH                                                  |
| 2722 | Strontium zirconate                     | SrZrO <sub>3</sub>                                             | 12036-39-4  | 226.84      | col cry                             | 2600                   |          |                            |                                     |                                                         |
| 2723 | Sulfur (rhombic)                        | S                                                              | 7704-34-9   | 32.065      | yel orth cry                        | 95.3 (trans to monocl) | 444.61   | 2.07                       |                                     | i H <sub>2</sub> O; sl EtOH, bz, eth; s CS <sub>2</sub> |
| 2724 | Sulfur (monoclinic)                     | S                                                              | 7704-34-9   | 32.065      | yel monocl needles, stable 95.3-120 | 115.21                 | 444.61   | 2.00                       |                                     | i H <sub>2</sub> O; sl EtOH, bz, eth; s CS <sub>2</sub> |
| 2725 | Sulfuric acid                           | H <sub>2</sub> SO <sub>4</sub>                                 | 7664-93-9   | 98.079      | col oily liq                        | 10.31                  | 337      | 1.8302                     |                                     | vs H <sub>2</sub> O                                     |
| 2726 | Peroxydisulfuric acid                   | H <sub>2</sub> SO <sub>5</sub>                                 | 7722-86-3   | 114.078     | wh cry; unstab                      | 45 dec                 |          |                            |                                     | vs H <sub>2</sub> O                                     |
| 2727 | Nitrosylsulfuric acid                   | HNOSO <sub>4</sub>                                             | 7782-78-7   | 127.077     | prisms                              | 73 dec                 |          |                            |                                     | reac H <sub>2</sub> O; s H <sub>2</sub> SO <sub>4</sub> |
| 2728 | Chlorosulfonic acid                     | SO <sub>2</sub> (OH)Cl                                         | 7790-94-5   | 116.524     | col-yel liq                         | -80                    | 152      | 1.75                       |                                     | reac H <sub>2</sub> O; s py                             |
| 2729 | Fluorosulfonic acid                     | SO <sub>2</sub> (OH)F                                          | 7789-21-1   | 100.069     | col liq                             | -89                    | 163      | 1.726                      |                                     | reac H <sub>2</sub> O                                   |
| 2730 | Sulfurous acid                          | H <sub>2</sub> SO <sub>3</sub>                                 | 7782-99-2   | 82.079      | exists only in aq soln              |                        |          |                            |                                     |                                                         |
| 2731 | Sulfamic acid                           | H <sub>2</sub> NSO <sub>3</sub> H                              | 5329-14-6   | 97.094      | orth cry                            | ≈205 dec               |          | 2.15                       | 14.7 <sup>0</sup>                   | sl ace; i eth                                           |
| 2732 | Sulfur dioxide                          | SO <sub>2</sub>                                                | 7446-09-5   | 64.064      | col gas                             | -75.5                  | -10.05   | 2.619 g/L                  |                                     | s H <sub>2</sub> O, EtOH, eth, chl                      |

| No.  | Name                                      | Formula                                         | CAS Reg No. | Mol. weight | Physical form          | mp/°C      | bp/°C       | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                            |
|------|-------------------------------------------|-------------------------------------------------|-------------|-------------|------------------------|------------|-------------|----------------------------|-------------------------------------|---------------------------------------------------|
| 2733 | Sulfur trioxide                           | SO <sub>3</sub>                                 | 7446-11-9   | 80.063      | wh needles             | 62.2       | subl        |                            |                                     | reac H <sub>2</sub> O                             |
| 2734 | Sulfur trioxide (γ-form)                  | SO <sub>3</sub>                                 | 7446-11-9   | 80.063      | col solid or liq       | 16.8       | 44.5        | 1.90                       |                                     | reac H <sub>2</sub> O                             |
| 2735 | Sulfur trioxide (β-form)                  | SO <sub>3</sub>                                 | 7446-11-9   | 80.063      | wh needles             | 30.5       | 44.5        |                            |                                     | reac H <sub>2</sub> O                             |
| 2736 | Sulfur bromide (SSBr <sub>2</sub> )       | SSBr <sub>2</sub>                               | 13172-31-1  | 223.938     | red oily liq           | -46        | >25 dec     | 2.63                       |                                     | reac H <sub>2</sub> O                             |
| 2737 | Sulfur chloride (SSCl <sub>2</sub> )      | SSCl <sub>2</sub>                               | 10025-67-9  | 135.036     | yel-red oily liq       | -77        | 137         | 1.69                       |                                     | reac H <sub>2</sub> O; s EtOH, bz, eth, etc       |
| 2738 | Sulfur fluoride (SSF <sub>2</sub> )       | SSF <sub>2</sub>                                | 16860-99-4  | 102.127     | col gas                | -164.6     | -10.6       | 4.174 g/L                  |                                     | reac H <sub>2</sub> O                             |
| 2739 | Sulfur fluoride (FSSF)                    | FSSF                                            | 13709-35-8  | 102.127     | col gas                | -133       | 15          | 4.174 g/L                  |                                     | reac H <sub>2</sub> O                             |
| 2740 | Sulfur dichloride                         | SCl <sub>2</sub>                                | 10545-99-0  | 102.971     | red visc liq           | -122       | 59.6        | 1.62                       |                                     | reac H <sub>2</sub> O                             |
| 2741 | Sulfur tetrafluoride                      | SF <sub>4</sub>                                 | 7783-60-0   | 108.059     | col gas                | -125       | -40.45      | 4.417 g/L                  |                                     | reac H <sub>2</sub> O                             |
| 2742 | Sulfur hexafluoride                       | SF <sub>6</sub>                                 | 2551-62-4   | 146.055     | col gas                | -49.596 tp | -63.8 sp    | 5.970 g/L                  |                                     | sl H <sub>2</sub> O; s EtOH                       |
| 2743 | Sulfur bromide pentafluoride              | SF <sub>5</sub> Br                              | 15607-89-3  | 206.961     | col gas                | -79        | 3.1         | 8.459 g/L                  |                                     |                                                   |
| 2744 | Sulfur chloride pentafluoride             | SF <sub>5</sub> Cl                              | 13780-57-9  | 162.510     | col gas                | -64        | -19.05      | 6.642 g/L                  |                                     |                                                   |
| 2745 | Sulfur decafluoride                       | S <sub>2</sub> F <sub>10</sub>                  | 5714-22-7   | 254.114     | liq                    | -52.7      | 30; dec 150 | 2.08                       |                                     | i H <sub>2</sub> O                                |
| 2746 | Sulfuryl amide                            | (NH <sub>2</sub> ) <sub>2</sub> SO <sub>2</sub> | 7803-58-9   | 96.109      | orth plates            | 93         | 250 dec     |                            |                                     | vs H <sub>2</sub> O; sl EtOH                      |
| 2747 | Sulfuryl chloride                         | SO <sub>2</sub> Cl <sub>2</sub>                 | 7791-25-5   | 134.970     | col liq                | -51        | 69.4        | 1.680                      |                                     | reac H <sub>2</sub> O; s bz, tol, eth             |
| 2748 | Sulfuryl fluoride                         | SO <sub>2</sub> F <sub>2</sub>                  | 2699-79-8   | 102.061     | col gas                | -135.8     | -55.4       | 4.172 g/L                  |                                     | sl H <sub>2</sub> O; EtOH; s tol, etc             |
| 2749 | Sulfuryl bromide fluoride                 | SO <sub>2</sub> BrF                             | 13536-61-3  | 162.966     | col liq                | -86        | 41          |                            |                                     | reac H <sub>2</sub> O                             |
| 2750 | Sulfuryl chloride fluoride                | SO <sub>2</sub> ClF                             | 13637-84-8  | 118.515     | col gas                | -124.7     | 7.1         | 1.62 <sup>o</sup>          |                                     | reac H <sub>2</sub> O                             |
| 2751 | Pyrosulfuryl chloride                     | S <sub>2</sub> O <sub>2</sub> Cl <sub>2</sub>   | 7791-27-7   | 215.033     | col fuming liq         | -37        | 151         | 1.837                      |                                     | reac H <sub>2</sub> O                             |
| 2752 | Thionyl bromide                           | SOBr <sub>2</sub>                               | 507-16-4    | 207.872     | yel liq                | -50        | 140         |                            |                                     | reac H <sub>2</sub> O                             |
| 2753 | Thionyl chloride                          | SOCl <sub>2</sub>                               | 7719-09-7   | 118.970     | yel fuming liq         | -101       | 75.6        | 1.631                      |                                     | reac H <sub>2</sub> O; s bz, etc, chl             |
| 2754 | Thionyl fluoride                          | SOF <sub>2</sub>                                | 7783-42-8   | 86.061      | col gas                | -129.5     | -43.8       | 3.518 g/L                  |                                     | reac H <sub>2</sub> O; s bz, eth                  |
| 2755 | Sulfur fluoride oxide (SOF <sub>4</sub> ) | SOF <sub>4</sub>                                | 13709-54-1  | 124.058     | col gas                | -99.6      | -48.5       | 1.95 <sup>-82</sup>        |                                     | reac H <sub>2</sub> O                             |
| 2756 | Sulfur fluoride hypofluorite              | F <sub>3</sub> SOF                              | 15179-32-5  | 162.054     | col gas                | -86        | -35.1       | 6.624 g/L                  |                                     |                                                   |
| 2757 | Tetrasulfur tetranitride                  | S <sub>4</sub> N <sub>4</sub>                   | 28950-34-7  | 184.287     | yel-oran cry           | 178.2      | subl        |                            |                                     | i H <sub>2</sub> O; reac alk, acid                |
| 2758 | Tantalum                                  | Ta                                              | 7440-25-7   | 180.948     | gray metal; cub        | 3017       | 5458        | 16.4                       |                                     | reac HF                                           |
| 2759 | Tantalum aluminate                        | TaAl <sub>3</sub>                               | 12004-76-1  | 261.893     | gray refrac powder     | ≈1400      |             | 7.02                       |                                     | i H <sub>2</sub> O, acid, alk                     |
| 2760 | Tantalum boride (TaB)                     | TaB                                             | 12007-07-7  | 191.759     | refrac orth cry        | 2040       |             | 14.2                       |                                     |                                                   |
| 2761 | Tantalum boride (TaB <sub>2</sub> )       | TaB <sub>2</sub>                                | 12007-35-1  | 202.570     | blk hex cry            | 3100       |             | 11.2                       |                                     | i H <sub>2</sub> O, acid, alk                     |
| 2762 | Tantalum carbide (TaC)                    | TaC                                             | 12070-06-3  | 192.959     | gold-brown powder; cub | 3880       | 4780        | 14.3                       |                                     | s HF-HNO <sub>3</sub> mixture                     |
| 2763 | Tantalum carbide (Ta <sub>2</sub> C)      | Ta <sub>2</sub> C                               | 12070-07-4  | 373.907     | refrac hex cry         | 3327       |             | 15.1                       |                                     |                                                   |
| 2764 | Tantalum hydride                          | TaH                                             | 13981-95-8  | 181.956     | gray metallic solid    |            |             | 15.1                       |                                     | i acid                                            |
| 2765 | Tantalum nitride                          | TaN                                             | 12033-62-4  | 194.955     | blk hex cry            | 3090       |             | 13.7                       |                                     | i H <sub>2</sub> O; sl aqua regia; reac alk       |
| 2766 | Tantalum silicide                         | TaSi <sub>2</sub>                               | 12039-79-1  | 237.119     | gray powder            | 2200       |             | 9.14                       |                                     |                                                   |
| 2767 | Tantalum(III) bromide                     | TaBr <sub>3</sub>                               | 13842-73-4  | 420.660     | gray-grn solid         | dec 220    |             |                            |                                     |                                                   |
| 2768 | Tantalum(III) chloride                    | TaCl <sub>3</sub>                               | 13569-67-0  | 287.307     | blk-grn solid          | dec 440    |             |                            |                                     | s H <sub>2</sub> O                                |
| 2769 | Tantalum(IV) bromide                      | TaBr <sub>4</sub>                               | 13842-76-7  | 500.564     | dark blue solid        | 392        |             | 5.77                       |                                     | reac H <sub>2</sub> O                             |
| 2770 | Tantalum(IV) chloride                     | TaCl <sub>4</sub>                               | 13569-72-7  | 322.760     | dark grn solid         | dec 300    | subl        | 4.35                       |                                     | reac H <sub>2</sub> O                             |
| 2771 | Tantalum(IV) iodide                       | TaI <sub>4</sub>                                | 14693-80-2  | 688.566     | gray-blk solid         | 400 dec    |             |                            |                                     | reac H <sub>2</sub> O                             |
| 2772 | Tantalum(IV) oxide                        | Ta <sub>2</sub> O <sub>5</sub>                  | 12036-14-5  | 212.947     | tetr cry               |            |             | 10.0                       |                                     |                                                   |
| 2773 | Tantalum(IV) selenide                     | TaSe <sub>2</sub>                               | 12039-55-3  | 338.87      | hex cry                |            |             | 6.7                        |                                     |                                                   |
| 2774 | Tantalum(IV) sulfide                      | TaS <sub>2</sub>                                | 12143-72-5  | 245.078     | blk hex cry            | >3000      |             | 6.86                       |                                     | i H <sub>2</sub> O                                |
| 2775 | Tantalum(IV) telluride                    | TaTe <sub>2</sub>                               | 12067-66-2  | 436.15      | monocl cry             |            |             | 9.4                        |                                     |                                                   |
| 2776 | Tantalum(V) bromide                       | TaBr <sub>5</sub>                               | 13451-11-1  | 580.468     | yel cry powder         | 265.8      | 348.8       | 4.67                       |                                     |                                                   |
| 2777 | Tantalum(V) chloride                      | TaCl <sub>5</sub>                               | 7721-01-9   | 358.213     | yel-wh monocl cry; hyg | 216.6      | 239         | 3.68                       |                                     | reac H <sub>2</sub> O; s EtOH                     |
| 2778 | Tantalum(V) fluoride                      | TaF <sub>5</sub>                                | 7783-71-3   | 275.940     | wh monocl cry; hyg     | 96.9       | 229.5       | 4.74                       |                                     | s H <sub>2</sub> O, eth; sl CS <sub>2</sub> , etc |
| 2779 | Tantalum(V) iodide                        | TaI <sub>5</sub>                                | 14693-81-3  | 815.470     | blk hex cry; hyg       | 496        | 543         | 5.80                       |                                     | reac H <sub>2</sub> O                             |
| 2780 | Tantalum(V) oxide                         | Ta <sub>2</sub> O <sub>5</sub>                  | 1314-61-0   | 441.893     | wh rhomb cry or powder | 1875       |             | 8.24                       |                                     | i H <sub>2</sub> O, EtOH, acid; s HF              |
| 2781 | Technetium                                | Tc                                              | 7440-26-8   | 98          | hex cry                | 2157       | 4265        | 11                         |                                     |                                                   |
| 2782 | Technetium(V) fluoride                    | TcF <sub>5</sub>                                | 31052-14-9  | 193         | yel solid              | 50         | dec         |                            |                                     |                                                   |
| 2783 | Technetium(VI) fluoride                   | TcF <sub>6</sub>                                | 13842-93-8  | 212         | yel cub cry            | 37.4       | 55.3        | 3.0                        |                                     |                                                   |
| 2784 | Tellurium                                 | Te                                              | 13494-80-9  | 127.60      | gray-wh rhomb cry      | 449.51     | 988         | 6.232                      |                                     | i H <sub>2</sub> O, bz, CS <sub>2</sub>           |
| 2785 | Telluric(VI) acid                         | H <sub>6</sub> TeO <sub>6</sub>                 | 7803-68-1   | 229.64      | wh monocl cry          | 136        |             | 3.07                       | 50.1 <sup>30</sup>                  |                                                   |
| 2786 | Tellurous acid                            | H <sub>2</sub> TeO <sub>3</sub>                 | 10049-23-7  | 177.61      | wh cry                 | 40 dec     |             | 3.0                        |                                     | sl H <sub>2</sub> O; s dil acid, alk              |
| 2787 | Tellurium dioxide                         | TeO <sub>2</sub>                                | 7446-07-3   | 159.60      | wh orth cry            | 733        | 1245        | 5.9                        |                                     | i H <sub>2</sub> O; s alk, acid                   |
| 2788 | Tellurium trioxide                        | TeO <sub>3</sub>                                | 13451-18-8  | 175.60      | yel-oran cry           | 430        |             | 5.07                       |                                     | i H <sub>2</sub> O                                |

| No.  | Name                                | Formula                                                             | CAS Reg No. | Mol. weight | Physical form           | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility               |
|------|-------------------------------------|---------------------------------------------------------------------|-------------|-------------|-------------------------|----------|----------|----------------------------|-------------------------------------|--------------------------------------|
| 2789 | Tellurium dibromide                 | TeBr <sub>2</sub>                                                   | 7789-54-0   | 287.41      | grn-brn hyg cry         | 210      | 339      |                            |                                     | reac H <sub>2</sub> O; s eth; sl chl |
| 2790 | Tellurium dichloride                | TeCl <sub>2</sub>                                                   | 10025-71-5  | 198.51      | blk amorp solid; hyg    | 208      | 328      | 6.9                        |                                     | reac H <sub>2</sub> O; i ctc         |
| 2791 | Tellurium tetrabromide              | TeBr <sub>4</sub>                                                   | 10031-27-3  | 447.22      | yel-oran monocl cry     | 380      | ≈420 dec | 4.3                        |                                     | reac H <sub>2</sub> O; s eth         |
| 2792 | Tellurium tetrachloride             | TeCl <sub>4</sub>                                                   | 10026-07-0  | 269.41      | wh monocl cry; hyg      | 224      | 387      | 3.0                        |                                     | reac H <sub>2</sub> O; s EtOH, tol   |
| 2793 | Tellurium tetrafluoride             | TeF <sub>4</sub>                                                    | 15192-26-4  | 203.59      | col cry                 | 129      | 195 dec  |                            |                                     | reac H <sub>2</sub> O                |
| 2794 | Tellurium decafluoride              | Te <sub>2</sub> F <sub>10</sub>                                     | 53214-07-6  | 445.18      | col liq                 | -33.7    | 59       |                            |                                     |                                      |
| 2795 | Tellurium tetraiodide               | TeI <sub>4</sub>                                                    | 7790-48-9   | 635.22      | blk orth cry            | 280      |          | 5.05                       |                                     | reac H <sub>2</sub> O; sl ace        |
| 2796 | Tellurium hexafluoride              | TeF <sub>6</sub>                                                    | 7783-80-4   | 241.59      | col gas                 | -37.6 tp | -38.9 sp | 9.875 g/L                  |                                     | reac H <sub>2</sub> O                |
| 2797 | Terbium                             | Tb                                                                  | 7440-27-9   | 158.925     | silv metal; hex         | 1359     | 3230     | 8.23                       |                                     |                                      |
| 2798 | Terbium nitride                     | TbN                                                                 | 12033-64-6  | 172.932     | cub cry                 |          |          | 9.55                       |                                     |                                      |
| 2799 | Terbium silicide                    | TbSi <sub>2</sub>                                                   | 12039-80-4  | 215.096     | orth cry                |          |          | 6.66                       |                                     |                                      |
| 2800 | Terbium(III) bromide                | TbBr <sub>3</sub>                                                   | 14456-47-4  | 398.637     | wh hex cry              | 830      | 1490     |                            |                                     | s H <sub>2</sub> O                   |
| 2801 | Terbium(III) chloride               | TbCl <sub>3</sub>                                                   | 10042-88-3  | 265.284     | wh orth cry; hyg        | 582      |          | 4.35                       |                                     | s H <sub>2</sub> O                   |
| 2802 | Terbium(III) chloride hexahydrate   | TbCl <sub>3</sub> · 6H <sub>2</sub> O                               | 13798-24-8  | 373.375     | hyg cry                 |          |          | 4.35                       |                                     | vs H <sub>2</sub> O                  |
| 2803 | Terbium(III) iodide                 | TbI <sub>3</sub>                                                    | 13813-40-6  | 539.638     | hex cry; hyg            | 955      |          | ≈5.2                       |                                     | s H <sub>2</sub> O                   |
| 2804 | Terbium(III) nitrate                | Tb(NO <sub>3</sub> ) <sub>3</sub>                                   | 10043-27-3  | 344.940     | pink hyg solid          |          |          |                            | 157 <sup>25</sup>                   | s EtOH                               |
| 2805 | Terbium(III) nitrate hexahydrate    | Tb(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O               | 13451-19-9  | 453.031     | col needles             | 89       |          |                            |                                     | s H <sub>2</sub> O, EtOH, ace        |
| 2806 | Terbium(III) oxide                  | Tb <sub>2</sub> O <sub>3</sub>                                      | 12036-41-8  | 365.849     | wh cub cry              | 2303     |          | 7.91                       |                                     |                                      |
| 2807 | Terbium(III) sulfate octahydrate    | Tb <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O | 13842-67-6  | 750.161     | wh cry                  | dec 360  |          |                            |                                     | sl H <sub>2</sub> O                  |
| 2808 | Terbium(III) sulfide                | Tb <sub>2</sub> S <sub>3</sub>                                      | 12138-11-3  | 414.046     | cub cry                 |          |          | 6.35                       |                                     |                                      |
| 2809 | Terbium(III) fluoride               | TbF <sub>3</sub>                                                    | 13708-63-9  | 215.920     | wh solid                | 1175     | 2280     |                            |                                     | i H <sub>2</sub> O                   |
| 2810 | Terbium(IV) fluoride                | TbF <sub>4</sub>                                                    | 36781-15-4  | 234.919     | wh monocl cry           | dec 300  |          |                            |                                     | i H <sub>2</sub> O                   |
| 2811 | Thallium                            | Tl                                                                  | 7440-28-0   | 204.383     | soft blue-wh metal      | 304      | 1473     | 11.8                       |                                     | i H <sub>2</sub> O; reac acid        |
| 2812 | Thallium(I) acetate                 | TlC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                      | 563-68-8    | 263.427     | hyg wh cry              | 131      |          | 3.68                       |                                     | s H <sub>2</sub> O, EtOH             |
| 2813 | Thallium(I) azide                   | TlN <sub>3</sub>                                                    | 13847-66-0  | 246.403     | yel cry                 | 334      | exp      |                            |                                     | s H <sub>2</sub> O                   |
| 2814 | Thallium(I) bromate                 | TlBrO <sub>3</sub>                                                  | 14550-84-6  | 332.285     | col needles             | 120 dec  |          |                            | 0.49 <sup>30</sup>                  | s EtOH                               |
| 2815 | Thallium(I) bromide                 | TlBr                                                                | 7789-40-4   | 284.287     | yel cub cry             | 460      | 819      | 7.5                        | 0.059 <sup>20</sup>                 |                                      |
| 2816 | Thallium(I) carbonate               | Tl <sub>2</sub> CO <sub>3</sub>                                     | 6533-73-9   | 468.776     | wh monocl cry           | 273      |          | 7.11                       | 4.69 <sup>20</sup>                  | i EtOH                               |
| 2817 | Thallium(I) chlorate                | TlClO <sub>3</sub>                                                  | 13453-30-0  | 287.834     | col hex cry             | dec 500  |          | 5.5                        | 3.92 <sup>20</sup>                  |                                      |
| 2818 | Thallium(I) chloride                | TlCl                                                                | 7791-12-0   | 239.836     | wh cub cry              | 431      | 720      | 7.0                        | 0.33 <sup>20</sup>                  | i EtOH                               |
| 2819 | Thallium(I) chromate                | Tl <sub>2</sub> CrO <sub>4</sub>                                    | 13473-75-1  | 524.761     | yel cry                 |          |          |                            | 0.003 <sup>20</sup>                 | sl acid, alk                         |
| 2820 | Thallium(I) cyanide                 | TlCN                                                                | 13453-34-4  | 230.401     | wh hex plates           |          |          | 6.523                      |                                     | s H <sub>2</sub> O, acid, EtOH       |
| 2821 | Thallium(I) ethanolate              | TlC <sub>2</sub> H <sub>5</sub> O                                   | 20398-06-5  | 249.443     | cloudy liq              | -3       | 130 dec  | 3.49                       |                                     | reac H <sub>2</sub> O                |
| 2822 | Thallium(I) fluoride                | TlF                                                                 | 7789-27-7   | 223.381     | wh orth cry             | 326      | 826      | 8.36                       | 245 <sup>25</sup>                   |                                      |
| 2823 | Thallium(I) formate                 | TlCHO <sub>2</sub>                                                  | 992-98-3    | 249.401     | hyg col needles         | 101      |          | 4.97                       |                                     | vs H <sub>2</sub> O; s MeOH          |
| 2824 | Thallium(I) hexafluorophosphate     | TlPF <sub>6</sub>                                                   | 60969-19-9  | 349.347     | wh cub cry              |          |          | 4.6                        |                                     |                                      |
| 2825 | Thallium(I) hydroxide               | TlOH                                                                | 12026-06-1  | 221.390     | yel needles             | 139 dec  |          | 7.44                       | 34.3 <sup>18</sup>                  |                                      |
| 2826 | Thallium(I) iodate                  | TlIO <sub>3</sub>                                                   | 14767-09-0  | 379.285     | wh needles              |          |          |                            | 0.058                               | sl HNO <sub>3</sub>                  |
| 2827 | Thallium(I) iodide                  | TlI                                                                 | 7790-30-9   | 331.287     | yel cry powder          | 441.7    | 824      | 7.1                        | 0.0085 <sup>20</sup>                | i EtOH                               |
| 2828 | Thallium(I) molybdate               | Tl <sub>2</sub> MoO <sub>4</sub>                                    | 34128-09-1  | 568.71      | yel-wh cub cry          |          |          |                            |                                     | i H <sub>2</sub> O                   |
| 2829 | Thallium(I) nitrate                 | TlNO <sub>3</sub>                                                   | 10102-45-1  | 266.388     | wh cry                  | 206      | 450 dec  | 5.55                       | 9.55 <sup>20</sup>                  | s H <sub>2</sub> O; i EtOH           |
| 2830 | Thallium(I) nitrite                 | TlNO <sub>2</sub>                                                   | 13826-63-6  | 250.389     | yel cub cry             | 186      |          | 5.7                        | 32.1 <sup>25</sup>                  | s H <sub>2</sub> O                   |
| 2831 | Thallium(I) oxalate                 | Tl <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                       | 30737-24-7  | 496.786     | wh powder               |          |          | 6.31                       | 1.83 <sup>20</sup>                  |                                      |
| 2832 | Thallium(I) oxide                   | Tl <sub>2</sub> O                                                   | 1314-12-1   | 424.766     | blk rhomb cry; hyg      | 579      | ≈1080    | 9.52                       |                                     | s H <sub>2</sub> O, EtOH             |
| 2833 | Thallium(I) perchlorate             | TlClO <sub>4</sub>                                                  | 13453-40-2  | 303.834     | col orth cry            | 501      |          | 4.89                       | 19.7 <sup>30</sup>                  |                                      |
| 2834 | Thallium(I) selenate                | Tl <sub>2</sub> SeO <sub>4</sub>                                    | 7446-22-2   | 551.73      | orth cry                | >400     |          | 6.875                      | 2.8 <sup>20</sup>                   | i EtOH, eth                          |
| 2835 | Thallium(I) selenide                | Tl <sub>2</sub> Se                                                  | 15572-25-5  | 487.73      | gray plates             | 340      |          |                            |                                     | i H <sub>2</sub> O, acid             |
| 2836 | Thallium(I) sulfate                 | Tl <sub>2</sub> SO <sub>4</sub>                                     | 7446-18-6   | 504.830     | wh rhomb prisms         | 632      |          | 6.77                       | 5.47 <sup>25</sup>                  |                                      |
| 2837 | Thallium(I) sulfide                 | Tl <sub>2</sub> S                                                   | 1314-97-2   | 440.832     | blue-blk cry            | 457      | 1367     | 8.39                       | 0.02 <sup>20</sup>                  | sl alk; s acid                       |
| 2838 | Thallium(III) acetate               | Tl(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub>      | 2570-63-0   | 381.514     | hyg wh platelets        | 182 dec  |          |                            |                                     |                                      |
| 2839 | Thallium(III) bromide tetrahydrate  | TlBr <sub>3</sub> · 4H <sub>2</sub> O                               | 13701-90-1  | 516.157     | yel orth cry            |          |          | 3.65                       |                                     | s H <sub>2</sub> O, EtOH             |
| 2840 | Thallium(III) chloride              | TlCl <sub>3</sub>                                                   | 13453-32-2  | 310.742     | monocl cry              | 155      |          | 4.7                        |                                     | vs H <sub>2</sub> O, EtOH, eth       |
| 2841 | Thallium(III) chloride tetrahydrate | TlCl <sub>3</sub> · 4H <sub>2</sub> O                               | 13453-32-2* | 382.804     | orth cry                |          |          | 3.00                       |                                     | s H <sub>2</sub> O                   |
| 2842 | Thallium(III) fluoride              | TlF <sub>3</sub>                                                    | 7783-57-5   | 261.378     | wh orth cry; hyg        | 550 dec  |          | 8.65                       |                                     | reac H <sub>2</sub> O                |
| 2843 | Thallium(III) nitrate               | Tl(NO <sub>3</sub> ) <sub>3</sub>                                   | 13746-98-0  | 390.398     | col cry                 |          |          |                            |                                     | reac H <sub>2</sub> O                |
| 2844 | Thallium(III) oxide                 | Tl <sub>2</sub> O <sub>3</sub>                                      | 1314-32-5   | 456.765     | brn cub cry             | 834      |          | 10.2                       |                                     | i H <sub>2</sub> O; reac acid        |
| 2845 | Thallium(III) sulfate               | Tl <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                     | 16222-66-5  | 696.955     | col leaflets            |          |          |                            |                                     | reac H <sub>2</sub> O                |
| 2846 | Thallium selenide                   | TlSe                                                                | 12039-52-0  | 283.34      | blk solid               | 330      |          |                            |                                     | i H <sub>2</sub> O, acid             |
| 2847 | Thorium                             | Th                                                                  | 7440-29-1   | 232.038     | soft gray-wh metal; cub | 1750     | 4788     | 11.7                       |                                     | s acid                               |
| 2848 | Thorium hydride                     | ThH <sub>2</sub>                                                    | 16689-88-6  | 234.054     | tetr cry                |          |          | 9.5                        |                                     |                                      |
| 2849 | Thorium boride                      | ThB <sub>6</sub>                                                    | 12229-63-9  | 296.904     | refrac solid            | 2450     |          | 6.99                       |                                     |                                      |
| 2850 | Thorium(IV) bromide                 | ThBr <sub>4</sub>                                                   | 13453-49-1  | 551.654     | wh hyg cry              | 679      |          |                            | 65 <sup>20</sup>                    |                                      |

| No.  | Name                               | Formula                                                                           | CAS Reg No. | Mol. weight | Physical form             | mp/°C               | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                      |
|------|------------------------------------|-----------------------------------------------------------------------------------|-------------|-------------|---------------------------|---------------------|----------|----------------------------|-------------------------------------|---------------------------------------------|
| 2851 | Thorium carbide                    | ThC                                                                               | 12012-16-7  | 244.049     | cub cry                   | 2500                |          | 10.6                       |                                     | reac H <sub>2</sub> O                       |
| 2852 | Thorium dicarbide                  | ThC <sub>2</sub>                                                                  | 12071-31-7  | 256.059     | yel monocl cry            | ≈2650               |          | 9.0                        |                                     | reac H <sub>2</sub> O                       |
| 2853 | Thorium(IV) chloride               | ThCl <sub>4</sub>                                                                 | 10026-08-1  | 373.850     | gray-wh tetr needles; hyg | 770                 | 921      | 4.59                       |                                     | s H <sub>2</sub> O, EtOH                    |
| 2854 | Thorium(IV) fluoride               | ThF <sub>4</sub>                                                                  | 13709-59-6  | 308.032     | wh monocl cry; hyg        | 1110                | 1680     | 6.1                        |                                     |                                             |
| 2855 | Thorium(IV) iodide                 | ThI <sub>4</sub>                                                                  | 7790-49-0   | 739.656     | wh-yel monocl cry         | 566                 | 837      |                            |                                     |                                             |
| 2856 | Thorium(IV) nitrate                | Th(NO <sub>3</sub> ) <sub>4</sub>                                                 | 13823-29-5  | 480.058     | hyg wh plates             | 55 dec              |          |                            |                                     | vs H <sub>2</sub> O, EtOH                   |
| 2857 | Thorium(IV) nitrate tetrahydrate   | Th(NO <sub>3</sub> ) <sub>4</sub> · 4H <sub>2</sub> O                             | 13470-07-0  | 552.119     | wh hyg cry                | 500 dec             |          |                            | 191 <sup>20</sup>                   | s EtOH                                      |
| 2858 | Thorium nitride                    | ThN                                                                               | 12033-65-7  | 246.045     | refrac cub cry            | 2820                |          | 11.6                       |                                     | reac H <sub>2</sub> O                       |
| 2859 | Thorium(IV) oxide                  | ThO <sub>2</sub>                                                                  | 1314-20-1   | 264.037     | wh cub cry                | 3350                | 4400     | 10.0                       |                                     | i H <sub>2</sub> O, alk; sl acid            |
| 2860 | Thorium(IV) selenide               | ThSe <sub>2</sub>                                                                 | 60763-24-8  | 389.96      | orth cry                  |                     |          | 8.5                        |                                     |                                             |
| 2861 | Thorium orthosilicate              | ThSiO <sub>4</sub>                                                                | 14553-44-7  | 324.122     | brn tetr cry              |                     |          | 6.7                        |                                     |                                             |
| 2862 | Thorium silicide                   | ThSi <sub>2</sub>                                                                 | 12067-54-8  | 288.209     | tetr cry                  | 1850                |          | 7.9                        |                                     |                                             |
| 2863 | Thorium(IV) sulfate nonahydrate    | Th(SO <sub>4</sub> ) <sub>2</sub> · 9H <sub>2</sub> O                             | 10381-37-0  | 586.301     | wh monocl cry             | dec                 |          | 2.8                        | 4.2 <sup>20</sup>                   |                                             |
| 2864 | Thorium(IV) sulfide                | ThS <sub>2</sub>                                                                  | 12138-07-7  | 296.168     | dark brn cry              | 1905                |          | 7.30                       |                                     | i H <sub>2</sub> O; s acid                  |
| 2865 | Thulium                            | Tm                                                                                | 7440-30-4   | 168.934     | silv metal; hex           | 1545                | 1950     | 9.32                       |                                     | s dil acid                                  |
| 2866 | Thulium(II) bromide                | TmBr <sub>2</sub>                                                                 | 64171-97-7  | 328.742     | dark grn solid            | 619                 |          |                            |                                     |                                             |
| 2867 | Thulium(II) chloride               | TmCl <sub>2</sub>                                                                 | 22852-11-5  | 239.840     | red or grn cry            | 718                 |          |                            |                                     | reac H <sub>2</sub> O                       |
| 2868 | Thulium(II) iodide                 | TmI <sub>2</sub>                                                                  | 60864-26-8  | 422.743     | blk hyg solid             | 756                 |          |                            |                                     | reac H <sub>2</sub> O                       |
| 2869 | Thulium(III) bromide               | TmBr <sub>3</sub>                                                                 | 14456-51-0  | 408.646     | wh hyg cry                | 954                 |          |                            |                                     | s H <sub>2</sub> O                          |
| 2870 | Thulium(III) chloride              | TmCl <sub>3</sub>                                                                 | 13537-18-3  | 275.293     | yel hyg cry               | 845                 |          |                            |                                     | s H <sub>2</sub> O                          |
| 2871 | Thulium(III) chloride heptahydrate | TmCl <sub>3</sub> · 7H <sub>2</sub> O                                             | 13778-39-7  | 401.400     | hyg cry                   |                     |          |                            |                                     | s H <sub>2</sub> O, EtOH                    |
| 2872 | Thulium(III) fluoride              | TmF <sub>3</sub>                                                                  | 13760-79-7  | 225.929     | wh cry                    | 1158                |          |                            |                                     | s H <sub>2</sub> O                          |
| 2873 | Thulium(III) hydroxide             | Tm(OH) <sub>3</sub>                                                               | 1311-33-7   | 219.956     | wh or grn prec            |                     |          |                            |                                     | i H <sub>2</sub> O                          |
| 2874 | Thulium(III) iodide                | TmI <sub>3</sub>                                                                  | 13813-43-9  | 549.647     | yel hyg cry               | 1021                |          |                            |                                     |                                             |
| 2875 | Thulium(III) nitrate               | Tm(NO <sub>3</sub> ) <sub>3</sub>                                                 | 14985-19-4  | 354.949     | grn hyg solid             |                     |          |                            | 212 <sup>25</sup>                   | s EtOH                                      |
| 2876 | Thulium(III) nitrate pentahydrate  | Tm(NO <sub>3</sub> ) <sub>3</sub> · 5H <sub>2</sub> O                             | 36548-87-5  | 445.025     | grn hyg cry               |                     |          |                            |                                     | s H <sub>2</sub> O, EtOH, ace               |
| 2877 | Thulium(III) oxalate hexahydrate   | Tm <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> · 6H <sub>2</sub> O | 26677-68-9  | 710.016     | grn solid                 | dec 50              |          |                            |                                     | s alk oxalates                              |
| 2878 | Thulium(III) oxide                 | Tm <sub>2</sub> O <sub>3</sub>                                                    | 12036-44-1  | 385.866     | grn-wh cub cry            | 2341                | 3945     | 8.6                        |                                     | sl acid                                     |
| 2879 | Tin (gray)                         | Sn                                                                                | 7440-31-5   | 118.710     | cub cry                   | trans to wh Sn 13.2 | 2602     | 5.769                      |                                     |                                             |
| 2880 | Tin (white)                        | Sn                                                                                | 7440-31-5   | 118.710     | silv tetr cry             | 231.93              | 2602     | 7.287                      |                                     |                                             |
| 2881 | Stannane                           | SnH <sub>4</sub>                                                                  | 2406-52-2   | 122.742     | unstab col gas            | -146                | -51.8    | 5.017 g/L                  |                                     |                                             |
| 2882 | Methylstannane                     | SnH <sub>3</sub> CH <sub>3</sub>                                                  | 1631-78-3   | 136.769     | col gas                   |                     | 1.4      | 5.590 g/L                  |                                     | reac H <sub>2</sub> O                       |
| 2883 | (Dimethylamino)trimethylstannane   | Sn(CH <sub>3</sub> ) <sub>3</sub> N(CH <sub>3</sub> ) <sub>2</sub>                | 993-50-0    | 207.890     | liq                       | 1                   | 126      | 1.22                       |                                     | reac H <sub>2</sub> O                       |
| 2884 | Tin monophosphide                  | SnP                                                                               | 25324-56-5  | 149.684     | dull metallic solid       | 540                 |          |                            |                                     |                                             |
| 2885 | Tin triphosphide                   | Sn <sub>3</sub> P <sub>3</sub>                                                    | 12286-33-8  | 567.761     | wh cry                    | ≈550                |          | 5.2                        |                                     |                                             |
| 2886 | Tin(II) acetate                    | Sn(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>                    | 638-39-1    | 236.799     | wh orth cry               | 183                 | subl     | 2.31                       |                                     | s dil HCl                                   |
| 2887 | Tin(II) bromide                    | SnBr <sub>2</sub>                                                                 | 10031-24-0  | 278.518     | yel powder                | 215                 | 639      | 5.12                       | 85 <sup>0</sup>                     | s EtOH, eth, ace                            |
| 2888 | Tin(II) chloride                   | SnCl <sub>2</sub>                                                                 | 7772-99-8   | 189.616     | wh orth cry               | 247.0               | 623      | 3.90                       | 178 <sup>10</sup>                   | s EtOH, ace, eth; i xyl                     |
| 2889 | Tin(II) chloride dihydrate         | SnCl <sub>2</sub> · 2H <sub>2</sub> O                                             | 10025-69-1  | 225.647     | wh monocl cry             | 37 dec              |          | 2.71                       | 178 <sup>10</sup>                   | s EtOH, NaOH; vs HCl                        |
| 2890 | Tin(II) fluoride                   | SnF <sub>2</sub>                                                                  | 7783-47-3   | 156.707     | wh monocl cry; hyg        | 215                 | 850      | 4.57                       |                                     | s H <sub>2</sub> O; i EtOH, eth, chl        |
| 2891 | Tin(II) hexafluorozirconate        | SnZrF <sub>6</sub>                                                                | 12419-43-1  | 323.924     | cry                       |                     |          | 4.21                       |                                     | s H <sub>2</sub> O                          |
| 2892 | Tin(II) hydroxide                  | Sn(OH) <sub>2</sub>                                                               | 12026-24-3  | 152.725     | wh amorp solid            |                     |          |                            |                                     |                                             |
| 2893 | Tin(II) iodide                     | SnI <sub>2</sub>                                                                  | 10294-70-9  | 372.519     | red-oran powder           | 320                 | 714      | 5.28                       | 0.98 <sup>20</sup>                  | s bz, chl, CS <sub>2</sub>                  |
| 2894 | Tin(II) oxalate                    | SnC <sub>2</sub> O <sub>4</sub>                                                   | 814-94-8    | 206.729     | wh powder                 | 280 dec             |          | 3.56                       |                                     | i H <sub>2</sub> O; s dil HCl               |
| 2895 | Tin(II) oxide                      | SnO                                                                               | 21651-19-4  | 134.709     | blue-blk tetr cry         | 1080 dec            |          | 6.45                       |                                     | i H <sub>2</sub> O, EtOH; s acid            |
| 2896 | Tin(II) pyrophosphate              | Sn <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                                     | 15578-26-4  | 411.363     | wh amorp powder           | 400 dec             |          | 4.009                      |                                     | i H <sub>2</sub> O; s conc acid             |
| 2897 | Tin(II) selenide                   | SnSe                                                                              | 1315-06-6   | 197.67      | gray orth cry             | 861                 |          | 6.18                       |                                     | i H <sub>2</sub> O; s aqua regia            |
| 2898 | Tin(II) sulfate                    | SnSO <sub>4</sub>                                                                 | 7488-55-3   | 214.773     | wh orth cry               | 378 dec             |          | 4.15                       | 18.8 <sup>19</sup>                  |                                             |
| 2899 | Tin(II) sulfide                    | SnS                                                                               | 1314-95-0   | 150.775     | gray orth cry             | 881                 | 1210     | 5.08                       |                                     | i H <sub>2</sub> O; s conc acid             |
| 2900 | Tin(II) tartrate                   | SnC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                                    | 815-85-0    | 266.781     | wh cry powder             |                     |          |                            |                                     | s H <sub>2</sub> O, dil HCl                 |
| 2901 | Tin(II) telluride                  | SnTe                                                                              | 12040-02-7  | 246.31      | gray cub cry              | 806                 |          | 6.5                        |                                     |                                             |
| 2902 | Tin(IV) bromide                    | SnBr <sub>4</sub>                                                                 | 7789-67-5   | 438.326     | wh cry                    | 29.1                | 205      | 3.34                       |                                     | vs H <sub>2</sub> O; s EtOH                 |
| 2903 | Tin(IV) chloride                   | SnCl <sub>4</sub>                                                                 | 7646-78-8   | 260.522     | col fuming liq            | -34.07              | 114.15   | 2.234                      |                                     | reac H <sub>2</sub> O; s EtOH, ctc, bz, ace |
| 2904 | Tin(IV) chloride pentahydrate      | SnCl <sub>4</sub> · 5H <sub>2</sub> O                                             | 10026-06-9  | 350.598     | wh-yel cry                | 56 dec              |          | 2.04                       |                                     | vs H <sub>2</sub> O; s EtOH                 |
| 2905 | Tin(IV) chromate                   | Sn(CrO <sub>4</sub> ) <sub>2</sub>                                                | 38455-77-5  | 350.697     | brn-yel cry powder        | dec                 |          |                            |                                     | s H <sub>2</sub> O                          |
| 2906 | Tin(IV) fluoride                   | SnF <sub>4</sub>                                                                  | 7783-62-2   | 194.704     | wh tetr cry               | 442                 | 705 subl | 4.78                       |                                     | reac H <sub>2</sub> O                       |
| 2907 | Tin(IV) iodide                     | SnI <sub>4</sub>                                                                  | 7790-47-8   | 626.328     | yel-brn cub cry           | 143                 | 364.35   | 4.46                       |                                     | reac H <sub>2</sub> O; s EtOH, bz, chl, eth |
| 2908 | Tin(IV) oxide                      | SnO <sub>2</sub>                                                                  | 18282-10-5  | 150.709     | gray tetr cry             | 1630                |          | 6.85                       |                                     | i H <sub>2</sub> O, EtOH; s hot conc alk    |
| 2909 | Tin(IV) selenide                   | SnSe <sub>2</sub>                                                                 | 20770-09-6  | 276.63      | red-brn cry               | 650                 |          | ≈5.0                       |                                     | i H <sub>2</sub> O; s alk, conc acid        |

| No.  | Name                                                | Formula                                                         | CAS Reg No. | Mol. weight | Physical form          | mp/°C    | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                        |
|------|-----------------------------------------------------|-----------------------------------------------------------------|-------------|-------------|------------------------|----------|----------|----------------------------|-------------------------------------|-----------------------------------------------|
| 2910 | Tin(IV) selenite                                    | Sn(SeO <sub>3</sub> ) <sub>2</sub>                              | 7446-25-5   | 372.63      | cry powder             |          |          |                            |                                     | i H <sub>2</sub> O; s hot HCl                 |
| 2911 | Tin(IV) sulfide                                     | SnS <sub>2</sub>                                                | 1315-01-1   | 182.840     | gold-yel hex cry       | 600 dec  |          | 4.5                        |                                     | i H <sub>2</sub> O; s alk, aqua regia         |
| 2912 | Titanium                                            | Ti                                                              | 7440-32-6   | 47.867      | gray metal; hex        | 1668     | 3287     | 4.506                      |                                     |                                               |
| 2913 | Titanocene dichloride                               | Ti(C <sub>5</sub> H <sub>5</sub> ) <sub>2</sub> Cl <sub>2</sub> | 1271-19-8   | 248.959     | red cry                | 289      |          | 1.60                       |                                     | sl H <sub>2</sub> O, bz; s chl, EtOH, tol     |
| 2914 | Titanium hydride                                    | TiH <sub>2</sub>                                                | 7704-98-5   | 49.883      | gray-blk powder        | ≈450 dec |          | 3.75                       |                                     | i H <sub>2</sub> O                            |
| 2915 | Titanium boride                                     | TiB <sub>2</sub>                                                | 12045-63-5  | 69.489      | gray refrac solid; hex | 3225     |          | 4.38                       |                                     |                                               |
| 2916 | Titanium carbide                                    | TiC                                                             | 12070-08-5  | 59.878      | cub cry                | 3067     |          | 4.93                       |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub>        |
| 2917 | Titanium nitride                                    | TiN                                                             | 25583-20-4  | 61.874      | yel-brn cub cry        | 2947     |          | 5.21                       |                                     | i H <sub>2</sub> O; s aqua regia              |
| 2918 | Titanium phosphide                                  | TiP                                                             | 12037-65-9  | 78.841      | gray hex cry           | 1990     |          | 4.08                       |                                     |                                               |
| 2919 | Titanium silicide                                   | TiSi <sub>2</sub>                                               | 12039-83-7  | 104.038     | blk orth cry           | 1500     |          | 4.0                        |                                     | i H <sub>2</sub> O, acid, alk; s HF           |
| 2920 | Titanium(II) bromide                                | TiBr <sub>2</sub>                                               | 13783-04-5  | 207.675     | blk powder             | dec 400  |          | 4.0                        |                                     | reac H <sub>2</sub> O                         |
| 2921 | Titanium(II) chloride                               | TiCl <sub>2</sub>                                               | 10049-06-6  | 118.773     | blk hex cryc           | 1035     | 1500     | 3.13                       |                                     | reac H <sub>2</sub> O; s EtOH; i chl, eth     |
| 2922 | Titanium(II) iodide                                 | TiI <sub>2</sub>                                                | 13783-07-8  | 301.676     | blk hex cry            | dec 400  |          | 5.02                       |                                     | reac H <sub>2</sub> O                         |
| 2923 | Titanium(II) oxide                                  | TiO                                                             | 12137-20-1  | 63.866      | yel cub cry            | 1770     | 3227     | 4.95                       |                                     |                                               |
| 2924 | Titanium(II) sulfide                                | TiS                                                             | 12039-07-5  | 79.932      | brn hex cry            | 1927     |          | 3.85                       |                                     | i H <sub>2</sub> O; s conc acid               |
| 2925 | Titanium(III) bromide                               | TiBr <sub>3</sub>                                               | 13135-31-4  | 287.579     | viol hex cry           | dec 400  |          |                            |                                     | s H <sub>2</sub> O                            |
| 2926 | Titanium(III) chloride                              | TiCl <sub>3</sub>                                               | 7705-07-9   | 154.226     | red-viol hex cry; hyg  | 425 dec  | 960      | 2.64                       |                                     | reac H <sub>2</sub> O                         |
| 2927 | Titanium(III) fluoride                              | TiF <sub>3</sub>                                                | 13470-08-1  | 104.862     | viol hex cry           | 950 dec  |          | 2.98                       |                                     | i H <sub>2</sub> O, dil acid, alk             |
| 2928 | Titanium(III) iodide                                | TiI <sub>3</sub>                                                | 13783-08-9  | 428.580     | viol cry               | dec 350  |          |                            |                                     |                                               |
| 2929 | Titanium(III) oxide                                 | Ti <sub>2</sub> O <sub>3</sub>                                  | 1344-54-3   | 143.732     | blk hex cry            | 1842     |          | 4.486                      |                                     | s hot HF                                      |
| 2930 | Titanium(III) sulfate                               | Ti <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                 | 10343-61-0  | 383.922     | grn cry                |          |          |                            |                                     | i H <sub>2</sub> O, EtOH; s dil HCl           |
| 2931 | Titanium(III) sulfide                               | Ti <sub>2</sub> S <sub>3</sub>                                  | 12039-16-6  | 191.929     | blk hex cry            |          |          | 3.56                       |                                     |                                               |
| 2932 | Titanium(III,IV) oxide                              | Ti <sub>4</sub> O <sub>5</sub>                                  | 12065-65-5  | 223.598     | blk monocl cry         | 1777     |          | 4.24                       |                                     |                                               |
| 2933 | Titanium(IV) bromide                                | TiBr <sub>4</sub>                                               | 7789-68-6   | 367.483     | yel-oran cub cry; hyg  | 38.3     | 233.5    | 3.37                       |                                     | reac H <sub>2</sub> O                         |
| 2934 | Titanium(IV) chloride                               | TiCl <sub>4</sub>                                               | 7550-45-0   | 189.679     | col or yel liq         | -24.12   | 136.45   | 1.73                       |                                     | reac H <sub>2</sub> O; s EtOH                 |
| 2935 | Titanium(IV) fluoride                               | TiF <sub>4</sub>                                                | 7783-63-3   | 123.861     | wh hyg powder          | 377      | subl 284 | 2.798                      |                                     | reac H <sub>2</sub> O; s EtOH, py             |
| 2936 | Titanium(IV) iodide                                 | TiI <sub>4</sub>                                                | 7720-83-4   | 555.485     | red hyg powder         | 155      | 377      | 4.3                        |                                     | reac H <sub>2</sub> O                         |
| 2937 | Titanium(IV) oxide (anatase)                        | TiO <sub>2</sub>                                                | 1317-70-0   | 79.866      | brn tetr cry           | 1560     |          | 3.9                        |                                     |                                               |
| 2938 | Titanium(IV) oxide (brookite)                       | TiO <sub>2</sub>                                                | 12188-41-9  | 79.866      | wh orth cry            |          |          | 4.17                       |                                     |                                               |
| 2939 | Titanium(IV) oxide (rutile)                         | TiO <sub>2</sub>                                                | 1317-80-2   | 79.866      | wh tetr cry            | 1843     | ≈3000    | 4.17                       |                                     | i H <sub>2</sub> O, dil acid; s conc acid     |
| 2940 | Titanium(IV) oxysulfate monohydrate                 | TiOSO <sub>4</sub> · H <sub>2</sub> O                           | 13825-74-6* | 177.944     | col orth cry           |          |          | 2.71                       |                                     | reac H <sub>2</sub> O                         |
| 2941 | Titanium(IV) sulfate                                | Ti(SO <sub>4</sub> ) <sub>2</sub>                               | 13693-11-3  | 239.992     | wh-yel hyg cry         | 150 dec  |          |                            |                                     | s H <sub>2</sub> O                            |
| 2942 | Titanium(IV) sulfide                                | TiS <sub>2</sub>                                                | 12039-13-3  | 111.997     | yel-brn hex cry; hyg   |          |          | 3.37                       |                                     | s H <sub>2</sub> SO <sub>4</sub>              |
| 2943 | Tungsten                                            | W                                                               | 7440-33-7   | 183.84      | gray-wh metal; cub     | 3422     | 5555     | 19.3                       |                                     |                                               |
| 2944 | Tungstic acid                                       | H <sub>2</sub> WO <sub>4</sub>                                  | 7783-03-1   | 249.85      | yel amorp powder       | 100 dec  |          | 5.5                        |                                     | i H <sub>2</sub> O, acid; s alk               |
| 2945 | Tungsten boride (W <sub>2</sub> B)                  | W <sub>2</sub> B                                                | 12007-10-2  | 378.49      | refrac blk powder      | 2670     |          | 16.0                       |                                     | i H <sub>2</sub> O                            |
| 2946 | Tungsten boride (WB)                                | WB                                                              | 12007-09-9  | 194.65      | blk refrac powder      | 2665     |          | 15.2                       |                                     | i H <sub>2</sub> O                            |
| 2947 | Tungsten boride (W <sub>2</sub> B <sub>3</sub> )    | W <sub>2</sub> B <sub>3</sub>                                   | 12007-98-6  | 421.74      | refrac solid           | 2370     |          | 11.0                       |                                     | i H <sub>2</sub> O                            |
| 2948 | Tungsten carbide (W <sub>2</sub> C)                 | W <sub>2</sub> C                                                | 12070-13-2  | 379.69      | refrac hex cry         | ≈2800    |          | 14.8                       |                                     | i H <sub>2</sub> O                            |
| 2949 | Tungsten carbide (WC)                               | WC                                                              | 12070-12-1  | 195.85      | gray hex cry           | 2785     |          | 15.6                       |                                     | i H <sub>2</sub> O; s HNO <sub>3</sub> /HF    |
| 2950 | Tungsten carbonyl                                   | W(CO) <sub>6</sub>                                              | 14040-11-0  | 351.90      | wh cry                 | 170 dec  | subl     | 2.65                       |                                     | i H <sub>2</sub> O; s os                      |
| 2951 | Tungsten nitride (WN <sub>2</sub> )                 | WN <sub>2</sub>                                                 | 60922-26-1  | 211.85      | hex cry                | 600 dec  |          | 7.7                        |                                     |                                               |
| 2952 | Tungsten nitride (W <sub>4</sub> N)                 | W <sub>4</sub> N                                                | 12033-72-6  | 381.69      | gray cub cry           | dec      |          | 17.8                       |                                     |                                               |
| 2953 | Tungsten silicide (WSi <sub>2</sub> )               | WSi <sub>2</sub>                                                | 12039-88-2  | 240.01      | blue-gray tetr cry     | 2160     |          | 9.3                        |                                     | i H <sub>2</sub> O                            |
| 2954 | Tungsten silicide (W <sub>5</sub> Si <sub>3</sub> ) | W <sub>5</sub> Si <sub>3</sub>                                  | 12039-95-1  | 1003.46     | blue-gray refrac solid | 2320     |          | 14.4                       |                                     |                                               |
| 2955 | Tungsten(II) bromide                                | WBr <sub>2</sub>                                                | 13470-10-5  | 343.65      | yel powder             | dec 400  |          |                            |                                     | i H <sub>2</sub> O                            |
| 2956 | Tungsten(II) chloride                               | WCl <sub>2</sub>                                                | 13470-12-7  | 254.75      | gray solid             | dec 500  |          | 5.44                       |                                     | sl H <sub>2</sub> O                           |
| 2957 | Tungsten(II) iodide                                 | WI <sub>2</sub>                                                 | 13470-17-2  | 437.65      | oran-brn cry           | dec 800  |          | 6.79                       |                                     | i H <sub>2</sub> O                            |
| 2958 | Tungsten(III) bromide                               | WBr <sub>3</sub>                                                | 15163-24-3  | 423.55      | blk hex cry            | dec 180  |          |                            |                                     | i H <sub>2</sub> O                            |
| 2959 | Tungsten(III) chloride                              | WCl <sub>3</sub>                                                | 20193-56-0  | 290.20      | red solid              | 550 dec  | subl     |                            |                                     | reac H <sub>2</sub> O                         |
| 2960 | Tungsten(III) iodide                                | WI <sub>3</sub>                                                 | 15513-69-6  | 564.55      | blk solid              | dec r.t. |          |                            |                                     | i H <sub>2</sub> O; s ace; sl EtOH, chl       |
| 2961 | Tungsten(IV) bromide                                | WBr <sub>4</sub>                                                | 14055-81-3  | 503.46      | blk orth cry           |          | 240 subl |                            |                                     | reac H <sub>2</sub> O                         |
| 2962 | Tungsten(IV) chloride                               | WCl <sub>4</sub>                                                | 13470-13-8  | 325.65      | blk hyg powder         | 450 dec  |          | 4.62                       |                                     | reac H <sub>2</sub> O                         |
| 2963 | Tungsten(IV) fluoride                               | WF <sub>4</sub>                                                 | 13766-47-7  | 259.83      | red-brn cry            | dec 800  |          |                            |                                     | reac H <sub>2</sub> O; s MeCN; i bz, tol, etc |

| No.  | Name                                             | Formula                                                                                          | CAS Reg No. | Mol. weight | Physical form           | mp/°C     | bp/°C          | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                       |
|------|--------------------------------------------------|--------------------------------------------------------------------------------------------------|-------------|-------------|-------------------------|-----------|----------------|----------------------------|-------------------------------------|----------------------------------------------|
| 2964 | Tungsten(IV) iodide                              | WI <sub>4</sub>                                                                                  | 14055-84-6  | 691.46      | blk cry                 | dec       |                |                            |                                     | reac H <sub>2</sub> O; s EtOH; i eth chl     |
| 2965 | Tungsten(IV) oxide                               | WO <sub>2</sub>                                                                                  | 12036-22-5  | 215.84      | brn monoc cry           | ≈1500 dec | 1730           | 10.8                       |                                     | i H <sub>2</sub> O, os                       |
| 2966 | Tungsten(IV) selenide                            | WSe <sub>2</sub>                                                                                 | 12067-46-8  | 341.76      | gray hex cry            |           |                | 9.2                        |                                     |                                              |
| 2967 | Tungsten(IV) sulfide                             | WS <sub>2</sub>                                                                                  | 12138-09-9  | 247.97      | gray hex cry            | 1250 dec  |                | 7.6                        |                                     | i H <sub>2</sub> O, HCl, alk                 |
| 2968 | Tungsten(IV) telluride                           | WTe <sub>2</sub>                                                                                 | 12067-76-4  | 439.04      | gray orth cry           | 1020      |                | 9.43                       |                                     |                                              |
| 2969 | Tungsten(V) bromide                              | WBr <sub>5</sub>                                                                                 | 13470-11-6  | 583.36      | brn-blk hyg solid       | 286       | 333            |                            |                                     | reac H <sub>2</sub> O                        |
| 2970 | Tungsten(V) chloride                             | WCl <sub>5</sub>                                                                                 | 13470-14-9  | 361.11      | blk-grn hyg cry         | 253       | 286            | 3.88                       |                                     | reac H <sub>2</sub> O                        |
| 2971 | Tungsten(V) ethanolate                           | W(C <sub>2</sub> H <sub>5</sub> O) <sub>5</sub>                                                  | 62571-53-3  | 409.14      | powder                  |           | 105(0.05 mmHg) |                            |                                     | s EtAc                                       |
| 2972 | Tungsten(V) fluoride                             | WF <sub>5</sub>                                                                                  | 19357-83-6  | 278.83      | yel solid               | dec 20    |                |                            |                                     | reac H <sub>2</sub> O                        |
| 2973 | Tungsten(V) oxytribromide                        | WOBBr <sub>3</sub>                                                                               | 20213-56-3  | 439.55      | dark brn tetr cry       |           |                | ≈5.9                       |                                     |                                              |
| 2974 | Tungsten(V) oxytrichloride                       | WOCl <sub>3</sub>                                                                                | 14249-98-0  | 306.20      | grn tetr cry            |           |                | ≈4.6                       |                                     |                                              |
| 2975 | Tungsten(VI) bromide                             | WBr <sub>6</sub>                                                                                 | 13701-86-5  | 663.26      | blue-blk cry            | 309       |                | 6.9                        |                                     | reac H <sub>2</sub> O                        |
| 2976 | Tungsten(VI) chloride                            | WCl <sub>6</sub>                                                                                 | 13283-01-7  | 396.56      | purp hex cry; hyg       | 282       | 337            | 3.52                       |                                     | reac H <sub>2</sub> O; s EtOH, os            |
| 2977 | Tungsten(VI) dioxidybromide                      | WO <sub>2</sub> Br <sub>2</sub>                                                                  | 13520-75-7  | 375.65      | red cry                 |           | 440 subl       |                            |                                     |                                              |
| 2978 | Tungsten(VI) dioxidydichloride                   | WO <sub>2</sub> Cl <sub>2</sub>                                                                  | 13520-76-8  | 286.75      | yel orth cry            | 265       |                | 4.67                       |                                     | i H <sub>2</sub> O                           |
| 2979 | Tungsten(VI) dioxidydiiodide                     | WO <sub>2</sub> I <sub>2</sub>                                                                   | 14447-89-3  | 469.65      | grn monoc cry           | 400 dec   |                | 6.39                       |                                     |                                              |
| 2980 | Tungsten(VI) fluoride                            | WF <sub>6</sub>                                                                                  | 7783-82-6   | 297.83      | yel liq or col gas      | 1.9       | 17.1           | 3.44                       |                                     | reac H <sub>2</sub> O; vs ctc, cyhex         |
| 2981 | Tungsten(VI) oxide                               | WO <sub>3</sub>                                                                                  | 1314-35-8   | 231.84      | yel powder              | 1473      | ≈1700          | 7.2                        |                                     | i H <sub>2</sub> O, os; sl acid; s alk       |
| 2982 | Tungsten(VI) oxytetrabromide                     | WOBBr <sub>4</sub>                                                                               | 13520-77-9  | 519.46      | red tetr cry            | 277       | 327            | ≈5.5                       |                                     | reac H <sub>2</sub> O                        |
| 2983 | Tungsten(VI) oxytetrachloride                    | WOCl <sub>4</sub>                                                                                | 13520-78-0  | 341.65      | red hyg cry             | 210       | 230            | 11.92                      |                                     | reac H <sub>2</sub> O; s bz, CS <sub>2</sub> |
| 2984 | Tungsten(VI) oxytetrafluoride                    | WOF <sub>4</sub>                                                                                 | 13520-79-1  | 275.83      | wh monoc cry            | 105       | 185.9          | 5.07                       |                                     | reac H <sub>2</sub> O                        |
| 2985 | Tungsten(VI) sulfide                             | WS <sub>3</sub>                                                                                  | 12125-19-8  | 280.04      | brn powder              |           |                |                            |                                     | sl H <sub>2</sub> O; s alk                   |
| 2986 | Uranium                                          | U                                                                                                | 7440-61-1   | 238.029     | silv-wh orth cry        | 1135      | 4131           | 19.1                       |                                     |                                              |
| 2987 | Uranium boride (UB <sub>2</sub> )                | UB <sub>2</sub>                                                                                  | 12007-36-2  | 259.651     | refrac solid            | 2430      |                | 12.7                       |                                     |                                              |
| 2988 | Uranium boride (UB <sub>4</sub> )                | UB <sub>4</sub>                                                                                  | 12007-84-0  | 281.273     | refrac solid            | 2530      |                | 9.32                       |                                     | i H <sub>2</sub> O                           |
| 2989 | Uranium carbide (UC)                             | UC                                                                                               | 12070-09-6  | 250.040     | gray cub cry            | 2790      |                |                            |                                     |                                              |
| 2990 | Uranium carbide (UC <sub>2</sub> )               | UC <sub>2</sub>                                                                                  | 12071-33-9  | 262.050     | gray tetr cry           | 2350      | 4370           | 11.3                       |                                     | reac H <sub>2</sub> O; sl EtOH               |
| 2991 | Uranium carbide (U <sub>2</sub> C <sub>3</sub> ) | U <sub>2</sub> C <sub>3</sub>                                                                    | 12076-62-9  | 512.090     | gray cub cry            | ≈1700 dec |                | 12.7                       |                                     |                                              |
| 2992 | Uranium nitride (UN)                             | UN                                                                                               | 25658-43-9  | 252.036     | gray cub cry            | 2805      |                | 14.3                       |                                     | i H <sub>2</sub> O                           |
| 2993 | Uranium nitride (U <sub>3</sub> N <sub>4</sub> ) | U <sub>3</sub> N <sub>4</sub>                                                                    | 12033-83-9  | 518.078     | cub cry                 | dec       |                | 11.3                       |                                     |                                              |
| 2994 | Uranium(III) bromide                             | UBr <sub>3</sub>                                                                                 | 13470-19-4  | 477.741     | red hyg cry             | 727       |                |                            |                                     | s H <sub>2</sub> O                           |
| 2995 | Uranium(III) chloride                            | UCl <sub>3</sub>                                                                                 | 10025-93-1  | 344.388     | grn hyg cry             | 837       |                | 5.51                       |                                     | vs H <sub>2</sub> O; i bz, ctc               |
| 2996 | Uranium(III) fluoride                            | UF <sub>3</sub>                                                                                  | 13775-06-9  | 295.024     | blk hex cry             | 1495      |                | 8.9                        |                                     | i H <sub>2</sub> O; s acid                   |
| 2997 | Uranium(III) hydride                             | UH <sub>3</sub>                                                                                  | 13598-56-6  | 241.053     | gray-blk cub cry        |           |                | 11.1                       |                                     |                                              |
| 2998 | Uranium(III) iodide                              | UI <sub>3</sub>                                                                                  | 13775-18-3  | 618.742     | blk hyg cry             | 766       |                |                            |                                     | s H <sub>2</sub> O                           |
| 2999 | Uranium(IV) bromide                              | UBr <sub>4</sub>                                                                                 | 13470-20-7  | 557.645     | brn hyg cry             | 519       |                |                            |                                     | s H <sub>2</sub> O, EtOH                     |
| 3000 | Uranium(IV) chloride                             | UCl <sub>4</sub>                                                                                 | 10026-10-5  | 379.841     | grn octahed cry         | 590       | 791            | 4.72                       |                                     | reac H <sub>2</sub> O; s EtOH                |
| 3001 | Uranium(IV) fluoride                             | UF <sub>4</sub>                                                                                  | 10049-14-6  | 314.023     | grn monoc cry           | 1036      | 1417           | 6.7                        | 0.01 <sup>25</sup>                  | s conc acid, alk                             |
| 3002 | Uranium(IV) iodide                               | UI <sub>4</sub>                                                                                  | 13470-22-9  | 745.647     | blk hyg cry             | 506       |                |                            |                                     | s H <sub>2</sub> O, EtOH                     |
| 3003 | Uranium(IV) oxide                                | UO <sub>2</sub>                                                                                  | 1344-57-6   | 270.028     | brn cub cry             | 2847      |                | 10.97                      |                                     | i H <sub>2</sub> O, dil acid; s conc acid    |
| 3004 | Uranium(IV,V) oxide                              | U <sub>4</sub> O <sub>9</sub>                                                                    | 12037-15-9  | 1096.111    | cub cry                 |           |                | 11.2                       |                                     |                                              |
| 3005 | Uranium(V) bromide                               | UBr <sub>5</sub>                                                                                 | 13775-16-1  | 637.549     | brn hyg cry             |           |                |                            |                                     | reac H <sub>2</sub> O                        |
| 3006 | Uranium(V) chloride                              | UCl <sub>5</sub>                                                                                 | 13470-21-8  | 415.294     | brn hyg cry             | 287       |                |                            |                                     | reac H <sub>2</sub> O                        |
| 3007 | Uranium(V) fluoride                              | UF <sub>5</sub>                                                                                  | 13775-07-0  | 333.021     | pale blue tetr cry; hyg | 348       |                | 5.81                       |                                     | s H <sub>2</sub> O                           |
| 3008 | Uranium(V,VI) oxide                              | U <sub>3</sub> O <sub>8</sub>                                                                    | 1344-59-8   | 842.082     | grn-blk orth cry        | 1300 dec  |                | 8.38                       |                                     |                                              |
| 3009 | Uranium(VI) chloride                             | UCl <sub>6</sub>                                                                                 | 13763-23-0  | 450.747     | grn hex cry             | 177       |                | 3.6                        |                                     |                                              |
| 3010 | Uranium(VI) fluoride                             | UF <sub>6</sub>                                                                                  | 7783-81-5   | 352.019     | wh monoc solid          | 64.06 tp  | 56.5 sp        | 5.09                       |                                     | reac H <sub>2</sub> O; s ctc, chl            |
| 3011 | Uranium(VI) oxide                                | UO <sub>3</sub>                                                                                  | 1344-58-7   | 286.027     | oran-yel cry            |           |                | ≈7.3                       |                                     | i H <sub>2</sub> O; s acid                   |
| 3012 | Uranium(VI) oxide monohydrate                    | UO <sub>3</sub> · H <sub>2</sub> O                                                               | 12326-21-5  | 304.043     | yel orth cry            | 570 dec   |                | 7.05                       |                                     |                                              |
| 3013 | Uranium peroxide dihydrate                       | UO <sub>2</sub> · 2H <sub>2</sub> O                                                              | 19525-15-6  | 338.057     | yel hyg cry             | 115 dec   |                |                            |                                     | i H <sub>2</sub> O                           |
| 3014 | Uranyl acetate dihydrate                         | UO <sub>2</sub> (C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O | 6159-44-0   | 424.146     | ye cry (HOAc)           | 80 dec    |                | 2.89                       |                                     | sl EtOH                                      |
| 3015 | Uranyl chloride                                  | UO <sub>2</sub> Cl <sub>2</sub>                                                                  | 7791-26-6   | 340.934     | yel orth cry; hyg       | 577       |                |                            |                                     | vs H <sub>2</sub> O; s EtOH, ace; i bz       |
| 3016 | Uranyl fluoride                                  | UO <sub>2</sub> F <sub>2</sub>                                                                   | 13536-84-0  | 308.025     | yel hyg solid           |           |                |                            | 64.4 <sup>20</sup>                  | i bz                                         |
| 3017 | Uranyl hydrogen phosphate tetrahydrate           | UO <sub>2</sub> HPO <sub>4</sub> · 4H <sub>2</sub> O                                             | 18433-48-2  | 438.068     | yel cry pow             |           |                |                            |                                     | i H <sub>2</sub> O; s acid                   |
| 3018 | Uranyl nitrate                                   | UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>                                                  | 10102-06-4  | 394.037     | yel cry                 |           |                |                            | 127 <sup>25</sup>                   | s eth                                        |
| 3019 | Uranyl nitrate hexahydrate                       | UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                              | 13520-83-7  | 502.129     | yel orth cry; hyg       | 60        | 118 dec        | 2.81                       | 127 <sup>25</sup>                   | s EtOH, eth                                  |
| 3020 | Uranyl sulfate                                   | UO <sub>2</sub> SO <sub>4</sub>                                                                  | 1314-64-3   | 366.090     | yel cry                 |           |                |                            |                                     |                                              |
| 3021 | Uranyl sulfate trihydrate                        | UO <sub>2</sub> SO <sub>4</sub> · 3H <sub>2</sub> O                                              | 20910-28-5  | 420.137     | yel cry                 |           |                | 3.28                       | 152 <sup>16</sup>                   | sl EtOH                                      |
| 3022 | Vanadium                                         | V                                                                                                | 7440-62-2   | 50.942      | gray-wh metal; cub      | 1910      | 3407           | 6.0                        |                                     | i H <sub>2</sub> O; s acid                   |



| No.  | Name                                   | Formula                                                        | CAS Reg No. | Mol. weight | Physical form             | mp/°C                  | bp/°C     | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                  |
|------|----------------------------------------|----------------------------------------------------------------|-------------|-------------|---------------------------|------------------------|-----------|----------------------------|-------------------------------------|-----------------------------------------|
| 3023 | Vanadocene                             | V(C <sub>5</sub> H <sub>5</sub> ) <sub>2</sub>                 | 1277-47-0   | 181.128     | viol cry; hyg             | 167                    |           |                            |                                     | s bz, thf                               |
| 3024 | Vanadocene dichloride                  | V(C <sub>5</sub> H <sub>5</sub> ) <sub>2</sub> Cl <sub>2</sub> | 12083-48-6  | 252.034     | dark grn cry              | 205 dec                |           |                            |                                     | s H <sub>2</sub> O, chl, EtOH           |
| 3025 | Vanadium boride (VB)                   | VB                                                             | 12045-27-1  | 61.753      | refrac solid              | 2250                   |           |                            |                                     | i H <sub>2</sub> O                      |
| 3026 | Vanadium boride (VB <sub>2</sub> )     | VB <sub>2</sub>                                                | 12007-37-3  | 72.564      | refrac solid              | 2450                   |           |                            |                                     |                                         |
| 3027 | Vanadium carbide (VC)                  | VC                                                             | 12070-10-9  | 62.953      | refrac blk cry; cub       | 2810                   |           | 5.77                       |                                     | i H <sub>2</sub> O                      |
| 3028 | Vanadium carbide (V <sub>2</sub> C)    | V <sub>2</sub> C                                               | 12012-17-8  | 113.894     | hex cry                   | 2167                   |           |                            |                                     |                                         |
| 3029 | Vanadium carbonyl                      | V(CO) <sub>6</sub>                                             | 14024-00-1  | 219.002     | blue-grn cry; flam        | 60 dec                 | subl      |                            |                                     |                                         |
| 3030 | Vanadium nitride                       | VN                                                             | 24646-85-3  | 64.949      | blk powder; cub           | 2050                   |           | 6.13                       |                                     | i H <sub>2</sub> O; s aqua regia        |
| 3031 | Vanadium silicide (VSi <sub>2</sub> )  | VSi <sub>2</sub>                                               | 12039-87-1  | 107.113     | metallic prisms           |                        |           | 4.42                       |                                     | s HF                                    |
| 3032 | Vanadium silicide (V <sub>3</sub> Si)  | V <sub>3</sub> Si                                              | 12039-76-8  | 180.911     | cub cry                   | 1935                   |           | 5.70                       |                                     |                                         |
| 3033 | Vanadium(II) bromide                   | VBr <sub>2</sub>                                               | 14890-41-6  | 210.750     | oran-brn hex cry          |                        | 800 subl  | 4.58                       |                                     | reac H <sub>2</sub> O                   |
| 3034 | Vanadium(II) chloride                  | VCl <sub>2</sub>                                               | 10580-52-6  | 121.848     | grn hex plates            | 1350                   | 910 subl  | 3.23                       |                                     | reac H <sub>2</sub> O; s EtOH, eth      |
| 3035 | Vanadium(II) fluoride                  | VF <sub>2</sub>                                                | 13842-80-3  | 88.939      | blue hyg cry              | 1490                   |           |                            |                                     | reac H <sub>2</sub> O                   |
| 3036 | Vanadium(II) iodide                    | VI <sub>2</sub>                                                | 15513-84-5  | 304.751     | red-viol hex cry          |                        | subl 800  | 5.44                       |                                     | reac H <sub>2</sub> O                   |
| 3037 | Vanadium(II) oxide                     | VO                                                             | 12035-98-2  | 66.941      | gray-blk cry              | 1790                   |           | 5.758                      |                                     | s acid                                  |
| 3038 | Vanadium(II) sulfate heptahydrate      | VSO <sub>4</sub> · 7H <sub>2</sub> O                           | 36907-42-3  | 273.111     | viol cry                  |                        |           |                            |                                     |                                         |
| 3039 | Vanadium(III) bromide                  | VBr <sub>3</sub>                                               | 13470-26-3  | 290.654     | blk-grn hyg cry           | dec 500                | subl      | 4.00                       |                                     | reac H <sub>2</sub> O                   |
| 3040 | Vanadium(III) chloride                 | VCl <sub>3</sub>                                               | 7718-98-1   | 157.301     | red-viol hex cry; hyg     | 500 dec                |           | 3.00                       |                                     | reac H <sub>2</sub> O; s EtOH, eth      |
| 3041 | Vanadium(III) fluoride                 | VF <sub>3</sub>                                                | 10049-12-4  | 107.937     | yel-grn hex cry           | 1395                   | subl      | 3.363                      |                                     | i H <sub>2</sub> O, EtOH                |
| 3042 | Vanadium(III) fluoride trihydrate      | VF <sub>3</sub> · 3H <sub>2</sub> O                            | 10049-12-4* | 161.983     | grn rhomb cry             | ≈100 dec               |           |                            |                                     | sl H <sub>2</sub> O                     |
| 3043 | Vanadium(III) iodide                   | VI <sub>3</sub>                                                | 15513-94-7  | 431.655     | brn-blk rhomb cry; hyg    | dec 300                |           | 5.21                       |                                     | reac H <sub>2</sub> O                   |
| 3044 | Vanadium(III) oxide                    | V <sub>2</sub> O <sub>3</sub>                                  | 1314-34-7   | 149.881     | blk powder                | 1957                   | ≈3000     | 4.87                       |                                     | i H <sub>2</sub> O                      |
| 3045 | Vanadium(III) 2,4-pentanedioate        | V(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>3</sub>         | 13476-99-8  | 348.266     | brn cry                   | ≈185                   | subl      | ≈1.0                       |                                     | s MeOH, ace, bz chl                     |
| 3046 | Vanadium(III) sulfate                  | V <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                 | 13701-70-7  | 390.071     | yel powder                | ≈400 dec               |           |                            |                                     | sl H <sub>2</sub> O                     |
| 3047 | Vanadium(III) sulfide                  | V <sub>2</sub> S <sub>3</sub>                                  | 1315-03-3   | 198.078     | grn-blk powder            | dec                    |           | 4.7                        |                                     | i H <sub>2</sub> O; s hot HCl           |
| 3048 | Vanadium(IV) bromide                   | VBr <sub>4</sub>                                               | 13595-30-7  | 370.558     | unstab purp cry           | -23 dec                |           |                            |                                     |                                         |
| 3049 | Vanadium(IV) chloride                  | VCl <sub>4</sub>                                               | 7632-51-1   | 192.754     | red-brn liq               | -28                    | 151       | 1.816                      |                                     | reac H <sub>2</sub> O; s EtOH, eth      |
| 3050 | Vanadium(IV) fluoride                  | VF <sub>4</sub>                                                | 10049-16-8  | 126.936     | grn hyg powder            | 325 dec                | subl      | 3.15                       |                                     | vs H <sub>2</sub> O                     |
| 3051 | Vanadium(IV) oxide                     | VO <sub>2</sub>                                                | 12036-21-4  | 82.941      | blue-blk powder           | 1967                   |           | 4.339                      |                                     | i H <sub>2</sub> O; s acid, alk         |
| 3052 | Vanadium(V) fluoride                   | VF <sub>5</sub>                                                | 7783-72-4   | 145.934     | col liq                   | 19.5                   | 48.3      | 2.50                       |                                     | reac H <sub>2</sub> O                   |
| 3053 | Vanadium(V) dioxide fluoride           | VO <sub>2</sub> F                                              | 14259-82-6  | 101.939     | brn hyg cry               | 350 dec                |           |                            |                                     | reac H <sub>2</sub> O                   |
| 3054 | Vanadium(V) dioxide chloride           | VO <sub>2</sub> Cl                                             | 13759-30-3  | 118.394     | oran hyg cry              | dec 180                |           |                            |                                     | s thf                                   |
| 3055 | Vanadium(V) oxide                      | V <sub>2</sub> O <sub>5</sub>                                  | 1314-62-1   | 181.880     | yel-brn orth cry          | 681                    | 1750      | 3.35                       | 0.07 <sup>25</sup>                  | s conc acid, alk; i EtOH                |
| 3056 | Vanadium(V) sulfide                    | V <sub>2</sub> S <sub>5</sub>                                  | 12138-17-9  | 262.208     | grn-blk pow               | dec                    |           | 3.0                        |                                     | i H <sub>2</sub> O; s acid, alk         |
| 3057 | Vanadyl bromide                        | VOBr                                                           | 13520-88-2  | 146.845     | viol cry                  | 480 dec                |           |                            |                                     |                                         |
| 3058 | Vanadyl chloride                       | VOCl                                                           | 13520-87-1  | 102.394     | brn orth cry              |                        | 127       | 1.72                       |                                     |                                         |
| 3059 | Vanadyl dibromide                      | VOBr <sub>2</sub>                                              | 13520-89-3  | 226.749     | yel-brn cry               | 180 dec                |           |                            |                                     |                                         |
| 3060 | Vanadyl dichloride                     | VOCl <sub>2</sub>                                              | 10213-09-9  | 137.847     | grn hyg cry               | 380 dec                |           | 2.88                       |                                     | reac H <sub>2</sub> O; s EtOH           |
| 3061 | Vanadyl difluoride                     | VOF <sub>2</sub>                                               | 13814-83-0  | 104.938     | yel cry                   |                        |           |                            |                                     |                                         |
| 3062 | Vanadyl selenite hydrate               | VSeO <sub>3</sub> · H <sub>2</sub> O                           | 133578-89-9 | 211.92      | grn tricl plates          |                        |           | 3.506                      |                                     |                                         |
| 3063 | Vanadyl sulfate dihydrate              | VOSO <sub>4</sub> · 2H <sub>2</sub> O                          | 27774-13-6  | 199.035     | blue cry powder           |                        |           |                            |                                     | s H <sub>2</sub> O                      |
| 3064 | Vanadyl tribromide                     | VOBr <sub>3</sub>                                              | 13520-90-6  | 306.653     | deep red liq              | -59                    | 170       |                            |                                     | reac H <sub>2</sub> O                   |
| 3065 | Vanadyl trichloride                    | VOCl <sub>3</sub>                                              | 7727-18-6   | 173.300     | fuming red-yel liq        | -79                    | 127       | 1.829                      |                                     | reac H <sub>2</sub> O; s MeOH, eth, ace |
| 3066 | Vanadyl trifluoride                    | VOF <sub>3</sub>                                               | 13709-31-4  | 123.936     | yel hyg powder            | 300                    | 480       | 2.459                      |                                     | reac H <sub>2</sub> O                   |
| 3067 | Water                                  | H <sub>2</sub> O                                               | 7732-18-5   | 18.015      | col liq                   | 0.00                   | 99.974    | 0.9970 <sup>25</sup>       |                                     | vs EtOH, MeOH, ace                      |
| 3068 | Water-d <sub>2</sub>                   | D <sub>2</sub> O                                               | 7789-20-0   | 20.027      | col liq                   | 3.82                   | 101.42    | 1.1044 <sup>25</sup>       |                                     |                                         |
| 3069 | Water-t <sub>2</sub>                   | T <sub>2</sub> O                                               | 14940-65-9  | 22.032      | col liq                   | 4.48                   | 101.51    | 1.2138 <sup>25</sup>       |                                     |                                         |
| 3070 | Xenon                                  | Xe                                                             | 7440-63-3   | 131.293     | col gas                   | -111.745 tp (81.6 kPa) | -108.09   | 5.366 g/L                  |                                     | sl H <sub>2</sub> O                     |
| 3071 | Xenon trioxide                         | XeO <sub>3</sub>                                               | 13776-58-4  | 179.291     | col orth cry              | exp ≈25                |           | 4.55                       |                                     | s H <sub>2</sub> O                      |
| 3072 | Xenon tetroxide                        | XeO <sub>4</sub>                                               | 12340-14-6  | 195.291     | yel solid or col gas; exp | -35.9                  | ≈0 dec    |                            |                                     |                                         |
| 3073 | Xenon difluoride                       | XeF <sub>2</sub>                                               | 13709-36-9  | 169.290     | col tetr cry              | 129.03 tp              | 114.35 sp | 4.32                       |                                     | sl H <sub>2</sub> O                     |
| 3074 | Xenon tetrafluoride                    | XeF <sub>4</sub>                                               | 13709-61-0  | 207.287     | col monocl cry            | 117.10 tp              | 115.75 sp | 4.04                       |                                     | reac H <sub>2</sub> O                   |
| 3075 | Xenon hexafluoride                     | XeF <sub>6</sub>                                               | 13693-09-9  | 245.283     | col monocl cry            | 49.48                  | 75.6      | 3.56                       |                                     | reac H <sub>2</sub> O                   |
| 3076 | Xenon fluoride oxide                   | XeOF <sub>2</sub>                                              | 13780-64-8  | 185.289     | yel solid, stab <-25      | exp ≈0                 |           |                            |                                     | reac H <sub>2</sub> O                   |
| 3077 | Xenon oxytetrafluoride                 | XeOF <sub>4</sub>                                              | 13774-85-1  | 223.286     | col liq                   | -46.2                  |           | 3.17 <sup>9</sup>          |                                     | reac H <sub>2</sub> O                   |
| 3078 | Xenon dioxydifluoride                  | XeO <sub>2</sub> F <sub>2</sub>                                | 13875-06-4  | 201.289     | col orth cry              | 30.8 exp               |           | 4.10                       |                                     |                                         |
| 3079 | Xenon difluoride trioxide              | XeO <sub>3</sub> F <sub>2</sub>                                | 15192-14-0  | 217.288     | unstab at r.t.            | -54.1                  | exp       |                            |                                     |                                         |
| 3080 | Xenon pentafluoride hexafluoroarsenate | XeF <sub>5</sub> AsF <sub>6</sub>                              | 20328-94-3  | 415.197     | wh monocl cry             | 130.5                  |           | 3.51                       |                                     |                                         |

| No.  | Name                                     | Formula                                                                            | CAS Reg No. | Mol. weight | Physical form      | mp/°C   | bp/°C | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility            |
|------|------------------------------------------|------------------------------------------------------------------------------------|-------------|-------------|--------------------|---------|-------|----------------------------|-------------------------------------|-----------------------------------|
| 3081 | Xenon pentafluoride hexafluororuthenate  | XeF <sub>5</sub> RuF <sub>6</sub>                                                  | 39796-98-0  | 441.35      | grn orth cry       | 152     |       | 3.79                       |                                     |                                   |
| 3082 | Xenon fluoride hexafluoroantimonate      | XeF <sub>3</sub> SbF <sub>6</sub>                                                  | 39797-63-2  | 424.039     | yel-grn monocl cry | ≈110    |       | 3.92                       |                                     |                                   |
| 3083 | Xenon fluoride hexafluoroarsenate        | XeF <sub>3</sub> AsF <sub>6</sub>                                                  | 50432-32-1  | 508.494     | yel-grn monocl cry | 99      |       | 3.62                       |                                     | reac H <sub>2</sub> O             |
| 3084 | Xenon fluoride hexafluororuthenate       | XeFRuF <sub>6</sub>                                                                | 22527-13-5  | 365.35      | yel-grn monocl cry | 110     |       | 3.78                       |                                     |                                   |
| 3085 | Xenon fluoride undecafluoroantimonate    | XeFSb <sub>2</sub> F <sub>11</sub>                                                 | 15364-10-0  | 602.794     | yel monocl cry     | 63      |       | 3.69                       |                                     |                                   |
| 3086 | Xenon trifluoride undecafluoroantimonate | XeF <sub>3</sub> Sb <sub>2</sub> F <sub>11</sub>                                   | 35718-37-7  | 640.791     | yel-grn tricl cry  | 82      |       | 3.98                       |                                     |                                   |
| 3087 | Ytterbium                                | Yb                                                                                 | 7440-64-4   | 173.04      | silv metal; cub    | 824     | 1196  | 6.90                       |                                     | s dil acid                        |
| 3088 | Ytterbium silicide                       | YbSi <sub>2</sub>                                                                  | 12039-89-3  | 229.21      | hex cry            |         |       | 7.54                       |                                     |                                   |
| 3089 | Ytterbium(II) bromide                    | YbBr <sub>2</sub>                                                                  | 25502-05-0  | 332.85      | yel cry            | 673     |       |                            |                                     | reac H <sub>2</sub> O             |
| 3090 | Ytterbium(II) chloride                   | YbCl <sub>2</sub>                                                                  | 13874-77-6  | 243.95      | grn cry            | 721     |       | 5.27                       |                                     | reac H <sub>2</sub> O             |
| 3091 | Ytterbium(II) fluoride                   | YbF <sub>2</sub>                                                                   | 15192-18-4  | 211.04      | gray solid         | 1407    |       |                            |                                     | i H <sub>2</sub> O                |
| 3092 | Ytterbium(II) iodide                     | YbI <sub>2</sub>                                                                   | 19357-86-9  | 426.85      | blk cry            | 772     |       |                            |                                     | reac H <sub>2</sub> O             |
| 3093 | Ytterbium(III) acetate tetrahydrate      | Yb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>3</sub> · 4H <sub>2</sub> O | 15280-58-7  | 422.23      | hyg col cry        | dec 70  |       | 2.09                       |                                     | vs H <sub>2</sub> O               |
| 3094 | Ytterbium(III) bromide                   | YbBr <sub>3</sub>                                                                  | 13759-89-2  | 412.75      | col cry            | 956 dec |       |                            |                                     | s H <sub>2</sub> O                |
| 3095 | Ytterbium(III) chloride                  | YbCl <sub>3</sub>                                                                  | 10361-91-8  | 279.40      | wh hyg powder      | 854     |       |                            |                                     | s H <sub>2</sub> O                |
| 3096 | Ytterbium(III) chloride hexahydrate      | YbCl <sub>3</sub> · 6H <sub>2</sub> O                                              | 19423-87-1  | 387.49      | grn hyg cry        | 150 dec |       | 2.57                       |                                     | vs H <sub>2</sub> O               |
| 3097 | Ytterbium(III) fluoride                  | YbF <sub>3</sub>                                                                   | 13760-80-0  | 230.04      | wh cry             | 1157    |       | 8.2                        |                                     | i H <sub>2</sub> O                |
| 3098 | Ytterbium(III) iodide                    | YbI <sub>3</sub>                                                                   | 13813-44-0  | 553.75      | yel cry            | dec 700 |       |                            |                                     | s H <sub>2</sub> O                |
| 3099 | Ytterbium(III) nitrate                   | Yb(NO <sub>3</sub> ) <sub>3</sub>                                                  | 13768-67-7  | 359.06      | col hyg solid      |         |       |                            | 239 <sup>25</sup>                   | s EtOH                            |
| 3100 | Ytterbium(III) oxide                     | Yb <sub>2</sub> O <sub>3</sub>                                                     | 1314-37-0   | 394.08      | col cub cry        | 2355    | 4070  | 9.2                        |                                     | s dil acid                        |
| 3101 | Ytterbium(III) sulfate octahydrate       | Yb <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                | 10034-98-7  | 778.39      | col cry            |         |       | 3.3                        | 38.4 <sup>20</sup>                  |                                   |
| 3102 | Yttrium                                  | Y                                                                                  | 7440-65-5   | 88.906      | silv metal; hex    | 1522    | 3345  | 4.47                       |                                     | reac H <sub>2</sub> O; s dil acid |
| 3103 | Yttrium aluminum oxide                   | Y <sub>2</sub> Al <sub>5</sub> O <sub>12</sub>                                     | 12005-21-9  | 593.619     | grn cub cry        |         |       | ≈4.5                       |                                     |                                   |
| 3104 | Yttrium antimonide                       | YSb                                                                                | 12186-97-9  | 210.666     | cub cry            | 2310    |       | 5.97                       |                                     |                                   |
| 3105 | Yttrium arsenide                         | YAs                                                                                | 12255-48-0  | 163.828     | cub cry            |         |       | 5.59                       |                                     |                                   |
| 3106 | Yttrium boride                           | YB <sub>3</sub>                                                                    | 12008-32-1  | 153.772     | refrac solid       | 2600    |       | 3.72                       |                                     |                                   |
| 3107 | Yttrium bromide                          | YBr <sub>3</sub>                                                                   | 13469-98-2  | 328.618     | col hyg cry        | 904     |       |                            | 83.3 <sup>30</sup>                  |                                   |
| 3108 | Yttrium carbide                          | YC <sub>2</sub>                                                                    | 12071-35-1  | 112.927     | refrac solid       | ≈2400   |       | 4.13                       |                                     |                                   |
| 3109 | Yttrium carbonate trihydrate             | Y <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub> · 3H <sub>2</sub> O                 | 5970-44-5   | 411.885     | red-brn powder     |         |       |                            |                                     | i H <sub>2</sub> O; s dil acid    |
| 3110 | Yttrium chloride                         | YCl <sub>3</sub>                                                                   | 10361-92-9  | 195.265     | wh monocl cry; hyg | 721     | 1482  | 2.61                       | 75.1 <sup>20</sup>                  | vs H <sub>2</sub> O               |
| 3111 | Yttrium chloride hexahydrate             | YCl <sub>3</sub> · 6H <sub>2</sub> O                                               | 10025-94-2  | 303.356     | hyg col cry        | dec 100 |       |                            |                                     | vs H <sub>2</sub> O; s EtOH       |
| 3112 | Yttrium fluoride                         | YF <sub>3</sub>                                                                    | 13709-49-4  | 145.901     | wh hyg powder      | 1155    |       | 4.0                        |                                     | i H <sub>2</sub> O                |
| 3113 | Yttrium hydroxide                        | Y(OH) <sub>3</sub>                                                                 | 16469-22-0  | 139.928     | wh prec or pow     | dec 190 |       |                            |                                     | i H <sub>2</sub> O                |
| 3114 | Yttrium iodide                           | YI <sub>3</sub>                                                                    | 13470-38-7  | 469.619     | hyg wh-yel cry     | 997     |       |                            |                                     | s H <sub>2</sub> O, ace, EtOH     |
| 3115 | Yttrium iron oxide                       | Y <sub>2</sub> Fe <sub>2</sub> O <sub>12</sub>                                     | 12063-56-8  | 737.936     | cub cry            | 1555    |       |                            |                                     |                                   |
| 3116 | Yttrium nitrate                          | Y(NO <sub>3</sub> ) <sub>3</sub>                                                   | 10361-93-0  | 274.921     | wh hyg solid       |         |       |                            | 149 <sup>25</sup>                   | s EtOH                            |
| 3117 | Yttrium nitrate tetrahydrate             | Y(NO <sub>3</sub> ) <sub>3</sub> · 4H <sub>2</sub> O                               | 13773-69-8  | 346.982     | red-wh prisms      |         |       | 2.68                       | 149 <sup>25</sup>                   |                                   |
| 3118 | Yttrium nitrate hexahydrate              | Y(NO <sub>3</sub> ) <sub>3</sub> · 6H <sub>2</sub> O                               | 13494-98-9  | 383.012     | hyg cry            |         |       |                            | 149 <sup>25</sup>                   |                                   |
| 3119 | Yttrium oxide                            | Y <sub>2</sub> O <sub>3</sub>                                                      | 1314-36-9   | 225.810     | wh cry; cub        | 2439    |       | 5.03                       |                                     | s dil acid                        |
| 3120 | Yttrium phosphide                        | YP                                                                                 | 12294-01-8  | 119.880     | cub cry            |         |       | ≈4.4                       |                                     |                                   |
| 3121 | Yttrium sulfate octahydrate              | Y <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 8H <sub>2</sub> O                 | 7446-33-5   | 610.122     | red monocl cry     |         |       | 2.6                        | 7.47 <sup>16</sup>                  |                                   |
| 3122 | Yttrium sulfide                          | Y <sub>2</sub> S <sub>3</sub>                                                      | 12039-19-9  | 274.007     | yel cub cry        | 1925    |       | 3.87                       |                                     |                                   |
| 3123 | Zinc                                     | Zn                                                                                 | 7440-66-6   | 65.409      | blue-wh metal; hex | 419.53  | 907   | 7.134                      |                                     | s acid, alk                       |
| 3124 | Zinc acetate dihydrate                   | Zn(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O | 5970-45-6   | 219.527     | wh powder          | 237 dec |       | 1.735                      | 30.0 <sup>20</sup>                  | s EtOH                            |
| 3125 | Zinc ammonium sulfate                    | Zn(NH <sub>4</sub> ) <sub>6</sub> (SO <sub>4</sub> ) <sub>2</sub>                  | 7783-24-6   | 293.611     | wh cry             |         |       |                            | 9.2 <sup>20</sup>                   |                                   |
| 3126 | Zinc antimonide                          | ZnSb                                                                               | 12039-35-9  | 187.169     | silv-wh orth cry   | 565     |       | 6.33                       |                                     | reac H <sub>2</sub> O             |
| 3127 | Zinc arsenate                            | Zn <sub>2</sub> (AsO <sub>4</sub> ) <sub>2</sub>                                   | 13464-44-3  | 474.065     | wh powder          |         |       |                            | 0.000078 <sup>20</sup>              | s acid, alk                       |
| 3128 | Zinc arsenate octahydrate                | Zn <sub>2</sub> (AsO <sub>4</sub> ) <sub>2</sub> · 8H <sub>2</sub> O               | 13464-45-4  | 618.187     | wh monocl cry      |         |       | 3.33                       | 0.000078 <sup>20</sup>              | s acid, alk                       |
| 3129 | Zinc arsenide                            | Zn <sub>3</sub> As <sub>2</sub>                                                    | 12006-40-5  | 346.070     | powder             | 1015    |       | 5.528                      |                                     |                                   |
| 3130 | Zinc arsenite                            | Zn(AsO <sub>2</sub> ) <sub>2</sub>                                                 | 10326-24-6  | 279.250     | col powder         |         |       |                            |                                     | i H <sub>2</sub> O; s acid        |
| 3131 | Zinc borate                              | 3ZnO · 2B <sub>2</sub> O <sub>3</sub>                                              | 27043-84-1  | 383.466     | wh amorp powder    |         |       | 3.64                       |                                     | sl H <sub>2</sub> O; s dil acid   |
| 3132 | Zinc borate hemiheptahydrate             | 2ZnO · 3B <sub>2</sub> O <sub>3</sub> · 3.5H <sub>2</sub> O                        | 12513-27-8  | 434.69      | wh cry             | 980     |       | 4.22                       |                                     | i H <sub>2</sub> O                |
| 3133 | Zinc borate pentahydrate                 | 2ZnO · 3B <sub>2</sub> O <sub>3</sub> · 5H <sub>2</sub> O                          | 12536-65-1  | 461.753     | wh powder          |         |       | 3.64                       | 0.007 <sup>25</sup>                 | sl HCl                            |
| 3134 | Zinc bromate hexahydrate                 | Zn(BrO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                             | 13517-27-6  | 429.305     | wh hyg solid       | 100     |       | 2.57                       |                                     | vs H <sub>2</sub> O               |
| 3135 | Zinc bromide                             | ZnBr <sub>2</sub>                                                                  | 7699-45-8   | 225.217     | wh hex cry; hyg    | 402     | ≈670  | 4.5                        | 488 <sup>25</sup>                   | vs EtOH; s eth                    |
| 3136 | Zinc caprylate                           | Zn(C <sub>8</sub> H <sub>15</sub> O <sub>2</sub> ) <sub>2</sub>                    | 557-09-5    | 351.816     | wh hyg cry         | 136     |       |                            |                                     | sl H <sub>2</sub> O               |
| 3137 | Zinc carbonate                           | ZnCO <sub>3</sub>                                                                  | 3486-35-9   | 125.418     | wh hex cry         | 140 dec |       | 4.434                      | 0.000091 <sup>20</sup>              | s dil acid, alk                   |
| 3138 | Zinc carbonate hydroxide                 | 3Zn(OH) <sub>2</sub> · 2ZnCO <sub>3</sub>                                          | 12070-69-8  | 549.107     | wh powder          |         |       |                            |                                     |                                   |
| 3139 | Zinc chlorate                            | Zn(ClO <sub>3</sub> ) <sub>2</sub>                                                 | 10361-95-2  | 232.311     | yel hyg cry        | 60 dec  |       | 2.15                       | 200 <sup>20</sup>                   |                                   |
| 3140 | Zinc chloride                            | ZnCl <sub>2</sub>                                                                  | 7646-85-7   | 136.315     | wh hyg cry         | 290     | 732   | 2.907                      | 408 <sup>25</sup>                   | vs H <sub>2</sub> O; s EtOH, ace  |



| No.  | Name                                | Formula                                                                                          | CAS Reg No. | Mol. weight | Physical form          | mp/°C               | bp/°C    | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility                    |
|------|-------------------------------------|--------------------------------------------------------------------------------------------------|-------------|-------------|------------------------|---------------------|----------|----------------------------|-------------------------------------|-------------------------------------------|
| 3141 | Zinc chromate                       | ZnCrO <sub>4</sub>                                                                               | 13530-65-9  | 181.403     | yel prisms             | 316                 |          | 3.40                       | 3.08                                | s acid; i ace                             |
| 3142 | Zinc chromite                       | ZnCr <sub>2</sub> O <sub>4</sub>                                                                 | 12018-19-8  | 233.399     | grn cub cry            |                     |          | 5.29                       |                                     |                                           |
| 3143 | Zinc citrate dihydrate              | Zn <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) <sub>2</sub> · 2H <sub>2</sub> O | 546-46-3    | 610.456     | col powder             |                     |          |                            |                                     | sl H <sub>2</sub> O; s dil acid, alk      |
| 3144 | Zinc cyanide                        | Zn(CN) <sub>2</sub>                                                                              | 557-21-1    | 117.443     | wh powder              |                     |          | 1.852                      | 0.00047 <sup>20</sup>               | reac acid                                 |
| 3145 | Zinc diethyl                        | Zn(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>                                                  | 557-20-0    | 123.531     | col liq                | -28                 | 118      | 1.2065                     |                                     | reac H <sub>2</sub> O; msc eth, peth, bz  |
| 3146 | Zinc dithionate                     | ZnS <sub>2</sub> O <sub>4</sub>                                                                  | 7779-86-4   | 193.537     | wh amorp solid         | 200 dec             |          |                            | 40 <sup>20</sup>                    |                                           |
| 3147 | Zinc fluoride                       | ZnF <sub>2</sub>                                                                                 | 7783-49-5   | 103.406     | wh tetr needles; hyg   | 872                 | 1500     | 4.9                        | 1.55 <sup>25</sup>                  | sl H <sub>2</sub> O                       |
| 3148 | Zinc fluoride tetrahydrate          | ZnF <sub>2</sub> · 4H <sub>2</sub> O                                                             | 13986-18-0  | 175.468     | wh orth cry            |                     |          | 2.30                       | 1.55 <sup>25</sup>                  |                                           |
| 3149 | Zinc fluoroborate hexahydrate       | Zn(BF <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                            | 27860-83-9  | 347.109     | hex cry                |                     |          | 2.12                       |                                     | vs H <sub>2</sub> O; s EtOH               |
| 3150 | Zinc formate dihydrate              | Zn(CHO <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O                                           | 5970-62-7   | 191.474     | wh cry                 |                     |          | 2.207                      | 5.2 <sup>20</sup>                   | i EtOH                                    |
| 3151 | Zinc hexafluorosilicate hexahydrate | ZnSiF <sub>6</sub> · 6H <sub>2</sub> O                                                           | 16871-71-9  | 315.576     | wh cry                 |                     |          |                            |                                     | s H <sub>2</sub> O                        |
| 3152 | Zinc hydroxide                      | Zn(OH) <sub>2</sub>                                                                              | 20427-58-1  | 99.424      | col orth cry           | 125 dec             |          | 3.05                       | 0.000042 <sup>20</sup>              |                                           |
| 3153 | Zinc iodate                         | Zn(IO <sub>3</sub> ) <sub>2</sub>                                                                | 7790-37-6   | 415.214     | wh cry powder          |                     |          |                            | 0.64 <sup>25</sup>                  |                                           |
| 3154 | Zinc iodide                         | ZnI <sub>2</sub>                                                                                 | 10139-47-6  | 319.218     | wh-yel hyg cry         | 450                 | 625      | 4.74                       | 438 <sup>25</sup>                   | vs H <sub>2</sub> O; s EtOH, eth          |
| 3155 | Zinc laurate                        | Zn(C <sub>11</sub> H <sub>23</sub> O <sub>2</sub> ) <sub>2</sub>                                 | 2452-01-9   | 464.029     | wh powder              | 128                 |          |                            |                                     | sl H <sub>2</sub> O                       |
| 3156 | Zinc molybdate                      | ZnMoO <sub>4</sub>                                                                               | 13767-32-3  | 225.35      | wh tetr cry            | >700                |          | 4.3                        |                                     | i H <sub>2</sub> O                        |
| 3157 | Zinc nitrate                        | Zn(NO <sub>3</sub> ) <sub>2</sub>                                                                | 7779-88-6   | 189.418     | wh powder              |                     |          |                            | 120 <sup>25</sup>                   |                                           |
| 3158 | Zinc nitrate hexahydrate            | Zn(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                            | 10196-18-6  | 297.510     | col orth cry           | 36 dec              |          | 2.067                      | 120 <sup>25</sup>                   | vs EtOH                                   |
| 3159 | Zinc nitride                        | Zn <sub>3</sub> N <sub>2</sub>                                                                   | 1313-49-1   | 224.240     | blue-gray cub cry      | 700 dec             |          | 6.22                       |                                     | i H <sub>2</sub> O                        |
| 3160 | Zinc nitrite                        | Zn(NO <sub>2</sub> ) <sub>2</sub>                                                                | 10102-02-0  | 157.420     | hyg solid              |                     |          |                            |                                     | reac H <sub>2</sub> O                     |
| 3161 | Zinc oleate                         | Zn(C <sub>18</sub> H <sub>33</sub> O <sub>2</sub> ) <sub>2</sub>                                 | 557-07-3    | 628.316     | wh powder              | 70 dec              |          |                            |                                     | i H <sub>2</sub> O; s EtOH, eth, bz       |
| 3162 | Zinc oxalate                        | ZnC <sub>2</sub> O <sub>4</sub>                                                                  | 547-68-2    | 153.428     | wh pwd                 |                     |          |                            | 0.0026 <sup>25</sup>                |                                           |
| 3163 | Zinc oxalate dihydrate              | ZnC <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O                                              | 4255-07-6   | 189.458     | wh powder              | 100 dec             |          | 2.56                       | 0.0026 <sup>25</sup>                | s dil acid                                |
| 3164 | Zinc tartrate dihydrate             | ZnC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> · 2H <sub>2</sub> O                               | 22570-08-7  | 249.511     | wh cry pow             | dec 150             |          |                            | 0.022 <sup>20</sup>                 |                                           |
| 3165 | Zinc oxide                          | ZnO                                                                                              | 1314-13-2   | 81.408      | wh powder; hex         | 1974                |          | 5.6                        |                                     | i H <sub>2</sub> O; s dil acid            |
| 3166 | Zinc 2,4-pentanedioate              | Zn(CH <sub>3</sub> COCHCOCH <sub>3</sub> ) <sub>2</sub>                                          | 14024-63-6  | 263.625     | cry                    | 137 dec             |          |                            |                                     | sl H <sub>2</sub> O; s EtOH, DMSO         |
| 3167 | Zinc pentanoate dihydrate           | Zn(C <sub>5</sub> H <sub>9</sub> O <sub>2</sub> ) <sub>2</sub> · 2H <sub>2</sub> O               | 556-38-7    | 303.687     | scales or powder       |                     |          |                            |                                     | sl H <sub>2</sub> O; reac acid; s EtOH    |
| 3168 | Zinc perchlorate hexahydrate        | Zn(ClO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                           | 10025-64-6  | 372.402     | wh cub cry; hyg        | 106 dec             |          | 2.2                        | 121.3 <sup>25</sup>                 | s EtOH                                    |
| 3169 | Zinc permanganate hexahydrate       | Zn(MnO <sub>4</sub> ) <sub>2</sub> · 6H <sub>2</sub> O                                           | 23414-72-4  | 411.372     | blk orth cry; hyg      |                     |          | 2.45                       |                                     | s H <sub>2</sub> O; reac EtOH             |
| 3170 | Zinc peroxide                       | ZnO <sub>2</sub>                                                                                 | 1314-22-3   | 97.408      | yel-wh powder          | >150 dec            | 212 exp  | 1.57                       |                                     | i H <sub>2</sub> O; reac acid, EtOH, ace  |
| 3171 | Zinc phosphate                      | Zn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>                                                  | 7779-90-0   | 386.170     | wh monoc cry           | 900                 |          | 4.0                        |                                     | i H <sub>2</sub> O                        |
| 3172 | Zinc phosphate tetrahydrate         | Zn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                              | 7543-51-3   | 458.231     | col orth cry           |                     |          | 3.04                       |                                     | i H <sub>2</sub> O, EtOH; s dil acid, alk |
| 3173 | Zinc phosphide                      | Zn <sub>3</sub> P <sub>2</sub>                                                                   | 1314-84-7   | 258.175     | gray tetr cry          | 1160                |          | 4.55                       |                                     | i H <sub>2</sub> O, EtOH; reac acid; s bz |
| 3174 | Zinc pyrophosphate                  | Zn <sub>2</sub> P <sub>2</sub> O <sub>7</sub>                                                    | 7446-26-6   | 304.761     | wh cry powder          |                     |          | 3.75                       |                                     | i H <sub>2</sub> O; s dil acid            |
| 3175 | Zinc selenate pentahydrate          | ZnSeO <sub>4</sub> · 5H <sub>2</sub> O                                                           | 13597-54-1  | 298.44      | tricl cry              | 50 dec              |          | 2.59                       | 63.4 <sup>25</sup>                  |                                           |
| 3176 | Zinc selenide                       | ZnSe                                                                                             | 1315-09-9   | 144.37      | yel-red cub cry        | >1100               | subl     | 5.65                       |                                     | i H <sub>2</sub> O; s dil acid            |
| 3177 | Zinc orthosilicate                  | Zn <sub>2</sub> SiO <sub>4</sub>                                                                 | 13597-65-4  | 222.902     | wh hex cry             | 1509                |          | 4.1                        |                                     | i H <sub>2</sub> O, dil acid              |
| 3178 | Zinc selenite                       | ZnSeO <sub>3</sub>                                                                               | 13597-46-1  | 192.37      | wh powder              | 621                 |          |                            |                                     |                                           |
| 3179 | Zinc stearate                       | Zn(C <sub>18</sub> H <sub>35</sub> O <sub>2</sub> ) <sub>2</sub>                                 | 557-05-1    | 632.348     | wh powder              | 130                 |          | 1.095                      |                                     | i H <sub>2</sub> O, EtOH, eth; s bz       |
| 3180 | Zinc sulfate                        | ZnSO <sub>4</sub>                                                                                | 7733-02-0   | 161.472     | col orth cry           | 680 dec             |          | 3.8                        | 57.7 <sup>25</sup>                  |                                           |
| 3181 | Zinc sulfate monohydrate            | ZnSO <sub>4</sub> · H <sub>2</sub> O                                                             | 7446-19-7   | 179.487     | wh monoc cry           | 238 dec             |          | 3.20                       | 57.7 <sup>25</sup>                  | i EtOH                                    |
| 3182 | Zinc sulfate heptahydrate           | ZnSO <sub>4</sub> · 7H <sub>2</sub> O                                                            | 7446-20-0   | 287.578     | col orth cry           | 100 dec             |          | 1.97                       | 57.7 <sup>25</sup>                  | i EtOH                                    |
| 3183 | Zinc sulfide (sphalerite)           | ZnS                                                                                              | 1314-98-3   | 97.474      | gray-wh cub cry        | trans wurtzite 1020 |          | 4.04                       |                                     | i H <sub>2</sub> O, EtOH; s dil acid      |
| 3184 | Zinc sulfide (wurtzite)             | ZnS                                                                                              | 1314-98-3   | 97.474      | wh hex cry             | 1700                | subl     | 4.09                       |                                     | i H <sub>2</sub> O; s dil acid            |
| 3185 | Zinc sulfite dihydrate              | ZnSO <sub>3</sub> · 2H <sub>2</sub> O                                                            | 7488-52-0   | 181.503     | wh powder              | 200 dec             |          |                            | 0.224 <sup>25</sup>                 | i EtOH                                    |
| 3186 | Zinc telluride                      | ZnTe                                                                                             | 1315-11-3   | 193.01      | red cub cry            | 1239                |          | 5.9                        |                                     | i H <sub>2</sub> O                        |
| 3187 | Zinc thiocyanate                    | Zn(SCN) <sub>2</sub>                                                                             | 557-42-6    | 181.573     | wh hyg cry             |                     |          |                            |                                     | sl H <sub>2</sub> O; s EtOH               |
| 3188 | Zirconium                           | Zr                                                                                               | 7440-67-7   | 91.224      | gray-wh metal; hex     | 1854.7              | 4409     | 6.52                       |                                     | s hot conc acid                           |
| 3189 | Zirconocene dichloride              | Zr(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> Cl <sub>2</sub>                                  | 1291-32-3   | 292.316     | col cry                | 248                 | subl 150 |                            |                                     |                                           |
| 3190 | Zirconium boride                    | ZrB <sub>2</sub>                                                                                 | 12045-64-6  | 112.846     | gray refrac solid; hex | 3050                |          | 6.17                       |                                     |                                           |
| 3191 | Zirconium carbide                   | ZrC                                                                                              | 12020-14-3  | 103.235     | gray refrac solid; cub | 3532                |          | 6.73                       |                                     | s HF                                      |
| 3192 | Zirconium nitride                   | ZrN                                                                                              | 25658-42-8  | 105.231     | yel cub cry            | 2952                |          | 7.09                       |                                     | s conc HF; sl dil acid                    |
| 3193 | Zirconium phosphide                 | ZrP <sub>2</sub>                                                                                 | 12037-80-8  | 153.172     | orth cry               |                     |          | ≈5.1                       |                                     |                                           |
| 3194 | Zirconium silicide                  | ZrSi <sub>2</sub>                                                                                | 12039-90-6  | 147.395     | gray powder            | 1620                |          | 4.88                       |                                     | i H <sub>2</sub> O, aqua regia; s HF      |

| No.  | Name                                       | Formula                                                                                 | CAS Reg No. | Mol. weight | Physical form      | mp/°C    | bp/°C  | Density g cm <sup>-3</sup> | Solubility g/100 g H <sub>2</sub> O | Qualitative solubility             |
|------|--------------------------------------------|-----------------------------------------------------------------------------------------|-------------|-------------|--------------------|----------|--------|----------------------------|-------------------------------------|------------------------------------|
| 3195 | Zirconium(II) bromide                      | ZrBr <sub>2</sub>                                                                       | 24621-17-8  | 251.032     | blue-blk cry       | dec 400  |        |                            |                                     |                                    |
| 3196 | Zirconium(II) chloride                     | ZrCl <sub>2</sub>                                                                       | 13762-26-0  | 162.130     | blk cry            | 772      |        | 3.16                       |                                     | reac H <sub>2</sub> O              |
| 3197 | Zirconium(II) fluoride                     | ZrF <sub>2</sub>                                                                        | 13842-94-9  | 129.221     | blk cry            | 902      |        |                            |                                     |                                    |
| 3198 | Zirconium(II) hydride                      | ZrH <sub>2</sub>                                                                        | 7704-99-6   | 93.240      | gray tetr cry      | 800 dec  |        | 5.6                        |                                     | i H <sub>2</sub> O                 |
| 3199 | Zirconium(II) iodide                       | ZrI <sub>2</sub>                                                                        | 15513-85-6  | 345.033     | blk cry            | 827      |        |                            |                                     |                                    |
| 3200 | Zirconium(III) bromide                     | ZrBr <sub>3</sub>                                                                       | 24621-18-9  | 330.936     | dark blue cry      | dec 300  |        |                            |                                     |                                    |
| 3201 | Zirconium(III) chloride                    | ZrCl <sub>3</sub>                                                                       | 10241-03-9  | 197.583     | dark blue cry      | 627      |        | 3.05                       |                                     | reac H <sub>2</sub> O              |
| 3202 | Zirconium(III) fluoride                    | ZrF <sub>3</sub>                                                                        | 13814-22-7  | 148.219     | blue-grn cry       | 927      |        | 4.26                       |                                     | i H <sub>2</sub> O; s acid         |
| 3203 | Zirconium(III) iodide                      | ZrI <sub>3</sub>                                                                        | 13779-87-8  | 471.937     | dark blue cry      | 727      |        |                            |                                     |                                    |
| 3204 | Zirconium(IV) acetate hydroxide            | Zr(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> (OH) <sub>2</sub>        | 14311-93-4  | 243.327     | wh amorp solid     |          |        |                            |                                     | s H <sub>2</sub> O                 |
| 3205 | Zirconium(IV) ammonium carbonate dihydrate | Zr(NH <sub>4</sub> ) <sub>3</sub> OH(CO <sub>3</sub> ) <sub>3</sub> · 2H <sub>2</sub> O | 12616-24-9* | 362.404     | prisms; unstab     |          |        |                            |                                     | s H <sub>2</sub> O                 |
| 3206 | Zirconium(IV) bromide                      | ZrBr <sub>4</sub>                                                                       | 13777-25-8  | 410.840     | wh cub cry         | 450 tp   | 360 sp | 3.98                       |                                     | reac H <sub>2</sub> O              |
| 3207 | Zirconium(IV) chloride                     | ZrCl <sub>4</sub>                                                                       | 10026-11-6  | 233.036     | wh monocl cry; hyg | 437 tp   | 331 sp | 2.80                       |                                     | reac H <sub>2</sub> O; s EtOH, eth |
| 3208 | Zirconium(IV) fluoride                     | ZrF <sub>4</sub>                                                                        | 7783-64-4   | 167.218     | wh monocl cry      | 910      | 912 sp | 4.43                       | 1.5 <sup>25</sup>                   |                                    |
| 3209 | Zirconium(IV) hydroxide                    | Zr(OH) <sub>4</sub>                                                                     | 14475-63-9  | 159.254     | wh amorp powder    | dec      |        | 3.25                       |                                     | i H <sub>2</sub> O; s acid         |
| 3210 | Zirconium(IV) iodide                       | ZrI <sub>4</sub>                                                                        | 13986-26-0  | 598.842     | yel-oran cub cry   | 500      | 431 sp | 4.85                       |                                     | vs H <sub>2</sub> O                |
| 3211 | Zirconium(IV) nitrate pentahydrate         | Zr(NO <sub>3</sub> ) <sub>4</sub> · 5H <sub>2</sub> O                                   | 13746-89-9  | 429.320     | wh hyg cry         | 100 dec  |        |                            |                                     | vs H <sub>2</sub> O; s EtOH        |
| 3212 | Zirconium(IV) orthosilicate                | ZrSiO <sub>4</sub>                                                                      | 10101-52-7  | 183.308     | wh tetr cry        | 1540 dec |        | 4.6                        |                                     | i H <sub>2</sub> O, acid           |
| 3213 | Zirconium(IV) oxide                        | ZrO <sub>2</sub>                                                                        | 1314-23-4   | 123.223     | wh amorp powder    | 2710     | 4300   | 5.68                       |                                     | i H <sub>2</sub> O; sl acid        |
| 3214 | Zirconium(IV) pyrophosphate                | ZrP <sub>2</sub> O <sub>7</sub>                                                         | 13565-97-4  | 265.167     | wh refrac solid    | dec 1550 |        |                            |                                     | i H <sub>2</sub> O, dil acid; s HF |
| 3215 | Zirconium(IV) sulfate                      | Zr(SO <sub>4</sub> ) <sub>2</sub>                                                       | 14644-61-2  | 283.349     | wh hyg cry         | 410 dec  |        | 3.22                       |                                     | s H <sub>2</sub> O; sl EtOH        |
| 3216 | Zirconium(IV) sulfate tetrahydrate         | Zr(SO <sub>4</sub> ) <sub>2</sub> · 4H <sub>2</sub> O                                   | 7446-31-3   | 355.411     | wh tetr cry        | 100 dec  |        | 2.80                       |                                     | vs H <sub>2</sub> O                |
| 3217 | Zirconium(IV) sulfide                      | ZrS <sub>2</sub>                                                                        | 12039-15-5  | 155.354     | red-brn hex cry    | 1550     |        | 3.87                       |                                     | i H <sub>2</sub> O                 |
| 3218 | Zirconium(IV) tungstate                    | Zr(WO <sub>4</sub> ) <sub>2</sub>                                                       | 16853-74-0  | 586.90      | grn pow            |          |        |                            |                                     |                                    |
| 3219 | Zirconyl chloride                          | ZrOCl <sub>2</sub>                                                                      | 7699-43-6   | 178.129     | wh solid           | 250 dec  |        |                            |                                     | s H <sub>2</sub> O, EtOH           |
| 3220 | Zirconyl chloride octahydrate              | ZrOCl <sub>2</sub> · 8H <sub>2</sub> O                                                  | 13520-92-8  | 322.252     | tetr cry           | 400 dec  |        | 1.91                       |                                     | vs H <sub>2</sub> O, EtOH          |

# PHYSICAL PROPERTIES OF THE RARE EARTH METALS

K.A. Gschneidner, Jr.

TABLE 1. Data for the Trivalent Ions of the Rare Earth Elements

| Rare earth   | Symbol | Atomic no. | Atomic wt. <sup>a</sup> | Electronic configuration for R <sup>3+</sup> |     |   |      | Spectroscopic ground state symbol |
|--------------|--------|------------|-------------------------|----------------------------------------------|-----|---|------|-----------------------------------|
|              |        |            |                         | No. 4f electrons                             | S   | L | J    |                                   |
| Scandium     | Sc     | 21         | 44.955910               | 0                                            | —   | — | —    | —                                 |
| Yttrium      | Y      | 39         | 88.90585                | 0                                            | —   | — | —    | —                                 |
| Lanthanum    | La     | 57         | 138.9055                | 0                                            | —   | — | —    | —                                 |
| Cerium       | Ce     | 58         | 140.115                 | 1                                            | 1/2 | 3 | 5/2  | <sup>2</sup> F <sub>5/2</sub>     |
| Praseodymium | Pr     | 59         | 140.90765               | 2                                            | 1   | 5 | 4    | <sup>3</sup> H <sub>4</sub>       |
| Neodymium    | Nd     | 60         | 144.24                  | 3                                            | 3/2 | 6 | 9/2  | <sup>4</sup> I <sub>9/2</sub>     |
| Promethium   | Pm     | 61         | (145)                   | 4                                            | 2   | 6 | 4    | <sup>5</sup> I <sub>4</sub>       |
| Samarium     | Sm     | 62         | 150.36                  | 5                                            | 5/2 | 5 | 5/2  | <sup>6</sup> H <sub>5/2</sub>     |
| Europium     | Eu     | 63         | 151.965                 | 6                                            | 3   | 3 | 0    | <sup>7</sup> F <sub>0</sub>       |
| Gadolinium   | Gd     | 64         | 157.25                  | 7                                            | 7/2 | 0 | 7/2  | <sup>8</sup> S <sub>7/2</sub>     |
| Terbium      | Tb     | 65         | 158.92534               | 8                                            | 3   | 3 | 6    | <sup>7</sup> F <sub>6</sub>       |
| Dysprosium   | Dy     | 66         | 162.50                  | 9                                            | 5/2 | 5 | 15/2 | <sup>6</sup> H <sub>15/2</sub>    |
| Holmium      | Ho     | 67         | 164.93032               | 10                                           | 2   | 6 | 8    | <sup>5</sup> I <sub>8</sub>       |
| Erbium       | Er     | 68         | 167.26                  | 11                                           | 3/2 | 6 | 15/2 | <sup>4</sup> I <sub>15/2</sub>    |
| Thulium      | Tm     | 69         | 168.93421               | 12                                           | 1   | 5 | 6    | <sup>3</sup> H <sub>6</sub>       |
| Ytterbium    | Yb     | 70         | 173.04                  | 13                                           | 1/2 | 3 | 7/2  | <sup>2</sup> F <sub>7/2</sub>     |
| Lutetium     | Lu     | 71         | 174.967                 | 14                                           | —   | — | —    | —                                 |

Note: For additional information, see Goldschmidt, Z.B., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978; DeLaeter, J.R., and Heumann, K.G., *J. Phys. Chem. Ref. Data*, 20, 1313, 1991; *Pure Appl. Chem.*, 66, 2423, 1994.

<sup>a</sup> 1993 standard atomic weights.

TABLE 2. Crystallographic Data for the Rare Earth Metals at 24 °C (297 K) or Below

| Rare earth metal  | Crystal structure <sup>a</sup> | Lattice constants (Å) |                    |                     | Metallic radius<br>CN = 12 (Å) | Atomic volume<br>(cm <sup>3</sup> /mol) | Density<br>(g/cm <sup>3</sup> ) |
|-------------------|--------------------------------|-----------------------|--------------------|---------------------|--------------------------------|-----------------------------------------|---------------------------------|
|                   |                                | a <sub>0</sub>        | b <sub>0</sub>     | c <sub>0</sub>      |                                |                                         |                                 |
| αSc               | hcp                            | 3.3088                | —                  | 5.2680              | 1.6406                         | 15.039                                  | 2.989                           |
| αY                | hcp                            | 3.6482                | —                  | 5.7318              | 1.8012                         | 19.893                                  | 4.469                           |
| αLa               | dhcp                           | 3.7740                | —                  | 12.171              | 1.8791                         | 22.602                                  | 6.146                           |
| αCe <sup>b</sup>  | fcc                            | 4.85 <sup>b</sup>     | —                  | —                   | 1.72 <sup>b</sup>              | 17.2 <sup>b</sup>                       | 8.16 <sup>b</sup>               |
| βCe               | dhcp                           | 3.6810                | —                  | 11.857              | 1.8321                         | 20.947                                  | 6.689                           |
| γCe <sup>c</sup>  | fcc                            | 5.1610                | —                  | —                   | 1.8247                         | 20.696                                  | 6.770                           |
| αPr               | dhcp                           | 3.6721                | —                  | 11.8326             | 1.8279                         | 20.803                                  | 6.773                           |
| αNd               | dhcp                           | 3.6582                | —                  | 11.7966             | 1.8214                         | 20.583                                  | 7.008                           |
| αPm               | dhcp                           | 3.65                  | —                  | 11.65               | 1.811                          | 20.24                                   | 7.264                           |
| αSm               | rhomb <sup>d</sup>             | 3.6290 <sup>d</sup>   | —                  | 26.207              | 1.8041                         | 20.000                                  | 7.520                           |
| Eu                | bcc                            | 4.5827                | —                  | —                   | 2.0418                         | 28.979                                  | 5.244                           |
| αGd               | hcp                            | 3.6336                | —                  | 5.7810              | 1.8013                         | 19.903                                  | 7.901                           |
| α'Tb <sup>e</sup> | ortho                          | 3.605 <sup>e</sup>    | 6.244 <sup>e</sup> | 5.706 <sup>e</sup>  | 1.784 <sup>e</sup>             | 19.34 <sup>e</sup>                      | 8.219 <sup>e</sup>              |
| αTb               | hcp                            | 3.6055                | —                  | 5.6966              | 1.7833                         | 19.310                                  | 8.230                           |
| α'Dy <sup>f</sup> | ortho                          | 3.595 <sup>f</sup>    | 6.184 <sup>f</sup> | 5.678 <sup>f</sup>  | 1.774 <sup>f</sup>             | 19.00 <sup>f</sup>                      | 8.551 <sup>f</sup>              |
| αDy               | hcp                            | 3.5915                | —                  | 5.6501              | 1.7740                         | 19.004                                  | 8.551                           |
| Ho                | hcp                            | 3.5778                | —                  | 5.6178              | 1.7661                         | 18.752                                  | 8.795                           |
| Er                | hcp                            | 3.5592                | —                  | 5.5850              | 1.7566                         | 18.449                                  | 9.066                           |
| Tm                | hcp                            | 3.5375                | —                  | 5.5540              | 1.7462                         | 18.124                                  | 9.321                           |
| αYb <sup>g</sup>  | hcp                            | 3.8799 <sup>g</sup>   | —                  | 6.3859 <sup>g</sup> | 1.9451 <sup>g</sup>            | 25.067 <sup>g</sup>                     | 6.903 <sup>g</sup>              |
| βYb               | fcc                            | 5.4848                | —                  | —                   | 1.9392                         | 24.841                                  | 6.966                           |
| Lu                | hcp                            | 3.5052                | —                  | 5.5494              | 1.7349                         | 17.779                                  | 9.841                           |

Note: For additional information, see Gschneidner, K.A., Jr. and Calderwood, F.W., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 8, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1986; Gschneidner, K.A., Jr., Pecharsky, V.K., Cho, Jaephil and Martin, S.W., *Scripta Mater.*, 34, 1717, 1996.

<sup>a</sup> hcp = hexagonal close-packed; P6<sub>3</sub>/mmc, hP2, A3, Mg-type; dhcp = double-c hexagonal close-packed; P6<sub>3</sub>/mmc, hP4, A3', αLa-type; fcc = face-centered cubic; Fm3m, cF4, A1, Cu-type; rhomb = rhombohedral; R3m, hR3, αSm-type; bcc = body-centered cubic; Im3m, cI2, A2, W-type; ortho = orthorhombic; Cmc, oC4, α' Dy-type.

<sup>b</sup> At 77 K (−196 °C).

<sup>c</sup> Equilibrium room temperature (standard state) phase.

<sup>d</sup> Rhombohedral is the primitive cell. Lattice parameters given are for the nonprimitive hexagonal cell.

<sup>e</sup> At 220 K (−53 °C).

<sup>f</sup> At 86 K (−187 °C).

<sup>g</sup> At 23 °C.

TABLE 3. Crystallographic Data for Rare Earth Metals at High Temperature

| Rare earth metal | Structure | Lattice parameter (Å)                  | Temp. (°C)       | Metallic radius |             | Atomic volume (cm <sup>3</sup> /mol) | Density (g/cm <sup>3</sup> ) |
|------------------|-----------|----------------------------------------|------------------|-----------------|-------------|--------------------------------------|------------------------------|
|                  |           |                                        |                  | CN = 8 (Å)      | CN = 12 (Å) |                                      |                              |
| βSc              | bcc       | 3.73 (est.)                            | 1337             | 1.62            | 1.66        | 15.6                                 | 2.88                         |
| βY               | bcc       | 4.10 <sup>a</sup>                      | 1478             | 1.78            | 1.83        | 20.8                                 | 4.28                         |
| βLa              | fcc       | 5.303                                  | 325              | —               | 1.875       | 22.45                                | 6.187                        |
| γLa              | bcc       | 4.26                                   | 887              | 1.84            | 1.90        | 23.3                                 | 5.97                         |
| δCe              | bcc       | 4.12                                   | 757              | 1.78            | 1.84        | 21.1                                 | 6.65                         |
| βPr              | bcc       | 4.13                                   | 821              | 1.79            | 1.84        | 21.2                                 | 6.64                         |
| βNd              | bcc       | 4.13                                   | 883              | 1.79            | 1.84        | 21.2                                 | 6.80                         |
| βPm              | bcc       | 4.10 (est.)                            | 890              | 1.78            | 1.83        | 20.8                                 | 6.99                         |
| βSm              | hcp       | <i>a</i> = 3.6630<br><i>c</i> = 5.8448 | 450 <sup>b</sup> | —               | 1.8176      | 20.450                               | 7.353                        |
| γSm              | bcc       | 4.10 (est.)                            | 922              | 1.77            | 1.82        | 20.8                                 | 7.25                         |
| βGd              | bcc       | 4.06                                   | 1265             | 1.76            | 1.81        | 20.2                                 | 7.80                         |
| βTb              | bcc       | 4.07 <sup>a</sup>                      | 1289             | 1.76            | 1.81        | 20.3                                 | 7.82                         |
| βDy              | bcc       | 4.03 <sup>a</sup>                      | 1381             | 1.75            | 1.80        | 19.7                                 | 8.23                         |
| γYb              | bcc       | 4.44                                   | 763 <sup>c</sup> | 1.92            | 1.98        | 26.4                                 | 6.57                         |

Note: The rare earths Eu, Ho, Er, Tm, and Lu are monomorphic. For additional information, see Gschneidner, K.A., Jr. and Calderwood, F.W., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 8, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1986, 1.

<sup>a</sup> Determined by extrapolation to 0% solute of a vs. composition data for R-Mg alloys at 24 °C and corrected for thermal expansion to temperature given.

<sup>b</sup> The hcp phase was stabilized by impurities and the temperature of measurement was below the equilibrium transition temperature (see Table 4).

<sup>c</sup> The bcc phase was stabilized by impurities and the temperature of measurement was below the equilibrium transition temperature (see Table 4).

TABLE 4. High Temperature Transition Temperatures and Melting Point of Rare Earth Metals

| Rare earth metal  | Transition I ( $\alpha - \beta$ ) <sup>a</sup> |                                                    | Transition II ( $\beta - \gamma$ ) <sup>a</sup> |                                                    | Melting point (°C) |
|-------------------|------------------------------------------------|----------------------------------------------------|-------------------------------------------------|----------------------------------------------------|--------------------|
|                   | Temp. (°C)                                     | Phases                                             | Temp. (°C)                                      | Phases                                             |                    |
| Sc                | 1337                                           | hcp $\rightleftharpoons$ bcc                       | —                                               | —                                                  | 1541               |
| Y                 | 1478                                           | hcp $\rightleftharpoons$ bcc                       | —                                               | —                                                  | 1522               |
| La <sup>b</sup>   | 310                                            | dhcp $\rightleftharpoons$ fcc                      | 865                                             | fcc $\rightleftharpoons$ bcc                       | 918                |
| Ce <sup>c,d</sup> | 139                                            | dhcp $\rightleftharpoons$ fcc ( $\beta - \gamma$ ) | 726                                             | fcc $\rightleftharpoons$ bcc ( $\gamma - \delta$ ) | 798                |
| Pr                | 795                                            | dhcp $\rightleftharpoons$ bcc                      | —                                               | —                                                  | 931                |
| Nd                | 863                                            | dhcp $\rightleftharpoons$ bcc                      | —                                               | —                                                  | 1021               |
| Pm                | 890                                            | dhcp $\rightleftharpoons$ bcc                      | —                                               | —                                                  | 1042               |
| Sm <sup>e</sup>   | 734                                            | rhomb $\rightleftharpoons$ hcp                     | 922                                             | hcp $\rightleftharpoons$ bcc                       | 1074               |
| Eu                | —                                              | —                                                  | —                                               | —                                                  | 822                |
| Gd                | 1235                                           | hcp $\rightleftharpoons$ bcc                       | —                                               | —                                                  | 1313               |
| Tb                | 1289                                           | hcp $\rightleftharpoons$ bcc                       | —                                               | —                                                  | 1356               |
| Dy                | 1381                                           | hcp $\rightleftharpoons$ bcc                       | —                                               | —                                                  | 1412               |
| Ho                | —                                              | —                                                  | —                                               | —                                                  | 1474               |
| Er                | —                                              | —                                                  | —                                               | —                                                  | 1529               |
| Tm                | —                                              | —                                                  | —                                               | —                                                  | 1545               |
| Yb                | 795                                            | fcc $\rightleftharpoons$ bcc ( $\beta - \gamma$ )  | —                                               | —                                                  | 819                |
| Lu                | —                                              | —                                                  | —                                               | —                                                  | 1663               |

Note: For additional information, see Gschneidner, K.A., Jr. and Calderwood, F.W., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 8, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1986; Gschneidner, K.A., Jr., Pecharsky, V.K., Cho, Jaephil and Martin, S.W., *Scripta Mater.*, 34, 1717, 1996.

<sup>a</sup> For all the transformations listed, unless otherwise noted.

<sup>b</sup> On cooling, fcc  $\rightarrow$  dhcp ( $\beta \rightarrow \alpha$ ), 260 °C.

<sup>c</sup> The  $\beta \rightleftharpoons \gamma$  equilibrium transition temperature is  $10 \pm 5$  °C.

<sup>d</sup> On cooling, fcc  $\rightarrow$  dhcp ( $\gamma \rightarrow \beta$ ), -16 °C.

<sup>e</sup> On cooling, hcp  $\rightarrow$  rhomb ( $\beta \rightarrow \alpha$ ), 727 °C.

TABLE 5. Low Temperature Transition Temperatures of the Rare Earth Metals

| Rare earth metal | Cooling                      |      |     | Rare earth metal | Heating                             |      |     |
|------------------|------------------------------|------|-----|------------------|-------------------------------------|------|-----|
|                  | Transformation               | °C   | K   |                  | Transformation                      | °C   | K   |
| Ce               | $\gamma \rightarrow \beta^a$ | -16  | 257 | Ce               | $\alpha \rightarrow \beta$          | -148 | 125 |
|                  | $\gamma \rightarrow \alpha$  | -172 | 101 |                  | $\alpha \rightarrow \beta + \gamma$ | -104 | 169 |
|                  | $\beta \rightarrow \alpha$   | -228 | 45  |                  | $\beta \rightarrow \gamma^a$        | 139  | 412 |
| Tb               | $\alpha \rightarrow \alpha'$ | -53  | 220 | Yb               | $\alpha \rightarrow \beta$          | 7    | 280 |
| Dy               | $\alpha \rightarrow \alpha'$ | -187 | 86  |                  |                                     |      |     |
| Yb               | $\beta \rightarrow \alpha$   | -13  | 260 |                  |                                     |      |     |

Note: For additional information, see Beaudry, B.J. and Gschneidner, K.A., Jr., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 173; Koskenmaki, D.C. and Gschneidner, K.A., Jr., 1978, in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 337; Gschneidner, K.A., Jr., Pecharsky, V.K., Cho, Jaephil and Martin, S.W., *Scripta Mater.*, 34, 1717, 1996.

<sup>a</sup> The  $\beta \rightleftharpoons \gamma$  equilibrium transition temperature is  $10 \pm 5$  °C ( $283 \pm 5$  K).

TABLE 6. Heat Capacity, Standard Entropy, Heats of Transformation, and Fusion of the Rare Earth Metals

| Rare earth metal | Heat capacity at 298 K (J/mol K) | Standard entropy $S^{\circ}_{298}$ (J/mol K) | Heat of transformation (kJ/mol)   |                   |                                    |                   | Heat of fusion (kJ/mol) |
|------------------|----------------------------------|----------------------------------------------|-----------------------------------|-------------------|------------------------------------|-------------------|-------------------------|
|                  |                                  |                                              | trans. 1                          | $\Delta H_{tr}^1$ | trans. 2                           | $\Delta H_{tr}^2$ |                         |
| Sc               | 25.5                             | 34.6                                         | $\alpha \rightleftharpoons \beta$ | 4.00              | —                                  | —                 | 14.1                    |
| Y                | 26.5                             | 44.4                                         | $\alpha \rightleftharpoons \beta$ | 4.99              | —                                  | —                 | 11.4                    |
| La               | 27.1                             | 56.9                                         | $\alpha \rightleftharpoons \beta$ | 0.36              | $\beta \rightleftharpoons \gamma$  | 3.12              | 6.20                    |
| Ce               | 26.9                             | 72.0                                         | $\beta \rightleftharpoons \gamma$ | 0.05              | $\gamma \rightleftharpoons \delta$ | 2.99              | 5.46                    |
| Pr               | 27.2                             | 73.2                                         | $\alpha \rightleftharpoons \beta$ | 3.17              | —                                  | —                 | 6.89                    |
| Nd               | 27.5                             | 71.5                                         | $\alpha \rightleftharpoons \beta$ | 3.03              | —                                  | —                 | 7.14                    |
| Pm               | 27.3 <sup>a</sup>                | 71.6 <sup>a</sup>                            | $\alpha \rightleftharpoons \beta$ | 3.0 <sup>a</sup>  | —                                  | —                 | 7.7 <sup>a</sup>        |
| Sm               | 29.5                             | 69.6                                         | $\alpha \rightleftharpoons \beta$ | 0.2 <sup>a</sup>  | $\beta \rightleftharpoons \gamma$  | 3.11              | 8.62                    |
| Eu               | 27.7                             | 77.8                                         | —                                 | —                 | —                                  | —                 | 9.21                    |
| Gd               | 37.0                             | 68.1                                         | $\alpha \rightleftharpoons \beta$ | 3.91              | —                                  | —                 | 10.0                    |
| Tb               | 28.9                             | 73.2                                         | $\alpha \rightleftharpoons \beta$ | 5.02              | —                                  | —                 | 10.79                   |
| Dy               | 27.7                             | 75.6                                         | $\alpha \rightleftharpoons \beta$ | 4.16              | —                                  | —                 | 11.06                   |
| Ho               | 27.2                             | 75.3                                         | —                                 | —                 | —                                  | —                 | 17.0 <sup>a</sup>       |
| Er               | 28.1                             | 73.2                                         | —                                 | —                 | —                                  | —                 | 19.9                    |
| Tm               | 27.0                             | 74.0                                         | —                                 | —                 | —                                  | —                 | 16.8                    |
| Yb               | 26.7                             | 59.9                                         | $\beta \rightleftharpoons \gamma$ | 1.75              | —                                  | —                 | 7.66                    |
| Lu               | 26.9                             | 51.0                                         | —                                 | —                 | —                                  | —                 | 22 <sup>a</sup>         |

Note: For additional information, see Hultgren, R., Desai, P.D., Hawkins, D.T., Gleiser, M., Kelley, K.K., and Wagman, D.D., *Selected Values of the Thermodynamic Properties of the Elements*, ASM International, Metals Park, Ohio, 1973; Wagman, D.D., Evans, W.H., Parker, V.B., Schumm, R.H., Halow, I., Bailey, S.M., Churney, K.L., and Nuttall, R.L., *The NBS Tables of Chemical Thermodynamic Properties*, *J. Phys. Chem. Ref. Data*, Vol. 11, Suppl. 2, 1982; Amitin, E.B., Bessergenev, W.G., Kovalevskaya, Yu. A., and Paukov, I.E., *J. Chem. Thermodyn.*, 15, 181, 1983; Amitin, E.B., Bessergenev, W.G., Kovalevskaya, Yu. A., and Paukov, I.E., *J. Chem. Thermodyn.*, 15, 181, 1983.

<sup>a</sup> Estimated.

TABLE 7. Vapor Pressures, Boiling Points, and Heats of Sublimation of Rare Earth Metals

| Rare earth metal | Temperature in °C <sup>a</sup> for a vapor pressure of |                                 |                                |                                | Boiling point <sup>a</sup> (°C) | Heat of sublimation at 25 °C (kJ/mol) |
|------------------|--------------------------------------------------------|---------------------------------|--------------------------------|--------------------------------|---------------------------------|---------------------------------------|
|                  | 10 <sup>-8</sup> atm (0.001 Pa)                        | 10 <sup>-6</sup> atm (0.101 Pa) | 10 <sup>-4</sup> atm (10.1 Pa) | 10 <sup>-2</sup> atm (1013 Pa) |                                 |                                       |
| Sc               | 1036                                                   | 1243                            | 1533                           | 1999                           | 2836                            | 377.8                                 |
| Y                | 1222                                                   | 1460                            | 1812                           | 2360                           | 3345                            | 424.7                                 |
| La               | 1301                                                   | 1566                            | 1938                           | 2506                           | 3464                            | 431.0                                 |
| Ce               | 1290                                                   | 1554                            | 1926                           | 2487                           | 3443                            | 422.6                                 |
| Pr               | 1083                                                   | 1333                            | 1701                           | 2305                           | 3520                            | 355.6                                 |
| Nd               | 955                                                    | 1175                            | 1500                           | 2029                           | 3074                            | 327.6                                 |
| Pm               | —                                                      | —                               | —                              | —                              | 3000 <sup>b</sup>               | 348 <sup>b</sup>                      |
| Sm               | 508                                                    | 642                             | 835                            | 1150                           | 1794                            | 206.7                                 |
| Eu               | 399                                                    | 515                             | 685                            | 964                            | 1529                            | 175.3                                 |
| Gd               | 1167                                                   | 1408                            | 1760                           | 2306                           | 3273                            | 397.5                                 |
| Tb               | 1124                                                   | 1354                            | 1698                           | 2237                           | 3230                            | 388.7                                 |
| Dy               | 804                                                    | 988                             | 1252                           | 1685                           | 2567                            | 290.4                                 |
| Ho               | 845                                                    | 1036                            | 1313                           | 1771                           | 2700                            | 300.8                                 |
| Er               | 908                                                    | 1113                            | 1405                           | 1896                           | 2868                            | 317.1                                 |
| Tm               | 599                                                    | 748                             | 964                            | 1300                           | 1950                            | 232.2                                 |
| Yb               | 301                                                    | 400                             | 541                            | 776                            | 1196                            | 152.1                                 |
| Lu               | 1241                                                   | 1483                            | 1832                           | 2387                           | 3402                            | 427.6                                 |

Note: For additional information, see Hultgren, R., Desai, P.D., Hawkins, D.T., Gleiser, M., Kelley, K.K., and Wagman, D.D., *Selected Values of the Thermodynamic Properties of the Elements*, ASM International, Metals Park, Ohio, 1973; Beaudry, B.J. and Gschneidner, K.A., Jr., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 173.

<sup>a</sup> International Temperature Scale of 1990 (ITS-90) values.

<sup>b</sup> Estimated.

TABLE 8. Magnetic Properties of the Rare Earth Metals

| Rare earth metal | $\chi_A \times 10^6$ at 298 K (emu/mol) | Effective magnetic moment    |       |                             |                  | Easy axis              | Néel temp. $T_N$ (K) |             | Curie temp. $T_C$ (K) | $\theta_p$ (K) |           |                    |
|------------------|-----------------------------------------|------------------------------|-------|-----------------------------|------------------|------------------------|----------------------|-------------|-----------------------|----------------|-----------|--------------------|
|                  |                                         | Paramagnetic at $\sim 298$ K |       | Ferromagnetic at $\sim 0$ K |                  |                        | Hex sites            | Cubic sites |                       | $\parallel c$  | $\perp c$ | Polycryst. or avg. |
|                  |                                         | Theory <sup>a</sup>          | Obs.  | Theory <sup>b</sup>         | Obs.             |                        |                      |             |                       |                |           |                    |
| $\alpha$ Sc      | 295.2                                   | —                            | —     | —                           | —                | —                      | —                    | —           | —                     | —              | —         | —                  |
| $\alpha$ Y       | 187.7                                   | —                            | —     | —                           | —                | —                      | —                    | —           | —                     | —              | —         | —                  |
| $\alpha$ La      | 95.9                                    | —                            | —     | —                           | —                | —                      | —                    | —           | —                     | —              | —         | —                  |
| $\beta$ La       | 105                                     | —                            | —     | —                           | —                | —                      | —                    | —           | —                     | —              | —         | —                  |
| $\gamma$ Ce      | 2,270                                   | 2.54                         | 2.52  | 2.14                        | —                | —                      | —                    | 14.4        | —                     | —              | —         | -50                |
| $\beta$ Ce       | 2,500                                   | 2.54                         | 2.61  | 2.14                        | —                | —                      | 13.7                 | 12.5        | —                     | —              | —         | -41                |
| $\alpha$ Pr      | 5,530                                   | 3.58                         | 3.56  | 3.20                        | 2.7 <sup>c</sup> | <b>a</b>               | 0.03                 | —           | —                     | —              | —         | 0                  |
| $\alpha$ Nd      | 5,930                                   | 3.62                         | 3.45  | 3.27                        | 2.2 <sup>c</sup> | <b>b</b>               | 19.9                 | 7.5         | —                     | 0              | 5         | 3.3                |
| $\alpha$ Pm      | —                                       | 2.68                         | —     | 2.40                        | —                | —                      | —                    | —           | —                     | —              | —         | —                  |
| $\alpha$ Sm      | 1,278 <sup>d</sup>                      | 0.85                         | 1.74  | 0.71                        | 0.5 <sup>c</sup> | <b>a</b>               | 109                  | 14.0        | —                     | —              | —         | —                  |
| Eu               | 30,900                                  | 7.94                         | 8.48  | 7.0                         | 5.9              | $\langle 110 \rangle$  | —                    | 90.4        | —                     | —              | —         | 100                |
| $\alpha$ Gd      | 185,000 <sup>e</sup>                    | 7.94                         | 7.98  | 7.0                         | 7.63             | $30^\circ$ to <b>c</b> | —                    | —           | 293.4                 | 317            | 317       | 317                |
| $\alpha$ Tb      | 170,000                                 | 9.72                         | 9.77  | —                           | —                | —                      | 230.0                | —           | —                     | 195            | 239       | 224                |
| $\alpha'$ Tb     | —                                       | —                            | —     | 9.0                         | 9.34             | <b>b</b>               | —                    | —           | 219.5                 | —              | —         | —                  |
| $\alpha$ Dy      | 98,000                                  | 10.64                        | 10.83 | —                           | —                | —                      | 180.2                | —           | —                     | 121            | 169       | 153                |
| $\alpha'$ Dy     | —                                       | —                            | —     | 10.0                        | 10.33            | <b>a</b>               | —                    | —           | 90.5 <sup>g</sup>     | —              | —         | —                  |
| Ho               | 72,900                                  | 10.60                        | 11.2  | 10.0                        | 10.34            | <b>b</b>               | 132                  | —           | 19.5                  | 73.0           | 88.0      | 83.0               |
| Er               | 48,000                                  | 9.58                         | 9.9   | 9.0                         | 9.1              | $30^\circ$ to <b>c</b> | 85                   | —           | 18.7                  | 61.7           | 32.5      | 42.2               |
| Tm               | 24,700                                  | 7.56                         | 7.61  | 7.0                         | 7.14             | <b>c</b>               | 58                   | —           | 32.0                  | 41.0           | -17.0     | 2.3                |
| $\beta$ Yb       | 67 <sup>d</sup>                         | —                            | —     | —                           | —                | —                      | —                    | —           | —                     | —              | —         | —                  |
| Lu               | 182.9                                   | —                            | —     | —                           | —                | —                      | —                    | —           | —                     | —              | —         | —                  |

Note: For additional information, see McEwen, K.A., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 411; Legvold, S., in *Ferromagnetic Materials*, Vol. 1, Wohlfarth, E.P., Ed., North-Holland Physics, Amsterdam, 1980, 183; Pecharsky, V.K., Gschneidner, K.A., Jr. and Fort, D., *Phys. Rev. B*, 47, 5063, 1993; Pecharsky, V.K., Gschneidner, K.A., Jr. and Fort, D., 1996, to be published; Steward, A.M. and Collocott, S.J., *J. Phys.: Condens. Matter*, 1, 677, 1988.

<sup>a</sup>  $g[J(J+1)]^{1/2}$ .

<sup>b</sup>  $gJ$ .

<sup>c</sup> At 38 T and 4.2 K.

<sup>d</sup> At 290 K.

<sup>e</sup> At 350 K.

<sup>f</sup> On cooling  $T_C = 89.6$  K and on warming  $T_C = 91.5$  K.

TABLE 9. Room Temperature Coefficient of Thermal Expansion, Thermal Conductivity, Electrical Resistance, and Hall Coefficient

| Rare earth metal | Expansion ( $\alpha_i \times 10^6$ ) ( $^\circ\text{C}^{-1}$ ) |                   |                        | Thermal conductivity (W/cm K) | Electrical resistance ( $\mu\Omega\cdot\text{cm}$ ) |          |                      | Hall coefficient ( $R_i \times 10^{12}$ ) (V·cm/A·Oe) |       |                    |
|------------------|----------------------------------------------------------------|-------------------|------------------------|-------------------------------|-----------------------------------------------------|----------|----------------------|-------------------------------------------------------|-------|--------------------|
|                  | $\alpha_a$                                                     | $\alpha_c$        | $\alpha_{\text{poly}}$ |                               | $\rho_a$                                            | $\rho_c$ | $\rho_{\text{poly}}$ | $R_a$                                                 | $R_c$ | $R_{\text{poly}}$  |
| $\alpha$ Sc      | 7.6                                                            | 15.3              | 10.2                   | 0.158                         | 70.9                                                | 26.9     | 56.2 <sup>a</sup>    | —                                                     | —     | -0.13              |
| $\alpha$ Y       | 6.0                                                            | 19.7              | 10.6                   | 0.172                         | 72.5                                                | 35.5     | 59.6                 | -0.27                                                 | -1.6  | —                  |
| $\alpha$ La      | 4.5                                                            | 27.2              | 12.1                   | 0.134                         | —                                                   | —        | 61.5                 | —                                                     | —     | -0.35              |
| $\beta$ Ce       | —                                                              | —                 | —                      | —                             | —                                                   | —        | 82.8                 | —                                                     | —     | —                  |
| $\gamma$ Ce      | 6.3                                                            | —                 | 6.3                    | 0.113                         | —                                                   | —        | 74.4                 | —                                                     | —     | +1.81              |
| $\alpha$ Pr      | 4.5                                                            | 11.2              | 6.7                    | 0.125                         | —                                                   | —        | 70.0                 | —                                                     | —     | +0.709             |
| $\alpha$ Nd      | 7.6                                                            | 13.5              | 9.6                    | 0.165                         | —                                                   | —        | 64.3                 | —                                                     | —     | +0.971             |
| $\alpha$ Pm      | 9 <sup>b</sup>                                                 | 16 <sup>b</sup>   | 11 <sup>b</sup>        | 0.15 <sup>b</sup>             | —                                                   | —        | 75 <sup>b</sup>      | —                                                     | —     | —                  |
| $\alpha$ Sm      | 9.6                                                            | 19.0              | 12.7                   | 0.133                         | —                                                   | —        | 94.0                 | —                                                     | —     | -0.21              |
| Eu               | 35.0                                                           | —                 | 35.0                   | 0.139 <sup>b</sup>            | —                                                   | —        | 90.0                 | —                                                     | —     | +24.4              |
| $\alpha$ Gd      | 9.1 <sup>c</sup>                                               | 10.0 <sup>c</sup> | 9.4 <sup>c</sup>       | 0.105                         | 135.1                                               | 121.7    | 131.0                | -10                                                   | -54   | -4.48 <sup>d</sup> |
| $\alpha$ Tb      | 9.3                                                            | 12.4              | 10.3                   | 0.111                         | 123.5                                               | 101.5    | 115.0                | -1.0                                                  | -3.7  | —                  |
| $\alpha$ Dy      | 7.1                                                            | 15.6              | 9.9                    | 0.107                         | 111.0                                               | 76.6     | 92.6                 | -0.3                                                  | -3.7  | —                  |
| Ho               | 7.0                                                            | 19.5              | 11.2                   | 0.162                         | 101.5                                               | 60.5     | 81.4                 | +0.2                                                  | -3.2  | —                  |
| Er               | 7.9                                                            | 20.9              | 12.2                   | 0.145                         | 94.5                                                | 60.3     | 86.0                 | +0.3                                                  | -3.6  | —                  |
| Tm               | 8.8                                                            | 22.2              | 13.3                   | 0.169                         | 88.0                                                | 47.2     | 67.6                 | —                                                     | —     | -1.8               |
| $\beta$ Yb       | 26.3                                                           | —                 | 26.3                   | 0.385                         | —                                                   | —        | 25.0                 | —                                                     | —     | +3.77              |
| Lu               | 4.8                                                            | 20.0              | 9.9                    | 0.164                         | 76.6                                                | 34.7     | 58.2                 | +0.45                                                 | -2.6  | -0.535             |

Note: For additional information, see Beaudry, B. J. and Gschneidner, K.A., Jr., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 173; McEwen, K.A., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 411.

<sup>a</sup> Calculated from single crystal values.

<sup>b</sup> Estimated.

<sup>c</sup> At 100  $^\circ\text{C}$ .

<sup>d</sup> At 77  $^\circ\text{C}$ .

TABLE 10. Electronic Specific Heat Constant ( $\gamma$ ), Electron–Electron (Coulomb) Coupling Constant ( $\mu^*$ ), Electron–Phonon Coupling Constant ( $\lambda$ ), Debye Temperature at 0 K ( $\theta_D$ ), and Superconducting Transition Temperature

| Rare earth metal | $\gamma$ (mJ/mol·K <sup>2</sup> ) | $\mu^*$ | $\lambda$         | $\theta_D$ (K) from |                   | Superconducting temperature (K) |
|------------------|-----------------------------------|---------|-------------------|---------------------|-------------------|---------------------------------|
|                  |                                   |         |                   | Heat capacity       | Elastic constants |                                 |
| $\alpha$ Sc      | 10.334                            | 0.16    | 0.30              | 345.3               | —                 | 0.050 <sup>a</sup>              |
| $\alpha$ Y       | 7.878                             | 0.15    | 0.30              | 244.4               | 258               | 1.3 <sup>b</sup>                |
| $\alpha$ La      | 9.45                              | 0.08    | 0.76              | 150                 | 154               | 5.10                            |
| $\beta$ La       | 11.5                              | —       | —                 | 140                 | —                 | 6.00                            |
| $\alpha$ Ce      | 12.8                              | —       | —                 | 179                 | —                 | 0.022 <sup>c</sup>              |
| $\alpha$ Pr      | 20                                | —       | 1.07 <sup>d</sup> | 155 <sup>e</sup>    | 153               | —                               |
| $\alpha$ Nd      | f                                 | —       | 0.86 <sup>d</sup> | 157 <sup>e</sup>    | 163               | —                               |
| $\alpha$ Pm      | —                                 | —       | —                 | 159 <sup>e</sup>    | —                 | —                               |
| $\alpha$ Sm      | 8.1 $\pm$ 1.5 <sup>g</sup>        | —       | 0.81 <sup>d</sup> | 162 <sup>e,f</sup>  | 169               | —                               |
| Eu               | f                                 | —       | —                 | f                   | 118               | —                               |
| $\alpha$ Gd      | 4.48                              | —       | 0.30              | 169                 | 182               | —                               |
| $\alpha'$ Tb     | 3.71                              | —       | 0.34 <sup>d</sup> | 169.6               | 177               | —                               |
| $\alpha'$ Dy     | 4.9                               | —       | 0.32 <sup>d</sup> | 192                 | 183               | —                               |
| Ho               | 2.1                               | —       | 0.30 <sup>d</sup> | 175 <sup>e</sup>    | 190               | —                               |
| Er               | 8.7                               | —       | 0.33 <sup>d</sup> | 176.9               | 188               | —                               |
| Tm               | f                                 | —       | 0.36 <sup>d</sup> | 179 <sup>e</sup>    | 200               | —                               |
| $\alpha$ Yb      | 3.30                              | —       | —                 | 117.6               | 118               | —                               |
| $\beta$ Yb       | 8.36                              | —       | —                 | 109                 | —                 | —                               |
| Lu               | 8.194                             | 0.14    | 0.31              | 183.2               | 185               | 0.022 <sup>h</sup>              |

Note: For additional information, see Sundström, L.J., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr., and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 379; Scott, T., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 591; Probst, C. and Wittig, J., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 749; Tsang, T.-W.E., Gschneidner, K.A., Jr., Schmidt, F.A., and Thome, D.K., *Phys. Rev.*, B, 31, 235, 1985; Collocott, S.J., Hill, R.W. and Stewart, A.M., *J. Phys. F* 18, L223, 1988; Hill, R.W. and Gschneidner, K.A., Jr., *J. Phys. F* 18, 2545, 1988; Skriver, H.L. and Mertig, I., *Phys. Rev. B*, 41, 6553, 1990; Collocott, S.J. and Stewart, A.M., *J. Phys.: Condens. Matter*, 4, 6743, 1992; Pecharsky, V.K., Gschneidner, K.A., Jr. and Fort, D., *Phys. Rev. B*, 47, 5063, 1993.

<sup>a</sup> At 18.6 GPa.

<sup>b</sup> At 11 GPa.

<sup>c</sup> At 2.2 GPa.

<sup>d</sup> Calculated value.

<sup>e</sup> Estimated.

<sup>f</sup> Heat capacity results have been reported, but the resultant  $\gamma$  and  $\theta_D$  values are unreliable because of the presence of impurities and/or there was no reliable procedure or model to correct for the magnetic contribution to the heat capacity.

<sup>g</sup> Based on the values reported for the purer Sm sample (IV).

<sup>h</sup> At 4.5 GPa.

TABLE 11. Room Temperature Elastic Moduli and Mechanical Properties

| Rare earth metal | Elastic moduli (GPa)      |                 |                 |                   | Mechanical properties (MPa) |                           |                        |                       |                     |
|------------------|---------------------------|-----------------|-----------------|-------------------|-----------------------------|---------------------------|------------------------|-----------------------|---------------------|
|                  | Young's (elastic) modulus | Shear modulus   | Bulk modulus    | Poisson's ratio   | Yield strength 0.2% offset  | Ultimate tensile strength | Uniform elongation (%) | Reduction in area (%) | Recryst. temp. (°C) |
| Sc               | 74.4                      | 29.1            | 56.6            | 0.279             | 173 <sup>a</sup>            | 255 <sup>a</sup>          | 5.0 <sup>a</sup>       | 8.0 <sup>a</sup>      | 550                 |
| Y                | 63.5                      | 25.6            | 41.2            | 0.243             | 42                          | 129                       | 34.0                   | —                     | 550                 |
| $\alpha$ La      | 36.6                      | 14.3            | 27.9            | 0.280             | 126 <sup>a</sup>            | 130                       | 7.9 <sup>a</sup>       | —                     | 300                 |
| $\beta$ Ce       | —                         | —               | —               | —                 | 86                          | 138                       | —                      | 24.0                  | —                   |
| $\gamma$ Ce      | 33.6                      | 13.5            | 21.5            | 0.24              | 28                          | 117                       | 22.0                   | 30.0                  | 325                 |
| $\alpha$ Pr      | 37.3                      | 14.8            | 28.8            | 0.281             | 73                          | 147                       | 15.4                   | 67.0                  | 400                 |
| $\alpha$ Nd      | 41.4                      | 16.3            | 31.8            | 0.281             | 71                          | 164                       | 25.0                   | 72.0                  | 400                 |
| $\alpha$ Pm      | 46 <sup>b</sup>           | 18 <sup>b</sup> | 33 <sup>b</sup> | 0.28 <sup>b</sup> | —                           | —                         | —                      | —                     | 400 <sup>b</sup>    |
| $\alpha$ Sm      | 49.7                      | 19.5            | 37.8            | 0.274             | 68                          | 156                       | 17.0                   | 29.5                  | 440                 |
| Eu               | 18.2                      | 7.9             | 8.3             | 0.152             | —                           | —                         | —                      | —                     | 300                 |
| $\alpha$ Gd      | 54.8                      | 21.8            | 37.9            | 0.259             | 15                          | 118                       | 37.0                   | 56.0                  | 500                 |
| $\alpha$ Tb      | 55.7                      | 22.1            | 38.7            | 0.261             | —                           | —                         | —                      | —                     | 500                 |
| $\alpha$ Dy      | 61.4                      | 24.7            | 40.5            | 0.247             | 43                          | 139                       | 30.0                   | 30.0                  | 550                 |
| Ho               | 64.8                      | 26.3            | 40.2            | 0.231             | —                           | —                         | —                      | —                     | 520                 |
| Er               | 69.9                      | 28.3            | 44.4            | 0.237             | 60                          | 136                       | 11.5                   | 11.9                  | 520                 |
| Tm               | 74.0                      | 30.5            | 44.5            | 0.213             | —                           | —                         | —                      | —                     | 600                 |
| $\beta$ Yb       | 23.9                      | 9.9             | 30.5            | 0.207             | 7                           | 58                        | 43.0                   | 92.0                  | 300                 |
| Lu               | 68.6                      | 27.2            | 47.6            | 0.261             | —                           | —                         | —                      | —                     | 600                 |

Note: For additional information, see Scott, T., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 591.

<sup>a</sup> Value is questionable.

<sup>b</sup> Estimated.



TABLE 12. Liquid Metal Properties near the Melting Point

| Rare earth metal | Density (g/cm <sup>3</sup> ) | Surface tension (N/m) | Viscosity (centipoise) | Heat capacity (J/mol K) | Thermal conductivity (W/cm K) | Magnetic susceptibility $\chi \times 10^4$ (emu/mol) | Electrical resistivity ( $\mu\Omega\cdot\text{cm}$ ) | $\Delta V$ (l→s) <sup>a</sup> (%) | Spectral emittance at $\lambda = 645 \text{ nm}$ |                  |
|------------------|------------------------------|-----------------------|------------------------|-------------------------|-------------------------------|------------------------------------------------------|------------------------------------------------------|-----------------------------------|--------------------------------------------------|------------------|
|                  |                              |                       |                        |                         |                               |                                                      |                                                      |                                   | $\epsilon$ (%)                                   | Temp. range (°C) |
| Sc               | 2.80                         | 0.954                 | —                      | 44.2 <sup>b</sup>       | —                             | —                                                    | —                                                    | —                                 | —                                                | —                |
| Y                | 4.24                         | 0.871                 | —                      | 43.1                    | —                             | —                                                    | —                                                    | —                                 | 36.8                                             | 1522–1647        |
| La               | 5.96                         | 0.718                 | 2.65                   | 34.3                    | 0.238                         | 1.20                                                 | 133                                                  | −0.6                              | 25.4                                             | 920–1287         |
| Ce               | 6.68                         | 0.706                 | 3.20                   | 37.7                    | 0.210                         | 9.37                                                 | 130                                                  | +1.1                              | 32.2                                             | 877–1547         |
| Pr               | 6.59                         | 0.707                 | 2.85                   | 43.0                    | 0.251                         | 17.3                                                 | 139                                                  | −0.02                             | 28.4                                             | 931–1537         |
| Nd               | 6.72                         | 0.687                 | —                      | 48.8                    | 0.195                         | 18.7                                                 | 151                                                  | −0.9                              | 39.4                                             | 1021–1567        |
| Pm               | 6.9 <sup>b</sup>             | 0.680 <sup>b</sup>    | —                      | 50 <sup>b</sup>         | —                             | —                                                    | 160 <sup>b</sup>                                     | —                                 | —                                                | —                |
| Sm               | 7.16                         | 0.431                 | —                      | 50.2 <sup>b</sup>       | —                             | 18.3                                                 | 182                                                  | −3.6                              | 43.7                                             | 1075             |
| Eu               | 4.87                         | 0.264                 | —                      | 38.1                    | —                             | 97                                                   | 242                                                  | −4.8                              | —                                                | —                |
| Gd               | 7.4                          | 0.664                 | —                      | 37.2                    | 0.149                         | 67                                                   | 195                                                  | −2.0                              | 34.2                                             | 1313–1600        |
| Tb               | 7.65                         | 0.669                 | —                      | 46.5                    | —                             | 82                                                   | 193                                                  | −3.1                              | —                                                | —                |
| Dy               | 8.2                          | 0.648                 | —                      | 49.9                    | 0.187                         | 95                                                   | 210                                                  | −4.5                              | 29.7                                             | 1412–1437        |
| Ho               | 8.34                         | 0.650                 | —                      | 43.9                    | —                             | 88                                                   | 221                                                  | −7.4                              | —                                                | —                |
| Er               | 8.6                          | 0.637                 | —                      | 38.7                    | —                             | 69                                                   | 226                                                  | −9.0                              | 37.2                                             | 1529–1587        |
| Tm               | 9.0 <sup>b</sup>             | —                     | —                      | 41.4                    | —                             | 41                                                   | 235 <sup>b</sup>                                     | −6.9                              | —                                                | —                |
| Yb               | 6.21                         | 0.320                 | 2.67                   | 36.8                    | —                             | —                                                    | 113                                                  | −5.1                              | —                                                | —                |
| Lu               | 9.3                          | 0.940                 | —                      | 47.9 <sup>b</sup>       | —                             | —                                                    | 224                                                  | −3.6                              | —                                                | —                |

Note: For additional information, see Van Zytveld, J., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 12, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1989, 357; Stretz, L.A. and Bautista, R.G., in *Temperature, Its Measurement and Control in Science and Industry*, Vol. 4, part I, H.H. Plumb, Ed., Instrument Society of America, Pittsburgh, 1972, 489; King, T.S., Baria, D.N., and Bautista, R.G., *Met. Trans. B*, 7, 411, 1976; Baria, D.N., King, T.S., and Bautista, R.G., *Met. Trans. B*, 7, 577, 1976.

<sup>a</sup> Volume change on freezing.

<sup>b</sup> Estimated.

TABLE 13. Ionization Potentials (Electronvolts)

| Rare earth | I Neutral atom | II Singly ionized | III Doubly ionized | IV Triply ionized | V Quadrupty ionized |
|------------|----------------|-------------------|--------------------|-------------------|---------------------|
| Sc         | 6.56144        | 12.79967          | 24.75666           | 73.4894           | 91.65               |
| Y          | 6.217          | 12.24             | 20.52              | 60.597            | 77.0                |
| La         | 5.5770         | 11.060            | 19.1773            | 49.95             | 61.6                |
| Ce         | 5.5387         | 10.85             | 20.198             | 36.758            | 65.55               |
| Pr         | 5.464          | 10.55             | 21.624             | 38.98             | 57.53               |
| Nd         | 5.5250         | 10.73             | 22.1               | 40.41             | —                   |
| Pm         | 5.554          | 10.90             | 22.3               | 41.1              | —                   |
| Sm         | 5.6437         | 11.07             | 23.4               | 41.4              | —                   |
| Eu         | 5.6704         | 11.241            | 24.92              | 42.7              | —                   |
| Gd         | 6.1500         | 12.09             | 20.63              | 44.0              | —                   |
| Tb         | 5.8639         | 11.52             | 21.91              | 39.79             | —                   |
| Dy         | 5.9389         | 11.67             | 22.8               | 41.47             | —                   |
| Ho         | 6.0216         | 11.80             | 22.84              | 42.5              | —                   |
| Er         | 6.1078         | 11.93             | 22.74              | 42.7              | —                   |
| Tm         | 6.18431        | 12.05             | 23.68              | 42.7              | —                   |
| Yb         | 6.25416        | 12.1761           | 25.05              | 43.56             | —                   |
| Lu         | 5.42585        | 13.9              | 20.9594            | 45.25             | 66.8                |

Note: For references, see the table "Ionization Potentials of Atoms and Atomic Ions" in Section 10.

TABLE 14. Effective Ionic Radii (Å)<sup>a</sup>

| Rare earth ion | $R^{2+}$ |        | $R^{3+}$ |        |         | $R^{4+}$ |        |
|----------------|----------|--------|----------|--------|---------|----------|--------|
|                | CN = 6   | CN = 8 | CN = 6   | CN = 8 | CN = 12 | CN = 6   | CN = 8 |
| Sc             | —        | —      | 0.745    | 0.87   | 1.116   | —        | —      |
| Y              | —        | —      | 0.900    | 1.015  | 1.220   | —        | —      |
| La             | —        | —      | 1.045    | 1.18   | 1.320   | —        | —      |
| Ce             | —        | —      | 1.010    | 1.14   | 1.290   | 0.80     | 0.97   |
| Pr             | —        | —      | 0.997    | 1.14   | 1.286   | 0.78     | 0.96   |
| Nd             | —        | —      | 0.983    | 1.12   | 1.276   | —        | —      |
| Pm             | —        | —      | 0.97     | 1.10   | 1.267   | —        | —      |
| Sm             | 1.19     | 1.27   | 0.958    | 1.09   | 1.260   | —        | —      |
| Eu             | 1.17     | 1.25   | 0.947    | 1.07   | 1.252   | —        | —      |
| Gd             | —        | —      | 0.938    | 1.06   | 1.246   | —        | —      |
| Tb             | —        | —      | 0.923    | 1.04   | 1.236   | 0.76     | 0.88   |
| Dy             | —        | —      | 0.912    | 1.03   | 1.228   | —        | —      |
| Ho             | —        | —      | 0.901    | 1.02   | 1.221   | —        | —      |
| Er             | —        | —      | 0.890    | 1.00   | 1.214   | —        | —      |
| Tm             | —        | —      | 0.880    | 0.99   | 1.207   | —        | —      |
| Yb             | 1.00     | 1.07   | 0.868    | 0.98   | 1.199   | —        | —      |
| Lu             | —        | —      | 0.861    | 0.97   | 1.194   | —        | —      |

Note: For additional information, see Shannon, R.D. and Prewitt, C.T., *Acta Cryst.*, 25, 925, 1969 and Shannon, R.D. and Prewitt, C.T., *Acta Cryst.*, 26, 1046, 1970.

<sup>a</sup> Radius of O<sup>2−</sup> is 1.40 Å for a coordination number (CN) of 6.



# MELTING, BOILING, TRIPLE, AND CRITICAL POINT TEMPERATURES OF THE ELEMENTS

This table summarizes the significant points on the phase diagrams for the elements for which data are available. Values are given for the solid–liquid–gas triple point  $t_{\text{tp}}$ , normal melting point  $t_{\text{m}}$ , normal boiling point  $t_{\text{b}}$ , and critical temperature  $t_{\text{c}}$ ; all are on the ITS-90 scale. An “sp” notation indicates a sublimation point, where the vapor pressure of the solid phase reaches 101.325 kPa (1 atm). Transition temperatures between allotropic forms are included for several elements. The major data sources are listed below; values from Reference 1, which deals with reference points on the ITS-90 scale, were adopted when applicable.

## References

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3. Chase, M.W., Davies, C.A., Downey, J.R., Frurip, D.J., McDonald, R.A., and Syverud, A.N., *JANAF Thermochemical Tables, Third Edition*, *J. Phys. Chem. Ref. Data*, Vol. 14, Suppl. 1, 1985.
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| Element                   | $t_{\text{tp}}/^{\circ}\text{C}$ | $t_{\text{m}}/^{\circ}\text{C}$ | $t_{\text{b}}/^{\circ}\text{C}$ | $t_{\text{c}}/^{\circ}\text{C}$ |
|---------------------------|----------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Actinium                  |                                  | 1050                            | 3198                            |                                 |
| Aluminum                  |                                  | 660.32                          | 2519                            |                                 |
| Americium                 |                                  | 1176                            | 2011                            |                                 |
| Antimony                  |                                  | 630.628                         | 1587                            |                                 |
| Argon                     | –189.36 (69 kPa)                 |                                 | –185.847                        | –122.28                         |
| Arsenic (gray)            | 817 (3.70 MPa)                   |                                 | 616 sp                          | 1400                            |
| Astatine                  |                                  | 302                             |                                 |                                 |
| Barium                    |                                  | 727                             | 1897                            |                                 |
| Berkelium ( $\beta$ form) |                                  | 986                             |                                 |                                 |
| Beryllium                 |                                  | 1287                            | 2471                            |                                 |
| Bismuth                   |                                  | 271.406                         | 1564                            |                                 |
| Boron                     |                                  | 2075                            | 4000                            |                                 |
| Bromine                   |                                  | –7.2                            | 58.8                            | 315                             |
| Cadmium                   |                                  | 321.069                         | 767                             |                                 |
| Calcium                   |                                  | 842                             | 1484                            |                                 |
| Californium               |                                  | 900                             |                                 |                                 |
| Carbon (graphite)         | 4489 (10.3 MPa)                  |                                 | 3825 sp                         |                                 |
| Carbon (diamond)          |                                  | 4440 (12.4 GPa)                 |                                 |                                 |
| Cerium                    |                                  | 799                             | 3443                            |                                 |
| Cesium                    |                                  | 28.5                            | 671                             | 1665                            |
| Chlorine                  |                                  | –101.5                          | –34.04                          | 143.8                           |
| Chromium                  |                                  | 1907                            | 2671                            |                                 |
| Cobalt                    |                                  | 1495                            | 2927                            |                                 |
| Copper                    |                                  | 1084.62                         | 2562                            |                                 |
| Curium                    |                                  | 1345                            | ~3100                           |                                 |
| Dysprosium                |                                  | 1412                            | 2567                            |                                 |
| Einsteinium               |                                  | 860                             |                                 |                                 |
| Erbium                    |                                  | 1529                            | 2868                            |                                 |
| Europium                  |                                  | 822                             | 1529                            |                                 |
| Fermium                   |                                  | 1527                            |                                 |                                 |
| Fluorine                  | –219.67                          |                                 | –188.12                         | –129.02                         |
| Francium                  |                                  | 27                              |                                 |                                 |
| Gadolinium                |                                  | 1313                            | 3273                            |                                 |
| Gallium                   | 29.7666                          |                                 | 2204                            |                                 |
| Germanium                 |                                  | 938.25                          | 2833                            |                                 |
| Gold                      |                                  | 1064.18                         | 2856                            |                                 |
| Hafnium                   |                                  | 2233                            | 4603                            |                                 |
| Helium                    |                                  |                                 | –268.93                         | –267.96                         |
| Holmium                   |                                  | 1472                            | 2700                            |                                 |
| Hydrogen                  | –259.198 (7.2 kPa)               | –259.1                          | –252.762                        | –240.18                         |
| Indium                    | 156.5936                         | 156.60                          | 2072                            |                                 |
| Iodine                    |                                  | 113.7                           | 184.4                           | 546                             |
| Iridium                   |                                  | 2446                            | 4428                            |                                 |
| Iron                      |                                  | 1538                            | 2861                            |                                 |
| Krypton                   | –157.38 (73.2 kPa)               |                                 | –153.34                         | –63.67                          |
| Lanthanum                 |                                  | 920                             | 3464                            |                                 |
| Lawrencium                |                                  | 1627                            |                                 |                                 |
| Lead                      |                                  | 327.462                         | 1749                            |                                 |

| Element             | $t_{\text{tp}}/^{\circ}\text{C}$ | $t_{\text{m}}/^{\circ}\text{C}$ | $t_{\text{b}}/^{\circ}\text{C}$ | $t_{\text{c}}/^{\circ}\text{C}$ |
|---------------------|----------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Lithium             |                                  | 180.50                          | 1342                            | 2950                            |
| Lutetium            |                                  | 1663                            | 3402                            |                                 |
| Magnesium           |                                  | 650                             | 1090                            |                                 |
| Manganese           |                                  | 1246                            | 2061                            |                                 |
| Mendelevium         |                                  | 827                             |                                 |                                 |
| Mercury             | -38.837                          | -38.8290                        | 356.62                          | 1491                            |
| Molybdenum          |                                  | 2623                            | 4639                            |                                 |
| Neodymium           |                                  | 1016                            | 3074                            |                                 |
| Neon                | -248.609 (43 kPa)                |                                 | -246.053                        | -228.7                          |
| Neptunium           |                                  | 644                             |                                 |                                 |
| Nickel              |                                  | 1455                            | 2913                            |                                 |
| Niobium             |                                  | 2477                            | 4744                            |                                 |
| Nitrogen            | -209.999                         | -210.0                          | -195.798                        | -146.94                         |
| Nobelium            |                                  | 827                             |                                 |                                 |
| Osmium              |                                  | 3033                            | 5012                            |                                 |
| Oxygen              |                                  | -218.79                         | -182.953                        | -118.56                         |
| Palladium           |                                  | 1554.8                          | 2963                            |                                 |
| Phosphorus (white)  |                                  | 44.15                           | 280.5                           | 721                             |
| Phosphorus (red)    | 590                              |                                 | 431 sp                          | 721                             |
| Phosphorus (black)  |                                  | 610                             |                                 |                                 |
| Platinum            |                                  | 1768.2                          | 3825                            |                                 |
| Plutonium           |                                  | 640                             | 3228                            |                                 |
| Polonium            |                                  | 254                             | 962                             |                                 |
| Potassium           |                                  | 63.5                            | 759                             | 1950                            |
| Praseodymium        |                                  | 931                             | 3520                            |                                 |
| Promethium          |                                  | 1042                            | 3000                            |                                 |
| Protactinium        |                                  | 1572                            |                                 |                                 |
| Radium              |                                  | 696                             |                                 |                                 |
| Radon               |                                  | -71                             | -61.7                           | 104                             |
| Rhenium             |                                  | 3185                            | 5596                            |                                 |
| Rhodium             |                                  | 1964                            | 3695                            |                                 |
| Rubidium            | 39.26                            | 39.30                           | 688                             | 1820                            |
| Ruthenium           |                                  | 2333                            | 4150                            |                                 |
| Samarium            |                                  | 1072                            | 1794                            |                                 |
| Scandium            |                                  | 1541                            | 2836                            |                                 |
| Selenium (vitreous) |                                  | 180 (trans to gray)             | 685                             | 1493                            |
| Selenium (gray)     |                                  | 220.8                           | 685                             | 1493                            |
| Silicon             |                                  | 1414                            | 3265                            |                                 |
| Silver              |                                  | 961.78                          | 2162                            |                                 |
| Sodium              |                                  | 97.794                          | 882.940                         | 2300                            |
| Strontium           |                                  | 777                             | 1382                            |                                 |
| Sulfur (rhombic)    |                                  | 95.3 (trans to monocl)          | 444.61                          | 1041                            |
| Sulfur (monoclinic) |                                  | 115.21                          | 444.61                          | 1041                            |
| Tantalum            |                                  | 3017                            | 5458                            |                                 |
| Technetium          |                                  | 2157                            | 4265                            |                                 |
| Tellurium           |                                  | 449.51                          | 988                             |                                 |
| Terbium             |                                  | 1359                            | 3230                            |                                 |
| Thallium            |                                  | 304                             | 1473                            |                                 |
| Thorium             |                                  | 1750                            | 4788                            |                                 |
| Thulium             |                                  | 1545                            | 1950                            |                                 |
| Tin (gray)          |                                  | 13.2 (trans to white)           | 2602                            |                                 |
| Tin (white)         |                                  | 231.93                          | 2602                            |                                 |
| Titanium            |                                  | 1668                            | 3287                            |                                 |
| Tungsten            |                                  | 3422                            | 5555                            |                                 |
| Uranium             |                                  | 1135                            | 4131                            |                                 |
| Vanadium            |                                  | 1910                            | 3407                            |                                 |
| Xenon               | -111.745 (81.6 kPa)              |                                 | -108.09                         | 16.58                           |
| Ytterbium           |                                  | 824                             | 1196                            |                                 |
| Yttrium             |                                  | 1522                            | 3345                            |                                 |
| Zinc                |                                  | 419.53                          | 907                             |                                 |
| Zirconium           |                                  | 1854.7                          | 4409                            |                                 |

## HEAT CAPACITY OF THE ELEMENTS AT 25 °C

This table gives the specific heat capacity ( $c_p$ ) in J/g K and the molar heat capacity ( $C_p$ ) in J/mol K at a temperature of 25 °C and

a pressure of 100 kPa (1 bar or 0.987 standard atmospheres) for all the elements for which reliable data are available.

| Name                        | $c_p$<br>J/g K | $C_p$<br>J/mol K |
|-----------------------------|----------------|------------------|
| Actinium                    | 0.120          | 27.2             |
| Aluminum                    | 0.897          | 24.20            |
| Antimony                    | 0.207          | 25.23            |
| Argon                       | 0.520          | 20.786           |
| Arsenic                     | 0.329          | 24.64            |
| Barium                      | 0.204          | 28.07            |
| Beryllium                   | 1.825          | 16.443           |
| Bismuth                     | 0.122          | 25.52            |
| Boron                       | 1.026          | 11.087           |
| Bromine (Br <sub>2</sub> )  | 0.474          | 75.69            |
| Cadmium                     | 0.232          | 26.020           |
| Calcium                     | 0.647          | 25.929           |
| Carbon (graphite)           | 0.709          | 8.517            |
| Cerium                      | 0.192          | 26.94            |
| Cesium                      | 0.242          | 32.210           |
| Chlorine (Cl <sub>2</sub> ) | 0.479          | 33.949           |
| Chromium                    | 0.449          | 23.35            |
| Cobalt                      | 0.421          | 24.81            |
| Copper                      | 0.385          | 24.440           |
| Dysprosium                  | 0.173          | 28.16            |
| Erbium                      | 0.168          | 28.12            |
| Europium                    | 0.182          | 27.66            |
| Fluorine (F <sub>2</sub> )  | 0.824          | 31.304           |
| Gadolinium                  | 0.236          | 37.03            |
| Gallium                     | 0.373          | 26.03            |
| Germanium                   | 0.320          | 23.222           |
| Gold                        | 0.129          | 25.418           |
| Hafnium                     | 0.144          | 25.73            |
| Helium                      | 5.193          | 20.786           |
| Holmium                     | 0.165          | 27.15            |
| Hydrogen (H <sub>2</sub> )  | 14.304         | 28.836           |
| Indium                      | 0.233          | 26.74            |
| Iodine (I <sub>2</sub> )    | 0.214          | 54.43            |
| Iridium                     | 0.131          | 25.10            |
| Iron                        | 0.449          | 25.10            |
| Krypton                     | 0.248          | 20.786           |
| Lanthanum                   | 0.195          | 27.11            |
| Lead                        | 0.130          | 26.84            |
| Lithium                     | 3.582          | 24.860           |
| Lutetium                    | 0.154          | 26.86            |
| Magnesium                   | 1.023          | 24.869           |
| Manganese                   | 0.479          | 26.32            |
| Mercury                     | 0.140          | 27.983           |

| Name                       | $c_p$<br>J/g K | $C_p$<br>J/mol K |
|----------------------------|----------------|------------------|
| Molybdenum                 | 0.251          | 24.06            |
| Neodymium                  | 0.190          | 27.45            |
| Neon                       | 1.030          | 20.786           |
| Nickel                     | 0.444          | 26.07            |
| Niobium                    | 0.265          | 24.60            |
| Nitrogen (N <sub>2</sub> ) | 1.040          | 29.124           |
| Osmium                     | 0.130          | 24.7             |
| Oxygen (O <sub>2</sub> )   | 0.918          | 29.378           |
| Palladium                  | 0.246          | 25.98            |
| Phosphorus (white)         | 0.769          | 23.824           |
| Platinum                   | 0.133          | 25.86            |
| Potassium                  | 0.757          | 29.600           |
| Praseodymium               | 0.193          | 27.20            |
| Radon                      | 0.094          | 20.786           |
| Rhenium                    | 0.137          | 25.48            |
| Rhodium                    | 0.243          | 24.98            |
| Rubidium                   | 0.363          | 31.060           |
| Ruthenium                  | 0.238          | 24.06            |
| Samarium                   | 0.197          | 29.54            |
| Scandium                   | 0.568          | 25.52            |
| Selenium                   | 0.321          | 25.363           |
| Silicon                    | 0.712          | 19.99            |
| Silver                     | 0.235          | 25.350           |
| Sodium                     | 1.228          | 28.230           |
| Strontium                  | 0.306          | 26.79            |
| Sulfur (rhombic)           | 0.708          | 22.70            |
| Tantalum                   | 0.140          | 25.36            |
| Tellurium                  | 0.202          | 25.73            |
| Terbium                    | 0.182          | 28.91            |
| Thallium                   | 0.129          | 26.32            |
| Thorium                    | 0.118          | 27.32            |
| Thulium                    | 0.160          | 27.03            |
| Tin (white)                | 0.227          | 26.99            |
| Titanium                   | 0.523          | 25.060           |
| Tungsten                   | 0.132          | 24.27            |
| Uranium                    | 0.116          | 27.665           |
| Vanadium                   | 0.489          | 24.89            |
| Xenon                      | 0.158          | 20.786           |
| Ytterbium                  | 0.155          | 26.74            |
| Yttrium                    | 0.298          | 26.53            |
| Zinc                       | 0.388          | 25.390           |
| Zirconium                  | 0.278          | 25.36            |

# VAPOR PRESSURE OF THE METALLIC ELEMENTS — EQUATIONS

C. B. Alcock

This table gives coefficients in an equation for the vapor pressure of 65 metallic elements in both the solid and liquid states. Vapor pressures in the range  $10^{-10}$  to  $10^2$  Pa ( $10^{-15}$  to  $10^{-3}$  atm) are covered. The equation is:

$$\text{for } p \text{ in atmospheres: } \log(p/\text{atm}) = A + BT^{-1} + C\log T + DT^{-3}$$

$$\text{for } p \text{ in pascals: } \log(p/\text{Pa}) = 5.006 + A + BT^{-1} + C\log T + DT^{-3}$$

$$\text{for } p \text{ in torr (mmHg): } \log(p/\text{torr}) = 2.881 + A + BT^{-1} + C\log T + DT^{-3}$$

where  $T$  is the temperature in K.

This equation reproduces the observed vapor pressures to an accuracy of 5% or better. The metals are listed alphabetically by name, and the melting point is included.

The table following this one gives values of the vapor pressure at several temperatures in the 400 K to 2400 K range, as calculated from these equations.

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## Reference

Alcock, C. B., Itkin, V. P., and Horrigan, M. K., *Canadian Metallurgical Quarterly*, 23, 309, 1984.

| Element    | Phase  | A      | B      | C       | D       | Range/K  | mp/K |
|------------|--------|--------|--------|---------|---------|----------|------|
| Aluminum   | Solid  | 9.459  | -17342 | -0.7927 |         | 298-mp   | 933  |
| Aluminum   | Liquid | 5.911  | -16211 |         |         | mp-1800  |      |
| Americium  | Solid  | 11.311 | -15059 | -1.3449 |         | 298-mp   | 1449 |
| Barium     | Solid  | 12.405 | -9690  | -2.2890 |         | 298-mp   | 1000 |
| Barium     | Liquid | 4.007  | -8163  |         |         | mp-1200  |      |
| Beryllium  | Solid  | 8.042  | -17020 | -0.4440 |         | 298-mp   | 1560 |
| Beryllium  | Liquid | 5.786  | -15731 |         |         | mp-1800  |      |
| Cadmium    | Solid  | 5.939  | -5799  |         |         | 298-mp   | 594  |
| Cadmium    | Liquid | 5.242  | -5392  |         |         | mp-650   |      |
| Calcium    | Solid  | 10.127 | -9517  | -1.4030 |         | 298-mp   | 1115 |
| Cerium     | Solid  | 6.139  | -21752 |         |         | 298-mp   | 1071 |
| Cerium     | Liquid | 5.611  | -21200 |         |         | mp-2450  |      |
| Cesium     | Solid  | 4.711  | -3999  |         |         | 298-mp   | 302  |
| Cesium     | Liquid | 4.165  | -3830  |         |         | mp-550   |      |
| Chromium   | Solid  | 6.800  | -20733 | 0.4391  | -0.4094 | 298-2000 | 2180 |
| Cobalt     | Solid  | 10.976 | -22576 | -1.0280 |         | 298-mp   | 1768 |
| Cobalt     | Liquid | 6.488  | -20578 |         |         | mp-2150  |      |
| Copper     | Solid  | 9.123  | -17748 | -0.7317 |         | 298-mp   | 1358 |
| Copper     | Liquid | 5.849  | -16415 |         |         | mp-1850  |      |
| Curium     | Solid  | 8.369  | -20364 | -0.5770 |         | 298-mp   | 1618 |
| Curium     | Liquid | 5.223  | -18292 |         |         | mp-2200  |      |
| Dysprosium | Solid  | 9.579  | -15336 | -1.1114 |         | 298-mp   | 1685 |
| Erbium     | Solid  | 9.916  | -16642 | -1.2154 |         | 298-mp   | 1802 |
| Erbium     | Liquid | 4.668  | -14380 |         |         | mp-1900  |      |
| Europium   | Solid  | 9.240  | -9459  | -1.1661 |         | 298-mp   | 1095 |
| Gadolinium | Solid  | 8.344  | -20861 | -0.5775 |         | 298-mp   | 1586 |
| Gadolinium | Liquid | 5.557  | -19389 |         |         | mp-2250  |      |
| Gallium    | Solid  | 6.657  | -14208 |         |         | 298-mp   | 303  |
| Gallium    | Liquid | 6.754  | -13984 | -0.3413 |         | mp-1600  |      |
| Gold       | Solid  | 9.152  | -19343 | -0.7479 |         | 298-mp   | 1337 |
| Gold       | Liquid | 5.832  | -18024 |         |         | mp-2050  |      |
| Hafnium    | Solid  | 9.445  | -32482 | -0.6735 |         | 298-mp   | 2506 |
| Holmium    | Solid  | 9.785  | -15899 | -1.1753 |         | 298-mp   | 1747 |
| Indium     | Solid  | 5.991  | -12548 |         |         | 298-mp   | 430  |
| Indium     | Liquid | 5.374  | -12276 |         |         | mp-1500  |      |
| Iridium    | Solid  | 10.506 | -35099 | -0.7500 |         | 298-2500 | 2719 |
| Iron       | Solid  | 7.100  | -21723 | 0.4536  | -0.5846 | 298-mp   | 1811 |
| Iron       | Liquid | 6.347  | -19574 |         |         | mp-2100  |      |
| Lanthanum  | Solid  | 7.463  | -22551 | -0.3142 |         | 298-mp   | 1191 |
| Lanthanum  | Liquid | 5.911  | -21855 |         |         | mp-2450  |      |
| Lead       | Solid  | 5.643  | -10143 |         |         | 298-mp   | 600  |
| Lead       | Liquid | 4.911  | -9701  |         |         | mp-1200  |      |
| Lithium    | Solid  | 5.667  | -8310  |         |         | 298-mp   | 454  |
| Lithium    | Liquid | 5.055  | -8023  |         |         | mp-1000  |      |
| Lutetium   | Solid  | 8.793  | -22423 | -0.6200 |         | 298-mp   | 1936 |
| Lutetium   | Liquid | 5.648  | -20302 |         |         | mp-2350  |      |

| Element      | Phase  | A       | B      | C        | D       | Range/K   | mp/K |
|--------------|--------|---------|--------|----------|---------|-----------|------|
| Magnesium    | Solid  | 8.489   | -7813  | -0.8253  |         | 298-mp    | 923  |
| Manganese    | Solid  | 12.805  | -15097 | -1.7896  |         | 298-mp    | 1519 |
| Mercury      | Liquid | 5.116   | -3190  |          |         | 298-400   | 234  |
| Molybdenum   | Solid  | 11.529  | -34626 | -1.1331  |         | 298-2500  | 2895 |
| Neodymium    | Solid  | 8.996   | -17264 | -0.9519  |         | 298-mp    | 1294 |
| Neodymium    | Liquid | 4.912   | -15824 |          |         | mp-2000   |      |
| Neptunium    | Solid  | 19.643  | -24886 | -3.9991  |         | 298-mp    | 917  |
| Neptunium    | Liquid | 10.076  | -23378 | -1.3250  |         | mp-2500   |      |
| Nickel       | Solid  | 10.557  | -22606 | -0.8717  |         | 298-mp    | 1728 |
| Nickel       | Liquid | 6.666   | -20765 |          |         | mp-2150   |      |
| Niobium      | Solid  | 8.882   | -37818 | -0.2575  |         | 298-2500  | 2750 |
| Osmium       | Solid  | 9.419   | -41198 | -0.3896  |         | 298-2500  | 3306 |
| Palladium    | Solid  | 9.502   | -19813 | -0.9258  |         | 298-mp    | 1828 |
| Palladium    | Liquid | 5.426   | -17899 |          |         | mp-2100   |      |
| Platinum     | Solid  | 4.882   | -29387 | 1.1039   | -0.4527 | 298-mp    | 2041 |
| Platinum     | Liquid | 6.386   | -26856 |          |         | mp-2500   |      |
| Plutonium    | Solid  | 26.160  | -19162 | -6.6675  |         | 298-600   | 913  |
| Plutonium    | Solid  | 18.858  | -18460 | -4.4720  |         | 500-mp    |      |
| Plutonium    | Liquid | 3.666   | -16658 |          |         | mp-2450   |      |
| Potassium    | Solid  | 4.961   | -4646  |          |         | 298-mp    | 337  |
| Potassium    | Liquid | 4.402   | -4453  |          |         | mp-600    |      |
| Praseodymium | Solid  | 8.859   | -18720 | -0.9512  |         | 298-mp    | 1204 |
| Praseodymium | Liquid | 4.772   | -17315 |          |         | mp-2200   |      |
| Protactinium | Solid  | 10.552  | -34869 | -1.0075  |         | 298-mp    | 1845 |
| Protactinium | Liquid | 6.177   | -32874 |          |         | mp-2500   |      |
| Rhenium      | Solid  | 11.543  | -40726 | -1.1629  |         | 298-2500  | 3459 |
| Rhodium      | Solid  | 10.168  | -29010 | -0.7068  |         | 298-mp    | 2236 |
| Rhodium      | Liquid | 6.802   | -26792 |          |         | mp-2500   |      |
| Rubidium     | Solid  | 4.857   | -4215  |          |         | 298-mp    | 312  |
| Rubidium     | Liquid | 4.312   | -4040  |          |         | mp-550    |      |
| Ruthenium    | Solid  | 9.755   | -34154 | -0.4723  |         | 298-mp    | 2606 |
| Samarium     | Solid  | 9.988   | -11034 | -1.3287  |         | 298-mp    | 1347 |
| Scandium     | Solid  | 6.650   | -19721 | 0.2885   | -0.3663 | 298-mp    | 1814 |
| Scandium     | Liquid | 5.795   | -17681 |          |         | mp-2000   |      |
| Silver       | Solid  | 9.127   | -14999 | -0.7845  |         | 298-mp    | 1235 |
| Silver       | Liquid | 5.752   | -13827 |          |         | mp-1600   |      |
| Sodium       | Solid  | 5.298   | -5603  |          |         | 298-mp    | 371  |
| Sodium       | Liquid | 4.704   | -5377  |          |         | mp-700    |      |
| Strontium    | Solid  | 9.226   | -8572  | -1.1926  |         | 298-mp    | 1050 |
| Tantalum     | Solid  | 16.807  | -41346 | -3.2152  | 0.7437  | 298-2500  | 3280 |
| Terbium      | Solid  | 9.510   | -20457 | -0.9247  |         | 298-mp    | 1629 |
| Terbium      | Liquid | 5.411   | -18639 |          |         | mp-2200   |      |
| Thallium     | Solid  | 5.971   | -9447  |          |         | 298-mp    | 577  |
| Thallium     | Liquid | 5.259   | -9037  |          |         | mp-1100   |      |
| Thorium      | Solid  | 8.668   | -31483 | -0.5288  |         | 298-mp    | 2023 |
| Thorium      | Liquid | -18.453 | -24569 | 6.6473   |         | mp-2500   |      |
| Thulium      | Solid  | 8.882   | -12270 | -0.9564  |         | 298-1400  | 1818 |
| Tin          | Solid  | 6.036   | -15710 |          |         | 298-mp    | 505  |
| Tin          | Liquid | 5.262   | -15332 |          |         | mp-1850   |      |
| Titanium     | Solid  | 11.925  | -24991 | -1.3376  |         | 298-mp    | 1943 |
| Titanium     | Liquid | 6.358   | -22747 |          |         | mp-2400   |      |
| Tungsten     | Solid  | 2.945   | -44094 | 1.3677   |         | 298-2350  | 3687 |
| Tungsten     | Solid  | 54.527  | -57687 | -12.2231 |         | 2200-2500 |      |
| Uranium      | Solid  | 0.770   | -27729 | 2.6982   | -1.5471 | 298-mp    | 1408 |
| Uranium      | Liquid | 20.735  | -28776 | -4.0962  |         | mp-2500   |      |
| Vanadium     | Solid  | 9.744   | -27132 | -0.5501  |         | 298-mp    | 2183 |
| Vanadium     | Liquid | 6.929   | -25011 |          |         | mp-2500   |      |
| Ytterbium    | Solid  | 9.111   | -8111  | -1.0849  |         | 298-900   | 1092 |
| Yttrium      | Solid  | 9.735   | -22306 | -0.8705  |         | 298-mp    | 1795 |
| Yttrium      | Liquid | 5.795   | -20341 |          |         | mp-2300   |      |
| Zinc         | Solid  | 6.102   | -6776  |          |         | 298-mp    | 693  |
| Zinc         | Liquid | 5.378   | -6286  |          |         | mp-750    |      |
| Zirconium    | Solid  | 10.008  | -31512 | -0.7890  |         | 298-m.p   | 2127 |
| Zirconium    | Liquid | 6.806   | -30295 |          |         | mp-2500   |      |

## DENSITY OF MOLTEN ELEMENTS AND REPRESENTATIVE SALTS

This table lists the liquid density at the melting point,  $\rho_m$ , for elements that are solid at room temperature, as well as for some representative salts of these elements. Densities at higher temperatures (up to the  $t_{\max}$  given in the last column) may be estimated from the equation

$$\rho(t) = \rho_m - k(t - t_m)$$

where  $t_m$  is the melting point and  $k$  is given in the fifth column of the table. If a value of  $t_{\max}$  is not given, the equation should not be used to extrapolate more than about 20°C beyond the melting point.

Data for the elements were selected from the primary literature; the assistance of Gernot Lang in compiling these data is gratefully acknowledged. The molten salt data were derived from Reference 1.

### References

1. Janz, G. J., Thermodynamic and Transport Properties of Molten Salts: Correlation Equations for Critically Evaluated Density, Surface Tension, Electrical Conductance, and Viscosity Data, *J. Phys. Chem. Ref. Data*, 17, Suppl. 2, 1988.
2. Nasch, P. M., and Steinemann, S. G., *Phys. Chem. Liq.*, 29, 43, 1995.

| Formula                         | Name                 | $t_m/^\circ\text{C}$ | $\rho_m/\text{g cm}^{-3}$ | $k/\text{g cm}^{-3} \text{ } ^\circ\text{C}^{-1}$ | $t_{\max}$ |
|---------------------------------|----------------------|----------------------|---------------------------|---------------------------------------------------|------------|
| Ag                              | Silver               | 961.78               | 9.320                     | 0.0009                                            | 1500       |
| AgBr                            | Silver(I) bromide    | 430                  | 5.577                     | 0.001035                                          | 667        |
| AgCl                            | Silver(I) chloride   | 455                  | 4.83                      | 0.00094                                           | 627        |
| AgI                             | Silver(I) iodide     | 558                  | 5.58                      | 0.00101                                           | 802        |
| AgNO <sub>3</sub>               | Silver(I) nitrate    | 210                  | 3.970                     | 0.001098                                          | 360        |
| Ag <sub>2</sub> SO <sub>4</sub> | Silver(I) sulfate    | 660                  | 4.84                      | 0.001089                                          | 770        |
| Al                              | Aluminum             | 660.32               | 2.375                     | 0.000233                                          | 1340       |
| AlBr <sub>3</sub>               | Aluminum bromide     | 97.5                 | 2.647                     | 0.002435                                          | 267        |
| AlCl <sub>3</sub>               | Aluminum chloride    | 192.6                | 1.302                     | 0.002711                                          | 296        |
| AlI <sub>3</sub>                | Aluminum iodide      | 188.32               | 3.223                     | 0.0025                                            | 240        |
| As                              | Arsenic              | 817                  | 5.22                      | 0.000544                                          |            |
| Au                              | Gold                 | 1064.18              | 17.31                     | 0.001343                                          | 1200       |
| B                               | Boron                | 2075                 | 2.08                      |                                                   |            |
| Ba                              | Barium               | 727                  | 3.338                     | 0.000299                                          | 1550       |
| BaBr <sub>2</sub>               | Barium bromide       | 857                  | 3.991                     | 0.000924                                          | 900        |
| BaCl <sub>2</sub>               | Barium chloride      | 961                  | 3.174                     | 0.000681                                          | 1081       |
| BaF <sub>2</sub>                | Barium fluoride      | 1368                 | 4.14                      | 0.000999                                          | 1727       |
| BaI <sub>2</sub>                | Barium iodide        | 711                  | 4.26                      | 0.000977                                          | 975        |
| Be                              | Beryllium            | 1287                 | 1.690                     | 0.00011                                           |            |
| BeCl <sub>2</sub>               | Beryllium chloride   | 415                  | 1.54                      | 0.0011                                            | 473        |
| BeF <sub>2</sub>                | Beryllium fluoride   | 552                  | 1.96                      | 0.000015                                          | 850        |
| Bi                              | Bismuth              | 271.406              | 10.05                     | 0.00135                                           | 800        |
| BiBr <sub>3</sub>               | Bismuth bromide      | 219                  | 4.76                      | 0.002637                                          | 927        |
| BiCl <sub>3</sub>               | Bismuth chloride     | 234                  | 3.916                     | 0.0023                                            | 350        |
| Ca                              | Calcium              | 842                  | 1.378                     | 0.000230                                          | 1484       |
| CaBr <sub>2</sub>               | Calcium bromide      | 742                  | 3.111                     | 0.0005                                            | 791        |
| CaCl <sub>2</sub>               | Calcium chloride     | 775                  | 2.085                     | 0.000422                                          | 950        |
| CaF <sub>2</sub>                | Calcium fluoride     | 1418                 | 2.52                      | 0.000391                                          | 2027       |
| CaI <sub>2</sub>                | Calcium iodide       | 783                  | 3.443                     | 0.000751                                          | 1028       |
| Cd                              | Cadmium              | 321.069              | 7.996                     | 0.001218                                          | 500        |
| CdBr <sub>2</sub>               | Cadmium bromide      | 568                  | 4.075                     | 0.00108                                           | 720        |
| CdCl <sub>2</sub>               | Cadmium chloride     | 568                  | 3.392                     | 0.00082                                           | 807        |
| CdI <sub>2</sub>                | Cadmium iodide       | 388                  | 4.396                     | 0.001117                                          | 700        |
| Ce                              | Cerium               | 799                  | 6.55                      | 0.000710                                          | 1460       |
| CeCl <sub>3</sub>               | Cerium(III) chloride | 807                  | 3.25                      | 0.00092                                           | 950        |
| CeF <sub>3</sub>                | Cerium(III) fluoride | 1430                 | 4.659                     | 0.000936                                          | 1927       |
| Co                              | Cobalt               | 1495                 | 7.75                      | 0.00165                                           | 1580       |
| Cr                              | Chromium             | 1907                 | 6.3                       | 0.0011                                            | 2100       |
| Cs                              | Cesium               | 28.44                | 1.843                     | 0.000556                                          | 510        |
| CsBr                            | Cesium bromide       | 636                  | 3.133                     | 0.001223                                          | 860        |
| CsCl                            | Cesium chloride      | 646                  | 2.79                      | 0.001065                                          | 906        |
| CsF                             | Cesium fluoride      | 703                  | 3.649                     | 0.001282                                          | 912        |
| CsI                             | Cesium iodide        | 632                  | 3.197                     | 0.001183                                          | 907        |
| CsNO <sub>3</sub>               | Cesium nitrate       | 409                  | 2.820                     | 0.001166                                          | 491        |
| Cs <sub>2</sub> SO <sub>4</sub> | Cesium sulfate       | 1005                 | 3.1                       | 0.00095                                           | 1530       |
| Cu                              | Copper               | 1084.62              | 8.02                      | 0.000609                                          | 1630       |
| CuCl                            | Copper(I) chloride   | 423                  | 3.692                     | 0.00076                                           | 585        |

| Formula                         | Name                     | $t_m/^\circ\text{C}$ | $\rho_m/\text{g cm}^{-3}$ | $k/\text{g cm}^{-3} \text{ } ^\circ\text{C}^{-1}$ | $t_{\text{max}}$ |
|---------------------------------|--------------------------|----------------------|---------------------------|---------------------------------------------------|------------------|
| Dy                              | Dysprosium               | 1411                 | 8.37                      | 0.00143                                           | 1540             |
| DyCl <sub>3</sub>               | Dysprosium(III) chloride | 718                  | 3.62                      | 0.00068                                           | 987              |
| Er                              | Erbium                   | 1529                 | 8.86                      | 0.00157                                           | 1700             |
| Eu                              | Europium                 | 822                  | 5.13                      | 0.0028                                            | 980              |
| Fe                              | Iron                     | 1538                 | 6.98                      | 0.000572                                          | 1680             |
| FeCl <sub>2</sub>               | Iron(II) chloride        | 677                  | 2.348                     | 0.000555                                          | 877              |
| Ga                              | Gallium                  | 29.7666              | 6.08                      | 0.00062                                           | 400              |
| GaBr <sub>3</sub>               | Gallium(III) bromide     | 123                  | 3.116                     | 0.00246                                           | 135              |
| GaCl <sub>3</sub>               | Gallium(III) chloride    | 77.9                 | 2.053                     | 0.002083                                          | 141              |
| GaI <sub>3</sub>                | Gallium(III) iodide      | 212                  | 3.630                     | 0.002377                                          | 252              |
| Gd                              | Gadolinium               | 1314                 | 7.4                       |                                                   |                  |
| GdCl <sub>3</sub>               | Gadolinium(III) chloride | 602                  | 3.56                      | 0.000671                                          | 1007             |
| GdI <sub>3</sub>                | Gadolinium(III) iodide   | 930                  | 4.12                      | 0.000908                                          | 1032             |
| Ge                              | Germanium                | 938.25               | 5.60                      | 0.00055                                           | 1600             |
| Hf                              | Hafnium                  | 2233                 | 12                        |                                                   |                  |
| HgBr <sub>2</sub>               | Mercury(II) bromide      | 241                  | 5.126                     | 0.003233                                          | 319              |
| HgCl <sub>2</sub>               | Mercury(II) chloride     | 277                  | 4.368                     | 0.002862                                          | 304              |
| HgI <sub>2</sub>                | Mercury(II) iodide       | 256                  | 5.222                     | 0.003235                                          | 354              |
| Ho                              | Holmium                  | 1472                 | 8.34                      |                                                   |                  |
| In                              | Indium                   | 156.60               | 7.02                      | 0.000836                                          | 500              |
| InBr <sub>3</sub>               | Indium(III) bromide      | 420                  | 3.121                     | 0.0015                                            | 528              |
| InCl <sub>3</sub>               | Indium(III) chloride     | 583                  | 2.140                     | 0.0021                                            | 666              |
| InI <sub>3</sub>                | Indium(III) iodide       | 207                  | 3.820                     | 0.0015                                            | 360              |
| Ir                              | Iridium                  | 2446                 | 19                        |                                                   |                  |
| K                               | Potassium                | 63.38                | 0.828                     | 0.000232                                          | 500              |
| KBr                             | Potassium bromide        | 734                  | 2.127                     | 0.000825                                          | 930              |
| KCl                             | Potassium chloride       | 771                  | 1.527                     | 0.000583                                          | 939              |
| KF                              | Potassium fluoride       | 858                  | 1.910                     | 0.000651                                          | 1037             |
| KI                              | Potassium iodide         | 681                  | 2.448                     | 0.000956                                          | 904              |
| KNO <sub>3</sub>                | Potassium nitrate        | 334                  | 1.865                     | 0.000723                                          | 457              |
| La                              | Lanthanum                | 920                  | 5.94                      | 0.00061                                           | 1600             |
| LaBr <sub>3</sub>               | Lanthanum bromide        | 788                  | 4.933                     | 0.000096                                          | 912              |
| LaCl <sub>3</sub>               | Lanthanum chloride       | 888                  | 3.209                     | 0.000777                                          | 973              |
| LaF <sub>3</sub>                | Lanthanum fluoride       | 1493                 | 4.589                     | 0.000682                                          | 2177             |
| LaI <sub>3</sub>                | Lanthanum iodide         | 778                  | 4.29                      | 0.001110                                          | 907              |
| Li                              | Lithium                  | 180.5                | 0.512                     | 0.00052                                           | 285              |
| LiBr                            | Lithium bromide          | 550                  | 2.528                     | 0.000652                                          | 739              |
| LiCl                            | Lithium chloride         | 610                  | 1.502                     | 0.000432                                          | 781              |
| LiF                             | Lithium fluoride         | 848.2                | 1.81                      | 0.000490                                          | 1047             |
| LiI                             | Lithium iodide           | 469                  | 3.109                     | 0.000917                                          | 667              |
| LiNO <sub>3</sub>               | Lithium nitrate          | 253                  | 1.781                     | 0.000546                                          | 441              |
| Li <sub>2</sub> SO <sub>4</sub> | Lithium sulfate          | 860                  | 2.003                     | 0.000407                                          | 1214             |
| Lu                              | Lutetium                 | 1663                 | 9.3                       |                                                   |                  |
| Mg                              | Magnesium                | 650                  | 1.584                     | 0.000234                                          | 900              |
| MgBr <sub>2</sub>               | Magnesium bromide        | 711                  | 2.62                      | 0.000478                                          | 935              |
| MgCl <sub>2</sub>               | Magnesium chloride       | 714                  | 1.68                      | 0.000271                                          | 826              |
| MgI <sub>2</sub>                | Magnesium iodide         | 634                  | 3.05                      | 0.000651                                          | 888              |
| Mn                              | Manganese                | 1246                 | 5.95                      | 0.00105                                           | 1590             |
| MnCl <sub>2</sub>               | Manganese(II) chloride   | 650                  | 2.353                     | 0.000437                                          | 850              |
| Mo                              | Molybdenum               | 2623                 | 9.33                      |                                                   |                  |
| Na                              | Sodium                   | 97.794               | 0.927                     | 0.00023                                           | 600              |
| NaBr                            | Sodium bromide           | 747                  | 2.342                     | 0.000816                                          | 945              |
| Na <sub>2</sub> CO <sub>3</sub> | Sodium carbonate         | 856                  | 1.972                     | 0.000448                                          | 1004             |
| NaCl                            | Sodium chloride          | 800.7                | 1.556                     | 0.000543                                          | 1027             |
| NaF                             | Sodium fluoride          | 996                  | 1.948                     | 0.000636                                          | 1097             |
| NaI                             | Sodium iodide            | 661                  | 2.742                     | 0.000949                                          | 912              |
| NaNO <sub>3</sub>               | Sodium nitrate           | 306.5                | 1.90                      | 0.000715                                          | 370              |
| Na <sub>2</sub> SO <sub>4</sub> | Sodium sulfate           | 884                  | 2.069                     | 0.000483                                          | 1077             |
| Nd                              | Neodymium                | 1016                 | 6.89                      | 0.00076                                           | 1350             |
| Ni                              | Nickel                   | 1455                 | 7.81                      | 0.000726                                          | 1700             |
| NiCl <sub>2</sub>               | Nickel(II) chloride      | 1031                 | 2.653                     | 0.00066                                           | 1057             |
| Os                              | Osmium                   | 3033                 | 20                        |                                                   |                  |
| Pb                              | Lead                     | 327.462              | 10.66                     | 0.00122                                           | 700              |
| PbBr <sub>2</sub>               | Lead(II) bromide         | 371                  | 5.73                      | 0.00165                                           | 600              |
| PbCl <sub>2</sub>               | Lead(II) chloride        | 501                  | 4.951                     | 0.0015                                            | 710              |

| Formula                         | Name                   | $t_m/^\circ\text{C}$ | $\rho_m/\text{g cm}^{-3}$ | $k/\text{g cm}^{-3} \text{ } ^\circ\text{C}^{-1}$ | $t_{\text{max}}$ |
|---------------------------------|------------------------|----------------------|---------------------------|---------------------------------------------------|------------------|
| PbI <sub>2</sub>                | Lead(II) iodide        | 410                  | 5.691                     | 0.001594                                          | 697              |
| Pd                              | Palladium              | 1554.8               | 10.38                     | 0.001169                                          | 1700             |
| Pr                              | Praseodymium           | 931                  | 6.50                      | 0.00093                                           | 1460             |
| PrCl <sub>3</sub>               | Praseodymium chloride  | 786                  | 3.23                      | 0.00074                                           | 977              |
| Pt                              | Platinum               | 1768.2               | 19.77                     | 0.0024                                            | 2200             |
| Pu                              | Plutonium              | 640                  | 16.63                     | 0.001419                                          | 950              |
| Rb                              | Rubidium               | 39.31                | 1.46                      | 0.000451                                          | 800              |
| RbBr                            | Rubidium bromide       | 692                  | 2.715                     | 0.001072                                          | 907              |
| Rb <sub>2</sub> CO <sub>3</sub> | Rubidium carbonate     | 837                  | 2.84                      | 0.000640                                          | 1007             |
| RbCl                            | Rubidium chloride      | 724                  | 2.248                     | 0.000883                                          | 923              |
| RbF                             | Rubidium fluoride      | 795                  | 2.87                      | 0.00102                                           | 1067             |
| RbI                             | Rubidium iodide        | 656                  | 2.904                     | 0.001143                                          | 902              |
| RbNO <sub>3</sub>               | Rubidium nitrate       | 310                  | 2.519                     | 0.001068                                          | 417              |
| Rb <sub>2</sub> SO <sub>4</sub> | Rubidium sulfate       | 1066                 | 2.56                      | 0.000665                                          | 1545             |
| Re                              | Rhenium                | 3185                 | 18.9                      |                                                   |                  |
| Rh                              | Rhodium                | 1964                 | 10.7                      | 0.000895                                          | 2200             |
| Ru                              | Ruthenium              | 2334                 | 10.65                     |                                                   |                  |
| S                               | Sulfur                 | 115.21               | 1.819                     | 0.00080                                           | 160              |
| Sb                              | Antimony               | 630.628              | 6.53                      | 0.00067                                           | 745              |
| SbCl <sub>3</sub>               | Antimony(III) chloride | 73.4                 | 2.681                     | 0.002293                                          | 77               |
| SbCl <sub>5</sub>               | Antimony(V) chloride   | 4                    | 2.37                      | 0.001869                                          | 77               |
| SbI <sub>3</sub>                | Antimony(III) iodide   | 171                  | 4.171                     | 0.002483                                          | 322              |
| Sc                              | Scandium               | 1541                 | 2.80                      |                                                   |                  |
| Se                              | Selenium               | 220.8                | 3.99                      |                                                   |                  |
| Si                              | Silicon                | 1414                 | 2.57                      | 0.00036                                           | 1500             |
| Sm                              | Samarium               | 1072                 | 7.16                      |                                                   |                  |
| Sn                              | Tin                    | 231.93               | 6.99                      | 0.000601                                          | 1200             |
| SnCl <sub>2</sub>               | Tin(II) chloride       | 247                  | 3.36                      | 0.001253                                          | 480              |
| SnCl <sub>4</sub>               | Tin(IV) chloride       | -33                  | 2.37                      | 0.002687                                          | 138              |
| Sr                              | Strontium              | 777                  | 6.980                     |                                                   |                  |
| SrBr <sub>2</sub>               | Strontium bromide      | 657                  | 3.70                      | 0.000745                                          | 1004             |
| SrCl <sub>2</sub>               | Strontium chloride     | 874                  | 2.727                     | 0.000578                                          | 1037             |
| SrF <sub>2</sub>                | Strontium fluoride     | 1477                 | 3.470                     | 0.000751                                          | 1927             |
| SrI <sub>2</sub>                | Strontium iodide       | 538                  | 4.085                     | 0.000885                                          | 1026             |
| Ta                              | Tantalum               | 3017                 | 15                        |                                                   |                  |
| TaCl <sub>5</sub>               | Tantalum(V) chloride   | 216.6                | 2.700                     | 0.004316                                          | 457              |
| Tb                              | Terbium                | 1359                 | 7.65                      |                                                   |                  |
| Te                              | Tellurium              | 449.51               | 5.70                      | 0.00035                                           | 600              |
| ThCl <sub>4</sub>               | Thorium chloride       | 770                  | 3.363                     | 0.0014                                            | 847              |
| ThF <sub>4</sub>                | Thorium fluoride       | 1110                 | 6.058                     | 0.000759                                          | 1378             |
| Ti                              | Titanium               | 1668                 | 4.11                      |                                                   |                  |
| TiCl <sub>4</sub>               | Titanium(IV) chloride  | -25                  | 1.807                     | 0.001735                                          | 137              |
| Tl                              | Thallium               | 304                  | 11.22                     | 0.00144                                           | 600              |
| TlBr                            | Thallium(I) bromide    | 460                  | 5.98                      | 0.001755                                          | 647              |
| TlCl                            | Thallium(I) chloride   | 431                  | 5.628                     | 0.0018                                            | 642              |
| TlI                             | Thallium(I) iodide     | 441.8                | 6.15                      | 0.001761                                          | 737              |
| TlNO <sub>3</sub>               | Thallium(I) nitrate    | 206                  | 4.91                      | 0.001873                                          | 279              |
| Tl <sub>2</sub> SO <sub>4</sub> | Thallium(I) sulfate    | 632                  | 5.62                      | 0.00130                                           | 927              |
| Tm                              | Thulium                | 1545                 | 8.56                      | 0.00050                                           | 1675             |
| U                               | Uranium                | 1135                 | 17.3                      |                                                   |                  |
| UCl <sub>3</sub>                | Uranium(III) chloride  | 837                  | 4.84                      | 0.007943                                          | 1057             |
| UCl <sub>4</sub>                | Uranium(IV) chloride   | 590                  | 3.572                     | 0.001945                                          | 667              |
| UF <sub>4</sub>                 | Uranium(IV) fluoride   | 1036                 | 6.485                     | 0.000992                                          | 1341             |
| V                               | Vanadium               | 1910                 | 5.5                       |                                                   |                  |
| W                               | Tungsten               | 3422                 | 17.6                      |                                                   |                  |
| Y                               | Yttrium                | 1526                 | 4.24                      |                                                   |                  |
| YCl <sub>3</sub>                | Yttrium chloride       | 721                  | 2.510                     | 0.0005                                            | 845              |
| Yb                              | Ytterbium              | 824                  | 6.21                      |                                                   |                  |
| Zn                              | Zinc                   | 419.53               | 6.57                      | 0.0011                                            | 700              |
| ZnBr <sub>2</sub>               | Zinc bromide           | 402                  | 3.47                      | 0.000959                                          | 602              |
| ZnCl <sub>2</sub>               | Zinc chloride          | 290                  | 2.54                      | 0.00053                                           | 557              |
| ZnI <sub>2</sub>                | Zinc iodide            | 450                  | 3.878                     | 0.00136                                           | 588              |
| ZnSO <sub>4</sub>               | Zinc sulfate           | 680                  | 3.14                      | 0.00047                                           | 987              |
| Zr                              | Zirconium              | 1854.7               | 5.8                       |                                                   |                  |
| ZrCl <sub>4</sub>               | Zirconium chloride     | 437                  | 1.643                     | 0.007464                                          | 492              |



# MAGNETIC SUSCEPTIBILITY OF THE ELEMENTS AND INORGANIC COMPOUNDS

When a material is placed in a magnetic field  $H$ , a magnetization (magnetic moment per unit volume)  $M$  is induced in the material which is related to  $H$  by  $M = \kappa H$ , where  $\kappa$  is called the volume susceptibility. Since  $H$  and  $M$  have the same dimensions,  $\kappa$  is dimensionless. A more useful parameter is the molar susceptibility  $\chi_m$ , defined by

$$\chi_m = \kappa V_m = \kappa M / \rho$$

where  $V_m$  is the molar volume of the substance,  $M$  the molar mass, and  $\rho$  the mass density. When the cgs system is used, the customary units for  $\chi_m$  are  $\text{cm}^3 \text{mol}^{-1}$ ; the corresponding SI units are  $\text{m}^3 \text{mol}^{-1}$ .

Substances that have no unpaired electron orbital or spin angular momentum generally have negative values of  $\chi_m$  and are called diamagnetic. Their molar susceptibility varies only slightly with temperature. Substances with unpaired electrons, which are termed paramagnetic, have positive  $\chi_m$  and show a much stronger temperature dependence, varying roughly as  $1/T$ . The net susceptibility of a paramagnetic substance is the sum of the paramagnetic and diamagnetic contributions, but the former almost always dominates.

This table gives values of  $\chi_m$  for the elements and selected inorganic compounds. All values refer to nominal room temperature (285 to 300 K) unless otherwise indicated. When the physical state (s = solid, l = liquid, g = gas, aq = aqueous solution) is not given, the

most common crystalline form is understood. An entry of Ferro. indicates a ferromagnetic substance.

Substances are arranged in alphabetical order by the most common name, except that compounds such as hydrides, oxides, and acids are grouped with the parent element (the same ordering used in the table "Physical Constants of Inorganic Compounds").

In keeping with customary practice, the molar susceptibility is given here in units appropriate to the cgs system. These values should be multiplied by  $4\pi$  to obtain values for use in SI equations (where the magnetic field strength  $H$  has units of  $\text{A m}^{-1}$ ).

## References

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4. *Tables de Constantes et Données Numérique, Volume 7, Relaxation Paramagnétique*, Masson, Paris, 1957.

| Name                   | Formula                                                      | $\chi_m / 10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Name                      | Formula                              | $\chi_m / 10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|------------------------|--------------------------------------------------------------|--------------------------------------------------|---------------------------|--------------------------------------|--------------------------------------------------|
| Aluminum               | Al                                                           | +16.5                                            | Arsenic(III) bromide      | AsBr <sub>3</sub>                    | -106                                             |
| Aluminum trifluoride   | AlF <sub>3</sub>                                             | -13.9                                            | Arsenic(III) chloride     | AsCl <sub>3</sub>                    | -72.5                                            |
| Aluminum oxide         | Al <sub>2</sub> O <sub>3</sub>                               | -37                                              | Arsenic(III) iodide       | AsI <sub>3</sub>                     | -142.2                                           |
| Aluminum sulfate       | Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>              | -93                                              | Arsenic(III) oxide        | As <sub>2</sub> O <sub>3</sub>       | -30.34                                           |
| Ammonia (g)            | NH <sub>3</sub>                                              | -16.3                                            | Arsenic(III) sulfide      | As <sub>2</sub> S <sub>3</sub>       | -70                                              |
| Ammonia (aq)           | NH <sub>3</sub>                                              | -18.3                                            | Barium                    | Ba                                   | +20.6                                            |
| Ammonium acetate       | NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> | -41.1                                            | Barium bromide            | BaBr <sub>2</sub>                    | -92                                              |
| Ammonium bromide       | NH <sub>4</sub> Br                                           | -47                                              | Barium bromide dihydrate  | BaBr <sub>2</sub> ·2H <sub>2</sub> O | -119.3                                           |
| Ammonium carbonate     | (NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>              | -42.5                                            | Barium carbonate          | BaCO <sub>3</sub>                    | -58.9                                            |
| Ammonium chlorate      | NH <sub>4</sub> ClO <sub>3</sub>                             | -42.1                                            | Barium chloride           | BaCl <sub>2</sub>                    | -72.6                                            |
| Ammonium chloride      | NH <sub>4</sub> Cl                                           | -36.7                                            | Barium chloride dihydrate | BaCl <sub>2</sub> ·2H <sub>2</sub> O | -100                                             |
| Ammonium fluoride      | NH <sub>4</sub> F                                            | -23                                              | Barium fluoride           | BaF <sub>2</sub>                     | -51                                              |
| Ammonium iodate        | NH <sub>4</sub> IO <sub>3</sub>                              | -62.3                                            | Barium hydroxide          | Ba(OH) <sub>2</sub>                  | -53.2                                            |
| Ammonium iodide        | NH <sub>4</sub> I                                            | -66                                              | Barium iodate             | Ba(IO <sub>3</sub> ) <sub>2</sub>    | -122.5                                           |
| Ammonium nitrate       | NH <sub>4</sub> NO <sub>3</sub>                              | -33                                              | Barium iodide             | BaI <sub>2</sub>                     | -124.4                                           |
| Ammonium sulfate       | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>              | -67                                              | Barium iodide dihydrate   | BaI <sub>2</sub> ·2H <sub>2</sub> O  | -163                                             |
| Ammonium thiocyanate   | NH <sub>4</sub> SCN                                          | -48.1                                            | Barium nitrate            | Ba(NO <sub>3</sub> ) <sub>2</sub>    | -66.5                                            |
| Antimony               | Sb                                                           | -99                                              | Barium oxide              | BaO                                  | -29.1                                            |
| Stibine (g)            | SbH <sub>3</sub>                                             | -34.6                                            | Barium peroxide           | BaO <sub>2</sub>                     | -40.6                                            |
| Antimony(III) bromide  | SbBr <sub>3</sub>                                            | -111.4                                           | Barium sulfate            | BaSO <sub>4</sub>                    | -65.8                                            |
| Antimony(III) chloride | SbCl <sub>3</sub>                                            | -86.7                                            | Beryllium                 | Be                                   | -9.0                                             |
| Antimony(III) fluoride | SbF <sub>3</sub>                                             | -46                                              | Beryllium chloride        | BeCl <sub>2</sub>                    | -26.5                                            |
| Antimony(III) iodide   | SbI <sub>3</sub>                                             | -147.2                                           | Beryllium hydroxide       | Be(OH) <sub>2</sub>                  | -23.1                                            |
| Antimony(III) oxide    | Sb <sub>2</sub> O <sub>3</sub>                               | -69.4                                            | Beryllium oxide           | BeO                                  | -11.9                                            |
| Antimony(III) sulfide  | Sb <sub>2</sub> S <sub>3</sub>                               | -86                                              | Beryllium sulfate         | BeSO <sub>4</sub>                    | -37                                              |
| Antimony(V) chloride   | SbCl <sub>5</sub>                                            | -120.5                                           | Bismuth                   | Bi                                   | -280.1                                           |
| Argon (g)              | Ar                                                           | -19.32                                           | Bismuth tribromide        | BiBr <sub>3</sub>                    | -147                                             |
| Arsenic (gray)         | As                                                           | -5.6                                             | Bismuth trichloride       | BiCl <sub>3</sub>                    | -26.5                                            |
| Arsenic (yellow)       | As                                                           | -23.2                                            | Bismuth fluoride          | BiF <sub>3</sub>                     | -61.2                                            |
| Arsine (g)             | AsH <sub>3</sub>                                             | -35.2                                            | Bismuth hydroxide         | Bi(OH) <sub>3</sub>                  | -65.8                                            |

| Name                            | Formula                                              | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Name                            | Formula                                                | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|---------------------------------|------------------------------------------------------|------------------------------------------------|---------------------------------|--------------------------------------------------------|------------------------------------------------|
| Bismuth triiodide               | $\text{BiI}_3$                                       | -200.5                                         | Cesium iodide                   | $\text{CsI}$                                           | -82.6                                          |
| Bismuth nitrate pentahydrate    | $\text{Bi}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$ | -159                                           | Cesium superoxide               | $\text{CsO}_2$                                         | +1534                                          |
| Bismuth oxide                   | $\text{Bi}_2\text{O}_3$                              | -83                                            | Cesium sulfate                  | $\text{Cs}_2\text{SO}_4$                               | -116                                           |
| Bismuth phosphate               | $\text{BiPO}_4$                                      | -77                                            | Chlorine (l)                    | $\text{Cl}_2$                                          | -40.4                                          |
| Bismuth sulfate                 | $\text{Bi}_2(\text{SO}_4)_3$                         | -199                                           | Chlorine trifluoride (g)        | $\text{ClF}_3$                                         | -26.5                                          |
| Bismuth sulfide                 | $\text{Bi}_2\text{S}_3$                              | -123                                           | Chromium                        | $\text{Cr}$                                            | +167                                           |
| Boron                           | $\text{B}$                                           | -6.7                                           | Chromium(II) chloride           | $\text{CrCl}_2$                                        | +7230                                          |
| Diborane (g)                    | $\text{B}_2\text{H}_6$                               | -21.0                                          | Chromium(III) chloride          | $\text{CrCl}_3$                                        | +6350                                          |
| Boric acid (orthoboric acid)    | $\text{H}_3\text{BO}_3$                              | -34.1                                          | Chromium(III) fluoride          | $\text{CrF}_3$                                         | +4370                                          |
| Boron trichloride               | $\text{BCl}_3$                                       | -59.9                                          | Chromium(III) oxide             | $\text{Cr}_2\text{O}_3$                                | +1960                                          |
| Boron oxide                     | $\text{B}_2\text{O}_3$                               | -38.7                                          | Chromium(III) sulfate           | $\text{Cr}_2(\text{SO}_4)_3$                           | +11800                                         |
| Bromine (l)                     | $\text{Br}_2$                                        | -56.4                                          | Chromium(VI) oxide              | $\text{CrO}_3$                                         | +40                                            |
| Bromine (g)                     | $\text{Br}_2$                                        | -73.5                                          | Cobalt                          | $\text{Co}$                                            | Ferro.                                         |
| Bromine trifluoride             | $\text{BrF}_3$                                       | -33.9                                          | Cobalt(II) bromide              | $\text{CoBr}_2$                                        | +13000                                         |
| Bromine pentafluoride           | $\text{BrF}_5$                                       | -45.1                                          | Cobalt(II) chloride             | $\text{CoCl}_2$                                        | +12660                                         |
| Cadmium                         | $\text{Cd}$                                          | -19.7                                          | Cobalt(II) chloride hexahydrate | $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$              | +9710                                          |
| Cadmium bromide                 | $\text{CdBr}_2$                                      | -87.3                                          | Cobalt(II) cyanide              | $\text{Co}(\text{CN})_2$                               | +3825                                          |
| Cadmium bromide tetrahydrate    | $\text{CdBr}_2 \cdot 4\text{H}_2\text{O}$            | -131.5                                         | Cobalt(II) fluoride             | $\text{CoF}_2$                                         | +9490                                          |
| Cadmium carbonate               | $\text{CdCO}_3$                                      | -46.7                                          | Cobalt(II) iodide               | $\text{CoI}_2$                                         | +10760                                         |
| Cadmium chloride                | $\text{CdCl}_2$                                      | -68.7                                          | Cobalt(II) sulfate              | $\text{CoSO}_4$                                        | +10000                                         |
| Cadmium chromate                | $\text{CdCrO}_4$                                     | -16.8                                          | Cobalt(II) sulfide              | $\text{CoS}$                                           | +225                                           |
| Cadmium cyanide                 | $\text{Cd}(\text{CN})_2$                             | -54                                            | Cobalt(II,III) oxide            | $\text{Co}_3\text{O}_4$                                | +7380                                          |
| Cadmium fluoride                | $\text{CdF}_2$                                       | -40.6                                          | Cobalt(III) fluoride            | $\text{CoF}_3$                                         | +1900                                          |
| Cadmium hydroxide               | $\text{Cd}(\text{OH})_2$                             | -41                                            | Cobalt(III) oxide               | $\text{Co}_2\text{O}_3$                                | +4560                                          |
| Cadmium iodate                  | $\text{Cd}(\text{IO}_3)_2$                           | -108.4                                         | Copper                          | $\text{Cu}$                                            | -5.46                                          |
| Cadmium iodide                  | $\text{CdI}_2$                                       | -117.2                                         | Copper(I) bromide               | $\text{CuBr}$                                          | -49                                            |
| Cadmium nitrate                 | $\text{Cd}(\text{NO}_3)_2$                           | -55.1                                          | Copper(I) chloride              | $\text{CuCl}$                                          | -40                                            |
| Cadmium nitrate tetrahydrate    | $\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ | -140                                           | Copper(I) cyanide               | $\text{CuCN}$                                          | -24                                            |
| Cadmium oxide                   | $\text{CdO}$                                         | -30                                            | Copper(I) iodide                | $\text{CuI}$                                           | -63                                            |
| Cadmium sulfate                 | $\text{CdSO}_4$                                      | -59.2                                          | Copper(I) oxide                 | $\text{Cu}_2\text{O}$                                  | -20                                            |
| Cadmium sulfide                 | $\text{CdS}$                                         | -50                                            | Copper(II) bromide              | $\text{CuBr}_2$                                        | +685                                           |
| Calcium                         | $\text{Ca}$                                          | +40                                            | Copper(II) chloride             | $\text{CuCl}_2$                                        | +1080                                          |
| Calcium bromide                 | $\text{CaBr}_2$                                      | -73.8                                          | Copper(II) chloride dihydrate   | $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$              | +1420                                          |
| Calcium carbonate               | $\text{CaCO}_3$                                      | -38.2                                          | Copper(II) fluoride             | $\text{CuF}_2$                                         | +1050                                          |
| Calcium chloride                | $\text{CaCl}_2$                                      | -54.7                                          | Copper(II) fluoride dihydrate   | $\text{CuF}_2 \cdot 2\text{H}_2\text{O}$               | +1600                                          |
| Calcium fluoride                | $\text{CaF}_2$                                       | -28                                            | Copper(II) hydroxide            | $\text{Cu}(\text{OH})_2$                               | +1170                                          |
| Calcium hydroxide               | $\text{Ca}(\text{OH})_2$                             | -22                                            | Copper(II) nitrate trihydrate   | $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$   | +1570                                          |
| Calcium iodate                  | $\text{Ca}(\text{IO}_3)_2$                           | -101.4                                         | Copper(II) nitrate hexahydrate  | $\text{Cu}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   | +1625                                          |
| Calcium iodide                  | $\text{CaI}_2$                                       | -109                                           | Copper(II) oxide                | $\text{CuO}$                                           | +238                                           |
| Calcium oxide                   | $\text{CaO}$                                         | -15.0                                          | Copper(II) sulfate              | $\text{CuSO}_4$                                        | +1330                                          |
| Calcium sulfate                 | $\text{CaSO}_4$                                      | -49.7                                          | Copper(II) sulfate pentahydrate | $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$              | +1460                                          |
| Calcium sulfate dihydrate       | $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$            | -74                                            | Copper(II) sulfide              | $\text{CuS}$                                           | -2.0                                           |
| Carbon (diamond)                | $\text{C}$                                           | -5.9                                           | Dysprosium ( $\alpha$ )         | $\text{Dy}$                                            | +98000                                         |
| Carbon (graphite)               | $\text{C}$                                           | -6.0                                           | Dysprosium(III) oxide           | $\text{Dy}_2\text{O}_3$                                | +89600                                         |
| Carbon monoxide (g)             | $\text{CO}$                                          | -11.8                                          | Dysprosium(III) sulfide         | $\text{Dy}_2\text{S}_3$                                | +95200                                         |
| Carbon dioxide (g)              | $\text{CO}_2$                                        | -21.0                                          | Erbium                          | $\text{Er}$                                            | +48000                                         |
| Cerium ( $\beta$ )              | $\text{Ce}$                                          | +2500                                          | Erbium oxide                    | $\text{Er}_2\text{O}_3$                                | +73920                                         |
| Cerium(II) sulfide              | $\text{CeS}$                                         | +2110                                          | Erbium sulfate octahydrate      | $\text{Er}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$ | +74600                                         |
| Cerium(III) chloride            | $\text{CeCl}_3$                                      | +2490                                          | Erbium sulfide                  | $\text{Er}_2\text{S}_3$                                | +77200                                         |
| Cerium(III) fluoride            | $\text{CeF}_3$                                       | +2190                                          | Europium                        | $\text{Eu}$                                            | +30900                                         |
| Cerium(III) sulfide             | $\text{Ce}_2\text{S}_3$                              | +5080                                          | Europium(II) bromide            | $\text{EuBr}_2$                                        | +26800                                         |
| Cerium(IV) oxide                | $\text{CeO}_2$                                       | +26                                            | Europium(II) chloride           | $\text{EuCl}_2$                                        | +26500                                         |
| Cerium(IV) sulfate tetrahydrate | $\text{Ce}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$ | -97                                            | Europium(II) fluoride           | $\text{EuF}_2$                                         | +23750                                         |
| Cesium                          | $\text{Cs}$                                          | +29                                            | Europium(II) iodide             | $\text{EuI}_2$                                         | +26000                                         |
| Cesium bromate                  | $\text{CsBrO}_3$                                     | -75.1                                          | Europium(II) sulfide            | $\text{EuS}$                                           | +23800                                         |
| Cesium bromide                  | $\text{CsBr}$                                        | -67.2                                          | Europium(III) oxide             | $\text{Eu}_2\text{O}_3$                                | +10100                                         |
| Cesium carbonate                | $\text{Cs}_2\text{CO}_3$                             | -103.6                                         | Europium(III) sulfate           | $\text{Eu}_2(\text{SO}_4)_3$                           | +10400                                         |
| Cesium chlorate                 | $\text{CsClO}_3$                                     | -65                                            | Fluorine                        | $\text{F}_2$                                           | -9.63                                          |
| Cesium chloride                 | $\text{CsCl}$                                        | -56.7                                          | Gadolinium (350 K)              | $\text{Gd}$                                            | +185000                                        |
| Cesium fluoride                 | $\text{CsF}$                                         | -44.5                                          | Gadolinium(III) chloride        | $\text{GdCl}_3$                                        | +27930                                         |

| Name                                | Formula                                                            | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Name                                | Formula                                                            | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|-------------------------------------|--------------------------------------------------------------------|------------------------------------------------|-------------------------------------|--------------------------------------------------------------------|------------------------------------------------|
| Gadolinium(III) oxide               | Gd <sub>2</sub> O <sub>3</sub>                                     | +53200                                         | Iron(II) chloride tetrahydrate      | FeCl <sub>2</sub> ·4H <sub>2</sub> O                               | +12900                                         |
| Gadolinium(III) sulfate octahydrate | Gd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·8H <sub>2</sub> O | +53280                                         | Iron(II) fluoride                   | FeF <sub>2</sub>                                                   | +9500                                          |
| Gadolinium(III) sulfide             | Gd <sub>2</sub> S <sub>3</sub>                                     | +55500                                         | Iron(II) iodide                     | FeI <sub>2</sub>                                                   | +13600                                         |
| Gallium                             | Ga                                                                 | -21.6                                          | Iron(II) oxide                      | FeO                                                                | +7200                                          |
| Gallium suboxide                    | Ga <sub>2</sub> O                                                  | -34                                            | Iron(II) sulfate                    | FeSO <sub>4</sub>                                                  | +12400                                         |
| Gallium(II) sulfide                 | GaS                                                                | -23                                            | Iron(II) sulfate monohydrate        | FeSO <sub>4</sub> ·H <sub>2</sub> O                                | +10500                                         |
| Gallium(III) chloride               | GaCl <sub>3</sub>                                                  | -63                                            | Iron(II) sulfate heptahydrate       | FeSO <sub>4</sub> ·7H <sub>2</sub> O                               | +11200                                         |
| Gallium(III) sulfide                | Ga <sub>2</sub> S <sub>3</sub>                                     | -80                                            | Iron(II) sulfide                    | FeS                                                                | +1074                                          |
| Germanium                           | Ge                                                                 | -11.6                                          | Iron(III) chloride                  | FeCl <sub>3</sub>                                                  | +13450                                         |
| Germane (g)                         | GeH <sub>4</sub>                                                   | -29.7                                          | Iron(III) chloride hexahydrate      | FeCl <sub>3</sub> ·6H <sub>2</sub> O                               | +15250                                         |
| Germanium(II) oxide                 | GeO                                                                | -28.8                                          | Iron(III) fluoride                  | FeF <sub>3</sub>                                                   | +13760                                         |
| Germanium(II) sulfide               | GeS                                                                | -40.9                                          | Iron(III) fluoride trihydrate       | FeF <sub>3</sub> ·3H <sub>2</sub> O                                | +7870                                          |
| Germanium(IV) chloride              | GeCl <sub>4</sub>                                                  | -72                                            | Iron(III) nitrate nonahydrate       | Fe(NO <sub>3</sub> ) <sub>3</sub> ·9H <sub>2</sub> O               | +15200                                         |
| Germanium(IV) fluoride              | GeF <sub>4</sub>                                                   | -50                                            | Krypton (g)                         | Kr                                                                 | -29.0                                          |
| Germanium(IV) iodide                | GeI <sub>4</sub>                                                   | -171                                           | Lanthanum (α)                       | La                                                                 | +95.9                                          |
| Germanium(IV) oxide                 | GeO <sub>2</sub>                                                   | -34.3                                          | Lanthanum oxide                     | La <sub>2</sub> O <sub>3</sub>                                     | -78                                            |
| Germanium(IV) sulfide               | GeS <sub>2</sub>                                                   | -53.9                                          | Lanthanum sulfate nonahydrate       | La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·9H <sub>2</sub> O | -262                                           |
| Gold                                | Au                                                                 | -28                                            | Lanthanum sulfide                   | La <sub>2</sub> S <sub>3</sub>                                     | -37                                            |
| Gold(I) bromide                     | AuBr                                                               | -61                                            | Lead                                | Pb                                                                 | -23                                            |
| Gold(I) chloride                    | AuCl                                                               | -67                                            | Lead(II) acetate                    | Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>     | -89.1                                          |
| Gold(I) iodide                      | AuI                                                                | -91                                            | Lead(II) bromide                    | PbBr <sub>2</sub>                                                  | -90.6                                          |
| Gold(III) chloride                  | AuCl <sub>3</sub>                                                  | -112                                           | Lead(II) carbonate                  | PbCO <sub>3</sub>                                                  | -61.2                                          |
| Hafnium                             | Hf                                                                 | +71                                            | Lead(II) chloride                   | PbCl <sub>2</sub>                                                  | -73.8                                          |
| Hafnium oxide                       | HfO <sub>2</sub>                                                   | -23                                            | Lead(II) chromate                   | PbCrO <sub>4</sub>                                                 | -18                                            |
| Helium (g)                          | He                                                                 | -2.02                                          | Lead(II) fluoride                   | PbF <sub>2</sub>                                                   | -58.1                                          |
| Holmium                             | Ho                                                                 | +72900                                         | Lead(II) iodate                     | Pb(IO <sub>3</sub> ) <sub>2</sub>                                  | -131                                           |
| Holmium oxide                       | Ho <sub>2</sub> O <sub>3</sub>                                     | +88100                                         | Lead(II) iodide                     | PbI <sub>2</sub>                                                   | -126.5                                         |
| Hydrazine (l)                       | N <sub>2</sub> H <sub>4</sub>                                      | -201                                           | Lead(II) nitrate                    | Pb(NO <sub>3</sub> ) <sub>2</sub>                                  | -74                                            |
| Hydrogen (l, 20.3 K)                | H <sub>2</sub>                                                     | -5.44                                          | Lead(II) oxide                      | PbO                                                                | -42                                            |
| Hydrogen (g)                        | H <sub>2</sub>                                                     | -3.99                                          | Lead(II) phosphate                  | Pb <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>                    | -182                                           |
| Hydrogen chloride (l)               | HCl                                                                | -22.6                                          | Lead(II) sulfate                    | PbSO <sub>4</sub>                                                  | -69.7                                          |
| Hydrogen chloride (aq)              | HCl                                                                | -22                                            | Lead(II) sulfide                    | PbS                                                                | -83.6                                          |
| Hydrogen fluoride (l)               | HF                                                                 | -8.6                                           | Lithium                             | Li                                                                 | +14.2                                          |
| Hydrogen fluoride (aq)              | HF                                                                 | -9.3                                           | Lithium bromide                     | LiBr                                                               | -34.3                                          |
| Hydrogen iodide (s, 195 K)          | HI                                                                 | -47.3                                          | Lithium carbonate                   | Li <sub>2</sub> CO <sub>3</sub>                                    | -27                                            |
| Hydrogen iodide (l, 233 K)          | HI                                                                 | -48.3                                          | Lithium chloride                    | LiCl                                                               | -24.3                                          |
| Hydrogen iodide (aq)                | HI                                                                 | -50.2                                          | Lithium fluoride                    | LiF                                                                | -10.1                                          |
| Hydrogen peroxide (l)               | H <sub>2</sub> O <sub>2</sub>                                      | -17.3                                          | Lithium hydride                     | LiH                                                                | -4.6                                           |
| Hydrogen sulfide (g)                | H <sub>2</sub> S                                                   | -25.5                                          | Lithium hydroxide (aq)              | LiOH                                                               | -12.3                                          |
| Indium                              | In                                                                 | -10.2                                          | Lithium iodide                      | LiI                                                                | -50                                            |
| Indium(I) chloride                  | InCl                                                               | -30                                            | Lithium sulfate                     | Li <sub>2</sub> SO <sub>4</sub>                                    | -41.6                                          |
| Indium(II) chloride                 | InCl <sub>2</sub>                                                  | -56                                            | Lutetium                            | Lu                                                                 | +182.9                                         |
| Indium(II) sulfide                  | InS                                                                | -28                                            | Magnesium                           | Mg                                                                 | +13.1                                          |
| Indium(III) bromide                 | InBr <sub>3</sub>                                                  | -107                                           | Magnesium bromide                   | MgBr <sub>2</sub>                                                  | -72                                            |
| Indium(III) chloride                | InCl <sub>3</sub>                                                  | -86                                            | Magnesium carbonate                 | MgCO <sub>3</sub>                                                  | -32.4                                          |
| Indium(III) oxide                   | In <sub>2</sub> O <sub>3</sub>                                     | -56                                            | Magnesium chloride                  | MgCl <sub>2</sub>                                                  | -47.4                                          |
| Indium(III) sulfide                 | In <sub>2</sub> S <sub>3</sub>                                     | -98                                            | Magnesium fluoride                  | MgF <sub>2</sub>                                                   | -22.7                                          |
| Iodine                              | I <sub>2</sub>                                                     | -90                                            | Magnesium hydroxide                 | Mg(OH) <sub>2</sub>                                                | -22.1                                          |
| Iodic acid                          | HIO <sub>3</sub>                                                   | -48                                            | Magnesium iodide                    | MgI <sub>2</sub>                                                   | -111                                           |
| Iodine pentoxide                    | I <sub>2</sub> O <sub>5</sub>                                      | -79.4                                          | Magnesium oxide                     | MgO                                                                | -10.2                                          |
| Iodine chloride                     | ICl                                                                | -54.6                                          | Magnesium sulfate                   | MgSO <sub>4</sub>                                                  | -42                                            |
| Iodine trichloride                  | ICl <sub>3</sub>                                                   | -90.2                                          | Magnesium sulfate monohydrate       | MgSO <sub>4</sub> ·H <sub>2</sub> O                                | -61                                            |
| Iodine pentafluoride                | IF <sub>5</sub>                                                    | -58.1                                          | Magnesium sulfate heptahydrate      | MgSO <sub>4</sub> ·7H <sub>2</sub> O                               | -135.7                                         |
| Iridium                             | Ir                                                                 | +25                                            | Manganese                           | Mn                                                                 | +511                                           |
| Iridium(III) chloride               | IrCl <sub>3</sub>                                                  | -14.4                                          | Manganese(II) bromide               | MnBr <sub>2</sub>                                                  | +13900                                         |
| Iridium(IV) oxide                   | IrO <sub>2</sub>                                                   | +224                                           | Manganese(II) carbonate             | MnCO <sub>3</sub>                                                  | +11400                                         |
| Iron                                | Fe                                                                 | Ferro.                                         | Manganese(II) chloride              | MnCl <sub>2</sub>                                                  | +14350                                         |
| Iron(II) bromide                    | FeBr <sub>2</sub>                                                  | +13600                                         | Manganese(II) chloride tetrahydrate | MnCl <sub>2</sub> ·4H <sub>2</sub> O                               | +14600                                         |
| Iron(II) carbonate                  | FeCO <sub>3</sub>                                                  | +11300                                         | Manganese(II) fluoride              | MnF <sub>2</sub>                                                   | +10700                                         |
| Iron(II) chloride                   | FeCl <sub>2</sub>                                                  | +14750                                         | Manganese(II) hydroxide             | Mn(OH) <sub>2</sub>                                                | +13500                                         |

| Name                               | Formula                                              | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Name                              | Formula                                               | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|------------------------------------|------------------------------------------------------|------------------------------------------------|-----------------------------------|-------------------------------------------------------|------------------------------------------------|
| Manganese(II) iodide               | MnI <sub>2</sub>                                     | +14400                                         | Niobium(V) oxide                  | Nb <sub>2</sub> O <sub>5</sub>                        | -10                                            |
| Manganese(II) oxide                | MnO                                                  | +4850                                          | Nitrogen (g)                      | N <sub>2</sub>                                        | -12.0                                          |
| Manganese(II) sulfate              | MnSO <sub>4</sub>                                    | +13660                                         | Nitric acid (l)                   | HNO <sub>3</sub>                                      | -19.9                                          |
| Manganese(II) sulfate monohydrate  | MnSO <sub>4</sub> ·H <sub>2</sub> O                  | +14200                                         | Nitrous oxide (g)                 | N <sub>2</sub> O                                      | -18.9                                          |
| Manganese(II) sulfate tetrahydrate | MnSO <sub>4</sub> ·4H <sub>2</sub> O                 | +14600                                         | Nitric oxide (s, 90 K)            | NO                                                    | +19.8                                          |
| Manganese(II) sulfide (α form)     | MnS                                                  | +5630                                          | Nitric oxide (l, 118 K)           | NO                                                    | +114.2                                         |
| Manganese(II) sulfide (β form)     | MnS                                                  | +3850                                          | Nitric oxide (g)                  | NO                                                    | +1461                                          |
| Manganese(II,III) oxide            | Mn <sub>3</sub> O <sub>4</sub>                       | +12400                                         | Nitrogen dioxide (g, 408 K)       | NO <sub>2</sub>                                       | +150                                           |
| Manganese(III) fluoride            | MnF <sub>3</sub>                                     | +10500                                         | Nitrogen trioxide (g)             | N <sub>2</sub> O <sub>3</sub>                         | -16                                            |
| Manganese(III) oxide               | Mn <sub>2</sub> O <sub>3</sub>                       | +14100                                         | Nitrogen tetroxide (g)            | N <sub>2</sub> O <sub>4</sub>                         | -23.0                                          |
| Manganese(IV) oxide                | MnO <sub>2</sub>                                     | +2280                                          | Osmium                            | Os                                                    | +11                                            |
| Mercury (s, 234 K)                 | Hg                                                   | -24.1                                          | Oxygen (s, 54 K)                  | O <sub>2</sub>                                        | +10200                                         |
| Mercury (l)                        | Hg                                                   | -33.5                                          | Oxygen (l, 90 K)                  | O <sub>2</sub>                                        | +7699                                          |
| Mercury(I) bromide                 | Hg <sub>2</sub> Br <sub>2</sub>                      | -105                                           | Oxygen (g)                        | O <sub>2</sub>                                        | +3415                                          |
| Mercury(I) chloride                | Hg <sub>2</sub> Cl <sub>2</sub>                      | -120                                           | Ozone (l)                         | O <sub>3</sub>                                        | +6.7                                           |
| Mercury(I) fluoride                | Hg <sub>2</sub> F <sub>2</sub>                       | -106                                           | Palladium                         | Pd                                                    | +540                                           |
| Mercury(I) iodide                  | Hg <sub>2</sub> I <sub>2</sub>                       | -166                                           | Palladium(II) chloride            | PdCl <sub>2</sub>                                     | -38                                            |
| Mercury(I) nitrate                 | Hg <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>      | -121                                           | Phosphorus (white)                | P                                                     | -26.66                                         |
| Mercury(I) oxide                   | Hg <sub>2</sub> O                                    | -76.3                                          | Phosphorus (red)                  | P                                                     | -20.77                                         |
| Mercury(I) sulfate                 | Hg <sub>2</sub> SO <sub>4</sub>                      | -123                                           | Phosphine (g)                     | PH <sub>3</sub>                                       | -26.2                                          |
| Mercury(II) bromide                | HgBr <sub>2</sub>                                    | -94.2                                          | Phosphoric acid (aq)              | H <sub>3</sub> PO <sub>4</sub>                        | -43.8                                          |
| Mercury(II) chloride               | HgCl <sub>2</sub>                                    | -82                                            | Phosphorous acid (aq)             | H <sub>3</sub> PO <sub>3</sub>                        | -42.5                                          |
| Mercury(II) cyanide                | Hg(CN) <sub>2</sub>                                  | -67                                            | Phosphorus(III) chloride (l)      | PCl <sub>3</sub>                                      | -63.4                                          |
| Mercury(II) fluoride               | HgF <sub>2</sub>                                     | -57.3                                          | Platinum                          | Pt                                                    | +193                                           |
| Mercury(II) iodide                 | HgI <sub>2</sub>                                     | -165                                           | Platinum(II) chloride             | PtCl <sub>2</sub>                                     | -54                                            |
| Mercury(II) nitrate                | Hg(NO <sub>3</sub> ) <sub>2</sub>                    | -74                                            | Platinum(III) chloride            | PtCl <sub>3</sub>                                     | -66.7                                          |
| Mercury(II) oxide                  | HgO                                                  | -46                                            | Platinum(IV) chloride             | PtCl <sub>4</sub>                                     | -93                                            |
| Mercury(II) sulfate                | HgSO <sub>4</sub>                                    | -78.1                                          | Platinum(IV) fluoride             | PtF <sub>4</sub>                                      | +445                                           |
| Mercury(II) sulfide                | HgS                                                  | -55.4                                          | Plutonium                         | Pu                                                    | +525                                           |
| Mercury(II) thiocyanate            | Hg(SCN) <sub>2</sub>                                 | -96.5                                          | Plutonium(IV) fluoride            | PuF <sub>4</sub>                                      | +1760                                          |
| Molybdenum                         | Mo                                                   | +72                                            | Plutonium(IV) oxide               | PuO <sub>2</sub>                                      | +730                                           |
| Molybdenum(III) bromide            | MoBr <sub>3</sub>                                    | +525                                           | Plutonium(VI) fluoride            | PuF <sub>6</sub>                                      | +173                                           |
| Molybdenum(III) chloride           | MoCl <sub>3</sub>                                    | +43                                            | Potassium                         | K                                                     | +20.8                                          |
| Molybdenum(III) oxide              | Mo <sub>2</sub> O <sub>3</sub>                       | -42.0                                          | Potassium bromate                 | KBrO <sub>3</sub>                                     | -52.6                                          |
| Molybdenum(IV) bromide             | MoBr <sub>4</sub>                                    | +520                                           | Potassium bromide                 | KBr                                                   | -49.1                                          |
| Molybdenum(IV) chloride            | MoCl <sub>4</sub>                                    | +1750                                          | Potassium carbonate               | K <sub>2</sub> CO <sub>3</sub>                        | -59                                            |
| Molybdenum(IV) oxide               | MoO <sub>2</sub>                                     | +41                                            | Potassium chlorate                | KClO <sub>3</sub>                                     | -42.8                                          |
| Molybdenum(V) chloride             | MoCl <sub>5</sub>                                    | +990                                           | Potassium chloride                | KCl                                                   | -38.8                                          |
| Molybdenum(VI) fluoride            | MoF <sub>6</sub>                                     | -26.0                                          | Potassium chromate                | K <sub>2</sub> CrO <sub>4</sub>                       | -3.9                                           |
| Molybdenum(VI) oxide               | MoO <sub>3</sub>                                     | +3                                             | Potassium cyanide                 | KCN                                                   | -37                                            |
| Neodymium (α)                      | Nd                                                   | +5930                                          | Potassium ferricyanide            | K <sub>3</sub> Fe(CN) <sub>6</sub>                    | +2290                                          |
| Neodymium fluoride                 | NdF <sub>3</sub>                                     | +4980                                          | Potassium ferrocyanide trihydrate | K <sub>4</sub> Fe(CN) <sub>6</sub> ·3H <sub>2</sub> O | -172.3                                         |
| Neodymium oxide                    | Nd <sub>2</sub> O <sub>3</sub>                       | +10200                                         | Potassium fluoride                | KF                                                    | -23.6                                          |
| Neodymium sulfate                  | Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>      | +9990                                          | Potassium hydrogen sulfate        | KHSO <sub>4</sub>                                     | -49.8                                          |
| Neodymium sulfide                  | Nd <sub>2</sub> S <sub>3</sub>                       | +5550                                          | Potassium hydroxide (aq)          | KOH                                                   | -22                                            |
| Neon (g)                           | Ne                                                   | -6.96                                          | Potassium iodate                  | KIO <sub>3</sub>                                      | -63.1                                          |
| Neptunium                          | Np                                                   | +575                                           | Potassium iodide                  | KI                                                    | -63.8                                          |
| Nickel                             | Ni                                                   | Ferro.                                         | Potassium nitrate                 | KNO <sub>3</sub>                                      | -33.7                                          |
| Nickel(II) bromide                 | NiBr <sub>2</sub>                                    | +5600                                          | Potassium nitrite                 | KNO <sub>2</sub>                                      | -23.3                                          |
| Nickel(II) chloride                | NiCl <sub>2</sub>                                    | +6145                                          | Potassium permanganate            | KMnO <sub>4</sub>                                     | +20                                            |
| Nickel(II) chloride hexahydrate    | NiCl <sub>2</sub> ·6H <sub>2</sub> O                 | +4240                                          | Potassium sulfate                 | K <sub>2</sub> SO <sub>4</sub>                        | -67                                            |
| Nickel(II) fluoride                | NiF <sub>2</sub>                                     | +2410                                          | Potassium sulfide                 | K <sub>2</sub> S                                      | -60                                            |
| Nickel(II) hydroxide               | Ni(OH) <sub>2</sub>                                  | +4500                                          | Potassium superoxide              | KO <sub>2</sub>                                       | +3230                                          |
| Nickel(II) iodide                  | NiI <sub>2</sub>                                     | +3875                                          | Potassium thiocyanate             | KSCN                                                  | -48                                            |
| Nickel(II) nitrate hexahydrate     | Ni(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O | +4300                                          | Praseodymium (α)                  | Pr                                                    | +5530                                          |
| Nickel(II) oxide                   | NiO                                                  | +660                                           | Praseodymium chloride             | PrCl <sub>3</sub>                                     | +44.5                                          |
| Nickel(II) sulfate                 | NiSO <sub>4</sub>                                    | +4005                                          | Praseodymium oxide                | Pr <sub>2</sub> O <sub>3</sub>                        | +8994                                          |
| Nickel(II) sulfide                 | NiS                                                  | +190                                           | Praseodymium sulfide              | Pr <sub>2</sub> S <sub>3</sub>                        | +10770                                         |
| Nickel(III) sulfide                | Ni <sub>3</sub> S <sub>2</sub>                       | +1030                                          | Protactinium                      | Pa                                                    | +277                                           |
| Niobium                            | Nb                                                   | +208                                           | Rhenium                           | Re                                                    | +67                                            |

| Name                              | Formula                                                            | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Name                           | Formula                                             | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|-----------------------------------|--------------------------------------------------------------------|------------------------------------------------|--------------------------------|-----------------------------------------------------|------------------------------------------------|
| Rhenium(IV) oxide                 | ReO <sub>2</sub>                                                   | +44                                            | Sodium carbonate               | Na <sub>2</sub> CO <sub>3</sub>                     | -41                                            |
| Rhenium(IV) sulfide               | ReS <sub>2</sub>                                                   | +38                                            | Sodium chlorate                | NaClO <sub>3</sub>                                  | -34.7                                          |
| Rhenium(V) chloride               | ReCl <sub>5</sub>                                                  | +1225                                          | Sodium chloride                | NaCl                                                | -30.2                                          |
| Rhenium(VI) oxide                 | ReO <sub>3</sub>                                                   | +16                                            | Sodium dichromate              | Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>      | +55                                            |
| Rhenium(VII) oxide                | Re <sub>2</sub> O <sub>7</sub>                                     | -16                                            | Sodium fluoride                | NaF                                                 | -15.6                                          |
| Rhodium                           | Rh                                                                 | +102                                           | Sodium hydrogen phosphate      | Na <sub>2</sub> HPO <sub>4</sub>                    | -56.6                                          |
| Rhodium(III) chloride             | RhCl <sub>3</sub>                                                  | -7.5                                           | Sodium hydroxide (aq)          | NaOH                                                | -15.8                                          |
| Rhodium(III) oxide                | Rh <sub>2</sub> O <sub>3</sub>                                     | +104                                           | Sodium iodate                  | NaIO <sub>3</sub>                                   | -53                                            |
| Rubidium                          | Rb                                                                 | +17                                            | Sodium iodide                  | NaI                                                 | -57                                            |
| Rubidium bromide                  | RbBr                                                               | -56.4                                          | Sodium nitrate                 | NaNO <sub>3</sub>                                   | -25.6                                          |
| Rubidium carbonate                | Rb <sub>2</sub> CO <sub>3</sub>                                    | -75.4                                          | Sodium nitrite                 | NaNO <sub>2</sub>                                   | -14.5                                          |
| Rubidium chloride                 | RbCl                                                               | -46                                            | Sodium oxide                   | Na <sub>2</sub> O                                   | -19.8                                          |
| Rubidium fluoride                 | RbF                                                                | -31.9                                          | Sodium peroxide                | Na <sub>2</sub> O <sub>2</sub>                      | -28.10                                         |
| Rubidium iodide                   | RbI                                                                | -72.2                                          | Sodium sulfate                 | Na <sub>2</sub> SO <sub>4</sub>                     | -52                                            |
| Rubidium nitrate                  | RbNO <sub>3</sub>                                                  | -41                                            | Sodium sulfate decahydrate     | Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O | -184                                           |
| Rubidium sulfate                  | Rb <sub>2</sub> SO <sub>4</sub>                                    | -88.4                                          | Sodium sulfide                 | Na <sub>2</sub> S                                   | -39                                            |
| Rubidium superoxide               | RbO <sub>2</sub>                                                   | +1527                                          | Sodium tetraborate             | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub>       | -85                                            |
| Ruthenium                         | Ru                                                                 | +39                                            | Strontium                      | Sr                                                  | +92                                            |
| Ruthenium(III) chloride           | RuCl <sub>3</sub>                                                  | +1998                                          | Strontium bromide              | SrBr <sub>2</sub>                                   | -86.6                                          |
| Ruthenium(IV) oxide               | RuO <sub>2</sub>                                                   | +162                                           | Strontium bromide hexahydrate  | SrBr <sub>2</sub> ·6H <sub>2</sub> O                | -160                                           |
| Samarium (α)                      | Sm                                                                 | +1278                                          | Strontium carbonate            | SrCO <sub>3</sub>                                   | -47                                            |
| Samarium(II) bromide              | SmBr <sub>2</sub>                                                  | +5337                                          | Strontium chlorate             | Sr(ClO <sub>3</sub> ) <sub>2</sub>                  | -73                                            |
| Samarium(III) bromide             | SmBr <sub>3</sub>                                                  | +972                                           | Strontium chloride             | SrCl <sub>2</sub>                                   | -61.5                                          |
| Samarium(III) oxide               | Sm <sub>2</sub> O <sub>3</sub>                                     | +1988                                          | Strontium chloride hexahydrate | SrCl <sub>2</sub> ·6H <sub>2</sub> O                | -145                                           |
| Samarium(III) sulfate octahydrate | Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·8H <sub>2</sub> O | +1710                                          | Strontium chromate             | SrCrO <sub>4</sub>                                  | -5.1                                           |
| Samarium(III) sulfide             | Sm <sub>2</sub> S <sub>3</sub>                                     | +3300                                          | Strontium fluoride             | SrF <sub>2</sub>                                    | -37.2                                          |
| Scandium (α)                      | Sc                                                                 | +295.2                                         | Strontium hydroxide            | Sr(OH) <sub>2</sub>                                 | -40                                            |
| Selenium                          | Se                                                                 | -25                                            | Strontium iodate               | Sr(IO <sub>3</sub> ) <sub>2</sub>                   | -108                                           |
| Selenium dioxide                  | SeO <sub>2</sub>                                                   | -27.2                                          | Strontium iodide               | SrI <sub>2</sub>                                    | -112                                           |
| Selenium bromide                  | Se <sub>2</sub> Br <sub>2</sub>                                    | -113                                           | Strontium nitrate              | Sr(NO <sub>3</sub> ) <sub>2</sub>                   | -57.2                                          |
| Selenium chloride (I)             | Se <sub>2</sub> Cl <sub>2</sub>                                    | -94.8                                          | Strontium oxide                | SrO                                                 | -35                                            |
| Selenium hexafluoride (g)         | SeF <sub>6</sub>                                                   | -51                                            | Strontium peroxide             | SrO <sub>2</sub>                                    | -32.3                                          |
| Silicon                           | Si                                                                 | -3.12                                          | Strontium sulfate              | SrSO <sub>4</sub>                                   | -57.9                                          |
| Silane (g)                        | SiH <sub>4</sub>                                                   | -20.4                                          | Sulfur (rhombic)               | S                                                   | -15.5                                          |
| Disilane (g)                      | Si <sub>2</sub> H <sub>6</sub>                                     | -37.3                                          | Sulfur (monoclinic)            | S                                                   | -14.9                                          |
| Tetramethylsilane (l)             | (CH <sub>3</sub> ) <sub>4</sub> Si                                 | -74.80                                         | Sulfuric acid (l)              | H <sub>2</sub> SO <sub>4</sub>                      | -39                                            |
| Tetraethylsilane (l)              | (C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> Si                   | -120.2                                         | Sulfur dioxide (g)             | SO <sub>2</sub>                                     | -18.2                                          |
| Tetrabromosilane (l)              | SiBr <sub>4</sub>                                                  | -126                                           | Sulfur trioxide (l)            | SO <sub>3</sub>                                     | -28.54                                         |
| Tetrachlorosilane (l)             | SiCl <sub>4</sub>                                                  | -87.5                                          | Sulfur chloride (l)            | SSCl <sub>2</sub>                                   | -62.2                                          |
| Silicon carbide                   | SiC                                                                | -12.8                                          | Sulfur dichloride (l)          | SCl <sub>2</sub>                                    | -49.4                                          |
| Silicon dioxide                   | SiO <sub>2</sub>                                                   | -29.6                                          | Sulfur hexafluoride (g)        | SF <sub>6</sub>                                     | -44                                            |
| Silver                            | Ag                                                                 | -19.5                                          | Thionyl chloride (l)           | SOCl <sub>2</sub>                                   | -44.3                                          |
| Silver(I) bromide                 | AgBr                                                               | -61                                            | Tantalum                       | Ta                                                  | +154                                           |
| Silver(I) carbonate               | Ag <sub>2</sub> CO <sub>3</sub>                                    | -80.90                                         | Tantalum(V) chloride           | TaCl <sub>5</sub>                                   | +140                                           |
| Silver(I) chloride                | AgCl                                                               | -49                                            | Tantalum(V) oxide              | Ta <sub>2</sub> O <sub>5</sub>                      | -32                                            |
| Silver(I) chromate                | Ag <sub>2</sub> CrO <sub>4</sub>                                   | -40                                            | Technetium                     | Tc                                                  | +115                                           |
| Silver(I) cyanide                 | AgCN                                                               | -43.2                                          | Tellurium                      | Te                                                  | -38                                            |
| Silver(I) fluoride                | AgF                                                                | -36.5                                          | Tellurium dibromide            | TeBr <sub>2</sub>                                   | -106                                           |
| Silver(I) iodide                  | AgI                                                                | -80                                            | Tellurium dichloride           | TeCl <sub>2</sub>                                   | -94                                            |
| Silver(I) nitrate                 | AgNO <sub>3</sub>                                                  | -45.7                                          | Tellurium hexafluoride (g)     | TeF <sub>6</sub>                                    | -66                                            |
| Silver(I) nitrite                 | AgNO <sub>2</sub>                                                  | -42                                            | Terbium (α)                    | Tb                                                  | +170000                                        |
| Silver(I) oxide                   | Ag <sub>2</sub> O                                                  | -134                                           | Terbium oxide                  | Tb <sub>2</sub> O <sub>3</sub>                      | +78340                                         |
| Silver(I) phosphate               | Ag <sub>3</sub> PO <sub>4</sub>                                    | -120                                           | Thallium                       | Tl                                                  | -50                                            |
| Silver(I) sulfate                 | Ag <sub>2</sub> SO <sub>4</sub>                                    | -92.90                                         | Thallium(I) bromate            | TlBrO <sub>3</sub>                                  | -75.9                                          |
| Silver(I) thiocyanate             | AgSCN                                                              | -61.8                                          | Thallium(I) bromide            | TlBr                                                | -63.9                                          |
| Silver(II) oxide                  | AgO                                                                | -19.6                                          | Thallium(I) carbonate          | Tl <sub>2</sub> CO <sub>3</sub>                     | -101.6                                         |
| Sodium                            | Na                                                                 | +16                                            | Thallium(I) chlorate           | TlClO <sub>3</sub>                                  | -65.5                                          |
| Sodium acetate                    | NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | -37.6                                          | Thallium(I) chloride           | TlCl                                                | -57.8                                          |
| Sodium bromate                    | NaBrO <sub>3</sub>                                                 | -44.2                                          | Thallium(I) chromate           | Tl <sub>2</sub> CrO <sub>4</sub>                    | -39.3                                          |
| Sodium bromide                    | NaBr                                                               | -41                                            | Thallium(I) cyanide            | TlCN                                                | -49                                            |



| Name                       | Formula                              | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ | Name                           | Formula                                              | $\chi_m/10^{-6} \text{ cm}^3 \text{ mol}^{-1}$ |
|----------------------------|--------------------------------------|------------------------------------------------|--------------------------------|------------------------------------------------------|------------------------------------------------|
| Thallium(I) fluoride       | TlF                                  | -44.4                                          | Uranium(IV) bromide            | U <sub>4</sub> Br <sub>4</sub>                       | +3530                                          |
| Thallium(I) iodate         | TlIO <sub>3</sub>                    | -86.8                                          | Uranium(IV) chloride           | UCl <sub>4</sub>                                     | +3680                                          |
| Thallium(I) iodide         | TlI                                  | -82.2                                          | Uranium(IV) fluoride           | UF <sub>4</sub>                                      | +3530                                          |
| Thallium(I) nitrate        | TlNO <sub>3</sub>                    | -56.5                                          | Uranium(IV) oxide              | UO <sub>2</sub>                                      | +2360                                          |
| Thallium(I) nitrite        | TlNO <sub>2</sub>                    | -50.8                                          | Uranium(VI) fluoride           | UF <sub>6</sub>                                      | +43                                            |
| Thallium(I) sulfate        | Tl <sub>2</sub> SO <sub>4</sub>      | -112.6                                         | Uranium(VI) oxide              | UO <sub>3</sub>                                      | +128                                           |
| Thallium(I) sulfide        | Tl <sub>2</sub> S                    | -88.8                                          | Vanadium                       | V                                                    | +285                                           |
| Thorium                    | Th                                   | +97                                            | Vanadium(II) bromide           | VBr <sub>2</sub>                                     | +3230                                          |
| Thorium(IV) oxide          | ThO <sub>2</sub>                     | -16                                            | Vanadium(II) chloride          | VCl <sub>2</sub>                                     | +2410                                          |
| Thulium                    | Tm                                   | +24700                                         | Vanadium(III) bromide          | VBr <sub>3</sub>                                     | +2910                                          |
| Thulium oxide              | Tm <sub>2</sub> O <sub>3</sub>       | +51444                                         | Vanadium(III) chloride         | VCl <sub>3</sub>                                     | +3030                                          |
| Tin (gray)                 | Sn                                   | -37.4                                          | Vanadium(III) fluoride         | VF <sub>3</sub>                                      | +2757                                          |
| Tin(II) chloride           | SnCl <sub>2</sub>                    | -69                                            | Vanadium(III) oxide            | V <sub>2</sub> O <sub>3</sub>                        | +1976                                          |
| Tin(II) chloride dihydrate | SnCl <sub>2</sub> ·2H <sub>2</sub> O | -91.4                                          | Vanadium(III) sulfide          | V <sub>2</sub> S <sub>3</sub>                        | +1560                                          |
| Tin(II) oxide              | SnO                                  | -19                                            | Vanadium(IV) chloride          | VCl <sub>4</sub>                                     | +1215                                          |
| Tin(IV) bromide            | SnBr <sub>4</sub>                    | -149                                           | Vanadium(IV) oxide             | VO <sub>2</sub>                                      | +99                                            |
| Tin(IV) chloride (I)       | SnCl <sub>4</sub>                    | -115                                           | Vanadium(V) oxide              | V <sub>2</sub> O <sub>5</sub>                        | +128                                           |
| Tin(IV) oxide              | SnO <sub>2</sub>                     | -41                                            | Water (s, 273 K)               | H <sub>2</sub> O                                     | -12.63                                         |
| Titanium                   | Ti                                   | +151                                           | Water (l, 293 K)               | H <sub>2</sub> O                                     | -12.96                                         |
| Titanium(II) bromide       | TiBr <sub>2</sub>                    | +720                                           | Water (l, 373 K)               | H <sub>2</sub> O                                     | -13.09                                         |
| Titanium(II) chloride      | TiCl <sub>2</sub>                    | +484                                           | Water (g, 373 K))              | H <sub>2</sub> O                                     | -13.1                                          |
| Titanium(II) iodide        | TiI <sub>2</sub>                     | +1790                                          | Xenon (g)                      | Xe                                                   | -45.5                                          |
| Titanium(II) sulfide       | TiS                                  | +432                                           | Ytterbium (β)                  | Yb                                                   | +67                                            |
| Titanium(III) bromide      | TiBr <sub>3</sub>                    | +660                                           | Yttrium (α)                    | Y                                                    | +187.7                                         |
| Titanium(III) chloride     | TiCl <sub>3</sub>                    | +1110                                          | Yttrium oxide                  | Y <sub>2</sub> O <sub>3</sub>                        | +44.4                                          |
| Titanium(III) fluoride     | TiF <sub>3</sub>                     | +1300                                          | Yttrium sulfide                | Y <sub>2</sub> S <sub>3</sub>                        | +100                                           |
| Titanium(III) oxide        | Ti <sub>2</sub> O <sub>3</sub>       | +132                                           | Zinc                           | Zn                                                   | -9.15                                          |
| Titanium(IV) chloride      | TiCl <sub>4</sub>                    | -54                                            | Zinc carbonate                 | ZnCO <sub>3</sub>                                    | -34                                            |
| Titanium(IV) oxide         | TiO <sub>2</sub>                     | +5.9                                           | Zinc chloride                  | ZnCl <sub>2</sub>                                    | -55.33                                         |
| Tungsten                   | W                                    | +53                                            | Zinc cyanide                   | Zn(CN) <sub>2</sub>                                  | -46                                            |
| Tungsten carbide           | WC                                   | +10                                            | Zinc fluoride                  | ZnF <sub>2</sub>                                     | -34.3                                          |
| Tungsten(II) chloride      | WCl <sub>2</sub>                     | -25                                            | Zinc hydroxide                 | Zn(OH) <sub>2</sub>                                  | -67                                            |
| Tungsten(IV) oxide         | WO <sub>2</sub>                      | +57                                            | Zinc iodide                    | ZnI <sub>2</sub>                                     | -108                                           |
| Tungsten(IV) sulfide       | WS <sub>2</sub>                      | +5850                                          | Zinc oxide                     | ZnO                                                  | -27.2                                          |
| Tungsten(V) bromide        | WBr <sub>5</sub>                     | +270                                           | Zinc phosphate                 | Zn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>      | -141                                           |
| Tungsten(V) chloride       | WCl <sub>5</sub>                     | +387                                           | Zinc sulfate                   | ZnSO <sub>4</sub>                                    | -47.8                                          |
| Tungsten(VI) chloride      | WCl <sub>6</sub>                     | -71                                            | Zinc sulfate monohydrate       | ZnSO <sub>4</sub> ·H <sub>2</sub> O                  | -63                                            |
| Tungsten(VI) fluoride (g)  | WF <sub>6</sub>                      | -53                                            | Zinc sulfate heptahydrate      | ZnSO <sub>4</sub> ·7H <sub>2</sub> O                 | -138                                           |
| Tungsten(VI) oxide         | WO <sub>3</sub>                      | -15.8                                          | Zinc sulfide                   | ZnS                                                  | -25                                            |
| Uranium                    | U                                    | +409                                           | Zirconium                      | Zr                                                   | +120                                           |
| Uranium(III) bromide       | UBr <sub>3</sub>                     | +4740                                          | Zirconium carbide              | ZrC                                                  | -26                                            |
| Uranium(III) chloride      | UCl <sub>3</sub>                     | +3460                                          | Zirconium nitrate pentahydrate | Zr(NO <sub>3</sub> ) <sub>4</sub> ·5H <sub>2</sub> O | -77                                            |
| Uranium(III) hydride       | UH <sub>3</sub>                      | +6244                                          | Zirconium(IV) oxide            | ZrO <sub>2</sub>                                     | -13.8                                          |
| Uranium(III) iodide        | UI <sub>3</sub>                      | +4460                                          |                                |                                                      |                                                |

# INDEX OF REFRACTION OF INORGANIC LIQUIDS

This table gives the index of refraction  $n$  of several inorganic substances in the liquid state at specified temperatures. The measurements refer to ambient atmospheric pressure except for substances whose normal boiling points are greater than the indicated temperature; in this case the pressure is the saturated vapor pressure of the substance. All values refer to a wavelength of 589 nm unless otherwise indicated. Entries are arranged in alphabetical order by chemical formula as normally written.

Data on the index of refraction at other temperatures and wavelengths may be found in Reference 1.

## References

1. Wohlfarth, C., and Wohlfarth, B., *Landolt-Börnstein, Numerical Data and Functional Relationships in Science and Technology, New Series*, III/38A, Martienssen, W., Editor, Springer-Verlag, Heidelberg, 1996.
2. Francis, A.W., *J. Chem. Eng. Data*, 5, 534, 1960.

| Formula                          | Name                   | $t/^{\circ}\text{C}$ | $n$                 |
|----------------------------------|------------------------|----------------------|---------------------|
| Ar                               | Argon                  | -188                 | 1.2312              |
| AsCl <sub>3</sub>                | Arsenic(III) chloride  | 16                   | 1.604               |
| BBr <sub>3</sub>                 | Boron tribromide       | 16                   | 1.312               |
| BrF <sub>3</sub>                 | Bromine trifluoride    | 25                   | 1.4536              |
| BrF <sub>5</sub>                 | Bromine pentafluoride  | 25                   | 1.3529              |
| Br <sub>2</sub>                  | Bromine                | 15                   | 1.659               |
| COS                              | Carbon oxysulfide      | 25                   | 1.3506              |
| CO <sub>2</sub>                  | Carbon dioxide         | 24                   | 1.6630              |
| CS <sub>2</sub>                  | Carbon disulfide       | 20                   | 1.62774             |
| C <sub>3</sub> O <sub>2</sub>    | Carbon suboxide        | 0                    | 1.453               |
| Cl <sub>2</sub>                  | Chlorine               | 20                   | 1.3834              |
| CrO <sub>2</sub> Cl <sub>2</sub> | Chromyl chloride       | 23                   | 1.524               |
| Fe(CO) <sub>5</sub>              | Iron pentacarbonyl     | 14                   | 1.523               |
| GeBr <sub>4</sub>                | Germanium(IV) bromide  | 26                   | 1.6269              |
| GeCl <sub>4</sub>                | Germanium(IV) chloride | 25                   | 1.4614              |
| HBr                              | Hydrogen bromide       | 10                   | 1.325               |
| HCN                              | Hydrogen cyanide       | 20                   | 1.26136             |
| HCl                              | Hydrogen chloride      | 18                   | 1.3287 <sup>a</sup> |
| HClO <sub>4</sub>                | Perchloric acid        | 50                   | 1.3819              |
| HF                               | Hydrogen fluoride      | 25                   | 1.1574              |
| HI                               | Hydrogen iodide        | 16                   | 1.466               |
| HNO <sub>3</sub>                 | Nitric acid            | 25                   | 1.393               |
| H <sub>2</sub>                   | Hydrogen               | -253                 | 1.1096              |
| H <sub>2</sub> O                 | Water                  | 20                   | 1.33336             |
| H <sub>2</sub> O <sub>2</sub>    | Hydrogen peroxide      | 28                   | 1.4061              |
| H <sub>2</sub> S                 | Hydrogen sulfide       | -80                  | 1.460               |
|                                  |                        | 20                   | 1.3682              |
| H <sub>2</sub> SO <sub>4</sub>   | Sulfuric acid          | 20                   | 1.4183              |
| H <sub>2</sub> S <sub>2</sub>    | Hydrogen disulfide     | 20                   | 1.630               |

| Formula                         | Name                     | $t/^{\circ}\text{C}$ | $n$                  |
|---------------------------------|--------------------------|----------------------|----------------------|
| He                              | Helium                   | -269                 | 1.02451 <sup>c</sup> |
| Kr                              | Krypton                  | -157                 | 1.3032 <sup>c</sup>  |
| NH <sub>3</sub>                 | Ammonia                  | -77                  | 1.3944 <sup>b</sup>  |
|                                 |                          | 20                   | 1.3327               |
| NO                              | Nitric oxide             | -90                  | 1.330                |
| N <sub>2</sub>                  | Nitrogen                 | -196                 | 1.19876 <sup>b</sup> |
| N <sub>2</sub> H <sub>4</sub>   | Hydrazine                | 22                   | 1.470                |
| N <sub>2</sub> O                | Nitrous oxide            | 25                   | 1.238                |
| O <sub>2</sub>                  | Oxygen                   | -183                 | 1.2243 <sup>c</sup>  |
| PBr <sub>3</sub>                | Phosphorus(III) bromide  | 25                   | 1.687                |
| PCl <sub>3</sub>                | Phosphorus(III) chloride | 21                   | 1.5122               |
| PH <sub>3</sub>                 | Phosphine                | 17                   | 1.317                |
| P <sub>2</sub> O <sub>3</sub>   | Phosphorus(III) oxide    | 27                   | 1.540                |
| S                               | Sulfur                   | 125                  | 1.9170               |
| SCl <sub>2</sub>                | Sulfur dichloride        | 14                   | 1.557                |
| SF <sub>6</sub>                 | Sulfur hexafluoride      | 25                   | 1.167                |
| SOCl <sub>2</sub>               | Thionyl chloride         | 10                   | 1.527                |
| SO <sub>2</sub>                 | Sulfur dioxide           | 25                   | 1.3396               |
| SO <sub>2</sub> Cl <sub>2</sub> | Sulfuryl chloride        | 12                   | 1.444                |
| SO <sub>3</sub>                 | Sulfur trioxide          | 20                   | 1.40965              |
| SSCl <sub>2</sub>               | Sulfur chloride          | 20                   | 1.671                |
| SbCl <sub>5</sub>               | Antimony(V) chloride     | 22                   | 1.5925               |
| SiBr <sub>4</sub>               | Tetrabromosilane         | 31                   | 1.5685               |
| SiCl <sub>4</sub>               | Tetrachlorosilane        | 25                   | 1.41156              |
| SnBr <sub>4</sub>               | Tin(IV) bromide          | 31                   | 1.6628               |
| SnCl <sub>4</sub>               | Tin(IV) chloride         | 25                   | 1.5086               |
| TiCl <sub>4</sub>               | Titanium(IV) chloride    | 18                   | 1.6076               |
| Xe                              | Xenon                    | -112                 | 1.3918 <sup>c</sup>  |

<sup>a</sup> At 581 nm

<sup>b</sup> At 578 nm

<sup>c</sup> At 546 nm

# PHYSICAL AND OPTICAL PROPERTIES OF MINERALS

The chemical formula, crystal system, density, hardness, and index of refraction of some common minerals are given in this table. Entries are arranged alphabetically by mineral name. The columns are:

- ♦ **Formula:** Chemical formula for a typical sample of the mineral. Composition often varies considerably with the origin of the sample.
- ♦ **Crystal system:** tricl = triclinic; monocl = monoclinic; orth = orthorhombic; tetr = tetragonal; hex = hexagonal; rhomb = rhombohedral; cub = cubic.
- ♦ **Density:** Typical density in g/cm<sup>3</sup>. Individual samples may vary by a few percent.
- ♦ **Hardness:** On the Mohs' scale (range of 1 to 10, with talc = 1 and diamond = 10).
- ♦ **Index of refraction:** Values are given for the three coordinate axes in the order of least, intermediate, and greatest

index. For cubic crystals there is only a single value. See Reference 1 for details on the axis systems. Variations of several percent, depending on the origin and exact composition of the sample, are common.

## References

1. Deer, W. A., Howie, R. A., and Zussman, J., *An Introduction to the Rock-Forming Minerals*, 2nd Edition, Longman Scientific & Technical, Harlow, Essex, 1992.
2. Carmichael, R. S., *Practical Handbook of Physical Properties of Rocks and Minerals*, CRC Press, Boca Raton, FL, 1989.
3. Donnay, J. D. H., and Ondik, H. M., *Crystal Data Determinative Tables, Third Edition, Volume 2, Inorganic Compounds*, Joint Committee on Powder Diffraction Standards, Swarthmore, PA, 1973.

| Name          | Formula                                                                                                    | Crystal system | Density g/cm <sup>3</sup> | Hardness | Index of refraction |           |            |
|---------------|------------------------------------------------------------------------------------------------------------|----------------|---------------------------|----------|---------------------|-----------|------------|
|               |                                                                                                            |                |                           |          | $n_\alpha$          | $n_\beta$ | $n_\gamma$ |
| Acanthite     | Ag <sub>2</sub> S                                                                                          | orth           | 7.2                       | 2.3      |                     |           |            |
| Actinolite    | Ca <sub>2</sub> (Mg,Fe) <sub>5</sub> Si <sub>8</sub> O <sub>22</sub> (OH,F) <sub>2</sub>                   | monocl         | 3.23                      | 5.5      | 1.624               | 1.655     | 1.664      |
| Aegirine      | NaFe(SiO <sub>3</sub> ) <sub>2</sub>                                                                       | monocl         | 3.58                      | 6        | 1.763               | 1.800     | 1.815      |
| Akermanite    | Ca <sub>2</sub> MgSi <sub>2</sub> O <sub>7</sub>                                                           | tetr           | 2.94                      | 5.5      | 1.632               | 1.640     |            |
| Alabandite    | MnS                                                                                                        | cub            | 4.0                       | 3.8      |                     |           |            |
| Albite        | NaAlSi <sub>3</sub> O <sub>8</sub>                                                                         | tricl          | 2.63                      | 6.3      | 1.527               | 1.531     | 1.538      |
| Allanite      | (Ca,Mn,Ce,La,Y,Th) <sub>2</sub> (Fe,Ti)(Al,Fe)O·OH<br>(Si <sub>2</sub> O <sub>7</sub> )(SiO <sub>4</sub> ) | monocl         | 3.8                       | 5.8      | 1.75                | 1.78      | 1.80       |
| Allemontite   | SbAs                                                                                                       | hex            | 6.0                       | 3.5      |                     |           |            |
| Almandine     | Fe <sub>3</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                                            | cub            | 4.32                      | 6.8      | 1.830               |           |            |
| Altaite       | PbTe                                                                                                       | cub            | 8.16                      | 3        |                     |           |            |
| Aluminite     | Al <sub>2</sub> (SO <sub>4</sub> )(OH) <sub>4</sub> ·7H <sub>2</sub> O                                     | monocl         | 1.74                      | 1.5      | 1.459               | 1.464     | 1.470      |
| Alunite       | (K,Na)Al <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> (OH) <sub>6</sub>                                    | rhomb          | 2.8                       | 3.8      | 1.572               | 1.592     |            |
| Alunogen      | Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·18H <sub>2</sub> O                                        | monocl         | 1.69                      | 1.8      | 1.467               | 1.47      | 1.478      |
| Amblygonite   | (Li,Na)Al(PO <sub>4</sub> )(F,OH)                                                                          | tricl          | 3.1                       | 5.8      | 1.591               | 1.604     | 1.613      |
| Analcite      | NaAlSi <sub>2</sub> O <sub>6</sub> ·H <sub>2</sub> O                                                       | cub            | 2.27                      | 5.5      | 1.486               |           |            |
| Anatase       | TiO <sub>2</sub>                                                                                           | tetr           | 4.23                      | 5.8      | 2.488               | 2.561     |            |
| Andalusite    | Al <sub>2</sub> OSiO <sub>4</sub>                                                                          | orth           | 3.15                      | 7.5      | 1.635               | 1.639     | 1.644      |
| Andesine      | NaAlSi <sub>3</sub> O <sub>8</sub> ·CaAl <sub>2</sub> Si <sub>2</sub> O <sub>8</sub>                       | tricl          | 2.67                      | 6.3      | 1.550               | 1.553     | 1.557      |
| Andorite      | PbAgSb <sub>3</sub> S <sub>6</sub>                                                                         | rhomb          | 5.35                      | 3.3      |                     |           |            |
| Andradite     | Ca <sub>3</sub> (Fe,Ti) <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                                       | cub            | 3.86                      | 6.8      | 1.887               |           |            |
| Anglesite     | PbSO <sub>4</sub>                                                                                          | orth           | 6.29                      | 2.8      | 1.877               | 1.883     | 1.894      |
| Anhydrite     | CaSO <sub>4</sub>                                                                                          | orth           | 2.96                      | 3.5      | 1.570               | 1.575     | 1.614      |
| Ankerite      | Ca(Fe,Mg,Mn)(CO <sub>3</sub> ) <sub>2</sub>                                                                | rhomb          | 3.0                       | 3.8      | 1.529               | 1.720     |            |
| Anorthite     | CaAl <sub>2</sub> Si <sub>2</sub> O <sub>8</sub>                                                           | tricl          | 2.76                      | 6.3      | 1.577               | 1.585     | 1.590      |
| Anorthoclase  | (Na,K)AlSi <sub>3</sub> O <sub>8</sub>                                                                     | tricl          | 2.58                      | 6        | 1.523               | 1.528     | 1.529      |
| Anthophyllite | (Mg,Fe) <sub>7</sub> Si <sub>8</sub> O <sub>22</sub> (OH,F) <sub>2</sub>                                   | rhomb          | 3.21                      | 5.8      | 1.645               | 1.658     | 1.668      |
| Apatite       | Ca <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> (OH,F,Cl)                                                  | hex            | 3.2                       | 5        | 1.645               | 1.648     |            |
| Apophyllite   | KFCa <sub>4</sub> Si <sub>8</sub> O <sub>20</sub> ·8H <sub>2</sub> O                                       | tetr           | 2.35                      | 4.8      | 1.535               | 1.536     |            |
| Aragonite     | CaCO <sub>3</sub>                                                                                          | orth           | 2.83                      | 3.5      | 1.531               | 1.680     | 1.686      |
| Arcanite      | K <sub>2</sub> SO <sub>4</sub>                                                                             | orth           | 2.66                      |          | 1.494               | 1.494     | 1.497      |
| Argentite     | Ag <sub>2</sub> S                                                                                          | orth           | 7.2                       | 2.3      |                     |           |            |
| Arsenolite    | As <sub>2</sub> O <sub>3</sub>                                                                             | cub            | 3.86                      | 1.5      | 1.755               |           |            |
| Arsenopyrite  | FeAsS                                                                                                      | monocl         | 6.1                       | 5.8      |                     |           |            |
| Atacamite     | Cu <sub>2</sub> (OH) <sub>3</sub> Cl                                                                       | rhomb          | 3.76                      | 3.3      | 1.831               | 1.861     | 1.880      |
| Augelite      | Al <sub>2</sub> (PO <sub>4</sub> )(OH) <sub>3</sub>                                                        | monocl         | 2.70                      | 4.8      | 1.574               | 1.576     | 1.588      |
| Augite        | (Ca,Mg,Fe,Ti,Al) <sub>2</sub> (Si,Al) <sub>2</sub> O <sub>6</sub>                                          | monocl         | 3.38                      | 6        | 1.703               | 1.707     | 1.738      |
| Autunite      | Ca(UO <sub>2</sub> ) <sub>2</sub> (PO <sub>4</sub> ) <sub>2</sub> ·10H <sub>2</sub> O                      | tetr           | 3.2                       | 2.3      | 1.553               | 1.577     |            |
| Axinite       | (Ca,Mn,Fe) <sub>3</sub> Al <sub>2</sub> BO <sub>3</sub> Si <sub>4</sub> O <sub>12</sub> (OH)               | tricl          | 3.31                      | 6.8      | 1.684               | 1.691     | 1.694      |



| Name          | Formula                                                                                                                                         | Crystal system | Density g/cm <sup>3</sup> | Hardness | Index of refraction |           |            |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------|----------|---------------------|-----------|------------|
|               |                                                                                                                                                 |                |                           |          | $n_\alpha$          | $n_\beta$ | $n_\gamma$ |
| Azurite       | $\text{Cu}_3(\text{OH})_2(\text{CO}_3)_2$                                                                                                       | monocl         | 3.77                      | 3.8      | 1.730               | 1.758     | 1.838      |
| Baddeleyite   | $\text{ZrO}_2$                                                                                                                                  | monocl         | 5.7                       | 6.5      | 2.13                | 2.19      | 2.20       |
| Barite        | $\text{BaSO}_4$                                                                                                                                 | orth           | 4.49                      | 3.3      | 1.636               | 1.637     | 1.648      |
| Benitoite     | $\text{BaTi}(\text{SiO}_3)_3$                                                                                                                   | rhomb          | 3.65                      | 6.3      | 1.757               | 1.804     |            |
| Bertrandite   | $\text{Be}_4\text{Si}_2\text{O}_7(\text{OH})_2$                                                                                                 | rhomb          | 2.6                       | 6        | 1.589               | 1.602     | 1.613      |
| Beryl         | $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$                                                                                                        | hex            | 2.64                      | 7.8      | 1.582               | 1.589     |            |
| Beryllonite   | $\text{NaBe}(\text{PO})_4$                                                                                                                      | monocl         | 2.81                      | 5.8      | 1.552               | 1.558     | 1.561      |
| Biotite       | $\text{K}(\text{Mg},\text{Fe})_3\text{AlSi}_3\text{O}_{10}(\text{OH},\text{F})_2$                                                               | monocl         | 3.0                       | 2.8      | 1.595               | 1.651     | 1.651      |
| Bismuthinite  | $\text{Bi}_2\text{S}_3$                                                                                                                         | orth           | 6.78                      | 2        |                     |           |            |
| Bixbyite      | $(\text{Mn},\text{Fe})_2\text{O}_3$                                                                                                             | cub            | 4.95                      | 6.3      |                     |           |            |
| Bloedite      | $\text{Na}_2\text{Mg}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$                                                                                 | monocl         | 2.25                      | 2.8      | 1.483               | 1.486     | 1.487      |
| Boehmite      | $\text{AlO}(\text{OH})$                                                                                                                         | orth           | 3.44                      | 3.8      | 1.64                | 1.65      | 1.66       |
| Boracite      | $\text{Mg}_3\text{B}_7\text{O}_{13}\text{Cl}$                                                                                                   | rhomb          | 2.94                      | 7.3      | 1.66                | 1.66      | 1.67       |
| Borax         | $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$                                                                                    | monocl         | 1.73                      | 2.3      | 1.447               | 1.469     | 1.472      |
| Bornite       | $\text{Cu}_5\text{FeS}_4$                                                                                                                       | cub            | 5.07                      | 3        |                     |           |            |
| Boulangerite  | $\text{Pb}_5\text{Sb}_4\text{S}_{11}$                                                                                                           | monocl         | 6.1                       | 2.8      |                     |           |            |
| Bournonite    | $\text{PbCuSbS}_3$                                                                                                                              | rhomb          | 5.83                      | 2.8      |                     |           |            |
| Braggite      | $\text{PtS}$                                                                                                                                    | tetr           | 10.2                      |          |                     |           |            |
| Braunite      | $(\text{Mn},\text{Si})_2\text{O}_3$                                                                                                             | tetr           | 4.78                      | 6.3      |                     |           |            |
| Bravoite      | $(\text{Ni},\text{Fe})\text{S}_2$                                                                                                               | cub            | 4.62                      | 5.8      |                     |           |            |
| Breithauptite | $\text{NiSb}$                                                                                                                                   | hex            | ≈8.7                      | 5.5      |                     |           |            |
| Brochantite   | $\text{Cu}_4(\text{SO}_4)(\text{OH})_6$                                                                                                         | monocl         | 3.79                      | 3.8      | 1.728               | 1.771     | 1.800      |
| Bromyrite     | $\text{AgBr}$                                                                                                                                   | cub            | 6.47                      | 2.5      | 2.253               |           |            |
| Brookite      | $\text{TiO}_2$                                                                                                                                  | orth           | 4.23                      | 5.8      | 2.583               | 2.584     | 2.700      |
| Brucite       | $\text{Mg}(\text{OH})_2$                                                                                                                        | hex            | 2.37                      | 2.5      | 1.575               | 1.59      |            |
| Bunsenite     | $\text{NiO}$                                                                                                                                    | cub            | 6.72                      | 5.5      |                     |           |            |
| Cacoxenite    | $\text{Fe}_4(\text{PO}_4)_3(\text{OH})_3 \cdot 12\text{H}_2\text{O}$                                                                            | hex            | 2.3                       | 3.5      | 1.580               | 1.646     |            |
| Calcite       | $\text{CaCO}_3$                                                                                                                                 | hex            | 2.71                      | 3        | 1.486               | 1.658     |            |
| Caledonite    | $\text{Cu}_2\text{Pb}_5(\text{SO}_4)_3(\text{CO}_3)(\text{OH})_6$                                                                               | rhomb          | 5.76                      | 2.8      | 1.818               | 1.866     | 1.909      |
| Calomel       | $\text{Hg}_2\text{Cl}_2$                                                                                                                        | tetr           | 7.16                      | 1.5      | 1.973               | 2.656     |            |
| Cancrinite    | $(\text{Na},\text{Ca},\text{K})_7[\text{Al}_6\text{Si}_6\text{O}_{24}](\text{CO}_3,\text{SO}_4,\text{Cl},\text{OH})_2 \cdot \text{H}_2\text{O}$ | hex            | 2.42                      | 5.5      | 1.495               | 1.509     |            |
| Carnalite     | $\text{KMgCl}_3 \cdot 6\text{H}_2\text{O}$                                                                                                      | rhomb          | 1.60                      | 2.5      | 1.466               | 1.475     | 1.494      |
| Carnotite     | $\text{K}_2(\text{UO}_2)_2(\text{VO}_4)_2 \cdot 3\text{H}_2\text{O}$                                                                            | rhomb          |                           | 1.5      | 1.75                | 1.92      | 1.95       |
| Cassiterite   | $\text{SnO}_2$                                                                                                                                  | tetr           | 6.85                      | 6.5      | 2.006               | 2.097     |            |
| Celestite     | $\text{SrSO}_4$                                                                                                                                 | orth           | 3.96                      | 3.3      | 1.622               | 1.624     | 1.631      |
| Celsian       | $\text{BaAl}_2\text{Si}_2\text{O}_8$                                                                                                            | monocl         | 3.25                      | 6.3      | 1.583               | 1.588     | 1.594      |
| Cerargyrite   | $\text{AgCl}$                                                                                                                                   | cub            | 5.56                      | 2.5      | 2.071               |           |            |
| Cerussite     | $\text{PbCO}_3$                                                                                                                                 | orth           | 6.6                       | 3.3      | 1.804               | 2.076     | 2.079      |
| Cervantite    | $\text{Sb}_2\text{O}_4$                                                                                                                         | orth           | 6.64                      | 4.5      |                     |           |            |
| Chabazite     | $\text{Ca}[\text{Al}_2\text{Si}_4\text{O}_{12}] \cdot 6\text{H}_2\text{O}$                                                                      | trig           | 2.08                      | 4.5      | 1.482               |           |            |
| Chalcanthite  | $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$                                                                                                       | tricl          | 2.29                      | 2.5      | 1.514               | 1.537     | 1.543      |
| Chalcocite    | $\text{Cu}_2\text{S}$                                                                                                                           | orth           | 5.6                       | 2.8      |                     |           |            |
| Chalcopyrite  | $\text{CuFeS}_2$                                                                                                                                | tetr           | 4.2                       | 3.8      |                     |           |            |
| Chiolite      | $\text{Na}_5\text{Al}_3\text{F}_{14}$                                                                                                           | tetr           | 3.00                      | 3.8      | 1.342               | 1.349     |            |
| Chlorite      | $(\text{Mg},\text{Al},\text{Fe})_{12}(\text{Si},\text{Al})_8\text{O}_{20}(\text{OH})_{16}$                                                      | monocl         | 3.0                       | 2.5      | 1.61                | 1.62      | 1.62       |
| Chloritoid    | $\text{FeAl}_4\text{O}_2(\text{SiO}_4)_2(\text{OH})_4$                                                                                          | monocl         | 3.66                      | 6.5      | 1.717               | 1.721     | 1.726      |
| Chondrodite   | $\text{Mg}(\text{OH},\text{F})_2 \cdot 2\text{Mg}_2\text{SiO}_4$                                                                                | monocl         | 3.21                      | 6.5      | 1.604               | 1.615     | 1.634      |
| Chromite      | $\text{FeCr}_2\text{O}_4$                                                                                                                       | cub            | 5.0                       | 5.5      | 2.16                |           |            |
| Chrysoberyl   | $\text{BeAl}_2\text{O}_4$                                                                                                                       | orth           | 3.65                      | 8.5      | 1.746               | 1.748     | 1.756      |
| Chrysocolla   | $\text{CuSiO}_3 \cdot 2\text{H}_2\text{O}$                                                                                                      | rhomb          | 2.4                       | 2        | 1.575               | 1.597     | 1.598      |
| Cinnabar      | $\text{HgS}$                                                                                                                                    | hex            | 8.17                      | 2.3      | 2.814               | 3.143     |            |
| Claudetite    | $\text{As}_2\text{O}_3$                                                                                                                         | monocl         | 3.74                      | 2.5      | 1.87                | 1.92      | 2.01       |
| Clinohumite   | $\text{Mg}(\text{OH},\text{F})_2 \cdot 4\text{Mg}_2\text{SiO}_4$                                                                                | monocl         | 3.21                      | 6        | 1.633               | 1.647     | 1.668      |
| Clinozoisite  | $\text{Ca}_2\text{Al}_3\text{Si}_3\text{O}_{12}(\text{OH})$                                                                                     | monocl         | 3.30                      | 6.5      | 1.693               | 1.700     | 1.712      |
| Cobaltite     | $\text{CoAsS}$                                                                                                                                  | cub            | ≈6.1                      | 5.5      |                     |           |            |
| Colemanite    | $\text{Ca}_2\text{B}_6\text{O}_{11} \cdot 5\text{H}_2\text{O}$                                                                                  | monocl         | 2.42                      | 4.5      | 1.586               | 1.592     | 1.614      |
| Columbite     | $(\text{Fe},\text{Mn})(\text{Nb},\text{Ta})_2\text{O}_6$                                                                                        | rhomb          | 5.20                      | 6        |                     |           |            |
| Connellite    | $\text{Cu}_{19}(\text{SO}_4)\text{Cl}_4(\text{OH})_{32} \cdot 3\text{H}_2\text{O}$                                                              | hex            | 3.36                      | 3        | 1.731               | 1.752     |            |
| Copiapite     | $(\text{Fe},\text{Mg})\text{Fe}_4(\text{SO}_4)_6(\text{OH})_2 \cdot 20\text{H}_2\text{O}$                                                       | tricl          | 2.13                      | 2.8      | 1.52                | 1.54      | 1.59       |
| Coquimbite    | $\text{Fe}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$                                                                                          | hex            | 2.1                       | 2.5      | 1.54                | 1.56      |            |

| Name             | Formula                                                                                                                          | Crystal system | Density g/cm <sup>3</sup> | Hardness | Index of refraction |           |            |
|------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------|----------|---------------------|-----------|------------|
|                  |                                                                                                                                  |                |                           |          | $n_\alpha$          | $n_\beta$ | $n_\gamma$ |
| Cordierite       | Al <sub>3</sub> (Mg,Fe) <sub>2</sub> Si <sub>5</sub> AlO <sub>18</sub>                                                           | rhomb          | 2.66                      | 7        | 1.540               | 1.549     | 1.553      |
| Corundum         | Al <sub>2</sub> O <sub>3</sub>                                                                                                   | hex            | 3.97                      | 9        | 1.761               | 1.769     |            |
| Cotunnite        | PbCl <sub>2</sub>                                                                                                                | orth           | 5.98                      | 2.5      | 2.199               | 2.217     | 2.260      |
| Covellite        | CuS                                                                                                                              | hex            | 4.8                       | 1.8      |                     |           |            |
| Cristobalite     | SiO <sub>2</sub>                                                                                                                 | hex            | 2.33                      | 6.5      | 1.484               | 1.487     |            |
| Crocoite         | PbCrO <sub>4</sub>                                                                                                               | monocl         | 6.12                      | 2.8      | 2.29                | 2.36      | 2.66       |
| Cryolite         | Na <sub>3</sub> AlF <sub>6</sub>                                                                                                 | monocl         | 2.97                      | 2.5      | 1.338               | 1.338     | 1.339      |
| Cryolithionite   | Na <sub>3</sub> Li <sub>3</sub> Al <sub>2</sub> F <sub>12</sub>                                                                  | cub            | 2.77                      | 2.8      | 1.340               |           |            |
| Cubanite         | CuFe <sub>2</sub> S <sub>3</sub>                                                                                                 | rhomb          | 4.11                      | 3.5      |                     |           |            |
| Cummingtonite    | (Mg,Fe) <sub>7</sub> Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>                                                           | monocl         | 3.4                       | 5.5      | 1.650               | 1.660     | 1.676      |
| Cuprite          | Cu <sub>2</sub> O                                                                                                                | cub            | 6.0                       | 3.8      |                     |           |            |
| Danburite        | CaSi <sub>2</sub> B <sub>2</sub> O <sub>8</sub>                                                                                  | rhomb          | 3.0                       | 7        | 1.63                | 1.63      | 1.63       |
| Datolite         | CaBSiO <sub>4</sub> (OH)                                                                                                         | monocl         | 2.98                      | 5.3      | 1.624               | 1.652     | 1.668      |
| Daubreelite      | Cr <sub>2</sub> FeS <sub>4</sub>                                                                                                 | cub            | 3.81                      |          |                     |           |            |
| Derbylite        | Fe <sub>6</sub> Ti <sub>6</sub> Sb <sub>2</sub> O <sub>23</sub>                                                                  | rhomb          | 4.53                      | 5        | 2.45                | 2.45      | 2.51       |
| Diamond          | C                                                                                                                                | cub            | 3.51                      | 10       | 2.418               |           |            |
| Diaspore         | AlO(OH)                                                                                                                          | orth           | 3.4                       | 6.8      | 1.694               | 1.715     | 1.741      |
| Digenite         | Cu <sub>2-x</sub> S                                                                                                              | cub            | 5.55                      | 2.8      |                     |           |            |
| Diopside         | CaMgSi <sub>2</sub> O <sub>6</sub>                                                                                               | monocl         | 3.30                      | 6        | 1.680               | 1.687     | 1.708      |
| Diopside         | CuSiO <sub>3</sub> (OH) <sub>2</sub>                                                                                             | rhomb          | 3.5                       | 5        | 1.65                | 1.70      |            |
| Dolomite         | CaMg(CO <sub>3</sub> ) <sub>2</sub>                                                                                              | rhomb          | 2.86                      | 3.5      | 1.500               | 1.679     |            |
| Douglasite       | K <sub>2</sub> FeCl <sub>4</sub> ·2H <sub>2</sub> O                                                                              | orth           | 2.16                      |          | 1.488               | 1.500     |            |
| Dyscrasite       | Ag <sub>3</sub> Sb                                                                                                               | rhomb          | 9.74                      | 3.8      |                     |           |            |
| Eddingtonite     | BaAl <sub>2</sub> Si <sub>3</sub> O <sub>10</sub> ·4H <sub>2</sub> O                                                             | rhomb          | 2.8                       |          | 1.541               | 1.553     | 1.557      |
| Eglestonite      | Hg <sub>2</sub> OCl <sub>2</sub>                                                                                                 | cub            | 8.4                       | 2.5      | 2.49                |           |            |
| Emplectite       | CuBiS <sub>2</sub>                                                                                                               | rhomb          | 6.38                      | 2        |                     |           |            |
| Enargite         | Cu <sub>3</sub> AsS <sub>4</sub>                                                                                                 | rhomb          | 4.5                       | 3        |                     |           |            |
| Enstatite        | MgSiO <sub>3</sub>                                                                                                               | monocl         | 3.19                      | 5.5      | 1.656               | 1.662     | 1.669      |
| Epidote          | Ca <sub>2</sub> Al <sub>2</sub> (Al,Fe)OH(SiO <sub>4</sub> ) <sub>3</sub>                                                        | monocl         | 3.44                      | 6        | 1.733               | 1.755     | 1.765      |
| Epsomite         | MgSO <sub>4</sub> ·7H <sub>2</sub> O                                                                                             | orth           | 1.67                      | 2.3      | 1.433               | 1.455     | 1.461      |
| Erythrite        | (Co,Ni) <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O                                                         | monocl         | 3.06                      | 2        | 1.626               | 1.661     | 1.699      |
| Eucairite        | CuAgSe                                                                                                                           | orth           | 7.7                       | 2.5      |                     |           |            |
| Euclase          | BeAlSiO <sub>4</sub> (OH)                                                                                                        | monocl         | 3.1                       | 7.5      | 1.651               | 1.655     | 1.671      |
| Eudialite        | (Na,Ca,Ce) <sub>5</sub> (Fe,Mn)(Zr,Ti)(Si <sub>3</sub> O <sub>9</sub> ) <sub>2</sub> (OH,Cl)                                     | hex            | 3.0                       | 5.5      | 1.623               | 1.600     | 1.615      |
| Eulytite         | Bi <sub>4</sub> Si <sub>3</sub> O <sub>12</sub>                                                                                  | cub            | 6.6                       | 4.5      | 2.05                |           |            |
| Euxenite         | (Y,Ca,Ce,U,Th)(Nb,Ta,Ti) <sub>2</sub> O <sub>6</sub>                                                                             | rhomb          | 5.5                       | 6        | 2.2                 |           |            |
| Fayalite         | Fe <sub>2</sub> SiO <sub>4</sub>                                                                                                 | orth           | 4.30                      | 6.5      | 1.827               | 1.869     | 1.879      |
| Ferberite        | FeWO <sub>4</sub>                                                                                                                | monocl         | 7.51                      | 4.3      |                     |           |            |
| Fergusonite      | (Y,Er,Ce,Fe)(Nb,Ta,Ti)O <sub>4</sub>                                                                                             | tetr           | 5.7                       | 6        | 2.1                 |           |            |
| Fluorite         | CaF <sub>2</sub>                                                                                                                 | cub            | 3.18                      | 4        | 1.434               |           |            |
| Forsterite       | Mg <sub>2</sub> SiO <sub>4</sub>                                                                                                 | orth           | 3.21                      | 7        | 1.635               | 1.651     | 1.670      |
| Franklinite      | ZnFe <sub>2</sub> O <sub>4</sub>                                                                                                 | cub            | 5.21                      | 6        | 2.36                |           |            |
| Gahnite          | ZnAl <sub>2</sub> O <sub>4</sub>                                                                                                 | cub            | 4.62                      | 7.8      | 1.805               |           |            |
| Galaxite         | MnAl <sub>2</sub> O <sub>4</sub>                                                                                                 | cub            | 4.04                      | 7.8      | 1.92                |           |            |
| Galena           | PbS                                                                                                                              | cub            | 7.60                      | 2.5      | 3.91                |           |            |
| Galenabismuthite | PbBi <sub>2</sub> S <sub>4</sub>                                                                                                 | rhomb          | 7.04                      | 3        |                     |           |            |
| Ganomalite       | (Ca,Pb) <sub>10</sub> (OH,Cl) <sub>2</sub> (Si <sub>2</sub> O <sub>7</sub> ) <sub>3</sub>                                        | hex            | 5.6                       | 3.5      | 1.910               | 1.945     |            |
| Gaylussite       | Na <sub>2</sub> Ca(CO <sub>3</sub> ) <sub>2</sub> ·5H <sub>2</sub> O                                                             | monocl         | 1.99                      | 2.8      | 1.444               | 1.516     | 1.523      |
| Gehlenite        | Ca <sub>2</sub> Al <sub>2</sub> SiO <sub>7</sub>                                                                                 | tetr           | 3.04                      | 5.5      | 1.658               | 1.669     |            |
| Geikielite       | MgTiO <sub>3</sub>                                                                                                               | hex            | 3.85                      | 5.5      | 1.95                | 2.31      |            |
| Gibbsite         | Al(OH) <sub>3</sub>                                                                                                              | monocl         | 2.42                      | 3        | 1.57                | 1.57      | 1.59       |
| Glauberite       | Na <sub>2</sub> Ca(SO <sub>4</sub> ) <sub>2</sub>                                                                                | monocl         | 2.80                      | 2.8      | 1.515               | 1.535     | 1.536      |
| Glaucosite       | (K,Na,Ca) <sub>1.6</sub> (Fe,Al,Mg) <sub>4.0-7.3</sub> Si <sub>1.0-0.7</sub> Al <sub>0.7</sub> O <sub>20</sub> (OH) <sub>4</sub> | monocl         | 2.7                       | 2        | 1.60                | 1.63      | 1.63       |
| Glaucophane      | Na <sub>2</sub> Mg <sub>3</sub> Al <sub>2</sub> Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>                                | monocl         | 3.19                      | 6        | 1.634               | 1.645     | 1.648      |
| Gmelinite        | (Ca,Na) <sub>2</sub> [Al <sub>2</sub> Si <sub>4</sub> O <sub>12</sub> ]·6H <sub>2</sub> O                                        | hex            | 2.10                      | 4.5      | 1.477               | 1.485     |            |
| Goethite         | FeO(OH)                                                                                                                          | orth           | 4.3                       | 5.3      | 2.268               | 2.401     | 2.457      |
| Goslarite        | ZnSO <sub>4</sub> ·7H <sub>2</sub> O                                                                                             | orth           | 1.97                      | 2.3      | 1.457               | 1.480     | 1.484      |
| Greenockite      | CdS                                                                                                                              | hex            | 4.8                       | 3.3      | 2.506               | 2.529     |            |
| Grossularite     | Ca <sub>3</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                                                                  | cub            | 3.59                      | 6.8      | 1.734               |           |            |
| Gummite          | UO <sub>3</sub> ·H <sub>2</sub> O                                                                                                | orth           | 7.05                      | 3.8      |                     |           |            |

| Name              | Formula                                                                                                              | Crystal system | Density g/cm <sup>3</sup> | Hardness | Index of refraction |           |            |
|-------------------|----------------------------------------------------------------------------------------------------------------------|----------------|---------------------------|----------|---------------------|-----------|------------|
|                   |                                                                                                                      |                |                           |          | $n_\alpha$          | $n_\beta$ | $n_\gamma$ |
| Gypsum            | CaSO <sub>4</sub> ·2H <sub>2</sub> O                                                                                 | monocl         | 2.32                      | 2        | 1.520               | 1.525     | 1.530      |
| Halite            | NaCl                                                                                                                 | cub            | 2.17                      | 2        | 1.544               |           |            |
| Hamburgite        | Be <sub>2</sub> (OH)(BO <sub>3</sub> )                                                                               | rhomb          | 2.36                      | 7.5      | 1.56                | 1.59      | 1.63       |
| Hanksite          | Na <sub>22</sub> K(SO <sub>4</sub> ) <sub>9</sub> (CO <sub>3</sub> ) <sub>2</sub> Cl                                 | hex            | 2.56                      | 3.3      | 1.461               | 1.481     |            |
| Harmotome         | Ba[Al <sub>2</sub> Si <sub>6</sub> O <sub>16</sub> ]·6H <sub>2</sub> O                                               | monocl         | 2.44                      | 4.5      | 1.506               | 1.507     | 1.511      |
| Hausmannite       | Mn <sub>3</sub> O <sub>4</sub>                                                                                       | tetr           | 4.84                      | 5.5      | 2.15                | 2.46      |            |
| Haüyne            | (Na,Ca) <sub>4-8</sub> Al <sub>6</sub> Si <sub>6</sub> O <sub>24</sub> (SO <sub>4</sub> ,S) <sub>1-2</sub>           | cub            | 2.47                      | 5.8      | 1.502               |           |            |
| Hedenbergite      | CaFeSi <sub>2</sub> O <sub>6</sub>                                                                                   | monocl         | 3.53                      | 6        | 1.721               | 1.727     | 1.746      |
| Helvite           | Mn <sub>4</sub> Be <sub>3</sub> Si <sub>3</sub> O <sub>12</sub> S                                                    | cub            | 3.32                      | 6        | 1.739               |           |            |
| Hematite          | Fe <sub>2</sub> O <sub>3</sub>                                                                                       | hex            | 5.25                      | 6        | 2.91                | 3.19      |            |
| Hemimorphite      | Zn <sub>4</sub> Si <sub>2</sub> O <sub>7</sub> (OH) <sub>2</sub> ·H <sub>2</sub> O                                   | rhomb          | 3.45                      | 5        | 1.614               | 1.617     | 1.636      |
| Hercynite         | Fe(AlO <sub>2</sub> ) <sub>2</sub>                                                                                   | cub            | 4.3                       | 7.8      | 1.835               |           |            |
| Herderite         | CaBe(PO <sub>4</sub> )(Fe,OH)                                                                                        | monocl         | 2.98                      | 5.3      | 1.592               | 1.612     | 1.621      |
| Hessite           | Ag <sub>3</sub> Te                                                                                                   | orth           | 8.4                       | 2.5      |                     |           |            |
| Heulandite        | (Ca,Na <sub>2</sub> ,K <sub>2</sub> )[Al <sub>2</sub> Si <sub>7</sub> O <sub>18</sub> ]·6H <sub>2</sub> O            | monocl         | 2.2                       | 3.8      | 1.498               | 1.498     | 1.506      |
| Hopeite           | Zn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O                                                   | orth           | 3.0                       | 3.2      | 1.58                | 1.59      | 1.59       |
| Hornblende        | Ca <sub>2</sub> (Mg,Fe) <sub>4</sub> Al(Si <sub>7</sub> AlO <sub>22</sub> )(OH) <sub>2</sub>                         | monocl         | 3.24                      | 5.5      | 1.67                | 1.67      | 1.69       |
| Huebnerite        | MnWO <sub>4</sub>                                                                                                    | monocl         | 7.2                       | 4.3      | 2.17                | 2.22      | 2.32       |
| Humite            | Mg(OH,F) <sub>2</sub> ·3Mg <sub>2</sub> SiO <sub>4</sub>                                                             | orth           | 3.3                       | 6        | 1.625               | 1.636     | 1.657      |
| Huntite           | Mg <sub>3</sub> Ca(CO <sub>3</sub> ) <sub>4</sub>                                                                    | trig           | 2.70                      |          |                     |           |            |
| Hydrogrossularite | Ca <sub>3</sub> Al <sub>2</sub> Si <sub>2</sub> O <sub>8</sub> (SiO <sub>4</sub> ) <sub>1-m</sub> (OH) <sub>4m</sub> | cub            | 3.4                       | 6.8      | 1.70                |           |            |
| Hydromagnesite    | 3MgCO <sub>3</sub> ·Mg(OH) <sub>2</sub> ·3H <sub>2</sub> O                                                           | monocl         | 2.24                      | 3.5      | 1.523               | 1.527     | 1.545      |
| Illite            | KAl <sub>4</sub> [Si <sub>7</sub> AlO <sub>20</sub> ](OH) <sub>4</sub>                                               | monocl         | 2.8                       | 1.5      | 1.56                | 1.59      | 1.59       |
| Ilmenite          | FeTiO <sub>3</sub>                                                                                                   | rhomb          | 4.72                      | 5.5      |                     |           |            |
| Iodyrite          | AgI                                                                                                                  | hex            | 5.68                      | 1.5      | 2.21                | 2.22      |            |
| Jacobsite         | MnFe <sub>2</sub> O <sub>4</sub>                                                                                     | cub            | 4.87                      | 7.8      | 2.3                 |           |            |
| Jadeite           | NaAlSi <sub>2</sub> O <sub>6</sub>                                                                                   | monocl         | 3.34                      | 6        | 1.649               | 1.654     | 1.663      |
| Jamesonite        | Pb <sub>4</sub> FeSb <sub>6</sub> S <sub>14</sub>                                                                    | monocl         | 5.63                      | 2.5      |                     |           |            |
| Jarosite          | KFe <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> (OH) <sub>6</sub>                                                   | rhomb          | 3.09                      | 3        | 1.715               | 1.820     |            |
| Kainite           | KMg(SO <sub>4</sub> )Cl·3H <sub>2</sub> O                                                                            | monocl         | 2.15                      | 2.8      | 1.494               | 1.505     | 1.516      |
| Kaliophyllite     | KAlSiO <sub>4</sub>                                                                                                  | hex            | 2.61                      | 6        | 1.532               | 1.537     |            |
| Kaolinite         | Al <sub>4</sub> Si <sub>4</sub> O <sub>10</sub> (OH) <sub>8</sub>                                                    | tricl          | 2.65                      | 2.3      | 1.549               | 1.564     | 1.565      |
| Kernite           | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·4H <sub>2</sub> O                                                     | monocl         | 1.95                      | 2.5      | 1.454               | 1.472     | 1.488      |
| Kieserite         | MgSO <sub>4</sub> ·H <sub>2</sub> O                                                                                  | monocl         | 2.57                      | 3.5      | 1.520               | 1.533     | 1.584      |
| Kyanite           | Al <sub>2</sub> OSiO <sub>4</sub>                                                                                    | tricl          | 3.59                      | 6.3      | 1.715               | 1.722     | 1.731      |
| Lanarkite         | Pb <sub>2</sub> (SO <sub>4</sub> )O                                                                                  | monocl         | 6.92                      | 2.3      | 1.928               | 2.007     | 2.036      |
| Lanthanite        | (La,Ce) <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub> ·8H <sub>2</sub> O                                              | rhomb          | 2.72                      | 2.8      | 1.52                | 1.587     | 1.613      |
| Laumontite        | Ca <sub>4</sub> [Al <sub>8</sub> Si <sub>16</sub> O <sub>48</sub> ]·16H <sub>2</sub> O                               | monocl         | 2.3                       | 3.3      | 1.508               | 1.517     | 1.519      |
| Laurionite        | Pb(OH)Cl                                                                                                             | rhomb          | 6.24                      | 3.3      | 2.08                | 2.12      | 2.16       |
| Lawsonite         | CaAl <sub>2</sub> (OH) <sub>2</sub> Si <sub>2</sub> O <sub>7</sub> ·H <sub>2</sub> O                                 | rhomb          | 3.08                      | 6        | 1.655               | 1.675     | 1.685      |
| Lazulite          | (Mg,Fe)Al <sub>2</sub> (PO <sub>4</sub> ) <sub>2</sub> (OH) <sub>2</sub>                                             | monocl         | 3.23                      | 5.8      | 1.615               | 1.64      | 1.650      |
| Lazurite          | Na <sub>3</sub> SSi <sub>3</sub> Al <sub>3</sub> O <sub>12</sub>                                                     | cub            | 2.42                      | 5.3      | 1.500               |           |            |
| Leadhillite       | Pb <sub>4</sub> (SO <sub>4</sub> )(CO <sub>3</sub> ) <sub>2</sub> (OH) <sub>2</sub>                                  | monocl         | 6.55                      | 2.8      | 1.87                | 2.00      | 2.01       |
| Lepidocrocite     | FeO(OH)                                                                                                              | orth           | 4.26                      | 5        | 1.94                | 2.20      | 2.51       |
| Lepidolite        | K <sub>2</sub> (Li,Al) <sub>5-6</sub> [Si <sub>6-7</sub> Al <sub>2-1</sub> O <sub>20</sub> ](OH,F) <sub>4</sub>      | monocl         | 2.85                      | 3.3      | 1.536               | 1.565     | 1.566      |
| Leucite           | KAlSi <sub>2</sub> O <sub>6</sub>                                                                                    | tetr           | 2.49                      | 5.8      | 1.510               |           |            |
| Levyne            | (Ca,Na <sub>2</sub> )Al <sub>2</sub> Si <sub>4</sub> O <sub>12</sub> ·6H <sub>2</sub> O                              | rhomb          | 2.10                      | 4.5      | 1.496               | 1.501     |            |
| Litharge          | PbO                                                                                                                  | tetr           | 9.35                      | 2        | 2.535               | 2.665     |            |
| Loellingite       | FeAs <sub>2</sub>                                                                                                    | rhomb          | 7.40                      | 5.3      |                     |           |            |
| Maghemite         | Fe <sub>2</sub> O <sub>3</sub>                                                                                       | cub            | 4.88                      | 7.8      | 2.63                |           |            |
| Magnesite         | MgCO <sub>3</sub>                                                                                                    | hex            | 3.05                      | 4        | 1.536               | 1.741     |            |
| Magnetite         | Fe <sub>3</sub> O <sub>4</sub>                                                                                       | cub            | 5.17                      | 6        | 2.42                |           |            |
| Malachite         | Cu <sub>2</sub> (OH) <sub>2</sub> (CO <sub>3</sub> )                                                                 | monocl         | 4.05                      | 3.8      | 1.655               | 1.875     | 1.909      |
| Manganite         | MnO(OH)                                                                                                              | monocl         | ≈4.3                      | 4        | 2.25                | 2.25      | 2.53       |
| Manganosite       | MnO                                                                                                                  | cub            | 5.37                      | 5.5      |                     |           |            |
| Marcasite         | FeS <sub>2</sub>                                                                                                     | cub            | 5.02                      | 6.3      |                     |           |            |
| Marialite         | Na <sub>4</sub> Al <sub>3</sub> Si <sub>3</sub> O <sub>24</sub> Cl                                                   | tetr           | 2.56                      | 5.5      | 1.541               | 1.548     |            |
| Marshite          | CuI                                                                                                                  | cub            | 5.67                      | 2.5      | 2.346               |           |            |
| Mascagnite        | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>                                                                      | orth           | 1.77                      | 2.3      | 1.520               | 1.523     | 1.533      |
| Matlockite        | PbClF                                                                                                                | tetr           | 7.05                      | 2.8      | 2.006               | 2.145     |            |

| Name             | Formula                                                                                                                                            | Crystal system | Density g/cm <sup>3</sup> | Hardness | Index of refraction |           |            |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------|----------|---------------------|-----------|------------|
|                  |                                                                                                                                                    |                |                           |          | $n_\alpha$          | $n_\beta$ | $n_\gamma$ |
| Meionite         | $\text{Ca}_4\text{Al}_6\text{Si}_6\text{O}_{24}\text{CO}_3$                                                                                        | tetr           | 2.78                      | 5.5      | 1.559               | 1.595     |            |
| Melanterite      | $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$                                                                                                          | monocl         | 1.89                      | 2        | 1.47                | 1.48      | 1.49       |
| Melilite         | $(\text{Ca}, \text{Na})_2(\text{Mg}, \text{Fe}, \text{Al}, \text{Si})_3\text{O}_7$                                                                 | tetr           | 3.00                      | 5.5      | 1.639               | 1.645     |            |
| Mellite          | $\text{Al}_2\text{C}_{12}\text{O}_{12} \cdot 18\text{H}_2\text{O}$                                                                                 | tetr           | 1.64                      | 2.3      | 1.511               | 1.539     |            |
| Mendipite        | $\text{Pb}_3\text{O}_2\text{Cl}_2$                                                                                                                 | rhomb          | 7.24                      | 2.5      | 2.24                | 2.27      | 2.31       |
| Mesolite         | $\text{Na}_2\text{Ca}_2(\text{Al}_2\text{Si}_3\text{O}_{10})_3 \cdot 8\text{H}_2\text{O}$                                                          | orth           | 2.26                      | 5        | 1.506               |           |            |
| Metacinnabar     | $\text{HgS}$                                                                                                                                       | cub            | 7.70                      | 3        |                     |           |            |
| Microcline       | $\text{KAlSi}_3\text{O}_8$                                                                                                                         | monocl         | 2.56                      | 6.3      | 1.522               | 1.526     | 1.530      |
| Miersite         | $\text{AgI}$                                                                                                                                       | hex            | 5.68                      | 2.5      | 2.20                |           |            |
| Millerite        | $\text{NiS}$                                                                                                                                       | hex            | 5.5                       | 3.3      |                     |           |            |
| Mimetite         | $\text{Pb}_3(\text{AsO}_4\text{PO}_4)\text{Cl}$                                                                                                    | hex            | 7.24                      | 3.8      | 2.128               | 2.147     |            |
| Minium           | $\text{Pb}_3\text{O}_4$                                                                                                                            | tetr           | 8.9                       | 2.5      |                     |           |            |
| Mirabilite       | $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$                                                                                                | monocl         | 1.46                      | 1.8      | 1.394               | 1.396     | 1.398      |
| Moissanite       | $\text{SiC}$                                                                                                                                       | hex            | 3.16                      | 9.5      | 2.648               | 2.691     |            |
| Molybdenite      | $\text{MoS}_2$                                                                                                                                     | hex            | 5.06                      | 1.3      |                     |           |            |
| Monazite         | $(\text{Ce}, \text{La}, \text{Th})\text{PO}_4$                                                                                                     | monocl         | 5.2                       | 5        | 1.787               | 1.789     | 1.840      |
| Monetite         | $\text{CaHPO}_4$                                                                                                                                   | tricl          | 2.92                      | 3.5      | 1.587               | 1.61      | 1.640      |
| Monticellite     | $\text{Ca}(\text{Mg}, \text{Fe})\text{SiO}_4$                                                                                                      | orth           | 3.18                      | 5.5      | 1.647               | 1.655     | 1.664      |
| Montmorillonite  | $(0.5\text{Ca}, \text{Na})_{0.7}(\text{Al}, \text{Mg}, \text{Fe})_4[(\text{Si}, \text{Al})_8\text{O}_{20}](\text{OH})_4 \cdot n\text{H}_2\text{O}$ | monocl         | 2.5                       | 1.5      | 1.55                | 1.57      | 1.57       |
| Montroydite      | $\text{HgO}$                                                                                                                                       | orth           | 11.14                     | 2.5      | 2.37                | 2.50      | 2.65       |
| Mordenite        | $(\text{Na}, \text{K}, \text{Ca})[\text{Al}_2\text{Si}_{10}\text{O}_{24}] \cdot 7\text{H}_2\text{O}$                                               | orth           | 2.13                      | 3.5      | 1.478               | 1.480     | 1.482      |
| Muscovite        | $\text{KAl}_2\text{Si}_3\text{AlO}_{10}(\text{OH}, \text{F})_2$                                                                                    | monocl         | 2.83                      | 2.8      | 1.563               | 1.596     | 1.602      |
| Nantokite        | $\text{CuCl}$                                                                                                                                      | cub            | 4.14                      | 2.5      | 1.930               |           |            |
| Natrolite        | $\text{Na}_2\text{Al}_2\text{Si}_3\text{O}_{10} \cdot 2\text{H}_2\text{O}$                                                                         | orth           | 2.23                      | 5        | 1.478               | 1.481     | 1.491      |
| Nepheline        | $\text{Na}_3\text{KAl}_4\text{Si}_4\text{O}_{16}$                                                                                                  | hex            | 2.61                      | 5.8      | 1.534               | 1.538     |            |
| Newberyite       | $\text{MgHPO}_4 \cdot 3\text{H}_2\text{O}$                                                                                                         | orth           | 2.13                      | 3.3      | 1.514               | 1.517     | 1.533      |
| Niccolite        | $\text{NiAs}$                                                                                                                                      | hex            | 7.77                      | 5.3      |                     |           |            |
| Norbergite       | $\text{Mg}(\text{OH}, \text{F})_2 \cdot \text{Mg}_2\text{SiO}_4$                                                                                   | orth           | 3.21                      | 6.5      | 1.565               | 1.573     | 1.592      |
| Nosean           | $\text{Na}_8\text{Al}_6\text{Si}_6\text{O}_{24}\text{SO}_4$                                                                                        | cub            | 2.35                      | 5.5      | 1.495               |           |            |
| Oldhamite        | $\text{CaS}$                                                                                                                                       | cub            | 2.59                      | 4        | 2.137               |           |            |
| Oligoclase       | $([\text{NaSi}]_{0.9-0.7}[\text{CaAl}]_{0.1-0.3})\text{AlSi}_2\text{O}_8$                                                                          | tricl          | 2.64                      | 6.3      | 1.539               | 1.543     | 1.547      |
| Olivinite        | $\text{Cu}_2(\text{AsO}_4)(\text{OH})$                                                                                                             | rhomb          | 4.2                       | 3        | 1.77                | 1.80      | 1.85       |
| Olivine          | $(\text{Mg}, \text{Fe})\text{SiO}_4$                                                                                                               | rhomb          | 3.81                      | 6.8      | 1.73                | 1.76      | 1.78       |
| Opal             | $\text{SiO}_2 \cdot n\text{H}_2\text{O}$                                                                                                           | amorp          | 1.9                       | 5        | 1.44                |           |            |
| Orpiment         | $\text{As}_2\text{S}_3$                                                                                                                            | monocl         | 3.46                      | 1.8      | 2.40                | 2.81      | 3.02       |
| Orthoclase       | $\text{KAlSi}_3\text{O}_8$                                                                                                                         | monocl         | 2.56                      | 6        | 1.523               | 1.527     | 1.531      |
| Orthopyroxene    | $(\text{Mg}, \text{Fe})\text{SiO}_3$                                                                                                               | rhomb          | 3.6                       | 5.5      | 1.709               | 1.712     | 1.723      |
| Paragonite       | $\text{NaAl}_2\text{Si}_3\text{AlO}_{10}(\text{OH})_2$                                                                                             | monocl         | 2.85                      | 2.5      | 1.572               | 1.602     | 1.605      |
| Parisite         | $(\text{Ce}, \text{La}, \text{Na})\text{FCO}_3 \cdot \text{CaCO}_3$                                                                                | hex            | 4.42                      | 4.5      | 1.672               | 1.771     |            |
| Pectolite        | $\text{Ca}_2\text{NaH}(\text{SiO}_3)_3$                                                                                                            | tricl          | 2.88                      | 4.8      | 1.603               | 1.610     | 1.639      |
| Penfieldite      | $\text{Pb}_4\text{Cl}_6(\text{OH})_2$                                                                                                              | hex            | 6.6                       |          | 2.13                | 2.21      |            |
| Pentlandite      | $(\text{Fe}, \text{Ni})_9\text{S}_8$                                                                                                               | cub            | 4.8                       | 3.8      |                     |           |            |
| Percylite        | $\text{PbCuCl}_2(\text{OH})_2$                                                                                                                     | cub            |                           | 2.5      | 2.05                |           |            |
| Periclase        | $\text{MgO}$                                                                                                                                       | cub            | 3.6                       | 5.5      | 1.735               |           |            |
| Perovskite       | $\text{CaTiO}_3$                                                                                                                                   | cub            | 3.98                      | 5.5      | 2.34                |           |            |
| Petalite         | $\text{LiAlSi}_4\text{O}_{10}$                                                                                                                     | monocl         | 2.42                      | 6.5      | 1.506               | 1.511     | 1.519      |
| Pharmacosiderite | $\text{Fe}_3(\text{AsO}_4)_2(\text{OH})_3 \cdot 5\text{H}_2\text{O}$                                                                               | cub            | 2.80                      | 2.5      | 1.690               |           |            |
| Phenakite        | $\text{Be}_2\text{SiO}_4$                                                                                                                          | rhomb          | 2.98                      | 7.5      | 1.654               | 1.670     |            |
| Phillipsite      | $\text{K}(\text{Ca}_{0.5}, \text{Na})_2[\text{Al}_3\text{Si}_5\text{O}_{16}] \cdot 6\text{H}_2\text{O}$                                            | monocl         | 2.2                       | 4.3      | 1.494               | 1.497     | 1.505      |
| Phlogopite       | $\text{KMg}_3\text{AlSi}_3\text{O}_{10}(\text{OH}, \text{F})_2$                                                                                    | monocl         | 2.83                      | 2.3      | 1.560               | 1.597     | 1.598      |
| Phosgenite       | $\text{Pb}_2(\text{CO}_3)\text{Cl}_2$                                                                                                              | tetr           | 6.13                      | 2.5      | 2.118               | 2.145     |            |
| Piemontite       | $\text{Ca}_2(\text{Mn}, \text{Fe}, \text{Al})_3\text{O}(\text{Si}_2\text{O}_7)(\text{SiO}_4)(\text{OH})$                                           | monocl         | 3.49                      | 6        | 1.762               | 1.773     | 1.796      |
| Pigeonite        | $(\text{Mg}, \text{Fe}, \text{Ca})(\text{Mg}, \text{Fe})\text{Si}_2\text{O}_6$                                                                     | monocl         | 3.38                      | 6        | 1.702               | 1.703     | 1.728      |
| Pollucite        | $\text{CsAlSi}_2\text{O}_6$                                                                                                                        | tetr           | 2.9                       | 6.5      | 1.517               |           |            |
| Polybasite       | $(\text{Ag}, \text{Cu})_{16}\text{Sb}_2\text{S}_{11}$                                                                                              | monocl         | 6.1                       | 2.5      |                     |           |            |
| Powellite        | $\text{Ca}(\text{Mo}, \text{W})\text{O}_4$                                                                                                         | tetr           | 4.35                      | 3.8      | 1.971               | 1.980     |            |
| Prehnite         | $\text{Ca}_2\text{Al}_2\text{Si}_3\text{O}_{10}(\text{OH})_2$                                                                                      | rhomb          | 2.93                      | 6.3      | 1.622               | 1.628     | 1.648      |
| Proustite        | $\text{Ag}_3\text{AsS}_3$                                                                                                                          | rhomb          | 5.57                      | 2.3      | 2.792               | 3.088     |            |
| Pseudobrookite   | $\text{Fe}_2\text{TiO}_5$                                                                                                                          | rhomb          | 4.36                      | 6        | 2.38                | 2.39      | 2.42       |
| Psilomelane      | $\text{BaMn}_9\text{O}_{16}(\text{OH})_4$                                                                                                          | rhomb          | 4.71                      | 5.5      |                     |           |            |

| Name              | Formula                                                                                                    | Crystal system | Density g/cm <sup>3</sup> | Hardness | Index of refraction |           |            |
|-------------------|------------------------------------------------------------------------------------------------------------|----------------|---------------------------|----------|---------------------|-----------|------------|
|                   |                                                                                                            |                |                           |          | $n_\alpha$          | $n_\beta$ | $n_\gamma$ |
| Pumpellyite       | $\text{Ca}_2\text{Al}_2(\text{Al,Fe,Mg})[\text{Si}_2(\text{O,OH})_7] (\text{SiO}_4)(\text{OH},\text{O})_3$ | monocl         | 3.21                      | 5.5      | 1.688               | 1.695     | 1.705      |
| Pyrargyrite       | $\text{Ag}_3\text{SbS}_3$                                                                                  | rhomb          | 5.85                      | 2.5      | 2.88                | 3.08      |            |
| Pyrite            | $\text{FeS}_2$                                                                                             | cub            | 5.02                      | 6.3      |                     |           |            |
| Pyrochlore        | $\text{NaCaNb}_2\text{O}_6\text{F}$                                                                        | cub            | 5.3                       | 5.3      |                     |           |            |
| Pyrochroite       | $\text{Mn}(\text{OH})_2$                                                                                   | hex            | 3.26                      | 2.5      | 1.68                | 1.72      |            |
| Pyrolusite        | $\text{MnO}_2$                                                                                             | tetr           | 5.08                      | 6.3      |                     |           |            |
| Pyromorphite      | $\text{Pb}_5(\text{PO}_4)_3\text{AsO}_4\text{Cl}$                                                          | hex            | 7.04                      | 3.8      | 2.048               | 2.058     |            |
| Pyrope            | $\text{Mg}_3\text{Al}_2\text{Si}_3\text{O}_{12}$                                                           | cub            | 3.58                      | 6.8      | 1.714               |           |            |
| Pyrophyllite      | $\text{Al}_2\text{Si}_4\text{O}_{10}(\text{OH})_2$                                                         | monocl         | 2.78                      | 1.5      | 1.545               | 1.579     | 1.599      |
| Pyrrhotite        | $\text{Fe}_7\text{S}_8$                                                                                    | hex            | 4.62                      | 4        |                     |           |            |
| Quartz            | $\text{SiO}_2$                                                                                             | hex            | 2.65                      | 7        | 1.544               | 1.553     |            |
| Rammelsbergite    | $\text{NiAs}_2$                                                                                            | orth           | 7.1                       | 5.8      |                     |           |            |
| Raspite           | $\text{PbWO}_4$                                                                                            | monocl         | 8.46                      | 2.8      | 1.27                | 1.27      | 1.30       |
| Realgar           | $\text{As}_4\text{S}_4$                                                                                    | monocl         | 3.5                       | 1.8      | 2.538               | 2.684     | 2.704      |
| Rhodochrosite     | $\text{MnCO}_3$                                                                                            | hex            | 3.70                      | 3.8      | 1.597               | 1.816     |            |
| Rhodonite         | $(\text{Mn,Fe,Ca})\text{SiO}_3$                                                                            | orth           | 3.48                      | 6        | 1.725               | 1.729     | 1.737      |
| Riebeckite        | $\text{Na}_2\text{Fe}_5(\text{Si}_8\text{O}_{22})(\text{OH})_2$                                            | monocl         | 3.3                       | 5        | 1.675               | 1.683     | 1.694      |
| Rutile            | $\text{TiO}_2$                                                                                             | tetr           | 4.23                      | 6.2      | 2.609               | 2.900     |            |
| Safflorite        | $(\text{Co,Fe})\text{As}_2$                                                                                | rhomb          | 7.3                       | 4.8      |                     |           |            |
| Samarskite        | $(\text{Y,Er,Ce,U,Ca,Fe,Pb,Th}) (\text{Nb,Ta,Ti,Sn})_2\text{O}_6$                                          | rhomb          | 5.69                      | 5.5      | 2.200               |           |            |
| Sapphirine        | $(\text{Mg,Fe})_2\text{Al}_4\text{O}_6\text{SiO}_4$                                                        | monocl         | 3.49                      | 7.5      | 1.709               | 1.712     | 1.715      |
| Scapolite         | $(\text{Na,Ca})_4\text{Al}_3(\text{Al,Si})_3\text{Si}_6\text{O}_{24} (\text{Cl,F,OH,CO}_3,\text{SO}_4)$    | tetr           | 2.64                      | 5.5      | 1.551               | 1.573     |            |
| Scheelite         | $\text{CaWO}_4$                                                                                            | tetr           | 6.06                      | 4.8      | 1.920               | 1.936     |            |
| Scolecite         | $\text{CaAl}_2\text{Si}_3\text{O}_{10}\cdot 3\text{H}_2\text{O}$                                           | monocl         | 2.27                      | 5        | 1.510               | 1.518     | 1.519      |
| Scorodite         | $\text{Fe}(\text{AsO}_4)\cdot 2\text{H}_2\text{O}$                                                         | rhomb          | 3.28                      | 3.8      | 1.784               | 1.795     | 1.814      |
| Sellaite          | $\text{MgF}_2$                                                                                             | tetr           | 3.15                      | 5        | 1.378               | 1.390     |            |
| Senarmontite      | $\text{Sb}_2\text{O}_3$                                                                                    | cub            | 5.58                      | 2.3      | 2.087               |           |            |
| Serpentine        | $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$                                                            | monocl         | 2.55                      | 3        | 1.55                | 1.56      | 1.56       |
| Siderite          | $\text{FeCO}_3$                                                                                            | hex            | 3.9                       | 4.3      | 1.635               | 1.875     |            |
| Sillimanite       | $\text{Al}_2\text{OSiO}_4$                                                                                 | rhomb          | 3.25                      | 7        | 1.658               | 1.660     | 1.660      |
| Skutterudite      | $(\text{Co,Ni})\text{As}_3$                                                                                | cub            | 6.8                       | 5.8      |                     |           |            |
| Smithsonite       | $\text{ZnCO}_3$                                                                                            | rhomb          | 4.4                       | 4.3      | 1.621               | 1.848     |            |
| Sodalite          | $\text{Na}_8\text{Al}_6\text{Si}_6\text{O}_{24}\text{Cl}_2$                                                | cub            | 2.30                      | 5.8      | 1.485               |           |            |
| Sperryite         | $\text{PtAs}_2$                                                                                            | cub            | 10.58                     | 6.5      |                     |           |            |
| Spessartite       | $\text{Mn}_3\text{Al}_2\text{Si}_3\text{O}_{12}$                                                           | cub            | 4.19                      | 6.8      | 1.800               |           |            |
| Sphalerite        | $\text{ZnS}$                                                                                               | cub            | 4.0                       | 3.8      | 2.369               |           |            |
| Sphene            | $\text{CaTiSiO}_4(\text{O,OH,F})$                                                                          | monocl         | 3.50                      | 5        | 1.90                | 1.95      | 2.03       |
| Spinel            | $\text{MgAl}_2\text{O}_4$                                                                                  | cub            | 3.55                      | 7.8      | 1.719               |           |            |
| Spodumene         | $\text{LiAlSi}_2\text{O}_6$                                                                                | monocl         | 3.13                      | 6.8      | 1.656               | 1.662     | 1.671      |
| Stannite          | $\text{Cu}_2\text{FeSn}_4$                                                                                 | tetr           | 4.4                       | 4        |                     |           |            |
| Staurolite        | $(\text{Fe,Mg,Zn})_2(\text{Al,Fe,Ti})_3\text{O}_6 [(\text{Si,Al})\text{O}_4]_4(\text{O,OH})_2$             | monocl         | 3.79                      | 7.5      | 1.743               | 1.747     | 1.755      |
| Stercorite        | $\text{Na}(\text{NH}_4)\text{H}(\text{PO}_4)\cdot 4\text{H}_2\text{O}$                                     | tricl          | 1.62                      | 2        | 1.439               | 1.442     | 1.469      |
| Stibiotantalite   | $\text{Sb}(\text{Ta,Nb})\text{O}_4$                                                                        | rhomb          | 6.6                       | 5.5      | 2.38                | 2.41      | 2.46       |
| Stibnite          | $\text{Sb}_2\text{S}_3$                                                                                    | orth           | 4.56                      | 2        |                     |           |            |
| Stilbite          | $\text{NaCa}_2[\text{Al}_5\text{Si}_{13}\text{O}_{36}]\cdot 14\text{H}_2\text{O}$                          | monocl         | 2.2                       | 3.8      | 1.492               | 1.499     | 1.503      |
| Stilpnomelane     | $(\text{K,Na,Ca})_{0.6}(\text{Fe,Mg})_6\text{Si}_8\text{Al} (\text{O,OH})_{27}\cdot 2\text{H}_2\text{O}$   | monocl         | 2.8                       | 3.5      | 1.585               | 1.665     | 1.665      |
| Stolzite          | $\text{PbWO}_4$                                                                                            | tetr           | 8.2                       | 2.8      | 2.19                | 2.27      |            |
| Strengite         | $\text{FePO}_4\cdot 2\text{H}_2\text{O}$                                                                   | orth           | 2.87                      | 4        | 1.707               | 1.719     | 1.741      |
| Strontianite      | $\text{SrCO}_3$                                                                                            | orth           | 3.5                       | 3.5      | 1.518               | 1.666     | 1.668      |
| Struvite          | $\text{Mg}(\text{NH}_4)(\text{PO}_4)\cdot 6\text{H}_2\text{O}$                                             | rhomb          | 1.71                      | 2        | 1.495               | 1.496     | 1.504      |
| Sulfur            | $\text{S}$                                                                                                 | orth           | 2.07                      | 2        | 1.958               | 2.038     | 2.245      |
| Sylvanite         | $(\text{Ag,Au})\text{Te}_2$                                                                                | monocl         | 8.16                      | 1.8      |                     |           |            |
| Sylvite           | $\text{KCl}$                                                                                               | cub            | 1.99                      | 2        | 1.490               |           |            |
| Talc              | $\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$                                                         | monocl         | 2.71                      | 1        | 1.545               | 1.592     | 1.595      |
| Tantalite         | $(\text{Fe,Mn})(\text{Ta,Nb})_2\text{O}_6$                                                                 | rhomb          | 7.95                      | 6.5      | 2.26                | 2.32      | 2.43       |
| Tapiolite         | $\text{FeTa}_2\text{O}_6$                                                                                  | tetr           | 7.9                       | 6.3      | 2.27                | 2.42      |            |
| Tellurobismuthite | $\text{Bi}_2\text{Te}_3$                                                                                   | hex            | 7.74                      | 1.8      |                     |           |            |
| Terlinguaite      | $\text{Hg}_2\text{OCl}$                                                                                    | monocl         | 8.73                      | 2.5      | 2.35                | 2.64      | 2.66       |
| Tetrahedrite      | $(\text{Cu,Fe})_{12}\text{Sb}_4\text{S}_{13}$                                                              | cub            | 4.9                       | 3.8      |                     |           |            |
| Thenardite        | $\text{Na}_2\text{SO}_4$                                                                                   | orth           | 2.7                       | 2.8      | 1.468               | 1.475     | 1.483      |

| Name                       | Formula                                                                                                                                                   | Crystal system | Density g/cm <sup>3</sup> | Hardness | Index of refraction |           |            |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------|----------|---------------------|-----------|------------|
|                            |                                                                                                                                                           |                |                           |          | $n_\alpha$          | $n_\beta$ | $n_\gamma$ |
| Thermonatrite              | Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O                                                                                                         | orth           | 2.25                      | 1.3      | 1.420               | 1.506     | 1.524      |
| Thomsenolite               | NaCaAlF <sub>6</sub> ·H <sub>2</sub> O                                                                                                                    | monocl         | 2.98                      | 2        | 1.407               | 1.414     | 1.415      |
| Thorianite                 | ThO <sub>2</sub>                                                                                                                                          | cub            | 10.0                      | 6.5      | 2.200               |           |            |
| Thorite                    | ThSiO <sub>4</sub>                                                                                                                                        | tetr           | 6.7                       | 4.8      | 1.8                 |           |            |
| Topaz                      | Al <sub>2</sub> SiO <sub>4</sub> (OH,F) <sub>2</sub>                                                                                                      | rhomb          | 3.53                      | 8        | 1.618               | 1.620     | 1.627      |
| Torbernite                 | Cu(UO <sub>2</sub> ) <sub>2</sub> (PO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O                                                                      | tetr           | 3.22                      | 2.3      | 1.582               | 1.592     |            |
| Tourmaline                 | Na(Mg,Fe,Mn,Li,Al) <sub>3</sub> Al <sub>6</sub> Si <sub>6</sub> O <sub>18</sub> (BO <sub>3</sub> ) <sub>3</sub>                                           | rhomb          | 3.14                      | 7        | 1.62                | 1.65      |            |
| Tremolite                  | Ca <sub>2</sub> Mg <sub>5</sub> Si <sub>8</sub> O <sub>22</sub> (OH,F) <sub>2</sub>                                                                       | monocl         | 3.0                       | 5.5      | 1.599               | 1.612     | 1.622      |
| Trevorite                  | NiFe <sub>2</sub> O <sub>4</sub>                                                                                                                          | cub            | 5.33                      | 7.8      | 2.3                 |           |            |
| Tridymite                  | SiO <sub>2</sub>                                                                                                                                          | hex            | 2.27                      | 7        | 1.475               | 1.476     | 1.479      |
| Triphyllite-Lithiophyllite | Li(Fe,Mn)PO <sub>4</sub>                                                                                                                                  | rhomb          | 3.46                      | 4.5      | 1.68                | 1.68      | 1.69       |
| Troegerite                 | (UO <sub>2</sub> ) <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O                                                                      | tetr           |                           | 2.5      | 1.59                | 1.630     |            |
| Troilite                   | FeS                                                                                                                                                       | hex            | 4.7                       | 4        |                     |           |            |
| Trona                      | Na <sub>3</sub> H(CO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O                                                                                       | monocl         | 2.14                      | 2.8      | 1.412               | 1.492     | 1.540      |
| Turquoise                  | Cu(Al,Fe) <sub>6</sub> (PO <sub>4</sub> ) <sub>4</sub> (OH) <sub>8</sub> ·4H <sub>2</sub> O                                                               | tricl          | 2.9                       | 5.3      | 1.70                | 1.73      | 1.75       |
| Ullmannite                 | NiSbS                                                                                                                                                     | cub            | 6.65                      | 5.3      |                     |           |            |
| Uraninite                  | UO <sub>2</sub>                                                                                                                                           | cub            | 11.0                      | 5.5      |                     |           |            |
| Uvarovite                  | Ca <sub>3</sub> Cr <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                                                                                           | cub            | 3.83                      | 6.8      | 1.865               |           |            |
| Valentinite                | Sb <sub>2</sub> O <sub>3</sub>                                                                                                                            | orth           | 5.7                       | 2.8      | 2.18                | 2.35      | 2.35       |
| Vanadinite                 | Pb <sub>5</sub> (VO <sub>4</sub> ) <sub>3</sub> Cl                                                                                                        | hex            | 6.8                       | 2.9      | 2.350               | 2.416     |            |
| Variseite-Strengite        | (Al,Fe)(PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O                                                                                                 | rhomb          | 2.72                      | 4        | 1.635               | 1.654     | 1.668      |
| Vaterite                   | CaCO <sub>3</sub>                                                                                                                                         | hex            | 2.71                      |          | 1.550               | 1.645     |            |
| Vermiculite                | (Mg,Ca) <sub>0.7</sub> (Mg,Fe,Al) <sub>6</sub> [(Al,Si) <sub>8</sub> O <sub>20</sub> ](OH) <sub>4</sub> ·8H <sub>2</sub> O                                | monocl         | 2.3                       | 1.5      | 1.542               | 1.556     | 1.556      |
| Vesuvianite                | Ca <sub>10</sub> (Mg,Fe) <sub>2</sub> Al <sub>4</sub> (Si <sub>2</sub> O <sub>7</sub> ) <sub>2</sub> (SiO <sub>4</sub> ) <sub>5</sub> (OH,F) <sub>4</sub> | tetr           | 3.33                      | 6.5      | 1.72                | 1.73      |            |
| Villiaumite                | NaF                                                                                                                                                       | cub            | 2.78                      | 2.3      | 1.327               |           |            |
| Vivianite                  | Fe <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O                                                                                        | monocl         | 2.58                      | 1.8      | 1.598               | 1.629     | 1.652      |
| Wagnerite                  | Mg <sub>2</sub> (PO <sub>4</sub> )F                                                                                                                       | monocl         | 3.15                      | 5.3      | 1.568               | 1.572     | 1.582      |
| Wavellite                  | Al <sub>3</sub> (OH) <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> ·5H <sub>2</sub> O                                                                      | rhomb          | 2.36                      | 3.6      | 1.527               | 1.535     | 1.553      |
| Whewellite                 | CaC <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O                                                                                                         | cub            | 2.2                       | 2.8      | 1.491               | 1.554     | 1.650      |
| Willemite                  | Zn <sub>2</sub> SiO <sub>4</sub>                                                                                                                          | hex            | 4.1                       | 5.5      | 1.691               | 1.719     |            |
| Witherite                  | BaCO <sub>3</sub>                                                                                                                                         | orth           | 4.29                      | 3.5      | 1.529               | 1.676     | 1.677      |
| Wolframite                 | (Fe,Mn)WO <sub>4</sub>                                                                                                                                    | monocl         | 7.3                       | 4.3      | 2.26                | 2.32      | 2.42       |
| Wollastonite               | CaSiO <sub>3</sub>                                                                                                                                        | monocl         | 2.92                      | 4.8      | 1.628               | 1.639     | 1.642      |
| Wulfenite                  | PbMoO <sub>4</sub>                                                                                                                                        | tetr           | 6.7                       | 2.9      | 2.283               | 2.403     |            |
| Wurtzite                   | ZnS                                                                                                                                                       | hex            | 4.09                      | 3.8      | 2.356               | 2.378     |            |
| Xenotime                   | YPO <sub>4</sub>                                                                                                                                          | tetr           | 4.8                       | 4.5      | 1.721               | 1.816     |            |
| Zeunerite                  | Cu(UO <sub>2</sub> ) <sub>2</sub> (AsO <sub>4</sub> ) <sub>2</sub> ·10H <sub>2</sub> O                                                                    | tetr           |                           |          | 1.606               |           |            |
| Zincite                    | ZnO                                                                                                                                                       | hex            | 5.6                       | 4        | 2.013               | 2.029     |            |
| Zircon                     | ZrSiO <sub>4</sub>                                                                                                                                        | tetr           | 4.6                       | 7.5      | 1.94                | 1.99      |            |
| Zoisite                    | Ca <sub>2</sub> Al <sub>3</sub> Si <sub>3</sub> O <sub>12</sub> (OH)                                                                                      | rhomb          | 3.26                      | 6        | 1.695               | 1.699     | 1.711      |

# CRYSTALLOGRAPHIC DATA ON MINERALS

This table contains x-ray crystallographic data on about 400 common minerals, as well as selected crystalline elements. Entries are arranged alphabetically by mineral name. The columns are:

Name: Common name of the mineral.

Formula: Chemical formula for a typical sample of the mineral.

Composition often varies considerably with the origin of the sample.

Crystal system: tricl = triclinic; monocl = monoclinic; orth = orthorhombic; tetr = tetragonal; hex = hexagonal; rhomb = rhombohedral; cubic = cubic.

Structure type: Prototype for the structural arrangement of the crystallographic cell.

Z: Number of formula units per the unit cell.

$a, b, c$ : Lengths of the cell edges in Å ( $1\text{ Å} = 10^{-8}\text{ cm}$ ).

$\alpha, \beta, \gamma$ : Angles between cell axes.

## References

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3. Deer, W.A., Howie, R.A., and Zussman, J., *An Introduction to the Rock-Forming Minerals, 2nd Edition*, Longman Scientific & Technical, Harlow, Essex, 1992.

| Name                  | Formula                                                      | Crystal system | Structure type    | Z  | $a/\text{Å}$ | $b/\text{Å}$ | $c/\text{Å}$ | $\alpha$ | $\beta$ | $\gamma$ |
|-----------------------|--------------------------------------------------------------|----------------|-------------------|----|--------------|--------------|--------------|----------|---------|----------|
| Acanthite             | $\text{Ag}_2\text{S}$                                        | monocl         |                   | 4  | 4.228        | 6.928        | 7.862        |          | 99.58°  |          |
| Acmite (Aegirine)     | $\text{NaFe}(\text{SiO}_3)_2$                                | monocl         | diopside          | 4  | 9.658        | 8.795        | 5.294        |          | 107.42° |          |
| Akermanite            | $\text{Ca}_2\text{MgSi}_2\text{O}_7$                         | tetr           | melilite          | 2  | 7.8435       |              | 5.010        |          |         |          |
| Alabandite            | $\text{MnS}$                                                 | cubic          | rock salt         | 4  | 5.223        |              |              |          |         |          |
| Almandine (Almandite) | $\text{Fe}_3\text{Al}_2\text{Si}_3\text{O}_{12}$             | cubic          | garnet            | 8  | 11.526       |              |              |          |         |          |
| Altaite               | $\text{PbTe}$                                                | cubic          | rock salt         | 4  | 6.4606       |              |              |          |         |          |
| Aluminum              | Al                                                           | cubic          | copper            | 4  | 4.049        |              |              |          |         |          |
| Alunite               | $\text{KAl}_3(\text{SO}_4)_2(\text{OH})_6$                   | rhomb          |                   | 3  | 6.982        |              | 17.32        |          |         |          |
| Analcite              | $\text{NaAlSi}_2\text{O}_6 \cdot \text{H}_2\text{O}$         | cubic          |                   | 16 | 13.733       |              |              |          |         |          |
| Anatase               | $\text{TiO}_2$                                               | tetr           |                   | 4  | 3.785        |              | 9.514        |          |         |          |
| Andalusite            | $\text{Al}_2\text{OSiO}_4$                                   | orth           |                   | 4  | 7.7959       | 7.8983       | 5.5583       |          |         |          |
| Andradite             | $\text{Ca}_3\text{Fe}_2\text{Si}_3\text{O}_{12}$             | cubic          | garnet            | 8  | 12.048       |              |              |          |         |          |
| Anglesite             | $\text{PbSO}_4$                                              | orth           | barite            | 4  | 8.480        | 5.398        | 6.958        |          |         |          |
| Anhydrite             | $\text{CaSO}_4$                                              | orth           | anhydrite         | 4  | 6.991        | 6.996        | 6.238        |          |         |          |
| Annite                | $\text{KFe}_3[\text{AlSi}_3\text{O}_{10}](\text{OH})_2$      | monocl         | 1M mica           | 2  | 10.29        | 9.33         | 5.39         |          | 105.1°  |          |
| Anorthite             | $\text{CaAl}_2\text{Si}_2\text{O}_8$                         | tricl          | primitive cell    | 8  | 8.177        | 12.877       | 14.169       | 93.17°   | 115.85° | 91.22°   |
| Anthophyllite         | $\text{Mg}_7\text{Si}_8\text{O}_{22}(\text{OH})_2$           | orth           |                   | 4  | 18.61        | 18.01        | 5.24         |          |         |          |
| Antimony              | Sb                                                           | rhomb          | arsenic           | 6  | 4.2996       |              | 11.2516      |          |         |          |
| Aragonite             | $\text{CaCO}_3$                                              | orth           | aragonite         | 4  | 5.741        | 7.968        | 4.959        |          |         |          |
| Arcanite              | $\text{K}_2\text{SO}_4$                                      | orth           | arcanite          | 4  | 5.772        | 10.072       | 7.483        |          |         |          |
| Argentite             | $\text{Ag}_2\text{S}$                                        | cubic          |                   | 2  | 4.870        |              |              |          |         |          |
| Argentopyrite         | $\text{AgFe}_2\text{S}_3$                                    | orth           |                   | 4  | 6.64         | 11.47        | 6.45         |          |         |          |
| Arsenic               | As                                                           | rhomb          | arsenic           | 6  | 3.760        |              | 10.555       |          |         |          |
| Arsenolite            | $\text{As}_2\text{O}_3$                                      | cubic          | diamond           | 16 | 11.074       |              |              |          |         |          |
| Arsenopyrite          | $\text{FeAsS}$                                               | tricl          |                   | 4  | 5.760        | 5.690        | 5.785        | 90.00°   | 112.23° | 90.00°   |
| Azurite               | $\text{Cu}_3(\text{OH})_2(\text{CO}_3)_2$                    | monocl         |                   | 2  | 5.008        | 5.844        | 10.336       |          | 92.45°  |          |
| Baddeleyite           | $\text{ZrO}_2$                                               | monocl         | baddeleyite       | 4  | 5.1454       | 5.2075       | 5.3107       |          | 99.23°  |          |
| Banalsite             | $\text{BaNa}_2\text{Al}_4\text{Si}_4\text{O}_{16}$           | orth           |                   | 4  | 8.50         | 9.97         | 16.72        |          |         |          |
| Barite                | $\text{BaSO}_4$                                              | orth           | barite            | 4  | 8.878        | 5.450        | 7.152        |          |         |          |
| Berlinite             | $\text{AlPO}_4$                                              | hex            | $\alpha$ -quartz  | 3  | 4.942        |              | 10.97        |          |         |          |
| Beryl                 | $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$                     | hex            | beryl             | 2  | 9.215        |              | 9.192        |          |         |          |
| Berzelianite          | $\text{Cu}_2\text{Se}$                                       | cubic          |                   | 4  | 5.85         |              |              |          |         |          |
| Bismite               | $\text{Bi}_2\text{O}_3$                                      | monocl         | pseudo-orth       | 4  | 7.48         | 8.14         | 5.83         |          | 112.9°  |          |
| Bismuth               | Bi                                                           | rhomb          | arsenic           | 6  | 4.5367       |              | 11.8383      |          |         |          |
| Bismuthinite          | $\text{Bi}_2\text{S}_3$                                      | orth           | stibnite          | 4  | 11.150       | 11.300       | 3.981        |          |         |          |
| Bixbyite              | $\text{Mn}_2\text{O}_3$                                      | cubic          | thallium trioxide | 16 | 9.411        |              |              |          |         |          |
| Boehmite              | $\text{AlO}(\text{OH})$                                      | orth           | lepidocrocite     | 4  | 2.868        | 12.227       | 3.700        |          |         |          |
| Borax                 | $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ | monocl         |                   | 4  | 11.858       | 10.674       | 12.197       |          | 106.68° |          |

| Name                 | Formula                                                                                   | Crystal system | Structure type      | Z  | <i>a</i> /Å | <i>b</i> /Å | <i>c</i> /Å | α      | β       | γ       |
|----------------------|-------------------------------------------------------------------------------------------|----------------|---------------------|----|-------------|-------------|-------------|--------|---------|---------|
| Bornite (metastable) | Cu <sub>5</sub> FeS <sub>4</sub>                                                          | cubic          |                     | 8  | 10.94       |             |             |        |         |         |
| Breithauptite        | NiSb                                                                                      | hex            | niccolite           | 2  | 3.942       |             | 5.155       |        |         |         |
| Brochantite          | Cu <sub>4</sub> SO <sub>4</sub> (OH) <sub>6</sub>                                         | monocl         |                     | 4  | 13.066      | 9.85        | 6.022       |        | 103.27° |         |
| Bromargyrite         | AgBr                                                                                      | cubic          | rock salt           | 4  | 5.7745      |             |             |        |         |         |
| Bromellite           | BeO                                                                                       | hex            | zincite             | 2  | 2.6979      |             | 4.3772      |        |         |         |
| Brookite             | TiO <sub>2</sub>                                                                          | orth           |                     | 8  | 5.456       | 9.182       | 5.143       |        |         |         |
| Brucite              | Mg(OH) <sub>2</sub>                                                                       | hex            | cadmium iodide      | 1  | 3.147       |             | 4.769       |        |         |         |
| Bunsenite            | NiO                                                                                       | cubic          | rock salt           | 4  | 4.177       |             |             |        |         |         |
| Bustamite            | CaMn(SiO <sub>3</sub> ) <sub>2</sub>                                                      | tricl          |                     | 6  | 7.736       | 7.157       | 13.824      | 90.52° | 94.58°  | 103.87° |
| Cadmium telluride    | CdTe                                                                                      | cubic          | sphalerite          | 4  | 6.4805      |             |             |        |         |         |
| Cadmoselite          | CdSe                                                                                      | hex            | zincite             | 2  | 4.2977      |             | 7.0021      |        |         |         |
| Calcite              | CaCO <sub>3</sub>                                                                         | rhomb          | calcite             | 6  | 4.9899      |             | 17.064      |        |         |         |
| Calomel              | Hg <sub>2</sub> Cl <sub>2</sub>                                                           | tetr           |                     | 4  | 4.478       |             | 10.910      |        |         |         |
| Carbonate-apatite    | Ca <sub>10</sub> (PO <sub>4</sub> ) <sub>6</sub> CO <sub>3</sub> ·H <sub>2</sub> O        | hex            | apatite             | 1  | 9.436       |             | 6.883       |        |         |         |
| Cassiterite          | SnO <sub>2</sub>                                                                          | tetr           | rutile              | 2  | 4.738       |             | 3.188       |        |         |         |
| Cattierite           | CoS <sub>2</sub>                                                                          | cubic          | pyrite              | 4  | 5.5345      |             |             |        |         |         |
| Celestite            | SrSO <sub>4</sub>                                                                         | orth           | barite              | 4  | 8.359       | 5.352       | 6.866       |        |         |         |
| Celsian              | BaAl <sub>2</sub> Si <sub>2</sub> O <sub>8</sub>                                          | monocl         |                     | 8  | 8.627       | 13.045      | 14.408      |        | 115.20° |         |
| Cerianite            | CeO <sub>2</sub>                                                                          | cubic          | fluorite            | 4  | 5.4110      |             |             |        |         |         |
| Cerussite            | PbCO <sub>3</sub>                                                                         | orth           | aragonite           | 4  | 6.152       | 8.436       | 5.195       |        |         |         |
| Cervantite           | Sb <sub>2</sub> O <sub>4</sub>                                                            | orth           |                     | 4  | 5.424       | 11.76       | 4.804       |        |         |         |
| Chalcanthite         | CuSO <sub>4</sub> ·5H <sub>2</sub> O                                                      | tricl          |                     | 2  | 6.1045      | 10.72       | 5.949       | 97.57° | 107.28° | 77.43°  |
| Chalcocite           | Cu <sub>2</sub> S                                                                         | orth           |                     | 96 | 11.881      | 27.323      | 13.491      |        |         |         |
| Chalcopyrite         | CuFeS <sub>2</sub>                                                                        | tetr           |                     | 4  | 5.2988      |             | 10.434      |        |         |         |
| Chlorapatite         | Ca <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> Cl                                        | hex            | apatite             | 2  | 9.629       |             | 6.777       |        |         |         |
| Chlorargyrite        | AgCl                                                                                      | cubic          | rock salt           | 4  | 5.5491      |             |             |        |         |         |
| Chloritoid           | FeAl <sub>4</sub> O <sub>2</sub> (SiO <sub>4</sub> ) <sub>2</sub> (OH) <sub>4</sub>       | monocl         |                     | 8  | 9.48        | 5.48        | 18.18       |        | 101.77° |         |
| Chloromagnesite      | MgCl <sub>2</sub>                                                                         | rhomb          |                     | 3  | 3.632       |             | 17.795      |        |         |         |
| Chondrodite          | 2Mg <sub>2</sub> SiO <sub>4</sub> ·MgF <sub>2</sub>                                       | monocl         |                     | 2  | 7.89        | 4.743       | 10.29       |        | 109.03° |         |
| Chrysoberyl          | BeAl <sub>2</sub> O <sub>4</sub>                                                          | orth           | olivine             | 4  | 5.4756      | 9.4041      | 4.4267      |        |         |         |
| Cinnabar             | HgS                                                                                       | hex            | cinnabar            | 3  | 4.149       |             | 9.495       |        |         |         |
| Claudetite           | As <sub>2</sub> O <sub>3</sub>                                                            | monocl         |                     | 4  | 5.339       | 12.984      | 4.5405      |        | 94.27°  |         |
| Clausthalite         | PbSe                                                                                      | cubic          | rock salt           | 4  | 6.1255      |             |             |        |         |         |
| Clinoenstatite       | MgSiO <sub>3</sub>                                                                        | monocl         |                     | 8  | 9.620       | 8.825       | 5.188       |        | 108.33° |         |
| Clinoferrosilite     | FeSiO <sub>3</sub>                                                                        | monocl         |                     | 8  | 9.7085      | 9.0872      | 5.2284      |        | 108.43° |         |
| Clinohumite          | 4Mg <sub>2</sub> SiO <sub>4</sub> ·MgF <sub>2</sub>                                       | monocl         |                     | 2  | 13.68       | 4.75        | 10.27       |        | 100.83° |         |
| Clinozoisite         | Ca <sub>2</sub> Al <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> OH                       | monocl         |                     | 2  | 8.887       | 5.581       | 10.14       |        | 115.93° |         |
| Cobalt olivine       | Co <sub>2</sub> SiO <sub>4</sub>                                                          | orth           | olivine             | 4  | 4.782       | 10.301      | 6.003       |        |         |         |
| Cobalt oxide         | CoO                                                                                       | cubic          | rock salt           | 4  | 4.260       |             |             |        |         |         |
| Cobalt sulfide       | CoS                                                                                       | cubic          | sphalerite          | 4  | 5.339       |             |             |        |         |         |
| Cobalt titanate      | CoTiO <sub>3</sub>                                                                        | rhomb          | ilmenite            | 6  | 5.066       |             | 13.918      |        |         |         |
| Cobaltcalcite        | CoCO <sub>3</sub>                                                                         | rhomb          | calcite             | 6  | 4.6581      |             | 14.958      |        |         |         |
| Cobaltite            | CoAsS                                                                                     | cubic          | NiSbS               | 4  | 5.60        |             |             |        |         |         |
| Coesite              | SiO <sub>2</sub>                                                                          | monocl         |                     | 16 | 7.152       | 12.379      | 7.152       |        | 120.00° |         |
| Coffinite            | USiO <sub>4</sub>                                                                         | tetr           | zircon              | 4  | 6.995       |             | 6.263       |        |         |         |
| Colemanite           | Ca <sub>2</sub> B <sub>6</sub> O <sub>11</sub> ·5H <sub>2</sub> O                         | monocl         |                     | 4  | 8.743       | 11.264      | 6.102       |        | 110.12° |         |
| Coloradoite          | HgTe                                                                                      | cubic          | sphalerite          | 4  | 6.4600      |             |             |        |         |         |
| Cooperite            | PtS                                                                                       | tetr           |                     | 2  | 3.4699      |             | 6.1098      |        |         |         |
| Copper               | Cu                                                                                        | cubic          | face-centered cubic | 4  | 3.6150      |             |             |        |         |         |
| Corundum             | Al <sub>2</sub> O <sub>3</sub>                                                            | rhomb          | corundum            | 6  | 4.7591      |             | 12.9894     |        |         |         |
| Cotunnite            | PbCl <sub>2</sub>                                                                         | orth           |                     | 4  | 4.535       | 7.62        | 9.05        |        |         |         |
| Covellite            | CuS                                                                                       | hex            |                     | 6  | 3.792       |             | 16.34       |        |         |         |
| Cristobalite (α)     | SiO <sub>2</sub>                                                                          | tetr           |                     | 4  | 4.971       |             | 6.918       |        |         |         |
| Cristobalite (β)     | SiO <sub>2</sub>                                                                          | cubic          |                     | 8  | 7.1382      |             |             |        |         |         |
| Cryolite             | Na <sub>3</sub> AlF <sub>6</sub>                                                          | monocl         |                     | 2  | 5.40        | 5.60        | 7.776       |        | 90.18°  |         |
| Cubanite             | CuFe <sub>2</sub> S <sub>3</sub>                                                          | orth           |                     | 4  | 6.46        | 11.12       | 6.23        |        |         |         |
| Cumingtonite         | (Mg,Fe,Mn) <sub>7</sub> (Si <sub>4</sub> O <sub>11</sub> ) <sub>2</sub> (OH) <sub>2</sub> | monocl         | tremolite           | 2  | 9.522       | 18.223      | 5.332       |        | 101.92° |         |
| Cuprite              | Cu <sub>2</sub> O                                                                         | cubic          |                     | 2  | 4.2696      |             |             |        |         |         |
| Danburite            | CaB <sub>2</sub> Si <sub>2</sub> O <sub>8</sub>                                           | orth           |                     | 4  | 8.04        | 8.77        | 7.74        |        |         |         |



| Name             | Formula                                                                                             | Crystal system | Structure type      | Z  | <i>a</i> /Å | <i>b</i> /Å | <i>c</i> /Å | α      | β       | γ      |
|------------------|-----------------------------------------------------------------------------------------------------|----------------|---------------------|----|-------------|-------------|-------------|--------|---------|--------|
| Datolite         | CaBSiO <sub>4</sub> (OH)                                                                            | monocl         |                     | 4  | 9.62        | 7.60        | 4.84        |        | 90.15°  |        |
| Daubreite        | FeCr <sub>2</sub> S <sub>4</sub>                                                                    | cubic          | spinel              | 8  | 9.966       |             |             |        |         |        |
| Diamond          | C                                                                                                   | cubic          | diamond             | 8  | 3.5670      |             |             |        |         |        |
| Diaspore         | AlO(OH)                                                                                             | orth           |                     | 4  | 4.401       | 9.421       | 2.845       |        |         |        |
| Dickite          | Al <sub>2</sub> Si <sub>2</sub> O <sub>5</sub> (OH) <sub>4</sub>                                    | monocl         |                     | 4  | 5.150       | 8.940       | 14.736      |        | 103.58° |        |
| Digenite         | Cu <sub>1.79</sub> S                                                                                | cubic          | deformed fluorite   | 4  | 5.5695      |             |             |        |         |        |
| Diopside         | CaMg(SiO <sub>3</sub> ) <sub>2</sub>                                                                | monocl         | diopside            | 4  | 9.743       | 8.923       | 5.251       |        | 105.93° |        |
| Diopside         | CuSiO <sub>2</sub> (OH) <sub>2</sub>                                                                | rhomb          | phenacite           | 18 | 14.61       |             | 7.80        |        |         |        |
| Dolerophanite    | Cu <sub>2</sub> O(SO <sub>4</sub> )                                                                 | monocl         |                     | 4  | 8.334       | 6.312       | 7.628       |        | 108.4°  |        |
| Dolomite         | CaMg(CO <sub>3</sub> ) <sub>2</sub>                                                                 | rhomb          | calcite             | 3  | 4.8079      |             | 16.010      |        |         |        |
| Dravite          | NaMg <sub>3</sub> Al <sub>6</sub> B <sub>3</sub> Si <sub>6</sub> O <sub>27</sub> (OH) <sub>4</sub>  | rhomb          | tourmaline          | 3  | 15.942      |             | 7.224       |        |         |        |
| Elbaite          | NaLiAl <sub>1.67</sub> B <sub>3</sub> Si <sub>6</sub> O <sub>27</sub> (OH) <sub>4</sub>             | rhomb          | tourmaline          | 3  | 15.842      |             | 7.009       |        |         |        |
| Enargite         | Cu <sub>3</sub> AsS <sub>4</sub>                                                                    | orth           |                     | 2  | 6.426       | 7.422       | 6.144       |        |         |        |
| Enstatite        | MgSiO <sub>3</sub>                                                                                  | orth           |                     | 16 | 8.829       | 18.22       | 5.192       |        |         |        |
| Epidote          | Ca <sub>2</sub> Al <sub>2</sub> (Al,Fe)OH(SiO <sub>4</sub> ) <sub>3</sub>                           | monocl         |                     | 2  | 8.89        | 5.63        | 10.19       |        | 115.40° |        |
| Epsomite         | MgSO <sub>4</sub> ·7H <sub>2</sub> O                                                                | orth           |                     | 4  | 11.86       | 11.99       | 6.858       |        |         |        |
| Eskolaite        | Cr <sub>2</sub> O <sub>3</sub>                                                                      | rhomb          | corundum            | 6  | 4.9607      |             | 13.599      |        |         |        |
| Eucairite        | AgCuSe                                                                                              | orth           |                     | 10 | 4.105       | 20.35       | 6.31        |        |         |        |
| Euclase          | AlBeSiO <sub>4</sub> (OH)                                                                           | monocl         |                     | 4  | 4.763       | 14.29       | 4.618       |        | 100.25° |        |
| Famatimite       | Cu <sub>3</sub> SbS <sub>4</sub>                                                                    | tetr           |                     | 2  | 5.384       |             | 10.770      |        |         |        |
| Fayalite         | Fe <sub>2</sub> SiO <sub>4</sub>                                                                    | orth           | olivine             | 4  | 4.817       | 10.477      | 6.105       |        |         |        |
| Fe-Cordierite    | Fe <sub>2</sub> Al <sub>3</sub> (AlSi <sub>5</sub> O <sub>18</sub> )                                | orth           | cordierite          | 4  | 9.726       | 17.065      | 9.287       |        |         |        |
| Fe-Gehlenite     | Ca <sub>2</sub> Fe <sub>2</sub> SiO <sub>7</sub>                                                    | tetr           | melilite            | 2  | 7.54        |             | 4.855       |        |         |        |
| Fe-Indialite     | Fe <sub>2</sub> Al <sub>3</sub> (AlSi <sub>5</sub> O <sub>18</sub> )                                | hex            | beryl               | 2  | 9.860       |             | 9.285       |        |         |        |
| Fe-Leucite       | KFeSi <sub>2</sub> O <sub>6</sub>                                                                   | tetr           |                     | 16 | 13.205      |             | 13.970      |        |         |        |
| Fe-Microcline    | KFeSi <sub>3</sub> O <sub>8</sub>                                                                   | tricl          |                     | 4  | 8.68        | 13.10       | 7.340       | 90.75° | 116.05° | 86.23° |
| Fe-Sanidine      | KFeSi <sub>3</sub> O <sub>8</sub>                                                                   | monocl         |                     | 4  | 8.689       | 13.12       | 7.319       |        | 116.10° |        |
| Fe-Skuterrudite  | FeAs <sub>2.95</sub>                                                                                | cubic          |                     | 8  | 8.1814      |             |             |        |         |        |
| Ferberite        | FeWO <sub>4</sub>                                                                                   | monocl         | wolframite          | 2  | 4.732       | 5.708       | 4.965       |        | 90.00°  |        |
| Ferriannite      | KFe <sub>3</sub> [FeSi <sub>3</sub> O <sub>10</sub> ](OH) <sub>2</sub>                              | monocl         |                     | 2  | 5.430       | 9.404       | 10.341      |        | 100.07° |        |
| Ferroselite      | FeSe <sub>2</sub>                                                                                   | orth           | marcasite           | 2  | 4.801       | 5.778       | 3.587       |        |         |        |
| Ferrotremolite   | Ca <sub>2</sub> Fe <sub>5</sub> [Si <sub>8</sub> O <sub>22</sub> ](OH) <sub>2</sub>                 | monocl         | tremolite           | 2  | 9.97        | 18.34       | 5.30        |        | 104.50° |        |
| Fluor-edenite    | NaCa <sub>2</sub> Mg <sub>5</sub> [AlSi <sub>7</sub> O <sub>22</sub> ]F <sub>2</sub>                | monocl         | tremolite           | 2  | 9.847       | 18.00       | 5.282       |        | 104.83° |        |
| Fluor-humite     | 3Mg <sub>2</sub> SiO <sub>4</sub> ·MgF <sub>2</sub>                                                 | orth           |                     | 4  | 10.243      | 20.72       | 4.735       |        |         |        |
| Fluor-norbergite | Mg <sub>2</sub> SiO <sub>4</sub> ·MgF <sub>2</sub>                                                  | orth           |                     | 4  | 8.727       | 10.271      | 4.709       |        |         |        |
| Fluor-phlogopite | KMg <sub>3</sub> [AlSi <sub>3</sub> O <sub>10</sub> ]F <sub>2</sub>                                 | monocl         | 1M mica             | 2  | 5.299       | 9.188       | 10.135      |        | 99.92°  |        |
| Fluor-richterite | Na <sub>2</sub> CaMg <sub>5</sub> [Si <sub>8</sub> O <sub>22</sub> ]F <sub>2</sub>                  | monocl         | tremolite           | 2  | 9.823       | 17.96       | 5.268       |        | 104.33° |        |
| Fluor-tremolite  | Ca <sub>2</sub> Mg <sub>5</sub> [Si <sub>8</sub> O <sub>22</sub> ]F <sub>2</sub>                    | monocl         | tremolite           | 2  | 9.781       | 18.01       | 5.267       |        | 104.52° |        |
| Fluorapatite     | Ca <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> F                                                   | hex            | apatite             | 2  | 9.3684      |             | 6.8841      |        |         |        |
| Fluorite         | CaF <sub>2</sub>                                                                                    | cubic          | fluorite            | 4  | 5.4638      |             |             |        |         |        |
| Forsterite       | Mg <sub>2</sub> SiO <sub>4</sub>                                                                    | orth           | olivine             | 4  | 4.758       | 10.214      | 5.984       |        |         |        |
| Frohbergite      | FeTe <sub>2</sub>                                                                                   | orth           | marcasite           | 2  | 5.265       | 6.265       | 3.869       |        |         |        |
| Gahnite          | ZnAl <sub>2</sub> O <sub>4</sub>                                                                    | cubic          | spinel              | 8  | 8.0848      |             |             |        |         |        |
| Galaxite         | MnAl <sub>2</sub> O <sub>4</sub>                                                                    | cubic          | spinel              | 8  | 8.258       |             |             |        |         |        |
| Galena           | PbS                                                                                                 | cubic          | rock salt           | 4  | 5.9360      |             |             |        |         |        |
| Gallium oxide    | Ga <sub>2</sub> O <sub>3</sub>                                                                      | rhomb          | corundum            | 6  | 4.9793      |             | 13.429      |        |         |        |
| Gehlenite        | Ca <sub>2</sub> Al <sub>2</sub> SiO <sub>7</sub>                                                    | tetr           | melilite            | 2  | 7.690       |             | 5.0675      |        |         |        |
| Geikielite       | MgTiO <sub>3</sub>                                                                                  | rhomb          | ilmenite            | 6  | 5.054       |             | 13.898      |        |         |        |
| Gerhardite       | Cu <sub>2</sub> (NO <sub>3</sub> )(OH) <sub>3</sub>                                                 | orth           |                     | 4  | 6.075       | 13.812      | 5.592       |        |         |        |
| Gersdorffite     | NiAsS                                                                                               | cubic          |                     | 4  | 5.693       |             |             |        |         |        |
| Gibbsite         | Al(OH) <sub>3</sub>                                                                                 | monocl         |                     | 8  | 9.719       | 5.0705      | 8.6412      |        | 94.57°  |        |
| Glauchroite      | CaMnSiO <sub>4</sub>                                                                                | orth           | olivine             | 4  | 4.944       | 11.19       | 6.529       |        |         |        |
| Glaucodot        | (Co,Fe)AsS                                                                                          | orth           |                     | 24 | 6.64        | 28.39       | 5.64        |        |         |        |
| Glaucophane I    | Na <sub>2</sub> Mg <sub>3</sub> Al <sub>2</sub> [Si <sub>8</sub> O <sub>22</sub> ](OH) <sub>2</sub> | monocl         | tremolite           | 2  | 9.748       | 17.915      | 5.273       |        | 102.78° |        |
| Glaucophane II   | Na <sub>2</sub> Mg <sub>3</sub> Al <sub>2</sub> [Si <sub>8</sub> O <sub>22</sub> ](OH) <sub>2</sub> | monocl         | tremolite           | 2  | 9.663       | 17.696      | 5.277       |        | 103.67° |        |
| Goethite         | FeO(OH)                                                                                             | orth           |                     | 4  | 4.596       | 9.957       | 3.021       |        |         |        |
| Gold             | Au                                                                                                  | cubic          | face-centered cubic | 4  | 4.0786      |             |             |        |         |        |
| Goldmanite       | Ca <sub>3</sub> V <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                                      | cubic          | garnet              | 8  | 12.070      |             |             |        |         |        |
| Goslarite        | ZnSO <sub>4</sub> ·7H <sub>2</sub> O                                                                | orth           | epsomite            | 4  | 11.779      | 12.050      | 6.822       |        |         |        |

| Name                   | Formula                                                                            | Crystal system | Structure type      | Z  | <i>a</i> /Å | <i>b</i> /Å | <i>c</i> /Å | α      | β       | γ       |
|------------------------|------------------------------------------------------------------------------------|----------------|---------------------|----|-------------|-------------|-------------|--------|---------|---------|
| Graphite               | C                                                                                  | hex            | graphite            | 4  | 2.4612      |             | 6.7079      |        |         |         |
| Greenockite            | CdS                                                                                | hex            | zincite             | 2  | 4.1354      |             | 6.7120      |        |         |         |
| Greigite               | Fe <sub>3</sub> S <sub>4</sub>                                                     | cubic          | spinel              | 8  | 9.876       |             |             |        |         |         |
| Grossularite           | Ca <sub>3</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                    | cubic          | garnet              | 8  | 11.851      |             |             |        |         |         |
| Grunerite              | Fe <sub>7</sub> [Si <sub>8</sub> O <sub>22</sub> ](OH) <sub>2</sub>                | monocl         | tremolite           | 2  | 9.572       | 18.44       | 5.342       |        | 101.77° |         |
| Gudmundite             | FeSbS                                                                              | monocl         |                     | 8  | 10.00       | 5.93        | 6.73        |        | 90.00°  |         |
| Gypsum                 | CaSO <sub>4</sub> ·2H <sub>2</sub> O                                               | monocl         |                     | 4  | 5.68        | 15.18       | 6.29        |        | 113.83° |         |
| Hafnia                 | HfO <sub>2</sub>                                                                   | monocl         | baddeleyite         | 4  | 5.1156      | 5.1722      | 5.2948      |        | 99.18°  |         |
| Halite                 | NaCl                                                                               | cubic          | rock salt           | 4  | 5.6402      |             |             |        |         |         |
| Hambergite             | Be <sub>2</sub> (OH,F)BO <sub>3</sub>                                              | orth           |                     | 8  | 9.755       | 12.201      | 4.426       |        |         |         |
| Hardystonite           | Ca <sub>2</sub> ZnSi <sub>2</sub> O <sub>7</sub>                                   | tetr           | melilite            | 2  | 7.87        |             | 5.01        |        |         |         |
| Hauerite               | MnS <sub>2</sub>                                                                   | cubic          | pyrite              | 4  | 6.1014      |             |             |        |         |         |
| Hausmannite            | Mn <sub>3</sub> O <sub>4</sub>                                                     | tetr           |                     | 8  | 8.136       |             | 9.422       |        |         |         |
| Hawleyite              | CdS                                                                                | cubic          | sphalerite          | 4  | 5.833       |             |             |        |         |         |
| Heazlewoodite          | Ni <sub>3</sub> S <sub>2</sub>                                                     | rhomb          |                     | 3  | 5.746       |             | 7.134       |        |         |         |
| Hedenbergite           | CaFe(SiO <sub>3</sub> ) <sub>2</sub>                                               | monocl         | diopside            | 4  | 9.854       | 9.024       | 5.263       |        | 104.23° |         |
| Hematite               | Fe <sub>2</sub> O <sub>3</sub>                                                     | rhomb          | corundum            | 6  | 5.025       |             | 13.735      |        |         |         |
| Hemimorphite           | Zn <sub>4</sub> (OH) <sub>2</sub> Si <sub>2</sub> O <sub>7</sub> ·H <sub>2</sub> O | orth           |                     | 2  | 8.370       | 10.719      | 5.120       |        |         |         |
| Hercynite              | Fe(AlO <sub>2</sub> ) <sub>2</sub>                                                 | cubic          | spinel              | 8  | 8.150       |             |             |        |         |         |
| Herzenbergite          | SnS                                                                                | orth           | germanium sulfide   | 4  | 4.328       | 11.190      | 3.978       |        |         |         |
| Hessite                | Ag <sub>2</sub> Te                                                                 | monocl         |                     | 4  | 8.13        | 4.48        | 8.09        |        | 111.9°  |         |
| Hexahydrite            | MgSO <sub>4</sub> ·6H <sub>2</sub> O                                               | monocl         |                     | 8  | 10.110      | 7.212       | 24.41       |        | 98.30°  |         |
| High albite (Analcite) | NaAlSi <sub>3</sub> O <sub>8</sub>                                                 | tricl          |                     | 4  | 8.160       | 12.870      | 7.106       | 93.54° | 116.36° | 90.19°  |
| High argentite         | Ag <sub>2</sub> S                                                                  | cubic          |                     | 4  | 6.269       |             |             |        |         |         |
| High bornite           | Cu <sub>5</sub> FeS <sub>4</sub>                                                   | cubic          |                     | 1  | 5.50        |             |             |        |         |         |
| High carnegite         | NaAlSiO <sub>4</sub>                                                               | cubic          |                     | 4  | 7.325       |             |             |        |         |         |
| High chalcocite        | Cu <sub>2</sub> S                                                                  | hex            |                     | 2  | 3.961       |             | 6.722       |        |         |         |
| High clinoenstatite    | MgSiO <sub>3</sub>                                                                 | tricl          |                     | 8  | 10.000      | 8.934       | 5.170       | 88.27° | 70.03°  | 91.01°  |
| High digenite          | Cu <sub>2</sub> S                                                                  | cubic          |                     | 4  | 5.725       |             |             |        |         |         |
| High germania          | GeO <sub>2</sub>                                                                   | hex            | α-quartz            | 3  | 4.987       |             | 5.652       |        |         |         |
| High leucite           | KAlSi <sub>2</sub> O <sub>6</sub>                                                  | cubic          |                     | 16 | 13.43       |             |             |        |         |         |
| High naumanite         | Ag <sub>2</sub> Se                                                                 | cubic          |                     | 2  | 4.993       |             |             |        |         |         |
| High sanidine          | KAlSi <sub>3</sub> O <sub>8</sub>                                                  | monocl         |                     | 4  | 8.615       | 13.031      | 7.177       |        | 115.98° |         |
| Huebnerite             | MnWO <sub>4</sub>                                                                  | monocl         | wolframite          | 2  | 4.834       | 5.758       | 4.999       |        | 91.18°  |         |
| Huntite                | Mg <sub>3</sub> Ca(CO <sub>3</sub> ) <sub>4</sub>                                  | rhomb          | calcite             | 3  | 9.498       |             | 7.816       |        |         |         |
| Hydroxylapatite        | Ca <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> OH                                 | hex            | apatite             | 2  | 9.418       |             | 6.883       |        |         |         |
| Ice                    | H <sub>2</sub> O                                                                   | hex            |                     | 4  | 4.5212      |             | 7.3666      |        |         |         |
| Ilmenite               | FeTiO <sub>3</sub>                                                                 | rhomb          | ilmenite            | 6  | 5.093       |             | 14.055      |        |         |         |
| Indialite (Cordierite) | Mg <sub>2</sub> Al <sub>3</sub> (AlSi <sub>5</sub> O <sub>18</sub> )               | hex            | beryl               | 2  | 9.7698      |             | 9.3517      |        |         |         |
| Iodargyrite            | AgI                                                                                | hex            | zincite             | 2  | 4.5955      |             | 7.5005      |        |         |         |
| Iron (α)               | Fe                                                                                 | cubic          | body-centered cubic | 2  | 2.8664      |             |             |        |         |         |
| Jacobsite              | MnFe <sub>2</sub> O <sub>4</sub>                                                   | cubic          | spinel              | 8  | 8.499       |             |             |        |         |         |
| Jadeite                | NaAl(SiO <sub>3</sub> ) <sub>2</sub>                                               | monocl         | diopside            | 4  | 9.409       | 8.564       | 5.220       |        | 107.50° |         |
| Jalpaite               | Ag <sub>1.55</sub> Cu <sub>0.45</sub> S                                            | tetr           |                     | 16 | 8.673       |             | 11.756      |        |         |         |
| Johannsenite           | CaMn(SiO <sub>3</sub> ) <sub>2</sub>                                               | monocl         | diopside            | 4  | 9.83        | 9.04        | 5.27        |        | 105.00° |         |
| Kaliophilite           | KAlSiO <sub>4</sub>                                                                | hex            |                     | 54 | 26.930      |             | 8.522       |        |         |         |
| Kalsilite              | KAlSiO <sub>4</sub>                                                                | hex            |                     | 2  | 5.1597      |             | 8.7032      |        |         |         |
| Kaolinite              | Al <sub>2</sub> Si <sub>2</sub> O <sub>5</sub> (OH) <sub>4</sub>                   | tricl          |                     | 2  | 5.155       | 8.959       | 7.407       | 91.68° | 104.87° | 89.93°  |
| Karelianite            | V <sub>2</sub> O <sub>3</sub>                                                      | rhomb          | corundum            | 6  | 4.952       |             | 14.002      |        |         |         |
| Keatite                | SiO <sub>2</sub>                                                                   | tetr           |                     | 12 | 7.456       |             | 8.604       |        |         |         |
| Kernite                | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·4H <sub>2</sub> O                   | monocl         |                     | 4  | 7.022       | 9.151       | 15.676      |        | 108.83° |         |
| Kerschsteinite         | CaFeSiO <sub>4</sub>                                                               | orth           | olivine             | 4  | 4.886       | 11.146      | 6.434       |        |         |         |
| Klockmannite           | CuSe                                                                               | hex            | deformed covellite  | 78 | 14.206      |             | 17.25       |        |         |         |
| Knebelite              | MnFeSiO <sub>4</sub>                                                               | orth           | olivine             | 4  | 4.854       | 10.602      | 6.162       |        |         |         |
| Kyanite                | Al <sub>2</sub> OSiO <sub>4</sub>                                                  | tricl          |                     | 4  | 7.123       | 7.848       | 5.564       | 89.92° | 101.25° | 105.97° |
| Larnite                | Ca <sub>2</sub> SiO <sub>4</sub>                                                   | monocl         |                     | 4  | 5.48        | 6.76        | 9.28        |        | 94.55°  |         |
| Laurite                | RuS <sub>2</sub>                                                                   | cubic          | pyrite              | 4  | 5.60        |             |             |        |         |         |

| Name                  | Formula                                                                                             | Crystal system | Structure type      | Z  | <i>a</i> /Å | <i>b</i> /Å | <i>c</i> /Å | α      | β       | γ      |
|-----------------------|-----------------------------------------------------------------------------------------------------|----------------|---------------------|----|-------------|-------------|-------------|--------|---------|--------|
| Lawrencite            | FeCl <sub>2</sub>                                                                                   | rhomb          |                     | 3  | 3.593       |             | 17.58       |        |         |        |
| Lawsonite             | CaAl <sub>2</sub> Si <sub>2</sub> O <sub>7</sub> (OH) <sub>2</sub> ·H <sub>2</sub> O                | orth           |                     | 4  | 8.787       | 5.836       | 13.123      |        |         |        |
| Lead                  | Pb                                                                                                  | cubic          | face-centered cubic | 4  | 4.9505      |             |             |        |         |        |
| Leonhardtite          | MgSO <sub>4</sub> ·4H <sub>2</sub> O                                                                | monocl         |                     | 4  | 5.922       | 13.604      | 7.905       |        | 90.85°  |        |
| Lepidocrocite         | FeO(OH)                                                                                             | orth           |                     | 4  | 3.868       | 12.525      | 3.066       |        |         |        |
| Lepidolite            | K <sub>2</sub> Al <sub>3</sub> Li <sub>3</sub> AlSi <sub>7</sub> O <sub>20</sub> (OH) <sub>4</sub>  | monocl         | 2M2 mica            | 2  | 9.2         | 5.3         | 20.0        |        | 98.00°  |        |
| Leucite               | KAlSi <sub>2</sub> O <sub>6</sub>                                                                   | tetr           |                     | 16 | 13.074      |             | 13.738      |        |         |        |
| Lime                  | CaO                                                                                                 | cubic          | rock salt           | 4  | 4.8108      |             |             |        |         |        |
| Lime olivine          | Ca <sub>2</sub> SiO <sub>4</sub>                                                                    | orth           | olivine             | 4  | 5.091       | 11.371      | 6.782       |        |         |        |
| Linnaeite             | Co <sub>3</sub> S <sub>4</sub>                                                                      | cubic          | spinel              | 8  | 9.401       |             |             |        |         |        |
| Litharge              | PbO                                                                                                 | tetr           |                     | 2  | 3.9759      |             | 5.023       |        |         |        |
| Loellingite           | FeAs <sub>2</sub>                                                                                   | orth           | marcasite           | 2  | 5.300       | 5.981       | 2.882       |        |         |        |
| Low albite            | NaAlSi <sub>3</sub> O <sub>8</sub>                                                                  | tricl          |                     | 4  | 8.139       | 12.788      | 7.160       | 94.27° | 116.57° | 87.68° |
| Low bornite           | Cu <sub>5</sub> FeS <sub>4</sub>                                                                    | tetr           |                     | 16 | 10.94       |             | 21.88       |        |         |        |
| Low cordierite        | Mg <sub>2</sub> Al <sub>3</sub> (AlSi <sub>5</sub> O <sub>18</sub> )                                | orth           |                     | 4  | 9.721       | 17.062      | 9.339       |        |         |        |
| Low germania          | GeO <sub>2</sub>                                                                                    | tetr           | rutile              | 2  | 4.3963      |             | 2.8626      |        |         |        |
| Low nepheline         | NaAlSiO <sub>4</sub>                                                                                | hex            |                     | 8  | 9.986       |             | 8.330       |        |         |        |
| Luzonite              | Cu <sub>3</sub> AsS <sub>4</sub>                                                                    | tetr           |                     | 2  | 5.289       |             | 10.440      |        |         |        |
| Mackinawite           | FeS                                                                                                 | tetr           |                     | 2  | 3.675       |             | 5.030       |        |         |        |
| Magnesioriebeckite    | Na <sub>2</sub> Mg <sub>3</sub> Fe <sub>2</sub> [Si <sub>8</sub> O <sub>22</sub> ](OH) <sub>2</sub> | monocl         | tremolite           | 2  | 9.733       | 17.946      | 5.299       |        | 103.30° |        |
| Magnetite             | MgCO <sub>3</sub>                                                                                   | rhomb          | calcite             | 6  | 4.6330      |             | 15.016      |        |         |        |
| Magnetite             | Fe <sub>3</sub> O <sub>4</sub>                                                                      | cubic          | spinel              | 8  | 8.3940      |             |             |        |         |        |
| Malachite             | Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub>                                                   | monocl         |                     | 4  | 9.502       | 11.974      | 3.240       |        | 98.75°  |        |
| Maldonite             | Au <sub>2</sub> Bi                                                                                  | cubic          |                     | 8  | 7.958       |             |             |        |         |        |
| Manganese sulfide (γ) | MnS                                                                                                 | hex            | zincite             | 2  | 3.976       |             | 6.432       |        |         |        |
| Manganese sulfide (β) | MnS                                                                                                 | cubic          | sphalerite          | 4  | 5.611       |             |             |        |         |        |
| Manganosite           | MnO                                                                                                 | cubic          | rock salt           | 4  | 4.4448      |             |             |        |         |        |
| Marcasite             | FeS <sub>2</sub>                                                                                    | orth           | marcasite           | 2  | 4.443       | 5.423       | 3.3876      |        |         |        |
| Margarite             | CaAl <sub>2</sub> [AlSi <sub>2</sub> O <sub>10</sub> ](OH) <sub>2</sub>                             | monocl         | 2M mica             | 4  | 5.13        | 8.92        | 19.50       |        | 95.00°  |        |
| Marialite             | Na <sub>4</sub> Al <sub>3</sub> Si <sub>9</sub> O <sub>24</sub> Cl                                  | tetr           |                     | 2  | 12.064      |             | 7.514       |        |         |        |
| Marshite              | CuI                                                                                                 | cubic          | sphalerite          | 4  | 6.0507      |             |             |        |         |        |
| Mascagnite            | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>                                                     | orth           | arcanite            | 4  | 7.782       | 5.993       | 10.636      |        |         |        |
| Massicot              | PbO                                                                                                 | orth           |                     | 4  | 5.489       | 4.755       | 5.891       |        |         |        |
| Matlockite            | PbClF                                                                                               | tetr           |                     | 2  | 4.106       |             | 7.23        |        |         |        |
| Maucherite            | Ni <sub>11</sub> As <sub>8</sub>                                                                    | tetr           |                     | 4  | 6.870       |             | 21.81       |        |         |        |
| Meionite              | Ca <sub>4</sub> Al <sub>6</sub> Si <sub>6</sub> O <sub>24</sub> CO <sub>3</sub>                     | tetr           |                     | 2  | 12.174      |             | 7.652       |        |         |        |
| Melanophlogite        | SiO <sub>2</sub>                                                                                    | cubic          | clathrate type      | 46 | 13.402      |             |             |        |         |        |
| Melanterite           | FeSO <sub>4</sub> ·7H <sub>2</sub> O                                                                | monocl         |                     | 4  | 14.072      | 6.503       | 11.041      |        | 105.57° |        |
| Melonite              | NiTe <sub>2</sub>                                                                                   | hex            | cadmium iodide      | 1  | 3.869       |             | 5.308       |        |         |        |
| Metacinnabar          | HgS                                                                                                 | cubic          | sphalerite          | 4  | 5.8517      |             |             |        |         |        |
| Miargyrite            | AgSbS <sub>2</sub>                                                                                  | monocl         |                     | 8  | 12.862      | 4.111       | 13.220      |        | 98.63°  |        |
| Microcline            | KAlSi <sub>3</sub> O <sub>8</sub>                                                                   | tricl          |                     | 4  | 8.582       | 12.964      | 7.222       | 90.62° | 115.92° | 87.68° |
| Miersite              | AgI                                                                                                 | cubic          | sphalerite          | 4  | 6.4963      |             |             |        |         |        |
| Millerite             | NiS                                                                                                 | rhomb          |                     | 9  | 9.616       |             | 3.152       |        |         |        |
| Minium                | Pb <sub>3</sub> O <sub>4</sub>                                                                      | tetr           |                     | 4  | 8.815       |             | 6.565       |        |         |        |
| Minnesotaite          | Fe <sub>3</sub> Si <sub>4</sub> O <sub>10</sub> (OH) <sub>2</sub>                                   | monocl         |                     | 4  | 5.4         | 9.42        | 19.4        |        | 100.00° |        |
| Mirabilite            | Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O                                                 | monocl         |                     | 4  | 11.51       | 10.38       | 12.83       |        | 107.75° |        |
| Mn-Indialite          | Mn <sub>2</sub> Al <sub>3</sub> (AlSi <sub>5</sub> O <sub>18</sub> )                                | hex            | beryl               | 2  | 9.925       |             | 9.297       |        |         |        |
| Molybdenite           | MoS <sub>2</sub>                                                                                    | hex            | molybdenite         | 2  | 3.1604      |             | 12.295      |        |         |        |
| Molybdenum            | Mo                                                                                                  | cubic          |                     | 2  | 3.1653      |             |             |        |         |        |
| Molybdate             | MoO <sub>3</sub>                                                                                    | orth           |                     | 4  | 3.962       | 13.858      | 3.697       |        |         |        |
| Monteponite           | CdO                                                                                                 | cubic          | rock salt           | 4  | 4.6953      |             |             |        |         |        |
| Monticellite          | CaMgSiO <sub>4</sub>                                                                                | orth           | olivine             | 4  | 4.827       | 11.084      | 6.376       |        |         |        |
| Montroydite           | HgO                                                                                                 | orth           |                     | 4  | 6.608       | 5.518       | 3.519       |        |         |        |
| Mullite (2:1)         | 2Al <sub>2</sub> O <sub>3</sub> ·SiO <sub>2</sub>                                                   | orth           |                     | 6  | 7.5788      | 7.6909      | 2.8883      |        |         |        |
| Mullite (3:2)         | 3Al <sub>2</sub> O <sub>3</sub> ·2SiO <sub>2</sub>                                                  | orth           |                     | 3  | 7.557       | 7.6876      | 2.8842      |        |         |        |
| Muscovite             | KAl <sub>2</sub> AlSi <sub>3</sub> O <sub>10</sub> (OH) <sub>2</sub>                                | monocl         | 2M2 mica            | 4  | 5.203       | 8.995       | 20.030      |        | 94.47°  |        |

| Name               | Formula                                                                                 | Crystal system | Structure type      | Z  | a/Å    | b/Å    | c/Å    | α      | β       | γ       |
|--------------------|-----------------------------------------------------------------------------------------|----------------|---------------------|----|--------|--------|--------|--------|---------|---------|
| Nacrite            | Al <sub>2</sub> Si <sub>2</sub> O <sub>5</sub> (OH) <sub>4</sub>                        | monocl         |                     | 4  | 8.909  | 5.146  | 15.697 |        | 113.70° |         |
| Nantokite          | CuCl                                                                                    | cubic          | sphalerite          | 4  | 5.416  |        |        |        |         |         |
| Natroalunite       | NaAl <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> (OH) <sub>6</sub>                     | rhomb          |                     | 3  | 6.974  |        | 16.69  |        |         |         |
| Natrolite          | Na <sub>2</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>10</sub> ·2H <sub>2</sub> O      | orth           |                     | 8  | 18.30  | 18.63  | 6.60   |        |         |         |
| Neighborite        | NaMgF <sub>3</sub>                                                                      | orth           | perovskite          | 4  | 5.363  | 7.676  | 5.503  |        |         |         |
| Ni-Skutterudite    | NiAs <sub>2.95</sub>                                                                    | cubic          |                     | 8  | 8.3300 |        |        |        |         |         |
| Niccolite          | NiAs                                                                                    | hex            | niccolite           | 2  | 3.618  |        | 5.034  |        |         |         |
| Nickel             | Ni                                                                                      | cubic          | face-centered cubic | 4  | 3.5238 |        |        |        |         |         |
| Nickel carbonate   | NiCO <sub>3</sub>                                                                       | rhomb          | calcite             | 6  | 4.5975 |        | 14.723 |        |         |         |
| Nickel olivine     | Ni <sub>2</sub> SiO <sub>4</sub>                                                        | orth           | olivine             | 4  | 4.727  | 10.121 | 5.915  |        |         |         |
| Nickel selenide    | NiSe <sub>2</sub>                                                                       | cubic          | pyrite              | 4  | 5.9604 |        |        |        |         |         |
| Niter              | KNO <sub>3</sub>                                                                        | orth           | aragonite           | 4  | 6.431  | 9.164  | 5.414  |        |         |         |
| Norsethite         | BaMg(CO <sub>3</sub> ) <sub>2</sub>                                                     | rhomb          | calcite             | 3  | 5.020  |        | 16.75  |        |         |         |
| Oldhamite          | CaS                                                                                     | cubic          | rock salt           | 4  | 5.689  |        |        |        |         |         |
| Orpiment           | As <sub>2</sub> S <sub>3</sub>                                                          | monocl         |                     | 4  | 11.49  | 9.59   | 4.25   |        | 90.45°  |         |
| Orthoclase         | KAlSi <sub>3</sub> O <sub>8</sub>                                                       | monocl         |                     | 4  | 8.562  | 12.996 | 7.193  |        | 116.02° |         |
| Orthoferrosilite   | FeSiO <sub>3</sub>                                                                      | orth           | enstatite           | 16 | 9.080  | 18.431 | 5.238  |        |         |         |
| Otavite            | CdCO <sub>3</sub>                                                                       | rhomb          | calcite             | 6  | 4.9204 |        | 16.298 |        |         |         |
| Paracelsian        | BaAl <sub>2</sub> Si <sub>2</sub> O <sub>8</sub>                                        | monocl         |                     | 4  | 8.58   | 9.583  | 9.08   |        | 90.00°  |         |
| Paragonite         | NaAl <sub>2</sub> AlSi <sub>3</sub> O <sub>10</sub> (OH) <sub>2</sub>                   | monocl         | 2M1 mica            | 4  | 5.13   | 8.89   | 19.32  |        | 95.17°  |         |
| Pararammelsbergite | NiAs <sub>2</sub>                                                                       | orth           |                     | 8  | 5.75   | 5.82   | 11.428 |        |         |         |
| Paratellurite      | TeO <sub>2</sub>                                                                        | tetr           |                     | 4  | 4.810  |        | 7.613  |        |         |         |
| Parawollastonite   | CaSiO <sub>3</sub>                                                                      | monocl         |                     | 12 | 15.417 | 7.321  | 7.066  |        | 95.40°  |         |
| Pectolite          | Ca <sub>2</sub> NaH(SiO <sub>3</sub> ) <sub>3</sub>                                     | tricl          |                     | 2  | 7.99   | 7.04   | 7.02   | 90.05° | 95.27°  | 102.47° |
| Pentlandite        | Fe <sub>5.25</sub> Ni <sub>3.75</sub> S <sub>8</sub>                                    | cubic          |                     | 4  | 10.196 |        |        |        |         |         |
| Pentlandite        | Fe <sub>4.75</sub> Ni <sub>5.25</sub> S <sub>8</sub>                                    | cubic          |                     | 4  | 10.095 |        |        |        |         |         |
| Periclase          | MgO                                                                                     | cubic          | rock salt           | 4  | 4.2117 |        |        |        |         |         |
| Perovskite         | CaTiO <sub>3</sub>                                                                      | orth           | perovskite          | 4  | 5.3670 | 7.6438 | 5.4439 |        |         |         |
| Petalite           | LiAlSi <sub>4</sub> O <sub>10</sub>                                                     | monocl         |                     | 2  | 11.32  | 5.14   | 7.62   |        | 105.90° |         |
| Petzite            | Ag <sub>3</sub> AuTe <sub>2</sub>                                                       | cubic          |                     | 8  | 10.38  |        |        |        |         |         |
| Phenacite          | Be <sub>2</sub> SiO <sub>4</sub>                                                        | rhomb          | phenacite           | 18 | 12.472 |        | 8.252  |        |         |         |
| Phlogopite         | KMg <sub>3</sub> AlSi <sub>3</sub> O <sub>10</sub> (OH) <sub>2</sub>                    | monocl         | 1M mica             | 2  | 5.326  | 9.210  | 10.311 |        | 100.17° |         |
| Picrochromite      | MgCr <sub>2</sub> O <sub>4</sub>                                                        | cubic          | spinel              | 8  | 8.333  |        |        |        |         |         |
| Piemontite         | Ca <sub>2</sub> Al <sub>1.5</sub> Mn <sub>1.5</sub> (SiO <sub>4</sub> ) <sub>3</sub> OH | monocl         |                     | 2  | 8.95   | 5.70   | 9.41   |        | 115.70° |         |
| Platinum           | Pt                                                                                      | cubic          | face-centered cubic | 4  | 3.9231 |        |        |        |         |         |
| Polymidite         | Ni <sub>3</sub> S <sub>4</sub>                                                          | cubic          | spinel              | 8  | 9.480  |        |        |        |         |         |
| Portlandite        | Ca(OH) <sub>2</sub>                                                                     | hex            | cadmium iodide      | 1  | 3.5933 |        | 4.9086 |        |         |         |
| Powellite          | CaMoO <sub>4</sub>                                                                      | tetr           | scheelite           | 4  | 5.226  |        | 11.43  |        |         |         |
| Protoenstatite     | MgSiO <sub>3</sub>                                                                      | orth           |                     | 8  | 9.25   | 8.74   | 5.32   |        |         |         |
| Proustite          | Ag <sub>3</sub> AsS <sub>3</sub>                                                        | rhomb          |                     | 6  | 10.816 |        | 8.6948 |        |         |         |
| Pseudowollastonite | CaSiO <sub>3</sub>                                                                      | tricl          |                     | 24 | 6.90   | 11.78  | 19.65  | 90.00° | 90.80°  | 90.00°  |
| Pyrargyrite        | Ag <sub>3</sub> SbS <sub>3</sub>                                                        | rhomb          |                     | 6  | 11.052 |        | 8.7177 |        |         |         |
| Pyrite             | FeS <sub>2</sub>                                                                        | cubic          | pyrite              | 4  | 5.4175 |        |        |        |         |         |
| Pyrolusite         | MnO <sub>2</sub>                                                                        | tetr           | rutile              | 2  | 4.388  |        | 2.865  |        |         |         |
| Pyrope             | Mg <sub>3</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                         | cubic          | garnet              | 8  | 11.459 |        |        |        |         |         |
| Pyrophanite        | MnTiO <sub>3</sub>                                                                      | rhomb          | ilmenite            | 6  | 5.155  |        | 14.18  |        |         |         |
| Pyrophyllite       | Al <sub>2</sub> Si <sub>4</sub> O <sub>10</sub> (OH) <sub>2</sub>                       | monocl         | 2M1 mica            | 4  | 5.14   | 8.90   | 18.55  |        | 99.92°  |         |
| Pyroxmangite       | MnFe(SiO <sub>3</sub> ) <sub>2</sub>                                                    | tricl          |                     | 7  | 7.56   | 17.45  | 6.67   | 84.00° | 94.30°  | 113.70° |
| Pyrrhotite         | Fe <sub>0.980</sub> S                                                                   | hex            | defect niccolite    | 2  | 3.446  |        | 5.848  |        |         |         |
| Pyrrhotite         | Fe <sub>0.885</sub> S                                                                   | hex            | defect niccolite    | 2  | 3.440  |        | 5.709  |        |         |         |
| Quartz (α)         | SiO <sub>2</sub>                                                                        | hex            |                     | 3  | 4.9136 |        | 5.4051 |        |         |         |
| Quartz (β)         | SiO <sub>2</sub>                                                                        | hex            |                     | 3  | 4.999  |        | 5.4592 |        |         |         |
| Rammelsbergite     | NiAs <sub>2</sub>                                                                       | orth           | marcasite           | 2  | 4.757  | 5.797  | 3.542  |        |         |         |
| Realgar            | As <sub>4</sub> S <sub>4</sub>                                                          | monocl         |                     | 16 | 9.29   | 13.53  | 6.57   |        | 106.55° |         |
| Retgersite         | NiSO <sub>4</sub> ·4H <sub>2</sub> O                                                    | tetr           |                     | 4  | 6.782  |        | 18.28  |        |         |         |
| Rhodochrosite      | MnCO <sub>3</sub>                                                                       | rhomb          | calcite             | 6  | 4.7771 |        | 15.664 |        |         |         |

| Name                  | Formula                                                                                            | Crystal system | Structure type      | Z   | a/Å     | b/Å     | c/Å     | α      | β       | γ       |
|-----------------------|----------------------------------------------------------------------------------------------------|----------------|---------------------|-----|---------|---------|---------|--------|---------|---------|
| Rhodonite             | MnSiO <sub>3</sub>                                                                                 | tricl          |                     | 10  | 7.682   | 11.818  | 6.707   | 92.36° | 93.95°  | 105.66° |
| Riebeckite            | Na <sub>2</sub> Fe <sub>5</sub> FSi <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>                 | monocl         | tremolite           | 2   | 9.729   | 18.065  | 5.334   |        | 103.31° |         |
| Rutile                | TiO <sub>2</sub>                                                                                   | tetr           |                     | 2   | 4.5937  |         | 2.9618  |        |         |         |
| Safflorite            | Co <sub>0.5</sub> Fe <sub>0.5</sub> As <sub>2</sub>                                                | orth           | marcasite           | 2   | 5.231   | 5.953   | 2.962   |        |         |         |
| Sanmartinite          | ZnWO <sub>4</sub>                                                                                  | monocl         | wolframite          | 2   | 4.691   | 5.720   | 4.925   |        | 89.36°  |         |
| Sapphirine            | Mg <sub>2</sub> Al <sub>4</sub> O <sub>6</sub> SiO <sub>4</sub>                                    | monocl         |                     | 8   | 9.96    | 28.60   | 9.85    |        | 110.5°  |         |
| Scacchite             | MnCl <sub>2</sub>                                                                                  | rhomb          |                     | 3   | 3.711   |         | 17.59   |        |         |         |
| Scheelite             | CaWO <sub>4</sub>                                                                                  | tetr           | scheelite           | 4   | 5.242   |         | 11.372  |        |         |         |
| Schorl                | NaFe <sub>3</sub> Al <sub>6</sub> B <sub>3</sub> Si <sub>6</sub> O <sub>27</sub> (OH) <sub>4</sub> | rhomb          | tourmaline          | 3   | 16.032  |         | 7.149   |        |         |         |
| Selenium              | Se                                                                                                 | hex            |                     | 3   | 4.3642  |         | 4.9588  |        |         |         |
| Selenolite            | SeO <sub>2</sub>                                                                                   | tetr           |                     | 8   | 8.35    |         | 5.05    |        |         |         |
| Sellaite              | MgF <sub>2</sub>                                                                                   | tetr           | rutile              | 2   | 4.621   |         | 3.050   |        |         |         |
| Senarmontite          | Sb <sub>2</sub> O <sub>3</sub>                                                                     | cubic          | arsenic trioxide    | 16  | 11.152  |         |         |        |         |         |
| Shandite              | Ni <sub>3</sub> Pb <sub>2</sub> S <sub>2</sub>                                                     | rhomb          |                     | 3   | 5.576   |         | 13.658  |        |         |         |
| Shortite              | Na <sub>2</sub> Ca <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub>                                    | orth           |                     | 2   | 4.961   | 11.03   | 7.12    |        |         |         |
| Siderite              | FeCO <sub>3</sub>                                                                                  | rhomb          | calcite             | 6   | 4.6887  |         | 15.373  |        |         |         |
| Silicon               | Si                                                                                                 | cubic          | diamond             | 8   | 5.4305  |         |         |        |         |         |
| Sillimanite           | Al <sub>2</sub> OSiO <sub>4</sub>                                                                  | orth           |                     | 4   | 7.4843  | 7.6730  | 5.7711  |        |         |         |
| Silver                | Ag                                                                                                 | cubic          | face-centered cubic | 4   | 4.0862  |         |         |        |         |         |
| Silver telluride I    | Ag <sub>2</sub> Te                                                                                 | cubic          |                     | 2   | 5.29    |         |         |        |         |         |
| Silver telluride II   | Ag <sub>2</sub> Te                                                                                 | cubic          |                     | 4   | 6.585   |         |         |        |         |         |
| Smithsonite           | ZnCO <sub>3</sub>                                                                                  | rhomb          | calcite             | 6   | 4.6528  |         | 15.025  |        |         |         |
| Soda niter            | NaNO <sub>3</sub>                                                                                  | rhomb          | calcite             | 6   | 5.0696  |         | 16.829  |        |         |         |
| Sodium melilite       | NaCaAlSi <sub>2</sub> O <sub>7</sub>                                                               | tetr           | melilite            | 2   | 8.511   |         | 4.809   |        |         |         |
| Sperrylite            | PtAs <sub>2</sub>                                                                                  | cubic          | pyrite              | 4   | 5.968   |         |         |        |         |         |
| Spessartite           | Mn <sub>3</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                                    | cubic          | garnet              | 8   | 11.621  |         |         |        |         |         |
| Sphalerite            | ZnS                                                                                                | cubic          | sphalerite          | 4   | 5.4093  |         |         |        |         |         |
| Sphene                | CaTiSiO <sub>5</sub>                                                                               | monocl         |                     | 4   | 7.07    | 8.72    | 6.56    |        | 113.95° |         |
| Spinel                | MgAl <sub>2</sub> O <sub>4</sub>                                                                   | cubic          | spinel              | 8   | 8.080   |         |         |        |         |         |
| Spodumene             | LiAl(SiO <sub>3</sub> ) <sub>2</sub>                                                               | monocl         | diopside            | 4   | 9.451   | 8.387   | 5.208   |        | 110.07° |         |
| Spodumene (β)         | LiAl(SiO <sub>3</sub> ) <sub>2</sub>                                                               | tetr           |                     | 4   | 7.5332  |         | 9.1540  |        |         |         |
| Staurolite            | Fe <sub>2</sub> Al <sub>9</sub> Si <sub>4</sub> O <sub>22</sub> (OH) <sub>2</sub>                  | monocl         |                     | 2   | 7.90    | 16.65   | 5.63    |        | 90.00°  |         |
| Sternbergite          | AgFe <sub>2</sub> S <sub>3</sub>                                                                   | orth           |                     | 8   | 11.60   | 12.675  | 6.63    |        |         |         |
| Stibnite              | Sb <sub>2</sub> S <sub>3</sub>                                                                     | orth           | stibnite            | 4   | 11.229  | 11.310  | 3.8389  |        |         |         |
| Stilleite             | ZnSe                                                                                               | cubic          | sphalerite          | 4   | 5.6685  |         |         |        |         |         |
| Stishovite            | SiO <sub>2</sub>                                                                                   | tetr           | rutile              | 2   | 4.1790  |         | 2.6649  |        |         |         |
| Stolzite              | PbWO <sub>4</sub>                                                                                  | tetr           | scheelite           | 4   | 5.4616  |         | 12.046  |        |         |         |
| Stromeyerite          | Ag <sub>0.93</sub> Cu <sub>1.07</sub> S                                                            | orth           |                     | 4   | 4.066   | 6.628   | 7.972   |        |         |         |
| Strontianite          | SrCO <sub>3</sub>                                                                                  | orth           | aragonite           | 4   | 6.029   | 8.414   | 5.107   |        |         |         |
| Sulfur (monoclinic)   | S                                                                                                  | monocl         | S8 ring molecules   | 48  | 11.04   | 10.98   | 10.92   |        | 96.73°  |         |
| Sulfur (orthorhombic) | S                                                                                                  | orth           | S8 ring molecules   | 128 | 10.4646 | 12.8660 | 24.4860 |        |         |         |
| Sulfur (rhombohedral) | S                                                                                                  | rhomb          | S6 ring molecules   | 18  | 10.818  |         | 4.280   |        |         |         |
| Sylvite               | KCl                                                                                                | cubic          | rock salt           | 4   | 6.2931  |         |         |        |         |         |
| Syngenite             | K <sub>2</sub> Ca(SO <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> O                                 | monocl         |                     | 2   | 9.775   | 7.156   | 6.251   |        | 104.00° |         |
| Synthetic anorthite   | CaAl <sub>2</sub> Si <sub>2</sub> O <sub>8</sub>                                                   | hex            |                     | 2   | 5.10    |         | 14.72   |        |         |         |
| Synthetic anorthite   | CaAl <sub>2</sub> Si <sub>2</sub> O <sub>8</sub>                                                   | orth           |                     | 2   | 8.22    | 8.60    | 4.83    |        |         |         |
| Talc                  | Mg <sub>3</sub> Si <sub>4</sub> O <sub>10</sub> (OH) <sub>2</sub>                                  | monocl         | 2M1 mica            | 4   | 5.287   | 9.158   | 18.95   |        | 99.50°  |         |
| Tantalum              | Ta                                                                                                 | cubic          | tungsten            | 2   | 3.3058  |         |         |        |         |         |
| Teallite              | PbSnS <sub>2</sub>                                                                                 | orth           | germanium sulfide   | 2   | 4.266   | 11.419  | 4.090   |        |         |         |
| Tellurite             | TeO <sub>2</sub>                                                                                   | orth           | tellurite           | 8   | 5.607   | 12.034  | 5.463   |        |         |         |
| Tellurium             | Te                                                                                                 | hex            | selenium            | 3   | 4.4570  |         | 5.9290  |        |         |         |
| Tellurobismuthite     | Bi <sub>2</sub> Te <sub>3</sub>                                                                    | rhomb          |                     | 3   | 4.3835  |         | 30.487  |        |         |         |
| Tennantite            | Cu <sub>12</sub> As <sub>4</sub> S <sub>13</sub>                                                   | cubic          | tetrahedrite        | 2   | 10.190  |         |         |        |         |         |
| Tenorite              | CuO                                                                                                | monocl         |                     | 4   | 4.684   | 3.425   | 5.129   |        | 99.47°  |         |
| Tephroite             | Mn <sub>2</sub> SiO <sub>4</sub>                                                                   | orth           | olivine             | 4   | 4.871   | 10.636  | 6.232   |        |         |         |

| Name                | Formula                                                                                            | Crystal system | Structure type       | Z  | a/Å    | b/Å    | c/Å    | α      | β       | γ       |
|---------------------|----------------------------------------------------------------------------------------------------|----------------|----------------------|----|--------|--------|--------|--------|---------|---------|
| Tetrahedrite        | Cu <sub>12</sub> Sb <sub>4</sub> S <sub>13</sub>                                                   | cubic          | tetrahedrite         | 2  | 10.327 |        |        |        |         |         |
| Thenardite          | Na <sub>2</sub> SO <sub>4</sub>                                                                    | orth           | thenardite           | 8  | 5.863  | 12.304 | 9.821  |        |         |         |
| Thorianite          | ThO <sub>2</sub>                                                                                   | cubic          | fluorite             | 4  | 5.5952 |        |        |        |         |         |
| Thorite             | ThSiO <sub>4</sub>                                                                                 | tetr           | zircon               | 4  | 7.143  |        | 6.327  |        |         |         |
| Tiemannite          | HgSe                                                                                               | cubic          | sphalerite           | 4  | 6.0853 |        |        |        |         |         |
| Tin                 | Sn                                                                                                 | tetr           |                      | 4  | 5.8315 |        | 3.1813 |        |         |         |
| Titanium            | Ti                                                                                                 | hex            |                      | 2  | 2.953  |        | 4.729  |        |         |         |
| Titanium(III) oxide | Ti <sub>2</sub> O <sub>3</sub>                                                                     | rhomb          | corundum             | 6  | 5.149  |        | 13.642 |        |         |         |
| Topaz               | Al <sub>2</sub> SiO <sub>4</sub> (OH,F) <sub>2</sub>                                               | orth           |                      | 4  | 8.394  | 8.792  | 4.649  |        |         |         |
| Tremolite           | Ca <sub>2</sub> Mg <sub>5</sub> Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>                  | monocl         | tremolite            | 2  | 9.840  | 18.052 | 5.275  |        | 104.70° |         |
| Trevorite           | NiFe <sub>2</sub> O <sub>4</sub>                                                                   | cubic          | spinel               | 8  | 8.339  |        |        |        |         |         |
| Tridymite (β)       | SiO <sub>2</sub>                                                                                   | hex            |                      | 4  | 5.0463 |        | 8.2563 |        |         |         |
| Trogtalite          | CoSe <sub>2</sub>                                                                                  | cubic          | pyrite               | 4  | 5.8588 |        |        |        |         |         |
| Troilite            | FeS                                                                                                | hex            | niccolite            | 2  | 3.446  |        | 5.877  |        |         |         |
| Tschemakite         | CaAl <sub>2</sub> SiO <sub>6</sub>                                                                 | monocl         | diopside             | 4  | 9.615  | 8.661  | 5.272  |        | 106.12° |         |
| Tungsten            | W                                                                                                  | cubic          |                      | 2  | 3.1653 |        |        |        |         |         |
| Tungstenite         | WS <sub>2</sub>                                                                                    | hex            | molybdenite          | 2  | 3.154  |        | 12.362 |        |         |         |
| Turquoise           | CuAl <sub>6</sub> (PO <sub>4</sub> ) <sub>4</sub> (OH) <sub>8</sub> ·4H <sub>2</sub> O             | tricl          |                      | 1  | 7.424  | 7.629  | 9.910  | 68.61° | 69.71°  | 65.08°  |
| Umangite            | Cu <sub>3</sub> Se <sub>2</sub>                                                                    | tetr           |                      | 2  | 6.402  |        | 4.276  |        |         |         |
| Uraninite           | UO <sub>2</sub>                                                                                    | cubic          | fluorite             | 4  | 5.4682 |        |        |        |         |         |
| Ureyite             | NaCr(SiO <sub>3</sub> ) <sub>2</sub>                                                               | monocl         | diopside             | 4  | 9.550  | 8.712  | 5.273  |        | 107.44° |         |
| Uvarovite           | Ca <sub>3</sub> Cr <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>                                    | cubic          | garnet               | 8  | 11.999 |        |        |        |         |         |
| Uvite               | CaMg <sub>4</sub> Al <sub>3</sub> B <sub>3</sub> Si <sub>6</sub> O <sub>27</sub> (OH) <sub>4</sub> | rhomb          | tourmaline           | 3  | 15.86  |        | 7.19   |        |         |         |
| Vaesite             | NiS <sub>2</sub>                                                                                   | cubic          | pyrite               | 4  | 5.6873 |        |        |        |         |         |
| Valentinite         | Sb <sub>2</sub> O <sub>3</sub>                                                                     | orth           | antimony trioxide    | 4  | 4.914  | 12.468 | 5.421  |        |         |         |
| Vanthoffite         | MgSO <sub>4</sub> ·3Na <sub>2</sub> SO <sub>4</sub>                                                | monocl         |                      | 2  | 9.797  | 9.217  | 8.199  |        | 113.50° |         |
| Vaterite            | CaCO <sub>3</sub>                                                                                  | hex            |                      | 6  | 7.135  |        | 8.524  |        |         |         |
| Villiaumite         | NaF                                                                                                | cubic          | rock salt            | 4  | 4.6342 |        |        |        |         |         |
| Violarite           | FeNi <sub>2</sub> S <sub>4</sub>                                                                   | cubic          | spinel               | 8  | 9.464  |        |        |        |         |         |
| Willemite           | Zn <sub>2</sub> SiO <sub>4</sub>                                                                   | rhomb          | phenacite            | 18 | 13.94  |        | 9.309  |        |         |         |
| Witherite           | BaCO <sub>3</sub>                                                                                  | orth           | aragonite            | 4  | 6.430  | 8.904  | 5.314  |        |         |         |
| Wolframite          | Fe <sub>0.5</sub> Mn <sub>0.5</sub> WO <sub>4</sub>                                                | monocl         | wolframite           | 2  | 4.782  | 5.731  | 4.982  |        | 90.57°  |         |
| Wollastonite        | CaSiO <sub>3</sub>                                                                                 | tricl          |                      | 6  | 7.94   | 7.32   | 7.07   | 90.03° | 95.37°  | 103.43° |
| Wulfenite           | PbMoO <sub>4</sub>                                                                                 | tetr           | scheelite            | 4  | 5.435  |        | 12.110 |        |         |         |
| Wurtzite            | ZnS                                                                                                | hex            | zincite              | 2  | 3.8230 |        | 6.2565 |        |         |         |
| Wustite             | Fe <sub>0.953</sub> O                                                                              | cubic          | defect rock salt     | 4  | 4.3088 |        |        |        |         |         |
| Xenotime            | YPO <sub>4</sub>                                                                                   | tetr           | zircon               | 4  | 6.885  |        | 5.982  |        |         |         |
| Zinc                | Zn                                                                                                 | hex            | hexagonal close pack | 2  | 2.665  |        | 4.947  |        |         |         |
| Zinc telluride      | ZnTe                                                                                               | cubic          | sphalerite           | 4  | 6.1020 |        |        |        |         |         |
| Zincite             | ZnO                                                                                                | hex            | zincite              | 2  | 3.2495 |        | 5.2069 |        |         |         |
| Zinkosite           | ZnSO <sub>4</sub>                                                                                  | orth           | barite               | 4  | 8.588  | 6.740  | 4.770  |        |         |         |
| Zircon              | ZrSiO <sub>4</sub>                                                                                 | tetr           | zircon               | 4  | 6.604  |        | 5.979  |        |         |         |
| Zoisite             | Ca <sub>2</sub> Al <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> OH                                | orth           |                      | 4  | 16.15  | 5.581  | 10.06  |        |         |         |

# VAPOR PRESSURE OF THE METALLIC ELEMENTS — DATA

The following values of the vapor pressure of metallic elements are given in pascals. For conversion, note that 1 Pa = 7.50 μmHg are calculated from the equations in the preceding table. All values = 9.87·10<sup>-6</sup> atm.

| Metal        | mp/K | Vapor Pressure in Pa   |                        |                        |                        |                        |                        |                        |                        |                        |                       |                       |
|--------------|------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-----------------------|-----------------------|
|              |      | 400 K                  | 600 K                  | 800 K                  | 1000 K                 | 1200 K                 | 1400 K                 | 1600 K                 | 1800 K                 | 2000 K                 | 2200 K                | 2400 K                |
| Aluminum     | 933  |                        |                        | 3.06×10 <sup>-10</sup> | 5.08×10 <sup>-6</sup>  | 0.00256                | 0.218                  | 6.10                   | 81.4                   |                        |                       |                       |
| Americium    | 1449 |                        |                        | 3.88×10 <sup>-7</sup>  | 0.00167                | 0.423                  | 21.35                  |                        |                        |                        |                       |                       |
| Barium       | 1000 |                        | 7.97×10 <sup>-6</sup>  | 0.0450                 | 7.11                   | 162                    |                        |                        |                        |                        |                       |                       |
| Beryllium    | 1560 |                        |                        | 3.04×10 <sup>-10</sup> | 4.96×10 <sup>-6</sup>  | 0.00314                | 0.312                  | 9.12                   | 113                    |                        |                       |                       |
| Cadmium      | 594  | 0.000280               | 18.2                   |                        |                        |                        |                        |                        |                        |                        |                       |                       |
| Calcium      | 1115 |                        | 2.36×10 <sup>-5</sup>  | 0.146                  | 25.5                   |                        |                        |                        |                        |                        |                       |                       |
| Cerium       | 1071 |                        |                        |                        | 2.47×10 <sup>-11</sup> | 8.91×10 <sup>-8</sup>  | 2.97×10 <sup>-5</sup>  | 0.00233                | 0.0691                 | 1.04                   | 9.56                  | 60.8                  |
| Cesium       | 302  | 0.394                  |                        |                        |                        |                        |                        |                        |                        |                        |                       |                       |
| Chromium     | 2180 |                        |                        |                        | 2.45×10 <sup>-8</sup>  | 7.59×10 <sup>-5</sup>  | 0.0239                 | 1.80                   | 52.1                   | 774                    |                       |                       |
| Cobalt       | 1768 |                        |                        |                        | 2.09×10 <sup>-10</sup> | 1.00×10 <sup>-6</sup>  | 0.000419               | 0.0379                 | 1.15                   | 16.0                   |                       |                       |
| Copper       | 1358 |                        |                        | 6.60×10 <sup>-11</sup> | 1.53×10 <sup>-6</sup>  | 0.00122                | 0.135                  | 3.94                   | 54.4                   |                        |                       |                       |
| Curium       | 1618 |                        |                        |                        | 1.90×10 <sup>-9</sup>  | 4.24×10 <sup>-6</sup>  | 0.00103                | 0.0629                 | 1.17                   | 12.1                   | 82.1                  |                       |
| Dysprosium   | 1685 |                        |                        | 1.54×10 <sup>-8</sup>  | 8.21×10 <sup>-5</sup>  | 0.0241                 | 1.362                  | 27.5                   |                        |                        |                       |                       |
| Erbium       | 1802 |                        |                        | 3.90×10 <sup>-10</sup> | 4.30×10 <sup>-6</sup>  | 0.00205                | 0.163                  | 4.23                   | 52.5                   |                        |                       |                       |
| Europium     | 1095 |                        | 1.74×10 <sup>-5</sup>  | 0.109                  | 19.4                   |                        |                        |                        |                        |                        |                       |                       |
| Gadolinium   | 1586 |                        |                        |                        | 5.70×10 <sup>-10</sup> | 1.54×10 <sup>-6</sup>  | 0.000429               | 0.0279                 | 0.618                  | 7.39                   | 56.2                  |                       |
| Gallium      | 303  |                        |                        | 1.94×10 <sup>-7</sup>  | 0.000565               | 0.114                  | 4.98                   | 84.4                   |                        |                        |                       |                       |
| Gold         | 1337 |                        |                        |                        | 3.72×10 <sup>-8</sup>  | 5.44×10 <sup>-5</sup>  | 0.00920                | 0.374                  | 6.68                   | 67.0                   |                       |                       |
| Hafnium      | 2506 |                        |                        |                        |                        |                        | 1.35×10 <sup>-11</sup> | 9.81×10 <sup>-9</sup>  | 1.63×10 <sup>-6</sup>  | 9.69×10 <sup>-5</sup>  | 0.00272               | 0.0437                |
| Holmium      | 1747 |                        |                        | 3.20×10 <sup>-9</sup>  | 2.32×10 <sup>-5</sup>  | 0.00837                | 0.546                  | 12.3                   |                        |                        |                       |                       |
| Indium       | 430  |                        | 8.31×10 <sup>-11</sup> | 1.08×10 <sup>-5</sup>  | 0.0127                 | 1.413                  | 40.9                   |                        |                        |                        |                       |                       |
| Iridium      | 2719 |                        |                        |                        |                        |                        |                        | 1.48×10 <sup>-9</sup>  | 3.72×10 <sup>-7</sup>  | 3.06×10 <sup>-5</sup>  | 0.00112               | 0.0225                |
| Iron         | 1811 |                        |                        |                        | 5.54×10 <sup>-9</sup>  | 2.51×10 <sup>-5</sup>  | 0.0104                 | 0.961                  | 32.7                   | 36.8                   |                       |                       |
| Lanthanum    | 1191 |                        |                        |                        |                        | 5.09×10 <sup>-8</sup>  | 2.02×10 <sup>-5</sup>  | 0.00181                | 0.0596                 | 0.976                  | 9.61                  | 64.7                  |
| Lead         | 601  |                        | 5.54×10 <sup>-7</sup>  | 0.00618                | 1.64                   | 68.1                   |                        |                        |                        |                        |                       |                       |
| Lithium      | 454  | 7.90×10 <sup>-11</sup> | 0.000489               | 1.08                   | 109                    |                        |                        |                        |                        |                        |                       |                       |
| Lutetium     | 1936 |                        |                        |                        | 3.28×10 <sup>-11</sup> | 1.59×10 <sup>-7</sup>  | 6.79×10 <sup>-5</sup>  | 0.00628                | 0.211                  | 3.18                   | 26.7                  |                       |
| Magnesium    | 923  | 6.53×10 <sup>-9</sup>  | 0.0152                 | 21.5                   |                        |                        |                        |                        |                        |                        |                       |                       |
| Manganese    | 1519 |                        |                        | 5.55×10 <sup>-7</sup>  | 0.00221                | 0.524                  | 24.9                   |                        |                        |                        |                       |                       |
| Mercury      | 234  | 140                    |                        |                        |                        |                        |                        |                        |                        |                        |                       |                       |
| Molybdenum   | 2895 |                        |                        |                        |                        |                        |                        | 1.83×10 <sup>-9</sup>  | 4.07×10 <sup>-7</sup>  | 3.03×10 <sup>-5</sup>  | 0.00102               | 0.0189                |
| Neodymium    | 1294 |                        |                        | 4.55×10 <sup>-11</sup> | 7.62×10 <sup>-7</sup>  | 0.000483               | 0.0412                 | 1.07                   | 13.4                   | 101                    |                       |                       |
| Neptunium    | 917  |                        |                        |                        | 3.31×10 <sup>-9</sup>  | 1.63×10 <sup>-6</sup>  | 0.000168               | 0.00604                | 0.105                  | 1.06                   | 7.28                  |                       |
| Nickel       | 1728 |                        |                        |                        | 2.19×10 <sup>-10</sup> | 1.09×10 <sup>-6</sup>  | 0.000471               | 0.0438                 | 1.37                   | 19.5                   |                       |                       |
| Niobium      | 2750 |                        |                        |                        |                        |                        |                        | 2.32×10 <sup>-11</sup> | 9.54×10 <sup>-9</sup>  | 1.17×10 <sup>-6</sup>  | 5.98×10 <sup>-5</sup> | 0.00158               |
| Osmium       | 3306 |                        |                        |                        |                        |                        |                        |                        | 1.85×10 <sup>-10</sup> | 3.46×10 <sup>-8</sup>  | 2.49×10 <sup>-6</sup> | 8.75×10 <sup>-5</sup> |
| Palladium    | 1828 |                        |                        |                        | 8.27×10 <sup>-9</sup>  | 1.40×10 <sup>-5</sup>  | 0.00277                | 0.144                  | 3.07                   | 30.4                   |                       |                       |
| Platinum     | 2041 |                        |                        |                        |                        |                        | 2.34×10 <sup>-8</sup>  | 1.14×10 <sup>-5</sup>  | 0.00143                | 0.0689                 | 0.153                 | 1.59                  |
| Plutonium    | 913  |                        |                        |                        | 1.03×10 <sup>-8</sup>  | 6.17×10 <sup>-6</sup>  | 0.000594               | 0.0182                 | 0.262                  | 2.20                   | 12.6                  | 53.8                  |
| Potassium    | 337  | 0.0188                 | 96.9                   |                        |                        |                        |                        |                        |                        |                        |                       |                       |
| Praseodymium | 1204 |                        |                        |                        | 1.95×10 <sup>-8</sup>  | 2.16×10 <sup>-5</sup>  | 0.00257                | 0.0904                 | 1.44                   | 13.2                   | 80.8                  |                       |
| Protactinium | 1845 |                        |                        |                        |                        |                        |                        | 3.44×10 <sup>-10</sup> | 8.06×10 <sup>-8</sup>  | 5.57×10 <sup>-6</sup>  | 0.000174              | 0.00306               |
| Rhenium      | 3459 |                        |                        |                        |                        |                        |                        |                        | 1.37×10 <sup>-10</sup> | 2.22×10 <sup>-8</sup>  | 1.41×10 <sup>-6</sup> | 4.45×10 <sup>-5</sup> |
| Rhodium      | 2236 |                        |                        |                        |                        |                        | 1.69×10 <sup>-8</sup>  | 5.99×10 <sup>-6</sup>  | 0.000571               | 0.0217                 | 0.422                 | 4.41                  |
| Rubidium     | 312  | 0.165                  |                        |                        |                        |                        |                        |                        |                        |                        |                       |                       |
| Ruthenium    | 2606 |                        |                        |                        |                        |                        |                        | 7.96×10 <sup>-9</sup>  | 1.77×10 <sup>-6</sup>  | 0.000133               | 0.00455               | 0.0858                |
| Samarium     | 1347 |                        | 8.17×10 <sup>-8</sup>  | 0.00221                | 0.942                  | 51.0                   |                        |                        |                        |                        |                       |                       |
| Scandium     | 1814 |                        |                        |                        | 6.31×10 <sup>-8</sup>  | 0.000129               | 0.0300                 | 1.80                   | 43.6                   | 91.3                   |                       |                       |
| Silver       | 1235 |                        |                        | 1.27×10 <sup>-7</sup>  | 0.000603               | 0.165                  | 7.61                   | 131                    |                        |                        |                       |                       |
| Sodium       | 371  | 0.000185               | 5.60                   |                        |                        |                        |                        |                        |                        |                        |                       |                       |
| Strontium    | 1050 | 4.99×10 <sup>-11</sup> | 0.000429               | 1.134                  | 121                    |                        |                        |                        |                        |                        |                       |                       |
| Tantalum     | 3280 |                        |                        |                        |                        |                        |                        |                        |                        | 3.36×10 <sup>-10</sup> | 1.87×10 <sup>-8</sup> | 5.21×10 <sup>-7</sup> |
| Terbium      | 1629 |                        |                        |                        | 1.92×10 <sup>-9</sup>  | 4.18×10 <sup>-6</sup>  | 0.000988               | 0.0585                 | 1.15                   | 12.5                   | 88.0                  |                       |
| Thallium     | 577  |                        | 1.59×10 <sup>-5</sup>  | 0.0931                 | 16.9                   |                        |                        |                        |                        |                        |                       |                       |
| Thorium      | 2023 |                        |                        |                        |                        |                        | 3.33×10 <sup>-11</sup> | 2.00×10 <sup>-8</sup>  | 2.89×10 <sup>-6</sup>  | 0.000154               | 0.00401               | 0.0610                |
| Thulium      | 1818 |                        | 6.03×10 <sup>-10</sup> | 5.94×10 <sup>-5</sup>  | 0.0561                 | 5.22                   | 130                    |                        |                        |                        |                       |                       |
| Tin          | 505  |                        |                        | 1.26×10 <sup>-9</sup>  | 8.62×10 <sup>-6</sup>  | 0.00310                | 0.207                  | 4.85                   | 56.3                   |                        |                       |                       |
| Titanium     | 1943 |                        |                        |                        |                        | 9.69×10 <sup>-9</sup>  | 7.44×10 <sup>-6</sup>  | 0.00106                | 0.0493                 | 0.978                  | 10.6                  | 76.9                  |
| Tungsten     | 3687 |                        |                        |                        |                        |                        |                        |                        |                        | 2.62×10 <sup>-10</sup> | 3.01×10 <sup>-8</sup> | 1.59×10 <sup>-6</sup> |
| Uranium      | 1408 |                        |                        |                        |                        | 9.47×10 <sup>-10</sup> | 2.87×10 <sup>-6</sup>  | 4.27×10 <sup>-6</sup>  | 0.000263               | 0.00678                | 0.0933                | 0.803                 |
| Vanadium     | 2183 |                        |                        |                        |                        | 2.79×10 <sup>-10</sup> | 4.35×10 <sup>-7</sup>  | 0.000107               | 0.00769                | 0.233                  | 3.68                  | 32.6                  |
| Ytterbium    | 1092 | 1.03×10 <sup>-9</sup>  | 0.00384                | 6.74                   |                        |                        |                        |                        |                        |                        |                       |                       |
| Yttrium      | 1795 |                        |                        |                        | 6.66×10 <sup>-11</sup> | 2.96×10 <sup>-7</sup>  | 0.000117               | 0.0102                 | 0.316                  | 4.27                   | 35.9                  |                       |
| Zinc         | 693  | 1.47×10 <sup>-6</sup>  | 0.653                  |                        |                        |                        |                        |                        |                        |                        |                       |                       |
| Zirconium    | 2127 |                        |                        |                        |                        |                        | 1.05×10 <sup>-10</sup> | 6.17×10 <sup>-8</sup>  | 8.68×10 <sup>-6</sup>  | 0.000450               | 0.0110                | 0.155                 |

# CODATA KEY VALUES FOR THERMODYNAMICS

The Committee on Data for Science and Technology (CODATA) has conducted a project to establish internationally agreed values for the thermodynamic properties of key chemical substances. This table presents the final results of the project. Use of these recommended, internally consistent values is encouraged in the analysis of thermodynamic measurements, data reduction, and preparation of other thermodynamic tables.

The table includes the standard enthalpy of formation at 298.15 K, the entropy at 298.15 K, and the quantity  $H^\circ(298.15\text{ K}) - H^\circ(0)$ . A value of 0 in the  $\Delta_f H^\circ$  column for an element indicates the reference state for that element. The standard state pressure is 100000

Pa (1 bar). See the reference for information on the dependence of gas-phase entropy on the choice of standard state pressure.

Substances are listed in alphabetical order of their chemical formulas when written in the most common form.

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## Reference

Cox, J. D., Wagman, D. D., and Medvedev, V. A., *CODATA Key Values for Thermodynamics*, Hemisphere Publishing Corp., New York, 1989.

| Substance                              | State         | $\Delta_f H^\circ(298.15\text{ K})$<br>$\text{kJ}\cdot\text{mol}^{-1}$ | $S^\circ(298.15\text{ K})$<br>$\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$ | $H^\circ(298.15\text{ K}) - H^\circ(0)$<br>$\text{kJ}\cdot\text{mol}^{-1}$ |
|----------------------------------------|---------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Ag                                     | cr            | 0                                                                      | $42.55 \pm 0.20$                                                               | $5.745 \pm 0.020$                                                          |
| Ag                                     | g             | $284.9 \pm 0.8$                                                        | $172.997 \pm 0.004$                                                            | $6.197 \pm 0.001$                                                          |
| Ag <sup>+</sup>                        | aq            | $105.79 \pm 0.08$                                                      | $73.45 \pm 0.40$                                                               |                                                                            |
| AgCl                                   | cr            | $-127.01 \pm 0.05$                                                     | $96.25 \pm 0.20$                                                               | $12.033 \pm 0.020$                                                         |
| Al                                     | cr            | 0                                                                      | $28.30 \pm 0.10$                                                               | $4.540 \pm 0.020$                                                          |
| Al                                     | g             | $330.0 \pm 4.0$                                                        | $164.554 \pm 0.004$                                                            | $6.919 \pm 0.001$                                                          |
| Al <sup>3+</sup>                       | aq            | $-538.4 \pm 1.5$                                                       | $-325 \pm 10$                                                                  |                                                                            |
| AlF <sub>3</sub>                       | cr            | $-1510.4 \pm 1.3$                                                      | $66.5 \pm 0.5$                                                                 | $11.62 \pm 0.04$                                                           |
| Al <sub>2</sub> O <sub>3</sub>         | cr, corundum  | $-1675.7 \pm 1.3$                                                      | $50.92 \pm 0.10$                                                               | $10.016 \pm 0.020$                                                         |
| Ar                                     | g             | 0                                                                      | $154.846 \pm 0.003$                                                            | $6.197 \pm 0.001$                                                          |
| B                                      | cr, rhombic   | 0                                                                      | $5.90 \pm 0.08$                                                                | $1.222 \pm 0.008$                                                          |
| B                                      | g             | $565 \pm 5$                                                            | $153.436 \pm 0.015$                                                            | $6.316 \pm 0.002$                                                          |
| BF <sub>3</sub>                        | g             | $-1136.0 \pm 0.8$                                                      | $254.42 \pm 0.20$                                                              | $11.650 \pm 0.020$                                                         |
| B <sub>2</sub> O <sub>3</sub>          | cr            | $-1273.5 \pm 1.4$                                                      | $53.97 \pm 0.30$                                                               | $9.301 \pm 0.040$                                                          |
| Be                                     | cr            | 0                                                                      | $9.50 \pm 0.08$                                                                | $1.950 \pm 0.020$                                                          |
| Be                                     | g             | $324 \pm 5$                                                            | $136.275 \pm 0.003$                                                            | $6.197 \pm 0.001$                                                          |
| BeO                                    | cr            | $-609.4 \pm 2.5$                                                       | $13.77 \pm 0.04$                                                               | $2.837 \pm 0.008$                                                          |
| Br                                     | g             | $111.87 \pm 0.12$                                                      | $175.018 \pm 0.004$                                                            | $6.197 \pm 0.001$                                                          |
| Br <sup>-</sup>                        | aq            | $-121.41 \pm 0.15$                                                     | $82.55 \pm 0.20$                                                               |                                                                            |
| Br <sub>2</sub>                        | l             | 0                                                                      | $152.21 \pm 0.30$                                                              | $24.52 \pm 0.01$                                                           |
| Br <sub>2</sub>                        | g             | $30.91 \pm 0.11$                                                       | $245.468 \pm 0.005$                                                            | $9.725 \pm 0.001$                                                          |
| C                                      | cr, graphite  | 0                                                                      | $5.74 \pm 0.10$                                                                | $1.050 \pm 0.020$                                                          |
| C                                      | g             | $716.68 \pm 0.45$                                                      | $158.100 \pm 0.003$                                                            | $6.536 \pm 0.001$                                                          |
| CO                                     | g             | $-110.53 \pm 0.17$                                                     | $197.660 \pm 0.004$                                                            | $8.671 \pm 0.001$                                                          |
| CO <sub>2</sub>                        | g             | $-393.51 \pm 0.13$                                                     | $213.785 \pm 0.010$                                                            | $9.365 \pm 0.003$                                                          |
| CO <sub>2</sub>                        | aq, undissoc. | $-413.26 \pm 0.20$                                                     | $119.36 \pm 0.60$                                                              |                                                                            |
| CO <sub>3</sub> <sup>-2</sup>          | aq            | $-675.23 \pm 0.25$                                                     | $-50.0 \pm 1.0$                                                                |                                                                            |
| Ca                                     | cr            | 0                                                                      | $41.59 \pm 0.40$                                                               | $5.736 \pm 0.040$                                                          |
| Ca                                     | g             | $177.8 \pm 0.8$                                                        | $154.887 \pm 0.004$                                                            | $6.197 \pm 0.001$                                                          |
| Ca <sup>2+</sup>                       | aq            | $-543.0 \pm 1.0$                                                       | $-56.2 \pm 1.0$                                                                |                                                                            |
| CaO                                    | cr            | $-634.92 \pm 0.90$                                                     | $38.1 \pm 0.4$                                                                 | $6.75 \pm 0.06$                                                            |
| Cd                                     | cr            | 0                                                                      | $51.80 \pm 0.15$                                                               | $6.247 \pm 0.015$                                                          |
| Cd                                     | g             | $111.80 \pm 0.20$                                                      | $167.749 \pm 0.004$                                                            | $6.197 \pm 0.001$                                                          |
| Cd <sup>2+</sup>                       | aq            | $-75.92 \pm 0.60$                                                      | $-72.8 \pm 1.5$                                                                |                                                                            |
| CdO                                    | cr            | $-258.35 \pm 0.40$                                                     | $54.8 \pm 1.5$                                                                 | $8.41 \pm 0.08$                                                            |
| CdSO <sub>4</sub> ·8/3H <sub>2</sub> O | cr            | $-1729.30 \pm 0.80$                                                    | $229.65 \pm 0.40$                                                              | $35.56 \pm 0.04$                                                           |
| Cl                                     | g             | $121.301 \pm 0.008$                                                    | $165.190 \pm 0.004$                                                            | $6.272 \pm 0.001$                                                          |
| Cl <sup>-</sup>                        | aq            | $-167.080 \pm 0.10$                                                    | $56.60 \pm 0.20$                                                               |                                                                            |
| ClO <sub>4</sub> <sup>-</sup>          | aq            | $-128.10 \pm 0.40$                                                     | $184.0 \pm 1.5$                                                                |                                                                            |
| Cl <sub>2</sub>                        | g             | 0                                                                      | $223.081 \pm 0.010$                                                            | $9.181 \pm 0.001$                                                          |
| Cs                                     | cr            | 0                                                                      | $85.23 \pm 0.40$                                                               | $7.711 \pm 0.020$                                                          |
| Cs                                     | g             | $76.5 \pm 1.0$                                                         | $175.601 \pm 0.003$                                                            | $6.197 \pm 0.001$                                                          |
| Cs <sup>+</sup>                        | aq            | $-258.00 \pm 0.50$                                                     | $132.1 \pm 0.5$                                                                |                                                                            |
| Cu                                     | cr            | 0                                                                      | $33.15 \pm 0.08$                                                               | $5.004 \pm 0.008$                                                          |



| Substance                                   | State          | $\Delta_f H^\circ (298.15 \text{ K})$ | $S^\circ (298.15 \text{ K})$                         | $H^\circ (298.15 \text{ K}) - H^\circ (0)$ |
|---------------------------------------------|----------------|---------------------------------------|------------------------------------------------------|--------------------------------------------|
|                                             |                | $\text{kJ} \cdot \text{mol}^{-1}$     | $\text{J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ | $\text{kJ} \cdot \text{mol}^{-1}$          |
| Cu                                          | g              | $337.4 \pm 1.2$                       | $166.398 \pm 0.004$                                  | $6.197 \pm 0.001$                          |
| Cu <sup>+2</sup>                            | aq             | $64.9 \pm 1.0$                        | $-98 \pm 4$                                          |                                            |
| CuSO <sub>4</sub>                           | cr             | $-771.4 \pm 1.2$                      | $109.2 \pm 0.4$                                      | $16.86 \pm 0.08$                           |
| F                                           | g              | $79.38 \pm 0.30$                      | $158.751 \pm 0.004$                                  | $6.518 \pm 0.001$                          |
| F <sup>-</sup>                              | aq             | $-335.35 \pm 0.65$                    | $-13.8 \pm 0.8$                                      |                                            |
| F <sub>2</sub>                              | g              | 0                                     | $202.791 \pm 0.005$                                  | $8.825 \pm 0.001$                          |
| Ge                                          | cr             | 0                                     | $31.09 \pm 0.15$                                     | $4.636 \pm 0.020$                          |
| Ge                                          | g              | $372 \pm 3$                           | $167.904 \pm 0.005$                                  | $7.398 \pm 0.001$                          |
| GeF <sub>4</sub>                            | g              | $-1190.20 \pm 0.50$                   | $301.9 \pm 1.0$                                      | $17.29 \pm 0.10$                           |
| GeO <sub>2</sub>                            | cr, tetragonal | $-580.0 \pm 1.0$                      | $39.71 \pm 0.15$                                     | $7.230 \pm 0.020$                          |
| H                                           | g              | $217.998 \pm 0.006$                   | $114.717 \pm 0.002$                                  | $6.197 \pm 0.001$                          |
| H <sup>+</sup>                              | aq             | 0                                     | 0                                                    |                                            |
| HBr                                         | g              | $-36.29 \pm 0.16$                     | $198.700 \pm 0.004$                                  | $8.648 \pm 0.001$                          |
| HCO <sub>3</sub> <sup>-</sup>               | aq             | $-689.93 \pm 0.20$                    | $98.4 \pm 0.5$                                       |                                            |
| HCl                                         | g              | $-92.31 \pm 0.10$                     | $186.902 \pm 0.005$                                  | $8.640 \pm 0.001$                          |
| HF                                          | g              | $-273.30 \pm 0.70$                    | $173.779 \pm 0.003$                                  | $8.599 \pm 0.001$                          |
| HI                                          | g              | $26.50 \pm 0.10$                      | $206.590 \pm 0.004$                                  | $8.657 \pm 0.001$                          |
| HPO <sub>4</sub> <sup>-2</sup>              | aq             | $-1299.0 \pm 1.5$                     | $-33.5 \pm 1.5$                                      |                                            |
| HS <sup>-</sup>                             | aq             | $-16.3 \pm 1.5$                       | $67 \pm 5$                                           |                                            |
| HSO <sub>4</sub> <sup>-</sup>               | aq             | $-886.9 \pm 1.0$                      | $131.7 \pm 3.0$                                      |                                            |
| H <sub>2</sub>                              | g              | 0                                     | $130.680 \pm 0.003$                                  | $8.468 \pm 0.001$                          |
| H <sub>2</sub> O                            | l              | $-285.830 \pm 0.040$                  | $69.95 \pm 0.03$                                     | $13.273 \pm 0.020$                         |
| H <sub>2</sub> O                            | g              | $-241.826 \pm 0.040$                  | $188.835 \pm 0.010$                                  | $9.905 \pm 0.005$                          |
| H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | aq             | $-1302.6 \pm 1.5$                     | $92.5 \pm 1.5$                                       |                                            |
| H <sub>2</sub> S                            | g              | $-20.6 \pm 0.5$                       | $205.81 \pm 0.05$                                    | $9.957 \pm 0.010$                          |
| H <sub>2</sub> S                            | aq, undissoc.  | $-38.6 \pm 1.5$                       | $126 \pm 5$                                          |                                            |
| H <sub>3</sub> BO <sub>3</sub>              | cr             | $-1094.8 \pm 0.8$                     | $89.95 \pm 0.60$                                     | $13.52 \pm 0.04$                           |
| H <sub>3</sub> BO <sub>3</sub>              | aq, undissoc.  | $-1072.8 \pm 0.8$                     | $162.4 \pm 0.6$                                      |                                            |
| He                                          | g              | 0                                     | $126.153 \pm 0.002$                                  | $6.197 \pm 0.001$                          |
| Hg                                          | l              | 0                                     | $75.90 \pm 0.12$                                     | $9.342 \pm 0.008$                          |
| Hg                                          | g              | $61.38 \pm 0.04$                      | $174.971 \pm 0.005$                                  | $6.197 \pm 0.001$                          |
| Hg <sup>+2</sup>                            | aq             | $170.21 \pm 0.20$                     | $-36.19 \pm 0.80$                                    |                                            |
| HgO                                         | cr, red        | $-90.79 \pm 0.12$                     | $70.25 \pm 0.30$                                     | $9.117 \pm 0.025$                          |
| Hg <sub>2</sub> <sup>+2</sup>               | aq             | $166.87 \pm 0.50$                     | $65.74 \pm 0.80$                                     |                                            |
| Hg <sub>2</sub> Cl <sub>2</sub>             | cr             | $-265.37 \pm 0.40$                    | $191.6 \pm 0.8$                                      | $23.35 \pm 0.20$                           |
| Hg <sub>2</sub> SO <sub>4</sub>             | cr             | $-743.09 \pm 0.40$                    | $200.70 \pm 0.20$                                    | $26.070 \pm 0.030$                         |
| I                                           | g              | $106.76 \pm 0.04$                     | $180.787 \pm 0.004$                                  | $6.197 \pm 0.001$                          |
| I <sup>-</sup>                              | aq             | $-56.78 \pm 0.05$                     | $106.45 \pm 0.30$                                    |                                            |
| I <sub>2</sub>                              | cr             | 0                                     | $116.14 \pm 0.30$                                    | $13.196 \pm 0.040$                         |
| I <sub>2</sub>                              | g              | $62.42 \pm 0.08$                      | $260.687 \pm 0.005$                                  | $10.116 \pm 0.001$                         |
| K                                           | cr             | 0                                     | $64.68 \pm 0.20$                                     | $7.088 \pm 0.020$                          |
| K                                           | g              | $89.0 \pm 0.8$                        | $160.341 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| K <sup>+</sup>                              | aq             | $-252.14 \pm 0.08$                    | $101.20 \pm 0.20$                                    |                                            |
| Kr                                          | g              | 0                                     | $164.085 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| Li                                          | cr             | 0                                     | $29.12 \pm 0.20$                                     | $4.632 \pm 0.040$                          |
| Li                                          | g              | $159.3 \pm 1.0$                       | $138.782 \pm 0.010$                                  | $6.197 \pm 0.001$                          |
| Li <sup>+</sup>                             | aq             | $-278.47 \pm 0.08$                    | $12.24 \pm 0.15$                                     |                                            |
| Mg                                          | cr             | 0                                     | $32.67 \pm 0.10$                                     | $4.998 \pm 0.030$                          |
| Mg                                          | g              | $147.1 \pm 0.8$                       | $148.648 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| Mg <sup>+2</sup>                            | aq             | $-467.0 \pm 0.6$                      | $-137 \pm 4$                                         |                                            |
| MgF <sub>2</sub>                            | cr             | $-1124.2 \pm 1.2$                     | $57.2 \pm 0.5$                                       | $9.91 \pm 0.06$                            |
| MgO                                         | cr             | $-601.60 \pm 0.30$                    | $26.95 \pm 0.15$                                     | $5.160 \pm 0.020$                          |
| N                                           | g              | $472.68 \pm 0.40$                     | $153.301 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| NH <sub>3</sub>                             | g              | $-45.94 \pm 0.35$                     | $192.77 \pm 0.05$                                    | $10.043 \pm 0.010$                         |
| NH <sub>4</sub> <sup>+</sup>                | aq             | $-133.26 \pm 0.25$                    | $111.17 \pm 0.40$                                    |                                            |
| NO <sub>3</sub> <sup>-</sup>                | aq             | $-206.85 \pm 0.40$                    | $146.70 \pm 0.40$                                    |                                            |
| N <sub>2</sub>                              | g              | 0                                     | $191.609 \pm 0.004$                                  | $8.670 \pm 0.001$                          |
| Na                                          | cr             | 0                                     | $51.30 \pm 0.20$                                     | $6.460 \pm 0.020$                          |
| Na                                          | g              | $107.5 \pm 0.7$                       | $153.718 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| Na <sup>+</sup>                             | aq             | $-240.34 \pm 0.06$                    | $58.45 \pm 0.15$                                     |                                            |

| Substance                     | State            | $\Delta_f H^\circ (298.15 \text{ K})$ | $S^\circ (298.15 \text{ K})$                         | $H^\circ (298.15 \text{ K}) - H^\circ (0)$ |
|-------------------------------|------------------|---------------------------------------|------------------------------------------------------|--------------------------------------------|
|                               |                  | $\text{kJ} \cdot \text{mol}^{-1}$     | $\text{J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ | $\text{kJ} \cdot \text{mol}^{-1}$          |
| Ne                            | g                | 0                                     | $146.328 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| O                             | g                | $249.18 \pm 0.10$                     | $161.059 \pm 0.003$                                  | $6.725 \pm 0.001$                          |
| OH <sup>-</sup>               | aq               | $-230.015 \pm 0.040$                  | $-10.90 \pm 0.20$                                    |                                            |
| O <sub>2</sub>                | g                | 0                                     | $205.152 \pm 0.005$                                  | $8.680 \pm 0.002$                          |
| P                             | cr, white        | 0                                     | $41.09 \pm 0.25$                                     | $5.360 \pm 0.015$                          |
| P                             | g                | $316.5 \pm 1.0$                       | $163.199 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| P <sub>2</sub>                | g                | $144.0 \pm 2.0$                       | $218.123 \pm 0.004$                                  | $8.904 \pm 0.001$                          |
| P <sub>4</sub>                | g                | $58.9 \pm 0.3$                        | $280.01 \pm 0.50$                                    | $14.10 \pm 0.20$                           |
| Pb                            | cr               | 0                                     | $64.80 \pm 0.30$                                     | $6.870 \pm 0.030$                          |
| Pb                            | g                | $195.2 \pm 0.8$                       | $175.375 \pm 0.005$                                  | $6.197 \pm 0.001$                          |
| Pb <sup>+2</sup>              | aq               | $0.92 \pm 0.25$                       | $18.5 \pm 1.0$                                       |                                            |
| PbSO <sub>4</sub>             | cr               | $-919.97 \pm 0.40$                    | $148.50 \pm 0.60$                                    | $20.050 \pm 0.040$                         |
| Rb                            | cr               | 0                                     | $76.78 \pm 0.30$                                     | $7.489 \pm 0.020$                          |
| Rb                            | g                | $80.9 \pm 0.8$                        | $170.094 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| Rb <sup>+</sup>               | aq               | $-251.12 \pm 0.10$                    | $121.75 \pm 0.25$                                    |                                            |
| S                             | cr, rhombic      | 0                                     | $32.054 \pm 0.050$                                   | $4.412 \pm 0.006$                          |
| S                             | g                | $277.17 \pm 0.15$                     | $167.829 \pm 0.006$                                  | $6.657 \pm 0.001$                          |
| SO <sub>2</sub>               | g                | $-296.81 \pm 0.20$                    | $248.223 \pm 0.050$                                  | $10.549 \pm 0.010$                         |
| SO <sub>4</sub> <sup>-2</sup> | aq               | $-909.34 \pm 0.40$                    | $18.50 \pm 0.40$                                     |                                            |
| S <sub>2</sub>                | g                | $128.60 \pm 0.30$                     | $228.167 \pm 0.010$                                  | $9.132 \pm 0.002$                          |
| Si                            | cr               | 0                                     | $18.81 \pm 0.08$                                     | $3.217 \pm 0.008$                          |
| Si                            | g                | $450 \pm 8$                           | $167.981 \pm 0.004$                                  | $7.550 \pm 0.001$                          |
| SiF <sub>4</sub>              | g                | $-1615.0 \pm 0.8$                     | $282.76 \pm 0.50$                                    | $15.36 \pm 0.05$                           |
| SiO <sub>2</sub>              | cr, alpha quartz | $-910.7 \pm 1.0$                      | $41.46 \pm 0.20$                                     | $6.916 \pm 0.020$                          |
| Sn                            | cr, white        | 0                                     | $51.18 \pm 0.08$                                     | $6.323 \pm 0.008$                          |
| Sn                            | g                | $301.2 \pm 1.5$                       | $168.492 \pm 0.004$                                  | $6.215 \pm 0.001$                          |
| Sn <sup>+2</sup>              | aq               | $-8.9 \pm 1.0$                        | $-16.7 \pm 4.0$                                      |                                            |
| SnO                           | cr, tetragonal   | $-280.71 \pm 0.20$                    | $57.17 \pm 0.30$                                     | $8.736 \pm 0.020$                          |
| SnO <sub>2</sub>              | cr, tetragonal   | $-577.63 \pm 0.20$                    | $49.04 \pm 0.10$                                     | $8.384 \pm 0.020$                          |
| Th                            | cr               | 0                                     | $51.8 \pm 0.5$                                       | $6.35 \pm 0.05$                            |
| Th                            | g                | $602 \pm 6$                           | $190.17 \pm 0.05$                                    | $6.197 \pm 0.003$                          |
| ThO <sub>2</sub>              | cr               | $-1226.4 \pm 3.5$                     | $65.23 \pm 0.20$                                     | $10.560 \pm 0.020$                         |
| Ti                            | cr               | 0                                     | $30.72 \pm 0.10$                                     | $4.824 \pm 0.015$                          |
| Ti                            | g                | $473 \pm 3$                           | $180.298 \pm 0.010$                                  | $7.539 \pm 0.002$                          |
| TiCl <sub>4</sub>             | g                | $-763.2 \pm 3.0$                      | $353.2 \pm 4.0$                                      | $21.5 \pm 0.5$                             |
| TiO <sub>2</sub>              | cr, rutile       | $-944.0 \pm 0.8$                      | $50.62 \pm 0.30$                                     | $8.68 \pm 0.05$                            |
| U                             | cr               | 0                                     | $50.20 \pm 0.20$                                     | $6.364 \pm 0.020$                          |
| U                             | g                | $533 \pm 8$                           | $199.79 \pm 0.10$                                    | $6.499 \pm 0.020$                          |
| UO <sub>2</sub>               | cr               | $-1085.0 \pm 1.0$                     | $77.03 \pm 0.20$                                     | $11.280 \pm 0.020$                         |
| UO <sub>2</sub> <sup>+2</sup> | aq               | $-1019.0 \pm 1.5$                     | $-98.2 \pm 3.0$                                      |                                            |
| UO <sub>3</sub>               | cr, gamma        | $-1223.8 \pm 1.2$                     | $96.11 \pm 0.40$                                     | $14.585 \pm 0.050$                         |
| U <sub>3</sub> O <sub>8</sub> | cr               | $-3574.8 \pm 2.5$                     | $282.55 \pm 0.50$                                    | $42.74 \pm 0.10$                           |
| Xe                            | g                | 0                                     | $169.685 \pm 0.003$                                  | $6.197 \pm 0.001$                          |
| Zn                            | cr               | 0                                     | $41.63 \pm 0.15$                                     | $5.657 \pm 0.020$                          |
| Zn                            | g                | $130.40 \pm 0.40$                     | $160.990 \pm 0.004$                                  | $6.197 \pm 0.001$                          |
| Zn <sup>+2</sup>              | aq               | $-153.39 \pm 0.20$                    | $-109.8 \pm 0.5$                                     |                                            |
| ZnO                           | cr               | $-350.46 \pm 0.27$                    | $43.65 \pm 0.40$                                     | $6.933 \pm 0.040$                          |

# STANDARD THERMODYNAMIC PROPERTIES OF CHEMICAL SUBSTANCES

This table gives the standard state chemical thermodynamic properties of about 2500 individual substances in the crystalline, liquid, and gaseous states. Substances are listed by molecular formula in a modified Hill order; all substances not containing carbon appear first, followed by those that contain carbon. The properties tabulated are:

|                    |                                                                   |
|--------------------|-------------------------------------------------------------------|
| $\Delta_f H^\circ$ | Standard molar enthalpy (heat) of formation at 298.15 K in kJ/mol |
| $\Delta_f G^\circ$ | Standard molar Gibbs energy of formation at 298.15 K in kJ/mol    |
| $S^\circ$          | Standard molar entropy at 298.15 K in J/mol K                     |
| $C_p$              | Molar heat capacity at constant pressure at 298.15 K in J/mol K   |

The standard state pressure is 100 kPa (1 bar). The standard states are defined for different phases by:

- The standard state of a pure gaseous substance is that of the substance as a (hypothetical) ideal gas at the standard state pressure.
- The standard state of a pure liquid substance is that of the liquid under the standard state pressure.
- The standard state of a pure crystalline substance is that of the crystalline substance under the standard state pressure.

An entry of 0.0 for  $\Delta_f H^\circ$  for an element indicates the reference state of that element. See References 1 and 2 for further information on reference states. A blank means no value is available.

The data are derived from the sources listed in the references, from other papers appearing in the *Journal of Physical and Chemical Reference Data*, and from the primary research literature. We are indebted to M. V. Korobov for providing data on fullerene compounds.

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| Molecular<br>formula                     | Name                          | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|------------------------------------------|-------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                          |                               | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| <i>Substances not containing carbon:</i> |                               |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ac                                       | Actinium                      | 0.0                          |                              | 56.5                 | 27.2             |                              |                              |                      |                  | 406.0                        | 366.0                        | 188.1                | 20.8             |
| Ag                                       | Silver                        | 0.0                          |                              | 42.6                 | 25.4             |                              |                              |                      |                  | 284.9                        | 246.0                        | 173.0                | 20.8             |
| AgBr                                     | Silver(I) bromide             | -100.4                       | -96.9                        | 107.1                | 52.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| AgBrO <sub>3</sub>                       | Silver(I) bromate             | -10.5                        | 71.3                         | 151.9                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AgCl                                     | Silver(I) chloride            | -127.0                       | -109.8                       | 96.3                 | 50.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| AgClO <sub>3</sub>                       | Silver(I) chlorate            | -30.3                        | 64.5                         | 142.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AgClO <sub>4</sub>                       | Silver(I) perchlorate         | -31.1                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AgF                                      | Silver(I) fluoride            | -204.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AgF <sub>2</sub>                         | Silver(II) fluoride           | -360.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AgI                                      | Silver(I) iodide              | -61.8                        | -66.2                        | 115.5                | 56.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| AgIO <sub>3</sub>                        | Silver(I) iodate              | -171.1                       | -93.7                        | 149.4                | 102.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| AgNO <sub>3</sub>                        | Silver(I) nitrate             | -124.4                       | -33.4                        | 140.9                | 93.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| Ag <sub>2</sub>                          | Disilver                      |                              |                              |                      |                  |                              |                              |                      |                  | 410.0                        | 358.8                        | 257.1                | 37.0             |
| Ag <sub>2</sub> CrO <sub>4</sub>         | Silver(I) chromate            | -731.7                       | -641.8                       | 217.6                | 142.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| Ag <sub>2</sub> O                        | Silver(I) oxide               | -31.1                        | -11.2                        | 121.3                | 65.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| Ag <sub>2</sub> O <sub>2</sub>           | Silver(II) oxide              | -24.3                        | 27.6                         | 117.0                | 88.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| Ag <sub>2</sub> O <sub>3</sub>           | Silver(III) oxide             | 33.9                         | 121.4                        | 100.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ag <sub>2</sub> O <sub>4</sub> S         | Silver(I) sulfate             | -715.9                       | -618.4                       | 200.4                | 131.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| Ag <sub>2</sub> S                        | Silver(I) sulfide (argentite) | -32.6                        | -40.7                        | 144.0                | 76.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| Al                                       | Aluminum                      | 0.0                          |                              | 28.3                 | 24.2             |                              |                              |                      |                  | 330.0                        | 289.4                        | 164.6                | 21.4             |

| Molecular<br>formula             | Name                               | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|----------------------------------|------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                  |                                    | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| AlB <sub>3</sub> H <sub>12</sub> | Aluminum borohydride               |                              |                              |                      |                  | -16.3                        | 145.0                        | 289.1                | 194.6            | 13.0                         | 147.0                        | 379.2                |                  |
| AlBr                             | Aluminum monobromide               |                              |                              |                      |                  |                              |                              |                      |                  | -4.0                         | -42.0                        | 239.5                | 35.6             |
| AlBr <sub>3</sub>                | Aluminum bromide                   | -527.2                       |                              | 180.2                | 100.6            |                              |                              |                      |                  | -425.1                       |                              |                      |                  |
| AlCl                             | Aluminum monochloride              |                              |                              |                      |                  |                              |                              |                      |                  | -47.7                        | -74.1                        | 228.1                | 35.0             |
| AlCl <sub>2</sub>                | Aluminum dichloride                |                              |                              |                      |                  |                              |                              |                      |                  | -331.0                       |                              |                      |                  |
| AlCl <sub>3</sub>                | Aluminum chloride                  | -704.2                       | -628.8                       | 109.3                | 91.1             |                              |                              |                      |                  | -583.2                       |                              |                      |                  |
| AlF                              | Aluminum monofluoride              |                              |                              |                      |                  |                              |                              |                      |                  | -258.2                       | -283.7                       | 215.0                | 31.9             |
| AlF <sub>3</sub>                 | Aluminum fluoride                  | -1510.4                      | -1431.1                      | 66.5                 | 75.1             |                              |                              |                      |                  | -1204.6                      | -1188.2                      | 277.1                | 62.6             |
| AlF <sub>4</sub> Na              | Sodium tetrafluoroaluminate        |                              |                              |                      |                  |                              |                              |                      |                  | -1869.0                      | -1827.5                      | 345.7                | 105.9            |
| AlH                              | Aluminum monohydride               |                              |                              |                      |                  |                              |                              |                      |                  | 259.2                        | 231.2                        | 187.9                | 29.4             |
| AlH <sub>3</sub>                 | Aluminum hydride                   | -46.0                        |                              | 30.0                 | 40.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| AlH <sub>4</sub> K               | Potassium aluminum hydride         | -183.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AlH <sub>4</sub> Li              | Lithium aluminum hydride           | -116.3                       | -44.7                        | 78.7                 | 83.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| AlH <sub>4</sub> Na              | Sodium aluminum hydride            | -115.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AlI                              | Aluminum monoiodide                |                              |                              |                      |                  |                              |                              |                      |                  | 65.5                         |                              |                      | 36.0             |
| AlI <sub>3</sub>                 | Aluminum iodide                    | -302.9                       |                              | 195.9                | 98.7             |                              |                              |                      |                  | -289.4                       |                              | 223.6                |                  |
| AlN                              | Aluminum nitride                   | -318.0                       | -287.0                       | 20.2                 | 30.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| AlO                              | Aluminum monoxide                  |                              |                              |                      |                  |                              |                              |                      |                  | 91.2                         | 65.3                         | 218.4                | 30.9             |
| AlO <sub>4</sub> P               | Aluminum phosphate                 | -1733.8                      | -1617.9                      | 90.8                 | 93.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| AlP                              | Aluminum phosphide                 | -166.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AlS                              | Aluminum monosulfide               |                              |                              |                      |                  |                              |                              |                      |                  | 200.9                        | 150.1                        | 230.6                | 33.4             |
| Al <sub>2</sub>                  | Dialuminum                         |                              |                              |                      |                  |                              |                              |                      |                  | 485.9                        | 433.3                        | 233.2                | 36.4             |
| Al <sub>2</sub> Br <sub>6</sub>  | Aluminum hexabromide               |                              |                              |                      |                  |                              |                              |                      |                  | -970.7                       |                              |                      |                  |
| Al <sub>2</sub> Cl <sub>6</sub>  | Aluminum hexachloride              |                              |                              |                      |                  |                              |                              |                      |                  | -1290.8                      | -1220.4                      | 490.0                |                  |
| Al <sub>2</sub> F <sub>6</sub>   | Aluminum hexafluoride              |                              |                              |                      |                  |                              |                              |                      |                  | -2628.0                      |                              |                      |                  |
| Al <sub>2</sub> I <sub>6</sub>   | Aluminum hexaiodide                |                              |                              |                      |                  |                              |                              |                      |                  | -516.7                       |                              |                      |                  |
| Al <sub>2</sub> O                | Aluminum oxide (Al <sub>2</sub> O) |                              |                              |                      |                  |                              |                              |                      |                  | -130.0                       | -159.0                       | 259.4                | 45.7             |
| Al <sub>2</sub> O <sub>3</sub>   | Aluminum oxide (corundum)          | -1675.7                      | -1582.3                      | 50.9                 | 79.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| Al <sub>2</sub> S <sub>3</sub>   | Aluminum sulfide                   | -724.0                       |                              | 116.9                | 105.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| Am                               | Americium                          | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ar                               | Argon                              |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          |                              | 154.8                | 20.8             |
| As                               | Arsenic (gray)                     | 0.0                          |                              | 35.1                 | 24.6             |                              |                              |                      |                  | 302.5                        | 261.0                        | 174.2                | 20.8             |
| As                               | Arsenic (yellow)                   | 14.6                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AsBr <sub>3</sub>                | Arsenic(III) bromide               | -197.5                       |                              |                      |                  |                              |                              |                      |                  | -130.0                       | -159.0                       | 363.9                | 79.2             |
| AsCl <sub>3</sub>                | Arsenic(III) chloride              |                              |                              |                      |                  | -305.0                       | -259.4                       | 216.3                |                  | -261.5                       | -248.9                       | 327.2                | 75.7             |
| AsF <sub>3</sub>                 | Arsenic(III) fluoride              |                              |                              |                      |                  | -821.3                       | -774.2                       | 181.2                | 126.6            | -785.8                       | -770.8                       | 289.1                | 65.6             |
| AsGa                             | Gallium arsenide                   | -71.0                        | -67.8                        | 64.2                 | 46.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| AsH <sub>3</sub>                 | Arsine                             |                              |                              |                      |                  |                              |                              |                      |                  | 66.4                         | 68.9                         | 222.8                | 38.1             |
| AsH <sub>3</sub> O <sub>4</sub>  | Arsenic acid                       | -906.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AsI <sub>3</sub>                 | Arsenic(III) iodide                | -58.2                        | -59.4                        | 213.1                | 105.8            |                              |                              |                      |                  |                              |                              | 388.3                | 80.6             |
| AsIn                             | Indium arsenide                    | -58.6                        | -53.6                        | 75.7                 | 47.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| AsO                              | Arsenic monoxide                   |                              |                              |                      |                  |                              |                              |                      |                  | 70.0                         |                              |                      |                  |
| As <sub>2</sub>                  | Diarsenic                          |                              |                              |                      |                  |                              |                              |                      |                  | 222.2                        | 171.9                        | 239.4                | 35.0             |
| As <sub>2</sub> O <sub>5</sub>   | Arsenic(V) oxide                   | -924.9                       | -782.3                       | 105.4                | 116.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| As <sub>2</sub> S <sub>3</sub>   | Arsenic(III) sulfide               | -169.0                       | -168.6                       | 163.6                | 116.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| At                               | Astatine                           | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Au                               | Gold                               | 0.0                          |                              | 47.4                 | 25.4             |                              |                              |                      |                  | 366.1                        | 326.3                        | 180.5                | 20.8             |
| AuBr                             | Gold(I) bromide                    | -14.0                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AuBr <sub>3</sub>                | Gold(III) bromide                  | -53.3                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AuCl                             | Gold(I) chloride                   | -34.7                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AuCl <sub>3</sub>                | Gold(III) chloride                 | -117.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AuF <sub>3</sub>                 | Gold(III) fluoride                 | -363.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| AuH                              | Gold hydride                       |                              |                              |                      |                  |                              |                              |                      |                  | 295.0                        | 265.7                        | 211.2                | 29.2             |
| AuI                              | Gold(I) iodide                     | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Au <sub>2</sub>                  | Digold                             |                              |                              |                      |                  |                              |                              |                      |                  | 515.1                        |                              |                      | 36.9             |
| B                                | Boron (β-rhombohedral)             | 0.0                          |                              | 5.9                  | 11.1             |                              |                              |                      |                  | 565.0                        | 521.0                        | 153.4                | 20.8             |
| BBr                              | Bromoborane(1)                     |                              |                              |                      |                  |                              |                              |                      |                  | 238.1                        | 195.4                        | 225.0                | 32.9             |
| BBr <sub>3</sub>                 | Boron tribromide                   |                              |                              |                      |                  | -239.7                       | -238.5                       | 229.7                |                  | -205.6                       | -232.5                       | 324.2                | 67.8             |
| BCl                              | Chloroborane(1)                    |                              |                              |                      |                  |                              |                              |                      |                  | 149.5                        | 120.9                        | 213.2                | 31.7             |
| BClO                             | Chloroxyborane                     |                              |                              |                      |                  |                              |                              |                      |                  | -314.0                       |                              |                      |                  |
| BCl <sub>3</sub>                 | Boron trichloride                  |                              |                              |                      |                  | -427.2                       | -387.4                       | 206.3                | 106.7            | -403.8                       | -388.7                       | 290.1                | 62.7             |
| BCsO <sub>2</sub>                | Cesium metaborate                  | -972.0                       | -915.0                       | 104.4                | 80.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| BF                               | Fluoroborane(1)                    |                              |                              |                      |                  |                              |                              |                      |                  | -122.2                       | -149.8                       | 200.5                | 29.6             |
| BFO                              | Fluoroxyborane                     |                              |                              |                      |                  |                              |                              |                      |                  | -607.0                       |                              |                      |                  |
| BF <sub>3</sub>                  | Boron trifluoride                  |                              |                              |                      |                  |                              |                              |                      |                  | -1136.0                      | -1119.4                      | 254.4                |                  |
| BF <sub>3</sub> H <sub>3</sub> N | Aminetrifluoroboron                | -1353.9                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                            | Name                                  | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------|---------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                 |                                       | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| BF <sub>3</sub> H <sub>3</sub> P                | Trihydro(phosphorus trifluoride)boron |                              |                              |                      |                  |                              |                              |                      |                  | -854.0                       |                              |                      |                  |
| BF <sub>4</sub> Na                              | Sodium tetrafluoroborate              | -1844.7                      | -1750.1                      | 145.3                | 120.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| BH                                              | Borane(1)                             |                              |                              |                      |                  |                              |                              |                      |                  | 442.7                        | 412.7                        | 171.8                | 29.2             |
| BHO <sub>2</sub>                                | Metaboric acid (β, monoclinic)        | -794.3                       | -723.4                       | 38.0                 |                  |                              |                              |                      |                  | -561.9                       | -551.0                       | 240.1                | 42.2             |
| BH <sub>3</sub>                                 | Borane(3)                             |                              |                              |                      |                  |                              |                              |                      |                  | 89.2                         | 93.3                         | 188.2                | 36.0             |
| BH <sub>3</sub> O <sub>3</sub>                  | Boric acid                            | -1094.3                      | -968.9                       | 90.0                 | 86.1             |                              |                              |                      |                  | -994.1                       |                              |                      |                  |
| BH <sub>4</sub> K                               | Potassium borohydride                 | -227.4                       | -160.3                       | 106.3                | 96.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| BH <sub>4</sub> Li                              | Lithium borohydride                   | -190.8                       | -125.0                       | 75.9                 | 82.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| BH <sub>4</sub> Na                              | Sodium borohydride                    | -188.6                       | -123.9                       | 101.3                | 86.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| BI <sub>3</sub>                                 | Boron triiodide                       |                              |                              |                      |                  |                              |                              |                      |                  | 71.1                         | 20.7                         | 349.2                | 70.8             |
| BKO <sub>2</sub>                                | Potassium metaborate                  | -981.6                       | -923.4                       | 80.0                 | 66.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| BLiO <sub>2</sub>                               | Lithium metaborate                    | -1032.2                      | -976.1                       | 51.5                 | 59.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| BN                                              | Boron nitride                         | -254.4                       | -228.4                       | 14.8                 | 19.7             |                              |                              |                      |                  | 647.5                        | 614.5                        | 212.3                | 29.5             |
| BNaO <sub>2</sub>                               | Sodium metaborate                     | -977.0                       | -920.7                       | 73.5                 | 65.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| BO                                              | Boron monoxide                        |                              |                              |                      |                  |                              |                              |                      |                  | 25.0                         | -4.0                         | 203.5                | 29.2             |
| BO <sub>2</sub>                                 | Boron dioxide                         |                              |                              |                      |                  |                              |                              |                      |                  | -300.4                       | -305.9                       | 229.6                | 43.0             |
| BO <sub>2</sub> Rb                              | Rubidium metaborate                   | -971.0                       | -913.0                       | 94.3                 | 74.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| BS                                              | Boron monosulfide                     |                              |                              |                      |                  |                              |                              |                      |                  | 342.0                        | 288.8                        | 216.2                | 30.0             |
| B <sub>2</sub>                                  | Diboron                               |                              |                              |                      |                  |                              |                              |                      |                  | 830.5                        | 774.0                        | 201.9                | 30.5             |
| B <sub>2</sub> Cl <sub>4</sub>                  | Tetrachlorodiborane                   |                              |                              |                      |                  | -523.0                       | -464.8                       | 262.3                | 137.7            | -490.4                       | -460.6                       | 357.4                | 95.4             |
| B <sub>2</sub> F <sub>4</sub>                   | Tetrafluorodiborane                   |                              |                              |                      |                  |                              |                              |                      |                  | -1440.1                      | -1410.4                      | 317.3                | 79.1             |
| B <sub>2</sub> H <sub>6</sub>                   | Diborane                              |                              |                              |                      |                  |                              |                              |                      |                  | 36.4                         | 87.6                         | 232.1                | 56.7             |
| B <sub>2</sub> O <sub>2</sub>                   | Diboron dioxide                       |                              |                              |                      |                  |                              |                              |                      |                  | -454.8                       | -462.3                       | 242.5                | 57.3             |
| B <sub>2</sub> O <sub>3</sub>                   | Boron oxide                           | -1273.5                      | -1194.3                      | 54.0                 | 62.8             |                              |                              |                      |                  | -843.8                       | -832.0                       | 279.8                | 66.9             |
| B <sub>2</sub> S <sub>3</sub>                   | Boron sulfide                         | -240.6                       |                              | 100.0                | 111.7            |                              |                              |                      |                  | 67.0                         |                              |                      |                  |
| B <sub>3</sub> H <sub>6</sub> N <sub>3</sub>    | Borazine                              |                              |                              |                      |                  | -541.0                       | -392.7                       | 199.6                |                  |                              |                              |                      |                  |
| B <sub>4</sub> H <sub>10</sub>                  | Tetraborane(10)                       |                              |                              |                      |                  |                              |                              |                      |                  | 66.1                         | 184.3                        | 280.3                | 93.2             |
| B <sub>4</sub> Na <sub>2</sub> O <sub>7</sub>   | Sodium tetraborate                    | -3291.1                      | -3096.0                      | 189.5                | 186.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| B <sub>5</sub> H <sub>9</sub>                   | Pentaborane(9)                        |                              |                              |                      |                  | 42.7                         | 171.8                        | 184.2                | 151.1            | 73.2                         | 173.6                        | 280.6                | 99.6             |
| B <sub>5</sub> H <sub>11</sub>                  | Pentaborane(11)                       |                              |                              |                      |                  | 73.2                         |                              |                      |                  | 103.3                        | 230.6                        | 321.0                | 130.3            |
| B <sub>6</sub> H <sub>10</sub>                  | Hexaborane(10)                        |                              |                              |                      |                  | 56.3                         |                              |                      |                  | 94.6                         | 211.3                        | 296.8                | 125.7            |
| B <sub>9</sub> H <sub>15</sub>                  | Nonaborane(15)                        |                              |                              |                      |                  |                              |                              |                      |                  | 158.4                        | 357.5                        | 364.9                | 187.0            |
| B <sub>10</sub> H <sub>14</sub>                 | Decaborane(14)                        |                              |                              |                      |                  |                              |                              |                      |                  | 47.3                         | 232.8                        | 350.7                | 186.1            |
| Ba                                              | Barium                                | 0.0                          |                              | 62.5                 | 28.1             |                              |                              |                      |                  | 180.0                        | 146.0                        | 170.2                | 20.8             |
| BaBr <sub>2</sub>                               | Barium bromide                        | -757.3                       | -736.8                       | 146.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| BaCl <sub>2</sub>                               | Barium chloride                       | -855.0                       | -806.7                       | 123.7                | 75.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| BaCl <sub>2</sub> H <sub>4</sub> O <sub>2</sub> | Barium chloride dihydrate             | -1456.9                      | -1293.2                      | 203.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| BaF <sub>2</sub>                                | Barium fluoride                       | -1207.1                      | -1156.8                      | 96.4                 | 71.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| BaH <sub>2</sub>                                | Barium hydride                        | -177.0                       | -138.2                       | 63.0                 | 46.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| BaH <sub>2</sub> O <sub>2</sub>                 | Barium hydroxide                      | -944.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| BaI <sub>2</sub>                                | Barium iodide                         | -602.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| BaN <sub>2</sub> O <sub>4</sub>                 | Barium nitrite                        | -768.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| BaN <sub>2</sub> O <sub>6</sub>                 | Barium nitrate                        | -988.0                       | -792.6                       | 214.0                | 151.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| BaO                                             | Barium oxide                          | -548.0                       | -520.3                       | 72.1                 | 47.3             |                              |                              |                      |                  | -112.0                       |                              |                      |                  |
| BaO <sub>4</sub> S                              | Barium sulfate                        | -1473.2                      | -1362.2                      | 132.2                | 101.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| BaS                                             | Barium sulfide                        | -460.0                       | -456.0                       | 78.2                 | 49.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| Be                                              | Beryllium                             | 0.0                          |                              | 9.5                  | 16.4             |                              |                              |                      |                  | 324.0                        | 286.6                        | 136.3                | 20.8             |
| BeBr <sub>2</sub>                               | Beryllium bromide                     | -353.5                       |                              | 108.0                | 69.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| BeCl <sub>2</sub>                               | Beryllium chloride                    | -490.4                       | -445.6                       | 75.8                 | 62.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| BeF <sub>2</sub>                                | Beryllium fluoride                    | -1026.8                      | -979.4                       | 53.4                 | 51.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| BeH <sub>2</sub> O <sub>2</sub>                 | Beryllium hydroxide                   | -902.5                       | -815.0                       | 45.5                 | 62.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| BeI <sub>2</sub>                                | Beryllium iodide                      | -192.5                       |                              | 121.0                | 71.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| BeO                                             | Beryllium oxide                       | -609.4                       | -580.1                       | 13.8                 | 25.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| BeO <sub>4</sub> S                              | Beryllium sulfate                     | -1205.2                      | -1093.8                      | 77.9                 | 85.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| BeS                                             | Beryllium sulfide                     | -234.3                       |                              | 34.0                 | 34.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| Bi                                              | Bismuth                               | 0.0                          |                              | 56.7                 | 25.5             |                              |                              |                      |                  | 207.1                        | 168.2                        | 187.0                | 20.8             |
| BiClO                                           | Bismuth oxychloride                   | -366.9                       | -322.1                       | 120.5                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| BiCl <sub>3</sub>                               | Bismuth trichloride                   | -379.1                       | -315.0                       | 177.0                | 105.0            |                              |                              |                      |                  | -265.7                       | -256.0                       | 358.9                | 79.7             |
| BiH <sub>3</sub> O <sub>3</sub>                 | Bismuth hydroxide                     | -711.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| BiI <sub>3</sub>                                | Bismuth triiodide                     |                              | -175.3                       |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Bi <sub>2</sub>                                 | Dibismuth                             |                              |                              |                      |                  |                              |                              |                      |                  | 219.7                        |                              |                      | 36.9             |
| Bi <sub>2</sub> O <sub>3</sub>                  | Bismuth oxide                         | -573.9                       | -493.7                       | 151.5                | 113.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| Bi <sub>2</sub> O <sub>12</sub> S <sub>3</sub>  | Bismuth sulfate                       | -2544.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Bi <sub>2</sub> S <sub>3</sub>                  | Bismuth sulfide                       | -143.1                       | -140.6                       | 200.4                | 122.2            |                              |                              |                      |                  |                              |                              |                      |                  |
| Bk                                              | Berkelium                             | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |

[illegible]

| Molecular<br>formula                          | Name                          | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-----------------------------------------------|-------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                               |                               | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| Br <sub>4</sub> Pt                            | Platinum(IV) bromide          | -156.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Br <sub>4</sub> Si                            | Tetrabromosilane              |                              |                              |                      |                  | -457.3                       | -443.9                       | 277.8                |                  | -415.5                       | -431.8                       | 377.9                | 97.1             |
| Br <sub>4</sub> Sn                            | Tin(IV) bromide               | -377.4                       | -350.2                       | 264.4                |                  |                              |                              |                      |                  | -314.6                       | -331.4                       | 411.9                | 103.4            |
| Br <sub>4</sub> Te                            | Tellurium tetrabromide        | -190.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Br <sub>4</sub> Ti                            | Titanium(IV) bromide          | -616.7                       | -589.5                       | 243.5                | 131.5            |                              |                              |                      |                  | -549.4                       | -568.2                       | 398.4                | 100.8            |
| Br <sub>4</sub> V                             | Vanadium(IV) bromide          |                              |                              |                      |                  |                              |                              |                      |                  | -336.8                       |                              |                      |                  |
| Br <sub>4</sub> Zr                            | Zirconium(IV) bromide         | -760.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Br <sub>5</sub> P                             | Phosphorus(V) bromide         | -269.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Br <sub>5</sub> Ta                            | Tantalum(V) bromide           | -598.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Br <sub>6</sub> W                             | Tungsten(VI) bromide          | -348.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ca                                            | Calcium                       | 0.0                          |                              | 41.6                 | 25.9             |                              |                              |                      |                  | 177.8                        | 144.0                        | 154.9                | 20.8             |
| CaCl <sub>2</sub>                             | Calcium chloride              | -795.4                       | -748.8                       | 108.4                | 72.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| CaF <sub>2</sub>                              | Calcium fluoride              | -1228.0                      | -1175.6                      | 68.5                 | 67.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| CaH <sub>2</sub>                              | Calcium hydride               | -181.5                       | -142.5                       | 41.4                 | 41.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| CaH <sub>2</sub> O <sub>2</sub>               | Calcium hydroxide             | -985.2                       | -897.5                       | 83.4                 | 87.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| CaI <sub>2</sub>                              | Calcium iodide                | -533.5                       | -528.9                       | 142.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CaN <sub>2</sub> O <sub>6</sub>               | Calcium nitrate               | -938.2                       | -742.8                       | 193.2                | 149.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| CaO                                           | Calcium oxide                 | -634.9                       | -603.3                       | 38.1                 | 42.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| CaO <sub>3</sub> S                            | Calcium sulfate               | -1434.5                      | -1322.0                      | 106.5                | 99.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| CaS                                           | Calcium sulfide               | -482.4                       | -477.4                       | 56.5                 | 47.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| Ca <sub>3</sub> O <sub>8</sub> P <sub>2</sub> | Calcium phosphate             | -4120.8                      | -3884.7                      | 236.0                | 227.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cd                                            | Cadmium                       | 0.0                          |                              | 51.8                 | 26.0             |                              |                              |                      |                  | 111.8                        |                              | 167.7                | 20.8             |
| CdCl <sub>2</sub>                             | Cadmium chloride              | -391.5                       | -343.9                       | 115.3                | 74.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| CdF <sub>2</sub>                              | Cadmium fluoride              | -700.4                       | -647.7                       | 77.4                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CdH <sub>2</sub> O <sub>2</sub>               | Cadmium hydroxide             | -560.7                       | -473.6                       | 96.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CdI <sub>2</sub>                              | Cadmium iodide                | -203.3                       | -201.4                       | 161.1                | 80.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| CdO                                           | Cadmium oxide                 | -258.4                       | -228.7                       | 54.8                 | 43.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| CdO <sub>3</sub> S                            | Cadmium sulfate               | -933.3                       | -822.7                       | 123.0                | 99.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| CdS                                           | Cadmium sulfide               | -161.9                       | -156.5                       | 64.9                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CdTe                                          | Cadmium telluride             | -92.5                        | -92.0                        | 100.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ce                                            | Cerium (γ, fcc)               | 0.0                          |                              | 72.0                 | 26.9             |                              |                              |                      |                  | 423.0                        | 385.0                        | 191.8                | 23.1             |
| CeCl <sub>3</sub>                             | Cerium(III) chloride          | -1060.5                      | -984.8                       | 151.0                | 87.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| CeI <sub>3</sub>                              | Cerium(III) iodide            | -669.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CeO <sub>2</sub>                              | Cerium(IV) oxide              | -1088.7                      | -1024.6                      | 62.3                 | 61.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| CeS                                           | Cerium(II) sulfide            | -459.4                       | -451.5                       | 78.2                 | 50.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| Ce <sub>2</sub> O <sub>3</sub>                | Cerium(III) oxide             | -1796.2                      | -1706.2                      | 150.6                | 114.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cf                                            | Californium                   | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl                                            | Chlorine (atomic)             |                              |                              |                      |                  |                              |                              |                      |                  | 121.3                        | 105.3                        | 165.2                | 21.8             |
| ClCs                                          | Cesium chloride               | -443.0                       | -414.5                       | 101.2                | 52.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| ClCsO <sub>4</sub>                            | Cesium perchlorate            | -443.1                       | -314.3                       | 175.1                | 108.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| ClCu                                          | Copper(I) chloride            | -137.2                       | -119.9                       | 86.2                 | 48.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| ClF                                           | Chlorine fluoride             |                              |                              |                      |                  |                              |                              |                      |                  | -50.3                        | -51.8                        | 217.9                | 32.1             |
| ClFO <sub>3</sub>                             | Perchloryl fluoride           |                              |                              |                      |                  |                              |                              |                      |                  | -23.8                        | 48.2                         | 279.0                | 64.9             |
| ClF <sub>3</sub>                              | Chlorine trifluoride          |                              |                              |                      |                  | -189.5                       |                              |                      |                  | -163.2                       | -123.0                       | 281.6                | 63.9             |
| ClF <sub>5</sub> S                            | Sulfur chloride pentafluoride |                              |                              |                      |                  | -1065.7                      |                              |                      |                  |                              |                              |                      |                  |
| ClGe                                          | Germanium monochloride        |                              |                              |                      |                  |                              |                              |                      |                  | 155.2                        | 124.2                        | 247.0                | 36.9             |
| ClGeH <sub>3</sub>                            | Chlorogermane                 |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 263.7                | 54.7             |
| ClH                                           | Hydrogen chloride             |                              |                              |                      |                  |                              |                              |                      |                  | -92.3                        | -95.3                        | 186.9                | 29.1             |
| ClHO                                          | Hypochlorous acid             |                              |                              |                      |                  |                              |                              |                      |                  | -78.7                        | -66.1                        | 236.7                | 37.2             |
| ClHO <sub>4</sub>                             | Perchloric acid               |                              |                              |                      |                  | -40.6                        |                              |                      |                  |                              |                              |                      |                  |
| ClH <sub>3</sub> Si                           | Chlorosilane                  |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 250.7                | 51.0             |
| ClH <sub>4</sub> N                            | Ammonium chloride             | -314.4                       | -202.9                       | 94.6                 | 84.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| ClH <sub>4</sub> NO <sub>4</sub>              | Ammonium perchlorate          | -295.3                       | -88.8                        | 186.2                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| ClH <sub>4</sub> P                            | Phosphonium chloride          | -145.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| ClI                                           | Iodine chloride               |                              |                              |                      |                  | -23.9                        | -13.6                        | 135.1                |                  | 17.8                         | -5.5                         | 247.6                | 35.6             |
| ClIn                                          | Indium(I) chloride            | -186.2                       |                              |                      |                  |                              |                              |                      |                  | -75.0                        |                              |                      |                  |
| ClK                                           | Potassium chloride            | -436.5                       | -408.5                       | 82.6                 | 51.3             |                              |                              |                      |                  | -214.6                       | -233.3                       | 239.1                | 36.5             |
| ClKO <sub>3</sub>                             | Potassium chlorate            | -397.7                       | -296.3                       | 143.1                | 100.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| ClKO <sub>4</sub>                             | Potassium perchlorate         | -432.8                       | -303.1                       | 151.0                | 112.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| ClLi                                          | Lithium chloride              | -408.6                       | -384.4                       | 59.3                 | 48.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| ClLiO <sub>4</sub>                            | Lithium perchlorate           | -381.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| ClNO                                          | Nitrosyl chloride             |                              |                              |                      |                  |                              |                              |                      |                  | 51.7                         | 66.1                         | 261.7                | 44.7             |
| ClNO <sub>2</sub>                             | Nitryl chloride               |                              |                              |                      |                  |                              |                              |                      |                  | 12.6                         | 54.4                         | 272.2                | 53.2             |
| ClNa                                          | Sodium chloride               | -411.2                       | -384.1                       | 72.1                 | 50.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| ClNaO <sub>2</sub>                            | Sodium chlorite               | -307.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| ClNaO <sub>3</sub>                            | Sodium chlorate               | -365.8                       | -262.3                       | 123.4                |                  |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula              | Name                       | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-----------------------------------|----------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                   |                            | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| ClNaO <sub>4</sub>                | Sodium perchlorate         | -383.3                       | -254.9                       | 142.3                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| ClO                               | Chlorine oxide             |                              |                              |                      |                  |                              |                              |                      |                  | 101.8                        | 98.1                         | 226.6                | 31.5             |
| ClOV                              | Vanadyl chloride           | -607.0                       | -556.0                       | 75.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| ClO <sub>2</sub>                  | Chlorine dioxide           |                              |                              |                      |                  |                              |                              |                      |                  | 102.5                        | 120.5                        | 256.8                | 42.0             |
| ClO <sub>2</sub>                  | Chlorine superoxide (ClOO) |                              |                              |                      |                  |                              |                              |                      |                  | 89.1                         | 105.0                        | 263.7                | 46.0             |
| ClO <sub>4</sub> Rb               | Rubidium perchlorate       | -437.2                       | -306.9                       | 161.1                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| ClRb                              | Rubidium chloride          | -435.4                       | -407.8                       | 95.9                 | 52.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| ClSi                              | Chlorosilylidyne           |                              |                              |                      |                  |                              |                              |                      |                  | 189.9                        |                              |                      | 36.9             |
| ClTI                              | Thallium(I) chloride       | -204.1                       | -184.9                       | 111.3                | 50.9             |                              |                              |                      |                  | -67.8                        |                              |                      |                  |
| Cl <sub>2</sub>                   | Chlorine                   |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          |                              | 223.1                | 33.9             |
| Cl <sub>2</sub> Co                | Cobalt(II) chloride        | -312.5                       | -269.8                       | 109.2                | 78.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Cr                | Chromium(II) chloride      | -395.4                       | -356.0                       | 115.3                | 71.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> CrO <sub>2</sub>  | Chromyl chloride           |                              |                              |                      |                  | -579.5                       | -510.8                       | 221.8                |                  | -538.1                       | -501.6                       | 329.8                | 84.5             |
| Cl <sub>2</sub> Cu                | Copper(II) chloride        | -220.1                       | -175.7                       | 108.1                | 71.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Fe                | Iron(II) chloride          | -341.8                       | -302.3                       | 118.0                | 76.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> H <sub>2</sub> Si | Dichlorosilane             |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 285.7                | 60.5             |
| Cl <sub>2</sub> Hg                | Mercury(II) chloride       | -224.3                       | -178.6                       | 146.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Hg <sub>2</sub>   | Mercury(I) chloride        | -265.4                       | -210.7                       | 191.6                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Mg                | Magnesium chloride         | -641.3                       | -591.8                       | 89.6                 | 71.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Mn                | Manganese(II) chloride     | -481.3                       | -440.5                       | 118.2                | 72.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Ni                | Nickel(II) chloride        | -305.3                       | -259.0                       | 97.7                 | 71.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> O                 | Chlorine monoxide          |                              |                              |                      |                  |                              |                              |                      |                  | 80.3                         | 97.9                         | 266.2                | 45.4             |
| Cl <sub>2</sub> OS                | Thionyl chloride           |                              |                              |                      |                  | -245.6                       |                              |                      | 121.0            | -212.5                       | -198.3                       | 309.8                | 66.5             |
| Cl <sub>2</sub> O <sub>2</sub> S  | Sulfuryl chloride          |                              |                              |                      |                  | -394.1                       |                              |                      | 134.0            | -364.0                       | -320.0                       | 311.9                | 77.0             |
| Cl <sub>2</sub> O <sub>2</sub> U  | Uranyl chloride            | -1243.9                      | -1146.4                      | 150.5                | 107.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Pb                | Lead(II) chloride          | -359.4                       | -314.1                       | 136.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Pt                | Platinum(II) chloride      | -123.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> S                 | Sulfur dichloride          |                              |                              |                      |                  | -50.0                        |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> S <sub>2</sub>    | Sulfur chloride            |                              |                              |                      |                  | -59.4                        |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Sn                | Tin(II) chloride           | -325.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Sr                | Strontium chloride         | -828.9                       | -781.1                       | 114.9                | 75.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Ti                | Titanium(II) chloride      | -513.8                       | -464.4                       | 87.4                 | 69.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>2</sub> Zn                | Zinc chloride              | -415.1                       | -369.4                       | 111.5                | 71.3             |                              |                              |                      |                  | -266.1                       |                              |                      |                  |
| Cl <sub>2</sub> Zr                | Zirconium(II) chloride     | -502.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Cr                | Chromium(III) chloride     | -556.5                       | -486.1                       | 123.0                | 91.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Dy                | Dysprosium(III) chloride   | -1000.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Er                | Erbium chloride            | -998.7                       |                              |                      | 100.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Eu                | Europium(III) chloride     | -936.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Fe                | Iron(III) chloride         | -399.5                       | -334.0                       | 142.3                | 96.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Ga                | Gallium(III) chloride      | -524.7                       | -454.8                       | 142.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Gd                | Gadolinium(III) chloride   | -1008.0                      |                              |                      | 88.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> HSi               | Trichlorosilane            |                              |                              |                      |                  | -539.3                       | -482.5                       | 227.6                |                  | -513.0                       | -482.0                       | 313.9                | 75.8             |
| Cl <sub>3</sub> Ho                | Holmium chloride           | -1005.4                      |                              |                      | 88.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> In                | Indium(III) chloride       | -537.2                       |                              |                      |                  |                              |                              |                      |                  | -374.0                       |                              |                      |                  |
| Cl <sub>3</sub> Ir                | Iridium(III) chloride      | -245.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> La                | Lanthanum chloride         | -1072.2                      |                              |                      | 108.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Lu                | Lutetium chloride          | -945.6                       |                              |                      |                  |                              |                              |                      |                  | -649.0                       |                              |                      |                  |
| Cl <sub>3</sub> N                 | Nitrogen trichloride       |                              |                              |                      |                  | 230.0                        |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Nd                | Neodymium chloride         | -1041.0                      |                              |                      | 113.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> OP                | Phosphoric trichloride     |                              |                              |                      |                  | -597.1                       | -520.8                       | 222.5                | 138.8            | -558.5                       | -512.9                       | 325.5                | 84.9             |
| Cl <sub>3</sub> OV                | Vanadyl trichloride        |                              |                              |                      |                  | -734.7                       | -668.5                       | 244.3                |                  | -695.6                       | -659.3                       | 344.3                | 89.9             |
| Cl <sub>3</sub> Os                | Osmium(III) chloride       | -190.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> P                 | Phosphorus(III) chloride   |                              |                              |                      |                  | -319.7                       | -272.3                       | 217.1                |                  | -287.0                       | -267.8                       | 311.8                | 71.8             |
| Cl <sub>3</sub> Pr                | Praseodymium chloride      | -1056.9                      |                              |                      | 100.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Pt                | Platinum(III) chloride     | -182.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Re                | Rhenium(III) chloride      | -264.0                       | -188.0                       | 123.8                | 92.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Rh                | Rhodium(III) chloride      | -299.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Ru                | Ruthenium(III) chloride    | -205.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Sb                | Antimony(III) chloride     | -382.2                       | -323.7                       | 184.1                | 107.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Sc                | Scandium chloride          | -925.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Sm                | Samarium(III) chloride     | -1025.9                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Tb                | Terbium chloride           | -997.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Ti                | Titanium(III) chloride     | -720.9                       | -653.5                       | 139.7                | 97.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Tl                | Thallium(III) chloride     | -315.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Tm                | Thulium chloride           | -986.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> U                 | Uranium(III) chloride      | -866.5                       | -799.1                       | 159.0                | 102.5            |                              |                              |                      |                  |                              |                              |                      |                  |



| Molecular<br>formula             | Name                      | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|----------------------------------|---------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                  |                           | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| Cl <sub>3</sub> V                | Vanadium(III) chloride    | -580.7                       | -511.2                       | 131.0                | 93.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>3</sub> Y                | Yttrium chloride          | -1000.0                      |                              |                      |                  |                              |                              |                      |                  | -750.2                       |                              |                      | 75.0             |
| Cl <sub>3</sub> Yb               | Ytterbium(III) chloride   | -959.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>4</sub> Ge               | Germanium(IV) chloride    |                              |                              |                      |                  | -531.8                       | -462.7                       | 245.6                |                  | -495.8                       | -457.3                       | 347.7                | 96.1             |
| Cl <sub>4</sub> Hf               | Hafnium(IV) chloride      | -990.4                       | -901.3                       | 190.8                | 120.5            |                              |                              |                      |                  | -884.5                       |                              |                      |                  |
| Cl <sub>4</sub> Pa               | Protactinium(IV) chloride | -1043.0                      | -953.0                       | 192.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>4</sub> Pb               | Lead(IV) chloride         |                              |                              |                      |                  | -329.3                       |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>4</sub> Pt               | Platinum(IV) chloride     | -231.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>4</sub> Si               | Tetrachlorosilane         |                              |                              |                      |                  | -687.0                       | -619.8                       | 239.7                | 145.3            | -657.0                       | -617.0                       | 330.7                | 90.3             |
| Cl <sub>4</sub> Sn               | Tin(IV) chloride          |                              |                              |                      |                  | -511.3                       | -440.1                       | 258.6                | 165.3            | -471.5                       | -432.2                       | 365.8                | 98.3             |
| Cl <sub>4</sub> Te               | Tellurium tetrachloride   | -326.4                       |                              |                      | 138.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>4</sub> Th               | Thorium(IV) chloride      | -1186.2                      | -1094.1                      | 190.4                | 120.3            |                              |                              |                      |                  | -964.4                       | -932.0                       | 390.7                | 107.5            |
| Cl <sub>4</sub> Ti               | Titanium(IV) chloride     |                              |                              |                      |                  | -804.2                       | -737.2                       | 252.3                | 145.2            | -763.2                       | -726.3                       | 353.2                | 95.4             |
| Cl <sub>4</sub> U                | Uranium(IV) chloride      | -1019.2                      | -930.0                       | 197.1                | 122.0            |                              |                              |                      |                  | -809.6                       | -786.6                       | 419.0                |                  |
| Cl <sub>4</sub> V                | Vanadium(IV) chloride     |                              |                              |                      |                  | -569.4                       | -503.7                       | 255.0                |                  | -525.5                       | -492.0                       | 362.4                | 96.2             |
| Cl <sub>4</sub> Zr               | Zirconium(IV) chloride    | -980.5                       | -889.9                       | 181.6                | 119.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>5</sub> Nb               | Niobium(V) chloride       | -797.5                       | -683.2                       | 210.5                | 148.1            |                              |                              |                      |                  | -703.7                       | -646.0                       | 400.6                | 120.8            |
| Cl <sub>5</sub> P                | Phosphorus(V) chloride    | -443.5                       |                              |                      |                  |                              |                              |                      |                  | -374.9                       | -305.0                       | 364.6                | 112.8            |
| Cl <sub>5</sub> Pa               | Protactinium(V) chloride  | -1145.0                      | -1034.0                      | 238.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>5</sub> Ta               | Tantalum(V) chloride      | -859.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cl <sub>6</sub> U                | Uranium(VI) chloride      | -1092.0                      | -962.0                       | 285.8                | 175.7            |                              |                              |                      |                  | -1013.0                      | -928.0                       | 431.0                |                  |
| Cl <sub>6</sub> W                | Tungsten(VI) chloride     | -602.5                       |                              |                      |                  |                              |                              |                      |                  | -513.8                       |                              |                      |                  |
| Cm                               | Curium                    | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Co                               | Cobalt                    | 0.0                          |                              | 30.0                 | 24.8             |                              |                              |                      |                  | 424.7                        | 380.3                        | 179.5                | 23.0             |
| CoF <sub>2</sub>                 | Cobalt(II) fluoride       | -692.0                       | -647.2                       | 82.0                 | 68.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| CoH <sub>2</sub> O <sub>2</sub>  | Cobalt(II) hydroxide      | -539.7                       | -454.3                       | 79.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CoI <sub>2</sub>                 | Cobalt(II) iodide         | -88.7                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CoN <sub>2</sub> O <sub>6</sub>  | Cobalt(II) nitrate        | -420.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CoO                              | Cobalt(II) oxide          | -237.9                       | -214.2                       | 53.0                 | 55.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| CoO <sub>4</sub> S               | Cobalt(II) sulfate        | -888.3                       | -782.3                       | 118.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CoS                              | Cobalt(II) sulfide        | -82.8                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Co <sub>2</sub> S <sub>3</sub>   | Cobalt(III) sulfide       | -147.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Co <sub>3</sub> O <sub>4</sub>   | Cobalt(II,III) oxide      | -891.0                       | -774.0                       | 102.5                | 123.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cr                               | Chromium                  | 0.0                          |                              | 23.8                 | 23.4             |                              |                              |                      |                  | 396.6                        | 351.8                        | 174.5                | 20.8             |
| CrF <sub>2</sub>                 | Chromium(II) fluoride     | -778.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CrF <sub>3</sub>                 | Chromium(III) fluoride    | -1159.0                      | -1088.0                      | 93.9                 | 78.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| CrI <sub>2</sub>                 | Chromium(II) iodide       | -156.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CrI <sub>3</sub>                 | Chromium(III) iodide      | -205.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CrO <sub>2</sub>                 | Chromium(IV) oxide        | -598.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CrO <sub>3</sub>                 | Chromium(VI) oxide        |                              |                              |                      |                  |                              |                              |                      |                  | -292.9                       |                              | 266.2                | 56.0             |
| CrO <sub>4</sub> Pb              | Lead(II) chromate         | -930.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cr <sub>2</sub> FeO <sub>4</sub> | Chromium iron oxide       | -1444.7                      | -1343.8                      | 146.0                | 133.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cr <sub>2</sub> O <sub>3</sub>   | Chromium(III) oxide       | -1139.7                      | -1058.1                      | 81.2                 | 118.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cr <sub>3</sub> O <sub>4</sub>   | Chromium(II,III) oxide    | -1531.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cs                               | Cesium                    | 0.0                          |                              | 85.2                 | 32.2             |                              |                              |                      |                  | 76.5                         | 49.6                         | 175.6                | 20.8             |
| CsF                              | Cesium fluoride           | -553.5                       | -525.5                       | 92.8                 | 51.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| CsF <sub>2</sub> H               | Cesium hydrogen fluoride  | -923.8                       | -858.9                       | 135.2                | 87.3             |                              |                              |                      |                  |                              |                              |                      |                  |
| CsH                              | Cesium hydride            | -54.2                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CsHO                             | Cesium hydroxide          | -416.2                       | -371.8                       | 104.2                | 69.9             |                              |                              |                      |                  | -256.0                       | -256.5                       | 254.8                | 49.7             |
| CsHO <sub>4</sub> S              | Cesium hydrogen sulfate   | -1158.1                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CsH <sub>2</sub> N               | Cesium amide              | -118.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CsI                              | Cesium iodide             | -346.6                       | -340.6                       | 123.1                | 52.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| CsNO <sub>3</sub>                | Cesium nitrate            | -506.0                       | -406.5                       | 155.2                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CsO <sub>2</sub>                 | Cesium superoxide         | -286.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cs <sub>2</sub> O                | Cesium oxide              | -345.8                       | -308.1                       | 146.9                | 76.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cs <sub>2</sub> O <sub>2</sub> S | Cesium sulfite            | -1134.7                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cs <sub>2</sub> O <sub>4</sub> S | Cesium sulfate            | -1443.0                      | -1323.6                      | 211.9                | 134.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| Cs <sub>2</sub> S                | Cesium sulfide            | -359.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cu                               | Copper                    | 0.0                          |                              | 33.2                 | 24.4             |                              |                              |                      |                  | 337.4                        | 297.7                        | 166.4                | 20.8             |
| CuF <sub>2</sub>                 | Copper(II) fluoride       | -542.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CuH <sub>2</sub> O <sub>2</sub>  | Copper(II) hydroxide      | -449.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CuI                              | Copper(I) iodide          | -67.8                        | -69.5                        | 96.7                 | 54.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| CuN <sub>2</sub> O <sub>6</sub>  | Copper(II) nitrate        | -302.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CuO                              | Copper(II) oxide          | -157.3                       | -129.7                       | 42.6                 | 42.3             |                              |                              |                      |                  |                              |                              |                      |                  |
| CuO <sub>4</sub> S               | Copper(II) sulfate        | -771.4                       | -662.2                       | 109.2                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CuO <sub>4</sub> W               | Copper(II) tungstate      | -1105.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula            | Name                        | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|---------------------------------|-----------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                 |                             | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| CuS                             | Copper(II) sulfide          | -53.1                        | -53.6                        | 66.5                 | 47.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| CuSe                            | Copper(II) selenide         | -39.5                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Cu <sub>2</sub>                 | Dicopper                    |                              |                              |                      |                  |                              |                              |                      |                  | 484.2                        | 431.9                        | 241.6                | 36.6             |
| Cu <sub>2</sub> O               | Copper(I) oxide             | -168.6                       | -146.0                       | 93.1                 | 63.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| Cu <sub>2</sub> S               | Copper(I) sulfide           | -79.5                        | -86.2                        | 120.9                | 76.3             |                              |                              |                      |                  |                              |                              |                      |                  |
| Dy                              | Dysprosium                  | 0.0                          |                              | 75.6                 | 27.7             |                              |                              |                      |                  | 290.4                        | 254.4                        | 196.6                | 20.8             |
| DyI <sub>3</sub>                | Dysprosium(III) iodide      | -620.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Dy <sub>2</sub> O <sub>3</sub>  | Dysprosium(III) oxide       | -1863.1                      | -1771.5                      | 149.8                | 116.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| Er                              | Erbium                      | 0.0                          |                              | 73.2                 | 28.1             |                              |                              |                      |                  | 317.1                        | 280.7                        | 195.6                | 20.8             |
| ErF <sub>3</sub>                | Erbium fluoride             | -1711.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Er <sub>2</sub> O <sub>3</sub>  | Erbium oxide                | -1897.9                      | -1808.7                      | 155.6                | 108.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| Es                              | Einsteinium                 | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Eu                              | Europium                    | 0.0                          |                              | 77.8                 | 27.7             |                              |                              |                      |                  | 175.3                        | 142.2                        | 188.8                | 20.8             |
| Eu <sub>2</sub> O <sub>3</sub>  | Europium(III) oxide         | -1651.4                      | -1556.8                      | 146.0                | 122.2            |                              |                              |                      |                  |                              |                              |                      |                  |
| Eu <sub>3</sub> O <sub>4</sub>  | Europium(II,III) oxide      | -2272.0                      | -2142.0                      | 205.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F                               | Fluorine (atomic)           |                              |                              |                      |                  |                              |                              |                      |                  | 79.4                         | 62.3                         | 158.8                | 22.7             |
| FGa                             | Gallium monofluoride        |                              |                              |                      |                  |                              |                              |                      |                  | -251.9                       |                              |                      | 33.3             |
| FGe                             | Germanium monofluoride      |                              |                              |                      |                  |                              |                              |                      |                  | -33.4                        |                              |                      | 34.7             |
| FGeH <sub>3</sub>               | Fluorogermane               |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 252.8                | 51.6             |
| FH                              | Hydrogen fluoride           |                              |                              |                      |                  | -299.8                       |                              |                      |                  | -273.3                       | -275.4                       | 173.8                |                  |
| FH <sub>3</sub> Si              | Fluorosilane                |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 238.4                | 47.4             |
| FH <sub>4</sub> N               | Ammonium fluoride           | -464.0                       | -348.7                       | 72.0                 | 65.3             |                              |                              |                      |                  |                              |                              |                      |                  |
| FI                              | Iodine fluoride             |                              |                              |                      |                  |                              |                              |                      |                  | -95.7                        | -118.5                       | 236.2                | 33.4             |
| Fln                             | Indium(I) fluoride          |                              |                              |                      |                  |                              |                              |                      |                  | -203.4                       |                              |                      |                  |
| FK                              | Potassium fluoride          | -567.3                       | -537.8                       | 66.6                 | 49.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| FLi                             | Lithium fluoride            | -616.0                       | -587.7                       | 35.7                 | 41.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| FNO                             | Nitrosyl fluoride           |                              |                              |                      |                  |                              |                              |                      |                  | -66.5                        | -51.0                        | 248.1                | 41.3             |
| FNO <sub>2</sub>                | Nitryl fluoride             |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 260.4                | 49.8             |
| FNS                             | Thionitrosyl fluoride (NSF) |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 259.8                | 44.1             |
| FNa                             | Sodium fluoride             | -576.6                       | -546.3                       | 51.1                 | 46.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| FO                              | Fluorine oxide              |                              |                              |                      |                  |                              |                              |                      |                  | 109.0                        | 105.3                        | 216.4                | 32.0             |
| FO <sub>2</sub>                 | Fluorine superoxide (FOO)   |                              |                              |                      |                  |                              |                              |                      |                  | 25.4                         | 39.4                         | 259.5                | 44.5             |
| FRb                             | Rubidium fluoride           | -557.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| FSi                             | Fluorosilyldiyne            |                              |                              |                      |                  |                              |                              |                      |                  | 7.1                          | -24.3                        | 225.8                | 32.6             |
| FTl                             | Thallium(I) fluoride        | -324.7                       |                              |                      |                  |                              |                              |                      |                  | -182.4                       |                              |                      |                  |
| F <sub>2</sub>                  | Fluorine                    |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          |                              | 202.8                | 31.3             |
| F <sub>2</sub> Fe               | Iron(II) fluoride           | -711.3                       | -668.6                       | 87.0                 | 68.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> HK               | Potassium hydrogen fluoride | -927.7                       | -859.7                       | 104.3                | 76.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> HN               | Difluoramine                |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 252.8                | 43.4             |
| F <sub>2</sub> HNa              | Sodium hydrogen fluoride    | -920.3                       | -852.2                       | 90.9                 | 75.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> HRb              | Rubidium hydrogen fluoride  | -922.6                       | -855.6                       | 120.1                | 79.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> Mg               | Magnesium fluoride          | -1124.2                      | -1071.1                      | 57.2                 | 61.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> N                | Difluoroamidogen            |                              |                              |                      |                  |                              |                              |                      |                  | 43.1                         | 57.8                         | 249.9                | 41.0             |
| F <sub>2</sub> N <sub>2</sub>   | cis-Difluorodiazine         |                              |                              |                      |                  |                              |                              |                      |                  | 69.5                         |                              |                      |                  |
| F <sub>2</sub> N <sub>2</sub>   | trans-Difluorodiazine       |                              |                              |                      |                  |                              |                              |                      |                  | 82.0                         |                              |                      |                  |
| F <sub>2</sub> Ni               | Nickel(II) fluoride         | -651.4                       | -604.1                       | 73.6                 | 64.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> O                | Fluorine monoxide           |                              |                              |                      |                  |                              |                              |                      |                  | 24.5                         | 41.8                         | 247.5                | 43.3             |
| F <sub>2</sub> OS               | Thionyl fluoride            |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 278.7                | 56.8             |
| F <sub>2</sub> O <sub>2</sub>   | Fluorine dioxide            |                              |                              |                      |                  |                              |                              |                      |                  | 19.2                         | 58.2                         | 277.2                | 62.1             |
| F <sub>2</sub> O <sub>2</sub> S | Sulfuryl fluoride           |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 284.0                | 66.0             |
| F <sub>2</sub> O <sub>2</sub> U | Uranyl fluoride             | -1653.5                      | -1557.4                      | 135.6                | 103.2            |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> Pb               | Lead(II) fluoride           | -664.0                       | -617.1                       | 110.5                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> Si               | Difluorosilylene            |                              |                              |                      |                  |                              |                              |                      |                  | -619.0                       | -628.0                       | 252.7                | 43.9             |
| F <sub>2</sub> Sr               | Strontium fluoride          | -1216.3                      | -1164.8                      | 82.1                 | 70.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>2</sub> Zn               | Zinc fluoride               | -764.4                       | -713.3                       | 73.7                 | 65.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>3</sub> Ga               | Gallium(III) fluoride       | -1163.0                      | -1085.3                      | 84.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>3</sub> Gd               | Gadolinium(III) fluoride    |                              |                              |                      |                  |                              |                              |                      |                  | -1297.0                      |                              |                      |                  |
| F <sub>3</sub> Hsi              | Trifluorosilane             |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 271.9                | 60.5             |
| F <sub>3</sub> Ho               | Holmium fluoride            | -1707.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>3</sub> N                | Nitrogen trifluoride        |                              |                              |                      |                  |                              |                              |                      |                  | -132.1                       | -90.6                        | 260.8                | 53.4             |
| F <sub>3</sub> Nd               | Neodymium fluoride          | -1657.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>3</sub> OP               | Phosphoric trifluoride      |                              |                              |                      |                  |                              |                              |                      |                  | -1254.3                      | -1205.8                      | 285.4                | 68.8             |
| F <sub>3</sub> P                | Phosphorus(III) fluoride    |                              |                              |                      |                  |                              |                              |                      |                  | -958.4                       | -936.9                       | 273.1                | 58.7             |
| F <sub>3</sub> Sb               | Antimony(III) fluoride      | -915.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>3</sub> Sc               | Scandium fluoride           | -1629.2                      | -1555.6                      | 92.0                 |                  |                              |                              |                      |                  | -1247.0                      | -1234.0                      | 300.5                | 67.8             |
| F <sub>3</sub> Sm               | Samarium(III) fluoride      | -1778.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                            | Name                         | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------|------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                 |                              | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| F <sub>3</sub> Th                               | Thorium(III) fluoride        |                              |                              |                      |                  |                              |                              |                      |                  | -1166.1                      | -1160.6                      | 339.2                | 73.3             |
| F <sub>3</sub> U                                | Uranium(III) fluoride        | -1502.1                      | -1433.4                      | 123.4                | 95.1             |                              |                              |                      |                  | -1058.5                      | -1051.9                      | 331.9                | 74.3             |
| F <sub>3</sub> Y                                | Yttrium fluoride             | -1718.8                      | -1644.7                      | 100.0                |                  |                              |                              |                      |                  | -1288.7                      | -1277.8                      | 311.8                | 70.3             |
| F <sub>4</sub> Ge                               | Germanium(IV) fluoride       |                              |                              |                      |                  |                              |                              |                      |                  | -1190.2                      | -1150.0                      | 301.9                |                  |
| F <sub>4</sub> Hf                               | Hafnium fluoride             | -1930.5                      | -1830.4                      | 113.0                |                  |                              |                              |                      |                  | -1669.8                      |                              |                      |                  |
| F <sub>4</sub> N <sub>2</sub>                   | Tetrafluorohydrazine         |                              |                              |                      |                  |                              |                              |                      |                  | -8.4                         | 79.9                         | 301.2                | 79.2             |
| F <sub>4</sub> Pb                               | Lead(IV) fluoride            | -941.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>4</sub> S                                | Sulfur tetrafluoride         |                              |                              |                      |                  |                              |                              |                      |                  | -763.2                       | -722.0                       | 299.6                | 77.6             |
| F <sub>4</sub> Si                               | Tetrafluorosilane            |                              |                              |                      |                  |                              |                              |                      |                  | -1615.0                      | -1572.8                      | 282.8                | 73.6             |
| F <sub>4</sub> Th                               | Thorium(IV) fluoride         | -2097.8                      | -2003.4                      | 142.0                | 110.7            |                              |                              |                      |                  | -1759.0                      | -1724.0                      | 341.7                | 93.0             |
| F <sub>4</sub> U                                | Uranium(IV) fluoride         | -1914.2                      | -1823.3                      | 151.7                | 116.0            |                              |                              |                      |                  | -1598.7                      | -1572.7                      | 368.0                | 91.2             |
| F <sub>4</sub> V                                | Vanadium(IV) fluoride        | -1403.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>4</sub> Xe                               | Xenon tetrafluoride          | -261.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>4</sub> Zr                               | Zirconium(IV) fluoride       | -1911.3                      | -1809.9                      | 104.6                | 103.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>5</sub> I                                | Iodine pentafluoride         |                              |                              |                      |                  | -864.8                       |                              |                      |                  | -822.5                       | -751.7                       | 327.7                | 99.2             |
| F <sub>5</sub> Nb                               | Niobium(V) fluoride          | -1813.8                      | -1699.0                      | 160.2                | 134.7            |                              |                              |                      |                  | -1739.7                      | -1673.6                      | 321.9                | 97.1             |
| F <sub>5</sub> P                                | Phosphorus(V) fluoride       |                              |                              |                      |                  |                              |                              |                      |                  | -1594.4                      | -1520.7                      | 300.8                | 84.8             |
| F <sub>5</sub> Ta                               | Tantalum(V) fluoride         | -1903.6                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>5</sub> V                                | Vanadium(V) fluoride         |                              |                              |                      |                  | -1480.3                      | -1373.1                      | 175.7                |                  | -1433.9                      | -1369.8                      | 320.9                | 98.6             |
| F <sub>6</sub> H <sub>8</sub> N <sub>2</sub> Si | Ammonium hexafluorosilicate  | -2681.7                      | -2365.3                      | 280.2                | 228.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>6</sub> Ir                               | Iridium(VI) fluoride         | -579.7                       | -461.6                       | 247.7                |                  |                              |                              |                      |                  | -544.0                       | -460.0                       | 357.8                | 121.1            |
| F <sub>6</sub> K <sub>2</sub> Si                | Potassium hexafluorosilicate | -2956.0                      | -2798.6                      | 226.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>6</sub> Mo                               | Molybdenum(VI) fluoride      |                              |                              |                      |                  | -1585.5                      | -1473.0                      | 259.7                | 169.8            | -1557.7                      | -1472.2                      | 350.5                | 120.6            |
| F <sub>6</sub> Na <sub>2</sub> Si               | Sodium hexafluorosilicate    | -2909.6                      | -2754.2                      | 207.1                | 187.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| F <sub>6</sub> Os                               | Osmium(VI) fluoride          |                              |                              | 246.0                |                  |                              |                              |                      |                  |                              |                              | 358.1                | 120.8            |
| F <sub>6</sub> Pt                               | Platinum(VI) fluoride        |                              |                              | 235.6                |                  |                              |                              |                      |                  |                              |                              | 348.3                | 122.8            |
| F <sub>6</sub> S                                | Sulfur hexafluoride          |                              |                              |                      |                  |                              |                              |                      |                  | -1220.5                      | -1116.5                      | 291.5                | 97.0             |
| F <sub>6</sub> Se                               | Selenium hexafluoride        |                              |                              |                      |                  |                              |                              |                      |                  | -1117.0                      | -1017.0                      | 313.9                | 110.5            |
| F <sub>6</sub> Si <sub>2</sub>                  | Hexafluorodisilane           | -2427.0                      | -2299.7                      | 219.1                | 129.5            |                              |                              |                      |                  | -2383.3                      | -2307.3                      | 391.0                | 129.9            |
| F <sub>6</sub> Te                               | Tellurium hexafluoride       |                              |                              |                      |                  |                              |                              |                      |                  | -1318.0                      |                              |                      |                  |
| F <sub>6</sub> U                                | Uranium(VI) fluoride         | -2197.0                      | -2068.5                      | 227.6                | 166.8            |                              |                              |                      |                  | -2147.4                      | -2063.7                      | 377.9                | 129.6            |
| F <sub>6</sub> W                                | Tungsten(VI) fluoride        |                              |                              |                      |                  | -1747.7                      | -1631.4                      | 251.5                |                  | -1721.7                      | -1632.1                      | 341.1                | 119.0            |
| Fe                                              | Iron                         | 0.0                          |                              | 27.3                 | 25.1             |                              |                              |                      |                  | 416.3                        | 370.7                        | 180.5                | 25.7             |
| FeI <sub>2</sub>                                | Iron(II) iodide              | -113.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| FeI <sub>3</sub>                                | Iron(III) iodide             |                              |                              |                      |                  |                              |                              |                      |                  | 71.0                         |                              |                      |                  |
| FeMoO <sub>4</sub>                              | Iron(II) molybdate           | -1075.0                      | -975.0                       | 129.3                | 118.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| FeO                                             | Iron(II) oxide               | -272.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| FeO <sub>4</sub> S                              | Iron(II) sulfate             | -928.4                       | -820.8                       | 107.5                | 100.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| FeO <sub>4</sub> W                              | Iron(II) tungstate           | -1155.0                      | -1054.0                      | 131.8                | 114.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| FeS                                             | Iron(II) sulfide             | -100.0                       | -100.4                       | 60.3                 | 50.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| FeS <sub>2</sub>                                | Iron disulfide               | -178.2                       | -166.9                       | 52.9                 | 62.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| Fe <sub>2</sub> O <sub>3</sub>                  | Iron(III) oxide              | -824.2                       | -742.2                       | 87.4                 | 103.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| Fe <sub>2</sub> O <sub>4</sub> Si               | Iron(II) orthosilicate       | -1479.9                      | -1379.0                      | 145.2                | 132.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| Fe <sub>3</sub> O <sub>4</sub>                  | Iron(II,III) oxide           | -1118.4                      | -1015.4                      | 146.4                | 143.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| Fm                                              | Fermium                      | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Fr                                              | Francium                     | 0.0                          |                              | 95.4                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ga                                              | Gallium                      | 0.0                          | 0.0                          | 40.8                 | 26.1             | 5.6                          |                              |                      |                  | 272.0                        | 233.7                        | 169.0                | 25.3             |
| GaH <sub>3</sub> O <sub>3</sub>                 | Gallium(III) hydroxide       | -964.4                       | -831.3                       | 100.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Gal <sub>3</sub>                                | Gallium(III) iodide          | -238.9                       |                              | 205.0                | 100.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| GaN                                             | Gallium nitride              | -110.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| GaO                                             | Gallium monoxide             |                              |                              |                      |                  |                              |                              |                      |                  | 279.5                        | 253.5                        | 231.1                | 32.1             |
| GaP                                             | Gallium phosphide            | -88.0                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| GaSb                                            | Gallium antimonide           | -41.8                        | -38.9                        | 76.1                 | 48.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| Ga <sub>2</sub>                                 | Digallium                    |                              |                              |                      |                  |                              |                              |                      |                  | 438.5                        |                              |                      |                  |
| Ga <sub>2</sub> O                               | Gallium suboxide             | -356.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ga <sub>2</sub> O <sub>3</sub>                  | Gallium(III) oxide           | -1089.1                      | -998.3                       | 85.0                 | 92.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| Gd                                              | Gadolinium                   | 0.0                          |                              | 68.1                 | 37.0             |                              |                              |                      |                  | 397.5                        | 359.8                        | 194.3                | 27.5             |
| Gd <sub>2</sub> O <sub>3</sub>                  | Gadolinium(III) oxide        | -1819.6                      |                              |                      | 106.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| Ge                                              | Germanium                    | 0.0                          |                              | 31.1                 | 23.3             |                              |                              |                      |                  | 372.0                        | 331.2                        | 167.9                | 30.7             |
| GeH <sub>3</sub> I                              | Iodogermane                  |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 283.2                | 57.5             |
| GeH <sub>4</sub>                                | Germane                      |                              |                              |                      |                  |                              |                              |                      |                  | 90.8                         | 113.4                        | 217.1                | 45.0             |
| GeI <sub>4</sub>                                | Germanium(IV) iodide         | -141.8                       | -144.3                       | 271.1                |                  |                              |                              |                      |                  | -56.9                        | -106.3                       | 428.9                | 104.1            |
| GeO                                             | Germanium(II) oxide          | -261.9                       | -237.2                       | 50.0                 |                  |                              |                              |                      |                  | -46.2                        | -73.2                        | 224.3                | 30.9             |
| GeO <sub>2</sub>                                | Germanium(IV) oxide          | -580.0                       | -521.4                       | 39.7                 | 52.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| GeP                                             | Germanium phosphide          | -21.0                        | -17.0                        | 63.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| GeS                                             | Germanium(II) sulfide        | -69.0                        | -71.5                        | 71.0                 |                  |                              |                              |                      |                  | 92.0                         | 42.0                         | 234.0                | 33.7             |

| Molecular<br>formula                         | Name                           | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|----------------------------------------------|--------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                              |                                | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| GeTe                                         | Germanium(II) telluride        | 20.0                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ge <sub>2</sub>                              | Digermanium                    |                              |                              |                      |                  |                              |                              |                      |                  | 473.1                        | 416.3                        | 252.8                | 35.6             |
| Ge <sub>2</sub> H <sub>6</sub>               | Digermane                      |                              |                              |                      |                  | 137.3                        |                              |                      |                  | 162.3                        |                              |                      |                  |
| Ge <sub>3</sub> H <sub>8</sub>               | Trigermane                     |                              |                              |                      |                  | 193.7                        |                              |                      |                  | 226.8                        |                              |                      |                  |
| H                                            | Hydrogen (atomic)              |                              |                              |                      |                  |                              |                              |                      |                  | 218.0                        | 203.3                        | 114.7                | 20.8             |
| HI                                           | Hydrogen iodide                |                              |                              |                      |                  |                              |                              |                      |                  | 26.5                         | 1.7                          | 206.6                | 29.2             |
| HIO <sub>3</sub>                             | Iodic acid                     | -230.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HK                                           | Potassium hydride              | -57.7                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HKO                                          | Potassium hydroxide            | -424.6                       | -379.4                       | 81.2                 | 68.9             |                              |                              |                      |                  | -232.0                       | -229.7                       | 238.3                | 49.2             |
| HKO <sub>3</sub> S                           | Potassium hydrogen sulfate     | -1160.6                      | -1031.3                      | 138.1                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HLi                                          | Lithium hydride                | -90.5                        | -68.3                        | 20.0                 | 27.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| HLiO                                         | Lithium hydroxide              | -487.5                       | -441.5                       | 42.8                 | 49.6             |                              |                              |                      |                  | -229.0                       | -234.2                       | 214.4                | 46.0             |
| HN                                           | Imidogen                       |                              |                              |                      |                  |                              |                              |                      |                  | 351.5                        | 345.6                        | 181.2                | 29.2             |
| HNO <sub>2</sub>                             | Nitrous acid                   |                              |                              |                      |                  |                              |                              |                      |                  | -79.5                        | -46.0                        | 254.1                | 45.6             |
| HNO <sub>3</sub>                             | Nitric acid                    |                              |                              |                      |                  | -174.1                       | -80.7                        | 155.6                | 109.9            | -133.9                       | -73.5                        | 266.9                | 54.1             |
| HN <sub>3</sub>                              | Hydrazoic acid                 |                              |                              |                      |                  | 264.0                        | 327.3                        | 140.6                |                  | 294.1                        | 328.1                        | 239.0                | 43.7             |
| HNa                                          | Sodium hydride                 | -56.3                        | -33.5                        | 40.0                 | 36.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| HNaO                                         | Sodium hydroxide               | -425.8                       | -379.7                       | 64.4                 | 59.5             |                              |                              |                      |                  | -191.0                       | -193.9                       | 229.0                | 48.0             |
| HNaO <sub>3</sub> S                          | Sodium hydrogen sulfate        | -1125.5                      | -992.8                       | 113.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HNa <sub>2</sub> O <sub>4</sub> P            | Sodium hydrogen phosphate      | -1748.1                      | -1608.2                      | 150.5                | 135.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| HO                                           | Hydroxyl                       |                              |                              |                      |                  |                              |                              |                      |                  | 39.0                         | 34.2                         | 183.7                | 29.9             |
| HORb                                         | Rubidium hydroxide             | -418.8                       | -373.9                       | 94.0                 | 69.0             |                              |                              |                      |                  | -238.0                       | -239.1                       | 248.5                | 49.5             |
| HOTl                                         | Thallium(I) hydroxide          | -238.9                       | -195.8                       | 88.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HO <sub>2</sub>                              | Hydroperoxy                    |                              |                              |                      |                  |                              |                              |                      |                  | 10.5                         | 22.6                         | 229.0                | 34.9             |
| HO <sub>3</sub> P                            | Metaphosphoric acid            | -948.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HO <sub>4</sub> RbS                          | Rubidium hydrogen sulfate      | -1159.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HO <sub>4</sub> Re                           | Perrhenic acid                 | -762.3                       | -656.4                       | 158.2                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HRb                                          | Rubidium hydride               | -52.3                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HS                                           | Mercapto                       |                              |                              |                      |                  |                              |                              |                      |                  | 142.7                        | 113.3                        | 195.7                | 32.3             |
| HSi                                          | Silylidyne                     |                              |                              |                      |                  |                              |                              |                      |                  | 361.0                        |                              |                      |                  |
| HTa <sub>2</sub>                             | Tantalum hydride               | -32.6                        | -69.0                        | 79.1                 | 90.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub>                               | Hydrogen                       |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          |                              | 130.7                | 28.8             |
| H <sub>2</sub> KN                            | Potassium amide                | -128.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> KO <sub>4</sub> P             | Potassium dihydrogen phosphate | -1568.3                      | -1415.9                      | 134.9                | 116.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> LiN                           | Lithium amide                  | -179.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> Mg                            | Magnesium hydride              | -75.3                        | -35.9                        | 31.1                 | 35.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> MgO <sub>2</sub>              | Magnesium hydroxide            | -924.5                       | -833.5                       | 63.2                 | 77.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> N                             | Amidogen                       |                              |                              |                      |                  |                              |                              |                      |                  | 184.9                        | 194.6                        | 195.0                | 33.9             |
| H <sub>2</sub> NNa                           | Sodium amide                   | -123.8                       | -64.0                        | 76.9                 | 66.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> NRb                           | Rubidium amide                 | -113.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | Nitramide                      | -89.5                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> NiO <sub>2</sub>              | Nickel(II) hydroxide           | -529.7                       | -447.2                       | 88.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> O                             | Water                          |                              |                              |                      |                  | -285.8                       | -237.1                       | 70.0                 | 75.3             | -241.8                       | -228.6                       | 188.8                | 33.6             |
| H <sub>2</sub> O <sub>2</sub>                | Hydrogen peroxide              |                              |                              |                      |                  | -187.8                       | -120.4                       | 109.6                | 89.1             | -136.3                       | -105.6                       | 232.7                | 43.1             |
| H <sub>2</sub> O <sub>2</sub> Sn             | Tin(II) hydroxide              | -561.1                       | -491.6                       | 155.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> O <sub>2</sub> Sr             | Strontium hydroxide            | -959.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> O <sub>2</sub> Zn             | Zinc hydroxide                 | -641.9                       | -553.5                       | 81.2                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> O <sub>3</sub> Si             | Metasilicic acid               | -1188.7                      | -1092.4                      | 134.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> O <sub>4</sub> S              | Sulfuric acid                  |                              |                              |                      |                  | -814.0                       | -690.0                       | 156.9                | 138.9            |                              |                              |                      |                  |
| H <sub>2</sub> O <sub>4</sub> Se             | Selenic acid                   | -530.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> S                             | Hydrogen sulfide               |                              |                              |                      |                  |                              |                              |                      |                  | -20.6                        | -33.4                        | 205.8                | 34.2             |
| H <sub>2</sub> S <sub>2</sub>                | Hydrogen disulfide             |                              |                              |                      |                  | -18.1                        |                              |                      | 84.1             | 15.5                         |                              |                      | 51.5             |
| H <sub>2</sub> Se                            | Hydrogen selenide              |                              |                              |                      |                  |                              |                              |                      |                  | 29.7                         | 15.9                         | 219.0                | 34.7             |
| H <sub>2</sub> Sr                            | Strontium hydride              | -180.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> Te                            | Hydrogen telluride             |                              |                              |                      |                  |                              |                              |                      |                  | 99.6                         |                              |                      |                  |
| H <sub>2</sub> Th                            | Thorium hydride                | -139.7                       | -100.0                       | 50.7                 | 36.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>2</sub> Zr                            | Zirconium(II) hydride          | -169.0                       | -128.8                       | 35.0                 | 31.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>3</sub> Si                            | Iodosilane                     |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 270.9                | 54.4             |
| H <sub>3</sub> N                             | Ammonia                        |                              |                              |                      |                  |                              |                              |                      |                  | -45.9                        | -16.4                        | 192.8                | 35.1             |
| H <sub>3</sub> NO                            | Hydroxylamine                  | -114.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>3</sub> O <sub>2</sub> P              | Phosphinic acid                | -604.6                       |                              |                      |                  | -595.4                       |                              |                      |                  |                              |                              |                      |                  |
| H <sub>3</sub> O <sub>3</sub> P              | Phosphonic acid                | -964.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>3</sub> O <sub>4</sub> P              | Phosphoric acid                | -1284.4                      | -1124.3                      | 110.5                | 106.1            | -1271.7                      | -1123.6                      | 150.8                | 145.0            |                              |                              |                      |                  |
| H <sub>3</sub> P                             | Phosphine                      |                              |                              |                      |                  |                              |                              |                      |                  | 5.4                          | 13.5                         | 210.2                | 37.1             |
| H <sub>3</sub> Sb                            | Stibine                        |                              |                              |                      |                  |                              |                              |                      |                  | 145.1                        | 147.8                        | 232.8                | 41.1             |
| H <sub>3</sub> U                             | Uranium(III) hydride           | -127.2                       | -72.8                        | 63.7                 | 49.3             |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                            | Name                        | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------|-----------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                 |                             | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| H <sub>4</sub> IN                               | Ammonium iodide             | -201.4                       | -112.5                       | 117.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>4</sub> N <sub>2</sub>                   | Hydrazine                   |                              |                              |                      |                  | 50.6                         | 149.3                        | 121.2                | 98.9             | 95.4                         | 159.4                        | 238.5                | 48.4             |
| H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>    | Ammonium nitrite            | -256.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>4</sub> N <sub>2</sub> O <sub>3</sub>    | Ammonium nitrate            | -365.6                       | -183.9                       | 151.1                | 139.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>4</sub> N <sub>4</sub>                   | Ammonium azide              | 115.5                        | 274.2                        | 112.5                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>4</sub> O <sub>4</sub> Si                | Orthosilicic acid           | -1481.1                      | -1332.9                      | 192.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>4</sub> O <sub>7</sub> P <sub>2</sub>    | Diphosphoric acid           | -2241.0                      |                              |                      |                  | -2231.7                      |                              |                      |                  |                              |                              |                      |                  |
| H <sub>4</sub> P <sub>2</sub>                   | Diphosphine                 |                              |                              |                      |                  | -5.0                         |                              |                      |                  | 20.9                         |                              |                      |                  |
| H <sub>4</sub> Si                               | Silane                      |                              |                              |                      |                  |                              |                              |                      |                  | 34.3                         | 56.9                         | 204.6                | 42.8             |
| H <sub>4</sub> Sn                               | Stannane                    |                              |                              |                      |                  |                              |                              |                      |                  | 162.8                        | 188.3                        | 227.7                | 49.0             |
| H <sub>5</sub> NO                               | Ammonium hydroxide          |                              |                              |                      |                  | -361.2                       | -254.0                       | 165.6                | 154.9            |                              |                              |                      |                  |
| H <sub>5</sub> NO <sub>3</sub> S                | Ammonium hydrogen sulfite   | -768.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>5</sub> NO <sub>4</sub> S                | Ammonium hydrogen sulfate   | -1027.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>6</sub> Si <sub>2</sub>                  | Disilane                    |                              |                              |                      |                  |                              |                              |                      |                  | 80.3                         | 127.3                        | 272.7                | 80.8             |
| H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> S  | Ammonium sulfate            | -1180.9                      | -901.7                       | 220.1                | 187.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>6</sub> Si <sub>3</sub>                  | Trisilane                   |                              |                              |                      |                  | 92.5                         |                              |                      |                  | 120.9                        |                              |                      |                  |
| H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> P  | Ammonium hydrogen phosphate | -1566.9                      |                              |                      | 188.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| H <sub>12</sub> N <sub>4</sub> O <sub>4</sub> P | Ammonium phosphate          | -1671.9                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| He                                              | Helium                      |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          |                              | 126.2                | 20.8             |
| Hf                                              | Hafnium                     | 0.0                          |                              | 43.6                 | 25.7             |                              |                              |                      |                  | 619.2                        | 576.5                        | 186.9                | 20.8             |
| HfO <sub>2</sub>                                | Hafnium oxide               | -1144.7                      | -1088.2                      | 59.3                 | 60.3             |                              |                              |                      |                  |                              |                              |                      |                  |
| Hg                                              | Mercury                     |                              |                              |                      |                  | 0.0                          |                              | 75.9                 | 28.0             | 61.4                         | 31.8                         | 175.0                | 20.8             |
| HgI <sub>2</sub>                                | Mercury(II) iodide          | -105.4                       | -101.7                       | 180.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HgO                                             | Mercury(II) oxide           | -90.8                        | -58.5                        | 70.3                 | 44.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| HgO <sub>2</sub> S                              | Mercury(II) sulfate         | -707.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| HgS                                             | Mercury(II) sulfide (red)   | -58.2                        | -50.6                        | 82.4                 | 48.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| HgTe                                            | Mercury(II) telluride       | -42.0                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Hg <sub>2</sub>                                 | Dimercury                   |                              |                              |                      |                  |                              |                              |                      |                  | 108.8                        | 68.2                         | 288.1                | 37.4             |
| Hg <sub>2</sub> I <sub>2</sub>                  | Mercury(I) iodide           | -121.3                       | -111.0                       | 233.5                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Hg <sub>2</sub> O <sub>4</sub> S                | Mercury(I) sulfate          | -743.1                       | -625.8                       | 200.7                | 132.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| Ho                                              | Holmium                     | 0.0                          |                              | 75.3                 | 27.2             |                              |                              |                      |                  | 300.8                        | 264.8                        | 195.6                | 20.8             |
| Ho <sub>2</sub> O <sub>3</sub>                  | Holmium oxide               | -1880.7                      | -1791.1                      | 158.2                | 115.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| I                                               | Iodine (atomic)             |                              |                              |                      |                  |                              |                              |                      |                  | 106.8                        | 70.2                         | 180.8                | 20.8             |
| IN                                              | Indium(I) iodide            | -116.3                       | -120.5                       | 130.0                |                  |                              |                              |                      |                  | 7.5                          | -37.7                        | 267.3                | 36.8             |
| IK                                              | Potassium iodide            | -327.9                       | -324.9                       | 106.3                | 52.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| IKO <sub>3</sub>                                | Potassium iodate            | -501.4                       | -418.4                       | 151.5                | 106.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| IKO <sub>4</sub>                                | Potassium periodate         | -467.2                       | -361.4                       | 175.7                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| ILi                                             | Lithium iodide              | -270.4                       | -270.3                       | 86.8                 | 51.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| INa                                             | Sodium iodide               | -287.8                       | -286.1                       | 98.5                 | 52.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| INaO <sub>3</sub>                               | Sodium iodate               | -481.8                       |                              |                      | 92.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| INaO <sub>4</sub>                               | Sodium periodate            | -429.3                       | -323.0                       | 163.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| IO                                              | Iodine monoxide             |                              |                              |                      |                  |                              |                              |                      |                  | 126.0                        | 102.5                        | 239.6                | 32.9             |
| IRb                                             | Rubidium iodide             | -333.8                       | -328.9                       | 118.4                | 53.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| ITl                                             | Thallium(I) iodide          | -123.8                       | -125.4                       | 127.6                |                  |                              |                              |                      |                  | 7.1                          |                              |                      |                  |
| I <sub>2</sub>                                  | Iodine (rhombic)            | 0.0                          |                              | 116.1                | 54.4             |                              |                              |                      |                  | 62.4                         | 19.3                         | 260.7                | 36.9             |
| I <sub>2</sub> Mg                               | Magnesium iodide            | -364.0                       | -358.2                       | 129.7                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>2</sub> Ni                               | Nickel(II) iodide           | -78.2                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>2</sub> Pb                               | Lead(II) iodide             | -175.5                       | -173.6                       | 174.9                | 77.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>2</sub> Sn                               | Tin(II) iodide              | -143.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>2</sub> Sr                               | Strontium iodide            | -558.1                       |                              |                      | 81.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>2</sub> Zn                               | Zinc iodide                 | -208.0                       | -209.0                       | 161.1                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>3</sub> In                               | Indium(III) iodide          | -238.0                       |                              |                      |                  |                              |                              |                      |                  | -120.5                       |                              |                      |                  |
| I <sub>3</sub> La                               | Lanthanum iodide            | -668.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>3</sub> Lu                               | Lutetium iodide             | -548.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>3</sub> P                                | Phosphorus(III) iodide      | -45.6                        |                              |                      |                  |                              |                              |                      |                  |                              |                              | 374.4                | 78.4             |
| I <sub>3</sub> Ru                               | Ruthenium(III) iodide       | -65.7                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>3</sub> Sb                               | Antimony(III) iodide        | -100.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>4</sub> Pt                               | Platinum(IV) iodide         | -72.8                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>4</sub> Si                               | Tetraiodosilane             | -189.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| I <sub>4</sub> Sn                               | Tin(IV) iodide              |                              |                              |                      | 84.9             |                              |                              |                      |                  |                              |                              | 446.1                | 105.4            |
| I <sub>4</sub> Ti                               | Titanium(IV) iodide         | -375.7                       | -371.5                       | 249.4                | 125.7            |                              |                              |                      |                  | -277.8                       |                              |                      |                  |
| I <sub>4</sub> V                                | Vanadium(IV) iodide         |                              |                              |                      |                  |                              |                              |                      |                  | -122.6                       |                              |                      |                  |
| I <sub>4</sub> Zr                               | Zirconium(IV) iodide        | -481.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| In                                              | Indium                      | 0.0                          |                              | 57.8                 | 26.7             |                              |                              |                      |                  | 243.3                        | 208.7                        | 173.8                | 20.8             |
| InO                                             | Indium monoxide             |                              |                              |                      |                  |                              |                              |                      |                  | 387.0                        | 364.4                        | 236.5                | 32.6             |
| InP                                             | Indium phosphide            | -88.7                        | -77.0                        | 59.8                 | 45.4             |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula              | Name                                   | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-----------------------------------|----------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                   |                                        | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| InS                               | Indium(II) sulfide                     | -138.1                       | -131.8                       | 67.0                 |                  |                              |                              |                      |                  | 238.0                        |                              |                      |                  |
| InSb                              | Indium antimonide                      | -30.5                        | -25.5                        | 86.2                 | 49.5             |                              |                              |                      |                  | 344.3                        |                              |                      |                  |
| In <sub>2</sub>                   | Diindium                               |                              |                              |                      |                  |                              |                              |                      |                  | 380.9                        |                              |                      |                  |
| In <sub>2</sub> O <sub>3</sub>    | Indium(III) oxide                      | -925.8                       | -830.7                       | 104.2                | 92.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| In <sub>2</sub> S <sub>3</sub>    | Indium(III) sulfide                    | -427.0                       | -412.5                       | 163.6                | 118.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| In <sub>2</sub> Te <sub>5</sub>   | Indium(IV) telluride                   | -175.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ir                                | Iridium                                | 0.0                          |                              | 35.5                 | 25.1             |                              |                              |                      |                  | 665.3                        | 617.9                        | 193.6                | 20.8             |
| IrO <sub>2</sub>                  | Iridium(IV) oxide                      | -274.1                       |                              |                      | 57.3             |                              |                              |                      |                  |                              |                              |                      |                  |
| IrS <sub>2</sub>                  | Iridium(IV) sulfide                    | -138.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ir <sub>2</sub> S <sub>3</sub>    | Iridium(III) sulfide                   | -234.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| K                                 | Potassium                              | 0.0                          |                              | 64.7                 | 29.6             |                              |                              |                      |                  | 89.0                         | 60.5                         | 160.3                | 20.8             |
| KMnO <sub>4</sub>                 | Potassium permanganate                 | -837.2                       | -737.6                       | 171.7                | 117.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| KNO <sub>2</sub>                  | Potassium nitrite                      | -369.8                       | -306.6                       | 152.1                | 107.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| KNO <sub>3</sub>                  | Potassium nitrate                      | -494.6                       | -394.9                       | 133.1                | 96.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| KNa                               | Potassium sodium                       |                              |                              |                      |                  | 6.3                          |                              |                      |                  |                              |                              |                      |                  |
| KO <sub>2</sub>                   | Potassium superoxide                   | -284.9                       | -239.4                       | 116.7                | 77.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| K <sub>2</sub>                    | Dipotassium                            |                              |                              |                      |                  |                              |                              |                      |                  | 123.7                        | 87.5                         | 249.7                | 37.9             |
| K <sub>2</sub> O                  | Potassium oxide                        | -361.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| K <sub>2</sub> O <sub>2</sub>     | Potassium peroxide                     | -494.1                       | -425.1                       | 102.1                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| K <sub>2</sub> O <sub>4</sub> S   | Potassium sulfate                      | -1437.8                      | -1321.4                      | 175.6                | 131.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| K <sub>2</sub> S                  | Potassium sulfide                      | -380.7                       | -364.0                       | 105.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| K <sub>3</sub> O <sub>4</sub> P   | Potassium phosphate                    | -1950.2                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Kr                                | Krypton                                |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          |                              | 164.1                | 20.8             |
| La                                | Lanthanum                              | 0.0                          |                              | 56.9                 | 27.1             |                              |                              |                      |                  | 431.0                        | 393.6                        | 182.4                | 22.8             |
| LaS                               | Lanthanum monosulfide                  | -456.0                       | -451.5                       | 73.2                 | 59.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| La <sub>2</sub> O <sub>3</sub>    | Lanthanum oxide                        | -1793.7                      | -1705.8                      | 127.3                | 108.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| Li                                | Lithium                                | 0.0                          |                              | 29.1                 | 24.8             |                              |                              |                      |                  | 159.3                        | 126.6                        | 138.8                | 20.8             |
| LiNO <sub>2</sub>                 | Lithium nitrite                        | -372.4                       | -302.0                       | 96.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| LiNO <sub>3</sub>                 | Lithium nitrate                        | -483.1                       | -381.1                       | 90.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Li <sub>2</sub>                   | Dilithium                              |                              |                              |                      |                  |                              |                              |                      |                  | 215.9                        | 174.4                        | 197.0                | 36.1             |
| Li <sub>2</sub> O                 | Lithium oxide                          | -597.9                       | -561.2                       | 37.6                 | 54.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| Li <sub>2</sub> O <sub>2</sub>    | Lithium peroxide                       | -634.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Li <sub>2</sub> O <sub>3</sub> Si | Lithium metasilicate                   | -1648.1                      | -1557.2                      | 79.8                 | 99.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| Li <sub>2</sub> O <sub>4</sub> S  | Lithium sulfate                        | -1436.5                      | -1321.7                      | 115.1                | 117.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| Li <sub>2</sub> S                 | Lithium sulfide                        | -441.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Li <sub>3</sub> O <sub>4</sub> P  | Lithium phosphate                      | -2095.8                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Lr                                | Lawrencium                             | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Lu                                | Lutetium                               | 0.0                          |                              | 51.0                 | 26.9             |                              |                              |                      |                  | 427.6                        | 387.8                        | 184.8                | 20.9             |
| Lu <sub>2</sub> O <sub>3</sub>    | Lutetium oxide                         | -1878.2                      | -1789.0                      | 110.0                | 101.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| Md                                | Mendelevium                            | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Mg                                | Magnesium                              | 0.0                          |                              | 32.7                 | 24.9             |                              |                              |                      |                  | 147.1                        | 112.5                        | 148.6                | 20.8             |
| MgN <sub>2</sub> O <sub>6</sub>   | Magnesium nitrate                      | -790.7                       | -589.4                       | 164.0                | 141.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| MgO                               | Magnesium oxide                        | -601.6                       | -569.3                       | 27.0                 | 37.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| MgO <sub>4</sub> S                | Magnesium sulfate                      | -1284.9                      | -1170.6                      | 91.6                 | 96.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| MgO <sub>4</sub> Se               | Magnesium selenate                     | -968.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| MgS                               | Magnesium sulfide                      | -346.0                       | -341.8                       | 50.3                 | 45.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| Mg <sub>2</sub>                   | Dimagnesium                            |                              |                              |                      |                  |                              |                              |                      |                  | 287.7                        |                              |                      |                  |
| Mg <sub>2</sub> O <sub>4</sub> Si | Magnesium orthosilicate                | -2174.0                      | -2055.1                      | 95.1                 | 118.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| Mn                                | Manganese                              | 0.0                          |                              | 32.0                 | 26.3             |                              |                              |                      |                  | 280.7                        | 238.5                        | 173.7                | 20.8             |
| MnN <sub>2</sub> O <sub>6</sub>   | Manganese(II) nitrate                  | -576.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| MnNaO <sub>4</sub>                | Sodium permanganate                    | -1156.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| MnO                               | Manganese(II) oxide                    | -385.2                       | -362.9                       | 59.7                 | 45.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| MnO <sub>2</sub>                  | Manganese(IV) oxide                    | -520.0                       | -465.1                       | 53.1                 | 54.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| MnO <sub>2</sub> Si               | Manganese(II) metasilicate             | -1320.9                      | -1240.5                      | 89.1                 | 86.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| MnS                               | Manganese(II) sulfide ( $\alpha$ form) | -214.2                       | -218.4                       | 78.2                 | 50.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| MnSe                              | Manganese(II) selenide                 | -106.7                       | -111.7                       | 90.8                 | 51.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| Mn <sub>2</sub> O <sub>3</sub>    | Manganese(III) oxide                   | -959.0                       | -881.1                       | 110.5                | 107.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| Mn <sub>2</sub> O <sub>4</sub> Si | Manganese(II) orthosilicate            | -1730.5                      | -1632.1                      | 163.2                | 129.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| Mn <sub>3</sub> O <sub>4</sub>    | Manganese(II,III) oxide                | -1387.8                      | -1283.2                      | 155.6                | 139.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| Mo                                | Molybdenum                             | 0.0                          |                              | 28.7                 | 24.1             |                              |                              |                      |                  | 658.1                        | 612.5                        | 182.0                | 20.8             |
| MoNa <sub>2</sub> O <sub>4</sub>  | Sodium molybdate                       | -1468.1                      | -1354.3                      | 159.7                | 141.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| MoO <sub>2</sub>                  | Molybdenum(IV) oxide                   | -588.9                       | -533.0                       | 46.3                 | 56.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| MoO <sub>3</sub>                  | Molybdenum(VI) oxide                   | -745.1                       | -668.0                       | 77.7                 | 75.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| MoO <sub>4</sub> Pb               | Lead(II) molybdate                     | -1051.9                      | -951.4                       | 166.1                | 119.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| MoS <sub>2</sub>                  | Molybdenum(IV) sulfide                 | -235.1                       | -225.9                       | 62.6                 | 63.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| Mo <sub>3</sub> Si                | Molybdenum silicide                    | -125.2                       | -125.7                       | 106.3                | 93.1             |                              |                              |                      |                  |                              |                              |                      |                  |



| Molecular<br>formula              | Name                                | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-----------------------------------|-------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                   |                                     | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| O <sub>2</sub> S                  | Sulfur dioxide                      |                              |                              |                      |                  | -320.5                       |                              |                      |                  | -296.8                       | -300.1                       | 248.2                | 39.9             |
| O <sub>2</sub> Se                 | Selenium dioxide                    | -225.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>2</sub> Si                 | Silicon dioxide ( $\alpha$ -quartz) | -910.7                       | -856.3                       | 41.5                 | 44.4             |                              |                              |                      |                  | -322.0                       |                              |                      |                  |
| O <sub>2</sub> Sn                 | Tin(IV) oxide                       | -577.6                       | -515.8                       | 49.0                 | 52.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>2</sub> Te                 | Tellurium dioxide                   | -322.6                       | -270.3                       | 79.5                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>2</sub> Th                 | Thorium(IV) oxide                   | -1226.4                      | -1169.2                      | 65.2                 | 61.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>2</sub> Ti                 | Titanium(IV) oxide                  | -944.0                       | -888.8                       | 50.6                 | 55.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>2</sub> U                  | Uranium(IV) oxide                   | -1085.0                      | -1031.8                      | 77.0                 | 63.6             |                              |                              |                      |                  | -465.7                       | -471.5                       | 274.6                | 51.4             |
| O <sub>2</sub> W                  | Tungsten(IV) oxide                  | -589.7                       | -533.9                       | 50.5                 | 56.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>2</sub> Zr                 | Zirconium(IV) oxide                 | -1100.6                      | -1042.8                      | 50.4                 | 56.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub>                    | Ozone                               |                              |                              |                      |                  |                              |                              |                      |                  | 142.7                        | 163.2                        | 238.9                | 39.2             |
| O <sub>3</sub> PbS                | Lead(II) sulfite                    | -669.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> PbSi               | Lead(II) metasilicate               | -1145.7                      | -1062.1                      | 109.6                | 90.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> Pr <sub>2</sub>    | Praseodymium oxide                  | -1809.6                      |                              |                      | 117.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> Rh <sub>2</sub>    | Rhodium(III) oxide                  | -343.0                       |                              |                      | 103.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> S                  | Sulfur trioxide                     | -454.5                       | -374.2                       | 70.7                 |                  | -441.0                       | -373.8                       | 113.8                |                  | -395.7                       | -371.1                       | 256.8                | 50.7             |
| O <sub>3</sub> Sc <sub>2</sub>    | Scandium oxide                      | -1908.8                      | -1819.4                      | 77.0                 | 94.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> SiSr               | Strontium metasilicate              | -1633.9                      | -1549.7                      | 96.7                 | 88.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> Sm <sub>2</sub>    | Samarium(III) oxide                 | -1823.0                      | -1734.6                      | 151.0                | 114.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> Tb <sub>2</sub>    | Terbium oxide                       | -1865.2                      |                              |                      | 115.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> Ti <sub>2</sub>    | Titanium(III) oxide                 | -1520.9                      | -1434.2                      | 78.8                 | 97.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> Tm <sub>2</sub>    | Thulium oxide                       | -1888.7                      | -1794.5                      | 139.7                | 116.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> U                  | Uranium(VI) oxide                   | -1223.8                      | -1145.7                      | 96.1                 | 81.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> V <sub>2</sub>     | Vanadium(III) oxide                 | -1218.8                      | -1139.3                      | 98.3                 | 103.2            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> W                  | Tungsten(VI) oxide                  | -842.9                       | -764.0                       | 75.9                 | 73.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> Y <sub>2</sub>     | Yttrium oxide                       | -1905.3                      | -1816.6                      | 99.1                 | 102.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>3</sub> Yb <sub>2</sub>    | Ytterbium(III) oxide                | -1814.6                      | -1726.7                      | 133.1                | 115.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> Os                 | Osmium(VIII) oxide                  | -394.1                       | -304.9                       | 143.9                |                  |                              |                              |                      |                  | -337.2                       | -292.8                       | 293.8                | 74.1             |
| O <sub>4</sub> PbS                | Lead(II) sulfate                    | -920.0                       | -813.0                       | 148.5                | 103.2            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> PbSe               | Lead(II) selenate                   | -609.2                       | -504.9                       | 167.8                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> Pb <sub>2</sub> Si | Lead(II) orthosilicate              | -1363.1                      | -1252.6                      | 186.6                | 137.2            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> Pb <sub>3</sub>    | Lead(II,II,IV) oxide                | -718.4                       | -601.2                       | 211.3                | 146.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> RaS                | Radium sulfate                      | -1471.1                      | -1365.6                      | 138.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> Rb <sub>2</sub> S  | Rubidium sulfate                    | -1435.6                      | -1316.9                      | 197.4                | 134.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> Ru                 | Ruthenium(VIII) oxide               | -239.3                       | -152.2                       | 146.4                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> SSr                | Strontium sulfate                   | -1453.1                      | -1340.9                      | 117.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> STl <sub>2</sub>   | Thallium(I) sulfate                 | -931.8                       | -830.4                       | 230.5                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> SZn                | Zinc sulfate                        | -982.8                       | -871.5                       | 110.5                | 99.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> SiSr <sub>2</sub>  | Strontium orthosilicate             | -2304.5                      | -2191.1                      | 153.1                | 134.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> SiZn <sub>2</sub>  | Zinc orthosilicate                  | -1636.7                      | -1523.2                      | 131.4                | 123.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> SiZr               | Zirconium(IV) orthosilicate         | -2033.4                      | -1919.1                      | 84.1                 | 98.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>4</sub> TiZr               | Zirconium titanate                  | -2024.1                      | -1915.8                      | 116.7                | 114.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>5</sub> Sb <sub>2</sub>    | Antimony(V) oxide                   | -971.9                       | -829.2                       | 125.1                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>5</sub> Ta <sub>2</sub>    | Tantalum(V) oxide                   | -2046.0                      | -1911.2                      | 143.1                | 135.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>5</sub> Ti <sub>3</sub>    | Titanium(III,IV) oxide              | -2459.4                      | -2317.4                      | 129.3                | 154.8            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>5</sub> V <sub>2</sub>     | Vanadium(V) oxide                   | -1550.6                      | -1419.5                      | 131.0                | 127.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>5</sub> V <sub>3</sub>     | Vanadium(III,IV) oxide              | -1933.0                      | -1803.0                      | 163.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>7</sub> Re <sub>2</sub>    | Rhenium(VII) oxide                  | -1240.1                      | -1066.0                      | 207.1                | 166.1            |                              |                              |                      |                  | -1100.0                      | -994.0                       | 452.0                |                  |
| O <sub>7</sub> U <sub>3</sub>     | Uranium(IV,V) oxide                 | -3427.1                      | -3242.9                      | 250.5                | 215.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>8</sub> S <sub>2</sub> Zr  | Zirconium(IV) sulfate               | -2217.1                      |                              |                      | 172.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>8</sub> U <sub>3</sub>     | Uranium(V,V) oxide                  | -3574.8                      | -3369.5                      | 282.6                | 238.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| O <sub>9</sub> U <sub>4</sub>     | Uranium(IV,V) oxide                 | -4510.4                      | -4275.1                      | 334.1                | 293.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| Os                                | Osmium                              | 0.0                          |                              | 32.6                 | 24.7             |                              |                              |                      |                  | 791.0                        | 745.0                        | 192.6                | 20.8             |
| P                                 | Phosphorus (white)                  | 0.0                          |                              | 41.1                 | 23.8             |                              |                              |                      |                  | 316.5                        | 280.1                        | 163.2                | 20.8             |
| P                                 | Phosphorus (red)                    | -17.6                        |                              | 22.8                 | 21.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| P                                 | Phosphorus (black)                  | -39.3                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| P <sub>2</sub>                    | Diphosphorus                        |                              |                              |                      |                  |                              |                              |                      |                  | 144.0                        | 103.5                        | 218.1                | 32.1             |
| P <sub>4</sub>                    | Tetraphosphorus                     |                              |                              |                      |                  |                              |                              |                      |                  | 58.9                         | 24.4                         | 280.0                | 67.2             |
| Pa                                | Protactinium                        | 0.0                          |                              | 51.9                 |                  |                              |                              |                      |                  | 607.0                        | 563.0                        | 198.1                | 22.9             |
| Pb                                | Lead                                | 0.0                          |                              | 64.8                 | 26.4             |                              |                              |                      |                  | 195.2                        | 162.2                        | 175.4                | 20.8             |
| PbS                               | Lead(II) sulfide                    | -100.4                       | -98.7                        | 91.2                 | 49.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| PbSe                              | Lead(II) selenide                   | -102.9                       | -101.7                       | 102.5                | 50.2             |                              |                              |                      |                  |                              |                              |                      |                  |
| PbTe                              | Lead(II) telluride                  | -70.7                        | -69.5                        | 110.0                | 50.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| Pd                                | Palladium                           | 0.0                          |                              | 37.6                 | 26.0             |                              |                              |                      |                  | 378.2                        | 339.7                        | 167.1                | 20.8             |
| PdS                               | Palladium(II) sulfide               | -75.0                        | -67.0                        | 46.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Pm                                | Promethium                          | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              | 187.1                | 24.3             |



| Molecular<br>formula                 | Name                       | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|--------------------------------------|----------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                      |                            | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| Po                                   | Polonium                   | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Pr                                   | Praseodymium               | 0.0                          |                              | 73.2                 | 27.2             |                              |                              |                      |                  | 355.6                        | 320.9                        | 189.8                | 21.4             |
| Pt                                   | Platinum                   | 0.0                          |                              | 41.6                 | 25.9             |                              |                              |                      |                  | 565.3                        | 520.5                        | 192.4                | 25.5             |
| PtS                                  | Platinum(II) sulfide       | -81.6                        | -76.1                        | 55.1                 | 43.4             |                              |                              |                      |                  |                              |                              |                      |                  |
| PtS <sub>2</sub>                     | Platinum(IV) sulfide       | -108.8                       | -99.6                        | 74.7                 | 65.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| Pu                                   | Plutonium                  | 0.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Ra                                   | Radium                     | 0.0                          |                              | 71.0                 |                  |                              |                              |                      |                  | 159.0                        | 130.0                        | 176.5                | 20.8             |
| Rb                                   | Rubidium                   | 0.0                          |                              | 76.8                 | 31.1             |                              |                              |                      |                  | 80.9                         | 53.1                         | 170.1                | 20.8             |
| Re                                   | Rhenium                    | 0.0                          |                              | 36.9                 | 25.5             |                              |                              |                      |                  | 769.9                        | 724.6                        | 188.9                | 20.8             |
| Rh                                   | Rhodium                    | 0.0                          |                              | 31.5                 | 25.0             |                              |                              |                      |                  | 556.9                        | 510.8                        | 185.8                | 21.0             |
| Rn                                   | Radon                      |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          |                              | 176.2                | 20.8             |
| Ru                                   | Ruthenium                  | 0.0                          |                              | 28.5                 | 24.1             |                              |                              |                      |                  | 642.7                        | 595.8                        | 186.5                | 21.5             |
| S                                    | Sulfur (rhombic)           | 0.0                          |                              | 32.1                 | 22.6             |                              |                              |                      |                  | 277.2                        | 236.7                        | 167.8                | 23.7             |
| S                                    | Sulfur (monoclinic)        | 0.3                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| SSi                                  | Silicon monosulfide        |                              |                              |                      |                  |                              |                              |                      |                  | 112.5                        | 60.9                         | 223.7                | 32.3             |
| SSn                                  | Tin(II) sulfide            | -100.0                       | -98.3                        | 77.0                 | 49.3             |                              |                              |                      |                  |                              |                              |                      |                  |
| SSr                                  | Strontium sulfide          | -472.4                       | -467.8                       | 68.2                 | 48.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| STl <sub>2</sub>                     | Thallium(I) sulfide        | -97.1                        | -93.7                        | 151.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| SZn                                  | Zinc sulfide (wurtzite)    | -192.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| SZn                                  | Zinc sulfide (sphalerite)  | -206.0                       | -201.3                       | 57.7                 | 46.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| S <sub>2</sub>                       | Disulfur                   |                              |                              |                      |                  |                              |                              |                      |                  | 128.6                        | 79.7                         | 228.2                | 32.5             |
| Sb                                   | Antimony                   | 0.0                          |                              | 45.7                 | 25.2             |                              |                              |                      |                  | 262.3                        | 222.1                        | 180.3                | 20.8             |
| Sb <sub>2</sub>                      | Diantimony                 |                              |                              |                      |                  |                              |                              |                      |                  | 235.6                        | 187.0                        | 254.9                | 36.4             |
| Sc                                   | Scandium                   | 0.0                          |                              | 34.6                 | 25.5             |                              |                              |                      |                  | 377.8                        | 336.0                        | 174.8                | 22.1             |
| Se                                   | Selenium (gray)            | 0.0                          |                              | 42.4                 | 25.4             |                              |                              |                      |                  | 227.1                        | 187.0                        | 176.7                | 20.8             |
| Se                                   | Selenium ( $\alpha$ form)  | 6.7                          |                              |                      |                  |                              |                              |                      |                  | 227.1                        |                              |                      |                  |
| Se                                   | Selenium (vitreous)        | 5.0                          |                              |                      |                  |                              |                              |                      |                  | 227.1                        |                              |                      |                  |
| SeSr                                 | Strontium selenide         | -385.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| SeTl <sub>2</sub>                    | Thallium(I) selenide       | -59.0                        | -59.0                        | 172.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| SeZn                                 | Zinc selenide              | -163.0                       | -163.0                       | 84.0                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| Se <sub>2</sub>                      | Diselenium                 |                              |                              |                      |                  |                              |                              |                      |                  | 146.0                        | 96.2                         | 252.0                | 35.4             |
| Si                                   | Silicon                    | 0.0                          |                              | 18.8                 | 20.0             |                              |                              |                      |                  | 450.0                        | 405.5                        | 168.0                | 22.3             |
| Si <sub>2</sub>                      | Disilicon                  |                              |                              |                      |                  |                              |                              |                      |                  | 594.0                        | 536.0                        | 229.9                | 34.4             |
| Sm                                   | Samarium                   | 0.0                          |                              | 69.6                 | 29.5             |                              |                              |                      |                  | 206.7                        | 172.8                        | 183.0                | 30.4             |
| Sn                                   | Tin (white)                | 0.0                          |                              | 51.2                 | 27.0             |                              |                              |                      |                  | 301.2                        | 266.2                        | 168.5                | 21.3             |
| Sn                                   | Tin (gray)                 | -2.1                         | 0.1                          | 44.1                 | 25.8             |                              |                              |                      |                  |                              |                              |                      |                  |
| Sr                                   | Strontium                  | 0.0                          |                              | 55.0                 | 26.8             |                              |                              |                      |                  | 164.4                        | 130.9                        | 164.6                | 20.8             |
| Ta                                   | Tantalum                   | 0.0                          |                              | 41.5                 | 25.4             |                              |                              |                      |                  | 782.0                        | 739.3                        | 185.2                | 20.9             |
| Tb                                   | Terbium                    | 0.0                          |                              | 73.2                 | 28.9             |                              |                              |                      |                  | 388.7                        | 349.7                        | 203.6                | 24.6             |
| Tc                                   | Technetium                 | 0.0                          |                              |                      |                  |                              |                              |                      |                  | 678.0                        |                              | 181.1                | 20.8             |
| Te                                   | Tellurium                  | 0.0                          |                              | 49.7                 | 25.7             |                              |                              |                      |                  | 196.7                        | 157.1                        | 182.7                | 20.8             |
| Te <sub>2</sub>                      | Ditellurium                |                              |                              |                      |                  |                              |                              |                      |                  | 168.2                        | 118.0                        | 268.1                | 36.7             |
| Th                                   | Thorium                    | 0.0                          |                              | 51.8                 | 27.3             |                              |                              |                      |                  | 602.0                        | 560.7                        | 190.2                | 20.8             |
| Ti                                   | Titanium                   | 0.0                          |                              | 30.7                 | 25.0             |                              |                              |                      |                  | 473.0                        | 428.4                        | 180.3                | 24.4             |
| Tl                                   | Thallium                   | 0.0                          |                              | 64.2                 | 26.3             |                              |                              |                      |                  | 182.2                        | 147.4                        | 181.0                | 20.8             |
| Tm                                   | Thulium                    | 0.0                          |                              | 74.0                 | 27.0             |                              |                              |                      |                  | 232.2                        | 197.5                        | 190.1                | 20.8             |
| U                                    | Uranium                    | 0.0                          |                              | 50.2                 | 27.7             |                              |                              |                      |                  | 533.0                        | 488.4                        | 199.8                | 23.7             |
| V                                    | Vanadium                   | 0.0                          |                              | 28.9                 | 24.9             |                              |                              |                      |                  | 514.2                        | 754.4                        | 182.3                | 26.0             |
| W                                    | Tungsten                   | 0.0                          |                              | 32.6                 | 24.3             |                              |                              |                      |                  | 849.4                        | 807.1                        | 174.0                | 21.3             |
| Xe                                   | Xenon                      |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          |                              | 169.7                | 20.8             |
| Y                                    | Yttrium                    | 0.0                          |                              | 44.4                 | 26.5             |                              |                              |                      |                  | 421.3                        | 381.1                        | 179.5                | 25.9             |
| Yb                                   | Ytterbium                  | 0.0                          |                              | 59.9                 | 26.7             |                              |                              |                      |                  | 152.3                        | 118.4                        | 173.1                | 20.8             |
| Zn                                   | Zinc                       | 0.0                          |                              | 41.6                 | 25.4             |                              |                              |                      |                  | 130.4                        | 94.8                         | 161.0                | 20.8             |
| Zr                                   | Zirconium                  | 0.0                          |                              | 39.0                 | 25.4             |                              |                              |                      |                  | 608.8                        | 566.5                        | 181.4                | 26.7             |
| <b>Substances containing carbon:</b> |                            |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C                                    | Carbon (graphite)          | 0.0                          |                              | 5.7                  | 8.5              |                              |                              |                      |                  | 716.7                        | 671.3                        | 158.1                | 20.8             |
| C                                    | Carbon (diamond)           | 1.9                          | 2.9                          | 2.4                  | 6.1              |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>Ag</sub> N                    | Silver(I) cyanide          | 146.0                        | 156.9                        | 107.2                | 66.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| CAg <sub>2</sub> O <sub>3</sub>      | Silver(I) carbonate        | -505.8                       | -436.8                       | 167.4                | 112.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| CBaO <sub>3</sub>                    | Barium carbonate           | -1213.0                      | -1134.4                      | 112.1                | 86.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| CBeO <sub>3</sub>                    | Beryllium carbonate        | -1025.0                      |                              | 52.0                 | 65.0             |                              |                              |                      |                  |                              |                              |                      |                  |
| CBrClF <sub>2</sub>                  | Bromochlorodifluoromethane |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 318.5                | 74.6             |
| CBrCl <sub>2</sub> F                 | Bromodichlorofluoromethane |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 330.6                | 80.0             |
| CBrCl <sub>3</sub>                   | Bromotrichloromethane      |                              |                              |                      |                  |                              |                              |                      |                  | -41.1                        |                              |                      | 85.3             |
| CBrF <sub>3</sub>                    | Bromotrifluoromethane      |                              |                              |                      |                  |                              |                              |                      |                  | -648.3                       |                              |                      | 69.3             |

| Molecular<br>formula                          | Name                          | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-----------------------------------------------|-------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                               |                               | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| CBrN                                          | Cyanogen bromide              | 140.5                        |                              |                      |                  |                              |                              |                      |                  | 186.2                        | 165.3                        | 248.3                | 46.9             |
| CBrN <sub>3</sub> O <sub>6</sub>              | Bromotrinitromethane          |                              |                              |                      |                  | 32.5                         |                              |                      |                  | 80.3                         |                              |                      |                  |
| CBr <sub>2</sub> ClF                          | Dibromochlorofluoromethane    |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 342.8                | 82.4             |
| CBr <sub>2</sub> Cl <sub>2</sub>              | Dibromodichloromethane        |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 347.8                | 87.1             |
| CBr <sub>2</sub> F <sub>2</sub>               | Dibromodifluoromethane        |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 325.3                | 77.0             |
| CBr <sub>2</sub> O                            | Carbonyl bromide              |                              |                              |                      |                  | -127.2                       |                              |                      |                  | -96.2                        | -110.9                       | 309.1                | 61.8             |
| CBr <sub>3</sub> Cl                           | Tribromochloromethane         |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 357.8                | 89.4             |
| CBr <sub>3</sub> F                            | Tribromofluoromethane         |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 345.9                | 84.4             |
| CBr <sub>4</sub>                              | Tetrabromomethane             | 29.4                         | 47.7                         | 212.5                | 144.3            |                              |                              |                      |                  | 83.9                         | 67.0                         | 358.1                | 91.2             |
| CCaO <sub>3</sub>                             | Calcium carbonate (calcite)   | -1207.6                      | -1129.1                      | 91.7                 | 83.5             |                              |                              |                      |                  |                              |                              |                      |                  |
| CCaO <sub>3</sub>                             | Calcium carbonate (aragonite) | -1207.8                      | -1128.2                      | 88.0                 | 82.3             |                              |                              |                      |                  |                              |                              |                      |                  |
| CCdO <sub>3</sub>                             | Cadmium carbonate             | -750.6                       | -669.4                       | 92.5                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CClFO                                         | Carbonyl chloride fluoride    |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 276.7                | 52.4             |
| CClF <sub>3</sub>                             | Chlorotrifluoromethane        |                              |                              |                      |                  |                              |                              |                      |                  | -706.3                       |                              |                      | 66.9             |
| CCIN                                          | Cyanogen chloride             |                              |                              |                      |                  | 112.1                        |                              |                      |                  | 138.0                        | 131.0                        | 236.2                | 45.0             |
| CCIN <sub>3</sub> O <sub>6</sub>              | Chlorotrinitromethane         |                              |                              |                      |                  | -27.1                        |                              |                      |                  | 18.4                         |                              |                      |                  |
| CCl <sub>2</sub> F <sub>2</sub>               | Dichlorodifluoromethane       |                              |                              |                      |                  |                              |                              |                      |                  | -477.4                       | -439.4                       | 300.8                | 72.3             |
| CCl <sub>2</sub> O                            | Carbonyl chloride             |                              |                              |                      |                  |                              |                              |                      |                  | -219.1                       | -204.9                       | 283.5                | 57.7             |
| CCl <sub>3</sub>                              | Trichloromethyl               |                              |                              |                      |                  |                              |                              |                      |                  | 59.0                         |                              |                      |                  |
| CCl <sub>3</sub> F                            | Trichlorofluoromethane        |                              |                              |                      |                  | -301.3                       | -236.8                       | 225.4                | 121.6            | -268.3                       |                              |                      | 78.1             |
| CCl <sub>4</sub>                              | Tetrachloromethane            |                              |                              |                      |                  | -128.2                       |                              |                      | 130.7            | -95.7                        |                              |                      | 83.3             |
| CCoO <sub>3</sub>                             | Cobalt(II) carbonate          | -713.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CCs <sub>2</sub> O <sub>3</sub>               | Cesium carbonate              | -1139.7                      | -1054.3                      | 204.5                | 123.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| CCuN                                          | Copper(I) cyanide             | 96.2                         | 111.3                        | 84.5                 |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CFN                                           | Cyanogen fluoride             |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 224.7                | 41.8             |
| CF <sub>2</sub> O                             | Carbonyl fluoride             |                              |                              |                      |                  |                              |                              |                      |                  | -639.8                       |                              |                      | 46.8             |
| CF <sub>3</sub>                               | Trifluoromethyl               |                              |                              |                      |                  |                              |                              |                      |                  | -477.0                       | -464.0                       | 264.5                | 49.6             |
| CF <sub>3</sub> I                             | Trifluoroiodomethane          |                              |                              |                      |                  |                              |                              |                      |                  | -587.8                       |                              | 307.4                | 70.9             |
| CF <sub>4</sub>                               | Tetrafluoromethane            |                              |                              |                      |                  |                              |                              |                      |                  | -933.6                       |                              | 261.6                | 61.1             |
| CFeO <sub>3</sub>                             | Iron(II) carbonate            | -740.6                       | -666.7                       | 92.9                 | 82.1             |                              |                              |                      |                  |                              |                              |                      |                  |
| CFe <sub>3</sub>                              | Iron carbide                  | 25.1                         | 20.1                         | 104.6                | 105.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| CH                                            | Methylidyne                   |                              |                              |                      |                  |                              |                              |                      |                  | 595.8                        |                              |                      |                  |
| CHBrClF                                       | Bromochlorofluoromethane      |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 304.3                | 63.2             |
| CHBrCl <sub>2</sub>                           | Bromodichloromethane          |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 316.4                | 67.4             |
| CHBrF <sub>2</sub>                            | Bromodifluoromethane          |                              |                              |                      |                  |                              |                              |                      |                  | -424.9                       |                              | 295.1                | 58.7             |
| CHBr <sub>2</sub> Cl                          | Chlorodibromomethane          |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 327.7                | 69.2             |
| CHBr <sub>2</sub> F                           | Dibromofluoromethane          |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 316.8                | 65.1             |
| CHBr <sub>3</sub>                             | Tribromomethane               |                              |                              |                      |                  | -22.3                        | -5.0                         | 220.9                | 130.7            | 23.8                         | 8.0                          | 330.9                | 71.2             |
| CHClF <sub>2</sub>                            | Chlorodifluoromethane         |                              |                              |                      |                  |                              |                              |                      |                  | -482.6                       |                              | 280.9                | 55.9             |
| CHCl <sub>2</sub> F                           | Dichlorofluoromethane         |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 293.1                | 60.9             |
| CHCl <sub>3</sub>                             | Trichloromethane              |                              |                              |                      |                  | -134.1                       | -73.7                        | 201.7                | 114.2            | -102.7                       | 6.0                          | 295.7                | 65.7             |
| CHCsO <sub>3</sub>                            | Cesium hydrogen carbonate     | -966.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CHFO                                          | Formyl fluoride               |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 246.6                | 39.9             |
| CHF <sub>3</sub>                              | Trifluoromethane              |                              |                              |                      |                  |                              |                              |                      |                  | -695.4                       |                              | 259.7                | 51.0             |
| CHI <sub>3</sub>                              | Triiodomethane                | -181.1                       |                              |                      |                  |                              |                              |                      |                  | 251.0                        |                              | 356.2                | 75.0             |
| CHKO <sub>2</sub>                             | Potassium formate             | -679.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CHKO <sub>3</sub>                             | Potassium hydrogen carbonate  | -963.2                       | -863.5                       | 115.5                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CHN                                           | Hydrogen cyanide              |                              |                              |                      |                  | 108.9                        | 125.0                        | 112.8                | 70.6             | 135.1                        | 124.7                        | 201.8                | 35.9             |
| CHNO                                          | Isocyanic acid (HNCO)         |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 238.0                | 44.9             |
| CHNS                                          | Isothiocyanic acid            |                              |                              |                      |                  |                              |                              |                      |                  | 127.6                        | 113.0                        | 247.8                | 46.9             |
| CHN <sub>3</sub> O <sub>6</sub>               | Trinitromethane               |                              |                              |                      |                  | -32.8                        |                              |                      |                  | -13.4                        |                              | 435.6                | 134.1            |
| CHNaO <sub>2</sub>                            | Sodium formate                | -666.5                       | -599.9                       | 103.8                | 82.7             |                              |                              |                      |                  |                              |                              |                      |                  |
| CHNaO <sub>3</sub>                            | Sodium hydrogen carbonate     | -950.8                       | -851.0                       | 101.7                | 87.6             |                              |                              |                      |                  |                              |                              |                      |                  |
| CHO                                           | Oxomethyl (HCO)               |                              |                              |                      |                  |                              |                              |                      |                  | 43.1                         | 28.0                         | 224.7                | 34.6             |
| CH <sub>2</sub>                               | Methylene                     |                              |                              |                      |                  |                              |                              |                      |                  | 390.4                        | 372.9                        | 194.9                | 33.8             |
| CH <sub>2</sub> BrCl                          | Bromochloromethane            |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 287.6                | 52.7             |
| CH <sub>2</sub> BrF                           | Bromofluoromethane            |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 276.3                | 49.2             |
| CH <sub>2</sub> Br <sub>2</sub>               | Dibromomethane                |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 293.2                | 54.7             |
| CH <sub>2</sub> ClF                           | Chlorofluoromethane           |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 264.4                | 47.0             |
| CH <sub>2</sub> Cl <sub>2</sub>               | Dichloromethane               |                              |                              |                      |                  | -124.2                       |                              | 177.8                | 101.2            | -95.4                        |                              | 270.2                | 51.0             |
| CH <sub>2</sub> F <sub>2</sub>                | Difluoromethane               |                              |                              |                      |                  |                              |                              |                      |                  | -452.3                       |                              | 246.7                | 42.9             |
| CH <sub>2</sub> I <sub>2</sub>                | Diiodomethane                 |                              |                              |                      |                  | 68.5                         | 90.4                         | 174.1                | 134.0            | 119.5                        | 95.8                         | 309.7                | 57.7             |
| CH <sub>2</sub> N <sub>2</sub>                | Diazomethane                  |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 242.9                | 52.5             |
| CH <sub>2</sub> N <sub>2</sub>                | Cyanamide                     | 58.8                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| CH <sub>2</sub> N <sub>2</sub> O <sub>4</sub> | Dinitromethane                |                              |                              |                      |                  | -104.9                       |                              |                      |                  | -61.5                        |                              | 358.1                | 86.4             |
| CH <sub>2</sub> O                             | Formaldehyde                  |                              |                              |                      |                  |                              |                              |                      |                  | -108.6                       | -102.5                       | 218.8                | 35.4             |

[illegible]

| Molecular<br>formula                                          | Name                                    | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|---------------------------------------------------------------|-----------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                               |                                         | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>2</sub> ClF <sub>3</sub>                               | Chlorotrifluoroethene                   |                              |                              |                      |                  | -522.7                       |                              |                      |                  | -505.5                       | -523.8                       | 322.1                | 83.9             |
| C <sub>2</sub> ClF <sub>5</sub>                               | Chloropentafluoroethane                 |                              |                              |                      |                  |                              |                              |                      |                  | -1118.8                      |                              |                      | 184.2            |
| C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>                 | 1,2-Dichloro-1,1,2,2-tetrafluoroethane  |                              |                              |                      |                  | -960.2                       |                              |                      | 111.7            | -937.0                       |                              |                      |                  |
| C <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>                 | Oxalyl chloride                         |                              |                              |                      |                  | -367.6                       |                              |                      |                  | -335.8                       |                              |                      |                  |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>                 | 1,1,2-Trichloro-1,1,2,2-trifluoroethane |                              |                              |                      |                  | -745.0                       |                              |                      | 170.1            | -716.8                       |                              |                      |                  |
| C <sub>2</sub> Cl <sub>3</sub> N                              | Trichloroacetonitrile                   |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 336.6                | 96.1             |
| C <sub>2</sub> Cl <sub>4</sub>                                | Tetrachloroethene                       |                              |                              |                      |                  | -50.6                        | 3.0                          | 266.9                | 143.4            | -10.9                        |                              |                      |                  |
| C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>                 | 1,1,1,2-Tetrachloro-2,2-difluoroethane  |                              |                              |                      |                  |                              |                              |                      |                  | -489.9                       | -407.0                       | 382.9                | 123.4            |
| C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>                 | 1,1,2,2-Tetrachloro-1,2-difluoroethane  |                              |                              |                      |                  |                              |                              |                      | 173.6            |                              |                              |                      |                  |
| C <sub>2</sub> Cl <sub>4</sub> O                              | Trichloroacetyl chloride                |                              |                              |                      |                  | -280.8                       |                              |                      |                  | -239.8                       |                              |                      |                  |
| C <sub>2</sub> Cl <sub>6</sub>                                | Hexachloroethane                        | -202.8                       |                              | 237.3                | 198.2            |                              |                              |                      |                  | -143.6                       |                              |                      |                  |
| C <sub>2</sub> F <sub>3</sub> N                               | Trifluoroacetonitrile                   |                              |                              |                      |                  |                              |                              |                      |                  | -497.9                       |                              | 298.1                | 77.9             |
| C <sub>2</sub> F <sub>4</sub>                                 | Tetrafluoroethene                       | -820.5                       |                              |                      |                  |                              |                              |                      |                  | -658.9                       |                              | 300.1                | 80.5             |
| C <sub>2</sub> F <sub>6</sub>                                 | Hexafluoroethane                        |                              |                              |                      |                  |                              |                              |                      |                  | -1344.2                      |                              | 332.3                | 106.7            |
| C <sub>2</sub> HBr                                            | Bromoacetylene                          |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 253.7                | 55.7             |
| C <sub>2</sub> HBrClF <sub>3</sub>                            | 1-Bromo-2-chloro-1,1,2-trifluoroethane  |                              |                              |                      |                  | -675.3                       |                              |                      |                  | -644.8                       |                              |                      |                  |
| C <sub>2</sub> HBrClF <sub>3</sub>                            | 2-Bromo-2-chloro-1,1,1-trifluoroethane  |                              |                              |                      |                  | -720.0                       |                              |                      |                  | -690.4                       |                              |                      |                  |
| C <sub>2</sub> HCl                                            | Chloroacetylene                         |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 242.0                | 54.3             |
| C <sub>2</sub> HCIF <sub>2</sub>                              | 1-Chloro-2,2-difluoroethene             |                              |                              |                      |                  |                              |                              |                      |                  | -315.5                       | -289.1                       | 303.0                | 72.1             |
| C <sub>2</sub> HCl <sub>2</sub> F                             | 1,1-Dichloro-2-fluoroethene             |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 313.9                | 76.5             |
| C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>                | 2,2-Dichloro-1,1,1-trifluoroethane      |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 352.8                | 102.5            |
| C <sub>2</sub> HCl <sub>3</sub>                               | Trichloroethene                         |                              |                              |                      |                  | -43.6                        |                              | 228.4                | 124.4            | -9.0                         |                              | 324.8                | 80.3             |
| C <sub>2</sub> HCl <sub>3</sub> O                             | Trichloroacetaldehyde                   |                              |                              |                      |                  | -234.5                       |                              |                      | 151.0            | -196.6                       |                              |                      |                  |
| C <sub>2</sub> HCl <sub>3</sub> O                             | Dichloroacetyl chloride                 |                              |                              |                      |                  | -280.4                       |                              |                      |                  | -241.0                       |                              |                      |                  |
| C <sub>2</sub> HCl <sub>3</sub> O <sub>2</sub>                | Trichloroacetic acid                    | -503.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> HCl <sub>5</sub>                               | Pentachloroethane                       |                              |                              |                      |                  | -187.6                       |                              |                      | 173.8            | -142.0                       |                              |                      |                  |
| C <sub>2</sub> HF                                             | Fluoroacetylene                         |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 231.7                | 52.4             |
| C <sub>2</sub> HF <sub>3</sub>                                | Trifluoroethene                         |                              |                              |                      |                  |                              |                              |                      |                  | -490.5                       |                              |                      |                  |
| C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>                 | Trifluoroacetic acid                    |                              |                              |                      |                  | -1069.9                      |                              |                      |                  | -1031.4                      |                              |                      |                  |
| C <sub>2</sub> HF <sub>5</sub>                                | Pentafluoroethane                       |                              |                              |                      |                  |                              |                              |                      |                  | -1100.4                      |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub>                                 | Acetylene                               |                              |                              |                      |                  |                              |                              |                      |                  | 227.4                        | 209.9                        | 200.9                | 44.0             |
| C <sub>2</sub> H <sub>2</sub> BrF <sub>3</sub>                | 2-Bromo-1,1,1-trifluoroethane           |                              |                              |                      |                  |                              |                              |                      |                  | -694.5                       |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub>                 | <i>cis</i> -1,2-Dibromoethene           |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 311.3                | 68.8             |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub>                 | <i>trans</i> -1,2-Dibromoethene         |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 313.5                | 70.3             |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> Cl <sub>2</sub> | 1,2-Dibromo-1,2-dichloroethane          |                              |                              |                      |                  |                              |                              |                      |                  | -36.9                        |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> Br <sub>4</sub>                 | 1,1,2,2-Tetrabromoethane                |                              |                              |                      |                  |                              |                              |                      | 165.7            |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> ClF <sub>3</sub>                | 2-Chloro-1,1,1-trifluoroethane          |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 326.5                | 89.1             |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | 1,1-Dichloroethene                      |                              |                              |                      |                  | -23.9                        | 24.1                         | 201.5                | 111.3            | 2.8                          | 25.4                         | 289.0                | 67.1             |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | <i>cis</i> -1,2-Dichloroethene          |                              |                              |                      |                  | -26.4                        |                              | 198.4                | 116.4            | 4.6                          |                              | 289.6                | 65.1             |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | <i>trans</i> -1,2-Dichloroethene        |                              |                              |                      |                  | -24.3                        | 27.3                         | 195.9                | 116.8            | 5.0                          | 28.6                         | 290.0                | 66.7             |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O               | Chloroacetyl chloride                   |                              |                              |                      |                  | -283.7                       |                              |                      |                  | -244.8                       |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>  | Dichloroacetic acid                     |                              |                              |                      |                  | -496.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>3</sub> NO              | 2,2,2-Trichloroacetamide                | -358.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 1,1,1,2-Tetrachloroethane               |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 356.0                | 102.7            |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 1,1,2,2-Tetrachloroethane               |                              |                              |                      |                  | -195.0                       |                              | 246.9                | 162.3            | -149.2                       |                              | 362.8                | 100.8            |
| C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>                  | 1,1-Difluoroethene                      |                              |                              |                      |                  |                              |                              |                      |                  | -335.0                       |                              | 266.2                | 60.1             |
| C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>                  | <i>cis</i> -1,2-Difluoroethene          |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 268.3                | 58.2             |
| C <sub>2</sub> H <sub>2</sub> F <sub>3</sub> I                | 1,1,1-Trifluoro-2-iodoethane            |                              |                              |                      |                  |                              |                              |                      |                  | -644.5                       |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> I <sub>2</sub>                  | <i>cis</i> -1,2-Diiodoethene            |                              |                              |                      |                  |                              |                              |                      |                  | -207.4                       |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> O                               | Ketene                                  |                              |                              |                      |                  | -67.9                        |                              |                      |                  | -47.5                        | -48.3                        | 247.6                | 51.8             |
| C <sub>2</sub> H <sub>2</sub> O <sub>2</sub>                  | Glyoxal                                 |                              |                              |                      |                  |                              |                              |                      |                  | -212.0                       | -189.7                       | 272.5                | 60.6             |
| C <sub>2</sub> H <sub>2</sub> O <sub>4</sub>                  | Oxalic acid                             | -829.9                       |                              | 109.8                | 91.0             |                              |                              |                      |                  | -731.8                       | -662.7                       | 320.6                | 86.2             |
| C <sub>2</sub> H <sub>2</sub> O <sub>4</sub> Sr               | Strontium formate                       | -1393.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>2</sub> S                               | Thiirene                                |                              |                              |                      |                  |                              |                              |                      |                  | 300.0                        | 275.8                        | 255.3                | 54.7             |
| C <sub>2</sub> H <sub>3</sub> Br                              | Bromoethene                             |                              |                              |                      |                  |                              |                              |                      |                  | 79.2                         | 81.8                         | 275.8                | 55.5             |
| C <sub>2</sub> H <sub>3</sub> BrO                             | Acetyl bromide                          |                              |                              |                      |                  | -223.5                       |                              |                      |                  | -190.4                       |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> BrO <sub>2</sub>                | Bromoacetic acid                        |                              |                              |                      |                  |                              |                              |                      |                  | -383.5                       | -338.3                       | 337.0                | 80.5             |
| C <sub>2</sub> H <sub>3</sub> Cl                              | Chloroethene                            | -94.1                        |                              |                      | 59.4             | 14.6                         |                              |                      |                  | 37.2                         | 53.6                         | 264.0                | 53.7             |
| C <sub>2</sub> H <sub>3</sub> ClF <sub>2</sub>                | 1-Chloro-1,1-difluoroethane             |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 307.2                | 82.5             |
| C <sub>2</sub> H <sub>3</sub> ClO                             | Acetyl chloride                         |                              |                              |                      |                  | -272.9                       | -208.0                       | 200.8                | 117.0            | -242.8                       | -205.8                       | 295.1                | 67.8             |
| C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>                | Chloroacetic acid                       | -509.7                       |                              |                      |                  |                              |                              |                      |                  | -427.6                       | -368.5                       | 325.9                | 78.8             |

| Molecular<br>formula                                        | Name                              | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------------------|-----------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                             |                                   | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> F             | 1,1-Dichloro-1-fluoroethane       |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 320.2                | 88.7             |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>               | 1,1,1-Trichloroethane             |                              |                              |                      |                  | -177.4                       |                              | 227.4                | 144.3            | -144.4                       |                              | 323.1                | 93.3             |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>               | 1,1,2-Trichloroethane             |                              |                              |                      |                  | -190.8                       |                              | 232.6                | 150.9            | -151.3                       |                              | 337.2                | 89.0             |
| C <sub>2</sub> H <sub>3</sub> F                             | Fluoroethene                      |                              |                              |                      |                  |                              |                              |                      |                  | -138.8                       |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> FO                            | Acetyl fluoride                   |                              |                              |                      |                  | -467.2                       |                              |                      |                  | -442.1                       |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>                | 1,1,1-Trifluoroethane             |                              |                              |                      |                  |                              |                              |                      |                  | -744.6                       |                              | 279.9                | 78.2             |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>                | 1,1,2-Trifluoroethane             |                              |                              |                      |                  |                              |                              |                      |                  | -730.7                       |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O              | 2,2,2-Trifluoroethanol            |                              |                              |                      |                  | -932.4                       |                              |                      |                  | -888.4                       |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> I                             | Iodoethene                        |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 285.0                | 57.9             |
| C <sub>2</sub> H <sub>3</sub> IO                            | Acetyl iodide                     |                              |                              |                      |                  | -163.5                       |                              |                      |                  | -126.4                       |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> KO <sub>2</sub>               | Potassium acetate                 | -723.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> N                             | Acetonitrile                      |                              |                              |                      |                  | 40.6                         | 86.5                         | 149.6                | 91.5             | 74.0                         | 91.9                         | 243.4                | 52.2             |
| C <sub>2</sub> H <sub>3</sub> N                             | Isocyanomethane                   |                              |                              |                      |                  | 130.8                        | 159.5                        | 159.0                |                  | 163.5                        | 165.7                        | 246.9                | 52.9             |
| C <sub>2</sub> H <sub>3</sub> NO                            | Methyl isocyanate                 |                              |                              |                      |                  | -92.0                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> NO <sub>2</sub>               | Nitroethene                       |                              |                              |                      |                  |                              |                              |                      |                  | 33.3                         |                              | 300.5                | 73.7             |
| C <sub>2</sub> H <sub>3</sub> NO <sub>3</sub>               | Oxamic acid                       | -661.2                       |                              |                      |                  |                              |                              |                      |                  | -552.3                       |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> NS                            | Methyl isothiocyanate             | 79.4                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>3</sub> NaO <sub>2</sub>              | Sodium acetate                    | -708.8                       | -607.2                       | 123.0                | 79.9             |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub>                               | Ethylene                          |                              |                              |                      |                  |                              |                              |                      |                  | 52.4                         | 68.4                         | 219.3                | 42.9             |
| C <sub>2</sub> H <sub>4</sub> BrCl                          | 1-Bromo-2-chloroethane            |                              |                              |                      |                  |                              |                              |                      | 130.1            |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>               | 1,1-Dibromoethane                 |                              |                              |                      |                  | -66.2                        |                              |                      |                  |                              |                              | 327.7                | 80.8             |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>               | 1,2-Dibromoethane                 |                              |                              |                      |                  | -79.2                        |                              | 223.3                | 136.0            | -37.5                        |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> ClF                           | 1-Chloro-1-fluoroethane           |                              |                              |                      |                  |                              |                              |                      |                  | -313.4                       |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>               | 1,1-Dichloroethane                |                              |                              |                      |                  | -158.4                       | -73.8                        | 211.8                | 126.3            | -127.7                       | -70.8                        | 305.1                | 76.2             |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>               | 1,2-Dichloroethane                |                              |                              |                      |                  | -166.8                       |                              |                      | 128.4            | -126.4                       |                              | 308.4                | 78.7             |
| C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>                | 1,1-Difluoroethane                |                              |                              |                      |                  |                              |                              |                      |                  | -497.0                       |                              | 282.5                | 67.8             |
| C <sub>2</sub> H <sub>4</sub> I <sub>2</sub>                | 1,2-Diiodoethane                  | 9.3                          |                              |                      |                  |                              |                              |                      |                  | 75.0                         |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> | Oxamide                           | -504.4                       |                              |                      |                  |                              |                              |                      |                  | -387.1                       |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> | Ethanedial dioxime                | -90.5                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub> | 1,1-Dinitroethane                 |                              |                              |                      |                  | -148.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub> | 1,2-Dinitroethane                 |                              |                              |                      |                  | -165.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> S <sub>2</sub> | Ethanedithioamide                 | -20.8                        |                              |                      |                  |                              |                              |                      |                  | 83.0                         |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> N <sub>4</sub>                | 1 <i>H</i> -1,2,4-Triazol-3-amine | 76.8                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> O                             | Acetaldehyde                      |                              |                              |                      |                  | -192.2                       | -127.6                       | 160.2                | 89.0             | -166.2                       | -133.0                       | 263.8                | 55.3             |
| C <sub>2</sub> H <sub>4</sub> O                             | Oxirane                           |                              |                              |                      |                  | -78.0                        | -11.8                        | 153.9                | 88.0             | -52.6                        | -13.0                        | 242.5                | 47.9             |
| C <sub>2</sub> H <sub>4</sub> OS                            | Thioacetic acid                   |                              |                              |                      |                  | -216.9                       |                              |                      |                  | -175.1                       |                              |                      |                  |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                | Acetic acid                       |                              |                              |                      |                  | -484.3                       | -389.9                       | 159.8                | 123.3            | -432.2                       | -374.2                       | 283.5                | 63.4             |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                | Methyl formate                    |                              |                              |                      |                  | -386.1                       |                              |                      | 119.1            | -357.4                       |                              | 285.3                | 64.4             |
| C <sub>2</sub> H <sub>4</sub> O <sub>3</sub>                | Peroxyacetic acid                 |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      | 82.4             |
| C <sub>2</sub> H <sub>4</sub> O <sub>3</sub>                | Glycolic acid                     |                              |                              |                      |                  |                              |                              |                      |                  | -583.0                       | -504.9                       | 318.6                | 87.1             |
| C <sub>2</sub> H <sub>4</sub> S                             | Thiirane                          |                              |                              |                      |                  | 51.6                         |                              |                      |                  | 82.0                         | 96.8                         | 255.2                | 53.3             |
| C <sub>2</sub> H <sub>4</sub> Si                            | Ethynylsilane                     |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 269.4                | 72.6             |
| C <sub>2</sub> H <sub>5</sub> Br                            | Bromoethane                       |                              |                              |                      |                  | -90.5                        | -25.8                        | 198.7                | 100.8            | -61.9                        | -23.9                        | 286.7                | 64.5             |
| C <sub>2</sub> H <sub>5</sub> Cl                            | Chloroethane                      |                              |                              |                      |                  | -136.8                       | -59.3                        | 190.8                | 104.3            | -112.1                       | -60.4                        | 276.0                | 62.8             |
| C <sub>2</sub> H <sub>5</sub> ClO                           | 2-Chloroethanol                   |                              |                              |                      |                  | -295.4                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>5</sub> F                             | Fluoroethane                      |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 264.5                | 58.6             |
| C <sub>2</sub> H <sub>5</sub> I                             | Iodoethane                        |                              |                              |                      |                  | -40.0                        | 14.7                         | 211.7                | 115.1            | -8.1                         | 19.2                         | 306.0                | 66.9             |
| C <sub>2</sub> H <sub>5</sub> N                             | Ethyleneimine                     |                              |                              |                      |                  | 91.9                         |                              |                      |                  | 126.5                        |                              |                      |                  |
| C <sub>2</sub> H <sub>5</sub> NO                            | Acetamide                         | -317.0                       |                              | 115.0                | 91.3             |                              |                              |                      |                  | -238.3                       |                              |                      |                  |
| C <sub>2</sub> H <sub>5</sub> NO                            | <i>N</i> -Methylformamide         |                              |                              |                      |                  |                              |                              |                      | 123.8            |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>               | Nitroethane                       |                              |                              |                      |                  | -143.9                       |                              |                      | 134.4            | -103.8                       |                              | 320.5                | 79.0             |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>               | Glycine                           | -528.5                       |                              |                      |                  |                              |                              |                      |                  | -392.1                       |                              |                      |                  |
| C <sub>2</sub> H <sub>5</sub> NO <sub>3</sub>               | 2-Nitroethanol                    |                              |                              |                      |                  | -350.7                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>5</sub> NO <sub>3</sub>               | Ethyl nitrate                     |                              |                              |                      |                  | -190.4                       |                              |                      |                  | -154.1                       |                              |                      |                  |
| C <sub>2</sub> H <sub>5</sub> NS                            | Thioacetamide                     | -71.7                        |                              |                      |                  |                              |                              |                      |                  | 11.4                         |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub>                               | Ethane                            |                              |                              |                      |                  |                              |                              |                      |                  | -84.0                        | -32.0                        | 229.2                | 52.5             |
| C <sub>2</sub> H <sub>6</sub> Cd                            | Dimethyl cadmium                  |                              |                              |                      |                  | 63.6                         | 139.0                        | 201.9                | 132.0            | 101.6                        | 146.9                        | 303.0                |                  |
| C <sub>2</sub> H <sub>6</sub> Hg                            | Dimethyl mercury                  |                              |                              |                      |                  | 59.8                         | 140.3                        | 209.0                |                  | 94.4                         | 146.1                        | 306.0                | 83.3             |
| C <sub>2</sub> H <sub>6</sub> N <sub>2</sub> O              | <i>N</i> -Methylurea              | -332.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub> N <sub>4</sub> O <sub>2</sub> | 1,2-Hydrazinedicarboxamide        | -498.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub> N <sub>4</sub> O <sub>2</sub> | Oxalyl dihydrazide                | -295.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub> O                             | Ethanol                           |                              |                              |                      |                  | -277.6                       | -174.8                       | 160.7                | 112.3            | -234.8                       | -167.9                       | 281.6                | 65.6             |
| C <sub>2</sub> H <sub>6</sub> O                             | Dimethyl ether                    |                              |                              |                      |                  | -203.3                       |                              |                      |                  | -184.1                       | -112.6                       | 266.4                | 64.4             |
| C <sub>2</sub> H <sub>6</sub> OS                            | Dimethyl sulfoxide                |                              |                              |                      |                  | -204.2                       | -99.9                        | 188.3                | 153.0            | -151.3                       |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>                | Ethylene glycol                   |                              |                              |                      |                  | -460.0                       |                              | 163.2                | 148.6            | -392.2                       |                              | 303.8                | 82.7             |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub> S              | Dimethyl sulfone                  | -450.1                       | -302.4                       | 142.0                |                  |                              |                              |                      |                  | -373.1                       | -272.7                       | 310.6                | 100.0            |

| Molecular<br>formula                                        | Name                           | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------------------|--------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                             |                                | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>2</sub> H <sub>6</sub> O <sub>3</sub> S              | Dimethyl sulfite               |                              |                              |                      |                  | -523.6                       |                              |                      |                  | -483.4                       |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub> O <sub>4</sub> S              | Dimethyl sulfate               |                              |                              |                      |                  | -735.5                       |                              |                      |                  | -687.0                       |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub> S                             | Ethanethiol                    |                              |                              |                      |                  | -73.6                        | -5.5                         | 207.0                | 117.9            | -46.1                        | -4.8                         | 296.2                | 72.7             |
| C <sub>2</sub> H <sub>6</sub> S                             | Dimethyl sulfide               |                              |                              |                      |                  | -65.3                        |                              | 196.4                | 118.1            | -37.4                        |                              | 286.0                | 74.1             |
| C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>                | 1,2-Ethanedithiol              |                              |                              |                      |                  | -54.3                        |                              |                      |                  | -9.7                         |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>                | Dimethyl disulfide             |                              |                              |                      |                  | -62.6                        |                              | 235.4                | 146.1            | -24.7                        |                              |                      |                  |
| C <sub>2</sub> H <sub>6</sub> Zn                            | Dimethyl zinc                  |                              |                              |                      |                  | 23.4                         |                              | 201.6                | 129.2            | 53.0                         |                              |                      |                  |
| C <sub>2</sub> H <sub>7</sub> N                             | Ethylamine                     |                              |                              |                      |                  | -74.1                        |                              |                      | 130.0            | -47.5                        | 36.3                         | 283.8                | 71.5             |
| C <sub>2</sub> H <sub>7</sub> N                             | Dimethylamine                  |                              |                              |                      |                  | -43.9                        | 70.0                         | 182.3                | 137.7            | -18.8                        | 68.5                         | 273.1                | 70.7             |
| C <sub>2</sub> H <sub>7</sub> NO                            | Ethanolamine                   |                              |                              |                      |                  |                              |                              |                      | 195.5            |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>9</sub> ClN                           | Dimethylamine hydrochloride    | -289.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                | 1,2-Ethanediamine              |                              |                              |                      |                  | -63.0                        |                              |                      | 172.6            | -18.0                        |                              |                      |                  |
| C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                | 1,1-Dimethylhydrazine          |                              |                              |                      |                  | 48.9                         | 206.4                        | 198.0                | 164.1            | 84.1                         |                              |                      |                  |
| C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                | 1,2-Dimethylhydrazine          |                              |                              |                      |                  | 52.7                         |                              |                      |                  | 92.2                         |                              |                      |                  |
| C <sub>2</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub> | Ammonium oxalate               | -1123.0                      |                              |                      | 226.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> HgO <sub>4</sub>                             | Mercury(II) oxalate            | -678.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> I <sub>2</sub>                               | Diiodoacetylene                |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 313.1                | 70.3             |
| C <sub>2</sub> I <sub>4</sub>                               | Tetraiodoethene                | 305.0                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> K <sub>2</sub> O <sub>4</sub>                | Potassium oxalate              | -1346.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> MgO <sub>4</sub>                             | Magnesium oxalate              | -1269.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> N <sub>2</sub>                               | Cyanogen                       |                              |                              |                      |                  | 285.9                        |                              |                      |                  | 306.7                        |                              | 241.9                | 56.8             |
| C <sub>2</sub> N <sub>4</sub> O <sub>6</sub>                | Trinitroacetone                |                              |                              |                      |                  | 183.7                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>2</sub> Na <sub>2</sub> O <sub>4</sub>               | Sodium oxalate                 |                              |                              |                      |                  |                              |                              |                      |                  | -1318.0                      |                              |                      |                  |
| C <sub>2</sub> O <sub>3</sub> Pb                            | Lead(II) oxalate               | -851.4                       | -750.1                       | 146.0                | 105.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> F <sub>8</sub>                               | Perfluoropropane               |                              |                              |                      |                  |                              |                              |                      |                  | -1783.2                      |                              |                      |                  |
| C <sub>3</sub> H <sub>2</sub> N <sub>2</sub>                | Malononitrile                  | 186.4                        |                              |                      |                  |                              |                              |                      |                  | 265.5                        |                              |                      |                  |
| C <sub>3</sub> H <sub>2</sub> O <sub>2</sub>                | 2-Propynoic acid               |                              |                              |                      |                  | -193.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>2</sub> O <sub>3</sub>                | 1,3-Dioxol-2-one               |                              |                              |                      |                  | -459.9                       |                              |                      |                  | -418.6                       |                              |                      |                  |
| C <sub>3</sub> H <sub>3</sub> Cl <sub>3</sub>               | 1,2,3-Trichloropropene         |                              |                              |                      |                  | -101.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>3</sub> F <sub>3</sub>                | 3,3,3-Trifluoropropene         |                              |                              |                      |                  |                              |                              |                      |                  | -614.2                       |                              |                      |                  |
| C <sub>3</sub> H <sub>3</sub> N                             | Acrylonitrile                  |                              |                              |                      |                  | 147.1                        |                              |                      |                  | 180.6                        |                              |                      |                  |
| C <sub>3</sub> H <sub>3</sub> NO                            | Oxazole                        |                              |                              |                      |                  | -48.0                        |                              |                      |                  | -15.5                        |                              |                      |                  |
| C <sub>3</sub> H <sub>3</sub> NO                            | Isoxazole                      |                              |                              |                      |                  | 42.1                         |                              |                      |                  | 78.6                         |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub>                               | Allene                         |                              |                              |                      |                  |                              |                              |                      |                  | 190.5                        |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub>                               | Propyne                        |                              |                              |                      |                  |                              |                              |                      |                  | 184.9                        |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub>                               | Cyclopropene                   |                              |                              |                      |                  |                              |                              |                      |                  | 277.1                        |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>               | 2,3-Dichloropropene            |                              |                              |                      |                  | -73.3                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> Cl <sub>4</sub>               | 1,1,1,3-Tetrachloropropene     |                              |                              |                      |                  | -208.7                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> Cl <sub>4</sub>               | 1,2,2,3-Tetrachloropropene     |                              |                              |                      |                  | -251.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> F <sub>7</sub> O              | 2,2,3,3-Tetrafluoro-1-propanol |                              |                              |                      |                  | -1114.9                      |                              |                      |                  | -1061.3                      |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>                | 1 <i>H</i> -Pyrazole           | 105.4                        |                              |                      | 81.0             |                              |                              |                      |                  | 179.4                        |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>                | Imidazole                      | 49.8                         |                              |                      |                  |                              |                              |                      |                  | 132.9                        |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> O                             | Acrolein                       |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      | 71.3             |
| C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                | 1,2-Propanedione               |                              |                              |                      |                  | -309.1                       |                              |                      |                  | -271.0                       |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                | Acrylic acid                   |                              |                              |                      |                  | -383.8                       |                              |                      | 145.7            |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                | 2-Oxetanone                    |                              |                              |                      |                  | -329.9                       |                              | 175.3                | 122.1            | -282.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>4</sub> O <sub>3</sub>                | Ethylene carbonate             |                              |                              |                      |                  | -682.8                       |                              |                      | 133.9            | -508.4                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> Br                            | <i>cis</i> -1-Bromopropene     |                              |                              |                      |                  | 7.9                          |                              |                      |                  | 40.8                         |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> Br                            | 3-Bromopropene                 |                              |                              |                      |                  | 12.2                         |                              |                      |                  | 45.2                         |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> BrO                           | Bromoacetone                   |                              |                              |                      |                  |                              |                              |                      |                  | -181.0                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> Cl                            | 2-Chloropropene                |                              |                              |                      |                  |                              |                              |                      |                  | -21.0                        |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> Cl                            | 3-Chloropropene                |                              |                              |                      |                  |                              |                              |                      | 125.1            |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> ClO                           | Epichlorohydrin                |                              |                              |                      |                  | -148.4                       |                              |                      | 131.6            | -107.8                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>              | 2-Chloropropanoic acid         |                              |                              |                      |                  | -522.5                       |                              |                      |                  | -475.8                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>              | 3-Chloropropanoic acid         | -549.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>              | Ethyl chloroformate            |                              |                              |                      |                  | -505.3                       |                              |                      |                  | -462.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>              | Methyl chloroacetate           |                              |                              |                      |                  | -487.0                       |                              |                      |                  | -444.0                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>               | 1,2,3-Trichloropropane         |                              |                              |                      |                  | -230.6                       |                              |                      | 183.6            | -182.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> I                             | 3-Iodopropene                  |                              |                              |                      |                  | 53.7                         |                              |                      |                  | 91.5                         |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> IO                            | Iodoacetone                    |                              |                              |                      |                  |                              |                              |                      |                  | -130.5                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> IO <sub>2</sub>               | 3-Iodopropanoic acid           | -460.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> N                             | Propanenitrile                 |                              |                              |                      |                  | 15.5                         |                              |                      | 119.3            | 51.7                         |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> N                             | 2-Propyn-1-amine               |                              |                              |                      |                  | 205.7                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> N                             | Ethyl isocyanide               |                              |                              |                      |                  | 108.6                        |                              |                      |                  | 141.7                        |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> NO                            | Acrylamide                     | -212.1                       |                              |                      | 110.6            | -224.0                       |                              |                      |                  | -130.2                       |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> NO <sub>3</sub>               | Nitroacetone                   |                              |                              |                      |                  | -278.6                       |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                                        | Name                                    | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------------------|-----------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                             |                                         | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>3</sub> H <sub>5</sub> NO <sub>4</sub>               | Methyl nitroacetate                     |                              |                              |                      |                  | -464.0                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>5</sub> N <sub>3</sub> O <sub>9</sub> | Trinitroglycerol                        |                              |                              |                      |                  | -370.9                       |                              |                      |                  | -279.1                       |                              | 545.9                | 234.2            |
| C <sub>3</sub> H <sub>6</sub>                               | Propene                                 |                              |                              |                      |                  | 4.0                          |                              |                      |                  | 20.0                         |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub>                               | Cyclopropane                            |                              |                              |                      |                  | 35.2                         |                              |                      |                  | 53.3                         | 104.5                        | 237.5                | 55.6             |
| C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>               | 1,2-Dibromopropane                      |                              |                              |                      |                  | -113.6                       |                              |                      |                  | -71.6                        |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>               | 1,2-Dichloropropane, (±)                |                              |                              |                      |                  | -198.8                       |                              |                      | 149.1            | -162.8                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>               | 1,3-Dichloropropane                     |                              |                              |                      |                  | -199.9                       |                              |                      |                  | -159.2                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>               | 2,2-Dichloropropane                     |                              |                              |                      |                  | -205.8                       |                              |                      |                  | -173.2                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub> O             | 2,3-Dichloro-1-propanol                 |                              |                              |                      |                  | -381.5                       |                              |                      |                  | -316.3                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub> O             | 1,3-Dichloro-2-propanol                 |                              |                              |                      |                  | -385.3                       |                              |                      |                  | -318.4                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> I <sub>2</sub>                | 1,2-Diiodopropane                       |                              |                              |                      |                  |                              |                              |                      |                  | 35.6                         |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> I <sub>2</sub>                | 1,3-Diiodopropane                       |                              |                              |                      |                  | -9.0                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | Propanediamide                          | -546.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | <i>N</i> -(Aminocarbonyl)acetamide      | -544.2                       |                              |                      |                  |                              |                              |                      |                  | -441.2                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> | 1,1-Dinitropropane                      |                              |                              |                      |                  | -163.2                       |                              |                      |                  | -100.7                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> | 1,3-Dinitropropane                      |                              |                              |                      |                  | -207.1                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> | 2,2-Dinitropropane                      |                              |                              |                      |                  | -181.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> N <sub>6</sub> O <sub>6</sub> | Hexahydro-1,3,5-trinitro-1,3,5-triazine |                              |                              |                      |                  |                              |                              |                      |                  | 192.0                        |                              | 482.4                | 230.2            |
| C <sub>3</sub> H <sub>6</sub> O                             | Allyl alcohol                           |                              |                              |                      |                  | -171.8                       |                              |                      | 138.9            | -124.5                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> O                             | Propanal                                |                              |                              |                      |                  | -215.6                       |                              |                      |                  | -185.6                       |                              | 304.5                | 80.7             |
| C <sub>3</sub> H <sub>6</sub> O                             | Acetone                                 |                              |                              |                      |                  | -248.4                       |                              | 199.8                | 126.3            | -217.1                       | -152.7                       | 295.3                | 74.5             |
| C <sub>3</sub> H <sub>6</sub> O                             | Methyloxirane                           |                              |                              |                      |                  | -123.0                       |                              | 196.5                | 120.4            | -94.7                        |                              | 286.9                | 72.6             |
| C <sub>3</sub> H <sub>6</sub> O                             | Oxetane                                 |                              |                              |                      |                  | -110.8                       |                              |                      |                  | -80.5                        |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | Propanoic acid                          |                              |                              |                      |                  | -510.7                       |                              | 191.0                | 152.8            | -455.7                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | Ethyl formate                           |                              |                              |                      |                  |                              |                              |                      | 149.3            |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | Methyl acetate                          |                              |                              |                      |                  | -445.9                       |                              |                      | 141.9            | -413.3                       |                              | 324.4                | 86.0             |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | 1,3-Dioxolane                           |                              |                              |                      |                  | -333.5                       |                              |                      | 118.0            | -298.0                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> S              | Thiolactic acid                         |                              |                              |                      |                  | -468.4                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                | 1,3,5-Trioxane                          | -522.5                       |                              | 133.0                | 111.4            |                              |                              |                      |                  | -465.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> S                             | Thietane                                |                              |                              |                      |                  | 24.7                         |                              | 184.9                |                  | 60.6                         | 107.1                        | 285.0                | 68.3             |
| C <sub>3</sub> H <sub>6</sub> S                             | Methylthiirane                          |                              |                              |                      |                  | 11.3                         |                              |                      |                  | 45.8                         |                              |                      |                  |
| C <sub>3</sub> H <sub>6</sub> S <sub>2</sub>                | 1,2-Dithiolane                          |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          | 47.7                         | 313.5                | 86.5             |
| C <sub>3</sub> H <sub>6</sub> S <sub>2</sub>                | 1,3-Dithiolane                          |                              |                              |                      |                  |                              |                              |                      |                  | 10.0                         | 54.7                         | 323.3                | 84.7             |
| C <sub>3</sub> H <sub>6</sub> S <sub>3</sub>                | 1,3,5-Trithiane                         |                              |                              |                      |                  |                              |                              |                      |                  | 80.0                         | 130.4                        | 336.4                | 111.3            |
| C <sub>3</sub> H <sub>7</sub> Br                            | 1-Bromopropane                          |                              |                              |                      |                  | -121.9                       |                              |                      |                  | -87.0                        |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> Br                            | 2-Bromopropane                          |                              |                              |                      |                  | -130.5                       |                              |                      |                  | -99.4                        |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> Cl                            | 1-Chloropropane                         |                              |                              |                      |                  | -160.5                       |                              |                      |                  | -131.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> Cl                            | 2-Chloropropane                         |                              |                              |                      |                  | -172.3                       |                              |                      |                  | -144.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> ClO <sub>2</sub>              | 3-Chloro-1,2-propanediol                |                              |                              |                      |                  | -525.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> ClO <sub>2</sub>              | 2-Chloro-1,3-propanediol                |                              |                              |                      |                  | -517.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> F                             | 1-Fluoropropane                         |                              |                              |                      |                  |                              |                              |                      |                  | -285.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> F                             | 2-Fluoropropane                         |                              |                              |                      |                  |                              |                              |                      |                  | -293.5                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> I                             | 1-Iodopropane                           |                              |                              |                      |                  | -66.0                        |                              |                      |                  | -30.0                        |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> I                             | 2-Iodopropane                           |                              |                              |                      |                  | -74.8                        |                              |                      |                  | -40.3                        |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> N                             | Allylamine                              |                              |                              |                      |                  | -10.0                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> N                             | Cyclopropylamine                        |                              |                              |                      |                  | 45.8                         |                              | 187.7                | 147.1            | 77.0                         |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO                            | <i>N,N</i> -Dimethylformamide           |                              |                              |                      |                  | -239.3                       |                              |                      | 150.6            | -192.4                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO                            | Propanamide                             | -338.2                       |                              |                      |                  |                              |                              |                      |                  | -259.0                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | 1-Nitropropane                          |                              |                              |                      |                  | -167.2                       |                              |                      |                  | -124.3                       |                              | 350.0                | 104.1            |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | 2-Nitropropane                          |                              |                              |                      |                  | -180.3                       |                              |                      | 170.3            | -138.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | Ethyl carbamate                         | -517.1                       |                              |                      | 156.4            | -497.3                       |                              |                      |                  | -446.3                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | <i>DL</i> -Alanine                      | -563.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | <i>D</i> -Alanine                       | -561.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | <i>L</i> -Alanine                       | -604.0                       |                              |                      |                  |                              |                              |                      |                  | -465.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | β-Alanine                               | -558.0                       |                              |                      |                  |                              |                              |                      |                  | -424.0                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | Sarcosine                               | -513.3                       |                              |                      |                  |                              |                              |                      |                  | -367.3                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub> S             | <i>L</i> -Cysteine                      | -534.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>               | Propyl nitrate                          |                              |                              |                      |                  | -214.5                       |                              |                      |                  | -174.1                       |                              | 362.6                | 123.2            |
| C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>               | Isopropyl nitrate                       |                              |                              |                      |                  | -229.7                       |                              |                      |                  | -191.0                       |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>               | <i>DL</i> -Serine                       | -739.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>               | <i>L</i> -Serine                        | -732.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub>                               | Propane                                 |                              |                              |                      |                  | -120.9                       |                              |                      |                  | -103.8                       | -23.4                        | 270.3                | 73.6             |
| C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O              | <i>N</i> -Ethylurea                     | -357.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O              | <i>N,N</i> -Dimethylurea                | -319.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O              | <i>N,N</i> -Dimethylurea                | -312.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                                        | Name                             | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------------------|----------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                             |                                  | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> | Oxymethurea                      | -717.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> O                             | 1-Propanol                       |                              |                              |                      |                  | -302.6                       |                              | 193.6                | 143.9            | -255.1                       |                              | 322.6                | 85.6             |
| C <sub>3</sub> H <sub>8</sub> O                             | 2-Propanol                       |                              |                              |                      |                  | -318.1                       |                              | 181.1                | 156.5            | -272.6                       |                              | 309.2                | 89.3             |
| C <sub>3</sub> H <sub>8</sub> O                             | Ethyl methyl ether               |                              |                              |                      |                  |                              |                              |                      |                  | -216.4                       |                              | 309.2                | 93.3             |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                | 1,2-Propylene glycol             |                              |                              |                      |                  | -501.0                       |                              |                      | 190.8            | -429.8                       |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                | 1,3-Propylene glycol             |                              |                              |                      |                  | -480.8                       |                              |                      |                  | -408.0                       |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                | Ethylene glycol monomethyl ether |                              |                              |                      |                  |                              |                              |                      | 171.1            |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                | Dimethoxymethane                 |                              |                              |                      |                  | -377.8                       |                              | 244.0                | 162.0            | -348.5                       |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>                | Glycerol                         |                              |                              |                      |                  | -669.6                       |                              | 206.3                | 218.9            | -577.9                       |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> S                             | 1-Propanethiol                   |                              |                              |                      |                  | -99.9                        |                              | 242.5                | 144.6            | -67.8                        |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> S                             | 2-Propanethiol                   |                              |                              |                      |                  | -105.9                       |                              | 233.5                | 145.3            | -76.2                        |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> S                             | Ethyl methyl sulfide             |                              |                              |                      |                  | -91.6                        |                              | 239.1                | 144.6            | -59.6                        |                              |                      |                  |
| C <sub>3</sub> H <sub>8</sub> S <sub>2</sub>                | 1,3-Propanedithiol               |                              |                              |                      |                  | -79.4                        |                              |                      |                  | -29.8                        |                              |                      |                  |
| C <sub>3</sub> H <sub>9</sub> Al                            | Trimethyl aluminum               |                              |                              |                      |                  | -136.4                       | -9.9                         | 209.4                | 155.6            | -74.1                        |                              |                      |                  |
| C <sub>3</sub> H <sub>9</sub> B                             | Trimethylborane                  |                              |                              |                      |                  | -143.1                       | -32.1                        | 238.9                |                  | -124.3                       | -35.9                        | 314.7                | 88.5             |
| C <sub>3</sub> H <sub>9</sub> BO <sub>3</sub>               | Trimethyl borate                 |                              |                              |                      |                  |                              |                              |                      | 189.9            |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>9</sub> ClSi                          | Trimethylchlorosilane            |                              |                              |                      |                  | -382.8                       | -246.4                       | 278.2                |                  | -352.8                       | -243.5                       | 369.1                |                  |
| C <sub>3</sub> H <sub>9</sub> N                             | Propylamine                      |                              |                              |                      |                  | -101.5                       |                              |                      | 164.1            | -70.1                        | 39.9                         | 325.4                | 91.2             |
| C <sub>3</sub> H <sub>9</sub> N                             | Isopropylamine                   |                              |                              |                      |                  | -112.3                       |                              | 218.3                | 163.8            | -83.7                        | 32.2                         | 312.2                | 97.5             |
| C <sub>3</sub> H <sub>9</sub> N                             | Trimethylamine                   |                              |                              |                      |                  | -45.7                        |                              | 208.5                | 137.9            | -23.6                        |                              | 287.1                | 91.8             |
| C <sub>3</sub> H <sub>10</sub> ClN                          | Propylamine hydrochloride        | -354.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>10</sub> ClN                          | Trimethylamine hydrochloride     | -282.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>               | 1,2-Propanediamine, (±)          |                              |                              |                      |                  | -97.8                        |                              |                      |                  | -53.6                        |                              |                      |                  |
| C <sub>3</sub> H <sub>10</sub> Si                           | Trimethylsilane                  |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | 331.0                | 117.9            |
| C <sub>3</sub> H <sub>12</sub> BN                           | Trimethylamine borane            | -142.5                       | 70.7                         | 187.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>3</sub> H <sub>12</sub> BN                           | Aminetrimethylboron              | -284.1                       | -79.3                        | 218.0                |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> Cl <sub>6</sub>                              | Hexachloro-1,3-butadiene         |                              |                              |                      |                  | -24.5                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> F <sub>8</sub>                               | Perfluorocyclobutane             |                              |                              |                      |                  |                              |                              |                      |                  | -1542.6                      |                              |                      |                  |
| C <sub>4</sub> F <sub>10</sub>                              | Perfluorobutane                  |                              |                              |                      |                  |                              |                              |                      | 127.2            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>2</sub> N <sub>2</sub>                | <i>trans</i> -2-Butenedinitrile  | 268.2                        |                              |                      |                  |                              |                              |                      |                  | 340.2                        |                              |                      |                  |
| C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>                | Maleic anhydride                 | -469.8                       |                              |                      |                  |                              |                              |                      |                  | -398.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>2</sub> O <sub>4</sub>                | 2-Butyenedioic acid              | -577.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>3</sub> NO <sub>3</sub>               | 2-Nitrofuran                     | -104.1                       |                              |                      |                  |                              |                              |                      |                  | -28.8                        |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> BrNO <sub>2</sub>             | <i>N</i> -Bromosuccinimide       | -335.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> ClNO <sub>2</sub>             | <i>N</i> -Chlorosuccinimide      | -357.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                | Succinonitrile                   | 139.7                        |                              | 191.6                | 145.6            |                              |                              |                      |                  | 209.7                        |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                | Pyrazine                         | 139.8                        |                              |                      |                  |                              |                              |                      |                  | 196.1                        |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                | Pyrimidine                       |                              |                              |                      |                  | 145.9                        |                              |                      |                  | 195.7                        |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                | Pyridazine                       |                              |                              |                      |                  | 224.9                        |                              |                      |                  | 278.3                        |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> | Uracil                           | -429.4                       |                              |                      | 120.5            |                              |                              |                      |                  | -302.9                       |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>3</sub> | Barbituric acid                  | -634.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> O                             | Furan                            |                              |                              |                      |                  | -62.3                        |                              | 177.0                | 114.8            | -34.8                        |                              | 267.2                | 65.4             |
| C <sub>4</sub> H <sub>4</sub> O <sub>2</sub>                | Diketene                         |                              |                              |                      |                  | -233.1                       |                              |                      |                  | -190.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> O <sub>3</sub>                | Succinic anhydride               | -608.6                       |                              |                      |                  |                              |                              |                      |                  | -527.9                       |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                | Maleic acid                      | -789.4                       |                              | 160.8                | 137.0            |                              |                              |                      |                  | -679.4                       |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                | Fumaric acid                     | -811.7                       |                              | 168.0                | 142.0            |                              |                              |                      |                  | -675.8                       |                              |                      |                  |
| C <sub>4</sub> H <sub>4</sub> S                             | Thiophene                        |                              |                              |                      |                  | 80.2                         |                              | 181.2                | 123.8            | 114.9                        | 126.1                        | 278.8                | 72.8             |
| C <sub>4</sub> H <sub>5</sub> N                             | <i>trans</i> -2-Butenenitrile    |                              |                              |                      |                  | 95.1                         |                              |                      |                  | 134.3                        |                              |                      |                  |
| C <sub>4</sub> H <sub>5</sub> N                             | 3-Butenenitrile                  |                              |                              |                      |                  | 117.8                        |                              |                      |                  | 159.7                        |                              |                      |                  |
| C <sub>4</sub> H <sub>5</sub> N                             | 2-Methylacrylonitrile            |                              |                              |                      |                  |                              |                              |                      | 126.3            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>5</sub> N                             | Pyrrole                          |                              |                              |                      |                  | 63.1                         |                              | 156.4                | 127.7            | 108.2                        |                              |                      |                  |
| C <sub>4</sub> H <sub>5</sub> N                             | Cyclopropanecarbonitrile         |                              |                              |                      |                  | 140.8                        |                              |                      |                  | 182.8                        |                              |                      |                  |
| C <sub>4</sub> H <sub>5</sub> NO <sub>2</sub>               | Succinimide                      | -459.0                       |                              |                      |                  |                              |                              |                      |                  | -375.4                       |                              |                      |                  |
| C <sub>4</sub> H <sub>5</sub> NS                            | 4-Methylthiazole                 |                              |                              |                      |                  | 67.9                         |                              |                      |                  | 111.8                        |                              |                      |                  |
| C <sub>4</sub> H <sub>5</sub> N <sub>3</sub> O              | Cytosine                         | -221.3                       |                              |                      | 132.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub>                               | 1,2-Butadiene                    |                              |                              |                      |                  | 138.6                        |                              |                      |                  | 162.3                        |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub>                               | 1,3-Butadiene                    |                              |                              |                      |                  | 88.5                         |                              | 199.0                | 123.6            | 110.0                        |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub>                               | 1-Butyne                         |                              |                              |                      |                  | 141.4                        |                              |                      |                  | 165.2                        |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub>                               | 2-Butyne                         |                              |                              |                      |                  | 119.1                        |                              |                      |                  | 145.7                        |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub>                               | Cyclobutene                      |                              |                              |                      |                  |                              |                              |                      |                  | 156.7                        |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | 2,5-Piperazinedione              | -446.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O                             | Divinyl ether                    |                              |                              |                      |                  | -39.8                        |                              |                      |                  | -13.6                        |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O                             | <i>trans</i> -2-Butenal          |                              |                              |                      |                  | -138.7                       |                              |                      |                  | -100.6                       |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                | <i>trans</i> -2-Butenoic acid    |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                | Methacrylic acid                 |                              |                              |                      |                  |                              |                              |                      | 161.1            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                | Vinyl acetate                    |                              |                              |                      |                  | -349.2                       |                              |                      |                  | -314.4                       |                              |                      |                  |



| Molecular<br>formula                                        | Name                              | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------------------|-----------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                             |                                   | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                | Methyl acrylate                   |                              |                              |                      |                  | -362.2                       |                              | 239.5                | 158.8            | -333.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                | $\gamma$ -Butyrolactone           |                              |                              |                      |                  | -420.9                       |                              |                      | 141.4            | -366.5                       |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                | Acetic anhydride                  |                              |                              |                      |                  | -624.4                       |                              |                      |                  | -572.5                       |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                | Propylene carbonate               |                              |                              |                      |                  | -613.2                       |                              |                      | 218.6            | -582.5                       |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | Succinic acid                     | -940.5                       |                              | 167.3                | 153.1            |                              |                              |                      |                  | -823.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | Dimethyl oxalate                  | -756.3                       |                              |                      |                  |                              |                              |                      |                  | -708.9                       |                              |                      |                  |
| C <sub>4</sub> H <sub>6</sub> S                             | 2,3-Dihydrothiophene              |                              |                              |                      |                  | 52.9                         |                              |                      |                  | 90.7                         | 133.5                        | 303.5                | 79.8             |
| C <sub>4</sub> H <sub>6</sub> S                             | 2,5-Dihydrothiophene              |                              |                              |                      |                  | 47.0                         |                              |                      |                  | 86.9                         | 131.6                        | 297.1                | 83.3             |
| C <sub>4</sub> H <sub>7</sub> ClO                           | 2-Chloroethyl vinyl ether         |                              |                              |                      |                  | -208.1                       |                              |                      |                  | -170.1                       |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>              | 2-Chlorobutanoic acid             |                              |                              |                      |                  | -575.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>              | 3-Chlorobutanoic acid             |                              |                              |                      |                  | -556.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>              | 4-Chlorobutanoic acid             |                              |                              |                      |                  | -566.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>              | Propyl chlorocarbonate            |                              |                              |                      |                  | -533.4                       |                              |                      |                  | -492.7                       |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> N                             | Butanenitrile                     |                              |                              |                      |                  | -5.8                         |                              |                      |                  | 33.6                         |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> N                             | 2-Methylpropanenitrile            |                              |                              |                      |                  | -13.8                        |                              |                      |                  | 23.4                         |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> NO                            | Acetone cyanohydrin               |                              |                              |                      |                  | -120.9                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> NO                            | 2-Pyrrolidone                     |                              |                              |                      |                  | -286.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> NO                            | 2-Methyl-2-oxazoline              |                              |                              |                      |                  | -169.5                       |                              |                      |                  | -130.5                       |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>               | Iminodiacetic acid                | -932.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>               | Ethyl nitroacetate                |                              |                              |                      |                  | -487.1                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>               | L-Aspartic acid                   | -973.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>7</sub> N <sub>2</sub> O              | Creatinine                        | -238.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub>                               | 1-Butene                          |                              |                              |                      |                  | -20.8                        |                              | 227.0                | 118.0            | 0.1                          |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub>                               | cis-2-Butene                      |                              |                              |                      |                  | -29.8                        |                              | 219.9                | 127.0            | -7.1                         |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub>                               | trans-2-Butene                    |                              |                              |                      |                  | -33.3                        |                              |                      |                  | -11.4                        |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub>                               | Isobutene                         |                              |                              |                      |                  | -37.5                        |                              |                      |                  | -16.9                        |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub>                               | Cyclobutane                       |                              |                              |                      |                  | 3.7                          |                              |                      |                  | 27.7                         |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub>                               | Methylcyclopropane                |                              |                              |                      |                  | 1.7                          |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>               | 1,2-Dibromobutane                 |                              |                              |                      |                  | -142.1                       |                              |                      |                  | -91.6                        |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>               | 1,3-Dibromobutane                 |                              |                              |                      |                  | -148.0                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>               | 1,4-Dibromobutane                 |                              |                              |                      |                  | -140.3                       |                              |                      |                  | -87.8                        |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>               | 2,3-Dibromobutane                 |                              |                              |                      |                  | -139.6                       |                              |                      |                  | -102.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>               | 1,2-Dibromo-2-methylpropane       |                              |                              |                      |                  | -156.6                       |                              |                      |                  | -113.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>               | 1,3-Dichlorobutane                |                              |                              |                      |                  | -237.3                       |                              |                      |                  | -195.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>               | 1,4-Dichlorobutane                |                              |                              |                      |                  | -229.8                       |                              |                      |                  | -183.4                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O             | Bis(2-chloroethyl) ether          |                              |                              |                      |                  |                              |                              |                      | 220.9            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> I <sub>2</sub>                | 1,4-Diiodobutane                  |                              |                              |                      |                  | -30.0                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> | Succinamide                       | -581.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> | Dimethylglyoxime                  | -199.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> | L-Asparagine                      | -789.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> | N-Glycylglycine                   | -747.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub> | 1,4-Dinitrobutane                 |                              |                              |                      |                  | -237.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> N <sub>6</sub> O <sub>8</sub> | Cyclotetramethylenetetranitramine |                              |                              |                      |                  |                              |                              |                      |                  | 187.9                        |                              | 568.8                | 275.5            |
| C <sub>4</sub> H <sub>8</sub> O                             | Ethyl vinyl ether                 |                              |                              |                      |                  | -167.4                       |                              |                      |                  | -140.8                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O                             | 1,2-Epoxybutane                   |                              |                              |                      |                  | -168.9                       |                              | 230.9                | 147.0            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O                             | Butanal                           |                              |                              |                      |                  | -239.2                       |                              | 246.6                | 163.7            | -204.8                       |                              | 343.7                | 103.4            |
| C <sub>4</sub> H <sub>8</sub> O                             | Isobutanal                        |                              |                              |                      |                  | -247.3                       |                              |                      |                  | -215.7                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O                             | 2-Butanone                        |                              |                              |                      |                  | -273.3                       |                              | 239.1                | 158.7            | -238.5                       |                              | 339.9                | 101.7            |
| C <sub>4</sub> H <sub>8</sub> O                             | Tetrahydrofuran                   |                              |                              |                      |                  | -216.2                       |                              | 204.3                | 124.0            | -184.1                       |                              | 302.4                | 76.3             |
| C <sub>4</sub> H <sub>8</sub> OS                            | S-Ethyl thioacetate               |                              |                              |                      |                  | -268.2                       |                              |                      |                  | -228.1                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | Butanoic acid                     |                              |                              |                      |                  | -533.8                       |                              | 222.2                | 178.6            | -475.9                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | 2-Methylpropanoic acid            |                              |                              |                      |                  |                              |                              |                      | 173.0            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | Propyl formate                    |                              |                              |                      |                  | -500.3                       |                              |                      |                  | -462.7                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | Ethyl acetate                     |                              |                              |                      |                  | -479.3                       |                              | 257.7                | 170.7            | -443.6                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | Methyl propanoate                 |                              |                              |                      |                  |                              |                              |                      | 171.2            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | 1,3-Dioxane                       |                              |                              |                      |                  | -379.7                       |                              |                      | 143.9            | -340.6                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | 1,4-Dioxane                       |                              |                              |                      |                  | -353.9                       |                              | 270.2                | 152.1            | -315.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                | 2-Methyl-1,3-dioxolane            |                              |                              |                      |                  | -386.9                       |                              |                      |                  | -352.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S              | Sulfolane                         |                              |                              |                      |                  |                              |                              |                      | 180.0            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>8</sub> S                             | Tetrahydrothiophene               |                              |                              |                      |                  | -72.9                        |                              |                      |                  | -34.1                        | 45.8                         | 309.6                | 92.5             |
| C <sub>4</sub> H <sub>8</sub> S <sub>2</sub>                | 1,3-Dithiane                      |                              |                              |                      |                  |                              |                              |                      |                  | -10.0                        | 72.4                         | 333.5                | 110.4            |
| C <sub>4</sub> H <sub>8</sub> S <sub>2</sub>                | 1,4-Dithiane                      |                              |                              |                      |                  |                              |                              |                      |                  | 0.0                          | 84.5                         | 326.2                | 109.7            |
| C <sub>4</sub> H <sub>9</sub> Br                            | 1-Bromobutane                     |                              |                              |                      |                  | -143.8                       |                              |                      |                  | -107.1                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> Br                            | 2-Bromobutane, ( $\pm$ )          |                              |                              |                      |                  | -154.9                       |                              |                      |                  | -120.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> Br                            | 2-Bromo-2-methylpropane           |                              |                              |                      |                  | -164.4                       |                              |                      |                  | -132.4                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> Cl                            | 1-Chlorobutane                    |                              |                              |                      |                  | -188.1                       |                              |                      |                  | -154.4                       |                              |                      |                  |

| Molecular<br>formula                                         | Name                            | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|--------------------------------------------------------------|---------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                              |                                 | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>4</sub> H <sub>9</sub> Cl                             | 2-Chlorobutane                  |                              |                              |                      |                  | -192.8                       |                              |                      |                  | -161.1                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> Cl                             | 1-Chloro-2-methylpropane        |                              |                              |                      |                  | -191.1                       |                              |                      |                  | -159.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> Cl                             | 2-Chloro-2-methylpropane        |                              |                              |                      |                  | -211.3                       |                              |                      |                  | -182.2                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> ClO                            | 2-Chloroethyl ethyl ether       |                              |                              |                      |                  | -335.6                       |                              |                      |                  | -301.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> I                              | 1-Iodo-2-methylpropane          |                              |                              |                      |                  |                              |                              |                      | 162.3            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> I                              | 2-Iodo-2-methylpropane          |                              |                              |                      |                  | -107.5                       |                              |                      |                  | -72.1                        |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> N                              | Cyclobutanamine                 |                              |                              |                      |                  | 5.6                          |                              |                      |                  | 41.2                         |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> N                              | Pyrrolidine                     |                              |                              |                      |                  | -41.1                        |                              | 204.1                | 156.6            | -3.6                         |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO                             | Butanamide                      | -364.8                       |                              |                      |                  |                              |                              |                      |                  | -282.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO                             | N-Methylpropanamide             |                              |                              |                      |                  |                              |                              |                      | 179.0            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO                             | 2-Methylpropanamide             | -368.6                       |                              |                      |                  |                              |                              |                      |                  | -282.6                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO                             | N,N-Dimethylacetamide           |                              |                              |                      |                  | -278.3                       |                              |                      | 175.6            | -228.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO                             | Morpholine                      |                              |                              |                      |                  |                              |                              |                      | 164.8            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 1-Nitrobutane                   |                              |                              |                      |                  | -192.5                       |                              |                      |                  | -143.9                       |                              | 369.9                | 115.1            |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 2-Nitroisobutane                |                              |                              |                      |                  | -217.2                       |                              |                      |                  | -177.1                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | Propyl carbamate                | -552.6                       |                              |                      |                  |                              |                              |                      |                  | -471.4                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 4-Aminobutanoic acid            | -581.0                       |                              |                      |                  |                              |                              |                      |                  | -441.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | 3-Nitro-2-butanol               |                              |                              |                      |                  | -390.0                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | 2-Methyl-2-nitro-1-propanol     | -410.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | DL-Threonine                    | -758.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | L-Threonine                     | -807.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>  | Creatine                        | -537.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub>                               | Butane                          |                              |                              |                      |                  | -147.3                       |                              |                      | 140.9            | -125.7                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub>                               | Isobutane                       |                              |                              |                      |                  | -154.2                       |                              |                      |                  | -134.2                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> Hg                            | Diethyl mercury                 |                              |                              |                      |                  | 30.1                         |                              |                      | 182.8            | 75.3                         |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> N <sub>2</sub>                | Piperazine                      | -45.6                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O              | Trimethylurea                   | -330.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | N-Nitrodiethylamine             |                              |                              |                      |                  | -106.2                       |                              |                      |                  | -53.0                        |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub> | L-Asparagine, monohydrate       | -1086.6                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O                             | 1-Butanol                       |                              |                              |                      |                  | -327.3                       |                              | 225.8                | 177.2            | -274.9                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O                             | 2-Butanol                       |                              |                              |                      |                  | -342.6                       |                              | 214.9                | 196.9            | -292.8                       |                              | 359.5                | 112.7            |
| C <sub>4</sub> H <sub>10</sub> O                             | 2-Methyl-1-propanol             |                              |                              |                      |                  | -334.7                       |                              | 214.7                | 181.5            | -283.8                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O                             | 2-Methyl-2-propanol             |                              |                              |                      |                  | -359.2                       |                              | 193.3                | 218.6            | -312.5                       |                              | 326.7                | 113.6            |
| C <sub>4</sub> H <sub>10</sub> O                             | Diethyl ether                   |                              |                              |                      |                  | -279.5                       |                              | 172.4                | 175.6            | -252.1                       |                              | 342.7                | 119.5            |
| C <sub>4</sub> H <sub>10</sub> O                             | Methyl propyl ether             |                              |                              |                      |                  | -266.0                       |                              | 262.9                | 165.4            | -238.1                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O                             | Isopropyl methyl ether          |                              |                              |                      |                  | -278.8                       |                              | 253.8                | 161.9            | -252.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> OS                            | Diethyl sulfoxide               |                              |                              |                      |                  | -268.0                       |                              |                      |                  | -205.6                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | 1,2-Butanediol, (±)             |                              |                              |                      |                  | -523.6                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | 1,3-Butanediol                  |                              |                              |                      |                  | -501.0                       |                              |                      |                  | -433.2                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | 1,4-Butanediol                  |                              |                              |                      |                  | -505.3                       |                              | 223.4                | 200.1            | -428.7                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | 2,3-Butanediol                  |                              |                              |                      |                  | -541.5                       |                              |                      | 213.0            | -482.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | 2-Methyl-1,2-propanediol        |                              |                              |                      |                  | -539.7                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | Ethylene glycol monoethyl ether |                              |                              |                      |                  |                              |                              |                      | 210.8            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | Ethylene glycol dimethyl ether  |                              |                              |                      |                  | -376.6                       |                              |                      | 193.3            |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | Dimethylacetal                  |                              |                              |                      |                  | -420.6                       |                              |                      |                  | -389.7                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | tert-Butyl hydroperoxide        |                              |                              |                      |                  | -293.6                       |                              |                      |                  | -245.9                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>                | Diethylene glycol               |                              |                              |                      |                  | -628.5                       |                              |                      | 244.8            | -571.2                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>3</sub> S              | Diethyl sulfite                 |                              |                              |                      |                  | -600.7                       |                              |                      |                  | -552.2                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> O <sub>4</sub> S              | Diethyl sulfate                 |                              |                              |                      |                  | -813.2                       |                              |                      |                  | -756.3                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> S                             | 1-Butanethiol                   |                              |                              |                      |                  | -124.7                       |                              |                      | 171.2            | -88.0                        |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> S                             | 2-Butanethiol                   |                              |                              |                      |                  | -131.0                       |                              |                      |                  | -96.9                        |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> S                             | 2-Methyl-1-propanethiol         |                              |                              |                      |                  | -132.0                       |                              |                      |                  | -97.3                        |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> S                             | 2-Methyl-2-propanethiol         |                              |                              |                      |                  | -140.5                       |                              |                      |                  | -109.6                       |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> S                             | Diethyl sulfide                 |                              |                              |                      |                  | -119.4                       |                              | 269.3                | 171.4            | -83.5                        |                              | 368.1                | 117.0            |
| C <sub>4</sub> H <sub>10</sub> S                             | Methyl propyl sulfide           |                              |                              |                      |                  | -118.5                       |                              | 272.5                | 171.6            | -82.2                        |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> S                             | Isopropyl methyl sulfide        |                              |                              |                      |                  | -124.7                       |                              | 263.1                | 172.4            | -90.5                        |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> S <sub>2</sub>                | 1,4-Butanedithiol               |                              |                              |                      |                  | -105.7                       |                              |                      |                  | -50.6                        |                              |                      |                  |
| C <sub>4</sub> H <sub>10</sub> S <sub>2</sub>                | Diethyl disulfide               |                              |                              |                      |                  | -120.1                       |                              | 269.3                | 171.4            | -79.4                        |                              |                      |                  |
| C <sub>4</sub> H <sub>11</sub> N                             | Butylamine                      |                              |                              |                      |                  | -127.6                       |                              |                      | 179.2            | -91.9                        |                              |                      |                  |
| C <sub>4</sub> H <sub>11</sub> N                             | sec-Butylamine                  |                              |                              |                      |                  | -137.5                       |                              |                      |                  | -104.6                       |                              |                      |                  |
| C <sub>4</sub> H <sub>11</sub> N                             | tert-Butylamine                 |                              |                              |                      |                  | -150.6                       |                              |                      | 192.1            | -121.0                       |                              |                      |                  |
| C <sub>4</sub> H <sub>11</sub> N                             | Isobutylamine                   |                              |                              |                      |                  | -132.6                       |                              |                      | 183.2            | -98.7                        |                              |                      |                  |
| C <sub>4</sub> H <sub>11</sub> N                             | Diethylamine                    |                              |                              |                      |                  | -103.7                       |                              |                      | 169.2            | -72.2                        |                              |                      |                  |
| C <sub>4</sub> H <sub>11</sub> NO                            | N,N-Dimethylethanolamine        |                              |                              |                      |                  | -253.7                       |                              |                      |                  | -203.6                       |                              |                      |                  |
| C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>               | Diethanolamine                  | -493.8                       |                              |                      | 233.5            |                              |                              |                      |                  | -397.1                       |                              |                      |                  |
| C <sub>4</sub> H <sub>11</sub> NO <sub>3</sub>               | Tris(hydroxymethyl)methylamine  | -717.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                                         | Name                                          | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|--------------------------------------------------------------|-----------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                              |                                               | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>4</sub> H <sub>12</sub> BrN                           | Tetramethylammonium bromide                   | -251.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>12</sub> ClN                           | Diethylamine hydrochloride                    | -358.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>12</sub> ClN                           | Tetramethylammonium chloride                  | -276.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>12</sub> IN                            | Tetramethylammonium iodide                    | -203.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>4</sub> H <sub>12</sub> N <sub>2</sub>                | 2-Methyl-1,2-propanediamine                   |                              |                              |                      |                  | -133.9                       |                              |                      |                  | -90.3                        |                              |                      |                  |
| C <sub>4</sub> H <sub>12</sub> Pb                            | Tetramethyl lead                              |                              |                              |                      |                  | 97.9                         |                              |                      |                  | 135.9                        |                              |                      |                  |
| C <sub>4</sub> H <sub>12</sub> Si                            | Tetramethylsilane                             |                              |                              |                      |                  | -264.0                       | -100.0                       | 277.3                | 204.1            | -239.1                       | -99.9                        | 359.0                | 143.9            |
| C <sub>4</sub> H <sub>12</sub> Sn                            | Tetramethylstannane                           |                              |                              |                      |                  | -52.3                        |                              |                      |                  | -18.8                        |                              |                      |                  |
| C <sub>4</sub> H <sub>12</sub> N <sub>3</sub>                | Bis(2-aminoethyl)amine                        |                              |                              |                      |                  |                              |                              |                      | 254.0            |                              |                              |                      |                  |
| C <sub>4</sub> N <sub>2</sub>                                | 2-Butynedinitrile                             |                              |                              |                      |                  | 500.4                        |                              |                      |                  | 529.2                        |                              |                      |                  |
| C <sub>2</sub> NiO <sub>4</sub>                              | Nickel carbonyl                               |                              |                              |                      |                  | -633.0                       | -588.2                       | 313.4                | 204.6            | -602.9                       | -587.2                       | 410.6                | 145.2            |
| C <sub>5</sub> FeO <sub>5</sub>                              | Iron pentacarbonyl                            |                              |                              |                      |                  | -774.0                       | -705.3                       | 338.1                | 240.6            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>2</sub> F <sub>6</sub> O <sub>2</sub>  | Hexafluoroacetylacetone                       | -2286.7                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>2</sub> NO <sub>5</sub>                | 5-Nitro-2-furancarboxylic acid                | -516.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub>                 | 1 <i>H</i> -Purine                            | 169.4                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O               | Hypoxanthine                                  | -110.8                       |                              | 145.6                | 134.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub>  | Xanthine                                      | -379.6                       |                              | 161.1                | 151.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>3</sub>  | Uric acid                                     | -618.8                       |                              | 173.2                | 166.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                 | Furfural                                      |                              |                              |                      |                  | -201.6                       |                              |                      | 163.2            | -151.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                 | 2-Furancarboxylic acid                        | -498.4                       |                              |                      |                  |                              |                              |                      |                  | -390.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                 | 3-Methyl-2,5-furandione                       |                              |                              |                      |                  | -504.5                       |                              |                      |                  | -447.2                       |                              |                      |                  |
| C <sub>5</sub> H <sub>2</sub> F <sub>3</sub> O <sub>2</sub>  | 1,1,1-Trifluoro-2,4-pentanedione              |                              |                              |                      |                  | -1040.2                      |                              |                      |                  | -993.3                       |                              |                      |                  |
| C <sub>5</sub> H <sub>5</sub> N                              | Pyridine                                      |                              |                              |                      |                  | 100.2                        |                              |                      | 132.7            | 140.4                        |                              |                      |                  |
| C <sub>5</sub> H <sub>5</sub> NO                             | 1 <i>H</i> -Pyrrole-2-carboxaldehyde          | -106.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>5</sub> N <sub>5</sub>                 | Adenine                                       | 96.9                         |                              |                      | 147.0            |                              |                              |                      |                  | 205.7                        |                              |                      |                  |
| C <sub>5</sub> H <sub>5</sub> N <sub>5</sub> O               | Guanine                                       | -183.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>6</sub>                                | <i>cis</i> -3-Penten-1-yne                    |                              |                              |                      |                  | 226.5                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>6</sub>                                | <i>trans</i> -3-Penten-1-yne                  |                              |                              |                      |                  | 228.2                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>6</sub>                                | 1,3-Cyclopentadiene                           |                              |                              |                      |                  | 105.9                        |                              |                      |                  | 134.3                        |                              |                      |                  |
| C <sub>5</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>  | Thymine                                       | -462.8                       |                              |                      | 150.8            |                              |                              |                      |                  | -328.7                       |                              |                      |                  |
| C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                 | Furfuryl alcohol                              |                              |                              |                      |                  | -276.2                       |                              |                      | 204.0            | -211.8                       |                              |                      |                  |
| C <sub>5</sub> H <sub>6</sub> O <sub>4</sub>                 | <i>trans</i> -1-Propene-1,2-dicarboxylic acid | -824.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>6</sub> S                              | 2-Methylthiophene                             |                              |                              |                      |                  | 44.6                         |                              | 218.5                | 149.8            | 83.5                         |                              |                      |                  |
| C <sub>5</sub> H <sub>6</sub> S                              | 3-Methylthiophene                             |                              |                              |                      |                  | 43.1                         |                              |                      |                  | 82.5                         |                              |                      |                  |
| C <sub>5</sub> H <sub>7</sub> N                              | <i>trans</i> -3-Pentenitrile                  |                              |                              |                      |                  | 80.9                         |                              |                      |                  | 125.7                        |                              |                      |                  |
| C <sub>5</sub> H <sub>7</sub> N                              | Cyclobutanecarbonitrile                       |                              |                              |                      |                  | 103.0                        |                              |                      |                  | 147.4                        |                              |                      |                  |
| C <sub>5</sub> H <sub>7</sub> N                              | 1-Methylpyrrole                               |                              |                              |                      |                  | 62.4                         |                              |                      |                  | 103.1                        |                              |                      |                  |
| C <sub>5</sub> H <sub>7</sub> N                              | 2-Methylpyrrole                               |                              |                              |                      |                  | 23.3                         |                              |                      |                  | 74.0                         |                              |                      |                  |
| C <sub>5</sub> H <sub>7</sub> N                              | 3-Methylpyrrole                               |                              |                              |                      |                  | 20.5                         |                              |                      |                  | 70.2                         |                              |                      |                  |
| C <sub>5</sub> H <sub>7</sub> NO <sub>2</sub>                | Ethyl cyanoacetate                            |                              |                              |                      |                  |                              |                              |                      | 220.2            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | 1,2-Pentadiene                                |                              |                              |                      |                  |                              |                              |                      |                  | 140.7                        |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | <i>cis</i> -1,3-Pentadiene                    |                              |                              |                      |                  |                              |                              |                      |                  | 81.4                         |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | <i>trans</i> -1,3-Pentadiene                  |                              |                              |                      |                  |                              |                              |                      |                  | 76.1                         |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | 1,4-Pentadiene                                |                              |                              |                      |                  |                              |                              |                      |                  | 105.7                        |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | 2,3-Pentadiene                                |                              |                              |                      |                  |                              |                              |                      |                  | 133.1                        |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | 3-Methyl-1,2-butadiene                        |                              |                              |                      |                  | 101.2                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | 2-Methyl-1,3-butadiene                        |                              |                              |                      |                  | 48.2                         |                              | 229.3                | 152.6            | 75.5                         |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | Cyclopentene                                  |                              |                              |                      |                  | 4.3                          |                              | 201.2                | 122.4            | 34.0                         |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | Spiropentane                                  |                              |                              |                      |                  | 157.5                        |                              | 193.7                | 134.5            | 185.2                        |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub>                                | Methylenecyclobutane                          |                              |                              |                      |                  | 93.8                         |                              |                      |                  | 121.6                        |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> N <sub>4</sub> O <sub>12</sub> | Pentaerythritol tetranitrate                  | -538.6                       |                              |                      |                  |                              |                              |                      |                  | -387.0                       |                              | 614.7                | 294.8            |
| C <sub>5</sub> H <sub>8</sub> O                              | Cyclopentanone                                |                              |                              |                      |                  | -235.9                       |                              |                      |                  | -192.1                       |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | 4-Pentenoic acid                              |                              |                              |                      |                  | -430.6                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Allyl acetate                                 |                              |                              |                      |                  |                              |                              |                      | 184.1            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Ethyl acrylate                                |                              |                              |                      |                  | -370.6                       |                              |                      |                  | -354.2                       |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Methyl <i>trans</i> -2-butenate               |                              |                              |                      |                  | -382.9                       |                              |                      |                  | -341.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Methyl methacrylate                           |                              |                              |                      |                  |                              |                              |                      | 191.2            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | 2,4-Pentanedione                              |                              |                              |                      |                  | -423.8                       |                              |                      |                  | -382.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Dihydro-4-methyl-2(3 <i>H</i> )-furanone      |                              |                              |                      |                  | -461.3                       |                              |                      |                  | -406.5                       |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Tetrahydro-2 <i>H</i> -pyran-2-one            |                              |                              |                      |                  | -436.7                       |                              |                      |                  | -379.6                       |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>                 | Methyl acetoacetate                           |                              |                              |                      |                  | -623.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                 | Glutaric acid                                 | -960.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>               | Propyl chloroacetate                          |                              |                              |                      |                  | -515.5                       |                              |                      |                  | -467.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>9</sub> N                              | Pentanenitrile                                |                              |                              |                      |                  | -33.1                        |                              |                      |                  | 10.5                         |                              |                      |                  |
| C <sub>5</sub> H <sub>9</sub> N                              | 2,2-Dimethylpropanenitrile                    |                              |                              |                      |                  | -39.8                        |                              | 232.0                | 179.4            | -2.3                         |                              |                      |                  |

| Molecular<br>formula                                         | Name                                     | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|--------------------------------------------------------------|------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                              |                                          | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>5</sub> H <sub>9</sub> N                              | 1,2,5,6-Tetrahydropyridine               |                              |                              |                      |                  | 33.5                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>9</sub> NO                             | 2-Piperidinone                           | -306.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>9</sub> NO                             | <i>N</i> -Methyl-2-pyrrolidone           |                              |                              |                      |                  | -262.2                       |                              |                      | 307.8            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>9</sub> NO <sub>2</sub>                | <i>L</i> -Proline                        | -515.2                       |                              |                      |                  |                              |                              |                      |                  | -366.2                       |                              |                      |                  |
| C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                | <i>D</i> -Glutamic acid                  | -1005.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                | <i>L</i> -Glutamic acid                  | -1009.7                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | 1-Pentene                                |                              |                              |                      |                  | -46.9                        |                              | 262.6                | 154.0            | -21.1                        |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | <i>cis</i> -2-Pentene                    |                              |                              |                      |                  | -53.7                        |                              | 258.6                | 151.7            | -27.6                        |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | <i>trans</i> -2-Pentene                  |                              |                              |                      |                  | -58.2                        |                              | 256.5                | 157.0            | -31.9                        |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | 2-Methyl-1-butene                        |                              |                              |                      |                  | -61.1                        |                              | 254.0                | 157.2            | -35.2                        |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | 3-Methyl-1-butene                        |                              |                              |                      |                  | -51.5                        |                              | 253.3                | 156.1            | -27.5                        |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | 2-Methyl-2-butene                        |                              |                              |                      |                  | -68.6                        |                              | 251.0                | 152.8            | -41.7                        |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | Cyclopentane                             |                              |                              |                      |                  | -105.1                       |                              | 204.5                | 128.8            | -76.4                        |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | Methylcyclobutane                        |                              |                              |                      |                  | -44.5                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | Ethylcyclopropane                        |                              |                              |                      |                  | -24.8                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | 1,1-Dimethylcyclopropane                 |                              |                              |                      |                  | -33.3                        |                              |                      |                  | -8.2                         |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | <i>cis</i> -1,2-Dimethylcyclopropane     |                              |                              |                      |                  | -26.3                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub>                               | <i>trans</i> -1,2-Dimethylcyclopropane   |                              |                              |                      |                  | -30.7                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>               | 2,3-Dibromo-2-methylbutane               |                              |                              |                      |                  |                              |                              |                      |                  | -137.6                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O              | <i>N</i> -Nitrosopiperidine              |                              |                              |                      |                  | -31.1                        |                              |                      |                  | 16.6                         |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | <i>N</i> -Nitropiperidine                |                              |                              |                      |                  | -93.0                        |                              |                      |                  | -44.5                        |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub> | <i>L</i> -Glutamine                      | -826.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O                             | Cyclopentanol                            |                              |                              |                      |                  | -300.1                       |                              | 204.1                | 182.5            | -242.5                       |                              | 362.9                |                  |
| C <sub>5</sub> H <sub>10</sub> O                             | Pentanal                                 |                              |                              |                      |                  | -267.2                       |                              |                      |                  | -228.4                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O                             | 2-Pentanone                              |                              |                              |                      |                  | -297.3                       |                              |                      | 184.1            | -258.8                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O                             | 3-Pentanone                              |                              |                              |                      |                  | -296.5                       |                              | 266.0                | 190.9            | -257.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O                             | 3-Methyl-2-butanone                      |                              |                              |                      |                  | -299.5                       |                              | 268.5                | 179.9            | -262.6                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O                             | 3,3-Dimethyloxetane                      |                              |                              |                      |                  | -182.2                       |                              |                      |                  | -148.2                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O                             | Tetrahydropyran                          |                              |                              |                      |                  | -258.3                       |                              |                      |                  | -223.4                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> OS                            | <i>S</i> -Propyl thioacetate             |                              |                              |                      |                  | -294.5                       |                              |                      |                  | -250.4                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | Pentanoic acid                           |                              |                              |                      |                  | -559.4                       |                              | 259.8                | 210.3            | -491.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | 2-Methylbutanoic acid                    |                              |                              |                      |                  | -554.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | 3-Methylbutanoic acid                    |                              |                              |                      |                  | -561.6                       |                              |                      |                  | -510.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | 2,2-Dimethylpropanoic acid               | -564.5                       |                              |                      |                  |                              |                              |                      |                  | -491.3                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | Butyl formate                            |                              |                              |                      |                  |                              |                              |                      | 200.2            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | Propyl acetate                           |                              |                              |                      |                  |                              |                              |                      | 196.2            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | Isopropyl acetate                        |                              |                              |                      |                  | -518.9                       |                              |                      | 199.4            | -481.6                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | Ethyl propanoate                         |                              |                              |                      |                  | -502.7                       |                              |                      |                  | -463.4                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | Methyl butanoate                         |                              |                              |                      |                  |                              |                              |                      | 198.2            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | (Ethoxymethyl)oxirane                    |                              |                              |                      |                  | -296.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | 4-Methyl-1,3-dioxane                     |                              |                              |                      |                  | -416.1                       |                              |                      |                  | -376.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | <i>cis</i> -1,2-Cyclopentanediol         | -485.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | <i>trans</i> -1,2-Cyclopentanediol       | -490.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                | Tetrahydrofurfuryl alcohol               |                              |                              |                      |                  | -435.7                       |                              |                      |                  | -369.1                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>                | Diethyl carbonate                        |                              |                              |                      |                  | -681.5                       |                              |                      |                  | -637.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>                | Ethylene glycol monomethyl ether acetate |                              |                              |                      |                  |                              |                              |                      | 310.0            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>                | Ethyl lactate                            |                              |                              |                      |                  |                              |                              |                      | 254.0            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>                | Glycerol 1-acetate, ( <i>DL</i> )        |                              |                              |                      |                  | -909.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                | <i>D</i> -Ribose                         | -1047.2                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                | <i>D</i> -Xylose                         | -1057.8                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                | $\alpha$ - <i>D</i> -Arabinopyranose     | -1057.9                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>10</sub> S                             | Thiacyclohexane                          |                              |                              |                      |                  | -106.3                       |                              | 218.2                | 163.3            | -63.5                        | 53.1                         | 323.0                | 109.7            |
| C <sub>5</sub> H <sub>10</sub> S                             | Cyclopentanethiol                        |                              |                              |                      |                  | -89.5                        |                              | 256.9                | 165.2            | -48.1                        |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> Br                            | 1-Bromopentane                           |                              |                              |                      |                  | -170.2                       |                              |                      |                  | -128.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> Cl                            | 1-Chloropentane                          |                              |                              |                      |                  | -213.2                       |                              |                      |                  | -174.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> Cl                            | 1-Chloro-3-methylbutane                  |                              |                              |                      |                  | -216.0                       |                              |                      |                  | -179.7                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> Cl                            | 2-Chloro-2-methylbutane                  |                              |                              |                      |                  | -235.7                       |                              |                      |                  | -202.2                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> Cl                            | 2-Chloro-3-methylbutane                  |                              |                              |                      |                  | -226.6                       |                              |                      |                  | -185.1                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> N                             | Cyclopentylamine                         |                              |                              |                      |                  | -95.1                        |                              | 241.0                | 181.2            | -54.9                        |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> N                             | Piperidine                               |                              |                              |                      |                  | -86.4                        |                              | 210.0                | 179.9            | -47.1                        |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> NO                            | Pentanamide                              | -379.5                       |                              |                      |                  |                              |                              |                      |                  | -290.2                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> NO                            | 2,2-Dimethylpropanamide                  | -399.7                       |                              |                      |                  |                              |                              |                      |                  | -313.1                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>               | 1-Nitropentane                           |                              |                              |                      |                  | -215.4                       |                              |                      |                  | -164.4                       |                              | 390.9                | 137.1            |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>               | <i>DL</i> -Valine                        | -628.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>               | <i>L</i> -Valine                         | -617.9                       |                              |                      |                  |                              |                              |                      |                  | -455.1                       |                              |                      |                  |

| Molecular<br>formula                                        | Name                                        | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------------------|---------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                             |                                             | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>              | 5-Aminopentanoic acid                       | -604.1                       |                              |                      |                  |                              |                              |                      |                  | -460.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub> S            | L-Methionine                                | -577.5                       |                              |                      |                  |                              |                              |                      |                  | -413.5                       |                              |                      |                  |
| C <sub>5</sub> H <sub>11</sub> NO <sub>4</sub>              | 2-Ethyl-2-nitro-1,3-propanediol             | -606.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub>                              | Pentane                                     |                              |                              |                      |                  | -173.5                       |                              |                      | 167.2            | -146.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub>                              | Isopentane                                  |                              |                              |                      |                  | -178.4                       |                              | 260.4                | 164.8            | -153.6                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub>                              | Neopentane                                  |                              |                              |                      |                  | -190.2                       |                              |                      |                  | -168.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O             | Butylurea                                   | -419.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O             | <i>tert</i> -Butylurea                      | -417.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O             | <i>N,N</i> -Diethylurea                     | -372.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O             | Tetramethylurea                             |                              |                              |                      |                  | -262.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> S             | Tetramethylthiourea                         | -38.1                        |                              |                      |                  |                              |                              |                      |                  | 44.9                         |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | 1-Pentanol                                  |                              |                              |                      |                  | -351.6                       |                              |                      | 208.1            | -294.6                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | 2-Pentanol                                  |                              |                              |                      |                  | -365.2                       |                              |                      |                  | -311.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | 3-Pentanol                                  |                              |                              |                      |                  | -368.9                       |                              |                      | 239.7            | -314.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | 2-Methyl-1-butanol, ( $\pm$ )               |                              |                              |                      |                  | -356.6                       |                              |                      |                  | -301.4                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | 3-Methyl-1-butanol                          |                              |                              |                      |                  | -356.4                       |                              |                      |                  | -300.7                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | 2-Methyl-2-butanol                          |                              |                              |                      |                  | -379.5                       |                              |                      | 247.1            | -329.3                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | 3-Methyl-2-butanol, ( $\pm$ )               |                              |                              |                      |                  | -366.6                       |                              |                      |                  | -313.5                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | 2,2-Dimethyl-1-propanol                     |                              |                              |                      |                  | -399.4                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | Butyl methyl ether                          |                              |                              |                      |                  | -290.6                       |                              | 295.3                | 192.7            | -258.1                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | Methyl <i>tert</i> -butyl ether             |                              |                              |                      |                  | -313.6                       |                              | 265.3                | 187.5            | -283.7                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O                            | Ethyl propyl ether                          |                              |                              |                      |                  | -303.6                       |                              | 295.0                | 197.2            | -272.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 1,5-Pentanediol                             |                              |                              |                      |                  | -528.8                       |                              |                      |                  | -450.8                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 2,2-Dimethyl-1,3-propanediol                | -551.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | Diethoxymethane                             |                              |                              |                      |                  | -450.5                       |                              |                      |                  | -414.7                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 1,1-Dimethoxypropane                        |                              |                              |                      |                  | -443.6                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 2,2-Dimethoxypropane                        |                              |                              |                      |                  | -459.4                       |                              |                      |                  | -429.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>3</sub>               | Diethylene glycol monomethyl ether          |                              |                              |                      |                  |                              |                              |                      | 271.1            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>3</sub>               | 2-(Hydroxymethyl)-2-methyl-1,3-propanediol  | -744.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>4</sub>               | Pentaerythritol                             | -920.6                       |                              |                      |                  |                              |                              |                      |                  | -776.7                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> O <sub>5</sub>               | Xylitol                                     | -1118.5                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | 1-Pentanethiol                              |                              |                              |                      |                  | -151.3                       |                              |                      |                  | -110.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | 2-Methyl-1-butanethiol, (+)                 |                              |                              |                      |                  | -154.4                       |                              |                      |                  | -114.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | 3-Methyl-1-butanethiol                      |                              |                              |                      |                  | -154.4                       |                              |                      |                  | -114.9                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | 2-Methyl-2-butanethiol                      |                              |                              |                      |                  | -162.8                       |                              | 290.1                | 198.1            | -127.1                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | 3-Methyl-2-butanethiol                      |                              |                              |                      |                  | -158.8                       |                              |                      |                  | -121.3                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | 2,2-Dimethyl-1-propanethiol                 |                              |                              |                      |                  | -165.4                       |                              |                      |                  | -129.0                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | Butyl methyl sulfide                        |                              |                              |                      |                  | -142.9                       |                              | 307.5                | 200.9            | -102.4                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | <i>tert</i> -Butyl methyl sulfide           |                              |                              |                      |                  | -157.1                       |                              | 276.1                | 199.9            | -121.3                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | Ethyl propyl sulfide                        |                              |                              |                      |                  | -144.8                       |                              | 309.5                | 198.4            | -104.8                       |                              |                      |                  |
| C <sub>5</sub> H <sub>12</sub> S                            | Ethyl isopropyl sulfide                     |                              |                              |                      |                  | -156.1                       |                              |                      |                  | -118.3                       |                              |                      |                  |
| C <sub>5</sub> H <sub>13</sub> N                            | Pentylamine                                 |                              |                              |                      |                  |                              |                              |                      | 218.0            |                              |                              |                      |                  |
| C <sub>5</sub> H <sub>14</sub> N <sub>2</sub>               | <i>N,N,N',N'</i> -Tetramethylmethanediamine |                              |                              |                      |                  | -51.1                        |                              |                      |                  | -18.2                        |                              |                      |                  |
| C <sub>6</sub> ClF <sub>5</sub>                             | Chloropentafluorobenzene                    | -858.4                       |                              |                      |                  |                              |                              |                      |                  | -809.3                       |                              |                      |                  |
| C <sub>6</sub> Cl <sub>6</sub>                              | Hexachlorobenzene                           | -127.6                       |                              | 260.2                | 201.2            |                              |                              |                      |                  | -35.5                        |                              |                      |                  |
| C <sub>6</sub> F <sub>6</sub>                               | Hexafluorobenzene                           |                              |                              |                      |                  | -991.3                       |                              | 280.8                | 221.6            | -955.4                       |                              |                      |                  |
| C <sub>6</sub> F <sub>10</sub>                              | Perfluorocyclohexene                        |                              |                              |                      |                  | -1963.5                      |                              |                      |                  | -1932.7                      |                              |                      |                  |
| C <sub>6</sub> F <sub>12</sub>                              | Perfluorocyclohexane                        |                              |                              |                      |                  | -2406.3                      |                              |                      |                  | -2370.4                      |                              |                      |                  |
| C <sub>6</sub> HC1 <sub>5</sub> O                           | Pentachlorophenol                           | -292.5                       |                              | 253.2                | 202.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> HF <sub>5</sub>                              | Pentafluorobenzene                          | -852.7                       |                              |                      |                  | -841.8                       |                              |                      |                  | -806.5                       |                              |                      |                  |
| C <sub>6</sub> HF <sub>5</sub> O                            | Pentafluorophenol                           | -1024.1                      |                              |                      |                  | -1007.7                      |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>                | 1,2,4,5-Tetrafluorobenzene                  |                              |                              |                      |                  | -683.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>               | 1,2,3-Trichlorobenzene                      | -70.8                        |                              |                      |                  |                              |                              |                      |                  | 3.8                          |                              |                      |                  |
| C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>               | 1,2,4-Trichlorobenzene                      |                              |                              |                      |                  | -63.1                        |                              |                      |                  | -8.1                         |                              |                      |                  |
| C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>               | 1,3,5-Trichlorobenzene                      | -78.4                        |                              |                      |                  |                              |                              |                      |                  | -13.4                        |                              |                      |                  |
| C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>6</sub> | 1,3,5-Trinitrobenzene                       | -37.0                        |                              |                      | 214.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>7</sub> | 2,4,6-Trinitrophenol                        | -217.9                       |                              |                      | 239.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>8</sub> | 2,4,6-Trinitro-1,3-benzenediol              | -467.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> CINO <sub>2</sub>             | 1-Chloro-4-nitrobenzene                     | -48.7                        |                              |                      | 250.2            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>o</i> -Dichlorobenzene                   |                              |                              |                      |                  | -17.5                        |                              |                      | 162.4            | 30.2                         |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>m</i> -Dichlorobenzene                   |                              |                              |                      |                  | -20.7                        |                              |                      |                  | 25.7                         |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>p</i> -Dichlorobenzene                   | -42.3                        |                              | 175.4                | 147.8            |                              |                              |                      |                  | 22.5                         |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O             | 2,4-Dichlorophenol                          | -226.4                       |                              |                      |                  |                              |                              |                      |                  | -156.3                       |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                | <i>o</i> -Difluorobenzene                   |                              |                              |                      |                  | -330.0                       |                              | 222.6                | 159.0            | -293.8                       |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                | <i>m</i> -Difluorobenzene                   |                              |                              |                      |                  | -343.9                       |                              | 223.8                | 159.1            | -309.2                       |                              |                      |                  |

| Molecular<br>formula                                         |                                                  | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|--------------------------------------------------------------|--------------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                              |                                                  | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                 | <i>p</i> -Difluorobenzene                        |                              |                              |                      |                  | -342.3                       |                              |                      | 157.5            | -306.7                       |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>  | 1,2-Dinitrobenzene                               | -2.0                         |                              |                      | 200.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>  | 1,3-Dinitrobenzene                               | -27.0                        |                              |                      | 197.5            | -36.0                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>  | 1,4-Dinitrobenzene                               | -38.0                        |                              |                      | 200.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>  | 2,4-Dinitrophenol                                | -232.7                       |                              |                      |                  |                              |                              |                      |                  | -128.1                       |                              |                      |                  |
| C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>                 | <i>p</i> -Benzoquinone                           | -185.7                       |                              |                      | 129.0            |                              |                              |                      |                  | -122.9                       |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> Br                             | Bromobenzene                                     |                              |                              |                      |                  | 60.9                         |                              | 219.2                | 154.3            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> Cl                             | Chlorobenzene                                    |                              |                              |                      |                  | 11.1                         |                              |                      | 150.1            | 52.0                         |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> ClO                            | 2-Chlorophenol                                   |                              |                              |                      |                  |                              |                              |                      | 188.7            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> ClO                            | 3-Chlorophenol                                   | -206.4                       |                              |                      |                  | -189.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> ClO                            | 4-Chlorophenol                                   | -197.7                       |                              |                      |                  | -181.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> Cl <sub>2</sub> N              | 3,4-Dichloroaniline                              | -89.1                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> F                              | Fluorobenzene                                    |                              |                              |                      |                  | -150.6                       |                              | 205.9                | 146.4            | -115.9                       |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> I                              | Iodobenzene                                      |                              |                              |                      |                  | 117.2                        |                              | 205.4                | 158.7            | 164.9                        |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                | Nitrobenzene                                     |                              |                              |                      |                  | 12.5                         |                              |                      | 185.8            | 68.5                         |                              | 348.8                | 120.4            |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                | 3-Pyridinecarboxylic acid                        | -344.9                       |                              |                      |                  |                              |                              |                      |                  | -221.5                       |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                | 2-Nitrophenol                                    | -202.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> N <sub>3</sub>                 | 1 <i>H</i> -Benzotriazole                        | 236.5                        |                              |                      |                  |                              |                              |                      |                  | 335.5                        |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>  | 2,3-Dinitroaniline                               | -11.7                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>  | 2,4-Dinitroaniline                               | -67.8                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>  | 2,5-Dinitroaniline                               | -44.3                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>  | 2,6-Dinitroaniline                               | -50.6                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>  | 3,5-Dinitroaniline                               | -38.9                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub>                                | 1,5-Hexadiyne                                    |                              |                              |                      |                  | 384.2                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub>                                | Benzene                                          |                              |                              |                      |                  | 49.1                         | 124.5                        | 173.4                | 136.0            | 82.9                         | 129.7                        | 269.2                | 82.4             |
| C <sub>6</sub> H <sub>6</sub> CIN                            | 2-Chloroaniline                                  |                              |                              |                      |                  | -4.6                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> CIN                            | 3-Chloroaniline                                  |                              |                              |                      |                  | -20.3                        |                              |                      | 198.7            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> CIN                            | 4-Chloroaniline                                  | -33.3                        |                              |                      | 147.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>  | 2-Nitroaniline                                   | -26.1                        |                              |                      | 166.0            | -9.4                         |                              |                      |                  | 63.8                         |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>  | 3-Nitroaniline                                   | -38.3                        |                              |                      | 158.8            | -14.4                        |                              |                      |                  | 58.4                         |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>  | 4-Nitroaniline                                   | -42.0                        |                              |                      | 167.0            | -20.7                        |                              |                      |                  | 58.8                         |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O                              | Phenol                                           | -165.1                       |                              | 144.0                | 127.4            |                              |                              |                      |                  | -96.4                        |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O                              | 2-Vinylfuran                                     |                              |                              |                      |                  | -10.3                        |                              |                      |                  | 27.8                         |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                 | <i>p</i> -Hydroquinone                           | -364.5                       |                              |                      | 136.0            |                              |                              |                      |                  | -265.3                       |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                 | Pyrocatechol                                     | -354.1                       |                              |                      |                  |                              |                              |                      |                  | -267.5                       |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                 | Resorcinol                                       | -368.0                       |                              |                      |                  |                              |                              |                      |                  | -274.7                       |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                 | 1,2,3-Benzenetriol                               | -551.1                       |                              |                      |                  |                              |                              |                      |                  | -434.2                       |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                 | 1,2,4-Benzenetriol                               | -563.8                       |                              |                      |                  |                              |                              |                      |                  | -444.0                       |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                 | 1,3,5-Benzenetriol                               | -584.6                       |                              |                      |                  |                              |                              |                      |                  | -452.9                       |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                 | 3,4-Dimethyl-2,5-furandione                      | -581.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                 | <i>cis</i> -1-Propene-1,2,3-tricarboxylic acid   | -1224.4                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                 | <i>trans</i> -1-Propene-1,2,3-tricarboxylic acid | -1232.7                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>6</sub> S                              | Benzenethiol                                     |                              |                              |                      |                  | 63.7                         |                              | 222.8                | 173.2            | 111.3                        |                              |                      |                  |
| C <sub>6</sub> H <sub>7</sub> N                              | Aniline                                          |                              |                              |                      |                  | 31.6                         |                              |                      | 191.9            | 87.5                         | -7.0                         | 317.9                | 107.9            |
| C <sub>6</sub> H <sub>7</sub> N                              | 2-Methylpyridine                                 |                              |                              |                      |                  | 56.7                         |                              |                      | 158.6            | 99.2                         |                              |                      |                  |
| C <sub>6</sub> H <sub>7</sub> N                              | 3-Methylpyridine                                 |                              |                              |                      |                  | 61.9                         |                              | 216.3                | 158.7            | 106.4                        |                              |                      |                  |
| C <sub>6</sub> H <sub>7</sub> N                              | 4-Methylpyridine                                 |                              |                              |                      |                  | 59.2                         |                              | 209.1                | 159.0            | 103.8                        |                              |                      |                  |
| C <sub>6</sub> H <sub>7</sub> N                              | 1-Cyclopentenecarbonitrile                       |                              |                              |                      |                  | 111.5                        |                              |                      |                  | 156.5                        |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | Adiponitrile                                     |                              |                              |                      |                  | 85.1                         |                              |                      | 128.7            | 149.5                        |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 1,2-Benzenediamine                               | -0.3                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 1,3-Benzenediamine                               | -7.8                         |                              | 154.5                | 159.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 1,4-Benzenediamine                               | 3.0                          |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | Phenylhydrazine                                  |                              |                              |                      |                  | 141.0                        |                              |                      | 217.0            | 202.9                        |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> S               | Bis(2-cyanoethyl) sulfide                        |                              |                              |                      |                  | 96.3                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                 | Dimethyl maleate                                 |                              |                              |                      |                  |                              |                              |                      | 263.2            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> O <sub>6</sub>                 | <i>L</i> -Ascorbic acid                          | -1164.6                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>8</sub> O <sub>7</sub>                 | Citric acid                                      | -1543.8                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>9</sub> Cl <sub>3</sub> O <sub>2</sub> | Butyl trichloroacetate                           |                              |                              |                      |                  | -545.8                       |                              |                      |                  | -492.3                       |                              |                      |                  |
| C <sub>6</sub> H <sub>9</sub> Cl <sub>3</sub> O <sub>2</sub> | Isobutyl trichloroacetate                        |                              |                              |                      |                  | -553.4                       |                              |                      |                  | -500.2                       |                              |                      |                  |
| C <sub>6</sub> H <sub>9</sub> N                              | Cyclopentanecarbonitrile                         |                              |                              |                      |                  | 0.7                          |                              |                      |                  | 44.1                         |                              |                      |                  |
| C <sub>6</sub> H <sub>9</sub> N                              | 2,4-Dimethylpyrrole                              | -422.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>9</sub> N                              | 2,5-Dimethylpyrrole                              |                              |                              |                      |                  | -16.7                        |                              |                      |                  | 39.8                         |                              |                      |                  |
| C <sub>6</sub> H <sub>9</sub> NO <sub>3</sub>                | Triacetamide                                     |                              |                              |                      |                  | -610.5                       |                              |                      |                  | -550.1                       |                              |                      |                  |
| C <sub>6</sub> H <sub>9</sub> NO <sub>6</sub>                | Nitrilotriacetic acid                            | -1311.9                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>  | <i>L</i> -Histidine                              | -466.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                                                        | Name                                    | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-----------------------------------------------------------------------------|-----------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                                             |                                         | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>6</sub> H <sub>10</sub>                                              | 1,5-Hexadiene                           |                              |                              |                      |                  | 54.1                         |                              |                      |                  | 84.2                         |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub>                                              | 3,3-Dimethyl-1-butyne                   |                              |                              |                      |                  | 78.4                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub>                                              | Cyclohexene                             |                              |                              |                      |                  | -38.5                        |                              | 214.6                | 148.3            | -5.0                         |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub>                                              | 1-Methylcyclopentene                    |                              |                              |                      |                  | -36.4                        |                              |                      |                  | -3.8                         |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub>                                              | 3-Methylcyclopentene                    |                              |                              |                      |                  | -23.7                        |                              |                      |                  | 7.4                          |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub>                                              | 4-Methylcyclopentene                    |                              |                              |                      |                  | -17.6                        |                              |                      |                  | 14.6                         |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>2</sub>               | Butyl dichloroacetate                   |                              |                              |                      |                  | -550.1                       |                              |                      |                  | -497.8                       |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O                                            | Cyclohexanone                           |                              |                              |                      |                  | -271.2                       |                              |                      | 182.2            | -226.1                       |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O                                            | 2-Methylcyclopentanone                  |                              |                              |                      |                  | -265.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O                                            | Mesityl oxide                           |                              |                              |                      |                  |                              |                              |                      | 212.5            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                               | Ethyl <i>trans</i> -2-butenolate        |                              |                              |                      |                  | -420.0                       |                              |                      |                  | -375.6                       |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                               | Methyl cyclobutanecarboxylate           |                              |                              |                      |                  | -395.0                       |                              |                      |                  | -350.2                       |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                               | Ethyl acetoacetate                      |                              |                              |                      |                  |                              |                              |                      | 248.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                               | Propanoic anhydride                     |                              |                              |                      |                  | -679.1                       |                              |                      |                  | -626.5                       |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                               | Adipic acid                             | -994.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                               | Diethyl oxalate                         |                              |                              |                      |                  | -805.5                       |                              |                      |                  | -742.0                       |                              |                      |                  |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                               | Ethylene glycol diacetate               |                              |                              |                      |                  |                              |                              |                      | 310.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>11</sub> Cl                                           | Chlorocyclohexane                       |                              |                              |                      |                  | -207.2                       |                              |                      |                  | -163.7                       |                              |                      |                  |
| C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>                             | Ethyl 4-chlorobutanolate                |                              |                              |                      |                  | -566.5                       |                              |                      |                  | -513.8                       |                              |                      |                  |
| C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>                             | Propyl 3-chloropropanoate               |                              |                              |                      |                  | -537.6                       |                              |                      |                  | -485.7                       |                              |                      |                  |
| C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>                             | Butyl chloroacetate                     |                              |                              |                      |                  | -538.4                       |                              |                      |                  | -487.4                       |                              |                      |                  |
| C <sub>6</sub> H <sub>11</sub> NO                                           | Caprolactam                             | -329.4                       |                              |                      | 156.8            |                              |                              |                      |                  | -239.6                       |                              |                      |                  |
| C <sub>6</sub> H <sub>11</sub> NO                                           | 1-Methyl-2-piperidinone                 |                              |                              |                      |                  | -293.0                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 1-Hexene                                |                              |                              |                      |                  | -74.2                        |                              | 295.2                | 183.3            | -43.5                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | <i>cis</i> -2-Hexene                    |                              |                              |                      |                  | -83.9                        |                              |                      |                  | -52.3                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | <i>trans</i> -2-Hexene                  |                              |                              |                      |                  | -85.5                        |                              |                      |                  | -53.9                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | <i>cis</i> -3-Hexene                    |                              |                              |                      |                  | -78.9                        |                              |                      |                  | -47.6                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | <i>trans</i> -3-Hexene                  |                              |                              |                      |                  | -86.1                        |                              |                      |                  | -54.4                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 2-Methyl-1-pentene                      |                              |                              |                      |                  | -90.0                        |                              |                      |                  | -59.4                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 3-Methyl-1-pentene                      |                              |                              |                      |                  | -78.2                        |                              |                      |                  | -49.5                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 4-Methyl-1-pentene                      |                              |                              |                      |                  | -80.0                        |                              |                      |                  | -51.3                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 2-Methyl-2-pentene                      |                              |                              |                      |                  | -98.5                        |                              |                      |                  | -66.9                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 3-Methyl- <i>cis</i> -2-pentene         |                              |                              |                      |                  | -94.5                        |                              |                      |                  | -62.3                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 3-Methyl- <i>trans</i> -2-pentene       |                              |                              |                      |                  | -94.6                        |                              |                      |                  | -63.1                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 4-Methyl- <i>cis</i> -2-pentene         |                              |                              |                      |                  | -87.0                        |                              |                      |                  | -57.5                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 4-Methyl- <i>trans</i> -2-pentene       |                              |                              |                      |                  | -91.6                        |                              |                      |                  | -61.5                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 2-Ethyl-1-butene                        |                              |                              |                      |                  | -87.1                        |                              |                      |                  | -56.0                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 2,3-Dimethyl-1-butene                   |                              |                              |                      |                  | -93.2                        |                              |                      |                  | -62.4                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 3,3-Dimethyl-1-butene                   |                              |                              |                      |                  | -87.5                        |                              |                      |                  | -60.3                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 2,3-Dimethyl-2-butene                   |                              |                              |                      |                  | -101.4                       |                              | 270.2                | 174.7            | -68.1                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | Cyclohexane                             |                              |                              |                      |                  | -156.4                       |                              |                      | 154.9            | -123.4                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | Methylcyclopentane                      |                              |                              |                      |                  | -137.9                       |                              |                      |                  | -106.2                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | Ethylcyclobutane                        |                              |                              |                      |                  | -59.0                        |                              |                      |                  | -27.5                        |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub>                                              | 1,1,2-Trimethylcyclopropane             |                              |                              |                      |                  | -96.2                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | L-Cystine                               | -1032.7                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> S <sub>4</sub>                | Thiram                                  | 40.2                         |                              |                      | 301.7            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | Butyl vinyl ether                       |                              |                              |                      |                  | -218.8                       |                              |                      | 232.0            | -182.6                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | Hexanal                                 |                              |                              |                      |                  |                              |                              | 280.3                | 210.4            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | 2-Hexanone                              |                              |                              |                      |                  | -322.0                       |                              |                      | 213.3            | -278.9                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | 3-Hexanone                              |                              |                              |                      |                  | -320.2                       |                              | 305.3                | 216.9            | -277.6                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | 4-Methyl-2-pentanone                    |                              |                              |                      |                  |                              |                              |                      | 213.3            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | 2-Methyl-3-pentanone                    |                              |                              |                      |                  | -325.9                       |                              |                      |                  | -286.0                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | 3,3-Dimethyl-2-butanone                 |                              |                              |                      |                  | -328.6                       |                              |                      |                  | -290.6                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | Cyclohexanol                            |                              |                              |                      |                  | -348.2                       |                              |                      | 208.2            | -286.2                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O                                            | <i>cis</i> -2-Methylcyclopentanol       |                              |                              |                      |                  | -345.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | Hexanoic acid                           |                              |                              |                      |                  | -583.8                       |                              |                      |                  | -511.9                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | Butyl acetate                           |                              |                              |                      |                  | -529.2                       |                              |                      | 227.8            | -485.3                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | <i>tert</i> -Butyl acetate              |                              |                              |                      |                  | -554.5                       |                              |                      | 231.0            | -516.5                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | Isobutyl acetate                        |                              |                              |                      |                  |                              |                              |                      | 233.8            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | Ethyl butanoate                         |                              |                              |                      |                  |                              |                              |                      | 228.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | Methyl pentanoate                       |                              |                              |                      |                  | -514.2                       |                              |                      | 229.3            | -471.1                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | Methyl 2,2-dimethylpropanoate           |                              |                              |                      |                  | -530.0                       |                              |                      | 257.9            | -491.2                       |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | Diacetone alcohol                       |                              |                              |                      |                  |                              |                              |                      | 221.3            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                               | Ethylene glycol monoethyl ether acetate |                              |                              |                      |                  |                              |                              |                      | 376.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                               | Paraldehyde                             |                              |                              |                      |                  | -673.1                       |                              |                      |                  | -631.7                       |                              |                      |                  |

| Molecular<br>formula                                         | Name                              | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|--------------------------------------------------------------|-----------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                              |                                   | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | $\beta$ -D-Fructose               | -1265.6                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | D-Galactose                       | -1286.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | $\alpha$ -D-Glucose               | -1273.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | D-Mannose                         | -1263.0                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | L-Sorbose                         | -1271.5                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>12</sub> S                             | Thiepane                          |                              |                              |                      |                  |                              |                              |                      |                  | -65.8                        | 79.4                         | 363.5                | 131.3            |
| C <sub>6</sub> H <sub>12</sub> S                             | Cyclohexanethiol                  |                              |                              |                      |                  | -140.7                       |                              | 255.6                | 192.6            |                              |                              | -96.2                |                  |
| C <sub>6</sub> H <sub>12</sub> S                             | Cyclopentyl methyl sulfide        |                              |                              |                      |                  | -109.8                       |                              |                      |                  |                              |                              | -64.7                |                  |
| C <sub>6</sub> H <sub>13</sub> Br                            | 1-Bromohexane                     |                              |                              |                      |                  | -194.2                       |                              | 453.0                | 204.0            |                              |                              | -148.3               |                  |
| C <sub>6</sub> H <sub>13</sub> Cl                            | 2-Chlorohexane                    |                              |                              |                      |                  | -246.1                       |                              |                      |                  |                              |                              | -204.3               |                  |
| C <sub>6</sub> H <sub>13</sub> N                             | Cyclohexylamine                   |                              |                              |                      |                  | -147.6                       |                              |                      |                  |                              |                              | -104.0               |                  |
| C <sub>6</sub> H <sub>13</sub> N                             | 2-Methylpiperidine, ( $\pm$ )     |                              |                              |                      |                  | -124.9                       |                              |                      |                  |                              |                              | -84.4                |                  |
| C <sub>6</sub> H <sub>13</sub> NO                            | Hexanamide                        | -423.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              | -324.2               |                  |
| C <sub>6</sub> H <sub>13</sub> NO                            | N-Butylacetamide                  |                              |                              |                      |                  | -380.9                       |                              |                      |                  |                              |                              | -305.9               |                  |
| C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>               | DL-Leucine                        | -640.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>               | D-Leucine                         | -637.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>               | L-Leucine                         | -637.4                       |                              |                      | 200.1            |                              |                              |                      |                  |                              |                              | -486.8               |                  |
| C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>               | DL-Isoleucine                     | -635.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>               | L-Isoleucine                      | -637.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>               | L-Norleucine                      | -639.1                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>               | 6-Aminohexanoic acid              | -637.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub>                               | Hexane                            |                              |                              |                      |                  | -198.7                       |                              |                      | 195.6            |                              |                              | -166.9               |                  |
| C <sub>6</sub> H <sub>14</sub>                               | 2-Methylpentane                   |                              |                              |                      |                  | -204.6                       |                              | 290.6                | 193.7            |                              |                              | -174.6               |                  |
| C <sub>6</sub> H <sub>14</sub>                               | 3-Methylpentane                   |                              |                              |                      |                  | -202.4                       |                              | 292.5                | 190.7            |                              |                              | -171.9               |                  |
| C <sub>6</sub> H <sub>14</sub>                               | 2,2-Dimethylbutane                |                              |                              |                      |                  | -213.8                       |                              | 272.5                | 191.9            |                              |                              | -185.9               |                  |
| C <sub>6</sub> H <sub>14</sub>                               | 2,3-Dimethylbutane                |                              |                              |                      |                  | -207.4                       |                              | 287.8                | 189.7            |                              |                              | -178.1               |                  |
| C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                | Azopropane                        |                              |                              |                      |                  | 11.5                         |                              |                      |                  |                              |                              | 51.3                 |                  |
| C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub> | DL-Lysine                         | -678.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub> | D-Arginine                        | -623.5                       |                              | 250.6                | 232.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | 1-Hexanol                         |                              |                              |                      |                  | -377.5                       |                              | 287.4                | 240.4            |                              |                              | -315.9               |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | 2-Hexanol                         |                              |                              |                      |                  | -392.0                       |                              |                      |                  |                              |                              | -333.5               |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | 3-Hexanol                         |                              |                              |                      |                  | -392.4                       |                              |                      | 286.2            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | 2-Methyl-1-pentanol               |                              |                              |                      |                  |                              |                              |                      | 248.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | 3-Methyl-2-pentanol               |                              |                              |                      |                  |                              |                              |                      | 275.9            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | 4-Methyl-2-pentanol               |                              |                              |                      |                  | -394.7                       |                              |                      | 273.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | 2-Methyl-3-pentanol               |                              |                              |                      |                  | -396.4                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | 3-Methyl-3-pentanol               |                              |                              |                      |                  |                              |                              |                      | 293.4            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | Dipropyl ether                    |                              |                              |                      |                  | -328.8                       |                              | 323.9                | 221.6            |                              |                              | -293.0               |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | Diisopropyl ether                 |                              |                              |                      |                  | -351.5                       |                              |                      | 216.8            |                              |                              | -319.2               |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | Butyl ethyl ether                 |                              |                              |                      |                  |                              |                              |                      | 159.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O                             | tert-Butyl ethyl ether            |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              | -313.9               |                  |
| C <sub>6</sub> H <sub>14</sub> OS                            | Dipropyl sulfoxide                |                              |                              |                      |                  | -329.4                       |                              |                      |                  |                              |                              | -254.9               |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                | 1,2-Hexanediol                    |                              |                              |                      |                  | -577.1                       |                              |                      |                  |                              |                              | -490.1               |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                | 1,6-Hexanediol                    | -569.9                       |                              |                      |                  | -548.6                       |                              |                      |                  |                              |                              | -461.2               |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                | 2-Methyl-2,4-pentanediol          |                              |                              |                      |                  |                              |                              |                      | 336.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                | Ethylene glycol monobutyl ether   |                              |                              |                      |                  |                              |                              |                      | 281.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                | 1,1-Diethoxyethane                |                              |                              |                      |                  | -491.4                       |                              |                      |                  |                              |                              | -453.5               |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                | Ethylene glycol diethyl ether     |                              |                              |                      |                  | -451.4                       |                              |                      | 259.4            |                              |                              | -408.1               |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                | Diethylene glycol monoethyl ether |                              |                              |                      |                  |                              |                              |                      | 301.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                | Diethylene glycol dimethyl ether  |                              |                              |                      |                  |                              |                              |                      | 274.1            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                | Trimethylolpropane                | -750.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>4</sub>                | Triethylene glycol                |                              |                              |                      |                  | -804.3                       |                              |                      |                  |                              |                              | -725.0               |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>4</sub> S              | Dipropyl sulfate                  |                              |                              |                      |                  | -859.0                       |                              |                      |                  |                              |                              | -792.0               |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                | Galactitol                        |                              |                              |                      |                  | -1317.0                      |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                | D-Mannitol                        |                              |                              |                      |                  | -1314.5                      |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>16</sub> S                             | 1-Hexanethiol                     |                              |                              |                      |                  | -175.7                       |                              |                      |                  |                              |                              | -129.9               |                  |
| C <sub>6</sub> H <sub>14</sub> S                             | 2-Methyl-2-pentanethiol           |                              |                              |                      |                  | -188.3                       |                              |                      |                  |                              |                              | -148.3               |                  |
| C <sub>6</sub> H <sub>14</sub> S                             | 2,3-Dimethyl-2-butanethiol        |                              |                              |                      |                  | -187.1                       |                              |                      |                  |                              |                              | -147.9               |                  |
| C <sub>6</sub> H <sub>16</sub> S                             | Diisopropyl sulfide               |                              |                              |                      |                  | -181.6                       |                              | 313.0                | 232.0            |                              |                              | -142.0               |                  |
| C <sub>6</sub> H <sub>14</sub> S                             | Butyl ethyl sulfide               |                              |                              |                      |                  | -172.3                       |                              |                      |                  |                              |                              | -127.8               |                  |
| C <sub>6</sub> H <sub>14</sub> S                             | Methyl pentyl sulfide             |                              |                              |                      |                  | -167.1                       |                              |                      |                  |                              |                              | -121.8               |                  |
| C <sub>6</sub> H <sub>16</sub> S <sub>2</sub>                | Dipropyl disulfide                |                              |                              |                      |                  | -171.5                       |                              |                      |                  |                              |                              | -118.3               |                  |
| C <sub>6</sub> H <sub>15</sub> B                             | Triethylborane                    |                              |                              |                      |                  | -194.6                       | 9.4                          | 336.7                | 241.2            |                              |                              | -157.7               | 16.1 437.8       |
| C <sub>6</sub> H <sub>16</sub> N                             | Dipropylamine                     |                              |                              |                      |                  | -156.1                       |                              |                      |                  |                              |                              | -116.0               |                  |
| C <sub>6</sub> H <sub>16</sub> N                             | Diisopropylamine                  |                              |                              |                      |                  | -178.5                       |                              |                      |                  |                              |                              | -143.8               |                  |
| C <sub>6</sub> H <sub>15</sub> N                             | Triethylamine                     |                              |                              |                      |                  | -127.7                       |                              |                      | 219.9            |                              |                              | -92.7                |                  |



| Molecular<br>formula                                        | Name                          | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------------------|-------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                             |                               | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>6</sub> H <sub>12</sub> NO                           | 2-Diethylaminoethanol         |                              |                              |                      |                  | -305.9                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>15</sub> NO <sub>3</sub>              | Triethanolamine               | -664.2                       |                              |                      | 389.0            |                              |                              |                      |                  | -558.3                       |                              |                      |                  |
| C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>               | 1,6-Hexanediamine             | -205.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>18</sub> N <sub>3</sub> OP            | Hexamethylphosphoric triamide |                              |                              |                      |                  |                              |                              |                      | 321.0            |                              |                              |                      |                  |
| C <sub>6</sub> H <sub>18</sub> OSi <sub>2</sub>             | Hexamethyldisiloxane          |                              |                              |                      |                  | -815.0                       | -541.5                       | 433.8                | 311.4            | -777.7                       | -534.5                       | 535.0                | 238.5            |
| C <sub>6</sub> MoO <sub>6</sub>                             | Molybdenum hexacarbonyl       | -982.8                       | -877.7                       | 325.9                | 242.3            |                              |                              |                      |                  | -912.1                       | -856.0                       | 490.0                | 205.0            |
| C <sub>6</sub> N <sub>4</sub>                               | Tetracyanoethene              | 623.8                        |                              |                      |                  |                              |                              |                      |                  | 705.0                        |                              |                      |                  |
| C <sub>7</sub> F <sub>8</sub>                               | Perfluorotoluene              |                              |                              |                      |                  | -1311.1                      |                              | 355.5                | 262.3            |                              |                              |                      |                  |
| C <sub>7</sub> F <sub>14</sub>                              | Perfluoromethylcyclohexane    |                              |                              |                      |                  | -2931.1                      |                              |                      | 353.1            | -2897.2                      |                              |                      |                  |
| C <sub>7</sub> F <sub>16</sub>                              | Perfluoroheptane              |                              |                              |                      |                  | -3420.0                      |                              | 561.8                | 419.0            | -3383.6                      |                              |                      |                  |
| C <sub>7</sub> H <sub>3</sub> F <sub>5</sub>                | 2,3,4,5,6-Pentafluorotoluene  |                              |                              |                      |                  | -883.8                       |                              | 306.4                | 225.8            | -842.7                       |                              |                      |                  |
| C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O             | 3-Chlorobenzoyl chloride      |                              |                              |                      |                  | -189.7                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub> | 3,5-Dinitrobenzoic acid       | -409.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> ClO                           | Benzoyl chloride              |                              |                              |                      |                  | -158.0                       |                              |                      |                  | -103.2                       |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>              | 2-Chlorobenzoic acid          | -404.5                       |                              |                      |                  |                              |                              |                      |                  | -325.0                       |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>              | 3-Chlorobenzoic acid          | -424.3                       |                              |                      |                  |                              |                              |                      |                  | -342.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>              | 4-Chlorobenzoic acid          | -428.9                       |                              |                      | 163.2            |                              |                              |                      |                  | -341.0                       |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> F <sub>3</sub>                | (Trifluoromethyl)benzene      |                              |                              |                      |                  |                              |                              |                      | 188.4            |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> N                             | Benzonitrile                  |                              |                              |                      |                  | 163.2                        |                              | 209.1                | 165.2            | 215.7                        |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> NO                            | Benzoxazole                   | -24.2                        |                              |                      |                  |                              |                              |                      |                  | 44.8                         |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>               | 2-Nitrobenzoic acid           | -378.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>               | 3-Nitrobenzoic acid           | -394.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>               | 4-Nitrobenzoic acid           | -392.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>6</sub> | 2,4,6-Trinitrotoluene         | -63.2                        |                              |                      | 243.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                | 1 <i>H</i> -Benzimidazole     | 79.5                         |                              |                      |                  |                              |                              |                      |                  | 181.7                        |                              |                      |                  |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                | 1 <i>H</i> -Indazole          | 151.9                        |                              |                      |                  |                              |                              |                      |                  | 243.0                        |                              |                      |                  |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> | 1-Methyl-2,4-dinitrobenzene   | -66.4                        |                              |                      |                  |                              |                              |                      |                  | 33.2                         |                              |                      |                  |
| C <sub>7</sub> H <sub>6</sub> O                             | Benzaldehyde                  |                              |                              |                      |                  | -87.0                        |                              | 221.2                | 172.0            | -36.7                        |                              |                      |                  |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                | Benzoic acid                  | -385.2                       |                              | 167.6                | 146.8            |                              |                              |                      |                  | -294.0                       |                              |                      |                  |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                | Salicylaldehyde               |                              |                              |                      |                  |                              |                              |                      | 222.0            |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                | 3-(2-Furanyl)-2-propenal      | -182.0                       |                              |                      |                  |                              |                              |                      |                  | -105.9                       |                              |                      |                  |
| C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                | 2-Hydroxybenzoic acid         | -589.9                       |                              |                      |                  |                              |                              |                      |                  | -494.8                       |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> Br                            | 4-Bromotoluene                |                              |                              |                      |                  | 12.0                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> Cl                            | 2-Chlorotoluene               |                              |                              |                      |                  |                              |                              |                      | 166.8            |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> Cl                            | (Chloromethyl)benzene         |                              |                              |                      |                  | -32.5                        |                              |                      |                  | 18.9                         |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> F                             | 4-Fluorotoluene               |                              |                              |                      |                  | -186.9                       |                              |                      | 171.2            | -147.4                       |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO                            | Benzamide                     | -202.6                       |                              |                      |                  |                              |                              |                      |                  | -100.9                       |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>               | Aniline-2-carboxylic acid     | -401.1                       |                              |                      |                  |                              |                              |                      |                  | -296.0                       |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>               | Aniline-3-carboxylic acid     | -417.3                       |                              |                      |                  |                              |                              |                      |                  | -283.6                       |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>               | Aniline-4-carboxylic acid     | -410.0                       |                              |                      | 177.8            |                              |                              |                      |                  | -296.7                       |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>               | 2-Nitrotoluene                |                              |                              |                      |                  | -9.7                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>               | 3-Nitrotoluene                |                              |                              |                      |                  | -31.5                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>               | 4-Nitrotoluene                | -48.1                        |                              |                      | 172.3            |                              |                              |                      |                  | 31.0                         |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>               | (Nitromethyl)benzene          |                              |                              |                      |                  | -22.8                        |                              |                      |                  | 30.7                         |                              |                      |                  |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>               | Salicylaldoxime               | -183.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>8</sub>                               | Toluene                       |                              |                              |                      |                  | 12.4                         |                              |                      | 157.3            | 50.5                         |                              |                      |                  |
| C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> O              | Phenylurea                    | -218.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>8</sub> O                             | <i>o</i> -Cresol              | -204.6                       |                              | 165.4                | 154.6            |                              |                              |                      |                  | -128.6                       |                              |                      |                  |
| C <sub>7</sub> H <sub>8</sub> O                             | <i>m</i> -Cresol              |                              |                              |                      |                  | -194.0                       |                              | 212.6                | 224.9            | -132.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>8</sub> O                             | <i>p</i> -Cresol              | -199.3                       |                              | 167.3                | 150.2            |                              |                              |                      |                  | -125.4                       |                              |                      |                  |
| C <sub>7</sub> H <sub>8</sub> O                             | Benzyl alcohol                |                              |                              |                      |                  | -160.7                       |                              | 216.7                | 217.9            | -100.4                       |                              |                      |                  |
| C <sub>7</sub> H <sub>8</sub> O                             | Anisole                       |                              |                              |                      |                  | -114.8                       |                              |                      |                  | -67.9                        |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | Benzylamine                   |                              |                              |                      |                  | 34.2                         |                              |                      | 207.2            | 94.4                         |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | 2-Methylaniline               |                              |                              |                      |                  | -6.3                         |                              |                      |                  | 56.4                         | 167.6                        | 351.0                | 130.2            |
| C <sub>7</sub> H <sub>9</sub> N                             | 3-Methylaniline               |                              |                              |                      |                  | -8.1                         |                              |                      |                  | 54.6                         | 165.4                        | 352.5                | 125.5            |
| C <sub>7</sub> H <sub>9</sub> N                             | 4-Methylaniline               | -23.5                        |                              |                      |                  |                              |                              |                      |                  | 55.3                         | 167.7                        | 347.0                | 126.2            |
| C <sub>7</sub> H <sub>9</sub> N                             | <i>N</i> -Methylaniline       |                              |                              |                      |                  |                              |                              |                      | 207.1            |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | 1-Cyclohexenecarbonitrile     |                              |                              |                      |                  | 48.1                         |                              |                      |                  | 101.6                        |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | 2,3-Dimethylpyridine          |                              |                              |                      |                  | 19.4                         |                              | 243.7                | 189.5            | 67.1                         |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | 2,4-Dimethylpyridine          |                              |                              |                      |                  | 16.1                         |                              | 248.5                | 184.8            | 63.6                         |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | 2,5-Dimethylpyridine          |                              |                              |                      |                  | 18.7                         |                              | 248.8                | 184.7            | 66.5                         |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | 2,6-Dimethylpyridine          |                              |                              |                      |                  | 12.7                         |                              | 244.2                | 185.2            | 58.1                         |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | 3,4-Dimethylpyridine          |                              |                              |                      |                  | 18.3                         |                              | 240.7                | 191.8            | 68.8                         |                              |                      |                  |
| C <sub>7</sub> H <sub>9</sub> N                             | 3,5-Dimethylpyridine          |                              |                              |                      |                  | 22.5                         |                              | 241.7                | 184.5            | 72.0                         |                              |                      |                  |
| C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>               | Ethyl 2-pentynoate            |                              |                              |                      |                  | -301.8                       |                              |                      |                  | -250.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>10</sub> O <sub>2</sub>               | Methyl 2-hexynoate            |                              |                              |                      |                  | -242.7                       |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                                          | Name                                          | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|---------------------------------------------------------------|-----------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                               |                                               | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>7</sub> H <sub>11</sub> Cl <sub>3</sub> O <sub>2</sub> | Isopentyl trichloroacetate                    |                              |                              |                      |                  | -580.9                       |                              |                      |                  | -523.1                       |                              |                      |                  |
| C <sub>7</sub> H <sub>11</sub> N                              | Cyclohexanecarbonitrile                       |                              |                              |                      |                  | -47.2                        |                              |                      |                  |                              |                              | 4.8                  |                  |
| C <sub>7</sub> H <sub>12</sub>                                | Bicyclo[2.2.1]heptane                         | -95.1                        |                              |                      | 151.0            |                              |                              |                      |                  | -54.8                        |                              |                      |                  |
| C <sub>7</sub> H <sub>12</sub>                                | 1-Methylbicyclo(3,1,0)hexane                  |                              |                              |                      |                  | -33.2                        |                              |                      |                  | 1.7                          |                              |                      |                  |
| C <sub>7</sub> H <sub>12</sub>                                | Methylenecyclohexane                          |                              |                              |                      |                  | -61.3                        |                              |                      |                  | -25.2                        |                              |                      |                  |
| C <sub>7</sub> H <sub>12</sub>                                | Vinylcyclopentane                             |                              |                              |                      |                  | -34.8                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>12</sub>                                | 1-Ethylcyclopentene                           |                              |                              |                      |                  | -53.3                        |                              |                      |                  | -19.8                        |                              |                      |                  |
| C <sub>7</sub> H <sub>12</sub> O                              | 2-Methylenecyclohexanol                       |                              |                              |                      |                  | -277.6                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                 | Butyl acrylate                                |                              |                              |                      |                  | -422.6                       |                              |                      | 251.0            | -375.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | Diethyl malonate                              |                              |                              |                      |                  |                              |                              |                      | 285.0            |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>               | Butyl 2-chloropropanoate                      |                              |                              |                      |                  | -571.7                       |                              |                      |                  | -517.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>               | Isobutyl 2-chloropropanoate                   |                              |                              |                      |                  | -603.1                       |                              |                      |                  | -549.6                       |                              |                      |                  |
| C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>               | Butyl 3-chloropropanoate                      |                              |                              |                      |                  | -557.9                       |                              |                      |                  | -502.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>               | Isobutyl 3-chloropropanoate                   |                              |                              |                      |                  | -572.6                       |                              |                      |                  | -517.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>13</sub> ClO <sub>2</sub>               | Propyl 2-chlorobutanoate                      |                              |                              |                      |                  | -630.7                       |                              |                      |                  | -578.4                       |                              |                      |                  |
| C <sub>7</sub> H <sub>13</sub> N                              | Heptanenitrile                                |                              |                              |                      |                  | -82.8                        |                              |                      |                  | -31.0                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 1-Heptene                                     |                              |                              |                      |                  | -97.9                        |                              | 327.6                | 211.8            | -62.3                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>cis</i> -2-Heptene                         |                              |                              |                      |                  | -105.1                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>trans</i> -2-Heptene                       |                              |                              |                      |                  | -109.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>cis</i> -3-Heptene                         |                              |                              |                      |                  | -104.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>trans</i> -3-Heptene                       |                              |                              |                      |                  | -109.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 5-Methyl-1-hexene                             |                              |                              |                      |                  | -100.0                       |                              |                      |                  | -65.7                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>cis</i> -3-Methyl-3-hexene                 |                              |                              |                      |                  | -115.9                       |                              |                      |                  | -79.4                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>trans</i> -3-Methyl-3-hexene               |                              |                              |                      |                  | -112.7                       |                              |                      |                  | -76.8                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 2,4-Dimethyl-1-pentene                        |                              |                              |                      |                  | -117.0                       |                              |                      |                  | -83.8                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 4,4-Dimethyl-1-pentene                        |                              |                              |                      |                  | -110.6                       |                              |                      |                  | -81.6                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 2,4-Dimethyl-2-pentene                        |                              |                              |                      |                  | -123.1                       |                              |                      |                  | -88.7                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>cis</i> -4,4-Dimethyl-2-pentene            |                              |                              |                      |                  | -105.3                       |                              |                      |                  | -72.6                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>trans</i> -4,4-Dimethyl-2-pentene          |                              |                              |                      |                  | -121.7                       |                              |                      |                  | -88.8                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 2-Ethyl-3-methyl-1-butene                     |                              |                              |                      |                  | -114.1                       |                              |                      |                  | -79.5                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 2,3,3-Trimethyl-1-butene                      |                              |                              |                      |                  | -117.7                       |                              |                      |                  | -85.5                        |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | Cycloheptane                                  |                              |                              |                      |                  | -156.6                       |                              |                      |                  | -118.1                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | Methylcyclohexane                             |                              |                              |                      |                  | -190.1                       |                              |                      | 184.8            | -154.7                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | Ethylcyclopentane                             |                              |                              |                      |                  | -163.4                       |                              | 279.9                |                  | -126.9                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 1,1-Dimethylcyclopentane                      |                              |                              |                      |                  | -172.1                       |                              |                      |                  | -138.2                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>cis</i> -1,2-Dimethylcyclopentane          |                              |                              |                      |                  | -165.3                       |                              | 269.2                |                  | -129.5                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>trans</i> -1,2-Dimethylcyclopentane        |                              |                              |                      |                  | -171.2                       |                              |                      |                  | -136.6                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>cis</i> -1,3-Dimethylcyclopentane          |                              |                              |                      |                  | -170.1                       |                              |                      |                  | -135.8                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | <i>trans</i> -1,3-Dimethylcyclopentane        |                              |                              |                      |                  | -168.1                       |                              |                      |                  | -133.6                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub>                                | 1,1,2,2-Tetramethylcyclopropane               |                              |                              |                      |                  | -119.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> Br <sub>2</sub>                | 1,2-Dibromoheptane                            |                              |                              |                      |                  | -212.3                       |                              |                      |                  | -157.9                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | 1-Heptanal                                    |                              |                              |                      |                  | -311.5                       |                              | 335.4                | 230.1            | -263.8                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | 2-Heptanone                                   |                              |                              |                      |                  |                              |                              |                      | 232.6            |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | 3-Heptanone                                   |                              |                              |                      |                  |                              |                              |                      |                  | -297.1                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | 4-Heptanone                                   |                              |                              |                      |                  |                              |                              |                      |                  | -298.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | 2,2-Dimethyl-3-pentanone                      |                              |                              |                      |                  | -356.1                       |                              |                      |                  | -313.6                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | 2,4-Dimethyl-3-pentanone                      |                              |                              |                      |                  | -352.9                       |                              | 318.0                | 233.7            | -311.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | <i>cis</i> -2-Methylcyclohexanol              |                              |                              |                      |                  | -390.2                       |                              |                      |                  | -327.0                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | <i>trans</i> -2-Methylcyclohexanol, ( $\pm$ ) |                              |                              |                      |                  | -415.7                       |                              |                      |                  | -352.5                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | <i>cis</i> -3-Methylcyclohexanol, ( $\pm$ )   |                              |                              |                      |                  | -416.1                       |                              |                      |                  | -350.9                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | <i>trans</i> -3-Methylcyclohexanol, ( $\pm$ ) |                              |                              |                      |                  | -394.4                       |                              |                      |                  | -329.1                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | <i>cis</i> -4-Methylcyclohexanol              |                              |                              |                      |                  | -413.2                       |                              |                      |                  | -347.5                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O                              | <i>trans</i> -4-Methylcyclohexanol            |                              |                              |                      |                  | -433.3                       |                              |                      |                  | -367.2                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Heptanoic acid                                |                              |                              |                      |                  | -610.2                       |                              |                      | 265.4            | -536.2                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Pentyl acetate                                |                              |                              |                      |                  |                              |                              |                      | 261.0            |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Isopentyl acetate                             |                              |                              |                      |                  |                              |                              |                      | 248.5            |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Ethyl pentanoate                              |                              |                              |                      |                  | -553.0                       |                              |                      |                  | -505.9                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Ethyl 3-methylbutanoate                       |                              |                              |                      |                  | -571.0                       |                              |                      |                  | -527.0                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Ethyl 2,2-dimethylpropanoate                  |                              |                              |                      |                  | -577.2                       |                              |                      |                  | -536.0                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Methyl hexanoate                              |                              |                              |                      |                  | -540.2                       |                              |                      |                  | -492.2                       |                              |                      |                  |
| C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                 | $\alpha$ -Methylglucoside                     | -1233.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>15</sub> Br                             | 1-Bromoheptane                                |                              |                              |                      |                  | -218.4                       |                              |                      |                  | -167.8                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub>                                | Heptane                                       |                              |                              |                      |                  | -224.2                       |                              |                      | 224.7            | -187.6                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub>                                | 2-Methylhexane                                |                              |                              |                      |                  | -229.5                       |                              | 323.3                | 222.9            | -194.5                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub>                                | 3-Methylhexane                                |                              |                              |                      |                  | -226.4                       |                              |                      |                  | -191.3                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub>                                | 3-Ethylpentane                                |                              |                              |                      |                  | -224.9                       |                              | 314.5                | 219.6            | -189.5                       |                              |                      |                  |

| Molecular<br>formula                            | Name                                     | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------|------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                 |                                          | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>7</sub> H <sub>16</sub>                  | 2,2-Dimethylpentane                      |                              |                              |                      |                  | -238.3                       |                              | 300.3                | 221.1            | -205.7                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub>                  | 2,3-Dimethylpentane                      |                              |                              |                      |                  | -233.1                       |                              |                      |                  | -198.7                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub>                  | 2,4-Dimethylpentane                      |                              |                              |                      |                  | -234.6                       |                              | 303.2                | 224.2            | -201.6                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub>                  | 3,3-Dimethylpentane                      |                              |                              |                      |                  | -234.2                       |                              |                      |                  | -201.0                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub>                  | 2,2,3-Trimethylbutane                    |                              |                              |                      |                  | -236.5                       |                              | 292.2                | 213.5            | -204.4                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub> O                | 1-Heptanol                               |                              |                              |                      |                  | -403.3                       |                              |                      | 272.1            | -336.5                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub> O                | <i>tert</i> -Butyl isopropyl ether       |                              |                              |                      |                  | -392.8                       |                              |                      |                  | -358.1                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>   | 1,7-Heptanediol                          |                              |                              |                      |                  | -574.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>   | 2,2-Diethoxypropane                      |                              |                              |                      |                  | -538.9                       |                              |                      |                  | -506.9                       |                              |                      |                  |
| C <sub>7</sub> H <sub>16</sub> S                | 1-Heptanethiol                           |                              |                              |                      |                  | -200.5                       |                              |                      |                  | -149.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>    | Phthalic anhydride                       | -460.1                       |                              | 180.0                | 160.0            |                              |                              |                      |                  | -371.4                       |                              |                      |                  |
| C <sub>8</sub> H <sub>5</sub> NO <sub>2</sub>   | 1 <i>H</i> -Indole-2,3-dione             | -268.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>    | Phthalic acid                            | -782.0                       |                              | 207.9                | 188.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>    | Isophthalic acid                         | -803.0                       |                              |                      |                  |                              |                              |                      |                  | -696.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>    | Terephthalic acid                        | -816.1                       |                              |                      |                  |                              |                              |                      |                  | -717.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>6</sub> S                 | Benzo[b]thiophene                        | 100.6                        |                              |                      |                  |                              |                              |                      |                  | 166.3                        |                              |                      |                  |
| C <sub>8</sub> H <sub>7</sub> N                 | 1 <i>H</i> -Indole                       | 86.6                         |                              |                      |                  |                              |                              |                      |                  | 156.5                        |                              |                      |                  |
| C <sub>8</sub> H <sub>8</sub>                   | Styrene                                  |                              |                              |                      |                  | 103.8                        |                              |                      | 182.0            | 147.9                        |                              |                      |                  |
| C <sub>8</sub> H <sub>8</sub> O                 | Phenyl vinyl ether                       |                              |                              |                      |                  | -26.2                        |                              |                      |                  | 22.7                         |                              |                      |                  |
| C <sub>8</sub> H <sub>8</sub> O                 | Acetophenone                             |                              |                              |                      |                  | -142.5                       |                              |                      |                  | -86.7                        |                              |                      |                  |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>    | <i>o</i> -Toluic acid                    | -416.5                       |                              |                      | 174.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>    | <i>m</i> -Toluic acid                    | -426.1                       |                              |                      | 163.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>    | <i>p</i> -Toluic acid                    | -429.2                       |                              |                      | 169.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>    | Methyl benzoate                          |                              |                              |                      |                  | -343.5                       |                              |                      | 221.3            | -287.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>    | Methyl salicylate                        |                              |                              |                      |                  |                              |                              |                      | 249.0            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>9</sub> NO                | Acetanilide                              | -209.4                       |                              |                      | 179.3            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub>                  | 1,7-Octadiyne                            |                              |                              |                      |                  | 334.4                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub>                  | Ethylbenzene                             |                              |                              |                      |                  | -12.3                        |                              |                      | 183.2            | 29.9                         |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub>                  | <i>o</i> -Xylene                         |                              |                              |                      |                  | -24.4                        |                              |                      | 186.1            | 19.1                         |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub>                  | <i>m</i> -Xylene                         |                              |                              |                      |                  | -25.4                        |                              |                      | 183.0            | 17.3                         |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub>                  | <i>p</i> -Xylene                         |                              |                              |                      |                  | -24.4                        |                              |                      | 181.5            | 18.0                         |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 2-Ethylphenol                            |                              |                              |                      |                  | -208.8                       |                              |                      |                  | -145.2                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 3-Ethylphenol                            |                              |                              |                      |                  | -214.3                       |                              |                      |                  | -146.1                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 4-Ethylphenol                            | -224.4                       |                              |                      | 206.9            |                              |                              |                      |                  | -144.1                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 2,3-Xylenol                              | -241.1                       |                              |                      |                  |                              |                              |                      |                  | -157.2                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 2,4-Xylenol                              |                              |                              |                      |                  | -228.7                       |                              |                      |                  | -163.8                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 2,5-Xylenol                              | -246.6                       |                              |                      |                  |                              |                              |                      |                  | -161.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 2,6-Xylenol                              | -237.4                       |                              |                      |                  |                              |                              |                      |                  | -162.1                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 3,4-Xylenol                              | -242.3                       |                              |                      |                  |                              |                              |                      |                  | -157.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | 3,5-Xylenol                              | -244.4                       |                              |                      |                  |                              |                              |                      |                  | -162.4                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | Benzeneethanol                           |                              |                              |                      |                  |                              |                              |                      | 252.6            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O                | Ethoxybenzene                            |                              |                              |                      |                  | -152.6                       |                              |                      | 228.5            | -101.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>   | 1,2-Dimethoxybenzene                     |                              |                              |                      |                  | -290.3                       |                              |                      |                  | -223.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>11</sub> N                | <i>N</i> -Ethylaniline                   |                              |                              |                      |                  | 8.2                          |                              |                      |                  | 56.3                         |                              |                      |                  |
| C <sub>8</sub> H <sub>11</sub> N                | <i>N,N</i> -Dimethylaniline              |                              |                              |                      |                  | 46.0                         |                              |                      |                  | 100.5                        |                              |                      |                  |
| C <sub>8</sub> H <sub>11</sub> N                | 2,4-Dimethylaniline                      |                              |                              |                      |                  | -39.2                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>11</sub> N                | 2,5-Dimethylaniline                      |                              |                              |                      |                  | -38.9                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>11</sub> N                | 2,6-Dimethylaniline                      |                              |                              |                      |                  |                              |                              |                      | 238.9            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>12</sub>                  | 1-Octen-3-yne                            |                              |                              |                      |                  | 140.7                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>12</sub>                  | <i>cis</i> -1,2-Divinylcyclobutane       |                              |                              |                      |                  | 124.3                        |                              |                      |                  | 166.5                        |                              |                      |                  |
| C <sub>8</sub> H <sub>12</sub>                  | <i>trans</i> -1,2-Divinylcyclobutane     |                              |                              |                      |                  | 101.3                        |                              |                      |                  | 143.5                        |                              |                      |                  |
| C <sub>8</sub> H <sub>12</sub> N <sub>4</sub>   | 2,2'-Azobis[isobutyronitrile]            | 246.0                        |                              |                      | 237.6            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>   | 2,2,4,4-Tetramethyl-1,3-cyclobutanedione | -379.9                       |                              |                      |                  |                              |                              |                      |                  | -307.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>14</sub>                  | Ethylidenecyclohexane                    |                              |                              |                      |                  | -103.5                       |                              |                      |                  | -59.5                        |                              |                      |                  |
| C <sub>8</sub> H <sub>14</sub>                  | Allylcyclopentane                        |                              |                              |                      |                  | -64.5                        |                              |                      |                  | -24.1                        |                              |                      |                  |
| C <sub>8</sub> H <sub>14</sub> ClN <sub>5</sub> | Atrazine                                 | -125.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>   | Butanoic anhydride                       |                              |                              |                      |                  |                              |                              |                      | 283.7            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>15</sub> ClO <sub>2</sub> | 3-Methylbutyl 2-chloropropanoate         |                              |                              |                      |                  | -627.3                       |                              |                      |                  | -575.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>15</sub> ClO <sub>2</sub> | 3-Methylbutyl 3-chloropropanoate         |                              |                              |                      |                  | -593.4                       |                              |                      |                  | -539.4                       |                              |                      |                  |
| C <sub>8</sub> H <sub>15</sub> N                | Octanenitrile                            |                              |                              |                      |                  | -107.3                       |                              |                      |                  | -50.5                        |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | 1-Octene                                 |                              |                              |                      |                  | -124.5                       |                              |                      | 241.0            | -81.3                        |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>cis</i> -2-Octene                     |                              |                              |                      |                  | -135.7                       |                              |                      | 239.0            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>trans</i> -2-Octene                   |                              |                              |                      |                  | -135.7                       |                              |                      | 239.0            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>cis</i> -2,2-Dimethyl-3-hexene        |                              |                              |                      |                  | -126.4                       |                              |                      |                  | -89.3                        |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>trans</i> -2,2-Dimethyl-3-hexene      |                              |                              |                      |                  | -144.9                       |                              |                      |                  | -107.7                       |                              |                      |                  |

| Molecular<br>formula                            | Name                                       | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-------------------------------------------------|--------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                 |                                            | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>8</sub> H <sub>16</sub>                  | 3-Ethyl-2-methyl-1-pentene                 |                              |                              |                      |                  | -137.9                       |                              |                      |                  | -100.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | 2,4,4-Trimethyl-1-pentene                  |                              |                              |                      |                  | -145.9                       |                              |                      |                  | -110.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | 2,4,4-Trimethyl-2-pentene                  |                              |                              |                      |                  | -142.4                       |                              |                      |                  | -104.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | Cyclooctane                                |                              |                              |                      |                  | -167.7                       |                              |                      |                  | -124.4                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | Ethylcyclohexane                           |                              |                              |                      |                  | -212.1                       |                              | 280.9                | 211.8            | -171.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | 1,1-Dimethylcyclohexane                    |                              |                              |                      |                  | -218.7                       |                              | 267.2                | 209.2            | -180.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>cis</i> -1,2-Dimethylcyclohexane        |                              |                              |                      |                  | -211.8                       |                              | 274.1                | 210.2            | -172.1                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>trans</i> -1,2-Dimethylcyclohexane      |                              |                              |                      |                  | -218.2                       |                              | 273.2                | 209.4            | -179.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>cis</i> -1,3-Dimethylcyclohexane        |                              |                              |                      |                  | -222.9                       |                              | 272.6                | 209.4            | -184.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>trans</i> -1,3-Dimethylcyclohexane      |                              |                              |                      |                  | -215.7                       |                              | 276.3                | 212.8            | -176.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>cis</i> -1,4-Dimethylcyclohexane        |                              |                              |                      |                  | -215.6                       |                              | 271.1                | 212.1            | -176.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>trans</i> -1,4-Dimethylcyclohexane      |                              |                              |                      |                  | -222.4                       |                              | 268.0                | 210.2            | -184.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | Propylcyclopentane                         |                              |                              |                      |                  | -188.8                       |                              | 310.8                | 216.3            | -147.7                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | 1-Ethyl-1-methylcyclopentane               |                              |                              |                      |                  | -193.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>cis</i> -1-Ethyl-2-methylcyclopentane   |                              |                              |                      |                  | -190.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>trans</i> -1-Ethyl-2-methylcyclopentane |                              |                              |                      |                  | -195.1                       |                              |                      |                  | -156.2                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>cis</i> -1-Ethyl-3-methylcyclopentane   |                              |                              |                      |                  | -194.4                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub>                  | <i>trans</i> -1-Ethyl-3-methylcyclopentane |                              |                              |                      |                  | -196.0                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O                | Octanal                                    |                              |                              |                      |                  |                              |                              |                      |                  | -291.9                       |                              | 365.4                |                  |
| C <sub>8</sub> H <sub>16</sub> O                | 2-Ethylhexanal                             |                              |                              |                      |                  | -348.5                       |                              |                      |                  | -299.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O                | 2-Octanone                                 |                              |                              |                      |                  |                              |                              |                      | 273.3            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O                | 2,2,4-Trimethyl-3-pentanone                |                              |                              |                      |                  | -381.6                       |                              |                      |                  | -338.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>   | Octanoic acid                              |                              |                              |                      |                  | -636.0                       |                              |                      | 297.9            | -554.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>   | 2-Ethylhexanoic acid                       |                              |                              |                      |                  | -635.1                       |                              |                      |                  | -559.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>   | Hexyl acetate                              |                              |                              |                      |                  |                              |                              |                      | 282.8            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>   | Isobutyl isobutanoate                      |                              |                              |                      |                  | -587.4                       |                              |                      |                  | -542.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>   | Propyl pentanoate                          |                              |                              |                      |                  | -583.0                       |                              |                      |                  | -533.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>   | Isopropyl pentanoate                       |                              |                              |                      |                  | -592.2                       |                              |                      |                  | -544.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>   | Methyl heptanoate                          |                              |                              |                      |                  | -567.1                       |                              |                      | 285.1            | -515.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>17</sub> Br               | 1-Bromooctane                              |                              |                              |                      |                  | -245.1                       |                              |                      |                  | -189.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>17</sub> Cl               | 1-Chlorooctane                             |                              |                              |                      |                  | -291.3                       |                              |                      |                  | -238.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>17</sub> NO               | Octanamide                                 | -473.2                       |                              |                      |                  |                              |                              |                      |                  | -362.7                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | Octane                                     |                              |                              |                      |                  | -250.1                       |                              |                      | 254.6            | -208.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2-Methylheptane                            |                              |                              |                      |                  | -255.0                       |                              | 356.4                | 252.0            | -215.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 3-Methylheptane, (S)                       |                              |                              |                      |                  | -252.3                       |                              | 362.6                | 250.2            | -212.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 4-Methylheptane                            |                              |                              |                      |                  | -251.6                       |                              |                      | 251.1            | -211.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 3-Ethylhexane                              |                              |                              |                      |                  | -250.4                       |                              |                      |                  | -210.7                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,2-Dimethylhexane                         |                              |                              |                      |                  | -261.9                       |                              |                      |                  | -224.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,3-Dimethylhexane                         |                              |                              |                      |                  | -252.6                       |                              |                      |                  | -213.8                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,4-Dimethylhexane                         |                              |                              |                      |                  | -257.0                       |                              |                      |                  | -219.2                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,5-Dimethylhexane                         |                              |                              |                      |                  | -260.4                       |                              |                      | 249.2            | -222.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 3,3-Dimethylhexane                         |                              |                              |                      |                  | -257.5                       |                              |                      | 246.6            | -219.9                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 3,4-Dimethylhexane                         |                              |                              |                      |                  | -251.8                       |                              |                      |                  | -212.8                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 3-Ethyl-2-methylpentane                    |                              |                              |                      |                  | -249.6                       |                              |                      |                  | -211.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 3-Ethyl-3-methylpentane                    |                              |                              |                      |                  | -252.8                       |                              |                      |                  | -214.8                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,2,3-Trimethylpentane                     |                              |                              |                      |                  | -256.9                       |                              |                      |                  | -220.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,2,4-Trimethylpentane                     |                              |                              |                      |                  | -259.2                       |                              |                      | 239.1            | -224.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,3,3-Trimethylpentane                     |                              |                              |                      |                  | -253.5                       |                              |                      | 245.6            | -216.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,3,4-Trimethylpentane                     |                              |                              |                      |                  | -255.0                       |                              | 329.3                | 247.3            | -217.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub>                  | 2,2,3,3-Tetramethylbutane                  | -269.0                       |                              | 273.7                | 239.2            |                              |                              |                      |                  | -226.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> N <sub>2</sub>   | Azobutane                                  |                              |                              |                      |                  | -40.1                        |                              |                      |                  | 9.2                          |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O                | 1-Octanol                                  |                              |                              |                      |                  | -426.5                       |                              |                      | 305.2            | -355.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O                | 2-Octanol                                  |                              |                              |                      |                  |                              |                              |                      | 330.1            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O                | 2-Ethyl-1-hexanol                          |                              |                              |                      |                  | -432.8                       |                              | 347.0                | 317.5            | -365.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O                | Dibutyl ether                              |                              |                              |                      |                  | -377.9                       |                              |                      | 278.2            | -332.8                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O                | Di- <i>sec</i> -butyl ether                |                              |                              |                      |                  | -401.5                       |                              |                      |                  | -360.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O                | Di- <i>tert</i> -butyl ether               |                              |                              |                      |                  | -399.6                       |                              |                      | 276.1            | -362.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O                | <i>tert</i> -Butyl isobutyl ether          |                              |                              |                      |                  | -409.1                       |                              |                      |                  | -369.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>   | 1,8-Octanediol                             | -626.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>   | 2,5-Dimethyl-2,5-hexanediol                | -681.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>   | Diethylene glycol monobutyl ether          |                              |                              |                      |                  |                              |                              |                      | 354.9            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>   | Diethylene glycol diethyl ether            |                              |                              |                      |                  |                              |                              |                      | 341.4            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O <sub>3</sub> S | Dibutyl sulfite                            |                              |                              |                      |                  | -693.1                       |                              |                      |                  | -625.3                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>   | Tetraethylene glycol                       |                              |                              |                      |                  | -981.7                       |                              |                      | 428.8            | -883.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> S                | Dibutyl sulfide                            |                              |                              |                      |                  | -220.7                       |                              | 405.1                | 284.3            | -167.7                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> S                | Di- <i>sec</i> -butyl sulfide              |                              |                              |                      |                  | -220.7                       |                              |                      |                  | -167.7                       |                              |                      |                  |

| Molecular<br>formula                                            | Name                                                          | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|-----------------------------------------------------------------|---------------------------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                                 |                                                               | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>8</sub> H <sub>18</sub> S                                | Di- <i>tert</i> -butyl sulfide                                |                              |                              |                      |                  | -232.6                       |                              |                      |                  | -188.8                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> S                                | Diisobutyl sulfide                                            |                              |                              |                      |                  | -229.2                       |                              |                      |                  | -180.5                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> S <sub>2</sub>                   | Dibutyl disulfide                                             |                              |                              |                      |                  | -222.9                       |                              |                      |                  | -160.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>18</sub> S <sub>2</sub>                   | Di- <i>tert</i> -butyl disulfide                              |                              |                              |                      |                  | -255.2                       |                              |                      |                  | -201.0                       |                              |                      |                  |
| C <sub>8</sub> H <sub>19</sub> N                                | Dibutylamine                                                  |                              |                              |                      |                  | -206.0                       |                              |                      | 292.9            | -156.6                       |                              |                      |                  |
| C <sub>8</sub> H <sub>19</sub> N                                | Diisobutylamine                                               |                              |                              |                      |                  | -218.5                       |                              |                      |                  | -179.2                       |                              |                      |                  |
| C <sub>8</sub> H <sub>20</sub> BrN                              | Tetraethylammonium bromide                                    | -342.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>20</sub> O <sub>4</sub> Si                | Ethyl silicate                                                |                              |                              |                      |                  |                              |                              | 533.1                | 364.4            |                              |                              |                      |                  |
| C <sub>8</sub> H <sub>20</sub> Pb                               | Tetraethyl lead                                               |                              |                              |                      |                  | 52.7                         |                              | 464.6                | 307.4            | 109.6                        |                              |                      |                  |
| C <sub>8</sub> H <sub>20</sub> Si                               | Tetraethylsilane                                              |                              |                              |                      |                  |                              |                              |                      | 298.1            |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>     | Toluene-2,4-diisocyanate                                      |                              |                              |                      |                  |                              |                              |                      | 287.8            |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>7</sub> N                                 | Quinoline                                                     |                              |                              |                      |                  | 141.2                        |                              |                      |                  | 200.5                        |                              |                      |                  |
| C <sub>9</sub> H <sub>7</sub> N                                 | Isoquinoline                                                  |                              |                              |                      |                  | 144.3                        |                              | 216.0                | 196.2            | 204.6                        |                              |                      |                  |
| C <sub>9</sub> H <sub>7</sub> NO                                | 2-Quinolinol                                                  | -144.9                       |                              |                      |                  |                              |                              |                      |                  | -25.5                        |                              |                      |                  |
| C <sub>9</sub> H <sub>7</sub> NO                                | 8-Quinolinol                                                  | 82.1                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>8</sub>                                   | Indene                                                        |                              |                              |                      |                  | 110.6                        |                              | 215.3                | 186.9            | 163.4                        |                              |                      |                  |
| C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                    | 2-(Acetyloxy)benzoic acid                                     | -815.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>10</sub>                                  | Cyclopropylbenzene                                            |                              |                              |                      |                  | 100.3                        |                              |                      |                  | 150.5                        |                              |                      |                  |
| C <sub>9</sub> H <sub>10</sub>                                  | Indan                                                         |                              |                              |                      |                  | 11.5                         |                              | 56.0                 | 190.2            | 60.3                         |                              |                      |                  |
| C <sub>9</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> O | Diuron                                                        | -329.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>10</sub> N <sub>2</sub>                   | 2,2'-Dipyrrolylmethane                                        | 126.2                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                   | Ethyl benzoate                                                |                              |                              |                      |                  |                              |                              |                      | 246.0            |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                   | Benzyl acetate                                                |                              |                              |                      |                  |                              |                              |                      | 148.5            |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                  | <i>L</i> -Phenylalanine                                       | -466.9                       |                              | 213.6                | 203.0            |                              |                              |                      |                  | -312.9                       |                              |                      |                  |
| C <sub>9</sub> H <sub>11</sub> NO <sub>3</sub>                  | <i>L</i> -Tyrosine                                            | -685.1                       |                              | 214.0                | 216.4            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub>                                  | Propylbenzene                                                 |                              |                              |                      |                  | -38.3                        |                              | 287.8                | 214.7            | 7.9                          |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub>                                  | Isopropylbenzene                                              |                              |                              |                      |                  | -41.1                        |                              |                      | 210.7            | 4.0                          |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub>                                  | 2-Ethyltoluene                                                |                              |                              |                      |                  | -46.4                        |                              |                      |                  | 1.3                          |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub>                                  | 3-Ethyltoluene                                                |                              |                              |                      |                  | -48.7                        |                              |                      |                  | -1.8                         |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub>                                  | 4-Ethyltoluene                                                |                              |                              |                      |                  | -49.8                        |                              |                      |                  | -3.2                         |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub>                                  | 1,2,3-Trimethylbenzene                                        |                              |                              |                      |                  | -58.5                        |                              | 267.9                | 216.4            | -9.5                         |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub>                                  | 1,2,4-Trimethylbenzene                                        |                              |                              |                      |                  | -61.8                        |                              |                      | 215.0            | -13.8                        |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub>                                  | 1,3,5-Trimethylbenzene                                        |                              |                              |                      |                  | -63.4                        |                              |                      | 209.3            | -15.9                        |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub> O                                | 2-Isopropylphenol                                             |                              |                              |                      |                  | -233.7                       |                              |                      |                  | -182.2                       |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub> O                                | 3-Isopropylphenol                                             |                              |                              |                      |                  | -252.5                       |                              |                      |                  | -196.0                       |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub> O                                | 4-Isopropylphenol                                             | -270.0                       |                              |                      |                  |                              |                              |                      |                  | -175.3                       |                              |                      |                  |
| C <sub>9</sub> H <sub>12</sub> O <sub>2</sub>                   | Isopropylbenzene hydroperoxide                                |                              |                              |                      |                  | -148.3                       |                              |                      |                  | -78.4                        |                              |                      |                  |
| C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | Ethyl 3,5-dimethylpyrrole-2-carboxylate                       | -474.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | Ethyl 2,4-dimethylpyrrole-3-carboxylate                       | -463.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | Ethyl 2,5-dimethylpyrrole-3-carboxylate                       | -478.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>13</sub> NO <sub>2</sub>                  | Ethyl 4,5-dimethylpyrrole-3-carboxylate                       | -470.3                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>14</sub> O                                | Isophorone                                                    |                              |                              |                      |                  |                              |                              |                      | 253.5            |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>14</sub> O <sub>6</sub>                   | Triacetin                                                     |                              |                              |                      |                  | -1330.8                      |                              | 458.3                | 384.7            | -1245.0                      |                              |                      |                  |
| C <sub>9</sub> H <sub>15</sub> N                                | 3-Ethyl-2,4,5-trimethylpyrrole                                | -89.2                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>16</sub>                                  | 1-Nonyne                                                      |                              |                              |                      |                  | 16.3                         |                              |                      |                  | 62.3                         |                              |                      |                  |
| C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                   | Nonanedioic acid                                              | -1054.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>17</sub> NO                               | 2,2,6,6-Tetramethyl-4-piperidinone                            | -334.2                       |                              |                      |                  |                              |                              |                      |                  | -273.4                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub>                                  | Propylcyclohexane                                             |                              |                              |                      |                  | -237.4                       |                              | 311.9                | 242.0            | -192.3                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub>                                  | 1 $\alpha$ ,3 $\alpha$ ,5 $\beta$ -1,3,5-Trimethylcyclohexane |                              |                              |                      |                  |                              |                              |                      |                  | -212.1                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub> O                                | 2-Nonanone                                                    |                              |                              |                      |                  | -397.2                       |                              |                      |                  | -340.7                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub> O                                | 5-Nonanone                                                    |                              |                              |                      |                  | -398.2                       |                              | 401.4                | 303.6            | -344.9                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub> O                                | 2,6-Dimethyl-4-heptanone                                      |                              |                              |                      |                  | -408.5                       |                              |                      | 297.3            | -357.6                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                   | Nonanoic acid                                                 |                              |                              |                      |                  | -659.7                       |                              |                      | 362.4            | -577.3                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                   | Butyl pentanoate                                              |                              |                              |                      |                  | -613.3                       |                              |                      |                  | -560.2                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                   | <i>sec</i> -Butyl pentanoate                                  |                              |                              |                      |                  | -624.2                       |                              |                      |                  | -573.2                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                   | Isobutyl pentanoate                                           |                              |                              |                      |                  | -620.0                       |                              |                      |                  | -568.6                       |                              |                      |                  |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                   | Methyl octanoate                                              |                              |                              |                      |                  | -590.3                       |                              |                      |                  | -533.9                       |                              |                      |                  |
| C <sub>9</sub> H <sub>19</sub> N                                | <i>N</i> -Butylpiperidine                                     |                              |                              |                      |                  | -171.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>19</sub> N                                | 2,2,6,6-Tetramethylpiperidine                                 |                              |                              |                      |                  | -206.9                       |                              |                      |                  | -159.9                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                  | Nonane                                                        |                              |                              |                      |                  | -274.7                       |                              |                      | 284.4            | -228.2                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                  | 2,2-Dimethylheptane                                           |                              |                              |                      |                  | -288.1                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                  | 2,2,3-Trimethylhexane                                         |                              |                              |                      |                  | -282.7                       |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                                          | Name                                           | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|---------------------------------------------------------------|------------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                               |                                                | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>9</sub> H <sub>20</sub>                                | 2,2,4-Trimethylhexane                          |                              |                              |                      |                  | -282.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 2,2,5-Trimethylhexane                          |                              |                              |                      |                  | -293.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 2,3,3-Trimethylhexane                          |                              |                              |                      |                  | -281.1                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 2,3,5-Trimethylhexane                          |                              |                              |                      |                  | -284.0                       |                              |                      |                  | -242.6                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 2,4,4-Trimethylhexane                          |                              |                              |                      |                  | -280.2                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 3,3,4-Trimethylhexane                          |                              |                              |                      |                  | -277.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 3,3-Diethylpentane                             |                              |                              |                      |                  | -275.4                       |                              |                      | 278.2            | -233.3                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 3-Ethyl-2,2-dimethylpentane                    |                              |                              |                      |                  | -272.7                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 3-Ethyl-2,4-dimethylpentane                    |                              |                              |                      |                  | -269.7                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 2,2,3,3-Tetramethylpentane                     |                              |                              |                      |                  | -278.3                       |                              |                      | 271.5            | -237.1                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 2,2,3,4-Tetramethylpentane                     |                              |                              |                      |                  | -277.7                       |                              |                      |                  | -236.9                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 2,2,4,4-Tetramethylpentane                     |                              |                              |                      |                  | -280.0                       |                              |                      | 266.3            | -241.6                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub>                                | 2,3,3,4-Tetramethylpentane                     |                              |                              |                      |                  | -277.9                       |                              |                      |                  | -236.1                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub> N <sub>2</sub> O               | Tetraethylurea                                 |                              |                              |                      |                  | -380.0                       |                              |                      |                  | -316.4                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub> O                              | 1-Nonanol                                      |                              |                              |                      |                  | -453.4                       |                              |                      |                  | -376.5                       |                              |                      |                  |
| C <sub>9</sub> H <sub>20</sub> O <sub>2</sub>                 | 1,9-Nonanediol                                 | -657.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>9</sub> H <sub>21</sub> N                              | Tripropylamine                                 |                              |                              |                      |                  | -207.1                       |                              |                      |                  | -161.0                       |                              |                      |                  |
| C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                 | 2-Quinolinecarbonitrile                        | 246.5                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                 | 3-Quinolinecarbonitrile                        | 242.3                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub>  | 1,5-Dinitronaphthalene                         | 29.8                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub>  | 1,8-Dinitronaphthalene                         | 39.7                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>7</sub> Cl                             | 1-Chloronaphthalene                            |                              |                              |                      |                  | 54.6                         |                              |                      | 212.6            | 119.8                        |                              |                      |                  |
| C <sub>10</sub> H <sub>7</sub> Cl                             | 2-Chloronaphthalene                            | 55.4                         |                              |                      |                  |                              |                              |                      |                  | 137.4                        |                              |                      |                  |
| C <sub>10</sub> H <sub>7</sub> I                              | 1-Iodonaphthalene                              |                              |                              |                      |                  | 161.5                        |                              |                      |                  | 233.8                        |                              |                      |                  |
| C <sub>10</sub> H <sub>7</sub> I                              | 2-Iodonaphthalene                              | 144.3                        |                              |                      |                  |                              |                              |                      |                  | 235.1                        |                              |                      |                  |
| C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>                | 1-Nitronaphthalene                             | 42.6                         |                              |                      |                  |                              |                              |                      |                  | 111.2                        |                              |                      |                  |
| C <sub>10</sub> H <sub>8</sub>                                | Naphthalene                                    | 78.5                         | 201.6                        | 167.4                | 165.7            |                              |                              |                      |                  | 150.6                        | 224.1                        | 333.1                | 131.9            |
| C <sub>10</sub> H <sub>8</sub>                                | Azulene                                        | 212.3                        |                              |                      |                  |                              |                              |                      |                  | 289.1                        |                              |                      |                  |
| C <sub>10</sub> H <sub>8</sub> O                              | 1-Naphthol                                     | -121.5                       |                              |                      | 166.9            |                              |                              |                      |                  | -30.4                        |                              |                      | 149.4            |
| C <sub>10</sub> H <sub>8</sub> O                              | 2-Naphthol                                     | -124.1                       |                              | 179.0                | 172.8            |                              |                              |                      |                  | -29.9                        |                              | 366.6                | 147.8            |
| C <sub>10</sub> H <sub>8</sub> N                              | 1-Naphthylamine                                | 67.8                         |                              |                      |                  |                              |                              |                      |                  | 132.8                        |                              |                      |                  |
| C <sub>10</sub> H <sub>8</sub> N                              | 2-Naphthylamine                                | 60.2                         |                              |                      |                  |                              |                              |                      |                  | 134.3                        |                              |                      |                  |
| C <sub>10</sub> H <sub>10</sub>                               | 1,2-Dihydronaphthalene                         |                              |                              |                      |                  | 71.6                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>10</sub>                               | 1,4-Dihydronaphthalene                         |                              |                              |                      |                  | 84.2                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>10</sub> O                             | 1-Tetralone                                    | -209.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                | Dimethyl phthalate                             |                              |                              |                      |                  |                              |                              |                      | 303.1            |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                | Dimethyl isophthalate                          | -730.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                | Dimethyl terephthalate                         | -732.6                       |                              |                      | 261.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>12</sub>                               | 1,2,3,4-Tetrahydronaphthalene                  |                              |                              |                      |                  | -29.2                        |                              |                      | 217.5            | 26.0                         |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | Butylbenzene                                   |                              |                              |                      |                  | -63.2                        |                              | 321.2                | 243.4            | -11.8                        |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | <i>sec</i> -Butylbenzene, (±)                  |                              |                              |                      |                  | -66.4                        |                              |                      |                  | -18.4                        |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | <i>tert</i> -Butylbenzene                      |                              |                              |                      |                  | -71.9                        |                              |                      |                  | -23.0                        |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | Isobutylbenzene                                |                              |                              |                      |                  | -69.8                        |                              |                      |                  | -21.9                        |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 1-Isopropyl-2-methylbenzene                    |                              |                              |                      |                  | -73.3                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 1-Isopropyl-3-methylbenzene                    |                              |                              |                      |                  | -78.6                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 1-Isopropyl-4-methylbenzene                    |                              |                              |                      |                  | -78.0                        |                              |                      | 236.4            |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | <i>o</i> -Diethylbenzene                       |                              |                              |                      |                  | -68.5                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | <i>m</i> -Diethylbenzene                       |                              |                              |                      |                  | -73.5                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | <i>p</i> -Diethylbenzene                       |                              |                              |                      |                  | -72.8                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 3-Ethyl-1,2-dimethylbenzene                    |                              |                              |                      |                  | -80.5                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 4-Ethyl-1,2-dimethylbenzene                    |                              |                              |                      |                  | -86.0                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 2-Ethyl-1,3-dimethylbenzene                    |                              |                              |                      |                  | -80.1                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 2-Ethyl-1,4-dimethylbenzene                    |                              |                              |                      |                  | -84.8                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 1-Ethyl-2,4-dimethylbenzene                    |                              |                              |                      |                  | -84.1                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 1-Ethyl-3,5-dimethylbenzene                    |                              |                              |                      |                  | -87.8                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub>                               | 1,2,4,5-Tetramethylbenzene                     | -119.9                       |                              | 245.6                | 215.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>14</sub> O                             | Thymol                                         | -309.7                       |                              |                      |                  |                              |                              |                      |                  | -218.5                       |                              |                      |                  |
| C <sub>10</sub> H <sub>16</sub>                               | Dipentene                                      |                              |                              |                      |                  | -50.8                        |                              |                      | 249.4            | -2.6                         |                              |                      |                  |
| C <sub>10</sub> H <sub>16</sub>                               | $\alpha$ -Limonene                             |                              |                              |                      |                  | -54.5                        |                              |                      | 249.0            |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>16</sub>                               | $\alpha$ -Pinene                               |                              |                              |                      |                  | -16.4                        |                              |                      |                  | 28.3                         |                              |                      |                  |
| C <sub>10</sub> H <sub>16</sub>                               | $\beta$ -Pinene                                |                              |                              |                      |                  | -7.7                         |                              |                      |                  | 38.7                         |                              |                      |                  |
| C <sub>10</sub> H <sub>16</sub>                               | $\alpha$ -Terpinene                            |                              |                              |                      |                  |                              |                              |                      |                  | -20.6                        |                              |                      |                  |
| C <sub>10</sub> H <sub>16</sub>                               | $\beta$ -Myrcene                               |                              |                              |                      |                  | 14.5                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>16</sub>                               | <i>cis, cis</i> -2,6-Dimethyl-2,4,6-octatriene |                              |                              |                      |                  | -24.0                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>16</sub> N <sub>2</sub> O <sub>8</sub> | Ethylenediaminetetraacetic acid                | -1759.5                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |

| Molecular<br>formula                                          | Name                                          | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|---------------------------------------------------------------|-----------------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                               |                                               | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>10</sub> H <sub>16</sub> O                             | Camphor, (±)                                  | -319.4                       |                              |                      | 271.2            |                              |                              |                      |                  | -267.5                       |                              |                      |                  |
| C <sub>10</sub> H <sub>18</sub>                               | 1,1'-Bicyclopentyl                            |                              |                              |                      |                  | -178.9                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>18</sub>                               | <i>cis</i> -Decahydronaphthalene              |                              |                              |                      |                  | -219.4                       |                              | 265.0                | 232.0            | -169.2                       |                              |                      |                  |
| C <sub>10</sub> H <sub>18</sub>                               | <i>trans</i> -Decahydronaphthalene            |                              |                              |                      |                  | -230.6                       |                              | 264.9                | 228.5            | -182.1                       |                              |                      |                  |
| C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                | Sebacic acid                                  | -1082.6                      |                              |                      |                  |                              |                              |                      |                  | -921.9                       |                              |                      |                  |
| C <sub>10</sub> H <sub>19</sub> N                             | Decanenitrile                                 |                              |                              |                      |                  | -158.4                       |                              |                      |                  | -91.5                        |                              |                      |                  |
| C <sub>10</sub> H <sub>20</sub>                               | 1-Decene                                      |                              |                              |                      |                  | -173.8                       |                              | 425.0                | 300.8            | -123.3                       |                              |                      |                  |
| C <sub>10</sub> H <sub>20</sub>                               | <i>cis</i> -1,2-Di- <i>tert</i> -butylethene  |                              |                              |                      |                  | -163.6                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>20</sub>                               | Butylcyclohexane                              |                              |                              |                      |                  | -263.1                       |                              | 345.0                | 271.0            | -213.7                       |                              |                      |                  |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                | Decanoic acid                                 | -713.7                       |                              |                      |                  | -684.3                       |                              |                      |                  | -594.9                       |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>                | Methyl nonanoate                              |                              |                              |                      |                  | -616.2                       |                              |                      |                  | -554.2                       |                              |                      |                  |
| C <sub>10</sub> H <sub>21</sub> NO <sub>2</sub>               | 1-Nitrodecane                                 |                              |                              |                      |                  | -351.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub>                               | Decane                                        |                              |                              |                      |                  | -300.9                       |                              |                      | 314.4            | -249.5                       |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub>                               | 2-Methylnonane                                |                              |                              |                      |                  | -309.8                       |                              | 420.1                | 313.3            | -260.2                       |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub>                               | 5-Methylnonane                                |                              |                              |                      |                  | -307.9                       |                              | 423.8                | 314.4            | -258.6                       |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> O                             | 1-Decanol                                     |                              |                              |                      |                  | -478.1                       |                              |                      | 370.6            | -396.6                       |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> O                             | Dipentyl ether                                |                              |                              |                      |                  |                              |                              |                      | 250.0            |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> O                             | Diisopentyl ether                             |                              |                              |                      |                  |                              |                              |                      | 379.0            |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>                | 1,10-Decanediol                               | -678.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>                | Ethylene glycol dibutyl ether                 |                              |                              |                      |                  |                              |                              |                      | 350.0            |                              |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> S                             | 1-Decanethiol                                 | -309.9                       |                              |                      |                  | -276.5                       |                              | 476.1                | 350.4            | -211.5                       |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> S                             | Dipentyl sulfide                              |                              |                              |                      |                  | -266.4                       |                              |                      |                  | -204.9                       |                              |                      |                  |
| C <sub>10</sub> H <sub>22</sub> S                             | Diisopentyl sulfide                           |                              |                              |                      |                  | -281.8                       |                              |                      |                  | -221.5                       |                              |                      |                  |
| C <sub>10</sub> H <sub>23</sub> N                             | Octyldimethylamine                            |                              |                              |                      |                  | -232.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>11</sub> H <sub>6</sub> O <sub>2</sub>                 | 1-Naphthalenecarboxylic acid                  | -333.5                       |                              |                      |                  |                              |                              |                      |                  | -223.1                       |                              |                      |                  |
| C <sub>11</sub> H <sub>6</sub> O <sub>2</sub>                 | 2-Naphthalenecarboxylic acid                  | -346.1                       |                              |                      |                  |                              |                              |                      |                  | -232.5                       |                              |                      |                  |
| C <sub>11</sub> H <sub>10</sub>                               | 1-Methylnaphthalene                           |                              |                              |                      |                  | 56.3                         |                              | 254.8                | 224.4            |                              |                              |                      |                  |
| C <sub>11</sub> H <sub>10</sub>                               | 2-Methylnaphthalene                           | 44.9                         |                              | 220.0                | 196.0            |                              |                              |                      |                  | 106.7                        |                              |                      |                  |
| C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> | <i>L</i> -Tryptophan                          | -415.3                       |                              | 251.0                | 238.1            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>11</sub> H <sub>14</sub>                               | 1,1-Dimethylindan                             |                              |                              |                      |                  | -53.6                        |                              |                      |                  | -1.6                         |                              |                      |                  |
| C <sub>11</sub> H <sub>16</sub>                               | 1- <i>tert</i> -Butyl-3-methylbenzene         |                              |                              |                      |                  | -109.7                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>11</sub> H <sub>16</sub>                               | 1- <i>tert</i> -Butyl-4-methylbenzene         |                              |                              |                      |                  | -109.7                       |                              |                      |                  | -57.0                        |                              |                      |                  |
| C <sub>11</sub> H <sub>16</sub>                               | Pentamethylbenzene                            | -144.6                       |                              |                      |                  |                              |                              |                      |                  | -67.2                        |                              |                      |                  |
| C <sub>11</sub> H <sub>20</sub>                               | Spiro[5.5]undecane                            |                              |                              |                      |                  | -244.5                       |                              |                      |                  | -188.3                       |                              |                      |                  |
| C <sub>11</sub> H <sub>22</sub>                               | 1-Undecene                                    |                              |                              |                      |                  |                              |                              |                      | 344.9            |                              |                              |                      |                  |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                | Methyl decanoate                              |                              |                              |                      |                  | -640.5                       |                              |                      |                  | -573.8                       |                              |                      |                  |
| C <sub>11</sub> H <sub>24</sub>                               | Undecane                                      |                              |                              |                      |                  | -327.2                       |                              |                      | 344.9            | -270.8                       |                              |                      |                  |
| C <sub>11</sub> H <sub>24</sub> O                             | 1-Undecanol                                   |                              |                              |                      |                  | -504.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> F <sub>27</sub> N                             | Tris(perfluorobutyl)amine                     |                              |                              |                      |                  |                              |                              |                      | 418.4            |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>8</sub>                                | Acenaphthylene                                | 186.7                        |                              |                      | 166.4            |                              |                              |                      |                  | 259.7                        |                              |                      |                  |
| C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>                 | Phenazine                                     | 237.0                        |                              |                      |                  |                              |                              |                      |                  | 328.8                        |                              |                      |                  |
| C <sub>12</sub> H <sub>6</sub> O                              | Dibenzofuran                                  | -5.3                         |                              |                      |                  |                              |                              |                      |                  | 83.4                         |                              |                      |                  |
| C <sub>12</sub> H <sub>6</sub> S                              | Dibenzothiophene                              | 120.0                        |                              |                      |                  |                              |                              |                      |                  | 205.1                        |                              |                      |                  |
| C <sub>12</sub> H <sub>6</sub> S <sub>2</sub>                 | Thianthrene                                   | 182.0                        |                              |                      |                  |                              |                              |                      |                  | 286.0                        |                              |                      |                  |
| C <sub>12</sub> H <sub>6</sub> N                              | Carbazole                                     | 101.7                        |                              |                      |                  |                              |                              |                      |                  | 200.7                        |                              |                      |                  |
| C <sub>12</sub> H <sub>10</sub>                               | Acenaphthene                                  | 70.3                         |                              | 188.9                | 190.4            |                              |                              |                      |                  | 156.0                        |                              |                      |                  |
| C <sub>12</sub> H <sub>10</sub>                               | Biphenyl                                      | 99.4                         |                              | 209.4                | 198.4            |                              |                              |                      |                  | 181.4                        |                              |                      |                  |
| C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O              | <i>trans</i> -Azoxybenzene                    | 243.4                        |                              |                      |                  |                              |                              |                      |                  | 342.0                        |                              |                      |                  |
| C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O              | <i>N</i> -Nitrosodiphenylamine                | 227.2                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>10</sub> O                             | Diphenyl ether                                | -32.1                        |                              | 233.9                | 216.6            | -14.9                        |                              |                      |                  | 52.0                         |                              |                      |                  |
| C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                | 1-Naphthaleneacetic acid                      | -359.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                | 2-Naphthaleneacetic acid                      | -371.9                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>11</sub> N                             | Diphenylamine                                 | 130.2                        |                              |                      |                  |                              |                              |                      |                  | 219.3                        |                              |                      |                  |
| C <sub>12</sub> H <sub>11</sub> N                             | 2-Aminobiphenyl                               | 93.8                         |                              |                      |                  |                              |                              |                      |                  | 184.4                        |                              |                      |                  |
| C <sub>12</sub> H <sub>11</sub> N                             | 4-Aminobiphenyl                               | 81.0                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                | <i>p</i> -Benzidine                           | 70.7                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                | Diethyl phthalate                             |                              |                              |                      |                  | -776.6                       |                              | 425.1                | 366.1            | -688.4                       |                              |                      |                  |
| C <sub>12</sub> H <sub>16</sub>                               | Cyclohexylbenzene                             |                              |                              |                      |                  | -76.6                        |                              |                      |                  | -16.7                        |                              |                      |                  |
| C <sub>12</sub> H <sub>17</sub> NO <sub>4</sub>               | Diethyl 3,5-dimethylpyrrole-2,4-dicarboxylate | -916.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>18</sub>                               | 3,9-Dodecadiyne                               |                              |                              |                      |                  | 197.8                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>18</sub>                               | 5,7-Dodecadiyne                               |                              |                              |                      |                  | 181.5                        |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>18</sub>                               | 1- <i>tert</i> -Butyl-3,5-dimethylbenzene     |                              |                              |                      |                  | -146.5                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>18</sub>                               | Hexamethylbenzene                             | -162.4                       |                              | 306.3                | 245.6            |                              |                              |                      |                  | -77.4                        |                              |                      |                  |
| C <sub>12</sub> H <sub>22</sub>                               | Cyclohexylcyclohexane                         |                              |                              |                      |                  | -273.7                       |                              |                      |                  | -215.7                       |                              |                      |                  |
| C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                | Dodecanedioic acid                            | -1130.0                      |                              |                      |                  |                              |                              |                      |                  | -976.9                       |                              |                      |                  |

| Molecular<br>formula                                           | Name                               | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|----------------------------------------------------------------|------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                                |                                    | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                | Sucrose                            | -2226.1                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                | $\beta$ -D-Lactose                 | -2236.7                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>24</sub>                                | 1-Dodecene                         |                              |                              |                      |                  | -226.2                       |                              | 484.8                | 360.7            | -165.4                       |                              |                      |                  |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                 | Dodecanoic acid                    | -774.6                       |                              |                      | 404.3            | -737.9                       |                              |                      |                  | -642.0                       |                              |                      |                  |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                 | Methyl undecanoate                 |                              |                              |                      |                  | -665.2                       |                              |                      |                  | -593.8                       |                              |                      |                  |
| C <sub>12</sub> H <sub>24</sub> O <sub>12</sub>                | $\alpha$ -Lactose monohydrate      | -2484.1                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>26</sub> Br                             | 1-Bromododecane                    |                              |                              |                      |                  | -344.7                       |                              |                      |                  | -269.9                       |                              |                      |                  |
| C <sub>12</sub> H <sub>26</sub> Cl                             | 1-Chlorododecane                   |                              |                              |                      |                  | -392.3                       |                              |                      |                  | -321.1                       |                              |                      |                  |
| C <sub>12</sub> H <sub>26</sub>                                | Dodecane                           |                              |                              |                      |                  | -350.9                       |                              |                      | 375.8            | -289.4                       |                              |                      |                  |
| C <sub>12</sub> H <sub>26</sub> O                              | 1-Dodecanol                        |                              |                              |                      |                  | -528.5                       |                              |                      | 438.1            | -436.6                       |                              |                      |                  |
| C <sub>12</sub> H <sub>26</sub> O <sub>3</sub>                 | Diethylene glycol dibutyl ether    |                              |                              |                      |                  |                              |                              |                      | 452.0            |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>27</sub> N                              | Tributylamine                      |                              |                              |                      |                  | -281.6                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>12</sub> H <sub>27</sub> O <sub>4</sub> P               | Tributyl phosphate                 |                              |                              |                      |                  |                              |                              |                      | 379.4            |                              |                              |                      |                  |
| C <sub>13</sub> H <sub>6</sub> O <sub>2</sub>                  | Xanthone                           | -191.5                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>13</sub> H <sub>9</sub> N                               | Acridine                           | 179.4                        |                              |                      |                  |                              |                              |                      |                  | 273.9                        |                              |                      |                  |
| C <sub>13</sub> H <sub>9</sub> N                               | Phenanthridine                     | 141.9                        |                              |                      |                  |                              |                              |                      |                  | 240.5                        |                              |                      |                  |
| C <sub>13</sub> H <sub>9</sub> N                               | Benzo[f]quinoline                  | 150.6                        |                              |                      |                  |                              |                              |                      |                  | 233.7                        |                              |                      |                  |
| C <sub>13</sub> H <sub>10</sub>                                | 9H-Fluorene                        | 89.9                         |                              | 207.3                | 203.1            |                              |                              |                      |                  | 175.0                        |                              |                      | 173.1            |
| C <sub>13</sub> H <sub>10</sub> N <sub>2</sub>                 | 9-Acridinamine                     | 159.2                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>13</sub> H <sub>10</sub> O                              | Benzophenone                       | -34.5                        |                              |                      | 224.8            |                              |                              |                      |                  | 54.9                         |                              |                      |                  |
| C <sub>13</sub> H <sub>11</sub> N                              | 9-Methyl-9H-carbazole              | 105.5                        |                              |                      |                  |                              |                              |                      |                  | 201.0                        |                              |                      |                  |
| C <sub>13</sub> H <sub>12</sub>                                | Diphenylmethane                    | 71.5                         |                              | 239.3                |                  | 89.7                         |                              |                      |                  | 139.0                        |                              |                      |                  |
| C <sub>13</sub> H <sub>13</sub> N                              | N-Benzylaniline                    | 101.4                        |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>13</sub> H <sub>14</sub> N <sub>2</sub>                 | 4,4'-Diaminodiphenylmethane        |                              |                              |                      | 270.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>13</sub> H <sub>24</sub> O <sub>4</sub>                 | Tridecanedioic acid                | -1148.3                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>13</sub> H <sub>26</sub>                                | 1-Tridecene                        |                              |                              |                      |                  |                              |                              |                      | 391.8            |                              |                              |                      |                  |
| C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                 | Methyl dodecanoate                 |                              |                              |                      |                  | -693.0                       |                              |                      |                  | -614.9                       |                              |                      |                  |
| C <sub>13</sub> H <sub>28</sub>                                | Tridecane                          |                              |                              |                      |                  |                              |                              |                      | 406.7            |                              |                              |                      |                  |
| C <sub>13</sub> H <sub>28</sub> O                              | 1-Tridecanol                       | -599.4                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>14</sub> H <sub>6</sub> O <sub>2</sub>                  | 9,10-Anthracenedione               | -188.5                       |                              |                      |                  |                              |                              |                      |                  | -75.7                        |                              |                      |                  |
| C <sub>14</sub> H <sub>6</sub> O <sub>2</sub>                  | 9,10-Phenanthrenedione             | -154.7                       |                              |                      |                  |                              |                              |                      |                  | -46.6                        |                              |                      |                  |
| C <sub>14</sub> H <sub>6</sub> O <sub>4</sub>                  | 1,4-Dihydroxy-9,10-anthracenedione | -595.8                       |                              |                      |                  |                              |                              |                      |                  | -471.7                       |                              |                      |                  |
| C <sub>14</sub> H <sub>10</sub>                                | Anthracene                         | 129.2                        |                              | 207.5                | 210.5            |                              |                              |                      |                  | 230.9                        |                              |                      |                  |
| C <sub>14</sub> H <sub>10</sub>                                | Phenanthrene                       | 116.2                        |                              | 215.1                | 220.6            |                              |                              |                      |                  | 207.5                        |                              |                      |                  |
| C <sub>14</sub> H <sub>10</sub>                                | Diphenylacetylene                  | 312.4                        |                              |                      | 225.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>14</sub> H <sub>10</sub> O <sub>2</sub>                 | Benzil                             | -153.9                       |                              |                      |                  |                              |                              |                      |                  | -55.5                        |                              |                      |                  |
| C <sub>14</sub> H <sub>10</sub> O <sub>4</sub>                 | Benzoyl peroxide                   | -369.4                       |                              |                      |                  |                              |                              |                      |                  | -281.7                       |                              |                      |                  |
| C <sub>14</sub> H <sub>12</sub>                                | cis-Stilbene                       |                              |                              |                      |                  | 183.3                        |                              |                      |                  | 252.3                        |                              |                      |                  |
| C <sub>14</sub> H <sub>12</sub>                                | trans-Stilbene                     | 136.9                        |                              |                      |                  |                              |                              |                      |                  | 236.1                        |                              |                      |                  |
| C <sub>14</sub> H <sub>14</sub>                                | 1,1-Diphenylethane                 |                              |                              |                      |                  | 48.7                         |                              |                      |                  |                              |                              |                      |                  |
| C <sub>14</sub> H <sub>14</sub>                                | 1,2-Diphenylethane                 | 51.5                         |                              |                      |                  |                              |                              |                      |                  | 142.9                        |                              |                      |                  |
| C <sub>14</sub> H <sub>22</sub>                                | 1,3-Di-tert-butylbenzene           |                              |                              |                      |                  | -188.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>14</sub> H <sub>22</sub>                                | 1,4-Di-tert-butylbenzene           | -212.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>14</sub> H <sub>23</sub> N <sub>3</sub> O <sub>10</sub> | Pentetic acid                      | -2225.2                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>14</sub> H <sub>27</sub> N                              | Tetradecanenitrile                 |                              |                              |                      |                  | -260.2                       |                              |                      |                  | -174.9                       |                              |                      |                  |
| C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                 | Tetradecanoic acid                 | -833.5                       |                              |                      | 432.0            | -788.8                       |                              |                      |                  | -693.7                       |                              |                      |                  |
| C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                 | Methyl tridecanoate                |                              |                              |                      |                  | -717.9                       |                              |                      |                  | -635.3                       |                              |                      |                  |
| C <sub>14</sub> H <sub>30</sub> O                              | 1-Tetradecanol                     | -629.6                       |                              |                      | 388.0            | -580.6                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>15</sub> H <sub>16</sub> O <sub>2</sub>                 | 2,2-Bis(4-hydroxyphenyl)propane    | -368.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>15</sub> H <sub>24</sub>                                | 1,3-Di-tert-butyl-5-methylbenzene  | -245.8                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>15</sub> H <sub>24</sub> O                              | 2,6-Di-tert-butyl-4-methylphenol   | -410.0                       |                              |                      |                  |                              |                              |                      |                  | -296.9                       |                              |                      |                  |
| C <sub>15</sub> H <sub>30</sub>                                | Decylcyclopentane                  |                              |                              |                      |                  | -367.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>15</sub> H <sub>30</sub> O <sub>2</sub>                 | Pentadecanoic acid                 | -861.7                       |                              |                      | 443.3            | -811.7                       |                              |                      |                  | -699.0                       |                              |                      |                  |
| C <sub>15</sub> H <sub>30</sub> O <sub>2</sub>                 | Methyl tetradecanoate              |                              |                              |                      |                  | -743.9                       |                              |                      |                  | -656.9                       |                              |                      |                  |
| C <sub>15</sub> H <sub>32</sub> O                              | 1-Pentadecanol                     | -658.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>16</sub> H <sub>10</sub>                                | Fluoranthene                       | 189.9                        |                              | 230.6                | 230.2            |                              |                              |                      |                  | 289.0                        |                              |                      |                  |
| C <sub>16</sub> H <sub>10</sub>                                | Pyrene                             | 125.5                        |                              | 224.9                | 229.7            |                              |                              |                      |                  | 225.7                        |                              |                      |                  |
| C <sub>16</sub> H <sub>22</sub> O <sub>4</sub>                 | Dibutyl phthalate                  |                              |                              |                      |                  | -842.6                       |                              |                      |                  | -750.9                       |                              |                      |                  |
| C <sub>16</sub> H <sub>22</sub> O <sub>11</sub>                | $\alpha$ -D-Glucose pentaacetate   | -2249.4                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>16</sub> H <sub>22</sub> O <sub>11</sub>                | $\beta$ -D-Glucose pentaacetate    | -2232.6                      |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>16</sub> H <sub>26</sub>                                | Decylbenzene                       |                              |                              |                      |                  | -218.3                       |                              |                      |                  | -138.6                       |                              |                      |                  |
| C <sub>16</sub> H <sub>32</sub>                                | 1-Hexadecene                       |                              |                              |                      |                  | -328.7                       |                              | 587.9                | 488.9            | -248.4                       |                              |                      |                  |
| C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                 | Hexadecanoic acid                  | -891.5                       |                              | 452.4                | 460.7            | -838.1                       |                              |                      |                  | -737.1                       |                              |                      |                  |
| C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                 | Methyl pentadecanoate              |                              |                              |                      |                  | -771.0                       |                              |                      |                  | -680.0                       |                              |                      |                  |
| C <sub>16</sub> H <sub>33</sub> Br                             | 1-Bromohexadecane                  |                              |                              |                      |                  | -444.5                       |                              |                      |                  | -350.2                       |                              |                      |                  |



| Molecular<br>formula                             | Name                                 | Crystal                      |                              |                      |                  | Liquid                       |                              |                      |                  | Gas                          |                              |                      |                  |
|--------------------------------------------------|--------------------------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|------------------------------|------------------------------|----------------------|------------------|
|                                                  |                                      | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K | $\Delta_f H^\circ$<br>kJ/mol | $\Delta_f G^\circ$<br>kJ/mol | $S^\circ$<br>J/mol K | $C_p$<br>J/mol K |
| C <sub>16</sub> H <sub>34</sub>                  | Hexadecane                           |                              |                              |                      |                  | -456.1                       |                              |                      | 501.6            | -374.8                       |                              |                      |                  |
| C <sub>16</sub> H <sub>34</sub> O                | 1-Hexadecanol                        | -686.5                       |                              |                      | 422.0            |                              |                              |                      |                  | -517.0                       |                              |                      |                  |
| C <sub>16</sub> H <sub>36</sub> N                | Tetrabutylammonium iodide            | -498.6                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>   | Heptadecanoic acid                   | -924.4                       |                              |                      | 475.7            | -865.6                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>18</sub> H <sub>12</sub>                  | Benz[a]anthracene                    | 170.8                        |                              |                      |                  |                              |                              |                      |                  | 293.0                        |                              |                      |                  |
| C <sub>18</sub> H <sub>12</sub>                  | Chrysene                             | 145.3                        |                              |                      |                  |                              |                              |                      |                  | 269.8                        |                              |                      |                  |
| C <sub>18</sub> H <sub>14</sub>                  | <i>o</i> -Terphenyl                  |                              |                              | 298.8                | 274.8            |                              |                              | 337.1                | 369.1            |                              |                              |                      |                  |
| C <sub>18</sub> H <sub>14</sub>                  | <i>p</i> -Terphenyl                  | 163.0                        |                              | 285.6                | 278.7            |                              |                              |                      |                  | 279.0                        |                              |                      |                  |
| C <sub>18</sub> H <sub>15</sub> N                | Triphenylamine                       | 234.7                        |                              |                      |                  |                              |                              |                      |                  | 326.8                        |                              |                      |                  |
| C <sub>18</sub> H <sub>15</sub> O <sub>4</sub> P | Triphenyl phosphate                  |                              |                              | 397.5                | 356.2            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>18</sub> H <sub>15</sub> P                | Triphenylphosphine                   |                              |                              |                      | 312.5            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>18</sub> H <sub>30</sub>                  | 1,3,5-Tri- <i>tert</i> -butylbenzene | -320.0                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>   | Oleic acid                           |                              |                              |                      |                  |                              |                              |                      | 577.0            |                              |                              |                      |                  |
| C <sub>18</sub> H <sub>34</sub> O <sub>4</sub>   | Dibutyl sebacate                     |                              |                              |                      |                  |                              |                              |                      | 619.0            |                              |                              |                      |                  |
| C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>   | Stearic acid                         | -947.7                       |                              |                      | 501.5            | -884.7                       |                              |                      |                  | -781.2                       |                              |                      |                  |
| C <sub>18</sub> H <sub>37</sub> Cl               | 1-Chlorooctadecane                   |                              |                              |                      |                  | -544.1                       |                              |                      |                  | -446.0                       |                              |                      |                  |
| C <sub>18</sub> H <sub>38</sub>                  | Octadecane                           | -567.4                       |                              | 480.2                | 485.6            |                              |                              |                      |                  | -414.6                       |                              |                      |                  |
| C <sub>18</sub> H <sub>39</sub> N                | Trihexylamine                        |                              |                              |                      |                  | -433.0                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>19</sub> H <sub>16</sub> O                | Triphenylmethanol                    | -2.5                         |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>   | Methyl oleate                        |                              |                              |                      |                  | -734.5                       |                              |                      |                  | -649.9                       |                              |                      |                  |
| C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>   | Methyl <i>trans</i> -9-octadecenoate |                              |                              |                      |                  | -737.0                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>20</sub> H <sub>12</sub>                  | Perylene                             | 182.8                        |                              | 264.6                | 274.9            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>20</sub> H <sub>12</sub>                  | Benzo[a]pyrene                       |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      | 254.8            |
| C <sub>20</sub> H <sub>14</sub> O <sub>4</sub>   | Diphenyl phthalate                   | -489.2                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>20</sub> H <sub>36</sub> O <sub>2</sub>   | Ethyl oleate                         |                              |                              |                      |                  | -775.8                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>20</sub> H <sub>36</sub> O <sub>2</sub>   | Ethyl <i>trans</i> -9-octadecenoate  |                              |                              |                      |                  | -773.3                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>   | Eicosanoic acid                      | -1011.9                      |                              |                      | 545.1            | -940.0                       |                              |                      |                  | -812.4                       |                              |                      |                  |
| C <sub>21</sub> H <sub>27</sub> O <sub>4</sub> P | Tri- <i>o</i> -cresyl phosphate      |                              |                              | 570.0                | 578.0            |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>22</sub> H <sub>14</sub>                  | Dibenz[a,h]anthracene                |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      | 283.9            |
| C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>   | <i>trans</i> -13-Docosenoic acid     | -960.7                       |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>   | Butyl oleate                         |                              |                              |                      |                  | -816.9                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>   | Butyl stearate                       |                              |                              |                      |                  |                              |                              |                      |                  |                              |                              |                      |                  |
| C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>   | Bis(2-ethylhexyl) phthalate          |                              |                              |                      |                  |                              |                              |                      | 704.7            |                              |                              |                      |                  |
| C <sub>24</sub> H <sub>51</sub> N                | Trioctylamine                        |                              |                              |                      |                  | -585.0                       |                              |                      |                  |                              |                              |                      |                  |
| C <sub>26</sub> H <sub>18</sub>                  | 9,10-Diphenylanthracene              | 308.7                        |                              |                      |                  |                              |                              |                      |                  | 465.6                        |                              |                      |                  |
| C <sub>26</sub> H <sub>54</sub>                  | 5-Butyldocosane                      |                              |                              |                      |                  | -713.5                       |                              |                      |                  | -587.6                       |                              |                      |                  |
| C <sub>26</sub> H <sub>54</sub>                  | 11-Butyldocosane                     |                              |                              |                      |                  | -716.0                       |                              |                      |                  | -593.4                       |                              |                      |                  |
| C <sub>28</sub> H <sub>18</sub>                  | 9,9'-Bianthracene                    | 326.2                        |                              |                      |                  |                              |                              |                      |                  | 454.3                        |                              |                      |                  |
| C <sub>31</sub> H <sub>64</sub>                  | 11-Decylheneicosane                  |                              |                              |                      |                  | -848.0                       |                              |                      |                  | -705.8                       |                              |                      |                  |
| C <sub>32</sub> H <sub>66</sub>                  | Dotriacontane                        | -968.3                       |                              |                      |                  |                              |                              |                      |                  | -697.2                       |                              |                      |                  |
| C <sub>60</sub>                                  | Carbon (fullerene-C <sub>60</sub> )  | 2327.0                       | 2302.0                       | 426.0                | 520.0            |                              |                              |                      |                  | 2502.0                       | 2442.0                       | 544.0                | 512.0            |
| C <sub>70</sub>                                  | Carbon (fullerene-C <sub>70</sub> )  | 2555.0                       | 2537.0                       | 464.0                | 650.0            |                              |                              |                      |                  | 2755.0                       | 2692.0                       | 614.0                | 585.0            |

# THERMODYNAMIC PROPERTIES AS A FUNCTION OF TEMPERATURE

L. V. Gurvich, V. S. Iorish, V. S. Yungman, and O. V. Dorofeeva

The thermodynamic properties  $C_p^\circ(T)$ ,  $S^\circ(T)$ ,  $H^\circ(T)-H^\circ(T_r)$ ,  $-[G^\circ(T)-H^\circ(T_r)]/T$  and formation properties  $\Delta_f H^\circ(T)$ ,  $\Delta_f G^\circ(T)$ ,  $\log K_f^\circ(T)$  are tabulated as functions of temperature in the range 298.15 to 1500 K for 80 substances in the standard state. The reference temperature,  $T_r$ , is equal to 298.15 K. The standard state pressure is taken as 1 bar (100,000 Pa). The tables are presented in the JANAF Thermochemical Tables format (Reference 2). The numerical data are extracted from IVTANTHERMO databases except for  $C_2H_4O$ ,  $C_3H_6O$ ,  $C_6H_6$ ,  $C_6H_6O$ ,  $C_{10}H_8$ , and  $CH_5N$ , which

are based upon TRC Tables. See the references for information on standard states and other details.

## References

1. Gurvich, L. V., Veyts, I. V., and Alcock, C. B., Eds., *Thermodynamic Properties of Individual Substances*, 4th ed., Hemisphere Publishing Corp., New York, 1989.
2. Chase, M. W., et al., *JANAF Thermochemical Tables*, 3rd ed., *J. Phys. Chem. Ref. Data*, 14, Suppl. 1, 1985.

## Order of Listing of Tables

| No. | Formula                                      | Name                    | State | No. | Formula           | Name                    | State |
|-----|----------------------------------------------|-------------------------|-------|-----|-------------------|-------------------------|-------|
| 1   | Ar                                           | Argon                   | g     | 42  | CuCl <sub>2</sub> | Copper dichloride       | g     |
| 2   | Br                                           | Bromine                 | g     | 43  | F                 | Fluorine                | g     |
| 3   | Br <sub>2</sub>                              | Dibromine               | g     | 44  | F <sub>2</sub>    | Difluorine              | g     |
| 4   | BrH                                          | Hydrogen bromide        | g     | 45  | FH                | Hydrogen fluoride       | g     |
| 5   | C                                            | Carbon (graphite)       | cr    | 46  | Ge                | Germanium               | cr, l |
| 6   | C                                            | Carbon (diamond)        | cr    | 47  | Ge                | Germanium               | g     |
| 7   | C <sub>2</sub>                               | Dicarbon                | g     | 48  | GeO <sub>2</sub>  | Germanium dioxide       | cr, l |
| 8   | C <sub>3</sub>                               | Tricarbon               | g     | 49  | GeCl <sub>4</sub> | Germanium tetrachloride | g     |
| 9   | CO                                           | Carbon oxide            | g     | 50  | H                 | Hydrogen                | g     |
| 10  | CO <sub>2</sub>                              | Carbon dioxide          | g     | 51  | H <sub>2</sub>    | Dihydrogen              | g     |
| 11  | CH <sub>4</sub>                              | Methane                 | g     | 52  | HO                | Hydroxyl                | g     |
| 12  | C <sub>2</sub> H <sub>2</sub>                | Acetylene               | g     | 53  | H <sub>2</sub> O  | Water                   | l     |
| 13  | C <sub>2</sub> H <sub>4</sub>                | Ethylene                | g     | 54  | H <sub>2</sub> O  | Water                   | g     |
| 14  | C <sub>2</sub> H <sub>6</sub>                | Ethane                  | g     | 55  | I                 | Iodine                  | g     |
| 15  | C <sub>3</sub> H <sub>6</sub>                | Cyclopropane            | g     | 56  | I <sub>2</sub>    | Diiodine                | cr, l |
| 16  | C <sub>3</sub> H <sub>8</sub>                | Propane                 | g     | 57  | I <sub>2</sub>    | Diiodine                | g     |
| 17  | C <sub>6</sub> H <sub>6</sub>                | Benzene                 | l     | 58  | IH                | Hydrogen iodide         | g     |
| 18  | C <sub>6</sub> H <sub>6</sub>                | Benzene                 | g     | 59  | K                 | Potassium               | cr, l |
| 19  | C <sub>10</sub> H <sub>8</sub>               | Naphthalene             | cr, l | 60  | K                 | Potassium               | g     |
| 20  | C <sub>10</sub> H <sub>8</sub>               | Naphthalene             | g     | 61  | K <sub>2</sub> O  | Dipotassium oxide       | cr, l |
| 21  | CH <sub>2</sub> O                            | Formaldehyde            | g     | 62  | KOH               | Potassium hydroxide     | cr, l |
| 22  | CH <sub>4</sub> O                            | Methanol                | g     | 63  | KOH               | Potassium hydroxide     | g     |
| 23  | C <sub>2</sub> H <sub>4</sub> O              | Acetaldehyde            | g     | 64  | KCl               | Potassium chloride      | cr, l |
| 24  | C <sub>2</sub> H <sub>6</sub> O              | Ethanol                 | g     | 65  | KCl               | Potassium chloride      | g     |
| 25  | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> | Acetic acid             | g     | 66  | N <sub>2</sub>    | Dinitrogen              | g     |
| 26  | C <sub>3</sub> H <sub>6</sub> O              | Acetone                 | g     | 67  | NO                | Nitric oxide            | g     |
| 27  | C <sub>6</sub> H <sub>6</sub> O              | Phenol                  | g     | 68  | NO <sub>2</sub>   | Nitrogen dioxide        | g     |
| 28  | CF <sub>4</sub>                              | Carbon tetrafluoride    | g     | 69  | NH <sub>3</sub>   | Ammonia                 | g     |
| 29  | CHF <sub>3</sub>                             | Trifluoromethane        | g     | 70  | O                 | Oxygen                  | g     |
| 30  | CClF <sub>3</sub>                            | Chlorotrifluoromethane  | g     | 71  | O <sub>2</sub>    | Dioxygen                | g     |
| 31  | CCl <sub>2</sub> F <sub>2</sub>              | Dichlorodifluoromethane | g     | 72  | S                 | Sulfur                  | cr, l |
| 32  | CHClF <sub>2</sub>                           | Chlorodifluoromethane   | g     | 73  | S                 | Sulfur                  | g     |
| 33  | CH <sub>5</sub> N                            | Methylamine             | g     | 74  | S <sub>2</sub>    | Disulfur                | g     |
| 34  | Cl                                           | Chlorine                | g     | 75  | S <sub>8</sub>    | Octasulfur              | g     |
| 35  | Cl <sub>2</sub>                              | Dichlorine              | g     | 76  | SO <sub>2</sub>   | Sulfur dioxide          | g     |
| 36  | ClH                                          | Hydrogen chloride       | g     | 77  | Si                | Silicon                 | cr    |
| 37  | Cu                                           | Copper                  | cr, l | 78  | Si                | Silicon                 | g     |
| 38  | Cu                                           | Copper                  | g     | 79  | SiO <sub>2</sub>  | Silicon dioxide         | cr    |
| 39  | CuO                                          | Copper oxide            | cr    | 80  | SiCl <sub>4</sub> | Silicon tetrachloride   | g     |
| 40  | Cu <sub>2</sub> O                            | Dicopper oxide          | cr    |     |                   |                         |       |
| 41  | CuCl <sub>2</sub>                            | Copper dichloride       | cr, l |     |                   |                         |       |

| <i>T</i> /K                               | J/K mol                           |                       |                     | kJ/mol         |                |                  | Log <i>K<sub>f</sub></i> |
|-------------------------------------------|-----------------------------------|-----------------------|---------------------|----------------|----------------|------------------|--------------------------|
|                                           | <i>C<sub>p</sub></i> <sup>o</sup> | <i>S</i> <sup>o</sup> | $-(G^o-H^o(T_i))/T$ | $H^o-H^o(T_i)$ | $\Delta_f H^o$ | $\Delta_f G^o$   |                          |
| <b>1. ARGON    Ar (g)</b>                 |                                   |                       |                     |                |                |                  |                          |
| 298.15                                    | 20.786                            | 154.845               | 154.845             | 0.000          | 0.000          | 0.000            | 0.000                    |
| 300                                       | 20.786                            | 154.973               | 154.845             | 0.038          | 0.000          | 0.000            | 0.000                    |
| 400                                       | 20.786                            | 160.953               | 155.660             | 2.117          | 0.000          | 0.000            | 0.000                    |
| 500                                       | 20.786                            | 165.591               | 157.200             | 4.196          | 0.000          | 0.000            | 0.000                    |
| 600                                       | 20.786                            | 169.381               | 158.924             | 6.274          | 0.000          | 0.000            | 0.000                    |
| 700                                       | 20.786                            | 172.585               | 160.653             | 8.353          | 0.000          | 0.000            | 0.000                    |
| 800                                       | 20.786                            | 175.361               | 162.322             | 10.431         | 0.000          | 0.000            | 0.000                    |
| 900                                       | 20.786                            | 177.809               | 163.909             | 12.510         | 0.000          | 0.000            | 0.000                    |
| 1000                                      | 20.786                            | 179.999               | 165.410             | 14.589         | 0.000          | 0.000            | 0.000                    |
| 1100                                      | 20.786                            | 181.980               | 166.828             | 16.667         | 0.000          | 0.000            | 0.000                    |
| 1200                                      | 20.786                            | 183.789               | 168.167             | 18.746         | 0.000          | 0.000            | 0.000                    |
| 1300                                      | 20.786                            | 185.453               | 169.434             | 20.824         | 0.000          | 0.000            | 0.000                    |
| 1400                                      | 20.786                            | 186.993               | 170.634             | 22.903         | 0.000          | 0.000            | 0.000                    |
| 1500                                      | 20.786                            | 188.427               | 171.773             | 24.982         | 0.000          | 0.000            | 0.000                    |
| <b>2. BROMINE    Br (g)</b>               |                                   |                       |                     |                |                |                  |                          |
| 298.15                                    | 20.786                            | 175.017               | 175.017             | 0.000          | 111.870        | 82.379           | −14.432                  |
| 300                                       | 20.786                            | 175.146               | 175.018             | 0.038          | 111.838        | 82.196           | −14.311                  |
| 400                                       | 20.787                            | 181.126               | 175.833             | 2.117          | 96.677         | 75.460           | −9.854                   |
| 500                                       | 20.798                            | 185.765               | 177.373             | 4.196          | 96.910         | 70.129           | −7.326                   |
| 600                                       | 20.833                            | 189.559               | 179.097             | 6.277          | 97.131         | 64.752           | −5.637                   |
| 700                                       | 20.908                            | 192.776               | 180.827             | 8.364          | 97.348         | 59.338           | −4.428                   |
| 800                                       | 21.027                            | 195.575               | 182.499             | 10.461         | 97.568         | 53.893           | −3.519                   |
| 900                                       | 21.184                            | 198.061               | 184.093             | 12.571         | 97.796         | 48.420           | −2.810                   |
| 1000                                      | 21.365                            | 200.302               | 185.604             | 14.698         | 98.036         | 42.921           | −2.242                   |
| 1100                                      | 21.559                            | 202.347               | 187.034             | 16.844         | 98.291         | 37.397           | −1.776                   |
| 1200                                      | 21.752                            | 204.231               | 188.390             | 19.010         | 98.560         | 31.850           | −1.386                   |
| 1300                                      | 21.937                            | 205.980               | 189.676             | 21.195         | 98.844         | 26.279           | −1.056                   |
| 1400                                      | 22.107                            | 207.612               | 190.900             | 23.397         | 99.141         | 20.686           | −0.772                   |
| 1500                                      | 22.258                            | 209.142               | 192.065             | 25.615         | 99.449         | 15.072           | −0.525                   |
| <b>3. DIBROMINE    Br<sub>2</sub> (g)</b> |                                   |                       |                     |                |                |                  |                          |
| 298.15                                    | 36.057                            | 245.467               | 245.467             | 0.000          | 30.910         | 3.105            | −0.544                   |
| 300                                       | 36.074                            | 245.690               | 245.468             | 0.067          | 30.836         | 2.933            | −0.511                   |
| 332.25                                    | 36.340                            | 249.387               | 245.671             | 1.235          |                | pressure = 1 bar |                          |
| 400                                       | 36.729                            | 256.169               | 246.892             | 3.711          | 0.000          |                  | 0.000                    |
| 500                                       | 37.082                            | 264.406               | 249.600             | 7.403          | 0.000          | 0.000            | 0.000                    |
| 600                                       | 37.305                            | 271.188               | 252.650             | 11.123         | 0.000          | 0.000            | 0.000                    |
| 700                                       | 37.464                            | 276.951               | 255.720             | 14.862         | 0.000          | 0.000            | 0.000                    |
| 800                                       | 37.590                            | 281.962               | 258.694             | 18.615         | 0.000          | 0.000            | 0.000                    |
| 900                                       | 37.697                            | 286.396               | 261.530             | 22.379         | 0.000          | 0.000            | 0.000                    |
| 1000                                      | 37.793                            | 290.373               | 264.219             | 26.154         | 0.000          | 0.000            | 0.000                    |
| 1100                                      | 37.883                            | 293.979               | 266.763             | 29.938         | 0.000          | 0.000            | 0.000                    |
| 1200                                      | 37.970                            | 297.279               | 269.170             | 33.730         | 0.000          | 0.000            | 0.000                    |
| 1300                                      | 38.060                            | 300.322               | 271.451             | 37.532         | 0.000          | 0.000            | 0.000                    |
| 1400                                      | 38.158                            | 303.146               | 273.615             | 41.343         | 0.000          | 0.000            | 0.000                    |
| 1500                                      | 38.264                            | 305.782               | 275.673             | 45.164         | 0.000          | 0.000            | 0.000                    |
| <b>4. HYDROGEN BROMIDE    HBr (g)</b>     |                                   |                       |                     |                |                |                  |                          |
| 298.15                                    | 29.141                            | 198.697               | 198.697             | 0.000          | −36.290        | −53.360          | 9.348                    |
| 300                                       | 29.141                            | 198.878               | 198.698             | 0.054          | −36.333        | −53.466          | 9.309                    |
| 400                                       | 29.220                            | 207.269               | 199.842             | 2.971          | −52.109        | −55.940          | 7.305                    |
| 500                                       | 29.454                            | 213.811               | 202.005             | 5.903          | −52.484        | −56.854          | 5.939                    |
| 600                                       | 29.872                            | 219.216               | 204.436             | 8.868          | −52.844        | −57.694          | 5.023                    |
| 700                                       | 30.431                            | 223.861               | 206.886             | 11.882         | −53.168        | −58.476          | 4.363                    |
| 800                                       | 31.063                            | 227.965               | 209.269             | 14.957         | −53.446        | −59.214          | 3.866                    |
| 900                                       | 31.709                            | 231.661               | 211.555             | 18.095         | −53.677        | −59.921          | 3.478                    |
| 1000                                      | 32.335                            | 235.035               | 213.737             | 21.298         | −53.864        | −60.604          | 3.166                    |
| 1100                                      | 32.919                            | 238.145               | 215.816             | 24.561         | −54.012        | −61.271          | 2.909                    |

| $T/K$ | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|-------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|       | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 1200  | 33.454      | 241.032   | 217.799                       | 27.880                   | -54.129            | -61.925            | 2.696     |
| 1300  | 33.938      | 243.729   | 219.691                       | 31.250                   | -54.220            | -62.571            | 2.514     |
| 1400  | 34.374      | 246.261   | 221.499                       | 34.666                   | -54.291            | -63.211            | 2.358     |
| 1500  | 34.766      | 248.646   | 223.230                       | 38.123                   | -54.348            | -63.846            | 2.223     |

**5. CARBON (GRAPHITE) C (cr; graphite)**

|        |        |        |        |        |       |       |       |
|--------|--------|--------|--------|--------|-------|-------|-------|
| 298.15 | 8.536  | 5.740  | 5.740  | 0.000  | 0.000 | 0.000 | 0.000 |
| 300    | 8.610  | 5.793  | 5.740  | 0.016  | 0.000 | 0.000 | 0.000 |
| 400    | 11.974 | 8.757  | 6.122  | 1.054  | 0.000 | 0.000 | 0.000 |
| 500    | 14.537 | 11.715 | 6.946  | 2.385  | 0.000 | 0.000 | 0.000 |
| 600    | 16.607 | 14.555 | 7.979  | 3.945  | 0.000 | 0.000 | 0.000 |
| 700    | 18.306 | 17.247 | 9.113  | 5.694  | 0.000 | 0.000 | 0.000 |
| 800    | 19.699 | 19.785 | 10.290 | 7.596  | 0.000 | 0.000 | 0.000 |
| 900    | 20.832 | 22.173 | 11.479 | 9.625  | 0.000 | 0.000 | 0.000 |
| 1000   | 21.739 | 24.417 | 12.662 | 11.755 | 0.000 | 0.000 | 0.000 |
| 1100   | 22.452 | 26.524 | 13.827 | 13.966 | 0.000 | 0.000 | 0.000 |
| 1200   | 23.000 | 28.502 | 14.968 | 16.240 | 0.000 | 0.000 | 0.000 |
| 1300   | 23.409 | 30.360 | 16.082 | 18.562 | 0.000 | 0.000 | 0.000 |
| 1400   | 23.707 | 32.106 | 17.164 | 20.918 | 0.000 | 0.000 | 0.000 |
| 1500   | 23.919 | 33.749 | 18.216 | 23.300 | 0.000 | 0.000 | 0.000 |

**6. CARBON (DIAMOND) C (cr; diamond)**

|        |        |        |        |        |       |       |        |
|--------|--------|--------|--------|--------|-------|-------|--------|
| 298.15 | 6.109  | 2.362  | 2.362  | 0.000  | 1.850 | 2.857 | -0.501 |
| 300    | 6.201  | 2.400  | 2.362  | 0.011  | 1.846 | 2.863 | -0.499 |
| 400    | 10.321 | 4.783  | 2.659  | 0.850  | 1.645 | 3.235 | -0.422 |
| 500    | 13.404 | 7.431  | 3.347  | 2.042  | 1.507 | 3.649 | -0.381 |
| 600    | 15.885 | 10.102 | 4.251  | 3.511  | 1.415 | 4.087 | -0.356 |
| 700    | 17.930 | 12.709 | 5.274  | 5.205  | 1.361 | 4.537 | -0.339 |
| 800    | 19.619 | 15.217 | 6.361  | 7.085  | 1.338 | 4.993 | -0.326 |
| 900    | 21.006 | 17.611 | 7.479  | 9.118  | 1.343 | 5.450 | -0.316 |
| 1000   | 22.129 | 19.884 | 8.607  | 11.277 | 1.372 | 5.905 | -0.308 |
| 1100   | 23.020 | 22.037 | 9.731  | 13.536 | 1.420 | 6.356 | -0.302 |
| 1200   | 23.709 | 24.071 | 10.842 | 15.874 | 1.484 | 6.802 | -0.296 |
| 1300   | 24.222 | 25.990 | 11.934 | 18.272 | 1.561 | 7.242 | -0.291 |
| 1400   | 24.585 | 27.799 | 13.003 | 20.714 | 1.646 | 7.675 | -0.286 |
| 1500   | 24.824 | 29.504 | 14.047 | 23.185 | 1.735 | 8.103 | -0.282 |

**7. DICARBON C<sub>2</sub> (g)**

|        |        |         |         |        |         |         |          |
|--------|--------|---------|---------|--------|---------|---------|----------|
| 298.15 | 43.548 | 197.095 | 197.095 | 0.000  | 830.457 | 775.116 | -135.795 |
| 300    | 43.575 | 197.365 | 197.096 | 0.081  | 830.506 | 774.772 | -134.898 |
| 400    | 42.169 | 209.809 | 198.802 | 4.403  | 832.751 | 755.833 | -98.700  |
| 500    | 39.529 | 218.924 | 201.959 | 8.483  | 834.170 | 736.423 | -76.933  |
| 600    | 37.837 | 225.966 | 205.395 | 12.342 | 834.909 | 716.795 | -62.402  |
| 700    | 36.984 | 231.726 | 208.758 | 16.078 | 835.148 | 697.085 | -52.016  |
| 800    | 36.621 | 236.637 | 211.943 | 19.755 | 835.020 | 677.366 | -44.227  |
| 900    | 36.524 | 240.943 | 214.931 | 23.411 | 834.618 | 657.681 | -38.170  |
| 1000   | 36.569 | 244.793 | 217.728 | 27.065 | 834.012 | 638.052 | -33.328  |
| 1100   | 36.696 | 248.284 | 220.349 | 30.728 | 833.252 | 618.492 | -29.369  |
| 1200   | 36.874 | 251.484 | 222.812 | 34.406 | 832.383 | 599.006 | -26.074  |
| 1300   | 37.089 | 254.444 | 225.133 | 38.104 | 831.437 | 579.596 | -23.288  |
| 1400   | 37.329 | 257.201 | 227.326 | 41.824 | 830.445 | 560.261 | -20.903  |
| 1500   | 37.589 | 259.785 | 229.405 | 45.570 | 829.427 | 540.997 | -18.839  |

**8. TRICARBON C<sub>3</sub> (g)**

|        |        |         |         |        |         |         |          |
|--------|--------|---------|---------|--------|---------|---------|----------|
| 298.15 | 42.202 | 237.611 | 237.611 | 0.000  | 839.958 | 774.249 | -135.643 |
| 300    | 42.218 | 237.872 | 237.611 | 0.078  | 839.989 | 773.841 | -134.736 |
| 400    | 43.383 | 250.164 | 239.280 | 4.354  | 841.149 | 751.592 | -98.147  |
| 500    | 44.883 | 260.003 | 242.471 | 8.766  | 841.570 | 729.141 | -76.172  |
| 600    | 46.406 | 268.322 | 246.104 | 13.331 | 841.453 | 706.659 | -61.519  |
| 700    | 47.796 | 275.582 | 249.807 | 18.042 | 840.919 | 684.230 | -51.057  |
| 800    | 48.997 | 282.045 | 253.440 | 22.884 | 840.053 | 661.901 | -43.217  |

| $T/K$                                               | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|-----------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                     | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 900                                                 | 50.006      | 287.876   | 256.948                       | 27.835                   | 838.919            | 639.698            | -37.127   |
| 1000                                                | 50.844      | 293.189   | 260.310                       | 32.879                   | 837.572            | 617.633            | -32.261   |
| 1100                                                | 51.535      | 298.069   | 263.524                       | 37.999                   | 836.059            | 595.711            | -28.288   |
| 1200                                                | 52.106      | 302.578   | 266.593                       | 43.182                   | 834.420            | 573.933            | -24.982   |
| 1300                                                | 52.579      | 306.768   | 269.524                       | 48.417                   | 832.690            | 552.295            | -22.191   |
| 1400                                                | 52.974      | 310.679   | 272.326                       | 53.695                   | 830.899            | 530.793            | -19.804   |
| 1500                                                | 53.307      | 314.346   | 275.006                       | 59.010                   | 829.068            | 509.421            | -17.739   |
| <b>9. CARBON OXIDE CO (g)</b>                       |             |           |                               |                          |                    |                    |           |
| 298.15                                              | 29.141      | 197.658   | 197.658                       | 0.000                    | -110.530           | -137.168           | 24.031    |
| 300                                                 | 29.142      | 197.838   | 197.659                       | 0.054                    | -110.519           | -137.333           | 23.912    |
| 400                                                 | 29.340      | 206.243   | 198.803                       | 2.976                    | -110.121           | -146.341           | 19.110    |
| 500                                                 | 29.792      | 212.834   | 200.973                       | 5.930                    | -110.027           | -155.412           | 16.236    |
| 600                                                 | 30.440      | 218.321   | 203.419                       | 8.941                    | -110.157           | -164.480           | 14.319    |
| 700                                                 | 31.170      | 223.067   | 205.895                       | 12.021                   | -110.453           | -173.513           | 12.948    |
| 800                                                 | 31.898      | 227.277   | 208.309                       | 15.175                   | -110.870           | -182.494           | 11.915    |
| 900                                                 | 32.573      | 231.074   | 210.631                       | 18.399                   | -111.378           | -191.417           | 11.109    |
| 1000                                                | 33.178      | 234.538   | 212.851                       | 21.687                   | -111.952           | -200.281           | 10.461    |
| 1100                                                | 33.709      | 237.726   | 214.969                       | 25.032                   | -112.573           | -209.084           | 9.928     |
| 1200                                                | 34.169      | 240.679   | 216.990                       | 28.426                   | -113.228           | -217.829           | 9.482     |
| 1300                                                | 34.568      | 243.430   | 218.920                       | 31.864                   | -113.904           | -226.518           | 9.101     |
| 1400                                                | 34.914      | 246.005   | 220.763                       | 35.338                   | -114.594           | -235.155           | 8.774     |
| 1500                                                | 35.213      | 248.424   | 222.527                       | 38.845                   | -115.291           | -243.742           | 8.488     |
| <b>10. CARBON DIOXIDE CO<sub>2</sub> (g)</b>        |             |           |                               |                          |                    |                    |           |
| 298.15                                              | 37.135      | 213.783   | 213.783                       | 0.000                    | -393.510           | -394.373           | 69.092    |
| 300                                                 | 37.220      | 214.013   | 213.784                       | 0.069                    | -393.511           | -394.379           | 68.667    |
| 400                                                 | 41.328      | 225.305   | 215.296                       | 4.004                    | -393.586           | -394.656           | 51.536    |
| 500                                                 | 44.627      | 234.895   | 218.280                       | 8.307                    | -393.672           | -394.914           | 41.256    |
| 600                                                 | 47.327      | 243.278   | 221.762                       | 12.909                   | -393.791           | -395.152           | 34.401    |
| 700                                                 | 49.569      | 250.747   | 225.379                       | 17.758                   | -393.946           | -395.367           | 29.502    |
| 800                                                 | 51.442      | 257.492   | 228.978                       | 22.811                   | -394.133           | -395.558           | 25.827    |
| 900                                                 | 53.008      | 263.644   | 232.493                       | 28.036                   | -394.343           | -395.724           | 22.967    |
| 1000                                                | 54.320      | 269.299   | 235.895                       | 33.404                   | -394.568           | -395.865           | 20.678    |
| 1100                                                | 55.423      | 274.529   | 239.172                       | 38.893                   | -394.801           | -395.984           | 18.803    |
| 1200                                                | 56.354      | 279.393   | 242.324                       | 44.483                   | -395.035           | -396.081           | 17.241    |
| 1300                                                | 57.144      | 283.936   | 245.352                       | 50.159                   | -395.265           | -396.159           | 15.918    |
| 1400                                                | 57.818      | 288.196   | 248.261                       | 55.908                   | -395.488           | -396.219           | 14.783    |
| 1500                                                | 58.397      | 292.205   | 251.059                       | 61.719                   | -395.702           | -396.264           | 13.799    |
| <b>11. METHANE CH<sub>4</sub> (g)</b>               |             |           |                               |                          |                    |                    |           |
| 298.15                                              | 35.695      | 186.369   | 186.369                       | 0.000                    | -74.600            | -50.530            | 8.853     |
| 300                                                 | 35.765      | 186.590   | 186.370                       | 0.066                    | -74.656            | -50.381            | 8.772     |
| 400                                                 | 40.631      | 197.501   | 187.825                       | 3.871                    | -77.703            | -41.827            | 5.462     |
| 500                                                 | 46.627      | 207.202   | 190.744                       | 8.229                    | -80.520            | -32.525            | 3.398     |
| 600                                                 | 52.742      | 216.246   | 194.248                       | 13.199                   | -82.969            | -22.690            | 1.975     |
| 700                                                 | 58.603      | 224.821   | 198.008                       | 18.769                   | -85.023            | -12.476            | 0.931     |
| 800                                                 | 64.084      | 233.008   | 201.875                       | 24.907                   | -86.693            | -1.993             | 0.130     |
| 900                                                 | 69.137      | 240.852   | 205.773                       | 31.571                   | -88.006            | 8.677              | -0.504    |
| 1000                                                | 73.746      | 248.379   | 209.660                       | 38.719                   | -88.996            | 19.475             | -1.017    |
| 1100                                                | 77.919      | 255.607   | 213.511                       | 46.306                   | -89.698            | 30.358             | -1.442    |
| 1200                                                | 81.682      | 262.551   | 217.310                       | 54.289                   | -90.145            | 41.294             | -1.797    |
| 1300                                                | 85.067      | 269.225   | 221.048                       | 62.630                   | -90.367            | 52.258             | -2.100    |
| 1400                                                | 88.112      | 275.643   | 224.720                       | 71.291                   | -90.390            | 63.231             | -2.359    |
| 1500                                                | 90.856      | 281.817   | 228.322                       | 80.242                   | -90.237            | 74.200             | -2.584    |
| <b>12. ACETYLENE C<sub>2</sub>H<sub>2</sub> (g)</b> |             |           |                               |                          |                    |                    |           |
| 298.15                                              | 44.036      | 200.927   | 200.927                       | 0.000                    | 227.400            | 209.879            | -36.769   |
| 300                                                 | 44.174      | 201.199   | 200.927                       | 0.082                    | 227.397            | 209.770            | -36.524   |
| 400                                                 | 50.388      | 214.814   | 202.741                       | 4.829                    | 227.161            | 203.928            | -26.630   |
| 500                                                 | 54.751      | 226.552   | 206.357                       | 10.097                   | 226.846            | 198.154            | -20.701   |

| $T/K$                                          | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 600                                            | 58.121      | 236.842   | 210.598                       | 15.747                   | 226.445            | 192.452            | -16.754   |
| 700                                            | 60.970      | 246.021   | 215.014                       | 21.704                   | 225.968            | 186.823            | -13.941   |
| 800                                            | 63.511      | 254.331   | 219.418                       | 27.931                   | 225.436            | 181.267            | -11.835   |
| 900                                            | 65.831      | 261.947   | 223.726                       | 34.399                   | 224.873            | 175.779            | -10.202   |
| 1000                                           | 67.960      | 268.995   | 227.905                       | 41.090                   | 224.300            | 170.355            | -8.898    |
| 1100                                           | 69.909      | 275.565   | 231.942                       | 47.985                   | 223.734            | 164.988            | -7.835    |
| 1200                                           | 71.686      | 281.725   | 235.837                       | 55.067                   | 223.189            | 159.672            | -6.950    |
| 1300                                           | 73.299      | 287.528   | 239.592                       | 62.317                   | 222.676            | 154.400            | -6.204    |
| 1400                                           | 74.758      | 293.014   | 243.214                       | 69.721                   | 222.203            | 149.166            | -5.565    |
| 1500                                           | 76.077      | 298.218   | 246.709                       | 77.264                   | 221.774            | 143.964            | -5.013    |
| <b>13. ETHYLENE <math>C_2H_4(g)</math></b>     |             |           |                               |                          |                    |                    |           |
| 298.15                                         | 42.883      | 219.316   | 219.316                       | 0.000                    | 52.400             | 68.358             | -11.976   |
| 300                                            | 43.059      | 219.582   | 219.317                       | 0.079                    | 52.341             | 68.457             | -11.919   |
| 400                                            | 53.045      | 233.327   | 221.124                       | 4.881                    | 49.254             | 74.302             | -9.703    |
| 500                                            | 62.479      | 246.198   | 224.864                       | 10.667                   | 46.533             | 80.887             | -8.450    |
| 600                                            | 70.673      | 258.332   | 229.441                       | 17.335                   | 44.221             | 87.982             | -7.659    |
| 700                                            | 77.733      | 269.770   | 234.393                       | 24.764                   | 42.278             | 95.434             | -7.121    |
| 800                                            | 83.868      | 280.559   | 239.496                       | 32.851                   | 40.655             | 103.142            | -6.734    |
| 900                                            | 89.234      | 290.754   | 244.630                       | 41.512                   | 39.310             | 111.036            | -6.444    |
| 1000                                           | 93.939      | 300.405   | 249.730                       | 50.675                   | 38.205             | 119.067            | -6.219    |
| 1100                                           | 98.061      | 309.556   | 254.756                       | 60.280                   | 37.310             | 127.198            | -6.040    |
| 1200                                           | 101.670     | 318.247   | 259.688                       | 70.271                   | 36.596             | 135.402            | -5.894    |
| 1300                                           | 104.829     | 326.512   | 264.513                       | 80.599                   | 36.041             | 143.660            | -5.772    |
| 1400                                           | 107.594     | 334.384   | 269.225                       | 91.223                   | 35.623             | 151.955            | -5.669    |
| 1500                                           | 110.018     | 341.892   | 273.821                       | 102.107                  | 35.327             | 160.275            | -5.581    |
| <b>14. ETHANE <math>C_2H_6(g)</math></b>       |             |           |                               |                          |                    |                    |           |
| 298.15                                         | 52.487      | 229.161   | 229.161                       | 0.000                    | -84.000            | -32.015            | 5.609     |
| 300                                            | 52.711      | 229.487   | 229.162                       | 0.097                    | -84.094            | -31.692            | 5.518     |
| 400                                            | 65.459      | 246.378   | 231.379                       | 5.999                    | -88.988            | -13.473            | 1.759     |
| 500                                            | 77.941      | 262.344   | 235.989                       | 13.177                   | -93.238            | 5.912              | -0.618    |
| 600                                            | 89.188      | 277.568   | 241.660                       | 21.545                   | -96.779            | 26.086             | -2.271    |
| 700                                            | 99.136      | 292.080   | 247.835                       | 30.972                   | -99.663            | 46.800             | -3.492    |
| 800                                            | 107.936     | 305.904   | 254.236                       | 41.334                   | -101.963           | 67.887             | -4.433    |
| 900                                            | 115.709     | 319.075   | 260.715                       | 52.525                   | -103.754           | 89.231             | -5.179    |
| 1000                                           | 122.552     | 331.628   | 267.183                       | 64.445                   | -105.105           | 110.750            | -5.785    |
| 1100                                           | 128.553     | 343.597   | 273.590                       | 77.007                   | -106.082           | 132.385            | -6.286    |
| 1200                                           | 133.804     | 355.012   | 279.904                       | 90.131                   | -106.741           | 154.096            | -6.708    |
| 1300                                           | 138.391     | 365.908   | 286.103                       | 103.746                  | -107.131           | 175.850            | -7.066    |
| 1400                                           | 142.399     | 376.314   | 292.178                       | 117.790                  | -107.292           | 197.625            | -7.373    |
| 1500                                           | 145.905     | 386.260   | 298.121                       | 132.209                  | -107.260           | 219.404            | -7.640    |
| <b>15. CYCLOPROPANE <math>C_3H_6(g)</math></b> |             |           |                               |                          |                    |                    |           |
| 298.15                                         | 55.571      | 237.488   | 237.488                       | 0.000                    | 53.300             | 104.514            | -18.310   |
| 300                                            | 55.941      | 237.832   | 237.489                       | 0.103                    | 53.195             | 104.832            | -18.253   |
| 400                                            | 76.052      | 256.695   | 239.924                       | 6.708                    | 47.967             | 122.857            | -16.043   |
| 500                                            | 93.859      | 275.637   | 245.177                       | 15.230                   | 43.730             | 142.091            | -14.844   |
| 600                                            | 108.542     | 294.092   | 251.801                       | 25.374                   | 40.405             | 162.089            | -14.111   |
| 700                                            | 120.682     | 311.763   | 259.115                       | 36.854                   | 37.825             | 182.583            | -13.624   |
| 800                                            | 130.910     | 328.564   | 266.755                       | 49.447                   | 35.854             | 203.404            | -13.281   |
| 900                                            | 139.658     | 344.501   | 274.516                       | 62.987                   | 34.384             | 224.441            | -13.026   |
| 1000                                           | 147.207     | 359.616   | 282.277                       | 77.339                   | 33.334             | 245.618            | -12.830   |
| 1100                                           | 153.749     | 373.961   | 289.965                       | 92.395                   | 32.640             | 266.883            | -12.673   |
| 1200                                           | 159.432     | 387.588   | 297.538                       | 108.060                  | 32.249             | 288.197            | -12.545   |
| 1300                                           | 164.378     | 400.549   | 304.967                       | 124.257                  | 32.119             | 309.533            | -12.437   |
| 1400                                           | 168.689     | 412.892   | 312.239                       | 140.915                  | 32.215             | 330.870            | -12.345   |
| 1500                                           | 172.453     | 424.662   | 319.344                       | 157.976                  | 32.507             | 352.193            | -12.264   |
| <b>16. PROPANE <math>C_3H_8(g)</math></b>      |             |           |                               |                          |                    |                    |           |
| 298.15                                         | 73.597      | 270.313   | 270.313                       | 0.000                    | -103.847           | -23.458            | 4.110     |

| <i>T</i> /K                                                                                                | J/Kmol                            |                       |                                                                                      | kJ/mol                                                                 |                                             |                                             | Log <i>K<sub>f</sub></i> |
|------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------|--------------------------|
|                                                                                                            | <i>C<sub>p</sub></i> <sup>o</sup> | <i>S</i> <sup>o</sup> | −( <i>G</i> <sup>o</sup> − <i>H</i> <sup>o</sup> ( <i>T<sub>f</sub></i> ))/ <i>T</i> | <i>H</i> <sup>o</sup> − <i>H</i> <sup>o</sup> ( <i>T<sub>f</sub></i> ) | Δ <sub><i>f</i></sub> <i>H</i> <sup>o</sup> | Δ <sub><i>f</i></sub> <i>G</i> <sup>o</sup> |                          |
| 300                                                                                                        | 73.931                            | 270.769               | 270.314                                                                              | 0.136                                                                  | −103.972                                    | −22.959                                     | 3.997                    |
| 400                                                                                                        | 94.014                            | 294.739               | 273.447                                                                              | 8.517                                                                  | −110.33                                     | 15.029                                      | −0.657                   |
| 500                                                                                                        | 112.591                           | 317.768               | 280.025                                                                              | 18.872                                                                 | −115.658                                    | 34.507                                      | −3.605                   |
| 600                                                                                                        | 128.700                           | 339.753               | 288.162                                                                              | 30.955                                                                 | −119.973                                    | 64.961                                      | −5.655                   |
| 700                                                                                                        | 142.674                           | 360.668               | 297.039                                                                              | 44.540                                                                 | −123.384                                    | 96.065                                      | −7.168                   |
| 800                                                                                                        | 154.766                           | 380.528               | 306.245                                                                              | 59.427                                                                 | −126.016                                    | 127.603                                     | −8.331                   |
| 900                                                                                                        | 165.352                           | 399.381               | 315.555                                                                              | 75.444                                                                 | −127.982                                    | 159.430                                     | −9.253                   |
| 1000                                                                                                       | 174.598                           | 417.293               | 324.841                                                                              | 92.452                                                                 | −129.380                                    | 191.444                                     | −10.000                  |
| 1100                                                                                                       | 182.673                           | 434.321               | 334.026                                                                              | 110.325                                                                | −130.296                                    | 223.574                                     | −10.617                  |
| 1200                                                                                                       | 189.745                           | 450.526               | 343.064                                                                              | 128.954                                                                | −130.802                                    | 255.770                                     | −11.133                  |
| 1300                                                                                                       | 195.853                           | 465.961               | 351.929                                                                              | 148.241                                                                | −130.961                                    | 287.993                                     | −11.572                  |
| 1400                                                                                                       | 201.209                           | 480.675               | 360.604                                                                              | 168.100                                                                | −130.829                                    | 320.217                                     | −11.947                  |
| 1500                                                                                                       | 205.895                           | 494.721               | 369.080                                                                              | 188.460                                                                | −130.445                                    | 352.422                                     | −12.272                  |
| 17. BENZENE C <sub>6</sub> H <sub>6</sub> (l)                                                              |                                   |                       |                                                                                      |                                                                        |                                             |                                             |                          |
| 298.15                                                                                                     | 135.950                           | 173.450               | 173.450                                                                              | 0.000                                                                  | 49.080                                      | 124.521                                     | −21.815                  |
| 300                                                                                                        | 136.312                           | 174.292               | 173.453                                                                              | .252                                                                   | 49.077                                      | 124.989                                     | −21.762                  |
| 400                                                                                                        | 161.793                           | 216.837               | 179.082                                                                              | 15.102                                                                 | 48.978                                      | 150.320                                     | −19.630                  |
| 500                                                                                                        | 207.599                           | 257.048               | 190.639                                                                              | 33.204                                                                 | 50.330                                      | 175.559                                     | −18.340                  |
| 18. BENZENE C <sub>6</sub> H <sub>6</sub> (g)                                                              |                                   |                       |                                                                                      |                                                                        |                                             |                                             |                          |
| 298.15                                                                                                     | 82.430                            | 269.190               | 269.190                                                                              | 0.000                                                                  | 82.880                                      | 129.750                                     | −22.731                  |
| 300                                                                                                        | 83.020                            | 269.700               | 269.190                                                                              | 0.153                                                                  | 82.780                                      | 130.040                                     | −22.641                  |
| 400                                                                                                        | 113.510                           | 297.840               | 272.823                                                                              | 10.007                                                                 | 77.780                                      | 146.570                                     | −19.140                  |
| 500                                                                                                        | 139.340                           | 326.050               | 280.658                                                                              | 22.696                                                                 | 73.740                                      | 164.260                                     | −17.160                  |
| 600                                                                                                        | 160.090                           | 353.360               | 290.517                                                                              | 37.706                                                                 | 70.490                                      | 182.680                                     | −15.903                  |
| 700                                                                                                        | 176.790                           | 379.330               | 301.360                                                                              | 54.579                                                                 | 67.910                                      | 201.590                                     | −15.042                  |
| 800                                                                                                        | 190.460                           | 403.860               | 312.658                                                                              | 72.962                                                                 | 65.910                                      | 220.820                                     | −14.418                  |
| 900                                                                                                        | 201.840                           | 426.970               | 324.084                                                                              | 92.597                                                                 | 64.410                                      | 240.280                                     | −13.945                  |
| 1000                                                                                                       | 211.430                           | 448.740               | 335.473                                                                              | 113.267                                                                | 63.340                                      | 259.890                                     | −13.575                  |
| 1100                                                                                                       | 219.580                           | 469.280               | 346.710                                                                              | 134.827                                                                | 62.620                                      | 277.640                                     | −13.184                  |
| 1200                                                                                                       | 226.540                           | 488.690               | 357.743                                                                              | 157.137                                                                | 62.200                                      | 299.320                                     | −13.029                  |
| 1300                                                                                                       | 232.520                           | 507.070               | 368.534                                                                              | 180.097                                                                | 62.000                                      | 319.090                                     | −12.821                  |
| 1400                                                                                                       | 237.680                           | 524.490               | 379.056                                                                              | 203.607                                                                | 61.990                                      | 338.870                                     | −12.643                  |
| 1500                                                                                                       | 242.140                           | 541.040               | 389.302                                                                              | 227.607                                                                | 62.110                                      | 358.640                                     | −12.489                  |
| 19. NAPHTHALENE C <sub>10</sub> H <sub>8</sub> (cr, l)                                                     |                                   |                       |                                                                                      |                                                                        |                                             |                                             |                          |
| 298.15                                                                                                     | 165.720                           | 167.390               | 167.390                                                                              | 0.000                                                                  | 78.530                                      | 201.585                                     | −35.316                  |
| 300                                                                                                        | 167.001                           | 168.419               | 167.393                                                                              | 0.308                                                                  | 78.466                                      | 202.349                                     | −35.232                  |
| 353.43                                                                                                     | 208.722                           | 198.948               | 169.833                                                                              | 10.290                                                                 | 96.099                                      | 224.543                                     | −33.186                  |
| PHASE TRANSITION: Δ <sub>tr</sub> <i>H</i> = 18.980 kJ/mol, Δ <sub>tr</sub> <i>S</i> = 53.702 J/Kmol, cr–l |                                   |                       |                                                                                      |                                                                        |                                             |                                             |                          |
| 353.43                                                                                                     | 217.200                           | 252.650               | 169.833                                                                              | 29.270                                                                 | 96.099                                      | 224.543                                     | −33.186                  |
| 400                                                                                                        | 241.577                           | 280.916               | 181.124                                                                              | 39.917                                                                 | 96.067                                      | 241.475                                     | −31.533                  |
| 470                                                                                                        | 276.409                           | 322.712               | 199.114                                                                              | 58.091                                                                 | 97.012                                      | 266.859                                     | −29.658                  |
| 20. NAPHTHALENE C <sub>10</sub> H <sub>8</sub> (g)                                                         |                                   |                       |                                                                                      |                                                                        |                                             |                                             |                          |
| 298.15                                                                                                     | 131.920                           | 333.150               | 333.150                                                                              | 0.000                                                                  | 150.580                                     | 224.100                                     | −39.260                  |
| 300                                                                                                        | 132.840                           | 333.970               | 333.157                                                                              | 0.244                                                                  | 150.450                                     | 224.560                                     | −39.098                  |
| 400                                                                                                        | 180.070                           | 378.800               | 338.950                                                                              | 15.940                                                                 | 144.190                                     | 250.270                                     | −32.681                  |
| 500                                                                                                        | 219.740                           | 423.400               | 351.400                                                                              | 36.000                                                                 | 139.220                                     | 277.340                                     | −28.973                  |
| 600                                                                                                        | 251.530                           | 466.380               | 367.007                                                                              | 59.624                                                                 | 135.350                                     | 305.330                                     | −26.581                  |
| 700                                                                                                        | 277.010                           | 507.140               | 384.146                                                                              | 86.096                                                                 | 132.330                                     | 333.950                                     | −24.919                  |
| 800                                                                                                        | 297.730                           | 545.520               | 401.935                                                                              | 114.868                                                                | 130.050                                     | 362.920                                     | −23.696                  |
| 900                                                                                                        | 314.850                           | 581.610               | 419.918                                                                              | 145.523                                                                | 128.430                                     | 392.150                                     | −22.759                  |
| 1000                                                                                                       | 329.170                           | 615.550               | 437.806                                                                              | 177.744                                                                | 127.510                                     | 421.700                                     | −22.027                  |
| 1100                                                                                                       | 341.240                           | 647.500               | 455.426                                                                              | 211.281                                                                | 127.100                                     | 450.630                                     | −21.398                  |
| 1200                                                                                                       | 351.500                           | 677.650               | 472.707                                                                              | 245.932                                                                | 126.960                                     | 480.450                                     | −20.913                  |
| 1300                                                                                                       | 360.260                           | 706.130               | 489.568                                                                              | 281.531                                                                | 127.060                                     | 509.770                                     | −20.482                  |
| 1400                                                                                                       | 367.780                           | 733.110               | 506.009                                                                              | 317.941                                                                | 127.390                                     | 539.740                                     | −20.137                  |
| 1500                                                                                                       | 374.270                           | 758.720               | 522.019                                                                              | 355.051                                                                | 127.920                                     | 568.940                                     | −19.812                  |

| $T/K$                                               | J/Kmol      |           |                             | kJ/mol                 |                    |                    | $\text{Log } K_f$ |
|-----------------------------------------------------|-------------|-----------|-----------------------------|------------------------|--------------------|--------------------|-------------------|
|                                                     | $C_p^\circ$ | $S^\circ$ | $-(G^\circ-H^\circ(T_f))/T$ | $H^\circ-H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |                   |
| 21. FORMALDEHYDE $\text{H}_2\text{CO (g)}$          |             |           |                             |                        |                    |                    |                   |
| 298.15                                              | 35.387      | 218.760   | 218.760                     | 0.000                  | -108.700           | -102.667           | 17.987            |
| 300                                                 | 35.443      | 218.979   | 218.761                     | 0.066                  | -108.731           | -102.630           | 17.869            |
| 400                                                 | 39.240      | 229.665   | 220.192                     | 3.789                  | -110.438           | -100.340           | 13.103            |
| 500                                                 | 43.736      | 238.900   | 223.028                     | 7.936                  | -112.073           | -97.623            | 10.198            |
| 600                                                 | 48.181      | 247.270   | 226.381                     | 12.534                 | -113.545           | -94.592            | 8.235             |
| 700                                                 | 52.280      | 255.011   | 229.924                     | 17.560                 | -114.833           | -91.328            | 6.815             |
| 800                                                 | 55.941      | 262.236   | 233.517                     | 22.975                 | -115.942           | -87.893            | 5.739             |
| 900                                                 | 59.156      | 269.014   | 237.088                     | 28.734                 | -116.889           | -84.328            | 4.894             |
| 1000                                                | 61.951      | 275.395   | 240.603                     | 34.792                 | -117.696           | -80.666            | 4.213             |
| 1100                                                | 64.368      | 281.416   | 244.042                     | 41.111                 | -118.382           | -76.929            | 3.653             |
| 1200                                                | 66.453      | 287.108   | 247.396                     | 47.655                 | -118.966           | -73.134            | 3.183             |
| 1300                                                | 68.251      | 292.500   | 250.660                     | 54.392                 | -119.463           | -69.294            | 2.784             |
| 1400                                                | 69.803      | 297.616   | 253.833                     | 61.297                 | -119.887           | -65.418            | 2.441             |
| 1500                                                | 71.146      | 302.479   | 256.915                     | 68.346                 | -120.249           | -61.514            | 2.142             |
| 22. METHANOL $\text{CH}_3\text{OH (g)}$             |             |           |                             |                        |                    |                    |                   |
| 298.15                                              | 44.101      | 239.865   | 239.865                     | 0.000                  | -201.000           | -162.298           | 28.434            |
| 300                                                 | 44.219      | 240.139   | 239.866                     | 0.082                  | -201.068           | -162.057           | 28.216            |
| 400                                                 | 51.713      | 253.845   | 241.685                     | 4.864                  | -204.622           | -148.509           | 19.393            |
| 500                                                 | 59.800      | 266.257   | 245.374                     | 10.442                 | -207.750           | -134.109           | 14.010            |
| 600                                                 | 67.294      | 277.835   | 249.830                     | 16.803                 | -210.387           | -119.125           | 10.371            |
| 700                                                 | 73.958      | 288.719   | 254.616                     | 23.873                 | -212.570           | -103.737           | 7.741             |
| 800                                                 | 79.838      | 298.987   | 259.526                     | 31.569                 | -214.350           | -88.063            | 5.750             |
| 900                                                 | 85.025      | 308.696   | 264.455                     | 39.817                 | -215.782           | -72.188            | 4.190             |
| 1000                                                | 89.597      | 317.896   | 269.343                     | 48.553                 | -216.916           | -56.170            | 2.934             |
| 1100                                                | 93.624      | 326.629   | 274.158                     | 57.718                 | -217.794           | -40.050            | 1.902             |
| 1200                                                | 97.165      | 334.930   | 278.879                     | 67.262                 | -218.457           | -23.861            | 1.039             |
| 1300                                                | 100.277     | 342.833   | 283.497                     | 77.137                 | -218.936           | -7.624             | 0.306             |
| 1400                                                | 103.014     | 350.367   | 288.007                     | 87.304                 | -219.261           | 8.644              | -0.322            |
| 1500                                                | 105.422     | 357.558   | 292.405                     | 97.729                 | -219.456           | 24.930             | -0.868            |
| 23. ACETALDEHYDE $\text{C}_2\text{H}_4\text{O (g)}$ |             |           |                             |                        |                    |                    |                   |
| 298.15                                              | 55.318      | 263.840   | 263.840                     | 0.000                  | -166.190           | -133.010           | 23.302            |
| 300                                                 | 55.510      | 264.180   | 263.837                     | 0.103                  | -166.250           | -132.800           | 23.122            |
| 400                                                 | 66.282      | 281.620   | 266.147                     | 6.189                  | -169.530           | -121.130           | 15.818            |
| 500                                                 | 76.675      | 297.540   | 270.850                     | 13.345                 | -172.420           | -108.700           | 11.356            |
| 600                                                 | 85.942      | 312.360   | 276.550                     | 21.486                 | -174.870           | -95.720            | 8.334             |
| 700                                                 | 94.035      | 326.230   | 282.667                     | 30.494                 | -176.910           | -82.350            | 6.145             |
| 800                                                 | 101.070     | 339.260   | 288.938                     | 40.258                 | -178.570           | -68.730            | 4.487             |
| 900                                                 | 107.190     | 351.520   | 295.189                     | 50.698                 | -179.880           | -54.920            | 3.187             |
| 1000                                                | 112.490     | 363.100   | 301.431                     | 61.669                 | -180.850           | -40.930            | 2.138             |
| 1100                                                | 117.080     | 374.040   | 307.537                     | 73.153                 | -181.560           | -27.010            | 1.283             |
| 1200                                                | 121.060     | 384.400   | 313.512                     | 85.065                 | -182.070           | -12.860            | 0.560             |
| 1300                                                | 124.500     | 394.230   | 319.350                     | 97.344                 | -182.420           | 1.240              | -0.050            |
| 1400                                                | 127.490     | 403.570   | 325.031                     | 109.954                | -182.640           | 15.470             | -0.577            |
| 1500                                                | 130.090     | 412.460   | 330.571                     | 122.834                | -182.750           | 29.580             | -1.030            |
| 24. ETHANOL $\text{C}_2\text{H}_5\text{OH (g)}$     |             |           |                             |                        |                    |                    |                   |
| 298.15                                              | 65.652      | 281.622   | 281.622                     | 0.000                  | -234.800           | -167.874           | 29.410            |
| 300                                                 | 65.926      | 282.029   | 281.623                     | 0.122                  | -234.897           | -167.458           | 29.157            |
| 400                                                 | 81.169      | 303.076   | 284.390                     | 7.474                  | -239.826           | -144.216           | 18.832            |
| 500                                                 | 95.400      | 322.750   | 290.115                     | 16.318                 | -243.940           | -119.820           | 12.517            |
| 600                                                 | 107.656     | 341.257   | 297.112                     | 26.487                 | -247.260           | -94.672            | 8.242             |
| 700                                                 | 118.129     | 358.659   | 304.674                     | 37.790                 | -249.895           | -69.023            | 5.151             |
| 800                                                 | 127.171     | 375.038   | 312.456                     | 50.065                 | -251.951           | -43.038            | 2.810             |
| 900                                                 | 135.049     | 390.482   | 320.276                     | 63.185                 | -253.515           | -16.825            | 0.976             |
| 1000                                                | 141.934     | 405.075   | 328.033                     | 77.042                 | -254.662           | 9.539              | -0.498            |
| 1100                                                | 147.958     | 418.892   | 335.670                     | 91.543                 | -255.454           | 36.000             | -1.709            |
| 1200                                                | 153.232     | 431.997   | 343.156                     | 106.609                | -255.947           | 62.520             | -2.721            |



| $T/K$                                                 | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|-------------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                       | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 1300                                                  | 157.849     | 444.448   | 350.473                       | 122.168                  | -256.184           | 89.070             | -3.579    |
| 1400                                                  | 161.896     | 456.298   | 357.612                       | 138.160                  | -256.206           | 115.630            | -4.314    |
| 1500                                                  | 165.447     | 467.591   | 364.571                       | 154.531                  | -256.044           | 142.185            | -4.951    |
| <b>25. ACETIC ACID <math>C_2H_4O_2</math> (g)</b>     |             |           |                               |                          |                    |                    |           |
| 298.15                                                | 63.438      | 283.470   | 283.470                       | 0.000                    | -432.249           | -374.254           | 65.567    |
| 300                                                   | 63.739      | 283.863   | 283.471                       | 0.118                    | -432.324           | -373.893           | 65.100    |
| 400                                                   | 79.665      | 304.404   | 286.164                       | 7.296                    | -436.006           | -353.840           | 46.206    |
| 500                                                   | 93.926      | 323.751   | 291.765                       | 15.993                   | -438.875           | -332.950           | 34.783    |
| 600                                                   | 106.181     | 341.988   | 298.631                       | 26.014                   | -440.993           | -311.554           | 27.123    |
| 700                                                   | 116.627     | 359.162   | 306.064                       | 37.169                   | -442.466           | -289.856           | 21.629    |
| 800                                                   | 125.501     | 375.331   | 313.722                       | 49.287                   | -443.395           | -267.985           | 17.497    |
| 900                                                   | 132.989     | 390.558   | 321.422                       | 62.223                   | -443.873           | -246.026           | 14.279    |
| 1000                                                  | 139.257     | 404.904   | 329.060                       | 75.844                   | -443.982           | -224.034           | 11.702    |
| 1100                                                  | 144.462     | 418.429   | 336.576                       | 90.039                   | -443.798           | -202.046           | 9.594     |
| 1200                                                  | 148.760     | 431.189   | 343.933                       | 104.707                  | -443.385           | -180.086           | 7.839     |
| 1300                                                  | 152.302     | 443.240   | 351.113                       | 119.765                  | -442.795           | -158.167           | 6.355     |
| 1400                                                  | 155.220     | 454.637   | 358.105                       | 135.146                  | -442.071           | -136.299           | 5.085     |
| 1500                                                  | 157.631     | 465.432   | 364.903                       | 150.793                  | -441.247           | -114.486           | 3.987     |
| <b>26. ACETONE <math>C_3H_6O</math> (g)</b>           |             |           |                               |                          |                    |                    |           |
| 298.15                                                | 74.517      | 295.349   | 295.349                       | 0.000                    | -217.150           | -152.716           | 26.757    |
| 300                                                   | 74.810      | 295.809   | 295.349                       | 0.138                    | -217.233           | -152.339           | 26.521    |
| 400                                                   | 91.755      | 319.658   | 298.498                       | 8.464                    | -222.212           | -129.913           | 16.962    |
| 500                                                   | 107.864     | 341.916   | 304.988                       | 18.464                   | -226.522           | -106.315           | 11.107    |
| 600                                                   | 122.047     | 362.836   | 312.873                       | 29.978                   | -230.120           | -81.923            | 7.133     |
| 700                                                   | 134.306     | 382.627   | 321.470                       | 42.810                   | -233.049           | -56.986            | 4.252     |
| 800                                                   | 144.934     | 401.246   | 330.265                       | 56.785                   | -235.350           | -31.673            | 2.068     |
| 900                                                   | 154.097     | 418.860   | 339.141                       | 71.747                   | -237.149           | -6.109             | 0.353     |
| 1000                                                  | 162.046     | 435.513   | 347.950                       | 87.563                   | -238.404           | 19.707             | -1.030    |
| 1100                                                  | 168.908     | 451.286   | 356.617                       | 104.136                  | -239.283           | 45.396             | -2.157    |
| 1200                                                  | 174.891     | 466.265   | 365.155                       | 121.332                  | -239.827           | 71.463             | -3.110    |
| 1300                                                  | 180.079     | 480.491   | 373.513                       | 139.072                  | -240.120           | 97.362             | -3.912    |
| 1400                                                  | 184.556     | 493.963   | 381.596                       | 157.314                  | -240.203           | 123.470            | -4.607    |
| 1500                                                  | 188.447     | 506.850   | 389.533                       | 175.975                  | -240.120           | 149.369            | -5.202    |
| <b>27. PHENOL <math>C_6H_6O</math> (g)</b>            |             |           |                               |                          |                    |                    |           |
| 298.15                                                | 103.220     | 314.810   | 314.810                       | 0.000                    | -96.400            | -32.630            | 5.720     |
| 300                                                   | 103.860     | 315.450   | 314.810                       | 0.192                    | -96.490            | -32.230            | 5.610     |
| 400                                                   | 135.790     | 349.820   | 319.278                       | 12.217                   | -100.870           | -10.180            | 1.330     |
| 500                                                   | 161.910     | 383.040   | 328.736                       | 27.152                   | -104.240           | 12.970             | -1.360    |
| 600                                                   | 182.480     | 414.450   | 340.430                       | 44.412                   | -106.810           | 36.650             | -3.190    |
| 700                                                   | 198.840     | 443.860   | 353.134                       | 63.508                   | -108.800           | 60.750             | -4.530    |
| 800                                                   | 212.140     | 471.310   | 366.211                       | 84.079                   | -110.300           | 85.020             | -5.550    |
| 900                                                   | 223.190     | 496.950   | 379.327                       | 105.861                  | -111.370           | 109.590            | -6.360    |
| 1000                                                  | 232.490     | 520.960   | 392.302                       | 128.658                  | -111.990           | 134.280            | -7.010    |
| 1100                                                  | 240.410     | 543.500   | 405.033                       | 152.314                  | -112.280           | 158.620            | -7.530    |
| 1200                                                  | 247.200     | 564.720   | 417.468                       | 176.703                  | -112.390           | 183.350            | -7.980    |
| 1300                                                  | 253.060     | 584.740   | 429.568                       | 201.723                  | -112.330           | 208.070            | -8.360    |
| 1400                                                  | 258.120     | 603.680   | 441.331                       | 227.288                  | -112.120           | 233.050            | -8.700    |
| 1500                                                  | 262.520     | 621.650   | 452.767                       | 253.325                  | -111.780           | 257.540            | -8.970    |
| <b>28. CARBON TETRAFLUORIDE <math>CF_4</math> (g)</b> |             |           |                               |                          |                    |                    |           |
| 298.15                                                | 61.050      | 261.455   | 261.455                       | 0.000                    | -933.200           | -888.518           | 155.663   |
| 300                                                   | 61.284      | 261.833   | 261.456                       | 0.113                    | -933.219           | -888.240           | 154.654   |
| 400                                                   | 72.399      | 281.057   | 264.001                       | 6.822                    | -933.986           | -873.120           | 114.016   |
| 500                                                   | 80.713      | 298.153   | 269.155                       | 14.499                   | -934.372           | -857.852           | 89.618    |
| 600                                                   | 86.783      | 313.434   | 275.284                       | 22.890                   | -934.490           | -842.533           | 73.348    |
| 700                                                   | 91.212      | 327.162   | 281.732                       | 31.801                   | -934.431           | -827.210           | 61.726    |
| 800                                                   | 94.479      | 339.566   | 288.199                       | 41.094                   | -934.261           | -811.903           | 53.011    |
| 900                                                   | 96.929      | 350.842   | 294.542                       | 50.670                   | -934.024           | -796.622           | 46.234    |

| $T/K$                                                                      | J/K mol     |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|----------------------------------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                                            | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 1000                                                                       | 98.798      | 361.156   | 300.695                       | 60.460                   | -933.745           | -781.369           | 40.814    |
| 1100                                                                       | 100.250     | 370.643   | 306.629                       | 70.416                   | -933.442           | -766.146           | 36.381    |
| 1200                                                                       | 101.396     | 379.417   | 312.334                       | 80.500                   | -933.125           | -750.952           | 32.688    |
| 1300                                                                       | 102.314     | 387.571   | 317.811                       | 90.687                   | -932.800           | -735.784           | 29.564    |
| 1400                                                                       | 103.059     | 395.181   | 323.069                       | 100.957                  | -932.470           | -720.641           | 26.887    |
| 1500                                                                       | 103.671     | 402.313   | 328.116                       | 111.295                  | -932.137           | -705.522           | 24.568    |
| <b>29. TRIFLUOROMETHANE <math>\text{CHF}_3</math> (g)</b>                  |             |           |                               |                          |                    |                    |           |
| 298.15                                                                     | 51.069      | 259.675   | 259.675                       | 0.000                    | -696.700           | -662.237           | 116.020   |
| 300                                                                        | 51.258      | 259.991   | 259.676                       | 0.095                    | -696.735           | -662.023           | 115.267   |
| 400                                                                        | 61.148      | 276.113   | 261.807                       | 5.722                    | -698.427           | -650.186           | 84.905    |
| 500                                                                        | 69.631      | 290.700   | 266.149                       | 12.275                   | -699.715           | -637.969           | 66.647    |
| 600                                                                        | 76.453      | 304.022   | 271.368                       | 19.593                   | -700.634           | -625.528           | 54.456    |
| 700                                                                        | 81.868      | 316.230   | 276.917                       | 27.519                   | -701.253           | -612.957           | 45.739    |
| 800                                                                        | 86.201      | 327.455   | 282.542                       | 35.930                   | -701.636           | -600.315           | 39.196    |
| 900                                                                        | 89.719      | 337.818   | 288.116                       | 44.732                   | -701.832           | -587.636           | 34.105    |
| 1000                                                                       | 92.617      | 347.426   | 293.572                       | 53.854                   | -701.879           | -574.944           | 30.032    |
| 1100                                                                       | 95.038      | 356.370   | 298.879                       | 63.240                   | -701.805           | -562.253           | 26.699    |
| 1200                                                                       | 97.084      | 364.730   | 304.022                       | 72.849                   | -701.629           | -549.574           | 23.922    |
| 1300                                                                       | 98.833      | 372.571   | 308.997                       | 82.647                   | -701.368           | -536.913           | 21.573    |
| 1400                                                                       | 100.344     | 379.952   | 313.804                       | 92.607                   | -701.033           | -524.274           | 19.561    |
| 1500                                                                       | 101.660     | 386.921   | 318.449                       | 102.709                  | -700.635           | -511.662           | 17.817    |
| <b>30. CHLOROTRIFLUOROMETHANE <math>\text{CClF}_3</math> (g)</b>           |             |           |                               |                          |                    |                    |           |
| 298.15                                                                     | 66.886      | 285.419   | 285.419                       | 0.000                    | -707.800           | -667.238           | 116.896   |
| 300                                                                        | 67.111      | 285.834   | 285.421                       | 0.124                    | -707.810           | -666.986           | 116.131   |
| 400                                                                        | 77.528      | 306.646   | 288.187                       | 7.383                    | -708.153           | -653.316           | 85.313    |
| 500                                                                        | 85.013      | 324.797   | 293.734                       | 15.532                   | -708.170           | -639.599           | 66.818    |
| 600                                                                        | 90.329      | 340.794   | 300.271                       | 24.314                   | -707.975           | -625.901           | 54.489    |
| 700                                                                        | 94.132      | 355.020   | 307.096                       | 33.547                   | -707.654           | -612.246           | 45.686    |
| 800                                                                        | 96.899      | 367.780   | 313.897                       | 43.106                   | -707.264           | -598.642           | 39.087    |
| 900                                                                        | 98.951      | 379.317   | 320.536                       | 52.903                   | -706.837           | -585.090           | 33.957    |
| 1000                                                                       | 100.507     | 389.827   | 326.947                       | 62.880                   | -706.396           | -571.586           | 29.856    |
| 1100                                                                       | 101.708     | 399.465   | 333.108                       | 72.993                   | -705.950           | -558.126           | 26.503    |
| 1200                                                                       | 102.651     | 408.357   | 339.013                       | 83.213                   | -705.505           | -544.707           | 23.710    |
| 1300                                                                       | 103.404     | 416.604   | 344.668                       | 93.517                   | -705.064           | -531.326           | 21.349    |
| 1400                                                                       | 104.012     | 424.290   | 350.084                       | 103.889                  | -704.628           | -517.977           | 19.326    |
| 1500                                                                       | 104.512     | 431.484   | 355.273                       | 114.316                  | -704.196           | -504.660           | 17.574    |
| <b>31. DICHLORODIFLUOROMETHANE <math>\text{CCl}_2\text{F}_2</math> (g)</b> |             |           |                               |                          |                    |                    |           |
| 298.15                                                                     | 72.476      | 300.903   | 300.903                       | 0.000                    | -486.000           | -447.030           | 78.317    |
| 300                                                                        | 72.691      | 301.352   | 300.905                       | 0.134                    | -486.002           | -446.788           | 77.792    |
| 400                                                                        | 82.408      | 323.682   | 303.883                       | 7.919                    | -485.945           | -433.716           | 56.637    |
| 500                                                                        | 89.063      | 342.833   | 309.804                       | 16.514                   | -485.618           | -420.692           | 43.949    |
| 600                                                                        | 93.635      | 359.500   | 316.729                       | 25.663                   | -485.136           | -407.751           | 35.497    |
| 700                                                                        | 96.832      | 374.189   | 323.909                       | 35.196                   | -484.576           | -394.897           | 29.467    |
| 800                                                                        | 99.121      | 387.276   | 331.027                       | 44.999                   | -483.984           | -382.126           | 24.950    |
| 900                                                                        | 100.801     | 399.053   | 337.942                       | 55.000                   | -483.388           | -369.429           | 21.441    |
| 1000                                                                       | 102.062     | 409.742   | 344.596                       | 65.146                   | -482.800           | -356.799           | 18.637    |
| 1100                                                                       | 103.030     | 419.517   | 350.969                       | 75.402                   | -482.226           | -344.227           | 16.346    |
| 1200                                                                       | 103.786     | 428.515   | 357.061                       | 85.745                   | -481.667           | -331.706           | 14.439    |
| 1300                                                                       | 104.388     | 436.847   | 362.882                       | 96.154                   | -481.121           | -319.232           | 12.827    |
| 1400                                                                       | 104.874     | 444.602   | 368.445                       | 106.618                  | -480.588           | -306.799           | 11.447    |
| 1500                                                                       | 105.270     | 451.851   | 373.767                       | 117.126                  | -480.065           | -294.404           | 10.252    |
| <b>32. CHLORODIFLUOROMETHANE <math>\text{CHClF}_2</math> (g)</b>           |             |           |                               |                          |                    |                    |           |
| 298.15                                                                     | 55.853      | 280.915   | 280.915                       | 0.000                    | -475.000           | -443.845           | 77.759    |
| 300                                                                        | 56.039      | 281.261   | 280.916                       | 0.104                    | -475.028           | -443.652           | 77.246    |
| 400                                                                        | 65.395      | 298.701   | 283.231                       | 6.188                    | -476.390           | -432.978           | 56.540    |
| 500                                                                        | 73.008      | 314.145   | 287.898                       | 13.123                   | -477.398           | -422.001           | 44.086    |
| 600                                                                        | 78.940      | 328.003   | 293.448                       | 20.733                   | -478.103           | -410.851           | 35.767    |

| $T/K$                                                       | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|-------------------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                             | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 700                                                         | 83.551      | 340.533   | 299.294                       | 28.867                   | -478.574           | -399.603           | 29.818    |
| 800                                                         | 87.185      | 351.936   | 305.172                       | 37.411                   | -478.870           | -388.299           | 25.353    |
| 900                                                         | 90.100      | 362.379   | 310.956                       | 46.280                   | -479.031           | -376.967           | 21.878    |
| 1000                                                        | 92.475      | 371.999   | 316.586                       | 55.413                   | -479.090           | -365.622           | 19.098    |
| 1100                                                        | 94.433      | 380.908   | 322.033                       | 64.761                   | -479.068           | -354.276           | 16.823    |
| 1200                                                        | 96.066      | 389.196   | 327.289                       | 74.289                   | -478.982           | -342.935           | 14.927    |
| 1300                                                        | 97.438      | 396.941   | 332.352                       | 83.966                   | -478.843           | -331.603           | 13.324    |
| 1400                                                        | 98.601      | 404.206   | 337.228                       | 93.769                   | -478.661           | -320.283           | 11.950    |
| 1500                                                        | 99.593      | 411.044   | 341.923                       | 103.681                  | -478.443           | -308.978           | 10.759    |
| <b>33. METHYLAMINE <math>\text{CH}_5\text{N (g)}</math></b> |             |           |                               |                          |                    |                    |           |
| 298.15                                                      | 50.053      | 242.881   | 242.881                       | 0.000                    | -22.529            | 32.734             | -5.735    |
| 300                                                         | 50.227      | 243.196   | 242.893                       | 0.091                    | -22.614            | 33.077             | -5.759    |
| 400                                                         | 60.171      | 258.986   | 244.975                       | 5.604                    | -26.846            | 52.294             | -6.829    |
| 500                                                         | 70.057      | 273.486   | 249.244                       | 12.121                   | -30.431            | 72.510             | -7.575    |
| 600                                                         | 78.929      | 287.063   | 254.431                       | 19.579                   | -33.364            | 93.382             | -8.129    |
| 700                                                         | 86.711      | 299.826   | 260.008                       | 27.873                   | -35.712            | 114.702            | -8.559    |
| 800                                                         | 93.545      | 311.865   | 265.749                       | 36.893                   | -37.548            | 136.316            | -8.900    |
| 900                                                         | 99.573      | 323.239   | 271.511                       | 46.555                   | -38.949            | 158.138            | -9.178    |
| 1000                                                        | 104.886     | 334.006   | 277.220                       | 56.786                   | -39.967            | 180.098            | -9.407    |
| 1100                                                        | 109.576     | 344.233   | 282.861                       | 67.509                   | -40.681            | 201.822            | -9.584    |
| 1200                                                        | 113.708     | 353.944   | 288.374                       | 78.685                   | -41.136            | 224.240            | -9.761    |
| 1300                                                        | 117.341     | 363.190   | 293.775                       | 90.239                   | -41.376            | 246.364            | -9.899    |
| 1400                                                        | 120.542     | 372.012   | 299.061                       | 102.131                  | -41.451            | 268.504            | -10.018   |
| 1500                                                        | 123.353     | 380.426   | 304.209                       | 114.326                  | -41.381            | 290.639            | -10.121   |
| <b>34. CHLORINE <math>\text{Cl (g)}</math></b>              |             |           |                               |                          |                    |                    |           |
| 298.15                                                      | 21.838      | 165.190   | 165.190                       | 0.000                    | 121.302            | 105.306            | -18.449   |
| 300                                                         | 21.852      | 165.325   | 165.190                       | 0.040                    | 121.311            | 105.207            | -18.318   |
| 400                                                         | 22.467      | 171.703   | 166.055                       | 2.259                    | 121.795            | 99.766             | -13.028   |
| 500                                                         | 22.744      | 176.752   | 167.708                       | 4.522                    | 122.272            | 94.203             | -9.841    |
| 600                                                         | 22.781      | 180.905   | 169.571                       | 6.800                    | 122.734            | 88.546             | -7.709    |
| 700                                                         | 22.692      | 184.411   | 171.448                       | 9.074                    | 123.172            | 82.813             | -6.179    |
| 800                                                         | 22.549      | 187.432   | 173.261                       | 11.337                   | 123.585            | 77.019             | -5.029    |
| 900                                                         | 22.389      | 190.079   | 174.986                       | 13.584                   | 123.971            | 71.175             | -4.131    |
| 1000                                                        | 22.233      | 192.430   | 176.615                       | 15.815                   | 124.334            | 65.289             | -3.410    |
| 1100                                                        | 22.089      | 194.542   | 178.150                       | 18.031                   | 124.675            | 59.368             | -2.819    |
| 1200                                                        | 21.959      | 196.458   | 179.597                       | 20.233                   | 124.996            | 53.416             | -2.325    |
| 1300                                                        | 21.843      | 198.211   | 180.963                       | 22.423                   | 125.299            | 47.439             | -1.906    |
| 1400                                                        | 21.742      | 199.826   | 182.253                       | 24.602                   | 125.587            | 41.439             | -1.546    |
| 1500                                                        | 21.652      | 201.323   | 183.475                       | 26.772                   | 125.861            | 35.418             | -1.233    |
| <b>35. DICHLORINE <math>\text{Cl}_2 \text{ (g)}</math></b>  |             |           |                               |                          |                    |                    |           |
| 298.15                                                      | 33.949      | 223.079   | 223.079                       | 0.000                    | 0.000              | 0.000              | 0.000     |
| 300                                                         | 33.981      | 223.290   | 223.080                       | 0.063                    | 0.000              | 0.000              | 0.000     |
| 400                                                         | 35.296      | 233.263   | 224.431                       | 3.533                    | 0.000              | 0.000              | 0.000     |
| 500                                                         | 36.064      | 241.229   | 227.021                       | 7.104                    | 0.000              | 0.000              | 0.000     |
| 600                                                         | 36.547      | 247.850   | 229.956                       | 10.736                   | 0.000              | 0.000              | 0.000     |
| 700                                                         | 36.874      | 253.510   | 232.926                       | 14.408                   | 0.000              | 0.000              | 0.000     |
| 800                                                         | 37.111      | 258.450   | 235.815                       | 18.108                   | 0.000              | 0.000              | 0.000     |
| 900                                                         | 37.294      | 262.832   | 238.578                       | 21.829                   | 0.000              | 0.000              | 0.000     |
| 1000                                                        | 37.442      | 266.769   | 241.203                       | 25.566                   | 0.000              | 0.000              | 0.000     |
| 1100                                                        | 37.567      | 270.343   | 243.692                       | 29.316                   | 0.000              | 0.000              | 0.000     |
| 1200                                                        | 37.678      | 273.617   | 246.052                       | 33.079                   | 0.000              | 0.000              | 0.000     |
| 1300                                                        | 37.778      | 276.637   | 248.290                       | 36.851                   | 0.000              | 0.000              | 0.000     |
| 1400                                                        | 37.872      | 279.440   | 250.416                       | 40.634                   | 0.000              | 0.000              | 0.000     |
| 1500                                                        | 37.961      | 282.056   | 252.439                       | 44.426                   | 0.000              | 0.000              | 0.000     |
| <b>36. HYDROGEN CHLORIDE <math>\text{HCl (g)}</math></b>    |             |           |                               |                          |                    |                    |           |
| 298.15                                                      | 29.136      | 186.902   | 186.902                       | 0.000                    | -92.310            | -95.298            | 16.696    |
| 300                                                         | 29.137      | 187.082   | 186.902                       | 0.054                    | -92.314            | -95.317            | 16.596    |

| $T/K$ | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|-------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|       | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 400   | 29.175      | 195.468   | 188.045                       | 2.969                    | -92.587            | -96.278            | 12.573    |
| 500   | 29.304      | 201.990   | 190.206                       | 5.892                    | -92.911            | -97.164            | 10.151    |
| 600   | 29.576      | 207.354   | 192.630                       | 8.835                    | -93.249            | -97.983            | 8.530     |
| 700   | 29.988      | 211.943   | 195.069                       | 11.812                   | -93.577            | -98.746            | 7.368     |
| 800   | 30.500      | 215.980   | 197.435                       | 14.836                   | -93.879            | -99.464            | 6.494     |
| 900   | 31.063      | 219.604   | 199.700                       | 17.913                   | -94.149            | -100.145           | 5.812     |
| 1000  | 31.639      | 222.907   | 201.858                       | 21.049                   | -94.384            | -100.798           | 5.265     |
| 1100  | 32.201      | 225.949   | 203.912                       | 24.241                   | -94.587            | -101.430           | 4.816     |
| 1200  | 32.734      | 228.774   | 205.867                       | 27.488                   | -94.760            | -102.044           | 4.442     |
| 1300  | 33.229      | 231.414   | 207.732                       | 30.786                   | -94.908            | -102.645           | 4.124     |
| 1400  | 33.684      | 233.893   | 209.513                       | 34.132                   | -95.035            | -103.235           | 3.852     |
| 1500  | 34.100      | 236.232   | 211.217                       | 37.522                   | -95.146            | -103.817           | 3.615     |

**37. COPPER Cu (cr, l)**

|        |        |        |        |        |       |       |       |
|--------|--------|--------|--------|--------|-------|-------|-------|
| 298.15 | 24.440 | 33.150 | 33.150 | 0.000  | 0.000 | 0.000 | 0.000 |
| 300    | 24.460 | 33.301 | 33.150 | 0.045  | 0.000 | 0.000 | 0.000 |
| 400    | 25.339 | 40.467 | 34.122 | 2.538  | 0.000 | 0.000 | 0.000 |
| 500    | 25.966 | 46.192 | 35.982 | 5.105  | 0.000 | 0.000 | 0.000 |
| 600    | 26.479 | 50.973 | 38.093 | 7.728  | 0.000 | 0.000 | 0.000 |
| 700    | 26.953 | 55.090 | 40.234 | 10.399 | 0.000 | 0.000 | 0.000 |
| 800    | 27.448 | 58.721 | 42.322 | 13.119 | 0.000 | 0.000 | 0.000 |
| 900    | 28.014 | 61.986 | 44.328 | 15.891 | 0.000 | 0.000 | 0.000 |
| 1000   | 28.700 | 64.971 | 46.245 | 18.726 | 0.000 | 0.000 | 0.000 |
| 1100   | 29.553 | 67.745 | 48.075 | 21.637 | 0.000 | 0.000 | 0.000 |
| 1200   | 30.617 | 70.361 | 49.824 | 24.644 | 0.000 | 0.000 | 0.000 |
| 1300   | 31.940 | 72.862 | 51.501 | 27.769 | 0.000 | 0.000 | 0.000 |
| 1358   | 32.844 | 74.275 | 52.443 | 29.647 | 0.000 | 0.000 | 0.000 |

PHASE TRANSITION:  $\Delta_{\text{trs}} H = 13.141$  kJ/mol,  $\Delta_{\text{trs}} S = 9.676$  J/K·mol, cr-l

|      |        |        |        |        |       |       |       |
|------|--------|--------|--------|--------|-------|-------|-------|
| 1358 | 32.800 | 83.951 | 52.443 | 42.788 | 0.000 | 0.000 | 0.000 |
| 1400 | 32.800 | 84.950 | 53.403 | 44.166 | 0.000 | 0.000 | 0.000 |
| 1500 | 32.800 | 87.213 | 55.583 | 47.446 | 0.000 | 0.000 | 0.000 |

**38. COPPER Cu (g)**

|        |        |         |         |        |         |         |         |
|--------|--------|---------|---------|--------|---------|---------|---------|
| 298.15 | 20.786 | 166.397 | 166.397 | 0.000  | 337.600 | 297.873 | -52.185 |
| 300    | 20.786 | 166.525 | 166.397 | 0.038  | 337.594 | 297.626 | -51.821 |
| 400    | 20.786 | 172.505 | 167.213 | 2.117  | 337.179 | 284.364 | -37.134 |
| 500    | 20.786 | 177.143 | 168.752 | 4.196  | 336.691 | 271.215 | -28.333 |
| 600    | 20.786 | 180.933 | 170.476 | 6.274  | 336.147 | 258.170 | -22.475 |
| 700    | 20.786 | 184.137 | 172.205 | 8.353  | 335.554 | 245.221 | -18.298 |
| 800    | 20.786 | 186.913 | 173.874 | 10.431 | 334.913 | 232.359 | -15.171 |
| 900    | 20.786 | 189.361 | 175.461 | 12.510 | 334.219 | 219.581 | -12.744 |
| 1000   | 20.786 | 191.551 | 176.963 | 14.589 | 333.463 | 206.883 | -10.806 |
| 1100   | 20.788 | 193.532 | 178.380 | 16.667 | 332.631 | 194.265 | -9.225  |
| 1200   | 20.793 | 195.341 | 179.719 | 18.746 | 331.703 | 181.726 | -7.910  |
| 1300   | 20.803 | 197.006 | 180.986 | 20.826 | 330.657 | 169.270 | -6.801  |
| 1400   | 20.823 | 198.548 | 182.186 | 22.907 | 316.342 | 157.305 | -5.869  |
| 1500   | 20.856 | 199.986 | 183.325 | 24.991 | 315.146 | 145.987 | -5.084  |

**39. COPPER OXIDE CuO (cr)**

|        |        |         |        |        |          |          |        |
|--------|--------|---------|--------|--------|----------|----------|--------|
| 298.15 | 42.300 | 42.740  | 42.740 | 0.000  | -162.000 | -134.277 | 23.524 |
| 300    | 42.417 | 43.002  | 42.741 | 0.078  | -161.994 | -134.105 | 23.349 |
| 400    | 46.783 | 55.878  | 44.467 | 4.564  | -161.487 | -124.876 | 16.307 |
| 500    | 49.190 | 66.596  | 47.852 | 9.372  | -160.775 | -115.803 | 12.098 |
| 600    | 50.827 | 75.717  | 51.755 | 14.377 | -159.973 | -106.883 | 9.305  |
| 700    | 52.099 | 83.651  | 55.757 | 19.526 | -159.124 | -98.102  | 7.320  |
| 800    | 53.178 | 90.680  | 59.691 | 24.791 | -158.247 | -89.444  | 5.840  |
| 900    | 54.144 | 97.000  | 63.491 | 30.158 | -157.356 | -80.897  | 4.695  |
| 1000   | 55.040 | 102.751 | 67.134 | 35.617 | -156.462 | -72.450  | 3.784  |
| 1100   | 55.890 | 108.037 | 70.615 | 41.164 | -155.582 | -64.091  | 3.043  |
| 1200   | 56.709 | 112.936 | 73.941 | 46.794 | -154.733 | -55.812  | 2.429  |

| $T/K$                                                                                                      | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|------------------------------------------------------------------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                                                                            | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 1300                                                                                                       | 57.507      | 117.507   | 77.118                        | 52.505                   | -153.940           | -47.601            | 1.913     |
| 1400                                                                                                       | 58.288      | 121.797   | 80.158                        | 58.295                   | -166.354           | -39.043            | 1.457     |
| 1500                                                                                                       | 59.057      | 125.845   | 83.070                        | 64.163                   | -165.589           | -29.975            | 1.044     |
| <b>40. DICOPPER OXIDE <math>\text{Cu}_2\text{O}</math> (cr)</b>                                            |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                     | 62.600      | 92.550    | 92.550                        | 0.000                    | -173.100           | -150.344           | 26.339    |
| 300                                                                                                        | 62.721      | 92.938    | 92.551                        | 0.116                    | -173.102           | -150.203           | 26.152    |
| 400                                                                                                        | 67.587      | 111.712   | 95.078                        | 6.654                    | -173.036           | -142.572           | 18.618    |
| 500                                                                                                        | 70.784      | 127.155   | 99.995                        | 13.580                   | -172.772           | -134.984           | 14.101    |
| 600                                                                                                        | 73.323      | 140.291   | 105.643                       | 20.789                   | -172.389           | -127.460           | 11.096    |
| 700                                                                                                        | 75.552      | 151.764   | 111.429                       | 28.235                   | -171.914           | -120.009           | 8.955     |
| 800                                                                                                        | 77.616      | 161.989   | 117.121                       | 35.894                   | -171.363           | -112.631           | 7.354     |
| 900                                                                                                        | 79.584      | 171.245   | 122.629                       | 43.755                   | -170.750           | -105.325           | 6.113     |
| 1000                                                                                                       | 81.492      | 179.729   | 127.920                       | 51.809                   | -170.097           | -98.091            | 5.124     |
| 1100                                                                                                       | 83.360      | 187.584   | 132.992                       | 60.052                   | -169.431           | -90.922            | 4.317     |
| 1200                                                                                                       | 85.202      | 194.917   | 137.850                       | 68.480                   | -168.791           | -83.814            | 3.648     |
| 1300                                                                                                       | 87.026      | 201.808   | 142.507                       | 77.092                   | -168.223           | -76.756            | 3.084     |
| 1400                                                                                                       | 88.836      | 208.324   | 146.978                       | 85.885                   | -194.030           | -68.926            | 2.572     |
| 1500                                                                                                       | 90.636      | 214.515   | 151.276                       | 94.858                   | -193.438           | -60.010            | 2.090     |
| <b>41. COPPER DICHLORIDE <math>\text{CuCl}_2</math> (cr, l)</b>                                            |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                     | 71.880      | 108.070   | 108.070                       | 0.000                    | -218.000           | -173.826           | 30.453    |
| 300                                                                                                        | 71.998      | 108.515   | 108.071                       | 0.133                    | -217.975           | -173.552           | 30.218    |
| 400                                                                                                        | 76.338      | 129.899   | 110.957                       | 7.577                    | -216.494           | -158.962           | 20.758    |
| 500                                                                                                        | 78.654      | 147.204   | 116.532                       | 15.336                   | -214.873           | -144.765           | 15.123    |
| 600                                                                                                        | 80.175      | 161.687   | 122.884                       | 23.282                   | -213.182           | -130.901           | 11.396    |
| 675                                                                                                        | 81.056      | 171.183   | 127.732                       | 29.329                   | -211.185           | -120.693           | 9.340     |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 0.700$ kJ/mol, $\Delta_{\text{trs}} S = 1.037$ J/Kmol, crII-crI |             |           |                               |                          |                    |                    |           |
| 675                                                                                                        | 82.400      | 172.220   | 127.732                       | 30.029                   | -211.185           | -120.693           | 9.340     |
| 700                                                                                                        | 82.400      | 175.216   | 129.375                       | 32.089                   | -210.719           | -117.350           | 8.757     |
| 800                                                                                                        | 82.400      | 186.219   | 135.808                       | 40.329                   | -208.898           | -104.137           | 6.799     |
| 871                                                                                                        | 82.400      | 193.226   | 140.207                       | 46.179                   | -192.649           | -94.893            | 5.691     |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 15.001$ kJ/mol, $\Delta_{\text{trs}} S = 17.221$ J/Kmol, crI-l  |             |           |                               |                          |                    |                    |           |
| 871                                                                                                        | 100.000     | 210.447   | 140.207                       | 61.180                   | -192.649           | -94.893            | 5.691     |
| 900                                                                                                        | 100.000     | 213.723   | 142.523                       | 64.080                   | -191.640           | -91.655            | 5.319     |
| 1000                                                                                                       | 100.000     | 224.259   | 150.179                       | 74.080                   | -188.212           | -80.730            | 4.217     |
| 1100                                                                                                       | 100.000     | 233.790   | 157.353                       | 84.080                   | -184.873           | -70.144            | 3.331     |
| 1130.75                                                                                                    | 100.000     | 236.547   | 159.470                       | 87.155                   | -183.867           | -66.951            | 3.093     |
| <b>42. COPPER DICHLORIDE <math>\text{CuCl}_2</math> (g)</b>                                                |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                     | 56.814      | 278.418   | 278.418                       | 0.000                    | -43.268            | -49.883            | 8.739     |
| 300                                                                                                        | 56.869      | 278.769   | 278.419                       | 0.105                    | -43.271            | -49.924            | 8.692     |
| 400                                                                                                        | 58.992      | 295.456   | 280.679                       | 5.911                    | -43.428            | -52.119            | 6.806     |
| 500                                                                                                        | 60.111      | 308.752   | 285.010                       | 11.871                   | -43.606            | -54.271            | 5.670     |
| 600                                                                                                        | 60.761      | 319.774   | 289.911                       | 17.918                   | -43.814            | -56.385            | 4.909     |
| 700                                                                                                        | 61.168      | 329.173   | 294.865                       | 24.015                   | -44.060            | -58.462            | 4.362     |
| 800                                                                                                        | 61.439      | 337.360   | 299.677                       | 30.147                   | -44.349            | -60.500            | 3.950     |
| 900                                                                                                        | 61.630      | 344.608   | 304.274                       | 36.301                   | -44.688            | -62.499            | 3.627     |
| 1000                                                                                                       | 61.776      | 351.109   | 308.638                       | 42.471                   | -45.088            | -64.457            | 3.367     |
| 1100                                                                                                       | 61.900      | 357.003   | 312.771                       | 48.655                   | -45.566            | -66.372            | 3.152     |
| 1200                                                                                                       | 62.022      | 362.394   | 316.685                       | 54.851                   | -46.139            | -68.239            | 2.970     |
| 1300                                                                                                       | 62.159      | 367.364   | 320.395                       | 61.060                   | -46.829            | -70.053            | 2.815     |
| 1400                                                                                                       | 62.325      | 371.976   | 323.916                       | 67.284                   | -60.784            | -71.404            | 2.664     |
| 1500                                                                                                       | 62.531      | 376.283   | 327.265                       | 73.526                   | -61.613            | -72.133            | 2.512     |
| <b>43. FLUORINE <math>\text{F}</math> (g)</b>                                                              |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                     | 22.746      | 158.750   | 158.750                       | 0.000                    | 79.380             | 62.280             | -10.911   |
| 300                                                                                                        | 22.742      | 158.891   | 158.750                       | 0.042                    | 79.393             | 62.173             | -10.825   |
| 400                                                                                                        | 22.432      | 165.394   | 159.639                       | 2.302                    | 80.043             | 56.332             | -7.356    |
| 500                                                                                                        | 22.100      | 170.363   | 161.307                       | 4.528                    | 80.587             | 50.340             | -5.259    |

| $T/K$ | $J/K\text{mol}$ |           |                               | $\text{kJ/mol}$          |                    |                    | $\text{Log } K_f$ |
|-------|-----------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-------------------|
|       | $C_p^\circ$     | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |                   |
| 600   | 21.832          | 174.368   | 163.161                       | 6.724                    | 81.046             | 44.246             | -3.852            |
| 700   | 21.629          | 177.717   | 165.008                       | 8.897                    | 81.442             | 38.081             | -2.842            |
| 800   | 21.475          | 180.595   | 166.780                       | 11.052                   | 81.792             | 31.862             | -2.080            |
| 900   | 21.357          | 183.117   | 168.458                       | 13.193                   | 82.106             | 25.601             | -1.486            |
| 1000  | 21.266          | 185.362   | 170.039                       | 15.324                   | 82.391             | 19.308             | -1.009            |
| 1100  | 21.194          | 187.386   | 171.525                       | 17.447                   | 82.654             | 12.986             | -0.617            |
| 1200  | 21.137          | 189.227   | 172.925                       | 19.563                   | 82.897             | 6.642              | -0.289            |
| 1300  | 21.091          | 190.917   | 174.245                       | 21.675                   | 83.123             | 0.278              | -0.011            |
| 1400  | 21.054          | 192.479   | 175.492                       | 23.782                   | 83.335             | -6.103             | 0.228             |
| 1500  | 21.022          | 193.930   | 176.673                       | 25.886                   | 83.533             | -12.498            | 0.435             |

**44. DIFLUORINE  $F_2$  (g)**

|        |        |         |         |        |       |       |       |
|--------|--------|---------|---------|--------|-------|-------|-------|
| 298.15 | 31.304 | 202.790 | 202.790 | 0.000  | 0.000 | 0.000 | 0.000 |
| 300    | 31.337 | 202.984 | 202.790 | 0.058  | 0.000 | 0.000 | 0.000 |
| 400    | 32.995 | 212.233 | 204.040 | 3.277  | 0.000 | 0.000 | 0.000 |
| 500    | 34.258 | 219.739 | 206.453 | 6.643  | 0.000 | 0.000 | 0.000 |
| 600    | 35.171 | 226.070 | 209.208 | 10.117 | 0.000 | 0.000 | 0.000 |
| 700    | 35.839 | 231.545 | 212.017 | 13.669 | 0.000 | 0.000 | 0.000 |
| 800    | 36.343 | 236.365 | 214.765 | 17.279 | 0.000 | 0.000 | 0.000 |
| 900    | 36.740 | 240.669 | 217.409 | 20.934 | 0.000 | 0.000 | 0.000 |
| 1000   | 37.065 | 244.557 | 219.932 | 24.625 | 0.000 | 0.000 | 0.000 |
| 1100   | 37.342 | 248.103 | 222.334 | 28.346 | 0.000 | 0.000 | 0.000 |
| 1200   | 37.588 | 251.363 | 224.619 | 32.093 | 0.000 | 0.000 | 0.000 |
| 1300   | 37.811 | 254.381 | 226.794 | 35.863 | 0.000 | 0.000 | 0.000 |
| 1400   | 38.019 | 257.191 | 228.866 | 39.654 | 0.000 | 0.000 | 0.000 |
| 1500   | 38.214 | 259.820 | 230.843 | 43.466 | 0.000 | 0.000 | 0.000 |

**45. HYDROGEN FLUORIDE  $HF$  (g)**

|        |        |         |         |        |          |          |        |
|--------|--------|---------|---------|--------|----------|----------|--------|
| 298.15 | 29.137 | 173.776 | 173.776 | 0.000  | -273.300 | -275.399 | 48.248 |
| 300    | 29.137 | 173.956 | 173.776 | 0.054  | -273.302 | -275.412 | 47.953 |
| 400    | 29.149 | 182.340 | 174.919 | 2.968  | -273.450 | -276.096 | 36.054 |
| 500    | 29.172 | 188.846 | 177.078 | 5.884  | -273.679 | -276.733 | 28.910 |
| 600    | 29.230 | 194.169 | 179.496 | 8.804  | -273.961 | -277.318 | 24.142 |
| 700    | 29.350 | 198.683 | 181.923 | 11.732 | -274.277 | -277.852 | 20.733 |
| 800    | 29.549 | 202.614 | 184.269 | 14.676 | -274.614 | -278.340 | 18.174 |
| 900    | 29.827 | 206.110 | 186.505 | 17.645 | -274.961 | -278.785 | 16.180 |
| 1000   | 30.169 | 209.270 | 188.626 | 20.644 | -275.309 | -279.191 | 14.583 |
| 1100   | 30.558 | 212.163 | 190.636 | 23.680 | -275.652 | -279.563 | 13.275 |
| 1200   | 30.974 | 214.840 | 192.543 | 26.756 | -275.988 | -279.904 | 12.184 |
| 1300   | 31.403 | 217.336 | 194.355 | 29.875 | -276.315 | -280.217 | 11.259 |
| 1400   | 31.831 | 219.679 | 196.081 | 33.037 | -276.631 | -280.505 | 10.466 |
| 1500   | 32.250 | 221.889 | 197.729 | 36.241 | -276.937 | -280.771 | 9.777  |

**46. GERMANIUM  $Ge$  (cr, l)**

|        |        |        |        |        |       |       |       |
|--------|--------|--------|--------|--------|-------|-------|-------|
| 298.15 | 23.222 | 31.090 | 31.090 | 0.000  | 0.000 | 0.000 | 0.000 |
| 300    | 23.249 | 31.234 | 31.090 | 0.043  | 0.000 | 0.000 | 0.000 |
| 400    | 24.310 | 38.083 | 32.017 | 2.426  | 0.000 | 0.000 | 0.000 |
| 500    | 24.962 | 43.582 | 33.798 | 4.892  | 0.000 | 0.000 | 0.000 |
| 600    | 25.452 | 48.178 | 35.822 | 7.414  | 0.000 | 0.000 | 0.000 |
| 700    | 25.867 | 52.133 | 37.876 | 9.980  | 0.000 | 0.000 | 0.000 |
| 800    | 26.240 | 55.612 | 39.880 | 12.586 | 0.000 | 0.000 | 0.000 |
| 900    | 26.591 | 58.723 | 41.804 | 15.227 | 0.000 | 0.000 | 0.000 |
| 1000   | 26.926 | 61.542 | 43.639 | 17.903 | 0.000 | 0.000 | 0.000 |
| 1100   | 27.252 | 64.124 | 45.386 | 20.612 | 0.000 | 0.000 | 0.000 |
| 1200   | 27.571 | 66.509 | 47.048 | 23.353 | 0.000 | 0.000 | 0.000 |
| 1211.4 | 27.608 | 66.770 | 47.232 | 23.668 | 0.000 | 0.000 | 0.000 |

PHASE TRANSITION:  $\Delta_{\text{trs}} H = 37.030 \text{ kJ/mol}$ ,  $\Delta_{\text{trs}} S = 30.568 \text{ J/Kmol}$ , cr-l

|        |        |         |        |        |       |       |       |
|--------|--------|---------|--------|--------|-------|-------|-------|
| 1211.4 | 27.600 | 97.338  | 47.232 | 60.698 | 0.000 | 0.000 | 0.000 |
| 1300   | 27.600 | 99.286  | 50.714 | 63.143 | 0.000 | 0.000 | 0.000 |
| 1400   | 27.600 | 101.331 | 54.258 | 65.903 | 0.000 | 0.000 | 0.000 |
| 1500   | 27.600 | 103.236 | 57.460 | 68.663 | 0.000 | 0.000 | 0.000 |

| $T/\text{K}$                                                                                                                   | $\text{J/Kmol}$ |           |                               | $\text{kJ/mol}$          |                    |                    | $\text{Log } K_f$ |
|--------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-------------------|
|                                                                                                                                | $C_p^\circ$     | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |                   |
| 47. GERMANIUM $\text{Ge (g)}$                                                                                                  |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                         | 30.733          | 167.903   | 167.903                       | 0.000                    | 367.800            | 327.009            | -57.290           |
| 300                                                                                                                            | 30.757          | 168.094   | 167.904                       | 0.057                    | 367.814            | 326.756            | -56.893           |
| 400                                                                                                                            | 31.071          | 177.025   | 169.119                       | 3.162                    | 368.536            | 312.959            | -40.868           |
| 500                                                                                                                            | 30.360          | 183.893   | 171.415                       | 6.239                    | 369.147            | 298.991            | -31.235           |
| 600                                                                                                                            | 29.265          | 189.334   | 173.965                       | 9.222                    | 369.608            | 284.914            | -24.804           |
| 700                                                                                                                            | 28.102          | 193.758   | 176.487                       | 12.090                   | 369.910            | 270.773            | -20.205           |
| 800                                                                                                                            | 27.029          | 197.439   | 178.882                       | 14.845                   | 370.060            | 256.598            | -16.754           |
| 900                                                                                                                            | 26.108          | 200.567   | 181.122                       | 17.501                   | 370.073            | 242.414            | -14.069           |
| 1000                                                                                                                           | 25.349          | 203.277   | 183.205                       | 20.072                   | 369.969            | 228.234            | -11.922           |
| 1100                                                                                                                           | 24.741          | 205.664   | 185.141                       | 22.575                   | 369.763            | 214.069            | -10.165           |
| 1200                                                                                                                           | 24.264          | 207.795   | 186.941                       | 25.025                   | 369.471            | 199.928            | -8.703            |
| 1300                                                                                                                           | 23.898          | 209.722   | 188.621                       | 27.432                   | 332.088            | 188.521            | -7.575            |
| 1400                                                                                                                           | 23.624          | 211.483   | 190.192                       | 29.807                   | 331.704            | 177.492            | -6.622            |
| 1500                                                                                                                           | 23.426          | 213.105   | 191.666                       | 32.159                   | 331.296            | 166.491            | -5.798            |
| 48. GERMANIUM DIOXIDE $\text{GeO}_2 (\text{cr, l})$                                                                            |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                         | 50.166          | 39.710    | 39.710                        | 0.000                    | -580.200           | -521.605           | 91.382            |
| 300                                                                                                                            | 50.475          | 40.021    | 39.711                        | 0.093                    | -580.204           | -521.242           | 90.755            |
| 400                                                                                                                            | 61.281          | 56.248    | 41.850                        | 5.759                    | -579.893           | -501.610           | 65.503            |
| 500                                                                                                                            | 66.273          | 70.519    | 46.191                        | 12.164                   | -579.013           | -482.134           | 50.368            |
| 600                                                                                                                            | 69.089          | 82.872    | 51.299                        | 18.943                   | -577.915           | -462.859           | 40.295            |
| 700                                                                                                                            | 70.974          | 93.671    | 56.597                        | 25.952                   | -576.729           | -443.776           | 33.115            |
| 800                                                                                                                            | 72.449          | 103.247   | 61.841                        | 33.125                   | -575.498           | -424.866           | 27.741            |
| 900                                                                                                                            | 73.764          | 111.857   | 66.928                        | 40.436                   | -574.235           | -406.113           | 23.570            |
| 1000                                                                                                                           | 75.049          | 119.696   | 71.819                        | 47.877                   | -572.934           | -387.502           | 20.241            |
| 1100                                                                                                                           | 76.378          | 126.910   | 76.504                        | 55.447                   | -571.582           | -369.024           | 17.523            |
| 1200                                                                                                                           | 77.796          | 133.616   | 80.987                        | 63.155                   | -570.166           | -350.671           | 15.264            |
| 1300                                                                                                                           | 79.332          | 139.903   | 85.279                        | 71.010                   | -605.685           | -329.732           | 13.249            |
| 1308                                                                                                                           | 79.460          | 140.390   | 85.615                        | 71.646                   | -584.059           | -328.034           | 13.100            |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 21.500 \text{ kJ/mol}$ , $\Delta_{\text{trs}} S = 16.437 \text{ J/Kmol}$ , crII-crI |                 |           |                               |                          |                    |                    |                   |
| 1308                                                                                                                           | 80.075          | 156.827   | 85.615                        | 93.146                   | -584.059           | -328.034           | 13.100            |
| 1388                                                                                                                           | 81.297          | 161.617   | 89.858                        | 99.601                   | -565.504           | -312.415           | 11.757            |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 17.200 \text{ kJ/mol}$ , $\Delta_{\text{trs}} S = 12.392 \text{ J/Kmol}$ , crI-l    |                 |           |                               |                          |                    |                    |                   |
| 1388                                                                                                                           | 78.500          | 174.009   | 89.858                        | 116.801                  | -565.504           | -312.415           | 11.757            |
| 1400                                                                                                                           | 78.500          | 174.685   | 90.582                        | 117.743                  | -565.328           | -310.228           | 11.575            |
| 1500                                                                                                                           | 78.500          | 180.100   | 96.372                        | 125.593                  | -563.882           | -292.057           | 10.170            |
| 49. GERMANIUM TETRACHLORIDE $\text{GeCl}_4 (\text{g})$                                                                         |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                         | 95.918          | 348.393   | 348.393                       | 0.000                    | -500.000           | -461.582           | 80.866            |
| 300                                                                                                                            | 96.041          | 348.987   | 348.395                       | 0.178                    | -499.991           | -461.343           | 80.326            |
| 400                                                                                                                            | 100.750         | 377.342   | 352.229                       | 10.045                   | -499.447           | -448.540           | 58.573            |
| 500                                                                                                                            | 103.206         | 400.114   | 359.604                       | 20.255                   | -498.845           | -435.882           | 45.536            |
| 600                                                                                                                            | 104.624         | 419.067   | 367.980                       | 30.652                   | -498.234           | -423.347           | 36.855            |
| 700                                                                                                                            | 105.509         | 435.266   | 376.463                       | 41.162                   | -497.634           | -410.914           | 30.662            |
| 800                                                                                                                            | 106.096         | 449.396   | 384.715                       | 51.744                   | -497.057           | -398.565           | 26.023            |
| 900                                                                                                                            | 106.504         | 461.917   | 392.611                       | 62.375                   | -496.509           | -386.287           | 22.419            |
| 1000                                                                                                                           | 106.799         | 473.155   | 400.113                       | 73.041                   | -495.993           | -374.068           | 19.539            |
| 1100                                                                                                                           | 107.020         | 483.344   | 407.224                       | 83.733                   | -495.512           | -361.899           | 17.185            |
| 1200                                                                                                                           | 107.189         | 492.664   | 413.961                       | 94.444                   | -495.067           | -349.772           | 15.225            |
| 1300                                                                                                                           | 107.320         | 501.249   | 420.349                       | 105.169                  | -531.677           | -334.973           | 13.459            |
| 1400                                                                                                                           | 107.425         | 509.206   | 426.416                       | 115.907                  | -531.265           | -319.857           | 11.934            |
| 1500                                                                                                                           | 107.509         | 516.621   | 432.185                       | 126.654                  | -530.861           | -304.771           | 10.613            |
| 50. HYDROGEN $\text{H (g)}$                                                                                                    |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                         | 20.786          | 114.716   | 114.716                       | 0.000                    | 217.998            | 203.276            | -35.613           |
| 300                                                                                                                            | 20.786          | 114.845   | 114.716                       | 0.038                    | 218.010            | 203.185            | -35.377           |
| 400                                                                                                                            | 20.786          | 120.824   | 115.532                       | 2.117                    | 218.635            | 198.149            | -25.875           |
| 500                                                                                                                            | 20.786          | 125.463   | 117.071                       | 4.196                    | 219.253            | 192.956            | -20.158           |

| $T/K$                                     | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|-------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                           | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 600                                       | 20.786      | 129.252   | 118.795                       | 6.274                    | 219.867            | 187.639            | -16.335   |
| 700                                       | 20.786      | 132.457   | 120.524                       | 8.353                    | 220.476            | 182.219            | -13.597   |
| 800                                       | 20.786      | 135.232   | 122.193                       | 10.431                   | 221.079            | 176.712            | -11.538   |
| 900                                       | 20.786      | 137.680   | 123.780                       | 12.510                   | 221.670            | 171.131            | -9.932    |
| 1000                                      | 20.786      | 139.870   | 125.282                       | 14.589                   | 222.247            | 165.485            | -8.644    |
| 1100                                      | 20.786      | 141.852   | 126.700                       | 16.667                   | 222.806            | 159.781            | -7.587    |
| 1200                                      | 20.786      | 143.660   | 128.039                       | 18.746                   | 223.345            | 154.028            | -6.705    |
| 1300                                      | 20.786      | 145.324   | 129.305                       | 20.824                   | 223.864            | 148.230            | -5.956    |
| 1400                                      | 20.786      | 146.864   | 130.505                       | 22.903                   | 224.360            | 142.393            | -5.313    |
| 1500                                      | 20.786      | 148.298   | 131.644                       | 24.982                   | 224.835            | 136.522            | -4.754    |
| <b>51. DIHYDROGEN <math>H_2(g)</math></b> |             |           |                               |                          |                    |                    |           |
| 298.15                                    | 28.836      | 130.680   | 130.680                       | 0.000                    | 0.000              | 0.000              | 0.000     |
| 300                                       | 28.849      | 130.858   | 130.680                       | 0.053                    | 0.000              | 0.000              | 0.000     |
| 400                                       | 29.181      | 139.217   | 131.818                       | 2.960                    | 0.000              | 0.000              | 0.000     |
| 500                                       | 29.260      | 145.738   | 133.974                       | 5.882                    | 0.000              | 0.000              | 0.000     |
| 600                                       | 29.327      | 151.078   | 136.393                       | 8.811                    | 0.000              | 0.000              | 0.000     |
| 700                                       | 29.440      | 155.607   | 138.822                       | 11.749                   | 0.000              | 0.000              | 0.000     |
| 800                                       | 29.623      | 159.549   | 141.172                       | 14.702                   | 0.000              | 0.000              | 0.000     |
| 900                                       | 29.880      | 163.052   | 143.412                       | 17.676                   | 0.000              | 0.000              | 0.000     |
| 1000                                      | 30.204      | 166.217   | 145.537                       | 20.680                   | 0.000              | 0.000              | 0.000     |
| 1100                                      | 30.580      | 169.113   | 147.550                       | 23.719                   | 0.000              | 0.000              | 0.000     |
| 1200                                      | 30.991      | 171.791   | 149.460                       | 26.797                   | 0.000              | 0.000              | 0.000     |
| 1300                                      | 31.422      | 174.288   | 151.275                       | 29.918                   | 0.000              | 0.000              | 0.000     |
| 1400                                      | 31.860      | 176.633   | 153.003                       | 33.082                   | 0.000              | 0.000              | 0.000     |
| 1500                                      | 32.296      | 178.846   | 154.653                       | 36.290                   | 0.000              | 0.000              | 0.000     |
| <b>52. HYDROXYL <math>OH(g)</math></b>    |             |           |                               |                          |                    |                    |           |
| 298.15                                    | 29.886      | 183.737   | 183.737                       | 0.000                    | 39.349             | 34.631             | -6.067    |
| 300                                       | 29.879      | 183.922   | 183.738                       | 0.055                    | 39.350             | 34.602             | -6.025    |
| 400                                       | 29.604      | 192.476   | 184.906                       | 3.028                    | 39.384             | 33.012             | -4.311    |
| 500                                       | 29.495      | 199.067   | 187.104                       | 5.982                    | 39.347             | 31.422             | -3.283    |
| 600                                       | 29.513      | 204.445   | 189.560                       | 8.931                    | 39.252             | 29.845             | -2.598    |
| 700                                       | 29.655      | 209.003   | 192.020                       | 11.888                   | 39.113             | 28.287             | -2.111    |
| 800                                       | 29.914      | 212.979   | 194.396                       | 14.866                   | 38.945             | 26.752             | -1.747    |
| 900                                       | 30.265      | 216.522   | 196.661                       | 17.874                   | 38.763             | 25.239             | -1.465    |
| 1000                                      | 30.682      | 219.731   | 198.810                       | 20.921                   | 38.577             | 23.746             | -1.240    |
| 1100                                      | 31.135      | 222.677   | 200.848                       | 24.012                   | 38.393             | 22.272             | -1.058    |
| 1200                                      | 31.603      | 225.406   | 202.782                       | 27.149                   | 38.215             | 20.814             | -0.906    |
| 1300                                      | 32.069      | 227.954   | 204.621                       | 30.332                   | 38.046             | 19.371             | -0.778    |
| 1400                                      | 32.522      | 230.347   | 206.374                       | 33.562                   | 37.886             | 17.941             | -0.669    |
| 1500                                      | 32.956      | 232.606   | 208.048                       | 36.836                   | 37.735             | 16.521             | -0.575    |
| <b>53. WATER <math>H_2O(l)</math></b>     |             |           |                               |                          |                    |                    |           |
| 298.15                                    | 75.300      | 69.950    | 69.950                        | 0.000                    | -285.830           | -237.141           | 41.546    |
| 300                                       | 75.281      | 70.416    | 69.951                        | 0.139                    | -285.771           | -236.839           | 41.237    |
| 373.21                                    | 76.079      | 86.896    | 71.715                        | 5.666                    | -283.454           | -225.160           | 31.513    |
| <b>54. WATER <math>H_2O(g)</math></b>     |             |           |                               |                          |                    |                    |           |
| 298.15                                    | 33.598      | 188.832   | 188.832                       | 0.000                    | -241.826           | -228.582           | 40.046    |
| 300                                       | 33.606      | 189.040   | 188.833                       | 0.062                    | -241.844           | -228.500           | 39.785    |
| 400                                       | 34.283      | 198.791   | 190.158                       | 3.453                    | -242.845           | -223.900           | 29.238    |
| 500                                       | 35.259      | 206.542   | 192.685                       | 6.929                    | -243.822           | -219.050           | 22.884    |
| 600                                       | 36.371      | 213.067   | 195.552                       | 10.509                   | -244.751           | -214.008           | 18.631    |
| 700                                       | 37.557      | 218.762   | 198.469                       | 14.205                   | -245.620           | -208.814           | 15.582    |
| 800                                       | 38.800      | 223.858   | 201.329                       | 18.023                   | -246.424           | -203.501           | 13.287    |
| 900                                       | 40.084      | 228.501   | 204.094                       | 21.966                   | -247.158           | -198.091           | 11.497    |
| 1000                                      | 41.385      | 232.792   | 206.752                       | 26.040                   | -247.820           | -192.603           | 10.060    |
| 1100                                      | 42.675      | 236.797   | 209.303                       | 30.243                   | -248.410           | -187.052           | 8.882     |
| 1200                                      | 43.932      | 240.565   | 211.753                       | 34.574                   | -248.933           | -181.450           | 7.898     |
| 1300                                      | 45.138      | 244.129   | 214.108                       | 39.028                   | -249.392           | -175.807           | 7.064     |



| $T/K$                                                                                                                                 | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|---------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                                                                                                       | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 1400                                                                                                                                  | 46.281      | 247.516   | 216.374                       | 43.599                   | -249.792           | -170.132           | 6.348     |
| 1500                                                                                                                                  | 47.356      | 250.746   | 218.559                       | 48.282                   | -250.139           | -164.429           | 5.726     |
| <b>55. IODINE I (g)</b>                                                                                                               |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                                                | 20.786      | 180.787   | 180.787                       | 0.000                    | 106.760            | 70.172             | -12.294   |
| 300                                                                                                                                   | 20.786      | 180.915   | 180.787                       | 0.038                    | 106.748            | 69.945             | -12.178   |
| 400                                                                                                                                   | 20.786      | 186.895   | 181.602                       | 2.117                    | 97.974             | 58.060             | -7.582    |
| 500                                                                                                                                   | 20.786      | 191.533   | 183.142                       | 4.196                    | 75.988             | 50.202             | -5.244    |
| 600                                                                                                                                   | 20.786      | 195.323   | 184.866                       | 6.274                    | 76.190             | 45.025             | -3.920    |
| 700                                                                                                                                   | 20.786      | 198.527   | 186.594                       | 8.353                    | 76.385             | 39.816             | -2.971    |
| 800                                                                                                                                   | 20.787      | 201.303   | 188.263                       | 10.432                   | 76.574             | 34.579             | -2.258    |
| 900                                                                                                                                   | 20.789      | 203.751   | 189.851                       | 12.510                   | 76.757             | 29.319             | -1.702    |
| 1000                                                                                                                                  | 20.795      | 205.942   | 191.352                       | 14.589                   | 76.936             | 24.038             | -1.256    |
| 1100                                                                                                                                  | 20.806      | 207.924   | 192.770                       | 16.669                   | 77.109             | 18.740             | -0.890    |
| 1200                                                                                                                                  | 20.824      | 209.735   | 194.110                       | 18.751                   | 77.277             | 13.426             | -0.584    |
| 1300                                                                                                                                  | 20.851      | 211.403   | 195.377                       | 20.835                   | 77.440             | 8.098              | -0.325    |
| 1400                                                                                                                                  | 20.889      | 212.950   | 196.577                       | 22.921                   | 77.596             | 2.758              | -0.103    |
| 1500                                                                                                                                  | 20.936      | 214.392   | 197.717                       | 25.013                   | 77.745             | -2.592             | 0.090     |
| <b>56. DIIODINE I<sub>2</sub> (cr, l)</b>                                                                                             |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                                                | 54.440      | 116.139   | 116.139                       | 0.000                    | 0.000              | 0.000              | 0.000     |
| 300                                                                                                                                   | 54.518      | 116.476   | 116.140                       | 0.101                    | 0.000              | 0.000              | 0.000     |
| 386.75                                                                                                                                | 61.531      | 131.039   | 117.884                       | 5.088                    | 0.000              | 0.000              | 0.000     |
| <b>PHASE TRANSITION: <math>\Delta_{\text{trs}} H = 15.665</math> kJ/mol, <math>\Delta_{\text{trs}} S = 40.504</math> J/Kmol, cr-l</b> |             |           |                               |                          |                    |                    |           |
| 386.75                                                                                                                                | 79.555      | 171.543   | 117.884                       | 20.753                   | 0.000              | 0.000              | 0.000     |
| 400                                                                                                                                   | 79.555      | 174.223   | 119.706                       | 21.807                   | 0.000              | 0.000              | 0.000     |
| 457.67                                                                                                                                | 79.555      | 184.938   | 127.266                       | 26.395                   | 0.000              | 0.000              | 0.000     |
| <b>57. DIIODINE I<sub>2</sub> (g)</b>                                                                                                 |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                                                | 36.887      | 260.685   | 260.685                       | 0.000                    | 62.420             | 19.324             | -3.385    |
| 300                                                                                                                                   | 36.897      | 260.913   | 260.685                       | 0.068                    | 62.387             | 19.056             | -3.318    |
| 400                                                                                                                                   | 37.256      | 271.584   | 262.138                       | 3.778                    | 44.391             | 5.447              | -0.711    |
| 457.67                                                                                                                                | 37.385      | 276.610   | 263.652                       | 5.931                    |                    | pressure = 1 bar   |           |
| 500                                                                                                                                   | 37.464      | 279.921   | 264.891                       | 7.515                    | 0.000              | 0.000              | 0.000     |
| 600                                                                                                                                   | 37.613      | 286.765   | 267.983                       | 11.269                   | 0.000              | 0.000              | 0.000     |
| 700                                                                                                                                   | 37.735      | 292.573   | 271.092                       | 15.037                   | 0.000              | 0.000              | 0.000     |
| 800                                                                                                                                   | 37.847      | 297.619   | 274.099                       | 18.816                   | 0.000              | 0.000              | 0.000     |
| 900                                                                                                                                   | 37.956      | 302.083   | 276.965                       | 22.606                   | 0.000              | 0.000              | 0.000     |
| 1000                                                                                                                                  | 38.070      | 306.088   | 279.681                       | 26.407                   | 0.000              | 0.000              | 0.000     |
| 1100                                                                                                                                  | 38.196      | 309.722   | 282.249                       | 30.220                   | 0.000              | 0.000              | 0.000     |
| 1200                                                                                                                                  | 38.341      | 313.052   | 284.679                       | 34.047                   | 0.000              | 0.000              | 0.000     |
| 1300                                                                                                                                  | 38.514      | 316.127   | 286.981                       | 37.890                   | 0.000              | 0.000              | 0.000     |
| 1400                                                                                                                                  | 38.719      | 318.989   | 289.166                       | 41.751                   | 0.000              | 0.000              | 0.000     |
| 1500                                                                                                                                  | 38.959      | 321.668   | 291.245                       | 45.635                   | 0.000              | 0.000              | 0.000     |
| <b>58. HYDROGEN IODIDE HI (g)</b>                                                                                                     |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                                                | 29.157      | 206.589   | 206.589                       | 0.000                    | 26.500             | 1.700              | -0.298    |
| 300                                                                                                                                   | 29.158      | 206.769   | 206.589                       | 0.054                    | 26.477             | 1.546              | -0.269    |
| 400                                                                                                                                   | 29.329      | 215.176   | 207.734                       | 2.977                    | 17.093             | -6.289             | 0.821     |
| 500                                                                                                                                   | 29.738      | 221.760   | 209.904                       | 5.928                    | -5.481             | -9.946             | 1.039     |
| 600                                                                                                                                   | 30.351      | 227.233   | 212.348                       | 8.931                    | -5.819             | -10.806            | 0.941     |
| 700                                                                                                                                   | 31.070      | 231.965   | 214.820                       | 12.002                   | -6.101             | -11.614            | 0.867     |
| 800                                                                                                                                   | 31.807      | 236.162   | 217.230                       | 15.145                   | -6.323             | -12.386            | 0.809     |
| 900                                                                                                                                   | 32.511      | 239.950   | 219.548                       | 18.362                   | -6.489             | -13.133            | 0.762     |
| 1000                                                                                                                                  | 33.156      | 243.409   | 221.763                       | 21.646                   | -6.608             | -13.865            | 0.724     |
| 1100                                                                                                                                  | 33.735      | 246.597   | 223.878                       | 24.991                   | -6.689             | -14.586            | 0.693     |
| 1200                                                                                                                                  | 34.249      | 249.555   | 225.896                       | 28.391                   | -6.741             | -15.302            | 0.666     |
| 1300                                                                                                                                  | 34.703      | 252.314   | 227.823                       | 31.839                   | -6.775             | -16.014            | 0.643     |
| 1400                                                                                                                                  | 35.106      | 254.901   | 229.666                       | 35.330                   | -6.797             | -16.723            | 0.624     |
| 1500                                                                                                                                  | 35.463      | 257.336   | 231.430                       | 38.858                   | -6.814             | -17.432            | 0.607     |

| T/K                                                                                                          | J/Kmol      |           |                             | kJ/mol                 |                    |                    | Log $K_f$ |
|--------------------------------------------------------------------------------------------------------------|-------------|-----------|-----------------------------|------------------------|--------------------|--------------------|-----------|
|                                                                                                              | $C_p^\circ$ | $S^\circ$ | $-(G^\circ-H^\circ(T_f))/T$ | $H^\circ-H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 59. POTASSIUM K (cr, l)                                                                                      |             |           |                             |                        |                    |                    |           |
| 298.15                                                                                                       | 29.600      | 64.680    | 64.680                      | 0.000                  | 0.000              | 0.000              | 0.000     |
| 300                                                                                                          | 29.671      | 64.863    | 64.681                      | 0.055                  | 0.000              | 0.000              | 0.000     |
| 336.86                                                                                                       | 32.130      | 68.422    | 64.896                      | 1.188                  | 0.000              | 0.000              | 0.000     |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 2.321$ kJ/mol, $\Delta_{\text{trs}} S = 6.891$ J/Kmol, cr-l       |             |           |                             |                        |                    |                    |           |
| 336.86                                                                                                       | 32.129      | 75.313    | 64.896                      | 3.509                  | 0.000              | 0.000              | 0.000     |
| 400                                                                                                          | 31.552      | 80.784    | 66.986                      | 5.519                  | 0.000              | 0.000              | 0.000     |
| 500                                                                                                          | 30.741      | 87.734    | 70.469                      | 8.632                  | 0.000              | 0.000              | 0.000     |
| 600                                                                                                          | 30.158      | 93.283    | 73.824                      | 11.675                 | 0.000              | 0.000              | 0.000     |
| 700                                                                                                          | 29.851      | 97.905    | 76.943                      | 14.673                 | 0.000              | 0.000              | 0.000     |
| 800                                                                                                          | 29.838      | 101.887   | 79.818                      | 17.655                 | 0.000              | 0.000              | 0.000     |
| 900                                                                                                          | 30.130      | 105.415   | 82.470                      | 20.651                 | 0.000              | 0.000              | 0.000     |
| 1000                                                                                                         | 30.730      | 108.618   | 84.927                      | 23.691                 | 0.000              | 0.000              | 0.000     |
| 1039.4                                                                                                       | 31.053      | 109.812   | 85.847                      | 24.908                 | 0.000              | 0.000              | 0.000     |
| 60. POTASSIUM K (g)                                                                                          |             |           |                             |                        |                    |                    |           |
| 298.15                                                                                                       | 20.786      | 160.340   | 160.340                     | 0.000                  | 89.000             | 60.479             | -10.596   |
| 300                                                                                                          | 20.786      | 160.468   | 160.340                     | 0.038                  | 88.984             | 60.302             | -10.499   |
| 400                                                                                                          | 20.786      | 166.448   | 161.155                     | 2.117                  | 85.598             | 51.332             | -6.703    |
| 500                                                                                                          | 20.786      | 171.086   | 162.695                     | 4.196                  | 84.563             | 42.887             | -4.480    |
| 600                                                                                                          | 20.786      | 174.876   | 164.419                     | 6.274                  | 83.599             | 34.643             | -3.016    |
| 700                                                                                                          | 20.786      | 178.080   | 166.148                     | 8.353                  | 82.680             | 26.557             | -1.982    |
| 800                                                                                                          | 20.786      | 180.856   | 167.817                     | 10.431                 | 81.776             | 18.601             | -1.215    |
| 900                                                                                                          | 20.786      | 183.304   | 169.404                     | 12.510                 | 80.859             | 10.759             | -0.624    |
| 1000                                                                                                         | 20.786      | 185.494   | 170.905                     | 14.589                 | 79.897             | 3.021              | -0.158    |
| 1039.4                                                                                                       | 20.786      | 186.297   | 171.474                     | 15.408                 |                    | pressure = 1 bar   |           |
| 1100                                                                                                         | 20.786      | 187.475   | 172.323                     | 16.667                 | 0.000              | 0.000              | 0.000     |
| 1200                                                                                                         | 20.786      | 189.284   | 173.662                     | 18.746                 | 0.000              | 0.000              | 0.000     |
| 1300                                                                                                         | 20.789      | 190.948   | 174.929                     | 20.825                 | 0.000              | 0.000              | 0.000     |
| 1400                                                                                                         | 20.793      | 192.489   | 176.129                     | 22.904                 | 0.000              | 0.000              | 0.000     |
| 1500                                                                                                         | 20.801      | 193.923   | 177.268                     | 24.983                 | 0.000              | 0.000              | 0.000     |
| 61. DIPOTASSIUM OXIDE K <sub>2</sub> O (cr, l)                                                               |             |           |                             |                        |                    |                    |           |
| 298.15                                                                                                       | 72.000      | 96.000    | 96.000                      | 0.000                  | -361.700           | -321.171           | 56.267    |
| 300                                                                                                          | 72.130      | 96.446    | 96.001                      | 0.133                  | -361.704           | -320.920           | 55.876    |
| 400                                                                                                          | 79.154      | 118.158   | 98.914                      | 7.698                  | -366.554           | -306.416           | 40.013    |
| 500                                                                                                          | 86.178      | 136.575   | 104.647                     | 15.964                 | -366.043           | -291.423           | 30.444    |
| 590                                                                                                          | 92.500      | 151.348   | 110.662                     | 24.005                 | -364.204           | -278.079           | 24.619    |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 0.700$ kJ/mol, $\Delta_{\text{trs}} S = 1.186$ J/Kmol, crIII-crII |             |           |                             |                        |                    |                    |           |
| 590                                                                                                          | 100.000     | 152.534   | 110.662                     | 24.705                 | -364.204           | -278.079           | 24.619    |
| 600                                                                                                          | 100.000     | 154.215   | 111.374                     | 25.705                 | -363.968           | -276.621           | 24.082    |
| 645                                                                                                          | 100.000     | 161.447   | 114.618                     | 30.205                 | -358.901           | -270.109           | 21.874    |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 4.000$ kJ/mol, $\Delta_{\text{trs}} S = 6.202$ J/Kmol, crII-crI   |             |           |                             |                        |                    |                    |           |
| 645                                                                                                          | 100.000     | 167.649   | 114.618                     | 34.205                 | -358.901           | -270.109           | 21.874    |
| 700                                                                                                          | 100.000     | 175.832   | 119.111                     | 39.705                 | -357.592           | -262.592           | 19.595    |
| 800                                                                                                          | 100.000     | 189.185   | 127.054                     | 49.705                 | -355.224           | -249.183           | 16.270    |
| 900                                                                                                          | 100.000     | 200.963   | 134.625                     | 59.705                 | -352.919           | -236.067           | 13.701    |
| 1000                                                                                                         | 100.000     | 211.499   | 141.794                     | 69.705                 | -350.732           | -223.202           | 11.659    |
| 1013                                                                                                         | 100.000     | 212.791   | 142.697                     | 71.005                 | -323.459           | -221.546           | 11.424    |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 27.000$ kJ/mol, $\Delta_{\text{trs}} S = 26.654$ J/Kmol, crI-l    |             |           |                             |                        |                    |                    |           |
| 1013                                                                                                         | 100.000     | 239.444   | 142.697                     | 98.005                 | -323.459           | -221.546           | 11.424    |
| 1100                                                                                                         | 100.000     | 247.684   | 150.679                     | 106.705                | -479.439           | -203.633           | 9.670     |
| 1200                                                                                                         | 100.000     | 256.385   | 159.131                     | 116.705                | -475.371           | -178.740           | 7.780     |
| 1300                                                                                                         | 100.000     | 264.389   | 166.924                     | 126.705                | -471.321           | -154.185           | 6.195     |
| 1400                                                                                                         | 100.000     | 271.800   | 174.154                     | 136.705                | -467.287           | -129.941           | 4.848     |
| 1500                                                                                                         | 100.000     | 278.699   | 180.896                     | 146.705                | -463.268           | -105.986           | 3.691     |

| $T/\text{K}$                                                                                                                  | $\text{J/Kmol}$ |           |                               | $\text{kJ/mol}$          |                    |                    | $\text{Log } K_f$ |
|-------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-------------------|
|                                                                                                                               | $C_p^\circ$     | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |                   |
| 62. POTASSIUM HYDROXIDE KOH (cr, l)                                                                                           |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                        | 64.900          | 78.870    | 78.870                        | 0.000                    | -424.580           | -378.747           | 66.354            |
| 300                                                                                                                           | 65.038          | 79.272    | 78.871                        | 0.120                    | -424.569           | -378.463           | 65.895            |
| 400                                                                                                                           | 72.519          | 99.007    | 81.512                        | 6.998                    | -426.094           | -362.765           | 47.372            |
| 500                                                                                                                           | 80.000          | 115.993   | 86.745                        | 14.624                   | -424.572           | -347.093           | 36.260            |
| 520                                                                                                                           | 81.496          | 119.159   | 87.931                        | 16.239                   | -417.725           | -344.002           | 34.555            |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 6.450 \text{ kJ/mol}$ , $\Delta_{\text{trs}} S = 12.404 \text{ J/Kmol}$ , crII-crI |                 |           |                               |                          |                    |                    |                   |
| 520                                                                                                                           | 79.000          | 131.563   | 87.931                        | 22.689                   | -417.725           | -344.002           | 34.555            |
| 600                                                                                                                           | 79.000          | 142.868   | 94.520                        | 29.009                   | -416.274           | -332.766           | 28.969            |
| 678                                                                                                                           | 79.000          | 152.523   | 100.649                       | 35.171                   | -405.464           | -321.998           | 24.807            |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 9.400 \text{ kJ/mol}$ , $\Delta_{\text{trs}} S = 13.865 \text{ J/Kmol}$ , crI-l    |                 |           |                               |                          |                    |                    |                   |
| 678                                                                                                                           | 83.000          | 166.388   | 100.649                       | 44.571                   | -405.464           | -321.998           | 24.807            |
| 700                                                                                                                           | 83.000          | 169.038   | 102.757                       | 46.397                   | -404.981           | -319.297           | 23.826            |
| 800                                                                                                                           | 83.000          | 180.121   | 111.750                       | 54.697                   | -402.808           | -307.206           | 20.058            |
| 900                                                                                                                           | 83.000          | 189.897   | 119.901                       | 62.997                   | -400.694           | -295.383           | 17.143            |
| 1000                                                                                                                          | 83.000          | 198.642   | 127.345                       | 71.297                   | -398.668           | -283.791           | 14.824            |
| 1100                                                                                                                          | 83.000          | 206.553   | 134.192                       | 79.597                   | -475.618           | -267.780           | 12.716            |
| 1200                                                                                                                          | 83.000          | 213.775   | 140.527                       | 87.897                   | -472.711           | -249.014           | 10.839            |
| 1300                                                                                                                          | 83.000          | 220.418   | 146.421                       | 96.197                   | -469.843           | -230.490           | 9.261             |
| 1400                                                                                                                          | 83.000          | 226.569   | 151.929                       | 104.497                  | -467.011           | -212.184           | 7.917             |
| 1500                                                                                                                          | 83.000          | 232.296   | 157.098                       | 112.797                  | -464.217           | -194.080           | 6.758             |
| 63. POTASSIUM HYDROXIDE KOH (g)                                                                                               |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                        | 49.184          | 238.283   | 238.283                       | 0.000                    | -227.989           | -229.685           | 40.239            |
| 300                                                                                                                           | 49.236          | 238.588   | 238.284                       | 0.091                    | -228.007           | -229.696           | 39.993            |
| 400                                                                                                                           | 51.178          | 253.053   | 240.243                       | 5.124                    | -231.377           | -229.667           | 29.991            |
| 500                                                                                                                           | 52.178          | 264.591   | 243.998                       | 10.296                   | -232.309           | -229.129           | 23.937            |
| 600                                                                                                                           | 52.804          | 274.163   | 248.251                       | 15.547                   | -233.145           | -228.413           | 19.885            |
| 700                                                                                                                           | 53.296          | 282.340   | 252.551                       | 20.853                   | -233.934           | -227.562           | 16.981            |
| 800                                                                                                                           | 53.758          | 289.487   | 256.730                       | 26.206                   | -234.708           | -226.599           | 14.795            |
| 900                                                                                                                           | 54.229          | 295.846   | 260.730                       | 31.605                   | -235.495           | -225.538           | 13.090            |
| 1000                                                                                                                          | 54.713          | 301.585   | 264.533                       | 37.052                   | -236.322           | -224.388           | 11.721            |
| 1100                                                                                                                          | 55.203          | 306.823   | 268.143                       | 42.548                   | -316.077           | -218.535           | 10.377            |
| 1200                                                                                                                          | 55.686          | 311.647   | 271.570                       | 48.092                   | -315.925           | -209.674           | 9.127             |
| 1300                                                                                                                          | 56.153          | 316.122   | 274.827                       | 53.684                   | -315.764           | -200.826           | 8.069             |
| 1400                                                                                                                          | 56.598          | 320.300   | 277.927                       | 59.322                   | -315.595           | -191.991           | 7.163             |
| 1500                                                                                                                          | 57.016          | 324.220   | 280.884                       | 65.003                   | -315.420           | -183.169           | 6.378             |
| 64. POTASSIUM CHLORIDE KCl (cr, l)                                                                                            |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                        | 51.300          | 82.570    | 82.570                        | 0.000                    | -436.490           | -408.568           | 71.579            |
| 300                                                                                                                           | 51.333          | 82.887    | 82.571                        | 0.095                    | -436.481           | -408.395           | 71.107            |
| 400                                                                                                                           | 52.977          | 97.886    | 84.605                        | 5.312                    | -438.463           | -398.651           | 52.058            |
| 500                                                                                                                           | 54.448          | 109.867   | 88.498                        | 10.685                   | -437.990           | -388.749           | 40.612            |
| 600                                                                                                                           | 55.885          | 119.921   | 92.919                        | 16.201                   | -437.332           | -378.960           | 32.991            |
| 700                                                                                                                           | 57.425          | 128.649   | 97.413                        | 21.865                   | -436.502           | -369.295           | 27.557            |
| 800                                                                                                                           | 59.205          | 136.430   | 101.812                       | 27.694                   | -435.505           | -359.760           | 23.490            |
| 900                                                                                                                           | 61.361          | 143.523   | 106.058                       | 33.719                   | -434.337           | -350.360           | 20.334            |
| 1000                                                                                                                          | 64.032          | 150.121   | 110.138                       | 39.983                   | -432.981           | -341.100           | 17.817            |
| 1044                                                                                                                          | 65.405          | 152.908   | 111.882                       | 42.830                   | -485.450           | -336.720           | 16.847            |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 26.320 \text{ kJ/mol}$ , $\Delta_{\text{trs}} S = 25.210 \text{ J/Kmol}$ , cr-l    |                 |           |                               |                          |                    |                    |                   |
| 1044                                                                                                                          | 72.000          | 178.118   | 111.882                       | 69.150                   | -485.450           | -336.720           | 16.847            |
| 1100                                                                                                                          | 72.000          | 181.880   | 115.351                       | 73.182                   | -483.633           | -328.790           | 15.613            |
| 1200                                                                                                                          | 72.000          | 188.145   | 121.160                       | 80.382                   | -480.393           | -314.856           | 13.705            |
| 1300                                                                                                                          | 72.000          | 193.908   | 126.537                       | 87.582                   | -477.158           | -301.192           | 12.102            |
| 1400                                                                                                                          | 72.000          | 199.244   | 131.542                       | 94.782                   | -473.928           | -287.778           | 10.737            |
| 1500                                                                                                                          | 72.000          | 204.211   | 136.223                       | 101.982                  | -470.704           | -274.594           | 9.562             |

| $T/K$                                       | J/Kmol      |           |                             | kJ/mol                 |                    |                    | $\text{Log } K_f$ |
|---------------------------------------------|-------------|-----------|-----------------------------|------------------------|--------------------|--------------------|-------------------|
|                                             | $C_p^\circ$ | $S^\circ$ | $-(G^\circ-H^\circ(T_f))/T$ | $H^\circ-H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |                   |
| 65. POTASSIUM CHLORIDE    KCl (g)           |             |           |                             |                        |                    |                    |                   |
| 298.15                                      | 36.505      | 239.091   | 239.091                     | 0.000                  | -214.575           | -233.320           | 40.876            |
| 300                                         | 36.518      | 239.317   | 239.092                     | 0.068                  | -214.594           | -233.436           | 40.644            |
| 400                                         | 37.066      | 249.904   | 240.532                     | 3.749                  | -218.112           | -239.107           | 31.224            |
| 500                                         | 37.384      | 258.212   | 243.267                     | 7.473                  | -219.287           | -244.219           | 25.513            |
| 600                                         | 37.597      | 265.048   | 246.344                     | 11.222                 | -220.396           | -249.100           | 21.686            |
| 700                                         | 37.769      | 270.857   | 249.441                     | 14.991                 | -221.461           | -253.799           | 18.938            |
| 800                                         | 37.907      | 275.910   | 252.441                     | 18.775                 | -222.509           | -258.347           | 16.868            |
| 900                                         | 38.041      | 280.382   | 255.302                     | 22.572                 | -223.568           | -262.764           | 15.250            |
| 1000                                        | 38.162      | 284.397   | 258.014                     | 26.383                 | -224.667           | -267.061           | 13.950            |
| 1100                                        | 38.279      | 288.039   | 260.581                     | 30.205                 | -304.696           | -266.627           | 12.661            |
| 1200                                        | 38.401      | 291.375   | 263.010                     | 34.039                 | -304.821           | -263.161           | 11.455            |
| 1300                                        | 38.518      | 294.454   | 265.312                     | 37.885                 | -304.941           | -259.684           | 10.434            |
| 1400                                        | 38.639      | 297.313   | 267.496                     | 41.743                 | -305.053           | -256.199           | 9.559             |
| 1500                                        | 38.761      | 299.983   | 269.574                     | 45.613                 | -305.159           | -252.706           | 8.800             |
| 66. DINITROGEN    N <sub>2</sub> (g)        |             |           |                             |                        |                    |                    |                   |
| 298.15                                      | 29.124      | 191.608   | 191.608                     | 0.000                  | 0.000              | 0.000              | 0.000             |
| 300                                         | 29.125      | 191.788   | 191.608                     | 0.054                  | 0.000              | 0.000              | 0.000             |
| 400                                         | 29.249      | 200.180   | 192.752                     | 2.971                  | 0.000              | 0.000              | 0.000             |
| 500                                         | 29.580      | 206.738   | 194.916                     | 5.911                  | 0.000              | 0.000              | 0.000             |
| 600                                         | 30.109      | 212.175   | 197.352                     | 8.894                  | 0.000              | 0.000              | 0.000             |
| 700                                         | 30.754      | 216.864   | 199.812                     | 11.936                 | 0.000              | 0.000              | 0.000             |
| 800                                         | 31.433      | 221.015   | 202.208                     | 15.046                 | 0.000              | 0.000              | 0.000             |
| 900                                         | 32.090      | 224.756   | 204.509                     | 18.222                 | 0.000              | 0.000              | 0.000             |
| 1000                                        | 32.696      | 228.169   | 206.706                     | 21.462                 | 0.000              | 0.000              | 0.000             |
| 1100                                        | 33.241      | 231.311   | 208.802                     | 24.759                 | 0.000              | 0.000              | 0.000             |
| 1200                                        | 33.723      | 234.224   | 210.801                     | 28.108                 | 0.000              | 0.000              | 0.000             |
| 1300                                        | 34.147      | 236.941   | 212.708                     | 31.502                 | 0.000              | 0.000              | 0.000             |
| 1400                                        | 34.517      | 239.485   | 214.531                     | 34.936                 | 0.000              | 0.000              | 0.000             |
| 1500                                        | 34.842      | 241.878   | 216.275                     | 38.404                 | 0.000              | 0.000              | 0.000             |
| 67. NITRIC OXIDE    NO (g)                  |             |           |                             |                        |                    |                    |                   |
| 298.15                                      | 29.862      | 210.745   | 210.745                     | 0.000                  | 91.277             | 87.590             | -15.345           |
| 300                                         | 29.858      | 210.930   | 210.746                     | 0.055                  | 91.278             | 87.567             | -15.247           |
| 400                                         | 29.954      | 219.519   | 211.916                     | 3.041                  | 91.320             | 86.323             | -11.272           |
| 500                                         | 30.493      | 226.255   | 214.133                     | 6.061                  | 91.340             | 85.071             | -8.887            |
| 600                                         | 31.243      | 231.879   | 216.635                     | 9.147                  | 91.354             | 83.816             | -7.297            |
| 700                                         | 32.031      | 236.754   | 219.168                     | 12.310                 | 91.369             | 82.558             | -6.160            |
| 800                                         | 32.770      | 241.081   | 221.642                     | 15.551                 | 91.386             | 81.298             | -5.308            |
| 900                                         | 33.425      | 244.979   | 224.022                     | 18.862                 | 91.405             | 80.036             | -4.645            |
| 1000                                        | 33.990      | 248.531   | 226.298                     | 22.233                 | 91.426             | 78.772             | -4.115            |
| 1100                                        | 34.473      | 251.794   | 228.469                     | 25.657                 | 91.445             | 77.505             | -3.680            |
| 1200                                        | 34.883      | 254.811   | 230.540                     | 29.125                 | 91.464             | 76.237             | -3.318            |
| 1300                                        | 35.234      | 257.618   | 232.516                     | 32.632                 | 91.481             | 74.967             | -3.012            |
| 1400                                        | 35.533      | 260.240   | 234.404                     | 36.170                 | 91.495             | 73.697             | -2.750            |
| 1500                                        | 35.792      | 262.700   | 236.209                     | 39.737                 | 91.506             | 72.425             | -2.522            |
| 68. NITROGEN DIOXIDE    NO <sub>2</sub> (g) |             |           |                             |                        |                    |                    |                   |
| 298.15                                      | 37.178      | 240.166   | 240.166                     | 0.000                  | 34.193             | 52.316             | -9.165            |
| 300                                         | 37.236      | 240.397   | 240.167                     | 0.069                  | 34.181             | 52.429             | -9.129            |
| 400                                         | 40.513      | 251.554   | 241.666                     | 3.955                  | 33.637             | 58.600             | -7.652            |
| 500                                         | 43.664      | 260.939   | 244.605                     | 8.167                  | 33.319             | 64.882             | -6.778            |
| 600                                         | 46.383      | 269.147   | 248.026                     | 12.673                 | 33.174             | 71.211             | -6.199            |
| 700                                         | 48.612      | 276.471   | 251.575                     | 17.427                 | 33.151             | 77.553             | -5.787            |
| 800                                         | 50.405      | 283.083   | 255.107                     | 22.381                 | 33.213             | 83.893             | -5.478            |
| 900                                         | 51.844      | 289.106   | 258.555                     | 27.496                 | 33.334             | 90.221             | -5.236            |
| 1000                                        | 53.007      | 294.631   | 261.891                     | 32.741                 | 33.495             | 96.534             | -5.042            |
| 1100                                        | 53.956      | 299.729   | 265.102                     | 38.090                 | 33.686             | 102.828            | -4.883            |
| 1200                                        | 54.741      | 304.459   | 268.187                     | 43.526                 | 33.898             | 109.105            | -4.749            |

| $T/K$                                                                                                                                   | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|-----------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                                                                                                         | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 1300                                                                                                                                    | 55.399      | 308.867   | 271.148                       | 49.034                   | 34.124             | 115.363            | -4.635    |
| 1400                                                                                                                                    | 55.960      | 312.994   | 273.992                       | 54.603                   | 34.360             | 121.603            | -4.537    |
| 1500                                                                                                                                    | 56.446      | 316.871   | 276.722                       | 60.224                   | 34.604             | 127.827            | -4.451    |
| <b>69. AMMONIA NH<sub>3</sub> (g)</b>                                                                                                   |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                                                  | 35.630      | 192.768   | 192.768                       | 0.000                    | -45.940            | -16.407            | 2.874     |
| 300                                                                                                                                     | 35.678      | 192.989   | 192.769                       | 0.066                    | -45.981            | -16.223            | 2.825     |
| 400                                                                                                                                     | 38.674      | 203.647   | 194.202                       | 3.778                    | -48.087            | -5.980             | 0.781     |
| 500                                                                                                                                     | 41.994      | 212.633   | 197.011                       | 7.811                    | -49.908            | 4.764              | -0.498    |
| 600                                                                                                                                     | 45.229      | 220.578   | 200.289                       | 12.174                   | -51.430            | 15.846             | -1.379    |
| 700                                                                                                                                     | 48.269      | 227.781   | 203.709                       | 16.850                   | -52.682            | 27.161             | -2.027    |
| 800                                                                                                                                     | 51.112      | 234.414   | 207.138                       | 21.821                   | -53.695            | 38.639             | -2.523    |
| 900                                                                                                                                     | 53.769      | 240.589   | 210.516                       | 27.066                   | -54.499            | 50.231             | -2.915    |
| 1000                                                                                                                                    | 56.244      | 246.384   | 213.816                       | 32.569                   | -55.122            | 61.903             | -3.233    |
| 1100                                                                                                                                    | 58.535      | 251.854   | 217.027                       | 38.309                   | -55.589            | 73.629             | -3.496    |
| 1200                                                                                                                                    | 60.644      | 257.039   | 220.147                       | 44.270                   | -55.920            | 85.392             | -3.717    |
| 1300                                                                                                                                    | 62.576      | 261.970   | 223.176                       | 50.432                   | -56.136            | 97.177             | -3.905    |
| 1400                                                                                                                                    | 64.339      | 266.673   | 226.117                       | 56.779                   | -56.251            | 108.975            | -4.066    |
| 1500                                                                                                                                    | 65.945      | 271.168   | 228.971                       | 63.295                   | -56.282            | 120.779            | -4.206    |
| <b>70. OXYGEN O (g)</b>                                                                                                                 |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                                                  | 21.911      | 161.058   | 161.058                       | 0.000                    | 249.180            | 231.743            | -40.600   |
| 300                                                                                                                                     | 21.901      | 161.194   | 161.059                       | 0.041                    | 249.193            | 231.635            | -40.331   |
| 400                                                                                                                                     | 21.482      | 167.430   | 161.912                       | 2.207                    | 249.874            | 225.677            | -29.470   |
| 500                                                                                                                                     | 21.257      | 172.197   | 163.511                       | 4.343                    | 250.481            | 219.556            | -22.937   |
| 600                                                                                                                                     | 21.124      | 176.060   | 165.290                       | 6.462                    | 251.019            | 213.319            | -18.571   |
| 700                                                                                                                                     | 21.040      | 179.310   | 167.067                       | 8.570                    | 251.500            | 206.997            | -15.446   |
| 800                                                                                                                                     | 20.984      | 182.115   | 168.777                       | 10.671                   | 251.932            | 200.610            | -13.098   |
| 900                                                                                                                                     | 20.944      | 184.584   | 170.399                       | 12.767                   | 252.325            | 194.171            | -11.269   |
| 1000                                                                                                                                    | 20.915      | 186.789   | 171.930                       | 14.860                   | 252.686            | 187.689            | -9.804    |
| 1100                                                                                                                                    | 20.893      | 188.782   | 173.372                       | 16.950                   | 253.022            | 181.173            | -8.603    |
| 1200                                                                                                                                    | 20.877      | 190.599   | 174.733                       | 19.039                   | 253.335            | 174.628            | -7.601    |
| 1300                                                                                                                                    | 20.864      | 192.270   | 176.019                       | 21.126                   | 253.630            | 168.057            | -6.753    |
| 1400                                                                                                                                    | 20.853      | 193.815   | 177.236                       | 23.212                   | 253.908            | 161.463            | -6.024    |
| 1500                                                                                                                                    | 20.845      | 195.254   | 178.389                       | 25.296                   | 254.171            | 154.851            | -5.392    |
| <b>71. DIOXYGEN O<sub>2</sub> (g)</b>                                                                                                   |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                                                  | 29.378      | 205.148   | 205.148                       | 0.000                    | 0.000              | 0.000              | 0.000     |
| 300                                                                                                                                     | 29.387      | 205.330   | 205.148                       | 0.054                    | 0.000              | 0.000              | 0.000     |
| 400                                                                                                                                     | 30.109      | 213.873   | 206.308                       | 3.026                    | 0.000              | 0.000              | 0.000     |
| 500                                                                                                                                     | 31.094      | 220.695   | 208.525                       | 6.085                    | 0.000              | 0.000              | 0.000     |
| 600                                                                                                                                     | 32.095      | 226.454   | 211.045                       | 9.245                    | 0.000              | 0.000              | 0.000     |
| 700                                                                                                                                     | 32.987      | 231.470   | 213.612                       | 12.500                   | 0.000              | 0.000              | 0.000     |
| 800                                                                                                                                     | 33.741      | 235.925   | 216.128                       | 15.838                   | 0.000              | 0.000              | 0.000     |
| 900                                                                                                                                     | 34.365      | 239.937   | 218.554                       | 19.244                   | 0.000              | 0.000              | 0.000     |
| 1000                                                                                                                                    | 34.881      | 243.585   | 220.878                       | 22.707                   | 0.000              | 0.000              | 0.000     |
| 1100                                                                                                                                    | 35.314      | 246.930   | 223.096                       | 26.217                   | 0.000              | 0.000              | 0.000     |
| 1200                                                                                                                                    | 35.683      | 250.019   | 225.213                       | 29.768                   | 0.000              | 0.000              | 0.000     |
| 1300                                                                                                                                    | 36.006      | 252.888   | 227.233                       | 33.352                   | 0.000              | 0.000              | 0.000     |
| 1400                                                                                                                                    | 36.297      | 255.568   | 229.162                       | 36.968                   | 0.000              | 0.000              | 0.000     |
| 1500                                                                                                                                    | 36.567      | 258.081   | 231.007                       | 40.611                   | 0.000              | 0.000              | 0.000     |
| <b>72. SULFUR S (cr, I)</b>                                                                                                             |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                                                  | 22.690      | 32.070    | 32.070                        | 0.000                    | 0.000              | 0.000              | 0.000     |
| 300                                                                                                                                     | 22.737      | 32.210    | 32.070                        | 0.042                    | 0.000              | 0.000              | 0.000     |
| 368.3                                                                                                                                   | 24.237      | 37.030    | 32.554                        | 1.649                    | 0.000              | 0.000              | 0.000     |
| <b>PHASE TRANSITION: <math>\Delta_{\text{trs}} H = 0.401</math> kJ/mol, <math>\Delta_{\text{trs}} S = 1.089</math> J/Kmol, crII-crI</b> |             |           |                               |                          |                    |                    |           |
| 368.3                                                                                                                                   | 24.773      | 38.119    | 32.553                        | 2.050                    | 0.000              | 0.000              | 0.000     |
| 388.36                                                                                                                                  | 25.180      | 39.444    | 32.875                        | 2.551                    | 0.000              | 0.000              | 0.000     |

| $T/\text{K}$                                                                                                              | $\text{J/Kmol}$ |           |                               | $\text{kJ/mol}$          |                    |                    | $\text{Log } K_f$ |
|---------------------------------------------------------------------------------------------------------------------------|-----------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-------------------|
|                                                                                                                           | $C_p^\circ$     | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |                   |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 1.722 \text{ kJ/mol}$ , $\Delta_{\text{trs}} S = 4.431 \text{ J/Kmol}$ , cr1-l |                 |           |                               |                          |                    |                    |                   |
| 388.36                                                                                                                    | 31.710          | 43.875    | 32.872                        | 4.273                    | 0.000              | 0.000              | 0.000             |
| 400                                                                                                                       | 32.369          | 44.824    | 33.206                        | 4.647                    | 0.000              | 0.000              | 0.000             |
| 500                                                                                                                       | 38.026          | 53.578    | 36.411                        | 8.584                    | 0.000              | 0.000              | 0.000             |
| 600                                                                                                                       | 34.371          | 60.116    | 39.842                        | 12.164                   | 0.000              | 0.000              | 0.000             |
| 700                                                                                                                       | 32.451          | 65.278    | 43.120                        | 15.511                   | 0.000              | 0.000              | 0.000             |
| 800                                                                                                                       | 32.000          | 69.557    | 46.163                        | 18.715                   | 0.000              | 0.000              | 0.000             |
| 882.38                                                                                                                    | 32.000          | 72.693    | 48.496                        | 21.351                   | 0.000              | 0.000              | 0.000             |
| 73. SULFUR $\text{S (g)}$                                                                                                 |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                    | 23.673          | 167.828   | 167.828                       | 0.000                    | 277.180            | 236.704            | -41.469           |
| 300                                                                                                                       | 23.669          | 167.974   | 167.828                       | 0.044                    | 277.182            | 236.453            | -41.170           |
| 400                                                                                                                       | 23.233          | 174.730   | 168.752                       | 2.391                    | 274.924            | 222.962            | -29.115           |
| 500                                                                                                                       | 22.741          | 179.860   | 170.482                       | 4.689                    | 273.286            | 210.145            | -21.953           |
| 600                                                                                                                       | 22.338          | 183.969   | 172.398                       | 6.942                    | 271.958            | 197.646            | -17.206           |
| 700                                                                                                                       | 22.031          | 187.388   | 174.302                       | 9.160                    | 270.829            | 185.352            | -13.831           |
| 800                                                                                                                       | 21.800          | 190.314   | 176.125                       | 11.351                   | 269.816            | 173.210            | -11.309           |
| 900                                                                                                                       | 21.624          | 192.871   | 177.847                       | 13.522                   | 215.723            | 162.258            | -9.417            |
| 1000                                                                                                                      | 21.489          | 195.142   | 179.465                       | 15.677                   | 216.018            | 156.301            | -8.164            |
| 1100                                                                                                                      | 21.386          | 197.185   | 180.985                       | 17.821                   | 216.284            | 150.317            | -7.138            |
| 1200                                                                                                                      | 21.307          | 199.043   | 182.413                       | 19.955                   | 216.525            | 144.309            | -6.282            |
| 1300                                                                                                                      | 21.249          | 200.746   | 183.759                       | 22.083                   | 216.743            | 138.282            | -5.556            |
| 1400                                                                                                                      | 21.209          | 202.319   | 185.029                       | 24.206                   | 216.940            | 132.239            | -4.934            |
| 1500                                                                                                                      | 21.186          | 203.781   | 186.231                       | 26.325                   | 217.119            | 126.182            | -4.394            |
| 74. DISULFUR $\text{S}_2(\text{g})$                                                                                       |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                    | 32.505          | 228.165   | 228.165                       | 0.000                    | 128.600            | 79.696             | -13.962           |
| 300                                                                                                                       | 32.540          | 228.366   | 228.165                       | 0.060                    | 128.576            | 79.393             | -13.823           |
| 400                                                                                                                       | 34.108          | 237.956   | 229.462                       | 3.398                    | 122.703            | 63.380             | -8.276            |
| 500                                                                                                                       | 35.133          | 245.686   | 231.959                       | 6.863                    | 118.296            | 49.031             | -5.122            |
| 600                                                                                                                       | 35.815          | 252.156   | 234.800                       | 10.413                   | 114.685            | 35.530             | -3.093            |
| 700                                                                                                                       | 36.305          | 257.715   | 237.686                       | 14.020                   | 111.599            | 22.588             | -1.685            |
| 800                                                                                                                       | 36.697          | 262.589   | 240.501                       | 17.671                   | 108.841            | 10.060             | -0.657            |
| 882.38                                                                                                                    | 36.985          | 266.200   | 242.734                       | 20.706                   | pressure = 1 bar   |                    |                   |
| 900                                                                                                                       | 37.045          | 266.932   | 243.201                       | 21.358                   | 0.000              | 0.000              | 0.000             |
| 1000                                                                                                                      | 37.377          | 270.852   | 245.773                       | 25.079                   | 0.000              | 0.000              | 0.000             |
| 1100                                                                                                                      | 37.704          | 274.430   | 248.218                       | 28.833                   | 0.000              | 0.000              | 0.000             |
| 1200                                                                                                                      | 38.030          | 277.725   | 250.541                       | 32.620                   | 0.000              | 0.000              | 0.000             |
| 1300                                                                                                                      | 38.353          | 280.781   | 252.751                       | 36.439                   | 0.000              | 0.000              | 0.000             |
| 1400                                                                                                                      | 38.669          | 283.635   | 254.856                       | 40.290                   | 0.000              | 0.000              | 0.000             |
| 1500                                                                                                                      | 38.976          | 286.314   | 256.865                       | 44.173                   | 0.000              | 0.000              | 0.000             |
| 75. OCTASULFUR $\text{S}_8(\text{g})$                                                                                     |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                    | 156.500         | 432.536   | 432.536                       | 0.000                    | 101.277            | 48.810             | -8.551            |
| 300                                                                                                                       | 156.768         | 433.505   | 432.539                       | 0.290                    | 101.231            | 48.484             | -8.442            |
| 400                                                                                                                       | 167.125         | 480.190   | 438.834                       | 16.542                   | 80.642             | 32.003             | -4.179            |
| 500                                                                                                                       | 173.181         | 518.176   | 451.022                       | 33.577                   | 66.185             | 21.409             | -2.237            |
| 600                                                                                                                       | 177.936         | 550.180   | 464.951                       | 51.137                   | 55.101             | 13.549             | -1.180            |
| 700                                                                                                                       | 182.441         | 577.948   | 479.152                       | 69.157                   | 46.349             | 7.343              | -0.548            |
| 800                                                                                                                       | 186.764         | 602.596   | 493.071                       | 87.620                   | 39.177             | 2.263              | -0.148            |
| 900                                                                                                                       | 190.595         | 624.821   | 506.495                       | 106.494                  | -392.062           | 6.554              | -0.380            |
| 1000                                                                                                                      | 193.618         | 645.067   | 519.355                       | 125.712                  | -387.728           | 50.614             | -2.644            |
| 1100                                                                                                                      | 195.684         | 663.625   | 531.639                       | 145.185                  | -383.272           | 94.233             | -4.475            |
| 1200                                                                                                                      | 196.825         | 680.707   | 543.359                       | 164.817                  | -378.786           | 137.444            | -5.983            |
| 1300                                                                                                                      | 197.195         | 696.480   | 554.539                       | 184.524                  | -374.356           | 180.283            | -7.244            |
| 1400                                                                                                                      | 196.988         | 711.089   | 565.206                       | 204.237                  | -370.048           | 222.785            | -8.312            |
| 1500                                                                                                                      | 196.396         | 724.662   | 575.389                       | 223.909                  | -365.905           | 264.984            | -9.227            |
| 76. SULFUR DIOXIDE $\text{SO}_2(\text{g})$                                                                                |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                    | 39.842          | 248.219   | 248.219                       | 0.000                    | -296.810           | -300.090           | 52.574            |
| 300                                                                                                                       | 39.909          | 248.466   | 248.220                       | 0.074                    | -296.833           | -300.110           | 52.253            |

| $T/K$                                                                                                        | J/Kmol      |           |                               | kJ/mol                   |                    |                    | Log $K_f$ |
|--------------------------------------------------------------------------------------------------------------|-------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-----------|
|                                                                                                              | $C_p^\circ$ | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |           |
| 400                                                                                                          | 43.427      | 260.435   | 249.828                       | 4.243                    | -300.240           | -300.935           | 39.298    |
| 500                                                                                                          | 46.490      | 270.465   | 252.978                       | 8.744                    | -302.735           | -300.831           | 31.427    |
| 600                                                                                                          | 48.938      | 279.167   | 256.634                       | 13.520                   | -304.699           | -300.258           | 26.139    |
| 700                                                                                                          | 50.829      | 286.859   | 260.413                       | 18.513                   | -306.308           | -299.386           | 22.340    |
| 800                                                                                                          | 52.282      | 293.746   | 264.157                       | 23.671                   | -307.691           | -298.302           | 19.477    |
| 900                                                                                                          | 53.407      | 299.971   | 267.796                       | 28.958                   | -362.075           | -295.987           | 17.178    |
| 1000                                                                                                         | 54.290      | 305.646   | 271.301                       | 34.345                   | -362.012           | -288.647           | 15.077    |
| 1100                                                                                                         | 54.993      | 310.855   | 274.664                       | 39.810                   | -361.934           | -281.314           | 13.358    |
| 1200                                                                                                         | 55.564      | 315.665   | 277.882                       | 45.339                   | -361.849           | -273.989           | 11.926    |
| 1300                                                                                                         | 56.033      | 320.131   | 280.963                       | 50.920                   | -361.763           | -266.671           | 10.715    |
| 1400                                                                                                         | 56.426      | 324.299   | 283.911                       | 56.543                   | -361.680           | -259.359           | 9.677     |
| 1500                                                                                                         | 56.759      | 328.203   | 286.735                       | 62.203                   | -361.605           | -252.053           | 8.777     |
| 77. SILICON Si (cr)                                                                                          |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                       | 19.789      | 18.810    | 18.810                        | 0.000                    | 0.000              | 0.000              | 0.000     |
| 300                                                                                                          | 19.855      | 18.933    | 18.810                        | 0.037                    | 0.000              | 0.000              | 0.000     |
| 400                                                                                                          | 22.301      | 25.023    | 19.624                        | 2.160                    | 0.000              | 0.000              | 0.000     |
| 500                                                                                                          | 23.610      | 30.152    | 21.231                        | 4.461                    | 0.000              | 0.000              | 0.000     |
| 600                                                                                                          | 24.472      | 34.537    | 23.092                        | 6.867                    | 0.000              | 0.000              | 0.000     |
| 700                                                                                                          | 25.124      | 38.361    | 25.006                        | 9.348                    | 0.000              | 0.000              | 0.000     |
| 800                                                                                                          | 25.662      | 41.752    | 26.891                        | 11.888                   | 0.000              | 0.000              | 0.000     |
| 900                                                                                                          | 26.135      | 44.802    | 28.715                        | 14.478                   | 0.000              | 0.000              | 0.000     |
| 1000                                                                                                         | 26.568      | 47.578    | 30.464                        | 17.114                   | 0.000              | 0.000              | 0.000     |
| 1100                                                                                                         | 26.974      | 50.130    | 32.138                        | 19.791                   | 0.000              | 0.000              | 0.000     |
| 1200                                                                                                         | 27.362      | 52.493    | 33.737                        | 22.508                   | 0.000              | 0.000              | 0.000     |
| 1300                                                                                                         | 27.737      | 54.698    | 35.265                        | 25.263                   | 0.000              | 0.000              | 0.000     |
| 1400                                                                                                         | 28.103      | 56.767    | 36.728                        | 28.055                   | 0.000              | 0.000              | 0.000     |
| 1500                                                                                                         | 28.462      | 58.719    | 38.130                        | 30.883                   | 0.000              | 0.000              | 0.000     |
| 78. SILICON Si (g)                                                                                           |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                       | 22.251      | 167.980   | 167.980                       | 0.000                    | 450.000            | 405.525            | -71.045   |
| 300                                                                                                          | 22.234      | 168.117   | 167.980                       | 0.041                    | 450.004            | 405.249            | -70.559   |
| 400                                                                                                          | 21.613      | 174.416   | 168.843                       | 2.229                    | 450.070            | 390.312            | -50.969   |
| 500                                                                                                          | 21.316      | 179.204   | 170.456                       | 4.374                    | 449.913            | 375.388            | -39.216   |
| 600                                                                                                          | 21.153      | 183.074   | 172.246                       | 6.497                    | 449.630            | 360.508            | -31.385   |
| 700                                                                                                          | 21.057      | 186.327   | 174.032                       | 8.607                    | 449.259            | 345.682            | -25.795   |
| 800                                                                                                          | 21.000      | 189.135   | 175.748                       | 10.709                   | 448.821            | 330.915            | -21.606   |
| 900                                                                                                          | 20.971      | 191.606   | 177.375                       | 12.808                   | 448.329            | 316.205            | -18.352   |
| 1000                                                                                                         | 20.968      | 193.815   | 178.911                       | 14.904                   | 447.791            | 301.553            | -15.751   |
| 1100                                                                                                         | 20.989      | 195.815   | 180.358                       | 17.002                   | 447.211            | 286.957            | -13.626   |
| 1200                                                                                                         | 21.033      | 197.643   | 181.723                       | 19.103                   | 446.595            | 272.416            | -11.858   |
| 1300                                                                                                         | 21.099      | 199.329   | 183.014                       | 21.209                   | 445.946            | 257.927            | -10.364   |
| 1400                                                                                                         | 21.183      | 200.895   | 184.236                       | 23.323                   | 445.268            | 243.489            | -9.085    |
| 1500                                                                                                         | 21.282      | 202.360   | 185.396                       | 25.446                   | 444.563            | 229.101            | -7.978    |
| 79. SILICON DIOXIDE SiO <sub>2</sub> (cr)                                                                    |             |           |                               |                          |                    |                    |           |
| 298.15                                                                                                       | 44.602      | 41.460    | 41.460                        | 0.000                    | -910.700           | -856.288           | 150.016   |
| 300                                                                                                          | 44.712      | 41.736    | 41.461                        | 0.083                    | -910.708           | -855.951           | 149.032   |
| 400                                                                                                          | 53.477      | 55.744    | 43.311                        | 4.973                    | -910.912           | -837.651           | 109.385   |
| 500                                                                                                          | 60.533      | 68.505    | 47.094                        | 10.705                   | -910.540           | -819.369           | 85.598    |
| 600                                                                                                          | 64.452      | 79.919    | 51.633                        | 16.971                   | -909.841           | -801.197           | 69.749    |
| 700                                                                                                          | 68.234      | 90.114    | 56.414                        | 23.590                   | -908.958           | -783.157           | 58.439    |
| 800                                                                                                          | 76.224      | 99.674    | 61.226                        | 30.758                   | -907.668           | -765.265           | 49.966    |
| 848                                                                                                          | 82.967      | 104.298   | 63.533                        | 34.569                   | -906.310           | -756.747           | 46.613    |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 0.411$ kJ/mol, $\Delta_{\text{trs}} S = 0.484$ J/Kmol, crII-crII' |             |           |                               |                          |                    |                    |           |
| 848                                                                                                          | 67.446      | 104.782   | 63.532                        | 34.980                   | -906.310           | -756.747           | 46.613    |
| 900                                                                                                          | 67.953      | 108.811   | 66.033                        | 38.500                   | -905.922           | -747.587           | 43.388    |
| 1000                                                                                                         | 68.941      | 116.021   | 70.676                        | 45.345                   | -905.176           | -730.034           | 38.133    |
| 1100                                                                                                         | 69.940      | 122.639   | 75.104                        | 52.289                   | -904.420           | -712.557           | 33.836    |
| 1200                                                                                                         | 70.947      | 128.768   | 79.323                        | 59.333                   | -901.382           | -695.148           | 30.259    |

| $T/\text{K}$                                                                                                                                    | $\text{J/Kmol}$ |           |                               | $\text{kJ/mol}$          |                    |                    | $\text{Log } K_f$ |
|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------|-------------------------------|--------------------------|--------------------|--------------------|-------------------|
|                                                                                                                                                 | $C_p^\circ$     | $S^\circ$ | $-(G^\circ - H^\circ(T_f))/T$ | $H^\circ - H^\circ(T_f)$ | $\Delta_f H^\circ$ | $\Delta_f G^\circ$ |                   |
| PHASE TRANSITION: $\Delta_{\text{trs}} H = 2.261 \text{ kJ/mol}$ , $\Delta_{\text{trs}} S = 1.883 \text{ J/Kmol}$ , $\text{crII}' - \text{crI}$ |                 |           |                               |                          |                    |                    |                   |
| 1200                                                                                                                                            | 71.199          | 130.651   | 79.323                        | 61.594                   | -901.382           | -695.148           | 30.259            |
| 1300                                                                                                                                            | 71.743          | 136.372   | 83.494                        | 68.742                   | -900.574           | -677.994           | 27.242            |
| 1400                                                                                                                                            | 72.249          | 141.707   | 87.463                        | 75.941                   | -899.782           | -660.903           | 24.658            |
| 1500                                                                                                                                            | 72.739          | 146.709   | 91.248                        | 83.191                   | -899.004           | -643.867           | 22.421            |
| 80. SILICON TETRACHLORIDE $\text{SiCl}_4(\text{g})$                                                                                             |                 |           |                               |                          |                    |                    |                   |
| 298.15                                                                                                                                          | 90.404          | 331.446   | 331.446                       | 0.000                    | -662.200           | -622.390           | 109.039           |
| 300                                                                                                                                             | 90.562          | 332.006   | 331.448                       | 0.167                    | -662.195           | -622.143           | 108.323           |
| 400                                                                                                                                             | 96.893          | 359.019   | 335.088                       | 9.572                    | -661.853           | -608.841           | 79.505            |
| 500                                                                                                                                             | 100.449         | 381.058   | 342.147                       | 19.456                   | -661.413           | -595.637           | 62.225            |
| 600                                                                                                                                             | 102.587         | 399.576   | 350.216                       | 29.616                   | -660.924           | -582.527           | 50.713            |
| 700                                                                                                                                             | 103.954         | 415.500   | 358.432                       | 39.948                   | -660.417           | -569.501           | 42.496            |
| 800                                                                                                                                             | 104.875         | 429.445   | 366.455                       | 50.392                   | -659.912           | -556.548           | 36.338            |
| 900                                                                                                                                             | 105.523         | 441.837   | 374.155                       | 60.914                   | -659.422           | -543.657           | 31.553            |
| 1000                                                                                                                                            | 105.995         | 452.981   | 381.490                       | 71.491                   | -658.954           | -530.819           | 27.727            |
| 1100                                                                                                                                            | 106.349         | 463.101   | 388.456                       | 82.109                   | -658.515           | -518.027           | 24.599            |
| 1200                                                                                                                                            | 106.620         | 472.366   | 395.068                       | 92.758                   | -658.107           | -505.274           | 21.994            |
| 1300                                                                                                                                            | 106.834         | 480.909   | 401.347                       | 103.431                  | -657.735           | -492.553           | 19.791            |
| 1400                                                                                                                                            | 107.003         | 488.833   | 407.316                       | 114.123                  | -657.400           | -479.860           | 17.904            |
| 1500                                                                                                                                            | 107.141         | 496.220   | 413.000                       | 124.830                  | -657.104           | -467.189           | 16.269            |



# THERMODYNAMIC PROPERTIES OF AQUEOUS IONS

This table contains standard state thermodynamic properties of positive and negative ions in aqueous solution. It includes enthalpy and Gibbs energy of formation, entropy, and heat capacity, and thus serves as a companion to the preceding table, "Standard Thermodynamic Properties of Chemical Substances". The standard state is the hypothetical ideal solution with molality  $m = 1$  mol/kg (mean ionic molality  $m_{\pm}$  in the case of a species which is assumed to dissociate at infinite dilution). Further details on conventions may be found in Reference 1.

All values refer to standard conditions of 25 °C and 100 kPa pressure.

## References

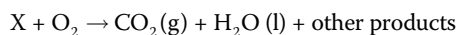
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| Species                          | $\Delta_f H^\circ /$<br>kJ mol <sup>-1</sup> | $\Delta_f G^\circ /$<br>kJ mol <sup>-1</sup> | $S^\circ /$<br>J mol <sup>-1</sup> K <sup>-1</sup> | $C_p /$<br>J mol <sup>-1</sup> K <sup>-1</sup> | Species                                    | $\Delta_f H^\circ /$<br>kJ mol <sup>-1</sup> | $\Delta_f G^\circ /$<br>kJ mol <sup>-1</sup> | $S^\circ /$<br>J mol <sup>-1</sup> K <sup>-1</sup> | $C_p /$<br>J mol <sup>-1</sup> K <sup>-1</sup> |
|----------------------------------|----------------------------------------------|----------------------------------------------|----------------------------------------------------|------------------------------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|----------------------------------------------------|------------------------------------------------|
| <b>Cations</b>                   |                                              |                                              |                                                    |                                                | InOH <sup>+2</sup>                         | -370.3                                       | -313.0                                       | -88.0                                              |                                                |
| Ag <sup>+</sup>                  | 105.6                                        | 77.1                                         | 72.7                                               | 21.8                                           | In(OH) <sub>2</sub> <sup>+</sup>           | -619.0                                       | -525.0                                       | 25.0                                               |                                                |
| Al <sup>+3</sup>                 | -531.0                                       | -485.0                                       | -321.7                                             |                                                | K <sup>+</sup>                             | -252.4                                       | -283.3                                       | 102.5                                              | 21.8                                           |
| AlOH <sup>+2</sup>               |                                              | -694.1                                       |                                                    |                                                | La <sup>+3</sup>                           | -707.1                                       | -683.7                                       | -217.6                                             | -13.0                                          |
| Ba <sup>+2</sup>                 | -537.6                                       | -560.8                                       | 9.6                                                |                                                | Li <sup>+</sup>                            | -278.5                                       | -293.3                                       | 13.4                                               | 68.6                                           |
| BaOH <sup>+</sup>                |                                              | -730.5                                       |                                                    |                                                | Lu <sup>+3</sup>                           | -665.0                                       | -628.0                                       | -264.0                                             | 25.0                                           |
| Be <sup>+2</sup>                 | -382.8                                       | -379.7                                       | -129.7                                             |                                                | LuF <sup>+2</sup>                          |                                              | -931.4                                       |                                                    |                                                |
| Bi <sup>+3</sup>                 |                                              | 82.8                                         |                                                    |                                                | Mg <sup>+2</sup>                           | -466.9                                       | -454.8                                       | -138.1                                             |                                                |
| BiOH <sup>+2</sup>               |                                              | -146.4                                       |                                                    |                                                | MgOH <sup>+</sup>                          |                                              | -626.7                                       |                                                    |                                                |
| Ca <sup>+2</sup>                 | -542.8                                       | -553.6                                       | -53.1                                              |                                                | Mn <sup>+2</sup>                           | -220.8                                       | -228.1                                       | -73.6                                              | 50.0                                           |
| CaOH <sup>+</sup>                |                                              | -718.4                                       |                                                    |                                                | MnOH <sup>+</sup>                          | -450.6                                       | -405.0                                       | -17.0                                              |                                                |
| Cd <sup>+2</sup>                 | -75.9                                        | -77.6                                        | -73.2                                              |                                                | NH <sub>4</sub> <sup>+</sup>               | -132.5                                       | -79.3                                        | 113.4                                              | 79.9                                           |
| CdOH <sup>+</sup>                |                                              | -261.1                                       |                                                    |                                                | N <sub>2</sub> H <sub>5</sub> <sup>+</sup> | -7.5                                         | 82.5                                         | 151.0                                              | 70.3                                           |
| Ce <sup>+3</sup>                 | -696.2                                       | -672.0                                       | -205.0                                             |                                                | Na <sup>+</sup>                            | -240.1                                       | -261.9                                       | 59.0                                               | 46.4                                           |
| Ce <sup>+4</sup>                 | -537.2                                       | -503.8                                       | -301.0                                             |                                                | Nd <sup>+3</sup>                           | -696.2                                       | -671.6                                       | -206.7                                             | -21.0                                          |
| Co <sup>+2</sup>                 | -58.2                                        | -54.4                                        | -113.0                                             |                                                | Ni <sup>+2</sup>                           | -54.0                                        | -45.6                                        | -128.9                                             |                                                |
| Co <sup>+3</sup>                 | 92.0                                         | 134.0                                        | -305.0                                             |                                                | NiOH <sup>+</sup>                          | -287.9                                       | -227.6                                       | -71.0                                              |                                                |
| Cr <sup>+2</sup>                 | -143.5                                       |                                              |                                                    |                                                | PH <sub>4</sub> <sup>+</sup>               |                                              | 92.1                                         |                                                    |                                                |
| Cs <sup>+</sup>                  | -258.3                                       | -292.0                                       | 133.1                                              | -10.5                                          | Pa <sup>+4</sup>                           | -619.0                                       |                                              |                                                    |                                                |
| Cu <sup>+</sup>                  | 71.7                                         | 50.0                                         | 40.6                                               |                                                | Pb <sup>+2</sup>                           | -1.7                                         | -24.4                                        | 10.5                                               |                                                |
| Cu <sup>+2</sup>                 | 64.8                                         | 65.5                                         | -99.6                                              |                                                | PbOH <sup>+</sup>                          |                                              | -226.3                                       |                                                    |                                                |
| Dy <sup>+3</sup>                 | -699.0                                       | -665.0                                       | -231.0                                             | 21.0                                           | Pd <sup>+2</sup>                           | 149.0                                        | 176.5                                        | -184.0                                             |                                                |
| Er <sup>+3</sup>                 | -705.4                                       | -669.1                                       | -244.3                                             | 21.0                                           | Po <sup>+2</sup>                           |                                              | 71.0                                         |                                                    |                                                |
| Eu <sup>+2</sup>                 | -527.0                                       | -540.2                                       | -8.0                                               |                                                | Po <sup>+4</sup>                           |                                              | 293.0                                        |                                                    |                                                |
| Eu <sup>+3</sup>                 | -605.0                                       | -574.1                                       | -222.0                                             | 8.0                                            | Pr <sup>+3</sup>                           | -704.6                                       | -679.1                                       | -209.0                                             | -29.0                                          |
| Fe <sup>+2</sup>                 | -89.1                                        | -78.9                                        | -137.7                                             |                                                | Pt <sup>+2</sup>                           |                                              | 254.8                                        |                                                    |                                                |
| Fe <sup>+3</sup>                 | -48.5                                        | -4.7                                         | -315.9                                             |                                                | Ra <sup>+2</sup>                           | -527.6                                       | -561.5                                       | 54.0                                               |                                                |
| FeOH <sup>+</sup>                | -324.7                                       | -277.4                                       | -29.0                                              |                                                | Rb <sup>+</sup>                            | -251.2                                       | -284.0                                       | 121.5                                              |                                                |
| FeOH <sup>+2</sup>               | -290.8                                       | -229.4                                       | -142.0                                             |                                                | Re <sup>+</sup>                            |                                              | -33.0                                        |                                                    |                                                |
| Fe(OH) <sub>2</sub> <sup>+</sup> |                                              | -438.0                                       |                                                    |                                                | Sc <sup>+3</sup>                           | -614.2                                       | -586.6                                       | -255.0                                             |                                                |
| Ga <sup>+2</sup>                 |                                              | -88.0                                        |                                                    |                                                | ScOH <sup>+2</sup>                         | -861.5                                       | -801.2                                       | -134.0                                             |                                                |
| Ga <sup>+3</sup>                 | -211.7                                       | -159.0                                       | -331.0                                             |                                                | Sm <sup>+2</sup>                           |                                              | -497.5                                       |                                                    |                                                |
| GaOH <sup>+2</sup>               |                                              | -380.3                                       |                                                    |                                                | Sm <sup>+3</sup>                           | -691.6                                       | -666.6                                       | -211.7                                             | -21.0                                          |
| Ga(OH) <sub>2</sub> <sup>+</sup> |                                              | -597.4                                       |                                                    |                                                | Sn <sup>+2</sup>                           | -8.8                                         | -27.2                                        | -17.0                                              |                                                |
| Gd <sup>+3</sup>                 | -686.0                                       | -661.0                                       | -205.9                                             |                                                | SnOH <sup>+</sup>                          | -286.2                                       | -254.8                                       | 50.0                                               |                                                |
| H <sup>+</sup>                   | 0                                            | 0                                            | 0                                                  | 0                                              | Sr <sup>+2</sup>                           | -545.8                                       | -559.5                                       | -32.6                                              |                                                |
| Hg <sup>+2</sup>                 | 171.1                                        | 164.4                                        | -32.2                                              |                                                | SrOH <sup>+</sup>                          |                                              | -721.3                                       |                                                    |                                                |
| Hg <sub>2</sub> <sup>+2</sup>    | 172.4                                        | 153.5                                        | 84.5                                               |                                                | Tb <sup>+3</sup>                           | -682.8                                       | -651.9                                       | -226.0                                             | 17.0                                           |
| HgOH <sup>+</sup>                | -84.5                                        | -52.3                                        | 71.0                                               |                                                | Te(OH) <sub>3</sub> <sup>+</sup>           | -608.4                                       | -496.1                                       | 111.7                                              |                                                |
| Ho <sup>+3</sup>                 | -705.0                                       | -673.7                                       | -226.8                                             | 17.0                                           | Th <sup>+4</sup>                           | -769.0                                       | -705.1                                       | -422.6                                             |                                                |
| In <sup>+</sup>                  |                                              | -12.1                                        |                                                    |                                                | Th(OH) <sup>+3</sup>                       | -1030.1                                      | -920.5                                       | -343.0                                             |                                                |
| In <sup>+2</sup>                 |                                              | -50.7                                        |                                                    |                                                | Th(OH) <sub>2</sub> <sup>+2</sup>          | -1282.4                                      | -1140.9                                      | -218.0                                             |                                                |
| In <sup>+3</sup>                 | -105.0                                       | -98.0                                        | -151.0                                             |                                                | Tl <sup>+</sup>                            | 5.4                                          | -32.4                                        | 125.5                                              |                                                |

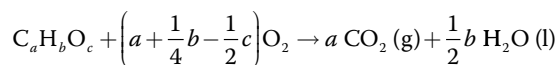
| Species                                       | $\Delta_f H^\circ /$<br>kJ mol <sup>-1</sup> | $\Delta_f G^\circ /$<br>kJ mol <sup>-1</sup> | $S^\circ /$<br>J mol <sup>-1</sup> K <sup>-1</sup> | $C_p /$<br>J mol <sup>-1</sup> K <sup>-1</sup> | Species                                                    | $\Delta_f H^\circ /$<br>kJ mol <sup>-1</sup> | $\Delta_f G^\circ /$<br>kJ mol <sup>-1</sup> | $S^\circ /$<br>J mol <sup>-1</sup> K <sup>-1</sup> | $C_p /$<br>J mol <sup>-1</sup> K <sup>-1</sup> |
|-----------------------------------------------|----------------------------------------------|----------------------------------------------|----------------------------------------------------|------------------------------------------------|------------------------------------------------------------|----------------------------------------------|----------------------------------------------|----------------------------------------------------|------------------------------------------------|
| Tl <sup>+</sup>                               | 196.6                                        | 214.6                                        | -192.0                                             |                                                | HF <sub>2</sub> <sup>-</sup>                               | -649.9                                       | -578.1                                       | 92.5                                               |                                                |
| TlOH <sup>+</sup>                             |                                              | -15.9                                        |                                                    |                                                | HPO <sub>3</sub> F <sup>-</sup>                            |                                              | -1198.2                                      |                                                    |                                                |
| Tl(OH) <sub>2</sub> <sup>+</sup>              |                                              | -244.7                                       |                                                    |                                                | HPO <sub>4</sub> <sup>-2</sup>                             | -1292.1                                      | -1089.2                                      | -33.5                                              |                                                |
| Tm <sup>+</sup>                               | -697.9                                       | -662.0                                       | -243.0                                             | 25.0                                           | HP <sub>2</sub> O <sub>7</sub> <sup>-3</sup>               | -2274.8                                      | -1972.2                                      | 46.0                                               |                                                |
| U <sup>+</sup>                                | -489.1                                       | -476.2                                       | -188.0                                             |                                                | HS <sup>-</sup>                                            | -17.6                                        | 12.1                                         | 62.8                                               |                                                |
| U <sup>+</sup>                                | -591.2                                       | -531.9                                       | -410.0                                             |                                                | HSO <sub>3</sub> <sup>-</sup>                              | -626.2                                       | -527.7                                       | 139.7                                              |                                                |
| Y <sup>+</sup>                                | -723.4                                       | -693.8                                       | -251.0                                             |                                                | HSO <sub>4</sub> <sup>-</sup>                              | -887.3                                       | -755.9                                       | 131.8                                              | -84.0                                          |
| Y <sub>2</sub> (OH) <sub>2</sub> <sup>+</sup> |                                              | -1780.3                                      |                                                    |                                                | HS <sub>2</sub> O <sub>4</sub> <sup>-</sup>                |                                              | -614.5                                       |                                                    |                                                |
| Yb <sup>+</sup>                               |                                              | -527.0                                       |                                                    |                                                | HSe <sup>-</sup>                                           | 15.9                                         | 44.0                                         | 79.0                                               |                                                |
| Yb <sup>+</sup>                               | -674.5                                       | -644.0                                       | -238.0                                             | 25.0                                           | HSeO <sub>3</sub> <sup>-</sup>                             | -514.6                                       | -411.5                                       | 135.1                                              |                                                |
| Y(OH) <sup>+</sup>                            |                                              | -879.1                                       |                                                    |                                                | HSeO <sub>4</sub> <sup>-</sup>                             | -581.6                                       | -452.2                                       | 149.4                                              |                                                |
| Zn <sup>+</sup>                               | -153.9                                       | -147.1                                       | -112.1                                             | 46.0                                           | H <sub>2</sub> AsO <sub>3</sub> <sup>-</sup>               | -714.8                                       | -587.1                                       | 110.5                                              |                                                |
| ZnOH <sup>+</sup>                             |                                              | -330.1                                       |                                                    |                                                | H <sub>2</sub> AsO <sub>4</sub> <sup>-</sup>               | -909.6                                       | -753.2                                       | 117.0                                              |                                                |
| <b>Anions</b>                                 |                                              |                                              |                                                    |                                                | H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>                | -1296.3                                      | -1130.2                                      | 90.4                                               |                                                |
| AlO <sub>2</sub> <sup>-</sup>                 | -930.9                                       | -830.9                                       | -36.8                                              |                                                | H <sub>2</sub> P <sub>2</sub> O <sub>7</sub> <sup>-2</sup> | -2278.6                                      | -2010.2                                      | 163.0                                              |                                                |
| Al(OH) <sub>4</sub> <sup>-</sup>              | -1502.5                                      | -1305.3                                      | 102.9                                              |                                                | I <sup>-</sup>                                             | -55.2                                        | -51.6                                        | 111.3                                              | -142.3                                         |
| AsO <sub>2</sub> <sup>-</sup>                 | -429.0                                       | -350.0                                       | 40.6                                               |                                                | IO <sup>-</sup>                                            | -107.5                                       | -38.5                                        | -5.4                                               |                                                |
| AsO <sub>4</sub> <sup>-3</sup>                | -888.1                                       | -648.4                                       | -162.8                                             |                                                | IO <sub>3</sub> <sup>-</sup>                               | -221.3                                       | -128.0                                       | 118.4                                              |                                                |
| BF <sub>4</sub> <sup>-</sup>                  | -1574.9                                      | -1486.9                                      | 180.0                                              |                                                | IO <sub>4</sub> <sup>-</sup>                               | -151.5                                       | -58.5                                        | 222.0                                              |                                                |
| BH <sub>4</sub> <sup>-</sup>                  | 48.2                                         | 114.4                                        | 110.5                                              |                                                | MnO <sub>4</sub> <sup>-</sup>                              | -541.4                                       | -447.2                                       | 191.2                                              | -82.0                                          |
| BO <sub>2</sub> <sup>-</sup>                  | -772.4                                       | -678.9                                       | -37.2                                              |                                                | MnO <sub>4</sub> <sup>-2</sup>                             | -653.0                                       | -500.7                                       | 59.0                                               |                                                |
| B <sub>4</sub> O <sub>7</sub> <sup>-2</sup>   |                                              | -2604.8                                      |                                                    |                                                | MoO <sub>4</sub> <sup>-2</sup>                             | -997.9                                       | -836.3                                       | 27.2                                               |                                                |
| BeO <sub>2</sub> <sup>-2</sup>                | -790.8                                       | -640.1                                       | -159.0                                             |                                                | NO <sub>2</sub> <sup>-</sup>                               | -104.6                                       | -32.2                                        | 123.0                                              | -97.5                                          |
| Br <sup>-</sup>                               | -121.6                                       | -104.0                                       | 82.4                                               | -141.8                                         | NO <sub>3</sub> <sup>-</sup>                               | -207.4                                       | -111.3                                       | 146.4                                              | -86.6                                          |
| BrO <sup>-</sup>                              | -94.1                                        | -33.4                                        | 42.0                                               |                                                | N <sub>3</sub> <sup>-</sup>                                | 275.1                                        | 348.2                                        | 107.9                                              |                                                |
| BrO <sub>3</sub> <sup>-</sup>                 | -67.1                                        | 18.6                                         | 161.7                                              |                                                | OCN <sup>-</sup>                                           | -146.0                                       | -97.4                                        | 106.7                                              |                                                |
| BrO <sub>4</sub> <sup>-</sup>                 | 13.0                                         | 118.1                                        | 199.6                                              |                                                | OH <sup>-</sup>                                            | -230.0                                       | -157.2                                       | -10.8                                              | -148.5                                         |
| CHOO <sup>-</sup>                             | -425.6                                       | -351.0                                       | 92.0                                               | -87.9                                          | PO <sub>4</sub> <sup>-3</sup>                              | -1277.4                                      | -1018.7                                      | -220.5                                             |                                                |
| CH <sub>3</sub> COO <sup>-</sup>              | -486.0                                       | -369.3                                       | 86.6                                               | -6.3                                           | P <sub>2</sub> O <sub>7</sub> <sup>-4</sup>                | -2271.1                                      | -1919.0                                      | -117.0                                             |                                                |
| C <sub>2</sub> O <sub>4</sub> <sup>-2</sup>   | -825.1                                       | -673.9                                       | 45.6                                               |                                                | Re <sup>-</sup>                                            | 46.0                                         | 10.1                                         | 230.0                                              |                                                |
| C <sub>2</sub> O <sub>4</sub> H <sup>-</sup>  | -818.4                                       | -698.3                                       | 149.4                                              |                                                | S <sup>-2</sup>                                            | 33.1                                         | 85.8                                         | -14.6                                              |                                                |
| Cl <sup>-</sup>                               | -167.2                                       | -131.2                                       | 56.5                                               | -136.4                                         | SCN <sup>-</sup>                                           | 76.4                                         | 92.7                                         | 144.3                                              | -40.2                                          |
| ClO <sup>-</sup>                              | -107.1                                       | -36.8                                        | 42.0                                               |                                                | SO <sub>3</sub> <sup>-2</sup>                              | -635.5                                       | -486.5                                       | -29.0                                              |                                                |
| ClO <sub>2</sub> <sup>-</sup>                 | -66.5                                        | 17.2                                         | 101.3                                              |                                                | SO <sub>4</sub> <sup>-2</sup>                              | -909.3                                       | -744.5                                       | 20.1                                               | -293.0                                         |
| ClO <sub>3</sub> <sup>-</sup>                 | -104.0                                       | -8.0                                         | 162.3                                              |                                                | S <sub>2</sub> <sup>-2</sup>                               | 30.1                                         | 79.5                                         | 28.5                                               |                                                |
| ClO <sub>4</sub> <sup>-</sup>                 | -129.3                                       | -8.5                                         | 182.0                                              |                                                | S <sub>2</sub> O <sub>3</sub> <sup>-2</sup>                | -652.3                                       | -522.5                                       | 67.0                                               |                                                |
| CN <sup>-</sup>                               | 150.6                                        | 172.4                                        | 94.1                                               |                                                | S <sub>2</sub> O <sub>4</sub> <sup>-2</sup>                | -753.5                                       | -600.3                                       | 92.0                                               |                                                |
| CO <sub>3</sub> <sup>-2</sup>                 | -677.1                                       | -527.8                                       | -56.9                                              |                                                | S <sub>2</sub> O <sub>8</sub> <sup>-2</sup>                | -1344.7                                      | -1114.9                                      | 244.3                                              |                                                |
| CrO <sub>4</sub> <sup>-2</sup>                | -881.2                                       | -727.8                                       | 50.2                                               |                                                | Se <sup>-2</sup>                                           |                                              | 129.3                                        |                                                    |                                                |
| Cr <sub>2</sub> O <sub>7</sub> <sup>-2</sup>  | -1490.3                                      | -1301.1                                      | 261.9                                              |                                                | SeO <sub>3</sub> <sup>-2</sup>                             | -509.2                                       | -369.8                                       | 13.0                                               |                                                |
| F <sup>-</sup>                                | -332.6                                       | -278.8                                       | -13.8                                              | -106.7                                         | SeO <sub>4</sub> <sup>-2</sup>                             | -599.1                                       | -441.3                                       | 54.0                                               |                                                |
| Fe(CN) <sub>6</sub> <sup>-3</sup>             | 561.9                                        | 729.4                                        | 270.3                                              |                                                | VO <sub>3</sub> <sup>-</sup>                               | -888.3                                       | -783.6                                       | 50.0                                               |                                                |
| Fe(CN) <sub>6</sub> <sup>-4</sup>             | 455.6                                        | 695.1                                        | 95.0                                               |                                                | VO <sub>4</sub> <sup>-3</sup>                              |                                              | -899.0                                       |                                                    |                                                |
| HB <sub>4</sub> O <sub>7</sub> <sup>-</sup>   |                                              | -2685.1                                      |                                                    |                                                | WO <sub>4</sub> <sup>-2</sup>                              | -1075.7                                      |                                              |                                                    |                                                |
| HCO <sub>3</sub> <sup>-</sup>                 | -692.0                                       | -586.8                                       | 91.2                                               |                                                |                                                            |                                              |                                              |                                                    |                                                |

## HEAT OF COMBUSTION

The heat of combustion of a substance at 25°C can be calculated from the enthalpy of formation ( $\Delta_f H^\circ$ ) data in the table “Standard Thermodynamic Properties of Chemical Substances” in this Section. We can write the general combustion reaction as



For a compound containing only carbon, hydrogen, and oxygen, the reaction is simply



and the standard heat of combustion  $\Delta_c H^\circ$ , which is defined as the negative of the enthalpy change for the reaction (i.e., the heat released in the combustion process), is given by

$$\begin{aligned} \Delta_c H^\circ &= -a\Delta_f H^\circ(CO_2, g) - \frac{1}{2}b\Delta_f H^\circ(H_2O, l) + \Delta_f H^\circ(C_a H_b O_c) \\ &= 393.51a + 142.915b + \Delta_f H^\circ(C_a H_b O_c) \end{aligned}$$

This equation applies if the reactants start in their standard states (25°C and one atmosphere pressure) and the products return to the same conditions. The same equation applies to a compound containing another element if that element ends in its standard reference state (e.g., nitrogen, if the product is  $N_2$ ); in general, however, the exact products containing the other elements must be known in order to calculate the heat of combustion.

The following table gives the standard heat of combustion calculated in this manner for a few representative substances.

| Molecular formula           | Name                | $\Delta_c H^\circ / \text{kJ mol}^{-1}$ | Molecular formula         | Name                 | $\Delta_c H^\circ / \text{kJ mol}^{-1}$ |
|-----------------------------|---------------------|-----------------------------------------|---------------------------|----------------------|-----------------------------------------|
| <b>Inorganic substances</b> |                     |                                         |                           |                      |                                         |
| C                           | Carbon (graphite)   | 393.5                                   | $C_3H_8O_3$               | Glycerol (l)         | 1655.4                                  |
| CO                          | Carbon monoxide (g) | 283.0                                   | $C_4H_{10}O$              | Diethyl ether (l)    | 2723.9                                  |
| $H_2$                       | Hydrogen (g)        | 285.8                                   | $C_5H_{12}O$              | 1-Pentanol (l)       | 3330.9                                  |
| $H_3N$                      | Ammonia (g)         | 382.8                                   | $C_6H_6O$                 | Phenol (s)           | 3053.5                                  |
| $H_4N_2$                    | Hydrazine (g)       | 667.1                                   | <b>Carbonyl compounds</b> |                      |                                         |
| $N_2O$                      | Nitrous oxide (g)   | 82.1                                    | $CH_2O$                   | Formaldehyde (g)     | 570.7                                   |
| <b>Hydrocarbons</b>         |                     |                                         | $C_2H_2O$                 | Ketene (g)           | 1025.4                                  |
| $CH_4$                      | Methane (g)         | 890.8                                   | $C_2H_4O$                 | Acetaldehyde (l)     | 1166.9                                  |
| $C_2H_2$                    | Acetylene (g)       | 1301.1                                  | $C_3H_6O$                 | Acetone (l)          | 1789.9                                  |
| $C_2H_4$                    | Ethylene (g)        | 1411.2                                  | $C_3H_6O$                 | Propanal (l)         | 1822.7                                  |
| $C_2H_6$                    | Ethane (g)          | 1560.7                                  | $C_4H_8O$                 | 2-Butanone (l)       | 2444.1                                  |
| $C_3H_6$                    | Propylene (g)       | 2058.0                                  | <b>Acids and esters</b>   |                      |                                         |
| $C_3H_6$                    | Cyclopropane (g)    | 2091.3                                  | $CH_2O_2$                 | Formic acid (l)      | 254.6                                   |
| $C_3H_8$                    | Propane (g)         | 2219.2                                  | $C_2H_4O_2$               | Acetic acid (l)      | 874.2                                   |
| $C_4H_6$                    | 1,3-Butadiene (g)   | 2541.5                                  | $C_2H_4O_2$               | Methyl formate (l)   | 972.6                                   |
| $C_4H_{10}$                 | Butane (g)          | 2877.6                                  | $C_3H_6O_2$               | Methyl acetate (l)   | 1592.2                                  |
| $C_5H_{12}$                 | Pentane (l)         | 3509.0                                  | $C_4H_8O_2$               | Ethyl acetate (l)    | 2238.1                                  |
| $C_6H_6$                    | Benzene (l)         | 3267.6                                  | $C_6H_5NO_2$              | Nicotinic acid (s)   | 2731.1                                  |
| $C_6H_{12}$                 | Cyclohexane (l)     | 3919.6                                  | $C_7H_6O_2$               | Benzoic acid (s)     | 3228.2                                  |
| $C_6H_{14}$                 | Hexane (l)          | 4163.2                                  | <b>Nitrogen compounds</b> |                      |                                         |
| $C_7H_8$                    | Toluene (l)         | 3910.3                                  | CHN                       | Hydrogen cyanide (g) | 671.5                                   |
| $C_7H_{16}$                 | Heptane (l)         | 4817.0                                  | $CH_3NO_2$                | Nitromethane (l)     | 709.2                                   |
| $C_{10}H_8$                 | Naphthalene (s)     | 5156.3                                  | $CH_4N_2O$                | Urea (s)             | 632.7                                   |
| <b>Alcohols and ethers</b>  |                     |                                         | $CH_5N$                   | Methylamine (g)      | 1085.6                                  |
| $CH_4O$                     | Methanol (l)        | 726.1                                   | $C_2H_3N$                 | Acetonitrile (l)     | 1247.2                                  |
| $C_2H_6O$                   | Ethanol (l)         | 1366.8                                  | $C_2H_5NO$                | Acetamide (s)        | 1184.6                                  |
| $C_2H_6O$                   | Dimethyl ether (g)  | 1460.4                                  | $C_3H_9N$                 | Trimethylamine (g)   | 2443.1                                  |
| $C_2H_6O_2$                 | Ethylene glycol (l) | 1189.2                                  | $C_5H_5N$                 | Pyridine (l)         | 2782.3                                  |
| $C_3H_8O$                   | 1-Propanol (l)      | 2021.3                                  | $C_6H_7N$                 | Aniline (l)          | 3392.8                                  |

## MOLAR CONDUCTIVITY OF AQUEOUS HF, HCl, HBr, AND HI

The molar conductivity  $\Lambda$  of an electrolyte solution is defined as the conductivity divided by amount-of-substance concentration. The customary unit is  $\text{S cm}^2 \text{mol}^{-1}$  (i.e.,  $\Omega^{-1} \text{cm}^2 \text{mol}^{-1}$ ). The first part of this table gives the molar conductivity of the hydrohalogen acids at 25 °C as a function of the concentration in mol/L. The second part gives the temperature dependence of  $\Lambda$  for HCl and HBr. More extensive tables and mathematical representations may be found in the reference.

### Reference

Hamer, W. J., and DeWane, H. J., *Electrolytic Conductance and the Conductances of the Hydrohalogen Acids in Water*, Natl. Stand. Ref. Data Sys.- Natl. Bur. Standards (U.S.), No. 33, 1970.

| $c/\text{mol L}^{-1}$ | HF    | HCl   | HBr   | HI    |
|-----------------------|-------|-------|-------|-------|
| Inf. dil.             | 405.1 | 426.1 | 427.7 | 426.4 |
| 0.0001                |       | 424.5 | 425.9 | 424.6 |
| 0.0005                |       | 422.6 | 424.3 | 423.0 |
| 0.001                 |       | 421.2 | 422.9 | 421.7 |
| 0.005                 | 128.1 | 415.7 | 417.6 | 416.4 |
| 0.01                  | 96.1  | 411.9 | 413.7 | 412.8 |
| 0.05                  | 50.1  | 398.9 | 400.4 | 400.8 |
| 0.10                  | 39.1  | 391.1 | 391.9 | 394.0 |
| 0.5                   | 26.3  | 360.7 | 361.9 | 369.8 |
| 1.0                   | 24.3  | 332.2 | 334.5 | 343.9 |
| 1.5                   |       | 305.8 | 307.6 | 316.4 |
| 2.0                   |       | 281.4 | 281.7 | 288.9 |
| 2.5                   |       | 258.9 | 257.8 | 262.5 |
| 3.0                   |       | 237.6 | 236.8 | 237.9 |

| $c/\text{mol L}^{-1}$ | HF | HCl   | HBr   | HI    |
|-----------------------|----|-------|-------|-------|
| 3.5                   |    | 218.3 | 217.5 | 215.4 |
| 4.0                   |    | 200.0 | 199.4 | 195.1 |
| 4.5                   |    | 183.1 | 182.4 | 176.8 |
| 5.0                   |    | 167.4 | 166.5 | 160.4 |
| 5.5                   |    | 152.9 | 151.8 | 145.5 |
| 6.0                   |    | 139.7 | 138.2 | 131.7 |
| 6.5                   |    | 127.7 | 125.7 | 118.6 |
| 7.0                   |    | 116.9 | 114.2 | 105.7 |
| 7.5                   |    | 107.0 | 103.8 |       |
| 8.0                   |    | 98.2  | 94.4  |       |
| 8.5                   |    | 90.3  | 85.8  |       |
| 9.0                   |    | 83.1  |       |       |
| 9.5                   |    | 76.6  |       |       |
| 10.0                  |    | 70.7  |       |       |

| $c/\text{mol L}^{-1}$ | -20 °C | -10 °C | 0 °C  | 10 °C | 20 °C | 30 °C | 40 °C | 50 °C |
|-----------------------|--------|--------|-------|-------|-------|-------|-------|-------|
| HCl                   |        |        |       |       |       |       |       |       |
| 0.5                   |        |        | 228.7 | 283.0 | 336.4 | 386.8 | 436.9 | 482.4 |
| 1.0                   |        |        | 211.7 | 261.6 | 312.2 | 359.0 | 402.9 | 445.3 |
| 1.5                   |        |        | 196.2 | 241.5 | 287.5 | 331.1 | 371.6 | 410.8 |
| 2.0                   |        |        | 182.0 | 222.7 | 262.9 | 303.3 | 342.4 | 378.2 |
| 2.5                   |        | 131.7  | 168.5 | 205.1 | 239.8 | 277.0 | 315.2 | 347.6 |
| 3.0                   |        | 120.8  | 154.6 | 188.5 | 219.3 | 253.3 | 289.3 | 319.0 |
| 3.5                   | 85.5   | 111.3  | 139.6 | 172.2 | 201.6 | 232.9 | 263.9 | 292.1 |
| 4.0                   | 79.3   | 102.7  | 129.2 | 158.1 | 185.6 | 214.2 | 242.2 | 268.2 |
| 4.5                   | 73.7   | 94.9   | 119.5 | 145.4 | 170.6 | 196.6 | 222.5 | 246.7 |
| 5.0                   | 68.5   | 87.8   | 110.3 | 133.5 | 156.6 | 180.2 | 204.1 | 226.5 |
| 5.5                   | 63.6   | 81.1   | 101.7 | 122.5 | 143.6 | 165.0 | 187.1 | 207.7 |
| 6.0                   | 58.9   | 74.9   | 93.7  | 112.3 | 131.5 | 151.0 | 171.3 | 190.3 |
| 6.5                   | 54.4   | 69.1   | 86.2  | 103.0 | 120.4 | 138.2 | 156.9 | 174.3 |
| 7.0                   | 50.2   | 63.7   | 79.3  | 94.4  | 110.2 | 126.4 | 143.3 | 159.7 |
| 7.5                   | 46.3   | 58.6   | 73.0  | 86.5  | 100.9 | 115.7 | 131.6 | 146.2 |
| 8.0                   | 42.7   | 54.0   | 67.1  | 79.4  | 92.4  | 106.1 | 120.6 | 134.0 |
| 8.5                   | 39.4   | 49.8   | 61.7  | 72.9  | 84.7  | 97.3  | 110.7 | 123.0 |
| 9.0                   | 36.4   | 45.9   | 56.8  | 67.1  | 77.8  | 89.4  | 101.7 | 112.9 |
| 9.5                   | 33.6   | 42.3   | 52.3  | 61.8  | 71.5  | 82.3  | 93.6  | 103.9 |
| 10.0                  | 31.2   | 39.1   | 48.2  | 57.0  | 65.8  | 75.9  | 86.3  | 95.7  |
| 10.5                  | 28.9   | 36.1   | 44.5  | 52.7  | 60.7  | 70.1  | 79.6  | 88.4  |
| 11.0                  | 26.8   | 33.4   | 41.1  | 48.8  | 56.1  | 64.9  | 73.6  | 81.7  |
| 11.5                  | 24.9   | 31.0   | 38.0  | 45.3  | 51.9  | 60.1  | 68.0  | 75.6  |
| 12.0                  | 23.1   | 28.7   | 35.3  | 42.0  | 48.0  | 55.6  | 62.8  | 70.0  |
| 12.5                  | 21.4   | 26.7   | 32.7  | 39.0  | 44.4  | 51.4  | 57.9  | 64.8  |

| $c/\text{mol L}^{-1}$ | -20 °C | -10 °C | 0 °C  | 10 °C | 20 °C | 30 °C | 40 °C | 50 °C |
|-----------------------|--------|--------|-------|-------|-------|-------|-------|-------|
| HBr                   |        |        |       |       |       |       |       |       |
| 0.5                   |        |        | 240.9 | 295.9 | 347.0 | 398.9 | 453.6 | 496.8 |
| 1.0                   |        |        | 229.6 | 276.0 | 329.0 | 380.4 | 418.6 | 465.2 |
| 1.5                   |        |        | 209.5 | 254.9 | 298.9 | 340.6 | 381.8 | 421.4 |
| 2.0                   |        | 150.8  | 188.6 | 231.3 | 271.8 | 314.1 | 350.5 | 387.4 |
| 2.5                   |        | 136.8  | 171.7 | 208.3 | 244.8 | 281.7 | 316.0 | 349.1 |
| 3.0                   |        | 125.7  | 157.2 | 189.5 | 222.2 | 255.0 | 287.8 | 318.6 |
| 3.5                   |        | 116.1  | 144.1 | 174.6 | 203.2 | 234.4 | 263.7 | 291.9 |
| 4.0                   | 84.0   | 107.5  | 132.3 | 160.2 | 186.8 | 214.2 | 239.7 | 266.9 |
| 4.5                   | 78.0   | 99.0   | 123.0 | 146.4 | 171.2 | 195.1 | 218.8 | 242.6 |
| 5.0                   | 72.3   | 91.4   | 112.6 | 134.0 | 155.7 | 178.2 | 199.6 | 221.3 |
| 5.5                   | 67.0   | 84.2   | 103.1 | 122.7 | 142.1 | 162.8 | 181.4 | 201.8 |
| 6.0                   | 61.8   | 77.2   | 94.3  | 112.0 | 129.6 | 148.0 | 165.4 | 183.4 |
| 6.5                   | 56.8   | 70.7   | 86.0  | 102.0 | 118.0 | 134.1 | 150.5 | 166.3 |
| 7.0                   | 51.9   | 64.6   | 78.4  | 92.6  | 107.1 | 121.4 | 136.3 | 150.8 |

## STANDARD KCl SOLUTIONS FOR CALIBRATING CONDUCTIVITY CELLS

This table presents recommended electrolytic conductivity ( $\kappa$ ) values for aqueous potassium chloride solutions with molalities of 0.01 mol/kg, 0.1 mol/kg and 1.0 mol/kg at temperatures from 0°C to 50°C. The values, which are based on measurements at the National Institute of Standards and Technology, provide primary standards for the calibration of conductivity cells. The measurements at 0.01 and 0.1 molal are described in Reference 1, while those at 1.0 molal are in Reference 2. Temperatures are given on the ITS-90 scale. The uncertainty in the conductivity is about 0.03% for the 0.01 molal values and about 0.04% for the 0.1 and 1.0 molal values. The conductivity of water saturated with atmospheric CO<sub>2</sub> is given in the last column. These values were subtracted from the original measurements to give the values in the second, third, and fourth columns. All  $\kappa$  values are given in units of 10<sup>-4</sup> S/m (numerically equal to  $\mu$ S/cm).

The assistance of Kenneth W. Pratt is appreciated.

| <i>t</i> /°C | 10 <sup>4</sup> $\kappa$ /S m <sup>-1</sup> |           |           |                                         |
|--------------|---------------------------------------------|-----------|-----------|-----------------------------------------|
|              | 0.01 m KCl                                  | 0.1 m KCl | 1.0 m KCl | H <sub>2</sub> O (CO <sub>2</sub> sat.) |
| 0            | 772.92                                      | 7 116.85  | 63 488    | 0.58                                    |
| 5            | 890.96                                      | 8 183.70  | 72 030    | 0.68                                    |
| 10           | 1 013.95                                    | 9 291.72  | 80 844    | 0.79                                    |
| 15           | 1 141.45                                    | 10 437.1  | 89 900    | 0.89                                    |
| 18           | 1 219.93                                    | 11 140.6  | —         | 0.95                                    |
| 20           | 1 273.03                                    | 11 615.9  | 99 170    | 0.99                                    |
| 25           | 1 408.23                                    | 12 824.6  | 108 620   | 1.10                                    |
| 30           | 1 546.63                                    | 14 059.2  | 118 240   | 1.20                                    |
| 35           | 1 687.79                                    | 15 316.0  | 127 970   | 1.30                                    |
| 40           | 1 831.27                                    | 16 591.0  | 137 810   | 1.40                                    |
| 45           | 1 976.62                                    | 17 880.6  | 147 720   | 1.51                                    |
| 50           | 2 123.43                                    | 19 180.9  | 157 670   | 1.61                                    |

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# EQUIVALENT CONDUCTIVITY OF ELECTROLYTES IN AQUEOUS SOLUTION

Petr Vanýsek

This table gives the equivalent (molar) conductivity  $\Lambda$  at 25 °C for some common electrolytes in aqueous solution at concentrations up to 0.1 mol/L. The units of  $\Lambda$  are  $10^{-4} \text{ m}^2 \text{ S mol}^{-1}$ .

For very dilute solutions, the equivalent conductivity for any electrolyte of concentration  $c$  can be approximately calculated using the Debye–Hückel–Onsager equation, which can be written for a symmetrical (equal charge on cation and anion) electrolyte as

$$\Lambda = \Lambda^\circ - (A + B\Lambda^\circ)c^{1/2}$$

For a solution at 25 °C and both cation and anion with charge |1|, the constants are  $A = 60.20$  and  $B = 0.229$ .  $\Lambda^\circ$  can be found from the next table, “Ionic Conductivity and Diffusion at Infinite Dilution.” The equation is reliable for  $c < 0.001 \text{ mol/L}$ ; with higher concentration the error increases.

| Compound                              | Infinite dilution<br>$\Lambda^\circ$ | Concentration (mol/L)                              |        |        |        |        |        |        |
|---------------------------------------|--------------------------------------|----------------------------------------------------|--------|--------|--------|--------|--------|--------|
|                                       |                                      | 0.0005                                             | 0.001  | 0.005  | 0.01   | 0.02   | 0.05   | 0.1    |
|                                       |                                      | $\Lambda (10^{-4} \text{ m}^2 \text{ S mol}^{-1})$ |        |        |        |        |        |        |
| AgNO <sub>3</sub>                     | 133.29                               | 131.29                                             | 130.45 | 127.14 | 124.70 | 121.35 | 115.18 | 109.09 |
| 1/2BaCl <sub>2</sub>                  | 139.91                               | 135.89                                             | 134.27 | 127.96 | 123.88 | 119.03 | 111.42 | 105.14 |
| 1/2CaCl <sub>2</sub>                  | 135.77                               | 131.86                                             | 130.30 | 124.19 | 120.30 | 115.59 | 108.42 | 102.41 |
| 1/2Ca(OH) <sub>2</sub>                | 258                                  | —                                                  | —      | 233    | 226    | 214    | —      | —      |
| CuSO <sub>4</sub>                     | 133.6                                | 121.6                                              | 115.20 | 94.02  | 83.08  | 72.16  | 59.02  | 50.55  |
| HCl                                   | 425.95                               | 422.53                                             | 421.15 | 415.59 | 411.80 | 407.04 | 398.89 | 391.13 |
| KBr                                   | 151.9                                | 149.8                                              | 148.9  | 146.02 | 143.36 | 140.41 | 135.61 | 131.32 |
| KCl                                   | 149.79                               | 147.74                                             | 146.88 | 143.48 | 141.20 | 138.27 | 133.30 | 128.90 |
| KClO <sub>4</sub>                     | 139.97                               | 138.69                                             | 137.80 | 134.09 | 131.39 | 127.86 | 121.56 | 115.14 |
| 1/3K <sub>3</sub> Fe(CN) <sub>6</sub> | 174.5                                | 166.4                                              | 163.1  | 150.7  | —      | —      | —      | —      |
| 1/4K <sub>4</sub> Fe(CN) <sub>6</sub> | 184                                  | —                                                  | 167.16 | 146.02 | 134.76 | 122.76 | 107.65 | 97.82  |
| KHCO <sub>3</sub>                     | 117.94                               | 116.04                                             | 115.28 | 112.18 | 110.03 | 107.17 | —      | —      |
| KI                                    | 150.31                               | 148.2                                              | 143.32 | 144.30 | 142.11 | 139.38 | 134.90 | 131.05 |
| KIO <sub>4</sub>                      | 127.86                               | 125.74                                             | 124.88 | 121.18 | 118.45 | 114.08 | 106.67 | 98.2   |
| KNO <sub>3</sub>                      | 144.89                               | 142.70                                             | 141.77 | 138.41 | 132.75 | 132.34 | 126.25 | 120.34 |
| KMnO <sub>4</sub>                     | 134.8                                | 132.7                                              | 131.9  | —      | 126.5  | —      | —      | 113    |
| KOH                                   | 271.5                                | —                                                  | 234    | 230    | 228    | —      | 219    | 213    |
| KReO <sub>4</sub>                     | 128.20                               | 126.03                                             | 125.12 | 121.31 | 118.49 | 114.49 | 106.40 | 97.40  |
| 1/3LaCl <sub>3</sub>                  | 145.9                                | 139.6                                              | 137.0  | 127.5  | 121.8  | 115.3  | 106.2  | 99.1   |
| LiCl                                  | 114.97                               | 113.09                                             | 112.34 | 109.35 | 107.27 | 104.60 | 100.06 | 95.81  |
| LiClO <sub>4</sub>                    | 105.93                               | 104.13                                             | 103.39 | 100.52 | 98.56  | 96.13  | 92.15  | 88.52  |
| 1/2MgCl <sub>2</sub>                  | 129.34                               | 125.55                                             | 124.15 | 118.25 | 114.49 | 109.99 | 103.03 | 97.05  |
| NH <sub>4</sub> Cl                    | 149.6                                | 147.5                                              | 146.7  | 143.9  | 141.21 | 138.25 | 133.22 | 128.69 |
| NaCl                                  | 126.39                               | 124.44                                             | 123.68 | 120.59 | 118.45 | 115.70 | 111.01 | 106.69 |
| NaClO <sub>4</sub>                    | 117.42                               | 115.58                                             | 114.82 | 111.70 | 109.54 | 106.91 | 102.35 | 98.38  |
| NaI                                   | 126.88                               | 125.30                                             | 124.19 | 121.19 | 119.18 | 116.64 | 112.73 | 108.73 |
| NaOOCCH <sub>3</sub>                  | 91.0                                 | 89.2                                               | 88.5   | 85.68  | 83.72  | 81.20  | 76.88  | 72.76  |
| NaOH                                  | 247.7                                | 245.5                                              | 244.6  | 240.7  | 237.9  | —      | —      | —      |
| Na picrate                            | 80.45                                | 78.7                                               | 78.6   | 75.7   | 73.7   | —      | 66.3   | 61.8   |
| 1/2Na <sub>2</sub> SO <sub>4</sub>    | 129.8                                | 125.68                                             | 124.09 | 117.09 | 112.38 | 106.73 | 97.70  | 89.94  |
| 1/2SrCl <sub>2</sub>                  | 135.73                               | 131.84                                             | 130.27 | 124.18 | 120.23 | 115.48 | 108.20 | 102.14 |
| ZnSO <sub>4</sub>                     | 132.7                                | 121.3                                              | 114.47 | 95.44  | 84.87  | 74.20  | 61.17  | 52.61  |

# IONIC CONDUCTIVITY AND DIFFUSION AT INFINITE DILUTION

Petr Vanyšek

This table gives the molar (equivalent) conductivity  $\lambda$  for common ions at infinite dilution. All values refer to aqueous solutions at 25°C. It also lists the diffusion coefficient  $D$  of the ion in dilute aqueous solution, which is related to  $\lambda$  through the equation

$$D = (RT / F^2)(\lambda / |z|)$$

where  $R$  is the molar gas constant,  $T$  the temperature,  $F$  the Faraday constant, and  $z$  the charge on the ion. The variation with temperature is fairly sharp; for typical ions,  $\lambda$  and  $D$  increase by 2 to 3% per degree as the temperature increases from 25°C.

The diffusion coefficient for a salt,  $D_{\text{salt}}$ , may be calculated from the  $D_+$  and  $D_-$  values of the constituent ions by the relation

$$D_{\text{salt}} = \frac{(z_+ + |z_-|)D_+D_-}{z_+D_+ + |z_-|D_-}$$

For solutions of simple, pure electrolytes (one positive and one negative ionic species), such as NaCl, equivalent ionic conductivity  $\Lambda^\circ$ , which is the molar conductivity per unit concentration of charge, is defined as

$$\Lambda^\circ = \Lambda_+ + \Lambda_-$$

where  $\Lambda_+$  and  $\Lambda_-$  are equivalent ionic conductivities of the cation and anion. The more general formula is

$$\Lambda^\circ = \nu_+\Lambda_+ + \nu_-\Lambda_-$$

where  $\nu_+$  and  $\nu_-$  refer to the number of moles of cations and anions to which one mole of the electrolyte gives a rise in the solution.

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| Ion                                                      | $\Lambda_+$                              | $D$                                   | Ion                                                         | $\Lambda_+$                              | $D$                                   |
|----------------------------------------------------------|------------------------------------------|---------------------------------------|-------------------------------------------------------------|------------------------------------------|---------------------------------------|
|                                                          | $10^{-4} \text{ m}^2 \text{ S mol}^{-1}$ | $10^{-5} \text{ cm}^2 \text{ s}^{-1}$ |                                                             | $10^{-4} \text{ m}^2 \text{ S mol}^{-1}$ | $10^{-5} \text{ cm}^2 \text{ s}^{-1}$ |
| <b>Inorganic Cations</b>                                 |                                          |                                       |                                                             |                                          |                                       |
| Ag <sup>+</sup>                                          | 61.9                                     | 1.648                                 | Na <sup>+</sup>                                             | 50.08                                    | 1.334                                 |
| 1/3Al <sup>3+</sup>                                      | 61                                       | 0.541                                 | 1/3Nd <sup>3+</sup>                                         | 69.4                                     | 0.616                                 |
| 1/2Ba <sup>2+</sup>                                      | 63.6                                     | 0.847                                 | 1/2Ni <sup>2+</sup>                                         | 49.6                                     | 0.661                                 |
| 1/2Be <sup>2+</sup>                                      | 45                                       | 0.599                                 | 1/4[Ni <sub>2</sub> (trien)] <sub>3</sub> <sup>4+</sup>     | 52                                       | 0.346                                 |
| 1/2Ca <sup>2+</sup>                                      | 59.47                                    | 0.792                                 | 1/2Pb <sup>2+</sup>                                         | 71                                       | 0.945                                 |
| 1/2Cd <sup>2+</sup>                                      | 54                                       | 0.719                                 | 1/3Pr <sup>3+</sup>                                         | 69.5                                     | 0.617                                 |
| 1/3Ce <sup>3+</sup>                                      | 69.8                                     | 0.620                                 | 1/2Ra <sup>2+</sup>                                         | 66.8                                     | 0.889                                 |
| 1/2Co <sup>2+</sup>                                      | 55                                       | 0.732                                 | Rb <sup>+</sup>                                             | 77.8                                     | 2.072                                 |
| 1/3[Co(NH <sub>3</sub> ) <sub>6</sub> ] <sup>3+</sup>    | 101.9                                    | 0.904                                 | 1/3Sc <sup>3+</sup>                                         | 64.7                                     | 0.574                                 |
| 1/3[Co(en) <sub>3</sub> ] <sup>3+</sup>                  | 74.7                                     | 0.663                                 | 1/3Sm <sup>3+</sup>                                         | 68.5                                     | 0.608                                 |
| 1/6[Co <sub>2</sub> (trien) <sub>3</sub> ] <sup>6+</sup> | 69                                       | 0.306                                 | 1/2Sr <sup>2+</sup>                                         | 59.4                                     | 0.791                                 |
| 1/3Cr <sup>3+</sup>                                      | 67                                       | 0.595                                 | Tl <sup>+</sup>                                             | 74.7                                     | 1.989                                 |
| Cs <sup>+</sup>                                          | 77.2                                     | 2.056                                 | 1/3Tm <sup>3+</sup>                                         | 65.4                                     | 0.581                                 |
| 1/2Cu <sup>2+</sup>                                      | 53.6                                     | 0.714                                 | 1/2UO <sub>2</sub> <sup>2+</sup>                            | 32                                       | 0.426                                 |
| D <sup>+</sup>                                           | 249.9                                    | 6.655                                 | 1/3Y <sup>3+</sup>                                          | 62                                       | 0.550                                 |
| 1/3Dy <sup>3+</sup>                                      | 65.6                                     | 0.582                                 | 1/3Yb <sup>3+</sup>                                         | 65.6                                     | 0.582                                 |
| 1/3Er <sup>3+</sup>                                      | 65.9                                     | 0.585                                 | 1/2Zn <sup>2+</sup>                                         | 52.8                                     | 0.703                                 |
| 1/3Eu <sup>3+</sup>                                      | 67.8                                     | 0.602                                 | <b>Inorganic Anions</b>                                     |                                          |                                       |
| 1/2Fe <sup>2+</sup>                                      | 54                                       | 0.719                                 | Au(CN) <sub>2</sub> <sup>−</sup>                            | 50                                       | 1.331                                 |
| 1/3Fe <sup>3+</sup>                                      | 68                                       | 0.604                                 | Au(CN) <sub>4</sub> <sup>−</sup>                            | 36                                       | 0.959                                 |
| 1/3Gd <sup>3+</sup>                                      | 67.3                                     | 0.597                                 | B(C <sub>6</sub> H <sub>5</sub> ) <sub>4</sub> <sup>−</sup> | 21                                       | 0.559                                 |
| H <sup>+</sup>                                           | 349.65                                   | 9.311                                 | Br <sup>−</sup>                                             | 78.1                                     | 2.080                                 |
| 1/2Hg <sup>2+</sup>                                      | 68.6                                     | 0.913                                 | Br <sub>3</sub> <sup>−</sup>                                | 43                                       | 1.145                                 |
| 1/2Hg <sup>2+</sup>                                      | 63.6                                     | 0.847                                 | BrO <sub>3</sub> <sup>−</sup>                               | 55.7                                     | 1.483                                 |
| 1/3Ho <sup>3+</sup>                                      | 66.3                                     | 0.589                                 | CN <sup>−</sup>                                             | 78                                       | 2.077                                 |
| K <sup>+</sup>                                           | 73.48                                    | 1.957                                 | CNO <sup>−</sup>                                            | 64.6                                     | 1.720                                 |
| 1/3La <sup>3+</sup>                                      | 69.7                                     | 0.619                                 | 1/2CO <sub>3</sub> <sup>2−</sup>                            | 69.3                                     | 0.923                                 |
| Li <sup>+</sup>                                          | 38.66                                    | 1.029                                 | Cl <sup>−</sup>                                             | 76.31                                    | 2.032                                 |
| 1/2Mg <sup>2+</sup>                                      | 53.0                                     | 0.706                                 | ClO <sub>2</sub> <sup>−</sup>                               | 52                                       | 1.385                                 |
| 1/2Mn <sup>2+</sup>                                      | 53.5                                     | 0.712                                 | ClO <sub>3</sub> <sup>−</sup>                               | 64.6                                     | 1.720                                 |
| NH <sub>4</sub> <sup>+</sup>                             | 73.5                                     | 1.957                                 | ClO <sub>4</sub> <sup>−</sup>                               | 67.3                                     | 1.792                                 |
| N <sub>2</sub> H <sub>5</sub> <sup>+</sup>               | 59                                       | 1.571                                 | 1/3[Co(CN) <sub>6</sub> ] <sup>3−</sup>                     | 98.9                                     | 0.878                                 |
|                                                          |                                          |                                       | 1/2CrO <sub>4</sub> <sup>2−</sup>                           | 85                                       | 1.132                                 |

| Ion                                             | $\Lambda_{\pm}$<br>$10^{-4} \text{ m}^2 \text{ S mol}^{-1}$ | $D$<br>$10^{-5} \text{ cm}^2 \text{ s}^{-1}$ | Ion                                             | $\Lambda_{\pm}$<br>$10^{-4} \text{ m}^2 \text{ S mol}^{-1}$ | $D$<br>$10^{-5} \text{ cm}^2 \text{ s}^{-1}$ |
|-------------------------------------------------|-------------------------------------------------------------|----------------------------------------------|-------------------------------------------------|-------------------------------------------------------------|----------------------------------------------|
| F <sup>-</sup>                                  | 55.4                                                        | 1.475                                        | Histidyl <sup>+</sup>                           | 23.0                                                        | 0.612                                        |
| 1/4[Fe(CN) <sub>6</sub> ] <sup>4-</sup>         | 110.4                                                       | 0.735                                        | Hydroxyethyltrimethylarsonium <sup>+</sup>      | 39.4                                                        | 1.049                                        |
| 1/3[Fe(CN) <sub>6</sub> ] <sup>3-</sup>         | 100.9                                                       | 0.896                                        | Methylammonium <sup>+</sup>                     | 58.7                                                        | 1.563                                        |
| H <sub>2</sub> AsO <sub>4</sub> <sup>-</sup>    | 34                                                          | 0.905                                        | Octadecylpyridinium <sup>+</sup>                | 20                                                          | 0.533                                        |
| HCO <sub>3</sub> <sup>-</sup>                   | 44.5                                                        | 1.185                                        | Octadecyltributylammonium <sup>+</sup>          | 16.6                                                        | 0.442                                        |
| HF <sub>2</sub> <sup>-</sup>                    | 75                                                          | 1.997                                        | Octadecyltriethylammonium <sup>+</sup>          | 17.9                                                        | 0.477                                        |
| 1/2HPO <sub>4</sub> <sup>2-</sup>               | 57                                                          | 0.759                                        | Octadecyltrimethylammonium <sup>+</sup>         | 19.9                                                        | 0.530                                        |
| H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>     | 36                                                          | 0.959                                        | Octadecyltripropylammonium <sup>+</sup>         | 17.2                                                        | 0.458                                        |
| H <sub>2</sub> PO <sub>2</sub> <sup>-</sup>     | 46                                                          | 1.225                                        | Octyltrimethylammonium <sup>+</sup>             | 26.5                                                        | 0.706                                        |
| HS <sup>-</sup>                                 | 65                                                          | 1.731                                        | Pentylammonium <sup>+</sup>                     | 37                                                          | 0.985                                        |
| HSO <sub>3</sub> <sup>-</sup>                   | 58                                                          | 1.545                                        | Piperidinium <sup>+</sup>                       | 37.2                                                        | 0.991                                        |
| HSO <sub>4</sub> <sup>-</sup>                   | 52                                                          | 1.385                                        | Propylammonium <sup>+</sup>                     | 40.8                                                        | 1.086                                        |
| H <sub>2</sub> SbO <sub>4</sub> <sup>-</sup>    | 31                                                          | 0.825                                        | Pyrimidinium <sup>+</sup>                       | 24.3                                                        | 0.647                                        |
| I <sup>-</sup>                                  | 76.8                                                        | 2.045                                        | Tetrabutylammonium <sup>+</sup>                 | 19.5                                                        | 0.519                                        |
| IO <sub>3</sub> <sup>-</sup>                    | 40.5                                                        | 1.078                                        | Tetradecyltrimethylammonium <sup>+</sup>        | 21.5                                                        | 0.573                                        |
| IO <sub>4</sub> <sup>-</sup>                    | 54.5                                                        | 1.451                                        | Tetraethylammonium <sup>+</sup>                 | 32.6                                                        | 0.868                                        |
| MnO <sub>4</sub> <sup>-</sup>                   | 61.3                                                        | 1.632                                        | Tetramethylammonium <sup>+</sup>                | 44.9                                                        | 1.196                                        |
| 1/2MoO <sub>4</sub> <sup>2-</sup>               | 74.5                                                        | 1.984                                        | Tetraisopentylammonium <sup>+</sup>             | 17.9                                                        | 0.477                                        |
| N(CN) <sub>2</sub> <sup>-</sup>                 | 54.5                                                        | 1.451                                        | Tetrapentylammonium <sup>+</sup>                | 17.5                                                        | 0.466                                        |
| NO <sub>2</sub> <sup>-</sup>                    | 71.8                                                        | 1.912                                        | Tetrapropylammonium <sup>+</sup>                | 23.4                                                        | 0.623                                        |
| NO <sub>3</sub> <sup>-</sup>                    | 71.42                                                       | 1.902                                        | Triethylammonium <sup>+</sup>                   | 34.3                                                        | 0.913                                        |
| NH <sub>2</sub> SO <sub>3</sub> <sup>-</sup>    | 48.3                                                        | 1.286                                        | Triethylsulfonium <sup>+</sup>                  | 36.1                                                        | 0.961                                        |
| N <sub>3</sub> <sup>-</sup>                     | 69                                                          | 1.837                                        | Trimethylammonium <sup>+</sup>                  | 47.23                                                       | 1.258                                        |
| OCN <sup>-</sup>                                | 64.6                                                        | 1.720                                        | Trimethylhexylammonium <sup>+</sup>             | 34.6                                                        | 0.921                                        |
| OD <sup>-</sup>                                 | 119                                                         | 3.169                                        | Trimethylsulfonium <sup>+</sup>                 | 51.4                                                        | 1.369                                        |
| OH <sup>-</sup>                                 | 198                                                         | 5.273                                        | Tripropylammonium <sup>+</sup>                  | 26.1                                                        | 0.695                                        |
| PF <sub>6</sub> <sup>-</sup>                    | 56.9                                                        | 1.515                                        | <i>Organic Anions</i>                           |                                                             |                                              |
| 1/2PO <sub>3</sub> F <sub>2</sub> <sup>-</sup>  | 63.3                                                        | 0.843                                        | Acetate <sup>-</sup>                            | 40.9                                                        | 1.089                                        |
| 1/3PO <sub>4</sub> <sup>3-</sup>                | 92.8                                                        | 0.824                                        | <i>p</i> -Anisate <sup>-</sup>                  | 29.0                                                        | 0.772                                        |
| 1/4P <sub>2</sub> O <sub>7</sub> <sup>4-</sup>  | 96                                                          | 0.639                                        | 1/2Azelate <sup>2-</sup>                        | 40.6                                                        | 0.541                                        |
| 1/3P <sub>3</sub> O <sub>9</sub> <sup>3-</sup>  | 83.6                                                        | 0.742                                        | Benzoate <sup>-</sup>                           | 32.4                                                        | 0.863                                        |
| 1/5P <sub>3</sub> O <sub>10</sub> <sup>5-</sup> | 109                                                         | 0.581                                        | Bromoacetate <sup>-</sup>                       | 39.2                                                        | 1.044                                        |
| ReO <sub>4</sub> <sup>-</sup>                   | 54.9                                                        | 1.462                                        | Bromobenzoate <sup>-</sup>                      | 30                                                          | 0.799                                        |
| SCN <sup>-</sup>                                | 66                                                          | 1.758                                        | Butyrate <sup>-</sup>                           | 32.6                                                        | 0.868                                        |
| 1/2SO <sub>3</sub> <sup>2-</sup>                | 72                                                          | 0.959                                        | Chloroacetate <sup>-</sup>                      | 39.8                                                        | 1.060                                        |
| 1/2SO <sub>4</sub> <sup>2-</sup>                | 80.0                                                        | 1.065                                        | <i>m</i> -Chlorobenzoate <sup>-</sup>           | 31                                                          | 0.825                                        |
| 1/2S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>  | 85.0                                                        | 1.132                                        | <i>o</i> -Chlorobenzoate <sup>-</sup>           | 30.2                                                        | 0.804                                        |
| 1/2S <sub>2</sub> O <sub>4</sub> <sup>2-</sup>  | 66.5                                                        | 0.885                                        | 1/3Citrate <sup>3-</sup>                        | 70.2                                                        | 0.623                                        |
| 1/2S <sub>2</sub> O <sub>6</sub> <sup>2-</sup>  | 93                                                          | 1.238                                        | Crotonate <sup>-</sup>                          | 33.2                                                        | 0.884                                        |
| 1/2S <sub>2</sub> O <sub>8</sub> <sup>2-</sup>  | 86                                                          | 1.145                                        | Cyanoacetate <sup>-</sup>                       | 43.4                                                        | 1.156                                        |
| Sb(OH) <sub>6</sub> <sup>-</sup>                | 31.9                                                        | 0.849                                        | Cyclohexane carboxylate <sup>-</sup>            | 28.7                                                        | 0.764                                        |
| SeCN <sup>-</sup>                               | 64.7                                                        | 1.723                                        | 1/2 1,1-Cyclopropanedicarboxylate <sup>2-</sup> | 53.4                                                        | 0.711                                        |
| 1/2SeO <sub>4</sub> <sup>2-</sup>               | 75.7                                                        | 1.008                                        | Decylsulfate <sup>-</sup>                       | 26                                                          | 0.692                                        |
| 1/2WO <sub>4</sub> <sup>2-</sup>                | 69                                                          | 0.919                                        | Dichloroacetate <sup>-</sup>                    | 38.3                                                        | 1.020                                        |
| <i>Organic Cations</i>                          |                                                             |                                              | 1/2Diethylbarbiturate <sup>2-</sup>             | 26.3                                                        | 0.350                                        |
| Benzyltrimethylammonium <sup>+</sup>            | 34.6                                                        | 0.921                                        | Dihydrogencitrate <sup>-</sup>                  | 30                                                          | 0.799                                        |
| Isobutylammonium <sup>+</sup>                   | 38                                                          | 1.012                                        | 1/2Dimethylmalonate <sup>2-</sup>               | 49.4                                                        | 0.658                                        |
| Butyltrimethylammonium <sup>+</sup>             | 33.6                                                        | 0.895                                        | 3,5-Dinitrobenzoate <sup>-</sup>                | 28.3                                                        | 0.754                                        |
| Decylpyridinium <sup>+</sup>                    | 29.5                                                        | 0.786                                        | Dodecylsulfate <sup>-</sup>                     | 24                                                          | 0.639                                        |
| Decyltrimethylammonium <sup>+</sup>             | 24.4                                                        | 0.650                                        | Ethylmalonate <sup>-</sup>                      | 49.3                                                        | 1.313                                        |
| Diethylammonium <sup>+</sup>                    | 42.0                                                        | 1.118                                        | Ethylsulfate <sup>-</sup>                       | 39.6                                                        | 1.055                                        |
| Dimethylammonium <sup>+</sup>                   | 51.8                                                        | 1.379                                        | Fluoroacetate <sup>-</sup>                      | 44.4                                                        | 1.182                                        |
| Dipropylammonium <sup>+</sup>                   | 30.1                                                        | 0.802                                        | Fluorobenzoate <sup>-</sup>                     | 33                                                          | 0.879                                        |
| Dodecylammonium <sup>+</sup>                    | 23.8                                                        | 0.634                                        | Formate <sup>-</sup>                            | 54.6                                                        | 1.454                                        |
| Dodecyltrimethylammonium <sup>+</sup>           | 22.6                                                        | 0.602                                        | 1/2Fumarate <sup>2-</sup>                       | 61.8                                                        | 0.823                                        |
| Ethanolammonium <sup>+</sup>                    | 42.2                                                        | 1.124                                        | 1/2Glutarate <sup>2-</sup>                      | 52.6                                                        | 0.700                                        |
| Ethylammonium <sup>+</sup>                      | 47.2                                                        | 1.257                                        | Hydrogenoxalate <sup>-</sup>                    | 40.2                                                        | 1.070                                        |
| Ethyltrimethylammonium <sup>+</sup>             | 40.5                                                        | 1.078                                        | Isovalerate <sup>-</sup>                        | 32.7                                                        | 0.871                                        |
| Hexadecyltrimethylammonium <sup>+</sup>         | 20.9                                                        | 0.557                                        | Iodoacetate <sup>-</sup>                        | 40.6                                                        | 1.081                                        |
| Hexyltrimethylammonium <sup>+</sup>             | 29.6                                                        | 0.788                                        | Lactate <sup>-</sup>                            | 38.8                                                        | 1.033                                        |



| Ion                                   | $\Lambda_{\pm}$<br>$10^{-4} \text{ m}^2 \text{ S mol}^{-1}$ | $D$<br>$10^{-5} \text{ cm}^2 \text{ s}^{-1}$ | Ion                           | $\Lambda_{\pm}$<br>$10^{-4} \text{ m}^2 \text{ S mol}^{-1}$ | $D$<br>$10^{-5} \text{ cm}^2 \text{ s}^{-1}$ |
|---------------------------------------|-------------------------------------------------------------|----------------------------------------------|-------------------------------|-------------------------------------------------------------|----------------------------------------------|
| 1/2Malate <sup>2-</sup>               | 58.8                                                        | 0.783                                        | Picrate <sup>-</sup>          | 30.37                                                       | 0.809                                        |
| 1/2Maleate <sup>2-</sup>              | 61.9                                                        | 0.824                                        | Pivalate <sup>-</sup>         | 31.9                                                        | 0.849                                        |
| 1/2Malonate <sup>2-</sup>             | 63.5                                                        | 0.845                                        | Propionate <sup>-</sup>       | 35.8                                                        | 0.953                                        |
| Methylsulfate <sup>-</sup>            | 48.8                                                        | 1.299                                        | Propylsulfate <sup>-</sup>    | 37.1                                                        | 0.988                                        |
| Naphthylacetate <sup>-</sup>          | 28.4                                                        | 0.756                                        | Salicylate <sup>-</sup>       | 36                                                          | 0.959                                        |
| 1/2Oxalate <sup>2-</sup>              | 74.11                                                       | 0.987                                        | 1/2Suberate <sup>2-</sup>     | 36                                                          | 0.479                                        |
| Octylsulfate <sup>-</sup>             | 29                                                          | 0.772                                        | 1/2Succinate <sup>2-</sup>    | 58.8                                                        | 0.783                                        |
| Phenylacetate <sup>-</sup>            | 30.6                                                        | 0.815                                        | <i>p</i> -Sulfonate           | 29.3                                                        | 0.780                                        |
| 1/2 <i>o</i> -Phthalate <sup>2-</sup> | 52.3                                                        | 0.696                                        | 1/2Tartarate <sup>2-</sup>    | 59.6                                                        | 0.794                                        |
| 1/2 <i>m</i> -Phthalate <sup>2-</sup> | 54.7                                                        | 0.728                                        | Trichloroacetate <sup>-</sup> | 35                                                          | 0.932                                        |

# ACTIVITY COEFFICIENTS OF ACIDS, BASES, AND SALTS

Petr Vanýsek

This table gives mean activity coefficients at 25°C for molalities in the range 0.1 to 1.0. See the following table for definitions, refer-

|                                                 | 0.1    | 0.2    | 0.3    | 0.4    | 0.5    | 0.6    | 0.7    | 0.8    | 0.9    | 1.0    |
|-------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| AgNO <sub>3</sub>                               | 0.734  | 0.657  | 0.606  | 0.567  | 0.536  | 0.509  | 0.485  | 0.464  | 0.446  | 0.429  |
| AlCl <sub>3</sub>                               | 0.337  | 0.305  | 0.302  | 0.313  | 0.331  | 0.356  | 0.388  | 0.429  | 0.479  | 0.539  |
| Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> | 0.035  | 0.0225 | 0.0176 | 0.0153 | 0.0143 | 0.014  | 0.0142 | 0.0149 | 0.0159 | 0.0175 |
| BaCl <sub>2</sub>                               | 0.500  | 0.444  | 0.419  | 0.405  | 0.397  | 0.391  | 0.391  | 0.391  | 0.392  | 0.395  |
| BeSO <sub>4</sub>                               | 0.150  | 0.109  | 0.0885 | 0.0769 | 0.0692 | 0.0639 | 0.0600 | 0.0570 | 0.0546 | 0.0530 |
| CaCl <sub>2</sub>                               | 0.518  | 0.472  | 0.455  | 0.448  | 0.448  | 0.453  | 0.460  | 0.470  | 0.484  | 0.500  |
| CdCl <sub>2</sub>                               | 0.2280 | 0.1638 | 0.1329 | 0.1139 | 0.1006 | 0.0905 | 0.0827 | 0.0765 | 0.0713 | 0.0669 |
| Cd(NO <sub>3</sub> ) <sub>2</sub>               | 0.513  | 0.464  | 0.442  | 0.430  | 0.425  | 0.423  | 0.423  | 0.425  | 0.428  | 0.433  |
| CdSO <sub>4</sub>                               | 0.150  | 0.103  | 0.0822 | 0.0699 | 0.0615 | 0.0553 | 0.0505 | 0.0468 | 0.0438 | 0.0415 |
| CoCl <sub>2</sub>                               | 0.522  | 0.479  | 0.463  | 0.459  | 0.462  | 0.470  | 0.479  | 0.492  | 0.511  | 0.531  |
| CrCl <sub>3</sub>                               | 0.331  | 0.298  | 0.294  | 0.300  | 0.314  | 0.335  | 0.362  | 0.397  | 0.436  | 0.481  |
| Cr(NO <sub>3</sub> ) <sub>3</sub>               | 0.319  | 0.285  | 0.279  | 0.281  | 0.291  | 0.304  | 0.322  | 0.344  | 0.371  | 0.401  |
| Cr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> | 0.0458 | 0.0300 | 0.0238 | 0.0207 | 0.0190 | 0.0182 | 0.0181 | 0.0185 | 0.0194 | 0.0208 |
| CsBr                                            | 0.754  | 0.694  | 0.654  | 0.626  | 0.603  | 0.586  | 0.571  | 0.558  | 0.547  | 0.538  |
| CsCl                                            | 0.756  | 0.694  | 0.656  | 0.628  | 0.606  | 0.589  | 0.575  | 0.563  | 0.553  | 0.544  |
| CsI                                             | 0.754  | 0.692  | 0.651  | 0.621  | 0.599  | 0.581  | 0.567  | 0.554  | 0.543  | 0.533  |
| CsNO <sub>3</sub>                               | 0.733  | 0.655  | 0.602  | 0.561  | 0.528  | 0.501  | 0.478  | 0.458  | 0.439  | 0.422  |
| CsOH                                            | 0.795  | 0.761  | 0.744  | 0.739  | 0.739  | 0.742  | 0.748  | 0.754  | 0.762  | 0.771  |
| CsOAc                                           | 0.799  | 0.771  | 0.761  | 0.759  | 0.762  | 0.768  | 0.776  | 0.783  | 0.792  | 0.802  |
| Cs <sub>2</sub> SO <sub>4</sub>                 | 0.456  | 0.382  | 0.338  | 0.311  | 0.291  | 0.274  | 0.262  | 0.251  | 0.242  | 0.235  |
| CuCl <sub>2</sub>                               | 0.508  | 0.455  | 0.429  | 0.417  | 0.411  | 0.409  | 0.409  | 0.410  | 0.413  | 0.417  |
| Cu(NO <sub>3</sub> ) <sub>2</sub>               | 0.511  | 0.460  | 0.439  | 0.429  | 0.426  | 0.427  | 0.431  | 0.437  | 0.445  | 0.455  |
| CuSO <sub>4</sub>                               | 0.150  | 0.104  | 0.0829 | 0.0704 | 0.0620 | 0.0559 | 0.0512 | 0.0475 | 0.0446 | 0.0423 |
| FeCl <sub>2</sub>                               | 0.5185 | 0.473  | 0.454  | 0.448  | 0.450  | 0.454  | 0.463  | 0.473  | 0.488  | 0.506  |
| HBr                                             | 0.805  | 0.782  | 0.777  | 0.781  | 0.789  | 0.801  | 0.815  | 0.832  | 0.850  | 0.871  |
| HCl                                             | 0.796  | 0.767  | 0.756  | 0.755  | 0.757  | 0.763  | 0.772  | 0.783  | 0.795  | 0.809  |
| HClO <sub>4</sub>                               | 0.803  | 0.778  | 0.768  | 0.766  | 0.769  | 0.776  | 0.785  | 0.795  | 0.808  | 0.823  |
| HI                                              | 0.818  | 0.807  | 0.811  | 0.823  | 0.839  | 0.860  | 0.883  | 0.908  | 0.935  | 0.963  |
| HNO <sub>3</sub>                                | 0.791  | 0.754  | 0.735  | 0.725  | 0.720  | 0.717  | 0.717  | 0.718  | 0.721  | 0.724  |
| H <sub>2</sub> SO <sub>4</sub>                  | 0.2655 | 0.2090 | 0.1826 | —      | 0.1557 | —      | 0.1417 | —      | —      | 0.1316 |
| KBr                                             | 0.772  | 0.722  | 0.693  | 0.673  | 0.657  | 0.646  | 0.636  | 0.629  | 0.622  | 0.617  |
| KCl                                             | 0.770  | 0.718  | 0.688  | 0.666  | 0.649  | 0.637  | 0.626  | 0.618  | 0.610  | 0.604  |
| KClO <sub>3</sub>                               | 0.749  | 0.681  | 0.635  | 0.599  | 0.568  | 0.541  | 0.518  | —      | —      | —      |
| K <sub>2</sub> CrO <sub>4</sub>                 | 0.456  | 0.382  | 0.340  | 0.313  | 0.292  | 0.276  | 0.263  | 0.253  | 0.243  | 0.235  |
| KF                                              | 0.775  | 0.727  | 0.700  | 0.682  | 0.670  | 0.661  | 0.654  | 0.650  | 0.646  | 0.645  |
| K <sub>3</sub> Fe(CN) <sub>6</sub>              | 0.268  | 0.212  | 0.184  | 0.167  | 0.155  | 0.146  | 0.140  | 0.135  | 0.131  | 0.128  |
| K <sub>4</sub> Fe(CN) <sub>6</sub>              | 0.139  | 0.0993 | 0.0808 | 0.0693 | 0.0614 | 0.0556 | 0.0512 | 0.0479 | 0.0454 | —      |
| KH <sub>2</sub> PO <sub>4</sub>                 | 0.731  | 0.653  | 0.602  | 0.561  | 0.529  | 0.501  | 0.477  | 0.456  | 0.438  | 0.421  |
| KI                                              | 0.778  | 0.733  | 0.707  | 0.689  | 0.676  | 0.667  | 0.660  | 0.654  | 0.649  | 0.645  |
| KNO <sub>3</sub>                                | 0.739  | 0.663  | 0.614  | 0.576  | 0.545  | 0.519  | 0.496  | 0.476  | 0.459  | 0.443  |
| KOAc                                            | 0.796  | 0.766  | 0.754  | 0.750  | 0.751  | 0.754  | 0.759  | 0.766  | 0.774  | 0.783  |
| KOH                                             | 0.798  | 0.760  | 0.742  | 0.734  | 0.732  | 0.733  | 0.736  | 0.742  | 0.749  | 0.756  |
| KSCN                                            | 0.769  | 0.716  | 0.685  | 0.663  | 0.646  | 0.633  | 0.623  | 0.614  | 0.606  | 0.599  |
| K <sub>2</sub> SO <sub>4</sub>                  | 0.441  | 0.360  | 0.316  | 0.286  | 0.264  | 0.246  | 0.232  | —      | —      | —      |
| LiBr                                            | 0.796  | 0.766  | 0.756  | 0.752  | 0.753  | 0.758  | 0.767  | 0.777  | 0.789  | 0.803  |
| LiCl                                            | 0.790  | 0.757  | 0.744  | 0.740  | 0.739  | 0.743  | 0.748  | 0.755  | 0.764  | 0.774  |
| LiClO <sub>4</sub>                              | 0.812  | 0.794  | 0.792  | 0.798  | 0.808  | 0.820  | 0.834  | 0.852  | 0.869  | 0.887  |
| LiI                                             | 0.815  | 0.802  | 0.804  | 0.813  | 0.824  | 0.838  | 0.852  | 0.870  | 0.888  | 0.910  |
| LiNO <sub>3</sub>                               | 0.788  | 0.752  | 0.736  | 0.728  | 0.726  | 0.727  | 0.729  | 0.733  | 0.737  | 0.743  |
| LiOH                                            | 0.760  | 0.702  | 0.665  | 0.638  | 0.617  | 0.599  | 0.585  | 0.573  | 0.563  | 0.554  |
| LiOAc                                           | 0.784  | 0.742  | 0.721  | 0.709  | 0.700  | 0.691  | 0.689  | 0.688  | 0.688  | 0.689  |
| Li <sub>2</sub> SO <sub>4</sub>                 | 0.468  | 0.398  | 0.361  | 0.337  | 0.319  | 0.307  | 0.297  | 0.289  | 0.282  | 0.277  |
| MgCl <sub>2</sub>                               | 0.529  | 0.489  | 0.477  | 0.475  | 0.481  | 0.491  | 0.506  | 0.522  | 0.544  | 0.570  |
| MgSO <sub>4</sub>                               | 0.150  | 0.107  | 0.0874 | 0.0756 | 0.0675 | 0.0616 | 0.0571 | 0.0536 | 0.0508 | 0.0485 |

|                                                 | 0.1   | 0.2   | 0.3    | 0.4    | 0.5    | 0.6    | 0.7    | 0.8    | 0.9    | 1.0    |
|-------------------------------------------------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| MnCl <sub>2</sub>                               | 0.516 | 0.469 | 0.450  | 0.442  | 0.440  | 0.443  | 0.448  | 0.455  | 0.466  | 0.479  |
| MnSO <sub>4</sub>                               | 0.150 | 0.105 | 0.0848 | 0.0725 | 0.0640 | 0.0578 | 0.0530 | 0.0493 | 0.0463 | 0.0439 |
| NH <sub>4</sub> Cl                              | 0.770 | 0.718 | 0.687  | 0.665  | 0.649  | 0.636  | 0.625  | 0.617  | 0.609  | 0.603  |
| NH <sub>4</sub> NO <sub>3</sub>                 | 0.740 | 0.677 | 0.636  | 0.606  | 0.582  | 0.562  | 0.545  | 0.530  | 0.516  | 0.504  |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 0.439 | 0.356 | 0.311  | 0.280  | 0.257  | 0.240  | 0.226  | 0.214  | 0.205  | 0.196  |
| NaBr                                            | 0.782 | 0.741 | 0.719  | 0.704  | 0.697  | 0.692  | 0.689  | 0.687  | 0.687  | 0.687  |
| NaCl                                            | 0.778 | 0.735 | 0.710  | 0.693  | 0.681  | 0.673  | 0.667  | 0.662  | 0.659  | 0.657  |
| NaClO <sub>3</sub>                              | 0.772 | 0.720 | 0.688  | 0.664  | 0.645  | 0.630  | 0.617  | 0.606  | 0.597  | 0.589  |
| NaClO <sub>4</sub>                              | 0.775 | 0.729 | 0.701  | 0.683  | 0.668  | 0.656  | 0.648  | 0.641  | 0.635  | 0.629  |
| Na <sub>2</sub> CrO <sub>4</sub>                | 0.464 | 0.394 | 0.353  | 0.327  | 0.307  | 0.292  | 0.280  | 0.269  | 0.261  | 0.253  |
| NaF                                             | 0.765 | 0.710 | 0.676  | 0.651  | 0.632  | 0.616  | 0.603  | 0.592  | 0.582  | 0.573  |
| NaH <sub>2</sub> PO <sub>4</sub>                | 0.744 | 0.675 | 0.629  | 0.593  | 0.563  | 0.539  | 0.517  | 0.499  | 0.483  | 0.468  |
| NaI                                             | 0.787 | 0.751 | 0.735  | 0.727  | 0.723  | 0.723  | 0.724  | 0.727  | 0.731  | 0.736  |
| NaNO <sub>3</sub>                               | 0.762 | 0.703 | 0.666  | 0.638  | 0.617  | 0.599  | 0.583  | 0.570  | 0.558  | 0.548  |
| NaOAc                                           | 0.791 | 0.757 | 0.744  | 0.737  | 0.735  | 0.736  | 0.740  | 0.745  | 0.752  | 0.757  |
| NaOH                                            | 0.766 | 0.727 | 0.708  | 0.697  | 0.690  | 0.685  | 0.681  | 0.679  | 0.678  | 0.678  |
| NaSCN                                           | 0.787 | 0.750 | —      | 0.720  | 0.715  | 0.712  | 0.710  | 0.710  | 0.711  | 0.712  |
| Na <sub>2</sub> SO <sub>4</sub>                 | 0.445 | 0.365 | 0.320  | 0.289  | 0.266  | 0.248  | 0.233  | 0.221  | 0.210  | 0.201  |
| NiCl <sub>2</sub>                               | 0.522 | 0.479 | 0.463  | 0.460  | 0.464  | 0.471  | 0.482  | 0.496  | 0.515  | 0.563  |
| NiSO <sub>4</sub>                               | 0.150 | 0.105 | 0.0841 | 0.0713 | 0.0627 | 0.0562 | 0.0515 | 0.0478 | 0.0448 | 0.0425 |
| Pb(NO <sub>3</sub> ) <sub>2</sub>               | 0.395 | 0.308 | 0.260  | 0.228  | 0.205  | 0.187  | 0.172  | 0.160  | 0.150  | 0.141  |
| RbBr                                            | 0.763 | 0.706 | 0.673  | 0.650  | 0.632  | 0.617  | 0.605  | 0.595  | 0.586  | 0.578  |
| RbCl                                            | 0.764 | 0.709 | 0.675  | 0.652  | 0.634  | 0.620  | 0.608  | 0.599  | 0.590  | 0.583  |
| RbI                                             | 0.762 | 0.705 | 0.671  | 0.647  | 0.629  | 0.614  | 0.602  | 0.591  | 0.583  | 0.575  |
| RbNO <sub>3</sub>                               | 0.734 | 0.658 | 0.606  | 0.565  | 0.534  | 0.508  | 0.485  | 0.465  | 0.446  | 0.430  |
| RbOAc                                           | 0.796 | 0.767 | 0.756  | 0.753  | 0.755  | 0.759  | 0.766  | 0.773  | 0.782  | 0.792  |
| Rb <sub>2</sub> SO <sub>4</sub>                 | 0.451 | 0.374 | 0.331  | 0.301  | 0.279  | 0.263  | 0.249  | 0.238  | 0.228  | 0.219  |
| SrCl <sub>2</sub>                               | 0.511 | 0.462 | 0.442  | 0.433  | 0.430  | 0.431  | 0.434  | 0.441  | 0.449  | 0.461  |
| TlClO <sub>4</sub>                              | 0.730 | 0.652 | 0.599  | 0.559  | 0.527  | —      | —      | —      | —      | —      |
| TlNO <sub>3</sub>                               | 0.702 | 0.606 | 0.545  | 0.500  | —      | —      | —      | —      | —      | —      |
| UO <sub>2</sub> Cl <sub>2</sub>                 | 0.544 | 0.510 | 0.520  | 0.505  | 0.517  | 0.532  | 0.549  | 0.571  | 0.595  | 0.620  |
| UO <sub>2</sub> SO <sub>4</sub>                 | 0.150 | 0.102 | 0.0807 | 0.0689 | 0.0611 | 0.0566 | 0.0515 | 0.0483 | 0.0458 | 0.0439 |
| ZnCl <sub>2</sub>                               | 0.515 | 0.462 | 0.432  | 0.411  | 0.394  | 0.380  | 0.369  | 0.357  | 0.348  | 0.339  |
| Zn(NO <sub>3</sub> ) <sub>2</sub>               | 0.531 | 0.489 | 0.474  | 0.469  | 0.473  | 0.480  | 0.489  | 0.501  | 0.518  | 0.535  |
| ZnSO <sub>4</sub>                               | 0.150 | 0.140 | 0.0835 | 0.0714 | 0.0630 | 0.0569 | 0.0523 | 0.0487 | 0.0458 | 0.0435 |

# MEAN ACTIVITY COEFFICIENTS OF ELECTROLYTES AS A FUNCTION OF CONCENTRATION

The mean activity coefficient  $\gamma$  of an electrolyte  $X_a Y_b$  is defined as

$$\gamma = (\gamma_+^a \gamma_-^b)^{1/(a+b)}$$

where  $\gamma_+$  and  $\gamma_-$  are activity coefficients of the individual ions (which cannot be directly measured). This table gives the mean activity coefficients of about 100 electrolytes in aqueous solution as a function of concentration, expressed in molality terms. All

values refer to a temperature of 25°C. Substances are arranged in alphabetical order by formula.

## References

1. Hamer, W. J., and Wu, Y. C., *J. Phys. Chem. Ref. Data*, 1, 1047, 1972.
2. Staples, B. R., *J. Phys. Chem. Ref. Data*, 6, 385, 1977; 10, 767, 1981; 10, 779, 1981.
3. Goldberg, R. N. et al., *J. Phys. Chem. Ref. Data*, 7, 263, 1978; 8, 923, 1979; 8, 1005, 1979; 10, 1, 1981; 10, 671, 1981.

### Mean Activity Coefficient at 25°C

| <i>m</i> /mol kg <sup>-1</sup> | AgNO <sub>3</sub> | BaBr <sub>2</sub> | BaCl <sub>2</sub> | BaI <sub>2</sub> | CaBr <sub>2</sub> | CaCl <sub>2</sub> | CaI <sub>2</sub> |
|--------------------------------|-------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|
| 0.001                          | 0.964             | 0.881             | 0.887             | 0.890            | 0.890             | 0.888             | 0.890            |
| 0.002                          | 0.950             | 0.850             | 0.849             | 0.853            | 0.853             | 0.851             | 0.853            |
| 0.005                          | 0.924             | 0.785             | 0.782             | 0.792            | 0.791             | 0.787             | 0.791            |
| 0.010                          | 0.896             | 0.727             | 0.721             | 0.737            | 0.735             | 0.727             | 0.736            |
| 0.020                          | 0.859             | 0.661             | 0.653             | 0.678            | 0.674             | 0.664             | 0.677            |
| 0.050                          | 0.794             | 0.573             | 0.559             | 0.600            | 0.594             | 0.577             | 0.600            |
| 0.100                          | 0.732             | 0.517             | 0.492             | 0.551            | 0.540             | 0.517             | 0.552            |
| 0.200                          | 0.656             | 0.463             | 0.436             | 0.520            | 0.502             | 0.469             | 0.524            |
| 0.500                          | 0.536             | 0.435             | 0.391             | 0.536            | 0.500             | 0.444             | 0.554            |
| 1.000                          | 0.430             | 0.470             | 0.393             | 0.664            | 0.604             | 0.495             | 0.729            |
| 2.000                          | 0.316             | 0.654             |                   | 1.242            | 1.125             | 0.784             |                  |
| 5.000                          | 0.181             |                   |                   |                  | 18.7              | 5.907             |                  |
| 10.000                         | 0.108             |                   |                   |                  |                   | 43.1              |                  |
| 15.000                         | 0.085             |                   |                   |                  |                   |                   |                  |

| <i>m</i> /mol kg <sup>-1</sup> | Cd(NO <sub>2</sub> ) <sub>2</sub> | Cd(NO <sub>3</sub> ) <sub>2</sub> | CoBr <sub>2</sub> | CoCl <sub>2</sub> | CoI <sub>2</sub> | Co(NO <sub>3</sub> ) <sub>2</sub> | CsBr  |
|--------------------------------|-----------------------------------|-----------------------------------|-------------------|-------------------|------------------|-----------------------------------|-------|
| 0.001                          | 0.881                             | 0.888                             | 0.890             | 0.889             | 0.887            | 0.888                             | 0.965 |
| 0.002                          | 0.837                             | 0.851                             | 0.854             | 0.852             | 0.849            | 0.850                             | 0.951 |
| 0.005                          | 0.759                             | 0.787                             | 0.794             | 0.789             | 0.783            | 0.786                             | 0.925 |
| 0.010                          | 0.681                             | 0.728                             | 0.740             | 0.732             | 0.724            | 0.728                             | 0.898 |
| 0.020                          | 0.589                             | 0.664                             | 0.681             | 0.670             | 0.661            | 0.663                             | 0.864 |
| 0.050                          | 0.451                             | 0.576                             | 0.605             | 0.586             | 0.582            | 0.576                             | 0.806 |
| 0.100                          | 0.344                             | 0.515                             | 0.556             | 0.528             | 0.540            | 0.516                             | 0.752 |
| 0.200                          | 0.247                             | 0.465                             | 0.523             | 0.483             | 0.527            | 0.469                             | 0.691 |
| 0.500                          | 0.148                             | 0.428                             | 0.538             | 0.465             | 0.596            | 0.446                             | 0.605 |
| 1.000                          | 0.098                             | 0.437                             | 0.685             | 0.532             | 0.845            | 0.492                             | 0.540 |
| 2.000                          | 0.069                             | 0.517                             | 1.421             | 0.864             | 2.287            | 0.722                             | 0.485 |
| 5.000                          | 0.054                             |                                   | 13.9              |                   | 55.3             | 3.338                             | 0.454 |
| 10.000                         |                                   |                                   |                   |                   | 196              |                                   |       |

| <i>m</i> /mol kg <sup>-1</sup> | CsCl  | CsF   | CsI   | CsNO <sub>3</sub> | CsOH  | Cs <sub>2</sub> SO <sub>4</sub> | CuBr <sub>2</sub> |
|--------------------------------|-------|-------|-------|-------------------|-------|---------------------------------|-------------------|
| 0.001                          | 0.965 | 0.965 | 0.965 | 0.964             | 0.966 | 0.885                           | 0.889             |
| 0.002                          | 0.951 | 0.952 | 0.951 | 0.951             | 0.953 | 0.845                           | 0.853             |
| 0.005                          | 0.925 | 0.929 | 0.925 | 0.924             | 0.930 | 0.775                           | 0.791             |
| 0.010                          | 0.898 | 0.905 | 0.898 | 0.897             | 0.906 | 0.709                           | 0.735             |
| 0.020                          | 0.864 | 0.876 | 0.863 | 0.860             | 0.878 | 0.634                           | 0.674             |
| 0.050                          | 0.805 | 0.830 | 0.804 | 0.796             | 0.836 | 0.526                           | 0.594             |
| 0.100                          | 0.751 | 0.792 | 0.749 | 0.733             | 0.802 | 0.444                           | 0.541             |
| 0.200                          | 0.691 | 0.755 | 0.688 | 0.655             | 0.772 | 0.369                           | 0.504             |
| 0.500                          | 0.607 | 0.721 | 0.601 | 0.529             | 0.755 | 0.285                           | 0.503             |
| 1.000                          | 0.546 | 0.726 | 0.534 | 0.421             | 0.782 | 0.233                           | 0.591             |
| 2.000                          | 0.496 | 0.803 | 0.470 |                   |       |                                 | 0.859             |
| 5.000                          | 0.474 |       |       |                   |       |                                 |                   |
| 10.000                         | 0.508 |       |       |                   |       |                                 |                   |

## Mean Activity Coefficients of Electrolytes as a Function of Concentration

| $m/\text{mol kg}^{-1}$ | $\text{CuCl}_2$ | $\text{Cu}(\text{ClO}_4)_2$ | $\text{Cu}(\text{NO}_3)_2$ | $\text{FeCl}_2$ | $\text{HBr}$ | $\text{HCl}$ | $\text{HClO}_4$ |
|------------------------|-----------------|-----------------------------|----------------------------|-----------------|--------------|--------------|-----------------|
| 0.001                  | 0.887           | 0.890                       | 0.888                      | 0.888           | 0.966        | 0.965        | 0.966           |
| 0.002                  | 0.849           | 0.854                       | 0.851                      | 0.850           | 0.953        | 0.952        | 0.953           |
| 0.005                  | 0.783           | 0.795                       | 0.787                      | 0.785           | 0.930        | 0.929        | 0.929           |
| 0.010                  | 0.722           | 0.741                       | 0.729                      | 0.725           | 0.907        | 0.905        | 0.906           |
| 0.020                  | 0.654           | 0.685                       | 0.664                      | 0.659           | 0.879        | 0.876        | 0.878           |
| 0.050                  | 0.561           | 0.613                       | 0.577                      | 0.570           | 0.837        | 0.832        | 0.836           |
| 0.100                  | 0.495           | 0.572                       | 0.516                      | 0.509           | 0.806        | 0.797        | 0.803           |
| 0.200                  | 0.441           | 0.553                       | 0.466                      | 0.462           | 0.783        | 0.768        | 0.776           |
| 0.500                  | 0.401           | 0.617                       | 0.431                      | 0.443           | 0.790        | 0.759        | 0.769           |
| 1.000                  | 0.405           | 0.892                       | 0.456                      | 0.500           | 0.872        | 0.811        | 0.826           |
| 2.000                  | 0.453           | 2.445                       | 0.615                      | 0.782           | 1.167        | 1.009        | 1.055           |
| 5.000                  | 0.601           |                             | 2.083                      |                 | 3.800        | 2.380        | 3.100           |
| 10.000                 |                 |                             |                            |                 | 33.4         | 10.4         | 30.8            |
| 15.000                 |                 |                             |                            |                 |              |              | 323             |

| $m/\text{mol kg}^{-1}$ | $\text{HF}$ | $\text{HI}$ | $\text{HNO}_3$ | $\text{H}_2\text{SO}_4$ | $\text{KBr}$ | $\text{KCNS}$ | $\text{KCl}$ |
|------------------------|-------------|-------------|----------------|-------------------------|--------------|---------------|--------------|
| 0.001                  | 0.551       | 0.966       | 0.965          | 0.804                   | 0.965        | 0.965         | 0.965        |
| 0.002                  | 0.429       | 0.953       | 0.952          | 0.740                   | 0.952        | 0.951         | 0.951        |
| 0.005                  | 0.302       | 0.931       | 0.929          | 0.634                   | 0.927        | 0.927         | 0.927        |
| 0.010                  | 0.225       | 0.909       | 0.905          | 0.542                   | 0.902        | 0.901         | 0.901        |
| 0.020                  | 0.163       | 0.884       | 0.875          | 0.445                   | 0.870        | 0.869         | 0.869        |
| 0.050                  | 0.106       | 0.847       | 0.829          | 0.325                   | 0.817        | 0.815         | 0.816        |
| 0.100                  | 0.0766      | 0.823       | 0.792          | 0.251                   | 0.771        | 0.768         | 0.768        |
| 0.200                  | 0.0550      | 0.811       | 0.756          | 0.195                   | 0.772        | 0.716         | 0.717        |
| 0.500                  | 0.0352      | 0.845       | 0.725          | 0.146                   | 0.658        | 0.647         | 0.649        |
| 1.000                  | 0.0249      | 0.969       | 0.730          | 0.125                   | 0.617        | 0.598         | 0.604        |
| 2.000                  | 0.0175      | 1.363       | 0.788          | 0.119                   | 0.593        | 0.556         | 0.573        |
| 5.000                  | 0.0110      | 4.760       | 1.063          | 0.197                   | 0.626        | 0.525         | 0.593        |
| 10.000                 | 0.0085      | 49.100      | 1.644          | 0.527                   |              |               |              |
| 15.000                 | 0.0077      |             | 2.212          | 1.077                   |              |               |              |
| 20.000                 | 0.0075      |             | 2.607          | 1.701                   |              |               |              |

| $m/\text{mol kg}^{-1}$ | $\text{KClO}_3$ | $\text{K}_2\text{CrO}_4$ | $\text{KF}$ | $\text{KH}_2\text{PO}_4^*$ | $\text{K}_2\text{HPO}_4^{**}$ | $\text{KI}$ | $\text{KNO}_3$ |
|------------------------|-----------------|--------------------------|-------------|----------------------------|-------------------------------|-------------|----------------|
| 0.001                  | 0.965           | 0.886                    | 0.965       | 0.964                      | 0.886                         | 0.965       | 0.964          |
| 0.002                  | 0.951           | 0.847                    | 0.952       | 0.950                      | 0.847                         | 0.952       | 0.950          |
| 0.005                  | 0.926           | 0.779                    | 0.927       | 0.924                      | 0.779                         | 0.927       | 0.924          |
| 0.010                  | 0.899           | 0.715                    | 0.902       | 0.896                      | 0.715                         | 0.902       | 0.896          |
| 0.020                  | 0.865           | 0.643                    | 0.870       | 0.859                      | 0.643                         | 0.871       | 0.860          |
| 0.050                  | 0.805           | 0.539                    | 0.818       | 0.793                      | 0.538                         | 0.820       | 0.797          |
| 0.100                  | 0.749           | 0.460                    | 0.773       | 0.730                      | 0.457                         | 0.776       | 0.735          |
| 0.200                  | 0.681           | 0.385                    | 0.726       | 0.652                      | 0.379                         | 0.731       | 0.662          |
| 0.500                  | 0.569           | 0.296                    | 0.670       | 0.529                      | 0.283                         | 0.676       | 0.546          |
| 1.000                  |                 | 0.239                    | 0.645       | 0.422                      |                               | 0.646       | 0.444          |
| 2.000                  |                 | 0.199                    | 0.658       |                            |                               | 0.638       | 0.332          |
| 5.000                  |                 |                          | 0.871       |                            |                               |             |                |
| 10.000                 |                 |                          | 1.715       |                            |                               |             |                |
| 15.000                 |                 |                          | 3.120       |                            |                               |             |                |

| $m/\text{mol kg}^{-1}$ | $\text{KOH}$ | $\text{K}_2\text{SO}_4$ | $\text{LiBr}$ | $\text{LiCl}$ | $\text{LiClO}_4$ | $\text{LiI}$ | $\text{LiNO}_3$ |
|------------------------|--------------|-------------------------|---------------|---------------|------------------|--------------|-----------------|
| 0.001                  | 0.965        | 0.885                   | 0.965         | 0.965         | 0.966            | 0.966        | 0.965           |
| 0.002                  | 0.952        | 0.844                   | 0.952         | 0.952         | 0.953            | 0.953        | 0.952           |
| 0.005                  | 0.927        | 0.772                   | 0.929         | 0.928         | 0.931            | 0.930        | 0.928           |
| 0.010                  | 0.902        | 0.704                   | 0.905         | 0.904         | 0.908            | 0.908        | 0.904           |
| 0.020                  | 0.871        | 0.625                   | 0.877         | 0.874         | 0.882            | 0.882        | 0.874           |
| 0.050                  | 0.821        | 0.511                   | 0.832         | 0.827         | 0.843            | 0.843        | 0.827           |
| 0.100                  | 0.779        | 0.424                   | 0.797         | 0.789         | 0.815            | 0.817        | 0.788           |
| 0.200                  | 0.740        | 0.343                   | 0.767         | 0.756         | 0.795            | 0.802        | 0.753           |
| 0.500                  | 0.710        | 0.251                   | 0.754         | 0.739         | 0.806            | 0.824        | 0.726           |
| 1.000                  | 0.733        |                         | 0.803         | 0.775         | 0.887            | 0.912        | 0.743           |
| 2.000                  | 0.860        |                         | 1.012         | 0.924         | 1.161            | 1.197        | 0.837           |
| 5.000                  | 1.697        |                         | 2.696         | 2.000         |                  |              | 1.298           |

| $m/\text{mol kg}^{-1}$ | KOH                                | K <sub>2</sub> SO <sub>4</sub>  | LiBr                             | LiCl                                                | LiClO <sub>4</sub>               | LiI                             | LiNO <sub>3</sub>                  |
|------------------------|------------------------------------|---------------------------------|----------------------------------|-----------------------------------------------------|----------------------------------|---------------------------------|------------------------------------|
| 10.000                 | 6.110                              |                                 | 20.0                             | 9.600                                               |                                  |                                 | 2.500                              |
| 15.000                 | 19.9                               |                                 | 147                              | 30.9                                                |                                  |                                 | 3.960                              |
| 20.000                 | 46.4                               |                                 | 486                              |                                                     |                                  |                                 | 4.970                              |
| $m/\text{mol kg}^{-1}$ | LiOH                               | Li <sub>2</sub> SO <sub>4</sub> | MgBr <sub>2</sub>                | MgCl <sub>2</sub>                                   | MgI <sub>2</sub>                 | MnBr <sub>2</sub>               | MnCl <sub>2</sub>                  |
| 0.001                  | 0.964                              | 0.887                           | 0.889                            | 0.889                                               | 0.889                            | 0.889                           | 0.888                              |
| 0.002                  | 0.950                              | 0.847                           | 0.852                            | 0.852                                               | 0.853                            | 0.853                           | 0.850                              |
| 0.005                  | 0.923                              | 0.780                           | 0.790                            | 0.790                                               | 0.791                            | 0.791                           | 0.786                              |
| 0.010                  | 0.895                              | 0.716                           | 0.733                            | 0.734                                               | 0.736                            | 0.735                           | 0.727                              |
| 0.020                  | 0.858                              | 0.645                           | 0.672                            | 0.672                                               | 0.677                            | 0.674                           | 0.662                              |
| 0.050                  | 0.794                              | 0.544                           | 0.593                            | 0.590                                               | 0.602                            | 0.595                           | 0.574                              |
| 0.100                  | 0.735                              | 0.469                           | 0.543                            | 0.535                                               | 0.556                            | 0.543                           | 0.513                              |
| 0.200                  | 0.668                              | 0.400                           | 0.512                            | 0.493                                               | 0.535                            | 0.508                           | 0.464                              |
| 0.500                  | 0.579                              | 0.325                           | 0.540                            | 0.485                                               | 0.594                            | 0.519                           | 0.437                              |
| 1.000                  | 0.522                              | 0.284                           | 0.715                            | 0.577                                               | 0.858                            | 0.650                           | 0.477                              |
| 2.000                  | 0.484                              | 0.270                           | 1.590                            | 1.065                                               | 2.326                            | 1.224                           | 0.661                              |
| 5.000                  | 0.493                              |                                 | 36.1                             | 14.40                                               | 109.8                            | 6.697                           | 1.539                              |
| $m/\text{mol kg}^{-1}$ | Mn(ClO <sub>4</sub> ) <sub>2</sub> | NH <sub>4</sub> Cl              | NH <sub>4</sub> ClO <sub>4</sub> | (NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub> ** | NH <sub>4</sub> NO <sub>3</sub>  | NaBr                            | NaBrO <sub>3</sub>                 |
| 0.001                  | 0.892                              | 0.965                           | 0.964                            | 0.882                                               | 0.964                            | 0.965                           | 0.965                              |
| 0.002                  | 0.858                              | 0.952                           | 0.950                            | 0.839                                               | 0.951                            | 0.952                           | 0.951                              |
| 0.005                  | 0.801                              | 0.927                           | 0.924                            | 0.763                                               | 0.925                            | 0.928                           | 0.926                              |
| 0.010                  | 0.752                              | 0.901                           | 0.895                            | 0.688                                               | 0.897                            | 0.903                           | 0.900                              |
| 0.020                  | 0.700                              | 0.869                           | 0.859                            | 0.600                                               | 0.862                            | 0.873                           | 0.867                              |
| 0.050                  | 0.637                              | 0.816                           | 0.794                            | 0.469                                               | 0.801                            | 0.824                           | 0.811                              |
| 0.100                  | 0.604                              | 0.769                           | 0.734                            | 0.367                                               | 0.744                            | 0.783                           | 0.759                              |
| 0.200                  | 0.596                              | 0.718                           | 0.663                            | 0.273                                               | 0.678                            | 0.742                           | 0.698                              |
| 0.500                  | 0.686                              | 0.649                           | 0.560                            | 0.171                                               | 0.582                            | 0.697                           | 0.605                              |
| 1.000                  | 1.030                              | 0.603                           | 0.479                            | 0.114                                               | 0.502                            | 0.687                           | 0.528                              |
| 2.000                  | 3.072                              | 0.569                           | 0.399                            | 0.074                                               | 0.419                            | 0.730                           | 0.449                              |
| 5.000                  |                                    | 0.563                           |                                  |                                                     | 0.303                            | 1.083                           |                                    |
| 10.000                 |                                    |                                 |                                  |                                                     | 0.220                            |                                 |                                    |
| 15.000                 |                                    |                                 |                                  |                                                     | 0.179                            |                                 |                                    |
| 20.000                 |                                    |                                 |                                  |                                                     | 0.154                            |                                 |                                    |
| $m/\text{mol kg}^{-1}$ | Na <sub>2</sub> CO <sub>3</sub>    | NaCl                            | NaClO <sub>3</sub>               | NaClO <sub>4</sub>                                  | Na <sub>2</sub> CrO <sub>4</sub> | NaF                             | Na <sub>2</sub> HPO <sub>4</sub> * |
| 0.001                  | 0.887                              | 0.965                           | 0.965                            | 0.965                                               | 0.887                            | 0.965                           | 0.887                              |
| 0.002                  | 0.847                              | 0.952                           | 0.952                            | 0.952                                               | 0.849                            | 0.951                           | 0.848                              |
| 0.005                  | 0.780                              | 0.928                           | 0.927                            | 0.928                                               | 0.783                            | 0.926                           | 0.780                              |
| 0.010                  | 0.716                              | 0.903                           | 0.902                            | 0.903                                               | 0.722                            | 0.901                           | 0.717                              |
| 0.020                  | 0.644                              | 0.872                           | 0.870                            | 0.872                                               | 0.653                            | 0.868                           | 0.644                              |
| 0.050                  | 0.541                              | 0.822                           | 0.818                            | 0.821                                               | 0.554                            | 0.813                           | 0.539                              |
| 0.100                  | 0.462                              | 0.779                           | 0.771                            | 0.777                                               | 0.479                            | 0.764                           | 0.456                              |
| 0.200                  | 0.385                              | 0.734                           | 0.719                            | 0.729                                               | 0.406                            | 0.710                           | 0.373                              |
| 0.500                  | 0.292                              | 0.681                           | 0.646                            | 0.668                                               | 0.318                            | 0.633                           | 0.266                              |
| 1.000                  | 0.229                              | 0.657                           | 0.590                            | 0.630                                               | 0.261                            | 0.573                           | 0.191                              |
| 2.000                  | 0.182                              | 0.668                           | 0.537                            | 0.608                                               | 0.231                            |                                 | 0.133                              |
| 5.000                  |                                    | 0.874                           |                                  | 0.648                                               |                                  |                                 |                                    |
| $m/\text{mol kg}^{-1}$ | NaI                                | NaNO <sub>3</sub>               | NaOH                             | Na <sub>2</sub> SO <sub>3</sub>                     | Na <sub>2</sub> SO <sub>4</sub>  | Na <sub>2</sub> WO <sub>4</sub> | NiBr <sub>2</sub>                  |
| 0.001                  | 0.965                              | 0.965                           | 0.965                            | 0.887                                               | 0.886                            | 0.886                           | 0.889                              |
| 0.002                  | 0.952                              | 0.951                           | 0.952                            | 0.847                                               | 0.846                            | 0.846                           | 0.853                              |
| 0.005                  | 0.928                              | 0.926                           | 0.927                            | 0.779                                               | 0.777                            | 0.777                           | 0.791                              |
| 0.010                  | 0.904                              | 0.900                           | 0.902                            | 0.716                                               | 0.712                            | 0.712                           | 0.735                              |
| 0.020                  | 0.874                              | 0.866                           | 0.870                            | 0.644                                               | 0.637                            | 0.638                           | 0.675                              |
| 0.050                  | 0.827                              | 0.810                           | 0.819                            | 0.540                                               | 0.529                            | 0.534                           | 0.596                              |
| 0.100                  | 0.789                              | 0.759                           | 0.775                            | 0.462                                               | 0.446                            | 0.457                           | 0.546                              |
| 0.200                  | 0.753                              | 0.701                           | 0.731                            | 0.386                                               | 0.366                            | 0.388                           | 0.514                              |
| 0.500                  | 0.722                              | 0.617                           | 0.685                            | 0.296                                               | 0.268                            | 0.320                           | 0.535                              |
| 1.000                  | 0.734                              | 0.550                           | 0.674                            | 0.237                                               | 0.204                            | 0.291                           | 0.692                              |
| 2.000                  | 0.823                              | 0.480                           | 0.714                            | 0.196                                               | 0.155                            | 0.291                           | 1.476                              |

## Mean Activity Coefficients of Electrolytes as a Function of Concentration

| $m/\text{mol kg}^{-1}$ | NaI   | NaNO <sub>3</sub> | NaOH   | Na <sub>2</sub> SO <sub>3</sub> | Na <sub>2</sub> SO <sub>4</sub> | Na <sub>2</sub> WO <sub>4</sub> | NiBr <sub>2</sub> |
|------------------------|-------|-------------------|--------|---------------------------------|---------------------------------|---------------------------------|-------------------|
| 5.000                  | 1.402 | 0.388             | 1.076  |                                 |                                 |                                 |                   |
| 10.000                 | 4.011 | 0.329             | 3.258  |                                 |                                 |                                 |                   |
| 15.000                 |       |                   | 9.796  |                                 |                                 |                                 |                   |
| 20.000                 |       |                   | 19.410 |                                 |                                 |                                 |                   |

| $m/\text{mol kg}^{-1}$ | NiCl <sub>2</sub> | Ni(ClO <sub>4</sub> ) <sub>2</sub> | Ni(NO <sub>3</sub> ) <sub>2</sub> | Pb(ClO <sub>4</sub> ) <sub>2</sub> | Pb(NO <sub>3</sub> ) <sub>2</sub> | RbBr  | RbCl  |
|------------------------|-------------------|------------------------------------|-----------------------------------|------------------------------------|-----------------------------------|-------|-------|
| 0.001                  | 0.889             | 0.891                              | 0.889                             | 0.889                              | 0.882                             | 0.965 | 0.965 |
| 0.002                  | 0.852             | 0.855                              | 0.851                             | 0.851                              | 0.840                             | 0.951 | 0.951 |
| 0.005                  | 0.789             | 0.797                              | 0.787                             | 0.787                              | 0.764                             | 0.926 | 0.926 |
| 0.010                  | 0.732             | 0.745                              | 0.730                             | 0.729                              | 0.690                             | 0.900 | 0.900 |
| 0.020                  | 0.669             | 0.690                              | 0.666                             | 0.666                              | 0.604                             | 0.866 | 0.867 |
| 0.050                  | 0.584             | 0.621                              | 0.581                             | 0.580                              | 0.476                             | 0.811 | 0.811 |
| 0.100                  | 0.527             | 0.582                              | 0.524                             | 0.522                              | 0.379                             | 0.760 | 0.761 |
| 0.200                  | 0.482             | 0.567                              | 0.481                             | 0.476                              | 0.291                             | 0.705 | 0.707 |
| 0.500                  | 0.465             | 0.639                              | 0.467                             | 0.458                              | 0.195                             | 0.630 | 0.633 |
| 1.000                  | 0.538             | 0.946                              | 0.528                             | 0.516                              | 0.136                             | 0.578 | 0.583 |
| 2.000                  | 0.915             | 2.812                              | 0.797                             | 0.799                              |                                   | 0.535 | 0.546 |
| 5.000                  | 4.785             |                                    |                                   | 4.043                              |                                   | 0.514 | 0.544 |
| 10.000                 |                   |                                    |                                   | 33.8                               |                                   |       |       |

| $m/\text{mol kg}^{-1}$ | RbF   | RbI   | RbNO <sub>3</sub> | Rb <sub>2</sub> SO <sub>4</sub> | SrBr <sub>2</sub> | SrCl <sub>2</sub> | SrI <sub>2</sub> |
|------------------------|-------|-------|-------------------|---------------------------------|-------------------|-------------------|------------------|
| 0.001                  | 0.965 | 0.965 | 0.964             | 0.886                           | 0.889             | 0.888             | 0.890            |
| 0.002                  | 0.952 | 0.951 | 0.950             | 0.845                           | 0.852             | 0.850             | 0.854            |
| 0.005                  | 0.927 | 0.926 | 0.924             | 0.776                           | 0.790             | 0.785             | 0.793            |
| 0.010                  | 0.902 | 0.900 | 0.896             | 0.710                           | 0.734             | 0.725             | 0.740            |
| 0.020                  | 0.871 | 0.866 | 0.859             | 0.635                           | 0.673             | 0.659             | 0.681            |
| 0.050                  | 0.821 | 0.810 | 0.795             | 0.526                           | 0.591             | 0.569             | 0.606            |
| 0.100                  | 0.780 | 0.759 | 0.733             | 0.443                           | 0.535             | 0.506             | 0.557            |
| 0.200                  | 0.739 | 0.703 | 0.657             | 0.365                           | 0.492             | 0.455             | 0.526            |
| 0.500                  | 0.701 | 0.627 | 0.536             | 0.274                           | 0.476             | 0.421             | 0.542            |
| 1.000                  | 0.697 | 0.574 | 0.430             | 0.217                           | 0.545             | 0.451             | 0.686            |
| 2.000                  | 0.724 | 0.532 | 0.320             |                                 | 0.921             | 0.650             |                  |
| 5.000                  |       | 0.517 |                   |                                 |                   |                   |                  |

| $m/\text{mol kg}^{-1}$ | UO <sub>2</sub> Cl <sub>2</sub> | UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> | ZnBr <sub>2</sub> | ZnCl <sub>2</sub> | ZnI <sub>2</sub> |
|------------------------|---------------------------------|-------------------------------------------------|-------------------|-------------------|------------------|
| 0.001                  | 0.888                           | 0.888                                           | 0.890             | 0.887             | 0.893            |
| 0.002                  | 0.851                           | 0.849                                           | 0.854             | 0.847             | 0.859            |
| 0.005                  | 0.787                           | 0.784                                           | 0.794             | 0.781             | 0.804            |
| 0.010                  | 0.729                           | 0.726                                           | 0.741             | 0.719             | 0.757            |
| 0.020                  | 0.666                           | 0.663                                           | 0.683             | 0.652             | 0.708            |
| 0.050                  | 0.583                           | 0.583                                           | 0.606             | 0.561             | 0.644            |
| 0.100                  | 0.529                           | 0.535                                           | 0.553             | 0.499             | 0.601            |
| 0.200                  | 0.493                           | 0.509                                           | 0.515             | 0.447             | 0.574            |
| 0.500                  | 0.501                           | 0.532                                           | 0.516             | 0.384             | 0.635            |
| 1.000                  | 0.601                           | 0.673                                           | 0.558             | 0.330             | 0.836            |
| 2.000                  | 0.948                           | 1.223                                           | 0.578             | 0.283             | 1.062            |
| 5.000                  |                                 | 3.020                                           | 0.788             | 0.342             | 1.546            |
| 10.000                 |                                 |                                                 | 2.317             | 0.876             | 4.698            |
| 15.000                 |                                 |                                                 | 5.381             | 1.914             |                  |
| 20.000                 |                                 |                                                 | 7.965             | 2.968             |                  |

\* The anion is H<sub>2</sub>PO<sub>4</sub><sup>-</sup>.\*\* The anion is HPO<sub>4</sub><sup>-2</sup>.

## ENTHALPY OF DILUTION OF ACIDS

The quantity given in this table is  $-\Delta_{\text{dil}}H$ , the negative of the enthalpy (heat) of dilution to infinite dilution for aqueous solutions of several common acids; i.e., the negative of the enthalpy change when a solution of molality  $m$  at a temperature of 25°C is diluted with an infinite amount of water. The tabulated numbers thus represent the heat produced (or, if the value is negative, the heat absorbed) when the acid is diluted. The initial molality  $m$  is given in the first column. The second column gives the dilution ratio, which is the number of moles of water that must be added

to one mole of the acid to produce a solution of the molality in the first column.

### Reference

Parker, V. B., *Thermal Properties of Aqueous Uni-Univalent Electrolytes*, Natl. Stand. Ref. Data Ser. - Natl. Bur. Stand. (U.S.) 2, U.S. Government Printing Office, 1965.

| $m$      | Dil. ratio | $-\Delta_{\text{dil}}H$ in kJ/mol at 25°C |       |                   |       |       |                  |                                   |                                                |
|----------|------------|-------------------------------------------|-------|-------------------|-------|-------|------------------|-----------------------------------|------------------------------------------------|
|          |            | HF                                        | HCl   | HClO <sub>4</sub> | HBr   | HI    | HNO <sub>3</sub> | CH <sub>3</sub> CO <sub>2</sub> H | C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> H |
| 55.506   | 1.0        |                                           | 45.61 |                   | 48.83 |       | 19.73            | 0.046                             | 2.167                                          |
| 20       | 2.775      | 14.88                                     | 19.87 | 13.81             | 19.92 | 21.71 | 9.498            | 0.038                             | 2.075                                          |
| 15       | 3.700      | 14.34                                     | 15.40 | 7.920             | 14.29 | 14.02 | 6.883            | 0.109                             | 1.962                                          |
| 10       | 5.551      | 13.87                                     | 10.24 | 2.013             | 8.694 | 7.615 | 3.933            | 0.205                             | 1.824                                          |
| 9        | 6.167      | 13.81                                     | 9.213 | 1.280             | 7.719 | 6.569 | 3.368            | 0.230                             | 1.782                                          |
| 8        | 6.938      | 13.77                                     | 8.201 | 0.611             | 6.786 | 5.607 | 2.791            | 0.255                             | 1.724                                          |
| 7        | 7.929      | 13.73                                     | 7.217 | 0.046             | 5.925 | 4.728 | 2.251            | 0.272                             | 1.648                                          |
| 6        | 9.251      | 13.69                                     | 6.268 | -0.351            | 5.004 | 3.975 | 1.749            | 0.280                             | 1.540                                          |
| 5.5506   | 10         | 13.66                                     | 5.841 | -0.490            | 4.590 | 3.577 | 1.540            | 0.285                             | 1.477                                          |
| 5        | 11.10      | 13.62                                     | 5.318 | -0.628            | 4.113 | 3.197 | 1.310            | 0.289                             | 1.393                                          |
| 4.5      | 12.33      | 13.58                                     | 4.899 | -0.732            | 3.711 | 2.828 | 1.109            | 0.289                             | 1.310                                          |
| 4        | 13.88      | 13.53                                     | 4.402 | -0.787            | 3.330 | 2.460 | 0.958            | 0.289                             | 1.218                                          |
| 3.5      | 15.86      | 13.47                                     | 3.958 | -0.820            | 2.966 | 2.105 | 0.791            | 0.289                             | 1.121                                          |
| 3        | 18.50      | 13.45                                     | 3.506 | -0.782            | 2.611 | 1.787 | 0.665            | 0.289                             | 1.025                                          |
| 2.5      | 22.20      | 13.43                                     | 3.063 | -0.724            | 2.301 | 1.527 | 0.582            | 0.285                             | 0.912                                          |
| 2        | 27.75      | 13.40                                     | 2.623 | -0.623            | 1.996 | 1.318 | 0.527            | 0.276                             | 0.803                                          |
| 1.5      | 37.00      | 13.36                                     | 2.167 | -0.431            | 1.665 | 1.125 | 0.506            | 0.259                             | 0.678                                          |
| 1        | 55.51      | 13.30                                     | 1.695 | -0.201            | 1.314 | 0.933 | 0.506            | 0.226                             | 0.544                                          |
| 0.5551   | 100        | 13.22                                     | 1.234 | 0.050             | 0.983 | 0.736 | 0.502            | 0.184                             | 0.423                                          |
| 0.5      | 111.0      | 13.20                                     | 1.172 | 0.075             | 0.941 | 0.711 | 0.498            | 0.176                             | 0.406                                          |
| 0.2      | 277.5      | 13.09                                     | 0.761 | 0.247             | 0.649 | 0.536 | 0.439            | 0.146                             | 0.331                                          |
| 0.1      | 555.1      | 12.80                                     | 0.556 | 0.272             | 0.498 | 0.439 | 0.372            | 0.134                             | 0.289                                          |
| 0.0925   | 600        | 12.79                                     | 0.540 | 0.272             | 0.481 | 0.427 | 0.368            | 0.134                             | 0.285                                          |
| 0.0793   | 700        | 12.70                                     | 0.502 | 0.272             | 0.452 | 0.402 | 0.351            | 0.134                             | 0.285                                          |
| 0.0694   | 800        | 12.61                                     | 0.473 | 0.268             | 0.427 | 0.385 | 0.339            | 0.130                             | 0.280                                          |
| 0.0617   | 900        | 12.50                                     | 0.448 | 0.264             | 0.406 | 0.368 | 0.326            | 0.126                             | 0.276                                          |
| 0.05551  | 1000       | 12.42                                     | 0.427 | 0.259             | 0.385 | 0.351 | 0.318            | 0.121                             | 0.272                                          |
| 0.05     | 1110       | 12.24                                     | 0.406 | 0.259             | 0.372 | 0.339 | 0.305            | 0.121                             | 0.272                                          |
| 0.02775  | 2000       | 11.29                                     | 0.310 | 0.226             | 0.285 | 0.264 | 0.247            | 0.117                             | 0.264                                          |
| 0.01850  | 3000       | 10.66                                     | 0.251 | 0.197             | 0.234 | 0.218 | 0.213            | 0.117                             | 0.259                                          |
| 0.01388  | 4000       | 10.25                                     | 0.226 | 0.180             | 0.205 | 0.192 | 0.192            | 0.113                             | 0.259                                          |
| 0.01110  | 5000       | 9.874                                     | 0.197 | 0.167             | 0.184 | 0.172 | 0.176            | 0.109                             | 0.255                                          |
| 0.00555  | 10000      | 8.912                                     | 0.142 | 0.126             | 0.130 | 0.121 | 0.130            | 0.105                             | 0.243                                          |
| 0.00278  | 20000      | 7.531                                     | 0.105 | 0.092             | 0.092 | 0.084 | 0.096            | 0.096                             | 0.230                                          |
| 0.00111  | 50000      | 5.439                                     | 0.067 | 0.059             | 0.054 | 0.050 | 0.063            | 0.084                             | 0.222                                          |
| 0.000555 | 100000     | 3.766                                     | 0.042 | 0.042             | 0.038 | 0.038 | 0.046            | 0.054                             | 0.209                                          |
| 0.000111 | 500000     | 1.255                                     | 0.021 | 0.021             | 0.021 | 0.021 | 0.021            | 0.038                             | 0.167                                          |
| 0        | ∞          | 0                                         | 0     | 0                 | 0     | 0     | 0                | 0                                 | 0                                              |



# ENTHALPY OF SOLUTION OF ELECTROLYTES

This table gives the molar enthalpy (heat) of solution at infinite dilution for some common uni-univalent electrolytes. This is the enthalpy change when 1 mol of solute in its standard state is dissolved in an infinite amount of water. Values are given in kilojoules per mole at 25°C.

## Reference

Parker, V. B., *Thermal Properties of Uni-Univalent Electrolytes*, Natl. Stand. Ref. Data Series — Natl. Bur. Stand.(U.S.), No.2, 1965.

| Solute                                                       | State | $\Delta_{\text{sol}} H^\circ$<br>kJ/mol | Solute                                                             | State | $\Delta_{\text{sol}} H^\circ$<br>kJ/mol | Solute                                        | State | $\Delta_{\text{sol}} H^\circ$<br>kJ/mol |
|--------------------------------------------------------------|-------|-----------------------------------------|--------------------------------------------------------------------|-------|-----------------------------------------|-----------------------------------------------|-------|-----------------------------------------|
| HF                                                           | g     | -61.50                                  | LiBr · 2H <sub>2</sub> O                                           | c     | -9.41                                   | KClO <sub>3</sub>                             | c     | 41.38                                   |
| HCl                                                          | g     | -74.84                                  | LiBrO <sub>3</sub>                                                 | c     | 1.42                                    | KClO <sub>4</sub>                             | c     | 51.04                                   |
| HClO <sub>4</sub>                                            | l     | -88.76                                  | LiI                                                                | c     | -63.30                                  | KBr                                           | c     | 19.87                                   |
| HClO <sub>4</sub> · H <sub>2</sub> O                         | c     | -32.95                                  | LiI · H <sub>2</sub> O                                             | c     | -29.66                                  | KBrO <sub>3</sub>                             | c     | 41.13                                   |
| HBr                                                          | g     | -85.14                                  | LiI · 2H <sub>2</sub> O                                            | c     | -14.77                                  | KI                                            | c     | 20.33                                   |
| HI                                                           | g     | -81.67                                  | LiI · 3H <sub>2</sub> O                                            | c     | 0.59                                    | KIO <sub>3</sub>                              | c     | 27.74                                   |
| HIO <sub>3</sub>                                             | c     | 8.79                                    | LiNO <sub>2</sub>                                                  | c     | -11.00                                  | KNO <sub>2</sub>                              | c     | 13.35                                   |
| HNO <sub>3</sub>                                             | l     | -33.28                                  | LiNO <sub>2</sub> · H <sub>2</sub> O                               | c     | 7.03                                    | KNO <sub>3</sub>                              | c     | 34.89                                   |
| HCOOH                                                        | l     | -0.86                                   | LiNO <sub>3</sub>                                                  | c     | -2.51                                   | KC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> | c     | -15.33                                  |
| CH <sub>3</sub> COOH                                         | l     | -1.51                                   |                                                                    |       |                                         | KCN                                           | c     | 11.72                                   |
|                                                              |       |                                         | NaOH                                                               | c     | -44.51                                  | KCNO                                          | c     | 20.25                                   |
| NH <sub>3</sub>                                              | g     | -30.50                                  | NaOH · H <sub>2</sub> O                                            | c     | -21.41                                  | KCNS                                          | c     | 24.23                                   |
| NH <sub>4</sub> Cl                                           | c     | 14.78                                   | NaF                                                                | c     | 0.91                                    | KMnO <sub>4</sub>                             | c     | 43.56                                   |
| NH <sub>4</sub> ClO <sub>4</sub>                             | c     | 33.47                                   | NaCl                                                               | c     | 3.88                                    |                                               |       |                                         |
| NH <sub>4</sub> Br                                           | c     | 16.78                                   | NaClO <sub>2</sub>                                                 | c     | 0.33                                    | RbOH                                          | c     | -62.34                                  |
| NH <sub>4</sub> I                                            | c     | 13.72                                   | NaClO <sub>2</sub> · 3H <sub>2</sub> O                             | c     | 28.58                                   | RbOH · H <sub>2</sub> O                       | c     | -17.99                                  |
| NH <sub>4</sub> IO <sub>3</sub>                              | c     | 31.80                                   | NaClO <sub>3</sub>                                                 | c     | 21.72                                   | RbOH · 2H <sub>2</sub> O                      | c     | 0.88                                    |
| NH <sub>4</sub> NO <sub>2</sub>                              | c     | 19.25                                   | NaClO <sub>4</sub>                                                 | c     | 13.88                                   | RbF                                           | c     | -26.11                                  |
| NH <sub>4</sub> NO <sub>3</sub>                              | c     | 25.69                                   | NaClO <sub>4</sub> · H <sub>2</sub> O                              | c     | 22.51                                   | RbF · H <sub>2</sub> O                        | c     | -0.42                                   |
| NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> | c     | -2.38                                   | NaBr                                                               | c     | -0.60                                   | RbF · 1.5H <sub>2</sub> O                     | c     | 1.34                                    |
| NH <sub>4</sub> CN                                           | c     | 17.57                                   | NaBr · 2H <sub>2</sub> O                                           | c     | 18.64                                   | RbCl                                          | c     | 17.28                                   |
| NH <sub>4</sub> CNS                                          | c     | 22.59                                   | NaBrO <sub>3</sub>                                                 | c     | 26.90                                   | RbClO <sub>3</sub>                            | c     | 47.74                                   |
| CH <sub>3</sub> NH <sub>3</sub> Cl                           | c     | 5.77                                    | NaI                                                                | c     | -7.53                                   | RbClO <sub>4</sub>                            | c     | 56.74                                   |
| (CH <sub>3</sub> ) <sub>3</sub> NHCl                         | c     | 1.46                                    | NaI · 2H <sub>2</sub> O                                            | c     | 16.13                                   | RbBr                                          | c     | 21.88                                   |
| N(CH <sub>3</sub> ) <sub>4</sub> Cl                          | c     | 4.08                                    | NaIO <sub>3</sub>                                                  | c     | 20.29                                   | RbBrO <sub>3</sub>                            | c     | 48.95                                   |
| N(CH <sub>3</sub> ) <sub>4</sub> Br                          | c     | 24.27                                   | NaNO <sub>2</sub>                                                  | c     | 13.89                                   | RbI                                           | c     | 25.10                                   |
| N(CH <sub>3</sub> ) <sub>4</sub> I                           | c     | 42.07                                   | NaNO <sub>3</sub>                                                  | c     | 20.50                                   | RbNO <sub>3</sub>                             | c     | 36.48                                   |
|                                                              |       |                                         | NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | c     | -17.32                                  |                                               |       |                                         |
| AgClO <sub>4</sub>                                           | c     | 7.36                                    | NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> · 3H <sub>2</sub> O | c     | 19.66                                   | CsOH                                          | c     | -71.55                                  |
| AgNO <sub>2</sub>                                            | c     | 36.94                                   | NaCN                                                               | c     | 1.21                                    | CsOH · H <sub>2</sub> O                       | c     | -20.50                                  |
| AgNO <sub>3</sub>                                            | c     | 22.59                                   | NaCN · 0.5H <sub>2</sub> O                                         | c     | 3.31                                    | CsF                                           | c     | -36.86                                  |
|                                                              |       |                                         | NaCN · 2H <sub>2</sub> O                                           | c     | 18.58                                   | CsF · H <sub>2</sub> O                        | c     | -10.46                                  |
| LiOH                                                         | c     | -23.56                                  | NaCNO                                                              | c     | 19.20                                   | CsF · 1.5H <sub>2</sub> O                     | c     | -5.44                                   |
| LiOH · H <sub>2</sub> O                                      | c     | -6.69                                   | NaCNS                                                              | c     | 6.83                                    | CsCl                                          | c     | 17.78                                   |
| LiF                                                          | c     | 4.73                                    |                                                                    |       |                                         | CsClO <sub>4</sub>                            | c     | 55.44                                   |
| LiCl                                                         | c     | -37.03                                  | KOH                                                                | c     | -57.61                                  | CsBr                                          | c     | 25.98                                   |
| LiCl · H <sub>2</sub> O                                      | c     | -19.08                                  | KOH · H <sub>2</sub> O                                             | c     | -14.64                                  | CsBrO <sub>3</sub>                            | c     | 50.46                                   |
| LiClO <sub>4</sub>                                           | c     | -26.55                                  | KOH · 1.5H <sub>2</sub> O                                          | c     | -10.46                                  | CsI                                           | c     | 33.35                                   |
| LiClO <sub>4</sub> · 3H <sub>2</sub> O                       | c     | 32.61                                   | KF                                                                 | c     | -17.73                                  | CsNO <sub>3</sub>                             | c     | 40.00                                   |
| LiBr                                                         | c     | -48.83                                  | KF · 2H <sub>2</sub> O                                             | c     | 6.97                                    |                                               |       |                                         |
| LiBr · H <sub>2</sub> O                                      | c     | -23.26                                  | KCl                                                                | c     | 17.22                                   |                                               |       |                                         |

# CHEMICAL KINETIC DATA FOR STRATOSPHERIC MODELING

The present compilation of kinetic data represents the 12th evaluation prepared by the NASA Panel for Data Evaluation. The Panel was established in 1977 by the NASA Upper Atmosphere Research Program Office for the purpose of providing a critical tabulation of the latest kinetic and photochemical data for use by modelers in computer simulations of stratospheric chemistry. The recommended rate data and cross sections are based on laboratory measurements. The major use of theoretical extrapolation of data is in connection with three-body reactions, in which the required pressure or temperature dependence is sometimes unavailable from laboratory measurements, and can be estimated by use of appropriate theoretical treatment. In the case of important rate constants for which no experimental data are available, the panel may provide estimates of rate constant parameters based on analogy to similar reactions for which data are available.

Rate constants are expressed in the form  $k(T) = A \exp(-E/RT)$ , where  $A$  is the pre-exponential factor,  $E$  the activation energy,  $R$  the gas constant, and  $T$  the absolute temperature. Uncertainties are expressed by the factor  $f$ , e.g., a value of  $4.2 \times 10^{-10}$  with  $f = 2$  indicates that the true value is believed to lie between  $2.1 \times 10^{-10}$  and  $8.4 \times 10^{-10}$ . The value of  $f$  at other temperatures may be calculated from  $f(298)$ , given in the last column, by:

$$f(T) = f(298) \exp[(\Delta E/R)(1/T - 1/298)],$$

where  $\Delta E/R$  is the uncertainty in  $E/R$ .

Table 1 covers rate constant data on second order reactions, grouped by class, while Table 2 covers association reactions. Relevant equilibrium constant data are given in Table 3. All concentrations are measured in molecules  $\text{cm}^{-3}$ . Notes on each reaction, as well as related photochemical data, may be found in the reference.

The assistance of Robert Hampson is gratefully acknowledged.

## Reference

DeMore, W. B., Sander, S. P., Golden, D. M., Hampson, R. F., Kurylo, M. J., Howard, C. J., Ravishankara, A. R., Kolb, C. E., and Molina, M. J., *Chemical Kinetics and Photochemical Data for Use in Atmospheric Modeling. Evaluation Number 12*, Jet Propulsion Laboratory Publication 97-4, Pasadena CA, 1997.

The report is also available at the World Wide Web site < <http://remus.jpl.nasa.gov/pub/jpl97> >.

TABLE 1. Rate Constants for Second Order Reactions

| Reaction                                                                            | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>K       | $k(298 \text{ K})$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------|------------------|--------------------------------------------------------------------------|----------|
| <b><math>\text{O}_x</math> Reactions</b>                                            |                                                           |                  |                                                                          |          |
| $\text{O} + \text{O}_3 \rightarrow \text{O}_2 + \text{O}_2$                         | $8.0 \times 10^{-12}$                                     | $2060 \pm 250$   | $8.0 \times 10^{-15}$                                                    | 1.15     |
| <b><math>\text{O}(^1\text{D})</math> Reactions</b>                                  |                                                           |                  |                                                                          |          |
| $\text{O}(^1\text{D}) + \text{O}_2 \rightarrow \text{O} + \text{O}_2$               | $3.2 \times 10^{-11}$                                     | $-(70 \pm 100)$  | $4.0 \times 10^{-11}$                                                    | 1.2      |
| $\text{O}(^1\text{D}) + \text{O}_3 \rightarrow \text{O}_2 + \text{O}_2$             | $1.2 \times 10^{-10}$                                     | $0 \pm 100$      | $1.2 \times 10^{-10}$                                                    | 1.3      |
| $\rightarrow \text{O}_2 + \text{O} + \text{O}$                                      | $1.2 \times 10^{-10}$                                     | $0 \pm 100$      | $1.2 \times 10^{-10}$                                                    | 1.3      |
| $\text{O}(^1\text{D}) + \text{H}_2 \rightarrow \text{OH} + \text{H}$                | $1.1 \times 10^{-10}$                                     | $0 \pm 100$      | $1.1 \times 10^{-10}$                                                    | 1.1      |
| $\text{O}(^1\text{D}) + \text{H}_2\text{O} \rightarrow \text{OH} + \text{OH}$       | $2.2 \times 10^{-10}$                                     | $0 \pm 100$      | $2.2 \times 10^{-10}$                                                    | 1.2      |
| $\text{O}(^1\text{D}) + \text{N}_2 \rightarrow \text{O} + \text{N}_2$               | $1.8 \times 10^{-11}$                                     | $-(110 \pm 100)$ | $2.6 \times 10^{-11}$                                                    | 1.2      |
| $\text{O}(^1\text{D}) + \text{N}_2\text{O} \rightarrow \text{N}_2 + \text{O}_2$     | $4.9 \times 10^{-11}$                                     | $0 \pm 100$      | $4.9 \times 10^{-11}$                                                    | 1.3      |
| $\rightarrow \text{NO} + \text{NO}$                                                 | $6.7 \times 10^{-11}$                                     | $0 \pm 100$      | $6.7 \times 10^{-11}$                                                    | 1.3      |
| $\text{O}(^1\text{D}) + \text{NH}_3 \rightarrow \text{OH} + \text{NH}_2$            | $2.5 \times 10^{-10}$                                     | $0 \pm 100$      | $2.5 \times 10^{-10}$                                                    | 1.3      |
| $\text{O}(^1\text{D}) + \text{CO}_2 \rightarrow \text{O} + \text{CO}_2$             | $7.4 \times 10^{-11}$                                     | $-(120 \pm 100)$ | $1.1 \times 10^{-10}$                                                    | 1.2      |
| $\text{O}(^1\text{D}) + \text{CH}_4 \rightarrow \text{products}$                    | $1.5 \times 10^{-10}$                                     | $0 \pm 100$      | $1.5 \times 10^{-10}$                                                    | 1.2      |
| $\text{O}(^1\text{D}) + \text{HCl} \rightarrow \text{products}$                     | $1.5 \times 10^{-10}$                                     | $0 \pm 100$      | $1.5 \times 10^{-10}$                                                    | 1.2      |
| $\text{O}(^1\text{D}) + \text{HF} \rightarrow \text{OH} + \text{F}$                 | $1.4 \times 10^{-10}$                                     | $0 \pm 100$      | $1.4 \times 10^{-10}$                                                    | 2.0      |
| $\text{O}(^1\text{D}) + \text{HBr} \rightarrow \text{products}$                     | $1.5 \times 10^{-10}$                                     | $0 \pm 100$      | $1.5 \times 10^{-10}$                                                    | 2.0      |
| $\text{O}(^1\text{D}) + \text{Cl}_2 \rightarrow \text{products}$                    | $2.8 \times 10^{-10}$                                     | $0 \pm 100$      | $2.8 \times 10^{-10}$                                                    | 2.0      |
| $\text{O}(^1\text{D}) + \text{CCl}_2\text{O} \rightarrow \text{products}$           | $3.6 \times 10^{-10}$                                     | $0 \pm 100$      | $3.6 \times 10^{-10}$                                                    | 2.0      |
| $\text{O}(^1\text{D}) + \text{CClFO} \rightarrow \text{products}$                   | $1.9 \times 10^{-10}$                                     | $0 \pm 100$      | $1.9 \times 10^{-10}$                                                    | 2.0      |
| $\text{O}(^1\text{D}) + \text{CF}_2\text{O} \rightarrow \text{products}$            | $7.4 \times 10^{-11}$                                     | $0 \pm 100$      | $7.4 \times 10^{-11}$                                                    | 2.0      |
| $\text{O}(^1\text{D}) + \text{CCl}_4 \rightarrow \text{products (CFC-10)}$          | $3.3 \times 10^{-10}$                                     | $0 \pm 100$      | $3.3 \times 10^{-10}$                                                    | 1.2      |
| $\text{O}(^1\text{D}) + \text{CH}_3\text{Br} \rightarrow \text{products}$           | $1.8 \times 10^{-10}$                                     | $0 \pm 100$      | $1.8 \times 10^{-10}$                                                    | 1.3      |
| $\text{O}(^1\text{D}) + \text{CH}_2\text{Br}_2 \rightarrow \text{products}$         | $2.7 \times 10^{-10}$                                     | $0 \pm 100$      | $2.7 \times 10^{-10}$                                                    | 1.3      |
| $\text{O}(^1\text{D}) + \text{CHBr}_3 \rightarrow \text{products}$                  | $6.6 \times 10^{-10}$                                     | $0 \pm 100$      | $6.6 \times 10^{-10}$                                                    | 1.5      |
| $\text{O}(^1\text{D}) + \text{CH}_3\text{F} \rightarrow \text{products (HFC-41)}$   | $1.5 \times 10^{-10}$                                     | $0 \pm 100$      | $1.5 \times 10^{-10}$                                                    | 1.2      |
| $\text{O}(^1\text{D}) + \text{CH}_2\text{F}_2 \rightarrow \text{products (HFC-32)}$ | $5.1 \times 10^{-11}$                                     | $0 \pm 100$      | $5.1 \times 10^{-11}$                                                    | 1.3      |
| $\text{O}(^1\text{D}) + \text{CHF}_3 \rightarrow \text{products (HFC-23)}$          | $9.1 \times 10^{-12}$                                     | $0 \pm 100$      | $9.1 \times 10^{-12}$                                                    | 1.2      |

| Reaction                                                                                                         | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>K       | $k$ (298 K)<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|------------------|-------------------------------------------------------------------|----------|
| $\text{O}(^1\text{D}) + \text{CHCl}_2\text{F} \rightarrow \text{products (HCFC-21)}$                             | $1.9 \times 10^{-10}$                                     | $0 \pm 100$      | $1.9 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CHClF}_2 \rightarrow \text{products (HCFC-22)}$                                    | $1.0 \times 10^{-10}$                                     | $0 \pm 100$      | $1.0 \times 10^{-10}$                                             | 1.2      |
| $\text{O}(^1\text{D}) + \text{CCl}_3\text{F} \rightarrow \text{products (CFC-11)}$                               | $2.3 \times 10^{-10}$                                     | $0 \pm 100$      | $2.3 \times 10^{-10}$                                             | 1.2      |
| $\text{O}(^1\text{D}) + \text{CCl}_2\text{F}_2 \rightarrow \text{products (CFC-12)}$                             | $1.4 \times 10^{-10}$                                     | $0 \pm 100$      | $1.4 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CClF}_3 \rightarrow \text{products (CFC-13)}$                                      | $8.7 \times 10^{-11}$                                     | $0 \pm 100$      | $8.7 \times 10^{-11}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CClBrF}_2 \rightarrow \text{products (Halon-1211)}$                                | $1.5 \times 10^{-10}$                                     | $0 \pm 100$      | $1.5 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CBr}_2\text{F}_2 \rightarrow \text{products (Halon-1202)}$                         | $2.2 \times 10^{-10}$                                     | $0 \pm 100$      | $2.2 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CBrF}_3 \rightarrow \text{products (Halon-1301)}$                                  | $1.0 \times 10^{-10}$                                     | $0 \pm 100$      | $1.0 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CF}_4 \rightarrow \text{CF}_4 + \text{O (CFC-14)}$                                 | —                                                         | —                | $2.0 \times 10^{-14}$                                             | 1.5      |
| $\text{O}(^1\text{D}) + \text{CH}_3\text{CH}_2\text{F} \rightarrow \text{products (HFC-161)}$                    | $2.6 \times 10^{-10}$                                     | $0 \pm 100$      | $2.6 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CH}_3\text{CHF}_2 \rightarrow \text{products (HFC-152a)}$                          | $2.0 \times 10^{-10}$                                     | $0 \pm 100$      | $2.0 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CH}_3\text{CCl}_2\text{F} \rightarrow \text{products (HCFC-141b)}$                 | $2.6 \times 10^{-10}$                                     | $0 \pm 100$      | $2.6 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CH}_3\text{CClF}_2 \rightarrow \text{products (HCFC-142b)}$                        | $2.2 \times 10^{-10}$                                     | $0 \pm 100$      | $2.2 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CH}_3\text{CF}_3 \rightarrow \text{products (HFC-143a)}$                           | $1.0 \times 10^{-10}$                                     | $0 \pm 100$      | $1.0 \times 10^{-10}$                                             | 3.0      |
| $\text{O}(^1\text{D}) + \text{CH}_2\text{ClCClF}_2 \rightarrow \text{products (HCFC-132b)}$                      | $1.6 \times 10^{-10}$                                     | $0 \pm 100$      | $1.6 \times 10^{-10}$                                             | 2.0      |
| $\text{O}(^1\text{D}) + \text{CH}_2\text{ClCF}_3 \rightarrow \text{products (HCFC-133a)}$                        | $1.2 \times 10^{-10}$                                     | $0 \pm 100$      | $1.2 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CH}_2\text{FCF}_3 \rightarrow \text{products (HFC-134a)}$                          | $4.9 \times 10^{-11}$                                     | $0 \pm 100$      | $4.9 \times 10^{-11}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CHCl}_2\text{CF}_3 \rightarrow \text{products (HCFC-123)}$                         | $2.0 \times 10^{-10}$                                     | $0 \pm 100$      | $2.0 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CHClFCF}_3 \rightarrow \text{products (HCFC-124)}$                                 | $8.6 \times 10^{-11}$                                     | $0 \pm 100$      | $8.6 \times 10^{-11}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CHF}_2\text{CF}_3 \rightarrow \text{products (HFC-125)}$                           | $1.2 \times 10^{-10}$                                     | $0 \pm 100$      | $1.2 \times 10^{-10}$                                             | 2.0      |
| $\text{O}(^1\text{D}) + \text{CCl}_3\text{CF}_3 \rightarrow \text{products (CFC-113a)}$                          | $2 \times 10^{-10}$                                       | $0 \pm 100$      | $2 \times 10^{-10}$                                               | 2.0      |
| $\text{O}(^1\text{D}) + \text{CCl}_2\text{FCClF}_2 \rightarrow \text{products (CFC-113)}$                        | $2 \times 10^{-10}$                                       | $0 \pm 100$      | $2 \times 10^{-10}$                                               | 2.0      |
| $\text{O}(^1\text{D}) + \text{CCl}_2\text{FCF}_3 \rightarrow \text{products (CFC-114a)}$                         | $1 \times 10^{-10}$                                       | $0 \pm 100$      | $1 \times 10^{-10}$                                               | 2.0      |
| $\text{O}(^1\text{D}) + \text{CClF}_2\text{CClF}_2 \rightarrow \text{products (CFC-114)}$                        | $1.3 \times 10^{-10}$                                     | $0 \pm 100$      | $1.3 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CClF}_2\text{CF}_3 \rightarrow \text{products (CFC-115)}$                          | $5 \times 10^{-11}$                                       | $0 \pm 100$      | $5 \times 10^{-11}$                                               | 1.3      |
| $\text{O}(^1\text{D}) + \text{CBrF}_2\text{CBrF}_2 \rightarrow \text{products (Halon-2402)}$                     | $1.6 \times 10^{-10}$                                     | $0 \pm 100$      | $1.6 \times 10^{-10}$                                             | 1.3      |
| $\text{O}(^1\text{D}) + \text{CF}_3\text{CF}_3 \rightarrow \text{O} + \text{CF}_3\text{CF}_3 \text{ (CFC-116)}$  | —                                                         | —                | $1.5 \times 10^{-13}$                                             | 1.5      |
| $\text{O}(^1\text{D}) + \text{CHF}_2\text{CF}_2\text{CF}_2\text{CHF}_2 \rightarrow \text{products (HFC-338pcc)}$ | $1.8 \times 10^{-11}$                                     | $0 \pm 100$      | $1.8 \times 10^{-11}$                                             | 1.5      |
| $\text{O}(^1\text{D}) + \text{c-C}_4\text{F}_8 \rightarrow \text{products}$                                      | —                                                         | —                | $8 \times 10^{-13}$                                               | 1.3      |
| $\text{O}(^1\text{D}) + \text{CF}_3\text{CHFCHFCF}_2\text{CF}_3 \rightarrow \text{products (HFC-43-10mee)}$      | $2.1 \times 10^{-10}$                                     | $0 \pm 100$      | $2.1 \times 10^{-10}$                                             | 4        |
| $\text{O}(^1\text{D}) + \text{C}_5\text{F}_{12} \rightarrow \text{products (CFC-41-12)}$                         | —                                                         | —                | $3.9 \times 10^{-13}$                                             | 2        |
| $\text{O}(^1\text{D}) + \text{C}_6\text{F}_{14} \rightarrow \text{products (CFC-51-14)}$                         | —                                                         | —                | $1 \times 10^{-12}$                                               | 2        |
| $\text{O}(^1\text{D}) + 1,2-(\text{CF}_3)_2\text{C}-\text{C}_4\text{F}_6 \rightarrow \text{products}$            | —                                                         | —                | $2.8 \times 10^{-13}$                                             | 2        |
| $\text{O}(^1\text{D}) + \text{SF}_6 \rightarrow \text{products}$                                                 | —                                                         | —                | $1.8 \times 10^{-14}$                                             | 1.5      |
| <b>Singlet <math>\text{O}_2</math> Reactions</b>                                                                 |                                                           |                  |                                                                   |          |
| $\text{O}_2(^1\Delta) + \text{O} \rightarrow \text{products}$                                                    | —                                                         | —                | $< 2 \times 10^{-16}$                                             | —        |
| $\text{O}_2(^1\Delta) + \text{O}_2 \rightarrow \text{products}$                                                  | $3.6 \times 10^{-18}$                                     | $220 \pm 100$    | $1.7 \times 10^{-18}$                                             | 1.2      |
| $\text{O}_2(^1\Delta) + \text{O}_3 \rightarrow \text{O} + 2\text{O}_2$                                           | $5.2 \times 10^{-11}$                                     | $2840 \pm 500$   | $3.8 \times 10^{-15}$                                             | 1.2      |
| $\text{O}_2(^1\Delta) + \text{H}_2\text{O} \rightarrow \text{products}$                                          | —                                                         | —                | $4.8 \times 10^{-18}$                                             | 1.5      |
| $\text{O}_2(^1\Delta) + \text{N} \rightarrow \text{NO} + \text{O}$                                               | —                                                         | —                | $< 9 \times 10^{-17}$                                             | —        |
| $\text{O}_2(^1\Delta) + \text{N}_2 \rightarrow \text{products}$                                                  | —                                                         | —                | $< 10^{-20}$                                                      | —        |
| $\text{O}_2(^1\Delta) + \text{CO}_2 \rightarrow \text{products}$                                                 | —                                                         | —                | $< 2 \times 10^{-20}$                                             | —        |
| $\text{O}_2(^1\Sigma) + \text{O} \rightarrow \text{products}$                                                    | —                                                         | —                | $8 \times 10^{-14}$                                               | 5.0      |
| $\text{O}_2(^1\Sigma) + \text{O}_2 \rightarrow \text{products}$                                                  | —                                                         | —                | $3.9 \times 10^{-17}$                                             | 1.5      |
| $\text{O}_2(^1\Sigma) + \text{O}_3 \rightarrow \text{products}$                                                  | $2.2 \times 10^{-11}$                                     | $0 \pm 200$      | $2.2 \times 10^{-11}$                                             | 1.2      |
| $\text{O}_2(^1\Sigma) + \text{H}_2\text{O} \rightarrow \text{products}$                                          | —                                                         | —                | $5.4 \times 10^{-12}$                                             | 1.3      |
| $\text{O}_2(^1\Sigma) + \text{N} \rightarrow \text{products}$                                                    | —                                                         | —                | $< 10^{-13}$                                                      | —        |
| $\text{O}_2(^1\Sigma) + \text{N}_2 \rightarrow \text{products}$                                                  | $2.1 \times 10^{-15}$                                     | $0 \pm 200$      | $2.1 \times 10^{-15}$                                             | 1.2      |
| $\text{O}_2(^1\Sigma) + \text{CO}_2 \rightarrow \text{products}$                                                 | $4.2 \times 10^{-13}$                                     | $0 \pm 200$      | $4.2 \times 10^{-13}$                                             | 1.2      |
| <b><math>\text{HO}_x</math> Reactions</b>                                                                        |                                                           |                  |                                                                   |          |
| $\text{O} + \text{OH} \rightarrow \text{O}_2 + \text{H}$                                                         | $2.2 \times 10^{-11}$                                     | $-(120 \pm 100)$ | $3.3 \times 10^{-11}$                                             | 1.2      |
| $\text{O} + \text{HO}_2 \rightarrow \text{OH} + \text{O}_2$                                                      | $3.0 \times 10^{-11}$                                     | $-(200 \pm 100)$ | $5.9 \times 10^{-11}$                                             | 1.2      |
| $\text{O} + \text{H}_2\text{O}_2 \rightarrow \text{OH} + \text{HO}_2$                                            | $1.4 \times 10^{-12}$                                     | $2000 \pm 1000$  | $1.7 \times 10^{-15}$                                             | 2.0      |
| $\text{H} + \text{O}_3 \rightarrow \text{OH} + \text{O}_2$                                                       | $1.4 \times 10^{-10}$                                     | $470 \pm 200$    | $2.9 \times 10^{-11}$                                             | 1.25     |
| $\text{H} + \text{HO}_2 \rightarrow \text{products}$                                                             | $8.1 \times 10^{-11}$                                     | $0 \pm 100$      | $8.1 \times 10^{-11}$                                             | 1.3      |
| $\text{OH} + \text{O}_3 \rightarrow \text{HO}_2 + \text{O}_2$                                                    | $1.6 \times 10^{-12}$                                     | $940 \pm 300$    | $6.8 \times 10^{-14}$                                             | 1.3      |
| $\text{OH} + \text{H}_2 \rightarrow \text{H}_2\text{O} + \text{H}$                                               | $5.5 \times 10^{-12}$                                     | $2000 \pm 100$   | $6.7 \times 10^{-15}$                                             | 1.1      |

| Reaction                                                                             | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>$\text{K}$ | $k$ (298 K)<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|--------------------------------------------------------------------------------------|-----------------------------------------------------------|---------------------|-------------------------------------------------------------------|----------|
| $\text{OH} + \text{HD} \rightarrow \text{products}$                                  | $5.0 \times 10^{-12}$                                     | $2130 \pm 200$      | $4.0 \times 10^{-15}$                                             | 1.2      |
| $\text{OH} + \text{OH} \rightarrow \text{H}_2\text{O} + \text{O}$                    | $4.2 \times 10^{-12}$                                     | $240 \pm 240$       | $1.9 \times 10^{-12}$                                             | 1.4      |
| $\text{OH} + \text{HO}_2 \rightarrow \text{H}_2\text{O} + \text{O}_2$                | $4.8 \times 10^{-11}$                                     | $-(250 \pm 200)$    | $1.1 \times 10^{-10}$                                             | 1.3      |
| $\text{OH} + \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{HO}_2$      | $2.9 \times 10^{-12}$                                     | $160 \pm 100$       | $1.7 \times 10^{-12}$                                             | 1.2      |
| $\text{HO}_2 + \text{O}_3 \rightarrow \text{OH} + 2\text{O}_2$                       | $1.1 \times 10^{-14}$                                     | $500 \pm$           | $2.0 \times 10^{-15}$                                             | 1.3      |
| $\text{HO}_2 + \text{HO}_2 \rightarrow \text{H}_2\text{O}_2 + \text{O}_2$            | $2.3 \times 10^{-13}$                                     | $-(600 \pm 200)$    | $1.7 \times 10^{-12}$                                             | 1.3      |
| $\text{H}_2\text{O}_2 + \text{O}_2$                                                  | $1.7 \times 10^{-33} [\text{M}]$                          | $-(1000 \pm 400)$   | $4.9 \times 10^{-32} [\text{M}]$                                  | 1.3      |
| <b><i>NO<sub>x</sub> Reactions</i></b>                                               |                                                           |                     |                                                                   |          |
| $\text{O} + \text{NO}_2 \rightarrow \text{NO} + \text{O}_2$                          | $6.5 \times 10^{-12}$                                     | $-(120 \pm 120)$    | $9.7 \times 10^{-12}$                                             | 1.1      |
| $\text{O} + \text{NO}_3 \rightarrow \text{O}_2 + \text{NO}_2$                        | $1.0 \times 10^{-11}$                                     | $0 \pm 150$         | $1.0 \times 10^{-11}$                                             | 1.5      |
| $\text{O} + \text{N}_2\text{O}_5 \rightarrow \text{products}$                        |                                                           |                     | $< 3.0 \times 10^{-16}$                                           |          |
| $\text{O} + \text{HNO}_3 \rightarrow \text{OH} + \text{NO}_3$                        |                                                           |                     | $< 3.0 \times 10^{-17}$                                           |          |
| $\text{O} + \text{HO}_2\text{NO}_2 \rightarrow \text{products}$                      | $7.8 \times 10^{-11}$                                     | $3400 \pm 750$      | $8.6 \times 10^{-16}$                                             | 3.0      |
| $\text{H} + \text{NO}_2 \rightarrow \text{OH} + \text{NO}$                           | $4.0 \times 10^{-10}$                                     | $340 \pm 300$       | $1.3 \times 10^{-10}$                                             | 1.3      |
| $\text{OH} + \text{NO}_3 \rightarrow \text{products}$                                |                                                           |                     | $2.2 \times 10^{-11}$                                             | 1.5      |
| $\text{OH} + \text{HONO} \rightarrow \text{H}_2\text{O} + \text{NO}_2$               | $1.8 \times 10^{-11}$                                     | $390 \pm$           | $4.5 \times 10^{-12}$                                             | 1.5      |
| $\text{OH} + \text{HNO}_3 \rightarrow \text{H}_2\text{O} + \text{NO}_3$              | See reference                                             | 1.3                 |                                                                   |          |
| $\text{OH} + \text{HO}_2\text{NO}_2 \rightarrow \text{products}$                     | $1.3 \times 10^{-12}$                                     | $-(380 \pm)$        | $4.6 \times 10^{-12}$                                             | 1.5      |
| $\text{OH} + \text{NH}_3 \rightarrow \text{H}_2\text{O} + \text{NH}_2$               | $1.7 \times 10^{-12}$                                     | $710 \pm 200$       | $1.6 \times 10^{-13}$                                             | 1.2      |
| $\text{HO}_2 + \text{NO} \rightarrow \text{NO}_2 + \text{OH}$                        | $3.5 \times 10^{-12}$                                     | $-(250 \pm 50)$     | $8.1 \times 10^{-12}$                                             | 1.15     |
| $\text{HO}_2 + \text{NO}_2 \rightarrow \text{HONO} + \text{O}_2$                     | See reference                                             |                     |                                                                   |          |
| $\text{HO}_2 + \text{NO}_3 \rightarrow \text{products}$                              |                                                           |                     | $3.5 \times 10^{-12}$                                             | 1.5      |
| $\text{HO}_2 + \text{NH}_2 \rightarrow \text{products}$                              |                                                           |                     | $3.4 \times 10^{-11}$                                             | 2.0      |
| $\text{N} + \text{O}_2 \rightarrow \text{NO} + \text{O}$                             | $1.5 \times 10^{-11}$                                     | $3600 \pm 400$      | $8.5 \times 10^{-17}$                                             | 1.25     |
| $\text{N} + \text{O}_3 \rightarrow \text{NO} + \text{O}_2$                           |                                                           |                     | $< 2.0 \times 10^{-16}$                                           |          |
| $\text{N} + \text{NO} \rightarrow \text{N}_2 + \text{O}$                             | $2.1 \times 10^{-11}$                                     | $-(100 \pm 100)$    | $3.0 \times 10^{-11}$                                             | 1.3      |
| $\text{N} + \text{NO}_2 \rightarrow \text{N}_2\text{O} + \text{O}$                   | $5.8 \times 10^{-12}$                                     | $-(220 \pm 100)$    | $1.2 \times 10^{-11}$                                             | 1.5      |
| $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2$                        | $2.0 \times 10^{-12}$                                     | $1400 \pm 200$      | $1.8 \times 10^{-14}$                                             | 1.1      |
| $\text{NO} + \text{NO}_3 \rightarrow 2\text{NO}_2$                                   | $1.5 \times 10^{-11}$                                     | $-(170 \pm 100)$    | $2.6 \times 10^{-11}$                                             | 1.3      |
| $\text{NO}_2 + \text{O}_3 \rightarrow \text{NO}_3 + \text{O}_2$                      | $1.2 \times 10^{-13}$                                     | $2450 \pm 150$      | $3.2 \times 10^{-17}$                                             | 1.15     |
| $\text{NO}_2 + \text{NO}_3 \rightarrow \text{NO} + \text{NO}_2 + \text{O}_2$         | See reference                                             |                     |                                                                   |          |
| $\text{NO}_3 + \text{NO}_3 \rightarrow 2\text{NO}_2 + \text{O}_2$                    | $8.5 \times 10^{-13}$                                     | $2450 \pm 500$      | $2.3 \times 10^{-16}$                                             | 1.5      |
| $\text{NH}_2 + \text{O}_2 \rightarrow \text{products}$                               |                                                           |                     | $< 6.0 \times 10^{-21}$                                           |          |
| $\text{NH}_2 + \text{O}_3 \rightarrow \text{products}$                               | $4.3 \times 10^{-12}$                                     | $930 \pm 500$       | $1.9 \times 10^{-13}$                                             | 3.0      |
| $\text{NH}_2 + \text{NO} \rightarrow \text{products}$                                | $4.0 \times 10^{-12}$                                     | $-(450 \pm 150)$    | $1.8 \times 10^{-11}$                                             | 1.3      |
| $\text{NH}_2 + \text{NO}_2 \rightarrow \text{products}$                              | $2.1 \times 10^{-12}$                                     | $-(650 \pm 250)$    | $1.9 \times 10^{-11}$                                             | 3.0      |
| $\text{NH} + \text{NO} \rightarrow \text{products}$                                  | $4.9 \times 10^{-11}$                                     | $0 \pm 300$         | $4.9 \times 10^{-11}$                                             | 1.5      |
| $\text{NH} + \text{NO}_2 \rightarrow \text{products}$                                | $3.5 \times 10^{-13}$                                     | $-(1140 \pm 500)$   | $1.6 \times 10^{-11}$                                             | 2.0      |
| $\text{O}_3 + \text{HNO}_2 \rightarrow \text{O}_2 + \text{HNO}_3$                    |                                                           |                     | $< 5.0 \times 10^{-19}$                                           |          |
| $\text{N}_2\text{O}_5 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_3$                |                                                           |                     | $< 2.0 \times 10^{-21}$                                           |          |
| $\text{N}_2(\text{A}, \nu) + \text{O}_2 \rightarrow \text{products}$                 |                                                           |                     | $2.5 \times 10^{-12}, \nu=0$                                      | 1.5      |
| $\text{N}_2(\text{A}, \nu) + \text{O}_3 \rightarrow \text{products}$                 |                                                           |                     | $4.1 \times 10^{-11}, \nu=0$                                      | 2.0      |
| <b><i>Reactions of Organic Compounds</i></b>                                         |                                                           |                     |                                                                   |          |
| $\text{O} + \text{CH}_3 \rightarrow \text{products}$                                 | $1.1 \times 10^{-10}$                                     | $0 \pm 250$         | $1.1 \times 10^{-10}$                                             | 1.3      |
| $\text{O} + \text{HCN} \rightarrow \text{products}$                                  | $1.0 \times 10^{-11}$                                     | $4000 \pm 1000$     | $1.5 \times 10^{-17}$                                             | 10       |
| $\text{O} + \text{C}_2\text{H}_2 \rightarrow \text{products}$                        | $3.0 \times 10^{-11}$                                     | $1600 \pm 250$      | $1.4 \times 10^{-13}$                                             | 1.3      |
| $\text{O} + \text{H}_2\text{CO} \rightarrow \text{products}$                         | $3.4 \times 10^{-11}$                                     | $1600 \pm 250$      | $1.6 \times 10^{-13}$                                             | 1.25     |
| $\text{O} + \text{CH}_3\text{CHO} \rightarrow \text{CH}_3\text{CO} + \text{OH}$      | $1.8 \times 10^{-11}$                                     | $1100 \pm 200$      | $4.5 \times 10^{-13}$                                             | 1.25     |
| $\text{O}_3 + \text{C}_2\text{H}_2 \rightarrow \text{products}$                      | $1.0 \times 10^{-14}$                                     | $4100 \pm 500$      | $1.0 \times 10^{-20}$                                             | 3        |
| $\text{O}_3 + \text{C}_2\text{H}_4 \rightarrow \text{products}$                      | $1.2 \times 10^{-14}$                                     | $2630 \pm 100$      | $1.7 \times 10^{-18}$                                             | 1.25     |
| $\text{O}_3 + \text{C}_3\text{H}_6 \rightarrow \text{products}$                      | $6.5 \times 10^{-15}$                                     | $1900 \pm 200$      | $1.1 \times 10^{-17}$                                             | 1.2      |
| $\text{OH} + \text{CO} \rightarrow \text{products}$                                  | $1.5 \times 10^{-13} \chi$<br>$(1 + 0.6P_{\text{atm}})$   | $0 \pm 300$         | $1.5 \times 10^{-13} \chi$<br>$(1 + 0.6P_{\text{atm}})$           | 1.3      |
| $\text{OH} + \text{CH}_4 \rightarrow \text{CH}_3 + \text{H}_2\text{O}$               | $2.45 \times 10^{-12}$                                    | $1775 \pm 100$      | $6.3 \times 10^{-15}$                                             | 1.1      |
| $\text{OH} + {}^{13}\text{CH}_4 \rightarrow {}^{13}\text{CH}_3 + \text{H}_2\text{O}$ | See reference                                             |                     |                                                                   |          |
| $\text{OH} + \text{CH}_3\text{D} \rightarrow \text{products}$                        | $3.5 \times 10^{-12}$                                     | $1950 \pm 200$      | $5.0 \times 10^{-15}$                                             | 1.15     |
| $\text{OH} + \text{H}_2\text{CO} \rightarrow \text{H}_2\text{O} + \text{HCO}$        | $1.0 \times 10^{-11}$                                     | $0 \pm 200$         | $1.0 \times 10^{-11}$                                             | 1.25     |

| Reaction                                                                                                                     | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>$K$      | $k$ (298 K)<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|-------------------|-------------------------------------------------------------------|----------|
| $\text{OH} + \text{CH}_3\text{OH} \rightarrow \text{products}$                                                               | $6.7 \times 10^{-12}$                                     | $600 \pm 300$     | $8.9 \times 10^{-13}$                                             | 1.2      |
| $\text{OH} + \text{CH}_3\text{OOH} \rightarrow \text{products}$                                                              | $3.8 \times 10^{-12}$                                     | $-(200 \pm 200)$  | $7.4 \times 10^{-12}$                                             | 1.5      |
| $\text{OH} + \text{HC(O)OH} \rightarrow \text{products}$                                                                     | $4.0 \times 10^{-13}$                                     | $0 \pm 200$       | $4.0 \times 10^{-13}$                                             | 1.3      |
| $\text{OH} + \text{HCN} \rightarrow \text{products}$                                                                         | $1.2 \times 10^{-13}$                                     | $400 \pm 150$     | $3.1 \times 10^{-14}$                                             | 3        |
| $\text{OH} + \text{C}_2\text{H}_6 \rightarrow \text{H}_2\text{O} + \text{C}_2\text{H}_5$                                     | $8.7 \times 10^{-12}$                                     | $1070 \pm 100$    | $2.4 \times 10^{-13}$                                             | 1.1      |
| $\text{OH} + \text{C}_3\text{H}_8 \rightarrow \text{H}_2\text{O} + \text{C}_3\text{H}_7$                                     | $1.0 \times 10^{-11}$                                     | $660 \pm 100$     | $1.1 \times 10^{-12}$                                             | 1.2      |
| $\text{OH} + \text{CH}_3\text{CHO} \rightarrow \text{CH}_3\text{CO} + \text{H}_2\text{O}$                                    | $5.6 \times 10^{-12}$                                     | $-(270 \pm 200)$  | $1.4 \times 10^{-11}$                                             | 1.2      |
| $\text{OH} + \text{C}_2\text{H}_5\text{OH} \rightarrow \text{products}$                                                      | $7.0 \times 10^{-12}$                                     | $235 \pm 100$     | $3.2 \times 10^{-12}$                                             | 1.3      |
| $\text{OH} + \text{CH}_3\text{C(O)OH} \rightarrow \text{products}$                                                           | $4.0 \times 10^{-13}$                                     | $-(200 \pm 400)$  | $8.0 \times 10^{-13}$                                             | 1.3      |
| $\text{OH} + \text{CH}_3\text{C(O)CH}_3 \rightarrow \text{CH}_3\text{C(O)CH}_2 + \text{H}_2\text{O}$                         | $2.2 \times 10^{-12}$                                     | $685 \pm 100$     | $2.2 \times 10^{-13}$                                             | 1.15     |
| $\text{OH} + \text{CH}_3\text{CN} \rightarrow \text{products}$                                                               | $7.8 \times 10^{-13}$                                     | $1050 \pm 200$    | $2.3 \times 10^{-14}$                                             | 1.5      |
| $\text{OH} + \text{CH}_3\text{ONO}_2 \rightarrow \text{products}$                                                            | $5.0 \times 10^{-13}$                                     | $890 \pm 500$     | $2.4 \times 10^{-14}$                                             | 3        |
| $\text{OH} + \text{CH}_3\text{C(O)O}_2\text{NO}_2$ (PAN) $\rightarrow \text{products}$                                       |                                                           |                   | $< 4 \times 10^{-14}$                                             |          |
| $\text{OH} + \text{C}_2\text{H}_5\text{ONO}_2 \rightarrow \text{products}$                                                   | $8.2 \times 10^{-13}$                                     | $450 \pm 300$     | $1.8 \times 10^{-13}$                                             | 3        |
| $\text{HO}_2 + \text{CH}_2\text{O} \rightarrow \text{adduct}$                                                                | $6.7 \times 10^{-15}$                                     | $-(600 \pm 600)$  | $5.0 \times 10^{-14}$                                             | 5        |
| $\text{HO}_2 + \text{CH}_3\text{O}_2 \rightarrow \text{CH}_3\text{OOH} + \text{O}_2$                                         | $3.8 \times 10^{-13}$                                     | $-(800 \pm 400)$  | $5.6 \times 10^{-12}$                                             | 2        |
| $\text{HO}_2 + \text{C}_2\text{H}_5\text{O}_2 \rightarrow \text{C}_2\text{H}_5\text{OOH} + \text{O}_2$                       | $7.5 \times 10^{-13}$                                     | $-(700 \pm 250)$  | $8.0 \times 10^{-12}$                                             | 1.5      |
| $\text{HO}_2 + \text{CH}_3\text{C(O)O}_2 \rightarrow \text{products}$                                                        | $4.5 \times 10^{-13}$                                     | $-(1000 \pm 600)$ | $1.3 \times 10^{-11}$                                             | 2        |
| $\text{NO}_3 + \text{CO} \rightarrow \text{products}$                                                                        |                                                           |                   | $< 4.0 \times 10^{-19}$                                           |          |
| $\text{NO}_3 + \text{CH}_2\text{O} \rightarrow \text{products}$                                                              |                                                           |                   | $5.8 \times 10^{-16}$                                             | 1.3      |
| $\text{NO}_3 + \text{CH}_3\text{CHO} \rightarrow \text{products}$                                                            | $1.4 \times 10^{-12}$                                     | $1900 \pm 300$    | $2.4 \times 10^{-15}$                                             | 1.3      |
| $\text{CH}_3 + \text{O}_2 \rightarrow \text{products}$                                                                       |                                                           |                   | $< 3.0 \times 10^{-16}$                                           |          |
| $\text{CH}_3 + \text{O}_3 \rightarrow \text{products}$                                                                       | $5.4 \times 10^{-12}$                                     | $220 \pm 150$     | $2.6 \times 10^{-12}$                                             | 2        |
| $\text{HCO} + \text{O}_2 \rightarrow \text{CO} + \text{HO}_2$                                                                | $3.5 \times 10^{-12}$                                     | $-(140 \pm 140)$  | $5.5 \times 10^{-12}$                                             | 1.3      |
| $\text{CH}_2\text{OH} + \text{O}_2 \rightarrow \text{CH}_2\text{O} + \text{HO}_2$                                            | $9.1 \times 10^{-12}$                                     | $0 \pm 200$       | $9.1 \times 10^{-12}$                                             | 1.3      |
| $\text{CH}_3\text{O} + \text{O}_2 \rightarrow \text{CH}_2\text{O} + \text{HO}_2$                                             | $3.9 \times 10^{-14}$                                     | $900 \pm 300$     | $1.9 \times 10^{-15}$                                             | 1.5      |
| $\text{CH}_3\text{O} + \text{NO} \rightarrow \text{CH}_2\text{O} + \text{HNO}$                                               | See reference                                             |                   |                                                                   |          |
| $\text{CH}_3\text{O} + \text{NO}_2 \rightarrow \text{CH}_2\text{O} + \text{HONO}$                                            | $1.1 \times 10^{-11}$                                     | $1200 \pm 600$    | $2.0 \times 10^{-13}$                                             | 5        |
| $\text{CH}_3\text{O}_2 + \text{O}_3 \rightarrow \text{products}$                                                             |                                                           |                   | $< 3.0 \times 10^{-17}$                                           |          |
| $\text{CH}_3\text{O}_2 + \text{CH}_3\text{O}_2 \rightarrow \text{products}$                                                  | $2.5 \times 10^{-13}$                                     | $-(190 \pm 190)$  | $4.7 \times 10^{-13}$                                             | 1.5      |
| $\text{CH}_3\text{O}_2 + \text{NO} \rightarrow \text{CH}_3\text{O} + \text{NO}_2$                                            | $3.0 \times 10^{-12}$                                     | $-(280 \pm 60)$   | $7.7 \times 10^{-12}$                                             | 1.15     |
| $\text{CH}_3\text{O}_2 + \text{CH}_3\text{C(O)O}_2 \rightarrow \text{products}$                                              | $1.3 \times 10^{-12}$                                     | $-(640 \pm 200)$  | $1.1 \times 10^{-11}$                                             | 1.5      |
| $\text{C}_2\text{H}_5 + \text{O}_2 \rightarrow \text{C}_2\text{H}_4 + \text{HO}_2$                                           |                                                           |                   | $< 2.0 \times 10^{-14}$                                           |          |
| $\text{C}_2\text{H}_5\text{O} + \text{O}_2 \rightarrow \text{CH}_3\text{CHO} + \text{HO}_2$                                  | $6.3 \times 10^{-14}$                                     | $550 \pm 200$     | $1.0 \times 10^{-14}$                                             | 1.5      |
| $\text{C}_2\text{H}_5\text{O}_2 + \text{C}_2\text{H}_5\text{O}_2 \rightarrow \text{products}$                                | $6.8 \times 10^{-14}$                                     | $0 \pm 300$       | $6.8 \times 10^{-14}$                                             | 2        |
| $\text{C}_2\text{H}_5\text{O}_2 + \text{NO} \rightarrow \text{products}$                                                     | $2.6 \times 10^{-12}$                                     | $-(365 \pm 150)$  | $8.7 \times 10^{-12}$                                             | 1.2      |
| $\text{CH}_3\text{C(O)O}_2 + \text{CH}_3\text{C(O)O}_2 \rightarrow \text{products}$                                          | $2.9 \times 10^{-12}$                                     | $-(500 \pm 150)$  | $1.5 \times 10^{-11}$                                             | 1.5      |
| $\text{CH}_3\text{C(O)O}_2 + \text{NO} \rightarrow \text{products}$                                                          | $5.3 \times 10^{-12}$                                     | $-(360 \pm 150)$  | $1.8 \times 10^{-11}$                                             | 1.4      |
| <b><i>FO<sub>x</sub> Reactions</i></b>                                                                                       |                                                           |                   |                                                                   |          |
| $\text{O} + \text{FO} \rightarrow \text{F} + \text{O}_2$                                                                     | $2.7 \times 10^{-11}$                                     | $0 \pm 250$       | $2.7 \times 10^{-11}$                                             | 3.0      |
| $\text{O} + \text{FO}_2 \rightarrow \text{FO} + \text{O}_2$                                                                  | $5.0 \times 10^{-11}$                                     | $0 \pm 250$       | $5.0 \times 10^{-11}$                                             | 5.0      |
| $\text{OH} + \text{CH}_3\text{F} \rightarrow \text{CH}_2\text{F} + \text{H}_2\text{O}$ (HFC-41)                              | $3.0 \times 10^{-12}$                                     | $1500 \pm 300$    | $2.0 \times 10^{-14}$                                             | 1.1      |
| $\text{OH} + \text{CH}_2\text{F}_2 \rightarrow \text{CHF}_2 + \text{H}_2\text{O}$ (HFC-32)                                   | $1.9 \times 10^{-12}$                                     | $1550 \pm 200$    | $1.0 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CHF}_3 \rightarrow \text{CF}_3 + \text{H}_2\text{O}$ (HFC-23)                                             | $1.0 \times 10^{-12}$                                     | $2440 \pm 200$    | $2.8 \times 10^{-16}$                                             | 1.3      |
| $\text{OH} + \text{CF}_3\text{OH} \rightarrow \text{CF}_3\text{O} + \text{H}_2\text{O}$                                      |                                                           |                   | $< 2 \times 10^{-17}$                                             |          |
| $\text{OH} + \text{CH}_3\text{CHF}_2 \rightarrow \text{products}$ (HFC-161)                                                  | $7.0 \times 10^{-12}$                                     | $1100 \pm 300$    | $1.7 \times 10^{-13}$                                             | 1.4      |
| $\text{OH} + \text{CH}_3\text{CHF}_2 \rightarrow \text{products}$ (HFC-152a)                                                 | $2.4 \times 10^{-12}$                                     | $1260 \pm 200$    | $3.5 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CH}_2\text{FCH}_2\text{F} \rightarrow \text{CHFCH}_2\text{F}$ (HFC-152) + $\text{H}_2\text{O}$            | $1.7 \times 10^{-11}$                                     | $1500 \pm 500$    | $1.1 \times 10^{-13}$                                             | 2.0      |
| $\text{OH} + \text{CH}_3\text{CF}_3 \rightarrow \text{CH}_2\text{CF}_3 + \text{H}_2\text{O}$ (HFC-143a)                      | $1.8 \times 10^{-12}$                                     | $2170 \pm 150$    | $1.2 \times 10^{-15}$                                             | 1.1      |
| $\text{OH} + \text{CH}_2\text{FCHF}_2 \rightarrow \text{products}$ (HFC-143)                                                 | $4.0 \times 10^{-12}$                                     | $1650 \pm 300$    | $1.6 \times 10^{-14}$                                             | 1.5      |
| $\text{OH} + \text{CH}_2\text{FCF}_3 \rightarrow \text{CHFCH}_2\text{F} + \text{H}_2\text{O}$ (HFC-134a)                     | $1.5 \times 10^{-12}$                                     | $1750 \pm 200$    | $4.2 \times 10^{-15}$                                             | 1.1      |
| $\text{OH} + \text{CHF}_2\text{CHF}_2 \rightarrow \text{CF}_2\text{CHF}_2$ (HFC-134) + $\text{H}_2\text{O}$                  | $1.6 \times 10^{-12}$                                     | $1680 \pm 300$    | $5.7 \times 10^{-15}$                                             | 2.0      |
| $\text{OH} + \text{CHF}_2\text{CF}_3 \rightarrow \text{CF}_2\text{CF}_3 + \text{H}_2\text{O}$ (HFC-125)                      | $5.6 \times 10^{-13}$                                     | $1700 \pm 300$    | $1.9 \times 10^{-15}$                                             | 1.3      |
| $\text{OH} + \text{CH}_3\text{OCHF}_2 \rightarrow \text{products}$ (HFOC-152a)                                               | $6.0 \times 10^{-12}$                                     | $1530 \pm 150$    | $3.5 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CF}_3\text{OCH}_3 \rightarrow \text{CF}_3\text{OCH}_2 + \text{H}_2\text{O}$ (HFOC-143a)                   | $1.5 \times 10^{-12}$                                     | $1450 \pm 150$    | $1.2 \times 10^{-14}$                                             | 1.1      |
| $\text{OH} + \text{CF}_2\text{HOCF}_2\text{H} \rightarrow \text{CF}_2\text{OCF}_2\text{H}$ (HFOC-134) + $\text{H}_2\text{O}$ | $1.9 \times 10^{-12}$                                     | $2000 \pm 150$    | $2.3 \times 10^{-15}$                                             | 1.2      |
| $\text{OH} + \text{CF}_3\text{OCHF}_2 \rightarrow \text{CF}_3\text{OCF}_2 + \text{H}_2\text{O}$ (HFOC-125)                   | $4.7 \times 10^{-13}$                                     | $2100 \pm 300$    | $4.1 \times 10^{-16}$                                             | 1.2      |

| Reaction                                                                                                                              | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>K       | $k$ (298 K)<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|------------------|-------------------------------------------------------------------|----------|
| $\text{OH} + \text{CF}_3\text{CH}_2\text{CH}_3 \rightarrow \text{products (HFC-263fb)}$                                               | —                                                         | —                | $4.2 \times 10^{-14}$                                             | 1.5      |
| $\text{OH} + \text{CH}_2\text{FCF}_2\text{CHF}_2 \rightarrow \text{products (HFC-245ca)}$                                             | $2.4 \times 10^{-12}$                                     | $1660 \pm 150$   | $9.1 \times 10^{-15}$                                             | 1.3      |
| $\text{OH} + \text{CHF}_2\text{CHFCHF}_2 \rightarrow \text{products (HFC-245ea)}$                                                     | —                                                         | —                | $1.6 \times 10^{-14}$                                             | 2.0      |
| $\text{OH} + \text{CF}_3\text{CHFCH}_2\text{F} \rightarrow \text{products (HFC-245eb)}$                                               | —                                                         | —                | $1.5 \times 10^{-14}$                                             | 2.0      |
| $\text{OH} + \text{CHF}_2\text{CH}_2\text{CF}_3 \rightarrow \text{products (HFC-245fa)}$                                              | $6.1 \times 10^{-13}$                                     | $1330 \pm 150$   | $7.0 \times 10^{-15}$                                             | 1.2      |
| $\text{OH} + \text{CF}_3\text{CF}_2\text{CH}_2\text{F} \rightarrow \text{CF}_3\text{CF}_2\text{CHF (HFC-236cb)} + \text{H}_2\text{O}$ | $1.5 \times 10^{-12}$                                     | $1750 \pm 500$   | $4.2 \times 10^{-15}$                                             | 2.0      |
| $\text{OH} + \text{CF}_3\text{CHFCHF}_2 \rightarrow \text{products (HFC-236ea)}$                                                      | $1.1 \times 10^{-12}$                                     | $1590 \pm 150$   | $5.3 \times 10^{-15}$                                             | 1.1      |
| $\text{OH} + \text{CF}_3\text{CH}_2\text{CF}_3 \rightarrow \text{CF}_3\text{CHCF}_3 \text{ (HFC-236fa)} + \text{H}_2\text{O}$         | $1.3 \times 10^{-12}$                                     | $2480 \pm 150$   | $3.2 \times 10^{-16}$                                             | 1.1      |
| $\text{OH} + \text{CF}_3\text{CHF}_2\text{CF}_3 \rightarrow \text{CF}_3\text{CF}_2\text{CF}_3 + \text{H}_2\text{O (HFC-227ea)}$       | $5.0 \times 10^{-13}$                                     | $1700 \pm 300$   | $1.7 \times 10^{-15}$                                             | 1.1      |
| $\text{OH} + \text{CHF}_2\text{OCH}_2\text{CF}_3 \rightarrow \text{products (HFOC-245fa)}$                                            | $2.6 \times 10^{-12}$                                     | $1610 \pm 150$   | $1.2 \times 10^{-14}$                                             | 2.0      |
| $\text{OH} + \text{CF}_3\text{CH}_2\text{CF}_2\text{CH}_3 \rightarrow \text{products (HFC-365mfc)}$                                   | $2.0 \times 10^{-12}$                                     | $1750 \pm 200$   | $5.7 \times 10^{-15}$                                             | 1.3      |
| $\text{OH} + \text{CF}_3\text{CH}_2\text{CH}_2\text{CF}_3 \rightarrow \text{products (HFC-356mff)}$                                   | $3.0 \times 10^{-12}$                                     | $1800 \pm 300$   | $7.1 \times 10^{-15}$                                             | 1.3      |
| $\text{OH} + \text{CF}_3\text{CF}_2\text{CH}_2\text{CH}_2\text{F} \rightarrow \text{products (HFC-356mcf)}$                           | $1.7 \times 10^{-12}$                                     | $1110 \pm 200$   | $4.2 \times 10^{-14}$                                             | 2.0      |
| $\text{OH} + \text{CHF}_2\text{CF}_2\text{CF}_2\text{CF}_2\text{H} \rightarrow \text{products (HFC-338pcc)}$                          | $7.8 \times 10^{-13}$                                     | $1530 \pm 200$   | $4.6 \times 10^{-15}$                                             | 1.5      |
| $\text{OH} + \text{CF}_3\text{CH}_2\text{CF}_2\text{CH}_2\text{CF}_3 \rightarrow \text{products (HFC-458mfcf)}$                       | $1.2 \times 10^{-12}$                                     | $1830 \pm 200$   | $2.6 \times 10^{-15}$                                             | 2.0      |
| $\text{OH} + \text{CF}_3\text{CHFCHFCF}_2\text{CF}_3 \rightarrow \text{products (HFC-43-10mee)}$                                      | $5.2 \times 10^{-13}$                                     | $1500 \pm 300$   | $3.4 \times 10^{-15}$                                             | 1.3      |
| $\text{OH} + \text{CF}_3\text{CF}_2\text{CH}_2\text{CH}_2\text{CF}_2\text{CF}_3 \rightarrow \text{(HFC-55-10-mcff) products}$         | —                                                         | —                | $8.3 \times 10^{-15}$                                             | 1.5      |
| $\text{F} + \text{O}_3 \rightarrow \text{FO} + \text{O}_2$                                                                            | $2.2 \times 10^{-11}$                                     | $230 \pm 200$    | $1.0 \times 10^{-11}$                                             | 1.5      |
| $\text{F} + \text{H}_2 \rightarrow \text{HF} + \text{H}$                                                                              | $1.4 \times 10^{-10}$                                     | $500 \pm 200$    | $2.6 \times 10^{-11}$                                             | 1.2      |
| $\text{F} + \text{H}_2\text{O} \rightarrow \text{HF} + \text{OH}$                                                                     | $1.4 \times 10^{-11}$                                     | $0 \pm 200$      | $1.4 \times 10^{-11}$                                             | 1.3      |
| $\text{F} + \text{HNO}_3 \rightarrow \text{HF} + \text{NO}_3$                                                                         | $6.0 \times 10^{-12}$                                     | $-(400 \pm 200)$ | $2.3 \times 10^{-11}$                                             | 1.3      |
| $\text{F} + \text{CH}_4 \rightarrow \text{HF} + \text{CH}_3$                                                                          | $1.6 \times 10^{-10}$                                     | $260 \pm 200$    | $6.7 \times 10^{-11}$                                             | 1.4      |
| $\text{FO} + \text{O}_3 \rightarrow \text{products}$                                                                                  |                                                           |                  | $< 1 \times 10^{-14}$                                             |          |
| $\text{FO} + \text{NO} \rightarrow \text{NO}_2 + \text{F}$                                                                            | $8.2 \times 10^{-12}$                                     | $-(300 \pm 200)$ | $2.2 \times 10^{-11}$                                             | 1.5      |
| $\text{FO} + \text{FO} \rightarrow 2 \text{F} + \text{O}_2$                                                                           | $1.0 \times 10^{-11}$                                     | $0 \pm 250$      | $1.0 \times 10^{-11}$                                             | 1.5      |
| $\text{FO}_2 + \text{O}_3 \rightarrow \text{products}$                                                                                |                                                           |                  | $< 3.4 \times 10^{-16}$                                           |          |
| $\text{FO}_2 + \text{NO} \rightarrow \text{FNO} + \text{O}_2$                                                                         | $7.5 \times 10^{-12}$                                     | $690 \pm 400$    | $7.5 \times 10^{-13}$                                             | 2.0      |
| $\text{FO}_2 + \text{NO}_2 \rightarrow \text{products}$                                                                               | $3.8 \times 10^{-11}$                                     | $2040 \pm 500$   | $4.0 \times 10^{-14}$                                             | 2.0      |
| $\text{FO}_2 + \text{CO} \rightarrow \text{products}$                                                                                 |                                                           |                  | $< 5.1 \times 10^{-16}$                                           |          |
| $\text{FO}_2 + \text{CH}_4 \rightarrow \text{products}$                                                                               |                                                           |                  | $< 2 \times 10^{-16}$                                             |          |
| $\text{CF}_3\text{O} + \text{O}_2 \rightarrow \text{FO}_2 + \text{CF}_2\text{O}$                                                      | $< 3 \times 10^{-11}$                                     | 5000             | $< 1.5 \times 10^{-18}$                                           |          |
| $\text{CF}_3\text{O} + \text{O}_3 \rightarrow \text{CF}_3\text{O}_2 + \text{O}_2$                                                     | $2 \times 10^{-12}$                                       | $1400 \pm 600$   | $1.8 \times 10^{-14}$                                             | 1.3      |
| $\text{CF}_3\text{O} + \text{H}_2\text{O} \rightarrow \text{OH} + \text{CF}_3\text{OH}$                                               | $3 \times 10^{-12}$                                       | $> 3600$         | $< 2 \times 10^{-17}$                                             |          |
| $\text{CF}_3\text{O} + \text{NO} \rightarrow \text{CF}_2\text{O} + \text{FNO}$                                                        | $3.7 \times 10^{-11}$                                     | $-(110 \pm 70)$  | $5.4 \times 10^{-11}$                                             | 1.2      |
| $\text{CF}_3\text{O} + \text{NO}_2 \rightarrow \text{products}$                                                                       | See reference                                             |                  |                                                                   |          |
| $\text{CF}_3\text{O} + \text{CO} \rightarrow \text{products}$                                                                         |                                                           |                  | $< 2 \times 10^{-15}$                                             |          |
| $\text{CF}_3\text{O} + \text{CH}_4 \rightarrow \text{CH}_3 + \text{CF}_3\text{OH}$                                                    | $2.6 \times 10^{-12}$                                     | $1420 \pm 200$   | $2.2 \times 10^{-14}$                                             | 1.1      |
| $\text{CF}_3\text{O} + \text{C}_2\text{H}_6 \rightarrow \text{C}_2\text{H}_5 + \text{CF}_3\text{OH}$                                  | $4.9 \times 10^{-12}$                                     | $400 \pm 100$    | $1.3 \times 10^{-12}$                                             | 1.2      |
| $\text{CF}_3\text{O}_2 + \text{O}_3 \rightarrow \text{CF}_3\text{O} + 2\text{O}_2$                                                    |                                                           |                  | $< 3 \times 10^{-15}$                                             |          |
| $\text{CF}_3\text{O}_2 + \text{CO} \rightarrow \text{CF}_3\text{O} + \text{CO}_2$                                                     |                                                           |                  | $< 5 \times 10^{-16}$                                             |          |
| $\text{CF}_3\text{O}_2 + \text{NO} \rightarrow \text{CF}_3\text{O} + \text{NO}_2$                                                     | $5.4 \times 10^{-12}$                                     | $-(320 \pm 150)$ | $1.6 \times 10^{-11}$                                             | 1.1      |
| <b><i>ClO<sub>x</sub> Reactions</i></b>                                                                                               |                                                           |                  |                                                                   |          |
| $\text{O} + \text{ClO} \rightarrow \text{Cl} + \text{O}_2$                                                                            | $3.0 \times 10^{-11}$                                     | $-(70 \pm 70)$   | $3.8 \times 10^{-11}$                                             | 1.2      |
| $\text{O} + \text{OCIO} \rightarrow \text{ClO} + \text{O}_2$                                                                          | $2.4 \times 10^{-12}$                                     | $960 \pm 300$    | $1.0 \times 10^{-13}$                                             | 2.0      |
| $\text{O} + \text{Cl}_2\text{O} \rightarrow \text{ClO} + \text{ClO}$                                                                  | $2.7 \times 10^{-11}$                                     | $530 \pm 150$    | $4.5 \times 10^{-12}$                                             | 1.3      |
| $\text{O} + \text{HCl} \rightarrow \text{OH} + \text{Cl}$                                                                             | $1.0 \times 10^{-11}$                                     | $3300 \pm 350$   | $1.5 \times 10^{-16}$                                             | 2.0      |
| $\text{O} + \text{HOCl} \rightarrow \text{OH} + \text{ClO}$                                                                           | $1.7 \times 10^{-13}$                                     | $0 \pm 300$      | $1.7 \times 10^{-13}$                                             | 3.0      |
| $\text{O} + \text{ClONO}_2 \rightarrow \text{products}$                                                                               | $2.9 \times 10^{-12}$                                     | $800 \pm 200$    | $2.0 \times 10^{-13}$                                             | 1.5      |
| $\text{O}_3 + \text{OCIO} \rightarrow \text{products}$                                                                                | $2.1 \times 10^{-12}$                                     | $4700 \pm 1000$  | $3.0 \times 10^{-19}$                                             | 2.5      |
| $\text{O}_3 + \text{Cl}_2\text{O}_2 \rightarrow \text{products}$                                                                      | —                                                         | —                | $< 1.0 \times 10^{-19}$                                           | —        |
| $\text{OH} + \text{Cl}_2 \rightarrow \text{HOCl} + \text{Cl}$                                                                         | $1.4 \times 10^{-12}$                                     | $900 \pm 400$    | $6.7 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{ClO} \rightarrow \text{products}$                                                                                  | $1.1 \times 10^{-11}$                                     | $-(120 \pm 150)$ | $1.7 \times 10^{-11}$                                             | 1.5      |
| $\text{OH} + \text{OCIO} \rightarrow \text{HOCl} + \text{O}_2$                                                                        | $4.5 \times 10^{-13}$                                     | $-(800 \pm 200)$ | $6.8 \times 10^{-12}$                                             | 2.0      |
| $\text{OH} + \text{HCl} \rightarrow \text{H}_2\text{O} + \text{Cl}$                                                                   | $2.6 \times 10^{-12}$                                     | $350 \pm 100$    | $8.0 \times 10^{-13}$                                             | 1.2      |
| $\text{OH} + \text{HOCl} \rightarrow \text{H}_2\text{O} + \text{ClO}$                                                                 | $3.0 \times 10^{-12}$                                     | $500 \pm 500$    | $5.0 \times 10^{-13}$                                             | 3.0      |
| $\text{OH} + \text{ClONO}_2 \rightarrow \text{HOCl} + \text{NO}_2$                                                                    | $2.4 \times 10^{-12}$                                     | $1250 \pm 300$   | $3.6 \times 10^{-14}$                                             | 2.0      |
| $\text{OH} + \text{ClONO}_2 \rightarrow \text{products}$                                                                              | $1.2 \times 10^{-12}$                                     | $330 \pm 200$    | $3.9 \times 10^{-13}$                                             | 1.5      |

| Reaction                                                                                                                     | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>$K$ | $k$ (298 K)<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|--------------|-------------------------------------------------------------------|----------|
| $\text{OH} + \text{CH}_3\text{Cl} \rightarrow \text{CH}_2\text{Cl} + \text{H}_2\text{O}$                                     | $4.0 \times 10^{-12}$                                     | 1400±250     | $3.6 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CH}_2\text{Cl}_2 \rightarrow \text{CHCl}_2 + \text{H}_2\text{O}$                                          | $3.8 \times 10^{-12}$                                     | 1050±150     | $1.1 \times 10^{-13}$                                             | 1.4      |
| $\text{OH} + \text{CHCl}_3 \rightarrow \text{CCl}_3 + \text{H}_2\text{O}$                                                    | $2.0 \times 10^{-12}$                                     | 900±150      | $1.0 \times 10^{-13}$                                             | 1.2      |
| $\text{OH} + \text{CCl}_4 \rightarrow \text{products}$                                                                       | $\sim 1.0 \times 10^{-12}$                                | >2300        | $< 5.0 \times 10^{-16}$                                           | —        |
| $\text{OH} + \text{CFCl}_3 \rightarrow \text{products (CFC-11)}$                                                             | $\sim 1.0 \times 10^{-12}$                                | >3700        | $< 5.0 \times 10^{-18}$                                           | —        |
| $\text{OH} + \text{CF}_2\text{Cl}_2 \rightarrow \text{products (CFC-12)}$                                                    | $\sim 1.0 \times 10^{-12}$                                | >3600        | $< 6.0 \times 10^{-18}$                                           | —        |
| $\text{OH} + \text{CH}_2\text{ClF} \rightarrow \text{CHClF} + \text{H}_2\text{O (HCFC-31)}$                                  | $2.8 \times 10^{-12}$                                     | 1270±200     | $3.9 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CHFCl}_2 \rightarrow \text{CFCl}_2 + \text{H}_2\text{O (HCFC-21)}$                                        | $1.7 \times 10^{-12}$                                     | 1250±150     | $2.6 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CHF}_2\text{Cl} \rightarrow \text{CF}_2\text{Cl} + \text{H}_2\text{O (HCFC-22)}$                          | $1.0 \times 10^{-12}$                                     | 1600±150     | $4.7 \times 10^{-15}$                                             | 1.1      |
| $\text{OH} + \text{CH}_3\text{OCl} \rightarrow \text{products}$                                                              | $2.4 \times 10^{-12}$                                     | 360±200      | $7.2 \times 10^{-13}$                                             | 3.0      |
| $\text{OH} + \text{CH}_3\text{CCl}_3 \rightarrow \text{CH}_2\text{CCl}_3 + \text{H}_2\text{O (HCC-140)}$                     | $1.8 \times 10^{-12}$                                     | 1550±150     | $1.0 \times 10^{-14}$                                             | 1.1      |
| $\text{OH} + \text{C}_2\text{HCl}_3 \rightarrow \text{products}$                                                             | $4.9 \times 10^{-13}$                                     | —(450±200)   | $2.2 \times 10^{-12}$                                             | 1.25     |
| $\text{OH} + \text{C}_2\text{Cl}_4 \rightarrow \text{products}$                                                              | $9.4 \times 10^{-12}$                                     | 1200±200     | $1.7 \times 10^{-13}$                                             | 1.25     |
| $\text{OH} + \text{CCl}_3\text{CHO} \rightarrow \text{H}_2\text{O} + \text{CCl}_3\text{CO}$                                  | $8.2 \times 10^{-12}$                                     | 600±300      | $1.1 \times 10^{-12}$                                             | 1.5      |
| $\text{OH} + \text{CH}_3\text{CFCl}_2 \rightarrow \text{CH}_2\text{CFCl}_2 + \text{H}_2\text{O (HCFC-141b)}$                 | $1.7 \times 10^{-12}$                                     | 1700±150     | $5.7 \times 10^{-15}$                                             | 1.2      |
| $\text{OH} + \text{CH}_3\text{CF}_2\text{Cl} \rightarrow \text{CH}_2\text{CF}_2\text{Cl} + \text{H}_2\text{O (HCFC-142b)}$   | $1.3 \times 10^{-12}$                                     | 1800±150     | $3.1 \times 10^{-15}$                                             | 1.2      |
| $\text{OH} + \text{CH}_2\text{ClCF}_2\text{Cl} \rightarrow \text{CHClCF}_2\text{Cl (HCFC-132b)} + \text{H}_2\text{O}$        | $3.6 \times 10^{-12}$                                     | 1600±400     | $1.7 \times 10^{-14}$                                             | 2.0      |
| $\text{OH} + \text{CHCl}_2\text{CF}_2\text{Cl} \rightarrow \text{CCl}_2\text{CF}_2\text{Cl (HCFC-122)} + \text{H}_2\text{O}$ | $1.0 \times 10^{-12}$                                     | 900±150      | $4.9 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CHFClCF}_2\text{Cl} \rightarrow \text{CFClCF}_2\text{Cl (HCFC-122a)} + \text{H}_2\text{O}$                | $1.0 \times 10^{-12}$                                     | 1250±150     | $1.5 \times 10^{-14}$                                             | 1.1      |
| $\text{OH} + \text{CH}_2\text{ClCF}_3 \rightarrow \text{CHClCF}_3 + \text{H}_2\text{O (HCFC-133a)}$                          | $5.2 \times 10^{-13}$                                     | 1100±300     | $1.3 \times 10^{-14}$                                             | 1.3      |
| $\text{OH} + \text{CHCl}_2\text{CF}_3 \rightarrow \text{CCl}_2\text{CF}_3 + \text{H}_2\text{O (HCFC-123)}$                   | $7.0 \times 10^{-13}$                                     | 900±150      | $3.4 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CHFClCF}_2\text{Cl} \rightarrow \text{CFClCF}_2\text{Cl (HCFC-123a)} + \text{H}_2\text{O}$                | $9.2 \times 10^{-13}$                                     | 1280±150     | $1.3 \times 10^{-14}$                                             | 1.2      |
| $\text{OH} + \text{CHFClCF}_3 \rightarrow \text{CFClCF}_3 + \text{H}_2\text{O (HCFC-124)}$                                   | $8.0 \times 10^{-13}$                                     | 1350±150     | $8.6 \times 10^{-15}$                                             | 1.2      |
| $\text{OH} + \text{CH}_3\text{CF}_2\text{CFCl}_2 \rightarrow \text{products (HCFC-243cc)}$                                   | $7.7 \times 10^{-13}$                                     | 1700±300     | $2.6 \times 10^{-15}$                                             | 2.0      |
| $\text{OH} + \text{CF}_3\text{CF}_2\text{CHCl}_2 \rightarrow \text{products (HCFC-225ca)}$                                   | $1.0 \times 10^{-12}$                                     | 1100±200     | $2.5 \times 10^{-14}$                                             | 1.3      |
| $\text{OH} + \text{CF}_2\text{ClCF}_2\text{CH}_2\text{F} \rightarrow \text{products (HCFC-225cb)}$                           | $5.5 \times 10^{-13}$                                     | 1250±200     | $8.3 \times 10^{-15}$                                             | 1.3      |
| $\text{HO}_2 + \text{Cl} \rightarrow \text{HCl} + \text{O}_2$                                                                | $1.8 \times 10^{-11}$                                     | —(170±200)   | $3.2 \times 10^{-11}$                                             | 1.5      |
| $\rightarrow \text{OH} + \text{ClO}$                                                                                         | $4.1 \times 10^{-11}$                                     | 450±200      | $9.1 \times 10^{-12}$                                             | 2.0      |
| $\text{HO}_2 + \text{ClO} \rightarrow \text{HOCl} + \text{O}_2$                                                              | $4.8 \times 10^{-13}$                                     | —(700±)      | $5.0 \times 10^{-12}$                                             | 1.4      |
| $\text{H}_2\text{O} + \text{ClONO}_2 \rightarrow \text{products}$                                                            | —                                                         | —            | $< 2.0 \times 10^{-21}$                                           | —        |
| $\text{NO} + \text{OCIO} \rightarrow \text{NO}_2 + \text{ClO}$                                                               | $2.5 \times 10^{-12}$                                     | 600±300      | $3.4 \times 10^{-13}$                                             | 2.0      |
| $\text{NO} + \text{Cl}_2\text{O}_2 \rightarrow \text{products}$                                                              | —                                                         | —            | $< 2.0 \times 10^{-14}$                                           | —        |
| $\text{NO}_3 + \text{HCl} \rightarrow \text{HNO}_3 + \text{Cl}$                                                              | —                                                         | —            | $< 5.0 \times 10^{-17}$                                           | —        |
| $\text{HO}_2\text{NO}_2 + \text{HCl} \rightarrow \text{products}$                                                            | —                                                         | —            | $< 1.0 \times 10^{-21}$                                           | —        |
| $\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$                                                                 | $2.9 \times 10^{-11}$                                     | 260±100      | $1.2 \times 10^{-11}$                                             | 1.15     |
| $\text{Cl} + \text{H}_2 \rightarrow \text{HCl} + \text{H}$                                                                   | $3.7 \times 10^{-11}$                                     | 2300±200     | $1.6 \times 10^{-14}$                                             | 1.25     |
| $\text{Cl} + \text{H}_2\text{O}_2 \rightarrow \text{HCl} + \text{HO}_2$                                                      | $1.1 \times 10^{-11}$                                     | 980±500      | $4.1 \times 10^{-13}$                                             | 1.5      |
| $\text{Cl} + \text{NO}_3 \rightarrow \text{ClO} + \text{NO}_2$                                                               | $2.4 \times 10^{-11}$                                     | 0±400        | $2.4 \times 10^{-11}$                                             | 1.5      |
| $\text{Cl} + \text{N}_2\text{O} \rightarrow \text{ClO} + \text{N}_2$                                                         | See reference                                             | —            | —                                                                 | —        |
| $\text{Cl} + \text{HNO}_3 \rightarrow \text{products}$                                                                       | —                                                         | —            | $< 2.0 \times 10^{-16}$                                           | —        |
| $\text{Cl} + \text{CH}_4 \rightarrow \text{HCl} + \text{CH}_3$                                                               | $1.1 \times 10^{-11}$                                     | 1400±150     | $1.0 \times 10^{-13}$                                             | 1.1      |
| $\text{Cl} + \text{CH}_3\text{D} \rightarrow \text{products}$                                                                | —                                                         | —            | $7.4 \times 10^{-14}$                                             | 2.0      |
| $\text{Cl} + \text{H}_2\text{CO} \rightarrow \text{HCl} + \text{HCO}$                                                        | $8.1 \times 10^{-11}$                                     | 30±100       | $7.3 \times 10^{-11}$                                             | 1.15     |
| $\text{Cl} + \text{CH}_3\text{O}_2 \rightarrow \text{products}$                                                              | —                                                         | —            | $1.6 \times 10^{-10}$                                             | 1.5      |
| $\text{Cl} + \text{CH}_3\text{OH} \rightarrow \text{CH}_2\text{OH} + \text{HCl}$                                             | $5.4 \times 10^{-11}$                                     | 0±250        | $5.4 \times 10^{-11}$                                             | 1.5      |
| $\text{Cl} + \text{C}_2\text{H}_6 \rightarrow \text{HCl} + \text{C}_2\text{H}_5$                                             | $7.7 \times 10^{-11}$                                     | 90±90        | $5.7 \times 10^{-11}$                                             | 1.1      |
| $\text{Cl} + \text{C}_2\text{H}_5\text{O}_2 \rightarrow \text{ClO} + \text{C}_2\text{H}_5\text{O}$                           | —                                                         | —            | $7.4 \times 10^{-11}$                                             | 2.0      |
| $\rightarrow \text{HCl} + \text{C}_2\text{H}_4\text{O}_2$                                                                    | —                                                         | —            | $7.7 \times 10^{-11}$                                             | 2.0      |
| $\text{Cl} + \text{CH}_3\text{CN} \rightarrow \text{products}$                                                               | $1.6 \times 10^{-11}$                                     | 2140±300     | $1.2 \times 10^{-14}$                                             | 2.0      |
| $\text{Cl} + \text{CH}_3\text{CO}_3\text{NO}_2 \rightarrow \text{products}$                                                  | —                                                         | —            | $< 1 \times 10^{-14}$                                             | —        |
| $\text{Cl} + \text{C}_3\text{H}_8 \rightarrow \text{HCl} + \text{C}_3\text{H}_7$                                             | $1.2 \times 10^{-10}$                                     | —(40±250)    | $1.4 \times 10^{-10}$                                             | 1.3      |
| $\text{Cl} + \text{OCIO} \rightarrow \text{ClO} + \text{ClO}$                                                                | $3.4 \times 10^{-11}$                                     | —(160±200)   | $5.8 \times 10^{-11}$                                             | 1.25     |
| $\text{Cl} + \text{ClOO} \rightarrow \text{Cl}_2 + \text{O}_2$                                                               | $2.3 \times 10^{-10}$                                     | 0±250        | $2.3 \times 10^{-10}$                                             | 3.0      |
| $\rightarrow \text{ClO} + \text{ClO}$                                                                                        | $1.2 \times 10^{-11}$                                     | 0±250        | $1.2 \times 10^{-11}$                                             | 3.0      |
| $\text{Cl} + \text{Cl}_2\text{O} \rightarrow \text{Cl}_2 + \text{ClO}$                                                       | $6.2 \times 10^{-11}$                                     | —(130±130)   | $9.6 \times 10^{-11}$                                             | 1.2      |
| $\text{Cl} + \text{Cl}_2\text{O}_2 \rightarrow \text{products}$                                                              | —                                                         | —            | $1.0 \times 10^{-10}$                                             | 2.0      |
| $\text{Cl} + \text{HOCl} \rightarrow \text{products}$                                                                        | $2.5 \times 10^{-12}$                                     | 130±250      | $1.6 \times 10^{-12}$                                             | 1.5      |
| $\text{Cl} + \text{ClNO} \rightarrow \text{NO} + \text{Cl}_2$                                                                | $5.8 \times 10^{-11}$                                     | —(100±200)   | $8.1 \times 10^{-11}$                                             | 1.5      |

| Reaction                                                                                                 | A<br>cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup> | E/R<br>K   | k (298 K)<br>cm <sup>3</sup> molecule <sup>-1</sup> s <sup>-1</sup> | f(298) |
|----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------|---------------------------------------------------------------------|--------|
| Cl + ClONO <sub>2</sub> → products                                                                       | 6.5×10 <sup>-12</sup>                                       | -(135±50)  | 1.0×10 <sup>-11</sup>                                               | 1.2    |
| Cl + CH <sub>3</sub> Cl → CH <sub>2</sub> Cl + HCl                                                       | 3.2×10 <sup>-11</sup>                                       | 1250±200   | 4.8×10 <sup>-13</sup>                                               | 1.2    |
| Cl + CH <sub>2</sub> Cl <sub>2</sub> → HCl + CHCl <sub>2</sub>                                           | 3.1×10 <sup>-11</sup>                                       | 1350±500   | 3.3×10 <sup>-13</sup>                                               | 1.5    |
| Cl + CHCl <sub>3</sub> → HCl + CCl <sub>3</sub>                                                          | 8.2×10 <sup>-12</sup>                                       | 1325±300   | 9.6×10 <sup>-14</sup>                                               | 1.3    |
| Cl + CH <sub>3</sub> F → HCl + CH <sub>2</sub> F (HFC-41)                                                | 2.0×10 <sup>-11</sup>                                       | 1200±500   | 3.5×10 <sup>-13</sup>                                               | 1.3    |
| Cl + CH <sub>2</sub> F <sub>2</sub> → HCl + CHF <sub>2</sub> (HFC-32)                                    | 1.2×10 <sup>-11</sup>                                       | 1630±500   | 5.0×10 <sup>-14</sup>                                               | 1.5    |
| Cl + CF <sub>3</sub> H → HCl + CF <sub>3</sub> (HFC-23)                                                  | —                                                           | —          | 3.0×10 <sup>-18</sup>                                               | 5.0    |
| Cl + CH <sub>2</sub> FCI → HCl + CHFCl (HCFC-31)                                                         | 1.2×10 <sup>-11</sup>                                       | 1390±500   | 1.1×10 <sup>-13</sup>                                               | 2.0    |
| Cl + CHFCl <sub>2</sub> → HCl + CFCl <sub>2</sub> (HCFC-21)                                              | 5.5×10 <sup>-12</sup>                                       | 1675±200   | 2.0×10 <sup>-14</sup>                                               | 1.3    |
| Cl + CHF <sub>2</sub> Cl → HCl + CF <sub>2</sub> Cl (HCFC-22)                                            | 5.9×10 <sup>-12</sup>                                       | 2430±200   | 1.7×10 <sup>-15</sup>                                               | 1.3    |
| Cl + CH <sub>3</sub> CCl <sub>3</sub> → CH <sub>2</sub> CCl <sub>3</sub> + HCl                           | 2.8×10 <sup>-12</sup>                                       | 1790±400   | 7.0×10 <sup>-15</sup>                                               | 2.0    |
| Cl + CH <sub>3</sub> CH <sub>2</sub> F → HCl + CH <sub>3</sub> CHF (HFC-161)                             | 1.8×10 <sup>-11</sup>                                       | 290±500    | 6.8×10 <sup>-12</sup>                                               | 3.0    |
| → HCl + CH <sub>2</sub> CH <sub>2</sub> F                                                                | 1.4×10 <sup>-11</sup>                                       | 880±500    | 7.3×10 <sup>-13</sup>                                               | 3.0    |
| Cl + CH <sub>3</sub> CHF <sub>2</sub> → HCl + CH <sub>3</sub> CF <sub>2</sub> (HFC-152a)                 | 6.4×10 <sup>-12</sup>                                       | 950±500    | 2.6×10 <sup>-13</sup>                                               | 1.3    |
| → HCl + CH <sub>2</sub> CHF <sub>2</sub>                                                                 | 7.2×10 <sup>-12</sup>                                       | 2390±500   | 2.4×10 <sup>-15</sup>                                               | 3.0    |
| Cl + CH <sub>2</sub> FCH <sub>2</sub> F → HCl + CHFCH <sub>2</sub> F (HFC-152)                           | 2.6×10 <sup>-11</sup>                                       | 1060±500   | 7.5×10 <sup>-13</sup>                                               | 3.0    |
| Cl + CH <sub>3</sub> CFCl <sub>2</sub> → HCl + CH <sub>2</sub> CFCl <sub>2</sub> (HCFC-141b)             | 1.8×10 <sup>-12</sup>                                       | 2000±300   | 2.2×10 <sup>-15</sup>                                               | 1.2    |
| Cl + CH <sub>3</sub> CF <sub>2</sub> Cl → HCl + CH <sub>2</sub> CF <sub>2</sub> Cl (HCFC-142b)           | 1.4×10 <sup>-12</sup>                                       | 2420±500   | 4.2×10 <sup>-16</sup>                                               | 1.2    |
| Cl + CH <sub>3</sub> CF <sub>3</sub> → HCl + CH <sub>2</sub> CF <sub>3</sub> (HFC-143a)                  | 1.2×10 <sup>-11</sup>                                       | 3880±500   | 2.6×10 <sup>-17</sup>                                               | 5.0    |
| Cl + CH <sub>2</sub> FCHF <sub>2</sub> → HCl + CH <sub>2</sub> FCF <sub>2</sub> (HFC-143)                | 5.5×10 <sup>-12</sup>                                       | 1610±500   | 2.5×10 <sup>-14</sup>                                               | 3.0    |
| → HCl + CHFCHF <sub>2</sub>                                                                              | 7.7×10 <sup>-12</sup>                                       | 1720±500   | 2.4×10 <sup>-14</sup>                                               | 3.0    |
| Cl + CH <sub>2</sub> ClCF <sub>3</sub> → HCl + CHClCF <sub>3</sub> (HCFC-133a)                           | 1.8×10 <sup>-12</sup>                                       | 1710±500   | 5.9×10 <sup>-15</sup>                                               | 3.0    |
| Cl + CH <sub>2</sub> FCF <sub>3</sub> → HCl + CHF <sub>2</sub> CF <sub>3</sub> (HFC-134a)                | —                                                           | —          | 1.5×10 <sup>-15</sup>                                               | 1.2    |
| Cl + CHF <sub>2</sub> CHF <sub>2</sub> → HCl + CF <sub>2</sub> CHF <sub>2</sub> (HCF-134)                | 7.5×10 <sup>-12</sup>                                       | 2430±500   | 2.2×10 <sup>-15</sup>                                               | 1.5    |
| Cl + CHCl <sub>2</sub> CF <sub>3</sub> → HCl + CCl <sub>2</sub> CF <sub>3</sub> (HCFC-123)               | 4.4×10 <sup>-12</sup>                                       | 1750±500   | 1.2×10 <sup>-14</sup>                                               | 1.3    |
| Cl + CHFClCF <sub>3</sub> → HCl + CFClCF <sub>3</sub> (HCFC-124)                                         | 1.1×10 <sup>-12</sup>                                       | 1800±500   | 2.7×10 <sup>-15</sup>                                               | 1.3    |
| Cl + CHF <sub>2</sub> CF <sub>3</sub> → HCl + CF <sub>2</sub> CF <sub>3</sub> (HFC-125)                  | —                                                           | —          | 2.4×10 <sup>-16</sup>                                               | 1.3    |
| ClO + O <sub>3</sub> → ClOO + O <sub>2</sub>                                                             | —                                                           | —          | <1.4×10 <sup>-17</sup>                                              | —      |
| → OClO + O <sub>2</sub>                                                                                  | 1.0×10 <sup>-12</sup>                                       | >4000      | <1.0×10 <sup>-18</sup>                                              | —      |
| ClO + H <sub>2</sub> → products                                                                          | ~1.0×10 <sup>-12</sup>                                      | >4800      | <1.0×10 <sup>-19</sup>                                              | —      |
| ClO + NO → NO <sub>2</sub> + Cl                                                                          | 6.4×10 <sup>-12</sup>                                       | -(290±100) | 1.7×10 <sup>-11</sup>                                               | 1.15   |
| ClO + NO <sub>3</sub> → ClOO + NO <sub>2</sub>                                                           | 4.7×10 <sup>-13</sup>                                       | 0±400      | 4.7×10 <sup>-13</sup>                                               | 1.5    |
| ClO + N <sub>2</sub> O → products                                                                        | ~1.0×10 <sup>-12</sup>                                      | >4300      | <6.0×10 <sup>-19</sup>                                              | —      |
| ClO + CO → products                                                                                      | ~1.0×10 <sup>-12</sup>                                      | >3700      | <4.0×10 <sup>-18</sup>                                              | —      |
| ClO + CH <sub>4</sub> → products                                                                         | ~1.0×10 <sup>-12</sup>                                      | >3700      | <4.0×10 <sup>-18</sup>                                              | —      |
| ClO + H <sub>2</sub> CO → products                                                                       | ~1.0×10 <sup>-12</sup>                                      | >2100      | <1.0×10 <sup>-15</sup>                                              | —      |
| ClO + CH <sub>3</sub> O <sub>2</sub> → products                                                          | 3.3×10 <sup>-12</sup>                                       | 115±115    | 2.2×10 <sup>-12</sup>                                               | 1.5    |
| ClO + ClO → Cl <sub>2</sub> + O <sub>2</sub>                                                             | 1.0×10 <sup>-12</sup>                                       | 1590±300   | 4.8×10 <sup>-15</sup>                                               | 1.5    |
| → ClOO + Cl                                                                                              | 3.0×10 <sup>-11</sup>                                       | 2450±500   | 8.0×10 <sup>-15</sup>                                               | 1.5    |
| → OClO + Cl                                                                                              | 3.5×10 <sup>-13</sup>                                       | 1370±300   | 3.5×10 <sup>-15</sup>                                               | 1.5    |
| HCl + ClONO <sub>2</sub> → products                                                                      | —                                                           | —          | <1.0×10 <sup>-20</sup>                                              | —      |
| CH <sub>2</sub> ClO + O <sub>2</sub> → CHClO + HO <sub>2</sub>                                           | —                                                           | —          | 6 × 10 <sup>-14</sup>                                               | 5      |
| CH <sub>2</sub> ClO <sub>2</sub> + HO <sub>2</sub> → CH <sub>2</sub> ClO <sub>2</sub> H + O <sub>2</sub> | 3.3 × 10 <sup>-13</sup>                                     | -(820±200) | 5.2 × 10 <sup>-12</sup>                                             | 1.5    |
| CH <sub>2</sub> ClO <sub>2</sub> + NO → CH <sub>2</sub> ClO + NO <sub>2</sub>                            | 7 × 10 <sup>-12</sup>                                       | -(300±200) | 1.9 × 10 <sup>-11</sup>                                             | 1.5    |
| CCl <sub>3</sub> O <sub>2</sub> + NO → CCl <sub>2</sub> O + NO <sub>2</sub> + Cl                         | 7.3 × 10 <sup>-12</sup>                                     | -(270±200) | 1.8 × 10 <sup>-11</sup>                                             | 1.3    |
| CCl <sub>2</sub> FO <sub>2</sub> + NO → CClFO + NO <sub>2</sub> + Cl                                     | 4.5 × 10 <sup>-12</sup>                                     | -(350±200) | 1.5 × 10 <sup>-11</sup>                                             | 1.3    |
| CClF <sub>2</sub> O <sub>2</sub> + NO → CF <sub>2</sub> O + NO <sub>2</sub> + Cl                         | 3.8 × 10 <sup>-12</sup>                                     | -(400±200) | 1.5 × 10 <sup>-11</sup>                                             | 1.2    |
| <b>BrO<sub>x</sub> Reactions</b>                                                                         |                                                             |            |                                                                     |        |
| O + BrO → Br + O <sub>2</sub>                                                                            | 1.9×10 <sup>-11</sup>                                       | -(230±150) | 4.1×10 <sup>-11</sup>                                               | 1.5    |
| O + HBr → OH + Br                                                                                        | 5.8×10 <sup>-12</sup>                                       | 1500±200   | 3.8×10 <sup>-14</sup>                                               | 1.3    |
| O + HOBr → OH + BrO                                                                                      | 1.2×10 <sup>-10</sup>                                       | 430±300    | 2.8×10 <sup>-11</sup>                                               | 3.0    |
| OH + Br <sub>2</sub> → HOBr + Br                                                                         | 4.2×10 <sup>-11</sup>                                       | 0±600      | 4.2×10 <sup>-11</sup>                                               | 1.3    |
| OH + BrO → products                                                                                      | —                                                           | —          | 7.5×10 <sup>-11</sup>                                               | 3.0    |
| OH + HBr → H <sub>2</sub> O + Br                                                                         | 1.1×10 <sup>-11</sup>                                       | 0±250      | 1.1×10 <sup>-11</sup>                                               | 1.2    |
| OH + CH <sub>3</sub> Br → CH <sub>2</sub> Br + H <sub>2</sub> O                                          | 4.0×10 <sup>-12</sup>                                       | 1470±150   | 2.9×10 <sup>-14</sup>                                               | 1.1    |
| OH + CH <sub>2</sub> Br <sub>2</sub> → CHBr <sub>2</sub> + H <sub>2</sub> O                              | 2.4×10 <sup>-12</sup>                                       | 900±300    | 1.2×10 <sup>-13</sup>                                               | 1.1    |
| OH + CHBr <sub>3</sub> → CBr <sub>3</sub> + H <sub>2</sub> O                                             | 1.6×10 <sup>-12</sup>                                       | 710±200    | 1.5×10 <sup>-13</sup>                                               | 2.0    |



| Reaction                                                                                                   | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>$\text{K}$ | $k$ (298 K)<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|---------------------|-------------------------------------------------------------------|----------|
| $\text{OH} + \text{CHF}_2\text{Br} \rightarrow \text{CF}_2\text{Br} + \text{H}_2\text{O}$                  | $1.1 \times 10^{-12}$                                     | $1400 \pm 200$      | $1.0 \times 10^{-14}$                                             | 1.1      |
| $\text{OH} + \text{CH}_2\text{ClBr} \rightarrow \text{CHClBr} + \text{H}_2\text{O}$                        | $2.3 \times 10^{-12}$                                     | $930 \pm 150$       | $1.0 \times 10^{-13}$                                             | 1.2      |
| $\text{OH} + \text{CF}_2\text{ClBr} \rightarrow \text{products}$                                           | —                                                         | —                   | $< 1.5 \times 10^{-16}$                                           | —        |
| $\text{OH} + \text{CF}_2\text{Br}_2 \rightarrow \text{products}$                                           | —                                                         | —                   | $< 5.0 \times 10^{-16}$                                           | —        |
| $\text{OH} + \text{CF}_3\text{Br} \rightarrow \text{products}$                                             | —                                                         | —                   | $< 1.2 \times 10^{-16}$                                           | —        |
| $\text{OH} + \text{CH}_2\text{BrCF}_3 \rightarrow \text{CHBrCF}_3 + \text{H}_2\text{O}$                    | $1.4 \times 10^{-12}$                                     | $1340 \pm 200$      | $1.6 \times 10^{-14}$                                             | 1.3      |
| $\text{OH} + \text{CHFBrCF}_3 \rightarrow \text{CFBrCF}_3$                                                 | $7.2 \times 10^{-13}$                                     | $1110 \pm 150$      | $1.8 \times 10^{-14}$                                             | 1.5      |
| $\text{OH} + \text{CHClBrCF}_3 \rightarrow \text{CClBrCF}_3 + \text{H}_2\text{O}$                          | $1.3 \times 10^{-12}$                                     | $995 \pm 150$       | $4.5 \times 10^{-14}$                                             | 1.5      |
| $\text{OH} + \text{CF}_2\text{BrCH}_2\text{FCl} \rightarrow \text{CF}_2\text{BrCFCl} + \text{H}_2\text{O}$ | $9.3 \times 10^{-13}$                                     | $1250 \pm 150$      | $1.4 \times 10^{-14}$                                             | 1.5      |
| $\text{OH} + \text{CF}_2\text{BrCF}_2\text{Br} \rightarrow \text{products}$                                | —                                                         | —                   | $< 1.5 \times 10^{-16}$                                           | —        |
| $\text{HO}_2 + \text{Br} \rightarrow \text{HBr} + \text{O}_2$                                              | $1.5 \times 10^{-11}$                                     | $600 \pm 600$       | $2.0 \times 10^{-12}$                                             | 2.0      |
| $\text{HO}_2 + \text{BrO} \rightarrow \text{products}$                                                     | $3.4 \times 10^{-12}$                                     | $-(540 \pm 200)$    | $2.1 \times 10^{-11}$                                             | 1.5      |
| $\text{NO}_3 + \text{HBr} \rightarrow \text{HNO}_3 + \text{Br}$                                            | —                                                         | —                   | $< 1.0 \times 10^{-16}$                                           | —        |
| $\text{Cl} + \text{CH}_2\text{ClBr} \rightarrow \text{HCl} + \text{CHClBr}$                                | $4.3 \times 10^{-11}$                                     | $1370 \pm 500$      | $4.3 \times 10^{-13}$                                             | 3.0      |
| $\text{Cl} + \text{CH}_3\text{Br} \rightarrow \text{HCl} + \text{CH}_2\text{Br}$                           | $1.5 \times 10^{-11}$                                     | $1060 \pm 100$      | $4.3 \times 10^{-13}$                                             | 1.2      |
| $\text{Cl} + \text{CH}_2\text{Br}_2 \rightarrow \text{HCl} + \text{CHBr}_2$                                | $6.4 \times 10^{-12}$                                     | $810 \pm 100$       | $4.2 \times 10^{-13}$                                             | 1.2      |
| $\text{Br} + \text{O}_3 \rightarrow \text{BrO} + \text{O}_2$                                               | $1.7 \times 10^{-11}$                                     | $800 \pm 200$       | $1.2 \times 10^{-12}$                                             | 1.2      |
| $\text{Br} + \text{H}_2\text{O}_2 \rightarrow \text{HBr} + \text{HO}_2$                                    | $1.0 \times 10^{-11}$                                     | $> 3000$            | $< 5.0 \times 10^{-16}$                                           | —        |
| $\text{Br} + \text{NO}_3 \rightarrow \text{BrO} + \text{NO}_2$                                             | —                                                         | —                   | $1.6 \times 10^{-11}$                                             | 2.0      |
| $\text{Br} + \text{H}_2\text{CO} \rightarrow \text{HBr} + \text{HCO}$                                      | $1.7 \times 10^{-11}$                                     | $800 \pm 200$       | $1.1 \times 10^{-12}$                                             | 1.3      |
| $\text{Br} + \text{OCIO} \rightarrow \text{BrO} + \text{ClO}$                                              | $2.6 \times 10^{-11}$                                     | $1300 \pm 300$      | $3.4 \times 10^{-13}$                                             | 2.0      |
| $\text{Br} + \text{Cl}_2\text{O} \rightarrow \text{BrCl} + \text{ClO}$                                     | $2.1 \times 10^{-11}$                                     | $470 \pm 150$       | $4.3 \times 10^{-12}$                                             | 1.3      |
| $\text{Br} + \text{Cl}_2\text{O}_2 \rightarrow \text{products}$                                            | —                                                         | —                   | $3.0 \times 10^{-12}$                                             | 2.0      |
| $\text{BrO} + \text{O}_3 \rightarrow \text{products}$                                                      | $\sim 1.0 \times 10^{-12}$                                | $> 3200$            | $< 2.0 \times 10^{-17}$                                           | —        |
| $\text{BrO} + \text{NO} \rightarrow \text{NO}_2 + \text{Br}$                                               | $8.8 \times 10^{-12}$                                     | $-(260 \pm 130)$    | $2.1 \times 10^{-11}$                                             | 1.15     |
| $\text{BrO} + \text{NO}_3 \rightarrow \text{products}$                                                     | —                                                         | —                   | $1.0 \times 10^{-12}$                                             | 3.0      |
| $\text{BrO} + \text{ClO} \rightarrow \text{Br} + \text{ClOO}$                                              | $1.6 \times 10^{-12}$                                     | $-(430 \pm 200)$    | $6.8 \times 10^{-12}$                                             | 1.25     |
| $\quad \quad \rightarrow \text{Br} + \text{ClOO}$                                                          | $2.9 \times 10^{-12}$                                     | $-(220 \pm 200)$    | $6.1 \times 10^{-12}$                                             | 1.25     |
| $\quad \quad \rightarrow \text{BrCl} + \text{O}_2$                                                         | $5.8 \times 10^{-13}$                                     | $-(170 \pm 200)$    | $1.0 \times 10^{-12}$                                             | 1.25     |
| $\text{BrO} + \text{BrO} \rightarrow \text{products}$                                                      | $1.5 \times 10^{-12}$                                     | $-(230 \pm 150)$    | $3.2 \times 10^{-12}$                                             | 1.15     |
| $\text{CH}_2\text{BrO}_2 + \text{NO} \rightarrow \text{CH}_2\text{O} + \text{NO}_2 + \text{Br}$            | $4 \times 10^{-12}$                                       | $-(300 \pm 200)$    | $1.1 \times 10^{-11}$                                             | 1.5      |
| <b><i>IO<sub>x</sub> Reactions</i></b>                                                                     |                                                           |                     |                                                                   |          |
| $\text{O} + \text{I}_2 \rightarrow \text{IO} + \text{I}$                                                   | $1.4 \times 10^{-10}$                                     | $0 \pm 250$         | $1.4 \times 10^{-10}$                                             | 1.4      |
| $\text{O} + \text{IO} \rightarrow \text{O}_2 + \text{I}$                                                   |                                                           |                     | $1.2 \times 10^{-10}$                                             | 2.0      |
| $\text{OH} + \text{I}_2 \rightarrow \text{HOI} + \text{I}$                                                 |                                                           |                     | $1.8 \times 10^{-10}$                                             | 2.0      |
| $\text{OH} + \text{HI} \rightarrow \text{H}_2\text{O} + \text{I}$                                          |                                                           |                     | $3.0 \times 10^{-11}$                                             | 2.0      |
| $\text{OH} + \text{CH}_3\text{I} \rightarrow \text{H}_2\text{O} + \text{CH}_2\text{I}$                     | $3.1 \times 10^{-12}$                                     | $1120 \pm 500$      | $7.2 \times 10^{-14}$                                             | 3.0      |
| $\text{OH} + \text{CF}_3\text{I} \rightarrow \text{HOI} + \text{CF}_3$                                     |                                                           |                     | $3.1 \times 10^{-14}$                                             | 5.0      |
| $\text{HO}_2 + \text{I} \rightarrow \text{HI} + \text{O}_2$                                                | $1.5 \times 10^{-11}$                                     | $1090 \pm 500$      | $3.8 \times 10^{-13}$                                             | 2.0      |
| $\text{HO}_2 + \text{IO} \rightarrow \text{HOI} + \text{O}_2$                                              |                                                           |                     | $8.4 \times 10^{-11}$                                             | 1.5      |
| $\text{NO}_3 + \text{HI} \rightarrow \text{HNO}_3 + \text{I}$                                              | See reference                                             |                     |                                                                   |          |
| $\text{I} + \text{O}_3 \rightarrow \text{IO} + \text{O}_2$                                                 | $2.3 \times 10^{-11}$                                     | $870 \pm 200$       | $1.2 \times 10^{-12}$                                             | 1.2      |
| $\text{I} + \text{BrO} \rightarrow \text{IO} + \text{Br}$                                                  | —                                                         | —                   | $1.2 \times 10^{-11}$                                             | 2.0      |
| $\text{IO} + \text{NO} \rightarrow \text{I} + \text{NO}_2$                                                 | $9.1 \times 10^{-12}$                                     | $-(240 \pm 150)$    | $2.0 \times 10^{-11}$                                             | 1.2      |
| $\text{IO} + \text{ClO} \rightarrow \text{products}$                                                       | $5.1 \times 10^{-12}$                                     | $-(280 \pm 200)$    | $1.3 \times 10^{-11}$                                             | 2.0      |
| $\text{IO} + \text{BrO} \rightarrow \text{products}$                                                       | —                                                         | —                   | $6.9 \times 10^{-11}$                                             | 1.5      |
| $\text{IO} + \text{IO} \rightarrow \text{products}$                                                        | $1.5 \times 10^{-11}$                                     | $-(500 \pm 500)$    | $8.0 \times 10^{-11}$                                             | 1.5      |
| $\text{INO} + \text{INO} \rightarrow \text{I}_2 + 2\text{NO}$                                              | $8.4 \times 10^{-11}$                                     | $2620 \pm 600$      | $1.3 \times 10^{-14}$                                             | 2.5      |
| $\text{INO}_2 + \text{INO}_2 \rightarrow \text{I}_2 + 2\text{NO}_2$                                        | $2.9 \times 10^{-11}$                                     | $2600 \pm 1000$     | $4.7 \times 10^{-15}$                                             | 3.0      |
| <b><i>SO<sub>x</sub> Reactions</i></b>                                                                     |                                                           |                     |                                                                   |          |
| $\text{O} + \text{SH} \rightarrow \text{SO} + \text{H}$                                                    | —                                                         | —                   | $1.6 \times 10^{-10}$                                             | 5.0      |
| $\text{O} + \text{CS} \rightarrow \text{CO} + \text{S}$                                                    | $2.7 \times 10^{-10}$                                     | $760 \pm 250$       | $2.1 \times 10^{-11}$                                             | 1.1      |
| $\text{O} + \text{H}_2\text{S} \rightarrow \text{OH} + \text{SH}$                                          | $9.2 \times 10^{-12}$                                     | $1800 \pm 550$      | $2.2 \times 10^{-14}$                                             | 1.7      |
| $\text{O} + \text{OCS} \rightarrow \text{CO} + \text{SO}$                                                  | $2.1 \times 10^{-11}$                                     | $2200 \pm 150$      | $1.3 \times 10^{-14}$                                             | 1.2      |
| $\text{O} + \text{CS}_2 \rightarrow \text{CS} + \text{SO}$                                                 | $3.2 \times 10^{-11}$                                     | $650 \pm 150$       | $3.6 \times 10^{-12}$                                             | 1.2      |
| $\text{O} + \text{CH}_3\text{SCH}_3 \rightarrow \text{CH}_3\text{SO} + \text{CH}_3$                        | $1.3 \times 10^{-11}$                                     | $-(410 \pm 100)$    | $5.0 \times 10^{-11}$                                             | 1.1      |
| $\text{O} + \text{CH}_3\text{SSCH}_3 \rightarrow \text{CH}_3\text{SO} + \text{CH}_3\text{S}$               | $5.5 \times 10^{-11}$                                     | $-(250 \pm 100)$    | $1.3 \times 10^{-10}$                                             | 1.3      |

| Reaction                                                                                       | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>K       | $k$ (298 K)<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|------------------------------------------------------------------------------------------------|-----------------------------------------------------------|------------------|-------------------------------------------------------------------|----------|
| $\text{O}_3 + \text{H}_2\text{S} \rightarrow \text{products}$                                  | —                                                         | —                | $<2.0 \times 10^{-20}$                                            | —        |
| $\text{O}_3 + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                             | —                                                         | —                | $<1.0 \times 10^{-18}$                                            | —        |
| $\text{O}_3 + \text{SO}_2 \rightarrow \text{SO}_3 + \text{O}_2$                                | $3.0 \times 10^{-12}$                                     | $>7000$          | $<2.0 \times 10^{-22}$                                            | —        |
| $\text{OH} + \text{H}_2\text{S} \rightarrow \text{SH} + \text{H}_2\text{O}$                    | $6.0 \times 10^{-12}$                                     | $75 \pm 75$      | $4.7 \times 10^{-12}$                                             | 1.2      |
| $\text{OH} + \text{OCS} \rightarrow \text{products}$                                           | $1.1 \times 10^{-13}$                                     | $1200 \pm 500$   | $1.9 \times 10^{-15}$                                             | 2.0      |
| $\text{OH} + \text{CS}_2 \rightarrow \text{products}$                                          | See reference                                             | —                | —                                                                 | —        |
| $\text{OH} + \text{CH}_3\text{SH} \rightarrow \text{CH}_3\text{S} + \text{H}_2\text{O}$        | $9.9 \times 10^{-12}$                                     | $-(360 \pm 100)$ | $3.3 \times 10^{-11}$                                             | 1.2      |
| $\text{OH} + \text{CH}_3\text{SCH}_3 \rightarrow \text{H}_2\text{O} + \text{CH}_2\text{SCH}_3$ | $1.2 \times 10^{-11}$                                     | $260 \pm 100$    | $5.0 \times 10^{-12}$                                             | 1.15     |
| $\text{OH} + \text{CH}_3\text{SSCH}_3 \rightarrow \text{products}$                             | $6.0 \times 10^{-11}$                                     | $-(400 \pm 200)$ | $2.3 \times 10^{-10}$                                             | 1.2      |
| $\text{OH} + \text{S} \rightarrow \text{H} + \text{SO}$                                        | —                                                         | —                | $6.6 \times 10^{-11}$                                             | 3.0      |
| $\text{OH} + \text{SO} \rightarrow \text{H} + \text{SO}_2$                                     | —                                                         | —                | $8.6 \times 10^{-11}$                                             | 2.0      |
| $\text{HO}_2 + \text{H}_2\text{S} \rightarrow \text{products}$                                 | —                                                         | —                | $<3.0 \times 10^{-15}$                                            | —        |
| $\text{HO}_2 + \text{CH}_3\text{SH} \rightarrow \text{products}$                               | —                                                         | —                | $<4.0 \times 10^{-15}$                                            | —        |
| $\text{HO}_2 + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                            | —                                                         | —                | $<5.0 \times 10^{-15}$                                            | —        |
| $\text{HO}_2 + \text{SO}_2 \rightarrow \text{products}$                                        | —                                                         | —                | $<1.0 \times 10^{-18}$                                            | —        |
| $\text{NO}_2 + \text{SO}_2 \rightarrow \text{products}$                                        | —                                                         | —                | $<2.0 \times 10^{-26}$                                            | —        |
| $\text{NO}_3 + \text{H}_2\text{S} \rightarrow \text{products}$                                 | —                                                         | —                | $<8.0 \times 10^{-16}$                                            | —        |
| $\text{NO}_3 + \text{OCS} \rightarrow \text{products}$                                         | —                                                         | —                | $<1.0 \times 10^{-16}$                                            | —        |
| $\text{NO}_3 + \text{CS}_2 \rightarrow \text{products}$                                        | —                                                         | —                | $<4.0 \times 10^{-16}$                                            | —        |
| $\text{NO}_3 + \text{CH}_3\text{SH} \rightarrow \text{products}$                               | $4.4 \times 10^{-13}$                                     | $-(210 \pm 210)$ | $8.9 \times 10^{-13}$                                             | 1.25     |
| $\text{NO}_3 + \text{CH}_3\text{SCH}_3 \rightarrow \text{CH}_3\text{SCH}_2 + \text{HNO}_3$     | $1.9 \times 10^{-13}$                                     | $-(500 \pm 200)$ | $1.0 \times 10^{-12}$                                             | 1.2      |
| $\text{NO}_3 + \text{CH}_3\text{SSCH}_3 \rightarrow \text{products}$                           | $1.3 \times 10^{-12}$                                     | $270 \pm 270$    | $5.3 \times 10^{-13}$                                             | 1.4      |
| $\text{NO}_3 + \text{SO}_2 \rightarrow \text{products}$                                        | —                                                         | —                | $<7.0 \times 10^{-21}$                                            | —        |
| $\text{N}_2\text{O}_5 + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                   | —                                                         | —                | $<1.0 \times 10^{-17}$                                            | —        |
| $\text{CH}_3\text{O}_2 + \text{SO}_2 \rightarrow \text{products}$                              | —                                                         | —                | $<5.0 \times 10^{-17}$                                            | —        |
| $\text{F} + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                               | —                                                         | —                | $2.4 \times 10^{-10}$                                             | 2.0      |
| $\text{Cl} + \text{H}_2\text{S} \rightarrow \text{HCl} + \text{SH}$                            | $3.7 \times 10^{-11}$                                     | $-(210 \pm 100)$ | $7.4 \times 10^{-11}$                                             | 1.25     |
| $\text{Cl} + \text{OCS} \rightarrow \text{products}$                                           | —                                                         | —                | $<1.0 \times 10^{-16}$                                            | —        |
| $\text{Cl} + \text{CS}_2 \rightarrow \text{products}$                                          | —                                                         | —                | $<4.0 \times 10^{-15}$                                            | —        |
| $\text{Cl} + \text{CH}_3\text{SH} \rightarrow \text{CH}_3\text{S} + \text{HCl}$                | $1.2 \times 10^{-10}$                                     | $-(150 \pm 50)$  | $2.0 \times 10^{-10}$                                             | 1.25     |
| $\text{Cl} + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                              | See reference                                             | —                | —                                                                 | —        |
| $\text{ClO} + \text{OCS} \rightarrow \text{products}$                                          | —                                                         | —                | $<2.0 \times 10^{-16}$                                            | —        |
| $\text{ClO} + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                             | —                                                         | —                | $9.5 \times 10^{-15}$                                             | 2.0      |
| $\text{ClO} + \text{SO} \rightarrow \text{Cl} + \text{SO}_2$                                   | $2.8 \times 10^{-11}$                                     | $0 \pm 50$       | $2.8 \times 10^{-11}$                                             | 1.3      |
| $\text{ClO} + \text{SO}_2 \rightarrow \text{Cl} + \text{SO}_3$                                 | —                                                         | —                | $<4.0 \times 10^{-18}$                                            | —        |
| $\text{Br} + \text{H}_2\text{S} \rightarrow \text{HBr} + \text{SH}$                            | $1.4 \times 10^{-11}$                                     | $2750 \pm 300$   | $1.4 \times 10^{-15}$                                             | 2.0      |
| $\text{Br} + \text{CH}_3\text{SH} \rightarrow \text{CH}_3\text{S} + \text{HBr}$                | $9.2 \times 10^{-12}$                                     | $390 \pm 100$    | $2.5 \times 10^{-12}$                                             | 2.0      |
| $\text{Br} + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                              | See reference                                             | —                | —                                                                 | —        |
| $\text{BrO} + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                             | $1.5 \times 10^{-14}$                                     | $-(850 \pm 200)$ | $2.6 \times 10^{-13}$                                             | 1.3      |
| $\text{BrO} + \text{SO} \rightarrow \text{Br} + \text{SO}_2$                                   | —                                                         | —                | $5.7 \times 10^{-11}$                                             | 1.4      |
| $\text{IO} + \text{CH}_3\text{SH} \rightarrow \text{products}$                                 | —                                                         | —                | $6.6 \times 10^{-16}$                                             | 2.0      |
| $\text{IO} + \text{CH}_3\text{SCH}_3 \rightarrow \text{products}$                              | —                                                         | —                | $1.2 \times 10^{-14}$                                             | 1.5      |
| $\text{S} + \text{O}_2 \rightarrow \text{SO} + \text{O}$                                       | $2.3 \times 10^{-12}$                                     | $0 \pm 200$      | $2.3 \times 10^{-12}$                                             | 1.2      |
| $\text{S} + \text{O}_3 \rightarrow \text{SO} + \text{O}_2$                                     | —                                                         | —                | $1.2 \times 10^{-11}$                                             | 2.0      |
| $\text{SO} + \text{O}_2 \rightarrow \text{SO}_2 + \text{O}$                                    | $2.6 \times 10^{-13}$                                     | $2400 \pm 500$   | $8.4 \times 10^{-17}$                                             | 2.0      |
| $\text{SO} + \text{O}_3 \rightarrow \text{SO}_2 + \text{O}_2$                                  | $3.6 \times 10^{-12}$                                     | $1100 \pm 200$   | $9.0 \times 10^{-14}$                                             | 1.2      |
| $\text{SO} + \text{NO}_2 \rightarrow \text{SO}_2 + \text{NO}$                                  | $1.4 \times 10^{-11}$                                     | $0 \pm 50$       | $1.4 \times 10^{-11}$                                             | 1.2      |
| $\text{SO} + \text{OClO} \rightarrow \text{SO}_2 + \text{ClO}$                                 | —                                                         | —                | $1.9 \times 10^{-12}$                                             | 3.0      |
| $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{products}$                                 | See reference                                             | —                | —                                                                 | —        |
| $\text{SO}_3 + \text{NO}_2 \rightarrow \text{products}$                                        | —                                                         | —                | $1.0 \times 10^{-19}$                                             | 10.0     |
| $\text{SH} + \text{O}_2 \rightarrow \text{OH} + \text{SO}$                                     | —                                                         | —                | $<4.0 \times 10^{-19}$                                            | —        |
| $\text{SH} + \text{O}_3 \rightarrow \text{HSO} + \text{O}_2$                                   | $9.0 \times 10^{-12}$                                     | $280 \pm 200$    | $3.5 \times 10^{-12}$                                             | 1.3      |
| $\text{SH} + \text{H}_2\text{O}_2 \rightarrow \text{products}$                                 | —                                                         | —                | $<5.0 \times 10^{-15}$                                            | —        |
| $\text{SH} + \text{NO}_2 \rightarrow \text{HSO} + \text{NO}$                                   | $2.9 \times 10^{-11}$                                     | $-(240 \pm 50)$  | $6.5 \times 10^{-11}$                                             | 1.2      |
| $\text{SH} + \text{Cl}_2 \rightarrow \text{ClSH} + \text{Cl}$                                  | $1.7 \times 10^{-11}$                                     | $690 \pm 200$    | $1.7 \times 10^{-12}$                                             | 2.0      |
| $\text{SH} + \text{BrCl} \rightarrow \text{products}$                                          | $2.3 \times 10^{-11}$                                     | $-(350 \pm 200)$ | $7.4 \times 10^{-11}$                                             | 2.0      |
| $\text{SH} + \text{Br}_2 \rightarrow \text{BrSH} + \text{Br}$                                  | $6.0 \times 10^{-11}$                                     | $-(160 \pm 160)$ | $1.0 \times 10^{-10}$                                             | 2.0      |
| $\text{SH} + \text{F}_2 \rightarrow \text{FSH} + \text{F}$                                     | $4.3 \times 10^{-11}$                                     | $1390 \pm 200$   | $4.0 \times 10^{-13}$                                             | 2.0      |

| Reaction                                                                                                  | $A$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $E/R$<br>K       | $k(298 \text{ K})$<br>$\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $f(298)$ |
|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|------------------|--------------------------------------------------------------------------|----------|
| $\text{HSO} + \text{O}_2 \rightarrow \text{products}$                                                     |                                                           |                  | $<2.0 \times 10^{-17}$                                                   | —        |
| $\text{HSO} + \text{O}_3 \rightarrow \text{products}$                                                     |                                                           |                  | $1.0 \times 10^{-13}$                                                    | 1.3      |
| $\text{HSO} + \text{NO} \rightarrow \text{products}$                                                      |                                                           |                  | $<1.0 \times 10^{-15}$                                                   | —        |
| $\text{HSO} + \text{NO}_2 \rightarrow \text{HSO}_2 + \text{NO}$                                           |                                                           |                  | $9.6 \times 10^{-12}$                                                    | 2.0      |
| $\text{HSO}_2 + \text{O}_2 \rightarrow \text{HO}_2 + \text{SO}_2$                                         |                                                           |                  | $3.0 \times 10^{-13}$                                                    | 3.0      |
| $\text{HOSO}_2 + \text{O}_2 \rightarrow \text{HO}_2 + \text{SO}_3$                                        | $1.3 \times 10^{-12}$                                     | $330 \pm 200$    | $4.4 \times 10^{-13}$                                                    | 1.2      |
| $\text{CS} + \text{O}_2 \rightarrow \text{OCS} + \text{O}$                                                |                                                           |                  | $2.9 \times 10^{-19}$                                                    | 2.0      |
| $\text{CS} + \text{O}_3 \rightarrow \text{OCS} + \text{O}_2$                                              |                                                           |                  | $3.0 \times 10^{-16}$                                                    | 3.0      |
| $\text{CS} + \text{NO}_2 \rightarrow \text{OCS} + \text{NO}$                                              |                                                           |                  | $7.6 \times 10^{-17}$                                                    | 3.0      |
| $\text{CH}_3\text{S} + \text{O}_2 \rightarrow \text{products}$                                            |                                                           |                  | $<3.0 \times 10^{-18}$                                                   | —        |
| $\text{CH}_3\text{S} + \text{O}_3 \rightarrow \text{products}$                                            | $2.0 \times 10^{-12}$                                     | $-(290 \pm 100)$ | $5.3 \times 10^{-12}$                                                    | 1.15     |
| $\text{CH}_3\text{S} + \text{NO} \rightarrow \text{products}$                                             |                                                           |                  | $<1.0 \times 10^{-13}$                                                   | —        |
| $\text{CH}_3\text{S} + \text{NO}_2 \rightarrow \text{CH}_3\text{SO} + \text{NO}$                          | $2.1 \times 10^{-11}$                                     | $-(320 \pm 100)$ | $6.1 \times 10^{-11}$                                                    | 1.15     |
| $\text{CH}_2\text{SH} + \text{O}_2 \rightarrow \text{products}$                                           |                                                           |                  | $6.5 \times 10^{-12}$                                                    | 2.0      |
| $\text{CH}_2\text{SH} + \text{O}_3 \rightarrow \text{products}$                                           |                                                           |                  | $3.5 \times 10^{-11}$                                                    | 2.0      |
| $\text{CH}_2\text{SH} + \text{NO} \rightarrow \text{products}$                                            |                                                           |                  | $1.9 \times 10^{-11}$                                                    | 2.0      |
| $\text{CH}_2\text{SH} + \text{NO}_2 \rightarrow \text{products}$                                          |                                                           |                  | $5.2 \times 10^{-11}$                                                    | 2.0      |
| $\text{CH}_3\text{SO} + \text{O}_3 \rightarrow \text{products}$                                           |                                                           |                  | $6.0 \times 10^{-13}$                                                    | 1.5      |
| $\text{CH}_3\text{SO} + \text{NO}_2 \rightarrow \text{CH}_3\text{SO}_2 + \text{NO}$                       |                                                           |                  | $1.2 \times 10^{-11}$                                                    | 1.4      |
| $\text{CH}_3\text{SOO} + \text{O}_3 \rightarrow \text{products}$                                          |                                                           |                  | $<8.0 \times 10^{-13}$                                                   | —        |
| $\text{CH}_3\text{SOO} + \text{NO} \rightarrow \text{products}$                                           | $1.1 \times 10^{-11}$                                     | $0 \pm 100$      | $1.1 \times 10^{-11}$                                                    | 2.0      |
| $\text{CH}_3\text{SO}_2 + \text{NO}_2 \rightarrow \text{products}$                                        | $2.2 \times 10^{-11}$                                     | $0 \pm 100$      | $2.2 \times 10^{-11}$                                                    | 2.0      |
| $\text{CH}_3\text{SCH}_2 + \text{NO}_3 \rightarrow \text{products}$                                       |                                                           |                  | $3.0 \times 10^{-10}$                                                    | 2.0      |
| $\text{CH}_3\text{SCH}_2\text{O}_2 + \text{NO} \rightarrow \text{CH}_3\text{SCH}_2\text{O} + \text{NO}_2$ |                                                           |                  | $1.9 \times 10^{-11}$                                                    | 2.0      |
| $\text{CH}_3\text{SS} + \text{O}_3 \rightarrow \text{products}$                                           |                                                           |                  | $4.6 \times 10^{-13}$                                                    | 2.0      |
| $\text{CH}_3\text{SS} + \text{NO}_2 \rightarrow \text{products}$                                          |                                                           |                  | $1.8 \times 10^{-11}$                                                    | 2.0      |
| $\text{CH}_3\text{SSO} + \text{NO}_2 \rightarrow \text{products}$                                         |                                                           |                  | $4.5 \times 10^{-12}$                                                    | 2.0      |
| <b>Metal Reactions</b>                                                                                    |                                                           |                  |                                                                          |          |
| $\text{Na} + \text{O}_3 \rightarrow \text{NaO} + \text{O}_2$                                              | $1.0 \times 10^{-9}$                                      | $95 \pm 50$      | $7.3 \times 10^{-10}$                                                    | 1.2      |
| $\quad \rightarrow \text{NaO}_2 + \text{O}$                                                               | —                                                         | —                | $<4.0 \times 10^{-11}$                                                   | —        |
| $\text{Na} + \text{N}_2\text{O} \rightarrow \text{NaO} + \text{N}_2$                                      | $2.8 \times 10^{-10}$                                     | $1600 \pm 400$   | $1.3 \times 10^{-12}$                                                    | 1.2      |
| $\text{Na} + \text{Cl}_2 \rightarrow \text{NaCl} + \text{Cl}$                                             | $7.3 \times 10^{-10}$                                     | $0 \pm 200$      | $7.3 \times 10^{-10}$                                                    | 1.3      |
| $\text{NaO} + \text{O} \rightarrow \text{Na} + \text{O}_2$                                                | $3.7 \times 10^{-10}$                                     | $0 \pm 400$      | $3.7 \times 10^{-10}$                                                    | 3.0      |
| $\text{NaO} + \text{O}_3 \rightarrow \text{NaO}_2 + \text{O}_2$                                           | $1.1 \times 10^{-9}$                                      | $570 \pm 300$    | $1.6 \times 10^{-10}$                                                    | 1.5      |
| $\quad \rightarrow \text{Na} + 2\text{O}_2$                                                               | $6.0 \times 10^{-11}$                                     | $0 \pm 800$      | $6.0 \times 10^{-11}$                                                    | 3.0      |
| $\text{NaO} + \text{H}_2 \rightarrow \text{NaOH} + \text{H}$                                              | $2.6 \times 10^{-11}$                                     | $0 \pm 600$      | $2.6 \times 10^{-11}$                                                    | 2.0      |
| $\text{NaO} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \text{OH}$                                     | $2.2 \times 10^{-10}$                                     | $0 \pm 400$      | $2.2 \times 10^{-10}$                                                    | 2.0      |
| $\text{NaO} + \text{NO} \rightarrow \text{Na} + \text{NO}_2$                                              | $1.5 \times 10^{-10}$                                     | $0 \pm 400$      | $1.5 \times 10^{-10}$                                                    | 4.0      |
| $\text{NaO} + \text{HCl} \rightarrow \text{products}$                                                     | $2.8 \times 10^{-10}$                                     | $0 \pm 400$      | $2.8 \times 10^{-10}$                                                    | 3.0      |
| $\text{NaO}_2 + \text{O} \rightarrow \text{NaO} + \text{O}_2$                                             | $2.2 \times 10^{-11}$                                     | $0 \pm 600$      | $2.2 \times 10^{-11}$                                                    | 5.0      |
| $\text{NaO}_2 + \text{NO} \rightarrow \text{NaO} + \text{NO}_2$                                           | —                                                         | —                | $<10^{-14}$                                                              | —        |
| $\text{NaO}_2 + \text{HCl} \rightarrow \text{products}$                                                   | $2.3 \times 10^{-10}$                                     | $0 \pm 400$      | $2.3 \times 10^{-10}$                                                    | 3.0      |
| $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$                                   | $2.8 \times 10^{-10}$                                     | $0 \pm 400$      | $2.8 \times 10^{-10}$                                                    | 3.0      |

TABLE 2. Rate Constants for Association Reactions

The values quoted are suitable for air as the third body, M. The integer in parentheses is the power of ten.

| Reaction                                                          | Low pressure limit                                                                 |               | High pressure limit                                                                              |     |
|-------------------------------------------------------------------|------------------------------------------------------------------------------------|---------------|--------------------------------------------------------------------------------------------------|-----|
|                                                                   | $k_a(T) = k_a(300) (T/300)^{-n} \text{ cm}^6 \text{ molecule}^{-2} \text{ s}^{-1}$ |               | $k_{\infty}(T) = k_{\infty}(300) (T/300)^{-m} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ |     |
|                                                                   | $k_a(300)$                                                                         | $n$           | $k_{\infty}(300)$                                                                                | $m$ |
| <i>O<sub>x</sub> Reactions</i>                                    |                                                                                    |               |                                                                                                  |     |
| $\text{O} + \text{O}_2 \rightarrow \text{O}_3$                    | $(6.0 \pm 0.5) (-34)$                                                              | $2.3 \pm 0.5$ | —                                                                                                | —   |
| <i>O(<sup>1</sup>D) Reactions</i>                                 |                                                                                    |               |                                                                                                  |     |
| $\text{O}(1\text{D}) + \text{N}_2 \rightarrow \text{N}_2\text{O}$ | $(3.5 \pm 3.0) (-37)$                                                              | 0.6           | —                                                                                                | —   |

| Reaction                                                                                                  | Low pressure limit                                                                 |         | High pressure limit                                                                          |         |
|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------|---------|
|                                                                                                           | $k_0(T) = k_0(300) (T/300)^{-n} \text{ cm}^6 \text{ molecule}^{-2} \text{ s}^{-1}$ | $n$     | $k_\infty(T) = k_\infty(300) (T/300)^{-m} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $m$     |
| <i>HO<sub>x</sub> Reactions</i>                                                                           |                                                                                    |         |                                                                                              |         |
| H + O <sub>2</sub> → HO <sub>2</sub>                                                                      | (5.7±0.5) (−32)                                                                    | 1.6±0.5 | (7.5±4.0) (−11)                                                                              | 0±1.0   |
| OH + OH → H <sub>2</sub> O <sub>2</sub>                                                                   | (6.2±1.2) (−31)                                                                    | 1.0     | (2.6±1.0) (−11)                                                                              | 0±0.5   |
| <i>NO<sub>x</sub> Reactions</i>                                                                           |                                                                                    |         |                                                                                              |         |
| O + NO → NO <sub>2</sub>                                                                                  | (9.0±2.0) (−32)                                                                    | 1.5±0.3 | (3.0±1.0) (−11)                                                                              | 0±1.0   |
| O + NO <sub>2</sub> → NO <sub>3</sub>                                                                     | (9.0±1.0) (−32)                                                                    | 2.0±1.0 | (2.2±0.3) (−11)                                                                              | 0±1.0   |
| OH + NO → HONO                                                                                            | (7.0±1.0) (−31)                                                                    | 2.6±0.3 | (3.6±1.0) (−11)                                                                              | 0.1±0.5 |
| OH + NO <sub>2</sub> → HNO <sub>3</sub>                                                                   | (2.5±0.1) (−30)                                                                    | 4.4±0.3 | (1.6±0.2) (−11)                                                                              | 1.7±0.2 |
| HO <sub>2</sub> + NO <sub>2</sub> → HO <sub>2</sub> NO <sub>2</sub>                                       | (1.8±0.3) (−31)                                                                    | 3.2±0.4 | (4.7±1.0) (−12)                                                                              | 1.4±1.4 |
| NO <sub>2</sub> + NO <sub>3</sub> → N <sub>2</sub> O <sub>5</sub>                                         | (2.2±0.5) (−30)                                                                    | 3.9±1.0 | (1.5±0.8) (−12)                                                                              | 0.7±0.4 |
| NO <sub>3</sub> → NO + O <sub>2</sub>                                                                     | See reference                                                                      |         |                                                                                              |         |
| <i>Hydrocarbon Reactions</i>                                                                              |                                                                                    |         |                                                                                              |         |
| CH <sub>3</sub> + O <sub>2</sub> → CH <sub>3</sub> O <sub>2</sub>                                         | (4.5±1.5) (−31)                                                                    | 3.0±1.0 | (1.8±0.2) (−12)                                                                              | 1.7±1.7 |
| C <sub>2</sub> H <sub>5</sub> + O <sub>2</sub> → C <sub>2</sub> H <sub>5</sub> O <sub>2</sub>             | (1.5±1.0) (−28)                                                                    | 3.0±1.0 | (8.0±1.0) (−12)                                                                              | 0±1.0   |
| OH + C <sub>2</sub> H <sub>2</sub> → HOCHCH                                                               | (5.5±2.0) (−30)                                                                    | 0.0±0.2 | (8.3±1.0) (−13)                                                                              | −2      |
| OH + C <sub>2</sub> H <sub>4</sub> → HOCH <sub>2</sub> CH <sub>2</sub>                                    | (1.0±0.6) (−28)                                                                    | 0.8±2.0 | (8.8±0.9) (−12)                                                                              | 0       |
| CH <sub>3</sub> O + NO → CH <sub>3</sub> ONO                                                              | (1.4±0.5) (−29)                                                                    | 3.8±1.0 | (3.6±1.6) (−11)                                                                              | 0.6±1.0 |
| CH <sub>3</sub> O + NO <sub>2</sub> → CH <sub>3</sub> ONO <sub>2</sub>                                    | (1.1±0.4) (−28)                                                                    | 4.0±2.0 | (1.6±0.5) (−11)                                                                              | 1.0±1.0 |
| C <sub>2</sub> H <sub>5</sub> O + NO → C <sub>2</sub> H <sub>5</sub> ONO                                  | (2.8±1.0) (−27)                                                                    | 4.0±2.0 | (5.0±1.0) (−11)                                                                              | 1.0±1.0 |
| C <sub>2</sub> H <sub>5</sub> O + NO <sub>2</sub> → C <sub>2</sub> H <sub>5</sub> ONO <sub>2</sub>        | (2.0±1.0) (−27)                                                                    | 4.0±2.0 | (2.8±0.4) (−11)                                                                              | 1.0±1.0 |
| CH <sub>3</sub> O <sub>2</sub> + NO <sub>2</sub> → CH <sub>3</sub> O <sub>2</sub> NO <sub>2</sub>         | (1.5±0.8) (−30)                                                                    | 4.0±2.0 | (6.5±3.2) (−12)                                                                              | 2.0±2.0 |
| CH <sub>3</sub> C(O)O <sub>2</sub> + NO <sub>2</sub> → CH <sub>3</sub> C(O)O <sub>2</sub> NO <sub>2</sub> | (9.7±3.8) (−29)                                                                    | 5.6±2.8 | (9.3±0.4) (−12)                                                                              | 1.5±0.3 |
| <i>FO<sub>x</sub> Reactions</i>                                                                           |                                                                                    |         |                                                                                              |         |
| F + O <sub>2</sub> → FO <sub>2</sub>                                                                      | (4.4±0.4) (−33)                                                                    | 1.2±0.5 | —                                                                                            | —       |
| F + NO → FNO                                                                                              | (1.8±0.3) (−31)                                                                    | 1.0±1.0 | (2.8±1.4) (−10)                                                                              | 0.0±1.0 |
| F + NO <sub>2</sub> → FNO <sub>2</sub>                                                                    | (6.3±3.0) (−32)                                                                    | 2.0±2.0 | (2.6±1.3) (−10)                                                                              | 0.0±1.0 |
| FO + NO <sub>2</sub> → FONO <sub>2</sub>                                                                  | (2.6±2.0) (−31)                                                                    | 1.3±1.3 | (2.0±1.0) (−11)                                                                              | 1.5±1.5 |
| CF <sub>3</sub> + O <sub>2</sub> → CF <sub>3</sub> O <sub>2</sub>                                         | (3.0±0.3) (−29)                                                                    | 4.0±2.0 | (4.0±1.0) (−12)                                                                              | 1.0±1.0 |
| CF <sub>3</sub> O + NO <sub>2</sub> → CF <sub>3</sub> ONO <sub>2</sub>                                    | See reference                                                                      |         |                                                                                              |         |
| CF <sub>3</sub> O <sub>2</sub> + NO <sub>2</sub> CF <sub>3</sub> O <sub>2</sub> NO <sub>2</sub>           | (2.2±0.5) (−29)                                                                    | 5.0±1.0 | (6.0±1.0) (−12)                                                                              | 2.5±1.0 |
| CF <sub>3</sub> O + CO → CF <sub>3</sub> OCO                                                              | (2.5±0.2) (−31)                                                                    | —       | (6.8±0.4) (−14)                                                                              | −1.2    |
| CF <sub>3</sub> O → CF <sub>2</sub> O + F                                                                 | See reference                                                                      |         |                                                                                              |         |
| <i>ClO<sub>x</sub> Reactions</i>                                                                          |                                                                                    |         |                                                                                              |         |
| Cl + O <sub>2</sub> → ClOO                                                                                | (2.7±1.0) (−33)                                                                    | 1.5±0.5 | —                                                                                            | —       |
| Cl + NO → ClNO                                                                                            | (9.0±2.0) (−32)                                                                    | 1.6±0.5 | —                                                                                            | —       |
| Cl + NO <sub>2</sub> ClONO →                                                                              | (1.3±0.2) (−30)                                                                    | 2.0±1.0 | (1.0±0.5) (−10)                                                                              | 1.0±1.0 |
| ClONO <sub>2</sub>                                                                                        | (1.8±0.3) (−31)                                                                    | 2.0±1.0 | (1.0±0.5) (−10)                                                                              | 1.0±1.0 |
| Cl + CO → ClCO                                                                                            | (1.3±0.5) (−33)                                                                    | 3.8±0.5 | —                                                                                            | —       |
| Cl + C <sub>2</sub> H <sub>2</sub> → ClC <sub>2</sub> H <sub>2</sub>                                      | ((5.9±1.0) (−30)                                                                   | 2.1±1.0 | (2.1±0.4) (−10)                                                                              | 1.0±0.5 |
| Cl + C <sub>2</sub> H <sub>4</sub> → ClC <sub>2</sub> H <sub>4</sub>                                      | (1.6±1) (−29)                                                                      | 3.3±1.0 | (3.1±2) (−10)                                                                                | 1.0±0.5 |
| Cl + C <sub>2</sub> Cl <sub>4</sub> → C <sub>2</sub> Cl <sub>5</sub>                                      | (1.4±0.6) (−28)                                                                    | 8.5±1.0 | (4.0±1.0) (−11)                                                                              | 1.2±0.5 |
| ClO + NO <sub>2</sub> → ClONO <sub>2</sub>                                                                | (1.8±0.3) (−31)                                                                    | 3.4±1.0 | (1.5±0.7) (−11)                                                                              | 1.9±1.9 |
| OCIO + NO <sub>3</sub> → O <sub>2</sub> ClONO <sub>2</sub>                                                | See reference                                                                      |         |                                                                                              |         |
| ClO + ClO → Cl <sub>2</sub> O <sub>2</sub>                                                                | (2.2±0.4) (−32)                                                                    | 3.1±0.5 | (3.5±2) (−12)                                                                                | 1.0±1.0 |
| ClO + OCIO → Cl <sub>2</sub> O <sub>3</sub>                                                               | (6.2±1.0) (−32)                                                                    | 4.7±0.6 | (2.4±1.2) (−11)                                                                              | 0±1.0   |
| OCIO + O → ClO <sub>3</sub>                                                                               | (1.9±0.5) (−31)                                                                    | 1.1±1.0 | (3.1±0.8) (−11)                                                                              | 0±1.0   |
| CH <sub>2</sub> Cl + O <sub>2</sub> → CH <sub>2</sub> ClO <sub>2</sub>                                    | (1.9±0.1) (−30)                                                                    | 3.2±0.2 | (2.9±0.2) (−12)                                                                              | 1.2±0.6 |
| CHCl <sub>2</sub> + O <sub>2</sub> → CHCl <sub>2</sub> O <sub>2</sub>                                     | (1.3±0.1) (−30)                                                                    | 4.0±0.2 | (2.8±0.2) (−12)                                                                              | 1.4±0.6 |
| CCl <sub>3</sub> + O <sub>2</sub> → CCl <sub>3</sub> O <sub>2</sub>                                       | (6.9±0.2) (−31)                                                                    | 6.4±0.3 | (2.4±0.2) (−12)                                                                              | 2.1±0.6 |
| CFCl <sub>2</sub> + O <sub>2</sub> → CFCl <sub>2</sub> O <sub>2</sub>                                     | (5.0±0.8) (−30)                                                                    | 4.0±2.0 | (6.0±1.0) (−12)                                                                              | 1.0±1.0 |
| CF <sub>2</sub> Cl + O <sub>2</sub> → CF <sub>2</sub> ClO <sub>2</sub>                                    | (3.0±1.5) (−30)                                                                    | 4.0±2.0 | (3±2) (−12)                                                                                  | 1.0±1.0 |
| CCl <sub>3</sub> O <sub>2</sub> + NO <sub>2</sub> → CCl <sub>3</sub> O <sub>2</sub> NO <sub>2</sub>       | (5.0±1.0) (−29)                                                                    | 5.0±1.0 | (6.0±1.0) (−12)                                                                              | 2.5±1.0 |
| CFCl <sub>2</sub> O <sub>2</sub> + NO <sub>2</sub> → CFCl <sub>2</sub> O <sub>2</sub> NO <sub>2</sub>     | (3.5±0.5) (−29)                                                                    | 5.0±1.0 | (6.0±1.0) (−12)                                                                              | 2.5±1.0 |
| CF <sub>2</sub> ClO <sub>2</sub> + NO <sub>2</sub> → CF <sub>2</sub> ClO <sub>2</sub> NO <sub>2</sub>     | (3.3±0.7) (−29)                                                                    | 6.7±1.3 | (4.1±1.9) (−12)                                                                              | 2.8±0.7 |

| Reaction                                                                                            | Low pressure limit                                                                 |          | High pressure limit                                                                          |         |
|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|----------|----------------------------------------------------------------------------------------------|---------|
|                                                                                                     | $k_0(T) = k_0(300) (T/300)^{-n} \text{ cm}^6 \text{ molecule}^{-2} \text{ s}^{-1}$ | $n$      | $k_\infty(T) = k_\infty(300) (T/300)^{-m} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | $m$     |
| <i>BrO<sub>x</sub> Reactions</i>                                                                    |                                                                                    |          |                                                                                              |         |
| Br + NO <sub>2</sub> → BrNO <sub>2</sub>                                                            | (4.2±0.8) (−31)                                                                    | 2.4±0.5  | (2.7±0.5) (−11)                                                                              | 0±1.0   |
| BrO + NO <sub>2</sub> → BrONO <sub>2</sub>                                                          | (5.2±0.6) (−31)                                                                    | 3.2±0.8  | (6.9±1.0) (−12)                                                                              | 2.9±1.0 |
| <i>IO<sub>x</sub> Reactions</i>                                                                     |                                                                                    |          |                                                                                              |         |
| I + NO → INO                                                                                        | (1.8±0.5) (−32)                                                                    | 1.0±0.5  | (1.7±1.0) (−11)                                                                              | 0±1.0   |
| I + NO <sub>2</sub> → INO <sub>2</sub>                                                              | (3.0±1.5) (−31)                                                                    | 1.0±1.0  | (6.6±5.0) (−11)                                                                              | 0±1.0   |
| IO + NO <sub>2</sub> → IONO <sub>2</sub>                                                            | (5.9±2.0) (−31)                                                                    | 3.5±1.0  | (9.0±1.0) (−12)                                                                              | 1.5±1.0 |
| <i>SO<sub>x</sub> Reactions</i>                                                                     |                                                                                    |          |                                                                                              |         |
| HS + NO → HSNO                                                                                      | (2.4±0.4) (−31)                                                                    | 3.0±1.0  | (2.7±0.5) (−11)                                                                              | 0       |
| CH <sub>3</sub> S + NO → CH <sub>3</sub> SNO                                                        | (3.2±0.4) (−29)                                                                    | 4.0±1.0  | (3.9±0.6) (−11)                                                                              | 2.7±1.0 |
| O + SO <sub>2</sub> → SO <sub>3</sub>                                                               | (1.3±)(−33)                                                                        | −3.6±0.7 |                                                                                              |         |
| OH + SO <sub>2</sub> → HOSO <sub>2</sub>                                                            | (3.0±1.0) (−31)                                                                    | 3.3±1.5  | (1.5±0.5) (−12)                                                                              | 0       |
| CH <sub>3</sub> SCH <sub>2</sub> + O <sub>2</sub> → CH <sub>3</sub> SCH <sub>2</sub> O <sub>2</sub> | See reference                                                                      |          |                                                                                              |         |
| SO <sub>3</sub> + NH <sub>3</sub> → H <sub>3</sub> NSO <sub>3</sub>                                 | (3.9±0.8) (−30)                                                                    | 3.0±3.0  | (4.7±1.3) (−11)                                                                              | 0±1.0   |
| <i>Metal Reactions</i>                                                                              |                                                                                    |          |                                                                                              |         |
| Na + O <sub>2</sub> → NaO <sub>2</sub>                                                              | (3.2±0.3) (−30)                                                                    | 1.4±0.3  | (6.0±2.0) (−10)                                                                              | 0±1.0   |
| NaO + O <sub>2</sub> → NaO <sub>3</sub>                                                             | (3.5±0.7) (−30)                                                                    | 2.0±2.0  | (5.7±3.0) (−10)                                                                              | 0±1.0   |
| NaO + CO <sub>2</sub> → NaCO <sub>3</sub>                                                           | (8.7±2.6) (−28)                                                                    | 2.0±2.0  | (6.5±3.0) (−10)                                                                              | 0±1.0   |
| NaOH + CO <sub>2</sub> → NaHCO <sub>3</sub>                                                         | (1.3±0.3) (−28)                                                                    | 2.0±2.0  | (6.8±4.0) (−10)                                                                              | 0±1.0   |

TABLE 3. Equilibrium Constants

$$K(T)/\text{cm}^3 \text{ molecule}^{-1} = A \exp(B/T) \quad [200 < T/K < 300]$$

| Reaction                                                                                                  | $A/\text{cm}^3 \text{ molecule}^{-1}$ | $B/K$      | $K(298 \text{ K})$     | $f(298 \text{ K})$ |
|-----------------------------------------------------------------------------------------------------------|---------------------------------------|------------|------------------------|--------------------|
| HO <sub>2</sub> + NO <sub>2</sub> → HO <sub>2</sub> NO <sub>2</sub>                                       | 2.1x10 <sup>−27</sup>                 | 10900±1000 | 1.6x10 <sup>−11</sup>  | 5                  |
| NO + NO <sub>2</sub> → N <sub>2</sub> O <sub>3</sub>                                                      | 3.3x10 <sup>−27</sup>                 | 4667±100   | 2.1x10 <sup>−20</sup>  | 2                  |
| NO <sub>2</sub> + NO <sub>2</sub> → N <sub>2</sub> O <sub>4</sub>                                         | 5.2x10 <sup>−29</sup>                 | 6643±250   | 2.5x10 <sup>−19</sup>  | 2                  |
| NO <sub>2</sub> + NO <sub>3</sub> → N <sub>2</sub> O <sub>5</sub>                                         | 2.7x10 <sup>−27</sup>                 | 11000±500  | 2.9x10 <sup>−11</sup>  | 1.3                |
| CH <sub>3</sub> O <sub>2</sub> + NO <sub>2</sub> → CH <sub>3</sub> O <sub>2</sub> NO <sub>2</sub>         | 1.3x10 <sup>−28</sup>                 | 11200±1000 | 2.7x10 <sup>−12</sup>  | 2                  |
| CH <sub>3</sub> C(O)O <sub>2</sub> + NO <sub>2</sub> → CH <sub>3</sub> C(O)O <sub>2</sub> NO <sub>2</sub> | 9.0x10 <sup>−29</sup>                 | 14000±200  | 2.3x10 <sup>−8</sup>   | 2                  |
| F + O <sub>2</sub> → FOO                                                                                  | 3.2x10 <sup>−25</sup>                 | 6100±1200  | 2.5x10 <sup>−16</sup>  | 1.0                |
| Cl + O <sub>2</sub> → ClOO                                                                                | 5.7x10 <sup>−25</sup>                 | 2500±750   | 2.5x10 <sup>−21</sup>  | 2                  |
| Cl + CO → ClCO                                                                                            | 1.6x10 <sup>−25</sup>                 | 4000±500   | 1.1x10 <sup>−19</sup>  | 5                  |
| ClO + O <sub>2</sub> → ClOO <sub>2</sub>                                                                  | 2.9x10 <sup>−26</sup>                 | <3700      | <7.2x10 <sup>−21</sup> | —                  |
| ClO + ClO → Cl <sub>2</sub> O <sub>2</sub>                                                                | 1.3x10 <sup>−27</sup>                 | 8744±850   | 7.2x10 <sup>−15</sup>  | 1.5                |
| ClO + OClO → Cl <sub>2</sub> O <sub>3</sub>                                                               | 1.1x10 <sup>−24</sup>                 | 5455±300   | 9.8x10 <sup>−17</sup>  | 3                  |
| OCLO + NO <sub>3</sub> → O <sub>2</sub> ClONO <sub>2</sub>                                                | 1x10 <sup>−28</sup>                   | 9300±1000  | 3.6x10 <sup>−15</sup>  | 5                  |
| OH + CS <sub>2</sub> → CS <sub>2</sub> OH                                                                 | 4.5x10 <sup>−25</sup>                 | 5140±500   | 1.4x10 <sup>−17</sup>  | 1.4                |
| CH <sub>3</sub> S + O <sub>2</sub> → CH <sub>3</sub> SO <sub>2</sub>                                      | 1.8x10 <sup>−27</sup>                 | 5545±300   | 2.2x10 <sup>−19</sup>  | 1.4                |

# KINETIC DATA FOR COMBUSTION MODELLING

D. L. Baulch, C. J. Cobos, R. A. Cox, C. Esser, P. Frank, Th. Just, J. A. Kerr,  
M. J. Pilling, J. Troe, R. W. Walker, and J. Warnatz

The following tables present evaluated rate constants and other chemical kinetic data required for modelling the combustion of hydrocarbons. The compilation was prepared as part of the project "Kinetics and Mechanisms of Chemical Processes in Combustion", which is one of the projects in the third European Community Energy Research and Development Program. The tables are reprinted from the *Journal of Physical and Chemical Reference Data* by permission of the authors and the American Institute of Physics.

Table 1 lists all the reactions studied and gives the recommended rate constant  $k$  for every bimolecular reaction, as well as the applicable temperature range and the associated error limits. Where more than one set of products is possible, rate constants or branching ratios are given for all channels considered feasible. The data for decomposition reactions and combination reactions are given in Tables 2 and 3, respectively. The reference includes a detailed data sheet for each reaction listed here, covering the thermodynamic data, kinetic measurements, and reliability assessments.

## REFERENCE

Baulch, D. L., et al., *J. Phys. Chem. Ref. Data*, 21, 411-734, 1992.

Table 1  
BIMOLECULAR REACTIONS

| Reaction                                                                                                                      | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                    | Temp/K               | Error limits ( $\Delta \log k$ )                           |
|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|----------------------|------------------------------------------------------------|
| <i>O Atom Reactions</i>                                                                                                       |                                                                         |                      |                                                            |
| $\text{O} + \text{H}_2 \rightarrow \text{OH} + \text{H}$                                                                      | $8.5 \times 10^{-20} T^{2.67} \exp(-3160/T)$                            | 300-2500             | $\pm 0.5$ at 300 K falling to<br>$\pm 0.2$ for $T > 500$ K |
| $\text{O} + \text{OH} \rightarrow \text{O}_2 + \text{H}$                                                                      | $2.0 \times 10^{-11} \exp(112/T)$<br>$2.4 \times 10^{-11} \exp(-353/T)$ | 220-500<br>1000-2000 | $\pm 0.2$<br>$\pm 0.1$                                     |
| $\text{O} + \text{HO}_2 \rightarrow \text{OH} + \text{O}_2$                                                                   | $5.3 \times 10^{-11}$                                                   | 300-1000             | $\pm 0.3$ at 300 K rising to<br>$\pm 0.5$ at 1000 K.       |
| $\text{O} + \text{H}_2\text{O}_2 \rightarrow \text{OH} + \text{HO}_2$                                                         | $1.1 \times 10^{-12} \exp(-2000/T)$                                     | 300-500              | $\pm 0.3$                                                  |
| $\text{O} + \text{NH}_3 \rightarrow \text{OH} + \text{NH}_2$                                                                  | $1.6 \times 10^{-11} \exp(-3670/T)$                                     | 500-2500             | $\pm 0.5$                                                  |
| $\text{O} + \text{CH} \rightarrow \text{CO} + \text{H}$<br>$\rightarrow \text{CHO}^+ + e$                                     | $6.6 \times 10^{-11}$<br>$4.2 \times 10^{-13} \exp(-850/T)$             | 300-2000<br>300-2500 | $\pm 0.5$<br>$\pm 0.5$                                     |
| $\text{O} + {}^3\text{CH}_2 \rightarrow \text{CO} + 2\text{H}$ ]<br>$\rightarrow \text{CO} + \text{H}_2$ ]                    | $2 \times 10^{-10}$<br>$k_1/k = 0.6 \pm 0.3$ over whole range           | 300-2500             | $\pm 0.2$ at 300 K rising to<br>$\pm 0.7$ at 2500 K.       |
| $\text{O} + \text{CH}_3 \rightarrow \text{HCHO} + \text{H}$                                                                   | $1.4 \times 10^{-10}$                                                   | 300-2500             | $\pm 0.2$                                                  |
| $\text{O} + \text{CH}_4 \rightarrow \text{OH} + \text{CH}_3$                                                                  | $1.5 \times 10^{-15} T^{1.56} \exp(-4270/T)$                            | 300-2500             | $\pm 0.3$ at 300 K falling to<br>$\pm 0.15$ at 2500 K.     |
| $\text{O} + \text{CHO} \rightarrow \text{OH} + \text{CO}$<br>$\rightarrow \text{CO}_2 + \text{H}$                             | $5.0 \times 10^{-11}$<br>$5.0 \times 10^{-11}$                          | 300-2500<br>300-2500 | $\pm 0.3$<br>$\pm 0.3$                                     |
| $\text{O} + \text{HCHO} \rightarrow \text{OH} + \text{CHO}$                                                                   | $6.9 \times 10^{-13} T^{0.57} \exp(-1390/T)$                            | 250-2200             | $\pm 0.1$ at 250 K rising to<br>$\pm 0.3$ at 2200 K.       |
| $\text{O} + \text{CH}_3\text{O} \rightarrow \text{O}_2 + \text{CH}_3$ ]<br>$\rightarrow \text{OH} + \text{HCHO}$ ]            | $2.5 \times 10^{-11}$<br>$k_2/k = (0.12 \pm 0.1)$ at 300 K              | 300-1000             | $\pm 0.3$ at 300 K rising to<br>$\pm 0.7$ at 1000 K.       |
| $\text{O} + \text{CN} \rightarrow \text{CO} + \text{N}({}^4\text{S})$ ]<br>$\rightarrow \text{CO} + \text{N}({}^2\text{D})$ ] | $1.7 \times 10^{-11}$                                                   | 300-5000             | $\pm 0.2$ at 300 K rising to<br>$\pm 0.6$ at 5000 K.       |
| $\text{O} + \text{NCO} \rightarrow \text{NO} + \text{CO}$ ]<br>$\rightarrow \text{O}_2 + \text{CN}$ ]                         | $7.0 \times 10^{-11}$                                                   | 1450-2600            | $\pm 0.8$                                                  |

## KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 1  
BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                               | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                                                 | Temp/K                                         | Error limits ( $\Delta \log k$ )                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------|
| $\text{O} + \text{HCN} \rightarrow \text{NCO} + \text{H}$<br>$\rightarrow \text{CO} + \text{NH}$<br>$\rightarrow \text{OH} + \text{CN}$                                                                                | $2.3 \times 10^{-18} T^{2.1} \exp(-3075/T)$                                                          | 450–2500                                       | $\pm 0.2$ at 450 K rising to<br>$\pm 0.3$ at 2500 K.          |
| $\text{O} + \text{CH}_3\text{OOH} \rightarrow \text{OH} + \text{CH}_2\text{COOH}$<br>$\rightarrow \text{OH} + \text{CH}_3\text{O}_2$                                                                                   | $6.9 \times 10^{-13} T^{0.57} \exp(-1390/T)$<br>[estimate]                                           | 250–2200                                       | $\pm 0.1$ at 250 K rising to<br>$\pm 0.3$ at 2200 K.          |
| $\text{O} + \text{C}_2\text{H} \rightarrow \text{CO} + \text{CH}$                                                                                                                                                      | $1.7 \times 10^{-11}$                                                                                | 300–2500                                       | $\pm 1.0$                                                     |
| $\text{O} + \text{C}_2\text{H}_2 \rightarrow \text{CO} + {}^3\text{CH}_2$<br>$\rightarrow \text{CHCO} + \text{H}$                                                                                                      | $3.6 \times 10^{-20} T^{2.8} \exp(-250/T)$<br>$k_1/k = 0.5 \pm 0.3$ over whole range.                | 300–2500                                       | $\pm 0.2$                                                     |
| $\text{O} + \text{C}_2\text{H}_3 \rightarrow \text{OH} + \text{C}_2\text{H}_2$<br>$\rightarrow \text{CO} + \text{CH}_3$<br>$\rightarrow \text{HCO} + \text{CH}_2$                                                      | $5 \times 10^{-11}$                                                                                  | 300–2000                                       | $\pm 0.5$                                                     |
| $\text{O} + \text{C}_2\text{H}_4 \rightarrow \text{CH}_2\text{CHO} + \text{H}$<br>$\rightarrow \text{HCO} + \text{CH}_3$<br>$\rightarrow \text{HCHO} + \text{CH}_2$<br>$\rightarrow \text{CH}_2\text{CO} + \text{H}_2$ | $5.75 \times 10^{-18} T^{2.08}$<br>$k_1/k = 0.35 \pm 0.05$ at $p > 3$ Torr<br>$k_2/k = 0.6 \pm 0.10$ | 300–2000<br>over whole<br>temperature<br>range | $\pm 0.1$ for $T < 1000$ K<br>rising to $\pm 0.3$ at 2000 K.  |
| $\text{O} + \text{C}_2\text{H}_5 \rightarrow \text{CH}_3\text{CHO} + \text{H}$<br>$\rightarrow \text{HCHO} + \text{CH}_3$                                                                                              | $1.1 \times 10^{-10}$<br>$k_2/k = 0.17 \pm 0.2$ at 300 K                                             | 300–2500                                       | $\pm 0.3$ from 300 to 1000 K<br>$\pm 0.5$ from 1000 to 2500 K |
| $\text{O} + \text{C}_2\text{H}_6 \rightarrow \text{OH} + \text{C}_2\text{H}_5$                                                                                                                                         | $1.66 \times 10^{-15} T^{1.5} \exp(-2920/T)$                                                         | 300–1200                                       | $\pm 0.3$ at 300 K falling to<br>$\pm 0.15$ at 1200 K.        |
| $\text{O} + \text{CHCO} \rightarrow 2\text{CO} + \text{H}$                                                                                                                                                             | $1.6 \times 10^{-10}$                                                                                | 300–2500                                       | $\pm 0.3$                                                     |
| $\text{O} + \text{CH}_2\text{CO} \rightarrow \text{CH}_2\text{O} + \text{CO}$<br>$\rightarrow \text{HCO} + \text{H} + \text{CO}$<br>$\rightarrow \text{HCO} + \text{HCO}$                                              | $3.8 \times 10^{-12} \exp(-680/T)$                                                                   | 230–500                                        | $\pm 0.3$                                                     |
| $\text{O} + \text{CH}_3\text{CHO} \rightarrow \text{OH} + \text{CH}_3\text{CO}$<br>$\rightarrow \text{OH} + \text{CH}_2\text{CHO}$                                                                                     | $9.7 \times 10^{-12} \exp(-910/T)$                                                                   | 300–1500                                       | $\pm 0.05$ at 300 K rising to<br>$\pm 0.5$ at 1500 K.         |
| $\text{O} + \text{C}_2\text{H}_5\text{OOH} \rightarrow \text{OH} + \text{C}_2\text{H}_4\text{OOH}$<br>$\rightarrow \text{OH} + \text{C}_2\text{H}_5\text{OO}$                                                          | $6.9 \times 10^{-13} T^{0.57} \exp(-1390/T)$<br>[estimate]                                           | 250–2200                                       | $\pm 0.1$ at 150 K rising to<br>$\pm 0.3$ at 2200 K.          |
| $\text{O} + \text{C}_6\text{H}_6 \rightarrow \text{OH} + \text{C}_6\text{H}_5$<br>$\rightarrow \text{C}_6\text{H}_5\text{OH}$                                                                                          | $1.2 \times 10^{-22} T^{3.7} \exp(-570/T)$                                                           | 300–1000                                       | $\pm 0.5$                                                     |
| $\text{O} + \text{C}_6\text{H}_5\text{CH}_2 \rightarrow \text{HCO} + \text{C}_6\text{H}_6$<br>$\rightarrow \text{C}_6\text{H}_5\text{CH} + \text{H}$<br>$\rightarrow \text{CH}_2\text{O} + \text{C}_6\text{H}_5$       | $5.5 \times 10^{-10}$<br><br>No recommendation                                                       | 300                                            | $\pm 0.3$                                                     |
| $\text{O} + \text{C}_6\text{H}_5\text{CH}_3 \rightarrow \text{products}$                                                                                                                                               | $5.3 \times 10^{-15} T^{1.21} \exp(-1260/T)$                                                         | 300–2800                                       | $\pm 0.1$ at 300 K rising to<br>$\pm 0.4$ at 2800 K           |
| $\text{O} + p\text{-C}_6\text{H}_4(\text{CH}_3)_2 \rightarrow \text{products}$                                                                                                                                         | $2.6 \times 10^{-11} \exp(-1409/T)$                                                                  | 300–600                                        | $\pm 0.3$                                                     |
| $\text{O} + \text{C}_6\text{H}_5\text{C}_2\text{H}_5 \rightarrow \text{products}$                                                                                                                                      | $1.0 \times 10^{-13}$                                                                                | 298                                            | $\pm 0.3$                                                     |
| <i>O<sub>2</sub> Reactions</i>                                                                                                                                                                                         |                                                                                                      |                                                |                                                               |
| $\text{O}_2 + \text{CH}_4 \rightarrow \text{HO}_2 + \text{CH}_3$                                                                                                                                                       | $6.6 \times 10^{-11} \exp(-28630/T)$                                                                 | 500–2000                                       | $\pm 0.5$ at 500 K rising to<br>$\pm 1.0$ at 2000 K.          |

## KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 1  
BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                        | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | Temp/K    | Error limits ( $\Delta \log k$ )                     |
|-------------------------------------------------------------------------------------------------|------------------------------------------------------|-----------|------------------------------------------------------|
| $\text{O}_2 + \text{C}_2\text{H}_6 \rightarrow \text{HO}_2 + \text{C}_2\text{H}_5$              | $1.0 \times 10^{-10} \exp(-26100/T)$                 | 500-2000  | $\pm 0.5$ at 500 K rising to<br>$\pm 1.0$ at 2000 K  |
| $\text{O}_2 + \text{HCHO} \rightarrow \text{HO}_2 + \text{HCO}$                                 | $1.0 \times 10^{-10} \exp(-20460/T)$                 | 700-1000  | $\pm 0.5$                                            |
| $\text{O}_2 + \text{CH}_3\text{CHO} \rightarrow \text{HO}_2 + \text{CH}_3\text{CO}$             | $5.0 \times 10^{-11} \exp(-19700/T)$                 | 600-1100  | $\pm 0.5$ at 600 K rising to<br>$\pm 1.0$ at 1100 K. |
| <i>H Atom Reactions</i>                                                                         |                                                      |           |                                                      |
| $\text{H} + \text{O}_2 \rightarrow \text{OH} + \text{O}$                                        | $3.3 \times 10^{-10} \exp(-8460/T)$                  | 300-2500  | $\pm 0.1$ at 300 K rising to<br>$\pm 0.2$ at 2500 K. |
| $\text{H} + \text{O}_2 + \text{Ar} \rightarrow \text{HO}_2 + \text{Ar}$                         | See Table 3                                          |           |                                                      |
| $\text{H} + \text{O}_2 + \text{H}_2 \rightarrow \text{HO}_2 + \text{H}_2$                       | See Table 3                                          |           |                                                      |
| $\text{H} + \text{O}_2 + \text{N}_2 \rightarrow \text{HO}_2 + \text{N}_2$                       | See Table 3                                          |           |                                                      |
| $\text{H} + \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{HO}_2 + \text{H}_2\text{O}$       | See Table 3                                          |           |                                                      |
| $\text{H} + \text{H} + \text{Ar} \rightarrow \text{H}_2 + \text{Ar}$                            | See Table 3                                          |           |                                                      |
| $\text{H} + \text{H} + \text{H}_2 \rightarrow \text{H}_2 + \text{H}_2$                          | See Table 3                                          |           |                                                      |
| $\text{H} + \text{OH} + \text{H}_2\text{O} \rightarrow \text{H}_2\text{O} + \text{H}_2\text{O}$ | See Table 3                                          |           |                                                      |
| $\text{H} + \text{OH} + \text{Ar} \rightarrow \text{H}_2\text{O} + \text{Ar}$                   | See Table 3                                          |           |                                                      |
| $\text{H} + \text{HO} + \text{N}_2 \rightarrow \text{H}_2\text{O} + \text{N}_2$                 | See Table 3                                          |           |                                                      |
| $\text{H} + \text{HO}_2 \rightarrow \text{H}_2 + \text{O}_2$                                    | $7.1 \times 10^{-11} \exp(-710/T)$                   | 300-1000  | $\pm 0.3$                                            |
| $\quad \quad \rightarrow 2 \text{OH}$                                                           | $2.8 \times 10^{-10} \exp(-440/T)$                   | 300-1000  | $\pm 0.3$                                            |
| $\quad \quad \rightarrow \text{H}_2\text{O} + \text{O}$                                         | $5.0 \times 10^{-11} \exp(-866/T)$                   | 300-1000  | $\pm 0.3$                                            |
| $\text{H} + \text{H}_2\text{O} \rightarrow \text{OH} + \text{H}_2$                              | $7.5 \times 10^{-16} T^{1.6} \exp(-9270/T)$          | 300-2500  | $\pm 0.2$                                            |
| $\text{H} + \text{H}_2\text{O}_2 \rightarrow \text{H}_2 + \text{HO}_2$                          | $2.8 \times 10^{-12} \exp(-1890/T)$                  | 300-1000  | $\pm 0.3$                                            |
| $\quad \quad \rightarrow \text{OH} + \text{H}_2\text{O}$                                        | $1.7 \times 10^{-11} \exp(-1800/T)$                  | 300-1000  | $\pm 0.3$                                            |
| $\text{H} + \text{NH} \rightarrow \text{H}_2 + \text{N}$                                        | $1.7 \times 10^{-11}$                                | 1500-2500 | $\pm 1.0$                                            |
| $\text{H} + \text{NH}_2 \rightarrow \text{H}_2 + \text{NH}$                                     | $1.0 \times 10^{-11}$                                | 2000-3000 | $\pm 1.0$                                            |
| $\text{H} + {}^3\text{CH}_2 \rightarrow \text{H}_2 + \text{CH}$                                 | $1.0 \times 10^{-11} \exp(900/T)$                    | 300-3000  | $\pm 0.7$                                            |
| $\text{H} + \text{CH}_3 \rightarrow \text{H}_2 + {}^1\text{CH}_2$                               | $1.0 \times 10^{-10} \exp(-7600/T)$                  | 300-2500  | $\pm 1.0$                                            |
| $\quad \quad \rightarrow \text{CH}_4$                                                           | See Table 3                                          |           |                                                      |
| $\text{H} + \text{CH}_4 \rightarrow \text{H}_2 + \text{CH}_3$                                   | $2.2 \times 10^{-20} T^{3.0} \exp(-4045/T)$          | 300-2500  | $\pm 0.2$                                            |
| $\text{H} + \text{CHO} \rightarrow \text{H}_2 + \text{CO}$                                      | $1.5 \times 10^{-10}$                                | 300-2500  | $\pm 0.3$                                            |
| $\text{H} + \text{HCHO} \rightarrow \text{H}_2 + \text{HCO}$                                    | $3.8 \times 10^{-14} T^{1.05} \exp(-1650/T)$         | 300-2200  | $\pm 0.1$ at 300 K rising to<br>$\pm 0.5$ at 2200 K  |
| $\text{H} + \text{CH}_3\text{O} \rightarrow \text{H}_2 + \text{HCHO}$                           | $3.0 \times 10^{-11}$                                | 300-1000  | $\pm 0.5$                                            |
| $\text{H} + \text{HNCO} \rightarrow \text{NH}_2 + \text{CO}$                                    | No recommendation                                    |           |                                                      |
| $\quad \quad \rightarrow \text{H}_2 + \text{NCO}$                                               | $3.4 \times 10^{-10} T^{-0.27} \exp(-10190/T)$       | 500-1000  | $\pm 1.0$                                            |
| $\text{H} + \text{NCO} \rightarrow \text{NH} + \text{CO}$                                       | $8.7 \times 10^{-11}$                                | 1400-1500 | $\pm 0.5$                                            |
| $\quad \quad \rightarrow \text{HCN} + \text{O}$                                                 |                                                      |           |                                                      |



## KINETIC DATA FOR COMBUSTION MODELLING (continued)

 Table 1  
 BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                                                                                 | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                                                  | Temp/K                 | Error limits ( $\Delta \log k$ )                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------|------------------------------------------------------|
| $\text{H} + \text{C}_2\text{H}_2 \rightarrow \text{H}_2 + \text{C}_2\text{H}$<br>$\rightarrow \text{C}_2\text{H}_3$                                                                                                                                                      | $1.0 \times 10^{-10} \exp(-14000/T)$<br>See Table 3                                                   | 1000–3000              | $\pm 1.0$                                            |
| $\text{H} + \text{C}_2\text{H}_3 \rightarrow \text{H}_2 + \text{C}_2\text{H}_2$<br>$\rightarrow \text{C}_2\text{H}_4$                                                                                                                                                    | $2.0 \times 10^{-11}$<br>See Table 3                                                                  | 300–2500               | $\pm 0.5$                                            |
| $\text{H} + \text{C}_2\text{H}_4 \rightarrow \text{C}_2\text{H}_3 + \text{H}_2$<br>$\rightarrow \text{C}_2\text{H}_5$                                                                                                                                                    | $9.0 \times 10^{-10} \exp(-7500/T)$<br>See Table 3                                                    | 700–2000               | $\pm 0.5$                                            |
| $\text{H} + \text{C}_2\text{H}_5 \rightarrow 2\text{CH}_3$<br>$\rightarrow \text{C}_2\text{H}_6$                                                                                                                                                                         | $6.0 \times 10^{-11}$<br>See Table 3                                                                  | 300–2000               | $\pm 0.3$                                            |
| $\text{H} + \text{C}_2\text{H}_6 \rightarrow \text{H}_2 + \text{C}_2\text{H}_5$                                                                                                                                                                                          | $2.4 \times 10^{-15} T^{1.5} \exp(-3730/T)$                                                           | 300–2000               | $\pm 0.15$ at 300 K rising to<br>$\pm 0.3$ at 2000 K |
| $\text{H} + \text{CHCO} \rightarrow \text{CH}_2 + \text{CO}$<br>$\rightarrow \text{H}_2 + \text{C}_2\text{O}$<br>$\rightarrow \text{HCCOH}$ ]                                                                                                                            | $2.5 \times 10^{-10}$                                                                                 | 300–2500               | $\pm 0.4$                                            |
| $\text{H} + \text{CH}_3\text{CO} \rightarrow \text{CH}_3 + \text{CO}$<br>$\rightarrow \text{CH}_2\text{CHO}$                                                                                                                                                             | $3.0 \times 10^{-11} \exp(-1700/T)$<br>$k_2/k$ very small                                             | 200–2000               | $\pm 0.5$ at 200 K rising to<br>$\pm 1.0$ at 2000 K. |
| $\text{H} + \text{CH}_3\text{CHO} \rightarrow \text{H}_2 + \text{CH}_3\text{CO}$<br>$\rightarrow \text{H}_2 + \text{CH}_2\text{CHO}$ ]                                                                                                                                   | $6.8 \times 10^{-15} T^{1.16} \exp(-1210/T)$                                                          | 300–2000               | $\pm 0.1$ at 300 rising to<br>$\pm 0.4$ at 2000 K.   |
| $\text{H} + \text{C}_6\text{H}_5 + \text{M} \rightarrow \text{C}_6\text{H}_6 + \text{M}$                                                                                                                                                                                 | See Table 3                                                                                           |                        |                                                      |
| $\text{H} + \text{C}_6\text{H}_6 \rightarrow \text{H}_2 + \text{C}_6\text{H}_5$<br>$\rightarrow \text{C}_6\text{H}_7$                                                                                                                                                    | No recommendation<br>See Table 3                                                                      |                        |                                                      |
| $\text{H} + \text{C}_6\text{H}_5\text{O} + \text{M} \rightarrow \text{C}_6\text{H}_5\text{OH} + \text{M}$                                                                                                                                                                | See Table 3                                                                                           |                        |                                                      |
| $\text{H} + \text{C}_6\text{H}_5\text{OH} \rightarrow \text{C}_6\text{H}_5\text{O} + \text{H}_2$<br>$\rightarrow \text{C}_6\text{H}_6 + \text{OH}$                                                                                                                       | $1.9 \times 10^{-10} \exp(-6240/T)$<br>$3.7 \times 10^{-11} \exp(-3990/T)$                            | 1000–1150<br>1000–1150 | $\pm 0.3$<br>$\pm 0.3$                               |
| $\text{H} + \text{C}_6\text{H}_5\text{CH}_2 + \text{M} \rightarrow \text{C}_6\text{H}_5\text{CH}_3 + \text{M}$                                                                                                                                                           | See Table 3                                                                                           |                        |                                                      |
| $\text{H} + \text{C}_6\text{H}_5\text{CH}_3 \rightarrow \text{H}_2 + \text{C}_6\text{H}_5\text{CH}_2$<br>$\rightarrow \text{H}_2 + \text{C}_6\text{H}_4\text{CH}_3$<br>$\rightarrow \text{C}_6\text{H}_6 + \text{CH}_3$<br>$\rightarrow \text{C}_6\text{H}_6\text{CH}_3$ | $6.6 \times 10^{-22} T^{3.44} \exp(-1570/T)$<br>No recommendation<br>No recommendation<br>See Table 3 | 600–2800               | $\pm 0.3$ at 600 K rising to<br>$\pm 0.5$ at 2800 K. |
| $\text{H} + p\text{-C}_6\text{H}_4(\text{CH}_3)_2 \rightarrow \text{products}$                                                                                                                                                                                           | $5.8 \times 10^{-13}$                                                                                 | 298                    | $\pm 0.1$                                            |
| $\text{H} + \text{C}_6\text{H}_5\text{C}_2\text{H}_5 \rightarrow \text{H}_2 + \text{C}_6\text{H}_5\text{C}_2\text{H}_4$<br>$\rightarrow \text{C}_6\text{H}_6\text{C}_2\text{H}_5$                                                                                        | $2.4 \times 10^{-12}$<br>See Table 3                                                                  | 773                    | $\pm 0.1$                                            |

*H<sub>2</sub> Reactions*

|                                                              |             |
|--------------------------------------------------------------|-------------|
| $\text{H}_2 + \text{Ar} \rightarrow 2\text{H} + \text{Ar}$   | See Table 2 |
| $\text{H}_2 + \text{H}_2 \rightarrow 2\text{H} + \text{H}_2$ | See Table 2 |

*OH Radical Reactions*

|                                                                                |                                             |          |                                                     |
|--------------------------------------------------------------------------------|---------------------------------------------|----------|-----------------------------------------------------|
| $\text{OH} + \text{H}_2 \rightarrow \text{H}_2\text{O} + \text{H}$             | $1.7 \times 10^{-16} T^{1.6} \exp(-1660/T)$ | 300–2500 | $\pm 0.1$ at 300 K rising to<br>$\pm 0.3$ at 2500 K |
| $\text{OH} + \text{OH} \rightarrow \text{H}_2\text{O} + \text{O}$              | $2.5 \times 10^{-15} T^{1.14} \exp(-50/T)$  | 250–2500 | $\pm 0.2$                                           |
| $\text{OH} + \text{OH} + \text{M} \rightarrow \text{H}_2\text{O}_2 + \text{M}$ | See Table 3                                 |          |                                                     |

## KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 1  
BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                                                                                  | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                   | Temp/K               | Error limits ( $\Delta \log k$ )                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------|
| $\text{OH} + \text{HO}_2 \rightarrow \text{H}_2\text{O} + \text{O}_2$                                                                                                                                                                                                     | $4.8 \times 10^{-11} \exp(250/T)$                                      | 300–2000             | $\pm 0.2$ at 300 K rising to<br>$\pm 0.5$ at 2000 K.                                                        |
| $\text{OH} + \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{HO}_2$                                                                                                                                                                                           | $1.3 \times 10^{-11} \exp(-670/T)$                                     | 300–1000             | $\pm 0.2$                                                                                                   |
| $\text{OH} + \text{NH} \rightarrow \text{NO} + \text{H}_2$<br>$\quad \quad \quad \rightarrow \text{H}_2\text{O} + \text{N}$ ]                                                                                                                                             | $8.0 \times 10^{-11}$                                                  | 300–1000             | $\pm 0.5$                                                                                                   |
| $\text{OH} + \text{NH}_2 \rightarrow \text{O} + \text{NH}_3$<br>$\quad \quad \quad \rightarrow \text{H}_2\text{O} + \text{NH}$                                                                                                                                            | $3.3 \times 10^{-14} T^{0.405} \exp(-250/T)$<br>No recommendation      | 500–2500             | $\pm 0.5$                                                                                                   |
| $\text{OH} + \text{CO} \rightarrow \text{H} + \text{CO}_2$                                                                                                                                                                                                                | $1.05 \times 10^{-17} T^{1.5} \exp(250/T)$                             | 300–2000             | $\pm 0.2$ at 300 K rising to<br>$\pm 0.5$ at 2000 K.                                                        |
| $\text{OH} + \text{CH}_3 \rightarrow \text{H} + \text{CH}_2\text{OH}$<br>$\quad \quad \quad \rightarrow \text{H} + \text{CH}_3\text{O}$ ]<br>$\quad \quad \quad \rightarrow \text{H}_2\text{O} + {}^1\text{CH}_2$<br>$\quad \quad \quad \rightarrow \text{CH}_3\text{OH}$ | $6.0 \times 10^{-11}$<br>See Table 3                                   | 300–2000             | $\pm 0.7$                                                                                                   |
| $\text{OH} + \text{CH}_4 \rightarrow \text{H}_2\text{O} + \text{CH}_3$                                                                                                                                                                                                    | $2.6 \times 10^{-17} T^{1.83} \exp(-1400/T)$                           | 250–2500             | $\pm 0.07$ at 250 K rising to<br>$\pm 0.15$ at 1200 K.                                                      |
| $\text{OH} + \text{CHO} \rightarrow \text{H}_2\text{O} + \text{CO}$                                                                                                                                                                                                       | $1.7 \times 10^{-10}$                                                  | 300–2500             | $\pm 0.3$                                                                                                   |
| $\text{OH} + \text{HCHO} \rightarrow \text{H}_2\text{O} + \text{CHO}$                                                                                                                                                                                                     | $5.7 \times 10^{-15} T^{1.18} \exp(225/T)$                             | 300–3000             | $\pm 0.1$ at 300 K rising to<br>$\pm 0.7$ at 3000 K.                                                        |
| $\text{OH} + \text{CN} \rightarrow \text{O} + \text{HCN}$<br>$\quad \quad \quad \rightarrow \text{NCO} + \text{H}$ ]                                                                                                                                                      | $1.0 \times 10^{-10}$                                                  | 1500–3000            | $\pm 0.5$                                                                                                   |
| $\text{OH} + \text{HCN} \rightarrow \text{H}_2\text{O} + \text{CN}$<br>$\quad \quad \quad \rightarrow \text{HOCN} + \text{H}$ ]<br>$\quad \quad \quad \rightarrow \text{HNCO} + \text{H}$ ]                                                                               | $1.5 \times 10^{-11} \exp(-5400/T)$<br>No recommendation               | 1500–2500            | $\pm 0.5$                                                                                                   |
| $\text{OH} + \text{CH}_3\text{OOH} \rightarrow \text{H}_2\text{O} + \text{CH}_3\text{OO}$<br>$\quad \quad \quad \rightarrow \text{H}_2\text{O} + \text{CH}_2\text{OOH}$                                                                                                   | $1.2 \times 10^{-12} \exp(130/T)$<br>$1.8 \times 10^{-12} \exp(220/T)$ | 300–1000<br>300–1000 | $\pm 0.2$ at 300 K rising to<br>$\pm 0.4$ at 1000 K<br>$\pm 0.1$ at 300 K rising to<br>$\pm 0.3$ at 1000 K. |
| $\text{OH} + \text{C}_2\text{H}_2 \rightarrow \text{H}_2\text{O} + \text{C}_2\text{H}$<br>$\quad \quad \quad \rightarrow \text{H} + \text{CH}_2\text{CO}$ ]<br>$\quad \quad \quad \rightarrow \text{C}_2\text{H}_2\text{OH}$                                              | $1.0 \times 10^{-10} \exp(-6500/T)$<br>See Table 3                     | 1000–2000            | $\pm 1.0$                                                                                                   |
| $\text{OH} + \text{C}_2\text{H}_4 \rightarrow \text{H}_2\text{O} + \text{C}_2\text{H}_3$                                                                                                                                                                                  | $3.4 \times 10^{-11} \exp(-2990/T)$                                    | 650–1500             | $\pm 0.5$                                                                                                   |
| $\text{OH} + \text{C}_2\text{H}_6 \rightarrow \text{H}_2\text{O} + \text{C}_2\text{H}_5$                                                                                                                                                                                  | $1.2 \times 10^{-17} T^{2.0} \exp(-435/T)$                             | 250–2000             | $\pm 0.07$ at 250 K rising to<br>$\pm 0.15$ at 2000 K.                                                      |
| $\text{OH} + \text{CH}_2\text{CO} \rightarrow \text{CH}_2\text{OH} + \text{CO}$<br>$\quad \quad \quad \rightarrow \text{H}_2\text{CO} + \text{HCO}$ ]                                                                                                                     | $1.7 \times 10^{-11}$                                                  | 300–2000             | $\pm 1.0$                                                                                                   |
| $\text{OH} + \text{CH}_3\text{CHO} \rightarrow \text{H}_2\text{O} + \text{CH}_3\text{CO}$<br>$\quad \quad \quad \rightarrow \text{H}_2\text{O} + \text{CH}_2\text{CHO}$ ]                                                                                                 | $3.9 \times 10^{-14} T^{0.73} \exp(560/T)$                             | 250–1200             | $\pm 0.1$ at 250 K rising to<br>$\pm 0.3$ at 1200 K.                                                        |
| $\text{OH} + \text{C}_2\text{H}_5\text{OOH} \rightarrow \text{H}_2\text{O} + \text{C}_2\text{H}_5\text{OO}$<br>$\quad \quad \quad \rightarrow \text{H}_2\text{O} + \text{C}_2\text{H}_4\text{OOH}$ ]                                                                      | $3.0 \times 10^{-12} \exp(190/T)$<br>[estimate]                        | 250–1000             | $\pm 0.3$ at 250 K rising to<br>$\pm 0.7$ at 1000 K.                                                        |

# KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 1  
BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                                                                                      | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                                              | Temp/K                | Error limits ( $\Delta \log k$ )                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------|--------------------------------------------------------|
| $\text{OH} + \text{C}_6\text{H}_6 \rightarrow \text{H}_2\text{O} + \text{C}_6\text{H}_5$<br>$\rightarrow \text{H} + \text{C}_6\text{H}_5\text{OH}$<br>$\rightarrow \text{C}_6\text{H}_6\text{OH}$                                                                             | $2.7 \times 10^{-16} T^{1.42} \exp(-730/T)$<br>$2.2 \times 10^{-11} \exp(-5330/T)$<br>See Table 3 | 400–1500<br>1000–1150 | $\pm 0.3$<br>$\pm 0.3$                                 |
| $\text{OH} + \text{C}_6\text{H}_5\text{OH} \rightarrow \text{C}_6\text{H}_5(\text{OH})_2$<br>$\rightarrow \text{H}_2\text{O} + \text{C}_6\text{H}_5\text{O}$<br>$\rightarrow \text{H}_2\text{O} + \text{C}_6\text{H}_4\text{OH}$ ]                                            | See Table 3<br><br>$1.0 \times 10^{-11}$                                                          | 1000–1150             | $\pm 0.5$                                              |
| $\text{OH} + \text{C}_6\text{H}_5\text{CH}_3 \rightarrow \text{H}_2\text{O} + \text{C}_6\text{H}_5\text{CH}_2$                                                                                                                                                                | $8.6 \cdot 10^{-15} T \exp(-1440/T)$<br>See Table 3                                               | 400–1200              | $\pm 0.5$ at 400 K reducing to<br>$\pm 0.3$ at 1200 K. |
| $\text{OH} + p\text{-C}_6\text{H}_4(\text{CH}_3)_2 \rightarrow \text{C}_6\text{H}_4\text{CH}_2\text{CH}_3 + \text{H}_2\text{O}$<br>$\rightarrow p\text{-C}_6\text{H}_4(\text{CH}_3)_2\text{OH}$                                                                               | $6.4 \times 10^{-11} \exp(-1440/T)$<br>See Table 3                                                | 500–960               | $\pm 0.1$                                              |
| $\text{OH} + \text{C}_6\text{H}_5\text{C}_2\text{H}_5 \rightarrow \text{HOC}_6\text{H}_5\text{C}_2\text{H}_5$<br>$\rightarrow \text{H}_2\text{O} + \text{C}_6\text{H}_5\text{C}_2\text{H}_4$<br>$\rightarrow \text{H}_2\text{O} + \text{C}_6\text{H}_4\text{C}_2\text{H}_5$ ] | See Table 3<br>$8.7 \times 10^{-12}$                                                              | 773                   | $\pm 0.1$                                              |
| <i>H<sub>2</sub>O Reactions</i>                                                                                                                                                                                                                                               |                                                                                                   |                       |                                                        |
| $\text{H}_2\text{O} + \text{M} \rightarrow \text{H} + \text{OH} + \text{M}$                                                                                                                                                                                                   | See Table 2                                                                                       |                       |                                                        |
| <i>HO<sub>2</sub> Radical Reactions</i>                                                                                                                                                                                                                                       |                                                                                                   |                       |                                                        |
| $\text{HO}_2 + \text{HO}_2 \rightarrow \text{H}_2\text{O}_2 + \text{O}_2$                                                                                                                                                                                                     | $3.1 \times 10^{-12} \exp(-775/T)$                                                                | 550–1250              | $\pm 0.15$ at 550 K rising to<br>$\pm 0.3$ at 1250 K.  |
| $\text{HO}_2 + \text{NH}_2 \rightarrow \text{NH}_3 + \text{O}_2$<br>$\rightarrow \text{HNO} + \text{H}_2\text{O}$ ]                                                                                                                                                           | $2.6 \times 10^{-11}$                                                                             | 300–400               | $\pm 0.4$                                              |
| $\text{HO}_2 + \text{CH}_3 \rightarrow \text{OH} + \text{CH}_3\text{O}$<br>$\rightarrow \text{O}_2 + \text{CH}_4$                                                                                                                                                             | $3 \times 10^{-11}$<br>No recommendation                                                          | 300–2500              | $\pm 0.7$                                              |
| $\text{HO}_2 + \text{CH}_4 \rightarrow \text{H}_2\text{O}_2 + \text{CH}_3$                                                                                                                                                                                                    | $1.5 \times 10^{-11} \exp(-12400/T)$                                                              | 600–1000              | $\pm 0.2$ at 600 K rising to<br>$\pm 0.3$ at 1000 K.   |
| $\text{HO}_2 + \text{HCHO} \rightarrow \text{H}_2\text{O}_2 + \text{CHO}$                                                                                                                                                                                                     | $5.0 \times 10^{-12} \exp(-6580/T)$                                                               | 600–1000              | $\pm 0.5$                                              |
| $\text{HO}_2 + \text{C}_2\text{H}_4 \rightarrow \text{OH} + \text{C}_2\text{H}_4\text{O}$                                                                                                                                                                                     | $3.7 \times 10^{-12} \exp(-8650/T)$                                                               | 600–900               | $\pm 0.15$ at 600 K rising to<br>$\pm 0.25$ at 900 K.  |
| $\text{HO}_2 + \text{C}_2\text{H}_6 \rightarrow \text{H}_2\text{O}_2 + \text{C}_2\text{H}_5$                                                                                                                                                                                  | $2.2 \times 10^{-11} \exp(-10300/T)$                                                              | 500–1000              | $\pm 0.2$ at 500 K rising to<br>$\pm 0.3$ at 1000 K.   |
| $\text{HO}_2 + \text{CH}_3\text{CHO} \rightarrow \text{H}_2\text{O}_2 + \text{CH}_3\text{CO}$                                                                                                                                                                                 | $5.0 \times 10^{-12} \exp(-6000/T)$                                                               | 900–1200              | $\pm 0.7$                                              |
| <i>H<sub>2</sub>O<sub>2</sub> Reactions</i>                                                                                                                                                                                                                                   |                                                                                                   |                       |                                                        |
| $\text{H}_2\text{O}_2 + \text{M} \rightarrow 2\text{OH} + \text{M}$                                                                                                                                                                                                           | See Table 2                                                                                       |                       |                                                        |
| <i>N Atom Reactions</i>                                                                                                                                                                                                                                                       |                                                                                                   |                       |                                                        |
| $\text{N} + \text{CN} \rightarrow \text{N}_2 + \text{C}$                                                                                                                                                                                                                      | $3 \times 10^{-10}$                                                                               | 300–2500              | $\pm 1.0$                                              |
| $\text{N} + \text{NCO} \rightarrow \text{NO} + \text{CN}$<br>$\rightarrow \text{N}_2 + \text{CO}$                                                                                                                                                                             | No recommendation<br>$3.3 \times 10^{-11}$                                                        | 1700                  | $\pm 0.5$                                              |

# KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 1  
BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                                  | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                        | Temp/K   | Error limits ( $\Delta \log k$ )                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------|------------------------------------------------------|
| <i>NH Radical Reactions</i>                                                                                                                                                                                               |                                                                             |          |                                                      |
| $\text{NH} + \text{O}_2 \rightarrow \text{NO} + \text{OH}$<br>$\rightarrow \text{NO}_2 + \text{H}$<br>$\rightarrow \text{HNO} + \text{O}$                                                                                 | $1.26 \times 10^{-13} \exp(-770/T)$                                         | 270–550  | $\pm 0.2$ at 270 K rising to<br>$\pm 0.5$ at 550 K.  |
| $\text{NH} + \text{NO} \rightarrow \text{N}_2\text{O} + \text{H}$<br>$\rightarrow \text{HN}_2 + \text{O}$<br>$\rightarrow \text{N}_2 + \text{OH}$                                                                         | $5.0 \times 10^{-11}$                                                       | 270–380  | $\pm 0.2$                                            |
| <i>NH<sub>2</sub> Radical Reactions</i>                                                                                                                                                                                   |                                                                             |          |                                                      |
| $\text{NH}_2 + \text{O}_2 \rightarrow \text{products}$                                                                                                                                                                    | $<3 \times 10^{-18}$                                                        | 298      |                                                      |
| $\text{NH}_2 + \text{NO} \rightarrow \text{N}_2 + \text{H}_2\text{O}$<br>$\rightarrow \text{N}_2 + \text{H} + \text{OH}$<br>$\rightarrow \text{N}_2\text{H} + \text{OH}$<br>$\rightarrow \text{N}_2\text{O} + \text{H}_2$ | $1.8 \times 10^{-12} \exp(650/T)$<br>$(k_2 + k_3)/k \approx 0.12$ at 298 K. | 220–2000 | $\pm 0.5$                                            |
| <i><sup>1</sup>C<sub>2</sub> and <sup>3</sup>C<sub>2</sub> Radical Reactions</i>                                                                                                                                          |                                                                             |          |                                                      |
| See data sheets.                                                                                                                                                                                                          |                                                                             |          |                                                      |
| <i>CH Radical Reactions</i>                                                                                                                                                                                               |                                                                             |          |                                                      |
| $\text{CH} + \text{O}_2 \rightarrow \text{CHO} + \text{O}$<br>$\rightarrow \text{CO} + \text{OH}$                                                                                                                         | $5.5 \times 10^{-11}$                                                       | 300–2000 | $\pm 0.3$ at 300 K rising to<br>$\pm 0.5$ at 2000 K. |
| $\text{CH} + \text{H}_2 \rightarrow \text{CH}_2 + \text{H}$<br>$\rightarrow \text{CH}_3$                                                                                                                                  | $2.4 \times 10^{-10} \exp(-1760/T)$                                         | 300–1000 | $\pm 0.3$                                            |
| $\text{CH} + \text{H}_2\text{O} \rightarrow \text{products}$                                                                                                                                                              | $9.5 \times 10^{-12} \exp(380/T)$                                           | 300–1000 | $\pm 1.0$                                            |
| $\text{CH} + \text{CO} \rightarrow \text{products}$                                                                                                                                                                       | $4.6 \times 10^{-13} \exp(860/T)$                                           | 300–1000 | $\pm 1.0$                                            |
| $\text{CH} + \text{CO}_2 \rightarrow \text{products}$                                                                                                                                                                     | $5.7 \times 10^{-12} \exp(-345/T)$                                          | 300–1000 | $\pm 1.0$                                            |
| $\text{CH} + \text{CH}_4 \rightarrow \text{products}$                                                                                                                                                                     | $5.0 \times 10^{-11} \exp(200/T)$                                           | 200–700  | $\pm 1.0$                                            |
| $\text{CH} + \text{C}_2\text{H}_2 \rightarrow \text{products}$                                                                                                                                                            | $3.5 \times 10^{-10} \exp(61/T)$                                            | 200–700  | $\pm 1.0$                                            |
| $\text{CH} + \text{C}_2\text{H}_4 \rightarrow \text{products}$                                                                                                                                                            | $2.2 \times 10^{-10} \exp(173/T)$                                           | 200–700  | $\pm 1.0$                                            |
| $\text{CH} + \text{C}_2\text{H}_6 \rightarrow \text{products}$                                                                                                                                                            | $1.8 \times 10^{-10} \exp(132/T)$                                           | 200–700  | $\pm 1.0$                                            |
| $\text{CH} + \text{C}_3\text{H}_8 \rightarrow \text{products}$                                                                                                                                                            | $1.9 \times 10^{-10} \exp(240/T)$                                           | 300–700  | $\pm 1.0$                                            |
| $\text{CH} + n\text{-C}_4\text{H}_{10} \rightarrow \text{products}$                                                                                                                                                       | $4.4 \times 10^{-10} \exp(28/T)$                                            | 250–700  | $\pm 1.0$                                            |
| $\text{CH} + i\text{-C}_4\text{H}_{10} \rightarrow \text{products}$                                                                                                                                                       | $2.0 \times 10^{-10} \exp(240/T)$                                           | 300–700  | $\pm 1.0$                                            |
| $\text{CH} + \text{neo-C}_5\text{H}_{12} \rightarrow \text{products}$                                                                                                                                                     | $1.6 \times 10^{-10} \exp(340/T)$                                           | 300–700  | $\pm 1.0$                                            |
| $\text{CH} + \text{CH}_3\text{C}_2\text{H} \rightarrow \text{products}$                                                                                                                                                   | No recommendation                                                           |          |                                                      |
| $\text{CH} + \text{CH}_2\text{O} \rightarrow \text{products}$                                                                                                                                                             | $1.6 \times 10^{-10} \exp(260/T)$                                           | 300–700  | $\pm 1.0$                                            |

## KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 1  
BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                                                                       | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                                       | Temp/K                | Error limits ( $\Delta \log k$ )                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------|------------------------------------------------------|
| <b><sup>3</sup>CH<sub>2</sub> Radical Reactions</b>                                                                                                                                                                                                            |                                                                                            |                       |                                                      |
| $^3\text{CH}_2 + \text{O}_2 \rightarrow \text{CO} + \text{H} + \text{OH}$<br>$\rightarrow \text{CO}_2 + \text{H} + \text{H}$<br>$\rightarrow \text{CO} + \text{H}_2\text{O}$<br>$\rightarrow \text{CO}_2 + \text{H}_2$<br>$\rightarrow \text{HCHO} + \text{O}$ | $4.1 \times 10^{-11} \exp(-750/T)$                                                         | 300–1000              | $\pm 0.3$ at 300 K rising to<br>$\pm 0.5$ at 1000 K. |
| $^3\text{CH}_2 + ^3\text{CH}_2 \rightarrow \text{C}_2\text{H}_2 + \text{H}_2$<br>$\rightarrow \text{C}_2\text{H}_2 + 2\text{H}$                                                                                                                                | $2.0 \times 10^{-10} \exp(-400/T)$<br>$k_2/k = 0.9 \pm 0.1$ over range 300–3000 K.         | 300–3000              | $\pm 0.5$                                            |
| $^3\text{CH}_2 + \text{CH}_3 \rightarrow \text{C}_2\text{H}_4 + \text{H}$                                                                                                                                                                                      | $7.0 \times 10^{-11}$                                                                      | 300–3000              | $\pm 0.3$ at 300 K rising to<br>$\pm 0.5$ at 3000 K. |
| $^3\text{CH}_2 + \text{C}_2\text{H}_2 \rightarrow \text{C}_3\text{H}_4$                                                                                                                                                                                        | See Table 3                                                                                |                       |                                                      |
| $^3\text{CH}_2 + \text{C}_2\text{H}_4 \rightarrow \text{C}_3\text{H}_6$<br>$\rightarrow \text{c-C}_3\text{H}_6$<br>$\rightarrow \text{CH}_2\text{CHCH}_2 + \text{H}$                                                                                           | See Table 3                                                                                |                       |                                                      |
| <b><sup>1</sup>CH<sub>2</sub> Radical Reactions</b>                                                                                                                                                                                                            |                                                                                            |                       |                                                      |
| $^1\text{CH}_2 + \text{Ar} \rightarrow ^3\text{CH}_2 + \text{Ar}$                                                                                                                                                                                              | $6.0 \times 10^{-12}$                                                                      | 300–2000              | $\pm 0.3$                                            |
| $^1\text{CH}_2 + \text{N}_2 \rightarrow ^3\text{CH}_2 + \text{N}_2$                                                                                                                                                                                            | $1.0 \times 10^{-11}$                                                                      | 300–2000              | $\pm 0.3$                                            |
| $^1\text{CH}_2 + \text{CH}_4 \rightarrow ^3\text{CH}_2 + \text{CH}_4$                                                                                                                                                                                          | $1.2 \times 10^{-11}$                                                                      | 300–2000              | $\pm 0.4$                                            |
| $^1\text{CH}_2 + \text{C}_2\text{H}_2 \rightarrow ^3\text{CH}_2 + \text{C}_2\text{H}_2$                                                                                                                                                                        | $8.0 \times 10^{-11}$                                                                      | 300–2000              | $\pm 0.4$                                            |
| $^1\text{CH}_2 + \text{C}_2\text{H}_4 \rightarrow ^3\text{CH}_2 + \text{C}_2\text{H}_4$                                                                                                                                                                        | $2.3 \times 10^{-11}$                                                                      | 300–2000              | $\pm 0.4$                                            |
| $^1\text{CH}_2 + \text{C}_2\text{H}_6 \rightarrow ^3\text{CH}_2 + \text{C}_2\text{H}_6$                                                                                                                                                                        | $3.6 \times 10^{-11}$                                                                      | 300–2000              | $\pm 0.4$                                            |
| $^1\text{CH}_2 + \text{O}_2 \rightarrow \text{CO} + \text{H} + \text{OH}$<br>$\rightarrow \text{CO}_2 + \text{H}_2$<br>$\rightarrow \text{CO} + \text{H}_2\text{O}$<br>$\rightarrow ^3\text{CH}_2 + \text{O}_2$                                                | $5.2 \times 10^{-11}$                                                                      | 300–1000              | $\pm 0.3$ at 300 K rising to<br>$\pm 0.5$ at 1000 K. |
| $^1\text{CH}_2 + \text{H}_2 \rightarrow \text{CH}_3 + \text{H}$                                                                                                                                                                                                | $1.2 \times 10^{-10}$                                                                      | 300–1000              | $\pm 0.1$ at 300 K rising to<br>$\pm 0.3$ at 1000 K. |
| $^1\text{CH}_2 + \text{C}_2\text{H}_2 \rightarrow \text{CH}_2\text{CCH}_2$<br>$\rightarrow \text{CH}_3\text{CCH}$<br>$\rightarrow \text{CH}_2\text{CCH} + \text{H}$<br>$\rightarrow ^3\text{CH}_2 + \text{C}_2\text{H}_2$                                      | See Table 3<br><br>See earlier entry                                                       |                       |                                                      |
| $^1\text{CH}_2 + \text{C}_2\text{H}_4 \rightarrow \text{C}_3\text{H}_6$<br>$\rightarrow ^3\text{CH}_2 + \text{C}_2\text{H}_4$                                                                                                                                  | See Table 3<br>See earlier entry                                                           |                       |                                                      |
| <b>CH<sub>3</sub> Radical Reactions</b>                                                                                                                                                                                                                        |                                                                                            |                       |                                                      |
| $\text{CH}_3 + \text{M} \rightarrow \text{CH}_2 + \text{H} + \text{M}$                                                                                                                                                                                         | See Table 2                                                                                |                       |                                                      |
| $\text{CH}_3 + \text{O}_2 \rightarrow \text{CH}_3\text{O} + \text{O}$<br>$\rightarrow \text{HCHO} + \text{OH}$<br>$\rightarrow \text{CH}_3\text{O}_2$                                                                                                          | $2.2 \times 10^{-10} \exp(-15800/T)$<br>$5.5 \times 10^{-13} \exp(-4500/T)$<br>See Table 3 | 300–2500<br>1000–2500 | $\pm 0.5$<br>$\pm 0.5$                               |

## KINETIC DATA FOR COMBUSTION MODELLING (continued)

 Table 1  
 BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                     | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                                    | Temp/K    | Error limits ( $\Delta \log k$ )                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------|--------------------------------------------------------------------------|
| $\text{CH}_3 + \text{H}_2 \rightarrow \text{CH}_4 + \text{H}$                                                                                                                | $1.14 \times 10^{-20} T^{2.74} \exp(-4740/T)$                                           | 300–2500  | $\pm 0.15$ in the range 300–700 K.<br>$\pm 0.3$ in the range 700–2500 K. |
| $\text{CH}_3 + \text{CH}_3 \rightarrow \text{C}_2\text{H}_5 + \text{H}$<br>$\quad \rightarrow \text{C}_2\text{H}_4 + \text{H}_2$<br>$\quad \rightarrow \text{C}_2\text{H}_6$ | $5 \times 10^{-11} \exp(-6800/T)$<br>No recommendation (see data sheets)<br>See Table 3 | 1300–2500 | $\pm 0.6$                                                                |
| $\text{CH}_3 + \text{HCHO} \rightarrow \text{CH}_4 + \text{HCO}$                                                                                                             | $6.8 \times 10^{-12} \exp(-4450/T)$                                                     | 300–1000  | $\pm 0.3$                                                                |
| $\text{CH}_3 + \text{C}_2\text{H}_2 + \text{M} \rightarrow \text{C}_3\text{H}_3 + \text{M}$<br>$\quad \rightarrow \text{CH}_4 + \text{C}_2\text{H}$                          | See Table 3<br>No recommendation                                                        |           |                                                                          |
| $\text{CH}_3 + \text{C}_2\text{H}_4 \rightarrow \text{CH}_4 + \text{C}_2\text{H}_3$<br>$\quad \rightarrow n\text{-C}_3\text{H}_7$                                            | $6.9 \times 10^{-12} \exp(-5600/T)$<br>See Table 3                                      | 400–3000  | $\pm 0.5$                                                                |
| $\text{CH}_3 + \text{C}_2\text{H}_5 \rightarrow \text{CH}_4 + \text{C}_2\text{H}_4$<br>$\quad \rightarrow \text{C}_3\text{H}_6$                                              | $1.9 \times 10^{-12}$<br>See Table 3                                                    | 300–800   | $\pm 0.4$                                                                |
| $\text{CH}_3 + \text{C}_2\text{H}_6 \rightarrow \text{CH}_4 + \text{C}_2\text{H}_5$                                                                                          | $2.5 \times 10^{-31} T^{6.0} \exp(-3043/T)$                                             | 300–1500  | $\pm 0.1$ at 300 K rising to<br>$\pm 0.2$ at 1500 K.                     |
| $\text{CH}_3 + \text{CH}_3\text{CHO} \rightarrow \text{CH}_4 + \text{CH}_3\text{CO}$<br>$\quad \rightarrow \text{CH}_4 + \text{CH}_2\text{CHO}$                              | $3.3 \times 10^{-30} T^{5.64} \exp(-1240/T)$<br>No recommendation (see data sheets)     | 300–1250  | $\pm 0.3$                                                                |
| <i>CH<sub>4</sub> Reactions</i>                                                                                                                                              |                                                                                         |           |                                                                          |
| $\text{CH}_4 + \text{M} \rightarrow \text{CH}_3 + \text{H} + \text{M}$                                                                                                       | See Table 2                                                                             |           |                                                                          |
| <i>CHO Radical Reactions</i>                                                                                                                                                 |                                                                                         |           |                                                                          |
| $\text{CHO} + \text{O}_2 \rightarrow \text{CO} + \text{HO}_2$<br>$\quad \rightarrow \text{OH} + \text{CO}_2$<br>$\quad \rightarrow \text{HCO}_3$ ]                           | $5.0 \times 10^{-12}$                                                                   | 300–2500  | $\pm 0.3$                                                                |
| $\text{CHO} + \text{CHO} \rightarrow \text{HCHO} + \text{CO}$                                                                                                                | $5.0 \times 10^{-11}$                                                                   | 300       | $\pm 0.3$                                                                |
| <i>HCHO Reactions</i>                                                                                                                                                        |                                                                                         |           |                                                                          |
| $\text{HCHO} + \text{M} \rightarrow \text{H} + \text{CHO} + \text{M}$<br>$\quad \rightarrow \text{H}_2 + \text{CO} + \text{M}$ ]                                             | See Table 2                                                                             |           |                                                                          |
| <i>CH<sub>2</sub>OH Reactions</i>                                                                                                                                            |                                                                                         |           |                                                                          |
| $\text{CH}_2\text{OH} + \text{O}_2 \rightarrow \text{CH}_2\text{O} + \text{HO}_2$                                                                                            | $2.6 \times 10^{-9} T^{-1.0} +$<br>$1.2 \times 10^{-10} \exp(-1800/T)$                  | 300–1200  | $\pm 0.1$ at 300 K rising to<br>$\pm 0.3$ at 1200 K.                     |
| <i>CH<sub>3</sub>O Radical Reactions</i>                                                                                                                                     |                                                                                         |           |                                                                          |
| $\text{CH}_3\text{O} + \text{M} \rightarrow \text{HCHO} + \text{H} + \text{M}$                                                                                               | See Table 2                                                                             |           |                                                                          |
| $\text{CH}_3\text{O} + \text{O}_2 \rightarrow \text{HCHO} + \text{HO}_2$                                                                                                     | $6.7 \times 10^{-14} \exp(-1070/T)$                                                     | 300–1000  | $\pm 0.2$ at 500 K rising to<br>$\pm 0.3$ at 300 K and 1000 K.           |

# KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 1  
BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                                                                   | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | Temp/K   | Error limits ( $\Delta \log k$ )                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|----------|----------------------------------------------------|
| <i>CH<sub>3</sub>OOH Reactions</i>                                                                                                                                                                                                                         |                                                      |          |                                                    |
| $\text{CH}_3\text{OOH} + \text{M} \rightarrow \text{CH}_3\text{O} + \text{OH} + \text{M}$                                                                                                                                                                  | See Table 2                                          |          |                                                    |
| <i>CN Radical Reactions</i>                                                                                                                                                                                                                                |                                                      |          |                                                    |
| $\text{CN} + \text{O}_2 \rightarrow \text{NCO} + \text{O}$                                                                                                                                                                                                 | $1.1 \times 10^{-11} \exp(205/T)$                    | 300–2500 | $\pm 0.25$ at 300 K rising to $\pm 0.5$ at 2500 K. |
| $\text{CN} + \text{H}_2\text{O} \rightarrow \text{HCN} + \text{OH}$<br>$\quad \quad \quad \rightarrow \text{HOCN} + \text{H}$                                                                                                                              | $1.3 \times 10^{-11} \exp(-3750/T)$                  | 500–3000 | $\pm 0.3$ at 500 K rising to $\pm 0.5$ at 3000 K.  |
| $\text{CN} + \text{CH}_4 \rightarrow \text{HCN} + \text{CH}_3$                                                                                                                                                                                             | $1.5 \times 10^{-11} \exp(-940/T)$                   | 260–400  | $\pm 0.3$                                          |
| <i>NCO Radical Reactions</i>                                                                                                                                                                                                                               |                                                      |          |                                                    |
| $\text{NCO} + \text{M} \rightarrow \text{N} + \text{CO} + \text{M}$                                                                                                                                                                                        | See Table 2                                          |          |                                                    |
| $\text{NCO} + \text{NO} \rightarrow \text{N}_2\text{O} + \text{CO}$<br>$\quad \quad \quad \rightarrow \text{N}_2 + \text{CO}_2$<br>$\quad \quad \quad \rightarrow \text{N}_2 + \text{CO} + \text{O}$                                                       | $1.7 \times 10^{-11} \exp(200/T)$                    | 300–600  | $\pm 0.5$                                          |
| <i>C<sub>2</sub>H Radical Reactions</i>                                                                                                                                                                                                                    |                                                      |          |                                                    |
| $\text{C}_2\text{H} + \text{O}_2 \rightarrow \text{CO}_2 + \text{CH}$<br>$\quad \quad \quad \rightarrow 2\text{CO} + \text{H}$<br>$\quad \quad \quad \rightarrow \text{C}_2\text{HO} + \text{O}$<br>$\quad \quad \quad \rightarrow \text{CO} + \text{HCO}$ | $3.0 \times 10^{-11}$                                | 300      | $\pm 0.5$                                          |
| $\text{C}_2\text{H} + \text{H}_2 \rightarrow \text{C}_2\text{H}_2 + \text{H}$                                                                                                                                                                              | $2.5 \times 10^{-11} \exp(-1560/T)$                  | 300–2500 | $\pm 0.3$ at 300 K rising to $\pm 0.7$ at 2500 K   |
| $\text{C}_2\text{H} + \text{C}_2\text{H}_2 \rightarrow \text{C}_4\text{H}_2 + \text{H}$                                                                                                                                                                    | $5.0 \times 10^{-11}$                                | 300–2700 | $\pm 0.3$                                          |
| $\text{C}_2\text{H} + \text{CH}_4 \rightarrow \text{products}$                                                                                                                                                                                             | $2.0 \times 10^{-12}$                                | 298      | $\pm 1$                                            |
| $\text{C}_2\text{H} + \text{C}_2\text{H}_6 \rightarrow \text{products}$                                                                                                                                                                                    | No recommendation                                    |          |                                                    |
| <i>C<sub>2</sub>H<sub>3</sub> Radical Reactions</i>                                                                                                                                                                                                        |                                                      |          |                                                    |
| $\text{C}_2\text{H}_3 + \text{M} \rightarrow \text{C}_2\text{H}_2 + \text{H} + \text{M}$                                                                                                                                                                   | See Table 2                                          |          |                                                    |
| $\text{C}_2\text{H}_3 + \text{O}_2 \rightarrow \text{HCHO} + \text{CHO}$                                                                                                                                                                                   | $9.0 \times 10^{-12}$                                | 300–2000 | $\pm 0.3$ at 300 K rising to $\pm 0.5$ at 2000 K   |
| <i>C<sub>2</sub>H<sub>5</sub> Radical Reactions</i>                                                                                                                                                                                                        |                                                      |          |                                                    |
| $\text{C}_2\text{H}_5 + \text{O}_2 \rightarrow \text{C}_2\text{H}_4 + \text{HO}_2$                                                                                                                                                                         | $1.7 \times 10^{-14} \exp(1100/T)$                   | 600–1200 | $\pm 0.3$                                          |
| $\text{C}_2\text{H}_5 + \text{C}_2\text{H}_5 \rightarrow \text{C}_2\text{H}_6 + \text{C}_2\text{H}_4$<br>$\quad \quad \quad \rightarrow n\text{-C}_4\text{H}_{10}$                                                                                         | $2.4 \times 10^{-12}$<br>See Table 3                 | 300–1200 | $\pm 0.4$                                          |
| <i>C<sub>2</sub>H<sub>6</sub> Reactions</i>                                                                                                                                                                                                                |                                                      |          |                                                    |
| $\text{C}_2\text{H}_6 + \text{M} \rightarrow \text{CH}_3 + \text{CH}_3 + \text{M}$                                                                                                                                                                         | See Table 2                                          |          |                                                    |

## KINETIC DATA FOR COMBUSTION MODELLING (continued)

 Table 1  
 BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                                                                                                   | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$                 | Temp/K          | Error limits ( $\Delta \log k$ )                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|-----------------|-----------------------------------------------------|
| <i>CHCO Reactions</i>                                                                                                                                                                                                                                                                      |                                                                      |                 |                                                     |
| $\text{CHCO} + \text{O}_2 \rightarrow \text{CO}_2 + \text{HCO}$<br>$\rightarrow 2\text{CO} + \text{OH}$<br>$\rightarrow \text{C}_2\text{O} + \text{HO}_2$<br>$\rightarrow \text{CHO}_2\text{CO}$                                                                                           | $2.7 \times 10^{-12} \exp(430/T)$<br>$M = \text{He}, 2 \text{ Torr}$ | 300–550         | $\pm 0.7$                                           |
| <i>CH<sub>2</sub>CHO Radical Reactions</i>                                                                                                                                                                                                                                                 |                                                                      |                 |                                                     |
| $\text{CH}_2\text{CHO} + \text{O}_2 \rightarrow \text{HO}_2 + \text{CH}_2\text{CHO}$<br>$\rightarrow \text{HCHO} + \text{CO} + \text{OH}$<br>$\rightarrow \text{O}_2\text{CH}_2\text{CHO}$                                                                                                 | $k_\infty = 2.6 \times 10^{-13}$<br>$k_2 = 3.0 \times 10^{-14}$      | 250–1000<br>300 | $\pm 0.2$<br>$\pm 0.3$                              |
| <i>CH<sub>3</sub>CO Radical Reactions</i>                                                                                                                                                                                                                                                  |                                                                      |                 |                                                     |
| $\text{CH}_3\text{CO} + \text{O}_2 + M \rightarrow \text{CH}_3\text{CO}_3 + M$                                                                                                                                                                                                             | See Table 3                                                          |                 |                                                     |
| <i>CH<sub>3</sub>CHO Reactions</i>                                                                                                                                                                                                                                                         |                                                                      |                 |                                                     |
| $\text{CH}_3\text{CHO} + M \rightarrow \text{CH}_3 + \text{HCO} + M$                                                                                                                                                                                                                       | See Table 2                                                          |                 |                                                     |
| <i>C<sub>2</sub>H<sub>3</sub>O Reactions</i>                                                                                                                                                                                                                                               |                                                                      |                 |                                                     |
| $\text{C}_2\text{H}_3\text{O} + M \rightarrow \text{HCHO} + \text{CH}_3 + M$<br>$\rightarrow \text{CH}_3\text{CHO} + \text{H} + M$                                                                                                                                                         | See Table 2                                                          |                 |                                                     |
| $\text{C}_2\text{H}_3\text{O} + \text{O}_2 \rightarrow \text{CH}_3\text{CHO} + \text{HO}_2$                                                                                                                                                                                                | $1.0 \times 10^{-13} \exp(-830/T)$                                   | 300–1000        | $\pm 0.3$ at 300 K rising to<br>$\pm 0.5$ at 1000 K |
| <i>C<sub>2</sub>H<sub>3</sub>OOH Reactions</i>                                                                                                                                                                                                                                             |                                                                      |                 |                                                     |
| $\text{C}_2\text{H}_3\text{OOH} + M \rightarrow \text{C}_2\text{H}_3\text{O} + \text{OH} + M$                                                                                                                                                                                              | See Table 2                                                          |                 |                                                     |
| <i>C<sub>6</sub>H<sub>3</sub> Radical Reactions</i>                                                                                                                                                                                                                                        |                                                                      |                 |                                                     |
| $\text{C}_6\text{H}_3 + M \rightarrow \text{C}_2\text{H}_2 + \text{C}_4\text{H}_3 + M$<br>$\rightarrow \text{C}_2\text{H}_3 + \text{C}_4\text{H}_2 + M$<br>$\rightarrow \text{linear-C}_6\text{H}_5 + M$                                                                                   | See Table 2                                                          |                 |                                                     |
| <i>C<sub>6</sub>H<sub>6</sub> Reactions</i>                                                                                                                                                                                                                                                |                                                                      |                 |                                                     |
| $\text{C}_6\text{H}_6 + M \rightarrow \text{C}_6\text{H}_5 + \text{H} + M$<br>$\rightarrow \text{C}_4\text{H}_4 + \text{C}_2\text{H}_2 + M$                                                                                                                                                | See Table 2                                                          |                 |                                                     |
| <i>C<sub>6</sub>H<sub>5</sub>O Radical Reactions</i>                                                                                                                                                                                                                                       |                                                                      |                 |                                                     |
| $\text{C}_6\text{H}_5\text{O} + M \rightarrow \text{C}_3\text{H}_5 + \text{CO} + M$                                                                                                                                                                                                        | See Table 2                                                          |                 |                                                     |
| <i>C<sub>6</sub>H<sub>5</sub>CH<sub>2</sub> Radical Reactions</i>                                                                                                                                                                                                                          |                                                                      |                 |                                                     |
| $\text{C}_6\text{H}_5\text{CH}_2 + M \rightarrow \text{C}_3\text{H}_3 + 2\text{C}_2\text{H}_2 + M$<br>$\rightarrow \text{C}_4\text{H}_4 + \text{C}_3\text{H}_3 + M$<br>$\rightarrow \text{C}_3\text{H}_5 + \text{C}_2\text{H}_2 + M$<br>$\rightarrow \text{C}_7\text{H}_7(\text{BCH}) + M$ | See Table 2                                                          |                 |                                                     |



## KINETIC DATA FOR COMBUSTION MODELLING (continued)

 Table 1  
 BIMOLECULAR REACTIONS (continued)

| Reaction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$ | Temp/K | Error limits ( $\Delta \log k$ ) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|--------|----------------------------------|
| <i>C<sub>6</sub>H<sub>5</sub>CH<sub>3</sub> Reactions</i>                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |        |                                  |
| $\text{C}_6\text{H}_5\text{CH}_3 + \text{M} \rightarrow \text{C}_6\text{H}_5\text{CH}_2 + \text{H} + \text{M}$<br>$\quad \quad \quad \rightarrow \text{C}_6\text{H}_5 + \text{CH}_3 + \text{M}$                                                                                                                                                                                                                                                                                                        | See Table 2                                          |        |                                  |
| <i>p-C<sub>6</sub>H<sub>4</sub>(CH<sub>3</sub>)<sub>2</sub> Reactions</i>                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |        |                                  |
| $p\text{-C}_6\text{H}_4(\text{CH}_3)_2 + \text{M} \rightarrow \text{C}_6\text{H}_4\text{CH}_2\text{CH}_3 + \text{H} + \text{M}$                                                                                                                                                                                                                                                                                                                                                                        | See Table 2                                          |        |                                  |
| <i>C<sub>6</sub>H<sub>5</sub>C<sub>2</sub>H<sub>5</sub> Reactions</i>                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                      |        |                                  |
| $\text{C}_6\text{H}_5\text{C}_2\text{H}_5 + \text{M} \rightarrow \text{C}_6\text{H}_5\text{CH}_2 + \text{CH}_3 + \text{M}$<br>$\quad \quad \quad \rightarrow \text{C}_6\text{H}_5 + \text{C}_2\text{H}_5 + \text{M}$<br>$\quad \quad \quad \rightarrow \text{C}_6\text{H}_5\text{CHCH}_2 + \text{H}_2 + \text{M}$<br>$\quad \quad \quad \rightarrow \text{C}_6\text{H}_5 + \text{C}_2\text{H}_5 + \text{M}$<br>$\quad \quad \quad \rightarrow \text{C}_6\text{H}_5\text{CHCH}_3 + \text{H} + \text{M}$ | See Table 2                                          |        |                                  |

 Table 2  
 DECOMPOSITION REACTIONS

| Reaction                                                                                                                                   | $k_\infty/\text{s}^{-1}$<br>$k_0/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$<br>$F_c$<br>$k/\text{s}^{-1} = \frac{k_0 k_\infty [\text{M}]}{k_0 [\text{M}] + k_\infty} F$                                                                           | Temp/K                                                        | Error limits ( $\Delta \log k$ )                                                                       |
|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| $\text{H}_2 + \text{Ar} \rightarrow 2\text{H} + \text{Ar}$                                                                                 | $k_0 = 3.7 \times 10^{-10} \exp(-48350/T)$                                                                                                                                                                                                               | 2500–8000                                                     | $\pm 0.3$                                                                                              |
| $\text{H}_2 + \text{H}_2 \rightarrow 2\text{H} + \text{H}_2$                                                                               | $k_0 = 1.5 \times 10^{-9} \exp(-48350/T)$                                                                                                                                                                                                                | 2500–8000                                                     | $\pm 0.5$                                                                                              |
| $\text{H}_2\text{O} + \text{N}_2 \rightarrow \text{H} + \text{OH} + \text{N}_2$                                                            | $k_0 = 5.8 \times 10^{-9} \exp(-52920/T)$                                                                                                                                                                                                                | 2000–6000                                                     | $\pm 0.5$                                                                                              |
| $\text{H}_2\text{O}_2 + \text{M} \rightarrow 2\text{OH} + \text{M}$                                                                        | $k_0(\text{Ar}) = 3 \times 10^{-8} \exp(-21600/T)$<br>$k_0(\text{N}_2) = 2 \times 10^{-7} \exp(-22900/T)$<br>$k_\infty = 3 \times 10^{14} \exp(-24400/T)$<br>$F_c(\text{Ar}) = 0.5$                                                                      | 1000–1500<br>700–1500<br>1000–1500<br>700–1500                | $\pm 0.2$<br>$\pm 0.2$<br>$\pm 0.5$<br>$\Delta F_c = \pm 0.1$                                          |
| $\text{CH}_3 + \text{M} \rightarrow \text{CH}_2 + \text{H} + \text{M}$                                                                     | $k_0 = 1.7 \times 10^{-8} \exp(-45600/T)$                                                                                                                                                                                                                | 1500–3000                                                     | $\pm 0.5$                                                                                              |
| $\text{CH}_4 + \text{M} \rightarrow \text{CH}_3 + \text{H} + \text{M}$                                                                     | $k_0(\text{Ar}) = 1.2 \times 10^{-6} \exp(-47000/T)$<br>$k_0(\text{CH}_4) = 1.4 \times 10^{-5} \exp(-48100/T)$<br>$k_\infty = 2.4 \times 10^{16} \exp(-52800/T)$<br>$F_c(\text{Ar}) = \exp(-0.45 - T/3231)$<br>$F_c(\text{CH}_4) = \exp(-0.37 - T/2210)$ | 1000–3000<br>1000–2000<br>1000–3000<br>1000–3000<br>1000–2000 | $\pm 0.3$<br>$\pm 0.3$<br>$\pm 0.5$<br>$\Delta F_c = \pm 0.1$<br>$\Delta F_c = \pm 0.1$                |
| $\text{HCHO} + \text{M} \rightarrow \text{H} + \text{CHO} + \text{M}$<br>$\quad \quad \quad \rightarrow \text{H}_2 + \text{CO} + \text{M}$ | $k_0(1) = 2.1 \times 10^{-8} \exp(-39200/T)$<br>$k_1/k_2 = 0.5 \text{ at } 2200 \text{ K}$                                                                                                                                                               | 1500–2500                                                     | $\pm 0.3$                                                                                              |
| $\text{CH}_3\text{O} + \text{M} \rightarrow \text{HCHO} + \text{H} + \text{M}$                                                             | $k_0 = 3.16 \times 10^2 T^{-2.7} \exp(-15400/T)$<br>[estimate]                                                                                                                                                                                           | 300–1000                                                      | $\pm 1.0$                                                                                              |
| $\text{CH}_3\text{OOH} + \text{M} \rightarrow \text{CH}_3\text{O} + \text{OH} + \text{M}$                                                  | $k_\infty = 4 \times 10^{15} \exp(-21600/T)$                                                                                                                                                                                                             | 400–1000                                                      | $\pm 0.5 \text{ at } 600 \text{ K rising to}$<br>$\pm 1.0 \text{ at } 400 \text{ and } 1000 \text{ K}$ |
| $\text{NCO} + \text{Ar} \rightarrow \text{N} + \text{CO} + \text{Ar}$                                                                      | $k_0 = 1.7 \times 10^{-9} \exp(-23500/T)$                                                                                                                                                                                                                | 1450–2600                                                     | $\pm 0.4$                                                                                              |

# KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 2  
DECOMPOSITION REACTIONS (continued)

| Reaction                                                                                                                                                                                                   | $k_{\infty}/s^{-1}$<br>$k_0/cm^3 \text{ molecule}^{-1} s^{-1}$<br>$F_c$<br>$k/s^{-1} = \frac{k_0 k_{\infty} [M]}{k_0[M] + k_{\infty}} F$                                                                                                                              | Temp/K                                                   | Error limits ( $\Delta \log k$ )                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------|
| $C_2H_3 + M \rightarrow C_2H_2 + H + M$                                                                                                                                                                    | $k_0 = 6.9 \times 10^{17} T^{-7.5} \exp(-22900/T)$<br>$k_{\infty} = 2 \times 10^{14} \exp(-20000/T)$<br>$F_c = 0.35$                                                                                                                                                  | 500-2500<br>500-2500<br>500-2500                         | $\pm 0.5$<br>$\pm 0.5$<br>$\Delta F_c = \pm 0.1$                                        |
| $C_2H_6 + M \rightarrow 2CH_3 + M$                                                                                                                                                                         | $k_0(Ar) = 1.1 \times 10^{25} T^{-8.24} \exp(-47090/T)$<br>$k_0(C_2H_6) = 4.5 \times 10^{-2} \exp(-41930/T)$<br>$k_{\infty} = 1.8 \times 10^{21} T^{-1.24} \exp(-45700/T)$<br>$F_c(Ar) = 0.38 \exp(-T/73) + 0.62 \exp(-T/1180)$<br>$F_c(C_2H_6) = 0.54 \exp(-T/1250)$ | 300-2000<br>800-1000<br>300-2000<br>300-2000<br>800-1000 | $\pm 0.5$<br>$\pm 0.5$<br>$\pm 0.3$<br>$\Delta F_c = \pm 0.1$<br>$\Delta F_c = \pm 0.1$ |
| $CH_3CHO + M \rightarrow CH_3 + CHO + M$                                                                                                                                                                   | $k(1 \text{ atm.}) = 7 \times 10^{15} \exp(-41100/T)$<br>(pressure dependent region)                                                                                                                                                                                  | 750-1200                                                 | $\pm 0.4$                                                                               |
| $C_2H_5O + M \rightarrow HCHO + CH_3 + M$                                                                                                                                                                  | $k_{\infty} = 8 \times 10^{13} \exp(-10830/T)$<br>[estimate]                                                                                                                                                                                                          | 300-600                                                  | $\pm 1.0$                                                                               |
| $C_2H_5OOH + M \rightarrow C_2H_5O + OH + M$                                                                                                                                                               | $k_{\infty} 4 \times 10^{15} \exp(-21600/T)$                                                                                                                                                                                                                          | 400-1000                                                 | $\pm 1.0$                                                                               |
| $C_6H_5 + M \rightarrow C_2H_2 + C_4H_3 + M$<br>$\rightarrow C_2H_3 + C_4H_2 + M$<br>$\rightarrow \text{linear-CH}_5 + M$                                                                                  | No recommendation<br>$4.0 \times 10^{13} \exp(-36700/T)$                                                                                                                                                                                                              | 1450-1900                                                | $\pm 0.4$                                                                               |
| $C_6H_6 + M \rightarrow C_6H_5 + H + M$<br>$\rightarrow C_4H_4 + H_2 + M$                                                                                                                                  | $9.0 \times 10^{15} \exp(-54060/T)$                                                                                                                                                                                                                                   | 1200-2500                                                | $\pm 0.4$ at 1200 K<br>reducing to $\pm 0.3$<br>at 2500 K                               |
| $C_6H_5O + M \rightarrow C_3H_5 + CO + M$                                                                                                                                                                  | $2.5 \times 10^{11} \exp(-22100/T)$                                                                                                                                                                                                                                   | 1000-1580                                                | $\pm 0.2$                                                                               |
| $C_6H_5CH_2 + M \rightarrow C_3H_3 + 2C_2H_2 + M$<br>$\rightarrow C_4H_4 + C_3H_3 + M$<br>$\rightarrow C_3H_5 + C_2H_2 + M$<br>$\rightarrow C_7H_7 \text{ (BCH)} + M$                                      | $5.1 \times 10^{13} \exp(-36370/T)$                                                                                                                                                                                                                                   | 1350-1900                                                | $\pm 0.3$ at 1350 K rising<br>to $\pm 0.5$ 1900 K                                       |
| $C_6H_5CH_3 + M \rightarrow C_6H_5CH_2 + H + M$<br>$\rightarrow C_6H_5 + CH_3 + M$                                                                                                                         | $3.1 \times 10^{15} \exp(-44890/T)$<br>No recommendation                                                                                                                                                                                                              | 920-2200                                                 | $\pm 0.3$ at 900 K<br>rising to $\pm 0.5$<br>at 2200 K                                  |
| $p\text{-}C_6H_4(CH_3)_2 + M \rightarrow p\text{-}C_6H_4CH_2CH_3 + H + M$                                                                                                                                  | $4.0 \times 10^{15} \exp(-42600/T)$                                                                                                                                                                                                                                   | 1400-1800                                                | $\pm 0.5$                                                                               |
| $C_6H_5C_2H_5 + M \rightarrow C_6H_5CH_2 + CH + M$<br>$\rightarrow C_6H_6 + C_2H_4 + M$<br>$\rightarrow C_6H_5CHCH_2 + H_2 + M$<br>$\rightarrow C_6H_5 + C_2H_5 + M$<br>$\rightarrow C_6H_5CHCH_3 + H + M$ | $6.1 \times 10^{15} \exp(-37800/T)$<br>No recommendations                                                                                                                                                                                                             | 770-1800                                                 | $\pm 0.1$ at 770 K<br>rising to $\pm 0.4$ at                                            |

Table 3  
COMBINATION REACTIONS

| Reaction                             | $k_{\infty}/cm^3 \text{ molecule}^{-1} s^{-1}$<br>$k_0/cm^6 \text{ molecule}^{-2} s^{-1}$<br>$F_c$<br>$k/cm^3 \text{ molecule}^{-1} s^{-1} = \frac{k_0 k_{\infty} [M]}{k_0[M] + k_{\infty}} F$ | Temp/K   | Error limits ( $\Delta \log k$ ) |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------------------------------|
| $H + O_2 + Ar \rightarrow HO_2 + Ar$ | $k_0 = 1.7 \times 10^{-30} T^{-0.8}$                                                                                                                                                           | 300-2000 | $\pm 0.5$                        |

## KINETIC DATA FOR COMBUSTION MODELLING (continued)

 Table 3  
 COMBINATION REACTIONS (continued)

| Reaction                                                                                                                         | $k_{\infty}/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$<br>$k_0/\text{cm}^6 \text{ molecule}^{-2} \text{ s}^{-1}$<br>$F_c$<br>$k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1} = \frac{k_0 k_{\infty} [M]}{k_0 [M] + k_{\infty}} F$                                                                              | Temp/K                                                               | Error limits ( $\Delta \log k$ )                                                                     |
|----------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| $\text{H} + \text{O}_2 + \text{H}_2 \rightarrow \text{HO}_2 + \text{H}_2$                                                        | $k_0 = 5.8 \times 10^{-30} T^{-0.8}$                                                                                                                                                                                                                                                                                      | 300–2000                                                             | $\pm 0.5$                                                                                            |
| $\text{H} + \text{O}_2 + \text{N}_2 \rightarrow \text{HO}_2 + \text{N}_2$                                                        | $k_0 = 3.9 \times 10^{-30} T^{-0.8}$                                                                                                                                                                                                                                                                                      | 300–2000                                                             | $\pm 0.5$                                                                                            |
| $\text{H} + \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{HO}_2 + \text{H}_2\text{O}$                                        | $k_0 = 4.3 \times 10^{-30} T^{-0.8}$                                                                                                                                                                                                                                                                                      | 300–2000                                                             | $\pm 0.5$                                                                                            |
| $\text{H} + \text{H} + \text{Ar} \rightarrow \text{H}_2 + \text{Ar}$                                                             | $k_0 = 1.8 \times 10^{-30} T^{-1.0}$                                                                                                                                                                                                                                                                                      | 300–2500                                                             | $\pm 0.5$                                                                                            |
| $\text{H} + \text{H} + \text{H}_2 \rightarrow \text{H}_2 + \text{H}_2$                                                           | $k_0 = 2.7 \times 10^{-31} T^{-0.6}$                                                                                                                                                                                                                                                                                      | 100–5000                                                             | $\pm 0.5$                                                                                            |
| $\text{H} + \text{OH} + \text{H}_2\text{O} \rightarrow \text{H}_2\text{O} + \text{H}_2\text{O}$                                  | $k_0 = 3.9 \times 10^{-25} T^{-2.0}$                                                                                                                                                                                                                                                                                      | 300–3000                                                             | $\pm 0.3$                                                                                            |
| $\text{H} + \text{OH} + \text{Ar} \rightarrow \text{H}_2\text{O} + \text{Ar}$                                                    | $k_0 = 2.3 \times 10^{-26} T^{-2.0}$                                                                                                                                                                                                                                                                                      | 300–3000                                                             | $\pm 0.3$                                                                                            |
| $\text{H} + \text{OH} + \text{N}_2 \rightarrow \text{H}_2\text{O} + \text{N}_2$                                                  | $k_0 = 6.1 \times 10^{-26} T^{-2.0}$                                                                                                                                                                                                                                                                                      | 300–3000                                                             | $\pm 0.3$                                                                                            |
| $\text{H} + \text{CH}_3 + \text{M} \rightarrow \text{CH}_4 + \text{M}$                                                           | $k_0(\text{He}) = 6.2 \times 10^{-29} (T/3000)^{-1.8}$<br>$k_0(\text{Ar}) = 6 \times 10^{-29} (T/300)^{-1.8}$<br>$k_0(\text{C}_2\text{H}_6) = 3 \times 10^{-28} (T/300)^{-1.8}$<br>$k_{\infty} = 3.5 \times 10^{-10}$<br>$F_c(\text{He,Ar}) = \exp(-0.45 - T/3231)$<br>$F_c(\text{C}_2\text{H}_6) = \exp(-0.34 - T/3053)$ | 300–1000<br>300–1000<br>300–1000<br>300–1000<br>300–1000<br>300–1000 | $\pm 0.3$<br>$\pm 0.5$<br>$\pm 0.5$<br>$\pm 0.3$<br>$\Delta F_c = \pm 0.1$<br>$\Delta F_c = \pm 0.1$ |
| $\text{H} + \text{C}_2\text{H}_2 + \text{He} \rightarrow \text{C}_2\text{H}_3 + \text{He}$                                       | $k_{\infty} = 1.4 \times 10^{-11} \exp(-1300/T)$<br>$k_0 = 3.3 \times 10^{-30} \exp(-740/T)$<br>$F_c = 0.44$                                                                                                                                                                                                              | 200–400<br>200–400<br>200–400                                        | $\pm 0.3$<br>$\pm 0.5$<br>$\Delta F_c = \pm 0.1$                                                     |
| $\text{H} + \text{C}_2\text{H}_3 + \text{M} \rightarrow \text{C}_2\text{H}_4 + \text{M}$                                         | No recommendation                                                                                                                                                                                                                                                                                                         |                                                                      |                                                                                                      |
| $\text{H} + \text{C}_2\text{H}_4 + \text{M} \rightarrow \text{C}_2\text{H}_5 + \text{M}$                                         | No recommendation                                                                                                                                                                                                                                                                                                         |                                                                      |                                                                                                      |
| $\text{H} + \text{C}_2\text{H}_5 + \text{M} \rightarrow \text{C}_2\text{H}_6 + \text{M}$                                         | No recommendation                                                                                                                                                                                                                                                                                                         |                                                                      |                                                                                                      |
| $\text{H} + \text{C}_6\text{H}_5 + \text{M} \rightarrow \text{C}_6\text{H}_6 + \text{M}$                                         | $k_{\infty} = 1.3 \times 10^{-10}$                                                                                                                                                                                                                                                                                        | 1400–1700                                                            | $\pm 0.5$                                                                                            |
| $\text{H} + \text{C}_6\text{H}_6 + \text{M} \rightarrow \text{C}_6\text{H}_7 + \text{M}$                                         | $k_{\infty} = 6.7 \times 10^{-11} \exp(-2170/T)$                                                                                                                                                                                                                                                                          | 300–1000                                                             | $\pm 0.2$                                                                                            |
| $\text{H} + \text{C}_6\text{H}_5\text{O} + \text{M} \rightarrow \text{C}_6\text{H}_5\text{OH} + \text{M}$                        | $k_{\infty} = 4.2 \times 10^{-10}$                                                                                                                                                                                                                                                                                        | 1000                                                                 | $\pm 0.3$                                                                                            |
| $\text{H} + \text{C}_6\text{H}_5\text{CH}_2 + \text{M} \rightarrow \text{C}_6\text{H}_5\text{CH}_3 + \text{M}$                   | $k_{\infty} = 5.5 \times 10^{-10}$                                                                                                                                                                                                                                                                                        | 300–2000                                                             | $\pm 0.2$ at 300 K rising to<br>$\pm 0.7$ at 2000 K.                                                 |
| $\text{H} + \text{C}_6\text{H}_5\text{CH}_3 + \text{M} \rightarrow \text{C}_6\text{H}_6\text{CH}_3 + \text{M}$                   | $k_{\infty} = 1.2 \times 10^{-13}$                                                                                                                                                                                                                                                                                        | 298                                                                  | $\pm 0.2$                                                                                            |
| $\text{H} + \text{C}_6\text{H}_5\text{C}_2\text{H}_5 + \text{M} \rightarrow \text{C}_6\text{H}_6\text{C}_2\text{H}_5 + \text{M}$ | $k_{\infty} = 3.3 \times 10^{-13}$                                                                                                                                                                                                                                                                                        | 298                                                                  | $\pm 0.1$                                                                                            |
| $\text{OH} + \text{OH} + \text{M} \rightarrow \text{H}_2\text{O}_2 + \text{M}$                                                   | $k_0(\text{N}_2) = 8 \times 10^{-31} (T/300)^{-0.76}$<br>$k_0(\text{H}_2\text{O}) = 4 \times 10^{-30}$<br>$k_{\infty} = 1.5 \times 10^{-11} (T/300)^{-0.37}$<br>$F_c(\text{N}_2) = 0.5$                                                                                                                                   | 250–1400<br>300–400<br>200–1500<br>200–1500                          | $\pm 0.4$<br>$\pm 0.5$<br>$\Delta F_c = \pm 0.2$                                                     |
| $\text{OH} + \text{CH}_3 + \text{M} \rightarrow \text{CH}_3\text{OH} + \text{M}$                                                 | No data available for this channel<br>(See Table 1)                                                                                                                                                                                                                                                                       |                                                                      |                                                                                                      |

## KINETIC DATA FOR COMBUSTION MODELLING (continued)

Table 3  
COMBINATION REACTIONS (continued)

| Reaction                                                                                                                                                                                                        | $k_{\infty}/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$<br>$k_0/\text{cm}^6 \text{ molecule}^{-2} \text{ s}^{-1}$<br>$F_c$<br>$k/\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1} = \frac{k_0 k_{\infty} [M]}{k_0 [M] + k_{\infty}} F$ | Temp/K                                   | Error limits ( $\Delta \log k$ )                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------------------|
| $\text{OH} + \text{C}_2\text{H}_2 + \text{M} \rightarrow \text{C}_2\text{H}_2\text{OH} + \text{M}$                                                                                                              | See data sheet                                                                                                                                                                                                                               |                                          |                                                                                             |
| $\text{OH} + \text{C}_6\text{H}_6 + \text{M} \rightarrow \text{C}_6\text{H}_6\text{OH} + \text{M}$                                                                                                              | $k_{\infty} = 3.8 \times 10^{-12} \exp(-340/T)$                                                                                                                                                                                              | 240-340                                  | $\pm 0.2$                                                                                   |
| $\text{OH} + \text{C}_6\text{H}_5\text{OH} + \text{M} \rightarrow \text{C}_6\text{H}_5(\text{OH})_2 + \text{M}$                                                                                                 | $k_{\infty} = 2.8 \times 10^{-11}$                                                                                                                                                                                                           | 298                                      | $\pm 0.1$                                                                                   |
| $\text{OH} + \text{C}_6\text{H}_5\text{CH}_3 + \text{M} \rightarrow \text{HOC}_6\text{H}_5\text{CH}_3 + \text{M}$                                                                                               | $k_{\infty} = 3.8 \times 10^{-12} \exp(180/T)$                                                                                                                                                                                               | 200-300                                  | $\pm 0.4$                                                                                   |
| $\text{OH} + \text{C}_6\text{H}_4(\text{CH}_3)_2 + \text{M} \rightarrow \text{C}_6\text{H}_4(\text{CH}_3)_2\text{OH} + \text{M}$                                                                                | $k_{\infty} = 1.4 \times 10^{-11}$                                                                                                                                                                                                           | 300-320                                  | $\pm 0.1$                                                                                   |
| $\text{OH} + \text{C}_6\text{H}_5\text{C}_2\text{H}_5 + \text{M} \rightarrow \text{HOC}_6\text{H}_5\text{C}_2\text{H}_5 + \text{M}$                                                                             | $7.5 \times 10^{-12}$ at $p \leq 1$ atm.                                                                                                                                                                                                     | 298                                      | $\pm 0.1$                                                                                   |
| $^3\text{CH}_2 + \text{C}_2\text{H}_2 + \text{M} \rightarrow \text{C}_3\text{H}_4 + \text{M}$                                                                                                                   | $2.0 \times 10^{-11} \exp(-3330/T)$<br>at $p = \leq 10$ Torr.                                                                                                                                                                                | 300-1000                                 | $\pm 0.3$                                                                                   |
| $^3\text{CH}_2 + \text{C}_2\text{H}_4 + \text{M} \rightarrow \begin{matrix} \text{C}_3\text{H}_6 + \text{M} \\ \text{c-C}_3\text{H}_6 + \text{M} \\ \text{C}_3\text{H}_5 + \text{H} + \text{M} \end{matrix}$    | $5.3 \times 10^{-12} \exp(-2660/T)$                                                                                                                                                                                                          | 300-1000                                 | $\pm 0.2$ at 300 K rising to<br>$\pm 0.3$ at 1000 K                                         |
| $^1\text{CH}_2 + \text{C}_2\text{H}_2 + \text{M} \rightarrow \begin{matrix} \text{CH}_2\text{CCH}_2 + \text{M} \\ \text{CH}_3\text{CCH} + \text{M} \\ \text{CH}_2\text{CCH} + \text{H} + \text{M} \end{matrix}$ | $3.7 \times 10^{-10}$ independent of $p$                                                                                                                                                                                                     | 300-1000                                 | $\pm 0.3$ at 300 K rising to<br>$\pm 0.7$ at 1000 K.                                        |
| $^1\text{CH}_2 + \text{C}_2\text{H}_4 + \text{M} \rightarrow \text{C}_3\text{H}_6$                                                                                                                              | $1.1 \times 10^{-10}$ independent of $p$                                                                                                                                                                                                     | 300-1000                                 | $\pm 0.2$ at 300 K rising to<br>$\pm 0.5$ at 1000 K.                                        |
| $\text{CH}_3 + \text{O}_2 + \text{M} \rightarrow \text{CH}_3\text{O}_2 + \text{M}$                                                                                                                              | $k_0(\text{Ar}) = 1.5 \times 10^{-22} T^{-3.3}$<br>$k_0(\text{N}_2) = 1.6 \times 10^{-22} T^{-3.3}$<br>$k_{\infty} = 1.3 \times 10^{-15} T^{-1.2}$<br>$F_c = 0.466 - 1.30 \times 10^{-4} T$                                                  | 300-800<br>300-800<br>300-800<br>300-800 | $\pm 0.3$<br>$\pm 0.3$<br>$\pm 0.3$                                                         |
| $\text{CH}_3 + \text{CH}_3 + \text{Ar} \rightarrow \text{C}_2\text{H}_6 + \text{Ar}$                                                                                                                            | $k_{\infty} = 6 \times 10^{-11}$<br>$k_0 = 3.5 \times 10^{-7} T^{-7.0} \exp(-1390/T)$<br>$F_c = 0.38 \exp(-T/73)$<br>$+ 0.62 \exp(-T/1180)$                                                                                                  | 300-2000<br>300-2000<br>300-2000         | $\pm 0.05$ at 300 K rising to<br>$\pm 0.3$ at 2000 K<br>$\pm 0.3$<br>$\Delta F_c = \pm 0.1$ |
| $\text{CH}_3 + \text{C}_2\text{H}_2 + \text{M} \rightarrow \text{C}_3\text{H}_5 + \text{M}$                                                                                                                     | $k_{\infty} = 1 \times 10^{-12} \exp(-3900/T)$                                                                                                                                                                                               | 300-600                                  | $\pm 0.5$                                                                                   |
| $\text{CH}_3 + \text{C}_2\text{H}_4 + \text{M} \rightarrow n\text{-C}_3\text{H}_7 + \text{M}$                                                                                                                   | $3.5 \times 10^{-13} \exp(-3700/T)$                                                                                                                                                                                                          | 300-600                                  | $\pm 0.3$                                                                                   |
| $\text{CH}_3 + \text{C}_2\text{H}_5 + \text{M} \rightarrow \text{C}_3\text{H}_8 + \text{M}$                                                                                                                     | $k_{\infty} = 4.7 \times 10^{-11}$                                                                                                                                                                                                           | 300-800                                  | $\pm 0.3$                                                                                   |
| $\text{C}_2\text{H}_5 + \text{C}_2\text{H}_5 + \text{M} \rightarrow n\text{-C}_4\text{H}_{10} + \text{M}$                                                                                                       | $k_{\infty} = 1.9 \times 10^{-11}$                                                                                                                                                                                                           | 300-1200                                 | $\pm 0.3$                                                                                   |
| $\text{CH}_3\text{CO} + \text{O}_2 + \text{M} \rightarrow \text{CH}_3\text{CO}_3 + \text{M}$                                                                                                                    | $2 \times 10^{-12}$<br>for $p = 1\text{--}4$ Torr.                                                                                                                                                                                           | 300                                      | $\pm 0.3$                                                                                   |

## ELECTRICAL CONDUCTIVITY OF WATER

This table gives the electrical conductivity of highly purified water over a range of temperature and pressure. The first column of conductivity data refers to water at its own vapor pressure. Equations for calculating the conductivity at any temperature and pressure may be found in the reference.

### Reference

Marshall, W. L., *J. Chem. Eng. Data* 32, 221, 1987.

#### Conductivity in $\mu\text{S}/\text{cm}$ at the Indicated Pressure

| $t/^{\circ}\text{C}$ | Sat. vapor | 50 MPa | 100 MPa | 200 MPa | 400 MPa | 600 MPa |
|----------------------|------------|--------|---------|---------|---------|---------|
| 0                    | 0.0115     | 0.0150 | 0.0189  | 0.0275  | 0.0458  | 0.0667  |
| 25                   | 0.0550     | 0.0686 | 0.0836  | 0.117   | 0.194   | 0.291   |
| 100                  | 0.765      | 0.942  | 1.13    | 1.53    | 2.45    | 3.51    |
| 200                  | 2.99       | 4.08   | 5.22    | 7.65    | 13.1    | 19.5    |
| 300                  | 2.41       | 4.87   | 7.80    | 14.1    | 28.9    | 46.5    |
| 400                  |            | 1.17   | 4.91    | 14.3    | 39.2    | 71.3    |
| 600                  |            |        | 0.134   | 4.65    | 33.8    | 85.7    |

## ELECTRICAL CONDUCTIVITY OF AQUEOUS SOLUTIONS

The following table gives the electrical conductivity of aqueous solutions of some acids, bases, and salts as a function of concentration. All values refer to 20 °C. The conductivity  $\kappa$  (often called specific conductance in older literature) is the reciprocal of the resistivity. The molar conductivity  $\Lambda$  is related to this by  $\Lambda = \kappa/c$ , where  $c$  is the amount-of-substance concentration of the electrolyte. Thus if  $\kappa$  has units of millisiemens per centimeter (mS/cm), as in this table, and  $c$  is expressed in mol/L, then  $\Lambda$  has units of S cm<sup>2</sup> mol<sup>-1</sup>. For these electrolytes the concentration  $c$  correspond-

ing to the mass percent values given here can be found in the table "Concentrative Properties of Aqueous Solutions" in Section 8.

### References

1. *CRC Handbook of Chemistry, and Physics, 70th Edition*, Weast, R. C., Ed., CRC Press, Boca Raton, FL, 1989, p. D-221.
2. Wolf, A. V., *Aqueous Solutions and Body Fluids*, Harper and Row, New York, 1966.

**Electrical Conductivity  $\kappa$  in mS/cm for the Indicated Concentration in Mass Percent**

| Name                           | Formula                                                      | 0.5% | 1%   | 2%   | 5%   | 10%  | 15%   | 20%   | 25%  | 30%  | 40%  | 50% |
|--------------------------------|--------------------------------------------------------------|------|------|------|------|------|-------|-------|------|------|------|-----|
| Acetic acid                    | CH <sub>3</sub> COOH                                         | 0.3  | 0.6  | 0.8  | 1.2  | 1.5  | 1.7   | 1.7   | 1.6  | 1.4  | 1.1  | 0.8 |
| Ammonia                        | NH <sub>3</sub>                                              | 0.5  | 0.7  | 1.0  | 1.1  | 1.0  | 0.7   | 0.5   | 0.4  |      |      |     |
| Ammonium chloride              | NH <sub>4</sub> Cl                                           | 10.5 | 20.4 | 40.3 | 95.3 | 180  |       |       |      |      |      |     |
| Ammonium sulfate               | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>              | 7.4  | 14.2 | 25.7 | 57.4 | 105  | 147   | 185   | 215  |      |      |     |
| Barium chloride                | BaCl <sub>2</sub>                                            | 4.7  | 9.1  | 17.4 | 40.4 | 76.7 | 109.0 | 137.0 |      |      |      |     |
| Calcium chloride               | CaCl <sub>2</sub>                                            | 8.1  | 15.7 | 29.4 | 67.0 | 117  | 157   | 177   | 183  | 172  | 106  |     |
| Cesium chloride                | CsCl                                                         | 3.8  | 7.4  | 13.8 | 32.9 | 65.8 | 102   | 142   |      |      |      |     |
| Citric acid                    | H <sub>3</sub> C(OH)(COO) <sub>3</sub>                       | 1.2  | 2.1  | 3.0  | 4.7  | 6.2  | 7.0   | 7.2   | 7.1  |      |      |     |
| Copper(II) sulfate             | CuSO <sub>4</sub>                                            | 2.9  | 5.4  | 9.3  | 19.0 | 32.2 | 42.3  |       |      |      |      |     |
| Formic acid                    | HCOOH                                                        | 1.4  | 2.4  | 3.5  | 5.6  | 7.8  | 9.0   | 9.9   | 10.4 | 10.5 | 9.9  | 8.6 |
| Hydrogen chloride              | HCl                                                          | 45.1 | 92.9 | 183  |      |      |       |       |      |      |      |     |
| Lithium chloride               | LiCl                                                         | 10.1 | 19.0 | 34.9 | 76.4 | 127  | 155   | 170   | 165  | 146  |      |     |
| Magnesium chloride             | MgCl <sub>2</sub>                                            | 8.6  | 16.6 | 31.2 | 66.9 | 108  | 129   | 134   | 122  | 98   |      |     |
| Magnesium sulfate              | MgSO <sub>4</sub>                                            | 4.1  | 7.6  | 13.3 | 27.4 | 42.7 | 54.2  | 51.1  | 44.1 |      |      |     |
| Manganese(II) sulfate          | MnSO <sub>4</sub>                                            |      | 6.2  | 10.6 | 21.6 | 34.5 | 43.7  | 47.6  |      |      |      |     |
| Nitric acid                    | HNO <sub>3</sub>                                             | 28.4 | 56.1 | 108  |      |      |       |       |      |      |      |     |
| Oxalic acid                    | H <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                 | 14.0 | 21.8 | 35.3 | 65.6 |      |       |       |      |      |      |     |
| Phosphoric acid                | H <sub>3</sub> PO <sub>4</sub>                               | 5.5  | 10.1 | 16.2 | 31.5 | 59.4 | 88.4  | 118   | 146  | 173  | 209  |     |
| Potassium bromide              | KBr                                                          | 5.2  | 10.2 | 19.5 | 47.7 | 95.6 | 144   | 194   |      |      |      |     |
| Potassium carbonate            | K <sub>2</sub> CO <sub>3</sub>                               | 7.0  | 13.6 | 25.4 | 58.0 | 109  | 152   | 188   | 223  |      |      |     |
| Potassium chloride             | KCl                                                          | 8.2  | 15.7 | 29.5 | 71.9 | 143  | 208   |       |      |      |      |     |
| Potassium dihydrogen phosphate | KH <sub>2</sub> PO <sub>4</sub>                              | 3.0  | 5.9  | 11.0 | 25.0 | 44.6 |       |       |      |      |      |     |
| Potassium hydrogen carbonate   | KHCO <sub>3</sub>                                            | 4.6  | 8.9  | 17.0 | 38.8 | 72.4 | 101   | 128   |      |      |      |     |
| Potassium hydrogen phosphate   | K <sub>2</sub> HPO <sub>4</sub>                              | 5.2  | 9.9  | 18.3 | 40.3 |      |       |       |      |      |      |     |
| Potassium hydroxide            | KOH                                                          | 20.0 | 38.5 | 75.0 | 178  |      |       |       |      |      |      |     |
| Potassium iodide               | KI                                                           | 3.8  | 7.5  | 14.2 | 35.2 | 71.8 | 110   | 188   | 224  |      |      |     |
| Potassium nitrate              | KNO <sub>3</sub>                                             | 5.5  | 10.7 | 20.1 | 47.0 | 87.3 | 124   | 157   | 182  |      |      |     |
| Potassium permanganate         | KMnO <sub>4</sub>                                            | 3.5  | 6.9  | 13.0 | 30.5 |      |       |       |      |      |      |     |
| Potassium sulfate              | K <sub>2</sub> SO <sub>4</sub>                               | 5.8  | 11.2 | 21.0 | 48.0 | 88.6 |       |       |      |      |      |     |
| Silver(I) nitrate              | AgNO <sub>3</sub>                                            | 3.1  | 6.1  | 12.0 | 26.7 | 49.8 | 72.0  | 92.8  | 112  | 129  | 162  |     |
| Sodium acetate                 | NaCH <sub>3</sub> COO                                        | 3.9  | 7.6  | 14.4 | 30.9 | 53.4 | 64.1  | 69.3  | 69.2 | 64.3 |      |     |
| Sodium bromide                 | NaBr                                                         | 5.0  | 9.7  | 18.4 | 44.0 | 84.6 | 122   | 157   | 191  | 216  |      |     |
| Sodium carbonate               | Na <sub>2</sub> CO <sub>3</sub>                              | 7.0  | 13.1 | 23.3 | 47.0 | 74.4 | 88.6  |       |      |      |      |     |
| Sodium chloride                | NaCl                                                         | 8.2  | 16.0 | 30.2 | 70.1 | 126  | 171   | 204   | 222  |      |      |     |
| Sodium citrate                 | Na <sub>3</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> |      | 7.4  | 12.8 | 26.2 | 42.1 | 52.0  | 57.1  | 57.3 | 53.5 |      |     |
| Sodium dihydrogen phosphate    | NaH <sub>2</sub> PO <sub>4</sub>                             | 2.2  | 4.4  | 9.1  | 21.0 | 33.2 | 43.3  | 49.6  | 53.1 | 54.0 | 46.1 |     |
| Sodium hydrogen carbonate      | NaHCO <sub>3</sub>                                           | 4.2  | 8.2  | 15.0 | 31.4 |      |       |       |      |      |      |     |
| Sodium hydrogen phosphate      | Na <sub>2</sub> HPO <sub>4</sub>                             | 4.6  | 8.7  | 15.6 | 31.4 |      |       |       |      |      |      |     |
| Sodium hydroxide               | NaOH                                                         | 24.8 | 48.6 | 93.1 | 206  |      |       |       |      |      |      |     |
| Sodium nitrate                 | NaNO <sub>3</sub>                                            | 5.4  | 10.6 | 20.4 | 46.2 | 82.6 | 111   | 134   | 152  | 165  | 178  |     |
| Sodium phosphate               | Na <sub>3</sub> PO <sub>4</sub>                              | 7.3  | 14.1 | 22.7 | 43.5 |      |       |       |      |      |      |     |
| Sodium sulfate                 | Na <sub>2</sub> SO <sub>4</sub>                              | 5.9  | 11.2 | 19.8 | 42.7 | 71.3 | 91.1  | 109   |      |      |      |     |
| Sodium thiosulfate             | Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>                | 5.7  | 10.7 | 19.5 | 43.3 | 76.7 | 104   | 123   | 134  | 136  | 118  |     |
| Strontium chloride             | SrCl <sub>2</sub>                                            | 5.9  | 11.4 | 22.0 | 49.1 | 91.5 | 127   | 153   | 168  | 178  |      |     |
| Sulfuric acid                  | H <sub>2</sub> SO <sub>4</sub>                               | 24.3 | 47.8 | 92   | 211  |      |       |       |      |      |      |     |
| Trichloroacetic acid           | CCl <sub>3</sub> COOH                                        | 10.3 | 19.6 | 37.2 | 84.7 | 148  | 193   | 221   |      |      |      |     |
| Zinc sulfate                   | ZnSO <sub>4</sub>                                            | 2.8  | 5.4  | 10.0 | 20.5 | 33.7 | 43.3  |       |      |      |      |     |

## ENERGY CONTENT OF FUELS

Several fuels are compared in this table with respect to their energy content per unit mass and the amount of CO<sub>2</sub> released per unit of available energy. The energy content is taken to be the negative of the standard enthalpy of combustion (see the table “Heat of Combustion” in this section for more details). The energy is assumed to be released by combustion with oxygen at normal atmospheric pressure, with products of gaseous CO<sub>2</sub> and liquid H<sub>2</sub>O at room temperature. This quantity is often called the “gross heat of combustion” to distinguish it from the “net heat of combustion,” for which the water remains in the gas state. The latter quantity is typically 5% to 10% less than the values given here.

The energy content is given both in SI units of MJ/kg and conventional units of BTU/lb. Values for the fossil fuels and other materials are typical; individual samples show wide variations.

The last column gives the grams of carbon released as carbon dioxide per megajoule of energy. Examination of the table shows

that the minimum CO<sub>2</sub> release occurs for fuels that have a high ratio of hydrogen to carbon. Furthermore, fuels containing oxygen have a lower energy content and higher CO<sub>2</sub> release than hydrocarbons with the same number of carbon atoms.

### References

1. Domalski, E. S., Jobe, T. L., and Milne, T. A., *Thermodynamic Data for Biomass Conversion and Waste Incineration*, SERI/SP-271-2839, Solar Technical Information Program, U. S. Department of Energy, September 1986; see also NBSIR 78-1479, National Bureau of Standards, August 1978.
2. Green, D. W., and Ackers, D. E., *Perry's Chemical Engineers' Handbook, Eighth Edition*, McGraw-Hill, New York, 2007.
3. *Transportation Energy Data Book*, U. S. Department of Energy, May 2007, <http://cta.ornl.gov/data/index.shtml>.
4. *Chemical Composition of Natural Gas*, Union Gas Limited, <http://www.uniongas.com/aboutus/aboutnrg/composition.asp>.

| Fuel                            | Energy content |                        | g of C<br>per MJ |
|---------------------------------|----------------|------------------------|------------------|
|                                 | MJ/kg          | 10 <sup>3</sup> BTU/lb |                  |
| <i>Pure compounds</i>           |                |                        |                  |
| Hydrogen                        | 141.8          | 61.0                   | 0.0              |
| Methane                         | 55.5           | 23.9                   | 13.5             |
| Ethane                          | 51.9           | 22.3                   | 15.4             |
| Propane                         | 50.3           | 21.7                   | 16.2             |
| Hexane                          | 48.3           | 20.8                   | 17.3             |
| Heptane                         | 48.1           | 20.7                   | 17.5             |
| Octane                          | 47.9           | 20.6                   | 17.6             |
| Methanol                        | 22.7           | 9.7                    | 16.5             |
| Ethanol                         | 29.7           | 12.8                   | 17.6             |
| 1-Propanol                      | 33.6           | 14.5                   | 17.8             |
| 1-Butanol                       | 36.1           | 15.5                   | 18.0             |
| 1-Octanol                       | 40.7           | 17.5                   | 18.1             |
| Methyl <i>tert</i> -butyl ether | 38.2           | 16.4                   | 17.8             |

| Fuel                     | Energy content |                        | g of C<br>per MJ |
|--------------------------|----------------|------------------------|------------------|
|                          | MJ/kg          | 10 <sup>3</sup> BTU/lb |                  |
| <i>Fossil fuels</i>      |                |                        |                  |
| Natural gas <sup>a</sup> | 54.0           | 23.2                   | 13.9             |
| Gasoline                 | 46.5           | 20.0                   | 17.6             |
| Kerosene                 | 46.4           | 20.0                   | 18.5             |
| Fuel oil                 | 40.9           | 17.6                   | 21.3             |
| Coal, high bituminous    | 36.3           | 15.6                   | 23.5             |
| Coal, low bituminous     | 28.9           | 12.4                   | 26.3             |
| Coal, anthracite         | 34.6           | 14.9                   | 27.3             |
| <i>Other materials</i>   |                |                        |                  |
| Wood, oak                | 18.9           | 8.1                    | 25.3             |
| Wood, locust             | 19.7           | 8.5                    | 25.7             |
| Wood, Ponderosa pine     | 20.0           | 8.6                    | 24.6             |
| Wood, redwood            | 20.7           | 8.9                    | 24.4             |
| Charcoal, wood           | 34.7           | 14.9                   | 26.8             |
| Newsprint                | 18.6           | 8.0                    | 26.5             |
| Cellulose                | 17.3           | 7.5                    | 25.6             |
| Grass (lawn clippings)   | 19.3           | 8.3                    | 24.9             |

<sup>a</sup> Assumed to be 95% methane, 2.5% ethane, and 2.5% inert compounds; however, the actual composition varies widely (see Reference 4).

## ENTHALPY OF HYDRATION OF GASES

The molar enthalpy of hydration  $\Delta_{\text{hyd}}H^\infty$  is defined as the enthalpy change when one mole of an ideal gas is dissolved in an infinite amount of water. Another term for this quantity is enthalpy (heat) of solvation in water at infinite dilution. The enthalpy of hydration influences the distribution of a volatile compound between the aqueous solution phase and air and is thus important in fields such as environmental science, geochemistry, and chemical engineering. It is related to the enthalpy of solution of the liquid or solid phase,  $\Delta_{\text{sol}}H^\infty$ , by

$$\Delta_{\text{hyd}}H^\infty = \Delta_{\text{sol}}H^\infty - \Delta_{\text{vap}}H^0$$

where  $\Delta_{\text{vap}}H^0$  is the molar enthalpy of vaporization. This table gives the molar enthalpy of hydration for a number of common substances.

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| Name                    | Mol. Form.                          | $\Delta_{\text{hyd}}H^\infty/\text{kJ mol}^{-1}$<br>at 298.15 K |
|-------------------------|-------------------------------------|-----------------------------------------------------------------|
| Acenaphthene            | $\text{C}_{12}\text{H}_{10}$        | -52.1                                                           |
| Acetic acid             | $\text{C}_2\text{H}_4\text{O}_2$    | -52.8                                                           |
| Acetone                 | $\text{C}_3\text{H}_6\text{O}$      | -39.7                                                           |
| Acetonitrile            | $\text{C}_2\text{H}_3\text{N}$      | -34.9                                                           |
| Acetophenone            | $\text{C}_8\text{H}_8\text{O}$      | -53.3                                                           |
| Ammonia                 | $\text{H}_3\text{N}$                | -35.4                                                           |
| Aniline                 | $\text{C}_6\text{H}_7\text{N}$      | -56.5                                                           |
| Anisole                 | $\text{C}_7\text{H}_8\text{O}$      | -41.4                                                           |
| Argon                   | Ar                                  | -12.2                                                           |
| Benzaldehyde            | $\text{C}_7\text{H}_6\text{O}$      | -42.1                                                           |
| Benzene                 | $\text{C}_6\text{H}_6$              | -28.1                                                           |
| Benzonitrile            | $\text{C}_7\text{H}_5\text{N}$      | -48.5                                                           |
| Benzyl alcohol          | $\text{C}_7\text{H}_8\text{O}$      | -66.9                                                           |
| Biphenyl                | $\text{C}_{12}\text{H}_{10}$        | -47.2                                                           |
| Bromobenzene            | $\text{C}_6\text{H}_5\text{Br}$     | -33.5                                                           |
| Bromodichloromethane    | $\text{CHBrCl}_2$                   | -28.9                                                           |
| Bromoethane             | $\text{C}_2\text{H}_5\text{Br}$     | -29.5                                                           |
| Bromomethane            | $\text{CH}_3\text{Br}$              | -23.8                                                           |
| 2-Bromo-2-methylpropane | $\text{C}_4\text{H}_9\text{Br}$     | -25.4                                                           |
| 1,3-Butadiene           | $\text{C}_4\text{H}_6$              | -31.4                                                           |
| Butane                  | $\text{C}_4\text{H}_{10}$           | -24.8                                                           |
| 1,4-Butanediamine       | $\text{C}_4\text{H}_{12}\text{N}_2$ | -91.6                                                           |
| 1,4-Butanediol          | $\text{C}_4\text{H}_{10}\text{O}_2$ | -89.6                                                           |
| Butanenitrile           | $\text{C}_4\text{H}_7\text{N}$      | -42.1                                                           |
| 1,2,3,4-Butanetetrol    | $\text{C}_4\text{H}_{10}\text{O}_4$ | -114                                                            |
| 1-Butanethiol           | $\text{C}_4\text{H}_{10}\text{S}$   | -36.3                                                           |
| Butanoic acid           | $\text{C}_4\text{H}_8\text{O}_2$    | -59.5                                                           |
| 1-Butanol               | $\text{C}_4\text{H}_{10}\text{O}$   | -61.9                                                           |
| 2-Butanol               | $\text{C}_4\text{H}_{10}\text{O}$   | -62.7                                                           |
| 2-Butanone              | $\text{C}_4\text{H}_8\text{O}$      | -41.9                                                           |
| 1-Butene                | $\text{C}_4\text{H}_8$              | -24.1                                                           |
| 2-Butoxyethanol         | $\text{C}_6\text{H}_{14}\text{O}_2$ | -73.6                                                           |
| Butyl acetate           | $\text{C}_6\text{H}_{12}\text{O}_2$ | -52.7                                                           |

| Name                   | Mol. Form.                           | $\Delta_{\text{hyd}}H^\infty/\text{kJ mol}^{-1}$<br>at 298.15 K |
|------------------------|--------------------------------------|-----------------------------------------------------------------|
| sec-Butyl acetate      | $\text{C}_6\text{H}_{12}\text{O}_2$  | -51.9                                                           |
| tert-Butyl acetate     | $\text{C}_6\text{H}_{12}\text{O}_2$  | -46.2                                                           |
| Butylamine             | $\text{C}_4\text{H}_{11}\text{N}$    | -59.2                                                           |
| sec-Butylamine         | $\text{C}_4\text{H}_{11}\text{N}$    | -57.1                                                           |
| tert-Butylamine        | $\text{C}_4\text{H}_{11}\text{N}$    | -59.0                                                           |
| Butylbenzene           | $\text{C}_{10}\text{H}_{14}$         | -38.5                                                           |
| Butyl butanoate        | $\text{C}_8\text{H}_{16}\text{O}_2$  | -63.5                                                           |
| Butyl ethyl ether      | $\text{C}_6\text{H}_{14}\text{O}$    | -48.4                                                           |
| tert-Butyl ethyl ether | $\text{C}_6\text{H}_{14}\text{O}$    | -53.4                                                           |
| 4-tert-Butylphenol     | $\text{C}_{10}\text{H}_{14}\text{O}$ | -63.8                                                           |
| Butyl propanoate       | $\text{C}_7\text{H}_{14}\text{O}_2$  | -57.8                                                           |
| 1-Butyne               | $\text{C}_4\text{H}_6$               | -13.5                                                           |
| Carbon dioxide         | $\text{CO}_2$                        | -17.9                                                           |
| Carbon monoxide        | CO                                   | -11.1                                                           |
| Chlorine               | $\text{Cl}_2$                        | -23.4                                                           |
| Chlorine dioxide       | $\text{ClO}_2$                       | -27.8                                                           |
| Chlorobenzene          | $\text{C}_6\text{H}_5\text{Cl}$      | -30.6                                                           |
| 2-Chloro-1,1'-biphenyl | $\text{C}_{12}\text{H}_9\text{Cl}$   | -42.8                                                           |
| 1-Chlorobutane         | $\text{C}_4\text{H}_9\text{Cl}$      | -28.2                                                           |
| 2-Chlorobutane         | $\text{C}_4\text{H}_9\text{Cl}$      | -34.6                                                           |
| Chlorodibromomethane   | $\text{CHBr}_2\text{Cl}$             | -33.3                                                           |
| Chlorodifluoromethane  | $\text{CHClF}_2$                     | -22.8                                                           |
| Chloroethane           | $\text{C}_2\text{H}_5\text{Cl}$      | -22.0                                                           |
| Chlorofluoromethane    | $\text{CH}_2\text{ClF}$              | -21.7                                                           |
| 1-Chlorohexane         | $\text{C}_6\text{H}_{13}\text{Cl}$   | -34.5                                                           |
| Chloromethane          | $\text{CH}_3\text{Cl}$               | -20.2                                                           |
| 1-Chloropentane        | $\text{C}_5\text{H}_{11}\text{Cl}$   | -34.1                                                           |
| 3-Chlorophenol         | $\text{C}_6\text{H}_5\text{ClO}$     | -50.3                                                           |
| 1-Chloropropane        | $\text{C}_3\text{H}_7\text{Cl}$      | -27.0                                                           |
| 2-Chloropyridine       | $\text{C}_5\text{H}_4\text{ClN}$     | -42.6                                                           |
| 3-Chloropyridine       | $\text{C}_5\text{H}_4\text{ClN}$     | -46.2                                                           |
| 2-Chlorotoluene        | $\text{C}_7\text{H}_7\text{Cl}$      | -38.3                                                           |
| 3-Chlorotoluene        | $\text{C}_7\text{H}_7\text{Cl}$      | -37.0                                                           |



| Name                                      | Mol. Form.                                          | $\Delta_{\text{hyd}}H^\circ/\text{kJ mol}^{-1}$<br>at 298.15 K |
|-------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------|
| 4-Chlorotoluene                           | $\text{C}_7\text{H}_7\text{Cl}$                     | -33.3                                                          |
| <i>o</i> -Cresol                          | $\text{C}_7\text{H}_8\text{O}$                      | -64.8                                                          |
| <i>m</i> -Cresol                          | $\text{C}_7\text{H}_8\text{O}$                      | -58.7                                                          |
| <i>p</i> -Cresol                          | $\text{C}_7\text{H}_8\text{O}$                      | -61.3                                                          |
| Cycloheptanol                             | $\text{C}_7\text{H}_{14}\text{O}$                   | -74.6                                                          |
| Cyclohexane                               | $\text{C}_6\text{H}_{12}$                           | -30.0                                                          |
| <i>cis</i> -1,2-Cyclohexanediol           | $\text{C}_6\text{H}_{12}\text{O}_2$                 | -82.4                                                          |
| Cyclohexanol                              | $\text{C}_6\text{H}_{12}\text{O}$                   | -70.7                                                          |
| Cyclohexanone                             | $\text{C}_6\text{H}_{10}\text{O}$                   | -49.8                                                          |
| Cyclohexene                               | $\text{C}_6\text{H}_{10}$                           | -27.3                                                          |
| Cyclooctane                               | $\text{C}_8\text{H}_{16}$                           | -39.0                                                          |
| <i>cis</i> -Cyclooctene                   | $\text{C}_8\text{H}_{14}$                           | -45.5                                                          |
| Cyclopentane                              | $\text{C}_5\text{H}_{10}$                           | -30.3                                                          |
| Cyclopentanol                             | $\text{C}_5\text{H}_{10}\text{O}$                   | -58.5                                                          |
| Cyclopentanone                            | $\text{C}_5\text{H}_8\text{O}$                      | -44.3                                                          |
| Cyclopropane                              | $\text{C}_3\text{H}_6$                              | -15.4                                                          |
| Dibromomethane                            | $\text{CH}_2\text{Br}_2$                            | -33.0                                                          |
| Dibutylamine                              | $\text{C}_8\text{H}_{19}\text{N}$                   | -59.3                                                          |
| Dibutyl ether                             | $\text{C}_8\text{H}_{18}\text{O}$                   | -55.8                                                          |
| <i>o</i> -Dichlorobenzene                 | $\text{C}_6\text{H}_4\text{Cl}_2$                   | -37.3                                                          |
| <i>m</i> -Dichlorobenzene                 | $\text{C}_6\text{H}_4\text{Cl}_2$                   | -35.3                                                          |
| <i>p</i> -Dichlorobenzene                 | $\text{C}_6\text{H}_4\text{Cl}_2$                   | -28.4                                                          |
| 2,3-Dichloro-1,1'-biphenyl                | $\text{C}_{12}\text{H}_8\text{Cl}_2$                | -45.6                                                          |
| 2,4-Dichloro-1,1'-biphenyl                | $\text{C}_{12}\text{H}_8\text{Cl}_2$                | -43.0                                                          |
| 2,4'-Dichloro-1,1'-biphenyl               | $\text{C}_{12}\text{H}_8\text{Cl}_2$                | -44.2                                                          |
| 2,5-Dichlorobiphenyl                      | $\text{C}_{12}\text{H}_8\text{Cl}_2$                | -45.6                                                          |
| Dichlorodifluoromethane                   | $\text{CCl}_2\text{F}_2$                            | -26.0                                                          |
| 2,2-Dichloro-1,1-difluoro-1-methoxyethane | $\text{C}_3\text{H}_4\text{Cl}_2\text{F}_2\text{O}$ | -30.4                                                          |
| 1,1-Dichloroethane                        | $\text{C}_2\text{H}_4\text{Cl}_2$                   | -30.3                                                          |
| 1,2-Dichloroethane                        | $\text{C}_2\text{H}_4\text{Cl}_2$                   | -27.9                                                          |
| 1,1-Dichloroethene                        | $\text{C}_2\text{H}_2\text{Cl}_2$                   | -28.5                                                          |
| <i>cis</i> -1,2-Dichloroethene            | $\text{C}_2\text{H}_2\text{Cl}_2$                   | -26.9                                                          |
| <i>trans</i> -1,2-Dichloroethene          | $\text{C}_2\text{H}_2\text{Cl}_2$                   | -29.3                                                          |
| Dichloromethane                           | $\text{CH}_2\text{Cl}_2$                            | -30.3                                                          |
| 1,2-Dichloropropane                       | $\text{C}_3\text{H}_6\text{Cl}_2$                   | -31.1                                                          |
| 1,3-Dichloropropane                       | $\text{C}_3\text{H}_6\text{Cl}_2$                   | -29.7                                                          |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane    | $\text{C}_2\text{Cl}_2\text{F}_4$                   | -20.2                                                          |
| 1,2-Diethoxyethane                        | $\text{C}_6\text{H}_{14}\text{O}_2$                 | -71.9                                                          |
| Diethylamine                              | $\text{C}_4\text{H}_{11}\text{N}$                   | -64.3                                                          |
| <i>N,N</i> -Diethylaniline                | $\text{C}_{10}\text{H}_{15}\text{N}$                | -45.7                                                          |
| <i>p</i> -Diethylbenzene                  | $\text{C}_{10}\text{H}_{14}$                        | -46.4                                                          |
| Diethylene glycol dimethyl ether          | $\text{C}_6\text{H}_{14}\text{O}_3$                 | -96.2                                                          |
| Diethyl ether                             | $\text{C}_4\text{H}_{10}\text{O}$                   | -46.4                                                          |
| Diethyl sulfide                           | $\text{C}_4\text{H}_{10}\text{S}$                   | -40.2                                                          |
| 1,1-Difluoroethane                        | $\text{C}_2\text{H}_4\text{F}_2$                    | -20.7                                                          |
| Difluoromethane                           | $\text{CH}_2\text{F}_2$                             | -17.2                                                          |
| Diiodomethane                             | $\text{CH}_2\text{I}_2$                             | -41.6                                                          |
| Diisopropyl ether                         | $\text{C}_6\text{H}_{14}\text{O}$                   | -51.7                                                          |
| 1,2-Dimethoxyethane                       | $\text{C}_4\text{H}_{10}\text{O}_2$                 | -59.3                                                          |

| Name                                  | Mol. Form.                           | $\Delta_{\text{hyd}}H^\circ/\text{kJ mol}^{-1}$<br>at 298.15 K |
|---------------------------------------|--------------------------------------|----------------------------------------------------------------|
| Dimethylamine                         | $\text{C}_2\text{H}_7\text{N}$       | -53.1                                                          |
| 2,4-Dimethylaniline                   | $\text{C}_8\text{H}_{11}\text{N}$    | -58.7                                                          |
| 2,5-Dimethylaniline                   | $\text{C}_8\text{H}_{11}\text{N}$    | -61.5                                                          |
| 2,6-Dimethylaniline                   | $\text{C}_8\text{H}_{11}\text{N}$    | -60.5                                                          |
| <i>N,N</i> -Dimethylaniline           | $\text{C}_8\text{H}_{11}\text{N}$    | -49.6                                                          |
| 2,3-Dimethylbutane                    | $\text{C}_6\text{H}_{14}$            | -32.4                                                          |
| 3,3-Dimethyl-2-butanone               | $\text{C}_6\text{H}_{12}\text{O}$    | -47.5                                                          |
| <i>cis</i> -1,2-Dimethylcyclohexane   | $\text{C}_8\text{H}_{16}$            | -38.3                                                          |
| <i>trans</i> -1,2-Dimethylcyclohexane | $\text{C}_8\text{H}_{16}$            | -36.1                                                          |
| Dimethyl ether                        | $\text{C}_2\text{H}_6\text{O}$       | -34.0                                                          |
| <i>N,N</i> -Dimethylformamide         | $\text{C}_3\text{H}_7\text{NO}$      | -62.9                                                          |
| 2,4-Dimethyl-3-pentanone              | $\text{C}_7\text{H}_{14}\text{O}$    | -54.0                                                          |
| 2,3-Dimethylpyridine                  | $\text{C}_7\text{H}_9\text{N}$       | -57.7                                                          |
| 2,4-Dimethylpyridine                  | $\text{C}_7\text{H}_9\text{N}$       | -60.7                                                          |
| 2,5-Dimethylpyridine                  | $\text{C}_7\text{H}_9\text{N}$       | -54.9                                                          |
| 2,6-Dimethylpyridine                  | $\text{C}_7\text{H}_9\text{N}$       | -52.3                                                          |
| 3,4-Dimethylpyridine                  | $\text{C}_7\text{H}_9\text{N}$       | -50.5                                                          |
| 3,5-Dimethylpyridine                  | $\text{C}_7\text{H}_9\text{N}$       | -51.3                                                          |
| Dimethyl sulfide                      | $\text{C}_2\text{H}_6\text{S}$       | -31.5                                                          |
| Dimethyl sulfoxide                    | $\text{C}_2\text{H}_6\text{OS}$      | -71.9                                                          |
| 2,5-Dimethyltetrahydrofuran           | $\text{C}_6\text{H}_{12}\text{O}$    | -56.3                                                          |
| 1,4-Dioxane                           | $\text{C}_4\text{H}_8\text{O}_2$     | -48.4                                                          |
| 1,2-Dipropoxyethane                   | $\text{C}_8\text{H}_{18}\text{O}_2$  | -76.8                                                          |
| Dipropylamine                         | $\text{C}_6\text{H}_{15}\text{N}$    | -65.2                                                          |
| Dipropyl ether                        | $\text{C}_6\text{H}_{14}\text{O}$    | -49.9                                                          |
| Dipropyl sulfide                      | $\text{C}_6\text{H}_{14}\text{S}$    | -47.7                                                          |
| 1-Dodecanol                           | $\text{C}_{12}\text{H}_{26}\text{O}$ | -81.9                                                          |
| Ethane                                | $\text{C}_2\text{H}_6$               | -17.9                                                          |
| 1,2-Ethanediamine                     | $\text{C}_2\text{H}_8\text{N}_2$     | -76.1                                                          |
| 1,2-Ethenediol                        | $\text{C}_2\text{H}_2\text{O}_2$     | -77.3                                                          |
| Ethanethiol                           | $\text{C}_2\text{H}_6\text{S}$       | -28.9                                                          |
| Ethanol                               | $\text{C}_2\text{H}_6\text{O}$       | -50.6                                                          |
| 2-Ethoxyethanol                       | $\text{C}_4\text{H}_{10}\text{O}_2$  | -66.4                                                          |
| 1-Ethoxy-2-methoxyethane              | $\text{C}_5\text{H}_{12}\text{O}_2$  | -66.1                                                          |
| Ethyl acetate                         | $\text{C}_4\text{H}_8\text{O}_2$     | -45.3                                                          |
| Ethylamine                            | $\text{C}_2\text{H}_7\text{N}$       | -53.7                                                          |
| 2-Ethylaniline                        | $\text{C}_8\text{H}_{11}\text{N}$    | -59.7                                                          |
| 4-Ethylaniline                        | $\text{C}_8\text{H}_{11}\text{N}$    | -65.0                                                          |
| Ethylbenzene                          | $\text{C}_8\text{H}_{10}$            | -39.4                                                          |
| Ethyl butanoate                       | $\text{C}_6\text{H}_{12}\text{O}_2$  | -52.7                                                          |
| Ethylcyclohexane                      | $\text{C}_8\text{H}_{16}$            | -36.8                                                          |
| Ethyl 2,2-dimethylpropanoate          | $\text{C}_7\text{H}_{14}\text{O}_2$  | -50.3                                                          |
| Ethylene                              | $\text{C}_2\text{H}_4$               | -13.7                                                          |
| Ethyl formate                         | $\text{C}_3\text{H}_6\text{O}_2$     | -38.1                                                          |
| Ethyl hexanoate                       | $\text{C}_8\text{H}_{16}\text{O}_2$  | -60.2                                                          |
| Ethyl 3-methylbutanoate               | $\text{C}_7\text{H}_{14}\text{O}_2$  | -56.0                                                          |
| Ethyl 2-methylbutanoate               | $\text{C}_7\text{H}_{14}\text{O}_2$  | -55.4                                                          |
| Ethyl 2-methylpropanoate              | $\text{C}_6\text{H}_{12}\text{O}_2$  | -51.3                                                          |
| Ethyl pentanoate                      | $\text{C}_7\text{H}_{14}\text{O}_2$  | -56.5                                                          |
| Ethyl propanoate                      | $\text{C}_5\text{H}_{10}\text{O}_2$  | -49.5                                                          |
| 2-Ethylpyridine                       | $\text{C}_7\text{H}_9\text{N}$       | -55.7                                                          |

| Name                              | Mol. Form.                                 | $\Delta_{\text{hyd}} H^\circ / \text{kJ mol}^{-1}$<br>at 298.15 K |
|-----------------------------------|--------------------------------------------|-------------------------------------------------------------------|
| 3-Ethylpyridine                   | $\text{C}_7\text{H}_9\text{N}$             | -53.5                                                             |
| 4-Ethylpyridine                   | $\text{C}_7\text{H}_9\text{N}$             | -52.2                                                             |
| 9H-Fluorene                       | $\text{C}_{13}\text{H}_{10}$               | -42.7                                                             |
| Fluorobenzene                     | $\text{C}_6\text{H}_5\text{F}$             | -29.3                                                             |
| Fluoromethane                     | $\text{CH}_3\text{F}$                      | -16.1                                                             |
| Glycerol                          | $\text{C}_3\text{H}_8\text{O}_3$           | -103.5                                                            |
| Helium                            | He                                         | -0.67                                                             |
| 1,1,1,2,3,3,3-Heptafluoropropane  | $\text{C}_3\text{HF}_7$                    | -24.8                                                             |
| Heptanal                          | $\text{C}_7\text{H}_{14}\text{O}$          | -56.6                                                             |
| Heptane                           | $\text{C}_7\text{H}_{16}$                  | -34.0                                                             |
| 1-Heptanol                        | $\text{C}_7\text{H}_{16}\text{O}$          | -72.1                                                             |
| 2-Heptanol                        | $\text{C}_7\text{H}_{16}\text{O}$          | -72.6                                                             |
| 4-Heptanol                        | $\text{C}_7\text{H}_{16}\text{O}$          | -75.3                                                             |
| 2-Heptanone                       | $\text{C}_7\text{H}_{14}\text{O}$          | -54.9                                                             |
| 4-Heptanone                       | $\text{C}_7\text{H}_{14}\text{O}$          | -58.1                                                             |
| 1,1,1,3,3,3-Hexafluoro-2-propanol | $\text{C}_3\text{H}_2\text{F}_6\text{O}$   | -57.1                                                             |
| Hexanal                           | $\text{C}_6\text{H}_{12}\text{O}$          | -55.2                                                             |
| Hexane                            | $\text{C}_6\text{H}_{14}$                  | -31.9                                                             |
| Hexanedinitrile                   | $\text{C}_6\text{H}_8\text{N}_2$           | -66.6                                                             |
| 1-Hexanol                         | $\text{C}_6\text{H}_{14}\text{O}$          | -67.4                                                             |
| 3-Hexanol                         | $\text{C}_6\text{H}_{14}\text{O}$          | -69.6                                                             |
| 2-Hexanone                        | $\text{C}_6\text{H}_{12}\text{O}$          | -48.9                                                             |
| 3-Hexanone                        | $\text{C}_6\text{H}_{12}\text{O}$          | -46.0                                                             |
| 1-Hexene                          | $\text{C}_6\text{H}_{12}$                  | -30.4                                                             |
| Hexyl acetate                     | $\text{C}_8\text{H}_{16}\text{O}_2$        | -60.8                                                             |
| Hexylamine                        | $\text{C}_6\text{H}_{15}\text{N}$          | -65.9                                                             |
| Hexylbenzene                      | $\text{C}_{12}\text{H}_{18}$               | -52.7                                                             |
| Hydrogen                          | $\text{H}_2$                               | -0.402                                                            |
| Hydrogen selenide                 | $\text{H}_2\text{Se}$                      | -15.7                                                             |
| Hydrogen sulfide                  | $\text{H}_2\text{S}$                       | -18.0                                                             |
| 3-Hydroxybenzaldehyde             | $\text{C}_7\text{H}_6\text{O}_2$           | -70.7                                                             |
| 3-Hydroxybenzonitrile             | $\text{C}_7\text{H}_5\text{NO}$            | -70.7                                                             |
| 4-Hydroxybenzonitrile             | $\text{C}_7\text{H}_5\text{NO}$            | -70.3                                                             |
| Iodoethane                        | $\text{C}_2\text{H}_5\text{I}$             | -31.7                                                             |
| Iodomethane                       | $\text{CH}_3\text{I}$                      | -28.2                                                             |
| 1-Iodopropane                     | $\text{C}_3\text{H}_7\text{I}$             | -35.3                                                             |
| 2-Iodopropane                     | $\text{C}_3\text{H}_7\text{I}$             | -36.6                                                             |
| Isobutanal                        | $\text{C}_4\text{H}_8\text{O}$             | -40.0                                                             |
| Isobutane                         | $\text{C}_4\text{H}_{10}$                  | -21.7                                                             |
| Isobutene                         | $\text{C}_4\text{H}_8$                     | -22.7                                                             |
| Isobutyl acetate                  | $\text{C}_6\text{H}_{12}\text{O}_2$        | -51.8                                                             |
| Isobutyl formate                  | $\text{C}_5\text{H}_{10}\text{O}_2$        | -43.0                                                             |
| Isobutyl isobutanoate             | $\text{C}_8\text{H}_{16}\text{O}_2$        | -55.3                                                             |
| Isobutyl propanoate               | $\text{C}_7\text{H}_{14}\text{O}_2$        | -54.7                                                             |
| Isoflurane                        | $\text{C}_3\text{H}_2\text{ClF}_5\text{O}$ | -35.3                                                             |
| Isopentyl acetate                 | $\text{C}_7\text{H}_{14}\text{O}_2$        | -53.8                                                             |
| Isopentyl formate                 | $\text{C}_6\text{H}_{12}\text{O}_2$        | -47.7                                                             |
| Isophorone                        | $\text{C}_9\text{H}_{14}\text{O}$          | -59.1                                                             |
| Isopropyl acetate                 | $\text{C}_5\text{H}_{10}\text{O}_2$        | -46.8                                                             |
| Isopropylamine                    | $\text{C}_3\text{H}_9\text{N}$             | -55.0                                                             |
| Isopropylbenzene                  | $\text{C}_9\text{H}_{12}$                  | -33.7                                                             |

| Name                            | Mol. Form.                          | $\Delta_{\text{hyd}} H^\circ / \text{kJ mol}^{-1}$<br>at 298.15 K |
|---------------------------------|-------------------------------------|-------------------------------------------------------------------|
| Isopropyl formate               | $\text{C}_4\text{H}_8\text{O}_2$    | -43.0                                                             |
| 1-Isopropyl-4-methylbenzene     | $\text{C}_{10}\text{H}_{14}$        | -34.6                                                             |
| Krypton                         | Kr                                  | -15.6                                                             |
| Methane                         | $\text{CH}_4$                       | -12.0                                                             |
| Methanethiol                    | $\text{CH}_4\text{S}$               | -24.4                                                             |
| Methanol                        | $\text{CH}_4\text{O}$               | -52.0                                                             |
| 2-Methoxyethanol                | $\text{C}_3\text{H}_8\text{O}_2$    | -60.4                                                             |
| 2-Methoxy-2-methylbutane        | $\text{C}_6\text{H}_{14}\text{O}$   | -52.5                                                             |
| 2-Methoxyphenol                 | $\text{C}_7\text{H}_8\text{O}_2$    | -62.6                                                             |
| Methyl acetate                  | $\text{C}_3\text{H}_6\text{O}_2$    | -40.1                                                             |
| Methylamine                     | $\text{CH}_5\text{N}$               | -45.3                                                             |
| Methyl benzoate                 | $\text{C}_8\text{H}_8\text{O}_2$    | -50.3                                                             |
| Methyl butanoate                | $\text{C}_5\text{H}_{10}\text{O}_2$ | -47.5                                                             |
| 3-Methyl-1-butanol              | $\text{C}_5\text{H}_{12}\text{O}$   | -66.0                                                             |
| 2-Methyl-2-butanol              | $\text{C}_5\text{H}_{12}\text{O}$   | -68.4                                                             |
| 3-Methyl-2-butanone             | $\text{C}_5\text{H}_{10}\text{O}$   | -57.6                                                             |
| 2-Methyl-2-butene               | $\text{C}_5\text{H}_{10}$           | -26.6                                                             |
| Methyl <i>tert</i> -butyl ether | $\text{C}_5\text{H}_{12}\text{O}$   | -48.7                                                             |
| Methyl 2,2-dimethylpropanoate   | $\text{C}_6\text{H}_{12}\text{O}_2$ | -46.2                                                             |
| Methyl formate                  | $\text{C}_2\text{H}_4\text{O}_2$    | -32.0                                                             |
| Methyl hexanoate                | $\text{C}_7\text{H}_{14}\text{O}_2$ | -54.7                                                             |
| Methyl isobutanoate             | $\text{C}_5\text{H}_{10}\text{O}_2$ | -46.0                                                             |
| 4-Methylmorpholine              | $\text{C}_5\text{H}_{11}\text{NO}$  | -68.7                                                             |
| 1-Methylnaphthalene             | $\text{C}_{11}\text{H}_{10}$        | -45.0                                                             |
| 2-Methylnaphthalene             | $\text{C}_{11}\text{H}_{10}$        | -44.9                                                             |
| 2-Methylpentane                 | $\text{C}_6\text{H}_{14}$           | -30.5                                                             |
| 3-Methylpentane                 | $\text{C}_6\text{H}_{14}$           | -36.8                                                             |
| Methyl pentanoate               | $\text{C}_6\text{H}_{12}\text{O}_2$ | -50.4                                                             |
| 4-Methyl-2-pentanol             | $\text{C}_6\text{H}_{14}\text{O}$   | -69.9                                                             |
| 4-Methyl-2-pentanone            | $\text{C}_6\text{H}_{12}\text{O}$   | -44.6                                                             |
| 1-Methylpiperidine              | $\text{C}_6\text{H}_{13}\text{N}$   | -65.8                                                             |
| 2-Methylpropanenitrile          | $\text{C}_4\text{H}_7\text{N}$      | -40.0                                                             |
| Methyl propanoate               | $\text{C}_4\text{H}_8\text{O}_2$    | -44.5                                                             |
| 2-Methyl-1-propanol             | $\text{C}_4\text{H}_{10}\text{O}$   | -60.2                                                             |
| 2-Methyl-2-propanol             | $\text{C}_4\text{H}_{10}\text{O}$   | -62.9                                                             |
| Methyl propyl ether             | $\text{C}_4\text{H}_{10}\text{O}$   | -38.0                                                             |
| 2-Methylpyridine                | $\text{C}_6\text{H}_7\text{N}$      | -50.3                                                             |
| 3-Methylpyridine                | $\text{C}_6\text{H}_7\text{N}$      | -50.3                                                             |
| 4-Methylpyridine                | $\text{C}_6\text{H}_7\text{N}$      | -51.8                                                             |
| <i>N</i> -Methylpyrrolidine     | $\text{C}_5\text{H}_{11}\text{N}$   | -63.4                                                             |
| 2-Methyltetrahydrofuran         | $\text{C}_5\text{H}_{10}\text{O}$   | -51.4                                                             |
| Morpholine                      | $\text{C}_4\text{H}_9\text{NO}$     | -69.5                                                             |
| Naphthalene                     | $\text{C}_{10}\text{H}_8$           | -42.8                                                             |
| Neon                            | Ne                                  | -3.90                                                             |
| Neopentane                      | $\text{C}_5\text{H}_{12}$           | -23.4                                                             |
| Nitric oxide                    | NO                                  | -11.9                                                             |
| Nitrobenzene                    | $\text{C}_6\text{H}_5\text{NO}_2$   | -43.8                                                             |
| Nitroethane                     | $\text{C}_2\text{H}_5\text{NO}_2$   | -32.5                                                             |
| Nitrogen                        | $\text{N}_2$                        | -1.04                                                             |
| Nitromethane                    | $\text{CH}_3\text{NO}_2$            | -35.7                                                             |
| 2-Nitrophenol                   | $\text{C}_6\text{H}_5\text{NO}_3$   | -49.8                                                             |

| Name                             | Mol. Form.                               | $\Delta_{\text{hyd}}H^\circ/\text{kJ mol}^{-1}$<br>at 298.15 K |
|----------------------------------|------------------------------------------|----------------------------------------------------------------|
| 3-Nitrophenol                    | $\text{C}_6\text{H}_5\text{NO}_3$        | -67.7                                                          |
| 4-Nitrophenol                    | $\text{C}_6\text{H}_5\text{NO}_3$        | -68.6                                                          |
| 1-Nitropropane                   | $\text{C}_3\text{H}_7\text{NO}_2$        | -34.4                                                          |
| 2-Nitropropane                   | $\text{C}_3\text{H}_7\text{NO}_2$        | -34.1                                                          |
| 2-Nitrotoluene                   | $\text{C}_7\text{H}_7\text{NO}_2$        | -46.4                                                          |
| 3-Nitrotoluene                   | $\text{C}_7\text{H}_7\text{NO}_2$        | -38.5                                                          |
| Nitrous oxide                    | $\text{N}_2\text{O}$                     | -19.8                                                          |
| 5-Nonanone                       | $\text{C}_9\text{H}_{18}\text{O}$        | -62.8                                                          |
| 2-Nonanone                       | $\text{C}_9\text{H}_{18}\text{O}$        | -65.3                                                          |
| Octanal                          | $\text{C}_8\text{H}_{16}\text{O}$        | -48.8                                                          |
| Octane                           | $\text{C}_8\text{H}_{18}$                | -36.0                                                          |
| 1-Octanol                        | $\text{C}_8\text{H}_{18}\text{O}$        | -74.1                                                          |
| 2-Octanone                       | $\text{C}_8\text{H}_{16}\text{O}$        | -58.3                                                          |
| 1-Octene                         | $\text{C}_8\text{H}_{16}$                | -39.2                                                          |
| Octylamine                       | $\text{C}_8\text{H}_{19}\text{N}$        | -52.3                                                          |
| Oxygen                           | $\text{O}_2$                             | -1.20                                                          |
| Pentachlorobenzene               | $\text{C}_6\text{HCl}_5$                 | -39.9                                                          |
| Pentafluoroethane                | $\text{C}_2\text{HF}_5$                  | -21.5                                                          |
| 2,2,3,3,3-Pentafluoro-1-propanol | $\text{C}_3\text{H}_3\text{F}_5\text{O}$ | -51.9                                                          |
| Pentanal                         | $\text{C}_5\text{H}_{10}\text{O}$        | -42.9                                                          |
| Pentane                          | $\text{C}_5\text{H}_{12}$                | -28.3                                                          |
| 1,5-Pentanediamine               | $\text{C}_5\text{H}_{14}\text{N}_2$      | -95.1                                                          |
| Pentanedinitrile                 | $\text{C}_5\text{H}_6\text{N}_2$         | -63.5                                                          |
| Pentanenitrile                   | $\text{C}_5\text{H}_9\text{N}$           | -45.6                                                          |
| 1-Pentanol                       | $\text{C}_5\text{H}_{12}\text{O}$        | -61.9                                                          |
| 2-Pentanol                       | $\text{C}_5\text{H}_{12}\text{O}$        | -63.3                                                          |
| 3-Pentanol                       | $\text{C}_5\text{H}_{12}\text{O}$        | -59.6                                                          |
| 2-Pentanone                      | $\text{C}_5\text{H}_{10}\text{O}$        | -45.3                                                          |
| 3-Pentanone                      | $\text{C}_5\text{H}_{10}\text{O}$        | -49.6                                                          |
| Pentyl acetate                   | $\text{C}_7\text{H}_{14}\text{O}_2$      | -55.3                                                          |
| Pentylamine                      | $\text{C}_5\text{H}_{13}\text{N}$        | -62.1                                                          |
| Pentylbenzene                    | $\text{C}_{11}\text{H}_{16}$             | -49.5                                                          |
| Pentyl formate                   | $\text{C}_6\text{H}_{12}\text{O}_2$      | -48.1                                                          |
| Perfluoropropene                 | $\text{C}_3\text{F}_6$                   | -17.4                                                          |
| Phenol                           | $\text{C}_6\text{H}_6\text{O}$           | -57.7                                                          |
| 1-Phenyl-1-propanone             | $\text{C}_9\text{H}_{10}\text{O}$        | -61.9                                                          |
| Piperidine                       | $\text{C}_5\text{H}_{11}\text{N}$        | -65.4                                                          |
| Propanal                         | $\text{C}_3\text{H}_6\text{O}$           | -39.4                                                          |
| Propanamide                      | $\text{C}_3\text{H}_7\text{NO}$          | -73.4                                                          |
| Propane                          | $\text{C}_3\text{H}_8$                   | -20.4                                                          |
| 1,3-Propanediamine               | $\text{C}_3\text{H}_{10}\text{N}_2$      | -85.6                                                          |
| 1,3-Propanediol                  | $\text{C}_3\text{H}_8\text{O}_2$         | -81.1                                                          |
| Propanenitrile                   | $\text{C}_3\text{H}_5\text{N}$           | -39.5                                                          |
| 1-Propanethiol                   | $\text{C}_3\text{H}_8\text{S}$           | -30.2                                                          |
| Propanoic acid                   | $\text{C}_3\text{H}_6\text{O}_2$         | -56.5                                                          |
| 1-Propanol                       | $\text{C}_3\text{H}_8\text{O}$           | -59.9                                                          |
| 2-Propanol                       | $\text{C}_3\text{H}_8\text{O}$           | -58.2                                                          |
| Propene                          | $\text{C}_3\text{H}_6$                   | -21.6                                                          |
| 2-Propoxyethanol                 | $\text{C}_5\text{H}_{12}\text{O}_2$      | -69.6                                                          |
| Propyl acetate                   | $\text{C}_5\text{H}_{10}\text{O}_2$      | -48.7                                                          |
| Propylamine                      | $\text{C}_3\text{H}_9\text{N}$           | -56.0                                                          |

| Name                                  | Mol. Form.                               | $\Delta_{\text{hyd}}H^\circ/\text{kJ mol}^{-1}$<br>at 298.15 K |
|---------------------------------------|------------------------------------------|----------------------------------------------------------------|
| Propylbenzene                         | $\text{C}_9\text{H}_{12}$                | -36.4                                                          |
| Propyl butanoate                      | $\text{C}_7\text{H}_{14}\text{O}_2$      | -54.9                                                          |
| Propyl formate                        | $\text{C}_4\text{H}_8\text{O}_2$         | -40.5                                                          |
| Propyl propanoate                     | $\text{C}_6\text{H}_{12}\text{O}_2$      | -51.2                                                          |
| Propyne                               | $\text{C}_3\text{H}_4$                   | -15.6                                                          |
| Pyridine                              | $\text{C}_5\text{H}_5\text{N}$           | -42.1                                                          |
| Quinoline                             | $\text{C}_9\text{H}_7\text{N}$           | -58.2                                                          |
| Radon                                 | Rn                                       | -24.0                                                          |
| Styrene                               | $\text{C}_8\text{H}_8$                   | -28.4                                                          |
| Succinonitrile                        | $\text{C}_4\text{H}_4\text{N}_2$         | -58.2                                                          |
| Sulfur hexafluoride                   | $\text{F}_6\text{S}$                     | -20.7                                                          |
| 1,2,3,4-Tetrachlorobenzene            | $\text{C}_6\text{H}_2\text{Cl}_4$        | -35.0                                                          |
| 1,1,2,2-Tetrachloroethane             | $\text{C}_2\text{H}_2\text{Cl}_4$        | -34.8                                                          |
| 1,1,1,2-Tetrachloroethane             | $\text{C}_2\text{H}_2\text{Cl}_4$        | -36.2                                                          |
| Tetrachloroethene                     | $\text{C}_2\text{Cl}_4$                  | -41.5                                                          |
| Tetrachloromethane                    | $\text{CCl}_4$                           | -30.5                                                          |
| Tetraethylene glycol dimethyl ether   | $\text{C}_{10}\text{H}_{22}\text{O}_5$   | -126                                                           |
| 1,1,1,2-Tetrafluoroethane             | $\text{C}_2\text{H}_2\text{F}_4$         | -22.2                                                          |
| Tetrafluoroethene                     | $\text{C}_2\text{F}_4$                   | -15.1                                                          |
| Tetrafluoromethane                    | $\text{CF}_4$                            | -13.5                                                          |
| 2,2,3,3-Tetrafluoro-1-propanol        | $\text{C}_3\text{H}_4\text{F}_4\text{O}$ | -57.9                                                          |
| Tetrahydrofuran                       | $\text{C}_4\text{H}_8\text{O}$           | -47.3                                                          |
| Tetrahydropyran                       | $\text{C}_5\text{H}_{10}\text{O}$        | -48.9                                                          |
| Thiophene                             | $\text{C}_4\text{H}_4\text{S}$           | -29.9                                                          |
| Toluene                               | $\text{C}_7\text{H}_8$                   | -32.4                                                          |
| Tribromomethane                       | $\text{CHBr}_3$                          | -35.8                                                          |
| 1,2,3-Trichlorobenzene                | $\text{C}_6\text{H}_3\text{Cl}_3$        | -32.6                                                          |
| 1,3,5-Trichlorobenzene                | $\text{C}_6\text{H}_3\text{Cl}_3$        | -34.2                                                          |
| 1,1,1-Trichloroethane                 | $\text{C}_2\text{H}_3\text{Cl}_3$        | -28.7                                                          |
| 1,1,2-Trichloroethane                 | $\text{C}_2\text{H}_3\text{Cl}_3$        | -32.5                                                          |
| Trichloroethene                       | $\text{C}_2\text{HCl}_3$                 | -32.2                                                          |
| Trichlorofluoromethane                | $\text{CCl}_3\text{F}$                   | -19.8                                                          |
| Trichloromethane                      | $\text{CHCl}_3$                          | -33.5                                                          |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | $\text{C}_2\text{Cl}_3\text{F}_3$        | -28.8                                                          |
| Triethylamine                         | $\text{C}_6\text{H}_{15}\text{N}$        | -69.7                                                          |
| Triethylene glycol dimethyl ether     | $\text{C}_8\text{H}_{18}\text{O}_4$      | -102.4                                                         |
| 2,2,2-Trifluoroethanol                | $\text{C}_2\text{H}_3\text{F}_3\text{O}$ | -50.2                                                          |
| Trifluoromethane                      | $\text{CHF}_3$                           | -22.6                                                          |
| 1,1,1-Trifluoro-2-propanol            | $\text{C}_3\text{H}_5\text{F}_3\text{O}$ | -53.5                                                          |
| Trimethylamine                        | $\text{C}_3\text{H}_9\text{N}$           | -52.7                                                          |
| 1,2,3-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$                | -37.4                                                          |
| 1,2,4-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$                | -36.6                                                          |
| 1,3,5-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$                | -39.1                                                          |
| 2,2,4-Trimethylpentane                | $\text{C}_8\text{H}_{18}$                | -31.0                                                          |
| 2,3,4-Trimethylpentane                | $\text{C}_8\text{H}_{18}$                | -38.5                                                          |
| Xenon                                 | Xe                                       | -19.4                                                          |
| <i>o</i> -Xylene                      | $\text{C}_8\text{H}_{10}$                | -37.7                                                          |
| <i>m</i> -Xylene                      | $\text{C}_8\text{H}_{10}$                | -38.6                                                          |
| <i>p</i> -Xylene                      | $\text{C}_8\text{H}_{10}$                | -34.8                                                          |

# THERMOPHYSICAL PROPERTIES OF AIR

Eric W. Lemmon

These tables summarize the thermophysical properties of air in the liquid and gaseous states as calculated from the pseudo-pure fluid equation of state of Lemmon et al. (2000). The first table refers to liquid and gaseous air at equilibrium as a function of temperature. The tabulated properties are the bubble-point pressure (i.e., pressure at which boiling begins as the pressure of the liquid is lowered); the dew-point pressure (i.e., pressure at which condensation begins as the pressure of the gas is raised); density ( $\rho$ ); enthalpy ( $H$ ); entropy ( $S$ ); isochoric heat capacity ( $C_v$ ); isobaric heat capacity ( $C_p$ ); speed of sound ( $u$ ); viscosity ( $\eta$ ); and thermal conductivity ( $\lambda$ ). The first line of identical temperatures is the bubble-point (liquid) and the second line is the dew point (vapor). The normal boiling point of air, i.e., the temperature at which the bubble-point pressure reaches 1 standard atmosphere (1.01325 bar), is 78.90 K (−194.25 °C).

The second table gives the properties of air along various isobars. An entry with non-integer temperatures in the isobar section indicates a phase transition (liquid–vapor) at these temperatures; property values are then given for both phases. These are identi-

fied by the high densities in the liquid and the low densities in the vapor. Additional calculations at state points not listed below can be obtained by using the NIST program REFPROP (<http://www.nist.gov/srd/nist23.htm>).

## References

1. Lemmon, E.W., Jacobsen, R.T., Penoncello, S.G., and Friend, D.G., Thermodynamic Properties of Air and Mixtures of Nitrogen, Argon, and Oxygen from 60 to 2000 K at Pressures to 2000 MPa, *J. Phys. Chem. Ref. Data*, 29, 331, 2000.
2. Lemmon, E.W. and Jacobsen, R.T., Viscosity and Thermal Conductivity Equations for Nitrogen, Oxygen, Argon, and Air, *Int. J. Thermophys.*, 25, 21, 2004.
3. Lemmon, E.W., Huber, M.L., McLinden, M.O., NIST Standard Reference Database 23: Reference Fluid Thermodynamic and Transport Properties-REFPROP, Version 8.0, National Institute of Standards and Technology, Standard Reference Data Program, Gaithersburg, Maryland, 2007 ([www.nist.gov/srd/nist23.htm](http://www.nist.gov/srd/nist23.htm)).

## Thermophysical Properties of Air along the Boiling and Condensation Curves

| $T$<br>K | $P$<br>MPa | $\rho$<br>kg m <sup>−3</sup> | $H$<br>kJ kg <sup>−1</sup> | $S$<br>kJ kg <sup>−1</sup> K <sup>−1</sup> | $C_v$<br>kJ kg <sup>−1</sup> K <sup>−1</sup> | $C_p$<br>kJ kg <sup>−1</sup> K <sup>−1</sup> | $u$<br>m s <sup>−1</sup> | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>−1</sup> K <sup>−1</sup> |
|----------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|-----------------|-------------------------------------------------|
| 59.75    | 0.005265   | 957.6                        | −36.66                     | −0.5306                                    | 1.174                                        | 1.901                                        | 1030.                    | 376.6           | 171.4                                           |
| 59.75    | 0.002432   | 0.1421                       | 185.5                      | 3.340                                      | 0.7184                                       | 1.009                                        | 154.8                    | 4.220           | 5.294                                           |
| 60       | 0.005546   | 956.5                        | −36.19                     | −0.5226                                    | 1.173                                        | 1.901                                        | 1028.                    | 371.9           | 171.0                                           |
| 60       | 0.002584   | 0.1504                       | 185.8                      | 3.326                                      | 0.7186                                       | 1.009                                        | 155.1                    | 4.238           | 5.320                                           |
| 62       | 0.008270   | 948.2                        | −32.38                     | −0.4603                                    | 1.157                                        | 1.901                                        | 1012.                    | 336.9           | 167.8                                           |
| 62       | 0.004111   | 0.2318                       | 187.7                      | 3.225                                      | 0.7198                                       | 1.012                                        | 157.6                    | 4.386           | 5.529                                           |
| 64       | 0.01200    | 939.9                        | −28.58                     | −0.3999                                    | 1.143                                        | 1.902                                        | 995.8                    | 306.3           | 164.5                                           |
| 64       | 0.006325   | 0.3460                       | 189.6                      | 3.132                                      | 0.7212                                       | 1.015                                        | 160.0                    | 4.532           | 5.739                                           |
| 66       | 0.01699    | 931.5                        | −24.77                     | −0.3414                                    | 1.129                                        | 1.903                                        | 979.1                    | 279.4           | 161.3                                           |
| 66       | 0.009442   | 0.5018                       | 191.5                      | 3.047                                      | 0.7230                                       | 1.019                                        | 162.3                    | 4.679           | 5.950                                           |
| 68       | 0.02352    | 923.0                        | −20.95                     | −0.2846                                    | 1.115                                        | 1.906                                        | 962.2                    | 255.7           | 158.0                                           |
| 68       | 0.01371    | 0.7089                       | 193.4                      | 2.968                                      | 0.7252                                       | 1.024                                        | 164.5                    | 4.825           | 6.162                                           |
| 70       | 0.03191    | 914.4                        | −17.13                     | −0.2293                                    | 1.102                                        | 1.908                                        | 945.1                    | 234.8           | 154.7                                           |
| 70       | 0.01943    | 0.9785                       | 195.2                      | 2.896                                      | 0.7277                                       | 1.030                                        | 166.7                    | 4.970           | 6.376                                           |
| 72       | 0.04250    | 905.7                        | −13.31                     | −0.1756                                    | 1.090                                        | 1.912                                        | 927.7                    | 216.3           | 151.4                                           |
| 72       | 0.02692    | 1.322                        | 197.0                      | 2.828                                      | 0.7305                                       | 1.037                                        | 168.7                    | 5.115           | 6.592                                           |
| 74       | 0.05566    | 897.0                        | −9.468                     | −0.1232                                    | 1.078                                        | 1.917                                        | 910.0                    | 199.9           | 148.1                                           |
| 74       | 0.03655    | 1.753                        | 198.7                      | 2.766                                      | 0.7338                                       | 1.046                                        | 170.6                    | 5.260           | 6.810                                           |
| 76       | 0.07179    | 888.1                        | −5.617                     | −0.07209                                   | 1.067                                        | 1.923                                        | 892.1                    | 185.2           | 144.8                                           |
| 76       | 0.04870    | 2.285                        | 200.4                      | 2.708                                      | 0.7375                                       | 1.055                                        | 172.5                    | 5.405           | 7.031                                           |
| 78       | 0.09129    | 879.1                        | −1.751                     | −0.02217                                   | 1.056                                        | 1.930                                        | 873.9                    | 172.1           | 141.5                                           |
| 78       | 0.06381    | 2.933                        | 202.0                      | 2.653                                      | 0.7416                                       | 1.066                                        | 174.2                    | 5.549           | 7.256                                           |
| 80       | 0.1146     | 870.0                        | 2.132                      | 0.02665                                    | 1.045                                        | 1.938                                        | 855.4                    | 160.4           | 138.2                                           |
| 80       | 0.08232    | 3.711                        | 203.6                      | 2.602                                      | 0.7460                                       | 1.078                                        | 175.8                    | 5.694           | 7.485                                           |
| 82       | 0.1422     | 860.7                        | 6.036                      | 0.07444                                    | 1.035                                        | 1.948                                        | 836.7                    | 149.8           | 134.8                                           |
| 82       | 0.1047     | 4.635                        | 205.1                      | 2.554                                      | 0.7510                                       | 1.092                                        | 177.4                    | 5.839           | 7.719                                           |
| 84       | 0.1745     | 851.3                        | 9.962                      | 0.1213                                     | 1.025                                        | 1.959                                        | 817.6                    | 140.2           | 131.4                                           |
| 84       | 0.1315     | 5.724                        | 206.5                      | 2.509                                      | 0.7563                                       | 1.108                                        | 178.8                    | 5.984           | 7.959                                           |
| 86       | 0.2121     | 841.7                        | 13.91                      | 0.1673                                     | 1.016                                        | 1.972                                        | 798.2                    | 131.5           | 128.1                                           |
| 86       | 0.1631     | 6.993                        | 207.8                      | 2.466                                      | 0.7620                                       | 1.125                                        | 180.0                    | 6.131           | 8.206                                           |
| 88       | 0.2553     | 832.0                        | 17.90                      | 0.2125                                     | 1.007                                        | 1.986                                        | 778.6                    | 123.6           | 124.8                                           |
| 88       | 0.2002     | 8.464                        | 209.1                      | 2.425                                      | 0.7682                                       | 1.144                                        | 181.2                    | 6.278           | 8.461                                           |

| $T$<br>K | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|----------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|-----------------|-------------------------------------------------|
| 90       | 0.3048     | 822.0                        | 21.91                      | 0.2569                                     | 0.9984                                       | 2.003                                        | 758.5                    | 116.4           | 121.4                                           |
| 90       | 0.2432     | 10.16                        | 210.3                      | 2.386                                      | 0.7748                                       | 1.166                                        | 182.2                    | 6.427           | 8.725                                           |
| 92       | 0.3609     | 811.8                        | 25.97                      | 0.3007                                     | 0.9902                                       | 2.022                                        | 738.2                    | 109.7           | 118.0                                           |
| 92       | 0.2927     | 12.09                        | 211.4                      | 2.349                                      | 0.7817                                       | 1.190                                        | 183.1                    | 6.578           | 9.001                                           |
| 94       | 0.4243     | 801.4                        | 30.06                      | 0.3439                                     | 0.9825                                       | 2.044                                        | 717.5                    | 103.6           | 114.6                                           |
| 94       | 0.3493     | 14.29                        | 212.3                      | 2.313                                      | 0.7891                                       | 1.217                                        | 183.8                    | 6.732           | 9.289                                           |
| 96       | 0.4954     | 790.7                        | 34.21                      | 0.3866                                     | 0.9752                                       | 2.069                                        | 696.5                    | 97.88           | 111.2                                           |
| 96       | 0.4136     | 16.78                        | 213.2                      | 2.279                                      | 0.7969                                       | 1.248                                        | 184.5                    | 6.889           | 9.593                                           |
| 98       | 0.5749     | 779.7                        | 38.41                      | 0.4288                                     | 0.9684                                       | 2.098                                        | 675.0                    | 92.57           | 107.8                                           |
| 98       | 0.4861     | 19.60                        | 214.0                      | 2.246                                      | 0.8052                                       | 1.282                                        | 184.9                    | 7.050           | 9.915                                           |
| 100      | 0.6631     | 768.4                        | 42.66                      | 0.4707                                     | 0.9619                                       | 2.131                                        | 653.3                    | 87.61           | 104.4                                           |
| 100      | 0.5674     | 22.76                        | 214.6                      | 2.213                                      | 0.8138                                       | 1.320                                        | 185.3                    | 7.215           | 10.26                                           |
| 102      | 0.7608     | 756.7                        | 46.98                      | 0.5122                                     | 0.9560                                       | 2.168                                        | 631.1                    | 82.94           | 101.0                                           |
| 102      | 0.6582     | 26.32                        | 215.1                      | 2.182                                      | 0.8230                                       | 1.363                                        | 185.5                    | 7.387           | 10.63                                           |
| 104      | 0.8684     | 744.6                        | 51.38                      | 0.5535                                     | 0.9505                                       | 2.212                                        | 608.5                    | 78.53           | 97.62                                           |
| 104      | 0.7590     | 30.31                        | 215.5                      | 2.151                                      | 0.8326                                       | 1.413                                        | 185.6                    | 7.566           | 11.02                                           |
| 106      | 0.9864     | 732.1                        | 55.86                      | 0.5947                                     | 0.9456                                       | 2.262                                        | 585.5                    | 74.35           | 94.25                                           |
| 106      | 0.8706     | 34.78                        | 215.7                      | 2.120                                      | 0.8429                                       | 1.470                                        | 185.5                    | 7.754           | 11.46                                           |
| 108      | 1.116      | 719.1                        | 60.44                      | 0.6358                                     | 0.9412                                       | 2.321                                        | 562.1                    | 70.36           | 90.89                                           |
| 108      | 0.9934     | 39.79                        | 215.8                      | 2.089                                      | 0.8537                                       | 1.536                                        | 185.2                    | 7.952           | 11.94                                           |
| 110      | 1.256      | 705.5                        | 65.12                      | 0.6769                                     | 0.9375                                       | 2.390                                        | 538.2                    | 66.54           | 87.55                                           |
| 110      | 1.128      | 45.41                        | 215.6                      | 2.059                                      | 0.8653                                       | 1.614                                        | 184.9                    | 8.163           | 12.47                                           |
| 112      | 1.409      | 691.2                        | 69.93                      | 0.7182                                     | 0.9345                                       | 2.472                                        | 513.9                    | 62.87           | 84.24                                           |
| 112      | 1.276      | 51.73                        | 215.2                      | 2.028                                      | 0.8777                                       | 1.708                                        | 184.3                    | 8.391           | 13.07                                           |
| 114      | 1.575      | 676.2                        | 74.87                      | 0.7598                                     | 0.9324                                       | 2.571                                        | 489.0                    | 59.31           | 80.96                                           |
| 114      | 1.437      | 58.84                        | 214.6                      | 1.997                                      | 0.8912                                       | 1.821                                        | 183.6                    | 8.637           | 13.76                                           |
| 116      | 1.755      | 660.3                        | 79.98                      | 0.8019                                     | 0.9312                                       | 2.693                                        | 463.5                    | 55.85           | 77.72                                           |
| 116      | 1.612      | 66.88                        | 213.8                      | 1.965                                      | 0.9059                                       | 1.961                                        | 182.7                    | 8.909           | 14.56                                           |
| 118      | 1.948      | 643.4                        | 85.29                      | 0.8447                                     | 0.9312                                       | 2.847                                        | 437.3                    | 52.47           | 74.52                                           |
| 118      | 1.801      | 76.04                        | 212.6                      | 1.932                                      | 0.9220                                       | 2.139                                        | 181.7                    | 9.210           | 15.50                                           |
| 120      | 2.156      | 625.1                        | 90.83                      | 0.8885                                     | 0.9327                                       | 3.048                                        | 410.2                    | 49.13           | 71.36                                           |
| 120      | 2.007      | 86.55                        | 211.0                      | 1.898                                      | 0.9402                                       | 2.374                                        | 180.4                    | 9.552           | 16.63                                           |
| 122      | 2.379      | 605.3                        | 96.66                      | 0.9338                                     | 0.9363                                       | 3.323                                        | 382.0                    | 45.81           | 68.24                                           |
| 122      | 2.229      | 98.76                        | 208.9                      | 1.861                                      | 0.9608                                       | 2.694                                        | 179.1                    | 9.946           | 18.04                                           |
| 124      | 2.617      | 583.3                        | 102.9                      | 0.9811                                     | 0.9427                                       | 3.723                                        | 352.3                    | 42.46           | 65.17                                           |
| 124      | 2.468      | 113.2                        | 206.3                      | 1.821                                      | 0.9847                                       | 3.157                                        | 177.5                    | 10.41           | 19.85                                           |
| 126      | 2.872      | 558.3                        | 109.7                      | 1.032                                      | 0.9537                                       | 4.367                                        | 320.4                    | 39.01           | 62.18                                           |
| 126      | 2.727      | 130.6                        | 202.9                      | 1.777                                      | 1.013                                        | 3.882                                        | 175.8                    | 10.98           | 22.29                                           |
| 128      | 3.143      | 528.3                        | 117.3                      | 1.088                                      | 0.9728                                       | 5.589                                        | 285.0                    | 35.33           | 59.44                                           |
| 128      | 3.006      | 152.6                        | 198.3                      | 1.725                                      | 1.049                                        | 5.166                                        | 174.0                    | 11.72           | 25.84                                           |
| 130      | 3.429      | 488.3                        | 126.7                      | 1.157                                      | 1.010                                        | 8.849                                        | 243.7                    | 31.07           | 58.05                                           |
| 130      | 3.308      | 182.7                        | 191.7                      | 1.660                                      | 1.096                                        | 8.033                                        | 171.9                    | 12.77           | 31.81                                           |
| 132      | 3.723      | 411.2                        | 142.6                      | 1.273                                      | 1.117                                        | 35.04                                        | 189.1                    | 24.47           | 67.80                                           |
| 132      | 3.646      | 235.4                        | 179.7                      | 1.556                                      | 1.168                                        | 20.65                                        | 169.4                    | 14.80           | 47.00                                           |
| 132.63   | 3.785      | 302.6                        | 164.5                      | 1.437                                      |                                              |                                              |                          | 17.83           |                                                 |

### Thermophysical Properties of Air along Various Isobars

| $T$<br>K              | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|-----------------|-------------------------------------------------|
| $P = 0.1$ MPa (1 bar) |                              |                            |                                            |                                              |                                              |                          |                 |                                                 |
| 60                    | 956.7                        | -36.11                     | -0.5230                                    | 1.173                                        | 1.901                                        | 1029.                    | 372.4           | 171.1                                           |
| 78.79                 | 875.5                        | -0.2237                    | -0.002818                                  | 1.051                                        | 1.933                                        | 866.7                    | 167.4           | 140.2                                           |
| 81.61                 | 4.442                        | 204.8                      | 2.563                                      | 0.7500                                       | 1.089                                        | 177.1                    | 5.811           | 7.673                                           |
| 100                   | 3.557                        | 224.3                      | 2.779                                      | 0.7282                                       | 1.040                                        | 198.2                    | 7.107           | 9.469                                           |

| $T$<br>K | $\rho$<br>$\text{kg m}^{-3}$ | $H$<br>$\text{kJ kg}^{-1}$ | $S$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $C_v$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $C_p$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $u$<br>$\text{m s}^{-1}$ | $\eta$<br>$\mu\text{Pa s}$ | $\lambda$<br>$\text{mW m}^{-1} \text{K}^{-1}$ |
|----------|------------------------------|----------------------------|------------------------------------------|--------------------------------------------|--------------------------------------------|--------------------------|----------------------------|-----------------------------------------------|
| 120      | 2.938                        | 244.9                      | 2.966                                    | 0.7211                                     | 1.022                                      | 218.3                    | 8.457                      | 11.38                                         |
| 140      | 2.507                        | 265.2                      | 3.123                                    | 0.7184                                     | 1.014                                      | 236.4                    | 9.750                      | 13.24                                         |
| 160      | 2.188                        | 285.5                      | 3.258                                    | 0.7172                                     | 1.011                                      | 253.2                    | 10.99                      | 15.05                                         |
| 180      | 1.942                        | 305.6                      | 3.377                                    | 0.7166                                     | 1.008                                      | 268.8                    | 12.18                      | 16.80                                         |
| 200      | 1.746                        | 325.8                      | 3.483                                    | 0.7163                                     | 1.007                                      | 283.5                    | 13.33                      | 18.50                                         |
| 220      | 1.586                        | 345.9                      | 3.579                                    | 0.7163                                     | 1.006                                      | 297.4                    | 14.44                      | 20.16                                         |
| 240      | 1.453                        | 366.0                      | 3.667                                    | 0.7164                                     | 1.006                                      | 310.7                    | 15.51                      | 21.77                                         |
| 260      | 1.341                        | 386.2                      | 3.747                                    | 0.7168                                     | 1.006                                      | 323.4                    | 16.55                      | 23.35                                         |
| 280      | 1.245                        | 406.3                      | 3.822                                    | 0.7173                                     | 1.006                                      | 335.6                    | 17.56                      | 24.88                                         |
| 300      | 1.161                        | 426.4                      | 3.891                                    | 0.7181                                     | 1.007                                      | 347.4                    | 18.54                      | 26.38                                         |
| 320      | 1.089                        | 446.5                      | 3.956                                    | 0.7192                                     | 1.007                                      | 358.7                    | 19.49                      | 27.85                                         |
| 340      | 1.024                        | 466.7                      | 4.018                                    | 0.7206                                     | 1.009                                      | 369.6                    | 20.41                      | 29.29                                         |
| 360      | 0.9674                       | 486.9                      | 4.075                                    | 0.7223                                     | 1.010                                      | 380.3                    | 21.32                      | 30.71                                         |
| 380      | 0.9164                       | 507.1                      | 4.130                                    | 0.7243                                     | 1.012                                      | 390.5                    | 22.20                      | 32.09                                         |
| 400      | 0.8706                       | 527.4                      | 4.182                                    | 0.7266                                     | 1.014                                      | 400.5                    | 23.06                      | 33.45                                         |
| 500      | 0.6964                       | 629.5                      | 4.410                                    | 0.7426                                     | 1.030                                      | 446.4                    | 27.09                      | 39.94                                         |
| 600      | 0.5803                       | 733.6                      | 4.599                                    | 0.7641                                     | 1.051                                      | 487.1                    | 30.77                      | 46.01                                         |
| 700      | 0.4974                       | 839.9                      | 4.763                                    | 0.7879                                     | 1.075                                      | 523.9                    | 34.18                      | 51.76                                         |
| 800      | 0.4352                       | 948.6                      | 4.908                                    | 0.8117                                     | 1.099                                      | 557.8                    | 37.37                      | 57.25                                         |
| 900      | 0.3869                       | 1060.                      | 5.039                                    | 0.8340                                     | 1.121                                      | 589.6                    | 40.39                      | 62.54                                         |
| 1000     | 0.3482                       | 1173.                      | 5.158                                    | 0.8540                                     | 1.141                                      | 619.6                    | 43.28                      | 67.68                                         |

 **$P = 0.5 \text{ MPa (5 bar)}$** 

|       |       |        |         |        |       |       |       |       |
|-------|-------|--------|---------|--------|-------|-------|-------|-------|
| 60    | 957.3 | -35.80 | -0.5248 | 1.173  | 1.900 | 1031. | 374.6 | 171.4 |
| 80    | 870.9 | 2.387  | 0.02430 | 1.046  | 1.934 | 858.5 | 161.4 | 138.6 |
| 96.12 | 790.0 | 34.46  | 0.3892  | 0.9748 | 2.071 | 695.2 | 97.55 | 111.0 |
| 98.36 | 20.14 | 214.1  | 2.240   | 0.8067 | 1.288 | 185.0 | 7.079 | 9.974 |
| 100   | 19.65 | 216.2  | 2.261   | 0.7967 | 1.261 | 187.4 | 7.192 | 10.10 |
| 120   | 15.48 | 239.6  | 2.475   | 0.7461 | 1.115 | 212.4 | 8.542 | 11.81 |
| 140   | 12.94 | 261.4  | 2.643   | 0.7311 | 1.068 | 232.8 | 9.834 | 13.58 |
| 160   | 11.17 | 282.5  | 2.784   | 0.7245 | 1.045 | 250.9 | 11.07 | 15.32 |
| 180   | 9.842 | 303.3  | 2.906   | 0.7213 | 1.032 | 267.4 | 12.26 | 17.04 |
| 200   | 8.811 | 323.8  | 3.014   | 0.7195 | 1.025 | 282.6 | 13.41 | 18.71 |
| 220   | 7.981 | 344.3  | 3.112   | 0.7186 | 1.020 | 297.0 | 14.51 | 20.34 |
| 240   | 7.297 | 364.6  | 3.200   | 0.7182 | 1.017 | 310.6 | 15.58 | 21.94 |
| 260   | 6.724 | 385.0  | 3.282   | 0.7182 | 1.015 | 323.5 | 16.62 | 23.50 |
| 280   | 6.235 | 405.2  | 3.357   | 0.7185 | 1.014 | 335.9 | 17.62 | 25.02 |
| 300   | 5.813 | 425.5  | 3.427   | 0.7191 | 1.013 | 347.8 | 18.60 | 26.51 |
| 320   | 5.446 | 445.8  | 3.492   | 0.7200 | 1.013 | 359.3 | 19.54 | 27.97 |
| 340   | 5.123 | 466.0  | 3.553   | 0.7213 | 1.013 | 370.3 | 20.47 | 29.41 |
| 360   | 4.836 | 486.3  | 3.611   | 0.7229 | 1.014 | 381.0 | 21.37 | 30.81 |
| 380   | 4.580 | 506.6  | 3.666   | 0.7248 | 1.016 | 391.3 | 22.24 | 32.19 |
| 400   | 4.350 | 526.9  | 3.718   | 0.7271 | 1.018 | 401.3 | 23.10 | 33.55 |
| 500   | 3.477 | 629.3  | 3.947   | 0.7429 | 1.032 | 447.3 | 27.13 | 40.02 |
| 600   | 2.897 | 733.5  | 4.137   | 0.7643 | 1.053 | 488.0 | 30.80 | 46.07 |
| 700   | 2.483 | 840.0  | 4.301   | 0.7881 | 1.076 | 524.8 | 34.20 | 51.80 |
| 800   | 2.173 | 948.8  | 4.446   | 0.8119 | 1.100 | 558.7 | 37.40 | 57.29 |
| 900   | 1.932 | 1060.  | 4.577   | 0.8341 | 1.122 | 590.5 | 40.42 | 62.58 |
| 1000  | 1.739 | 1173.  | 4.696   | 0.8542 | 1.142 | 620.4 | 43.30 | 67.71 |

 **$P = 1 \text{ MPa (10 bar)}$** 

|        |       |        |         |        |       |       |       |       |
|--------|-------|--------|---------|--------|-------|-------|-------|-------|
| 60     | 958.0 | -35.42 | -0.5271 | 1.174  | 1.898 | 1033. | 377.2 | 171.7 |
| 80     | 872.2 | 2.720  | 0.02129 | 1.047  | 1.930 | 862.5 | 162.8 | 139.1 |
| 100    | 770.1 | 42.76  | 0.4673  | 0.9623 | 2.119 | 658.2 | 88.33 | 105.0 |
| 106.22 | 730.7 | 56.36  | 0.5992  | 0.9451 | 2.268 | 583.0 | 73.90 | 93.88 |
| 108.10 | 40.07 | 215.8  | 2.088   | 0.8543 | 1.540 | 185.2 | 7.963 | 11.96 |

| $T$<br>K | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|----------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|-----------------|-------------------------------------------------|
| 120      | 33.48                        | 232.3                      | 2.233                                      | 0.7844                                       | 1.285                                        | 204.0                    | 8.718           | 12.59                                           |
| 140      | 27.02                        | 256.3                      | 2.419                                      | 0.7481                                       | 1.148                                        | 228.2                    | 9.978           | 14.11                                           |
| 160      | 22.94                        | 278.7                      | 2.568                                      | 0.7341                                       | 1.093                                        | 248.1                    | 11.20           | 15.74                                           |
| 180      | 20.03                        | 300.2                      | 2.695                                      | 0.7273                                       | 1.065                                        | 265.7                    | 12.38           | 17.38                                           |
| 200      | 17.83                        | 321.3                      | 2.806                                      | 0.7236                                       | 1.048                                        | 281.7                    | 13.51           | 19.00                                           |
| 220      | 16.09                        | 342.2                      | 2.906                                      | 0.7216                                       | 1.038                                        | 296.6                    | 14.61           | 20.60                                           |
| 240      | 14.68                        | 362.9                      | 2.996                                      | 0.7204                                       | 1.031                                        | 310.6                    | 15.67           | 22.17                                           |
| 260      | 13.50                        | 383.5                      | 3.078                                      | 0.7199                                       | 1.026                                        | 323.8                    | 16.70           | 23.70                                           |
| 280      | 12.50                        | 403.9                      | 3.154                                      | 0.7199                                       | 1.023                                        | 336.4                    | 17.70           | 25.21                                           |
| 300      | 11.64                        | 424.4                      | 3.224                                      | 0.7203                                       | 1.021                                        | 348.4                    | 18.67           | 26.68                                           |
| 320      | 10.90                        | 444.8                      | 3.290                                      | 0.7211                                       | 1.020                                        | 360.0                    | 19.62           | 28.13                                           |
| 340      | 10.25                        | 465.2                      | 3.352                                      | 0.7222                                       | 1.019                                        | 371.1                    | 20.54           | 29.55                                           |
| 360      | 9.668                        | 485.6                      | 3.410                                      | 0.7237                                       | 1.019                                        | 381.9                    | 21.43           | 30.95                                           |
| 380      | 9.153                        | 506.0                      | 3.465                                      | 0.7255                                       | 1.020                                        | 392.3                    | 22.31           | 32.32                                           |
| 400      | 8.690                        | 526.4                      | 3.518                                      | 0.7277                                       | 1.022                                        | 402.3                    | 23.16           | 33.67                                           |
| 500      | 6.943                        | 629.1                      | 3.747                                      | 0.7434                                       | 1.034                                        | 448.5                    | 27.18           | 40.11                                           |
| 600      | 5.784                        | 733.5                      | 3.937                                      | 0.7646                                       | 1.054                                        | 489.2                    | 30.84           | 46.15                                           |
| 700      | 4.957                        | 840.0                      | 4.101                                      | 0.7884                                       | 1.077                                        | 526.0                    | 34.24           | 51.87                                           |
| 800      | 4.338                        | 948.9                      | 4.247                                      | 0.8121                                       | 1.100                                        | 559.9                    | 37.43           | 57.35                                           |
| 900      | 3.857                        | 1060.                      | 4.378                                      | 0.8343                                       | 1.122                                        | 591.5                    | 40.45           | 62.63                                           |
| 1000     | 3.472                        | 1173.                      | 4.497                                      | 0.8543                                       | 1.142                                        | 621.5                    | 43.33           | 67.75                                           |

 **$P = 2$  MPa (20 bar)**

|                    |       |        |         |        |       |       |       |       |
|--------------------|-------|--------|---------|--------|-------|-------|-------|-------|
| 60.11 <sup>a</sup> | 959.1 | -34.44 | -0.5282 | 1.175  | 1.895 | 1037. | 380.5 | 172.2 |
| 80                 | 874.6 | 3.390  | 0.01535 | 1.048  | 1.921 | 870.2 | 165.5 | 140.1 |
| 100                | 775.0 | 43.09  | 0.4576  | 0.9636 | 2.086 | 672.5 | 90.43 | 106.6 |
| 118.52             | 638.8 | 86.69  | 0.8559  | 0.9314 | 2.894 | 430.4 | 51.60 | 73.71 |
| 119.94             | 86.20 | 211.0  | 1.899   | 0.9396 | 2.365 | 180.5 | 9.540 | 16.59 |
| 120                | 86.03 | 211.2  | 1.900   | 0.9382 | 2.354 | 180.7 | 9.542 | 16.57 |
| 140                | 59.88 | 244.8  | 2.161   | 0.7883 | 1.387 | 218.3 | 10.44 | 15.68 |
| 160                | 48.61 | 270.5  | 2.333   | 0.7545 | 1.213 | 242.7 | 11.55 | 16.80 |
| 180                | 41.54 | 294.0  | 2.471   | 0.7396 | 1.139 | 262.8 | 12.67 | 18.21 |
| 200                | 36.52 | 316.3  | 2.589   | 0.7319 | 1.100 | 280.3 | 13.77 | 19.69 |
| 220                | 32.70 | 338.0  | 2.692   | 0.7275 | 1.076 | 296.2 | 14.84 | 21.19 |
| 240                | 29.66 | 359.4  | 2.785   | 0.7249 | 1.060 | 310.8 | 15.88 | 22.68 |
| 260                | 27.18 | 380.5  | 2.870   | 0.7235 | 1.050 | 324.6 | 16.89 | 24.16 |
| 280                | 25.11 | 401.4  | 2.947   | 0.7228 | 1.042 | 337.6 | 17.88 | 25.62 |
| 300                | 23.34 | 422.2  | 3.019   | 0.7227 | 1.037 | 349.9 | 18.84 | 27.06 |
| 320                | 21.82 | 442.9  | 3.086   | 0.7231 | 1.033 | 361.7 | 19.77 | 28.47 |
| 340                | 20.49 | 463.5  | 3.148   | 0.7240 | 1.031 | 373.0 | 20.68 | 29.87 |
| 360                | 19.32 | 484.1  | 3.207   | 0.7253 | 1.030 | 383.9 | 21.57 | 31.24 |
| 380                | 18.27 | 504.7  | 3.263   | 0.7269 | 1.029 | 394.4 | 22.44 | 32.59 |
| 400                | 17.34 | 525.3  | 3.315   | 0.7290 | 1.029 | 404.5 | 23.29 | 33.93 |
| 500                | 13.84 | 628.6  | 3.546   | 0.7442 | 1.039 | 450.8 | 27.28 | 40.31 |
| 600                | 11.52 | 733.4  | 3.737   | 0.7653 | 1.057 | 491.5 | 30.93 | 46.30 |
| 700                | 9.878 | 840.2  | 3.902   | 0.7889 | 1.079 | 528.3 | 34.32 | 52.00 |
| 800                | 8.646 | 949.3  | 4.047   | 0.8125 | 1.102 | 562.1 | 37.49 | 57.46 |
| 900                | 7.689 | 1061.  | 4.178   | 0.8346 | 1.123 | 593.7 | 40.50 | 62.73 |
| 1000               | 6.923 | 1174.  | 4.298   | 0.8546 | 1.143 | 623.6 | 43.38 | 67.84 |

 **$P = 5$  MPa (50 bar)**

|                    |       |        |           |        |       |       |       |       |
|--------------------|-------|--------|-----------|--------|-------|-------|-------|-------|
| 60.64 <sup>a</sup> | 961.4 | -31.10 | -0.5246   | 1.176  | 1.886 | 1048. | 386.2 | 173.3 |
| 80                 | 881.7 | 5.437  | -0.001766 | 1.054  | 1.898 | 892.1 | 173.5 | 143.0 |
| 100                | 788.3 | 44.27  | 0.4311    | 0.9681 | 2.009 | 710.6 | 96.44 | 111.1 |
| 120                | 665.1 | 87.67  | 0.8256    | 0.9194 | 2.429 | 496.8 | 57.06 | 79.02 |
| 140                | 321.3 | 172.5  | 1.467     | 1.049  | 8.515 | 199.5 | 19.25 | 43.18 |



| $T$<br>K | $\rho$<br>$\text{kg m}^{-3}$ | $H$<br>$\text{kJ kg}^{-1}$ | $S$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $C_v$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $C_p$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $u$<br>$\text{m s}^{-1}$ | $\eta$<br>$\mu\text{Pa s}$ | $\lambda$<br>$\text{mW m}^{-1} \text{K}^{-1}$ |
|----------|------------------------------|----------------------------|------------------------------------------|--------------------------------------------|--------------------------------------------|--------------------------|----------------------------|-----------------------------------------------|
| 160      | 151.4                        | 240.7                      | 1.930                                    | 0.8269                                     | 1.916                                      | 231.8                    | 13.80                      | 22.96                                         |
| 180      | 116.7                        | 273.4                      | 2.123                                    | 0.7785                                     | 1.453                                      | 258.2                    | 14.14                      | 22.02                                         |
| 200      | 97.93                        | 300.6                      | 2.267                                    | 0.7569                                     | 1.288                                      | 279.4                    | 14.90                      | 22.54                                         |
| 220      | 85.43                        | 325.5                      | 2.385                                    | 0.7451                                     | 1.205                                      | 297.7                    | 15.77                      | 23.49                                         |
| 240      | 76.25                        | 349.0                      | 2.488                                    | 0.7381                                     | 1.155                                      | 314.0                    | 16.68                      | 24.62                                         |
| 260      | 69.12                        | 371.8                      | 2.579                                    | 0.7338                                     | 1.123                                      | 328.8                    | 17.60                      | 25.83                                         |
| 280      | 63.36                        | 394.0                      | 2.661                                    | 0.7312                                     | 1.101                                      | 342.7                    | 18.52                      | 27.09                                         |
| 300      | 58.59                        | 415.8                      | 2.736                                    | 0.7297                                     | 1.085                                      | 355.6                    | 19.42                      | 28.39                                         |
| 320      | 54.55                        | 437.4                      | 2.806                                    | 0.7291                                     | 1.074                                      | 367.9                    | 20.31                      | 29.69                                         |
| 340      | 51.07                        | 458.8                      | 2.871                                    | 0.7292                                     | 1.065                                      | 379.6                    | 21.18                      | 30.98                                         |
| 360      | 48.05                        | 480.1                      | 2.932                                    | 0.7298                                     | 1.059                                      | 390.7                    | 22.04                      | 32.27                                         |
| 380      | 45.38                        | 501.2                      | 2.989                                    | 0.7310                                     | 1.055                                      | 401.4                    | 22.88                      | 33.55                                         |
| 400      | 43.01                        | 522.3                      | 3.043                                    | 0.7327                                     | 1.052                                      | 411.7                    | 23.70                      | 34.81                                         |
| 500      | 34.21                        | 627.4                      | 3.277                                    | 0.7466                                     | 1.052                                      | 458.3                    | 27.61                      | 40.97                                         |
| 600      | 28.48                        | 733.2                      | 3.470                                    | 0.7671                                     | 1.066                                      | 498.9                    | 31.20                      | 46.83                                         |
| 700      | 24.42                        | 840.8                      | 3.636                                    | 0.7903                                     | 1.085                                      | 535.4                    | 34.55                      | 52.43                                         |
| 800      | 21.39                        | 950.4                      | 3.782                                    | 0.8136                                     | 1.106                                      | 569.0                    | 37.69                      | 57.83                                         |
| 900      | 19.03                        | 1062.                      | 3.914                                    | 0.8356                                     | 1.127                                      | 600.3                    | 40.68                      | 63.04                                         |
| 1000     | 17.14                        | 1176.                      | 4.034                                    | 0.8554                                     | 1.146                                      | 629.9                    | 43.54                      | 68.12                                         |

 **$P = 10 \text{ MPa (100 bar)}$** 

|                    |       |        |          |        |       |       |       |       |
|--------------------|-------|--------|----------|--------|-------|-------|-------|-------|
| 61.52 <sup>a</sup> | 965.2 | -25.55 | -0.5187  | 1.177  | 1.871 | 1064. | 395.1 | 175.0 |
| 80                 | 892.4 | 8.950  | -0.02831 | 1.063  | 1.868 | 925.2 | 186.8 | 147.5 |
| 100                | 806.9 | 46.73  | 0.3930   | 0.9767 | 1.924 | 763.5 | 105.8 | 117.8 |
| 120                | 706.1 | 86.65  | 0.7565   | 0.9192 | 2.094 | 591.1 | 67.00 | 89.01 |
| 140                | 573.7 | 132.1  | 1.106    | 0.8916 | 2.517 | 418.1 | 41.82 | 63.61 |
| 160                | 397.0 | 188.0  | 1.479    | 0.8787 | 2.882 | 297.6 | 24.99 | 43.38 |
| 180                | 273.3 | 238.0  | 1.774    | 0.8267 | 2.098 | 283.1 | 19.31 | 32.89 |
| 200                | 214.1 | 274.8  | 1.968    | 0.7908 | 1.646 | 296.3 | 18.16 | 29.63 |
| 220                | 179.9 | 305.4  | 2.114    | 0.7701 | 1.434 | 312.4 | 18.17 | 28.80 |
| 240                | 157.0 | 332.8  | 2.233    | 0.7574 | 1.317 | 328.0 | 18.60 | 28.89 |
| 260                | 140.2 | 358.3  | 2.336    | 0.7492 | 1.245 | 342.7 | 19.20 | 29.38 |
| 280                | 127.3 | 382.7  | 2.426    | 0.7439 | 1.196 | 356.5 | 19.90 | 30.15 |
| 300                | 116.9 | 406.3  | 2.507    | 0.7404 | 1.162 | 369.5 | 20.64 | 31.12 |
| 320                | 108.3 | 429.3  | 2.582    | 0.7383 | 1.138 | 381.8 | 21.40 | 32.15 |
| 340                | 101.0 | 451.8  | 2.650    | 0.7372 | 1.120 | 393.5 | 22.17 | 33.22 |
| 360                | 94.80 | 474.1  | 2.714    | 0.7369 | 1.106 | 404.6 | 22.95 | 34.33 |
| 380                | 89.36 | 496.1  | 2.773    | 0.7374 | 1.096 | 415.3 | 23.72 | 35.45 |
| 400                | 84.57 | 517.9  | 2.829    | 0.7384 | 1.088 | 425.6 | 24.49 | 36.58 |
| 500                | 67.06 | 625.7  | 3.070    | 0.7505 | 1.073 | 471.8 | 28.19 | 42.26 |
| 600                | 55.82 | 733.3  | 3.266    | 0.7699 | 1.080 | 511.9 | 31.67 | 47.84 |
| 700                | 47.90 | 842.0  | 3.433    | 0.7926 | 1.095 | 547.8 | 34.94 | 53.26 |
| 800                | 42.00 | 952.4  | 3.581    | 0.8155 | 1.113 | 580.8 | 38.04 | 58.52 |
| 900                | 37.42 | 1065.  | 3.713    | 0.8372 | 1.132 | 611.6 | 40.99 | 63.64 |
| 1000               | 33.75 | 1179.  | 3.833    | 0.8568 | 1.150 | 640.7 | 43.81 | 68.64 |

 **$P = 20 \text{ MPa (200 bar)}$** 

|                    |       |        |          |        |       |       |       |       |
|--------------------|-------|--------|----------|--------|-------|-------|-------|-------|
| 63.24 <sup>a</sup> | 972.3 | -14.49 | -0.5069  | 1.180  | 1.847 | 1094. | 411.4 | 178.4 |
| 80                 | 911.3 | 16.25  | -0.07568 | 1.081  | 1.825 | 982.1 | 213.1 | 155.4 |
| 100                | 836.2 | 52.71  | 0.3311   | 0.9948 | 1.827 | 846.0 | 123.1 | 128.7 |
| 120                | 755.9 | 89.57  | 0.6670   | 0.9334 | 1.864 | 711.9 | 82.28 | 103.9 |
| 140                | 668.7 | 127.4  | 0.9589   | 0.8906 | 1.926 | 589.6 | 58.52 | 82.08 |
| 160                | 575.8 | 166.5  | 1.220    | 0.8606 | 1.977 | 491.8 | 43.00 | 65.18 |
| 180                | 484.9 | 206.0  | 1.452    | 0.8365 | 1.946 | 428.0 | 33.22 | 53.43 |
| 200                | 407.6 | 243.6  | 1.651    | 0.8143 | 1.808 | 397.2 | 27.80 | 46.02 |
| 220                | 348.5 | 278.1  | 1.815    | 0.7956 | 1.642 | 387.6 | 25.12 | 41.70 |



| $T$<br>K                                         | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|--------------------------------------------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|-----------------|-------------------------------------------------|
| 240                                              | 304.6                        | 309.5                      | 1.952                                      | 0.7812                                       | 1.506                                        | 388.7                    | 23.92           | 39.30                                           |
| 260                                              | 271.5                        | 338.6                      | 2.068                                      | 0.7705                                       | 1.405                                        | 394.7                    | 23.48           | 37.98                                           |
| 280                                              | 245.7                        | 365.9                      | 2.169                                      | 0.7627                                       | 1.331                                        | 402.8                    | 23.47           | 37.46                                           |
| 300                                              | 225.0                        | 392.0                      | 2.259                                      | 0.7572                                       | 1.277                                        | 412.0                    | 23.70           | 37.57                                           |
| 320                                              | 208.0                        | 417.1                      | 2.340                                      | 0.7532                                       | 1.236                                        | 421.5                    | 24.08           | 37.94                                           |
| 340                                              | 193.7                        | 441.5                      | 2.414                                      | 0.7506                                       | 1.204                                        | 431.1                    | 24.56           | 38.47                                           |
| 360                                              | 181.5                        | 465.3                      | 2.482                                      | 0.7491                                       | 1.180                                        | 440.6                    | 25.10           | 39.13                                           |
| 380                                              | 170.9                        | 488.7                      | 2.546                                      | 0.7485                                       | 1.161                                        | 450.0                    | 25.68           | 39.88                                           |
| 400                                              | 161.7                        | 511.7                      | 2.605                                      | 0.7486                                       | 1.146                                        | 459.2                    | 26.29           | 40.69                                           |
| 500                                              | 128.3                        | 624.0                      | 2.856                                      | 0.7575                                       | 1.108                                        | 501.8                    | 29.49           | 45.27                                           |
| 600                                              | 107.0                        | 734.4                      | 3.057                                      | 0.7753                                       | 1.103                                        | 539.5                    | 32.69           | 50.19                                           |
| 700                                              | 92.10                        | 845.1                      | 3.227                                      | 0.7969                                       | 1.112                                        | 573.7                    | 35.78           | 55.18                                           |
| 800                                              | 80.99                        | 957.0                      | 3.377                                      | 0.8191                                       | 1.126                                        | 605.2                    | 38.75           | 60.13                                           |
| 900                                              | 72.34                        | 1070.                      | 3.510                                      | 0.8402                                       | 1.142                                        | 634.8                    | 41.61           | 65.02                                           |
| 1000                                             | 65.41                        | 1185.                      | 3.631                                      | 0.8594                                       | 1.157                                        | 662.8                    | 44.36           | 69.84                                           |
| <b><math>P = 50 \text{ MPa (500 bar)}</math></b> |                              |                            |                                            |                                              |                                              |                          |                 |                                                 |
| 68.21 <sup>a</sup>                               | 991.5                        | 18.30                      | -0.4728                                    | 1.192                                        | 1.793                                        | 1173.                    | 450.9           | 187.5                                           |
| 80                                               | 955.5                        | 39.24                      | -0.1896                                    | 1.128                                        | 1.761                                        | 1112.                    | 292.7           | 174.1                                           |
| 100                                              | 895.9                        | 73.98                      | 0.1982                                     | 1.043                                        | 1.715                                        | 1012.                    | 171.6           | 152.8                                           |
| 120                                              | 837.8                        | 107.9                      | 0.5077                                     | 0.9811                                       | 1.680                                        | 920.9                    | 118.9           | 133.2                                           |
| 140                                              | 781.1                        | 141.2                      | 0.7643                                     | 0.9342                                       | 1.649                                        | 839.4                    | 90.60           | 115.9                                           |
| 160                                              | 726.2                        | 173.9                      | 0.9826                                     | 0.8983                                       | 1.619                                        | 770.2                    | 72.86           | 101.0                                           |
| 180                                              | 673.9                        | 205.9                      | 1.171                                      | 0.8706                                       | 1.586                                        | 714.1                    | 60.73           | 88.73                                           |
| 200                                              | 624.9                        | 237.3                      | 1.337                                      | 0.8488                                       | 1.549                                        | 670.6                    | 52.14           | 79.05                                           |
| 220                                              | 579.8                        | 267.9                      | 1.482                                      | 0.8313                                       | 1.509                                        | 638.1                    | 45.98           | 71.65                                           |
| 240                                              | 539.0                        | 297.7                      | 1.612                                      | 0.8171                                       | 1.467                                        | 614.7                    | 41.60           | 66.11                                           |
| 260                                              | 502.4                        | 326.6                      | 1.728                                      | 0.8057                                       | 1.425                                        | 598.5                    | 38.49           | 61.97                                           |
| 280                                              | 470.0                        | 354.7                      | 1.832                                      | 0.7964                                       | 1.385                                        | 588.0                    | 36.32           | 58.99                                           |
| 300                                              | 441.2                        | 382.0                      | 1.926                                      | 0.7890                                       | 1.349                                        | 581.7                    | 34.82           | 57.07                                           |
| 320                                              | 415.6                        | 408.7                      | 2.012                                      | 0.7832                                       | 1.316                                        | 578.4                    | 33.83           | 55.77                                           |
| 340                                              | 392.9                        | 434.7                      | 2.091                                      | 0.7787                                       | 1.287                                        | 577.4                    | 33.19           | 54.93                                           |
| 360                                              | 372.7                        | 460.2                      | 2.164                                      | 0.7754                                       | 1.262                                        | 578.1                    | 32.82           | 54.41                                           |
| 380                                              | 354.6                        | 485.2                      | 2.232                                      | 0.7731                                       | 1.241                                        | 580.0                    | 32.66           | 54.15                                           |
| 400                                              | 338.2                        | 509.8                      | 2.295                                      | 0.7717                                       | 1.223                                        | 582.9                    | 32.64           | 54.07                                           |
| 500                                              | 276.1                        | 629.0                      | 2.561                                      | 0.7749                                       | 1.168                                        | 604.1                    | 33.85           | 55.45                                           |
| 600                                              | 234.6                        | 744.6                      | 2.772                                      | 0.7890                                       | 1.148                                        | 629.5                    | 36.00           | 58.34                                           |
| 700                                              | 204.6                        | 859.2                      | 2.948                                      | 0.8080                                       | 1.147                                        | 655.5                    | 38.46           | 61.93                                           |
| 800                                              | 181.8                        | 974.2                      | 3.102                                      | 0.8285                                       | 1.154                                        | 681.0                    | 41.00           | 65.86                                           |
| 900                                              | 163.8                        | 1090.                      | 3.238                                      | 0.8483                                       | 1.164                                        | 705.9                    | 43.55           | 69.98                                           |
| 1000                                             | 149.2                        | 1207.                      | 3.362                                      | 0.8665                                       | 1.175                                        | 730.1                    | 46.07           | 74.20                                           |

<sup>a</sup> Freezing point for the liquid state.

## FIXED POINT PROPERTIES OF H<sub>2</sub>O AND D<sub>2</sub>O

Temperatures are given on the IPTS-68 scale.

### References

1. Haar, L., Gallagher, J. S., and Kell, G. S., *NBS/NRC Steam Tables*, Hemisphere Publishing Corp., New York, 1984.
2. Levelt Sengers, J. M. H., Straub, J., Watanabe, K., and Hill, P. G., Assessment of critical parameter values for H<sub>2</sub>O and D<sub>2</sub>O, *J. Phys. Chem. Ref. Data*, 14, 193, 1985.
3. Kestin, J. et. al., Thermophysical properties of fluid D<sub>2</sub>O, *J. Phys. Chem. Ref. Data*, 13, 601, 1984.
4. Kestin, J. et. al., Thermophysical properties of fluid H<sub>2</sub>O, *J. Phys. Chem. Ref. Data*, 13, 175, 1984.
5. Hill, P. G., MacMillan, R. D. C., and Lee, V., A fundamental equation of state for heavy water, *J. Phys. Chem. Ref. Data*, 11, 1, 1982.

|                                   | Unit               | H <sub>2</sub> O | D <sub>2</sub> O |
|-----------------------------------|--------------------|------------------|------------------|
| Molar mass                        | g/mol              | 18.01528         | 20.02748         |
| Melting point(101.325 kPa)        | °C                 | 0.00             | 3.82             |
| Boiling point(101.325 kPa)        | °C                 | 100.00           | 101.42           |
| Triple point temperature          | °C                 | 0.01             | 3.82             |
| Triple point pressure             | Pa                 | 611.73           | 661              |
| Triple point density(l)           | g/cm <sup>3</sup>  | 0.99978          | 1.1055           |
| Triple point density(g)           | mg/L               | 4.885            | 5.75             |
| Critical temperature              | °C                 | 373.99           | 370.74           |
| Critical pressure                 | MPa                | 22.064           | 21.671           |
| Critical density                  | g/cm <sup>3</sup>  | 0.322            | 0.356            |
| Critical specific volume          | cm <sup>3</sup> /g | 3.11             | 2.81             |
| Maximum density(saturated liquid) | g/cm <sup>3</sup>  | 0.99995          | 1.1053           |
| Temperature of maximum density    | °C                 | 4.0              | 11.2             |

## THERMAL CONDUCTIVITY OF SATURATED H<sub>2</sub>O AND D<sub>2</sub>O

This table gives the thermal conductivity  $\lambda$  for water (H<sub>2</sub>O or D<sub>2</sub>O) in equilibrium with its vapor. Values for the liquid ( $\lambda_l$ ) and vapor ( $\lambda_v$ ) are listed, as well as the vapor pressure.

### References

1. Sengers, J.V. and Watson, J.T.R., Improved international formulations for the viscosity and thermal conductivity of water substance, *J. Phys. Chem. Ref. Data*, 15, 1291, 1986.
2. Matsunaga, N. and Nagashima, A., Transport properties of liquid and gaseous D<sub>2</sub>O over a wide range of temperature and pressure, *J. Phys. Chem. Ref. Data*, 12, 933, 1983.

| $t/^{\circ}\text{C}$ | H <sub>2</sub> O |                               |                               | D <sub>2</sub> O |                               |                               |
|----------------------|------------------|-------------------------------|-------------------------------|------------------|-------------------------------|-------------------------------|
|                      | $P/\text{kPa}$   | $\lambda_l / (\text{mW/K m})$ | $\lambda_v / (\text{mW/K m})$ | $P/\text{kPa}$   | $\lambda_l / (\text{mW/K m})$ | $\lambda_v / (\text{mW/K m})$ |
| 0                    | 0.6              | 561.0                         | 16.49                         |                  |                               |                               |
| 10                   | 1.2              | 580.0                         | 17.21                         | 1.0              | 575                           | 17.0                          |
| 20                   | 2.3              | 598.4                         | 17.95                         | 2.0              | 589                           | 17.8                          |
| 30                   | 4.2              | 615.4                         | 18.70                         | 3.7              | 600                           | 18.5                          |
| 40                   | 7.4              | 630.5                         | 19.48                         | 6.5              | 610                           | 19.3                          |
| 50                   | 12.3             | 643.5                         | 20.28                         | 11.1             | 618                           | 20.2                          |
| 60                   | 19.9             | 654.3                         | 21.10                         | 18.2             | 625                           | 21.0                          |
| 70                   | 31.2             | 663.1                         | 21.96                         | 28.8             | 629                           | 21.9                          |
| 80                   | 47.4             | 670.0                         | 22.86                         | 44.2             | 633                           | 22.8                          |
| 90                   | 70.1             | 675.3                         | 23.80                         | 66.1             | 635                           | 23.8                          |
| 100                  | 101.3            | 679.1                         | 24.79                         | 96.2             | 636                           | 24.8                          |
| 150                  | 476              | 682.1                         | 30.77                         | 465              | 625                           | 30.8                          |
| 200                  | 1555             | 663.4                         | 39.10                         | 1546             | 592                           | 39.0                          |
| 250                  | 3978             | 621.4                         | 51.18                         | 3995             | 541                           | 52.0                          |
| 300                  | 8593             | 547.7                         | 71.78                         | 8688             | 473                           | 75.2                          |
| 350                  | 16530            | 447.6                         | 134.59                        | 16820            | 391                           | 143.0                         |

## STANDARD DENSITY OF WATER

This table gives the density  $\rho$  of water in the temperature range from 0°C to 100°C at a pressure of 101325 Pa (one standard atmosphere). From 0°C to 40°C the values are taken from the IUPAC publication in Reference 1 and refer to standard mean ocean water (SMOW), free from dissolved salts and gases. SMOW is a standard water sample of high purity and known isotopic composition. Methods of correcting for different isotopic compositions are discussed in Reference 1. The remaining values are taken from the NIST Chemistry WebBook, Reference 2.

Note that the IUPAC values refer to the IPTS-68 temperature scale, while the NIST values are based on the ITS-90 scale (where the normal boiling point is 99.974°C). The conversion between these scales can be found in Sec. 1. The difference between the scales leads to a difference in the density of water of about 20 ppm in the neighborhood of 100°C and much less at lower temperatures.

## References

1. Marsh, K. N., Ed., *Recommended Reference Materials for the Realization of Physicochemical Properties*, Blackwell Scientific Publications, Oxford, 1987.
2. Lemmon, E.W., McLinden, M.O., and Friend, D.G., "Thermophysical Properties of Fluid Systems" in NIST Chemistry WebBook, NIST Standard Reference Database Number 69, Eds. P.J. Linstrom and W.G. Mallard, June 2005, National Institute of Standards and Technology, Gaithersburg MD, 20899 (<http://webbook.nist.gov>).
3. Wagner, W., and Pruss, A., "The IAPWS formulation 1995 for the thermodynamic properties of ordinary water substance for general and scientific use", *J. Phys. Chem. Ref. Data* 31, 387-535, 2002.
4. Saul, A., and Wagner, W., "A Fundamental Equation for Water Covering the Range From the Melting Line to 1273 K at Pressures up to 25000 MPa", *J. Phys. Chem. Ref. Data* 18, 1537-1564, 1989.

| $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ |
|----------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|
| 0.1                  | 0.9998493               | 4.3                  | 0.9999742               | 8.5                  | 0.9998189               | 12.7                 | 0.9994167               | 16.9                 | 0.9987942               |
| 0.2                  | 0.9998558               | 4.4                  | 0.9999736               | 8.6                  | 0.9998121               | 12.8                 | 0.9994043               | 17.0                 | 0.9987769               |
| 0.3                  | 0.9998622               | 4.5                  | 0.9999728               | 8.7                  | 0.9998051               | 12.9                 | 0.9993918               | 17.1                 | 0.9987595               |
| 0.4                  | 0.9998683               | 4.6                  | 0.9999719               | 8.8                  | 0.9997980               | 13.0                 | 0.9993792               | 17.2                 | 0.9987419               |
| 0.5                  | 0.9998743               | 4.7                  | 0.9999709               | 8.9                  | 0.9997908               | 13.1                 | 0.9993665               | 17.3                 | 0.9987243               |
| 0.6                  | 0.9998801               | 4.8                  | 0.9999696               | 9.0                  | 0.9997834               | 13.2                 | 0.9993536               | 17.4                 | 0.9987065               |
| 0.7                  | 0.9998857               | 4.9                  | 0.9999683               | 9.1                  | 0.9997759               | 13.3                 | 0.9993407               | 17.5                 | 0.9986886               |
| 0.8                  | 0.9998912               | 5.0                  | 0.9999668               | 9.2                  | 0.9997682               | 13.4                 | 0.9993276               | 17.6                 | 0.9986706               |
| 0.9                  | 0.9998964               | 5.1                  | 0.9999651               | 9.3                  | 0.9997604               | 13.5                 | 0.9993143               | 17.7                 | 0.9986525               |
| 1.0                  | 0.9999015               | 5.2                  | 0.9999632               | 9.4                  | 0.9997525               | 13.6                 | 0.9993010               | 17.8                 | 0.9986343               |
| 1.1                  | 0.9999065               | 5.3                  | 0.9999612               | 9.5                  | 0.9997444               | 13.7                 | 0.9992875               | 17.9                 | 0.9986160               |
| 1.2                  | 0.9999112               | 5.4                  | 0.9999591               | 9.6                  | 0.9997362               | 13.8                 | 0.9992740               | 18.0                 | 0.9985976               |
| 1.3                  | 0.9999158               | 5.5                  | 0.9999568               | 9.7                  | 0.9997279               | 13.9                 | 0.9992602               | 18.1                 | 0.9985790               |
| 1.4                  | 0.9999202               | 5.6                  | 0.9999544               | 9.8                  | 0.9997194               | 14.0                 | 0.9992464               | 18.2                 | 0.9985604               |
| 1.5                  | 0.9999244               | 5.7                  | 0.9999518               | 9.9                  | 0.9997108               | 14.1                 | 0.9992325               | 18.3                 | 0.9985416               |
| 1.6                  | 0.9999284               | 5.8                  | 0.9999490               | 10.0                 | 0.9997021               | 14.2                 | 0.9992184               | 18.4                 | 0.9985228               |
| 1.7                  | 0.9999323               | 5.9                  | 0.9999461               | 10.1                 | 0.9996932               | 14.3                 | 0.9992042               | 18.5                 | 0.9985038               |
| 1.8                  | 0.9999360               | 6.0                  | 0.9999430               | 10.2                 | 0.9996842               | 14.4                 | 0.9991899               | 18.6                 | 0.9984847               |
| 1.9                  | 0.9999395               | 6.1                  | 0.9999398               | 10.3                 | 0.9996751               | 14.5                 | 0.9991755               | 18.7                 | 0.9984655               |
| 2.0                  | 0.9999429               | 6.2                  | 0.9999365               | 10.4                 | 0.9996658               | 14.6                 | 0.9991609               | 18.8                 | 0.9984462               |
| 2.1                  | 0.9999461               | 6.3                  | 0.9999330               | 10.5                 | 0.9996564               | 14.7                 | 0.9991463               | 18.9                 | 0.9984268               |
| 2.2                  | 0.9999491               | 6.4                  | 0.9999293               | 10.6                 | 0.9996468               | 14.8                 | 0.9991315               | 19.0                 | 0.9984073               |
| 2.3                  | 0.9999519               | 6.5                  | 0.9999255               | 10.7                 | 0.9996372               | 14.9                 | 0.9991166               | 19.1                 | 0.9983877               |
| 2.4                  | 0.9999546               | 6.6                  | 0.9999216               | 10.8                 | 0.9996274               | 15.0                 | 0.9991016               | 19.2                 | 0.9983680               |
| 2.5                  | 0.9999571               | 6.7                  | 0.9999175               | 10.9                 | 0.9996174               | 15.1                 | 0.9990864               | 19.3                 | 0.9983481               |
| 2.6                  | 0.9999595               | 6.8                  | 0.9999132               | 11.0                 | 0.9996074               | 15.2                 | 0.9990712               | 19.4                 | 0.9983282               |
| 2.7                  | 0.9999616               | 6.9                  | 0.9999088               | 11.1                 | 0.9995972               | 15.3                 | 0.9990558               | 19.5                 | 0.9983081               |
| 2.8                  | 0.9999636               | 7.0                  | 0.9999043               | 11.2                 | 0.9995869               | 15.4                 | 0.9990403               | 19.6                 | 0.9982880               |
| 2.9                  | 0.9999655               | 7.1                  | 0.9998996               | 11.3                 | 0.9995764               | 15.5                 | 0.9990247               | 19.7                 | 0.9982677               |
| 3.0                  | 0.9999672               | 7.2                  | 0.9998948               | 11.4                 | 0.9995658               | 15.6                 | 0.9990090               | 19.8                 | 0.9982474               |
| 3.1                  | 0.9999687               | 7.3                  | 0.9998898               | 11.5                 | 0.9995551               | 15.7                 | 0.9989932               | 19.9                 | 0.9982269               |
| 3.2                  | 0.9999700               | 7.4                  | 0.9998847               | 11.6                 | 0.9995443               | 15.8                 | 0.9989772               | 20.0                 | 0.9982063               |
| 3.3                  | 0.9999712               | 7.5                  | 0.9998794               | 11.7                 | 0.9995333               | 15.9                 | 0.9989612               | 20.1                 | 0.9981856               |
| 3.4                  | 0.9999722               | 7.6                  | 0.9998740               | 11.8                 | 0.9995222               | 16.0                 | 0.9989450               | 20.2                 | 0.9981649               |
| 3.5                  | 0.9999731               | 7.7                  | 0.9998684               | 11.9                 | 0.9995110               | 16.1                 | 0.9989287               | 20.3                 | 0.9981440               |
| 3.6                  | 0.9999738               | 7.8                  | 0.9998627               | 12.0                 | 0.9994996               | 16.2                 | 0.9989123               | 20.4                 | 0.9981230               |
| 3.7                  | 0.9999743               | 7.9                  | 0.9998569               | 12.1                 | 0.9994882               | 16.3                 | 0.9988957               | 20.5                 | 0.9981019               |
| 3.8                  | 0.9999747               | 8.0                  | 0.9998509               | 12.2                 | 0.9994766               | 16.4                 | 0.9988791               | 20.6                 | 0.9980807               |
| 3.9                  | 0.9999749               | 8.1                  | 0.9998448               | 12.3                 | 0.9994648               | 16.5                 | 0.9988623               | 20.7                 | 0.9980594               |
| 4.0                  | 0.9999750               | 8.2                  | 0.9998385               | 12.4                 | 0.9994530               | 16.6                 | 0.9988455               | 20.8                 | 0.9980380               |
| 4.1                  | 0.9999748               | 8.3                  | 0.9998321               | 12.5                 | 0.9994410               | 16.7                 | 0.9988285               | 20.9                 | 0.9980164               |
| 4.2                  | 0.9999746               | 8.4                  | 0.9998256               | 12.6                 | 0.9994289               | 16.8                 | 0.9988114               | 21.0                 | 0.9979948               |

| $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $t/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ |
|----------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|
| 21.1                 | 0.9979731               | 26.1                 | 0.9967604               | 31.1                 | 0.9953139               | 36.1                 | 0.9936531               | 51.0                 | 0.98758                 |
| 21.2                 | 0.9979513               | 26.2                 | 0.9967337               | 31.2                 | 0.9952827               | 36.2                 | 0.9936178               | 52.0                 | 0.98712                 |
| 21.3                 | 0.9979294               | 26.3                 | 0.9967069               | 31.3                 | 0.9952514               | 36.3                 | 0.9935825               | 53.0                 | 0.98665                 |
| 21.4                 | 0.9979073               | 26.4                 | 0.9966800               | 31.4                 | 0.9952201               | 36.4                 | 0.9935470               | 54.0                 | 0.98617                 |
| 21.5                 | 0.9978852               | 26.5                 | 0.9966530               | 31.5                 | 0.9951887               | 36.5                 | 0.9935115               | 55.0                 | 0.98569                 |
| 21.6                 | 0.9978630               | 26.6                 | 0.9966259               | 31.6                 | 0.9951572               | 36.6                 | 0.9934759               | 56.0                 | 0.98521                 |
| 21.7                 | 0.9978406               | 26.7                 | 0.9965987               | 31.7                 | 0.9951255               | 36.7                 | 0.9934403               | 57.0                 | 0.98471                 |
| 21.8                 | 0.9978182               | 26.8                 | 0.9965714               | 31.8                 | 0.9950939               | 36.8                 | 0.9934045               | 58.0                 | 0.98421                 |
| 21.9                 | 0.9977957               | 26.9                 | 0.9965441               | 31.9                 | 0.9950621               | 36.9                 | 0.9933687               | 59.0                 | 0.98371                 |
| 22.0                 | 0.9977730               | 27.0                 | 0.9965166               | 32.0                 | 0.9950302               | 37.0                 | 0.9933328               | 60.0                 | 0.98320                 |
| 22.1                 | 0.9977503               | 27.1                 | 0.9964891               | 32.1                 | 0.9949983               | 37.1                 | 0.9932968               | 61.0                 | 0.98268                 |
| 22.2                 | 0.9977275               | 27.2                 | 0.9964615               | 32.2                 | 0.9949663               | 37.2                 | 0.9932607               | 62.0                 | 0.98216                 |
| 22.3                 | 0.9977045               | 27.3                 | 0.9964337               | 32.3                 | 0.9949342               | 37.3                 | 0.9932246               | 63.0                 | 0.98163                 |
| 22.4                 | 0.9976815               | 27.4                 | 0.9964059               | 32.4                 | 0.9949020               | 37.4                 | 0.9931884               | 64.0                 | 0.98109                 |
| 22.5                 | 0.9976584               | 27.5                 | 0.9963780               | 32.5                 | 0.9948697               | 37.5                 | 0.9931521               | 65.0                 | 0.98055                 |
| 22.6                 | 0.9976351               | 27.6                 | 0.9963500               | 32.6                 | 0.9948373               | 37.6                 | 0.9931157               | 66.0                 | 0.98000                 |
| 22.7                 | 0.9976118               | 27.7                 | 0.9963219               | 32.7                 | 0.9948049               | 37.7                 | 0.9930793               | 67.0                 | 0.97945                 |
| 22.8                 | 0.9975883               | 27.8                 | 0.9962938               | 32.8                 | 0.9947724               | 37.8                 | 0.9930428               | 68.0                 | 0.97890                 |
| 22.9                 | 0.9975648               | 27.9                 | 0.9962655               | 32.9                 | 0.9947397               | 37.9                 | 0.9930062               | 69.0                 | 0.97833                 |
| 23.0                 | 0.9975412               | 28.0                 | 0.9962371               | 33.0                 | 0.9947071               | 38.0                 | 0.9929695               | 70.0                 | 0.97776                 |
| 23.1                 | 0.9975174               | 28.1                 | 0.9962087               | 33.1                 | 0.9946743               | 38.1                 | 0.9929328               | 71.0                 | 0.97719                 |
| 23.2                 | 0.9974936               | 28.2                 | 0.9961801               | 33.2                 | 0.9946414               | 38.2                 | 0.9928960               | 72.0                 | 0.97661                 |
| 23.3                 | 0.9974697               | 28.3                 | 0.9961515               | 33.3                 | 0.9946085               | 38.3                 | 0.9928591               | 73.0                 | 0.97603                 |
| 23.4                 | 0.9974456               | 28.4                 | 0.9961228               | 33.4                 | 0.9945755               | 38.4                 | 0.9928221               | 74.0                 | 0.97544                 |
| 23.5                 | 0.9974215               | 28.5                 | 0.9960940               | 33.5                 | 0.9945423               | 38.5                 | 0.9927850               | 75.0                 | 0.97484                 |
| 23.6                 | 0.9973973               | 28.6                 | 0.9960651               | 33.6                 | 0.9945092               | 38.6                 | 0.9927479               | 76.0                 | 0.97424                 |
| 23.7                 | 0.9973730               | 28.7                 | 0.9960361               | 33.7                 | 0.9944759               | 38.7                 | 0.9927107               | 77.0                 | 0.97364                 |
| 23.8                 | 0.9973485               | 28.8                 | 0.9960070               | 33.8                 | 0.9944425               | 38.8                 | 0.9926735               | 78.0                 | 0.97303                 |
| 23.9                 | 0.9973240               | 28.9                 | 0.9959778               | 33.9                 | 0.9944091               | 38.9                 | 0.9926361               | 79.0                 | 0.97241                 |
| 24.0                 | 0.9972994               | 29.0                 | 0.9959486               | 34.0                 | 0.9943756               | 39.0                 | 0.9925987               | 80.0                 | 0.97179                 |
| 24.1                 | 0.9972747               | 29.1                 | 0.9959192               | 34.1                 | 0.9943420               | 39.1                 | 0.9925612               | 81.0                 | 0.97116                 |
| 24.2                 | 0.9972499               | 29.2                 | 0.9958898               | 34.2                 | 0.9943083               | 39.2                 | 0.9925236               | 82.0                 | 0.97053                 |
| 24.3                 | 0.9972250               | 29.3                 | 0.9958603               | 34.3                 | 0.9942745               | 39.3                 | 0.9924860               | 83.0                 | 0.96990                 |
| 24.4                 | 0.9972000               | 29.4                 | 0.9958306               | 34.4                 | 0.9942407               | 39.4                 | 0.9924483               | 84.0                 | 0.96926                 |
| 24.5                 | 0.9971749               | 29.5                 | 0.9958009               | 34.5                 | 0.9942068               | 39.5                 | 0.9924105               | 85.0                 | 0.96861                 |
| 24.6                 | 0.9971497               | 29.6                 | 0.9957712               | 34.6                 | 0.9941728               | 39.6                 | 0.9923726               | 86.0                 | 0.96796                 |
| 24.7                 | 0.9971244               | 29.7                 | 0.9957413               | 34.7                 | 0.9941387               | 39.7                 | 0.9923347               | 87.0                 | 0.96731                 |
| 24.8                 | 0.9970990               | 29.8                 | 0.9957113               | 34.8                 | 0.9941045               | 39.8                 | 0.9922966               | 88.0                 | 0.96664                 |
| 24.9                 | 0.9970735               | 29.9                 | 0.9956813               | 34.9                 | 0.9940703               | 39.9                 | 0.9922586               | 89.0                 | 0.96598                 |
| 25.0                 | 0.9970480               | 30.0                 | 0.9956511               | 35.0                 | 0.9940359               | 40.0                 | 0.9922204               | 90.0                 | 0.96531                 |
| 25.1                 | 0.9970223               | 30.1                 | 0.9956209               | 35.1                 | 0.9940015               | 41.0                 | 0.99183                 | 91.0                 | 0.96463                 |
| 25.2                 | 0.9969965               | 30.2                 | 0.9955906               | 35.2                 | 0.9939671               | 42.0                 | 0.99144                 | 92.0                 | 0.96396                 |
| 25.3                 | 0.9969707               | 30.3                 | 0.9955602               | 35.3                 | 0.9939325               | 43.0                 | 0.99104                 | 93.0                 | 0.96327                 |
| 25.4                 | 0.9969447               | 30.4                 | 0.9955297               | 35.4                 | 0.9938978               | 44.0                 | 0.99063                 | 94.0                 | 0.96258                 |
| 25.5                 | 0.9969186               | 30.5                 | 0.9954991               | 35.5                 | 0.9938631               | 45.0                 | 0.99021                 | 95.0                 | 0.96189                 |
| 25.6                 | 0.9968925               | 30.6                 | 0.9954685               | 35.6                 | 0.9938283               | 46.0                 | 0.98979                 | 96.0                 | 0.96119                 |
| 25.7                 | 0.9968663               | 30.7                 | 0.9954377               | 35.7                 | 0.9937934               | 47.0                 | 0.98936                 | 97.0                 | 0.96049                 |
| 25.8                 | 0.9968399               | 30.8                 | 0.9954069               | 35.8                 | 0.9937585               | 48.0                 | 0.98893                 | 98.0                 | 0.95978                 |
| 25.9                 | 0.9968135               | 30.9                 | 0.9953760               | 35.9                 | 0.9937234               | 49.0                 | 0.98848                 | 99.0                 | 0.95907                 |
| 26.0                 | 0.9967870               | 31.0                 | 0.9953450               | 36.0                 | 0.9936883               | 50.0                 | 0.98804                 | 99.974               | 0.95837                 |

# VOLUMETRIC PROPERTIES OF AQUEOUS SODIUM CHLORIDE SOLUTIONS

This table gives the following properties of aqueous solutions of NaCl as a function of temperature and concentration:

All data refer to a pressure of 100 kPa (1 bar). The reference gives properties over a wider range of temperature and pressure.

Specific volume  $v$  (reciprocal of density) in  $\text{cm}^3/\text{g}$   
 Isothermal compressibility  $\kappa_T = -(1/v)(\partial v/\partial P)_T$  in  $\text{GPa}^{-1}$   
 Cubic expansion coefficient  $\alpha_v = (1/v)(\partial v/\partial T)_P$  in  $\text{K}^{-1}$

## Reference

Rogers, P. S. Z., and Pitzer, K. S., *J. Phys. Chem. Ref. Data*, 11, 15, 1982.

| $t/^\circ\text{C}$                                                                      | Molality in mol/kg |          |          |          |          |          |          |          |          |
|-----------------------------------------------------------------------------------------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|
|                                                                                         | 0.100              | 0.250    | 0.500    | 0.750    | 1.000    | 2.000    | 3.000    | 4.000    | 5.000    |
| <b>Specific volume <math>v</math> in <math>\text{cm}^3/\text{g}</math></b>              |                    |          |          |          |          |          |          |          |          |
| 0                                                                                       | 0.995732           | 0.989259 | 0.978889 | 0.968991 | 0.959525 | 0.925426 | 0.896292 | 0.870996 | 0.848646 |
| 10                                                                                      | 0.995998           | 0.989781 | 0.979804 | 0.970256 | 0.961101 | 0.927905 | 0.899262 | 0.874201 | 0.851958 |
| 20                                                                                      | 0.997620           | 0.991564 | 0.981833 | 0.972505 | 0.963544 | 0.930909 | 0.902565 | 0.877643 | 0.855469 |
| 25                                                                                      | 0.998834           | 0.992832 | 0.983185 | 0.973932 | 0.965038 | 0.932590 | 0.904339 | 0.879457 | 0.857301 |
| 30                                                                                      | 1.000279           | 0.994319 | 0.984735 | 0.975539 | 0.966694 | 0.934382 | 0.906194 | 0.881334 | 0.859185 |
| 40                                                                                      | 1.003796           | 0.997883 | 0.988374 | 0.979243 | 0.970455 | 0.938287 | 0.910145 | 0.885276 | 0.863108 |
| 50                                                                                      | 1.008064           | 1.002161 | 0.992668 | 0.983551 | 0.974772 | 0.942603 | 0.914411 | 0.889473 | 0.867241 |
| 60                                                                                      | 1.0130             | 1.0071   | 0.9976   | 0.9885   | 0.9797   | 0.9474   | 0.9191   | 0.8940   | 0.8716   |
| 70                                                                                      | 1.0186             | 1.0127   | 1.0031   | 0.9939   | 0.9851   | 0.9526   | 0.9240   | 0.8987   | 0.8762   |
| 80                                                                                      | 1.0249             | 1.0188   | 1.0092   | 0.9999   | 0.9909   | 0.9581   | 0.9293   | 0.9037   | 0.8809   |
| 90                                                                                      | 1.0317             | 1.0256   | 1.0157   | 1.0063   | 0.9972   | 0.9640   | 0.9348   | 0.9089   | 0.8858   |
| 100                                                                                     | 1.0391             | 1.0329   | 1.0228   | 1.0133   | 1.0040   | 0.9703   | 0.9406   | 0.9144   | 0.8910   |
| <b>Isothermal Compressibility <math>\kappa_T</math> in <math>\text{GPa}^{-1}</math></b> |                    |          |          |          |          |          |          |          |          |
| 0                                                                                       | 0.503              | 0.492    | 0.475    | 0.459    | 0.443    | 0.389    | 0.346    | 0.315    | 0.294    |
| 10                                                                                      | 0.472              | 0.463    | 0.449    | 0.436    | 0.423    | 0.377    | 0.341    | 0.313    | 0.294    |
| 20                                                                                      | 0.453              | 0.446    | 0.433    | 0.422    | 0.411    | 0.371    | 0.338    | 0.313    | 0.294    |
| 25                                                                                      | 0.447              | 0.440    | 0.428    | 0.417    | 0.407    | 0.369    | 0.337    | 0.313    | 0.294    |
| 30                                                                                      | 0.443              | 0.436    | 0.425    | 0.414    | 0.404    | 0.367    | 0.337    | 0.313    | 0.294    |
| 40                                                                                      | 0.438              | 0.432    | 0.421    | 0.411    | 0.401    | 0.367    | 0.338    | 0.315    | 0.296    |
| 50                                                                                      | 0.438              | 0.431    | 0.421    | 0.411    | 0.402    | 0.369    | 0.340    | 0.317    | 0.299    |
| 60                                                                                      | 0.44               | 0.44     | 0.43     | 0.42     | 0.41     | 0.38     | 0.35     | 0.32     | 0.30     |
| 70                                                                                      | 0.45               | 0.44     | 0.43     | 0.42     | 0.42     | 0.38     | 0.36     | 0.33     | 0.31     |
| 80                                                                                      | 0.46               | 0.45     | 0.44     | 0.43     | 0.43     | 0.39     | 0.37     | 0.34     | 0.32     |
| 90                                                                                      | 0.47               | 0.47     | 0.46     | 0.45     | 0.44     | 0.41     | 0.38     | 0.35     | 0.33     |
| 100                                                                                     | 0.49               | 0.48     | 0.47     | 0.46     | 0.45     | 0.42     | 0.39     | 0.37     | 0.34     |
| <b>Cubic expansion coefficient <math>\alpha_v</math> in <math>\text{K}^{-1}</math></b>  |                    |          |          |          |          |          |          |          |          |
| 0                                                                                       | -0.058             | -0.026   | 0.024    | 0.069    | 0.110    | 0.237    | 0.313    | 0.355    |          |
| 10                                                                                      | 0.102              | 0.123    | 0.156    | 0.186    | 0.213    | 0.297    | 0.349    | 0.380    |          |
| 20                                                                                      | 0.218              | 0.232    | 0.254    | 0.274    | 0.292    | 0.349    | 0.384    | 0.406    |          |
| 25                                                                                      | 0.267              | 0.278    | 0.296    | 0.312    | 0.327    | 0.373    | 0.401    | 0.420    |          |
| 30                                                                                      | 0.311              | 0.320    | 0.334    | 0.347    | 0.359    | 0.395    | 0.418    | 0.433    |          |
| 40                                                                                      | 0.389              | 0.394    | 0.402    | 0.410    | 0.417    | 0.438    | 0.451    | 0.460    |          |
| 50                                                                                      | 0.458              | 0.460    | 0.464    | 0.467    | 0.470    | 0.479    | 0.484    | 0.486    |          |
| 60                                                                                      | 0.52               | 0.52     | 0.52     | 0.52     | 0.52     | 0.52     | 0.52     | 0.52     |          |
| 70                                                                                      | 0.58               | 0.58     | 0.58     | 0.57     | 0.57     | 0.56     | 0.55     | 0.54     |          |
| 80                                                                                      | 0.64               | 0.63     | 0.63     | 0.62     | 0.61     | 0.60     | 0.58     | 0.56     |          |
| 90                                                                                      | 0.69               | 0.68     | 0.67     | 0.67     | 0.66     | 0.63     | 0.61     | 0.59     |          |
| 100                                                                                     | 0.74               | 0.73     | 0.72     | 0.71     | 0.70     | 0.66     | 0.64     | 0.61     |          |

## VAPOR PRESSURE OF ICE

The values of the vapor (sublimation) pressure of ice in this table were calculated from the equation recommended by the International Association for the Properties of Steam (IAPS) in 1993. Temperature values correspond to the ITS-90 temperature scale. The uncertainty in the pressure is estimated to be 0.1% for  $t > -25^{\circ}\text{C}$  and 0.5% for  $t < -25^{\circ}\text{C}$ . The first entry in the table is the triple point of water.

### Reference

Wagner, W., Saul, A., and Pruss, A., *J. Phys. Chem. Ref. Data*, 23, 515, 1994.

| $t/^{\circ}\text{C}$ | $p/\text{Pa}$ | $t/^{\circ}\text{C}$ | $p/\text{Pa}$ | $t/^{\circ}\text{C}$ | $p/\text{Pa}$ |
|----------------------|---------------|----------------------|---------------|----------------------|---------------|
| 0.01                 | 611.657       | -16                  | 150.68        | -33                  | 27.71         |
| 0                    | 611.15        | -17                  | 137.25        | -34                  | 24.90         |
| -1                   | 562.67        | -18                  | 124.92        | -35                  | 22.35         |
| -2                   | 517.72        | -19                  | 113.62        | -36                  | 20.04         |
| -3                   | 476.06        | -20                  | 103.26        | -37                  | 17.96         |
| -4                   | 437.47        | -21                  | 93.77         | -38                  | 16.07         |
| -5                   | 401.76        | -22                  | 85.10         | -39                  | 14.37         |
| -6                   | 368.73        | -23                  | 77.16         | -40                  | 12.84         |
| -7                   | 338.19        | -24                  | 69.91         | -45                  | 7.202         |
| -8                   | 309.98        | -25                  | 63.29         | -50                  | 3.936         |
| -9                   | 283.94        | -26                  | 57.25         | -55                  | 2.093         |
| -10                  | 259.90        | -27                  | 51.74         | -60                  | 1.080         |
| -11                  | 237.74        | -28                  | 46.73         | -65                  | 0.540         |
| -12                  | 217.32        | -29                  | 42.16         | -70                  | 0.261         |
| -13                  | 198.52        | -30                  | 38.01         | -75                  | 0.122         |
| -14                  | 181.22        | -31                  | 34.24         | -80                  | 0.055         |
| -15                  | 165.30        | -32                  | 30.82         |                      |               |

# VAPOR PRESSURE AND OTHER SATURATION PROPERTIES OF WATER

Eric W. Lemmon

This table summarizes the vapor pressure, enthalpy (heat) of vaporization, and surface tension of water as accepted by the International Association for the Properties of Water and Steam ([www.iapws.org](http://www.iapws.org)) for general and scientific use. The vapor pressure and heat of vaporization are calculated from the equation of state of Wagner and Pruss (Ref. 1). The temperature scale is ITS-90. Additional calculations at state points not listed below can be obtained by using the NIST Standard Reference Data program REFPROP ([www.nist.gov/srd/nist23.htm](http://www.nist.gov/srd/nist23.htm)) or the water-specific program Steam ([www.nist.gov/srd/nist10.htm](http://www.nist.gov/srd/nist10.htm)).

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| $t$<br>°C | $P$<br>kPa | $\Delta_{\text{vap}}H$<br>kJ kg <sup>-1</sup> | Surf. Ten.<br>mN m <sup>-1</sup> |
|-----------|------------|-----------------------------------------------|----------------------------------|
| 0.01      | 0.61165    | 2500.9                                        | 75.65                            |
| 2         | 0.70599    | 2496.2                                        | 75.37                            |
| 4         | 0.81355    | 2491.4                                        | 75.08                            |
| 6         | 0.93536    | 2486.7                                        | 74.80                            |
| 8         | 1.0730     | 2481.9                                        | 74.51                            |
| 10        | 1.2282     | 2477.2                                        | 74.22                            |
| 12        | 1.4028     | 2472.5                                        | 73.93                            |
| 14        | 1.5990     | 2467.7                                        | 73.63                            |
| 16        | 1.8188     | 2463.0                                        | 73.34                            |
| 18        | 2.0647     | 2458.3                                        | 73.04                            |
| 20        | 2.3393     | 2453.5                                        | 72.74                            |
| 22        | 2.6453     | 2448.8                                        | 72.43                            |
| 24        | 2.9858     | 2444.0                                        | 72.13                            |
| 25        | 3.1699     | 2441.7                                        | 71.97                            |
| 26        | 3.3639     | 2439.3                                        | 71.82                            |
| 28        | 3.7831     | 2434.6                                        | 71.51                            |
| 30        | 4.2470     | 2429.8                                        | 71.19                            |
| 32        | 4.7596     | 2425.1                                        | 70.88                            |
| 34        | 5.3251     | 2420.3                                        | 70.56                            |
| 36        | 5.9479     | 2415.5                                        | 70.24                            |
| 38        | 6.6328     | 2410.8                                        | 69.92                            |
| 40        | 7.3849     | 2406.0                                        | 69.60                            |
| 42        | 8.2096     | 2401.2                                        | 69.27                            |
| 44        | 9.1124     | 2396.4                                        | 68.94                            |
| 46        | 10.099     | 2391.6                                        | 68.61                            |
| 48        | 11.177     | 2386.8                                        | 68.28                            |
| 50        | 12.352     | 2381.9                                        | 67.94                            |
| 52        | 13.631     | 2377.1                                        | 67.61                            |
| 54        | 15.022     | 2372.3                                        | 67.27                            |
| 56        | 16.533     | 2367.4                                        | 66.93                            |
| 58        | 18.171     | 2362.5                                        | 66.58                            |
| 60        | 19.946     | 2357.7                                        | 66.24                            |
| 62        | 21.867     | 2352.8                                        | 65.89                            |
| 64        | 23.943     | 2347.8                                        | 65.54                            |
| 66        | 26.183     | 2342.9                                        | 65.19                            |
| 68        | 28.599     | 2338.0                                        | 64.84                            |
| 70        | 31.201     | 2333.0                                        | 64.48                            |
| 72        | 34.000     | 2328.1                                        | 64.12                            |
| 74        | 37.009     | 2323.1                                        | 63.76                            |
| 76        | 40.239     | 2318.1                                        | 63.40                            |
| 78        | 43.703     | 2313.0                                        | 63.04                            |

| $t$<br>°C | $P$<br>kPa | $\Delta_{\text{vap}}H$<br>kJ kg <sup>-1</sup> | Surf. Ten.<br>mN m <sup>-1</sup> |
|-----------|------------|-----------------------------------------------|----------------------------------|
| 80        | 47.414     | 2308.0                                        | 62.67                            |
| 82        | 51.387     | 2302.9                                        | 62.31                            |
| 84        | 55.635     | 2297.9                                        | 61.94                            |
| 86        | 60.173     | 2292.8                                        | 61.56                            |
| 88        | 65.017     | 2287.6                                        | 61.19                            |
| 90        | 70.182     | 2282.5                                        | 60.82                            |
| 92        | 75.684     | 2277.3                                        | 60.44                            |
| 94        | 81.541     | 2272.1                                        | 60.06                            |
| 96        | 87.771     | 2266.9                                        | 59.68                            |
| 98        | 94.390     | 2261.7                                        | 59.30                            |
| 100       | 101.42     | 2256.4                                        | 58.91                            |
| 102       | 108.87     | 2251.1                                        | 58.53                            |
| 104       | 116.78     | 2245.8                                        | 58.14                            |
| 106       | 125.15     | 2240.4                                        | 57.75                            |
| 108       | 134.01     | 2235.1                                        | 57.36                            |
| 110       | 143.38     | 2229.6                                        | 56.96                            |
| 112       | 153.28     | 2224.2                                        | 56.57                            |
| 114       | 163.74     | 2218.7                                        | 56.17                            |
| 116       | 174.77     | 2213.2                                        | 55.77                            |
| 118       | 186.41     | 2207.7                                        | 55.37                            |
| 120       | 198.67     | 2202.1                                        | 54.97                            |
| 122       | 211.59     | 2196.5                                        | 54.56                            |
| 124       | 225.18     | 2190.9                                        | 54.16                            |
| 126       | 239.47     | 2185.2                                        | 53.75                            |
| 128       | 254.50     | 2179.5                                        | 53.34                            |
| 130       | 270.28     | 2173.7                                        | 52.93                            |
| 132       | 286.85     | 2167.9                                        | 52.52                            |
| 134       | 304.23     | 2162.1                                        | 52.11                            |
| 136       | 322.45     | 2156.2                                        | 51.69                            |
| 138       | 341.54     | 2150.3                                        | 51.27                            |
| 140       | 361.54     | 2144.3                                        | 50.86                            |
| 142       | 382.47     | 2138.3                                        | 50.44                            |
| 144       | 404.37     | 2132.2                                        | 50.01                            |
| 146       | 427.26     | 2126.1                                        | 49.59                            |
| 148       | 451.18     | 2119.9                                        | 49.17                            |
| 150       | 476.16     | 2113.7                                        | 48.74                            |
| 152       | 502.25     | 2107.5                                        | 48.31                            |
| 154       | 529.46     | 2101.2                                        | 47.89                            |
| 156       | 557.84     | 2094.8                                        | 47.46                            |
| 158       | 587.42     | 2088.4                                        | 47.02                            |
| 160       | 618.23     | 2082.0                                        | 46.59                            |

| $t$<br>°C | $P$<br>kPa | $\Delta_{\text{vap}}H$<br>kJ kg <sup>-1</sup> | Surf. Ten.<br>mN m <sup>-1</sup> | $t$<br>°C | $P$<br>kPa | $\Delta_{\text{vap}}H$<br>kJ kg <sup>-1</sup> | Surf. Ten.<br>mN m <sup>-1</sup> |
|-----------|------------|-----------------------------------------------|----------------------------------|-----------|------------|-----------------------------------------------|----------------------------------|
| 162       | 650.33     | 2075.5                                        | 46.16                            | 270       | 5503.0     | 1604.4                                        | 21.34                            |
| 164       | 683.73     | 2068.9                                        | 45.72                            | 272       | 5677.2     | 1592.5                                        | 20.87                            |
| 166       | 718.48     | 2062.3                                        | 45.28                            | 274       | 5855.6     | 1580.4                                        | 20.40                            |
| 168       | 754.62     | 2055.6                                        | 44.85                            | 276       | 6038.3     | 1568.1                                        | 19.93                            |
| 170       | 792.19     | 2048.8                                        | 44.41                            | 278       | 6225.2     | 1555.6                                        | 19.46                            |
| 172       | 831.22     | 2042.0                                        | 43.97                            | 280       | 6416.6     | 1543.0                                        | 18.99                            |
| 174       | 871.76     | 2035.1                                        | 43.52                            | 282       | 6612.4     | 1530.1                                        | 18.53                            |
| 176       | 913.84     | 2028.2                                        | 43.08                            | 284       | 6812.8     | 1517.1                                        | 18.06                            |
| 178       | 957.51     | 2021.2                                        | 42.64                            | 286       | 7017.7     | 1503.8                                        | 17.59                            |
| 180       | 1002.8     | 2014.2                                        | 42.19                            | 288       | 7227.4     | 1490.4                                        | 17.13                            |
| 182       | 1049.8     | 2007.0                                        | 41.74                            | 290       | 7441.8     | 1476.7                                        | 16.66                            |
| 184       | 1098.5     | 1999.8                                        | 41.30                            | 292       | 7661.0     | 1462.7                                        | 16.20                            |
| 186       | 1148.9     | 1992.6                                        | 40.85                            | 294       | 7885.2     | 1448.6                                        | 15.74                            |
| 188       | 1201.1     | 1985.3                                        | 40.40                            | 296       | 8114.3     | 1434.2                                        | 15.28                            |
| 190       | 1255.2     | 1977.9                                        | 39.95                            | 298       | 8348.5     | 1419.5                                        | 14.82                            |
| 192       | 1311.2     | 1970.4                                        | 39.49                            | 300       | 8587.9     | 1404.6                                        | 14.36                            |
| 194       | 1369.1     | 1962.8                                        | 39.04                            | 302       | 8832.5     | 1389.4                                        | 13.90                            |
| 196       | 1429.0     | 1955.2                                        | 38.59                            | 304       | 9082.4     | 1374.0                                        | 13.45                            |
| 198       | 1490.9     | 1947.5                                        | 38.13                            | 306       | 9337.8     | 1358.2                                        | 12.99                            |
| 200       | 1554.9     | 1939.7                                        | 37.67                            | 308       | 9598.6     | 1342.1                                        | 12.54                            |
| 202       | 1621.0     | 1931.9                                        | 37.22                            | 310       | 9865.1     | 1325.7                                        | 12.09                            |
| 204       | 1689.3     | 1923.9                                        | 36.76                            | 312       | 10137.     | 1309.0                                        | 11.64                            |
| 206       | 1759.8     | 1915.9                                        | 36.30                            | 314       | 10415.     | 1291.9                                        | 11.19                            |
| 208       | 1832.6     | 1907.8                                        | 35.84                            | 316       | 10699.     | 1274.5                                        | 10.75                            |
| 210       | 1907.7     | 1899.6                                        | 35.38                            | 318       | 10989.     | 1256.6                                        | 10.30                            |
| 212       | 1985.1     | 1891.4                                        | 34.92                            | 320       | 11284.     | 1238.4                                        | 9.86                             |
| 214       | 2065.0     | 1883.0                                        | 34.46                            | 322       | 11586.     | 1219.7                                        | 9.43                             |
| 216       | 2147.3     | 1874.6                                        | 33.99                            | 324       | 11895.     | 1200.6                                        | 8.99                             |
| 218       | 2232.2     | 1866.0                                        | 33.53                            | 326       | 12209.     | 1180.9                                        | 8.56                             |
| 220       | 2319.6     | 1857.4                                        | 33.07                            | 328       | 12530.     | 1160.8                                        | 8.13                             |
| 222       | 2409.6     | 1848.6                                        | 32.60                            | 330       | 12858.     | 1140.2                                        | 7.70                             |
| 224       | 2502.3     | 1839.8                                        | 32.14                            | 332       | 13193.     | 1118.9                                        | 7.28                             |
| 226       | 2597.8     | 1830.9                                        | 31.67                            | 334       | 13534.     | 1097.1                                        | 6.86                             |
| 228       | 2696.0     | 1821.8                                        | 31.20                            | 336       | 13882.     | 1074.6                                        | 6.44                             |
| 230       | 2797.1     | 1812.7                                        | 30.74                            | 338       | 14238.     | 1051.3                                        | 6.03                             |
| 232       | 2901.0     | 1803.5                                        | 30.27                            | 340       | 14601.     | 1027.3                                        | 5.63                             |
| 234       | 3008.0     | 1794.1                                        | 29.80                            | 342       | 14971.     | 1002.5                                        | 5.22                             |
| 236       | 3117.9     | 1784.7                                        | 29.33                            | 344       | 15349.     | 976.7                                         | 4.83                             |
| 238       | 3230.8     | 1775.1                                        | 28.86                            | 346       | 15734.     | 949.9                                         | 4.43                             |
| 240       | 3346.9     | 1765.4                                        | 28.39                            | 348       | 16128.     | 922.0                                         | 4.05                             |
| 242       | 3466.2     | 1755.6                                        | 27.92                            | 350       | 16529.     | 892.7                                         | 3.67                             |
| 244       | 3588.7     | 1745.7                                        | 27.45                            | 352       | 16939.     | 862.1                                         | 3.29                             |
| 246       | 3714.5     | 1735.6                                        | 26.98                            | 354       | 17358.     | 829.8                                         | 2.93                             |
| 248       | 3843.6     | 1725.5                                        | 26.51                            | 356       | 17785.     | 795.5                                         | 2.57                             |
| 250       | 3976.2     | 1715.2                                        | 26.04                            | 358       | 18221.     | 759.0                                         | 2.22                             |
| 252       | 4112.2     | 1704.7                                        | 25.57                            | 360       | 18666.     | 719.8                                         | 1.88                             |
| 254       | 4251.8     | 1694.2                                        | 25.10                            | 362       | 19121.     | 677.3                                         | 1.55                             |
| 256       | 4394.9     | 1683.5                                        | 24.63                            | 364       | 19585.     | 630.5                                         | 1.23                             |
| 258       | 4541.7     | 1672.6                                        | 24.16                            | 366       | 20060.     | 578.2                                         | 0.93                             |
| 260       | 4692.3     | 1661.6                                        | 23.69                            | 368       | 20546.     | 517.8                                         | 0.65                             |
| 262       | 4846.6     | 1650.5                                        | 23.22                            | 370       | 21044.     | 443.8                                         | 0.39                             |
| 264       | 5004.7     | 1639.2                                        | 22.75                            | 372       | 21554.     | 340.3                                         | 0.16                             |
| 266       | 5166.8     | 1627.8                                        | 22.28                            | 373.95    | 22064.     | 0.0                                           | 0.0                              |
| 268       | 5332.9     | 1616.2                                        | 21.81                            |           |            |                                               |                                  |



## MELTING POINT OF ICE AS A FUNCTION OF PRESSURE

This table gives values of the melting temperature of ice at various pressures, as calculated from the equation for the ice I - liquid water phase boundary recommended by the International Association for the Properties of Steam (IAPS). Temperatures are on the ITS-90 scale. See the Reference for information on forms of ice that exist at higher pressures. The transition points for transformations of the various forms of ice (in each case in equilibrium with liquid water) are:

|                  |           |            |
|------------------|-----------|------------|
| ice I - ice III  | 209.9 MPa | -21.985 °C |
| ice III - ice V  | 350.1     | -16.986    |
| ice V - ice VI   | 632.4     | 0.16       |
| ice VI - ice VII | 2216      | 82         |

### Reference

Wagner, W., Saul, A., and Pruss, A., *J. Phys. Chem. Ref. Data*, 23, 515, 1994.

| $p/\text{MPa}$ | $t/^\circ\text{C}$ | $p/\text{MPa}$ | $t/^\circ\text{C}$ | $p/\text{MPa}$ | $t/^\circ\text{C}$ |
|----------------|--------------------|----------------|--------------------|----------------|--------------------|
| 0.1            | 0.00               | 40             | -3.15              | 130            | -12.07             |
| 1              | -0.06              | 50             | -4.02              | 140            | -13.22             |
| 2              | -0.14              | 60             | -4.91              | 150            | -14.40             |
| 3              | -0.21              | 70             | -5.83              | 160            | -15.62             |
| 4              | -0.29              | 80             | -6.79              | 170            | -16.85             |
| 5              | -0.36              | 90             | -7.78              | 180            | -18.11             |
| 10             | -0.74              | 100            | -8.80              | 190            | -19.39             |
| 20             | -1.52              | 110            | -9.86              | 200            | -20.69             |
| 30             | -2.32              | 120            | -10.95             | 210            | -22.00             |

# THERMOPHYSICAL PROPERTIES OF WATER AND STEAM

Eric W. Lemmon

These tables summarize the thermophysical properties of water and steam at equilibrium as accepted by the International Association for the Properties of Water and Steam ([www.iapws.org](http://www.iapws.org)) for general and scientific use. The thermodynamic properties are calculated from the equation of state of Wagner and Pruss (Ref. 6). The reference state for these tables is the liquid at the triple point, at which the internal energy and entropy are taken as zero. These tables refer to states at 1 bar (100 kPa) pressure with temperatures in °C in the first section; liquid and gaseous states at equilibrium as a function of temperature in the second section; and properties along isobars in the third section. The tabulated properties are pressure ( $P$ ), density ( $\rho$ ), enthalpy ( $H$ ), entropy ( $S$ ), isochoric heat capacity ( $C_v$ ), isobaric heat capacity ( $C_p$ ), speed of sound ( $u$ ), viscosity ( $\eta$ ), thermal conductivity ( $\lambda$ ), and static dielectric constant ( $D$ ). In the saturation tables, the first line of identical temperatures is for the liquid state and the second line is for the vapor state. A duplicate entry in the isobar section indicates a phase transition (liquid-vapor) at that temperature; property values are then given for both phases. These are identified by the high densities in the liquid and the low densities in the vapor. The temperature scale is ITS-90. Additional calculations at state points not listed below can be obtained by using the NIST Standard Reference Data program REFPROP (Ref. 5) or the water-specific program Steam (Ref. 2).

## References

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| $T$<br>°C                               | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b><math>P = 0.1</math> MPa (1 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 0.01                                    | 0.1        | 999.84                       | 0.10186                    | 0.000007                                   | 4.2170                                       | 4.2194                                       | 1402.4                   | 87.899  | 1791.1          | 561.09                                          |
| 10                                      | 0.1        | 999.70                       | 42.118                     | 0.15108                                    | 4.1906                                       | 4.1952                                       | 1447.3                   | 83.974  | 1305.9          | 580.05                                          |
| 20                                      | 0.1        | 998.21                       | 84.006                     | 0.29646                                    | 4.1567                                       | 4.1841                                       | 1482.3                   | 80.223  | 1001.6          | 598.46                                          |
| 25                                      | 0.1        | 997.05                       | 104.92                     | 0.36720                                    | 4.1376                                       | 4.1813                                       | 1496.7                   | 78.408  | 890.02          | 607.19                                          |
| 30                                      | 0.1        | 995.65                       | 125.82                     | 0.43673                                    | 4.1172                                       | 4.1798                                       | 1509.2                   | 76.634  | 797.22          | 615.50                                          |
| 40                                      | 0.1        | 992.22                       | 167.62                     | 0.57237                                    | 4.0734                                       | 4.1794                                       | 1528.9                   | 73.201  | 652.73          | 630.63                                          |
| 50                                      | 0.1        | 988.03                       | 209.42                     | 0.70377                                    | 4.0262                                       | 4.1813                                       | 1542.6                   | 69.916  | 546.52          | 643.59                                          |
| 60                                      | 0.1        | 983.20                       | 251.25                     | 0.83125                                    | 3.9765                                       | 4.1850                                       | 1551.0                   | 66.774  | 466.03          | 654.39                                          |
| 70                                      | 0.1        | 977.76                       | 293.12                     | 0.95509                                    | 3.9251                                       | 4.1901                                       | 1554.7                   | 63.770  | 403.55          | 663.13                                          |
| 80                                      | 0.1        | 971.79                       | 335.05                     | 1.0755                                     | 3.8728                                       | 4.1968                                       | 1554.4                   | 60.898  | 354.05          | 670.01                                          |
| 90                                      | 0.1        | 965.31                       | 377.06                     | 1.1928                                     | 3.8204                                       | 4.2052                                       | 1550.4                   | 58.152  | 314.17          | 675.27                                          |
| 99.606                                  | 0.1        | 958.63                       | 417.50                     | 1.3028                                     | 3.7702                                       | 4.2152                                       | 1543.5                   | 55.628  | 282.75          | 678.97                                          |
| 99.606                                  | 0.1        | 0.59034                      | 2674.9                     | 7.3588                                     | 1.5548                                       | 2.0784                                       | 471.99                   | 1.0058  | 12.218          | 25.053                                          |
| 100                                     | 0.1        | 0.58967                      | 2675.8                     | 7.3610                                     | 1.5535                                       | 2.0766                                       | 472.28                   | 1.0058  | 12.234          | 25.079                                          |
| <b>Saturation</b>                       |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 0.01                                    | 0.000612   | 999.79                       | 0.000612                   | 0.0                                        | 4.2174                                       | 4.2199                                       | 1402.3                   | 87.895  | 1791.4          | 561.04                                          |
| 0.01                                    | 0.000612   | 0.0048546                    | 2500.9                     | 9.1555                                     | 1.4184                                       | 1.8844                                       | 409.00                   | 1.00006 | 8.9458          | 17.071                                          |
| 10                                      | 0.0012282  | 999.65                       | 42.021                     | 0.15109                                    | 4.1910                                       | 4.1955                                       | 1447.1                   | 83.971  | 1306.0          | 580.00                                          |
| 10                                      | 0.0012282  | 0.0094071                    | 2519.2                     | 8.8998                                     | 1.4269                                       | 1.8947                                       | 416.17                   | 1.00012 | 9.2384          | 17.621                                          |
| 20                                      | 0.0023393  | 998.16                       | 83.914                     | 0.29648                                    | 4.1570                                       | 4.1844                                       | 1482.2                   | 80.219  | 1001.6          | 598.42                                          |
| 20                                      | 0.0023393  | 0.017314                     | 2537.4                     | 8.6660                                     | 1.4359                                       | 1.9059                                       | 423.18                   | 1.00021 | 9.5441          | 18.227                                          |
| 25                                      | 0.0031699  | 997.00                       | 104.83                     | 0.36722                                    | 4.1379                                       | 4.1816                                       | 1496.5                   | 78.405  | 890.04          | 607.15                                          |
| 25                                      | 0.0031699  | 0.023075                     | 2546.5                     | 8.5566                                     | 1.4405                                       | 1.9118                                       | 426.63                   | 1.00028 | 9.7009          | 18.550                                          |
| 30                                      | 0.0042470  | 995.61                       | 125.73                     | 0.43675                                    | 4.1175                                       | 4.1801                                       | 1509.0                   | 76.630  | 797.22          | 615.46                                          |
| 30                                      | 0.0042470  | 0.030415                     | 2555.5                     | 8.4520                                     | 1.4452                                       | 1.9180                                       | 430.03                   | 1.00036 | 9.8602          | 18.887                                          |
| 40                                      | 0.0073849  | 992.18                       | 167.53                     | 0.57240                                    | 4.0737                                       | 4.1796                                       | 1528.7                   | 73.197  | 652.72          | 630.58                                          |

| $T$<br>°C | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 40        | 0.0073849  | 0.051242                     | 2573.5                     | 8.2555                                     | 1.4552                                       | 1.9314                                       | 436.71                   | 1.00059 | 10.185          | 19.599                                          |
| 50        | 0.012352   | 988.00                       | 209.34                     | 0.70381                                    | 4.0264                                       | 4.1815                                       | 1542.4                   | 69.913  | 546.50          | 643.55                                          |
| 50        | 0.012352   | 0.083147                     | 2591.3                     | 8.0748                                     | 1.4663                                       | 1.9468                                       | 443.21                   | 1.00094 | 10.516          | 20.365                                          |
| 60        | 0.019946   | 983.16                       | 251.18                     | 0.83129                                    | 3.9767                                       | 4.1851                                       | 1550.8                   | 66.772  | 466.02          | 654.35                                          |
| 60        | 0.019946   | 0.13043                      | 2608.8                     | 7.9081                                     | 1.4789                                       | 1.9648                                       | 449.50                   | 1.0014  | 10.854          | 21.187                                          |
| 70        | 0.031201   | 977.73                       | 293.07                     | 0.95513                                    | 3.9252                                       | 4.1902                                       | 1554.6                   | 63.768  | 403.53          | 663.09                                          |
| 70        | 0.031201   | 0.19843                      | 2626.1                     | 7.7540                                     | 1.4937                                       | 1.9862                                       | 455.57                   | 1.0021  | 11.195          | 22.068                                          |
| 80        | 0.047414   | 971.77                       | 335.01                     | 1.0756                                     | 3.8729                                       | 4.1969                                       | 1554.3                   | 60.896  | 354.04          | 669.99                                          |
| 80        | 0.047414   | 0.29367                      | 2643.0                     | 7.6111                                     | 1.5111                                       | 2.0120                                       | 461.39                   | 1.0030  | 11.539          | 23.011                                          |
| 90        | 0.070182   | 965.30                       | 377.04                     | 1.1929                                     | 3.8204                                       | 4.2053                                       | 1550.4                   | 58.151  | 314.17          | 675.25                                          |
| 90        | 0.070182   | 0.42390                      | 2659.5                     | 7.4781                                     | 1.5316                                       | 2.0429                                       | 466.94                   | 1.0043  | 11.885          | 24.019                                          |
| 100       | 0.10142    | 958.35                       | 419.17                     | 1.3072                                     | 3.7682                                       | 4.2157                                       | 1543.2                   | 55.527  | 281.58          | 679.09                                          |
| 100       | 0.10142    | 0.59817                      | 2675.6                     | 7.3541                                     | 1.5558                                       | 2.0800                                       | 472.20                   | 1.0059  | 12.232          | 25.096                                          |
| 100       | 0.10142    | 958.35                       | 419.17                     | 1.3072                                     | 3.7682                                       | 4.2157                                       | 1543.2                   | 55.527  | 281.58          | 679.09                                          |
| 100       | 0.10142    | 0.59817                      | 2675.6                     | 7.3541                                     | 1.5558                                       | 2.0800                                       | 472.20                   | 1.0059  | 12.232          | 25.096                                          |
| 120       | 0.19867    | 943.11                       | 503.81                     | 1.5279                                     | 3.6662                                       | 4.2435                                       | 1519.9                   | 50.620  | 232.03          | 683.19                                          |
| 120       | 0.19867    | 1.1221                       | 2705.9                     | 7.1291                                     | 1.6177                                       | 2.1770                                       | 481.73                   | 1.0105  | 12.927          | 27.467                                          |
| 140       | 0.36154    | 926.13                       | 589.16                     | 1.7392                                     | 3.5694                                       | 4.2826                                       | 1486.2                   | 46.131  | 196.64          | 683.30                                          |
| 140       | 0.36154    | 1.9667                       | 2733.4                     | 6.9293                                     | 1.7002                                       | 2.3109                                       | 489.82                   | 1.0177  | 13.618          | 30.140                                          |
| 160       | 0.61823    | 907.45                       | 675.47                     | 1.9426                                     | 3.4788                                       | 4.3354                                       | 1443.2                   | 42.018  | 170.43          | 679.96                                          |
| 160       | 0.61823    | 3.2596                       | 2757.4                     | 6.7491                                     | 1.8044                                       | 2.4883                                       | 496.29                   | 1.0282  | 14.304          | 33.131                                          |
| 180       | 1.0028     | 887.00                       | 763.05                     | 2.1392                                     | 3.3949                                       | 4.4050                                       | 1391.7                   | 38.235  | 150.38          | 673.32                                          |
| 180       | 1.0028     | 5.1588                       | 2777.2                     | 6.5840                                     | 1.9279                                       | 2.7129                                       | 501.04                   | 1.0431  | 14.985          | 36.449                                          |
| 200       | 1.5549     | 864.66                       | 852.27                     | 2.3305                                     | 3.3179                                       | 4.4958                                       | 1332.1                   | 34.742  | 134.58          | 663.31                                          |
| 200       | 1.5549     | 7.8610                       | 2792.0                     | 6.4302                                     | 2.0666                                       | 2.9895                                       | 503.92                   | 1.0636  | 15.666          | 40.113                                          |
| 220       | 2.3196     | 840.22                       | 943.58                     | 2.5177                                     | 3.2479                                       | 4.6146                                       | 1264.5                   | 31.495  | 121.77          | 649.65                                          |
| 220       | 2.3196     | 11.615                       | 2800.9                     | 6.2840                                     | 2.2172                                       | 3.3289                                       | 504.77                   | 1.0915  | 16.354          | 44.170                                          |
| 240       | 3.3469     | 813.37                       | 1037.6                     | 2.7020                                     | 3.1850                                       | 4.7719                                       | 1189.0                   | 28.455  | 111.06          | 631.85                                          |
| 240       | 3.3469     | 16.749                       | 2803.0                     | 6.1423                                     | 2.3794                                       | 3.7537                                       | 503.32                   | 1.1292  | 17.062          | 48.729                                          |
| 260       | 4.6923     | 783.63                       | 1135.0                     | 2.8849                                     | 3.1301                                       | 4.9856                                       | 1105.3                   | 25.580  | 101.81          | 609.24                                          |
| 260       | 4.6923     | 23.712                       | 2796.6                     | 6.0016                                     | 2.5555                                       | 4.3075                                       | 499.21                   | 1.1802  | 17.810          | 54.035                                          |
| 280       | 6.4166     | 750.28                       | 1236.9                     | 3.0685                                     | 3.0849                                       | 5.2889                                       | 1012.6                   | 22.824  | 93.550          | 581.15                                          |
| 280       | 6.4166     | 33.165                       | 2779.9                     | 5.8579                                     | 2.7503                                       | 5.0731                                       | 491.93                   | 1.2505  | 18.630          | 60.622                                          |
| 300       | 8.5879     | 712.14                       | 1345.0                     | 3.2552                                     | 3.0530                                       | 5.7504                                       | 909.40                   | 20.135  | 85.855          | 547.43                                          |
| 300       | 8.5879     | 46.168                       | 2749.6                     | 5.7059                                     | 2.9708                                       | 6.2197                                       | 480.73                   | 1.3504  | 19.580          | 69.667                                          |
| 320       | 11.284     | 667.09                       | 1462.2                     | 3.4494                                     | 3.0428                                       | 6.5373                                       | 793.16                   | 17.440  | 78.310          | 509.21                                          |
| 320       | 11.284     | 64.638                       | 2700.6                     | 5.5372                                     | 3.2276                                       | 8.1589                                       | 464.43                   | 1.5012  | 20.773          | 83.944                                          |
| 340       | 14.601     | 610.67                       | 1594.5                     | 3.6601                                     | 3.0781                                       | 8.2080                                       | 658.27                   | 14.606  | 70.331          | 468.55                                          |
| 340       | 14.601     | 92.759                       | 2621.8                     | 5.3356                                     | 3.5430                                       | 12.236                                       | 440.72                   | 1.7555  | 22.477          | 111.00                                          |
| 360       | 18.666     | 527.59                       | 1761.7                     | 3.9167                                     | 3.2972                                       | 15.004                                       | 479.74                   | 11.225  | 60.306          | 425.77                                          |
| 360       | 18.666     | 143.90                       | 2481.5                     | 5.0536                                     | 4.0068                                       | 27.356                                       | 402.37                   | 2.3096  | 25.638          | 181.77                                          |
| 373.95    | 22.064     | 322.00                       | 2084.3                     | 4.4070                                     |                                              |                                              |                          | 5.3606  | 79.791          |                                                 |

| $T$<br>K                                | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$    | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|--------|-----------------|-------------------------------------------------|
| <b><math>P = 0.1</math> MPa (1 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |        |                 |                                                 |
| 273.16                                  | 0.1        | 999.84                       | 0.10186                    | 0.000007                                   | 4.2170                                       | 4.2194                                       | 1402.4                   | 87.899 | 1791.1          | 561.09                                          |
| 280                                     | 0.1        | 999.91                       | 28.894                     | 0.10411                                    | 4.1998                                       | 4.2009                                       | 1434.3                   | 85.192 | 1433.6          | 574.09                                          |
| 300                                     | 0.1        | 996.56                       | 112.65                     | 0.39306                                    | 4.1302                                       | 4.1806                                       | 1501.5                   | 77.747 | 853.74          | 610.32                                          |
| 320                                     | 0.1        | 989.43                       | 196.25                     | 0.66281                                    | 4.0414                                       | 4.1805                                       | 1538.9                   | 70.935 | 576.73          | 639.75                                          |
| 340                                     | 0.1        | 979.54                       | 279.93                     | 0.91646                                    | 3.9414                                       | 4.1883                                       | 1554.0                   | 64.702 | 421.63          | 660.58                                          |
| 360                                     | 0.1        | 967.40                       | 363.82                     | 1.1562                                     | 3.8369                                       | 4.2023                                       | 1552.1                   | 59.004 | 325.86          | 673.78                                          |
| 372.756                                 | 0.1        | 958.63                       | 417.50                     | 1.3028                                     | 3.7702                                       | 4.2152                                       | 1543.5                   | 55.628 | 282.75          | 678.97                                          |
| 372.756                                 | 0.1        | 0.59034                      | 2674.9                     | 7.3588                                     | 1.5548                                       | 2.0784                                       | 471.99                   | 1.0058 | 12.218          | 25.053                                          |
| 380                                     | 0.1        | 0.57824                      | 2689.9                     | 7.3986                                     | 1.5356                                       | 2.0507                                       | 477.08                   | 1.0056 | 12.498          | 25.546                                          |

| $T$<br>K                                         | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|--------------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 400                                              | 0.1        | 0.54761                      | 2730.4                     | 7.5025                                     | 1.5082                                       | 2.0078                                       | 490.31                   | 1.0051  | 13.278          | 27.008                                          |
| 450                                              | 0.1        | 0.48458                      | 2829.7                     | 7.7365                                     | 1.4943                                       | 1.9752                                       | 520.60                   | 1.0040  | 15.267          | 31.168                                          |
| 500                                              | 0.1        | 0.43514                      | 2928.6                     | 7.9447                                     | 1.5082                                       | 1.9813                                       | 548.31                   | 1.0033  | 17.299          | 35.861                                          |
| 550                                              | 0.1        | 0.39507                      | 3028.1                     | 8.1344                                     | 1.5319                                       | 2.0010                                       | 574.19                   | 1.0027  | 19.356          | 40.953                                          |
| 600                                              | 0.1        | 0.36185                      | 3128.8                     | 8.3096                                     | 1.5600                                       | 2.0268                                       | 598.61                   | 1.0023  | 21.425          | 46.367                                          |
| 650                                              | 0.1        | 0.33384                      | 3230.8                     | 8.4730                                     | 1.5903                                       | 2.0557                                       | 621.79                   | 1.0020  | 23.496          | 52.049                                          |
| 700                                              | 0.1        | 0.30988                      | 3334.4                     | 8.6264                                     | 1.6222                                       | 2.0867                                       | 643.92                   | 1.0017  | 25.562          | 57.964                                          |
| 750                                              | 0.1        | 0.28915                      | 3439.5                     | 8.7715                                     | 1.6553                                       | 2.1191                                       | 665.11                   | 1.0015  | 27.617          | 64.083                                          |
| 800                                              | 0.1        | 0.27102                      | 3546.3                     | 8.9093                                     | 1.6892                                       | 2.1525                                       | 685.47                   | 1.0013  | 29.657          | 70.385                                          |
| 900                                              | 0.1        | 0.24085                      | 3765.0                     | 9.1668                                     | 1.7589                                       | 2.2216                                       | 724.03                   | 1.0011  | 33.680          | 83.466                                          |
| 1000                                             | 0.1        | 0.21673                      | 3990.7                     | 9.4045                                     | 1.8297                                       | 2.2921                                       | 760.17                   | 1.00088 | 37.615          | 97.085                                          |
| 1100                                             | 0.1        | 0.19701                      | 4223.4                     | 9.6263                                     | 1.9000                                       | 2.3621                                       | 794.33                   | 1.00074 | 41.453          | 111.15                                          |
| 1200                                             | 0.1        | 0.18058                      | 4463.0                     | 9.8348                                     | 1.9682                                       | 2.4302                                       | 826.85                   | 1.00063 | 45.192          | 125.58                                          |
| <b><math>P = 1 \text{ MPa (10 bar)}</math></b>   |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 273.16                                           | 1.0        | 1000.3                       | 1.0180                     | 0.000066                                   | 4.2127                                       | 4.2150                                       | 1403.9                   | 87.937  | 1789.1          | 561.59                                          |
| 280                                              | 1.0        | 1000.3                       | 29.783                     | 0.10407                                    | 4.1960                                       | 4.1973                                       | 1435.7                   | 85.228  | 1432.5          | 574.54                                          |
| 300                                              | 1.0        | 996.96                       | 113.48                     | 0.39281                                    | 4.1272                                       | 4.1781                                       | 1503.0                   | 77.781  | 853.66          | 610.73                                          |
| 320                                              | 1.0        | 989.82                       | 197.03                     | 0.66242                                    | 4.0390                                       | 4.1784                                       | 1540.5                   | 70.967  | 576.89          | 640.16                                          |
| 340                                              | 1.0        | 979.93                       | 280.67                     | 0.91594                                    | 3.9395                                       | 4.1863                                       | 1555.7                   | 64.734  | 421.86          | 661.02                                          |
| 360                                              | 1.0        | 967.81                       | 364.52                     | 1.1556                                     | 3.8353                                       | 4.2004                                       | 1553.9                   | 59.035  | 326.10          | 674.24                                          |
| 380                                              | 1.0        | 953.74                       | 448.73                     | 1.3832                                     | 3.7315                                       | 4.2220                                       | 1538.4                   | 53.827  | 262.82          | 681.49                                          |
| 400                                              | 1.0        | 937.87                       | 533.47                     | 1.6005                                     | 3.6315                                       | 4.2535                                       | 1511.3                   | 49.065  | 218.82          | 684.10                                          |
| 450                                              | 1.0        | 890.39                       | 749.20                     | 2.1086                                     | 3.4076                                       | 4.3924                                       | 1400.6                   | 38.814  | 153.23          | 674.64                                          |
| 453.028                                          | 1.0        | 887.13                       | 762.52                     | 2.1381                                     | 3.3954                                       | 4.4045                                       | 1392.0                   | 38.258  | 150.49          | 673.37                                          |
| 453.028                                          | 1.0        | 5.1450                       | 2777.1                     | 6.5850                                     | 1.9271                                       | 2.7114                                       | 501.02                   | 1.0430  | 14.981          | 36.428                                          |
| 500                                              | 1.0        | 4.5323                       | 2891.2                     | 6.8250                                     | 1.6699                                       | 2.2795                                       | 535.74                   | 1.0344  | 17.054          | 38.799                                          |
| 550                                              | 1.0        | 4.0581                       | 3001.8                     | 7.0359                                     | 1.6159                                       | 2.1647                                       | 565.75                   | 1.0282  | 19.215          | 42.798                                          |
| 600                                              | 1.0        | 3.6871                       | 3109.0                     | 7.2224                                     | 1.6098                                       | 2.1292                                       | 592.58                   | 1.0236  | 21.349          | 47.636                                          |
| 650                                              | 1.0        | 3.3843                       | 3215.2                     | 7.3925                                     | 1.6227                                       | 2.1254                                       | 617.34                   | 1.0202  | 23.462          | 53.002                                          |
| 700                                              | 1.0        | 3.1305                       | 3321.7                     | 7.5504                                     | 1.6447                                       | 2.1368                                       | 640.55                   | 1.0174  | 25.555          | 58.735                                          |
| 750                                              | 1.0        | 2.9140                       | 3429.0                     | 7.6984                                     | 1.6715                                       | 2.1566                                       | 662.53                   | 1.0153  | 27.628          | 64.745                                          |
| 800                                              | 1.0        | 2.7265                       | 3537.5                     | 7.8384                                     | 1.7014                                       | 2.1816                                       | 683.48                   | 1.0135  | 29.680          | 70.983                                          |
| 900                                              | 1.0        | 2.4174                       | 3758.5                     | 8.0986                                     | 1.7663                                       | 2.2402                                       | 722.85                   | 1.0108  | 33.716          | 84.000                                          |
| 1000                                             | 1.0        | 2.1723                       | 3985.7                     | 8.3380                                     | 1.8346                                       | 2.3048                                       | 759.50                   | 1.0088  | 37.655          | 97.573                                          |
| 1100                                             | 1.0        | 1.9729                       | 4219.5                     | 8.5608                                     | 1.9034                                       | 2.3713                                       | 794.01                   | 1.0074  | 41.494          | 111.57                                          |
| 1200                                             | 1.0        | 1.8074                       | 4460.0                     | 8.7699                                     | 1.9708                                       | 2.4371                                       | 826.77                   | 1.0063  | 45.231          | 125.89                                          |
| <b><math>P = 10 \text{ MPa (100 bar)}</math></b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 273.16                                           | 10.0       | 1004.8                       | 10.111                     | 0.00049                                    | 4.1721                                       | 4.1726                                       | 1418.4                   | 88.311  | 1770.0          | 566.56                                          |
| 280                                              | 10.0       | 1004.7                       | 38.613                     | 0.10355                                    | 4.1593                                       | 4.1622                                       | 1450.3                   | 85.588  | 1422.2          | 579.06                                          |
| 300                                              | 10.0       | 1001.0                       | 121.73                     | 0.39029                                    | 4.0984                                       | 4.1536                                       | 1518.2                   | 78.113  | 852.99          | 614.81                                          |
| 320                                              | 10.0       | 993.70                       | 204.84                     | 0.65846                                    | 4.0157                                       | 4.1580                                       | 1556.4                   | 71.284  | 578.57          | 644.31                                          |
| 340                                              | 10.0       | 983.84                       | 288.08                     | 0.91079                                    | 3.9205                                       | 4.1672                                       | 1572.6                   | 65.044  | 424.17          | 665.40                                          |
| 360                                              | 10.0       | 971.85                       | 371.56                     | 1.1493                                     | 3.8198                                       | 4.1810                                       | 1572.0                   | 59.345  | 328.53          | 678.93                                          |
| 380                                              | 10.0       | 957.99                       | 455.37                     | 1.3759                                     | 3.7188                                       | 4.2013                                       | 1558.0                   | 54.140  | 265.22          | 686.53                                          |
| 400                                              | 10.0       | 942.42                       | 539.67                     | 1.5921                                     | 3.6210                                       | 4.2302                                       | 1532.7                   | 49.385  | 221.17          | 689.57                                          |
| 450                                              | 10.0       | 896.16                       | 753.94                     | 2.0967                                     | 3.4010                                       | 4.3553                                       | 1428.4                   | 39.172  | 155.48          | 681.51                                          |
| 500                                              | 10.0       | 838.02                       | 977.18                     | 2.5669                                     | 3.2211                                       | 4.6022                                       | 1271.3                   | 30.794  | 119.83          | 651.64                                          |
| 550                                              | 10.0       | 761.82                       | 1218.8                     | 3.0270                                     | 3.0865                                       | 5.1407                                       | 1054.6                   | 23.531  | 96.080          | 592.51                                          |
| 584.147                                          | 10.0       | 688.42                       | 1408.1                     | 3.3606                                     | 3.0438                                       | 6.1237                                       | 847.33                   | 18.660  | 81.718          | 526.84                                          |
| 584.147                                          | 10.0       | 55.463                       | 2725.5                     | 5.6160                                     | 3.1065                                       | 7.1408                                       | 472.51                   | 1.4248  | 20.194          | 76.569                                          |
| 600                                              | 10.0       | 49.773                       | 2820.0                     | 5.7756                                     | 2.6239                                       | 5.1365                                       | 503.34                   | 1.3649  | 21.017          | 71.115                                          |
| 650                                              | 10.0       | 40.479                       | 3022.6                     | 6.1009                                     | 2.1103                                       | 3.3968                                       | 562.10                   | 1.2672  | 23.472          | 67.341                                          |
| 700                                              | 10.0       | 35.355                       | 3177.4                     | 6.3305                                     | 1.9338                                       | 2.8741                                       | 602.20                   | 1.2145  | 25.773          | 69.297                                          |
| 750                                              | 10.0       | 31.810                       | 3314.6                     | 6.5200                                     | 1.8625                                       | 2.6452                                       | 634.58                   | 1.1793  | 27.973          | 73.331                                          |

| $T$<br>K                                   | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$    | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|--------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|--------|-----------------|-------------------------------------------------|
| 800                                        | 10.0       | 29.107                       | 3443.7                     | 6.6867                                     | 1.8367                                       | 2.5313                                       | 662.61                   | 1.1536 | 30.101          | 78.476                                          |
| 900                                        | 10.0       | 25.123                       | 3691.6                     | 6.9787                                     | 1.8439                                       | 2.4458                                       | 710.98                   | 1.1182 | 34.201          | 90.516                                          |
| 1000                                       | 10.0       | 22.241                       | 3935.5                     | 7.2357                                     | 1.8843                                       | 2.4397                                       | 753.03                   | 1.0948 | 38.144          | 103.50                                          |
| 1100                                       | 10.0       | 20.017                       | 4180.6                     | 7.4693                                     | 1.9377                                       | 2.4661                                       | 791.02                   | 1.0782 | 41.960          | 116.73                                          |
| 1200                                       | 10.0       | 18.230                       | 4429.2                     | 7.6855                                     | 1.9957                                       | 2.5070                                       | 826.16                   | 1.0659 | 45.663          | 130.00                                          |
| <b><math>P = 100</math> MPa (1000 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |        |                 |                                                 |
| 273.16                                     | 100.0      | 1045.3                       | 95.444                     | -0.0083717                                 | 3.8761                                       | 3.9053                                       | 1575.5                   | 91.834 | 1660.1          | 612.20                                          |
| 280                                        | 100.0      | 1043.6                       | 122.26                     | 0.088571                                   | 3.8869                                       | 3.9328                                       | 1603.8                   | 88.976 | 1367.4          | 621.51                                          |
| 300                                        | 100.0      | 1037.2                       | 201.44                     | 0.36171                                    | 3.8751                                       | 3.9798                                       | 1667.9                   | 81.216 | 859.19          | 654.50                                          |
| 320                                        | 100.0      | 1028.9                       | 281.30                     | 0.61941                                    | 3.8289                                       | 4.0043                                       | 1707.7                   | 74.222 | 599.18          | 684.86                                          |
| 340                                        | 100.0      | 1019.0                       | 361.55                     | 0.86265                                    | 3.7637                                       | 4.0194                                       | 1728.7                   | 67.891 | 448.03          | 707.90                                          |
| 360                                        | 100.0      | 1007.8                       | 442.05                     | 1.0927                                     | 3.6883                                       | 4.0309                                       | 1735.4                   | 62.150 | 352.49          | 724.05                                          |
| 380                                        | 100.0      | 995.37                       | 522.79                     | 1.3110                                     | 3.6089                                       | 4.0427                                       | 1730.9                   | 56.937 | 288.37          | 734.91                                          |
| 400                                        | 100.0      | 981.82                       | 603.78                     | 1.5187                                     | 3.5293                                       | 4.0569                                       | 1717.3                   | 52.201 | 243.33          | 741.80                                          |
| 450                                        | 100.0      | 943.51                       | 807.84                     | 1.9993                                     | 3.3430                                       | 4.1105                                       | 1652.8                   | 42.149 | 175.71          | 745.40                                          |
| 500                                        | 100.0      | 899.21                       | 1015.4                     | 2.4366                                     | 3.1820                                       | 4.1968                                       | 1555.7                   | 34.149 | 139.57          | 730.42                                          |
| 550                                        | 100.0      | 848.78                       | 1228.2                     | 2.8421                                     | 3.0452                                       | 4.3234                                       | 1435.5                   | 27.667 | 117.36          | 696.87                                          |
| 600                                        | 100.0      | 791.49                       | 1448.6                     | 3.2256                                     | 2.9295                                       | 4.5019                                       | 1300.4                   | 22.290 | 101.85          | 645.83                                          |
| 650                                        | 100.0      | 726.21                       | 1679.5                     | 3.5952                                     | 2.8329                                       | 4.7503                                       | 1158.6                   | 17.717 | 89.647          | 580.63                                          |
| 700                                        | 100.0      | 651.77                       | 1925.0                     | 3.9589                                     | 2.7538                                       | 5.0832                                       | 1020.0                   | 13.754 | 79.123          | 510.19                                          |
| 750                                        | 100.0      | 568.52                       | 2188.5                     | 4.3223                                     | 2.6866                                       | 5.4492                                       | 898.84                   | 10.336 | 69.732          | 433.71                                          |
| 800                                        | 100.0      | 482.23                       | 2466.5                     | 4.6811                                     | 2.6169                                       | 5.6108                                       | 813.97                   | 7.5622 | 61.842          | 351.53                                          |
| 900                                        | 100.0      | 343.61                       | 3000.1                     | 5.3104                                     | 2.4386                                       | 4.8879                                       | 765.30                   | 4.2835 | 52.771          | 257.05                                          |
| 1000                                       | 100.0      | 265.45                       | 3440.1                     | 5.7749                                     | 2.2950                                       | 3.9788                                       | 792.50                   | 2.9559 | 50.506          | 232.07                                          |
| 1100                                       | 100.0      | 220.62                       | 3809.8                     | 6.1276                                     | 2.2276                                       | 3.4715                                       | 832.67                   | 2.3472 | 51.089          | 223.70                                          |
| 1200                                       | 100.0      | 191.53                       | 4142.5                     | 6.4172                                     | 2.2098                                       | 3.2098                                       | 872.28                   | 2.0111 | 52.802          | 219.07                                          |

## PERMITTIVITY (DIELECTRIC CONSTANT) OF WATER AT VARIOUS FREQUENCIES

The permittivity of liquid water in the radiofrequency and microwave regions can be represented by the Debye equation (References 1 and 2):

$$\epsilon' = \epsilon_{\infty} + \frac{\epsilon_s - \epsilon_{\infty}}{1 + \omega^2 \tau^2}$$

$$\epsilon'' = \frac{(\epsilon_s - \epsilon_{\infty})\omega\tau}{1 + \omega^2 \tau^2}$$

where  $\epsilon = \epsilon' + i\epsilon''$  is the (complex) relative permittivity (i.e., the absolute permittivity divided by the permittivity of free space  $\epsilon_0 = 8.854 \cdot 10^{-12} \text{ F m}^{-1}$ ). Here  $\epsilon_s$  is the static permittivity (see Reference 3 and the table "Thermophysical Properties of Water and Steam" in this Section);  $\epsilon_{\infty}$  is a parameter describing the permittivity in the high frequency limit;  $\tau$  is the relaxation time for molecular orientation; and  $\omega = 2\pi f$  is the angular frequency. The values in this table have been calculated from parameters given in Reference 2:

|                     | 0 °C  | 25 °C | 50 °C |
|---------------------|-------|-------|-------|
| $\epsilon_{\infty}$ | 5.7   | 5.2   | 4.0   |
| $\tau/\text{ps}$    | 17.67 | 8.27  | 4.75  |

Other useful quantities that can be calculated from the values in the table are the loss tangent:

$$\tan \delta = \epsilon'' / \epsilon'$$

and the absorption coefficient  $\alpha$  which describes the power attenuation per unit length ( $P = P_0 e^{-\alpha l}$ ):

$$\alpha = \frac{\pi f \epsilon''}{c \sqrt{\epsilon'}}$$

and  $c$  is the speed of light. The last equation is valid when  $\epsilon''/\epsilon' \ll 1$ .

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| Frequency | 0 °C        |              | 25 °C       |              | 50 °C       |              |
|-----------|-------------|--------------|-------------|--------------|-------------|--------------|
|           | $\epsilon'$ | $\epsilon''$ | $\epsilon'$ | $\epsilon''$ | $\epsilon'$ | $\epsilon''$ |
| 0         | 87.90       | 0.00         | 78.36       | 0.00         | 69.88       | 0.00         |
| 1 kHz     | 87.90       | 0.00         | 78.36       | 0.00         | 69.88       | 0.00         |
| 1 MHz     | 87.90       | 0.01         | 78.36       | 0.00         | 69.88       | 0.00         |
| 10 MHz    | 87.90       | 0.09         | 78.36       | 0.04         | 69.88       | 0.02         |
| 100 MHz   | 87.89       | 0.91         | 78.36       | 0.38         | 69.88       | 0.20         |
| 200 MHz   | 87.86       | 1.82         | 78.35       | 0.76         | 69.88       | 0.39         |
| 500 MHz   | 87.65       | 4.55         | 78.31       | 1.90         | 69.87       | 0.98         |
| 1 GHz     | 86.90       | 9.01         | 78.16       | 3.79         | 69.82       | 1.96         |
| 2 GHz     | 84.04       | 17.39        | 77.58       | 7.52         | 69.65       | 3.92         |
| 3 GHz     | 79.69       | 24.64        | 76.62       | 11.13        | 69.36       | 5.85         |
| 4 GHz     | 74.36       | 30.49        | 75.33       | 14.58        | 68.95       | 7.75         |
| 5 GHz     | 68.54       | 34.88        | 73.73       | 17.81        | 68.45       | 9.62         |
| 10 GHz    | 42.52       | 40.88        | 62.81       | 29.93        | 64.49       | 18.05        |
| 20 GHz    | 19.56       | 30.78        | 40.37       | 36.55        | 52.57       | 28.99        |
| 30 GHz    | 12.50       | 22.64        | 26.53       | 33.25        | 40.57       | 32.74        |
| 40 GHz    | 9.67        | 17.62        | 18.95       | 28.58        | 31.17       | 32.43        |
| 50 GHz    | 8.28        | 14.34        | 14.64       | 24.53        | 24.42       | 30.47        |

# THERMOPHYSICAL PROPERTIES OF FLUIDS

Eric W. Lemmon

These tables give thermodynamic and transport properties of a variety of fluids, as generated from the equations of state presented in the references below. The properties tabulated are pressure ( $P$ ), density ( $\rho$ ), enthalpy ( $H$ ), entropy ( $S$ ), isochoric heat capacity ( $C_v$ ), isobaric heat capacity ( $C_p$ ), speed of sound ( $u$ ), viscosity ( $\eta$ ), thermal conductivity ( $\lambda$ ), and static dielectric constant ( $D$ ). All extensive properties are given on a mass basis. Not all properties are included for every substance. The references should be consulted for information on the uncertainties.

Values are given first along the saturation line. The first two points are the properties at the triple point. The final line gives the properties at the critical point. Two lines are given for each temperature (except at the critical point); the first line gives the values of the liquid phase (note the high density) and the second line gives the values of the vapor phase (at low densities). Following the saturation tables, values are given as a function of temperature for several isobars. A duplicate entry in the isobar section indicates a phase transition (liquid–vapor) at that temperature; property values are then given for both phases. The phase can be determined by noting the sharp decrease in density between two successive temperature entries; all lines above this point refer to the liquid phase, and all lines below refer to the gas phase. If there is no sharp discontinuity in density, all data in the table refer to the supercritical region (*i.e.*, the isobar is above the critical pressure). If the first temperature in the isobars is not an integer, this state point refers to the properties of the liquid at the melting line.

All temperatures are given on ITS-90, except those for oxygen (Ref. 16) and helium (Ref. 13), where the source equations of state still use the IPTS-68 temperature scale. Nitrogen, oxygen, and argon use a reference state based on zero enthalpy in the gas phase at 0 K; parahydrogen, helium, methane, and ethane use a reference state of zero enthalpy and entropy at the saturated liquid state at the normal boiling point; and propane and carbon dioxide use a reference state of 200 kJ kg<sup>-1</sup> and 1 kJ kg<sup>-1</sup> K<sup>-1</sup>, respectively, at -40 °C. Additional calculations at state points not listed below and for fluids not contained here can be obtained at the NIST Chemistry WebBook website ([webbook.nist.gov/chemistry/fluid/](http://webbook.nist.gov/chemistry/fluid/)), or by using the NIST Standard Reference Data program REFPROP (Ref. 9).

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Nitrogen (N<sub>2</sub>)

| $T$<br>K                   | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|----------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b>Saturation</b>          |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 63.15                      | 0.01252    | 867.2                        | -150.7                     | 2.426                                      | 1.176                                        | 2.000                                        | 995.3                    | 1.47003 | 311.6           | 173.2                                           |
| 63.15                      | 0.01252    | 0.6743                       | 64.78                      | 5.838                                      | 0.7499                                       | 1.058                                        | 161.1                    | 1.00032 | 4.376           | 5.621                                           |
| 70                         | 0.03854    | 838.5                        | -137.0                     | 2.632                                      | 1.130                                        | 2.014                                        | 925.7                    | 1.45241 | 220.2           | 159.5                                           |
| 70                         | 0.03854    | 1.896                        | 71.10                      | 5.605                                      | 0.7580                                       | 1.082                                        | 168.4                    | 1.00089 | 4.883           | 6.355                                           |
| 80                         | 0.1369     | 793.9                        | -116.6                     | 2.903                                      | 1.069                                        | 2.056                                        | 824.4                    | 1.42541 | 145.1           | 139.5                                           |
| 80                         | 0.1369     | 6.089                        | 79.10                      | 5.349                                      | 0.7773                                       | 1.145                                        | 176.7                    | 1.00286 | 5.652           | 7.506                                           |
| 90                         | 0.3605     | 745.0                        | -95.52                     | 3.147                                      | 1.020                                        | 2.141                                        | 719.0                    | 1.39622 | 102.8           | 119.8                                           |
| 90                         | 0.3605     | 15.08                        | 84.97                      | 5.153                                      | 0.8078                                       | 1.266                                        | 181.8                    | 1.00710 | 6.482           | 8.868                                           |
| 100                        | 0.7783     | 689.4                        | -73.21                     | 3.376                                      | 0.9832                                       | 2.318                                        | 605.2                    | 1.36351 | 75.76           | 100.1                                           |
| 100                        | 0.7783     | 31.96                        | 87.77                      | 4.986                                      | 0.8548                                       | 1.503                                        | 183.3                    | 1.01510 | 7.429           | 10.73                                           |
| 110                        | 1.466      | 621.5                        | -48.49                     | 3.601                                      | 0.9667                                       | 2.743                                        | 476.4                    | 1.32430 | 55.99           | 80.44                                           |
| 110                        | 1.466      | 62.58                        | 85.84                      | 4.823                                      | 0.9284                                       | 2.062                                        | 180.8                    | 1.02974 | 8.626           | 13.83                                           |
| 120                        | 2.511      | 523.4                        | -17.87                     | 3.851                                      | 1.011                                        | 4.508                                        | 317.3                    | 1.26895 | 38.43           | 61.01                                           |
| 120                        | 2.511      | 125.1                        | 74.17                      | 4.618                                      | 1.099                                        | 4.631                                        | 172.6                    | 1.06012 | 10.62           | 21.72                                           |
| 126.19                     | 3.396      | 313.3                        | 29.23                      | 4.215                                      |                                              |                                              |                          | 1.15559 | 18.30           |                                                 |
| <b>P = 0.1 MPa (1 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 63.17                      | 0.1        | 867.3                        | -150.6                     | 2.426                                      | 1.176                                        | 2.000                                        | 995.6                    | 1.47007 | 311.6           | 173.3                                           |
| 77.24                      | 0.1        | 806.6                        | -122.2                     | 2.831                                      | 1.085                                        | 2.041                                        | 852.5                    | 1.43304 | 161.4           | 145.0                                           |
| 77.24                      | 0.1        | 4.556                        | 77.07                      | 5.412                                      | 0.7710                                       | 1.123                                        | 174.7                    | 1.00214 | 5.435           | 7.174                                           |
| 80                         | 0.1        | 4.379                        | 80.15                      | 5.451                                      | 0.7666                                       | 1.112                                        | 178.3                    | 1.00206 | 5.623           | 7.443                                           |
| 100                        | 0.1        | 3.437                        | 101.9                      | 5.694                                      | 0.7514                                       | 1.071                                        | 201.6                    | 1.00162 | 6.958           | 9.381                                           |
| 120                        | 0.1        | 2.840                        | 123.2                      | 5.888                                      | 0.7466                                       | 1.057                                        | 222.0                    | 1.00133 | 8.244           | 11.27                                           |
| 140                        | 0.1        | 2.424                        | 144.2                      | 6.050                                      | 0.7447                                       | 1.050                                        | 240.4                    | 1.00114 | 9.480           | 13.11                                           |
| 160                        | 0.1        | 2.116                        | 165.2                      | 6.190                                      | 0.7438                                       | 1.047                                        | 257.3                    | 1.00099 | 10.67           | 14.89                                           |
| 180                        | 0.1        | 1.878                        | 186.1                      | 6.313                                      | 0.7433                                       | 1.045                                        | 273.2                    | 1.00088 | 11.81           | 16.61                                           |
| 200                        | 0.1        | 1.688                        | 207.0                      | 6.423                                      | 0.7430                                       | 1.043                                        | 288.1                    | 1.00079 | 12.91           | 18.28                                           |
| 220                        | 0.1        | 1.534                        | 227.9                      | 6.523                                      | 0.7429                                       | 1.043                                        | 302.3                    | 1.00072 | 13.97           | 19.90                                           |
| 240                        | 0.1        | 1.405                        | 248.7                      | 6.613                                      | 0.7428                                       | 1.042                                        | 315.8                    | 1.00066 | 15.00           | 21.48                                           |
| 260                        | 0.1        | 1.297                        | 269.5                      | 6.697                                      | 0.7428                                       | 1.042                                        | 328.7                    | 1.00061 | 15.99           | 23.01                                           |
| 280                        | 0.1        | 1.204                        | 290.4                      | 6.774                                      | 0.7429                                       | 1.041                                        | 341.2                    | 1.00057 | 16.96           | 24.51                                           |
| 300                        | 0.1        | 1.123                        | 311.2                      | 6.846                                      | 0.7432                                       | 1.041                                        | 353.2                    | 1.00053 | 17.89           | 25.97                                           |
| 320                        | 0.1        | 1.053                        | 332.0                      | 6.913                                      | 0.7436                                       | 1.042                                        | 364.7                    | 1.00049 | 18.80           | 27.39                                           |
| 340                        | 0.1        | 0.9909                       | 352.9                      | 6.976                                      | 0.7441                                       | 1.042                                        | 375.9                    | 1.00047 | 19.68           | 28.79                                           |
| 360                        | 0.1        | 0.9357                       | 373.7                      | 7.036                                      | 0.7450                                       | 1.043                                        | 386.8                    | 1.00044 | 20.55           | 30.15                                           |
| 400                        | 0.1        | 0.8421                       | 415.5                      | 7.146                                      | 0.7475                                       | 1.045                                        | 407.5                    | 1.00040 | 22.21           | 32.81                                           |
| 500                        | 0.1        | 0.6736                       | 520.5                      | 7.380                                      | 0.7592                                       | 1.056                                        | 454.6                    | 1.00032 | 26.06           | 39.04                                           |
| 600                        | 0.1        | 0.5613                       | 627.0                      | 7.574                                      | 0.7781                                       | 1.075                                        | 496.3                    | 1.00026 | 29.58           | 44.84                                           |
| 700                        | 0.1        | 0.4811                       | 735.6                      | 7.741                                      | 0.8011                                       | 1.098                                        | 533.9                    | 1.00023 | 32.83           | 50.31                                           |
| 800                        | 0.1        | 0.4210                       | 846.6                      | 7.890                                      | 0.8254                                       | 1.122                                        | 568.4                    | 1.00020 | 35.89           | 55.51                                           |
| 900                        | 0.1        | 0.3742                       | 960.0                      | 8.023                                      | 0.8488                                       | 1.146                                        | 600.7                    | 1.00018 | 38.78           | 60.52                                           |
| 1000                       | 0.1        | 0.3368                       | 1076.                      | 8.145                                      | 0.8705                                       | 1.167                                        | 631.1                    | 1.00016 | 41.54           | 65.36                                           |
| <b>P = 1 MPa (10 bar)</b>  |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 63.37                      | 1.0        | 868.0                        | -149.5                     | 2.427                                      | 1.177                                        | 1.995                                        | 998.9                    | 1.47049 | 311.8           | 173.6                                           |
| 80                         | 1.0        | 796.3                        | -116.0                     | 2.896                                      | 1.071                                        | 2.044                                        | 832.3                    | 1.42683 | 147.3           | 140.5                                           |
| 100                        | 1.0        | 690.8                        | -73.18                     | 3.373                                      | 0.9833                                       | 2.305                                        | 609.4                    | 1.36432 | 76.26           | 100.6                                           |
| 103.75                     | 1.0        | 665.8                        | -64.33                     | 3.460                                      | 0.9739                                       | 2.431                                        | 559.2                    | 1.34984 | 67.78           | 92.74                                           |
| 103.75                     | 1.0        | 41.33                        | 87.73                      | 4.926                                      | 0.8786                                       | 1.652                                        | 182.8                    | 1.01956 | 7.835           | 11.67                                           |
| 120                        | 1.0        | 32.10                        | 110.9                      | 5.134                                      | 0.7980                                       | 1.297                                        | 208.9                    | 1.01517 | 8.714           | 12.49                                           |
| 140                        | 1.0        | 26.01                        | 135.5                      | 5.324                                      | 0.7701                                       | 1.177                                        | 232.8                    | 1.01227 | 9.844           | 14.00                                           |
| 160                        | 1.0        | 22.11                        | 158.5                      | 5.477                                      | 0.7588                                       | 1.127                                        | 252.9                    | 1.01043 | 10.96           | 15.60                                           |
| 180                        | 1.0        | 19.33                        | 180.7                      | 5.608                                      | 0.7531                                       | 1.101                                        | 270.6                    | 1.00911 | 12.06           | 17.21                                           |
| 200                        | 1.0        | 17.21                        | 202.6                      | 5.723                                      | 0.7500                                       | 1.085                                        | 286.9                    | 1.00811 | 13.13           | 18.81                                           |
| 220                        | 1.0        | 15.54                        | 224.2                      | 5.826                                      | 0.7480                                       | 1.075                                        | 301.9                    | 1.00732 | 14.16           | 20.37                                           |
| 240                        | 1.0        | 14.17                        | 245.6                      | 5.919                                      | 0.7468                                       | 1.067                                        | 316.1                    | 1.00667 | 15.17           | 21.90                                           |
| 260                        | 1.0        | 13.04                        | 266.9                      | 6.005                                      | 0.7460                                       | 1.062                                        | 329.5                    | 1.00614 | 16.14           | 23.39                                           |



| $T$<br>K                                 | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 280                                      | 1.0        | 12.07                        | 288.1                      | 6.083                                      | 0.7456                                       | 1.059                                        | 342.4                    | 1.00569 | 17.09           | 24.86                                           |
| 300                                      | 1.0        | 11.25                        | 309.2                      | 6.156                                      | 0.7454                                       | 1.056                                        | 354.6                    | 1.00530 | 18.01           | 26.29                                           |
| 320                                      | 1.0        | 10.53                        | 330.3                      | 6.224                                      | 0.7455                                       | 1.054                                        | 366.4                    | 1.00496 | 18.91           | 27.69                                           |
| 340                                      | 1.0        | 9.901                        | 351.4                      | 6.288                                      | 0.7458                                       | 1.053                                        | 377.8                    | 1.00466 | 19.79           | 29.07                                           |
| 360                                      | 1.0        | 9.343                        | 372.4                      | 6.348                                      | 0.7464                                       | 1.052                                        | 388.8                    | 1.00440 | 20.64           | 30.42                                           |
| 400                                      | 1.0        | 8.399                        | 414.5                      | 6.459                                      | 0.7486                                       | 1.052                                        | 409.7                    | 1.00395 | 22.29           | 33.04                                           |
| 500                                      | 1.0        | 6.711                        | 520.1                      | 6.695                                      | 0.7600                                       | 1.061                                        | 457.0                    | 1.00316 | 26.13           | 39.23                                           |
| 600                                      | 1.0        | 5.592                        | 627.0                      | 6.889                                      | 0.7786                                       | 1.078                                        | 498.7                    | 1.00263 | 29.63           | 44.99                                           |
| 700                                      | 1.0        | 4.793                        | 735.8                      | 7.057                                      | 0.8015                                       | 1.100                                        | 536.2                    | 1.00226 | 32.87           | 50.43                                           |
| 800                                      | 1.0        | 4.195                        | 847.0                      | 7.206                                      | 0.8257                                       | 1.124                                        | 570.7                    | 1.00197 | 35.92           | 55.63                                           |
| 900                                      | 1.0        | 3.730                        | 960.6                      | 7.339                                      | 0.8492                                       | 1.147                                        | 602.9                    | 1.00176 | 38.81           | 60.62                                           |
| 1000                                     | 1.0        | 3.358                        | 1076.                      | 7.461                                      | 0.8708                                       | 1.168                                        | 633.2                    | 1.00158 | 41.57           | 65.45                                           |
| <b><math>P = 10</math> MPa (100 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 65.32                                    | 10.0       | 875.0                        | -138.3                     | 2.441                                      | 1.186                                        | 1.955                                        | 1031.                    | 1.47447 | 314.0           | 177.1                                           |
| 80                                       | 10.0       | 818.4                        | -109.6                     | 2.837                                      | 1.093                                        | 1.960                                        | 904.1                    | 1.43984 | 169.0           | 150.4                                           |
| 100                                      | 10.0       | 733.6                        | -69.89                     | 3.280                                      | 0.9997                                       | 2.022                                        | 734.2                    | 1.38918 | 93.65           | 115.9                                           |
| 120                                      | 10.0       | 632.9                        | -27.82                     | 3.663                                      | 0.9401                                       | 2.218                                        | 559.6                    | 1.33060 | 58.57           | 84.11                                           |
| 140                                      | 10.0       | 499.8                        | 20.66                      | 4.036                                      | 0.9127                                       | 2.676                                        | 392.0                    | 1.25566 | 36.11           | 57.60                                           |
| 160                                      | 10.0       | 344.2                        | 76.44                      | 4.408                                      | 0.8849                                       | 2.668                                        | 300.8                    | 1.17162 | 22.40           | 40.20                                           |
| 180                                      | 10.0       | 248.7                        | 122.6                      | 4.681                                      | 0.8407                                       | 1.990                                        | 294.7                    | 1.12203 | 18.50           | 32.06                                           |
| 200                                      | 10.0       | 199.4                        | 158.4                      | 4.870                                      | 0.8107                                       | 1.628                                        | 307.7                    | 1.09701 | 17.70           | 29.38                                           |
| 220                                      | 10.0       | 169.4                        | 188.9                      | 5.015                                      | 0.7927                                       | 1.445                                        | 323.2                    | 1.08198 | 17.74           | 28.72                                           |
| 240                                      | 10.0       | 148.8                        | 216.7                      | 5.136                                      | 0.7813                                       | 1.340                                        | 338.4                    | 1.07172 | 18.13           | 28.87                                           |
| 260                                      | 10.0       | 133.4                        | 242.8                      | 5.240                                      | 0.7737                                       | 1.273                                        | 352.9                    | 1.06415 | 18.67           | 29.39                                           |
| 280                                      | 10.0       | 121.4                        | 267.7                      | 5.333                                      | 0.7685                                       | 1.227                                        | 366.6                    | 1.05827 | 19.29           | 30.21                                           |
| 300                                      | 10.0       | 111.7                        | 291.9                      | 5.417                                      | 0.7649                                       | 1.195                                        | 379.5                    | 1.05351 | 19.96           | 31.14                                           |
| 320                                      | 10.0       | 103.6                        | 315.6                      | 5.493                                      | 0.7623                                       | 1.171                                        | 391.8                    | 1.04958 | 20.66           | 32.13                                           |
| 340                                      | 10.0       | 96.80                        | 338.8                      | 5.563                                      | 0.7606                                       | 1.153                                        | 403.6                    | 1.04625 | 21.37           | 33.16                                           |
| 360                                      | 10.0       | 90.89                        | 361.7                      | 5.629                                      | 0.7596                                       | 1.138                                        | 414.8                    | 1.04338 | 22.08           | 34.21                                           |
| 400                                      | 10.0       | 81.19                        | 406.8                      | 5.748                                      | 0.7593                                       | 1.119                                        | 436.0                    | 1.03869 | 23.51           | 36.35                                           |
| 500                                      | 10.0       | 64.50                        | 517.5                      | 5.995                                      | 0.7672                                       | 1.100                                        | 483.1                    | 1.03065 | 26.99           | 41.73                                           |
| 600                                      | 10.0       | 53.74                        | 627.6                      | 6.195                                      | 0.7841                                       | 1.104                                        | 523.9                    | 1.02549 | 30.28           | 47.00                                           |
| 700                                      | 10.0       | 46.15                        | 738.7                      | 6.367                                      | 0.8059                                       | 1.118                                        | 560.4                    | 1.02187 | 33.40           | 52.10                                           |
| 800                                      | 10.0       | 40.49                        | 851.4                      | 6.517                                      | 0.8294                                       | 1.137                                        | 593.8                    | 1.01917 | 36.35           | 57.04                                           |
| 900                                      | 10.0       | 36.08                        | 966.1                      | 6.652                                      | 0.8523                                       | 1.157                                        | 625.0                    | 1.01708 | 39.17           | 61.85                                           |
| 1000                                     | 10.0       | 32.56                        | 1083.                      | 6.775                                      | 0.8735                                       | 1.176                                        | 654.4                    | 1.01540 | 41.88           | 66.54                                           |

Oxygen (O<sub>2</sub>)

| $T$<br>K          | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b>Saturation</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 54.36             | 0.0001463  | 1306.                        | -193.6                     | 2.092                                      | 1.195                                        | 1.673                                        | 1123                     | 1.56799 | 773.6           | 201.9                                           |
| 54.36             | 0.0001463  | 0.01036                      | 49.11                      | 6.557                                      | 0.6638                                       | 0.9260                                       | 140.3                    | 1.00000 | 4.096           | 4.420                                           |
| 60                | 0.0007258  | 1282.                        | -184.2                     | 2.257                                      | 1.089                                        | 1.673                                        | 1127.                    | 1.55615 | 578.1           | 193.9                                           |
| 60                | 0.0007258  | 0.04659                      | 54.19                      | 6.230                                      | 0.6817                                       | 0.9475                                       | 147.0                    | 1.00002 | 4.553           | 4.984                                           |
| 70                | 0.006262   | 1237.                        | -167.4                     | 2.516                                      | 1.017                                        | 1.678                                        | 1066.                    | 1.53399 | 371.8           | 179.7                                           |
| 70                | 0.006262   | 0.3457                       | 63.09                      | 5.809                                      | 0.7052                                       | 0.9780                                       | 158.1                    | 1.00013 | 5.356           | 5.992                                           |
| 80                | 0.03012    | 1190.                        | -150.6                     | 2.740                                      | 0.9697                                       | 1.682                                        | 987.4                    | 1.51120 | 261.2           | 165.4                                           |
| 80                | 0.03012    | 1.468                        | 71.69                      | 5.519                                      | 0.6950                                       | 0.9743                                       | 168.4                    | 1.00054 | 6.149           | 7.028                                           |
| 90                | 0.09935    | 1142.                        | -133.7                     | 2.938                                      | 0.9296                                       | 1.699                                        | 905.9                    | 1.48766 | 195.6           | 151.0                                           |
| 90                | 0.09935    | 4.387                        | 79.55                      | 5.308                                      | 0.6758                                       | 0.9705                                       | 177.3                    | 1.00163 | 6.936           | 8.124                                           |
| 100               | 0.2540     | 1091.                        | -116.4                     | 3.118                                      | 0.8949                                       | 1.738                                        | 822.2                    | 1.46295 | 152.6           | 136.6                                           |
| 100               | 0.2540     | 10.42                        | 86.16                      | 5.144                                      | 0.6752                                       | 1.006                                        | 184.1                    | 1.00387 | 7.728           | 9.336                                           |
| 110               | 0.5434     | 1035.                        | -98.64                     | 3.286                                      | 0.8658                                       | 1.807                                        | 734.8                    | 1.43650 | 121.5           | 121.9                                           |
| 110               | 0.5434     | 21.28                        | 91.05                      | 5.010                                      | 0.6988                                       | 1.101                                        | 188.1                    | 1.00791 | 8.547           | 10.75                                           |
| 120               | 1.022      | 973.9                        | -79.90                     | 3.444                                      | 0.8430                                       | 1.927                                        | 641.5                    | 1.40746 | 97.43           | 107.2                                           |
| 120               | 1.022      | 39.31                        | 93.75                      | 4.892                                      | 0.7415                                       | 1.276                                        | 189.4                    | 1.01465 | 9.427           | 12.51                                           |

| $T$<br>K                                | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 130                                     | 1.749      | 902.5                        | -59.66                     | 3.600                                      | 0.8293                                       | 2.153                                        | 539.5                    | 1.37432 | 77.57           | 92.63                                           |
| 130                                     | 1.749      | 68.37                        | 93.47                      | 4.778                                      | 0.8002                                       | 1.600                                        | 187.8                    | 1.02558 | 10.45           | 14.94                                           |
| 140                                     | 2.788      | 813.2                        | -36.70                     | 3.761                                      | 0.8323                                       | 2.691                                        | 423.1                    | 1.33363 | 60.22           | 78.22                                           |
| 140                                     | 2.788      | 116.8                        | 88.47                      | 4.655                                      | 0.8834                                       | 2.370                                        | 182.8                    | 1.04395 | 11.82           | 18.98                                           |
| 150                                     | 4.219      | 675.5                        | -6.671                     | 3.955                                      | 0.9057                                       | 5.464                                        | 273.8                    | 1.27248 | 42.90           | 64.19                                           |
| 150                                     | 4.219      | 214.9                        | 72.56                      | 4.483                                      | 1.049                                        | 6.625                                        | 172.8                    | 1.08192 | 14.72           | 29.67                                           |
| 154.58                                  | 5.043      | 436.1                        | 32.42                      | 4.201                                      |                                              |                                              |                          | 1.17084 | 24.84           |                                                 |
| <b><math>P = 0.1</math> MPa (1 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 54.37                                   | 0.1        | 1306.                        | -193.5                     | 2.092                                      | 1.195                                        | 1.673                                        | 1124.                    | 1.56802 | 773.8           | 201.9                                           |
| 60                                      | 0.1        | 1282.                        | -184.1                     | 2.257                                      | 1.089                                        | 1.673                                        | 1128.                    | 1.55621 | 578.5           | 194.0                                           |
| 80                                      | 0.1        | 1191.                        | -150.6                     | 2.739                                      | 0.9699                                       | 1.681                                        | 987.7                    | 1.51126 | 261.4           | 165.5                                           |
| 90.06                                   | 0.1        | 1142.                        | -133.6                     | 2.939                                      | 0.9293                                       | 1.699                                        | 905.4                    | 1.48751 | 195.3           | 151.0                                           |
| 90.06                                   | 0.1        | 4.413                        | 79.60                      | 5.307                                      | 0.6757                                       | 0.9705                                       | 177.4                    | 1.00164 | 6.940           | 8.131                                           |
| 100                                     | 0.1        | 3.941                        | 88.99                      | 5.405                                      | 0.6527                                       | 0.9352                                       | 188.4                    | 1.00146 | 7.712           | 9.085                                           |
| 120                                     | 0.1        | 3.252                        | 107.6                      | 5.575                                      | 0.6543                                       | 0.9280                                       | 207.3                    | 1.00121 | 9.219           | 10.99                                           |
| 140                                     | 0.1        | 2.774                        | 126.1                      | 5.718                                      | 0.6530                                       | 0.9218                                       | 224.6                    | 1.00103 | 10.67           | 12.86                                           |
| 160                                     | 0.1        | 2.420                        | 144.5                      | 5.841                                      | 0.6519                                       | 0.9180                                       | 240.5                    | 1.00090 | 12.07           | 14.69                                           |
| 180                                     | 0.1        | 2.147                        | 162.8                      | 5.949                                      | 0.6513                                       | 0.9158                                       | 255.4                    | 1.00080 | 13.41           | 16.48                                           |
| 200                                     | 0.1        | 1.930                        | 181.1                      | 6.045                                      | 0.6512                                       | 0.9146                                       | 269.3                    | 1.00072 | 14.72           | 18.24                                           |
| 220                                     | 0.1        | 1.753                        | 199.4                      | 6.132                                      | 0.6516                                       | 0.9142                                       | 282.6                    | 1.00065 | 15.98           | 19.95                                           |
| 240                                     | 0.1        | 1.606                        | 217.7                      | 6.212                                      | 0.6525                                       | 0.9146                                       | 295.2                    | 1.00060 | 17.20           | 21.64                                           |
| 260                                     | 0.1        | 1.482                        | 236.0                      | 6.285                                      | 0.6539                                       | 0.9156                                       | 307.2                    | 1.00055 | 18.38           | 23.28                                           |
| 280                                     | 0.1        | 1.376                        | 254.3                      | 6.353                                      | 0.6560                                       | 0.9174                                       | 318.7                    | 1.00051 | 19.53           | 24.90                                           |
| 300                                     | 0.1        | 1.284                        | 272.7                      | 6.416                                      | 0.6587                                       | 0.9199                                       | 329.7                    | 1.00048 | 20.65           | 26.49                                           |
| 320                                     | 0.1        | 1.203                        | 291.1                      | 6.476                                      | 0.6621                                       | 0.9231                                       | 340.3                    | 1.00045 | 21.74           | 28.04                                           |
| 340                                     | 0.1        | 1.132                        | 309.6                      | 6.532                                      | 0.6661                                       | 0.9269                                       | 350.5                    | 1.00042 | 22.80           | 29.58                                           |
| 360                                     | 0.1        | 1.069                        | 328.2                      | 6.585                                      | 0.6707                                       | 0.9313                                       | 360.4                    | 1.00040 | 23.84           | 31.08                                           |
| 400                                     | 0.1        | 0.9622                       | 365.7                      | 6.684                                      | 0.6812                                       | 0.9416                                       | 379.0                    | 1.00036 | 25.84           | 34.03                                           |
| 500                                     | 0.1        | 0.7696                       | 461.3                      | 6.897                                      | 0.7119                                       | 0.9722                                       | 421.3                    | 1.00029 | 30.49           | 41.05                                           |
| 600                                     | 0.1        | 0.6413                       | 560.1                      | 7.077                                      | 0.7432                                       | 1.003                                        | 458.9                    | 1.00024 | 34.73           | 47.66                                           |
| 700                                     | 0.1        | 0.5497                       | 661.9                      | 7.234                                      | 0.7710                                       | 1.031                                        | 493.3                    | 1.00020 | 38.65           | 53.97                                           |
| 800                                     | 0.1        | 0.4809                       | 766.2                      | 7.373                                      | 0.7945                                       | 1.055                                        | 525.4                    | 1.00018 | 42.33           | 60.02                                           |
| 900                                     | 0.1        | 0.4275                       | 872.6                      | 7.498                                      | 0.8140                                       | 1.074                                        | 555.6                    | 1.00016 | 45.81           | 65.87                                           |
| 1000                                    | 0.1        | 0.3848                       | 980.9                      | 7.612                                      | 0.8301                                       | 1.090                                        | 584.3                    | 1.00014 | 49.12           | 71.55                                           |
| <b><math>P = 1</math> MPa (10 bar)</b>  |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 54.47                                   | 1.0        | 1307.                        | -192.8                     | 2.093                                      | 1.190                                        | 1.669                                        | 1127.                    | 1.56831 | 775.0           | 202.1                                           |
| 60                                      | 1.0        | 1283.                        | -183.6                     | 2.254                                      | 1.089                                        | 1.671                                        | 1130.                    | 1.55674 | 582.7           | 194.3                                           |
| 80                                      | 1.0        | 1192.                        | -150.1                     | 2.736                                      | 0.9716                                       | 1.679                                        | 991.1                    | 1.51204 | 263.6           | 166.0                                           |
| 100                                     | 1.0        | 1093.                        | -116.1                     | 3.115                                      | 0.8964                                       | 1.731                                        | 826.8                    | 1.46397 | 153.9           | 137.2                                           |
| 119.62                                  | 1.0        | 976.3                        | -80.64                     | 3.438                                      | 0.8438                                       | 1.921                                        | 645.2                    | 1.40862 | 98.25           | 107.8                                           |
| 119.62                                  | 1.0        | 38.46                        | 93.70                      | 4.896                                      | 0.7396                                       | 1.268                                        | 189.4                    | 1.01433 | 9.392           | 12.43                                           |
| 120                                     | 1.0        | 38.25                        | 94.18                      | 4.900                                      | 0.7355                                       | 1.257                                        | 190.0                    | 1.01425 | 9.421           | 12.45                                           |
| 140                                     | 1.0        | 30.39                        | 116.8                      | 5.075                                      | 0.6851                                       | 1.065                                        | 214.2                    | 1.01131 | 10.89           | 13.90                                           |
| 160                                     | 1.0        | 25.65                        | 137.5                      | 5.213                                      | 0.6708                                       | 1.005                                        | 233.7                    | 1.00954 | 12.29           | 15.54                                           |
| 180                                     | 1.0        | 22.33                        | 157.2                      | 5.329                                      | 0.6631                                       | 0.9743                                       | 250.8                    | 1.00831 | 13.64           | 17.21                                           |
| 200                                     | 1.0        | 19.84                        | 176.5                      | 5.431                                      | 0.6590                                       | 0.9568                                       | 266.3                    | 1.00738 | 14.94           | 18.88                                           |
| 220                                     | 1.0        | 17.88                        | 195.5                      | 5.521                                      | 0.6571                                       | 0.9462                                       | 280.6                    | 1.00665 | 16.20           | 20.53                                           |
| 240                                     | 1.0        | 16.30                        | 214.4                      | 5.603                                      | 0.6566                                       | 0.9397                                       | 294.0                    | 1.00606 | 17.41           | 22.15                                           |
| 260                                     | 1.0        | 14.98                        | 233.1                      | 5.678                                      | 0.6572                                       | 0.9359                                       | 306.6                    | 1.00557 | 18.59           | 23.76                                           |
| 280                                     | 1.0        | 13.86                        | 251.8                      | 5.748                                      | 0.6586                                       | 0.9342                                       | 318.5                    | 1.00515 | 19.73           | 25.34                                           |
| 300                                     | 1.0        | 12.91                        | 270.5                      | 5.812                                      | 0.6609                                       | 0.9340                                       | 329.9                    | 1.00480 | 20.85           | 26.89                                           |
| 320                                     | 1.0        | 12.08                        | 289.2                      | 5.872                                      | 0.6640                                       | 0.9351                                       | 340.8                    | 1.00449 | 21.93           | 28.43                                           |
| 340                                     | 1.0        | 11.35                        | 307.9                      | 5.929                                      | 0.6677                                       | 0.9373                                       | 351.2                    | 1.00422 | 22.99           | 29.93                                           |
| 360                                     | 1.0        | 10.71                        | 326.7                      | 5.983                                      | 0.6720                                       | 0.9404                                       | 361.2                    | 1.00398 | 24.02           | 31.42                                           |
| 400                                     | 1.0        | 9.623                        | 364.5                      | 6.082                                      | 0.6823                                       | 0.9487                                       | 380.1                    | 1.00358 | 26.01           | 34.33                                           |
| 500                                     | 1.0        | 7.683                        | 460.7                      | 6.297                                      | 0.7126                                       | 0.9763                                       | 422.7                    | 1.00286 | 30.63           | 41.29                                           |
| 600                                     | 1.0        | 6.398                        | 559.8                      | 6.478                                      | 0.7436                                       | 1.006                                        | 460.4                    | 1.00238 | 34.85           | 47.86                                           |

| $T$<br>K                                 | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 700                                      | 1.0        | 5.483                        | 661.8                      | 6.635                                      | 0.7713                                       | 1.033                                        | 494.9                    | 1.00204 | 38.77           | 54.14                                           |
| 800                                      | 1.0        | 4.798                        | 766.2                      | 6.774                                      | 0.7948                                       | 1.056                                        | 526.9                    | 1.00179 | 42.43           | 60.17                                           |
| 900                                      | 1.0        | 4.265                        | 872.8                      | 6.900                                      | 0.8142                                       | 1.075                                        | 557.1                    | 1.00159 | 45.90           | 66.00                                           |
| 1000                                     | 1.0        | 3.839                        | 981.1                      | 7.014                                      | 0.8303                                       | 1.091                                        | 585.8                    | 1.00143 | 49.20           | 71.67                                           |
| <b><math>P = 10</math> MPa (100 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 55.50                                    | 10.0       | 1312.                        | -185.4                     | 2.103                                      | 1.149                                        | 1.640                                        | 1158.                    | 1.57109 | 786.0           | 203.9                                           |
| 60                                       | 10.0       | 1294.                        | -178.0                     | 2.231                                      | 1.092                                        | 1.653                                        | 1155.                    | 1.56193 | 625.3           | 197.9                                           |
| 80                                       | 10.0       | 1207.                        | -144.8                     | 2.708                                      | 0.9885                                       | 1.654                                        | 1023.                    | 1.51940 | 285.2           | 171.5                                           |
| 100                                      | 10.0       | 1116.                        | -111.6                     | 3.078                                      | 0.9136                                       | 1.672                                        | 877.1                    | 1.47515 | 169.5           | 144.8                                           |
| 120                                      | 10.0       | 1015.                        | -77.51                     | 3.389                                      | 0.8571                                       | 1.755                                        | 727.0                    | 1.42679 | 112.4           | 118.1                                           |
| 140                                      | 10.0       | 892.5                        | -40.64                     | 3.673                                      | 0.8191                                       | 1.966                                        | 564.5                    | 1.36967 | 75.70           | 91.70                                           |
| 160                                      | 10.0       | 716.0                        | 4.057                      | 3.970                                      | 0.8137                                       | 2.659                                        | 379.7                    | 1.29022 | 47.96           | 66.52                                           |
| 180                                      | 10.0       | 423.3                        | 70.35                      | 4.360                                      | 0.8161                                       | 3.312                                        | 250.9                    | 1.16550 | 26.07           | 42.24                                           |
| 200                                      | 10.0       | 277.6                        | 119.7                      | 4.621                                      | 0.7506                                       | 1.894                                        | 259.0                    | 1.10662 | 20.74           | 31.77                                           |
| 220                                      | 10.0       | 219.9                        | 152.6                      | 4.778                                      | 0.7152                                       | 1.462                                        | 278.2                    | 1.08384 | 20.24           | 29.46                                           |
| 240                                      | 10.0       | 186.7                        | 179.8                      | 4.896                                      | 0.6973                                       | 1.280                                        | 295.8                    | 1.07090 | 20.67           | 29.19                                           |
| 260                                      | 10.0       | 164.2                        | 204.3                      | 4.995                                      | 0.6878                                       | 1.183                                        | 311.6                    | 1.06220 | 21.40           | 29.67                                           |
| 280                                      | 10.0       | 147.6                        | 227.3                      | 5.080                                      | 0.6830                                       | 1.124                                        | 326.1                    | 1.05578 | 22.25           | 30.48                                           |
| 300                                      | 10.0       | 134.6                        | 249.4                      | 5.156                                      | 0.6809                                       | 1.086                                        | 339.4                    | 1.05078 | 23.15           | 31.47                                           |
| 320                                      | 10.0       | 124.0                        | 270.8                      | 5.225                                      | 0.6809                                       | 1.060                                        | 351.7                    | 1.04675 | 24.07           | 32.56                                           |
| 340                                      | 10.0       | 115.2                        | 291.9                      | 5.289                                      | 0.6823                                       | 1.042                                        | 363.3                    | 1.04339 | 25.00           | 33.74                                           |
| 360                                      | 10.0       | 107.8                        | 312.6                      | 5.348                                      | 0.6848                                       | 1.030                                        | 374.2                    | 1.04054 | 25.92           | 34.96                                           |
| 400                                      | 10.0       | 95.67                        | 353.5                      | 5.456                                      | 0.6923                                       | 1.017                                        | 394.5                    | 1.03595 | 27.74           | 37.45                                           |
| 500                                      | 10.0       | 75.32                        | 454.8                      | 5.682                                      | 0.7187                                       | 1.015                                        | 438.7                    | 1.02825 | 32.07           | 43.71                                           |
| 600                                      | 10.0       | 62.44                        | 557.1                      | 5.869                                      | 0.7477                                       | 1.031                                        | 476.8                    | 1.02339 | 36.10           | 49.86                                           |
| 700                                      | 10.0       | 53.46                        | 661.2                      | 6.029                                      | 0.7743                                       | 1.050                                        | 511.2                    | 1.02002 | 39.87           | 55.84                                           |
| 800                                      | 10.0       | 46.79                        | 767.1                      | 6.170                                      | 0.7970                                       | 1.069                                        | 543.1                    | 1.01752 | 43.43           | 61.66                                           |
| 900                                      | 10.0       | 41.63                        | 874.8                      | 6.297                                      | 0.8159                                       | 1.085                                        | 572.9                    | 1.01558 | 46.80           | 67.32                                           |
| 1000                                     | 10.0       | 37.51                        | 984.0                      | 6.412                                      | 0.8316                                       | 1.098                                        | 601.2                    | 1.01404 | 50.03           | 72.85                                           |

Parahydrogen (H<sub>2</sub>)

| $T$<br>K          | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b>Saturation</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 13.80             | 0.007041   | 76.98                        | -53.74                     | -3.084                                     | 5.131                                        | 6.924                                        | 1263.                    | 1.25267 | 25.90           | 75.27                                           |
| 13.80             | 0.007041   | 0.1255                       | 396.3                      | 29.52                                      | 6.226                                        | 10.53                                        | 305.6                    | 1.00038 | 0.6507          | 10.46                                           |
| 14                | 0.007884   | 76.82                        | -52.36                     | -2.986                                     | 5.158                                        | 6.981                                        | 1257.                    | 1.25208 | 25.21           | 76.86                                           |
| 14                | 0.007884   | 0.1388                       | 398.1                      | 29.19                                      | 6.236                                        | 10.56                                        | 307.6                    | 1.00042 | 0.6669          | 10.65                                           |
| 16                | 0.02155    | 75.13                        | -37.60                     | -2.013                                     | 5.334                                        | 7.659                                        | 1210.                    | 1.24585 | 19.81           | 90.02                                           |
| 16                | 0.02155    | 0.3377                       | 415.8                      | 26.33                                      | 6.323                                        | 10.87                                        | 325.4                    | 1.00102 | 0.8106          | 12.60                                           |
| 18                | 0.04815    | 73.25                        | -21.18                     | -1.068                                     | 5.472                                        | 8.513                                        | 1168.                    | 1.23903 | 16.22           | 98.39                                           |
| 18                | 0.04815    | 0.6880                       | 431.5                      | 24.08                                      | 6.387                                        | 11.29                                        | 340.7                    | 1.00207 | 0.9355          | 14.60                                           |
| 20                | 0.09341    | 71.14                        | -2.692                     | -1.281                                     | 5.637                                        | 9.569                                        | 1119.                    | 1.23147 | 13.63           | 103.0                                           |
| 20                | 0.09341    | 1.244                        | 444.5                      | 22.23                                      | 6.450                                        | 11.92                                        | 353.5                    | 1.00375 | 1.057           | 16.71                                           |
| 22                | 0.1635     | 68.74                        | 18.32                      | 0.8244                                     | 5.811                                        | 10.86                                        | 1059.                    | 1.22301 | 11.65           | 104.9                                           |
| 22                | 0.1635     | 2.071                        | 454.2                      | 20.64                                      | 6.541                                        | 12.88                                        | 363.7                    | 1.00625 | 1.182           | 18.98                                           |
| 24                | 0.2648     | 66.01                        | 42.37                      | 1.805                                      | 5.974                                        | 12.52                                        | 989.9                    | 1.21345 | 10.06           | 104.7                                           |
| 24                | 0.2648     | 3.255                        | 459.7                      | 19.19                                      | 6.681                                        | 14.40                                        | 371.3                    | 1.00984 | 1.315           | 21.54                                           |
| 26                | 0.4038     | 62.83                        | 70.23                      | 2.832                                      | 6.120                                        | 14.83                                        | 909.3                    | 1.20242 | 8.725           | 102.6                                           |
| 26                | 0.4038     | 4.924                        | 460.0                      | 17.82                                      | 6.890                                        | 16.90                                        | 376.1                    | 1.01491 | 1.463           | 24.53                                           |
| 28                | 0.5875     | 58.98                        | 103.2                      | 3.941                                      | 6.266                                        | 18.57                                        | 813.3                    | 1.18922 | 7.533           | 98.79                                           |
| 28                | 0.5875     | 7.300                        | 453.4                      | 16.45                                      | 7.188                                        | 21.53                                        | 378.2                    | 1.02216 | 1.634           | 28.26                                           |
| 30                | 0.8232     | 53.98                        | 144.2                      | 5.211                                      | 6.472                                        | 26.65                                        | 693.0                    | 1.17223 | 6.390           | 92.78                                           |
| 30                | 0.8232     | 10.87                        | 435.7                      | 14.93                                      | 7.625                                        | 32.58                                        | 377.2                    | 1.03313 | 1.865           | 33.47                                           |
| 32                | 1.120      | 45.90                        | 204.1                      | 6.945                                      | 7.010                                        | 68.19                                        | 522.6                    | 1.14520 | 5.076           | 82.53                                           |
| 32                | 1.120      | 17.49                        | 392.3                      | 12.83                                      | 8.336                                        | 92.39                                        | 372.0                    | 1.05368 | 2.337           | 43.17                                           |
| 32.94             | 1.286      | 31.32                        | 295.6                      | 9.625                                      |                                              |                                              |                          | 1.09756 | 3.512           |                                                 |

| $T$<br>K                                | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b><math>P = 0.1</math> MPa (1 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 20                                      | 0.1        | 71.14                        | -2.629                     | -.1296                                     | 5.637                                        | 9.566                                        | 1119.                    | 1.23150 | 13.63           | 103.1                                           |
| 20.23                                   | 0.1        | 70.88                        | -.4432                     | -.02096                                    | 5.657                                        | 9.702                                        | 1112.                    | 1.23055 | 13.38           | 103.4                                           |
| 20.23                                   | 0.1        | 1.323                        | 445.8                      | 22.04                                      | 6.458                                        | 12.01                                        | 354.8                    | 1.00399 | 1.071           | 16.95                                           |
| 40                                      | 0.1        | 0.6157                       | 661.5                      | 29.52                                      | 6.218                                        | 10.57                                        | 521.4                    | 1.00186 | 2.039           | 31.85                                           |
| 60                                      | 0.1        | 0.4059                       | 873.1                      | 33.81                                      | 6.503                                        | 10.72                                        | 635.7                    | 1.00122 | 2.865           | 45.53                                           |
| 80                                      | 0.1        | 0.3035                       | 1096.                      | 37.02                                      | 7.598                                        | 11.77                                        | 713.9                    | 1.00091 | 3.566           | 61.36                                           |
| 100                                     | 0.1        | 0.2425                       | 1348.                      | 39.82                                      | 9.277                                        | 13.43                                        | 772.5                    | 1.00073 | 4.190           | 80.43                                           |
| 120                                     | 0.1        | 0.2020                       | 1633.                      | 42.41                                      | 10.83                                        | 14.98                                        | 827.4                    | 1.00061 | 4.763           | 101.4                                           |
| 140                                     | 0.1        | 0.1731                       | 1943.                      | 44.80                                      | 11.82                                        | 15.96                                        | 883.4                    | 1.00052 | 5.301           | 119.7                                           |
| 160                                     | 0.1        | 0.1514                       | 2267.                      | 46.96                                      | 12.21                                        | 16.35                                        | 940.4                    | 1.00046 | 5.814           | 134.8                                           |
| 180                                     | 0.1        | 0.1346                       | 2594.                      | 48.89                                      | 12.19                                        | 16.32                                        | 997.7                    | 1.00041 | 6.306           | 146.5                                           |
| 200                                     | 0.1        | 0.1211                       | 2918.                      | 50.60                                      | 11.95                                        | 16.08                                        | 1054.                    | 1.00037 | 6.780           | 155.6                                           |
| 220                                     | 0.1        | 0.1101                       | 3237.                      | 52.11                                      | 11.63                                        | 15.76                                        | 1110.                    | 1.00033 | 7.239           | 163.4                                           |
| 240                                     | 0.1        | 0.1010                       | 3549.                      | 53.47                                      | 11.33                                        | 15.46                                        | 1163.                    | 1.00030 | 7.684           | 170.6                                           |
| 260                                     | 0.1        | 0.09319                      | 3856.                      | 54.70                                      | 11.07                                        | 15.20                                        | 1214.                    | 1.00028 | 8.118           | 177.7                                           |
| 280                                     | 0.1        | 0.08654                      | 4157.                      | 55.82                                      | 10.87                                        | 15.00                                        | 1263.                    | 1.00026 | 8.540           | 184.9                                           |
| 300                                     | 0.1        | 0.08077                      | 4456.                      | 56.85                                      | 10.72                                        | 14.85                                        | 1310.                    | 1.00024 | 8.953           | 192.3                                           |
| 320                                     | 0.1        | 0.07572                      | 4752.                      | 57.80                                      | 10.61                                        | 14.74                                        | 1355.                    | 1.00023 | 9.357           | 200.0                                           |
| 340                                     | 0.1        | 0.07127                      | 5045.                      | 58.69                                      | 10.53                                        | 14.66                                        | 1398.                    | 1.00022 | 9.752           | 208.0                                           |
| 360                                     | 0.1        | 0.06731                      | 5338.                      | 59.53                                      | 10.48                                        | 14.61                                        | 1439.                    | 1.00020 | 10.14           | 216.4                                           |
| 400                                     | 0.1        | 0.06058                      | 5921.                      | 61.06                                      | 10.43                                        | 14.55                                        | 1518.                    | 1.00018 | 10.89           | 233.1                                           |
| 500                                     | 0.1        | 0.04847                      | 7374.                      | 64.31                                      | 10.40                                        | 14.53                                        | 1698.                    | 1.00015 | 12.67           | 275.0                                           |
| 600                                     | 0.1        | 0.04040                      | 8828.                      | 66.96                                      | 10.42                                        | 14.55                                        | 1859.                    | 1.00012 | 14.34           | 317.6                                           |
| 700                                     | 0.1        | 0.03463                      | 10290                      | 69.20                                      | 10.48                                        | 14.60                                        | 2006.                    | 1.00011 | 15.92           | 360.8                                           |
| 800                                     | 0.1        | 0.03030                      | 11750                      | 71.16                                      | 10.57                                        | 14.70                                        | 2142.                    | 1.00009 | 17.43           | 404.7                                           |
| 900                                     | 0.1        | 0.02693                      | 13230                      | 72.90                                      | 10.71                                        | 14.83                                        | 2268.                    | 1.00008 | 18.89           | 449.2                                           |
| 1000                                    | 0.1        | 0.02424                      | 14720                      | 74.47                                      | 10.87                                        | 14.99                                        | 2386.                    | 1.00007 | 20.30           | 494.3                                           |
| <b><math>P = 1</math> MPa (10 bar)</b>  |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 20                                      | 1.0        | 72.29                        | 6.046                      | -.3233                                     | 5.634                                        | 9.187                                        | 1164.                    | 1.23552 | 14.53           | 105.1                                           |
| 31.24                                   | 1.0        | 49.65                        | 177.4                      | 6.181                                      | 6.718                                        | 40.77                                        | 596.5                    | 1.15769 | 5.627           | 87.27                                           |
| 31.24                                   | 1.0        | 14.31                        | 414.3                      | 13.76                                      | 8.017                                        | 52.90                                        | 374.7                    | 1.04376 | 2.096           | 38.44                                           |
| 40                                      | 1.0        | 7.270                        | 590.6                      | 18.85                                      | 6.455                                        | 14.12                                        | 497.2                    | 1.02207 | 2.228           | 37.28                                           |
| 60                                      | 1.0        | 4.228                        | 838.4                      | 23.90                                      | 6.588                                        | 11.70                                        | 634.2                    | 1.01279 | 2.976           | 48.40                                           |
| 80                                      | 1.0        | 3.072                        | 1075.                      | 27.31                                      | 7.645                                        | 12.25                                        | 717.9                    | 1.00929 | 3.648           | 63.68                                           |
| 100                                     | 1.0        | 2.429                        | 1335.                      | 30.19                                      | 9.307                                        | 13.72                                        | 778.4                    | 1.00734 | 4.255           | 82.51                                           |
| 120                                     | 1.0        | 2.015                        | 1624.                      | 32.83                                      | 10.85                                        | 15.17                                        | 834.2                    | 1.00609 | 4.817           | 103.1                                           |
| 140                                     | 1.0        | 1.723                        | 1938.                      | 35.24                                      | 11.84                                        | 16.09                                        | 890.7                    | 1.00520 | 5.348           | 121.2                                           |
| 160                                     | 1.0        | 1.506                        | 2264.                      | 37.42                                      | 12.23                                        | 16.45                                        | 948.1                    | 1.00455 | 5.854           | 136.1                                           |
| 180                                     | 1.0        | 1.338                        | 2593.                      | 39.36                                      | 12.20                                        | 16.40                                        | 1006.                    | 1.00404 | 6.341           | 147.6                                           |
| 200                                     | 1.0        | 1.204                        | 2918.                      | 41.07                                      | 11.96                                        | 16.14                                        | 1062.                    | 1.00364 | 6.812           | 156.7                                           |
| 220                                     | 1.0        | 1.095                        | 3238.                      | 42.60                                      | 11.64                                        | 15.81                                        | 1117.                    | 1.00331 | 7.268           | 164.3                                           |
| 240                                     | 1.0        | 1.004                        | 3551.                      | 43.96                                      | 11.34                                        | 15.50                                        | 1171.                    | 1.00303 | 7.711           | 171.5                                           |
| 260                                     | 1.0        | 0.9267                       | 3858.                      | 45.19                                      | 11.08                                        | 15.24                                        | 1222.                    | 1.00280 | 8.143           | 178.6                                           |
| 280                                     | 1.0        | 0.8607                       | 4161.                      | 46.31                                      | 10.88                                        | 15.03                                        | 1271.                    | 1.00260 | 8.563           | 185.7                                           |
| 300                                     | 1.0        | 0.8035                       | 4460.                      | 47.34                                      | 10.73                                        | 14.87                                        | 1317.                    | 1.00243 | 8.975           | 193.0                                           |
| 320                                     | 1.0        | 0.7534                       | 4756.                      | 48.30                                      | 10.62                                        | 14.76                                        | 1362.                    | 1.00228 | 9.377           | 200.7                                           |
| 340                                     | 1.0        | 0.7093                       | 5050.                      | 49.19                                      | 10.54                                        | 14.68                                        | 1405.                    | 1.00215 | 9.771           | 208.7                                           |
| 360                                     | 1.0        | 0.6700                       | 5343.                      | 50.03                                      | 10.49                                        | 14.62                                        | 1446.                    | 1.00203 | 10.16           | 217.0                                           |
| 400                                     | 1.0        | 0.6033                       | 5927.                      | 51.56                                      | 10.43                                        | 14.56                                        | 1525.                    | 1.00183 | 10.91           | 233.7                                           |
| 500                                     | 1.0        | 0.4830                       | 7381.                      | 54.81                                      | 10.41                                        | 14.53                                        | 1704.                    | 1.00146 | 12.68           | 275.5                                           |
| 600                                     | 1.0        | 0.4027                       | 8835.                      | 57.46                                      | 10.43                                        | 14.55                                        | 1865.                    | 1.00122 | 14.35           | 318.0                                           |
| 700                                     | 1.0        | 0.3454                       | 10290                      | 59.71                                      | 10.48                                        | 14.61                                        | 2011.                    | 1.00105 | 15.93           | 361.2                                           |
| 800                                     | 1.0        | 0.3023                       | 11760                      | 61.66                                      | 10.58                                        | 14.70                                        | 2147.                    | 1.00092 | 17.44           | 405.0                                           |
| 900                                     | 1.0        | 0.2688                       | 13230                      | 63.40                                      | 10.71                                        | 14.83                                        | 2272.                    | 1.00082 | 18.90           | 449.5                                           |
| 1000                                    | 1.0        | 0.2420                       | 14720                      | 64.97                                      | 10.87                                        | 15.00                                        | 2390.                    | 1.00074 | 20.30           | 494.6                                           |

| $T$<br>K                                 | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b><math>P = 10</math> MPa (100 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 20                                       | 10.0       | 79.91                        | 98.92                      | -1.567                                     | 5.529                                        | 7.566                                        | 1467.                    | 1.26244 | 23.45           | 120.3                                           |
| 40                                       | 10.0       | 63.19                        | 310.5                      | 5.532                                      | 6.665                                        | 13.45                                        | 1154.                    | 1.20345 | 8.791           | 121.8                                           |
| 60                                       | 10.0       | 42.86                        | 617.0                      | 11.71                                      | 6.960                                        | 16.19                                        | 923.2                    | 1.13508 | 5.594           | 100.6                                           |
| 80                                       | 10.0       | 29.87                        | 933.6                      | 16.27                                      | 7.952                                        | 15.47                                        | 884.9                    | 1.09289 | 5.034           | 96.74                                           |
| 100                                      | 10.0       | 23.01                        | 1244.                      | 19.73                                      | 9.546                                        | 15.76                                        | 904.3                    | 1.07104 | 5.169           | 106.3                                           |
| 120                                      | 10.0       | 18.87                        | 1567.                      | 22.67                                      | 11.05                                        | 16.56                                        | 942.4                    | 1.05803 | 5.497           | 121.6                                           |
| 140                                      | 10.0       | 16.08                        | 1905.                      | 25.27                                      | 12.00                                        | 17.11                                        | 990.1                    | 1.04932 | 5.888           | 136.6                                           |
| 160                                      | 10.0       | 14.06                        | 2249.                      | 27.57                                      | 12.37                                        | 17.22                                        | 1042.                    | 1.04303 | 6.303           | 149.4                                           |
| 180                                      | 10.0       | 12.51                        | 2592.                      | 29.59                                      | 12.32                                        | 17.01                                        | 1096.                    | 1.03824 | 6.727           | 159.4                                           |
| 200                                      | 10.0       | 11.28                        | 2928.                      | 31.36                                      | 12.07                                        | 16.63                                        | 1150.                    | 1.03445 | 7.151           | 167.3                                           |
| 220                                      | 10.0       | 10.28                        | 3257.                      | 32.93                                      | 11.74                                        | 16.22                                        | 1203.                    | 1.03138 | 7.571           | 173.9                                           |
| 240                                      | 10.0       | 9.453                        | 3577.                      | 34.32                                      | 11.43                                        | 15.84                                        | 1254.                    | 1.02883 | 7.985           | 180.4                                           |
| 260                                      | 10.0       | 8.751                        | 3891.                      | 35.58                                      | 11.17                                        | 15.52                                        | 1303.                    | 1.02667 | 8.393           | 186.8                                           |
| 280                                      | 10.0       | 8.149                        | 4199.                      | 36.72                                      | 10.96                                        | 15.27                                        | 1350.                    | 1.02483 | 8.795           | 193.3                                           |
| 300                                      | 10.0       | 7.626                        | 4502.                      | 37.77                                      | 10.80                                        | 15.08                                        | 1394.                    | 1.02323 | 9.189           | 200.2                                           |
| 320                                      | 10.0       | 7.167                        | 4802.                      | 38.73                                      | 10.68                                        | 14.94                                        | 1437.                    | 1.02183 | 9.577           | 207.4                                           |
| 340                                      | 10.0       | 6.762                        | 5100.                      | 39.64                                      | 10.60                                        | 14.84                                        | 1478.                    | 1.02059 | 9.959           | 215.0                                           |
| 360                                      | 10.0       | 6.400                        | 5396.                      | 40.48                                      | 10.55                                        | 14.77                                        | 1518.                    | 1.01948 | 10.33           | 223.0                                           |
| 400                                      | 10.0       | 5.784                        | 5985.                      | 42.03                                      | 10.49                                        | 14.68                                        | 1593.                    | 1.01761 | 11.07           | 239.2                                           |
| 500                                      | 10.0       | 4.665                        | 7447.                      | 45.30                                      | 10.45                                        | 14.60                                        | 1764.                    | 1.01420 | 12.81           | 280.0                                           |
| 600                                      | 10.0       | 3.911                        | 8907.                      | 47.96                                      | 10.46                                        | 14.59                                        | 1919.                    | 1.01191 | 14.46           | 321.9                                           |
| 700                                      | 10.0       | 3.368                        | 10370                      | 50.21                                      | 10.51                                        | 14.63                                        | 2062.                    | 1.01026 | 16.02           | 364.7                                           |
| 800                                      | 10.0       | 2.957                        | 11830                      | 52.17                                      | 10.60                                        | 14.72                                        | 2193.                    | 1.00902 | 17.52           | 408.2                                           |
| 900                                      | 10.0       | 2.636                        | 13310                      | 53.91                                      | 10.73                                        | 14.84                                        | 2315.                    | 1.00805 | 18.97           | 452.4                                           |
| 1000                                     | 10.0       | 2.378                        | 14800                      | 55.48                                      | 10.89                                        | 15.00                                        | 2430.                    | 1.00727 | 20.37           | 497.3                                           |

**Helium (He-4)**

| $T$<br>K                                | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b>Saturation</b>                       |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 2.177                                   | 0.004856   | 146.2                        | -7.501                     | -2.177                                     | 6.287                                        | 6.318                                        | 216.8                    | 1.07842 | 3.596           | 13.52                                           |
| 2.177                                   | 0.004856   | 1.146                        | 15.73                      | 8.494                                      | 3.470                                        | 6.061                                        | 83.22                    | 1.00045 | 0.5376          | 3.977                                           |
| 2.5                                     | 0.01000    | 145.0                        | -6.180                     | -1.620                                     | 2.521                                        | 2.700                                        | 216.0                    | 1.07491 | 3.746           | 14.89                                           |
| 2.5                                     | 0.01000    | 2.116                        | 16.97                      | 7.641                                      | 3.486                                        | 6.258                                        | 87.62                    | 1.00082 | 0.6382          | 4.765                                           |
| 3                                       | 0.02373    | 141.3                        | -4.869                     | -1.177                                     | 2.061                                        | 2.598                                        | 214.3                    | 1.06975 | 3.694           | 16.55                                           |
| 3                                       | 0.02373    | 4.428                        | 18.66                      | 6.666                                      | 3.452                                        | 6.592                                        | 93.04                    | 1.00173 | 0.7961          | 5.893                                           |
| 3.5                                     | 0.04663    | 136.1                        | -3.258                     | -7.324                                     | 2.332                                        | 3.414                                        | 202.4                    | 1.06471 | 3.511           | 17.75                                           |
| 3.5                                     | 0.04663    | 8.022                        | 19.95                      | 5.898                                      | 3.378                                        | 7.122                                        | 96.94                    | 1.00315 | 0.9640          | 7.060                                           |
| 4                                       | 0.08100    | 128.9                        | -1.164                     | -.2439                                     | 2.504                                        | 4.523                                        | 185.7                    | 1.05941 | 3.278           | 18.47                                           |
| 4                                       | 0.08100    | 13.41                        | 20.68                      | 5.217                                      | 3.284                                        | 8.179                                        | 99.47                    | 1.00529 | 1.151           | 8.356                                           |
| 4.5                                     | 0.1292     | 118.8                        | 1.586                      | 0.3106                                     | 2.601                                        | 6.776                                        | 164.0                    | 1.05319 | 3.010           | 18.77                                           |
| 4.5                                     | 0.1292     | 21.76                        | 20.52                      | 4.519                                      | 3.179                                        | 10.96                                        | 100.8                    | 1.00865 | 1.372           | 10.04                                           |
| 5                                       | 0.1945     | 100.8                        | 5.854                      | 1.081                                      | 2.709                                        | 20.24                                        | 133.0                    | 1.04367 | 2.634           | 19.28                                           |
| 5                                       | 0.1945     | 38.21                        | 18.18                      | 3.547                                      | 3.053                                        | 29.09                                        | 101.6                    | 1.01543 | 1.687           | 13.60                                           |
| 5.195                                   | 0.2275     | 69.64                        | 11.87                      | 2.183                                      |                                              |                                              |                          | 1.02904 | 2.129           |                                                 |
| <b><math>P = 0.1</math> MPa (1 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 20                                      | 0.1        | 2.408                        | 108.5                      | 13.94                                      | 3.121                                        | 5.250                                        | 264.3                    | 1.00093 | 3.582           | 26.20                                           |
| 40                                      | 0.1        | 1.200                        | 212.9                      | 17.56                                      | 3.119                                        | 5.206                                        | 373.4                    | 1.00047 | 5.542           | 40.44                                           |
| 60                                      | 0.1        | 0.8006                       | 317.0                      | 19.67                                      | 3.118                                        | 5.198                                        | 456.9                    | 1.00031 | 7.116           | 52.55                                           |
| 80                                      | 0.1        | 0.6007                       | 420.9                      | 21.16                                      | 3.117                                        | 5.195                                        | 527.2                    | 1.00023 | 8.503           | 63.52                                           |
| 100                                     | 0.1        | 0.4807                       | 524.8                      | 22.32                                      | 3.117                                        | 5.194                                        | 589.2                    | 1.00019 | 9.778           | 73.71                                           |
| 120                                     | 0.1        | 0.4007                       | 628.7                      | 23.27                                      | 3.117                                        | 5.194                                        | 645.3                    | 1.00016 | 10.79           | 83.33                                           |
| 140                                     | 0.1        | 0.3435                       | 732.6                      | 24.07                                      | 3.116                                        | 5.193                                        | 696.9                    | 1.00013 | 11.94           | 92.50                                           |
| 160                                     | 0.1        | 0.3006                       | 836.4                      | 24.76                                      | 3.116                                        | 5.193                                        | 744.9                    | 1.00012 | 13.05           | 101.3                                           |
| 180                                     | 0.1        | 0.2672                       | 940.3                      | 25.37                                      | 3.116                                        | 5.193                                        | 790.0                    | 1.00010 | 14.11           | 109.8                                           |
| 200                                     | 0.1        | 0.2405                       | 1044.                      | 25.92                                      | 3.116                                        | 5.193                                        | 832.7                    | 1.00009 | 15.14           | 118.0                                           |

| $T$<br>K                                 | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 220                                      | 0.1        | 0.2187                       | 1148.                      | 26.42                                      | 3.116                                        | 5.193                                        | 873.3                    | 1.00008 | 16.14           | 126.0                                           |
| 240                                      | 0.1        | 0.2005                       | 1252.                      | 26.87                                      | 3.116                                        | 5.193                                        | 912.0                    | 1.00008 | 17.12           | 133.7                                           |
| 260                                      | 0.1        | 0.1851                       | 1356.                      | 27.28                                      | 3.116                                        | 5.193                                        | 949.2                    | 1.00007 | 18.08           | 141.3                                           |
| 280                                      | 0.1        | 0.1718                       | 1460.                      | 27.67                                      | 3.116                                        | 5.193                                        | 985.0                    | 1.00007 | 19.01           | 148.7                                           |
| 300                                      | 0.1        | 0.1604                       | 1563.                      | 28.03                                      | 3.116                                        | 5.193                                        | 1020.                    | 1.00006 | 19.93           | 156.0                                           |
| 320                                      | 0.1        | 0.1504                       | 1667.                      | 28.36                                      | 3.116                                        | 5.193                                        | 1053.                    | 1.00006 | 20.83           | 163.1                                           |
| 340                                      | 0.1        | 0.1415                       | 1771.                      | 28.68                                      | 3.116                                        | 5.193                                        | 1085.                    | 1.00005 | 21.72           | 170.1                                           |
| 360                                      | 0.1        | 0.1337                       | 1875.                      | 28.97                                      | 3.116                                        | 5.193                                        | 1117.                    | 1.00005 | 22.59           | 177.0                                           |
| 400                                      | 0.1        | 0.1203                       | 2083.                      | 29.52                                      | 3.116                                        | 5.193                                        | 1177.                    | 1.00005 | 24.29           | 190.4                                           |
| 500                                      | 0.1        | 0.09626                      | 2602.                      | 30.68                                      | 3.116                                        | 5.193                                        | 1316.                    | 1.00004 | 28.36           | 222.3                                           |
| 600                                      | 0.1        | 0.08022                      | 3121.                      | 31.63                                      | 3.116                                        | 5.193                                        | 1442.                    | 1.00003 | 32.22           | 252.4                                           |
| 700                                      | 0.1        | 0.06876                      | 3641.                      | 32.43                                      | 3.116                                        | 5.193                                        | 1557.                    | 1.00003 | 35.89           | 281.1                                           |
| 800                                      | 0.1        | 0.06017                      | 4160.                      | 33.12                                      | 3.116                                        | 5.193                                        | 1664.                    | 1.00002 | 39.43           | 308.5                                           |
| 900                                      | 0.1        | 0.05348                      | 4679.                      | 33.73                                      | 3.116                                        | 5.193                                        | 1765.                    | 1.00002 | 42.85           | 335.0                                           |
| 1000                                     | 0.1        | 0.04814                      | 5199.                      | 34.28                                      | 3.116                                        | 5.193                                        | 1861.                    | 1.00002 | 46.16           | 360.6                                           |
| <b><math>P = 1</math> MPa (10 bar)</b>   |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 20                                       | 1.0        | 24.02                        | 104.1                      | 8.936                                      | 3.156                                        | 5.728                                        | 276.4                    | 1.00938 | 3.933           | 29.04                                           |
| 40                                       | 1.0        | 11.72                        | 213.2                      | 12.73                                      | 3.143                                        | 5.317                                        | 384.9                    | 1.00455 | 5.740           | 42.01                                           |
| 60                                       | 1.0        | 7.850                        | 318.6                      | 14.87                                      | 3.133                                        | 5.242                                        | 466.8                    | 1.00305 | 7.269           | 53.72                                           |
| 80                                       | 1.0        | 5.912                        | 423.1                      | 16.37                                      | 3.128                                        | 5.217                                        | 535.8                    | 1.00229 | 8.633           | 64.50                                           |
| 100                                      | 1.0        | 4.745                        | 527.4                      | 17.54                                      | 3.125                                        | 5.206                                        | 596.9                    | 1.00184 | 9.892           | 74.60                                           |
| 120                                      | 1.0        | 3.963                        | 631.4                      | 18.48                                      | 3.123                                        | 5.200                                        | 652.2                    | 1.00154 | 10.90           | 84.16                                           |
| 140                                      | 1.0        | 3.403                        | 735.4                      | 19.29                                      | 3.121                                        | 5.197                                        | 703.2                    | 1.00132 | 12.04           | 93.29                                           |
| 160                                      | 1.0        | 2.982                        | 839.3                      | 19.98                                      | 3.120                                        | 5.195                                        | 750.7                    | 1.00116 | 13.13           | 102.1                                           |
| 180                                      | 1.0        | 2.653                        | 943.2                      | 20.59                                      | 3.120                                        | 5.194                                        | 795.4                    | 1.00103 | 14.19           | 110.5                                           |
| 200                                      | 1.0        | 2.390                        | 1047.                      | 21.14                                      | 3.119                                        | 5.194                                        | 837.7                    | 1.00093 | 15.21           | 118.7                                           |
| 220                                      | 1.0        | 2.174                        | 1151.                      | 21.63                                      | 3.119                                        | 5.193                                        | 878.0                    | 1.00084 | 16.20           | 126.7                                           |
| 240                                      | 1.0        | 1.994                        | 1255.                      | 22.09                                      | 3.118                                        | 5.193                                        | 916.5                    | 1.00077 | 17.17           | 134.4                                           |
| 260                                      | 1.0        | 1.842                        | 1359.                      | 22.50                                      | 3.118                                        | 5.193                                        | 953.5                    | 1.00071 | 18.12           | 142.0                                           |
| 280                                      | 1.0        | 1.711                        | 1463.                      | 22.89                                      | 3.118                                        | 5.192                                        | 989.1                    | 1.00066 | 19.05           | 149.4                                           |
| 300                                      | 1.0        | 1.597                        | 1566.                      | 23.24                                      | 3.118                                        | 5.192                                        | 1023.                    | 1.00062 | 19.96           | 156.6                                           |
| 320                                      | 1.0        | 1.498                        | 1670.                      | 23.58                                      | 3.117                                        | 5.192                                        | 1057.                    | 1.00058 | 20.86           | 163.8                                           |
| 340                                      | 1.0        | 1.410                        | 1774.                      | 23.89                                      | 3.117                                        | 5.192                                        | 1089.                    | 1.00055 | 21.74           | 170.7                                           |
| 360                                      | 1.0        | 1.332                        | 1878.                      | 24.19                                      | 3.117                                        | 5.192                                        | 1120.                    | 1.00052 | 22.61           | 177.6                                           |
| 400                                      | 1.0        | 1.200                        | 2086.                      | 24.74                                      | 3.117                                        | 5.192                                        | 1180.                    | 1.00047 | 24.32           | 191.0                                           |
| 500                                      | 1.0        | 0.9604                       | 2605.                      | 25.90                                      | 3.117                                        | 5.192                                        | 1319.                    | 1.00037 | 28.38           | 222.9                                           |
| 600                                      | 1.0        | 0.8007                       | 3124.                      | 26.84                                      | 3.116                                        | 5.192                                        | 1444.                    | 1.00031 | 32.23           | 253.0                                           |
| 700                                      | 1.0        | 0.6866                       | 3643.                      | 27.64                                      | 3.116                                        | 5.192                                        | 1559.                    | 1.00027 | 35.91           | 281.6                                           |
| 800                                      | 1.0        | 0.6009                       | 4163.                      | 28.34                                      | 3.116                                        | 5.192                                        | 1666.                    | 1.00023 | 39.44           | 309.1                                           |
| 900                                      | 1.0        | 0.5342                       | 4682.                      | 28.95                                      | 3.116                                        | 5.193                                        | 1767.                    | 1.00021 | 42.86           | 335.5                                           |
| 1000                                     | 1.0        | 0.4809                       | 5201.                      | 29.50                                      | 3.116                                        | 5.193                                        | 1863.                    | 1.00019 | 46.17           | 361.1                                           |
| <b><math>P = 10</math> MPa (100 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 20                                       | 10.0       | 147.2                        | 111.0                      | 3.756                                      | 3.286                                        | 5.413                                        | 497.6                    | 1.06056 | 6.928           | 58.72                                           |
| 40                                       | 10.0       | 91.33                        | 225.2                      | 7.703                                      | 3.305                                        | 5.721                                        | 512.2                    | 1.03614 | 7.483           | 59.90                                           |
| 60                                       | 10.0       | 65.36                        | 337.4                      | 9.980                                      | 3.251                                        | 5.506                                        | 566.3                    | 1.02560 | 8.638           | 68.12                                           |
| 80                                       | 10.0       | 51.09                        | 446.0                      | 11.54                                      | 3.215                                        | 5.376                                        | 620.9                    | 1.01993 | 9.802           | 76.83                                           |
| 100                                      | 10.0       | 42.05                        | 552.8                      | 12.74                                      | 3.192                                        | 5.303                                        | 672.3                    | 1.01637 | 10.93           | 85.42                                           |
| 120                                      | 10.0       | 35.77                        | 658.4                      | 13.70                                      | 3.176                                        | 5.261                                        | 720.4                    | 1.01391 | 11.82           | 93.82                                           |
| 140                                      | 10.0       | 31.14                        | 763.3                      | 14.51                                      | 3.165                                        | 5.235                                        | 765.6                    | 1.01210 | 12.88           | 102.0                                           |
| 160                                      | 10.0       | 27.58                        | 867.8                      | 15.21                                      | 3.157                                        | 5.219                                        | 808.5                    | 1.01071 | 13.89           | 110.1                                           |
| 180                                      | 10.0       | 24.75                        | 972.1                      | 15.82                                      | 3.151                                        | 5.208                                        | 849.2                    | 1.00961 | 14.87           | 118.0                                           |
| 200                                      | 10.0       | 22.46                        | 1076.                      | 16.37                                      | 3.146                                        | 5.201                                        | 888.2                    | 1.00872 | 15.82           | 125.7                                           |
| 220                                      | 10.0       | 20.55                        | 1180.                      | 16.86                                      | 3.142                                        | 5.196                                        | 925.6                    | 1.00798 | 16.75           | 133.3                                           |
| 240                                      | 10.0       | 18.94                        | 1284.                      | 17.31                                      | 3.139                                        | 5.193                                        | 961.6                    | 1.00735 | 17.65           | 140.7                                           |
| 260                                      | 10.0       | 17.57                        | 1388.                      | 17.73                                      | 3.137                                        | 5.190                                        | 996.4                    | 1.00682 | 18.54           | 148.0                                           |
| 280                                      | 10.0       | 16.38                        | 1492.                      | 18.11                                      | 3.135                                        | 5.188                                        | 1030.                    | 1.00635 | 19.41           | 155.2                                           |
| 300                                      | 10.0       | 15.34                        | 1595.                      | 18.47                                      | 3.133                                        | 5.187                                        | 1063.                    | 1.00595 | 20.26           | 162.3                                           |

| $T$<br>K | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|----------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 320      | 10.0       | 14.43                        | 1699.                      | 18.81                                      | 3.132                                        | 5.186                                        | 1094.                    | 1.00560 | 21.14           | 169.2                                           |
| 340      | 10.0       | 13.62                        | 1803.                      | 19.12                                      | 3.130                                        | 5.186                                        | 1125.                    | 1.00528 | 22.01           | 176.0                                           |
| 360      | 10.0       | 12.89                        | 1907.                      | 19.42                                      | 3.129                                        | 5.185                                        | 1155.                    | 1.00500 | 22.86           | 182.8                                           |
| 400      | 10.0       | 11.65                        | 2114.                      | 19.96                                      | 3.127                                        | 5.185                                        | 1213.                    | 1.00452 | 24.54           | 196.0                                           |
| 500      | 10.0       | 9.387                        | 2632.                      | 21.12                                      | 3.124                                        | 5.185                                        | 1347.                    | 1.00364 | 28.56           | 227.6                                           |
| 600      | 10.0       | 7.860                        | 3151.                      | 22.07                                      | 3.122                                        | 5.186                                        | 1469.                    | 1.00305 | 32.38           | 257.4                                           |
| 700      | 10.0       | 6.760                        | 3670.                      | 22.87                                      | 3.121                                        | 5.186                                        | 1582.                    | 1.00262 | 36.04           | 285.9                                           |
| 800      | 10.0       | 5.930                        | 4188.                      | 23.56                                      | 3.120                                        | 5.187                                        | 1687.                    | 1.00230 | 39.56           | 313.2                                           |
| 900      | 10.0       | 5.281                        | 4707.                      | 24.17                                      | 3.119                                        | 5.188                                        | 1786.                    | 1.00205 | 42.96           | 339.6                                           |
| 1000     | 10.0       | 4.760                        | 5226.                      | 24.72                                      | 3.119                                        | 5.188                                        | 1880.                    | 1.00185 | 46.26           | 365.1                                           |

## Argon (Ar)

| $T$<br>K              | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| Saturation            |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 83.81                 | 0.06889    | 1417.                        | -121.4                     | 1.329                                      | 0.5496                                       | 1.116                                        | 862.4                    | 1.51232 | 290.2           | 133.6                                           |
| 83.81                 | 0.06889    | 4.055                        | 42.28                      | 3.283                                      | 0.3247                                       | 0.5550                                       | 168.1                    | 1.00126 | 6.856           | 5.359                                           |
| 90                    | 0.1335     | 1379.                        | -114.5                     | 1.409                                      | 0.5268                                       | 1.121                                        | 819.5                    | 1.49650 | 240.0           | 124.5                                           |
| 90                    | 0.1335     | 7.436                        | 44.57                      | 3.176                                      | 0.3309                                       | 0.5757                                       | 172.8                    | 1.00231 | 7.413           | 5.835                                           |
| 100                   | 0.3238     | 1314.                        | -103.1                     | 1.528                                      | 0.4976                                       | 1.154                                        | 746.9                    | 1.46993 | 181.3           | 110.2                                           |
| 100                   | 0.3238     | 16.86                        | 47.40                      | 3.032                                      | 0.3445                                       | 0.6269                                       | 178.9                    | 1.00525 | 8.349           | 6.689                                           |
| 110                   | 0.6653     | 1243.                        | -91.13                     | 1.639                                      | 0.4747                                       | 1.218                                        | 669.2                    | 1.44136 | 140.4           | 96.41                                           |
| 110                   | 0.6653     | 33.29                        | 48.84                      | 2.911                                      | 0.3633                                       | 0.7122                                       | 183.0                    | 1.01039 | 9.366           | 7.732                                           |
| 120                   | 1.213      | 1163.                        | -78.35                     | 1.746                                      | 0.4576                                       | 1.332                                        | 584.2                    | 1.40965 | 110.2           | 83.13                                           |
| 120                   | 1.213      | 60.14                        | 48.41                      | 2.802                                      | 0.3893                                       | 0.8627                                       | 185.1                    | 1.01884 | 10.54           | 9.154                                           |
| 130                   | 2.025      | 1068.                        | -64.16                     | 1.854                                      | 0.4492                                       | 1.564                                        | 487.9                    | 1.37273 | 85.86           | 70.43                                           |
| 130                   | 2.025      | 103.6                        | 45.30                      | 2.696                                      | 0.4275                                       | 1.172                                        | 184.8                    | 1.03259 | 12.03           | 11.45                                           |
| 140                   | 3.168      | 943.7                        | -47.16                     | 1.971                                      | 0.4598                                       | 2.225                                        | 371.6                    | 1.32519 | 63.62           | 58.06                                           |
| 140                   | 3.168      | 178.9                        | 37.47                      | 2.576                                      | 0.4940                                       | 2.104                                        | 181.5                    | 1.05677 | 14.32           | 16.39                                           |
| 150                   | 4.735      | 680.4                        | -17.88                     | 2.159                                      | 0.7060                                       | 23.58                                        | 174.7                    | 1.22816 | 36.78           | 57.63                                           |
| 150                   | 4.735      | 394.5                        | 11.52                      | 2.355                                      | 0.8218                                       | 35.47                                        | 157.0                    | 1.12827 | 21.18           | 55.88                                           |
| 150.69                | 4.863      | 535.6                        | -4.332                     | 2.248                                      |                                              |                                              |                          | 1.17684 | 27.63           |                                                 |
| $P = 0.1$ MPa (1 bar) |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 83.81                 | 0.1        | 1417.                        | -121.4                     | 1.329                                      | 0.5496                                       | 1.116                                        | 862.5                    | 1.51233 | 290.2           | 133.6                                           |
| 87.18                 | 0.1        | 1396.                        | -117.7                     | 1.373                                      | 0.5366                                       | 1.117                                        | 839.2                    | 1.50375 | 261.3           | 128.6                                           |
| 87.18                 | 0.1        | 5.704                        | 43.57                      | 3.223                                      | 0.3279                                       | 0.5654                                       | 170.8                    | 1.00178 | 7.157           | 5.614                                           |
| 100                   | 0.1        | 4.915                        | 50.69                      | 3.299                                      | 0.3206                                       | 0.5470                                       | 184.2                    | 1.00153 | 8.234           | 6.450                                           |
| 120                   | 0.1        | 4.058                        | 61.49                      | 3.398                                      | 0.3161                                       | 0.5347                                       | 202.8                    | 1.00126 | 9.878           | 7.735                                           |
| 140                   | 0.1        | 3.461                        | 72.12                      | 3.480                                      | 0.3144                                       | 0.5293                                       | 219.6                    | 1.00108 | 11.48           | 8.987                                           |
| 160                   | 0.1        | 3.020                        | 82.68                      | 3.550                                      | 0.3135                                       | 0.5264                                       | 235.1                    | 1.00094 | 13.03           | 10.21                                           |
| 180                   | 0.1        | 2.680                        | 93.19                      | 3.612                                      | 0.3131                                       | 0.5247                                       | 249.6                    | 1.00083 | 14.53           | 11.39                                           |
| 200                   | 0.1        | 2.409                        | 103.7                      | 3.667                                      | 0.3128                                       | 0.5236                                       | 263.2                    | 1.00075 | 16.00           | 12.54                                           |
| 220                   | 0.1        | 2.189                        | 114.1                      | 3.717                                      | 0.3127                                       | 0.5229                                       | 276.2                    | 1.00068 | 17.42           | 13.66                                           |
| 240                   | 0.1        | 2.005                        | 124.6                      | 3.762                                      | 0.3125                                       | 0.5224                                       | 288.5                    | 1.00062 | 18.80           | 14.74                                           |
| 260                   | 0.1        | 1.850                        | 135.0                      | 3.804                                      | 0.3125                                       | 0.5220                                       | 300.3                    | 1.00058 | 20.15           | 15.80                                           |
| 280                   | 0.1        | 1.717                        | 145.5                      | 3.843                                      | 0.3124                                       | 0.5217                                       | 311.7                    | 1.00053 | 21.46           | 16.83                                           |
| 300                   | 0.1        | 1.603                        | 155.9                      | 3.879                                      | 0.3124                                       | 0.5215                                       | 322.7                    | 1.00050 | 22.74           | 17.84                                           |
| 320                   | 0.1        | 1.502                        | 166.3                      | 3.913                                      | 0.3124                                       | 0.5214                                       | 333.3                    | 1.00047 | 23.99           | 18.82                                           |
| 340                   | 0.1        | 1.414                        | 176.8                      | 3.944                                      | 0.3123                                       | 0.5212                                       | 343.5                    | 1.00044 | 25.21           | 19.77                                           |
| 360                   | 0.1        | 1.335                        | 187.2                      | 3.974                                      | 0.3123                                       | 0.5211                                       | 353.5                    | 1.00042 | 26.40           | 20.71                                           |
| 400                   | 0.1        | 1.201                        | 208.0                      | 4.029                                      | 0.3123                                       | 0.5209                                       | 372.7                    | 1.00037 | 28.70           | 22.52                                           |
| 500                   | 0.1        | 0.9608                       | 260.1                      | 4.145                                      | 0.3123                                       | 0.5207                                       | 416.6                    | 1.00030 | 34.08           | 26.73                                           |
| 600                   | 0.1        | 0.8006                       | 312.2                      | 4.240                                      | 0.3122                                       | 0.5206                                       | 456.4                    | 1.00025 | 39.00           | 30.57                                           |
| 700                   | 0.1        | 0.6862                       | 364.2                      | 4.320                                      | 0.3122                                       | 0.5205                                       | 493.0                    | 1.00021 | 43.56           | 34.13                                           |
| 800                   | 0.1        | 0.6004                       | 416.3                      | 4.390                                      | 0.3122                                       | 0.5205                                       | 527.0                    | 1.00019 | 47.82           | 37.46                                           |
| 900                   | 0.1        | 0.5337                       | 468.3                      | 4.451                                      | 0.3122                                       | 0.5204                                       | 558.9                    | 1.00017 | 51.85           | 40.60                                           |
| 1000                  | 0.1        | 0.4803                       | 520.3                      | 4.506                                      | 0.3122                                       | 0.5204                                       | 589.1                    | 1.00015 | 55.69           | 43.58                                           |



| $T$<br>K                                 | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b><math>P = 1</math> MPa (10 bar)</b>   |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 84.04                                    | 1.0        | 1418.                        | -120.8                     | 1.330                                      | 0.5498                                       | 1.113                                        | 865.3                    | 1.51276 | 291.1           | 134.0                                           |
| 100                                      | 1.0        | 1316.                        | -102.8                     | 1.525                                      | 0.4984                                       | 1.148                                        | 751.6                    | 1.47104 | 183.1           | 110.9                                           |
| 116.60                                   | 1.0        | 1191.                        | -82.82                     | 1.710                                      | 0.4627                                       | 1.285                                        | 614.1                    | 1.42088 | 119.7           | 87.58                                           |
| 116.60                                   | 1.0        | 49.55                        | 48.81                      | 2.839                                      | 0.3795                                       | 0.8007                                       | 184.6                    | 1.01550 | 10.12           | 8.608                                           |
| 120                                      | 1.0        | 47.20                        | 51.45                      | 2.861                                      | 0.3682                                       | 0.7559                                       | 189.3                    | 1.01476 | 10.37           | 8.732                                           |
| 140                                      | 1.0        | 37.75                        | 65.11                      | 2.967                                      | 0.3375                                       | 0.6350                                       | 212.1                    | 1.01179 | 11.87           | 9.704                                           |
| 160                                      | 1.0        | 31.93                        | 77.31                      | 3.048                                      | 0.3266                                       | 0.5907                                       | 230.5                    | 1.00997 | 13.36           | 10.80                                           |
| 180                                      | 1.0        | 27.83                        | 88.89                      | 3.116                                      | 0.3214                                       | 0.5686                                       | 246.8                    | 1.00868 | 14.83           | 11.90                                           |
| 200                                      | 1.0        | 24.74                        | 100.1                      | 3.176                                      | 0.3185                                       | 0.5556                                       | 261.6                    | 1.00772 | 16.26           | 13.00                                           |
| 220                                      | 1.0        | 22.31                        | 111.1                      | 3.228                                      | 0.3168                                       | 0.5473                                       | 275.3                    | 1.00696 | 17.65           | 14.07                                           |
| 240                                      | 1.0        | 20.33                        | 122.0                      | 3.275                                      | 0.3157                                       | 0.5417                                       | 288.3                    | 1.00634 | 19.01           | 15.12                                           |
| 260                                      | 1.0        | 18.69                        | 132.8                      | 3.319                                      | 0.3149                                       | 0.5376                                       | 300.5                    | 1.00583 | 20.34           | 16.15                                           |
| 280                                      | 1.0        | 17.30                        | 143.5                      | 3.358                                      | 0.3144                                       | 0.5346                                       | 312.2                    | 1.00539 | 21.64           | 17.16                                           |
| 300                                      | 1.0        | 16.11                        | 154.2                      | 3.395                                      | 0.3140                                       | 0.5324                                       | 323.4                    | 1.00502 | 22.90           | 18.14                                           |
| 320                                      | 1.0        | 15.08                        | 164.8                      | 3.429                                      | 0.3137                                       | 0.5306                                       | 334.2                    | 1.00470 | 24.14           | 19.10                                           |
| 340                                      | 1.0        | 14.17                        | 175.4                      | 3.462                                      | 0.3135                                       | 0.5292                                       | 344.7                    | 1.00441 | 25.35           | 20.04                                           |
| 360                                      | 1.0        | 13.37                        | 186.0                      | 3.492                                      | 0.3133                                       | 0.5280                                       | 354.7                    | 1.00416 | 26.53           | 20.96                                           |
| 400                                      | 1.0        | 12.01                        | 207.1                      | 3.547                                      | 0.3131                                       | 0.5263                                       | 374.1                    | 1.00374 | 28.82           | 22.75                                           |
| 500                                      | 1.0        | 9.593                        | 259.6                      | 3.664                                      | 0.3127                                       | 0.5239                                       | 418.3                    | 1.00299 | 34.16           | 26.92                                           |
| 600                                      | 1.0        | 7.988                        | 311.9                      | 3.760                                      | 0.3126                                       | 0.5227                                       | 458.1                    | 1.00249 | 39.06           | 30.73                                           |
| 700                                      | 1.0        | 6.846                        | 364.1                      | 3.840                                      | 0.3125                                       | 0.5220                                       | 494.6                    | 1.00213 | 43.61           | 34.27                                           |
| 800                                      | 1.0        | 5.990                        | 416.3                      | 3.910                                      | 0.3124                                       | 0.5215                                       | 528.6                    | 1.00186 | 47.87           | 37.58                                           |
| 900                                      | 1.0        | 5.325                        | 468.4                      | 3.971                                      | 0.3124                                       | 0.5212                                       | 560.5                    | 1.00166 | 51.90           | 40.71                                           |
| 1000                                     | 1.0        | 4.793                        | 520.6                      | 4.026                                      | 0.3124                                       | 0.5210                                       | 590.7                    | 1.00149 | 55.72           | 43.68                                           |
| <b><math>P = 10</math> MPa (100 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 86.27                                    | 10.0       | 1428.                        | -114.2                     | 1.333                                      | 0.5519                                       | 1.085                                        | 891.3                    | 1.51685 | 300.0           | 137.1                                           |
| 100                                      | 10.0       | 1349.                        | -99.27                     | 1.493                                      | 0.5089                                       | 1.093                                        | 805.9                    | 1.48430 | 205.8           | 118.6                                           |
| 120                                      | 10.0       | 1222.                        | -76.82                     | 1.698                                      | 0.4650                                       | 1.163                                        | 674.3                    | 1.43296 | 130.0           | 93.55                                           |
| 140                                      | 10.0       | 1066.                        | -52.01                     | 1.888                                      | 0.4374                                       | 1.349                                        | 527.4                    | 1.37161 | 85.36           | 70.81                                           |
| 160                                      | 10.0       | 833.6                        | -20.15                     | 2.100                                      | 0.4356                                       | 1.970                                        | 357.8                    | 1.28395 | 50.84           | 49.64                                           |
| 180                                      | 10.0       | 491.9                        | 26.15                      | 2.373                                      | 0.4254                                       | 2.091                                        | 259.3                    | 1.16159 | 27.88           | 30.35                                           |
| 200                                      | 10.0       | 337.7                        | 57.55                      | 2.539                                      | 0.3815                                       | 1.215                                        | 267.7                    | 1.10910 | 23.43           | 23.57                                           |
| 220                                      | 10.0       | 270.9                        | 78.52                      | 2.639                                      | 0.3585                                       | 0.9257                                       | 283.7                    | 1.08686 | 22.90           | 21.77                                           |
| 240                                      | 10.0       | 231.2                        | 95.59                      | 2.713                                      | 0.3457                                       | 0.7960                                       | 299.0                    | 1.07382 | 23.22           | 21.31                                           |
| 260                                      | 10.0       | 204.0                        | 110.7                      | 2.774                                      | 0.3379                                       | 0.7240                                       | 313.1                    | 1.06491 | 23.87           | 21.39                                           |
| 280                                      | 10.0       | 183.6                        | 124.7                      | 2.826                                      | 0.3327                                       | 0.6789                                       | 326.1                    | 1.05829 | 24.68           | 21.73                                           |
| 300                                      | 10.0       | 167.6                        | 138.0                      | 2.872                                      | 0.3290                                       | 0.6481                                       | 338.4                    | 1.05312 | 25.58           | 22.19                                           |
| 320                                      | 10.0       | 154.6                        | 150.7                      | 2.913                                      | 0.3264                                       | 0.6261                                       | 350.0                    | 1.04892 | 26.53           | 22.78                                           |
| 340                                      | 10.0       | 143.7                        | 163.1                      | 2.950                                      | 0.3243                                       | 0.6095                                       | 361.0                    | 1.04542 | 27.51           | 23.43                                           |
| 360                                      | 10.0       | 134.4                        | 175.1                      | 2.985                                      | 0.3228                                       | 0.5967                                       | 371.6                    | 1.04245 | 28.49           | 24.11                                           |
| 400                                      | 10.0       | 119.4                        | 198.6                      | 3.046                                      | 0.3205                                       | 0.5784                                       | 391.5                    | 1.03765 | 30.48           | 25.50                                           |
| 500                                      | 10.0       | 94.09                        | 255.0                      | 3.173                                      | 0.3174                                       | 0.5540                                       | 436.1                    | 1.02957 | 35.35           | 29.04                                           |
| 600                                      | 10.0       | 78.03                        | 309.8                      | 3.272                                      | 0.3159                                       | 0.5423                                       | 475.7                    | 1.02448 | 39.97           | 32.48                                           |
| 700                                      | 10.0       | 66.80                        | 363.7                      | 3.355                                      | 0.3151                                       | 0.5357                                       | 511.7                    | 1.02093 | 44.34           | 35.76                                           |
| 800                                      | 10.0       | 58.47                        | 417.0                      | 3.427                                      | 0.3145                                       | 0.5317                                       | 545.1                    | 1.01830 | 48.47           | 38.88                                           |
| 900                                      | 10.0       | 52.03                        | 470.0                      | 3.489                                      | 0.3142                                       | 0.5290                                       | 576.4                    | 1.01628 | 52.40           | 41.86                                           |
| 1000                                     | 10.0       | 46.88                        | 522.8                      | 3.545                                      | 0.3139                                       | 0.5271                                       | 606.0                    | 1.01466 | 56.16           | 44.71                                           |

**Methane (CH<sub>4</sub>)**

| $T$<br>K          | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b>Saturation</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 90.69             | 0.01170    | 451.5                        | -71.82                     | -7.099                                     | 2.168                                        | 3.368                                        | 1539.                    | 1.67721 | 193.4           | 211.2                                           |
| 90.69             | 0.01170    | 0.2507                       | 472.4                      | 5.291                                      | 1.574                                        | 2.110                                        | 249.1                    | 1.00031 | 3.585           | 8.776                                           |
| 100               | 0.03438    | 438.9                        | -40.27                     | -3.793                                     | 2.114                                        | 3.408                                        | 1452.                    | 1.65478 | 151.1           | 199.6                                           |
| 100               | 0.03438    | 0.6746                       | 490.2                      | 4.925                                      | 1.589                                        | 2.146                                        | 260.1                    | 1.00082 | 3.914           | 9.910                                           |



| $T$<br>K                                        | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-------------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 110                                             | 0.08813    | 424.8                        | -5.813                     | -0.05217                                   | 2.064                                        | 3.469                                        | 1355.                    | 1.62995 | 121.0           | 186.1                                           |
| 110                                             | 0.08813    | 1.598                        | 508.0                      | 4.619                                      | 1.611                                        | 2.205                                        | 270.0                    | 1.00196 | 4.273           | 11.22                                           |
| 120                                             | 0.1914     | 409.9                        | 29.41                      | 0.2521                                     | 2.020                                        | 3.549                                        | 1253.                    | 1.60408 | 98.68           | 172.0                                           |
| 120                                             | 0.1914     | 3.262                        | 524.0                      | 4.374                                      | 1.639                                        | 2.293                                        | 277.8                    | 1.00399 | 4.636           | 12.66                                           |
| 130                                             | 0.3673     | 394.0                        | 65.63                      | 0.5385                                     | 1.980                                        | 3.658                                        | 1148.                    | 1.57683 | 81.29           | 157.7                                           |
| 130                                             | 0.3673     | 5.980                        | 537.7                      | 4.170                                      | 1.674                                        | 2.421                                        | 283.1                    | 1.00733 | 5.008           | 14.28                                           |
| 140                                             | 0.6412     | 376.9                        | 103.2                      | 0.8116                                     | 1.945                                        | 3.813                                        | 1038.                    | 1.54771 | 67.35           | 143.5                                           |
| 140                                             | 0.6412     | 10.15                        | 548.3                      | 3.991                                      | 1.717                                        | 2.611                                        | 285.9                    | 1.01248 | 5.398           | 16.15                                           |
| 150                                             | 1.040      | 357.9                        | 142.6                      | 1.076                                      | 1.919                                        | 4.047                                        | 920.8                    | 1.51599 | 55.99           | 129.2                                           |
| 150                                             | 1.040      | 16.33                        | 555.2                      | 3.827                                      | 1.773                                        | 2.908                                        | 286.0                    | 1.02013 | 5.827           | 18.38                                           |
| 160                                             | 1.592      | 336.3                        | 184.8                      | 1.338                                      | 1.904                                        | 4.435                                        | 795.4                    | 1.48045 | 46.55           | 115.0                                           |
| 160                                             | 1.592      | 25.38                        | 557.1                      | 3.664                                      | 1.847                                        | 3.419                                        | 283.0                    | 1.03144 | 6.335           | 21.23                                           |
| 170                                             | 2.328      | 310.5                        | 231.2                      | 1.605                                      | 1.910                                        | 5.187                                        | 657.5                    | 1.43870 | 38.45           | 100.5                                           |
| 170                                             | 2.328      | 38.97                        | 551.5                      | 3.490                                      | 1.956                                        | 4.459                                        | 276.7                    | 1.04861 | 7.012           | 25.34                                           |
| 180                                             | 3.285      | 276.2                        | 285.9                      | 1.899                                      | 1.967                                        | 7.292                                        | 497.0                    | 1.38453 | 30.92           | 85.50                                           |
| 180                                             | 3.285      | 61.38                        | 532.8                      | 3.271                                      | 2.140                                        | 7.574                                        | 266.0                    | 1.07739 | 8.127           | 33.50                                           |
| 190                                             | 4.519      | 200.8                        | 378.3                      | 2.369                                      | 2.602                                        | 94.01                                        | 250.3                    | 1.27031 | 20.34           | 94.07                                           |
| 190                                             | 4.519      | 125.2                        | 459.0                      | 2.794                                      | 2.855                                        | 140.8                                        | 238.5                    | 1.16274 | 12.24           | 120.5                                           |
| 190.56                                          | 4.599      | 162.7                        | 415.6                      | 2.562                                      |                                              |                                              |                          | 1.21521 | 15.91           |                                                 |
| <b><math>P = 0.1 \text{ MPa (1 bar)}</math></b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 90.72                                           | 0.1        | 451.5                        | -71.60                     | -7.097                                     | 2.168                                        | 3.367                                        | 1539.                    | 1.67726 | 193.6           | 211.2                                           |
| 100                                             | 0.1        | 438.9                        | -40.17                     | -3.798                                     | 2.114                                        | 3.408                                        | 1453.                    | 1.65487 | 151.2           | 199.6                                           |
| 111.51                                          | 0.1        | 422.6                        | -5.573                     | -0.04967                                   | 2.057                                        | 3.480                                        | 1340.                    | 1.62612 | 117.2           | 184.0                                           |
| 111.51                                          | 0.1        | 1.795                        | 510.6                      | 4.579                                      | 1.615                                        | 2.216                                        | 271.3                    | 1.00220 | 4.327           | 11.43                                           |
| 120                                             | 0.1        | 1.655                        | 529.2                      | 4.740                                      | 1.594                                        | 2.174                                        | 282.8                    | 1.00202 | 4.668           | 12.35                                           |
| 140                                             | 0.1        | 1.403                        | 572.1                      | 5.071                                      | 1.574                                        | 2.129                                        | 307.6                    | 1.00172 | 5.449           | 14.65                                           |
| 160                                             | 0.1        | 1.221                        | 614.5                      | 5.354                                      | 1.568                                        | 2.110                                        | 330.0                    | 1.00149 | 6.213           | 16.98                                           |
| 180                                             | 0.1        | 1.081                        | 656.6                      | 5.602                                      | 1.568                                        | 2.104                                        | 350.7                    | 1.00132 | 6.963           | 19.32                                           |
| 200                                             | 0.1        | 0.9709                       | 698.7                      | 5.824                                      | 1.574                                        | 2.106                                        | 370.0                    | 1.00119 | 7.697           | 21.65                                           |
| 220                                             | 0.1        | 0.8812                       | 740.9                      | 6.025                                      | 1.587                                        | 2.115                                        | 388.0                    | 1.00108 | 8.416           | 23.99                                           |
| 240                                             | 0.1        | 0.8069                       | 783.4                      | 6.209                                      | 1.607                                        | 2.133                                        | 404.9                    | 1.00099 | 9.117           | 26.39                                           |
| 260                                             | 0.1        | 0.7442                       | 826.3                      | 6.381                                      | 1.634                                        | 2.159                                        | 420.8                    | 1.00091 | 9.803           | 28.88                                           |
| 280                                             | 0.1        | 0.6906                       | 869.8                      | 6.542                                      | 1.670                                        | 2.194                                        | 435.7                    | 1.00085 | 10.47           | 31.47                                           |
| 300                                             | 0.1        | 0.6443                       | 914.1                      | 6.695                                      | 1.713                                        | 2.236                                        | 449.7                    | 1.00079 | 11.13           | 34.19                                           |
| 320                                             | 0.1        | 0.6038                       | 959.3                      | 6.841                                      | 1.763                                        | 2.285                                        | 463.1                    | 1.00074 | 11.77           | 37.04                                           |
| 340                                             | 0.1        | 0.5681                       | 1006.                      | 6.981                                      | 1.819                                        | 2.340                                        | 475.7                    | 1.00070 | 12.39           | 40.03                                           |
| 360                                             | 0.1        | 0.5364                       | 1053.                      | 7.117                                      | 1.880                                        | 2.401                                        | 487.8                    | 1.00066 | 13.00           | 43.15                                           |
| 400                                             | 0.1        | 0.4826                       | 1152.                      | 7.376                                      | 2.013                                        | 2.534                                        | 510.6                    | 1.00059 | 14.18           | 49.80                                           |
| 500                                             | 0.1        | 0.3859                       | 1423.                      | 7.981                                      | 2.381                                        | 2.901                                        | 561.9                    | 1.00047 | 16.92           | 68.34                                           |
| 600                                             | 0.1        | 0.3215                       | 1732.                      | 8.543                                      | 2.754                                        | 3.273                                        | 608.0                    | 1.00039 | 19.41           | 88.80                                           |
| 700                                             | 0.1        | 0.2756                       | 2077.                      | 9.074                                      | 3.110                                        | 3.629                                        | 650.8                    | 1.00034 | 21.68           | 110.4                                           |
| 800                                             | 0.1        | 0.2411                       | 2457.                      | 9.581                                      | 3.441                                        | 3.959                                        | 690.9                    | 1.00030 | 23.76           | 132.5                                           |
| 900                                             | 0.1        | 0.2143                       | 2868.                      | 10.06                                      | 3.744                                        | 4.263                                        | 729.0                    | 1.00026 | 25.70           | 154.7                                           |
| 1000                                            | 0.1        | 0.1929                       | 3308.                      | 10.53                                      | 4.020                                        | 4.538                                        | 765.2                    | 1.00024 | 27.49           | 176.7                                           |
| <b><math>P = 1 \text{ MPa (10 bar)}</math></b>  |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 90.95                                           | 1.0        | 451.8                        | -69.37                     | -7.070                                     | 2.169                                        | 3.363                                        | 1543.                    | 1.67772 | 195.7           | 211.7                                           |
| 100                                             | 1.0        | 439.6                        | -38.76                     | -3.862                                     | 2.116                                        | 3.401                                        | 1460.                    | 1.65604 | 153.4           | 200.5                                           |
| 120                                             | 1.0        | 410.8                        | 30.49                      | 0.2447                                     | 2.022                                        | 3.536                                        | 1262.                    | 1.60560 | 99.86           | 173.0                                           |
| 140                                             | 1.0        | 377.5                        | 103.5                      | 0.8069                                     | 1.946                                        | 3.798                                        | 1044.                    | 1.54879 | 67.81           | 144.0                                           |
| 149.14                                          | 1.0        | 359.6                        | 139.2                      | 1.054                                      | 1.920                                        | 4.023                                        | 931.2                    | 1.51885 | 56.88           | 130.4                                           |
| 149.14                                          | 1.0        | 15.70                        | 554.8                      | 3.841                                      | 1.767                                        | 2.876                                        | 286.1                    | 1.01935 | 5.788           | 18.17                                           |
| 160                                             | 1.0        | 13.97                        | 584.2                      | 4.031                                      | 1.682                                        | 2.588                                        | 305.2                    | 1.01720 | 6.287           | 18.79                                           |
| 180                                             | 1.0        | 11.81                        | 633.6                      | 4.322                                      | 1.631                                        | 2.380                                        | 333.7                    | 1.01453 | 7.089           | 20.65                                           |
| 200                                             | 1.0        | 10.33                        | 680.2                      | 4.568                                      | 1.613                                        | 2.289                                        | 357.8                    | 1.01269 | 7.838           | 22.74                                           |
| 220                                             | 1.0        | 9.217                        | 725.5                      | 4.784                                      | 1.613                                        | 2.248                                        | 379.1                    | 1.01133 | 8.558           | 24.90                                           |
| 240                                             | 1.0        | 8.344                        | 770.3                      | 4.978                                      | 1.626                                        | 2.234                                        | 398.2                    | 1.01025 | 9.258           | 27.19                                           |
| 260                                             | 1.0        | 7.634                        | 815.0                      | 5.157                                      | 1.648                                        | 2.238                                        | 415.8                    | 1.00938 | 9.939           | 29.60                                           |

| $T$<br>K                                 | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 280                                      | 1.0        | 7.043                        | 859.9                      | 5.324                                      | 1.681                                        | 2.258                                        | 432.0                    | 1.00865 | 10.60           | 32.12                                           |
| 300                                      | 1.0        | 6.542                        | 905.4                      | 5.480                                      | 1.722                                        | 2.289                                        | 447.0                    | 1.00803 | 11.25           | 34.79                                           |
| 320                                      | 1.0        | 6.110                        | 951.5                      | 5.629                                      | 1.770                                        | 2.330                                        | 461.1                    | 1.00750 | 11.89           | 37.59                                           |
| 340                                      | 1.0        | 5.733                        | 998.6                      | 5.772                                      | 1.825                                        | 2.379                                        | 474.4                    | 1.00704 | 12.51           | 40.54                                           |
| 360                                      | 1.0        | 5.402                        | 1047.                      | 5.910                                      | 1.885                                        | 2.434                                        | 487.0                    | 1.00663 | 13.11           | 43.64                                           |
| 400                                      | 1.0        | 4.846                        | 1147.                      | 6.172                                      | 2.017                                        | 2.559                                        | 510.6                    | 1.00595 | 14.28           | 50.23                                           |
| 500                                      | 1.0        | 3.860                        | 1420.                      | 6.781                                      | 2.383                                        | 2.915                                        | 563.0                    | 1.00474 | 17.01           | 68.68                                           |
| 600                                      | 1.0        | 3.210                        | 1730.                      | 7.345                                      | 2.755                                        | 3.282                                        | 609.7                    | 1.00394 | 19.48           | 89.08                                           |
| 700                                      | 1.0        | 2.750                        | 2076.                      | 7.878                                      | 3.110                                        | 3.635                                        | 652.8                    | 1.00338 | 21.74           | 110.6                                           |
| 800                                      | 1.0        | 2.405                        | 2456.                      | 8.385                                      | 3.441                                        | 3.964                                        | 693.1                    | 1.00296 | 23.82           | 132.7                                           |
| 900                                      | 1.0        | 2.137                        | 2868.                      | 8.870                                      | 3.744                                        | 4.266                                        | 731.2                    | 1.00263 | 25.75           | 154.9                                           |
| 1000                                     | 1.0        | 1.924                        | 3308.                      | 9.334                                      | 4.020                                        | 4.541                                        | 767.5                    | 1.00237 | 27.54           | 176.8                                           |
| <b><math>P = 10</math> MPa (100 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 93.22                                    | 10.0       | 454.5                        | -47.07                     | -.6806                                     | 2.176                                        | 3.325                                        | 1582.                    | 1.68223 | 212.8           | 216.9                                           |
| 100                                      | 10.0       | 446.0                        | -24.48                     | -.4466                                     | 2.139                                        | 3.344                                        | 1526.                    | 1.66701 | 174.8           | 209.0                                           |
| 120                                      | 10.0       | 419.8                        | 43.14                      | 0.1696                                     | 2.047                                        | 3.424                                        | 1352.                    | 1.62085 | 112.1           | 183.3                                           |
| 140                                      | 10.0       | 391.2                        | 112.8                      | 0.7062                                     | 1.969                                        | 3.552                                        | 1171.                    | 1.57167 | 78.30           | 157.0                                           |
| 160                                      | 10.0       | 358.8                        | 185.8                      | 1.194                                      | 1.909                                        | 3.777                                        | 981.8                    | 1.51718 | 56.70           | 131.5                                           |
| 180                                      | 10.0       | 319.6                        | 265.3                      | 1.661                                      | 1.873                                        | 4.226                                        | 780.8                    | 1.45298 | 41.52           | 107.0                                           |
| 200                                      | 10.0       | 266.2                        | 358.9                      | 2.153                                      | 1.878                                        | 5.304                                        | 567.9                    | 1.36870 | 29.55           | 83.93                                           |
| 220                                      | 10.0       | 187.6                        | 482.7                      | 2.742                                      | 1.903                                        | 6.713                                        | 404.4                    | 1.25087 | 19.37           | 63.29                                           |
| 240                                      | 10.0       | 128.4                        | 599.6                      | 3.252                                      | 1.847                                        | 4.853                                        | 383.6                    | 1.16707 | 14.89           | 49.74                                           |
| 260                                      | 10.0       | 101.0                        | 683.8                      | 3.589                                      | 1.803                                        | 3.730                                        | 402.8                    | 1.12974 | 13.80           | 44.85                                           |
| 280                                      | 10.0       | 85.51                        | 752.9                      | 3.846                                      | 1.793                                        | 3.242                                        | 424.5                    | 1.10902 | 13.61           | 43.81                                           |
| 300                                      | 10.0       | 75.18                        | 815.1                      | 4.060                                      | 1.807                                        | 3.002                                        | 444.5                    | 1.09539 | 13.75           | 44.37                                           |
| 320                                      | 10.0       | 67.61                        | 873.8                      | 4.250                                      | 1.838                                        | 2.878                                        | 462.8                    | 1.08549 | 14.04           | 45.79                                           |
| 340                                      | 10.0       | 61.75                        | 930.6                      | 4.422                                      | 1.880                                        | 2.817                                        | 479.5                    | 1.07786 | 14.41           | 47.75                                           |
| 360                                      | 10.0       | 57.01                        | 986.7                      | 4.582                                      | 1.931                                        | 2.795                                        | 494.8                    | 1.07173 | 14.82           | 50.09                                           |
| 400                                      | 10.0       | 49.74                        | 1099.                      | 4.877                                      | 2.051                                        | 2.819                                        | 522.6                    | 1.06238 | 15.72           | 55.61                                           |
| 500                                      | 10.0       | 38.32                        | 1391.                      | 5.529                                      | 2.401                                        | 3.055                                        | 581.0                    | 1.04783 | 18.06           | 72.56                                           |
| 600                                      | 10.0       | 31.47                        | 1712.                      | 6.113                                      | 2.766                                        | 3.370                                        | 630.6                    | 1.03918 | 20.32           | 92.15                                           |
| 700                                      | 10.0       | 26.82                        | 2066.                      | 6.657                                      | 3.117                                        | 3.696                                        | 675.2                    | 1.03334 | 22.44           | 113.2                                           |
| 800                                      | 10.0       | 23.41                        | 2451.                      | 7.171                                      | 3.445                                        | 4.008                                        | 716.3                    | 1.02907 | 24.43           | 134.9                                           |
| 900                                      | 10.0       | 20.79                        | 2866.                      | 7.660                                      | 3.747                                        | 4.300                                        | 754.7                    | 1.02581 | 26.28           | 156.8                                           |
| 1000                                     | 10.0       | 18.72                        | 3310.                      | 8.128                                      | 4.022                                        | 4.568                                        | 791.1                    | 1.02323 | 28.02           | 178.5                                           |

**Ethane (C<sub>2</sub>H<sub>6</sub>)**

| $T$<br>K          | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b>Saturation</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 90.37             | 0.0000011  | 651.5                        | -219.2                     | -1.655                                     | 1.605                                        | 2.326                                        | 2009.                    | 1.94483 | 1281.           | 255.6                                           |
| 90.37             | 0.0000011  | 0.0000457                    | 375.6                      | 4.927                                      | 0.8916                                       | 1.168                                        | 180.9                    | 1.00000 | 3.043           | 2.908                                           |
| 100               | 0.0000111  | 640.9                        | -197.0                     | -1.422                                     | 1.541                                        | 2.283                                        | 1938.                    | 1.92579 | 873.2           | 247.8                                           |
| 100               | 0.0000111  | 0.0004007                    | 386.9                      | 4.418                                      | 0.9107                                       | 1.187                                        | 189.9                    | 1.00000 | 3.316           | 3.456                                           |
| 120               | 0.0003523  | 618.9                        | -151.5                     | -1.007                                     | 1.478                                        | 2.280                                        | 1794.                    | 1.88657 | 485.8           | 229.9                                           |
| 120               | 0.0003523  | 0.01062                      | 411.0                      | 3.681                                      | 0.9528                                       | 1.230                                        | 206.9                    | 1.00001 | 3.896           | 4.657                                           |
| 140               | 0.003814   | 596.6                        | -105.6                     | -.6532                                     | 1.450                                        | 2.311                                        | 1649.                    | 1.84725 | 319.8           | 210.6                                           |
| 140               | 0.003814   | 0.09880                      | 435.6                      | 3.213                                      | 1.003                                        | 1.284                                        | 222.0                    | 1.00011 | 4.496           | 5.966                                           |
| 160               | 0.02141    | 573.6                        | -58.95                     | -.3418                                     | 1.436                                        | 2.357                                        | 1501.                    | 1.80737 | 231.2           | 190.8                                           |
| 160               | 0.02141    | 0.4890                       | 460.3                      | 2.904                                      | 1.048                                        | 1.338                                        | 235.1                    | 1.00054 | 5.110           | 7.422                                           |
| 180               | 0.07864    | 549.5                        | -11.13                     | -.06082                                    | 1.434                                        | 2.421                                        | 1350.                    | 1.76641 | 176.2           | 171.3                                           |
| 180               | 0.07864    | 1.625                        | 484.2                      | 2.691                                      | 1.098                                        | 1.409                                        | 245.5                    | 1.00181 | 5.739           | 9.079                                           |
| 200               | 0.2172     | 524.0                        | 38.30                      | 0.1981                                     | 1.444                                        | 2.512                                        | 1196.                    | 1.72364 | 138.3           | 152.6                                           |
| 200               | 0.2172     | 4.170                        | 506.2                      | 2.538                                      | 1.179                                        | 1.537                                        | 252.3                    | 1.00465 | 6.391           | 11.01                                           |
| 220               | 0.4920     | 496.3                        | 90.01                      | 0.4419                                     | 1.468                                        | 2.645                                        | 1037.                    | 1.67809 | 110.1           | 134.6                                           |
| 220               | 0.4920     | 9.017                        | 525.5                      | 2.421                                      | 1.280                                        | 1.720                                        | 254.6                    | 1.01008 | 7.089           | 13.32                                           |
| 240               | 0.9668     | 465.3                        | 145.0                      | 0.6767                                     | 1.507                                        | 2.847                                        | 873.3                    | 1.62822 | 87.80           | 117.5                                           |

| $T$<br>K                                | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 240                                     | 0.9668     | 17.43                        | 540.9                      | 2.326                                      | 1.388                                        | 1.976                                        | 252.1                    | 1.01957 | 7.881           | 16.18                                           |
| 260                                     | 1.712      | 429.1                        | 204.9                      | 0.9095                                     | 1.566                                        | 3.195                                        | 700.5                    | 1.57121 | 69.30           | 101.2                                           |
| 260                                     | 1.712      | 31.58                        | 550.2                      | 2.238                                      | 1.516                                        | 2.418                                        | 243.8                    | 1.03567 | 8.876           | 20.02                                           |
| 280                                     | 2.807      | 382.7                        | 273.1                      | 1.152                                      | 1.654                                        | 3.987                                        | 512.4                    | 1.50037 | 52.84           | 85.43                                           |
| 280                                     | 2.807      | 56.37                        | 548.6                      | 2.136                                      | 1.696                                        | 3.522                                        | 228.1                    | 1.06440 | 10.37           | 26.33                                           |
| 300                                     | 4.357      | 303.5                        | 364.4                      | 1.451                                      | 1.912                                        | 10.02                                        | 274.9                    | 1.38458 | 34.97           | 71.49                                           |
| 300                                     | 4.357      | 114.5                        | 514.1                      | 1.950                                      | 2.089                                        | 13.30                                        | 200.5                    | 1.13418 | 14.02           | 47.46                                           |
| 305.32                                  | 4.872      | 206.2                        | 439.0                      | 1.690                                      |                                              |                                              |                          | 1.25115 | 21.80           |                                                 |
| <b><math>P = 0.1</math> MPa (1 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 90.38                                   | 0.1        | 651.5                        | -219.0                     | -1.655                                     | 1.605                                        | 2.326                                        | 2009.                    | 1.94485 | 1281.           | 255.6                                           |
| 100                                     | 0.1        | 641.0                        | -196.9                     | -1.422                                     | 1.541                                        | 2.283                                        | 1939.                    | 1.92586 | 873.9           | 247.9                                           |
| 120                                     | 0.1        | 619.0                        | -151.4                     | -1.007                                     | 1.478                                        | 2.279                                        | 1795.                    | 1.88665 | 486.1           | 230.0                                           |
| 140                                     | 0.1        | 596.6                        | -105.5                     | -0.6535                                    | 1.450                                        | 2.311                                        | 1650.                    | 1.84735 | 320.0           | 210.6                                           |
| 160                                     | 0.1        | 573.6                        | -58.85                     | -0.3420                                    | 1.436                                        | 2.357                                        | 1502.                    | 1.80747 | 231.3           | 190.9                                           |
| 180                                     | 0.1        | 549.5                        | -11.10                     | -0.06091                                   | 1.434                                        | 2.421                                        | 1351.                    | 1.76644 | 176.2           | 171.4                                           |
| 184.33                                  | 0.1        | 544.1                        | -5954                      | -0.03215                                   | 1.435                                        | 2.438                                        | 1317.                    | 1.75734 | 166.9           | 167.2                                           |
| 184.33                                  | 0.1        | 2.030                        | 489.1                      | 2.654                                      | 1.113                                        | 1.432                                        | 247.3                    | 1.00226 | 5.877           | 9.471                                           |
| 200                                     | 0.1        | 1.856                        | 511.8                      | 2.771                                      | 1.149                                        | 1.457                                        | 257.9                    | 1.00207 | 6.368           | 10.72                                           |
| 220                                     | 0.1        | 1.676                        | 541.3                      | 2.912                                      | 1.200                                        | 1.499                                        | 270.3                    | 1.00187 | 6.991           | 12.47                                           |
| 240                                     | 0.1        | 1.529                        | 571.8                      | 3.045                                      | 1.260                                        | 1.554                                        | 281.8                    | 1.00170 | 7.608           | 14.39                                           |
| 260                                     | 0.1        | 1.407                        | 603.5                      | 3.172                                      | 1.328                                        | 1.617                                        | 292.5                    | 1.00157 | 8.217           | 16.48                                           |
| 280                                     | 0.1        | 1.303                        | 636.5                      | 3.294                                      | 1.401                                        | 1.688                                        | 302.6                    | 1.00145 | 8.817           | 18.76                                           |
| 300                                     | 0.1        | 1.214                        | 671.1                      | 3.413                                      | 1.479                                        | 1.764                                        | 312.2                    | 1.00135 | 9.408           | 21.22                                           |
| 320                                     | 0.1        | 1.137                        | 707.1                      | 3.530                                      | 1.560                                        | 1.844                                        | 321.4                    | 1.00127 | 9.989           | 23.85                                           |
| 340                                     | 0.1        | 1.069                        | 744.8                      | 3.644                                      | 1.644                                        | 1.927                                        | 330.3                    | 1.00119 | 10.56           | 26.65                                           |
| 360                                     | 0.1        | 1.009                        | 784.2                      | 3.756                                      | 1.729                                        | 2.011                                        | 338.8                    | 1.00112 | 11.12           | 29.61                                           |
| 400                                     | 0.1        | 0.9067                       | 868.1                      | 3.977                                      | 1.901                                        | 2.181                                        | 355.2                    | 1.00101 | 12.21           | 35.96                                           |
| 500                                     | 0.1        | 0.7242                       | 1107.                      | 4.509                                      | 2.315                                        | 2.594                                        | 393.1                    | 1.00081 | 14.78           | 53.77                                           |
| 600                                     | 0.1        | 0.6031                       | 1386.                      | 5.015                                      | 2.689                                        | 2.967                                        | 427.6                    | 1.00067 | 17.13           | 73.34                                           |
| 700                                     | 0.1        | 0.5167                       | 1699.                      | 5.498                                      | 3.021                                        | 3.298                                        | 459.6                    | 1.00058 | 19.32           | 93.86                                           |
| 800                                     | 0.1        | 0.4520                       | 2044.                      | 5.958                                      | 3.314                                        | 3.591                                        | 489.6                    | 1.00050 | 21.36           | 114.8                                           |
| 900                                     | 0.1        | 0.4018                       | 2416.                      | 6.396                                      | 3.572                                        | 3.849                                        | 517.9                    | 1.00045 | 23.28           | 135.9                                           |
| 1000                                    | 0.1        | 0.3616                       | 2813.                      | 6.814                                      | 3.799                                        | 4.076                                        | 544.8                    | 1.00040 | 25.10           | 156.8                                           |
| <b><math>P = 1</math> MPa (10 bar)</b>  |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 90.53                                   | 1.0        | 651.7                        | -217.5                     | -1.653                                     | 1.605                                        | 2.324                                        | 2012.                    | 1.94510 | 1283.           | 255.9                                           |
| 100                                     | 1.0        | 641.3                        | -195.7                     | -1.424                                     | 1.542                                        | 2.282                                        | 1942.                    | 1.92644 | 880.2           | 248.3                                           |
| 120                                     | 1.0        | 619.4                        | -150.2                     | -1.010                                     | 1.480                                        | 2.278                                        | 1799.                    | 1.88737 | 489.1           | 230.5                                           |
| 140                                     | 1.0        | 597.2                        | -104.4                     | -0.6563                                    | 1.452                                        | 2.309                                        | 1654.                    | 1.84822 | 322.0           | 211.2                                           |
| 160                                     | 1.0        | 574.3                        | -57.80                     | -0.3452                                    | 1.437                                        | 2.354                                        | 1508.                    | 1.80855 | 232.8           | 191.6                                           |
| 180                                     | 1.0        | 550.4                        | -10.13                     | -0.06458                                   | 1.435                                        | 2.416                                        | 1358.                    | 1.76780 | 177.5           | 172.1                                           |
| 200                                     | 1.0        | 524.9                        | 39.03                      | 0.1943                                     | 1.445                                        | 2.505                                        | 1204.                    | 1.72518 | 139.3           | 153.3                                           |
| 220                                     | 1.0        | 497.1                        | 90.36                      | 0.4388                                     | 1.468                                        | 2.637                                        | 1044.                    | 1.67944 | 110.7           | 135.2                                           |
| 240                                     | 1.0        | 465.4                        | 145.0                      | 0.6764                                     | 1.507                                        | 2.846                                        | 873.9                    | 1.62834 | 87.85           | 117.6                                           |
| 241.10                                  | 1.0        | 463.5                        | 148.1                      | 0.6894                                     | 1.510                                        | 2.861                                        | 864.0                    | 1.62531 | 86.70           | 116.6                                           |
| 241.10                                  | 1.0        | 18.04                        | 541.6                      | 2.321                                      | 1.395                                        | 1.994                                        | 251.8                    | 1.02025 | 7.929           | 16.36                                           |
| 260                                     | 1.0        | 15.93                        | 577.9                      | 2.466                                      | 1.400                                        | 1.880                                        | 268.9                    | 1.01786 | 8.485           | 17.92                                           |
| 280                                     | 1.0        | 14.32                        | 615.3                      | 2.605                                      | 1.449                                        | 1.869                                        | 283.8                    | 1.01604 | 9.072           | 19.91                                           |
| 300                                     | 1.0        | 13.07                        | 652.9                      | 2.735                                      | 1.513                                        | 1.898                                        | 296.9                    | 1.01463 | 9.652           | 22.18                                           |
| 320                                     | 1.0        | 12.05                        | 691.3                      | 2.859                                      | 1.585                                        | 1.948                                        | 308.7                    | 1.01349 | 10.22           | 24.67                                           |
| 340                                     | 1.0        | 11.21                        | 730.9                      | 2.979                                      | 1.663                                        | 2.010                                        | 319.6                    | 1.01254 | 10.79           | 27.36                                           |
| 360                                     | 1.0        | 10.49                        | 771.8                      | 3.095                                      | 1.745                                        | 2.079                                        | 329.9                    | 1.01173 | 11.34           | 30.24                                           |
| 400                                     | 1.0        | 9.312                        | 857.9                      | 3.322                                      | 1.911                                        | 2.230                                        | 348.8                    | 1.01041 | 12.42           | 36.46                                           |
| 500                                     | 1.0        | 7.323                        | 1101.                      | 3.862                                      | 2.321                                        | 2.620                                        | 390.2                    | 1.00818 | 14.95           | 54.08                                           |
| 600                                     | 1.0        | 6.058                        | 1381.                      | 4.372                                      | 2.693                                        | 2.983                                        | 426.6                    | 1.00677 | 17.29           | 73.56                                           |
| 700                                     | 1.0        | 5.173                        | 1696.                      | 4.857                                      | 3.023                                        | 3.309                                        | 459.7                    | 1.00578 | 19.46           | 94.03                                           |
| 800                                     | 1.0        | 4.518                        | 2042.                      | 5.318                                      | 3.315                                        | 3.598                                        | 490.3                    | 1.00505 | 21.48           | 115.0                                           |

| $T$<br>K                                 | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 900                                      | 1.0        | 4.011                        | 2415.                      | 5.757                                      | 3.573                                        | 3.855                                        | 519.0                    | 1.00448 | 23.39           | 136.0                                           |
| 1000                                     | 1.0        | 3.608                        | 2812.                      | 6.175                                      | 3.800                                        | 4.081                                        | 546.2                    | 1.00403 | 25.20           | 156.9                                           |
| <b><math>P = 10</math> MPa (100 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 91.96                                    | 10.0       | 653.3                        | -202.5                     | -1.640                                     | 1.605                                        | 2.310                                        | 2034.                    | 1.94751 | 1310.           | 258.6                                           |
| 100                                      | 10.0       | 644.8                        | -184.1                     | -1.448                                     | 1.553                                        | 2.275                                        | 1976.                    | 1.93215 | 947.3           | 252.5                                           |
| 120                                      | 10.0       | 623.6                        | -138.8                     | -1.035                                     | 1.490                                        | 2.266                                        | 1839.                    | 1.89429 | 520.6           | 235.4                                           |
| 140                                      | 10.0       | 602.2                        | -93.25                     | -.6839                                     | 1.463                                        | 2.290                                        | 1701.                    | 1.85661 | 342.0           | 216.9                                           |
| 160                                      | 10.0       | 580.4                        | -47.10                     | -.3758                                     | 1.449                                        | 2.326                                        | 1564.                    | 1.81879 | 248.1           | 197.9                                           |
| 180                                      | 10.0       | 558.1                        | -.1206                     | -.09918                                    | 1.447                                        | 2.374                                        | 1425.                    | 1.78049 | 190.5           | 179.3                                           |
| 200                                      | 10.0       | 534.8                        | 47.98                      | 0.1542                                     | 1.456                                        | 2.439                                        | 1287.                    | 1.74125 | 151.3           | 161.4                                           |
| 220                                      | 10.0       | 510.2                        | 97.60                      | 0.3905                                     | 1.478                                        | 2.527                                        | 1147.                    | 1.70050 | 122.4           | 144.4                                           |
| 240                                      | 10.0       | 483.8                        | 149.3                      | 0.6152                                     | 1.511                                        | 2.646                                        | 1008.                    | 1.65744 | 99.96           | 128.5                                           |
| 260                                      | 10.0       | 454.6                        | 203.7                      | 0.8331                                     | 1.557                                        | 2.809                                        | 866.9                    | 1.61088 | 81.74           | 113.6                                           |
| 280                                      | 10.0       | 421.4                        | 262.1                      | 1.049                                      | 1.616                                        | 3.044                                        | 724.4                    | 1.55888 | 66.38           | 99.57                                           |
| 300                                      | 10.0       | 381.3                        | 326.4                      | 1.271                                      | 1.689                                        | 3.419                                        | 579.3                    | 1.49786 | 52.87           | 86.39                                           |
| 320                                      | 10.0       | 328.8                        | 400.9                      | 1.511                                      | 1.783                                        | 4.109                                        | 434.8                    | 1.42048 | 40.36           | 73.81                                           |
| 340                                      | 10.0       | 255.9                        | 493.3                      | 1.791                                      | 1.888                                        | 5.070                                        | 319.9                    | 1.31781 | 28.77           | 62.21                                           |
| 360                                      | 10.0       | 187.0                        | 591.3                      | 2.071                                      | 1.941                                        | 4.452                                        | 286.8                    | 1.22573 | 21.62           | 53.36                                           |
| 400                                      | 10.0       | 126.2                        | 738.6                      | 2.460                                      | 2.025                                        | 3.205                                        | 310.4                    | 1.14850 | 17.94           | 48.70                                           |
| 500                                      | 10.0       | 80.57                        | 1035.                      | 3.123                                      | 2.369                                        | 2.933                                        | 377.8                    | 1.09293 | 17.95           | 59.52                                           |
| 600                                      | 10.0       | 62.41                        | 1338.                      | 3.675                                      | 2.722                                        | 3.150                                        | 427.4                    | 1.07144 | 19.50           | 76.88                                           |
| 700                                      | 10.0       | 51.79                        | 1666.                      | 4.180                                      | 3.043                                        | 3.415                                        | 467.8                    | 1.05903 | 21.26           | 96.40                                           |
| 800                                      | 10.0       | 44.59                        | 2021.                      | 4.653                                      | 3.330                                        | 3.672                                        | 502.9                    | 1.05068 | 23.01           | 116.8                                           |
| 900                                      | 10.0       | 39.30                        | 2400.                      | 5.100                                      | 3.584                                        | 3.909                                        | 534.3                    | 1.04457 | 24.73           | 137.5                                           |
| 1000                                     | 10.0       | 35.20                        | 2802.                      | 5.523                                      | 3.809                                        | 4.122                                        | 563.2                    | 1.03988 | 26.40           | 158.2                                           |

**Propane (C<sub>3</sub>H<sub>8</sub>)**

| $T$<br>K          | $P$<br>MPa            | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-------------------|-----------------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| <b>Saturation</b> |                       |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 85.53             | 0.17×10 <sup>-9</sup> | 733.1                        | -196.6                     | -1.396                                     | 1.355                                        | 1.916                                        | 2136.                    | 2.08838 | 10780           | 207.9                                           |
| 85.53             | 0.17×10 <sup>-9</sup> | 0.11×10 <sup>-7</sup>        | 366.3                      | 5.186                                      | 0.6907                                       | 0.8792                                       | 143.3                    | 1.00000 | 2.641           | 1.706                                           |
| 100               | 0.25×10 <sup>-7</sup> | 718.1                        | -168.8                     | -1.095                                     | 1.341                                        | 1.930                                        | 2038.                    | 2.05908 | 3774.           | 203.2                                           |
| 100               | 0.25×10 <sup>-7</sup> | 0.0000013                    | 379.4                      | 4.387                                      | 0.7475                                       | 0.9361                                       | 153.7                    | 1.00000 | 2.979           | 2.417                                           |
| 120               | 0.0000030             | 697.8                        | -129.9                     | -.7411                                     | 1.335                                        | 1.957                                        | 1901.                    | 2.01930 | 1500.           | 194.4                                           |
| 120               | 0.0000030             | 0.0001310                    | 398.9                      | 3.666                                      | 0.8210                                       | 1.010                                        | 166.8                    | 1.00000 | 3.467           | 3.500                                           |
| 140               | 0.0000790             | 677.6                        | -90.51                     | -.4372                                     | 1.335                                        | 1.988                                        | 1767.                    | 1.98025 | 822.2           | 183.9                                           |
| 140               | 0.0000790             | 0.002993                     | 419.7                      | 3.207                                      | 0.8878                                       | 1.076                                        | 178.9                    | 1.00000 | 3.970           | 4.699                                           |
| 160               | 0.0008502             | 657.3                        | -50.38                     | -.1693                                     | 1.342                                        | 2.025                                        | 1633.                    | 1.94163 | 535.0           | 172.3                                           |
| 160               | 0.0008502             | 0.02821                      | 441.8                      | 2.907                                      | 0.9514                                       | 1.141                                        | 190.0                    | 1.00003 | 4.483           | 6.013                                           |
| 180               | 0.005068              | 636.6                        | -9.433                     | 0.07174                                    | 1.356                                        | 2.070                                        | 1499.                    | 1.90310 | 382.2           | 160.2                                           |
| 180               | 0.005068              | 0.1499                       | 464.9                      | 2.707                                      | 1.017                                        | 1.209                                        | 200.1                    | 1.00016 | 5.000           | 7.439                                           |
| 200               | 0.02019               | 615.4                        | 32.53                      | 0.2926                                     | 1.383                                        | 2.127                                        | 1366.                    | 1.86434 | 288.0           | 147.8                                           |
| 200               | 0.02019               | 0.5417                       | 488.6                      | 2.573                                      | 1.088                                        | 1.287                                        | 208.7                    | 1.00059 | 5.515           | 8.971                                           |
| 220               | 0.06057               | 593.4                        | 75.80                      | 0.4984                                     | 1.421                                        | 2.199                                        | 1233.                    | 1.82499 | 224.2           | 135.7                                           |
| 220               | 0.06057               | 1.499                        | 512.7                      | 2.484                                      | 1.169                                        | 1.381                                        | 215.6                    | 1.00164 | 6.026           | 10.61                                           |
| 240               | 0.1480                | 570.4                        | 120.7                      | 0.6932                                     | 1.469                                        | 2.289                                        | 1102.                    | 1.78460 | 178.4           | 124.0                                           |
| 240               | 0.1480                | 3.438                        | 536.6                      | 2.426                                      | 1.259                                        | 1.494                                        | 220.1                    | 1.00376 | 6.540           | 12.38                                           |
| 260               | 0.3107                | 545.8                        | 167.7                      | 0.8801                                     | 1.528                                        | 2.403                                        | 971.7                    | 1.74256 | 143.9           | 112.9                                           |
| 260               | 0.3107                | 6.903                        | 560.1                      | 2.389                                      | 1.357                                        | 1.630                                        | 221.9                    | 1.00755 | 7.073           | 14.32                                           |
| 280               | 0.5817                | 519.2                        | 217.3                      | 1.062                                      | 1.596                                        | 2.547                                        | 840.3                    | 1.69800 | 117.1           | 102.5                                           |
| 280               | 0.5817                | 12.62                        | 582.3                      | 2.365                                      | 1.466                                        | 1.803                                        | 220.4                    | 1.01383 | 7.655           | 16.54                                           |
| 300               | 0.9977                | 489.4                        | 270.2                      | 1.241                                      | 1.675                                        | 2.740                                        | 706.8                    | 1.64961 | 95.28           | 92.86                                           |
| 300               | 0.9977                | 21.63                        | 602.6                      | 2.349                                      | 1.588                                        | 2.041                                        | 214.8                    | 1.02381 | 8.340           | 19.24                                           |
| 320               | 1.599                 | 454.9                        | 327.3                      | 1.421                                      | 1.764                                        | 3.028                                        | 569.1                    | 1.59504 | 76.78           | 83.94                                           |
| 320               | 1.599                 | 35.74                        | 619.5                      | 2.334                                      | 1.729                                        | 2.416                                        | 204.4                    | 1.03957 | 9.230           | 22.78                                           |
| 340               | 2.431                 | 411.8                        | 390.9                      | 1.608                                      | 1.872                                        | 3.585                                        | 422.5                    | 1.52907 | 59.98           | 75.57                                           |

| $T$<br>K                                 | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|------------------------------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 340                                      | 2.431      | 58.88                        | 629.8                      | 2.311                                      | 1.898                                        | 3.197                                        | 187.4                    | 1.06579 | 10.57           | 28.20                                           |
| 360                                      | 3.555      | 345.6                        | 468.2                      | 1.820                                      | 2.049                                        | 5.984                                        | 251.0                    | 1.43242 | 42.27           | 67.72                                           |
| 360                                      | 3.555      | 105.4                        | 622.4                      | 2.249                                      | 2.183                                        | 7.111                                        | 161.1                    | 1.11995 | 13.38           | 41.36                                           |
| 369.89                                   | 4.251      | 220.5                        | 555.2                      | 2.052                                      |                                              |                                              |                          | 1.26277 | 22.89           |                                                 |
| <b><math>P = 0.1</math> MPa (1 bar)</b>  |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 85.53                                    | 0.1        | 733.1                        | -196.5                     | -1.396                                     | 1.355                                        | 1.916                                        | 2137.                    | 2.08840 | 10790           | 207.9                                           |
| 100                                      | 0.1        | 718.2                        | -168.7                     | -1.096                                     | 1.341                                        | 1.930                                        | 2038.                    | 2.05912 | 3778.           | 203.2                                           |
| 120                                      | 0.1        | 697.8                        | -129.8                     | -.7413                                     | 1.335                                        | 1.957                                        | 1902.                    | 2.01936 | 1502.           | 194.5                                           |
| 140                                      | 0.1        | 677.6                        | -90.39                     | -.4374                                     | 1.335                                        | 1.988                                        | 1767.                    | 1.98032 | 822.9           | 184.0                                           |
| 160                                      | 0.1        | 657.3                        | -50.27                     | -.1695                                     | 1.342                                        | 2.025                                        | 1633.                    | 1.94172 | 535.5           | 172.4                                           |
| 180                                      | 0.1        | 636.7                        | -9.328                     | 0.07149                                    | 1.357                                        | 2.070                                        | 1500.                    | 1.90320 | 382.5           | 160.2                                           |
| 200                                      | 0.1        | 615.5                        | 32.62                      | 0.2924                                     | 1.383                                        | 2.127                                        | 1366.                    | 1.86444 | 288.2           | 147.9                                           |
| 220                                      | 0.1        | 593.5                        | 75.84                      | 0.4983                                     | 1.421                                        | 2.198                                        | 1234.                    | 1.82505 | 224.3           | 135.7                                           |
| 230.74                                   | 0.1        | 581.2                        | 99.69                      | 0.6042                                     | 1.446                                        | 2.245                                        | 1163.                    | 1.80347 | 197.9           | 129.4                                           |
| 230.74                                   | 0.1        | 2.387                        | 525.6                      | 2.450                                      | 1.216                                        | 1.439                                        | 218.3                    | 1.00261 | 6.301           | 11.54                                           |
| 240                                      | 0.1        | 2.284                        | 539.0                      | 2.507                                      | 1.249                                        | 1.467                                        | 222.9                    | 1.00249 | 6.559           | 12.40                                           |
| 260                                      | 0.1        | 2.092                        | 569.0                      | 2.627                                      | 1.324                                        | 1.535                                        | 232.3                    | 1.00228 | 7.110           | 14.32                                           |
| 280                                      | 0.1        | 1.932                        | 600.5                      | 2.744                                      | 1.405                                        | 1.610                                        | 241.1                    | 1.00211 | 7.656           | 16.36                                           |
| 300                                      | 0.1        | 1.796                        | 633.5                      | 2.857                                      | 1.490                                        | 1.692                                        | 249.4                    | 1.00196 | 8.196           | 18.51                                           |
| 320                                      | 0.1        | 1.679                        | 668.2                      | 2.969                                      | 1.578                                        | 1.777                                        | 257.3                    | 1.00183 | 8.732           | 20.78                                           |
| 340                                      | 0.1        | 1.576                        | 704.6                      | 3.080                                      | 1.668                                        | 1.865                                        | 264.9                    | 1.00172 | 9.262           | 23.16                                           |
| 360                                      | 0.1        | 1.486                        | 742.8                      | 3.189                                      | 1.758                                        | 1.954                                        | 272.3                    | 1.00162 | 9.787           | 25.66                                           |
| 400                                      | 0.1        | 1.334                        | 824.5                      | 3.404                                      | 1.937                                        | 2.130                                        | 286.2                    | 1.00145 | 10.82           | 30.99                                           |
| 500                                      | 0.1        | 1.064                        | 1059.                      | 3.925                                      | 2.356                                        | 2.547                                        | 318.3                    | 1.00116 | 13.29           | 46.36                                           |
| 600                                      | 0.1        | 0.8852                       | 1332.                      | 4.422                                      | 2.722                                        | 2.912                                        | 347.4                    | 1.00096 | 15.59           | 64.63                                           |
| 700                                      | 0.1        | 0.7581                       | 1640.                      | 4.896                                      | 3.038                                        | 3.228                                        | 374.2                    | 1.00082 | 17.70           | 85.81                                           |
| 800                                      | 0.1        | 0.6631                       | 1976.                      | 5.345                                      | 3.313                                        | 3.502                                        | 399.3                    | 1.00072 | 19.62           | 109.9                                           |
| 900                                      | 0.1        | 0.5892                       | 2339.                      | 5.772                                      | 3.553                                        | 3.743                                        | 422.8                    | 1.00064 | 21.36           | 136.9                                           |
| 1000                                     | 0.1        | 0.5302                       | 2724.                      | 6.177                                      | 3.764                                        | 3.953                                        | 445.1                    | 1.00058 | 22.93           | 166.8                                           |
| <b><math>P = 1</math> MPa (10 bar)</b>   |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 85.62                                    | 1.0        | 733.3                        | -195.3                     | -1.396                                     | 1.356                                        | 1.916                                        | 2139.                    | 2.08856 | 10840           | 208.1                                           |
| 100                                      | 1.0        | 718.5                        | -167.6                     | -1.097                                     | 1.342                                        | 1.930                                        | 2041.                    | 2.05953 | 3816.           | 203.5                                           |
| 120                                      | 1.0        | 698.2                        | -128.8                     | -.7432                                     | 1.336                                        | 1.956                                        | 1905.                    | 2.01987 | 1515.           | 194.8                                           |
| 140                                      | 1.0        | 678.1                        | -89.34                     | -.4394                                     | 1.336                                        | 1.987                                        | 1771.                    | 1.98096 | 829.3           | 184.3                                           |
| 160                                      | 1.0        | 657.8                        | -49.24                     | -.1717                                     | 1.343                                        | 2.024                                        | 1638.                    | 1.94249 | 539.4           | 172.8                                           |
| 180                                      | 1.0        | 637.3                        | -8.331                     | 0.06918                                    | 1.358                                        | 2.068                                        | 1505.                    | 1.90415 | 385.3           | 160.7                                           |
| 200                                      | 1.0        | 616.2                        | 33.57                      | 0.2899                                     | 1.384                                        | 2.124                                        | 1372.                    | 1.86560 | 290.4           | 148.4                                           |
| 220                                      | 1.0        | 594.4                        | 76.72                      | 0.4955                                     | 1.422                                        | 2.194                                        | 1241.                    | 1.82648 | 226.2           | 136.3                                           |
| 240                                      | 1.0        | 571.5                        | 121.5                      | 0.6901                                     | 1.470                                        | 2.284                                        | 1111.                    | 1.78630 | 180.0           | 124.6                                           |
| 260                                      | 1.0        | 547.0                        | 168.2                      | 0.8771                                     | 1.528                                        | 2.395                                        | 980.1                    | 1.74433 | 145.2           | 113.5                                           |
| 280                                      | 1.0        | 520.1                        | 217.5                      | 1.060                                      | 1.596                                        | 2.539                                        | 846.7                    | 1.69945 | 117.9           | 102.9                                           |
| 300                                      | 1.0        | 489.5                        | 270.2                      | 1.241                                      | 1.675                                        | 2.740                                        | 706.9                    | 1.64962 | 95.28           | 92.86                                           |
| 300.09                                   | 1.0        | 489.3                        | 270.4                      | 1.242                                      | 1.675                                        | 2.741                                        | 706.2                    | 1.64937 | 95.19           | 92.82                                           |
| 300.09                                   | 1.0        | 21.68                        | 602.7                      | 2.349                                      | 1.588                                        | 2.042                                        | 214.8                    | 1.02386 | 8.344           | 19.25                                           |
| 320                                      | 1.0        | 19.34                        | 642.9                      | 2.479                                      | 1.646                                        | 2.009                                        | 229.9                    | 1.02125 | 8.877           | 21.49                                           |
| 340                                      | 1.0        | 17.61                        | 683.2                      | 2.601                                      | 1.717                                        | 2.032                                        | 242.4                    | 1.01931 | 9.414           | 23.91                                           |
| 360                                      | 1.0        | 16.25                        | 724.3                      | 2.719                                      | 1.795                                        | 2.081                                        | 253.5                    | 1.01779 | 9.948           | 26.46                                           |
| 400                                      | 1.0        | 14.17                        | 810.1                      | 2.944                                      | 1.958                                        | 2.211                                        | 272.6                    | 1.01549 | 11.00           | 31.92                                           |
| 500                                      | 1.0        | 10.93                        | 1050.                      | 3.478                                      | 2.363                                        | 2.583                                        | 311.6                    | 1.01191 | 13.48           | 47.56                                           |
| 600                                      | 1.0        | 8.964                        | 1326.                      | 3.980                                      | 2.725                                        | 2.933                                        | 344.1                    | 1.00976 | 15.76           | 66.04                                           |
| 700                                      | 1.0        | 7.623                        | 1635.                      | 4.456                                      | 3.040                                        | 3.242                                        | 372.9                    | 1.00830 | 17.86           | 87.38                                           |
| 800                                      | 1.0        | 6.641                        | 1973.                      | 4.907                                      | 3.315                                        | 3.512                                        | 399.1                    | 1.00723 | 19.76           | 111.6                                           |
| 900                                      | 1.0        | 5.889                        | 2336.                      | 5.334                                      | 3.555                                        | 3.750                                        | 423.4                    | 1.00641 | 21.49           | 138.7                                           |
| 1000                                     | 1.0        | 5.292                        | 2722.                      | 5.741                                      | 3.765                                        | 3.959                                        | 446.3                    | 1.00576 | 23.04           | 168.7                                           |
| <b><math>P = 10</math> MPa (100 bar)</b> |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 86.45                                    | 10.0       | 735.2                        | -182.9                     | -1.394                                     | 1.362                                        | 1.914                                        | 2159.                    | 2.09013 | 11310           | 209.8                                           |
| 100                                      | 10.0       | 721.5                        | -156.9                     | -1.115                                     | 1.350                                        | 1.927                                        | 2070.                    | 2.06349 | 4212.           | 205.7                                           |

| $T$<br>K | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|----------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| 120      | 10.0       | 701.8                        | -118.1                     | -0.7615                                    | 1.344                                        | 1.951                                        | 1939.                    | 2.02490 | 1649.           | 197.6                                           |
| 140      | 10.0       | 682.2                        | -78.80                     | -0.4586                                    | 1.345                                        | 1.979                                        | 1809.                    | 1.98713 | 894.7           | 187.7                                           |
| 160      | 10.0       | 662.7                        | -38.90                     | -0.1922                                    | 1.352                                        | 2.012                                        | 1682.                    | 1.94997 | 579.3           | 176.7                                           |
| 180      | 10.0       | 643.1                        | 1.726                      | 0.04696                                    | 1.367                                        | 2.052                                        | 1556.                    | 1.91318 | 413.7           | 165.2                                           |
| 200      | 10.0       | 623.2                        | 43.23                      | 0.2656                                     | 1.393                                        | 2.101                                        | 1432.                    | 1.87653 | 312.8           | 153.5                                           |
| 220      | 10.0       | 602.8                        | 85.84                      | 0.4686                                     | 1.430                                        | 2.162                                        | 1310.                    | 1.83978 | 245.3           | 142.0                                           |
| 240      | 10.0       | 581.9                        | 129.8                      | 0.6598                                     | 1.478                                        | 2.236                                        | 1192.                    | 1.80267 | 197.1           | 130.9                                           |
| 260      | 10.0       | 560.1                        | 175.4                      | 0.8422                                     | 1.535                                        | 2.325                                        | 1077.                    | 1.76484 | 161.3           | 120.5                                           |
| 280      | 10.0       | 537.1                        | 222.9                      | 1.018                                      | 1.600                                        | 2.429                                        | 963.4                    | 1.72590 | 133.7           | 110.7                                           |
| 300      | 10.0       | 512.7                        | 272.7                      | 1.190                                      | 1.673                                        | 2.550                                        | 852.7                    | 1.68529 | 111.7           | 101.8                                           |
| 320      | 10.0       | 486.1                        | 325.0                      | 1.359                                      | 1.751                                        | 2.692                                        | 744.0                    | 1.64228 | 93.65           | 93.68                                           |
| 340      | 10.0       | 456.7                        | 380.5                      | 1.527                                      | 1.833                                        | 2.865                                        | 637.1                    | 1.59580 | 78.30           | 86.37                                           |
| 360      | 10.0       | 423.2                        | 439.9                      | 1.697                                      | 1.921                                        | 3.085                                        | 532.1                    | 1.54422 | 64.77           | 79.79                                           |
| 400      | 10.0       | 334.5                        | 576.0                      | 2.054                                      | 2.111                                        | 3.790                                        | 339.0                    | 1.41464 | 41.09           | 68.25                                           |
| 500      | 10.0       | 143.3                        | 947.1                      | 2.887                                      | 2.438                                        | 3.221                                        | 275.9                    | 1.16393 | 19.83           | 58.85                                           |
| 600      | 10.0       | 99.02                        | 1263.                      | 3.462                                      | 2.755                                        | 3.183                                        | 330.8                    | 1.11103 | 19.67           | 73.95                                           |
| 700      | 10.0       | 78.82                        | 1591.                      | 3.967                                      | 3.058                                        | 3.386                                        | 372.8                    | 1.08759 | 20.88           | 95.32                                           |
| 800      | 10.0       | 66.46                        | 1940.                      | 4.434                                      | 3.328                                        | 3.610                                        | 407.1                    | 1.07350 | 22.27           | 120.1                                           |
| 900      | 10.0       | 57.89                        | 2312.                      | 4.871                                      | 3.565                                        | 3.821                                        | 436.7                    | 1.06382 | 23.62           | 148.0                                           |
| 1000     | 10.0       | 51.49                        | 2704.                      | 5.284                                      | 3.774                                        | 4.013                                        | 463.1                    | 1.05665 | 24.89           | 178.8                                           |

Carbon Dioxide (CO<sub>2</sub>)

| $T$<br>K              | $P$<br>MPa | $\rho$<br>kg m <sup>-3</sup> | $H$<br>kJ kg <sup>-1</sup> | $S$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_v$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $C_p$<br>kJ kg <sup>-1</sup> K <sup>-1</sup> | $u$<br>m s <sup>-1</sup> | $D$     | $\eta$<br>μPa s | $\lambda$<br>mW m <sup>-1</sup> K <sup>-1</sup> |
|-----------------------|------------|------------------------------|----------------------------|--------------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------|---------|-----------------|-------------------------------------------------|
| Saturation            |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 216.59                | 0.5180     | 1178.                        | 80.04                      | 0.5213                                     | 0.9747                                       | 1.953                                        | 975.8                    | 1.75696 | 256.7           | 180.6                                           |
| 216.59                | 0.5180     | 13.76                        | 430.4                      | 2.139                                      | 0.6292                                       | 0.9087                                       | 222.8                    | 1.00694 | 10.95           | 11.01                                           |
| 220                   | 0.5991     | 1166.                        | 86.73                      | 0.5517                                     | 0.9698                                       | 1.962                                        | 951.2                    | 1.74853 | 242.0           | 176.2                                           |
| 220                   | 0.5991     | 15.82                        | 431.6                      | 2.119                                      | 0.6389                                       | 0.9303                                       | 223.1                    | 1.00798 | 11.14           | 11.30                                           |
| 230                   | 0.8929     | 1129.                        | 106.6                      | 0.6387                                     | 0.9567                                       | 1.997                                        | 879.1                    | 1.72239 | 204.2           | 163.3                                           |
| 230                   | 0.8929     | 23.27                        | 434.6                      | 2.065                                      | 0.6700                                       | 1.005                                        | 223.6                    | 1.01178 | 11.69           | 12.22                                           |
| 240                   | 1.282      | 1089.                        | 126.8                      | 0.7235                                     | 0.9454                                       | 2.051                                        | 806.4                    | 1.69398 | 173.0           | 150.7                                           |
| 240                   | 1.282      | 33.30                        | 436.5                      | 2.014                                      | 0.7053                                       | 1.103                                        | 223.0                    | 1.01692 | 12.27           | 13.30                                           |
| 250                   | 1.785      | 1046.                        | 147.7                      | 0.8068                                     | 0.9364                                       | 2.132                                        | 731.8                    | 1.66298 | 146.7           | 138.5                                           |
| 250                   | 1.785      | 46.64                        | 437.0                      | 1.964                                      | 0.7459                                       | 1.237                                        | 221.2                    | 1.02382 | 12.90           | 14.61                                           |
| 260                   | 2.419      | 998.9                        | 169.4                      | 0.8895                                     | 0.9323                                       | 2.255                                        | 652.6                    | 1.62876 | 124.4           | 126.3                                           |
| 260                   | 2.419      | 64.42                        | 435.9                      | 1.914                                      | 0.7943                                       | 1.429                                        | 218.2                    | 1.03309 | 13.61           | 16.31                                           |
| 270                   | 3.203      | 945.8                        | 192.4                      | 0.9732                                     | 0.9396                                       | 2.453                                        | 565.5                    | 1.59026 | 105.0           | 114.3                                           |
| 270                   | 3.203      | 88.37                        | 432.6                      | 1.863                                      | 0.8517                                       | 1.731                                        | 213.8                    | 1.04574 | 14.47           | 18.69                                           |
| 280                   | 4.161      | 883.6                        | 217.3                      | 1.060                                      | 0.9605                                       | 2.814                                        | 471.5                    | 1.54547 | 87.73           | 102.0                                           |
| 280                   | 4.161      | 121.7                        | 425.9                      | 1.805                                      | 0.9232                                       | 2.277                                        | 207.7                    | 1.06363 | 15.60           | 22.47                                           |
| 290                   | 5.318      | 804.7                        | 245.6                      | 1.154                                      | 0.9937                                       | 3.676                                        | 371.9                    | 1.48961 | 71.41           | 89.55                                           |
| 290                   | 5.318      | 172.0                        | 413.8                      | 1.734                                      | 1.026                                        | 3.614                                        | 199.4                    | 1.09112 | 17.36           | 29.82                                           |
| 300                   | 6.713      | 679.2                        | 283.4                      | 1.276                                      | 1.120                                        | 8.698                                        | 245.7                    | 1.40346 | 53.11           | 80.59                                           |
| 300                   | 6.713      | 268.6                        | 387.1                      | 1.622                                      | 1.248                                        | 11.92                                        | 185.3                    | 1.14588 | 21.31           | 53.69                                           |
| 304.13                | 7.377      | 467.6                        | 332.2                      | 1.434                                      |                                              |                                              |                          | 1.26600 | 33.04           |                                                 |
| $P = 0.1$ MPa (1 bar) |            |                              |                            |                                            |                                              |                                              |                          |         |                 |                                                 |
| 220                   | 0.1        | 2.439                        | 442.2                      | 2.492                                      | 0.5791                                       | 0.7807                                       | 233.4                    | 1.00122 | 11.06           | 10.90                                           |
| 240                   | 0.1        | 2.228                        | 458.0                      | 2.561                                      | 0.5981                                       | 0.7962                                       | 243.2                    | 1.00112 | 12.07           | 12.24                                           |
| 260                   | 0.1        | 2.052                        | 474.1                      | 2.625                                      | 0.6184                                       | 0.8142                                       | 252.3                    | 1.00103 | 13.06           | 13.68                                           |
| 280                   | 0.1        | 1.902                        | 490.6                      | 2.686                                      | 0.6390                                       | 0.8333                                       | 261.0                    | 1.00095 | 14.05           | 15.20                                           |
| 300                   | 0.1        | 1.773                        | 507.4                      | 2.745                                      | 0.6593                                       | 0.8525                                       | 269.4                    | 1.00089 | 15.02           | 16.79                                           |
| 320                   | 0.1        | 1.661                        | 524.7                      | 2.800                                      | 0.6791                                       | 0.8715                                       | 277.4                    | 1.00083 | 15.98           | 18.42                                           |
| 340                   | 0.1        | 1.562                        | 542.3                      | 2.854                                      | 0.6982                                       | 0.8900                                       | 285.2                    | 1.00078 | 16.93           | 20.09                                           |
| 360                   | 0.1        | 1.474                        | 560.3                      | 2.905                                      | 0.7165                                       | 0.9079                                       | 292.8                    | 1.00074 | 17.87           | 21.77                                           |
| 400                   | 0.1        | 1.326                        | 597.3                      | 3.002                                      | 0.7510                                       | 0.9417                                       | 307.3                    | 1.00066 | 19.70           | 25.14                                           |
| 500                   | 0.1        | 1.059                        | 695.2                      | 3.221                                      | 0.8255                                       | 1.015                                        | 340.6                    | 1.00053 | 24.02           | 33.49                                           |
| 600                   | 0.1        | 0.8824                       | 799.9                      | 3.411                                      | 0.8867                                       | 1.076                                        | 370.8                    | 1.00044 | 28.00           | 41.55                                           |

| $T$<br>K                                         | $P$<br>MPa | $\rho$<br>$\text{kg m}^{-3}$ | $H$<br>$\text{kJ kg}^{-1}$ | $S$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $C_v$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $C_p$<br>$\text{kJ kg}^{-1} \text{K}^{-1}$ | $u$<br>$\text{m s}^{-1}$ | $D$     | $\eta$<br>$\mu\text{Pa s}$ | $\lambda$<br>$\text{mW m}^{-1} \text{K}^{-1}$ |
|--------------------------------------------------|------------|------------------------------|----------------------------|------------------------------------------|--------------------------------------------|--------------------------------------------|--------------------------|---------|----------------------------|-----------------------------------------------|
| 700                                              | 0.1        | 0.7562                       | 910.2                      | 3.581                                    | 0.9375                                     | 1.127                                      | 398.7                    | 1.00038 | 31.68                      | 49.30                                         |
| 800                                              | 0.1        | 0.6616                       | 1025.                      | 3.735                                    | 0.9800                                     | 1.169                                      | 424.7                    | 1.00033 | 35.09                      | 56.71                                         |
| 900                                              | 0.1        | 0.5880                       | 1144.                      | 3.874                                    | 1.015                                      | 1.205                                      | 449.2                    | 1.00029 | 38.27                      | 63.80                                         |
| 1000                                             | 0.1        | 0.5292                       | 1266.                      | 4.003                                    | 1.045                                      | 1.234                                      | 472.4                    | 1.00027 | 41.26                      | 70.57                                         |
| <b><math>P = 1 \text{ MPa (10 bar)}</math></b>   |            |                              |                            |                                          |                                            |                                            |                          |         |                            |                                               |
| 216.70                                           | 1.0        | 1179.                        | 80.37                      | 0.5210                                   | 0.9751                                     | 1.950                                      | 977.8                    | 1.75735 | 257.2                      | 180.9                                         |
| 220                                              | 1.0        | 1167.                        | 86.83                      | 0.5506                                   | 0.9703                                     | 1.959                                      | 953.6                    | 1.74911 | 242.8                      | 176.5                                         |
| 233.03                                           | 1.0        | 1117.                        | 112.7                      | 0.6646                                   | 0.9530                                     | 2.011                                      | 857.2                    | 1.71404 | 194.1                      | 159.5                                         |
| 233.03                                           | 1.0        | 26.01                        | 435.3                      | 2.049                                    | 0.6803                                     | 1.032                                      | 223.5                    | 1.01318 | 11.86                      | 12.53                                         |
| 240                                              | 1.0        | 24.86                        | 442.4                      | 2.079                                    | 0.6733                                     | 0.9991                                     | 228.5                    | 1.01259 | 12.20                      | 12.94                                         |
| 260                                              | 1.0        | 22.21                        | 461.7                      | 2.157                                    | 0.6656                                     | 0.9450                                     | 241.2                    | 1.01123 | 13.18                      | 14.26                                         |
| 280                                              | 1.0        | 20.20                        | 480.4                      | 2.226                                    | 0.6709                                     | 0.9252                                     | 252.3                    | 1.01019 | 14.15                      | 15.71                                         |
| 300                                              | 1.0        | 18.58                        | 498.8                      | 2.289                                    | 0.6822                                     | 0.9209                                     | 262.4                    | 1.00937 | 15.11                      | 17.25                                         |
| 320                                              | 1.0        | 17.23                        | 517.3                      | 2.349                                    | 0.6960                                     | 0.9243                                     | 271.8                    | 1.00868 | 16.07                      | 18.84                                         |
| 340                                              | 1.0        | 16.09                        | 535.8                      | 2.405                                    | 0.7111                                     | 0.9320                                     | 280.6                    | 1.00810 | 17.01                      | 20.47                                         |
| 360                                              | 1.0        | 15.11                        | 554.6                      | 2.459                                    | 0.7266                                     | 0.9421                                     | 289.0                    | 1.00760 | 17.94                      | 22.12                                         |
| 400                                              | 1.0        | 13.48                        | 592.7                      | 2.559                                    | 0.7575                                     | 0.9655                                     | 304.7                    | 1.00677 | 19.76                      | 25.46                                         |
| 500                                              | 1.0        | 10.66                        | 692.4                      | 2.781                                    | 0.8282                                     | 1.027                                      | 339.8                    | 1.00535 | 24.06                      | 33.74                                         |
| 600                                              | 1.0        | 8.845                        | 798.0                      | 2.974                                    | 0.8881                                     | 1.083                                      | 370.9                    | 1.00444 | 28.04                      | 41.76                                         |
| 700                                              | 1.0        | 7.564                        | 908.8                      | 3.144                                    | 0.9384                                     | 1.132                                      | 399.2                    | 1.00379 | 31.71                      | 49.47                                         |
| 800                                              | 1.0        | 6.610                        | 1024.                      | 3.298                                    | 0.9805                                     | 1.173                                      | 425.5                    | 1.00332 | 35.12                      | 56.86                                         |
| 900                                              | 1.0        | 5.872                        | 1143.                      | 3.438                                    | 1.016                                      | 1.207                                      | 450.2                    | 1.00295 | 38.30                      | 63.93                                         |
| 1000                                             | 1.0        | 5.283                        | 1265.                      | 3.567                                    | 1.046                                      | 1.236                                      | 473.6                    | 1.00265 | 41.28                      | 70.69                                         |
| <b><math>P = 10 \text{ MPa (100 bar)}</math></b> |            |                              |                            |                                          |                                            |                                            |                          |         |                            |                                               |
| 218.60                                           | 10.0       | 1190.                        | 86.78                      | 0.5155                                   | 0.9827                                     | 1.902                                      | 1012.                    | 1.76433 | 266.3                      | 185.4                                         |
| 220                                              | 10.0       | 1186.                        | 89.44                      | 0.5277                                   | 0.9806                                     | 1.904                                      | 1003.                    | 1.76113 | 260.2                      | 183.6                                         |
| 240                                              | 10.0       | 1115.                        | 127.9                      | 0.6949                                   | 0.9536                                     | 1.949                                      | 870.9                    | 1.71160 | 189.4                      | 159.2                                         |
| 260                                              | 10.0       | 1035.                        | 167.8                      | 0.8545                                   | 0.9340                                     | 2.052                                      | 735.5                    | 1.65372 | 139.5                      | 136.0                                         |
| 280                                              | 10.0       | 938.2                        | 210.8                      | 1.014                                    | 0.9263                                     | 2.280                                      | 588.7                    | 1.58337 | 102.2                      | 113.1                                         |
| 300                                              | 10.0       | 801.6                        | 261.8                      | 1.189                                    | 0.9496                                     | 2.991                                      | 414.3                    | 1.48612 | 71.03                      | 88.91                                         |
| 320                                              | 10.0       | 448.3                        | 362.9                      | 1.514                                    | 1.058                                      | 7.617                                      | 219.1                    | 1.25290 | 32.39                      | 60.44                                         |
| 340                                              | 10.0       | 258.6                        | 443.4                      | 1.759                                    | 0.9025                                     | 2.402                                      | 238.1                    | 1.13908 | 22.80                      | 35.70                                         |
| 360                                              | 10.0       | 208.2                        | 483.0                      | 1.873                                    | 0.8526                                     | 1.707                                      | 257.8                    | 1.11030 | 21.83                      | 31.88                                         |
| 400                                              | 10.0       | 161.5                        | 542.1                      | 2.029                                    | 0.8287                                     | 1.333                                      | 286.9                    | 1.08425 | 22.23                      | 31.58                                         |
| 500                                              | 10.0       | 113.1                        | 663.8                      | 2.301                                    | 0.8552                                     | 1.162                                      | 337.4                    | 1.05801 | 25.39                      | 37.26                                         |
| 600                                              | 10.0       | 89.94                        | 779.3                      | 2.511                                    | 0.9017                                     | 1.156                                      | 375.4                    | 1.04580 | 28.94                      | 44.39                                         |
| 700                                              | 10.0       | 75.49                        | 895.9                      | 2.691                                    | 0.9465                                     | 1.178                                      | 407.4                    | 1.03828 | 32.39                      | 51.59                                         |
| 800                                              | 10.0       | 65.35                        | 1015.                      | 2.850                                    | 0.9859                                     | 1.205                                      | 435.8                    | 1.03305 | 35.66                      | 58.65                                         |
| 900                                              | 10.0       | 57.76                        | 1137.                      | 2.993                                    | 1.020                                      | 1.231                                      | 461.8                    | 1.02916 | 38.75                      | 65.48                                         |
| 1000                                             | 10.0       | 51.82                        | 1261.                      | 3.124                                    | 1.048                                      | 1.255                                      | 485.9                    | 1.02613 | 41.66                      | 72.05                                         |



# VIRIAL COEFFICIENTS OF SELECTED GASES

Henry V. Kehiaian

This table gives second virial coefficients of about 110 inorganic and organic gases as a function of temperature. Selected data from the literature have been fitted by least squares to the equation

$$B/\text{cm}^3\text{mol}^{-1} = \sum_{i=1}^n a(i)[(T_0/T) - 1]^{i-1}$$

where  $T_0 = 298.15$  K. The table gives the coefficients  $a(i)$  and values of  $B$  at fixed temperature increments, as calculated from this smoothing equation.

The equation may be used with the tabulated coefficients for interpolation within the indicated temperature range. It should not be used for extrapolation beyond this range.

Compounds are listed in the modified Hill order (see Introduction), with carbon-containing compounds following those compounds not containing carbon.

A useful compilation of virial coefficient data from the literature may be found in the reference.

## Reference

J. H. Dymond and E. B. Smith, *The Virial Coefficients of Pure Gases and Mixtures, A Critical Compilation*, Oxford University Press, Oxford, 1980.

| Compounds Not Containing Carbon |                   |               |      | Mol. form.        | Name                     | T/K             | B/cm <sup>3</sup> mol <sup>-1</sup> |
|---------------------------------|-------------------|---------------|------|-------------------|--------------------------|-----------------|-------------------------------------|
| Ar                              | Argon             | 100           | -184 | F <sub>2</sub>    | Fluorine                 | 500             | -97                                 |
|                                 |                   | 120           | -131 |                   |                          | 600             | -59                                 |
|                                 |                   | 140           | -98  |                   |                          | 700             | -36                                 |
|                                 |                   |               |      |                   |                          | 800             | -22                                 |
|                                 |                   | $a(1) = -16$  | 160  |                   |                          | 900             | -12                                 |
|                                 |                   | $a(2) = -60$  | 180  |                   |                          | 80              | -378                                |
|                                 |                   | $a(3) = -9.7$ | 200  |                   |                          | 110             | -165                                |
|                                 |                   | $a(4) = -1.5$ | 300  |                   |                          | 140             | -109                                |
|                                 |                   |               | 400  |                   |                          | $a(1) = 8.5$    | -79                                 |
|                                 |                   |               | 500  |                   |                          | $a(2) = -163.2$ | -55                                 |
|                                 |                   |               | 600  |                   |                          | $a(3) = 84.0$   | -33                                 |
|                                 |                   |               | 700  |                   |                          | $a(4) = -27.9$  | -14                                 |
|                                 |                   |               | 800  | F <sub>4</sub> Si | Silicon tetrafluoride    | 260             | -268                                |
|                                 |                   |               | 900  |                   |                          | 210             | -213                                |
|                                 |                   |               | 1000 |                   |                          | 240             | -213                                |
| BF <sub>3</sub>                 | Boron trifluoride | 200           | -338 |                   |                          | 270             | -170                                |
|                                 |                   | 240           | -202 |                   |                          | $a(1) = -138$   | -136                                |
|                                 |                   | 280           | -129 |                   |                          | $a(2) = -312$   | -108                                |
|                                 |                   | $a(1) = -106$ | 320  |                   |                          | 360             | -84                                 |
|                                 |                   | $a(2) = -330$ | 360  |                   |                          | 390             | -64                                 |
|                                 |                   | $a(3) = -251$ | 400  |                   |                          | 420             | -47                                 |
|                                 |                   | $a(4) = -80$  | 440  |                   |                          | 450             | -32                                 |
| ClH                             | Hydrogen chloride | 190           | -451 | F <sub>5</sub> I  | Iodine pentafluoride     | 320             | -2540                               |
|                                 |                   | 230           | -269 |                   |                          | 330             | -2344                               |
|                                 |                   | 270           | -181 |                   |                          | 340             | -2172                               |
|                                 |                   | $a(1) = -144$ | 310  |                   |                          | $a(1) = -3077$  | -2021                               |
|                                 |                   | $a(2) = -325$ | 350  |                   |                          | $a(2) = -8474$  | -1890                               |
|                                 |                   | $a(3) = -277$ | 390  |                   |                          | $a(3) = -9116$  | -1775                               |
|                                 |                   | $a(4) = -170$ | 430  |                   |                          | 380             | -1674                               |
|                                 |                   |               | 470  |                   |                          | 390             | -1587                               |
| Cl <sub>2</sub>                 | Chlorine          | 210           | -508 |                   |                          | 400             | -1510                               |
|                                 |                   | 220           | -483 | F <sub>5</sub> P  | Phosphorus pentafluoride | 410             | -1443                               |
|                                 |                   | 230           | -457 |                   |                          | 320             | -162                                |
|                                 |                   | $a(1) = -303$ | 240  |                   |                          | 340             | -143                                |
|                                 |                   | $a(2) = -555$ | 250  |                   |                          | 360             | -127                                |
|                                 |                   | $a(3) = 9$    | 260  |                   |                          | $a(1) = -186$   | -112                                |
|                                 |                   | $a(4) = 329$  | 270  |                   |                          | $a(2) = -345$   | -98                                 |
|                                 |                   | $a(5) = 68$   | 280  |                   |                          | 420             | -86                                 |
|                                 |                   |               | 290  |                   |                          | 440             | -75                                 |
|                                 |                   |               | 300  |                   |                          | 460             | -64                                 |
|                                 |                   |               | 350  | F <sub>6</sub> Mo | Molybdenum hexafluoride  | 300             | -896                                |
|                                 |                   |               | 400  |                   |                          | 310             | -810                                |
|                                 |                   |               | 450  |                   |                          | 320             | -737                                |
|                                 |                   |               |      |                   |                          |                 |                                     |
|                                 |                   |               |      |                   |                          |                 |                                     |
|                                 |                   |               |      |                   |                          |                 |                                     |



| Mol. form.           | Name                 | $T/\text{K}$    | $B/\text{cm}^3 \text{ mol}^{-1}$ | Mol. form.           | Name         | $T/\text{K}$   | $B/\text{cm}^3 \text{ mol}^{-1}$ |        |      |      |
|----------------------|----------------------|-----------------|----------------------------------|----------------------|--------------|----------------|----------------------------------|--------|------|------|
| $\text{F}_6\text{S}$ | $a(1) = -914$        | 330             | -677                             | $\text{H}_3\text{N}$ | Ammonia      | 1100           | -14                              |        |      |      |
|                      | $a(2) = -2922$       | 340             | -627                             |                      |              | 1200           | -11                              |        |      |      |
|                      | $a(3) = -4778$       | 350             | -586                             |                      |              | 290            | -302                             |        |      |      |
|                      |                      | 360             | -553                             |                      |              | 300            | -265                             |        |      |      |
|                      |                      | 370             | -527                             |                      |              | 310            | -236                             |        |      |      |
|                      |                      | 380             | -506                             |                      |              | $a(1) = -271$  | 320                              | -213   |      |      |
|                      |                      | 390             | -491                             |                      |              | $a(2) = -1022$ | 330                              | -194   |      |      |
|                      |                      | 200             | -685                             |                      |              | $a(3) = -2715$ | 340                              | -179   |      |      |
|                      |                      | 250             | -416                             |                      |              | $a(4) = -4189$ | 350                              | -166   |      |      |
|                      |                      | 300             | -275                             |                      |              |                | 360                              | -154   |      |      |
|                      |                      | 350             | -190                             |                      |              |                | 370                              | -144   |      |      |
|                      |                      | 400             | -135                             |                      |              |                | 380                              | -135   |      |      |
|                      |                      | 450             | -96                              |                      |              |                | 400                              | -118   |      |      |
|                      |                      | 500             | -68                              |                      |              |                | 420                              | -101   |      |      |
| $\text{F}_6\text{U}$ | Uranium hexafluoride | 320             | -1030                            | $\text{H}_3\text{P}$ | Phosphine    | 190            | -457                             |        |      |      |
|                      |                      | 340             | -905                             |                      |              | 200            | -404                             |        |      |      |
|                      |                      | 360             | -805                             |                      |              | 210            | -364                             |        |      |      |
|                      |                      | $a(1) = -1204$  | 380                              |                      |              | -724           | $a(1) = -146$                    | 220    | -332 |      |
|                      |                      | $a(2) = -2690$  | 400                              |                      |              | -658           | $a(2) = -733$                    | 230    | -305 |      |
|                      |                      | $a(3) = -2144$  | 420                              |                      |              | -604           | $a(3) = 1022$                    | 240    | -281 |      |
|                      |                      |                 | 440                              |                      |              | -560           | $a(4) = -1220$                   | 250    | -258 |      |
|                      |                      |                 | 320                              |                      |              | -641           |                                  | 260    | -235 |      |
|                      |                      |                 | 340                              |                      |              | -578           |                                  | 270    | -213 |      |
|                      |                      |                 | 360                              |                      |              | -523           |                                  | 280    | -190 |      |
|                      |                      | $a(1) = -719$   | 380                              |                      |              | -473           |                                  | 290    | -166 |      |
|                      |                      | $a(2) = -1143$  | 400                              |                      |              | -428           | He                               | Helium | 2    | -172 |
|                      |                      |                 | 420                              |                      |              | -387           |                                  |        | 6    | -48  |
|                      |                      |                 | 440                              |                      |              | -350           |                                  |        | 10   | -24  |
|                      | 460                  | -317            | $a(1) = 12.44$                   | 14                   | -13          |                |                                  |        |      |      |
|                      | 15                   | -230            | $a(2) = -1.25$                   | 18                   | -7           |                |                                  |        |      |      |
|                      | 20                   | -151            |                                  | 22                   | -3           |                |                                  |        |      |      |
|                      | 25                   | -108            |                                  | 26                   | -1           |                |                                  |        |      |      |
| $a(1) = 15.4$        | 30                   | -82             |                                  | 30                   | 1            |                |                                  |        |      |      |
| $a(2) = -9.0$        | 35                   | -64             |                                  | 50                   | 6            |                |                                  |        |      |      |
| $a(3) = -0.21$       | 40                   | -52             |                                  | 70                   | 8            |                |                                  |        |      |      |
|                      | 45                   | -42             |                                  | 90                   | 10           |                |                                  |        |      |      |
|                      | 50                   | -35             |                                  | 110                  | 10           |                |                                  |        |      |      |
|                      | 60                   | -24             |                                  | 150                  | 11           |                |                                  |        |      |      |
|                      | 70                   | -16             |                                  | 250                  | 12           |                |                                  |        |      |      |
|                      | 80                   | -11             |                                  | 650                  | 13           |                |                                  |        |      |      |
|                      | 90                   | -7              |                                  | 700                  | 13           |                |                                  |        |      |      |
|                      | 100                  | -3              | Kr                               | Krypton              | 110          | -363           |                                  |        |      |      |
|                      | 200                  | 11              |                                  |                      | 120          | -307           |                                  |        |      |      |
|                      | 300                  | 15              |                                  |                      | 130          | -263           |                                  |        |      |      |
|                      | 400                  | 18              |                                  |                      | $a(1) = -51$ | 140            | -229                             |        |      |      |
| $\text{H}_2\text{O}$ | Water                | 300             |                                  |                      | -1126        | $a(2) = -118$  | 150                              | -201   |      |      |
|                      |                      | 320             |                                  |                      | -850         | $a(3) = -29$   | 160                              | -178   |      |      |
|                      |                      | 340             |                                  |                      | -660         | $a(4) = -5$    | 170                              | -159   |      |      |
|                      |                      | $a(1) = -1158$  |                                  |                      | 360          | -526           |                                  | 180    | -143 |      |
|                      |                      | $a(2) = -5157$  |                                  |                      | 380          | -428           |                                  | 190    | -129 |      |
|                      |                      | $a(3) = -10301$ |                                  |                      | 400          | -356           |                                  | 200    | -117 |      |
|                      |                      | $a(4) = -10597$ |                                  |                      | 420          | -301           |                                  | 250    | -75  |      |
|                      |                      | $a(5) = -4415$  |                                  |                      | 440          | -258           |                                  | 300    | -51  |      |
|                      |                      |                 |                                  |                      | 460          | -224           |                                  | 400    | -23  |      |
|                      |                      |                 |                                  |                      | 480          | -197           |                                  | 500    | -8   |      |
|                      |                      |                 | 500                              | -175                 |              | 600            | 2                                |        |      |      |
|                      |                      |                 | 600                              | -104                 |              | 700            | 8                                |        |      |      |
|                      |                      |                 | 700                              | -67                  | NO           | Nitric oxide   | 120                              | -232   |      |      |
|                      |                      |                 | 800                              | -44                  |              |                | 130                              | -176   |      |      |
|                      | 900                  | -30             | 140                              | -138                 |              |                |                                  |        |      |      |
|                      | 1000                 | -20             | $a(1) = -12$                     | 150                  |              |                | -113                             |        |      |      |

| Mol. form.       | Name                 | <i>T</i> /K         | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> | Mol. form.                  | Name                   | <i>T</i> /K | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> |                         |                      |       |       |     |
|------------------|----------------------|---------------------|---------------------------------------------|-----------------------------|------------------------|-------------|---------------------------------------------|-------------------------|----------------------|-------|-------|-----|
| N <sub>2</sub>   | <i>a</i> (2) = -119  | 160                 | -96                                         | Xe                          | <i>a</i> (1) = -430    | 380         | -221                                        |                         |                      |       |       |     |
|                  | <i>a</i> (3) = 89    | 170                 | -83                                         |                             | <i>a</i> (2) = -1193   | 410         | -181                                        |                         |                      |       |       |     |
|                  | <i>a</i> (4) = -73   | 180                 | -73                                         |                             | <i>a</i> (3) = -1029   | 440         | -153                                        |                         |                      |       |       |     |
|                  |                      | 190                 | -65                                         |                             |                        | 470         | -132                                        |                         |                      |       |       |     |
|                  |                      | 200                 | -58                                         |                             |                        | 160         | -421                                        |                         |                      |       |       |     |
|                  |                      | 210                 | -52                                         |                             |                        | 170         | -377                                        |                         |                      |       |       |     |
|                  |                      | 230                 | -42                                         |                             |                        | 180         | -340                                        |                         |                      |       |       |     |
|                  |                      | 250                 | -32                                         |                             | <i>a</i> (1) = -130    | 190         | -307                                        |                         |                      |       |       |     |
|                  |                      | 270                 | -24                                         |                             | <i>a</i> (2) = -262    | 200         | -280                                        |                         |                      |       |       |     |
|                  |                      | 75                  | -274                                        |                             | <i>a</i> (3) = -87     | 210         | -255                                        |                         |                      |       |       |     |
|                  |                      | 100                 | -161                                        |                             |                        | 220         | -234                                        |                         |                      |       |       |     |
|                  |                      | 125                 | -104                                        |                             |                        | 230         | -215                                        |                         |                      |       |       |     |
|                  | <i>a</i> (1) = -4.3  | 150                 | -71                                         |                             |                        | 240         | -199                                        |                         |                      |       |       |     |
|                  | <i>a</i> (2) = -55.7 | 175                 | -49                                         |                             |                        | 250         | -184                                        |                         |                      |       |       |     |
|                  | <i>a</i> (3) = -11.8 | 200                 | -34                                         |                             |                        | 300         | -129                                        |                         |                      |       |       |     |
|                  |                      | 225                 | -24                                         |                             |                        | 350         | -93                                         |                         |                      |       |       |     |
|                  |                      | 250                 | -15                                         |                             |                        | 400         | -69                                         |                         |                      |       |       |     |
|                  |                      | 300                 | -4                                          |                             |                        | 500         | -39                                         |                         |                      |       |       |     |
|                  |                      | 400                 | 9                                           |                             |                        | 600         | -21                                         |                         |                      |       |       |     |
|                  |                      | 500                 | 16                                          |                             |                        | 650         | -14                                         |                         |                      |       |       |     |
|                  |                      | 600                 | 21                                          |                             |                        |             |                                             |                         |                      |       |       |     |
|                  |                      | 700                 | 24                                          |                             |                        |             |                                             |                         |                      |       |       |     |
| N <sub>2</sub> O | Nitrous oxide        | 240                 | -219                                        | Compounds Containing Carbon |                        |             |                                             |                         |                      |       |       |     |
|                  |                      | 260                 | -181                                        |                             |                        |             |                                             |                         |                      |       |       |     |
|                  |                      | 280                 | -151                                        |                             |                        |             |                                             |                         |                      |       |       |     |
|                  |                      | <i>a</i> (1) = -130 | 300                                         |                             |                        |             |                                             | -128                    |                      |       |       |     |
|                  |                      | <i>a</i> (2) = -307 | 320                                         |                             |                        |             |                                             | -110                    |                      |       |       |     |
|                  |                      | <i>a</i> (3) = -248 | 340                                         |                             |                        |             |                                             | -96                     |                      |       |       |     |
|                  |                      |                     | 360                                         |                             |                        |             |                                             | -85                     |                      |       |       |     |
|                  |                      |                     | 380                                         |                             |                        |             |                                             | -76                     |                      |       |       |     |
|                  |                      |                     | 400                                         |                             |                        |             |                                             | -68                     |                      |       |       |     |
|                  |                      |                     | 60                                          |                             |                        |             |                                             | -25                     |                      |       |       |     |
|                  |                      |                     | 80                                          |                             |                        |             |                                             | -13                     |                      |       |       |     |
| Ne               | Neon                 | 100                 | -6                                          | CClF <sub>3</sub>           | Chlorotrifluoromethane | 240         | -369                                        |                         |                      |       |       |     |
|                  |                      | <i>a</i> (1) = 10.8 | 120                                         |                             |                        | -1          |                                             | 290                     | -237                 |       |       |     |
|                  |                      | <i>a</i> (2) = -7.5 | 140                                         |                             |                        | 2           |                                             | 340                     | -165                 |       |       |     |
|                  |                      | <i>a</i> (3) = -0.4 | 160                                         |                             |                        | 4           | <i>a</i> (1) = -223                         | 390                     | -119                 |       |       |     |
|                  |                      |                     | 180                                         |                             |                        | 6           | <i>a</i> (2) = -504                         | 440                     | -86                  |       |       |     |
|                  |                      |                     | 200                                         |                             |                        | 7           | <i>a</i> (3) = -340                         | 490                     | -60                  |       |       |     |
|                  |                      |                     | 300                                         |                             |                        | 11          | <i>a</i> (4) = -291                         | 540                     | -39                  |       |       |     |
|                  |                      |                     | 400                                         |                             |                        | 13          | CCl <sub>2</sub> F <sub>2</sub>             | Dichlorodifluoromethane | 250                  | -769  |       |     |
|                  |                      |                     | 500                                         |                             |                        | 14          |                                             |                         |                      | 280   | -570  |     |
|                  |                      |                     | 600                                         |                             |                        | 15          |                                             |                         |                      | 310   | -441  |     |
|                  |                      |                     |                                             |                             |                        |             |                                             |                         | <i>a</i> (1) = -486  | 340   | -353  |     |
|                  |                      |                     | <i>a</i> (2) = -1217                        | 370                         | -289                   |             |                                             |                         |                      |       |       |     |
| O <sub>2</sub>   | Oxygen               | 90                  | -241                                        | CCl <sub>3</sub> F          | Trichlorofluoromethane | 240         | -1140                                       |                         |                      |       |       |     |
|                  |                      | 110                 | -161                                        |                             |                        |             | 280                                         | -879                    |                      |       |       |     |
|                  |                      | 130                 | -117                                        |                             |                        |             | 320                                         | -689                    |                      |       |       |     |
|                  |                      | <i>a</i> (1) = -16  | 150                                         |                             |                        | -88         | <i>a</i> (1) = -786                         | 360                     | -545                 |       |       |     |
|                  |                      | <i>a</i> (2) = -62  | 170                                         |                             |                        | -69         | <i>a</i> (2) = -1428                        | 400                     | -431                 |       |       |     |
|                  |                      | <i>a</i> (3) = -8   | 190                                         |                             |                        | -55         | <i>a</i> (3) = -142                         | 440                     | -340                 |       |       |     |
|                  |                      | <i>a</i> (4) = -3   | 210                                         |                             |                        | -44         |                                             | 480                     | -265                 |       |       |     |
|                  |                      |                     | 230                                         |                             |                        | -36         | CCl <sub>4</sub>                            | Tetrachloromethane      | 320                  | -1345 |       |     |
|                  |                      |                     | 250                                         |                             |                        | -29         |                                             |                         |                      | 340   | -1171 |     |
|                  |                      |                     | 270                                         |                             |                        | -23         |                                             |                         |                      | 360   | -1040 |     |
|                  |                      |                     | 290                                         |                             |                        | -18         |                                             |                         | <i>a</i> (1) = -1600 | 380   | -942  |     |
|                  |                      |                     | 310                                         |                             |                        | -14         |                                             |                         | <i>a</i> (2) = -4059 | 400   | -868  |     |
|                  |                      | O <sub>2</sub> S    | Sulfur dioxide                              |                             |                        | 330         | -10                                         | CF <sub>4</sub>         | Tetrafluoromethane   | 250   | -137  |     |
|                  |                      |                     |                                             |                             |                        | 350         | -7                                          |                         |                      |       | 300   | -87 |
|                  |                      |                     |                                             |                             |                        | 400         | -1                                          |                         |                      |       | 350   | -55 |
| 290              | -465                 |                     |                                             | <i>a</i> (1) = -88          | 400                    | -32         |                                             |                         |                      |       |       |     |
| 320              | -354                 |                     |                                             | <i>a</i> (2) = -238         | 450                    | -16         |                                             |                         |                      |       |       |     |
| 350              | -276                 |                     |                                             | <i>a</i> (3) = -70          | 500                    | -4          |                                             |                         |                      |       |       |     |
|                  |                      |                     |                                             |                             | 600                    | 14          |                                             |                         |                      |       |       |     |
|                  |                      |                     |                                             |                             | 700                    | 25          |                                             |                         |                      |       |       |     |

| Mol. form.                      | Name                  | <i>T</i> /K          | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> | Mol. form.           | Name                 | <i>T</i> /K          | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> |      |
|---------------------------------|-----------------------|----------------------|---------------------------------------------|----------------------|----------------------|----------------------|---------------------------------------------|------|
| CHClF <sub>2</sub>              | Chlorodifluoromethane | 800                  | 33                                          | CH <sub>3</sub> Cl   | Chloromethane        | 280                  | -466                                        |      |
|                                 |                       | 300                  | -343                                        |                      |                      | 300                  | -402                                        |      |
|                                 |                       | 325                  | -298                                        |                      |                      | 320                  | -348                                        |      |
|                                 |                       | 350                  | -257                                        |                      |                      | 340                  | -304                                        |      |
|                                 |                       | <i>a</i> (1) = -347  | 375                                         |                      |                      | -221                 | 360                                         | -266 |
|                                 |                       | <i>a</i> (2) = -575  | 400                                         |                      |                      | -188                 | 380                                         | -234 |
|                                 |                       | <i>a</i> (3) = 187   | 425                                         |                      |                      | -158                 | 400                                         | -206 |
| CHCl <sub>2</sub> F             | Dichlorofluoromethane | 250                  | -728                                        | CH <sub>3</sub> F    | Fluoromethane        | 420                  | -182                                        |      |
|                                 |                       | 275                  | -634                                        |                      |                      | 440                  | -161                                        |      |
|                                 |                       | 300                  | -557                                        |                      |                      | 460                  | -142                                        |      |
|                                 |                       | <i>a</i> (1) = -562  | 325                                         |                      |                      | -491                 | 480                                         | -126 |
|                                 |                       | <i>a</i> (2) = -862  | 350                                         |                      |                      | -434                 | 500                                         | -112 |
|                                 |                       | 375                  | -385                                        |                      |                      | 600                  | -58                                         |      |
|                                 |                       | 400                  | -343                                        |                      |                      | 280                  | -244                                        |      |
| CHCl <sub>3</sub>               | Trichloromethane      | 425                  | -305                                        | CH <sub>3</sub> I    | Iodomethane          | 300                  | -205                                        |      |
|                                 |                       | 450                  | -271                                        |                      |                      | 320                  | -174                                        |      |
|                                 |                       | 320                  | -1001                                       |                      |                      | <i>a</i> (1) = -209  | 340                                         | -150 |
|                                 |                       | 330                  | -926                                        |                      |                      | <i>a</i> (2) = -525  | 360                                         | -129 |
|                                 |                       | 340                  | -858                                        |                      |                      | <i>a</i> (3) = -365  | 380                                         | -112 |
|                                 |                       | <i>a</i> (1) = -1193 | 350                                         |                      |                      | -797                 | 400                                         | -99  |
|                                 |                       | <i>a</i> (2) = -2936 | 360                                         |                      |                      | -740                 | 420                                         | -87  |
| CHF <sub>3</sub>                | Trifluoromethane      | 370                  | -689                                        | CH <sub>4</sub>      | Methane              | 310                  | -725                                        |      |
|                                 |                       | 380                  | -642                                        |                      |                      | 320                  | -646                                        |      |
|                                 |                       | 390                  | -599                                        |                      |                      | 330                  | -582                                        |      |
|                                 |                       | 400                  | -559                                        |                      |                      | <i>a</i> (1) = -844  | 340                                         | -531 |
|                                 |                       | 200                  | -433                                        |                      |                      | <i>a</i> (2) = -3353 | 350                                         | -492 |
|                                 |                       | 220                  | -350                                        |                      |                      | <i>a</i> (3) = -6590 | 360                                         | -462 |
|                                 |                       | 240                  | -288                                        |                      |                      | 370                  | -441                                        |      |
| CH <sub>2</sub> Cl <sub>2</sub> | Dichloromethane       | 260                  | -241                                        | CH <sub>4</sub> O    | Methanol             | 380                  | -427                                        |      |
|                                 |                       | 280                  | -204                                        |                      |                      | 110                  | -328                                        |      |
|                                 |                       | 300                  | -174                                        |                      |                      | 120                  | -276                                        |      |
|                                 |                       | 320                  | -151                                        |                      |                      | 130                  | -237                                        |      |
|                                 |                       | 340                  | -132                                        |                      |                      | 140                  | -206                                        |      |
|                                 |                       | 360                  | -116                                        |                      |                      | <i>a</i> (1) = -43   | 150                                         | -181 |
|                                 |                       | 380                  | -103                                        |                      |                      | <i>a</i> (2) = -114  | 160                                         | -160 |
| CH <sub>2</sub> F <sub>2</sub>  | Difluoromethane       | 400                  | -91                                         | <i>a</i> (3) = -19   | 170                  | -143                 |                                             |      |
|                                 |                       | 320                  | -706                                        | <i>a</i> (4) = -7    | 180                  | -128                 |                                             |      |
|                                 |                       | 330                  | -634                                        | 190                  | -116                 |                      |                                             |      |
|                                 |                       | 340                  | -574                                        | 200                  | -105                 |                      |                                             |      |
|                                 |                       | <i>a</i> (1) = -913  | 350                                         | -524                 | 250                  | -66                  |                                             |      |
|                                 |                       | <i>a</i> (2) = -3371 | 360                                         | -482                 | 300                  | -43                  |                                             |      |
|                                 |                       | <i>a</i> (3) = -5013 | 370                                         | -447                 | 350                  | -27                  |                                             |      |
| CH <sub>3</sub> Br              | Bromomethane          | 380                  | -420                                        | CH <sub>5</sub> N    | Methylamine          | 400                  | -16                                         |      |
|                                 |                       | 400                  | -380                                        |                      |                      | 500                  | 0                                           |      |
|                                 |                       | 420                  | -357                                        |                      |                      | 600                  | 10                                          |      |
|                                 |                       | 280                  | -375                                        |                      |                      | 320                  | -1431                                       |      |
|                                 |                       | 290                  | -343                                        |                      |                      | 330                  | -1299                                       |      |
|                                 |                       | 300                  | -316                                        |                      |                      | 340                  | -1174                                       |      |
|                                 |                       | <i>a</i> (1) = -321  | 310                                         |                      |                      | -294                 | <i>a</i> (1) = -1752                        | 350  |
| CH <sub>3</sub> I               | Iodomethane           | <i>a</i> (2) = -754  | 320                                         | -275                 | <i>a</i> (2) = -4694 | 360                  | -945                                        |      |
|                                 |                       | <i>a</i> (3) = -1300 | 330                                         | -260                 | 370                  | -840                 |                                             |      |
|                                 |                       | 340                  | -248                                        | 380                  | -741                 |                      |                                             |      |
|                                 |                       | 350                  | -238                                        | 390                  | -646                 |                      |                                             |      |
|                                 |                       | 280                  | -645                                        | 400                  | -557                 |                      |                                             |      |
|                                 |                       | 290                  | -596                                        | 300                  | -451                 |                      |                                             |      |
|                                 |                       | 300                  | -551                                        | 325                  | -367                 |                      |                                             |      |
| CH <sub>3</sub> N               | Methylamine           | <i>a</i> (1) = -559  | 310                                         | -509                 | 350                  | -304                 |                                             |      |
|                                 |                       | <i>a</i> (2) = -1324 | 320                                         | -469                 | <i>a</i> (1) = -459  | 375                  | -257                                        |      |
|                                 |                       | 340                  | -396                                        | <i>a</i> (2) = -1191 | 400                  | -220                 |                                             |      |
|                                 |                       | 360                  | -332                                        | <i>a</i> (3) = -995  | 425                  | -192                 |                                             |      |
|                                 |                       | 380                  | -274                                        | 450                  | -170                 |                      |                                             |      |

| Mol. form.                                    | Name                                          | <i>T</i> /K          | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> | Mol. form.                                    | Name               | <i>T</i> /K          | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> |
|-----------------------------------------------|-----------------------------------------------|----------------------|---------------------------------------------|-----------------------------------------------|--------------------|----------------------|---------------------------------------------|
| CO                                            | Carbon monoxide                               | 500                  | -140                                        | C <sub>2</sub> H <sub>3</sub> N               | Ethanenitrile      | 270                  | -263                                        |
|                                               |                                               | 550                  | -122                                        |                                               |                    | 330                  | -3468                                       |
|                                               |                                               | 210                  | -36                                         |                                               |                    | 340                  | -2971                                       |
|                                               |                                               | 240                  | -24                                         |                                               |                    | 350                  | -2563                                       |
|                                               |                                               | 270                  | -15                                         |                                               |                    | 360                  | -2233                                       |
|                                               |                                               | <i>a</i> (1) = -9    | -8                                          |                                               |                    | 370                  | -1970                                       |
|                                               |                                               | <i>a</i> (2) = -58   | -3                                          |                                               |                    | 380                  | -1765                                       |
|                                               |                                               | <i>a</i> (3) = -18   | 1                                           |                                               |                    | 390                  | -1610                                       |
|                                               |                                               | 420                  | 7                                           |                                               |                    | 400                  | -1499                                       |
|                                               |                                               | 480                  | 11                                          |                                               |                    | 410                  | -1425                                       |
| CO <sub>2</sub>                               | Carbon dioxide                                | 220                  | -244                                        | C <sub>2</sub> H <sub>4</sub>                 | Ethene             | 240                  | -218                                        |
|                                               |                                               | 240                  | -204                                        |                                               |                    | 270                  | -172                                        |
|                                               |                                               | 260                  | -172                                        |                                               |                    | 300                  | -139                                        |
|                                               |                                               | <i>a</i> (1) = -127  | -146                                        |                                               |                    | 330                  | -113                                        |
|                                               |                                               | <i>a</i> (2) = -288  | -126                                        |                                               |                    | 360                  | -92                                         |
|                                               |                                               | <i>a</i> (3) = -118  | -108                                        |                                               |                    | 390                  | -76                                         |
|                                               |                                               | 340                  | -94                                         |                                               |                    | 420                  | -63                                         |
|                                               |                                               | 360                  | -81                                         |                                               |                    | 450                  | -52                                         |
|                                               |                                               | 380                  | -71                                         | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,2-Dichloroethane | 370                  | -812                                        |
|                                               |                                               | 400                  | -62                                         |                                               |                    | 390                  | -716                                        |
|                                               |                                               | 500                  | -30                                         |                                               |                    | 410                  | -635                                        |
|                                               |                                               | 600                  | -13                                         |                                               |                    | <i>a</i> (1) = -1362 | -566                                        |
|                                               |                                               | 700                  | -1                                          |                                               |                    | <i>a</i> (2) = -3240 | -508                                        |
|                                               |                                               | 800                  | 7                                           |                                               |                    | <i>a</i> (3) = -2100 | -458                                        |
|                                               |                                               | 900                  | 12                                          |                                               |                    | 490                  | -416                                        |
|                                               |                                               | 1000                 | 16                                          |                                               |                    | 510                  | -379                                        |
|                                               |                                               | 1100                 | 19                                          |                                               |                    | 530                  | -347                                        |
|                                               |                                               | 280                  | -932                                        |                                               |                    | 550                  | -319                                        |
| CS <sub>2</sub>                               | Carbon disulfide                              | 310                  | -740                                        | C <sub>2</sub> H <sub>4</sub> O               | Ethanal            | 570                  | -295                                        |
|                                               |                                               | 340                  | -603                                        |                                               |                    | 290                  | -1352                                       |
|                                               |                                               | <i>a</i> (1) = -807  | -504                                        |                                               |                    | 320                  | -927                                        |
|                                               |                                               | <i>a</i> (2) = -1829 | -431                                        |                                               |                    | 350                  | -654                                        |
|                                               |                                               | <i>a</i> (3) = -1371 | -375                                        |                                               |                    | <i>a</i> (1) = -1217 | -482                                        |
|                                               | C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub> | 300                  | -801                                        |                                               |                    | <i>a</i> (2) = -4647 | -375                                        |
|                                               |                                               | 320                  | -695                                        |                                               |                    | <i>a</i> (3) = -5725 | -314                                        |
|                                               |                                               | 340                  | -608                                        |                                               |                    | 440                  | -283                                        |
|                                               |                                               | <i>a</i> (1) = -812  | -536                                        | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>  | Methyl methanoate  | 470                  | -283                                        |
|                                               |                                               | <i>a</i> (2) = -1773 | -475                                        |                                               |                    | 320                  | -821                                        |
|                                               |                                               | <i>a</i> (3) = -963  | -423                                        |                                               |                    | 330                  | -744                                        |
|                                               |                                               | 420                  | -379                                        |                                               |                    | 340                  | -677                                        |
|                                               |                                               | 440                  | -341                                        |                                               |                    | <i>a</i> (1) = -1035 | -620                                        |
|                                               |                                               | 460                  | -307                                        |                                               |                    | <i>a</i> (2) = -3425 | -571                                        |
|                                               |                                               | 480                  | -279                                        |                                               |                    | <i>a</i> (3) = -4203 | -528                                        |
|                                               |                                               | 500                  | -253                                        |                                               |                    | 370                  | -528                                        |
|                                               |                                               | 290                  | -1041                                       |                                               |                    | 380                  | -492                                        |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub> | 1,1,2-Trichloro-1,2,2-trifluoroethane         | 310                  | -943                                        | C <sub>2</sub> H <sub>5</sub> Cl              | Chloroethane       | 390                  | -461                                        |
|                                               |                                               | 330                  | -856                                        |                                               |                    | 400                  | -435                                        |
|                                               |                                               | <i>a</i> (1) = -999  | -780                                        |                                               |                    | 320                  | -634                                        |
|                                               |                                               | <i>a</i> (2) = -1479 | -712                                        |                                               |                    | 360                  | -450                                        |
|                                               |                                               | 390                  | -651                                        |                                               |                    | 400                  | -330                                        |
|                                               |                                               | 410                  | -596                                        |                                               |                    | <i>a</i> (1) = -777  | -249                                        |
|                                               |                                               | 430                  | -546                                        |                                               |                    | <i>a</i> (2) = -2205 | -195                                        |
|                                               |                                               | 450                  | -500                                        |                                               |                    | <i>a</i> (3) = -1764 | -157                                        |
|                                               |                                               | 200                  | -573                                        |                                               |                    | 520                  | -157                                        |
|                                               |                                               | 210                  | -500                                        |                                               |                    | 560                  | -131                                        |
| C <sub>2</sub> H <sub>2</sub>                 | Ethyne                                        | 220                  | -440                                        | C <sub>2</sub> H <sub>6</sub>                 | Ethane             | 600                  | -114                                        |
|                                               |                                               | 230                  | -390                                        |                                               |                    | 200                  | -409                                        |
|                                               |                                               | <i>a</i> (1) = -216  | -349                                        |                                               |                    | 220                  | -337                                        |
|                                               |                                               | <i>a</i> (2) = -375  | -315                                        |                                               |                    | 240                  | -284                                        |
|                                               |                                               | <i>a</i> (3) = -716  | -287                                        |                                               |                    | <i>a</i> (1) = -184  | -242                                        |
|                                               |                                               | 260                  | -287                                        |                                               |                    | <i>a</i> (2) = -376  | -209                                        |
|                                               |                                               |                      |                                             |                                               |                    | <i>a</i> (3) = -143  | -181                                        |
|                                               |                                               |                      |                                             |                                               |                    | <i>a</i> (4) = -54   | -159                                        |
|                                               |                                               |                      |                                             |                                               |                    | 320                  | -159                                        |
|                                               |                                               |                      |                                             |                                               |                    | 340                  | -140                                        |

| Mol. form.                      | Name                  | <i>T</i> /K | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> | Mol. form.                       | Name                  | <i>T</i> /K | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> |
|---------------------------------|-----------------------|-------------|---------------------------------------------|----------------------------------|-----------------------|-------------|---------------------------------------------|
|                                 |                       | 360         | -123                                        |                                  |                       | 440         | -146                                        |
|                                 |                       | 380         | -109                                        |                                  |                       | 460         | -131                                        |
|                                 |                       | 400         | -96                                         |                                  |                       | 480         | -118                                        |
|                                 |                       | 500         | -52                                         |                                  |                       | 500         | -106                                        |
| C <sub>2</sub> H <sub>6</sub> O | Ethanol               | 600         | -24                                         | C <sub>3</sub> H <sub>6</sub> O  | 2-Propanone           | 300         | -1996                                       |
|                                 |                       | 320         | -2710                                       |                                  |                       | 320         | -1522                                       |
|                                 |                       | 330         | -2135                                       |                                  |                       | 340         | -1198                                       |
|                                 |                       | 340         | -1676                                       |                                  | <i>a</i> (1) = -2051  | 360         | -971                                        |
|                                 | <i>a</i> (1) = -4475  | 350         | -1317                                       |                                  | <i>a</i> (2) = -8903  | 380         | -806                                        |
|                                 | <i>a</i> (2) = -29719 | 360         | -1043                                       |                                  | <i>a</i> (3) = -18056 | 400         | -683                                        |
|                                 | <i>a</i> (3) = -56716 | 370         | -843                                        |                                  | <i>a</i> (4) = -16448 | 420         | -586                                        |
|                                 |                       | 380         | -705                                        |                                  |                       | 440         | -506                                        |
|                                 |                       | 390         | -622                                        |                                  |                       | 460         | -437                                        |
| C <sub>2</sub> H <sub>6</sub> O | Dimethyl ether        | 275         | -536                                        |                                  |                       | 480         | -375                                        |
|                                 |                       | 280         | -517                                        | C <sub>3</sub> H <sub>6</sub> O  | Ethyl methanoate      | 330         | -1003                                       |
|                                 |                       | 285         | -499                                        |                                  |                       | 340         | -916                                        |
|                                 | <i>a</i> (1) = -455   | 290         | -482                                        |                                  |                       | 350         | -839                                        |
|                                 | <i>a</i> (2) = -965   | 295         | -465                                        |                                  | <i>a</i> (1) = -1371  | 360         | -771                                        |
|                                 |                       | 300         | -449                                        |                                  | <i>a</i> (2) = -4231  | 370         | -712                                        |
|                                 |                       | 305         | -433                                        |                                  | <i>a</i> (3) = -4312  | 380         | -660                                        |
|                                 |                       | 310         | -418                                        |                                  |                       | 390         | -614                                        |
| C <sub>2</sub> H <sub>7</sub> N | Dimethylamine         | 310         | -606                                        | C <sub>3</sub> H <sub>6</sub> O  | Methyl ethanoate      | 320         | -1320                                       |
|                                 |                       | 320         | -563                                        |                                  |                       | 330         | -1186                                       |
|                                 |                       | 330         | -523                                        |                                  |                       | 340         | -1074                                       |
|                                 | <i>a</i> (1) = -662   | 340         | -487                                        |                                  | <i>a</i> (1) = -1709  | 350         | -980                                        |
|                                 | <i>a</i> (2) = -1504  | 350         | -454                                        |                                  | <i>a</i> (2) = -6348  | 360         | -903                                        |
|                                 | <i>a</i> (3) = -667   | 360         | -423                                        |                                  | <i>a</i> (3) = -9650  | 370         | -840                                        |
|                                 |                       | 370         | -395                                        |                                  |                       | 380         | -789                                        |
|                                 |                       | 380         | -369                                        |                                  |                       | 390         | -749                                        |
|                                 |                       | 390         | -345                                        | C <sub>3</sub> H <sub>7</sub> Cl | 1-Chloropropane       | 310         | -1001                                       |
|                                 |                       | 400         | -322                                        |                                  |                       | 340         | -772                                        |
| C <sub>2</sub> H <sub>7</sub> N | Ethylamine            | 300         | -773                                        |                                  |                       | 370         | -614                                        |
|                                 |                       | 310         | -710                                        |                                  | <i>a</i> (1) = -1121  | 400         | -501                                        |
|                                 |                       | 320         | -654                                        |                                  | <i>a</i> (2) = -3271  | 430         | -417                                        |
|                                 | <i>a</i> (1) = -785   | 330         | -604                                        |                                  | <i>a</i> (3) = -3786  | 460         | -352                                        |
|                                 | <i>a</i> (2) = -2012  | 340         | -558                                        |                                  | <i>a</i> (4) = -1974  | 490         | -302                                        |
|                                 | <i>a</i> (3) = -1397  | 350         | -517                                        |                                  |                       | 520         | -261                                        |
|                                 |                       | 360         | -480                                        |                                  |                       | 550         | -227                                        |
|                                 |                       | 370         | -447                                        |                                  |                       | 580         | -198                                        |
|                                 |                       | 380         | -416                                        | C <sub>3</sub> H <sub>8</sub>    | Propane               | 240         | -641                                        |
|                                 |                       | 390         | -389                                        |                                  |                       | 260         | -527                                        |
|                                 |                       | 400         | -363                                        |                                  |                       | 280         | -444                                        |
| C <sub>3</sub> H <sub>6</sub>   | Cyclopropane          | 300         | -383                                        |                                  | <i>a</i> (1) = -386   | 300         | -381                                        |
|                                 |                       | 310         | -356                                        |                                  | <i>a</i> (2) = -844   | 320         | -331                                        |
|                                 |                       | 320         | -332                                        |                                  | <i>a</i> (3) = -720   | 340         | -292                                        |
|                                 | <i>a</i> (1) = -388   | 330         | -310                                        |                                  | <i>a</i> (4) = -574   | 360         | -259                                        |
|                                 | <i>a</i> (2) = -861   | 340         | -290                                        |                                  |                       | 380         | -232                                        |
|                                 | <i>a</i> (3) = -538   | 350         | -272                                        |                                  |                       | 400         | -208                                        |
|                                 |                       | 360         | -256                                        |                                  |                       | 440         | -169                                        |
|                                 |                       | 370         | -241                                        |                                  |                       | 480         | -138                                        |
|                                 |                       | 380         | -227                                        |                                  |                       | 520         | -112                                        |
|                                 |                       | 390         | -215                                        |                                  |                       | 560         | -90                                         |
|                                 |                       | 400         | -204                                        | C <sub>3</sub> H <sub>8</sub> O  | 1-Propanol            | 380         | -873                                        |
| C <sub>3</sub> H <sub>6</sub>   | Propene               | 280         | -395                                        |                                  |                       | 385         | -826                                        |
|                                 |                       | 300         | -342                                        |                                  |                       | 390         | -783                                        |
|                                 |                       | 320         | -299                                        |                                  | <i>a</i> (1) = -2690  | 395         | -744                                        |
|                                 | <i>a</i> (1) = -347   | 340         | -262                                        |                                  | <i>a</i> (2) = -12040 | 400         | -709                                        |
|                                 | <i>a</i> (2) = -727   | 360         | -232                                        |                                  | <i>a</i> (3) = -16738 | 405         | -679                                        |
|                                 | <i>a</i> (3) = -325   | 380         | -205                                        |                                  |                       | 410         | -651                                        |
|                                 |                       | 400         | -183                                        |                                  |                       | 415         | -627                                        |
|                                 |                       | 420         | -163                                        |                                  |                       | 420         | -606                                        |

| Mol. form.                                   | Name              | <i>T</i> /K           | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> | Mol. form.                       | Name                | <i>T</i> /K           | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> |
|----------------------------------------------|-------------------|-----------------------|---------------------------------------------|----------------------------------|---------------------|-----------------------|---------------------------------------------|
| C <sub>3</sub> H <sub>8</sub> O              | 2-Propanol        | 380                   | -821                                        | C <sub>4</sub> H <sub>10</sub>   | Butane              | 250                   | -1170                                       |
|                                              |                   | 385                   | -766                                        |                                  |                     | 280                   | -863                                        |
|                                              |                   | 390                   | -717                                        |                                  |                     | 310                   | -668                                        |
|                                              |                   | <i>a</i> (1) = -3165  | -674                                        |                                  |                     | <i>a</i> (1) = -735   | -536                                        |
|                                              |                   | <i>a</i> (2) = -16092 | -636                                        |                                  |                     | <i>a</i> (2) = -1835  | -442                                        |
|                                              |                   | <i>a</i> (3) = -24197 | -604                                        |                                  |                     | <i>a</i> (3) = -1922  | -371                                        |
|                                              |                   |                       | -576                                        |                                  |                     | <i>a</i> (4) = -1330  | -315                                        |
|                                              |                   |                       | -552                                        |                                  |                     |                       | -270                                        |
|                                              |                   |                       | -533                                        |                                  |                     |                       | -232                                        |
|                                              |                   |                       | -675                                        |                                  |                     |                       | -199                                        |
| C <sub>3</sub> H <sub>9</sub> N              | Trimethylamine    | 310                   | -675                                        | C <sub>4</sub> H <sub>10</sub>   | 2-Methylpropane     | 270                   | -900                                        |
|                                              |                   | 320                   | -628                                        |                                  |                     | 300                   | -697                                        |
|                                              |                   | 330                   | -585                                        |                                  |                     | 330                   | -553                                        |
|                                              |                   | <i>a</i> (1) = -737   | -547                                        |                                  |                     | <i>a</i> (1) = -707   | -450                                        |
|                                              |                   | <i>a</i> (2) = -1669  | -512                                        |                                  |                     | <i>a</i> (2) = -1719  | -374                                        |
|                                              |                   | <i>a</i> (3) = -986   | -480                                        |                                  |                     | <i>a</i> (3) = -1282  | -317                                        |
|                                              |                   |                       | -450                                        |                                  |                     |                       | -273                                        |
|                                              |                   |                       | -624                                        |                                  |                     |                       | -240                                        |
|                                              |                   |                       | -539                                        |                                  |                     |                       | -215                                        |
|                                              |                   |                       | -470                                        |                                  |                     |                       | -1693                                       |
| C <sub>4</sub> H <sub>8</sub>                | 1-Butene          | 300                   | -624                                        | C <sub>4</sub> H <sub>10</sub> O | 1-Butanol           | 350                   | -1544                                       |
|                                              |                   | 320                   | -539                                        |                                  |                     | 360                   | -1402                                       |
|                                              |                   | 340                   | -470                                        |                                  |                     | 370                   | -1402                                       |
|                                              |                   | <i>a</i> (1) = -633   | -413                                        |                                  |                     | <i>a</i> (1) = -2629  | -1268                                       |
|                                              |                   | <i>a</i> (2) = -1442  | -366                                        |                                  |                     | <i>a</i> (2) = -6315  | -1141                                       |
|                                              |                   | <i>a</i> (3) = -932   | -327                                        |                                  |                     |                       | -1021                                       |
|                                              |                   |                       | -294                                        |                                  |                     |                       | -796                                        |
|                                              |                   |                       | -2056                                       |                                  |                     |                       | -593                                        |
|                                              |                   |                       | -1878                                       |                                  |                     |                       | -1076                                       |
|                                              |                   |                       | -1712                                       |                                  |                     |                       | -979                                        |
| C <sub>4</sub> H <sub>8</sub> O              | 2-Butanone        | 310                   | -2056                                       | C <sub>4</sub> H <sub>10</sub> O | 2-Methyl-1-propanol | 390                   | -1076                                       |
|                                              |                   | 320                   | -1878                                       |                                  |                     | 400                   | -979                                        |
|                                              |                   | 330                   | -1712                                       |                                  |                     | 410                   | -887                                        |
|                                              |                   | <i>a</i> (1) = -2282  | -1555                                       |                                  |                     | <i>a</i> (1) = -2269  | -800                                        |
|                                              |                   | <i>a</i> (2) = -5907  | -1407                                       |                                  |                     | <i>a</i> (2) = -5065  | -716                                        |
|                                              |                   |                       | -1267                                       |                                  |                     |                       | -636                                        |
|                                              |                   |                       | -1135                                       |                                  |                     |                       | -1110                                       |
|                                              |                   |                       | -1496                                       |                                  |                     |                       | -1005                                       |
|                                              |                   |                       | -1354                                       |                                  |                     |                       | -906                                        |
|                                              |                   |                       | -1231                                       |                                  |                     |                       | -811                                        |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> | Propyl methanoate | 330                   | -1496                                       | C <sub>4</sub> H <sub>10</sub> O | 2-Butanol           | 380                   | -1110                                       |
|                                              |                   | 340                   | -1354                                       |                                  |                     | 390                   | -1005                                       |
|                                              |                   | 350                   | -1231                                       |                                  |                     | 400                   | -906                                        |
|                                              |                   | <i>a</i> (1) = -2118  | -1126                                       |                                  |                     | <i>a</i> (1) = -2232  | -811                                        |
|                                              |                   | <i>a</i> (2) = -7299  | -1035                                       |                                  |                     | <i>a</i> (2) = -5209  | -721                                        |
|                                              |                   | <i>a</i> (3) = -8851  | -957                                        |                                  |                     |                       | -721                                        |
|                                              |                   |                       | -890                                        |                                  |                     |                       | -924                                        |
|                                              |                   |                       | -834                                        |                                  |                     |                       | -827                                        |
|                                              |                   |                       | -1543                                       |                                  |                     |                       | -736                                        |
|                                              |                   |                       | -1385                                       |                                  |                     |                       | -649                                        |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> | Ethyl ethanoate   | 330                   | -1543                                       | C <sub>4</sub> H <sub>10</sub> O | 2-Methyl-2-propanol | 380                   | -924                                        |
|                                              |                   | 340                   | -1385                                       |                                  |                     | 390                   | -827                                        |
|                                              |                   | 350                   | -1254                                       |                                  |                     | 400                   | -736                                        |
|                                              |                   | <i>a</i> (1) = -2272  | -1144                                       |                                  |                     | <i>a</i> (1) = -1952  | -649                                        |
|                                              |                   | <i>a</i> (2) = -8818  | -1055                                       |                                  |                     | <i>a</i> (2) = -4775  | -567                                        |
|                                              |                   | <i>a</i> (3) = -13130 | -982                                        |                                  |                     |                       | -1550                                       |
|                                              |                   |                       | -923                                        |                                  |                     |                       | -1199                                       |
|                                              |                   |                       | -878                                        |                                  |                     |                       | -954                                        |
|                                              |                   |                       | -1588                                       |                                  |                     |                       | -776                                        |
|                                              |                   |                       | -1444                                       |                                  |                     |                       | -638                                        |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> | Methyl propanoate | 330                   | -1588                                       | C <sub>4</sub> H <sub>10</sub> O | Diethyl ether       | 320                   | -954                                        |
|                                              |                   | 340                   | -1444                                       |                                  |                     | 340                   | -776                                        |
|                                              |                   | 350                   | -1319                                       |                                  |                     | <i>a</i> (1) = -1226  | -776                                        |
|                                              |                   | <i>a</i> (1) = -2216  | -1211                                       |                                  |                     | <i>a</i> (2) = -4458  | -638                                        |
|                                              |                   | <i>a</i> (2) = -7339  | -1117                                       |                                  |                     | <i>a</i> (3) = -7746  | -525                                        |
|                                              |                   | <i>a</i> (3) = -8658  | -1037                                       |                                  |                     | <i>a</i> (4) = -10005 | -428                                        |
|                                              |                   |                       | -968                                        |                                  |                     |                       | -340                                        |
|                                              |                   |                       | -908                                        |                                  |                     |                       | -1228                                       |
|                                              |                   |                       | -1224                                       |                                  |                     |                       | -1134                                       |
|                                              |                   |                       | -898                                        |                                  |                     |                       | -1056                                       |
| C <sub>4</sub> H <sub>9</sub> Cl             | 1-Chlorobutane    | 330                   | -1224                                       | C <sub>4</sub> H <sub>11</sub> N | Diethylamine        | 320                   | -1228                                       |
|                                              |                   | 370                   | -898                                        |                                  |                     | 330                   | -1134                                       |
|                                              |                   | 410                   | -691                                        |                                  |                     | 340                   | -1056                                       |
|                                              |                   | <i>a</i> (1) = -1643  | -551                                        |                                  |                     | <i>a</i> (1) = -1522  | -988                                        |
|                                              |                   | <i>a</i> (2) = -4897  | -449                                        |                                  |                     | <i>a</i> (2) = -5204  | -926                                        |
|                                              |                   | <i>a</i> (3) = -6178  | -371                                        |                                  |                     | <i>a</i> (3) = -15047 | -868                                        |
|                                              |                   | <i>a</i> (4) = -3718  | -309                                        |                                  |                     | <i>a</i> (4) = -28835 | -812                                        |
|                                              |                   |                       |                                             |                                  |                     |                       | -755                                        |
|                                              |                   |                       |                                             |                                  |                     |                       |                                             |
|                                              |                   |                       |                                             |                                  |                     |                       |                                             |

| Mol. form.                       | Name                | <i>T</i> /K           | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> | Mol. form.                      | Name               | <i>T</i> /K           | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> |
|----------------------------------|---------------------|-----------------------|---------------------------------------------|---------------------------------|--------------------|-----------------------|---------------------------------------------|
| C <sub>5</sub> H <sub>5</sub> N  | Pyridine            | 400                   | -697                                        | C <sub>6</sub> H <sub>6</sub>   | Benzene            | 390                   | -492                                        |
|                                  |                     | 350                   | -1257                                       |                                 |                    | 400                   | -464                                        |
|                                  |                     | 360                   | -1176                                       |                                 |                    | 450                   | -357                                        |
|                                  |                     | 370                   | -1099                                       |                                 |                    | 500                   | -279                                        |
|                                  |                     | <i>a</i> (1) = -1765  | 380                                         |                                 |                    | 550                   | -218                                        |
|                                  |                     | <i>a</i> (2) = -3431  | 390                                         |                                 |                    | 290                   | -1588                                       |
|                                  |                     |                       | 400                                         |                                 |                    | 300                   | -1454                                       |
|                                  |                     |                       | 420                                         |                                 |                    | 310                   | -1335                                       |
|                                  |                     |                       | 440                                         |                                 |                    | 320                   | -1231                                       |
|                                  |                     |                       |                                             |                                 |                    | 330                   | -1139                                       |
| C <sub>5</sub> H <sub>10</sub>   | Cyclopentane        | 300                   | -1049                                       |                                 |                    | 340                   | -1056                                       |
|                                  |                     | 305                   | -1015                                       |                                 |                    | 350                   | -983                                        |
|                                  |                     | 310                   | -981                                        |                                 |                    | 400                   | -712                                        |
|                                  |                     | <i>a</i> (1) = -1062  | 315                                         |                                 |                    | 450                   | -542                                        |
|                                  |                     | <i>a</i> (2) = -2116  | 320                                         |                                 |                    | 500                   | -429                                        |
|                                  |                     |                       |                                             |                                 |                    | 550                   | -349                                        |
| C <sub>5</sub> H <sub>10</sub>   | 1-Pentene           | 310                   | -966                                        | C <sub>6</sub> H <sub>7</sub> N | 2-Methylpyridine   | 600                   | -291                                        |
|                                  |                     | 320                   | -898                                        |                                 |                    | 360                   | -1656                                       |
|                                  |                     | 330                   | -836                                        |                                 |                    | 370                   | -1523                                       |
|                                  |                     | <i>a</i> (1) = -1055  | 340                                         |                                 |                    | 380                   | -1404                                       |
|                                  |                     | <i>a</i> (2) = -2377  | 350                                         |                                 |                    | <i>a</i> (1) = -2940  | 390                                         |
|                                  |                     | <i>a</i> (3) = -1189  | 360                                         |                                 |                    | <i>a</i> (2) = -8813  | 400                                         |
|                                  |                     |                       | 370                                         |                                 |                    | <i>a</i> (3) = -7809  | 410                                         |
|                                  |                     |                       | 380                                         |                                 |                    |                       | 420                                         |
|                                  |                     |                       | 390                                         |                                 |                    |                       | 430                                         |
|                                  |                     |                       | 400                                         |                                 |                    |                       | -972                                        |
| C <sub>5</sub> H <sub>10</sub> O | 2-Pentanone         | 410                   | -495                                        | C <sub>6</sub> H <sub>7</sub> N | 3-Methylpyridine   | 380                   | -1819                                       |
|                                  |                     | 330                   | -2850                                       |                                 |                    | 390                   | -1612                                       |
|                                  |                     | 340                   | -2420                                       |                                 |                    | 400                   | -1448                                       |
|                                  |                     | 350                   | -2076                                       |                                 |                    | <i>a</i> (1) = -6304  | 410                                         |
|                                  |                     | <i>a</i> (1) = -4962  | 360                                         |                                 |                    | <i>a</i> (2) = -30415 | 420                                         |
|                                  |                     | <i>a</i> (2) = -26372 | 370                                         |                                 |                    | <i>a</i> (3) = -44549 | 430                                         |
| C <sub>5</sub> H <sub>12</sub>   | Pentane             | 380                   | -1440                                       | C <sub>6</sub> H <sub>7</sub> N | 4-Methylpyridine   | 380                   | -1787                                       |
|                                  |                     | <i>a</i> (3) = -46537 | 390                                         |                                 |                    | 390                   | -1578                                       |
|                                  |                     |                       | 300                                         |                                 |                    | 400                   | -1417                                       |
|                                  |                     |                       | 310                                         |                                 |                    | <i>a</i> (1) = -6553  | 410                                         |
|                                  |                     |                       | 320                                         |                                 |                    | <i>a</i> (2) = -32873 | 420                                         |
|                                  |                     | <i>a</i> (1) = -1254  | 330                                         |                                 |                    | <i>a</i> (3) = -49874 | 430                                         |
|                                  |                     | <i>a</i> (2) = -3345  | 340                                         |                                 |                    |                       | -1163                                       |
|                                  |                     | <i>a</i> (3) = -2726  | 350                                         |                                 |                    |                       | -1698                                       |
|                                  |                     |                       | 400                                         |                                 |                    |                       | -1391                                       |
|                                  |                     |                       | 450                                         |                                 |                    |                       | -1170                                       |
| C <sub>5</sub> H <sub>12</sub>   | 2-Methylbutane      | 500                   | -348                                        | C <sub>6</sub> H <sub>12</sub>  | Cyclohexane        | 360                   | -1007                                       |
|                                  |                     | 550                   | -294                                        |                                 |                    | <i>a</i> (1) = -1733  | 380                                         |
|                                  |                     | 280                   | -1263                                       |                                 |                    | <i>a</i> (2) = -5618  | 400                                         |
|                                  |                     | 290                   | -1166                                       |                                 |                    | <i>a</i> (3) = -9486  | 420                                         |
|                                  |                     | 300                   | -1079                                       |                                 |                    | <i>a</i> (4) = -7936  | 440                                         |
|                                  |                     | <i>a</i> (1) = -1095  | 310                                         |                                 |                    |                       | -641                                        |
|                                  |                     | <i>a</i> (2) = -2503  | 320                                         |                                 |                    |                       | -584                                        |
|                                  |                     | <i>a</i> (3) = -1534  | 330                                         |                                 |                    |                       | -534                                        |
|                                  |                     |                       | 340                                         |                                 |                    |                       | -488                                        |
|                                  |                     |                       | 350                                         |                                 |                    |                       | -446                                        |
| C <sub>5</sub> H <sub>12</sub>   | 2,2-Dimethylpropane | 400                   | -557                                        | C <sub>6</sub> H <sub>12</sub>  | Methylcyclopentane | 540                   | -406                                        |
|                                  |                     | 450                   | -424                                        |                                 |                    | 560                   | -368                                        |
|                                  |                     | 300                   | -916                                        |                                 |                    | 305                   | -1447                                       |
|                                  |                     | 310                   | -843                                        |                                 |                    | 315                   | -1357                                       |
|                                  |                     | 320                   | -780                                        |                                 |                    | 325                   | -1272                                       |
|                                  |                     | <i>a</i> (1) = -931   | 330                                         |                                 |                    | <i>a</i> (1) = -1512  | 335                                         |
|                                  |                     | <i>a</i> (2) = -2387  | 340                                         |                                 |                    | <i>a</i> (2) = -2910  | 345                                         |
|                                  |                     | <i>a</i> (3) = -2641  | 350                                         |                                 |                    |                       | -1192                                       |
|                                  |                     | <i>a</i> (4) = -1810  | 360                                         |                                 |                    |                       | -1117                                       |
|                                  |                     |                       | 370                                         |                                 |                    |                       | -1920                                       |
|                                  |                     | 380                   | -521                                        | C <sub>6</sub> H <sub>14</sub>  | Hexane             | 310                   | -1724                                       |
|                                  |                     |                       |                                             |                                 |                    | 320                   | -1561                                       |
|                                  |                     |                       |                                             |                                 |                    | <i>a</i> (1) = -1961  | 330                                         |
|                                  |                     |                       |                                             |                                 |                    | <i>a</i> (2) = -6691  | 340                                         |
|                                  |                     |                       |                                             |                                 |                    |                       | -1424                                       |
|                                  |                     |                       |                                             |                                 |                    |                       | -1309                                       |

| Mol. form.                       | Name                  | <i>T</i> /K                    | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> | Mol. form.                     | Name                           | <i>T</i> /K                    | <i>B</i> /cm <sup>3</sup> mol <sup>-1</sup> |                     |                       |                                |          |       |
|----------------------------------|-----------------------|--------------------------------|---------------------------------------------|--------------------------------|--------------------------------|--------------------------------|---------------------------------------------|---------------------|-----------------------|--------------------------------|----------|-------|
| C <sub>6</sub> H <sub>15</sub> N | <i>a</i> (3) = -13167 | 350                            | -1209                                       | C <sub>8</sub> H <sub>10</sub> | 1,2-Dimethylbenzene            | 500                            | -702                                        |                     |                       |                                |          |       |
|                                  | <i>a</i> (4) = -15273 | 360                            | -1123                                       |                                |                                | 540                            | -583                                        |                     |                       |                                |          |       |
|                                  |                       | 370                            | -1046                                       |                                |                                | 580                            | -490                                        |                     |                       |                                |          |       |
|                                  |                       | 380                            | -978                                        |                                |                                | 620                            | -416                                        |                     |                       |                                |          |       |
|                                  |                       | 390                            | -916                                        |                                |                                | 660                            | -355                                        |                     |                       |                                |          |       |
|                                  |                       | 400                            | -859                                        |                                |                                | 700                            | -304                                        |                     |                       |                                |          |       |
|                                  |                       | 410                            | -806                                        |                                |                                | 380                            | -2046                                       |                     |                       |                                |          |       |
|                                  |                       | 430                            | -707                                        |                                |                                | 390                            | -1848                                       |                     |                       |                                |          |       |
|                                  |                       | 450                            | -616                                        |                                |                                | 400                            | -1681                                       |                     |                       |                                |          |       |
|                                  | Triethylamine         | 330                            | -1562                                       |                                |                                | <i>a</i> (1) = -5632           | 410                                         | -1543               |                       |                                |          |       |
|                                  |                       | 340                            | -1444                                       |                                |                                | <i>a</i> (2) = -22873          | 420                                         | -1428               |                       |                                |          |       |
|                                  |                       | 350                            | -1340                                       |                                |                                | <i>a</i> (3) = -28900          | 430                                         | -1335               |                       |                                |          |       |
|                                  | <i>a</i> (1) = -2061  | 360                            | -1249                                       |                                |                                |                                | 440                                         | -1261               |                       |                                |          |       |
|                                  | <i>a</i> (2) = -5735  | 370                            | -1169                                       |                                |                                | C <sub>8</sub> H <sub>10</sub> | 1,3-Dimethylbenzene                         | 380                 | -2082                 |                                |          |       |
|                                  | <i>a</i> (3) = -5899  | 380                            | -1099                                       |                                |                                |                                |                                             | 390                 | -1865                 |                                |          |       |
| C <sub>7</sub> H <sub>8</sub>    | Toluene               | 390                            | -1037                                       | 400                            | -1679                          |                                |                                             |                     |                       |                                |          |       |
|                                  |                       | 400                            | -983                                        | 410                            | -1521                          |                                |                                             |                     |                       |                                |          |       |
|                                  |                       | 350                            | -1641                                       | 420                            | -1388                          |                                |                                             |                     |                       |                                |          |       |
|                                  |                       | 360                            | -1511                                       | 430                            | -1276                          |                                |                                             |                     |                       |                                |          |       |
|                                  |                       | 370                            | -1394                                       | 440                            | -1184                          |                                |                                             |                     |                       |                                |          |       |
|                                  |                       | <i>a</i> (1) = -2620           | 380                                         | -1289                          | C <sub>8</sub> H <sub>10</sub> |                                |                                             | 1,4-Dimethylbenzene | 380                   | -2043                          |          |       |
|                                  |                       | <i>a</i> (2) = -7548           | 390                                         | -1195                          |                                |                                |                                             |                     | 390                   | -1851                          |          |       |
|                                  |                       | <i>a</i> (3) = -6349           | 400                                         | -1110                          |                                |                                |                                             |                     | 400                   | -1680                          |          |       |
|                                  |                       |                                | 410                                         | -1034                          |                                |                                |                                             |                     | <i>a</i> (1) = -4921  | 410                            | -1529    |       |
|                                  |                       |                                | 420                                         | -965                           |                                |                                |                                             |                     | <i>a</i> (2) = -16843 | 420                            | -1395    |       |
|                                  |                       |                                | 430                                         | -903                           |                                |                                |                                             |                     | <i>a</i> (3) = -16159 | 430                            | -1276    |       |
|                                  |                       | C <sub>7</sub> H <sub>14</sub> | 1-Heptene                                   | 340                            |                                |                                |                                             |                     | -1781                 | 440                            | -1171    |       |
|                                  |                       |                                |                                             | 350                            |                                |                                |                                             |                     | -1651                 | C <sub>8</sub> H <sub>16</sub> | 1-Octene | 360   |
|                                  |                       |                                |                                             | 360                            |                                | -1532                          | 370                                         |                     | -2000                 |                                |          |       |
|                                  |                       |                                |                                             | <i>a</i> (1) = -2491           |                                | 370                            | -1424                                       |                     | 380                   |                                |          | -1861 |
| <i>a</i> (2) = -6230             | 380                   |                                |                                             | -1324                          |                                | <i>a</i> (1) = -3273           | 390                                         |                     | -1729                 |                                |          |       |
| <i>a</i> (3) = -3780             | 390                   |                                |                                             | -1233                          |                                | <i>a</i> (2) = -6557           | 400                                         |                     | -1604                 |                                |          |       |
|                                  | 400                   |                                |                                             | -1150                          |                                | 410                            | -1485                                       |                     |                       |                                |          |       |
|                                  | 410                   |                                |                                             | -1073                          |                                | C <sub>8</sub> H <sub>18</sub> | Octane                                      |                     | 300                   |                                |          | -4042 |
|                                  | 300                   |                                |                                             | -2782                          |                                |                                |                                             |                     | 350                   |                                |          | -2511 |
|                                  | 320                   |                                |                                             | -2297                          | 400                            |                                |                                             | -1704               |                       |                                |          |       |
|                                  | 340                   |                                |                                             | -1928                          | <i>a</i> (1) = -4123           |                                |                                             | 450                 | -1234                 |                                |          |       |
| <i>a</i> (1) = -2834             | 360                   |                                |                                             | -1641                          | <i>a</i> (2) = -13120          |                                |                                             | 500                 | -936                  |                                |          |       |
| <i>a</i> (2) = -8523             | 380                   |                                |                                             | -1415                          | <i>a</i> (3) = -16408          |                                |                                             | 550                 | -732                  |                                |          |       |
| <i>a</i> (3) = -10068            | 400                   |                                |                                             | -1233                          | <i>a</i> (4) = -8580           |                                |                                             | 600                 | -583                  |                                |          |       |
| <i>a</i> (4) = -5051             | 420                   |                                |                                             | -1085                          | 650                            |                                |                                             | -468                |                       |                                |          |       |
|                                  | 440                   | -963                           | 700                                         | -375                           |                                |                                |                                             |                     |                       |                                |          |       |
|                                  | 460                   | -862                           |                                             |                                |                                |                                |                                             |                     |                       |                                |          |       |
|                                  | 480                   | -775                           |                                             |                                |                                |                                |                                             |                     |                       |                                |          |       |



## VAN DER WAALS CONSTANTS FOR GASES

The van der Waals equation of state for a real gas is

$$(P + n^2 a/V^2)(V - nb) = nRT$$

where  $P$  is the pressure,  $V$  the volume,  $T$  the temperature,  $n$  the amount of substance (in moles), and  $R$  the gas constant. The van der Waals constants  $a$  and  $b$  are characteristic of the substance and are independent of temperature. They are related to the critical temperature and pressure,  $T_c$  and  $P_c$ , by

$$a = 27R^2T_c^2/64P_c \quad b = RT_c/8P_c$$

This table gives values of  $a$  and  $b$  for some common gases. Most of the values have been calculated from the critical temperature and pressure values given in the table "Critical Constants" in this section. Van der Waals constants for other gases may easily be calculated from the data in that table.

To convert the van der Waals constants to SI units, note that 1 bar L<sup>2</sup>/mol<sup>2</sup> = 0.1 Pa m<sup>6</sup>/mol<sup>2</sup> and 1 L/mol = 0.001 m<sup>3</sup>/mol.

### Reference

Reid, R. C., Prausnitz, J. M., and Poling, B. E., *The Properties of Gases and Liquids, Fourth Edition*, McGraw-Hill, New York, 1987.

| Substance         | $a$<br>bar L <sup>2</sup> /mol <sup>2</sup> | $b$<br>L/mol |
|-------------------|---------------------------------------------|--------------|
| Acetic acid       | 17.71                                       | 0.1065       |
| Acetone           | 16.02                                       | 0.1124       |
| Acetylene         | 4.516                                       | 0.0522       |
| Ammonia           | 4.225                                       | 0.0371       |
| Aniline           | 29.14                                       | 0.1486       |
| Argon             | 1.355                                       | 0.0320       |
| Benzene           | 18.82                                       | 0.1193       |
| Bromine           | 9.75                                        | 0.0591       |
| Butane            | 13.89                                       | 0.1164       |
| 1-Butanol         | 20.94                                       | 0.1326       |
| 2-Butanone        | 19.97                                       | 0.1326       |
| Carbon dioxide    | 3.658                                       | 0.0429       |
| Carbon disulfide  | 11.25                                       | 0.0726       |
| Carbon monoxide   | 1.472                                       | 0.0395       |
| Chlorine          | 6.343                                       | 0.0542       |
| Chlorobenzene     | 25.80                                       | 0.1454       |
| Chloroethane      | 11.66                                       | 0.0903       |
| Chloromethane     | 7.566                                       | 0.0648       |
| Cyclohexane       | 21.92                                       | 0.1411       |
| Cyclopropane      | 8.34                                        | 0.0747       |
| Decane            | 52.74                                       | 0.3043       |
| 1-Decanol         | 59.51                                       | 0.3086       |
| Diethyl ether     | 17.46                                       | 0.1333       |
| Dimethyl ether    | 8.690                                       | 0.0774       |
| Dodecane          | 69.38                                       | 0.3758       |
| 1-Dodecanol       | 75.70                                       | 0.3750       |
| Ethane            | 5.580                                       | 0.0651       |
| Ethanol           | 12.56                                       | 0.0871       |
| Ethylene          | 4.612                                       | 0.0582       |
| Fluorine          | 1.171                                       | 0.0290       |
| Furan             | 12.74                                       | 0.0926       |
| Helium            | 0.0346                                      | 0.0238       |
| Heptane           | 31.06                                       | 0.2049       |
| 1-Heptanol        | 38.17                                       | 0.2150       |
| Hexane            | 24.84                                       | 0.1744       |
| 1-Hexanol         | 31.79                                       | 0.1856       |
| Hydrazine         | 8.46                                        | 0.0462       |
| Hydrogen          | 0.2452                                      | 0.0265       |
| Hydrogen bromide  | 4.500                                       | 0.0442       |
| Hydrogen chloride | 3.700                                       | 0.0406       |
| Hydrogen cyanide  | 11.29                                       | 0.0881       |
| Hydrogen fluoride | 9.565                                       | 0.0739       |
| Hydrogen iodide   | 6.309                                       | 0.0530       |

| Substance             | $a$<br>bar L <sup>2</sup> /mol <sup>2</sup> | $b$<br>L/mol |
|-----------------------|---------------------------------------------|--------------|
| Hydrogen sulfide      | 4.544                                       | 0.0434       |
| Isobutane             | 13.32                                       | 0.1164       |
| Krypton               | 5.193                                       | 0.0106       |
| Methane               | 2.303                                       | 0.0431       |
| Methanol              | 9.476                                       | 0.0659       |
| Methylamine           | 7.106                                       | 0.0588       |
| Neon                  | 0.208                                       | 0.0167       |
| Neopentane            | 17.17                                       | 0.1411       |
| Nitric oxide          | 1.46                                        | 0.0289       |
| Nitrogen              | 1.370                                       | 0.0387       |
| Nitrogen dioxide      | 5.36                                        | 0.0443       |
| Nitrogen trifluoride  | 3.58                                        | 0.0545       |
| Nitrous oxide         | 3.852                                       | 0.0444       |
| Octane                | 37.88                                       | 0.2374       |
| 1-Octanol             | 44.71                                       | 0.2442       |
| Oxygen                | 1.382                                       | 0.0319       |
| Ozone                 | 3.570                                       | 0.0487       |
| Pentane               | 19.09                                       | 0.1449       |
| 1-Pentanol            | 25.88                                       | 0.1568       |
| Phenol                | 22.93                                       | 0.1177       |
| Propane               | 9.39                                        | 0.0905       |
| 1-Propanol            | 16.26                                       | 0.1079       |
| 2-Propanol            | 15.82                                       | 0.1109       |
| Propene               | 8.442                                       | 0.0824       |
| Pyridine              | 19.77                                       | 0.1137       |
| Pyrrole               | 18.82                                       | 0.1049       |
| Silane                | 4.38                                        | 0.0579       |
| Sulfur dioxide        | 6.865                                       | 0.0568       |
| Sulfur hexafluoride   | 7.857                                       | 0.0879       |
| Tetrachloromethane    | 20.01                                       | 0.1281       |
| Tetrachlorosilane     | 20.96                                       | 0.1470       |
| Tetrafluoroethylene   | 6.954                                       | 0.0809       |
| Tetrafluoromethane    | 4.040                                       | 0.0633       |
| Tetrafluorosilane     | 5.259                                       | 0.0724       |
| Tetrahydrofuran       | 16.39                                       | 0.1082       |
| Thiophene             | 17.21                                       | 0.1058       |
| Toluene               | 24.86                                       | 0.1497       |
| 1,1,1-Trichloroethane | 20.15                                       | 0.1317       |
| Trichloromethane      | 15.34                                       | 0.1019       |
| Trifluoromethane      | 5.378                                       | 0.0640       |
| Trimethylamine        | 13.37                                       | 0.1101       |
| Water                 | 5.537                                       | 0.0305       |
| Xenon                 | 4.192                                       | 0.0516       |

## MEAN FREE PATH AND RELATED PROPERTIES OF GASES

In the simplest version of the kinetic theory of gases, molecules are treated as hard spheres of diameter  $d$  which make binary collisions only. In this approximation the mean distance traveled by a molecule between successive collisions, the mean free path  $l$ , is related to the collision diameter by:

$$l = \frac{kT}{\pi\sqrt{2}Pd^2}$$

where  $P$  is the pressure,  $T$  the absolute temperature, and  $k$  the Boltzmann constant. At standard conditions ( $P = 100,000$  Pa and  $T = 298.15$  K) this relation becomes:

$$l = \frac{9.27 \cdot 10^{-27}}{d^2}$$

where  $l$  and  $d$  are in meters.

Using the same model and the same standard pressure, the collision diameter can be calculated from the viscosity  $\eta$  by the kinetic theory relation:

$$\eta = \frac{2.67 \cdot 10^{-20} (MT)^{1/2}}{d^2}$$

where  $\eta$  is in units of  $\mu\text{Pa s}$  and  $M$  is the molar mass in g/mol. Kinetic theory also gives a relation for the mean velocity  $\bar{v}$  of molecules of mass  $m$ :

$$\bar{v} = \left( \frac{8kT}{\pi m} \right)^{1/2} = 145.5(T/M)^{1/2} \text{ m/s}$$

Finally, the mean time  $\tau$  between collisions can be calculated from the relation  $\tau\bar{v} = l$ .

The table below gives values of  $l$ ,  $\bar{v}$ , and  $\tau$  for some common gases at 25 °C and atmospheric pressure, as well as the value of  $d$ , all calculated from measured gas viscosities (see References 2 and 3 and the table "Viscosity of Gases" in this section). It is seen from the above equations that the mean free path varies directly with  $T$  and inversely with  $P$ , while the mean velocity varies as the square root of  $T$  and, in this approximation, is independent of  $P$ .

A more accurate model, in which molecular interactions are described by a Lennard-Jones potential, gives mean free path values about 5% lower than this table (see Reference 4).

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| Gas             | $d/\text{m}$          | $l/\text{m}$         | $\bar{v}/\text{m s}^{-1}$ | $\tau/\text{ps}$ |
|-----------------|-----------------------|----------------------|---------------------------|------------------|
| Air             | $3.66 \cdot 10^{-10}$ | $6.91 \cdot 10^{-8}$ | 467                       | 148              |
| Ar              | 3.58                  | 7.22                 | 397                       | 182              |
| CO <sub>2</sub> | 4.53                  | 4.51                 | 379                       | 119              |
| H <sub>2</sub>  | 2.71                  | 12.6                 | 1769                      | 71               |
| He              | 2.15                  | 20.0                 | 1256                      | 159              |
| Kr              | 4.08                  | 5.58                 | 274                       | 203              |
| N <sub>2</sub>  | 3.70                  | 6.76                 | 475                       | 142              |
| NH <sub>3</sub> | 4.32                  | 4.97                 | 609                       | 82               |
| Ne              | 2.54                  | 14.3                 | 559                       | 256              |
| O <sub>2</sub>  | 3.55                  | 7.36                 | 444                       | 166              |
| Xe              | 4.78                  | 4.05                 | 219                       | 185              |

## INFLUENCE OF PRESSURE ON FREEZING POINTS

This table illustrates the variation of the freezing point of representative types of liquids with pressure. Substances are listed in alphabetical order. Note that 1 MPa = 0.01 kbar = 9.87 atm.

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2. Merrill, L., *J. Phys. Chem. Ref. Data*, 6, 1205, 1977; 11, 1005, 1982.

| Substance                   | Molecular formula                               | Freezing point in °C at: |         |          |
|-----------------------------|-------------------------------------------------|--------------------------|---------|----------|
|                             |                                                 | 0.1 MPa                  | 100 MPa | 1000 MPa |
| Acetic acid                 | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>    | 16.6                     | 37      |          |
| Acetophenone                | C <sub>8</sub> H <sub>8</sub> O                 | 20.0                     | 41.2    |          |
| Aniline                     | C <sub>6</sub> H <sub>7</sub> N                 | -6.0                     | 13.5    | 140      |
| Benzene                     | C <sub>6</sub> H <sub>6</sub>                   | 5.5                      | 33.4    |          |
| Benzonitrile                | C <sub>7</sub> H <sub>5</sub> N                 | -12.8                    | 7.6     |          |
| Benzyl alcohol              | C <sub>7</sub> H <sub>8</sub> O                 | -15.2                    | 0.2     |          |
| Bromobenzene                | C <sub>6</sub> H <sub>5</sub> Br                | -30.6                    | -12     | 108      |
| Bromoethane                 | C <sub>2</sub> H <sub>5</sub> Br                | -118.6                   | -108    |          |
| 1-Bromonaphthalene          | C <sub>10</sub> H <sub>7</sub> Br               | -1.8                     | 6.1     |          |
| 1-Bromopropane              | C <sub>3</sub> H <sub>7</sub> Br                | -110                     | -98     |          |
| <i>p</i> -Bromotoluene      | C <sub>7</sub> H <sub>7</sub> Br                | 28.0                     | 56.7    |          |
| Butanoic acid               | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>    | -5.7                     | 13.8    |          |
| 1-Butanol                   | C <sub>4</sub> H <sub>10</sub> O                | -89.8                    | -77.2   |          |
| Carbon disulfide            | CS <sub>2</sub>                                 | -111.5                   | -98     |          |
| Chlorobenzene               | C <sub>6</sub> H <sub>5</sub> Cl                | -45.2                    | -28     | 84       |
| <i>p</i> -Chlorotoluene     | C <sub>7</sub> H <sub>7</sub> Cl                | 6.9                      | 33.1    |          |
| <i>o</i> -Cresol            | C <sub>7</sub> H <sub>8</sub> O                 | 29.8                     | 47.7    |          |
| <i>m</i> -Cresol            | C <sub>7</sub> H <sub>8</sub> O                 | 11.8                     | 25.6    |          |
| <i>p</i> -Cresol            | C <sub>7</sub> H <sub>8</sub> O                 | 35.8                     | 56.2    |          |
| Cyclohexane                 | C <sub>6</sub> H <sub>12</sub>                  | 6.6                      | 32.5    |          |
| Cyclohexanol                | C <sub>6</sub> H <sub>12</sub> O                | 25.5                     | 62.3    |          |
| 1,2-Dibromoethane           | C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>   | 9.9                      | 34.0    |          |
| <i>p</i> -Dichlorobenzene   | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>   | 52.7                     | 79.1    |          |
| Dichloromethane             | CH <sub>2</sub> Cl <sub>2</sub>                 | -95.1                    | -83     |          |
| <i>N,N</i> -Dimethylaniline | C <sub>8</sub> H <sub>11</sub> N                | 2.5                      | 26.3    |          |
| 1,4-Dioxane                 | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>    | 11                       | 23      |          |
| Ethanol                     | C <sub>2</sub> H <sub>6</sub> O                 | -114.1                   | -108    |          |
| Formamide                   | CH <sub>3</sub> NO                              | -15.5                    | 10.8    |          |
| Formic acid                 | CH <sub>2</sub> O <sub>2</sub>                  | 8.3                      | 20.6    |          |
| Furan                       | C <sub>4</sub> H <sub>4</sub> O                 | -85.6                    | -73     |          |
| Hexamethyldisiloxane        | C <sub>6</sub> H <sub>18</sub> OSi <sub>2</sub> | -66                      | -37     |          |
| Menthol                     | C <sub>10</sub> H <sub>20</sub> O               | 42                       | 60      |          |
| Methyl benzoate             | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>    | -15                      | 31.8    |          |
| 2-Methyl-2-butanol          | C <sub>5</sub> H <sub>12</sub> O                | -8.8                     | 13.4    |          |
| 2-Methyl-2-propanol         | C <sub>4</sub> H <sub>10</sub> O                | 25.4                     | 58.1    |          |
| Naphthalene                 | C <sub>10</sub> H <sub>8</sub>                  | 78.2                     | 115.7   |          |
| Nitrobenzene                | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>   | 5.7                      | 13.5    |          |
| <i>m</i> -Nitrotoluene      | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>   | 15.5                     | 40.6    |          |
| Pentachloroethane           | C <sub>2</sub> HCl <sub>5</sub>                 | -29.0                    | -6.3    |          |
| Potassium                   | K                                               | 63.7                     | 78      | 170      |
| Potassium chloride          | ClK                                             | 771                      |         | 945      |
| Propanoic acid              | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>    | -20.7                    | -1.2    |          |
| Silver chloride             | AgCl                                            | 455                      |         | 545      |
| Sodium                      | Na                                              | 97.8                     | 106     | 167      |
| Sodium chloride             | ClNa                                            | 800.7                    |         | 997      |
| Sodium fluoride             | FNa                                             | 996                      |         | 1115     |
| Tetrachloromethane          | CCl <sub>4</sub>                                | -23.0                    | 14.2    |          |
| Tribromomethane             | CHBr <sub>3</sub>                               | 8.1                      | 31.5    |          |
| Trichloromethane            | CHCl <sub>3</sub>                               | -63.6                    | -45.2   |          |
| Water                       | H <sub>2</sub> O                                | 0.0                      | -9.0    |          |
| <i>o</i> -Xylene            | C <sub>8</sub> H <sub>10</sub>                  | -25.2                    | -3.5    |          |
| <i>m</i> -Xylene            | C <sub>8</sub> H <sub>10</sub>                  | -47.8                    | -25.2   |          |
| <i>p</i> -Xylene            | C <sub>8</sub> H <sub>10</sub>                  | 13.2                     | 46.0    |          |

## CRITICAL CONSTANTS

The parameters of the liquid–gas critical point are important constants in determining the behavior of fluids. This table lists the critical temperature, pressure, and molar volume, as well as the normal boiling point, for over 1000 inorganic and organic substances. The properties and their units are:

$T_b$ : Normal boiling point in kelvins at a pressure of 101.325 kPa (1 atmosphere); an “s” following the value indicates a sublimation point (temperature at which the solid is in equilibrium with the gas at a pressure of 101.325 kPa)

$T_c$ : Critical temperature in kelvins

$P_c$ : Critical pressure in megapascals

$V_c$ : Critical molar volume in cm<sup>3</sup>/mol

The number of digits given for  $T_b$ ,  $T_c$ , and  $P_c$  indicates the estimated accuracy of these quantities; however, values of  $T_c$  greater than 750 K may be in error by 10 K or more. Although most  $V_c$  values are given to three figures, they cannot be assumed accurate to better than a few percent. All values are experimentally determined except for a few values, indicated by an asterisk\*, that are based on extrapolations. Methods of measurement are described and critiqued in Reference 1.

Some of the compounds in the table undergo thermal decomposition at temperatures near the critical temperature. The listed values were obtained by pulse heating methods, as described in the references by Nikitin, et al. (References 16, 31, 48, 50, etc.).

Many of the critical constants in this table are taken from reviews produced by the IUPAC Commission on Thermodynamics (References 1–9). Compounds are listed alphabetically by name, with compounds not containing carbon preceding those that do contain carbon.

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| Name                                   | Mol. Form.                        | $T_b$ /K | $T_c$ /K | $P_c$ /MPa | $V_c$ /cm <sup>3</sup> mol <sup>-1</sup> | Ref.  |
|----------------------------------------|-----------------------------------|----------|----------|------------|------------------------------------------|-------|
| <i>Compounds not containing carbon</i> |                                   |          |          |            |                                          |       |
| Aluminum bromide                       | AlBr <sub>3</sub>                 | 528      | 763      | 2.89       | 310                                      | 49    |
| Aluminum chloride                      | AlCl <sub>3</sub>                 | 453 s    | 620      | 2.63       | 257                                      | 49    |
| Aluminum iodide                        | AlI <sub>3</sub>                  | 655      | 983      |            | 408                                      | 49    |
| Ammonia                                | H <sub>3</sub> N                  | 239.82   | 405.56   | 11.357     | 69.8                                     | 49,73 |
| Ammonium chloride                      | CH <sub>4</sub> N                 | 611 s    | 1155     | 163.5      |                                          | 49    |
| Antimony(III) bromide                  | Br <sub>3</sub> Sb                | 561      | 904      |            | 300                                      | 49    |
| Antimony(III) chloride                 | Cl <sub>3</sub> Sb                | 493.5    | 794      |            | 272                                      | 49    |
| Antimony(III) iodide                   | I <sub>3</sub> Sb                 | 673      | 1102     |            |                                          | 49    |
| Argon                                  | Ar                                | 87.30    | 150.87   | 4.898      | 75                                       | 49    |
| Arsenic                                | As                                | 889 s    | 1673     |            | 35                                       | 49    |
| Arsenic(III) chloride                  | AsCl <sub>3</sub>                 | 403      | 654      |            | 252                                      | 49    |
| Arsine                                 | AsH <sub>3</sub>                  | 210.7    | 373.1    |            |                                          | 49    |
| Beryllium                              | Be                                | 2744     | 5205*    |            |                                          | 71    |
| Bismuth                                | Bi                                | 1837     | 4620*    |            |                                          | 71    |
| Bismuth tribromide                     | BiBr <sub>3</sub>                 | 735      | 1220     |            | 301                                      | 49    |
| Bismuth trichloride                    | BiCl <sub>3</sub>                 | 714      | 1179     | 12.0       | 261                                      | 49    |
| Boron tribromide                       | BBr <sub>3</sub>                  | 364.4    | 581      |            | 272                                      | 49    |
| Boron trichloride                      | BCl <sub>3</sub>                  | 285.80   | 455      | 3.87       | 239                                      | 49    |
| Boron trifluoride                      | BF <sub>3</sub>                   | 173.3    | 260.8    | 4.98       | 115                                      | 49    |
| Boron triiodide                        | BI <sub>3</sub>                   | 482.7    | 773      |            | 356                                      | 49    |
| Bromine                                | Br <sub>2</sub>                   | 332.0    | 588      | 10.34      | 127                                      | 49    |
| Cesium                                 | Cs                                | 944      | 1938     | 9.4        | 341                                      | 43    |
| Chlorine                               | Cl <sub>2</sub>                   | 239.11   | 416.9    | 7.991      | 123                                      | 49    |
| Chlorine pentafluoride                 | ClF <sub>5</sub>                  | 260.1    | 416      | 5.27       | 233                                      | 49    |
| Chlorotrifluorosilane                  | ClF <sub>3</sub> Si               | 203.2    | 307.7    | 3.46       |                                          | 49    |
| Diborane                               | B <sub>2</sub> H <sub>6</sub>     | 180.8    | 289.8    | 4.05       |                                          | 49    |
| Dichlorodifluorosilane                 | Cl <sub>2</sub> F <sub>2</sub> Si | 241      | 369.0    | 3.5        |                                          | 49    |
| Difluoramine                           | F <sub>2</sub> HN                 | 250      | 403      |            |                                          | 49    |
| cis-Difluorodiazine                    | F <sub>2</sub> N <sub>2</sub>     | 167.40   | 272      | 7.09       |                                          | 49    |

| Name                               | Mol. Form.                    | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.  |
|------------------------------------|-------------------------------|---------|---------|-----------|--------------------|-------|
| <i>trans</i> -Difluorodiazine      | F <sub>2</sub> N <sub>2</sub> | 161.70  | 260     | 5.57      |                    | 49    |
| Fluorine                           | F <sub>2</sub>                | 85.03   | 144.13  | 5.172     | 66                 | 49    |
| Fluorine monoxide                  | F <sub>2</sub> O              | 128.8   | 215     |           |                    | 49    |
| Gallium(III) bromide               | Br <sub>3</sub> Ga            | 552     | 806.7   |           | 303                | 49    |
| Gallium(III) chloride              | Cl <sub>3</sub> Ga            | 474     | 694     |           | 263                | 49    |
| Gallium(III) iodide                | Gal <sub>3</sub>              | 613     | 951     |           | 395                | 49    |
| Germane                            | GeH <sub>4</sub>              | 185.1   | 312.2   | 4.95      | 147                | 49    |
| Germanium                          | Ge                            | 3106    | 9802*   |           |                    | 71    |
| Germanium(IV) bromide              | Br <sub>4</sub> Ge            | 459.50  | 718     |           | 392                | 49    |
| Germanium(IV) chloride             | Cl <sub>4</sub> Ge            | 359.70  | 553.2   | 3.861     | 330                | 49    |
| Germanium(IV) iodide               | GeI <sub>4</sub>              | 621     | 973     |           | 500                | 49    |
| Hafnium(IV) bromide                | Br <sub>4</sub> Hf            | 596 s   | 746     |           | 415                | 49    |
| Hafnium(IV) chloride               | Cl <sub>4</sub> Hf            | 590 s   | 725.7   | 5.42      | 314                | 49    |
| Hafnium(IV) iodide                 | HfI <sub>4</sub>              | 667 s   | 916     |           | 528                | 49    |
| Helium                             | He                            | 4.22    | 5.19    | 0.227     | 57                 | 49    |
| Hydrazine                          | H <sub>4</sub> N <sub>2</sub> | 386.70  | 653     | 14.7      |                    | 49    |
| Hydrogen                           | H <sub>2</sub>                | 20.28   | 32.97   | 1.293     | 65                 | 49    |
| Hydrogen bromide                   | BrH                           | 206.77  | 363.2   | 8.55      |                    | 49    |
| Hydrogen chloride                  | ClH                           | 188     | 324.7   | 8.31      | 81                 | 49    |
| Hydrogen fluoride                  | FH                            | 293     | 461     | 6.48      | 69                 | 49    |
| Hydrogen iodide                    | HI                            | 237.60  | 424.0   | 8.31      |                    | 49    |
| Hydrogen peroxide                  | H <sub>2</sub> O <sub>2</sub> | 423.4   | 728*    | 22*       |                    | 31    |
| Hydrogen selenide                  | H <sub>2</sub> Se             | 231.90  | 411     | 8.92      |                    | 49    |
| Hydrogen sulfide                   | H <sub>2</sub> S              | 213.60  | 373.1   | 9.00      | 99                 | 49,54 |
| Iodine                             | I <sub>2</sub>                | 457.6   | 819     |           | 155                | 49    |
| Iodine bromide                     | BrI                           | 389     | 719     |           | 139                | 49    |
| Iron                               | Fe                            | 3134    | 9340*   |           |                    | 71    |
| Krypton                            | Kr                            | 119.93  | 209.48  | 5.525     | 91                 | 49,54 |
| Lithium                            | Li                            | 1615    | 3223*   | 67*       | 66*                | 20    |
| Manganese                          | Mn                            | 2334    | 4325*   |           |                    | 71    |
| Mercury                            | Hg                            | 629.77  | 1764    | 167       | 43                 | 49,83 |
| Mercury(II) bromide                | Br <sub>2</sub> Hg            | 591     | 1012    |           |                    | 49    |
| Mercury(II) chloride               | Cl <sub>2</sub> Hg            | 577     | 973     |           | 174                | 49    |
| Mercury(II) iodide                 | HgI <sub>2</sub>              | 624     | 1072    |           |                    | 49    |
| Molybdenum(V) chloride             | Cl <sub>5</sub> Mo            | 541     | 850     |           | 369                | 49    |
| Molybdenum(VI) fluoride            | F <sub>6</sub> Mo             | 307.2   | 473     | 4.75      | 226                | 49    |
| Neon                               | Ne                            | 27.10   | 44.4    | 2.76      | 42                 | 49    |
| Niobium(V) chloride                | Cl <sub>5</sub> Nb            | 520.6   | 803.5   | 4.88      | 397                | 49    |
| Niobium(V) fluoride                | F <sub>5</sub> Nb             | 507     | 737     | 6.28      | 155                | 49    |
| Nitric oxide                       | NO                            | 121.41  | 180     | 6.48      | 58                 | 49    |
| Nitrogen                           | N <sub>2</sub>                | 77.35   | 126.21  | 3.39      | 90                 | 49    |
| Nitrogen chloride difluoride       | ClF <sub>2</sub> N            | 206     | 337.5   | 5.15      |                    | 49    |
| Nitrogen tetroxide                 | N <sub>2</sub> O <sub>4</sub> | 294.30  | 431     | 10.1      | 167                | 49    |
| Nitrogen trifluoride               | F <sub>3</sub> N              | 144.40  | 234.0   | 4.46      | 126                | 49    |
| Nitrosyl chloride                  | ClNO                          | 267.7   | 440     |           |                    | 49    |
| Nitrous oxide                      | N <sub>2</sub> O              | 184.67  | 309.52  | 7.245     | 97                 | 49,54 |
| Nitryl fluoride                    | FNO <sub>2</sub>              | 200.8   | 349.5   |           |                    | 49    |
| Osmium(VIII) oxide                 | O <sub>4</sub> Os             | 404.4   | 678     |           |                    | 49    |
| Oxygen                             | O <sub>2</sub>                | 90.20   | 154.59  | 5.043     | 73                 | 49    |
| Ozone                              | O <sub>3</sub>                | 161.80  | 261.1   | 5.57      | 89                 | 49    |
| Perchloryl fluoride                | ClFO <sub>3</sub>             | 226.40  | 368.4   | 5.37      | 161                | 49    |
| Phosphine                          | H <sub>3</sub> P              | 185.40  | 324.5   | 6.54      |                    | 49    |
| Phosphonium chloride               | ClH <sub>4</sub> P            | 246 s   | 322.3   | 7.37      |                    | 49    |
| Phosphorothioc chloride difluoride | ClF <sub>2</sub> PS           | 279.5   | 439.2   | 4.14      |                    | 49    |
| Phosphorothioc trifluoride         | F <sub>3</sub> PS             | 220.90  | 346.0   | 3.82      |                    | 49    |

| Name                                | Mol. Form.                     | $T_b$ /K | $T_c$ /K | $P_c$ /MPa | $V_c$ /cm <sup>3</sup> mol <sup>-1</sup> | Ref.  |
|-------------------------------------|--------------------------------|----------|----------|------------|------------------------------------------|-------|
| Phosphorus                          | P                              | 553.7    | 994      |            |                                          | 49    |
| Phosphorus(III) bromide             | Br <sub>3</sub> P              | 446.4    | 711      |            | 300                                      | 49    |
| Phosphorus(III) chloride            | Cl <sub>3</sub> P              | 349.3    | 563      |            | 264                                      | 49    |
| Phosphorus(V) chloride              | Cl <sub>5</sub> P              | 433 s    | 646      |            |                                          | 49    |
| Phosphorus(III) chloride difluoride | ClF <sub>2</sub> P             | 225.9    | 362.4    | 4.52       |                                          | 49    |
| Phosphorus(III) dichloride fluoride | Cl <sub>2</sub> FP             | 287.00   | 463.0    | 4.96       |                                          | 49    |
| Phosphorus(III) fluoride            | F <sub>3</sub> P               | 171.4    | 271.2    | 4.33       |                                          | 49    |
| Potassium                           | K                              | 1032     | 2223*    | 16*        | 209*                                     | 20    |
| Radon                               | Rn                             | 211.5    | 377      | 6.28       |                                          | 49    |
| Rhenium(VII) oxide                  | O <sub>7</sub> Re <sub>2</sub> | 633      | 942      |            | 334                                      | 49    |
| Rhenium(VI) oxytetrachloride        | Cl <sub>4</sub> ORe            | 496      | 781      |            | 362                                      | 49    |
| Rubidium                            | Rb                             | 961      | 2093*    | 16*        | 247*                                     | 20    |
| Selenium                            | Se                             | 958      | 1766     | 27.2       |                                          | 49    |
| Selenium hexafluoride               | F <sub>6</sub> Se              | 226.55 s | 345.5    |            |                                          | 49    |
| Selenium oxychloride                | Cl <sub>2</sub> OSe            | 450      | 730      | 7.09       | 235                                      | 49    |
| Silver                              | Ag                             | 2435     | 6410*    |            |                                          | 71    |
| Sodium                              | Na                             | 1156     | 2573*    | 35*        | 116*                                     | 20    |
| Sulfur                              | S                              | 717.76   | 1314     | 20.7       |                                          | 49    |
| Sulfur chloride pentafluoride       | ClF <sub>5</sub> S             | 254.10   | 390.9    |            |                                          | 49    |
| Sulfur dioxide                      | O <sub>2</sub> S               | 263.10   | 430.64   | 7.884      | 122                                      | 49,54 |
| Sulfur hexafluoride                 | F <sub>6</sub> S               | 209.35 s | 318.723  | 3.77       | 197                                      | 49,70 |
| Sulfur tetrafluoride                | F <sub>4</sub> S               | 232.70   | 364      |            |                                          | 49    |
| Sulfur trioxide                     | O <sub>3</sub> S               | 317.7    | 491.0    | 8.2        | 127                                      | 49    |
| Tantalum(V) bromide                 | Br <sub>5</sub> Ta             | 622      | 974      |            | 461                                      | 49    |
| Tantalum(V) chloride                | Cl <sub>5</sub> Ta             | 512.50   | 767      |            | 402                                      | 49    |
| Tellurium                           | Te                             | 1261     | 2329*    |            |                                          | 71    |
| Tellurium hexafluoride              | F <sub>6</sub> Te              | 234.25 s | 356      |            |                                          | 49    |
| Tellurium tetrachloride             | Cl <sub>4</sub> Te             | 660      | 1002     | 8.56       | 310                                      | 49    |
| Tetrabromosilane                    | Br <sub>4</sub> Si             | 427      | 663      |            | 382                                      | 49    |
| Tetrachlorosilane                   | Cl <sub>4</sub> Si             | 330.80   | 508.1    | 3.593      | 326                                      | 49    |
| Tetrafluorohydrazine                | F <sub>4</sub> N <sub>2</sub>  | 199      | 309      | 3.75       |                                          | 49    |
| Tetrafluorosilane                   | F <sub>4</sub> Si              | 187      | 259.0    | 3.72       |                                          | 49    |
| Tetraiodosilane                     | I <sub>4</sub> Si              | 560.50   | 944      |            | 558                                      | 49    |
| Tin(IV) bromide                     | Br <sub>4</sub> Sn             | 478      | 744      |            | 417                                      | 49    |
| Tin(IV) chloride                    | Cl <sub>4</sub> Sn             | 387.30   | 591.9    | 3.75       | 351                                      | 49    |
| Tin(IV) iodide                      | I <sub>4</sub> Sn              | 637.50   | 968      |            | 531                                      | 49    |
| Titanium(IV) bromide                | Br <sub>4</sub> Ti             | 506.7    | 795.7    |            | 391                                      | 49    |
| Titanium(IV) chloride               | Cl <sub>4</sub> Ti             | 409.60   | 638      | 4.66       | 339                                      | 49    |
| Titanium(IV) iodide                 | I <sub>4</sub> Ti              | 650      | 1040     |            | 505                                      | 49    |
| Tribromosilane                      | Br <sub>3</sub> HSi            | 382      | 610.0    |            | 305                                      | 49    |
| Trichlorofluorosilane               | Cl <sub>3</sub> FSi            | 285.40   | 438.6    | 3.58       |                                          | 49    |
| Trichlorosilane                     | Cl <sub>3</sub> HSi            | 306      | 479      |            | 268                                      | 49    |
| Trifluoramine oxide                 | F <sub>3</sub> NO              | 185.7    | 303      | 6.43       | 147                                      | 49    |
| Tungsten(VI) chloride               | Cl <sub>6</sub> W              | 610      | 923      |            | 422                                      | 49    |
| Tungsten(VI) fluoride               | F <sub>6</sub> W               | 290.3    | 444      | 4.34       | 233                                      | 49    |
| Tungsten(VI) oxytetrachloride       | Cl <sub>4</sub> OW             | 503      | 782      |            | 338                                      | 49    |
| Uranium(VI) fluoride                | F <sub>6</sub> U               | 329.65 s | 505.8    | 4.66       | 250                                      | 49    |
| Vanadyl chloride                    | ClOV                           | 400      | 636      |            | 171                                      | 49    |
| Water                               | H <sub>2</sub> O               | 373.2    | 647.14   | 22.06      | 56                                       | 49    |
| Xenon                               | Xe                             | 165.03   | 289.733  | 5.842      | 118                                      | 34,54 |
| Xenon difluoride                    | F <sub>2</sub> Xe              | 387.50 s | 631      | 9.32       | 148                                      | 49    |
| Xenon tetrafluoride                 | F <sub>4</sub> Xe              | 388.90 s | 612      | 7.04       | 188                                      | 49    |
| Zirconium(IV) bromide               | Br <sub>4</sub> Zr             | 633 s    | 805      |            | 424                                      | 49    |
| Zirconium(IV) chloride              | Cl <sub>4</sub> Zr             | 604 s    | 778      | 5.77       | 319                                      | 49    |
| Zirconium(IV) iodide                | I <sub>4</sub> Zr              | 704 s    | 960      |            | 530                                      | 49    |



| Name                                               | Mol. Form.        | $T_b/K$  | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.    |
|----------------------------------------------------|-------------------|----------|---------|-----------|--------------------|---------|
| <i>Compounds containing carbon</i>                 |                   |          |         |           |                    |         |
| Acenaphthylene                                     | $C_{12}H_8$       | 553      | 792     | 3.20      |                    | 21      |
| Acetaldehyde                                       | $C_2H_4O$         | 293.3    | 466     |           | 154                | 7       |
| Acetic acid                                        | $C_2H_4O_2$       | 391.1    | 590.7   | 5.78      | 171                | 7       |
| Acetic anhydride                                   | $C_4H_6O_3$       | 412.7    | 606     | 4.0       |                    | 7       |
| Acetone                                            | $C_3H_6O$         | 329.20   | 508.1   | 4.70      | 213                | 7,54    |
| Acetonitrile                                       | $C_2H_3N$         | 354.80   | 545.5   | 4.85      | 171                | 9,14    |
| Acetophenone                                       | $C_8H_8O$         | 475      | 709.6   | 4.01      | 388                | 7,23    |
| Acetylene                                          | $C_2H_2$          | 188.45 s | 308.3   | 6.138     | 112.2              | 6       |
| Acridine                                           | $C_{13}H_9N$      | 618.01   | 891.1   | 3.21      | 548                | 10      |
| Acrylonitrile                                      | $C_3H_3N$         | 350.5    | 540     | 4.66      |                    | 9,11,12 |
| Allene                                             | $C_3H_4$          | 238.8    | 394     | 5.25      |                    | 6       |
| Allyl alcohol                                      | $C_3H_6O$         | 370.5    | 547.1   | 5.64      |                    | 60,4    |
| Allylamine                                         | $C_3H_7N$         | 326.5    | 540.0   | 4.83      |                    | 9       |
| Allyl ethyl ether                                  | $C_5H_{10}O$      | 340.8    | 518     |           |                    | 7       |
| 2-Aminobiphenyl                                    | $C_{12}H_{11}N$   | 572      | 838     | 3.93      | 584                | 9       |
| 2-(2-Aminoethoxy)ethanol                           | $C_4H_{11}NO_2$   | 494      | 721.2   | 4.80      |                    | 82      |
| N-(2-Aminoethyl)ethanolamine                       | $C_4H_{12}N_2O$   | 512      | 739.2   | 4.65      |                    | 17      |
| Aniline                                            | $C_6H_7N$         | 457.32   | 705     | 5.63      | 291                | 9,49    |
| Anisole                                            | $C_7H_8O$         | 426.9    | 646.5   | 4.24      | 341                | 7,11,12 |
| Anthracene                                         | $C_{14}H_{10}$    | 613.1    | 869.3   |           | 554                | 49      |
| Benzaldehyde                                       | $C_7H_6O$         | 452.0    | 695     | 4.7       |                    | 7       |
| Benzene                                            | $C_6H_6$          | 353.24   | 562.05  | 4.895     | 256                | 3       |
| Benzeneacetic acid                                 | $C_8H_8O_2$       | 538.7    | 766     | 3.95      |                    | 50      |
| Benzenebutanoic acid                               | $C_{10}H_{12}O_2$ | 563      | 783     | 3.21      |                    | 50      |
| Benzeneethanol                                     | $C_8H_{10}O$      | 491.9    | 723.5   | 3.99      |                    | 60      |
| Benzeneheptanoic acid                              | $C_{13}H_{18}O_2$ |          | 798     | 2.47      |                    | 50      |
| Benzenehexanoic acid                               | $C_{12}H_{16}O_2$ |          | 794     | 2.60      |                    | 50      |
| Benzenepentanoic acid                              | $C_{11}H_{14}O_2$ |          | 790     | 2.95      |                    | 50      |
| Benzenepropanoic acid                              | $C_9H_{10}O_2$    | 553.0    | 776     | 3.46      |                    | 50      |
| Benzonitrile                                       | $C_7H_5N$         | 464.3    | 700     | 4.2       |                    | 9,49    |
| Benzophenone                                       | $C_{13}H_{10}O$   | 578.6    | 830     | 3.35      | 568                | 7       |
| Benzo[b]thiophene                                  | $C_8H_6S$         | 494      | 764     | 4.76      | 379                | 8       |
| Benzyl alcohol                                     | $C_7H_8O$         | 478.46   | 715     | 4.3       |                    | 49      |
| [1,1'-Bicyclohexyl]-2-one                          | $C_{12}H_{20}O$   | 537      | 787     |           |                    | 7       |
| Biphenyl                                           | $C_{12}H_{10}$    | 529.3    | 773     | 3.38      | 497                | 3       |
| Bis(2-aminoethyl)amine                             | $C_4H_{13}N_3$    | 480      | 710     | 4.4       |                    | 9,14,17 |
| 1,1-Bis(difluoromethoxy)-1,2,2,2-tetrafluoroethane | $C_4H_2F_8O_2$    | 319.95   | 449.81  | 2.421     |                    | 63      |
| Bis(difluoromethyl) ether [HFE-134]                | $C_2H_2F_4O$      | 275      | 420.25  | 4.228     | 223                | 46      |
| Bis(2-ethylhexyl) phthalate                        | $C_{24}H_{38}O_4$ | 657      | 835     | 1.07      |                    | 51      |
| Bis(2-hydroxyethyl)methylamine                     | $C_5H_{13}NO_2$   | 520      | 741.9   | 4.16      |                    | 82      |
| Bis(2,2,2-trifluoroethyl) ether                    | $C_4H_4F_6O$      | 336.91   | 476.31  | 2.783     |                    | 65      |
| Bis(trimethylsilyl)methane                         | $C_4H_{20}Si_2$   | 406      | 573.9   | 1.99      |                    | 8       |
| Bromobenzene                                       | $C_6H_5Br$        | 429.21   | 670     | 4.52      | 324                | 49      |
| 1-Bromobutane                                      | $C_4H_9Br$        | 374.8    | 572     |           | 325                | 74      |
| Bromochlorodifluoromethane [R-12B1]                | $CBrClF_2$        | 269.5    | 426.88  | 4.254     | 246                | 49      |
| Bromodifluoromethane [R-22B1]                      | $CHBrF_2$         | 258.6    | 411.98  | 5.132     | 275                | 47      |
| Bromoethane                                        | $C_2H_5Br$        | 311.7    | 503.9   | 6.23      | 215                | 49      |
| 1-Bromo-2-fluorobenzene                            | $C_6H_4BrF$       | 427      | 669.6   |           |                    | 13      |
| 1-Bromo-3-fluorobenzene                            | $C_6H_4BrF$       | 423      | 652.0   |           |                    | 13      |
| 1-Bromo-4-fluorobenzene                            | $C_6H_4BrF$       | 424.7    | 654.8   |           |                    | 13      |
| Bromomethane                                       | $CH_3Br$          | 276.7    | 464     |           | 153                | 74      |
| Bromopentafluorobenzene                            | $C_6BrF_5$        | 410      | 601     | 3.0       |                    | 49      |
| 1-Bromopropane                                     | $C_3H_7Br$        | 344.3    | 536     |           | 270                | 74      |
| 2-Bromopropane                                     | $C_3H_7Br$        | 332.7    | 521     |           | 266                | 74      |



| Name                                   | Mol. Form.     | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.     |
|----------------------------------------|----------------|---------|---------|-----------|--------------------|----------|
| Bromotrifluoromethane [R-13B1]         | $CBrF_3$       | 215.4   | 340.2   | 3.97      | 196                | 49       |
| 1-Bromo-2-(trifluoromethyl)benzene     | $C_7H_4BrF_3$  | 440.7   | 656.5   |           |                    | 13       |
| 1-Bromo-3-(trifluoromethyl)benzene     | $C_7H_4BrF_3$  | 424.7   | 627.1   |           |                    | 13       |
| 1-Bromo-4-(trifluoromethyl)benzene     | $C_7H_4BrF_3$  | 433     | 629.8   |           |                    | 13       |
| 1,3-Butadiene                          | $C_4H_6$       | 268.74  | 425     | 4.32      | 221                | 6        |
| Butanal                                | $C_4H_8O$      | 348.0   | 537     | 4.32      | 258                | 7        |
| Butane                                 | $C_4H_{10}$    | 272.7   | 425.16  | 3.787     | 255                | 2,67     |
| 1,4-Butanediamine                      | $C_4H_{12}N_2$ | 431.7   | 651     | 4.54      |                    | 9,56     |
| 1,2-Butanediol                         | $C_4H_{10}O_2$ | 463.7   | 680     | 5.21      | 303                | 7,23     |
| 1,3-Butanediol                         | $C_4H_{10}O_2$ | 480.7   | 692.4   | 5.18      | 305                | 7,23,81  |
| 1,4-Butanediol                         | $C_4H_{10}O_2$ | 508     | 723.8   | 5.52      |                    | 17       |
| Butanenitrile                          | $C_4H_7N$      | 390.8   | 585.4   | 3.88      |                    | 9,49     |
| 1-Butanethiol                          | $C_4H_{10}S$   | 371.7   | 570     | 4.0       | 324                | 8        |
| Butanoic acid                          | $C_4H_8O_2$    | 436.90  | 615.2   | 4.06      | 292                | 7        |
| 1-Butanol                              | $C_4H_{10}O$   | 390.88  | 563.0   | 4.414     | 274                | 4        |
| 2-Butanol                              | $C_4H_{10}O$   | 372.66  | 536.2   | 4.202     | 269                | 4        |
| 2-Butanone                             | $C_4H_8O$      | 352.74  | 536.7   | 4.207     | 267                | 7        |
| 1-Butene                               | $C_4H_8$       | 266.89  | 419.29  | 4.005     | 235.8              | 6,72     |
| <i>cis</i> -2-Butene                   | $C_4H_8$       | 276.86  | 435.75  | 4.226     | 235.6              | 6,72     |
| <i>trans</i> -2-Butene                 | $C_4H_8$       | 274.03  | 428.61  | 4.027     | 237.3              | 6,72     |
| 2-Butoxyethanol                        | $C_6H_{14}O_2$ | 441.6   | 634     | 3.27      | 424                | 7        |
| 1- <i>tert</i> -Butoxy-2-ethoxyethane  | $C_8H_{18}O_2$ | 421.2   | 585     |           |                    | 7        |
| 2-Butoxyethyl acetate                  | $C_8H_{16}O_3$ | 465     | 640.7   | 2.694     | 549                | 7        |
| 1- <i>tert</i> -Butoxy-2-methoxyethane | $C_7H_{16}O_2$ |         | 574     |           |                    | 7        |
| 1-Butoxy-2-propanol                    | $C_7H_{16}O_2$ | 444.7   | 624.9   | 2.739     |                    | 14       |
| Butyl acetate                          | $C_6H_{12}O_2$ | 399.3   | 575.6   | 3.14      |                    | 7        |
| <i>sec</i> -Butyl acetate              | $C_6H_{12}O_2$ | 385     | 571     | 3.01      |                    | 7        |
| <i>tert</i> -Butyl acetate             | $C_6H_{12}O_2$ | 368.3   | 541.2   | 3.04      |                    | 82       |
| Butyl acrylate                         | $C_7H_{12}O_2$ | 418     | 601.2   | 2.84      |                    | 82       |
| Butylamine                             | $C_4H_{11}N$   | 350.15  | 531.9   | 4.20      |                    | 9,10     |
| <i>sec</i> -Butylamine                 | $C_4H_{11}N$   | 335.88  | 514     | 5.0       |                    | 9,10     |
| <i>tert</i> -Butylamine                | $C_4H_{11}N$   | 317.19  | 483.7   | 3.85      | 293                | 9,10     |
| Butylbenzene                           | $C_{10}H_{14}$ | 456.46  | 660.5   | 2.89      | 497                | 3        |
| <i>sec</i> -Butylbenzene               | $C_{10}H_{14}$ | 446.5   | 652.5   | 3.025     | 490                | 75       |
| <i>tert</i> -Butylbenzene              | $C_{10}H_{14}$ | 442.3   | 647.5   | 2.90      | 485                | 75       |
| Butyl butanoate                        | $C_8H_{16}O_2$ | 439     | 612.1   |           |                    | 7        |
| Butylcyclohexane                       | $C_{10}H_{20}$ | 453     | 653.1   | 2.56      |                    | 58,59    |
| <i>tert</i> -Butylcyclohexane          | $C_{10}H_{20}$ | 444.7   | 652.0   |           |                    | 59       |
| <i>tert</i> -Butyl ethyl ether         | $C_6H_{14}O$   | 345.8   | 509.4   | 2.934     | 395                | 7        |
| Butyl methyl ether                     | $C_5H_{12}O$   | 343.31  | 512.7   | 3.37      | 329                | 7        |
| Butyl propanoate                       | $C_7H_{14}O_2$ | 420.0   | 594.5   |           |                    | 7        |
| Butyl vinyl ether                      | $C_6H_{12}O$   | 367     | 540     | 3.20      | 384                | 7        |
| 1-Butyne                               | $C_4H_6$       | 281.23  | 440     | 4.60      | 208                | 6        |
| 2-Butyne                               | $C_4H_6$       | 300.1   | 488.7   |           |                    | 49       |
| $\gamma$ -Butyrolactone                | $C_4H_6O_2$    | 477     | 732.5   | 5.10      |                    | 7,11,82  |
| Carbazole                              | $C_{12}H_9N$   | 627.84  | 901.8   | 3.13      | 454                | 10       |
| Carbon dioxide                         | $CO_2$         | 194.6 s | 304.13  | 7.375     | 94                 | 22       |
| Carbon disulfide                       | $CS_2$         | 319     | 552     | 7.90      | 173                | 49       |
| Carbon monoxide                        | $CO$           | 81.7    | 132.86  | 3.494     | 93                 | 49,54,55 |
| Carbon oxysulfide                      | $COS$          | 223     | 375     | 5.88      | 137                | 49,54    |
| Carbonyl chloride                      | $CCl_2O$       | 281     | 455     | 5.67      | 190                | 49       |
| 3-Carene                               | $C_{10}H_{16}$ | 444     | 658     |           | 487                | 6        |
| Chlorobenzene                          | $C_6H_5Cl$     | 404.87  | 633.4   | 4.52      | 308                | 13,49    |
| 1-Chlorobutane                         | $C_4H_9Cl$     | 351.6   | 539.2   |           |                    | 13       |
| 2-Chlorobutane                         | $C_4H_9Cl$     | 341.4   | 518.6   |           |                    | 13       |

| Name                                        | Mol. Form.     | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.     |
|---------------------------------------------|----------------|---------|---------|-----------|--------------------|----------|
| Chlorocyclohexane                           | $C_6H_{11}Cl$  | 415     | 586     |           |                    | 13       |
| 1-Chloro-2,4-difluorobenzene                | $C_6H_3ClF_2$  | 400     | 609.6   |           |                    | 13       |
| 1-Chloro-2,5-difluorobenzene                | $C_6H_3ClF_2$  | 401     | 612.5   |           |                    | 13       |
| 1-Chloro-3,4-difluorobenzene                | $C_6H_3ClF_2$  | 400     | 609.2   |           |                    | 13       |
| 1-Chloro-3,5-difluorobenzene                | $C_6H_3ClF_2$  | 391.7   | 592.0   |           |                    | 13       |
| 1-Chloro-1,1-difluoroethane [R-142b]        | $C_2H_3ClF_2$  | 264.1   | 410.34  | 4.048     | 226                | 19,32,65 |
| 1-Chloro-2,2-difluoroethene                 | $C_2HClF_2$    | 254.7   | 400.6   | 4.46      | 197                | 49       |
| Chlorodifluoromethane [R-22]                | $CHClF_2$      | 232.5   | 369.5   | 5.035     | 164                | 18       |
| Chloroethane [R-160]                        | $C_2H_5Cl$     | 285.5   | 460.4   | 5.3       |                    | 49       |
| Chloroethene [R-1140]                       | $C_2H_3Cl$     | 259.4   | 432     | 5.67      | 179                | 12       |
| 1-Chloro-2-fluorobenzene                    | $C_6H_4ClF$    | 410.8   | 633.8   |           |                    | 13       |
| 1-Chloro-3-fluorobenzene                    | $C_6H_4ClF$    | 400.8   | 615.9   |           |                    | 13       |
| 1-Chloro-4-fluorobenzene                    | $C_6H_4ClF$    | 403     | 620.1   |           |                    | 13       |
| Chlorofluoromethane [R-31]                  | $CH_2ClF$      | 264.1   | 427     | 5.70      |                    | 37       |
| 1-Chloroheptane                             | $C_7H_{15}Cl$  | 433.6   | 614     |           |                    | 13       |
| 1-Chlorohexane                              | $C_6H_{13}Cl$  | 408.3   | 599     |           |                    | 13       |
| Chloromethane [R-40]                        | $CH_3Cl$       | 249.06  | 416.25  | 6.679     | 139                | 49       |
| 2-Chloro-2-methylbutane                     | $C_5H_{11}Cl$  | 358.8   | 509.1   |           |                    | 13       |
| 3-Chloro-3-methylpentane                    | $C_6H_{13}Cl$  | 389     | 528     |           |                    | 13       |
| 2-Chloro-2-methylpropane                    | $C_4H_9Cl$     | 324.1   | 500     |           |                    | 13       |
| Chloromethylsilane                          | $CH_3ClSi$     | 280     | 517.8   |           |                    | 49       |
| 1-Chlorooctane                              | $C_8H_{17}Cl$  | 456.7   | 643     |           |                    | 13       |
| Chloropentafluoroacetone                    | $C_3ClF_5O$    | 281     | 410.6   | 2.878     |                    | 49       |
| Chloropentafluorobenzene                    | $C_6ClF_5$     | 391.11  | 570.81  | 3.238     | 376                | 49       |
| Chloropentafluoroethane [R-115]             | $C_2ClF_5$     | 234.1   | 353.2   | 3.229     | 252                | 49       |
| 1-Chloropentane                             | $C_5H_{11}Cl$  | 381.6   | 571.2   |           |                    | 13       |
| 1-Chloropropane                             | $C_3H_7Cl$     | 319.7   | 503     | 4.58      |                    | 49       |
| 2-Chloropropane                             | $C_3H_7Cl$     | 308.9   | 484     |           |                    | 13       |
| 3-Chloropropene                             | $C_3H_5Cl$     | 318.3   | 514     |           |                    | 49       |
| 1-Chloro-1,1,2,2-tetrafluoroethane [R-124a] | $C_2HClF_4$    | 261.5   | 399.9   | 3.72      | 244                | 49       |
| 1-Chloro-1,2,2,2-tetrafluoroethane [R-124]  | $C_2HClF_4$    | 261     | 395.65  | 3.643     | 244                | 42       |
| 2-Chloro-1,1,1-trifluoroethane [R-133a]     | $C_2H_2ClF_3$  | 279.3   | 425.01  |           | 228                | 40       |
| Chlorotrifluoroethene [R-1113]              | $C_2ClF_3$     | 245.4   | 379     | 4.05      | 212                | 49       |
| Chlorotrifluoromethane [R-13]               | $CClF_3$       | 191.8   | 302     | 3.870     | 180                | 49       |
| <i>o</i> -Cresol                            | $C_7H_8O$      | 464.19  | 697.6   | 4.17      |                    | 7        |
| <i>m</i> -Cresol                            | $C_7H_8O$      | 475.42  | 705.8   | 4.36      |                    | 7        |
| <i>p</i> -Cresol                            | $C_7H_8O$      | 475.13  | 704.6   | 4.07      |                    | 7        |
| Cyanogen                                    | $C_2N_2$       | 252.1   | 400     | 6.0       |                    | 9,49     |
| Cyclobutane                                 | $C_4H_8$       | 285.8   | 460.0   | 4.98      | 210                | 49       |
| Cycloheptane                                | $C_7H_{14}$    | 391.6   | 604.2   | 3.82      | 353                | 5        |
| Cyclohexane                                 | $C_6H_{12}$    | 353.88  | 553.8   | 4.08      | 308                | 5,58,59  |
| Cyclohexanethiol                            | $C_6H_{12}S$   | 432.0   | 684     |           | 401                | 8        |
| Cyclohexanol                                | $C_6H_{12}O$   | 433.99  | 647.1   | 4.401     |                    | 11,12    |
| Cyclohexanone                               | $C_6H_{10}O$   | 428.58  | 665     | 4.6       |                    | 7        |
| Cyclohexene                                 | $C_6H_{10}$    | 356.13  | 560.4   |           |                    | 6        |
| Cyclohexylamine                             | $C_6H_{13}N$   | 407     | 626.8   |           |                    | 9,59     |
| Cyclononane                                 | $C_9H_{18}$    | 451.6   | 682     | 3.34      |                    | 21       |
| Cyclooctane                                 | $C_8H_{16}$    | 422     | 647.2   | 3.56      | 410                | 5,59     |
| Cyclopentane                                | $C_5H_{10}$    | 322.5   | 511.7   | 4.51      | 260                | 5        |
| Cyclopentanol                               | $C_5H_{10}O$   | 413.57  | 619.5   | 4.9       |                    | 4        |
| Cyclopentanone                              | $C_5H_8O$      | 403.72  | 624     | 4.60      |                    | 7        |
| Cyclopentene                                | $C_5H_8$       | 317.4   | 506.5   | 4.80      | 245                | 6        |
| Cyclopropane                                | $C_3H_6$       | 240.34  | 398.0   | 5.54      | 162                | 5        |
| 1,3-Decadiene                               | $C_{10}H_{18}$ | 442     | 615     |           |                    | 49       |
| <i>cis</i> -Decahydronaphthalene            | $C_{10}H_{18}$ | 469.0   | 702.3   | 3.20      |                    | 49       |

| Name                                                    | Mol. Form.                                       | $T_b$ /K | $T_c$ /K | $P_c$ /MPa | $V_c$ /cm <sup>3</sup> mol <sup>-1</sup> | Ref.  |
|---------------------------------------------------------|--------------------------------------------------|----------|----------|------------|------------------------------------------|-------|
| <i>trans</i> -Decahydronaphthalene                      | C <sub>10</sub> H <sub>18</sub>                  | 460.5    | 687.1    |            |                                          | 49    |
| Decanal                                                 | C <sub>10</sub> H <sub>20</sub> O                | 481.7    | 674      | 2.60       | 599                                      | 7     |
| Decane                                                  | C <sub>10</sub> H <sub>22</sub>                  | 447.30   | 617.7    | 2.11       | 624                                      | 2,54  |
| 1,10-Decanediamine                                      | C <sub>10</sub> H <sub>24</sub> N <sub>2</sub>   |          | 736      | 2.43       |                                          | 9,56  |
| Decanedioic acid                                        | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>   | 627.0    | 845      | 2.50       |                                          | 57    |
| Decanoic acid                                           | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>   | 541.9    | 722      | 2.10       | 638                                      | 7     |
| 1-Decanol                                               | C <sub>10</sub> H <sub>22</sub> O                | 504.3    | 687.3    | 2.315      | 649                                      | 4     |
| 2-Decanol                                               | C <sub>10</sub> H <sub>22</sub> O                | 484      | 668.6    |            | 646                                      | 4     |
| 3-Decanol                                               | C <sub>10</sub> H <sub>22</sub> O                | 486      | 666.1    |            | 643                                      | 4     |
| 4-Decanol                                               | C <sub>10</sub> H <sub>22</sub> O                | 483.7    | 663.7    |            | 643                                      | 4     |
| 5-Decanol                                               | C <sub>10</sub> H <sub>22</sub> O                | 474      | 663.2    |            | 646                                      | 4     |
| 2-Decanone                                              | C <sub>10</sub> H <sub>20</sub> O                | 483      | 671.8    |            | 625                                      | 7     |
| 3-Decanone                                              | C <sub>10</sub> H <sub>20</sub> O                | 476      | 667.6    |            | 628                                      | 7     |
| 4-Decanone                                              | C <sub>10</sub> H <sub>20</sub> O                | 479.7    | 662.9    |            | 628                                      | 7     |
| 5-Decanone                                              | C <sub>10</sub> H <sub>20</sub> O                | 477      | 661.0    |            | 628                                      | 7     |
| 1-Decene                                                | C <sub>10</sub> H <sub>20</sub>                  | 443.7    | 617      | 2.22       | 584                                      | 6     |
| Decylbenzene                                            | C <sub>16</sub> H <sub>26</sub>                  | 566      | 752      | 1.72       |                                          | 16    |
| Diallyl sulfide                                         | C <sub>6</sub> H <sub>10</sub> S                 | 411.8    | 653      |            |                                          | 8     |
| Dibenzofuran                                            | C <sub>12</sub> H <sub>8</sub> O                 | 560      | 824      | 3.64       | 495                                      | 7     |
| Dibenzothiophene                                        | C <sub>12</sub> H <sub>8</sub> S                 | 605.7    | 897      | 3.86       | 512                                      | 8     |
| 1,2-Dibromo-1-chloro-1,2,2-trifluoroethane              | C <sub>2</sub> Br <sub>2</sub> ClF <sub>3</sub>  | 366      | 560.7    | 3.61       | 368                                      | 49    |
| Dibromodifluoromethane [R-12B2]                         | CBr <sub>2</sub> F <sub>2</sub>                  | 295.91   | 471.3    | 4.45       |                                          | 49    |
| 1,2-Dibromoethane                                       | C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>    | 404.8    | 583.0    | 7.2        |                                          | 49    |
| 1,4-Dibromooctafluorobutane                             | C <sub>4</sub> Br <sub>2</sub> F <sub>8</sub>    | 370      | 532.5    | 2.39       |                                          | 49    |
| 1,2-Dibromotetrafluoroethane [R-114B2]                  | C <sub>2</sub> Br <sub>2</sub> F <sub>4</sub>    | 320.50   | 487.8    | 3.393      | 341                                      | 49    |
| Dibutylamine                                            | C <sub>8</sub> H <sub>19</sub> N                 | 432.8    | 607.5    | 3.11       |                                          | 9,59  |
| Dibutyl disulfide                                       | C <sub>8</sub> H <sub>18</sub> S <sub>2</sub>    | 499      | 711      | 2.5        |                                          | 82    |
| Dibutyl ether                                           | C <sub>8</sub> H <sub>18</sub> O                 | 413.43   | 584      | 3.0        |                                          | 7     |
| Di- <i>tert</i> -butyl ether                            | C <sub>8</sub> H <sub>18</sub> O                 | 380.38   | 550      |            |                                          | 49    |
| Dibutyl phthalate                                       | C <sub>16</sub> H <sub>22</sub> O <sub>4</sub>   | 613      | 797      | 1.66       |                                          | 51    |
| Dibutyl sulfide                                         | C <sub>8</sub> H <sub>18</sub> S                 | 458      | 650      | 2.48       |                                          | 8     |
| <i>m</i> -Dichlorobenzene                               | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>    | 446      | 685.7    |            |                                          | 13    |
| Dichlorodifluoromethane [R-12]                          | CCl <sub>2</sub> F <sub>2</sub>                  | 243.4    | 384.95   | 4.136      | 217                                      | 49    |
| Dichlorodimethylsilane                                  | C <sub>2</sub> H <sub>6</sub> Cl <sub>2</sub> Si | 343.5    | 520.4    | 3.49       | 350                                      | 49    |
| 1,1-Dichloroethane [R-150a]                             | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>    | 330.5    | 523      | 5.07       | 236                                      | 49    |
| 1,2-Dichloroethane [R-150]                              | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>    | 356.7    | 561      | 5.4        | 225                                      | 49    |
| <i>cis</i> -1,2-Dichloroethene                          | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>    | 333.3    | 544.2    |            |                                          | 49    |
| <i>trans</i> -1,2-Dichloroethene [R-1130]               | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>    | 321.9    | 516.5    | 5.51       |                                          | 49    |
| 1,1-Dichloro-1-fluoroethane [R-141b]                    | C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> F  | 305.2    | 477.5    | 4.194      | 255                                      | 26,42 |
| Dichlorofluoromethane [R-21]                            | CHCl <sub>2</sub> F                              | 282.1    | 451.58   | 5.18       | 196                                      | 49    |
| 1,2-Dichloro-1,2,3,3,4,4-hexafluorocyclobutane [R-C316] | C <sub>4</sub> Cl <sub>2</sub> F <sub>6</sub>    | 332.7    | 497*     | 2.73*      | 386*                                     | 12    |
| 1,3-Dichloro-1,1,2,2,3,3-hexafluoropropane [R-216ca]    | C <sub>3</sub> Cl <sub>2</sub> F <sub>6</sub>    | 308.9    | 453      | 2.753      |                                          | 41    |
| Dichloromethane [R-30]                                  | CH <sub>2</sub> Cl <sub>2</sub>                  | 313      | 510      | 6.10       |                                          | 49    |
| 1,2-Dichloropropane                                     | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>    | 369.6    | 578.5    |            |                                          | 13    |
| 1,3-Dichloropropane                                     | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>    | 394.1    | 614.6    |            |                                          | 13    |
| 1,2-Dichloro-3,4,5,6-tetrafluorobenzene                 | C <sub>6</sub> Cl <sub>2</sub> F <sub>4</sub>    | 430.9    | 626      | 5.32       |                                          | 49    |
| 1,1-Dichloro-1,2,2,2-tetrafluoroethane [R-114a]         | C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>    | 276.6    | 418.6    | 3.30       | 294                                      | 49    |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane [R-114]          | C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>    | 276.7    | 418.78   | 3.252      | 297                                      | 42    |
| 1,2-Dichloro-1,1,2-trifluoroethane [R-123a]             | C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>   | 302.7    | 461.6    |            | 278                                      | 19    |
| 2,2-Dichloro-1,1,1-trifluoroethane [R-123]              | C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>   | 300.97   | 456.83   | 3.661      | 278                                      | 35    |
| Didecyl phthalate                                       | C <sub>28</sub> H <sub>46</sub> O <sub>4</sub>   |          | 870      | 0.94       |                                          | 51    |
| 1,1-Diethoxyethane                                      | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>    | 375.40   | 540      | 3.22       |                                          | 7     |
| 1,2-Diethoxyethane                                      | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>    | 394.4    | 542      |            |                                          | 7     |
| Diethoxymethane                                         | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>    | 361      | 531.7    |            |                                          | 7     |
| 2,2-Diethoxypropane                                     | C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>    | 387      | 510.7    |            |                                          | 7     |

| Name                                                  | Mol. Form.                                     | $T_b$ /K | $T_c$ /K | $P_c$ /MPa | $V_c$ /cm <sup>3</sup> mol <sup>-1</sup> | Ref.  |
|-------------------------------------------------------|------------------------------------------------|----------|----------|------------|------------------------------------------|-------|
| Diethylamine                                          | C <sub>4</sub> H <sub>11</sub> N               | 328.7    | 499.7    | 3.754      | 304                                      | 9,49  |
| <i>p</i> -Diethylbenzene                              | C <sub>10</sub> H <sub>14</sub>                | 456.9    | 657.9    | 2.803      |                                          | 3     |
| Diethyl disulfide                                     | C <sub>4</sub> H <sub>10</sub> S <sub>2</sub>  | 427.2    | 642      |            |                                          | 8     |
| Diethylene glycol                                     | C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>  | 519.0    | 750      | 4.7        |                                          | 7     |
| Diethylene glycol diethyl ether                       | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>  | 461      | 612      |            |                                          | 7     |
| Diethylene glycol dimethyl ether                      | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>  | 435      | 617      |            |                                          | 7     |
| Diethylene glycol monobutyl ether acetate             | C <sub>10</sub> H <sub>20</sub> O <sub>4</sub> | 518      | 693.9    | 2.15       |                                          | 17    |
| Diethylene glycol monobutyl ether                     | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>  | 504      | 692      | 2.79       |                                          | 7     |
| Diethylene glycol monoethyl ether                     | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>  | 469      | 670      | 3.167      |                                          | 11,12 |
| Diethylene glycol monoethyl ether acetate             | C <sub>8</sub> H <sub>16</sub> O <sub>4</sub>  | 491.7    | 673.5    | 2.59       |                                          | 17    |
| Diethylene glycol monomethyl ether                    | C <sub>5</sub> H <sub>12</sub> O <sub>3</sub>  | 466      | 672      | 3.67       |                                          | 11,12 |
| Diethylene glycol monopropyl ether                    | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>  | 486      | 680      | 3.00       | 489                                      | 7     |
| Diethyl ether                                         | C <sub>4</sub> H <sub>10</sub> O               | 307.7    | 466.7    | 3.644      | 281                                      | 7     |
| Diethyl oxalate                                       | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>  | 458.9    | 645.8    | 3.06       |                                          | 82    |
| Diethyl phthalate                                     | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub> | 568      | 776      | 2.26       |                                          | 51    |
| Diethyl succinate                                     | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>  | 490.9    | 663      |            |                                          | 7     |
| Diethyl sulfide                                       | C <sub>4</sub> H <sub>10</sub> S               | 365.3    | 557.8    | 3.90       | 317.6                                    | 8,15  |
| <i>o</i> -Difluorobenzene                             | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>   | 367      | 566.0    |            |                                          | 13    |
| <i>m</i> -Difluorobenzene                             | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>   | 355.8    | 548.4    |            |                                          | 13    |
| <i>p</i> -Difluorobenzene                             | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>   | 362      | 556.9    | 4.40       |                                          | 13,49 |
| 1,1-Difluoroethane [R-152a]                           | C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>   | 249.10   | 386.7    | 4.50       | 179                                      | 19,49 |
| 1,1-Difluoroethene [R-1132a]                          | C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>   | 187.5    | 302.9    | 4.46       | 154                                      | 49    |
| 2,2-Difluoroethylbis(trifluoromethyl)amine            | C <sub>4</sub> H <sub>3</sub> F <sub>8</sub> N | 324.50   | 460.20   | 2.642      |                                          | 61    |
| Difluoromethane [R-32]                                | CH <sub>2</sub> F <sub>2</sub>                 | 221.6    | 351.56   | 5.83       | 123                                      | 42    |
| 3-Difluoromethoxy-1,1,1,2,2-pentafluoropropane        | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O | 319.09   | 455.10   | 2.773      |                                          | 65    |
| 3-Difluoromethoxy-1,1,2,2-tetrafluoropropane          | C <sub>4</sub> H <sub>4</sub> F <sub>6</sub> O | 348.6    | 505.35   | 3.279      |                                          | 65    |
| 2-(Difluoromethoxy)-1,1,1-trifluoroethane             | C <sub>3</sub> H <sub>3</sub> F <sub>5</sub> O | 302.15   | 445      | 3.46       |                                          | 65    |
| Difluoromethyl 2,2,2-trifluoroethyl ether [HFE-245mf] | C <sub>3</sub> H <sub>3</sub> F <sub>5</sub> O | 302.39   | 443.99   |            |                                          | 38    |
| 2,4-Difluorotoluene                                   | C <sub>7</sub> H <sub>6</sub> F <sub>2</sub>   | 390      | 581.4    |            |                                          | 13    |
| 2,5-Difluorotoluene                                   | C <sub>7</sub> H <sub>6</sub> F <sub>2</sub>   | 391      | 587.8    |            |                                          | 13    |
| 2,6-Difluorotoluene                                   | C <sub>7</sub> H <sub>6</sub> F <sub>2</sub>   | 385      | 581.8    |            |                                          | 13    |
| 3,4-Difluorotoluene                                   | C <sub>7</sub> H <sub>6</sub> F <sub>2</sub>   | 385      | 598.5    |            |                                          | 13    |
| Diheptyl phthalate                                    | C <sub>22</sub> H <sub>34</sub> O <sub>4</sub> | 633      | 830      | 1.24       |                                          | 51    |
| Dihexyl phthalate                                     | C <sub>20</sub> H <sub>30</sub> O <sub>4</sub> |          | 817      | 1.34       |                                          | 51    |
| 3,4-Dihydro-2 <i>H</i> -pyran                         | C <sub>5</sub> H <sub>8</sub> O                | 359      | 562      | 4.56       | 268                                      | 7     |
| Diisobutylamine                                       | C <sub>8</sub> H <sub>19</sub> N               | 412.8    | 584.4    | 3.20       |                                          | 9,49  |
| Diisopentyl sulfide                                   | C <sub>10</sub> H <sub>22</sub> S              | 484      | 664      |            |                                          | 8     |
| Diisopropylamine                                      | C <sub>6</sub> H <sub>15</sub> N               | 357.1    | 523.1    | 3.02       |                                          | 9,49  |
| 1,4-Diisopropylbenzene                                | C <sub>12</sub> H <sub>18</sub>                | 483.5    | 675      | 2.33       | 617                                      | 77    |
| 1,4-Diisopropylbenzene                                | C <sub>12</sub> H <sub>18</sub>                | 483.5    | 676.2    | 2.36       |                                          | 82    |
| Diisopropyl ether                                     | C <sub>6</sub> H <sub>14</sub> O               | 341.6    | 500.3    | 2.832      | 386                                      | 7     |
| 1,2-Dimethoxyethane                                   | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>  | 357.7    | 540      | 3.90       | 308                                      | 7     |
| Dimethoxymethane                                      | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>   | 315      | 491      | 3.96       | 213                                      | 7     |
| 1,2-Dimethoxypropane                                  | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | 369      | 543.0    |            |                                          | 7     |
| 2,2-Dimethoxypropane                                  | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | 356      | 510      |            |                                          | 7     |
| Dimethylamine                                         | C <sub>2</sub> H <sub>7</sub> N                | 280.03   | 437.2    | 5.34       |                                          | 9,49  |
| <i>N,N</i> -Dimethylaniline                           | C <sub>8</sub> H <sub>11</sub> N               | 467.30   | 688      | 3.6        |                                          | 9,49  |
| 2,2-Dimethylbutane                                    | C <sub>6</sub> H <sub>14</sub>                 | 322.88   | 489.0    | 3.10       | 358                                      | 5     |
| 2,3-Dimethylbutane                                    | C <sub>6</sub> H <sub>14</sub>                 | 331.08   | 500.0    | 3.15       | 361                                      | 5     |
| 3,3-Dimethyl-2-butanone                               | C <sub>6</sub> H <sub>12</sub> O               | 379.3    | 570.9    | 3.43       | 382                                      | 7     |
| 2,3-Dimethyl-1-butene                                 | C <sub>6</sub> H <sub>12</sub>                 | 328.8    | 497.7    |            |                                          | 59    |
| 3,3-Dimethyl-1-butene                                 | C <sub>6</sub> H <sub>12</sub>                 | 314.4    | 477.4    |            |                                          | 59    |
| 2,3-Dimethyl-2-butene                                 | C <sub>6</sub> H <sub>12</sub>                 | 346.5    | 521.0    |            |                                          | 59    |
| Dimethyl carbonate                                    | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>   | 363.7    | 557      | 4.80       | 252                                      | 7     |
| <i>cis</i> -1,2-Dimethylcyclohexane                   | C <sub>8</sub> H <sub>16</sub>                 | 403.0    | 606      | 2.95       |                                          | 21    |

| Name                                                | Mol. Form.        | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.    |
|-----------------------------------------------------|-------------------|---------|---------|-----------|--------------------|---------|
| <i>trans</i> -1,2-Dimethylcyclohexane               | $C_8H_{16}$       | 396.7   | 596     | 2.94      |                    | 21      |
| <i>cis</i> -1,3-Dimethylcyclohexane                 | $C_8H_{16}$       | 393.3   | 591     | 2.94      |                    | 21      |
| <i>trans</i> -1,3-Dimethylcyclohexane               | $C_8H_{16}$       | 397.7   | 598     | 2.94      |                    | 21      |
| <i>trans</i> -1,4-Dimethylcyclohexane               | $C_8H_{16}$       | 392.6   | 587.7   |           |                    | 5       |
| 1,1-Dimethylcyclopentane                            | $C_7H_{14}$       | 360.7   | 547     | 3.45      |                    | 21      |
| <i>cis</i> -1,2-Dimethylcyclopentane                | $C_7H_{14}$       | 372.7   | 565     | 3.45      |                    | 21      |
| <i>trans</i> -1,2-Dimethylcyclopentane              | $C_7H_{14}$       | 365.1   | 553     | 3.45      |                    | 21      |
| <i>cis</i> -1,3-Dimethylcyclopentane                | $C_7H_{14}$       | 364.0   | 551     | 3.45      |                    | 21      |
| <i>trans</i> -1,3-Dimethylcyclopentane              | $C_7H_{14}$       | 364.9   | 553     | 3.45      |                    | 21      |
| Dimethyl disulfide                                  | $C_2H_6S_2$       | 382.89  | 607.8   | 5.07      |                    | 8,81    |
| Dimethyl ether                                      | $C_2H_6O$         | 248.4   | 400.378 | 5.356     | 169                | 7,62,67 |
| <i>N,N</i> -Dimethylformamide                       | $C_3H_7NO$        | 426     | 649.6   |           | 262                | 49      |
| 2,2-Dimethylheptane                                 | $C_9H_{20}$       | 405.9   | 576.7   | 2.35      |                    | 5       |
| 2,2-Dimethylhexane                                  | $C_8H_{18}$       | 380.01  | 549.8   | 2.53      | 478                | 5       |
| 2,3-Dimethylhexane                                  | $C_8H_{18}$       | 388.77  | 563.5   | 2.63      | 468                | 5       |
| 2,4-Dimethylhexane                                  | $C_8H_{18}$       | 382.7   | 553.5   | 2.56      | 472                | 5       |
| 2,5-Dimethylhexane                                  | $C_8H_{18}$       | 382.27  | 550.0   | 2.49      | 482                | 5       |
| 3,3-Dimethylhexane                                  | $C_8H_{18}$       | 385.12  | 562.0   | 2.65      | 443                | 5       |
| 3,4-Dimethylhexane                                  | $C_8H_{18}$       | 390.88  | 568.8   | 2.69      | 466                | 5       |
| Dimethyl malonate                                   | $C_5H_8O_4$       | 454.6   | 647     | 3.60      | 377                | 77      |
| 2,7-Dimethylnaphthalene                             | $C_{12}H_{12}$    | 538     | 775     | 3.23      | 601                | 3       |
| 2,2-Dimethyloxirane                                 | $C_3H_8O$         | 325     | 499.9   | 4.35      |                    | 82      |
| 2,2-Dimethylpentane                                 | $C_7H_{16}$       | 352.4   | 520.5   | 2.77      | 416                | 5       |
| 2,3-Dimethylpentane                                 | $C_7H_{16}$       | 362.93  | 537.3   | 2.91      | 393                | 5       |
| 2,4-Dimethylpentane                                 | $C_7H_{16}$       | 353.64  | 519.8   | 2.74      | 418                | 5       |
| 3,3-Dimethylpentane                                 | $C_7H_{16}$       | 359.21  | 536.4   | 2.95      | 414                | 5       |
| 2,3-Dimethyl-1-pentene                              | $C_7H_{14}$       | 357.5   | 533.6   |           |                    | 59      |
| 4,4-Dimethyl-1-pentene                              | $C_7H_{14}$       | 345.7   | 516     |           |                    | 59      |
| Dimethyl phthalate                                  | $C_{10}H_{10}O_4$ | 556.9   | 772     | 2.77      |                    | 51      |
| 2,3-Dimethylpyridine                                | $C_7H_9N$         | 434.27  | 655.5   | 4.10      | 356                | 9,23    |
| 2,4-Dimethylpyridine                                | $C_7H_9N$         | 431.53  | 647     | 3.95      | 361                | 9,23    |
| 2,5-Dimethylpyridine                                | $C_7H_9N$         | 430.13  | 644.3   | 3.85      | 361                | 9,23    |
| 2,6-Dimethylpyridine                                | $C_7H_9N$         | 417.16  | 624.0   | 3.85      | 361                | 9,23    |
| 3,4-Dimethylpyridine                                | $C_7H_9N$         | 452.25  | 683.7   | 4.20      | 355                | 9,23    |
| 3,5-Dimethylpyridine                                | $C_7H_9N$         | 444.99  | 667.7   | 4.05      | 361                | 9,23    |
| Dimethyl sulfide                                    | $C_2H_6S$         | 310.48  | 503     | 5.53      | 203.7              | 8       |
| 1,3-Dimethyltricyclo[3.3.1.1 <sup>3,7</sup> ]decane | $C_{12}H_{20}$    | 476.53  | 704     | 2.75      | 566                | 69      |
| Dinonyl phthalate                                   | $C_{26}H_{42}O_4$ | 686     | 858     | 1.02      |                    | 51      |
| Diocetyl phthalate                                  | $C_{24}H_{38}O_4$ |         | 840     | 1.08      |                    | 51      |
| 1,4-Dioxane                                         | $C_4H_8O_2$       | 374.7   | 588     | 5.21      | 238                | 7       |
| Dipentyl phthalate                                  | $C_{18}H_{26}O_4$ |         | 811     | 1.43      |                    | 51      |
| Diphenyl ether                                      | $C_{12}H_{10}O$   | 531.2   | 767     |           |                    | 7       |
| Diphenylmethane                                     | $C_{13}H_{12}$    | 538.2   | 760     | 2.71      | 563                | 3       |
| Dipropylamine                                       | $C_6H_{15}N$      | 382.5   | 555.8   | 3.63      |                    | 9,59    |
| Dipropylene glycol                                  | $C_6H_{14}O_3$    | 503.7   | 705.2   | 3.38      |                    | 82      |
| Dipropyl ether                                      | $C_6H_{14}O$      | 363.23  | 530.6   | 3.028     |                    | 7       |
| Dipropyl phthalate                                  | $C_{14}H_{18}O_4$ | 577.7   | 784     | 1.90      |                    | 51      |
| Diundecyl phthalate                                 | $C_{30}H_{50}O_4$ |         | 886     | 0.89      |                    | 51      |
| Docosane                                            | $C_{22}H_{46}$    | 641.8   | 786     | 0.98      |                    | 2       |
| Docosanoic acid                                     | $C_{22}H_{44}O_2$ |         | 837     | 1.11      |                    | 48      |
| 1-Docosanol                                         | $C_{22}H_{46}O$   |         | 827     | 1.07      |                    | 80      |
| Dodecane                                            | $C_{12}H_{26}$    | 489.47  | 658     | 1.82      | 754                | 2       |
| 1,12-Dodecanediamine                                | $C_{12}H_{28}N_2$ |         | 767     | 2.01      |                    | 9,56    |
| Dodecanedioic acid                                  | $C_{12}H_{22}O_4$ |         | 859     | 2.15      |                    | 57      |
| 1-Dodecanethiol                                     | $C_{12}H_{26}S$   | 549.9   | 733.7   | 1.81      |                    | 60      |

| Name                                        | Mol. Form.        | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.     |
|---------------------------------------------|-------------------|---------|---------|-----------|--------------------|----------|
| Dodecanoic acid                             | $C_{12}H_{24}O_2$ |         | 743     | 1.93      |                    | 48       |
| 1-Dodecanol                                 | $C_{12}H_{26}O$   | 533     | 719.4   | 1.994     |                    | 4        |
| 2-Dodecanone                                | $C_{12}H_{24}O$   | 519.7   | 702     |           | 752                | 7        |
| 3-Dodecanone                                | $C_{12}H_{24}O$   |         | 701     |           | 752                | 7        |
| 4-Dodecanone                                | $C_{12}H_{24}O$   |         | 697     |           | 759                | 7        |
| 5-Dodecanone                                | $C_{12}H_{24}O$   |         | 695     |           | 759                | 7        |
| 6-Dodecanone                                | $C_{12}H_{24}O$   |         | 694     |           | 762                | 7        |
| 1-Dodecene                                  | $C_{12}H_{24}$    | 487.0   | 658     | 1.93      |                    | 6        |
| Eicosane                                    | $C_{20}H_{42}$    | 616     | 768     | 1.07      |                    | 3        |
| Eicosanoic acid                             | $C_{20}H_{40}O_2$ | 601     | 820     | 1.20      |                    | 48       |
| 1-Eicosanol                                 | $C_{20}H_{42}O$   | 629     | 809     | 1.30      |                    | 49       |
| Ethane                                      | $C_2H_6$          | 184.6   | 305.32  | 4.872     | 145.5              | 2        |
| 1,2-Ethanediamine                           | $C_2H_8N_2$       | 390     | 613.1   | 6.71      |                    | 9,11,12  |
| 1,2-Ethanediol                              | $C_2H_6O_2$       | 470.5   | 720     | 8         |                    | 7,14     |
| 1,1-Ethanediol, diacetate                   | $C_6H_{10}O_4$    | 442     | 618.2   | 2.97      |                    | 82       |
| Ethanethiol                                 | $C_2H_6S$         | 308.2   | 499     | 5.49      | 207                | 8        |
| Ethanol                                     | $C_2H_6O$         | 351.44  | 514.0   | 6.137     | 168                | 4        |
| Ethoxybenzene                               | $C_8H_{10}O$      | 442.96  | 647     | 3.4       |                    | 7        |
| 2-Ethoxyethyl acetate                       | $C_6H_{12}O_3$    | 429.6   | 608.0   | 3.17      | 441                | 7,23     |
| 2-Ethoxy-2-methylbutane                     | $C_7H_{16}O$      | 374.6   | 546     | 2.935     | 463                | 7        |
| 4-Ethoxy-1,1,1,2,2,3,3,4,4-nonafluorobutane | $C_6H_5F_9O$      | 350.04  | 482.02  | 1.976     |                    | 65       |
| Ethyl acetate                               | $C_4H_8O_2$       | 350.26  | 523.3   | 3.87      | 286                | 7        |
| Ethylamine                                  | $C_2H_7N$         | 289.7   | 456     | 5.6       | 180                | 9,49     |
| N-Ethylaniline                              | $C_8H_{11}N$      | 476.2   | 700     |           |                    | 9,49     |
| Ethylbenzene                                | $C_8H_{10}$       | 409.34  | 617.15  | 3.609     | 374                | 3,15     |
| Ethyl butanoate                             | $C_6H_{12}O_2$    | 394.5   | 568.8   | 3.1       | 415                | 7        |
| Ethyl <i>trans</i> -2-butenolate            | $C_6H_{10}O_2$    | 411     | 599     |           |                    | 7        |
| Ethylcyclohexane                            | $C_8H_{16}$       | 405.1   | 606.9   | 3.25      |                    | 21,58,59 |
| Ethylcyclopentane                           | $C_7H_{14}$       | 376.7   | 569.5   | 3.40      | 375                | 5        |
| Ethyl 2,2-dimethylpropanoate                | $C_7H_{14}O_2$    | 391.6   | 566     | 2.95      | 465                | 79       |
| Ethylene                                    | $C_2H_4$          | 169.38  | 282.34  | 5.041     | 131                | 6        |
| Ethyl 3-ethoxypropanoate                    | $C_7H_{14}O_3$    | 439     | 621.0   | 2.66      | 458                | 7        |
| Ethyl formate                               | $C_3H_6O_2$       | 327.6   | 508.54  | 4.74      | 229                | 7        |
| Ethyl heptanoate                            | $C_9H_{18}O_2$    | 460     | 634     |           |                    | 7        |
| 3-Ethylhexane                               | $C_8H_{18}$       | 391.8   | 565.5   | 2.61      | 455                | 5        |
| Ethyl hexanoate                             | $C_8H_{16}O_2$    | 440     | 615.2   |           |                    | 7        |
| 2-Ethylhexanoic acid                        | $C_8H_{16}O_2$    | 501     | 674     | 2.78      | 528                | 7        |
| 2-Ethyl-1-hexanol                           | $C_8H_{18}O$      | 457.8   | 640.6   | 2.8       |                    | 4        |
| 2-Ethylhexyl acetate                        | $C_{10}H_{20}O_2$ | 472     | 642     | 2.09      | 681                | 7        |
| Ethyl 3-methylbutanoate                     | $C_7H_{14}O_2$    | 408.2   | 582.4   |           |                    | 7        |
| Ethyl methyl ether                          | $C_3H_8O$         | 280.6   | 437.9   | 4.38      | 222                | 7        |
| 3-Ethyl-2-methylpentane                     | $C_8H_{18}$       | 388.81  | 567.1   | 2.70      | 442                | 5        |
| 3-Ethyl-3-methylpentane                     | $C_8H_{18}$       | 391.42  | 576.5   | 2.81      | 455                | 5        |
| Ethyl 2-methylpropanoate                    | $C_6H_{12}O_2$    | 383.3   | 554     | 3.1       | 415                | 7        |
| Ethyl methyl sulfide                        | $C_3H_8S$         | 339.9   | 533     | 4.25      |                    | 8        |
| Ethyl nonanoate                             | $C_{11}H_{22}O_2$ | 500.2   | 664     |           |                    | 7        |
| Ethyl octanoate                             | $C_{10}H_{20}O_2$ | 481.7   | 649     |           |                    | 7        |
| 3-Ethylpentane                              | $C_7H_{16}$       | 366.7   | 540.6   | 2.89      | 416                | 5        |
| Ethyl pentanoate                            | $C_7H_{14}O_2$    | 419.3   | 593.3   |           |                    | 7        |
| 2-Ethylphenol                               | $C_8H_{10}O$      | 477.7   | 703.0   |           |                    | 7        |
| 3-Ethylphenol                               | $C_8H_{10}O$      | 491.6   | 716.4   |           |                    | 7        |
| 4-Ethylphenol                               | $C_8H_{10}O$      | 491.1   | 716.4   |           |                    | 7        |
| Ethyl propanoate                            | $C_5H_{10}O_2$    | 372.3   | 546.7   | 3.45      | 342                | 7        |
| Ethyl propyl ether                          | $C_5H_{12}O$      | 336.36  | 500.2   | 3.370     | 339                | 7        |
| S-Ethyl thioacetate                         | $C_4H_8OS$        | 389.6   | 590.55  | 4.075     | 319                | 11,12    |

| Name                                                           | Mol. Form.                                                  | $T_b$ /K | $T_c$ /K | $P_c$ /MPa | $V_c$ /cm <sup>3</sup> mol <sup>-1</sup> | Ref.     |
|----------------------------------------------------------------|-------------------------------------------------------------|----------|----------|------------|------------------------------------------|----------|
| 2-Ethyltoluene                                                 | C <sub>9</sub> H <sub>12</sub>                              | 438.4    | 651      | 3.38       |                                          | 21       |
| 3-Ethyltoluene                                                 | C <sub>9</sub> H <sub>12</sub>                              | 434.5    | 637      | 3.25       |                                          | 21       |
| 4-Ethyltoluene                                                 | C <sub>9</sub> H <sub>12</sub>                              | 435      | 640.2    | 3.23       |                                          | 3        |
| Ethyl vinyl ether                                              | C <sub>4</sub> H <sub>8</sub> O                             | 308.7    | 475      | 4.07       |                                          | 7        |
| Fluorobenzene                                                  | C <sub>6</sub> H <sub>5</sub> F                             | 357.88   | 560.09   | 4.551      | 269                                      | 49       |
| Fluoroethane [R-161]                                           | C <sub>2</sub> H <sub>5</sub> F                             | 235.5    | 375.31   | 5.028      |                                          | 49       |
| Fluoroethene [R-1141]                                          | C <sub>2</sub> H <sub>3</sub> F                             | 201      | 327.9    | 5.24       | 144                                      | 49       |
| Fluoromethane [R-41]                                           | CH <sub>3</sub> F                                           | 194.8    | 317.28   | 5.897      | 108                                      | 49,54    |
| 2-Fluorotoluene                                                | C <sub>7</sub> H <sub>7</sub> F                             | 388      | 591.2    |            |                                          | 13       |
| 3-Fluorotoluene                                                | C <sub>7</sub> H <sub>7</sub> F                             | 388      | 591.8    |            |                                          | 13       |
| 4-Fluorotoluene                                                | C <sub>7</sub> H <sub>7</sub> F                             | 389.8    | 592.1    |            |                                          | 13       |
| Formic acid                                                    | CH <sub>2</sub> O <sub>2</sub>                              | 374      | 588      |            |                                          | 7        |
| Furan                                                          | C <sub>4</sub> H <sub>4</sub> O                             | 304.7    | 490.2    | 5.3        | 218                                      | 7        |
| Furfural                                                       | C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                | 434.9    | 670*     | 5.89*      |                                          | 7        |
| Glycerol                                                       | C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>                | 563      | 850      | 7.5        |                                          | 7        |
| Heneicosane                                                    | C <sub>21</sub> H <sub>44</sub>                             | 629.7    | 778      | 1.03       |                                          | 2        |
| Heptadecane                                                    | C <sub>17</sub> H <sub>36</sub>                             | 575.2    | 736      | 1.34       | 1103                                     | 2        |
| Heptadecanoic acid                                             | C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>              |          | 792      | 1.37       |                                          | 48       |
| 1-Heptadecanol                                                 | C <sub>17</sub> H <sub>36</sub> O                           | 597      | 780      | 1.50       |                                          | 49       |
| 2,2,3,3,5,5,6-Heptafluoro-1,4-dioxane                          | C <sub>4</sub> HF <sub>7</sub> O <sub>2</sub>               | 312.72   | 452.88   | 2.866      |                                          | 63       |
| 1,1,1,2,2,3,3-Heptafluoropentan-4-one                          | C <sub>5</sub> H <sub>3</sub> F <sub>7</sub> O              | 337.40   | 476.55   | 2.578      |                                          | 61       |
| 1,1,1,2,3,3,3-Heptafluoropropane [HFC-227ea]                   | C <sub>3</sub> HF <sub>7</sub>                              | 257.65   | 375.00   | 2.930      | 284                                      | 39,47,66 |
| 1,1,1,2,4,4,4-Heptafluoro-2-trifluoromethoxybutane             | C <sub>5</sub> H <sub>2</sub> F <sub>10</sub> O             | 322.72   | 447.40   | 2.140      |                                          | 63       |
| 2,2,4,4,6,8,8-Heptamethylnonane                                | C <sub>16</sub> H <sub>34</sub>                             | 519.5    | 692      |            |                                          | 5        |
| Heptanal                                                       | C <sub>7</sub> H <sub>14</sub> O                            | 426.0    | 617      | 3.16       | 434                                      | 7        |
| 2-Heptanamine                                                  | C <sub>7</sub> H <sub>17</sub> N                            | 415      | 598.0    |            |                                          | 9,59     |
| Heptane                                                        | C <sub>7</sub> H <sub>16</sub>                              | 371.6    | 540.2    | 2.74       | 428                                      | 2        |
| Heptanedioic acid                                              | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>               | 615.1    | 842      | 3.28       |                                          | 57       |
| Heptanoic acid                                                 | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>               | 495.4    | 678      | 3.16       |                                          | 7        |
| 1-Heptanol                                                     | C <sub>7</sub> H <sub>16</sub> O                            | 449.60   | 632.6    | 3.058      | 435                                      | 4        |
| 2-Heptanol                                                     | C <sub>7</sub> H <sub>16</sub> O                            | 432      | 608.3    | 3.021      | 442                                      | 4        |
| 3-Heptanol                                                     | C <sub>7</sub> H <sub>16</sub> O                            | 430      | 605.4    |            | 434                                      | 4        |
| 4-Heptanol                                                     | C <sub>7</sub> H <sub>16</sub> O                            | 429      | 602.6    |            | 432                                      | 4        |
| 2-Heptanone                                                    | C <sub>7</sub> H <sub>14</sub> O                            | 424.20   | 611.4    | 2.97       | 436                                      | 7        |
| 3-Heptanone                                                    | C <sub>7</sub> H <sub>14</sub> O                            | 420      | 606.6    |            | 433                                      | 7        |
| 4-Heptanone                                                    | C <sub>7</sub> H <sub>14</sub> O                            | 417      | 602.0    |            | 434                                      | 7        |
| 1-Heptene                                                      | C <sub>7</sub> H <sub>14</sub>                              | 366.79   | 537.3    | 2.92       | 409                                      | 6        |
| <i>cis</i> -2-Heptene                                          | C <sub>7</sub> H <sub>14</sub>                              | 371.6    | 548.5    |            |                                          | 59       |
| <i>trans</i> -2-Heptene                                        | C <sub>7</sub> H <sub>14</sub>                              | 371      | 542.8    |            |                                          | 59       |
| <i>trans</i> -3-Heptene                                        | C <sub>7</sub> H <sub>14</sub>                              | 368.9    | 538.6    |            |                                          | 59       |
| Heptylbenzene                                                  | C <sub>13</sub> H <sub>20</sub>                             | 513      | 708      | 2.14       |                                          | 16       |
| Hexachloroethane [R-110]                                       | C <sub>2</sub> Cl <sub>6</sub>                              | 457.85 s | 695      | 3.34*      | 412*                                     | 12       |
| Hexadecane                                                     | C <sub>16</sub> H <sub>34</sub>                             | 560.01   | 723      | 1.40       | 1034                                     | 2        |
| Hexadecanoic acid                                              | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>              | 624.7    | 785      | 1.49       |                                          | 48       |
| 1-Hexadecanol                                                  | C <sub>16</sub> H <sub>34</sub> O                           | 585      | 770      | 1.61       |                                          | 49       |
| 1,5-Hexadiene                                                  | C <sub>6</sub> H <sub>10</sub>                              | 332.6    | 508      |            |                                          | 6        |
| Hexafluoroacetylacetone                                        | C <sub>5</sub> H <sub>2</sub> F <sub>6</sub> O <sub>2</sub> | 327.30   | 485.1    | 2.767      |                                          | 49       |
| Hexafluorobenzene                                              | C <sub>6</sub> F <sub>6</sub>                               | 353.41   | 516.73   | 3.273      | 335                                      | 49       |
| Hexafluoroethane [HFC-116]                                     | C <sub>2</sub> F <sub>6</sub>                               | 195.1    | 293.03   | 3.048      | 222                                      | 49,54    |
| 1,1,1,2,3,3-Hexafluoro-3-(2,2,3,3,3-pentafluoropropoxy)propane | C <sub>6</sub> H <sub>3</sub> F <sub>11</sub> O             | 360.64   | 486.48   | 1.950      |                                          | 65       |
| 1,1,1,2,3,3-Hexafluoropropane [HFC-236ea]                      | C <sub>3</sub> H <sub>2</sub> F <sub>6</sub>                | 277.65   | 412.41   | 3.416      | 271                                      | 33,64,66 |
| 1,1,1,3,3,3-Hexafluoropropane [HFC-236fa]                      | C <sub>3</sub> H <sub>2</sub> F <sub>6</sub>                | 272.2    | 398.07   |            |                                          | 45       |
| 1,1,1,2,3,3-Hexafluoro-3-(2,2,3,3-tetrafluoropropoxy)propane   | C <sub>6</sub> H <sub>4</sub> F <sub>10</sub> O             | 379.07   | 516.2    | 2.17       |                                          | 65       |
| 1,1,1,2,3,3-Hexafluoro-3-(2,2,2-trifluoroethoxy)propane        | C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O              | 345.87   | 475.74   | 2.233      |                                          | 65       |
| 1,1,1,3,3,3-Hexafluoro-2-trifluoromethyl-2-methoxypropane      | C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O              | 326.50   | 462.72   | 2.366      |                                          | 63       |



| Name                        | Mol. Form.     | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.    |
|-----------------------------|----------------|---------|---------|-----------|--------------------|---------|
| Hexamethylbenzene           | $C_{12}H_{18}$ | 536.6   | 758     |           |                    | 3       |
| Hexanal                     | $C_6H_{12}O$   | 404     | 592     | 3.46      | 378                | 7       |
| Hexane                      | $C_6H_{14}$    | 341.88  | 507.6   | 3.025     | 368                | 2       |
| 1,6-Hexanediamine           | $C_6H_{16}N_2$ | 477.7   | 685     | 3.59      |                    | 9,56    |
| 1,6-Hexanedioic acid        | $C_6H_{10}O_4$ | 610.5   | 841     | 3.85      |                    | 57      |
| 1,6-Hexanediol              | $C_6H_{14}O_2$ | 481     | 740.8   | 4.08      |                    | 81      |
| Hexanenitrile               | $C_6H_{11}N$   | 436.80  | 633.8   | 3.30      |                    | 9,49    |
| Hexanoic acid               | $C_6H_{12}O_2$ | 478.4   | 655     | 3.38      | 413                | 7       |
| 1-Hexanol                   | $C_6H_{14}O$   | 430.8   | 610.3   | 3.417     | 387                | 4       |
| 2-Hexanol                   | $C_6H_{14}O$   | 413     | 585.9   | 3.31      | 384                | 4       |
| 3-Hexanol                   | $C_6H_{14}O$   | 408     | 582.4   | 3.36      | 383                | 4       |
| 2-Hexanone                  | $C_6H_{12}O$   | 400.8   | 587.1   | 3.30      | 377                | 7       |
| 3-Hexanone                  | $C_6H_{12}O$   | 396.7   | 583.0   | 3.320     | 378                | 7       |
| 1-Hexene                    | $C_6H_{12}$    | 336.63  | 504.0   | 3.21      | 355.1              | 6       |
| <i>cis</i> -2-Hexene        | $C_6H_{12}$    | 342.0   | 513.4   |           |                    | 59      |
| <i>trans</i> -2-Hexene      | $C_6H_{12}$    | 341.1   | 509.0   |           |                    | 59      |
| <i>cis</i> -3-Hexene        | $C_6H_{12}$    | 339.6   | 510.2   |           |                    | 59      |
| <i>trans</i> -3-Hexene      | $C_6H_{12}$    | 340.3   | 507.4   |           |                    | 59      |
| Hexyl acetate               | $C_8H_{16}O_2$ | 444.7   | 618.4   |           |                    | 7       |
| Hexylamine                  | $C_6H_{15}N$   | 406.0   | 592.3   |           |                    | 9,59    |
| Hexylbenzene                | $C_{12}H_{18}$ | 499.3   | 695     | 2.35      |                    | 16      |
| Hydrogen cyanide            | CHN            | 299     | 457     | 5.4       | 135                | 9,49    |
| Indan                       | $C_9H_{10}$    | 451.12  | 684.9   | 3.95      |                    | 3       |
| 1 <i>H</i> -Indole          | $C_8H_7N$      | 526.8   | 794     | 4.8       | 356                | 10      |
| Iodobenzene                 | $C_6H_5I$      | 461.6   | 721     | 4.52      | 351                | 49      |
| Iodomethane                 | $CH_3I$        | 315.58  | 528     |           |                    | 49      |
| Isobutanal                  | $C_4H_8O$      | 337.7   | 544     | 5.1       |                    | 7       |
| Isobutane                   | $C_4H_{10}$    | 261.42  | 407.885 | 3.6390    | 255.5              | 5,52,68 |
| Isobutene                   | $C_4H_8$       | 266.3   | 418.09  | 4.010     | 239.8              | 6,72    |
| Isobutyl acetate            | $C_6H_{12}O_2$ | 389.7   | 561     | 2.99      | 401                | 7       |
| Isobutylamine               | $C_4H_{11}N$   | 340.90  | 519     | 4.07      | 278                | 10      |
| Isobutylbenzene             | $C_{10}H_{14}$ | 445.94  | 650     | 3.05      |                    | 4       |
| Isobutyl butanoate          | $C_8H_{16}O_2$ | 430.1   | 611     |           |                    | 7       |
| Isobutylcyclohexane         | $C_{10}H_{20}$ | 444.5   | 642.1   |           |                    | 59      |
| Isobutyl formate            | $C_5H_{10}O_2$ | 371.4   | 551     | 3.88      | 355                | 7       |
| Isobutyl isobutanoate       | $C_8H_{16}O_2$ | 421.8   | 602     |           |                    | 7       |
| Isobutyl 3-methylbutanoate  | $C_9H_{18}O_2$ | 441.7   | 621     |           |                    | 7       |
| Isobutyl propanoate         | $C_7H_{14}O_2$ | 410     | 584     |           |                    | 7       |
| Isopentane                  | $C_5H_{12}$    | 301.03  | 460.4   | 3.38      | 306                | 5       |
| Isopentyl acetate           | $C_7H_{14}O_2$ | 415.7   | 586.1   | 2.76      |                    | 7       |
| Isopentyl butanoate         | $C_9H_{18}O_2$ | 452     | 619     |           |                    | 7       |
| Isopentyl formate           | $C_6H_{12}O_2$ | 396.7   | 578     |           |                    | 7       |
| Isopentyl propanoate        | $C_8H_{16}O_2$ | 433.4   | 611     |           |                    | 7       |
| Isopropyl acetate           | $C_5H_{10}O_2$ | 361.8   | 531.0   | 3.31      | 344                | 7       |
| Isopropylamine              | $C_3H_9N$      | 304.91  | 472.2   | 4.55      | 219                | 9,59    |
| Isopropylbenzene            | $C_9H_{12}$    | 425.56  | 631.0   | 3.209     |                    | 3       |
| Isopropylcyclohexane        | $C_9H_{18}$    | 428.0   | 632.2   |           |                    | 59      |
| Isopropyl formate           | $C_4H_8O_2$    | 341.4   | 535     | 3.95      |                    | 7       |
| 1-Isopropyl-4-methylbenzene | $C_{10}H_{14}$ | 450.3   | 652     | 2.8       |                    | 3       |
| Isopropyl methyl ether      | $C_4H_{10}O$   | 303.92  | 464.4   | 3.762     |                    | 7       |
| Isoquinoline                | $C_9H_7N$      | 516.37  | 803     |           |                    | 9,10    |
| Isoxazole                   | $C_3H_3NO$     | 368     | 552.0   |           |                    | 49      |
| <i>d</i> -Limonene          | $C_{10}H_{16}$ | 451     | 653     |           | 470                | 6       |
| Maleic acid                 | $C_4H_4O_4$    |         | 620     |           |                    | 7       |
| Mesityl oxide               | $C_6H_{10}O$   | 403     | 605     | 4.00      | 353                | 7       |



| Name                                        | Mol. Form.                                     | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.    |
|---------------------------------------------|------------------------------------------------|---------|---------|-----------|--------------------|---------|
| Methane                                     | CH <sub>4</sub>                                | 111.67  | 190.56  | 4.599     | 98.60              | 2       |
| Methanethiol                                | CH <sub>4</sub> S                              | 279.1   | 470     | 7.23      | 147                | 8       |
| Methanol                                    | CH <sub>4</sub> O                              | 337.8   | 512.5   | 8.084     | 117                | 4       |
| 2-Methoxy-1,4-dimethylbenzene               | C <sub>9</sub> H <sub>12</sub> O               | 467     | 677.3   |           |                    | 7       |
| 1-Methoxy-2,4-dimethylbenzene               | C <sub>9</sub> H <sub>12</sub> O               | 465     | 682     |           |                    | 7       |
| 2-Methoxyethanol                            | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>   | 397.3   | 597.6   | 5.285     | 263                | 7,11,12 |
| 2-Methoxyethyl acetate                      | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>  | 416     | 630.0   |           |                    | 7       |
| 4-Methoxy-1,1,1,2,2,3,3-heptafluorobutane   | C <sub>4</sub> H <sub>5</sub> F <sub>7</sub> O | 344.13  | 481.54  | 2.381     |                    | 65      |
| 3-Methoxy-1,1,2,2,3,3-hexafluoropropane     | C <sub>3</sub> H <sub>4</sub> F <sub>6</sub> O | 341.02  | 487     | 3.1       |                    | 65      |
| 2-Methoxy-2-methylbutane                    | C <sub>6</sub> H <sub>14</sub> O               | 359.3   | 535     | 3.20      | 374                | 7       |
| 5-Methoxy-1,1,2,2,3,3,4,4-octafluoropentane | C <sub>5</sub> H <sub>6</sub> F <sub>8</sub> O | 395.83  | 546.1   | 2.5       |                    | 65      |
| Methyl acetate                              | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | 330.02  | 506.5   | 4.750     | 228                | 7       |
| Methylamine                                 | CH <sub>5</sub> N                              | 266.83  | 430.8   | 7.62      | 141                | 9,49    |
| 2-Methylaniline                             | C <sub>8</sub> H <sub>9</sub> N                | 473.5   | 717     | 4.7       | 346                | 9,49    |
| 3-Methylaniline                             | C <sub>8</sub> H <sub>9</sub> N                | 476.5   | 709     | 4.2       |                    | 9,49    |
| 4-Methylaniline                             | C <sub>8</sub> H <sub>9</sub> N                | 473.6   | 667     | 2.4       |                    | 9,49    |
| <i>N</i> -Methylaniline                     | C <sub>8</sub> H <sub>9</sub> N                | 469.4   | 702     | 5.2       |                    | 9,49    |
| 2-Methylanisole                             | C <sub>8</sub> H <sub>10</sub> O               | 444     | 662.0   |           |                    | 7       |
| 3-Methylanisole                             | C <sub>8</sub> H <sub>10</sub> O               | 448.7   | 665.3   |           |                    | 7       |
| 4-Methylanisole                             | C <sub>8</sub> H <sub>10</sub> O               | 448.7   | 666     |           |                    | 7       |
| $\alpha$ -Methylbenzenemethanol             | C <sub>8</sub> H <sub>10</sub> O               | 478     | 699     | 3.77      |                    | 14      |
| Methyl benzoate                             | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>   | 472     | 702     | 4.02      | 408                | 76      |
| 4-Methylbenzonitrile                        | C <sub>8</sub> H <sub>7</sub> N                | 490.2   | 723     |           |                    | 9,49    |
| 3-Methyl-1-butanethiol                      | C <sub>5</sub> H <sub>12</sub> S               | 389     | 594     |           |                    | 8       |
| Methyl butanoate                            | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | 376.0   | 554.5   | 3.47      | 340                | 7       |
| 3-Methylbutanoic acid                       | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | 449.7   | 629     | 3.40      |                    | 7       |
| 2-Methyl-1-butanol                          | C <sub>5</sub> H <sub>12</sub> O               | 400.7   | 575.4   | 3.94      |                    | 4       |
| 3-Methyl-1-butanol                          | C <sub>5</sub> H <sub>12</sub> O               | 404.3   | 577.2   | 3.93      |                    | 4       |
| 2-Methyl-2-butanol                          | C <sub>5</sub> H <sub>12</sub> O               | 375.6   | 543.7   | 3.71      |                    | 4       |
| 3-Methyl-2-butanol                          | C <sub>5</sub> H <sub>12</sub> O               | 386.1   | 556.1   | 3.87      |                    | 4       |
| 3-Methyl-2-butanone                         | C <sub>5</sub> H <sub>10</sub> O               | 367.48  | 553.0   | 3.80      | 308                | 7       |
| 2-Methyl-1-butene                           | C <sub>5</sub> H <sub>10</sub>                 | 304.4   | 467.0   | 3.8       |                    | 49,59   |
| 3-Methyl-1-butene                           | C <sub>5</sub> H <sub>10</sub>                 | 293.3   | 452.7   | 3.53      | 304.9              | 6       |
| 2-Methyl-2-butene                           | C <sub>5</sub> H <sub>10</sub>                 | 311.71  | 470     | 3.42      |                    | 6       |
| Methyl <i>tert</i> -butyl ether             | C <sub>5</sub> H <sub>12</sub> O               | 328.2   | 497.1   | 3.430     |                    | 7       |
| 9-Methyl-9 <i>H</i> -carbazole              | C <sub>13</sub> H <sub>11</sub> N              | 616.79  | 890     | 3.38      | 572                | 10      |
| Methylcyclohexane                           | C <sub>7</sub> H <sub>14</sub>                 | 374.08  | 572.1   | 3.48      | 369                | 5,58    |
| Methylcyclopentane                          | C <sub>6</sub> H <sub>12</sub>                 | 345.0   | 532.7   | 3.79      | 318                | 5       |
| 2-Methylcyclopentanone                      | C <sub>6</sub> H <sub>10</sub> O               | 412.7   | 631     |           |                    | 7       |
| 2-Methyl- <i>N,N</i> -dimethylaniline       | C <sub>9</sub> H <sub>13</sub> N               | 467.3   | 668     | 3.1       |                    | 9,49    |
| Methyl dodecanoate                          | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub> | 540     | 712     |           |                    | 7       |
| Methyl formate                              | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>   | 304.9   | 487.2   | 6.00      | 172                | 7       |
| 2-Methylfuran                               | C <sub>5</sub> H <sub>6</sub> O                | 337.9   | 528     | 4.7       | 247                | 7       |
| 2-Methylheptane                             | C <sub>8</sub> H <sub>18</sub>                 | 390.81  | 559.7   | 2.50      | 488                | 5       |
| 3-Methylheptane                             | C <sub>8</sub> H <sub>18</sub>                 | 392.1   | 563.6   | 2.55      | 464                | 5       |
| 4-Methylheptane                             | C <sub>8</sub> H <sub>18</sub>                 | 390.87  | 561.7   | 2.54      | 476                | 5       |
| Methyl heptanoate                           | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>  | 447     | 628     |           |                    | 7       |
| 4-Methyl-3-heptanol                         | C <sub>8</sub> H <sub>18</sub> O               | 443     | 623.5   |           |                    | 4       |
| 5-Methyl-3-heptanol                         | C <sub>8</sub> H <sub>18</sub> O               | 445     | 621.2   |           |                    | 4       |
| 2-Methyl-3-heptanone                        | C <sub>8</sub> H <sub>16</sub> O               | 431     | 614.9   |           |                    | 7       |
| 5-Methyl-3-heptanone                        | C <sub>8</sub> H <sub>16</sub> O               | 434     | 619.0   |           |                    | 7       |
| 2-Methyl-1-heptene                          | C <sub>8</sub> H <sub>16</sub>                 | 392.5   | 567.5   |           |                    | 59      |
| 2-Methyl-2-heptene                          | C <sub>8</sub> H <sub>16</sub>                 | 395.8   | 568.9   |           |                    | 59      |
| 2-Methylhexane                              | C <sub>7</sub> H <sub>16</sub>                 | 363.19  | 530.4   | 2.74      | 421                | 5       |
| 3-Methylhexane                              | C <sub>7</sub> H <sub>16</sub>                 | 365     | 535.2   | 2.81      | 404                | 5       |

| Name                                      | Mol. Form.      | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.  |
|-------------------------------------------|-----------------|---------|---------|-----------|--------------------|-------|
| 5-Methyl-2-hexanone                       | $C_7H_{14}O$    | 417     | 604.1   |           |                    | 7     |
| 2-Methyl-3-hexanone                       | $C_7H_{14}O$    | 408     | 593.3   |           |                    | 7     |
| 2-Methyl-1-hexene                         | $C_7H_{14}$     | 365     | 541.8   |           |                    | 59    |
| 5-Methyl-1-hexene                         | $C_7H_{14}$     | 358.5   | 528.7   |           |                    | 59    |
| <i>N</i> -Methylhexylamine                | $C_8H_{17}N$    |         | 592     |           |                    | 9,59  |
| Methylhydrazine                           | $CH_6N_2$       | 360.7   | 567     | 8.24      | 271                | 49    |
| Methyl isobutanoate                       | $C_5H_{10}O_2$  | 365.7   | 540.7   | 3.43      | 339                | 7     |
| 5-Methyl-2-isopropylcyclohexanol          | $C_{10}H_{20}O$ | 489     | 694     |           |                    | 49    |
| 1-Methylnaphthalene                       | $C_{11}H_{10}$  | 517.9   | 772     | 3.60      |                    | 3     |
| 2-Methylnaphthalene                       | $C_{11}H_{10}$  | 514.3   | 761     |           |                    | 3     |
| 2-Methyloctane                            | $C_9H_{20}$     | 416.4   | 582.8   | 2.31      |                    | 5     |
| Methyloxirane                             | $C_3H_6O$       | 308     | 485     | 5.2       | 190                | 7     |
| Methyl pentafluoroethyl ether [HFE-245mc] | $C_3H_3F_5O$    | 278.74  | 406.80  | 2.887     | 301                | 32,64 |
| 2-Methylpentane                           | $C_6H_{14}$     | 333.41  | 497.7   | 3.04      | 368                | 5     |
| 3-Methylpentane                           | $C_6H_{14}$     | 336.42  | 504.6   | 3.12      | 368                | 5     |
| Methyl pentanoate                         | $C_6H_{12}O_2$  | 400.6   | 590     | 3.20      | 422                | 7     |
| 2-Methyl-1-pentanol                       | $C_6H_{14}O$    | 422     | 604.4   | 3.45      |                    | 4     |
| 4-Methyl-1-pentanol                       | $C_6H_{14}O$    | 425.1   | 603.5   |           |                    | 4     |
| 2-Methyl-2-pentanol                       | $C_6H_{14}O$    | 394.3   | 559.5   |           |                    | 4     |
| 4-Methyl-2-pentanol                       | $C_6H_{14}O$    | 404.8   | 574.4   |           |                    | 4     |
| 2-Methyl-3-pentanol                       | $C_6H_{14}O$    | 399.7   | 576.0   | 3.46      |                    | 4     |
| 3-Methyl-3-pentanol                       | $C_6H_{14}O$    | 395.6   | 575.6   | 3.52      |                    | 4     |
| 4-Methyl-2-pentanone                      | $C_6H_{12}O$    | 389.7   | 574.6   | 3.270     |                    | 7     |
| 2-Methyl-1-pentene                        | $C_6H_{12}$     | 335.3   | 521.0   |           |                    | 59    |
| 4-Methyl-1-pentene                        | $C_6H_{12}$     | 327.1   | 493.1   |           |                    | 59    |
| 2-Methyl-2-pentene                        | $C_6H_{12}$     | 340.5   | 509.3   |           |                    | 59    |
| 4-Methyl- <i>cis</i> -2-pentene           | $C_6H_{12}$     | 329.5   | 496.3   |           |                    | 59    |
| Methyl pentyl ether                       | $C_6H_{14}O$    | 372     | 546.5   | 3.042     | 391                | 7     |
| 2-Methyl-1,3-propanediol                  | $C_4H_{10}O_2$  | 484.8   | 708.0   | 5.35      |                    | 17    |
| Methyl propanoate                         | $C_4H_8O_2$     | 353.0   | 530.7   | 4.00      | 282                | 7     |
| 2-Methylpropanoic acid                    | $C_4H_8O_2$     | 427.60  | 605.0   | 3.70      | 290                | 7     |
| 2-Methyl-1-propanol                       | $C_4H_{10}O$    | 381.04  | 547.8   | 4.295     | 274                | 4     |
| 2-Methyl-2-propanol                       | $C_4H_{10}O$    | 355.6   | 506.2   | 3.972     | 275                | 4     |
| Methylpropylamine                         | $C_4H_{11}N$    | 336     | 550     | 3.1       |                    | 9     |
| Methyl propyl ether                       | $C_4H_{10}O$    | 312.3   | 476.2   | 3.801     |                    | 7     |
| 2-Methylpyrazine                          | $C_5H_6N_2$     | 410     | 634     | 5.01      | 285                | 9,49  |
| 2-Methylpyridine                          | $C_6H_7N$       | 402.53  | 621     | 4.62      | 300                | 9,10  |
| 3-Methylpyridine                          | $C_6H_7N$       | 417.29  | 644.6   | 4.65      | 300                | 9,10  |
| 4-Methylpyridine                          | $C_6H_7N$       | 418.51  | 646.0   | 4.67      | 300                | 9,10  |
| 1-Methylpyrrole                           | $C_5H_7N$       | 385.96  | 596.0   | 4.86      | 271                | 10    |
| 2-Methylpyrrole                           | $C_5H_7N$       | 420.8   | 654     | 5.08      | 266                | 10    |
| 3-Methylpyrrole                           | $C_5H_7N$       | 416.1   | 647     | 5.08      | 266                | 10    |
| <i>N</i> -Methyl-2-pyrrolidinone          | $C_5H_9NO$      | 475     | 721.8   |           | 311                | 49    |
| 2-Methylquinoline                         | $C_{10}H_9N$    | 519.7   | 778     | 4.0       | 447                | 9     |
| 8-Methylquinoline                         | $C_{10}H_9N$    | 520.7   | 787     | 4.3       | 434                | 9     |
| Methyl salicylate                         | $C_8H_8O_3$     | 496.1   | 709     |           |                    | 7     |
| Methylsilane                              | $CH_6Si$        | 215.7   | 352.4   |           |                    | 8     |
| 2-Methyltetrahydrofuran                   | $C_5H_{10}O$    | 351     | 537     | 3.76      | 267                | 7     |
| (Methylthio)benzene                       | $C_6H_8S$       | 467.5   | 705.9   | 4.05      |                    | 60    |
| Trichloromethylsilane                     | $CH_3Cl_3Si$    | 338.8   | 517     | 3.28      | 348                | 49    |
| Methyl trifluoromethyl ether [HFE-143m]   | $C_2H_3F_3O$    | 249.15  | 377.92  | 3.640     | 218                | 47,66 |
| 4-Morpholinecarboxaldehyde                | $C_5H_9NO_2$    | 512     | 779.3   | 5.08      |                    | 82    |
| Naphthalene                               | $C_{10}H_8$     | 491.1   | 748.4   | 4.05      | 407                | 3,60  |
| 1-Naphthylamine                           | $C_{10}H_9N$    | 573.9   | 850     | 5.0       | 438                | 10    |
| 2-Naphthylamine                           | $C_{10}H_9N$    | 579.4   | 850     | 4.9       | 438                | 10    |

| Name                                                       | Mol. Form.                                     | $T_b$ /K | $T_c$ /K | $P_c$ /MPa | $V_c$ /cm <sup>3</sup> mol <sup>-1</sup> | Ref.     |
|------------------------------------------------------------|------------------------------------------------|----------|----------|------------|------------------------------------------|----------|
| Neopentane                                                 | C <sub>5</sub> H <sub>12</sub>                 | 282.63   | 433.74   | 3.196      | 307                                      | 5,54     |
| Nitromethane                                               | CH <sub>3</sub> NO <sub>2</sub>                | 374.34   | 588      | 5.87       | 173                                      | 49       |
| Nonadecane                                                 | C <sub>19</sub> H <sub>40</sub>                | 603.1    | 755      | 1.16       |                                          | 3        |
| 1,1,1,2,2,3,3,4,4-Nonafluorohexan-5-one                    | C <sub>6</sub> H <sub>3</sub> F <sub>9</sub> O | 360.47   | 498.97   | 2.198      |                                          | 61       |
| Nonanal                                                    | C <sub>9</sub> H <sub>18</sub> O               | 464      | 659      | 2.68       | 543                                      | 7        |
| Nonane                                                     | C <sub>9</sub> H <sub>20</sub>                 | 423.97   | 594.55   | 2.281      | 555                                      | 2,54     |
| 1,9-Nonanediamine                                          | C <sub>9</sub> H <sub>22</sub> N <sub>2</sub>  | 531.8    | 726      | 2.63       |                                          | 9,56     |
| Nonanedioic acid                                           | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>  | 630.2    | 844      | 2.72       |                                          | 57       |
| Nonanoic acid                                              | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | 527.7    | 712      | 2.35       |                                          | 7        |
| 1-Nonanol                                                  | C <sub>9</sub> H <sub>20</sub> O               | 486.52   | 670.7    | 2.528      | 572                                      | 4        |
| 2-Nonanol                                                  | C <sub>9</sub> H <sub>20</sub> O               | 466.7    | 649.6    | 2.53       | 575                                      | 4        |
| 3-Nonanol                                                  | C <sub>9</sub> H <sub>20</sub> O               | 468      | 648.0    |            | 577                                      | 4        |
| 4-Nonanol                                                  | C <sub>9</sub> H <sub>20</sub> O               | 465.7    | 645.1    |            | 575                                      | 4        |
| 2-Nonanone                                                 | C <sub>9</sub> H <sub>18</sub> O               | 468.5    | 652.2    | 2.48       | 560                                      | 7,11,12  |
| 3-Nonanone                                                 | C <sub>9</sub> H <sub>18</sub> O               | 463      | 648.1    |            | 560                                      | 7        |
| 4-Nonanone                                                 | C <sub>9</sub> H <sub>18</sub> O               | 460.7    | 643.7    |            | 560                                      | 7        |
| 5-Nonanone                                                 | C <sub>9</sub> H <sub>18</sub> O               | 461.60   | 641.4    | 2.32       | 560                                      | 7        |
| 1-Nonene                                                   | C <sub>9</sub> H <sub>18</sub>                 | 420.1    | 594.0    |            | 526                                      | 6        |
| Octadecane                                                 | C <sub>18</sub> H <sub>38</sub>                | 589.5    | 747      | 1.29       | 1189                                     | 2        |
| 1-Octadecanol                                              | C <sub>18</sub> H <sub>38</sub> O              | 608      | 790      | 1.44       |                                          | 49       |
| Octanal                                                    | C <sub>8</sub> H <sub>16</sub> O               | 444      | 639      | 2.96       | 488                                      | 7        |
| Octane                                                     | C <sub>8</sub> H <sub>18</sub>                 | 398.82   | 568.7    | 2.49       | 492                                      | 2        |
| 1,8-Octanediamine                                          | C <sub>8</sub> H <sub>20</sub> N <sub>2</sub>  | 498.7    | 712      | 2.80       |                                          | 9,56     |
| Octanedioic acid                                           | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>  | 618.6    | 843      | 2.97       |                                          | 57       |
| Octanenitrile                                              | C <sub>8</sub> H <sub>15</sub> N               | 478.40   | 674.4    | 2.85       |                                          | 9,49     |
| 1-Octanethiol                                              | C <sub>8</sub> H <sub>18</sub> S               | 472.3    | 667      |            | 504                                      | 8        |
| Octanoic acid                                              | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>  | 512      | 693      | 2.87       | 519                                      | 7        |
| 1-Octanol                                                  | C <sub>8</sub> H <sub>18</sub> O               | 468.31   | 652.5    | 2.777      | 497                                      | 4        |
| 2-Octanol                                                  | C <sub>8</sub> H <sub>18</sub> O               | 452.5    | 629.6    | 2.754      | 519                                      | 4        |
| 3-Octanol                                                  | C <sub>8</sub> H <sub>18</sub> O               | 444      | 628.5    |            | 515                                      | 4        |
| 4-Octanol                                                  | C <sub>8</sub> H <sub>18</sub> O               | 449.5    | 625.1    |            | 515                                      | 4        |
| 2-Octanone                                                 | C <sub>8</sub> H <sub>16</sub> O               | 445.7    | 632.7    |            | 497                                      | 7        |
| 3-Octanone                                                 | C <sub>8</sub> H <sub>16</sub> O               | 440.7    | 627.7    |            | 497                                      | 7        |
| 4-Octanone                                                 | C <sub>8</sub> H <sub>16</sub> O               | 436      | 623.8    |            | 497                                      | 7        |
| 1-Octene                                                   | C <sub>8</sub> H <sub>16</sub>                 | 394.44   | 567.0    | 2.68       | 468                                      | 6        |
| <i>trans</i> -2-Octene                                     | C <sub>8</sub> H <sub>16</sub>                 | 398      | 569.8    |            |                                          | 59       |
| <i>trans</i> -4-Octene                                     | C <sub>8</sub> H <sub>16</sub>                 | 395.5    | 566.3    |            |                                          | 59       |
| Octylamine                                                 | C <sub>8</sub> H <sub>19</sub> N               | 452.8    | 641      | 2.6        | 517                                      | 9        |
| Octylbenzene                                               | C <sub>14</sub> H <sub>22</sub>                | 537      | 725      | 1.98       |                                          | 16       |
| Oxazole                                                    | C <sub>3</sub> H <sub>3</sub> NO               | 342.7    | 550.8    | 6.77       |                                          | 82       |
| Oxirane                                                    | C <sub>2</sub> H <sub>4</sub> O                | 283.8    | 469      | 7.2        | 142                                      | 7        |
| Paraldehyde                                                | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>  | 397.5    | 563      |            |                                          | 7        |
| 1 <i>H</i> -Pentadecafluoroheptane                         | C <sub>7</sub> HF <sub>15</sub>                | 369.2    | 495.8    |            |                                          | 49       |
| Pentadecane                                                | C <sub>15</sub> H <sub>32</sub>                | 543.8    | 708      | 1.48       | 966                                      | 2        |
| Pentadecanoic acid                                         | C <sub>15</sub> H <sub>30</sub> O <sub>2</sub> |          | 777      | 1.57       |                                          | 48       |
| 1-Pentadecanol                                             | C <sub>15</sub> H <sub>32</sub> O              | 573      | 757      | 1.60       |                                          | 80       |
| Pentafluorobenzene                                         | C <sub>6</sub> HF <sub>5</sub>                 | 358.89   | 530.97   | 3.531      | 324                                      | 49       |
| 3,3,4,4,4-Pentafluorobutan-2-one                           | C <sub>4</sub> H <sub>3</sub> F <sub>5</sub> O | 314.37   | 453.03   | 2.912      |                                          | 63       |
| Pentafluoroethane [HFC-125]                                | C <sub>2</sub> HF <sub>5</sub>                 | 224.65   | 339.20   | 3.617      | 214                                      | 30,64,66 |
| 1,1,1,2,2-Pentafluoropentan-3-one                          | C <sub>5</sub> H <sub>5</sub> F <sub>5</sub> O | 335.24   | 475.54   | 2.642      |                                          | 61       |
| Pentafluorophenol                                          | C <sub>6</sub> HF <sub>5</sub> O               | 418.8    | 609      | 4.0        | 348                                      | 49       |
| 1,1,1,2,2-Pentafluoropropane [R-245cb]                     | C <sub>3</sub> H <sub>3</sub> F <sub>5</sub>   | 255.8    | 380.11   | 3.137      | 273                                      | 49       |
| 1,1,2,2,3-Pentafluoropropane [HFC-245ca]                   | C <sub>3</sub> H <sub>3</sub> F <sub>5</sub>   | 298.2    | 447.57   |            |                                          | 45       |
| 1,1,1,3,3-Pentafluoropropane [HFC-245fa]                   | C <sub>3</sub> H <sub>3</sub> F <sub>5</sub>   | 288.5    | 427.16   | 3.651      | 260                                      | 45,54    |
| 1,1,1,2,2-Pentafluoro-3-(1,1,2,2-tetrafluoroethoxy)propane | C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O | 343.4    | 473.01   | 2.244      |                                          | 65       |

| Name                                         | Mol. Form.                                     | $T_b$ /K | $T_c$ /K | $P_c$ /MPa | $V_c$ /cm <sup>3</sup> mol <sup>-1</sup> | Ref.  |
|----------------------------------------------|------------------------------------------------|----------|----------|------------|------------------------------------------|-------|
| 2,3,4,5,6-Pentafluorotoluene                 | C <sub>7</sub> H <sub>3</sub> F <sub>5</sub>   | 390.7    | 566.52   | 3.126      | 384                                      | 49    |
| Pentanal                                     | C <sub>5</sub> H <sub>10</sub> O               | 376      | 567      | 3.97       | 313                                      | 7     |
| Pentane                                      | C <sub>5</sub> H <sub>12</sub>                 | 309.21   | 469.7    | 3.370      | 311                                      | 2     |
| Pentanedioic acid                            | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>   | 576.0    | 840      | 4.27       |                                          | 57    |
| Pentanenitrile                               | C <sub>5</sub> H <sub>9</sub> N                | 414.5    | 610.3    | 3.58       |                                          | 9,49  |
| Pentanoic acid                               | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | 459.3    | 637.2    | 3.63       | 346                                      | 7     |
| 1-Pentanol                                   | C <sub>5</sub> H <sub>12</sub> O               | 411.13   | 588.1    | 3.897      | 326                                      | 4     |
| 2-Pentanol                                   | C <sub>5</sub> H <sub>12</sub> O               | 392.5    | 560.3    | 3.675      | 329                                      | 4     |
| 3-Pentanol                                   | C <sub>5</sub> H <sub>12</sub> O               | 389.40   | 559.6    |            | 325                                      | 4     |
| 2-Pentanone                                  | C <sub>5</sub> H <sub>10</sub> O               | 375.41   | 561.1    | 3.683      | 321                                      | 7     |
| 3-Pentanone                                  | C <sub>5</sub> H <sub>10</sub> O               | 374.9    | 561.4    | 3.729      | 331                                      | 7     |
| 1-Pentene                                    | C <sub>5</sub> H <sub>10</sub>                 | 303.11   | 464.8    | 3.56       | 298.4                                    | 6     |
| <i>cis</i> -2-Pentene                        | C <sub>5</sub> H <sub>10</sub>                 | 310.08   | 475      | 3.69       |                                          | 6     |
| <i>trans</i> -2-Pentene                      | C <sub>5</sub> H <sub>10</sub>                 | 309.49   | 471      | 3.52       |                                          | 49    |
| Pentyl acetate                               | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>  | 422.4    | 599      | 2.73       | 470                                      | 7,23  |
| Pentylbenzene                                | C <sub>11</sub> H <sub>16</sub>                | 478.6    | 675      | 2.58       |                                          | 16    |
| Pentyl formate                               | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | 403.6    | 576      | 3.46       | 412                                      | 7     |
| 1-Pentyne                                    | C <sub>5</sub> H <sub>8</sub>                  | 313.3    | 493.5    |            |                                          | 49    |
| Perfluoroacetone                             | C <sub>3</sub> F <sub>6</sub> O                | 245.8    | 357.14   | 2.84       | 329                                      | 49    |
| Perfluorobutane                              | C <sub>4</sub> F <sub>10</sub>                 | 271.3    | 386.4    | 2.323      | 378                                      | 49    |
| Perfluoro-2-butyltetrahydrofuran             | C <sub>8</sub> F <sub>16</sub> O               | 375.8    | 500.2    | 1.607      | 588                                      | 49    |
| Perfluorocyclobutane [R-C318]                | C <sub>4</sub> F <sub>8</sub>                  | 267.3    | 388.46   | 2.784      | 324                                      | 49    |
| Perfluorocyclohexane                         | C <sub>6</sub> F <sub>12</sub>                 | 325.95 s | 457.2    | 2.43       |                                          | 49    |
| Perfluorocyclohexene                         | C <sub>6</sub> F <sub>10</sub>                 | 325.2    | 461.8    |            |                                          | 49    |
| Perfluorodecalin                             | C <sub>10</sub> F <sub>18</sub>                | 415      | 566      | 1.52       |                                          | 49    |
| Perfluorodecane                              | C <sub>10</sub> F <sub>22</sub>                | 417.4    | 542      | 1.45       |                                          | 49    |
| Perfluorodimethoxymethane                    | C <sub>3</sub> F <sub>8</sub> O <sub>2</sub>   | 263      | 372.3    | 2.333      | 363                                      | 18    |
| Perfluoro-2,3-dimethylbutane                 | C <sub>6</sub> F <sub>14</sub>                 | 333.0    | 463      | 1.87       | 525                                      | 49    |
| Perfluoroethyl ethyl ether                   | C <sub>4</sub> H <sub>5</sub> F <sub>5</sub> O | 301.26   | 431.23   | 2.533      | 366                                      | 32    |
| Perfluoroethyl 2,2,2-trifluoroethyl ether    | C <sub>4</sub> H <sub>2</sub> F <sub>8</sub> O | 301.04   | 421.68   | 2.330      | 409                                      | 32    |
| Perfluoroheptane                             | C <sub>7</sub> F <sub>16</sub>                 | 355.7    | 474.8    | 1.62       | 664                                      | 49    |
| Perfluoro-1-heptene                          | C <sub>7</sub> F <sub>14</sub>                 | 354.2    | 478.2    |            |                                          | 49    |
| Perfluorohexane                              | C <sub>6</sub> F <sub>14</sub>                 | 330.3    | 448.77   | 1.868      | 606                                      | 49    |
| Perfluoro-1-hexene                           | C <sub>6</sub> F <sub>12</sub>                 | 330.2    | 454.4    |            |                                          | 49    |
| Perfluoroisobutane                           | C <sub>4</sub> F <sub>10</sub>                 | 273      | 395.4    |            |                                          | 49    |
| Perfluoroisopropyl methyl ether [HFE-347mmy] | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O | 302.49   | 433.30   | 2.553      | 369                                      | 32    |
| Perfluoromethylcyclohexane                   | C <sub>7</sub> F <sub>14</sub>                 | 349.5    | 485.91   | 2.019      | 570                                      | 49    |
| Perfluoro-2-methylpentane                    | C <sub>6</sub> F <sub>14</sub>                 | 330.8    | 455.3    | 1.923      | 532                                      | 49    |
| Perfluoro-3-methylpentane                    | C <sub>6</sub> F <sub>14</sub>                 | 331.6    | 450      | 1.69       |                                          | 49    |
| Perfluoronaphthalene                         | C <sub>10</sub> F <sub>8</sub>                 | 482      | 673.1    |            |                                          | 49    |
| Perfluorononane                              | C <sub>9</sub> F <sub>20</sub>                 | 390.76   | 524      | 1.56       |                                          | 49    |
| Perfluorooctane                              | C <sub>8</sub> F <sub>18</sub>                 | 379.1    | 502      | 1.66       |                                          | 49    |
| Perfluorooxetane                             | C <sub>3</sub> F <sub>6</sub> O                | 244.8    | 361.8    | 3.03       | 272                                      | 18,47 |
| Perfluoropentane                             | C <sub>5</sub> F <sub>12</sub>                 | 302.4    | 420.59   | 2.045      | 473                                      | 49    |
| Perfluoropropane [HFC-218]                   | C <sub>3</sub> F <sub>8</sub>                  | 236.6    | 345.1    | 2.680      | 299                                      | 49    |
| Perfluoropropyl methyl ether [HFE-347mcc]    | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O | 307.38   | 437.70   | 2.481      | 377                                      | 32    |
| Perfluorotoluene                             | C <sub>7</sub> F <sub>8</sub>                  | 376.70   | 534.47   | 2.705      | 428                                      | 49    |
| Phenanthrene                                 | C <sub>14</sub> H <sub>10</sub>                | 613      | 869      |            |                                          | 4     |
| Phenanthridine                               | C <sub>13</sub> H <sub>9</sub> N               | 622.1    | 895      | 3.6        | 548                                      | 10    |
| Phenol                                       | C <sub>6</sub> H <sub>6</sub> O                | 455.02   | 694.2    | 5.93       |                                          | 7     |
| Phenyl acetate                               | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>   | 469      | 685.7    | 3.59       |                                          | 17    |
| Phenyl isocyanate                            | C <sub>7</sub> H <sub>5</sub> NO               | 436      | 656.9    | 4.00       |                                          | 82    |
| α-Pinene                                     | C <sub>10</sub> H <sub>16</sub>                | 429.4    | 644      |            | 454                                      | 6     |
| Piperazine                                   | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub>  | 421.8    | 656.3    | 5.42       | 269                                      | 9,81  |
| Piperidine                                   | C <sub>5</sub> H <sub>11</sub> N               | 379.37   | 594.1    |            |                                          | 9,10  |

| Name                                             | Mol. Form.        | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.  |
|--------------------------------------------------|-------------------|---------|---------|-----------|--------------------|-------|
| Propanal                                         | $C_3H_6O$         | 321     | 505     | 5.26      | 204                | 7     |
| Propane                                          | $C_3H_8$          | 231.1   | 369.83  | 4.248     | 203                | 2,67  |
| 1,3-Propanediamine                               | $C_3H_{10}N_2$    | 413.2   | 632     | 5.59      |                    | 9,56  |
| Propanenitrile                                   | $C_3H_5N$         | 370.29  | 561.3   | 4.26      | 246                | 9,49  |
| 1-Propanethiol                                   | $C_3H_8S$         | 341.0   | 537     | 4.6       | 286                | 8     |
| Propanoic acid                                   | $C_3H_6O_2$       | 414.30  | 598.5   | 4.67      | 233                | 7     |
| 1-Propanol                                       | $C_3H_8O$         | 370.4   | 536.8   | 5.169     | 218                | 4     |
| 2-Propanol                                       | $C_3H_8O$         | 355.5   | 508.3   | 4.764     | 222                | 4     |
| Propene                                          | $C_3H_6$          | 225.46  | 364.9   | 4.60      | 185                | 6     |
| 2-Propoxyethanol                                 | $C_5H_{12}O_2$    | 423.0   | 615     | 3.65      | 364                | 7     |
| 1-Propoxy-2-propanol                             | $C_6H_{14}O_2$    | 423     | 605.1   | 3.051     |                    | 14    |
| Propyl acetate                                   | $C_5H_{10}O_2$    | 374.69  | 549.7   | 3.36      | 345                | 7     |
| Propylamine                                      | $C_3H_9N$         | 320.37  | 499.2   | 4.74      |                    | 9,59  |
| Propylbenzene                                    | $C_9H_{12}$       | 432.39  | 638.35  | 3.200     | 440                | 3     |
| Propyl butanoate                                 | $C_7H_{14}O_2$    | 416.2   | 593.1   | 2.72      |                    | 7     |
| Propylcyclohexane                                | $C_9H_{18}$       | 429     | 630.8   | 2.86      |                    | 58,59 |
| Propylene carbonate                              | $C_4H_6O_3$       | 515     | 762.7   | 4.14      |                    | 17    |
| 1,2-Propanediol                                  | $C_3H_8O_2$       | 460.8   | 676.4   | 5.941     |                    | 7,14  |
| 1,3-Propanediol                                  | $C_3H_8O_2$       | 487.6   | 718.2   | 6.55      |                    | 14,17 |
| 1,2-Propylene glycol 1- <i>tert</i> -butyl ether | $C_7H_{16}O_2$    | 425.2   | 600.7   | 2.72      |                    | 60    |
| 1-Methoxy-2-propanol                             | $C_4H_{10}O_2$    | 392     | 579.8   | 4.113     |                    | 11,12 |
| 1,2-Propylene glycol monomethyl ether acetate    | $C_6H_{12}O_3$    | 420     | 597.8   | 3.01      | 432                | 7     |
| Propyl formate                                   | $C_4H_8O_2$       | 354.1   | 538.0   | 4.06      | 285                | 7     |
| Propyl isobutanoate                              | $C_7H_{14}O_2$    | 408.6   | 579.4   |           |                    | 7     |
| Propyl 3-methylbutanoate                         | $C_8H_{16}O_2$    | 429.1   | 609     |           |                    | 7     |
| Propyl propanoate                                | $C_6H_{12}O_2$    | 395.7   | 570     | 3.06      |                    | 7     |
| Propyne                                          | $C_3H_4$          | 250.0   | 402.4   | 5.63      | 163.5              | 6     |
| Pyrazine                                         | $C_4H_4N_2$       | 388     | 627     | 6.70      | 229                | 9     |
| Pyridine                                         | $C_5H_5N$         | 388.38  | 620.0   | 5.65      | 247                | 9,10  |
| Pyrocatechol                                     | $C_6H_6O_2$       | 518     | 800     | 6.24      |                    | 81    |
| Pyrrole                                          | $C_4H_5N$         | 402.94  | 640     | 5.7       |                    | 9,10  |
| Pyrrolidine                                      | $C_4H_9N$         | 359.71  | 569     | 5.7       | 245                | 9,10  |
| Quinoline                                        | $C_9H_7N$         | 510.31  | 782     |           |                    | 9,10  |
| Resorcinol                                       | $C_6H_6O_2$       | 549.7   | 836     | 6.24      |                    | 81    |
| Squalene                                         | $C_{30}H_{50}$    | 694.5   | 795.9   | 0.59      |                    | 15    |
| Stearic acid                                     | $C_{18}H_{36}O_2$ | 623     | 803     | 1.33      |                    | 48    |
| Styrene                                          | $C_8H_8$          | 418     | 635.2   | 3.87      |                    | 15    |
| Succinic acid                                    | $C_4H_6O_4$       | 508.2   | 851     | 6.59      |                    | 57    |
| Sulfolane                                        | $C_4H_8O_2S$      | 560.5   | 868     | 6.0       |                    | 82    |
| <i>o</i> -Terphenyl                              | $C_{18}H_{14}$    | 605     | 857     | 2.99      | 731                | 3     |
| <i>m</i> -Terphenyl                              | $C_{18}H_{14}$    | 636     | 883     | 2.48      | 724                | 3     |
| <i>p</i> -Terphenyl                              | $C_{18}H_{14}$    | 649     | 908     | 2.99      | 729                | 3     |
| 1,1,2,2-Tetrachloro-1,2-difluoroethane [R-112]   | $C_2Cl_4F_2$      | 366.0   | 551     |           |                    | 49    |
| 1,1,2,2-Tetrachloroethane [R-130]                | $C_2H_2Cl_4$      | 418.4   | 661.15  |           |                    | 49    |
| Tetrachloroethene                                | $C_2Cl_4$         | 394.5   | 620.2   |           |                    | 49    |
| Tetrachloromethane [R-10]                        | $CCl_4$           | 350.0   | 556.6   | 4.516     | 276                | 49    |
| Tetracosane                                      | $C_{24}H_{50}$    | 664.5   | 800     | 0.87      |                    | 2     |
| Tetradecane                                      | $C_{14}H_{30}$    | 526.73  | 693     | 1.57      | 894                | 2     |
| Tetradecanedioic acid                            | $C_{14}H_{26}O_4$ |         | 862     | 1.90      |                    | 57    |
| Tetradecanoic acid                               | $C_{14}H_{28}O_2$ |         | 763     | 1.64      |                    | 48    |
| 1-Tetradecanol                                   | $C_{14}H_{30}O$   | 560     | 747     | 1.81      |                    | 49    |
| 2-Tetradecanone                                  | $C_{14}H_{28}O$   |         | 728     |           | 896                | 7     |
| 3-Tetradecanone                                  | $C_{14}H_{28}O$   |         | 727     |           | 896                | 7     |
| 4-Tetradecanone                                  | $C_{14}H_{28}O$   |         | 725     |           | 900                | 7     |
| 7-Tetradecanone                                  | $C_{14}H_{28}O$   |         | 723     |           | 904                | 7     |

| Name                                                      | Mol. Form.                                     | $T_b$ /K | $T_c$ /K | $P_c$ /MPa | $V_c$ /cm <sup>3</sup> mol <sup>-1</sup> | Ref.     |
|-----------------------------------------------------------|------------------------------------------------|----------|----------|------------|------------------------------------------|----------|
| Tetraethylene glycol                                      | C <sub>8</sub> H <sub>18</sub> O <sub>5</sub>  | 601      | 800      | 3.2        |                                          | 7        |
| Tetraethylsilane                                          | C <sub>8</sub> H <sub>20</sub> Si              | 427.9    | 605      | 2.50       | 587                                      | 8        |
| 1,2,3,4-Tetrafluorobenzene                                | C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>   | 367.5    | 550.83   | 3.791      | 313                                      | 49       |
| 1,2,3,5-Tetrafluorobenzene                                | C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>   | 357.6    | 535.25   | 3.747      |                                          | 49       |
| 1,2,4,5-Tetrafluorobenzene                                | C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>   | 363.4    | 543.35   | 3.801      |                                          | 49       |
| 1,1,2,2-Tetrafluoro-2-(2,2-difluoromethoxy)ethane         | C <sub>4</sub> H <sub>4</sub> F <sub>6</sub> O | 352.13   | 501.08   | 3.090      |                                          | 65       |
| 1,1,1,2-Tetrafluoroethane [HFC-134a]                      | C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>   | 246.6    | 374.13   | 4.053      | 201                                      | 36,64,66 |
| 1,1,2,2-Tetrafluoroethane [HFC-134]                       | C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>   | 253.3    | 391.74   | 4.615      | 191                                      | 19,42    |
| Tetrafluoroethene [HFC-1114]                              | C <sub>2</sub> F <sub>4</sub>                  | 197.3    | 306.5    | 3.94       | 172                                      | 49       |
| 1,2,2,2-Tetrafluoroethyl difluoromethyl ether [HFE-236me] | C <sub>3</sub> H <sub>2</sub> F <sub>6</sub> O | 296.50   | 428.95   | 3.050      | 315                                      | 32       |
| 1,1,2,2-Tetrafluoroethyl 1,1,1-trifluoroethyl ether       | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O | 329.37   | 463.89   | 2.713      |                                          | 65       |
| Tetrafluoromethane [R-14]                                 | CF <sub>4</sub>                                | 145.2    | 227.6    | 3.74       | 140                                      | 49       |
| 1,1,2,2-Tetrafluoro-3-(1,1,2,2-tetrafluoroethoxy)propane  | C <sub>5</sub> H <sub>4</sub> F <sub>8</sub> O | 366.32   | 510.07   | 2.581      |                                          | 65       |
| 4,4,5,5-Tetrafluoro-2-trifluoromethyl-1,3-dioxolane       | C <sub>4</sub> HF <sub>7</sub> O <sub>2</sub>  | 304.98   | 435.06   | 2.645      |                                          | 63       |
| 3,4,4,4-Tetrafluoro-3-trifluoromethylbutan-2-one          | C <sub>5</sub> H <sub>3</sub> F <sub>7</sub> O | 328.78   | 467.64   | 2.522      |                                          | 63       |
| Tetrahydrofuran                                           | C <sub>4</sub> H <sub>8</sub> O                | 338      | 540.5    | 5.19       | 224                                      | 7        |
| 1,2,3,4-Tetrahydronaphthalene                             | C <sub>10</sub> H <sub>12</sub>                | 480.8    | 720      | 3.65       | 408                                      | 4        |
| Tetrahydropyran                                           | C <sub>5</sub> H <sub>10</sub> O               | 361      | 572      | 4.77       | 263                                      | 7        |
| Tetrahydrothiophene                                       | C <sub>4</sub> H <sub>8</sub> S                | 394.3    | 632      | 5.4        |                                          | 8        |
| 1,2,4,5-Tetraisopropylbenzene                             | C <sub>18</sub> H <sub>30</sub>                | 532      | 703      | 1.60       | 913                                      | 77       |
| 1,2,4,5-Tetramethylbenzene                                | C <sub>10</sub> H <sub>14</sub>                | 470.0    | 676      | 2.9        |                                          | 3        |
| 2,2,3,3-Tetramethylbutane                                 | C <sub>8</sub> H <sub>18</sub>                 | 379.60   | 567.8    | 2.87       | 461                                      | 49       |
| 2,2,3,3-Tetramethylhexane                                 | C <sub>10</sub> H <sub>22</sub>                | 433.5    | 623.0    | 2.51       |                                          | 5        |
| 2,2,5,5-Tetramethylhexane                                 | C <sub>10</sub> H <sub>22</sub>                | 410.6    | 581.4    | 2.19       |                                          | 5        |
| 2,2,3,3-Tetramethylpentane                                | C <sub>9</sub> H <sub>20</sub>                 | 413.4    | 607.5    | 2.74       |                                          | 5        |
| 2,2,3,4-Tetramethylpentane                                | C <sub>9</sub> H <sub>20</sub>                 | 406.2    | 592.6    | 2.60       |                                          | 5        |
| 2,2,4,4-Tetramethylpentane                                | C <sub>9</sub> H <sub>20</sub>                 | 395.44   | 574.6    | 2.49       |                                          | 5        |
| 2,3,3,4-Tetramethylpentane                                | C <sub>9</sub> H <sub>20</sub>                 | 414.7    | 607.5    | 2.72       |                                          | 5        |
| Tetramethylsilane                                         | C <sub>4</sub> H <sub>12</sub> Si              | 299.8    | 448.6    | 2.821      | 361.6                                    | 8        |
| Tetramethylstannane                                       | C <sub>4</sub> H <sub>12</sub> Sn              | 351      | 521.8    | 2.981      |                                          | 8        |
| Thiophene                                                 | C <sub>4</sub> H <sub>4</sub> S                | 357.2    | 580      | 5.70       | 219                                      | 8        |
| Thymol                                                    | C <sub>10</sub> H <sub>14</sub> O              | 505.7    | 698      |            |                                          | 7        |
| Toluene                                                   | C <sub>7</sub> H <sub>8</sub>                  | 383.78   | 591.80   | 4.110      | 316                                      | 3,15     |
| Triacontane                                               | C <sub>30</sub> H <sub>62</sub>                | 725.1    | 842      | 0.64       |                                          | 60       |
| 1,1,1-Trichloroethane [R-140a]                            | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>  | 347.24   | 545      | 4.30       |                                          | 49       |
| 1,1,2-Trichloroethane [R-140]                             | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>  | 387.0    | 602*     | 4.48*      | 281*                                     | 12       |
| Trichloroethene [R-1120]                                  | C <sub>2</sub> HCl <sub>3</sub>                | 360.36   | 544.2    | 5.02       |                                          | 49       |
| Trichlorofluoromethane [R-11]                             | CCl <sub>3</sub> F                             | 296.9    | 471.1    | 4.47       | 247                                      | 18       |
| Trichloromethane [R-20]                                   | CHCl <sub>3</sub>                              | 334.32   | 536.4    | 5.47       | 239                                      | 49       |
| 1,3,5-Trichloro-2,4,6-trifluorobenzene                    | C <sub>6</sub> Cl <sub>3</sub> F <sub>3</sub>  | 471.6    | 684.8    | 3.27       | 448                                      | 49       |
| 1,1,1-Trichloro-2,2,2-trifluoroethane [R-113a]            | C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>  | 318.7    | 482.9    |            |                                          | 40       |
| 1,1,2-Trichloro-1,2,2-trifluoroethane [R-113]             | C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>  | 320.9    | 487.3    | 3.42       | 325                                      | 49       |
| Tricosane                                                 | C <sub>23</sub> H <sub>48</sub>                | 653      | 790      | 0.92       |                                          | 2        |
| Tridecane                                                 | C <sub>13</sub> H <sub>28</sub>                | 508.62   | 675      | 1.68       | 823                                      | 2        |
| 1-Tridecanol                                              | C <sub>13</sub> H <sub>28</sub> O              | 547      | 734      | 1.935      |                                          | 49       |
| 2-Tridecanone                                             | C <sub>13</sub> H <sub>26</sub> O              | 536      | 717      |            | 820                                      | 7        |
| 3-Tridecanone                                             | C <sub>13</sub> H <sub>26</sub> O              |          | 716      |            | 823                                      | 7        |
| 4-Tridecanone                                             | C <sub>13</sub> H <sub>26</sub> O              |          | 712      |            | 823                                      | 7        |
| 5-Tridecanone                                             | C <sub>13</sub> H <sub>26</sub> O              |          | 710      |            | 826                                      | 7        |
| 6-Tridecanone                                             | C <sub>13</sub> H <sub>26</sub> O              |          | 709      |            | 826                                      | 7        |
| 7-Tridecanone                                             | C <sub>13</sub> H <sub>26</sub> O              | 534      | 708      |            | 830                                      | 7        |
| Tridecylbenzene                                           | C <sub>19</sub> H <sub>32</sub>                | 619      | 790      | 1.54       |                                          | 16       |
| Triethylamine                                             | C <sub>6</sub> H <sub>15</sub> N               | 362      | 535.6    | 3.03       | 389                                      | 9,49     |
| Triethylene glycol                                        | C <sub>6</sub> H <sub>14</sub> O <sub>4</sub>  | 558      | 780      | 3.3        |                                          | 7        |
| Trifluoroacetic acid                                      | C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>  | 346      | 491.3    | 3.258      | 204                                      | 49       |

| Name                                                          | Mol. Form.        | $T_b/K$ | $T_c/K$ | $P_c/MPa$ | $V_c/cm^3mol^{-1}$ | Ref.     |
|---------------------------------------------------------------|-------------------|---------|---------|-----------|--------------------|----------|
| Trifluoroacetonitrile                                         | $C_2F_3N$         | 204.4   | 311.11  | 3.618     | 202                | 49       |
| 1,2,3-Trifluorobenzene                                        | $C_6H_3F_3$       | 368     | 560.3   |           |                    | 13       |
| 1,2,4-Trifluorobenzene                                        | $C_6H_3F_3$       | 363     | 551.1   |           |                    | 13       |
| 1,3,5-Trifluorobenzene                                        | $C_6H_3F_3$       | 348.7   | 530.9   |           |                    | 13       |
| 1,1,1-Trifluoroethane [R-143a]                                | $C_2H_3F_3$       | 225.90  | 345.86  | 3.764     | 194                | 27,28    |
| 1,1,2-Trifluoroethane [R-143]                                 | $C_2H_3F_3$       | 276.9   | 429.8   | 5.241     | 207                | 40       |
| 2,2,2-Trifluoroethyl methyl ether [HFE-143a]                  | $C_3H_5F_3O$      | 304.77  | 448.98  | 3.513     | 277                | 32       |
| Trifluoroiodomethane                                          | $CF_3I$           | 250.7   | 396.44  | 3.953     | 226                | 24       |
| Trifluoromethane [R-23]                                       | $CHF_3$           | 191.1   | 298.98  | 4.82      | 135                | 42,78    |
| Trifluoromethyl difluoromethyl ether [HFE-125]                | $C_2HF_5O$        | 235     | 354.0   | 3.33      | 192                | 25,45,46 |
| Trifluoromethyl 1,1,2,2-tetrafluoroethyl ether [HFE-227ca2]   | $C_3HF_7O$        | 270     | 387.78  | 2.293     | 337                | 18,47    |
| 3,3,3-Trifluoropropene                                        | $C_3H_3F_3$       | 256     | 376.2   | 3.80      | 211                | 49       |
| Trimethylamine                                                | $C_3H_9N$         | 276.02  | 433     | 4.08      | 257                | 9,49     |
| 1,2,3-Trimethylbenzene                                        | $C_9H_{12}$       | 449.27  | 664.5   | 3.454     |                    | 3        |
| 1,2,4-Trimethylbenzene                                        | $C_9H_{12}$       | 442.53  | 649.1   | 3.232     |                    | 3        |
| 1,3,5-Trimethylbenzene                                        | $C_9H_{12}$       | 437.89  | 637.3   | 3.127     |                    | 3        |
| Trimethyl borate                                              | $C_3H_9BO_3$      | 340.7   | 501.7   | 3.59      |                    | 49       |
| 2,2,3-Trimethylbutane                                         | $C_7H_{16}$       | 354.01  | 531.1   | 2.95      | 398                | 5        |
| Trimethylchlorosilane                                         | $C_3H_9ClSi$      | 333     | 497.8   | 3.20      | 366                | 49       |
| 1 $\alpha$ ,3 $\alpha$ ,5 $\beta$ -1,3,5-Trimethylcyclohexane | $C_9H_{18}$       | 413.7   | 602.2   |           |                    | 5        |
| 3,3,5-Trimethylheptane                                        | $C_{10}H_{22}$    | 428.9   | 609.5   | 2.32      |                    | 5        |
| 2,2,5-Trimethylhexane                                         | $C_9H_{20}$       | 397.24  | 569.8   |           |                    | 5        |
| 2,2,3-Trimethylpentane                                        | $C_8H_{18}$       | 383     | 563.5   | 2.73      | 436                | 5        |
| 2,2,4-Trimethylpentane                                        | $C_8H_{18}$       | 372.37  | 543.8   | 2.57      | 468                | 5        |
| 2,3,3-Trimethylpentane                                        | $C_8H_{18}$       | 388.0   | 573.5   | 2.82      | 455                | 5        |
| 2,3,4-Trimethylpentane                                        | $C_8H_{18}$       | 386.7   | 566.4   | 2.73      | 461                | 5        |
| Tripropylamine                                                | $C_9H_{21}N$      | 429     | 637.9   |           |                    | 9        |
| Undecafluorocyclohexane                                       | $C_6HF_{11}$      | 335.2   | 477.7   |           |                    | 49       |
| Undecane                                                      | $C_{11}H_{24}$    | 469.1   | 639     | 1.98      | 689                | 2        |
| Undecanoic acid                                               | $C_{11}H_{22}O_2$ | 553     | 728     | 2.13      |                    | 48       |
| 1-Undecanol                                                   | $C_{11}H_{24}O$   | 518     | 703.6   | 2.147     | 718                | 4        |
| 2-Undecanone                                                  | $C_{11}H_{22}O$   | 504.7   | 688     |           | 692                | 7        |
| 3-Undecanone                                                  | $C_{11}H_{22}O$   | 500     | 685     |           | 692                | 7        |
| 4-Undecanone                                                  | $C_{11}H_{22}O$   |         | 681     |           | 692                | 7        |
| 5-Undecanone                                                  | $C_{11}H_{22}O$   | 500     | 679     |           | 692                | 7        |
| 6-Undecanone                                                  | $C_{11}H_{22}O$   | 501     | 678     |           | 692                | 7        |
| Undecylbenzene                                                | $C_{17}H_{28}$    | 589     | 763     | 1.64      |                    | 16       |
| Vinyl acetate                                                 | $C_4H_6O_2$       | 346.0   | 519.2   | 4.185     |                    | 7        |
| <i>o</i> -Xylene                                              | $C_8H_{10}$       | 417.7   | 630.3   | 3.732     | 370                | 3        |
| <i>m</i> -Xylene                                              | $C_8H_{10}$       | 412.27  | 617.0   | 3.541     | 375                | 3        |
| <i>p</i> -Xylene                                              | $C_8H_{10}$       | 411.52  | 616.2   | 3.511     | 378                | 3        |
| 2,3-Xylenol                                                   | $C_8H_{10}O$      | 490.1   | 722.8   |           |                    | 7        |
| 2,4-Xylenol                                                   | $C_8H_{10}O$      | 484.13  | 707.6   |           |                    | 7        |
| 2,5-Xylenol                                                   | $C_8H_{10}O$      | 484.3   | 706.9   |           |                    | 7        |
| 2,6-Xylenol                                                   | $C_8H_{10}O$      | 474.22  | 701.0   |           |                    | 7        |
| 3,4-Xylenol                                                   | $C_8H_{10}O$      | 500     | 729.8   |           |                    | 7        |
| 3,5-Xylenol                                                   | $C_8H_{10}O$      | 494.89  | 715.6   |           |                    | 7        |



## SUBLIMATION PRESSURE OF SOLIDS

This table gives the sublimation (vapor) pressure of some representative solids as a function of temperature. Entries include simple inorganic and organic substances in their solid phase below room temperature, as well as polycyclic organic compounds which show measurable sublimation pressure only at elevated temperatures. Substances are listed by molecular formula in the Hill order. Values marked by \* represent the solid-liquid-gas triple point. Note that some pressure values are in pascals (Pa) and others are in kilopascals (kPa). For conversion, 1 kPa = 7.506 mmHg = 0.0098692 atm.

## References

1. Lide, D. R. and Kehiaian, H. V., *CRC Handbook of Thermophysical and Thermochemical Data*, CRC Press, Boca Raton, FL, 1994.
2. *TRC Thermodynamic Tables*, Thermodynamic Research Center, Texas A&M University, College Station, TX.
3. Oja, V. and Suuberg, E. M., *J. Chem. Eng. Data*, 43, 486, 1998.

|                                              |       |       |       |       |       |        |        |        |         |
|----------------------------------------------|-------|-------|-------|-------|-------|--------|--------|--------|---------|
| Ar                                           | T/K   | 55    | 60    | 65    | 70    | 75     | 80     | 83.81* |         |
| Argon                                        | p/kPa | 0.2   | 0.8   | 2.8   | 7.7   | 18.7   | 40.7   | 68.8*  |         |
| BrH                                          | T/K   | 135   | 140   | 150   | 160   | 170    | 180    | 185.1* |         |
| Hydrogen bromide                             | p/kPa | 0.1   | 0.3   | 1.1   | 3.3   | 8.7    | 20.1   | 27.4*  |         |
| Br <sub>2</sub>                              | T/K   | 170   | 180   | 190   | 200   | 210    | 220    | 230    | 240*    |
| Bromine                                      | p/Pa  | 0.069 | 0.416 | 2.04  | 8.45  | 30.3   | 96.0   | 273    | 710*    |
| ClH                                          | T/K   | 120   | 130   | 140   | 150   | 155    | 159.0* |        |         |
| Hydrogen chloride                            | p/kPa | 0.1   | 0.5   | 1.9   | 5.8   | 9.5    | 13.5*  |        |         |
| Cl <sub>2</sub>                              | T/K   | 120   | 130   | 140   | 150   | 160    | 170*   |        |         |
| Chlorine                                     | p/Pa  | 0.144 | 1.52  | 11.2  | 63.1  | 283    | 1054*  |        |         |
| F <sub>4</sub> Si                            | T/K   | 130   | 140   | 150   | 160   | 170    | 175    | 180    | 186.3*  |
| Tetrafluorosilane                            | p/kPa | 0.2   | 0.9   | 3.9   | 14.0  | 43.8   | 74.2   | 122.4  | 220.8*  |
| F <sub>6</sub> S                             | T/K   | 150   | 165   | 180   | 190   | 200    | 210    | 220    | 223.1*  |
| Sulfur hexafluoride                          | p/kPa | 0.4   | 2.6   | 11.3  | 25.9  | 54.5   | 106.1  | 195.1  | 232.7*  |
| HI                                           | T/K   | 160   | 170   | 180   | 190   | 200    | 210    | 220    | 222.4*  |
| Hydrogen iodide                              | p/kPa | 0.2   | 0.8   | 2.2   | 5.3   | 11.7   | 23.6   | 44.1   | 49.3*   |
| H <sub>2</sub> O                             | T/K   | 190   | 210   | 225   | 240   | 250    | 260    | 270    | 273.16* |
| Water                                        | p/Pa  | 0.032 | 0.702 | 4.942 | 27.28 | 76.04  | 195.8  | 470.1  | 611.66* |
| H <sub>2</sub> S                             | T/K   | 140   | 150   | 160   | 165   | 170    | 175    | 180    | 187.6*  |
| Hydrogen sulfide                             | p/kPa | 0.2   | 0.6   | 1.9   | 3.2   | 5.2    | 8.3    | 12.7   | 22.7*   |
| H <sub>3</sub> N                             | T/K   | 160   | 170   | 180   | 190   | 195    | 195.4* |        |         |
| Ammonia                                      | p/kPa | 0.1   | 0.4   | 1.2   | 3.5   | 5.8    | 6.12*  |        |         |
| I <sub>2</sub>                               | T/K   | 240   | 250   | 260   | 270   | 280    | 290    | 300    | 310*    |
| Iodine                                       | p/Pa  | 0.081 | 0.297 | 0.971 | 2.89  | 7.92   | 20.1   | 47.9   | 107*    |
| Kr                                           | T/K   | 80    | 90    | 95    | 100   | 105    | 110    | 115.8* |         |
| Krypton                                      | p/kPa | 0.4   | 2.7   | 6.0   | 12.1  | 22.8   | 40.4   | 73.1*  |         |
| NO                                           | T/K   | 85    | 90    | 95    | 100   | 105    | 109.5* |        |         |
| Nitric oxide                                 | p/kPa | 0.1   | 0.4   | 1.3   | 3.8   | 10.0   | 21.9*  |        |         |
| Xe                                           | T/K   | 110   | 120   | 130   | 140   | 150    | 155    | 160    | 161.4*  |
| Xenon                                        | p/kPa | 0.3   | 1.5   | 4.9   | 14.0  | 34.2   | 51.1   | 74.2   | 81.7*   |
| CHN                                          | T/K   | 200   | 210   | 220   | 230   | 240    | 250    | 255    | 259.83* |
| Hydrogen cyanide                             | p/kPa | 0.2   | 0.4   | 1.0   | 2.2   | 4.8    | 9.7    | 13.6   | 18.62*  |
| CH <sub>4</sub>                              | T/K   | 65    | 70    | 75    | 80    | 85     | 90.69* |        |         |
| Methane                                      | p/kPa | 0.1   | 0.3   | 0.8   | 2.1   | 4.9    | 11.70* |        |         |
| CO                                           | T/K   | 50    | 55    | 60    | 65    | 68.13* |        |        |         |
| Carbon monoxide                              | p/kPa | 0.1   | 0.6   | 2.6   | 8.2   | 15.4*  |        |        |         |
| CO <sub>2</sub>                              | T/K   | 130   | 140   | 155   | 170   | 185    | 194.7  | 205    | 216.58* |
| Carbon dioxide                               | p/kPa | 0.032 | 0.187 | 1.674 | 9.987 | 44.02  | 101.3  | 227.1  | 518.0*  |
| C <sub>2</sub> Cl <sub>6</sub>               | T/K   | 275   | 300   | 325   | 350   | 375    | 400    | 425    | 459.9*  |
| Hexachloroethane                             | p/Pa  | 0.004 | 0.056 | 0.383 | 1.62  | 5.30   | 14.8   | 36.4   | 107.4*  |
| C <sub>2</sub> H <sub>2</sub>                | T/K   | 130   | 140   | 150   | 160   | 170    | 180    | 190    | 192.4*  |
| Acetylene                                    | p/kPa | 0.2   | 0.7   | 2.6   | 7.8   | 20.6   | 49.0   | 106.3  | 126.0*  |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> | T/K   | 250   | 260   | 270   | 280   | 289.7* |        |        |         |
| Acetic acid                                  | p/kPa | 0.092 | 0.199 | 0.406 | 0.79  | 1.29*  |        |        |         |
| C <sub>5</sub> H <sub>12</sub>               | T/K   | 200   | 210   | 220   | 230   | 240    | 250    | 255    | 256.58* |
| Neopentane                                   | p/kPa | 0.7   | 1.6   | 3.6   | 7.3   | 13.9   | 24.8   | 32.4   | 35.8*   |



|                                                                          |                             |               |               |               |               |              |              |              |                   |
|--------------------------------------------------------------------------|-----------------------------|---------------|---------------|---------------|---------------|--------------|--------------|--------------|-------------------|
| $C_6H_6Cl_6$<br>1,2,3,4,5,6-Hexa-<br>chlorocyclohexane (Lindane)         | <i>T</i> /K<br><i>p</i> /Pa | 300<br>0.01   | 320<br>0.13   | 330<br>0.39   | 340<br>1.04   | 350<br>2.66  | 360<br>6.42  | 370<br>14.8  | 380<br>32.7       |
| $C_6H_6O_2$<br>Resorcinol                                                | <i>T</i> /K<br><i>p</i> /Pa | 330<br>1.03   | 340<br>2.78   | 350<br>7.09   | 360<br>17.2   | 370<br>39.6  | 380<br>87.6  |              |                   |
| $C_6H_6O_2$<br><i>p</i> -Hydroquinone                                    | <i>T</i> /K<br><i>p</i> /Pa | 350<br>1.20   | 360<br>3.18   | 370<br>7.96   | 380<br>19.0   | 390<br>43.4  | 400<br>95.1  |              |                   |
| $C_{10}H_8$<br>Naphthalene                                               | <i>T</i> /K<br><i>p</i> /Pa | 250<br>0.036  | 270<br>0.514  | 280<br>1.662  | 290<br>4.918  | 300<br>13.43 | 310<br>34.15 | 330<br>182.9 | 353.43*<br>999.6* |
| $C_{12}H_8N_2$<br>Phenazine                                              | <i>T</i> /K<br><i>p</i> /Pa | 290<br>0.0013 | 300<br>0.0046 | 310<br>0.0150 | 320<br>0.0448 |              |              |              |                   |
| $C_{12}H_8O$<br>Dibenzofuran                                             | <i>T</i> /K<br><i>p</i> /Pa | 300<br>0.408  | 310<br>1.21   | 320<br>3.35   | 330<br>8.71   | 340<br>21.4  | 350<br>50.0  |              |                   |
| $C_{12}H_9N$<br>Carbazole                                                | <i>T</i> /K<br><i>p</i> /Pa | 350<br>0.086  | 355<br>0.140  | 360<br>0.245  |               |              |              |              |                   |
| $C_{13}H_7NO_2$<br>Benz[ <i>g</i> ]isoquinoline-5,10-dione               | <i>T</i> /K<br><i>p</i> /Pa | 330<br>0.006  | 340<br>0.018  | 350<br>0.053  | 360<br>0.148  | 370<br>0.394 | 380<br>0.994 |              |                   |
| $C_{13}H_8O$<br>1 <i>H</i> -Phenalen-1-one                               | <i>T</i> /K<br><i>p</i> /Pa | 330<br>0.040  | 340<br>0.113  | 350<br>0.302  |               |              |              |              |                   |
| $C_{13}H_8O_2$<br>3-Hydroxy-1 <i>H</i> -phenalen-1-one                   | <i>T</i> /K<br><i>p</i> /Pa | 400<br>0.006  | 410<br>0.018  | 420<br>0.053  | 430<br>0.144  |              |              |              |                   |
| $C_{13}H_9N$<br>Acridine                                                 | <i>T</i> /K<br><i>p</i> /Pa | 290<br>0.0024 | 300<br>0.0085 | 310<br>0.0278 | 320<br>0.0845 |              |              |              |                   |
| $C_{13}H_9N$<br>Phenanthridine                                           | <i>T</i> /K<br><i>p</i> /Pa | 310<br>0.020  | 320<br>0.066  | 330<br>0.206  | 340<br>0.603  |              |              |              |                   |
| $C_{14}H_{10}$<br>Anthracene                                             | <i>T</i> /K<br><i>p</i> /Pa | 320<br>0.014  | 330<br>0.043  | 340<br>0.125  | 350<br>0.342  | 360<br>1.01  | 370<br>2.38  | 380<br>5.35  | 390<br>11.5       |
| $C_{14}H_{10}$<br>Phenanthrene                                           | <i>T</i> /K<br><i>p</i> /Pa | 300<br>0.025  | 310<br>0.085  | 320<br>0.270  | 330<br>0.796  | 340<br>2.02  | 350<br>4.89  | 360<br>11.2  |                   |
| $C_{16}H_{10}$<br>Pyrene                                                 | <i>T</i> /K<br><i>p</i> /Pa | 320<br>0.008  | 330<br>0.024  | 340<br>0.073  | 350<br>0.208  | 360<br>0.556 | 370<br>1.32  | 380<br>2.86  | 390<br>6.30       |
| $C_{16}H_{10}O$<br>1-Pyrenol                                             | <i>T</i> /K<br><i>p</i> /Pa | 360<br>0.005  | 370<br>0.016  | 380<br>0.047  | 390<br>0.135  | 400<br>0.364 |              |              |                   |
| $C_{16}H_{12}S$<br>Benzo[ <i>b</i> ]naphtho-(2,1-<br><i>d</i> )thiophene | <i>T</i> /K<br><i>p</i> /Pa | 330<br>0.001  | 340<br>0.004  | 350<br>0.012  | 360<br>0.036  | 370<br>0.098 | 380<br>0.255 | 390<br>0.631 |                   |
| $C_{17}H_{12}$<br>11 <i>H</i> -Benzo[ <i>b</i> ]fluorene                 | <i>T</i> /K<br><i>p</i> /Pa | 340<br>0.003  | 350<br>0.009  | 360<br>0.029  | 370<br>0.085  | 380<br>0.235 | 390<br>0.619 | 400<br>1.55  |                   |
| $C_{18}H_{10}O_4$<br>6,11-Dihydroxy-5,12-<br>naphthacenedione            | <i>T</i> /K<br><i>p</i> /Pa | 420<br>0.008  | 430<br>0.022  | 440<br>0.055  | 450<br>0.131  |              |              |              |                   |
| $C_{18}H_{12}$<br>Chrysene                                               | <i>T</i> /K<br><i>p</i> /Pa | 390<br>0.087  | 400<br>0.221  | 410<br>0.539  | 420<br>1.26   |              |              |              |                   |
| $C_{18}H_{12}$<br>Naphthacene                                            | <i>T</i> /K<br><i>p</i> /Pa | 390<br>0.005  | 400<br>0.014  | 410<br>0.035  | 420<br>0.084  | 430<br>0.194 | 440<br>0.432 | 450<br>0.928 | 460<br>1.929      |
| $C_{20}H_{12}$<br>Perylene                                               | <i>T</i> /K<br><i>p</i> /Pa | 390<br>0.006  | 400<br>0.015  | 410<br>0.040  | 420<br>0.102  | 430<br>0.246 |              |              |                   |
| $C_{22}H_{14}$<br>Pentacene                                              | <i>T</i> /K<br><i>p</i> /Pa | 450<br>0.002  | 460<br>0.006  | 470<br>0.013  | 480<br>0.031  | 490<br>0.069 |              |              |                   |
| $C_{24}H_{12}$<br>Coronene                                               | <i>T</i> /K<br><i>p</i> /Pa | 430<br>0.004  | 440<br>0.010  | 450<br>0.021  | 460<br>0.046  | 470<br>0.097 | 480<br>0.197 | 490<br>0.389 | 500<br>0.747      |

## VAPOR PRESSURE

This table gives vapor pressure data for about 1800 inorganic and organic substances. In order to accommodate elements and compounds ranging from refractory to highly volatile in a single table, the temperature at which the vapor pressure reaches specified pressure values is listed. The pressure values run in decade steps from 1 Pa (about 7.5  $\mu$ m Hg) to 100 kPa (about 750 mm Hg). All temperatures are given in  $^{\circ}$ C.

The data used in preparing the table came from a large number of sources; the main references used for each substance are indicated in the last column. Since the data were refit in most cases, values appearing in this table may not be identical with values in the source cited. The temperature entry in the 100 kPa column is close to, but not identical with, the normal boiling point (which is defined as the temperature at which the vapor pressure reaches 101.325 kPa). Although some temperatures are quoted to 0.1  $^{\circ}$ C, uncertainties of several degrees should generally be assumed. Values followed by an "e" were obtained by extrapolating (usually with an Antoine equation) beyond the region for which experimental measurements were available and are thus subject to even greater uncertainty.

Compounds are listed by molecular formula following the Hill convention. Substances not containing carbon are listed first, followed by those that contain carbon. To locate an organic compound by name or CAS Registry Number when the molecular formula is not known, use the table "Physical Constants of Organic Compounds" in Section 3 and its indexes to determine the molecular formula. The indexes to "Physical Constants of Inorganic Compounds" in Section 4 can be used in a similar way.

More extensive and detailed vapor pressure data on selected important substances appear in other tables in this section of the *Handbook*. These substances are flagged by a symbol following the name as follows:

- \* See "Vapor Pressure of Fluids at Temperatures below 300 K"
- \*\* See "IUPAC Recommended Data for Vapor Pressure Calibration"
- \*\*\* See "Vapor Pressure of Ice" and "Vapor Pressure and other Saturation Properties of Water"

The following notations appear after individual temperature entries:

- s — Indicates the substance is a solid at this temperature.
- e — Indicates an extrapolation beyond the region where experimental measurements exist.
- i — Indicates the value was calculated from ideal gas thermodynamic functions, such as those in the *JANAF Thermochemical Tables* (see Reference 8).

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| Mol. form.                               | Name                            | Temperature in °C for the indicated pressure |          |          |          |          |         | Ref.   |
|------------------------------------------|---------------------------------|----------------------------------------------|----------|----------|----------|----------|---------|--------|
|                                          |                                 | 1 Pa                                         | 10 Pa    | 100 Pa   | 1 kPa    | 10 kPa   | 100 kPa |        |
| <i>Substances not containing carbon:</i> |                                 |                                              |          |          |          |          |         |        |
| Ag                                       | Silver                          | 1010                                         | 1140     | 1302     | 1509     | 1782     | 2160    | 2      |
| AgBr                                     | Silver(I) bromide               | 569 i                                        | 656 i    | 765 i    | 905 i    | 1093 i   | 1359 i  | 9      |
| AgCl                                     | Silver(I) chloride              | 670                                          | 769      | 873      | 1052     | 1264     | 1561    | 4      |
| AgI                                      | Silver(I) iodide                | 594                                          | 686      | 803      | 959      | 1177     | 1503    | 4      |
| Al                                       | Aluminum                        | 1209                                         | 1359     | 1544     | 1781     | 2091     | 2517    | 2      |
| AlB <sub>3</sub> H <sub>12</sub>         | Aluminum borohydride            |                                              |          |          | −46.8    | −9.4     | 45.5    | 4      |
| AlCl <sub>3</sub>                        | Aluminum trichloride            | 58.4 s                                       | 76.5 s   | 97.1 s   | 120.7 s  | 148.2 s  | 180.5 s | 4      |
| AlF <sub>3</sub>                         | Aluminum trifluoride            | 744 s                                        | 819 s    | 906 s    | 1008 s   | 1130 s   | 1276 s  | 8      |
| AlI <sub>3</sub>                         | Aluminum triiodide              |                                              |          |          | 218      | 285      | 385     | 4      |
| Al <sub>2</sub> O <sub>3</sub>           | Aluminum oxide                  |                                              |          | 2122     | 2351     | 2629     | 2975    | 4      |
| Ar                                       | Argon*                          |                                              | −226.4 s | −220.3 s | −212.4 s | −201.7 s | −186.0  | 1,5,31 |
| As                                       | Arsenic                         | 280 s                                        | 323 s    | 373 s    | 433 s    | 508 s    | 601 s   | 3      |
| AsCl <sub>3</sub>                        | Arsenic(III) chloride           |                                              |          | −8 e     | 21.3     | 63.1     | 129.4   | 1      |
| AsF <sub>3</sub>                         | Arsenic(III) fluoride           |                                              |          |          |          | 8.1      | 56.0    | 4      |
| AsI <sub>3</sub>                         | Arsenic(III) iodide             |                                              |          |          | 187      | 261      | 367 e   | 7      |
| As <sub>2</sub> O <sub>3</sub>           | Arsenic(III) oxide (arsenolite) | 133.7 s                                      | 163.0 s  | 196.8 s  | 236.2 s  | 283.0    |         | 34     |
| At                                       | Astatine                        | 88 s                                         | 119 s    | 156 s    | 202 s    | 258 s    | 334     | 2      |
| Au                                       | Gold                            | 1373                                         | 1541     | 1748     | 2008     | 2347     | 2805    | 2      |
| B                                        | Boron                           | 2075                                         | 2289     | 2549     | 2868     | 3272     | 3799    | 2      |
| BBr <sub>3</sub>                         | Boron tribromide                |                                              |          | −45 e    | −15 e    | 27.5     | 90.4    | 1      |
| BCl <sub>3</sub>                         | Boron trichloride*              |                                              |          | −94.0    | −70.5    | −37.4    | 12.3    | 4      |
| BF <sub>3</sub>                          | Boron trifluoride*              | −173.9 s                                     | −166.0 s | −156.0 s | −143.0 s | −125.9   | −101.1  | 4      |
| B <sub>2</sub> F <sub>4</sub>            | Tetrafluorodiborane             |                                              |          |          |          |          | −34     | 1      |
| B <sub>2</sub> H <sub>6</sub>            | Diborane                        |                                              |          | −162 e   | −147.0   | −125.8   | −92.6   | 1      |
| B <sub>5</sub> H <sub>9</sub>            | Pentaborane(9)                  |                                              |          |          | −34.8    | 3.8      | 57.6    | 4      |
| Ba                                       | Barium                          | 638 s                                        | 765      | 912      | 1115     | 1413     | 1897    | 9      |
| Be                                       | Beryllium                       | 1189 s                                       | 1335     | 1518     | 1750     | 2054     | 2469    | 2      |
| BeBr <sub>2</sub>                        | Beryllium bromide               | 203 s                                        | 240 s    | 283 s    | 335 s    | 397 s    | 473 s   | 4      |
| BeCl <sub>2</sub>                        | Beryllium chloride              | 196 s                                        | 237 s    | 284 s    | 339 s    | 402 s    | 487     | 4      |
| BeF <sub>2</sub>                         | Beryllium fluoride              |                                              | 686 e    | 767 e    | 869      | 999      | 1172 e  | 7      |
| BeI <sub>2</sub>                         | Beryllium iodide                | 188 s                                        | 229 s    | 276 s    | 333 s    | 402 s    | 487     | 4      |
| Bi                                       | Bismuth                         | 668                                          | 768      | 892      | 1052     | 1265     | 1562    | 2      |
| BiBr <sub>3</sub>                        | Bismuth tribromide              |                                              |          | 217 s    | 273 i    | 348 i    | 455 i   | 4,9    |
| BiCl <sub>3</sub>                        | Bismuth trichloride             |                                              |          |          | 248.9    | 328.6    | 438.7   | 1,4    |
| BrCs                                     | Cesium bromide                  | 531 s                                        | 601 s    | 701 i    | 834 i    | 1019 i   | 1293 e  | 9      |
| BrH                                      | Hydrogen bromide*               |                                              | −153.3 s | −140.4 s | −123.8 s | −101.5 s | −67.0   | 5      |
| BrH <sub>3</sub> Si                      | Bromosilane                     |                                              |          |          | −81.0    | −47.3    | 2.2     | 4      |
| BrH <sub>4</sub> N                       | Ammonium bromide                | 121 s                                        | 154 s    | 195 s    | 246 s    | 310.4 s  | 395.1 s | 5      |
| BrK                                      | Potassium bromide               | 597 s                                        | 674 s    | 773      |          |          |         | 25     |
| BrLi                                     | Lithium bromide                 |                                              | 630      | 733      | 868      | 1049     | 1308    | 4      |
| BrNa                                     | Sodium bromide                  |                                              |          | 791      | 931      | 1120     | 1389    | 4      |
| BrRb                                     | Rubidium bromide                |                                              |          | 766      | 903      | 1087     | 1350    | 4      |
| BrTl                                     | Thallium(I) bromide             |                                              |          |          | 509      | 635      | 817     | 4      |
| Br <sub>2</sub>                          | Bromine*                        | −87.7 s                                      | −71.8 s  | −52.7 s  | −29.3 s  | 2.5      | 58.4    | 1      |
| Br <sub>2</sub> Cd                       | Cadmium bromide                 | 373 s                                        | 435 s    | 509 s    |          |          |         | 27     |
| Br <sub>2</sub> Hg                       | Mercury(II) bromide             | 71 s                                         | 98 s     | 132 s    | 174 s    | 227 s    | 318     | 4      |
| Br <sub>2</sub> OS                       | Thionyl bromide                 | −49 e                                        | −29 e    | −5 e     | 27.8     | 72.9     | 139.6   | 5      |
| Br <sub>2</sub> Pb                       | Lead(II) bromide                | 374                                          | 431      | 502      | 597      | 726      | 914     | 4      |
| Br <sub>2</sub> S <sub>2</sub>           | Sulfur bromide                  | −7 e                                         | 15 e     | 42 e     | 78.4     | 128.1    | 200.9   | 5      |
| Br <sub>3</sub> In                       | Indium(III) bromide             |                                              |          | 304.6 s  | 328.7 s  | 364.8 s  |         | 1      |
| Br <sub>3</sub> OP                       | Phosphorus(V) oxybromide        |                                              |          |          | 64 e     | 115.5    | 191.4   | 5      |
| Br <sub>3</sub> P                        | Phosphorus(III) bromide         |                                              | −23 e    | 5 e      | 42.3     | 94.6     | 172.6   | 5      |
| Br <sub>3</sub> Sb                       | Antimony(III) bromide           |                                              |          |          | 136.5    | 196.9    | 286.5   | 1      |
| Br <sub>4</sub> Ge                       | Germanium(IV) bromide           |                                              |          |          | 51       | 105      | 188     | 4      |
| Br <sub>4</sub> Sn                       | Tin(IV) bromide                 |                                              |          |          | 67       | 122      | 204     | 4      |
| Br <sub>4</sub> Zr                       | Zirconium(IV) bromide           | 136 s                                        | 167 s    | 203 s    | 245 s    | 295 s    | 356 s   | 4      |
| Br <sub>5</sub> P                        | Phosphorus(V) bromide           |                                              | −19 s    | 4 s      | 31 s     | 65.5 s   | 110.1   | 5      |
| Ca                                       | Calcium                         | 591 s                                        | 683 s    | 798 s    | 954      | 1170     | 1482    | 2      |
| Cd                                       | Cadmium                         | 257 s                                        | 310 s    | 381      | 472      | 594      | 767     | 2      |

| Mol. form.                       | Name                                 | Temperature in °C for the indicated pressure |          |          |          |         |         | Ref.   |
|----------------------------------|--------------------------------------|----------------------------------------------|----------|----------|----------|---------|---------|--------|
|                                  |                                      | 1 Pa                                         | 10 Pa    | 100 Pa   | 1 kPa    | 10 kPa  | 100 kPa |        |
| CdCl <sub>2</sub>                | Cadmium chloride                     | 412 s                                        | 471 s    | 541 s    | 634      | 768     | 959     | 23, 27 |
| CdF <sub>2</sub>                 | Cadmium fluoride                     |                                              |          |          | 1257     | 1461    | 1742    | 4      |
| CdI <sub>2</sub>                 | Cadmium iodide                       | 296 s                                        | 344 s    | 406      | 498      | 622     | 795     | 4,27   |
| CdO                              | Cadmium oxide                        | 770 s                                        | 866 s    | 983 s    | 1128 s   | 1314 s  | 1558 s  | 4      |
| Ce                               | Cerium                               | 1719                                         | 1921     | 2169     | 2481     | 2886    | 3432    | 14     |
| ClCs                             | Cesium chloride                      |                                              |          | 730      | 864      | 1043    | 1297    | 4      |
| ClCu                             | Copper(I) chloride                   |                                              | 459      | 543      | 675      | 914     | 1477    | 4      |
| ClF                              | Chlorine fluoride*                   |                                              |          |          | -144.4   | -122.6  | -90.2   | 5      |
| ClF <sub>2</sub> P               | Phosphorus(III) chloride difluoride  |                                              |          |          | -119.5   | -91.1   | -47.6   | 5      |
| ClF <sub>3</sub>                 | Chlorine trifluoride                 |                                              |          |          | -63.7    | -33.0   | 11.4    | 5      |
| ClF <sub>5</sub>                 | Chlorine pentafluoride               |                                              |          |          | -88 e    | -59     | -14     | 7      |
| ClH                              | Hydrogen chloride*                   |                                              |          |          | -138.2 s | -118.0  | -85.2   | 1,5    |
| ClHO <sub>3</sub> S              | Chlorosulfonic acid                  | -40 e                                        | -20 e    | 5 e      | 38.7     | 85.0    | 153.6   | 5      |
| ClH <sub>4</sub> N               | Ammonium chloride                    | 91 s                                         | 121 s    | 159 s    | 204.7 s  | 263.1 s | 339.5 s | 5      |
| ClK                              | Potassium chloride                   | 625 s                                        | 704 s    | 804      | 945      | 1137    | 1411    | 23,25  |
| CLi                              | Lithium chloride                     |                                              | 649 i    | 761 i    | 905 i    | 1101 i  | 1381 i  | 8      |
| ClNO                             | Nitrosyl chloride                    |                                              | -116 s   | -100 s   | -78.7 s  | -50.2   | -5.7    | 5      |
| ClNO <sub>2</sub>                | Nitryl chloride                      | -121 e                                       | -113 e   | -102 e   | -86.1    | -60.9   | -15.7   | 5      |
| ClNa                             | Sodium chloride                      | 653 s                                        | 733 s    | 835      | 987      | 1182    | 1461    | 23,25  |
| ClO <sub>2</sub>                 | Chlorine dioxide*                    |                                              |          |          |          | -34.3   | 10.5    | 5      |
| ClRb                             | Rubidium chloride                    |                                              |          | 777      | 916      | 1105    | 1379    | 4      |
| ClTl                             | Thallium(I) chloride                 |                                              |          |          | 504      | 626     | 806     | 4      |
| Cl <sub>2</sub>                  | Chlorine*                            | -145 s                                       | -133.7 s | -120.2 s | -103.6 s | -76.1   | -34.2   | 1      |
| Cl <sub>2</sub> Co               | Cobalt(II) chloride                  |                                              |          |          |          | 818     | 1048    | 4      |
| Cl <sub>2</sub> FP               | Phosphorus(III) dichloride fluoride  |                                              |          |          | -71.1    | -37.4   | 13.5    | 5      |
| Cl <sub>2</sub> F <sub>3</sub> P | Phosphorus(V) dichloride trifluoride |                                              | -120 e   | -101 e   | -77.1    | -44.3   | 3 e     | 7      |
| Cl <sub>2</sub> Fe               | Iron(II) chloride                    |                                              |          |          | 685      | 821     | 1025    | 4      |
| Cl <sub>2</sub> Hg               | Mercury(II) chloride                 | 64.4 s                                       | 94.7 s   | 130.8 s  | 174.5 s  | 228.5 s | 304.0   | 4      |
| Cl <sub>2</sub> Mg               | Magnesium chloride                   |                                              |          | 762      | 908      | 1111    | 1414    | 4      |
| Cl <sub>2</sub> Mn               | Manganese(II) chloride               |                                              |          |          | 760      | 933     | 1189    | 4      |
| Cl <sub>2</sub> Ni               | Nickel(II) chloride                  | 534 s                                        | 592 s    | 662 s    | 747 s    | 852 s   | 985 s   | 4      |
| Cl <sub>2</sub> OS               | Thionyl chloride                     | -99 e                                        | -81 e    | -58 e    | -27.1    | 14.6    | 75.2    | 5      |
| Cl <sub>2</sub> O <sub>2</sub> S | Sulfuryl chloride                    |                                              |          |          | -27 e    | 11.8    | 69.0    | 5      |
| Cl <sub>2</sub> Pb               | Lead(II) chloride                    |                                              |          | 541 e    | 637      | 765     | 949     | 23     |
| Cl <sub>2</sub> S                | Sulfur dichloride                    | -76 e                                        | -61 e    | -41 e    | -16.7    | 15.3    | 58.7    | 5      |
| Cl <sub>2</sub> S <sub>2</sub>   | Sulfur chloride                      | -55 e                                        | -36 e    | -12 e    | 21.0     | 67.2    | 137.1   | 5      |
| Cl <sub>2</sub> Sn               | Tin(II) chloride                     |                                              | 253      | 308      | 381      | 479     | 622     | 4      |
| Cl <sub>2</sub> Zn               | Zinc chloride                        | 305 i                                        | 356 i    | 419 i    | 497 i    | 596 i   | 726 i   | 4,9,12 |
| Cl <sub>3</sub> Fe               | Iron(III) chloride                   | 118 s                                        | 153 s    | 190 s    | 229 s    | 268 s   | 319     | 4      |
| Cl <sub>3</sub> HSi              | Trichlorosilane                      |                                              |          | -81 e    | -56 e    | -21 e   | 31.6    | 7      |
| Cl <sub>3</sub> N                | Nitrogen trichloride                 |                                              |          |          | -25 e    | 13.2    | 70.6    | 5      |
| Cl <sub>3</sub> OP               | Phosphorus(V) oxychloride            |                                              |          |          |          | 39.9    | 105.0   | 5      |
| Cl <sub>3</sub> P                | Phosphorus(III) chloride             | -93 e                                        | -77 e    | -55 e    | -26.0    | 14.5    | 75.7    | 5      |
| Cl <sub>4</sub> Po               | Polonium(IV) chloride                |                                              |          |          |          | 300.6   | 389.4   | 5      |
| Cl <sub>4</sub> Se               | Selenium tetrachloride               | 23 s                                         | 45 s     | 71 s     | 102 s    | 141.4 s | 191.1 s | 5      |
| Cl <sub>4</sub> Si               | Tetrachlorosilane*                   |                                              |          |          | -39 e    | 0 e     | 57.3    | 1      |
| Cl <sub>4</sub> Te               | Tellurium tetrachloride              |                                              |          |          | 237 e    | 299.4   | 387.8   | 5      |
| Cl <sub>4</sub> Zr               | Zirconium(IV) chloride               | 117 s                                        | 146 s    | 181 s    | 222 s    | 272 s   | 336 s   | 9      |
| Cl <sub>5</sub> P                | Phosphorus(V) chloride               | -2 s                                         | 19 s     | 44 s     | 74 s     | 111.4 s | 158.9 s | 5      |
| Co                               | Cobalt                               | 1517                                         | 1687     | 1892     | 2150     | 2482    | 2925    | 2      |
| Cr                               | Chromium                             | 1383 s                                       | 1534 s   | 1718 s   | 1950     | 2257    | 2669    | 2      |
| Cs                               | Cesium                               | 144.5                                        | 195.6    | 260.9    | 350.0    | 477.1   | 667.0   | 13,30  |
| CsF                              | Cesium fluoride                      |                                              |          |          | 825      | 999     | 1249    | 4      |
| CsI                              | Cesium iodide                        | 523 s                                        | 595 s    | 692      | 854      | 1029    | 1278    | 4,25   |
| Cu                               | Copper                               | 1236                                         | 1388     | 1577     | 1816     | 2131    | 2563    | 2      |
| CuI                              | Copper(I) iodide                     |                                              |          |          | 636      | 864     | 1331    | 4      |
| Dy                               | Dysprosium                           | 1105 s                                       | 1250 s   | 1431 i   | 1681 i   | 2031 i  | 2558 i  | 3      |
| Er                               | Erbium                               | 1231 s                                       | 1390 s   | 1612 i   | 1890 i   | 2279 i  | 2859 i  | 3      |

| Mol. form.                       | Name                            | Temperature in °C for the indicated pressure |          |          |          |          |         | Ref.    |
|----------------------------------|---------------------------------|----------------------------------------------|----------|----------|----------|----------|---------|---------|
|                                  |                                 | 1 Pa                                         | 10 Pa    | 100 Pa   | 1 kPa    | 10 kPa   | 100 kPa |         |
| Eu                               | Europium                        | 590 s                                        | 684 s    | 799 s    | 961      | 1179     | 1523    | 14      |
| FH                               | Hydrogen fluoride*              |                                              |          |          | -71.1    | -33.7    | 19.2    | 1,5     |
| FHO <sub>3</sub> S               | Fluorosulfonic acid             | -14 e                                        | 4 e      | 28 e     | 59.1     | 101.3    | 162.2   | 5       |
| FK                               | Potassium fluoride              |                                              |          | 869      | 1017     | 1216     | 1499    | 4       |
| FLi                              | Lithium fluoride                | 801 s                                        | 896      | 1024     | 1188     | 1395     | 1672    | 4,12,25 |
| FNO                              | Nitrosyl fluoride               |                                              |          | -131 e   | -116.1   | -94.3    | -60.1   | 5       |
| FNO <sub>2</sub>                 | Nitryl fluoride                 |                                              | -156 e   | -144 e   | -128.1   | -106.0   | -72.6   | 5       |
| FNO <sub>3</sub>                 | Fluorine nitrate                | -160 e                                       | -149 e   | -135 e   | -115.1   | -87.4    | -45.0   | 5       |
| FNa                              | Sodium fluoride                 |                                              | 920 s    | 1058     | 1218     | 1426     | 1702    | 4,12,24 |
| FRb                              | Rubidium fluoride               |                                              |          | 910      | 1001     | 1145     | 1409    | 4,12    |
| F <sub>2</sub>                   | Fluorine*                       | -235 s                                       | -229.5 s | -222.9 s | -214.8   | -204.3   | -188.3  | 1,5     |
| F <sub>2</sub> O                 | Fluorine monoxide*              | -211.7                                       | -204.7   | -195.9   | -184.2   | -168.2   | -144.9  | 5       |
| F <sub>2</sub> OS                | Thionyl fluoride                |                                              |          | -124 e   | -106.5   | -81.5    | -44.1   | 5       |
| F <sub>2</sub> O <sub>2</sub> Re | Rhenium(VI) dioxidydifluoride   |                                              |          |          | 89.2     | 131.9    | 185 e   | 26      |
| F <sub>2</sub> Pb                | Lead(II) fluoride               |                                              |          |          | 865      | 1054     | 1292    | 4       |
| F <sub>2</sub> Xe                | Xenon difluoride                |                                              |          | 2.9 s    | 31.8 s   | 67.9 s   | 114 s   | 1,5     |
| F <sub>2</sub> Zn                | Zinc fluoride                   | 731 s                                        | 813 s    | 911 i    | 1048 i   | 1237 i   | 1503 i  | 9       |
| F <sub>3</sub> N                 | Nitrogen trifluoride*           | -201 e                                       | -194 e   | -185 e   | -172.8   | -155.5   | -129.2  | 5       |
| F <sub>3</sub> OP                | Phosphorus(V) oxyfluoride       | -124 s                                       | -113 s   | -100 s   | -83.7 s  | -64.1 s  | -39.7 s | 5       |
| F <sub>3</sub> P                 | Phosphorus(III) fluoride*       |                                              |          |          | -152 e   | -132.6   | -101.4  | 5       |
| F <sub>4</sub> MoO               | Molybdenum(VI) oxytetrafluoride | -21 s                                        | 3 s      | 33 s     | 69.3 s   | 117.3    | 184.1   | 26      |
| F <sub>4</sub> ORe               | Rhenium(VI) oxytetrafluoride    | 5 s                                          | 26 s     | 50.7 s   | 80.1 s   | 117.1    | 171.2   | 26      |
| F <sub>4</sub> OW                | Tungsten(VI) oxytetrafluoride   | 2 s                                          | 25 s     | 52.1 s   | 84.3 s   | 126.7    | 185.4   | 26      |
| F <sub>4</sub> S                 | Sulfur tetrafluoride            |                                              |          |          | -110.0   | -82.1    | -40.3   | 5       |
| F <sub>4</sub> Se                | Selenium tetrafluoride          |                                              |          |          | 13.6     | 51.6     | 104.7   | 5       |
| F <sub>4</sub> Si                | Tetrafluorosilane*              | -166 s                                       | -157 s   | -145.6 s | -132.3 s | -115.7 s | -94.9 s | 4,7     |
| F <sub>5</sub> Mo                | Molybdenum(V) fluoride          |                                              |          |          | 86.6     | 140.3    | 213 e   | 26      |
| F <sub>5</sub> Nb                | Niobium(V) fluoride             |                                              |          |          | 80       | 140      | 224     | 4       |
| F <sub>5</sub> ORe               | Rhenium(VII) oxypentafluoride   | -103 s                                       | -84 s    | -59 s    | -28 s    | 13.7 s   | 72.8    | 26      |
| F <sub>5</sub> Os                | Osmium(V) fluoride              |                                              |          | 74.1     | 113.2    | 162.3    | 226 e   | 26      |
| F <sub>5</sub> P                 | Phosphorus(V) fluoride          | -157 s                                       | -148 s   | -137 s   | -124.5 s | -108.6 s | -84.8   | 5       |
| F <sub>5</sub> Re                | Rhenium(V) fluoride             |                                              |          | 58.8     | 99.5     | 152 e    | 221 e   | 26      |
| F <sub>5</sub> Ta                | Tantalum(V) fluoride            |                                              |          |          |          | 119      | 229     | 4       |
| F <sub>6</sub> Ir                | Iridium(VI) fluoride            | -88 s                                        | -71 s    | -51 s    | -27 s    | 3.8 s    | 53.1    | 26      |
| F <sub>6</sub> Mo                | Molybdenum(VI) fluoride         | -98 s                                        | -82 s    | -64 s    | -41.2 s  | -13.4 s  | 33.5    | 26      |
| F <sub>6</sub> Os                | Osmium(VI) fluoride             | -89 s                                        | -73 s    | -54 s    | -30.6 s  | -1.7 s   | 47.4    | 26      |
| F <sub>6</sub> Re                | Rhenium(VI) fluoride            | -97 s                                        | -82 s    | -63 s    | -40.2 s  | -11.9 s  | 33.4    | 26      |
| F <sub>6</sub> S                 | Sulfur hexafluoride*            | -158 s                                       | -147 s   | -133.6 s | -116.6 s | -94.4 s  | -64.1 s | 5       |
| F <sub>6</sub> Se                | Selenium hexafluoride           | -143 s                                       | -132 s   | -118 s   | -100.7 s | -77.8 s  | -46.5 s | 5       |
| F <sub>6</sub> Te                | Tellurium hexafluoride          | -142 s                                       | -130 s   | -115 s   | -96 s    | -71.8 s  | -39.1 s | 5       |
| F <sub>6</sub> W                 | Tungsten(VI) fluoride           | -107 s                                       | -92 s    | -74 s    | -52.1 s  | -24.8 s  | 16.9    | 26      |
| F <sub>10</sub> S <sub>2</sub>   | Sulfur decafluoride             |                                              |          |          |          | -22.0    | 28.5    | 5       |
| Fe                               | Iron                            | 1455 s                                       | 1617     | 1818     | 2073     | 2406     | 2859    | 2       |
| Fr                               | Francium                        | 131 e                                        | 181 e    | 246 e    | 335 e    | 465 e    | 673 e   | 2       |
| Ga                               | Gallium                         | 1037                                         | 1175     | 1347     | 1565     | 1852     | 2245    | 2       |
| Gd                               | Gadolinium                      | 1563 i                                       | 1755 i   | 1994 i   | 2300 i   | 2703 i   | 3262 i  | 3       |
| Ge                               | Germanium                       | 1371                                         | 1541     | 1750     | 2014     | 2360     | 2831    | 2       |
| HI                               | Hydrogen iodide*                | -146 s                                       | -135.2 s | -120.8 s | -101.9 s | -75.9 s  | -35.9   | 5       |
| HKO                              | Potassium hydroxide             | 520 e                                        | 601 e    | 704      | 842      | 1035     | 1325    | 4       |
| HNO <sub>3</sub>                 | Nitric acid                     |                                              |          | -37 e    | -9 e     | 28.4     | 82.2    | 5       |
| HN <sub>3</sub>                  | Hydrazoic acid                  |                                              |          | -79 e    | -54 e    | -18.0    | 35.7    | 5       |
| HNaO                             | Sodium hydroxide                | 513                                          | 605      | 722      | 874      | 1080     | 1377    | 4       |
| H <sub>2</sub>                   | Hydrogen*                       |                                              |          |          |          | -258.6   | -252.8  | 1       |
| H <sub>2</sub> I <sub>2</sub> Si | Diiodosilane                    |                                              |          |          | 11.8     | 70.5     | 149.4   | 4       |
| H <sub>2</sub> O                 | Water***                        | -60.7 s                                      | -42.2 s  | -20.3 s  | 7.0      | 45.8     | 99.6    | 36,37   |
| H <sub>2</sub> O <sub>2</sub>    | Hydrogen peroxide               |                                              |          | 13 e     | 45 e     | 89.0     | 149.8   | 5       |
| H <sub>2</sub> O <sub>4</sub> S  | Sulfuric acid                   | 72                                           | 103      | 140      | 187      | 248      | 330     | 4       |
| H <sub>2</sub> S                 | Hydrogen sulfide*               |                                              | -149 s   | -136 s   | -118.9 s | -95.9 s  | -60.5   | 1,5     |
| H <sub>2</sub> S <sub>2</sub>    | Hydrogen disulfide              |                                              |          |          | -27 e    | 12.2     | 70.7    | 5       |

| Mol. form.                     | Name                                 | Temperature in °C for the indicated pressure |          |          |          |          |         | Ref.  |
|--------------------------------|--------------------------------------|----------------------------------------------|----------|----------|----------|----------|---------|-------|
|                                |                                      | 1 Pa                                         | 10 Pa    | 100 Pa   | 1 kPa    | 10 kPa   | 100 kPa |       |
| H <sub>2</sub> Se              | Hydrogen selenide                    | –145 s                                       | –134 s   | –120 s   | –102.8 s | –78.9 s  | –41.5   | 5     |
| H <sub>2</sub> Te              | Hydrogen telluride                   |                                              |          |          |          | –46.6    | –2.3    | 5     |
| H <sub>3</sub> Si              | Iodosilane                           |                                              |          |          | –47.7    | –10.1    | 45.2    | 4     |
| H <sub>3</sub> N               | Ammonia*                             | –139 s                                       | –127 s   | –112 s   | –94.5 s  | –71.3    | –33.6   | 1,5,6 |
| H <sub>3</sub> NO              | Hydroxylamine                        |                                              |          |          | 43.7     | 73.3     | 109.8   | 4     |
| H <sub>3</sub> P               | Phosphine*                           | –182 s                                       | –173 s   | –161 s   | –145 s   | –122.7   | –88.0   | 5     |
| H <sub>4</sub> IN              | Ammonium iodide                      | 125 s                                        | 159 s    | 201 s    | 253 s    | 318.4 s  | 405.2 s | 5     |
| H <sub>4</sub> N <sub>2</sub>  | Hydrazine                            |                                              |          |          | 14.7     | 55.6     | 113 e   | 5     |
| H <sub>4</sub> Si              | Silane*                              |                                              |          | –181     | –165.4   | –143.7   | –111.8  | 4     |
| He                             | Helium*                              |                                              |          |          |          | –270.6   | –268.9  | 2     |
| Hf                             | Hafnium                              | 2416                                         | 2681     | 3004     | 3406     | 3921     | 4603    | 9     |
| Hg                             | Mercury**                            | 42.0                                         | 76.6     | 120.0    | 175.6    | 250.3    | 355.9   | 29,30 |
| HgI <sub>2</sub>               | Mercury(II) iodide                   | 85.1 s                                       | 115.6 s  | 152.4 s  | 197.8 s  | 255.1 s  | 353.6   | 4     |
| Ho                             | Holmium                              | 1159 s                                       | 1311 s   | 1502 i   | 1767 i   | 2137 i   | 2691 i  | 3     |
| IK                             | Potassium iodide                     |                                              |          | 731      | 866      | 1052     | 1322    | 4     |
| ILi                            | Lithium iodide                       | 545                                          | 619      | 710      | 824      | 972      | 1170    | 4     |
| INa                            | Sodium iodide                        |                                              |          | 753      | 883      | 1058     | 1301    | 4     |
| IRb                            | Rubidium iodide                      |                                              |          | 733      | 866      | 1045     | 1302    | 4     |
| ITl                            | Thallium(I) iodide                   |                                              |          |          | 520      | 644      | 821     | 4     |
| I <sub>2</sub>                 | Iodine (rhombic)                     | –12.8 s                                      | 9.3 s    | 35.9 s   | 68.7 s   | 108 s    | 184.0   | 1,2   |
| I <sub>2</sub> Pb              | Lead(II) iodide                      |                                              |          | 470      | 558      | 682      | 869     | 4     |
| I <sub>2</sub> Zn              | Zinc iodide                          | 301 s                                        | 351 s    | 409 s    | 488 i    | 598 i    | 750 i   | 9     |
| I <sub>3</sub> Sb              | Antimony(III) iodide                 |                                              |          |          | 214.9    | 292.0    | 401.2   | 4     |
| I <sub>4</sub> Sn              | Tin(IV) iodide                       |                                              |          |          | 167.1    | 242.7    | 347.7   | 4     |
| I <sub>4</sub> Zr              | Zirconium(IV) iodide                 | 187 s                                        | 220 s    | 259 s    | 305 s    | 361 s    | 430 s   | 4     |
| In                             | Indium                               | 923                                          | 1052     | 1212     | 1417     | 1689     | 2067    | 2     |
| Ir                             | Iridium                              | 2440 s                                       | 2684     | 2979     | 3341     | 3796     | 4386    | 2     |
| K                              | Potassium                            | 200.2                                        | 256.5    | 328      | 424      | 559      | 756.2   | 13,30 |
| Kr                             | Krypton*                             | –214.0 s                                     | –208.0 s | –199.4 s | –188.9 s | –174.6 s | –153.6  | 5     |
| La                             | Lanthanum                            | 1732 i                                       | 1935 i   | 2185 i   | 2499 i   | 2905 i   | 3453 i  | 3     |
| Li                             | Lithium                              | 524.3                                        | 612.3    | 722.1    | 871.2    | 1064.3   | 1337.1  | 13,30 |
| Lu                             | Lutetium                             | 1633 s                                       | 1829.8   | 2072.8   | 2380 i   | 2799 i   | 3390 i  | 3     |
| Mg                             | Magnesium                            | 428 s                                        | 500 s    | 588 s    | 698      | 859      | 1088    | 2     |
| Mn                             | Manganese                            | 955 s                                        | 1074 s   | 1220 s   | 1418     | 1682     | 2060    | 2     |
| Mo                             | Molybdenum                           | 2469 s                                       | 2721     | 3039     | 3434     | 3939     | 4606    | 2     |
| MoO <sub>3</sub>               | Molybdenum(VI) oxide                 |                                              |          |          | 801      | 935      | 1151    | 4     |
| NO                             | Nitric oxide*                        | –201 s                                       | –195 s   | –188 s   | –179.3 s | –168.1 s | –151.9  | 5     |
| N <sub>2</sub>                 | Nitrogen*                            | –236 s                                       | –232 s   | –226.8 s | –220.2 s | –211.1 s | –195.9  | 1,5   |
| N <sub>2</sub> O               | Nitrous oxide*                       | –167 s                                       | –157 s   | –145.4 s | –131.1 s | –112.9 s | –88.7   | 5     |
| N <sub>2</sub> O <sub>4</sub>  | Nitrogen tetroxide                   | –92 s                                        | –78 s    | –61 s    | –41.1 s  | –16.6 s  | 28.7    | 5     |
| N <sub>2</sub> O <sub>5</sub>  | Nitrogen pentoxide                   | –71 s                                        | –56 s    | –40 s    | –19.9 s  | 3.9 s    | 33.2    | 5     |
| Na                             | Sodium                               | 280.6                                        | 344.2    | 424.3    | 529      | 673      | 880.2   | 13,30 |
| Nb                             | Niobium                              | 2669                                         | 2934     | 3251     | 3637     | 4120     | 4740    | 2     |
| Nd                             | Neodymium                            | 1322.3                                       | 1501.2   | 1725.3   | 2023 i   | 2442 i   | 3063 i  | 3     |
| Ne                             | Neon*                                | –261 s                                       | –260 s   | –258 s   | –255 s   | –252 s   | –246.1  | 2     |
| Ni                             | Nickel                               | 1510                                         | 1677     | 1881     | 2137     | 2468     | 2911    | 2     |
| OPb                            | Lead(II) oxide                       | 724                                          | 816      | 928      | 1065     | 1241     | 1471    | 4     |
| OSr                            | Strontium oxide                      | 1789 s                                       | 1903 s   | 2047 s   | 2235 s   | 2488 s   |         | 4     |
| O <sub>2</sub>                 | Oxygen*                              |                                              |          |          | –211.9   | –200.5   | –183.1  | 1,28  |
| O <sub>2</sub> S               | Sulfur dioxide*                      |                                              |          | –98 s    | –80 s    | –52.2    | –10.3   | 1,5   |
| O <sub>2</sub> Se              | Selenium dioxide                     | 124.5 s                                      | 153.9 s  | 188 s    | 228 s    | 275 s    | 315 s   | 38    |
| O <sub>2</sub> Si              | Silicon dioxide                      | 1966 i                                       | 2149 i   | 2368 i   |          |          |         | 8     |
| O <sub>3</sub>                 | Ozone*                               | –189 e                                       | –182 e   | –172 e   | –158 e   | –139.7   | –111.5  | 5     |
| O <sub>3</sub> P <sub>2</sub>  | Phosphorus(III) oxide                |                                              |          |          | 47.3     | 100.3    | 172.8   | 4     |
| O <sub>3</sub> S               | Sulfur trioxide                      |                                              |          |          | –20 s    | 6.6 s    | 44.5    | 5     |
| O <sub>3</sub> Sb <sub>2</sub> | Antimony(III) oxide<br>(valentinite) | 426.1 s                                      | 478 s    | 539 s    | 610 s    | 907      | 1420    | 4,35  |
| O <sub>5</sub> P <sub>2</sub>  | Phosphorus(V) oxide                  | 285 s                                        | 328 s    | 377.5 s  | 434.4 s  | 500.5 s  | 591     | 4     |
| O <sub>7</sub> Re <sub>2</sub> | Rhenium(VII) oxide                   | 147 s                                        | 176 s    | 208 s    | 244 s    | 284 s    | 362     | 4     |
| Os                             | Osmium                               | 2887 s                                       | 3150     | 3478     | 3875     | 4365     | 4983    | 2     |



| Mol. form. | Name               | Temperature in °C for the indicated pressure |        |        |          |          |         | Ref.  |
|------------|--------------------|----------------------------------------------|--------|--------|----------|----------|---------|-------|
|            |                    | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa    | 10 kPa   | 100 kPa |       |
| P          | Phosphorus (white) | 6 s                                          | 34 s   | 69     | 115      | 180      | 276     | 3,9   |
| P          | Phosphorus (red)   | 182 s                                        | 216 s  | 256 s  | 303 s    | 362 s    | 431 s   | 2,3   |
| Pb         | Lead               | 705                                          | 815    | 956    | 1139     | 1387     | 1754    | 2     |
| PbS        | Lead(II) sulfide   | 656 s                                        | 741 s  | 838 s  | 953 s    | 1088 s   | 1280    | 4     |
| Pd         | Palladium          | 1448 s                                       | 1624   | 1844   | 2122     | 2480     | 2961    | 2     |
| Po         | Polonium           |                                              |        |        | 573 e    | 730.2    | 963.3   | 5     |
| Pr         | Praseodymium       | 1497.7                                       | 1699.4 | 1954 i | 2298 i   | 2781 i   | 3506 i  | 3     |
| Pt         | Platinum           | 2057                                         | 2277 e | 2542   | 2870     | 3283     | 3821    | 2     |
| Pu         | Plutonium          | 1483                                         | 1680   | 1925   | 2238     | 2653     | 3226    | 2     |
| Ra         | Radium             | 546 s                                        | 633 s  | 764    | 936      | 1173     | 1526    | 2     |
| Rb         | Rubidium           | 160.4                                        | 212.5  | 278.9  | 368      | 496.1    | 685.3   | 13,30 |
| Re         | Rhenium            | 3030 s                                       | 3341   | 3736   | 4227     | 4854     | 5681    | 2     |
| Rh         | Rhodium            | 2015                                         | 2223   | 2476   | 2790     | 3132     | 3724    | 2     |
| Rn         | Radon*             | -163 s                                       | -152 s | -139 s | -121.4 s | -97.6 s  | -62.3   | 5     |
| Ru         | Ruthenium          | 2315 s                                       | 2538   | 2814   | 3151     | 3572     | 4115    | 2     |
| S          | Sulfur             | 102 s                                        | 135    | 176    | 235      | 318      | 444     | 3     |
| Sb         | Antimony           | 534 s                                        | 603 s  | 738    | 946      | 1218     | 1585    | 2,3   |
| Sc         | Scandium           | 1372 s                                       | 1531 s | 1733 i | 1993 i   | 2340 i   | 2828 i  | 3     |
| Se         | Selenium           | 227                                          | 279    | 344    | 431      | 540      | 685     | 3     |
| Si         | Silicon            | 1635                                         | 1829   | 2066   | 2363     | 2748     | 3264    | 2     |
| Sm         | Samarium           | 728 s                                        | 833 s  | 967 s  | 1148 i   | 1402 i   | 1788 i  | 3     |
| Sn         | Tin                | 1224                                         | 1384   | 1582   | 1834     | 2165     | 2620    | 2     |
| Sr         | Strontium          | 523 s                                        | 609 s  | 717 s  | 866      | 1072     | 1373    | 2     |
| Ta         | Tantalum           | 3024                                         | 3324   | 3684   | 4122     | 4666     | 5361    | 2     |
| Tb         | Terbium            | 1516.1                                       | 1706.1 | 1928 i | 2232 i   | 2640 i   | 3218 i  | 3     |
| Tc         | Technetium         | 2454 e                                       | 2725 e | 3051 e | 3453 e   | 3961 e   | 4621 e  | 2     |
| Te         | Tellurium          |                                              |        | 502 e  | 615 e    | 768.8    | 992.4   | 5     |
| Th         | Thorium            | 2360                                         | 2634   | 2975   | 3410     | 3986     | 4782    | 2     |
| Ti         | Titanium           | 1709                                         | 1898   | 2130 e | 2419     | 2791     | 3285    | 2     |
| Tl         | Thallium           | 609                                          | 704    | 824    | 979      | 1188     | 1485    | 2     |
| Tm         | Thulium            | 844 s                                        | 962 s  | 1108 s | 1297 s   | 1548 i   | 1944 i  | 3     |
| U          | Uranium            | 2052                                         | 2291   | 2586   | 2961     | 3454     | 4129    | 2     |
| V          | Vanadium           | 1828 s                                       | 2016   | 2250   | 2541     | 2914     | 3406    | 2     |
| W          | Tungsten           | 3204 s                                       | 3500   | 3864   | 4306     | 4854     | 5550    | 2     |
| Xe         | Xenon*             | -190 s                                       | -181 s | -170 s | -155.8 s | -136.6 s | -108.4  | 5,32  |
| Y          | Yttrium            | 1610.1                                       | 1802.3 | 2047 i | 2354 i   | 2763 i   | 3334 i  | 3     |
| Yb         | Ytterbium          | 463 s                                        | 540 s  | 637 s  | 774 s    | 993 i    | 1192 i  | 3     |
| Zn         | Zinc               | 337 s                                        | 397 s  | 477    | 579      | 717      | 912 e   | 2     |
| Zr         | Zirconium          | 2366                                         | 2618   | 2924   | 3302     | 3780     | 4405    | 2     |

*Substances containing carbon:*

|                                  |                             |          |         |          |          |         |        |     |
|----------------------------------|-----------------------------|----------|---------|----------|----------|---------|--------|-----|
| C                                | Carbon (graphite)           |          | 2566 s  | 2775 s   | 3016 s   | 3299 s  | 3635 s | 15  |
| CBrClF <sub>2</sub>              | Bromochloro-difluoromethane | -136 e   | -123 e  | -106 e   | -83.4    | -51.8   | -4.3   | 1   |
| CBrCl <sub>3</sub>               | Bromotrichloromethane       |          |         |          | -6 e     | 38.9    | 104.4  | 5   |
| CBrF <sub>3</sub>                | Bromotrifluoromethane*      | -168 e   | -156 e  | -142 e   | -122.8   | -96.6   | -58.1  | 5   |
| CBrN                             | Cyanogen bromide            |          |         |          | -13 s    | 17.7 s  | 61.0   | 1   |
| CBr <sub>2</sub> F <sub>2</sub>  | Dibromodifluoromethane      |          | -110 e  | -91 e    | -66 e    | -30 e   | 22.5   | 1   |
| CBr <sub>4</sub>                 | Tetrabromomethane           |          |         | 25.6 s   | 65.8 s   | 111.6   | 188.9  | 5   |
| CClF <sub>3</sub>                | Chlorotrifluoromethane      | -176 e   | -167 e  | -155 e   | -139 e   | -116 e  | -81.7  | 5   |
| CClN                             | Cyanogen chloride           |          | -94.6 s | -78.1 s  | -57 s    | -29 s   | 13.0   | 5   |
| CCl <sub>2</sub> F <sub>2</sub>  | Dichlorodifluoromethane*    | -150 e   | -138 e  | -122 e   | -101.8   | -73.1   | -30.0  | 5   |
| CCl <sub>2</sub> O               | Carbonyl chloride           | -127 e   | -113 e  | -96 e    | -73 e    | -40.6   | 7.2    | 5   |
| CCl <sub>3</sub> F               | Trichlorofluoromethane*     |          | -107 e  | -89 e    | -63 e    | -28.5   | 23.3   | 1,5 |
| CCl <sub>3</sub> NO <sub>2</sub> | Trichloronitromethane       |          | -59 e   | -30 e    | 4.4      | 47.8    | 112.0  | 5   |
| CCl <sub>4</sub>                 | Tetrachloromethane*         | -79.4 s  | -70.8 s | -53.5 s  | -24.4 s  | 15.8    | 76.2   | 1,5 |
| CFN                              | Cyanogen fluoride           |          | -135 s  | -121.2 s | -104.1 s | -82.8 s | -46.2  | 1,5 |
| CF <sub>4</sub>                  | Tetrafluoromethane*         | -199.9 s | -193 s  | -183.9 s | -171.6   | -153.9  | -128.3 | 1,5 |
| CHBrF <sub>2</sub>               | Bromodifluoromethane        |          | -128 s  | -111.4 s | -89.7 s  | -59.7 s | -16 s  | 5   |
| CHBr <sub>3</sub>                | Tribromomethane             |          |         |          | 30.5     | 78.3    | 148.8  | 1   |
| CHClF <sub>2</sub>               | Chlorodifluoromethane*      | -152 e   | -141 e  | -126 e   | -107.1   | -80.5   | -41.1  | 5   |
| CHCl <sub>2</sub> F              | Dichlorofluoromethane       | -76 e    | -70 e   | -61 e    | -49 e    | -28.7   | 8.6    | 1   |

| Mol. form.                                                  | Name                                       | Temperature in °C for the indicated pressure |          |          |          |          |         | Ref. |
|-------------------------------------------------------------|--------------------------------------------|----------------------------------------------|----------|----------|----------|----------|---------|------|
|                                                             |                                            | 1 Pa                                         | 10 Pa    | 100 Pa   | 1 kPa    | 10 kPa   | 100 kPa |      |
| CHCl <sub>3</sub>                                           | Trichloromethane*                          |                                              |          | -61 e    | -34 e    | 4.3      | 60.8    | 1    |
| CHF <sub>3</sub>                                            | Trifluoromethane*                          |                                              |          | -152 e   | -136 e   | -114.4   | -82.3   | 1    |
| CHI <sub>3</sub>                                            | Triiodomethane                             | 51.1 s                                       | 82.7 s   | 121 e    |          |          | 218.0   | 5    |
| CHN                                                         | Hydrogen cyanide*                          |                                              |          | -77 s    | -52.6 s  | -22.7 s  | 25.4    | 1,5  |
| CHNO                                                        | Cyanic acid                                |                                              |          | -81.1    | -56.8    | -23.9    | 23 e    | 5    |
| CH <sub>2</sub> BrCl                                        | Bromochloromethane                         | -83 e                                        | -69 e    | -50 e    | -25 e    | 11.4     | 67.7    | 1    |
| CH <sub>2</sub> Br <sub>2</sub>                             | Dibromomethane                             |                                              |          | -37 e    | -7 e     | 35.2     | 96.5    | 5    |
| CH <sub>2</sub> ClF                                         | Chlorofluoromethane                        |                                              | -124 e   | -108 e   | -86.2    | -55.7    | -9.4    | 5    |
| CH <sub>2</sub> Cl <sub>2</sub>                             | Dichloromethane*                           |                                              | -92 e    | -73 e    | -48 e    | -12.5    | 39.3    | 1    |
| CH <sub>2</sub> F <sub>2</sub>                              | Difluoromethane*                           | -156.7                                       | -145.8   | -131.9   | -113.6   | -88.6    | -51.9   | 1    |
| CH <sub>2</sub> I <sub>2</sub>                              | Diiodomethane                              |                                              |          | 17 e     | 55 e     | 106.1    | 181.6   | 5    |
| CH <sub>2</sub> O                                           | Formaldehyde*                              |                                              |          |          | -91 e    | -61.7    | -19.3   | 1    |
| CH <sub>2</sub> O <sub>2</sub>                              | Formic acid                                | -56 s                                        | -40.4 s  | -22.3 s  | -0.8 s   | 37.0     | 100.2   | 1,5  |
| CH <sub>3</sub> AsF <sub>2</sub>                            | Methyldifluoroarsine                       |                                              |          |          | -15 e    | 22.1     | 76.1    | 5    |
| CH <sub>3</sub> BO                                          | Borane carbonyl                            |                                              |          |          | -124     | -99      | -64     | 4    |
| CH <sub>3</sub> Br                                          | Bromomethane                               |                                              |          |          | -77 e    | -44.3    | 3.3     | 1    |
| CH <sub>3</sub> Cl                                          | Chloromethane*                             | -140.2 s                                     | -128.6 s | -114.7 s | -96 e    | -67.1    | -24.4   | 1,33 |
| CH <sub>3</sub> Cl <sub>3</sub> Si                          | Methyltrichlorosilane                      |                                              | -83 e    | -61 e    | -33 e    | 7 e      | 65.7    | 1    |
| CH <sub>3</sub> F                                           | Fluoromethane*                             |                                              |          |          | -130 e   | -111 e   | -78.6   | 1    |
| CH <sub>3</sub> I                                           | Iodomethane                                |                                              |          |          | -49 e    | -12.4    | 42.1    | 1    |
| CH <sub>3</sub> NO                                          | Formamide                                  |                                              | 22 e     | 53 e     | 93 e     | 145.0    | 218 e   | 5    |
| CH <sub>3</sub> NO <sub>2</sub>                             | Nitromethane                               |                                              |          |          | -2 e     | 40 e     | 100.8   | 1    |
| CH <sub>3</sub> NO <sub>3</sub>                             | Methyl nitrate                             |                                              | -75 e    | -55 e    | -27 e    | 9.8      | 63 e    | 5    |
| CH <sub>4</sub>                                             | Methane*                                   | -220 s                                       | -214.2 s | -206.8 s | -197 s   | -183.6 s | -161.7  | 5,41 |
| CH <sub>4</sub> Cl <sub>2</sub> Si                          | Dichloromethylsilane                       |                                              |          | -77 e    | -51 e    | -14 e    | 40.5    | 1    |
| CH <sub>4</sub> O                                           | Methanol*                                  | -87 e                                        | -69 e    | -47.5    | -20.4    | 15.2     | 64.2    | 11   |
| CH <sub>4</sub> S                                           | Methanethiol                               |                                              | -115 e   | -97 e    | -74 e    | -41.7    | 5.7     | 1    |
| CH <sub>5</sub> ClSi                                        | Chloromethylsilane                         | -129 e                                       | -115 e   | -97.9    | -74.4    | -41.5    | 8.3     | 5    |
| CH <sub>5</sub> N                                           | Methylamine                                |                                              |          |          | -76.7    | -48.1    | -6.6    | 1    |
| CH <sub>6</sub> N <sub>2</sub>                              | Methylhydrazine                            |                                              |          | -31 e    | -4.7     | 32.9     | 91 e    | 1    |
| CH <sub>6</sub> OSi                                         | Methyl silyl ether                         |                                              |          |          | -90.2    | -61.8    | -18 e   | 1    |
| CH <sub>6</sub> Si                                          | Methylsilane                               |                                              |          | -144 e   | -124.6   | -97.5    | -57.5   | 5    |
| CIN                                                         | Cyanogen iodide                            |                                              |          |          |          |          | 153.8   | 5    |
| CNNa                                                        | Sodium cyanide                             |                                              | 672 e    | 798      | 961      | 1182     | 1497    | 4    |
| CN <sub>4</sub> O <sub>8</sub>                              | Tetranitromethane                          |                                              |          |          | 18.0     | 61.8     | 124 e   | 5    |
| CO                                                          | Carbon monoxide*                           |                                              |          | -223 s   | -216.5 s | -207.2 s | -191.7  | 40   |
| COS                                                         | Carbon oxysulfide*                         |                                              |          | -136 e   | -117 e   | -90.0    | -50.4   | 1    |
| COSe                                                        | Carbon oxyselenide                         |                                              |          | -120     | -98      | -67      | -22     | 4    |
| CO <sub>2</sub>                                             | Carbon dioxide*                            | -159.1 s                                     | -148.9 s | -136.7 s | -121.6 s | -103.1 s | -78.6 s | 5    |
| CS <sub>2</sub>                                             | Carbon disulfide                           |                                              | -96 e    | -76 e    | -49 e    | -10.9    | 45.9    | 1    |
| CSe <sub>2</sub>                                            | Carbon diselenide                          |                                              |          | -24 e    | 9.4      | 56.2     | 127 e   | 1    |
| C <sub>2</sub> Br <sub>2</sub> ClF <sub>3</sub>             | 1,2-Dibromo-1-chloro-1,2,2-trifluoroethane |                                              |          |          |          |          | 92.3    | 5    |
| C <sub>2</sub> Br <sub>2</sub> F <sub>4</sub>               | 1,2-Dibromotetrafluoroethane               |                                              | -97 e    | -75 e    | -46 e    | -7.2     | 47.1    | 5    |
| C <sub>2</sub> Br <sub>4</sub>                              | Tetrabromoethylene                         |                                              | -54.5 s  | -31.7 s  | -3.5 s   | 32.2 s   | 226.0   | 5    |
| C <sub>2</sub> ClF <sub>3</sub>                             | Chlorotrifluoroethylene                    | -146 e                                       | -134 e   | -119 e   | -99 e    | -71 e    | -28.4   | 1    |
| C <sub>2</sub> ClF <sub>5</sub>                             | Chloropentafluoroethane                    |                                              |          |          |          | -80.3    | -39.4   | 1    |
| C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>               | 1,1-Dichlorotetrafluoroethane              |                                              |          |          |          | -45.4    | 2.7     | 5    |
| C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>               | 1,2-Dichlorotetrafluoroethane              |                                              |          |          | -76.8    | -44.9    | 3.2     | 5    |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>               | 1,1,1-Trichlorotrifluoroethane             |                                              |          |          |          |          | 45.6    | 1,5  |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>               | 1,1,2-Trichlorotrifluoroethane             |                                              |          |          |          | -8.2     | 47.3    | 1,5  |
| C <sub>2</sub> Cl <sub>3</sub> N                            | Trichloroacetonitrile                      |                                              |          |          | -16 e    | 25.3     | 85.1    | 1    |
| C <sub>2</sub> Cl <sub>4</sub>                              | Tetrachloroethylene                        |                                              |          | -22 e    | 10 e     | 54.4     | 120.7   | 1    |
| C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>               | 1,1,1,2-Tetrachloro-2,2-difluoroethane     |                                              |          |          | -7 e     | 31.0     | 91.1    | 5    |
| C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>               | 1,1,2,2-Tetrachloro-1,2-difluoroethane     |                                              |          |          |          | 32.3     | 92.5    | 1    |
| C <sub>2</sub> Cl <sub>4</sub> O                            | Trichloroacetyl chloride                   |                                              |          | -25 e    | 7 e      | 51.7     | 117.8   | 1,5  |
| C <sub>2</sub> Cl <sub>6</sub>                              | Hexachloroethane                           | -7.6 s                                       | 9.9 s    | 33.6 s   | 67.7 s   | 116.9 s  | 184.2 s | 5    |
| C <sub>2</sub> F <sub>3</sub> N                             | Trifluoroacetonitrile                      |                                              |          |          | -126.1   | -102.5   | -67.8   | 1    |
| C <sub>2</sub> F <sub>4</sub>                               | Tetrafluoroethylene                        |                                              |          |          | -132.3   | -109.7   | -75.8   | 1    |
| C <sub>2</sub> F <sub>4</sub> N <sub>2</sub> O <sub>4</sub> | 1,1,2,2-Tetrafluoro-1,2-dinitroethane      |                                              |          |          | -30 e    | 6.4      | 59.5    | 5    |



| Mol. form.                                                    | Name                                   | Temperature in °C for the indicated pressure |         |          |          |          |         | Ref. |
|---------------------------------------------------------------|----------------------------------------|----------------------------------------------|---------|----------|----------|----------|---------|------|
|                                                               |                                        | 1 Pa                                         | 10 Pa   | 100 Pa   | 1 kPa    | 10 kPa   | 100 kPa |      |
| C <sub>2</sub> F <sub>6</sub>                                 | Hexafluoroethane**                     |                                              |         | −155.2 s | −137.5 s | −113.4 s | −78.4 s | 1,5  |
| C <sub>2</sub> HBrClF <sub>3</sub>                            | 2-Bromo-2-chloro-1,1,1-trifluoroethane |                                              |         |          | −41.4    | −4.8     | 49.8    | 1    |
| C <sub>2</sub> HBr <sub>3</sub> O                             | Tribromoacetaldehyde                   |                                              |         | 15.0     | 52.7     | 103.0    | 173.5   | 5    |
| C <sub>2</sub> HCIF <sub>4</sub>                              | 1-Chloro-1,1,2,2-tetrafluoroethane     |                                              |         | −110 e   | −87.6    | −57.0    | −12.1   | 5    |
| C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>                | 2,2-Dichloro-1,1,1-trifluoroethane     |                                              | −101.0  | −82.2    | −57.4    | −23.3    | 26.7    | 18   |
| C <sub>2</sub> HCl <sub>3</sub>                               | Trichloroethylene                      | −74 e                                        | −59 e   | −39 e    | −12 e    | 26.7     | 86.8    | 1    |
| C <sub>2</sub> HCl <sub>3</sub> O                             | Trichloroacetaldehyde                  |                                              |         | −41.6    | −9.8     | 33.8     | 97.4    | 5    |
| C <sub>2</sub> HCl <sub>3</sub> O <sub>2</sub>                | Trichloroacetic acid                   |                                              |         |          | 83.8     | 130.0    | 197.2   | 1,5  |
| C <sub>2</sub> HCl <sub>5</sub>                               | Pentachloroethane                      |                                              | −23 e   | 3 e      | 37.4     | 86.0     | 159.4   | 1    |
| C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>                 | Trifluoroacetic acid                   |                                              |         |          |          | 16.8     | 71.4    | 1,5  |
| C <sub>2</sub> HF <sub>5</sub> O                              | Trifluoromethyl difluoromethyl ether   | −147 e                                       | −136 e  | −121 e   | −102 e   | −75.0    | −35.4   | 20   |
| C <sub>2</sub> H <sub>2</sub>                                 | Acetylene*                             |                                              |         | −146.6 s | −130.7 s | −110.6 s | −84.8 s | 5    |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub>                 | <i>cis</i> -1,2-Dibromoethylene        |                                              | −45 e   | −21 e    | 10 e     | 52.2     | 114.8   | 1    |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub>                 | <i>trans</i> -1,2-Dibromoethylene      |                                              |         |          | −4 e     | 42.2     | 107.4   | 5    |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> Cl <sub>2</sub> | 1,2-Dibromo-1,1-dichloroethane         |                                              |         |          |          | 103.6    | 177.8   | 5    |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> Cl <sub>2</sub> | 1,2-Dibromo-1,2-dichloroethane         |                                              | −11 e   | 22 e     | 64.1     | 119 e    | 193 e   | 5    |
| C <sub>2</sub> H <sub>2</sub> Br <sub>4</sub>                 | 1,1,2,2-Tetrabromoethane               | 14 e                                         | 38 e    | 69 e     | 109 e    | 163.7    | 242.9   | 5    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | 1,1-Dichloroethylene                   | −116 e                                       | −101 e  | −82 e    | −57 e    | −21.4    | 31.2    | 1    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | <i>cis</i> -1,2-Dichloroethylene       |                                              |         | −62 e    | −34 e    | 3.8      | 60.3    | 1    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | <i>trans</i> -1,2-Dichloroethylene     |                                              |         |          | −44 e    | −7.5     | 47.3    | 1    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>  | 1,2-Dichloro-1,1-difluoroethane        | −101 e                                       | −87 e   | −68 e    | −42.2    | −6.8     | 46.3    | 5    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O               | Chloroacetyl chloride                  |                                              |         | −23.7    | 5.6      | 46.1     | 105.6   | 5    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 1,1,1,2-Tetrachloroethane              | −58 e                                        | −40 e   | −15 e    | 17 e     | 62.2     | 129.7   | 1    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 1,1,2,2-Tetrachloroethane              |                                              | −22 e   | 1 e      | 32.4     | 76.9     | 144.7   | 1    |
| C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>                  | 1,1,1,2-Tetrafluoroethane              |                                              |         |          | −94.3    | −66.8    | −26.4   | 17   |
| C <sub>2</sub> H <sub>2</sub> F <sub>4</sub>                  | 1,1,2,2-Tetrafluoroethane              |                                              |         |          | −96.0    | −66.9    | −23.3   | 5    |
| C <sub>2</sub> H <sub>2</sub> O                               | Ketene                                 |                                              | −151 e  | −135 e   | −115 e   | −88.2    | −50.0   | 1    |
| C <sub>2</sub> H <sub>3</sub> Br                              | Bromoethylene                          | −124 e                                       | −110 e  | −92 e    | −68 e    | −34.5    | 15.4    | 5    |
| C <sub>2</sub> H <sub>3</sub> BrO                             | Acetyl bromide                         | −78 e                                        | −65 e   | −49 e    | −25 e    | 13.9     | 84 e    | 5    |
| C <sub>2</sub> H <sub>3</sub> Br <sub>3</sub>                 | 1,1,2-Tribromoethane                   | −18 e                                        | 4 e     | 32 e     | 68 e     | 117.1    | 188.4   | 5    |
| C <sub>2</sub> H <sub>3</sub> Cl                              | Chloroethylene                         | −139 e                                       | −127 e  | −110 e   | −89 e    | −59.0    | −14.1   | 1    |
| C <sub>2</sub> H <sub>3</sub> ClF <sub>2</sub>                | 1-Chloro-1,1-difluoroethane            |                                              | −123 e  | −107 e   | −85.3    | −55.4    | −10.5   | 5    |
| C <sub>2</sub> H <sub>3</sub> ClO                             | Acetyl chloride                        | −100 e                                       | −85 e   | −66 e    | −40 e    | −3.6     | 50.4    | 1    |
| C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>                | Chloroacetic acid                      |                                              |         |          | 78.4     | 123.9    | 188.9   | 1    |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> F               | 1,1-Dichloro-1-fluoroethane            |                                              | −101 e  | −83 e    | −57.9    | −22.7    | 31.4    | 5    |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> F               | 1,2-Dichloro-1-fluoroethane            |                                              |         | −50 e    | −23.8    | 14.1     | 73.4    | 5    |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                 | 1,1,1-Trichloroethane                  |                                              |         |          | −25.3    | 14.2     | 73.7    | 5    |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                 | 1,1,2-Trichloroethane                  |                                              |         | −23 e    | 7 e      | 49.9     | 113.4   | 1    |
| C <sub>2</sub> H <sub>3</sub> F                               | Fluoroethylene                         |                                              |         | −153.3   | −135.2   | −109.9   | −72.2   | 5    |
| C <sub>2</sub> H <sub>3</sub> FO                              | Acetyl fluoride                        |                                              |         |          |          | −64.1    | 17.0    | 5    |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>                  | 1,1,1-Trifluoroethane                  |                                              |         |          | −113 e   | −86.6    | −47.8   | 1    |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O                | 2,2,2-Trifluoroethanol                 |                                              |         | −33 e    | −8 e     | 26.0     | 74 e    | 5    |
| C <sub>2</sub> H <sub>3</sub> I                               | Iodoethylene                           |                                              |         |          | −41 e    | −3 e     | 55.6    | 5    |
| C <sub>2</sub> H <sub>3</sub> IO                              | Acetyl iodide                          |                                              |         |          | −0.6     | 47 e     | 107.0   | 5    |
| C <sub>2</sub> H <sub>3</sub> N                               | Acetonitrile                           |                                              |         |          | −20 e    | 21.4     | 81.2    | 1    |
| C <sub>2</sub> H <sub>3</sub> NO                              | Methylisocyanate                       |                                              |         |          | −43.5    | −10.2    | 38.8    | 1    |
| C <sub>2</sub> H <sub>3</sub> NS                              | Methyl thiocyanate                     |                                              |         | −18.4    | 16.2     | 63.5     | 132.5   | 5    |
| C <sub>2</sub> H <sub>4</sub>                                 | Ethylene*                              |                                              |         |          | −155.6   | −135.1   | −104.0  | 1,10 |
| C <sub>2</sub> H <sub>4</sub> BrCl                            | 1-Bromo-2-chloroethane                 |                                              |         |          | −0.4     | 41.7     | 105.7   | 6    |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>                 | 1,1-Dibromoethane                      |                                              | −49 e   | −26 e    | 5 e      | 46.4     | 107.6   | 5    |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>                 | 1,2-Dibromoethane                      |                                              |         |          | 18 e     | 62.2     | 130.9   | 1    |
| C <sub>2</sub> H <sub>4</sub> ClF                             | 1-Chloro-1-fluoroethane                |                                              |         |          | −69.9    | −36.1    | 15.8    | 5    |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                 | 1,1-Dichloroethane                     |                                              | −84 e   | −64 e    | −36.7    | 1.0      | 56.9    | 1    |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                 | 1,2-Dichloroethane                     |                                              |         |          | −16.4    | 23.7     | 83.1    | 1    |
| C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>                  | 1,1-Difluoroethane                     |                                              |         | −115.2   | −94.6    | −66.1    | −24.3   | 19   |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>   | Ethylene glycol dinitrate              | 4 e                                          | 25.6    | 51.0     | 81 e     | 117 e    | 162 e   | 5    |
| C <sub>2</sub> H <sub>4</sub> O                               | Acetaldehyde                           |                                              | −105 e  | −87 e    | −62.8    | −29.4    | 20.0    | 5    |
| C <sub>2</sub> H <sub>4</sub> O                               | Ethylene oxide                         |                                              | −111 e  | −93 e    | −70 e    | −37.0    | 10.2    | 1    |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                  | Acetic acid                            | −42.8 s                                      | −26.7 s | −8 s     | 14.2 s   | 55.9     | 117.5   | 1,5  |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                  | Methyl formate                         |                                              | −95 e   | −76 e    | −51.8    | −18.1    | 31.4    | 5    |

| Mol. form.      | Name                              | Temperature in °C for the indicated pressure |          |         |         |         |         | Ref. |
|-----------------|-----------------------------------|----------------------------------------------|----------|---------|---------|---------|---------|------|
|                 |                                   | 1 Pa                                         | 10 Pa    | 100 Pa  | 1 kPa   | 10 kPa  | 100 kPa |      |
| $C_2H_4O_3$     | Peroxyacetic acid                 |                                              |          |         | 14.4    | 55.3    | 109.7   | 5    |
| $C_2H_4O_3$     | Glycolic acid                     |                                              |          |         |         |         | 99.9    | 5    |
| $C_2H_5AsF_2$   | Ethylidifluoroarsine              |                                              |          | −36 e   | −6.0    | 35.0    | 93.1    | 5    |
| $C_2H_5Br$      | Bromoethane                       | −111 e                                       | −96 e    | −77 e   | −51.3   | −15.5   | 38.0    | 5    |
| $C_2H_5Cl$      | Chloroethane                      | −126 e                                       | −112 e   | −94 e   | −70 e   | −37.0   | 12.0    | 1    |
| $C_2H_5ClO$     | 2-Chloroethanol                   |                                              | −61 e    | −39 e   | −12 e   | 23 e    | 67.1    | 5    |
| $C_2H_5ClO$     | Chloromethyl methyl ether         | −96 e                                        | −80 e    | −59 e   | −32 e   | 6 e     | 61 e    | 5    |
| $C_2H_5Cl_3OSi$ | Trichloroethoxysilane             | −78 e                                        | −60 e    | −36.0   | −4.6    | 38.7    | 102.0   | 5    |
| $C_2H_5Cl_3Si$  | Trichloroethylsilane              | −79 e                                        | −61 e    | −38 e   | −8 e    | 34.9    | 98.7    | 5    |
| $C_2H_5F$       | Fluoroethane                      |                                              | −142 e   | −127 e  | −106.3  | −78.7   | −37.9   | 1    |
| $C_2H_5FO$      | 2-Fluoroethanol                   |                                              |          | −22 e   | 8.3     | 47.5    | 99 e    | 5    |
| $C_2H_5I$       | Iodoethane                        | −94 e                                        | −78 e    | −56 e   | −27.9   | 11.9    | 71.9    | 5    |
| $C_2H_5N$       | Ethyleneimine                     |                                              | −74 e    | −55 e   | −30 e   | 4.1     | 55 e    | 5    |
| $C_2H_5NO$      | Acetamide                         | 16.7 s                                       | 39.1 s   | 65.2 s  | 102.8   | 150.8   | 218.2   | 5    |
| $C_2H_5NO$      | <i>N</i> -Methylformamide         |                                              | 13 e     | 41 e    | 78 e    | 127.9   | 199.1   | 1    |
| $C_2H_5NO_2$    | Nitroethane                       | −61 e                                        | −44 e    | −21 e   | 8.3     | 50.1    | 113.5   | 5    |
| $C_2H_5NO_3$    | Ethyl nitrate                     | −81 e                                        | −63 e    | −41 e   | −12 e   | 28.2    | 87 e    | 1    |
| $C_2H_6$        | Ethane*                           | −183.3 s                                     | −173.2   | −161.3  | −145.3  | −122.8  | −88.8   | 41   |
| $C_2H_6Cl_2Si$  | Dichlorodimethylsilane            |                                              |          |         |         | 11.1    | 70.1    | 5    |
| $C_2H_6Hg$      | Dimethyl mercury                  |                                              |          |         | −13.5   | 29.0    | 92.1    | 5    |
| $C_2H_6N_2O$    | <i>N</i> -Nitrosodimethylamine    |                                              |          |         | 30.7    | 80.5    | 149.8   | 5    |
| $C_2H_6O$       | Ethanol                           | −73 e                                        | −56 e    | −34 e   | −7 e    | 29.2    | 78.0    | 1,5  |
| $C_2H_6O$       | Dimethyl ether*                   |                                              | −135 e   | −118 e  | −96.8   | −67.6   | −25.1   | 1,5  |
| $C_2H_6OS$      | Dimethyl sulfoxide                |                                              |          | 27.4    | 65.0    | 115.9   | 188.6   | 1    |
| $C_2H_6O_2$     | Ethylene glycol                   | 2 e                                          | 24 e     | 51.1    | 86.1    | 132.5   | 196.9   | 1    |
| $C_2H_6O_2$     | Ethyl hydroperoxide               | −70 e                                        | −49 e    | −25 e   | 6.8     | 47.0    | 101 e   | 5    |
| $C_2H_6O_2S$    | Dimethyl sulfone                  |                                              |          |         | 109 e   | 166.8   | 248.9   | 5    |
| $C_2H_6S$       | Ethanethiol                       | −112 e                                       | −97 e    | −78 e   | −53 e   | −18 e   | 34.7    | 1    |
| $C_2H_6S$       | Dimethyl sulfide                  |                                              | −96 e    | −77 e   | −51.2   | −16.0   | 37.0    | 1,5  |
| $C_2H_6S_2$     | Dimethyl disulfide                | −71 e                                        | −53 e    | −29 e   | 1.7     | 45.0    | 109.3   | 5    |
| $C_2H_7BO_2$    | Dimethoxyborane                   | −116 e                                       | −101.9   | −83.5   | −59.2   | −25.4   | 25 e    | 5    |
| $C_2H_7N$       | Ethylamine                        |                                              |          | −71 e   | −53 e   | −27 e   | 16.4    | 1    |
| $C_2H_7N$       | Dimethylamine                     |                                              |          | −88 e   | −66.9   | −37.2   | 6.6     | 1    |
| $C_2H_7NO$      | Ethanolamine                      |                                              | 11 e     | 35 e    | 66.2    | 109.0   | 170.6   | 1    |
| $C_2H_8N_2$     | 1,2-Ethanediamine                 |                                              |          |         | 17.0    | 57.5    | 116.6   | 1,5  |
| $C_2H_8N_2$     | 1,1-Dimethylhydrazine             |                                              |          | −52 e   | −25.6   | 10.5    | 63 e    | 5    |
| $C_2H_8N_2$     | 1,2-Dimethylhydrazine             |                                              | −49 e    | −33 e   | −9 e    | 26.4    | 88 e    | 1    |
| $C_2N_2$        | Cyanogen                          | −127 s                                       | −114.1 s | −98.5 s | −79.2 s | −54.9 s | −21.4   | 5    |
| $C_3ClF_5O$     | Chloropentafluoroacetone          | −122 e                                       | −109 e   | −93 e   | −71 e   | −39.4   | 7.4     | 5    |
| $C_3Cl_6$       | Hexachloropropene                 | −12 e                                        | 11 e     | 40 e    | 79 e    | 132.8   | 213.6   | 5    |
| $C_3F_6$        | Perfluoropropene                  | −150 e                                       | −138 e   | −122 e  | −101 e  | −72 e   | −30.6   | 5    |
| $C_3F_6O$       | Perfluoroacetone                  |                                              |          | −113 e  | −94 e   | −67.8   | −27.6   | 5    |
| $C_3F_8$        | Perfluoropropane                  |                                              | −139 e   | −124 e  | −105 e  | −77.5   | −37.0   | 1    |
| $C_3HN$         | Cyanoacetylene                    |                                              |          | −58.7 s | −35.6 s | −7 s    | 42.0    | 5    |
| $C_3H_2F_6O$    | 1,1,1,3,3,3-Hexafluoro-2-propanol |                                              |          |         |         | 12.7    | 57.1    | 5    |
| $C_3H_3F_5$     | 1,1,1,2,2-Pentafluoropropane      |                                              |          |         |         | −60 e   | −17.9   | 5    |
| $C_3H_3N$       | 2-Propenenitrile                  |                                              | −72 e    | −50 e   | −22 e   | 17.7    | 77.0    | 1    |
| $C_3H_3NS$      | Thiazole                          |                                              |          |         |         | 54.4    | 117.8   | 5    |
| $C_3H_4$        | Allene*                           |                                              | −129 e   | −118 e  | −101.4  | −76.7   | −34.7   | 5    |
| $C_3H_4$        | Propyne                           |                                              |          |         | −94 e   | −65.3   | −23.2   | 1    |
| $C_3H_4ClF_3$   | 3-Chloro-1,1,1-trifluoropropane   | −102 e                                       | −87 e    | −68 e   | −43 e   | −8 e    | 45.3    | 5    |
| $C_3H_4Cl_2O$   | 1,1-Dichloroacetone               |                                              |          |         | 1 e     | 47.8    | 118.0   | 5    |
| $C_3H_4Cl_2O_2$ | Methyl dichloroacetate            | −44 e                                        | −25 e    | 0 e     | 33 e    | 77.7    | 142.3   | 5    |
| $C_3H_4Cl_4$    | 1,1,1,2-Tetrachloropropane        | −48 e                                        | −28 e    | −2 e    | 32 e    | 79.1    | 149.5   | 5    |
| $C_3H_4F_4O$    | 2,2,3,3-Tetrafluoro-1-propanol    |                                              |          | −10 e   | 17 e    | 53.9    | 107.2   | 5    |
| $C_3H_4O$       | Acrolein                          |                                              | −87 e    | −67 e   | −40 e   | −3.0    | 52.8    | 1    |
| $C_3H_4O_2$     | Propenoic acid                    |                                              |          |         | 35 e    | 78.0    | 140.7   | 1    |
| $C_3H_4O_2$     | Vinyl formate                     |                                              |          | −58 e   | −34 e   | −1.6    | 46.2    | 1    |
| $C_3H_4O_2$     | 2-Oxetanone                       |                                              | −21 e    | 8 e     | 45.5    | 93.8    | 159.3   | 5    |
| $C_3H_4O_3$     | Ethylene carbonate                | 12.7 s                                       | 37 e     |         |         |         | 247     | 5    |

| Mol. form.                                                  | Name                          | Temperature in °C for the indicated pressure |        |        |        |        |         | Ref. |
|-------------------------------------------------------------|-------------------------------|----------------------------------------------|--------|--------|--------|--------|---------|------|
|                                                             |                               | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa  | 10 kPa | 100 kPa |      |
| C <sub>3</sub> H <sub>5</sub> Br                            | <i>cis</i> -1-Bromopropene    | -100 e                                       | -84 e  | -64 e  | -37 e  | 1.0    | 57.4    | 5    |
| C <sub>3</sub> H <sub>5</sub> Br                            | 2-Bromopropene                | -112 e                                       | -95 e  | -75 e  | -47 e  | -9 e   | 48.0    | 5    |
| C <sub>3</sub> H <sub>5</sub> Br                            | 3-Bromopropene                | -98 e                                        | -80 e  | -58 e  | -28 e  | 12 e   | 69.6    | 5    |
| C <sub>3</sub> H <sub>5</sub> Cl                            | <i>cis</i> -1-Chloropropene   | -114 e                                       | -100 e | -81 e  | -55 e  | -20.1  | 32.4    | 5    |
| C <sub>3</sub> H <sub>5</sub> Cl                            | <i>trans</i> -1-Chloropropene |                                              | -97 e  | -77 e  | -52 e  | -16.2  | 37.0    | 5    |
| C <sub>3</sub> H <sub>5</sub> Cl                            | 2-Chloropropene               | -120 e                                       | -106 e | -87 e  | -63 e  | -28.7  | 22.3    | 5    |
| C <sub>3</sub> H <sub>5</sub> Cl                            | 3-Chloropropene               | -107 e                                       | -92 e  | -72.4  | -46.3  | -9.8   | 44.6    | 5    |
| C <sub>3</sub> H <sub>5</sub> ClO                           | Epichlorohydrin               |                                              |        | -21 e  | 11 e   | 53.8   | 115.5   | 5    |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>              | Methyl chloroacetate          |                                              | -28 e  | -5 e   | 25 e   | 66.9   | 129.1   | 5    |
| C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>               | 1,1,3-Trichloropropane        | -51 e                                        | -31 e  | -5 e   | 28 e   | 75.3   | 145.1   | 5    |
| C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>               | 1,2,3-Trichloropropane        |                                              |        | 2 e    | 37 e   | 84.9   | 156.3   | 5    |
| C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub> Si            | Trichloro-2-propenylsilane    |                                              |        |        |        | 53.0   | 116.5   | 5    |
| C <sub>3</sub> H <sub>5</sub> I                             | 3-Iodopropene                 | -80 e                                        | -62 e  | -39 e  | -8 e   | 36 e   | 101.5   | 5    |
| C <sub>3</sub> H <sub>5</sub> N                             | Propanenitrile                | -69.4                                        | -55.3  | -36.0  | -7.9   | 35.2   | 97.4    | 1,5  |
| C <sub>3</sub> H <sub>5</sub> NO                            | Acrylamide                    |                                              |        | 109.6  | 161 e  |        |         | 5    |
| C <sub>3</sub> H <sub>5</sub> NO                            | 3-Hydroxypropanenitrile       | -11 e                                        | 18 e   | 53 e   | 96.1   | 150.3  | 220.8   | 5    |
| C <sub>3</sub> H <sub>5</sub> NS                            | Ethyl thiocyanate             | -39 e                                        | -20 e  | 4 e    | 35 e   | 79.1   | 143.4   | 5    |
| C <sub>3</sub> H <sub>5</sub> NS                            | Ethyl isothiocyanate          |                                              |        |        | 17.4   | 66 e   | 136 e   | 5    |
| C <sub>3</sub> H <sub>5</sub> N <sub>3</sub> O <sub>9</sub> | Trinitroglycerol              | 48.6                                         | 75.7   | 118 e  | 191 e  | 353 e  | 1007 e  | 5    |
| C <sub>3</sub> H <sub>6</sub>                               | Propene*                      | -160.6                                       | -149.0 | -134.3 | -114.9 | -88.2  | -47.9   | 1,5  |
| C <sub>3</sub> H <sub>6</sub>                               | Cyclopropane                  |                                              |        | -124 e | -104 e | -75.7  | -33.1   | 1    |
| C <sub>3</sub> H <sub>6</sub> BrCl                          | 1-Bromo-3-chloropropane       | -51 e                                        | -31 e  | -6 e   | 28 e   | 74.1   | 142.9   | 5    |
| C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>               | 1,2-Dibromopropane            | -46 e                                        | -26 e  | -2 e   | 31 e   | 75.3   | 139.5   | 5    |
| C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>               | 1,3-Dibromopropane            | -30 e                                        | -9 e   | 17 e   | 52 e   | 98.7   | 166.8   | 5    |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>               | 1,1-Dichloropropane           |                                              |        |        | -14 e  | 27.0   | 87.7    | 5    |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>               | 1,2-Dichloropropane           | -78 e                                        | -61 e  | -38.1  | -8.1   | 33.7   | 95.9    | 5    |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>               | 1,3-Dichloropropane           | -65 e                                        | -46 e  | -22 e  | 10 e   | 54.0   | 119.9   | 5    |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>               | 2,2-Dichloropropane           |                                              |        |        | -28 e  | 10.8   | 68.9    | 5    |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub> O             | 1,3-Dichloro-2-propanol       |                                              |        | 21.8   | 59.0   | 107.6  | 173.9   | 5    |
| C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> | 1,1-Dinitropropane            | -9 e                                         | 12 e   | 39 e   | 73.2   | 120 e  | 187 e   | 5    |
| C <sub>3</sub> H <sub>6</sub> O                             | Allyl alcohol                 | -63 e                                        | -48 e  | -21.9  | 6.8    | 44.5   | 96.2    | 5    |
| C <sub>3</sub> H <sub>6</sub> O                             | Methyl vinyl ether            |                                              |        | -114 e | -89 e  | -52.7  | 4.6     | 1    |
| C <sub>3</sub> H <sub>6</sub> O                             | Propanal                      |                                              |        | -69 e  | -42 e  | -6 e   | 47.7    | 1    |
| C <sub>3</sub> H <sub>6</sub> O                             | Acetone                       | -95                                          | -81.8  | -62.8  | -35.6  | 1.3    | 55.7    | 1,5  |
| C <sub>3</sub> H <sub>6</sub> O                             | Methyloxirane                 | -109 e                                       | -95 e  | -76 e  | -51.5  | -17.2  | 33.9    | 5    |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | Propanoic acid                |                                              |        | 0 e    | 35.1   | 79.9   | 140.8   | 1,5  |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | Ethyl formate                 |                                              | -80 e  | -61 e  | -35 e  | 1 e    | 54.0    | 1    |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | Methyl acetate                | -95 e                                        | -79 e  | -59 e  | -33 e  | 3.3    | 56.6    | 1    |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | 1,3-Dioxolane                 |                                              | -72 e  | -50 e  | -22 e  | 17.0   | 75.3    | 1    |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                | 1,3,5-Trioxane                |                                              |        |        |        | 53 e   | 113.7   | 1    |
| C <sub>3</sub> H <sub>6</sub> S                             | Thietane                      |                                              | -62 e  | -40 e  | -9 e   | 32.5   | 94.5    | 5    |
| C <sub>3</sub> H <sub>7</sub> Br                            | 1-Bromopropane                | -95 e                                        | -78 e  | -57 e  | -28 e  | 11.6   | 70.6    | 1    |
| C <sub>3</sub> H <sub>7</sub> Br                            | 2-Bromopropane                |                                              | -84 e  | -65 e  | -39.6  | -1.7   | 59.1    | 1,5  |
| C <sub>3</sub> H <sub>7</sub> Cl                            | 1-Chloropropane               | -106 e                                       | -90 e  | -71 e  | -44.5  | -8.1   | 46.2    | 1    |
| C <sub>3</sub> H <sub>7</sub> Cl                            | 2-Chloropropane               |                                              | -91 e  | -74 e  | -51.1  | -17.8  | 35.4    | 1,5  |
| C <sub>3</sub> H <sub>7</sub> ClO                           | 2-Chloro-1-propanol           |                                              |        |        | 23 e   | 63.8   | 125.7   | 5    |
| C <sub>3</sub> H <sub>7</sub> F                             | 1-Fluoropropane               | -133 e                                       | -120 e | -103 e | -80.7  | -49.4  | -2.8    | 5    |
| C <sub>3</sub> H <sub>7</sub> I                             | 1-Iodopropane                 | -78 e                                        | -60 e  | -37 e  | -6 e   | 36.9   | 102.0   | 5    |
| C <sub>3</sub> H <sub>7</sub> I                             | 2-Iodopropane                 | -89 e                                        | -71 e  | -47 e  | -16.3  | 26.5   | 89.2    | 5    |
| C <sub>3</sub> H <sub>7</sub> N                             | Allylamine                    |                                              | -88 e  | -65 e  | -37 e  | 0.4    | 52 e    | 5    |
| C <sub>3</sub> H <sub>7</sub> NO                            | <i>N,N</i> -Dimethylformamide | -39 e                                        | -20 e  | 5 e    | 38.0   | 83.9   | 152.6   | 1    |
| C <sub>3</sub> H <sub>7</sub> NO                            | <i>N</i> -Methylacetamide     | -13.3 s                                      | 13 s   | 43 e   | 83.8   | 136.1  | 206.3   | 5    |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | 1-Nitropropane                | -56 e                                        | -37 e  | -13 e  | 20 e   | 64.8   | 130.8   | 1    |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | 2-Nitropropane                |                                              | -48 e  | -22 e  | 10.7   | 55.6   | 119.8   | 1    |
| C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>               | Propyl nitrate                |                                              |        | -23.9  | 6.1    | 48.1   | 111 e   | 5    |
| C <sub>3</sub> H <sub>8</sub>                               | Propane*                      | -156.9                                       | -145.6 | -130.9 | -111.4 | -83.8  | -42.3   | 1,41 |
| C <sub>3</sub> H <sub>8</sub> O                             | 1-Propanol                    | -54 e                                        | -38 e  | -16 e  | 10 e   | 47 e   | 96.9    | 1,5  |
| C <sub>3</sub> H <sub>8</sub> O                             | 2-Propanol                    | -65 e                                        | -49 e  | -28 e  | -1.3   | 33.6   | 82.0    | 1,5  |
| C <sub>3</sub> H <sub>8</sub> O                             | Ethyl methyl ether            | -98 e                                        | -89 e  | -77 e  | -60 e  | -34.8  | 7.0     | 5    |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                | 1,2-Propylene glycol          | -11 e                                        | 13 e   | 42 e   | 78 e   | 125.0  | 187.2   | 5    |

| Mol. form.                                                   | Name                                  | Temperature in °C for the indicated pressure |         |         |         |        |         | Ref. |
|--------------------------------------------------------------|---------------------------------------|----------------------------------------------|---------|---------|---------|--------|---------|------|
|                                                              |                                       | 1 Pa                                         | 10 Pa   | 100 Pa  | 1 kPa   | 10 kPa | 100 kPa |      |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                 | 1,3-Propylene glycol                  | 4 e                                          | 30 e    | 62 e    | 101 e   | 149.9  | 214.0   | 5    |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                 | Ethylene glycol monomethyl ether      | −57 e                                        | −37 e   | −12 e   | 21 e    | 63.8   | 124.3   | 1    |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                 | Dimethoxymethane                      | −93 e                                        | −81 e   | −64 e   | −42 e   | −9.3   | 41.7    | 5    |
| C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>                 | Glycerol                              | 96 e                                         | 113 e   | 136 e   | 168 e   | 213.4  | 287 e   | 1    |
| C <sub>3</sub> H <sub>8</sub> S                              | 1-Propanethiol                        | −94 e                                        | −78 e   | −57 e   | −29.1   | 9.6    | 67.4    | 1,5  |
| C <sub>3</sub> H <sub>8</sub> S                              | 2-Propanethiol                        | −102 e                                       | −87 e   | −67 e   | −41 e   | −3 e   | 52.2    | 1    |
| C <sub>3</sub> H <sub>8</sub> S                              | Ethyl methyl sulfide                  | −94 e                                        | −78 e   | −57 e   | −29.7   | 8.8    | 66.3    | 1    |
| C <sub>3</sub> H <sub>8</sub> S <sub>2</sub>                 | 1,3-Propanedithiol                    | −53 e                                        | −28 e   | 3 e     | 43 e    | 97 e   | 172.4   | 5    |
| C <sub>3</sub> H <sub>9</sub> As                             | Trimethylarsine                       |                                              |         | −74 e   | −45 e   | −5.4   | 52.0    | 5    |
| C <sub>3</sub> H <sub>9</sub> BO <sub>3</sub>                | Trimethyl borate                      |                                              |         |         | −14 e   | 15.6   | 67.9    | 5    |
| C <sub>3</sub> H <sub>9</sub> BS                             | Methyl dimethylthioborane             |                                              |         | −62 e   | −30.4   | 11.4   | 70.7    | 5    |
| C <sub>3</sub> H <sub>9</sub> ClSi                           | Trimethylchlorosilane                 |                                              |         |         | −37.8   | 0.4    | 57.3    | 5    |
| C <sub>3</sub> H <sub>9</sub> N                              | Propylamine                           |                                              | −81 e   | −63 e   | −38.3   | −4.1   | 46.9    | 1,5  |
| C <sub>3</sub> H <sub>9</sub> N                              | Isopropylamine                        |                                              | −91 e   | −74 e   | −50.4   | −17.6  | 31.5    | 1,5  |
| C <sub>3</sub> H <sub>9</sub> N                              | Trimethylamine                        |                                              | −114 e  | −97 e   | −75.0   | −43.8  | 2.6     | 1,5  |
| C <sub>3</sub> H <sub>9</sub> NO                             | 1-Amino-2-propanol                    |                                              |         | 18 e    | 53.2    | 98.2   | 157.9   | 5    |
| C <sub>3</sub> H <sub>9</sub> O <sub>4</sub> P               | Trimethyl phosphate                   | −31 e                                        | −7 e    | 23.6    | 62.8    | 116.0  | 192.0   | 5    |
| C <sub>3</sub> H <sub>9</sub> P                              | Trimethylphosphine                    |                                              |         | −81 e   | −53 e   | −15.0  | 37.1    | 5    |
| C <sub>3</sub> H <sub>9</sub> Sb                             | Trimethylstibine                      |                                              |         | −56 e   | −23.8   | 19 e   | 80 e    | 5    |
| C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>                | 1,2-Propanediamine                    |                                              | −35.4   | −12.0   | 18.8    | 61 e   | 119 e   | 5    |
| C <sub>3</sub> N <sub>2</sub> O                              | Carbonyl dicyanide                    |                                              |         |         | −21.7   | 15.3   | 65.2    | 5    |
| C <sub>4</sub> Cl <sub>6</sub>                               | Hexachloro-1,3-butadiene              | −1 e                                         | 22 e    | 50 e    | 86.7    | 137.0  | 209.7   | 5    |
| C <sub>4</sub> F <sub>6</sub> O <sub>3</sub>                 | Trifluoroacetic acid anhydride        |                                              |         | −63 e   | −39 e   | −7.1   | 38.8    | 5    |
| C <sub>4</sub> F <sub>8</sub>                                | Perfluorocyclobutane                  |                                              |         |         |         |        | −6.2    | 1    |
| C <sub>4</sub> F <sub>10</sub>                               | Perfluorobutane                       |                                              | −122 e  | −105 e  | −82 e   | −49.8  | −2.5    | 1,5  |
| C <sub>4</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub> | <i>trans</i> -2-Butenediyl dichloride |                                              |         | 8.0     | 45.6    | 94.3   | 159.8   | 5    |
| C <sub>4</sub> H <sub>2</sub> Cl <sub>2</sub> S              | 2,5-Dichlorothiophene                 |                                              |         | −20 e   | 22 e    | 81.4   | 171 e   | 5    |
| C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>                 | Maleic anhydride                      |                                              |         |         | 73.7    | 127.9  | 201.7   | 5    |
| C <sub>4</sub> H <sub>3</sub> ClS                            | 2-Chlorothiophene                     |                                              | −62 e   | −35 e   | 2 e     | 51.8   | 123 e   | 5    |
| C <sub>4</sub> H <sub>3</sub> IS                             | 2-Iodothiophene                       |                                              |         | −25 e   | 23 e    | 94.9   | 181.0   | 5    |
| C <sub>4</sub> H <sub>4</sub>                                | 1-Buten-3-yne                         |                                              |         | −96.1   | −73.4   | −41.8  | 4.9     | 5    |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                 | Succinonitrile                        | 24.8 s                                       |         |         |         |        | 266.0   | 5    |
| C <sub>4</sub> H <sub>4</sub> O                              | Furan                                 |                                              |         | −78 e   | −54 e   | −20 e  | 31.0    | 1    |
| C <sub>4</sub> H <sub>4</sub> O <sub>2</sub>                 | Diketene                              |                                              |         |         | 19.3    | 63.3   | 126 e   | 5    |
| C <sub>4</sub> H <sub>4</sub> O <sub>3</sub>                 | Succinic anhydride                    |                                              |         |         | 121 e   | 180.8  | 260.8   | 5    |
| C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                 | Fumaric acid                          | 123.9 s                                      | 150 s   | 180 s   |         |        |         | 5    |
| C <sub>4</sub> H <sub>4</sub> S                              | Thiophene                             |                                              |         |         | −17 e   | 23.7   | 83.7    | 5    |
| C <sub>4</sub> H <sub>5</sub> Cl                             | 2-Chloro-1,3-butadiene                | −113 e                                       | −95 e   | −71 e   | −41 e   | 0.3    | 59.0    | 5    |
| C <sub>4</sub> H <sub>5</sub> ClO                            | 2-Methyl-2-propenyl chloride          |                                              | −57 e   | −35 e   | −5 e    | 36.4   | 98.2    | 5    |
| C <sub>4</sub> H <sub>5</sub> Cl <sub>3</sub> O <sub>2</sub> | Ethyl trichloroacetate                |                                              |         | 15.3    | 51.9    | 100.1  | 166.6   | 5    |
| C <sub>4</sub> H <sub>5</sub> N                              | 3-Butenenitrile                       | −67 e                                        | −48 e   | −23.1   | 9.3     | 53.7   | 118.4   | 5    |
| C <sub>4</sub> H <sub>5</sub> N                              | Methylacrylonitrile                   |                                              |         |         | −12 e   | 29.0   | 89.8    | 5    |
| C <sub>4</sub> H <sub>5</sub> N                              | Pyrrole                               |                                              |         | −8 e    | 24 e    | 66.7   | 129.4   | 1    |
| C <sub>4</sub> H <sub>5</sub> NO <sub>2</sub>                | Methyl cyanoacetate                   | −3 e                                         | 19 e    | 48 e    | 84 e    | 134.0  | 204.6   | 5    |
| C <sub>4</sub> H <sub>5</sub> NS                             | Allyl isothiocyanate                  | −45 e                                        | −27 e   | −3 e    | 32.1    | 89 e   | 198 e   | 5    |
| C <sub>4</sub> H <sub>5</sub> NS                             | 4-Methylthiazole                      |                                              |         |         |         |        | 67.0    | 5    |
| C <sub>4</sub> H <sub>6</sub>                                | 1,2-Butadiene                         | −132 e                                       | −117 e  | −98 e   | −72.8   | −38.9  | 10.5    | 5    |
| C <sub>4</sub> H <sub>6</sub>                                | 1,3-Butadiene*                        |                                              |         | −106 e  | −83 e   | −51.9  | −4.7    | 1    |
| C <sub>4</sub> H <sub>6</sub>                                | 1-Butyne                              | −125 e                                       | −111 e  | −94 e   | −71.2   | −39.4  | 7.8     | 1    |
| C <sub>4</sub> H <sub>6</sub>                                | 2-Butyne                              |                                              | −89.2 s | −73.8 s | −53.5 s | −23.9  | 26.6    | 5    |
| C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub> | Ethyl dichloroacetate                 |                                              |         | 2.6     | 40.1    | 89.1   | 156.3   | 5    |
| C <sub>4</sub> H <sub>6</sub> O                              | Divinyl ether                         |                                              | −99 e   | −80 e   | −56 e   | −22.1  | 28.0    | 5    |
| C <sub>4</sub> H <sub>6</sub> O                              | <i>trans</i> -2-Butenal               | −74 e                                        | −56 e   | −33 e   | −3 e    | 39.7   | 102.4   | 5    |
| C <sub>4</sub> H <sub>6</sub> O                              | 3-Buten-2-one                         |                                              |         |         |         | 21 e   | 81.0    | 5    |
| C <sub>4</sub> H <sub>6</sub> O                              | Cyclobutanone                         |                                              |         | −34 e   | −4 e    | 37.1   | 97 e    | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                 | <i>cis</i> -Crotonic acid             |                                              |         | 30 e    | 63 e    | 106.7  | 168.9   | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                 | <i>trans</i> -Crotonic acid           |                                              |         |         | 74 e    | 120.8  | 184.9   | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                 | 3-Butenoic acid                       | −19 e                                        | 2 e     | 27 e    | 61 e    | 105.6  | 168.6   | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                 | Methacrylic acid                      |                                              |         | 22 e    | 56 e    | 99.9   | 161.5   | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                 | Vinyl acetate                         | −88 e                                        | −71 e   | −50 e   | −22 e   | 16.2   | 72.2    | 1    |

| Mol. form.                                       | Name                            | Temperature in °C for the indicated pressure |        |        |       |        |         | Ref. |
|--------------------------------------------------|---------------------------------|----------------------------------------------|--------|--------|-------|--------|---------|------|
|                                                  |                                 | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>     | Methyl acrylate                 |                                              | -71 e  | -48 e  | -18 e | 22 e   | 79.9    | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>     | 2,3-Butanedione                 |                                              |        |        |       | 30.7   | 84.8    | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>     | gamma-Butyrolactone             |                                              | -17 e  | 24 e   | 72 e  | 130.2  | 203 e   | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>     | Acetic anhydride                | -44 e                                        | -25 e  | -1 e   | 31 e  | 75.1   | 139.7   | 1    |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>     | Propylene carbonate             | -40 e                                        | -5 e   | 43 e   | 112 e | 220 e  | 410 e   | 5    |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>     | Dimethyl oxalate                |                                              |        |        | 50.5  | 98.1   | 163.0   | 5    |
| C <sub>4</sub> H <sub>7</sub> Br                 | <i>trans</i> -1-Bromo-1-butene  | -87 e                                        | -68 e  | -43.3  | -11.4 | 31.9   | 94.4    | 5    |
| C <sub>4</sub> H <sub>7</sub> Br                 | 2-Bromo-1-butene                | -87 e                                        | -70 e  | -48 e  | -20 e | 20.7   | 80.6    | 5    |
| C <sub>4</sub> H <sub>7</sub> Br                 | <i>cis</i> -2-Bromo-2-butene    | -90 e                                        | -72 e  | -49.0  | -18.5 | 23.5   | 85.2    | 5    |
| C <sub>4</sub> H <sub>7</sub> Br                 | <i>trans</i> -2-Bromo-2-butene  | -86 e                                        | -67 e  | -43.4  | -12.0 | 31.0   | 93.5    | 5    |
| C <sub>4</sub> H <sub>7</sub> Br <sub>3</sub>    | 1,2,3-Tribromobutane            | 0 e                                          | 23 e   | 53 e   | 91 e  | 143.7  | 219.5   | 5    |
| C <sub>4</sub> H <sub>7</sub> Br <sub>3</sub>    | 1,2,4-Tribromobutane            | -3 e                                         | 20 e   | 49 e   | 87 e  | 139.4  | 214.5   | 5    |
| C <sub>4</sub> H <sub>7</sub> Cl                 | 3-Chloro-1-butene               |                                              |        | -64 e  | -36 e | 4 e    | 63.6    | 5    |
| C <sub>4</sub> H <sub>7</sub> Cl                 | <i>cis</i> -2-Chloro-2-butene   | -100 e                                       | -83 e  | -62 e  | -34 e | 6 e    | 66.4    | 5    |
| C <sub>4</sub> H <sub>7</sub> Cl                 | <i>trans</i> -2-Chloro-2-butene | -102 e                                       | -86 e  | -65 e  | -37 e | 3 e    | 62.2    | 5    |
| C <sub>4</sub> H <sub>7</sub> Cl                 | 3-Chloro-2-methylpropene        |                                              | -75 e  | -54 e  | -25 e | 13.8   | 71.5    | 5    |
| C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>   | Ethyl chloroacetate             |                                              |        | -2.6   | 32.6  | 79.1   | 143.8   | 5    |
| C <sub>4</sub> H <sub>7</sub> N                  | Butanenitrile                   | -67 e                                        | -48 e  | -24 e  | 8 e   | 52.3   | 117.2   | 1    |
| C <sub>4</sub> H <sub>8</sub>                    | 1-Butene                        | -139.0                                       | -125.2 | -107.8 | -85.3 | -53.7  | -6.6    | 1,5  |
| C <sub>4</sub> H <sub>8</sub>                    | <i>cis</i> -2-Butene            | -131.2                                       | -117.4 | -99.8  | -76.7 | -44.8  | 3.4     | 1,5  |
| C <sub>4</sub> H <sub>8</sub>                    | <i>trans</i> -2-Butene          |                                              |        | -102 e | -80 e | -47.6  | 0.6     | 1    |
| C <sub>4</sub> H <sub>8</sub>                    | Isobutene                       | -139.1                                       | -125.5 | -108.2 | -85.5 | -54.5  | -7.3    | 1,5  |
| C <sub>4</sub> H <sub>8</sub>                    | Cyclobutane                     |                                              |        |        | -71.8 | -38.1  | 12.1    | 5    |
| C <sub>4</sub> H <sub>8</sub>                    | Methylcyclopropane              | -130 e                                       | -116 e | -99.3  | -76.3 | -44.2  | 4.2     | 5    |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>    | 1,2-Dibromobutane               | -54 e                                        | -30 e  | 0.4    | 39.6  | 92.1   | 166.1   | 5    |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>    | 1,4-Dibromobutane               | -13 e                                        | 9 e    | 37 e   | 74 e  | 124.0  | 196.5   | 5    |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>    | 1,1-Dichlorobutane              |                                              |        | -25 e  | 6 e   | 49.3   | 113.4   | 5    |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>    | 1,2-Dichlorobutane              |                                              |        | -28.4  | 5.8   | 53.1   | 123.1   | 5    |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>    | 1,4-Dichlorobutane              |                                              | -26 e  | 0 e    | 35 e  | 82.4   | 153.4   | 5    |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>    | 2,2-Dichlorobutane              |                                              | -58 e  | -35 e  | -5 e  | 37.8   | 102.1   | 5    |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O  | Bis(2-chloroethyl) ether        | -32 e                                        | -9 e   | 19.8   | 56.9  | 106.9  | 177.9   | 5    |
| C <sub>4</sub> H <sub>8</sub> O                  | Ethyl vinyl ether               |                                              | -102 e | -81 e  | -53.1 | -16.5  | 34.7    | 5    |
| C <sub>4</sub> H <sub>8</sub> O                  | 1,2-Epoxybutane                 | -135 e                                       | -114 e | -87 e  | -53 e | -5.5   | 62.1    | 5    |
| C <sub>4</sub> H <sub>8</sub> O                  | Butanal                         | -88 e                                        | -72 e  | -50 e  | -22 e | 16.6   | 74.5    | 1,5  |
| C <sub>4</sub> H <sub>8</sub> O                  | Isobutanal                      |                                              |        | -56 e  | -29 e | 8 e    | 63.8    | 1    |
| C <sub>4</sub> H <sub>8</sub> O                  | 2-Butanone                      | -85 e                                        | -68 e  | -46 e  | -18.1 | 21.2   | 79.2    | 1    |
| C <sub>4</sub> H <sub>8</sub> O                  | Tetrahydrofuran                 | -94 e                                        | -78 e  | -57.3  | -29.8 | 9 e    | 65.6    | 1    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | Butanoic acid                   |                                              |        | 12.9   | 52.2  | 101.4  | 163.3   | 1,5  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | 2-Methylpropanoic acid          | -30.1                                        | -8.2   | 18.1   | 50.5  | 92.9   | 154.0   | 5    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | Propyl formate                  | -78 e                                        | -62 e  | -42 e  | -15.1 | 23.0   | 80.4    | 1,5  |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | Isopropyl formate               | -80 e                                        | -65 e  | -47 e  | -22.2 | 13.2   | 67.7    | 5    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | Ethyl acetate                   | -83 e                                        | -66 e  | -45 e  | -18 e | 20.4   | 76.8    | 1    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | Methyl propanoate               | -80 e                                        | -64 e  | -43 e  | -15.8 | 22.2   | 79.0    | 1    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | <i>cis</i> -2-Butene-1,4-diol   | 17 e                                         | 44 e   | 77 e   | 117.4 | 168.5  | 234.9   | 5    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | 1,3-Dioxane                     |                                              |        | -37 e  | -3 e  | 43.4   | 106.0   | 5    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>     | 1,4-Dioxane                     |                                              |        |        |       | 39.6   | 101.0   | 1    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S   | Sulfolane                       |                                              | 49 e   | 87 e   | 135 e | 198.0  | 283.5   | 5    |
| C <sub>4</sub> H <sub>8</sub> S                  | Tetrahydrothiophene             | -66 e                                        | -47 e  | -23 e  | 9.4   | 54.1   | 120.5   | 1    |
| C <sub>4</sub> H <sub>9</sub> Br                 | 1-Bromobutane                   | -68.4                                        | -53.9  | -34.1  | -5.4  | 37.6   | 101.1   | 1,5  |
| C <sub>4</sub> H <sub>9</sub> Br                 | 2-Bromobutane                   | -86 e                                        | -68 e  | -46 e  | -16 e | 26.6   | 90.7    | 5    |
| C <sub>4</sub> H <sub>9</sub> Br                 | 1-Bromo-2-methylpropane         | -85 e                                        | -68 e  | -46 e  | -16 e | 26.8   | 91.1    | 5    |
| C <sub>4</sub> H <sub>9</sub> Br                 | 2-Bromo-2-methylpropane         |                                              |        |        |       | 11.7   | 72.4    | 1,5  |
| C <sub>4</sub> H <sub>9</sub> Cl                 | 1-Chlorobutane                  | -87 e                                        | -71 e  | -49 e  | -21 e | 18.4   | 78.1    | 1    |
| C <sub>4</sub> H <sub>9</sub> Cl                 | 2-Chlorobutane                  | -96 e                                        | -80 e  | -59 e  | -31.0 | 8.5    | 67.9    | 1    |
| C <sub>4</sub> H <sub>9</sub> Cl                 | 1-Chloro-2-methylpropane        | -94 e                                        | -78 e  | -56.6  | -28.7 | 10.2   | 68.5    | 5    |
| C <sub>4</sub> H <sub>9</sub> Cl                 | 2-Chloro-2-methylpropane        |                                              |        |        |       | -4.2   | 50.3    | 5    |
| C <sub>4</sub> H <sub>9</sub> Cl <sub>3</sub> Si | Butyltrichlorosilane            |                                              |        |        |       | 77.2   | 148.4   | 5    |
| C <sub>4</sub> H <sub>9</sub> F                  | 1-Fluorobutane                  | -114 e                                       | -99 e  | -80 e  | -55 e | -20.0  | 32.1    | 5    |
| C <sub>4</sub> H <sub>9</sub> F                  | 2-Fluorobutane                  | -117 e                                       | -103 e | -85 e  | -60.7 | -26.7  | 24.7    | 5    |
| C <sub>4</sub> H <sub>9</sub> I                  | 1-Iodobutane                    | -62 e                                        | -43 e  | -19 e  | 14 e  | 60.5   | 130.0   | 5    |

| Mol. form.                                                      | Name                                       | Temperature in °C for the indicated pressure |         |         |       |        |         | Ref. |
|-----------------------------------------------------------------|--------------------------------------------|----------------------------------------------|---------|---------|-------|--------|---------|------|
|                                                                 |                                            | 1 Pa                                         | 10 Pa   | 100 Pa  | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>4</sub> H <sub>9</sub> I                                 | 2-Iodobutane                               | −70 e                                        | −51 e   | −27 e   | 5 e   | 50 e   | 119.5   | 5    |
| C <sub>4</sub> H <sub>9</sub> I                                 | 1-Iodo-2-methylpropane                     |                                              | −47 e   | −21.4   | 12.0  | 56.8   | 120.0   | 5    |
| C <sub>4</sub> H <sub>9</sub> I                                 | 2-Iodo-2-methylpropane                     | −75.1 s                                      | −58.8 s | −39.5 s | −5.2  | 41 e   | 100.0   | 5    |
| C <sub>4</sub> H <sub>9</sub> N                                 | Pyrrolidine                                |                                              | −59 e   | −38 e   | −10 e | 28.5   | 86.2    | 1    |
| C <sub>4</sub> H <sub>9</sub> NO                                | <i>N</i> -Methylpropanamide                |                                              |         |         | 81.1  | 105 e  |         | 5    |
| C <sub>4</sub> H <sub>9</sub> NO                                | <i>N,N</i> -Dimethylacetamide              | −8 e                                         | 8 e     | 28.0    | 56.4  | 98.2   | 165.7   | 1    |
| C <sub>4</sub> H <sub>9</sub> NO                                | 2-Butanone oxime                           |                                              | −18 e   | 7 e     | 38.9  | 81.9   | 142.9   | 5    |
| C <sub>4</sub> H <sub>9</sub> NO                                | Morpholine                                 |                                              |         |         | 21 e  | 64.5   | 128.5   | 1    |
| C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                   | Isobutyl nitrate                           |                                              |         | −18 e   | 15.1  | 59.2   | 123.0   | 5    |
| C <sub>4</sub> H <sub>10</sub>                                  | Butane*                                    | −134.3                                       | −121.0  | −103.9  | −81.1 | −49.1  | −0.8    | 1,41 |
| C <sub>4</sub> H <sub>10</sub>                                  | Isobutane*                                 |                                              | −129.0  | −113.0  | −90.9 | −59.4  | −12.0   | 1,41 |
| C <sub>4</sub> H <sub>10</sub> O                                | 1-Butanol                                  | −37 e                                        | −20 e   | 0 e     | 28 e  | 64 e   | 117.4   | 1    |
| C <sub>4</sub> H <sub>10</sub> O                                | 2-Butanol                                  | −50 e                                        | −34 e   | −14 e   | 12.6  | 48.2   | 99.2    | 1,5  |
| C <sub>4</sub> H <sub>10</sub> O                                | 2-Methyl-1-propanol                        | −39 e                                        | −24 e   | −5 e    | 20.9  | 56.0   | 107.6   | 1,5  |
| C <sub>4</sub> H <sub>10</sub> O                                | 2-Methyl-2-propanol                        |                                              |         |         |       | 34.4   | 82.1    | 1,5  |
| C <sub>4</sub> H <sub>10</sub> O                                | Diethyl ether                              | −111 e                                       | −96 e   | −77 e   | −52.6 | −17.8  | 34.1    | 1    |
| C <sub>4</sub> H <sub>10</sub> O                                | Methyl propyl ether                        |                                              |         |         | −40 e | −11.3  | 38.7    | 5    |
| C <sub>4</sub> H <sub>10</sub> O                                | Isopropyl methyl ether                     |                                              |         |         | −56 e | −21.2  | 30.4    | 5    |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                   | 1,3-Butanediol                             | −4 e                                         | 23 e    | 55 e    | 94 e  | 142.9  | 206.1   | 5    |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                   | 1,4-Butanediol                             |                                              | 45 e    | 77 e    | 116 e | 164.7  | 227.6   | 5    |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                   | 2,3-Butanediol                             |                                              | 15 e    | 43 e    | 77 e  | 121.2  | 180.3   | 5    |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                   | Ethylene glycol monoethyl ether            | −49 e                                        | −29 e   | −3 e    | 30 e  | 73.6   | 135.3   | 1    |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                   | Ethylene glycol dimethyl ether             |                                              |         | −44 e   | −15 e | 25.2   | 85.2    | 1    |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                   | Dimethylacetal                             | −89 e                                        | −74 e   | −55 e   | −29 e | 7.7    | 64.1    | 5    |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                   | Diethylperoxide                            |                                              |         |         | −39 e | 3.6    | 65.0    | 5    |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub> S                 | Bis(2-hydroxyethyl) sulfide                |                                              |         | 31 e    | 114.2 |        | 282.0   | 5    |
| C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>                   | Diethylene glycol                          | 35 e                                         | 58 e    | 86 e    | 123 e | 173.6  | 245.2   | 1    |
| C <sub>4</sub> H <sub>10</sub> O <sub>4</sub> S                 | Diethyl sulfate                            |                                              | 3 e     | 36 e    | 79 e  | 134 e  | 208.3   | 5    |
| C <sub>4</sub> H <sub>10</sub> S                                | 1-Butanethiol                              | −77 e                                        | −59 e   | −37 e   | −6 e  | 35.4   | 98.0    | 5    |
| C <sub>4</sub> H <sub>10</sub> S                                | 2-Butanethiol                              | −86 e                                        | −69 e   | −47 e   | −17 e | 23.4   | 84.5    | 5    |
| C <sub>4</sub> H <sub>10</sub> S                                | 2-Methyl-1-propanethiol                    |                                              | −66 e   | −44 e   | −15 e | 26.5   | 88.1    | 5    |
| C <sub>4</sub> H <sub>10</sub> S                                | 2-Methyl-2-propanethiol                    |                                              |         |         |       | 5.8    | 63.8    | 5    |
| C <sub>4</sub> H <sub>10</sub> S                                | Diethyl sulfide                            | −80 e                                        | −62 e   | −40 e   | −10.8 | 30.3   | 91.7    | 1    |
| C <sub>4</sub> H <sub>10</sub> S                                | Methyl propyl sulfide                      | −78 e                                        | −61 e   | −38 e   | −8 e  | 33.1   | 95.1    | 5    |
| C <sub>4</sub> H <sub>10</sub> S                                | Isopropyl methyl sulfide                   | −85 e                                        | −68 e   | −46 e   | −17 e | 23.4   | 84.3    | 5    |
| C <sub>4</sub> H <sub>10</sub> S <sub>2</sub>                   | 1,4-Butanedithiol                          | −17 e                                        | 5 e     | 32 e    | 69.1  | 119.9  | 195.1   | 5    |
| C <sub>4</sub> H <sub>10</sub> S <sub>2</sub>                   | Diethyl disulfide                          | −46 e                                        | −26 e   | 0 e     | 35 e  | 82.4   | 153.5   | 5    |
| C <sub>4</sub> H <sub>11</sub> N                                | Butylamine                                 |                                              |         | −46 e   | −18.1 | 20.0   | 75.9    | 5    |
| C <sub>4</sub> H <sub>11</sub> N                                | <i>sec</i> -Butylamine                     |                                              |         | −55 e   | −29.1 | 7.5    | 62.3    | 5    |
| C <sub>4</sub> H <sub>11</sub> N                                | <i>tert</i> -Butylamine                    |                                              |         | −67 e   | −42.4 | −8.1   | 43.7    | 5    |
| C <sub>4</sub> H <sub>11</sub> N                                | Isobutylamine                              | −85 e                                        | −70 e   | −50 e   | −24.5 | 12.0   | 67.3    | 5    |
| C <sub>4</sub> H <sub>11</sub> N                                | Diethylamine                               |                                              |         | −46 e   | −26 e | 5 e    | 55.2    | 1    |
| C <sub>4</sub> H <sub>11</sub> NO                               | <i>N,N</i> -Dimethylethanolamine           | −52 e                                        | −31 e   | −6 e    | 27 e  | 70.9   | 133 e   | 5    |
| C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>                  | Diethanolamine                             | 53 e                                         | 77 e    | 107 e   | 146 e | 197.3  | 268 e   | 5    |
| C <sub>4</sub> H <sub>12</sub> BN                               | (Dimethylamino)dimethyl-borane             |                                              | −81 e   | −60.1   | −31.9 | 7.0    | 64.2    | 5    |
| C <sub>4</sub> H <sub>12</sub> Cl <sub>2</sub> OSi <sub>2</sub> | 1,3-Dichloro-1,1,3,3-tetramethyldisiloxane |                                              | −33 e   | −9 e    | 23.8  | 69.1   | 136.5   | 5    |
| C <sub>4</sub> H <sub>12</sub> O <sub>4</sub> Si                | Tetramethyl silicate                       |                                              |         |         | 14.4  | 59.3   | 119.7   | 5    |
| C <sub>4</sub> H <sub>12</sub> Si                               | Tetramethylsilane                          |                                              |         | −83 e   | −59 e | −25 e  | 26.7    | 5    |
| C <sub>4</sub> H <sub>12</sub> Sn                               | Tetramethylstannane                        |                                              |         | −55.0   | −25.6 | 16.6   | 77.7    | 5    |
| C <sub>4</sub> H <sub>13</sub> N <sub>3</sub>                   | Diethylenetriamine                         | −10 e                                        | 13 e    | 43 e    | 80 e  | 129.6  | 198 e   | 5    |
| C <sub>4</sub> NiO <sub>4</sub>                                 | Nickel carbonyl                            |                                              |         |         |       | −12    | 42      | 4    |
| C <sub>5</sub> F <sub>12</sub>                                  | Perfluoropentane                           |                                              |         |         | −54.7 | −20.9  | 28.6    | 5    |
| C <sub>5</sub> FeO <sub>5</sub>                                 | Iron pentacarbonyl                         |                                              |         |         | 0     | 44     | 105     | 4    |
| C <sub>5</sub> H <sub>4</sub> ClN                               | 2-Chloropyridine                           |                                              |         | 7.4     | 45.8  | 97.3   | 169.9   | 5    |
| C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                    | Furfural                                   | −26 e                                        | −8 e    | 16 e    | 47 e  | 92.4   | 161.4   | 1    |
| C <sub>5</sub> H <sub>5</sub> N                                 | Pyridine                                   |                                              |         | −23 e   | 8 e   | 51.0   | 114.9   | 1    |
| C <sub>5</sub> H <sub>6</sub>                                   | 1,3-Cyclopentadiene                        |                                              |         | −77 e   | −51 e | −14 e  | 39.8    | 5    |
| C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                    | Pentanedinitrile                           | 24.1                                         | 52 e    | 85 e    | 126 e | 178 e  | 245 e   | 5    |
| C <sub>5</sub> H <sub>6</sub> O                                 | 2-Methylfuran                              |                                              |         | −66 e   | −35 e | 6 e    | 64.5    | 1    |



| Mol. form.                                     | Name                                    | Temperature in °C for the indicated pressure |        |        |       |        |         | Ref. |
|------------------------------------------------|-----------------------------------------|----------------------------------------------|--------|--------|-------|--------|---------|------|
|                                                |                                         | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>   | Furfuryl alcohol                        | -30 e                                        | -5 e   | 25 e   | 62.6  | 109.3  | 169.7   | 5    |
| C <sub>5</sub> H <sub>6</sub> S                | 2-Methylthiophene                       |                                              | -58 e  | -32 e  | 2 e   | 47.9   | 112.2   | 1    |
| C <sub>5</sub> H <sub>6</sub> S                | 3-Methylthiophene                       |                                              | -53 e  | -28 e  | 6 e   | 50.6   | 115.1   | 1    |
| C <sub>5</sub> H <sub>7</sub> N                | 1-Methylpyrrole                         |                                              |        |        | 8 e   | 49.9   | 112.3   | 5    |
| C <sub>5</sub> H <sub>7</sub> NO <sub>2</sub>  | Ethyl cyanoacetate                      | 16 e                                         | 39 e   | 67.0   | 102.1 | 146.7  | 205.6   | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | 1,2-Pentadiene                          | -109 e                                       | -93 e  | -73 e  | -46.1 | -9.7   | 44.5    | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | <i>cis</i> -1,3-Pentadiene              | -109 e                                       | -93 e  | -73 e  | -47.0 | -10.5  | 43.7    | 1,5  |
| C <sub>5</sub> H <sub>8</sub>                  | <i>trans</i> -1,3-Pentadiene            |                                              |        | -75 e  | -49.0 | -13 e  | 42 e    | 1    |
| C <sub>5</sub> H <sub>8</sub>                  | 1,4-Pentadiene                          | -120 e                                       | -105 e | -86 e  | -60.9 | -26.2  | 25.6    | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | 2,3-Pentadiene                          | -106 e                                       | -90 e  | -70 e  | -42.9 | -6.3   | 47.9    | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | 3-Methyl-1,2-butadiene                  | -111 e                                       | -95 e  | -75 e  | -49.2 | -13.1  | 40.4    | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                  | -115 e                                       | -100 e | -81 e  | -55.4 | -19.7  | 33.7    | 1,5  |
| C <sub>5</sub> H <sub>8</sub>                  | 1-Pentyne                               |                                              |        | -75 e  | -49.1 | -13.5  | 39.9    | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | 2-Pentyne                               | -100 e                                       | -85 e  | -65 e  | -37.9 | -0.5   | 55.7    | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | 3-Methyl-1-butyne                       |                                              |        | -82 e  | -57.5 | -23.1  | 28.6    | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | Cyclopentene                            | -109 e                                       | -94 e  | -74 e  | -48 e | -11.1  | 43.8    | 5    |
| C <sub>5</sub> H <sub>8</sub>                  | Spiropentane                            | -110 e                                       | -95 e  | -76 e  | -51 e | -15 e  | 38.6    | 5    |
| C <sub>5</sub> H <sub>8</sub> O                | 3-Methyl-3-buten-2-one                  |                                              |        | -35 e  | -5 e  | 36.0   | 97.3    | 5    |
| C <sub>5</sub> H <sub>8</sub> O                | Cyclopropyl methyl ketone               |                                              | -57 e  | -31 e  | 3 e   | 49 e   | 112 e   | 5    |
| C <sub>5</sub> H <sub>8</sub> O                | Cyclopentanone                          |                                              | -39 e  | -14 e  | 19 e  | 64 e   | 130.3   | 1    |
| C <sub>5</sub> H <sub>8</sub> O                | 3,4-Dihydro-2H-pyran                    |                                              |        |        | -22 e | 22.0   | 84.9    | 5    |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>   | 4-Pentenoic acid                        | 0 e                                          | 19 e   | 44 e   | 77 e  | 122.0  | 187.5   | 5    |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>   | Vinyl propanoate                        |                                              |        |        |       | 31.2   | 94 e    | 5    |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>   | Ethyl acrylate                          |                                              | -55 e  | -32.7  | -2.8  | 38.5   | 99.2    | 5    |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>   | Methyl methacrylate                     |                                              |        | -31 e  | -1 e  | 39.7   | 100.0   | 1    |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>   | 2,4-Pentanedione                        |                                              |        | -5 e   | 24.7  | 67.8   | 137.4   | 1    |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>   | Tetrahydro-2H-pyran-2-one               |                                              | 5 e    | 35.1   | 74.4  | 128.3  | 207.0   | 5    |
| C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>   | Methyl acetoacetate                     |                                              |        |        | 50.1  | 101.1  | 171.3   | 5    |
| C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>   | Glutaric acid                           |                                              | 121 e  | 153.2  | 191.9 | 240.3  | 302.5   | 5    |
| C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>   | Dimethyl malonate                       | -22 e                                        | 1 e    | 30.0   | 66.7  | 114.7  | 180.2   | 5    |
| C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub> | Ethyl 2-chloropropanoate                |                                              |        | 1.4    | 36.4  | 82.5   | 146.0   | 5    |
| C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub> | Isopropyl chloroacetate                 |                                              |        | -2 e   | 35.0  | 83.3   | 148.1   | 5    |
| C <sub>5</sub> H <sub>9</sub> N                | Pentanenitrile                          | -54 e                                        | -34 e  | -8 e   | 26 e  | 72.2   | 140.9   | 1    |
| C <sub>5</sub> H <sub>9</sub> N                | 2,2-Dimethylpropanenitrile              |                                              |        |        |       | 41.1   | 104.8   | 5    |
| C <sub>5</sub> H <sub>9</sub> NO               | <i>N</i> -Methyl-2-pyrrolidone          | 1 e                                          | 24 e   | 53.1   | 92.3  | 147.2  | 229 e   | 5    |
| C <sub>5</sub> H <sub>10</sub>                 | 1-Pentene                               | -118.9                                       | -103.4 | -84.0  | -58.8 | -23.3  | 29.6    | 1,5  |
| C <sub>5</sub> H <sub>10</sub>                 | <i>cis</i> -2-Pentene                   | -113.8                                       | -98.1  | -78.4  | -52.7 | -16.8  | 36.6    | 1,5  |
| C <sub>5</sub> H <sub>10</sub>                 | <i>trans</i> -2-Pentene                 | -114.5                                       | -98.9  | -79.1  | -53.3 | -17.5  | 36.0    | 1,5  |
| C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-1-butene                       | -117.7                                       | -102.2 | -82.7  | -57.2 | -21.9  | 30.8    | 1,5  |
| C <sub>5</sub> H <sub>10</sub>                 | 3-Methyl-1-butene                       | -125.0                                       | -110.1 | -91.2  | -66.7 | -32.1  | 19.7    | 1,5  |
| C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-2-butene                       | -113.4                                       | -97.6  | -77.7  | -51.6 | -15.8  | 38.2    | 1,5  |
| C <sub>5</sub> H <sub>10</sub>                 | Cyclopentane                            |                                              |        | -77.0  | -45.4 | -7.1   | 48.8    | 5    |
| C <sub>5</sub> H <sub>10</sub>                 | Ethylcyclopropane                       | -118 e                                       | -102 e | -83 e  | -57 e | -20 e  | 35.5    | 5    |
| C <sub>5</sub> H <sub>10</sub>                 | <i>cis</i> -1,2-Dimethylcyclo-propane   | -118 e                                       | -103 e | -83 e  | -57 e | -20 e  | 36.6    | 5    |
| C <sub>5</sub> H <sub>10</sub>                 | <i>trans</i> -1,2-Dimethylcyclo-propane | -122 e                                       | -108 e | -89 e  | -63 e | -27 e  | 27.8    | 5    |
| C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub> | 1,5-Dibromopentane                      | 1 e                                          | 25 e   | 54 e   | 93 e  | 145.6  | 221.8   | 5    |
| C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub> | 1,2-Dichloropentane                     |                                              |        |        | 30 e  | 77.4   | 147.8   | 5    |
| C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub> | 1,5-Dichloropentane                     | -31 e                                        | -10 e  | 17 e   | 54 e  | 104.1  | 178.9   | 5    |
| C <sub>5</sub> H <sub>10</sub> N <sub>2</sub>  | 3-(Dimethylamino)-propanenitrile        |                                              |        |        | 51.1  | 101.8  | 171.4   | 5    |
| C <sub>5</sub> H <sub>10</sub> O               | Cyclopentanol                           |                                              | -13 e  | 11.5   | 42.2  | 82.5   | 140.0   | 5    |
| C <sub>5</sub> H <sub>10</sub> O               | Allyl ethyl ether                       |                                              |        | -56 e  | -28.7 | 9.8    | 67.2    | 5    |
| C <sub>5</sub> H <sub>10</sub> O               | Pentanal                                | -71 e                                        | -53 e  | -31 e  | -1 e  | 40.8   | 102.6   | 5    |
| C <sub>5</sub> H <sub>10</sub> O               | 2-Pentanone                             |                                              |        |        | -1 e  | 40.3   | 101.9   | 1,5  |
| C <sub>5</sub> H <sub>10</sub> O               | 3-Pentanone                             |                                              |        | -31 e  | -1 e  | 40 e   | 101.6   | 1    |
| C <sub>5</sub> H <sub>10</sub> O               | 3-Methyl-2-butanone                     | -69 e                                        | -54 e  | -34 e  | -6.9  | 32.2   | 94.0    | 1,5  |
| C <sub>5</sub> H <sub>10</sub> O               | Tetrahydropyran                         |                                              |        |        | -15 e | 26.0   | 88 e    | 5    |
| C <sub>5</sub> H <sub>10</sub> O               | 2-Methyltetrahydrofuran                 |                                              |        |        | -20 e | 19.7   | 79.8    | 5    |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Pentanoic acid                          | -7.4                                         | 15.3   | 42.7   | 76.3  | 122.1  | 185.7   | 5    |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | 2-Methylbutanoic acid                   | -10 e                                        | 10 e   | 36 e   | 69 e  | 112.8  | 175.2   | 5    |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | 3-Methylbutanoic acid                   | -15.8                                        | 4 e    | 30.0   | 64.7  | 110.6  | 176.1   | 5    |

| Mol. form.      | Name                                     | Temperature in °C for the indicated pressure |          |         |         |         |         | Ref. |
|-----------------|------------------------------------------|----------------------------------------------|----------|---------|---------|---------|---------|------|
|                 |                                          | 1 Pa                                         | 10 Pa    | 100 Pa  | 1 kPa   | 10 kPa  | 100 kPa |      |
| $C_5H_{10}O_2$  | Butyl formate                            |                                              |          | -29 e   | 2 e     | 44.4    | 105.7   | 5    |
| $C_5H_{10}O_2$  | Isobutyl formate                         | -69 e                                        | -53 e    | -31 e   | -3 e    | 37.4    | 97.6    | 5    |
| $C_5H_{10}O_2$  | Propyl acetate                           | -69 e                                        | -51 e    | -29 e   | 0 e     | 40.9    | 101.2   | 1    |
| $C_5H_{10}O_2$  | Isopropyl acetate                        |                                              | -61 e    | -40 e   | -11 e   | 29.8    | 88.2    | 5    |
| $C_5H_{10}O_2$  | Ethyl propanoate                         | -69 e                                        | -52 e    | -30 e   | -1 e    | 38.9    | 98.7    | 1    |
| $C_5H_{10}O_2$  | Methyl butanoate                         | -68 e                                        | -50 e    | -28 e   | 0.9     | 41.7    | 102.3   | 5    |
| $C_5H_{10}O_2$  | Methyl isobutanoate                      | -83 e                                        | -65 e    | -41 e   | -11 e   | 31 e    | 92.1    | 5    |
| $C_5H_{10}O_2$  | Tetrahydrofurfuryl alcohol               | -40 e                                        | -16 e    | 15 e    | 55 e    | 106 e   | 176.8   | 5    |
| $C_5H_{10}O_3$  | Diethyl carbonate                        |                                              | -42 e    | -17 e   | 17 e    | 61.6    | 125.9   | 5    |
| $C_5H_{10}O_3$  | Ethylene glycol monomethyl ether acetate | -47 e                                        | -26 e    | 0 e     | 34 e    | 79.4    | 144.1   | 5    |
| $C_5H_{10}S$    | Thiacyclohexane                          |                                              |          |         | 24 e    | 71.1    | 141.2   | 5    |
| $C_5H_{10}S$    | Cyclopentanethiol                        |                                              |          |         | 18 e    | 64 e    | 131.7   | 5    |
| $C_5H_{11}Br$   | 1-Bromopentane                           | -60 e                                        | -41 e    | -16 e   | 16 e    | 61.5    | 129.1   | 5    |
| $C_5H_{11}Br$   | 2-Bromopentane                           | -69 e                                        | -51 e    | -27 e   | 5 e     | 49.7    | 116.9   | 5    |
| $C_5H_{11}Br$   | 3-Bromopentane                           | -68 e                                        | -50 e    | -26 e   | 6 e     | 50.8    | 118.1   | 5    |
| $C_5H_{11}Br$   | 1-Bromo-3-methylbutane                   | -67 e                                        | -49 e    | -25 e   | 8 e     | 52.4    | 119.9   | 5    |
| $C_5H_{11}Cl$   | 1-Chloropentane                          | -73 e                                        | -55 e    | -32 e   | -1 e    | 42.5    | 107.9   | 5    |
| $C_5H_{11}Cl$   | 2-Chloropentane                          | -80 e                                        | -62 e    | -39 e   | -9 e    | 33.2    | 96.1    | 5    |
| $C_5H_{11}Cl$   | 3-Chloropentane                          | -77 e                                        | -60 e    | -37 e   | -7 e    | 34.9    | 97.3    | 5    |
| $C_5H_{11}Cl$   | 2-Chloro-2-methylbutane                  |                                              |          | -52 e   | -21 e   | 21.8    | 85.2    | 5    |
| $C_5H_{11}Cl$   | 1-Chloro-2,2-dimethyl-propane            |                                              |          |         | -17 e   | 23.5    | 83.9    | 5    |
| $C_5H_{11}F$    | 1-Fluoropentane                          | -97 e                                        | -80 e    | -60 e   | -32 e   | 5.7     | 62.4    | 5    |
| $C_5H_{11}I$    | 1-Iodopentane                            | -47 e                                        | -27 e    | -1 e    | 34 e    | 83.0    | 156.5   | 5    |
| $C_5H_{11}I$    | 1-Iodo-3-methylbutane                    |                                              | -34 e    | -6.6    | 28.8    | 77.3    | 147.8   | 5    |
| $C_5H_{11}N$    | Cyclopentylamine                         | -66 e                                        | -48 e    | -26 e   | 4 e     | 45.8    | 108 e   | 5    |
| $C_5H_{11}N$    | Piperidine                               |                                              |          |         | 2 e     | 43.3    | 105.8   | 5    |
| $C_5H_{11}N$    | N-Methylpyrrolidine                      |                                              |          |         | -23 e   | 18.5    | 78 e    | 5    |
| $C_5H_{11}NO_3$ | 3-Methylbutyl nitrate                    |                                              | -26 e    | 1.0     | 35.5    | 81.7    | 147.0   | 5    |
| $C_5H_{12}$     | Pentane**                                | -115.5                                       | -99.8    | -80.0   | -54.0   | -18.1   | 35.7    | 16   |
| $C_5H_{12}$     | Isopentane                               | -119 e                                       | -105 e   | -86 e   | -61 e   | -26 e   | 27.5    | 1    |
| $C_5H_{12}$     | Neopentane*                              |                                              | -107.5 s | -90.8 s | -68.8 s | -38.5 s | 9.2     | 1,5  |
| $C_5H_{12}N_2O$ | Tetramethylurea                          |                                              |          | 20.7    | 58.0    | 106.7   | 179.5   | 5    |
| $C_5H_{12}O$    | 1-Pentanol                               | -27 e                                        | -10 e    | 12 e    | 41 e    | 79.8    | 137.4   | 5    |
| $C_5H_{12}O$    | 2-Pentanol                               | -35 e                                        | -19 e    | 1 e     | 28.0    | 64.9    | 118.7   | 1    |
| $C_5H_{12}O$    | 3-Pentanol                               | -41 e                                        | -25 e    | -4 e    | 24 e    | 61.1    | 114.9   | 5    |
| $C_5H_{12}O$    | 2-Methyl-1-butanol                       | -27 e                                        | -11 e    | 9 e     | 36.2    | 73.4    | 128.3   | 1    |
| $C_5H_{12}O$    | 3-Methyl-1-butanol                       | -22 e                                        | -7 e     | 13 e    | 39.1    | 75.7    | 130.1   | 5    |
| $C_5H_{12}O$    | 2-Methyl-2-butanol                       |                                              |          | -5 e    | 17.7    | 50.6    | 101.7   | 1,5  |
| $C_5H_{12}O$    | 3-Methyl-2-butanol                       |                                              |          | -3 e    | 22.7    | 58.2    | 111.1   | 5    |
| $C_5H_{12}O$    | 2,2-Dimethyl-1-propanol                  |                                              |          |         |         | 59.2    | 112.7   | 5    |
| $C_5H_{12}O$    | Butyl methyl ether                       |                                              |          | -54 e   | -27 e   | 12 e    | 69.8    | 1    |
| $C_5H_{12}O$    | Methyl <i>tert</i> -butyl ether          |                                              |          | -66 e   | -39 e   | -2 e    | 54.8    | 1    |
| $C_5H_{12}O$    | Ethyl propyl ether                       | -92 e                                        | -77 e    | -57 e   | -30.5   | 6.7     | 63.4    | 1,5  |
| $C_5H_{12}O_2$  | 1,5-Pentanediol                          | 25 e                                         | 52 e     | 85 e    | 125 e   | 175.1   | 238.9   | 5    |
| $C_5H_{12}O_2$  | Ethylene glycol monopropyl ether         |                                              |          |         | 40 e    | 85.6    | 149.3   | 5    |
| $C_5H_{12}O_2$  | Diethoxymethane                          |                                              | -65 e    | -43 e   | -14 e   | 27.3    | 87.7    | 5    |
| $C_5H_{12}O_3$  | Diethylene glycol monomethyl ether       |                                              | 12 e     | 40 e    | 76 e    | 124.2   | 193.7   | 1    |
| $C_5H_{12}S$    | 1-Pentanethiol                           | -60 e                                        | -41 e    | -17 e   | 15 e    | 60 e    | 126.2   | 1    |
| $C_5H_{12}S$    | 2-Pentanethiol                           | -70 e                                        | -52 e    | -28 e   | 3 e     | 46.6    | 111.9   | 5    |
| $C_5H_{12}S$    | 3-Pentanethiol                           | -70 e                                        | -51 e    | -28 e   | 4 e     | 47.7    | 113.4   | 5    |
| $C_5H_{12}S$    | 2-Methyl-1-butanethiol                   |                                              |          |         | 8.0     | 52.3    | 118.5   | 5    |
| $C_5H_{12}S$    | 3-Methyl-1-butanethiol                   |                                              |          |         | 7.8     | 51.9    | 117.9   | 5    |
| $C_5H_{12}S$    | 2-Methyl-2-butanethiol                   |                                              |          |         | -8.0    | 34.6    | 98.7    | 5    |
| $C_5H_{12}S$    | Butyl methyl sulfide                     |                                              | -43 e    | -19 e   | 13 e    | 57 e    | 123.0   | 1    |
| $C_5H_{12}S$    | <i>tert</i> -Butyl methyl sulfide        |                                              |          |         | -7.8    | 34.7    | 98.4    | 5    |
| $C_5H_{12}S$    | Ethyl propyl sulfide                     | -64 e                                        | -46 e    | -23 e   | 9 e     | 52.7    | 118.0   | 5    |
| $C_5H_{12}S$    | Ethyl isopropyl sulfide                  | -72 e                                        | -54 e    | -31 e   | 0 e     | 42.7    | 106.9   | 5    |
| $C_5H_{13}N$    | Pentylamine                              |                                              | -52 e    | -29 e   | 1 e     | 42.8    | 104.0   | 5    |
| $C_6BrF_5$      | Bromopentafluorobenzene                  |                                              |          | -10 e   | 23 e    | 68 e    | 136.0   | 5    |
| $C_6ClF_5$      | Chloropentafluorobenzene                 |                                              | -44 e    | -21 e   | 11 e    | 53.8    | 117.6   | 1    |



| Mol. form.                                                  | Name                                   | Temperature in °C for the indicated pressure |         |        |         |         |         | Ref. |
|-------------------------------------------------------------|----------------------------------------|----------------------------------------------|---------|--------|---------|---------|---------|------|
|                                                             |                                        | 1 Pa                                         | 10 Pa   | 100 Pa | 1 kPa   | 10 kPa  | 100 kPa |      |
| C <sub>6</sub> Cl <sub>3</sub> F <sub>3</sub>               | 1,3,5-Trichloro-2,4,6-trifluorobenzene | -19 e                                        | 4 e     | 32 e   | 70 e    | 121.7   | 197.9   | 1    |
| C <sub>6</sub> F <sub>6</sub>                               | Hexafluorobenzene                      |                                              | -56.9 s | -36 s  | -11.5 s | 22.6    | 79.9    | 1,5  |
| C <sub>6</sub> F <sub>12</sub>                              | Perfluorocyclohexane                   |                                              |         |        | -46.2 s | -7.6 s  | 48.9 s  | 5    |
| C <sub>6</sub> F <sub>14</sub>                              | Perfluorohexane                        |                                              | -75 e   | -57 e  | -32 e   | 2.8     | 56.8    | 5    |
| C <sub>6</sub> F <sub>14</sub>                              | Perfluoro-2-methylpentane              |                                              |         |        | -33 e   | 2.9     | 57.1    | 5    |
| C <sub>6</sub> F <sub>14</sub>                              | Perfluoro-3-methylpentane              | -95 e                                        | -80 e   | -60 e  | -34 e   | 2.8     | 57.9    | 5    |
| C <sub>6</sub> F <sub>14</sub>                              | Perfluoro-2,3-dimethylbutane           |                                              |         |        |         | 4.3     | 59.3    | 5    |
| C <sub>6</sub> HF <sub>5</sub>                              | Pentafluorobenzene                     |                                              |         | -41 e  | -13 e   | 27 e    | 85.3    | 5    |
| C <sub>6</sub> HF <sub>5</sub> O                            | Pentafluorophenol                      |                                              |         |        | 39 e    | 82 e    | 145.2   | 5    |
| C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>                | 1,2,3,4-Tetrafluorobenzene             |                                              |         | -36 e  | -7 e    | 33.8    | 94.0    | 1    |
| C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>                | 1,2,3,5-Tetrafluorobenzene             |                                              |         | -43 e  | -14 e   | 25.5    | 84.1    | 1    |
| C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>                | 1,2,4,5-Tetrafluorobenzene             |                                              |         |        |         | 30.7    | 89.9    | 1    |
| C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O             | 2,4,6-Trichlorophenol                  |                                              |         | 71.8   | 114.0   | 169.5   | 245.7   | 5    |
| C <sub>6</sub> H <sub>3</sub> F <sub>3</sub>                | 1,3,5-Trifluorobenzene                 |                                              |         |        |         | 18.2    | 75.0    | 5    |
| C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>               | <i>m</i> -Dibromobenzene               | -7 e                                         | 16 e    | 44 e   | 83 e    | 137.0   | 218.2   | 5    |
| C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>             | 1-Chloro-4-nitrobenzene                | 15.4 s                                       | 35.8 s  |        | 97 e    | 156.0   | 238 e   | 5    |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>o</i> -Dichlorobenzene              |                                              | -13 e   | 16.3   | 53.9    | 104.6   | 180.0   | 1,5  |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>m</i> -Dichlorobenzene              |                                              | -22 e   | 8.0    | 46.7    | 97.8    | 172.5   | 1,5  |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>p</i> -Dichlorobenzene              | -45.5 s                                      | -21.8 s | 8 s    | 46.7 s  | 99.0    | 173.6   | 1,5  |
| C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>                | <i>p</i> -Benzoquinone                 | -4.1 s                                       | 17.8 s  | 43.5 s | 74.3 s  | 111.6 s |         | 5    |
| C <sub>6</sub> H <sub>5</sub> AsCl <sub>2</sub>             | Dichlorophenylarsine                   | 6.9                                          | 35.2    | 70 e   | 113 e   | 170 e   | 245 e   | 5    |
| C <sub>6</sub> H <sub>5</sub> Br                            | Bromobenzene                           |                                              | -25 e   | 1 e    | 34.9    | 83.1    | 155.4   | 1    |
| C <sub>6</sub> H <sub>5</sub> Cl                            | Chlorobenzene                          |                                              | -43 e   | -17 e  | 16.8    | 62.9    | 131.3   | 1,5  |
| C <sub>6</sub> H <sub>5</sub> ClO                           | <i>o</i> -Chlorophenol                 |                                              |         |        | 45.8    | 97.9    | 173.9   | 5    |
| C <sub>6</sub> H <sub>5</sub> ClO                           | <i>m</i> -Chlorophenol                 |                                              |         | 39.7   | 80.2    | 135.1   | 213.4   | 5    |
| C <sub>6</sub> H <sub>5</sub> ClO                           | <i>p</i> -Chlorophenol                 |                                              |         | 45.0   | 86.5    | 142.0   | 219.9   | 5    |
| C <sub>6</sub> H <sub>5</sub> Cl <sub>3</sub> Si            | Trichlorophenylsilane                  |                                              |         | 33 e   | 70.2    | 122.6   | 201 e   | 5    |
| C <sub>6</sub> H <sub>5</sub> F                             | Fluorobenzene                          |                                              |         |        | -16.9   | 24.2    | 84.4    | 1    |
| C <sub>6</sub> H <sub>5</sub> I                             | Iodobenzene                            | -30 e                                        | -7 e    | 20.9   | 58.5    | 110.6   | 187.8   | 1    |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>               | Nitrobenzene                           |                                              | 10 e    | 40 e   | 78 e    | 132 e   | 210.3   | 1    |
| C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>               | <i>p</i> -Nitrophenol                  | 72.6 s                                       | 97.4 s  |        |         |         |         | 5    |
| C <sub>6</sub> H <sub>6</sub>                               | 1,5-Hexadien-3-yne                     | -82 e                                        | -66 e   | -44.3  | -16.0   | 23.7    | 83.6    | 5    |
| C <sub>6</sub> H <sub>6</sub>                               | Benzene**                              |                                              |         | -40 s  | -15.1 s | 20.0    | 79.7    | 1,5  |
| C <sub>6</sub> H <sub>6</sub> ClN                           | <i>o</i> -Chloroaniline                |                                              | 10 e    | 39.0   | 75.2    | 131.4   | 208.3   | 5    |
| C <sub>6</sub> H <sub>6</sub> ClN                           | <i>m</i> -Chloroaniline                | -5 e                                         | 19.7    | 49.4   | 94.2    | 162 e   | 1069 e  | 5    |
| C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | <i>p</i> -Nitroaniline                 | 87.8 s                                       |         |        | 192.0   | 252.6   | 331.2   | 5    |
| C <sub>6</sub> H <sub>6</sub> O                             | Phenol                                 | -9.7 s                                       | 9.6 s   | 34.1 s | 68.9    | 113.7   | 181.4   | 1,5  |
| C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>                | 1,2,3-Benzenetriol                     |                                              |         |        | 162.0   | 222.8   | 308.3   | 5    |
| C <sub>6</sub> H <sub>6</sub> S                             | Benzenethiol                           |                                              | -15 e   | 12 e   | 47 e    | 96.0    | 168.6   | 5    |
| C <sub>6</sub> H <sub>7</sub> N                             | Aniline                                |                                              | -2.5    | 26.7   | 63.5    | 112.5   | 183.5   | 1,5  |
| C <sub>6</sub> H <sub>7</sub> N                             | 2-Methylpyridine                       | -56.5                                        | -37.8   | -13.9  | 18.3    | 62.9    | 129.0   | 1,5  |
| C <sub>6</sub> H <sub>7</sub> N                             | 3-Methylpyridine                       |                                              |         | -5 e   | 28.8    | 75.2    | 143.7   | 1    |
| C <sub>6</sub> H <sub>7</sub> N                             | 4-Methylpyridine                       | -58.2 s                                      | -43.1 s | -3.9 s | 29.6    | 76.1    | 144.9   | 1,5  |
| C <sub>6</sub> H <sub>8</sub>                               | <i>cis</i> -1,3,5-Hexatriene           |                                              |         |        |         | 21 e    | 78 e    | 5    |
| C <sub>6</sub> H <sub>8</sub>                               | 1,3-Cyclohexadiene                     | -88 e                                        | -71 e   | -50 e  | -21 e   | 19 e    | 79.9    | 5    |
| C <sub>6</sub> H <sub>8</sub>                               | 1,4-Cyclohexadiene                     |                                              |         |        | -15 e   | 27.3    | 85.0    | 5    |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                | Adiponitrile                           | 30 e                                         | 61 e    | 100 e  | 148.6   | 211.8   | 297 e   | 5    |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                | <i>m</i> -Phenylenediamine             |                                              |         | 94.5   | 140.2   | 200.8   | 285.0   | 5    |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                | Phenylhydrazine                        |                                              | 38 e    | 69 e   | 109 e   | 163.9   | 242.5   | 5    |
| C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                | Dimethyl maleate                       |                                              | 5 e     | 36 e   | 76 e    | 127.3   | 197 e   | 5    |
| C <sub>6</sub> H <sub>8</sub> S                             | 2,5-Dimethylthiophene                  |                                              | -43 e   | -16 e  | 20 e    | 67.5    | 134.8   | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>trans</i> -1,3-Hexadiene            | -86 e                                        | -70 e   | -51 e  | -24 e   | 14 e    | 72 e    | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>trans</i> -1,4-Hexadiene            | -98 e                                        | -81 e   | -60 e  | -33 e   | 7 e     | 65 e    | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | 1,5-Hexadiene                          | -99 e                                        | -84 e   | -64 e  | -37 e   | 0.9     | 59.2    | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>cis,cis</i> -2,4-Hexadiene          |                                              |         |        |         | 18 e    | 79.6    | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>trans,cis</i> -2,4-Hexadiene        | -89 e                                        | -73 e   | -52 e  | -23 e   | 18 e    | 79.6    | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>trans,trans</i> -2,4-Hexadiene      |                                              |         |        | -23 e   | 18 e    | 79.6    | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>trans</i> -2-Methyl-1,3-pentadiene  | -92 e                                        | -75 e   | -54 e  | -26 e   | 14 e    | 75.6    | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | 2,3-Dimethyl-1,3-butadiene             |                                              |         | -59 e  | -30 e   | 9.7     | 68.1    | 5    |
| C <sub>6</sub> H <sub>10</sub>                              | 1-Hexyne                               | -91 e                                        | -75 e   | -54 e  | -26 e   | 12.8    | 71.0    | 5    |

| Mol. form.                                       | Name                                | Temperature in °C for the indicated pressure |         |         |         |        |         | Ref. |
|--------------------------------------------------|-------------------------------------|----------------------------------------------|---------|---------|---------|--------|---------|------|
|                                                  |                                     | 1 Pa                                         | 10 Pa   | 100 Pa  | 1 kPa   | 10 kPa | 100 kPa |      |
| C <sub>6</sub> H <sub>10</sub>                   | 2-Hexyne                            | -84 e                                        | -67 e   | -46 e   | -17 e   | 23.6   | 84.1    | 5    |
| C <sub>6</sub> H <sub>10</sub>                   | 3-Hexyne                            | -86 e                                        | -69 e   | -48 e   | -19.1   | 21.0   | 81.0    | 1,5  |
| C <sub>6</sub> H <sub>10</sub>                   | 4-Methyl-1-pentyne                  | -97 e                                        | -81 e   | -61 e   | -34 e   | 4.1    | 60.7    | 5    |
| C <sub>6</sub> H <sub>10</sub>                   | 4-Methyl-2-pentyne                  | -91 e                                        | -74 e   | -54 e   | -26 e   | 13.8   | 72.7    | 5    |
| C <sub>6</sub> H <sub>10</sub>                   | Cyclohexene                         | -87 e                                        | -70 e   | -49 e   | -19 e   | 21 e   | 82.6    | 1    |
| C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub>   | 1,1-Dichlorocyclohexane             | -39 e                                        | -19 e   | 8 e     | 43 e    | 93.5   | 170.5   | 5    |
| C <sub>6</sub> H <sub>10</sub> Cl <sub>2</sub>   | <i>cis</i> -1,2-Dichlorocyclohexane |                                              |         | 27 e    | 69 e    | 125.7  | 206.2   | 5    |
| C <sub>6</sub> H <sub>10</sub> O                 | 4-Methyl-4-penten-2-one             | -59 e                                        | -41 e   | -17 e   | 14 e    | 57.0   | 121.0   | 5    |
| C <sub>6</sub> H <sub>10</sub> O                 | Cyclohexanone                       |                                              | -25 e   | 1 e     | 36 e    | 84 e   | 155.2   | 1    |
| C <sub>6</sub> H <sub>10</sub> O                 | Mesityl oxide                       | -56 e                                        | -37 e   | -13 e   | 19 e    | 63.5   | 129.3   | 5    |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | Vinyl butanoate                     |                                              |         |         |         | 53 e   | 114.5   | 5    |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | Ethyl methacrylate                  |                                              |         |         | 8 e     | 53.2   | 116.8   | 5    |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>    | Allyl glycidyl ether                |                                              |         |         | 40.1    | 85.7   | 152.8   | 5    |
| C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>    | Ethyl acetoacetate                  | -25 e                                        | -3 e    | 25.7    | 62.3    | 111.3  | 180.2   | 5    |
| C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>    | Propanoic anhydride                 | -32 e                                        | -15 e   | 6 e     | 36 e    | 77.6   | 142.9   | 5    |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>    | Diethyl oxalate                     | -5 e                                         | 18 e    | 44.9    | 79.4    | 124.3  | 185.2   | 5    |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>    | Dimethyl succinate                  |                                              |         | 30 e    | 70.4    | 123.3  | 195.4   | 5    |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>    | Ethylene glycol diacetate           | -17 e                                        | 6 e     | 35.0    | 71.9    | 121.1  | 190.0   | 5    |
| C <sub>6</sub> H <sub>10</sub> S                 | Diallylsulfide                      | -58 e                                        | -38 e   | -12.4   | 21.7    | 68.8   | 138.1   | 5    |
| C <sub>6</sub> H <sub>11</sub> Cl                | Chlorocyclohexane                   |                                              | -35 e   | -9 e    | 25 e    | 71.6   | 142.1   | 5    |
| C <sub>6</sub> H <sub>11</sub> N                 | Hexanenitrile                       | -40 e                                        | -19 e   | 8 e     | 43 e    | 91.5   | 163.2   | 1,5  |
| C <sub>6</sub> H <sub>11</sub> N                 | 4-Methylpentanenitrile              |                                              | -50 e   | -20 e   | 20 e    | 75.2   | 155.2   | 5    |
| C <sub>6</sub> H <sub>11</sub> NO                | Caprolactam                         | 36.8 s                                       | 58.9 s  | 86.6 s  |         |        | 270     | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 1-Hexene                            | -99.8                                        | -82.8   | -61.4   | -33.7   | 5.2    | 63.1    | 1,5  |
| C <sub>6</sub> H <sub>12</sub>                   | <i>cis</i> -2-Hexene                | -97 e                                        | -80 e   | -58 e   | -30 e   | 9.9    | 68.5    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | <i>trans</i> -2-Hexene              | -94 e                                        | -78 e   | -57 e   | -30 e   | 9.3    | 67.5    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | <i>cis</i> -3-Hexene                | -96 e                                        | -79 e   | -59 e   | -30.8   | 7.9    | 66.0    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | <i>trans</i> -3-Hexene              | -95 e                                        | -79 e   | -58 e   | -30.0   | 8.8    | 66.7    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 2-Methyl-1-pentene                  | -98 e                                        | -82 e   | -62 e   | -34.2   | 4.1    | 61.7    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 3-Methyl-1-pentene                  | -104 e                                       | -88 e   | -68 e   | -41.5   | -3.6   | 53.8    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 4-Methyl-1-pentene                  | -105 e                                       | -89 e   | -69 e   | -41.6   | -3.6   | 53.5    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 2-Methyl-2-pentene                  | -95 e                                        | -78 e   | -58 e   | -30 e   | 9.0    | 66.9    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 3-Methyl- <i>cis</i> -2-pentene     | -95 e                                        | -79 e   | -58 e   | -30 e   | 8.9    | 67.3    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 3-Methyl- <i>trans</i> -2-pentene   | -93 e                                        | -77 e   | -55 e   | -27.4   | 11.7   | 70.0    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 4-Methyl- <i>cis</i> -2-pentene     | -102 e                                       | -86 e   | -66 e   | -38.7   | -0.9   | 56.0    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 4-Methyl- <i>trans</i> -2-pentene   | -100 e                                       | -84 e   | -64 e   | -36.8   | 1.2    | 58.2    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 2-Ethyl-1-butene                    | -98 e                                        | -81 e   | -60 e   | -32 e   | 6.6    | 64.3    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 2,3-Dimethyl-1-butene               | -103 e                                       | -87 e   | -67 e   | -39.9   | -1.9   | 55.2    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 3,3-Dimethyl-1-butene               | -110 e                                       | -95 e   | -76 e   | -50.8   | -14.5  | 40.8    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 2,3-Dimethyl-2-butene               |                                              | -75 e   | -54 e   | -25 e   | 14 e   | 72.9    | 1    |
| C <sub>6</sub> H <sub>12</sub>                   | Cyclohexane                         | -85.6 s                                      | -68.9 s | -47.6 s | -19.8 s | 19.3   | 80.4    | 1,5  |
| C <sub>6</sub> H <sub>12</sub>                   | Methylcyclopentane                  | -97 e                                        | -80 e   | -58 e   | -28.8   | 11.6   | 71.4    | 1,5  |
| C <sub>6</sub> H <sub>12</sub>                   | Ethylcyclobutane                    | -99 e                                        | -82 e   | -61 e   | -32 e   | 9 e    | 70.2    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | Isopropylcyclopropane               | -104 e                                       | -88 e   | -68 e   | -40 e   | -1 e   | 57.9    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 1-Ethyl-1-methylcyclopropane        | -105 e                                       | -89 e   | -69 e   | -41 e   | -3 e   | 56.3    | 5    |
| C <sub>6</sub> H <sub>12</sub>                   | 1,1,2-Trimethylcyclopropane         | -109 e                                       | -94 e   | -73 e   | -46 e   | -7 e   | 52.0    | 5    |
| C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub>   | 1,2-Dichlorohexane                  |                                              |         |         | 49 e    | 98.1   | 171.7   | 5    |
| C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub> O | 2,2'-Dichlorodiisopropyl ether      |                                              | -1 e    | 27.3    | 63.4    | 112.3  | 182.1   | 5    |
| C <sub>6</sub> H <sub>12</sub> O                 | Butyl vinyl ether                   | -87 e                                        | -67 e   | -42 e   | -9.3    | 33.6   | 93.2    | 5    |
| C <sub>6</sub> H <sub>12</sub> O                 | Isobutyl vinyl ether                | -87 e                                        | -68 e   | -44 e   | -13 e   | 26.5   | 80.7    | 5    |
| C <sub>6</sub> H <sub>12</sub> O                 | Hexanal                             | -56 e                                        | -37 e   | -13 e   | 19 e    | 62.6   | 127.8   | 5    |
| C <sub>6</sub> H <sub>12</sub> O                 | 2-Hexanone                          | -43 e                                        | -21 e   | 4.2     | 34.5    | 61.9   | 127.2   | 1,5  |
| C <sub>6</sub> H <sub>12</sub> O                 | 3-Hexanone                          |                                              | -40 e   | -16 e   | 15 e    | 58.5   | 123.1   | 1    |
| C <sub>6</sub> H <sub>12</sub> O                 | 3-Methyl-2-pentanone                |                                              |         |         | 8.5     | 52.7   | 117.0   | 5    |
| C <sub>6</sub> H <sub>12</sub> O                 | 4-Methyl-2-pentanone                | -61 e                                        | -43 e   | -21 e   | 9 e     | 51.5   | 116.1   | 5    |
| C <sub>6</sub> H <sub>12</sub> O                 | 2-Methyl-3-pentanone                |                                              |         |         |         | 50.2   | 113.0   | 5    |
| C <sub>6</sub> H <sub>12</sub> O                 | 3,3-Dimethyl-2-butanone             |                                              |         | -30 e   | 0 e     | 42.5   | 105.7   | 1    |
| C <sub>6</sub> H <sub>12</sub> O                 | Cyclohexanol                        |                                              |         | 34 e    | 61 e    | 99.2   | 160.7   | 1    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>    | Hexanoic acid                       |                                              | 33 e    | 59 e    | 93 e    | 139.3  | 204.5   | 1    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>    | 4-Methylpentanoic acid              | 36 e                                         | 49 e    | 67.1    | 92.9    | 133.6  | 206.8   | 5    |

| Mol. form.                                    | Name                                         | Temperature in °C for the indicated pressure |       |        |       |        |         | Ref. |
|-----------------------------------------------|----------------------------------------------|----------------------------------------------|-------|--------|-------|--------|---------|------|
|                                               |                                              | 1 Pa                                         | 10 Pa | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Diethylacetic acid                           | −9 e                                         | 16 e  | 46 e   | 83 e  | 130.7  | 192.5   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Isopentyl formate                            | −60 e                                        | −41 e | −17 e  | 15 e  | 59.1   | 124 e   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Butyl acetate                                | −63 e                                        | −43 e | −19 e  | 14 e  | 61.0   | 125.6   | 1,5  |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Isobutyl acetate                             | −63 e                                        | −45 e | −21 e  | 10 e  | 53.4   | 116 e   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Propyl propanoate                            | −62 e                                        | −42 e | −18 e  | 14 e  | 58.3   | 122.0   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Ethyl butanoate                              | −49 e                                        | −34 e | −14 e  | 14.3  | 55.2   | 121.1   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Ethyl 2-methylpropanoate                     | −65 e                                        | −47 e | −24.6  | 5.4   | 47.3   | 109.8   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Methyl pentanoate                            |                                              |       |        | 19.2  | 63.7   | 127.4   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Methyl isopentanoate                         |                                              |       |        |       | 53.3   | 116.3   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Diacetone alcohol                            | −41 e                                        | −17 e | 13 e   | 50.1  | 98.5   | 164 e   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>3</sub> | Ethylene glycol monoethyl ether acetate      | −25 e                                        | −8 e  | 14 e   | 44.6  | 88.0   | 155.6   | 5    |
| C <sub>6</sub> H <sub>12</sub> O <sub>3</sub> | Paraldehyde                                  |                                              |       |        | 17 e  | 62.2   | 124 e   | 5    |
| C <sub>6</sub> H <sub>12</sub> S              | Cyclohexanethiol                             |                                              |       |        |       | 84.8   | 158.3   | 5    |
| C <sub>6</sub> H <sub>12</sub> S              | <i>cis</i> -Tetrahydro-2,5-dimethylthiophene | −53 e                                        | −34 e | −8 e   | 25 e  | 72.0   | 142.1   | 5    |
| C <sub>6</sub> H <sub>12</sub> S              | Tetrahydro-3-methyl-2H-thiopyran             | −48 e                                        | −27 e | 0 e    | 35 e  | 84.1   | 157.5   | 5    |
| C <sub>6</sub> H <sub>13</sub> Br             | 1-Bromohexane                                | −45 e                                        | −25 e | 2 e    | 36 e  | 83.7   | 154.8   | 5    |
| C <sub>6</sub> H <sub>13</sub> Cl             | 1-Chlorohexane                               | −55 e                                        | −36 e | −11 e  | 21 e  | 66.7   | 134.6   | 5    |
| C <sub>6</sub> H <sub>13</sub> F              | 1-Fluorohexane                               | −80 e                                        | −62 e | −40 e  | −11 e | 30.4   | 91.1    | 5    |
| C <sub>6</sub> H <sub>13</sub> I              | 1-Iodohexane                                 | −33 e                                        | −11 e | 16 e   | 53 e  | 104.0  | 180.8   | 5    |
| C <sub>6</sub> H <sub>13</sub> N              | Cyclohexylamine                              |                                              |       | −9 e   | 22 e  | 66.6   | 133.5   | 1    |
| C <sub>6</sub> H <sub>14</sub>                | Hexane                                       | −96.4 s                                      | −79.2 | −57.6  | −29.3 | 9.8    | 68.3    | 16   |
| C <sub>6</sub> H <sub>14</sub>                | 2-Methylpentane                              | −100 e                                       | −84 e | −64 e  | −36 e | 2 e    | 59.9    | 1    |
| C <sub>6</sub> H <sub>14</sub>                | 3-Methylpentane                              | −99 e                                        | −83 e | −62 e  | −34.3 | 4.6    | 62.9    | 1    |
| C <sub>6</sub> H <sub>14</sub>                | 2,2-Dimethylbutane                           |                                              | −90 e | −71.5  | −45.5 | −7.7   | 49.4    | 1    |
| C <sub>6</sub> H <sub>14</sub>                | 2,3-Dimethylbutane                           | −103 e                                       | −87 e | −66 e  | −39.0 | −0.4   | 57.6    | 1    |
| C <sub>6</sub> H <sub>14</sub> O              | 1-Hexanol                                    |                                              | 5 e   | 28 e   | 56.8  | 97.3   | 157.1   | 1    |
| C <sub>6</sub> H <sub>14</sub> O              | 2-Hexanol                                    | −28 e                                        | −10 e | 12 e   | 41.4  | 81.5   | 139.6   | 1    |
| C <sub>6</sub> H <sub>14</sub> O              | 3-Hexanol                                    | −43 e                                        | −23 e | 1 e    | 33 e  | 75.4   | 135.1   | 1    |
| C <sub>6</sub> H <sub>14</sub> O              | 2-Methyl-1-pentanol                          |                                              |       | 14 e   | 45.9  | 88.3   | 147.6   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 4-Methyl-1-pentanol                          |                                              |       | 24 e   | 53 e  | 92.4   | 151.4   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 2-Methyl-2-pentanol                          | −29 e                                        | −15 e | 3 e    | 27.1  | 63.0   | 120.9   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 3-Methyl-2-pentanol                          |                                              |       |        | 36.5  | 76.1   | 133.8   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 4-Methyl-2-pentanol                          | −43 e                                        | −24 e | 0 e    | 30 e  | 71.9   | 131.3   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 2-Methyl-3-pentanol                          |                                              |       |        | 29.8  | 68.8   | 126.0   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 3-Methyl-3-pentanol                          |                                              | −23 e | −4 e   | 22.9  | 61.1   | 121.1   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 2-Ethyl-1-butanol                            |                                              | −5 e  | 17 e   | 46 e  | 85.7   | 146.1   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 3,3-Dimethyl-1-butanol                       | −37 e                                        | −16 e | 9 e    | 42 e  | 84.3   | 142.5   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | 2,3-Dimethyl-2-butanol                       |                                              |       | −5 e   | 23 e  | 61.3   | 118.2   | 5    |
| C <sub>6</sub> H <sub>14</sub> O              | Dipropyl ether                               | −80 e                                        | −63 e | −41 e  | −12 e | 28.8   | 89.7    | 1    |
| C <sub>6</sub> H <sub>14</sub> O              | Diisopropyl ether                            |                                              | −76 e | −55 e  | −28 e | 11 e   | 68.1    | 1    |
| C <sub>6</sub> H <sub>14</sub> O              | Butyl ethyl ether                            | −78 e                                        | −61 e | −39 e  | −10 e | 31.0   | 91.9    | 1    |
| C <sub>6</sub> H <sub>14</sub> O              | <i>tert</i> -Butyl ethyl ether               | −90 e                                        | −74 e | −53 e  | −24.6 | 14.4   | 72.6    | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> | 2-Methyl-2,4-pentanediol                     | −8 e                                         | 17 e  | 48 e   | 86 e  | 134.4  | 197.5   | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> | Ethylene glycol monobutyl ether              | −31 e                                        | −8 e  | 20 e   | 55 e  | 103.2  | 170.2   | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> | 1,1-Diethoxyethane                           | −68 e                                        | −49 e | −26 e  | 3.7   | 44.2   | 101.9   | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> | Ethylene glycol diethyl ether                |                                              | −59 e | −35.3  | −2.8  | 44.4   | 118.8   | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub> | 1,2,6-Hexanetriol                            | 92 e                                         | 114.8 | 146.0  | 191 e |        |         | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub> | Dipropylene glycol                           |                                              |       |        | 110 e | 162.6  | 231.4   | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub> | Diethylene glycol monoethyl ether            |                                              |       | 40 e   | 80.3  | 132.4  | 201.4   | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub> | Diethylene glycol dimethyl ether             | −42 e                                        | −20 e | 8.3    | 44.3  | 92.3   | 159.4   | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub> | Trimethylolpropane                           | 73 e                                         | 98 e  | 128 e  | 167.8 | 220.5  | 295 e   | 5    |
| C <sub>6</sub> H <sub>14</sub> O <sub>4</sub> | Triethylene glycol                           | 44 e                                         | 74 e  | 109.0  | 152.6 | 207.2  | 277.9   | 5    |
| C <sub>6</sub> H <sub>14</sub> S              | 1-Hexanethiol                                | −45 e                                        | −25 e | 1 e    | 35 e  | 81.7   | 152.2   | 5    |
| C <sub>6</sub> H <sub>14</sub> S              | 2-Hexanethiol                                | −50 e                                        | −32 e | −8 e   | 25 e  | 69.9   | 138.4   | 5    |
| C <sub>6</sub> H <sub>14</sub> S              | Dipropyl sulfide                             | −50 e                                        | −30 e | −6 e   | 28 e  | 73.6   | 142.4   | 5    |
| C <sub>6</sub> H <sub>14</sub> S              | Diisopropyl sulfide                          | −65 e                                        | −47 e | −23 e  | 9 e   | 53.1   | 119.6   | 5    |
| C <sub>6</sub> H <sub>14</sub> S              | Isopropyl propyl sulfide                     |                                              |       |        | 18.5  | 63.8   | 131.6   | 5    |
| C <sub>6</sub> H <sub>14</sub> S              | Butyl ethyl sulfide                          | −49 e                                        | −30 e | −5 e   | 29 e  | 74.8   | 143.8   | 5    |
| C <sub>6</sub> H <sub>15</sub> N              | Hexylamine                                   |                                              |       | −10 e  | 22 e  | 66.0   | 130.6   | 5    |
| C <sub>6</sub> H <sub>15</sub> N              | Butylethylamine                              |                                              |       |        | 6.1   | 47.7   | 107.0   | 5    |

| Mol. form.                                                                    | Name                                           | Temperature in °C for the indicated pressure |        |        |        |         |         | Ref. |
|-------------------------------------------------------------------------------|------------------------------------------------|----------------------------------------------|--------|--------|--------|---------|---------|------|
|                                                                               |                                                | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa  | 10 kPa  | 100 kPa |      |
| C <sub>6</sub> H <sub>15</sub> N                                              | Dipropylamine                                  |                                              | −48 e  | −25 e  | 6 e    | 47.5    | 108.8   | 5    |
| C <sub>6</sub> H <sub>15</sub> N                                              | Diisopropylamine                               |                                              |        | −47 e  | −17.5  | 23.5    | 84.0    | 5    |
| C <sub>6</sub> H <sub>15</sub> N                                              | Triethylamine                                  | −58 e                                        | −45 e  | −29 e  | −5 e   | 29.9    | 88.5    | 1    |
| C <sub>6</sub> H <sub>15</sub> NO                                             | 2-Diethylaminoethanol                          |                                              |        |        |        | 97 e    | 160.6   | 5    |
| C <sub>6</sub> H <sub>15</sub> NO <sub>3</sub>                                | Triethanolamine                                | 75 e                                         | 108 e  | 148 e  | 196 e  | 256.7   | 334 e   | 5    |
| C <sub>6</sub> H <sub>15</sub> O <sub>4</sub> P                               | Triethyl phosphate                             |                                              |        | 34     | 76     | 132     | 211     | 4    |
| C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                                 | Hexamethylenediamine                           |                                              |        |        | 76.0   | 128.2   | 199.0   | 5    |
| C <sub>6</sub> H <sub>16</sub> O <sub>2</sub> Si                              | Diethoxydimethylsilane                         | −62 e                                        | −44 e  | −21.2  | 9.1    | 51.0    | 113.0   | 5    |
| C <sub>6</sub> H <sub>18</sub> Cl <sub>2</sub> O <sub>2</sub> Si <sub>3</sub> | 1,5-Dichloro-1,1,3,3,5,5-hexamethyltrisiloxane | −29 e                                        | −7 e   | 22.2   | 59.7   | 110.5   | 183.4   | 5    |
| C <sub>6</sub> H <sub>18</sub> OSi <sub>2</sub>                               | Hexamethyldisiloxane                           |                                              | −56 e  | −34 e  | −5 e   | 37.1    | 100.1   | 5    |
| C <sub>6</sub> MoO <sub>6</sub>                                               | Molybdenum hexacarbonyl                        |                                              | 17.4 s | 42.8 s | 73.1 s | 109.9 s | 155.4 s | 5    |
| C <sub>7</sub> F <sub>14</sub>                                                | Perfluoromethylcyclohexane                     |                                              |        |        | −21 e  | 18 e    | 75.9    | 1    |
| C <sub>7</sub> F <sub>16</sub>                                                | Perfluoroheptane                               |                                              | −62 e  | −41 e  | −14 e  | 24.7    | 82.1    | 1    |
| C <sub>7</sub> HF <sub>15</sub>                                               | 1H-Pentadecafluoroheptane                      |                                              |        |        | −7 e   | 35.9    | 96.0    | 5    |
| C <sub>7</sub> H <sub>3</sub> ClF <sub>3</sub> NO <sub>2</sub>                | 1-Chloro-2-nitro-4-(trifluoromethyl)benzene    | 3 e                                          | 26 e   | 55 e   | 92.8   | 145.2   | 222.0   | 5    |
| C <sub>7</sub> H <sub>3</sub> F <sub>5</sub>                                  | 2,3,4,5,6-Pentafluorotoluene                   |                                              |        | −20 e  | 11 e   | 53.6    | 117.0   | 5    |
| C <sub>7</sub> H <sub>4</sub> ClF <sub>3</sub>                                | 1-Chloro-2-(trifluoromethyl) benzene           |                                              |        | 1 e    | 34.5   | 81.8    | 151.8   | 5    |
| C <sub>7</sub> H <sub>4</sub> ClF <sub>3</sub>                                | 1-Chloro-3-(trifluoromethyl) benzene           | −53 e                                        | −34 e  | −9 e   | 24.2   | 69.8    | 137.2   | 5    |
| C <sub>7</sub> H <sub>4</sub> ClF <sub>3</sub>                                | 1-Chloro-4-(trifluoromethyl) benzene           |                                              |        | −9 e   | 24.2   | 70.4    | 138.1   | 5    |
| C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O                               | <i>o</i> -Chlorobenzoyl chloride               |                                              |        |        | 93 e   | 149 e   | 237.0   | 5    |
| C <sub>7</sub> H <sub>4</sub> Cl <sub>2</sub> O                               | <i>m</i> -Chlorobenzoyl chloride               |                                              |        |        | 87.8   | 147 e   | 225.0   | 5    |
| C <sub>7</sub> H <sub>4</sub> F <sub>3</sub> NO <sub>2</sub>                  | 1-Nitro-3-(trifluoromethyl) benzene            |                                              | 11 e   | 39 e   | 76.2   | 127.3   | 202.2   | 5    |
| C <sub>7</sub> H <sub>4</sub> F <sub>4</sub>                                  | 1-Fluoro-4-(trifluoromethyl) benzene           |                                              |        | −38 e  | −6 e   | 38.6    | 102.3   | 5    |
| C <sub>7</sub> H <sub>5</sub> BrO                                             | Benzoyl bromide                                | −15 e                                        | 11 e   | 42.6   | 83.9   | 139.5   | 218.0   | 5    |
| C <sub>7</sub> H <sub>5</sub> ClO                                             | Benzoyl chloride                               |                                              |        | 27.5   | 67.0   | 120.4   | 196.7   | 5    |
| C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub>                                 | (Trichloromethyl)benzene                       |                                              | 9 e    | 40.6   | 81.5   | 136.2   | 213.0   | 5    |
| C <sub>7</sub> H <sub>5</sub> F <sub>3</sub>                                  | (Trifluoromethyl)benzene                       |                                              |        |        | −3 e   | 39 e    | 101.6   | 5    |
| C <sub>7</sub> H <sub>5</sub> N                                               | Benzonitrile                                   |                                              | −6 e   | 23.9   | 63.1   | 115.7   | 190.0   | 5    |
| C <sub>7</sub> H <sub>5</sub> NS                                              | Phenyl isothiocyanate                          |                                              |        |        | 79.4   | 105 e   | 117 e   | 5    |
| C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                                 | 2,4-Dichlorotoluene                            |                                              | 6 e    | 33 e   | 68.3   | 119.5   | 199.1   | 5    |
| C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                                 | 3,4-Dichlorotoluene                            | −13 e                                        | 9 e    | 38 e   | 76 e   | 129.3   | 208.4   | 5    |
| C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                                 | (Dichloromethyl)benzene                        |                                              |        | 31     | 72     | 130     | 213     | 4    |
| C <sub>7</sub> H <sub>6</sub> O                                               | Benzaldehyde                                   |                                              | −9 e   | 19 e   | 54.6   | 104.6   | 178.3   | 1    |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                  | Salicylaldehyde                                |                                              | −1 e   | 29 e   | 68 e   | 120.7   | 196.2   | 5    |
| C <sub>7</sub> H <sub>7</sub> Br                                              | <i>o</i> -Bromotoluene                         |                                              | −10 e  | 17 e   | 54 e   | 104.8   | 181.1   | 5    |
| C <sub>7</sub> H <sub>7</sub> Br                                              | <i>m</i> -Bromotoluene                         | −34 e                                        | −11 e  | 19.4   | 58.1   | 109.9   | 183.1   | 5    |
| C <sub>7</sub> H <sub>7</sub> Br                                              | <i>p</i> -Bromotoluene                         |                                              |        |        | 57 e   | 107.8   | 183.8   | 5    |
| C <sub>7</sub> H <sub>7</sub> Br                                              | (Bromomethyl)benzene                           |                                              |        | 25.4   | 66.8   | 121.7   | 198.3   | 5    |
| C <sub>7</sub> H <sub>7</sub> Cl                                              | <i>o</i> -Chlorotoluene                        |                                              | −24 e  | 3 e    | 38 e   | 86.3    | 158.7   | 1,5  |
| C <sub>7</sub> H <sub>7</sub> Cl                                              | <i>m</i> -Chlorotoluene                        | −41 e                                        | −21 e  | 6 e    | 41 e   | 89 e    | 161.8   | 5    |
| C <sub>7</sub> H <sub>7</sub> Cl                                              | <i>p</i> -Chlorotoluene                        |                                              |        |        | 40 e   | 88.9    | 161.5   | 1,5  |
| C <sub>7</sub> H <sub>7</sub> Cl                                              | (Chloromethyl)benzene                          | −34 e                                        | −11 e  | 17.7   | 55.4   | 106.3   | 178.9   | 5    |
| C <sub>7</sub> H <sub>7</sub> ClO                                             | 1-Chloro-2-methoxy-benzene                     | −22 e                                        | 2 e    | 33 e   | 72 e   | 125.2   | 201 e   | 5    |
| C <sub>7</sub> H <sub>7</sub> F                                               | <i>o</i> -Fluorotoluene                        |                                              | −50 e  | −26 e  | 5 e    | 49.0    | 113.9   | 5    |
| C <sub>7</sub> H <sub>7</sub> F                                               | <i>m</i> -Fluorotoluene                        | −67 e                                        | −48 e  | −25 e  | 7 e    | 51.0    | 116.1   | 5    |
| C <sub>7</sub> H <sub>7</sub> F                                               | <i>p</i> -Fluorotoluene                        |                                              | −48 e  | −24 e  | 7 e    | 51 e    | 116.2   | 5    |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                 | <i>o</i> -Nitrotoluene                         | 23 e                                         | 40 e   | 62 e   | 94 e   | 141.9   | 221.9   | 5    |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                 | <i>m</i> -Nitrotoluene                         |                                              |        | 45 e   | 89.7   | 148.7   | 231.3   | 5    |
| C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                                 | 2-Nitroanisole                                 | 15 e                                         | 45 e   | 82 e   | 129 e  | 189.4   | 271.8   | 5    |
| C <sub>7</sub> H <sub>8</sub>                                                 | Toluene                                        | −78.1                                        | −57.1  | −31.3  | 1.5    | 45.2    | 110.1   | 5    |
| C <sub>7</sub> H <sub>8</sub>                                                 | Bicyclo[2.2.1]hepta-2,5-diene                  |                                              |        |        | −15 e  | 27.4    | 91 e    | 5    |
| C <sub>7</sub> H <sub>8</sub> Cl <sub>2</sub> Si                              | Dichloromethylphenylsilane                     |                                              |        | 32.4   | 71.8   | 126.0   | 205.0   | 5    |
| C <sub>7</sub> H <sub>8</sub> O                                               | <i>o</i> -Cresol                               | −6.4 s                                       | 12.8 s | 40.2   | 72.3   | 120.3   | 190.5   | 1,5  |
| C <sub>7</sub> H <sub>8</sub> O                                               | <i>m</i> -Cresol                               | 20.8                                         | 33.6   | 52.4   | 82.6   | 130.6   | 201.8   | 1,5  |
| C <sub>7</sub> H <sub>8</sub> O                                               | <i>p</i> -Cresol                               | −0.2 s                                       | 20.7 s | 52.7   | 83.1   | 130.7   | 201.5   | 1,5  |
| C <sub>7</sub> H <sub>8</sub> O                                               | Benzyl alcohol                                 | 8 e                                          | 28 e   | 54 e   | 88 e   | 134.7   | 204.9   | 1    |
| C <sub>7</sub> H <sub>8</sub> O                                               | Anisole                                        |                                              | −21 e  | 4 e    | 38 e   | 84 e    | 153.2   | 1,5  |
| C <sub>7</sub> H <sub>8</sub> S                                               | 3-Methylbenzenethiol                           |                                              | 0 e    | 29 e   | 66 e   | 117.9   | 194.6   | 5    |
| C <sub>7</sub> H <sub>9</sub> N                                               | Benzylamine                                    |                                              |        | 25.6   | 62.6   | 112.7   | 183.9   | 5    |

| Mol. form.                                    | Name                                 | Temperature in °C for the indicated pressure |       |        |       |        |         | Ref. |
|-----------------------------------------------|--------------------------------------|----------------------------------------------|-------|--------|-------|--------|---------|------|
|                                               |                                      | 1 Pa                                         | 10 Pa | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>7</sub> H <sub>9</sub> N               | <i>o</i> -Methylaniline              | 1.0                                          | 18.8  | 42.6   | 76.1  | 125.6  | 199.9   | 1,5  |
| C <sub>7</sub> H <sub>9</sub> N               | <i>m</i> -Methylaniline              | 3.8                                          | 22.0  | 46.2   | 80.1  | 128.8  | 202.9   | 1,5  |
| C <sub>7</sub> H <sub>9</sub> N               | <i>p</i> -Methylaniline              |                                              |       |        | 77.1  | 126.2  | 199.9   | 5    |
| C <sub>7</sub> H <sub>9</sub> N               | <i>N</i> -Methylaniline              | -16 e                                        | 6 e   | 34 e   | 70.3  | 121.1  | 195.8   | 1    |
| C <sub>7</sub> H <sub>9</sub> N               | 2-Ethylpyridine                      | -46 e                                        | -26 e | -1 e   | 33 e  | 79.3   | 149.0   | 5    |
| C <sub>7</sub> H <sub>9</sub> N               | 3-Ethylpyridine                      | -38 e                                        | -17 e | 9 e    | 44 e  | 92.7   | 166.5   | 5    |
| C <sub>7</sub> H <sub>9</sub> N               | 4-Ethylpyridine                      | -35 e                                        | -15 e | 11 e   | 46 e  | 94.4   | 168.6   | 5    |
| C <sub>7</sub> H <sub>9</sub> N               | 2,3-Dimethylpyridine                 |                                              |       |        | 42 e  | 89.9   | 160.6   | 5    |
| C <sub>7</sub> H <sub>9</sub> N               | 2,4-Dimethylpyridine                 |                                              | -25 e | 3.7    | 40.0  | 87.5   | 157.9   | 1,5  |
| C <sub>7</sub> H <sub>9</sub> N               | 2,5-Dimethylpyridine                 |                                              |       | 4 e    | 39 e  | 86.2   | 156.6   | 1    |
| C <sub>7</sub> H <sub>9</sub> N               | 2,6-Dimethylpyridine                 |                                              |       | -3 e   | 29.9  | 75.8   | 143.6   | 1    |
| C <sub>7</sub> H <sub>9</sub> N               | 3,4-Dimethylpyridine                 |                                              | -9 e  | 19 e   | 55 e  | 104.8  | 178.6   | 5    |
| C <sub>7</sub> H <sub>9</sub> N               | 3,5-Dimethylpyridine                 |                                              |       | 11 e   | 48 e  | 98 e   | 171.5   | 1    |
| C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> | Toluene-2,4- diamine                 |                                              |       | 100.4  | 145.3 | 202.9  | 279.5   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 1-Heptyne                            | -75 e                                        | -57 e | -35 e  | -5 e  | 37.1   | 99.5    | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 2-Heptyne                            |                                              | -51 e | -27 e  | 4 e   | 46.9   | 111.5   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 3-Heptyne                            | -71 e                                        | -53 e | -31 e  | 0 e   | 42.7   | 106.4   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 5-Methyl-1-hexyne                    | -80 e                                        | -62 e | -40 e  | -11 e | 30.1   | 91.4    | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 5-Methyl-2-hexyne                    | -75 e                                        | -57 e | -34 e  | -4 e  | 38.6   | 102.0   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 2-Methyl-3-hexyne                    | -78 e                                        | -61 e | -39 e  | -9 e  | 32.6   | 94.8    | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 4,4-Dimethyl-1-pentyne               |                                              | -73 e | -52 e  | -24 e | 15.9   | 75.6    | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 4,4-Dimethyl-2-pentyne               |                                              | -70 e | -48 e  | -19 e | 21.4   | 82.6    | 5    |
| C <sub>7</sub> H <sub>12</sub>                | Bicyclo[4.1.0]heptane                |                                              |       |        |       | 49.9   | 116.3   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | Cycloheptene                         |                                              |       | -30.0  | 3.4   | 47.5   | 108 e   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 1-Methylbicyclo(3,1,0)hexane         |                                              |       |        |       | 29.8   | 92.6    | 5    |
| C <sub>7</sub> H <sub>12</sub>                | Methylenecyclohexane                 | -76 e                                        | -58 e | -35 e  | -5 e  | 38 e   | 103.0   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 1-Methylcyclohexene                  | -72 e                                        | -53 e | -30 e  | 1 e   | 45 e   | 109.8   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 4-Methylcyclohexene                  | -76 e                                        | -59 e | -36 e  | -5 e  | 37.9   | 102.3   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 1-Ethylcyclopentene                  | -75 e                                        | -57 e | -34 e  | -3 e  | 40.7   | 105.8   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 1,2-Dimethylcyclopentene             | -75 e                                        | -57 e | -34 e  | -3 e  | 40.2   | 105.3   | 5    |
| C <sub>7</sub> H <sub>12</sub>                | 1,5-Dimethylcyclopentene             | -77 e                                        | -59 e | -36 e  | -5.5  | 37.3   | 101.5   | 5    |
| C <sub>7</sub> H <sub>12</sub> O              | Cycloheptanone                       |                                              |       | 18 e   | 53.7  | 104.0  | 178.7   | 5    |
| C <sub>7</sub> H <sub>12</sub> O <sub>2</sub> | Butyl acrylate                       | -52 e                                        | -31 e | -4.5   | 30.4  | 78.0   | 146.9   | 5    |
| C <sub>7</sub> H <sub>12</sub> O <sub>2</sub> | Propyl methacrylate                  |                                              |       |        | 26 e  | 73.8   | 139.7   | 5    |
| C <sub>7</sub> H <sub>12</sub> O <sub>3</sub> | Ethyl levulinate                     |                                              | 17 e  | 45.3   | 82.6  | 133.2  | 205.7   | 5    |
| C <sub>7</sub> H <sub>12</sub> O <sub>4</sub> | Diethyl malonate                     | -23 e                                        | 4 e   | 36.0   | 76.4  | 128.5  | 198.3   | 5    |
| C <sub>7</sub> H <sub>12</sub> O <sub>4</sub> | Dimethyl glutarate                   | -11 e                                        | 15 e  | 47 e   | 87.7  | 139.8  | 209.5   | 5    |
| C <sub>7</sub> H <sub>13</sub> ClO            | Heptanoyl chloride                   | -17 e                                        | 4 e   | 29.4   | 59.7  | 96.9   | 144.0   | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 1-Heptene                            | -82.1                                        | -63.8 | -40.6  | -10.7 | 31.1   | 93.2    | 1,5  |
| C <sub>7</sub> H <sub>14</sub>                | <i>cis</i> -2-Heptene                | -79 e                                        | -61 e | -38 e  | -8 e  | 34.3   | 98.0    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>trans</i> -2-Heptene              | -79 e                                        | -61 e | -39 e  | -8 e  | 34.0   | 97.5    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>cis</i> -3-Heptene                | -80 e                                        | -62 e | -40 e  | -10 e | 32.3   | 95.3    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>trans</i> -3-Heptene              | -80 e                                        | -62 e | -40 e  | -10 e | 32.2   | 95.2    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 2-Methyl-1-hexene                    | -81 e                                        | -64 e | -42 e  | -12 e | 29.3   | 91.6    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 4-Methyl-1-hexene                    | -84 e                                        | -67 e | -45 e  | -16 e | 25.3   | 86.3    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 2-Methyl-2-hexene                    | -80 e                                        | -63 e | -40 e  | -10 e | 32.0   | 95.0    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>cis</i> -3-Methyl-2-hexene        | -79 e                                        | -62 e | -39 e  | -9 e  | 33.4   | 96.8    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>trans</i> -4-Methyl-2-hexene      | -83 e                                        | -66 e | -44 e  | -15 e | 25.9   | 87.1    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>trans</i> -5-Methyl-2-hexene      | -83 e                                        | -66 e | -44 e  | -15 e | 26.3   | 87.7    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>trans</i> -2-Methyl-3-hexene      | -84 e                                        | -67 e | -45 e  | -16 e | 24.6   | 85.5    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 3-Ethyl-1-pentene                    | -85 e                                        | -68 e | -46 e  | -17 e | 23.2   | 83.7    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 2,3-Dimethyl-1-pentene               | -85 e                                        | -68 e | -46 e  | -17 e | 23.4   | 83.8    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 2,4-Dimethyl-1-pentene               | -88 e                                        | -71 e | -50 e  | -21 e | 20.0   | 81.2    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 3,3-Dimethyl-1-pentene               | -87 e                                        | -71 e | -50 e  | -21 e | 18.1   | 77.1    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 4,4-Dimethyl-1-pentene               | -94 e                                        | -78 e | -57 e  | -28 e | 11.5   | 72.1    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 2,3-Dimethyl-2-pentene               | -79 e                                        | -62 e | -39 e  | -9 e  | 33.5   | 96.9    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | 2,4-Dimethyl-2-pentene               | -84 e                                        | -68 e | -46 e  | -18 e | 22.6   | 82.9    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>cis</i> -3,4-Dimethyl-2-pentene   | -83 e                                        | -65 e | -43 e  | -14 e | 27.2   | 88.8    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>trans</i> -3,4-Dimethyl-2-pentene | -82 e                                        | -64 e | -42 e  | -13 e | 29.0   | 91.1    | 5    |
| C <sub>7</sub> H <sub>14</sub>                | <i>cis</i> -4,4-Dimethyl-2-pentene   | -90 e                                        | -73 e | -51 e  | -22 e | 18.6   | 80.0    | 5    |

| Mol. form.     | Name                                   | Temperature in °C for the indicated pressure |        |        |       |        |         | Ref. |
|----------------|----------------------------------------|----------------------------------------------|--------|--------|-------|--------|---------|------|
|                |                                        | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| $C_7H_{14}$    | <i>trans</i> -4,4-Dimethyl-2-pentene   | -90 e                                        | -73 e  | -52 e  | -23 e | 16.6   | 76.3    | 5    |
| $C_7H_{14}$    | 2,3,3-Trimethyl-1-butene               | -91 e                                        | -75 e  | -53 e  | -24.2 | 16.3   | 77.5    | 5    |
| $C_7H_{14}$    | Cycloheptane                           |                                              |        |        | 6 e   | 51.1   | 118.4   | 1    |
| $C_7H_{14}$    | Methylcyclohexane                      | -79 e                                        | -62 e  | -39 e  | -7.9  | 35.5   | 100.5   | 1    |
| $C_7H_{14}$    | Ethylcyclopentane                      | -76 e                                        | -59 e  | -35 e  | -5 e  | 38.4   | 103.0   | 5    |
| $C_7H_{14}$    | 1,1-Dimethylcyclopentane               |                                              | -69 e  | -47 e  | -17 e | 24.8   | 87.4    | 5    |
| $C_7H_{14}$    | <i>cis</i> -1,2-Dimethylcyclopentane   |                                              |        | -38 e  | -8 e  | 34.9   | 99.0    | 5    |
| $C_7H_{14}$    | <i>trans</i> -1,2-Dimethylcyclopentane | -83 e                                        | -66 e  | -43 e  | -13 e | 28.4   | 91.4    | 5    |
| $C_7H_{14}$    | <i>cis</i> -1,3-Dimethylcyclopentane   | -84 e                                        | -66 e  | -44 e  | -14 e | 28.2   | 91.1    | 5    |
| $C_7H_{14}$    | <i>trans</i> -1,3-Dimethylcyclopentane | -84 e                                        | -67 e  | -44 e  | -14 e | 27.4   | 90.3    | 5    |
| $C_7H_{14}O$   | 1-Heptanal                             | -41 e                                        | -21 e  | 4 e    | 37 e  | 83.7   | 152.3   | 5    |
| $C_7H_{14}O$   | 2-Heptanone                            |                                              | -22 e  | 3 e    | 36 e  | 82.2   | 150.6   | 1    |
| $C_7H_{14}O$   | 3-Heptanone                            |                                              | -28 e  | 0 e    | 36 e  | 83.2   | 147.0   | 5    |
| $C_7H_{14}O$   | 4-Heptanone                            | -27 e                                        | -6 e   | 18.8   | 50.2  | 90.3   | 143.4   | 5    |
| $C_7H_{14}O$   | 5-Methyl-2-hexanone                    |                                              | -27 e  | -2 e   | 31.0  | 76.6   | 144.4   | 5    |
| $C_7H_{14}O$   | 2,4-Dimethyl-3-pentanone               | -61 e                                        | -42 e  | -18 e  | 14 e  | 58.5   | 124.8   | 1    |
| $C_7H_{14}O_2$ | Heptanoic acid                         | 24 e                                         | 46 e   | 72 e   | 107 e | 154.6  | 222.6   | 5    |
| $C_7H_{14}O_2$ | Pentyl acetate                         | -58 e                                        | -39 e  | -14 e  | 20 e  | 70.1   | 149 e   | 5    |
| $C_7H_{14}O_2$ | Isopentyl acetate                      | -51 e                                        | -30 e  | -4 e   | 30.3  | 76.2   | 141.4   | 5    |
| $C_7H_{14}O_2$ | Isobutyl propanoate                    | -35 e                                        | -19 e  | 2 e    | 31 e  | 72.0   | 136.1   | 5    |
| $C_7H_{14}O_2$ | Propyl butanoate                       | -35 e                                        | -19 e  | 3 e    | 32.0  | 74.9   | 142.8   | 5    |
| $C_7H_{14}O_2$ | Propyl isobutanoate                    |                                              | -28 e  | -5.7   | 24.5  | 67.5   | 133.3   | 5    |
| $C_7H_{14}O_2$ | Isopropyl isobutanoate                 |                                              | -44 e  | -19.7  | 12.2  | 56.0   | 120.1   | 5    |
| $C_7H_{14}O_2$ | Ethyl 3-methylbutanoate                | -57 e                                        | -36 e  | -10 e  | 23.9  | 69.5   | 134.4   | 5    |
| $C_7H_{14}O_2$ | Methyl hexanoate                       | -47 e                                        | -26 e  | 2 e    | 36.6  | 83.3   | 149 e   | 5    |
| $C_7H_{14}O_2$ | 4-Methoxy-4-methyl-2-pentanone         |                                              |        |        | 43 e  | 89.8   | 160 e   | 5    |
| $C_7H_{15}Br$  | 1-Bromoheptane                         | -30 e                                        | -9 e   | 18 e   | 54 e  | 104.4  | 178.4   | 5    |
| $C_7H_{15}Cl$  | 1-Chloroheptane                        | -39 e                                        | -19 e  | 7 e    | 41 e  | 88.6   | 159.9   | 5    |
| $C_7H_{15}F$   | 1-Fluoroheptane                        | -64 e                                        | -45 e  | -22 e  | 10 e  | 53.3   | 117.4   | 5    |
| $C_7H_{15}I$   | 1-Iodoheptane                          | -19 e                                        | 3 e    | 32 e   | 71 e  | 123.8  | 203.4   | 5    |
| $C_7H_{16}$    | Heptane                                | -78.6                                        | -60.2  | -37.0  | -6.6  | 35.4   | 98.0    | 16   |
| $C_7H_{16}$    | 2-Methylhexane                         | -82 e                                        | -65 e  | -43 e  | -13 e | 27.8   | 89.7    | 1    |
| $C_7H_{16}$    | 3-Methylhexane                         | -81 e                                        | -64 e  | -42 e  | -12 e | 29.2   | 91.5    | 1    |
| $C_7H_{16}$    | 3-Ethylpentane                         | -81 e                                        | -63 e  | -41 e  | -11 e | 30.5   | 93.1    | 1    |
| $C_7H_{16}$    | 2,2-Dimethylpentane                    | -90 e                                        | -73 e  | -52 e  | -22.9 | 17.6   | 78.8    | 1    |
| $C_7H_{16}$    | 2,3-Dimethylpentane                    | -87 e                                        | -68.4  | -45.3  | -14.9 | 26.8   | 89.3    | 5    |
| $C_7H_{16}$    | 2,4-Dimethylpentane                    | -89 e                                        | -72 e  | -50 e  | -21.3 | 19.2   | 80.1    | 1    |
| $C_7H_{16}$    | 3,3-Dimethylpentane                    | -88 e                                        | -71 e  | -49 e  | -18.8 | 22.9   | 85.6    | 1    |
| $C_7H_{16}$    | 2,2,3-Trimethylbutane                  |                                              |        |        | -23.2 | 18.1   | 80.4    | 5    |
| $C_7H_{16}O$   | 1-Heptanol                             |                                              | 17 e   | 40 e   | 70.1  | 112.5  | 176 e   | 1    |
| $C_7H_{16}O$   | 2-Heptanol                             | -9 e                                         | 7 e    | 27 e   | 55.0  | 95.2   | 158.7   | 5    |
| $C_7H_{16}O$   | 3-Heptanol                             | -8 e                                         | 7 e    | 27 e   | 54.5  | 93.9   | 156.3   | 5    |
| $C_7H_{16}O$   | 4-Heptanol                             | -16 e                                        | 1 e    | 22 e   | 51 e  | 91.9   | 154.6   | 5    |
| $C_7H_{16}O$   | 2,2-Dimethyl-3-pentanol                |                                              |        | 9 e    | 35 e  | 73.1   | 135.5   | 5    |
| $C_7H_{16}S$   | 1-Heptanethiol                         | -30 e                                        | -9 e   | 18 e   | 53 e  | 102.7  | 176.4   | 5    |
| $C_7H_{17}N$   | Heptylamine                            |                                              |        | 5 e    | 39 e  | 86.7   | 156.4   | 5    |
| $C_7H_{18}N_2$ | <i>N,N</i> -Diethyl-1,3-propanediamine |                                              |        |        | 50.1  | 99.9   | 167.7   | 5    |
| $C_8F_{18}$    | Perfluorooctane                        |                                              |        |        | 5 e   | 45.0   | 105.6   | 5    |
| $C_8H_4O_3$    | Phthalic anhydride                     | 48.2 s                                       | 72.4 s |        |       | 192.7  | 284.2   | 5    |
| $C_8H_6O$      | Benzofuran                             |                                              | -16 e  | 12 e   | 47.9  | 97.7   | 170.7   | 5    |
| $C_8H_7Cl$     | <i>o</i> -Chlorostyrene                | -33 e                                        | -10 e  | 20 e   | 58 e  | 110.8  | 188 e   | 5    |
| $C_8H_7N$      | 2-Methylbenzonitrile                   |                                              | 1 e    | 32.1   | 72.2  | 126.6  | 204.7   | 5    |
| $C_8H_7N$      | 4-Methylbenzonitrile                   |                                              |        | 40.1   | 78.7  | 134.3  | 221.3   | 5    |
| $C_8H_7N$      | Benzeneacetonitrile                    | -3 e                                         | 23 e   | 55.3   | 97.4  | 153.7  | 233.1   | 5    |
| $C_8H_7N$      | Indole                                 | 20.6 s                                       | 44.5 s |        |       |        | 254.0   | 5    |
| $C_8H_7NO_4$   | Methyl 2-nitrobenzoate                 | 17 e                                         | 49 e   | 89 e   | 140 e | 208 e  | 302 e   | 5    |
| $C_8H_8$       | Styrene                                |                                              | -31 e  | -5 e   | 28.6  | 75.4   | 144.7   | 1    |
| $C_8H_8$       | 1,3,5,7-Cyclooctatetraene              |                                              |        |        | 24.3  | 71.0   | 140.1   | 5    |
| $C_8H_8O$      | Acetophenone                           |                                              |        | 36 e   | 73 e  | 125.3  | 201.5   | 5    |
| $C_8H_8O_2$    | Phenyl acetate                         |                                              | 3 e    | 33.1   | 72.2  | 123.9  | 195.5   | 5    |



| Mol. form.                                    | Name                               | Temperature in °C for the indicated pressure |        |        |       |        |         | Ref. |
|-----------------------------------------------|------------------------------------|----------------------------------------------|--------|--------|-------|--------|---------|------|
|                                               |                                    | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | Methyl benzoate                    |                                              | −1 e   | 29 e   | 68 e  | 121.2  | 198.9   | 5    |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | 4-Methoxybenzaldehyde              | 9 e                                          | 35 e   | 68.1   | 110.8 | 167.9  | 248.5   | 5    |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>  | Methyl salicylate                  | −1 e                                         | 22 e   | 51 e   | 88.8  | 141.8  | 219.9   | 5    |
| C <sub>8</sub> H <sub>9</sub> Cl              | 1-Chloro-2-ethylbenzene            | −30 e                                        | −9 e   | 18 e   | 54 e  | 103.7  | 177.9   | 5    |
| C <sub>8</sub> H <sub>9</sub> Cl              | 1-Chloro-4-ethylbenzene            | −27 e                                        | −6 e   | 22 e   | 58 e  | 108.7  | 183.9   | 5    |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub> | 1-Ethyl-4-nitrobenzene             | 10 e                                         | 36 e   | 69 e   | 111.6 | 168 e  | 245 e   | 5    |
| C <sub>8</sub> H <sub>10</sub>                | Ethylbenzene                       | −56.2                                        | −36.8  | −12.0  | 21.1  | 67.1   | 135.7   | 1    |
| C <sub>8</sub> H <sub>10</sub>                | <i>o</i> -Xylene                   |                                              |        | −7 e   | 27 e  | 74.2   | 143.9   | 1    |
| C <sub>8</sub> H <sub>10</sub>                | <i>m</i> -Xylene                   |                                              | −35 e  | −10 e  | 23.4  | 69.8   | 138.7   | 1    |
| C <sub>8</sub> H <sub>10</sub>                | <i>p</i> -Xylene                   |                                              |        |        | 22.4  | 68.9   | 137.9   | 1    |
| C <sub>8</sub> H <sub>10</sub> O              | <i>o</i> -Ethylphenol              |                                              | 16.9   | 44.5   | 81.1  | 130.9  | 204.0   | 5    |
| C <sub>8</sub> H <sub>10</sub> O              | <i>m</i> -Ethylphenol              | 5.6                                          | 29.2   | 57.5   | 91.9  | 144.8  | 217.9   | 5    |
| C <sub>8</sub> H <sub>10</sub> O              | <i>p</i> -Ethylphenol              |                                              |        | 60 e   | 95.5  | 144.6  | 217.5   | 5    |
| C <sub>8</sub> H <sub>10</sub> O              | 2,3-Xylenol                        | 14.3 s                                       | 34.3 s | 57.2 s | 91.4  | 141.7  | 216.4   | 1,5  |
| C <sub>8</sub> H <sub>10</sub> O              | 2,4-Xylenol                        |                                              |        | 50.2   | 85.5  | 137.2  | 210.5   | 1,5  |
| C <sub>8</sub> H <sub>10</sub> O              | 2,5-Xylenol                        | 13.4 s                                       | 33.2 s | 55.9 s | 87.4  | 137.0  | 210.6   | 5    |
| C <sub>8</sub> H <sub>10</sub> O              | 2,6-Xylenol                        | −3.1 s                                       | 16.7 s | 39.6 s | 75.3  | 125.9  | 200.6   | 1,5  |
| C <sub>8</sub> H <sub>10</sub> O              | 3,4-Xylenol                        | 19.7 s                                       | 40.2 s | 63.7 s | 102.1 | 152.3  | 226.4   | 1,5  |
| C <sub>8</sub> H <sub>10</sub> O              | 3,5-Xylenol                        | 16.5 s                                       | 37.2 s | 61.1 s | 98.0  | 147.9  | 221.3   | 1,5  |
| C <sub>8</sub> H <sub>10</sub> O              | Benzeneethanol                     | 2 e                                          | 25 e   | 54 e   | 92 e  | 143.6  | 217.7   | 5    |
| C <sub>8</sub> H <sub>10</sub> O              | Phenetole                          |                                              | −9 e   | 17 e   | 51 e  | 99 e   | 169.3   | 5    |
| C <sub>8</sub> H <sub>10</sub> O <sub>2</sub> | 2-Phenoxyethanol                   | 21 e                                         | 46 e   | 75.9   | 115.4 | 168.7  | 244.8   | 5    |
| C <sub>8</sub> H <sub>10</sub> O <sub>2</sub> | 1,3-Dimethoxybenzene               | 18 e                                         | 34 e   | 56 e   | 86.7  | 135.5  | 223 e   | 5    |
| C <sub>8</sub> H <sub>11</sub> N              | <i>p</i> -Ethylaniline             | −2 e                                         | 21 e   | 49 e   | 87 e  | 139.4  | 216.7   | 5    |
| C <sub>8</sub> H <sub>11</sub> N              | <i>N</i> -Ethylaniline             | −15 e                                        | 8 e    | 38 e   | 76.4  | 128.8  | 204.2   | 5    |
| C <sub>8</sub> H <sub>11</sub> N              | <i>N,N</i> -Dimethylaniline        |                                              |        | 28 e   | 66 e  | 118.1  | 193.6   | 1    |
| C <sub>8</sub> H <sub>11</sub> N              | 2,4-Xylidine                       | −2 e                                         | 21 e   | 51 e   | 88 e  | 139.1  | 210.9   | 5    |
| C <sub>8</sub> H <sub>11</sub> N              | 2,6-Xylidine                       |                                              |        | 37 e   | 80 e  | 137.7  | 217.7   | 5    |
| C <sub>8</sub> H <sub>11</sub> N              | 5-Ethyl-2-picoline                 | −33 e                                        | −9.3   | 20 e   |       |        | 178.0   | 5    |
| C <sub>8</sub> H <sub>11</sub> NO             | <i>o</i> -Phenetidine              | 0 e                                          | 27 e   | 60 e   | 102.2 | 156.0  | 228.1   | 5    |
| C <sub>8</sub> H <sub>12</sub>                | 1,5-Cyclooctadiene                 |                                              | −37 e  | −8 e   | 30 e  | 80.2   | 150 e   | 5    |
| C <sub>8</sub> H <sub>12</sub>                | 4-Vinylcyclohexene                 | −62 e                                        | −43 e  | −19 e  | 14.1  | 59.9   | 129 e   | 5    |
| C <sub>8</sub> H <sub>12</sub> O <sub>4</sub> | Diethyl maleate                    | −6 e                                         | 20 e   | 52.2   | 93.5  | 148.4  | 224.8   | 5    |
| C <sub>8</sub> H <sub>14</sub>                | 2,5-Dimethyl-1,5-hexadiene         | −38 e                                        | −26 e  | −10 e  | 14 e  | 50.8   | 115.1   | 5    |
| C <sub>8</sub> H <sub>14</sub>                | 1-Octyne                           | −59 e                                        | −40 e  | −16 e  | 16 e  | 60.3   | 125.8   | 1    |
| C <sub>8</sub> H <sub>14</sub>                | 2-Octyne                           | −52 e                                        | −33 e  | −8 e   | 25 e  | 70.6   | 137.8   | 1    |
| C <sub>8</sub> H <sub>14</sub>                | 3-Octyne                           | −55 e                                        | −35 e  | −11 e  | 22 e  | 66.8   | 132.8   | 1    |
| C <sub>8</sub> H <sub>14</sub>                | 4-Octyne                           | −56 e                                        | −36 e  | −12 e  | 21 e  | 65.6   | 131.4   | 1    |
| C <sub>8</sub> H <sub>14</sub>                | 1-Ethylcyclohexene                 | −55 e                                        | −35 e  | −11 e  | 22 e  | 68 e   | 136.5   | 5    |
| C <sub>8</sub> H <sub>14</sub> O <sub>2</sub> | Cyclohexyl acetate                 |                                              |        |        |       | 103.1  | 172.9   | 5    |
| C <sub>8</sub> H <sub>14</sub> O <sub>2</sub> | Butyl methacrylate                 |                                              |        |        | 47 e  | 93.3   | 159.0   | 5    |
| C <sub>8</sub> H <sub>14</sub> O <sub>3</sub> | Butanoic anhydride                 | −28 e                                        | −2 e   | 30 e   | 71 e  | 123.8  | 196.5   | 5    |
| C <sub>8</sub> H <sub>14</sub> O <sub>4</sub> | Ethyl succinate                    | −6 e                                         | 20 e   | 51.0   | 91.1  | 143.7  | 216.1   | 5    |
| C <sub>8</sub> H <sub>14</sub> O <sub>4</sub> | Dipropyl oxalate                   | −4 e                                         | 20 e   | 49.9   | 88.6  | 140.4  | 213.0   | 5    |
| C <sub>8</sub> H <sub>14</sub> O <sub>4</sub> | Dimethyl adipate                   |                                              | 28 e   | 61 e   | 103 e | 156.1  | 227.3   | 5    |
| C <sub>8</sub> H <sub>15</sub> Br             | (2-Bromoethyl)cyclohexane          | −14 e                                        | 8 e    | 36.9   | 75.3  | 129.7  | 212.5   | 5    |
| C <sub>8</sub> H <sub>15</sub> ClO            | Octanoyl chloride                  | 1 e                                          | 22 e   | 46 e   | 74.7  | 109 e  | 150 e   | 5    |
| C <sub>8</sub> H <sub>15</sub> N              | Octanenitrile                      | −15 e                                        | 8 e    | 37 e   | 75 e  | 127.7  | 204.4   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 1-Octene                           | −65.7                                        | −46.1  | −21.4  | 10.5  | 54.9   | 120.9   | 1,5  |
| C <sub>8</sub> H <sub>16</sub>                | <i>cis</i> -2-Octene               | −59 e                                        | −41 e  | −17 e  | 15 e  | 59 e   | 125.2   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>trans</i> -2-Octene             | −59 e                                        | −41 e  | −17 e  | 14 e  | 59 e   | 124.5   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>cis</i> -3-Octene               | −65 e                                        | −46 e  | −22 e  | 10 e  | 55.1   | 122.4   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>trans</i> -3-Octene             | −61 e                                        | −43 e  | −19 e  | 13 e  | 57 e   | 122.8   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>cis</i> -4-Octene               | −63 e                                        | −44 e  | −20 e  | 11 e  | 56 e   | 122.1   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>trans</i> -4-Octene             | −65 e                                        | −46 e  | −22 e  | 10 e  | 54.6   | 121.8   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 2-Methyl-1-heptene                 | −66 e                                        | −48 e  | −24 e  | 8 e   | 52.3   | 118.7   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 2,2-Dimethyl- <i>cis</i> -3-hexene | −74 e                                        | −56 e  | −33 e  | −3 e  | 40.1   | 105.0   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 2,3-Dimethyl-2-hexene              | −65 e                                        | −47 e  | −23 e  | 10 e  | 54.3   | 121.3   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 2,3,3-Trimethyl-1-pentene          |                                              | −53 e  | −30 e  | 1 e   | 43.8   | 107.9   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 2,4,4-Trimethyl-1-pentene          | −79 e                                        | −61 e  | −38 e  | −7 e  | 36.2   | 101.0   | 5    |

| Mol. form.                                    | Name                                      | Temperature in °C for the indicated pressure |       |         |       |        |         | Ref. |
|-----------------------------------------------|-------------------------------------------|----------------------------------------------|-------|---------|-------|--------|---------|------|
|                                               |                                           | 1 Pa                                         | 10 Pa | 100 Pa  | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>8</sub> H <sub>16</sub>                | 2,3,4-Trimethyl-2-pentene                 | -68 e                                        | -49 e | -26 e   | 6 e   | 50.0   | 115.8   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 2,4,4-Trimethyl-2-pentene                 | -73 e                                        | -56 e | -33 e   | -2 e  | 40.4   | 104.5   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | Cyclooctane                               |                                              |       |         | 30 e  | 78 e   | 150.7   | 1    |
| C <sub>8</sub> H <sub>16</sub>                | Ethylcyclohexane                          | -61 e                                        | -42 e | -17 e   | 15.8  | 61.9   | 131.3   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 1,1-Dimethylcyclohexane                   |                                              |       | -27 e   | 5 e   | 50.6   | 119.1   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>cis</i> -1,2-Dimethylcyclohexane       |                                              | -44 e | -20 e   | 14 e  | 59.7   | 129.2   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>trans</i> -1,2-Dimethylcyclohexane     | -68 e                                        | -49 e | -25 e   | 8 e   | 53.9   | 122.9   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>cis</i> -1,3-Dimethylcyclohexane       | -68 e                                        | -48 e | -23 e   | 10 e  | 55.6   | 123.1   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>trans</i> -1,3-Dimethylcyclohexane     | -62 e                                        | -45 e | -23 e   | 8 e   | 51.5   | 120.9   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>cis</i> -1,4-Dimethylcyclohexane       | -66 e                                        | -47 e | -23 e   | 10 e  | 55.3   | 123.8   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>trans</i> -1,4-Dimethylcyclohexane     |                                              |       | -27 e   | 5 e   | 50.6   | 118.9   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | Propylcyclopentane                        | -60 e                                        | -41 e | -16 e   | 16.5  | 62.1   | 130.5   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | Isopropylcyclopentane                     | -65 e                                        | -46 e | -21 e   | 12 e  | 57.3   | 125.9   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 1-Ethyl-1-methylcyclopentane              | -67 e                                        | -49 e | -24 e   | 8 e   | 53.2   | 121.0   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | <i>cis</i> -1-Ethyl-2-methylcyclopentane  | -63 e                                        | -44 e | -19 e   | 13.3  | 59.1   | 127.6   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 1,1,2-Trimethylcyclopentane               |                                              |       |         | 2 e   | 46.2   | 113.2   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 1,1,3-Trimethylcyclopentane               | -77 e                                        | -59 e | -36 e   | -5 e  | 38.7   | 104.4   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 1',2',4a-1,2,4-Trimethylcyclo-pentane     | -70 e                                        | -52 e | -28 e   | 4 e   | 48.9   | 116.2   | 5    |
| C <sub>8</sub> H <sub>16</sub>                | 1',2a,4'-1,2,4-Trimethylcyclo-pentane     | -74 e                                        | -56 e | -33 e   | -1 e  | 42.8   | 108.8   | 5    |
| C <sub>8</sub> H <sub>16</sub> O              | 1-Propylcyclopentanol                     | 9 e                                          | 24 e  | 43 e    | 69.0  | 108.4  | 173.5   | 5    |
| C <sub>8</sub> H <sub>16</sub> O              | Octanal                                   |                                              |       | 6 e     | 45.7  | 97.8   | 170.2   | 5    |
| C <sub>8</sub> H <sub>16</sub> O              | 2-Octanone                                |                                              | -3 e  | 23 e    | 57 e  | 103.8  | 172.1   | 5    |
| C <sub>8</sub> H <sub>16</sub> O              | 3-Octanone                                |                                              |       | 8 e     | 47.7  | 97 e   | 161 e   | 5    |
| C <sub>8</sub> H <sub>16</sub> O              | 2,2,4-Trimethyl-3-pentanone               |                                              |       | 11.3    | 42.1  | 81.7   | 134.6   | 5    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Octanoic acid                             | 37 e                                         | 58 e  | 85 e    | 120 e | 165.5  | 238.4   | 1,5  |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | 2-Ethylhexanoic acid                      |                                              |       |         | 108 e | 159.6  | 226.6   | 5    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Hexyl acetate                             | -37 e                                        | -13 e | 16 e    | 52.8  | 100.4  | 164 e   | 5    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Isopentyl propanoate                      |                                              |       | 3.1     | 40.7  | 90.6   | 159.8   | 5    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Isobutyl isobutanoate                     | -47 e                                        | -26 e | 0.4     | 34.8  | 81.1   | 147.0   | 5    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Propyl 3-methylbutanoate                  |                                              |       | 1.8     | 38.9  | 87.9   | 155.6   | 5    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Ethyl hexanoate                           | -31 e                                        | -9 e  | 18.7    | 53.9  | 100.7  | 166.2   | 5    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Methyl heptanoate                         | -30 e                                        | -9 e  | 19 e    | 54.2  | 102.4  | 172 e   | 5    |
| C <sub>8</sub> H <sub>16</sub> O <sub>4</sub> | Diethylene glycol monoethyl ether acetate | -16 e                                        | 10.6  | 43.9    | 86.2  | 141.3  | 216.6   | 5    |
| C <sub>8</sub> H <sub>17</sub> Br             | 1-Bromooctane                             | -17 e                                        | 6 e   | 34 e    | 72 e  | 123.8  | 200.3   | 5    |
| C <sub>8</sub> H <sub>17</sub> Cl             | 1-Chlorooctane                            | -25 e                                        | -4 e  | 23 e    | 59 e  | 108.8  | 182.9   | 5    |
| C <sub>8</sub> H <sub>17</sub> Cl             | 3-(Chloromethyl)heptane                   |                                              |       |         |       | 100.3  | 172.4   | 5    |
| C <sub>8</sub> H <sub>17</sub> F              | 1-Fluorooctane                            |                                              |       |         | 29 e  | 74.6   | 141.8   | 5    |
| C <sub>8</sub> H <sub>17</sub> I              | 1-Iodoctane                               | -6 e                                         | 18 e  | 48 e    | 87 e  | 142.5  | 224.5   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | Octane                                    |                                              | -42.6 | -17.9   | 14.4  | 58.9   | 125.3   | 16   |
| C <sub>8</sub> H <sub>18</sub>                | 2-Methylheptane                           | -69 e                                        | -49.1 | -24.5   | 7.6   | 51.6   | 117.2   | 1,5  |
| C <sub>8</sub> H <sub>18</sub>                | 3-Methylheptane                           | -67 e                                        | -48.1 | -23.6   | 8.5   | 52.7   | 118.5   | 1,5  |
| C <sub>8</sub> H <sub>18</sub>                | 4-Methylheptane                           | -65 e                                        | -47 e | -24 e   | 7.8   | 51.6   | 117.2   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 3-Ethylhexane                             |                                              |       |         | 8 e   | 52.1   | 118.1   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 2,2-Dimethylhexane                        | -73 e                                        | -55 e | -32 e   | -1.5  | 41.6   | 106.4   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 2,3-Dimethylhexane                        |                                              |       |         | 5 e   | 49.2   | 115.1   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 2,4-Dimethylhexane                        |                                              |       |         | 0.6   | 43.9   | 109.0   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 2,5-Dimethylhexane                        | -71 e                                        | -53 e | -30 e   | 0.7   | 43.8   | 108.6   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 3,3-Dimethylhexane                        | -72 e                                        | -54 e | -30 e   | 1.4   | 45.4   | 111.5   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 3,4-Dimethylhexane                        |                                              |       |         | 7 e   | 50.9   | 117.3   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 3-Ethyl-2-methylpentane                   | -69 e                                        | -50 e | -27 e   | 5 e   | 48.9   | 115.2   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 3-Ethyl-3-methylpentane                   | -70 e                                        | -51 e | -27 e   | 5 e   | 50.2   | 117.8   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 2,2,3-Trimethylpentane                    | -74 e                                        | -56 e | -32 e   | -0.8  | 43.1   | 109.4   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 2,2,4-Trimethylpentane                    | -81.9                                        | -63.4 | -39.8   | -8.9  | 34.0   | 98.8    | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 2,3,3-Trimethylpentane                    | -72 e                                        | -54 e | -30 e   | 2.1   | 46.9   | 114.3   | 5    |
| C <sub>8</sub> H <sub>18</sub>                | 2,3,4-Trimethylpentane                    | -74 e                                        | -54.5 | -30.0   | 2.2   | 46.7   | 113.1   | 1,5  |
| C <sub>8</sub> H <sub>18</sub>                | 2,2,3,3-Tetramethylbutane                 | -62.5 s                                      | -44 s | -20.9 s | 8.9 s | 48.8 s | 105.8   | 5    |
| C <sub>8</sub> H <sub>18</sub> O              | 1-Octanol                                 | 12 e                                         | 30 e  | 53 e    | 84 e  | 128.2  | 194.8   | 1,39 |
| C <sub>8</sub> H <sub>18</sub> O              | 2-Octanol                                 |                                              |       | 40 e    | 69.9  | 112.5  | 179.4   | 1,39 |
| C <sub>8</sub> H <sub>18</sub> O              | 3-Octanol                                 | 12 e                                         | 24 e  | 40 e    | 64 e  | 102.8  | 174.1   | 1    |



| Mol. form.                                                  | Name                                      | Temperature in °C for the indicated pressure |       |        |       |        |         | Ref. |
|-------------------------------------------------------------|-------------------------------------------|----------------------------------------------|-------|--------|-------|--------|---------|------|
|                                                             |                                           | 1 Pa                                         | 10 Pa | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>8</sub> H <sub>18</sub> O                            | 4-Octanol                                 |                                              |       | 40 e   | 66.9  | 107.3  | 176.0   | 1,39 |
| C <sub>8</sub> H <sub>18</sub> O                            | 4-Methyl-3-heptanol                       | −52 e                                        | −28 e | 1 e    | 39 e  | 87.6   | 155.0   | 5    |
| C <sub>8</sub> H <sub>18</sub> O                            | 5-Methyl-3-heptanol                       | −35 e                                        | −16 e | 8 e    | 40 e  | 84.8   | 153.0   | 5    |
| C <sub>8</sub> H <sub>18</sub> O                            | 4-Methyl-4-heptanol                       | −17 e                                        | 1 e   | 24 e   | 55 e  | 97.2   | 160.7   | 5    |
| C <sub>8</sub> H <sub>18</sub> O                            | 2-Ethyl-1-hexanol                         |                                              |       | 45 e   | 75 e  | 118.3  | 184.2   | 1    |
| C <sub>8</sub> H <sub>18</sub> O                            | 2-Ethyl-2-hexanol                         | −13 e                                        | 4 e   | 26 e   | 55 e  | 96.3   | 160.3   | 5    |
| C <sub>8</sub> H <sub>18</sub> O                            | 2,4,4-Trimethyl-2-pentanol                |                                              | −7 e  | 13 e   | 40 e  | 79.8   | 146.1   | 5    |
| C <sub>8</sub> H <sub>18</sub> O                            | 2,2,4-Trimethyl-3-pentanol                | −2 e                                         | 9 e   | 24 e   | 47 e  | 82.6   | 150.4   | 5    |
| C <sub>8</sub> H <sub>18</sub> O                            | Dibutyl ether                             | −55 e                                        | −35 e | −8 e   | 26 e  | 73.0   | 141.2   | 5    |
| C <sub>8</sub> H <sub>18</sub> O                            | Di- <i>sec</i> -butyl ether               |                                              |       | −19 e  | 12.1  | 55.4   | 120.6   | 5    |
| C <sub>8</sub> H <sub>18</sub> O                            | Di- <i>tert</i> -butyl ether              |                                              |       | −33 e  | −2 e  | 41.7   | 106.8   | 1    |
| C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>               | Ethylene glycol monohexyl ether           | −13 e                                        | 14 e  | 46 e   | 86 e  | 137.7  | 206.9   | 5    |
| C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>               | 1,2-Dipropoxyethane                       |                                              |       | −44.2  | −2.0  | 63.6   | 179.2   | 5    |
| C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>               | Di- <i>tert</i> -butyl peroxide           |                                              |       | −26 e  | 4.3   | 46.6   | 110.5   | 5    |
| C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>               | Diethylene glycol monobutyl ether         | 14 e                                         | 37 e  | 66.8   | 104.9 | 153 e  | 230.4   | 5    |
| C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>               | Diethylene glycol diethyl ether           | −32 e                                        | −7 e  | 25 e   | 64.9  | 117.1  | 189 e   | 5    |
| C <sub>8</sub> H <sub>18</sub> O <sub>5</sub>               | Tetraethylene glycol                      | 89 e                                         | 117 e | 151.1  | 192.2 | 242.9  | 307.3   | 5    |
| C <sub>8</sub> H <sub>18</sub> S                            | 1-Octanethiol                             | −15 e                                        | 6 e   | 34 e   | 71 e  | 122.1  | 198.5   | 5    |
| C <sub>8</sub> H <sub>18</sub> S                            | Dibutyl sulfide                           | −22 e                                        | 0 e   | 27 e   | 63 e  | 113.5  | 188.4   | 5    |
| C <sub>8</sub> H <sub>19</sub> N                            | Dibutylamine                              | −37 e                                        | −16 e | 10 e   | 44 e  | 90.8   | 159.1   | 5    |
| C <sub>8</sub> H <sub>19</sub> N                            | Diisobutylamine                           | −57 e                                        | −36 e | −9.0   | 25.5  | 72.2   | 139.0   | 5    |
| C <sub>8</sub> H <sub>20</sub> O <sub>4</sub> Si            | Ethyl silicate                            | −77 e                                        | −52 e | −21 e  | 21.6  | 80.5   | 164.1   | 5    |
| C <sub>8</sub> H <sub>20</sub> Si                           | Tetraethylsilane                          |                                              |       | −6.5   | 30.5  | 80.6   | 152.6   | 5    |
| C <sub>9</sub> F <sub>20</sub>                              | Perfluorononane                           |                                              |       |        |       | 40 e   | 114.7   | 5    |
| C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | Toluene-2,4-diisocyanate                  |                                              | 39 e  | 72 e   | 113.9 | 169.7  | 247 e   | 5    |
| C <sub>9</sub> H <sub>7</sub> N                             | Quinoline                                 | −1.3                                         | 23.7  | 55.4   | 96.8  | 153.4  | 236.5   | 1,5  |
| C <sub>9</sub> H <sub>7</sub> N                             | Isoquinoline                              |                                              | 30.2  | 60.7   | 101.3 | 157.9  | 242.7   | 1,5  |
| C <sub>9</sub> H <sub>8</sub>                               | Indene                                    |                                              |       | 12 e   | 53.0  | 106.8  | 181.0   | 5    |
| C <sub>9</sub> H <sub>10</sub>                              | <i>cis</i> -1-Propenylbenzene             | −38 e                                        | −15.4 | 13.3   | 51.4  | 103.7  | 178.4   | 5    |
| C <sub>9</sub> H <sub>10</sub>                              | <i>trans</i> -1-Propenylbenzene           |                                              | −16 e | 13.3   | 51.6  | 103.7  | 178.4   | 5    |
| C <sub>9</sub> H <sub>10</sub>                              | Isopropenylbenzene                        |                                              |       | 3.2    | 41.5  | 92.8   | 164.9   | 5    |
| C <sub>9</sub> H <sub>10</sub>                              | Indan                                     | −33 e                                        | −12 e | 16 e   | 52 e  | 102.3  | 177.5   | 1    |
| C <sub>9</sub> H <sub>10</sub> O                            | 2,4-Dimethylbenzaldehyde                  | −3 e                                         | 23 e  | 54 e   | 93.2  | 144.6  | 214.5   | 5    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>               | Ethyl benzoate                            | −18 e                                        | 8 e   | 39 e   | 80.1  | 135.1  | 212.8   | 5    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>               | Benzyl acetate                            | −11 e                                        | 15 e  | 46.6   | 86.9  | 139.5  | 211 e   | 5    |
| C <sub>9</sub> H <sub>11</sub> Br                           | 1-Bromo-4-isopropylbenzene                | −8 e                                         | 15 e  | 45 e   | 84 e  | 138.1  | 218.5   | 5    |
| C <sub>9</sub> H <sub>11</sub> Cl                           | 1-Chloro-2-isopropylbenzene               | −23 e                                        | −1 e  | 27 e   | 64 e  | 114.6  | 190.5   | 5    |
| C <sub>9</sub> H <sub>11</sub> Cl                           | 1-Chloro-4-isopropylbenzene               |                                              | 3 e   | 31 e   | 69 e  | 120.5  | 197.8   | 5    |
| C <sub>9</sub> H <sub>12</sub>                              | Propylbenzene                             | −43 e                                        | −23 e | 4 e    | 38 e  | 86.7   | 158.8   | 1    |
| C <sub>9</sub> H <sub>12</sub>                              | Isopropylbenzene                          | −46 e                                        | −26 e | −1 e   | 33 e  | 80.9   | 152.0   | 1    |
| C <sub>9</sub> H <sub>12</sub>                              | <i>o</i> -Ethyltoluene                    | −40 e                                        | −19 e | 8 e    | 43 e  | 92.1   | 164.7   | 5    |
| C <sub>9</sub> H <sub>12</sub>                              | <i>m</i> -Ethyltoluene                    | −42 e                                        | −21 e | 5 e    | 40.4  | 88.9   | 160.8   | 5    |
| C <sub>9</sub> H <sub>12</sub>                              | <i>p</i> -Ethyltoluene                    | −41 e                                        | −21 e | 6 e    | 41 e  | 89.2   | 161.5   | 5    |
| C <sub>9</sub> H <sub>12</sub>                              | 1,2,3-Trimethylbenzene                    |                                              | −12 e | 15 e   | 52 e  | 101.5  | 175.6   | 1    |
| C <sub>9</sub> H <sub>12</sub>                              | 1,2,4-Trimethylbenzene                    | −37 e                                        | −16 e | 11 e   | 47 e  | 95.9   | 168.9   | 1    |
| C <sub>9</sub> H <sub>12</sub>                              | 1,3,5-Trimethylbenzene                    | −39 e                                        | −18 e | 9 e    | 43.7  | 92.4   | 164.3   | 1    |
| C <sub>9</sub> H <sub>12</sub> O                            | Benzyl ethyl ether                        |                                              | −10 e | 20.4   | 59.3  | 111.3  | 184.5   | 5    |
| C <sub>9</sub> H <sub>12</sub> O                            | Phenyl propyl ether                       |                                              | −10 e | 21 e   | 61 e  | 113.9  | 189.3   | 5    |
| C <sub>9</sub> H <sub>12</sub> O                            | Phenyl isopropyl ether                    | −20 e                                        | −1 e  | 23 e   | 56 e  | 103.7  | 176.9   | 5    |
| C <sub>9</sub> H <sub>13</sub> N                            | 2,4,6-Trimethylaniline                    | 12 e                                         | 36 e  | 66 e   | 104.1 | 154.9  | 226 e   | 5    |
| C <sub>9</sub> H <sub>13</sub> N                            | <i>N,N</i> -Dimethyl- <i>o</i> -toluidine | −25 e                                        | −3 e  | 24.4   | 60.6  | 110.7  | 184.5   | 5    |
| C <sub>9</sub> H <sub>13</sub> N                            | Amphetamine                               |                                              |       | 33 e   | 70.1  | 118 e  | 202.0   | 5    |
| C <sub>9</sub> H <sub>14</sub> O                            | Isophorone                                |                                              | 1 e   | 33.1   | 75.1  | 132.4  | 215.1   | 5    |
| C <sub>9</sub> H <sub>14</sub> O <sub>6</sub>               | Triacetin                                 | 37.6                                         | 62 e  | 90 e   | 124 e | 165 e  | 214 e   | 5    |
| C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>               | Diethyl glutarate                         | −1 e                                         | 26 e  | 60.2   | 103.3 | 159.6  | 236.5   | 5    |
| C <sub>9</sub> H <sub>17</sub> N                            | Nonanenitrile                             | −3 e                                         | 21 e  | 50.9   | 90.7  | 145.4  | 225.1   | 5    |
| C <sub>9</sub> H <sub>18</sub>                              | 1-Nonene                                  | −50.1                                        | −29.4 | −3.3   | 30.4  | 77.1   | 146.4   | 1,5  |
| C <sub>9</sub> H <sub>18</sub>                              | 2-Methyl-1-octene                         | −53 e                                        | −34 e | −9 e   | 25 e  | 72 e   | 144.1   | 5    |
| C <sub>9</sub> H <sub>18</sub>                              | Butylcyclopentane                         | −45 e                                        | −24 e | 1 e    | 36 e  | 84 e   | 156.1   | 5    |
| C <sub>9</sub> H <sub>18</sub>                              | Propylcyclohexane                         | −46 e                                        | −26 e | 0 e    | 35.1  | 83.6   | 156.2   | 5    |

| Mol. form.                                     | Name                                         | Temperature in °C for the indicated pressure |        |        |       |        |         | Ref. |
|------------------------------------------------|----------------------------------------------|----------------------------------------------|--------|--------|-------|--------|---------|------|
|                                                |                                              | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>9</sub> H <sub>18</sub>                 | Isopropylcyclohexane                         | −48 e                                        | −28 e  | −2 e   | 33 e  | 81.3   | 154.0   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | <i>trans</i> -1-Ethyl-4-methylcyclo-hexane   | −53 e                                        | −33 e  | −8 e   | 25 e  | 71.8   | 141.5   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | 1,1,2-Trimethylcyclohexane                   |                                              |        | −12 e  | 23 e  | 71.5   | 145.5   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | 1,1,3-Trimethylcyclohexane                   | −60 e                                        | −41 e  | −16 e  | 18 e  | 65.2   | 136.1   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | 1',2a,4a-1,2,4-Trimethylcyclo-hexane         | −71 e                                        | −50 e  | −22 e  | 15 e  | 65.7   | 140.7   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | 1',3',5'-1,3,5-Trimethylcyclo-hexane         | −72 e                                        | −50 e  | −22 e  | 14 e  | 65.1   | 140.0   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | Isobutylcyclopentane                         | −105 e                                       | −88 e  | −64 e  | −28 e | 31 e   | 147.0   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | <i>cis</i> -1-Methyl-2-propylcyclo-pentane   | −52 e                                        | −33 e  | −7 e   | 28 e  | 77 e   | 152.0   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | <i>trans</i> -1-Methyl-2-propylcyclo-pentane | −56 e                                        | −36 e  | −11 e  | 23 e  | 72 e   | 145.8   | 5    |
| C <sub>9</sub> H <sub>18</sub>                 | 1,1,3,3-Tetramethylcyclo-pentane             | −72 e                                        | −54 e  | −30 e  | 2 e   | 47 e   | 117.4   | 5    |
| C <sub>9</sub> H <sub>18</sub> O               | Nonanal                                      |                                              | −3 e   | 27.4   | 65.5  | 115.6  | 184.6   | 5    |
| C <sub>9</sub> H <sub>18</sub> O               | 2-Nonanone                                   |                                              | 8 e    | 35 e   | 71 e  | 121.0  | 194.0   | 5    |
| C <sub>9</sub> H <sub>18</sub> O               | 5-Nonanone                                   |                                              |        | −1 e   | 39.1  | 94 e   | 188 e   | 5    |
| C <sub>9</sub> H <sub>18</sub> O               | 2,6-Dimethyl-4-heptanone                     | −32 e                                        | −12 e  | 14 e   | 48 e  | 96.2   | 167.7   | 5    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | Nonanoic acid                                | 48 e                                         | 69 e   | 97 e   | 133 e | 182.7  | 255.1   | 5    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | Heptyl acetate                               | −16 e                                        | 6 e    | 34 e   | 70 e  | 119.9  | 191.9   | 5    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | Isopentyl butanoate                          |                                              |        |        | 55 e  | 105.6  | 178.4   | 5    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | Isobutyl 3-methylbutanoate                   |                                              |        | 11.3   | 48.3  | 97.9   | 168.3   | 5    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | Propyl hexanoate                             | −26 e                                        | −2 e   | 28 e   | 65.1  | 113.4  | 178 e   | 5    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | Methyl octanoate                             | −26 e                                        | −9 e   | 13 e   | 40 e  | 76 e   | 127.9   | 5    |
| C <sub>9</sub> H <sub>19</sub> Cl              | 1-Chlorononane                               | −11 e                                        | 11 e   | 39 e   | 76 e  | 127.8  | 204.7   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | Nonane                                       | −46.8                                        | −26.0  | 0.0    | 34.0  | 80.8   | 150.3   | 16   |
| C <sub>9</sub> H <sub>20</sub>                 | 2-Methyloctane                               | −49 e                                        | −30 e  | −5 e   | 28 e  | 73.9   | 142.8   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 3-Methyloctane                               | −49 e                                        | −29 e  | −5 e   | 29 e  | 74.7   | 143.7   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 4-Methyloctane                               | −50 e                                        | −30 e  | −6 e   | 27 e  | 73.2   | 141.9   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,2-Dimethylheptane                          | −58 e                                        | −39 e  | −15 e  | 18 e  | 63.6   | 132.3   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,3-Dimethylheptane                          | −53 e                                        | −33 e  | −9 e   | 25 e  | 70.8   | 140.0   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,6-Dimethylheptane                          | −55 e                                        | −36 e  | −12 e  | 21 e  | 66.4   | 134.7   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 3-Ethyl-4-methylhexane                       |                                              |        | −9 e   | 24 e  | 70.6   | 139.9   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,2,4-Trimethylhexane                        | −66.1                                        | −46.4  | −21.3  | 11.8  | 57.7   | 126.0   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,2,5-Trimethylhexane                        | −65.1                                        | −45.8  | −21.2  | 11.2  | 56.2   | 123.7   | 1,5  |
| C <sub>9</sub> H <sub>20</sub>                 | 2,3,3-Trimethylhexane                        | −58 e                                        | −38 e  | −13 e  | 20 e  | 66.7   | 137.2   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,3,5-Trimethylhexane                        | −60 e                                        | −41 e  | −16 e  | 17 e  | 62.3   | 130.9   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,4,4-Trimethylhexane                        | −62 e                                        | −43 e  | −18 e  | 15 e  | 61.0   | 130.2   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 3,3,4-Trimethylhexane                        | −53 e                                        | −33 e  | −7 e   | 28 e  | 76.3   | 148.9   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 3,3-Diethylpentane                           |                                              |        | −9 e   | 26 e  | 73.7   | 145.7   | 1    |
| C <sub>9</sub> H <sub>20</sub>                 | 3-Ethyl-2,4-dimethylpentane                  | −58 e                                        | −38 e  | −13 e  | 20 e  | 66.7   | 136.2   | 5    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,2,3,3-Tetramethylpentane                   |                                              |        | 21 e   | 68.5  | 139.8  | 1       |      |
| C <sub>9</sub> H <sub>20</sub>                 | 2,2,3,4-Tetramethylpentane                   | −61 e                                        | −42 e  | −17 e  | 16 e  | 62.5   | 132.6   | 1    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,2,4,4-Tetramethylpentane                   |                                              | −49 e  | −25 e  | 8 e   | 53.2   | 121.8   | 1    |
| C <sub>9</sub> H <sub>20</sub>                 | 2,3,3,4-Tetramethylpentane                   | −57 e                                        | −37 e  | −12 e  | 22 e  | 69.7   | 141.1   | 1    |
| C <sub>9</sub> H <sub>20</sub> O               | 1-Nonanol                                    |                                              | 40 e   | 64 e   | 96.9  | 141.0  | 213.0   | 5,39 |
| C <sub>9</sub> H <sub>20</sub> O               | 3-Nonanol                                    |                                              | 24 e   | 47 e   | 78 e  | 123.0  | 194.2   | 5    |
| C <sub>9</sub> H <sub>20</sub> O               | 4-Nonanol                                    |                                              |        | 45 e   | 76.4  | 121.3  | 192.0   | 5    |
| C <sub>9</sub> H <sub>20</sub> O               | 5-Nonanol                                    | 13 e                                         | 31 e   | 54 e   | 84.5  | 128.1  | 194.7   | 5    |
| C <sub>9</sub> H <sub>20</sub> O               | 2,2,4,4-Tetramethyl-3-pentanol               |                                              |        |        | 58    | 100    | 167     | 5    |
| C <sub>9</sub> H <sub>20</sub> S               | 1-Nonanethiol                                | −2 e                                         | 21 e   | 49 e   | 87 e  | 140.4  | 219.2   | 5    |
| C <sub>9</sub> H <sub>21</sub> BO <sub>3</sub> | Triisopropyl borate                          |                                              |        |        |       | 73.1   | 139.0   | 5    |
| C <sub>9</sub> H <sub>21</sub> N               | Nonylamine                                   |                                              | 9 e    | 37 e   | 75 e  | 126.2  | 202.1   | 5    |
| C <sub>9</sub> H <sub>21</sub> N               | Tripropylamine                               | −39 e                                        | −18 e  | 8 e    | 42 e  | 88.2   | 156.0   | 5    |
| C <sub>10</sub> F <sub>8</sub>                 | Perfluoronaphthalene                         | 5.2 s                                        | 25.1 s | 48.1 s |       |        |         | 5    |
| C <sub>10</sub> F <sub>22</sub>                | Perfluorodecane                              |                                              |        |        |       | 52 e   | 132.9   | 5    |
| C <sub>10</sub> H <sub>7</sub> Br              | 1-Bromonaphthalene                           | 17 e                                         | 45 e   | 80.3   | 126.7 | 189.8  | 280.5   | 5    |
| C <sub>10</sub> H <sub>7</sub> Cl              | 1-Chloronaphthalene                          | 14 e                                         | 39 e   | 70.5   | 112.8 | 171.6  | 258.6   | 5    |
| C <sub>10</sub> H <sub>8</sub>                 | Naphthalene**                                | 3.2 s                                        | 24.1 s | 49.3 s | 80.7  | 135.6  | 217.5   | 1,5  |
| C <sub>10</sub> H <sub>8</sub>                 | Azulene                                      | 24.1 s                                       | 46 s   | 71.5 s | 103.3 | 162.6  | 244.0   | 5    |
| C <sub>10</sub> H <sub>8</sub> O               | 1-Naphthol                                   |                                              |        |        | 137.2 | 196.7  | 281.8   | 5    |
| C <sub>10</sub> H <sub>8</sub> O               | 2-Naphthol                                   |                                              |        |        | 140.7 | 200.5  | 286.8   | 5    |
| C <sub>10</sub> H <sub>9</sub> N               | 1-Naphthalenamine                            |                                              | 62 e   | 99.0   | 146.9 | 210.7  | 300.1   | 5    |
| C <sub>10</sub> H <sub>9</sub> N               | 2-Naphthalenamine                            | 36.3 s                                       | 65.9 s | 103 s  | 150.9 | 215.1  | 305.5   | 5    |

| Mol. form.                                     | Name                             | Temperature in °C for the indicated pressure |        |         |         |         |         | Ref. |
|------------------------------------------------|----------------------------------|----------------------------------------------|--------|---------|---------|---------|---------|------|
|                                                |                                  | 1 Pa                                         | 10 Pa  | 100 Pa  | 1 kPa   | 10 kPa  | 100 kPa |      |
| C <sub>10</sub> H <sub>9</sub> N               | 2-Methylquinoline                | 5.3                                          | 31.9   | 63.8    | 102.9   | 165.8   | 247.2   | 5    |
| C <sub>10</sub> H <sub>9</sub> N               | 4-Methylquinoline                | 29 e                                         | 54 e   | 85 e    | 127 e   | 183.0   | 265.1   | 5    |
| C <sub>10</sub> H <sub>9</sub> N               | 6-Methylquinoline                | 27 e                                         | 51 e   | 81 e    | 122 e   | 179.2   | 264.5   | 5    |
| C <sub>10</sub> H <sub>9</sub> N               | 8-Methylquinoline                | 15 e                                         | 40 e   | 70 e    | 111 e   | 166.1   | 247.3   | 5    |
| C <sub>10</sub> H <sub>10</sub>                | <i>m</i> -Divinylbenzene         | -29 e                                        | -4 e   | 27.1    | 67.6    | 122.1   | 199 e   | 5    |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub> | Dimethyl phthalate               | 27 e                                         | 56 e   | 92.7    | 137.8   | 195.8   | 272.7   | 5    |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub> | Dimethyl isophthalate            |                                              |        | 85 e    | 129.5   | 189.2   | 273 e   | 5    |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub> | Dimethyl terephthalate           | 56.6 s                                       | 79.4 s | 106.1 s | 137.9 s | 197.9   | 282 e   | 5    |
| C <sub>10</sub> H <sub>12</sub>                | 1,2,3,4-Tetrahydronaphthalene    | -21 e                                        | 3 e    | 33.2    | 74.1    | 127.4   | 207.8   | 5    |
| C <sub>10</sub> H <sub>12</sub>                | 2-Ethylstyrene                   | -31 e                                        | -8 e   | 21 e    | 60 e    | 111.7   | 187 e   | 5    |
| C <sub>10</sub> H <sub>12</sub>                | 3-Ethylstyrene                   | -28 e                                        | -5.3   | 24.1    | 62.6    | 116 e   | 193 e   | 5    |
| C <sub>10</sub> H <sub>12</sub>                | 4-Ethylstyrene                   | -31 e                                        | -8.2   | 21.3    | 60.5    | 115 e   | 196 e   | 5    |
| C <sub>10</sub> H <sub>12</sub> O              | Estragole                        |                                              |        | 48.5    | 88.0    | 140.7   | 214.6   | 5    |
| C <sub>10</sub> H <sub>12</sub> O              | 4-Isopropylbenzaldehyde          |                                              |        | 54.1    | 96.0    | 152.2   | 231.5   | 5    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> | 4-Allyl-2-methoxyphenol          | 9 e                                          | 37 e   | 72 e    | 115.9   | 173.8   | 252.9   | 5    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> | 2-Phenylethyl acetate            | -4 e                                         | 22 e   | 54 e    | 96 e    | 152.3   | 232.0   | 5    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> | Propyl benzoate                  | -8 e                                         | 18 e   | 50.2    | 92.3    | 149.2   | 230.5   | 5    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> | Ethyl phenylacetate              | -9 e                                         | 19 e   | 52 e    | 95 e    | 150.2   | 225 e   | 5    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> | Isoeugenol                       |                                              |        |         | 125 e   | 185.3   | 267.1   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | Butylbenzene                     | -28 e                                        | -7 e   | 21 e    | 56.9    | 107.6   | 182.8   | 1,5  |
| C <sub>10</sub> H <sub>14</sub>                | <i>sec</i> -Butylbenzene         | -35 e                                        | -14 e  | 13 e    | 48 e    | 98.3    | 172.8   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | <i>tert</i> -Butylbenzene        | -37 e                                        | -16 e  | 10 e    | 46 e    | 94.9    | 168.6   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | Isobutylbenzene                  | -36 e                                        | -15 e  | 12 e    | 47.9    | 97.8    | 172.3   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | <i>o</i> -Cymene                 | -39 e                                        | -16 e  | 13 e    | 51 e    | 103.1   | 177.8   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | <i>m</i> -Cymene                 | -34 e                                        | -13 e  | 14 e    | 50 e    | 99.9    | 174.6   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | <i>p</i> -Cymene                 | -33 e                                        | -12 e  | 16 e    | 52 e    | 102.2   | 176.6   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | <i>o</i> -Diethylbenzene         | -28 e                                        | -6 e   | 21 e    | 58 e    | 107.9   | 182.9   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | <i>m</i> -Diethylbenzene         | -28 e                                        | -7 e   | 20 e    | 56 e    | 106.2   | 180.6   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | <i>p</i> -Diethylbenzene         | -28 e                                        | -6 e   | 21 e    | 57 e    | 108.1   | 183.3   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 3-Ethyl-1,2-dimethylbenzene      | -22 e                                        | 0 e    | 28 e    | 66 e    | 117.2   | 193.4   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 4-Ethyl-1,2-dimethylbenzene      | -24 e                                        | -2 e   | 26 e    | 63 e    | 113.6   | 189.2   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 2-Ethyl-1,3-dimethylbenzene      |                                              | -2 e   | 26 e    | 63 e    | 113.7   | 189.5   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 2-Ethyl-1,4-dimethylbenzene      | -27 e                                        | -5 e   | 23 e    | 60 e    | 110.6   | 186.4   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 1-Ethyl-2,4-dimethylbenzene      | -25 e                                        | -4 e   | 24 e    | 61 e    | 112.2   | 187.9   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 1-Ethyl-3,5-dimethylbenzene      | -28 e                                        | -6 e   | 21 e    | 58 e    | 108.3   | 183.2   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 1-Methyl-2-propylbenzene         | -27 e                                        | -6 e   | 22 e    | 58.2    | 108.9   | 184.3   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 1-Methyl-3-propylbenzene         | -29 e                                        | -8 e   | 20 e    | 56.1    | 106.5   | 181.3   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 1-Methyl-4-propylbenzene         | -29 e                                        | -7 e   | 20 e    | 56.6    | 107.4   | 182.8   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 1,2,3,4-Tetramethylbenzene       |                                              | 7 e    | 36 e    | 74 e    | 126.6   | 204.5   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 1,2,3,5-Tetramethylbenzene       | -19 e                                        | 3 e    | 32 e    | 69 e    | 120.9   | 197.5   | 5    |
| C <sub>10</sub> H <sub>14</sub>                | 1,2,4,5-Tetramethylbenzene       |                                              |        |         |         | 119.9   | 196.3   | 5    |
| C <sub>10</sub> H <sub>14</sub> O              | 2-Butylphenol                    | 7 e                                          | 31 e   | 61 e    | 101 e   | 155.2   | 234.4   | 5    |
| C <sub>10</sub> H <sub>14</sub> O              | Butyl phenyl ether               | -16 e                                        | 8 e    | 38 e    | 77 e    | 131.3   | 209.7   | 5    |
| C <sub>10</sub> H <sub>14</sub> O              | Thymol                           | 18.9 s                                       | 37.9 s | 59.5    | 101.2   | 155.0   | 230.4   | 5    |
| C <sub>10</sub> H <sub>15</sub> N              | 2-Methyl-5-isopropylaniline      | 19 e                                         | 43 e   | 72 e    | 107.4   | 150 e   | 204 e   | 5    |
| C <sub>10</sub> H <sub>15</sub> N              | <i>N</i> -Butylaniline           | 11 e                                         | 35 e   | 66 e    | 106 e   | 160.9   | 241.0   | 5    |
| C <sub>10</sub> H <sub>15</sub> N              | <i>N,N</i> -Diethylaniline       | -11 e                                        | 14 e   | 44.3    | 84.2    | 138.4   | 216.3   | 5    |
| C <sub>10</sub> H <sub>16</sub>                | Dipentene                        | -42 e                                        | -19 e  | 10.6    | 48.7    | 100.2   | 173.9   | 5    |
| C <sub>10</sub> H <sub>16</sub>                | <i>d</i> -Limonene               | -45 e                                        | -21 e  | 9.1     | 48.0    | 100.4   | 174.5   | 5    |
| C <sub>10</sub> H <sub>16</sub>                | <i>l</i> -Limonene               | -33 e                                        | -12 e  | 16 e    | 52.0    | 102.3   | 177.0   | 21   |
| C <sub>10</sub> H <sub>16</sub>                | β-Myrcene                        |                                              |        | 9.4     | 47.3    | 98.3    | 171.0   | 5    |
| C <sub>10</sub> H <sub>16</sub>                | α-Pinene                         | -48 e                                        | -27 e  | -1 e    | 33.6    | 82.2    | 155.1   | 21   |
| C <sub>10</sub> H <sub>16</sub>                | β-Pinene                         | -43 e                                        | -22 e  | 5.0     | 40.6    | 90.5    | 165.5   | 21   |
| C <sub>10</sub> H <sub>16</sub>                | Camphene                         |                                              |        |         |         | 90.7    | 160.1   | 4    |
| C <sub>10</sub> H <sub>16</sub>                | Terpinolene                      |                                              |        | 26.5    | 64.9    | 115.4   | 184.6   | 5    |
| C <sub>10</sub> H <sub>16</sub>                | β-Phellandrene                   |                                              |        | 16 e    | 53.2    | 104 e   | 171.0   | 5    |
| C <sub>10</sub> H <sub>16</sub> O              | (+)-Camphor                      | -15.8 s                                      | 10 s   | 41.5 s  | 80.8 s  | 131.4 s | 207.6   | 5    |
| C <sub>10</sub> H <sub>16</sub> O              | Pulegone                         | 37 e                                         | 49.1   | 66.4    | 92.2    | 135.1   | 220.2   | 5    |
| C <sub>10</sub> H <sub>18</sub>                | 1-Decyne                         | -34 e                                        | -13 e  | 14 e    | 51 e    | 100.3   | 173.5   | 5    |
| C <sub>10</sub> H <sub>18</sub>                | <i>cis</i> -Decahydronaphthalene | -26 e                                        | -4 e   | 24 e    | 62.4    | 115.5   | 195.3   | 1    |

| Mol. form.                                                     | Name                                      | Temperature in °C for the indicated pressure |       |        |       |        |         | Ref. |
|----------------------------------------------------------------|-------------------------------------------|----------------------------------------------|-------|--------|-------|--------|---------|------|
|                                                                |                                           | 1 Pa                                         | 10 Pa | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>10</sub> H <sub>18</sub>                                | <i>trans</i> -Decahydronaphthalene        |                                              | −10 e | 18 e   | 55.3  | 107.9  | 186.8   | 1    |
| C <sub>10</sub> H <sub>18</sub> O                              | α-Terpineol                               |                                              |       | 48     | 89    | 142    | 217     | 4    |
| C <sub>10</sub> H <sub>18</sub> O                              | Eucalyptol                                |                                              |       | 10.6   | 48.5  | 100.3  | 175.4   | 5    |
| C <sub>10</sub> H <sub>18</sub> O                              | <i>trans</i> -Geraniol                    | 4 e                                          | 31 e  | 63.2   | 104.3 | 157.7  | 229.6   | 5    |
| C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                 | Sebacic acid                              | 125.9 s                                      |       |        |       |        |         | 5    |
| C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                 | Dipropyl succinate                        | 11 e                                         | 38 e  | 72.1   | 115.4 | 172.3  | 250.4   | 5    |
| C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                 | Diethyl adipate                           | 4 e                                          | 35 e  | 72 e   | 116.6 | 171.2  | 239.5   | 5    |
| C <sub>10</sub> H <sub>19</sub> N                              | Decanenitrile                             | 13 e                                         | 36 e  | 66 e   | 105.8 | 160.6  | 241.6   | 5    |
| C <sub>10</sub> H <sub>20</sub>                                | 1-Decene                                  | −35.5                                        | −13.7 | 13.7   | 49.0  | 97.9   | 170.1   | 1,5  |
| C <sub>10</sub> H <sub>20</sub>                                | Cyclodecane                               |                                              |       | 29 e   | 68 e  | 121.3  | 201.8   | 1    |
| C <sub>10</sub> H <sub>20</sub>                                | Butylcyclohexane                          | −31 e                                        | −9 e  | 18 e   | 54 e  | 104.7  | 180.4   | 5    |
| C <sub>10</sub> H <sub>20</sub>                                | Isobutylcyclohexane                       | −37 e                                        | −16 e | 10 e   | 46 e  | 95.9   | 170.8   | 5    |
| C <sub>10</sub> H <sub>20</sub>                                | <i>tert</i> -Butylcyclohexane             | −39 e                                        | −18 e | 9 e    | 45 e  | 95.3   | 171.1   | 5    |
| C <sub>10</sub> H <sub>20</sub> O                              | Decanal                                   |                                              | 16 e  | 47.2   | 86.3  | 137.7  | 208.0   | 5    |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Decanoic acid                             | 58 e                                         | 80 e  | 108 e  | 145 e | 195.2  | 269.5   | 5    |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Octyl acetate                             | −26 e                                        | −3 e  | 27 e   | 66.3  | 120.0  | 198.2   | 5    |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | 2-Ethylhexyl acetate                      | −11 e                                        | 5 e   | 26 e   | 57.6  | 107.1  | 197.2   | 5    |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Isopentyl isopentanoate                   |                                              |       | 22 e   | 62.8  | 116.9  | 193.6   | 5    |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Ethyl octanoate                           | −17 e                                        | 9 e   | 41 e   | 81.4  | 133.2  | 203 e   | 5    |
| C <sub>10</sub> H <sub>20</sub> O <sub>4</sub>                 | Diethylene glycol monobutyl ether acetate | 6 e                                          | 34 e  | 69 e   | 112.6 | 169.2  | 245.4   | 5    |
| C <sub>10</sub> H <sub>21</sub> Br                             | 1-Bromodecane                             | 9 e                                          | 33 e  | 63 e   | 104 e | 159.2  | 240.0   | 5    |
| C <sub>10</sub> H <sub>21</sub> Cl                             | 1-Chlorodecane                            | 2 e                                          | 25 e  | 54 e   | 92 e  | 145.7  | 225.3   | 5    |
| C <sub>10</sub> H <sub>21</sub> F                              | 1-Fluorodecane                            | −22 e                                        | 0 e   | 27 e   | 64 e  | 113.3  | 185.7   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | Decane                                    |                                              | −10.6 | 16.7   | 52.3  | 101.1  | 173.7   | 16   |
| C <sub>10</sub> H <sub>22</sub>                                | 2-Methylnonane                            | −34 e                                        | −14 e | 12 e   | 47 e  | 94.8   | 166.5   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 3-Methylnonane                            | −34 e                                        | −14 e | 12 e   | 47 e  | 95.1   | 167.3   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 4-Methylnonane                            | −36 e                                        | −16 e | 10 e   | 45 e  | 93.1   | 165.2   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 5-Methylnonane                            | −36 e                                        | −16 e | 10 e   | 45 e  | 92.6   | 164.6   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 2,4-Dimethyloctane                        |                                              |       |        | 38 e  | 84.9   | 155.4   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 2,7-Dimethyloctane                        | −39 e                                        | −19 e | 7 e    | 41 e  | 88.4   | 159.4   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 2,2,6-Trimethylheptane                    | −46 e                                        | −27 e | −2 e   | 32 e  | 78.5   | 148.4   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 3,3,5-Trimethylheptane                    |                                              |       | 0 e    | 35 e  | 82.7   | 155.2   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 2,2,3,3-Tetramethylhexane                 | −46 e                                        | −25 e | 1 e    | 36 e  | 85.6   | 159.8   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 2,2,5,5-Tetramethylhexane                 |                                              |       | −10 e  | 22 e  | 68.3   | 137.0   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 2,4-Dimethyl-3-isopentylpentane           | −46 e                                        | −26 e | 0 e    | 35 e  | 83.2   | 156.5   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 2,2,3,3,4-Pentamethylpentane              |                                              | −24 e | 3 e    | 39 e  | 89.1   | 165.5   | 5    |
| C <sub>10</sub> H <sub>22</sub>                                | 2,2,3,4,4-Pentamethylpentane              |                                              | −29 e | −3 e   | 33 e  | 82.8   | 158.7   | 5    |
| C <sub>10</sub> H <sub>22</sub> O                              | 1-Decanol                                 | 30 e                                         | 50 e  | 75 e   | 109 e | 157.3  | 230.6   | 1,39 |
| C <sub>10</sub> H <sub>22</sub> O                              | 4-Decanol                                 | 18 e                                         | 37 e  | 61 e   | 93 e  | 139 e  | 210 e   | 5    |
| C <sub>10</sub> H <sub>22</sub> O                              | Dipentyl ether                            | −31 e                                        | −8 e  | 22 e   | 60 e  | 111.6  | 186.2   | 5    |
| C <sub>10</sub> H <sub>22</sub> O                              | Diisopentyl ether                         |                                              |       | 14.0   | 51.5  | 101.8  | 172.8   | 5    |
| C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>                 | Ethylene glycol dibutyl ether             | 0 e                                          | 20 e  | 44 e   | 78.4  | 127.1  | 202.9   | 5    |
| C <sub>10</sub> H <sub>22</sub> O <sub>5</sub>                 | Tetraethylene glycol dimethyl ether       |                                              |       |        | 138 e | 200.9  | 275.3   | 5    |
| C <sub>10</sub> H <sub>22</sub> S                              | 1-Decanethiol                             | 11 e                                         | 34 e  | 64 e   | 103 e | 157.5  | 238.6   | 5    |
| C <sub>10</sub> H <sub>22</sub> S                              | Diisopentylsulfide                        |                                              |       | 7 e    | 82 e  | 118 e  | 139 e   | 5    |
| C <sub>10</sub> H <sub>23</sub> N                              | Dipentylamine                             |                                              |       |        | 77 e  | 127.7  | 202.0   | 5    |
| C <sub>10</sub> H <sub>30</sub> O <sub>3</sub> Si <sub>4</sub> | Decamethyltetrasiloxane                   | −31 e                                        | −6 e  | 26 e   | 66.8  | 118.8  | 193.9   | 5    |
| C <sub>10</sub> H <sub>30</sub> O <sub>5</sub> Si <sub>5</sub> | Decamethylcyclopentasiloxane              | −2 e                                         | 19 e  | 46 e   | 82 e  | 132.9  | 210.4   | 5    |
| C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                  | 1-Naphthalenecarboxylic acid              |                                              |       |        | 191.9 | 239.3  | 299.6   | 5    |
| C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                  | 2-Naphthalenecarboxylic acid              |                                              |       |        | 197.9 | 246.0  | 308.1   | 5    |
| C <sub>11</sub> H <sub>10</sub>                                | 1-Methylnaphthalene                       | 5 e                                          | 29 e  | 60 e   | 102 e | 159.1  | 244.1   | 1    |
| C <sub>11</sub> H <sub>10</sub>                                | 2-Methylnaphthalene                       |                                              |       | 57 e   | 99 e  | 156.0  | 240.5   | 1    |
| C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>                 | Ethyl <i>trans</i> -cinnamate             |                                              |       | 79     | 125   | 187    | 271     | 4    |
| C <sub>11</sub> H <sub>12</sub> O <sub>3</sub>                 | Myristicin                                | 23 e                                         | 53 e  | 88.9   | 135.2 | 196.0  | 279.4   | 5    |
| C <sub>11</sub> H <sub>14</sub>                                | 4-Isopropylstyrene                        | −25 e                                        | −1 e  | 30.2   | 70.3  | 124.5  | 202.1   | 5    |
| C <sub>11</sub> H <sub>14</sub>                                | 1,2,3,4-Tetrahydro-5-methylnaphthalene    | 9 e                                          | 31 e  | 60 e   | 99 e  | 153.1  | 233.8   | 5    |
| C <sub>11</sub> H <sub>14</sub>                                | 1,2,3,4-Tetrahydro-6-methylnaphthalene    | 17 e                                         | 36 e  | 62 e   | 97 e  | 147.8  | 228.5   | 5    |
| C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | Butyl benzoate                            | 6 e                                          | 34 e  | 67.9   | 110.3 | 165 e  | 237 e   | 5    |
| C <sub>11</sub> H <sub>16</sub>                                | Pentylbenzene                             | −14 e                                        | 8 e   | 37 e   | 74 e  | 126.7  | 204.9   | 5    |

| Mol. form.                                     | Name                                  | Temperature in °C for the indicated pressure |        |        |         |        |         | Ref. |
|------------------------------------------------|---------------------------------------|----------------------------------------------|--------|--------|---------|--------|---------|------|
|                                                |                                       | 1 Pa                                         | 10 Pa  | 100 Pa | 1 kPa   | 10 kPa | 100 kPa |      |
| C <sub>11</sub> H <sub>16</sub>                | <i>p</i> -tert-Butyltoluene           | −24 e                                        | −2 e   | 27 e   | 64.1    | 115.5  | 190.8   | 5    |
| C <sub>11</sub> H <sub>16</sub>                | 1,3-Diethyl-5-methylbenzene           | −26 e                                        | −1 e   | 29.5   | 69.5    | 123.5  | 200.2   | 5    |
| C <sub>11</sub> H <sub>16</sub>                | 2-Ethyl-1,3,5-trimethylbenzene        |                                              | 6 e    | 36 e   | 75.7    | 129.6  | 207.6   | 5    |
| C <sub>11</sub> H <sub>16</sub>                | 1-Ethyl-2,4,5-trimethylbenzene        | −13 e                                        | 11 e   | 40 e   | 79.4    | 132.1  | 207.7   | 5    |
| C <sub>11</sub> H <sub>20</sub>                | 1-Undecyne                            | −22 e                                        | 0 e    | 29 e   | 67 e    | 118.5  | 194.5   | 5    |
| C <sub>11</sub> H <sub>20</sub>                | 2-Undecyne                            | −17 e                                        | 6 e    | 35 e   | 74 e    | 127.4  | 205.4   | 5    |
| C <sub>11</sub> H <sub>20</sub> O <sub>2</sub> | 10-Undecenoic acid                    | 35 e                                         | 67 e   | 105 e  | 150.0   | 205.4  | 274.5   | 5    |
| C <sub>11</sub> H <sub>20</sub> O <sub>4</sub> | Ethyl diethylmalonate                 |                                              |        | 74 e   | 105 e   | 149.4  | 219 e   | 5    |
| C <sub>11</sub> H <sub>21</sub> N              | Undecanenitrile                       |                                              |        | 78.6   | 120.3   | 177.3  | 259.9   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | 1-Undecene                            | −21.6                                        | 1.2    | 29.7   | 66.4    | 117.1  | 192.2   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | <i>cis</i> -2-Undecene                | −14 e                                        | 7 e    | 34 e   | 70.2    | 120.6  | 196 e   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | <i>trans</i> -2-Undecene              | −14 e                                        | 7 e    | 33 e   | 69.3    | 119.6  | 195 e   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | <i>cis</i> -4-Undecene                | −19 e                                        | 3 e    | 30 e   | 66.6    | 117.1  | 192 e   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | <i>trans</i> -4-Undecene              | −17 e                                        | 4 e    | 31 e   | 67.1    | 117.4  | 193 e   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | <i>cis</i> -5-Undecene                | −19 e                                        | 2 e    | 30 e   | 66.2    | 116.7  | 191 e   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | <i>trans</i> -5-Undecene              | −18 e                                        | 3 e    | 31 e   | 67.0    | 117.4  | 192 e   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | Pentylcyclohexane                     | −17 e                                        | 6 e    | 34 e   | 72 e    | 124.2  | 202.7   | 5    |
| C <sub>11</sub> H <sub>22</sub>                | Hexylcyclopentane                     | −15 e                                        | 7 e    | 36 e   | 73 e    | 125.0  | 202.5   | 5    |
| C <sub>11</sub> H <sub>22</sub> O              | 2-Undecanone                          | 17 e                                         | 37 e   | 64.3   | 103.0   | 153.6  | 232.6   | 1,5  |
| C <sub>11</sub> H <sub>22</sub> O              | 6-Undecanone                          |                                              | 28 e   | 57 e   | 95 e    | 148.4  | 226.9   | 1    |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | Undecanoic acid                       | 68 e                                         | 90 e   | 118 e  | 156 e   | 207.2  | 283.6   | 5    |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | Heptyl butanoate                      | 2 e                                          | 29 e   | 62 e   | 102.6   | 155.1  | 224.7   | 5    |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | Propyl octanoate                      | −2 e                                         | 23 e   | 55 e   | 94.0    | 145.2  | 215 e   | 5    |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | Methyl decanoate                      | 10 e                                         | 33 e   | 62 e   | 100.9   | 154.0  | 232 e   | 5    |
| C <sub>11</sub> H <sub>24</sub>                | Undecane                              | −18.4                                        | 4.3    | 32.6   | 69.5    | 120.2  | 195.4   | 16   |
| C <sub>11</sub> H <sub>24</sub>                | 2-Methyldecane                        | −20 e                                        | 1 e    | 28 e   | 64 e    | 114.0  | 188.7   | 5    |
| C <sub>11</sub> H <sub>24</sub>                | 3-Methyldecane                        | −35 e                                        | −10 e  | 22 e   | 61.9    | 115.6  | 190.4   | 5    |
| C <sub>11</sub> H <sub>24</sub>                | 4-Methyldecane                        | −38 e                                        | −12 e  | 20 e   | 60.8    | 113.9  | 186.4   | 5    |
| C <sub>11</sub> H <sub>24</sub>                | 2,4,7-Trimethyloctane                 |                                              |        |        | 43 e    | 94 e   | 170.4   | 5    |
| C <sub>11</sub> H <sub>24</sub> O              | 1-Undecanol                           | 52.2                                         | 80.0   | 82 e   | 118 e   | 167.6  | 244.1   | 5    |
| C <sub>11</sub> H <sub>24</sub> S              | 1-Undecanethiol                       | 23 e                                         | 47 e   | 77 e   | 118 e   | 173.6  | 256.8   | 5    |
| C <sub>12</sub> F <sub>27</sub> N              | Trinonafluorobutylamine               |                                              | 3 e    | 29.0   | 63.3    | 109.9  | 176.8   | 5    |
| C <sub>12</sub> H <sub>8</sub>                 | Acenaphthylene                        | 24 s                                         | 49.8 s | 80.6 s |         |        |         | 5    |
| C <sub>12</sub> H <sub>9</sub> N               | Carbazole                             |                                              |        |        |         | 254.7  | 354.0   | 5    |
| C <sub>12</sub> H <sub>10</sub>                | Acenaphthene                          |                                              |        |        | 126.2   | 187 e  | 276 e   | 1    |
| C <sub>12</sub> H <sub>10</sub>                | Biphenyl                              |                                              |        | 69.0   | 111.1   | 169.5  | 254.7   | 1    |
| C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> | Azobenzene                            |                                              |        | 98.1   | 144.8   | 206.7  | 292.7   | 4    |
| C <sub>12</sub> H <sub>10</sub> O              | Diphenyl ether                        |                                              | 44 e   | 75 e   | 116 e   | 173 e  | 257.4   | 5    |
| C <sub>12</sub> H <sub>10</sub> O              | 1-Acetonaphthone                      | 37 e                                         | 69 e   | 107.0  | 154.6   | 215.2  | 294.9   | 5    |
| C <sub>12</sub> H <sub>10</sub> O              | 2-Acetonaphthone                      | 48.3 s                                       |        | 118.7  | 163.0   | 221.1  | 300.3   | 5    |
| C <sub>12</sub> H <sub>10</sub> S              | Diphenyl sulfide                      | 20 e                                         | 51 e   | 88.7   | 137.5   | 202.2  | 291.8   | 5    |
| C <sub>12</sub> H <sub>11</sub> N              | Diphenylamine                         | 48 s                                         |        | 102.8  | 150.5   | 213.7  | 301.4   | 5    |
| C <sub>12</sub> H <sub>12</sub>                | 1-Ethyl-naphthalene                   | 16 e                                         | 41 e   | 72 e   | 114 e   | 171.8  | 257.7   | 5    |
| C <sub>12</sub> H <sub>12</sub>                | 2-Ethyl-naphthalene                   | 14 e                                         | 39 e   | 71 e   | 113 e   | 171.2  | 257.3   | 5    |
| C <sub>12</sub> H <sub>12</sub>                | 1,2-Dimethylnaphthalene               | 26 e                                         | 51 e   | 82 e   | 123 e   | 180.5  | 265.7   | 5    |
| C <sub>12</sub> H <sub>12</sub>                | 2,7-Dimethylnaphthalene               | 31.5 s                                       | 53.1 s | 78.8 s | 115.9   | 175 e  | 260 e   | 5    |
| C <sub>12</sub> H <sub>14</sub> O <sub>4</sub> | Diethyl phthalate                     | 12 e                                         | 51 e   | 96 e   | 150.5   | 215.9  | 296.2   | 5    |
| C <sub>12</sub> H <sub>16</sub>                | <i>p</i> -Isopropenylisopropylbenzene | −11 e                                        | 15 e   | 46 e   | 87 e    | 142.4  | 221 e   | 5    |
| C <sub>12</sub> H <sub>16</sub>                | Cyclohexylbenzene                     |                                              | 28 e   | 58 e   | 98 e    | 154.7  | 239.5   | 5    |
| C <sub>12</sub> H <sub>16</sub> O <sub>2</sub> | 3-Methylbutyl benzoate                |                                              |        | 66 e   | 115.0   | 177.7  | 261.4   | 5    |
| C <sub>12</sub> H <sub>18</sub>                | Hexylbenzene                          | −2 e                                         | 22 e   | 51 e   | 90 e    | 144.5  | 225.5   | 5    |
| C <sub>12</sub> H <sub>18</sub>                | 1,2-Diisopropylbenzene                | −14 e                                        | 9 e    | 37 e   | 74 e    | 125.9  | 203.2   | 5    |
| C <sub>12</sub> H <sub>18</sub>                | 1,3-Diisopropylbenzene                | −14 e                                        | 8 e    | 36 e   | 74 e    | 125.5  | 202.6   | 5    |
| C <sub>12</sub> H <sub>18</sub>                | 1,4-Diisopropylbenzene                | −6 e                                         | 18 e   | 49 e   | 90 e    | 148.8  | 238 e   | 5    |
| C <sub>12</sub> H <sub>18</sub>                | Hexamethylbenzene                     | 46.3 s                                       | 72.5 s | 81.7 s | 121.8 s | 178.3  | 263.7   | 5    |
| C <sub>12</sub> H <sub>18</sub>                | 1,5,9-Cyclododecatiene                | −14 e                                        | 11 e   | 44 e   | 87 e    | 145.0  | 229.8   | 5    |
| C <sub>12</sub> H <sub>20</sub> O <sub>2</sub> | Geranyl acetate                       |                                              |        | 67.7   | 110.8   | 166.9  | 242.9   | 5    |
| C <sub>12</sub> H <sub>20</sub> O <sub>4</sub> | Dibutyl maleate                       | 12.3                                         | 50.4   | 94.0   | 144.2   | 203 e  | 272 e   | 5    |
| C <sub>12</sub> H <sub>22</sub>                | 1-Dodecane                            | −11 e                                        | 13 e   | 43 e   | 82 e    | 135.8  | 214.4   | 5    |
| C <sub>12</sub> H <sub>22</sub>                | Cyclohexylcyclohexane                 |                                              | 20 e   | 53.1   | 96.0    | 154.1  | 237.2   | 5    |

| Mol. form.                                                     | Name                            | Temperature in °C for the indicated pressure |         |         |       |        |         | Ref. |
|----------------------------------------------------------------|---------------------------------|----------------------------------------------|---------|---------|-------|--------|---------|------|
|                                                                |                                 | 1 Pa                                         | 10 Pa   | 100 Pa  | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>                 | Methyl 10-undecenoate           | 10 e                                         | 38 e    | 73 e    | 116 e | 172.2  | 247.1   | 5    |
| C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                 | Dimethyl sebacate               |                                              | 53 e    | 97      | 150   | 214    | 293     | 4    |
| C <sub>12</sub> H <sub>23</sub> N                              | Dodecanenitrile                 | 36 e                                         | 60 e    | 92 e    | 133 e | 190.5  | 275.5   | 5    |
| C <sub>12</sub> H <sub>24</sub>                                | 1-Dodecene                      | −8.3                                         | 15.2    | 44.8    | 82.9  | 135.4  | 212.8   | 5    |
| C <sub>12</sub> H <sub>24</sub>                                | Hexylcyclohexane                | −3 e                                         | 20 e    | 50 e    | 89 e  | 143.1  | 224.2   | 5    |
| C <sub>12</sub> H <sub>24</sub>                                | Heptylcyclopentane              | −1 e                                         | 22 e    | 51 e    | 90 e  | 143.5  | 223.5   | 5    |
| C <sub>12</sub> H <sub>24</sub> O                              | Dodecanal                       |                                              |         | 70 e    | 116.2 | 175.9  | 256.6   | 5    |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                 | Dodecanoic acid                 | 78 e                                         | 100 e   | 128 e   | 166 e | 219.1  | 298.1   | 5    |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                 | Decyl acetate                   | 12 e                                         | 40 e    | 74 e    | 115.1 | 168.1  | 238 e   | 5    |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                 | Ethyl decanoate                 | 8 e                                          | 35 e    | 69 e    | 111.8 | 166.1  | 238 e   | 5    |
| C <sub>12</sub> H <sub>25</sub> Br                             | 1-Bromododecane                 | 31 e                                         | 57 e    | 90 e    | 132 e | 190.8  | 275.3   | 5    |
| C <sub>12</sub> H <sub>25</sub> Cl                             | 1-Chlorododecane                | 27 e                                         | 51 e    | 81 e    | 122 e | 178.7  | 262.6   | 5    |
| C <sub>12</sub> H <sub>26</sub>                                | Dodecane                        | −5.4                                         | 18.2    | 47.6    | 85.8  | 138.2  | 215.8   | 16   |
| C <sub>12</sub> H <sub>26</sub> O                              | 1-Dodecanol                     |                                              |         |         | 133 e | 185.0  | 264.1   | 1    |
| C <sub>12</sub> H <sub>26</sub> O <sub>3</sub>                 | Diethylene glycol dibutyl ether | 5 e                                          | 34.4    | 70.2    | 115.3 | 174.1  | 253.8   | 5    |
| C <sub>12</sub> H <sub>27</sub> N                              | Tributylamine                   | −26 e                                        | 1 e     | 35 e    | 77.7  | 134.5  | 213.4   | 5    |
| C <sub>12</sub> H <sub>27</sub> N                              | Triisobutylamine                |                                              | 1 e     | 28.9    | 64.9  | 112.5  | 178.5   | 5    |
| C <sub>12</sub> H <sub>27</sub> O <sub>4</sub> P               | Tributyl phosphate              |                                              |         |         |       | 205 e  | 288.3   | 5    |
| C <sub>12</sub> H <sub>36</sub> O <sub>6</sub> Si <sub>6</sub> | Dodecamethylcyclohexasiloxane   | 18 e                                         | 41 e    | 69 e    | 108 e | 162.2  | 244.7   | 5    |
| C <sub>13</sub> H <sub>9</sub> N                               | Acridine                        |                                              |         | 124.4   | 176.2 | 246.0  | 345.4   | 5    |
| C <sub>13</sub> H <sub>9</sub> N                               | Phenanthridine                  | 79 s                                         |         |         |       |        |         | 5    |
| C <sub>13</sub> H <sub>10</sub>                                | Fluorene                        | 48.4 s                                       |         |         | 137.4 | 205.4  | 295 e   | 5    |
| C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                 | Phenyl benzoate                 |                                              |         | 102.3   | 151.4 | 217.9  | 313.3   | 5    |
| C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                 | Phenyl salicylate               |                                              |         |         | 166.0 | 224.8  | 312.4   | 5    |
| C <sub>13</sub> H <sub>12</sub>                                | Diphenylmethane                 |                                              | 45 e    | 77 e    | 119.3 | 177.7  | 263.6   | 1,5  |
| C <sub>13</sub> H <sub>13</sub> N                              | Methyldiphenylamine             | 35 e                                         | 63 e    | 98.4    | 143.1 | 201.6  | 281.6   | 5    |
| C <sub>13</sub> H <sub>14</sub>                                | 1-Isopropyl-naphthalene         | 27 e                                         | 51 e    | 82 e    | 123.2 | 180.8  | 267.3   | 5    |
| C <sub>13</sub> H <sub>20</sub>                                | Heptylbenzene                   | 12 e                                         | 36 e    | 66 e    | 107 e | 162.7  | 246.2   | 5    |
| C <sub>13</sub> H <sub>24</sub> O <sub>2</sub>                 | Ethyl 10-undecenoate            | 32 e                                         | 55 e    | 86 e    | 125.2 | 179.5  | 258.4   | 5    |
| C <sub>13</sub> H <sub>26</sub>                                | 1-Tridecene                     | 4.1                                          | 28.5    | 59.0    | 98.3  | 152.5  | 232.3   | 5    |
| C <sub>13</sub> H <sub>26</sub>                                | Heptylcyclohexane               | 11 e                                         | 34 e    | 65 e    | 105 e | 160.9  | 244.3   | 5    |
| C <sub>13</sub> H <sub>26</sub>                                | Octylcyclopentane               | 13 e                                         | 36 e    | 66 e    | 106 e | 160.9  | 243.1   | 5    |
| C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                 | Tridecanoic acid                | 87 e                                         | 109 e   | 138 e   | 176 e | 230.3  | 311.5   | 5    |
| C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                 | Methyl dodecanoate              | 38 e                                         | 61 e    | 90 e    | 130 e | 184.9  | 269 e   | 5    |
| C <sub>13</sub> H <sub>28</sub>                                | Tridecane                       | 7.2                                          | 31.5    | 61.8    | 101.1 | 155.1  | 234.9   | 16   |
| C <sub>13</sub> H <sub>28</sub> O                              | 1-Tridecanol                    | 71.6                                         | 101.0   | 103 e   | 140 e | 192.3  | 273.1   | 5    |
| C <sub>14</sub> H <sub>10</sub>                                | Anthracene                      | 89.2 s                                       | 125.9 s | 151.5 s | 165 s | 238.8  | 340.2   | 1,5  |
| C <sub>14</sub> H <sub>10</sub>                                | Phenanthrene                    | 53 s                                         | 83 s    | 120.8   | 170.4 | 238.4  | 337.7   | 5    |
| C <sub>14</sub> H <sub>10</sub> O <sub>2</sub>                 | Benzil                          |                                              |         | 123     | 175   | 246    | 346     | 4    |
| C <sub>14</sub> H <sub>12</sub>                                | cis-Stilbene                    | 26 e                                         | 54 e    | 88 e    | 130.4 | 183 e  | 253 e   | 5    |
| C <sub>14</sub> H <sub>12</sub>                                | trans-Stilbene                  |                                              |         |         | 155.6 | 218.1  | 305.8   | 5    |
| C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>                 | Benzoin                         |                                              |         |         | 181   | 248    | 342     | 4    |
| C <sub>14</sub> H <sub>14</sub>                                | 1,1-Diphenylethane              | 19 e                                         | 47 e    | 82.0    | 125.3 | 181 e  | 254 e   | 5    |
| C <sub>14</sub> H <sub>15</sub> N                              | Dibenzylamine                   | 48 e                                         | 77 e    | 113.1   | 158.9 | 218.5  | 299.4   | 5    |
| C <sub>14</sub> H <sub>16</sub>                                | 1-Butyl-naphthalene             | 67 e                                         | 82 e    | 103 e   | 135 e | 186.7  | 288.6   | 5    |
| C <sub>14</sub> H <sub>16</sub>                                | 2-Butyl-naphthalene             | 44 e                                         | 67 e    | 98 e    | 139 e | 197.5  | 287.4   | 5    |
| C <sub>14</sub> H <sub>22</sub>                                | Octylbenzene                    | 20.1                                         | 46.2    | 79.1    | 121.9 | 178.1  | 263.8   | 5    |
| C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>                 | Diethyl sebacate                |                                              | 83 e    | 120     | 166   | 225    | 305     | 4    |
| C <sub>14</sub> H <sub>27</sub> N                              | Tetradecanenitrile              | 52 e                                         | 79 e    | 114.0   | 159.0 | 219.7  | 306.3   | 5    |
| C <sub>14</sub> H <sub>28</sub>                                | 1-Tetradecene                   | 16.1                                         | 41.3    | 72.7    | 113.2 | 168.7  | 250.6   | 5    |
| C <sub>14</sub> H <sub>28</sub>                                | Octylcyclohexane                | 16.9                                         | 44.3    | 77.8    | 120.0 | 177.6  | 263.2   | 5    |
| C <sub>14</sub> H <sub>28</sub>                                | Nonylcyclopentane               | 25 e                                         | 49 e    | 80 e    | 120 e | 177.2  | 261.5   | 5    |
| C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                 | Tetradecanoic acid              | 96 e                                         | 118 e   | 147 e   | 186 e | 241.3  | 325.6   | 5    |
| C <sub>14</sub> H <sub>30</sub>                                | Tetradecane                     | 19.1                                         | 44.1    | 75.3    | 115.7 | 171.1  | 253.0   | 16   |
| C <sub>14</sub> H <sub>30</sub> O                              | 1-Tetradecanol                  | 80.0                                         | 110.5   | 149.6   | 152 e | 205.3  | 286.7   | 5    |
| C <sub>14</sub> H <sub>31</sub> N                              | Tetradecylamine                 |                                              |         | 104 e   | 147 e | 206.1  | 290.9   | 5    |
| C <sub>14</sub> H <sub>42</sub> O <sub>6</sub> Si <sub>6</sub> | Tetradecamethylhexasiloxane     | 6 e                                          | 36 e    | 72 e    | 117 e | 176.0  | 259.1   | 5    |
| C <sub>15</sub> H <sub>18</sub>                                | 1-Pentyl-naphthalene            | 34 e                                         | 62 e    | 96 e    | 141.3 | 202.2  | 289 e   | 5    |
| C <sub>15</sub> H <sub>24</sub>                                | Nonylbenzene                    | 33.0                                         | 58.9    | 92.0    | 135.4 | 193.7  | 281.4   | 5    |
| C <sub>15</sub> H <sub>30</sub>                                | Nonylcyclohexane                | 35 e                                         | 60 e    | 92 e    | 134 e | 193.4  | 280.9   | 5    |



| Mol. form.                                                     | Name                                | Temperature in °C for the indicated pressure |         |        |       |        |         | Ref. |
|----------------------------------------------------------------|-------------------------------------|----------------------------------------------|---------|--------|-------|--------|---------|------|
|                                                                |                                     | 1 Pa                                         | 10 Pa   | 100 Pa | 1 kPa | 10 kPa | 100 kPa |      |
| C <sub>15</sub> H <sub>30</sub>                                | Decylcyclopentane                   | 37 e                                         | 61 e    | 93 e   | 134 e | 192.5  | 278.8   | 5    |
| C <sub>15</sub> H <sub>30</sub> O <sub>2</sub>                 | Methyl tetradecanoate               |                                              | 75 e    | 110    | 155   | 214    | 295     | 4    |
| C <sub>15</sub> H <sub>32</sub>                                | Pentadecane                         | 30.5                                         | 56.1    | 88.1   | 129.6 | 186.3  | 270.1   | 16   |
| C <sub>16</sub> H <sub>22</sub> O <sub>4</sub>                 | Dibutyl phthalate                   |                                              | 104.0   | 142.7  | 191.5 | 254.5  | 339.4   | 4    |
| C <sub>16</sub> H <sub>32</sub>                                | 1-Hexadecene                        | 38.4                                         | 65.0    | 98.1   | 140.5 | 198.8  | 284.3   | 5    |
| C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>                 | Hexadecanoic acid                   |                                              | 136 e   | 165 e  | 205 e | 261.9  | 350.2   | 5    |
| C <sub>16</sub> H <sub>34</sub>                                | Hexadecane                          | 41.1                                         | 67.4    | 100.3  | 142.7 | 200.7  | 286.3   | 16   |
| C <sub>16</sub> H <sub>34</sub> O                              | 1-Hexadecanol                       | 99.5                                         | 130.6   | 171.9  | 175 e | 229.0  | 311.7   | 5    |
| C <sub>16</sub> H <sub>35</sub> N                              | Hexadecylamine                      | 63 e                                         | 91 e    | 126 e  | 171 e | 232.6  | 320.5   | 5    |
| C <sub>17</sub> H <sub>10</sub> O                              | Benzanthrone                        |                                              | 184 e   | 229.3  | 290.3 | 377.2  | 511 e   | 5    |
| C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>                 | Methyl hexadecanoate                | 65 e                                         | 93      | 129    | 177   |        |         | 4    |
| C <sub>17</sub> H <sub>36</sub>                                | Heptadecane                         | 51.5                                         | 78.5    | 112.0  | 155.3 | 214.5  | 302 e   | 16   |
| C <sub>17</sub> H <sub>36</sub> O                              | 1-Heptadecanol                      | 94 e                                         | 117 e   | 146 e  | 185 e | 240.1  | 323.3   | 5    |
| C <sub>18</sub> H <sub>14</sub>                                | <i>o</i> -Terphenyl                 | 66 e                                         | 94 e    | 129 e  | 176 e | 241.3  | 336.3   | 5    |
| C <sub>18</sub> H <sub>14</sub>                                | <i>m</i> -Terphenyl                 | 87 e                                         | 118 e   | 156 e  | 206.6 | 275.3  | 374.6   | 5    |
| C <sub>18</sub> H <sub>14</sub>                                | <i>p</i> -Terphenyl                 | 127.1 s                                      | 154.7 s |        | 217.2 | 284.0  | 383.0   | 5    |
| C <sub>18</sub> H <sub>30</sub>                                | Hexaethylbenzene                    |                                              |         |        | 144.1 | 206.8  | 297.5   | 5    |
| C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>                 | Oleic acid                          | 94 e                                         | 126 e   | 165.5  | 214.5 | 277.0  | 359.7   | 5    |
| C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>                 | Elaidic acid                        |                                              | 124 e   | 166    | 216   | 280    | 361     | 4    |
| C <sub>18</sub> H <sub>36</sub> O                              | Stearaldehyde                       |                                              |         | 142 e  | 186 e | 246.9  | 336.7   | 5    |
| C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>                 | Stearic acid                        |                                              | 153 e   | 183 e  | 223 e | 281.6  | 374.5   | 5    |
| C <sub>18</sub> H <sub>38</sub>                                | Octadecane                          | 61.5                                         | 89.0    | 123.1  | 167.3 | 227.6  | 316 e   | 16   |
| C <sub>18</sub> H <sub>38</sub> O                              | 1-Octadecanol                       | 106 e                                        | 130 e   | 160 e  | 200.5 | 257.3  | 343.0   | 5    |
| C <sub>19</sub> H <sub>16</sub>                                | Triphenylmethane                    | 81 s                                         |         | 112 e  | 175 e | 254.6  | 360.0   | 5    |
| C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>                 | Methyl oleate                       | 85 e                                         | 114 e   | 149.7  | 195.6 | 256 e  | 340 e   | 5    |
| C <sub>19</sub> H <sub>40</sub>                                | Nonadecane                          | 71.1                                         | 99.1    | 133.8  | 178.8 | 240.1  | 330 e   | 16   |
| C <sub>20</sub> H <sub>42</sub>                                | Eicosane                            | 80.4                                         | 108.9   | 144.2  | 189.8 | 252.1  | 344 e   | 16   |
| C <sub>20</sub> H <sub>42</sub> O                              | 1-Eicosanol                         | 119 e                                        | 143 e   | 173 e  | 213 e | 270.0  | 355.1   | 5    |
| C <sub>20</sub> H <sub>60</sub> O <sub>8</sub> Si <sub>9</sub> | Eicosamethylnonasiloxane            |                                              |         | 141 e  | 183.1 | 236.7  | 307.1   | 5    |
| C <sub>21</sub> H <sub>21</sub> O <sub>4</sub> P               | Tri- <i>o</i> -cresyl phosphate     | 119.0                                        | 156.1   | 201.0  | 256.3 | 326.3  | 418 e   | 5    |
| C <sub>21</sub> H <sub>21</sub> O <sub>4</sub> P               | Tri- <i>m</i> -cresyl phosphate     | 147.8                                        | 177.3   | 211.4  | 251.3 | 298 e  | 355 e   | 5    |
| C <sub>21</sub> H <sub>21</sub> O <sub>4</sub> P               | Tri- <i>p</i> -cresyl phosphate     | 140.6                                        | 174 e   | 214 e  | 262 e | 320 e  | 392 e   | 5    |
| C <sub>21</sub> H <sub>44</sub>                                | Heneicosane                         | 82.3                                         | 113.5   | 152.2  | 201.6 | 263.8  | 355.9   | 5    |
| C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>                 | Brassicic acid                      | 134 e                                        | 166 e   | 203.6  | 249.8 | 307.6  | 382.0   | 5    |
| C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>                 | Erucic acid                         | 126 e                                        | 160 e   | 199.4  | 247.4 | 306.5  | 381.1   | 5    |
| C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>                 | Butyl oleate                        | 95.5                                         | 124.2   | 158 e  | 198 e | 245 e  | 304 e   | 5    |
| C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>                 | Behenic acid                        | 145.4                                        | 176.5   | 213.7  | 259.3 | 316.2  | 390 e   | 5    |
| C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>                 | Butyl stearate                      | 99.6                                         | 128 e   | 162 e  | 201 e | 249 e  | 307 e   | 5    |
| C <sub>22</sub> H <sub>46</sub>                                | Docosane                            | 83.5                                         | 115.0   | 154.0  | 203.6 | 274.8  | 368.0   | 5    |
| C <sub>23</sub> H <sub>48</sub>                                | Tricosane                           | 102.9                                        | 135.1   | 174.8  | 221 e | 285.3  | 379.5   | 5    |
| C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                 | Diethyl phthalate                   | 130 e                                        | 163.7   | 203.8  | 252 e | 311 e  | 385 e   | 5    |
| C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                 | Bis(2-ethylhexyl) phthalate         | 122.0                                        | 153.2   | 189.2  | 231.3 | 281.1  | 341.1   | 5    |
| C <sub>24</sub> H <sub>50</sub>                                | Tetracosane                         | 115.0                                        | 148.1   | 188.5  | 239.1 | 295.4  | 390.6   | 5    |
| C <sub>25</sub> H <sub>52</sub>                                | Pentacosane                         | 119.7                                        | 152.7   | 193.2  | 244.4 | 305.0  | 401.1   | 5    |
| C <sub>26</sub> H <sub>54</sub>                                | Hexacosane                          | 125.1                                        | 158.8   | 200.1  | 252.1 | 314.3  | 411.3   | 5    |
| C <sub>27</sub> H <sub>56</sub>                                | Heptacosane                         | 136.7                                        | 168.8   | 206.5  | 255.8 | 323.3  | 421.2   | 5    |
| C <sub>28</sub> H <sub>58</sub>                                | Octacosane                          | 136.5                                        | 169.8   | 210.9  | 263.1 | 332.0  | 430.6   | 5    |
| C <sub>29</sub> H <sub>60</sub>                                | Nonacosane                          | 148.2                                        | 182.8   | 221.2  | 271.5 | 340.2  | 439.7   | 5    |
| C <sub>30</sub> H <sub>62</sub>                                | Squalane                            | 66 e                                         | 84 e    | 105.8  | 131.9 | 163.7  | 203.2   | 5    |
| C <sub>70</sub>                                                | Carbon (fullerene-C <sub>70</sub> ) | 598 s                                        | 662 s   |        |       |        |         | 22   |

## VAPOR PRESSURE OF FLUIDS AT TEMPERATURES BELOW 300 K

This table gives vapor pressures of 67 important fluids in the temperature range 2 to 300 K. Helium (<sup>4</sup>He), hydrogen (H<sub>2</sub>), and neon (Ne) are covered on this page. The remaining fluids are listed on subsequent pages by molecular formula in the Hill order (see Introduction). The data have been taken from evaluated sources; references are listed at the end of the table.

Pressures are given in kilopascals (kPa). Note that:

1 kPa = 7.50062 Torr

100 kPa = 1 bar

101.325 kPa = 1 atm

“s” following an entry indicates that the compound is solid at that temperature.

| Helium |       | Hydrogen |       | Neon |       | Helium |       | Hydrogen |        | Neon |       |
|--------|-------|----------|-------|------|-------|--------|-------|----------|--------|------|-------|
| T/K    | P/kPa | T/K      | P/kPa | T/K  | P/kPa | T/K    | P/kPa | T/K      | P/kPa  | T/K  | P/kPa |
| 2.2    | 5.3   | 14.0     | 7.90  | 25.0 | 51.3  | 4.2    | 99.0  | 24.0     | 264.2  |      |       |
| 2.3    | 6.7   | 14.5     | 10.38 | 26.0 | 71.8  | 4.3    | 108.7 | 24.5     | 295.1  |      |       |
| 2.4    | 8.3   | 15.0     | 13.43 | 27.0 | 98.5  | 4.4    | 119.0 | 25.0     | 328.5  |      |       |
| 2.5    | 10.2  | 15.5     | 17.12 | 28.0 | 132.1 | 4.5    | 129.9 | 25.5     | 364.3  |      |       |
| 2.6    | 12.4  | 16.0     | 21.53 | 29.0 | 173.5 | 4.6    | 141.6 | 26.0     | 402.9  |      |       |
| 2.7    | 14.8  | 16.5     | 26.74 | 30.0 | 223.8 | 4.7    | 153.9 | 26.5     | 444.3  |      |       |
| 2.8    | 17.5  | 17.0     | 32.84 | 31.0 | 284.0 | 4.8    | 167.0 | 27.0     | 488.5  |      |       |
| 2.9    | 20.6  | 17.5     | 39.92 | 32.0 | 355.2 | 4.9    | 180.8 | 27.5     | 535.7  |      |       |
| 3.0    | 24.0  | 18.0     | 48.08 | 33.0 | 438.6 | 5.0    | 195.4 | 28.0     | 586.1  |      |       |
| 3.1    | 27.8  | 18.5     | 57.39 | 34.0 | 535.2 | 5.1    | 210.9 | 28.5     | 639.7  |      |       |
| 3.2    | 32.0  | 19.0     | 67.96 | 35.0 | 646.2 |        |       | 29.0     | 696.7  |      |       |
| 3.3    | 36.5  | 19.5     | 79.89 | 36.0 | 772.8 |        |       | 29.5     | 757.3  |      |       |
| 3.4    | 41.5  | 20.0     | 93.26 | 37.0 | 916.4 |        |       | 30.0     | 821.4  |      |       |
| 3.5    | 47.0  | 20.5     | 108.2 | 38.0 | 1078  |        |       | 30.5     | 889.5  |      |       |
| 3.6    | 52.9  | 21.0     | 124.7 | 39.0 | 1260  |        |       | 31.0     | 961.5  |      |       |
| 3.7    | 59.3  | 21.5     | 143.1 | 40.0 | 1462  |        |       | 31.5     | 1038.0 |      |       |
| 3.8    | 66.1  | 22.0     | 163.2 | 41.0 | 1688  |        |       | 32.0     | 1119.0 |      |       |
| 3.9    | 73.5  | 22.5     | 185.3 | 42.0 | 1939  |        |       | 32.5     | 1204.0 |      |       |
| 4.0    | 81.5  | 23.0     | 209.4 | 43.0 | 2216  | Ref.   | 17,18 |          | 1      |      | 13    |
| 4.1    | 90.0  | 23.5     | 235.7 | 44.0 | 2522  |        |       |          |        |      |       |

| T/K | Ar<br>Argon | BCl <sub>3</sub><br>Boron<br>trichloride | BF <sub>3</sub><br>Boron<br>trifluoride | BrH<br>Hydrogen<br>bromide | Br <sub>2</sub><br>Bromine | ClF<br>Chlorine<br>fluoride | ClH<br>Hydrogen<br>chloride |
|-----|-------------|------------------------------------------|-----------------------------------------|----------------------------|----------------------------|-----------------------------|-----------------------------|
| 50  | 0.1 s       |                                          |                                         |                            |                            |                             |                             |
| 55  | 0.2 s       |                                          |                                         |                            |                            |                             |                             |
| 60  | 0.8 s       |                                          |                                         |                            |                            |                             |                             |
| 65  | 2.8 s       |                                          |                                         |                            |                            |                             |                             |
| 70  | 7.7 s       |                                          |                                         |                            |                            |                             |                             |
| 75  | 18.7 s      |                                          |                                         |                            |                            |                             |                             |
| 80  | 40.7 s      |                                          |                                         |                            |                            |                             |                             |
| 85  | 79.0        |                                          |                                         |                            |                            |                             |                             |
| 90  | 134         |                                          |                                         |                            |                            |                             |                             |
| 95  | 213         |                                          |                                         |                            |                            |                             |                             |
| 100 | 324         |                                          |                                         |                            |                            |                             |                             |
| 105 | 473         |                                          |                                         |                            |                            |                             |                             |
| 110 | 666         |                                          |                                         |                            |                            |                             |                             |
| 115 | 910         |                                          |                                         |                            |                            | 0.1                         |                             |
| 120 | 1214        |                                          |                                         |                            |                            | 0.3                         | 0.1 s                       |
| 125 | 1584        |                                          |                                         |                            |                            | 0.6                         | 0.3 s                       |
| 130 | 2027        |                                          |                                         |                            |                            | 1.2                         | 0.5 s                       |
| 135 | 2553        |                                          |                                         | 0.1 s                      |                            | 2.1                         | 1.0 s                       |
| 140 | 3170        |                                          |                                         | 0.3 s                      |                            | 3.6                         | 1.9 s                       |
| 145 | 3892        |                                          | 7.7                                     | 0.6 s                      |                            | 6.0                         | 3.4 s                       |
| 150 | 4736        |                                          | 13.4                                    | 1.1 s                      |                            | 9.5                         | 5.8 s                       |
| 155 |             |                                          | 22.3                                    | 1.9 s                      |                            | 14.6                        | 9.5 s                       |
| 160 |             |                                          | 35.2                                    | 3.3 s                      |                            | 21.8                        | 14.7                        |
| 165 |             |                                          | 53.7                                    | 5.4 s                      |                            | 31.7                        | 22.0                        |
| 170 |             |                                          | 79.1                                    | 8.7 s                      |                            | 44.8                        | 31.9                        |
| 175 |             |                                          | 113                                     | 13.4 s                     |                            | 62.0                        | 45.1                        |



| T/K  | Ar<br>Argon | BCl <sub>3</sub><br>Boron<br>trichloride | BF <sub>3</sub><br>Boron<br>trifluoride | BrH<br>Hydrogen<br>bromide | Br <sub>2</sub><br>Bromine | ClF<br>Chlorine<br>fluoride | ClH<br>Hydrogen<br>chloride |
|------|-------------|------------------------------------------|-----------------------------------------|----------------------------|----------------------------|-----------------------------|-----------------------------|
| 180  |             | 0.1                                      | 157                                     | 20.1 s                     |                            | 84.2                        | 62.5                        |
| 185  |             | 0.2                                      | 214                                     | 29.5 s                     |                            | 112                         | 84.7                        |
| 190  |             | 0.3                                      | 285                                     | 37.9                       |                            | 147                         | 113                         |
| 195  |             | 0.5                                      | 372                                     | 51.8                       |                            | 190                         | 148                         |
| 200  |             | 0.8                                      | 479                                     | 69.5                       |                            | 242                         | 190                         |
| 205  |             | 1.2                                      | 608                                     | 91.8                       |                            | 304                         | 242                         |
| 210  |             | 1.8                                      | 762                                     | 119                        |                            | 378                         | 304                         |
| 215  |             | 2.6                                      | 944                                     | 153                        |                            | 464                         | 377                         |
| 220  |             | 3.8                                      | 1160                                    | 194                        | 0.1 s                      | 564                         | 463                         |
| 225  |             | 5.2                                      | 1413                                    | 242                        | 0.2 s                      | 680                         | 563                         |
| 230  |             | 7.2                                      | 1709                                    | 299                        | 0.3 s                      | 812                         | 678                         |
| 235  |             | 9.7                                      | 2056                                    | 366                        | 0.4 s                      | 961                         | 811                         |
| 240  |             | 12.9                                     | 2460                                    | 443                        | 0.7 s                      | 1130                        | 961                         |
| 245  |             | 17.0                                     | 2913                                    | 532                        | 1.1 s                      | 1319                        | 1132                        |
| 250  |             | 22.0                                     | 3481                                    | 633                        | 1.7 s                      | 1529                        | 1325                        |
| 255  |             | 28.1                                     | 4123                                    | 748                        | 2.6 s                      | 1762                        | 1542                        |
| 260  |             | 35.6                                     | 4874                                    | 878                        | 3.8 s                      | 2019                        | 1784                        |
| 265  |             | 44.5                                     |                                         | 1023                       | 5.5 s                      | 2301                        | 2054                        |
| 270  |             | 55.1                                     |                                         | 1185                       | 7.3                        | 2608                        | 2354                        |
| 275  |             | 67.6                                     |                                         | 1364                       | 9.5                        | 2941                        | 2686                        |
| 280  |             | 82.2                                     |                                         | 1562                       | 12.3                       | 3303                        | 3053                        |
| 285  |             | 99.1                                     |                                         | 1780                       | 15.6                       | 3693                        | 3457                        |
| 290  |             | 119                                      |                                         | 2018                       | 19.7                       | 4111                        | 3901                        |
| 295  |             | 141                                      |                                         | 2278                       | 24.6                       | 4560                        | 4388                        |
| 300  |             | 166                                      |                                         | 2561                       | 30.5                       | 5039                        | 4921                        |
| Ref. | 8,15        | 12                                       | 12                                      | 12                         | 12                         | 12                          | 12                          |

| T/K | ClO <sub>2</sub><br>Chlorine<br>dioxide | Cl <sub>2</sub><br>Chlorine | Cl <sub>4</sub> Si<br>Silicon<br>tetrachloride | FH<br>Hydrogen<br>fluoride | F <sub>2</sub><br>Fluorine | F <sub>2</sub> O<br>Difluorine<br>oxide | F <sub>3</sub> N<br>Nitrogen<br>trifluoride |
|-----|-----------------------------------------|-----------------------------|------------------------------------------------|----------------------------|----------------------------|-----------------------------------------|---------------------------------------------|
| 50  |                                         |                             |                                                |                            |                            |                                         |                                             |
| 55  |                                         |                             |                                                |                            | 0.4                        |                                         |                                             |
| 60  |                                         |                             |                                                |                            | 1.5                        |                                         |                                             |
| 65  |                                         |                             |                                                |                            | 4.8                        |                                         |                                             |
| 70  |                                         |                             |                                                |                            | 12.3                       |                                         |                                             |
| 75  |                                         |                             |                                                |                            | 27.6                       | 0.1                                     |                                             |
| 80  |                                         |                             |                                                |                            | 55.3                       | 0.2                                     |                                             |
| 85  |                                         |                             |                                                |                            | 101                        | 0.5                                     | 0.1                                         |
| 90  |                                         |                             |                                                |                            | 172                        | 1.2                                     | 0.2                                         |
| 95  |                                         |                             |                                                |                            | 276                        | 2.6                                     | 0.4                                         |
| 100 |                                         |                             |                                                |                            | 420                        | 5.3                                     | 0.9                                         |
| 105 |                                         |                             |                                                |                            | 615                        | 10.1                                    | 2.0                                         |
| 110 |                                         |                             |                                                |                            | 870                        | 18.0                                    | 4.0                                         |
| 115 |                                         |                             |                                                |                            | 1196                       | 30.5                                    | 7.3                                         |
| 120 |                                         |                             |                                                |                            | 1605                       | 49.3                                    | 12.8                                        |
| 125 |                                         |                             |                                                |                            | 2108                       | 76.7                                    | 21.1                                        |
| 130 |                                         |                             |                                                |                            | 2721                       | 115                                     | 33.5                                        |
| 135 |                                         |                             |                                                |                            | 3458                       | 168                                     | 51.1                                        |
| 140 |                                         |                             |                                                |                            | 4339                       | 237                                     | 75.4                                        |
| 145 |                                         |                             |                                                |                            |                            | 328                                     | 108                                         |
| 150 |                                         |                             |                                                |                            |                            | 444                                     | 150                                         |
| 155 |                                         |                             |                                                |                            |                            | 588                                     | 205                                         |
| 160 |                                         |                             |                                                |                            |                            | 766                                     | 273                                         |
| 165 |                                         |                             |                                                |                            |                            | 981                                     | 357                                         |
| 170 |                                         |                             |                                                |                            |                            | 1238                                    | 459                                         |
| 175 |                                         | 1.8                         |                                                |                            |                            | 1541                                    | 581                                         |
| 180 |                                         | 2.8                         |                                                |                            |                            | 1895                                    | 726                                         |
| 185 |                                         | 4.2                         |                                                |                            |                            | 2303                                    | 896                                         |
| 190 |                                         | 6.1                         |                                                | 0.3                        |                            | 2771                                    | 1092                                        |
| 195 | 0.1                                     | 8.7                         |                                                | 0.5                        |                            | 3302                                    | 1319                                        |
| 200 | 0.3                                     | 12.3                        |                                                | 0.8                        |                            | 3899                                    | 1578                                        |
| 205 | 0.5                                     | 16.9                        |                                                | 1.2                        |                            | 4567                                    | 1871                                        |
| 210 | 0.9                                     | 22.9                        | 0.1                                            | 1.7                        |                            | 5308                                    | 2203                                        |

| T/K  | ClO <sub>2</sub><br>Chlorine<br>dioxide | Cl <sub>2</sub><br>Chlorine | Cl <sub>4</sub> Si<br>Silicon<br>tetrachloride | FH<br>Hydrogen<br>fluoride | F <sub>2</sub><br>Fluorine | F <sub>2</sub> O<br>Difluorine<br>oxide | F <sub>3</sub> N<br>Nitrogen<br>trifluoride |
|------|-----------------------------------------|-----------------------------|------------------------------------------------|----------------------------|----------------------------|-----------------------------------------|---------------------------------------------|
| 215  | 1.4                                     | 30.5                        | 0.2                                            | 2.3                        |                            |                                         | 2577                                        |
| 220  | 2.3                                     | 40.1                        | 0.3                                            | 3.2                        |                            |                                         | 2995                                        |
| 225  | 3.5                                     | 51.9                        | 0.5                                            | 4.4                        |                            |                                         | 3464                                        |
| 230  | 5.3                                     | 66.4                        | 0.7                                            | 5.9                        |                            |                                         | 3991                                        |
| 235  | 7.6                                     | 84.0                        | 1.0                                            | 7.9                        |                            |                                         |                                             |
| 240  | 10.8                                    | 105                         | 1.5                                            | 10.3                       |                            |                                         |                                             |
| 245  | 14.9                                    | 130                         | 2.0                                            | 13.4                       |                            |                                         |                                             |
| 250  | 20.1                                    | 160                         | 2.8                                            | 17.2                       |                            |                                         |                                             |
| 255  | 26.6                                    | 194                         | 3.8                                            | 21.8                       |                            |                                         |                                             |
| 260  | 34.6                                    | 234                         | 5.0                                            | 27.4                       |                            |                                         |                                             |
| 265  | 44.4                                    | 280                         | 6.6                                            | 34.2                       |                            |                                         |                                             |
| 270  | 56.1                                    | 332                         | 8.6                                            | 42.2                       |                            |                                         |                                             |
| 275  | 69.9                                    | 392                         | 11.1                                           | 51.8                       |                            |                                         |                                             |
| 280  | 86.2                                    | 459                         | 14.2                                           | 63.1                       |                            |                                         |                                             |
| 285  | 105                                     | 535                         | 17.9                                           | 76.3                       |                            |                                         |                                             |
| 290  | 127                                     | 619                         | 22.3                                           | 91.7                       |                            |                                         |                                             |
| 295  | 151                                     | 714                         | 27.7                                           | 110                        |                            |                                         |                                             |
| 300  | 179                                     | 818                         | 34.0                                           | 130                        |                            |                                         |                                             |
| Ref. | 12                                      | 5                           | 12                                             | 12                         | 12                         | 12                                      | 1                                           |

| T/K  | F <sub>3</sub> P<br>Phosphorus<br>trifluoride | F <sub>4</sub> Si<br>Silicon<br>tetrafluoride | F <sub>6</sub> S<br>Sulfur<br>hexafluoride | HI<br>Hydrogen<br>iodide | H <sub>2</sub> S<br>Hydrogen<br>sulfide | H <sub>3</sub> N<br>Ammonia | H <sub>3</sub> P<br>Phosphine |
|------|-----------------------------------------------|-----------------------------------------------|--------------------------------------------|--------------------------|-----------------------------------------|-----------------------------|-------------------------------|
| 105  | 0.1                                           |                                               |                                            |                          |                                         |                             |                               |
| 110  | 0.2                                           |                                               |                                            |                          |                                         |                             | 0.1                           |
| 115  | 0.5                                           |                                               |                                            |                          |                                         |                             | 0.2                           |
| 120  | 1.0                                           |                                               |                                            |                          |                                         |                             | 0.4                           |
| 125  | 1.9                                           | 0.1 s                                         |                                            |                          |                                         |                             | 0.7                           |
| 130  | 3.5                                           | 0.2 s                                         |                                            |                          |                                         |                             | 1.3                           |
| 135  | 5.9                                           | 0.4 s                                         |                                            |                          | 0.1 s                                   |                             | 2.3                           |
| 140  | 9.5                                           | 0.9 s                                         | 0.1 s                                      |                          | 0.2 s                                   |                             | 3.9                           |
| 145  | 14.9                                          | 1.9 s                                         | 0.2 s                                      |                          | 0.3 s                                   |                             | 6.2                           |
| 150  | 22.5                                          | 3.8 s                                         | 0.4 s                                      |                          | 0.6 s                                   |                             | 9.6                           |
| 155  | 33.1                                          | 7.5 s                                         | 0.8 s                                      | 0.1 s                    | 1.1 s                                   |                             | 14.5                          |
| 160  | 47.3                                          | 14.0 s                                        | 1.5 s                                      | 0.2 s                    | 1.9 s                                   | 0.1 s                       | 21.1                          |
| 165  | 66.0                                          | 25.2 s                                        | 2.6 s                                      | 0.4 s                    | 3.2 s                                   | 0.2 s                       | 30.0                          |
| 170  | 90.1                                          | 43.8 s                                        | 4.4 s                                      | 0.8 s                    | 5.2 s                                   | 0.3 s                       | 41.6                          |
| 175  | 121                                           | 74.2 s                                        | 7.1 s                                      | 1.3 s                    | 8.3 s                                   | 0.6 s                       | 56.6                          |
| 180  | 159                                           | 122 s                                         | 11.3 s                                     | 2.2 s                    | 12.7 s                                  | 1.2 s                       | 75.6                          |
| 185  | 206                                           | 197 s                                         | 17.3 s                                     | 3.4 s                    | 18.9 s                                  | 2.1 s                       | 99.2                          |
| 190  | 262                                           | 280                                           | 25.9 s                                     | 5.3 s                    | 26.6                                    | 3.5 s                       | 128                           |
| 195  | 330                                           | 376                                           | 38.0 s                                     | 8.0 s                    | 36.7                                    | 5.8 s                       | 163                           |
| 200  | 410                                           | 488                                           | 54.4 s                                     | 11.7 s                   | 49.8                                    | 8.7                         | 205                           |
| 205  | 503                                           | 618                                           | 76.6 s                                     | 16.8 s                   | 66.4                                    | 12.6                        | 254                           |
| 210  | 611                                           | 766                                           | 106 s                                      | 23.6 s                   | 87.1                                    | 17.9                        | 312                           |
| 215  | 736                                           | 932                                           | 145 s                                      | 32.5 s                   | 113                                     | 24.9                        | 379                           |
| 220  | 877                                           | 1117                                          | 195 s                                      | 44.0 s                   | 144                                     | 34.1                        | 456                           |
| 225  | 1037                                          | 1324                                          | 249                                        | 56.2                     | 182                                     | 45.9                        | 544                           |
| 230  | 1217                                          | 1555                                          | 305                                        | 71.4                     | 227                                     | 60.8                        | 644                           |
| 235  | 1418                                          | 1816                                          | 371                                        | 89.7                     | 281                                     | 79.6                        | 756                           |
| 240  | 1640                                          | 2111                                          | 448                                        | 112                      | 344                                     | 103                         | 881                           |
| 245  | 1885                                          | 2449                                          | 536                                        | 137                      | 416                                     | 131                         | 1019                          |
| 250  | 2154                                          | 2841                                          | 636                                        | 168                      | 500                                     | 165                         | 1172                          |
| 255  | 2448                                          | 3301                                          | 750                                        | 203                      | 597                                     | 207                         | 1341                          |
| 260  | 2767                                          |                                               | 878                                        | 244                      | 706                                     | 256                         | 1525                          |
| 265  | 3112                                          |                                               | 1021                                       | 290                      | 830                                     | 313                         | 1725                          |
| 270  |                                               |                                               | 1181                                       | 343                      | 969                                     | 381                         | 1942                          |
| 275  |                                               |                                               | 1358                                       | 404                      | 1124                                    | 460                         | 2176                          |
| 280  |                                               |                                               | 1554                                       | 472                      | 1297                                    | 552                         | 2428                          |
| 285  |                                               |                                               | 1768                                       | 548                      | 1488                                    | 655                         | 2699                          |
| 290  |                                               |                                               | 2003                                       | 633                      | 1698                                    | 774                         | 2987                          |
| 295  |                                               |                                               | 2258                                       | 727                      | 1929                                    | 909                         | 3295                          |
| 300  |                                               |                                               | 2534                                       | 831                      | 2181                                    | 1062                        | 3621                          |
| Ref. | 12                                            | 12                                            | 12,15                                      | 12                       | 12,15                                   | 11                          | 12                            |

| <i>T</i> /K | H <sub>4</sub> Si<br>Silane | Kr<br>Krypton | NO<br>Nitric oxide | N <sub>2</sub><br>Nitrogen                      | N <sub>2</sub> O<br>Nitrous oxide                | O <sub>2</sub><br>Oxygen                                        | O <sub>2</sub> S<br>Sulfur dioxide                |
|-------------|-----------------------------|---------------|--------------------|-------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------|
| 50          |                             |               |                    | 0.4 s                                           |                                                  |                                                                 |                                                   |
| 55          |                             |               |                    | 1.8 s                                           |                                                  | 0.2                                                             |                                                   |
| 60          |                             |               |                    | 6.3 s                                           |                                                  | 0.7                                                             |                                                   |
| 65          |                             |               |                    | 17.4                                            |                                                  | 2.3                                                             |                                                   |
| 70          |                             |               |                    | 38.6                                            |                                                  | 6.3                                                             |                                                   |
| 75          |                             | 0.1 s         |                    | 76.1                                            |                                                  | 14.5                                                            |                                                   |
| 80          |                             | 0.4 s         |                    | 137                                             |                                                  | 30.1                                                            |                                                   |
| 85          |                             | 1.1 s         | 0.1 s              | 229                                             |                                                  | 56.8                                                            |                                                   |
| 90          |                             | 2.7 s         | 0.4 s              | 361                                             |                                                  | 99.3                                                            |                                                   |
| 95          | 0.1                         | 6.0 s         | 1.3 s              | 541                                             |                                                  | 163                                                             |                                                   |
| 100         | 0.2                         | 12.1 s        | 3.8 s              | 779                                             |                                                  | 254                                                             |                                                   |
| 105         | 0.4                         | 22.8 s        | 10.0 s             | 1084                                            |                                                  | 379                                                             |                                                   |
| 110         | 1.0                         | 40.4 s        | 23.5               | 1467                                            |                                                  | 543                                                             |                                                   |
| 115         | 1.9                         | 68.0 s        | 46.8               | 1939                                            | 0.1                                              | 756                                                             |                                                   |
| 120         | 3.5                         | 103           | 86.5               | 2513                                            | 0.1                                              | 1022                                                            |                                                   |
| 125         | 6.1                         | 150           | 151                | 3209                                            | 0.3                                              | 1351                                                            |                                                   |
| 130         | 10.0                        | 211           | 248                |                                                 | 0.7                                              | 1749                                                            |                                                   |
| 135         | 15.8                        | 290           | 391                |                                                 | 1.3                                              | 2225                                                            |                                                   |
| 140         | 24.1                        | 388           | 592                |                                                 | 2.5                                              | 2788                                                            |                                                   |
| 145         | 35.3                        | 509           | 867                |                                                 | 4.3                                              | 3448                                                            |                                                   |
| 150         | 50.3                        | 655           | 1231               |                                                 | 7.1                                              | 4219                                                            |                                                   |
| 155         | 69.8                        | 830           | 1703               |                                                 | 11.4                                             |                                                                 |                                                   |
| 160         | 94.6                        | 1037          | 2302               |                                                 | 17.6                                             |                                                                 |                                                   |
| 165         | 126                         | 1278          | 3050               |                                                 | 26.4                                             |                                                                 |                                                   |
| 170         | 164                         | 1557          | 3971               |                                                 | 38.5                                             |                                                                 | 0.1                                               |
| 175         | 210                         | 1877          | 5089               |                                                 | 54.7                                             |                                                                 | 0.2                                               |
| 180         | 265                         | 2241          | 6433               |                                                 | 75.9                                             |                                                                 | 0.3                                               |
| 185         | 331                         | 2655          |                    |                                                 | 103                                              |                                                                 | 0.5                                               |
| 190         | 408                         | 3120          |                    |                                                 | 138                                              |                                                                 | 0.8                                               |
| 195         | 498                         | 3641          |                    |                                                 | 181                                              |                                                                 | 1.3                                               |
| 200         | 602                         | 4223          |                    |                                                 | 234                                              |                                                                 | 2.0                                               |
| 205         | 722                         | 4870          |                    |                                                 | 298                                              |                                                                 | 3.0                                               |
| 210         | 859                         |               |                    |                                                 | 374                                              |                                                                 | 4.4                                               |
| 215         | 1017                        |               |                    |                                                 | 465                                              |                                                                 | 6.3                                               |
| 220         | 1196                        |               |                    |                                                 | 571                                              |                                                                 | 9.0                                               |
| 225         | 1398                        |               |                    |                                                 | 694                                              |                                                                 | 12.6                                              |
| 230         | 1628                        |               |                    |                                                 | 835                                              |                                                                 | 17.3                                              |
| 235         | 1888                        |               |                    |                                                 | 996                                              |                                                                 | 23.3                                              |
| 240         | 2180                        |               |                    |                                                 | 1179                                             |                                                                 | 31.1                                              |
| 245         | 2509                        |               |                    |                                                 | 1385                                             |                                                                 | 40.9                                              |
| 250         | 2880                        |               |                    |                                                 | 1615                                             |                                                                 | 53.2                                              |
| 255         | 3296                        |               |                    |                                                 | 1870                                             |                                                                 | 68.3                                              |
| 260         | 3763                        |               |                    |                                                 | 2152                                             |                                                                 | 86.7                                              |
| 265         | 4288                        |               |                    |                                                 | 2462                                             |                                                                 | 109                                               |
| 270         |                             |               |                    |                                                 | 2802                                             |                                                                 | 136                                               |
| 275         |                             |               |                    |                                                 | 3172                                             |                                                                 | 168                                               |
| 280         |                             |               |                    |                                                 | 3573                                             |                                                                 | 205                                               |
| 285         |                             |               |                    |                                                 | 4006                                             |                                                                 | 249                                               |
| 290         |                             |               |                    |                                                 | 4473                                             |                                                                 | 300                                               |
| 295         |                             |               |                    |                                                 | 4973                                             |                                                                 | 359                                               |
| 300         |                             |               |                    |                                                 | 5508                                             |                                                                 | 426                                               |
| Ref.        | 12                          | 13, 15        | 12, 15             | 1                                               | 12                                               | 3                                                               | 12                                                |
| <i>T</i> /K | O <sub>3</sub><br>Ozone     | Rn<br>Radon   | Xe<br>Xenon        | CBrF <sub>3</sub><br>Bromotri-<br>fluoromethane | CClF <sub>3</sub><br>Chlorotri-<br>fluoromethane | CCl <sub>2</sub> F <sub>2</sub><br>Dichlorodi-<br>fluoromethane | CCl <sub>3</sub> F<br>Trichloro-<br>fluoromethane |
| 100         | 0.1                         |               | 0.1 s              |                                                 |                                                  |                                                                 |                                                   |
| 105         | 0.2                         |               | 0.1 s              |                                                 |                                                  |                                                                 |                                                   |
| 110         | 0.4                         |               | 0.3 s              |                                                 |                                                  |                                                                 |                                                   |
| 115         | 1.0                         |               | 0.7 s              |                                                 | 0.1                                              |                                                                 |                                                   |
| 120         | 2.0                         |               | 1.5 s              |                                                 | 0.2                                              |                                                                 |                                                   |
| 125         | 3.8                         |               | 2.7 s              |                                                 | 0.3                                              |                                                                 |                                                   |
| 130         | 6.8                         | 0.1           | 4.9 s              |                                                 | 0.6                                              |                                                                 |                                                   |

| <i>T</i> /K | O <sub>3</sub><br>Ozone | Rn<br>Radon | Xe<br>Xenon | CBrF <sub>3</sub><br>Bromotri-<br>fluoromethane | CClF <sub>3</sub><br>Chlorotri-<br>fluoromethane | CCl <sub>2</sub> F <sub>2</sub><br>Dichlorodi-<br>fluoromethane | CCl <sub>3</sub> F<br>Trichloro-<br>fluoromethane |
|-------------|-------------------------|-------------|-------------|-------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------|
| 135         | 11.5                    | 0.3         | 8.5 s       | 0.1                                             | 1.1                                              |                                                                 |                                                   |
| 140         | 18.7                    | 0.5         | 14.0 s      | 0.3                                             | 2.0                                              |                                                                 |                                                   |
| 145         | 29.1                    | 0.9         | 22.2 s      | 0.5                                             | 3.3                                              |                                                                 |                                                   |
| 150         | 43.7                    | 1.5         | 34.2 s      | 0.9                                             | 5.3                                              |                                                                 |                                                   |
| 155         | 63.6                    | 2.4         | 51.1 s      | 1.5                                             | 8.3                                              | 0.1                                                             |                                                   |
| 160         | 89.9                    | 3.8         | 74.2 s      | 2.5                                             | 12.6                                             | 0.3                                                             |                                                   |
| 165         | 124                     | 5.8         | 101         | 3.9                                             | 18.6                                             | 0.5                                                             |                                                   |
| 170         | 168                     | 8.6         | 134         | 5.9                                             | 26.8                                             | 0.8                                                             |                                                   |
| 175         | 222                     | 12.5        | 173         | 8.8                                             | 37.6                                             | 1.3                                                             |                                                   |
| 180         | 289                     | 17.7        | 222         | 12.8                                            | 51.7                                             | 2.1                                                             |                                                   |
| 185         | 367                     | 24.5        | 280         | 18.1                                            | 69.7                                             | 3.2                                                             |                                                   |
| 190         | 468                     | 33.2        | 348         | 25.1                                            | 92.3                                             | 4.8                                                             | 0.2                                               |
| 195         | 584                     | 44.4        | 428         | 34.1                                            | 120                                              | 6.9                                                             | 0.3                                               |
| 200         | 721                     | 58.2        | 521         | 45.6                                            | 155                                              | 9.9                                                             | 0.4                                               |
| 205         | 881                     | 75.3        | 628         | 60.0                                            | 196                                              | 13.7                                                            | 0.6                                               |
| 210         | 1068                    | 96          | 750         | 77.8                                            | 246                                              | 18.8                                                            | 1.0                                               |
| 215         | 1285                    | 121         | 889         | 99.5                                            | 304                                              | 25.2                                                            | 1.4                                               |
| 220         | 1536                    | 151         | 1045        | 126                                             | 372                                              | 33.3                                                            | 2.0                                               |
| 225         | 1824                    | 185         | 1220        | 157                                             | 451                                              | 43.3                                                            | 2.9                                               |
| 230         | 2155                    |             | 1416        | 194                                             | 542                                              | 55.5                                                            | 4.1                                               |
| 235         | 2534                    |             | 1633        | 237                                             | 646                                              | 70.4                                                            | 5.6                                               |
| 240         | 2968                    |             | 1872        | 287                                             | 763                                              | 88.1                                                            | 7.6                                               |
| 245         | 3464                    |             | 2136        | 344                                             | 896                                              | 109                                                             | 10.1                                              |
| 250         | 4031                    |             | 2425        | 410                                             | 1044                                             | 134                                                             | 13.3                                              |
| 255         | 4678                    |             | 2742        | 485                                             | 1210                                             | 163                                                             | 17.2                                              |
| 260         | 5417                    |             | 3087        | 570                                             | 1394                                             | 196                                                             | 22.1                                              |
| 265         |                         |             | 3462        | 665                                             | 1598                                             | 234                                                             | 28.0                                              |
| 270         |                         |             | 3869        | 771                                             | 1823                                             | 278                                                             | 35.1                                              |
| 275         |                         |             | 4310        | 889                                             | 2071                                             | 327                                                             | 43.7                                              |
| 280         |                         |             | 4786        | 1021                                            | 2343                                             | 383                                                             | 53.8                                              |
| 285         |                         |             | 5299        | 1166                                            | 2641                                             | 445                                                             | 65.7                                              |
| 290         |                         |             |             | 1325                                            | 2968                                             | 515                                                             | 79.6                                              |
| 295         |                         |             |             | 1501                                            | 3325                                             | 593                                                             | 95.6                                              |
| 300         |                         |             |             | 1692                                            | 3716                                             | 679                                                             | 114.1                                             |
| Ref.        | 12                      | 15          | 12,13       | 12                                              | 12                                               | 12                                                              | 12                                                |

| <i>T</i> /K | CCl <sub>4</sub><br>Tetrachloro-<br>methane | CF <sub>4</sub><br>Tetrafluoro-<br>methane | CO<br>Carbon<br>monoxide | COS<br>Carbon<br>oxysulfide | CO <sub>2</sub><br>Carbon<br>dioxide | CHClF <sub>2</sub><br>Chlorodifluoro-<br>methane | CHCl <sub>3</sub><br>Trichloro-<br>methane |
|-------------|---------------------------------------------|--------------------------------------------|--------------------------|-----------------------------|--------------------------------------|--------------------------------------------------|--------------------------------------------|
| 50          |                                             |                                            | 0.1 s                    |                             |                                      |                                                  |                                            |
| 55          |                                             |                                            | 0.6 s                    |                             |                                      |                                                  |                                            |
| 60          |                                             |                                            | 2.6 s                    |                             |                                      |                                                  |                                            |
| 65          |                                             |                                            | 8.2 s                    |                             |                                      |                                                  |                                            |
| 70          |                                             |                                            | 21.0                     |                             |                                      |                                                  |                                            |
| 75          |                                             |                                            | 44.4                     |                             |                                      |                                                  |                                            |
| 80          |                                             |                                            | 83.7                     |                             |                                      |                                                  |                                            |
| 85          |                                             |                                            | 147                      |                             |                                      |                                                  |                                            |
| 90          |                                             | 0.1                                        | 239                      |                             |                                      |                                                  |                                            |
| 95          |                                             | 0.3                                        | 371                      |                             |                                      |                                                  |                                            |
| 100         |                                             | 0.8                                        | 545                      |                             |                                      |                                                  |                                            |
| 105         |                                             | 1.7                                        | 771                      |                             |                                      |                                                  |                                            |
| 110         |                                             | 3.4                                        | 1067                     |                             |                                      |                                                  |                                            |
| 115         |                                             | 6.5                                        | 1428                     |                             |                                      |                                                  |                                            |
| 120         |                                             | 11.5                                       | 1877                     |                             |                                      |                                                  |                                            |
| 125         |                                             | 19.3                                       | 2400                     |                             |                                      |                                                  |                                            |
| 130         |                                             | 30.8                                       | 3064                     |                             |                                      |                                                  |                                            |
| 135         |                                             | 47.4                                       |                          |                             | 0.1 s                                |                                                  |                                            |
| 140         |                                             | 70.2                                       |                          | 0.1                         | 0.2 s                                |                                                  |                                            |
| 145         |                                             | 101                                        |                          | 0.2                         | 0.4 s                                |                                                  |                                            |
| 150         |                                             | 141                                        |                          | 0.4                         | 0.8 s                                | 0.1                                              |                                            |
| 155         |                                             | 191                                        |                          | 0.8                         | 1.7 s                                | 0.3                                              |                                            |

| <i>T</i> /K | CCl <sub>4</sub><br>Tetrachloro-<br>methane | CF <sub>4</sub><br>Tetrafluoro-<br>methane | CO<br>Carbon<br>monoxide | COS<br>Carbon<br>oxysulfide | CO <sub>2</sub><br>Carbon<br>dioxide | CHClF <sub>2</sub><br>Chlorodifluoro-<br>methane | CHCl <sub>3</sub><br>Trichloro-<br>methane |
|-------------|---------------------------------------------|--------------------------------------------|--------------------------|-----------------------------|--------------------------------------|--------------------------------------------------|--------------------------------------------|
| 160         |                                             | 254                                        |                          | 1.3                         | 3.1 s                                | 0.5                                              |                                            |
| 165         |                                             | 332                                        |                          | 2.2                         | 5.7 s                                | 0.8                                              |                                            |
| 170         |                                             | 425                                        |                          | 3.4                         | 9.9 s                                | 1.4                                              |                                            |
| 175         |                                             | 537                                        |                          | 5.2                         | 16.8 s                               | 2.3                                              |                                            |
| 180         |                                             | 669                                        |                          | 7.8                         | 27.6 s                               | 3.6                                              |                                            |
| 185         |                                             | 824                                        |                          | 11.3                        | 44.0 s                               | 5.5                                              |                                            |
| 190         |                                             | 1005                                       |                          | 15.9                        | 68.4 s                               | 8.1                                              |                                            |
| 195         |                                             | 1216                                       |                          | 22.1                        | 104 s                                | 11.8                                             |                                            |
| 200         |                                             | 1460                                       |                          | 30.0                        | 155 s                                | 16.7                                             |                                            |
| 205         |                                             | 1743                                       |                          | 40.1                        | 227 s                                | 23.1                                             |                                            |
| 210         |                                             | 2073                                       |                          | 52.7                        | 327 s                                | 31.5                                             |                                            |
| 215         |                                             | 2457                                       |                          | 68.2                        | 465 s                                | 42.1                                             | 0.1                                        |
| 220         |                                             | 2907                                       |                          | 87.2                        | 599                                  | 55.3                                             | 0.2                                        |
| 225         |                                             | 3438                                       |                          | 110                         | 734                                  | 71.7                                             | 0.3                                        |
| 230         |                                             |                                            |                          | 137                         | 893                                  | 91.6                                             | 0.4                                        |
| 235         |                                             |                                            |                          | 169                         | 1075                                 | 116                                              | 0.7                                        |
| 240         |                                             |                                            |                          | 207                         | 1283                                 | 144                                              | 1.0                                        |
| 245         |                                             |                                            |                          | 250                         | 1519                                 | 178                                              | 1.4                                        |
| 250         |                                             |                                            |                          | 301                         | 1785                                 | 218                                              | 2.0                                        |
| 255         | 1.5                                         |                                            |                          | 358                         | 2085                                 | 264                                              | 2.7                                        |
| 260         | 2.1                                         |                                            |                          | 423                         | 2419                                 | 317                                              | 3.7                                        |
| 265         | 2.8                                         |                                            |                          | 497                         | 2790                                 | 377                                              | 5.0                                        |
| 270         | 3.7                                         |                                            |                          | 580                         | 3203                                 | 446                                              | 6.6                                        |
| 275         | 4.9                                         |                                            |                          | 673                         | 3658                                 | 525                                              | 8.7                                        |
| 280         | 6.4                                         |                                            |                          | 777                         | 4161                                 | 613                                              | 11.3                                       |
| 285         | 8.2                                         |                                            |                          | 892                         | 4714                                 | 711                                              | 14.4                                       |
| 290         | 10.5                                        |                                            |                          | 1019                        | 5318                                 | 821                                              | 18.3                                       |
| 295         | 13.2                                        |                                            |                          | 1159                        | 5984                                 | 944                                              | 22.9                                       |
| 300         | 16.5                                        |                                            |                          | 1313                        | 6713                                 | 1080                                             | 28.5                                       |
| Ref.        | 12                                          | 12                                         | 9                        | 12                          | 6, 19                                | 12                                               | 12                                         |

| <i>T</i> /K | CHF <sub>3</sub><br>Trifluoro-<br>methane | CHN<br>Hydrogen<br>cyanide | CH <sub>2</sub> Cl <sub>2</sub><br>Dichloro-<br>methane | CH <sub>2</sub> F <sub>2</sub><br>Difluoro-<br>methane | CH <sub>2</sub> O<br>Formaldehyde | CH <sub>3</sub> Cl<br>Chloromethane | CH <sub>3</sub> F<br>Fluoromethane |
|-------------|-------------------------------------------|----------------------------|---------------------------------------------------------|--------------------------------------------------------|-----------------------------------|-------------------------------------|------------------------------------|
| 120         | 0.1                                       |                            |                                                         |                                                        |                                   |                                     |                                    |
| 125         | 0.2                                       |                            |                                                         |                                                        |                                   |                                     |                                    |
| 130         | 0.4                                       |                            |                                                         |                                                        |                                   |                                     |                                    |
| 135         | 0.7                                       |                            |                                                         |                                                        |                                   |                                     | 0.6                                |
| 140         | 1.4                                       |                            |                                                         | 0.1                                                    |                                   |                                     | 1.2                                |
| 145         | 2.5                                       |                            |                                                         | 0.2                                                    |                                   |                                     | 2.1                                |
| 150         | 4.3                                       |                            |                                                         | 0.3                                                    |                                   |                                     | 3.6                                |
| 155         | 7.1                                       |                            |                                                         | 0.6                                                    |                                   |                                     | 5.9                                |
| 160         | 11.1                                      |                            |                                                         | 1.0                                                    |                                   |                                     | 9.3                                |
| 165         | 17.0                                      |                            |                                                         | 1.7                                                    |                                   |                                     | 14.1                               |
| 170         | 25.3                                      |                            |                                                         | 2.8                                                    |                                   |                                     | 20.9                               |
| 175         | 36.5                                      |                            |                                                         | 4.4                                                    |                                   |                                     | 29.9                               |
| 180         | 51.4                                      |                            |                                                         | 6.8                                                    |                                   |                                     | 42.0                               |
| 185         | 70.9                                      |                            |                                                         | 10.2                                                   | 1.3                               | 2.1                                 | 57.6                               |
| 190         | 95.8                                      |                            |                                                         | 14.8                                                   | 2.0                               | 3.1                                 | 77.4                               |
| 195         | 127                                       |                            |                                                         | 21.2                                                   | 3.0                               | 4.6                                 | 102                                |
| 200         | 166                                       | 0.1 s                      | 0.1                                                     | 29.5                                                   | 4.4                               | 6.7                                 | 133                                |
| 205         | 214                                       | 0.2 s                      | 0.2                                                     | 40.5                                                   | 6.4                               | 9.5                                 | 171                                |
| 210         | 271                                       | 0.4 s                      | 0.3                                                     | 54.5                                                   | 9.1                               | 13.1                                | 216                                |
| 215         | 340                                       | 0.6 s                      | 0.4                                                     | 72.1                                                   | 12.7                              | 17.9                                | 270                                |
| 220         | 421                                       | 1 s                        | 0.6                                                     | 94.1                                                   | 17.4                              | 24.0                                | 333                                |
| 225         | 516                                       | 1.5 s                      | 0.9                                                     | 121                                                    | 23.4                              | 31.8                                | 408                                |
| 230         | 626                                       | 2.2 s                      | 1.4                                                     | 154                                                    | 31.0                              | 41.4                                | 495                                |
| 235         | 754                                       | 3.3 s                      | 2.0                                                     | 193                                                    | 40.6                              | 53.3                                | 595                                |
| 240         | 900                                       | 4.7 s                      | 2.8                                                     | 240                                                    | 52.5                              | 67.7                                | 711                                |
| 245         | 1067                                      | 6.8 s                      | 3.8                                                     | 295                                                    | 67.0                              | 85.1                                | 843                                |
| 250         | 1257                                      | 9.7 s                      | 5.3                                                     | 360                                                    | 84.6                              | 106                                 | 993                                |
| 255         | 1472                                      | 13.6 s                     | 7.1                                                     | 434                                                    | 106                               | 131                                 | 1163                               |
| 260         | 1713                                      | 18.8                       | 9.5                                                     | 521                                                    | 131                               | 159                                 | 1355                               |

| <i>T</i> /K | CHF <sub>3</sub><br>Trifluoro-<br>methane | CHN<br>Hydrogen<br>cyanide | CH <sub>2</sub> Cl <sub>2</sub><br>Dichloro-<br>methane | CH <sub>2</sub> F <sub>2</sub><br>Difluoro-<br>methane | CH <sub>2</sub> O<br>Formaldehyde | CH <sub>3</sub> Cl<br>Chloromethane | CH <sub>3</sub> F<br>Fluoromethane |
|-------------|-------------------------------------------|----------------------------|---------------------------------------------------------|--------------------------------------------------------|-----------------------------------|-------------------------------------|------------------------------------|
| 265         | 1984                                      | 24.1                       | 12.4                                                    | 620                                                    | 161                               | 193                                 | 1571                               |
| 270         | 2287                                      | 30.5                       | 16.1                                                    | 732                                                    | 196                               | 232                                 | 1813                               |
| 275         | 2624                                      | 38.3                       | 20.7                                                    | 860                                                    | 236                               | 277                                 | 2084                               |
| 280         | 3000                                      | 47.7                       | 26.3                                                    | 1004                                                   | 283                               | 327                                 | 2387                               |
| 285         | 3418                                      | 58.8                       | 33.0                                                    | 1165                                                   | 337                               | 385                                 | 2724                               |
| 290         | 3881                                      | 72.1                       | 41.1                                                    | 1346                                                   | 399                               | 450                                 | 3099                               |
| 295         | 4393                                      | 87.6                       | 50.8                                                    | 1547                                                   | 470                               | 524                                 | 3516                               |
| 300         |                                           | 105.9                      | 62.1                                                    | 1770                                                   | 549                               | 606                                 | 3978                               |
| Ref.        | 12                                        | 12,16                      | 12                                                      | 12                                                     | 12                                | 12                                  | 12                                 |

| <i>T</i> /K | CH <sub>4</sub><br>Methane | CH <sub>4</sub> O<br>Methanol | C <sub>2</sub> H <sub>2</sub><br>Acetylene | C <sub>2</sub> H <sub>4</sub><br>Ethylene | C <sub>2</sub> H <sub>6</sub><br>Ethane | C <sub>2</sub> H <sub>6</sub> O<br>Dimethyl<br>ether | C <sub>3</sub> H <sub>4</sub><br>Propadiene |
|-------------|----------------------------|-------------------------------|--------------------------------------------|-------------------------------------------|-----------------------------------------|------------------------------------------------------|---------------------------------------------|
| 65          | 0.1                        |                               |                                            |                                           |                                         |                                                      |                                             |
| 70          | 0.3                        |                               |                                            |                                           |                                         |                                                      |                                             |
| 75          | 0.8                        |                               |                                            |                                           |                                         |                                                      |                                             |
| 80          | 2.1                        |                               |                                            |                                           |                                         |                                                      |                                             |
| 85          | 4.9                        |                               |                                            |                                           |                                         |                                                      |                                             |
| 90          | 10.6                       |                               |                                            |                                           |                                         |                                                      |                                             |
| 95          | 20.0                       |                               |                                            |                                           |                                         |                                                      |                                             |
| 100         | 34.5                       |                               |                                            |                                           |                                         |                                                      |                                             |
| 105         | 57.0                       |                               |                                            |                                           |                                         |                                                      |                                             |
| 110         | 88.4                       |                               |                                            | 0.3                                       |                                         |                                                      |                                             |
| 115         | 133                        |                               |                                            | 0.8                                       | 0.1                                     |                                                      |                                             |
| 120         | 192                        |                               |                                            | 1.4                                       | 0.4                                     |                                                      |                                             |
| 125         | 269                        |                               |                                            | 2.7                                       | 0.7                                     |                                                      |                                             |
| 130         | 368                        |                               | 0.1 s                                      | 4.5                                       | 1.3                                     |                                                      |                                             |
| 135         | 491                        |                               | 0.3 s                                      | 7.7                                       | 2.2                                     |                                                      |                                             |
| 140         | 642                        |                               | 0.7 s                                      | 11.9                                      | 3.8                                     |                                                      |                                             |
| 145         | 824                        |                               | 1.3 s                                      | 18.3                                      | 6.0                                     |                                                      |                                             |
| 150         | 1041                       |                               | 2.6 s                                      | 27.5                                      | 9.7                                     |                                                      | 0.1                                         |
| 155         | 1297                       |                               | 4.6 s                                      | 39.9                                      | 15.0                                    | 0.1                                                  | 0.2                                         |
| 160         | 1594                       |                               | 7.8 s                                      | 56.4                                      | 21.5                                    | 0.2                                                  | 0.3                                         |
| 165         | 1937                       |                               | 12.8 s                                     | 77.9                                      | 31.0                                    | 0.3                                                  | 0.6                                         |
| 170         | 2331                       |                               | 20.6 s                                     | 105                                       | 42.9                                    | 0.5                                                  | 1.0                                         |
| 175         | 2779                       |                               | 32.2 s                                     | 140                                       | 59.0                                    | 0.9                                                  | 1.7                                         |
| 180         | 3288                       |                               | 49.0 s                                     | 182                                       | 78.7                                    | 1.4                                                  | 2.7                                         |
| 185         | 3865                       |                               | 72.9 s                                     | 234                                       | 104                                     | 2.1                                                  | 4.1                                         |
| 190         | 4520                       |                               | 106 s                                      | 296                                       | 135                                     | 3.2                                                  | 6.1                                         |
| 195         |                            |                               | 146                                        | 369                                       | 172                                     | 4.7                                                  | 8.9                                         |
| 200         |                            |                               | 190                                        | 456                                       | 217                                     | 6.8                                                  | 12.5                                        |
| 205         |                            |                               | 244                                        | 557                                       | 271                                     | 9.6                                                  | 17.4                                        |
| 210         |                            |                               | 309                                        | 673                                       | 334                                     | 13.3                                                 | 23.7                                        |
| 215         |                            |                               | 385                                        | 806                                       | 407                                     | 18.1                                                 | 31.6                                        |
| 220         |                            |                               | 475                                        | 958                                       | 492                                     | 24.3                                                 | 41.4                                        |
| 225         |                            |                               | 579                                        | 1128                                      | 590                                     | 32.1                                                 | 53.5                                        |
| 230         |                            | 0.1                           | 699                                        | 1321                                      | 700                                     | 41.9                                                 | 68.2                                        |
| 235         |                            | 0.2                           | 837                                        | 1535                                      | 826                                     | 53.9                                                 | 85.8                                        |
| 240         |                            | 0.4                           | 993                                        | 1774                                      | 967                                     | 68.6                                                 | 107                                         |
| 245         |                            | 0.5                           | 1170                                       | 2039                                      | 1125                                    | 86.3                                                 | 131                                         |
| 250         |                            | 0.8                           | 1370                                       | 2331                                      | 1301                                    | 108                                                  | 160                                         |
| 255         |                            | 1.2                           | 1593                                       | 2652                                      | 1496                                    | 133                                                  | 193                                         |
| 260         |                            | 1.7                           | 1843                                       | 3005                                      | 1712                                    | 162                                                  | 230                                         |
| 265         |                            | 2.4                           | 2121                                       | 3391                                      | 1949                                    | 197                                                  | 273                                         |
| 270         |                            | 3.3                           | 2429                                       | 3813                                      | 2210                                    | 237                                                  | 322                                         |
| 275         |                            | 4.5                           | 2771                                       | 4275                                      | 2495                                    | 283                                                  | 376                                         |
| 280         |                            | 6.2                           | 3150                                       |                                           | 2806                                    | 335                                                  | 438                                         |
| 285         |                            | 8.3                           | 3567                                       |                                           | 3146                                    | 395                                                  | 506                                         |
| 290         |                            | 11                            | 4028                                       |                                           | 3515                                    | 463                                                  | 582                                         |
| 295         |                            | 14.4                          | 4535                                       |                                           | 3917                                    | 538                                                  | 666                                         |
| 300         |                            | 18.7                          | 5093                                       |                                           | 4355                                    | 623                                                  | 759                                         |
| Ref.        | 2,16                       | 12                            | 12,16                                      | 4                                         | 2                                       | 12                                                   | 12                                          |

| $T/K$ | $C_3H_6$<br>Propylene | $C_3H_8$<br>Propane | $C_4H_6$<br>Buta-1,3-<br>diene | $C_4H_{10}$<br>Butane | $C_4H_{10}$<br>Isobutane | $C_5H_{12}$<br>Pentane | $C_5H_{12}$<br>Neopentane |
|-------|-----------------------|---------------------|--------------------------------|-----------------------|--------------------------|------------------------|---------------------------|
| 140   | 0.1                   |                     |                                |                       |                          |                        |                           |
| 145   | 0.2                   |                     |                                |                       |                          |                        |                           |
| 150   | 0.4                   |                     |                                |                       |                          |                        |                           |
| 155   | 0.7                   |                     |                                |                       |                          |                        |                           |
| 160   | 1.2                   | 0.8                 |                                |                       | 0.1                      |                        |                           |
| 165   | 2.0                   | 1.4                 |                                |                       | 0.1                      |                        |                           |
| 170   | 3.1                   | 2.2                 | 0.1                            | 0.1                   | 0.3                      |                        |                           |
| 175   | 4.7                   | 3.3                 | 0.2                            | 0.2                   | 0.4                      |                        |                           |
| 180   | 7.0                   | 5.0                 | 0.4                            | 0.3                   | 0.7                      |                        |                           |
| 185   | 10.1                  | 7.3                 | 0.6                            | 0.5                   | 1.1                      |                        | 0.1 s                     |
| 190   | 14.2                  | 10.5                | 1.0                            | 0.8                   | 1.7                      |                        | 0.2 s                     |
| 195   | 19.7                  | 15.0                | 1.5                            | 1.3                   | 2.5                      |                        | 0.4 s                     |
| 200   | 26.9                  | 20.1                | 2.3                            | 1.9                   | 3.7                      |                        | 0.7 s                     |
| 205   | 35.9                  | 27.0                | 3.4                            | 2.8                   | 5.3                      |                        | 1.1 s                     |
| 210   | 47.3                  | 36.0                | 4.8                            | 4.0                   | 7.4                      |                        | 1.6 s                     |
| 215   | 61.3                  | 47.0                | 6.7                            | 5.7                   | 10.2                     |                        | 2.4 s                     |
| 220   | 78.5                  | 60.0                | 9.2                            | 7.8                   | 13.8                     | 1.0                    | 3.6 s                     |
| 225   | 99.2                  | 77.0                | 12.5                           | 10.6                  | 18.3                     | 1.5                    | 5.2 s                     |
| 230   | 124                   | 97.0                | 16.7                           | 14.1                  | 24.0                     | 2.1                    | 7.3 s                     |
| 235   | 153                   | 120                 | 21.9                           | 18.5                  | 31.1                     | 3.0                    | 10.2 s                    |
| 240   | 188                   | 148                 | 28.4                           | 24.1                  | 39.8                     | 4.2                    | 13.9 s                    |
| 245   | 228                   | 180                 | 36.3                           | 30.9                  | 50.3                     | 5.7                    | 18.7 s                    |
| 250   | 274                   | 218                 | 46.0                           | 39.1                  | 62.9                     | 7.6                    | 24.8 s                    |
| 255   | 327                   | 261                 | 57.6                           | 49.1                  | 77.8                     | 10.0                   | 32.4 s                    |
| 260   | 387                   | 311                 | 71.3                           | 61.0                  | 95.4                     | 13.0                   | 41.6                      |
| 265   | 456                   | 367                 | 87.6                           | 75.0                  | 116                      | 16.6                   | 51.4                      |
| 270   | 533                   | 431                 | 107                            | 91.5                  | 140                      | 21.1                   | 63.0                      |
| 275   | 619                   | 502                 | 129                            | 111                   | 167                      | 26.6                   | 76.6                      |
| 280   | 715                   | 582                 | 154                            | 133                   | 198                      | 33.1                   | 92.3                      |
| 285   | 822                   | 671                 | 184                            | 159                   | 234                      | 40.8                   | 111                       |
| 290   | 940                   | 769                 | 217                            | 188                   | 274                      | 50.0                   | 131                       |
| 295   | 1069                  | 878                 | 255                            | 221                   | 319                      | 60.7                   | 155                       |
| 300   | 1212                  | 998                 | 297                            | 258                   | 370                      | 73.2                   | 182                       |
| Ref.  | 7                     | 2                   | 12                             | 2                     | 2                        | 14                     | 12,16                     |

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# IUPAC RECOMMENDED DATA FOR VAPOR PRESSURE CALIBRATION

These precise vapor pressure values are recommended as secondary standards. Values are given in kPa (1 kPa = 0.0098692 atm = 7.5006 Torr). Reprinted by permission of IUPAC.

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| <i>T</i> /K | CO <sub>2</sub> (s) | H <sub>2</sub> O(s) | C <sub>10</sub> H <sub>8</sub> (s) | <i>n</i> -C <sub>5</sub> H <sub>12</sub> | C <sub>6</sub> H <sub>6</sub> | C <sub>6</sub> F <sub>6</sub> | H <sub>2</sub> O | Hg     |
|-------------|---------------------|---------------------|------------------------------------|------------------------------------------|-------------------------------|-------------------------------|------------------|--------|
| 180         | 27.62               |                     | 3.04·10 <sup>-11</sup>             |                                          |                               |                               |                  |        |
| 190         | 68.44               |                     | 4.33·10 <sup>-10</sup>             |                                          |                               |                               |                  |        |
| 200         | 155.11              | 0.0002              | 4.69·10 <sup>-9</sup>              |                                          |                               |                               |                  |        |
| 210         | 327.17              | 0.0007              | 4.02·10 <sup>-8</sup>              |                                          |                               |                               |                  |        |
| 220         |                     | 0.0026              | 2.82·10 <sup>-7</sup>              |                                          |                               |                               |                  |        |
| 230         |                     | 0.0089              | 1.66·10 <sup>-6</sup>              |                                          |                               |                               |                  |        |
| 240         |                     | 0.0273              | 8.37·10 <sup>-6</sup>              |                                          |                               |                               |                  |        |
| 250         |                     | 0.0760              | 3.69·10 <sup>-5</sup>              | 7.60                                     |                               |                               |                  |        |
| 260         |                     | 0.1958              | 1.446·10 <sup>-4</sup>             | 12.98                                    |                               |                               |                  |        |
| 270         |                     | 0.4701              | 5.09·10 <sup>-4</sup>              | 21.15                                    |                               |                               | 0.485            |        |
| 280         |                     |                     | 0.00163                            | 33.11                                    | 5.148                         | 4.322                         | 0.991            |        |
| 290         |                     |                     | 0.004798                           | 50.01                                    | 8.606                         | 7.463                         | 1.919            |        |
| 300         |                     |                     | 0.01308                            | 73.17                                    | 13.816                        | 12.328                        | 3.535            |        |
| 310         |                     |                     | 0.03328                            | 104.07                                   | 21.389                        | 19.576                        | 6.228            |        |
| 320         |                     |                     | 0.07956                            | 144.3                                    | 32.054                        | 30.009                        | 10.540           |        |
| 330         |                     |                     | 0.1797                             | 195.7                                    | 46.656                        | 44.578                        | 17.202           |        |
| 340         |                     |                     | 0.3854                             | 260.1                                    | 66.152                        | 64.380                        | 27.167           |        |
| 350         |                     |                     | 0.7884                             | 339.4                                    | 91.609                        | 90.664                        | 41.647           |        |
| 360         |                     |                     |                                    | 435.9                                    | 124.192                       | 124.816                       | 62.139           |        |
| 370         |                     |                     |                                    | 551.5                                    | 165.2                         | 168.4                         | 90.453           |        |
| 380         |                     |                     |                                    | 688.8                                    | 215.9                         | 223.0                         | 128.74           |        |
| 390         |                     |                     |                                    | 850.2                                    | 277.7                         | 290.4                         | 179.48           |        |
| 400         |                     |                     |                                    | 1038                                     | 353.2                         | 372.6                         | 245.54           | 0.138  |
| 410         |                     |                     |                                    | 1256                                     | 441.0                         | 471.5                         | 330.15           | 0.215  |
| 420         |                     |                     |                                    | 1507                                     | 545.5                         | 589.3                         | 436.89           | 0.329  |
| 430         |                     |                     |                                    | 1793                                     | 667.6                         | 728.3                         | 569.73           | 0.493  |
| 440         |                     |                     |                                    | 2120                                     | 808.8                         | 890.9                         | 732.99           | 0.724  |
| 450         |                     |                     |                                    | 2490                                     | 971.1                         | 1080                          | 931.36           | 1.045  |
| 460         |                     |                     |                                    | 2910                                     | 1156                          | 1297                          | 1169.9           | 1.485  |
| 470         |                     |                     |                                    |                                          | 1366                          | 1547                          | 1453.9           | 2.078  |
| 480         |                     |                     |                                    |                                          | 1602                          | 1833                          | 1789.0           | 2.866  |
| 490         |                     |                     |                                    |                                          | 1868                          | 2159                          | 2181.4           | 3.899  |
| 500         |                     |                     |                                    |                                          | 2164                          | 2530                          | 2637.3           | 5.239  |
| 510         |                     |                     |                                    |                                          | 2494                          | 2954                          | 3163.3           | 6.955  |
| 520         |                     |                     |                                    |                                          | 2861                          |                               | 3766.4           | 9.131  |
| 530         |                     |                     |                                    |                                          | 3267                          |                               | 4453.9           | 11.861 |
| 540         |                     |                     |                                    |                                          | 3717                          |                               | 5233.5           | 15.256 |
| 550         |                     |                     |                                    |                                          | 4216                          |                               | 6113.4           | 19.438 |
| 560         |                     |                     |                                    |                                          | 4770                          |                               | 7102.0           | 25.547 |
| 570         |                     |                     |                                    |                                          |                               |                               | 8208.6           | 30.74  |
| 580         |                     |                     |                                    |                                          |                               |                               | 9443.0           | 38.19  |
| 590         |                     |                     |                                    |                                          |                               |                               | 10816            | 47.09  |
| 600         |                     |                     |                                    |                                          |                               |                               | 12339            | 57.64  |



## ENTHALPY OF VAPORIZATION

The molar enthalpy (heat) of vaporization  $\Delta_{\text{vap}}H$ , which is defined as the enthalpy change in the conversion of one mole of liquid to gas at constant temperature, is tabulated here for about 950 inorganic and organic compounds. Values are given, when available, both at the normal boiling point  $t_b$ , referred to a pressure of 101.325 kPa (760 mmHg), and at 25°C.

The values in this table were measured either by calorimetric techniques or by application of the Claperyon equation to the variation of vapor pressure with temperature. See Reference 1 for a discussion of the accuracy of different experimental techniques and methods of estimating enthalpy of vaporization at other temperatures. Several of the references present empirical techniques for correlating enthalpy of vaporization with molecular structure.

Compounds are listed by systematic name, with compounds not containing carbon preceding those that do contain carbon. To locate a compound by molecular formula or CAS Registry Number, use the indexes to the table "Physical Constants of Organic Compounds" in Section 3, which point to the entry in that table from which the name can be determined.

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| Name                                   | Mol. Form.                       | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|----------------------------------------|----------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| <i>Compounds not containing carbon</i> |                                  |             |                                       |                                                    |
| Aluminum                               | Al                               | 2519        | 294                                   |                                                    |
| Aluminum borohydride                   | AlB <sub>3</sub> H <sub>12</sub> | 44.5        | 30                                    |                                                    |
| Aluminum bromide                       | AlBr <sub>3</sub>                | 255         | 23.5                                  |                                                    |
| Aluminum iodide                        | AlI <sub>3</sub>                 | 382         | 32.2                                  |                                                    |
| Ammonia                                | H <sub>3</sub> N                 | –33.33      | 23.33                                 | 19.86                                              |
| Antimony(III) bromide                  | Br <sub>3</sub> Sb               | 288         | 59                                    |                                                    |
| Antimony(III) chloride                 | Cl <sub>3</sub> Sb               | 220.3       | 45.19                                 |                                                    |
| Antimony(III) iodide                   | I <sub>3</sub> Sb                | 400         | 68.6                                  |                                                    |
| Argon                                  | Ar                               | –185.85     | 6.43                                  |                                                    |
| Arsenic(III) bromide                   | AsBr <sub>3</sub>                | 221         | 41.8                                  |                                                    |
| Arsenic(III) chloride                  | AsCl <sub>3</sub>                | 130         | 35.01                                 |                                                    |
| Arsenic(III) fluoride                  | AsF <sub>3</sub>                 | 57.13       | 29.7                                  |                                                    |
| Arsenic(V) fluoride                    | AsF <sub>5</sub>                 | –52.8       | 20.8                                  |                                                    |
| Arsenic(III) iodide                    | AsI <sub>3</sub>                 | 424         | 59.3                                  |                                                    |
| Arsine                                 | AsH <sub>3</sub>                 | –62.5       | 16.69                                 |                                                    |
| Barium                                 | Ba                               | 1897        | 140                                   |                                                    |
| Beryllium chloride                     | BeCl <sub>2</sub>                | 482         | 105                                   |                                                    |
| Beryllium iodide                       | BeI <sub>2</sub>                 | 590         | 70.5                                  |                                                    |
| Bismuth                                | Bi                               | 1564        | 151                                   |                                                    |
| Bismuth tribromide                     | BiBr <sub>3</sub>                | 462         | 75.4                                  |                                                    |
| Bismuth trichloride                    | BiCl <sub>3</sub>                | 441         | 72.61                                 |                                                    |
| Boron                                  | B                                | 4000        | 480                                   |                                                    |
| Boron tribromide                       | BBr <sub>3</sub>                 | 91.3        | 30.5                                  |                                                    |
| Boron trichloride                      | BCl <sub>3</sub>                 | 12.5        | 23.77                                 | 23.1                                               |
| Boron trifluoride                      | BF <sub>3</sub>                  | –99.9       | 19.33                                 |                                                    |
| Boron triiodide                        | BI <sub>3</sub>                  | 209.5       | 40.5                                  |                                                    |

| Name                            | Mol. Form.                        | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|---------------------------------|-----------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Bromine                         | Br <sub>2</sub>                   | 58.8        | 29.96                                 | 30.91                                              |
| Bromine fluoride                | BrF                               | 20          | 25.1                                  |                                                    |
| Bromine pentafluoride           | BrF <sub>5</sub>                  | 41.3        | 30.6                                  |                                                    |
| Bromine trifluoride             | BrF <sub>3</sub>                  | 125.8       | 47.57                                 |                                                    |
| Bromosilane                     | BrH <sub>3</sub> Si               | 1.9         | 24.4                                  |                                                    |
| Cadmium                         | Cd                                | 767         | 99.87                                 |                                                    |
| Cadmium bromide                 | Br <sub>2</sub> Cd                | 863         | 115                                   |                                                    |
| Cadmium chloride                | CdCl <sub>2</sub>                 | 964         | 124.3                                 |                                                    |
| Cadmium fluoride                | CdF <sub>2</sub>                  | 1750        | 214                                   |                                                    |
| Cadmium iodide                  | CdI <sub>2</sub>                  | 744         | 115                                   |                                                    |
| Chlorine                        | Cl <sub>2</sub>                   | -34.04      | 20.41                                 | 17.65                                              |
| Chlorine dioxide                | ClO <sub>2</sub>                  | 11          | 30                                    |                                                    |
| Chlorine fluoride               | ClF                               | -101.1      | 24                                    |                                                    |
| Chlorine monoxide               | Cl <sub>2</sub> O                 | 2.2         | 25.9                                  |                                                    |
| Chlorine trifluoride            | ClF <sub>3</sub>                  | 11.75       | 27.53                                 |                                                    |
| Chlorosilane                    | ClH <sub>3</sub> Si               | -30.4       | 21                                    |                                                    |
| Chlorotrifluorosilane           | ClF <sub>3</sub> Si               | -70.0       | 18.7                                  |                                                    |
| Chromium(II) chloride           | Cl <sub>2</sub> Cr                | 1120        | 197                                   |                                                    |
| Chromium(VI) dichloride dioxide | Cl <sub>2</sub> CrO <sub>2</sub>  | 117         | 35.1                                  |                                                    |
| Diborane                        | B <sub>2</sub> H <sub>6</sub>     | -92.49      | 14.28                                 |                                                    |
| Dibromosilane                   | Br <sub>2</sub> H <sub>2</sub> Si | 66          | 31                                    |                                                    |
| Dichlorodifluorosilane          | Cl <sub>2</sub> F <sub>2</sub> Si | -32         | 21.2                                  |                                                    |
| Dichlorosilane                  | Cl <sub>2</sub> H <sub>2</sub> Si | 8.3         | 25                                    | 24.2                                               |
| Difluorine dioxide              | F <sub>2</sub> O <sub>2</sub>     | -57         | 19.1                                  |                                                    |
| Difluorosilane                  | F <sub>2</sub> H <sub>2</sub> Si  | -77.8       | 16.3                                  |                                                    |
| Digermane                       | Ge <sub>2</sub> H <sub>6</sub>    | 29          | 25.1                                  |                                                    |
| Diphosphine                     | H <sub>4</sub> P <sub>2</sub>     | 63.5        | 28.8                                  |                                                    |
| Disilane                        | H <sub>6</sub> Si <sub>2</sub>    | -14.8       | 21.2                                  |                                                    |
| Fluorine                        | F <sub>2</sub>                    | -188.12     | 6.62                                  |                                                    |
| Fluorine monoxide               | F <sub>2</sub> O                  | -144.3      | 11.09                                 |                                                    |
| Fluorosilane                    | FH <sub>3</sub> Si                | -98.6       | 18.8                                  |                                                    |
| Gallium                         | Ga                                | 2204        | 254                                   |                                                    |
| Gallium(III) bromide            | Br <sub>3</sub> Ga                | 279         | 38.9                                  |                                                    |
| Gallium(III) chloride           | Cl <sub>3</sub> Ga                | 201         | 23.9                                  |                                                    |
| Gallium(III) iodide             | GaI <sub>3</sub>                  | 340         | 56.5                                  |                                                    |
| Germane                         | GeH <sub>4</sub>                  | -88.1       | 14.06                                 |                                                    |
| Germanium                       | Ge                                | 2833        | 334                                   |                                                    |
| Germanium(IV) bromide           | Br <sub>4</sub> Ge                | 186.35      | 41.4                                  |                                                    |
| Germanium(IV) chloride          | Cl <sub>4</sub> Ge                | 86.55       | 27.9                                  |                                                    |
| Gold                            | Au                                | 2856        | 324                                   |                                                    |
| Helium                          | He                                | -268.93     | 0.08                                  |                                                    |
| Hydrazine                       | H <sub>4</sub> N <sub>2</sub>     | 113.55      | 41.8                                  | 44.7                                               |
| Hydrazoic acid                  | HN <sub>3</sub>                   | 35.7        | 30.5                                  |                                                    |
| Hydrogen                        | H <sub>2</sub>                    | -252.76     | 0.90                                  |                                                    |
| Hydrogen bromide                | BrH                               | -66.38      |                                       | 12.69                                              |
| Hydrogen chloride               | ClH                               | -85         | 16.15                                 | 9.08                                               |
| Hydrogen disulfide              | H <sub>2</sub> S <sub>2</sub>     | 70.7        |                                       | 33.78                                              |
| Hydrogen iodide                 | HI                                | -35.55      | 19.76                                 | 17.36                                              |
| Hydrogen peroxide               | H <sub>2</sub> O <sub>2</sub>     | 150.2       |                                       | 51.6                                               |
| Hydrogen selenide               | H <sub>2</sub> Se                 | -41.25      | 19.7                                  |                                                    |
| Hydrogen sulfide                | H <sub>2</sub> S                  | -59.55      | 18.67                                 | 14.08                                              |
| Hydrogen telluride              | H <sub>2</sub> Te                 | -2          | 19.2                                  |                                                    |
| Indium(I) bromide               | BrIn                              | 656         | 92                                    |                                                    |
| Indium(I) iodide                | IIn                               | 712         | 90.8                                  |                                                    |
| Iodine                          | I <sub>2</sub>                    | 184.4       | 41.57                                 |                                                    |

| Name                                | Mol. Form.                       | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|-------------------------------------|----------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Iodine pentafluoride                | F <sub>5</sub> I                 | 100.5       | 41.3                                  |                                                    |
| Iridium(VI) fluoride                | F <sub>6</sub> Ir                | 53.6        | 30.9                                  |                                                    |
| Krypton                             | Kr                               | -153.34     | 9.08                                  |                                                    |
| Lead                                | Pb                               | 1749        | 179.5                                 |                                                    |
| Lead(II) bromide                    | Br <sub>2</sub> Pb               | 892         | 133                                   |                                                    |
| Lead(II) chloride                   | Cl <sub>2</sub> Pb               | 951         | 127                                   |                                                    |
| Lead(II) fluoride                   | F <sub>2</sub> Pb                | 1293        | 160.4                                 |                                                    |
| Lead(II) iodide                     | I <sub>2</sub> Pb                | 872         | 104                                   |                                                    |
| Lithium fluoride                    | FLi                              | 1673        | 147                                   |                                                    |
| Lithium hydroxide                   | HLiO                             | 1626        | 188                                   |                                                    |
| Mercury                             | Hg                               | 356.62      | 59.11                                 |                                                    |
| Mercury(II) bromide                 | Br <sub>2</sub> Hg               | 318         | 58.89                                 |                                                    |
| Mercury(II) chloride                | Cl <sub>2</sub> Hg               | 304         | 58.9                                  |                                                    |
| Mercury(II) iodide                  | HgI <sub>2</sub>                 | 351         | 59.2                                  |                                                    |
| Molybdenum(V) chloride              | Cl <sub>5</sub> Mo               | 268         | 62.8                                  |                                                    |
| Molybdenum(V) fluoride              | F <sub>5</sub> Mo                | 213.6       | 51.8                                  |                                                    |
| Molybdenum(VI) fluoride             | F <sub>6</sub> Mo                | 34.0        | 29.0                                  |                                                    |
| Molybdenum(VI) oxide                | MoO <sub>3</sub>                 | 1155        | 138                                   |                                                    |
| Molybdenum(VI) oxytetrafluoride     | F <sub>4</sub> MoO               | 186.0       | 50.6                                  |                                                    |
| Neon                                | Ne                               | -246.05     | 1.71                                  |                                                    |
| Niobium(V) chloride                 | Cl <sub>5</sub> Nb               | 247.4       | 52.7                                  |                                                    |
| Niobium(V) fluoride                 | F <sub>5</sub> Nb                | 234         | 52.3                                  |                                                    |
| Nitric acid                         | HNO <sub>3</sub>                 | 83          |                                       | 39.1                                               |
| Nitric oxide                        | NO                               | -151.74     | 13.83                                 |                                                    |
| Nitrogen                            | N <sub>2</sub>                   | -195.79     | 5.57                                  |                                                    |
| Nitrogen tetroxide                  | N <sub>2</sub> O <sub>4</sub>    | 21.15       | 38.12                                 |                                                    |
| Nitrogen trifluoride                | F <sub>3</sub> N                 | -128.75     | 11.56                                 |                                                    |
| Nitrosyl chloride                   | ClNO                             | -5.5        | 25.78                                 |                                                    |
| Nitrosyl fluoride                   | FNO                              | -59.9       | 19.28                                 |                                                    |
| Nitrous oxide                       | N <sub>2</sub> O                 | -88.48      | 16.53                                 |                                                    |
| Nitryl chloride                     | ClNO <sub>2</sub>                | -15         | 25.7                                  |                                                    |
| Nitryl fluoride                     | FNO <sub>2</sub>                 | -72.4       | 18.05                                 |                                                    |
| Osmium(V) fluoride                  | F <sub>5</sub> Os                | 233         | 65.6                                  |                                                    |
| Osmium(VI) fluoride                 | F <sub>6</sub> Os                | 47.5        | 28.1                                  |                                                    |
| Oxygen                              | O <sub>2</sub>                   | -182.95     | 6.82                                  |                                                    |
| Pentaborane(11)                     | B <sub>5</sub> H <sub>11</sub>   | 65          | 31.8                                  |                                                    |
| Perchloryl fluoride                 | ClFO <sub>3</sub>                | -46.75      | 19.33                                 |                                                    |
| Phosphine                           | H <sub>3</sub> P                 | -87.75      | 14.6                                  |                                                    |
| Phosphorothioc trifluoride          | F <sub>3</sub> PS                | -52.25      | 19.6                                  |                                                    |
| Phosphorus                          | P                                | 280.5       | 12.4                                  | 14.2                                               |
| Phosphorus(III) bromide             | Br <sub>3</sub> P                | 173.2       | 38.8                                  |                                                    |
| Phosphorus(III) chloride            | Cl <sub>3</sub> P                | 76          | 30.5                                  | 32.1                                               |
| Phosphorus(III) chloride difluoride | ClF <sub>2</sub> P               | -47.3       | 17.6                                  |                                                    |
| Phosphorus(III) dichloride fluoride | Cl <sub>2</sub> FP               | 13.85       | 24.9                                  |                                                    |
| Phosphorus(III) fluoride            | F <sub>3</sub> P                 | -101.8      | 16.5                                  |                                                    |
| Phosphorus(V) fluoride              | F <sub>5</sub> P                 | -84.6       | 17.2                                  |                                                    |
| Phosphorus(III) iodide              | I <sub>3</sub> P                 | 227         | 43.9                                  |                                                    |
| Phosphoryl bromide                  | Br <sub>3</sub> OP               | 191.7       | 38                                    |                                                    |
| Phosphoryl chloride                 | Cl <sub>3</sub> OP               | 105.5       | 34.35                                 | 38.6                                               |
| Rhenium(VII) dioxytrifluoride       | F <sub>3</sub> O <sub>2</sub> Re | 185.4       | 65.7                                  |                                                    |
| Rhenium(V) fluoride                 | F <sub>5</sub> Re                | 221.3       | 58.1                                  |                                                    |
| Rhenium(VI) fluoride                | F <sub>6</sub> Re                | 33.8        | 28.7                                  |                                                    |
| Rhenium(VI) oxytetrafluoride        | F <sub>4</sub> ORe               | 171.7       | 61.0                                  |                                                    |
| Selenium                            | Se                               | 685         | 95.48                                 |                                                    |
| Selenium tetrafluoride              | F <sub>4</sub> Se                | 101.6       | 47.2                                  |                                                    |

| Name                          | Mol. Form.                       | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|-------------------------------|----------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Silane                        | H <sub>4</sub> Si                | −111.9      | 12.1                                  |                                                    |
| Silver(I) bromide             | AgBr                             | 1502        | 198                                   |                                                    |
| Silver(I) chloride            | AgCl                             | 1547        | 199                                   |                                                    |
| Silver(I) iodide              | AgI                              | 1506        | 143.9                                 |                                                    |
| Sodium hydroxide              | HNaO                             | 1388        | 175                                   |                                                    |
| Stannane                      | H <sub>4</sub> Sn                | −51.8       | 19.05                                 |                                                    |
| Stibine                       | H <sub>3</sub> Sb                | −17         | 21.3                                  |                                                    |
| Sulfur                        | S                                | 444.61      | 45                                    |                                                    |
| Sulfur dioxide                | O <sub>2</sub> S                 | −10.05      | 24.94                                 | 22.92                                              |
| Sulfur hexafluoride           | F <sub>6</sub> S                 |             |                                       | 8.99                                               |
| Sulfur tetrafluoride          | F <sub>4</sub> S                 | −40.45      | 26.44                                 |                                                    |
| Sulfur trioxide               | O <sub>3</sub> S                 | 44.5        | 40.69                                 | 43.14                                              |
| Sulfuryl chloride             | Cl <sub>2</sub> O <sub>2</sub> S | 69.4        | 31.4                                  | 30.1                                               |
| Tantalum(V) bromide           | Br <sub>5</sub> Ta               | 348.8       | 62.3                                  |                                                    |
| Tantalum(V) chloride          | Cl <sub>5</sub> Ta               | 239         | 54.8                                  |                                                    |
| Tantalum(V) fluoride          | F <sub>5</sub> Ta                | 229.5       | 56.9                                  |                                                    |
| Tellurium                     | Te                               | 988         | 114.1                                 |                                                    |
| Tellurium tetrachloride       | Cl <sub>4</sub> Te               | 387         | 77                                    |                                                    |
| Tetraborane(10)               | B <sub>4</sub> H <sub>10</sub>   | 18          | 27.1                                  |                                                    |
| Tetrabromosilane              | Br <sub>4</sub> Si               | 154         | 37.9                                  |                                                    |
| Tetrachlorosilane             | Cl <sub>4</sub> Si               | 57.65       | 28.7                                  | 29.7                                               |
| Tetrafluorodiborane           | B <sub>2</sub> F <sub>4</sub>    | −34.0       | 28                                    |                                                    |
| Tetrafluorohydrazine          | F <sub>4</sub> N <sub>2</sub>    | −74         | 13.27                                 |                                                    |
| Tetraiodosilane               | I <sub>4</sub> Si                | 287.35      | 50.2                                  |                                                    |
| Thallium(I) bromide           | BrTl                             | 819         | 99.56                                 |                                                    |
| Thallium(I) chloride          | ClTl                             | 720         | 102.2                                 |                                                    |
| Thallium(I) iodide            | ITl                              | 824         | 104.7                                 |                                                    |
| Thallium(I) sulfide           | STl <sub>2</sub>                 | 1367        | 154                                   |                                                    |
| Thionitrosyl fluoride (NSF)   | FNS                              | 4.8         | 22.2                                  |                                                    |
| Thionyl chloride              | Cl <sub>2</sub> OS               | 75.6        | 31.7                                  | 31                                                 |
| Thionyl fluoride              | F <sub>2</sub> OS                | −43.8       | 21.8                                  |                                                    |
| Thorium(IV) chloride          | Cl <sub>4</sub> Th               | 921         | 146.4                                 |                                                    |
| Thorium(IV) fluoride          | F <sub>4</sub> Th                | 1680        | 258                                   |                                                    |
| Tin(II) bromide               | Br <sub>2</sub> Sn               | 639         | 102                                   |                                                    |
| Tin(IV) bromide               | Br <sub>4</sub> Sn               | 205         | 43.5                                  |                                                    |
| Tin(II) chloride              | Cl <sub>2</sub> Sn               | 623         | 86.8                                  |                                                    |
| Tin(IV) chloride              | Cl <sub>4</sub> Sn               | 114.15      | 34.9                                  |                                                    |
| Tin(II) iodide                | I <sub>2</sub> Sn                | 714         | 105                                   |                                                    |
| Tin(IV) iodide                | I <sub>4</sub> Sn                | 364.35      | 56.9                                  |                                                    |
| Titanium(IV) bromide          | Br <sub>4</sub> Ti               | 233.5       | 44.37                                 |                                                    |
| Titanium(II) chloride         | Cl <sub>2</sub> Ti               | 1500        | 232                                   |                                                    |
| Titanium(III) chloride        | Cl <sub>3</sub> Ti               | 960         | 124                                   |                                                    |
| Titanium(IV) chloride         | Cl <sub>4</sub> Ti               | 136.45      | 36.2                                  |                                                    |
| Titanium(IV) iodide           | I <sub>4</sub> Ti                | 377         | 58.4                                  |                                                    |
| Tribromosilane                | Br <sub>3</sub> HSi              | 109         | 34.8                                  |                                                    |
| Trichlorosilane               | Cl <sub>3</sub> HSi              | 33          |                                       | 25.7                                               |
| Trifluorosilane               | F <sub>3</sub> HSi               | −95         | 16.2                                  |                                                    |
| Trigermane                    | Ge <sub>3</sub> H <sub>8</sub>   | 110.5       | 32.2                                  |                                                    |
| Trisilane                     | H <sub>8</sub> Si <sub>3</sub>   | 52.9        | 28.5                                  |                                                    |
| Tungsten(VI) chloride         | Cl <sub>6</sub> W                | 337         | 52.7                                  |                                                    |
| Tungsten(VI) fluoride         | F <sub>6</sub> W                 | 17.1        | 26.5                                  |                                                    |
| Tungsten(VI) oxytetrachloride | Cl <sub>4</sub> OW               | 230         | 67.8                                  |                                                    |
| Tungsten(VI) oxytetrafluoride | F <sub>4</sub> OW                | 185.9       | 59.5                                  |                                                    |
| Vanadium(IV) chloride         | Cl <sub>4</sub> V                | 151         | 41.4                                  | 42.5                                               |
| Vanadium(V) fluoride          | F <sub>5</sub> V                 | 48.3        | 44.52                                 |                                                    |

| Name                                   | Mol. Form.                                      | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|----------------------------------------|-------------------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Vanadyl trichloride                    | Cl <sub>3</sub> OV                              | 127         | 36.78                                 |                                                    |
| Water                                  | H <sub>2</sub> O                                | 99.97       | 40.65                                 | 43.98                                              |
| Xenon                                  | Xe                                              | -108.09     | 12.57                                 |                                                    |
| Zinc bromide                           | Br <sub>2</sub> Zn                              | 670         | 118                                   |                                                    |
| Zinc chloride                          | Cl <sub>2</sub> Zn                              | 732         | 126                                   |                                                    |
| Zinc fluoride                          | F <sub>2</sub> Zn                               | 1500        | 190.1                                 |                                                    |
| <i>Compounds containing carbon</i>     |                                                 |             |                                       |                                                    |
| Acetaldehyde                           | C <sub>2</sub> H <sub>4</sub> O                 | 20.1        | 25.76                                 | 25.47                                              |
| Acetic acid                            | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>    | 117.9       | 23.70                                 | 23.36                                              |
| Acetic anhydride                       | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>    | 139.5       | 38.2                                  |                                                    |
| Acetone                                | C <sub>3</sub> H <sub>6</sub> O                 | 56.05       | 29.10                                 | 30.99                                              |
| Acetonitrile                           | C <sub>2</sub> H <sub>3</sub> N                 | 81.65       | 29.75                                 | 32.94                                              |
| Acetophenone                           | C <sub>8</sub> H <sub>8</sub> O                 | 202         | 43.98                                 | 55.40                                              |
| Acrolein                               | C <sub>3</sub> H <sub>4</sub> O                 | 52.6        | 28.3                                  |                                                    |
| Acrylonitrile                          | C <sub>3</sub> H <sub>3</sub> N                 | 77.3        | 32.6                                  |                                                    |
| Allyl acetate                          | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>    | 103.5       | 36.3                                  |                                                    |
| Allyl alcohol                          | C <sub>3</sub> H <sub>6</sub> O                 | 97.4        | 40.0                                  |                                                    |
| 2-Amino-2-methyl-1-propanol            | C <sub>4</sub> H <sub>11</sub> NO               | 165.5       | 50.6                                  |                                                    |
| Aniline                                | C <sub>6</sub> H <sub>7</sub> N                 | 184.17      | 42.44                                 | 55.83                                              |
| Anisole                                | C <sub>7</sub> H <sub>8</sub> O                 | 153.7       | 38.97                                 | 46.90                                              |
| Azobutane                              | C <sub>8</sub> H <sub>18</sub> N <sub>2</sub>   |             |                                       | 49.31                                              |
| Azopropane                             | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>   | 114         |                                       | 39.88                                              |
| Benzaldehyde                           | C <sub>7</sub> H <sub>6</sub> O                 | 178.8       | 42.5                                  |                                                    |
| Benzene                                | C <sub>6</sub> H <sub>6</sub>                   | 80.09       | 30.72                                 | 33.83                                              |
| Benzenethiol                           | C <sub>6</sub> H <sub>6</sub> S                 | 169.1       | 39.93                                 | 47.56                                              |
| Benzonitrile                           | C <sub>7</sub> H <sub>5</sub> N                 | 191.1       | 45.9                                  |                                                    |
| Benzyl acetate                         | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>   | 213         | 49.4                                  |                                                    |
| Benzyl alcohol                         | C <sub>7</sub> H <sub>8</sub> O                 | 205.31      | 50.48                                 |                                                    |
| Benzylamine                            | C <sub>7</sub> H <sub>9</sub> N                 | 185         |                                       | 60.16                                              |
| N-Benzylaniline                        | C <sub>13</sub> H <sub>13</sub> N               | 306.5       |                                       | 79.6                                               |
| Benzyl benzoate                        | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>  | 323.5       | 53.6                                  |                                                    |
| Bis(2-chloroethyl) ether               | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O | 178.5       | 45.2                                  |                                                    |
| Bis(ethoxymethyl) ether                | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>   | 140.6       | 36.17                                 | 44.69                                              |
| Bromobenzene                           | C <sub>6</sub> H <sub>5</sub> Br                | 156.06      |                                       | 44.54                                              |
| 1-Bromobutane                          | C <sub>4</sub> H <sub>9</sub> Br                | 101.6       | 32.51                                 | 36.64                                              |
| 2-Bromobutane                          | C <sub>4</sub> H <sub>9</sub> Br                | 91.3        | 30.77                                 | 34.41                                              |
| Bromochloromethane                     | CH <sub>2</sub> BrCl                            | 68.0        | 30.0                                  |                                                    |
| 2-Bromo-2-chloro-1,1,1-trifluoroethane | C <sub>2</sub> HBrClF <sub>3</sub>              | 50.2        | 28.08                                 | 29.61                                              |
| Bromoethane                            | C <sub>2</sub> H <sub>5</sub> Br                | 38.5        | 27.04                                 | 28.03                                              |
| Bromoethene                            | C <sub>2</sub> H <sub>3</sub> Br                | 15.8        | 23.4                                  |                                                    |
| 1-Bromoheptane                         | C <sub>7</sub> H <sub>15</sub> Br               | 178.9       |                                       | 50.60                                              |
| 1-Bromohexane                          | C <sub>6</sub> H <sub>13</sub> Br               | 155.3       |                                       | 45.89                                              |
| Bromomethane                           | CH <sub>3</sub> Br                              | 3.5         | 23.91                                 | 22.81                                              |
| 1-Bromo-2-methylpropane                | C <sub>4</sub> H <sub>9</sub> Br                | 91.1        | 31.33                                 | 34.82                                              |
| 2-Bromo-2-methylpropane                | C <sub>4</sub> H <sub>9</sub> Br                | 73.3        | 29.23                                 | 31.81                                              |
| 1-Bromonaphthalene                     | C <sub>10</sub> H <sub>7</sub> Br               | 281         | 39.3                                  |                                                    |
| 1-Bromooctane                          | C <sub>8</sub> H <sub>17</sub> Br               | 200.8       |                                       | 55.77                                              |
| 1-Bromopentane                         | C <sub>5</sub> H <sub>11</sub> Br               | 129.8       | 35.01                                 | 41.28                                              |
| 1-Bromopropane                         | C <sub>3</sub> H <sub>7</sub> Br                | 71.1        | 29.84                                 | 32.01                                              |
| 2-Bromopropane                         | C <sub>3</sub> H <sub>7</sub> Br                | 59.5        | 28.33                                 | 30.17                                              |
| 3-Bromopropene                         | C <sub>3</sub> H <sub>5</sub> Br                | 70.1        | 30.24                                 | 32.73                                              |
| 1,2-Butadiene                          | C <sub>4</sub> H <sub>6</sub>                   | 10.9        | 24.02                                 | 23.21                                              |
| 1,3-Butadiene                          | C <sub>4</sub> H <sub>6</sub>                   | -4.41       | 22.47                                 | 20.86                                              |
| Butanal                                | C <sub>4</sub> H <sub>8</sub> O                 | 74.8        | 31.5                                  |                                                    |

| Name                              | Mol. Form.                           | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|-----------------------------------|--------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Butane                            | $\text{C}_4\text{H}_{10}$            | −0.5        | 22.44                                 | 21.02                                              |
| 1,2-Butanediol                    | $\text{C}_4\text{H}_{10}\text{O}_2$  | 190.5       | 52.84                                 | 71.55                                              |
| 1,3-Butanediol                    | $\text{C}_4\text{H}_{10}\text{O}_2$  | 207.5       | 54.31                                 | 74.46                                              |
| 1,4-Butanediol                    | $\text{C}_4\text{H}_{10}\text{O}_2$  | 235         |                                       | 77.1                                               |
| 1,4-Butanedithiol                 | $\text{C}_4\text{H}_{10}\text{S}_2$  | 195.5       |                                       | 55.10                                              |
| Butanenitrile                     | $\text{C}_4\text{H}_7\text{N}$       | 117.6       | 33.68                                 | 39.33                                              |
| 1-Butanethiol                     | $\text{C}_4\text{H}_{10}\text{S}$    | 98.5        | 32.23                                 | 36.63                                              |
| 2-Butanethiol                     | $\text{C}_4\text{H}_{10}\text{S}$    | 85.0        | 30.59                                 | 33.99                                              |
| Butanoic acid                     | $\text{C}_4\text{H}_8\text{O}_2$     | 163.75      |                                       | 40.45                                              |
| Butanoic anhydride                | $\text{C}_8\text{H}_{14}\text{O}_3$  | 200         | 50.0                                  |                                                    |
| 1-Butanol                         | $\text{C}_4\text{H}_{10}\text{O}$    | 117.73      | 43.29                                 | 52.35                                              |
| 2-Butanol                         | $\text{C}_4\text{H}_{10}\text{O}$    | 99.51       | 40.75                                 | 49.72                                              |
| 2-Butanone                        | $\text{C}_4\text{H}_8\text{O}$       | 79.59       | 31.30                                 | 34.79                                              |
| 1-Butene                          | $\text{C}_4\text{H}_8$               | −6.26       | 22.07                                 | 20.22                                              |
| <i>cis</i> -2-Butene              | $\text{C}_4\text{H}_8$               | 3.71        | 23.34                                 | 22.16                                              |
| <i>trans</i> -2-Butene            | $\text{C}_4\text{H}_8$               | 0.88        | 22.72                                 | 21.40                                              |
| 2-Butoxyethanol                   | $\text{C}_6\text{H}_{14}\text{O}_2$  | 168.4       |                                       | 56.59                                              |
| Butyl acetate                     | $\text{C}_6\text{H}_{12}\text{O}_2$  | 126.1       | 36.28                                 | 43.86                                              |
| <i>tert</i> -Butyl acetate        | $\text{C}_6\text{H}_{12}\text{O}_2$  | 95.1        | 33.07                                 | 38.03                                              |
| Butylamine                        | $\text{C}_4\text{H}_{11}\text{N}$    | 77.00       | 31.81                                 | 35.72                                              |
| <i>sec</i> -Butylamine            | $\text{C}_4\text{H}_{11}\text{N}$    | 62.73       | 29.92                                 | 32.85                                              |
| <i>tert</i> -Butylamine           | $\text{C}_4\text{H}_{11}\text{N}$    | 44.04       | 28.27                                 | 29.64                                              |
| Butylbenzene                      | $\text{C}_{10}\text{H}_{14}$         | 183.31      | 38.87                                 | 50.8                                               |
| <i>sec</i> -Butylbenzene          | $\text{C}_{10}\text{H}_{14}$         | 173.3       |                                       | 48.1                                               |
| <i>tert</i> -Butylbenzene         | $\text{C}_{10}\text{H}_{14}$         | 169.1       |                                       | 47.6                                               |
| Butylcyclohexane                  | $\text{C}_{10}\text{H}_{20}$         | 180         |                                       | 49.36                                              |
| Butylcyclopentane                 | $\text{C}_9\text{H}_{18}$            | 156.6       | 36.16                                 | 45.89                                              |
| Butylethylamine                   | $\text{C}_6\text{H}_{15}\text{N}$    | 107.5       | 33.97                                 | 40.15                                              |
| Butyl ethyl ether                 | $\text{C}_6\text{H}_{14}\text{O}$    | 92.3        | 31.63                                 | 36.32                                              |
| Butyl ethyl sulfide               | $\text{C}_6\text{H}_{14}\text{S}$    | 144.3       | 37.01                                 | 44.51                                              |
| Butyl formate                     | $\text{C}_5\text{H}_{10}\text{O}_2$  | 106.1       | 36.58                                 | 41.11                                              |
| <i>tert</i> -Butyl isobutyl ether | $\text{C}_8\text{H}_{18}\text{O}$    | 112.0       | 33.11                                 | 40.5                                               |
| Butyl methyl ether                | $\text{C}_5\text{H}_{12}\text{O}$    | 70.16       | 29.55                                 | 32.37                                              |
| <i>sec</i> -Butyl methyl ether    | $\text{C}_5\text{H}_{12}\text{O}$    | 59.1        | 28.09                                 | 30.23                                              |
| Butyl methyl sulfide              | $\text{C}_5\text{H}_{12}\text{S}$    | 123.4       | 34.47                                 | 40.46                                              |
| <i>tert</i> -Butyl methyl sulfide | $\text{C}_5\text{H}_{12}\text{S}$    | 98.9        | 31.47                                 | 35.84                                              |
| Butyl propyl ether                | $\text{C}_7\text{H}_{16}\text{O}$    | 118.1       | 33.72                                 | 40.22                                              |
| Butyl vinyl ether                 | $\text{C}_6\text{H}_{12}\text{O}$    | 94          | 31.58                                 | 36.17                                              |
| 1-Butyne                          | $\text{C}_4\text{H}_6$               | 8.08        | 24.52                                 | 23.35                                              |
| 2-Butyne-1,4-diol                 | $\text{C}_4\text{H}_6\text{O}_2$     | 238         |                                       | 81.5                                               |
| $\gamma$ -Butyrolactone           | $\text{C}_4\text{H}_6\text{O}_2$     | 204         | 52.2                                  |                                                    |
| Camphor, (+)                      | $\text{C}_{10}\text{H}_{16}\text{O}$ | 207.4       | 59.5                                  |                                                    |
| Carbon disulfide                  | $\text{CS}_2$                        | 46          | 26.74                                 | 27.51                                              |
| Carbon monoxide                   | $\text{CO}$                          | −191.5      | 6.04                                  |                                                    |
| 2-Chloroaniline                   | $\text{C}_6\text{H}_6\text{ClN}$     | 208.8       | 44.4                                  |                                                    |
| Chlorobenzene                     | $\text{C}_6\text{H}_5\text{Cl}$      | 131.72      | 35.19                                 | 40.97                                              |
| 1-Chlorobutane                    | $\text{C}_4\text{H}_9\text{Cl}$      | 78.4        | 30.39                                 | 33.51                                              |
| 2-Chlorobutane                    | $\text{C}_4\text{H}_9\text{Cl}$      | 68.2        | 29.17                                 | 31.53                                              |
| Chlorodifluoromethane             | $\text{CHClF}_2$                     | −40.7       | 20.2                                  |                                                    |
| Chloroethane                      | $\text{C}_2\text{H}_5\text{Cl}$      | 12.3        | 24.65                                 |                                                    |
| 2-Chloroethanol                   | $\text{C}_2\text{H}_5\text{ClO}$     | 128.6       | 41.4                                  |                                                    |
| Chloroethene                      | $\text{C}_2\text{H}_3\text{Cl}$      | −13.8       | 20.8                                  |                                                    |
| 1-Chloroheptane                   | $\text{C}_7\text{H}_{15}\text{Cl}$   | 160.4       |                                       | 47.66                                              |
| 1-Chlorohexane                    | $\text{C}_6\text{H}_{13}\text{Cl}$   | 135.1       | 35.67                                 | 42.83                                              |
| Chloromethane                     | $\text{CH}_3\text{Cl}$               | −24.09      | 21.40                                 | 18.92                                              |

| Name                                       | Mol. Form.                                      | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|--------------------------------------------|-------------------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| 1-Chloro-3-methylbutane                    | C <sub>5</sub> H <sub>11</sub> Cl               | 98.9        | 32.02                                 | 36.24                                              |
| 1-Chloro-2-methylpropane                   | C <sub>4</sub> H <sub>9</sub> Cl                | 68.5        | 29.22                                 | 31.67                                              |
| 2-Chloro-2-methylpropane                   | C <sub>4</sub> H <sub>9</sub> Cl                | 50.9        | 27.55                                 | 28.98                                              |
| 1-Chloronaphthalene                        | C <sub>10</sub> H <sub>7</sub> Cl               | 259         | 52.1                                  |                                                    |
| 1-Chlorooctane                             | C <sub>8</sub> H <sub>17</sub> Cl               | 183.5       |                                       | 52.42                                              |
| Chloropentafluorobenzene                   | C <sub>6</sub> ClF <sub>5</sub>                 | 117.96      | 34.76                                 | 41.07                                              |
| Chloropentafluoroethane                    | C <sub>2</sub> ClF <sub>5</sub>                 | -39.1       | 19.41                                 |                                                    |
| 1-Chloropentane                            | C <sub>5</sub> H <sub>11</sub> Cl               | 108.4       | 33.15                                 | 38.24                                              |
| 2-Chloropentane                            | C <sub>5</sub> H <sub>11</sub> Cl               | 97.0        | 31.79                                 | 36.03                                              |
| 1-Chloropropane                            | C <sub>3</sub> H <sub>7</sub> Cl                | 46.5        | 27.18                                 | 28.35                                              |
| 2-Chloropropane                            | C <sub>3</sub> H <sub>7</sub> Cl                | 35.7        | 26.30                                 | 26.90                                              |
| 3-Chloropropene                            | C <sub>3</sub> H <sub>5</sub> Cl                | 45.1        | 29.0                                  |                                                    |
| 2-Chlorotoluene                            | C <sub>7</sub> H <sub>7</sub> Cl                | 159.0       | 37.5                                  |                                                    |
| 4-Chlorotoluene                            | C <sub>7</sub> H <sub>7</sub> Cl                | 162.4       | 38.7                                  |                                                    |
| Chlorotrifluoromethane                     | CClF <sub>3</sub>                               | -81.37      | 15.8                                  |                                                    |
| Cholesterol                                | C <sub>27</sub> H <sub>46</sub> O               | 360 dec     |                                       | 148.0                                              |
| <i>o</i> -Cresol                           | C <sub>7</sub> H <sub>8</sub> O                 | 191.04      | 45.19                                 |                                                    |
| <i>m</i> -Cresol                           | C <sub>7</sub> H <sub>8</sub> O                 | 202.27      | 47.40                                 | 61.71                                              |
| <i>p</i> -Cresol                           | C <sub>7</sub> H <sub>8</sub> O                 | 201.98      | 47.45                                 |                                                    |
| Cyanogen                                   | C <sub>2</sub> N <sub>2</sub>                   | -21.1       | 23.33                                 | 19.75                                              |
| Cyclobutane                                | C <sub>4</sub> H <sub>8</sub>                   | 12.6        | 24.19                                 | 23.51                                              |
| Cyclobutanecarbonitrile                    | C <sub>5</sub> H <sub>7</sub> N                 | 149.6       | 36.88                                 | 44.34                                              |
| Cyclohexane                                | C <sub>6</sub> H <sub>12</sub>                  | 80.73       | 29.97                                 | 33.01                                              |
| Cyclohexanecarbonitrile                    | C <sub>7</sub> H <sub>11</sub> N                | 184         |                                       | 51.92                                              |
| Cyclohexanethiol                           | C <sub>6</sub> H <sub>12</sub> S                | 158.8       | 37.06                                 | 44.57                                              |
| Cyclohexanol                               | C <sub>6</sub> H <sub>12</sub> O                | 160.84      |                                       | 62.01                                              |
| Cyclohexanone                              | C <sub>6</sub> H <sub>10</sub> O                | 155.43      |                                       | 45.06                                              |
| Cyclohexene                                | C <sub>6</sub> H <sub>10</sub>                  | 82.98       | 30.46                                 | 33.47                                              |
| 1-Cyclohexenecarbonitrile                  | C <sub>7</sub> H <sub>9</sub> N                 |             |                                       | 53.55                                              |
| Cyclohexylamine                            | C <sub>6</sub> H <sub>13</sub> N                | 134         | 36.14                                 | 43.67                                              |
| Cyclohexylbenzene                          | C <sub>12</sub> H <sub>16</sub>                 | 240.1       |                                       | 60.8                                               |
| Cyclohexylcyclohexane                      | C <sub>12</sub> H <sub>22</sub>                 | 238         |                                       | 57.98                                              |
| Cyclopentane                               | C <sub>5</sub> H <sub>10</sub>                  | 49.3        | 27.30                                 | 28.52                                              |
| Cyclopentanecarbonitrile                   | C <sub>6</sub> H <sub>9</sub> N                 | 170         |                                       | 43.43                                              |
| Cyclopentanethiol                          | C <sub>5</sub> H <sub>10</sub> S                | 132.1       | 35.32                                 | 41.42                                              |
| Cyclopentanol                              | C <sub>5</sub> H <sub>10</sub> O                | 140.42      |                                       | 57.05                                              |
| Cyclopentanone                             | C <sub>5</sub> H <sub>8</sub> O                 | 130.57      | 36.35                                 | 42.72                                              |
| 1-Cyclopentenecarbonitrile                 | C <sub>6</sub> H <sub>7</sub> N                 |             |                                       | 44.98                                              |
| Cyclopropane                               | C <sub>3</sub> H <sub>6</sub>                   | -32.81      | 20.05                                 | 16.93                                              |
| Cyclopropanecarbonitrile                   | C <sub>4</sub> H <sub>5</sub> N                 | 135.1       | 35.55                                 | 41.94                                              |
| Cyclopropylbenzene                         | C <sub>9</sub> H <sub>10</sub>                  | 173.6       |                                       | 50.22                                              |
| Cyclopropyl methyl ketone                  | C <sub>5</sub> H <sub>8</sub> O                 | 111.3       | 34.07                                 | 39.41                                              |
| <i>cis</i> -Decahydronaphthalene           | C <sub>10</sub> H <sub>18</sub>                 | 195.8       | 41.0                                  |                                                    |
| <i>trans</i> -Decahydronaphthalene         | C <sub>10</sub> H <sub>18</sub>                 | 187.3       | 40.2                                  |                                                    |
| Decane                                     | C <sub>10</sub> H <sub>22</sub>                 | 174.15      | 39.58                                 | 51.42                                              |
| 1,10-Decanediol                            | C <sub>10</sub> H <sub>22</sub> O <sub>2</sub>  |             |                                       | 120.0                                              |
| Decanenitrile                              | C <sub>10</sub> H <sub>19</sub> N               | 243         |                                       | 66.84                                              |
| 1-Decanethiol                              | C <sub>10</sub> H <sub>22</sub> S               | 240.6       |                                       | 65.48                                              |
| 1-Decanol                                  | C <sub>10</sub> H <sub>22</sub> O               | 231.1       |                                       | 81.50                                              |
| 1-Decene                                   | C <sub>10</sub> H <sub>20</sub>                 | 170.5       |                                       | 50.43                                              |
| Decylbenzene                               | C <sub>16</sub> H <sub>26</sub>                 | 293         |                                       | 78.2                                               |
| 1,4-Dibromobutane                          | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>   | 197         |                                       | 53.09                                              |
| 1,2-Dibromo-1-chloro-1,2,2-trifluoroethane | C <sub>2</sub> Br <sub>2</sub> ClF <sub>3</sub> | 93          | 31.17                                 | 35.04                                              |
| 1,2-Dibromoethane                          | C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>   | 131.6       | 34.77                                 | 41.73                                              |
| Dibromomethane                             | CH <sub>2</sub> Br <sub>2</sub>                 | 97          | 32.92                                 | 36.97                                              |

| Name                                       | Mol. Form.                                | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|--------------------------------------------|-------------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| 1,2-Dibromopropane                         | $\text{C}_3\text{H}_6\text{Br}_2$         | 141.9       | 35.61                                 | 41.67                                              |
| 1,3-Dibromopropane                         | $\text{C}_3\text{H}_6\text{Br}_2$         | 167.3       |                                       | 47.45                                              |
| 1,2-Dibromotetrafluoroethane               | $\text{C}_2\text{Br}_2\text{F}_4$         | 47.35       | 27.03                                 | 28.39                                              |
| Dibutylamine                               | $\text{C}_8\text{H}_{19}\text{N}$         | 159.6       | 38.44                                 | 49.45                                              |
| Dibutyl ether                              | $\text{C}_8\text{H}_{18}\text{O}$         | 140.28      | 36.49                                 | 44.97                                              |
| Di- <i>sec</i> -butyl ether                | $\text{C}_8\text{H}_{18}\text{O}$         | 121.1       | 34.06                                 | 40.84                                              |
| Di- <i>tert</i> -butyl ether               | $\text{C}_8\text{H}_{18}\text{O}$         | 107.23      | 32.15                                 | 37.61                                              |
| Dibutyl phthalate                          | $\text{C}_{16}\text{H}_{22}\text{O}_4$    | 340         | 79.2                                  |                                                    |
| Dibutyl sulfide                            | $\text{C}_8\text{H}_{18}\text{S}$         | 185         |                                       | 52.96                                              |
| Di- <i>tert</i> -butyl sulfide             | $\text{C}_8\text{H}_{18}\text{S}$         | 149.1       | 33.26                                 | 43.76                                              |
| <i>o</i> -Dichlorobenzene                  | $\text{C}_6\text{H}_4\text{Cl}_2$         | 180         | 39.66                                 | 50.21                                              |
| <i>m</i> -Dichlorobenzene                  | $\text{C}_6\text{H}_4\text{Cl}_2$         | 173         | 38.62                                 | 48.58                                              |
| <i>p</i> -Dichlorobenzene                  | $\text{C}_6\text{H}_4\text{Cl}_2$         | 174         | 38.79                                 | 49.0                                               |
| 1,2-Dichlorobutane                         | $\text{C}_4\text{H}_8\text{Cl}_2$         | 124.1       | 33.90                                 | 39.58                                              |
| 1,4-Dichlorobutane                         | $\text{C}_4\text{H}_8\text{Cl}_2$         | 161         |                                       | 46.36                                              |
| Dichlorodifluoromethane                    | $\text{CCl}_2\text{F}_2$                  | -29.8       | 20.1                                  |                                                    |
| 1,1-Dichloroethane                         | $\text{C}_2\text{H}_4\text{Cl}_2$         | 57.3        | 28.85                                 | 30.62                                              |
| 1,2-Dichloroethane                         | $\text{C}_2\text{H}_4\text{Cl}_2$         | 83.5        | 31.98                                 | 35.16                                              |
| 1,1-Dichloroethene                         | $\text{C}_2\text{H}_2\text{Cl}_2$         | 31.6        | 26.14                                 | 26.48                                              |
| <i>cis</i> -1,2-Dichloroethene             | $\text{C}_2\text{H}_2\text{Cl}_2$         | 60.1        | 30.2                                  |                                                    |
| <i>trans</i> -1,2-Dichloroethene           | $\text{C}_2\text{H}_2\text{Cl}_2$         | 48.7        | 28.9                                  |                                                    |
| 1,1-Dichloro-1-fluoroethane                | $\text{C}_2\text{H}_3\text{Cl}_2\text{F}$ | 32.0        | 26.06                                 | 26.48                                              |
| Dichlorofluoromethane                      | $\text{CHCl}_2\text{F}$                   | 8.9         | 25.2                                  |                                                    |
| 1,2-Dichloro-1,1,2,3,3,3-hexafluoropropane | $\text{C}_3\text{Cl}_2\text{F}_6$         | 34.1        | 26.28                                 | 26.93                                              |
| 1,2-Dichlorohexane                         | $\text{C}_6\text{H}_{12}\text{Cl}_2$      | 173         |                                       | 48.16                                              |
| Dichloromethane                            | $\text{CH}_2\text{Cl}_2$                  | 40          | 28.06                                 | 28.82                                              |
| 1,2-Dichloropentane                        | $\text{C}_5\text{H}_{10}\text{Cl}_2$      | 148.3       | 36.45                                 | 43.89                                              |
| 1,5-Dichloropentane                        | $\text{C}_5\text{H}_{10}\text{Cl}_2$      | 179         |                                       | 50.71                                              |
| 1,3-Dichloropropane                        | $\text{C}_3\text{H}_6\text{Cl}_2$         | 120.9       | 35.18                                 | 40.75                                              |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane     | $\text{C}_2\text{Cl}_2\text{F}_4$         | 3.5         | 23.3                                  |                                                    |
| Dicyclopropyl ketone                       | $\text{C}_7\text{H}_{10}\text{O}$         | 161         |                                       | 53.70                                              |
| Diethanolamine                             | $\text{C}_4\text{H}_{11}\text{NO}_2$      | 268.8       | 65.2                                  |                                                    |
| 1,1-Diethoxyethane                         | $\text{C}_6\text{H}_{14}\text{O}_2$       | 102.25      | 36.28                                 | 43.20                                              |
| 1,2-Diethoxyethane                         | $\text{C}_6\text{H}_{14}\text{O}_2$       | 121.2       | 36.28                                 | 43.20                                              |
| Diethoxymethane                            | $\text{C}_5\text{H}_{12}\text{O}_2$       | 88          | 31.33                                 | 35.65                                              |
| Diethylamine                               | $\text{C}_4\text{H}_{11}\text{N}$         | 55.5        | 29.06                                 | 31.31                                              |
| Diethyl carbonate                          | $\text{C}_5\text{H}_{10}\text{O}_3$       | 126         |                                       | 43.60                                              |
| Diethyl disulfide                          | $\text{C}_4\text{H}_{10}\text{S}_2$       | 154.0       | 37.58                                 | 45.18                                              |
| Diethylene glycol                          | $\text{C}_4\text{H}_{10}\text{O}_3$       | 245.8       | 52.3                                  |                                                    |
| Diethylene glycol diethyl ether            | $\text{C}_8\text{H}_{18}\text{O}_3$       | 188         |                                       | 58.40                                              |
| Diethylene glycol dimethyl ether           | $\text{C}_6\text{H}_{14}\text{O}_3$       | 162         | 36.17                                 | 44.69                                              |
| Diethylene glycol monoethyl ether          | $\text{C}_6\text{H}_{14}\text{O}_3$       | 196         | 47.5                                  |                                                    |
| Diethylene glycol monomethyl ether         | $\text{C}_5\text{H}_{12}\text{O}_3$       | 193         | 46.6                                  |                                                    |
| Diethyl ether                              | $\text{C}_4\text{H}_{10}\text{O}$         | 34.5        | 26.52                                 | 27.10                                              |
| Diethyl malonate                           | $\text{C}_7\text{H}_{12}\text{O}_4$       | 200         | 54.8                                  |                                                    |
| Diethyl oxalate                            | $\text{C}_6\text{H}_{10}\text{O}_4$       | 185.7       | 42.0                                  |                                                    |
| 3,3-Diethylpentane                         | $\text{C}_9\text{H}_{20}$                 | 146.3       | 34.61                                 | 42.0                                               |
| Diethyl sulfide                            | $\text{C}_4\text{H}_{10}\text{S}$         | 92.1        | 31.77                                 | 35.80                                              |
| <i>o</i> -Difluorobenzene                  | $\text{C}_6\text{H}_4\text{F}_2$          | 94          | 32.21                                 | 36.18                                              |
| <i>m</i> -Difluorobenzene                  | $\text{C}_6\text{H}_4\text{F}_2$          | 82.6        | 31.10                                 | 34.59                                              |
| <i>p</i> -Difluorobenzene                  | $\text{C}_6\text{H}_4\text{F}_2$          | 89          | 31.77                                 | 35.54                                              |
| 1,1-Difluoroethane                         | $\text{C}_2\text{H}_4\text{F}_2$          | -24.05      | 21.56                                 | 19.08                                              |
| 2,3-Dihydrothiophene                       | $\text{C}_4\text{H}_6\text{S}$            | 112.1       | 33.24                                 | 37.74                                              |
| 2,5-Dihydrothiophene                       | $\text{C}_4\text{H}_6\text{S}$            | 122.4       | 34.83                                 | 39.95                                              |
| Diiodomethane                              | $\text{CH}_2\text{I}_2$                   | 182         | 42.5                                  |                                                    |



| Name                                  | Mol. Form.                             | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|---------------------------------------|----------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Diisobutyl sulfide                    | $\text{C}_8\text{H}_{18}\text{S}$      | 171         |                                       | 48.71                                              |
| Diisopentyl ether                     | $\text{C}_{10}\text{H}_{22}\text{O}$   | 172.5       | 35.1                                  |                                                    |
| Diisopropylamine                      | $\text{C}_6\text{H}_{15}\text{N}$      | 83.9        | 30.40                                 | 34.61                                              |
| Diisopropyl ether                     | $\text{C}_6\text{H}_{14}\text{O}$      | 68.4        | 29.10                                 | 32.12                                              |
| Diisopropyl sulfide                   | $\text{C}_6\text{H}_{14}\text{S}$      | 120.0       | 33.80                                 | 39.60                                              |
| Diketene                              | $\text{C}_4\text{H}_4\text{O}_2$       | 126.1       | 36.80                                 | 42.89                                              |
| 1,2-Dimethoxyethane                   | $\text{C}_4\text{H}_{10}\text{O}_2$    | 84.5        | 32.42                                 | 36.39                                              |
| <i>N,N</i> -Dimethylacetamide         | $\text{C}_4\text{H}_9\text{NO}$        | 165         |                                       | 50.24                                              |
| Dimethylamine                         | $\text{C}_2\text{H}_7\text{N}$         | 6.88        | 26.40                                 | 25.05                                              |
| 2,4-Dimethylaniline                   | $\text{C}_8\text{H}_{11}\text{N}$      | 214         |                                       | 61.3                                               |
| 2,5-Dimethylaniline                   | $\text{C}_8\text{H}_{11}\text{N}$      | 214         |                                       | 61.7                                               |
| <i>N,N</i> -Dimethylaniline           | $\text{C}_8\text{H}_{11}\text{N}$      | 194.15      |                                       | 52.83                                              |
| 2,2-Dimethylbutane                    | $\text{C}_6\text{H}_{14}$              | 49.73       | 26.31                                 | 27.68                                              |
| 2,3-Dimethylbutane                    | $\text{C}_6\text{H}_{14}$              | 57.93       | 27.38                                 | 29.12                                              |
| 2,3-Dimethyl-2-butanethiol            | $\text{C}_6\text{H}_{14}\text{S}$      | 126.1       |                                       | 39.3                                               |
| 3,3-Dimethyl-2-butanone               | $\text{C}_6\text{H}_{12}\text{O}$      | 106.1       | 33.39                                 | 37.91                                              |
| 2,3-Dimethyl-1-butene                 | $\text{C}_6\text{H}_{12}$              | 55.6        |                                       | 29.18                                              |
| 3,3-Dimethyl-1-butene                 | $\text{C}_6\text{H}_{12}$              | 41.2        |                                       | 26.61                                              |
| 2,3-Dimethyl-2-butene                 | $\text{C}_6\text{H}_{12}$              | 73.3        | 29.64                                 | 32.51                                              |
| 1,1-Dimethylcyclohexane               | $\text{C}_8\text{H}_{16}$              | 119.6       | 32.51                                 | 37.92                                              |
| <i>cis</i> -1,2-Dimethylcyclohexane   | $\text{C}_8\text{H}_{16}$              | 129.8       | 33.47                                 | 39.70                                              |
| <i>trans</i> -1,2-Dimethylcyclohexane | $\text{C}_8\text{H}_{16}$              | 123.5       | 32.96                                 | 38.36                                              |
| <i>cis</i> -1,3-Dimethylcyclohexane   | $\text{C}_8\text{H}_{16}$              | 120.1       | 32.91                                 | 38.26                                              |
| <i>trans</i> -1,3-Dimethylcyclohexane | $\text{C}_8\text{H}_{16}$              | 124.5       | 33.39                                 | 39.16                                              |
| <i>cis</i> -1,4-Dimethylcyclohexane   | $\text{C}_8\text{H}_{16}$              | 124.4       | 33.28                                 | 39.02                                              |
| <i>trans</i> -1,4-Dimethylcyclohexane | $\text{C}_8\text{H}_{16}$              | 119.4       | 32.56                                 | 37.90                                              |
| <i>cis</i> -1,3-Dimethylcyclopentane  | $\text{C}_7\text{H}_{14}$              | 90.8        | 30.40                                 | 34.20                                              |
| Dimethyl decanedioate                 | $\text{C}_{12}\text{H}_{22}\text{O}_4$ |             |                                       | 86.4                                               |
| Dimethyl disulfide                    | $\text{C}_2\text{H}_6\text{S}_2$       | 109.74      | 33.78                                 | 37.86                                              |
| Dimethyl ether                        | $\text{C}_2\text{H}_6\text{O}$         | -24.8       | 21.51                                 | 18.51                                              |
| <i>N,N</i> -Dimethylformamide         | $\text{C}_3\text{H}_7\text{NO}$        | 153         |                                       | 46.89                                              |
| Dimethyl glutarate                    | $\text{C}_7\text{H}_{12}\text{O}_4$    | 214         |                                       | 65.7                                               |
| Dimethyl heptanedioate                | $\text{C}_9\text{H}_{16}\text{O}_4$    |             |                                       | 73.5                                               |
| 2,6-Dimethyl-4-heptanol               | $\text{C}_9\text{H}_{20}\text{O}$      | 174.5       |                                       | 65.17                                              |
| 2,6-Dimethyl-4-heptanone              | $\text{C}_9\text{H}_{18}\text{O}$      | 169.4       |                                       | 50.92                                              |
| 2,2-Dimethylhexane                    | $\text{C}_8\text{H}_{18}$              | 106.86      | 32.07                                 | 37.28                                              |
| 2,3-Dimethylhexane                    | $\text{C}_8\text{H}_{18}$              | 115.62      | 33.17                                 | 38.78                                              |
| 2,4-Dimethylhexane                    | $\text{C}_8\text{H}_{18}$              | 109.5       | 32.51                                 | 37.76                                              |
| 2,5-Dimethylhexane                    | $\text{C}_8\text{H}_{18}$              | 109.12      | 32.54                                 | 37.85                                              |
| 3,3-Dimethylhexane                    | $\text{C}_8\text{H}_{18}$              | 111.97      | 32.31                                 | 37.53                                              |
| 3,4-Dimethylhexane                    | $\text{C}_8\text{H}_{18}$              | 117.73      | 33.24                                 | 38.97                                              |
| Dimethyl 1,6-hexanedioate             | $\text{C}_8\text{H}_{14}\text{O}_4$    |             |                                       | 69.0                                               |
| 2,5-Dimethyl-2,5-hexanediol           | $\text{C}_8\text{H}_{18}\text{O}_2$    | 214         |                                       | 85.2                                               |
| <i>cis</i> -2,2-Dimethyl-3-hexene     | $\text{C}_8\text{H}_{16}$              | 105.5       |                                       | 36.86                                              |
| <i>trans</i> -2,2-Dimethyl-3-hexene   | $\text{C}_8\text{H}_{16}$              | 100.8       |                                       | 37.03                                              |
| 2,5-Dimethyl-3-hexyne-2,5-diol        | $\text{C}_8\text{H}_{14}\text{O}_2$    | 205         |                                       | 82.8                                               |
| 1,1-Dimethylhydrazine                 | $\text{C}_2\text{H}_8\text{N}_2$       | 63.9        | 32.55                                 | 35.0                                               |
| Dimethyl malonate                     | $\text{C}_5\text{H}_8\text{O}_4$       | 181.4       |                                       | 57.5                                               |
| Dimethyl nonanedioate                 | $\text{C}_{11}\text{H}_{20}\text{O}_4$ |             |                                       | 82.3                                               |
| 2,4-Dimethyloctane                    | $\text{C}_{10}\text{H}_{22}$           | 156         | 36.47                                 | 47.13                                              |
| Dimethyl octanedioate                 | $\text{C}_{10}\text{H}_{18}\text{O}_4$ | 268         |                                       | 78.1                                               |
| Dimethyl oxalate                      | $\text{C}_4\text{H}_6\text{O}_4$       | 163.5       |                                       | 54.7                                               |
| 3,3-Dimethyloxetane                   | $\text{C}_5\text{H}_{10}\text{O}$      | 80.6        | 30.85                                 | 33.94                                              |
| 2,2-Dimethylpentane                   | $\text{C}_7\text{H}_{16}$              | 79.2        | 29.23                                 | 32.42                                              |
| 2,3-Dimethylpentane                   | $\text{C}_7\text{H}_{16}$              | 89.78       | 30.46                                 | 34.26                                              |

| Name                                 | Mol. Form.                                     | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|--------------------------------------|------------------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| 2,4-Dimethylpentane                  | C <sub>7</sub> H <sub>16</sub>                 | 80.49       | 29.55                                 | 32.88                                              |
| 3,3-Dimethylpentane                  | C <sub>7</sub> H <sub>16</sub>                 | 86.06       | 29.62                                 | 33.03                                              |
| 2,2-Dimethyl-3-pentanone             | C <sub>7</sub> H <sub>14</sub> O               | 125.6       | 36.09                                 | 42.34                                              |
| 2,4-Dimethyl-3-pentanone             | C <sub>7</sub> H <sub>14</sub> O               | 125.4       | 34.64                                 | 41.51                                              |
| 2,4-Dimethyl-1-pentene               | C <sub>7</sub> H <sub>14</sub>                 | 81.6        |                                       | 33.03                                              |
| 4,4-Dimethyl-1-pentene               | C <sub>7</sub> H <sub>14</sub>                 | 72.5        |                                       | 31.13                                              |
| 2,4-Dimethyl-2-pentene               | C <sub>7</sub> H <sub>14</sub>                 | 83.4        |                                       | 34.19                                              |
| <i>cis</i> -4,4-Dimethyl-2-pentene   | C <sub>7</sub> H <sub>14</sub>                 | 80.4        |                                       | 32.56                                              |
| <i>trans</i> -4,4-Dimethyl-2-pentene | C <sub>7</sub> H <sub>14</sub>                 | 76.7        |                                       | 32.81                                              |
| 2,2-Dimethylpropanenitrile           | C <sub>5</sub> H <sub>9</sub> N                | 106.1       | 32.40                                 | 37.35                                              |
| 2,2-Dimethyl-1-propanethiol          | C <sub>5</sub> H <sub>12</sub> S               | 103.7       |                                       | 36.4                                               |
| 2,3-Dimethylpyridine                 | C <sub>7</sub> H <sub>9</sub> N                | 161.12      | 39.08                                 | 47.82                                              |
| 2,4-Dimethylpyridine                 | C <sub>7</sub> H <sub>9</sub> N                | 158.38      | 38.53                                 | 47.49                                              |
| 2,5-Dimethylpyridine                 | C <sub>7</sub> H <sub>9</sub> N                | 156.98      | 38.68                                 | 47.04                                              |
| 2,6-Dimethylpyridine                 | C <sub>7</sub> H <sub>9</sub> N                | 144.01      | 37.46                                 | 45.34                                              |
| 3,4-Dimethylpyridine                 | C <sub>7</sub> H <sub>9</sub> N                | 179.10      | 39.99                                 | 50.50                                              |
| 3,5-Dimethylpyridine                 | C <sub>7</sub> H <sub>9</sub> N                | 171.84      | 39.46                                 | 49.33                                              |
| Dimethyl succinate                   | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>  | 196.4       |                                       | 61.0                                               |
| Dimethyl sulfide                     | C <sub>2</sub> H <sub>6</sub> S                | 37.33       | 27.0                                  | 27.65                                              |
| Dimethyl sulfoxide                   | C <sub>2</sub> H <sub>6</sub> OS               | 189         | 43.1                                  |                                                    |
| 1,3-Dioxane                          | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 106.1       | 34.37                                 | 39.09                                              |
| 1,4-Dioxane                          | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 101.5       | 34.16                                 | 38.60                                              |
| Diphenyl ether                       | C <sub>12</sub> H <sub>10</sub> O              | 258.0       | 48.2                                  |                                                    |
| 1,2-Dipropoxyethane                  | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>  | 163.2       |                                       | 50.62                                              |
| Dipropylamine                        | C <sub>6</sub> H <sub>15</sub> N               | 109.3       | 33.47                                 | 40.04                                              |
| Dipropyl ether                       | C <sub>6</sub> H <sub>14</sub> O               | 90.08       | 31.31                                 | 35.69                                              |
| Dipropyl sulfide                     | C <sub>6</sub> H <sub>14</sub> S               | 142.9       | 36.60                                 | 44.21                                              |
| 1-Docosanol                          | C <sub>22</sub> H <sub>46</sub> O              |             |                                       | 135.9                                              |
| Dodecane                             | C <sub>12</sub> H <sub>26</sub>                | 216.32      | 44.09                                 | 61.52                                              |
| 1,12-Dodecanediol                    | C <sub>12</sub> H <sub>26</sub> O <sub>2</sub> |             |                                       | 135                                                |
| Dodecanenitrile                      | C <sub>12</sub> H <sub>23</sub> N              | 277         |                                       | 76.12                                              |
| 1-Dodecanol                          | C <sub>12</sub> H <sub>26</sub> O              | 260         |                                       | 90.8                                               |
| 1-Dodecene                           | C <sub>12</sub> H <sub>24</sub>                | 213.8       |                                       | 60.78                                              |
| Dodecylbenzene                       | C <sub>18</sub> H <sub>30</sub>                | 328         |                                       | 86.6                                               |
| Eicosane                             | C <sub>20</sub> H <sub>42</sub>                | 343         | 58.49                                 | 101.81                                             |
| 1-Eicosanol                          | C <sub>20</sub> H <sub>42</sub> O              | 356         |                                       | 125.9                                              |
| 1,2-Epoxybutane                      | C <sub>4</sub> H <sub>8</sub> O                | 63.4        | 30.3                                  |                                                    |
| Ethane                               | C <sub>2</sub> H <sub>6</sub>                  | -88.6       | 14.69                                 | 5.16                                               |
| 1,2-Ethanediamine                    | C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>   | 117         | 37.98                                 | 44.98                                              |
| 1,2-Ethanediol                       | C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>   | 197.3       | 50.5                                  | 63.9                                               |
| 1,2-Ethanediol, diacetate            | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>  | 190         |                                       | 61.44                                              |
| 1,2-Ethanedithiol                    | C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>   | 146.1       | 37.93                                 | 44.68                                              |
| Ethanethiol                          | C <sub>2</sub> H <sub>6</sub> S                | 35.0        | 26.79                                 | 27.30                                              |
| Ethanol                              | C <sub>2</sub> H <sub>6</sub> O                | 78.29       | 38.56                                 | 42.32                                              |
| Ethanolamine                         | C <sub>2</sub> H <sub>7</sub> NO               | 171         | 49.83                                 |                                                    |
| Ethoxybenzene                        | C <sub>8</sub> H <sub>10</sub> O               | 169.81      |                                       | 51.04                                              |
| 2-Ethoxyethanol                      | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>  | 135         | 39.22                                 | 48.21                                              |
| 2-Ethoxyethyl acetate                | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>  | 156.4       | 40.76                                 | 52.61                                              |
| 1-Ethoxy-2-methoxyethane             | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | 103.5       | 34.33                                 | 39.83                                              |
| <i>N</i> -Ethylacetamide             | C <sub>4</sub> H <sub>9</sub> NO               | 205         |                                       | 64.89                                              |
| Ethyl acetate                        | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 77.11       | 31.94                                 | 35.60                                              |
| Ethyl acrylate                       | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>   | 99.4        | 34.7                                  |                                                    |
| <i>N</i> -Ethylaniline               | C <sub>8</sub> H <sub>11</sub> N               | 203.0       |                                       | 58.3                                               |
| Ethylbenzene                         | C <sub>8</sub> H <sub>10</sub>                 | 136.16      | 35.57                                 | 42.24                                              |
| Ethyl butanoate                      | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | 121.3       | 35.47                                 | 42.68                                              |

| Name                         | Mol. Form.                                  | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|------------------------------|---------------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| 2-Ethyl-1-butanol            | $\text{C}_6\text{H}_{14}\text{O}$           | 147         | 43.2                                  |                                                    |
| 2-Ethyl-1-butene             | $\text{C}_6\text{H}_{12}$                   | 64.7        |                                       | 31.13                                              |
| Ethyl chloroacetate          | $\text{C}_4\text{H}_7\text{ClO}_2$          | 144.3       | 40.43                                 | 49.47                                              |
| Ethylcyclobutane             | $\text{C}_6\text{H}_{12}$                   | 70.8        | 28.67                                 | 31.24                                              |
| Ethylcyclohexane             | $\text{C}_8\text{H}_{16}$                   | 131.9       | 34.04                                 | 40.56                                              |
| Ethylcyclopentane            | $\text{C}_7\text{H}_{14}$                   | 103.5       | 31.96                                 | 36.40                                              |
| Ethyl dichloroacetate        | $\text{C}_4\text{H}_6\text{Cl}_2\text{O}_2$ | 155         |                                       | 50.60                                              |
| Ethyl 2,2-dimethylpropanoate | $\text{C}_7\text{H}_{14}\text{O}_2$         | 118.4       | 34.51                                 | 41.25                                              |
| Ethylene                     | $\text{C}_2\text{H}_4$                      | -103.77     | 13.53                                 |                                                    |
| N-Ethylformamide             | $\text{C}_3\text{H}_7\text{NO}$             | 198         |                                       | 58.44                                              |
| Ethyl formate                | $\text{C}_3\text{H}_6\text{O}_2$            | 54.4        | 29.91                                 | 31.96                                              |
| 3-Ethylhexane                | $\text{C}_8\text{H}_{18}$                   | 118.6       | 33.59                                 | 39.64                                              |
| Ethyl hexanoate              | $\text{C}_8\text{H}_{16}\text{O}_2$         | 167         |                                       | 51.72                                              |
| 2-Ethylhexanoic acid         | $\text{C}_8\text{H}_{16}\text{O}_2$         | 228         |                                       | 75.60                                              |
| 2-Ethyl-1-hexanol            | $\text{C}_8\text{H}_{18}\text{O}$           | 184.6       | 54.2                                  | 68.51                                              |
| 2-Ethylhexyl acetate         | $\text{C}_{10}\text{H}_{20}\text{O}_2$      | 199         | 43.5                                  |                                                    |
| 2-Ethylhexylamine            | $\text{C}_8\text{H}_{19}\text{N}$           | 169.2       | 40.0                                  |                                                    |
| Ethylisopropylamine          | $\text{C}_5\text{H}_{13}\text{N}$           | 69.6        | 29.94                                 | 33.13                                              |
| Ethyl isopropyl ether        | $\text{C}_5\text{H}_{12}\text{O}$           | 54.1        | 28.21                                 | 30.08                                              |
| Ethyl isopropyl sulfide      | $\text{C}_5\text{H}_{12}\text{S}$           | 107.5       | 32.74                                 | 37.78                                              |
| Ethyl 3-methylbutanoate      | $\text{C}_7\text{H}_{14}\text{O}_2$         | 135.0       | 37.0                                  |                                                    |
| 2-Ethyl-3-methyl-1-butene    | $\text{C}_7\text{H}_{14}$                   | 89          |                                       | 34.35                                              |
| 1-Ethyl-1-methylcyclopentane | $\text{C}_8\text{H}_{16}$                   | 121.6       | 33.20                                 | 38.85                                              |
| 3-Ethyl-2-methylpentane      | $\text{C}_8\text{H}_{18}$                   | 115.66      | 32.93                                 | 38.52                                              |
| 3-Ethyl-3-methylpentane      | $\text{C}_8\text{H}_{18}$                   | 118.27      | 32.78                                 | 37.99                                              |
| 3-Ethyl-2-methyl-1-pentene   | $\text{C}_8\text{H}_{16}$                   | 109.5       |                                       | 37.27                                              |
| Ethyl 2-methylpropanoate     | $\text{C}_6\text{H}_{12}\text{O}_2$         | 110.1       | 33.67                                 | 39.83                                              |
| Ethyl methyl sulfide         | $\text{C}_3\text{H}_8\text{S}$              | 66.7        | 29.53                                 | 31.85                                              |
| 3-Ethylpentane               | $\text{C}_7\text{H}_{16}$                   | 93.5        | 31.12                                 | 35.22                                              |
| Ethyl pentanoate             | $\text{C}_7\text{H}_{14}\text{O}_2$         | 146.1       | 36.96                                 | 47.01                                              |
| 3-Ethyl-3-pentanol           | $\text{C}_7\text{H}_{16}\text{O}$           | 142         |                                       | 57.34                                              |
| Ethyl pentyl ether           | $\text{C}_7\text{H}_{16}\text{O}$           | 117.6       | 34.41                                 | 41.01                                              |
| Ethyl propanoate             | $\text{C}_5\text{H}_{10}\text{O}_2$         | 99.1        | 33.88                                 | 39.21                                              |
| Ethyl propyl ether           | $\text{C}_5\text{H}_{12}\text{O}$           | 63.21       | 28.94                                 | 31.43                                              |
| Ethyl propyl sulfide         | $\text{C}_5\text{H}_{12}\text{S}$           | 118.6       | 34.24                                 | 39.97                                              |
| Ethyl trichloroacetate       | $\text{C}_4\text{H}_5\text{Cl}_3\text{O}_2$ | 167.5       |                                       | 50.97                                              |
| Ethyl vinyl ether            | $\text{C}_4\text{H}_8\text{O}$              | 35.5        | 26.2                                  |                                                    |
| Fluorobenzene                | $\text{C}_6\text{H}_5\text{F}$              | 84.73       | 31.19                                 | 34.58                                              |
| 1-Fluorooctane               | $\text{C}_8\text{H}_{17}\text{F}$           | 142.3       | 40.43                                 | 49.65                                              |
| 2-Fluorotoluene              | $\text{C}_7\text{H}_7\text{F}$              | 115         | 35.4                                  |                                                    |
| 4-Fluorotoluene              | $\text{C}_7\text{H}_7\text{F}$              | 116.6       | 34.08                                 | 39.42                                              |
| Formamide                    | $\text{CH}_3\text{NO}$                      | 220         |                                       | 60.15                                              |
| Formic acid                  | $\text{CH}_2\text{O}_2$                     | 101         | 22.69                                 | 20.10                                              |
| Furan                        | $\text{C}_4\text{H}_4\text{O}$              | 31.5        | 27.10                                 | 27.45                                              |
| Furfural                     | $\text{C}_5\text{H}_4\text{O}_2$            | 161.7       | 43.2                                  |                                                    |
| Furfuryl alcohol             | $\text{C}_5\text{H}_6\text{O}_2$            | 171         | 53.6                                  |                                                    |
| Glycerol                     | $\text{C}_3\text{H}_8\text{O}_3$            | 290         | 61.0                                  |                                                    |
| Glycerol triacetate          | $\text{C}_9\text{H}_{14}\text{O}_6$         | 259         |                                       | 85.74                                              |
| Heptadecane                  | $\text{C}_{17}\text{H}_{36}$                | 302.0       | 53.58                                 | 86.47                                              |
| 1-Heptadecanol               | $\text{C}_{17}\text{H}_{36}\text{O}$        | 324         |                                       | 112.5                                              |
| 6-Heptadecanol               | $\text{C}_{17}\text{H}_{36}\text{O}$        |             |                                       | 108.6                                              |
| 7-Heptadecanol               | $\text{C}_{17}\text{H}_{36}\text{O}$        |             |                                       | 108.2                                              |
| 9-Heptadecanol               | $\text{C}_{17}\text{H}_{36}\text{O}$        |             |                                       | 108.5                                              |
| Heptane                      | $\text{C}_7\text{H}_{16}$                   | 98.4        | 31.77                                 | 36.57                                              |
| 1,7-Heptanediol              | $\text{C}_7\text{H}_{16}\text{O}_2$         | 262         |                                       | 97.9                                               |

| Name                    | Mol. Form.                                 | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|-------------------------|--------------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| 1-Heptanol              | $\text{C}_7\text{H}_{16}\text{O}$          | 176.45      |                                       | 66.81                                              |
| 3-Heptanol              | $\text{C}_7\text{H}_{16}\text{O}$          | 157         | 42.5                                  |                                                    |
| 2-Heptanone             | $\text{C}_7\text{H}_{14}\text{O}$          | 151.05      |                                       | 47.24                                              |
| 1-Heptene               | $\text{C}_7\text{H}_{14}$                  | 93.64       |                                       | 35.49                                              |
| <i>cis</i> -2-Heptene   | $\text{C}_7\text{H}_{14}$                  | 98.4        |                                       | 36.26                                              |
| <i>trans</i> -2-Heptene | $\text{C}_7\text{H}_{14}$                  | 98          |                                       | 36.27                                              |
| <i>cis</i> -3-Heptene   | $\text{C}_7\text{H}_{14}$                  | 95.8        |                                       | 35.81                                              |
| <i>trans</i> -3-Heptene | $\text{C}_7\text{H}_{14}$                  | 95.7        |                                       | 35.84                                              |
| Heptylamine             | $\text{C}_7\text{H}_{17}\text{N}$          | 156         |                                       | 49.96                                              |
| Heptylbenzene           | $\text{C}_{13}\text{H}_{20}$               | 240         |                                       | 64.2                                               |
| 1-Hexacosanol           | $\text{C}_{26}\text{H}_{54}\text{O}$       |             |                                       | 153.7                                              |
| Hexadecane              | $\text{C}_{16}\text{H}_{34}$               | 286.86      | 51.84                                 | 81.35                                              |
| 1,16-Hexadecanediol     | $\text{C}_{16}\text{H}_{34}\text{O}_2$     |             |                                       | 163                                                |
| 1-Hexadecanol           | $\text{C}_{16}\text{H}_{34}\text{O}$       | 312         |                                       | 107.7                                              |
| 1-Hexadecene            | $\text{C}_{16}\text{H}_{32}$               | 284.9       |                                       | 80.25                                              |
| Hexadecylbenzene        | $\text{C}_{22}\text{H}_{38}$               | 385         |                                       | 104.8                                              |
| Hexafluoroacetylacetone | $\text{C}_5\text{H}_2\text{F}_6\text{O}_2$ | 54.15       | 27.05                                 | 30.58                                              |
| Hexafluorobenzene       | $\text{C}_6\text{F}_6$                     | 80.32       | 31.66                                 | 35.71                                              |
| Hexafluoroethane        | $\text{C}_2\text{F}_6$                     | -78.1       | 16.15                                 |                                                    |
| Hexane                  | $\text{C}_6\text{H}_{14}$                  | 68.73       | 28.85                                 | 31.56                                              |
| 1,6-Hexanediol          | $\text{C}_6\text{H}_{14}\text{O}_2$        | 208         |                                       | 90.2                                               |
| Hexanenitrile           | $\text{C}_6\text{H}_{11}\text{N}$          | 163.65      |                                       | 47.91                                              |
| 1-Hexanol               | $\text{C}_6\text{H}_{14}\text{O}$          | 157.6       | 44.50                                 | 61.61                                              |
| 2-Hexanol               | $\text{C}_6\text{H}_{14}\text{O}$          | 140         | 41.01                                 | 58.46                                              |
| 2-Hexanone              | $\text{C}_6\text{H}_{12}\text{O}$          | 127.6       | 36.35                                 | 43.14                                              |
| 3-Hexanone              | $\text{C}_6\text{H}_{12}\text{O}$          | 123.5       | 35.36                                 | 42.47                                              |
| 1-Hexene                | $\text{C}_6\text{H}_{12}$                  | 63.48       |                                       | 30.61                                              |
| <i>cis</i> -2-Hexene    | $\text{C}_6\text{H}_{12}$                  | 68.8        |                                       | 32.19                                              |
| <i>trans</i> -2-Hexene  | $\text{C}_6\text{H}_{12}$                  | 67.9        |                                       | 31.60                                              |
| <i>cis</i> -3-Hexene    | $\text{C}_6\text{H}_{12}$                  | 66.4        |                                       | 31.23                                              |
| <i>trans</i> -3-Hexene  | $\text{C}_6\text{H}_{12}$                  | 67.1        |                                       | 31.55                                              |
| Hexylamine              | $\text{C}_6\text{H}_{15}\text{N}$          | 132.8       | 36.54                                 | 45.10                                              |
| Hexylbenzene            | $\text{C}_{12}\text{H}_{18}$               | 226.1       |                                       | 60.4                                               |
| Hexyl methyl ether      | $\text{C}_7\text{H}_{16}\text{O}$          | 126.1       | 34.93                                 | 42.07                                              |
| Indan                   | $\text{C}_9\text{H}_{10}$                  | 177.97      | 39.63                                 | 48.79                                              |
| Iodobenzene             | $\text{C}_6\text{H}_5\text{I}$             | 188.4       | 39.5                                  |                                                    |
| 1-Iodobutane            | $\text{C}_4\text{H}_9\text{I}$             | 130.5       | 34.66                                 | 40.63                                              |
| 2-Iodobutane            | $\text{C}_4\text{H}_9\text{I}$             | 120.1       | 33.27                                 | 38.46                                              |
| Iodoethane              | $\text{C}_2\text{H}_5\text{I}$             | 72.3        | 29.44                                 | 31.93                                              |
| 1-Iodoheptane           | $\text{C}_6\text{H}_{13}\text{I}$          | 181.3       |                                       | 49.75                                              |
| Iodomethane             | $\text{CH}_3\text{I}$                      | 42.43       | 27.34                                 | 27.97                                              |
| 1-Iodo-2-methylpropane  | $\text{C}_4\text{H}_9\text{I}$             | 121.1       | 33.54                                 | 38.83                                              |
| 2-Iodo-2-methylpropane  | $\text{C}_4\text{H}_9\text{I}$             | 100.1       | 31.43                                 | 35.41                                              |
| 1-Iodopentane           | $\text{C}_5\text{H}_{11}\text{I}$          | 157.0       |                                       | 45.27                                              |
| 1-Iodopropane           | $\text{C}_3\text{H}_7\text{I}$             | 102.5       | 32.08                                 | 36.25                                              |
| 2-Iodopropane           | $\text{C}_3\text{H}_7\text{I}$             | 89.5        | 30.68                                 | 34.06                                              |
| Isobutane               | $\text{C}_4\text{H}_{10}$                  | -11.73      | 21.30                                 | 19.23                                              |
| Isobutyl acetate        | $\text{C}_6\text{H}_{12}\text{O}_2$        | 116.5       | 35.9                                  |                                                    |
| Isobutylamine           | $\text{C}_4\text{H}_{11}\text{N}$          | 67.75       | 30.61                                 | 33.85                                              |
| Isobutylbenzene         | $\text{C}_{10}\text{H}_{14}$               | 172.79      |                                       | 48.0                                               |
| Isobutyl formate        | $\text{C}_5\text{H}_{10}\text{O}_2$        | 98.2        | 33.6                                  |                                                    |
| Isobutyl isobutanoate   | $\text{C}_8\text{H}_{16}\text{O}_2$        | 148.6       | 38.2                                  |                                                    |
| Isobutyl methyl ether   | $\text{C}_5\text{H}_{12}\text{O}$          | 58.6        | 28.02                                 | 30.13                                              |
| Isopentane              | $\text{C}_5\text{H}_{12}$                  | 27.88       | 24.69                                 | 24.85                                              |
| Isopentyl acetate       | $\text{C}_7\text{H}_{14}\text{O}_2$        | 142.5       | 37.5                                  |                                                    |

| Name                               | Mol. Form.                                  | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|------------------------------------|---------------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Isopentyl isopentanoate            | $\text{C}_{10}\text{H}_{20}\text{O}_2$      | 190.4       | 45.9                                  |                                                    |
| Isopropyl acetate                  | $\text{C}_5\text{H}_{10}\text{O}_2$         | 88.7        | 32.93                                 | 37.20                                              |
| Isopropylamine                     | $\text{C}_3\text{H}_9\text{N}$              | 31.76       | 27.83                                 | 28.36                                              |
| Isopropylbenzene                   | $\text{C}_9\text{H}_{12}$                   | 152.41      |                                       | 45.13                                              |
| Isopropylcyclohexane               | $\text{C}_9\text{H}_{18}$                   | 154.8       |                                       | 44.02                                              |
| Isopropylcyclopentane              | $\text{C}_8\text{H}_{16}$                   | 126.5       | 33.56                                 | 39.44                                              |
| Isopropylmethylamine               | $\text{C}_4\text{H}_{11}\text{N}$           | 50.4        | 28.71                                 | 30.69                                              |
| 1-Isopropyl-4-methylbenzene        | $\text{C}_{10}\text{H}_{14}$                | 177.1       | 38.2                                  |                                                    |
| Isopropyl methyl ether             | $\text{C}_4\text{H}_{10}\text{O}$           | 30.77       | 26.05                                 | 26.41                                              |
| Isopropyl methyl sulfide           | $\text{C}_4\text{H}_{10}\text{S}$           | 84.8        | 30.71                                 | 34.15                                              |
| Isopropylpropylamine               | $\text{C}_6\text{H}_{15}\text{N}$           | 96.9        | 32.14                                 | 37.23                                              |
| Isopropyl propyl sulfide           | $\text{C}_6\text{H}_{14}\text{S}$           | 132.1       | 35.11                                 | 41.78                                              |
| Isoquinoline                       | $\text{C}_9\text{H}_7\text{N}$              | 243.22      | 49.0                                  | 60.26                                              |
| Mesityl oxide                      | $\text{C}_6\text{H}_{10}\text{O}$           | 130         | 36.1                                  |                                                    |
| Methane                            | $\text{CH}_4$                               | -161.48     | 8.19                                  |                                                    |
| Methanol                           | $\text{CH}_3\text{O}$                       | 64.6        | 35.21                                 | 37.43                                              |
| 2-Methoxyethanol                   | $\text{C}_3\text{H}_8\text{O}_2$            | 124.1       | 37.54                                 | 45.17                                              |
| 2-Methoxyethyl acetate             | $\text{C}_5\text{H}_{10}\text{O}_3$         | 143         | 43.9                                  |                                                    |
| Methyl acetate                     | $\text{C}_3\text{H}_6\text{O}_2$            | 56.87       | 30.32                                 | 32.29                                              |
| Methyl acrylate                    | $\text{C}_4\text{H}_6\text{O}_2$            | 80.7        | 33.1                                  |                                                    |
| 2-Methylacrylonitrile              | $\text{C}_4\text{H}_5\text{N}$              | 90.3        | 31.8                                  |                                                    |
| Methylamine                        | $\text{CH}_5\text{N}$                       | -6.32       | 25.60                                 | 23.37                                              |
| 2-Methylaniline                    | $\text{C}_7\text{H}_9\text{N}$              | 200.3       | 44.6                                  |                                                    |
| 3-Methylaniline                    | $\text{C}_7\text{H}_9\text{N}$              | 203.3       | 44.9                                  |                                                    |
| 4-Methylaniline                    | $\text{C}_7\text{H}_9\text{N}$              | 200.4       | 44.3                                  |                                                    |
| Methyl benzoate                    | $\text{C}_8\text{H}_8\text{O}_2$            | 199         |                                       | 55.57                                              |
| 1-Methylbicyclo[3,1,0]hexane       | $\text{C}_7\text{H}_{12}$                   | 93.1        | 31.07                                 | 34.77                                              |
| 3-Methylbutanenitrile              | $\text{C}_5\text{H}_9\text{N}$              | 127.5       | 35.10                                 | 41.64                                              |
| 2-Methyl-1-butanethiol             | $\text{C}_5\text{H}_{12}\text{S}$           | 119.1       | 33.79                                 | 39.45                                              |
| 2-Methyl-2-butanethiol             | $\text{C}_5\text{H}_{12}\text{S}$           | 99.1        | 31.37                                 | 35.67                                              |
| 3-Methyl-2-butanethiol             | $\text{C}_5\text{H}_{12}\text{S}$           | 109.8       |                                       | 37.5                                               |
| Methyl butanoate                   | $\text{C}_5\text{H}_{10}\text{O}_2$         | 102.8       | 33.79                                 | 39.28                                              |
| 2-Methylbutanoic acid              | $\text{C}_5\text{H}_{10}\text{O}_2$         | 177         |                                       | 46.91                                              |
| 2-Methyl-1-butanol                 | $\text{C}_5\text{H}_{12}\text{O}$           | 127.5       |                                       | 55.16                                              |
| 3-Methyl-1-butanol                 | $\text{C}_5\text{H}_{12}\text{O}$           | 131.1       | 44.07                                 | 55.61                                              |
| 2-Methyl-2-butanol                 | $\text{C}_5\text{H}_{12}\text{O}$           | 102.4       | 39.04                                 | 50.10                                              |
| 3-Methyl-2-butanol                 | $\text{C}_5\text{H}_{12}\text{O}$           | 112.9       |                                       | 53.0                                               |
| 3-Methyl-2-butanone                | $\text{C}_5\text{H}_{10}\text{O}$           | 94.33       | 32.35                                 | 36.78                                              |
| 2-Methyl-1-butene                  | $\text{C}_5\text{H}_{10}$                   | 31.2        | 25.50                                 | 25.92                                              |
| 3-Methyl-1-butene                  | $\text{C}_5\text{H}_{10}$                   | 20.1        |                                       | 23.77                                              |
| 2-Methyl-2-butene                  | $\text{C}_5\text{H}_{10}$                   | 38.56       | 26.31                                 | 27.06                                              |
| (1-Methylbutyl)benzene             | $\text{C}_{11}\text{H}_{16}$                | 199         |                                       | 53.0                                               |
| Methyl <i>tert</i> -butyl ether    | $\text{C}_5\text{H}_{12}\text{O}$           | 55.0        | 27.94                                 | 29.82                                              |
| Methyl chloroacetate               | $\text{C}_3\text{H}_5\text{ClO}_2$          | 129.5       | 39.23                                 | 46.73                                              |
| Methyl cyanoacetate                | $\text{C}_4\text{H}_5\text{NO}_2$           | 200.5       | 48.2                                  |                                                    |
| Methyl cyclobutanecarboxylate      | $\text{C}_6\text{H}_{10}\text{O}_2$         | 135.5       | 37.13                                 | 44.72                                              |
| Methylcyclohexane                  | $\text{C}_7\text{H}_{14}$                   | 100.93      | 31.27                                 | 35.36                                              |
| 1-Methylcyclohexanol               | $\text{C}_7\text{H}_{14}\text{O}$           | 155         | 79.0                                  |                                                    |
| <i>cis</i> -2-Methylcyclohexanol   | $\text{C}_7\text{H}_{14}\text{O}$           | 165         | 48.5                                  |                                                    |
| <i>trans</i> -2-Methylcyclohexanol | $\text{C}_7\text{H}_{14}\text{O}$           | 167.5       | 53.0                                  |                                                    |
| Methylcyclopentane                 | $\text{C}_6\text{H}_{12}$                   | 71.8        | 29.08                                 | 31.64                                              |
| Methyl cyclopropanecarboxylate     | $\text{C}_5\text{H}_8\text{O}_2$            | 114.9       | 35.25                                 | 41.27                                              |
| 2-Methyldecane                     | $\text{C}_{11}\text{H}_{24}$                | 189.3       | 40.25                                 | 54.28                                              |
| 4-Methyldecane                     | $\text{C}_{11}\text{H}_{24}$                | 187         | 40.70                                 | 53.76                                              |
| Methyl dichloroacetate             | $\text{C}_3\text{H}_4\text{Cl}_2\text{O}_2$ | 142.9       | 39.28                                 | 47.72                                              |

| Name                              | Mol. Form.                             | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|-----------------------------------|----------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Methyl 2,2-dimethylpropanoate     | $\text{C}_6\text{H}_{12}\text{O}_2$    | 101.1       | 33.42                                 | 38.76                                              |
| Methyl dodecanoate                | $\text{C}_{13}\text{H}_{26}\text{O}_2$ | 267         |                                       | 77.17                                              |
| <i>N</i> -Methylformamide         | $\text{C}_2\text{H}_5\text{NO}$        | 199.51      |                                       | 56.19                                              |
| Methyl formate                    | $\text{C}_2\text{H}_4\text{O}_2$       | 31.7        | 27.92                                 | 28.35                                              |
| 2-Methylheptane                   | $\text{C}_8\text{H}_{18}$              | 117.66      | 33.26                                 | 39.67                                              |
| 3-Methylheptane                   | $\text{C}_8\text{H}_{18}$              | 118.9       | 33.66                                 | 39.83                                              |
| 4-Methylheptane                   | $\text{C}_8\text{H}_{18}$              | 117.72      | 33.35                                 | 39.69                                              |
| Methyl heptanoate                 | $\text{C}_8\text{H}_{16}\text{O}_2$    | 174         |                                       | 51.62                                              |
| 2-Methyl-2-heptanol               | $\text{C}_8\text{H}_{18}\text{O}$      | 156         |                                       | 62.87                                              |
| 2-Methylhexane                    | $\text{C}_7\text{H}_{16}$              | 90.04       | 30.62                                 | 34.87                                              |
| 3-Methylhexane                    | $\text{C}_7\text{H}_{16}$              | 92          | 30.9                                  |                                                    |
| Methyl hexanoate                  | $\text{C}_7\text{H}_{14}\text{O}_2$    | 149.5       | 38.55                                 | 48.04                                              |
| 2-Methyl-2-hexanol                | $\text{C}_7\text{H}_{16}\text{O}$      | 143         |                                       | 58.57                                              |
| 5-Methyl-3-hexanol                | $\text{C}_7\text{H}_{16}\text{O}$      | 147         |                                       | 59.82                                              |
| <i>cis</i> -3-Methyl-3-hexene     | $\text{C}_7\text{H}_{14}$              | 95.4        |                                       | 36.31                                              |
| <i>trans</i> -3-Methyl-3-hexene   | $\text{C}_7\text{H}_{14}$              | 93.5        |                                       | 35.70                                              |
| Methylhydrazine                   | $\text{CH}_6\text{N}_2$                | 87.5        | 36.12                                 | 40.37                                              |
| Methyl isobutanoate               | $\text{C}_5\text{H}_{10}\text{O}_2$    | 92.5        | 32.61                                 | 37.32                                              |
| Methyl methacrylate               | $\text{C}_5\text{H}_8\text{O}_2$       | 100.5       | 36.0                                  |                                                    |
| 1-Methylnaphthalene               | $\text{C}_{11}\text{H}_{10}$           | 244.7       | 45.5                                  |                                                    |
| 2-Methylnonane                    | $\text{C}_{10}\text{H}_{22}$           | 167.1       | 38.23                                 | 49.63                                              |
| 3-Methylnonane                    | $\text{C}_{10}\text{H}_{22}$           | 167.9       | 38.26                                 | 49.71                                              |
| 5-Methylnonane                    | $\text{C}_{10}\text{H}_{22}$           | 165.1       | 38.14                                 | 49.34                                              |
| Methyl octanoate                  | $\text{C}_9\text{H}_{18}\text{O}_2$    | 192.9       |                                       | 56.41                                              |
| Methyloxirane                     | $\text{C}_3\text{H}_6\text{O}$         | 35          | 27.35                                 | 27.89                                              |
| 2-Methylpentane                   | $\text{C}_6\text{H}_{14}$              | 60.26       | 27.79                                 | 29.89                                              |
| 3-Methylpentane                   | $\text{C}_6\text{H}_{14}$              | 63.27       | 28.06                                 | 30.28                                              |
| 2-Methyl-2,4-pentanediol          | $\text{C}_6\text{H}_{14}\text{O}_2$    | 197.1       | 57.3                                  |                                                    |
| Methyl pentanoate                 | $\text{C}_6\text{H}_{12}\text{O}_2$    | 127.4       | 35.36                                 | 43.10                                              |
| 2-Methyl-1-pentanol               | $\text{C}_6\text{H}_{14}\text{O}$      | 149         | 50.2                                  |                                                    |
| 4-Methyl-1-pentanol               | $\text{C}_6\text{H}_{14}\text{O}$      | 151.9       | 44.46                                 | 60.47                                              |
| 2-Methyl-2-pentanol               | $\text{C}_6\text{H}_{14}\text{O}$      | 121.1       | 39.59                                 | 54.77                                              |
| 4-Methyl-2-pentanol               | $\text{C}_6\text{H}_{14}\text{O}$      | 131.6       | 44.2                                  |                                                    |
| 3-Methyl-2-pentanone              | $\text{C}_6\text{H}_{12}\text{O}$      | 117.5       | 34.16                                 | 40.53                                              |
| 4-Methyl-2-pentanone              | $\text{C}_6\text{H}_{12}\text{O}$      | 116.5       | 34.49                                 | 40.61                                              |
| 2-Methyl-3-pentanone              | $\text{C}_6\text{H}_{12}\text{O}$      | 113.5       | 33.84                                 | 39.79                                              |
| 2-Methyl-1-pentene                | $\text{C}_6\text{H}_{12}$              | 62.1        |                                       | 30.48                                              |
| 3-Methyl-1-pentene                | $\text{C}_6\text{H}_{12}$              | 54.2        |                                       | 28.62                                              |
| 4-Methyl-1-pentene                | $\text{C}_6\text{H}_{12}$              | 53.9        |                                       | 28.71                                              |
| 2-Methyl-2-pentene                | $\text{C}_6\text{H}_{12}$              | 67.3        |                                       | 31.60                                              |
| 3-Methyl- <i>cis</i> -2-pentene   | $\text{C}_6\text{H}_{12}$              | 67.7        |                                       | 32.09                                              |
| 3-Methyl- <i>trans</i> -2-pentene | $\text{C}_6\text{H}_{12}$              | 70.4        |                                       | 31.35                                              |
| 4-Methyl- <i>cis</i> -2-pentene   | $\text{C}_6\text{H}_{12}$              | 56.3        |                                       | 29.48                                              |
| 4-Methyl- <i>trans</i> -2-pentene | $\text{C}_6\text{H}_{12}$              | 58.6        |                                       | 29.97                                              |
| Methyl pentyl ether               | $\text{C}_6\text{H}_{14}\text{O}$      | 99          | 32.02                                 | 36.85                                              |
| Methyl pentyl sulfide             | $\text{C}_6\text{H}_{14}\text{S}$      | 145.1       | 37.41                                 | 45.24                                              |
| 2-Methylpropanenitrile            | $\text{C}_4\text{H}_7\text{N}$         | 103.9       | 32.39                                 | 37.13                                              |
| 2-Methyl-1-propanethiol           | $\text{C}_4\text{H}_{10}\text{S}$      | 88.5        | 31.01                                 | 34.63                                              |
| 2-Methyl-2-propanethiol           | $\text{C}_4\text{H}_{10}\text{S}$      | 64.2        | 28.45                                 | 30.78                                              |
| Methyl propanoate                 | $\text{C}_4\text{H}_8\text{O}_2$       | 79.8        | 32.24                                 | 35.85                                              |
| 2-Methylpropanoic acid            | $\text{C}_4\text{H}_8\text{O}_2$       | 154.45      |                                       | 35.30                                              |
| 2-Methyl-1-propanol               | $\text{C}_4\text{H}_{10}\text{O}$      | 107.89      | 41.82                                 | 50.82                                              |
| 2-Methyl-2-propanol               | $\text{C}_4\text{H}_{10}\text{O}$      | 82.4        | 39.07                                 | 46.69                                              |
| Methyl propyl ether               | $\text{C}_4\text{H}_{10}\text{O}$      | 39.1        | 26.75                                 | 27.60                                              |
| Methyl propyl sulfide             | $\text{C}_4\text{H}_{10}\text{S}$      | 95.6        | 32.08                                 | 36.24                                              |

| Name                         | Mol. Form.                                                   | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|------------------------------|--------------------------------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| 2-Methylpyridine             | C <sub>6</sub> H <sub>7</sub> N                              | 129.38      | 36.17                                 | 42.48                                              |
| 3-Methylpyridine             | C <sub>6</sub> H <sub>7</sub> N                              | 144.14      | 37.35                                 | 44.44                                              |
| 4-Methylpyridine             | C <sub>6</sub> H <sub>7</sub> N                              | 145.36      | 37.51                                 | 44.56                                              |
| 2-Methylquinoline            | C <sub>10</sub> H <sub>9</sub> N                             | 246.5       |                                       | 66.1                                               |
| 4-Methylquinoline            | C <sub>10</sub> H <sub>9</sub> N                             | 262         |                                       | 67.6                                               |
| 6-Methylquinoline            | C <sub>10</sub> H <sub>9</sub> N                             | 258.6       |                                       | 67.7                                               |
| 8-Methylquinoline            | C <sub>10</sub> H <sub>9</sub> N                             | 247.5       |                                       | 65.7                                               |
| Methyl salicylate            | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | 222.9       | 46.7                                  |                                                    |
| 4-Methylthiazole             | C <sub>4</sub> H <sub>5</sub> NS                             | 133.3       | 37.58                                 | 43.85                                              |
| 2-Methylthiophene            | C <sub>5</sub> H <sub>6</sub> S                              | 112.6       | 33.90                                 | 38.87                                              |
| 3-Methylthiophene            | C <sub>5</sub> H <sub>6</sub> S                              | 115.5       | 34.24                                 | 39.43                                              |
| Methyl trichloroacetate      | C <sub>3</sub> H <sub>3</sub> Cl <sub>3</sub> O <sub>2</sub> | 153.8       |                                       | 48.33                                              |
| Molybdenum carbonyl          | C <sub>6</sub> MoO <sub>6</sub>                              | 701         | 72.51                                 |                                                    |
| Morpholine                   | C <sub>4</sub> H <sub>9</sub> NO                             | 128         | 37.1                                  |                                                    |
| Naphthalene                  | C <sub>10</sub> H <sub>8</sub>                               | 217.9       | 43.2                                  |                                                    |
| Neopentane                   | C <sub>5</sub> H <sub>12</sub>                               | 9.48        | 22.74                                 | 21.84                                              |
| Nitrobenzene                 | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                | 210.8       |                                       | 55.01                                              |
| Nitroethane                  | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                | 114.0       | 38.0                                  |                                                    |
| Nitromethane                 | CH <sub>3</sub> NO <sub>2</sub>                              | 101.19      | 33.99                                 | 38.27                                              |
| 1-Nitropropane               | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | 131.1       | 38.5                                  |                                                    |
| 2-Nitropropane               | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | 120.2       | 36.8                                  |                                                    |
| Nonadecane                   | C <sub>19</sub> H <sub>40</sub>                              | 329.9       | 56.93                                 | 96.4                                               |
| Nonane                       | C <sub>9</sub> H <sub>20</sub>                               | 150.82      | 37.18                                 | 46.55                                              |
| 1,9-Nonanediol               | C <sub>9</sub> H <sub>20</sub> O <sub>2</sub>                |             |                                       | 112.5                                              |
| 1-Nonanol                    | C <sub>9</sub> H <sub>20</sub> O                             | 213.37      |                                       | 76.86                                              |
| 2-Nonanone                   | C <sub>9</sub> H <sub>18</sub> O                             | 195.3       |                                       | 56.44                                              |
| 5-Nonanone                   | C <sub>9</sub> H <sub>18</sub> O                             | 188.45      |                                       | 53.30                                              |
| Nonylbenzene                 | C <sub>15</sub> H <sub>24</sub>                              | 280.5       |                                       | 74.1                                               |
| Octadecane                   | C <sub>18</sub> H <sub>38</sub>                              | 316.3       | 55.23                                 | 91.44                                              |
| 1-Octadecanol                | C <sub>18</sub> H <sub>38</sub> O                            | 335         |                                       | 116.8                                              |
| cis-9-Octadecenoic acid      | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>               | 360         | 67.4                                  |                                                    |
| Octane                       | C <sub>8</sub> H <sub>18</sub>                               | 125.67      | 34.41                                 | 41.49                                              |
| 1,8-Octanediol               | C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                |             |                                       | 104.9                                              |
| Octanenitrile                | C <sub>8</sub> H <sub>15</sub> N                             | 205.25      |                                       | 56.80                                              |
| Octanoic acid                | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | 239         | 58.5                                  |                                                    |
| 1-Octanol                    | C <sub>8</sub> H <sub>18</sub> O                             | 195.16      |                                       | 70.98                                              |
| 2-Octanol                    | C <sub>8</sub> H <sub>18</sub> O                             | 179.3       | 44.4                                  |                                                    |
| 1-Octene                     | C <sub>8</sub> H <sub>16</sub>                               | 121.29      | 34.07                                 | 40.34                                              |
| Octylbenzene                 | C <sub>14</sub> H <sub>22</sub>                              | 264         |                                       | 69.1                                               |
| 1-Octyne                     | C <sub>8</sub> H <sub>14</sub>                               | 126.3       | 35.83                                 | 42.30                                              |
| 2-Octyne                     | C <sub>8</sub> H <sub>14</sub>                               | 137.6       | 37.26                                 | 44.49                                              |
| 3-Octyne                     | C <sub>8</sub> H <sub>14</sub>                               | 133.1       | 36.94                                 | 43.92                                              |
| 4-Octyne                     | C <sub>8</sub> H <sub>14</sub>                               | 131.6       | 36.0                                  | 42.73                                              |
| Oxetane                      | C <sub>3</sub> H <sub>6</sub> O                              | 47.6        | 28.67                                 | 29.85                                              |
| 2-Oxetanone                  | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                 | 162         |                                       | 47.03                                              |
| Oxirane                      | C <sub>2</sub> H <sub>4</sub> O                              | 10.6        | 25.54                                 | 24.75                                              |
| Pentachloroethane            | C <sub>2</sub> HCl <sub>5</sub>                              | 162.0       | 36.9                                  |                                                    |
| Pentadecane                  | C <sub>15</sub> H <sub>32</sub>                              | 270.6       | 50.08                                 | 76.77                                              |
| 1,15-Pentadecanediol         | C <sub>15</sub> H <sub>32</sub> O <sub>2</sub>               |             |                                       | 139                                                |
| 1-Pentadecanol               | C <sub>15</sub> H <sub>32</sub> O                            | 300         |                                       | 103.5                                              |
| Pentadecylbenzene            | C <sub>21</sub> H <sub>36</sub>                              | 373         |                                       | 100.3                                              |
| Pentafluorobenzene           | C <sub>6</sub> HF <sub>5</sub>                               | 85.74       | 32.15                                 | 36.27                                              |
| 2,3,4,5,6-Pentafluorotoluene | C <sub>7</sub> H <sub>3</sub> F <sub>5</sub>                 | 117.5       | 34.75                                 | 41.12                                              |
| 2,2,4,6,6-Pentamethylheptane | C <sub>12</sub> H <sub>26</sub>                              | 177.8       |                                       | 48.97                                              |
| Pentane                      | C <sub>5</sub> H <sub>12</sub>                               | 36.06       | 25.79                                 | 26.43                                              |

| Name                         | Mol. Form.                          | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|------------------------------|-------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| 1,5-Pentanediol              | $\text{C}_5\text{H}_{12}\text{O}_2$ | 239         | 60.7                                  | 83.0                                               |
| 2,4-Pentanedione             | $\text{C}_5\text{H}_8\text{O}_2$    | 138         | 34.30                                 | 41.77                                              |
| Pentanenitrile               | $\text{C}_5\text{H}_9\text{N}$      | 141.3       | 36.09                                 | 43.60                                              |
| 1-Pentanethiol               | $\text{C}_5\text{H}_{12}\text{S}$   | 126.6       | 34.88                                 | 41.24                                              |
| Pentanoic acid               | $\text{C}_5\text{H}_{10}\text{O}_2$ | 186.1       | 44.1                                  |                                                    |
| 1-Pentanol                   | $\text{C}_5\text{H}_{12}\text{O}$   | 137.98      | 44.36                                 | 57.02                                              |
| 2-Pentanol                   | $\text{C}_5\text{H}_{12}\text{O}$   | 119.3       | 41.40                                 | 54.21                                              |
| 3-Pentanol                   | $\text{C}_5\text{H}_{12}\text{O}$   | 116.25      |                                       | 54.0                                               |
| 2-Pentanone                  | $\text{C}_5\text{H}_{10}\text{O}$   | 102.26      | 33.44                                 | 38.40                                              |
| 3-Pentanone                  | $\text{C}_5\text{H}_{10}\text{O}$   | 101.7       | 33.45                                 | 38.52                                              |
| 1-Pentene                    | $\text{C}_5\text{H}_{10}$           | 29.96       | 25.20                                 | 25.47                                              |
| <i>cis</i> -2-Pentene        | $\text{C}_5\text{H}_{10}$           | 36.93       |                                       | 26.86                                              |
| <i>trans</i> -2-Pentene      | $\text{C}_5\text{H}_{10}$           | 36.34       |                                       | 26.76                                              |
| <i>trans</i> -3-Pentenitrile | $\text{C}_5\text{H}_7\text{N}$      | 144         | 37.09                                 | 44.77                                              |
| Pentyl acetate               | $\text{C}_7\text{H}_{14}\text{O}_2$ | 149.2       | 38.42                                 | 48.56                                              |
| Pentylamine                  | $\text{C}_5\text{H}_{13}\text{N}$   | 104.3       | 34.01                                 | 40.08                                              |
| Pentylbenzene                | $\text{C}_{11}\text{H}_{16}$        | 205.4       |                                       | 55.1                                               |
| Pentylcyclohexane            | $\text{C}_{11}\text{H}_{22}$        | 203.7       |                                       | 53.88                                              |
| Perfluorobutane              | $\text{C}_4\text{F}_{10}$           | -1.9        | 22.9                                  |                                                    |
| Perfluorocyclobutane         | $\text{C}_4\text{F}_8$              | -5.91       | 23.2                                  |                                                    |
| Perfluorodecalin             | $\text{C}_{10}\text{F}_{18}$        | 142.02      |                                       | 41.54                                              |
| Perfluorohexane              | $\text{C}_6\text{F}_{14}$           | 57.14       |                                       | 32.47                                              |
| Perfluorononane              | $\text{C}_9\text{F}_{20}$           | 117.61      |                                       | 45.27                                              |
| Perfluorooctane              | $\text{C}_8\text{F}_{18}$           | 105.9       | 33.38                                 | 41.13                                              |
| Perfluorotoluene             | $\text{C}_7\text{F}_8$              | 103.55      |                                       | 40.52                                              |
| Phenanthrene                 | $\text{C}_{14}\text{H}_{10}$        | 340         |                                       | 75.50                                              |
| Phenol                       | $\text{C}_6\text{H}_6\text{O}$      | 181.87      | 45.69                                 | 57.82                                              |
| Piperidine                   | $\text{C}_5\text{H}_{11}\text{N}$   | 106.22      |                                       | 39.29                                              |
| Propanal                     | $\text{C}_3\text{H}_6\text{O}$      | 48          | 28.31                                 | 29.62                                              |
| Propane                      | $\text{C}_3\text{H}_8$              | -42.1       | 19.04                                 | 14.79                                              |
| 1,3-Propanediamine           | $\text{C}_3\text{H}_{10}\text{N}_2$ | 139.8       | 40.85                                 | 50.16                                              |
| 1,2-Propanediol              | $\text{C}_3\text{H}_8\text{O}_2$    | 187.6       | 52.4                                  |                                                    |
| 1,3-Propanediol              | $\text{C}_3\text{H}_8\text{O}_2$    | 214.4       | 57.9                                  | 69.8                                               |
| 1,3-Propanedithiol           | $\text{C}_3\text{H}_8\text{S}_2$    | 172.9       |                                       | 49.66                                              |
| Propanenitrile               | $\text{C}_3\text{H}_5\text{N}$      | 97.14       | 31.81                                 | 36.03                                              |
| 1-Propanethiol               | $\text{C}_3\text{H}_8\text{S}$      | 67.8        | 29.54                                 | 31.89                                              |
| 2-Propanethiol               | $\text{C}_3\text{H}_8\text{S}$      | 52.6        | 27.91                                 | 29.45                                              |
| Propanoic acid               | $\text{C}_3\text{H}_6\text{O}_2$    | 141.15      |                                       | 32.14                                              |
| Propanoic anhydride          | $\text{C}_6\text{H}_{10}\text{O}_3$ | 170         | 41.7                                  |                                                    |
| 1-Propanol                   | $\text{C}_3\text{H}_8\text{O}$      | 97.2        | 41.44                                 | 47.45                                              |
| 2-Propanol                   | $\text{C}_3\text{H}_8\text{O}$      | 82.3        | 39.85                                 | 45.39                                              |
| Propene                      | $\text{C}_3\text{H}_6$              | -47.69      | 18.42                                 | 14.24                                              |
| 2-Propoxyethanol             | $\text{C}_5\text{H}_{12}\text{O}_2$ | 149.8       | 41.40                                 | 52.12                                              |
| Propyl acetate               | $\text{C}_5\text{H}_{10}\text{O}_2$ | 101.3       | 33.92                                 | 39.72                                              |
| Propylamine                  | $\text{C}_3\text{H}_9\text{N}$      | 47.22       | 29.55                                 | 31.27                                              |
| Propylbenzene                | $\text{C}_9\text{H}_{12}$           | 159.24      |                                       | 46.22                                              |
| Propylcyclohexane            | $\text{C}_9\text{H}_{18}$           | 156         |                                       | 45.08                                              |
| Propylcyclopentane           | $\text{C}_8\text{H}_{16}$           | 131         | 34.70                                 | 41.08                                              |
| Propyl formate               | $\text{C}_4\text{H}_8\text{O}_2$    | 80.9        | 33.61                                 | 37.53                                              |
| Propyl propanoate            | $\text{C}_6\text{H}_{12}\text{O}_2$ | 122.5       | 35.54                                 | 43.45                                              |
| Pyridazine                   | $\text{C}_4\text{H}_4\text{N}_2$    | 208         |                                       | 53.47                                              |
| Pyridine                     | $\text{C}_5\text{H}_5\text{N}$      | 115.23      | 35.09                                 | 40.21                                              |
| Pyrimidine                   | $\text{C}_4\text{H}_4\text{N}_2$    | 123.8       | 43.09                                 | 49.79                                              |
| Pyrrole                      | $\text{C}_4\text{H}_5\text{N}$      | 129.79      | 38.75                                 | 45.09                                              |
| Pyrrolidine                  | $\text{C}_4\text{H}_9\text{N}$      | 86.56       | 33.01                                 | 37.52                                              |



| Name                                  | Mol. Form.                              | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|---------------------------------------|-----------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| Quinoline                             | $\text{C}_9\text{H}_7\text{N}$          | 237.16      | 49.7                                  | 59.30                                              |
| Salicylaldehyde                       | $\text{C}_7\text{H}_6\text{O}_2$        | 197         | 38.2                                  |                                                    |
| Spiro[2.2]pentane                     | $\text{C}_5\text{H}_8$                  | 39          | 26.76                                 | 27.49                                              |
| Styrene                               | $\text{C}_8\text{H}_8$                  | 145         | 38.7                                  |                                                    |
| Succinonitrile                        | $\text{C}_4\text{H}_4\text{N}_2$        | 266         | 48.5                                  |                                                    |
| 1,1,2,2-Tetrabromoethane              | $\text{C}_2\text{H}_2\text{Br}_4$       | 243.5       | 48.7                                  |                                                    |
| 1,1,2,2-Tetrachloroethane             | $\text{C}_2\text{H}_2\text{Cl}_4$       | 145.2       | 37.64                                 | 45.71                                              |
| Tetrachloroethene                     | $\text{C}_2\text{Cl}_4$                 | 121.3       | 34.68                                 | 39.68                                              |
| Tetrachloromethane                    | $\text{CCl}_4$                          | 76.8        | 29.82                                 | 32.43                                              |
| Tetradecane                           | $\text{C}_{14}\text{H}_{30}$            | 253.58      | 48.16                                 | 71.73                                              |
| 1,14-Tetradecanediol                  | $\text{C}_{14}\text{H}_{30}\text{O}_2$  |             |                                       | 149.7                                              |
| Tetradecanenitrile                    | $\text{C}_{14}\text{H}_{27}\text{N}$    |             |                                       | 85.29                                              |
| 1-Tetradecanol                        | $\text{C}_{14}\text{H}_{30}\text{O}$    | 287         |                                       | 98.9                                               |
| Tetradecylbenzene                     | $\text{C}_{20}\text{H}_{34}$            | 359         |                                       | 95.8                                               |
| Tetrahydrofuran                       | $\text{C}_4\text{H}_8\text{O}$          | 65          | 29.81                                 | 31.99                                              |
| Tetrahydrofurfuryl alcohol            | $\text{C}_5\text{H}_{10}\text{O}_2$     | 178         | 45.2                                  |                                                    |
| 1,2,3,4-Tetrahydronaphthalene         | $\text{C}_{10}\text{H}_{12}$            | 207.6       | 43.9                                  |                                                    |
| Tetrahydropyran                       | $\text{C}_5\text{H}_{10}\text{O}$       | 88          | 31.17                                 | 34.58                                              |
| Tetrahydrothiophene                   | $\text{C}_4\text{H}_8\text{S}$          | 121.1       | 34.66                                 | 39.43                                              |
| 2,2,3,3-Tetramethylbutane             | $\text{C}_8\text{H}_{18}$               | 106.45      |                                       | 42.90                                              |
| 2,2,4,4-Tetramethylpentane            | $\text{C}_9\text{H}_{20}$               | 122.29      | 32.51                                 | 38.49                                              |
| Tetranitromethane                     | $\text{CN}_4\text{O}_8$                 | 126.1       | 40.74                                 | 49.93                                              |
| Thiacyclohexane                       | $\text{C}_5\text{H}_{10}\text{S}$       | 141.8       | 35.96                                 | 42.58                                              |
| Thietane                              | $\text{C}_3\text{H}_6\text{S}$          | 95.0        | 32.32                                 | 35.97                                              |
| Thiophene                             | $\text{C}_4\text{H}_4\text{S}$          | 84.0        | 31.48                                 | 34.70                                              |
| Toluene                               | $\text{C}_7\text{H}_8$                  | 110.63      | 33.18                                 | 38.01                                              |
| Triacetamide                          | $\text{C}_6\text{H}_9\text{NO}_3$       |             |                                       | 60.41                                              |
| Tribromomethane                       | $\text{CHBr}_3$                         | 149.1       | 39.66                                 | 46.05                                              |
| Tributylamine                         | $\text{C}_{12}\text{H}_{27}\text{N}$    | 216.5       | 46.9                                  |                                                    |
| Tributyl borate                       | $\text{C}_{12}\text{H}_{27}\text{BO}_3$ | 234         | 56.1                                  |                                                    |
| 1,1,1-Trichloroethane                 | $\text{C}_2\text{H}_3\text{Cl}_3$       | 74.09       | 29.86                                 | 32.50                                              |
| 1,1,2-Trichloroethane                 | $\text{C}_2\text{H}_3\text{Cl}_3$       | 113.8       | 34.82                                 | 40.24                                              |
| Trichloroethene                       | $\text{C}_2\text{HCl}_3$                | 87.21       | 31.40                                 | 34.54                                              |
| Trichlorofluoromethane                | $\text{CCl}_3\text{F}$                  | 23.7        | 25.1                                  |                                                    |
| Trichloromethane                      | $\text{CHCl}_3$                         | 61.17       | 29.24                                 | 31.28                                              |
| 1,2,3-Trichloropropane                | $\text{C}_3\text{H}_5\text{Cl}_3$       | 157         | 37.1                                  |                                                    |
| 1,1,1-Trichloro-2,2,2-trifluoroethane | $\text{C}_2\text{Cl}_3\text{F}_3$       | 45.5        | 26.85                                 | 28.08                                              |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | $\text{C}_2\text{Cl}_3\text{F}_3$       | 47.7        | 27.04                                 | 28.40                                              |
| Tridecane                             | $\text{C}_{13}\text{H}_{28}$            | 235.47      | 46.20                                 | 66.68                                              |
| 1,13-Tridecanediol                    | $\text{C}_{13}\text{H}_{28}\text{O}_2$  |             |                                       | 133                                                |
| 1-Tridecanol                          | $\text{C}_{13}\text{H}_{28}\text{O}$    | 274         |                                       | 94.7                                               |
| Tridecylbenzene                       | $\text{C}_{19}\text{H}_{32}$            | 346         |                                       | 91.8                                               |
| Triethylamine                         | $\text{C}_6\text{H}_{15}\text{N}$       | 89          | 31.01                                 | 34.84                                              |
| Triethylene glycol                    | $\text{C}_6\text{H}_{14}\text{O}_4$     | 285         | 71.4                                  |                                                    |
| Trifluoroacetic acid                  | $\text{C}_2\text{HF}_3\text{O}_2$       | 73          | 33.3                                  |                                                    |
| 1,1,1-Trifluoroethane                 | $\text{C}_2\text{H}_3\text{F}_3$        | -47.25      | 18.99                                 |                                                    |
| (Trifluoromethyl)benzene              | $\text{C}_7\text{H}_5\text{F}_3$        | 102.1       | 32.63                                 | 37.60                                              |
| Trimethylamine                        | $\text{C}_3\text{H}_9\text{N}$          | 2.87        | 22.94                                 | 21.66                                              |
| 1,2,3-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$               | 176.12      |                                       | 49.05                                              |
| 1,2,4-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$               | 169.38      |                                       | 47.93                                              |
| 1,3,5-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$               | 164.74      |                                       | 47.50                                              |
| 2,2,3-Trimethylbutane                 | $\text{C}_7\text{H}_{16}$               | 80.86       | 28.90                                 | 32.05                                              |
| 2,3,3-Trimethyl-1-butene              | $\text{C}_7\text{H}_{14}$               | 77.9        |                                       | 32.09                                              |
| 2,2,5-Trimethylhexane                 | $\text{C}_9\text{H}_{20}$               | 124.09      | 33.65                                 | 40.16                                              |
| 2,3,5-Trimethylhexane                 | $\text{C}_9\text{H}_{20}$               | 131.4       | 34.43                                 | 41.41                                              |

| Name                        | Mol. Form.                             | $t_b$<br>°C | $\Delta_{\text{vap}}H(t_b)$<br>kJ/mol | $\Delta_{\text{vap}}H(25^\circ\text{C})$<br>kJ/mol |
|-----------------------------|----------------------------------------|-------------|---------------------------------------|----------------------------------------------------|
| 3,5,5-Trimethyl-1-hexanol   | $\text{C}_9\text{H}_{20}\text{O}$      | 194         |                                       | 67.86                                              |
| 2,4,7-Trimethyloctane       | $\text{C}_{11}\text{H}_{24}$           | 168.1       | 38.22                                 | 49.91                                              |
| 2,2,3-Trimethylpentane      | $\text{C}_8\text{H}_{18}$              | 110         | 31.94                                 | 36.91                                              |
| 2,2,4-Trimethylpentane      | $\text{C}_8\text{H}_{18}$              | 99.22       | 30.79                                 | 35.14                                              |
| 2,3,3-Trimethylpentane      | $\text{C}_8\text{H}_{18}$              | 114.8       | 32.12                                 | 37.27                                              |
| 2,3,4-Trimethylpentane      | $\text{C}_8\text{H}_{18}$              | 113.5       | 32.36                                 | 37.75                                              |
| 2,2,4-Trimethyl-3-pentanone | $\text{C}_8\text{H}_{16}\text{O}$      | 135.1       | 35.64                                 | 43.30                                              |
| 2,4,4-Trimethyl-1-pentene   | $\text{C}_8\text{H}_{16}$              | 101.4       |                                       | 35.59                                              |
| 2,4,4-Trimethyl-2-pentene   | $\text{C}_8\text{H}_{16}$              | 104.9       |                                       | 37.23                                              |
| 2,3,6-Trimethylpyridine     | $\text{C}_8\text{H}_{11}\text{N}$      | 171.6       | 39.95                                 | 50.61                                              |
| 2,4,6-Trimethylpyridine     | $\text{C}_8\text{H}_{11}\text{N}$      | 170.6       | 39.87                                 | 50.33                                              |
| Tris(perfluorobutyl)amine   | $\text{C}_{12}\text{F}_{27}\text{N}$   | 178         | 46.4                                  |                                                    |
| Undecane                    | $\text{C}_{11}\text{H}_{24}$           | 195.9       | 41.91                                 | 56.58                                              |
| 1,11-Undecanediol           | $\text{C}_{11}\text{H}_{24}\text{O}_2$ |             |                                       | 132                                                |
| Undecanenitrile             | $\text{C}_{11}\text{H}_{21}\text{N}$   | 253         |                                       | 71.14                                              |
| 1-Undecanol                 | $\text{C}_{11}\text{H}_{24}\text{O}$   | 245         |                                       | 85.8                                               |
| Undecylbenzene              | $\text{C}_{17}\text{H}_{28}$           | 316         |                                       | 82.4                                               |
| Vinyl acetate               | $\text{C}_4\text{H}_6\text{O}_2$       | 72.8        | 34.6                                  |                                                    |
| <i>o</i> -Xylene            | $\text{C}_8\text{H}_{10}$              | 144.5       | 36.24                                 | 43.43                                              |
| <i>m</i> -Xylene            | $\text{C}_8\text{H}_{10}$              | 139.07      | 35.66                                 | 42.65                                              |
| <i>p</i> -Xylene            | $\text{C}_8\text{H}_{10}$              | 138.23      | 35.67                                 | 42.40                                              |
| 2,4-Xylenol                 | $\text{C}_8\text{H}_{10}\text{O}$      | 210.98      |                                       | 64.96                                              |
| 2,5-Xylenol                 | $\text{C}_8\text{H}_{10}\text{O}$      | 211.1       | 46.9                                  |                                                    |
| 2,6-Xylenol                 | $\text{C}_8\text{H}_{10}\text{O}$      | 201.07      |                                       | 75.31                                              |
| 3,4-Xylenol                 | $\text{C}_8\text{H}_{10}\text{O}$      | 227         |                                       | 85.03                                              |
| 3,5-Xylenol                 | $\text{C}_8\text{H}_{10}\text{O}$      | 221.74      |                                       | 82.01                                              |

## ENTHALPY OF FUSION

This table lists the molar enthalpy (heat) of fusion,  $\Delta_{\text{fus}}H$ , of over 1100 inorganic and organic compounds. All values refer to the enthalpy change at equilibrium between the liquid phase and the most stable solid phase at the phase transition temperature. Most values of  $\Delta_{\text{fus}}H$  are given at the normal melting point  $t_{\text{m}}$ . However, a "t" following the entry in the melting point column indicates a triple-point temperature, where the solid, liquid, and gas phases are in equilibrium. Temperatures are given on the ITS-90 scale.

A \* following an entry indicates that the value includes the enthalpy of transition between crystalline phases whose transformation occurs within 1 °C of the melting point.

Substances are listed by name, either an IUPAC systematic name or, in the case of drugs and other complex compounds, a common synonym. Inorganic compounds, including metal salts of organic acids, are listed first, followed by organic compounds. The molecular formula in the Hill convention is included.

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| Name                                                          | Molecular formula                            | $t_{\text{m}}/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|---------------------------------------------------------------|----------------------------------------------|---------------------------------|-------------------------------------------|
| <i>Inorganic compounds (including salts of organic acids)</i> |                                              |                                 |                                           |
| Actinium                                                      | Ac                                           | 1050                            | 12.0                                      |
| Aluminum                                                      | Al                                           | 660.32                          | 10.71                                     |
| Aluminum bromide                                              | AlBr <sub>3</sub>                            | 97.5                            | 11.25                                     |
| Aluminum chloride                                             | AlCl <sub>3</sub>                            | 192.6                           | 35.35                                     |
| Aluminum fluoride                                             | AlF <sub>3</sub>                             | 2250 t                          | 98                                        |
| Aluminum iodide                                               | AlI <sub>3</sub>                             | 188.28                          | 15.90                                     |
| Aluminum oxide ( $\alpha$ )                                   | Al <sub>2</sub> O <sub>3</sub>               | 2054                            | 111.1                                     |
| Aluminum sulfide                                              | Al <sub>2</sub> S <sub>3</sub>               | 1100                            | 66                                        |
| Americium                                                     | Am                                           | 1176                            | 14.39                                     |
| Ammonia                                                       | H <sub>3</sub> N                             | –77.73                          | 5.66                                      |
| Ammonium chloride                                             | ClH <sub>4</sub> N                           | 520.1                           | 10.6                                      |
| Ammonium fluoride                                             | FH <sub>4</sub> N                            | 238                             | 12.6                                      |
| Ammonium iodide                                               | H <sub>4</sub> IN                            | 551                             | 21                                        |
| Ammonium nitrate                                              | H <sub>4</sub> N <sub>2</sub> O <sub>3</sub> | 169.7                           | 5.86                                      |
| Antimony (gray)                                               | Sb                                           | 630.628                         | 19.79                                     |
| Antimony(III) bromide                                         | Br <sub>3</sub> Sb                           | 97                              | 14.6                                      |
| Antimony(III) chloride                                        | Cl <sub>3</sub> Sb                           | 73.4                            | 12.97                                     |
| Antimony(III) fluoride                                        | F <sub>3</sub> Sb                            | 287                             | 22.8                                      |
| Antimony(III) iodide                                          | I <sub>3</sub> Sb                            | 171                             | 22.8                                      |
| Antimony(III) oxide (valentinite)                             | O <sub>3</sub> Sb <sub>2</sub>               | 655                             | 54                                        |
| Antimony(III) sulfide                                         | S <sub>3</sub> Sb <sub>2</sub>               | 550                             | 47.9                                      |
| Argon                                                         | Ar                                           | –189.36                         | 1.18                                      |
| Arsenic (gray)                                                | As                                           | 817                             | 24.44                                     |
| Arsenic(III) bromide                                          | AsBr <sub>3</sub>                            | 31.1                            | 11.7                                      |
| Arsenic(III) chloride                                         | AsCl <sub>3</sub>                            | –16                             | 10.1                                      |
| Arsenic(III) fluoride                                         | AsF <sub>3</sub>                             | –5.9                            | 10.4                                      |
| Arsenic(III) iodide                                           | AsI <sub>3</sub>                             | 141                             | 21.8                                      |

| Name                            | Molecular formula               | $t_{\text{m}}/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|---------------------------------|---------------------------------|---------------------------------|-------------------------------------------|
| Arsenic(III) oxide (claudetite) | As <sub>2</sub> O <sub>3</sub>  | 314                             | 18                                        |
| Arsenic(V) oxide                | As <sub>2</sub> O <sub>5</sub>  | 730                             | 60                                        |
| Arsenic(III) selenide           | As <sub>2</sub> Se <sub>3</sub> | 377                             | 40.8                                      |
| Arsenic(III) sulfide            | As <sub>2</sub> S <sub>3</sub>  | 312                             | 28.7                                      |
| Arsenic sulfide                 | As <sub>4</sub> S <sub>4</sub>  | 307                             | 25.4                                      |
| Arsenic(III) telluride          | As <sub>2</sub> Te <sub>3</sub> | 375                             | 46.0                                      |
| Barium                          | Ba                              | 727                             | 7.12                                      |
| Barium bromide                  | BaBr <sub>2</sub>               | 857                             | 32.2                                      |
| Barium carbonate                | CBaO <sub>3</sub>               | 1555 (high pres.)               | 40                                        |
| Barium chloride                 | BaCl <sub>2</sub>               | 961                             | 15.85                                     |
| Barium fluoride                 | BaF <sub>2</sub>                | 1368                            | 23.36                                     |
| Barium hydride                  | BaH <sub>2</sub>                | 1200                            | 25                                        |
| Barium hydroxide                | BaH <sub>2</sub> O <sub>2</sub> | 408                             | 16                                        |
| Barium iodide                   | BaI <sub>2</sub>                | 711                             | 26.5                                      |
| Barium oxide                    | BaO                             | 1973                            | 46                                        |
| Barium sulfate                  | BaO <sub>4</sub> S              | 1580                            | 40                                        |
| Barium sulfide                  | BaS                             | 2227                            | 63                                        |
| Beryllium                       | Be                              | 1287                            | 7.895                                     |
| Beryllium bromide               | BeBr <sub>2</sub>               | 508                             | 18                                        |
| Beryllium carbide               | CBe <sub>2</sub>                | 2127                            | 75.3                                      |
| Beryllium chloride              | BeCl <sub>2</sub>               | 415                             | 8.66                                      |
| Beryllium fluoride              | BeF <sub>2</sub>                | 552                             | 4.77                                      |
| Beryllium iodide                | BeI <sub>2</sub>                | 480                             | 20.92                                     |
| Beryllium nitride               | Be <sub>3</sub> N <sub>2</sub>  | 2200                            | 111                                       |
| Beryllium oxide                 | BeO                             | 2578                            | 86                                        |
| Beryllium sulfate               | BeO <sub>4</sub> S              | 1127                            | 6                                         |
| Bismuth                         | Bi                              | 271.406                         | 11.106                                    |
| Bismuth oxide                   | Bi <sub>2</sub> O <sub>3</sub>  | 825                             | 14.7                                      |

| Name                        | Molecular formula               | $t_m/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                     | Molecular formula            | $t_m/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|-----------------------------|---------------------------------|------------------------|-------------------------------------------|--------------------------|------------------------------|------------------------|-------------------------------------------|
| Bismuth sulfide             | $\text{Bi}_2\text{S}_3$         | 777                    | 78.2                                      | Chromium(II) fluoride    | $\text{CrF}_2$               | 894                    | 34                                        |
| Bismuth tribromide          | $\text{BiBr}_3$                 | 219                    | 21.7                                      | Chromium(III) fluoride   | $\text{CrF}_3$               | 1425                   | 66                                        |
| Bismuth trichloride         | $\text{BiCl}_3$                 | 234                    | 23.6                                      | Chromium(II) iodide      | $\text{CrI}_2$               | 867                    | 46                                        |
| Bismuth trifluoride         | $\text{BiF}_3$                  | 649                    | 21.6                                      | Chromium(III) iodide     | $\text{CrI}_3$               | 857                    | 61                                        |
| Bismuth triiodide           | $\text{BiI}_3$                  | 408.6                  | 39.1                                      | Chromium(III) oxide      | $\text{Cr}_2\text{O}_3$      | 2432                   | 125                                       |
| Boric acid                  | $\text{BH}_3\text{O}_3$         | 170.9                  | 22.3                                      | Chromium(VI) oxide       | $\text{CrO}_3$               | 197                    | 14.2                                      |
| Boron                       | B                               | 2075                   | 50.2                                      | Chromium(II) sulfide     | $\text{CrS}$                 | 1567                   | 25.5                                      |
| Boron nitride               | BN                              | 2967                   | 81                                        | Cobalt                   | Co                           | 1495                   | 16.20                                     |
| Boron oxide                 | $\text{B}_2\text{O}_3$          | 450                    | 24.56                                     | Cobalt(II) bromide       | $\text{Br}_2\text{Co}$       | 678                    | 43                                        |
| Boron sulfide               | $\text{B}_2\text{S}_3$          | 563                    | 48.12                                     | Cobalt(II) chloride      | $\text{Cl}_2\text{Co}$       | 737                    | 46.0                                      |
| Boron trichloride           | $\text{BCl}_3$                  | -107.3                 | 2.10                                      | Cobalt(II) fluoride      | $\text{CoF}_2$               | 1127                   | 58.1                                      |
| Boron trifluoride           | $\text{BF}_3$                   | -126.8                 | 4.20                                      | Cobalt(II) iodide        | $\text{CoI}_2$               | 520                    | 35                                        |
| Bromine                     | $\text{Br}_2$                   | -7.2                   | 10.57                                     | Cobalt(II) selenite      | $\text{CoO}_3\text{Se}$      | 659                    | 16.3                                      |
| Bromine pentafluoride       | $\text{BrF}_5$                  | -60.5                  | 5.67                                      | Cobalt(II) sulfide       | $\text{CoS}$                 | 1117                   | 30                                        |
| Cadmium                     | Cd                              | 321.069                | 6.21                                      | Copper                   | Cu                           | 1084.62                | 13.26                                     |
| Cadmium bromide             | $\text{Br}_2\text{Cd}$          | 568                    | 33.35                                     | Copper(I) bromide        | $\text{BrCu}$                | 483                    | 5.1                                       |
| Cadmium chloride            | $\text{CdCl}_2$                 | 568                    | 48.58                                     | Copper(I) chloride       | $\text{ClCu}$                | 423                    | 7.08                                      |
| Cadmium fluoride            | $\text{CdF}_2$                  | 1075                   | 22.6                                      | Copper(II) chloride      | $\text{Cl}_2\text{Cu}$       | 598                    | 15.0                                      |
| Cadmium iodide              | $\text{CdI}_2$                  | 388                    | 15.3                                      | Copper(II) fluoride      | $\text{CuF}_2$               | 836                    | 55                                        |
| Cadmium nitrate             | $\text{CdN}_2\text{O}_6$        | 360                    | 18.3                                      | Copper(I) iodide         | $\text{CuI}$                 | 591                    | 7.93                                      |
| Calcium                     | Ca                              | 842                    | 8.54                                      | Copper(I) oxide          | $\text{Cu}_2\text{O}$        | 1244                   | 65.6                                      |
| Calcium bromide             | $\text{Br}_2\text{Ca}$          | 742                    | 29.1                                      | Copper(II) oxide         | $\text{CuO}$                 | 1227                   | 49                                        |
| Calcium carbonate (calcite) | $\text{CCaO}_3$                 | 800                    | 36                                        | Copper(I) sulfide        | $\text{Cu}_2\text{S}$        | 1129                   | 9.62                                      |
| Calcium chloride            | $\text{CaCl}_2$                 | 775                    | 28.05                                     | Curium                   | Cm                           | 1345                   | 14.64                                     |
| Calcium fluoride            | $\text{CaF}_2$                  | 1418                   | 30                                        | Decaborane(14)           | $\text{B}_{10}\text{H}_{14}$ | 98.78                  | 21.97                                     |
| Calcium hydride             | $\text{CaH}_2$                  | 1000                   | 6.7                                       | Dysprosium               | Dy                           | 1412                   | 11.35                                     |
| Calcium iodide              | $\text{CaI}_2$                  | 783                    | 41.8                                      | Dysprosium(III) fluoride | $\text{DyF}_3$               | 1157                   | 58.6                                      |
| Calcium nitrate             | $\text{CaN}_2\text{O}_6$        | 561                    | 23.4                                      | Dysprosium(III) oxide    | $\text{Dy}_2\text{O}_3$      | 2408                   | 120                                       |
| Calcium oxide               | $\text{CaO}$                    | 2613                   | 80                                        | Einsteinium              | Es                           | 860                    | 9.41                                      |
| Calcium sulfate             | $\text{CaO}_4\text{S}$          | 1460                   | 28                                        | Erbium                   | Er                           | 1529                   | 19.90                                     |
| Calcium sulfide             | $\text{CaS}$                    | 2524                   | 70                                        | Erbium chloride          | $\text{Cl}_3\text{Er}$       | 776                    | 32.6                                      |
| Carbon (graphite)           | C                               | 4489                   | 117.4                                     | Erbium fluoride          | $\text{ErF}_3$               | 1146                   | 28.2                                      |
| Cerium                      | Ce                              | 799                    | 5.460                                     | Erbium oxide             | $\text{Er}_2\text{O}_3$      | 2418                   | 130                                       |
| Cerium(III) bromide         | $\text{Br}_3\text{Ce}$          | 732                    | 51.9                                      | Europium                 | Eu                           | 822                    | 9.21                                      |
| Cerium(III) chloride        | $\text{CeCl}_3$                 | 807                    | 53.1                                      | Europium(II) bromide     | $\text{Br}_2\text{Eu}$       | 683                    | 25.1                                      |
| Cerium(III) fluoride        | $\text{CeF}_3$                  | 1430                   | 55.6                                      | Europium(III) chloride   | $\text{Cl}_3\text{Eu}$       | 623                    | 33.1                                      |
| Cerium(III) iodide          | $\text{CeI}_3$                  | 760                    | 51.0                                      | Europium(III) fluoride   | $\text{EuF}_3$               | 647                    | 6.40                                      |
| Cerium(III) oxide           | $\text{Ce}_2\text{O}_3$         | 2250                   | 120                                       | Europium(II) oxide       | $\text{EuO}$                 | 1967                   | 40                                        |
| Cerium(IV) oxide            | $\text{CeO}_2$                  | 2480                   | 80                                        | Europium(III) oxide      | $\text{Eu}_2\text{O}_3$      | 2350                   | 117                                       |
| Cesium                      | Cs                              | 28.5                   | 2.09                                      | Fluorine                 | $\text{F}_2$                 | -219.67                | 0.51                                      |
| Cesium carbonate            | $\text{CCs}_2\text{O}_3$        | 793                    | 31                                        | Gadolinium               | Gd                           | 1313                   | 9.67                                      |
| Cesium chloride             | $\text{ClCs}$                   | 646                    | 20.4                                      | Gadolinium(III) bromide  | $\text{Br}_3\text{Gd}$       | 785                    | 38.1                                      |
| Cesium chromate             | $\text{CrCs}_2\text{O}_4$       | 963                    | 35.3                                      | Gadolinium(III) chloride | $\text{Cl}_3\text{Gd}$       | 602                    | 40.6                                      |
| Cesium fluoride             | $\text{CsF}$                    | 703                    | 21.7                                      | Gadolinium(III) fluoride | $\text{F}_3\text{Gd}$        | 1232                   | 52.4                                      |
| Cesium hydride              | $\text{CsH}$                    | 528                    | 15                                        | Gadolinium(III) iodide   | $\text{GdI}_3$               | 930                    | 54.0                                      |
| Cesium hydroxide            | $\text{CsHO}$                   | 342.3                  | 7.78                                      | Gadolinium(III) oxide    | $\text{Gd}_2\text{O}_3$      | 2425                   | 60                                        |
| Cesium iodide               | $\text{CsI}$                    | 632                    | 25.7                                      | Gallium                  | Ga                           | 29.7666                | 5.585                                     |
| Cesium metaborate           | $\text{BCsO}_2$                 | 732                    | 27                                        | Gallium antimonide       | $\text{GaSb}$                | 712                    | 25.1                                      |
| Cesium molybdate            | $\text{Cs}_2\text{MoO}_4$       | 956.3                  | 31.8                                      | Gallium arsenide         | $\text{AsGa}$                | 1238                   | 87.64                                     |
| Cesium nitrate              | $\text{CsNO}_3$                 | 409                    | 13.8                                      | Gallium(III) bromide     | $\text{Br}_3\text{Ga}$       | 123                    | 11.7                                      |
| Cesium nitrite              | $\text{CsNO}_2$                 | 406                    | 10.9                                      | Gallium(III) chloride    | $\text{Cl}_3\text{Ga}$       | 77.9                   | 11.51                                     |
| Cesium oxide                | $\text{Cs}_2\text{O}$           | 495                    | 20                                        | Gallium(III) iodide      | $\text{GaI}_3$               | 212                    | 12.9                                      |
| Cesium peroxide             | $\text{Cs}_2\text{O}_2$         | 594                    | 22                                        | Gallium(III) oxide       | $\text{Ga}_2\text{O}_3$      | 1807                   | 100                                       |
| Cesium sulfate              | $\text{Cs}_2\text{O}_4\text{S}$ | 1005                   | 35.7                                      | Germanium                | Ge                           | 938.25                 | 36.94                                     |
| Chlorine                    | $\text{Cl}_2$                   | -101.5                 | 6.40                                      | Germanium(IV) bromide    | $\text{Br}_4\text{Ge}$       | 26.1                   | 12                                        |
| Chromium                    | Cr                              | 1907                   | 21.00                                     | Germanium(II) iodide     | $\text{GeI}_2$               | 428                    | 33.3                                      |
| Chromium(II) bromide        | $\text{Br}_2\text{Cr}$          | 842                    | 45                                        | Germanium(IV) iodide     | $\text{GeI}_4$               | 146                    | 19.1                                      |
| Chromium(III) bromide       | $\text{Br}_3\text{Cr}$          | 812                    | 60                                        | Germanium(IV) oxide      | $\text{GeO}_2$               | 1116                   | 12.6                                      |
| Chromium(II) chloride       | $\text{Cl}_2\text{Cr}$          | 824                    | 45.0                                      | Germanium(II) selenide   | $\text{GeSe}$                | 675                    | 24.7                                      |
| Chromium(III) chloride      | $\text{Cl}_3\text{Cr}$          | 827                    | 60                                        | Germanium(II) sulfide    | $\text{GeS}$                 | 658                    | 21.3                                      |

| Name                    | Molecular<br>formula           | $t_m/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                                                | Molecular<br>formula                          | $t_m/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|-------------------------|--------------------------------|------------------------|-------------------------------------------|-----------------------------------------------------|-----------------------------------------------|------------------------|-------------------------------------------|
| Germanium(IV) sulfide   | GeS <sub>2</sub>               | 840                    | 16.3                                      | Lead(II) oxide (massicot)                           | OPb                                           | 887                    | 25.6                                      |
| Germanium(II) telluride | GeTe                           | 724                    | 47.3                                      | Lead(II) sulfate                                    | O <sub>4</sub> PbS                            | 1087                   | 40.2                                      |
| Gold                    | Au                             | 1064.18                | 12.55                                     | Lead(II) sulfide                                    | PbS                                           | 1113                   | 49.4                                      |
| Hafnium                 | Hf                             | 2233                   | 27.20                                     | Lithium                                             | Li                                            | 180.50                 | 3.00                                      |
| Hafnium nitride         | HfN                            | 3310                   | 62.8                                      | Lithium aluminate                                   | AlLiO <sub>2</sub>                            | 1610                   | 87.9                                      |
| Hafnium(IV) oxide       | HfO <sub>2</sub>               | 2800                   | 96                                        | Lithium bromide                                     | BrLi                                          | 550                    | 17.66                                     |
| Holmium                 | Ho                             | 1472                   | 11.76                                     | Lithium carbonate                                   | CLi <sub>2</sub> O <sub>3</sub>               | 732                    | 44.8                                      |
| Holmium bromide         | Br <sub>3</sub> Ho             | 919                    | 50.1                                      | Lithium chloride                                    | CLi                                           | 610                    | 19.8                                      |
| Holmium chloride        | Cl <sub>3</sub> Ho             | 720                    | 30.5                                      | Lithium chromate                                    | CrLi <sub>2</sub> O <sub>4</sub>              | 482                    | 30.5                                      |
| Holmium fluoride        | F <sub>3</sub> Ho              | 1143                   | 56.3                                      | Lithium fluoride                                    | FLi                                           | 848.2                  | 27.09                                     |
| Holmium oxide           | Ho <sub>2</sub> O <sub>3</sub> | 2415                   | 130                                       | Lithium hexafluoroaluminate                         | AlF <sub>6</sub> Li <sub>3</sub>              | 785                    | 86.19                                     |
| Hydrazine               | H <sub>4</sub> N <sub>2</sub>  | 1.54                   | 12.66                                     | Lithium hydride                                     | HLi                                           | 692                    | 21.8                                      |
| Hydrogen                | H <sub>2</sub>                 | -259.198 t             | 0.12                                      | Lithium hydride- <i>d</i>                           | DLi                                           | 694                    | 22                                        |
| Hydrogen bromide        | BrH                            | -86.80                 | 2.41                                      | Lithium hydroxide                                   | HLiO                                          | 473                    | 20.9                                      |
| Hydrogen chloride       | ClH                            | -114.17                | 2.00                                      | Lithium iodide                                      | ILi                                           | 469                    | 14.6                                      |
| Hydrogen fluoride       | FH                             | -83.36                 | 4.58                                      | Lithium metasilicate                                | Li <sub>2</sub> O <sub>3</sub> Si             | 1201                   | 28                                        |
| Hydrogen iodide         | HI                             | -50.76                 | 2.87                                      | Lithium nitrate                                     | LiNO <sub>3</sub>                             | 253                    | 26.7                                      |
| Hydrogen peroxide       | H <sub>2</sub> O <sub>2</sub>  | -0.43                  | 12.50                                     | Lithium nitrite                                     | LiNO <sub>2</sub>                             | 222                    | 9.2                                       |
| Hydrogen sulfide        | H <sub>2</sub> S               | -85.5                  | 2.38                                      | Lithium oxide                                       | Li <sub>2</sub> O                             | 1438                   | 35.6                                      |
| Indium                  | In                             | 156.60                 | 3.291                                     | Lithium perchlorate                                 | CLiO <sub>4</sub>                             | 236                    | 29.3                                      |
| Indium antimonide       | InSb                           | 524                    | 47.7                                      | Lithium sulfate                                     | Li <sub>2</sub> O <sub>4</sub> S              | 860                    | 9.00                                      |
| Indium arsenide         | AsIn                           | 942                    | 77.0                                      | Lutetium                                            | Lu                                            | 1663                   | 18.65                                     |
| Indium(I) bromide       | BrIn                           | 285                    | 24.3                                      | Lutetium oxide                                      | Lu <sub>2</sub> O <sub>3</sub>                | 2490                   | 133                                       |
| Indium(III) bromide     | Br <sub>3</sub> In             | 420                    | 26                                        | Magnesium                                           | Mg                                            | 650                    | 8.48                                      |
| Indium(I) chloride      | ClIn                           | 225                    | 9.20                                      | Magnesium bromide                                   | Br <sub>2</sub> Mg                            | 711                    | 39.3                                      |
| Indium(III) chloride    | Cl <sub>3</sub> In             | 583                    | 27                                        | Magnesium carbonate                                 | CMgO <sub>3</sub>                             | 990                    | 59                                        |
| Indium(III) fluoride    | F <sub>3</sub> In              | 1172                   | 64                                        | Magnesium chloride                                  | Cl <sub>2</sub> Mg                            | 714                    | 43.1                                      |
| Indium(I) iodide        | IIn                            | 364.4                  | 17.26                                     | Magnesium fluoride                                  | F <sub>2</sub> Mg                             | 1263                   | 58.7                                      |
| Indium(II) iodide       | I <sub>2</sub> In              | 155                    | 1.29                                      | Magnesium hydride                                   | H <sub>2</sub> Mg                             | 327                    | 14                                        |
| Indium(III) iodide      | I <sub>3</sub> In              | 207                    | 18.48                                     | Magnesium iodide                                    | I <sub>2</sub> Mg                             | 634                    | 26                                        |
| Indium(III) oxide       | In <sub>2</sub> O <sub>3</sub> | 1912                   | 105                                       | Magnesium orthosilicate                             | Mg <sub>2</sub> O <sub>4</sub> Si             | 1897                   | 71                                        |
| Indium(II) sulfide      | InS                            | 692                    | 36.0                                      | Magnesium oxide                                     | MgO                                           | 2825                   | 77                                        |
| Iodine                  | I <sub>2</sub>                 | 113.7                  | 15.52                                     | Magnesium phosphate                                 | Mg <sub>3</sub> O <sub>4</sub> P <sub>2</sub> | 1348                   | 121                                       |
| Iodine chloride         | ClI                            | 27.38                  | 11.6                                      | Magnesium sulfate                                   | MgO <sub>4</sub> S                            | 1137                   | 14.6                                      |
| Iridium                 | Ir                             | 2446                   | 41.12                                     | Magnesium sulfide                                   | MgS                                           | 2226                   | 63                                        |
| Iridium(VI) fluoride    | F <sub>6</sub> Ir              | 44                     | 8.40                                      | Magnesium tetraboride                               | B <sub>4</sub> Mg                             | 727                    | 0.0                                       |
| Iron                    | Fe                             | 1538                   | 13.81                                     | Manganese                                           | Mn                                            | 1246                   | 12.91                                     |
| Iron boride (FeB)       | BFe                            | 1658                   | 62.66                                     | Manganese(II) bromide                               | Br <sub>2</sub> Mn                            | 698                    | 33.5                                      |
| Iron(II) bromide        | Br <sub>2</sub> Fe             | 691                    | 43.0                                      | Manganese(II) chloride                              | Cl <sub>2</sub> Mn                            | 650                    | 30.7                                      |
| Iron(II) chloride       | Cl <sub>2</sub> Fe             | 677                    | 42.83                                     | Manganese(II) fluoride                              | F <sub>2</sub> Mn                             | 900                    | 30                                        |
| Iron(III) chloride      | Cl <sub>3</sub> Fe             | 307.6                  | 40                                        | Manganese(II) iodide                                | I <sub>2</sub> Mn                             | 638                    | 41.8                                      |
| Iron(II) fluoride       | F <sub>2</sub> Fe              | 1100                   | 50                                        | Manganese(II) oxide                                 | MnO                                           | 1842                   | 43.9                                      |
| Iron(III) fluoride      | F <sub>3</sub> Fe              | 367                    | 0.58                                      | Manganese(II) sulfide ( $\alpha$ form)              | MnS                                           | 1530                   | 26.1                                      |
| Iron(II) iodide         | FeI <sub>2</sub>               | 594                    | 39                                        | Mercury                                             | Hg                                            | -38.829                | 2.295                                     |
| Iron(II) oxide          | FeO                            | 1377                   | 24.1                                      | Mercury(II) bromide                                 | Br <sub>2</sub> Hg                            | 241                    | 17.9                                      |
| Iron(II,III) oxide      | Fe <sub>3</sub> O <sub>4</sub> | 1597                   | 138                                       | Mercury(II) chloride                                | Cl <sub>2</sub> Hg                            | 277                    | 19.41                                     |
| Iron(III) oxide         | Fe <sub>2</sub> O <sub>3</sub> | 1539                   | 87                                        | Mercury(II) fluoride                                | F <sub>2</sub> Hg                             | 645                    | 23.0                                      |
| Iron sodium oxide       | FeNaO <sub>2</sub>             | 1347                   | 49.4                                      | Mercury(I) iodide                                   | Hg <sub>2</sub> I <sub>2</sub>                | 290                    | 31.4                                      |
| Iron(II) sulfide        | FeS                            | 1188                   | 31.5                                      | Mercury(II) iodide (yellow)                         | HgI <sub>2</sub>                              | 256                    | 15.6                                      |
| Krypton                 | Kr                             | -157.38                | 1.64                                      | Mercury(II) sulfide (black)                         | HgS                                           | 820                    | 40                                        |
| Lanthanum               | La                             | 920                    | 6.20                                      | Metaboric acid ( $\gamma$ form)                     | BHO <sub>2</sub>                              | 236                    | 14.3                                      |
| Lanthanum bromide       | Br <sub>3</sub> La             | 788                    | 54.0                                      | Molybdenum                                          | Mo                                            | 2623                   | 37.48                                     |
| Lanthanum chloride      | Cl <sub>3</sub> La             | 858                    | 54.4                                      | Molybdenum boride (Mo <sub>2</sub> B <sub>5</sub> ) | B <sub>5</sub> Mo <sub>2</sub>                | 2210                   | 226                                       |
| Lanthanum fluoride      | F <sub>3</sub> La              | 1493                   | 50.2                                      | Molybdenum(IV) chloride                             | Cl <sub>4</sub> Mo                            | 317                    | 16.7                                      |
| Lanthanum iodide        | I <sub>3</sub> La              | 778                    | 56.1                                      | Molybdenum(V) chloride                              | Cl <sub>5</sub> Mo                            | 194                    | 19                                        |
| Lead                    | Pb                             | 327.462                | 4.774                                     | Molybdenum(VI) dioxydichloride                      | Cl <sub>2</sub> MoO <sub>2</sub>              | 176                    | 17.0                                      |
| Lead(II) bromide        | Br <sub>2</sub> Pb             | 371                    | 16.44                                     | Molybdenum(V) fluoride                              | F <sub>5</sub> Mo                             | 45.67                  | 6.1                                       |
| Lead(II) chloride       | Cl <sub>2</sub> Pb             | 501                    | 21.88                                     | Molybdenum(VI) fluoride                             | F <sub>6</sub> Mo                             | 17.5                   | 4.33                                      |
| Lead(II) fluoride       | F <sub>2</sub> Pb              | 830                    | 14.7                                      | Molybdenum monoboride                               | BMo                                           | 2600                   | 55.23                                     |
| Lead(II) iodide         | I <sub>2</sub> Pb              | 410                    | 23.4                                      | Molybdenum(VI) oxide                                | MoO <sub>3</sub>                              | 802                    | 48.7                                      |



| Name                                    | Molecular formula              | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                        | Molecular formula               | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|-----------------------------------------|--------------------------------|----------------------|-------------------------------------------|-----------------------------|---------------------------------|----------------------|-------------------------------------------|
| Molybdenum(VI) oxytetrachloride         | $\text{Cl}_4\text{MoO}$        | 105                  | 14.3                                      | Plutonium(III) iodide       | $\text{I}_3\text{Pu}$           | 777                  | 50.2                                      |
| Molybdenum(VI) oxytetrafluoride         | $\text{F}_4\text{MoO}$         | 97.2                 | 4                                         | Plutonium(III) oxide        | $\text{O}_3\text{Pu}_2$         | 2085                 | 113                                       |
| Molybdenum(V) oxytrichloride            | $\text{Cl}_3\text{MoO}$        | 310                  | 22                                        | Plutonium(IV) oxide         | $\text{O}_2\text{Pu}$           | 2390                 | 67                                        |
| Molybdenum(III) sulfide                 | $\text{Mo}_2\text{S}_3$        | 1807                 | 0.13                                      | Polonium                    | Po                              | 254                  | 10.0                                      |
| Neodymium                               | Nd                             | 1016                 | 7.14                                      | Potassium                   | K                               | 63.5                 | 2.335                                     |
| Neodymium(III) bromide                  | $\text{Br}_3\text{Nd}$         | 682                  | 45.3                                      | Potassium aluminate         | $\text{AlKO}_2$                 | 1713                 | 82                                        |
| Neodymium(III) chloride                 | $\text{Cl}_3\text{Nd}$         | 759                  | 48.5                                      | Potassium bromide           | BrK                             | 734                  | 25.52                                     |
| Neodymium(III) fluoride                 | $\text{F}_3\text{Nd}$          | 1377                 | 54.8                                      | Potassium carbonate         | $\text{CK}_2\text{O}_3$         | 899                  | 27.6                                      |
| Neodymium(III) iodide                   | $\text{I}_3\text{Nd}$          | 787                  | 41.5                                      | Potassium chloride          | ClK                             | 771                  | 26.28                                     |
| Neon                                    | Ne                             | -248.609             | 0.328                                     | Potassium chromate          | $\text{CrK}_2\text{O}_4$        | 974                  | 33.0                                      |
| Neptunium                               | Np                             | 644                  | 3.20                                      | Potassium cyanide           | CKN                             | 622                  | 14.6                                      |
| Nickel                                  | Ni                             | 1455                 | 17.48                                     | Potassium fluoride          | FK                              | 858                  | 27.2                                      |
| Nickel boride ( $\text{Ni}_2\text{B}$ ) | $\text{BNi}_2$                 | 1125                 | 42.15                                     | Potassium fluoroborate      | $\text{BF}_4\text{K}$           | 570                  | 17.66                                     |
| Nickel boride ( $\text{Ni}_3\text{B}$ ) | $\text{BNi}_3$                 | 1166                 | 72.28                                     | Potassium hydride           | HK                              | 619                  | 21                                        |
| Nickel(II) bromide                      | $\text{Br}_2\text{Ni}$         | 963                  | 56                                        | Potassium hydrogen fluoride | $\text{F}_2\text{HK}$           | 238.8                | 6.62                                      |
| Nickel(II) chloride                     | $\text{Cl}_2\text{Ni}$         | 1031                 | 77.9                                      | Potassium hydroxide         | HKO                             | 406                  | 7.90                                      |
| Nickel(II) fluoride                     | $\text{F}_2\text{Ni}$          | 1380                 | 69                                        | Potassium iodide            | IK                              | 681                  | 24.0                                      |
| Nickel(II) iodide                       | $\text{I}_2\text{Ni}$          | 800                  | 48                                        | Potassium metaborate        | $\text{BKO}_2$                  | 947                  | 31.38                                     |
| Nickel(II) oxide                        | NiO                            | 1957                 | 50.7                                      | Potassium nitrate           | $\text{KNO}_3$                  | 334                  | 9.6                                       |
| Nickel(II) sulfide                      | NiS                            | 976                  | 30.1                                      | Potassium nitrite           | $\text{KNO}_2$                  | 438                  | 16.7                                      |
| Nickel disulfide                        | $\text{NiS}_2$                 | 1007                 | 65.7                                      | Potassium oxide             | $\text{K}_2\text{O}$            | 740                  | 27                                        |
| Nickel subsulfide                       | $\text{Ni}_3\text{S}_2$        | 789                  | 19.7                                      | Potassium peroxide          | $\text{K}_2\text{O}_2$          | 545                  | 20.5                                      |
| Niobium                                 | Nb                             | 2477                 | 30                                        | Potassium sulfate           | $\text{K}_2\text{O}_4\text{S}$  | 1069                 | 36.6                                      |
| Niobium(V) bromide                      | $\text{Br}_5\text{Nb}$         | 254                  | 24.0                                      | Potassium sulfide           | $\text{K}_2\text{S}$            | 948                  | 16.15                                     |
| Niobium(V) chloride                     | $\text{Cl}_5\text{Nb}$         | 205.8                | 33.9                                      | Potassium superoxide        | $\text{KO}_2$                   | 535                  | 20.6                                      |
| Niobium(V) fluoride                     | $\text{F}_5\text{Nb}$          | 80                   | 12.2                                      | Praseodymium                | Pr                              | 931                  | 6.89                                      |
| Niobium(V) iodide                       | $\text{I}_5\text{Nb}$          | 327                  | 37.7                                      | Praseodymium(III) bromide   | $\text{Br}_3\text{Pr}$          | 693                  | 47.3                                      |
| Niobium nitride                         | NNb                            | 2050                 | 46.0                                      | Praseodymium(III) chloride  | $\text{Cl}_3\text{Pr}$          | 786                  | 50.6                                      |
| Niobium(II) oxide                       | NbO                            | 1937                 | 85.4                                      | Praseodymium(III) fluoride  | $\text{F}_3\text{Pr}$           | 1399                 | 57.3                                      |
| Niobium(IV) oxide                       | $\text{NbO}_2$                 | 1901                 | 92                                        | Praseodymium(III) iodide    | $\text{I}_3\text{Pr}$           | 738                  | 53.1                                      |
| Niobium(V) oxide                        | $\text{Nb}_2\text{O}_5$        | 1512                 | 104.3                                     | Protactinium                | Pa                              | 1572                 | 12.34                                     |
| Nitric acid                             | $\text{HNO}_3$                 | -41.6                | 10.5                                      | Radium                      | Ra                              | 696                  | 7.7                                       |
| Nitric oxide                            | NO                             | -163.6               | 2.30                                      | Rhenium                     | Re                              | 3185                 | 34.08                                     |
| Nitrogen                                | $\text{N}_2$                   | -210.0               | 0.71                                      | Rhenium(VII) oxide          | $\text{O}_7\text{Re}_2$         | 327                  | 65.7                                      |
| Nitrogen tetroxide                      | $\text{N}_2\text{O}_4$         | -9.3                 | 14.65                                     | Rhodium                     | Rh                              | 1964                 | 26.59                                     |
| Nitrous oxide                           | $\text{N}_2\text{O}$           | -90.8                | 6.54                                      | Rubidium                    | Rb                              | 39.30                | 2.19                                      |
| Osmium                                  | Os                             | 3033                 | 57.85                                     | Rubidium bromide            | BrRb                            | 692                  | 23.3                                      |
| Osmium(VIII) oxide                      | $\text{O}_4\text{Os}$          | 40.6                 | 14.3                                      | Rubidium carbonate          | $\text{CO}_3\text{Rb}_2$        | 873                  | 30                                        |
| Oxygen                                  | $\text{O}_2$                   | -218.79              | 0.44                                      | Rubidium chloride           | ClRb                            | 724                  | 24.4                                      |
| Palladium                               | Pd                             | 1554.8               | 16.74                                     | Rubidium fluoride           | FRb                             | 795                  | 25.8                                      |
| Palladium(II) chloride                  | $\text{Cl}_2\text{Pd}$         | 679                  | 18.41                                     | Rubidium hydride            | HRb                             | 585                  | 22                                        |
| Phosphinic acid                         | $\text{H}_3\text{O}_2\text{P}$ | 26.5                 | 9.7                                       | Rubidium hydroxide          | HORb                            | 385                  | 8.0                                       |
| Phosphonic acid                         | $\text{H}_3\text{O}_3\text{P}$ | 74.4                 | 12.8                                      | Rubidium iodide             | IRb                             | 656                  | 22.1                                      |
| Phosphoric acid                         | $\text{H}_3\text{O}_4\text{P}$ | 42.4                 | 13.4                                      | Rubidium metaborate         | $\text{BO}_2\text{Rb}$          | 860                  | 31                                        |
| Phosphorus (white)                      | P                              | 44.15                | 0.659                                     | Rubidium nitrate            | $\text{NO}_3\text{Rb}$          | 310                  | 4.6                                       |
| Phosphorus (red)                        | P                              | 579.2                | 18.54                                     | Rubidium nitrite            | $\text{NO}_2\text{Rb}$          | 422                  | 12.1                                      |
| Phosphorus(III) chloride                | $\text{Cl}_3\text{P}$          | -93                  | 7.10                                      | Rubidium oxide              | $\text{ORb}_2$                  | 505                  | 20                                        |
| Phosphorus heptasulfide                 | $\text{P}_4\text{S}_7$         | 308                  | 36.6                                      | Rubidium peroxide           | $\text{O}_2\text{Rb}_2$         | 570                  | 21                                        |
| Phosphorus(V) oxide                     | $\text{O}_5\text{P}_2$         | 562                  | 27.2                                      | Rubidium sulfate            | $\text{O}_4\text{Rb}_2\text{S}$ | 1066                 | 37.3                                      |
| Phosphorus sesquisulfide                | $\text{P}_4\text{S}_3$         | 173                  | 20.1                                      | Rubidium superoxide         | $\text{O}_2\text{Rb}$           | 540                  | 21                                        |
| Phosphoryl chloride                     | $\text{Cl}_3\text{OP}$         | 1.18                 | 13.1                                      | Ruthenium                   | Ru                              | 2333                 | 38.59                                     |
| Platinum                                | Pt                             | 1768.2               | 22.175                                    | Ruthenium(V) fluoride       | $\text{F}_5\text{Ru}$           | 101                  | 74.5                                      |
| Plutonium                               | Pu                             | 640                  | 2.824                                     | Samarium                    | Sm                              | 1072                 | 8.62                                      |
| Plutonium(III) bromide                  | $\text{Br}_3\text{Pu}$         | 681                  | 58.6                                      | Samarium(III) oxide         | $\text{O}_3\text{Sm}_2$         | 2335                 | 119                                       |
| Plutonium(III) chloride                 | $\text{Cl}_3\text{Pu}$         | 760                  | 63.6                                      | Scandium                    | Sc                              | 1541                 | 14.10                                     |
| Plutonium(III) fluoride                 | $\text{F}_3\text{Pu}$          | 1396                 | 59.8                                      | Scandium chloride           | $\text{Cl}_3\text{Sc}$          | 967                  | 67.4                                      |
| Plutonium(IV) fluoride                  | $\text{F}_4\text{Pu}$          | 1037                 | 42.7                                      | Scandium fluoride           | $\text{F}_3\text{Sc}$           | 1552                 | 62.6                                      |
| Plutonium(VI) fluoride                  | $\text{F}_6\text{Pu}$          | 51.6                 | 18.6                                      | Scandium oxide              | $\text{O}_3\text{Sc}_2$         | 2489                 | 127                                       |
|                                         |                                |                      |                                           | Selenium (gray)             | Se                              | 220.8                | 6.69                                      |
|                                         |                                |                      |                                           | Selenium dioxide            | $\text{O}_2\text{Se}$           | 360                  | 17.6                                      |

| Name                                 | Molecular formula                 | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                                             | Molecular formula               | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|--------------------------------------|-----------------------------------|----------------------|-------------------------------------------|--------------------------------------------------|---------------------------------|----------------------|-------------------------------------------|
| Silicon                              | Si                                | 1414                 | 50.21                                     | Tantalum(V) oxide                                | O <sub>5</sub> Ta <sub>2</sub>  | 1875                 | 120                                       |
| Silicon dioxide (cristobalite)       | O <sub>2</sub> Si                 | 1722                 | 9.6                                       | Techneium                                        | Tc                              | 2157                 | 33.29                                     |
| Silicon monosulfide                  | SSi                               | 1090                 | 31                                        | Tellurium                                        | Te                              | 449.51               | 17.38                                     |
| Silver                               | Ag                                | 961.78               | 11.30                                     | Tellurium dioxide                                | O <sub>2</sub> Te               | 733                  | 28.9                                      |
| Silver(I) bromide                    | AgBr                              | 430                  | 9.163                                     | Tellurium tetrabromide                           | Br <sub>4</sub> Te              | 380                  | 24.7                                      |
| Silver(I) chloride                   | AgCl                              | 455                  | 13.054                                    | Tellurium tetrachloride                          | Cl <sub>4</sub> Te              | 224                  | 18.9                                      |
| Silver(I) iodide                     | AgI                               | 558                  | 9.414                                     | Terbium                                          | Tb                              | 1359                 | 10.15                                     |
| Silver(I) nitrate                    | AgNO <sub>3</sub>                 | 210                  | 11.72                                     | Terbium(III) bromide                             | Br <sub>3</sub> Tb              | 830                  | 31.5                                      |
| Silver(I) oxide                      | Ag <sub>2</sub> O                 | 827                  | 15                                        | Terbium(III) chloride                            | Cl <sub>3</sub> Tb              | 582                  | 19.5                                      |
| Silver(I) sulfate                    | Ag <sub>2</sub> O <sub>4</sub> S  | 660                  | 17.99                                     | Tetrachlorosilane                                | Cl <sub>4</sub> Si              | -68.74               | 7.60                                      |
| Silver(I) sulfide                    | Ag <sub>2</sub> S                 | 836                  | 7.9                                       | Tetraiodosilane                                  | I <sub>4</sub> Si               | 120.5                | 19.7                                      |
| Sodium                               | Na                                | 97.794               | 2.60                                      | Thallium                                         | Tl                              | 304                  | 4.142                                     |
| Sodium bromate                       | BrNaO <sub>3</sub>                | 381                  | 28.11                                     | Thallium(I) bromide                              | BrTl                            | 460                  | 16.4                                      |
| Sodium bromide                       | BrNa                              | 747                  | 26.23                                     | Thallium(I) carbonate                            | CO <sub>3</sub> Tl <sub>2</sub> | 273                  | 18                                        |
| Sodium carbonate                     | CNa <sub>2</sub> O <sub>3</sub>   | 856                  | 29.7                                      | Thallium(I) chloride                             | ClTl                            | 431                  | 15.56                                     |
| Sodium chlorate                      | ClNaO <sub>3</sub>                | 248                  | 22.6                                      | Thallium(I) fluoride                             | FTl                             | 326                  | 13.87                                     |
| Sodium chloride                      | ClNa                              | 800.7                | 28.16                                     | Thallium(I) formate                              | CHO <sub>2</sub> Tl             | 101                  | 10.9                                      |
| Sodium chromate                      | CrNa <sub>2</sub> O <sub>4</sub>  | 794                  | 24.7                                      | Thallium(I) iodide                               | ITl                             | 441.7                | 14.7                                      |
| Sodium cyanide                       | CNNa                              | 562                  | 8.79                                      | Thallium(I) nitrate                              | NO <sub>3</sub> Tl              | 206                  | 9.6                                       |
| Sodium fluoride                      | FNa                               | 996                  | 33.35                                     | Thallium(I) oxide                                | OTl <sub>2</sub>                | 579                  | 30.3                                      |
| Sodium formate                       | CHNaO <sub>2</sub>                | 257.3                | 17.7                                      | Thallium(III) oxide                              | O <sub>3</sub> Tl <sub>2</sub>  | 834                  | 53                                        |
| Sodium hexafluoroaluminate           | AlF <sub>6</sub> Na <sub>3</sub>  | 1013                 | 114.4                                     | Thallium(I) sulfate                              | O <sub>3</sub> STl <sub>2</sub> | 632                  | 23.8                                      |
| Sodium hexafluorosilicate            | F <sub>6</sub> Na <sub>2</sub> Si | 847                  | 99.6                                      | Thallium(I) sulfide                              | STl <sub>2</sub>                | 457                  | 23.0                                      |
| Sodium hydride                       | HNa                               | 638                  | 26                                        | Thorium                                          | Th                              | 1750                 | 13.81                                     |
| Sodium hydroxide                     | HNaO                              | 323                  | 6.60                                      | Thorium(IV) bromide                              | Br <sub>4</sub> Th              | 679                  | 54.4                                      |
| Sodium iodate                        | INaO <sub>3</sub>                 | 422                  | 35.1                                      | Thorium(IV) chloride                             | Cl <sub>4</sub> Th              | 770                  | 43.9                                      |
| Sodium iodide                        | INa                               | 661                  | 23.7                                      | Thorium(IV) fluoride                             | F <sub>4</sub> Th               | 1110                 | 41.8                                      |
| Sodium metaborate                    | BNaO <sub>2</sub>                 | 966                  | 36.2                                      | Thorium(IV) iodide                               | I <sub>4</sub> Th               | 566                  | 48.1                                      |
| Sodium metasilicate                  | Na <sub>2</sub> O <sub>3</sub> Si | 1089                 | 51.8                                      | Thorium(IV) oxide                                | O <sub>2</sub> Th               | 3350                 | 90                                        |
| Sodium nitrate                       | NNaO <sub>3</sub>                 | 306.5                | 15.5                                      | Thulium                                          | Tm                              | 1545                 | 16.84                                     |
| Sodium nitrite                       | NNaO <sub>2</sub>                 | 284                  | 14.9                                      | Thulium(III) chloride                            | Cl <sub>3</sub> Tm              | 845                  | 34.9                                      |
| Sodium oxide                         | Na <sub>2</sub> O                 | 1134                 | 47.7                                      | Thulium(III) fluoride                            | F <sub>3</sub> Tm               | 1158                 | 28.9                                      |
| Sodium peroxide                      | Na <sub>2</sub> O <sub>2</sub>    | 675                  | 24.5                                      | Tin (white)                                      | Sn                              | 231.93               | 7.15                                      |
| Sodium sulfate                       | Na <sub>2</sub> O <sub>4</sub> S  | 884                  | 23.85                                     | Tin(II) bromide                                  | Br <sub>2</sub> Sn              | 232                  | 18.0                                      |
| Sodium sulfide                       | Na <sub>2</sub> S                 | 1172                 | 19                                        | Tin(IV) bromide                                  | Br <sub>4</sub> Sn              | 29.1                 | 12.2                                      |
| Sodium sulfite                       | Na <sub>2</sub> O <sub>3</sub> S  | 911                  | 25.9                                      | Tin(II) chloride                                 | Cl <sub>2</sub> Sn              | 247.0                | 14.52                                     |
| Strontium                            | Sr                                | 777                  | 7.43                                      | Tin(IV) chloride                                 | Cl <sub>4</sub> Sn              | -34.07               | 9.20                                      |
| Strontium bromide                    | Br <sub>2</sub> Sr                | 657                  | 10.5                                      | Tin(II) fluoride                                 | F <sub>2</sub> Sn               | 215                  | 10.5                                      |
| Strontium carbonate                  | CO <sub>3</sub> Sr                | 1494                 | 40                                        | Tin(IV) fluoride                                 | F <sub>4</sub> Sn               | 442                  | 27.6                                      |
| Strontium chloride                   | Cl <sub>2</sub> Sr                | 874                  | 16.22                                     | Tin(II) iodide                                   | I <sub>2</sub> Sn               | 320                  | 18.0                                      |
| Strontium fluoride                   | F <sub>2</sub> Sr                 | 1477                 | 29.7                                      | Tin(IV) iodide                                   | I <sub>4</sub> Sn               | 402                  | 0.16                                      |
| Strontium hydride                    | H <sub>2</sub> Sr                 | 1050                 | 23                                        | Tin(II) oxide                                    | OSn                             | 977                  | 27.7                                      |
| Strontium hydroxide                  | H <sub>2</sub> O <sub>2</sub> Sr  | 535                  | 23                                        | Tin(IV) oxide                                    | O <sub>2</sub> Sn               | 1630                 | 23.4                                      |
| Strontium iodide                     | I <sub>2</sub> Sr                 | 538                  | 19.7                                      | Tin(II) sulfide                                  | SSn                             | 881                  | 31.6                                      |
| Strontium nitrate                    | N <sub>2</sub> O <sub>6</sub> Sr  | 570                  | 44.6                                      | Tin(II) telluride                                | SnTe                            | 806                  | 45.2                                      |
| Strontium oxide                      | OSr                               | 2531                 | 81                                        | Titanium                                         | Ti                              | 1668                 | 14.15                                     |
| Strontium sulfate                    | O <sub>4</sub> SSr                | 1606                 | 36                                        | Titanium boride                                  | B <sub>2</sub> Ti               | 2920                 | 100.4                                     |
| Strontium sulfide                    | SSr                               | 2226                 | 63                                        | Titanium(IV) bromide                             | Br <sub>4</sub> Ti              | 38.3                 | 12.9                                      |
| Sulfur (monoclinic)                  | S                                 | 115.21               | 1.721                                     | Titanium(II) chloride                            | Cl <sub>2</sub> Ti              | 1035                 | 34.3                                      |
| Sulfur hexafluoride                  | F <sub>6</sub> S                  | -49.596              | 5.02                                      | Titanium(IV) chloride                            | Cl <sub>4</sub> Ti              | -24.12               | 9.97                                      |
| Sulfuric acid                        | H <sub>2</sub> O <sub>4</sub> S   | 10.31                | 10.71                                     | Titanium(IV) fluoride                            | F <sub>4</sub> Ti               | 377                  | 41                                        |
| Sulfur trioxide (γ-form)             | O <sub>3</sub> S                  | 16.8                 | 8.60                                      | Titanium(IV) iodide                              | I <sub>4</sub> Ti               | 155                  | 19.8                                      |
| Tantalum                             | Ta                                | 3017                 | 36.57                                     | Titanium nitride                                 | NTi                             | 2947                 | 66.9                                      |
| Tantalum boride (TaB <sub>2</sub> )  | B <sub>2</sub> Ta                 | 3100                 | 83.68                                     | Titanium(III) oxide                              | O <sub>3</sub> Ti <sub>2</sub>  | 1842                 | 104.6                                     |
| Tantalum(V) bromide                  | Br <sub>5</sub> Ta                | 240                  | 37.7                                      | Titanium(IV) oxide (rutile)                      | O <sub>2</sub> Ti               | 1912                 | 68                                        |
| Tantalum(V) chloride                 | Cl <sub>5</sub> Ta                | 216.6                | 35.1                                      | Titanium(II) sulfide                             | STi                             | 1927                 | 32                                        |
| Tantalum(V) fluoride                 | F <sub>5</sub> Ta                 | 96.9                 | 12                                        | Tungsten                                         | W                               | 3422                 | 52.31                                     |
| Tantalum(V) iodide                   | I <sub>5</sub> Ta                 | 496                  | 7.74                                      | Tungsten boride (WB)                             | BW                              | 2800                 | 80                                        |
| Tantalum nitride (TaN)               | NTa                               | 3090                 | 6.7                                       | Tungsten boride (W <sub>2</sub> B)               | BW <sub>2</sub>                 | 2740                 | 117                                       |
| Tantalum nitride (Ta <sub>2</sub> N) | NTa <sub>2</sub>                  | 2727                 | 92.0                                      | Tungsten boride (W <sub>2</sub> B <sub>3</sub> ) | B <sub>5</sub> W <sub>2</sub>   | 2370                 | 240                                       |

| Name                              | Molecular formula               | $t_m/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                       | Molecular formula                                | $t_m/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|-----------------------------------|---------------------------------|------------------------|-------------------------------------------|----------------------------|--------------------------------------------------|------------------------|-------------------------------------------|
| Tungsten(V) bromide               | $\text{Br}_5\text{W}$           | 286                    | 17.2                                      | Zirconium(II) iodide       | $\text{I}_2\text{Zr}$                            | 827                    | 28                                        |
| Tungsten(V) chloride              | $\text{Cl}_5\text{W}$           | 253                    | 20.6                                      | Zirconium(III) iodide      | $\text{I}_3\text{Zr}$                            | 727                    | 33                                        |
| Tungsten(VI) chloride             | $\text{Cl}_6\text{W}$           | 282                    | 6.69                                      | Zirconium(IV) iodide       | $\text{I}_4\text{Zr}$                            | 500                    | 32                                        |
| Tungsten(VI) fluoride             | $\text{F}_6\text{W}$            | 1.9                    | 4.10                                      | Zirconium nitride          | $\text{NZr}$                                     | 2952                   | 67.4                                      |
| Tungsten(VI) oxide                | $\text{O}_3\text{W}$            | 1473                   | 73                                        | Zirconium(IV) oxide        | $\text{O}_2\text{Zr}$                            | 2710                   | 90                                        |
| Tungsten(VI) oxytetrachloride     | $\text{Cl}_4\text{OW}$          | 210                    | 18.8                                      | Zirconium(IV) sulfide      | $\text{S}_2\text{Zr}$                            | 1550                   | 45                                        |
| Tungsten(VI) oxytetrafluoride     | $\text{F}_4\text{OW}$           | 105                    | 6                                         |                            |                                                  |                        |                                           |
| Uranium                           | $\text{U}$                      | 1135                   | 9.14                                      | <i>Organic compounds</i>   |                                                  |                        |                                           |
| Uranium(III) bromide              | $\text{Br}_3\text{U}$           | 727                    | 43.9                                      | Acenaphthene               | $\text{C}_{12}\text{H}_{10}$                     | 93.4                   | 21.49                                     |
| Uranium(IV) bromide               | $\text{Br}_4\text{U}$           | 519                    | 55.2                                      | Acenaphthylene             | $\text{C}_{12}\text{H}_8$                        | 91.8                   | 6.9                                       |
| Uranium(IV) chloride              | $\text{Cl}_4\text{U}$           | 590                    | 44.8                                      | Acetaldehyde               | $\text{C}_2\text{H}_4\text{O}$                   | -123.37                | 2.31                                      |
| Uranium(III) fluoride             | $\text{F}_3\text{U}$            | 1495                   | 36.8                                      | Acetamide                  | $\text{C}_2\text{H}_5\text{NO}$                  | 80.16                  | 15.59                                     |
| Uranium(IV) fluoride              | $\text{F}_4\text{U}$            | 1036                   | 47                                        | Acetaminophen              | $\text{C}_8\text{H}_9\text{NO}_2$                | 169.3                  | 30.5                                      |
| Uranium(V) fluoride               | $\text{F}_5\text{U}$            | 348                    | 35                                        | Acetanilide                | $\text{C}_8\text{H}_9\text{NO}$                  | 114.3                  | 21.3                                      |
| Uranium(VI) fluoride              | $\text{F}_6\text{U}$            | 64.06                  | 19.2                                      | Acetic acid                | $\text{C}_2\text{H}_4\text{O}_2$                 | 16.64                  | 11.73                                     |
| Uranium(IV) iodide                | $\text{I}_4\text{U}$            | 506                    | 42.1                                      | Acetic anhydride           | $\text{C}_4\text{H}_6\text{O}_3$                 | -74.1                  | 10.5                                      |
| Uranium(IV) oxide                 | $\text{O}_2\text{U}$            | 2847                   | 74.2                                      | Acetone                    | $\text{C}_3\text{H}_6\text{O}$                   | -94.7                  | 5.77                                      |
| Uranyl chloride                   | $\text{Cl}_2\text{O}_2\text{U}$ | 577                    | 44.06                                     | Acetonitrile               | $\text{C}_2\text{H}_3\text{N}$                   | -43.82                 | 8.16                                      |
| Vanadium                          | $\text{V}$                      | 1910                   | 21.5                                      | Acrylic acid               | $\text{C}_3\text{H}_4\text{O}_2$                 | 12.5                   | 9.51                                      |
| Vanadium(II) chloride             | $\text{Cl}_2\text{V}$           | 1350                   | 35.0                                      | Acrylonitrile              | $\text{C}_3\text{H}_3\text{N}$                   | -83.48                 | 6.23                                      |
| Vanadium(IV) chloride             | $\text{Cl}_4\text{V}$           | -28                    | 2.30                                      | Allene                     | $\text{C}_3\text{H}_4$                           | -136.6                 | 4.40                                      |
| Vanadium(II) fluoride             | $\text{F}_2\text{V}$            | 1490                   | 44                                        | Allobarbital               | $\text{C}_{10}\text{H}_{12}\text{N}_2\text{O}_3$ | 172                    | 32.3                                      |
| Vanadium(III) fluoride            | $\text{F}_3\text{V}$            | 1395                   | 57                                        | 2-Aminobenzoic acid        | $\text{C}_7\text{H}_7\text{NO}_2$                | 146                    | 20.5                                      |
| Vanadium(V) fluoride              | $\text{F}_5\text{V}$            | 19.5                   | 49.96                                     | 4-Aminobenzoic acid        | $\text{C}_7\text{H}_7\text{NO}_2$                | 188.2                  | 22.5                                      |
| Vanadium(II) oxide                | $\text{OV}$                     | 1790                   | 50                                        | 3-Amino-1-propanol         | $\text{C}_3\text{H}_9\text{NO}$                  | 12.4                   | 19.7                                      |
| Vanadium(III) oxide               | $\text{O}_3\text{V}_2$          | 1957                   | 140                                       | Aminopyrine                | $\text{C}_{13}\text{H}_{17}\text{N}_3\text{O}$   | 107.5                  | 27.6                                      |
| Vanadium(IV) oxide                | $\text{O}_2\text{V}$            | 1545                   | 56.0                                      | Ampyrone                   | $\text{C}_{11}\text{H}_{13}\text{N}_3\text{O}$   | 109                    | 24.9                                      |
| Vanadium(V) oxide                 | $\text{O}_5\text{V}_2$          | 681                    | 64                                        | Aniline                    | $\text{C}_6\text{H}_5\text{N}$                   | -6.02                  | 10.54                                     |
| Water                             | $\text{H}_2\text{O}$            | 0.00                   | 6.01                                      | Anisole                    | $\text{C}_7\text{H}_8\text{O}$                   | -37.13                 | 12.9                                      |
| Xenon                             | $\text{Xe}$                     | -111.745 t             | 2.27                                      | Anthracene                 | $\text{C}_{14}\text{H}_{10}$                     | 215.76                 | 29.4                                      |
| Xenon difluoride                  | $\text{F}_2\text{Xe}$           | 129.03                 | 16.8                                      | Antipyrine                 | $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}$   | 112                    | 27.3                                      |
| Xenon tetrafluoride               | $\text{F}_4\text{Xe}$           | 117.1                  | 16.3                                      | <i>trans</i> -Azobenzene   | $\text{C}_{12}\text{H}_{10}\text{N}_2$           | 67.88                  | 22.52                                     |
| Xenon hexafluoride                | $\text{F}_6\text{Xe}$           | 49.48                  | 5.74                                      | <i>trans</i> -Azoxybenzene | $\text{C}_{12}\text{H}_{10}\text{N}_2\text{O}$   | 34.6                   | 17.9                                      |
| Ytterbium                         | $\text{Yb}$                     | 824                    | 7.66                                      | Barbital                   | $\text{C}_8\text{H}_{12}\text{N}_2\text{O}_3$    | 190                    | 24.7                                      |
| Ytterbium(III) chloride           | $\text{Cl}_3\text{Yb}$          | 854                    | 35.4                                      | Benzaldehyde               | $\text{C}_7\text{H}_6\text{O}$                   | -57.1                  | 9.32                                      |
| Yttrium                           | $\text{Y}$                      | 1522                   | 11.39                                     | Benzamide                  | $\text{C}_7\text{H}_7\text{NO}$                  | 127.3                  | 19.5                                      |
| Yttrium chloride                  | $\text{Cl}_3\text{Y}$           | 721                    | 31.5                                      | Benz[a]anthracene          | $\text{C}_{18}\text{H}_{12}$                     | 160.5                  | 21.4                                      |
| Yttrium fluoride                  | $\text{F}_3\text{Y}$            | 1155                   | 27.9                                      | Benzene                    | $\text{C}_6\text{H}_6$                           | 5.49                   | 9.87                                      |
| Yttrium oxide                     | $\text{O}_3\text{Y}_2$          | 2439                   | 81                                        | Benzeneacetic acid         | $\text{C}_8\text{H}_8\text{O}_2$                 | 76.5                   | 16.3                                      |
| Zinc                              | $\text{Zn}$                     | 419.53                 | 7.068                                     | 1,2-Benzenediamine         | $\text{C}_6\text{H}_8\text{N}_2$                 | 102.1                  | 23.1                                      |
| Zinc bromide                      | $\text{Br}_2\text{Zn}$          | 402                    | 15.7                                      | 1,3-Benzenediamine         | $\text{C}_6\text{H}_8\text{N}_2$                 | 66.0                   | 15.57                                     |
| Zinc chloride                     | $\text{Cl}_2\text{Zn}$          | 325                    | 10.30                                     | 1,4-Benzenediamine         | $\text{C}_6\text{H}_8\text{N}_2$                 | 141.1                  | 23.8                                      |
| Zinc fluoride                     | $\text{F}_2\text{Zn}$           | 872                    | 40                                        | Benzenethiol               | $\text{C}_6\text{H}_5\text{S}$                   | -14.93                 | 11.48                                     |
| Zinc iodide                       | $\text{I}_2\text{Zn}$           | 450                    | 17                                        | <i>p</i> -Benzidine        | $\text{C}_{12}\text{H}_{12}\text{N}_2$           | 127                    | 19.1                                      |
| Zinc oxide                        | $\text{OZn}$                    | 1974                   | 70                                        | Benzil                     | $\text{C}_{14}\text{H}_{10}\text{O}_2$           | 94.87                  | 23.5                                      |
| Zinc phosphide ( $\text{ZnP}_2$ ) | $\text{P}_2\text{Zn}$           | 980                    | 92.9                                      | Benzocaine                 | $\text{C}_9\text{H}_{11}\text{NO}_2$             | 89.7                   | 22.3                                      |
| Zinc selenite                     | $\text{O}_3\text{SeZn}$         | 621                    | 46.4                                      | Benzoic acid               | $\text{C}_7\text{H}_6\text{O}_2$                 | 122.35                 | 18.02                                     |
| Zinc sulfide (wurtzite)           | $\text{SZn}$                    | 1827                   | 30                                        | Benzonitrile               | $\text{C}_7\text{H}_5\text{N}$                   | -13.99                 | 9.1                                       |
| Zinc telluride                    | $\text{TeZn}$                   | 1295                   | 63                                        | Benzo[c]phenanthrene       | $\text{C}_{18}\text{H}_{12}$                     | 68                     | 16.3                                      |
| Zirconium                         | $\text{Zr}$                     | 1854.7                 | 21.00                                     | Benzophenone               | $\text{C}_{13}\text{H}_{10}\text{O}$             | 47.9                   | 18.19                                     |
| Zirconium boride                  | $\text{B}_2\text{Zr}$           | 3050                   | 104.6                                     | Benzo[a]pyrene             | $\text{C}_{20}\text{H}_{12}$                     | 181.1                  | 17.3                                      |
| Zirconium(II) bromide             | $\text{Br}_2\text{Zr}$          | 827                    | 28                                        | Benzo[e]pyrene             | $\text{C}_{20}\text{H}_{12}$                     | 181.4                  | 16.6                                      |
| Zirconium(III) bromide            | $\text{Br}_3\text{Zr}$          | 727                    | 33                                        | <i>p</i> -Benzoquinone     | $\text{C}_6\text{H}_4\text{O}_2$                 | 115                    | 18.5                                      |
| Zirconium(IV) bromide             | $\text{Br}_4\text{Zr}$          | 450                    |                                           | Benzoyl chloride           | $\text{C}_7\text{H}_5\text{ClO}$                 | -0.4                   | 19.2                                      |
| Zirconium(II) chloride            | $\text{Cl}_2\text{Zr}$          | 722                    | 27.0                                      | Benzyl alcohol             | $\text{C}_7\text{H}_8\text{O}$                   | -15.4                  | 8.97                                      |
| Zirconium(III) chloride           | $\text{Cl}_3\text{Zr}$          | 627                    | 30                                        | 2,2'-Binaphthalene         | $\text{C}_{20}\text{H}_{14}$                     | 187.9                  | 38.9                                      |
| Zirconium(IV) chloride            | $\text{Cl}_4\text{Zr}$          | 437                    | 29                                        | Biphenyl                   | $\text{C}_{12}\text{H}_{10}$                     | 68.93                  | 18.57                                     |
| Zirconium(II) fluoride            | $\text{F}_2\text{Zr}$           | 902                    | 37.7                                      | Bromobenzene               | $\text{C}_6\text{H}_5\text{Br}$                  | -30.72                 | 10.70                                     |
| Zirconium(III) fluoride           | $\text{F}_3\text{Zr}$           | 927                    | 50                                        | 1-Bromobutane              | $\text{C}_4\text{H}_9\text{Br}$                  | -112.6                 | 9.23                                      |
| Zirconium(IV) fluoride            | $\text{F}_4\text{Zr}$           | 910                    | 61                                        | 2-Bromobutane              | $\text{C}_4\text{H}_9\text{Br}$                  | -112.65                | 6.89                                      |



| Name                          | Molecular formula                             | $t_m/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                                   | Molecular formula                      | $t_m/^{\circ}\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|-------------------------------|-----------------------------------------------|------------------------|-------------------------------------------|----------------------------------------|----------------------------------------|------------------------|-------------------------------------------|
| Bromoethane                   | $\text{C}_2\text{H}_5\text{Br}$               | -118.6                 | 7.47                                      | 2-Chlorophenol                         | $\text{C}_6\text{H}_5\text{ClO}$       | 9.4                    | 13.0                                      |
| Bromoethene                   | $\text{C}_2\text{H}_3\text{Br}$               | -139.54                | 5.12                                      | 3-Chlorophenol                         | $\text{C}_6\text{H}_4\text{ClO}$       | 32.6                   | 14.9                                      |
| 1-Bromoheptane                | $\text{C}_7\text{H}_{15}\text{Br}$            | -56.1                  | 21.8                                      | 4-Chlorophenol                         | $\text{C}_6\text{H}_3\text{ClO}$       | 42.8                   | 14.1                                      |
| 1-Bromohexane                 | $\text{C}_6\text{H}_{13}\text{Br}$            | -83.7                  | 18.1                                      | 1-Chloropropane                        | $\text{C}_3\text{H}_7\text{Cl}$        | -122.9                 | 5.54                                      |
| Bromomethane                  | $\text{CH}_3\text{Br}$                        | -93.68                 | 5.98                                      | 2-Chloropropane                        | $\text{C}_3\text{H}_7\text{Cl}$        | -117.18                | 7.39                                      |
| 1-Bromonaphthalene            | $\text{C}_{10}\text{H}_7\text{Br}$            | 6.1                    | 15.2                                      | 2-Chlorotoluene                        | $\text{C}_7\text{H}_7\text{Cl}$        | -35.8                  | 9.6                                       |
| 2-Bromonaphthalene            | $\text{C}_{10}\text{H}_7\text{Br}$            | 55.9                   | 14.4                                      | Chlorotrifluoroethene                  | $\text{C}_2\text{ClF}_3$               | -158.2                 | 5.55                                      |
| 1-Bromooctane                 | $\text{C}_8\text{H}_{17}\text{Br}$            | -55.0                  | 24.7                                      | Chrysene                               | $\text{C}_{18}\text{H}_{12}$           | 255.5                  | 26.2                                      |
| 1-Bromopentane                | $\text{C}_5\text{H}_{11}\text{Br}$            | -88.0                  | 14.37                                     | Coronene                               | $\text{C}_{24}\text{H}_{12}$           | 437.4                  | 19.2                                      |
| 1-Bromopropane                | $\text{C}_3\text{H}_7\text{Br}$               | -110.3                 | 6.44                                      | <i>o</i> -Cresol                       | $\text{C}_7\text{H}_8\text{O}$         | 31.03                  | 15.82                                     |
| 2-Bromopropane                | $\text{C}_3\text{H}_7\text{Br}$               | -89.0                  | 6.53                                      | <i>m</i> -Cresol                       | $\text{C}_7\text{H}_8\text{O}$         | 12.24                  | 10.71                                     |
| Bromotrichloromethane         | $\text{CBrCl}_3$                              | -5.65                  | 2.53                                      | <i>p</i> -Cresol                       | $\text{C}_7\text{H}_8\text{O}$         | 34.77                  | 12.71                                     |
| 1,2-Butadiene                 | $\text{C}_4\text{H}_6$                        | -136.2                 | 6.96                                      | Cyanamide                              | $\text{CH}_2\text{N}_2$                | 45.56                  | 7.27                                      |
| 1,3-Butadiene                 | $\text{C}_4\text{H}_6$                        | -108.91                | 7.98                                      | Cyanogen                               | $\text{C}_2\text{N}_2$                 | -27.83                 | 8.11                                      |
| Butanal                       | $\text{C}_4\text{H}_8\text{O}$                | -96.86                 | 10.77                                     | Cyclobutane                            | $\text{C}_4\text{H}_8$                 | -90.7                  | 1.09                                      |
| Butane                        | $\text{C}_4\text{H}_{10}$                     | -138.3                 | 4.66                                      | Cycloheptane                           | $\text{C}_7\text{H}_{14}$              | -8.46                  | 1.88                                      |
| 1,4-Butanediol                | $\text{C}_4\text{H}_{10}\text{O}_2$           | 20.4                   | 18.70                                     | Cycloheptanol                          | $\text{C}_7\text{H}_{14}\text{O}$      | 7.2                    | 1.60                                      |
| 1-Butanethiol                 | $\text{C}_4\text{H}_{10}\text{S}$             | -115.7                 | 10.46                                     | Cyclohexane                            | $\text{C}_6\text{H}_{12}$              | 6.59                   | 2.68                                      |
| Butanoic acid                 | $\text{C}_4\text{H}_8\text{O}_2$              | -5.1                   | 11.59                                     | Cyclohexanol                           | $\text{C}_6\text{H}_{12}\text{O}$      | 25.93                  | 1.78                                      |
| 1-Butanol                     | $\text{C}_4\text{H}_{10}\text{O}$             | -88.6                  | 9.37                                      | Cyclohexanone                          | $\text{C}_6\text{H}_{10}\text{O}$      | -27.9                  | 1.328                                     |
| 2-Butanol                     | $\text{C}_4\text{H}_{10}\text{O}$             | -88.5                  | 5.97                                      | Cyclohexene                            | $\text{C}_6\text{H}_{10}$              | -103.5                 | 3.29                                      |
| 2-Butanone                    | $\text{C}_4\text{H}_8\text{O}$                | -86.64                 | 8.39                                      | Cyclohexylamine                        | $\text{C}_6\text{H}_{13}\text{N}$      | -17.8                  | 17.5                                      |
| 1-Butene                      | $\text{C}_4\text{H}_8$                        | -185.34                | 3.96                                      | Cyclohexylbenzene                      | $\text{C}_{12}\text{H}_{16}$           | 7.07                   | 15.6                                      |
| <i>cis</i> -2-Butene          | $\text{C}_4\text{H}_8$                        | -138.88                | 7.31                                      | Cyclooctane                            | $\text{C}_8\text{H}_{16}$              | 14.59                  | 2.41                                      |
| <i>trans</i> -2-Butene        | $\text{C}_4\text{H}_8$                        | -105.52                | 9.76                                      | Cyclopentane                           | $\text{C}_5\text{H}_{10}$              | -93.4                  | 0.61                                      |
| <i>cis</i> -2-Butenoic acid   | $\text{C}_4\text{H}_6\text{O}_2$              | 15                     | 12.6                                      | Cyclopentanol                          | $\text{C}_5\text{H}_{10}\text{O}$      | -17.5                  | 1.535                                     |
| <i>trans</i> -2-Butenoic acid | $\text{C}_4\text{H}_6\text{O}_2$              | 71.5                   | 13.0                                      | Cyclopentene                           | $\text{C}_5\text{H}_8$                 | -135.0                 | 3.36                                      |
| <i>tert</i> -Butylamine       | $\text{C}_4\text{H}_{11}\text{N}$             | -66.94                 | 0.882                                     | Cyclopentylamine                       | $\text{C}_5\text{H}_{11}\text{N}$      | -82.7                  | 8.31                                      |
| Butylbenzene                  | $\text{C}_{10}\text{H}_{14}$                  | -87.85                 | 11.22                                     | Cyclopropane                           | $\text{C}_3\text{H}_6$                 | -127.58                | 5.44                                      |
| Butylcyclohexane              | $\text{C}_{10}\text{H}_{20}$                  | -74.73                 | 14.16                                     | Cyclopropylamine                       | $\text{C}_3\text{H}_7\text{N}$         | -35.39                 | 13.18                                     |
| Butyl methyl ether            | $\text{C}_5\text{H}_{12}\text{O}$             | -115.7                 | 10.85                                     | <i>cis</i> -Decahydronaphthalene       | $\text{C}_{10}\text{H}_{18}$           | -42.9                  | 9.49                                      |
| 1-Butyne                      | $\text{C}_4\text{H}_6$                        | -125.7                 | 6.03                                      | <i>trans</i> -Decahydronaphthalene     | $\text{C}_{10}\text{H}_{18}$           | -30.4                  | 14.41                                     |
| 2-Butyne                      | $\text{C}_4\text{H}_6$                        | -32.2                  | 9.23                                      | Decanal                                | $\text{C}_{10}\text{H}_{20}\text{O}$   | -4.0                   | 34.5                                      |
| $\gamma$ -Butyrolactone       | $\text{C}_4\text{H}_6\text{O}_2$              | -43.61                 | 9.57                                      | Decane                                 | $\text{C}_{10}\text{H}_{22}$           | -29.6                  | 28.72                                     |
| Caffeine                      | $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$ | 236.3                  | 22.0                                      | Decanoic acid                          | $\text{C}_{10}\text{H}_{20}\text{O}_2$ | 31.4                   | 27.8                                      |
| Carbazole                     | $\text{C}_{12}\text{H}_9\text{N}$             | 246.3                  | 24.1                                      | 1-Decanol                              | $\text{C}_{10}\text{H}_{22}\text{O}$   | 6.9                    | 43                                        |
| Carbon dioxide                | $\text{CO}_2$                                 | -56.558                | 9.02                                      | 1-Decene                               | $\text{C}_{10}\text{H}_{20}$           | -66.3                  | 13.81                                     |
| Carbon diselenide             | $\text{CSe}_2$                                | -43.7                  | 6.36                                      | 1,2-Dibromoethane                      | $\text{C}_2\text{H}_4\text{Br}_2$      | 9.84                   | 10.89                                     |
| Carbon disulfide              | $\text{CS}_2$                                 | -112.1                 | 4.39                                      | 1,2-Dibromopropane                     | $\text{C}_3\text{H}_6\text{Br}_2$      | -55.49                 | 8.94                                      |
| Carbon monoxide               | $\text{CO}$                                   | -205.02                | 0.833                                     | 1,3-Dibromopropane                     | $\text{C}_3\text{H}_6\text{Br}_2$      | -34.5                  | 14.6                                      |
| Carbon oxysulfide             | $\text{COS}$                                  | -138.8                 | 4.73                                      | 1,2-Dibromotetrafluoroethane           | $\text{C}_2\text{Br}_2\text{F}_4$      | -110.32                | 7.04                                      |
| Carbonyl chloride             | $\text{CCl}_2\text{O}$                        | -127.78                | 5.74                                      | <i>o</i> -Dichlorobenzene              | $\text{C}_6\text{H}_4\text{Cl}_2$      | -17.0                  | 12.4                                      |
| Chloroacetic acid             | $\text{C}_2\text{H}_3\text{ClO}_2$            | 63                     | 12.28                                     | <i>m</i> -Dichlorobenzene              | $\text{C}_6\text{H}_4\text{Cl}_2$      | -24.8                  | 12.6                                      |
| 2-Chloroaniline               | $\text{C}_6\text{H}_6\text{ClN}$              | -1.9                   | 11.9                                      | <i>p</i> -Dichlorobenzene              | $\text{C}_6\text{H}_4\text{Cl}_2$      | 53.09                  | 18.19                                     |
| 3-Chloroaniline               | $\text{C}_6\text{H}_6\text{ClN}$              | -10.28                 | 10.15                                     | 1,1-Dichloroethane                     | $\text{C}_2\text{H}_4\text{Cl}_2$      | -96.9                  | 7.87                                      |
| 4-Chloroaniline               | $\text{C}_6\text{H}_6\text{ClN}$              | 70.5                   | 20.0                                      | 1,2-Dichloroethane                     | $\text{C}_2\text{H}_4\text{Cl}_2$      | -35.7                  | 8.84                                      |
| Chlorobenzene                 | $\text{C}_6\text{H}_5\text{Cl}$               | -45.31                 | 9.6                                       | 1,1-Dichloroethene                     | $\text{C}_2\text{H}_2\text{Cl}_2$      | -122.56                | 6.51                                      |
| 2-Chlorobenzoic acid          | $\text{C}_7\text{H}_5\text{ClO}_2$            | 140.2                  | 25.6                                      | <i>cis</i> -1,2-Dichloroethene         | $\text{C}_2\text{H}_2\text{Cl}_2$      | -80.0                  | 7.2                                       |
| Chlorocyclohexane             | $\text{C}_6\text{H}_{11}\text{Cl}$            | -43.81                 | 2.043                                     | Dichloromethane                        | $\text{CH}_2\text{Cl}_2$               | -97.2                  | 4.60                                      |
| Chlorodifluoromethane         | $\text{CHClF}_2$                              | -157.42                | 4.12                                      | 1,2-Dichloropropane                    | $\text{C}_3\text{H}_6\text{Cl}_2$      | -100.53                | 6.40                                      |
| Chloroethane                  | $\text{C}_2\text{H}_5\text{Cl}$               | -138.4                 | 4.45                                      | 2,2-Dichloropropane                    | $\text{C}_3\text{H}_6\text{Cl}_2$      | -33.9                  | 2.30                                      |
| Chloroethene                  | $\text{C}_2\text{H}_3\text{Cl}$               | -153.84                | 4.92                                      | 1,2-Dichloro-1,1,2,2-tetrafluoroethane | $\text{C}_2\text{Cl}_2\text{F}_4$      | -92.53                 | 1.51                                      |
| Chloromethane                 | $\text{CH}_3\text{Cl}$                        | -97.7                  | 6.43                                      | Diethyl ether                          | $\text{C}_4\text{H}_{10}\text{O}$      | -116.2                 | 7.19                                      |
| 2-Chloro-2-methylpropane      | $\text{C}_4\text{H}_9\text{Cl}$               | -25.60                 | 2.07                                      | 3,3-Diethylpentane                     | $\text{C}_9\text{H}_{20}$              | -33.1                  | 10.09                                     |
| 1-Chloronaphthalene           | $\text{C}_{10}\text{H}_7\text{Cl}$            | -2.5                   | 12.9                                      | Diethyl sulfide                        | $\text{C}_4\text{H}_{10}\text{S}$      | -103.91                | 10.90                                     |
| 2-Chloronaphthalene           | $\text{C}_{10}\text{H}_7\text{Cl}$            | 58.0                   | 14.0                                      | <i>o</i> -Difluorobenzene              | $\text{C}_6\text{H}_4\text{F}_2$       | -47.1                  | 11.05                                     |
| 1-Chloro-2-nitrobenzene       | $\text{C}_6\text{H}_4\text{ClNO}_2$           | 32.1                   | 17.9                                      | <i>m</i> -Difluorobenzene              | $\text{C}_6\text{H}_4\text{F}_2$       | -69.12                 | 8.58                                      |
| 1-Chloro-3-nitrobenzene       | $\text{C}_6\text{H}_4\text{ClNO}_2$           | 44.4                   | 19.4                                      | Diisopropyl ether                      | $\text{C}_6\text{H}_{14}\text{O}$      | -85.4                  | 12.04                                     |
| 1-Chloro-4-nitrobenzene       | $\text{C}_6\text{H}_4\text{ClNO}_2$           | 82                     | 14.1                                      | 1,2-Dimethoxyethane                    | $\text{C}_4\text{H}_{10}\text{O}_2$    | -69.20                 | 12.6                                      |
| Chloropentafluoroethane       | $\text{C}_2\text{ClF}_5$                      | -99.4                  | 1.86                                      | Dimethoxymethane                       | $\text{C}_3\text{H}_8\text{O}_2$       | -105.1                 | 8.33                                      |

| Name                                  | Molecular formula                        | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                        | Molecular formula                         | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|---------------------------------------|------------------------------------------|----------------------|-------------------------------------------|-----------------------------|-------------------------------------------|----------------------|-------------------------------------------|
| Dimethylamine                         | $\text{C}_2\text{H}_7\text{N}$           | -92.18               | 5.94                                      | Formamide                   | $\text{CH}_3\text{NO}$                    | 2.49                 | 8.44                                      |
| 2,2-Dimethylbutane                    | $\text{C}_6\text{H}_{14}$                | -98.8                | 0.58                                      | Formic acid                 | $\text{CH}_2\text{O}_2$                   | 8.3                  | 12.68                                     |
| 2,3-Dimethylbutane                    | $\text{C}_6\text{H}_{14}$                | -128.10              | 0.79                                      | Furan                       | $\text{C}_4\text{H}_4\text{O}$            | -85.61               | 3.80                                      |
| 2,3-Dimethyl-2-butene                 | $\text{C}_6\text{H}_{12}$                | -74.19               | 6.45                                      | Furfural                    | $\text{C}_5\text{H}_4\text{O}_2$          | -38.1                | 14.37                                     |
| 1,1-Dimethylcyclohexane               | $\text{C}_8\text{H}_{16}$                | -33.3                | 2.07                                      | Furfuryl alcohol            | $\text{C}_5\text{H}_6\text{O}_2$          | -14.6                | 13.13                                     |
| <i>cis</i> -1,2-Dimethylcyclohexane   | $\text{C}_8\text{H}_{16}$                | -49.8                | 1.64                                      | Glycerol                    | $\text{C}_3\text{H}_8\text{O}_3$          | 18.1                 | 18.3                                      |
| <i>trans</i> -1,2-Dimethylcyclohexane | $\text{C}_8\text{H}_{16}$                | -88.15               | 10.49                                     | Heneicosane                 | $\text{C}_{21}\text{H}_{44}$              | 40.01                | 45.21                                     |
| <i>cis</i> -1,3-Dimethylcyclohexane   | $\text{C}_8\text{H}_{16}$                | -75.53               | 10.82                                     | Heptacosane                 | $\text{C}_{27}\text{H}_{56}$              | 59.23                | 61.9                                      |
| <i>trans</i> -1,3-Dimethylcyclohexane | $\text{C}_8\text{H}_{16}$                | -90.07               | 9.87                                      | Heptadecane                 | $\text{C}_{17}\text{H}_{36}$              | 22.0                 | 40.16                                     |
| <i>cis</i> -1,4-Dimethylcyclohexane   | $\text{C}_8\text{H}_{16}$                | -87.39               | 9.31                                      | Heptanal                    | $\text{C}_7\text{H}_{14}\text{O}$         | -43.4                | 23.2                                      |
| <i>trans</i> -1,4-Dimethylcyclohexane | $\text{C}_8\text{H}_{16}$                | -36.93               | 12.33                                     | Heptane                     | $\text{C}_7\text{H}_{16}$                 | -90.55               | 14.03                                     |
| Dimethyl disulfide                    | $\text{C}_2\text{H}_6\text{S}_2$         | -84.67               | 9.19                                      | Heptanoic acid              | $\text{C}_7\text{H}_{14}\text{O}_2$       | -7.17                | 15.13                                     |
| Dimethyl ether                        | $\text{C}_2\text{H}_6\text{O}$           | -141.5               | 4.94                                      | 1-Heptanol                  | $\text{C}_7\text{H}_{16}\text{O}$         | -33.2                | 18.17                                     |
| <i>N,N</i> -Dimethylformamide         | $\text{C}_3\text{H}_7\text{NO}$          | -60.48               | 7.90                                      | 1-Heptene                   | $\text{C}_7\text{H}_{14}$                 | -118.9               | 12.41                                     |
| 1,1-Dimethylhydrazine                 | $\text{C}_2\text{H}_8\text{N}_2$         | -57.20               | 10.07                                     | Hexachlorobenzene           | $\text{C}_6\text{Cl}_6$                   | 228.83               | 25.2                                      |
| 1,2-Dimethylhydrazine                 | $\text{C}_2\text{H}_8\text{N}_2$         | -8.9                 | 13.64                                     | Hexachloroethane            | $\text{C}_2\text{Cl}_6$                   | 186.8t               | 9.75                                      |
| Dimethyl oxalate                      | $\text{C}_4\text{H}_6\text{O}_4$         | 54.8                 | 21.1                                      | Hexacontane                 | $\text{C}_{60}\text{H}_{122}$             | 99.3                 | 193.2                                     |
| 2,2-Dimethylpentane                   | $\text{C}_7\text{H}_{16}$                | -123.7               | 5.82                                      | Hexacosane                  | $\text{C}_{26}\text{H}_{54}$              | 56.1                 | 60.0                                      |
| 2,4-Dimethylpentane                   | $\text{C}_7\text{H}_{16}$                | -119.2               | 6.85                                      | Hexadecane                  | $\text{C}_{16}\text{H}_{34}$              | 18.12                | 53.36                                     |
| 3,3-Dimethylpentane                   | $\text{C}_7\text{H}_{16}$                | -134.4               | 6.85                                      | Hexadecanoic acid           | $\text{C}_{16}\text{H}_{32}\text{O}_2$    | 62.5                 | 53.7                                      |
| Dimethyl sulfide                      | $\text{C}_2\text{H}_6\text{S}$           | -98.24               | 7.99                                      | 1-Hexadecanol               | $\text{C}_{16}\text{H}_{34}\text{O}$      | 49.2                 | 33.6                                      |
| Dimethyl sulfone                      | $\text{C}_2\text{H}_6\text{O}_2\text{S}$ | 108.9                | 18.30                                     | Hexafluorobenzene           | $\text{C}_6\text{F}_6$                    | 5.03                 | 11.59                                     |
| Dimethyl sulfoxide                    | $\text{C}_2\text{H}_6\text{OS}$          | 17.89                | 14.37                                     | Hexafluoroethane            | $\text{C}_2\text{F}_6$                    | -100.05              | 2.69                                      |
| <i>N,N</i> -Dimethylurea              | $\text{C}_3\text{H}_8\text{N}_2\text{O}$ | 182.1                | 23.0                                      | Hexamethylbenzene           | $\text{C}_{12}\text{H}_{18}$              | 165.5                | 20.6                                      |
| <i>N,N'</i> -Dimethylurea             | $\text{C}_3\text{H}_8\text{N}_2\text{O}$ | 106.6                | 13.0                                      | Hexanal                     | $\text{C}_6\text{H}_{12}\text{O}$         | -56                  | 13.3                                      |
| Dimethyl zinc                         | $\text{C}_2\text{H}_6\text{Zn}$          | -43.0                | 6.83                                      | Hexane                      | $\text{C}_6\text{H}_{14}$                 | -95.35               | 13.08                                     |
| 1,4-Dioxane                           | $\text{C}_4\text{H}_8\text{O}_2$         | 11.85                | 12.84                                     | 1,6-Hexanedioic acid        | $\text{C}_6\text{H}_{10}\text{O}_4$       | 152.5                | 36.3                                      |
| 1,3-Dioxolane                         | $\text{C}_3\text{H}_6\text{O}_2$         | -97.22               | 6.57                                      | 1,6-Hexanediol              | $\text{C}_6\text{H}_{14}\text{O}_2$       | 41.5                 | 22.2                                      |
| Diphenylamine                         | $\text{C}_{12}\text{H}_{11}\text{N}$     | 53.2                 | 18.5                                      | 1-Hexanol                   | $\text{C}_6\text{H}_{14}\text{O}$         | -47.4                | 15.38                                     |
| Diphenyl ether                        | $\text{C}_{12}\text{H}_{10}\text{O}$     | 26.864               | 17.22                                     | 2-Hexanone                  | $\text{C}_6\text{H}_{12}\text{O}$         | -55.5                | 14.9                                      |
| Diphenylmethane                       | $\text{C}_{13}\text{H}_{12}$             | 25.4                 | 18.6                                      | 3-Hexanone                  | $\text{C}_6\text{H}_{12}\text{O}$         | -55.4                | 13.49                                     |
| Dipropyl ether                        | $\text{C}_6\text{H}_{14}\text{O}$        | -114.8               | 10.8                                      | Hexatetracontane            | $\text{C}_{46}\text{H}_{94}$              | 87.6                 | 176.0                                     |
| Divinyl ether                         | $\text{C}_4\text{H}_6\text{O}$           | -100.6               | 7.9                                       | Hexatriacontane             | $\text{C}_{36}\text{H}_{74}$              | 75.8                 | 87.7                                      |
| Docosane                              | $\text{C}_{22}\text{H}_{46}$             | 43.6                 | 48.8                                      | 1-Hexene                    | $\text{C}_6\text{H}_{12}$                 | -139.76              | 9.35                                      |
| Dodecane                              | $\text{C}_{12}\text{H}_{26}$             | -9.57                | 36.8                                      | <i>cis</i> -2-Hexene        | $\text{C}_6\text{H}_{12}$                 | -141.11              | 8.88                                      |
| Dodecanoic acid                       | $\text{C}_{12}\text{H}_{24}\text{O}_2$   | 43.8                 | 36.3                                      | Hydrogen cyanide            | $\text{CHN}$                              | -13.29               | 8.41                                      |
| 1-Dodecanol                           | $\text{C}_{12}\text{H}_{26}\text{O}$     | 23.9                 | 40.2                                      | <i>p</i> -Hydroquinone      | $\text{C}_6\text{H}_6\text{O}_2$          | 172.4                | 26.8                                      |
| 1-Dodecene                            | $\text{C}_{12}\text{H}_{24}$             | -35.2                | 19.9                                      | 2-Hydroxybenzoic acid       | $\text{C}_7\text{H}_6\text{O}_3$          | 159.0                | 14.2                                      |
| Dotriacontane                         | $\text{C}_{32}\text{H}_{66}$             | 69.4                 | 75.8                                      | Imidazole                   | $\text{C}_3\text{H}_4\text{N}_2$          | 89.5                 | 12.82                                     |
| Eicosane                              | $\text{C}_{20}\text{H}_{42}$             | 36.6                 | 69.9                                      | Indan                       | $\text{C}_9\text{H}_{10}$                 | -51.38               | 8.60                                      |
| 1-Eicosanol                           | $\text{C}_{20}\text{H}_{42}\text{O}$     | 65.4                 | 42                                        | Indene                      | $\text{C}_9\text{H}_8$                    | -1.5                 | 10.20                                     |
| Estradiol benzoate                    | $\text{C}_{25}\text{H}_{28}\text{O}_3$   | 193                  | 41.8                                      | Indomethacin                | $\text{C}_{19}\text{H}_{16}\text{ClNO}_4$ | 160                  | 36.9                                      |
| Ethane                                | $\text{C}_2\text{H}_6$                   | -182.79              | 2.72*                                     | Iodobenzene                 | $\text{C}_6\text{H}_5\text{I}$            | -31.3                | 9.75                                      |
| 1,2-Ethanediamine                     | $\text{C}_2\text{H}_8\text{N}_2$         | 11.14                | 22.58                                     | Isobutane                   | $\text{C}_4\text{H}_{10}$                 | -159.4               | 4.54                                      |
| 1,2-Ethanediol                        | $\text{C}_2\text{H}_6\text{O}_2$         | -12.69               | 9.96                                      | Isobutene                   | $\text{C}_4\text{H}_8$                    | -140.7               | 5.92                                      |
| Ethanethiol                           | $\text{C}_2\text{H}_6\text{S}$           | -147.88              | 4.98                                      | Isopentane                  | $\text{C}_5\text{H}_{12}$                 | -159.77              | 5.15                                      |
| Ethanol                               | $\text{C}_2\text{H}_6\text{O}$           | -114.14              | 4.931                                     | Isopropylamine              | $\text{C}_3\text{H}_7\text{N}$            | -95.13               | 7.33                                      |
| Ethinylestradiol                      | $\text{C}_{20}\text{H}_{24}\text{O}_2$   | 183.5                | 27.9                                      | Isopropylbenzene            | $\text{C}_9\text{H}_{12}$                 | -96.02               | 7.33                                      |
| Ethyl acetate                         | $\text{C}_4\text{H}_8\text{O}_2$         | -83.8                | 10.48                                     | 1-Isopropyl-4-methylbenzene | $\text{C}_{10}\text{H}_{14}$              | -67.94               | 9.66                                      |
| Ethylbenzene                          | $\text{C}_8\text{H}_{10}$                | -94.96               | 9.18                                      | Isoquinoline                | $\text{C}_9\text{H}_7\text{N}$            | 26.47                | 13.54                                     |
| Ethylcyclohexane                      | $\text{C}_8\text{H}_{16}$                | -111.3               | 8.33                                      | Khellin                     | $\text{C}_{14}\text{H}_{12}\text{O}_5$    | 154                  | 32.3                                      |
| Ethylene                              | $\text{C}_2\text{H}_4$                   | -169.15              | 3.35                                      | Maleic anhydride            | $\text{C}_4\text{H}_2\text{O}_3$          | 52.56                | 13.60                                     |
| Ethyl methyl sulfide                  | $\text{C}_3\text{H}_8\text{S}$           | -105.93              | 9.76                                      | Methane                     | $\text{CH}_4$                             | -182.47              | 0.94                                      |
| 3-Ethylpentane                        | $\text{C}_7\text{H}_{16}$                | -118.55              | 9.55                                      | Methanethiol                | $\text{CH}_3\text{S}$                     | -123                 | 5.91                                      |
| 2-Ethyltoluene                        | $\text{C}_9\text{H}_{12}$                | -79.83               | 9.96                                      | Methanol                    | $\text{CH}_3\text{O}$                     | -97.53               | 3.215                                     |
| 3-Ethyltoluene                        | $\text{C}_9\text{H}_{12}$                | -95.6                | 7.6                                       | Methyl acetate              | $\text{C}_3\text{H}_6\text{O}_2$          | -98.25               | 7.49                                      |
| 4-Ethyltoluene                        | $\text{C}_9\text{H}_{12}$                | -62.35               | 12.7                                      | Methylamine                 | $\text{CH}_5\text{N}$                     | -93.5                | 6.13                                      |
| Fluoranthene                          | $\text{C}_{16}\text{H}_{10}$             | 110.19               | 18.69                                     | 2-Methylaniline             | $\text{C}_7\text{H}_9\text{N}$            | -14.41               | 11.66                                     |
| 9 <i>H</i> -Fluorene                  | $\text{C}_{13}\text{H}_{10}$             | 114.77               | 19.58                                     | 3-Methylaniline             | $\text{C}_7\text{H}_9\text{N}$            | -31.3                | 7.9                                       |
| Fluorobenzene                         | $\text{C}_6\text{H}_5\text{F}$           | -42.18               | 11.31                                     | 4-Methylaniline             | $\text{C}_7\text{H}_9\text{N}$            | 43.6                 | 18.9                                      |

| Name                            | Molecular formula                          | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                               | Molecular formula                                | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|---------------------------------|--------------------------------------------|----------------------|-------------------------------------------|------------------------------------|--------------------------------------------------|----------------------|-------------------------------------------|
| Methyl benzoate                 | $\text{C}_8\text{H}_8\text{O}_2$           | -12.4                | 9.74                                      | 1-Octene                           | $\text{C}_8\text{H}_{16}$                        | -101.7               | 15.31                                     |
| 2-Methyl-1,3-butadiene          | $\text{C}_5\text{H}_8$                     | -145.9               | 4.93                                      | 2-Oxepanone                        | $\text{C}_6\text{H}_{10}\text{O}_2$              | -1.0                 | 13.83                                     |
| 2-Methyl-2-butanol              | $\text{C}_5\text{H}_{12}\text{O}$          | -9.1                 | 4.46                                      | Oxetane                            | $\text{C}_3\text{H}_6\text{O}$                   | -97                  | 6.5                                       |
| 3-Methyl-2-butanone             | $\text{C}_5\text{H}_{10}\text{O}$          | -93.1                | 9.34                                      | Oxirane                            | $\text{C}_2\text{H}_4\text{O}$                   | -112.5               | 5.17                                      |
| 2-Methyl-1-butene               | $\text{C}_5\text{H}_{10}$                  | -137.53              | 7.91                                      | 4-Oxopentanoic acid                | $\text{C}_5\text{H}_8\text{O}_3$                 | 33                   | 9.22                                      |
| 3-Methyl-1-butene               | $\text{C}_5\text{H}_{10}$                  | -168.43              | 5.36                                      | Paraldehyde                        | $\text{C}_6\text{H}_{12}\text{O}_3$              | 12.6                 | 13.5                                      |
| 2-Methyl-2-butene               | $\text{C}_5\text{H}_{10}$                  | -133.72              | 7.60                                      | Pentachloroethane                  | $\text{C}_2\text{HCl}_5$                         | -28.78               | 11.3                                      |
| Methyl <i>tert</i> -butyl ether | $\text{C}_5\text{H}_{12}\text{O}$          | -108.6               | 7.60                                      | Pentacontane                       | $\text{C}_{50}\text{H}_{102}$                    | 92.1                 | 162.4                                     |
| Methylcyclohexane               | $\text{C}_7\text{H}_{14}$                  | -126.6               | 6.75                                      | Pentacosane                        | $\text{C}_{25}\text{H}_{52}$                     | 53.93                | 56.9                                      |
| Methylcyclopentane              | $\text{C}_6\text{H}_{12}$                  | -142.42              | 6.93                                      | Pentadecane                        | $\text{C}_{15}\text{H}_{32}$                     | 9.95                 | 34.6                                      |
| Methylcyclopropane              | $\text{C}_4\text{H}_8$                     | -177.6               | 2.8                                       | <i>cis</i> -1,3-Pentadiene         | $\text{C}_5\text{H}_8$                           | -140.8               | 5.64                                      |
| 2-Methylfuran                   | $\text{C}_5\text{H}_8\text{O}$             | -91.3                | 8.55                                      | <i>trans</i> -1,3-Pentadiene       | $\text{C}_5\text{H}_8$                           | -87.4                | 7.14                                      |
| 2-Methylheptane                 | $\text{C}_8\text{H}_{18}$                  | -109.02              | 11.92                                     | 1,4-Pentadiene                     | $\text{C}_5\text{H}_8$                           | -148.2               | 6.12                                      |
| 3-Methylheptane                 | $\text{C}_8\text{H}_{18}$                  | -120.48              | 11.69                                     | Pentaerythritol                    | $\text{C}_5\text{H}_{12}\text{O}_4$              | 258                  | 4.8                                       |
| 4-Methylheptane                 | $\text{C}_8\text{H}_{18}$                  | -121.0               | 10.8                                      | Pentafluorobenzene                 | $\text{C}_6\text{HF}_5$                          | -47.4                | 10.87                                     |
| 2-Methylhexane                  | $\text{C}_7\text{H}_{16}$                  | -118.2               | 9.19                                      | Pentafluorophenol                  | $\text{C}_6\text{HF}_5\text{O}$                  | 37.5                 | 16.41                                     |
| Methylhydrazine                 | $\text{CH}_6\text{N}_2$                    | -52.36               | 10.42                                     | 2,3,4,5,6-Pentafluorotoluene       | $\text{C}_7\text{H}_5\text{F}_5$                 | -29.78               | 13.1                                      |
| Methyl methacrylate             | $\text{C}_5\text{H}_8\text{O}_2$           | -47.55               | 14.4                                      | Pentane                            | $\text{C}_5\text{H}_{12}$                        | -129.67              | 8.40                                      |
| 1-Methylnaphthalene             | $\text{C}_{11}\text{H}_{10}$               | -30.43               | 6.95                                      | Pentanedioic acid                  | $\text{C}_5\text{H}_8\text{O}_4$                 | 97.8                 | 20.3                                      |
| 2-Methylnaphthalene             | $\text{C}_{11}\text{H}_{10}$               | 34.6                 | 12.13                                     | Pentanenitrile                     | $\text{C}_5\text{H}_9\text{N}$                   | -96.2                | 9                                         |
| Methyl nitrate                  | $\text{CH}_3\text{NO}_3$                   | -83.0                | 8.24                                      | 1-Pentanethiol                     | $\text{C}_5\text{H}_{12}\text{S}$                | -75.65               | 17.53                                     |
| Methyloxirane                   | $\text{C}_3\text{H}_6\text{O}$             | -111.9               | 6.53                                      | Pentanoic acid                     | $\text{C}_5\text{H}_{10}\text{O}_2$              | -33.6                | 14.16                                     |
| 2-Methylpentane                 | $\text{C}_6\text{H}_{14}$                  | -153.6               | 6.27                                      | 1-Pentanol                         | $\text{C}_5\text{H}_{12}\text{O}$                | -77.6                | 10.50                                     |
| 3-Methylpentane                 | $\text{C}_6\text{H}_{14}$                  | -162.90              | 5.30                                      | 2-Pentanone                        | $\text{C}_5\text{H}_{10}\text{O}$                | -76.8                | 10.63                                     |
| 2-Methyl-1-propanol             | $\text{C}_4\text{H}_{10}\text{O}$          | -101.9               | 6.32                                      | 3-Pentanone                        | $\text{C}_5\text{H}_{10}\text{O}$                | -39                  | 11.59                                     |
| 2-Methyl-2-propanol             | $\text{C}_4\text{H}_{10}\text{O}$          | 25.69                | 6.70                                      | Pentatriacontane                   | $\text{C}_{35}\text{H}_{72}$                     | 74.6                 | 86.3                                      |
| 2-Methylpyridine                | $\text{C}_6\text{H}_7\text{N}$             | -66.68               | 9.72                                      | 1-Pentene                          | $\text{C}_5\text{H}_{10}$                        | -165.12              | 5.94                                      |
| 3-Methylpyridine                | $\text{C}_6\text{H}_7\text{N}$             | -18.14               | 14.18                                     | <i>cis</i> -2-Pentene              | $\text{C}_5\text{H}_{10}$                        | -151.36              | 7.11                                      |
| 4-Methylpyridine                | $\text{C}_6\text{H}_7\text{N}$             | 3.67                 | 12.58                                     | <i>trans</i> -2-Pentene            | $\text{C}_5\text{H}_{10}$                        | -140.21              | 8.35                                      |
| <i>N</i> -Methylurea            | $\text{C}_2\text{H}_6\text{N}_2\text{O}$   | 104.9                | 14.0                                      | Perfluoroacetone                   | $\text{C}_3\text{F}_6\text{O}$                   | -125.45              | 8.38                                      |
| Morpholine                      | $\text{C}_4\text{H}_9\text{NO}$            | -4.8                 | 14.5                                      | Perfluorobutane                    | $\text{C}_4\text{F}_{10}$                        | -129.1               | 7.66                                      |
| Naphthalene                     | $\text{C}_{10}\text{H}_8$                  | 80.26                | 19.01                                     | Perfluorocyclobutane               | $\text{C}_4\text{F}_8$                           | -40.19               | 2.77                                      |
| 1-Naphthol                      | $\text{C}_{10}\text{H}_8\text{O}$          | 95.0                 | 23.1                                      | Perfluoroheptane                   | $\text{C}_7\text{F}_{16}$                        | -51.2                | 6.95                                      |
| 2-Naphthol                      | $\text{C}_{10}\text{H}_8\text{O}$          | 121.5                | 18.1                                      | Perfluorohexane                    | $\text{C}_6\text{F}_{14}$                        | -88.2                | 6.84                                      |
| Neopentane                      | $\text{C}_5\text{H}_{12}$                  | -16.4                | 3.10                                      | Perfluoropropane                   | $\text{C}_3\text{F}_8$                           | -147.70              | 0.477                                     |
| Niacinamide                     | $\text{C}_6\text{H}_6\text{N}_2\text{O}$   | 130                  | 23.2                                      | Perfluorotoluene                   | $\text{C}_7\text{F}_8$                           | -65.49               | 11.54                                     |
| 2-Nitroaniline                  | $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | 71.0                 | 16.1                                      | Perylene                           | $\text{C}_{20}\text{H}_{12}$                     | 277.76               | 31.9                                      |
| 3-Nitroaniline                  | $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | 113.4                | 23.6                                      | Phenacetin                         | $\text{C}_{10}\text{H}_{13}\text{NO}_2$          | 134                  | 33.0                                      |
| 4-Nitroaniline                  | $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | 147.5                | 21.2                                      | Phenanthrene                       | $\text{C}_{14}\text{H}_{10}$                     | 99.24                | 16.46                                     |
| Nitrobenzene                    | $\text{C}_6\text{H}_5\text{NO}_2$          | 5.7                  | 12.12                                     | Phenobarbital                      | $\text{C}_{12}\text{H}_{12}\text{N}_2\text{O}_3$ | 174.0                | 27.8                                      |
| Nitroethane                     | $\text{C}_2\text{H}_5\text{NO}_2$          | -89.5                | 9.85                                      | Phenol                             | $\text{C}_6\text{H}_6\text{O}$                   | 40.89                | 11.51                                     |
| Nitromethane                    | $\text{CH}_3\text{NO}_2$                   | -28.38               | 9.70                                      | $\alpha$ -Phenylbenzeneacetic acid | $\text{C}_{14}\text{H}_{12}\text{O}_2$           | 147.29               | 31.3                                      |
| 2-Nitrophenol                   | $\text{C}_6\text{H}_5\text{NO}_3$          | 44.8                 | 17.7                                      | Phenylbutazone                     | $\text{C}_{19}\text{H}_{20}\text{N}_2\text{O}_2$ | 105                  | 27.7                                      |
| 3-Nitrophenol                   | $\text{C}_6\text{H}_5\text{NO}_3$          | 96.8                 | 20.6                                      | Phenylhydrazine                    | $\text{C}_6\text{H}_8\text{N}_2$                 | 20.6                 | 14.05                                     |
| 4-Nitrophenol                   | $\text{C}_6\text{H}_5\text{NO}_3$          | 113.6                | 18.8                                      | Piperidine                         | $\text{C}_5\text{H}_{11}\text{N}$                | -11.02               | 14.85                                     |
| Nitrosobenzene                  | $\text{C}_6\text{H}_5\text{NO}$            | 67                   | 31.0                                      | Potassium acetate                  | $\text{C}_2\text{H}_3\text{KO}_2$                | 309                  | 7.65                                      |
| 4-Nitrotoluene                  | $\text{C}_7\text{H}_7\text{NO}_2$          | 51.63                | 16.81                                     | Propane                            | $\text{C}_3\text{H}_8$                           | -187.63              | 3.50                                      |
| Nonacosane                      | $\text{C}_{29}\text{H}_{60}$               | 63.7                 | 66.9                                      | 1,3-Propanediol                    | $\text{C}_3\text{H}_8\text{O}_2$                 | -27.7                | 7.1                                       |
| Nonadecane                      | $\text{C}_{19}\text{H}_{40}$               | 32.0                 | 45.8                                      | Propanenitrile                     | $\text{C}_3\text{H}_5\text{N}$                   | -92.78               | 5.03                                      |
| Nonanal                         | $\text{C}_9\text{H}_{18}\text{O}$          | -19.3                | 30.5                                      | 1-Propanethiol                     | $\text{C}_3\text{H}_7\text{S}$                   | -113.13              | 5.48                                      |
| Nonane                          | $\text{C}_9\text{H}_{20}$                  | -53.46               | 15.47                                     | 2-Propanethiol                     | $\text{C}_3\text{H}_7\text{S}$                   | -130.5               | 5.74                                      |
| Nonanoic acid                   | $\text{C}_9\text{H}_{18}\text{O}_2$        | 12.4                 | 19.82                                     | Propanoic acid                     | $\text{C}_3\text{H}_6\text{O}_2$                 | -20.5                | 10.66                                     |
| 5-Nonanone                      | $\text{C}_9\text{H}_{18}\text{O}$          | -3.8                 | 24.93                                     | 1-Propanol                         | $\text{C}_3\text{H}_8\text{O}$                   | -124.39              | 5.37                                      |
| Octacosane                      | $\text{C}_{28}\text{H}_{58}$               | 61.1                 | 65.1                                      | 2-Propanol                         | $\text{C}_3\text{H}_8\text{O}$                   | -87.9                | 5.41                                      |
| Octadecane                      | $\text{C}_{18}\text{H}_{38}$               | 28.2                 | 61.7                                      | Propene                            | $\text{C}_3\text{H}_6$                           | -185.24              | 3.003                                     |
| 1-Octadecanol                   | $\text{C}_{18}\text{H}_{38}\text{O}$       | 57.9                 | 45                                        | Propylamine                        | $\text{C}_3\text{H}_9\text{N}$                   | -84.75               | 10.97                                     |
| Octane                          | $\text{C}_8\text{H}_{18}$                  | -56.82               | 20.73                                     | Propylbenzene                      | $\text{C}_9\text{H}_{12}$                        | -99.6                | 9.27                                      |
| Octanoic acid                   | $\text{C}_8\text{H}_{16}\text{O}_2$        | 16.5                 | 21.35                                     | Propylcyclohexane                  | $\text{C}_9\text{H}_{18}$                        | -94.9                | 10.37                                     |
| 1-Octanol                       | $\text{C}_8\text{H}_{18}\text{O}$          | -14.8                | 23.7                                      | Pyrazine                           | $\text{C}_4\text{H}_4\text{N}_2$                 | 51.0                 | 12.9                                      |
| Octatriacontane                 | $\text{C}_{38}\text{H}_{78}$               | 78.6                 | 133.2                                     | 1 <i>H</i> -Pyrazole               | $\text{C}_3\text{H}_4\text{N}_2$                 | 70.7                 | 14.0                                      |

| Name                                   | Molecular formula                                        | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ | Name                                  | Molecular formula                                | $t_m/^\circ\text{C}$ | $\Delta_{\text{fus}}H/\text{kJ mol}^{-1}$ |
|----------------------------------------|----------------------------------------------------------|----------------------|-------------------------------------------|---------------------------------------|--------------------------------------------------|----------------------|-------------------------------------------|
| Pyrene                                 | $\text{C}_{16}\text{H}_{10}$                             | 150.62               | 17.36                                     | Thiazole                              | $\text{C}_3\text{H}_3\text{NS}$                  | -33.62               | 9.57                                      |
| Pyridine                               | $\text{C}_5\text{H}_5\text{N}$                           | -41.70               | 8.28                                      | Thietane                              | $\text{C}_3\text{H}_6\text{S}$                   | -73.24               | 8.25                                      |
| Pyrocatechol                           | $\text{C}_6\text{H}_6\text{O}_2$                         | 104.6                | 22.8                                      | Thiophene                             | $\text{C}_4\text{H}_4\text{S}$                   | -38.21               | 5.07                                      |
| Pyrrole                                | $\text{C}_4\text{H}_5\text{N}$                           | -23.39               | 7.91                                      | Thiourea                              | $\text{CH}_4\text{N}_2\text{S}$                  | 178                  | 14.0                                      |
| Pyrrolidine                            | $\text{C}_4\text{H}_9\text{N}$                           | -57.79               | 8.58                                      | Thymol                                | $\text{C}_{10}\text{H}_{14}\text{O}$             | 49.5                 | 21.3                                      |
| Quinoline                              | $\text{C}_9\text{H}_7\text{N}$                           | -14.78               | 10.66                                     | Toluene                               | $\text{C}_7\text{H}_8$                           | -94.95               | 6.64                                      |
| Resorcinol                             | $\text{C}_6\text{H}_6\text{O}_2$                         | 109.4                | 20.4                                      | <i>o</i> -Toluic acid                 | $\text{C}_8\text{H}_8\text{O}_2$                 | 103.5                | 19.5                                      |
| Sebacic acid                           | $\text{C}_{10}\text{H}_{18}\text{O}_4$                   | 130.9                | 40.8                                      | <i>m</i> -Toluic acid                 | $\text{C}_8\text{H}_8\text{O}_2$                 | 109.9                | 15.7                                      |
| Sodium acetate                         | $\text{C}_2\text{H}_3\text{NaO}_2$                       | 328.2                | 17.9                                      | <i>p</i> -Toluic acid                 | $\text{C}_8\text{H}_8\text{O}_2$                 | 179.6                | 22.7                                      |
| Sodium hydrogen carbonate              | $\text{CHNaO}_3$                                         | 527                  | 25                                        | Triacontane                           | $\text{C}_{30}\text{H}_{62}$                     | 65.1                 | 68.3                                      |
| Spiro[2.2]pentane                      | $\text{C}_5\text{H}_8$                                   | -107.0               | 6.43                                      | 1,3,5-Triazine                        | $\text{C}_3\text{H}_3\text{N}_3$                 | 80.3                 | 14.56                                     |
| Stearic acid                           | $\text{C}_{18}\text{H}_{36}\text{O}_2$                   | 69.3                 | 61.2                                      | Tribromomethane                       | $\text{CHBr}_3$                                  | 8.69                 | 11.05                                     |
| <i>trans</i> -Stilbene                 | $\text{C}_{14}\text{H}_{12}$                             | 124.2                | 27.7                                      | Trichloroacetic acid                  | $\text{C}_2\text{HCl}_3\text{O}_2$               | 59.2                 | 5.90                                      |
| Styrene                                | $\text{C}_8\text{H}_8$                                   | -30.65               | 10.9                                      | 1,2,3-Trichlorobenzene                | $\text{C}_6\text{H}_3\text{Cl}_3$                | 51.3                 | 17.9                                      |
| Succinic acid                          | $\text{C}_4\text{H}_6\text{O}_4$                         | 187.9                | 32.4                                      | 1,2,4-Trichlorobenzene                | $\text{C}_6\text{H}_3\text{Cl}_3$                | 16.92                | 16.4                                      |
| Succinic anhydride                     | $\text{C}_4\text{H}_4\text{O}_3$                         | 119                  | 20.4                                      | 1,3,5-Trichlorobenzene                | $\text{C}_6\text{H}_3\text{Cl}_3$                | 62.8                 | 18.1                                      |
| Succinonitrile                         | $\text{C}_4\text{H}_4\text{N}_2$                         | 58.06                | 3.70                                      | 1,1,1-Trichloroethane                 | $\text{C}_2\text{H}_3\text{Cl}_3$                | -30.01               | 2.35                                      |
| Sulfacetamide                          | $\text{C}_8\text{H}_{10}\text{N}_2\text{O}_3\text{S}$    | 183                  | 22.4                                      | 1,1,2-Trichloroethane                 | $\text{C}_2\text{H}_2\text{Cl}_3$                | -36.3                | 11.46                                     |
| Sulfadiazine                           | $\text{C}_{10}\text{H}_{10}\text{N}_4\text{O}_2\text{S}$ | 258                  | 42.6                                      | Trichloroethene                       | $\text{C}_2\text{HCl}_3$                         | -84.7                | 8.45                                      |
| Sulfamerazine                          | $\text{C}_{11}\text{H}_{12}\text{N}_4\text{O}_2\text{S}$ | 236                  | 38.7                                      | Trichlorofluoromethane                | $\text{CCl}_3\text{F}$                           | -110.44              | 6.89                                      |
| Sulfamethoxazole                       | $\text{C}_{10}\text{H}_{11}\text{N}_3\text{O}_3\text{S}$ | 170                  | 32.2                                      | Trichloromethane                      | $\text{CHCl}_3$                                  | -63.41               | 9.5                                       |
| Sulfamethoxypyridazine                 | $\text{C}_{11}\text{H}_{12}\text{N}_4\text{O}_3\text{S}$ | 182.5                | 31.3                                      | 1,1,2-Trichloro-1,2,2-trifluoroethane | $\text{C}_2\text{Cl}_3\text{F}_3$                | -36.22               | 2.47                                      |
| Sulfapyridine                          | $\text{C}_{11}\text{H}_{11}\text{N}_3\text{O}_2\text{S}$ | 192                  | 34.4                                      | Tricosane                             | $\text{C}_{23}\text{H}_{48}$                     | 47.76                | 50.86                                     |
| Sulfathiazole                          | $\text{C}_9\text{H}_9\text{N}_3\text{O}_2\text{S}_2$     | 202                  | 26.4                                      | Tridecane                             | $\text{C}_{13}\text{H}_{28}$                     | -5.4                 | 28.50                                     |
| Sulfisoxazole                          | $\text{C}_{11}\text{H}_{13}\text{N}_3\text{O}_3\text{S}$ | 196                  | 30.2                                      | 1-Tridecanol                          | $\text{C}_{13}\text{H}_{28}\text{O}$             | 31.7                 | 41.4                                      |
| <i>o</i> -Terphenyl                    | $\text{C}_{18}\text{H}_{14}$                             | 56.20                | 17.19                                     | 1,1,1-Trifluoroethane                 | $\text{C}_2\text{H}_3\text{F}_3$                 | -111.3               | 6.19                                      |
| <i>p</i> -Terphenyl                    | $\text{C}_{18}\text{H}_{14}$                             | 213.9                | 35.3                                      | Trifluoromethane                      | $\text{CHF}_3$                                   | -155.2               | 4.06                                      |
| Tetrabromomethane                      | $\text{CBr}_4$                                           | 92.3                 | 3.76                                      | Triiodomethane                        | $\text{CHI}_3$                                   | 121.2                | 16.44                                     |
| 1,1,2,2-Tetrachloro-1,2-difluoroethane | $\text{C}_2\text{Cl}_4\text{F}_2$                        | 24.8                 | 3.67                                      | Trimethoprim                          | $\text{C}_{14}\text{H}_{18}\text{N}_4\text{O}_3$ | 199                  | 49.4                                      |
| 1,1,2,2-Tetrachloroethane              | $\text{C}_2\text{H}_2\text{Cl}_4$                        | -42.4                | 9.17                                      | Trimethylamine                        | $\text{C}_3\text{H}_9\text{N}$                   | -117.1               | 7                                         |
| Tetrachloroethene                      | $\text{C}_2\text{Cl}_4$                                  | -22.3                | 10.88                                     | 1,2,3-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$                        | -25.4                | 8.18                                      |
| Tetrachloromethane                     | $\text{CCl}_4$                                           | -22.62               | 2.56                                      | 1,2,4-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$                        | -43.77               | 13.19                                     |
| Tetracontane                           | $\text{C}_{40}\text{H}_{82}$                             | 81.5                 | 135.5                                     | 1,3,5-Trimethylbenzene                | $\text{C}_9\text{H}_{12}$                        | -44.72               | 9.51                                      |
| Tetracosane                            | $\text{C}_{24}\text{H}_{50}$                             | 50.4                 | 54.4                                      | 2,2,3-Trimethylbutane                 | $\text{C}_7\text{H}_{16}$                        | -24.6                | 2.26                                      |
| Tetradecane                            | $\text{C}_{14}\text{H}_{30}$                             | 5.82                 | 45.07                                     | 2,2,4-Trimethylpentane                | $\text{C}_8\text{H}_{18}$                        | -107.3               | 9.20                                      |
| Tetradecanoic acid                     | $\text{C}_{14}\text{H}_{28}\text{O}_2$                   | 54.2                 | 45.1                                      | 1,3,5-Trinitrobenzene                 | $\text{C}_6\text{H}_3\text{N}_3\text{O}_6$       | 122.9                | 15.4                                      |
| 1-Tetradecanol                         | $\text{C}_{14}\text{H}_{30}\text{O}$                     | 38.2                 | 25.1*                                     | Trinitroglycerol                      | $\text{C}_3\text{H}_5\text{N}_3\text{O}_9$       | 13.5                 | 21.87                                     |
| 1,2,3,5-Tetrafluorobenzene             | $\text{C}_6\text{H}_2\text{F}_4$                         | -46.25               | 6.36                                      | 2,4,6-Trinitrotoluene                 | $\text{C}_7\text{H}_5\text{N}_3\text{O}_6$       | 80.5                 | 22.9                                      |
| 1,2,4,5-Tetrafluorobenzene             | $\text{C}_6\text{H}_2\text{F}_4$                         | 3.88                 | 15.05                                     | 1,3,5-Trioxane                        | $\text{C}_3\text{H}_6\text{O}_3$                 | 60.29                | 15.11                                     |
| Tetrafluoroethene                      | $\text{C}_2\text{F}_4$                                   | -131.15              | 7.72                                      | Triphenylamine                        | $\text{C}_{18}\text{H}_{15}\text{N}$             | 126.5                | 24.9                                      |
| Tetrafluoromethane                     | $\text{CF}_4$                                            | -183.60              | 0.704                                     | Triphenylene                          | $\text{C}_{18}\text{H}_{12}$                     | 197.8                | 24.74                                     |
| Tetrahydrofuran                        | $\text{C}_4\text{H}_8\text{O}$                           | -108.44              | 8.54                                      | Tritriacontane                        | $\text{C}_{33}\text{H}_{68}$                     | 71.2                 | 79.5                                      |
| Tetrahydropyran                        | $\text{C}_5\text{H}_{10}\text{O}$                        | -49.1                | 1.8                                       | Undecane                              | $\text{C}_{11}\text{H}_{24}$                     | -25.5                | 22.2                                      |
| Tetrahydrothiophene                    | $\text{C}_4\text{H}_8\text{S}$                           | -96.2                | 7.35                                      | Urea                                  | $\text{CH}_4\text{N}_2\text{O}$                  | 133.3                | 13.9                                      |
| 1,2,4,5-Tetramethylbenzene             | $\text{C}_{10}\text{H}_{14}$                             | 79.3                 | 21                                        | <i>o</i> -Xylene                      | $\text{C}_8\text{H}_{10}$                        | -25.2                | 13.6                                      |
| Tetramethyl lead                       | $\text{C}_4\text{H}_{12}\text{Pb}$                       | -30.2                | 10.80                                     | <i>m</i> -Xylene                      | $\text{C}_8\text{H}_{10}$                        | -47.8                | 11.6                                      |
| 2,2,3,3-Tetramethylpentane             | $\text{C}_9\text{H}_{20}$                                | -9.75                | 2.33                                      | <i>p</i> -Xylene                      | $\text{C}_8\text{H}_{10}$                        | 13.25                | 17.12                                     |
| 2,2,4,4-Tetramethylpentane             | $\text{C}_9\text{H}_{20}$                                | -66.54               | 9.74                                      | 2,3-Xylenol                           | $\text{C}_8\text{H}_{10}\text{O}$                | 72.5                 | 21.0                                      |
| Tetramethylsilane                      | $\text{C}_4\text{H}_{12}\text{Si}$                       | -99.06               | 6.87                                      | 2,5-Xylenol                           | $\text{C}_8\text{H}_{10}\text{O}$                | 74.8                 | 23.4                                      |
| Tetramethylstannane                    | $\text{C}_4\text{H}_{12}\text{Sn}$                       | -55.1                | 9.30                                      | 2,6-Xylenol                           | $\text{C}_8\text{H}_{10}\text{O}$                | 45.8                 | 18.9                                      |
| Tetratetracontane                      | $\text{C}_{44}\text{H}_{90}$                             | 85.6                 | 149.6                                     | 3,4-Xylenol                           | $\text{C}_8\text{H}_{10}\text{O}$                | 65.1                 | 18.1                                      |
| Tetratriacontane                       | $\text{C}_{34}\text{H}_{70}$                             | 72.5                 | 79.4                                      | 3,5-Xylenol                           | $\text{C}_8\text{H}_{10}\text{O}$                | 63.4                 | 17.4                                      |
| 1 <i>H</i> -Tetrazole                  | $\text{CH}_2\text{N}_4$                                  | 157.3                | 18.2                                      |                                       |                                                  |                      |                                           |

# PRESSURE AND TEMPERATURE DEPENDENCE OF LIQUID DENSITY

This table gives data on the variation of the density of some common liquids with pressure and temperature. The pressure dependence is described to first order by the isothermal compressibility coefficient  $\kappa$  defined as

$$\kappa = -(1/V) (\partial V/\partial P)_T$$

where  $V$  is the volume, and the temperature dependence by the cubic expansion coefficient  $\alpha$ ,

$$\alpha = (1/V) (\partial V/\partial T)_P$$

Substances are listed by molecular formula in the Hill order. More precise data on the variation of density with temperature over a wide temperature range can be found in Reference 1.

## References

1. Lide, D. R., and Kehiaian, H. V., *CRC Handbook of Thermophysical and Thermochemical Data*, CRC Press, Boca Raton, FL, 1994.
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3. Landolt-Börnstein, *Numerical Data and Functional Relationships in Science and Technology, New Series, IV/4, High-Pressure Properties of Matter*, Springer-Verlag, Heidelberg, 1980.
4. Riddick, J.A., Bunger, W.B., and Sakano, T.K., *Organic Solvents, Fourth Edition*, John Wiley & Sons, New York, 1986.
5. Isaacs, N. S., *Liquid Phase High Pressure Chemistry*, John Wiley, New York, 1981.

| Molecular<br>formula              | Name                               | Isothermal compressibility |                                      | Cubic expansion coefficient |                                            |
|-----------------------------------|------------------------------------|----------------------------|--------------------------------------|-----------------------------|--------------------------------------------|
|                                   |                                    | $t/^{\circ}\text{C}$       | $\kappa \times 10^4/\text{MPa}^{-1}$ | $t/^{\circ}\text{C}$        | $\alpha \times 10^3/^{\circ}\text{C}^{-1}$ |
| $\text{Cl}_3\text{P}$             | Phosphorus trichloride             | 20                         | 9.45                                 | 20                          | 1.9                                        |
| $\text{H}_2\text{O}$              | Water                              | 20                         | 4.591                                | 20                          | 0.206                                      |
|                                   |                                    | 25                         | 4.524                                | 25                          | 0.256                                      |
|                                   |                                    | 30                         | 4.475                                | 30                          | 0.302                                      |
| Hg                                | Mercury                            | 20                         | 0.401                                | 20                          | 0.1811                                     |
| $\text{CCl}_4$                    | Tetrachloromethane                 | 20                         | 10.50                                | 20                          | 1.14                                       |
|                                   |                                    | 40                         | 12.20                                | 40                          | 1.21                                       |
|                                   |                                    | 70                         | 15.6                                 | 70                          | 1.33                                       |
| $\text{CHBr}_3$                   | Tribromomethane                    | 50                         | 8.76                                 | 25                          | 0.91                                       |
| $\text{CHCl}_3$                   | Trichloromethane                   | 20                         | 9.96                                 | 20                          | 1.21                                       |
|                                   |                                    | 50                         | 12.9                                 | 50                          | 1.33                                       |
| $\text{CH}_2\text{Br}_2$          | Dibromomethane                     | 27                         | 6.85                                 |                             |                                            |
| $\text{CH}_2\text{Cl}_2$          | Dichloromethane                    | 25                         | 10.3                                 | 25                          | 1.39                                       |
| $\text{CH}_3\text{I}$             | Iodomethane                        | 27                         | 10.3                                 | 25                          | 1.26                                       |
| $\text{CH}_4\text{O}$             | Methanol                           | 20                         | 12.14                                | 20                          | 1.49                                       |
|                                   |                                    | 40                         | 13.83                                | 40                          | 1.59                                       |
| $\text{CS}_2$                     | Carbon disulfide                   | 20                         | 9.38                                 | 20                          | 1.12                                       |
|                                   |                                    | 40                         | 10.6                                 | 35                          | 1.16                                       |
| $\text{C}_2\text{Cl}_4$           | Tetrachloroethylene                | 25                         | 7.56                                 | 25                          | 1.02                                       |
| $\text{C}_2\text{HCl}_3$          | Trichloroethylene                  | 25                         | 8.57                                 | 25                          | 1.17                                       |
| $\text{C}_2\text{H}_2\text{Cl}_2$ | <i>trans</i> -1,2-Dichloroethylene | 25                         | 11.2                                 | 25                          | 1.36                                       |
| $\text{C}_2\text{H}_4\text{Cl}_2$ | 1,1-Dichloroethane                 | 20                         | 7.97                                 | 25                          | 0.93                                       |
| $\text{C}_2\text{H}_4\text{Cl}_2$ | 1,2-Dichloroethane                 | 30                         | 8.46                                 | 20                          | 1.14                                       |
| $\text{C}_2\text{H}_4\text{O}_2$  | Acetic acid                        | 20                         | 9.08                                 | 20                          | 1.08                                       |
|                                   |                                    | 80                         | 13.7                                 | 80                          | 1.38                                       |
| $\text{C}_2\text{H}_5\text{Br}$   | Bromoethane                        | 20                         | 11.53                                | 20                          | 1.31                                       |
| $\text{C}_2\text{H}_5\text{I}$    | Iodoethane                         | 20                         | 9.82                                 | 25                          | 1.17                                       |
| $\text{C}_2\text{H}_6\text{O}$    | Ethanol                            | 20                         | 11.19                                | 20                          | 1.40                                       |
|                                   |                                    | 70                         | 15.93                                | 70                          | 1.67                                       |
| $\text{C}_2\text{H}_6\text{O}_2$  | Ethylene glycol                    | 20                         | 3.64                                 | 20                          | 0.626                                      |
| $\text{C}_3\text{H}_6\text{O}$    | Acetone                            | 20                         | 12.62                                | 20                          | 1.46                                       |
|                                   |                                    | 40                         | 15.6                                 | 40                          | 1.57                                       |
| $\text{C}_3\text{H}_7\text{Br}$   | 1-Bromopropane                     | 0                          | 10.22                                | 25                          | 1.2                                        |
| $\text{C}_3\text{H}_7\text{Cl}$   | 1-Chloropropane                    | 0                          | 12.09                                | 20                          | 1.4                                        |
| $\text{C}_3\text{H}_7\text{I}$    | 1-Iodopropane                      | 0                          | 10.22                                | 25                          | 1.09                                       |
| $\text{C}_3\text{H}_8\text{O}$    | 1-Propanol                         | 0                          | 8.43                                 | 0                           | 1.22                                       |
| $\text{C}_3\text{H}_8\text{O}$    | 2-Propanol                         | 40                         | 13.32                                | 40                          | 1.55                                       |
| $\text{C}_3\text{H}_8\text{O}_2$  | 1,2-Propanediol                    | 0                          | 4.45                                 | 20                          | 0.695                                      |
| $\text{C}_3\text{H}_8\text{O}_2$  | 1,3-Propanediol                    | 0                          | 4.09                                 | 20                          | 0.61                                       |
| $\text{C}_3\text{H}_8\text{O}_3$  | Glycerol                           | 0                          | 2.54                                 | 20                          | 0.520                                      |
| $\text{C}_4\text{H}_8\text{O}_2$  | Ethyl acetate                      | 20                         | 11.32                                | 20                          | 1.35                                       |
|                                   |                                    | 60                         | 16.2                                 | 60                          | 1.54                                       |

| Molecular<br>formula                   | Name               | Isothermal compressibility |                                      | Cubic expansion coefficient |                                            |
|----------------------------------------|--------------------|----------------------------|--------------------------------------|-----------------------------|--------------------------------------------|
|                                        |                    | $t/^{\circ}\text{C}$       | $\kappa \times 10^4/\text{MPa}^{-1}$ | $t/^{\circ}\text{C}$        | $\alpha \times 10^3/^{\circ}\text{C}^{-1}$ |
| $\text{C}_4\text{H}_9\text{Br}$        | 1-Bromobutane      | 25                         | 10.26                                | 20                          | 1.13                                       |
| $\text{C}_4\text{H}_9\text{I}$         | 1-Iodobutane       | 0                          | 7.73                                 | 25                          | 1.02                                       |
| $\text{C}_4\text{H}_{10}\text{O}$      | 1-Butanol          | 0                          | 8.10                                 | 0                           | 1.12                                       |
| $\text{C}_4\text{H}_{10}\text{O}$      | Diethyl ether      | 20                         | 18.65                                | 20                          | 1.65                                       |
|                                        |                    | 30                         | 20.85                                | 30                          | 1.72                                       |
| $\text{C}_4\text{H}_{10}\text{O}_3$    | Diethylene glycol  | 0                          | 3.34                                 | 20                          | 0.635                                      |
| $\text{C}_5\text{H}_{10}$              | Cyclopentane       | 20                         | 13.31                                | 20                          | 1.35                                       |
| $\text{C}_5\text{H}_{11}\text{Br}$     | 1-Bromopentane     | 0                          | 8.42                                 | 25                          | 1.04                                       |
| $\text{C}_5\text{H}_{11}\text{I}$      | 1-Iodopentane      | 0                          | 7.56                                 |                             |                                            |
| $\text{C}_5\text{H}_{12}$              | Pentane            | 25                         | 21.80                                | 25                          | 1.64                                       |
| $\text{C}_5\text{H}_{12}\text{O}$      | 1-Pentanol         | 0                          | 7.71                                 | 0                           | 1.02                                       |
| $\text{C}_6\text{H}_5\text{Br}$        | Bromobenzene       | 20                         | 6.46                                 | 20                          | 0.86                                       |
| $\text{C}_6\text{H}_5\text{Cl}$        | Chlorobenzene      | 20                         | 7.45                                 | 20                          | 0.94                                       |
| $\text{C}_6\text{H}_5\text{NO}_2$      | Nitrobenzene       | 20                         | 4.93                                 | 25                          | 0.833                                      |
| $\text{C}_6\text{H}_6$                 | Benzene            | 25                         | 9.66                                 | 25                          | 1.14                                       |
|                                        |                    | 45                         | 11.28                                | 45                          | 1.21                                       |
| $\text{C}_6\text{H}_6\text{O}$         | Phenol             | 60                         | 6.05                                 | 60                          | 0.82                                       |
| $\text{C}_6\text{H}_7\text{N}$         | Aniline            | 20                         | 4.53                                 | 20                          | 0.81                                       |
|                                        |                    | 80                         | 6.32                                 | 80                          | 0.91                                       |
| $\text{C}_6\text{H}_{12}$              | Cyclohexane        | 20                         | 11.30                                | 20                          | 1.15                                       |
|                                        |                    | 60                         | 15.2                                 | 60                          | 1.29                                       |
| $\text{C}_6\text{H}_{14}$              | Hexane             | 25                         | 16.69                                | 25                          | 1.41                                       |
|                                        |                    | 45                         | 20.27                                | 45                          | 1.52                                       |
| $\text{C}_6\text{H}_{14}$              | 2-Methylpentane    | 0                          | 13.97                                | 25                          | 1.43                                       |
| $\text{C}_6\text{H}_{14}$              | 3-Methylpentane    | 0                          | 14.57                                | 25                          | 1.40                                       |
| $\text{C}_6\text{H}_{14}$              | 2,3-Dimethylbutane | 20                         | 17.97                                | 25                          | 1.39                                       |
| $\text{C}_6\text{H}_{14}\text{O}$      | 1-Hexanol          | 25                         | 8.24                                 | 25                          | 1.03                                       |
| $\text{C}_6\text{H}_{15}\text{NO}_3$   | Triethanolamine    | 0                          | 3.61                                 | 55                          | 0.53                                       |
| $\text{C}_7\text{H}_8$                 | Toluene            | 20                         | 8.96                                 | 20                          | 1.05                                       |
|                                        |                    | 50                         | 11.0                                 | 50                          | 1.13                                       |
| $\text{C}_7\text{H}_8\text{O}$         | Anisole            | 20                         | 6.60                                 | 20                          | 0.951                                      |
| $\text{C}_7\text{H}_{14}$              | Cycloheptane       | 20                         | 9.22                                 |                             |                                            |
| $\text{C}_7\text{H}_{16}$              | Heptane            | 25                         | 14.38                                | 25                          | 1.26                                       |
| $\text{C}_8\text{H}_{10}$              | <i>o</i> -Xylene   | 25                         | 8.10                                 | 25                          | 0.96                                       |
| $\text{C}_8\text{H}_{10}$              | <i>m</i> -Xylene   | 20                         | 8.46                                 | 20                          | 0.99                                       |
| $\text{C}_8\text{H}_{10}$              | <i>p</i> -Xylene   | 25                         | 8.59                                 | 25                          | 1.00                                       |
| $\text{C}_8\text{H}_{16}$              | Cyclooctane        | 20                         | 8.03                                 |                             |                                            |
| $\text{C}_8\text{H}_{18}$              | Octane             | 25                         | 12.82                                | 25                          | 1.16                                       |
|                                        |                    | 45                         | 15.06                                | 45                          | 1.23                                       |
| $\text{C}_8\text{H}_{18}\text{O}$      | 1-Octanol          | 25                         | 7.64                                 | 25                          | 0.827                                      |
| $\text{C}_9\text{H}_{12}$              | Mesitylene         | 25                         | 8.14                                 | 25                          | 0.94                                       |
| $\text{C}_9\text{H}_{14}\text{O}_6$    | Triacetin          | 0                          | 4.49                                 | 25                          | 0.94                                       |
| $\text{C}_9\text{H}_{20}$              | Nonane             | 25                         | 11.75                                | 25                          | 1.08                                       |
| $\text{C}_{10}\text{H}_{22}$           | Decane             | 25                         | 10.94                                | 25                          | 1.02                                       |
| $\text{C}_{11}\text{H}_{24}$           | Undecane           | 25                         | 10.31                                | 25                          | 0.97                                       |
| $\text{C}_{12}\text{H}_{26}$           | Dodecane           | 25                         | 9.88                                 | 25                          | 0.93                                       |
| $\text{C}_{13}\text{H}_{28}$           | Tridecane          | 25                         | 9.48                                 | 25                          | 0.90                                       |
| $\text{C}_{14}\text{H}_{30}$           | Tetradecane        | 25                         | 9.10                                 | 25                          | 0.87                                       |
| $\text{C}_{15}\text{H}_{32}$           | Pentadecane        | 25                         | 8.82                                 |                             |                                            |
| $\text{C}_{16}\text{H}_{22}\text{O}_4$ | Butyl phthalate    | 0                          | 5.0                                  | 25                          | 0.86                                       |
| $\text{C}_{16}\text{H}_{34}$           | Hexadecane         | 25                         | 8.57                                 |                             |                                            |
|                                        |                    | 45                         | 9.78                                 |                             |                                            |
| $\text{C}_{19}\text{H}_{36}\text{O}_2$ | Methyl oleate      | 0                          | 6.18                                 | 60                          | 0.85                                       |



## PROPERTIES OF CRYOGENIC FLUIDS

This table gives physical and thermodynamic properties of eight cryogenic fluids. The properties are:

|                               |                                                                                                 |
|-------------------------------|-------------------------------------------------------------------------------------------------|
| $M$                           | Molar mass in grams per mole                                                                    |
| $T_t$                         | Triple point temperature in kelvins                                                             |
| $P_t$                         | Triple point pressure in kilopascals                                                            |
| $\rho_t$ (l)                  | Liquid density at the triple point in grams per milliliter                                      |
| $\Delta_{\text{fus}} H @ T_t$ | Enthalpy of fusion at the triple point in joules per gram                                       |
| $T_b$                         | Normal boiling point in kelvins at a pressure of 101325 pascals (760 mmHg)                      |
| $\Delta_{\text{vap}} H @ T_b$ | Enthalpy of vaporization at the normal boiling point in joules per gram                         |
| $\rho$ (l) @ $T_b$            | Liquid density at the normal boiling point in grams per milliliter                              |
| $\rho$ (g) @ $T_b$            | Vapor density at the normal boiling point in grams per liter                                    |
| $C_p$ (l) @ $T_b$             | Liquid heat capacity at constant pressure at the normal boiling point in joules per gram kelvin |
| $C_p$ (g) @ $T_b$             | Vapor heat capacity at constant pressure at the normal boiling point in joules per gram kelvin  |
| $T_c$                         | Critical temperature in kelvins                                                                 |
| $P_c$                         | Critical pressure in megapascals                                                                |
| $\rho_c$                      | Critical density in grams per milliliter                                                        |

In the case of air, the value given for the triple point temperature is the incipient solidification temperature, and the normal boiling point value is the incipient boiling (bubble) point. See Reference 3 for more details.

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| Property                      | Units | Air    | N <sub>2</sub> | O <sub>2</sub> | H <sub>2</sub> | He       | Ne      | Ar      | Kr     | Xe      | CH <sub>4</sub> |
|-------------------------------|-------|--------|----------------|----------------|----------------|----------|---------|---------|--------|---------|-----------------|
| $M$                           | g/mol | 28.96  | 28.014         | 31.999         | 2.0159         | 4.0026   | 20.180  | 39.948  | 83.800 | 131.290 | 16.043          |
| $T_t$                         | K     | 59.75  | 63.15          | 54.3584        | 13.8           |          | 24.5561 | 83.8058 | 115.8  | 161.4   | 90.694          |
| $P_t$                         | kPa   |        | 12.463         | 0.14633        | 7.042          |          | 50      | 68.95   | 72.92  | 81.59   | 11.696          |
| $\rho_t$ (l)                  | g/mL  | 0.959  | 0.870          | 1.306          | 0.0770         |          | 1.251   | 1.417   | 2.449  | 2.978   | 0.4515          |
| $\Delta_{\text{fus}} H @ T_t$ | J/g   |        | 25.3           | 13.7           | 59.5           |          | 16.8    | 28.0    | 16.3   | 13.8    | 58.41           |
| $T_b$                         | K     | 78.67  | 77.35          | 90.188         | 20.28          | 4.2221   | 27.07   | 87.293  | 119.92 | 165.10  | 111.668         |
| $\Delta_{\text{vap}} H @ T_b$ | J/g   | 198.7  | 198.8          | 213.1          | 445            | 20.7     | 84.8    | 161.0   | 108.4  | 96.1    | 510.83          |
| $\rho$ (l) @ $T_b$            | g/mL  | 0.8754 | 0.807          | 1.141          | 0.0708         | 0.124901 | 1.204   | 1.396   | 2.418  | 2.953   | 0.4224          |
| $\rho$ (g) @ $T_b$            | g/L   | 3.199  | 4.622          | 4.467          | 1.3390         | 16.89    | 9.51    | 5.79    | 8.94   |         | 1.816           |
| $C_p$ (l) @ $T_b$             | J/g K | 1.865  | 2.042          | 1.699          | 9.668          | 4.545    | 1.877   | 1.078   | 0.533  | 0.340   | 3.481           |
| $C_p$ (g) @ $T_b$             | J/g K |        | 1.341          | 0.980          | 12.24          | 9.78     |         | 0.570   | 0.248  | 0.158   | 2.218           |
| $T_c$                         | K     | 132.5  | 126.20         | 154.581        | 32.98          | 5.1953   | 44.40   | 150.663 | 209.40 | 289.73  | 190.56          |
| $P_c$                         | MPa   | 3.766  | 3.390          | 5.043          | 1.293          | 0.227460 | 2.760   | 4.860   | 5.500  | 5.840   | 4.592           |
| $\rho_c$                      | g/mL  | 0.316  | 0.313          | 0.436          | 0.031          | 0.06964  | 0.484   | 0.531   | 0.919  | 1.110   | 0.1627          |

## PROPERTIES OF REFRIGERANTS

This table gives physical properties of compounds that have been used as working fluids in traditional refrigeration systems or are under consideration as replacements in newer systems. Some are also used as solvents and blowing agents. Many of the compounds listed are believed to be less harmful to the environment than the traditional halocarbon refrigerants.

Compounds are listed by their ASHRAE standard refrigerant designations (Reference 1), which appear in the first column. These codes are often prefixed by symbols such as CFC- (for chlorofluorocarbon), HCFC- (for hydrochlorofluorocarbon), or simply R- (for refrigerant). The "R" number assigned to refrigerants is specified by ANSI/ASHRAE Standard 34. This system is most useful for the hydrocarbons and halocarbons with one to three carbons; for such molecules the chemical composition can be determined from the number and vice versa. The first digit on the far right is the number of fluorine atoms in the compound. The second digit from the right is one more than the number of hydrogen atoms. The third digit from the right is one less than the number of carbon atoms; for single-carbon compounds, this digit is omitted. The fourth digit from the right is equal to the number of unsaturated carbon-carbon bonds; for saturated compounds, this digit is omitted. The number of bromine and iodine atoms is indicated, if needed, by appending "Bn" or "In" to the digits specified by the above rules, where "n" is the number of bromine or iodine atoms. All atoms not specified by the above are assumed to be chlorine. Appended lowercase letter(s) designate different isomers. Additional rules are used to specify cyclic compounds, ethers, inorganic fluids (R700- and R7000-series), miscellaneous organic compounds (R600-series), and blends (R400- and R500-series).

The properties tabulated are

|       |                                                                                                                                                                                                               |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $t_m$ | normal melting point in °C                                                                                                                                                                                    |
| $t_b$ | normal boiling point in °C (at 101.325 kPa or 760 mmHg)                                                                                                                                                       |
| $t_c$ | critical temperature in °C                                                                                                                                                                                    |
| TLV   | Threshold Limit Value, which is the maximum safe concentration in air in the workplace, expressed as the time-weighted average (TWA) in parts per million by volume, over an 8-hr workday and 40-hr workweek. |

Many of the critical temperatures and normal boiling points have been calculated from the equations of state described in References 9 and 10. These values differ slightly in some cases (generally no more than about 0.1 °C) from values elsewhere in this book, but the differences are probably within the experimental uncertainty. Further references and additional data on the critical properties may be found in the table "Critical Constants" in this Section.

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| Code | Name                       | Molecular Formula               | CAS Reg. No. | $t_m$ /°C | $t_b$ /°C | $t_c$ /°C | TLV/ppm |
|------|----------------------------|---------------------------------|--------------|-----------|-----------|-----------|---------|
| 10   | Tetrachloromethane         | CCl <sub>4</sub>                | 56-23-5      | -22.62    | 76.8      | 283.4     | 5       |
| 11   | Trichlorofluoromethane     | CCl <sub>3</sub> F              | 75-69-4      | -110.47   | 23.71     | 197.96    | 1000    |
| 12   | Dichlorodifluoromethane    | CCl <sub>2</sub> F <sub>2</sub> | 75-71-8      | -157.05   | -29.75    | 111.97    | 1000    |
| 12B1 | Bromochlorodifluoromethane | CBrClF <sub>2</sub>             | 353-59-3     | -159.5    | -3.7      | 153.73    |         |
| 12B2 | Dibromodifluoromethane     | CBr <sub>2</sub> F <sub>2</sub> | 75-61-6      | -110.1    | 22.76     | 198.1     | 100     |
| 13   | Chlorotrifluoromethane     | CClF <sub>3</sub>               | 75-72-9      | -181.15   | -81.48    | 28.85     |         |
| 13B1 | Bromotrifluoromethane      | CBrF <sub>3</sub>               | 75-63-8      | -172      | -57.8     | 67.0      | 1000    |
| 14   | Tetrafluoromethane         | CF <sub>4</sub>                 | 75-73-0      | -183.61   | -128.05   | -45.64    |         |
| 20   | Trichloromethane           | CHCl <sub>3</sub>               | 67-66-3      | -63.41    | 61.17     | 263.2     | 10      |
| 21   | Dichlorofluoromethane      | CHCl <sub>2</sub> F             | 75-43-4      | -130.35   | 8.86      | 178.33    | 10      |
| 22   | Chlorodifluoromethane      | CHClF <sub>2</sub>              | 75-45-6      | -157.42   | -40.81    | 96.15     | 1000    |
| 22B1 | Bromodifluoromethane       | CHBrF <sub>2</sub>              | 1511-62-2    | -145      | -14.6     | 138.83    |         |
| 23   | Trifluoromethane           | CHF <sub>3</sub>                | 75-46-7      | -155.13   | -82.02    | 26.14     |         |
| 30   | Dichloromethane            | CH <sub>2</sub> Cl <sub>2</sub> | 75-09-2      | -97.2     | 40        | 237       | 50      |



| Code  | Name                                   | Molecular<br>Formula                        | CAS Reg.<br>No. | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $t_c/^\circ\text{C}$ | TLV/<br>ppm |
|-------|----------------------------------------|---------------------------------------------|-----------------|----------------------|----------------------|----------------------|-------------|
| 31    | Chlorofluoromethane                    | $\text{CH}_2\text{ClF}$                     | 593-70-4        | -135.1               | -9.1                 | 154                  |             |
| 32    | Difluoromethane                        | $\text{CH}_2\text{F}_2$                     | 75-10-5         | -136.81              | -51.65               | 78.11                |             |
| 40    | Chloromethane                          | $\text{CH}_3\text{Cl}$                      | 74-87-3         | -97.7                | -24.09               | 143.10               | 50          |
| 41    | Fluoromethane                          | $\text{CH}_3\text{F}$                       | 593-53-3        | -143.33              | -78.31               | 44.13                |             |
| 50    | Methane                                | $\text{CH}_4$                               | 74-82-8         | -182.43              | -161.48              | -82.59               | 1000        |
| 110   | Hexachloroethane                       | $\text{C}_2\text{Cl}_6$                     | 67-72-1         | 186.8                | 184.7 sp             | 422                  | 1           |
| 111   | Pentachlorofluoroethane                | $\text{C}_2\text{Cl}_5\text{F}$             | 354-56-3        | 101.3                | 138                  |                      |             |
| 112   | 1,1,2,2-Tetrachloro-1,2-difluoroethane | $\text{C}_2\text{Cl}_4\text{F}_2$           | 76-12-0         | 24.8                 | 92.8                 | 278                  | 50          |
| 112a  | 1,1,1,2-Tetrachloro-2,2-difluoroethane | $\text{C}_2\text{Cl}_4\text{F}_2$           | 76-11-9         | 41.0                 | 92.8                 |                      | 100         |
| 113   | 1,1,2-Trichloro-1,2,2-trifluoroethane  | $\text{C}_2\text{Cl}_3\text{F}_3$           | 76-13-1         | -36.22               | 47.59                | 214.06               | 1000        |
| 113a  | 1,1,1-Trichloro-2,2,2-trifluoroethane  | $\text{C}_2\text{Cl}_3\text{F}_3$           | 354-58-5        | 14.37                | 45.5                 | 209.7                |             |
| 114   | 1,2-Dichloro-1,1,2,2-tetrafluoroethane | $\text{C}_2\text{Cl}_2\text{F}_4$           | 76-14-2         | -92.52               | 3.59                 | 145.68               | 1000        |
| 114a  | 1,1-Dichloro-1,2,2,2-tetrafluoroethane | $\text{C}_2\text{Cl}_2\text{F}_4$           | 374-07-2        | -56.6                | 3.4                  | 145.4                |             |
| 114B2 | 1,2-Dibromotetrafluoroethane           | $\text{C}_2\text{Br}_2\text{F}_4$           | 124-73-2        | -110.32              | 47.35                | 214.6                |             |
| 115   | Chloropentafluoroethane                | $\text{C}_2\text{ClF}_5$                    | 76-15-3         | -99.4                | -39.22               | 79.95                | 1000        |
| 116   | Hexafluoroethane                       | $\text{C}_2\text{F}_6$                      | 76-16-4         | -100.05              | -78.09               | 19.88                |             |
| 120   | Pentachloroethane                      | $\text{C}_2\text{HCl}_5$                    | 76-01-7         | -28.78               | 162.0                |                      |             |
| 121   | 1,1,2,2-Tetrachloro-1-fluoroethane     | $\text{C}_2\text{HCl}_4\text{F}$            | 354-14-3        | -82.6                | 116.7                |                      |             |
| 121a  | 1,1,1,2-Tetrachloro-2-fluoroethane     | $\text{C}_2\text{HCl}_4\text{F}$            | 354-11-0        | -95.3                | 117.1                |                      |             |
| 122   | 1,2,2-Trichloro-1,1-difluoroethane     | $\text{C}_2\text{HCl}_3\text{F}_2$          | 354-21-2        | -140                 | 71.9                 |                      |             |
| 122a  | 1,2,2-Trichloro-1,2-difluoroethane     | $\text{C}_2\text{HCl}_3\text{F}_2$          | 354-15-4        | -174                 | 72.5                 |                      |             |
| 122b  | 1,1,1-Trichloro-2,2-difluoroethane     | $\text{C}_2\text{HCl}_3\text{F}_2$          | 354-12-1        |                      | 73                   |                      |             |
| 123   | 2,2-Dichloro-1,1,1-trifluoroethane     | $\text{C}_2\text{HCl}_2\text{F}_3$          | 306-83-2        | -107.15              | 27.82                | 183.68               |             |
| 123a  | 1,2-Dichloro-1,1,2-trifluoroethane     | $\text{C}_2\text{HCl}_2\text{F}_3$          | 354-23-4        | -78                  | 29.5                 | 188.4                |             |
| 124   | 1-Chloro-1,2,2,2-tetrafluoroethane     | $\text{C}_2\text{HClF}_4$                   | 2837-89-0       | -199.15              | -11.96               | 122.28               |             |
| 124a  | 1-Chloro-1,1,2,2-tetrafluoroethane     | $\text{C}_2\text{HClF}_4$                   | 354-25-6        | -117                 | -11.7                | 126.7                |             |
| 125   | Pentafluoroethane                      | $\text{C}_2\text{HF}_5$                     | 354-33-6        | -100.63              | -48.09               | 66.02                |             |
| E125  | Trifluoromethyl difluoromethyl ether   | $\text{C}_2\text{HF}_5\text{O}$             | 3822-68-2       | -157                 | -38                  | 80.8                 |             |
| 130   | 1,1,2,2-Tetrachloroethane              | $\text{C}_2\text{H}_2\text{Cl}_4$           | 79-34-5         | -42.4                | 145.2                | 388.00               | 1           |
| 131   | 1,1,2-Trichloro-2-fluoroethane         | $\text{C}_2\text{H}_2\text{Cl}_3\text{F}$   | 359-28-4        |                      | 102.4                |                      |             |
| 132   | 1,2-Dichloro-1,2-difluoroethane        | $\text{C}_2\text{H}_2\text{Cl}_2\text{F}_2$ | 431-06-1        | -101.2               | 59.6                 |                      |             |
| 132b  | 1,2-Dichloro-1,1-difluoroethane        | $\text{C}_2\text{H}_2\text{Cl}_2\text{F}_2$ | 1649-08-7       | -101.2               | 46.2                 |                      |             |
| 133   | 1-Chloro-1,2,2-trifluoroethane         | $\text{C}_2\text{H}_2\text{ClF}_3$          | 431-07-2        |                      | 17.3                 |                      |             |
| 133a  | 2-Chloro-1,1,1-trifluoroethane         | $\text{C}_2\text{H}_2\text{ClF}_3$          | 75-88-7         | -105.5               | 6.1                  | 151.86               |             |
| 133b  | 1-Chloro-1,1,2-trifluoroethane         | $\text{C}_2\text{H}_2\text{ClF}_3$          | 421-04-5        |                      | 12                   |                      |             |
| 134   | 1,1,2,2-Tetrafluoroethane              | $\text{C}_2\text{H}_2\text{F}_4$            | 359-35-3        | -89                  | -19.9                | 118.59               |             |
| 134a  | 1,1,1,2-Tetrafluoroethane              | $\text{C}_2\text{H}_2\text{F}_4$            | 811-97-2        | -103.3               | -26.07               | 101.06               |             |
| E134  | Bis(difluoromethyl) ether              | $\text{C}_2\text{H}_2\text{F}_4\text{O}$    | 1691-17-4       |                      | 2                    | 147.10               |             |
| 140   | 1,1,2-Trichloroethane                  | $\text{C}_2\text{H}_3\text{Cl}_3$           | 79-00-5         | -36.3                | 113.8                | 329                  | 10          |
| 140a  | 1,1,1-Trichloroethane                  | $\text{C}_2\text{H}_3\text{Cl}_3$           | 71-55-6         | -30.01               | 74.09                | 272                  | 350         |
| 141   | 1,2-Dichloro-1-fluoroethane            | $\text{C}_2\text{H}_3\text{Cl}_2\text{F}$   | 430-57-9        | -60                  | 73.8                 |                      |             |
| 141b  | 1,1-Dichloro-1-fluoroethane            | $\text{C}_2\text{H}_3\text{Cl}_2\text{F}$   | 1717-00-6       | -103.47              | 32.05                | 204.35               |             |
| 142   | 1-Chloro-2,2-difluoroethane            | $\text{C}_2\text{H}_3\text{ClF}_2$          | 338-65-8        |                      | 35.1                 |                      |             |
| 142b  | 1-Chloro-1,1-difluoroethane            | $\text{C}_2\text{H}_3\text{ClF}_2$          | 75-68-3         | -130.43              | -9.12                | 137.11               |             |
| 143   | 1,1,2-Trifluoroethane                  | $\text{C}_2\text{H}_3\text{F}_3$            | 430-66-0        | -84                  | 3.7                  | 156.6                |             |
| 143a  | 1,1,1-Trifluoroethane                  | $\text{C}_2\text{H}_3\text{F}_3$            | 420-46-2        | -111.81              | -47.24               | 72.71                |             |
| 143m  | Methyl trifluoromethyl ether           | $\text{C}_2\text{H}_3\text{F}_3\text{O}$    | 421-14-7        | -149                 | -23.66               | 104.77               |             |
| E143a | 2,2,2-Trifluoroethyl methyl ether      | $\text{C}_3\text{H}_5\text{F}_3\text{O}$    | 460-43-5        |                      | 31.62                | 175.83               |             |
| 150   | 1,2-Dichloroethane                     | $\text{C}_2\text{H}_4\text{Cl}_2$           | 107-06-2        | -35.7                | 83.5                 | 288                  | 10          |
| 150a  | 1,1-Dichloroethane                     | $\text{C}_2\text{H}_4\text{Cl}_2$           | 75-34-3         | -96.9                | 57.3                 | 250                  | 100         |
| 151   | 1-Chloro-2-fluoroethane                | $\text{C}_2\text{H}_4\text{ClF}$            | 762-50-5        |                      | 52.8                 |                      |             |

| Code   | Name                                           | Molecular Formula                        | CAS Reg. No. | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $t_c/^\circ\text{C}$ | TLV/<br>ppm |
|--------|------------------------------------------------|------------------------------------------|--------------|----------------------|----------------------|----------------------|-------------|
| 151a   | 1-Chloro-1-fluoroethane                        | $\text{C}_2\text{H}_4\text{ClF}$         | 1615-75-4    |                      | 16.2                 |                      |             |
| 152    | 1,2-Difluoroethane                             | $\text{C}_2\text{H}_4\text{F}_2$         | 624-72-6     |                      | 26                   |                      |             |
| 152a   | 1,1-Difluoroethane                             | $\text{C}_2\text{H}_4\text{F}_2$         | 75-37-6      | -118.59              | -24.02               | 113.26               |             |
| 160    | Chloroethane                                   | $\text{C}_2\text{H}_5\text{Cl}$          | 75-00-3      | -138.4               | 12.3                 | 187.2                | 100         |
| 161    | Fluoroethane                                   | $\text{C}_2\text{H}_5\text{F}$           | 353-36-6     | -143.2               | -37.7                | 102.16               |             |
| 170    | Ethane                                         | $\text{C}_2\text{H}_6$                   | 74-84-0      | -182.77              | -88.58               | 32.17                | 1000        |
| E170   | Dimethyl ether                                 | $\text{C}_2\text{H}_6\text{O}$           | 115-10-6     | -141.50              | -24.81               | 127.15               |             |
| 216ca  | 1,3-Dichloro-1,1,2,2,3,3-hexafluoropropane     | $\text{C}_3\text{Cl}_2\text{F}_6$        | 662-01-1     | -125.4               | 35.7                 | 180                  |             |
| 218    | Perfluoropropane                               | $\text{C}_3\text{F}_8$                   | 76-19-7      | -147.70              | -36.79               | 71.87                |             |
| 227ca2 | Trifluoromethyl 1,1,2,2-tetrafluoroethyl ether | $\text{C}_3\text{HF}_7\text{O}$          | 2356-61-8    | -141                 | -3                   | 114.63               |             |
| 227ea  | 1,1,1,2,3,3,3-Heptafluoropropane               | $\text{C}_3\text{HF}_7$                  | 431-89-0     | -126.80              | -16.34               | 101.75               |             |
| 227me  | Trifluoromethyl 1,2,2,2-tetrafluoroethyl ether | $\text{C}_3\text{HF}_7\text{O}$          | 2356-62-9    |                      | -9.6                 |                      |             |
| 236ea  | 1,1,1,2,3,3-Hexafluoropropane                  | $\text{C}_3\text{H}_2\text{F}_6$         | 431-63-0     |                      | 6.20                 | 139.29               |             |
| 236fa  | 1,1,1,3,3,3-Hexafluoropropane                  | $\text{C}_3\text{H}_2\text{F}_6$         | 690-39-1     | -93.63               | -1.44                | 124.92               |             |
| 236me  | 1,2,2,2-Tetrafluoroethyl difluoromethyl ether  | $\text{C}_3\text{H}_2\text{F}_6\text{O}$ | 57041-67-5   |                      | 23.35                | 155.80               |             |
| 245ca  | 1,1,2,2,3-Pentafluoropropane                   | $\text{C}_3\text{H}_3\text{F}_5$         | 679-86-7     |                      | 25.13                | 174.42               |             |
| 245cb  | 1,1,1,2,2-Pentafluoropropane                   | $\text{C}_3\text{H}_3\text{F}_5$         | 1814-88-6    |                      | -17.4                | 106.96               |             |
| 245fa  | 1,1,1,3,3-Pentafluoropropane                   | $\text{C}_3\text{H}_3\text{F}_5$         | 460-73-1     | -102.10              | 15.14                | 154.01               |             |
| 245mc  | Methyl pentafluoroethyl ether                  | $\text{C}_3\text{H}_3\text{F}_5\text{O}$ | 22410-44-2   |                      | 5.59                 | 133.65               |             |
| 245mf  | Difluoromethyl 2,2,2-trifluoroethyl ether      | $\text{C}_3\text{H}_3\text{F}_5\text{O}$ | 1885-48-9    |                      | 29.24                | 170.84               |             |
| 245qc  | Difluoromethyl 1,1,2-trifluoroethyl ether      | $\text{C}_3\text{H}_3\text{F}_5\text{O}$ | 69948-24-9   |                      | 43.1                 |                      |             |
| 254pc  | Methyl 1,1,2,2-tetrafluoroethyl ether          | $\text{C}_3\text{H}_4\text{F}_4\text{O}$ | 425-88-7     | -107                 | 37.1                 |                      |             |
| 290    | Propane                                        | $\text{C}_3\text{H}_8$                   | 74-98-6      | -187.62              | -42.11               | 96.74                | 1000        |
| C316   | 1,2-Dichloro-1,2,3,3,4,4-hexafluorocyclobutane | $\text{C}_4\text{Cl}_2\text{F}_6$        | 356-18-3     | -24.2                | 59.5                 | 224                  |             |
| C317   | 1-Chloro-1,2,2,3,3,4,4-heptafluorocyclobutane  | $\text{C}_4\text{ClF}_7$                 | 377-41-3     | -39.1                | 25                   |                      |             |
| C318   | Perfluorocyclobutane                           | $\text{C}_4\text{F}_8$                   | 115-25-3     | -40.19               | -5.9                 | 115.31               |             |
| 347mcc | Perfluoropropyl methyl ether                   | $\text{C}_4\text{H}_3\text{F}_7\text{O}$ | 375-03-1     |                      | 34.23                | 164.55               |             |
| 347mmy | Perfluoroisopropyl methyl ether                | $\text{C}_4\text{H}_3\text{F}_7\text{O}$ | 22052-84-2   |                      | 29.34                | 160.15               |             |
| 600    | Butane                                         | $\text{C}_4\text{H}_{10}$                | 106-97-8     | -138.24              | -0.49                | 151.98               | 1000        |
| 600a   | Isobutane                                      | $\text{C}_4\text{H}_{10}$                | 75-28-5      | -159.38              | -11.75               | 134.66               | 1000        |
| 610    | Diethyl ether                                  | $\text{C}_4\text{H}_{10}\text{O}$        | 60-29-7      | -116.2               | 34.5                 | 193.5                | 400         |
| 611    | Methyl formate                                 | $\text{C}_2\text{H}_4\text{O}_2$         | 107-31-3     | -99                  | 31.7                 | 214.0                | 100         |
| 717    | Ammonia                                        | $\text{H}_3\text{N}$                     | 7664-41-7    | -77.65               | -33.33               | 132.25               | 25          |
| 744    | Carbon dioxide                                 | $\text{CO}_2$                            | 124-38-9     | -56.56               | -78.46 sp            | 30.98                | 5000        |
| 764    | Sulfur dioxide                                 | $\text{O}_2\text{S}$                     | 7446-09-5    | -75.45               | -10.02               | 157.49               | 2           |
| 1112a  | 1,1-Dichloro-2,2-difluoroethene                | $\text{C}_2\text{Cl}_2\text{F}_2$        | 79-35-6      | -116                 | 19                   |                      |             |
| 1113   | Chlorotrifluoroethene                          | $\text{C}_2\text{ClF}_3$                 | 79-38-9      | -158.2               | -27.8                | 106                  |             |
| 1114   | Tetrafluoroethene                              | $\text{C}_2\text{F}_4$                   | 116-14-3     | -131.15              | -75.9                | 33.3                 | 2           |
| 1120   | Trichloroethene                                | $\text{C}_2\text{HCl}_3$                 | 79-01-6      | -84.7                | 87.21                | 271.0                | 10          |
| 1130   | <i>trans</i> -1,2-Dichloroethene               | $\text{C}_2\text{H}_2\text{Cl}_2$        | 156-60-5     | -49.8                | 48.7                 | 243.3                | 200         |
| 1132a  | 1,1-Difluoroethene                             | $\text{C}_2\text{H}_2\text{F}_2$         | 75-38-7      | -144                 | -85.7                | 29.7                 | 500         |
| 1140   | Chloroethene                                   | $\text{C}_2\text{H}_3\text{Cl}$          | 75-01-4      | -153.84              | -13.8                | 159                  | 1           |
| 1141   | Fluoroethene                                   | $\text{C}_2\text{H}_3\text{F}$           | 75-02-5      | -160.5               | -72                  | 54.7                 | 1           |
| 1150   | Ethylene                                       | $\text{C}_2\text{H}_4$                   | 74-85-1      | -169.15              | -103.77              | 9.20                 | 200         |
| 1270   | Propene                                        | $\text{C}_3\text{H}_6$                   | 115-07-1     | -185.19              | -47.62               | 91.06                | 500         |

## DENSITY AND SPECIFIC VOLUME OF MERCURY

The data in this table have been adjusted to the ITS–90 temperature scale. The uncertainty in density values is 0.0003 g/mL between –20 and –10°C; 0.0001 or less between –10 and 200°C; and 0.0002 between 200 and 300°C.

### Reference

Ambrose, D., *Metrologia*, 27, 245, 1990.

| $t/^{\circ}\text{C}$ | $\rho/(\text{g/mL})$ | $\nu/(\text{mL/kg})$ | $t/^{\circ}\text{C}$ | $\rho/(\text{g/mL})$ | $\nu/(\text{mL/kg})$ | $t/^{\circ}\text{C}$ | $\rho/(\text{g/mL})$ | $\nu/(\text{mL/kg})$ |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| –20                  | 13.64461             | 73.2890              | 30                   | 13.52134             | 73.9572              | 80                   | 13.39971             | 74.6285              |
| –19                  | 13.64212             | 73.3024              | 31                   | 13.51889             | 73.9705              | 81                   | 13.39729             | 74.6420              |
| –18                  | 13.63964             | 73.3157              | 32                   | 13.51645             | 73.9839              | 82                   | 13.39487             | 74.6554              |
| –17                  | 13.63716             | 73.3291              | 33                   | 13.51400             | 73.9973              | 83                   | 13.39245             | 74.6689              |
| –16                  | 13.63468             | 73.3424              | 34                   | 13.51156             | 74.0107              | 84                   | 13.39003             | 74.6824              |
| –15                  | 13.63220             | 73.3558              | 35                   | 13.50911             | 74.0241              | 85                   | 13.38762             | 74.6959              |
| –14                  | 13.62972             | 73.3691              | 36                   | 13.50667             | 74.0375              | 86                   | 13.38520             | 74.7094              |
| –13                  | 13.62724             | 73.3824              | 37                   | 13.50422             | 74.0509              | 87                   | 13.38278             | 74.7229              |
| –12                  | 13.62476             | 73.3958              | 38                   | 13.50178             | 74.0643              | 88                   | 13.38037             | 74.7364              |
| –11                  | 13.62228             | 73.4091              | 39                   | 13.49934             | 74.0777              | 89                   | 13.37795             | 74.7498              |
| –10                  | 13.61981             | 73.4225              | 40                   | 13.49690             | 74.0911              | 90                   | 13.37554             | 74.7633              |
| –9                   | 13.61733             | 73.4358              | 41                   | 13.49446             | 74.1045              | 91                   | 13.37313             | 74.7768              |
| –8                   | 13.61485             | 73.4492              | 42                   | 13.49202             | 74.1179              | 92                   | 13.37071             | 74.7903              |
| –7                   | 13.61238             | 73.4625              | 43                   | 13.48958             | 74.1313              | 93                   | 13.36830             | 74.8038              |
| –6                   | 13.60991             | 73.4759              | 44                   | 13.48714             | 74.1447              | 94                   | 13.36589             | 74.8173              |
| –5                   | 13.60743             | 73.4892              | 45                   | 13.48470             | 74.1581              | 95                   | 13.36347             | 74.8308              |
| –4                   | 13.60496             | 73.5026              | 46                   | 13.48226             | 74.1715              | 96                   | 13.36106             | 74.8443              |
| –3                   | 13.60249             | 73.5160              | 47                   | 13.47982             | 74.1850              | 97                   | 13.35865             | 74.8579              |
| –2                   | 13.60002             | 73.5293              | 48                   | 13.47739             | 74.1984              | 98                   | 13.35624             | 74.8714              |
| –1                   | 13.59755             | 73.5427              | 49                   | 13.47495             | 74.2118              | 99                   | 13.35383             | 74.8849              |
| 0                    | 13.59508             | 73.5560              | 50                   | 13.47251             | 74.2252              | 100                  | 13.35142             | 74.8984              |
| 1                    | 13.59261             | 73.5694              | 51                   | 13.47008             | 74.2386              | 110                  | 13.3273              | 75.0337              |
| 2                    | 13.59014             | 73.5827              | 52                   | 13.46765             | 74.2520              | 120                  | 13.3033              | 75.1693              |
| 3                    | 13.58768             | 73.5961              | 53                   | 13.46521             | 74.2655              | 130                  | 13.2793              | 75.3052              |
| 4                    | 13.58521             | 73.6095              | 54                   | 13.46278             | 74.2789              | 140                  | 13.2553              | 75.4413              |
| 5                    | 13.58275             | 73.6228              | 55                   | 13.46035             | 74.2923              | 150                  | 13.2314              | 75.5778              |
| 6                    | 13.58028             | 73.6362              | 56                   | 13.45791             | 74.3057              | 160                  | 13.2075              | 75.7147              |
| 7                    | 13.57782             | 73.6495              | 57                   | 13.45548             | 74.3192              | 170                  | 13.1836              | 75.8519              |
| 8                    | 13.57535             | 73.6629              | 58                   | 13.45305             | 74.3326              | 180                  | 13.1597              | 75.9895              |
| 9                    | 13.57289             | 73.6763              | 59                   | 13.45062             | 74.3460              | 190                  | 13.1359              | 76.1274              |
| 10                   | 13.57043             | 73.6896              | 60                   | 13.44819             | 74.3594              | 200                  | 13.1120              | 76.2659              |
| 11                   | 13.56797             | 73.7030              | 61                   | 13.44576             | 74.3729              | 210                  | 13.0882              | 76.4047              |
| 12                   | 13.56551             | 73.7164              | 62                   | 13.44333             | 74.3863              | 220                  | 13.0644              | 76.5440              |
| 13                   | 13.56305             | 73.7297              | 63                   | 13.44090             | 74.3998              | 230                  | 13.0406              | 76.6838              |
| 14                   | 13.56059             | 73.7431              | 64                   | 13.43848             | 74.4132              | 240                  | 13.0167              | 76.8241              |
| 15                   | 13.55813             | 73.7565              | 65                   | 13.43605             | 74.4266              | 250                  | 12.9929              | 76.9650              |
| 16                   | 13.55567             | 73.7698              | 66                   | 13.43362             | 74.4401              | 260                  | 12.9691              | 77.1064              |
| 17                   | 13.55322             | 73.7832              | 67                   | 13.43120             | 74.4535              | 270                  | 12.9453              | 77.2484              |
| 18                   | 13.55076             | 73.7966              | 68                   | 13.42877             | 74.4670              | 280                  | 12.9214              | 77.3909              |
| 19                   | 13.54831             | 73.8100              | 69                   | 13.42635             | 74.4804              | 290                  | 12.8975              | 77.5341              |
| 20                   | 13.54585             | 73.8233              | 70                   | 13.42392             | 74.4939              | 300                  | 12.8736              | 77.6779              |
| 21                   | 13.54340             | 73.8367              | 71                   | 13.42150             | 74.5073              |                      |                      |                      |
| 22                   | 13.54094             | 73.8501              | 72                   | 13.41908             | 74.5208              |                      |                      |                      |
| 23                   | 13.53849             | 73.8635              | 73                   | 13.41665             | 74.5342              |                      |                      |                      |
| 24                   | 13.53604             | 73.8769              | 74                   | 13.41423             | 74.5477              |                      |                      |                      |
| 25                   | 13.53359             | 73.8902              | 75                   | 13.41181             | 74.5612              |                      |                      |                      |
| 26                   | 13.53114             | 73.9036              | 76                   | 13.40939             | 74.5746              |                      |                      |                      |
| 27                   | 13.52869             | 73.9170              | 77                   | 13.40697             | 74.5881              |                      |                      |                      |
| 28                   | 13.52624             | 73.9304              | 78                   | 13.40455             | 74.6016              |                      |                      |                      |
| 29                   | 13.52379             | 73.9438              | 79                   | 13.40213             | 74.6150              |                      |                      |                      |

# THERMAL PROPERTIES OF MERCURY

Lev R. Fokin

The first of these tables gives the molar heat capacity at constant pressure of liquid and gaseous mercury as a function of temperature. To convert to specific heat in units of J/g K, divide these values by 200.59, the atomic weight of mercury.

| $t/^{\circ}\text{C}$ | $C_p/(\text{J/mol K})$ |        |
|----------------------|------------------------|--------|
|                      | Liquid                 | Gas    |
| −38.84               | 28.2746                | 20.786 |
| −20                  | 28.1466                | 20.786 |
| 0                    | 28.0190                | 20.786 |
| 20                   | 27.9002                | 20.786 |
| 25                   | 27.8717                | 20.786 |
| 40                   | 27.7897                | 20.786 |
| 60                   | 27.6880                | 20.786 |
| 80                   | 27.5952                | 20.786 |
| 100                  | 27.5106                | 20.786 |
| 120                  | 27.4349                | 20.786 |

| $t/^{\circ}\text{C}$ | $C_p/(\text{J/mol K})$ |        |
|----------------------|------------------------|--------|
|                      | Liquid                 | Gas    |
| 140                  | 27.3675                | 20.786 |
| 160                  | 27.3090                | 20.786 |
| 180                  | 27.2588                | 20.790 |
| 200                  | 27.2169                | 20.790 |
| 220                  | 27.1834                | 20.794 |
| 240                  | 27.1583                | 20.794 |
| 260                  | 27.1412                | 20.799 |
| 280                  | 27.1320                | 20.807 |
| 300                  | 27.1303                | 20.815 |
| 320                  | 27.1366                | 20.824 |

## Reference

Douglas, T. B., Ball, A. T., and Ginnings, D. C., *J. Res. Natl. Bur. Stands.*, 46, 334, 1951.

## References

1. Busey and Giaque, *J. Am. Chem. Soc.*, 75, 806, 1953.
2. Amitin, Lebedeva, and Paukov, *Rus. J. Phys. Chem.*, 2666, 1979.

The second table gives the molar heat capacity of solid mercury in its rhombohedral ( $\alpha$ -mercury) form.

| $t/^{\circ}\text{C}$ | $C_p/(\text{J/mol K})$ |
|----------------------|------------------------|
| −268.99              | 0.99*                  |
| −268.99              | 0.97**                 |
| −268.15              | 1.6                    |
| −263.15              | 4.6                    |
| −258.15              | 7.6                    |
| −253.15              | 10.33                  |

| $t/^{\circ}\text{C}$ | $C_p/(\text{J/mol K})$ |
|----------------------|------------------------|
| −248.15              | 12.74                  |
| −243.15              | 14.78                  |
| −233.15              | 17.90                  |
| −223.15              | 19.94                  |
| −213.15              | 21.40                  |
| −203.15              | 22.42                  |

| $t/^{\circ}\text{C}$ | $C_p/(\text{J/mol K})$ |
|----------------------|------------------------|
| −193.15              | 23.16                  |
| −183.15              | 23.76                  |
| −173.15              | 24.24                  |
| −153.15              | 25.00                  |
| −133.15              | 25.61                  |
| −113.15              | 26.15                  |

| $t/^{\circ}\text{C}$ | $C_p/(\text{J/mol K})$ |
|----------------------|------------------------|
| −93.15               | 26.69                  |
| −73.15               | 27.28                  |
| −53.15               | 27.96                  |
| −38.87               | 28.5                   |

\* Superconducting state  
\*\* Normal state

The final table gives the cubic thermal expansion coefficient  $\alpha$ , the isothermal compressibility coefficient  $\kappa_T$ , and the speed of sound  $u$  for liquid mercury as a function of temperature. These properties are defined as follows:

$$\alpha = \frac{1}{\nu} \left( \frac{\partial \nu}{\partial T} \right)_p \quad \kappa_T = -\frac{1}{\nu} \left( \frac{\partial \nu}{\partial P} \right)_T \quad u^2 = \left( \frac{\partial P}{\partial \rho} \right)_s \quad \rho = \nu^{-1}$$

where  $\nu$  is the specific volume (given in the table on the preceding page).

## Reference

Vukalovich, M. P., et al., *Thermophysical Properties of Mercury*, Moscow Standard Press, 1971.

| $t/^{\circ}\text{C}$ | $\alpha \times 10^4/\text{K}^{-1}$ | $\kappa_T \times 10^6/\text{bar}^{-1}$ |             | $u/\text{m s}^{-1}$ |
|----------------------|------------------------------------|----------------------------------------|-------------|---------------------|
|                      |                                    | At 1 bar                               | At 1000 bar |                     |
| −20                  | 1.818                              | 3.83                                   |             | 1470                |
| 0                    | 1.8144                             | 3.918                                  | 3.78        | 1460.8              |
| 20                   | 1.8110                             | 4.013                                  | 3.87        | 1451.4              |
| 40                   | 1.8083                             | 4.109                                  | 3.96        | 1442.0              |
| 60                   | 1.8064                             | 4.207                                  |             | 1432.7              |
| 80                   | 1.8053                             | 4.308                                  | 4.14        | 1423.4              |
| 100                  | 1.8051                             | 4.410                                  |             | 1414.1              |

| $t/^{\circ}\text{C}$ | $\alpha \times 10^4/\text{K}^{-1}$ | $\kappa_T \times 10^6/\text{bar}^{-1}$ |             | $u/\text{m s}^{-1}$ |
|----------------------|------------------------------------|----------------------------------------|-------------|---------------------|
|                      |                                    | At 1 bar                               | At 1000 bar |                     |
| 120                  | 1.8058                             | 4.513                                  | 4.33        | 1404.7              |
| 140                  | 1.8074                             | 4.622                                  |             | 1395.4              |
| 160                  | 1.8100                             | 4.731                                  | 4.53        | 1386.1              |
| 180                  | 1.8136                             | 4.844                                  |             | 1376.7              |
| 200                  | 1.818                              | 4.96                                   |             | 1367                |
| 250                  | 1.834                              | 5.26                                   |             | 1344                |
| 300                  | 1.856                              | 5.59                                   |             | 1321                |

## SURFACE TENSION OF COMMON LIQUIDS

The surface tension  $\gamma$  of about 200 liquids is tabulated here as a function of temperature. Values of  $\gamma$  are given in units of millinewtons per meter (mN/m), which is equivalent to dyn/cm in cgs units. The values refer to a nominal pressure of one atmosphere (about 100 kPa) except in cases where the indicated temperature is above the normal boiling point of the substance; in those cases, the applicable pressure is the saturation vapor pressure at the temperature in question.

The uncertainty of the values is 0.1 to 0.2 mN/m or less in most cases. Values at temperatures between the points tabulated can be obtained by linear interpolation to a good approximation.

Substances are listed by molecular formula in the modified Hill order, with substances not containing carbon appearing before those that do contain carbon. A more extensive compilation of surface tension may be found in Reference 1.

### References

1. Jasper, J. J., *J. Phys. Chem. Ref. Data*, 1, 841, 1972.
2. Kahl, H., Wadewitz, T., and Winkelmann, J., *J. Chem. Eng. Data*, 48, 580, 2003.

| Mol. formula                                  | Name                      | $\gamma$ in mN/m |        |        |        |        |
|-----------------------------------------------|---------------------------|------------------|--------|--------|--------|--------|
|                                               |                           | 10°C             | 25°C   | 50°C   | 75°C   | 100°C  |
| Br <sub>2</sub>                               | Bromine                   | 43.68            | 40.95  | 36.40  |        |        |
| Cl <sub>2</sub> O <sub>2</sub> S              | Sulfuryl chloride         |                  | 28.78  |        |        |        |
| Cl <sub>3</sub> OP                            | Phosphoryl chloride       |                  | 32.03  | 28.85  | 25.66  |        |
| Cl <sub>3</sub> P                             | Phosphorus trichloride    |                  | 27.98  | 24.81  |        |        |
| Cl <sub>4</sub> Si                            | Silicon tetrachloride     | 19.78            | 18.29  | 15.80  |        |        |
| H <sub>2</sub> O                              | Water                     | 74.23            | 71.99  | 67.94  | 63.57  | 58.91  |
| H <sub>4</sub> N <sub>2</sub>                 | Hydrazine                 |                  | 66.39  |        |        |        |
| Hg                                            | Mercury                   | 488.55           | 485.48 | 480.36 | 475.23 | 470.11 |
| CCl <sub>4</sub>                              | Tetrachloromethane        |                  | 26.43  | 23.37  | 20.31  | 17.25  |
| CS <sub>2</sub>                               | Carbon disulfide          | 33.81            | 31.58  | 27.87  |        |        |
| CHBr <sub>3</sub>                             | Tribromomethane           |                  | 44.87  | 41.60  | 38.33  |        |
| CHCl <sub>3</sub>                             | Trichloromethane          |                  | 26.67  | 23.44  | 20.20  |        |
| CH <sub>2</sub> Br <sub>2</sub>               | Dibromomethane            |                  | 39.05  | 35.33  | 31.61  |        |
| CH <sub>2</sub> Cl <sub>2</sub>               | Dichloromethane           |                  | 27.20  |        |        |        |
| CH <sub>2</sub> O <sub>2</sub>                | Formic acid               |                  | 37.13  | 34.38  | 31.64  |        |
| CH <sub>3</sub> I                             | Iodomethane               | 32.19            | 30.34  |        |        |        |
| CH <sub>3</sub> NO                            | Formamide                 |                  | 57.03  | 54.92  | 52.82  | 50.71  |
| CH <sub>3</sub> NO <sub>2</sub>               | Nitromethane              | 39.04            | 36.53  | 32.33  |        |        |
| CH <sub>4</sub> O                             | Methanol                  | 23.23            | 22.07  | 20.14  |        |        |
| CH <sub>5</sub> N                             | Methylamine               |                  | 19.15  |        |        |        |
| C <sub>2</sub> HCl <sub>5</sub>               | Pentachloroethane         |                  | 34.15  | 31.20  | 28.26  |        |
| C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub> | Trifluoroacetic acid      |                  | 13.53  | 11.42  |        |        |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub> | 1,1,2,2-Tetrachloroethane |                  | 35.58  | 32.41  | 29.24  | 26.07  |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> | 1,1,1-Trichloroethane     |                  | 25.18  | 22.07  |        |        |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> | 1,1,2-Trichloroethane     |                  | 34.02  | 30.65  | 27.27  | 23.89  |
| C <sub>2</sub> H <sub>3</sub> N               | Acetonitrile              |                  | 28.66  | 25.51  |        |        |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub> | 1,2-Dibromoethane         |                  | 39.55  | 36.25  | 32.95  |        |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,1-Dichloroethane        |                  | 24.07  |        |        |        |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,2-Dichloroethane        |                  | 31.86  | 28.29  | 24.72  |        |
| C <sub>2</sub> H <sub>4</sub> O               | Acetaldehyde              | 22.54            | 20.50  | 17.10  |        |        |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>  | Acetic acid               |                  | 27.10  | 24.61  | 22.13  |        |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>  | Methyl formate            | 26.72            | 24.36  | 20.43  | 16.50  | 12.57  |
| C <sub>2</sub> H <sub>5</sub> Br              | Bromoethane               | 25.36            | 23.62  |        |        |        |
| C <sub>2</sub> H <sub>5</sub> I               | Iodoethane                | 30.38            | 28.46  | 25.24  |        |        |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub> | Nitroethane               | 34.02            | 32.13  | 29.00  |        |        |
| C <sub>2</sub> H <sub>6</sub> O               | Ethanol                   | 23.22            | 21.97  | 19.89  |        |        |
| C <sub>2</sub> H <sub>6</sub> OS              | Dimethyl sulfoxide        |                  | 42.92  | 40.06  |        |        |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>  | Ethylene glycol           |                  | 47.99  | 45.76  | 43.54  | 41.31  |
| C <sub>2</sub> H <sub>6</sub> S               | Dimethyl sulfide          | 25.27            | 24.06  |        |        |        |
| C <sub>2</sub> H <sub>6</sub> S               | Ethanethiol               |                  | 23.08  |        |        |        |
| C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>  | Dimethyl disulfide        |                  | 33.39  | 30.04  |        |        |
| C <sub>2</sub> H <sub>7</sub> N               | Dimethylamine             |                  | 26.34  |        |        |        |
| C <sub>2</sub> H <sub>7</sub> N               | Ethylamine                |                  | 19.20  |        |        |        |
| C <sub>2</sub> H <sub>7</sub> NO              | Ethanolamine              |                  | 48.32  | 45.53  | 42.73  |        |
| C <sub>3</sub> H <sub>5</sub> Br              | 3-Bromopropene            |                  | 26.31  | 23.17  |        |        |

| Mol. formula   | Name                             | $\gamma$ in mN/m |       |       |       |       |
|----------------|----------------------------------|------------------|-------|-------|-------|-------|
|                |                                  | 10°C             | 25°C  | 50°C  | 75°C  | 100°C |
| $C_3H_5Cl$     | 3-Chloropropene                  |                  | 23.14 |       |       |       |
| $C_3H_5ClO$    | Epichlorohydrin                  | 38.40            | 36.36 | 32.96 | 29.56 | 26.16 |
| $C_3H_5N$      | Propanenitrile                   |                  | 26.75 | 23.87 |       |       |
| $C_3H_6Cl_2$   | 1,2-Dichloropropane              |                  | 28.32 | 25.22 | 22.12 |       |
| $C_3H_6O$      | Acetone                          | 24.57            | 22.72 | 19.65 |       |       |
| $C_3H_6O$      | Allyl alcohol                    | 26.63            | 25.28 | 23.02 | 20.77 |       |
| $C_3H_6O_2$    | Ethyl formate                    | 25.16            | 23.18 |       |       |       |
| $C_3H_6O_2$    | Methyl acetate                   | 26.66            | 24.73 | 21.51 |       |       |
| $C_3H_6O_2$    | Propanoic acid                   |                  | 26.20 | 23.72 | 21.23 |       |
| $C_3H_7Br$     | 1-Bromopropane                   | 27.08            | 25.26 | 22.21 |       |       |
| $C_3H_7Br$     | 2-Bromopropane                   | 25.03            | 23.25 | 20.30 |       |       |
| $C_3H_7Cl$     | 1-Chloropropane                  | 23.16            | 21.30 |       |       |       |
| $C_3H_7Cl$     | 2-Chloropropane                  | 20.49            | 19.16 |       |       |       |
| $C_3H_7NO$     | <i>N,N</i> -Dimethylformamide    | 37.56            | 35.74 | 32.70 | 29.66 | 26.62 |
| $C_3H_7NO_2$   | 2-Nitropropane                   | 31.02            | 29.29 | 26.39 |       |       |
| $C_3H_8O$      | 1-Propanol                       | 24.48            | 23.32 | 21.38 | 19.43 |       |
| $C_3H_8O$      | 2-Propanol                       | 22.11            | 20.93 | 18.96 | 16.98 |       |
| $C_3H_8O_2$    | 2-Methoxyethanol                 | 32.32            | 30.84 | 28.38 | 25.92 | 23.46 |
| $C_3H_8S$      | 1-Propanethiol                   |                  | 24.20 | 21.02 |       |       |
| $C_3H_8S$      | 2-Propanethiol                   |                  | 21.33 | 18.39 |       |       |
| $C_3H_9N$      | Propylamine                      |                  | 21.75 |       |       |       |
| $C_3H_9N$      | Trimethylamine                   |                  | 13.41 |       |       |       |
| $C_4H_4N_2$    | Pyridazine                       | 49.51            | 47.96 | 45.37 | 42.78 | 40.19 |
| $C_4H_4N_2$    | Pyrimidine                       |                  | 30.33 | 27.80 | 25.28 | 22.75 |
| $C_4H_4S$      | Thiophene                        |                  | 30.68 | 27.36 |       |       |
| $C_4H_5N$      | Pyrrole                          | 38.71            | 37.06 | 34.31 |       |       |
| $C_4H_6O_3$    | Acetic anhydride                 | 34.08            | 31.93 | 28.34 | 24.75 | 21.16 |
| $C_4H_7N$      | Butanenitrile                    |                  | 26.92 | 24.33 | 21.73 |       |
| $C_4H_8O$      | 2-Butanone                       |                  | 23.97 | 21.16 |       |       |
| $C_4H_8O_2$    | 1,4-Dioxane                      |                  | 32.75 | 29.28 | 25.80 | 22.32 |
| $C_4H_8O_2$    | Ethyl acetate                    | 25.13            | 23.39 | 20.49 | 17.58 | 14.68 |
| $C_4H_8O_2$    | Methyl propanoate                | 26.32            | 24.44 | 21.29 |       |       |
| $C_4H_8O_2$    | Butanoic acid                    |                  | 26.05 | 23.75 | 21.45 |       |
| $C_4H_9Br$     | 1-Bromobutane                    | 27.58            | 25.90 | 23.08 | 20.27 | 17.45 |
| $C_4H_9Cl$     | 1-Chlorobutane                   | 24.85            | 23.18 | 20.39 |       |       |
| $C_4H_9I$      | 1-Iodobutane                     | 29.79            | 28.24 | 25.67 | 23.09 | 20.51 |
| $C_4H_9N$      | Pyrrolidine                      | 30.58            | 29.23 | 26.98 |       |       |
| $C_4H_{10}O$   | 1-Butanol                        | 26.28            | 24.93 | 22.69 | 20.44 | 18.20 |
| $C_4H_{10}O$   | 2-Butanol                        | 23.74            | 22.54 | 20.56 | 18.57 | 16.58 |
| $C_4H_{10}O$   | 2-Methyl-2-propanol              |                  | 19.96 | 17.71 |       |       |
| $C_4H_{10}O$   | Diethyl ether                    |                  | 16.65 |       |       |       |
| $C_4H_{10}O_2$ | 2-Ethoxyethanol                  |                  | 28.35 | 26.11 | 23.86 | 21.62 |
| $C_4H_{10}O_3$ | Diethylene glycol                |                  | 44.77 | 42.57 | 40.37 | 38.17 |
| $C_4H_{10}S$   | Diethyl sulfide                  | 26.22            | 24.57 | 21.80 |       |       |
| $C_4H_{11}N$   | Butylamine                       |                  | 23.44 | 20.63 |       |       |
| $C_4H_{11}N$   | Isobutylamine                    |                  | 21.75 | 19.02 |       |       |
| $C_4H_{11}N$   | <i>tert</i> -Butylamine          |                  | 16.87 |       |       |       |
| $C_4H_{11}N$   | Diethylamine                     |                  | 19.85 |       |       |       |
| $C_5H_4O_2$    | Furfural                         | 45.08            | 43.09 | 39.78 | 36.46 | 33.14 |
| $C_5H_5N$      | Pyridine                         |                  | 36.56 | 33.29 | 30.03 |       |
| $C_5H_8$       | Cyclopentene                     | 24.45            | 22.20 |       |       |       |
| $C_5H_8O$      | Cyclopentanone                   | 34.45            | 32.80 | 30.05 | 27.30 | 24.55 |
| $C_5H_9NO$     | <i>N</i> -Methyl-2-pyrrolidinone | 41.94            | 40.21 | 37.33 | 34.45 | 31.57 |
| $C_5H_{10}$    | 1-Pentene                        |                  | 17.10 | 15.45 |       |       |
| $C_5H_{10}$    | 2-Methyl-2-butene                | 18.61            | 17.15 |       |       |       |
| $C_5H_{10}$    | Cyclopentane                     | 24.07            | 21.88 | 18.22 |       |       |
| $C_5H_{10}O$   | 2-Pentanone                      |                  | 23.25 | 21.62 |       |       |
| $C_5H_{10}O$   | 3-Pentanone                      |                  | 24.74 | 22.13 |       |       |
| $C_5H_{10}O$   | Pentanal                         | 26.95            | 25.44 | 22.91 |       |       |
| $C_5H_{10}O_2$ | Butyl formate                    | 26.05            | 24.52 | 21.95 | 19.39 | 16.82 |

| Mol. formula   | Name                      | $\gamma$ in mN/m |       |       |       |       |
|----------------|---------------------------|------------------|-------|-------|-------|-------|
|                |                           | 10°C             | 25°C  | 50°C  | 75°C  | 100°C |
| $C_5H_{10}O_2$ | Propyl acetate            | 25.48            | 23.80 | 21.00 | 18.20 | 15.40 |
| $C_5H_{10}O_2$ | Isopropyl acetate         | 23.37            | 21.76 | 19.08 | 16.40 |       |
| $C_5H_{10}O_2$ | Ethyl propanoate          | 25.55            | 23.80 | 20.88 | 17.96 |       |
| $C_5H_{10}O_2$ | Methyl butanoate          | 26.34            | 24.62 | 21.76 | 18.89 | 16.03 |
| $C_5H_{11}Cl$  | 1-Chloropentane           | 26.01            | 24.40 | 21.71 | 19.02 | 16.33 |
| $C_5H_{11}N$   | Piperidine                | 30.64            | 28.91 | 26.03 | 23.14 | 20.26 |
| $C_5H_{12}$    | Pentane                   | 17.15            | 15.49 |       |       |       |
| $C_5H_{12}O$   | 1-Pentanol                | 26.67            | 25.36 | 23.17 | 20.99 | 18.80 |
| $C_5H_{12}O$   | 2-Pentanol                | 24.96            | 23.45 | 20.94 | 18.43 | 15.92 |
| $C_5H_{12}O$   | 3-Methyl-1-butanol        | 24.94            | 23.71 | 21.66 | 19.61 | 17.56 |
| $C_5H_{13}N$   | Pentylamine               |                  | 24.69 | 22.14 | 19.58 |       |
| $C_6H_4Cl_2$   | <i>m</i> -Dichlorobenzene | 37.15            | 35.43 | 32.57 | 29.70 | 26.83 |
| $C_6H_5Br$     | Bromobenzene              | 36.98            | 35.24 | 32.34 | 29.44 | 26.54 |
| $C_6H_5Cl$     | Chlorobenzene             | 34.78            | 32.99 | 30.02 | 27.04 | 24.06 |
| $C_6H_5ClO$    | <i>o</i> -Chlorophenol    |                  | 39.70 | 36.89 | 34.09 | 31.28 |
| $C_6H_5ClO$    | <i>m</i> -Chlorophenol    |                  | 41.18 | 38.66 | 36.13 | 33.61 |
| $C_6H_5F$      | Fluorobenzene             | 28.47            | 26.66 | 23.65 | 20.64 |       |
| $C_6H_5I$      | Iodobenzene               | 40.40            | 38.71 | 35.91 | 33.10 | 30.29 |
| $C_6H_5NO_2$   | Nitrobenzene              |                  |       | 40.56 | 37.66 | 34.77 |
| $C_6H_6$       | Benzene                   |                  | 28.22 | 25.00 | 21.77 |       |
| $C_6H_6O$      | Phenol                    |                  |       | 38.20 | 35.53 | 32.86 |
| $C_6H_7N$      | Aniline                   |                  | 42.12 | 39.41 | 36.69 |       |
| $C_6H_7N$      | 2-Methylpyridine          |                  | 33.00 | 29.90 | 26.79 |       |
| $C_6H_8N_2$    | Adiponitrile              |                  | 45.45 | 43.02 | 40.58 |       |
| $C_6H_{10}$    | Cyclohexene               | 28.01            | 26.17 | 23.12 |       |       |
| $C_6H_{10}O$   | Cyclohexanone             | 36.43            | 34.57 | 31.46 | 28.36 | 25.25 |
| $C_6H_{11}N$   | Hexanenitrile             |                  | 27.37 | 25.11 | 22.84 |       |
| $C_6H_{12}$    | Cyclohexane               | 25.91            | 24.16 | 21.26 | 15.44 |       |
| $C_6H_{12}$    | Methylcyclopentane        | 23.47            | 21.72 | 18.82 |       |       |
| $C_6H_{12}$    | 1-Hexene                  | 19.44            | 17.90 | 15.33 |       |       |
| $C_6H_{12}O$   | Cyclohexanol              |                  | 32.92 | 30.50 | 28.09 | 25.67 |
| $C_6H_{12}O$   | 2-Hexanone                |                  | 25.45 | 22.72 |       |       |
| $C_6H_{12}O_2$ | Butyl acetate             | 26.48            | 24.88 | 22.21 | 19.54 | 16.87 |
| $C_6H_{12}O_2$ | Isobutyl acetate          | 24.58            | 23.06 | 20.53 | 17.99 | 15.46 |
| $C_6H_{12}O_2$ | Ethyl butanoate           | 25.51            | 23.94 | 21.33 | 18.71 | 16.10 |
| $C_6H_{12}O_3$ | Paraldehyde               | 27.22            | 25.63 | 22.97 | 20.32 | 17.66 |
| $C_6H_{13}Cl$  | 1-Chlorohexane            | 27.28            | 25.73 | 23.13 | 20.54 | 17.94 |
| $C_6H_{13}N$   | Cyclohexylamine           |                  | 31.22 | 28.25 | 25.28 |       |
| $C_6H_{14}$    | Hexane                    | 19.42            | 17.89 | 15.33 |       |       |
| $C_6H_{14}$    | 2-Methylpentane           | 18.37            | 16.88 | 14.39 |       |       |
| $C_6H_{14}$    | 3-Methylpentane           | 19.20            | 17.61 | 14.96 |       |       |
| $C_6H_{14}O$   | Diisopropyl ether         |                  | 17.27 | 14.65 |       |       |
| $C_6H_{14}O$   | 1-Hexanol                 |                  | 25.81 | 23.81 | 21.80 | 19.80 |
| $C_6H_{14}O_2$ | 1,1-Diethoxyethane        |                  | 20.89 | 18.31 | 15.74 |       |
| $C_6H_{14}O_2$ | 2-Butoxyethanol           | 27.36            | 26.14 | 24.10 | 22.06 | 20.02 |
| $C_6H_{15}N$   | Triethylamine             |                  | 20.22 | 17.74 |       |       |
| $C_6H_{15}N$   | Dipropylamine             |                  | 22.31 | 19.75 | 17.20 |       |
| $C_6H_{15}N$   | Diisopropylamine          |                  | 19.14 | 16.45 |       |       |
| $C_7H_5N$      | Benzonitrile              |                  | 38.79 | 35.90 | 33.00 |       |
| $C_7H_6O$      | Benzaldehyde              | 39.63            | 38.00 | 35.27 | 32.55 | 29.82 |
| $C_7H_8$       | Toluene                   | 29.46            | 27.73 | 24.85 | 21.98 | 19.10 |
| $C_7H_8O$      | <i>o</i> -Cresol          |                  | 36.90 | 34.38 | 31.85 | 29.32 |
| $C_7H_8O$      | <i>m</i> -Cresol          |                  | 35.69 | 33.38 | 31.07 | 28.76 |
| $C_7H_8O$      | Benzyl alcohol            |                  |       |       | 27.89 | 24.44 |
| $C_7H_8O$      | Anisole                   |                  | 35.10 | 32.09 | 29.08 |       |
| $C_7H_9N$      | <i>N</i> -Methylaniline   |                  | 36.90 | 34.47 | 32.05 |       |
| $C_7H_9N$      | 2,3-Dimethylpyridine      |                  | 32.71 | 30.04 | 27.36 |       |
| $C_7H_9N$      | Benzylamine               |                  | 39.30 | 36.27 | 33.23 |       |
| $C_7H_{14}$    | Methylcyclohexane         | 24.98            | 23.29 | 20.46 |       |       |
| $C_7H_{14}$    | 1-Heptene                 | 21.29            | 19.80 | 17.33 | 14.85 |       |

| Mol. formula      | Name                          | $\gamma$ in mN/m |       |       |       |       |
|-------------------|-------------------------------|------------------|-------|-------|-------|-------|
|                   |                               | 10°C             | 25°C  | 50°C  | 75°C  | 100°C |
| $C_7H_{14}O$      | 2-Heptanone                   |                  | 26.12 | 23.48 |       |       |
| $C_7H_{14}O_2$    | Pentyl acetate                | 26.67            | 25.17 | 22.69 | 20.20 | 17.72 |
| $C_7H_{14}O_2$    | Heptanoic acid                |                  | 27.76 | 25.64 |       |       |
| $C_7H_{16}$       | Heptane                       | 21.14            | 19.66 | 17.19 | 14.73 |       |
| $C_7H_{16}$       | 3-Methylhexane                | 20.76            | 19.31 | 16.88 | 14.46 |       |
| $C_8H_8O$         | Acetophenone                  |                  | 39.04 | 36.15 | 33.27 |       |
| $C_8H_8O_2$       | Methyl benzoate               |                  | 37.17 | 34.25 | 31.32 |       |
| $C_8H_8O_3$       | Methyl salicylate             | 40.98            | 39.22 | 36.28 | 33.35 | 30.41 |
| $C_8H_{10}$       | Ethylbenzene                  | 30.39            | 28.75 | 26.01 | 23.28 | 20.54 |
| $C_8H_{10}$       | <i>o</i> -Xylene              | 31.41            | 29.76 | 27.01 | 24.25 | 21.50 |
| $C_8H_{10}$       | <i>m</i> -Xylene              | 30.13            | 28.47 | 25.71 | 22.95 | 20.19 |
| $C_8H_{10}$       | <i>p</i> -Xylene              |                  | 28.01 | 25.32 | 22.64 | 19.95 |
| $C_8H_{10}O$      | Phenetole                     |                  | 32.41 | 29.65 | 26.89 |       |
| $C_8H_{11}N$      | <i>N,N</i> -Dimethylaniline   |                  | 35.52 | 32.90 | 30.27 |       |
| $C_8H_{11}N$      | <i>N</i> -Ethylaniline        |                  | 36.33 | 33.65 | 30.98 |       |
| $C_8H_{16}$       | Ethylcyclohexane              | 26.73            | 25.15 | 22.51 |       |       |
| $C_8H_{18}$       | Octane                        | 22.57            | 21.14 | 18.77 | 16.39 | 14.01 |
| $C_8H_{18}$       | 2,5-Dimethylhexane            | 20.77            | 19.40 | 17.12 | 14.84 | 12.56 |
| $C_8H_{18}O$      | 1-Octanol                     | 28.30            | 27.10 | 25.12 |       |       |
| $C_8H_{19}N$      | Dibutylamine                  |                  | 24.12 | 21.74 | 19.36 |       |
| $C_8H_{19}N$      | Diisobutylamine               |                  | 21.72 | 19.44 | 17.16 |       |
| $C_9H_7N$         | Quinoline                     | 44.19            | 42.59 | 39.94 | 37.28 | 34.62 |
| $C_9H_{12}$       | Cumene                        | 29.27            | 27.69 | 25.05 | 22.42 | 19.78 |
| $C_9H_{12}$       | 1,2,4-Trimethylbenzene        | 30.74            | 29.20 | 26.64 | 24.07 | 21.51 |
| $C_9H_{12}$       | Mesitylene                    | 28.89            | 27.55 | 25.31 | 23.07 | 20.82 |
| $C_9H_{18}O$      | 5-Nonanone                    |                  | 26.28 | 23.85 |       |       |
| $C_9H_{20}$       | Nonane                        | 23.79            | 22.38 | 20.05 | 17.71 | 15.37 |
| $C_9H_{20}O$      | 1-Nonanol                     | 29.03            | 27.89 | 26.00 | 24.10 | 22.20 |
| $C_{10}H_{12}$    | 1,2,3,4-Tetrahydronaphthalene |                  | 33.17 | 30.78 | 28.40 |       |
| $C_{10}H_{22}$    | Decane                        | 24.75            | 23.37 | 21.07 | 18.77 | 16.47 |
| $C_{10}H_{22}O$   | 1-Decanol                     | 29.61            | 28.51 | 26.68 | 24.85 | 23.02 |
| $C_{11}H_{24}$    | Undecane                      | 25.56            | 24.21 | 21.96 | 19.70 | 17.45 |
| $C_{12}H_{10}O$   | Diphenyl ether                |                  | 26.75 | 24.80 |       |       |
| $C_{12}H_{27}N$   | Tributylamine                 |                  | 24.39 | 22.32 | 20.24 |       |
| $C_{13}H_{28}$    | Tridecane                     | 26.86            | 25.55 | 23.37 | 21.19 | 19.01 |
| $C_{14}H_{12}O_2$ | Benzyl benzoate               | 44.47            | 42.82 | 40.06 | 37.31 | 34.55 |
| $C_{14}H_{30}$    | Tetradecane                   | 27.43            | 26.13 | 23.96 | 21.78 | 19.61 |
| $C_{16}H_{34}$    | Hexadecane                    |                  | 27.05 | 24.91 | 22.78 | 20.64 |
| $C_{18}H_{38}$    | Octadecane                    |                  | 27.87 | 25.77 | 23.66 | 21.55 |



# PERMITTIVITY (DIELECTRIC CONSTANT) OF LIQUIDS

Christian Wohlfarth

The permittivity of a substance (often called the dielectric constant) is the ratio of the electric displacement  $D$  to the electric field strength  $E$  when an external field is applied to the substance. The quantity tabulated here is the relative permittivity, which is the ratio of the actual permittivity to the permittivity of a vacuum; it is a dimensionless number.

The table gives the static relative permittivity  $\epsilon_r$ , i.e., the relative permittivity measured in static fields or at low frequencies where no relaxation effects occur. The fourth column of the table lists the value of  $\epsilon_r$  at the temperature specified in the third column, usually 293.15 or 298.15 K. Otherwise, the temperature closest to 293.15 K was chosen, or (as it is the case for many of the substances included here)  $\epsilon_r$  is given at the only temperature for which data are available.

The static permittivity refers to nominal atmospheric pressure as long as the corresponding temperature is below the normal boiling point. Otherwise, at temperatures above the normal boiling point, the pressure is understood to be the saturated vapor pressure of the substance considered.

For substances where information on the temperature dependence of the permittivity is available, the table gives the coefficients of a simple polynomial fitting of permittivity to temperature with an equation of the form

$$\epsilon_r(T) = a + bT + cT^2 + dT^3$$

where  $T$  is the absolute temperature in K. Since the parameter  $d$  was used in only a few cases where the quadratic fit was not satisfactory, only  $a$ ,  $b$ , and  $c$  are listed as columns in the table, while the  $d$  values are given at the end of this introduction. For all other substances,  $d = 0$ . The temperature range of the fit is given in the last column. The coefficients of the fitting equation can be used to

calculate dielectric constants within the fitted temperature range but should not be used for extrapolation outside this range. The user who needs dielectric constant data with more accuracy than can be provided by this equation is referred to Reference 1, which gives the original data together with their literature source.

Substances are listed by molecular formula in modified Hill order, with substances not containing carbon preceding those that do contain carbon.

\* Indicates that the isomer was not specified in the original reference.

\*\* Indicates a compound for which the cubic term is needed:

|                           |                           |
|---------------------------|---------------------------|
| Ethanol                   | $d = -0.15512\text{E-}05$ |
| <i>N</i> -Methylacetamide | $d = -0.12998\text{E-}04$ |
| 1,2-Propylene glycol      | $d = -0.32544\text{E-}05$ |
| 1-Butanol                 | $d = -0.48841\text{E-}06$ |
| 2-Butanol                 | $d = -0.89512\text{E-}06$ |
| 2-Methyl-1-propanol       | $d = -0.45229\text{E-}06$ |
| 2-Methyl-2-propanol       | $d = -0.25968\text{E-}05$ |
| <i>N</i> -Butylacetamide  | $d = -0.48716\text{E-}05$ |

## References

1. Wohlfarth, Ch., Static Dielectric Constants of Pure Liquids and Binary Liquid Mixtures, *Landolt-Börnstein, Numerical Data and Functional Relationships in Science and Technology, New Series*, Editor in Chief, O. Madelung, Group IV, Macroscopic and Technical Properties of Matter, Volume 6, Springer-Verlag, Berlin, 1991.
2. Marsh, K. N., Ed., *Recommended Reference Materials for the Realization of Physicochemical Properties*, Blackwell Scientific Publications, Oxford, 1987.

| Mol. form.                       | Name                                 | <i>T</i> /K | $\epsilon_r$ | <i>a</i>    | <i>b</i>     | <i>c</i>     | Range/K |
|----------------------------------|--------------------------------------|-------------|--------------|-------------|--------------|--------------|---------|
| AlBr <sub>3</sub>                | Aluminum tribromide                  | 373.2       | 3.38         |             |              |              |         |
| Ar                               | Argon                                | 140.00      | 1.3247       | 0.12408E+01 | 0.68755E-02  | -0.45344E-04 | 87-149  |
| AsH <sub>3</sub>                 | Arsine                               | 200.9       | 2.40         | 0.37674E+01 | -0.97454E-02 | 0.14537E-04  | 157-201 |
| BBr <sub>3</sub>                 | Boron tribromide                     | 273.2       | 2.58         |             |              |              |         |
| B <sub>2</sub> H <sub>6</sub>    | Diborane                             | 180.66      | 1.8725       | 0.23848E+01 | -0.29501E-02 | 0.64189E-06  | 108-181 |
| B <sub>5</sub> H <sub>9</sub>    | Pentaborane(9)                       | 298.2       | 21.1         | 0.40952E+03 | -0.24414E+01 | 0.38225E-02  | 226-298 |
| BrF <sub>3</sub>                 | Bromine trifluoride                  | 298.2       | 106.8        |             |              |              |         |
| BrF <sub>5</sub>                 | Bromine pentafluoride                | 297.7       | 7.91         | 0.11428E+02 | -0.11822E-01 |              | 262-298 |
| BrH                              | Hydrogen bromide                     | 186.8       | 8.23         |             |              |              |         |
| BrNO                             | Nitrosyl bromide                     | 288.4       | 13.4         |             |              |              |         |
| Br <sub>2</sub>                  | Bromine                              | 297.9       | 3.1484       | 0.32701E+01 | -0.12535E-03 |              | 273-327 |
| Br <sub>2</sub> OS               | Thionyl bromide                      | 293.2       | 9.06         |             |              |              |         |
| Br <sub>3</sub> OV               | Vanadyl tribromide                   | 298.2       | 3.6          | 0.61112E+01 | -0.84211E-02 |              | 203-298 |
| Br <sub>4</sub> Ge               | Germanium(IV) bromide                | 299.9       | 2.955        | 0.34450E+01 | -0.16083E-02 |              | 300-316 |
| Br <sub>4</sub> Sn               | Tin(IV) bromide                      | 303.45      | 3.169        | 0.50001E+01 | -0.60383E-02 |              | 304-316 |
| ClFO <sub>3</sub>                | Perchloryl fluoride                  | 150.2       | 2.194        | 0.23808E+01 | -0.38629E-03 | -0.57143E-05 | 125-150 |
| ClF <sub>3</sub>                 | Chlorine trifluoride                 | 293.2       | 4.394        | 0.96716E+01 | -0.18000E-01 |              | 273-313 |
| ClF <sub>5</sub>                 | Chlorine pentafluoride               | 193.2       | 4.28         | 0.78192E+01 | -0.20860E-01 | 0.13132E-04  | 193-256 |
| ClH                              | Hydrogen chloride                    | 158.9       | 14.3         | 0.47316E+02 | -0.28455E+00 | 0.48650E-03  | 159-258 |
| ClNO                             | Nitrosyl chloride                    | 285.2       | 18.2         |             |              |              |         |
| Cl <sub>2</sub>                  | Chlorine                             | 208.0       | 2.147        | 0.29440E+01 | -0.44649E-02 | 0.30388E-05  | 208-240 |
| Cl <sub>2</sub> F <sub>3</sub> P | Phosphorus(V) dichloride trifluoride | 228.63      | 2.8129       | 0.46501E+01 | -0.80358E-02 |              | 172-229 |
| Cl <sub>2</sub> OS               | Thionyl chloride                     | 298.2       | 8.675        |             |              |              |         |
| Cl <sub>2</sub> OSe              | Selenium oxychloride                 | 293.2       | 46.2         |             |              |              |         |
| Cl <sub>2</sub> O <sub>2</sub> S | Sulfuryl chloride                    | 293.2       | 9.1          |             |              |              |         |

| Mol. form.                       | Name                                 | T/K    | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|----------------------------------|--------------------------------------|--------|--------------|--------------|--------------|--------------|---------|
| Cl <sub>2</sub> S                | Sulfur dichloride                    | 298.2  | 2.915        |              |              |              |         |
| Cl <sub>2</sub> S <sub>2</sub>   | Sulfur chloride                      | 288.2  | 4.79         |              |              |              |         |
| Cl <sub>3</sub> F <sub>2</sub> P | Phosphorus(V) trichloride difluoride | 268.0  | 2.3752       | 0.28905E+01  | -0.19228E-02 |              | 215-268 |
| Cl <sub>3</sub> OP               | Phosphorus(V) oxychloride            | 293.2  | 14.1         |              |              |              |         |
| Cl <sub>3</sub> OV               | Vanadyl trichloride                  | 298.2  | 3.4          |              |              |              |         |
| Cl <sub>3</sub> P                | Phosphorus(III) chloride             | 290.2  | 3.498        | 0.59098E+01  | -0.83322E-02 |              | 290-333 |
| Cl <sub>3</sub> PS               | Phosphorus(V) sulfide trichloride    | 298.2  | 4.94         |              |              |              |         |
| Cl <sub>4</sub> FP               | Phosphorus(V) tetrachloride fluoride | 272.64 | 2.6499       | 0.33503E+01  | -0.29651E-02 |              | 244-273 |
| Cl <sub>4</sub> Ge               | Germanium(IV) chloride               | 273.2  | 2.463        | -0.55078E+01 | 0.64881E-01  | -0.13091E-03 | 246-273 |
| Cl <sub>4</sub> Pb               | Lead(IV) chloride                    | 293.2  | 2.78         |              |              |              |         |
| Cl <sub>4</sub> Si               | Tetrachlorosilane                    | 273.2  | 2.248        | 0.58041E+01  | -0.27129E-01 | 0.51678E-04  | 207-273 |
| Cl <sub>4</sub> Sn               | Tin(IV) chloride                     | 273.2  | 3.014        | 0.43951E+01  | -0.48805E-02 |              | 234-273 |
| Cl <sub>4</sub> Ti               | Titanium(IV) chloride                | 257.4  | 2.843        | 0.33668E+01  | -0.19675E-02 |              | 237-257 |
| Cl <sub>4</sub> V                | Vanadium(IV) chloride                | 298.2  | 3.05         |              |              |              |         |
| Cl <sub>3</sub> P                | Phosphorus(V) chloride               | 433.2  | 2.85         |              |              |              |         |
| Cl <sub>3</sub> Sb               | Antimony(V) chloride                 | 293.0  | 3.222        | 0.45413E+01  | -0.45078E-02 |              | 276-320 |
| FH                               | Hydrogen fluoride                    | 273.2  | 83.6         | 0.50352E+03  | -0.19297E+01 | 0.14372E-02  | 200-273 |
| F <sub>2</sub>                   | Fluorine                             | 53.48  | 1.4913       | 0.14144E+01  | 0.26387E-02  | -0.28356E-04 | 54-144  |
| F <sub>5</sub> I                 | Iodine pentafluoride                 | 293.2  | 37.13        | 0.95184E+02  | -0.19800E+00 |              | 273-313 |
| F <sub>6</sub> S                 | Sulfur hexafluoride                  | 223.2  | 1.81         |              |              |              |         |
| F <sub>6</sub> Xe                | Xenon hexafluoride                   | 328.2  | 4.10         |              |              |              |         |
| F <sub>7</sub> I                 | Iodine heptafluoride                 | 298.2  | 1.75         |              |              |              |         |
| F <sub>10</sub> S <sub>2</sub>   | Sulfur decafluoride                  | 293.2  | 2.0202       |              |              |              |         |
| HI                               | Hydrogen iodide                      | 220.2  | 3.87         | 0.51557E+03  | -0.44552E+01 | 0.96795E-02  | 220-236 |
| H <sub>2</sub>                   | Hydrogen                             | 13.52  | 1.2792       | 0.13327E+01  | -0.51946E-02 |              | 14-19   |
| H <sub>2</sub> O                 | Water                                | 293.2  | 80.100       | 0.24921E+03  | -0.79069E+00 | 0.72997E-03  | 273-372 |
| H <sub>2</sub> O <sub>2</sub>    | Hydrogen peroxide                    | 290.2  | 74.6         | 0.48511E+03  | -0.23145E+01 | 0.31020E-02  | 233-303 |
| H <sub>2</sub> S                 | Hydrogen sulfide                     | 283.2  | 5.93         | 0.14736E+02  | -0.33675E-01 | 0.96740E-05  | 212-363 |
| H <sub>3</sub> N                 | Ammonia                              | 293.2  | 16.61        | 0.66756E+02  | -0.24696E+00 | 0.25913E-03  | 238-323 |
| H <sub>4</sub> N <sub>2</sub>    | Hydrazine                            | 298.2  | 51.7         | 0.22061E+03  | -0.89633E+00 | 0.11066E-02  | 278-323 |
| He                               | Helium                               | 2.055  | 1.0555       | 0.10640E+01  | -0.35584E-02 |              | 2-4     |
| I <sub>2</sub>                   | Iodine                               | 391.25 | 11.08        | 0.64730E+02  | -0.29266E+00 | 0.39759E-03  | 391-441 |
| Kr                               | Krypton                              | 119.80 | 1.664        |              |              |              |         |
| Mn <sub>2</sub> O <sub>7</sub>   | Manganese(VII) oxide                 | 293.2  | 3.28         | 0.37655E+01  | -0.16463E-02 |              | 283-312 |
| NO                               | Nitric oxide                         | 1.997  |              |              |              |              |         |
| N <sub>2</sub>                   | Nitrogen                             | 63.15  | 1.4680       | 0.12550E+01  | 0.67949E-02  | -0.56704E-04 | 63-126  |
| N <sub>2</sub> O <sub>3</sub>    | Nitrogen trioxide                    | 203.2  | 31.13        | 0.92287E+02  | -0.43306E+00 | 0.65000E-03  | 203-243 |
| N <sub>2</sub> O <sub>4</sub>    | Nitrogen tetroxide                   | 293.2  | 2.44         | 0.28212E+01  | -0.13000E-02 |              | 253-293 |
| Ne                               | Neon                                 | 26.11  | 1.1907       | 0.12667E+01  | -0.29064E-02 |              | 26-29   |
| O <sub>2</sub>                   | Oxygen                               | 54.478 | 1.5684       | 0.15434E+01  | 0.14615E-02  | -0.21964E-04 | 55-154  |
| O <sub>2</sub> S                 | Sulfur dioxide                       | 298.2  | 16.3         | 0.52045E+02  | -0.16125E+00 | 0.11042E-03  | 213-449 |
| O <sub>3</sub>                   | Ozone                                | 90.2   | 4.75         | 0.86344E+01  | -0.54807E-01 | 0.12596E-03  | 90-185  |
| O <sub>3</sub> S                 | Sulfur trioxide                      | 291.2  | 3.11         |              |              |              |         |
| P                                | Phosphorus                           | 307.2  | 4.096        | 0.79018E+00  | 0.23911E-01  | -0.42826E-04 | 307-358 |
| S                                | Sulfur                               | 407.2  | 3.4991       | 0.51651E+01  | -0.77381E-02 | 0.89120E-05  | 407-479 |
| Se                               | Selenium                             | 510.65 | 5.44         | 0.67569E+01  | -0.25829E-02 |              | 511-575 |
| Xe                               | Xenon                                | 161.35 | 1.880        |              |              |              |         |
| CBrClF <sub>2</sub>              | Bromochlorodifluoromethane           | 123.2  | 3.920        | 0.52442E+01  | -0.11000E-01 |              | 123-223 |
| CBrCl <sub>3</sub>               | Bromotrichloromethane                | 293.2  | 2.405        | 0.29249E+01  | -0.17650E-02 |              | 273-333 |
| CBrF <sub>3</sub>                | Bromotrifluoromethane                | 123.2  | 3.730        | 0.54154E+01  | -0.13680E-01 |              | 123-173 |
| CBr <sub>2</sub> Cl <sub>2</sub> | Dibromodichloromethane               | 298.2  | 2.542        | 0.32330E+01  | -0.23162E-02 |              | 298-333 |
| CBr <sub>2</sub> F <sub>2</sub>  | Dibromodifluoromethane               | 273.2  | 2.939        | 0.67296E+01  | -0.22133E-01 | 0.30213E-04  | 139-273 |
| CBr <sub>3</sub> Cl              | Tribromochloromethane                | 333.2  | 2.601        |              |              |              |         |
| CBr <sub>3</sub> F               | Tribromofluoromethane                | 293.2  | 3.00         | 0.53203E+01  | -0.11061E-01 | 0.10688E-04  | 206-323 |
| CBr <sub>3</sub> NO <sub>2</sub> | Tribromonitromethane                 | 298.2  | 9.034        | 0.16079E+02  | -0.23630E-01 |              | 298-328 |
| CClF <sub>3</sub>                | Chlorotrifluoromethane               | 123.2  | 3.010        | 0.43677E+01  | -0.11020E-01 |              | 123-173 |
| CCl <sub>2</sub> F <sub>2</sub>  | Dichlorodifluoromethane              | 123.2  | 3.500        | 0.46984E+01  | -0.97600E-02 |              | 123-223 |
| CCl <sub>2</sub> O               | Carbonyl chloride                    | 295.2  | 4.30         |              |              |              |         |
| CCl <sub>3</sub> D               | Trichloromethane- <i>d</i>           | 298.2  | 4.67         |              |              |              |         |
| CCl <sub>3</sub> F               | Trichlorofluoromethane               | 293.2  | 3.00         | 0.53203E+01  | -0.11061E-01 | 0.10688E-04  | 206-323 |
| CCl <sub>3</sub> NO <sub>2</sub> | Trichloronitromethane                | 293.2  | 7.319        | 0.14403E+02  | -0.24178E-01 |              | 276-333 |
| CCl <sub>4</sub>                 | Tetrachloromethane                   | 293.2  | 2.2379       | 0.28280E+01  | -0.20339E-02 | 0.71795E-07  | 283-333 |
| CF <sub>4</sub>                  | Tetrafluoromethane                   | 126.3  | 1.685        | 0.20350E+01  | -0.27616E-02 |              | 126-142 |

| Mol. form.                                                    | Name                                   | T/K    | $\epsilon_r$ | <i>a</i>    | <i>b</i>     | <i>c</i>     | Range/K |
|---------------------------------------------------------------|----------------------------------------|--------|--------------|-------------|--------------|--------------|---------|
| CHBr <sub>3</sub>                                             | Tribromomethane                        | 283.2  | 4.404        | 0.71707E+01 | −0.98000E-02 |              | 283-343 |
| CHCl <sub>3</sub>                                             | Trichloromethane                       | 293.2  | 4.8069       | 0.15115E+02 | −0.51830E-01 | 0.56803E-04  | 218-323 |
| CHF <sub>3</sub>                                              | Trifluoromethane                       | 294.0  | 5.2          | 0.11442E+03 | −0.75600E+00 | 0.13562E-02  | 130-263 |
| CHN                                                           | Hydrogen cyanide                       | 293.2  | 114.9        | 0.37331E+04 | −0.23180E+02 | 0.36963E-01  | 258-299 |
| CH <sub>2</sub> Br <sub>2</sub>                               | Dibromomethane                         | 283.2  | 7.77         | 0.18060E+02 | −0.36333E-01 |              | 283-313 |
| CH <sub>2</sub> Cl <sub>2</sub>                               | Dichloromethane                        | 298.0  | 8.93         | 0.40452E+02 | −0.17748E+00 | 0.23942E-03  | 184-306 |
| CH <sub>2</sub> F <sub>2</sub>                                | Diffuoromethane                        | 152.2  | 53.74        | 0.19428E+03 | −0.12939E+01 | 0.24280E-02  | 152-224 |
| CH <sub>2</sub> I <sub>2</sub>                                | Diiodomethane                          | 298.2  | 5.32         |             |              |              |         |
| CH <sub>2</sub> O <sub>2</sub>                                | Formic acid                            | 298.2  | 51.1         | 0.14040E+03 | −0.24673E+00 | −0.17151E-03 | 287-358 |
| CH <sub>3</sub> Br                                            | Bromomethane                           | 275.7  | 9.71         | 0.40580E+02 | −0.18418E+00 | 0.26219E-03  | 195-276 |
| CH <sub>3</sub> Cl                                            | Chloromethane                          | 295.2  | 10.0         | 0.42775E+02 | −0.16175E+00 | 0.17108E-03  | 190-392 |
| CH <sub>3</sub> ClO <sub>2</sub> S                            | Methanesulfonyl chloride               | 293.2  | 34.0         | 0.10384E+03 | −0.33838E+00 | 0.34156E-03  | 293-373 |
| CH <sub>3</sub> DO                                            | Methan- <i>d</i> <sub>1</sub> -ol      | 297.5  | 31.68        | 0.20839E+03 | −0.10318E+01 | 0.14740E-02  | 176-298 |
| CH <sub>3</sub> F                                             | Fluoromethane                          | 131.0  | 51.0         | 0.11338E+03 | −0.63979E+00 | 0.96983E-03  | 150-299 |
| CH <sub>3</sub> I                                             | Iodomethane                            | 293.2  | 6.97         | 0.24264E+02 | −0.93914E-01 | 0.11926E-03  | 223-303 |
| CH <sub>3</sub> NO                                            | Formamide                              | 293.2  | 111.0        | 0.26076E+03 | −0.61145E+00 | 0.34296E-03  | 278-333 |
| CH <sub>3</sub> NO <sub>2</sub>                               | Nitromethane                           | 293.2  | 37.27        | 0.11227E+03 | −0.35591E+00 | 0.34206E-03  | 288-343 |
| CH <sub>3</sub> NO <sub>2</sub>                               | Methyl nitrite                         | 200.0  | 20.77        | 0.11071E+03 | −0.73428E+00 | 0.14054E-02  | 110-260 |
| CH <sub>3</sub> NO <sub>3</sub>                               | Methyl nitrate                         | 293.2  | 23.9         |             |              |              |         |
| CH <sub>4</sub>                                               | Methane                                | 91.0   | 1.6761       | 0.15996E+01 | 0.27434E-02  | −0.22086E-04 | 91-184  |
| CH <sub>4</sub> O                                             | Methanol                               | 293.2  | 33.0         | 0.19341E+03 | −0.92211E+00 | 0.12839E-02  | 177-293 |
| CH <sub>5</sub> N                                             | Methylamine                            | 215.2  | 16.7         | 0.34398E+02 | −0.73630E-01 | −0.41279E-04 | 198-258 |
| CN <sub>4</sub> O <sub>8</sub>                                | Tetranitromethane                      | 293.2  | 2.317        |             |              |              |         |
| COS                                                           | Carbon oxysulfide                      | 185.0  | 4.47         | 0.84702E+01 | −0.21488E-01 |              | 143-185 |
| COSe                                                          | Carbon oxyselenide                     | 283.2  | 3.47         | 0.48740E+01 | −0.49425E-02 |              | 219-283 |
| CO <sub>2</sub>                                               | Carbon dioxide                         | 295.0  | 1.4492       | 0.79062E+00 | 0.10639E-01  | −0.28510E-04 | 220-300 |
| CS <sub>2</sub>                                               | Carbon disulfide                       | 293.2  | 2.6320       | 0.45024E+01 | −0.12054E-01 | 0.19147E-04  | 154-319 |
| C <sub>2</sub> Br <sub>2</sub> F <sub>4</sub>                 | 1,2-Dibromotetrafluoroethane           | 298.2  | 2.34         |             |              |              |         |
| C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>                 | 1,2-Dichlorotetrafluoroethane          | 273.2  | 2.4842       | 0.36663E+01 | −0.42271E-02 | −0.36255E-06 | 193-273 |
| C <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>                 | Oxalyl chloride                        | 294.35 | 3.470        |             |              |              |         |
| C <sub>2</sub> Cl <sub>3</sub> N                              | Trichloroacetonitrile                  | 292.2  | 7.85         |             |              |              |         |
| C <sub>2</sub> Cl <sub>4</sub>                                | Tetrachloroethylene                    | 303.2  | 2.268        |             |              |              |         |
| C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>                 | 1,1,2,2-Tetrachloro-1,2-difluoroethane | 308.2  | 2.52         |             |              |              |         |
| C <sub>2</sub> HBr <sub>3</sub> O                             | Tribromoacetaldehyde                   | 293.2  | 7.6          |             |              |              |         |
| C <sub>2</sub> HCl <sub>3</sub>                               | Trichloroethylene                      | 301.5  | 3.390        | 0.58319E+01 | −0.80828E-02 |              | 302-338 |
| C <sub>2</sub> HCl <sub>3</sub> F <sub>2</sub>                | 1,2,2-Trichloro-1,1-difluoroethane     | 303.2  | 4.01         | 0.75423E+01 | −0.11667E-01 |              | 303-333 |
| C <sub>2</sub> HCl <sub>3</sub> O                             | Trichloroacetaldehyde                  | 298.2  | 6.8          |             |              |              |         |
| C <sub>2</sub> HCl <sub>3</sub> O <sub>2</sub>                | Trichloroacetic acid                   | 333.2  | 4.34         | 0.13412E+01 | 0.90000E-02  | −0.24130E-14 | 333-393 |
| C <sub>2</sub> HCl <sub>5</sub>                               | Pentachloroethane                      | 298.2  | 3.716        | 0.65972E+01 | −0.96800E-02 |              | 298-338 |
| C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>                 | Trifluoroacetic acid                   | 293.2  | 8.42         | 0.21652E+02 | −0.68146E-01 | 0.78571E-04  | 263-323 |
| C <sub>2</sub> H <sub>2</sub>                                 | Acetylene                              | 195.0  | 2.4841       |             |              |              |         |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub>                 | <i>cis</i> -1,2-Dibromoethylene        | 298.2  | 7.08         |             |              |              |         |
| C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub>                 | <i>trans</i> -1,2-Dibromoethylene      | 298.2  | 2.88         |             |              |              |         |
| C <sub>2</sub> H <sub>2</sub> Br <sub>4</sub>                 | 1,1,2,2-Tetrabromoethane               | 303.2  | 6.72         | 0.16246E+02 | −0.31500E-01 |              | 303-333 |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | 1,1-Dichloroethylene                   | 293.2  | 4.60         |             |              |              |         |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | <i>cis</i> -1,2-Dichloroethylene       | 298.2  | 9.20         |             |              |              |         |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                 | <i>trans</i> -1,2-Dichloroethylene     | 293.2  | 2.14         |             |              |              |         |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>  | Dichloroacetic acid                    | 293.2  | 8.33         | 0.11014E+02 | −0.10859E-01 | 0.49242E-05  | 284-363 |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 1,1,1,2-Tetrachloroethane              | 207.2  | 9.22         | 0.19606E+02 | −0.49847E-01 |              | 207-233 |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 1,1,2,2-Tetrachloroethane              | 293.2  | 8.50         |             |              |              |         |
| C <sub>2</sub> H <sub>2</sub> I <sub>2</sub>                  | <i>cis</i> -1,2-Diiodoethylene         | 345.65 | 4.46         |             |              |              |         |
| C <sub>2</sub> H <sub>3</sub> ClO                             | Acetyl chloride                        | 295.2  | 15.8         |             |              |              |         |
| C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>                | Chloroacetic acid                      | 338.2  | 12.35        | 0.17310E+02 | −0.14674E-01 |              | 338-393 |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub> | 1,1-Dichloro-1-nitroethane             | 303.2  | 16.3         | 0.37576E+02 | −0.70400E-01 |              | 303-333 |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                 | 1,1,1-Trichloroethane                  | 293.2  | 7.243        | 0.27705E+02 | −0.10621E+00 | 0.12424E-03  | 258-318 |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                 | 1,1,2-Trichloroethane                  | 298.2  | 7.1937       | 0.17147E+02 | −0.33371E-01 |              | 288-318 |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O                | 2,2,2-Trifluoroethanol                 | 293.2  | 27.68        | 0.90593E+02 | −0.21421E+00 |              | 293-318 |
| C <sub>2</sub> H <sub>3</sub> N                               | Acetonitrile                           | 293.2  | 36.64        | 0.29724E+03 | −0.15508E+01 | 0.22591E-02  | 288-333 |
| C <sub>2</sub> H <sub>3</sub> NO                              | Methyl isocyanate                      | 288.7  | 21.75        |             |              |              |         |
| C <sub>2</sub> H <sub>4</sub>                                 | Ethylene                               | 270.0  | 1.4833       | 0.13546E+01 | 0.62614E-02  | −0.21374E-04 | 200-270 |
| C <sub>2</sub> H <sub>4</sub> BrCl                            | 1-Bromo-2-chloroethane                 | 283.2  | 7.41         | 0.19493E+02 | −0.59054E-01 | 0.58036E-04  | 263-363 |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>                 | 1,2-Dibromoethane                      | 293.2  | 4.9612       | 0.67142E+01 | −0.59800E-02 |              | 293-313 |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                 | 1,1-Dichloroethane                     | 298.2  | 10.10        | 0.24429E+02 | −0.48000E-01 |              | 288-318 |

| Mol. form.                                                    | Name                               | T/K    | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|---------------------------------------------------------------|------------------------------------|--------|--------------|--------------|--------------|--------------|---------|
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                 | 1,2-Dichloroethane                 | 293.2  | 10.42        | 0.24404E+02  | -0.47892E-01 |              | 293-343 |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> O               | Bis(chloromethyl) ether            | 293.2  | 3.51         |              |              |              |         |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>   | Ethylene glycol dinitrate          | 293.2  | 28.26        |              |              |              |         |
| C <sub>2</sub> H <sub>4</sub> O                               | Acetaldehyde                       | 291.2  | 21.0         |              |              |              |         |
| C <sub>2</sub> H <sub>4</sub> O                               | Ethylene oxide                     | 293.2  | 12.42        | 0.52661E+02  | -0.21337E+00 | 0.25947E-03  | 293-243 |
| C <sub>2</sub> H <sub>4</sub> OS                              | Thioacetic acid                    | 298.2  | 14.30        |              |              |              |         |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                  | Acetic acid                        | 293.2  | 6.20         | -0.15731E+02 | 0.12662E+00  | -0.17738E-03 | 293-363 |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                  | Methyl formate                     | 288.2  | 9.20         | 0.19699E+02  | -0.36429E-01 |              | 288-302 |
| C <sub>2</sub> H <sub>4</sub> O <sub>3</sub> S                | Ethylene glycol sulfite            | 298.2  | 39.6         | 0.85483E+02  | -0.15400E+00 |              | 298-328 |
| C <sub>2</sub> H <sub>5</sub> Br                              | Bromoethane                        | 298.2  | 9.01         | 0.28473E+02  | -0.85495E-01 | 0.67971E-04  | 243-308 |
| C <sub>2</sub> H <sub>5</sub> Cl                              | Chloroethane                       | 293.2  | 9.45         | 0.60693E+02  | -0.31290E+00 | 0.47154E-03  | 237-293 |
| C <sub>2</sub> H <sub>5</sub> ClO                             | 2-Chloroethanol                    | 293.2  | 25.80        | 0.11155E+03  | -0.30149E+00 |              | 140-175 |
| C <sub>2</sub> H <sub>5</sub> I                               | Iodoethane                         | 293.2  | 7.82         | 0.25598E+02  | -0.94367E-01 | 0.11424E-03  | 183-343 |
| C <sub>2</sub> H <sub>5</sub> N                               | Ethyleneimine                      | 298.2  | 18.3         | 0.61405E+02  | -0.14474E+00 |              | 273-298 |
| C <sub>2</sub> H <sub>5</sub> NO                              | Acetamide                          | 363.7  | 67.6         | -0.20055E+03 | 0.15515E+01  | -0.22392E-02 | 364-448 |
| C <sub>2</sub> H <sub>5</sub> NO                              | N-Methylformamide                  | 293.2  | 189.0        | 0.10383E+04  | -0.43165E+01 | 0.48398E-02  | 276-353 |
| C <sub>2</sub> H <sub>5</sub> NO                              | Acetaldoxime                       | 298.2  | 4.70         |              |              |              |         |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                 | Nitroethane                        | 288.2  | 29.11        | 0.57406E+02  | -0.97657E-01 |              | 276-333 |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                 | Methyl carbamate                   | 328.2  | 18.48        | 0.36773E+02  | -0.55700E-01 |              | 328-368 |
| C <sub>2</sub> H <sub>5</sub> NO <sub>3</sub>                 | Ethyl nitrate                      | 293.2  | 19.7         |              |              |              |         |
| C <sub>2</sub> H <sub>6</sub>                                 | Ethane                             | 95.0   | 1.9356       | 0.20185E+01  | -0.51493E-03 | -0.48148E-05 | 95-295  |
| C <sub>2</sub> H <sub>6</sub> O                               | Ethanol**                          | 293.2  | 25.3         | 0.15145E+03  | -0.87020E+00 | 0.19570E-02  | 163-523 |
| C <sub>2</sub> H <sub>6</sub> O                               | Dimethyl ether                     | 258.0  | 6.18         | 0.22389E+02  | -0.86524E-01 | 0.91291E-04  | 155-258 |
| C <sub>2</sub> H <sub>6</sub> OS                              | Dimethyl sulfoxide                 | 293.2  | 47.24        | 0.38478E+02  | 0.16939E+00  | -0.47423E-03 | 288-343 |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>                  | Ethylene glycol                    | 293.2  | 41.4         | 0.14355E+03  | -0.48573E+00 | 0.46703E-03  | 293-423 |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub> S                | Dimethyl sulfone                   | 383.2  | 47.39        | 0.10830E+03  | -0.15900E+00 |              | 383-398 |
| C <sub>2</sub> H <sub>6</sub> O <sub>4</sub> S                | Dimethyl sulfate                   | 298.2  | 55.0         |              |              |              |         |
| C <sub>2</sub> H <sub>6</sub> S                               | Ethanethiol                        | 298.2  | 6.667        |              |              |              |         |
| C <sub>2</sub> H <sub>6</sub> S                               | Dimethyl sulfide                   | 294.2  | 6.70         |              |              |              |         |
| C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>                  | 1,2-Ethanedithiol                  | 293.2  | 7.26         | 0.11228E+02  | -0.13500E-01 |              | 293-333 |
| C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>                  | Dimethyl disulfide                 | 298.2  | 9.6          | 0.19109E+02  | -0.32000E-01 |              | 298-323 |
| C <sub>2</sub> H <sub>7</sub> N                               | Ethylamine                         | 273.2  | 8.7          | 0.30163E+02  | -0.79000E-01 |              | 233-273 |
| C <sub>2</sub> H <sub>7</sub> NO                              | Ethanolamine                       | 293.2  | 31.94        | 0.14890E+03  | -0.62491E+00 | 0.77143E-03  | 253-293 |
| C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                  | 1,2-Ethanediamine                  | 293.2  | 13.82        | 0.48922E+02  | -0.17021E+00 | 0.17262E-03  | 273-333 |
| C <sub>3</sub> Cl <sub>6</sub> O                              | Hexachloroacetone                  | 291.9  | 3.925        | 0.76423E+01  | -0.15838E-01 | 0.10618E-04  | 269-303 |
| C <sub>3</sub> F <sub>6</sub> O                               | Perfluoroacetone                   | 202.2  | 2.104        | 0.34809E+01  | -0.92883E-02 | 0.12282E-04  | 151-238 |
| C <sub>3</sub> HN                                             | Cyanoacetylene                     | 291.9  | 72.3         | 0.91803E+03  | -0.49149E+01 | 0.69104E-02  | 281-314 |
| C <sub>3</sub> H <sub>2</sub> F <sub>6</sub> O                | 1,1,1,3,3,3-Hexafluoro-2-propanol  | 293.2  | 16.70        |              |              |              |         |
| C <sub>3</sub> H <sub>3</sub> ClO <sub>3</sub>                | 4-Chloro-1,3-dioxolan-2-one        | 313.2  | 62.0         |              |              |              |         |
| C <sub>3</sub> H <sub>3</sub> N                               | Acrylonitrile                      | 293.2  | 33.0         | 0.11109E+03  | -0.36806E+00 | 0.34879E-03  | 233-413 |
| C <sub>3</sub> H <sub>3</sub> NO <sub>2</sub>                 | Cyanoacetic acid                   | 277.2  | 33.4         |              |              |              |         |
| C <sub>3</sub> H <sub>4</sub>                                 | Allene                             | 269.0  | 2.025        | 0.26049E+01  | -0.44147E-03 | -0.63420E-05 | 156-269 |
| C <sub>3</sub> H <sub>4</sub>                                 | Propyne                            | 246.0  | 3.218        | 0.60871E+01  | -0.11730E-01 |              | 185-246 |
| C <sub>3</sub> H <sub>4</sub> ClF <sub>3</sub>                | 3-Chloro-1,1,1-trifluoropropane    | 295.2  | 7.32         | 0.22361E+02  | -0.68840E-01 | 0.60594E-04  | 275-313 |
| C <sub>3</sub> H <sub>4</sub> ClNO                            | 2-Chloroethyl isocyanate           | 288.2  | 29.1         | 0.64311E+02  | -0.12217E+00 |              | 288-403 |
| C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> O               | 1,1-Dichloroacetone                | 293.2  | 14.6         |              |              |              |         |
| C <sub>3</sub> H <sub>4</sub> F <sub>4</sub> O                | 2,2,3,3-Tetrafluoro-1-propanol     | 298.2  | 21.03        |              |              |              |         |
| C <sub>3</sub> H <sub>4</sub> O                               | Propargyl alcohol                  | 293.2  | 20.8         | 0.99895E+02  | -0.38911E+00 | 0.40776E-03  | 213-293 |
| C <sub>3</sub> H <sub>4</sub> O <sub>3</sub>                  | Ethylene carbonate                 | 313.2  | 89.78        | 0.20746E+03  | -0.37610E+00 |              | 313-343 |
| C <sub>3</sub> H <sub>5</sub> Br                              | 3-Bromopropene                     | 293.2  | 7.0          |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> BrO <sub>2</sub>                | 2-Bromopropanoic acid              | 294.2  | 11.0         |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> Br <sub>3</sub>                 | 1,2,3-Tribromopropane              | 303.2  | 6.00         | 0.11024E+02  | -0.16596E-01 |              | 303-358 |
| C <sub>3</sub> H <sub>5</sub> Cl                              | 2-Chloropropene                    | 299.25 | 8.92         |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> Cl                              | 3-Chloropropene                    | 293.2  | 8.2          |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> ClN <sub>2</sub> O <sub>6</sub> | 3-Chloro-1,2-propanediol dinitrate | 293.2  | 17.50        |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> ClO                             | Epichlorohydrin                    | 293.2  | 22.6         |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>                | Ethyl chloroformate                | 308.7  | 9.736        | 0.15356E+02  | -0.18250E-01 |              | 309-349 |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>                | Methyl chloroacetate               | 293.2  | 12.0         |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>                 | 1,2,3-Trichloropropane             | 293.2  | 7.5          |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> I                               | 3-Iodopropene                      | 292.2  | 6.1          |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> N                               | Propanenitrile                     | 293.2  | 29.7         | 0.82222E+02  | -0.22937E+00 | 0.17424E-03  | 213-473 |
| C <sub>3</sub> H <sub>5</sub> NO                              | Ethyl isocyanate                   | 293.2  | 19.7         |              |              |              |         |
| C <sub>3</sub> H <sub>5</sub> NS                              | Ethyl isothiocyanate               | 293.2  | 19.6         |              |              |              |         |

| Mol. form.                                                   | Name                                | T/K    | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|--------------------------------------------------------------|-------------------------------------|--------|--------------|--------------|--------------|--------------|---------|
| C <sub>3</sub> H <sub>5</sub> N <sub>3</sub> O <sub>9</sub>  | Trinitroglycerol                    | 293.2  | 19.25        |              |              |              |         |
| C <sub>3</sub> H <sub>6</sub>                                | Propene                             | 220.0  | 2.1365       | 0.29623E+01  | −0.37564E-02 |              | 220-250 |
| C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>                | 1,2-Dibromopropane                  | 283.2  | 4.60         | 0.54973E+01  | −0.31695E-02 |              | 283-333 |
| C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>                | 1,3-Dibromopropane                  | 293.2  | 9.482        | 0.29193E+02  | −0.94450E-01 | 0.92800E-04  | 293-368 |
| C <sub>3</sub> H <sub>6</sub> ClNO <sub>2</sub>              | 2-Chloro-2-nitropropane             | 250.4  | 31.90        |              |              |              |         |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                | 1,2-Dichloropropane                 | 293.2  | 8.37         | 0.18915E+02  | −0.35907E-01 |              | 281-323 |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                | 1,3-Dichloropropane                 | 303.2  | 10.27        | 0.21609E+02  | −0.37333E-01 |              | 303-333 |
| C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                | 2,2-Dichloropropane                 | 293.2  | 11.37        | 0.32421E+02  | −0.72188E-01 |              | 245-293 |
| C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>  | 2,2-Dinitropropane                  | 325.1  | 42.4         |              |              |              |         |
| C <sub>3</sub> H <sub>6</sub> O                              | Allyl alcohol                       | 293.2  | 19.7         | 0.62714E+02  | −0.14771E+00 | 0.37879E-05  | 213-303 |
| C <sub>3</sub> H <sub>6</sub> O                              | Propanal                            | 290.2  | 18.5         |              |              |              |         |
| C <sub>3</sub> H <sub>6</sub> O                              | Acetone                             | 293.2  | 21.01        | 0.88157E+02  | −0.34300E+00 | 0.38925E-03  | 273-323 |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                 | Propanoic acid                      | 298.2  | 3.44         | 0.18793E+01  | 0.46841E-02  | 0.19983E-05  | 289-408 |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                 | Ethyl formate                       | 288.2  | 8.57         | 0.15884E+02  | −0.25333E-01 |              | 288-318 |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                 | Methyl acetate                      | 288.2  | 7.07         | 0.13190E+02  | −0.21226E-01 |              | 276-318 |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                 | 3-Hydroxypropanoic acid             | 296.2  | 30.0         |              |              |              |         |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                 | Dimethyl carbonate                  | 298.2  | 3.087        |              |              |              |         |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                 | 1,3,5-Trioxane                      | 338.2  | 15.55        |              |              |              |         |
| C <sub>3</sub> H <sub>7</sub> Br                             | 1-Bromopropane                      | 293.2  | 8.09         | 0.17769E+02  | −0.32599E-01 |              | 274-328 |
| C <sub>3</sub> H <sub>7</sub> Br                             | 2-Bromopropane                      | 293.2  | 9.46         | 0.26195E+02  | −0.72995E-01 | 0.55454E-04  | 186-328 |
| C <sub>3</sub> H <sub>7</sub> Cl                             | 1-Chloropropane                     | 293.2  | 8.588        | 0.21214E+02  | −0.43130E-01 |              | 273-313 |
| C <sub>3</sub> H <sub>7</sub> ClO                            | 3-Chloro-1-propanol                 | 215.2  | 36.0         | 0.12436E+03  | −0.60841E+00 | 0.92060E-03  | 145-215 |
| C <sub>3</sub> H <sub>7</sub> ClO                            | 1-Chloro-2-propanol                 | 153.2  | 59.0         | −0.19169E+02 | 0.13605E+01  | −0.55567E-02 | 153-177 |
| C <sub>3</sub> H <sub>7</sub> ClO <sub>2</sub>               | 3-Chloro-1,2-propanediol            | 293.2  | 31.0         |              |              |              |         |
| C <sub>3</sub> H <sub>7</sub> I                              | 1-Iodopropane                       | 293.2  | 7.07         | 0.13744E+02  | −0.22745E-01 |              | 293-323 |
| C <sub>3</sub> H <sub>7</sub> I                              | 2-Iodopropane                       | 298.2  | 8.19         |              |              |              |         |
| C <sub>3</sub> H <sub>7</sub> NO                             | <i>N</i> -Ethylformamide            | 298.2  | 102.7        | 0.64764E+03  | −0.28499E+01 | 0.34286E-02  | 298-338 |
| C <sub>3</sub> H <sub>7</sub> NO                             | <i>N,N</i> -Dimethylformamide       | 293.2  | 38.25        | 0.15364E+03  | −0.60367E+00 | 0.71505E-03  | 213-353 |
| C <sub>3</sub> H <sub>7</sub> NO                             | <i>N</i> -Methylacetamide**         | 303.2  | 179.0        | 0.15975E+04  | −0.90451E+01 | 0.18345E-01  | 303-473 |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | 1-Nitropropane                      | 288.2  | 24.70        | 0.94999E+02  | −0.38358E+00 | 0.48480E-03  | 276-333 |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | 2-Nitropropane                      | 288.2  | 26.74        | 0.60138E+02  | −0.11566E+00 |              | 276-303 |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | Propyl nitrite                      | 250.0  | 12.35        | 0.70552E+02  | −0.40362E+00 | 0.66687E-03  | 110-310 |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | Isopropyl nitrite                   | 260.0  | 13.92        | 0.74578E+02  | −0.38283E+00 | 0.57071E-03  | 150-300 |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | Ethyl carbamate                     | 328.2  | 14.14        | 0.32431E+02  | −0.65097E-01 | 0.28571E-04  | 328-368 |
| C <sub>3</sub> H <sub>8</sub>                                | Propane                             | 293.19 | 1.6678       | 0.22883E+01  | −0.23276E-02 | 0.84710E-06  | 90-300  |
| C <sub>3</sub> H <sub>8</sub> O                              | 1-Propanol                          | 293.2  | 20.8         | 0.98045E+02  | −0.36860E+00 | 0.36422E-03  | 193-493 |
| C <sub>3</sub> H <sub>8</sub> O                              | 2-Propanol                          | 293.2  | 20.18        | 0.10416E+03  | −0.41011E+00 | 0.42049E-03  | 193-493 |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                 | 1,2-Propylene glycol**              | 303.2  | 27.5         | 0.24546E+03  | −0.15738E+01 | 0.38068E-02  | 193-403 |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                 | 1,3-Propylene glycol                | 293.2  | 35.1         | 0.11365E+03  | −0.36680E+00 | 0.33766E-03  | 288-328 |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                 | Ethylene glycol monomethyl ether    | 298.2  | 17.2         | 0.11803E+03  | −0.58000E+00 | 0.81001E-03  | 254-318 |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                 | Dimethoxymethane                    | 293.2  | 2.644        | 0.25877E+01  | −0.93019E-03 | 0.38472E-05  | 171-293 |
| C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>                 | Glycerol                            | 293.2  | 46.53        | 0.77503E+02  | −0.37984E-01 | −0.23107E-03 | 288-343 |
| C <sub>3</sub> H <sub>8</sub> S                              | 1-Propanethiol                      | 288.2  | 5.937        | 0.11602E+02  | −0.19580E-01 |              | 273-318 |
| C <sub>3</sub> H <sub>8</sub> S                              | 2-Propanethiol                      | 298.2  | 5.952        |              |              |              |         |
| C <sub>3</sub> H <sub>8</sub> S <sub>2</sub>                 | 1,2-Propanedithiol                  | 293.2  | 7.24         | 0.14667E+02  | −0.32660E-01 | 0.25000E-04  | 293-333 |
| C <sub>3</sub> H <sub>8</sub> S <sub>2</sub>                 | 1,3-Propanedithiol                  | 303.2  | 8.11         | 0.66607E+01  | 0.31310E-01  | −0.87500E-04 | 303-343 |
| C <sub>3</sub> H <sub>9</sub> BO <sub>3</sub>                | Trimethyl borate                    | 293.2  | 2.2762       |              |              |              |         |
| C <sub>3</sub> H <sub>9</sub> ClSi                           | Trimethylchlorosilane               | 273.2  | 10.21        | −0.19492E+02 | 0.29806E+00  | −0.69284E-03 | 223-273 |
| C <sub>3</sub> H <sub>9</sub> N                              | Propylamine                         | 296.2  | 5.08         | 0.17719E+02  | −0.59022E-01 | 0.54780E-04  | 204-296 |
| C <sub>3</sub> H <sub>9</sub> N                              | Isopropylamine                      | 293.2  | 5.6268       | 0.40429E+02  | −0.21441E+00 | 0.32634E-03  | 213-298 |
| C <sub>3</sub> H <sub>9</sub> N                              | Trimethylamine                      | 298.2  | 2.440        | 0.39745E+01  | −0.51331E-02 |              | 273-298 |
| C <sub>3</sub> H <sub>9</sub> O <sub>4</sub> P               | Trimethyl phosphate                 | 293.2  | 20.6         |              |              |              |         |
| C <sub>4</sub> Cl <sub>6</sub>                               | Hexachloro-1,3-butadiene            | 293.2  | 2.55         |              |              |              |         |
| C <sub>4</sub> Cl <sub>6</sub> O <sub>3</sub>                | Trichloroacetic anhydride           | 298.2  | 5.0          |              |              |              |         |
| C <sub>4</sub> F <sub>6</sub> O <sub>3</sub>                 | Trifluoroacetic acid anhydride      | 298.2  | 2.7          |              |              |              |         |
| C <sub>4</sub> H <sub>2</sub> Cl <sub>4</sub> O <sub>3</sub> | Dichloroacetic anhydride            | 298.2  | 15.8         |              |              |              |         |
| C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>                 | Maleic anhydride                    | 326.2  | 52.75        |              |              |              |         |
| C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O               | 2,2,3,3,4,4,4-Heptafluoro-1-butanol | 298.2  | 14.4         |              |              |              |         |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                 | Succinonitrile                      | 298.2  | 62.6         | 0.17724E+03  | −0.54654E+00 | 0.54046E-03  | 236-351 |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                 | Pyrazine                            | 323.2  | 2.80         |              |              |              |         |
| C <sub>4</sub> H <sub>4</sub> O                              | Furan                               | 277.1  | 2.88         | 0.13636E+01  | 0.12864E-01  | −0.22701E-04 | 188-277 |
| C <sub>4</sub> H <sub>4</sub> S                              | Thiophene                           | 293.2  | 2.739        | 0.32941E+01  | −0.19019E-02 |              | 253-293 |
| C <sub>4</sub> H <sub>5</sub> Cl                             | 2-Chloro-1,3-butadiene              | 293.2  | 4.914        |              |              |              |         |



| Mol. form.                                                   | Name                           | T/K   | $\epsilon_r$ | <i>a</i>    | <i>b</i>     | <i>c</i>     | Range/K |
|--------------------------------------------------------------|--------------------------------|-------|--------------|-------------|--------------|--------------|---------|
| C <sub>4</sub> H <sub>5</sub> Cl <sub>3</sub> O <sub>2</sub> | Ethyl trichloroacetate         | 293.2 | 8.428        |             |              |              |         |
| C <sub>4</sub> H <sub>5</sub> N                              | Pyrrole                        | 293.0 | 8.00         | 0.12672E+02 | -0.14075E-01 | -0.62671E-05 | 293-357 |
| C <sub>4</sub> H <sub>5</sub> NO                             | Allyl isocyanate               | 288.2 | 15.15        | 0.34299E+02 | -0.66444E-01 |              | 288-333 |
| C <sub>4</sub> H <sub>6</sub>                                | 1,3-Butadiene                  | 265.0 | 2.050        | 0.27674E+01 | -0.26738E-02 |              | 185-265 |
| C <sub>4</sub> H <sub>6</sub> O                              | Divinyl ether                  | 288.2 | 3.94         |             |              |              |         |
| C <sub>4</sub> H <sub>6</sub> O                              | Ethoxyacetylene                | 298.2 | 8.05         |             |              |              |         |
| C <sub>4</sub> H <sub>6</sub> O                              | Cyclobutanone                  | 298.2 | 14.27        | 0.43974E+02 | -0.15712E+00 | 0.19264E-03  | 220-317 |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                 | Methyl acrylate                | 303.2 | 7.03         | 0.11968E+02 | -0.16500E-01 |              | 303-333 |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                 | 2,3-Butanedione                | 298.2 | 4.04         | 0.46907E+01 | -0.22302E-02 |              | 278-348 |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                 | $\gamma$ -Butyrolactone        | 293.2 | 39.0         |             |              |              |         |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                 | Acetic anhydride               | 293.2 | 22.45        |             |              |              |         |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                 | Propylene carbonate            | 293.0 | 66.14        | 0.15940E+03 | -0.39530E+00 | 0.26284E-03  | 273-333 |
| C <sub>4</sub> H <sub>7</sub> Br                             | <i>cis</i> -2-Bromo-2-butene   | 293.2 | 5.38         |             |              |              |         |
| C <sub>4</sub> H <sub>7</sub> Br                             | <i>trans</i> -2-Bromo-2-butene | 293.2 | 6.76         |             |              |              |         |
| C <sub>4</sub> H <sub>7</sub> BrO <sub>2</sub>               | 2-Bromobutanoic acid           | 293.2 | 7.2          |             |              |              |         |
| C <sub>4</sub> H <sub>7</sub> BrO <sub>2</sub>               | Ethyl bromoacetate             | 303.2 | 9.75         | 0.15627E+02 | -0.19600E-01 |              | 303-333 |
| C <sub>4</sub> H <sub>7</sub> BrO <sub>2</sub>               | Methyl 3-bromopropanoate       | 303.2 | 5.81         | 0.36001E+01 | 0.72500E-02  |              | 303-343 |
| C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>               | Propyl chlorocarbonate         | 293.2 | 11.2         |             |              |              |         |
| C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>               | Methyl 2-chloropropanoate      | 303.2 | 11.45        | 0.22449E+02 | -0.36250E-01 |              | 303-343 |
| C <sub>4</sub> H <sub>7</sub> N                              | Butanenitrile                  | 293.2 | 24.83        | 0.53884E+02 | -0.99257E-01 |              | 293-333 |
| C <sub>4</sub> H <sub>7</sub> N                              | 2-Methylpropanenitrile         | 293.2 | 24.42        | 0.52554E+02 | -0.96000E-01 |              | 293-313 |
| C <sub>4</sub> H <sub>7</sub> NO                             | 2-Pyrrolidone                  | 298.2 | 28.18        | 0.11054E+03 | -0.47945E+00 | 0.68182E-03  | 298-338 |
| C <sub>4</sub> H <sub>8</sub>                                | 1-Butene                       | 220.0 | 2.2195       | 0.29354E+01 | -0.32580E-02 |              | 220-250 |
| C <sub>4</sub> H <sub>8</sub>                                | <i>cis</i> -2-Butene           | 296.0 | 1.960        | 0.28802E+01 | -0.31064E-02 |              | 197-296 |
| C <sub>4</sub> H <sub>8</sub>                                | Isobutene                      | 288.7 | 2.1225       | 0.33701E+01 | -0.43295E-02 |              | 220-289 |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                | 1,2-Dibromobutane              | 293.2 | 4.74         | 0.11199E+03 | -0.63334E+00 | 0.91250E-03  | 293-333 |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                | 1,3-Dibromobutane              | 293.2 | 9.14         | 0.34031E+02 | -0.13254E+00 | 0.16250E-03  | 293-333 |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                | 1,4-Dibromobutane              | 303.2 | 8.68         | 0.20944E+02 | -0.55620E-01 | 0.50000E-04  | 303-333 |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                | 2,3-Dibromobutane              | 298.2 | 6.245        | 0.23849E+02 | -0.96300E-01 | 0.12500E-03  | 293-333 |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                | 1,2-Dibromo-2-methylpropane    | 293.2 | 4.1          |             |              |              |         |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                | 1,2-Dichlorobutane             | 293.2 | 7.74         | 0.31925E+02 | -0.13232E+00 | 0.17007E-03  | 293-356 |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                | 1,4-Dichlorobutane             | 308.2 | 9.30         | 0.59766E+01 | 0.49300E-01  | -0.12500E-03 | 308-338 |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                | 1,2-Dichloro-2-methylpropane   | 296.0 | 7.15         | 0.39429E+02 | -0.20028E+00 | 0.30917E-03  | 165-296 |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O              | Bis(2-chloroethyl) ether       | 293.2 | 21.20        |             |              |              |         |
| C <sub>4</sub> H <sub>8</sub> O                              | Butanal                        | 298.2 | 13.45        |             |              |              |         |
| C <sub>4</sub> H <sub>8</sub> O                              | 2-Butanone                     | 293.2 | 18.56        | 0.15457E+02 | 0.90152E-01  | -0.27100E-03 | 293-333 |
| C <sub>4</sub> H <sub>8</sub> O                              | Tetrahydrofuran                | 295.2 | 7.52         | 0.30739E+02 | -0.12946E+00 | 0.17195E-03  | 224-295 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                 | Butanoic acid                  | 287.2 | 2.98         | 0.15010E+01 | 0.50046E-02  |              | 287-403 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                 | 2-Methylpropanoic acid         | 293.2 | 2.58         |             |              |              |         |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                 | Propyl formate                 | 303.2 | 6.92         |             |              |              |         |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                 | Ethyl acetate                  | 293.2 | 6.0814       | 0.15646E+02 | -0.44066E-01 | 0.39137E-04  | 293-433 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                 | Methyl propanoate              | 293.2 | 6.200        | 0.12798E+02 | -0.22540E-01 |              | 293-333 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                 | 1,4-Dioxane                    | 293.2 | 2.2189       | 0.27299E+01 | -0.17440E-02 |              | 293-313 |
| C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                 | 2-Hydroxybutanoic acid         | 296.2 | 37.7         |             |              |              |         |
| C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                 | 3-Hydroxybutanoic acid         | 296.2 | 31.5         |             |              |              |         |
| C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                 | Ethyl methyl carbonate         | 293.2 | 2.985        |             |              |              |         |
| C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                 | Ethylene glycol monoacetate    | 303.2 | 12.95        |             |              |              |         |
| C <sub>4</sub> H <sub>9</sub> Br                             | 1-Bromobutane                  | 283.2 | 7.315        | 0.22542E+02 | -0.79306E-01 | 0.89867E-04  | 183-363 |
| C <sub>4</sub> H <sub>9</sub> Br                             | 2-Bromobutane                  | 298.2 | 8.64         | 0.18461E+02 | -0.32933E-01 |              | 274-328 |
| C <sub>4</sub> H <sub>9</sub> Br                             | 1-Bromo-2-methylpropane        | 273.2 | 7.70         | 0.37558E+02 | -0.20571E+00 | 0.35496E-03  | 112-273 |
| C <sub>4</sub> H <sub>9</sub> Br                             | 2-Bromo-2-methylpropane        | 293.0 | 10.98        | 0.35085E+02 | -0.14075E+00 | 0.19960E-03  | 258-293 |
| C <sub>4</sub> H <sub>9</sub> Cl                             | 1-Chlorobutane                 | 293.2 | 7.276        | 0.13565E+02 | -0.10161E-01 | -0.38750E-04 | 273-323 |
| C <sub>4</sub> H <sub>9</sub> Cl                             | 2-Chlorobutane                 | 293.2 | 8.564        | 0.30376E+02 | -0.11377E+00 | 0.13429E-03  | 273-323 |
| C <sub>4</sub> H <sub>9</sub> Cl                             | 1-Chloro-2-methylpropane       | 293.2 | 7.027        | 0.14945E+02 | -0.33747E-01 | 0.23036E-04  | 273-323 |
| C <sub>4</sub> H <sub>9</sub> Cl                             | 2-Chloro-2-methylpropane       | 293.2 | 9.663        | 0.35077E+02 | -0.12867E+00 | 0.14304E-03  | 273-323 |
| C <sub>4</sub> H <sub>9</sub> I                              | 1-Iodobutane                   | 293.2 | 6.27         | 0.16493E+02 | -0.50262E-01 | 0.52485E-04  | 293-323 |
| C <sub>4</sub> H <sub>9</sub> I                              | 2-Iodobutane                   | 293.2 | 7.873        | 0.10883E+02 | -0.14680E-02 | -0.30000E-04 | 293-323 |
| C <sub>4</sub> H <sub>9</sub> I                              | 2-Iodo-2-methylpropane         | 283.2 | 6.65         | 0.76780E+01 | 0.69900E-02  | -0.37500E-04 | 283-323 |
| C <sub>4</sub> H <sub>9</sub> N                              | Pyrrolidine                    | 293.0 | 8.30         | 0.38191E+02 | -0.15462E+00 | 0.17941E-03  | 274-333 |
| C <sub>4</sub> H <sub>9</sub> NO                             | <i>N</i> -Methylpropanamide    | 293.2 | 170.0        |             |              |              |         |
| C <sub>4</sub> H <sub>9</sub> NO                             | <i>N</i> -Ethylacetamide       | 293.2 | 135.0        | 0.74494E+03 | -0.31400E+01 | 0.36131E-02  | 213-353 |
| C <sub>4</sub> H <sub>9</sub> NO                             | <i>N,N</i> -Dimethylacetamide  | 294.2 | 38.85        | 0.15420E+03 | -0.57506E+00 | 0.61911E-03  | 294-433 |
| C <sub>4</sub> H <sub>9</sub> NO                             | 2-Butanone oxime               | 293.2 | 3.4          |             |              |              |         |

| Mol. form.                                                   | Name                                  | T/K   | $\epsilon_r$ | <i>a</i>    | <i>b</i>     | <i>c</i>     | Range/K |
|--------------------------------------------------------------|---------------------------------------|-------|--------------|-------------|--------------|--------------|---------|
| C <sub>4</sub> H <sub>9</sub> NO                             | Morpholine                            | 298.2 | 7.42         |             |              |              |         |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | <i>tert</i> -Butyl nitrite            | 298.2 | 11.47        |             |              |              |         |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | Propyl carbamate                      | 338.2 | 12.06        | 0.24356E+02 | −0.36400E-01 |              | 338-378 |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | Ethyl- <i>N</i> -methyl carbamate     | 298.2 | 21.10        | 0.11477E+03 | −0.47568E+00 | 0.54127E-03  | 298-373 |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | <i>N</i> -Acetyethanolamine           | 298.2 | 96.6         | 0.37016E+03 | −0.13113E+01 | 0.13214E-02  | 298-348 |
| C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | Butyl nitrate                         | 293.2 | 13.10        |             |              |              |         |
| C <sub>4</sub> H <sub>10</sub>                               | Butane                                | 295.0 | 1.7697       | 0.22379E+01 | −0.13884E-02 | −0.66711E-06 | 135-303 |
| C <sub>4</sub> H <sub>10</sub>                               | Isobutane                             | 295.0 | 1.7518       | 0.23295E+01 | −0.19953E-02 | 0.14197E-06  | 115-303 |
| C <sub>4</sub> H <sub>10</sub> O                             | 1-Butanol**                           | 293.2 | 17.84        | 0.10578E+03 | −0.50587E+00 | 0.84733E-03  | 193-553 |
| C <sub>4</sub> H <sub>10</sub> O                             | 2-Butanol**                           | 293.2 | 17.26        | 0.13850E+03 | −0.75146E+00 | 0.14086E-02  | 172-533 |
| C <sub>4</sub> H <sub>10</sub> O                             | 2-Methyl-1-propanol**                 | 293.2 | 17.93        | 0.10762E+03 | −0.51398E+00 | 0.83702E-03  | 173-533 |
| C <sub>4</sub> H <sub>10</sub> O                             | 2-Methyl-2-propanol**                 | 298.2 | 12.47        | 0.22541E+03 | −0.14990E+01 | 0.34050E-02  | 298-503 |
| C <sub>4</sub> H <sub>10</sub> O                             | Diethyl ether                         | 293.2 | 4.2666       | 0.79725E+01 | −0.12519E-01 |              | 283-301 |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | 1,2-Butanediol                        | 298.2 | 22.4         | 0.63702E+02 | −0.13807E+00 |              | 278-323 |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | 1,3-Butanediol                        | 298.2 | 28.8         | 0.72883E+02 | −0.14770E+00 |              | 278-323 |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | 1,4-Butanediol                        | 298.2 | 31.9         | 0.13079E+03 | −0.46985E+00 | 0.46320E-03  | 288-328 |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | Ethylene glycol monoethyl ether       | 298.2 | 13.38        |             |              |              |         |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                | Ethylene glycol dimethyl ether        | 296.7 | 7.30         | 0.48832E+02 | −0.24218E+00 | 0.34413E-03  | 256-318 |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub> S              | Bis(2-hydroxyethyl) sulfide           | 293.2 | 28.61        | 0.13128E+03 | −0.52719E+00 | 0.60465E-03  | 253-333 |
| C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>                | Diethylene glycol                     | 293.2 | 31.82        | 0.13973E+03 | −0.54725E+00 | 0.61149E-03  | 288-343 |
| C <sub>4</sub> H <sub>10</sub> O <sub>3</sub> S              | Diethyl sulfite                       | 293.2 | 15.6         |             |              |              |         |
| C <sub>4</sub> H <sub>10</sub> O <sub>4</sub>                | 1,2,3,4-Butanetetrol                  | 293.2 | 28.2         |             |              |              |         |
| C <sub>4</sub> H <sub>10</sub> O <sub>4</sub> S              | Diethyl sulfate                       | 293.2 | 29.2         |             |              |              |         |
| C <sub>4</sub> H <sub>10</sub> S                             | 1-Butanethiol                         | 288.2 | 5.204        | 0.11201E+02 | −0.20767E-01 |              | 273-318 |
| C <sub>4</sub> H <sub>10</sub> S                             | 2-Butanethiol                         | 288.2 | 5.645        | 0.10866E+02 | −0.17993E-01 |              | 273-318 |
| C <sub>4</sub> H <sub>10</sub> S                             | 2-Methyl-1-propanethiol               | 298.2 | 4.961        |             |              |              |         |
| C <sub>4</sub> H <sub>10</sub> S                             | 2-Methyl-2-propanethiol               | 293.2 | 5.475        | 0.10597E+02 | −0.17500E-01 |              | 283-313 |
| C <sub>4</sub> H <sub>10</sub> S                             | Diethyl sulfide                       | 298.2 | 5.723        |             |              |              |         |
| C <sub>4</sub> H <sub>11</sub> N                             | Butylamine                            | 293.2 | 4.71         | 0.13322E+02 | −0.44176E-01 | 0.50250E-04  | 223-333 |
| C <sub>4</sub> H <sub>11</sub> N                             | Diethylamine                          | 293.2 | 3.680        | 0.26462E+02 | −0.13750E+00 | 0.20373E-03  | 243-323 |
| C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>               | Diethanolamine                        | 293.2 | 25.75        | 0.73435E+02 | −0.21377E+00 | 0.17500E-03  | 273-323 |
| C <sub>4</sub> H <sub>12</sub> O <sub>2</sub> Si             | Dimethoxydimethylsilane               | 298.2 | 3.663        |             |              |              |         |
| C <sub>4</sub> H <sub>12</sub> O <sub>3</sub> Si             | Trimethoxymethylsilane                | 298.2 | 4.9          |             |              |              |         |
| C <sub>4</sub> H <sub>12</sub> O <sub>4</sub> Si             | Tetramethyl silicate                  | 293.2 | 6.0          |             |              |              |         |
| C <sub>4</sub> H <sub>12</sub> Si                            | Diethylsilane                         | 293.2 | 2.544        |             |              |              |         |
| C <sub>4</sub> H <sub>12</sub> Si                            | Tetramethylsilane                     | 293.2 | 1.921        |             |              |              |         |
| C <sub>4</sub> H <sub>13</sub> N <sub>3</sub>                | Diethylenetriamine                    | 293.2 | 12.62        | 0.57840E+02 | −0.23873E+00 | 0.28841E-03  | 213-333 |
| C <sub>5</sub> FeO <sub>5</sub>                              | Iron pentacarbonyl                    | 293.2 | 2.602        |             |              |              |         |
| C <sub>5</sub> H <sub>4</sub> BrN                            | 2-Bromopyridine                       | 298.2 | 23.18        | 0.73391E+02 | −0.23678E+00 | 0.22930E-03  | 298-398 |
| C <sub>5</sub> H <sub>4</sub> ClN                            | 2-Chloropyridine                      | 298.2 | 27.32        | 0.98702E+02 | −0.34237E+00 | 0.34502E-03  | 298-398 |
| C <sub>5</sub> H <sub>4</sub> F <sub>8</sub> O               | 2,2,3,3,4,4,5,5-Octafluoro-1-pentanol | 298.2 | 15.30        |             |              |              |         |
| C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                 | Furfural                              | 293.2 | 42.1         |             |              |              |         |
| C <sub>5</sub> H <sub>5</sub> N                              | Pyridine                              | 293.2 | 13.260       | 0.43991E+02 | −0.15150E+00 | 0.15925E-03  | 293-323 |
| C <sub>5</sub> H <sub>5</sub> NO                             | Pyridine-1-oxide                      | 343.0 | 35.94        | 0.20878E+02 | 0.16450E+00  | −0.35269E-03 | 343-398 |
| C <sub>5</sub> H <sub>6</sub> O                              | 2-Methylfuran                         | 293.2 | 2.76         |             |              |              |         |
| C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                 | Furfuryl alcohol                      | 298.2 | 16.85        |             |              |              |         |
| C <sub>5</sub> H <sub>7</sub> Cl <sub>3</sub> O <sub>2</sub> | Propyl trichloroacetate               | 298.2 | 8.32         |             |              |              |         |
| C <sub>5</sub> H <sub>7</sub> NO <sub>2</sub>                | Ethyl cyanoacetate                    | 263.2 | 31.62        |             |              |              |         |
| C <sub>5</sub> H <sub>8</sub>                                | 1,3-Pentadiene*                       | 298.2 | 2.319        |             |              |              |         |
| C <sub>5</sub> H <sub>8</sub>                                | 1,4-Pentadiene                        | 294.0 | 2.054        | 0.29994E+01 | −0.34578E-02 | 0.85300E-06  | 178-294 |
| C <sub>5</sub> H <sub>8</sub>                                | 2-Methyl-1,3-butadiene                | 293.2 | 2.098        | 0.28170E+01 | −0.23147E-02 | −0.43975E-06 | 198-293 |
| C <sub>5</sub> H <sub>8</sub>                                | Cyclopentene                          | 295.0 | 2.083        | 0.28177E+01 | −0.27597E-02 | 0.89346E-06  | 171-319 |
| C <sub>5</sub> H <sub>8</sub> O                              | Cyclopentanone                        | 298.2 | 13.58        | 0.24083E+02 | −0.30286E-01 | −0.16802E-04 | 219-298 |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Ethyl acrylate                        | 303.2 | 6.05         | 0.47827E+02 | −0.24394E+00 | 0.35000E-03  | 303-343 |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Methyl <i>trans</i> -2-butenate       | 293.2 | 6.6645       |             |              |              |         |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | Methyl methacrylate                   | 303.2 | 6.32         | 0.32098E+02 | −0.14568E+00 | 0.20000E-03  | 303-343 |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                 | 2,4-Pentanedione                      | 303.2 | 26.524       |             |              |              |         |
| C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                 | Dimethyl malonate                     | 293.2 | 9.82         | 0.26470E+02 | −0.76656E-01 | 0.67888E-04  | 293-433 |
| C <sub>5</sub> H <sub>9</sub> BrO <sub>2</sub>               | Ethyl 2-bromopropanoate               | 293.2 | 9.4          |             |              |              |         |
| C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>               | Isobutyl chlorocarbonate              | 293.2 | 9.1          |             |              |              |         |
| C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>               | Ethyl 2-chloropropanoate              | 303.2 | 11.95        | 0.25965E+02 | −0.46250E-01 |              | 303-343 |
| C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>               | Ethyl 3-chloropropanoate              | 303.2 | 10.19        | 0.21951E+02 | −0.38750E-01 |              | 303-343 |
| C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>               | Methyl 4-chlorobutanoate              | 303.2 | 9.51         | 0.17127E+02 | −0.25000E-01 |              | 303-343 |

| Mol. form.                                      | Name                         | T/K    | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|-------------------------------------------------|------------------------------|--------|--------------|--------------|--------------|--------------|---------|
| C <sub>5</sub> H <sub>9</sub> N                 | Pentanenitrile               | 293.2  | 20.04        | 0.55793E+02  | -0.15750E+00 | 0.12432E-03  | 183-333 |
| C <sub>5</sub> H <sub>9</sub> N                 | 2,2-Dimethylpropanenitrile   | 293.2  | 21.1         | 0.58418E+02  | -0.16884E+00 | 0.14131E-03  | 293-453 |
| C <sub>5</sub> H <sub>9</sub> NO                | Isobutyl isocyanate          | 293.2  | 11.638       | 0.38026E+02  | -0.12714E+00 | 0.12679E-03  | 293-353 |
| C <sub>5</sub> H <sub>9</sub> NO                | N-Methyl-2-pyrrolidone       | 293.2  | 32.55        |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub>                  | 1-Pentene                    | 293.2  | 2.011        | -0.11438E+01 | 0.25420E-01  | -0.50000E-04 | 273-293 |
| C <sub>5</sub> H <sub>10</sub>                  | 2-Methyl-1-butene            | 293.2  | 2.180        |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub>                  | 2-Methyl-2-butene            | 296.0  | 1.979        | 0.26064E+01  | -0.19578E-02 | -0.53908E-06 | 225-296 |
| C <sub>5</sub> H <sub>10</sub>                  | Cyclopentane                 | 293.2  | 1.9687       | 0.24287E+01  | -0.15304E-02 | -0.13095E-06 | 278-313 |
| C <sub>5</sub> H <sub>10</sub>                  | Ethylcyclopropane            | 293.2  | 1.933        |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>  | 1,2-Dibromopentane           | 298.2  | 4.39         |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>  | 1,4-Dibromopentane           | 293.2  | 9.05         | 0.26443E+02  | -0.88640E-01 | 0.10000E-03  | 293-333 |
| C <sub>5</sub> H <sub>10</sub> Br <sub>2</sub>  | 1,5-Dibromopentane           | 303.2  | 9.14         | 0.38192E+02  | -0.15648E+00 | 0.20000E-03  | 303-333 |
| C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>  | 1,2-Dichloropentane          | 293.2  | 6.89         | 0.19016E+02  | -0.57954E-01 | 0.56801E-04  | 293-356 |
| C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>  | 1,5-Dichloropentane          | 298.2  | 9.92         |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> O                | Cyclopentanol                | 288.2  | 18.5         | 0.10565E+03  | -0.44244E+00 | 0.48657E-03  | 258-323 |
| C <sub>5</sub> H <sub>10</sub> O                | Pentanal                     | 293.2  | 10.00        |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> O                | 2,2-Dimethylpropanal         | 293.2  | 9.051        | 0.18645E+02  | -0.32395E-01 | -0.16157E-05 | 280-333 |
| C <sub>5</sub> H <sub>10</sub> O                | 2-Pentanone                  | 293.2  | 15.45        | 0.40893E+02  | -0.10423E+00 | 0.60557E-04  | 204-353 |
| C <sub>5</sub> H <sub>10</sub> O                | 3-Pentanone                  | 293.2  | 17.00        | 0.12690E+02  | 0.95177E-01  | -0.27321E-03 | 233-353 |
| C <sub>5</sub> H <sub>10</sub> O                | 3-Methyl-2-butanone          | 293.2  | 10.37        | 0.30695E+02  | -0.10962E+00 | 0.13810E-03  | 293-328 |
| C <sub>5</sub> H <sub>10</sub> O                | Tetrahydropyran              | 293.2  | 5.66         | 0.19793E+02  | -0.76071E-01 | 0.94852E-04  | 234-333 |
| C <sub>5</sub> H <sub>10</sub> O                | 2-Methyltetrahydrofuran      | 298.2  | 6.97         |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Pentanoic acid               | 294.4  | 2.661        | 0.33491E+01  | -0.75156E-02 | 0.17820E-04  | 250-344 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Butyl formate                | 303.2  | 6.10         | 0.21532E+02  | -0.84106E-01 | 0.10952E-03  | 288-323 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Isobutyl formate             | 293.2  | 6.41         |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Propyl acetate               | 293.2  | 5.62         | 0.17677E+02  | -0.61404E-01 | 0.69196E-04  | 253-353 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Ethyl propanoate             | 293.2  | 5.76         |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Methyl butanoate             | 301.2  | 5.48         | 0.38604E+02  | -0.19171E+00 | 0.27128E-03  | 301-343 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Tetrahydrofurfuryl alcohol   | 303.2  | 13.48        |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> S | 3-Methyl sulfolane           | 298.2  | 29.4         | 0.53158E+02  | -0.93730E-01 | 0.47275E-04  | 298-398 |
| C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>   | Diethyl carbonate            | 297.2  | 2.820        |              |              |              |         |
| C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>   | Ethyl lactate                | 303.2  | 15.4         | 0.31225E+02  | -0.43531E-01 | -0.28571E-04 | 273-373 |
| C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>   | 1,2,3-Propanetriol-1-acetate | 242.2  | 38.57        | 0.10653E+03  | -0.26439E+00 | -0.62371E-04 | 215-242 |
| C <sub>5</sub> H <sub>11</sub> Br               | 2-Bromo-2-methylbutane       | 298.2  | 9.21         |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> Br               | 1-Bromopentane               | 299.2  | 6.31         | 0.20954E+02  | -0.78743E-01 | 0.98908E-04  | 183-328 |
| C <sub>5</sub> H <sub>11</sub> Br               | 3-Bromopentane               | 298.2  | 8.37         |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> Br               | 1-Bromo-3-methylbutane       | 291.5  | 6.33         | 0.27743E+02  | -0.13927E+00 | 0.22627E-03  | 123-292 |
| C <sub>5</sub> H <sub>11</sub> Cl               | 1-Chloropentane              | 293.2  | 6.654        | 0.18626E+02  | -0.54719E-01 | 0.47143E-04  | 273-323 |
| C <sub>5</sub> H <sub>11</sub> Cl               | 1-Chloro-3-methylbutane      | 292.0  | 6.10         | 0.22228E+02  | -0.93189E-01 | 0.12991E-03  | 171-297 |
| C <sub>5</sub> H <sub>11</sub> Cl               | 2-Chloro-2-methylbutane      | 222.75 | 12.31        | 0.55104E+02  | -0.29866E+00 | 0.47840E-03  | 201-223 |
| C <sub>5</sub> H <sub>11</sub> F                | 1-Fluoropentane              | 293.2  | 3.931        |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> I                | 1-Iodopentane                | 293.2  | 5.78         | 0.15753E+02  | -0.50543E-01 | 0.56401E-04  | 293-323 |
| C <sub>5</sub> H <sub>11</sub> I                | 3-Iodopentane                | 293.2  | 7.432        |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> I                | 1-Iodo-3-methylbutane        | 292.2  | 5.6          |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> I                | 2-Iodo-2-methylbutane        | 293.2  | 8.192        |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> N                | Piperidine                   | 293.0  | 4.33         | 0.82317E+01  | -0.11229E-01 | -0.71429E-05 | 293-333 |
| C <sub>5</sub> H <sub>11</sub> N                | N-Methylpyrrolidine          | 298.2  | 32.2         |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> NO               | 2,2-Dimethylpropanamide      | 298.2  | 20.13        | 0.10400E+03  | -0.46017E+00 | 0.60000E-03  | 298-328 |
| C <sub>5</sub> H <sub>11</sub> NO               | N,N-Diethylformamide         | 293.2  | 29.6         |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> NO               | 2-Pentanone oxime            | 293.2  | 3.3          |              |              |              |         |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>  | Pentyl nitrite               | 298.2  | 7.21         |              |              |              |         |
| C <sub>5</sub> H <sub>12</sub>                  | Pentane                      | 293.2  | 1.8371       |              |              |              |         |
| C <sub>5</sub> H <sub>12</sub>                  | Isopentane                   | 293.2  | 1.845        | 0.22384E+01  | -0.12985E-02 | -0.16182E-06 | 143-293 |
| C <sub>5</sub> H <sub>12</sub>                  | Neopentane                   | 296.0  | 1.769        | 0.10949E+02  | -0.63057E-01 | 0.10835E-03  | 251-296 |
| C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O | Tetramethylurea              | 293.2  | 23.10        |              |              |              |         |
| C <sub>5</sub> H <sub>12</sub> O                | 1-Pentanol                   | 298.2  | 15.13        | 0.73397E+02  | -0.28165E+00 | 0.28427E-03  | 213-513 |
| C <sub>5</sub> H <sub>12</sub> O                | 2-Pentanol                   | 298.2  | 13.71        | 0.16437E+03  | -0.86506E+00 | 0.11955E-02  | 273-323 |
| C <sub>5</sub> H <sub>12</sub> O                | 3-Pentanol                   | 298.2  | 13.35        | 0.12838E+03  | -0.60980E+00 | 0.75000E-03  | 288-318 |
| C <sub>5</sub> H <sub>12</sub> O                | 2-Methyl-1-butanol           | 298.2  | 15.63        | 0.14020E+02  | 0.13948E+00  | -0.45000E-03 | 288-318 |
| C <sub>5</sub> H <sub>12</sub> O                | 3-Methyl-1-butanol           | 293.2  | 15.63        | 0.79733E+02  | -0.31272E+00 | 0.32014E-03  | 173-513 |
| C <sub>5</sub> H <sub>12</sub> O                | 2-Methyl-2-butanol           | 298.2  | 5.78         | 0.11662E+03  | -0.69756E+00 | 0.10920E-02  | 268-318 |
| C <sub>5</sub> H <sub>12</sub> O                | 3-Methyl-2-butanol           | 298.2  | 12.1         |              |              |              |         |
| C <sub>5</sub> H <sub>12</sub> O                | 2,2-Dimethyl-1-propanol      | 333.2  | 8.35         | 0.92350E+02  | -0.41870E+00 | 0.50000E-03  | 333-373 |



| Mol. form.                                                  | Name                         | T/K   | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|-------------------------------------------------------------|------------------------------|-------|--------------|--------------|--------------|--------------|---------|
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 1,2-Pentanediol              | 296.8 | 17.31        | 0.18436E+03  | −0.10682E+01 | 0.17037E-02  | 197-297 |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 1,4-Pentanediol              | 295.7 | 26.74        | 0.13568E+03  | −0.59198E+00 | 0.75398E-03  | 193-318 |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 1,5-Pentanediol              | 293.2 | 26.2         | 0.11858E+03  | −0.45920E+00 | 0.49341E-03  | 243-343 |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 2,3-Pentanediol              | 296.9 | 17.37        | 0.95876E+02  | −0.46463E+00 | 0.67434E-03  | 238-297 |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | 2,4-Pentanediol              | 294.2 | 24.69        | 0.11914E+03  | −0.52569E+00 | 0.69607E-03  | 224-294 |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>               | Diethoxymethane              | 293.2 | 2.527        | 0.25294E+01  | 0.73988E-04  | −0.28331E-06 | 227-293 |
| C <sub>5</sub> H <sub>12</sub> O <sub>4</sub>               | Tetramethoxymethane          | 293.2 | 2.40         |              |              |              |         |
| C <sub>5</sub> H <sub>12</sub> O <sub>5</sub>               | Xylitol                      | 293.2 | 40.0         |              |              |              |         |
| C <sub>5</sub> H <sub>12</sub> S                            | 1-Pentanethiol               | 293.2 | 4.847        | 0.71131E+01  | −0.30228E-02 | −0.16414E-04 | 273-333 |
| C <sub>5</sub> H <sub>12</sub> S                            | 2-Methyl-2-butanethiol       | 293.2 | 5.087        | 0.15116E+02  | −0.50700E-01 | 0.56250E-04  | 273-333 |
| C <sub>5</sub> H <sub>12</sub> S <sub>4</sub>               | Tetrakis(methylthio)methane  | 343.2 | 2.818        |              |              |              |         |
| C <sub>5</sub> H <sub>13</sub> N                            | Pentylamine                  | 293.2 | 4.27         | 0.11274E+02  | −0.34965E-01 | 0.37706E-04  | 223-353 |
| C <sub>5</sub> H <sub>13</sub> N <sub>3</sub>               | 1,1,3,3-Tetramethylguanidine | 298.2 | 11.5         |              |              |              |         |
| C <sub>5</sub> H <sub>14</sub> OSi                          | Ethoxytrimethylsilane        | 298.2 | 3.013        |              |              |              |         |
| C <sub>6</sub> F <sub>6</sub>                               | Hexafluorobenzene            | 298.2 | 2.029        | 0.24041E+01  | −0.83086E-03 | −0.14286E-05 | 298-338 |
| C <sub>6</sub> F <sub>14</sub>                              | Perfluorohexane              | 298.2 | 1.76         |              |              |              |         |
| C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>7</sub> | 2,4,6-Trinitrophenol         | 294.2 | 4.0          |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> BrF                           | 1-Bromo-2-fluorobenzene      | 298.2 | 4.72         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> BrF                           | 1-Bromo-3-fluorobenzene      | 298.2 | 4.85         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> BrF                           | 1-Bromo-4-fluorobenzene      | 298.2 | 2.60         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> BrNO <sub>2</sub>             | 1-Bromo-3-nitrobenzene       | 328.2 | 20.2         | 0.81413E+02  | −0.27645E+00 | 0.27367E-03  | 328-413 |
| C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>               | <i>o</i> -Dibromobenzene     | 293.2 | 7.86         | −0.81849E-02 | 0.62671E-01  | −0.12222E-03 | 293-353 |
| C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>               | <i>m</i> -Dibromobenzene     | 293.2 | 4.81         | 0.93214E+01  | −0.20273E-01 | 0.16667E-04  | 293-353 |
| C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>               | <i>p</i> -Dibromobenzene     | 368.2 | 2.57         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> ClF                           | 1-Chloro-2-fluorobenzene     | 298.2 | 6.10         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> ClF                           | 1-Chloro-3-fluorobenzene     | 298.2 | 4.96         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> ClF                           | 1-Chloro-4-fluorobenzene     | 298.2 | 3.34         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>             | 1-Chloro-2-nitrobenzene      | 323.2 | 37.7         | 0.16800E+03  | −0.59708E+00 | 0.59957E-03  | 323-436 |
| C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>             | 1-Chloro-3-nitrobenzene      | 323.2 | 20.9         | 0.77193E+02  | −0.25118E+00 | 0.23798E-03  | 323-433 |
| C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>             | 1-Chloro-4-nitrobenzene      | 393.2 | 8.09         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>o</i> -Dichlorobenzene    | 293.2 | 10.12        | 0.13629E+02  | 0.10622E-02  | −0.44444E-04 | 293-353 |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>m</i> -Dichlorobenzene    | 293.2 | 5.02         | 0.77565E+01  | −0.93333E-02 | −0.26880E-14 | 293-353 |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | <i>p</i> -Dichlorobenzene    | 328.2 | 2.3943       | 0.26999E+01  | −0.35325E-03 | −0.17619E-05 | 328-363 |
| C <sub>6</sub> H <sub>4</sub> FI                            | 1-Fluoro-2-iodobenzene       | 298.2 | 8.22         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> FI                            | 1-Fluoro-4-iodobenzene       | 298.2 | 3.12         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                | <i>o</i> -Difluorobenzene    | 301.2 | 13.38        | 0.59107E+02  | −0.23611E+00 | 0.27987E-03  | 273-323 |
| C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                | <i>m</i> -Difluorobenzene    | 301.2 | 5.01         | 0.14448E+02  | −0.46982E-01 | 0.51948E-04  | 273-323 |
| C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                | <i>o</i> -Diiodobenzene      | 323.2 | 5.41         | 0.31150E+02  | −0.14428E+00 | 0.20000E-03  | 323-353 |
| C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                | <i>m</i> -Diiodobenzene      | 323.2 | 4.11         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                | <i>p</i> -Diiodobenzene      | 393.2 | 2.88         |              |              |              |         |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub>                | 2-Pyridinecarbonitrile       | 303.2 | 93.77        | 0.45596E+03  | −0.17746E+01 | 0.19105E-02  | 303-398 |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub>                | 3-Pyridinecarbonitrile       | 323.2 | 20.54        | 0.60484E+02  | −0.17280E+00 | 0.15218E-03  | 323-398 |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub>                | 4-Pyridinecarbonitrile       | 353.2 | 5.23         | 0.12533E+02  | −0.30115E-01 | 0.26674E-04  | 353-398 |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub> | 1,3-Dinitrobenzene           | 365.2 | 22.9         | 0.10406E+03  | −0.34133E+00 | 0.32609E-03  | 365-413 |
| C <sub>6</sub> H <sub>5</sub> Br                            | Bromobenzene                 | 293.2 | 5.45         | 0.94100E+01  | −0.12537E-01 | −0.31127E-05 | 234-333 |
| C <sub>6</sub> H <sub>5</sub> Cl                            | Chlorobenzene                | 293.2 | 5.6895       | 0.19471E+02  | −0.70786E-01 | 0.82466E-04  | 293-430 |
| C <sub>6</sub> H <sub>5</sub> ClO                           | <i>o</i> -Chlorophenol       | 296.2 | 7.40         | 0.29755E+02  | −0.11256E+00 | 0.12390E-03  | 296-448 |
| C <sub>6</sub> H <sub>5</sub> ClO                           | <i>m</i> -Chlorophenol       | 293.2 | 6.255        |              |              |              |         |
| C <sub>6</sub> H <sub>5</sub> ClO                           | <i>p</i> -Chlorophenol       | 314.2 | 11.18        | 0.31997E+02  | −0.94241E-01 | 0.88392E-04  | 314-453 |
| C <sub>6</sub> H <sub>5</sub> ClO <sub>2</sub> S            | Benzenesulfonyl chloride     | 323.2 | 28.90        | 0.83886E+02  | −0.23405E+00 | 0.19713E-03  | 323-473 |
| C <sub>6</sub> H <sub>5</sub> ClS                           | 4-Chlorobenzenethiol         | 338.2 | 3.59         |              |              |              |         |
| C <sub>6</sub> H <sub>5</sub> F                             | Fluorobenzene                | 293.2 | 5.465        |              |              |              |         |
| C <sub>6</sub> H <sub>5</sub> I                             | Iodobenzene                  | 293.2 | 4.59         | 0.89442E+01  | −0.20008E-01 | 0.17641E-04  | 243-323 |
| C <sub>6</sub> H <sub>5</sub> NOS                           | <i>N</i> -Sulfinylaniline    | 298.2 | 6.97         |              |              |              |         |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>               | Nitrobenzene                 | 293.0 | 35.6         | 0.11212E+03  | −0.35211E+00 | 0.31128E-03  | 279-533 |
| C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>               | <i>o</i> -Nitrophenol        | 323.2 | 16.50        | 0.33827E+02  | −0.62123E-01 | 0.26774E-04  | 323-453 |
| C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>               | <i>m</i> -Nitrophenol        | 373.2 | 35.45        | 0.18967E+03  | −0.66144E+00 | 0.66532E-03  | 373-458 |
| C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>               | <i>p</i> -Nitrophenol        | 393.2 | 42.20        | 0.22901E+03  | −0.74264E+00 | 0.68006E-03  | 393-463 |
| C <sub>6</sub> H <sub>6</sub>                               | Benzene                      | 293.2 | 2.2825       | 0.26706E+01  | −0.91648E-03 | −0.14257E-05 | 293-513 |
| C <sub>6</sub> H <sub>6</sub> BrN                           | <i>m</i> -Bromoaniline       | 293.2 | 13.0         |              |              |              |         |
| C <sub>6</sub> H <sub>6</sub> ClN                           | <i>o</i> -Chloroaniline      | 293.2 | 13.40        |              |              |              |         |
| C <sub>6</sub> H <sub>6</sub> ClN                           | <i>m</i> -Chloroaniline      | 293.2 | 13.3         |              |              |              |         |
| C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | <i>o</i> -Nitroaniline       | 353.0 | 47.3         | 0.18900E+03  | −0.56977E+00 | 0.47484E-03  | 353-468 |

| Mol. form.                                                   | Name                              | T/K   | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|--------------------------------------------------------------|-----------------------------------|-------|--------------|--------------|--------------|--------------|---------|
| C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>  | <i>m</i> -Nitroaniline            | 398.0 | 35.6         | 0.20352E+03  | -0.66582E+00 | 0.61310E-03  | 398-468 |
| C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>  | <i>p</i> -Nitroaniline            | 428.0 | 78.5         | 0.48673E+03  | -0.15040E+01 | 0.12857E-02  | 428-468 |
| C <sub>6</sub> H <sub>6</sub> O                              | Phenol                            | 303.2 | 12.40        | 0.63391E+02  | -0.24988E+00 | 0.26930E-03  | 303-433 |
| C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                 | Pyrocatechol                      | 388.2 | 17.57        | 0.74930E+02  | -0.22142E+00 | 0.18919E-03  | 388-463 |
| C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                 | Resorcinol                        | 393.2 | 13.55        | 0.30252E+02  | -0.56443E-01 | 0.35578E-04  | 393-463 |
| C <sub>6</sub> H <sub>6</sub> S                              | Benzenethiol                      | 303.2 | 4.26         | 0.57155E+01  | -0.70336E-02 | 0.73617E-05  | 303-358 |
| C <sub>6</sub> H <sub>7</sub> N                              | Aniline                           | 293.2 | 7.06         | 0.89534E+01  | 0.38990E-02  | -0.36310E-04 | 293-413 |
| C <sub>6</sub> H <sub>7</sub> N                              | 2-Methylpyridine                  | 293.2 | 10.18        | 0.34560E+02  | -0.11980E+00 | 0.12500E-03  | 293-333 |
| C <sub>6</sub> H <sub>7</sub> N                              | 3-Methylpyridine                  | 303.0 | 11.10        | 0.19643E+03  | -0.11167E+01 | 0.16667E-02  | 303-333 |
| C <sub>6</sub> H <sub>7</sub> N                              | 4-Methylpyridine                  | 293.0 | 12.2         | 0.33765E+02  | -0.10113E+00 | 0.93860E-04  | 274-333 |
| C <sub>6</sub> H <sub>7</sub> NO                             | 2-Methylpyridine-1-oxide          | 323.2 | 36.4         | 0.11705E+03  | -0.35301E+00 | 0.32000E-03  | 323-398 |
| C <sub>6</sub> H <sub>7</sub> NO                             | 3-Methylpyridine-1-oxide          | 318.2 | 28.26        | 0.59851E+02  | -0.12682E+00 | 0.86622E-04  | 318-398 |
| C <sub>6</sub> H <sub>8</sub>                                | 1,3-Cyclohexadiene                | 184.2 | 2.68         |              |              |              |         |
| C <sub>6</sub> H <sub>8</sub>                                | 1,4-Cyclohexadiene                | 296.0 | 2.211        | 0.27459E+01  | -0.16975E-02 | -0.36461E-06 | 232-356 |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | Phenylhydrazine                   | 293.2 | 7.15         |              |              |              |         |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 2,5-Dimethylpyrazine              | 293.2 | 2.436        |              |              |              |         |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                 | 2,6-Dimethylpyrazine              | 308.2 | 2.653        |              |              |              |         |
| C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                 | 1,4-Cyclohexanedione              | 351.2 | 4.40         |              |              |              |         |
| C <sub>6</sub> H <sub>9</sub> Cl <sub>3</sub> O <sub>2</sub> | Butyl trichloroacetate            | 293.2 | 7.480        |              |              |              |         |
| C <sub>6</sub> H <sub>9</sub> Cl <sub>3</sub> O <sub>2</sub> | Isobutyl trichloroacetate         | 293.2 | 7.667        |              |              |              |         |
| C <sub>6</sub> H <sub>9</sub> N                              | Cyclopentanecarbonitrile          | 293.2 | 22.68        | 0.69830E+02  | -0.25303E+00 | 0.31491E-03  | 201-293 |
| C <sub>6</sub> H <sub>10</sub>                               | 1,5-Hexadiene                     | 294.0 | 2.125        | 0.30014E+01  | -0.28668E-02 | -0.31026E-06 | 151-294 |
| C <sub>6</sub> H <sub>10</sub>                               | <i>cis,cis</i> -2,4-Hexadiene     | 297.0 | 2.163        | 0.27284E+01  | -0.17178E-02 | -0.62926E-06 | 234-351 |
| C <sub>6</sub> H <sub>10</sub>                               | <i>trans,trans</i> -2,4-Hexadiene | 297.0 | 2.123        | 0.26774E+01  | -0.16977E-02 | -0.55637E-06 | 232-353 |
| C <sub>6</sub> H <sub>10</sub>                               | 2-Methyl-1,3-pentadiene*          | 298.2 | 2.422        |              |              |              |         |
| C <sub>6</sub> H <sub>10</sub>                               | 3-Methyl-1,3-pentadiene           | 298.2 | 2.426        |              |              |              |         |
| C <sub>6</sub> H <sub>10</sub>                               | 4-Methyl-1,3-pentadiene           | 293.2 | 2.599        | 0.51328E+01  | -0.12774E-01 | 0.14215E-04  | 198-323 |
| C <sub>6</sub> H <sub>10</sub>                               | 2,3-Dimethyl-1,3-butadiene        | 293.2 | 2.102        | 0.26258E+01  | -0.17990E-02 | 0.12035E-06  | 223-323 |
| C <sub>6</sub> H <sub>10</sub>                               | 1-Hexyne                          | 296.0 | 2.621        | 0.58591E+01  | -0.17099E-01 | 0.20856E-04  | 184-296 |
| C <sub>6</sub> H <sub>10</sub>                               | Cyclohexene                       | 293.2 | 2.2176       | 0.30598E+01  | -0.39841E-02 | 0.37554E-05  | 141-313 |
| C <sub>6</sub> H <sub>10</sub> O                             | Butoxyacetylene                   | 298.2 | 6.62         |              |              |              |         |
| C <sub>6</sub> H <sub>10</sub> O                             | Cyclohexanone                     | 293.0 | 16.1         | 0.41577E+02  | -0.11463E+00 | 0.92454E-04  | 253-423 |
| C <sub>6</sub> H <sub>10</sub> O                             | Mesityl oxide                     | 273.2 | 15.6         |              |              |              |         |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                | Ethyl 2-butenolate                | 293.2 | 5.4          |              |              |              |         |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                | Ethyl methacrylate                | 303.2 | 5.68         | 0.40962E+02  | -0.20520E+00 | 0.29286E-03  | 303-343 |
| C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                | Ethyl acetoacetate                | 293.2 | 14.0         |              |              |              |         |
| C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                | Propanoic anhydride               | 293.2 | 18.30        |              |              |              |         |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                | Monomethyl glutarate              | 293.2 | 8.37         | 0.16779E+02  | -0.39839E-01 | 0.38095E-04  | 293-363 |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                | Diethyl oxalate                   | 293.2 | 8.266        | 0.21938E+02  | -0.66226E-01 | 0.66800E-04  | 293-368 |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                | Dimethyl succinate                | 293.2 | 7.19         | 0.13551E+02  | -0.23109E-01 | 0.55440E-05  | 293-433 |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                | Ethylene glycol diacetate         | 290.2 | 7.7          | 0.25093E+02  | -0.95171E-01 | 0.12224E-03  | 223-290 |
| C <sub>6</sub> H <sub>11</sub> Br                            | Bromocyclohexane                  | 303.2 | 8.0026       |              |              |              |         |
| C <sub>6</sub> H <sub>11</sub> BrO <sub>2</sub>              | Ethyl 2-bromobutanoate            | 303.2 | 8.57         | 0.49005E+02  | -0.23193E+00 | 0.32500E-03  | 303-333 |
| C <sub>6</sub> H <sub>11</sub> BrO <sub>2</sub>              | Ethyl 2-bromo-2-methylpropanoate  | 303.2 | 8.55         | 0.77044E+02  | -0.40784E+00 | 0.60000E-03  | 303-333 |
| C <sub>6</sub> H <sub>11</sub> Cl                            | Chlorocyclohexane                 | 303.2 | 7.9505       |              |              |              |         |
| C <sub>6</sub> H <sub>11</sub> N                             | Hexanenitrile                     | 298.2 | 17.26        |              |              |              |         |
| C <sub>6</sub> H <sub>11</sub> N                             | 4-Methylpentanenitrile            | 295.2 | 17.5         |              |              |              |         |
| C <sub>6</sub> H <sub>11</sub> NO                            | Cyclohexanone oxime               | 362.2 | 3.04         |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub>                               | 1-Hexene                          | 294.0 | 2.077        | 0.31476E+01  | -0.50003E-02 | 0.46673E-05  | 149-294 |
| C <sub>6</sub> H <sub>12</sub>                               | <i>trans</i> -2-Hexene            | 295.0 | 1.978        | 0.24338E+01  | -0.11323E-02 | -0.13720E-05 | 157-295 |
| C <sub>6</sub> H <sub>12</sub>                               | <i>cis</i> -3-Hexene              | 296.0 | 2.069        | 0.30691E+01  | -0.45458E-02 | 0.39898E-05  | 155-296 |
| C <sub>6</sub> H <sub>12</sub>                               | <i>trans</i> -3-Hexene            | 293.2 | 1.954        |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub>                               | Cyclohexane                       | 293.2 | 2.0243       | 0.24293E+01  | -0.12095E-02 | -0.58741E-06 | 283-333 |
| C <sub>6</sub> H <sub>12</sub>                               | Methylcyclopentane                | 293.2 | 1.9853       | 0.21587E+01  | -0.22450E-03 | -0.12500E-05 | 293-323 |
| C <sub>6</sub> H <sub>12</sub>                               | Ethylcyclobutane                  | 293.2 | 1.965        |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub> Br <sub>2</sub>               | 1,6-Dibromohexane                 | 298.2 | 8.52         | -0.55185E+01 | 0.11746E+00  | -0.23658E-03 | 274-328 |
| C <sub>6</sub> H <sub>12</sub> Br <sub>2</sub>               | 3,4-Dibromohexane                 | 298.2 | 6.732        |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub> Cl <sub>2</sub>               | 1,6-Dichlorohexane                | 308.2 | 8.60         | 0.11277E+02  | 0.67200E-02  | -0.50000E-04 | 308-338 |
| C <sub>6</sub> H <sub>12</sub> O                             | 1-Methylcyclopentanol             | 310.1 | 7.11         | 0.75444E+02  | -0.36617E+00 | 0.47021E-03  | 310-333 |
| C <sub>6</sub> H <sub>12</sub> O                             | Isobutyl vinyl ether              | 293.2 | 3.34         | 0.48060E+01  | -0.50000E-02 | -0.41495E-14 | 293-323 |
| C <sub>6</sub> H <sub>12</sub> O                             | 2-Hexanone                        | 293.2 | 14.56        | 0.70378E+02  | -0.29385E+00 | 0.35289E-03  | 243-293 |
| C <sub>6</sub> H <sub>12</sub> O                             | 4-Methyl-2-pentanone              | 293.2 | 13.11        | 0.36341E+02  | -0.97119E-01 | 0.61896E-04  | 204-373 |
| C <sub>6</sub> H <sub>12</sub> O                             | 3,3-Dimethyl-2-butanone           | 293.2 | 12.73        | 0.66857E+02  | -0.28552E+00 | 0.34422E-03  | 243-293 |

| Mol. form.                                                    | Name                                             | T/K   | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|---------------------------------------------------------------|--------------------------------------------------|-------|--------------|--------------|--------------|--------------|---------|
| C <sub>6</sub> H <sub>12</sub> O                              | Cyclohexanol                                     | 293.2 | 16.40        | 0.10173E+03  | -0.43072E+00 | 0.47926E-03  | 293-423 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Hexanoic acid                                    | 298.2 | 2.600        | 0.21730E+01  | 0.14840E-02  | -0.16526E-06 | 298-433 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 2-Ethylbutanoic acid                             | 296.2 | 2.72         |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | <i>tert</i> -Butylacetic acid                    | 296.2 | 2.85         |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Pentyl formate                                   | 292.2 | 5.7          |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Isopentyl formate                                | 288.2 | 5.44         | 0.29257E+02  | -0.14028E+00 | 0.20000E-03  | 288-323 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Butyl acetate                                    | 293.2 | 5.07         | 0.13825E+02  | -0.43994E-01 | 0.48214E-04  | 253-353 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | <i>sec</i> -Butyl acetate                        | 293.2 | 5.135        | 0.12427E+02  | -0.32035E-01 | 0.24286E-04  | 273-323 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | <i>tert</i> -Butyl acetate                       | 293.2 | 5.672        | 0.55435E+02  | -0.30494E+00 | 0.46107E-03  | 273-323 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Isobutyl acetate                                 | 293.2 | 5.068        | 0.14323E+02  | -0.46048E-01 | 0.49286E-04  | 273-323 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Propyl propanoate                                | 293.2 | 5.249        |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Ethyl butanoate                                  | 301.2 | 5.18         | 0.48698E+02  | -0.25660E+00 | 0.37237E-03  | 301-343 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Methyl pentanoate                                | 293.2 | 4.992        |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | Diacetone alcohol                                | 298.2 | 18.2         |              |              |              |         |
| C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                 | Ethylene glycol monoethyl ether acetate          | 303.2 | 7.567        | 0.23290E+02  | -0.71566E-01 | 0.65000E-04  | 303-323 |
| C <sub>6</sub> H <sub>12</sub> S                              | Cyclohexanethiol                                 | 298.2 | 5.420        |              |              |              |         |
| C <sub>6</sub> H <sub>13</sub> Br                             | 1-Bromohexane                                    | 298.2 | 5.82         | 0.15233E+02  | -0.44385E-01 | 0.43039E-04  | 274-328 |
| C <sub>6</sub> H <sub>13</sub> Cl                             | 1-Chlorohexane                                   | 293.2 | 6.104        | 0.15994E+02  | -0.43647E-01 | 0.33393E-04  | 273-323 |
| C <sub>6</sub> H <sub>13</sub> ClO                            | 6-Chloro-1-hexanol                               | 242.2 | 21.6         | -0.73364E+01 | 0.46377E+00  | -0.14202E-02 | 195-242 |
| C <sub>6</sub> H <sub>13</sub> I                              | 1-Iodohehexane                                   | 293.3 | 5.35         | 0.16685E+02  | -0.61309E-01 | 0.77262E-04  | 293-323 |
| C <sub>6</sub> H <sub>13</sub> N                              | Cyclohexylamine                                  | 293.2 | 4.547        |              |              |              |         |
| C <sub>6</sub> H <sub>13</sub> NO                             | <i>N</i> -Propylpropanamide                      | 298.2 | 118.1        | 0.58846E+03  | -0.22012E+01 | 0.20870E-02  | 298-328 |
| C <sub>6</sub> H <sub>13</sub> NO                             | <i>N</i> -Butylacetamide**                       | 293.2 | 104.0        | 0.70739E+03  | -0.37369E+01 | 0.71585E-02  | 253-493 |
| C <sub>6</sub> H <sub>13</sub> NO                             | <i>N,N</i> -Diethylacetamide                     | 293.2 | 32.1         |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub>                                | Hexane                                           | 293.2 | 1.8865       | 0.19768E+01  | 0.70933E-03  | -0.34470E-05 | 293-473 |
| C <sub>6</sub> H <sub>14</sub>                                | 2-Methylpentane                                  | 293.2 | 1.886        | 0.20745E+01  | 0.50871E-03  | -0.39286E-05 | 273-323 |
| C <sub>6</sub> H <sub>14</sub>                                | 3-Methylpentane                                  | 293.2 | 1.886        | 0.24739E+01  | -0.23190E-02 | 0.10714E-05  | 273-323 |
| C <sub>6</sub> H <sub>14</sub>                                | 2,2-Dimethylbutane                               | 293.2 | 1.869        | 0.22740E+01  | -0.96229E-03 | -0.14286E-05 | 273-313 |
| C <sub>6</sub> H <sub>14</sub>                                | 2,3-Dimethylbutane                               | 293.2 | 1.889        | 0.24305E+01  | -0.20081E-02 | 0.53571E-06  | 273-323 |
| C <sub>6</sub> H <sub>14</sub> O                              | 1-Hexanol                                        | 293.2 | 13.03        | 0.62744E+02  | -0.24214E+00 | 0.24704E-03  | 233-513 |
| C <sub>6</sub> H <sub>14</sub> O                              | 2-Hexanol                                        | 298.2 | 11.06        |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub> O                              | 3-Hexanol                                        | 298.2 | 9.66         |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub> O                              | 3-Methyl-1-pentanol                              | 298.2 | 15.2         |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub> O                              | 3-Methyl-3-pentanol                              | 293.2 | 4.322        |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub> O                              | 2-Ethyl-1-butanol                                | 362.2 | 6.19         |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub> O                              | 2,2-Dimethyl-1-butanol                           | 293.2 | 10.5         | 0.14054E+03  | -0.72925E+00 | 0.97821E-03  | 243-393 |
| C <sub>6</sub> H <sub>14</sub> O                              | Dipropyl ether                                   | 297.0 | 3.38         | 0.14600E+02  | -0.72670E-01 | 0.11742E-03  | 161-297 |
| C <sub>6</sub> H <sub>14</sub> O                              | Diisopropyl ether                                | 303.2 | 3.805        |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub> OS                             | Dipropyl sulfoxide                               | 303.2 | 30.37        | 0.84868E+02  | -0.23486E+00 | 0.18198E-03  | 303-373 |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | 2-Methyl-2,4-pentanediol                         | 293.2 | 25.86        | 0.14531E+03  | -0.65285E+00 | 0.83503E-03  | 203-333 |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                 | Ethylene glycol diethyl ether                    | 293.2 | 3.90         | 0.99099E+01  | -0.33403E-01 | 0.44048E-04  | 223-303 |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> S               | Dipropyl sulfone                                 | 303.2 | 32.62        | 0.70195E+02  | -0.15008E+00 | 0.86506E-04  | 303-398 |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                 | 1,2,6-Hexanetriol                                | 285.3 | 31.5         | 0.26127E+03  | -0.14552E+01 | 0.22765E-02  | 261-285 |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>                 | Diethylene glycol dimethyl ether                 | 298.2 | 7.23         | 0.28291E+02  | -0.11236E+00 | 0.14000E-03  | 298-333 |
| C <sub>6</sub> H <sub>14</sub> O <sub>4</sub>                 | Triethylene glycol                               | 293.2 | 23.69        | 0.91845E+02  | -0.33827E+00 | 0.36062E-03  | 253-333 |
| C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                 | <i>D</i> -Glucitol                               | 353.2 | 35.5         |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                 | <i>D</i> -Mannitol                               | 443.2 | 24.6         |              |              |              |         |
| C <sub>6</sub> H <sub>14</sub> S                              | 1-Hexanethiol                                    | 293.2 | 4.436        | 0.11774E+02  | -0.37298E-01 | 0.41875E-04  | 273-333 |
| C <sub>6</sub> H <sub>15</sub> B                              | Triethylborane                                   | 293.2 | 1.974        |              |              |              |         |
| C <sub>6</sub> H <sub>15</sub> N                              | Hexylamine                                       | 293.2 | 4.08         | 0.80244E+01  | -0.16627E-01 | 0.10874E-04  | 253-373 |
| C <sub>6</sub> H <sub>15</sub> N                              | Dipropylamine                                    | 293.2 | 2.923        | 0.11376E+02  | -0.49796E-01 | 0.71792E-04  | 243-323 |
| C <sub>6</sub> H <sub>15</sub> N                              | Triethylamine                                    | 293.2 | 2.418        | 0.29205E+01  | -0.14007E-02 | -0.13469E-05 | 233-323 |
| C <sub>6</sub> H <sub>15</sub> OP                             | Triethylphosphine oxide                          | 323.2 | 35.5         |              |              |              |         |
| C <sub>6</sub> H <sub>15</sub> O <sub>4</sub> P               | Triethyl phosphate                               | 298.2 | 13.20        | 0.61230E+02  | -0.26047E+00 | 0.33333E-03  | 298-333 |
| C <sub>6</sub> H <sub>15</sub> PS                             | Triethylphosphine sulfide                        | 371.2 | 39.0         |              |              |              |         |
| C <sub>6</sub> H <sub>16</sub> O <sub>2</sub> Si              | Diethoxydimethylsilane                           | 298.2 | 3.216        |              |              |              |         |
| C <sub>6</sub> H <sub>16</sub> Si                             | Triethylsilane                                   | 293.2 | 2.323        |              |              |              |         |
| C <sub>6</sub> H <sub>18</sub> N <sub>3</sub> OP              | Hexamethylphosphoric triamide                    | 293.2 | 31.3         | 0.95666E+02  | -0.29769E+00 | 0.26407E-03  | 283-363 |
| C <sub>6</sub> H <sub>18</sub> N <sub>4</sub>                 | <i>N,N'</i> -Bis(2-aminoethyl)-1,2-ethanediamine | 293.2 | 10.76        | 0.50699E+02  | -0.21730E+00 | 0.27582E-03  | 213-333 |
| C <sub>6</sub> H <sub>18</sub> OSi <sub>2</sub>               | Hexamethyldisiloxane                             | 293.2 | 2.179        | 0.34537E+01  | -0.61530E-02 | 0.61544E-05  | 213-313 |
| C <sub>6</sub> H <sub>18</sub> O <sub>3</sub> Si <sub>3</sub> | Hexamethylcyclotrisiloxane                       | 343.2 | 2.139        |              |              |              |         |

| Mol. form.                                       | Name                               | T/K    | $\epsilon_r$ | <i>a</i>    | <i>b</i>     | <i>c</i>     | Range/K |
|--------------------------------------------------|------------------------------------|--------|--------------|-------------|--------------|--------------|---------|
| C <sub>6</sub> H <sub>19</sub> NSi <sub>2</sub>  | Hexamethyldisilazane               | 294.2  | 2.273        | 0.23358E+01 | 0.16127E-02  | -0.62078E-05 | 294-333 |
| C <sub>7</sub> F <sub>14</sub>                   | Perfluoromethylcyclohexane         | 298.2  | 1.82         |             |              |              |         |
| C <sub>7</sub> F <sub>16</sub>                   | Perfluoroheptane                   | 289.2  | 1.847        |             |              |              |         |
| C <sub>7</sub> H <sub>3</sub> Cl <sub>5</sub>    | 2,3,4,5,6-Pentachlorotoluene       | 293.2  | 4.8          |             |              |              |         |
| C <sub>7</sub> H <sub>4</sub> ClNO               | 4-Chlorophenyl isocyanate          | 288.2  | 3.177        | 0.40896E+01 | -0.31667E-02 |              | 288-348 |
| C <sub>7</sub> H <sub>5</sub> BrO                | Benzoyl bromide                    | 293.2  | 21.33        | 0.84231E+02 | -0.31089E+00 | 0.32857E-03  | 283-313 |
| C <sub>7</sub> H <sub>5</sub> ClO                | Benzoyl chloride                   | 293.2  | 23.0         |             |              |              |         |
| C <sub>7</sub> H <sub>5</sub> FO                 | Benzoyl fluoride                   | 293.2  | 22.7         |             |              |              |         |
| C <sub>7</sub> H <sub>5</sub> F <sub>3</sub>     | (Trifluoromethyl)benzene           | 298.2  | 9.22         |             |              |              |         |
| C <sub>7</sub> H <sub>5</sub> N                  | Benzonitrile                       | 293.2  | 25.9         | 0.57605E+02 | -0.13354E+00 | 0.87767E-04  | 273-453 |
| C <sub>7</sub> H <sub>5</sub> NO                 | Phenyl isocyanate                  | 293.2  | 8.940        | 0.17541E+02 | -0.29790E-01 | 0.15476E-05  | 293-353 |
| C <sub>7</sub> H <sub>6</sub> ClNO <sub>2</sub>  | 4-Chloro-3-nitrotoluene            | 301.2  | 28.07        |             |              |              |         |
| C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>    | 2,4-Dichlorotoluene                | 301.2  | 5.68         |             |              |              |         |
| C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>    | 2,6-Dichlorotoluene                | 301.2  | 3.36         |             |              |              |         |
| C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>    | 3,4-Dichlorotoluene                | 301.2  | 9.39         |             |              |              |         |
| C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>    | (Dichloromethyl)benzene            | 293.2  | 6.9          |             |              |              |         |
| C <sub>7</sub> H <sub>6</sub> O                  | Benzaldehyde                       | 293.2  | 17.85        | 0.35046E+02 | -0.61271E-01 | 0.16222E-04  | 301-346 |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>     | Salicylaldehyde                    | 293.2  | 18.35        | 0.51315E+02 | -0.15379E+00 | 0.14111E-03  | 289-453 |
| C <sub>7</sub> H <sub>7</sub> Br                 | <i>o</i> -Bromotoluene             | 293.2  | 4.641        | 0.10229E+02 | -0.25050E-01 | 0.20357E-04  | 273-323 |
| C <sub>7</sub> H <sub>7</sub> Br                 | <i>m</i> -Bromotoluene             | 293.2  | 5.566        | 0.11522E+02 | -0.24946E-01 | 0.15714E-04  | 273-323 |
| C <sub>7</sub> H <sub>7</sub> Br                 | <i>p</i> -Bromotoluene             | 293.2  | 5.503        | 0.10014E+02 | -0.13918E-01 | -0.50000E-05 | 273-293 |
| C <sub>7</sub> H <sub>7</sub> Br                 | (Bromomethyl)benzene               | 293.2  | 6.658        | 0.18482E+02 | -0.57207E-01 | 0.57321E-04  | 273-323 |
| C <sub>7</sub> H <sub>7</sub> BrO                | <i>o</i> -Bromoanisole             | 303.2  | 8.96         | 0.12023E+02 | -0.59116E-02 | -0.13787E-04 | 303-358 |
| C <sub>7</sub> H <sub>7</sub> BrO                | <i>p</i> -Bromoanisole             | 303.2  | 7.40         | 0.74367E+01 | 0.12648E-01  | -0.42128E-04 | 303-358 |
| C <sub>7</sub> H <sub>7</sub> Cl                 | <i>o</i> -Chlorotoluene            | 293.2  | 4.721        | 0.11507E+02 | -0.31148E-01 | 0.27143E-04  | 273-323 |
| C <sub>7</sub> H <sub>7</sub> Cl                 | <i>m</i> -Chlorotoluene            | 293.2  | 5.763        | 0.13921E+02 | -0.37186E-01 | 0.31786E-04  | 273-323 |
| C <sub>7</sub> H <sub>7</sub> Cl                 | <i>p</i> -Chlorotoluene            | 293.2  | 6.25         | 0.20265E+01 | 0.40060E-01  | -0.87500E-04 | 293-333 |
| C <sub>7</sub> H <sub>7</sub> Cl                 | (Chloromethyl)benzene              | 293.2  | 6.854        | 0.17108E+02 | -0.45285E-01 | 0.35000E-04  | 273-323 |
| C <sub>7</sub> H <sub>7</sub> ClO                | <i>p</i> -Chloroanisole            | 293.2  | 7.84         | 0.64019E+01 | 0.30560E-01  | -0.87500E-04 | 293-333 |
| C <sub>7</sub> H <sub>7</sub> ClO <sub>2</sub> S | <i>p</i> -Toluenesulfonyl chloride | 343.2  | 22.6         |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> ClO <sub>3</sub> S | 4-Methoxybenzenesulfonyl chloride  | 314.2  | 27.2         |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> F                  | <i>o</i> -Fluorotoluene            | 298.2  | 4.23         |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> F                  | <i>m</i> -Fluorotoluene            | 298.2  | 5.41         |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> F                  | <i>p</i> -Fluorotoluene            | 298.2  | 5.88         |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> I                  | <i>p</i> -Iodotoluene              | 308.2  | 4.4          |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> N                  | 2-Vinylpyridine                    | 293.2  | 9.126        |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> N                  | 4-Vinylpyridine                    | 293.2  | 10.50        |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>    | Benzyl nitrite                     | 298.2  | 7.78         |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>    | <i>o</i> -Nitrotoluene             | 293.0  | 26.26        | 0.10420E+03 | -0.41726E+00 | 0.51607E-03  | 273-323 |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>    | <i>m</i> -Nitrotoluene             | 303.2  | 24.95        | 0.62492E+02 | -0.16235E+00 | 0.12844E-03  | 303-403 |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>    | <i>p</i> -Nitrotoluene             | 331.2  | 22.2         |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub> S  | 4-Nitrothioanisole                 | 346.0  | 21.7         |             |              |              |         |
| C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>    | 2-Nitroanisole                     | 293.2  | 45.75        | 0.16684E+03 | -0.58196E+00 | 0.57382E-03  | 293-423 |
| C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>    | 3-Nitroanisole                     | 318.2  | 25.7         | 0.65402E+02 | -0.16460E+00 | 0.12560E-03  | 318-443 |
| C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>    | 4-Nitroanisole                     | 338.2  | 26.95        | 0.59811E+02 | -0.10955E+00 | 0.36042E-04  | 338-443 |
| C <sub>7</sub> H <sub>8</sub>                    | Toluene                            | 296.35 | 2.379        | 0.32584E+01 | -0.34410E-02 | 0.15937E-05  | 207-316 |
| C <sub>7</sub> H <sub>8</sub> O                  | <i>o</i> -Cresol                   | 298.2  | 6.76         | 0.21633E+02 | -0.71069E-01 | 0.70590E-04  | 298-453 |
| C <sub>7</sub> H <sub>8</sub> O                  | <i>m</i> -Cresol                   | 298.2  | 12.44        | 0.81716E+02 | -0.35039E+00 | 0.39878E-03  | 274-463 |
| C <sub>7</sub> H <sub>8</sub> O                  | <i>p</i> -Cresol                   | 298.2  | 13.05        | 0.70253E+02 | -0.28870E+00 | 0.31979E-03  | 298-453 |
| C <sub>7</sub> H <sub>8</sub> O                  | Benzyl alcohol                     | 303.2  | 11.916       | 0.13661E+03 | -0.72127E+00 | 0.10225E-02  | 303-333 |
| C <sub>7</sub> H <sub>8</sub> O                  | Anisole                            | 294.2  | 4.30         | 0.10887E+02 | -0.32372E-01 | 0.33629E-04  | 294-413 |
| C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>     | 2-Methoxyphenol                    | 298.2  | 11.95        | 0.31751E+02 | -0.88173E-01 | 0.72953E-04  | 291-448 |
| C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>     | 3-Methoxyphenol                    | 298.2  | 11.59        | 0.37279E+02 | -0.12113E+00 | 0.11698E-03  | 298-433 |
| C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>     | 4-Methoxyphenol                    | 333.7  | 11.05        | 0.39483E+02 | -0.12142E+00 | 0.10841E-03  | 334-453 |
| C <sub>7</sub> H <sub>8</sub> O <sub>2</sub> S   | Ethyl thiophene-2-carboxylate      | 293.2  | 6.18         |             |              |              |         |
| C <sub>7</sub> H <sub>8</sub> O <sub>2</sub> S   | Methyl phenyl sulfone              | 373.2  | 37.9         |             |              |              |         |
| C <sub>7</sub> H <sub>8</sub> S                  | Benzenemethanethiol                | 298.2  | 4.705        | 0.16628E+02 | -0.68276E-01 | 0.94636E-04  | 298-358 |
| C <sub>7</sub> H <sub>8</sub> S                  | 4-Methylbenzenethiol               | 323.2  | 4.74         | 0.87052E+01 | -0.15347E-01 | 0.95238E-05  | 323-358 |
| C <sub>7</sub> H <sub>8</sub> S                  | (Methylthio)benzene                | 303.2  | 4.88         | 0.21841E+02 | -0.97630E-01 | 0.13750E-03  | 303-343 |
| C <sub>7</sub> H <sub>9</sub> N                  | Benzylamine                        | 293.2  | 5.18         |             |              |              |         |
| C <sub>7</sub> H <sub>9</sub> N                  | <i>o</i> -Methylaniline            | 298.2  | 6.138        | 0.10988E+02 | -0.18976E-01 | 0.91958E-05  | 298-398 |
| C <sub>7</sub> H <sub>9</sub> N                  | <i>m</i> -Methylaniline            | 298.2  | 5.816        | 0.13477E+02 | -0.35551E-01 | 0.33135E-04  | 298-398 |
| C <sub>7</sub> H <sub>9</sub> N                  | <i>p</i> -Methylaniline            | 333.2  | 5.058        | 0.78897E+01 | -0.10196E-01 | 0.51190E-05  | 333-403 |

| Mol. form.                                                    | Name                             | T/K   | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|---------------------------------------------------------------|----------------------------------|-------|--------------|--------------|--------------|--------------|---------|
| C <sub>7</sub> H <sub>9</sub> N                               | <i>N</i> -Methylaniline          | 293.2 | 5.96         |              |              |              |         |
| C <sub>7</sub> H <sub>9</sub> N                               | 2-Ethylpyridine                  | 293.2 | 8.33         | 0.36397E+02  | −0.15070E+00 | 0.18750E-03  | 293-333 |
| C <sub>7</sub> H <sub>9</sub> N                               | 4-Ethylpyridine                  | 293.2 | 10.98        | −0.73831E+01 | 0.14326E+00  | −0.27500E-03 | 293-333 |
| C <sub>7</sub> H <sub>9</sub> N                               | 2,4-Dimethylpyridine             | 293.2 | 9.60         | 0.25895E+02  | −0.73900E-01 | 0.62500E-04  | 293-333 |
| C <sub>7</sub> H <sub>9</sub> N                               | 2,6-Dimethylpyridine             | 293.2 | 7.33         | 0.17714E+02  | −0.39080E-01 | 0.12500E-04  | 293-333 |
| C <sub>7</sub> H <sub>9</sub> NO                              | 2,6-Dimethylpyridine-1-oxide     | 298.2 | 46.11        | 0.22765E+03  | −0.90760E+00 | 0.10011E-02  | 298-398 |
| C <sub>7</sub> H <sub>9</sub> NO                              | <i>o</i> -Methoxyaniline         | 303.2 | 5.230        | 0.79911E+01  | −0.92183E-02 | 0.37879E-06  | 303-393 |
| C <sub>7</sub> H <sub>9</sub> NO                              | <i>m</i> -Methoxyaniline         | 298.2 | 8.76         | 0.28179E+02  | −0.97840E-01 | 0.11027E-03  | 289-393 |
| C <sub>7</sub> H <sub>9</sub> NO                              | <i>p</i> -Methoxyaniline         | 333.2 | 7.85         | 0.30149E+02  | −0.10523E+00 | 0.11467E-03  | 333-453 |
| C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>                 | 1-Methyl-1-phenylhydrazine       | 292.2 | 7.3          |              |              |              |         |
| C <sub>7</sub> H <sub>11</sub> Cl <sub>3</sub> O <sub>2</sub> | Isopentyl trichloroacetate       | 293.2 | 7.287        |              |              |              |         |
| C <sub>7</sub> H <sub>12</sub>                                | 1,6-Heptadiene                   | 293.0 | 2.161        | 0.30815E+01  | −0.36095E-02 | 0.16354E-05  | 184-293 |
| C <sub>7</sub> H <sub>12</sub>                                | Cycloheptene                     | 295.0 | 2.265        | 0.32309E+01  | −0.42373E-02 | 0.32572E-05  | 227-363 |
| C <sub>7</sub> H <sub>12</sub> O                              | Cycloheptanone                   | 298.2 | 13.16        | 0.17511E+03  | −0.11221E+01 | 0.19417E-02  | 258-298 |
| C <sub>7</sub> H <sub>12</sub> O                              | 2-Methylcyclohexanone            | 293.2 | 14.0         |              |              |              |         |
| C <sub>7</sub> H <sub>12</sub> O                              | 3-Methylcyclohexanone            | 293.2 | 12.4         |              |              |              |         |
| C <sub>7</sub> H <sub>12</sub> O                              | 4-Methylcyclohexanone            | 293.2 | 12.35        |              |              |              |         |
| C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                 | Cyclohexanecarboxylic acid       | 304.2 | 2.67         |              |              |              |         |
| C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                 | Cyclohexyl formate               | 293.2 | 6.47         |              |              |              |         |
| C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                 | Butyl acrylate                   | 301.2 | 5.25         | 0.38296E+02  | −0.19109E+00 | 0.27006E-03  | 301-343 |
| C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | Monomethyl adipate               | 293.2 | 6.69         | 0.11962E+02  | −0.23973E-01 | 0.20608E-04  | 293-433 |
| C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | Diethyl malonate                 | 304.2 | 7.550        | 0.14809E+02  | −0.31207E-01 | 0.24066E-04  | 304-393 |
| C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                 | Dimethyl glutarate               | 293.2 | 7.87         | 0.20697E+02  | −0.57794E-01 | 0.48405E-04  | 293-433 |
| C <sub>7</sub> H <sub>12</sub> O <sub>5</sub>                 | 1,2,3-Propanetriol-1,3-diacetate | 288.2 | 9.80         | 0.28321E+02  | −0.89073E-01 | 0.86891E-04  | 258-374 |
| C <sub>7</sub> H <sub>14</sub>                                | 1-Heptene                        | 293.2 | 2.092        | 0.21755E+01  | 0.13896E-02  | −0.57049E-05 | 273-323 |
| C <sub>7</sub> H <sub>14</sub>                                | 2-Methyl-2-hexene                | 293.2 | 2.962        |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub>                                | 3-Ethyl-2-pentene                | 293.2 | 2.051        |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub>                                | Cycloheptane                     | 293.2 | 2.0784       | 0.25136E+01  | −0.15089E-02 | 0.84915E-07  | 278-333 |
| C <sub>7</sub> H <sub>14</sub>                                | Methylcyclohexane                | 293.2 | 2.024        |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> Br <sub>2</sub>                | 1,2-Dibromoheptane               | 298.2 | 3.77         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> Br <sub>2</sub>                | 2,3-Dibromoheptane               | 298.2 | 5.08         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> Br <sub>2</sub>                | 3,4-Dibromoheptane               | 298.2 | 4.70         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> Cl <sub>2</sub>                | 1,7-Dichloroheptane              | 298.2 | 8.34         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> O                              | 1-Heptanal                       | 295.2 | 9.07         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> O                              | 2-Heptanone                      | 293.2 | 11.95        | 0.38348E+02  | −0.12531E+00 | 0.12005E-03  | 253-413 |
| C <sub>7</sub> H <sub>14</sub> O                              | 3-Heptanone                      | 293.2 | 12.7         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> O                              | 4-Heptanone                      | 293.2 | 12.60        | 0.41520E+02  | −0.13839E+00 | 0.13497E-03  | 253-393 |
| C <sub>7</sub> H <sub>14</sub> O                              | 5-Methyl-2-hexanone              | 293.2 | 13.53        | 0.52353E+02  | −0.17695E+00 | 0.15195E-03  | 293-333 |
| C <sub>7</sub> H <sub>14</sub> O                              | Cyclohexanemethanol              | 333.2 | 9.70         | 0.10164E+03  | −0.45839E+00 | 0.54762E-03  | 333-368 |
| C <sub>7</sub> H <sub>14</sub> O                              | 2-Methylcyclohexanol*            | 293.2 | 9.375        | 0.17315E+03  | −0.98794E+00 | 0.14634E-02  | 273-323 |
| C <sub>7</sub> H <sub>14</sub> O                              | 3-Methylcyclohexanol*            | 293.2 | 13.79        | 0.65896E+02  | −0.21954E+00 | 0.14107E-03  | 273-323 |
| C <sub>7</sub> H <sub>14</sub> O                              | 4-Methylcyclohexanol*            | 293.2 | 13.45        | 0.65021E+02  | −0.22896E+00 | 0.17946E-03  | 273-323 |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Heptanoic acid                   | 288.2 | 3.04         | 0.36423E+01  | −0.31996E-02 | 0.39362E-05  | 288-423 |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Pentyl acetate                   | 293.2 | 4.79         | 0.12091E+02  | −0.36536E-01 | 0.39732E-04  | 253-353 |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Isopentyl acetate                | 293.2 | 4.72         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Butyl propanoate                 | 293.2 | 4.838        |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Propyl butanoate                 | 293.2 | 4.3          |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Ethyl pentanoate                 | 291.2 | 4.71         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Ethyl 3-methylbutanoate          | 293.2 | 4.71         |              |              |              |         |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                 | Methyl hexanoate                 | 293.2 | 4.615        |              |              |              |         |
| C <sub>7</sub> H <sub>15</sub> Br                             | 1-Bromoheptane                   | 303.2 | 5.255        | 0.15289E+02  | −0.50621E-01 | 0.57753E-04  | 203-343 |
| C <sub>7</sub> H <sub>15</sub> Br                             | 2-Bromoheptane                   | 295.2 | 6.46         |              |              |              |         |
| C <sub>7</sub> H <sub>15</sub> Br                             | 4-Bromoheptane                   | 295.2 | 6.81         |              |              |              |         |
| C <sub>7</sub> H <sub>15</sub> Cl                             | 1-Chloroheptane                  | 293.2 | 5.521        | 0.14279E+02  | −0.39431E-01 | 0.32321E-04  | 273-323 |
| C <sub>7</sub> H <sub>15</sub> Cl                             | 2-Chloroheptane                  | 295.2 | 6.52         |              |              |              |         |
| C <sub>7</sub> H <sub>15</sub> Cl                             | 3-Chloroheptane                  | 295.2 | 6.70         |              |              |              |         |
| C <sub>7</sub> H <sub>15</sub> Cl                             | 4-Chloroheptane                  | 295.2 | 6.54         |              |              |              |         |
| C <sub>7</sub> H <sub>15</sub> I                              | 1-Iodoheptane                    | 298.2 | 4.92         | 0.11856E+02  | −0.33493E-01 | 0.34368E-04  | 294-323 |
| C <sub>7</sub> H <sub>15</sub> I                              | 3-Iodoheptane                    | 295.2 | 6.39         |              |              |              |         |
| C <sub>7</sub> H <sub>16</sub>                                | Heptane                          | 293.2 | 1.9209       | 0.24740E+01  | −0.22577E-02 | 0.12428E-05  | 273-373 |
| C <sub>7</sub> H <sub>16</sub>                                | 2-Methylhexane                   | 293.2 | 1.9221       | 0.24759E+01  | −0.22535E-02 | 0.12500E-05  | 293-323 |
| C <sub>7</sub> H <sub>16</sub>                                | 3-Methylhexane                   | 293.2 | 1.920        | 0.27089E+01  | −0.37908E-02 | 0.37500E-05  | 273-323 |
| C <sub>7</sub> H <sub>16</sub>                                | 3-Ethylpentane                   | 293.2 | 1.942        | 0.23771E+01  | −0.15140E-02 | 0.10093E-06  | 163-363 |



| Mol. form.                                       | Name                                    | T/K   | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|--------------------------------------------------|-----------------------------------------|-------|--------------|--------------|--------------|--------------|---------|
| C <sub>7</sub> H <sub>16</sub>                   | 2,2-Dimethylpentane                     | 293.2 | 1.915        | 0.23414E+01  | -0.14362E-02 | -0.51322E-07 | 153-353 |
| C <sub>7</sub> H <sub>16</sub>                   | 2,3-Dimethylpentane                     | 293.2 | 1.929        | 0.25637E+01  | -0.26328E-02 | 0.16071E-05  | 273-323 |
| C <sub>7</sub> H <sub>16</sub>                   | 2,4-Dimethylpentane                     | 293.2 | 1.902        | 0.23979E+01  | -0.17436E-02 | 0.17857E-06  | 273-323 |
| C <sub>7</sub> H <sub>16</sub>                   | 3,3-Dimethylpentane                     | 291.3 | 1.9419       | 0.24007E+01  | -0.16802E-02 | 0.36069E-06  | 291-322 |
| C <sub>7</sub> H <sub>16</sub>                   | 2,2,3-Trimethylbutane                   | 293.2 | 1.930        |              |              |              |         |
| C <sub>7</sub> H <sub>16</sub> O                 | 1-Heptanol                              | 293.2 | 11.75        | 0.60662E+02  | -0.24049E+00 | 0.25155E-03  | 239-513 |
| C <sub>7</sub> H <sub>16</sub> O                 | 2-Heptanol                              | 293.7 | 9.72         | 0.10050E+03  | -0.49793E+00 | 0.64504E-03  | 207-365 |
| C <sub>7</sub> H <sub>16</sub> O                 | 3-Heptanol                              | 296.1 | 7.07         | 0.19586E+03  | -0.11465E+01 | 0.17175E-02  | 248-349 |
| C <sub>7</sub> H <sub>16</sub> O                 | 4-Heptanol                              | 296.2 | 6.18         | 0.28995E+03  | -0.18499E+01 | 0.30109E-02  | 270-301 |
| C <sub>7</sub> H <sub>16</sub> O                 | 2-Methyl-2-hexanol                      | 297.0 | 3.257        |              |              |              |         |
| C <sub>7</sub> H <sub>16</sub> O                 | 3-Methyl-2-hexanol                      | 297.2 | 4.990        | 0.59724E+02  | -0.32417E+00 | 0.47058E-03  | 244-372 |
| C <sub>7</sub> H <sub>16</sub> O                 | 3-Methyl-3-hexanol                      | 298.2 | 3.248        |              |              |              |         |
| C <sub>7</sub> H <sub>16</sub> O                 | 3-Ethyl-3-pentanol                      | 293.2 | 3.158        |              |              |              |         |
| C <sub>7</sub> H <sub>16</sub> O                 | 2,2-Dimethyl-1-pentanol                 | 293.2 | 6.020        | 0.37318E+02  | -0.17095E+00 | 0.22022E-03  | 283-393 |
| C <sub>7</sub> H <sub>16</sub> O                 | Ethyl pentyl ether                      | 296.2 | 3.6          |              |              |              |         |
| C <sub>7</sub> H <sub>16</sub> O                 | Ethyl isopentyl ether                   | 293.2 | 3.955        | 0.66541E+01  | -0.55450E-02 | -0.12500E-04 | 293-323 |
| C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>    | Triethoxymethane                        | 293.2 | 4.779        |              |              |              |         |
| C <sub>7</sub> H <sub>16</sub> S                 | 1-Heptanethiol                          | 293.2 | 4.194        | 0.71333E+01  | -0.97320E-02 | -0.12500E-05 | 273-333 |
| C <sub>7</sub> H <sub>17</sub> N                 | Heptylamine                             | 293.2 | 3.81         | 0.87794E+01  | -0.24363E-01 | 0.25325E-04  | 253-373 |
| C <sub>7</sub> H <sub>18</sub> O <sub>3</sub> Si | Triethoxymethylsilane                   | 298.2 | 3.845        |              |              |              |         |
| C <sub>8</sub> H <sub>6</sub> F <sub>6</sub>     | 1,3-Bis(trifluoromethyl)benzene         | 303.2 | 5.98         |              |              |              |         |
| C <sub>8</sub> H <sub>6</sub>                    | Phenylacetylene                         | 298.2 | 2.98         |              |              |              |         |
| C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub>    | 2,5-Dichlorostyrene                     | 298.2 | 2.58         |              |              |              |         |
| C <sub>8</sub> H <sub>6</sub> Cl <sub>4</sub>    | 1,2,3,4-Tetrachloro-5,6-dimethylbenzene | 293.2 | 8.0          |              |              |              |         |
| C <sub>8</sub> H <sub>6</sub> Cl <sub>4</sub>    | 1,2,3,5-Tetrachloro-4,6-dimethylbenzene | 293.2 | 5.4          |              |              |              |         |
| C <sub>8</sub> H <sub>6</sub> O                  | Phenoxyacetylene                        | 298.2 | 4.76         |              |              |              |         |
| C <sub>8</sub> H <sub>7</sub> N                  | Benzeneacetonitrile                     | 299.2 | 17.87        | 0.82175E+02  | -0.37416E+00 | 0.53220E-03  | 299-343 |
| C <sub>8</sub> H <sub>7</sub> NO <sub>2</sub>    | 4-Methoxyphenyl isocyanate              | 333.2 | 10.26        | 0.20780E+02  | -0.31571E-01 |              | 333-403 |
| C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>    | Methyl 2-nitrobenzoate                  | 300.1 | 27.76        |              |              |              |         |
| C <sub>8</sub> H <sub>8</sub>                    | Styrene                                 | 293.2 | 2.4737       | 0.44473E+01  | -0.11422E-01 | 0.16000E-04  | 293-313 |
| C <sub>8</sub> H <sub>8</sub> O                  | Acetophenone                            | 298.2 | 17.44        | 0.26099E+02  | 0.64048E-02  | -0.11905E-03 | 298-333 |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>     | Benzeneacetic acid                      | 353.2 | 3.47         | 0.24104E+01  | 0.30000E-02  |              | 353-393 |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>     | Benzyl formate                          | 303.2 | 6.34         | 0.26162E+02  | -0.11026E+00 | 0.14787E-03  | 303-358 |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>     | Phenyl acetate                          | 298.2 | 5.403        | 0.11327E+02  | -0.26707E-01 | 0.22938E-04  | 298-404 |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>     | Methyl benzoate                         | 302.7 | 6.642        | 0.17486E+02  | -0.51027E-01 | 0.50222E-04  | 303-393 |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>     | (Hydroxyacetyl)benzene                  | 298.2 | 21.33        | 0.42286E+02  | -0.69215E-01 | -0.35714E-05 | 298-368 |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>     | 4-Methoxybenzaldehyde                   | 303.2 | 22.0         |              |              |              |         |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>     | Methyl salicylate                       | 314.4 | 8.80         | 0.20501E+02  | -0.39045E-01 | 0.68298E-05  | 223-398 |
| C <sub>8</sub> H <sub>9</sub> Br                 | 1-Bromo-2-ethylbenzene                  | 298.2 | 5.55         |              |              |              |         |
| C <sub>8</sub> H <sub>9</sub> Br                 | 1-Bromo-3-ethylbenzene                  | 298.2 | 5.56         |              |              |              |         |
| C <sub>8</sub> H <sub>9</sub> Br                 | 1-Bromo-4-ethylbenzene                  | 298.2 | 5.42         |              |              |              |         |
| C <sub>8</sub> H <sub>9</sub> BrO                | 1-Bromo-2-ethoxybenzene                 | 313.2 | 7.04         | 0.23146E+02  | -0.75753E-01 | 0.77778E-04  | 313-358 |
| C <sub>8</sub> H <sub>9</sub> Cl                 | 1-Chloro-2-ethylbenzene                 | 298.2 | 4.36         |              |              |              |         |
| C <sub>8</sub> H <sub>9</sub> Cl                 | 1-Chloro-3-ethylbenzene                 | 298.2 | 5.18         |              |              |              |         |
| C <sub>8</sub> H <sub>9</sub> Cl                 | 1-Chloro-4-ethylbenzene                 | 298.2 | 5.16         |              |              |              |         |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>    | 1-Ethyl-2-nitrobenzene                  | 273.4 | 21.9         |              |              |              |         |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>    | Methyl 2-aminobenzoate                  | 298.2 | 21.9         |              |              |              |         |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>    | Ethyl 4-pyridinecarboxylate             | 293.2 | 8.95         |              |              |              |         |
| C <sub>8</sub> H <sub>10</sub>                   | Ethylbenzene                            | 293.2 | 2.4463       | 0.35969E+01  | -0.53169E-02 | 0.47500E-05  | 293-323 |
| C <sub>8</sub> H <sub>10</sub>                   | <i>o</i> -Xylene                        | 293.2 | 2.562        | 0.36163E+01  | -0.40177E-02 | 0.14286E-05  | 273-323 |
| C <sub>8</sub> H <sub>10</sub>                   | <i>m</i> -Xylene                        | 293.2 | 2.359        | 0.28421E+01  | -0.10191E-02 | -0.21429E-05 | 273-323 |
| C <sub>8</sub> H <sub>10</sub>                   | <i>p</i> -Xylene                        | 293.2 | 2.2735       | 0.23140E+01  | 0.97221E-03  | -0.37500E-05 | 293-363 |
| C <sub>8</sub> H <sub>10</sub> O                 | 2,3-Xylenol                             | 343.2 | 4.81         | 0.14399E+02  | -0.41438E-01 | 0.39244E-04  | 343-433 |
| C <sub>8</sub> H <sub>10</sub> O                 | 2,4-Xylenol                             | 303.2 | 5.060        | 0.22125E+02  | -0.85543E-01 | 0.96548E-04  | 303-363 |
| C <sub>8</sub> H <sub>10</sub> O                 | 2,5-Xylenol                             | 338.2 | 5.36         | 0.18049E+02  | -0.54991E-01 | 0.51656E-04  | 338-455 |
| C <sub>8</sub> H <sub>10</sub> O                 | 2,6-Xylenol                             | 313.2 | 4.90         | 0.12284E+02  | -0.32996E-01 | 0.29867E-04  | 313-453 |
| C <sub>8</sub> H <sub>10</sub> O                 | 3,4-Xylenol                             | 333.2 | 9.02         | 0.54423E+02  | -0.21153E+00 | 0.22508E-03  | 333-453 |
| C <sub>8</sub> H <sub>10</sub> O                 | 3,5-Xylenol                             | 323.2 | 9.06         | 0.54251E+02  | -0.21647E+00 | 0.23542E-03  | 323-453 |
| C <sub>8</sub> H <sub>10</sub> O                 | Benzeneethanol                          | 293.2 | 12.31        | 0.12170E+03  | -0.63124E+00 | 0.87776E-03  | 278-333 |
| C <sub>8</sub> H <sub>10</sub> O                 | 1-Phenylethanol                         | 293.2 | 8.77         | 0.32971E+02  | -0.12042E+00 | 0.12809E-03  | 293-423 |
| C <sub>8</sub> H <sub>10</sub> O                 | Phenetole                               | 293.2 | 4.216        | -0.15043E+02 | 0.13752E+00  | -0.24500E-03 | 293-313 |

| Mol. form.                                                   | Name                          | T/K    | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|--------------------------------------------------------------|-------------------------------|--------|--------------|--------------|--------------|--------------|---------|
| C <sub>8</sub> H <sub>10</sub> O                             | 2-Methylanisole               | 293.2  | 3.502        | 0.50825E+01  | -0.62297E-02 | 0.28571E-05  | 293-333 |
| C <sub>8</sub> H <sub>10</sub> O                             | 3-Methylanisole               | 293.2  | 3.967        | 0.12830E+02  | -0.49701E-01 | 0.66429E-04  | 293-333 |
| C <sub>8</sub> H <sub>10</sub> O                             | 4-Methylanisole               | 293.2  | 3.914        | 0.86608E+01  | -0.23510E-01 | 0.25000E-04  | 293-333 |
| C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                | 1,2-Dimethoxybenzene          | 293.2  | 4.45         | 0.74604E+01  | -0.13445E-01 | 0.10737E-04  | 293-443 |
| C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                | 1,3-Dimethoxybenzene          | 298.2  | 5.363        | 0.11911E+02  | -0.30804E-01 | 0.29643E-04  | 298-358 |
| C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                | 1,4-Dimethoxybenzene          | 333.7  | 5.60         | 0.11289E+02  | -0.20765E-01 | 0.11987E-04  | 334-463 |
| C <sub>8</sub> H <sub>10</sub> O <sub>2</sub> S              | Ethyl phenyl sulfone          | 348.2  | 39.0         |              |              |              |         |
| C <sub>8</sub> H <sub>10</sub> S                             | (Ethylthio)benzene            | 298.2  | 4.95         |              |              |              |         |
| C <sub>8</sub> H <sub>11</sub> N                             | <i>p</i> -Ethylaniline        | 298.2  | 4.84         |              |              |              |         |
| C <sub>8</sub> H <sub>11</sub> N                             | <i>N</i> -Ethylaniline        | 293.2  | 5.87         |              |              |              |         |
| C <sub>8</sub> H <sub>11</sub> N                             | <i>N,N</i> -Dimethylaniline   | 298.2  | 4.90         | 0.84052E+01  | -0.13549E-01 | 0.62835E-05  | 289-453 |
| C <sub>8</sub> H <sub>11</sub> N                             | 2,4,6-Trimethylpyridine       | 298.2  | 7.807        | 0.20990E+02  | -0.57419E-01 | 0.44286E-04  | 298-358 |
| C <sub>8</sub> H <sub>11</sub> NO                            | 4-Ethoxyaniline               | 298.2  | 7.43         |              |              |              |         |
| C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> | Hexamethylene diisocyanate    | 288.2  | 14.41        | 0.26715E+02  | -0.42696E-01 |              | 288-403 |
| C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                | Diethyl maleate               | 298.2  | 7.560        | 0.13953E+02  | -0.21969E-01 | 0.17817E-05  | 298-343 |
| C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                | Diethyl fumarate              | 296.2  | 6.56         |              |              |              |         |
| C <sub>8</sub> H <sub>14</sub>                               | 1,7-Octadiene                 | 293.0  | 2.186        | 0.28376E+01  | -0.17442E-02 | -0.16141E-05 | 214-293 |
| C <sub>8</sub> H <sub>14</sub>                               | <i>cis</i> -Cyclooctene       | 296.0  | 2.306        | 0.31115E+01  | -0.32058E-02 | 0.16713E-05  | 269-406 |
| C <sub>8</sub> H <sub>14</sub>                               | 1,2-Dimethylcyclohexene       | 296.0  | 2.144        | 0.26443E+01  | -0.17973E-02 | 0.35815E-06  | 211-374 |
| C <sub>8</sub> H <sub>14</sub>                               | 1,3-Dimethylcyclohexene       | 296.0  | 2.182        | 0.29951E+01  | -0.34615E-02 | 0.24026E-05  | 213-373 |
| C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                | Methyl cyclohexanecarboxylate | 293.2  | 4.87         |              |              |              |         |
| C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>                | Cyclohexyl acetate            | 293.2  | 5.08         |              |              |              |         |
| C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>                | Butanoic anhydride            | 293.2  | 12.8         |              |              |              |         |
| C <sub>8</sub> H <sub>14</sub> O <sub>3</sub>                | 2-Methylpropanoic anhydride   | 292.2  | 13.6         |              |              |              |         |
| C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                | Diisopropyl oxalate           | 293.2  | 6.403        | 0.10709E+02  | -0.16328E-01 | 0.56000E-05  | 293-368 |
| C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                | Diethyl succinate             | 293.2  | 6.098        | 0.80213E+01  | 0.11810E-02  | -0.26400E-04 | 293-343 |
| C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                | Dimethyl adipate              | 293.2  | 6.84         | 0.11739E+02  | -0.17281E-01 | 0.11447E-05  | 293-433 |
| C <sub>8</sub> H <sub>15</sub> N                             | Octanenitrile                 | 293.2  | 13.90        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub>                               | 1-Octene                      | 293.2  | 2.113        | 0.24348E+01  | 0.34200E-03  | -0.50000E-05 | 273-323 |
| C <sub>8</sub> H <sub>16</sub>                               | <i>cis</i> -3-Octene          | 298.2  | 2.062        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub>                               | <i>trans</i> -3-Octene        | 298.2  | 2.002        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub>                               | <i>cis</i> -4-Octene          | 298.2  | 2.053        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub>                               | <i>trans</i> -4-Octene        | 298.2  | 2.004        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub>                               | 3-Methyl-2-heptene*           | 293.2  | 2.436        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub>                               | 2,5-Dimethyl-2-hexene         | 293.2  | 2.431        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub>                               | 2,4,4-Trimethyl-1-pentene     | 298.2  | 2.0908       |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub>                               | Cyclooctane                   | 295.0  | 2.116        | 0.25036E+01  | -0.12460E-02 | -0.23175E-06 | 295-411 |
| C <sub>8</sub> H <sub>16</sub> Br <sub>2</sub>               | 1,8-Dibromooctane             | 298.2  | 7.43         | 0.94117E+00  | 0.61520E-01  | -0.13333E-03 | 298-328 |
| C <sub>8</sub> H <sub>16</sub> Cl <sub>2</sub>               | 1,8-Dichlorooctane            | 298.2  | 7.64         |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub> O                             | 2-Octanone                    | 293.2  | 9.51         | -0.16219E+02 | 0.18799E+00  | -0.34156E-03 | 293-333 |
| C <sub>8</sub> H <sub>16</sub> O                             | 3-Octanone                    | 303.2  | 10.50        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | Octanoic acid                 | 288.2  | 2.85         | 0.29391E+01  | -0.38721E-03 |              | 288-423 |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | 2-Ethylhexanoic acid          | 296.2  | 2.64         |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | Hexyl acetate                 | 293.2  | 4.42         |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | Pentyl propanoate             | 293.2  | 4.552        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | Isopentyl propanoate          | 273.2  | 5.21         | 0.17665E+02  | -0.71718E-01 | 0.95635E-04  | 273-373 |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | Butyl butanoate               | 298.2  | 4.39         | 0.79684E+01  | -0.12000E-01 | 0.15266E-13  | 298-318 |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | Propyl pentanoate             | 292.2  | 4.0          |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | Ethyl hexanoate               | 293.2  | 4.45         | 0.11007E+02  | -0.32800E-01 | 0.35714E-04  | 253-353 |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                | Methyl heptanoate             | 293.2  | 4.355        |              |              |              |         |
| C <sub>8</sub> H <sub>16</sub> O <sub>3</sub>                | Isopentyl lactate             | 273.2  | 11.2         | 0.48649E+02  | -0.21253E+00 | 0.27619E-03  | 273-373 |
| C <sub>8</sub> H <sub>17</sub> Br                            | 1-Bromooctane                 | 293.2  | 5.0957       | 0.12404E+02  | -0.35050E-01 | 0.34542E-04  | 283-353 |
| C <sub>8</sub> H <sub>17</sub> Br                            | 2-Bromooctane                 | 293.2  | 5.44         |              |              |              |         |
| C <sub>8</sub> H <sub>17</sub> Cl                            | 1-Chlorooctane                | 298.2  | 5.05         | 0.11346E+02  | -0.25120E-01 | 0.13450E-04  | 274-328 |
| C <sub>8</sub> H <sub>17</sub> Cl                            | 2-Chlorooctane                | 293.2  | 5.42         |              |              |              |         |
| C <sub>8</sub> H <sub>17</sub> F                             | 1-Fluorooctane                | 293.2  | 3.89         |              |              |              |         |
| C <sub>8</sub> H <sub>17</sub> I                             | 1-Iodooctane                  | 293.2  | 4.67         | 0.12452E+02  | -0.41229E-01 | 0.50108E-04  | 233-313 |
| C <sub>8</sub> H <sub>17</sub> NO <sub>2</sub>               | 1-Nitrooctane                 | 293.2  | 11.46        |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub>                               | Octane                        | 293.2  | 1.948        | 0.22590E+01  | -0.84212E-03 | -0.75758E-06 | 233-393 |
| C <sub>8</sub> H <sub>18</sub>                               | 2-Methylheptane               | 293.2  | 1.9519       |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub>                               | 3-Ethylhexane                 | 293.2  | 1.9617       |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub>                               | 2,2-Dimethylhexane            | 293.2  | 1.9498       |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub>                               | 2,5-Dimethylhexane            | 293.95 | 1.9619       | 0.25821E+01  | -0.26804E-02 | 0.19404E-05  | 294-324 |

| Mol. form.                                                    | Name                              | T/K    | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|---------------------------------------------------------------|-----------------------------------|--------|--------------|--------------|--------------|--------------|---------|
| C <sub>8</sub> H <sub>18</sub>                                | 3,3-Dimethylhexane                | 293.2  | 1.9645       |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub>                                | 3,4-Dimethylhexane                | 292.1  | 1.9814       | 0.26849E+01  | -0.33712E-02 | 0.32949E-05  | 292-324 |
| C <sub>8</sub> H <sub>18</sub>                                | 3-Ethyl-3-methylpentane           | 291.49 | 1.9869       | 0.25983E+01  | -0.28027E-02 | 0.24195E-05  | 292-324 |
| C <sub>8</sub> H <sub>18</sub>                                | 2,2,3-Trimethylpentane            | 293.2  | 1.960        |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub>                                | 2,2,4-Trimethylpentane            | 293.2  | 1.943        | 0.23677E+01  | -0.14768E-02 | 0.94261E-07  | 173-373 |
| C <sub>8</sub> H <sub>18</sub>                                | 2,3,3-Trimethylpentane            | 293.2  | 1.9780       |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub>                                | 2,3,4-Trimethylpentane            | 293.2  | 1.9738       |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub> O                              | 1-Octanol                         | 293.2  | 10.30        | 0.51647E+02  | -0.20371E+00 | 0.21320E-03  | 258-513 |
| C <sub>8</sub> H <sub>18</sub> O                              | 2-Octanol                         | 293.2  | 8.13         | 0.63760E+02  | -0.27643E+00 | 0.31075E-03  | 213-513 |
| C <sub>8</sub> H <sub>18</sub> O                              | 3-Octanol                         | 293.2  | 5.55         | 0.12505E+03  | -0.70646E+00 | 0.10245E-02  | 223-383 |
| C <sub>8</sub> H <sub>18</sub> O                              | 4-Octanol                         | 293.2  | 4.48         | 0.51049E+02  | -0.26664E+00 | 0.37280E-03  | 243-403 |
| C <sub>8</sub> H <sub>18</sub> O                              | 2-Methyl-1-heptanol               | 293.1  | 5.16         | 0.61698E+02  | -0.33647E+00 | 0.49066E-03  | 236-328 |
| C <sub>8</sub> H <sub>18</sub> O                              | 3-Methyl-1-heptanol               | 290.3  | 2.884        | 0.84687E+01  | -0.33712E-01 | 0.49793E-04  | 241-316 |
| C <sub>8</sub> H <sub>18</sub> O                              | 4-Methyl-1-heptanol               | 290.6  | 4.63         | 0.48612E+02  | -0.26773E+00 | 0.39972E-03  | 237-332 |
| C <sub>8</sub> H <sub>18</sub> O                              | 5-Methyl-1-heptanol               | 290.4  | 7.68         | 0.54581E+02  | -0.24772E+00 | 0.29734E-03  | 235-328 |
| C <sub>8</sub> H <sub>18</sub> O                              | 6-Methyl-1-heptanol               | 290.3  | 10.54        | 0.57997E+02  | -0.23517E+00 | 0.24663E-03  | 265-328 |
| C <sub>8</sub> H <sub>18</sub> O                              | 2-Methyl-2-heptanol               | 292.2  | 3.43         |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub> O                              | 3-Methyl-2-heptanol               | 289.6  | 7.47         | 0.39178E+02  | -0.17976E+00 | 0.24218E-03  | 229-329 |
| C <sub>8</sub> H <sub>18</sub> O                              | 4-Methyl-2-heptanol               | 290.0  | 3.59         | 0.39715E+02  | -0.23115E+00 | 0.36771E-03  | 240-333 |
| C <sub>8</sub> H <sub>18</sub> O                              | 5-Methyl-2-heptanol               | 278.5  | 7.5          | 0.68568E+02  | -0.40706E+00 | 0.67433E-03  | 230-279 |
| C <sub>8</sub> H <sub>18</sub> O                              | 6-Methyl-2-heptanol               | 290.1  | 6.41         | 0.77520E+02  | -0.41724E+00 | 0.59448E-03  | 239-329 |
| C <sub>8</sub> H <sub>18</sub> O                              | 2-Methyl-3-heptanol               | 293.2  | 3.260        | -0.59739E+01 | 0.56700E-01  | -0.83125E-04 | 343-403 |
| C <sub>8</sub> H <sub>18</sub> O                              | 3-Methyl-3-heptanol               | 293.2  | 3.013        | -0.38440E+01 | 0.42327E-01  | -0.61250E-04 | 343-403 |
| C <sub>8</sub> H <sub>18</sub> O                              | 4-Methyl-3-heptanol               | 293.2  | 3.312        | -0.48003E+01 | 0.50740E-01  | -0.75000E-04 | 343-403 |
| C <sub>8</sub> H <sub>18</sub> O                              | 5-Methyl-3-heptanol               | 293.2  | 3.832        | 0.61967E+01  | -0.63750E-02 |              | 343-383 |
| C <sub>8</sub> H <sub>18</sub> O                              | 6-Methyl-3-heptanol               | 293.2  | 4.992        | 0.23037E+02  | -0.98029E-01 | 0.12479E-03  | 283-383 |
| C <sub>8</sub> H <sub>18</sub> O                              | 2-Methyl-4-heptanol               | 296.3  | 3.338        | 0.42102E+00  | 0.10427E-01  | -0.20438E-05 | 230-333 |
| C <sub>8</sub> H <sub>18</sub> O                              | 3-Methyl-4-heptanol               | 290.0  | 7.46         | 0.33354E+02  | -0.14077E+00 | 0.17750E-03  | 230-330 |
| C <sub>8</sub> H <sub>18</sub> O                              | 4-Methyl-4-heptanol               | 296.2  | 2.902        |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub> O                              | 2-Ethyl-1-hexanol                 | 298.2  | 7.58         | 0.86074E+02  | -0.42636E+00 | 0.55078E-03  | 208-318 |
| C <sub>8</sub> H <sub>18</sub> O                              | 2,2-Dimethyl-1-hexanol            | 293.2  | 4.50         | 0.91244E+01  | -0.21785E-01 | 0.21018E-04  | 283-393 |
| C <sub>8</sub> H <sub>18</sub> O                              | Dibutyl ether                     | 293.2  | 3.0830       | 0.65383E+01  | -0.16172E-01 | 0.14969E-04  | 293-314 |
| C <sub>8</sub> H <sub>18</sub> OS                             | Dibutyl sulfoxide                 | 313.2  | 24.73        | 0.67156E+02  | -0.16448E+00 | 0.92275E-04  | 313-393 |
| C <sub>8</sub> H <sub>18</sub> O <sub>2</sub>                 | 2-Ethyl-1,3-hexanediol            | 293.2  | 18.73        | 0.57919E+02  | -0.17128E+00 | 0.12949E-03  | 233-333 |
| C <sub>8</sub> H <sub>18</sub> O <sub>2</sub> S               | Dibutyl sulfone                   | 323.2  | 25.72        | 0.66248E+02  | -0.16417E+00 | 0.12001E-03  | 323-398 |
| C <sub>8</sub> H <sub>18</sub> O <sub>4</sub>                 | Triethylene glycol dimethyl ether | 298.2  | 7.62         |              |              |              |         |
| C <sub>8</sub> H <sub>18</sub> O <sub>5</sub>                 | Tetraethylene glycol              | 293.2  | 20.44        | 0.83547E+02  | -0.31691E+00 | 0.34689E-03  | 253-333 |
| C <sub>8</sub> H <sub>18</sub> S                              | 1-Octanethiol                     | 293.2  | 3.949        | 0.63667E+01  | -0.87920E-02 | 0.18750E-05  | 273-333 |
| C <sub>8</sub> H <sub>18</sub> S                              | Dibutyl sulfide                   | 298.2  | 4.29         |              |              |              |         |
| C <sub>8</sub> H <sub>19</sub> N                              | Octylamine                        | 293.2  | 3.58         | 0.77931E+01  | -0.20015E-01 | 0.19347E-04  | 273-373 |
| C <sub>8</sub> H <sub>19</sub> N                              | Dibutylamine                      | 293.2  | 2.765        | 0.52504E+01  | -0.10538E-01 | 0.71485E-05  | 243-323 |
| C <sub>8</sub> H <sub>20</sub> O <sub>4</sub> Si              | Ethyl silicate                    | 293.2  | 2.50         |              |              |              |         |
| C <sub>8</sub> H <sub>20</sub> Si                             | Tetraethylsilane                  | 293.2  | 2.090        |              |              |              |         |
| C <sub>8</sub> H <sub>20</sub> Sn                             | Tetraethylstannane                | 293.2  | 2.241        |              |              |              |         |
| C <sub>8</sub> H <sub>23</sub> N <sub>5</sub>                 | Tetraethylenepentamine            | 293.2  | 9.40         | 0.40553E+02  | -0.16681E+00 | 0.20659E-03  | 213-333 |
| C <sub>8</sub> H <sub>24</sub> O <sub>4</sub> Si <sub>4</sub> | Octamethylcyclotetrasiloxane      | 296.2  | 2.390        | 0.36286E+01  | -0.56885E-02 | 0.50874E-05  | 296-333 |
| C <sub>9</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>   | Toluene-2,4-diisocyanate          | 293.2  | 8.433        | 0.22174E+02  | -0.66982E-01 | 0.68571E-04  | 293-353 |
| C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>                  | 2 <i>H</i> -1-Benzopyran-2-one    | 343.2  | 34.04        | 0.11311E+03  | -0.33804E+00 | 0.31324E-03  | 343-423 |
| C <sub>9</sub> H <sub>7</sub> N                               | Quinoline                         | 293.2  | 9.16         | 0.33432E+02  | -0.13497E+00 | 0.17788E-03  | 258-323 |
| C <sub>9</sub> H <sub>7</sub> N                               | Isoquinoline                      | 298.2  | 11.0         | 0.14412E+03  | -0.79935E+00 | 0.11839E-02  | 298-323 |
| C <sub>9</sub> H <sub>8</sub> O                               | Cinnamaldehyde                    | 305.8  | 17.72        | 0.41837E+02  | -0.11060E+00 | 0.10401E-03  | 306-354 |
| C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                  | 2-(Acetyloxy)benzoic acid         | 333.2  | 6.55         | 0.69994E+01  | -0.14553E-02 |              | 333-416 |
| C <sub>9</sub> H <sub>10</sub>                                | 1-Propenylbenzene                 | 293.2  | 2.73         |              |              |              |         |
| C <sub>9</sub> H <sub>10</sub>                                | Allylbenzene                      | 293.2  | 2.63         |              |              |              |         |
| C <sub>9</sub> H <sub>10</sub>                                | Isopropenylbenzene                | 293.2  | 2.28         |              |              |              |         |
| C <sub>9</sub> H <sub>10</sub> OS                             | 4-Acetylthioanisole               | 355.2  | 11.34        |              |              |              |         |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | Ethyl benzoate                    | 293.2  | 6.20         | 0.18216E+02  | -0.62361E-01 | 0.72884E-04  | 288-343 |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | Methyl 4-methylbenzoate           | 306.2  | 4.3          |              |              |              |         |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | Benzyl acetate                    | 303.2  | 5.34         | 0.11727E+02  | -0.30869E-01 | 0.32340E-04  | 303-358 |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | Phenyl propanoate                 | 293.2  | 4.77         |              |              |              |         |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                 | 4-Acetylanisole                   | 313.2  | 17.3         |              |              |              |         |
| C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | Ethyl salicylate                  | 308.2  | 8.48         | 0.18910E+02  | -0.35623E-01 | 0.46529E-05  | 225-321 |
| C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                 | Methyl 2-methoxybenzoate          | 294.2  | 7.7          |              |              |              |         |



| Mol. form.                                      | Name                                     | T/K    | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|-------------------------------------------------|------------------------------------------|--------|--------------|--------------|--------------|--------------|---------|
| C <sub>9</sub> H <sub>11</sub> Br               | (3-Bromopropyl)benzene                   | 302.2  | 5.41         | 0.11360E+02  | -0.27471E-01 | 0.25775E-04  | 302-358 |
| C <sub>9</sub> H <sub>11</sub> NO               | <i>N</i> -Ethylbenzamide                 | 352.7  | 42.6         | -0.20109E+03 | 0.17866E+01  | -0.31065E-02 | 353-389 |
| C <sub>9</sub> H <sub>11</sub> NO               | <i>N,N</i> -Dimethylbenzamide            | 318.2  | 20.77        | 0.76725E+02  | -0.26908E+00 | 0.29409E-03  | 318-443 |
| C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>  | Ethyl 2-aminobenzoate                    | 298.2  | 4.14         |              |              |              |         |
| C <sub>9</sub> H <sub>12</sub>                  | Propylbenzene                            | 293.2  | 2.370        | 0.26933E+01  | 0.21679E-03  | -0.44643E-05 | 273-323 |
| C <sub>9</sub> H <sub>12</sub>                  | Isopropylbenzene                         | 293.2  | 2.381        | 0.31149E+01  | -0.30801E-02 | 0.19643E-05  | 273-323 |
| C <sub>9</sub> H <sub>12</sub>                  | <i>o</i> -Ethyltoluene                   | 293.2  | 2.595        |              |              |              |         |
| C <sub>9</sub> H <sub>12</sub>                  | <i>m</i> -Ethyltoluene                   | 293.2  | 2.365        |              |              |              |         |
| C <sub>9</sub> H <sub>12</sub>                  | <i>p</i> -Ethyltoluene                   | 293.2  | 2.265        |              |              |              |         |
| C <sub>9</sub> H <sub>12</sub>                  | 1,2,3-Trimethylbenzene                   | 293.2  | 2.656        | 0.76006E+01  | -0.29118E-01 | 0.41786E-04  | 273-323 |
| C <sub>9</sub> H <sub>12</sub>                  | 1,2,4-Trimethylbenzene                   | 293.2  | 2.377        | 0.31517E+01  | -0.30634E-02 | 0.14286E-05  | 273-323 |
| C <sub>9</sub> H <sub>12</sub>                  | 1,3,5-Trimethylbenzene                   | 293.2  | 2.279        | 0.38998E+01  | -0.88072E-02 | 0.11149E-04  | 288-358 |
| C <sub>9</sub> H <sub>12</sub> O                | Benzenepropanol                          | 293.2  | 11.97        | 0.94482E+02  | -0.45540E+00 | 0.59307E-03  | 213-303 |
| C <sub>9</sub> H <sub>12</sub> O                | $\alpha$ -Ethylbenzenemethanol           | 293.2  | 6.68         | 0.44520E+02  | -0.21505E+00 | 0.29443E-03  | 233-373 |
| C <sub>9</sub> H <sub>12</sub> O                | $\alpha,\alpha$ -Dimethylbenzenemethanol | 303.2  | 5.61         | 0.57072E+01  | 0.86568E-02  | -0.29580E-04 | 303-373 |
| C <sub>9</sub> H <sub>12</sub> O                | 1-Phenyl-2-propanol                      | 293.2  | 9.35         | 0.10762E+03  | -0.56026E+00 | 0.76915E-03  | 233-373 |
| C <sub>9</sub> H <sub>12</sub> O                | Benzyl ethyl ether                       | 298.2  | 3.90         |              |              |              |         |
| C <sub>9</sub> H <sub>12</sub> O                | 2,6-Dimethylanisole                      | 293.2  | 3.780        | 0.76700E+01  | -0.18298E-01 | 0.17143E-04  | 293-333 |
| C <sub>9</sub> H <sub>12</sub> O                | 3,5-Dimethylanisole                      | 293.2  | 3.711        | 0.54981E+01  | -0.56651E-02 | -0.14286E-05 | 293-333 |
| C <sub>9</sub> H <sub>12</sub> O <sub>2</sub> S | Butyl thiophene-2-carboxylate            | 293.2  | 6.40         |              |              |              |         |
| C <sub>9</sub> H <sub>12</sub> S                | Benzenepropanethiol                      | 303.2  | 4.36         | 0.82411E+01  | -0.15034E-01 | 0.73617E-05  | 303-358 |
| C <sub>9</sub> H <sub>13</sub> N                | Benzylethylamine                         | 293.2  | 4.3          |              |              |              |         |
| C <sub>9</sub> H <sub>13</sub> N                | <i>N</i> -Propylaniline                  | 293.2  | 5.48         |              |              |              |         |
| C <sub>9</sub> H <sub>13</sub> N                | 2-Methyl- <i>N,N</i> -dimethylaniline    | 293.2  | 3.4          |              |              |              |         |
| C <sub>9</sub> H <sub>13</sub> N                | 4-Methyl- <i>N,N</i> -dimethylaniline    | 293.2  | 3.9          |              |              |              |         |
| C <sub>9</sub> H <sub>14</sub> OSi              | Trimethylphenoxysilane                   | 298.2  | 3.3953       |              |              |              |         |
| C <sub>9</sub> H <sub>14</sub> O <sub>6</sub>   | Triacetin                                | 293.6  | 7.11         | 0.17819E+02  | -0.53656E-01 | 0.57759E-04  | 219-304 |
| C <sub>9</sub> H <sub>14</sub> Si               | Trimethylphenylsilane                    | 298.2  | 2.3533       | 0.21463E+01  | 0.32711E-02  | -0.86264E-05 | 288-323 |
| C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>   | 2-Nonenoic acid                          | 296.2  | 2.5          |              |              |              |         |
| C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>   | Cyclohexyl propanoate                    | 293.2  | 4.82         |              |              |              |         |
| C <sub>9</sub> H <sub>16</sub> O <sub>2</sub>   | Ethyl cyclohexanecarboxylate             | 293.2  | 4.64         |              |              |              |         |
| C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>   | Diethyl glutarate                        | 303.2  | 6.659        |              |              |              |         |
| C <sub>9</sub> H <sub>17</sub> N                | Nonanenitrile                            | 293.2  | 12.08        |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub>                  | 1-Nonene                                 | 293.2  | 2.180        | 0.22710E+01  | 0.15797E-02  | -0.64286E-05 | 273-323 |
| C <sub>9</sub> H <sub>18</sub> Br <sub>2</sub>  | 1,9-Dibromononane                        | 293.2  | 7.153        | 0.18931E+02  | -0.57764E-01 | 0.60000E-04  | 293-343 |
| C <sub>9</sub> H <sub>18</sub> O                | 2-Nonanone                               | 295.2  | 9.14         |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub> O                | 5-Nonanone                               | 293.2  | 10.6         |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub> O                | Di- <i>tert</i> -butyl ketone            | 287.65 | 10.0         |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub> O                | 2,6-Dimethyl-4-heptanone                 | 293.2  | 9.91         | 0.33178E+02  | -0.11290E+00 | 0.11454E-03  | 273-393 |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | Nonanoic acid                            | 294.9  | 2.475        | 0.25039E+01  | 0.67274E-03  | -0.24180E-05 | 295-365 |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | 2-Methyloctanoic acid                    | 293.2  | 2.39         |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | 2-Ethylheptanoic acid                    | 293.2  | 1.98         |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | Heptyl acetate                           | 293.2  | 4.2          |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | Pentyl butanoate                         | 301.2  | 4.08         | 0.59029E+01  | -0.49905E-02 | -0.34292E-05 | 301-343 |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | Isopentyl butanoate                      | 293.2  | 4.0          |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | Isobutyl pentanoate                      | 292.2  | 3.8          |              |              |              |         |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>   | Methyl octanoate                         | 293.2  | 4.101        |              |              |              |         |
| C <sub>9</sub> H <sub>19</sub> Br               | 1-Bromononane                            | 298.2  | 4.74         | 0.79870E+01  | -0.10488E-01 | -0.13450E-05 | 274-328 |
| C <sub>9</sub> H <sub>19</sub> Cl               | 1-Chlorononane                           | 293.2  | 4.803        | 0.95528E+01  | -0.16200E-01 | -0.16365E-13 | 293-323 |
| C <sub>9</sub> H <sub>19</sub> NO               | <i>N,N</i> -Dibutylformamide             | 293.2  | 18.4         |              |              |              |         |
| C <sub>9</sub> H <sub>20</sub>                  | Nonane                                   | 293.2  | 1.9722       | 0.23894E+01  | -0.14830E-02 | 0.14881E-06  | 253-393 |
| C <sub>9</sub> H <sub>20</sub>                  | 2-Methyloctane                           | 293.2  | 1.967        |              |              |              |         |
| C <sub>9</sub> H <sub>20</sub>                  | 4-Methyloctane                           | 293.2  | 1.967        |              |              |              |         |
| C <sub>9</sub> H <sub>20</sub>                  | 2,4-Dimethylheptane                      | 293.2  | 1.89         |              |              |              |         |
| C <sub>9</sub> H <sub>20</sub>                  | 2,5-Dimethylheptane                      | 293.2  | 1.89         |              |              |              |         |
| C <sub>9</sub> H <sub>20</sub>                  | 2,6-Dimethylheptane                      | 293.2  | 1.987        |              |              |              |         |
| C <sub>9</sub> H <sub>20</sub> N <sub>2</sub> O | Tetraethylurea                           | 296.8  | 14.29        | 0.52820E+02  | -0.18790E+00 | 0.19580E-03  | 205-411 |
| C <sub>9</sub> H <sub>20</sub> O                | 1-Nonanol                                | 293.2  | 8.83         | 0.97467E+02  | -0.51103E+00 | 0.71429E-03  | 288-343 |
| C <sub>9</sub> H <sub>20</sub> O                | 2-Nonanol                                | 298.2  | 6.66         | 0.10136E+03  | -0.55612E+00 | 0.80000E-03  | 288-308 |
| C <sub>9</sub> H <sub>20</sub> O                | 3-Nonanol                                | 298.2  | 4.49         | 0.55214E+02  | -0.31920E+00 | 0.50000E-03  | 288-308 |
| C <sub>9</sub> H <sub>20</sub> O                | 4-Nonanol                                | 298.2  | 3.69         | 0.27954E+01  | 0.30000E-02  | -0.52375E-13 | 288-308 |
| C <sub>9</sub> H <sub>20</sub> O                | 5-Nonanol                                | 298.2  | 3.54         | -0.25463E+01 | 0.35320E-01  | -0.50000E-04 | 288-308 |
| C <sub>9</sub> H <sub>21</sub> B                | Tripropylborane                          | 293.2  | 2.026        |              |              |              |         |

| Mol. form.                                      | Name                          | T/K   | $\epsilon_r$ | <i>a</i>    | <i>b</i>     | <i>c</i>     | Range/K |
|-------------------------------------------------|-------------------------------|-------|--------------|-------------|--------------|--------------|---------|
| C <sub>9</sub> H <sub>21</sub> N                | Nonylamine                    | 293.2 | 3.42         | 0.53575E+01 | -0.71982E-02 | 0.19481E-05  | 293-373 |
| C <sub>9</sub> H <sub>21</sub> N                | Tripropylamine                | 293.2 | 2.380        | 0.33380E+01 | -0.86332E-02 | 0.18322E-04  | 243-293 |
| C <sub>9</sub> H <sub>21</sub> O <sub>3</sub> P | Tripropyl phosphate           | 293.2 | 10.93        | 0.33166E+02 | -0.10514E+00 | 0.10000E-03  | 293-373 |
| C <sub>10</sub> H <sub>7</sub> Br               | 1-Bromonaphthalene            | 298.2 | 4.768        | 0.10561E+02 | -0.27671E-01 | 0.27655E-04  | 293-323 |
| C <sub>10</sub> H <sub>7</sub> Cl               | 1-Chloronaphthalene           | 298.2 | 5.04         | 0.84861E+01 | -0.12357E-01 | 0.26899E-05  | 274-328 |
| C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>  | 1-Nitronaphthalene            | 333.2 | 19.68        | 0.36267E+02 | -0.41283E-01 | -0.25595E-04 | 333-403 |
| C <sub>10</sub> H <sub>8</sub>                  | Naphthalene                   | 363.2 | 2.54         |             |              |              |         |
| C <sub>10</sub> H <sub>8</sub> O                | 1-Naphthol                    | 373.0 | 5.03         | 0.16489E+02 | -0.46700E-01 | 0.42857E-04  | 373-453 |
| C <sub>10</sub> H <sub>8</sub> O                | 2-Naphthol                    | 413.0 | 4.95         | 0.92865E+01 | -0.10500E-01 | 0.42501E-15  | 413-453 |
| C <sub>10</sub> H <sub>9</sub> N                | 1-Naphthylamine               | 333.2 | 5.20         | 0.10577E+02 | -0.22114E-01 | 0.17857E-04  | 333-453 |
| C <sub>10</sub> H <sub>9</sub> N                | 2-Naphthylamine               | 393.0 | 5.26         | 0.19722E+02 | -0.60679E-01 | 0.60714E-04  | 393-473 |
| C <sub>10</sub> H <sub>9</sub> N                | 2-Methylquinoline             | 293.2 | 7.24         | 0.11688E+02 | -0.78400E-02 | -0.25000E-04 | 293-333 |
| C <sub>10</sub> H <sub>9</sub> N                | 4-Methylquinoline             | 293.2 | 9.31         | 0.17788E+02 | -0.32580E-01 | 0.12500E-04  | 293-333 |
| C <sub>10</sub> H <sub>9</sub> N                | 6-Methylquinoline             | 293.2 | 8.48         | 0.21696E+02 | -0.63400E-01 | 0.62500E-04  | 293-333 |
| C <sub>10</sub> H <sub>9</sub> N                | 8-Methylquinoline             | 293.2 | 6.58         | 0.19356E+02 | -0.61900E-01 | 0.62500E-04  | 293-333 |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>  | Methyl 2-(acetyloxy)benzoate  | 328.9 | 5.31         | 0.19579E+02 | -0.69970E-01 | 0.80889E-04  | 329-371 |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>  | Dimethyl phthalate            | 293.2 | 8.66         |             |              |              |         |
| C <sub>10</sub> H <sub>12</sub>                 | 1,2,3,4-Tetrahydronaphthalene | 298.2 | 2.771        | 0.29172E+01 | 0.12832E-02  | -0.59453E-05 | 298-343 |
| C <sub>10</sub> H <sub>12</sub>                 | 4-Ethylstyrene                | 298.2 | 3.350        |             |              |              |         |
| C <sub>10</sub> H <sub>12</sub>                 | Dicyclopentadiene             | 313.2 | 2.43         | 0.30564E+01 | -0.20000E-02 | 0.82443E-15  | 313-373 |
| C <sub>10</sub> H <sub>12</sub> O               | Tetrahydro-2-naphthol*        | 293.2 | 11.70        | 0.98978E+02 | -0.48267E+00 | 0.63008E-03  | 293-363 |
| C <sub>10</sub> H <sub>12</sub> O               | 4-Isopropylbenzaldehyde       | 288.2 | 10.68        |             |              |              |         |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>  | 4-Allyl-2-methoxyphenol       | 293.2 | 9.55         | 0.52377E+02 | -0.24380E+00 | 0.33333E-03  | 273-323 |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>  | 2-Phenylethyl acetate         | 297.2 | 4.93         |             |              |              |         |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>  | Benzyl propanoate             | 303.0 | 5.11         | 0.42301E+01 | 0.13962E-01  | -0.36426E-04 | 303-358 |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>  | Phenyl butanoate              | 293.2 | 4.48         |             |              |              |         |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>  | Propyl benzoate               | 303.2 | 5.78         | 0.10927E+02 | -0.20535E-01 | 0.11745E-04  | 303-358 |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>  | Ethyl phenylacetate           | 293.2 | 5.320        |             |              |              |         |
| C <sub>10</sub> H <sub>14</sub>                 | Butylbenzene                  | 293.2 | 2.359        |             |              |              |         |
| C <sub>10</sub> H <sub>14</sub>                 | sec-Butylbenzene              | 293.2 | 2.357        | 0.28348E+01 | -0.68586E-03 | -0.32143E-05 | 273-323 |
| C <sub>10</sub> H <sub>14</sub>                 | tert-Butylbenzene             | 293.2 | 2.359        | 0.27924E+01 | -0.38350E-03 | -0.37500E-05 | 273-323 |
| C <sub>10</sub> H <sub>14</sub>                 | Isobutylbenzene               | 293.2 | 2.318        | 0.28055E+01 | -0.92614E-03 | -0.25000E-05 | 273-323 |
| C <sub>10</sub> H <sub>14</sub>                 | 1-Isopropyl-4-methylbenzene   | 298.2 | 2.2322       | 0.25266E+01 | -0.25121E-03 | -0.24867E-05 | 277-333 |
| C <sub>10</sub> H <sub>14</sub>                 | o-Diethylbenzene              | 293.2 | 2.594        |             |              |              |         |
| C <sub>10</sub> H <sub>14</sub>                 | m-Diethylbenzene              | 293.2 | 2.369        |             |              |              |         |
| C <sub>10</sub> H <sub>14</sub>                 | p-Diethylbenzene              | 293.2 | 2.259        |             |              |              |         |
| C <sub>10</sub> H <sub>14</sub>                 | 1-Ethyl-3,5-dimethylbenzene   | 293.2 | 2.275        |             |              |              |         |
| C <sub>10</sub> H <sub>14</sub>                 | 1,2,3,4-Tetramethylbenzene    | 296.0 | 2.538        | 0.33822E+01 | -0.33630E-02 | 0.17475E-05  | 273-412 |
| C <sub>10</sub> H <sub>14</sub>                 | 1,2,4,5-Tetramethylbenzene    | 356.0 | 2.223        | 0.26834E+01 | -0.10327E-02 | -0.73533E-06 | 356-430 |
| C <sub>10</sub> H <sub>14</sub> N <sub>2</sub>  | L-Nicotine                    | 293.2 | 8.937        | 0.21347E+02 | -0.57177E-01 | 0.50655E-04  | 293-363 |
| C <sub>10</sub> H <sub>14</sub> O               | 1-Phenyl-2-methyl-2-propanol  | 298.2 | 5.71         | 0.21922E+02 | -0.84231E-01 | 0.99475E-04  | 298-423 |
| C <sub>10</sub> H <sub>14</sub> O               | Butyl phenyl ether            | 293.2 | 3.734        |             |              |              |         |
| C <sub>10</sub> H <sub>14</sub> O               | Thymol                        | 333.2 | 4.259        |             |              |              |         |
| C <sub>10</sub> H <sub>15</sub> N               | N,N-Diethylaniline            | 303.2 | 5.15         | 0.50773E+01 | 0.15399E-01  | -0.50000E-04 | 303-328 |
| C <sub>10</sub> H <sub>16</sub>                 | γ-Terpinene                   | 298.2 | 2.2738       |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub>                 | d-Limonene                    | 298.2 | 2.3746       |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub>                 | l-Limonene                    | 298.2 | 2.3738       |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub>                 | Terpinolene                   | 298.2 | 2.2918       |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub>                 | α-Pinene                      | 298.2 | 2.1787       |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub>                 | β-Pinene                      | 298.2 | 2.4970       |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub>                 | α-Terpinene                   | 298.2 | 2.4526       |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub>                 | β-Myrcene                     | 298.2 | 2.3          |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub> O               | Carvenone                     | 293.2 | 18.8         |             |              |              |         |
| C <sub>10</sub> H <sub>16</sub> O               | d-Fenchone                    | 294.2 | 12.8         |             |              |              |         |
| C <sub>10</sub> H <sub>17</sub> Cl              | 2-Chlorobornane               | 368.2 | 5.21         |             |              |              |         |
| C <sub>10</sub> H <sub>18</sub>                 | Pinane                        | 298.2 | 2.1456       |             |              |              |         |
| C <sub>10</sub> H <sub>18</sub>                 | cis-Decahydronaphthalene      | 293.2 | 2.219        | 0.25410E+01 | -0.11420E-02 | 0.15092E-06  | 293-373 |
| C <sub>10</sub> H <sub>18</sub>                 | trans-Decahydronaphthalene    | 293.2 | 2.184        | 0.26615E+01 | -0.21241E-02 | 0.16864E-05  | 293-373 |
| C <sub>10</sub> H <sub>18</sub> O               | Eucalyptol                    | 298.2 | 4.57         |             |              |              |         |
| C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>  | Cyclohexyl butanoate          | 293.2 | 4.58         |             |              |              |         |
| C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>  | Diethyl adipate               | 293.2 | 6.109        | 0.14824E+02 | -0.40749E-01 | 0.37600E-04  | 293-343 |
| C <sub>10</sub> H <sub>20</sub>                 | 1-Decene                      | 293.2 | 2.136        | 0.19091E+01 | 0.33442E-02  | -0.87500E-05 | 273-323 |
| C <sub>10</sub> H <sub>20</sub>                 | cis-5-Decene                  | 298.2 | 2.071        |             |              |              |         |

| Mol. form.                                                     | Name                                | T/K   | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|----------------------------------------------------------------|-------------------------------------|-------|--------------|--------------|--------------|--------------|---------|
| C <sub>10</sub> H <sub>20</sub>                                | <i>trans</i> -5-Decene              | 298.2 | 2.030        |              |              |              |         |
| C <sub>10</sub> H <sub>20</sub>                                | 5-Methyl-4-nonene                   | 293.2 | 2.175        |              |              |              |         |
| C <sub>10</sub> H <sub>20</sub>                                | 2,4,6-Trimethyl-3-heptene           | 293.2 | 2.293        |              |              |              |         |
| C <sub>10</sub> H <sub>20</sub> Br <sub>2</sub>                | 1,10-Dibromodecane                  | 303.2 | 6.56         | 0.17350E+02  | −0.50328E-01 | 0.48633E-04  | 303-368 |
| C <sub>10</sub> H <sub>20</sub> Cl <sub>2</sub>                | 1,10-Dichlorodecane                 | 308.2 | 6.68         | −0.57423E+01 | 0.94220E-01  | −0.17500E-03 | 308-338 |
| C <sub>10</sub> H <sub>20</sub> O                              | 2-Decanone                          | 287.2 | 8.3          |              |              |              |         |
| C <sub>10</sub> H <sub>20</sub> O                              | Menthol                             | 309.3 | 3.90         | 0.68202E+01  | −0.15894E-01 | 0.20837E-04  | 309-358 |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | 2,2-Dimethyloctanoic acid           | 296.2 | 2.8          |              |              |              |         |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Octyl acetate                       | 288.2 | 4.18         | −0.34691E+01 | 0.58106E-01  | −0.10952E-03 | 288-323 |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | 2-Methylheptyl acetate              | 288.2 | 4.27         | 0.23285E+02  | −0.11538E+00 | 0.17143E-03  | 288-323 |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Pentyl pentanoate                   | 305.6 | 4.076        | 0.77641E+01  | −0.14335E-01 | 0.73740E-05  | 306-393 |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Isopentyl pentanoate                | 292.2 | 3.6          |              |              |              |         |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Isopentyl isopentanoate             | 288.2 | 4.39         | 0.14698E+02  | −0.57726E-01 | 0.76190E-04  | 288-323 |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | Methyl nonanoate                    | 293.2 | 3.943        |              |              |              |         |
| C <sub>10</sub> H <sub>21</sub> Br                             | 1-Bromodecane                       | 298.2 | 4.44         | 0.11202E+02  | −0.33491E-01 | 0.36314E-04  | 274-328 |
| C <sub>10</sub> H <sub>21</sub> Cl                             | 1-Chlorodecane                      | 293.2 | 4.581        | 0.68741E+01  | −0.12210E-02 | −0.22500E-04 | 293-323 |
| C <sub>10</sub> H <sub>21</sub> NO                             | <i>N,N</i> -Dibutylacetamide        | 293.2 | 19.1         |              |              |              |         |
| C <sub>10</sub> H <sub>22</sub>                                | Decane                              | 293.2 | 1.9853       | 0.24054E+01  | −0.15445E-02 | 0.44643E-06  | 253-393 |
| C <sub>10</sub> H <sub>22</sub>                                | 2,7-Dimethyloctane                  | 293.2 | 1.98         |              |              |              |         |
| C <sub>10</sub> H <sub>22</sub>                                | 4-Propylheptane                     | 293.2 | 1.9955       |              |              |              |         |
| C <sub>10</sub> H <sub>22</sub> O                              | 1-Decanol                           | 293.2 | 7.93         | 0.47195E+02  | −0.20740E+00 | 0.24942E-03  | 293-343 |
| C <sub>10</sub> H <sub>22</sub> O                              | 2-Decanol                           | 298.2 | 5.82         | 0.13621E+03  | −0.81000E+00 | 0.12500E-02  | 288-308 |
| C <sub>10</sub> H <sub>22</sub> O                              | 3-Decanol                           | 298.2 | 4.05         | 0.52090E+02  | −0.31020E+00 | 0.50000E-03  | 288-308 |
| C <sub>10</sub> H <sub>22</sub> O                              | 4-Decanol                           | 298.2 | 3.42         | −0.11260E+02 | 0.93960E-01  | −0.15000E-03 | 288-308 |
| C <sub>10</sub> H <sub>22</sub> O                              | 5-Decanol                           | 298.2 | 3.24         | −0.25832E+01 | 0.31456E-01  | −0.40000E-04 | 288-308 |
| C <sub>10</sub> H <sub>22</sub> O                              | 2,2-Dimethyl-1-octanol              | 293.2 | 7.86         | 0.69536E+02  | −0.34596E+00 | 0.46250E-03  | 293-333 |
| C <sub>10</sub> H <sub>22</sub> O                              | Dipentyl ether                      | 298.2 | 2.798        |              |              |              |         |
| C <sub>10</sub> H <sub>22</sub> O                              | Diisopentyl ether                   | 293.2 | 2.817        | 0.44690E+01  | −0.63710E-02 | 0.25000E-05  | 293-323 |
| C <sub>10</sub> H <sub>22</sub> OS                             | Dipentyl sulfoxide                  | 348.2 | 18.8         |              |              |              |         |
| C <sub>10</sub> H <sub>22</sub> O <sub>5</sub>                 | Tetraethylene glycol dimethyl ether | 298.2 | 7.68         |              |              |              |         |
| C <sub>10</sub> H <sub>22</sub> S                              | Dipentyl sulfide                    | 298.2 | 3.826        |              |              |              |         |
| C <sub>10</sub> H <sub>23</sub> N                              | Decylamine                          | 293.2 | 3.31         | 0.61497E+01  | −0.12801E-01 | 0.10606E-04  | 293-373 |
| C <sub>10</sub> H <sub>30</sub> O <sub>3</sub> Si <sub>4</sub> | Decamethyltetrasiloxane             | 293.2 | 2.370        |              |              |              |         |
| C <sub>10</sub> H <sub>30</sub> O <sub>5</sub> Si <sub>5</sub> | Decamethylcyclopentasiloxane        | 293.2 | 2.50         |              |              |              |         |
| C <sub>11</sub> H <sub>10</sub>                                | 1-Methylnaphthalene                 | 293.2 | 2.915        | 0.45126E+01  | −0.76480E-02 | 0.75000E-05  | 293-333 |
| C <sub>11</sub> H <sub>10</sub>                                | 2-Methylnaphthalene                 | 313.2 | 2.747        |              |              |              |         |
| C <sub>11</sub> H <sub>10</sub> O                              | 1-Methoxynaphthalene                | 293.2 | 4.020        | 0.71885E+01  | −0.14838E-01 | 0.13750E-04  | 293-333 |
| C <sub>11</sub> H <sub>10</sub> O                              | 2-Methoxynaphthalene                | 353.2 | 3.563        | 0.56702E+01  | −0.69754E-02 | 0.28571E-05  | 353-373 |
| C <sub>11</sub> H <sub>12</sub> O <sub>2</sub>                 | Ethyl <i>trans</i> -cinnamate       | 293.2 | 5.63         |              |              |              |         |
| C <sub>11</sub> H <sub>12</sub> O <sub>3</sub>                 | Ethyl benzoylacetate                | 303.2 | 13.50        | 0.93644E+01  | 0.74280E-01  | −0.20000E-03 | 303-323 |
| C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | Benzyl butanoate                    | 301.2 | 4.55         |              |              |              |         |
| C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | Phenyl pentanoate                   | 293.2 | 4.30         |              |              |              |         |
| C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | Butyl benzoate                      | 303.2 | 5.52         | 0.77854E+01  | −0.34972E-02 | −0.13149E-04 | 303-358 |
| C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                 | Isobutyl benzoate                   | 291.2 | 5.39         |              |              |              |         |
| C <sub>11</sub> H <sub>16</sub>                                | 1,3-Diethyl-5-methylbenzene         | 293.2 | 2.264        |              |              |              |         |
| C <sub>11</sub> H <sub>16</sub>                                | Pentamethylbenzene                  | 334.0 | 2.358        | 0.30196E+01  | −0.22619E-02 | 0.83831E-06  | 334-413 |
| C <sub>11</sub> H <sub>22</sub>                                | 1-Undecene                          | 293.2 | 2.137        | 0.22132E+01  | 0.13121E-02  | −0.53571E-05 | 273-323 |
| C <sub>11</sub> H <sub>22</sub> O                              | 2-Undecanone                        | 285.3 | 8.3          |              |              |              |         |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                 | Nonyl acetate                       | 293.2 | 3.87         |              |              |              |         |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                 | Pentyl hexanoate                    | 288.2 | 4.22         | 0.83503E+01  | −0.18449E-01 | 0.14286E-04  | 288-323 |
| C <sub>11</sub> H <sub>23</sub> Br                             | 1-Bromoundecane                     | 272.6 | 4.61         |              |              |              |         |
| C <sub>11</sub> H <sub>24</sub>                                | Undecane                            | 293.2 | 1.9972       | 0.23637E+01  | −0.12500E-02 | −0.85869E-16 | 283-363 |
| C <sub>11</sub> H <sub>24</sub> O                              | 1-Undecanol                         | 313.2 | 5.98         |              |              |              |         |
| C <sub>11</sub> H <sub>25</sub> N                              | Undecylamine                        | 293.2 | 3.25         | 0.54945E+01  | −0.96161E-02 | 0.66017E-05  | 293-373 |
| C <sub>12</sub> F <sub>27</sub> N                              | Tris(perfluorobutyl)amine           | 293.2 | 2.15         |              |              |              |         |
| C <sub>12</sub> H <sub>8</sub> O                               | Dibenzofuran                        | 373.2 | 3.00         |              |              |              |         |
| C <sub>12</sub> H <sub>10</sub>                                | Biphenyl                            | 348.2 | 2.53         | 0.26869E+01  | 0.63072E-03  | −0.30995E-05 | 348-428 |
| C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O               | <i>trans</i> -Azoxybenzene          | 311.2 | 5.2          |              |              |              |         |
| C <sub>12</sub> H <sub>10</sub> O                              | Diphenyl ether                      | 283.2 | 3.726        |              |              |              |         |
| C <sub>12</sub> H <sub>10</sub> O                              | 2-Acetonaphthone                    | 333.2 | 13.03        | 0.14538E+03  | −0.73040E+00 | 0.10000E-02  | 333-363 |
| C <sub>12</sub> H <sub>10</sub> OS                             | Diphenyl sulfoxide                  | 344.7 | 16.6         |              |              |              |         |
| C <sub>12</sub> H <sub>10</sub> O <sub>2</sub> S               | Diphenyl sulfone                    | 406.2 | 21.1         |              |              |              |         |
| C <sub>12</sub> H <sub>10</sub> S                              | Diphenyl sulfide                    | 298.2 | 5.43         |              |              |              |         |

| Mol. form.                                        | Name                                       | T/K    | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|---------------------------------------------------|--------------------------------------------|--------|--------------|--------------|--------------|--------------|---------|
| C <sub>12</sub> H <sub>11</sub> N                 | Diphenylamine                              | 323.2  | 3.73         |              |              |              |         |
| C <sub>12</sub> H <sub>11</sub> NO                | <i>N</i> -1-Naphthylenylacetamide          | 433.2  | 24.3         | 0.84739E+02  | -0.12391E+00 | -0.35714E-04 | 433-533 |
| C <sub>12</sub> H <sub>12</sub>                   | 1,6-Dimethylnaphthalene                    | 293.2  | 2.7250       |              |              |              |         |
| C <sub>12</sub> H <sub>12</sub> O                 | 1-Ethoxynaphthalene                        | 292.2  | 3.3          |              |              |              |         |
| C <sub>12</sub> H <sub>14</sub> O <sub>2</sub>    | Propyl cinnamate                           | 293.2  | 5.45         |              |              |              |         |
| C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>    | Diethyl phthalate                          | 293.2  | 7.86         |              |              |              |         |
| C <sub>12</sub> H <sub>16</sub> O                 | 2-Cyclohexylphenol                         | 328.2  | 3.97         |              |              |              |         |
| C <sub>12</sub> H <sub>16</sub> O                 | 4-Cyclohexylphenol                         | 404.2  | 4.42         |              |              |              |         |
| C <sub>12</sub> H <sub>16</sub> O <sub>2</sub>    | Pentyl benzoate                            | 293.2  | 5.07         |              |              |              |         |
| C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>    | Pentyl salicylate                          | 301.2  | 6.25         |              |              |              |         |
| C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>    | Isopentyl salicylate                       | 293.12 | 7.26         | 0.13129E+02  | -0.19190E-01 | -0.36060E-05 | 225-397 |
| C <sub>12</sub> H <sub>17</sub> NO                | <i>N</i> -Butyl- <i>N</i> -phenylacetamide | 298.2  | 11.66        |              |              |              |         |
| C <sub>12</sub> H <sub>18</sub>                   | Hexylbenzene                               | 293.2  | 2.3          |              |              |              |         |
| C <sub>12</sub> H <sub>18</sub>                   | 1,3,5-Triethylbenzene                      | 293.2  | 2.256        |              |              |              |         |
| C <sub>12</sub> H <sub>18</sub>                   | Hexamethylbenzene                          | 449.0  | 2.172        | 0.35710E+01  | -0.46912E-02 | 0.35088E-05  | 449-489 |
| C <sub>12</sub> H <sub>20</sub> O <sub>2</sub>    | <i>l</i> -Bornyl acetate                   | 303.2  | 4.46         | 0.60791E+01  | 0.98200E-02  | -0.50000E-04 | 303-323 |
| C <sub>12</sub> H <sub>22</sub> O                 | Dicyclohexyl ether                         | 293.2  | 3.45         | 0.95324E+01  | -0.31740E-01 | 0.37500E-04  | 293-333 |
| C <sub>12</sub> H <sub>22</sub> O                 | Cyclododecanone                            | 303.2  | 11.4         | 0.39327E+02  | -0.13248E+00 | 0.13298E-03  | 303-423 |
| C <sub>12</sub> H <sub>22</sub> O <sub>6</sub>    | Dibutyl tartrate                           | 314.2  | 9.4          |              |              |              |         |
| C <sub>12</sub> H <sub>24</sub>                   | 1-Dodecene                                 | 293.2  | 2.152        | 0.22581E+01  | 0.11106E-02  | -0.50000E-05 | 273-323 |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>    | Decyl acetate                              | 293.2  | 3.75         |              |              |              |         |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>    | Ethyl decanoate                            | 293.2  | 3.75         | 0.70969E+01  | -0.15080E-01 | 0.12500E-04  | 293-353 |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>    | Methyl undecanoate                         | 293.2  | 3.671        |              |              |              |         |
| C <sub>12</sub> H <sub>25</sub> Br                | 1-Bromododecane                            | 298.2  | 4.07         | 0.86103E+01  | -0.20891E-01 | 0.18994E-04  | 274-328 |
| C <sub>12</sub> H <sub>25</sub> Cl                | 1-Chlorododecane                           | 298.2  | 4.17         | 0.10002E+02  | -0.27798E-01 | 0.27559E-04  | 274-328 |
| C <sub>12</sub> H <sub>25</sub> I                 | 1-Iodododecane                             | 298.2  | 3.91         | 0.34641E+01  | 0.97404E-02  | -0.27602E-04 | 293-323 |
| C <sub>12</sub> H <sub>26</sub>                   | Dodecane                                   | 293.2  | 2.0120       | 0.23697E+01  | -0.12200E-02 | -0.36375E-16 | 283-363 |
| C <sub>12</sub> H <sub>26</sub> O                 | 1-Dodecanol                                | 303.2  | 5.82         | 0.18518E+02  | -0.44859E-01 | 0.99900E-05  | 303-358 |
| C <sub>12</sub> H <sub>26</sub> O                 | 2-Butyl-1-octanol                          | 363.2  | 3.28         |              |              |              |         |
| C <sub>12</sub> H <sub>27</sub> BO <sub>3</sub>   | Tributyl borate                            | 293.2  | 2.23         |              |              |              |         |
| C <sub>12</sub> H <sub>27</sub> N                 | Dodecylamine                               | 303.2  | 3.07         | 0.27999E+01  | 0.44810E-02  | -0.11905E-04 | 303-373 |
| C <sub>12</sub> H <sub>27</sub> N                 | Tributylamine                              | 293.2  | 2.340        | 0.19846E+01  | 0.28108E-02  | -0.54545E-05 | 233-293 |
| C <sub>12</sub> H <sub>27</sub> O <sub>4</sub> P  | Tributyl phosphate                         | 293.2  | 8.34         | 0.26304E+02  | -0.88480E-01 | 0.92857E-04  | 293-373 |
| C <sub>12</sub> H <sub>28</sub> O <sub>4</sub> Si | Tetrapropoxysilane                         | 298.2  | 3.21         |              |              |              |         |
| C <sub>12</sub> H <sub>28</sub> Sn                | Tetrapropylstannane                        | 293.2  | 2.267        |              |              |              |         |
| C <sub>12</sub> H <sub>30</sub> OSi <sub>2</sub>  | Hexaethyldisiloxane                        | 298.2  | 2.259        | 0.36559E+01  | -0.72406E-02 | 0.85714E-05  | 298-333 |
| C <sub>13</sub> H <sub>10</sub> O                 | Benzophenone                               | 300.2  | 12.62        | 0.34130E+02  | -0.10249E+00 | 0.10268E-03  | 300-420 |
| C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>    | Phenyl salicylate                          | 290.2  | 6.92         | 0.26545E+02  | -0.11180E+00 | 0.15220E-03  | 290-358 |
| C <sub>13</sub> H <sub>12</sub>                   | Diphenylmethane                            | 303.2  | 2.540        | 0.30638E+01  | -0.17286E-02 |              | 303-333 |
| C <sub>13</sub> H <sub>12</sub> O                 | Benzyl phenyl ether                        | 313.2  | 3.748        |              |              |              |         |
| C <sub>13</sub> H <sub>18</sub> O <sub>2</sub>    | Hexyl benzoate                             | 293.2  | 4.80         |              |              |              |         |
| C <sub>13</sub> H <sub>20</sub>                   | Heptylbenzene                              | 293.2  | 2.26         |              |              |              |         |
| C <sub>13</sub> H <sub>20</sub> O                 | $\alpha$ -Ionone*                          | 292.4  | 10.78        |              |              |              |         |
| C <sub>13</sub> H <sub>20</sub> O                 | $\beta$ -Ionone*                           | 297.65 | 11.66        |              |              |              |         |
| C <sub>13</sub> H <sub>24</sub> O <sub>4</sub>    | Diethyl nonanedioate                       | 303.2  | 5.133        |              |              |              |         |
| C <sub>13</sub> H <sub>26</sub>                   | 1-Tridecene                                | 293.2  | 2.139        | 0.14154E+01  | 0.66514E-02  | -0.14286E-04 | 273-323 |
| C <sub>13</sub> H <sub>26</sub> O                 | 7-Tridecanone                              | 303.2  | 7.6          |              |              |              |         |
| C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>    | Ethyl undecanoate                          | 293.2  | 3.55         |              |              |              |         |
| C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>    | Methyl dodecanoate                         | 293.2  | 3.539        |              |              |              |         |
| C <sub>13</sub> H <sub>27</sub> Br                | 1-Bromotridecane                           | 281.15 | 4.19         |              |              |              |         |
| C <sub>13</sub> H <sub>28</sub>                   | Tridecane                                  | 293.2  | 2.0213       | 0.23731E+01  | -0.12000E-02 | -0.21841E-15 | 283-363 |
| C <sub>13</sub> H <sub>28</sub>                   | 5-Butylnonane                              | 293.2  | 2.0319       |              |              |              |         |
| C <sub>13</sub> H <sub>28</sub> O                 | 1-Tridecanol                               | 333.2  | 4.02         |              |              |              |         |
| C <sub>14</sub> H <sub>10</sub>                   | Anthracene                                 | 502.0  | 2.649        | 0.20571E+02  | -0.69169E-01 | 0.66667E-04  | 502-516 |
| C <sub>14</sub> H <sub>10</sub>                   | Phenanthrene                               | 383.2  | 2.72         |              |              |              |         |
| C <sub>14</sub> H <sub>10</sub> O <sub>2</sub>    | Benzil                                     | 368.2  | 13.04        | -0.23599E+02 | 0.22715E+00  | -0.34667E-03 | 368-393 |
| C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>    | Benzyl benzoate                            | 303.2  | 5.26         | 0.76856E+01  | -0.80000E-02 | -0.80361E-15 | 303-358 |
| C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>    | Benzyl salicylate                          | 301.2  | 4.12         |              |              |              |         |
| C <sub>14</sub> H <sub>14</sub>                   | 1,2-Diphenylethane                         | 331.2  | 2.47         | 0.31178E+01  | -0.21572E-02 | 0.59800E-06  | 331-451 |
| C <sub>14</sub> H <sub>14</sub> O                 | Dibenzyl ether                             | 293.2  | 3.821        | 0.80154E+01  | -0.20536E-01 | 0.21250E-04  | 293-333 |
| C <sub>14</sub> H <sub>15</sub> N                 | Dibenzylamine                              | 293.2  | 3.446        |              |              |              |         |
| C <sub>14</sub> H <sub>16</sub> O <sub>2</sub> Si | Dimethyldiphenoxysilane                    | 298.2  | 3.500        | 0.51669E+01  | -0.77001E-02 | 0.70156E-05  | 283-353 |
| C <sub>14</sub> H <sub>18</sub> O <sub>2</sub>    | Pentyl cinnamate                           | 293.2  | 4.89         |              |              |              |         |

| Mol. form.                                        | Name                         | <i>T</i> /K | $\epsilon_r$ | <i>a</i>    | <i>b</i>     | <i>c</i>     | Range/K |
|---------------------------------------------------|------------------------------|-------------|--------------|-------------|--------------|--------------|---------|
| C <sub>14</sub> H <sub>22</sub>                   | Octylbenzene                 | 293.2       | 2.26         |             |              |              |         |
| C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>    | Diisobutyl adipate           | 293.2       | 5.19         |             |              |              |         |
| C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>    | Diethyl sebacate             | 303.2       | 4.995        | 0.39143E+02 | −0.20965E+00 | 0.32000E-03  | 303-313 |
| C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>    | Dodecyl acetate              | 293.2       | 3.6          |             |              |              |         |
| C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>    | Ethyl laurate                | 273.2       | 3.94         |             |              |              |         |
| C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>    | Methyl tridecanoate          | 293.2       | 3.442        |             |              |              |         |
| C <sub>14</sub> H <sub>29</sub> Br                | 1-Bromotetradecane           | 293.2       | 3.84         | 0.10058E+02 | −0.33905E-01 | 0.43528E-04  | 274-328 |
| C <sub>14</sub> H <sub>30</sub>                   | Tetradecane                  | 293.2       | 2.0343       | 0.23832E+01 | −0.11900E-02 | −0.51229E-16 | 283-363 |
| C <sub>14</sub> H <sub>30</sub> O                 | 1-Tetradecanol               | 318.2       | 4.42         | 0.12272E+02 | −0.24667E-01 | −0.13168E-13 | 318-358 |
| C <sub>14</sub> H <sub>31</sub> N                 | Tetradecylamine              | 312.55      | 2.90         |             |              |              |         |
| C <sub>15</sub> H <sub>12</sub> O <sub>4</sub>    | Phenyl 2-(acetyloxy)benzoate | 384.2       | 4.33         |             |              |              |         |
| C <sub>15</sub> H <sub>26</sub> O <sub>6</sub>    | Tributylin                   | 282.8       | 5.72         | 0.13152E+02 | −0.36684E-01 | 0.36795E-04  | 199-283 |
| C <sub>15</sub> H <sub>30</sub> O <sub>2</sub>    | Methyl tetradecanoate        | 293.2       | 3.352        |             |              |              |         |
| C <sub>15</sub> H <sub>31</sub> Br                | 1-Bromopentadecane           | 293.35      | 3.88         |             |              |              |         |
| C <sub>15</sub> H <sub>32</sub>                   | Pentadecane                  | 293.2       | 2.0391       | 0.23792E+01 | −0.11600E-02 | −0.71069E-16 | 283-363 |
| C <sub>15</sub> H <sub>32</sub> O                 | 1-Pentadecanol               | 333.2       | 3.70         |             |              |              |         |
| C <sub>15</sub> H <sub>33</sub> N                 | Pentadecylamine              | 313.25      | 2.85         |             |              |              |         |
| C <sub>15</sub> H <sub>33</sub> N                 | Triisopentylamine            | 294.2       | 2.29         |             |              |              |         |
| C <sub>16</sub> H <sub>22</sub> O <sub>4</sub>    | Dibutyl phthalate            | 293.2       | 6.58         | 0.12444E+02 | −0.20000E-01 |              | 293-333 |
| C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>    | Hexadecanoic acid            | 338.2       | 2.417        |             |              |              |         |
| C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>    | Ethyl myristate              | 293.2       | 3.50         | 0.52642E+01 | −0.60000E-02 | −0.47358E-15 | 293-353 |
| C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>    | Methyl pentadecanoate        | 293.2       | 3.296        |             |              |              |         |
| C <sub>16</sub> H <sub>33</sub> Br                | 1-Bromohexadecane            | 298.2       | 3.68         | 0.58668E+01 | −0.73333E-02 | −0.52666E-14 | 298-328 |
| C <sub>16</sub> H <sub>33</sub> I                 | 1-Iodohexadecane             | 293.2       | 3.57         | 0.79531E+01 | −0.22859E-01 | 0.26955E-04  | 293-323 |
| C <sub>16</sub> H <sub>34</sub>                   | Hexadecane                   | 293.2       | 2.0460       | 0.23861E+01 | −0.11600E-02 | 0.25555E-15  | 293-363 |
| C <sub>16</sub> H <sub>34</sub> O                 | 1-Hexadecanol                | 333.2       | 3.69         | 0.85935E+01 | −0.14714E-01 | −0.45533E-13 | 333-363 |
| C <sub>16</sub> H <sub>35</sub> N                 | Hexadecylamine               | 328.35      | 2.71         |             |              |              |         |
| C <sub>16</sub> H <sub>36</sub> Sn                | Tetrabutylstannane           | 293.2       | 9.74         | 0.56115E+02 | −0.24812E+00 | 0.30682E-03  | 293-313 |
| C <sub>17</sub> H <sub>12</sub> O <sub>3</sub>    | 2-Naphthyl salicylate        | 293.0       | 6.30         | 0.11229E+02 | −0.18857E-01 | 0.70332E-05  | 293-353 |
| C <sub>17</sub> H <sub>34</sub> O                 | 9-Heptadecanone              | 328.2       | 5.43         | 0.44176E+02 | −0.21183E+00 | 0.28571E-03  | 328-363 |
| C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>    | Methyl palmitate             | 313.2       | 3.124        |             |              |              |         |
| C <sub>17</sub> H <sub>36</sub>                   | Heptadecane                  | 293.2       | 2.0578       | 0.23627E+01 | −0.10400E-02 | −0.10397E-12 | 293-308 |
| C <sub>17</sub> H <sub>36</sub> O                 | 1-Heptadecanol               | 333.2       | 3.41         |             |              |              |         |
| C <sub>18</sub> H <sub>26</sub> O <sub>4</sub>    | Dipentyl phthalate           | 293.2       | 6.00         |             |              |              |         |
| C <sub>18</sub> H <sub>28</sub> O <sub>2</sub>    | Phenyl laurate               | 293.2       | 3.28         |             |              |              |         |
| C <sub>18</sub> H <sub>30</sub> O <sub>2</sub>    | Linolenic acid               | 293.2       | 2.825        | 0.33867E+01 | −0.19181E-02 |              | 274-368 |
| C <sub>18</sub> H <sub>30</sub> O <sub>4</sub>    | Dicyclohexyl adipate         | 308.2       | 4.84         |             |              |              |         |
| C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>    | Linoleic acid                | 293.2       | 2.754        | 0.32073E+01 | −0.15477E-02 |              | 275-368 |
| C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>    | Oleic acid                   | 293.2       | 2.336        | 0.25385E+01 | −0.69448E-03 |              | 275-368 |
| C <sub>18</sub> H <sub>34</sub> O <sub>4</sub>    | Dibutyl sebacate             | 293.2       | 4.54         |             |              |              |         |
| C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>    | Stearic acid                 | 293.2       | 2.314        | 0.27159E+01 | −0.13300E-02 |              | 293-373 |
| C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>    | Hexadecyl acetate            | 308.2       | 3.19         | 0.47310E+01 | −0.50000E-02 | 0.41338E-14  | 308-348 |
| C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>    | Ethyl palmitate              | 303.2       | 3.07         | 0.57938E+01 | −0.12294E-01 | 0.10919E-04  | 303-455 |
| C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>    | Methyl heptadecanoate        | 313.2       | 3.07         |             |              |              |         |
| C <sub>18</sub> H <sub>37</sub> Br                | 1-Bromooctadecane            | 303.35      | 3.53         | 0.46790E+01 | −0.30355E-02 | −0.24798E-05 | 303-332 |
| C <sub>18</sub> H <sub>38</sub> O                 | 1-Octadecanol                | 333.2       | 3.38         | 0.73784E+01 | −0.12000E-01 | −0.22871E-13 | 333-363 |
| C <sub>18</sub> H <sub>39</sub> BO <sub>3</sub>   | Trihexyl borate              | 293.2       | 2.22         |             |              |              |         |
| C <sub>18</sub> H <sub>39</sub> N                 | Octadecylamine               | 326.35      | 2.67         |             |              |              |         |
| C <sub>19</sub> H <sub>16</sub>                   | Triphenylmethane             | 367.2       | 2.46         | 0.40201E+01 | −0.66507E-02 | 0.65329E-05  | 367-448 |
| C <sub>19</sub> H <sub>18</sub> O <sub>3</sub> Si | Methyltriphenoxysilane       | 298.2       | 3.628        |             |              |              |         |
| C <sub>19</sub> H <sub>32</sub> O <sub>2</sub>    | Methyl linolenate            | 293.2       | 3.355        |             |              |              |         |
| C <sub>19</sub> H <sub>34</sub> O <sub>2</sub>    | Methyl linoleate             | 293.2       | 3.466        |             |              |              |         |
| C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>    | Methyl oleate                | 293.2       | 3.211        |             |              |              |         |
| C <sub>19</sub> H <sub>38</sub> O                 | 10-Nonadecanone              | 353.2       | 5.37         |             |              |              |         |
| C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>    | Methyl stearate              | 313.2       | 3.021        |             |              |              |         |
| C <sub>19</sub> H <sub>40</sub>                   | Nonadecane                   | 293.2       | 2.0706       |             |              |              |         |
| C <sub>20</sub> H <sub>30</sub> O <sub>4</sub>    | Dihexyl phthalate            | 293.2       | 5.62         |             |              |              |         |
| C <sub>20</sub> H <sub>38</sub> O <sub>2</sub>    | Ethyl oleate                 | 301.2       | 3.17         | 0.57033E+01 | −0.11223E-01 | 0.93447E-05  | 301-423 |
| C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>    | Octadecyl acetate            | 308.2       | 3.07         | 0.44569E+01 | −0.45000E-02 | 0.33923E-14  | 308-348 |
| C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>    | Ethyl stearate               | 313.2       | 2.958        | 0.70930E+01 | −0.19081E-01 | 0.19555E-04  | 331-440 |
| C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>    | Methyl nonadecanoate         | 313.2       | 2.982        |             |              |              |         |
| C <sub>20</sub> H <sub>42</sub> O                 | 1-Eicosanol                  | 338.2       | 3.13         | 0.21700E+01 | 0.12497E-01  | −0.28571E-04 | 338-363 |
| C <sub>20</sub> H <sub>42</sub> O                 | Didecyl ether                | 293.2       | 2.644        | 0.41465E+01 | −0.62240E-02 | 0.37500E-05  | 293-333 |

| Mol. form.                                                     | Name                                  | T/K   | $\epsilon_r$ | <i>a</i>     | <i>b</i>     | <i>c</i>     | Range/K |
|----------------------------------------------------------------|---------------------------------------|-------|--------------|--------------|--------------|--------------|---------|
| C <sub>20</sub> H <sub>60</sub> O <sub>8</sub> Si <sub>9</sub> | Eicosamethylnonasiloxane              | 293.2 | 2.645        | 0.57840E+01  | -0.16568E-01 | 0.20000E-04  | 293-323 |
| C <sub>21</sub> H <sub>21</sub> O <sub>4</sub> P               | Tricresyl phosphate*                  | 298.2 | 6.7          |              |              |              |         |
| C <sub>21</sub> H <sub>38</sub> O <sub>6</sub>                 | 1,2,3-Propanetriyl hexanoate          | 293.2 | 4.476        |              |              |              |         |
| C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>                 | Butyl oleate                          | 298.2 | 4.00         |              |              |              |         |
| C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>                 | Butyl stearate                        | 298.2 | 3.120        | 0.73894E+02  | -0.46261E+00 | 0.75500E-03  | 298-343 |
| C <sub>22</sub> H <sub>46</sub>                                | Docosane                              | 293.2 | 2.0840       |              |              |              |         |
| C <sub>22</sub> H <sub>46</sub> O                              | 1-Docosanol                           | 348.2 | 2.94         | 0.82062E+01  | -0.25069E-01 | 0.28571E-04  | 348-373 |
| C <sub>24</sub> H <sub>20</sub> O <sub>4</sub> Si              | Tetraphenoxysilane                    | 333.2 | 3.4915       |              |              |              |         |
| C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                 | Diocetyl phthalate                    | 293.2 | 5.22         |              |              |              |         |
| C <sub>26</sub> H <sub>50</sub> O <sub>4</sub>                 | Diocetyl sebacate                     | 299.2 | 4.01         |              |              |              |         |
| C <sub>27</sub> H <sub>50</sub> O <sub>6</sub>                 | 1,2,3-Propanetriyl octanoate          | 293.2 | 3.931        |              |              |              |         |
| C <sub>30</sub> H <sub>58</sub> O <sub>4</sub>                 | Ethylene glycol ditetradecanoate      | 343.2 | 2.98         |              |              |              |         |
| C <sub>30</sub> H <sub>62</sub>                                | Triacontane                           | 373.2 | 1.9112       |              |              |              |         |
| C <sub>30</sub> H <sub>62</sub>                                | 2,6,10,15,19,23-Hexamethyltetracosane | 373.2 | 1.9106       |              |              |              |         |
| C <sub>34</sub> H <sub>66</sub> O <sub>4</sub>                 | Ethylene glycol dipalmitate           | 348.2 | 2.89         |              |              |              |         |
| C <sub>34</sub> H <sub>68</sub> O <sub>2</sub>                 | Hexadecyl stearate                    | 333.2 | 2.61         |              |              |              |         |
| C <sub>38</sub> H <sub>74</sub> O <sub>4</sub>                 | Ethylene glycol distearate            | 353.2 | 2.79         |              |              |              |         |
| C <sub>39</sub> H <sub>74</sub> O <sub>6</sub>                 | Glycerol trilaurate                   | 313.2 | 3.287        |              |              |              |         |
| C <sub>51</sub> H <sub>98</sub> O <sub>6</sub>                 | Glycerol tripalmitate                 | 328.2 | 2.901        | -0.29131E+01 | 0.32206E-01  | -0.44154E-04 | 328-393 |
| C <sub>57</sub> H <sub>104</sub> O <sub>6</sub>                | Glycerol trioleate                    | 293.2 | 3.109        |              |              |              |         |
| C <sub>57</sub> H <sub>104</sub> O <sub>6</sub>                | Glycerol trielaidate                  | 313.2 | 2.980        |              |              |              |         |
| C <sub>57</sub> H <sub>110</sub> O <sub>6</sub>                | Glycerol tristearate                  | 353.2 | 2.740        |              |              |              |         |

\* Isomer was not specified in the original reference.

\*\* Cubic term is needed; see introduction.



## PERMITTIVITY (DIELECTRIC CONSTANT) OF GASES

This table gives the relative permittivity  $\epsilon$  (often called the dielectric constant) of some common gases at a temperature of 20 °C and pressure of one atmosphere (101.325 kPa). Values of the permanent dipole moment  $\mu$  in Debye Units (1 D =  $3.33564 \times 10^{-30}$  C m) are also included.

The density dependence of the permittivity is given by the equation

$$\frac{\epsilon - 1}{\epsilon - 2} = \rho_m \left( \frac{4\pi N \alpha}{3} + \frac{4\pi N \mu^2}{9kT} \right)$$

where  $\rho_m$  is the molar density,  $N$  is Avogadro's number,  $k$  is the Boltzmann constant,  $T$  is the temperature, and  $\alpha$  is the molecular polarizability. Therefore, in regions where the gas can be considered ideal,  $\epsilon - 1$  is approximately proportional to the pressure at constant temperature. For nonpolar gases ( $\mu = 0$ ),  $\epsilon - 1$  is inversely proportional to temperature at constant pressure.

The number of significant figures indicates the accuracy of the values given. The values of  $\epsilon$  for air, Ar, H<sub>2</sub>, He, N<sub>2</sub>, O<sub>2</sub>, and CO<sub>2</sub> are recommended as reference values; these are accurate to 1 ppm or better.

The second part of the table gives the permittivity of water vapor in equilibrium with liquid water as a function of temperature (derived from Reference 4).

### References

1. A. A. Maryott and F. Buckley, *Table of Dielectric Constants and Electric Dipole Moments of Substances in the Gaseous State*, National Bureau of Standards Circular 537, 1953.
2. B. A. Younglove, *J. Phys. Chem. Ref. Data*, 11, Suppl. 1, 1982; 16, 577, 1987 (for data on N<sub>2</sub>, H<sub>2</sub>, O<sub>2</sub>, and hydrocarbons over a range of pressure and temperature).
3. *Landolt-Börnstein, Numerical Data and Functional Relationships in Science and Technology*, New Series, Group IV, Vol. 4, Springer-Verlag, Heidelberg, 1980 (for data at high pressures).
4. G. Birnbaum and S. K. Chatterjee, *J. Appl. Phys.*, 23, 220, 1952 (for data on water vapor).

| Mol. form.                             | Name                            | $\epsilon$ | $\mu/D$ |
|----------------------------------------|---------------------------------|------------|---------|
| <i>Compounds not containing carbon</i> |                                 |            |         |
|                                        | Air (dry, CO <sub>2</sub> free) | 1.0005364  |         |
| Ar                                     | Argon                           | 1.0005172  | 0       |
| BF <sub>3</sub>                        | Boron trifluoride               | 1.0011     | 0       |
| BrH                                    | Hydrogen bromide                | 1.00279    | 0.827   |
| ClH                                    | Hydrogen chloride               | 1.00390    | 1.109   |
| F <sub>3</sub> N                       | Nitrogen trifluoride            | 1.0013     | 0.235   |
| F <sub>6</sub> S                       | Sulfur hexafluoride             | 1.00200    | 0       |
| HI                                     | Hydrogen iodide                 | 1.00214    | 0.448   |
| H <sub>2</sub>                         | Hydrogen                        | 1.0002538  | 0       |
| H <sub>2</sub> S                       | Hydrogen sulfide                | 1.00344    | 0.97    |
| H <sub>3</sub> N                       | Ammonia                         | 1.00622    | 1.471   |
| He                                     | Helium                          | 1.0000650  | 0       |
| Kr                                     | Krypton                         | 1.00078    | 0       |
| NO                                     | Nitric oxide                    | 1.00060    | 0.159   |
| N <sub>2</sub>                         | Nitrogen                        | 1.0005480  | 0       |
| N <sub>2</sub> O                       | Nitrous oxide                   | 1.00104    | 0.161   |
| Ne                                     | Neon                            | 1.00013    | 0       |
| O <sub>2</sub>                         | Oxygen                          | 1.0004947  | 0       |
| O <sub>2</sub> S                       | Sulfur dioxide                  | 1.00825    | 1.633   |
| O <sub>3</sub>                         | Ozone                           | 1.0017     | 0.534   |
| Xe                                     | Xenon                           | 1.00126    | 0       |

| Mol. form.                         | Name               | $\epsilon$ | $\mu/D$ |
|------------------------------------|--------------------|------------|---------|
| <i>Compounds containing carbon</i> |                    |            |         |
| CF <sub>4</sub>                    | Tetrafluoromethane | 1.00121    | 0       |
| CO                                 | Carbon monoxide    | 1.00065    | 0.110   |
| CO <sub>2</sub>                    | Carbon dioxide     | 1.000922   | 0       |
| CH <sub>3</sub> Br                 | Bromomethane       | 1.01028    | 1.822   |
| CH <sub>3</sub> Cl                 | Chloromethane      | 1.01080    | 1.892   |
| CH <sub>3</sub> F                  | Fluoromethane      | 1.00973    | 1.858   |
| CH <sub>3</sub> I                  | Iodomethane        | 1.00914    | 1.62    |
| CH <sub>4</sub>                    | Methane            | 1.00081    | 0       |
| C <sub>2</sub> H <sub>2</sub>      | Acetylene          | 1.00124    | 0       |
| C <sub>2</sub> H <sub>3</sub> Cl   | Chloroethylene     | 1.0075     | 1.45    |
| C <sub>2</sub> H <sub>4</sub>      | Ethylene           | 1.00134    | 0       |
| C <sub>2</sub> H <sub>5</sub> Cl   | Chloroethane       | 1.01325    | 2.05    |
| C <sub>2</sub> H <sub>6</sub>      | Ethane             | 1.00140    | 0       |
| C <sub>2</sub> H <sub>6</sub> O    | Dimethyl ether     | 1.0062     | 1.30    |
| C <sub>3</sub> H <sub>6</sub>      | Propene            | 1.00228    | 0.366   |
| C <sub>3</sub> H <sub>6</sub>      | Cyclopropane       | 1.00178    | 0       |
| C <sub>3</sub> H <sub>8</sub>      | Propane            | 1.00200    | 0.084   |
| C <sub>4</sub> H <sub>10</sub>     | Butane             | 1.00258    | 0       |
| C <sub>4</sub> H <sub>10</sub>     | Isobutane          | 1.00260    | 0.132   |

### Permittivity of Saturated Water Vapor

| $t/^{\circ}\text{C}$ | $\epsilon$ | $t/^{\circ}\text{C}$ | $\epsilon$ |
|----------------------|------------|----------------------|------------|
| 0                    | 1.00006    | 60                   | 1.00143    |
| 10                   | 1.00012    | 70                   | 1.00211    |
| 20                   | 1.00021    | 80                   | 1.00304    |
| 30                   | 1.00036    | 90                   | 1.00428    |
| 40                   | 1.00059    | 100                  | 1.00589    |
| 50                   | 1.00094    |                      |            |

# AZEOTROPIC DATA FOR BINARY MIXTURES

J. Gmehling, J. Menke, J. Krafczyk, K. Fischer, J.-C. Fontaine, and H. V. Kehiaian

Binary homogeneous (single-phase) liquid mixtures having an extremum (maximum or minimum) vapor pressure  $P$  at constant temperature  $T$ , as a function of composition, are called azeotropic mixtures, or simply azeotropes. The composition is usually expressed as mole fractions, where  $x_1$  for component 1 in the liquid phase and  $y_1$  for component 1 in the vapor phase are identical. Mixtures that do not show a maximum or minimum are called zeotropic. A maximum (minimum) of the  $P(x_1)$  or  $P(y_1)$  curves corresponds to a minimum (maximum) of the boiling temperature  $T$  at constant  $P$ , plotted as a function of  $x_1$  or  $y_1$  [see  $T(x_1)$  and  $T(y_1)$  curves, Types I and III, in Fig.1]. Azeotropes in which the pressure is a maximum (temperature is a minimum) are often called positive azeotropes, while pressure-minimum (temperature-maximum) azeotropes are called negative azeotropes. The coordinates of an azeotropic point are the azeotropic temperature  $T_{Az}$ , pressure  $P_{Az}$ , and the vapor-phase composition  $y_{1,Az}$ , which is the same as the liquid-phase composition  $x_{1,Az}$ .

In the two-phase liquid-liquid region of partially miscible (heterogeneous) mixtures, the vapor pressure at constant  $T$  (or the boiling temperature at constant  $P$ ) is independent of the global composition  $x_1$  of the two coexisting liquid phases between the equilibrium compositions  $x_1'$  and  $x_1''$  ( $x_1' < x_1''$ ).

The constant vapor pressure (boiling temperature) above the two-phase region of certain partially miscible mixtures is usually larger (smaller) than the vapor pressure (boiling temperature) at any other liquid-phase composition in the homogeneous region. In this case, the vapor-phase composition is inside the miscibility gap. Mixtures of this type are called heteroazeotropic mixtures, or simply heteroazeotropes. (Fig. 1, Type II), as opposed to the other types of azeotropes, called homoazeotropes.

Only in a few cases partially miscible mixtures present a positive or negative azeotropic point in the single-phase region, outside the miscibility gap, similar to the azeotropic points of homogeneous mixtures (Fig. 1, Types IV and VI).

A few binary mixtures, for example the system perfluorobenzene + benzene, may present two azeotropic points at constant temperature (pressure), a positive and a negative one. They are called double azeotropic mixtures, or simply double azeotropes. (Fig. 1, Type V).

The knowledge of the occurrence of azeotropic points in binary and higher systems is of special importance for the design of distillation processes. The number of theoretical stages of a distillation column required for the separation depends on the separation factor  $\alpha_{12}$ , i.e. the ratio of the  $K_i$ -factors ( $K_i = y_i/x_i$ ) of the components  $i$  ( $i = 1, 2$ ). The required separation factor can be calculated with the following simplified relation (Reference 1):

$$\alpha_{12} = K_1/K_2 = (y_1/x_1)/(y_2/x_2) = (\gamma_1 P_1^s)/(\gamma_2 P_2^s) \quad (1)$$

where  $\gamma_i$  is the activity coefficient of component  $i$  in the liquid phase and  $P_i^s$  is the vapor pressure of the pure component  $i$ .

In distillation processes, only the difference between the separation factor and unity ( $\alpha_{12} - 1$ ) can be exploited for the separation. If the separation factor is close to unity, a large number of theoretical stages is required for the separation. If the binary system to be separated shows an azeotropic point ( $\alpha_{12} = 1$ ), the separation is impossible by ordinary distillation, even with an infinitely large number of stages.

Following eq. (1) azeotropic behavior will always occur in homogeneous binary systems when the vapor pressure ratio  $P_1^s/P_2^s$  is equal to the ratio of the activity coefficients  $\gamma_2/\gamma_1$ .

Various thermodynamic methods based on  $g^E$ -models (Wilson, NRTL, UNIQUAC) or group contribution methods (UNIFAC, modified UNIFAC, ASOG, PSRK) can be used for either calculating or predicting the required activity coefficients for the components under given conditions of temperature and composition (Reference 2).

Because of the importance of azeotropic data for the design of distillation processes, compilations have been available in book form for quite some time (References 3-7). The most recent printed data collection was published in 1994 (Reference 8). A revised and extended version appeared in 2004 (Reference 9).

A collection of approximately 47,400 zeotropic and azeotropic data sets, compiled from 6600 references, are stored in a comprehensive computerized data bank (Reference 10). The references from the above-mentioned compilations and from the vapor-liquid equilibrium part of the Dortmund Data Bank (Reference 11) were supplemented by references found from CAS online searches, private communications, data from industry, etc.. Over 24,000 zeotropic data and over 20,000 azeotropic data are available for binary systems. Nearly 90% of the binary azeotropic data show a pressure maximum. In most cases (ca. 90%) these are homogeneous azeotropes, and in approximately 7-8% of the cases heterogeneous azeotropes are reported. Less than 10% of the data stored show a pressure minimum. Approximately 21,000 of the data sets stored were published after 1970.

The table below provides information about azeotropes for 808 selected binary systems. Compounds are listed in the modified Hill order, with carbon-containing compounds following those compounds not containing carbon. In columns 1 and 2 are the molecular formulas of components 1 and 2 written in the Hill convention. In column 3 the names of the components are given, either a systematic IUPAC name or a name in ubiquitous use. Columns 4, 5, and 6 contain the azeotropic coordinates of the mixtures: temperature  $T_{Az}$ , pressure  $P_{Az}$ , and vapor-phase composition  $y_{1,Az}$ . The explanation of the type of azeotrope (column 7) is given by the following codes:

- O: homogeneous azeotrope in a completely miscible system
- L: homogeneous azeotrope in a partially miscible system
- E: heterogeneous azeotrope
- X: pressure maximum
- N: pressure minimum
- D: double azeotrope
- C: system contains a supercritical compound

## References

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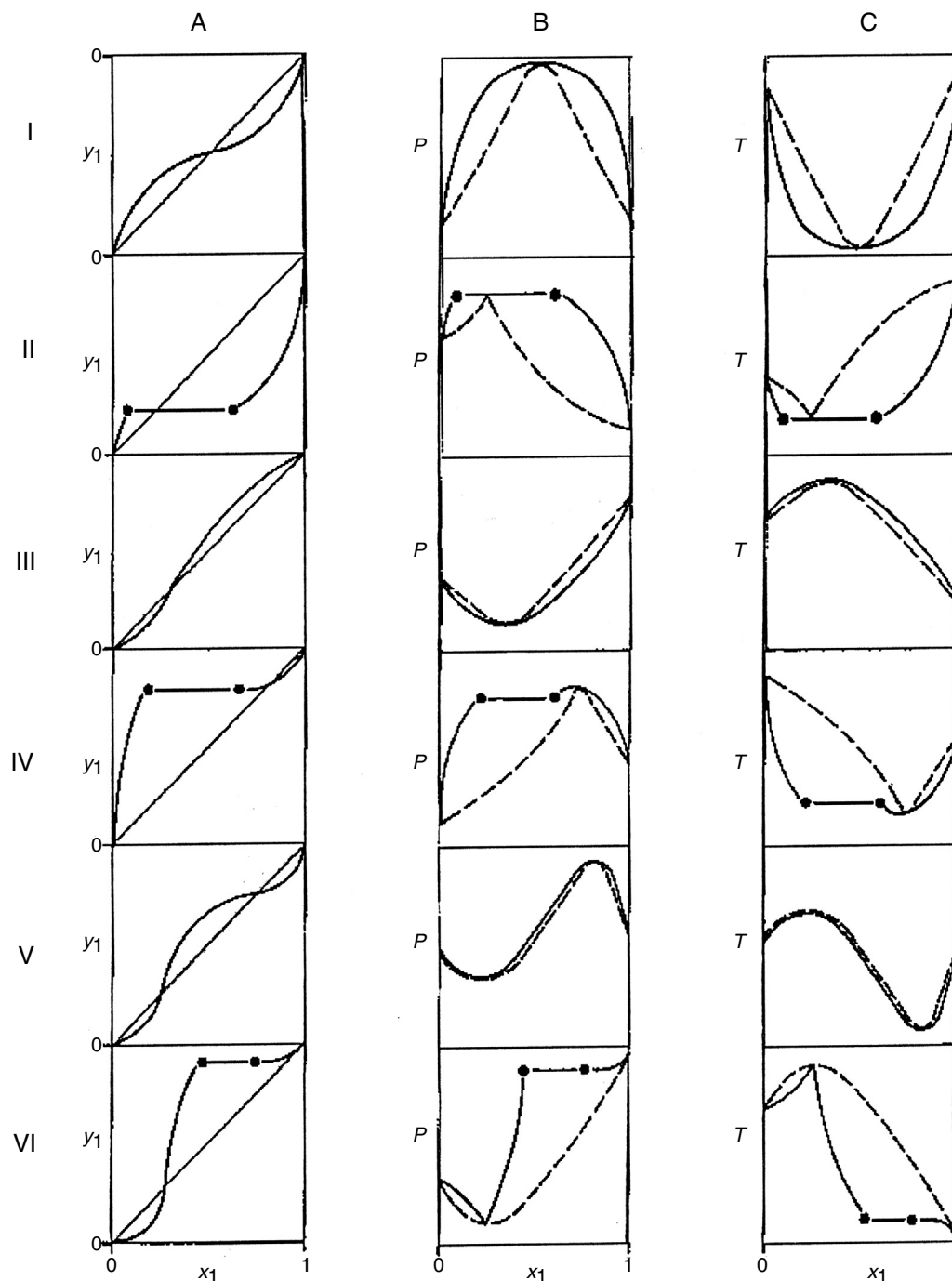


Figure 1 Different types of binary azeotropic systems: I - homogeneous pressure-maximum azeotrope in a completely miscible system (OX); II - heterogeneous pressure-maximum azeotrope (EX); III - homogeneous pressure-minimum azeotrope in a completely miscible system (ON); IV - homogeneous pressure-maximum azeotrope in a partially miscible system (LX); V - D: double azeotrope (OND, OXD); VI - homogeneous pressure-minimum azeotrope in a partially miscible system (LN). A -  $y_1(x_1)$ ; B -  $P(x_1)$  and  $P(y_1)$ ; C -  $T(x_1)$  and  $T(y_1)$ . Continuous line -  $(x_1)$ ; Dashed line -  $(y_1)$ .

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| Molecular formula                |                                               |                               |            |            |              |      |
|----------------------------------|-----------------------------------------------|-------------------------------|------------|------------|--------------|------|
| Comp. 1                          | Comp. 2                                       | Name                          | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
| AlCl <sub>3</sub>                |                                               | <b>Aluminum chloride</b>      |            |            |              |      |
|                                  | Cl <sub>3</sub> OP                            | Phosphoryl trichloride        | 660.15     | 0.5150     | 101.33       | ONC  |
| ClH                              |                                               | <b>Hydrogen chloride</b>      |            |            |              |      |
|                                  | H <sub>2</sub> O                              | Water                         | 389.34     | 0.1083     | 133.32       | ONC  |
| Cl <sub>2</sub> OS               |                                               | <b>Thionyl chloride</b>       |            |            |              |      |
|                                  | Cl <sub>3</sub> P                             | Phosphorus(III) chloride      | 345.85     | 0.4200     | 101.33       | OX   |
| Cl <sub>2</sub> O <sub>2</sub> S |                                               | <b>Sulfuryl chloride</b>      |            |            |              |      |
|                                  | Cl <sub>3</sub> P                             | Phosphorus(III) chloride      | 364.15     | 0.5000     | 101.33       | ON   |
| Cl <sub>3</sub> OP               |                                               | <b>Phosphoryl trichloride</b> |            |            |              |      |
|                                  | Cl <sub>5</sub> Nb                            | Niobium(V) chloride           | 536.15     | 0.4020     | 101.33       | ON   |
|                                  | Cl <sub>5</sub> Ta                            | Tantalum(V) chloride          | 558.85     | 0.4650     | 101.33       | ON   |
| Cl <sub>4</sub> Ge               |                                               | <b>Germanium(IV) chloride</b> |            |            |              |      |
|                                  | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,2-Dichloroethane            | 350.75     | 0.4630     | 101.33       | OX   |
| Cl <sub>4</sub> Si               |                                               | <b>Tetrachlorosilane</b>      |            |            |              |      |
|                                  | C <sub>2</sub> H <sub>3</sub> N               | Acetonitrile                  | 321.05     | 0.6900     | 101.33       | EX   |
| Cl <sub>5</sub> Mo               |                                               | <b>Molybdenum(V) chloride</b> |            |            |              |      |
|                                  | Cl <sub>6</sub> W                             | Tungsten(VI) chloride         | 274.70     | 0.9750     | 101.33       | OX   |
| FH                               |                                               | <b>Hydrogen fluoride</b>      |            |            |              |      |
|                                  | H <sub>2</sub> O                              | Water                         | 382.15     | 0.3508     | 101.33       | ON   |
|                                  | CCl <sub>3</sub> F                            | Trichlorofluoromethane        | 283.15     | 0.7840     | 129.45       | EX   |
| HNO <sub>3</sub>                 |                                               | <b>Nitric acid</b>            |            |            |              |      |
|                                  | H <sub>2</sub> O                              | Water                         | 393.20     | 0.3820     | 101.33       | ON   |
| H <sub>2</sub> O                 |                                               | <b>Water</b>                  |            |            |              |      |
|                                  | CHCl <sub>3</sub>                             | Trichloromethane              | 329.27     | 0.1603     | 101.33       | EX   |
|                                  | CH <sub>2</sub> O                             | Formaldehyde                  | 355.75     | 0.9300     | 53.33        | OX   |
|                                  | CH <sub>2</sub> O <sub>2</sub>                | Formic acid                   | 380.35     | 0.4272     | 101.33       | ON   |
|                                  | CH <sub>3</sub> NO <sub>2</sub>               | Nitromethane                  | 356.90     | 0.5160     | 101.33       | EX   |
|                                  | C <sub>2</sub> HCl <sub>3</sub>               | Trichloroethene               | 346.55     | 0.3560     | 101.33       | EX   |
|                                  | C <sub>2</sub> H <sub>3</sub> N               | Acetonitrile                  | 349.95     | 0.3100     | 101.33       | OX   |
|                                  | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,2-Dichloroethane            | 345.43     | 0.3570     | 101.33       | EX   |
|                                  | C <sub>2</sub> H <sub>6</sub> O               | Ethanol                       | 351.25     | 0.1030     | 101.33       | OX   |
|                                  | C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>  | 1,2-Ethanediamine             | 391.85     | 0.4450     | 101.33       | ON   |
|                                  | C <sub>3</sub> H <sub>3</sub> N               | Acrylonitrile                 | 344.05     | 0.2850     | 101.33       | EX   |
|                                  | C <sub>3</sub> H <sub>4</sub> O               | Acrolein                      | 325.45     | 0.0730     | 101.33       | LX   |
|                                  | C <sub>3</sub> H <sub>6</sub> O               | Propanal                      | 320.65     | 0.0600     | 101.33       | LX   |
|                                  | C <sub>3</sub> H <sub>6</sub> O               | Allyl alcohol                 | 361.15     | 0.5562     | 101.33       | OX   |
|                                  | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Methyl acetate                | 330.05     | 0.1060     | 103.62       | LX   |
|                                  | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | 1,3-Dioxolane                 | 344.95     | 0.2520     | 101.30       | OX   |
|                                  | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Ethyl formate                 | 325.75     | 0.0700     | 101.33       | EX   |
|                                  | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Propanoic acid                | 373.05     | 0.9500     | 101.33       | OX   |
|                                  | C <sub>3</sub> H <sub>7</sub> Br              | 1-Bromopropane                | 336.35     | 0.2210     | 101.33       | EX   |
|                                  | C <sub>3</sub> H <sub>8</sub> O               | 1-Propanol                    | 360.80     | 0.5680     | 101.33       | OX   |
|                                  | C <sub>3</sub> H <sub>8</sub> O               | 2-Propanol                    | 353.70     | 0.3260     | 101.33       | OX   |
|                                  | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>  | 2-Methoxyethanol              | 372.65     | 0.9441     | 99.99        | OX   |
|                                  | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>  | Dimethoxymethane              | 315.05     | 0.0269     | 101.38       | LX   |
|                                  | C <sub>4</sub> H <sub>5</sub> N               | <i>cis</i> -2-Butenenitrile   | 358.45     | 0.3832     | 101.33       | EX   |
|                                  | C <sub>4</sub> H <sub>5</sub> N               | <i>trans</i> -2-Butenenitrile | 363.05     | 0.6843     | 101.33       | EX   |
|                                  | C <sub>4</sub> H <sub>5</sub> N               | Pyrrole                       | 348.15     | 0.7514     | 50.13        | EX   |
|                                  | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>  | Methacrylic acid              | 372.25     | 0.9464     | 98.93        | OX   |
|                                  | C <sub>4</sub> H <sub>8</sub> O               | 2-Butanone                    | 346.54     | 0.3480     | 101.33       | LX   |
|                                  | C <sub>4</sub> H <sub>8</sub> O               | Tetrahydrofuran               | 336.67     | 0.1828     | 101.33       | OX   |
|                                  | C <sub>4</sub> H <sub>8</sub> O               | Isobutanal                    | 332.80     | 0.1698     | 100.99       | EX   |
|                                  | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Ethyl acetate                 | 343.55     | 0.2990     | 101.33       | EX   |
|                                  | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Butanoic acid                 | 372.95     | 0.9559     | 101.33       | OX   |
|                                  | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | 1,4-Dioxane                   | 360.65     | 0.5280     | 101.33       | OX   |
|                                  | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Propyl formate                | 344.85     | 0.3090     | 101.33       | EX   |
|                                  | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Methyl propanoate             | 344.75     | 0.3050     | 101.33       | EX   |
|                                  | C <sub>4</sub> H <sub>9</sub> Br              | 1-Bromobutane                 | 353.95     | 0.4950     | 101.33       | EX   |

| Molecular formula |                                               |                                               |            |            |              |      |  |
|-------------------|-----------------------------------------------|-----------------------------------------------|------------|------------|--------------|------|--|
| Comp. 1           | Comp. 2                                       | Name                                          | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |  |
|                   | C <sub>4</sub> H <sub>9</sub> Br              | 1-Bromo-2-methylpropane                       | 348.45     | 0.3730     | 101.33       | EX   |  |
|                   | C <sub>4</sub> H <sub>9</sub> Cl              | 1-Chloro-2-methylpropane                      | 333.95     | 0.1970     | 101.33       | LX   |  |
|                   | C <sub>4</sub> H <sub>10</sub> O              | 1-Butanol                                     | 365.45     | 0.7540     | 101.33       | EX   |  |
|                   | C <sub>4</sub> H <sub>10</sub> O              | 2-Butanol                                     | 360.50     | 0.6200     | 101.33       | LX   |  |
|                   | C <sub>4</sub> H <sub>10</sub> O              | 2-Methyl-2-propanol                           | 353.00     | 0.4011     | 101.33       | OX   |  |
|                   | C <sub>4</sub> H <sub>11</sub> N              | Butylamine                                    | 349.85     | 0.0700     | 101.33       | OX   |  |
|                   | C <sub>5</sub> H <sub>5</sub> N               | Pyridine                                      | 367.30     | 0.7500     | 101.33       | OX   |  |
|                   | C <sub>5</sub> H <sub>8</sub>                 | 2-Methyl-1,3-butadiene                        | 305.85     | 0.0520     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>8</sub>                 | Methylenecyclobutane                          | 313.15     | 0.0212     | 101.30       | EX   |  |
|                   | C <sub>5</sub> H <sub>8</sub> O               | Cyclopropyl methyl ketone                     | 361.65     | 0.7060     | 101.19       | EX   |  |
|                   | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>  | Methyl methacrylate                           | 354.45     | 0.4996     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>10</sub>                | 2-Methyl-2-butene                             | 309.75     | 0.0650     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>10</sub> O              | 3-Methyl-2-buten-1-ol                         | 369.55     | 0.9141     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>10</sub> O              | 3-Methyl-3-buten-1-ol                         | 333.15     | 0.8680     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>10</sub> O              | 2-Methyl-3-buten-2-ol                         | 359.25     | 0.5770     | 101.33       | LX   |  |
|                   | C <sub>5</sub> H <sub>10</sub> O              | 3-Pentanone                                   | 356.05     | 0.4750     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Isopropyl acetate                             | 349.75     | 0.3960     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Propyl acetate                                | 355.91     | 0.5228     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Butyl formate                                 | 356.95     | 0.5360     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Isobutyl formate                              | 352.75     | 0.4460     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>12</sub> O              | 3-Methyl-1-butanol                            | 367.97     | 0.8265     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>12</sub> O              | 2-Methyl-2-butanol                            | 360.85     | 0.6355     | 101.75       | EX   |  |
|                   | C <sub>5</sub> H <sub>12</sub> O              | 1-Pentanol                                    | 369.08     | 0.8633     | 101.33       | EX   |  |
|                   | C <sub>5</sub> H <sub>12</sub> O              | 2-Pentanol                                    | 363.15     | 0.7550     | 92.49        | EX   |  |
|                   | C <sub>6</sub> H <sub>6</sub>                 | Benzene                                       | 342.35     | 0.2980     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>7</sub> N               | Aniline                                       | 372.55     | 0.9580     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>7</sub> N               | 4-Methylpyridine                              | 370.50     | 0.8972     | 101.33       | OX   |  |
|                   | C <sub>6</sub> H <sub>10</sub>                | Cyclohexene                                   | 343.95     | 0.3090     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>10</sub> O              | Cyclohexanone                                 | 369.45     | 0.8694     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>10</sub> O              | Methyldihydropyran (unspecified isomer)       | 360.75     | 0.5841     | 100.93       | EX   |  |
|                   | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub> | 4-Vinyl-1,3-dioxane                           | 367.65     | 0.8955     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>12</sub>                | 1-Hexene                                      | 318.15     | 0.1510     | 63.35        | EX   |  |
|                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Butyl acetate                                 | 363.35     | 0.7013     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Isobutyl acetate                              | 361.05     | 0.6440     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | 4,4-Dimethyl-1,3-dioxane                      | 366.00     | 0.7779     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | 4,5-Dimethyl-1,3-dioxane (unspecified isomer) | 365.05     | 0.7966     | 101.50       | EX   |  |
|                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | 4-Ethyl-1,3-dioxane                           | 365.75     | 0.7257     | 101.30       | EX   |  |
|                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Diacetone alcohol                             | 370.00     | 0.9900     | 90.79        | OX   |  |
|                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Propyl propanoate                             | 362.05     | 0.6600     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>13</sub> N              | Cyclohexylamine                               | 369.55     | 0.8692     | 101.33       | OX   |  |
|                   | C <sub>6</sub> H <sub>14</sub>                | Hexane                                        | 334.75     | 0.2110     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>14</sub> O              | Butyl ethyl ether                             | 349.85     | 0.4070     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>14</sub> O              | 1-Hexanol                                     | 367.89     | 0.9432     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub> | Di(ethylene glycol) dimethyl ether            | 372.70     | 0.9679     | 101.33       | OX   |  |
|                   | C <sub>6</sub> H <sub>15</sub> N              | Diisopropylamine                              | 347.25     | 0.3654     | 101.33       | EX   |  |
|                   | C <sub>6</sub> H <sub>15</sub> N              | Dipropylamine                                 | 359.00     | 0.6046     | 101.33       | EX   |  |
|                   | C <sub>7</sub> H <sub>8</sub>                 | Toluene                                       | 357.25     | 0.5230     | 101.33       | EX   |  |
|                   | C <sub>7</sub> H <sub>8</sub> O               | Benzyl alcohol                                | 373.05     | 0.9840     | 101.33       | EX   |  |
|                   | C <sub>7</sub> H <sub>9</sub> N               | 2,6-Dimethylpyridine                          | 369.17     | 0.8647     | 101.33       | EX   |  |
|                   | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub> | 1,2-Propanediol diacetate                     | 358.15     | 0.9740     | 59.41        | EX   |  |
|                   | C <sub>7</sub> H <sub>14</sub>                | 1-Heptene                                     | 350.20     | 0.4100     | 101.33       | EX   |  |
|                   | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Isopentyl acetate                             | 367.05     | 0.7990     | 101.46       | EX   |  |
|                   | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Butyl propanoate                              | 367.95     | 0.8340     | 101.33       | EX   |  |
|                   | C <sub>7</sub> H <sub>16</sub>                | Heptane                                       | 352.35     | 0.4510     | 101.33       | EX   |  |
|                   | C <sub>7</sub> H <sub>16</sub> O              | 1-Heptanol                                    | 371.99     | 0.9703     | 101.33       | EX   |  |
|                   | C <sub>8</sub> H <sub>8</sub>                 | Styrene                                       | 367.15     | 0.8000     | 101.33       | EX   |  |
|                   | C <sub>8</sub> H <sub>8</sub> O               | Acetophenone                                  | 371.15     | 0.9675     | 101.19       | EX   |  |
|                   | C <sub>8</sub> H <sub>10</sub>                | <i>m</i> -Xylene                              | 365.15     | 0.7667     | 101.33       | EX   |  |

| Molecular formula               |                                               |                           |            |            |              |      |  |
|---------------------------------|-----------------------------------------------|---------------------------|------------|------------|--------------|------|--|
| Comp. 1                         | Comp. 2                                       | Name                      | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |  |
| CCl <sub>4</sub>                | C <sub>8</sub> H <sub>10</sub>                | <i>p</i> -Xylene          | 365.15     | 0.7450     | 101.33       | EX   |  |
|                                 | C <sub>8</sub> H <sub>10</sub>                | Ethylbenzene              | 364.15     | 0.7221     | 101.33       | EX   |  |
|                                 | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Butyl butanoate           | 369.85     | 0.9110     | 101.33       | EX   |  |
|                                 | C <sub>8</sub> H <sub>18</sub>                | Octane                    | 362.75     | 0.6850     | 101.33       | EX   |  |
|                                 | C <sub>8</sub> H <sub>18</sub>                | 2,2,4-Trimethylpentane    | 351.95     | 0.4420     | 101.33       | EX   |  |
|                                 | C <sub>8</sub> H <sub>18</sub> O              | Dibutyl ether             | 368.65     | 0.7628     | 101.33       | EX   |  |
|                                 | C <sub>8</sub> H <sub>18</sub> O              | 1-Octanol                 | 372.75     | 0.9820     | 101.33       | EX   |  |
|                                 | C <sub>8</sub> H <sub>19</sub> N              | Dibutylamine              | 370.05     | 0.8850     | 101.33       | EX   |  |
|                                 | C <sub>9</sub> H <sub>10</sub>                | Isopropenylbenzene        | 369.95     | 0.8880     | 101.33       | EX   |  |
|                                 | C <sub>9</sub> H <sub>12</sub>                | Isopropylbenzene          | 368.15     | 0.8340     | 101.33       | EX   |  |
|                                 | C <sub>9</sub> H <sub>12</sub> O              | 2-Phenyl-2-propanol       | 371.25     | 0.9718     | 101.33       | EX   |  |
|                                 | C <sub>9</sub> H <sub>20</sub>                | Nonane                    | 367.95     | 0.8280     | 101.33       | EX   |  |
|                                 | C <sub>9</sub> H <sub>20</sub> O              | 1-Nonanol                 | 373.00     | 0.9846     | 101.33       | EX   |  |
|                                 | C <sub>10</sub> H <sub>22</sub>               | Decane                    | 370.75     | 0.9180     | 101.33       | EX   |  |
|                                 | C <sub>10</sub> H <sub>22</sub> O             | 1-Decanol                 | 373.13     | 0.9865     | 101.33       | EX   |  |
|                                 | C <sub>12</sub> H <sub>27</sub> N             | Tributylamine             | 372.80     | 0.9762     | 101.46       | EX   |  |
|                                 |                                               | <b>Tetrachloromethane</b> |            |            |              |      |  |
|                                 | C <sub>2</sub> H <sub>6</sub> O               | Ethanol                   | 338.19     | 0.6140     | 101.33       | OX   |  |
|                                 | C <sub>3</sub> H <sub>6</sub> O               | Acetone                   | 341.25     | 0.0337     | 149.93       | OX   |  |
|                                 | C <sub>3</sub> H <sub>8</sub> O               | 1-Propanol                | 346.28     | 0.8032     | 101.33       | OX   |  |
| CS <sub>2</sub>                 | C <sub>3</sub> H <sub>8</sub> O               | 2-Propanol                | 341.83     | 0.6686     | 101.33       | OX   |  |
|                                 | C <sub>4</sub> H <sub>6</sub> O               | 2-Butenal                 | 348.15     | 0.6500     | 97.86        | OX   |  |
|                                 | C <sub>4</sub> H <sub>6</sub> O               | 2-Methylpropenal          | 339.15     | 0.6000     | 97.86        | OX   |  |
|                                 | C <sub>4</sub> H <sub>8</sub> O               | 2-Butanone                | 346.99     | 0.6630     | 101.33       | OX   |  |
|                                 | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Ethyl acetate             | 347.95     | 0.5700     | 101.33       | OX   |  |
|                                 | C <sub>4</sub> H <sub>10</sub> O              | 1-Butanol                 | 349.71     | 0.9500     | 101.33       | OX   |  |
|                                 | C <sub>4</sub> H <sub>10</sub> O              | 2-Methyl-1-propanol       | 348.95     | 0.9080     | 101.33       | OX   |  |
|                                 | C <sub>5</sub> H <sub>10</sub> O              | 2-Methyl-3-buten-2-ol     | 348.45     | 0.9009     | 101.06       | OX   |  |
|                                 |                                               | <b>Carbon disulfide</b>   |            |            |              |      |  |
|                                 | CH <sub>4</sub> O                             | Methanol                  | 310.65     | 0.7000     | 101.33       | LX   |  |
| CHCl <sub>3</sub>               |                                               | <b>Trichloromethane</b>   |            |            |              |      |  |
|                                 | CH <sub>4</sub> O                             | Methanol                  | 328.15     | 0.6480     | 107.99       | OX   |  |
|                                 | C <sub>2</sub> H <sub>6</sub> O               | Ethanol                   | 332.45     | 0.8410     | 101.33       | OX   |  |
|                                 | C <sub>3</sub> H <sub>6</sub> O               | Acetone                   | 337.58     | 0.6398     | 101.33       | ON   |  |
|                                 | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Methyl acetate            | 337.51     | 0.6760     | 101.33       | ON   |  |
|                                 | C <sub>3</sub> H <sub>8</sub> O               | 2-Propanol                | 334.15     | 0.9500     | 101.33       | OX   |  |
|                                 | C <sub>4</sub> H <sub>6</sub> O               | 2-Butenal                 | 329.15     | 0.9950     | 97.86        | OX   |  |
|                                 | C <sub>6</sub> H <sub>12</sub>                | 2-Methyl-1-pentene        | 333.95     | 0.6235     | 101.19       | OX   |  |
|                                 | C <sub>6</sub> H <sub>14</sub>                | Hexane                    | 333.45     | 0.7840     | 101.33       | OX   |  |
|                                 |                                               | <b>Hydrogen cyanide</b>   |            |            |              |      |  |
| CHN                             | C <sub>3</sub> H <sub>5</sub> Cl              | 3-Chloropropene           | 296.45     | 0.8016     | 101.33       | OX   |  |
| CH <sub>2</sub> Cl <sub>2</sub> |                                               | <b>Dichloromethane</b>    |            |            |              |      |  |
| CH <sub>2</sub> O <sub>2</sub>  | C <sub>2</sub> H <sub>6</sub> O               | Ethanol                   | 312.05     | 0.9600     | 101.33       | OX   |  |
| CH <sub>3</sub> NO <sub>2</sub> |                                               | <b>Formic acid</b>        |            |            |              |      |  |
|                                 | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,2-Dichloroethane        | 350.17     | 0.4275     | 101.33       | OX   |  |
|                                 | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Butyl formate             | 372.15     | 0.8700     | 101.33       | OX   |  |
|                                 | C <sub>8</sub> H <sub>10</sub>                | <i>m</i> -Xylene          | 365.95     | 0.8545     | 101.33       | EX   |  |
| CH <sub>3</sub> NO <sub>2</sub> |                                               | <b>Nitromethane</b>       |            |            |              |      |  |
|                                 | C <sub>2</sub> H <sub>6</sub> O               | Ethanol                   | 333.15     | 0.2850     | 53.61        | OX   |  |
|                                 | C <sub>3</sub> H <sub>7</sub> Br              | 1-Bromopropane            | 343.25     | 0.1020     | 99.82        | OX   |  |
|                                 | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | 1,4-Dioxane               | 373.25     | 0.4101     | 101.48       | OX   |  |
|                                 | C <sub>5</sub> H <sub>10</sub>                | 2-Methyl-2-butene         | 311.15     | 0.0570     | 101.33       | LX   |  |
|                                 | C <sub>7</sub> H <sub>14</sub>                | Methylcyclohexane         | 354.85     | 0.5123     | 101.33       | EX   |  |
|                                 | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 353.25     | 0.4790     | 101.33       | EX   |  |
|                                 | C <sub>8</sub> H <sub>18</sub>                | Octane                    | 363.38     | 0.6964     | 99.73        | EX   |  |
|                                 | C <sub>9</sub> H <sub>20</sub>                | Nonane                    | 369.29     | 0.8403     | 99.73        | EX   |  |
|                                 | C <sub>10</sub> H <sub>22</sub>               | Decane                    | 371.96     | 0.9239     | 99.73        | EX   |  |
|                                 | C <sub>11</sub> H <sub>24</sub>               | Undecane                  | 373.16     | 0.9619     | 99.73        | EX   |  |

| Molecular formula                             |                                                |                                                         |            |            |              |      |
|-----------------------------------------------|------------------------------------------------|---------------------------------------------------------|------------|------------|--------------|------|
| Comp. 1                                       | Comp. 2                                        | Name                                                    | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
| CH <sub>4</sub> O                             | C <sub>12</sub> H <sub>26</sub>                | Dodecane                                                | 373.75     | 0.9846     | 99.73        | EX   |
|                                               |                                                | <b>Methanol</b>                                         |            |            |              |      |
|                                               | C <sub>2</sub> HBrClF <sub>3</sub>             | 2-Bromo-2-chloro-1,1,1-trifluoroethane                  | 317.25     | 0.1890     | 93.33        | OX   |
|                                               | C <sub>2</sub> H <sub>5</sub> Br               | Bromoethane                                             | 308.05     | 0.1610     | 101.33       | OX   |
|                                               | C <sub>3</sub> H <sub>5</sub> Cl               | 3-Chloropropene                                         | 312.15     | 0.2570     | 100.39       | OX   |
|                                               | C <sub>3</sub> H <sub>6</sub> O                | Acetone                                                 | 328.29     | 0.2400     | 101.33       | OX   |
|                                               | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Methyl acetate                                          | 328.15     | 0.3480     | 107.19       | OX   |
|                                               | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | 1,3-Dioxolane                                           | 334.66     | 0.6910     | 101.30       | OX   |
|                                               | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Ethyl formate                                           | 318.15     | 0.3000     | 81.34        | OX   |
|                                               | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>   | Dimethyl carbonate                                      | 337.25     | 0.8504     | 102.52       | OX   |
|                                               | C <sub>3</sub> H <sub>7</sub> Cl               | 1-Chloropropane                                         | 313.35     | 0.2500     | 101.59       | OX   |
|                                               | C <sub>4</sub> H <sub>4</sub> F <sub>6</sub> O | Bis(2,2,2-trifluoroethyl) ether                         | 326.28     | 0.4450     | 101.30       | OX   |
|                                               | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | Vinyl acetate                                           | 332.05     | 0.6182     | 101.33       | OX   |
|                                               | C <sub>4</sub> H <sub>8</sub> O                | 2-Butanone                                              | 323.15     | 0.8020     | 58.80        | OX   |
|                                               | C <sub>4</sub> H <sub>8</sub> O                | Tetrahydrofuran                                         | 332.75     | 0.5040     | 101.33       | OX   |
|                                               | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Ethyl acetate                                           | 335.66     | 0.7120     | 101.33       | OX   |
|                                               | C <sub>4</sub> H <sub>10</sub> O               | Diethyl ether                                           | 305.15     | 0.0500     | 93.33        | OX   |
|                                               | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>  | Dimethylacetal                                          | 330.35     | 0.4700     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O | 1,1,1,2,3,3-Hexafluoro-3-(2,2,2-trifluoroethoxy)propane | 330.67     | 0.5600     | 101.30       | OX   |
|                                               | C <sub>5</sub> H <sub>6</sub>                  | 1,3-Cyclopentadiene                                     | 309.05     | 0.2120     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                                  | 303.55     | 0.1670     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>8</sub>                  | Methylenecyclobutane                                    | 309.05     | 0.2190     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>8</sub>                  | 1-Methylcyclobutene                                     | 304.85     | 0.1900     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>8</sub>                  | <i>cis</i> -1,3-Pentadiene                              | 311.10     | 0.2300     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>8</sub>                  | <i>trans</i> -1,3-Pentadiene                            | 309.65     | 0.2110     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-1-butene                                       | 300.55     | 0.1720     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>10</sub>                 | 3-Methyl-1-butene                                       | 291.05     | 0.0890     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-2-butene                                       | 306.25     | 0.2160     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>10</sub>                 | 1-Pentene                                               | 300.05     | 0.1469     | 102.47       | OX   |
|                                               | C <sub>5</sub> H <sub>10</sub> O               | 2,3-Epoxy-2-methylbutane                                | 334.95     | 0.6590     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>12</sub>                 | Isopentane                                              | 297.05     | 0.0930     | 101.33       | OX   |
|                                               | C <sub>5</sub> H <sub>12</sub>                 | Pentane                                                 | 303.20     | 0.1930     | 101.30       | OX   |
|                                               | C <sub>5</sub> H <sub>12</sub> O               | Butyl methyl ether                                      | 330.00     | 0.5515     | 100.08       | OX   |
|                                               | C <sub>5</sub> H <sub>12</sub> O               | Methyl <i>tert</i> -butyl ether                         | 325.00     | 0.3140     | 103.15       | OX   |
|                                               | C <sub>5</sub> H <sub>12</sub> O               | Ethyl propyl ether                                      | 330.00     | 0.4050     | 112.25       | OX   |
|                                               | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | Diethoxymethane                                         | 336.03     | 0.8127     | 101.52       | OX   |
|                                               | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | 2,2-Dimethoxypropane                                    | 334.15     | 0.7250     | 100.00       | OX   |
|                                               | C <sub>5</sub> H <sub>14</sub> N <sub>2</sub>  | <i>N,N,N',N'</i> -Tetramethylmethanediamine             | 335.15     | 0.7670     | 101.33       | OX   |
|                                               | C <sub>6</sub> F <sub>6</sub>                  | Hexafluorobenzene                                       | 318.15     | 0.6100     | 61.73        | OX   |
|                                               | C <sub>6</sub> H <sub>5</sub> F                | Fluorobenzene                                           | 333.35     | 0.6625     | 101.62       | OX   |
|                                               | C <sub>6</sub> H <sub>6</sub>                  | Benzene                                                 | 331.56     | 0.6090     | 101.33       | OX   |
|                                               | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                                             | 328.75     | 0.6090     | 106.66       | OX   |
|                                               | C <sub>6</sub> H <sub>12</sub>                 | 2-Methyl-1-pentene                                      | 330.00     | 0.4517     | 141.80       | OX   |
|                                               | C <sub>6</sub> H <sub>14</sub>                 | 2,3-Dimethylbutane                                      | 313.15     | 0.3620     | 85.50        | OX   |
|                                               | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                                  | 333.15     | 0.5160     | 149.64       | OX   |
|                                               | C <sub>6</sub> H <sub>14</sub> O               | <i>tert</i> -Butyl ethyl ether                          | 330.95     | 0.6002     | 101.54       | OX   |
|                                               | C <sub>6</sub> H <sub>14</sub> O               | Diisopropyl ether                                       | 330.00     | 0.5390     | 101.61       | OX   |
|                                               | C <sub>6</sub> H <sub>14</sub> O               | Butyl ethyl ether                                       | 335.00     | 0.8010     | 98.84        | OX   |
|                                               | C <sub>6</sub> H <sub>14</sub> O               | 2-Methoxy-2-methylbutane                                | 335.55     | 0.7735     | 101.69       | OX   |
|                                               | C <sub>7</sub> H <sub>8</sub>                  | Toluene                                                 | 336.65     | 0.8820     | 101.33       | OX   |
|                                               | C <sub>7</sub> H <sub>14</sub>                 | Methylcyclohexane                                       | 333.15     | 0.7520     | 102.87       | EX   |
|                                               | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                 | 331.95     | 0.7279     | 101.33       | OX   |
|                                               | C <sub>7</sub> H <sub>16</sub> O               | 2-Ethoxy-2-methylbutane                                 | 335.15     | 0.8736     | 97.28        | OX   |
|                                               | C <sub>8</sub> H <sub>18</sub>                 | Octane                                                  | 335.55     | 0.8830     | 101.33       | LX   |
|                                               | C <sub>9</sub> H <sub>20</sub>                 | Nonane                                                  | 337.25     | 0.9526     | 101.33       | OX   |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub> |                                                | <b>1,1,2-Trichloro-1,2,2-trifluoroethane</b>            |            |            |              |      |
|                                               | C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O | 2,2,2-Trifluoroethanol                                  | 316.58     | 0.7770     | 101.33       | EX   |

| Molecular formula |                |                                                         |            |            |              |      |
|-------------------|----------------|---------------------------------------------------------|------------|------------|--------------|------|
| Comp. 1           | Comp. 2        | Name                                                    | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
| $C_2Cl_4$         | $C_2H_6O$      | Ethanol                                                 | 317.75     | 0.8456     | 101.42       | OX   |
|                   | $C_3H_8O$      | 2-Propanol                                              | 319.35     | 0.9159     | 100.95       | OX   |
|                   | $C_4H_{10}O$   | 2-Methyl-2-propanol                                     | 319.95     | 0.9426     | 101.09       | OX   |
|                   |                | <b>Tetrachloroethene</b>                                |            |            |              |      |
| $C_2Cl_4F_2$      | $C_2H_3Cl_3$   | 1,1,2-Trichloroethane                                   | 385.95     | 0.2115     | 101.33       | OX   |
|                   | $C_8H_{16}$    | 1-Octene                                                | 393.15     | 0.5900     | 101.33       | OX   |
|                   | $C_8H_{16}$    | <i>cis</i> -4-Octene                                    | 393.65     | 0.7100     | 101.33       | OX   |
|                   | $C_8H_{16}$    | <i>trans</i> -4-Octene                                  | 393.45     | 0.6700     | 101.33       | OX   |
|                   | $C_8H_{18}$    | Octane                                                  | 371.90     | 0.8781     | 53.44        | OX   |
| $C_2H_4Cl_2$      |                | <b>1,1,2,2-Tetrachloro-1,2-difluoroethane</b>           |            |            |              |      |
| $C_2HBrClF_3$     | $C_2H_4Cl_2$   | 1,2-Dichloroethane                                      | 353.80     | 0.2700     | 101.33       | OX   |
| $C_2HCl_3$        | $C_4H_{10}O$   | 2-Bromo-2-chloro-1,1,1-trifluoroethane                  |            |            |              |      |
|                   |                | Diethyl ether                                           | 323.65     | 0.7200     | 93.33        | ON   |
|                   |                | <b>Trichloroethene</b>                                  |            |            |              |      |
|                   | $C_2H_4Cl_2$   | 1,2-Dichloroethane                                      | 355.35     | 0.3324     | 101.36       | OX   |
|                   | $C_2H_6O$      | Ethanol                                                 | 343.85     | 0.4741     | 101.33       | OX   |
|                   | $C_4H_6O$      | 2-Butenal                                               | 360.15     | 0.9000     | 97.86        | OX   |
|                   | $C_6H_{12}$    | Cyclohexane                                             | 353.40     | 0.0975     | 101.32       | OX   |
| $C_2H_2Cl_2$      |                | <b><i>trans</i>-1,2-Dichloroethene</b>                  |            |            |              |      |
|                   | $C_3H_3F_3O$   | 1,1,1,2,3,3-Hexafluoro-3-(2,2,2-trifluoroethoxy)propane | 318.50     | 0.8390     | 101.30       | OX   |
| $C_2H_3N$         |                | <b>Acetonitrile</b>                                     |            |            |              |      |
|                   | $C_3H_8O$      | 2-Propanol                                              | 348.15     | 0.5287     | 100.81       | OX   |
|                   | $C_4H_6O_2$    | Vinyl acetate                                           | 344.65     | 0.1948     | 98.33        | OX   |
|                   | $C_4H_8O$      | 2-Butanone                                              | 352.15     | 0.3195     | 101.15       | OX   |
|                   | $C_4H_8O$      | Tetrahydrofuran                                         | 338.95     | 0.0784     | 101.13       | OX   |
|                   | $C_4H_{10}O$   | 2-Methyl-2-propanol                                     | 333.15     | 0.6200     | 56.93        | OX   |
|                   | $C_5H_8$       | 2-Methyl-1,3-butadiene                                  | 306.75     | 0.0410     | 101.33       | OX   |
|                   | $C_5H_8$       | Methylenecyclobutane                                    | 312.45     | 0.1450     | 101.33       | OX   |
|                   | $C_5H_8O_2$    | Methyl methacrylate                                     | 355.25     | 0.9866     | 102.07       | OX   |
|                   | $C_5H_{10}$    | 2-Methyl-2-butene                                       | 308.95     | 0.1320     | 101.33       | OX   |
|                   | $C_5H_{10}$    | 1-Pentene                                               | 301.85     | 0.0830     | 101.33       | OX   |
|                   | $C_5H_{12}$    | Isopentane                                              | 298.45     | 0.1040     | 101.33       | EX   |
|                   | $C_6H_6$       | Benzene                                                 | 328.15     | 0.4560     | 54.65        | OX   |
|                   | $C_6H_{14}O$   | 2-Methoxy-2-methylbutane                                | 346.13     | 0.5835     | 100.56       | OX   |
|                   | $C_7H_{16}O$   | 2-Ethoxy-2-methylbutane                                 | 348.85     | 0.7219     | 98.99        | OX   |
|                   | $C_{10}H_{20}$ | 1-Decene                                                | 354.55     | 0.9924     | 100.51       | OX   |
| $C_2H_4Cl_2$      |                | <b>1,1-Dichloroethane</b>                               |            |            |              |      |
|                   | $C_3H_8O$      | 2-Propanol                                              | 329.55     | 0.8928     | 101.60       | OX   |
|                   | $C_6H_{14}$    | Hexane                                                  | 329.30     | 0.8025     | 101.21       | OX   |
| $C_2H_4Cl_2$      |                | <b>1,2-Dichloroethane</b>                               |            |            |              |      |
|                   | $C_3H_8O$      | 2-Propanol                                              | 347.25     | 0.5258     | 100.32       | OX   |
|                   | $C_4H_{10}O$   | 2-Methyl-1-propanol                                     | 356.05     | 0.9173     | 101.26       | OX   |
|                   | $C_4H_{10}O$   | 2-Methyl-2-propanol                                     | 349.45     | 0.5336     | 101.43       | OX   |
|                   | $C_7H_{14}$    | Methylcyclohexane                                       | 354.65     | 0.8036     | 101.21       | OX   |
|                   | $C_8H_{18}$    | 2,2,4-Trimethylpentane                                  | 343.15     | 0.7600     | 73.13        | OX   |
| $C_2H_4O$         |                | <b>Acetaldehyde</b>                                     |            |            |              |      |
|                   | $C_4H_6$       | 1,3-Butadiene                                           | 268.15     | 0.0520     | 101.33       | OX   |
|                   | $C_5H_8$       | 2-Methyl-1,3-butadiene                                  | 292.23     | 0.8140     | 101.33       | OX   |
| $C_2H_4O_2$       |                | <b>Acetic acid</b>                                      |            |            |              |      |
|                   | $C_5H_5N$      | Pyridine                                                | 411.25     | 0.5780     | 101.33       | ON   |
|                   | $C_5H_{12}O$   | 3-Methyl-2-butanol                                      | 392.65     | 0.7210     | 101.33       | ON   |
|                   | $C_6H_7N$      | 2-Methylpyridine                                        | 417.27     | 0.5120     | 101.33       | ON   |
|                   | $C_6H_{10}O_2$ | Vinyl butanoate                                         | 386.45     | 0.5750     | 101.33       | OX   |
|                   | $C_6H_{14}$    | Hexane                                                  | 341.40     | 0.0839     | 101.33       | OX   |
|                   | $C_7H_9N$      | 2,4-Dimethylpyridine                                    | 435.45     | 0.3022     | 101.33       | ON   |
|                   | $C_7H_{16}$    | Heptane                                                 | 364.95     | 0.4490     | 101.33       | OX   |
|                   | $C_8H_{10}$    | <i>o</i> -Xylene                                        | 389.75     | 0.8640     | 101.33       | OX   |

| Molecular formula                             |                                                |                                                         |            |            |              |      |  |
|-----------------------------------------------|------------------------------------------------|---------------------------------------------------------|------------|------------|--------------|------|--|
| Comp. 1                                       | Comp. 2                                        | Name                                                    | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |  |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>  | C <sub>8</sub> H <sub>10</sub>                 | <i>p</i> -Xylene                                        | 388.40     | 0.8200     | 101.33       | OX   |  |
|                                               | C <sub>8</sub> H <sub>18</sub>                 | Octane                                                  | 378.85     | 0.6870     | 101.33       | OX   |  |
|                                               | C <sub>9</sub> H <sub>20</sub>                 | Nonane                                                  | 386.05     | 0.8250     | 101.33       | OX   |  |
|                                               | C <sub>10</sub> H <sub>22</sub>                | Decane                                                  | 390.05     | 0.9250     | 101.33       | OX   |  |
|                                               | C <sub>11</sub> H <sub>24</sub>                | Undecane                                                | 391.15     | 0.9720     | 101.33       | OX   |  |
|                                               |                                                | <b>Methyl formate</b>                                   |            |            |              |      |  |
|                                               | C <sub>2</sub> H <sub>5</sub> Br               | Bromoethane                                             | 303.05     | 0.7360     | 101.33       | OX   |  |
|                                               | C <sub>4</sub> H <sub>10</sub> O               | Diethyl ether                                           | 301.55     | 0.6030     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                                  | 298.90     | 0.5150     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-2-butene                                       | 297.75     | 0.5760     | 101.33       | OX   |  |
| C <sub>2</sub> H <sub>5</sub> Br              | C <sub>5</sub> H <sub>12</sub>                 | Isopentane                                              | 291.55     | 0.4920     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                 | Pentane                                                 | 294.85     | 0.5740     | 101.33       | OX   |  |
|                                               | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                                  | 302.65     | 0.8490     | 101.33       | OX   |  |
|                                               |                                                | <b>Bromoethane</b>                                      |            |            |              |      |  |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub> | C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-2-butene                                       | 308.55     | 0.5110     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                 | Isopentane                                              | 300.55     | 0.2180     | 101.33       | OX   |  |
| C <sub>2</sub> H <sub>6</sub> O               |                                                | <b>Nitroethane</b>                                      |            |            |              |      |  |
|                                               | C <sub>4</sub> H <sub>10</sub> O               | 2-Methyl-1-propanol                                     | 375.81     | 0.4080     | 101.33       | OX   |  |
| C <sub>2</sub> H <sub>6</sub> O               | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                 | 362.95     | 0.3520     | 101.33       | OX   |  |
|                                               |                                                | <b>Ethanol</b>                                          |            |            |              |      |  |
|                                               | C <sub>3</sub> H <sub>3</sub> N                | Acrylonitrile                                           | 343.95     | 0.4440     | 101.33       | OX   |  |
|                                               | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Methyl acetate                                          | 329.79     | 0.0362     | 101.33       | OX   |  |
|                                               | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O | 1,1,2,2-Tetrafluoroethyl 1,1,1-trifluoroethyl ether     | 326.67     | 0.2000     | 101.30       | OX   |  |
|                                               | C <sub>4</sub> H <sub>4</sub> F <sub>6</sub> O | Bis(2,2,2-trifluoroethyl) ether                         | 331.90     | 0.2840     | 101.30       | OX   |  |
|                                               | C <sub>4</sub> H <sub>8</sub> O                | Butanal                                                 | 345.45     | 0.3690     | 101.33       | OX   |  |
|                                               | C <sub>4</sub> H <sub>8</sub> O                | 2-Butanone                                              | 347.15     | 0.5080     | 101.33       | OX   |  |
|                                               | C <sub>4</sub> H <sub>8</sub> O                | Tetrahydrofuran                                         | 344.95     | 0.1290     | 125.00       | OX   |  |
|                                               | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Ethyl acetate                                           | 344.85     | 0.4590     | 101.33       | OX   |  |
|                                               | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 1,4-Dioxane                                             | 351.33     | 0.9480     | 101.33       | OX   |  |
|                                               | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Methyl propanoate                                       | 346.30     | 0.5140     | 103.91       | OX   |  |
|                                               | C <sub>4</sub> H <sub>11</sub> N               | Butylamine                                              | 354.99     | 0.5900     | 101.33       | ON   |  |
|                                               | C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O | 1,1,1,2,3,3-Hexafluoro-3-(2,2,2-trifluoroethoxy)propane | 337.88     | 0.3980     | 101.30       | OX   |  |
|                                               | C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                                  | 305.95     | 0.1500     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>8</sub>                  | Cyclopentene                                            | 323.40     | 0.1440     | 134.00       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-2-butene                                       | 309.79     | 0.0795     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub>                 | Cyclopentane                                            | 323.44     | 0.1800     | 121.00       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub> O               | 2,3-Epoxy-2-methylbutane                                | 343.45     | 0.2930     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub> O               | 3-Methyl-2-butanone                                     | 350.85     | 0.8250     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub> O               | 2-Pentanone                                             | 351.15     | 0.9779     | 100.50       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub> O               | 3-Pentanone                                             | 351.33     | 0.9590     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Isopropyl acetate                                       | 349.85     | 0.7010     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Methyl butanoate                                        | 346.30     | 0.8800     | 83.88        | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                 | Isopentane                                              | 299.95     | 0.0540     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                 | Pentane                                                 | 307.15     | 0.0537     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub> O               | Methyl <i>tert</i> -butyl ether                         | 327.75     | 0.0380     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | Diethoxymethane                                         | 348.30     | 0.6497     | 102.35       | OX   |  |
|                                               | C <sub>6</sub> H <sub>5</sub> F                | Fluorobenzene                                           | 343.85     | 0.4752     | 101.54       | OX   |  |
|                                               | C <sub>6</sub> H <sub>6</sub>                  | Benzene                                                 | 341.25     | 0.4600     | 101.33       | OX   |  |
|                                               | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                                             | 337.95     | 0.4540     | 102.26       | OX   |  |
|                                               | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                                  | 331.65     | 0.3410     | 101.33       | OX   |  |
|                                               | C <sub>6</sub> H <sub>14</sub> O               | <i>tert</i> -Butyl ethyl ether                          | 339.95     | 0.3728     | 101.72       | OX   |  |
|                                               | C <sub>6</sub> H <sub>14</sub> O               | 2-Methoxy-2-methylbutane                                | 346.81     | 0.5820     | 101.32       | OX   |  |
|                                               | C <sub>7</sub> H <sub>8</sub>                  | Toluene                                                 | 349.75     | 0.8152     | 101.33       | OX   |  |
|                                               | C <sub>7</sub> H <sub>16</sub> O               | 2-Ethoxy-2-methylbutane                                 | 349.35     | 0.7644     | 101.54       | OX   |  |
|                                               | C <sub>8</sub> H <sub>18</sub>                 | Octane                                                  | 349.85     | 0.8250     | 101.33       | OX   |  |
|                                               | C <sub>8</sub> H <sub>18</sub>                 | 2,2,4-Trimethylpentane                                  | 344.42     | 0.6450     | 101.33       | OX   |  |

| Molecular formula                              |                                                |                                         |            |            |              |      |  |
|------------------------------------------------|------------------------------------------------|-----------------------------------------|------------|------------|--------------|------|--|
| Comp. 1                                        | Comp. 2                                        | Name                                    | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |  |
| <b>C<sub>2</sub>H<sub>6</sub>O<sub>2</sub></b> | C <sub>9</sub> H <sub>20</sub>                 | Nonane                                  | 351.35     | 0.9400     | 101.33       | OX   |  |
|                                                |                                                | <b>1,2-Ethanediol</b>                   |            |            |              |      |  |
|                                                | C <sub>5</sub> H <sub>12</sub> O <sub>3</sub>  | Di(ethylene glycol) monomethyl ether    | 463.95     | 0.4388     | 101.33       | OX   |  |
|                                                | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>  | Di(ethylene glycol) monoethyl ether     | 467.15     | 0.6480     | 101.33       | OX   |  |
|                                                | C <sub>7</sub> H <sub>8</sub> O                | <i>o</i> -Cresol                        | 462.67     | 0.3797     | 101.33       | OX   |  |
|                                                | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>  | Di(ethylene glycol) monoisopropyl ether | 466.35     | 0.6964     | 101.33       | OX   |  |
|                                                | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>  | Di(ethylene glycol) monopropyl ether    | 468.55     | 0.8448     | 101.33       | OX   |  |
|                                                | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>  | Di(propylene glycol) monomethyl ether   |            |            |              |      |  |
|                                                |                                                | (unspecified isomer)                    | 457.65     | 0.3500     | 101.33       | OX   |  |
|                                                | C <sub>8</sub> H <sub>11</sub> N               | 2,4,6-Trimethylpyridine                 | 443.65     | 0.1734     | 101.33       | OX   |  |
|                                                | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>  | Di(ethylene glycol) monobutyl ether     | 469.15     | 0.9102     | 101.33       | OX   |  |
|                                                | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>  | Di(ethylene glycol) monoisobutyl ether  | 467.55     | 0.8355     | 101.33       | OX   |  |
|                                                | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>  | Di(propylene glycol) monoethyl ether    |            |            |              |      |  |
|                                                |                                                | (unspecified isomer)                    | 458.65     | 0.4800     | 101.33       | OX   |  |
|                                                | C <sub>9</sub> H <sub>20</sub> O <sub>3</sub>  | Di(propylene glycol) monopropyl ether   |            |            |              |      |  |
|                                                |                                                | (unspecified isomer)                    | 463.15     | 0.6590     | 101.33       | OX   |  |
|                                                | C <sub>10</sub> H <sub>22</sub> O <sub>3</sub> | Di(propylene glycol) monobutyl ether    |            |            |              |      |  |
|                                                |                                                | (unspecified isomer)                    | 465.75     | 0.8130     | 101.33       | OX   |  |
| <b>C<sub>3</sub>H<sub>3</sub>N</b>             |                                                | <b>Acrylonitrile</b>                    |            |            |              |      |  |
|                                                | C <sub>5</sub> H <sub>8</sub>                  | Methylenecyclobutane                    | 313.80     | 0.1275     | 101.33       | OX   |  |
|                                                | C <sub>6</sub> H <sub>6</sub>                  | Benzene                                 | 347.45     | 0.5575     | 101.46       | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                             | 337.75     | 0.4836     | 101.94       | OX   |  |
|                                                | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                  | 330.90     | 0.4048     | 101.05       | OX   |  |
| <b>C<sub>3</sub>H<sub>4</sub>O</b>             |                                                | <b>Acrolein</b>                         |            |            |              |      |  |
|                                                | C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                  | 306.45     | 0.1980     | 101.33       | OX   |  |
| <b>C<sub>3</sub>H<sub>6</sub>O</b>             |                                                | <b>Propanal</b>                         |            |            |              |      |  |
|                                                | C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                  | 306.35     | 0.1700     | 101.33       | OX   |  |
|                                                | C <sub>5</sub> H <sub>8</sub>                  | Methylenecyclobutane                    | 311.30     | 0.3600     | 101.33       | OX   |  |
| <b>C<sub>3</sub>H<sub>6</sub>O</b>             |                                                | <b>Acetone</b>                          |            |            |              |      |  |
|                                                | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Methyl acetate                          | 328.85     | 0.6470     | 101.33       | OX   |  |
|                                                | C <sub>3</sub> H <sub>7</sub> Br               | 1-Bromopropane                          | 328.75     | 0.9915     | 99.75        | OX   |  |
|                                                | C <sub>4</sub> H <sub>8</sub> O                | Tetrahydrofuran                         | 328.85     | 0.9603     | 100.35       | OX   |  |
|                                                | C <sub>4</sub> H <sub>9</sub> Cl               | 2-Chloro-2-methylpropane                | 322.05     | 0.1944     | 102.11       | OX   |  |
|                                                | C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                  | 306.95     | 0.0610     | 101.33       | OX   |  |
|                                                | C <sub>5</sub> H <sub>8</sub>                  | Methylenecyclobutane                    | 311.25     | 0.2800     | 101.33       | OX   |  |
|                                                | C <sub>5</sub> H <sub>8</sub>                  | 1-Methylcyclobutene                     | 307.75     | 0.2220     | 101.33       | OX   |  |
|                                                | C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-1-butene                       | 303.25     | 0.1400     | 101.33       | OX   |  |
|                                                | C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-2-butene                       | 308.75     | 0.2440     | 101.33       | OX   |  |
|                                                | C <sub>5</sub> H <sub>12</sub>                 | Isopentane                              | 298.75     | 0.1730     | 101.33       | OX   |  |
|                                                | C <sub>5</sub> H <sub>12</sub> O               | Methyl <i>tert</i> -butyl ether         | 324.35     | 0.4824     | 102.19       | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                             | 330.05     | 0.7590     | 109.32       | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | 1-Hexene                                | 323.35     | 0.5973     | 101.40       | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | 2-Methyl-1-pentene                      | 333.40     | 0.5793     | 140.60       | OX   |  |
|                                                | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                  | 322.95     | 0.6480     | 101.33       | OX   |  |
|                                                | C <sub>6</sub> H <sub>14</sub> O               | Diisopropyl ether                       | 327.10     | 0.7424     | 100.17       | OX   |  |
|                                                | C <sub>6</sub> H <sub>15</sub> N               | Triethylamine                           | 318.15     | 0.9800     | 68.13        | OX   |  |
|                                                | C <sub>7</sub> H <sub>14</sub>                 | Methylcyclohexane                       | 318.15     | 0.9500     | 68.66        | OX   |  |
| <b>C<sub>3</sub>H<sub>6</sub>O</b>             |                                                | <b>Allyl alcohol</b>                    |            |            |              |      |  |
|                                                | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Ethyl propanoate                        | 367.65     | 0.5597     | 99.79        | OX   |  |
|                                                | C <sub>6</sub> H <sub>6</sub>                  | Benzene                                 | 349.90     | 0.2203     | 101.33       | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                             | 333.15     | 0.2790     | 63.98        | OX   |  |
| <b>C<sub>3</sub>H<sub>6</sub>O<sub>2</sub></b> |                                                | <b>Methyl acetate</b>                   |            |            |              |      |  |
|                                                | C <sub>3</sub> H <sub>7</sub> Br               | 1-Bromopropane                          | 329.60     | 0.9727     | 99.56        | OX   |  |
|                                                | C <sub>6</sub> H <sub>10</sub>                 | Cyclohexene                             | 330.35     | 0.9121     | 102.87       | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                             | 328.65     | 0.8000     | 101.33       | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | Methylcyclopentane                      | 325.85     | 0.6917     | 99.50        | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | 1-Hexene                                | 323.15     | 0.6340     | 92.08        | OX   |  |
|                                                | C <sub>6</sub> H <sub>12</sub>                 | 2-Methyl-1-pentene                      | 325.15     | 0.5931     | 100.38       | OX   |  |



| Molecular formula                               |                                                |                                                         |            |            |              |      |  |
|-------------------------------------------------|------------------------------------------------|---------------------------------------------------------|------------|------------|--------------|------|--|
| Comp. 1                                         | Comp. 2                                        | Name                                                    | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |  |
| <b>C<sub>3</sub>H<sub>6</sub>O<sub>2</sub></b>  | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                                  | 326.65     | 0.6590     | 106.66       | OX   |  |
|                                                 | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                 | 323.15     | 0.9570     | 79.48        | OX   |  |
|                                                 |                                                | <b>Ethyl formate</b>                                    |            |            |              |      |  |
| <b>C<sub>3</sub>H<sub>6</sub>O<sub>2</sub></b>  | C <sub>3</sub> H <sub>7</sub> Br               | 2-Bromopropane                                          | 326.15     | 0.7090     | 101.33       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                                             | 323.15     | 0.8210     | 91.46        | OX   |  |
| <b>C<sub>3</sub>H<sub>6</sub>O<sub>2</sub></b>  |                                                | <b>Propanoic acid</b>                                   |            |            |              |      |  |
|                                                 | C <sub>5</sub> H <sub>5</sub> N                | Pyridine                                                | 421.75     | 0.6860     | 101.33       | ON   |  |
| <b>C<sub>3</sub>H<sub>6</sub>O<sub>3</sub></b>  |                                                | <b>Dimethyl carbonate</b>                               |            |            |              |      |  |
|                                                 | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | Diethoxymethane                                         | 358.71     | 0.4437     | 100.42       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>6</sub>                  | Benzene                                                 | 353.50     | 0.1366     | 100.48       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                                             | 346.95     | 0.3780     | 101.49       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>12</sub>                 | Methylcyclopentane                                      | 342.35     | 0.2680     | 103.46       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                                  | 338.15     | 0.2540     | 98.46        | OX   |  |
|                                                 | C <sub>6</sub> H <sub>14</sub> O               | Dipropyl ether                                          | 356.45     | 0.5044     | 100.73       | OX   |  |
|                                                 | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                 | 355.15     | 0.5930     | 99.67        | OX   |  |
|                                                 |                                                | <b>1-Bromopropane</b>                                   |            |            |              |      |  |
| <b>C<sub>3</sub>H<sub>7</sub>Br</b>             | C <sub>3</sub> H <sub>8</sub> O                | 2-Propanol                                              | 339.15     | 0.7349     | 99.97        | OX   |  |
|                                                 | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                                             | 343.35     | 0.9219     | 98.84        | OX   |  |
| <b>C<sub>3</sub>H<sub>7</sub>NO</b>             |                                                | <i>N,N</i> -Dimethylformamide                           |            |            |              |      |  |
|                                                 | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                 | 370.15     | 0.0800     | 101.33       | OX   |  |
|                                                 | C <sub>10</sub> H <sub>16</sub>                | 1,4-Dimethyl-4-vinylcyclohexene                         | 415.65     | 0.5880     | 101.33       | OX   |  |
|                                                 | C <sub>10</sub> H <sub>16</sub>                | 1-Methyl-3-(1-methylethylidene)cyclohexene              | 419.05     | 0.7250     | 101.33       | OX   |  |
|                                                 |                                                | <b>1-Nitropropane</b>                                   |            |            |              |      |  |
| <b>C<sub>3</sub>H<sub>7</sub>NO<sub>2</sub></b> | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                 | 369.25     | 0.1630     | 101.33       | OX   |  |
|                                                 |                                                | <b>2-Nitropropane</b>                                   |            |            |              |      |  |
| <b>C<sub>3</sub>H<sub>7</sub>NO<sub>2</sub></b> | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                 | 367.55     | 0.2920     | 101.33       | OX   |  |
|                                                 |                                                | <b>1-Propanol</b>                                       |            |            |              |      |  |
| <b>C<sub>3</sub>H<sub>8</sub>O</b>              | C <sub>4</sub> H <sub>3</sub> F <sub>7</sub> O | 1,1,2,2-Tetrafluoroethyl 1,1,1-trifluoroethyl ether     | 329.23     | 0.0350     | 101.30       | OX   |  |
|                                                 | C <sub>4</sub> H <sub>4</sub> F <sub>6</sub> O | Bis(2,2,2-trifluoroethyl) ether                         | 336.22     | 0.1100     | 101.30       | OX   |  |
|                                                 | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | 2,3-Butanedione                                         | 359.30     | 0.3600     | 100.67       | OX   |  |
|                                                 | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 1,4-Dioxane                                             | 365.30     | 0.6418     | 101.30       | OX   |  |
|                                                 | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Propyl acetate                                          | 367.88     | 0.6190     | 101.33       | OX   |  |
|                                                 | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | Diethoxymethane                                         | 359.01     | 0.2320     | 99.43        | OX   |  |
|                                                 | C <sub>6</sub> H <sub>6</sub>                  | Benzene                                                 | 350.20     | 0.2060     | 101.33       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                                             | 347.68     | 0.2490     | 101.33       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>12</sub>                 | Methylcyclopentane                                      | 340.85     | 0.1729     | 101.19       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | 4,4-Dimethyl-1,3-dioxane                                | 368.20     | 0.9597     | 101.30       | OX   |  |
|                                                 | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                                  | 348.15     | 0.1900     | 137.23       | OX   |  |
|                                                 | C <sub>7</sub> H <sub>8</sub>                  | Toluene                                                 | 365.35     | 0.6770     | 101.33       | OX   |  |
|                                                 | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                 | 357.65     | 0.4830     | 101.33       | OX   |  |
|                                                 | C <sub>8</sub> H <sub>8</sub>                  | Styrene                                                 | 369.08     | 0.9884     | 98.13        | OX   |  |
|                                                 | C <sub>8</sub> H <sub>10</sub>                 | <i>o</i> -Xylene                                        | 369.85     | 0.9886     | 98.66        | OX   |  |
|                                                 | C <sub>8</sub> H <sub>10</sub>                 | <i>m</i> -Xylene                                        | 369.90     | 0.9531     | 99.06        | OX   |  |
|                                                 | C <sub>8</sub> H <sub>10</sub>                 | <i>p</i> -Xylene                                        | 369.60     | 0.9531     | 99.99        | OX   |  |
|                                                 | C <sub>8</sub> H <sub>14</sub>                 | 1-Octyne                                                | 369.00     | 0.8600     | 101.33       | OX   |  |
|                                                 | C <sub>8</sub> H <sub>18</sub>                 | Octane                                                  | 366.85     | 0.7483     | 101.33       | OX   |  |
|                                                 | C <sub>8</sub> H <sub>18</sub>                 | 2,2,4-Trimethylpentane                                  | 357.89     | 0.4580     | 101.30       | OX   |  |
|                                                 | C <sub>9</sub> H <sub>20</sub>                 | Nonane                                                  | 369.95     | 0.9225     | 101.33       | OX   |  |
|                                                 |                                                | <b>2-Propanol</b>                                       |            |            |              |      |  |
|                                                 | C <sub>4</sub> H <sub>4</sub> F <sub>6</sub> O | Bis(2,2,2-trifluoroethyl) ether                         | 334.16     | 0.2230     | 101.30       | OX   |  |
|                                                 | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | 2,3-Butanedione                                         | 350.85     | 0.6454     | 100.95       | OX   |  |
|                                                 | C <sub>4</sub> H <sub>8</sub> O                | 2-Butanone                                              | 350.55     | 0.3830     | 101.33       | OX   |  |
|                                                 | C <sub>4</sub> H <sub>10</sub> O               | 2-Methyl-2-propanol                                     | 343.05     | 0.5551     | 60.27        | ON   |  |
|                                                 | C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O | 1,1,1,2,3,3-Hexafluoro-3-(2,2,2-trifluoroethoxy)propane | 341.23     | 0.3420     | 101.30       | OX   |  |
|                                                 | C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                                  | 307.05     | 0.0150     | 101.33       | OX   |  |

| Molecular formula                            |                                                |                                                                  |            |            |              |      |
|----------------------------------------------|------------------------------------------------|------------------------------------------------------------------|------------|------------|--------------|------|
| Comp. 1                                      | Comp. 2                                        | Name                                                             | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
|                                              | C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-2-butene                                                | 310.95     | 0.0460     | 101.33       | OX   |
|                                              | C <sub>5</sub> H <sub>10</sub> O               | 2,3-Epoxy-2-methylbutane                                         | 346.10     | 0.1400     | 101.33       | OX   |
|                                              | C <sub>5</sub> H <sub>10</sub> O               | 3-Methyl-2-butanone                                              | 354.75     | 0.8500     | 101.33       | OX   |
|                                              | C <sub>5</sub> H <sub>12</sub>                 | Isopentane                                                       | 298.15     | 0.1370     | 101.33       | OX   |
|                                              | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>  | Diethoxymethane                                                  | 351.45     | 0.6107     | 98.61        | OX   |
|                                              | C <sub>6</sub> H <sub>5</sub> F                | Fluorobenzene                                                    | 347.75     | 0.4666     | 101.25       | OX   |
|                                              | C <sub>6</sub> H <sub>6</sub>                  | Benzene                                                          | 345.03     | 0.3960     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>10</sub>                 | Cyclohexene                                                      | 344.65     | 0.4271     | 101.40       | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                                                      | 342.75     | 0.4050     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub>                 | Methylcyclopentane                                               | 336.45     | 0.2900     | 98.14        | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                                           | 338.15     | 0.2900     | 112.66       | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub> O               | Diisopropyl ether                                                | 340.00     | 0.2050     | 103.36       | OX   |
|                                              | C <sub>6</sub> H <sub>15</sub> N               | Diisopropylamine                                                 | 352.94     | 0.4890     | 101.33       | OX   |
|                                              | C <sub>7</sub> H <sub>8</sub>                  | Toluene                                                          | 354.65     | 0.8370     | 101.33       | OX   |
|                                              | C <sub>7</sub> H <sub>14</sub>                 | Methylcyclohexane                                                | 350.85     | 0.6530     | 101.33       | OX   |
|                                              | C <sub>7</sub> H <sub>16</sub>                 | Heptane                                                          | 349.55     | 0.6023     | 101.33       | OX   |
|                                              | C <sub>7</sub> H <sub>16</sub> O               | <i>tert</i> -Butyl isopropyl ether                               | 349.95     | 0.5306     | 102.70       | OX   |
|                                              | C <sub>8</sub> H <sub>18</sub>                 | Octane                                                           | 354.63     | 0.8990     | 101.33       | OX   |
|                                              | C <sub>8</sub> H <sub>18</sub>                 | 2,2,4-Trimethylpentane                                           | 349.58     | 0.6350     | 101.30       | OX   |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub> |                                                | <b>2-Methoxyethanol</b>                                          |            |            |              |      |
|                                              | C <sub>8</sub> H <sub>8</sub>                  | Styrene                                                          | 393.95     | 0.7787     | 98.93        | OX   |
|                                              | C <sub>8</sub> H <sub>10</sub>                 | <i>o</i> -Xylene                                                 | 392.65     | 0.7127     | 98.79        | OX   |
|                                              | C <sub>8</sub> H <sub>10</sub>                 | <i>m</i> -Xylene                                                 | 392.15     | 0.6397     | 99.73        | OX   |
|                                              | C <sub>8</sub> H <sub>10</sub>                 | <i>p</i> -Xylene                                                 | 392.65     | 0.6303     | 99.99        | OX   |
|                                              | C <sub>8</sub> H <sub>16</sub>                 | 1-Octene                                                         | 380.75     | 0.4700     | 101.33       | OX   |
|                                              | C <sub>8</sub> H <sub>16</sub>                 | <i>cis</i> -4-Octene                                             | 381.25     | 0.4900     | 101.33       | OX   |
|                                              | C <sub>8</sub> H <sub>16</sub>                 | <i>trans</i> -4-Octene                                           | 381.05     | 0.4900     | 101.33       | OX   |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub> |                                                | <b>Dimethoxymethane</b>                                          |            |            |              |      |
|                                              | C <sub>5</sub> H <sub>6</sub>                  | 1,3-Cyclopentadiene                                              | 313.65     | 0.3350     | 101.33       | OX   |
|                                              | C <sub>5</sub> H <sub>8</sub>                  | 2-Methyl-1,3-butadiene                                           | 306.80     | 0.0160     | 101.33       | OX   |
|                                              | C <sub>5</sub> H <sub>8</sub>                  | Methylenecyclobutane                                             | 310.35     | 0.4630     | 101.33       | OX   |
|                                              | C <sub>5</sub> H <sub>8</sub>                  | 1-Methylcyclobutene                                              | 309.05     | 0.2900     | 101.33       | OX   |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub> |                                                | <b>1,2-Propanediol</b>                                           |            |            |              |      |
|                                              | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>  | Di(propylene glycol) monomethyl ether<br>(unspecified isomer)    | 456.85     | 0.5691     | 101.33       | OX   |
|                                              | C <sub>8</sub> H <sub>18</sub> O <sub>3</sub>  | Di(propylene glycol) monoethyl ether<br>(unspecified isomer)     | 458.75     | 0.7778     | 101.33       | OX   |
|                                              | C <sub>9</sub> H <sub>20</sub> O <sub>3</sub>  | Di(propylene glycol) monoisopropyl ether<br>(unspecified isomer) | 458.95     | 0.8130     | 101.33       | OX   |
|                                              | C <sub>9</sub> H <sub>20</sub> O <sub>3</sub>  | Di(propylene glycol) monopropyl ether<br>(unspecified isomer)    | 458.95     | 0.9010     | 101.33       | OX   |
|                                              | C <sub>10</sub> H <sub>22</sub> O <sub>3</sub> | Di(propylene glycol) monobutyl ether<br>(unspecified isomer)     | 459.65     | 0.9721     | 101.33       | OX   |
|                                              | C <sub>10</sub> H <sub>22</sub> O <sub>3</sub> | Di(propylene glycol) monoisobutyl ether<br>(unspecified isomer)  | 459.05     | 0.9255     | 101.33       | OX   |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub> |                                                | <b>1,3-Propanediol</b>                                           |            |            |              |      |
|                                              | C <sub>5</sub> H <sub>12</sub> O <sub>3</sub>  | Di(ethylene glycol) monomethyl ether                             | 455.25     | 0.6300     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>  | Di(ethylene glycol) monoethyl ether                              | 459.25     | 0.9350     | 101.33       | OX   |
| C <sub>4</sub> H <sub>6</sub>                |                                                | <b>1,3-Butadiene</b>                                             |            |            |              |      |
|                                              | C <sub>4</sub> H <sub>8</sub>                  | 2-Butene (unspecified isomer)                                    | 267.59     | 0.7650     | 101.33       | OX   |
| C <sub>4</sub> H <sub>6</sub> O              |                                                | <b>2-Butenal</b>                                                 |            |            |              |      |
|                                              | C <sub>7</sub> H <sub>8</sub>                  | Toluene                                                          | 374.15     | 0.5950     | 97.86        | OX   |
|                                              | C <sub>8</sub> H <sub>18</sub>                 | Octane                                                           | 353.15     | 0.4950     | 97.86        | OX   |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub> |                                                | <b>Vinyl acetate</b>                                             |            |            |              |      |
|                                              | C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane                                                      | 340.45     | 0.6200     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub>                 | Hexane                                                           | 335.25     | 0.4450     | 101.33       | OX   |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub> |                                                | <b>2,3-Butanedione</b>                                           |            |            |              |      |
|                                              | C <sub>7</sub> H <sub>8</sub>                  | Toluene                                                          | 362.70     | 0.9513     | 101.34       | OX   |

| Molecular formula                            |                                               |                         |                 |            |              |      |
|----------------------------------------------|-----------------------------------------------|-------------------------|-----------------|------------|--------------|------|
| Comp. 1                                      | Comp. 2                                       | Name                    | $T_{Az}/K$      | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub> |                                               | Acetic anhydride        |                 |            |              |      |
|                                              | C <sub>8</sub> H <sub>16</sub>                | 1-Octene                | 367.53          | 0.2840     | 53.88        | OX   |
|                                              | C <sub>8</sub> H <sub>18</sub>                | Octane                  | 397.65          | 0.3500     | 129.80       | OX   |
| C <sub>4</sub> H <sub>8</sub> O              |                                               | Butanal                 |                 |            |              |      |
|                                              | C <sub>6</sub> H <sub>12</sub>                | 2-Methyl-1-pentene      | 334.15          | 0.2293     | 101.48       | OX   |
| C <sub>4</sub> H <sub>8</sub> O              |                                               | 2-Butanone              |                 |            |              |      |
|                                              | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Ethyl acetate           | 349.55          | 0.1700     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>6</sub>                 | Benzene                 | 351.53          | 0.4790     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>10</sub>                | Cyclohexene             | 343.29          | 0.5110     | 89.35        | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub>                | 1-Hexene                | 334.75          | 0.1760     | 100.58       | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub>                | Hexane                  | 337.15          | 0.3280     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub> O              | Diisopropyl ether       | 340.55          | 0.1938     | 101.56       | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub> O              | Dipropyl ether          | 351.40          | 0.7785     | 100.88       | OX   |
|                                              | C <sub>7</sub> H <sub>14</sub>                | Methylcyclohexane       | 350.50          | 0.7984     | 98.93        | OX   |
|                                              | C <sub>7</sub> H <sub>16</sub>                | Heptane                 | 350.15          | 0.7670     | 101.33       | OX   |
|                                              | C <sub>4</sub> H <sub>8</sub> O               |                         | Tetrahydrofuran |            |              |      |
| C <sub>6</sub> H <sub>12</sub>               |                                               | 2-Methyl-1-pentene      | 334.65          | 0.2867     | 101.29       | OX   |
| C <sub>6</sub> H <sub>14</sub>               |                                               | Hexane                  | 323.15          | 0.5900     | 65.83        | OX   |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> |                                               | Ethyl acetate           |                 |            |              |      |
|                                              | C <sub>4</sub> H <sub>10</sub> O              | 2-Methyl-2-propanol     | 349.75          | 0.7778     | 101.28       | OX   |
|                                              | C <sub>6</sub> H <sub>6</sub>                 | Benzene                 | 350.55          | 0.9453     | 102.45       | OX   |
|                                              | C <sub>6</sub> H <sub>10</sub>                | Cyclohexene             | 347.45          | 0.6183     | 100.87       | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane             | 345.00          | 0.5390     | 102.45       | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub>                | 1-Hexene                | 333.15          | 0.1230     | 91.47        | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub>                | Hexane                  | 338.00          | 0.3430     | 101.32       | OX   |
|                                              | C <sub>7</sub> H <sub>14</sub>                | Methylcyclohexane       | 349.90          | 0.9001     | 101.83       | OX   |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> |                                               | Butanoic acid           |                 |            |              |      |
|                                              | C <sub>5</sub> H <sub>5</sub> N               | Pyridine                | 436.35          | 0.9117     | 101.33       | ON   |
|                                              | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Butyl butanoate         | 434.60          | 0.6532     | 93.33        | OXD  |
|                                              | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Butyl butanoate         | 434.78          | 0.8639     | 93.33        | OND  |
|                                              | C <sub>11</sub> H <sub>24</sub>               | Undecane                | 435.55          | 0.9060     | 101.33       | OX   |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> |                                               | 1,4-Dioxane             |                 |            |              |      |
|                                              | C <sub>4</sub> H <sub>10</sub> O              | 2-Butanol               | 371.75          | 0.4732     | 100.77       | OX   |
|                                              | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Propyl acetate          | 373.35          | 0.6334     | 101.13       | OX   |
|                                              | C <sub>5</sub> H <sub>12</sub> O              | 2-Methyl-2-butanol      | 373.75          | 0.8119     | 99.62        | OX   |
|                                              | C <sub>6</sub> H <sub>10</sub>                | Cyclohexene             | 355.75          | 0.1065     | 101.44       | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub>                | Methylcyclopentane      | 343.85          | 0.0538     | 99.79        | OX   |
|                                              | C <sub>6</sub> H <sub>15</sub> N              | Triethylamine           | 343.15          | 0.2500     | 56.80        | OX   |
|                                              | C <sub>7</sub> H <sub>16</sub>                | Heptane                 | 364.30          | 0.4868     | 101.06       | OX   |
|                                              | C <sub>7</sub> H <sub>16</sub> O              | 2-Ethoxy-2-methylbutane | 369.15          | 0.5452     | 100.27       | OX   |
|                                              | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  |                         | Propyl formate  |            |              |      |
| C <sub>6</sub> H <sub>6</sub>                |                                               | Benzene                 | 343.15          | 0.3770     | 76.08        | OX   |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> |                                               | Methyl propanoate       |                 |            |              |      |
|                                              | C <sub>7</sub> H <sub>14</sub>                | Methylcyclohexane       | 352.45          | 0.8956     | 101.33       | OX   |
| C <sub>4</sub> H <sub>9</sub> Cl             |                                               | 1-Chlorobutane          |                 |            |              |      |
| C <sub>4</sub> H <sub>9</sub> NO             | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane             | 348.31          | 0.5800     | 95.85        | OX   |
|                                              |                                               | N,N-Dimethylacetamide   |                 |            |              |      |
|                                              | C <sub>8</sub> H <sub>10</sub>                | o-Xylene                | 416.95          | 0.0591     | 103.40       | OX   |
| C <sub>4</sub> H <sub>10</sub> O             | C <sub>8</sub> H <sub>10</sub>                | Ethylbenzene            | 408.95          | 0.0037     | 101.70       | OX   |
|                                              |                                               | 1-Butanol               |                 |            |              |      |
|                                              | C <sub>5</sub> H <sub>5</sub> N               | Pyridine                | 392.00          | 0.7050     | 101.33       | ON   |
|                                              | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub> | Diethyl carbonate       | 370.85          | 0.6346     | 53.20        | OX   |
|                                              | C <sub>6</sub> H <sub>5</sub> Cl              | Chlorobenzene           | 388.25          | 0.6950     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane             | 352.68          | 0.0787     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Butyl acetate           | 389.97          | 0.7700     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Isobutyl acetate        | 387.15          | 0.5980     | 101.33       | OX   |
|                                              | C <sub>6</sub> H <sub>14</sub>                | Hexane                  | 341.35          | 0.0370     | 101.33       | OX   |
|                                              | C <sub>7</sub> H <sub>8</sub>                 | Toluene                 | 378.85          | 0.3320     | 101.33       | OX   |

| Molecular formula |                 |                                    |            |            |              |      |  |
|-------------------|-----------------|------------------------------------|------------|------------|--------------|------|--|
| Comp. 1           | Comp. 2         | Name                               | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |  |
|                   | $C_7H_{12}$     | 3-Ethylcyclopentene                | 367.65     | 0.1900     | 101.33       | OX   |  |
|                   | $C_7H_{16}$     | Heptane                            | 366.55     | 0.2272     | 101.38       | OX   |  |
|                   | $C_8H_8$        | Styrene                            | 388.71     | 0.8923     | 98.39        | OX   |  |
|                   | $C_8H_{10}$     | <i>o</i> -Xylene                   | 388.05     | 0.8671     | 100.13       | OX   |  |
|                   | $C_8H_{10}$     | <i>m</i> -Xylene                   | 387.75     | 0.7865     | 101.46       | OX   |  |
|                   | $C_8H_{10}$     | <i>p</i> -Xylene                   | 387.85     | 0.7823     | 99.73        | OX   |  |
|                   | $C_8H_{14}$     | 1-Octyne                           | 386.50     | 0.6200     | 101.33       | OX   |  |
|                   | $C_8H_{14}$     | 2-Octyne                           | 398.30     | 0.7910     | 101.33       | OX   |  |
|                   | $C_8H_{16}$     | 1-Octene                           | 363.45     | 0.4530     | 53.33        | OX   |  |
|                   | $C_8H_{16}$     | <i>cis</i> -4-Octene               | 382.35     | 0.5300     | 101.33       | OX   |  |
|                   | $C_8H_{16}$     | <i>trans</i> -4-Octene             | 382.15     | 0.5310     | 101.33       | OX   |  |
|                   | $C_8H_{18}$     | Octane                             | 383.15     | 0.5500     | 102.79       | OX   |  |
|                   | $C_8H_{18}O$    | Dibutyl ether                      | 390.59     | 0.8754     | 101.33       | OX   |  |
|                   | $C_9H_{16}$     | 1-Butylcyclopentene                | 356.70     | 0.8450     | 79.99        | OX   |  |
|                   | $C_9H_{16}$     | 1-Nonyne                           | 390.60     | 0.9400     | 101.33       | OX   |  |
|                   | $C_9H_{20}$     | Nonane                             | 389.05     | 0.8128     | 101.33       | OX   |  |
| $C_4H_{10}O$      |                 | <b>2-Butanol</b>                   |            |            |              |      |  |
|                   | $C_5H_{10}O$    | 3-Pentanone                        | 370.50     | 0.6075     | 99.98        | OX   |  |
|                   | $C_6H_{10}$     | Cyclohexene                        | 352.75     | 0.2046     | 101.25       | OX   |  |
|                   | $C_6H_{12}$     | Cyclohexane                        | 349.90     | 0.1892     | 101.02       | OX   |  |
|                   | $C_6H_{14}$     | Hexane                             | 348.15     | 0.1010     | 128.66       | OX   |  |
|                   | $C_6H_{14}O$    | 2-Methoxy-2-methylbutane           | 359.15     | 0.0991     | 102.12       | OX   |  |
|                   | $C_7H_8$        | Toluene                            | 353.44     | 0.5550     | 56.67        | OX   |  |
|                   | $C_7H_{16}$     | Heptane                            | 361.95     | 0.4116     | 102.70       | OX   |  |
|                   | $C_7H_{16}O$    | 2-Ethoxy-2-methylbutane            | 367.75     | 0.4931     | 102.89       | OX   |  |
|                   | $C_8H_{10}$     | <i>m</i> -Xylene                   | 369.85     | 0.9717     | 101.06       | OX   |  |
|                   | $C_8H_{10}$     | <i>p</i> -Xylene                   | 369.55     | 0.9646     | 101.46       | OX   |  |
|                   | $C_8H_{18}$     | Octane                             | 371.05     | 0.8001     | 101.30       | OX   |  |
| $C_4H_{10}O$      |                 | <b>Diethyl ether</b>               |            |            |              |      |  |
|                   | $C_5H_{12}$     | Pentane                            | 306.85     | 0.5500     | 101.33       | OX   |  |
| $C_4H_{10}O$      |                 | <b>2-Methyl-1-propanol</b>         |            |            |              |      |  |
|                   | $C_5H_{10}O_2$  | Isobutyl formate                   | 370.90     | 0.1930     | 101.33       | OX   |  |
|                   | $C_6H_6$        | Benzene                            | 352.45     | 0.0780     | 101.33       | OX   |  |
|                   | $C_6H_{10}$     | Cyclohexene                        | 353.75     | 0.1363     | 100.31       | OX   |  |
|                   | $C_6H_{12}$     | Cyclohexane                        | 351.35     | 0.1325     | 101.45       | OX   |  |
|                   | $C_6H_{12}$     | Methylcyclopentane                 | 343.15     | 0.0567     | 100.35       | OX   |  |
|                   | $C_7H_8$        | Toluene                            | 374.35     | 0.4941     | 101.33       | OX   |  |
|                   | $C_8H_{10}$     | <i>m</i> -Xylene                   | 380.35     | 0.9300     | 101.33       | OX   |  |
|                   | $C_8H_{10}$     | <i>p</i> -Xylene                   | 380.30     | 0.9200     | 101.33       | OX   |  |
|                   | $C_8H_{18}$     | Octane                             | 376.58     | 0.6700     | 101.30       | OX   |  |
| $C_4H_{10}O$      |                 | <b>2-Methyl-2-propanol</b>         |            |            |              |      |  |
|                   | $C_5H_8$        | Methylenecyclobutane               | 314.65     | 0.0150     | 101.33       | OX   |  |
|                   | $C_6H_{10}$     | Cyclohexene                        | 346.00     | 0.4172     | 99.61        | OX   |  |
|                   | $C_6H_{12}$     | Methylcyclopentane                 | 339.35     | 0.2559     | 99.93        | OX   |  |
|                   | $C_6H_{12}$     | 1-Hexene                           | 333.25     | 0.2650     | 101.30       | OX   |  |
|                   | $C_6H_{14}$     | Hexane                             | 337.70     | 0.2502     | 101.30       | OX   |  |
|                   | $C_6H_{14}O$    | <i>tert</i> -Butyl ethyl ether     | 342.85     | 0.2512     | 101.44       | OX   |  |
|                   | $C_6H_{14}O$    | Diisopropyl ether                  | 340.45     | 0.1058     | 101.72       | OX   |  |
|                   | $C_6H_{14}O$    | 2-Methoxy-2-methylbutane           | 353.20     | 0.5617     | 101.80       | OX   |  |
|                   | $C_7H_8$        | Toluene                            | 353.44     | 0.9200     | 93.61        | OX   |  |
|                   | $C_7H_{16}O$    | <i>tert</i> -Butyl isopropyl ether | 350.90     | 0.5390     | 102.94       | OX   |  |
|                   | $C_8H_{18}$     | Octane                             | 343.15     | 0.9680     | 61.18        | OX   |  |
|                   | $C_8H_{18}$     | 2,2,4-Trimethylpentane             | 339.28     | 0.6040     | 59.49        | OX   |  |
| $C_4H_{10}O_2$    |                 | <b>1,4-Butanediol</b>              |            |            |              |      |  |
|                   | $C_{15}H_{32}O$ | 1-Pentadecanol                     | 502.75     | 0.9980     | 101.33       | OX   |  |
| $C_4H_{10}O_2$    |                 | <b>1,2-Dimethoxyethane</b>         |            |            |              |      |  |
|                   | $C_7H_{14}$     | Methylcyclohexane                  | 350.00     | 0.8190     | 79.42        | OX   |  |
| $C_4H_{10}O_2$    |                 | <b>2-Ethoxyethanol</b>             |            |            |              |      |  |

| Molecular formula                             |                                               |                           |            |            |              |      |  |
|-----------------------------------------------|-----------------------------------------------|---------------------------|------------|------------|--------------|------|--|
| Comp. 1                                       | Comp. 2                                       | Name                      | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |  |
|                                               | C <sub>8</sub> H <sub>8</sub>                 | Styrene                   | 405.75     | 0.6438     | 101.33       | OX   |  |
|                                               | C <sub>8</sub> H <sub>10</sub>                | <i>o</i> -Xylene          | 404.95     | 0.5965     | 101.36       | OX   |  |
|                                               | C <sub>8</sub> H <sub>10</sub>                | <i>m</i> -Xylene          | 401.75     | 0.5159     | 101.33       | OX   |  |
|                                               | C <sub>8</sub> H <sub>10</sub>                | <i>p</i> -Xylene          | 402.55     | 0.5042     | 102.19       | OX   |  |
|                                               | C <sub>8</sub> H <sub>10</sub>                | Ethylbenzene              | 401.05     | 0.4632     | 100.94       | OX   |  |
| C <sub>4</sub> H <sub>10</sub> O <sub>3</sub> |                                               | Di(ethylene glycol)       |            |            |              |      |  |
|                                               | C <sub>9</sub> H <sub>20</sub> O              | 1-Nonanol                 | 486.65     | 0.0095     | 101.33       | OX   |  |
| C <sub>4</sub> H <sub>11</sub> N              |                                               | Butylamine                |            |            |              |      |  |
|                                               | C <sub>6</sub> H <sub>6</sub>                 | Benzene                   | 343.15     | 0.7000     | 80.89        | OX   |  |
| C <sub>5</sub> H <sub>5</sub> N               |                                               | Pyridine                  |            |            |              |      |  |
|                                               | C <sub>7</sub> H <sub>8</sub>                 | Toluene                   | 383.19     | 0.2250     | 101.33       | OX   |  |
|                                               | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 368.61     | 0.3002     | 101.33       | OX   |  |
|                                               | C <sub>9</sub> H <sub>20</sub>                | Nonane                    | 388.15     | 0.9350     | 101.33       | OX   |  |
| C <sub>5</sub> H <sub>6</sub>                 |                                               | 2-Methyl-1-buten-3-yne    |            |            |              |      |  |
|                                               | C <sub>5</sub> H <sub>8</sub>                 | 2-Methyl-1,3-butadiene    | 305.88     | 0.7210     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>10</sub>                | 2-Methyl-1-butene         | 303.15     | 0.3450     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                | Isopentane                | 299.35     | 0.3620     | 101.33       | OX   |  |
| C <sub>5</sub> H <sub>6</sub>                 |                                               | 1,3-Cyclopentadiene       |            |            |              |      |  |
|                                               | C <sub>5</sub> H <sub>10</sub>                | 2-Methyl-2-butene         | 310.85     | 0.3000     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                | Pentane                   | 307.75     | 0.1959     | 101.30       | OX   |  |
| C <sub>5</sub> H <sub>8</sub>                 |                                               | 2-Methyl-1,3-butadiene    |            |            |              |      |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                | Pentane                   | 310.55     | 0.7421     | 114.66       | OX   |  |
|                                               | C <sub>6</sub> F <sub>15</sub> N              | Tris(perfluoroethyl)amine | 303.35     | 0.8200     | 101.33       | EX   |  |
| C <sub>5</sub> H <sub>8</sub>                 |                                               | 3-Methyl-1-butyne         |            |            |              |      |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                | Isopentane                | 297.15     | 0.5650     | 101.33       | OX   |  |
| C <sub>5</sub> H <sub>8</sub>                 |                                               | 1-Pentyne                 |            |            |              |      |  |
|                                               | C <sub>5</sub> H <sub>10</sub>                | 2-Methyl-2-butene         | 310.95     | 0.3300     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub>                | Pentane                   | 307.55     | 0.3050     | 101.33       | OX   |  |
| C <sub>5</sub> H <sub>8</sub> O               |                                               | Cyclopentanone            |            |            |              |      |  |
|                                               | C <sub>5</sub> H <sub>12</sub> O              | 3-Methyl-1-butanol        | 402.02     | 0.5944     | 101.33       | OX   |  |
|                                               | C <sub>5</sub> H <sub>12</sub> O              | 1-Pentanol                | 403.84     | 0.9196     | 101.33       | OX   |  |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>  |                                               | Methyl methacrylate       |            |            |              |      |  |
|                                               | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 366.35     | 0.4597     | 99.94        | OX   |  |
|                                               | C <sub>8</sub> H <sub>18</sub>                | Octane                    | 373.70     | 0.9651     | 100.16       | OX   |  |
| C <sub>5</sub> H <sub>10</sub>                |                                               | 2-Methyl-1-butene         |            |            |              |      |  |
|                                               | C <sub>6</sub> F <sub>15</sub> N              | Tris(perfluoroethyl)amine | 301.95     | 0.8450     | 101.33       | OX   |  |
| C <sub>5</sub> H <sub>10</sub>                |                                               | 2-Methyl-2-butene         |            |            |              |      |  |
|                                               | C <sub>6</sub> F <sub>15</sub> N              | Tris(perfluoroethyl)amine | 307.65     | 0.8170     | 101.33       | OX   |  |
| C <sub>5</sub> H <sub>10</sub> O              |                                               | 3-Methyl-3-buten-1-ol     |            |            |              |      |  |
|                                               | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane               | 352.65     | 0.0215     | 101.10       | OX   |  |
|                                               | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | 4,4-Dimethyl-1,3-dioxane  | 403.05     | 0.7590     | 102.26       | OX   |  |
|                                               | C <sub>7</sub> H <sub>8</sub>                 | Toluene                   | 381.55     | 0.2391     | 101.60       | OX   |  |
|                                               | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 370.00     | 0.2100     | 101.30       | OX   |  |
| C <sub>5</sub> H <sub>10</sub> O              |                                               | 2-Methyl-3-buten-2-ol     |            |            |              |      |  |
|                                               | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane               | 350.15     | 0.1904     | 101.20       | OX   |  |
|                                               | C <sub>6</sub> H <sub>12</sub>                | 1-Hexene                  | 336.55     | 0.0479     | 101.30       | OX   |  |
|                                               | C <sub>7</sub> H <sub>8</sub>                 | Toluene                   | 366.55     | 0.7788     | 101.20       | OX   |  |
| C <sub>5</sub> H <sub>10</sub> O              |                                               | 3-Pentanone               |            |            |              |      |  |
|                                               | C <sub>7</sub> H <sub>14</sub>                | Methylcyclohexane         | 366.95     | 0.4441     | 99.82        | OX   |  |
|                                               | C <sub>7</sub> H <sub>16</sub> O              | 2-Ethoxy-2-methylbutane   | 371.15     | 0.4764     | 100.21       | OX   |  |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> |                                               | Propyl acetate            |            |            |              |      |  |
|                                               | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane               | 353.15     | 0.0598     | 100.43       | OX   |  |
|                                               | C <sub>7</sub> H <sub>14</sub>                | Methylcyclohexane         | 368.40     | 0.4746     | 100.90       | OX   |  |
|                                               | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 366.75     | 0.4215     | 101.38       | OX   |  |
|                                               | C <sub>7</sub> H <sub>16</sub> O              | 2-Ethoxy-2-methylbutane   | 370.95     | 0.6529     | 100.03       | OX   |  |
| C <sub>5</sub> H <sub>12</sub>                |                                               | Isopentane                |            |            |              |      |  |
|                                               | C <sub>6</sub> F <sub>15</sub> N              | Tris(perfluoroethyl)amine | 299.65     | 0.9020     | 101.33       | OX   |  |
| C <sub>5</sub> H <sub>12</sub> O              |                                               | 2-Methyl-1-butanol        |            |            |              |      |  |

| Molecular formula                |                                               |                           |            |            |              |      |
|----------------------------------|-----------------------------------------------|---------------------------|------------|------------|--------------|------|
| Comp. 1                          | Comp. 2                                       | Name                      | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
|                                  | C <sub>8</sub> H <sub>10</sub>                | <i>o</i> -Xylene          | 402.05     | 0.7417     | 101.87       | OX   |
|                                  | C <sub>8</sub> H <sub>10</sub>                | <i>m</i> -Xylene          | 400.65     | 0.6316     | 101.85       | OX   |
|                                  | C <sub>8</sub> H <sub>10</sub>                | <i>p</i> -Xylene          | 400.15     | 0.6273     | 101.07       | OX   |
|                                  | C <sub>8</sub> H <sub>10</sub>                | Ethylbenzene              | 398.75     | 0.5657     | 99.46        | OX   |
|                                  | C <sub>5</sub> H <sub>12</sub> O              | <b>3-Methyl-1-butanol</b> |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>10</sub> O              | Cyclohexanone             | 404.87     | 0.9094     | 101.33       | OX   |
|                                  | C <sub>7</sub> H <sub>8</sub>                 | Toluene                   | 383.15     | 0.1250     | 101.33       | OX   |
|                                  | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Isopentyl acetate         | 403.95     | 0.9900     | 101.33       | OX   |
|                                  | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 368.15     | 0.1016     | 95.06        | OX   |
|                                  | C <sub>5</sub> H <sub>12</sub> O              | <b>2-Methyl-2-butanol</b> |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>6</sub>                 | Benzene                   | 352.35     | 0.1500     | 101.33       | OX   |
|                                  | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane               | 351.95     | 0.1100     | 101.33       | OX   |
|                                  | C <sub>6</sub> H <sub>12</sub>                | Methylcyclopentane        | 344.75     | 0.0551     | 101.80       | OX   |
|                                  | C <sub>6</sub> H <sub>14</sub>                | Hexane                    | 339.06     | 0.0436     | 93.55        | OX   |
|                                  | C <sub>7</sub> H <sub>14</sub>                | Methylcyclohexane         | 366.60     | 0.3965     | 99.87        | OX   |
|                                  | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 348.15     | 0.3140     | 56.83        | OX   |
|                                  | C <sub>7</sub> H <sub>16</sub> O              | 2-Ethoxy-2-methylbutane   | 369.85     | 0.3904     | 100.52       | OX   |
|                                  | C <sub>5</sub> H <sub>12</sub> O              | <b>1-Pentanol</b>         |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>10</sub> O              | Cyclohexanone             | 392.37     | 0.9748     | 53.32        | OX   |
|                                  | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Isopentyl acetate         | 407.45     | 0.6000     | 101.33       | OX   |
|                                  | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 371.45     | 0.0576     | 101.33       | OX   |
|                                  | C <sub>8</sub> H <sub>18</sub>                | Octane                    | 393.15     | 0.2847     | 101.33       | OX   |
|                                  | C <sub>9</sub> H <sub>20</sub>                | Nonane                    | 404.45     | 0.6242     | 101.33       | OX   |
|                                  | C <sub>10</sub> H <sub>22</sub>               | Decane                    | 410.65     | 0.9221     | 101.33       | OX   |
|                                  | C <sub>5</sub> H <sub>12</sub> O              | <b>3-Pentanol</b>         |            |            |              |      |
|                                  | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 368.15     | 0.2001     | 98.62        | OX   |
|                                  | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub> | <b>Diethoxymethane</b>    |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane               | 353.21     | 0.1774     | 101.39       | OX   |
|                                  | C <sub>6</sub> H <sub>14</sub>                | Hexane                    | 361.27     | 0.9101     | 102.30       | OX   |
| C <sub>6</sub> F <sub>6</sub>    | <b>Hexafluorobenzene</b>                      |                           |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>6</sub>                 | Benzene                   | 353.60     | 0.7600     | 101.33       | OND  |
|                                  | C <sub>6</sub> H <sub>6</sub>                 | Benzene                   | 352.50     | 0.1832     | 101.33       | OXD  |
| C <sub>6</sub> F <sub>15</sub> N | <b>Tris(perfluoroethyl)amine</b>              |                           |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>6</sub>                 | Benzene                   | 329.95     | 0.5900     | 101.33       | EX   |
|                                  | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane               | 329.35     | 0.5690     | 101.33       | EX   |
|                                  | C <sub>6</sub> H <sub>14</sub>                | Hexane                    | 327.65     | 0.4840     | 101.33       | OX   |
| C <sub>6</sub> H <sub>5</sub> Br | <b>Bromobenzene</b>                           |                           |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>12</sub> O              | Cyclohexanol              | 403.15     | 0.7390     | 52.45        | OX   |
|                                  | C <sub>6</sub> H <sub>6</sub>                 | <b>Benzene</b>            |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>12</sub>                | Cyclohexane               | 353.15     | 0.5460     | 109.18       | OX   |
|                                  | C <sub>6</sub> H <sub>12</sub>                | Methylcyclopentane        | 333.15     | 0.1390     | 69.93        | OX   |
|                                  | C <sub>6</sub> H <sub>14</sub>                | Hexane                    | 341.45     | 0.0500     | 101.33       | OX   |
|                                  | C <sub>7</sub> H <sub>16</sub>                | Heptane                   | 353.25     | 0.9922     | 101.32       | OX   |
|                                  | C <sub>8</sub> H <sub>18</sub>                | 2,2,4-Trimethylpentane    | 353.25     | 0.9751     | 101.32       | OX   |
|                                  | C <sub>6</sub> H <sub>6</sub> O               | <b>Phenol</b>             |            |            |              |      |
|                                  | C <sub>6</sub> H <sub>7</sub> N               | Aniline                   | 459.09     | 0.3884     | 101.33       | ON   |
|                                  | C <sub>6</sub> H <sub>7</sub> N               | 2-Methylpyridine          | 458.33     | 0.7852     | 101.32       | ON   |
|                                  | C <sub>6</sub> H <sub>7</sub> N               | 3-Methylpyridine          | 462.93     | 0.6918     | 101.32       | ON   |
|                                  | C <sub>7</sub> H <sub>5</sub> N               | Benzonitrile              | 465.11     | 0.2345     | 101.33       | ON   |
|                                  | C <sub>7</sub> H <sub>6</sub> O               | Benzaldehyde              | 447.00     | 0.6001     | 73.00        | ON   |
|                                  | C <sub>7</sub> H <sub>9</sub> N               | 2,6-Dimethylpyridine      | 459.32     | 0.7539     | 101.32       | ON   |
|                                  | C <sub>8</sub> H <sub>18</sub>                | Octane                    | 398.17     | 0.0690     | 101.32       | OX   |
|                                  | C <sub>9</sub> H <sub>12</sub>                | Propylbenzene             | 428.15     | 0.1150     | 91.85        | OX   |
|                                  | C <sub>9</sub> H <sub>12</sub>                | 1,2,3-Trimethylbenzene    | 443.45     | 0.3936     | 101.33       | OX   |
|                                  | C <sub>9</sub> H <sub>12</sub>                | 1,2,4-Trimethylbenzene    | 440.65     | 0.2409     | 101.33       | OX   |
|                                  | C <sub>9</sub> H <sub>12</sub>                | 1,3,5-Trimethylbenzene    | 436.95     | 0.1828     | 101.33       | OX   |
|                                  | C <sub>9</sub> H <sub>18</sub>                | 1-Nonene                  | 413.15     | 0.1297     | 86.57        | OX   |
|                                  | C <sub>9</sub> H <sub>20</sub>                | Nonane                    | 419.18     | 0.2180     | 101.32       | OX   |

| Molecular formula               |                                 |                                     |            |            |              |      |
|---------------------------------|---------------------------------|-------------------------------------|------------|------------|--------------|------|
| Comp. 1                         | Comp. 2                         | Name                                | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
| C <sub>6</sub> H <sub>7</sub> N | C <sub>10</sub> H <sub>12</sub> | 1,2,3,4-Tetrahydronaphthalene       | 448.15     | 0.9031     | 84.25        | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | Butylbenzene                        | 447.05     | 0.5535     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>sec</i> -Butylbenzene            | 441.15     | 0.3129     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>tert</i> -Butylbenzene           | 439.95     | 0.2773     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | Diethylbenzene (unspecified isomer) | 446.45     | 0.4705     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>o</i> -Diethylbenzene            | 447.15     | 0.5565     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>m</i> -Diethylbenzene            | 445.95     | 0.5152     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Ethyl-3,5-dimethylbenzene         | 447.95     | 0.5840     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 2-Ethyl-1,4-dimethylbenzene         | 447.95     | 0.5840     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | Isobutylbenzene                     | 441.75     | 0.3522     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Isopropyl-2-methylbenzene         | 443.75     | 0.4643     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Isopropyl-3-methylbenzene         | 443.05     | 0.4027     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Isopropyl-4-methylbenzene         | 443.65     | 0.4430     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Methyl-2-propylbenzene            | 447.75     | 0.5801     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Methyl-3-propylbenzene            | 446.35     | 0.5264     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Methyl-4-propylbenzene            | 447.15     | 0.5575     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1,2,3,5-Tetramethylbenzene          | 454.25     | 0.7957     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1,2,4,5-Tetramethylbenzene          | 453.36     | 0.7857     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>18</sub> | <i>trans</i> -Decahydronaphthalene  | 443.15     | 0.5419     | 99.85        | OX   |
|                                 | C <sub>10</sub> H <sub>22</sub> | Decane                              | 434.15     | 0.4450     | 101.32       | OX   |
|                                 | C <sub>11</sub> H <sub>16</sub> | 1-Butyl-2-methylbenzene             | 455.55     | 0.8504     | 101.33       | OX   |
|                                 | C <sub>11</sub> H <sub>16</sub> | 1-Butyl-3-methylbenzene             | 454.15     | 0.8099     | 101.33       | OX   |
|                                 | C <sub>11</sub> H <sub>16</sub> | 1-Butyl-4-methylbenzene             | 454.55     | 0.8230     | 101.33       | OX   |
|                                 | C <sub>11</sub> H <sub>22</sub> | 1-Undecene                          | 443.15     | 0.6426     | 92.31        | OX   |
|                                 | C <sub>12</sub> H <sub>26</sub> | Dodecane                            | 450.73     | 0.7900     | 101.32       | OX   |
|                                 | C <sub>14</sub> H <sub>30</sub> | Tetradecane                         | 452.48     | 0.9650     | 101.32       | OX   |
|                                 |                                 | <b>Aniline</b>                      |            |            |              |      |
|                                 | C <sub>7</sub> H <sub>8</sub> O | <i>o</i> -Cresol                    | 464.29     | 0.0953     | 101.33       | ON   |
|                                 | C <sub>9</sub> H <sub>12</sub>  | 1,2,3-Trimethylbenzene              | 444.65     | 0.3331     | 101.33       | OX   |
|                                 | C <sub>9</sub> H <sub>12</sub>  | 1,2,4-Trimethylbenzene              | 441.80     | 0.1850     | 101.33       | OX   |
|                                 | C <sub>9</sub> H <sub>12</sub>  | 1,3,5-Trimethylbenzene              | 437.68     | 0.1071     | 101.33       | OX   |
|                                 | C <sub>9</sub> H <sub>20</sub>  | Nonane                              | 422.35     | 0.1770     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | Butylbenzene                        | 448.65     | 0.4993     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>sec</i> -Butylbenzene            | 443.15     | 0.3021     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>tert</i> -Butylbenzene           | 438.25     | 0.2104     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>o</i> -Diethylbenzene            | 448.75     | 0.5024     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>m</i> -Diethylbenzene            | 447.45     | 0.4584     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | <i>p</i> -Diethylbenzene            | 448.85     | 0.5086     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Ethyl-3,5-dimethylbenzene         | 449.65     | 0.5310     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 2-Ethyl-1,4-dimethylbenzene         | 449.65     | 0.5310     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | Isobutylbenzene                     | 442.75     | 0.2890     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Isopropyl-2-methylbenzene         | 445.95     | 0.4052     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Isopropyl-3-methylbenzene         | 444.15     | 0.3419     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Isopropyl-4-methylbenzene         | 445.35     | 0.3829     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Methyl-2-propylbenzene            | 449.45     | 0.5270     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Methyl-3-propylbenzene            | 447.85     | 0.4711     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1-Methyl-4-propylbenzene            | 448.75     | 0.5035     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1,2,3,5-Tetramethylbenzene          | 456.55     | 0.7504     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>14</sub> | 1,2,4,5-Tetramethylbenzene          | 455.36     | 0.7349     | 101.33       | OX   |
|                                 | C <sub>10</sub> H <sub>22</sub> | Decane                              | 440.43     | 0.4660     | 101.33       | OX   |
|                                 | C <sub>11</sub> H <sub>16</sub> | 1-Butyl-2-methylbenzene             | 458.15     | 0.8091     | 101.33       | OX   |
|                                 | C <sub>11</sub> H <sub>16</sub> | 1-Butyl-3-methylbenzene             | 456.55     | 0.7661     | 101.33       | OX   |
|                                 | C <sub>11</sub> H <sub>16</sub> | 1-Butyl-4-methylbenzene             | 457.05     | 0.7807     | 101.33       | OX   |
|                                 | C <sub>11</sub> H <sub>24</sub> | Undecane                            | 449.05     | 0.6970     | 101.33       | OX   |
|                                 | C <sub>12</sub> H <sub>26</sub> | Dodecane                            | 453.52     | 0.8220     | 101.33       | OX   |
|                                 | C <sub>13</sub> H <sub>28</sub> | Tridecane                           | 456.22     | 0.9300     | 101.33       | OX   |
|                                 | C <sub>14</sub> H <sub>30</sub> | Tetradecane                         | 457.05     | 0.9770     | 101.33       | OX   |
| C <sub>6</sub> H <sub>7</sub> N |                                 | <b>2-Methylpyridine</b>             |            |            |              |      |

| Molecular formula |                |                                               |            |            |              |      |
|-------------------|----------------|-----------------------------------------------|------------|------------|--------------|------|
| Comp. 1           | Comp. 2        | Name                                          | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
| $C_6H_7N$         | $C_8H_{18}$    | Octane                                        | 394.27     | 0.4610     | 101.33       | OX   |
|                   | $C_9H_{20}$    | Nonane                                        | 402.35     | 0.8790     | 101.33       | OX   |
|                   |                | <b>3-Methylpyridine</b>                       |            |            |              |      |
| $C_6H_7N$         | $C_7H_8O$      | <i>m</i> -Cresol                              | 477.01     | 0.1556     | 101.32       | ON   |
|                   | $C_7H_9N$      | 2,6-Dimethylpyridine                          | 416.64     | 0.2940     | 101.33       | OX   |
|                   |                | <b>4-Methylpyridine</b>                       |            |            |              |      |
| $C_6H_{10}O$      | $C_7H_8O$      | <i>m</i> -Cresol                              | 477.74     | 0.1822     | 101.32       | ON   |
|                   | $C_7H_9N$      | 2,6-Dimethylpyridine                          | 417.08     | 0.2000     | 101.32       | OX   |
|                   |                | <b>Methyldihdropyran (unspecified isomer)</b> |            |            |              |      |
| $C_6H_{10}O$      | $C_7H_8$       | Toluene                                       | 381.85     | 0.0207     | 101.30       | OX   |
|                   |                | <b>4-Methylenetetrahydropyran</b>             |            |            |              |      |
|                   | $C_7H_8$       | Toluene                                       | 381.15     | 0.5253     | 101.20       | OX   |
| $C_6H_{12}O$      |                | <b>Cyclohexanol</b>                           |            |            |              |      |
|                   | $C_8H_{10}$    | <i>o</i> -Xylene                              | 415.95     | 0.1426     | 101.33       | OX   |
|                   | $C_8H_{10}$    | <i>m</i> -Xylene                              | 411.85     | 0.0503     | 101.33       | OX   |
| $C_6H_{12}O_2$    | $C_8H_{10}$    | <i>p</i> -Xylene                              | 410.95     | 0.0505     | 101.33       | OX   |
|                   | $C_9H_{20}$    | Nonane                                        | 410.20     | 0.3350     | 79.99        | OX   |
|                   |                | <b>Butyl acetate</b>                          |            |            |              |      |
| $C_6H_{12}O_2$    | $C_8H_{16}$    | 1-Octene                                      | 393.00     | 0.3030     | 101.33       | OX   |
|                   |                | <b>4,4-Dimethyl-1,3-dioxane</b>               |            |            |              |      |
|                   | $C_8H_{10}$    | <i>o</i> -Xylene                              | 404.65     | 0.9662     | 101.30       | OX   |
| $C_6H_{14}O$      | $C_8H_{18}$    | Octane                                        | 393.95     | 0.3343     | 101.20       | OX   |
|                   | $C_9H_{20}$    | Nonane                                        | 402.15     | 0.8864     | 101.30       | OX   |
|                   | $C_{10}H_{22}$ | Decane                                        | 405.35     | 0.9999     | 100.60       | OX   |
| $C_6H_{14}O_2$    |                | <b>1-Hexanol</b>                              |            |            |              |      |
|                   | $C_8H_{18}$    | Octane                                        | 398.55     | 0.0886     | 101.33       | OX   |
|                   | $C_9H_{20}$    | Nonane                                        | 416.95     | 0.3649     | 101.33       | OX   |
| $C_7F_{16}$       | $C_{10}H_{22}$ | Decane                                        | 427.05     | 0.7123     | 101.33       | OX   |
|                   |                | <b>2,2-Dimethoxybutane</b>                    |            |            |              |      |
|                   | $C_7H_8$       | Toluene                                       | 380.15     | 0.9180     | 101.44       | OX   |
| $C_7H_5N$         |                | <b>Perfluoroheptane</b>                       |            |            |              |      |
|                   | $C_7H_{16}$    | Heptane                                       | 328.16     | 0.6100     | 53.60        | OX   |
|                   |                | <b>Benzonitrile</b>                           |            |            |              |      |
| $C_7H_8O$         | $C_7H_8O$      | <i>o</i> -Cresol                              | 468.91     | 0.5100     | 101.33       | ON   |
|                   | $C_7H_8O$      | <i>m</i> -Cresol                              | 476.10     | 0.1441     | 101.33       | ON   |
|                   | $C_7H_8O$      | <i>p</i> -Cresol                              | 476.95     | 0.0898     | 101.33       | ON   |
| $C_7H_8O$         | $C_8H_{10}O$   | 2,6-Xylenol                                   | 477.15     | 0.0807     | 101.33       | ON   |
|                   |                | <b><i>o</i>-Cresol</b>                        |            |            |              |      |
|                   | $C_8H_{11}N$   | 2,4,6-Trimethylpyridine                       | 470.35     | 0.6561     | 101.33       | ON   |
| $C_7H_8O$         | $C_{10}H_{14}$ | <i>sec</i> -Butylbenzene                      | 444.65     | 0.0938     | 101.33       | OX   |
|                   | $C_{10}H_{14}$ | Diethylbenzene (unspecified isomer)           | 453.10     | 0.2694     | 101.33       | OX   |
|                   | $C_{10}H_{14}$ | 1,2,4,5-Tetramethylbenzene                    | 462.37     | 0.6273     | 101.33       | OX   |
| $C_7H_8O$         | $C_{10}H_{22}$ | Decane                                        | 433.15     | 0.3100     | 78.71        | OX   |
|                   | $C_{11}H_{22}$ | 1-Undecene                                    | 448.15     | 0.5516     | 83.07        | OX   |
|                   | $C_{11}H_{24}$ | Undecane                                      | 433.15     | 0.5800     | 56.40        | OX   |
| $C_7H_8O$         | $C_{12}H_{26}$ | Dodecane                                      | 458.15     | 0.8466     | 93.55        | OX   |
|                   |                | <b><i>m</i>-Cresol</b>                        |            |            |              |      |
|                   | $C_7H_9N$      | 2,6-Dimethylpyridine                          | 475.66     | 0.9869     | 101.32       | ON   |
| $C_7H_8O$         | $C_9H_7N$      | Quinoline                                     | 511.20     | 0.0356     | 101.33       | ON   |
|                   | $C_9H_{20}$    | Nonane                                        | 413.15     | 0.0400     | 76.54        | OX   |
|                   | $C_{10}H_8$    | Naphthalene                                   | 474.65     | 0.9680     | 101.33       | OX   |
| $C_7H_8O$         | $C_{10}H_{12}$ | 1,2,3,4-Tetrahydronaphthalene                 | 468.45     | 0.5900     | 93.10        | OX   |
|                   | $C_{10}H_{14}$ | <i>sec</i> -Butylbenzene                      | 445.85     | 0.0136     | 101.33       | OX   |
|                   | $C_{10}H_{14}$ | Diethylbenzene (unspecified isomer)           | 454.10     | 0.1010     | 101.33       | OX   |
| $C_7H_8O$         | $C_{10}H_{14}$ | 1,2,4,5-Tetramethylbenzene                    | 466.87     | 0.3591     | 101.33       | OX   |
|                   | $C_{10}H_{22}$ | Decane                                        | 433.15     | 0.2170     | 75.85        | OX   |
|                   |                | <b><i>p</i>-Cresol</b>                        |            |            |              |      |
| $C_7H_8O$         | $C_{10}H_8$    | Naphthalene                                   | 474.55     | 0.9414     | 101.33       | OX   |



| Molecular formula |                 |                                     |            |            |              |      |  |
|-------------------|-----------------|-------------------------------------|------------|------------|--------------|------|--|
| Comp. 1           | Comp. 2         | Name                                | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |  |
| $C_7H_8O$         | $C_{10}H_{14}$  | <i>sec</i> -Butylbenzene            | 446.05     | 0.0186     | 101.33       | OX   |  |
|                   | $C_{10}H_{14}$  | Diethylbenzene (unspecified isomer) | 454.50     | 0.1105     | 101.33       | OX   |  |
|                   |                 | <b>Benzyl alcohol</b>               |            |            |              |      |  |
|                   | $C_{10}H_{22}$  | Decane                              | 445.75     | 0.2490     | 101.33       | OX   |  |
| $C_7H_9N$         |                 | <b>2-Methylaniline</b>              |            |            |              |      |  |
|                   | $C_{10}H_{22}$  | Decane                              | 446.91     | 0.1770     | 101.33       | OX   |  |
|                   | $C_{11}H_{24}$  | Undecane                            | 461.40     | 0.4930     | 101.33       | OX   |  |
|                   | $C_{12}H_{26}$  | Dodecane                            | 468.90     | 0.7650     | 101.33       | OX   |  |
|                   | $C_{13}H_{28}$  | Tridecane                           | 472.55     | 0.9070     | 101.33       | OX   |  |
| $C_7H_{14}O_2$    |                 | <b>Pentyl acetate</b>               |            |            |              |      |  |
|                   | $C_9H_{20}$     | Nonane                              | 419.20     | 0.5380     | 101.32       | OX   |  |
| $C_7H_{16}O$      |                 | <b>1-Heptanol</b>                   |            |            |              |      |  |
|                   | $C_9H_{20}$     | Nonane                              | 423.45     | 0.1071     | 101.33       | OX   |  |
|                   | $C_{10}H_{22}$  | Decane                              | 438.75     | 0.4308     | 101.33       | OX   |  |
|                   | $C_{11}H_{24}$  | Undecane                            | 447.85     | 0.8014     | 101.33       | OX   |  |
| $C_8H_{10}$       |                 | <i>o</i> -Xylene                    |            |            |              |      |  |
|                   | $C_9H_{20}$     | Nonane                              | 417.40     | 0.8498     | 101.33       | OX   |  |
| $C_8H_{10}O$      |                 | <b>2,6-Xylenol</b>                  |            |            |              |      |  |
|                   | $C_9H_7N$       | Quinoline                           | 511.00     | 0.0890     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 475.70     | 0.9381     | 101.33       | OX   |  |
|                   | $C_{10}H_{14}$  | 1,2,4,5-Tetramethylbenzene          | 468.85     | 0.3480     | 101.33       | OX   |  |
| $C_8H_{10}O$      |                 | <b>2,3-Xylenol</b>                  |            |            |              |      |  |
|                   | $C_9H_7N$       | Quinoline                           | 513.30     | 0.2684     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 485.45     | 0.4123     | 101.33       | OX   |  |
| $C_8H_{10}O$      |                 | <b>2,4-Xylenol</b>                  |            |            |              |      |  |
|                   | $C_9H_7N$       | Quinoline                           | 512.30     | 0.1717     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 481.25     | 0.6435     | 101.33       | OX   |  |
|                   | $C_{10}H_{14}$  | 1,2,4,5-Tetramethylbenzene          | 474.05     | 0.1869     | 101.33       | OX   |  |
| $C_8H_{10}O$      |                 | <b>2,5-Xylenol</b>                  |            |            |              |      |  |
|                   | $C_9H_7N$       | Quinoline                           | 512.30     | 0.1717     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 481.25     | 0.6435     | 101.33       | OX   |  |
|                   | $C_{10}H_{14}$  | 1,2,4,5-Tetramethylbenzene          | 474.35     | 0.1763     | 101.33       | OX   |  |
| $C_8H_{10}O$      |                 | <b>3,4-Xylenol</b>                  |            |            |              |      |  |
|                   | $C_9H_7N$       | Isoquinoline                        | 519.75     | 0.2955     | 101.33       | ON   |  |
|                   | $C_9H_7N$       | Quinoline                           | 514.77     | 0.3907     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 490.95     | 0.1158     | 101.33       | OX   |  |
|                   | $C_{10}H_9N$    | 3-Methylisoquinoline                | 524.35     | 0.0811     | 101.33       | ON   |  |
|                   | $C_{10}H_9N$    | 2-Methylquinoline                   | 521.17     | 0.1647     | 101.33       | ON   |  |
|                   | $C_{10}H_9N$    | 3-Methylquinoline                   | 523.60     | 0.1152     | 101.33       | ON   |  |
|                   | $C_{10}H_9N$    | 7-Methylquinoline                   | 525.85     | 0.0466     | 101.33       | ON   |  |
|                   | $C_{11}H_{11}N$ | 2,3-Dimethylquinoline               | 521.60     | 0.2113     | 101.33       | ON   |  |
|                   |                 | <b>3,5-Xylenol</b>                  |            |            |              |      |  |
| $C_8H_{10}O$      | $C_9H_7N$       | Isoquinoline                        | 518.05     | 0.1915     | 101.33       | ON   |  |
|                   | $C_9H_7N$       | Quinoline                           | 513.58     | 0.3287     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 489.33     | 0.2601     | 101.33       | OX   |  |
|                   | $C_{10}H_9N$    | 2-Methylquinoline                   | 520.65     | 0.0094     | 101.33       | ON   |  |
|                   | $C_{11}H_{11}N$ | 2,3-Dimethylquinoline               | 520.70     | 0.0530     | 101.33       | ON   |  |
|                   |                 | <b>2-Ethylphenol</b>                |            |            |              |      |  |
|                   | $C_9H_7N$       | Quinoline                           | 511.75     | 0.1041     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 478.35     | 0.8005     | 101.33       | OX   |  |
|                   | $C_{10}H_{14}$  | 1,2,4,5-Tetramethylbenzene          | 471.45     | 0.3707     | 101.33       | OX   |  |
| $C_8H_{10}O$      |                 | <b>3-Ethylphenol</b>                |            |            |              |      |  |
|                   | $C_9H_7N$       | Quinoline                           | 512.70     | 0.2089     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 483.45     | 0.5551     | 101.33       | OX   |  |
|                   | $C_{10}H_{14}$  | 1,2,4,5-Tetramethylbenzene          | 475.95     | 0.1249     | 101.33       | OX   |  |
| $C_8H_{10}O$      |                 | <b>4-Ethylphenol</b>                |            |            |              |      |  |
|                   | $C_9H_7N$       | Quinoline                           | 513.45     | 0.2832     | 101.33       | ON   |  |
|                   | $C_{10}H_8$     | Naphthalene                         | 486.10     | 0.3762     | 101.33       | OX   |  |

| Molecular formula                 |                                   |                                      |            |            |              |      |
|-----------------------------------|-----------------------------------|--------------------------------------|------------|------------|--------------|------|
| Comp. 1                           | Comp. 2                           | Name                                 | $T_{Az}/K$ | $y_{1,Az}$ | $P_{Az}/kPa$ | Type |
| C <sub>8</sub> H <sub>11</sub> N  |                                   | <b>2,4-Dimethylaniline</b>           |            |            |              |      |
|                                   | C <sub>11</sub> H <sub>24</sub>   | Undecane                             | 468.13     | 0.1490     | 101.33       | OX   |
|                                   | C <sub>12</sub> H <sub>26</sub>   | Dodecane                             | 482.95     | 0.4520     | 101.33       | OX   |
|                                   | C <sub>13</sub> H <sub>28</sub>   | Tridecane                            | 488.43     | 0.7880     | 101.33       | OX   |
| C <sub>8</sub> H <sub>18</sub> O  | C <sub>14</sub> H <sub>30</sub>   | Tetradecane                          | 490.53     | 0.9840     | 101.33       | OX   |
|                                   |                                   | <b>1-Octanol</b>                     |            |            |              |      |
|                                   | C <sub>10</sub> H <sub>22</sub>   | Decane                               | 446.45     | 0.1029     | 101.33       | OX   |
|                                   | C <sub>11</sub> H <sub>24</sub>   | Undecane                             | 460.05     | 0.4772     | 101.33       | OX   |
| C <sub>9</sub> H <sub>7</sub> N   | C <sub>12</sub> H <sub>26</sub>   | Dodecane                             | 466.95     | 0.8836     | 101.33       | OX   |
|                                   |                                   | <b>Isoquinoline</b>                  |            |            |              |      |
| C <sub>9</sub> H <sub>7</sub> N   | C <sub>11</sub> H <sub>10</sub>   | 2-Methylnaphthalene                  | 513.90     | 0.2074     | 101.33       | OX   |
| C <sub>9</sub> H <sub>7</sub> N   |                                   | <b>Quinoline</b>                     |            |            |              |      |
|                                   | C <sub>9</sub> H <sub>12</sub> O  | 3-Isopropylphenol                    | 514.70     | 0.6109     | 101.33       | ON   |
|                                   | C <sub>9</sub> H <sub>12</sub> O  | 2-Isopropylphenol                    | 512.75     | 0.8015     | 101.33       | ON   |
|                                   | C <sub>9</sub> H <sub>12</sub> O  | 2-Propylphenol                       | 513.60     | 0.7243     | 101.33       | ON   |
|                                   | C <sub>9</sub> H <sub>12</sub> O  | 3-Propylphenol                       | 514.70     | 0.6109     | 101.33       | ON   |
|                                   | C <sub>9</sub> H <sub>12</sub> O  | 4-Propylphenol                       | 515.35     | 0.5451     | 101.33       | ON   |
|                                   | C <sub>10</sub> H <sub>14</sub> O | 2-Butylphenol                        | 515.70     | 0.5350     | 101.33       | ON   |
|                                   | C <sub>10</sub> H <sub>14</sub> O | 2- <i>tert</i> -Butylphenol          | 513.70     | 0.7299     | 101.33       | ON   |
|                                   | C <sub>10</sub> H <sub>14</sub> O | 3- <i>tert</i> -Butylphenol          | 517.05     | 0.4315     | 101.33       | ON   |
|                                   | C <sub>10</sub> H <sub>14</sub> O | 4-Isobutylphenol                     | 515.95     | 0.5061     | 101.33       | ON   |
|                                   | C <sub>10</sub> H <sub>14</sub> O | 2- <i>sec</i> -Butylphenol           | 514.70     | 0.6339     | 101.33       | ON   |
|                                   | C <sub>10</sub> H <sub>14</sub> O | 4- <i>sec</i> -Butylphenol           | 516.45     | 0.4551     | 101.33       | ON   |
|                                   | C <sub>11</sub> H <sub>10</sub>   | 2-Methylnaphthalene                  | 511.05     | 0.9213     | 101.33       | OX   |
|                                   | C <sub>11</sub> H <sub>16</sub> O | 2- <i>tert</i> -Butyl-5-methylphenol | 515.45     | 0.5854     | 101.33       | ON   |
|                                   | C <sub>11</sub> H <sub>16</sub> O | 2- <i>sec</i> -Butyl-4-methylphenol  | 516.10     | 0.5139     | 101.33       | ON   |
| C <sub>9</sub> H <sub>12</sub>    |                                   | <b>1,2,3-Trimethylbenzene</b>        |            |            |              |      |
|                                   | C <sub>10</sub> H <sub>22</sub>   | Decane                               | 433.35     | 0.4010     | 72.54        | OX   |
| C <sub>9</sub> H <sub>12</sub>    |                                   | <b>1,2,4-Trimethylbenzene</b>        |            |            |              |      |
|                                   | C <sub>10</sub> H <sub>22</sub>   | Decane                               | 433.35     | 0.8600     | 80.25        | OX   |
| C <sub>9</sub> H <sub>12</sub> O  |                                   | <b>2-Ethyl-4-methylphenol</b>        |            |            |              |      |
|                                   | C <sub>10</sub> H <sub>8</sub>    | Naphthalene                          | 488.20     | 0.2218     | 101.33       | OX   |
| C <sub>9</sub> H <sub>12</sub> O  |                                   | <b>2-Ethyl-5-methylphenol</b>        |            |            |              |      |
|                                   | C <sub>10</sub> H <sub>8</sub>    | Naphthalene                          | 489.45     | 0.1710     | 101.33       | OX   |
| C <sub>9</sub> H <sub>12</sub> O  |                                   | <b>2-Isopropylphenol</b>             |            |            |              |      |
|                                   | C <sub>10</sub> H <sub>8</sub>    | Naphthalene                          | 483.15     | 0.5102     | 101.33       | OX   |
|                                   | C <sub>10</sub> H <sub>14</sub>   | 1,2,4,5-Tetramethylbenzene           | 476.25     | 0.1036     | 101.33       | OX   |
| C <sub>9</sub> H <sub>12</sub> O  |                                   | <b>2,4,6-Trimethylphenol</b>         |            |            |              |      |
|                                   | C <sub>10</sub> H <sub>8</sub>    | Naphthalene                          | 486.70     | 0.3161     | 101.33       | OX   |
| C <sub>9</sub> H <sub>20</sub> O  |                                   | <b>1-Nonanol</b>                     |            |            |              |      |
|                                   | C <sub>11</sub> H <sub>24</sub>   | Undecane                             | 468.45     | 0.0925     | 101.33       | OX   |
|                                   | C <sub>12</sub> H <sub>26</sub>   | Dodecane                             | 480.65     | 0.5235     | 101.33       | OX   |
| C <sub>10</sub> H <sub>22</sub> O |                                   | <b>1-Decanol</b>                     |            |            |              |      |
|                                   | C <sub>12</sub> H <sub>26</sub>   | Dodecane                             | 489.25     | 0.1068     | 101.33       | OX   |

## VISCOSITY OF GASES

The following table gives the viscosity of some common gases as a function of temperature. Unless otherwise noted, the viscosity values refer to a pressure of 100 kPa (1 bar). The notation  $P=0$  indicates the low pressure limiting value is given. The difference

between the viscosity at 100 kPa and the limiting value is generally less than 1%. Viscosity is given in units of  $\mu\text{Pa s}$ ; note that  $1 \mu\text{Pa s} = 10^{-5}$  poise. Substances are listed in the modified Hill order (see Introduction).

|                                   |                               | Viscosity in micropascal seconds ( $\mu\text{Pa s}$ ) |       |       |       |       |       | Ref. |
|-----------------------------------|-------------------------------|-------------------------------------------------------|-------|-------|-------|-------|-------|------|
|                                   |                               | 100 K                                                 | 200 K | 300 K | 400 K | 500 K | 600 K |      |
|                                   | Air                           | 7.1                                                   | 13.3  | 18.6  | 23.1  | 27.1  | 30.8  | 1    |
| Ar                                | Argon                         | 8.0                                                   | 15.9  | 22.9  | 28.8  | 34.2  | 39.0  | 2,8  |
| $\text{BF}_3$                     | Boron trifluoride             |                                                       | 12.3  | 17.1  | 21.7  | 26.1  | 30.2  | 13   |
| $\text{ClH}$                      | Hydrogen chloride             |                                                       |       | 14.6  | 19.7  | 24.3  |       | 13   |
| $\text{F}_6\text{S}$              | Sulfur hexafluoride ( $P=0$ ) |                                                       |       | 15.3  | 19.8  | 23.9  | 27.7  | 10   |
| $\text{H}_2$                      | Hydrogen ( $P=0$ )            | 4.2                                                   | 6.8   | 9.0   | 10.9  | 12.7  | 14.4  | 4    |
| $\text{D}_2$                      | Deuterium ( $P=0$ )           | 5.9                                                   | 9.6   | 12.6  | 15.4  | 17.9  | 20.3  | 11   |
| $\text{H}_2\text{O}$              | Water                         |                                                       |       | 10.0  | 13.3  | 17.3  | 21.4  | 6    |
| $\text{D}_2\text{O}$              | Deuterium oxide               |                                                       |       | 11.1  | 13.7  | 17.7  | 22.0  | 7    |
| He                                | Helium ( $P=0$ )              | 9.7                                                   | 15.3  | 20.0  | 24.4  | 28.4  | 32.3  | 8    |
| Kr                                | Krypton ( $P=0$ )             | 8.8                                                   | 17.1  | 25.6  | 33.1  | 39.8  | 45.9  | 8    |
| NO                                | Nitric oxide                  |                                                       | 13.8  | 19.2  | 23.8  | 28.0  | 31.9  | 13   |
| $\text{N}_2$                      | Nitrogen ( $P=0$ )            |                                                       | 12.9  | 17.9  | 22.2  | 26.1  | 29.6  | 12   |
| $\text{N}_2\text{O}$              | Nitrous oxide                 |                                                       | 10.0  | 15.0  | 19.4  | 23.6  | 27.4  | 13   |
| Ne                                | Neon ( $P=0$ )                | 14.4                                                  | 24.3  | 32.1  | 38.9  | 45.0  | 50.8  | 8    |
| $\text{O}_2$                      | Oxygen ( $P=0$ )              | 7.5                                                   | 14.6  | 20.8  | 26.1  | 30.8  | 35.1  | 12   |
| $\text{O}_2\text{S}$              | Sulfur dioxide                |                                                       | 8.6   | 12.9  | 17.5  | 21.7  |       | 13   |
| Xe                                | Xenon ( $P=0$ )               | 8.3                                                   | 15.4  | 23.2  | 30.7  | 37.6  | 44.0  | 8    |
| CO                                | Carbon monoxide               | 6.7                                                   | 12.9  | 17.8  | 22.1  | 25.8  | 29.1  | 13   |
| $\text{CO}_2$                     | Carbon dioxide                |                                                       | 10.0  | 15.0  | 19.7  | 24.0  | 28.0  | 9,10 |
| $\text{CHCl}_3$                   | Chloroform                    |                                                       |       | 10.2  | 13.7  | 16.9  | 20.1  | 13   |
| $\text{CH}_4$                     | Methane                       |                                                       | 7.7   | 11.2  | 14.3  | 17.0  | 19.4  | 10   |
| $\text{CH}_4\text{O}$             | Methanol                      |                                                       |       |       | 13.2  | 16.5  | 19.6  | 13   |
| $\text{C}_2\text{H}_2$            | Acetylene                     |                                                       |       | 10.4  | 13.5  | 16.5  |       | 13   |
| $\text{C}_2\text{H}_4$            | Ethylene                      |                                                       | 7.0   | 10.4  | 13.6  | 16.5  | 19.1  | 3    |
| $\text{C}_2\text{H}_6$            | Ethane                        |                                                       | 6.4   | 9.5   | 12.3  | 14.9  | 17.3  | 5    |
| $\text{C}_2\text{H}_6\text{O}$    | Ethanol                       |                                                       |       |       | 11.6  | 14.5  | 17.0  | 13   |
| $\text{C}_3\text{H}_8$            | Propane                       |                                                       |       | 8.3   | 10.9  | 13.4  | 15.8  | 5    |
| $\text{C}_4\text{H}_{10}$         | Butane                        |                                                       |       | 7.5   | 10.0  | 12.3  | 14.6  | 5    |
| $\text{C}_4\text{H}_{10}$         | Isobutane                     |                                                       |       | 7.6   | 10.0  | 12.3  | 14.6  | 5    |
| $\text{C}_4\text{H}_{10}\text{O}$ | Diethyl ether                 |                                                       |       | 7.6   | 10.1  | 12.4  |       | 13   |
| $\text{C}_5\text{H}_{12}$         | Pentane                       |                                                       |       | 6.7   | 9.2   | 11.4  | 13.4  | 13   |
| $\text{C}_6\text{H}_{14}$         | Hexane                        |                                                       |       |       | 8.6   | 10.8  | 12.8  | 13   |

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# VISCOSITY OF LIQUIDS

The absolute viscosity of some common liquids at temperatures between  $-25$  and  $100^{\circ}\text{C}$  is given in this table. Values were derived by fitting experimental data to suitable expressions for the temperature dependence. The substances are arranged by molecular formula in the modified Hill order (see Preface). All values are given in units of millipascal seconds (mPa s); this unit is identical to centipoise (cp).

Viscosity values correspond to a nominal pressure of 1 atmosphere. If a value is given at a temperature above the normal boiling point, the applicable pressure is understood to be the vapor pressure of the liquid at that temperature. A few values are given at a temperature slightly below the normal freezing point; these refer to the supercooled liquid.

The accuracy ranges from 1% in the best cases to 5 to 10% in the worst cases. Additional significant figures are included in the table to facilitate interpolation.

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| Molecular<br>formula                           | Name                               | Viscosity in mPa s |       |       |       |       |       |
|------------------------------------------------|------------------------------------|--------------------|-------|-------|-------|-------|-------|
|                                                |                                    | −25°C              | 0°C   | 25°C  | 50°C  | 75°C  | 100°C |
| <i>Compounds not containing carbon</i>         |                                    |                    |       |       |       |       |       |
| Br <sub>2</sub>                                | Bromine                            |                    | 1.252 | 0.944 | 0.746 |       |       |
| Cl <sub>3</sub> HSi                            | Trichlorosilane                    |                    | 0.415 | 0.326 |       |       |       |
| Cl <sub>3</sub> P                              | Phosphorous trichloride            | 0.870              | 0.662 | 0.529 | 0.439 |       |       |
| Cl <sub>4</sub> Si                             | Tetrachlorosilane                  |                    |       | 99.4  | 96.2  |       |       |
| H <sub>2</sub> O                               | Water                              |                    | 1.793 | 0.890 | 0.547 | 0.378 | 0.282 |
| H <sub>4</sub> N <sub>2</sub>                  | Hydrazine                          |                    |       | 0.876 | 0.628 | 0.480 | 0.384 |
| Hg                                             | Mercury                            |                    |       | 1.526 | 1.402 | 1.312 | 1.245 |
| NO <sub>2</sub>                                | Nitrogen dioxide                   |                    | 0.532 | 0.402 |       |       |       |
| <i>Compounds containing carbon</i>             |                                    |                    |       |       |       |       |       |
| CCl <sub>3</sub> F                             | Trichlorofluoromethane             | 0.740              | 0.539 | 0.421 |       |       |       |
| CCl <sub>4</sub>                               | Tetrachloromethane                 |                    | 1.321 | 0.908 | 0.656 | 0.494 |       |
| CS <sub>2</sub>                                | Carbon disulfide                   |                    | 0.429 | 0.352 |       |       |       |
| CHBr <sub>3</sub>                              | Tribromomethane                    |                    |       | 1.857 | 1.367 | 1.029 |       |
| CHCl <sub>3</sub>                              | Trichloromethane                   | 0.988              | 0.706 | 0.537 | 0.427 |       |       |
| CHN                                            | Hydrogen cyanide                   |                    | 0.235 | 0.183 |       |       |       |
| CH <sub>2</sub> Br <sub>2</sub>                | Dibromomethane                     | 1.948              | 1.320 | 0.980 | 0.779 | 0.652 |       |
| CH <sub>2</sub> Cl <sub>2</sub>                | Dichloromethane                    | 0.727              | 0.533 | 0.413 |       |       |       |
| CH <sub>2</sub> O <sub>2</sub>                 | Formic acid                        |                    |       | 1.607 | 1.030 | 0.724 | 0.545 |
| CH <sub>3</sub> I                              | Iodomethane                        |                    | 0.594 | 0.469 |       |       |       |
| CH <sub>3</sub> NO                             | Formamide                          |                    | 7.114 | 3.343 | 1.833 |       |       |
| CH <sub>3</sub> NO <sub>2</sub>                | Nitromethane                       | 1.311              | 0.875 | 0.630 | 0.481 | 0.383 | 0.317 |
| CH <sub>4</sub> O                              | Methanol                           | 1.258              | 0.793 | 0.544 |       |       |       |
| CH <sub>5</sub> N                              | Methylamine                        | 0.319              | 0.231 |       |       |       |       |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>  | 1,1,2-Trichlorotrifluoro-ethane    | 1.465              | 0.945 | 0.656 | 0.481 |       |       |
| C <sub>2</sub> Cl <sub>4</sub>                 | Tetrachloroethylene                |                    | 1.114 | 0.844 | 0.663 | 0.535 | 0.442 |
| C <sub>2</sub> HCl <sub>3</sub>                | Trichloroethylene                  |                    | 0.703 | 0.545 | 0.444 | 0.376 |       |
| C <sub>2</sub> HCl <sub>5</sub>                | Pentachloroethane                  |                    | 3.761 | 2.254 | 1.491 | 1.061 |       |
| C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>  | Trifluoroacetic acid               |                    |       | 0.808 | 0.571 |       |       |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>  | <i>cis</i> -1,2-Dichloroethylene   | 0.786              | 0.575 | 0.445 |       |       |       |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>  | <i>trans</i> -1,2-Dichloroethylene | 0.522              | 0.398 | 0.317 | 0.261 |       |       |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>  | 1,1,1,2-Tetrachloroethane          | 3.660              | 2.200 | 1.437 | 1.006 | 0.741 | 0.570 |
| C <sub>2</sub> H <sub>3</sub> ClF <sub>2</sub> | 1-Chloro-1,1-difluoro-ethane       | 0.477              | 0.376 |       |       |       |       |
| C <sub>2</sub> H <sub>3</sub> ClO              | Acetyl chloride                    |                    |       | 0.368 | 0.294 |       |       |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>  | 1,1,1-Trichloroethane              | 1.847              | 1.161 | 0.793 | 0.578 | 0.428 |       |
| C <sub>2</sub> H <sub>3</sub> N                | Acetonitrile                       |                    | 0.400 | 0.369 | 0.284 | 0.234 |       |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>  | 1,2-Dibromoethane                  |                    |       | 1.595 | 1.116 | 0.837 | 0.661 |

| Molecular<br>formula                           | Name                          | Viscosity in mPa s |       |       |       |       |       |
|------------------------------------------------|-------------------------------|--------------------|-------|-------|-------|-------|-------|
|                                                |                               | -25°C              | 0°C   | 25°C  | 50°C  | 75°C  | 100°C |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>  | 1,1-Dichloroethane            |                    |       | 0.464 | 0.362 |       |       |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>  | 1,2-Dichloroethane            |                    | 1.125 | 0.779 | 0.576 | 0.447 |       |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>   | Acetic acid                   |                    |       | 1.056 | 0.786 | 0.599 | 0.464 |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>   | Methyl formate                |                    | 0.424 | 0.325 |       |       |       |
| C <sub>2</sub> H <sub>5</sub> Br               | Bromoethane                   | 0.635              | 0.477 | 0.374 |       |       |       |
| C <sub>2</sub> H <sub>5</sub> Cl               | Chloroethane                  | 0.416              | 0.319 |       |       |       |       |
| C <sub>2</sub> H <sub>5</sub> I                | Iodoethane                    |                    | 0.723 | 0.556 | 0.444 | 0.365 |       |
| C <sub>2</sub> H <sub>5</sub> NO               | <i>N</i> -Methylformamide     |                    | 2.549 | 1.678 | 1.155 | 0.824 | 0.606 |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>  | Nitroethane                   | 1.354              | 0.940 | 0.688 | 0.526 | 0.415 | 0.337 |
| C <sub>2</sub> H <sub>6</sub> O                | Ethanol                       | 3.262              | 1.786 | 1.074 | 0.694 | 0.476 |       |
| C <sub>2</sub> H <sub>6</sub> OS               | Dimethyl sulfoxide            |                    |       | 1.987 | 1.290 |       |       |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>   | Ethylene glycol               |                    |       | 16.1  | 6.554 | 3.340 | 1.975 |
| C <sub>2</sub> H <sub>6</sub> S                | Dimethyl sulfide              |                    | 0.356 | 0.284 |       |       |       |
| C <sub>2</sub> H <sub>6</sub> S                | Ethanethiol                   |                    | 0.364 | 0.287 |       |       |       |
| C <sub>2</sub> H <sub>7</sub> N                | Dimethylamine                 | 0.300              | 0.232 |       |       |       |       |
| C <sub>2</sub> H <sub>7</sub> NO               | Ethanolamine                  |                    |       | 21.1  | 8.560 | 3.935 | 1.998 |
| C <sub>3</sub> H <sub>5</sub> Br               | 3-Bromopropene                |                    | 0.620 | 0.471 | 0.373 |       |       |
| C <sub>3</sub> H <sub>5</sub> Cl               | 3-Chloropropene               |                    | 0.408 | 0.314 |       |       |       |
| C <sub>3</sub> H <sub>5</sub> ClO              | Epichlorohydrin               | 2.492              | 1.570 | 1.073 | 0.781 | 0.597 | 0.474 |
| C <sub>3</sub> H <sub>5</sub> N                | Propanenitrile                |                    |       | 0.294 | 0.240 | 0.202 |       |
| C <sub>3</sub> H <sub>6</sub> O                | Acetone                       | 0.540              | 0.395 | 0.306 | 0.247 |       |       |
| C <sub>3</sub> H <sub>6</sub> O                | Allyl alcohol                 |                    |       | 1.218 | 0.759 | 0.505 |       |
| C <sub>3</sub> H <sub>6</sub> O                | Propanal                      |                    |       | 0.321 | 0.249 |       |       |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Ethyl formate                 |                    | 0.506 | 0.380 | 0.300 |       |       |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Methyl acetate                |                    | 0.477 | 0.364 | 0.284 |       |       |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Propanoic acid                |                    | 1.499 | 1.030 | 0.749 | 0.569 | 0.449 |
| C <sub>3</sub> H <sub>7</sub> Br               | 1-Bromopropane                |                    | 0.645 | 0.489 | 0.387 |       |       |
| C <sub>3</sub> H <sub>7</sub> Br               | 2-Bromopropane                |                    | 0.612 | 0.458 | 0.359 |       |       |
| C <sub>3</sub> H <sub>7</sub> Cl               | 1-Chloropropane               |                    | 0.436 | 0.334 |       |       |       |
| C <sub>3</sub> H <sub>7</sub> Cl               | 2-Chloropropane               |                    | 0.401 | 0.303 |       |       |       |
| C <sub>3</sub> H <sub>7</sub> I                | 1-Iodopropane                 |                    | 0.970 | 0.703 | 0.541 | 0.436 | 0.363 |
| C <sub>3</sub> H <sub>7</sub> I                | 2-Iodopropane                 |                    | 0.883 | 0.653 | 0.506 | 0.407 |       |
| C <sub>3</sub> H <sub>7</sub> NO               | <i>N,N</i> -Dimethylformamide |                    | 1.176 | 0.794 | 0.624 |       |       |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>  | 1-Nitropropane                | 1.851              | 1.160 | 0.798 | 0.589 | 0.460 | 0.374 |
| C <sub>3</sub> H <sub>8</sub> O                | 1-Propanol                    | 8.645              | 3.815 | 1.945 | 1.107 | 0.685 |       |
| C <sub>3</sub> H <sub>8</sub> O                | 2-Propanol                    |                    | 4.619 | 2.038 | 1.028 | 0.576 |       |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>   | 1,2-Propylene glycol          |                    | 248   | 40.4  | 11.3  | 4.770 | 2.750 |
| C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>   | Glycerol                      |                    |       | 934   | 152   | 39.8  | 14.8  |
| C <sub>3</sub> H <sub>8</sub> S                | 1-Propanethiol                |                    | 0.503 | 0.385 |       |       |       |
| C <sub>3</sub> H <sub>8</sub> S                | 2-Propanethiol                |                    | 0.477 | 0.357 | 0.280 |       |       |
| C <sub>3</sub> H <sub>9</sub> N                | Propylamine                   |                    |       | 0.376 |       |       |       |
| C <sub>3</sub> H <sub>9</sub> N                | Isopropylamine                |                    | 0.454 | 0.325 |       |       |       |
| C <sub>4</sub> H <sub>4</sub> O                | Furan                         | 0.661              | 0.475 | 0.361 |       |       |       |
| C <sub>4</sub> H <sub>5</sub> N                | Pyrrole                       |                    | 2.085 | 1.225 | 0.828 | 0.612 |       |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>   | Acetic anhydride              |                    | 1.241 | 0.843 | 0.614 | 0.472 | 0.377 |
| C <sub>4</sub> H <sub>7</sub> N                | Butanenitrile                 |                    |       | 0.553 | 0.418 | 0.330 | 0.268 |
| C <sub>4</sub> H <sub>8</sub> O                | 2-Butanone                    | 0.720              | 0.533 | 0.405 | 0.315 | 0.249 |       |
| C <sub>4</sub> H <sub>8</sub> O                | Tetrahydrofuran               | 0.849              | 0.605 | 0.456 | 0.359 |       |       |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 1,4-Dioxane                   |                    |       | 1.177 | 0.787 | 0.569 |       |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Ethyl acetate                 |                    | 0.578 | 0.423 | 0.325 | 0.259 |       |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Methyl propionate             |                    | 0.581 | 0.431 | 0.333 | 0.266 |       |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Propyl formate                |                    | 0.669 | 0.485 | 0.370 | 0.293 |       |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Butanoic acid                 |                    | 2.215 | 1.426 | 0.982 | 0.714 | 0.542 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 2-Methylpropanoic acid        |                    | 1.857 | 1.226 | 0.863 | 0.639 | 0.492 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S | Sulfolane                     |                    |       |       | 6.280 | 3.818 | 2.559 |
| C <sub>4</sub> H <sub>8</sub> S                | Tetrahydrothiophene           |                    |       | 0.973 | 0.912 |       |       |
| C <sub>4</sub> H <sub>9</sub> Br               | 1-Bromobutane                 |                    | 0.815 | 0.606 | 0.471 | 0.379 |       |
| C <sub>4</sub> H <sub>9</sub> Cl               | 1-Chlorobutane                |                    | 0.556 | 0.422 | 0.329 | 0.261 |       |
| C <sub>4</sub> H <sub>9</sub> N                | Pyrrolidine                   | 1.914              | 1.071 | 0.704 | 0.512 |       |       |
| C <sub>4</sub> H <sub>9</sub> NO               | <i>N,N</i> -Dimethylacetamide |                    |       | 1.927 |       |       |       |

| Molecular<br>formula                           | Name                      | Viscosity in mPa s |       |        |        |       |       |
|------------------------------------------------|---------------------------|--------------------|-------|--------|--------|-------|-------|
|                                                |                           | -25°C              | 0°C   | 25°C   | 50°C   | 75°C  | 100°C |
| C <sub>4</sub> H <sub>9</sub> NO               | Morpholine                |                    |       | 2.021  | 1.247  | 0.850 | 0.627 |
| C <sub>4</sub> H <sub>10</sub> O               | 1-Butanol                 | 12.19              | 5.185 | 2.544  | 1.394  | 0.833 | 0.533 |
| C <sub>4</sub> H <sub>10</sub> O               | 2-Butanol                 |                    |       | 3.096  | 1.332  | 0.698 | 0.419 |
| C <sub>4</sub> H <sub>10</sub> O               | 2-Methyl-2-propanol       |                    |       | 4.312  | 1.421  | 0.678 |       |
| C <sub>4</sub> H <sub>10</sub> O               | Diethyl ether             |                    | 0.283 | 0.224  |        |       |       |
| C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>  | Diethylene glycol         |                    |       | 30.200 | 11.130 | 4.917 | 2.505 |
| C <sub>4</sub> H <sub>10</sub> S               | Diethyl sulfide           |                    | 0.558 | 0.422  | 0.331  | 0.267 |       |
| C <sub>4</sub> H <sub>11</sub> N               | Butylamine                |                    | 0.830 | 0.574  | 0.409  | 0.298 |       |
| C <sub>4</sub> H <sub>11</sub> N               | Isobutylamine             |                    | 0.770 | 0.571  | 0.367  |       |       |
| C <sub>4</sub> H <sub>11</sub> N               | Diethylamine              |                    |       | 0.319  | 0.239  |       |       |
| C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub> | Diethanolamine            |                    |       |        | 109.5  | 28.7  | 9.100 |
| C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>   | Furfural                  |                    | 2.501 | 1.587  | 1.143  | 0.906 | 0.772 |
| C <sub>5</sub> H <sub>5</sub> N                | Pyridine                  |                    | 1.361 | 0.879  | 0.637  | 0.497 | 0.409 |
| C <sub>5</sub> H <sub>10</sub>                 | 1-Pentene                 | 0.313              | 0.241 | 0.195  |        |       |       |
| C <sub>5</sub> H <sub>10</sub>                 | 2-Methyl-2-butene         |                    | 0.255 | 0.203  |        |       |       |
| C <sub>5</sub> H <sub>10</sub>                 | Cyclopentane              |                    | 0.555 | 0.413  | 0.321  |       |       |
| C <sub>5</sub> H <sub>10</sub> O               | Mesityl oxide             | 1.291              | 0.838 | 0.602  | 0.465  | 0.381 | 0.326 |
| C <sub>5</sub> H <sub>10</sub> O               | 2-Pentanone               |                    | 0.641 | 0.470  | 0.362  | 0.289 | 0.238 |
| C <sub>5</sub> H <sub>10</sub> O               | 3-Pentanone               |                    | 0.592 | 0.444  | 0.345  | 0.276 | 0.227 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Butyl formate             |                    | 0.937 | 0.644  | 0.472  | 0.362 | 0.289 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Propyl acetate            |                    | 0.768 | 0.544  | 0.406  | 0.316 | 0.255 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Ethyl propanoate          |                    | 0.691 | 0.501  | 0.380  | 0.299 | 0.242 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Methyl butanoate          |                    | 0.759 | 0.541  | 0.406  | 0.318 | 0.257 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | Methyl isobutanoate       |                    | 0.672 | 0.488  | 0.373  | 0.296 |       |
| C <sub>5</sub> H <sub>11</sub> N               | Piperidine                |                    |       | 1.573  | 0.958  | 0.649 | 0.474 |
| C <sub>5</sub> H <sub>12</sub>                 | Pentane                   | 0.351              | 0.274 | 0.224  |        |       |       |
| C <sub>5</sub> H <sub>12</sub>                 | Isopentane                | 0.376              | 0.277 | 0.214  |        |       |       |
| C <sub>5</sub> H <sub>12</sub> O               | 1-Pentanol                | 25.4               | 8.512 | 3.619  | 1.820  | 1.035 | 0.646 |
| C <sub>5</sub> H <sub>12</sub> O               | 2-Pentanol                |                    |       | 3.470  | 1.447  | 0.761 | 0.465 |
| C <sub>5</sub> H <sub>12</sub> O               | 3-Pentanol                |                    |       | 4.149  | 1.473  | 0.727 | 0.436 |
| C <sub>5</sub> H <sub>12</sub> O               | 2-Methyl-1-butanol        |                    |       | 4.453  | 1.963  | 1.031 | 0.612 |
| C <sub>5</sub> H <sub>12</sub> O               | 3-Methyl-1-butanol        |                    | 8.627 | 3.692  | 1.842  | 1.031 | 0.631 |
| C <sub>5</sub> H <sub>13</sub> N               | Pentylamine               |                    | 1.030 | 0.702  | 0.493  | 0.356 |       |
| C <sub>6</sub> F <sub>6</sub>                  | Hexafluorobenzene         |                    |       | 2.789  | 1.730  | 1.151 |       |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>  | <i>o</i> -Dichlorobenzene |                    | 1.958 | 1.324  | 0.962  | 0.739 | 0.593 |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>  | <i>m</i> -Dichlorobenzene |                    | 1.492 | 1.044  | 0.787  | 0.628 | 0.525 |
| C <sub>6</sub> H <sub>5</sub> Br               | Bromobenzene              |                    | 1.560 | 1.074  | 0.798  | 0.627 | 0.512 |
| C <sub>6</sub> H <sub>5</sub> Cl               | Chlorobenzene             | 1.703              | 1.058 | 0.753  | 0.575  | 0.456 | 0.369 |
| C <sub>6</sub> H <sub>5</sub> ClO              | <i>o</i> -Chlorophenol    |                    |       | 3.589  | 1.835  | 1.131 | 0.786 |
| C <sub>6</sub> H <sub>5</sub> ClO              | <i>m</i> -Chlorophenol    |                    |       |        | 4.041  |       |       |
| C <sub>6</sub> H <sub>5</sub> F                | Fluorobenzene             |                    | 0.749 | 0.550  | 0.423  | 0.338 |       |
| C <sub>6</sub> H <sub>5</sub> I                | Iodobenzene               |                    | 2.354 | 1.554  | 1.117  | 0.854 | 0.683 |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>  | Nitrobenzene              |                    | 3.036 | 1.863  | 1.262  | 0.918 | 0.704 |
| C <sub>6</sub> H <sub>6</sub>                  | Benzene                   |                    |       | 0.604  | 0.436  | 0.335 |       |
| C <sub>6</sub> H <sub>6</sub> ClN              | <i>o</i> -Chloroaniline   |                    |       | 3.316  | 1.913  | 1.248 | 0.887 |
| C <sub>6</sub> H <sub>6</sub> O                | Phenol                    |                    |       |        | 3.437  | 1.784 | 1.099 |
| C <sub>6</sub> H <sub>7</sub> N                | Aniline                   |                    |       | 3.847  | 2.029  | 1.247 | 0.850 |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>   | Phenylhydrazine           |                    |       | 13.0   | 4.553  | 1.850 | 0.848 |
| C <sub>6</sub> H <sub>10</sub>                 | Cyclohexene               |                    | 0.882 | 0.625  | 0.467  | 0.364 |       |
| C <sub>6</sub> H <sub>10</sub> O               | Cyclohexanone             |                    |       | 2.017  | 1.321  | 0.919 | 0.671 |
| C <sub>6</sub> H <sub>11</sub> N               | Hexanenitrile             |                    |       | 0.912  | 0.650  | 0.488 | 0.382 |
| C <sub>6</sub> H <sub>12</sub>                 | Cyclohexane               |                    |       | 0.894  | 0.615  | 0.447 |       |
| C <sub>6</sub> H <sub>12</sub>                 | Methylcyclopentane        | 0.927              | 0.653 | 0.479  | 0.364  |       |       |
| C <sub>6</sub> H <sub>12</sub>                 | 1-Hexene                  | 0.441              | 0.326 | 0.252  | 0.202  |       |       |
| C <sub>6</sub> H <sub>12</sub> O               | Cyclohexanol              |                    |       | 57.5   | 12.3   | 4.274 | 1.982 |
| C <sub>6</sub> H <sub>12</sub> O               | 2-Hexanone                | 1.300              | 0.840 | 0.583  | 0.429  | 0.329 | 0.262 |
| C <sub>6</sub> H <sub>12</sub> O               | 4-Methyl-2-pentanone      |                    |       | 0.545  | 0.406  |       |       |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | Butyl acetate             |                    | 1.002 | 0.685  | 0.500  | 0.383 | 0.305 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | Isobutyl acetate          |                    |       | 0.676  | 0.493  | 0.370 | 0.286 |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | Ethyl butanoate           |                    |       | 0.639  | 0.453  |       |       |

| Molecular<br>formula                           | Name                        | Viscosity in mPa s |       |       |       |       |       |
|------------------------------------------------|-----------------------------|--------------------|-------|-------|-------|-------|-------|
|                                                |                             | -25°C              | 0°C   | 25°C  | 50°C  | 75°C  | 100°C |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | Diacetone alcohol           | 28.7               | 6.621 | 2.798 | 1.829 | 1.648 |       |
| C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>  | Paraldehyde                 |                    |       | 1.079 | 0.692 | 0.485 | 0.362 |
| C <sub>6</sub> H <sub>13</sub> N               | Cyclohexylamine             |                    |       | 1.944 | 1.169 | 0.782 | 0.565 |
| C <sub>6</sub> H <sub>14</sub>                 | Hexane                      |                    | 0.405 | 0.300 | 0.240 |       |       |
| C <sub>6</sub> H <sub>14</sub>                 | 2-Methylpentane             |                    | 0.372 | 0.286 | 0.226 |       |       |
| C <sub>6</sub> H <sub>14</sub>                 | 3-Methylpentane             |                    | 0.395 | 0.306 |       |       |       |
| C <sub>6</sub> H <sub>14</sub> O               | Dipropyl ether              |                    | 0.542 | 0.396 | 0.304 | 0.242 |       |
| C <sub>6</sub> H <sub>14</sub> O               | 1-Hexanol                   |                    |       | 4.578 | 2.271 | 1.270 | 0.781 |
| C <sub>6</sub> H <sub>15</sub> N               | Triethylamine               |                    | 0.455 | 0.347 | 0.273 | 0.221 |       |
| C <sub>6</sub> H <sub>15</sub> N               | Dipropylamine               |                    | 0.751 | 0.517 | 0.377 | 0.288 | 0.228 |
| C <sub>6</sub> H <sub>15</sub> N               | Diisopropylamine            |                    |       | 0.393 | 0.300 | 0.237 |       |
| C <sub>6</sub> H <sub>15</sub> NO <sub>3</sub> | Triethanolamine             |                    |       | 609   | 114   | 31.5  | 11.7  |
| C <sub>7</sub> H <sub>5</sub> N                | Benzonitrile                |                    |       | 1.267 | 0.883 | 0.662 | 0.524 |
| C <sub>7</sub> H <sub>7</sub> Cl               | <i>o</i> -Chlorotoluene     |                    | 1.390 | 0.964 | 0.710 | 0.547 | 0.437 |
| C <sub>7</sub> H <sub>7</sub> Cl               | <i>m</i> -Chlorotoluene     |                    | 1.165 | 0.823 | 0.616 | 0.482 | 0.391 |
| C <sub>7</sub> H <sub>7</sub> Cl               | <i>p</i> -Chlorotoluene     |                    |       | 0.837 | 0.621 | 0.483 | 0.390 |
| C <sub>7</sub> H <sub>8</sub>                  | Toluene                     | 1.165              | 0.778 | 0.560 | 0.424 | 0.333 | 0.270 |
| C <sub>7</sub> H <sub>8</sub> O                | <i>o</i> -Cresol            |                    |       |       | 3.035 | 1.562 | 0.961 |
| C <sub>7</sub> H <sub>8</sub> O                | <i>m</i> -Cresol            |                    |       | 12.9  | 4.417 | 2.093 | 1.207 |
| C <sub>7</sub> H <sub>8</sub> O                | Benzyl alcohol              |                    |       | 5.474 | 2.760 | 1.618 | 1.055 |
| C <sub>7</sub> H <sub>8</sub> O                | Anisole                     |                    |       | 1.056 | 0.747 | 0.554 | 0.427 |
| C <sub>7</sub> H <sub>9</sub> N                | <i>N</i> -Methylaniline     |                    | 4.120 | 2.042 | 1.222 | 0.825 | 0.606 |
| C <sub>7</sub> H <sub>9</sub> N                | <i>o</i> -Methyl aniline    |                    | 10.3  | 3.823 | 1.936 | 1.198 | 0.839 |
| C <sub>7</sub> H <sub>9</sub> N                | <i>m</i> -Methyl aniline    |                    | 8.180 | 3.306 | 1.679 | 1.014 | 0.699 |
| C <sub>7</sub> H <sub>9</sub> N                | Benzylamine                 |                    |       | 1.624 | 1.080 | 0.769 | 0.577 |
| C <sub>7</sub> H <sub>14</sub>                 | Methylcyclohexane           |                    | 0.991 | 0.679 | 0.501 | 0.390 | 0.316 |
| C <sub>7</sub> H <sub>14</sub>                 | 1-Heptene                   |                    | 0.441 | 0.340 | 0.273 | 0.226 |       |
| C <sub>7</sub> H <sub>14</sub> O               | 2-Heptanone                 |                    |       | 0.714 | 0.407 | 0.297 |       |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>  | Heptanoic acid              |                    |       | 3.840 | 2.282 | 1.488 | 1.041 |
| C <sub>7</sub> H <sub>16</sub>                 | Heptane                     | 0.757              | 0.523 | 0.387 | 0.301 | 0.243 |       |
| C <sub>7</sub> H <sub>16</sub>                 | 3-Methylhexane              |                    |       | 0.350 |       |       |       |
| C <sub>7</sub> H <sub>16</sub> O               | 1-Heptanol                  |                    |       | 5.810 | 2.603 | 1.389 | 0.849 |
| C <sub>7</sub> H <sub>16</sub> O               | 2-Heptanol                  |                    |       | 3.955 | 1.799 | 0.987 | 0.615 |
| C <sub>7</sub> H <sub>16</sub> O               | 3-Heptanol                  |                    |       |       | 1.957 | 0.976 | 0.584 |
| C <sub>7</sub> H <sub>16</sub> O               | 4-Heptanol                  |                    |       | 4.207 | 1.695 | 0.882 | 0.539 |
| C <sub>7</sub> H <sub>17</sub> N               | Heptylamine                 |                    |       | 1.314 | 0.865 | 0.600 | 0.434 |
| C <sub>8</sub> H <sub>8</sub>                  | Styrene                     |                    | 1.050 | 0.695 | 0.507 | 0.390 | 0.310 |
| C <sub>8</sub> H <sub>8</sub> O                | Acetophenone                |                    |       | 1.681 |       |       | 0.634 |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>   | Methyl benzoate             |                    |       | 1.857 |       |       |       |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>   | Methyl salicylate           |                    |       |       |       | 1.102 | 0.815 |
| C <sub>8</sub> H <sub>10</sub>                 | Ethylbenzene                |                    | 0.872 | 0.631 | 0.482 | 0.380 | 0.304 |
| C <sub>8</sub> H <sub>10</sub>                 | <i>o</i> -Xylene            |                    | 1.084 | 0.760 | 0.561 | 0.432 | 0.345 |
| C <sub>8</sub> H <sub>10</sub>                 | <i>m</i> -Xylene            |                    | 0.795 | 0.581 | 0.445 | 0.353 | 0.289 |
| C <sub>8</sub> H <sub>10</sub>                 | <i>p</i> -Xylene            |                    |       | 0.603 | 0.457 | 0.359 | 0.290 |
| C <sub>8</sub> H <sub>10</sub> O               | Phenetole                   |                    |       | 1.197 | 0.817 | 0.594 | 0.453 |
| C <sub>8</sub> H <sub>11</sub> N               | <i>N,N</i> -Dimethylaniline |                    | 1.996 | 1.300 | 0.911 | 0.675 | 0.523 |
| C <sub>8</sub> H <sub>11</sub> N               | <i>N</i> -Ethylaniline      |                    | 3.981 | 2.047 | 1.231 | 0.825 | 0.596 |
| C <sub>8</sub> H <sub>16</sub>                 | Ethylcyclohexane            |                    | 1.139 | 0.784 | 0.579 |       |       |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>  | Octanoic acid               |                    |       | 5.020 | 2.656 | 1.654 | 1.147 |
| C <sub>8</sub> H <sub>18</sub>                 | Octane                      |                    | 0.700 | 0.508 | 0.385 | 0.302 | 0.243 |
| C <sub>8</sub> H <sub>18</sub> O               | 1-Octanol                   |                    |       | 7.288 | 3.232 | 1.681 | 0.991 |
| C <sub>8</sub> H <sub>18</sub> O               | 4-Methyl-3-heptanol         |                    | 1.904 | 1.085 | 0.702 | 0.497 | 0.375 |
| C <sub>8</sub> H <sub>18</sub> O               | 5-Methyl-3-heptanol         |                    | 2.052 | 1.178 | 0.762 | 0.536 | 0.401 |
| C <sub>8</sub> H <sub>18</sub> O               | 2-Ethyl-1-hexanol           |                    | 20.7  | 6.271 | 2.631 | 1.360 | 0.810 |
| C <sub>8</sub> H <sub>18</sub> O               | Dibutyl ether               | 1.417              | 0.918 | 0.637 | 0.466 | 0.356 | 0.281 |
| C <sub>8</sub> H <sub>19</sub> N               | Dibutylamine                |                    | 1.509 | 0.918 | 0.619 | 0.449 | 0.345 |
| C <sub>8</sub> H <sub>19</sub> N               | Diisobutylamine             |                    | 1.115 | 0.723 | 0.511 | 0.384 | 0.303 |
| C <sub>9</sub> H <sub>7</sub> N                | Quinoline                   |                    |       | 3.337 | 1.892 | 1.201 | 0.833 |
| C <sub>9</sub> H <sub>10</sub>                 | Indane                      |                    | 2.230 | 1.357 | 0.931 | 0.692 | 0.545 |
| C <sub>9</sub> H <sub>12</sub>                 | Cumene                      |                    | 1.075 | 0.737 | 0.547 |       |       |

| Molecular<br>formula                           | Name                               | Viscosity in mPa s |       |       |       |       |       |
|------------------------------------------------|------------------------------------|--------------------|-------|-------|-------|-------|-------|
|                                                |                                    | -25°C              | 0°C   | 25°C  | 50°C  | 75°C  | 100°C |
| C <sub>9</sub> H <sub>14</sub> O               | Isophorone                         |                    | 4.201 | 2.329 | 1.415 | 0.923 | 0.638 |
| C <sub>9</sub> H <sub>18</sub> O               | 5-Nonanone                         |                    |       | 1.199 | 0.834 | 0.619 | 0.484 |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | Nonanoic acid                      |                    |       | 7.011 | 3.712 | 2.234 | 1.475 |
| C <sub>9</sub> H <sub>20</sub>                 | Nonane                             |                    | 0.964 | 0.665 | 0.488 | 0.375 | 0.300 |
| C <sub>9</sub> H <sub>20</sub> O               | 1-Nonanol                          |                    |       | 9.123 | 4.032 |       |       |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub> | Dimethyl phthalate                 |                    | 63.2  | 14.4  | 5.309 | 2.824 | 1.980 |
| C <sub>10</sub> H <sub>14</sub>                | Butylbenzene                       |                    |       | 0.950 | 0.683 | 0.515 |       |
| C <sub>10</sub> H <sub>18</sub>                | <i>cis</i> -Decahydronaphthalene   | 12.8               | 5.645 | 3.042 | 1.875 | 1.271 | 0.924 |
| C <sub>10</sub> H <sub>18</sub>                | <i>trans</i> -Decahydronaphthalene | 6.192              | 3.243 | 1.948 | 1.289 | 0.917 | 0.689 |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub> | Decanoic acid                      |                    |       |       | 4.327 | 2.651 |       |
| C <sub>10</sub> H <sub>22</sub>                | Decane                             | 2.188              | 1.277 | 0.838 | 0.598 | 0.453 | 0.359 |
| C <sub>10</sub> H <sub>22</sub> O              | 1-Decanol                          |                    |       | 10.9  | 4.590 |       |       |
| C <sub>11</sub> H <sub>24</sub>                | Undecane                           |                    | 1.707 | 1.098 | 0.763 | 0.562 | 0.433 |
| C <sub>12</sub> H <sub>10</sub> O              | Diphenyl ether                     |                    |       |       | 2.130 | 1.407 | 1.023 |
| C <sub>12</sub> H <sub>26</sub>                | Dodecane                           |                    | 2.277 | 1.383 | 0.930 | 0.673 | 0.514 |
| C <sub>13</sub> H <sub>12</sub>                | Diphenylmethane                    |                    |       |       |       | 1.265 | 0.929 |
| C <sub>13</sub> H <sub>28</sub>                | Tridecane                          |                    | 2.909 | 1.724 | 1.129 | 0.796 | 0.594 |
| C <sub>14</sub> H <sub>30</sub>                | Tetradecane                        |                    |       | 2.128 | 1.376 | 0.953 | 0.697 |
| C <sub>16</sub> H <sub>22</sub> O <sub>4</sub> | Dibutyl phthalate                  | 483                | 66.4  | 16.6  | 6.470 | 3.495 | 2.425 |
| C <sub>16</sub> H <sub>34</sub>                | Hexadecane                         |                    |       | 3.032 | 1.879 | 1.260 | 0.899 |
| C <sub>18</sub> H <sub>38</sub>                | Octadecane                         |                    |       |       | 2.487 | 1.609 | 1.132 |



## THERMAL CONDUCTIVITY OF GASES

This table gives the thermal conductivity of several gases as a function of temperature. Unless otherwise noted, the values refer to a pressure of 100 kPa (1 bar) or to the saturation vapor pressure if that is less than 100 kPa. The notation  $P = 0$  indicates the low

pressure limiting value is given. In general, the  $P = 0$  and  $P = 100$  kPa values differ by less than 1%. Units are milliwatts per meter kelvin. Substances are listed in the modified Hill order.

| MF                                            | Name                            | Thermal conductivity in mW/m K |       |       |       |       |       | Ref. |
|-----------------------------------------------|---------------------------------|--------------------------------|-------|-------|-------|-------|-------|------|
|                                               |                                 | 100 K                          | 200 K | 300 K | 400 K | 500 K | 600 K |      |
|                                               | Air                             | 9.4                            | 18.4  | 26.2  | 33.3  | 39.7  | 45.7  | 1    |
| Ar                                            | Argon                           | 6.2                            | 12.4  | 17.9  | 22.6  | 26.8  | 30.6  | 2,8  |
| BF <sub>3</sub>                               | Boron trifluoride               |                                |       | 19.0  | 24.6  |       |       | 11   |
| ClH                                           | Hydrogen chloride               |                                | 9.2   | 14.5  | 19.5  | 24.0  | 28.1  | 11   |
| F <sub>6</sub> S                              | Sulfur hexafluoride ( $P = 0$ ) |                                |       | 13.0  | 20.6  | 27.5  | 33.8  | 16   |
| H <sub>2</sub>                                | Hydrogen ( $P = 0$ )            | 68.6                           | 131.7 | 186.9 | 230.4 |       |       | 4    |
| H <sub>2</sub> O                              | Water                           |                                |       | 18.7  | 27.1  | 35.7  | 47.1  | 6    |
|                                               | Deuterium oxide                 |                                |       |       | 27.0  | 36.5  | 47.6  | 7    |
| H <sub>2</sub> S                              | Hydrogen sulfide                |                                |       | 14.6  | 20.5  | 26.4  | 32.4  | 11   |
| H <sub>3</sub> N                              | Ammonia                         |                                |       | 24.4  | 37.4  | 51.6  | 66.8  | 11   |
| He                                            | Helium ( $P = 0$ )              | 75.5                           | 119.3 | 156.7 | 190.6 | 222.3 | 252.4 | 8    |
| Kr                                            | Krypton ( $P = 0$ )             | 3.3                            | 6.4   | 9.5   | 12.3  | 14.8  | 17.1  | 8    |
| NO                                            | Nitric oxide                    |                                | 17.8  | 25.9  | 33.1  | 39.6  | 46.2  | 11   |
| N <sub>2</sub>                                | Nitrogen                        | 9.8                            | 18.7  | 26.0  | 32.3  | 38.3  | 44.0  | 12   |
| N <sub>2</sub> O                              | Nitrous oxide                   |                                | 9.8   | 17.4  | 26.0  | 34.1  | 41.8  | 11   |
| Ne                                            | Neon ( $P = 0$ )                | 22.3                           | 37.6  | 49.8  | 60.3  | 69.9  | 78.7  | 8    |
| O <sub>2</sub>                                | Oxygen                          | 9.3                            | 18.4  | 26.3  | 33.7  | 41.0  | 48.1  | 10   |
| O <sub>2</sub> S                              | Sulfur dioxide                  |                                |       | 9.6   | 14.3  | 20.0  | 25.6  | 11   |
| Xe                                            | Xenon ( $P = 0$ )               | 2.0                            | 3.6   | 5.5   | 7.3   | 8.9   | 10.4  | 8    |
| CCl <sub>2</sub> F <sub>2</sub>               | Dichlorodifluoromethane         |                                |       | 9.9   | 15.0  | 20.1  | 25.2  | 13   |
| CF <sub>4</sub>                               | Tetrafluoromethane ( $P = 0$ )  |                                |       | 16.0  | 24.1  | 32.2  | 39.9  | 16   |
| CO                                            | Carbon monoxide ( $P = 0$ )     |                                |       | 25.0  | 32.3  | 39.2  | 45.7  | 14   |
| CO <sub>2</sub>                               | Carbon dioxide                  |                                | 9.6   | 16.8  | 25.1  | 33.5  | 41.6  | 9    |
| CHCl <sub>3</sub>                             | Trichloromethane                |                                |       | 7.5   | 11.1  | 15.1  |       | 11   |
| CH <sub>4</sub>                               | Methane                         |                                | 22.5  | 34.1  | 49.1  | 66.5  | 84.1  | 5,15 |
| CH <sub>4</sub> O                             | Methanol                        |                                |       |       | 26.2  | 38.6  | 53.0  | 11   |
| C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub> | 1,2-Dichlorotetrafluoroethane   |                                |       | 10.25 | 15.7  | 21.1  |       | 13   |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub> | 1,1,2-Trichlorotrifluoroethane  |                                |       | 9.0   | 13.6  | 18.3  |       | 13   |
| C <sub>2</sub> H <sub>2</sub>                 | Acetylene                       |                                |       | 21.4  | 33.3  | 45.4  | 56.8  | 11   |
| C <sub>2</sub> H <sub>4</sub>                 | Ethylene                        |                                | 11.1  | 20.5  | 34.6  | 49.9  | 68.6  | 3    |
| C <sub>2</sub> H <sub>6</sub>                 | Ethane                          |                                | 11.0  | 21.3  | 35.4  | 52.2  | 70.5  | 5    |
| C <sub>2</sub> H <sub>6</sub> O               | Ethanol                         |                                |       | 14.4  | 25.8  | 38.4  | 53.2  | 11   |
| C <sub>3</sub> H <sub>6</sub> O               | Acetone                         |                                |       | 11.5  | 20.2  | 30.6  | 42.7  | 11   |
| C <sub>3</sub> H <sub>8</sub>                 | Propane                         |                                |       | 18.0  | 30.6  | 45.5  | 61.9  | 5    |
| C <sub>4</sub> F <sub>8</sub>                 | Perfluorocyclobutane            |                                |       | 12.5  | 19.5  |       |       | 13   |
| C <sub>4</sub> H <sub>10</sub>                | Butane                          |                                |       | 16.4  | 28.4  | 43.0  | 59.1  | 5    |
| C <sub>4</sub> H <sub>10</sub>                | Isobutane                       |                                |       | 16.1  | 27.9  | 42.1  | 57.6  | 5    |
| C <sub>4</sub> H <sub>10</sub> O              | Diethyl ether                   |                                |       | 15.1  | 25.0  | 37.1  |       | 11   |
| C <sub>5</sub> H <sub>12</sub>                | Pentane                         |                                |       | 14.4  | 24.9  | 37.8  | 52.7  | 11   |
| C <sub>6</sub> H <sub>14</sub>                | Hexane                          |                                |       |       | 23.4  | 35.4  | 48.7  | 11   |

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# THERMAL CONDUCTIVITY OF LIQUIDS

This table gives the thermal conductivity of about 275 liquids at temperatures between  $-25$  and  $100^{\circ}\text{C}$ . Values refer to nominal atmospheric pressure; when an entry is given for a temperature above the normal boiling point of the liquid, the pressure is understood to be the saturation vapor pressure at that temperature. Reference 1 contains data on many of these liquids at high pressures. Data on halocarbon refrigerants over a wide range of temperature and pressure may be found in Reference 6.

Values given to three decimal places (i.e., to  $0.001\text{ W/m K}$ ) have an uncertainty of 2% to 5%. Values given to  $0.0001\text{ W/m K}$  should be accurate to 1% or better.

Substances are arranged by molecular formula in Hill order, except that compounds not containing carbon precede those that do contain carbon.

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| Molecular<br>formula                          | Name                                   | Thermal conductivity in W/m K |        |        |        |        |        |    | Ref. |
|-----------------------------------------------|----------------------------------------|-------------------------------|--------|--------|--------|--------|--------|----|------|
|                                               |                                        | −25 °C                        | 0° C   | 25 °C  | 50 °C  | 75 °C  | 100 °C |    |      |
| Cl <sub>4</sub> Ge                            | Germanium(IV) chloride                 | 0.111                         | 0.105  | 0.100  | 0.095  | 0.090  | 0.084  | 1  |      |
| Cl <sub>4</sub> Si                            | Tetrachlorosilane                      |                               |        | 0.099  | 0.096  |        |        | 2  |      |
| Cl <sub>4</sub> Sn                            | Tin(IV) chloride                       | 0.123                         | 0.117  | 0.112  | 0.106  | 0.101  | 0.095  | 1  |      |
| Cl <sub>4</sub> Ti                            | Titanium(IV) chloride                  |                               | 0.143  | 0.138  | 0.134  | 0.129  | 0.124  | 1  |      |
| H <sub>2</sub> O                              | Water                                  |                               | 0.5562 | 0.6062 | 0.6423 | 0.6643 | 0.6729 | 8  |      |
| Hg                                            | Mercury                                | 7.85                          | 8.175  | 8.514  | 8.842  | 9.161  | 9.475  | 11 |      |
| CCl <sub>3</sub> F                            | Trichlorofluoromethane                 | 0.102                         | 0.096  | 0.089  | 0.083  | 0.076  | 0.070  | 1  |      |
| CCl <sub>4</sub>                              | Tetrachloromethane                     |                               | 0.109  | 0.103  | 0.098  | 0.092  | 0.087  | 1  |      |
| CHCl <sub>3</sub>                             | Trichloromethane                       | 0.127                         | 0.122  | 0.117  | 0.112  | 0.107  | 0.102  | 2  |      |
| CH <sub>2</sub> Br <sub>2</sub>               | Dibromomethane                         | 0.120                         | 0.114  | 0.108  | 0.103  | 0.097  |        | 2  |      |
| CH <sub>2</sub> Cl <sub>2</sub>               | Dichloromethane                        | 0.158                         | 0.149  | 0.140  | 0.133  | 0.128  | 0.127  | 1  |      |
| CH <sub>2</sub> I <sub>2</sub>                | Diiodomethane                          |                               |        | 0.098  | 0.093  | 0.088  | 0.083  | 1  |      |
| CH <sub>2</sub> O <sub>2</sub>                | Formic acid                            |                               |        | 0.267  | 0.265  | 0.263  | 0.261  | 1  |      |
| CH <sub>3</sub> NO <sub>2</sub>               | Nitromethane                           | 0.226                         | 0.215  | 0.204  | 0.193  | 0.182  | 0.171  | 1  |      |
| CH <sub>4</sub> O                             | Methanol                               | 0.218                         | 0.210  | 0.202  | 0.195  | 0.189  | 0.182  | 1  |      |
| CS <sub>2</sub>                               | Carbon disulfide                       |                               | 0.154  | 0.149  |        |        |        | 2  |      |
| C <sub>2</sub> Br <sub>2</sub> F <sub>4</sub> | 1,2-Dibromotetrafluoroethane           | 0.071                         | 0.066  | 0.061  | 0.057  | 0.053  | 0.049  | 1  |      |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub> | 1,1,2-Trichloro-1,2,2-trifluoroethane  | 0.0847                        | 0.0790 | 0.0736 | 0.0683 |        |        | 6  |      |
| C <sub>2</sub> Cl <sub>4</sub>                | Tetrachloroethene                      |                               | 0.117  | 0.110  | 0.104  | 0.098  | 0.093  | 1  |      |
| C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub> | 1,1,2,2-Tetrachloro-1,2-difluoroethane |                               |        | 0.082  | 0.078  | 0.074  | 0.069  | 1  |      |
| C <sub>2</sub> HCl <sub>3</sub>               | Trichloroethene                        | 0.128                         | 0.121  | 0.114  | 0.106  | 0.098  | 0.090  | 1  |      |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub> | 1,1,2,2-Tetrachloroethane              | 0.124                         | 0.118  | 0.111  | 0.104  | 0.098  | 0.091  | 1  |      |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> | 1,1,1-Trichloroethane                  |                               | 0.106  | 0.101  | 0.096  |        |        | 2  |      |
| C <sub>2</sub> H <sub>3</sub> N               | Acetonitrile                           | 0.208                         | 0.198  | 0.188  | 0.178  | 0.168  |        | 2  |      |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub> | 1,2-Dibromoethane                      |                               |        | 0.100  | 0.096  | 0.092  | 0.088  | 1  |      |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,2-Dichloroethane                     | 0.144                         | 0.139  | 0.133  | 0.128  | 0.122  | 0.117  | 1  |      |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>  | Acetic acid                            |                               |        | 0.158  | 0.153  | 0.149  | 0.144  | 2  |      |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>  | Methyl formate                         |                               | 0.194  | 0.187  |        |        |        | 1  |      |
| C <sub>2</sub> H <sub>5</sub> Br              | Bromoethane                            | 0.107                         | 0.104  | 0.101  |        |        |        | 1  |      |
| C <sub>2</sub> H <sub>5</sub> Cl              | Chloroethane                           | 0.145                         | 0.132  | 0.119  | 0.106  | 0.093  |        | 2  |      |
| C <sub>2</sub> H <sub>5</sub> I               | Iodoethane                             |                               | 0.091  | 0.087  | 0.083  | 0.079  |        | 1  |      |
| C <sub>2</sub> H <sub>5</sub> NO              | <i>N</i> -Methylformamide              |                               |        | 0.203  | 0.201  | 0.199  | 0.196  | 2  |      |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub> | Nitroethane                            |                               |        | 0.173  | 0.161  | 0.149  |        | 1  |      |
| C <sub>2</sub> H <sub>6</sub> O               | Ethanol                                | 0.181                         | 0.174  | 0.167  | 0.160  | 0.153  | 0.148  | 1  |      |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>  | 1,2-Ethanediol                         |                               | 0.248  | 0.254  | 0.258  | 0.261  | 0.261  | 1  |      |
| C <sub>2</sub> H <sub>7</sub> NO              | Ethanolamine                           |                               |        | 0.240  | 0.238  | 0.236  |        | 1  |      |

| Molecular<br>formula                          | Name                           | Thermal conductivity in W/m K |       |       |       |       |        |   | Ref. |
|-----------------------------------------------|--------------------------------|-------------------------------|-------|-------|-------|-------|--------|---|------|
|                                               |                                | −25 °C                        | 0° C  | 25 °C | 50 °C | 75 °C | 100 °C |   |      |
| C <sub>3</sub> F <sub>8</sub>                 | Perfluoropropane               | 0.062                         | 0.056 | 0.051 | 0.046 | 0.041 | 0.035  | 1 |      |
| C <sub>3</sub> H <sub>3</sub> N               | Acrylonitrile                  | 0.186                         | 0.176 | 0.166 | 0.156 | 0.146 | 0.136  | 1 |      |
| C <sub>3</sub> H <sub>5</sub> ClO             | Epichlorohydrin                | 0.142                         | 0.137 | 0.131 | 0.125 | 0.119 | 0.114  | 2 |      |
| C <sub>3</sub> H <sub>6</sub> O               | Allyl alcohol                  |                               |       | 0.162 |       |       |        | 1 |      |
| C <sub>3</sub> H <sub>6</sub> O               | Acetone                        |                               | 0.169 | 0.161 |       |       |        | 2 |      |
| C <sub>3</sub> H <sub>6</sub> O               | Methyloxirane                  |                               | 0.181 | 0.171 |       |       |        | 1 |      |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Propanoic acid                 |                               | 0.147 | 0.144 | 0.141 | 0.139 | 0.136  | 1 |      |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Ethyl formate                  | 0.181                         | 0.171 | 0.160 | 0.149 | 0.138 |        | 1 |      |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Methyl acetate                 | 0.174                         | 0.164 | 0.153 | 0.143 | 0.133 | 0.122  | 2 |      |
| C <sub>3</sub> H <sub>7</sub> Br              | 1-Bromopropane                 | 0.108                         | 0.104 | 0.099 | 0.094 |       |        | 1 |      |
| C <sub>3</sub> H <sub>7</sub> Cl              | 1-Chloropropane                | 0.129                         | 0.123 | 0.116 | 0.110 | 0.104 | 0.098  | 1 |      |
| C <sub>3</sub> H <sub>7</sub> I               | 1-Iodopropane                  | 0.096                         | 0.092 | 0.087 | 0.083 | 0.078 | 0.074  | 1 |      |
| C <sub>3</sub> H <sub>7</sub> I               | 2-Iodopropane                  | 0.089                         | 0.085 | 0.082 | 0.078 | 0.074 | 0.071  | 1 |      |
| C <sub>3</sub> H <sub>7</sub> NO              | <i>N,N</i> -Dimethylformamide  |                               |       | 0.183 | 0.175 | 0.167 | 0.159  | 1 |      |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub> | 1-Nitropropane                 |                               |       | 0.152 | 0.144 | 0.137 |        | 1 |      |
| C <sub>3</sub> H <sub>8</sub> O               | 1-Propanol                     | 0.162                         | 0.158 | 0.154 | 0.149 | 0.145 | 0.141  | 2 |      |
| C <sub>3</sub> H <sub>8</sub> O               | 2-Propanol                     | 0.146                         | 0.141 | 0.135 | 0.129 | 0.124 | 0.118  | 2 |      |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>  | 1,2-Propanediol                | 0.199                         | 0.200 | 0.200 | 0.200 | 0.199 | 0.197  | 1 |      |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>  | 2-Methoxyethanol               |                               |       | 0.190 | 0.180 | 0.170 |        | 1 |      |
| C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>  | Glycerol                       |                               |       | 0.285 | 0.288 | 0.292 | 0.296  | 1 |      |
| C <sub>3</sub> H <sub>9</sub> N               | Trimethylamine                 | 0.143                         | 0.133 |       |       |       |        | 2 |      |
| C <sub>4</sub> F <sub>8</sub>                 | Perfluorocyclobutane           | 0.082                         | 0.072 | 0.063 | 0.053 | 0.044 | 0.034  | 1 |      |
| C <sub>4</sub> H <sub>4</sub> O               | Furan                          | 0.142                         | 0.134 | 0.126 |       |       |        | 2 |      |
| C <sub>4</sub> H <sub>4</sub> S               | Thiophene                      |                               |       | 0.199 | 0.195 | 0.191 | 0.186  | 2 |      |
| C <sub>4</sub> H <sub>6</sub>                 | 1,2-Butadiene                  | 0.147                         | 0.134 |       |       |       |        | 1 |      |
| C <sub>4</sub> H <sub>6</sub>                 | 2-Butyne                       | 0.137                         | 0.129 | 0.121 |       |       |        | 2 |      |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>  | Vinyl acetate                  |                               |       | 0.151 | 0.141 | 0.131 | 0.120  | 1 |      |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>  | Acetic anhydride               |                               | 0.170 | 0.164 | 0.158 | 0.152 | 0.146  | 1 |      |
| C <sub>4</sub> H <sub>8</sub> O               | Butanal                        |                               | 0.155 | 0.147 | 0.140 | 0.132 |        | 1 |      |
| C <sub>4</sub> H <sub>8</sub> O               | 2-Butanone                     | 0.158                         | 0.151 | 0.145 | 0.139 | 0.133 |        | 2 |      |
| C <sub>4</sub> H <sub>8</sub> O               | Tetrahydrofuran                | 0.132                         | 0.126 | 0.120 | 0.114 |       |        | 2 |      |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Propyl formate                 |                               | 0.151 | 0.144 | 0.137 | 0.130 |        | 1 |      |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Ethyl acetate                  |                               | 0.151 | 0.144 | 0.136 |       |        | 1 |      |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | Methyl propanoate              |                               |       | 0.141 | 0.137 |       |        | 1 |      |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  | 1,4-Dioxane                    |                               |       | 0.159 | 0.147 | 0.135 | 0.123  | 2 |      |
| C <sub>4</sub> H <sub>9</sub> Br              | 1-Bromobutane                  | 0.112                         | 0.107 | 0.103 | 0.098 | 0.093 | 0.088  | 1 |      |
| C <sub>4</sub> H <sub>9</sub> I               | 1-Iodobutane                   |                               | 0.094 | 0.090 | 0.085 | 0.081 | 0.077  | 1 |      |
| C <sub>4</sub> H <sub>9</sub> NO              | <i>N,N</i> -Dimethylacetamide  |                               |       | 0.175 | 0.172 | 0.168 |        | 1 |      |
| C <sub>4</sub> H <sub>10</sub> O              | 1-Butanol                      |                               | 0.158 | 0.153 | 0.147 | 0.142 | 0.137  | 1 |      |
| C <sub>4</sub> H <sub>10</sub> O              | 2-Methyl-2-propanol            |                               |       | 0.112 | 0.110 | 0.109 | 0.108  | 1 |      |
| C <sub>4</sub> H <sub>10</sub> O              | Diethyl ether                  | 0.150                         | 0.140 | 0.130 | 0.120 | 0.110 | 0.100  | 2 |      |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub> | 2-Ethoxyethanol                |                               |       | 0.190 | 0.182 | 0.174 | 0.165  | 1 |      |
| C <sub>5</sub> H <sub>5</sub> N               | Pyridine                       |                               | 0.171 | 0.166 | 0.162 | 0.157 | 0.153  | 1 |      |
| C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>  | Furfuryl alcohol               |                               |       | 0.179 |       |       |        | 1 |      |
| C <sub>5</sub> H <sub>8</sub>                 | 2-Methyl-1,3-butadiene         | 0.141                         | 0.130 | 0.119 |       |       |        | 1 |      |
| C <sub>5</sub> H <sub>8</sub>                 | 1-Pentyne                      | 0.144                         | 0.136 | 0.127 | 0.119 |       |        | 1 |      |
| C <sub>5</sub> H <sub>8</sub>                 | Cyclopentene                   | 0.143                         | 0.136 | 0.129 |       |       |        | 2 |      |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>  | Methyl methacrylate            |                               | 0.156 | 0.147 | 0.137 | 0.127 | 0.117  | 1 |      |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>  | 2,4-Pentanedione               |                               |       | 0.154 | 0.150 | 0.146 | 0.143  | 1 |      |
| C <sub>5</sub> H <sub>9</sub> NO              | <i>N</i> -Methyl-2-pyrrolidone |                               |       | 0.167 | 0.162 | 0.157 |        | 1 |      |
| C <sub>5</sub> H <sub>10</sub>                | 1-Pentene                      | 0.131                         | 0.124 | 0.116 |       |       |        | 2 |      |
| C <sub>5</sub> H <sub>10</sub>                | Cyclopentane                   | 0.140                         | 0.133 | 0.126 |       |       |        | 2 |      |
| C <sub>5</sub> H <sub>10</sub> O              | Pentanal                       |                               | 0.146 | 0.139 | 0.133 | 0.127 | 0.121  | 1 |      |
| C <sub>5</sub> H <sub>10</sub> O              | 2-Pentanone                    |                               | 0.149 | 0.142 | 0.135 | 0.128 | 0.121  | 1 |      |
| C <sub>5</sub> H <sub>10</sub> O              | 3-Pentanone                    |                               | 0.151 | 0.144 | 0.137 | 0.129 | 0.122  | 1 |      |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Pentanoic acid                 |                               |       | 0.140 | 0.137 | 0.133 | 0.130  | 1 |      |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Butyl formate                  |                               |       | 0.136 | 0.130 | 0.123 | 0.117  | 1 |      |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Propyl acetate                 |                               | 0.146 | 0.140 | 0.135 | 0.130 | 0.124  | 1 |      |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Ethyl propanoate               |                               |       |       | 0.133 | 0.121 |        | 1 |      |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Methyl butanoate               |                               |       | 0.140 |       |       |        | 1 |      |
| C <sub>5</sub> H <sub>11</sub> Br             | 1-Bromopentane                 | 0.113                         | 0.109 | 0.105 | 0.101 | 0.097 | 0.093  | 1 |      |
| C <sub>5</sub> H <sub>11</sub> Cl             | 1-Chloropentane                |                               | 0.125 | 0.120 | 0.115 | 0.109 |        | 1 |      |

| Molecular<br>formula                          | Name                               | Thermal conductivity in W/m K |        |        |        |        |        |   | Ref. |
|-----------------------------------------------|------------------------------------|-------------------------------|--------|--------|--------|--------|--------|---|------|
|                                               |                                    | −25 °C                        | 0° C   | 25 °C  | 50 °C  | 75 °C  | 100 °C |   |      |
| C <sub>5</sub> H <sub>11</sub> I              | 1-Iodopentane                      |                               | 0.096  | 0.092  | 0.088  | 0.084  | 0.081  | 1 |      |
| C <sub>5</sub> H <sub>12</sub>                | Pentane                            | 0.130                         | 0.1207 | 0.1113 | 0.1018 | 0.0923 | 0.083  | 4 |      |
| C <sub>5</sub> H <sub>12</sub>                | Isopentane                         |                               |        | 0.111  |        |        |        | 1 |      |
| C <sub>5</sub> H <sub>12</sub> O              | 1-Pentanol                         | 0.159                         | 0.155  | 0.150  | 0.145  | 0.141  | 0.136  | 1 |      |
| C <sub>5</sub> H <sub>12</sub> O              | 2-Methyl-2-butanol                 |                               | 0.119  | 0.116  | 0.113  | 0.109  | 0.106  | 1 |      |
| C <sub>5</sub> H <sub>12</sub> O <sub>2</sub> | 1,5-Pentanediol                    |                               | 0.221  | 0.222  |        |        |        | 1 |      |
| C <sub>5</sub> H <sub>12</sub> O <sub>3</sub> | Diethylene glycol monomethyl ether |                               |        | 0.190  | 0.185  | 0.180  | 0.175  | 1 |      |
| C <sub>6</sub> F <sub>6</sub>                 | Hexafluorobenzene                  |                               |        |        | 0.083  |        |        | 1 |      |
| C <sub>6</sub> F <sub>14</sub>                | Perfluorohexane                    |                               | 0.067  | 0.065  | 0.064  |        |        | 1 |      |
| C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> | 1,2,3-Trichlorobenzene             |                               |        |        | 0.110  | 0.108  | 0.106  | 1 |      |
| C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> | 1,2,4-Trichlorobenzene             |                               |        | 0.112  | 0.109  | 0.106  |        | 1 |      |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> | <i>o</i> -Dichlorobenzene          |                               | 0.125  | 0.121  | 0.117  | 0.113  | 0.109  | 1 |      |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> | <i>m</i> -Dichlorobenzene          |                               | 0.120  | 0.116  | 0.113  | 0.109  |        | 1 |      |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> | <i>p</i> -Dichlorobenzene          |                               |        |        | 0.112  | 0.108  | 0.105  | 1 |      |
| C <sub>6</sub> H <sub>5</sub> Br              | Bromobenzene                       | 0.119                         | 0.115  | 0.111  | 0.107  | 0.103  | 0.099  | 1 |      |
| C <sub>6</sub> H <sub>5</sub> Cl              | Chlorobenzene                      | 0.137                         | 0.132  | 0.127  | 0.123  | 0.118  | 0.113  | 1 |      |
| C <sub>6</sub> H <sub>5</sub> F               | Fluorobenzene                      |                               |        | 0.136  | 0.131  | 0.126  |        | 1 |      |
| C <sub>6</sub> H <sub>5</sub> I               | Iodobenzene                        | 0.106                         | 0.103  | 0.101  | 0.098  | 0.095  | 0.092  | 1 |      |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub> | Nitrobenzene                       |                               |        | 0.149  | 0.145  | 0.142  | 0.139  | 1 |      |
| C <sub>6</sub> H <sub>6</sub>                 | Benzene                            |                               |        | 0.1411 | 0.1329 | 0.1247 |        | 7 |      |
| C <sub>6</sub> H <sub>6</sub> ClN             | 2-Chloroaniline                    |                               |        | 0.148  |        |        |        | 1 |      |
| C <sub>6</sub> H <sub>6</sub> O               | Phenol                             |                               |        |        | 0.153  | 0.149  | 0.147  | 1 |      |
| C <sub>6</sub> H <sub>7</sub> N               | Aniline                            |                               | 0.175  |        |        |        |        | 1 |      |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>  | Hexanedinitrile                    |                               |        | 0.174  | 0.168  |        |        | 1 |      |
| C <sub>6</sub> H <sub>10</sub>                | Cyclohexene                        | 0.142                         | 0.136  | 0.130  | 0.124  | 0.118  |        | 2 |      |
| C <sub>6</sub> H <sub>10</sub> O              | Cyclohexanone                      |                               |        | 0.138  | 0.134  | 0.130  | 0.126  | 1 |      |
| C <sub>6</sub> H <sub>10</sub> O              | Mesityl oxide                      | 0.170                         | 0.163  | 0.156  | 0.149  | 0.142  | 0.134  | 2 |      |
| C <sub>6</sub> H <sub>10</sub> O <sub>3</sub> | Ethyl acetoacetate                 |                               |        | 0.155  | 0.152  | 0.148  | 0.144  | 1 |      |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub> | Diethyl oxalate                    |                               |        | 0.157  |        |        |        | 1 |      |
| C <sub>6</sub> H <sub>12</sub>                | 1-Hexene                           | 0.138                         | 0.129  | 0.121  | 0.113  |        |        | 1 |      |
| C <sub>6</sub> H <sub>12</sub>                | Cyclohexane                        |                               |        | 0.123  | 0.117  | 0.111  |        | 2 |      |
| C <sub>6</sub> H <sub>12</sub> O              | 2-Hexanone                         |                               | 0.156  | 0.145  | 0.134  | 0.124  | 0.115  | 1 |      |
| C <sub>6</sub> H <sub>12</sub> O              | Cyclohexanol                       |                               |        | 0.138  | 0.134  | 0.130  | 0.126  | 1 |      |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Hexanoic acid                      |                               | 0.148  | 0.142  | 0.137  | 0.131  |        | 1 |      |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Butyl acetate                      |                               | 0.143  | 0.136  | 0.130  | 0.123  | 0.116  | 1 |      |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Propyl propanoate                  |                               |        |        | 0.133  |        |        | 1 |      |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Ethyl butanoate                    |                               | 0.143  | 0.137  | 0.131  | 0.126  |        | 1 |      |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub> | Methyl pentanoate                  |                               | 0.143  | 0.138  | 0.132  | 0.127  |        | 1 |      |
| C <sub>6</sub> H <sub>12</sub> O <sub>3</sub> | Paraldehyde                        |                               |        | 0.130  |        |        |        | 1 |      |
| C <sub>6</sub> H <sub>13</sub> Br             | 1-Bromohexane                      | 0.115                         | 0.111  | 0.108  | 0.104  | 0.101  | 0.097  | 1 |      |
| C <sub>6</sub> H <sub>13</sub> I              | 1-Iodoheptane                      |                               | 0.098  | 0.095  | 0.091  | 0.088  | 0.084  | 1 |      |
| C <sub>6</sub> H <sub>14</sub>                | Hexane                             | 0.133                         | 0.1250 | 0.1167 | 0.1083 | 0.0999 | 0.092  | 4 |      |
| C <sub>6</sub> H <sub>14</sub>                | 2-Methylpentane                    | 0.120                         | 0.1127 | 0.1050 | 0.0972 | 0.0894 | 0.082  | 3 |      |
| C <sub>6</sub> H <sub>14</sub>                | 3-Methylpentane                    | 0.122                         | 0.1142 | 0.1064 | 0.0986 | 0.0909 | 0.083  | 3 |      |
| C <sub>6</sub> H <sub>14</sub>                | 2,2-Dimethylbutane                 | 0.108                         | 0.1006 | 0.0934 | 0.0861 | 0.0788 | 0.072  | 3 |      |
| C <sub>6</sub> H <sub>14</sub>                | 2,3-Dimethylbutane                 | 0.115                         | 0.1076 | 0.1003 | 0.0930 | 0.0857 | 0.078  | 3 |      |
| C <sub>6</sub> H <sub>14</sub> O              | 1-Hexanol                          | 0.161                         | 0.157  | 0.152  | 0.147  | 0.142  | 0.137  | 1 |      |
| C <sub>6</sub> H <sub>14</sub> O              | Dipropyl ether                     |                               | 0.137  | 0.130  | 0.123  | 0.117  |        | 1 |      |
| C <sub>6</sub> H <sub>14</sub> O <sub>2</sub> | 1,2-Diethoxyethane                 |                               |        |        | 0.140  | 0.133  | 0.125  | 1 |      |
| C <sub>6</sub> H <sub>14</sub> O <sub>3</sub> | Diethylene glycol monoethyl ether  |                               |        |        | 0.188  | 0.184  | 0.180  | 1 |      |
| C <sub>6</sub> H <sub>14</sub> O <sub>4</sub> | Triethylene glycol                 |                               | 0.193  | 0.195  | 0.196  | 0.196  | 0.196  | 1 |      |
| C <sub>6</sub> H <sub>15</sub> N              | Triethylamine                      | 0.146                         | 0.139  | 0.132  | 0.125  | 0.118  | 0.111  | 1 |      |
| C <sub>7</sub> F <sub>16</sub>                | Perfluoroheptane                   | 0.068                         | 0.064  | 0.060  | 0.056  | 0.053  |        | 1 |      |
| C <sub>7</sub> H <sub>5</sub> N               | Benzonitrile                       |                               |        | 0.148  | 0.142  | 0.136  | 0.130  | 1 |      |
| C <sub>7</sub> H <sub>6</sub> O               | Benzaldehyde                       |                               |        | 0.153  | 0.148  | 0.143  | 0.139  | 1 |      |
| C <sub>7</sub> H <sub>8</sub>                 | Toluene                            | 0.1455                        | 0.1385 | 0.1310 | 0.1235 | 0.1162 | 0.1095 | 9 |      |
| C <sub>7</sub> H <sub>8</sub> O               | <i>o</i> -Cresol                   |                               |        |        |        |        |        | 1 |      |
| C <sub>7</sub> H <sub>8</sub> O               | <i>m</i> -Cresol                   |                               |        | 0.149  | 0.147  | 0.145  |        | 1 |      |
| C <sub>7</sub> H <sub>8</sub> O               | Benzyl alcohol                     |                               |        | 0.159  | 0.158  | 0.156  | 0.154  | 1 |      |
| C <sub>7</sub> H <sub>8</sub> O               | Anisole                            |                               |        | 0.145  | 0.142  | 0.139  | 0.136  | 1 |      |
| C <sub>7</sub> H <sub>9</sub> N               | 2-Methylaniline                    |                               |        | 0.162  |        |        |        | 1 |      |
| C <sub>7</sub> H <sub>9</sub> N               | 3-Methylaniline                    |                               |        | 0.161  |        |        |        | 1 |      |

| Molecular<br>formula                          | Name                              | Thermal conductivity in W/m K |        |        |        |        |        | Ref. |
|-----------------------------------------------|-----------------------------------|-------------------------------|--------|--------|--------|--------|--------|------|
|                                               |                                   | -25 °C                        | 0° C   | 25 °C  | 50 °C  | 75 °C  | 100 °C |      |
| C <sub>7</sub> H <sub>14</sub>                | 1-Heptene                         | 0.139                         | 0.132  | 0.125  | 0.118  | 0.111  |        | 1    |
| C <sub>7</sub> H <sub>14</sub>                | Cycloheptane                      |                               |        | 0.123  | 0.118  | 0.112  | 0.108  | 1    |
| C <sub>7</sub> H <sub>14</sub> O              | Heptanal                          |                               |        | 0.140  |        |        |        | 1    |
| C <sub>7</sub> H <sub>14</sub> O              | 3-Heptanone                       |                               | 0.143  | 0.137  | 0.131  | 0.125  | 0.119  | 1    |
| C <sub>7</sub> H <sub>14</sub> O              | 4-Heptanone                       |                               |        | 0.136  | 0.131  | 0.125  | 0.120  | 1    |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Hexyl formate                     |                               |        | 0.141  | 0.133  | 0.126  | 0.119  | 1    |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Heptanoic acid                    |                               |        | 0.140  | 0.137  | 0.133  |        | 1    |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Pentyl acetate                    |                               | 0.141  | 0.134  | 0.126  | 0.120  | 0.113  | 1    |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Butyl propanoate                  |                               |        | 0.139  | 0.133  | 0.126  | 0.121  | 1    |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Ethyl pentanoate                  |                               |        | 0.132  |        |        |        | 1    |
| C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> | Methyl hexanoate                  |                               |        | 0.136  | 0.131  | 0.126  | 0.121  | 1    |
| C <sub>7</sub> H <sub>16</sub>                | Heptane                           | 0.1378                        | 0.1303 | 0.1228 | 0.1152 | 0.1077 |        | 5    |
| C <sub>7</sub> H <sub>16</sub>                | 2-Methylhexane                    | 0.125                         | 0.1177 | 0.1105 | 0.1033 | 0.0961 | 0.089  | 3    |
| C <sub>7</sub> H <sub>16</sub>                | 3-Methylhexane                    | 0.126                         | 0.1184 | 0.1112 | 0.1040 | 0.0968 | 0.090  | 3    |
| C <sub>7</sub> H <sub>16</sub>                | 3-Ethylpentane                    | 0.128                         | 0.1203 | 0.1128 | 0.1053 | 0.0978 | 0.090  | 3    |
| C <sub>7</sub> H <sub>16</sub>                | 2,2-Dimethylpentane               | 0.111                         | 0.1046 | 0.0980 | 0.0913 | 0.0847 | 0.078  | 3    |
| C <sub>7</sub> H <sub>16</sub>                | 2,3-Dimethylpentane               | 0.120                         | 0.1127 | 0.1059 | 0.0990 | 0.0922 | 0.085  | 3    |
| C <sub>7</sub> H <sub>16</sub>                | 2,4-Dimethylpentane               | 0.116                         | 0.1089 | 0.1020 | 0.0951 | 0.0882 | 0.081  | 3    |
| C <sub>7</sub> H <sub>16</sub>                | 3,3-Dimethylpentane               | 0.113                         | 0.1068 | 0.1001 | 0.0934 | 0.0867 | 0.080  | 3    |
| C <sub>7</sub> H <sub>16</sub>                | 2,2,3-Trimethylbutane             | 0.107                         | 0.1011 | 0.0950 | 0.0889 | 0.0828 | 0.077  | 3    |
| C <sub>7</sub> H <sub>16</sub> O              | 1-Heptanol                        | 0.160                         | 0.158  | 0.153  | 0.149  | 0.144  | 0.139  | 1    |
| C <sub>8</sub> F <sub>18</sub>                | Perfluorooctane                   |                               | 0.066  | 0.062  | 0.059  | 0.055  | 0.052  | 1    |
| C <sub>8</sub> H <sub>8</sub>                 | Styrene                           | 0.148                         | 0.142  | 0.137  | 0.131  | 0.126  | 0.120  | 2    |
| C <sub>8</sub> H <sub>8</sub> O               | Acetophenone                      |                               |        | 0.147  | 0.146  | 0.144  | 0.142  | 1    |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | Methyl benzoate                   |                               |        | 0.147  |        |        |        | 1    |
| C <sub>8</sub> H <sub>10</sub>                | Ethylbenzene                      | 0.143                         | 0.137  | 0.130  | 0.123  | 0.116  | 0.110  | 1    |
| C <sub>8</sub> H <sub>10</sub>                | <i>o</i> -Xylene                  |                               |        | 0.131  | 0.126  | 0.120  | 0.114  | 2    |
| C <sub>8</sub> H <sub>10</sub>                | <i>m</i> -Xylene                  |                               |        | 0.130  | 0.124  | 0.118  | 0.113  | 2    |
| C <sub>8</sub> H <sub>10</sub>                | <i>p</i> -Xylene                  |                               |        | 0.130  | 0.124  | 0.118  | 0.112  | 2    |
| C <sub>8</sub> H <sub>10</sub> O              | Ethoxybenzene                     | 0.151                         | 0.145  | 0.140  | 0.135  | 0.130  |        | 1    |
| C <sub>8</sub> H <sub>10</sub> O <sub>2</sub> | 2-Phenoxyethanol                  |                               |        | 0.169  | 0.168  | 0.166  | 0.165  | 1    |
| C <sub>8</sub> H <sub>11</sub> N              | <i>N</i> -Ethylaniline            |                               |        | 0.150  |        |        |        | 1    |
| C <sub>8</sub> H <sub>11</sub> N              | <i>N,N</i> -Dimethylaniline       |                               |        | 0.122  | 0.119  | 0.115  |        | 1    |
| C <sub>8</sub> H <sub>16</sub>                | 1-Octene                          | 0.139                         | 0.133  | 0.126  | 0.120  | 0.114  | 0.107  | 1    |
| C <sub>8</sub> H <sub>16</sub> O              | 2-Octanone                        |                               | 0.141  | 0.135  | 0.129  | 0.124  | 0.118  | 1    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Heptyl formate                    |                               | 0.141  | 0.137  | 0.132  | 0.128  | 0.123  | 1    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Octanoic acid                     |                               |        | 0.146  | 0.143  | 0.139  | 0.135  | 1    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Hexyl acetate                     |                               |        | 0.135  | 0.129  | 0.123  | 0.118  | 1    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Pentyl propanoate                 |                               |        | 0.138  | 0.132  |        |        | 1    |
| C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Ethyl hexanoate                   |                               | 0.142  | 0.137  | 0.133  | 0.128  | 0.123  | 1    |
| C <sub>8</sub> H <sub>17</sub> Cl             | 1-Chlorooctane                    |                               | 0.130  | 0.127  | 0.124  | 0.121  | 0.119  | 1    |
| C <sub>8</sub> H <sub>18</sub>                | Octane                            | 0.139                         | 0.1317 | 0.1244 | 0.1171 | 0.1097 | 0.102  | 4    |
| C <sub>8</sub> H <sub>18</sub>                | 2-Methylheptane                   | 0.127                         | 0.1206 | 0.1139 | 0.1072 | 0.1005 | 0.094  | 3    |
| C <sub>8</sub> H <sub>18</sub>                | 3-Methylheptane                   | 0.128                         | 0.1216 | 0.1149 | 0.1081 | 0.1014 | 0.095  | 3    |
| C <sub>8</sub> H <sub>18</sub>                | 2,2,4-Trimethylpentane            | 0.107                         | 0.1007 | 0.0948 | 0.0888 | 0.0829 | 0.077  | 3    |
| C <sub>8</sub> H <sub>18</sub>                | 2,3,4-Trimethylpentane            | 0.115                         | 0.1093 | 0.1035 | 0.0976 | 0.0918 | 0.086  | 3    |
| C <sub>8</sub> H <sub>18</sub> O              | Ethyl hexyl ether                 |                               | 0.131  | 0.126  | 0.120  | 0.114  | 0.109  | 1    |
| C <sub>8</sub> H <sub>18</sub> O              | 1-Octanol                         |                               | 0.162  | 0.158  | 0.153  | 0.148  | 0.143  | 1    |
| C <sub>8</sub> H <sub>18</sub> O              | Dibutyl ether                     |                               | 0.139  | 0.132  | 0.125  | 0.118  | 0.112  | 1    |
| C <sub>8</sub> H <sub>18</sub> O <sub>3</sub> | Diethylene glycol monobutyl ether |                               |        | 0.163  | 0.158  | 0.153  | 0.148  | 1    |
| C <sub>8</sub> H <sub>18</sub> O <sub>4</sub> | Triethylene glycol dimethyl ether |                               |        | 0.169  | 0.158  | 0.147  |        | 1    |
| C <sub>8</sub> H <sub>18</sub> O <sub>5</sub> | Tetraethylene glycol              |                               |        | 0.191  | 0.192  |        |        | 1    |
| C <sub>9</sub> H <sub>7</sub> N               | Quinoline                         |                               |        | 0.147  | 0.144  | 0.141  | 0.138  | 1    |
| C <sub>9</sub> H <sub>10</sub>                | Indan                             |                               |        | 0.135  |        |        |        | 1    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub> | Ethyl benzoate                    |                               |        | 0.141  |        |        |        | 1    |
| C <sub>9</sub> H <sub>12</sub>                | Propylbenzene                     | 0.134                         | 0.130  | 0.125  | 0.120  | 0.115  | 0.109  | 1    |
| C <sub>9</sub> H <sub>12</sub>                | Isopropylbenzene                  | 0.132                         | 0.128  | 0.123  | 0.118  | 0.112  | 0.107  | 1    |
| C <sub>9</sub> H <sub>12</sub>                | 1,2,4-Trimethylbenzene            |                               |        | 0.129  | 0.124  | 0.118  | 0.114  | 1    |
| C <sub>9</sub> H <sub>12</sub>                | 1,3,5-Trimethylbenzene            | 0.143                         | 0.139  | 0.134  | 0.129  | 0.123  | 0.117  | 1    |
| C <sub>9</sub> H <sub>18</sub>                | 1-Nonene                          | 0.136                         | 0.130  | 0.123  | 0.116  | 0.110  | 0.104  | 1    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub> | Nonanoic acid                     |                               |        | 0.150  | 0.146  | 0.142  | 0.138  | 1    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub> | Heptyl acetate                    |                               |        | 0.135  | 0.128  | 0.122  | 0.116  | 1    |

| Molecular<br>formula                           | Name                               | Thermal conductivity in W/m K |        |        |        |        |        |    | Ref. |
|------------------------------------------------|------------------------------------|-------------------------------|--------|--------|--------|--------|--------|----|------|
|                                                |                                    | −25 °C                        | 0° C   | 25 °C  | 50 °C  | 75 °C  | 100 °C |    |      |
| C <sub>9</sub> H <sub>19</sub> Br              | 1-Bromononane                      |                               | 0.116  | 0.112  | 0.109  | 0.106  | 0.103  | 1  |      |
| C <sub>9</sub> H <sub>19</sub> Cl              | 1-Chlorononane                     |                               | 0.132  | 0.128  | 0.124  | 0.120  | 0.115  | 1  |      |
| C <sub>9</sub> H <sub>19</sub> I               | 1-Iodononane                       |                               | 0.105  | 0.102  | 0.099  | 0.095  | 0.092  | 1  |      |
| C <sub>9</sub> H <sub>20</sub>                 | Nonane                             | 0.141                         | 0.1337 | 0.1269 | 0.1201 | 0.1133 | 0.106  | 4  |      |
| C <sub>9</sub> H <sub>20</sub> O               | 1-Nonanol                          |                               | 0.164  | 0.159  | 0.155  | 0.150  | 0.145  | 1  |      |
| C <sub>10</sub> H <sub>7</sub> Br              | 1-Bromonaphthalene                 |                               |        | 0.110  | 0.109  | 0.108  | 0.106  | 1  |      |
| C <sub>10</sub> H <sub>7</sub> Cl              | 1-Chloronaphthalene                |                               |        | 0.126  |        |        |        | 1  |      |
| C <sub>10</sub> H <sub>10</sub> O <sub>4</sub> | Dimethyl phthalate                 |                               |        | 0.1473 | 0.1443 | 0.1409 | 0.1373 | 10 |      |
| C <sub>10</sub> H <sub>12</sub>                | 1,2,3,4-Tetrahydronaphthalene      |                               |        | 0.131  | 0.129  | 0.128  | 0.126  | 1  |      |
| C <sub>10</sub> H <sub>14</sub>                | Butylbenzene                       |                               |        | 0.126  | 0.121  | 0.116  | 0.111  | 1  |      |
| C <sub>10</sub> H <sub>14</sub>                | <i>sec</i> -Butylbenzene, (±)-     |                               | 0.129  | 0.124  | 0.119  | 0.114  | 0.108  | 1  |      |
| C <sub>10</sub> H <sub>14</sub>                | <i>tert</i> -Butylbenzene          |                               |        | 0.117  | 0.114  | 0.110  | 0.106  | 1  |      |
| C <sub>10</sub> H <sub>14</sub>                | 1-Isopropyl-4-methylbenzene        | 0.132                         | 0.127  | 0.122  | 0.117  | 0.112  | 0.107  | 2  |      |
| C <sub>10</sub> H <sub>14</sub>                | <i>o</i> -Diethylbenzene           |                               | 0.133  | 0.127  | 0.122  | 0.116  | 0.111  | 1  |      |
| C <sub>10</sub> H <sub>18</sub>                | <i>trans</i> -Decahydronaphthalene |                               |        | 0.113  |        |        |        | 1  |      |
| C <sub>10</sub> H <sub>20</sub>                | 1-Decene                           | 0.138                         | 0.132  | 0.126  | 0.120  | 0.114  | 0.109  | 1  |      |
| C <sub>10</sub> H <sub>20</sub> O              | Decanal                            |                               | 0.149  | 0.144  | 0.139  | 0.134  | 0.129  | 1  |      |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub> | Heptyl propanoate                  |                               |        | 0.137  | 0.132  | 0.127  | 0.122  | 1  |      |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub> | Hexyl butanoate                    |                               |        | 0.137  | 0.132  | 0.127  | 0.121  | 1  |      |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub> | Decanoic acid                      |                               |        |        | 0.148  | 0.144  | 0.140  | 1  |      |
| C <sub>10</sub> H <sub>22</sub>                | Decane                             | 0.142                         | 0.1360 | 0.1296 | 0.1232 | 0.1167 | 0.110  | 4  |      |
| C <sub>10</sub> H <sub>22</sub> O              | 1-Decanol                          |                               |        | 0.162  | 0.159  | 0.155  | 0.151  | 1  |      |
| C <sub>10</sub> H <sub>22</sub> O              | Dipentyl ether                     |                               |        | 0.131  | 0.125  | 0.121  | 0.116  | 1  |      |
| C <sub>10</sub> H <sub>22</sub> O <sub>2</sub> | 1,2-Dibutoxyethane                 |                               |        | 0.140  | 0.134  | 0.127  | 0.120  | 1  |      |
| C <sub>11</sub> H <sub>16</sub>                | Pentylbenzene                      |                               | 0.135  | 0.130  | 0.125  | 0.120  | 0.115  | 1  |      |
| C <sub>11</sub> H <sub>22</sub>                | 1-Undecene                         |                               |        | 0.126  | 0.118  | 0.114  | 0.108  | 1  |      |
| C <sub>11</sub> H <sub>22</sub> O              | 6-Undecanone                       |                               |        | 0.137  | 0.132  | 0.127  |        | 1  |      |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | Undecanoic acid                    |                               |        |        | 0.153  | 0.149  |        | 1  |      |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | Octyl propanoate                   |                               |        | 0.135  | 0.130  | 0.125  | 0.120  | 1  |      |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | Heptyl butanoate                   |                               |        | 0.139  | 0.134  | 0.129  | 0.123  | 1  |      |
| C <sub>11</sub> H <sub>24</sub>                | Undecane                           |                               |        | 0.136  | 0.128  | 0.122  | 0.116  | 1  |      |
| C <sub>11</sub> H <sub>24</sub> O              | 1-Undecanol                        |                               |        | 0.169  | 0.165  | 0.161  | 0.158  | 1  |      |
| C <sub>12</sub> H <sub>10</sub> O              | Diphenyl ether                     |                               |        |        | 0.139  | 0.135  | 0.131  | 2  |      |
| C <sub>12</sub> H <sub>14</sub> O <sub>4</sub> | Diethyl phthalate                  |                               |        | 0.172  | 0.169  | 0.166  |        | 1  |      |
| C <sub>12</sub> H <sub>16</sub>                | Cyclohexylbenzene                  |                               |        | 0.121  | 0.119  | 0.117  |        | 1  |      |
| C <sub>12</sub> H <sub>18</sub>                | Hexylbenzene                       |                               | 0.141  | 0.137  | 0.132  | 0.128  | 0.124  | 1  |      |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub> | Decyl acetate                      |                               |        | 0.146  | 0.136  | 0.126  |        | 1  |      |
| C <sub>12</sub> H <sub>24</sub> O <sub>2</sub> | Octyl butanoate                    |                               |        | 0.139  | 0.134  | 0.129  | 0.125  | 1  |      |
| C <sub>12</sub> H <sub>26</sub>                | Dodecane                           |                               |        | 0.135  | 0.130  | 0.124  | 0.119  | 1  |      |
| C <sub>12</sub> H <sub>26</sub> O              | 1-Dodecanol                        |                               |        |        | 0.167  | 0.163  | 0.159  | 1  |      |
| C <sub>12</sub> H <sub>26</sub> O <sub>3</sub> | Diethylene glycol dibutyl ether    |                               | 0.150  | 0.146  | 0.143  | 0.139  | 0.135  | 1  |      |
| C <sub>12</sub> H <sub>27</sub> N              | Tributylamine                      |                               |        | 0.129  |        |        |        | 1  |      |
| C <sub>13</sub> H <sub>26</sub>                | 1-Tridecene                        |                               |        | 0.130  | 0.125  | 0.120  | 0.115  | 1  |      |
| C <sub>13</sub> H <sub>28</sub>                | Tridecane                          |                               |        | 0.130  | 0.125  | 0.120  | 0.115  | 1  |      |
| C <sub>14</sub> H <sub>28</sub>                | 1-Tetradecene                      |                               |        | 0.136  | 0.131  | 0.126  | 0.121  | 1  |      |
| C <sub>14</sub> H <sub>30</sub>                | Tetradecane                        |                               |        | 0.139  | 0.134  | 0.129  | 0.124  | 1  |      |
| C <sub>14</sub> H <sub>30</sub> O              | 1-Tetradecanol                     |                               |        |        | 0.167  | 0.162  | 0.157  | 2  |      |
| C <sub>16</sub> H <sub>22</sub> O <sub>4</sub> | Dibutyl phthalate                  |                               | 0.139  | 0.136  | 0.134  | 0.131  | 0.129  | 1  |      |
| C <sub>16</sub> H <sub>34</sub>                | Hexadecane                         |                               |        | 0.140  | 0.135  | 0.130  | 0.125  | 2  |      |
| C <sub>18</sub> H <sub>38</sub>                | Octadecane                         |                               |        |        | 0.146  | 0.142  | 0.137  | 2  |      |
| C <sub>20</sub> H <sub>40</sub> O <sub>2</sub> | Butyl palmitate                    |                               |        | 0.151  | 0.148  | 0.144  | 0.140  | 1  |      |
| C <sub>22</sub> H <sub>42</sub> O <sub>2</sub> | Butyl oleate                       |                               |        | 0.157  | 0.153  | 0.149  | 0.145  | 1  |      |
| C <sub>22</sub> H <sub>42</sub> O <sub>4</sub> | Diocetyl hexanedioate              |                               |        | 0.157  | 0.153  | 0.149  | 0.145  | 1  |      |

## DIFFUSION IN GASES

This table gives binary diffusion coefficients  $D_{12}$  for a number of common gases as a function of temperature. Values refer to atmospheric pressure. The diffusion coefficient is inversely proportional to pressure as long as the gas is in a regime where binary collisions dominate. See Reference 1 for a discussion of the dependence of  $D_{12}$  on temperature and composition.

The first part of the table gives data for several gases in the presence of a large excess of air. The remainder applies to equimolar

mixtures of gases. Each gas pair is ordered alphabetically according to the most common way of writing the formula. The listing of pairs then follows alphabetical order by the first constituent.

### References

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$D_{12}/\text{cm}^2 \text{ s}^{-1}$  for  $p = 101.325 \text{ kPa}$  and the Specified  $T/\text{K}$

| System                                         | 200   | 273.15 | 293.15 | 373.15 | 473.15 | 573.15 | 673.15 |
|------------------------------------------------|-------|--------|--------|--------|--------|--------|--------|
| <i>Large Excess of Air</i>                     |       |        |        |        |        |        |        |
| Ar-air                                         |       | 0.167  | 0.189  | 0.289  | 0.437  | 0.612  | 0.810  |
| CH <sub>4</sub> -air                           |       |        | 0.210  | 0.321  | 0.485  | 0.678  | 0.899  |
| CO-air                                         |       |        | 0.208  | 0.315  | 0.475  | 0.662  | 0.875  |
| CO <sub>2</sub> -air                           |       |        | 0.160  | 0.252  | 0.390  | 0.549  | 0.728  |
| H <sub>2</sub> -air                            |       | 0.668  | 0.756  | 1.153  | 1.747  | 2.444  | 3.238  |
| H <sub>2</sub> O-air                           |       |        | 0.242  | 0.399  | 0.638  | 0.873  | 1.135  |
| He-air                                         |       | 0.617  | 0.697  | 1.057  | 1.594  | 2.221  | 2.933  |
| SF <sub>6</sub> -air                           |       |        |        | 0.150  | 0.233  | 0.329  | 0.438  |
| <i>Equimolar Mixture</i>                       |       |        |        |        |        |        |        |
| Ar-CH <sub>4</sub>                             |       |        |        | 0.306  | 0.467  | 0.657  | 0.876  |
| Ar-CO                                          |       | 0.168  | 0.190  | 0.290  | 0.439  | 0.615  | 0.815  |
| Ar-CO <sub>2</sub>                             |       | 0.129  | 0.148  | 0.235  | 0.365  | 0.517  | 0.689  |
| Ar-H <sub>2</sub>                              |       | 0.698  | 0.794  | 1.228  | 1.876  | 2.634  | 3.496  |
| Ar-He                                          | 0.381 | 0.645  | 0.726  | 1.088  | 1.617  | 2.226  | 2.911  |
| Ar-Kr                                          | 0.064 | 0.117  | 0.134  | 0.210  | 0.323  | 0.456  | 0.605  |
| Ar-N <sub>2</sub>                              |       | 0.168  | 0.190  | 0.290  | 0.439  | 0.615  | 0.815  |
| Ar-Ne                                          | 0.160 | 0.277  | 0.313  | 0.475  | 0.710  | 0.979  | 1.283  |
| Ar-O <sub>2</sub>                              |       | 0.166  | 0.187  | 0.285  | 0.430  | 0.600  | 0.793  |
| Ar-SF <sub>6</sub>                             |       |        |        | 0.128  | 0.202  | 0.290  | 0.389  |
| Ar-Xe                                          | 0.052 | 0.095  | 0.108  | 0.171  | 0.264  | 0.374  | 0.498  |
| CH <sub>4</sub> -H <sub>2</sub>                |       |        | 0.708  | 1.084  | 1.648  | 2.311  | 3.070  |
| CH <sub>4</sub> -He                            |       |        | 0.650  | 0.992  | 1.502  | 2.101  | 2.784  |
| CH <sub>4</sub> -N <sub>2</sub>                |       |        | 0.208  | 0.317  | 0.480  | 0.671  | 0.890  |
| CH <sub>4</sub> -O <sub>2</sub>                |       |        | 0.220  | 0.341  | 0.523  | 0.736  | 0.978  |
| CH <sub>4</sub> -SF <sub>6</sub>               |       |        |        | 0.167  | 0.257  | 0.363  | 0.482  |
| CO-CO <sub>2</sub>                             |       |        | 0.162  | 0.250  | 0.384  |        |        |
| CO-H <sub>2</sub>                              | 0.408 | 0.686  | 0.772  | 1.162  | 1.743  | 2.423  | 3.196  |
| CO-He                                          | 0.365 | 0.619  | 0.698  | 1.052  | 1.577  | 2.188  | 2.882  |
| CO-Kr                                          |       | 0.131  | 0.149  | 0.227  | 0.346  | 0.485  | 0.645  |
| CO-N <sub>2</sub>                              | 0.133 | 0.208  | 0.231  | 0.336  | 0.491  | 0.673  | 0.878  |
| CO-O <sub>2</sub>                              |       |        | 0.202  | 0.307  | 0.462  | 0.643  | 0.849  |
| CO-SF <sub>6</sub>                             |       |        |        | 0.144  | 0.226  | 0.323  | 0.432  |
| CO <sub>2</sub> -C <sub>3</sub> H <sub>8</sub> |       |        | 0.084  | 0.133  | 0.209  |        |        |
| CO <sub>2</sub> -H <sub>2</sub>                | 0.315 | 0.552  | 0.627  | 0.964  | 1.470  | 2.066  | 2.745  |
| CO <sub>2</sub> -H <sub>2</sub> O              |       |        | 0.162  | 0.292  | 0.496  | 0.741  | 1.021  |
| CO <sub>2</sub> -He                            | 0.300 | 0.513  | 0.580  | 0.878  | 1.321  |        |        |
| CO <sub>2</sub> -N <sub>2</sub>                |       |        | 0.160  | 0.253  | 0.392  | 0.553  | 0.733  |
| CO <sub>2</sub> -N <sub>2</sub> O              | 0.055 | 0.099  | 0.113  | 0.177  | 0.276  |        |        |
| CO <sub>2</sub> -Ne                            | 0.131 | 0.227  | 0.258  | 0.395  | 0.603  | 0.847  |        |
| CO <sub>2</sub> -O <sub>2</sub>                |       |        | 0.159  | 0.248  | 0.380  | 0.535  | 0.710  |
| CO <sub>2</sub> -SF <sub>6</sub>               |       |        |        | 0.099  | 0.155  |        |        |
| D <sub>2</sub> -H <sub>2</sub>                 | 0.631 | 1.079  | 1.219  | 1.846  | 2.778  | 3.866  | 5.103  |
| H <sub>2</sub> -He                             | 0.775 | 1.320  | 1.490  | 2.255  | 3.394  | 4.726  | 6.242  |
| H <sub>2</sub> -Kr                             | 0.340 | 0.601  | 0.682  | 1.053  | 1.607  | 2.258  | 2.999  |



| System                          | 200   | 273.15 | 293.15 | 373.15 | 473.15 | 573.15 | 673.15 |
|---------------------------------|-------|--------|--------|--------|--------|--------|--------|
| H <sub>2</sub> -N <sub>2</sub>  | 0.408 | 0.686  | 0.772  | 1.162  | 1.743  | 2.423  | 3.196  |
| H <sub>2</sub> -Ne              | 0.572 | 0.982  | 1.109  | 1.684  | 2.541  | 3.541  | 4.677  |
| H <sub>2</sub> -O <sub>2</sub>  |       | 0.692  | 0.782  | 1.188  | 1.792  | 2.497  | 3.299  |
| H <sub>2</sub> -SF <sub>6</sub> |       |        | 0.412  | 0.649  | 0.998  | 1.400  | 1.851  |
| H <sub>2</sub> -Xe              |       | 0.513  | 0.581  | 0.890  | 1.349  | 1.885  | 2.493  |
| H <sub>2</sub> O-N <sub>2</sub> |       |        | 0.242  | 0.399  |        |        |        |
| H <sub>2</sub> O-O <sub>2</sub> |       |        | 0.244  | 0.403  | 0.645  | 0.882  | 1.147  |
| He-Kr                           | 0.330 | 0.559  | 0.629  | 0.942  | 1.404  | 1.942  | 2.550  |
| He-N <sub>2</sub>               | 0.365 | 0.619  | 0.698  | 1.052  | 1.577  | 2.188  | 2.882  |
| He-Ne                           | 0.563 | 0.948  | 1.066  | 1.592  | 2.362  | 3.254  | 4.262  |
| He-O <sub>2</sub>               |       | 0.641  | 0.723  | 1.092  | 1.640  | 2.276  | 2.996  |
| He-SF <sub>6</sub>              |       |        | 0.400  | 0.592  | 0.871  | 1.190  | 1.545  |
| He-Xe                           | 0.282 | 0.478  | 0.538  | 0.807  | 1.201  | 1.655  | 2.168  |
| Kr-N <sub>2</sub>               |       | 0.131  | 0.149  | 0.227  | 0.346  | 0.485  | 0.645  |
| Kr-Ne                           | 0.131 | 0.228  | 0.258  | 0.392  | 0.587  | 0.812  | 1.063  |
| Kr-Xe                           | 0.035 | 0.064  | 0.073  | 0.116  | 0.181  | 0.257  | 0.344  |
| N <sub>2</sub> -Ne              |       |        | 0.317  | 0.483  | 0.731  | 1.021  | 1.351  |
| N <sub>2</sub> -O <sub>2</sub>  |       |        | 0.202  | 0.307  | 0.462  | 0.643  | 0.849  |
| N <sub>2</sub> -SF <sub>6</sub> |       |        |        | 0.148  | 0.231  | 0.328  | 0.436  |
| N <sub>2</sub> -Xe              |       | 0.107  | 0.122  | 0.188  | 0.287  | 0.404  | 0.539  |
| Ne-Xe                           | 0.111 | 0.193  | 0.219  | 0.332  | 0.498  | 0.688  | 0.901  |
| O <sub>2</sub> -SF <sub>6</sub> |       |        | 0.097  | 0.154  | 0.238  | 0.334  | 0.441  |

## DIFFUSION COEFFICIENTS IN LIQUIDS AT INFINITE DILUTION

This table lists diffusion coefficients  $D_{AB}$  at infinite dilution for some binary liquid mixtures. Values are given at 25°C when available; it should be noted that the diffusion coefficient generally increases by 10% to 20% for a 10°C increase above ambient temperature.

Solvents are listed in alphabetical order, as are the solutes within each solvent group.

## References

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3. Sanni, S. A., Fell, C. J. D., and Hutchison, H. P., *J. Chem. Eng. Data* 16, 424, 1971.
4. Fan, Y., Qian, R., Shi, M., and Shi, J., *J. Chem. Eng. Data* 40, 1053, 1995.
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| Solute                  | Solvent     | t/°C | $D_{AB}/10^{-5} \text{ cm}^2 \text{ s}^{-1}$ | Ref. | Solute             | Solvent       | t/°C | $D_{AB}/10^{-5} \text{ cm}^2 \text{ s}^{-1}$ | Ref. |
|-------------------------|-------------|------|----------------------------------------------|------|--------------------|---------------|------|----------------------------------------------|------|
| Acetic acid             | Acetone     | 25   | 3.31                                         | 5    | Perylene           | Cyclohexane   | 25   | 0.79                                         | 1    |
| Benzene                 | Acetone     | 25   | 4.25                                         | 2    | Pyrene             | Cyclohexane   | 25   | 0.95                                         | 1    |
| Benzoic acid            | Acetone     | 25   | 2.62                                         | 5    | Tetrachloromethane | Cyclohexane   | 25   | 1.49                                         | 3    |
| Formic acid             | Acetone     | 25   | 3.77                                         | 5    | Toluene            | Cyclohexane   | 25   | 1.66                                         | 1    |
| Nitrobenzene            | Acetone     | 20   | 2.94                                         | 5    | Benzene            | Decane        | 25   | 2.16                                         | 1    |
| Tetrachloromethane      | Acetone     | 25   | 3.29                                         | 5    | Chlorobenzene      | Decane        | 25   | 1.98                                         | 1    |
| Trichloromethane        | Acetone     | 25   | 3.64                                         | 5    | p-Chlorotoluene    | Decane        | 25   | 1.80                                         | 1    |
| Water                   | Acetone     | 25   | 4.56                                         | 5    | Ethylbenzene       | Decane        | 25   | 1.79                                         | 1    |
| Acetic acid             | Benzene     | 25   | 2.09                                         | 5    | Naphthalene        | Decane        | 25   | 1.65                                         | 1    |
| Aniline                 | Benzene     | 25   | 1.96                                         | 5    | Perylene           | Decane        | 25   | 1.08                                         | 1    |
| Benzoic acid            | Benzene     | 25   | 1.38                                         | 5    | Pyrene             | Decane        | 25   | 1.23                                         | 1    |
| Bromobenzene            | Benzene     | 8    | 1.45                                         | 5    | Toluene            | Decane        | 25   | 1.93                                         | 1    |
| 2-Butanone              | Benzene     | 30   | 2.09                                         | 5    | Trichloromethane   | Diethyl ether | 25   | 4.48                                         | 3    |
| Chloroethene            | Benzene     | 8    | 1.77                                         | 5    | Allyl alcohol      | Ethanol       | 20   | 0.98                                         | 5    |
| Cyclohexane             | Benzene     | 25   | 2.09                                         | 3    | Benzene            | Ethanol       | 25   | 1.88                                         | 2    |
| Ethanol                 | Benzene     | 25   | 3.02                                         | 5    | Iodine             | Ethanol       | 25   | 1.32                                         | 5    |
| Formic acid             | Benzene     | 25   | 2.28                                         | 5    | Iodobenzene        | Ethanol       | 20   | 1.00                                         | 5    |
| Heptane                 | Benzene     | 25   | 1.79                                         | 3    | 3-Methyl-1-butanol | Ethanol       | 20   | 0.81                                         | 5    |
| Methanol                | Benzene     | 25   | 3.80                                         | 5    | Pyridine           | Ethanol       | 20   | 1.10                                         | 5    |
| Toluene                 | Benzene     | 25   | 1.85                                         | 3    | Tetrachloromethane | Ethanol       | 25   | 1.50                                         | 5    |
| 1,2,4-Trichlorobenzene  | Benzene     | 8    | 1.34                                         | 5    | Water              | Ethanol       | 25   | 1.24                                         | 5    |
| Trichloromethane        | Benzene     | 25   | 2.26                                         | 5    | Acetic acid        | Ethyl acetate | 20   | 2.18                                         | 5    |
| Benzene                 | 1-Butanol   | 25   | 1.00                                         | 5    | Acetone            | Ethyl acetate | 20   | 3.18                                         | 5    |
| Biphenyl                | 1-Butanol   | 25   | 0.63                                         | 5    | 2-Butanone         | Ethyl acetate | 30   | 2.93                                         | 5    |
| Butanoic acid           | 1-Butanol   | 30   | 0.51                                         | 5    | Ethyl benzoate     | Ethyl acetate | 20   | 1.85                                         | 5    |
| p-Dichlorobenzene       | 1-Butanol   | 25   | 0.82                                         | 5    | Nitrobenzene       | Ethyl acetate | 20   | 2.25                                         | 5    |
| 1,6-Hexanedioic acid    | 1-Butanol   | 30   | 0.40                                         | 5    | Water              | Ethyl acetate | 25   | 3.20                                         | 5    |
| Methanol                | 1-Butanol   | 30   | 0.59                                         | 5    | Benzene            | Heptane       | 25   | 3.75                                         | 1    |
| cis-9-Octadecenoic acid | 1-Butanol   | 30   | 0.25                                         | 5    | Chlorobenzene      | Heptane       | 25   | 3.42                                         | 1    |
| Propane                 | 1-Butanol   | 25   | 1.57                                         | 5    | p-Chlorotoluene    | Heptane       | 25   | 3.11                                         | 1    |
| Water                   | 1-Butanol   | 25   | 0.56                                         | 5    | Ethylbenzene       | Heptane       | 25   | 3.15                                         | 1    |
| Benzene                 | Cyclohexane | 25   | 1.92                                         | 1    | Naphthalene        | Heptane       | 25   | 2.81                                         | 1    |
| Chlorobenzene           | Cyclohexane | 25   | 1.34                                         | 1    | Perylene           | Heptane       | 25   | 1.89                                         | 1    |
| p-Chlorotoluene         | Cyclohexane | 25   | 1.28                                         | 1    | Pyrene             | Heptane       | 25   | 2.16                                         | 1    |
| Ethylbenzene            | Cyclohexane | 25   | 1.36                                         | 1    | Toluene            | Heptane       | 25   | 3.42                                         | 1    |
| Naphthalene             | Cyclohexane | 25   | 1.18                                         | 1    | Benzene            | Hexane        | 25   | 4.70                                         | 1    |
|                         |             |      |                                              |      | Bromobenzene       | Hexane        | 8    | 2.60                                         | 5    |

| Solute                  | Solvent                | t/°C | $D_{AB}/10^{-5} \text{ cm}^2 \text{ s}^{-1}$ | Ref. | Solute                       | Solvent                | t/°C | $D_{AB}/10^{-5} \text{ cm}^2 \text{ s}^{-1}$ | Ref. |
|-------------------------|------------------------|------|----------------------------------------------|------|------------------------------|------------------------|------|----------------------------------------------|------|
| 2-Butanone              | Hexane                 | 30   | 3.74                                         | 5    | Ethylbenzene                 | 2,2,4-Trimethylpentane | 30   | 2.63                                         | 4    |
| Chlorobenzene           | Hexane                 | 25   | 4.16                                         | 1    | Toluene                      | 2,2,4-Trimethylpentane | 30   | 3.15                                         | 4    |
| <i>p</i> -Chlorotoluene | Hexane                 | 25   | 3.74                                         | 1    | 1,3,5-Trimethylbenzene       | 2,2,4-Trimethylpentane | 30   | 2.26                                         | 4    |
| Dodecane                | Hexane                 | 25   | 2.73                                         | 5    | <i>o</i> -Xylene             | 2,2,4-Trimethylpentane | 30   | 2.62                                         | 4    |
| Ethylbenzene            | Hexane                 | 25   | 3.73                                         | 1    | <i>p</i> -Xylene             | 2,2,4-Trimethylpentane | 30   | 3.03                                         | 4    |
| Iodine                  | Hexane                 | 25   | 4.45                                         | 5    | Acetic acid                  | Water                  | 25   | 1.29                                         | 5    |
| Methane                 | Hexane                 | 25   | 0.09                                         | 5    | Acetone                      | Water                  | 25   | 1.28                                         | 5    |
| Naphthalene             | Hexane                 | 25   | 3.55                                         | 1    | Acetonitrile                 | Water                  | 15   | 1.26                                         | 5    |
| Perylene                | Hexane                 | 25   | 2.30                                         | 1    | <i>L</i> -Alanine            | Water                  | 25   | 0.91                                         | 5    |
| Propane                 | Hexane                 | 25   | 4.87                                         | 5    | Allyl alcohol                | Water                  | 15   | 0.90                                         | 5    |
| Pyrene                  | Hexane                 | 25   | 2.58                                         | 1    | Aniline                      | Water                  | 20   | 0.92                                         | 5    |
| Tetrachloromethane      | Hexane                 | 25   | 3.70                                         | 5    | <i>DL</i> -Arabinose         | Water                  | 20   | 0.69                                         | 5    |
| Toluene                 | Hexane                 | 25   | 4.12                                         | 1    | Benzene                      | Water                  | 20   | 1.02                                         | 5    |
| Benzene                 | Octane                 | 25   | 3.19                                         | 1    | 1-Butanol                    | Water                  | 25   | 0.56                                         | 5    |
| Chlorobenzene           | Octane                 | 25   | 2.89                                         | 1    | Caprolactam                  | Water                  | 25   | 0.87                                         | 5    |
| <i>p</i> -Chlorotoluene | Octane                 | 25   | 2.62                                         | 1    | Chloroethene                 | Water                  | 25   | 1.34                                         | 5    |
| Ethylbenzene            | Octane                 | 25   | 2.58                                         | 1    | Cyclohexane                  | Water                  | 20   | 0.84                                         | 5    |
| Naphthalene             | Octane                 | 25   | 2.35                                         | 1    | Diethylamine                 | Water                  | 20   | 0.97                                         | 5    |
| Perylene                | Octane                 | 25   | 1.58                                         | 1    | 1,2-Ethanediol               | Water                  | 25   | 1.16                                         | 5    |
| Pyrene                  | Octane                 | 25   | 1.81                                         | 1    | Ethanol                      | Water                  | 25   | 1.24                                         | 5    |
| Toluene                 | Octane                 | 25   | 2.83                                         | 1    | Ethanolamine                 | Water                  | 25   | 1.08                                         | 5    |
| 1,3,5-Trimethylbenzene  | Octane                 | 30   | 2.21                                         | 4    | Ethyl acetate                | Water                  | 20   | 1.00                                         | 5    |
| <i>o</i> -Xylene        | Octane                 | 30   | 2.65                                         | 4    | Ethylbenzene                 | Water                  | 20   | 0.81                                         | 5    |
| <i>p</i> -Xylene        | Octane                 | 30   | 2.82                                         | 4    | Ethyl carbamate              | Water                  | 15   | 0.80                                         | 5    |
| Acetone                 | Tetrachloromethane     | 25   | 1.75                                         | 5    | $\alpha$ - <i>D</i> -Glucose | Water                  | 25   | 0.67                                         | 5    |
| Benzene                 | Tetrachloromethane     | 25   | 1.42                                         | 5    | Glycerol                     | Water                  | 25   | 1.06                                         | 5    |
| Cyclohexane             | Tetrachloromethane     | 25   | 1.30                                         | 5    | Glycine                      | Water                  | 25   | 1.05                                         | 5    |
| Ethanol                 | Tetrachloromethane     | 25   | 1.90                                         | 5    | $\beta$ - <i>D</i> -Lactose  | Water                  | 15   | 0.38                                         | 5    |
| Iodine                  | Tetrachloromethane     | 30   | 1.63                                         | 5    | $\alpha$ -Maltose            | Water                  | 15   | 0.38                                         | 5    |
| Trichloromethane        | Tetrachloromethane     | 25   | 1.66                                         | 5    | <i>D</i> -Mannitol           | Water                  | 15   | 0.50                                         | 5    |
| Acetic acid             | Toluene                | 25   | 2.26                                         | 5    | Methane                      | Water                  | 25   | 1.49                                         | 5    |
| Benzene                 | Toluene                | 25   | 2.54                                         | 3    | Methanol                     | Water                  | 15   | 1.28                                         | 5    |
| Benzoic acid            | Toluene                | 25   | 1.49                                         | 5    | 3-Methyl-1-butanol           | Water                  | 10   | 0.69                                         | 5    |
| Cyclohexane             | Toluene                | 25   | 2.42                                         | 3    | Methylcyclopentane           | Water                  | 20   | 0.85                                         | 5    |
| Formic acid             | Toluene                | 25   | 2.65                                         | 5    | Phenol                       | Water                  | 20   | 0.89                                         | 5    |
| Water                   | Toluene                | 25   | 6.19                                         | 5    | 1-Propanol                   | Water                  | 15   | 0.87                                         | 5    |
| Acetone                 | Trichloromethane       | 25   | 2.55                                         | 5    | Propene                      | Water                  | 25   | 1.44                                         | 5    |
| Benzene                 | Trichloromethane       | 25   | 2.89                                         | 5    | Pyridine                     | Water                  | 25   | 0.58                                         | 5    |
| 2-Butanone              | Trichloromethane       | 25   | 2.13                                         | 5    | Raffinose                    | Water                  | 15   | 0.33                                         | 5    |
| Butyl acetate           | Trichloromethane       | 25   | 1.71                                         | 5    | Sucrose                      | Water                  | 25   | 0.52                                         | 5    |
| Cyclohexane             | Trichloromethane       | 25   | 1.28                                         | 3    | Toluene                      | Water                  | 20   | 0.85                                         | 5    |
| Diethyl ether           | Trichloromethane       | 25   | 2.13                                         | 3    | Urea                         | Water                  | 25   | 1.38                                         | 5    |
| Ethanol                 | Trichloromethane       | 15   | 2.20                                         | 5    |                              |                        |      |                                              |      |
| Ethyl acetate           | Trichloromethane       | 25   | 2.02                                         | 5    |                              |                        |      |                                              |      |
| Benzene                 | 2,2,4-Trimethylpentane | 30   | 3.46                                         | 4    |                              |                        |      |                                              |      |

## VAPOR PRESSURE OF SATURATED SALT SOLUTIONS

This table gives the vapor pressure of water above saturated solutions of some common salts at ambient temperatures. Data on pure water are given on the last line for comparison.

The references provide additional information on water activity, osmotic coefficient, and enthalpy of vaporization.

### References

1. Apelblat, A., *J. Chem. Thermodynamics*, 24, 619, 1992.
2. Apelblat, A., *J. Chem. Thermodynamics*, 25, 63, 1993.
3. Apelblat, A., *J. Chem. Thermodynamics*, 25, 1513, 1993.
4. Apelblat, A. and Korin, E., *J. Chem. Thermodynamics*, 30, 59, 1998.

| Salt                                            | Vapor Pressure in kPa |       |       |       |       |       |       | Ref. |
|-------------------------------------------------|-----------------------|-------|-------|-------|-------|-------|-------|------|
|                                                 | 10°C                  | 15°C  | 20°C  | 25°C  | 30°C  | 35°C  | 40°C  |      |
| BaCl <sub>2</sub>                               | 0.971                 | 1.443 | 2.073 | 2.887 | 3.903 | 5.133 | 6.576 | 1    |
| Ca(NO <sub>3</sub> ) <sub>2</sub>               | 0.701                 | 1.015 | 1.381 | 1.772 | 2.154 | 2.487 |       | 1    |
| CuSO <sub>4</sub>                               | 1.113                 | 1.574 | 2.189 | 2.996 | 4.037 | 5.363 |       | 3    |
| FeSO <sub>4</sub>                               | 0.978                 | 1.516 | 2.208 | 3.035 | 3.950 | 4.884 |       | 3    |
| KBr                                             | 0.953                 | 1.338 | 1.853 | 2.533 | 3.419 | 4.563 |       | 3    |
| KIO <sub>3</sub>                                | 1.100                 | 1.564 | 2.177 | 2.970 | 3.979 | 5.236 | 6.778 | 4    |
| K <sub>2</sub> CO <sub>3</sub>                  | 0.541                 | 0.802 | 1.134 | 1.536 | 1.997 | 2.499 | 3.016 | 1    |
| LiCl                                            | 0.128                 | 0.193 | 0.279 | 0.384 |       |       |       | 2    |
| Mg(NO <sub>3</sub> ) <sub>2</sub>               | 0.726                 | 0.999 | 1.339 | 1.749 | 2.231 | 2.782 | 3.397 | 1    |
| MnCl <sub>2</sub>                               | 0.697                 | 1.064 | 1.515 | 2.020 | 2.535 | 3.002 |       | 3    |
| NH <sub>4</sub> Cl                              | 0.971                 | 1.328 | 1.836 | 2.481 |       |       |       | 2    |
| NH <sub>4</sub> NO <sub>3</sub>                 | 0.853                 | 1.152 | 1.524 | 1.972 |       |       |       | 2    |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 0.901                 | 1.319 | 1.871 | 2.573 | 3.439 | 4.474 |       | 3    |
| NaBr                                            | 0.722                 | 1.004 | 1.376 | 1.858 | 2.475 | 3.255 | 4.229 | 4    |
| NaCl                                            | 0.921                 | 1.285 | 1.768 | 2.401 | 3.218 | 4.262 | 5.581 | 4    |
| NaNO <sub>2</sub>                               | 0.703                 | 0.994 | 1.381 | 1.888 | 2.540 | 3.368 | 4.403 | 4    |
| NaNO <sub>3</sub>                               | 0.884                 | 1.244 | 1.719 | 2.335 | 3.121 | 4.109 | 5.333 | 4    |
| RbCl                                            | 0.862                 | 1.215 | 1.684 | 2.298 | 3.088 | 4.089 | 5.343 | 4    |
| ZnSO <sub>4</sub>                               | 0.945                 | 1.401 | 1.986 | 2.698 | 3.523 | 4.431 | 5.382 | 1    |
| Water                                           | 1.228                 | 1.706 | 2.339 | 3.169 | 4.246 | 5.627 | 7.381 |      |

## DIFFUSION OF GASES IN WATER

This table gives values of the diffusion coefficient,  $D$ , for diffusion of several common gases in water at various temperatures. For simple one-dimensional transport, the diffusion coefficient describes the time-rate of change of concentration,  $dc/dt$ , through the equation

$$dc/dt = D \, d^2c/dx^2$$

where  $x$  is, for example, the perpendicular distance from a gas–liquid interface. The values below have been selected from the references indicated; in some cases data have been refitted to permit interpolation in temperature.

Gas–liquid diffusion coefficients are difficult to measure, and large differences are found between values obtained by differ-

ent authors and through different experimental methods. See References 1 and 2 for a discussion of measurement techniques.

### References

1. Jähne, B., Heinz, G., and Dietrich, W., *J. Geophys. Res.*, 92, 10767, 1987.
2. Himmelblau, D. M., *Chem. Rev.*, 64, 527, 1964.
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4. O'Brien, R. N., and Hyslop, W. F., *Can. J. Chem.*, 55, 1415, 1977.
5. Maharajh, D. M., and Walkley, J., *Can. J. Chem.*, 51, 944, 1973.
6. *Landolt-Börnstein, Numerical Data and Functional Relationships in Science and Technology, Sixth Edition, II/5a, Transport Phenomena I (Viscosity and Diffusion)*, Springer-Verlag, Heidelberg, 1969.

|                               | $D/10^{-5} \text{ cm}^2 \text{ s}^{-1}$ |      |      |      |      |      |      |
|-------------------------------|-----------------------------------------|------|------|------|------|------|------|
|                               | 10°C                                    | 15°C | 20°C | 25°C | 30°C | 35°C | Ref. |
| Ar                            |                                         |      |      | 2.5  |      |      | 3,4  |
| CHCl <sub>2</sub> F           |                                         |      |      | 1.80 |      |      | 5    |
| CH <sub>3</sub> Br            |                                         |      |      | 1.35 |      |      | 5    |
| CH <sub>3</sub> Cl            |                                         |      |      | 1.40 |      |      | 5    |
| CH <sub>4</sub>               | 1.24                                    | 1.43 | 1.62 | 1.84 | 2.08 | 2.35 | 1    |
| CO <sub>2</sub>               | 1.26                                    | 1.45 | 1.67 | 1.91 | 2.17 | 2.47 | 1    |
| C <sub>2</sub> H <sub>2</sub> | 1.43                                    | 1.59 | 1.78 | 1.99 | 2.23 |      | 2    |
| Cl <sub>2</sub>               |                                         | 1.13 | 1.5  | 1.89 |      |      | 2,6  |
| HBr                           |                                         |      |      | 3.15 |      |      | 6    |
| HCl                           |                                         |      |      | 3.07 |      |      | 6    |
| H <sub>2</sub>                | 3.62                                    | 4.08 | 4.58 | 5.11 | 5.69 | 6.31 | 1    |
| H <sub>2</sub> S              |                                         |      |      | 1.36 |      |      | 2,6  |
| He                            | 5.67                                    | 6.18 | 6.71 | 7.28 | 7.87 | 8.48 | 1,3  |
| Kr                            | 1.20                                    | 1.39 | 1.60 | 1.84 | 2.11 | 2.40 | 1,3  |
| NH <sub>3</sub>               |                                         | 1.3  | 1.5  |      |      |      | 2    |
| NO <sub>2</sub>               |                                         |      | 1.23 | 1.4  | 1.59 |      | 2,6  |
| N <sub>2</sub>                |                                         |      |      | 2.0  |      |      | 2    |
| N <sub>2</sub> O              |                                         | 1.62 | 2.11 | 2.57 |      |      | 2,6  |
| Ne                            | 2.93                                    | 3.27 | 3.64 | 4.03 | 4.45 | 4.89 | 1,3  |
| O <sub>2</sub>                |                                         | 1.67 | 2.01 | 2.42 |      |      | 2,6  |
| Rn                            | 0.81                                    | 0.96 | 1.13 | 1.33 | 1.55 | 1.80 | 1    |
| SO <sub>2</sub>               |                                         |      | 1.62 | 1.83 | 2.07 | 2.32 | 2    |
| Xe                            | 0.93                                    | 1.08 | 1.27 | 1.47 | 1.70 | 1.95 | 1,3  |

# PROPERTIES OF ICE AND SUPERCOOLED WATER

The common form of ice at ambient temperature and pressure is hexagonal ice, designated as ice Ih (see phase diagram in Section 12). The data given here refer to that form. Data have been taken from the references indicated; values have been interpolated and smoothed in some cases. All properties are sensitive to the method of preparation of the sample, since air or other gases are sometimes occluded. For this reason there is often disagreement among values found in the literature.

## Density of ice Ih and supercooled water in g cm<sup>-3</sup>

| <i>t</i> /°C | $\rho$ (ice) | $\rho$ (supercooled water) |
|--------------|--------------|----------------------------|
| 0            | 0.9167       | 0.9998                     |
| -10          | 0.9187       | 0.9982                     |
| -20          | 0.9203       | 0.9935                     |
| -30          | 0.9216       | 0.9839                     |
| -40          | 0.9228       |                            |
| -50          | 0.9240       |                            |
| -60          | 0.9252       |                            |
| -80          | 0.9274       |                            |
| -100         | 0.9292       |                            |
| -120         | 0.9305       |                            |
| -140         | 0.9314       |                            |
| -160         | 0.9331       |                            |
| -180         | 0.9340       |                            |
| Ref.         | 1            | 8                          |

## Phase transition properties:

$$\Delta_{\text{fus}} H(0^\circ\text{C}) = 333.6 \text{ J/g (Ref. 2)}$$

$$\Delta_{\text{sub}} H(0^\circ\text{C}) = 2838 \text{ J/g (Ref. 2)}$$

## Other properties of ice I<sub>h</sub>:

$\alpha_v$ : cubic expansion coefficient,  $\alpha_v = -(1/V)(\partial V/\partial t)_p$   
 $\kappa_s$ : isentropic compressibility,  $\kappa_s = -(1/V)(\partial V/\partial p)_s$   
 $\epsilon$ : relative permittivity (dielectric constant)  
 $k$ : thermal conductivity  
 $c_p$ : specific heat capacity at constant pressure

| <i>t</i> /°C | $\alpha_v/10^{-6}^\circ\text{C}^{-1}$ | $\kappa/10^{-5} \text{ MPa}^{-1}$ | $\epsilon$ | $k/\text{W cm}^{-1}^\circ\text{C}^{-1}$ | $c_p/\text{J g}^{-1}^\circ\text{C}^{-1}$ |
|--------------|---------------------------------------|-----------------------------------|------------|-----------------------------------------|------------------------------------------|
| 0            | 159                                   | 13.0                              | 91.6       | 0.0214                                  | 2.11                                     |
| -10          | 155                                   | 12.8                              | 94.4       | 0.023                                   | 2.03                                     |
| -20          | 149                                   | 12.7                              | 97.5       | 0.024                                   | 1.96                                     |
| -30          | 143                                   | 12.5                              | 99.7       | 0.025                                   | 1.88                                     |
| -40          | 137                                   | 12.4                              | 101.9      | 0.026                                   | 1.80                                     |
| -50          | 130                                   | 12.2                              | 106.9      | 0.028                                   | 1.72                                     |
| -60          | 122                                   | 12.1                              | 119.5      | 0.030                                   | 1.65                                     |
| -80          | 105                                   | 11.9                              |            | 0.033                                   | 1.50                                     |
| -100         | 85                                    | 11.6                              |            | 0.037                                   | 1.36                                     |
| -120         | 77                                    | 11.4                              |            | 0.042                                   | 1.23                                     |
| -140         | 60                                    | 11.3                              |            | 0.049                                   | 1.10                                     |
| -160         | 45                                    | 11.2                              |            | 0.057                                   | 0.97                                     |
| -180         | 30                                    | 11.1                              |            | 0.070                                   | 0.83                                     |
| -200         |                                       | 11.0                              |            | 0.087                                   | 0.67                                     |
| -220         |                                       | 10.9                              |            | 0.118                                   | 0.50                                     |
| -240         |                                       | 10.9                              |            | 0.20                                    | 0.29                                     |
| -250         |                                       | 10.9                              |            | 0.32                                    | 0.17                                     |
| Ref.         | 1,2,3,5                               | 1,5                               | 6          | 7                                       | 1                                        |

## References

1. Eisenberg, D., and Kauzmann, W., *The Structure and Properties of Water*, Oxford University Press, Oxford, 1969.
2. Landolt-Börnstein, *Numerical Data and Functional Relationships in Science and Technology, New Series*, V/1b, Springer-Verlag, Heidelberg, 1982.
3. LaPlaca, S., and Post, B., *Acta Cryst.*, 13, 503, 1960. [Thermal expansion of lattice]
4. Brill, R., and Tippe, A., *Acta Cryst.*, 23, 343, 1967. [Thermal expansion of lattice]
5. Leadbetter, A. J., *Proc. Roy. Soc. A* 287, 403, 1965. [Compressibility and thermal expansion]
6. Auty, R. P., and Cole, R. H., *J. Chem. Phys.*, 20, 1309, 1952. [Dielectric constant]
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8. Hare, D. E., and Sorensen, C. M., *J. Chem. Phys.*, 87, 4840, 1987. [Supercooled water]
9. Hobbs, P. V., *Ice Physics*, Clarendon Press, Oxford, 1974.

## PROPERTIES OF LIQUID HELIUM

The following data were obtained by a critical evaluation of all existing experimental measurements on liquid helium, using a fitting procedure described in the reference. All values refer to liquid helium at saturated vapor pressure; temperatures are on the ITS-90 scale. Several properties show a singularity at the lambda point (2.1768 K).

$p$ : vapor pressure

$\rho$ : density

$C_s$ : molar heat capacity

$\Delta_{\text{vap}}H$ : molar enthalpy of vaporization

$\epsilon$ : relative permittivity (dielectric constant)

$\sigma$ : surface tension

$\alpha_v$ : cubic expansion coefficient

$\eta$ : viscosity

$\lambda$ : thermal conductivity

### Reference

Donnelly, R. J., and Barenghi, C. F., *J. Phys. Chem. Ref. Data*, 27, 1217, 1998.

| $T/\text{K}$ | $p/\text{kPa}$ | $\rho/\text{g cm}^{-3}$ | $C_s/\text{J mol}^{-1} \text{K}^{-1}$ | $\Delta_{\text{vap}}H/\text{J mol}^{-1}$ | $\epsilon$ | $\sigma/\text{mN m}^{-1}$ | $10^3\alpha_v/\text{K}^{-1}$ | $\eta/\mu\text{Pa s}$ | $\lambda/\text{W cm}^{-1} \text{K}^{-1}$ |
|--------------|----------------|-------------------------|---------------------------------------|------------------------------------------|------------|---------------------------|------------------------------|-----------------------|------------------------------------------|
| 0.0          |                | 0.1451397               | 0                                     | 59.83                                    | 1.057255   |                           | 0.000                        |                       |                                          |
| 0.5          |                | 0.1451377               | 0.010                                 | 70.24                                    | 1.057254   | 0.3530                    | 0.107                        |                       |                                          |
| 1.0          | 0.01558        | 0.1451183               | 0.415                                 | 80.33                                    | 1.057246   | 0.3471                    | 0.309                        | 3.873                 |                                          |
| 1.5          | 0.4715         | 0.1451646               | 4.468                                 | 89.35                                    | 1.057265   | 0.3322                    | -2.36                        | 1.346                 |                                          |
| 2.0          | 3.130          | 0.1456217               | 21.28                                 | 93.07                                    | 1.057449   | 0.3021                    | -12.2                        | 1.468                 |                                          |
| 2.5          | 10.23          | 0.1448402               | 9.083                                 | 92.50                                    | 1.057135   | 0.2623                    | 39.4                         | 3.259                 | 0.1497                                   |
| 3.0          | 24.05          | 0.1412269               | 9.944                                 | 94.11                                    | 1.055683   | 0.2161                    | 61.5                         | 3.517                 | 0.1717                                   |
| 3.5          | 47.05          | 0.1360736               | 12.37                                 | 92.84                                    | 1.053615   | 0.1626                    | 88.7                         | 3.509                 | 0.1868                                   |
| 4.0          | 81.62          | 0.1289745               | 15.96                                 | 87.00                                    | 1.050770   | 0.1095                    | 129                          | 3.319                 | 0.1965                                   |
| 4.5          | 130.3          | 0.1188552               | 21.8                                  | 75.86                                    | 1.046725   | 0.0609                    | 211                          |                       |                                          |
| 5.0          | 196.0          |                         | 44.7                                  | 47.67                                    |            | 0.0157                    |                              |                       |                                          |

## SURFACE TENSION OF AQUEOUS MIXTURES

The composition dependence of the surface tension of binary mixtures of several compounds with water is given in this table. The data are tabulated as a function of the mass percent of the non-aqueous component. Data for methanol, ethanol, 1-propanol, and 2-propanol are taken from Reference 1, which also gives values at other temperatures.

### References

1. Vazquez, G., Alvarez, E., and Navaza, J. M., *J. Chem. Eng. Data*, 40, 611, 1995.
2. Landolt-Börnstein, *Numerical Data and Functional Relationships in Science and Technology, New Series*, IV/16, *Surface Tension*, Springer-Verlag, Heidelberg, 1997.

| Compound              | <i>t</i> /°C | Surface Tension in mN/m for the Specified Mass % |       |       |       |       |       |       |       |       |       |       |
|-----------------------|--------------|--------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                       |              | 0%                                               | 10%   | 20%   | 30%   | 40%   | 50%   | 60%   | 70%   | 80%   | 90%   | 100%  |
| Acetic acid           | 30           | 71.2                                             | 51.4  | 43.3  | 41.2  | 38.2  | 37.4  | 36.1  | 33.5  | 31.5  | 30.2  | 26.3  |
| Acetone               | 25           | 72.0                                             | 44.9  | 40.5  | 36.7  | 33.0  | 30.1  | 29.4  | 29.4  | 27.6  | 24.5  | 23.1  |
| Acetonitrile          | 20           | 72.8                                             | 48.5  | 40.2  | 34.1  | 31.6  | 30.6  | 30.0  | 29.6  | 29.1  | 28.7  | 28.4  |
| 1,2-Butanediol        | 25           | 72.0                                             | 66.1  | 60.4  | 55.1  | 50.1  | 45.6  | 43.3  | 41.9  | 40.8  | 39.2  | 35.8  |
| 1,3-Butanediol        | 30           | 71.2                                             | 58.1  | 51.6  | 48.7  | 45.8  | 43.9  | 42.4  | 41.2  | 40.0  | 39.0  | 37.0  |
| 1,4-Butanediol        | 30           | 71.2                                             | 61.2  | 56.9  | 54.2  | 52.0  | 50.7  | 49.5  | 47.9  | 46.6  | 45.2  | 43.8  |
| Butanoic acid         | 30           | 71.2                                             | 42.4  | 37.5  | 35.5  | 34.8  | 32.2  | 30.8  | 29.2  | 27.4  | 26.3  | 25.5  |
| 2-Butanone            | 20           | 72.8                                             | 41.6  | 32.2  |       |       |       | 25.2  |       |       |       | 24.6  |
| γ-Butyrolactone       | 30           | 71.2                                             | 64    | 58    | 53    | 50    | 48    | 46    | 45    | 44    | 42.8  | 42.7  |
| Chloroacetic acid     | 25           | 72.0                                             | 59.8  | 53.6  | 51.3  | 49.7  | 48.3  | 47.5  | 46.1  |       |       |       |
| Diethanolamine        | 25           | 72.0                                             | 66.8  | 63.2  | 60.7  | 58.8  | 57.2  | 55.7  | 54.3  | 52.7  | 50.6  | 47.2  |
| N,N-Dimethylacetamide | 25           | 72.0                                             | 72.0  | 72.0  | 72.4  | 73.5  | 74.9  | 75.4  | 73.0  | 65.7  | 54.7  | 36.4  |
| N,N-Dimethylformamide | 25           | 72.0                                             | 65.4  | 59.2  | 53.8  | 49.6  | 47.3  | 46.9  | 44.9  | 42.3  | 38.4  | 35.2  |
| 1,4-Dioxane           | 25           | 72.0                                             |       |       |       |       | 41.2  | 39.6  | 37.9  | 36.2  | 34.5  | 33.7  |
| Ethanol               | 25           | 72.01                                            | 47.53 | 37.97 | 32.98 | 30.16 | 27.96 | 26.23 | 25.01 | 23.82 | 22.72 | 21.82 |
| Ethylene glycol       | 20           | 72.8                                             | 68.5  | 64.9  | 61.9  |       | 57.0  |       |       |       |       | 48.2  |
| Formic acid           | 20           | 72.8                                             | 66    | 60    | 55.7  | 52.2  | 50.3  | 48.8  | 47.1  | 44.7  | 40.9  | 38.0  |
| Glycerol              | 25           | 72.0                                             | 70.5  | 69.5  | 68.5  | 67.9  | 67.4  | 66.9  | 66.5  | 65.7  | 64.5  | 62.5  |
| Methanol              | 25           | 72.01                                            | 56.18 | 47.21 | 41.09 | 36.51 | 32.86 | 29.83 | 27.48 | 25.54 | 23.93 | 22.51 |
| Morpholine            | 20           | 72.8                                             | 65.1  | 60.7  | 58.9  | 56.7  | 53.0  | 49.6  | 47.0  | 43.7  | 41.8  | 38.7  |
| Nitric acid           | 20           | 72.8                                             | 71.9  | 70.7  | 68.9  | 66.6  | 63.8  | 60.6  | 56.8  | 52.6  | 47.9  | 42.6  |
| Propanoic acid        | 30           | 71.2                                             | 46.6  | 42.2  | 37.7  | 35.6  | 33.1  | 31.7  | 30.2  | 28.2  | 27.4  | 25.8  |
| 1-Propanol            | 25           | 72.01                                            | 34.32 | 27.84 | 25.98 | 25.26 | 24.80 | 24.49 | 24.08 | 23.86 | 23.59 | 23.28 |
| 2-Propanol            | 25           | 72.01                                            | 40.42 | 30.57 | 26.82 | 25.27 | 24.26 | 23.51 | 22.68 | 22.14 | 21.69 | 21.22 |
| 1,2-Propylene glycol  | 30           | 71.2                                             | 60.5  | 54.9  | 50.7  | 47.2  | 44.5  | 41.5  | 38.6  | 37.6  | 36.3  | 35.5  |
| 1,3-Propylene glycol  | 30           | 71.2                                             | 62.6  | 58.8  | 55.7  | 53.8  | 52.8  | 51.7  | 50.8  | 49.6  | 48.2  | 47.0  |
| Pyridine              | 25           | 72.0                                             | 52.8  | 51.2  | 48.0  | 46.8  | 46.6  | 45.8  | 45.0  | 43.6  | 40.9  | 37.0  |
| Sulfolane             | 20           | 72.8                                             |       |       |       |       | 62.5  | 61.6  | 59.6  | 57.1  | 54.9  | 50.9  |
| Sulfuric acid         | 50           | 67.9                                             | 73.5  | 75.1  | 73.6  | 71.2  | 68.0  | 64.1  | 60.0  | 56.4  | 53.6  | 51.7  |
| Trichloroacetaldehyde | 25           | 72.0                                             | 56.7  | 51.0  | 46.7  | 44.1  | 43.0  | 42.5  | 41.5  | 38.9  | 34.7  | 29.4  |
| Trichloroacetic acid  | 25           | 72.0                                             | 55.8  | 46.5  | 42.8  | 41.6  | 40.6  | 39.4  | 38.3  | 37.4  | 36.5  |       |



## VISCOSITY OF CARBON DIOXIDE ALONG THE SATURATION LINE

The table below gives the viscosity of gas and liquid CO<sub>2</sub> along the liquid–vapor saturation line.

### References

1. Fenghour, A., Wakeham, W. A., and Vesovic, V., *J. Phys. Chem. Ref. Data*, 27, 31, 1998.
2. Angus, S., et al., *International Tables for the Fluid State: Carbon Dioxide*, Pergamon Press, Oxford, 1976.

| <i>T</i> /K | <i>P</i> /kPa | Gas<br>$\eta/\mu\text{Pa s}$ | Liquid<br>$\eta/\mu\text{Pa s}$ |
|-------------|---------------|------------------------------|---------------------------------|
| 205         | 227           | 10.33                        |                                 |
| 210         | 327           | 10.60                        |                                 |
| 215         | 465           | 10.87                        |                                 |
| 220         | 600           | 11.13                        | 241.68                          |
| 225         | 735           | 11.41                        | 221.72                          |
| 230         | 894           | 11.69                        | 203.75                          |
| 235         | 1075          | 11.98                        | 187.48                          |
| 240         | 1283          | 12.27                        | 172.67                          |
| 245         | 1519          | 12.58                        | 159.13                          |
| 250         | 1786          | 12.90                        | 146.69                          |
| 255         | 2085          | 13.24                        | 135.20                          |
| 260         | 2419          | 13.61                        | 124.30                          |
| 265         | 2790          | 14.02                        | 114.63                          |
| 270         | 3203          | 14.47                        | 105.21                          |
| 275         | 3658          | 14.99                        | 96.44                           |
| 280         | 4160          | 15.61                        | 87.89                           |
| 285         | 4712          | 16.37                        | 79.64                           |
| 290         | 5315          | 17.36                        | 71.47                           |
| 295         | 5984          | 18.79                        | 63.01                           |
| 300         | 6710          | 21.29                        | 53.33                           |
| 302         | 6997          | 23.52                        | 48.30                           |

## VISCOSITY AND DENSITY OF AQUEOUS HYDROXIDE SOLUTIONS

The viscosity and density of aqueous hydroxide solutions at 25°C is tabulated here as a function of concentration. Viscosity is given in millipascal second, which is equal to the c.g.s. unit centipoise (cP). The last entry in each column refers to the saturated solution.

### Reference

Sipos, P. M., Hefter, G., and May, P. M., *J. Chem. Eng. Data*, 45, 613, 2000.

### Viscosity in mPa s

| $c/\text{mol L}^{-1}$ | LiOH  | NaOH   | KOH   | CsOH | $(\text{CH}_3)_4\text{NOH}$ |
|-----------------------|-------|--------|-------|------|-----------------------------|
| 0.5                   | 1.017 | 0.997  | 0.937 | 0.91 | 1.017                       |
| 1.0                   | 1.169 | 1.116  | 0.990 | 0.94 | 1.186                       |
| 1.5                   | 1.340 | 1.248  | 1.050 | 0.97 | 1.430                       |
| 2.0                   | 1.537 | 1.396  | 1.116 | 1.03 | 1.762                       |
| 3.0                   | 2.050 | 1.754  | 1.269 | 1.19 | 3.031                       |
| 4.0                   | 2.734 | 2.228  | 1.448 | 1.41 | 7.238                       |
| 5.0                   |       | 2.867  | 1.657 | 1.67 |                             |
| 6.0                   |       | 3.727  | 1.902 | 1.98 |                             |
| 7.0                   |       | 4.869  | 2.196 | 2.40 |                             |
| 8.0                   |       | 6.351  | 2.554 | 3.09 |                             |
| 9.0                   |       | 8.230  | 3.005 | 4.31 |                             |
| 10.0                  |       | 10.554 | 3.581 | 6.46 |                             |
| 11.0                  |       | 13.362 | 4.328 |      |                             |
| 12.0                  |       | 16.677 | 5.303 |      |                             |
| 13.0                  |       | 20.503 | 6.577 |      |                             |
| 14.0                  |       | 24.826 | 8.235 |      |                             |
| 15.0                  |       | 29.604 |       |      |                             |
| 16.0                  |       | 34.767 |       |      |                             |
| 17.0                  |       | 40.212 |       |      |                             |
| 18.0                  |       | 45.800 |       |      |                             |
| 19.0                  |       | 51.354 |       |      |                             |
| Sat.                  | 3.311 | 51.911 | 8.526 |      | 8.850                       |

### Density in g/cm<sup>3</sup>

| $c/\text{mol L}^{-1}$ | LiOH  | NaOH  | KOH   | CsOH  | $(\text{CH}_3)_4\text{NOH}$ |
|-----------------------|-------|-------|-------|-------|-----------------------------|
| 0.5                   | 1.012 | 1.019 | 1.022 | 1.063 | 0.999                       |
| 1.0                   | 1.025 | 1.040 | 1.045 | 1.128 | 1.002                       |
| 1.5                   | 1.038 | 1.059 | 1.068 | 1.193 | 1.005                       |
| 2.0                   | 1.050 | 1.078 | 1.090 | 1.257 | 1.009                       |
| 3.0                   | 1.072 | 1.115 | 1.133 | 1.383 | 1.019                       |
| 4.0                   | 1.093 | 1.149 | 1.174 | 1.508 | 1.030                       |
| 5.0                   |       | 1.182 | 1.214 | 1.632 |                             |
| 6.0                   |       | 1.213 | 1.253 | 1.755 |                             |
| 7.0                   |       | 1.243 | 1.290 | 1.876 |                             |
| 8.0                   |       | 1.271 | 1.326 | 1.997 |                             |
| 9.0                   |       | 1.299 | 1.362 | 2.117 |                             |
| 10.0                  |       | 1.325 | 1.396 | 2.236 |                             |
| 11.0                  |       | 1.350 | 1.429 | 2.354 |                             |
| 12.0                  |       | 1.374 | 1.462 | 2.471 |                             |
| 13.0                  |       | 1.397 | 1.494 | 2.587 |                             |
| 14.0                  |       | 1.419 | 1.524 | 2.703 |                             |
| 15.0                  |       | 1.441 |       |       |                             |
| 16.0                  |       | 1.461 |       |       |                             |
| 17.0                  |       | 1.481 |       |       |                             |
| 18.0                  |       | 1.499 |       |       |                             |
| 19.0                  |       | 1.517 |       |       |                             |
| Sat.                  | 1.109 | 1.519 | 1.529 | 2.800 | 1.032                       |

## VAPOR PRESSURE OF MERCURY

The following table gives the vapor pressure of mercury in kilopascals (100 kPa = 1 bar) from the triple point (234.3156 K) to the critical point (1764 K). The data are generated from the formulation of Huber, Laesecke, and Friend in Reference 1, which is based on a critical evaluation of all the published data on mercury vapor pressure and related thermodynamic properties. The estimated uncertainty in the vapor pressure is:

|               |       |
|---------------|-------|
| −38 to −10°C  | 3%    |
| 0 to 130°C    | 1%    |
| 140 to 350°C  | 0.15% |
| 360 to 620°C  | 0.5%  |
| 630 to 1491°C | 5%    |

Most of the entries in this table carry one significant figure beyond the estimated accuracy.

Note that the table refers to mercury vapor in equilibrium with liquid mercury, in the absence of air or other gases.

## References

1. Huber, M. L., Laesecke, A., and Friend, D. G., *The Vapor Pressure of Mercury*, NISTIR 6643, National Institute of Standards and Technology, Boulder, CO, March 2006.
2. Huber, M. L., Laesecke, A., and Friend, D. G., *Ind. Eng. Chem. Res.* 45, 7351, 2006.
3. Vargaftik, N. B., Vinogradov, Y. K., and Yargin, V. S., *Handbook of Physical Properties of Liquids and Gases, Third Edition*, Begell House, New York, 1996.

| <i>t</i> /°C | <i>p</i> /kPa            | <i>t</i> /°C | <i>p</i> /kPa | <i>t</i> /°C | <i>p</i> /kPa | <i>t</i> /°C | <i>p</i> /kPa |
|--------------|--------------------------|--------------|---------------|--------------|---------------|--------------|---------------|
| −38.83       | 2.985 × 10 <sup>−7</sup> | 38           | 0.0007350     | 300          | 32.965        | 720          | 6254          |
| −30          | 9.451 × 10 <sup>−7</sup> | 39           | 0.0007929     | 310          | 40.856        | 730          | 6718          |
| −20          | 3.160 × 10 <sup>−6</sup> | 40           | 0.0008551     | 320          | 50.260        | 740          | 7205          |
| −10          | 9.625 × 10 <sup>−6</sup> | 41           | 0.0009216     | 330          | 61.396        | 750          | 7718          |
| 0            | 2.699 × 10 <sup>−5</sup> | 42           | 0.0009928     | 340          | 74.498        | 760          | 8258          |
| 1            | 2.979 × 10 <sup>−5</sup> | 43           | 0.001069      | 350          | 89.823        | 770          | 8824          |
| 2            | 3.287 × 10 <sup>−5</sup> | 44           | 0.001151      | 360          | 107.65        | 780          | 9417          |
| 3            | 3.623 × 10 <sup>−5</sup> | 45           | 0.001238      | 370          | 128.26        | 790          | 10040         |
| 4            | 3.991 × 10 <sup>−5</sup> | 46           | 0.001331      | 380          | 151.99        | 800          | 10690         |
| 5            | 4.393 × 10 <sup>−5</sup> | 47           | 0.001430      | 390          | 179.17        | 810          | 11370         |
| 6            | 4.833 × 10 <sup>−5</sup> | 48           | 0.001537      | 400          | 210.15        | 820          | 12080         |
| 7            | 5.312 × 10 <sup>−5</sup> | 49           | 0.001650      | 410          | 245.32        | 830          | 12820         |
| 8            | 5.836 × 10 <sup>−5</sup> | 50           | 0.001771      | 420          | 285.07        | 840          | 13600         |
| 9            | 6.406 × 10 <sup>−5</sup> | 55           | 0.002506      | 430          | 329.82        | 850          | 14410         |
| 10           | 7.028 × 10 <sup>−5</sup> | 60           | 0.003508      | 440          | 380.00        | 860          | 15250         |
| 11           | 7.705 × 10 <sup>−5</sup> | 65           | 0.004862      | 450          | 436.07        | 870          | 16120         |
| 12           | 8.441 × 10 <sup>−5</sup> | 70           | 0.006673      | 460          | 498.51        | 880          | 17030         |
| 13           | 9.242 × 10 <sup>−5</sup> | 75           | 0.009075      | 470          | 567.81        | 890          | 17980         |
| 14           | 0.0001011                | 80           | 0.01223       | 480          | 644.46        | 900          | 18960         |
| 15           | 0.0001106                | 85           | 0.01635       | 490          | 729.01        | 910          | 19980         |
| 16           | 0.0001208                | 90           | 0.02167       | 500          | 821.99        | 920          | 21040         |
| 17           | 0.0001320                | 95           | 0.02850       | 510          | 923.96        | 930          | 22140         |
| 18           | 0.0001440                | 100          | 0.03721       | 520          | 1035.5        | 940          | 23270         |
| 19           | 0.0001571                | 110          | 0.06209       | 530          | 1157.2        | 950          | 24450         |
| 20           | 0.0001713                | 120          | 0.1009        | 540          | 1289.6        | 960          | 25670         |
| 21           | 0.0001866                | 130          | 0.1599        | 550          | 1433.3        | 970          | 26930         |
| 22           | 0.0002032                | 140          | 0.2478        | 560          | 1589.1        | 980          | 28230         |
| 23           | 0.0002211                | 150          | 0.3759        | 570          | 1757.4        | 990          | 29580         |
| 24           | 0.0002404                | 160          | 0.5592        | 580          | 1939          | 1000         | 30970         |
| 25           | 0.0002613                | 170          | 0.8168        | 590          | 2135          | 1050         | 38600         |
| 26           | 0.0002839                | 180          | 1.1728        | 600          | 2345          | 1100         | 47450         |
| 27           | 0.0003082                | 190          | 1.6573        | 610          | 2570          | 1150         | 57590         |
| 28           | 0.0003344                | 200          | 2.3071        | 620          | 2811          | 1200         | 69100         |
| 29           | 0.0003627                | 210          | 3.1670        | 630          | 3069          | 1250         | 82100         |
| 30           | 0.0003931                | 220          | 4.2906        | 640          | 3344          | 1300         | 96600         |
| 31           | 0.0004259                | 230          | 5.7414        | 650          | 3637          | 1350         | 112700        |
| 32           | 0.0004611                | 240          | 7.5939        | 660          | 3949          | 1400         | 130000        |
| 33           | 0.0004990                | 250          | 9.9347        | 670          | 4281          | 1450         | 150000        |
| 34           | 0.0005398                | 260          | 12.863        | 680          | 4632          | 1491         | 167000        |
| 35           | 0.0005835                | 270          | 16.494        | 690          | 5005          |              |               |
| 36           | 0.0006305                | 280          | 20.955        | 700          | 5399          |              |               |
| 37           | 0.0006809                | 290          | 26.392        | 710          | 5815          |              |               |

## VISCOSITY OF LIQUID METALS

This table gives the viscosity of several liquid metals as a function of temperature. Experimental data from some of the references were smoothed to produce the table. Viscosity is given in millipascal second (mPa s), which equals the c.g.s. unit centipoise (cP).

### References

1. Shpil'rain, E. E., Yakimovich, K. A., Fomin, V. A., Skovorodjko, S. N., and Mozgovoï, A. G., in *Handbook of Thermodynamic and Transport Properties of the Alkali Metals*, Ohse, R. H., Ed., Blackwell Scientific Publishers, Oxford, 1985. [Li, Na, K, Rb, Cs]
2. Rothwell, E., *J. Inst. Metals*, 90, 389, 1961. [Al]
3. Culpin, M. F., *Proc. Phys. Soc.*, 70, 1079, 1957. [Ca]
4. *Landolt-Börnstein, Numerical Data and Functional Relationships in Science and Technology, Sixth Edition*, II/5a, *Transport Phenomena I (Viscosity and Diffusion)*, Springer-Verlag, Heidelberg, 1961 [Co, Au, Mg, Ni, Ag]
5. Spells, K. E., *Proc. Phys. Soc.*, 48, 299, 1936. [Ga]
6. Walsdorfer, H., Arpshofen, I., and Predel, B., *Z. Met.*, 79, 503, 1988. [In]

| $t/^{\circ}\text{C}$ | Viscosity in mPa s |        |           |          |        |         |
|----------------------|--------------------|--------|-----------|----------|--------|---------|
|                      | Lithium            | Sodium | Potassium | Rubidium | Cesium | Gallium |
| 50                   |                    |        |           | 0.542    | 0.598  | 1.921   |
| 100                  |                    | 0.687  | 0.441     | 0.435    | 0.469  | 1.608   |
| 150                  |                    | 0.542  | 0.358     | 0.365    | 0.389  | 1.397   |
| 200                  | 0.566              | 0.451  | 0.303     | 0.316    | 0.334  | 1.245   |
| 250                  | 0.503              | 0.387  | 0.263     | 0.280    | 0.294  | 1.130   |
| 300                  | 0.453              | 0.341  | 0.234     | 0.252    | 0.264  | 1.040   |
| 350                  | 0.412              | 0.306  | 0.211     | 0.230    | 0.240  | 0.968   |
| 400                  | 0.379              | 0.278  | 0.193     | 0.212    | 0.221  | 0.909   |
| 450                  | 0.352              | 0.255  | 0.178     | 0.197    | 0.206  | 0.859   |
| 500                  | 0.328              | 0.237  | 0.166     | 0.185    | 0.192  | 0.817   |
| 550                  | 0.308              | 0.221  | 0.155     | 0.174    | 0.181  | 0.781   |
| 600                  | 0.290              | 0.208  | 0.146     | 0.165    | 0.171  | 0.750   |
| 650                  | 0.275              | 0.196  | 0.138     | 0.157    | 0.163  | 0.722   |
| 700                  | 0.261              | 0.186  | 0.132     | 0.150    | 0.156  | 0.698   |
| 750                  | 0.249              | 0.177  | 0.126     | 0.143    | 0.149  | 0.677   |
| 800                  | 0.238              | 0.170  | 0.120     | 0.138    | 0.143  | 0.657   |
| 850                  | 0.228              | 0.163  | 0.115     | 0.133    | 0.138  | 0.640   |
| 900                  | 0.219              | 0.156  | 0.111     | 0.128    | 0.134  | 0.624   |
| 950                  | 0.211              | 0.151  | 0.107     | 0.124    | 0.129  | 0.610   |
| 1000                 | 0.204              | 0.146  | 0.104     | 0.120    | 0.125  | 0.597   |
| 1050                 | 0.197              | 0.141  | 0.101     | 0.117    | 0.122  | 0.585   |
| 1100                 | 0.191              | 0.137  | 0.098     | 0.114    | 0.119  | 0.574   |
| 1150                 | 0.185              | 0.133  | 0.095     | 0.111    | 0.116  |         |
| 1200                 | 0.180              | 0.129  | 0.092     | 0.108    | 0.113  |         |
| 1250                 | 0.175              | 0.126  | 0.090     | 0.105    | 0.110  |         |
| 1300                 | 0.170              | 0.123  | 0.088     | 0.103    | 0.108  |         |
| 1350                 | 0.166              | 0.120  | 0.086     | 0.101    | 0.106  |         |
| 1400                 | 0.162              | 0.117  | 0.084     | 0.099    | 0.104  |         |
| 1450                 | 0.158              | 0.115  | 0.082     | 0.097    | 0.102  |         |
| 1500                 | 0.155              | 0.113  | 0.081     | 0.095    | 0.100  |         |
| 1550                 | 0.151              | 0.110  | 0.079     | 0.093    | 0.098  |         |
| 1600                 | 0.148              | 0.108  | 0.078     | 0.092    | 0.097  |         |
| 1650                 | 0.145              | 0.106  | 0.076     | 0.090    | 0.095  |         |
| 1700                 | 0.142              | 0.105  | 0.075     |          | 0.094  |         |
| 1750                 | 0.139              | 0.103  | 0.074     |          | 0.092  |         |
| 1800                 | 0.137              | 0.101  |           |          | 0.091  |         |
| 1850                 | 0.135              | 0.100  |           |          | 0.090  |         |
| 1900                 | 0.132              | 0.098  |           |          | 0.089  |         |
| 1950                 | 0.130              | 0.097  |           |          | 0.088  |         |
| 2000                 | 0.128              | 0.096  |           |          | 0.086  |         |

| $t/^{\circ}\text{C}$ | Viscosity in mPa s |         |        |       |        |           |        |        |
|----------------------|--------------------|---------|--------|-------|--------|-----------|--------|--------|
|                      | Aluminum           | Calcium | Cobalt | Gold  | Indium | Magnesium | Nickel | Silver |
| 250                  |                    |         |        |       | 1.35   |           |        |        |
| 300                  |                    |         |        |       | 1.22   |           |        |        |
| 350                  |                    |         |        |       | 1.12   |           |        |        |
| 400                  |                    |         |        |       | 1.04   |           |        |        |
| 450                  |                    |         |        |       | 0.98   |           |        |        |
| 700                  | 1.289              |         |        |       |        | 1.10      |        |        |
| 750                  | 1.200              |         |        |       |        | 0.96      |        |        |
| 800                  | 1.115              |         |        |       |        | 0.84      |        |        |
| 850                  | 1.028              | 1.107   |        |       |        | 0.74      |        |        |
| 900                  |                    | 0.959   |        |       |        | 0.67      |        |        |
| 1000                 |                    |         |        |       |        |           |        | 3.80   |
| 1050                 |                    |         |        |       |        |           |        | 3.56   |
| 1100                 |                    |         |        | 5.130 |        |           |        | 3.31   |
| 1150                 |                    |         |        | 4.874 |        |           |        | 3.06   |
| 1200                 |                    |         |        | 4.640 |        |           |        | 2.82   |
| 1250                 |                    |         |        | 4.429 |        |           |        | 2.61   |
| 1300                 |                    |         |        | 4.240 |        |           |        | 2.42   |
| 1350                 |                    |         |        |       |        |           |        | 2.28   |
| 1400                 |                    |         |        |       |        |           |        | 2.20   |
| 1450                 |                    |         |        |       |        |           |        | 2.19   |
| 1500                 |                    |         | 4.15   |       |        |           | 4.35   |        |
| 1550                 |                    |         | 3.89   |       |        |           | 4.09   |        |
| 1600                 |                    |         | 3.64   |       |        |           | 3.87   |        |
| 1650                 |                    |         | 3.41   |       |        |           | 3.67   |        |
| 1700                 |                    |         | 3.20   |       |        |           | 3.49   |        |
| 1750                 |                    |         | 2.99   |       |        |           | 3.32   |        |

## IONIC LIQUIDS

Ionic liquids are a class of organic salts with relatively low melting points. The term usually implies a melting point of 100 °C or lower, and many are liquid at room temperature. They offer several advantages as solvents, such as very low vapor pressure, good thermal stability, and nonflammable behavior. For these reasons they are attractive as constituents of environmentally friendly chemical processes.

This table lists some of the ionic liquids that have been studied. The following properties are given:

**Mol. Form.** — molecular formula in the Hill convention

**CASRN** — Chemical Abstracts Service Registry Number

**Mol. Wt.** — molecular weight (relative molar mass)

**$t_m$**  — normal melting point in °C; the notation “gl” indicates a glass–liquid transition, rather than a crystal–liquid transition

**$\rho$**  — density in g/cm<sup>3</sup>. The superscript indicates the temperature in °C; if there is no superscript, room temperature can be assumed.

**$\eta$**  — viscosity in mPa s. The superscript indicates the temperature in °C; if there is no superscript, room temperature can be assumed.

The phase behavior of ionic liquids can be complicated. Some are crystalline at low temperatures and show a sharp transition from crystal to liquid state (a true melting point) as the temperature is raised, but others exist as a glass at low temperatures and convert to a liquid at the glass–liquid transition temperature, denoted by a small change in heat capacity. Still others are glasses at very low temperatures, transform to crystals as the temperature is raised, and finally become liquid at a still higher temperature. See Reference 3 for a discussion of the types of phase behavior.

## References

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2. *Ionic Liquids — New Materials for New Applications*, 2006, <ilddb.merck.de/ionicliquids/en/startpage.htm>.
3. Crosthwaite, J. M., Muldoon, M. J., Dixon, J. K., Anderson, J. L., and Brennecke, J. F., *J. Chem. Thermodynamics* 37, 559, 2005.
4. Sun, J., Forsyth, M., and MacFarlane, D. R., *J. Phys. Chem. B* 102, 8858, 1998.
5. Fredlake, C. P., Crosthwaite, J. M., Hert, D. G., Aki, S. N. V. K., and Brennecke, J. F., *J. Chem. Eng. Data* 49, 954, 2004.

| Name                                                                    | Mol. Form.                                                                                  | CASRN       | Mol. Wt | $t_m$ /°C | $\rho$ /g cm <sup>-3</sup> | $\eta$ /mPa s      |
|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------|---------|-----------|----------------------------|--------------------|
| 1-Benzyl-3-methylimidazolium tetrafluoroborate                          | C <sub>11</sub> H <sub>13</sub> BF <sub>4</sub> N <sub>2</sub>                              | 500996-04-3 | 260.039 | 63        |                            |                    |
| 1-Butyl-4-(dimethylamino)pyridinium bromide                             | C <sub>11</sub> H <sub>19</sub> BrN <sub>2</sub>                                            |             | 259.186 | 222       |                            |                    |
| 1-Butyl-2,3-dimethylimidazolium chloride                                | C <sub>9</sub> H <sub>17</sub> ClN <sub>2</sub>                                             | 98892-75-2  | 188.697 | 99        |                            |                    |
| 1-Butyl-2,3-dimethylimidazolium hexafluorophosphate                     | C <sub>9</sub> H <sub>17</sub> F <sub>6</sub> N <sub>2</sub> P                              | 227617-70-1 | 298.208 | -58 gl    | 1.2416 <sup>23</sup>       |                    |
| 1-Butyl-2,3-dimethylimidazolium iodide                                  | C <sub>9</sub> H <sub>17</sub> IN <sub>2</sub>                                              | 108203-70-9 | 280.148 | 97        |                            |                    |
| 1-Butyl-2,3-dimethylimidazolium octylsulfate                            | C <sub>17</sub> H <sub>34</sub> N <sub>2</sub> O <sub>4</sub> S                             |             | 362.528 | 90        |                            |                    |
| 1-Butyl-2,3-dimethylimidazolium tetrafluoroborate                       | C <sub>9</sub> H <sub>17</sub> N <sub>2</sub> BF <sub>4</sub>                               | 402846-78-0 | 240.049 | 37        | 1.0762 <sup>40</sup>       |                    |
| 1-Butyl-2,3-dimethylimidazolium trifluoromethanesulfonate               | C <sub>10</sub> H <sub>18</sub> F <sub>3</sub> N <sub>2</sub> O <sub>3</sub> S              |             | 303.321 | 41        |                            |                    |
| 1-Butyl-3,5-dimethylpyridinium bromide                                  | C <sub>11</sub> H <sub>18</sub> BrN                                                         |             | 244.172 | 95        |                            |                    |
| 1-Butyl-3,4-dimethylpyridinium chloride                                 | C <sub>11</sub> H <sub>18</sub> ClN                                                         |             | 199.721 | 72        |                            |                    |
| 1-Butyl-3,5-dimethylpyridinium chloride                                 | C <sub>11</sub> H <sub>18</sub> ClN                                                         |             | 199.721 | 100       |                            |                    |
| 1-Butyl-3-methylimidazolium acetate                                     | C <sub>10</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub>                               |             | 198.262 |           |                            | 440 <sup>25</sup>  |
| 1-Butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide           | C <sub>10</sub> H <sub>15</sub> F <sub>6</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 174899-83-3 | 419.364 | -2        | 1.4370 <sup>25</sup>       | 70 <sup>25</sup>   |
| 1-Butyl-3-methylimidazolium bromide                                     | C <sub>8</sub> H <sub>15</sub> BrN <sub>2</sub>                                             | 85100-77-2  | 219.122 | 78        |                            |                    |
| 1-Butyl-3-methylimidazolium chloride                                    | C <sub>8</sub> H <sub>15</sub> ClN <sub>2</sub>                                             | 79917-90-1  | 174.671 | 67        | 1.08 <sup>25</sup>         |                    |
| 1-Butyl-3-methylimidazolium dicyanamide                                 | C <sub>10</sub> H <sub>15</sub> N <sub>5</sub>                                              | 448245-52-1 | 205.260 | -6        | 1.0580 <sup>24</sup>       |                    |
| 1-Butyl-3-methylimidazolium (diethylene glycol monomethyl ether)sulfate | C <sub>13</sub> H <sub>27</sub> N <sub>2</sub> O <sub>6</sub> S                             |             | 339.427 | -62 gl    |                            | 1033 <sup>25</sup> |
| 1-Butyl-3-methylimidazolium hexafluorophosphate                         | C <sub>8</sub> H <sub>15</sub> F <sub>6</sub> N <sub>2</sub> P                              | 174501-64-5 | 284.182 | 11        | 1.367 <sup>20</sup>        | 382 <sup>20</sup>  |
| 1-Butyl-3-methylimidazolium iodide                                      | C <sub>8</sub> H <sub>15</sub> IN <sub>2</sub>                                              | 65039-05-6  | 266.122 | -72       | 1.44 <sup>25</sup>         | 1100 <sup>25</sup> |
| 1-Butyl-3-methylimidazolium methide                                     | C <sub>12</sub> H <sub>15</sub> F <sub>9</sub> N <sub>2</sub> O <sub>6</sub> S <sub>2</sub> | 731774-32-6 | 550.437 |           | 1.57 <sup>25</sup>         |                    |
| 1-Butyl-3-methylimidazolium methylsulfate                               | C <sub>9</sub> H <sub>18</sub> N <sub>2</sub> O <sub>4</sub> S                              | 401788-98-5 | 250.315 | 13        | 1.212 <sup>25</sup>        |                    |
| 1-Butyl-3-methylimidazolium nitrate                                     | C <sub>8</sub> H <sub>15</sub> N <sub>3</sub> O <sub>3</sub>                                | 179075-88-8 | 201.223 |           | 1.15 <sup>40</sup>         | 67 <sup>35</sup>   |
| 1-Butyl-3-methylimidazolium octylsulfate                                | C <sub>16</sub> H <sub>32</sub> N <sub>2</sub> O <sub>4</sub> S                             | 445473-58-5 | 348.501 | 31        | 1.07                       |                    |
| 1-Butyl-3-methylimidazolium tetrafluoroborate                           | C <sub>8</sub> H <sub>15</sub> BF <sub>4</sub> N <sub>2</sub>                               | 174501-65-6 | 226.023 | -85 gl    | 1.2048 <sup>22</sup>       | 120 <sup>25</sup>  |
| 1-Butyl-3-methylimidazolium tosylate                                    | C <sub>15</sub> H <sub>22</sub> N <sub>2</sub> O <sub>3</sub> S                             | 410522-18-8 | 310.412 | 72        |                            |                    |
| 1-Butyl-3-methylimidazolium trifluoroacetate                            | C <sub>10</sub> H <sub>15</sub> F <sub>3</sub> N <sub>2</sub> O <sub>2</sub>                | 174899-94-6 | 252.233 |           |                            | 70 <sup>25</sup>   |
| 1-Butyl-3-methylimidazolium trifluoromethanesulfonate                   | C <sub>9</sub> H <sub>15</sub> F <sub>3</sub> N <sub>2</sub> O <sub>3</sub> S               | 174899-66-2 | 288.286 | 13        | 1.3013 <sup>23</sup>       |                    |
| 1-Butyl-3-methylpyridinium bis(trifluoromethylsulfonyl)imide            | C <sub>12</sub> H <sub>16</sub> F <sub>6</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> |             | 430.386 | -84 gl    |                            | 63 <sup>25</sup>   |
| 1-Butyl-3-methylpyridinium bromide                                      | C <sub>10</sub> H <sub>16</sub> BrN                                                         |             | 230.145 | -36 gl    |                            |                    |
| 1-Butyl-3-methylpyridinium chloride                                     | C <sub>10</sub> H <sub>16</sub> ClN                                                         | 125652-55-3 | 185.694 | 117       |                            |                    |
| 1-Butyl-3-methylpyridinium hexafluorophosphate                          | C <sub>10</sub> H <sub>16</sub> F <sub>6</sub> NP                                           |             | 295.205 | 46        |                            |                    |

| Name                                                                                                           | Mol. Form.                                                            | CASRN       | Mol. Wt | $t_m/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $\eta/\text{mPa s}$ |
|----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|-------------|---------|------------------------|-------------------------|---------------------|
| 1-Butyl-4-methylpyridinium hexafluorophosphate                                                                 | $\text{C}_{10}\text{H}_{16}\text{F}_6\text{NP}$                       | 401788-99-6 | 295.205 | 44                     |                         |                     |
| 1-Butyl-3-methylpyridinium methylsulfate                                                                       | $\text{C}_{11}\text{H}_{19}\text{NO}_4\text{S}$                       |             | 261.339 | <-50                   | 1.19                    |                     |
| 1-Butyl-4-methylpyridinium tetrafluoroborate                                                                   | $\text{C}_{10}\text{H}_{16}\text{BF}_4\text{N}$                       | 343952-33-0 | 237.046 |                        | 1.1842 <sup>25</sup>    |                     |
| 1-Butyl-3-methylpyridinium tetrafluoroborate                                                                   | $\text{C}_{10}\text{H}_{16}\text{BF}_4\text{N}$                       |             | 237.046 | -76 gl                 |                         | 177 <sup>25</sup>   |
| 1-Butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide                                                | $\text{C}_{11}\text{H}_{20}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$  | 223437-11-4 | 422.408 |                        | 1.394 <sup>25</sup>     |                     |
| 1-Butyl-1-methylpyrrolidinium dicyanamide                                                                      | $\text{C}_{11}\text{H}_{20}\text{N}_4$                                | 370865-80-8 | 208.304 | <-50                   | 1.02                    |                     |
| 1-Butyl-1-methylpyrrolidinium hexafluorophosphate                                                              | $\text{C}_9\text{H}_{20}\text{F}_6\text{NP}$                          | 330671-29-9 | 287.226 | 85                     |                         |                     |
| 1-Butyl-1-methylpyrrolidinium methylsulfate                                                                    | $\text{C}_{10}\text{H}_{23}\text{NO}_4\text{S}$                       |             | 253.360 | 10                     | 1.17                    |                     |
| 1-Butyl-1-methylpyrrolidinium trifluoroacetate                                                                 | $\text{C}_{11}\text{H}_{20}\text{F}_3\text{NO}_2$                     |             | 255.278 | 31                     |                         |                     |
| 1-Butyl-1-methylpyrrolidinium trifluoromethanesulfonate                                                        | $\text{C}_{10}\text{H}_{20}\text{F}_3\text{NO}_3\text{S}$             | 367522-96-1 | 291.331 | 3                      | 1.25                    |                     |
| 1-Butyl-1-methylpyrrolidinium tris(pentafluoroethyl)trifluorophosphate                                         | $\text{C}_{15}\text{H}_{20}\text{F}_{18}\text{NP}$                    | 851856-47-8 | 587.272 | 4                      | 1.59                    |                     |
| 1-Butylnicotinic acid                                                                                          | $\text{C}_{16}\text{H}_{22}\text{F}_6\text{N}_2\text{O}_6\text{S}_2$  |             | 516.475 | 15                     |                         | 531 <sup>25</sup>   |
| 1-Butylpyridinium bromide                                                                                      | $\text{C}_9\text{H}_{14}\text{BrN}$                                   | 874-80-6    | 216.118 | 105                    |                         |                     |
| 1-Butylpyridinium chloride                                                                                     | $\text{C}_9\text{H}_{14}\text{ClN}$                                   | 1124-64-7   | 171.667 | 127                    |                         |                     |
| 1-Butylpyridinium hexafluorophosphate                                                                          | $\text{C}_9\text{H}_{14}\text{F}_6\text{NP}$                          | 186088-50-6 | 281.178 | 75                     |                         |                     |
| 1-Butylpyridinium methylsulfate                                                                                | $\text{C}_{10}\text{H}_{17}\text{NO}_4\text{S}$                       |             | 247.312 | <-50                   | 1.22                    |                     |
| 1-Butylpyridinium tetrafluoroborate                                                                            | $\text{C}_9\text{H}_{14}\text{BF}_4\text{N}$                          | 203389-28-0 | 223.019 |                        | 1.214 <sup>25</sup>     |                     |
| 1-Butylpyridinium trifluoromethanesulfonate                                                                    | $\text{C}_{10}\text{H}_{14}\text{F}_3\text{NO}_3\text{S}$             | 390423-43-5 | 285.283 | 35                     |                         |                     |
| Cocosalky pentaethoxi methylammonium methylsulfate                                                             | $\text{C}_{23}\text{H}_{51}\text{NO}_9\text{S}$                       |             | 517.718 |                        |                         | 2800 <sup>25</sup>  |
| 1-Decyl-3-methylimidazolium bromide                                                                            | $\text{C}_{14}\text{H}_{27}\text{BrN}_2$                              | 188589-32-4 | 303.281 | 16                     | 112 <sup>20</sup>       |                     |
| 1-Decyl-3-methylimidazolium chloride                                                                           | $\text{C}_{14}\text{H}_{27}\text{ClN}_2$                              | 171058-18-7 | 258.830 | 38                     |                         |                     |
| 1,1-Dibutylpyrrolidinium bis(trifluoromethylsulfonyl)imide                                                     | $\text{C}_{14}\text{H}_{26}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$  |             | 464.487 | 41                     |                         |                     |
| <i>N,N</i> -Diethyl- <i>N</i> -(1-methylethyl)-2-propanaminium bis(trifluoromethylsulfonyl)imide               | $\text{C}_{12}\text{H}_{24}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$  | 210230-41-4 | 438.450 | 148                    |                         |                     |
| 1,3-Dimethylimidazolium bis(trifluoromethylsulfonyl)imide                                                      | $\text{C}_7\text{H}_9\text{F}_6\text{N}_3\text{O}_4\text{S}_2$        | 174899-81-1 | 377.284 |                        | 1.570 <sup>25</sup>     |                     |
| 1,3-Dimethylimidazolium chloride                                                                               | $\text{C}_5\text{H}_9\text{ClN}_2$                                    | 79917-88-7  | 132.591 | 126                    |                         |                     |
| 1,3-Dimethylimidazolium dimethylphosphate                                                                      | $\text{C}_7\text{H}_{15}\text{N}_2\text{O}_4\text{P}$                 | 654058-04-5 | 222.178 |                        | 1.253 <sup>30</sup>     |                     |
| 1,3-Dimethylimidazolium methoxyethylsulfate                                                                    | $\text{C}_8\text{H}_{16}\text{N}_2\text{O}_5\text{S}$                 | 790663-78-4 | 252.288 |                        | 1.314 <sup>25</sup>     |                     |
| 1,3-Dimethylimidazolium methylsulfate                                                                          | $\text{C}_6\text{H}_{12}\text{N}_2\text{O}_4\text{S}$                 | 97345-90-9  | 208.235 |                        |                         |                     |
| 1,3-Dimethylimidazolium trifluoromethylsulfonate                                                               | $\text{C}_6\text{H}_9\text{F}_3\text{N}_2\text{O}_3\text{S}$          | 121091-30-3 | 246.206 | 43                     |                         |                     |
| 1,2-Dimethyl-3-propylimidazolium bis(trifluoromethylsulfonyl)imide                                             | $\text{C}_{10}\text{H}_{15}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$  | 169051-76-7 | 419.364 | 11                     | 1.457 <sup>22</sup>     | 90.0 <sup>25</sup>  |
| 1,1-Dimethylpyrrolidinium tris(pentafluoroethyl)trifluorophosphate                                             | $\text{C}_{12}\text{H}_{14}\text{F}_{18}\text{NP}$                    |             | 545.191 | 107                    | 1.81                    |                     |
| 1-Dodecyl-3-methylimidazolium chloride                                                                         | $\text{C}_{16}\text{H}_{31}\text{ClN}_2$                              | 114569-84-5 | 286.883 | 97                     |                         |                     |
| 1-Dodecyl-3-methylimidazolium hexafluorophosphate                                                              | $\text{C}_{16}\text{H}_{31}\text{F}_6\text{N}_2\text{P}$              | 219947-93-0 | 396.394 |                        |                         |                     |
| 1-Dodecyl-3-methylimidazolium tetrafluoroborate                                                                | $\text{C}_{16}\text{H}_{31}\text{BF}_4\text{N}_2$                     | 244193-59-7 | 338.235 |                        |                         |                     |
| <i>N</i> -Ethyl- <i>N,N</i> -bis(1-methylethyl)-1-heptanaminium bis(trifluoromethylsulfonyl)imide              | $\text{C}_{17}\text{H}_{34}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$  | 210230-53-8 | 508.583 | -82 gl                 | 1.27 <sup>20</sup>      | 362 <sup>25</sup>   |
| 1-Ethyl-2,3-dimethylimidazolium bis(trifluoromethylsulfonyl)imide                                              | $\text{C}_9\text{H}_{13}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$     | 174899-90-2 | 405.337 | 25                     | 1.4913 <sup>23</sup>    |                     |
| 1-Ethyl-2,3-dimethylimidazolium bromide                                                                        | $\text{C}_7\text{H}_{13}\text{BrN}_2$                                 | 98892-76-3  | 205.095 | 138                    |                         |                     |
| 1-Ethyl-2,3-dimethylimidazolium methylsulfate                                                                  | $\text{C}_8\text{H}_{16}\text{N}_2\text{O}_4\text{S}$                 |             | 236.289 | 46                     |                         |                     |
| 1-Ethyl-2,3-dimethylimidazolium tetrafluoroborate                                                              | $\text{C}_7\text{H}_{13}\text{BF}_4\text{N}_2$                        | 307492-75-7 | 211.996 | 94                     |                         |                     |
| 1-Ethyl-2,3-dimethylimidazolium trifluoromethanesulfonate                                                      | $\text{C}_8\text{H}_{13}\text{F}_3\text{N}_2\text{O}_3\text{S}$       | 174899-72-0 | 274.260 | 110                    |                         |                     |
| 1-Ethyl-3-methylimidazolium bis(pentafluoroethyl)phosphinate                                                   | $\text{C}_{10}\text{H}_{11}\text{F}_{10}\text{N}_2\text{O}_2\text{P}$ |             | 412.164 | 20                     | 1.53                    |                     |
| 1-Ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide                                                  | $\text{C}_8\text{H}_{11}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$     | 174899-82-2 | 391.311 | -17                    | 1.5213 <sup>23</sup>    | 32 <sup>25</sup>    |
| 1-Ethyl-3-methylimidazolium bromide                                                                            | $\text{C}_6\text{H}_{11}\text{BrN}_2$                                 | 65039-08-9  | 191.068 | 77                     |                         |                     |
| 1-Ethyl-3-methylimidazolium chloride                                                                           | $\text{C}_6\text{H}_{11}\text{ClN}_2$                                 | 65039-09-0  | 146.617 | 85                     |                         |                     |
| 1-Ethyl-3-methylimidazolium ethylsulfate                                                                       | $\text{C}_8\text{H}_{16}\text{N}_2\text{O}_4\text{S}$                 | 342573-75-5 | 236.289 |                        | 1.2388 <sup>25</sup>    | 100 <sup>25</sup>   |
| 1-Ethyl-3-methylimidazolium hexafluorophosphate                                                                | $\text{C}_6\text{H}_{11}\text{F}_6\text{N}_2\text{P}$                 | 155371-19-0 | 256.128 | 59.6                   |                         |                     |
| 1-Ethyl-3-methylimidazolium methanesulfonate                                                                   | $\text{C}_7\text{H}_{14}\text{N}_2\text{O}_3\text{S}$                 | 145022-45-3 | 206.262 |                        | 1.2437 <sup>25</sup>    |                     |
| 1-Ethyl-3-methylimidazolium octyl sulfate                                                                      | $\text{C}_{14}\text{H}_{28}\text{N}_2\text{O}_4\text{S}$              | 790663-79-5 | 320.448 |                        |                         |                     |
| 1-Ethyl-3-methylimidazolium tetrafluoroborate                                                                  | $\text{C}_6\text{H}_{11}\text{BF}_4\text{N}_2$                        | 143314-16-3 | 197.969 | 14                     | 1.2526 <sup>60</sup>    | 36.1 <sup>25</sup>  |
| 1-Ethyl-3-methylimidazolium thiocyanate                                                                        | $\text{C}_7\text{H}_{11}\text{N}_3\text{S}$                           | 331717-63-6 | 169.247 | <-50                   | 1.11                    |                     |
| 1-Ethyl-3-methylimidazolium tosylate                                                                           | $\text{C}_{13}\text{H}_{18}\text{N}_2\text{O}_3\text{S}$              | 328090-25-1 | 282.358 | 56                     |                         |                     |
| 1-Ethyl-3-methylimidazolium trifluoromethanesulfonate                                                          | $\text{C}_7\text{H}_{11}\text{F}_3\text{N}_2\text{O}_3\text{S}$       | 145022-44-2 | 260.233 |                        | 1.385 <sup>25</sup>     |                     |
| <i>N</i> -Ethyl- <i>N</i> -methyl- <i>N</i> -(1-methylethyl)-2-propanaminium bis(trifluoromethylsulfonyl)imide | $\text{C}_{11}\text{H}_{22}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$  | 210230-42-5 | 424.424 | 140                    |                         |                     |

| Name                                                                           | Mol. Form.                                                           | CASRN       | Mol. Wt | $t_m/^\circ\text{C}$ | $\rho/\text{g cm}^{-3}$ | $\eta/\text{mPa s}$   |
|--------------------------------------------------------------------------------|----------------------------------------------------------------------|-------------|---------|----------------------|-------------------------|-----------------------|
| 1-Ethyl-3-methylpyridinium ethylsulfate                                        | $\text{C}_{10}\text{H}_{17}\text{NO}_4\text{S}$                      |             | 247.312 | -71 gl               |                         | 150 <sup>25</sup>     |
| 1-Ethyl-1-methylpyrrolidinium methylsulfate                                    | $\text{C}_8\text{H}_{19}\text{NO}_4\text{S}$                         |             | 225.307 | 23                   | 1.23                    |                       |
| 1-Ethyl-1-methylpyrrolidinium tetrafluoroborate                                | $\text{C}_7\text{H}_{16}\text{BF}_4\text{N}$                         | 15302-90-6  | 201.014 | 69                   |                         |                       |
| 1-Ethynicotinic acid ethyl ester ethylsulfate                                  | $\text{C}_{12}\text{H}_{19}\text{NO}_6\text{S}$                      |             | 305.347 | -44 gl               |                         | 3200 <sup>25</sup>    |
| 1-Ethylpyridinium bromide                                                      | $\text{C}_7\text{H}_{10}\text{BrN}$                                  | 1906-79-2   | 188.065 | 122                  |                         |                       |
| 1-Ethylpyridinium chloride                                                     | $\text{C}_7\text{H}_{10}\text{ClN}$                                  | 2294-38-4   | 143.614 | 119                  |                         |                       |
| 1-Ethylpyridinium ethylsulfate                                                 | $\text{C}_9\text{H}_{15}\text{NO}_4\text{S}$                         |             | 233.285 |                      |                         | 137 <sup>25</sup>     |
| 1-Ethylpyridinium tetrafluoroborate                                            | $\text{C}_7\text{H}_{10}\text{BF}_4\text{N}$                         | 350-48-1    | 194.966 |                      | 1.302 <sup>20</sup>     |                       |
| 1-Ethylpyridinium trifluoroacetate                                             | $\text{C}_9\text{H}_{10}\text{F}_3\text{NO}_2$                       | 474461-33-1 | 221.176 |                      | 1.273 <sup>20</sup>     |                       |
| 1-Ethylpyridinium bis(trifluoromethylsulfonyl)imide                            | $\text{C}_9\text{H}_{10}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 712354-97-7 | 388.306 |                      | 1.536 <sup>25</sup>     |                       |
| 1-Heptyl-3-methylimidazolium hexafluorophosphate                               | $\text{C}_{11}\text{H}_{21}\text{F}_6\text{N}_2\text{P}$             | 357915-04-9 | 326.262 | -84 gl               | 1.274 <sup>21</sup>     |                       |
| 1-Hexadecyl-2,3-dimethylimidazolium chloride                                   | $\text{C}_{21}\text{H}_{41}\text{ClN}_2$                             |             | 357.017 | 210                  |                         |                       |
| 1-Hexadecyl-3-methylimidazolium chloride                                       | $\text{C}_{20}\text{H}_{39}\text{ClN}_2$                             | 61546-01-8  | 342.990 | 222                  |                         |                       |
| 1-Hexyl-4-(dimethylamino)pyridinium bis(trifluoromethylsulfonyl)imide          | $\text{C}_{15}\text{H}_{23}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$ |             | 487.482 | -69                  |                         | 111 <sup>25</sup>     |
| 1-Hexyl-4-(dimethylamino)pyridinium bromide                                    | $\text{C}_{13}\text{H}_{23}\text{BrN}_2$                             |             | 287.239 | 196                  |                         |                       |
| 1-Hexyl-2,3-dimethylimidazolium bis(trifluoromethylsulfonyl)imide              | $\text{C}_{13}\text{H}_{21}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$ | 384347-22-2 | 461.444 | -5                   | 1.361 <sup>25</sup>     | 131 <sup>25</sup>     |
| 1-Hexyl-2,3-dimethylimidazolium chloride                                       | $\text{C}_{11}\text{H}_{21}\text{ClN}_2$                             | 455270-59-4 | 216.751 | 46                   |                         |                       |
| 1-Hexyl-2,3-dimethylimidazolium tetrafluoroborate                              | $\text{C}_{11}\text{H}_{21}\text{BF}_4\text{N}_2$                    | 384347-21-1 | 268.103 | 14                   | 1.15                    |                       |
| 1-Hexyl-3,5-dimethylpyridinium bis(trifluoromethylsulfonyl)imide               | $\text{C}_{15}\text{H}_{22}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$ |             | 472.467 | 10                   |                         | 104 <sup>25</sup>     |
| 1-Hexyl-2-ethyl-3,5-dimethylpyridinium bis(trifluoromethylsulfonyl)-imide      | $\text{C}_{17}\text{H}_{26}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$ |             | 500.519 | -66 gl               |                         | 245 <sup>25</sup>     |
| 1-Hexyl-3-methyl-4-(dimethylamino)pyridinium bis(trifluoromethylsulfonyl)imide | $\text{C}_{16}\text{H}_{25}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$ |             | 501.508 | -2                   |                         | 112 <sup>25</sup>     |
| 1-Hexyl-3-methyl-4-(dimethylamino)pyridinium bromide                           | $\text{C}_{14}\text{H}_{25}\text{BrN}_2$                             |             | 301.266 | 119                  |                         |                       |
| 1-Hexyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide                  | $\text{C}_{12}\text{H}_{19}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$ | 382150-50-7 | 447.417 | -7                   | 1.3708 <sup>25</sup>    | 68 <sup>25</sup>      |
| 1-Hexyl-3-methylimidazolium bromide                                            | $\text{C}_{10}\text{H}_{19}\text{BrN}_2$                             |             | 247.175 | -49 gl               |                         |                       |
| 1-Hexyl-3-methylimidazolium chloride                                           | $\text{C}_{10}\text{H}_{19}\text{ClN}_2$                             | 171058-17-6 | 202.724 | -75 gl               | 1.0400 <sup>25</sup>    | 3400000 <sup>40</sup> |
| 1-Hexyl-3-methylimidazolium hexafluorophosphate                                | $\text{C}_{10}\text{H}_{19}\text{F}_6\text{N}_2\text{P}$             | 304680-35-1 | 312.235 | -79 gl               | 1.294 <sup>25</sup>     | 585 <sup>25</sup>     |
| 1-Hexyl-3-methylimidazolium tetrafluoroborate                                  | $\text{C}_{10}\text{H}_{19}\text{BF}_4\text{N}_2$                    | 244193-50-8 | 254.076 | -79 gl               | 1.136 <sup>37</sup>     |                       |
| 1-Hexyl-3-methylimidazolium trifluoromethanesulfonate                          | $\text{C}_{11}\text{H}_{19}\text{F}_3\text{N}_2\text{O}_3\text{S}$   | 460345-16-8 | 316.340 | 28                   | 1.24                    |                       |
| 1-Hexyl-4-(4-methylpiperidino)pyridinium bis(trifluoromethylsulfonyl)-imide    | $\text{C}_{19}\text{H}_{29}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$ |             | 541.571 | 37                   |                         |                       |
| 1-Hexyl-4-(4-methylpiperidino)pyridinium bromide                               | $\text{C}_{17}\text{H}_{29}\text{BrN}_2$                             |             | 341.329 | 33 gl                |                         |                       |
| 1-Hexyl-3-methylpyridinium bis(trifluoromethylsulfonyl)imide                   | $\text{C}_{14}\text{H}_{20}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$ |             | 458.440 | -82 gl               |                         | 85 <sup>25</sup>      |
| 1-Hexyl-3-methylpyridinium bromide                                             | $\text{C}_{12}\text{H}_{20}\text{BrN}$                               |             | 258.198 | -37 gl               |                         |                       |
| 1-Hexyl-2-propyl-3,5-diethylpyridinium bis(trifluoromethylsulfonyl)-imide      | $\text{C}_{20}\text{H}_{32}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$ |             | 542.599 | -67 gl               |                         | 206 <sup>25</sup>     |
| 1-Hexylpyridinium bis(trifluoromethylsulfonyl)imide                            | $\text{C}_{13}\text{H}_{18}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$ |             | 444.413 | 0                    |                         | 80 <sup>25</sup>      |
| 1-Hexylpyridinium bromide                                                      | $\text{C}_{11}\text{H}_{18}\text{BrN}$                               | 74440-81-6  | 244.172 | 46                   |                         |                       |
| 1-Hexylpyridinium hexafluorophosphate                                          | $\text{C}_{11}\text{H}_{18}\text{F}_6\text{NP}$                      |             | 309.232 | 48                   |                         |                       |
| 1-Hexylpyridinium trifluoromethanesulfonate                                    | $\text{C}_{12}\text{H}_{18}\text{F}_3\text{NO}_3\text{S}$            |             | 313.336 | 62                   |                         |                       |
| 1-Methylimidazolium tetrafluoroborate                                          | $\text{C}_4\text{H}_7\text{BF}_4\text{N}_2$                          | 151200-14-5 | 169.917 | 63                   |                         |                       |
| 1-Methylimidazolium tosylate                                                   | $\text{C}_{11}\text{H}_{14}\text{N}_2\text{O}_3\text{S}$             | 63458-90-2  | 254.305 | 89                   |                         |                       |
| 1-Methyl-3-octadecylimidazolium bis(trifluoromethylsulfonyl)imide              | $\text{C}_{24}\text{H}_{43}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$ | 404001-51-0 | 615.736 | 52                   |                         |                       |
| 1-Methyl-3-octadecylimidazolium tris(pentafluoroethyl)trifluorophosphate       | $\text{C}_{28}\text{H}_{43}\text{F}_{18}\text{N}_2\text{P}$          |             | 780.599 | 43                   |                         |                       |
| 1-Methyl-3-octylimidazolium bromide                                            | $\text{C}_{12}\text{H}_{23}\text{BrN}_2$                             | 61545-99-1  | 275.228 |                      |                         |                       |
| 1-Methyl-3-octylimidazolium chloride                                           | $\text{C}_{12}\text{H}_{23}\text{ClN}_2$                             | 64697-40-1  | 230.777 | -87 gl               | 1.0088 <sup>25</sup>    | 4100000 <sup>40</sup> |
| 1-Methyl-3-octylimidazolium 2-(2-methoxyethoxy)ethyl sulfate                   | $\text{C}_{17}\text{H}_{34}\text{N}_2\text{O}_6\text{S}$             | 595565-55-2 | 394.526 |                      |                         |                       |
| 1-Methyl-3-octylimidazolium nitrate                                            | $\text{C}_{12}\text{H}_{23}\text{N}_3\text{O}_3$                     | 203389-27-9 | 257.329 |                      |                         | 1240 <sup>20</sup>    |
| 1-Methyl-3-octylimidazolium octylsulfate                                       | $\text{C}_{20}\text{H}_{40}\text{N}_2\text{O}_4\text{S}$             |             | 404.608 | 76                   |                         |                       |
| 1-Methyl-3-octylimidazolium tetrafluoroborate                                  | $\text{C}_{12}\text{H}_{23}\text{BF}_4\text{N}_2$                    | 244193-52-0 | 282.129 | -81 gl               | 1.104 <sup>25</sup>     | 341 <sup>25</sup>     |
| 1-Methyl-3-octylimidazolium trifluoromethanesulfonate                          | $\text{C}_{13}\text{H}_{23}\text{F}_3\text{N}_2\text{O}_3\text{S}$   | 403842-84-2 | 344.393 | 14                   | 1.19                    |                       |
| 1-Methyl-3-octylpyridinium bis(trifluoromethylsulfonyl)imide                   | $\text{C}_{16}\text{H}_{23}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$ |             | 486.493 | -80                  |                         | 112 <sup>25</sup>     |
| 1-Methyl-3-octylpyrrolidinium bis(trifluoromethylsulfonyl)imide                | $\text{C}_{15}\text{H}_{28}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$ |             | 478.514 | -12                  | 1.29                    |                       |
| 1-Methyl-3-pentylimidazolium hexafluorophosphate                               | $\text{C}_9\text{H}_{17}\text{F}_6\text{N}_2\text{P}$                | 280779-52-4 | 298.208 | -80 gl               | 1.333 <sup>21</sup>     |                       |
| 1-Methyl-3-propylimidazolium chloride                                          | $\text{C}_7\text{H}_{13}\text{ClN}_2$                                | 79917-89-8  | 160.644 | 62                   |                         |                       |



| Name                                                                             | Mol. Form.                                                              | CASRN       | Mol. Wt | $t_m/^{\circ}\text{C}$ | $\rho/\text{g cm}^{-3}$ | $\eta/\text{mPa s}$ |
|----------------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------|---------|------------------------|-------------------------|---------------------|
| 1-Methyl-1-propylpyrrolidinium bis(trifluoromethylsulfonyl)imide                 | $\text{C}_{10}\text{H}_{18}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 223437-05-6 | 408.381 |                        |                         |                     |
| 3-Methyl-1-tetradecylimidazolium chloride                                        | $\text{C}_{18}\text{H}_{35}\text{ClN}_2$                                | 171058-21-2 | 314.937 | 195                    |                         |                     |
| 1-Methyl-3-tetradecylimidazolium tetrafluoroborate                               | $\text{C}_{18}\text{H}_{35}\text{BF}_4\text{N}_2$                       | 244193-61-1 | 366.289 | 116                    |                         |                     |
| Methyltrioctylammonium trifluoroacetate                                          | $\text{C}_{27}\text{H}_{54}\text{F}_3\text{NO}_2$                       | 121107-16-2 | 481.719 | <-50                   | 0.97                    |                     |
| Methyltrioctylammonium trifluoromethanesulfonate                                 | $\text{C}_{26}\text{H}_{54}\text{F}_3\text{NO}_3\text{S}$               | 121107-18-4 | 517.772 | 56                     |                         |                     |
| 1-Nonyl-3-methylimidazolium hexafluorophosphate                                  | $\text{C}_{13}\text{H}_{25}\text{F}_6\text{N}_2\text{P}$                | 343952-29-4 | 354.315 | 14                     | 1.20 <sup>21</sup>      |                     |
| 1-Octyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide                    | $\text{C}_{14}\text{H}_{23}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$    | 178631-04-4 | 475.471 | -84 gl                 | 1.325 <sup>25</sup>     |                     |
| 1-Octyl-3-methylimidazolium hexafluorophosphate                                  | $\text{C}_{12}\text{H}_{23}\text{F}_6\text{N}_2\text{P}$                | 304680-36-2 | 340.288 | -82 gl                 | 1.237 <sup>25</sup>     | 734 <sup>25</sup>   |
| 1-Octylpyridinium chloride                                                       | $\text{C}_{13}\text{H}_{22}\text{ClN}$                                  | 4086-73-1   | 227.774 | 46                     |                         |                     |
| 1-Pentyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide                   | $\text{C}_{10}\text{H}_{15}\text{F}_6\text{N}_3\text{O}_4\text{S}_2$    | 280779-53-5 | 419.364 |                        |                         |                     |
| 1-(3,4,5,6-Perfluorohexyl)-3-methylimidazolium bis(trifluoromethylsulfonyl)imide | $\text{C}_{12}\text{H}_{10}\text{F}_{15}\text{N}_3\text{O}_4\text{S}_2$ |             | 609.331 | -56                    |                         |                     |
| 1-Propyl-3-methylimidazolium bromide                                             | $\text{C}_7\text{H}_{13}\text{BrN}_2$                                   |             | 205.095 | 37                     |                         |                     |
| 1-Propyl-3-methylimidazolium tetrafluoroborate                                   | $\text{C}_7\text{H}_{13}\text{BF}_4\text{N}_2$                          |             | 211.996 | -17                    | 1.240 <sup>25</sup>     | 103 <sup>25</sup>   |
| Pyridinium ethoxyethylsulfate                                                    | $\text{C}_9\text{H}_{15}\text{NO}_5\text{S}$                            | 630393-27-0 | 249.284 |                        | 1.281 <sup>25</sup>     |                     |
| Tetrabutylammonium bis(trifluoromethylsulfonyl)imide                             | $\text{C}_{18}\text{H}_{35}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-40-3 | 522.610 | 92                     |                         |                     |
| Tetrabutylammonium docusate                                                      | $\text{C}_{36}\text{H}_{73}\text{NO}_7\text{S}$                         |             | 664.033 | -62 gl                 |                         | 12000 <sup>25</sup> |
| Tetrabutylammonium tris(pentafluoroethyl)trifluorophosphate                      | $\text{C}_{22}\text{H}_{36}\text{F}_{18}\text{NP}$                      |             | 687.473 | 58                     |                         |                     |
| Tetrabutylammonium tris(trifluoromethylsulfonyl)methide                          | $\text{C}_{20}\text{H}_{36}\text{F}_9\text{NO}_6\text{S}_3$             | 196958-57-3 | 653.684 | 96                     |                         |                     |
| Tetramethylammonium tris(pentafluoroethyl)trifluorophosphate                     | $\text{C}_{14}\text{H}_{20}\text{F}_{18}\text{NP}$                      | 394692-80-9 | 575.261 | 97                     |                         |                     |
| <i>N,N,N</i> -Tributyl-1-heptanaminium bis(trifluoromethylsulfonyl)imide         | $\text{C}_{21}\text{H}_{42}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-50-5 | 564.689 | -67 gl                 | 1.17 <sup>20</sup>      | 606 <sup>25</sup>   |
| <i>N,N,N</i> -Tributyl-1-heptanaminium trifluoromethanesulfonate                 | $\text{C}_{20}\text{H}_{42}\text{F}_3\text{NO}_3\text{S}$               | 210230-54-9 | 433.612 | -55 gl                 |                         |                     |
| <i>N,N,N</i> -Tributyl-1-hexanaminium bis(trifluoromethylsulfonyl)imide          | $\text{C}_{20}\text{H}_{40}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-49-2 | 550.663 | 26                     | 1.15 <sup>20</sup>      | 595 <sup>25</sup>   |
| Tributylmethylammonium bis(trifluoromethylsulfonyl)imide                         | $\text{C}_{15}\text{H}_{30}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 405514-94-5 | 480.530 |                        | 1.266 <sup>24</sup>     |                     |
| <i>N,N,N</i> -Tributyl-1-octanaminium bis(trifluoromethylsulfonyl)imide          | $\text{C}_{22}\text{H}_{44}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-51-6 | 578.715 | -63 gl                 | 1.12 <sup>20</sup>      | 574 <sup>25</sup>   |
| <i>N,N,N</i> -Tributyl-1-octanaminium trifluoromethanesulfonate                  | $\text{C}_{21}\text{H}_{44}\text{F}_3\text{NO}_3\text{S}$               | 210230-58-3 | 447.639 | -57 gl                 | 1.02 <sup>20</sup>      | 2000 <sup>25</sup>  |
| <i>N,N,N</i> -Triethylethanaminium bis(trifluoromethylsulfonyl)imide             | $\text{C}_{10}\text{H}_{20}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 161401-26-9 | 410.397 |                        |                         |                     |
| <i>N,N,N</i> -Triethyl-1-heptanaminium bis(trifluoromethylsulfonyl)imide         | $\text{C}_{15}\text{H}_{30}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-47-0 | 480.530 | -79 gl                 | 1.26 <sup>20</sup>      | 76 <sup>25</sup>    |
| <i>N,N,N</i> -Triethyl-1-hexanaminium bis(trifluoromethylsulfonyl)imide          | $\text{C}_{14}\text{H}_{28}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-46-9 | 466.503 | 20                     | 1.27 <sup>20</sup>      | 167 <sup>25</sup>   |
| <i>N,N,N</i> -Triethyl-1-octanaminium bis(trifluoromethylsulfonyl)imide          | $\text{C}_{16}\text{H}_{32}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-48-1 | 494.556 | -74 gl                 | 1.25 <sup>20</sup>      | 202 <sup>25</sup>   |
| Trihexyl(tetradecyl)phosphonium acetate                                          | $\text{C}_{34}\text{H}_{71}\text{O}_2\text{P}$                          | 460092-04-0 | 542.901 |                        | 0.890 <sup>25</sup>     |                     |
| Trihexyl(tetradecyl)phosphonium bis(trifluoromethylsulfonyl)imide                | $\text{C}_{34}\text{H}_{68}\text{F}_6\text{NO}_4\text{PS}_2$            | 460092-03-9 | 764.002 |                        | 1.067 <sup>25</sup>     |                     |
| Trihexyl(tetradecyl)phosphonium chloride                                         | $\text{C}_{32}\text{H}_{68}\text{ClP}$                                  | 258864-54-9 | 519.309 |                        | 0.89 <sup>25</sup>      |                     |
| Trihexyltetradecylphosphonium hexafluorophosphate                                | $\text{C}_{32}\text{H}_{68}\text{F}_6\text{P}_2$                        | 374683-44-0 | 628.820 | 39                     |                         |                     |
| Trihexyltetradecylphosphonium tetrafluoroborate                                  | $\text{C}_{32}\text{H}_{68}\text{BF}_4\text{P}$                         | 374683-55-3 | 570.661 | 25                     | 0.94                    |                     |
| Trihexyl(tetradecyl)phosphonium tris(pentafluoroethyl)trifluorophosphate         | $\text{C}_{38}\text{H}_{68}\text{F}_{18}\text{P}_2$                     |             | 928.866 | <-50                   | 1.18                    |                     |
| Triisobutylmethylphosphonium <i>p</i> -toluenesulfonate                          | $\text{C}_{20}\text{H}_{37}\text{O}_3\text{PS}$                         | 344774-05-6 | 388.545 |                        | 1.069 <sup>25</sup>     |                     |
| <i>N,N,N</i> -Trimethyl-1-heptanaminium bis(trifluoromethylsulfonyl)imide        | $\text{C}_{12}\text{H}_{24}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-44-7 | 438.450 | -73 gl                 | 1.28 <sup>20</sup>      | 153 <sup>25</sup>   |
| <i>N,N,N</i> -Trimethyl-1-hexanaminium bis(trifluoromethylsulfonyl)imide         | $\text{C}_{11}\text{H}_{22}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-43-6 | 424.424 | -74 gl                 | 1.33 <sup>20</sup>      | 153 <sup>25</sup>   |
| <i>N,N,N</i> -Trimethylmethanaminium bis(trifluoromethylsulfonyl)imide           | $\text{C}_6\text{H}_{12}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$       | 161401-25-8 | 354.290 | 133                    |                         |                     |
| <i>N,N,N</i> -Trimethyl-1-octanaminium bis(trifluoromethylsulfonyl)imide         | $\text{C}_{13}\text{H}_{26}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-45-8 | 452.476 | -73 gl                 | 1.27 <sup>20</sup>      | 181 <sup>25</sup>   |
| <i>N,N,N</i> -Tripropyl-1-propanaminium bis(trifluoromethylsulfonyl)imide        | $\text{C}_{14}\text{H}_{28}\text{F}_6\text{N}_2\text{O}_4\text{S}_2$    | 210230-39-0 | 466.503 | 105                    |                         |                     |

## MELTING CURVE OF MERCURY

The solid–liquid phase boundary of mercury provides a convenient means of calibrating pressures up to 1 GPa in the neighborhood of room temperature. The best representation of this curve is given by:

$$p/\text{GPa} = 1.932845 \cdot 10^{-2}d + 1.8333 \cdot 10^{-6}d^2 + 5.9791 \cdot 10^{-8}d^3$$

where  $d = t/^{\circ}\text{C} - 38.8344$ . Temperature is on the ITS-90 scale, and the relation is valid for pressures up to about 1.2 GPa. The following table is calculated from this equation.

## Reference

Molinar, G. F., Bean, V., Houck, J., and Welch, B., *Metrologia* 16, 21, 1980; 28, 353, 1991.

| <i>p</i> vs. <i>t</i>         |               | <i>t</i> vs. <i>p</i> |                               |
|-------------------------------|---------------|-----------------------|-------------------------------|
| <i>t</i> / $^{\circ}\text{C}$ | <i>P</i> /GPa | <i>P</i> /GPa         | <i>t</i> / $^{\circ}\text{C}$ |
| −38.83                        | 0.000         | 0.010                 | −38.32                        |
| −35.00                        | 0.074         | 0.020                 | −37.80                        |
| −30.00                        | 0.171         | 0.050                 | −36.25                        |
| −25.00                        | 0.268         | 0.100                 | −33.66                        |
| −20.00                        | 0.365         | 0.200                 | −28.50                        |
| −15.00                        | 0.463         | 0.300                 | −23.35                        |
| −10.00                        | 0.560         | 0.400                 | −18.21                        |
| −5.00                         | 0.658         | 0.500                 | −13.08                        |
| 0.00                          | 0.757         | 0.600                 | −7.97                         |
| 5.00                          | 0.856         | 0.700                 | −2.88                         |
| 10.00                         | 0.955         | 0.800                 | 2.18                          |
| 15.00                         | 1.055         | 0.900                 | 7.23                          |
| 20.00                         | 1.156         | 1.000                 | 12.24                         |
| 25.00                         | 1.257         | 1.100                 | 17.23                         |
| 30.00                         | 1.359         | 1.200                 | 22.19                         |

# PROPERTIES OF GAS CLATHRATE HYDRATES

Carolyn A. Koh and E. Dendy Sloan

Gas clathrate hydrates (also known as gas hydrates) are crystalline inclusion compounds composed of hydrogen-bonded water cavities (host) which encage small gas (guest) molecules. Generally, a maximum of one guest molecule occupies each water cavity. Typical guest molecules that form gas hydrates are meth-

ane, ethane, carbon dioxide, and propane (see gas hydrate phase equilibria data in Table II). The structural and physical properties of gas hydrates are given in Tables Ia and Ib. Data have been taken from the references indicated.

**Table Ia. Gas Hydrate Structural Properties (Ref. 1)**

| Structure                                      | sI                                                                        |                                | sII                                                                         |                                | sH                                                                                                                         |                                              |                                |
|------------------------------------------------|---------------------------------------------------------------------------|--------------------------------|-----------------------------------------------------------------------------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------------------------|
| Crystal system                                 | Cubic                                                                     |                                | Cubic                                                                       |                                | Hexagonal                                                                                                                  |                                              |                                |
| Space group                                    | Pm3n (No. 223) <sup>b</sup>                                               |                                | Fd3m (No. 227) <sup>b</sup>                                                 |                                | P6/mmm (No. 191) <sup>b</sup>                                                                                              |                                              |                                |
| Lattice description                            | Primitive                                                                 |                                | Face centered                                                               |                                | Hexagonal                                                                                                                  |                                              |                                |
| Lattice parameters <sup>a</sup>                | a = 12 Å<br>α = β = γ = 90°                                               |                                | a = 17.3 Å<br>α = β = γ = 90°                                               |                                | a = 12.2 Å, c = 10.1 Å<br>α = β = 90°, γ = 120°                                                                            |                                              |                                |
| Ideal unit cell formula                        | 6(5 <sup>12</sup> 6 <sup>2</sup> )·2(5 <sup>12</sup> )·46H <sub>2</sub> O |                                | 8(5 <sup>12</sup> 6 <sup>4</sup> )·16(5 <sup>12</sup> )·136H <sub>2</sub> O |                                | 1(5 <sup>12</sup> 6 <sup>8</sup> )·3(5 <sup>12</sup> )·2(4 <sup>3</sup> 5 <sup>6</sup> 6 <sup>3</sup> )·34H <sub>2</sub> O |                                              |                                |
| Cavity                                         | Small                                                                     | Large                          | Small                                                                       | Large                          | Small                                                                                                                      | Medium                                       | Large                          |
| Description                                    | 5 <sup>12</sup>                                                           | 5 <sup>12</sup> 6 <sup>2</sup> | 5 <sup>12</sup>                                                             | 5 <sup>12</sup> 6 <sup>4</sup> | 5 <sup>12</sup>                                                                                                            | 4 <sup>3</sup> 5 <sup>6</sup> 6 <sup>3</sup> | 5 <sup>12</sup> 6 <sup>8</sup> |
| Number of cavities/unit cell                   | 2                                                                         | 6                              | 16                                                                          | 8                              | 3                                                                                                                          | 2                                            | 1                              |
| Average cavity radius <sup>c</sup> (Å)         | 3.95                                                                      | 4.33                           | 3.91                                                                        | 4.73                           | 3.94 <sup>d</sup>                                                                                                          | 4.04 <sup>d</sup>                            | 5.79 <sup>d</sup>              |
| H <sub>2</sub> O molecules/cavity <sup>e</sup> | 20                                                                        | 24                             | 20                                                                          | 28                             | 20                                                                                                                         | 20                                           | 36                             |

<sup>a</sup> Lattice parameters are a function of temperature, pressure, and guest composition. Typical average values given.

<sup>b</sup> Space group reference numbers from the International Tables of Crystallography.

<sup>c</sup> The average cavity radius will vary with temperature, pressure, and guest composition.

<sup>d</sup> From the atomic coordinates measured using single crystal x-ray diffraction on 2,2-dimethylpentane-5(Xe,H<sub>2</sub>S)·34H<sub>2</sub>O at 173 K (Ref. 2). The Rietveld refinement package, GSAS was used to determine the atomic distances for each cage oxygen to the cage center.

<sup>e</sup> Number of oxygen atoms at the periphery of each cavity.

**Table Ib. Physical Properties of sI, sII Hydrates Compared to Ice, Ih (Ref. 1,3,4,5)**

| Property                                                           | Ice                    | sI                     | sII                    |
|--------------------------------------------------------------------|------------------------|------------------------|------------------------|
| Dielectric constant at 273 K                                       | 94                     | ~58                    | ~58                    |
| H <sub>2</sub> O reorientation time at 273 K (μs)                  | 21                     | ~10                    | ~10                    |
| H <sub>2</sub> O diffusion jump time (μs)                          | 2.7                    | >200                   | >200                   |
| Isothermal Young's modulus at 268 K (10 <sup>9</sup> Pa)           | 9.5                    | 8.4 <sup>est</sup>     | 8.2 <sup>est</sup>     |
| Poisson's ratio                                                    | 0.3301 <sup>f</sup>    | 0.31403 <sup>f</sup>   | 0.31119 <sup>f</sup>   |
| Bulk modulus (GPa)                                                 | 9.097 <sup>f</sup>     | 8.762 <sup>f</sup>     | 8.482 <sup>f</sup>     |
| Shear modulus (GPa)                                                | 3.488 <sup>f</sup>     | 3.574 <sup>f</sup>     | 3.6663 <sup>f</sup>    |
| Compressional velocity, V <sub>p</sub> (m/s)                       | 3870.1 <sup>f</sup>    | 3778 <sup>f</sup>      | 3821.8 <sup>f</sup>    |
| Shear velocity, V <sub>s</sub> (m/s)                               | 1949 <sup>f</sup>      | 1963.6                 | 2001.14 <sup>g</sup>   |
| Linear thermal expansion at 200 K (K <sup>-1</sup> )               | 56 x 10 <sup>-6</sup>  | 77 x 10 <sup>-6</sup>  | 52 x 10 <sup>-6</sup>  |
| Thermal conductivity (W m <sup>-1</sup> K <sup>-1</sup> ) at 263 K | 2.18±0.01 <sup>h</sup> | 0.51±0.01 <sup>h</sup> | 0.50±0.01 <sup>h</sup> |
| Adiabatic bulk compression at 273 K (GPa)                          | 12                     | 14 <sup>est</sup>      | 14 <sup>est</sup>      |
| Heat capacity (J kg <sup>-1</sup> K <sup>-1</sup> )                | 1700±200 <sup>h</sup>  | 2080                   | 2130±40 <sup>h</sup>   |
| Refractive index (632.8 nm, -3 °C)                                 | 1.3082 (Ref. 9)        | 1.346 (Ref. 9)         | 1.350 (Ref. 9)         |
| Density (g/cm <sup>3</sup> )                                       | 0.91 <sup>j</sup>      | 0.94                   | 1.291 <sup>k</sup>     |

<sup>f</sup> At 253–268 K, 22.4–32.8 MPa (ice, Ih), 258–288 K, 27.1–62.1 MPa (CH<sub>4</sub>, sI), 258–288 K, 30.5–91.6 MPa (CH<sub>4</sub>–C<sub>2</sub>H<sub>6</sub>, sII), Ref. 6.

<sup>g</sup> At 258–288 K, 26.6–62.1 MPa, Ref. 7.

<sup>h</sup> At 248–268 K (ice, Ih), 253–288 K (CH<sub>4</sub>, sI), 248–265.5 K (THF, sII), Ref. 8.

<sup>j</sup> Fractional occupancy (calculated from a theoretical model) in small (S) and large (L) cavities: sI = CH<sub>4</sub>: 0.87 (S) and CH<sub>4</sub>: 0.973 (L); sII = CH<sub>4</sub>: 0.672 (S), 0.057 (L); C<sub>2</sub>H<sub>6</sub>: 0.096 (L) only; C<sub>3</sub>H<sub>8</sub>: 0.84 (L) only.

<sup>k</sup> Calculated for 2,2-dimethylpentane-5(Xe,H<sub>2</sub>S)·34H<sub>2</sub>O, Ref. 2; est = estimated.

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Table II: Phase Equilibria Data of Gas Clathrate Hydrates

This table gives measured phase equilibria data of sI and sII gas clathrate hydrates (see Table I for gas hydrate structure and physical property data). The temperature and pressure conditions at which gas hydrates are stable are listed here for typical guest molecules (Tables IIa–d). For example, data for methane hydrate show that at 277.1 K methane hydrate will dissociate at pressures below 3.81 MPa.

Table IIa. Methane Hydrate (Ref. 1)

| I–H–V               |                |              |                |              |                |              |                |
|---------------------|----------------|--------------|----------------|--------------|----------------|--------------|----------------|
| <i>T</i> (K)        | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) |
| 262.4               | 1.79           | 266.5        | 2.08           | 268.6        | 2.22           | 270.9        | 2.39           |
| 264.2               | 1.90           |              |                |              |                |              |                |
| I <sub>w</sub> –H–V |                |              |                |              |                |              |                |
| <i>T</i> (K)        | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) |
| 273.7               | 2.77           | 275.9        | 3.43           | 280.4        | 5.35           | 282.6        | 6.77           |
| 274.3               | 2.90           | 277.1        | 3.81           | 280.9        | 5.71           | 284.3        | 8.12           |
| 275.4               | 3.24           | 279.3        | 4.77           | 281.5        | 6.06           | 285.9        | 9.78           |
| 275.9               | 3.42           |              |                |              |                |              |                |
|                     |                |              |                |              |                |              | Ref. 2         |
| I <sub>w</sub> –H–V |                |              |                |              |                |              |                |
| <i>T</i> (K)        | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) |
| 295.7               | 33.99          | 295.9        | 35.30          | 301.0        | 64.81          | 302.0        | 77.50          |
|                     |                |              |                |              |                |              | Ref. 3         |
| I <sub>w</sub> –H–V |                |              |                |              |                |              |                |
| <i>T</i> (K)        | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) |
| 285.7               | 9.62           | 285.7        | 9.62           | 295.9        | 34.75          | 300.9        | 62.40          |
| 286.3               | 10.31          | 289.0        | 13.96          | 298.7        | 48.68          | 301.6        | 68.09          |
| 286.1               | 10.10          | 292.1        | 21.13          |              |                |              |                |
|                     |                |              |                |              |                |              | Ref. 4         |
| I <sub>w</sub> –H–V |                |              |                |              |                |              |                |
| <i>T</i> (K)        | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) |
| 275.4               | 2.87           | 277.2        | 3.90           | 279.2        | 4.90           | 281.2        | 6.10           |
| 276.2               | 3.37           | 278.2        | 4.50           |              |                |              |                |
|                     |                |              |                |              |                |              | Ref. 5         |
| I–H–V               |                |              |                |              |                |              |                |
| <i>T</i> (K)        | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) | <i>T</i> (K) | <i>P</i> (MPa) |
| 190.2               | 0.08251        | 208.2        | 0.222          | 243.2        | 0.9550         | 262.4        | 1.798          |
| 198.2               | 0.1314         | 218.2        | 0.3571         |              |                |              |                |
|                     |                |              |                |              |                |              | Ref. 6         |

**Table IIb. Ethane Hydrate (Ref. 1)**

| $T$ (K)             | $P$ (kPa) | Phases              | $T$ (K)   | $P$ (kPa) | Phases                           |         |           |  |
|---------------------|-----------|---------------------|-----------|-----------|----------------------------------|---------|-----------|--|
| 260.8               | 294       | I-H-V               | 285.8     | 2537      | L <sub>w</sub> -H-V              |         |           |  |
| 260.9               | 290       | I-H-V               | 287.0     | 3054      | L <sub>w</sub> -H-V              |         |           |  |
| 269.3               | 441       | I-H-V               | 287.7     | 4909      | L <sub>w</sub> -H-L <sub>E</sub> |         |           |  |
| 273.4               | 545       | L <sub>w</sub> -H-V | 287.8     | 3413      | L <sub>w</sub> -H-L <sub>E</sub> |         |           |  |
| 275.4               | 669       | L <sub>w</sub> -H-V | 287.8     | 4289      | L <sub>w</sub> -H-L <sub>E</sub> |         |           |  |
| 277.6               | 876       | L <sub>w</sub> -H-V | 288.1     | 3716      | L <sub>w</sub> -H-L <sub>E</sub> |         |           |  |
| 279.1               | 1048      | L <sub>w</sub> -H-V | 288.1     | 6840      | L <sub>w</sub> -H-L <sub>E</sub> |         |           |  |
| 219.7               | 1131      | L <sub>w</sub> -H-V | 288.2     | 4944      | L <sub>w</sub> -H-L <sub>E</sub> |         |           |  |
| 281.1               | 1317      | L <sub>w</sub> -H-V | 288.2     | 5082      | L <sub>w</sub> -H-L <sub>E</sub> |         |           |  |
| 282.8               | 1641      | L <sub>w</sub> -H-V | 288.3     | 4358      | L <sub>w</sub> -H-L <sub>E</sub> |         |           |  |
| 284.4               | 2137      | L <sub>w</sub> -H-V | 288.4     | 6840      | L <sub>w</sub> -H-L <sub>E</sub> | Ref. 7  |           |  |
| 284.6               | 2055      | L <sub>w</sub> -H-V |           |           |                                  |         |           |  |
| I-H-V               |           |                     |           |           |                                  |         |           |  |
| $T$ (K)             | $P$ (kPa) | $T$ (K)             | $P$ (kPa) | $T$ (K)   | $P$ (kPa)                        | $T$ (K) | $P$ (kPa) |  |
| 263.6               | 313       | 266.5               | 357       | 269.3     | 405                              | 272.0   | 457       |  |
| L <sub>w</sub> -H-V |           |                     |           |           |                                  |         |           |  |
| $T$ (K)             | $P$ (kPa) | $T$ (K)             | $P$ (kPa) | $T$ (K)   | $P$ (kPa)                        | $T$ (K) | $P$ (kPa) |  |
| 273.7               | 510       | 278.7               | 931       | 280.4     | 1165                             | 283.2   | 1689      |  |
| 273.7               | 503       | 278.7               | 931       | 280.9     | 1255                             | 284.3   | 1986      |  |
| 274.8               | 579       | 279.3               | 1007      | 281.5     | 1345                             | 285.4   | 2303      |  |
| 275.9               | 662       | 279.8               | 1083      | 282.1     | 1448                             | 285.4   | 2310      |  |
| 277.6               | 814       | 280.4               | 1165      | 282.6     | 1558                             | 286.5   | 2730      |  |
| Ref. 2              |           |                     |           |           |                                  |         |           |  |
| L <sub>w</sub> -H-V |           |                     |           |           |                                  |         |           |  |
| $T$ (K)             | $P$ (kPa) | $T$ (K)             | $P$ (kPa) | $T$ (K)   | $P$ (kPa)                        | $T$ (K) | $P$ (kPa) |  |
| 277.5               | 780       | 279.9               | 1040      | 283.3     | 1660                             | 286.5   | 2620      |  |
| 278.1               | 840       | 281.5               | 1380      | 284.5     | 2100                             | Ref. 8  |           |  |

**Table IIc. Propane Hydrate (Ref. 1)**

| I-H-V               |                |              |                |              |                |              |                |
|---------------------|----------------|--------------|----------------|--------------|----------------|--------------|----------------|
| <i>T</i> (K)        | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) |
| 261.2               | 100            | 267.4        | 132            | 269.8        | 149            | 272.9        | 172            |
| 264.2               | 115            | 267.6        | 135            | 272.2        | 167            |              |                |
| I <sub>w</sub> -H-V |                |              |                |              |                |              |                |
| <i>T</i> (K)        | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) |
| 273.7               | 183            | 274.8        | 232            | 275.9        | 301            | 277.1        | 386            |
| 273.7               | 183            | 275.4        | 270            |              |                |              |                |
|                     |                |              |                |              |                |              | Ref. 2         |
| I-H-V               |                |              |                |              |                |              |                |
| <i>T</i> (K)        | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) | <i>T</i> (K) | <i>P</i> (kPa) |
| 247.9               | 48.2           | 251.6        | 58.3           | 258.2        | 81.1           | 260.9        | 94.5           |
| 251.4               | 58.3           | 255.4        | 69.6           | 260.8        | 90.5           | 262.1        | 99.4           |
|                     |                |              |                |              |                |              | Ref. 9         |

Feed composition:  $x_{\text{H}_2\text{O}} = 0.9503$ ,  $x_{\text{C}_3\text{H}_8} = 0.0407$   
 $\text{Q}_2$  at  $T = 278.62$ ,  $P = 0.6$  MPa

| $\text{I}_w\text{-H-V}$ |           | $\text{I}_w\text{-H-L } x_{\text{C}_3\text{H}_8}$ |           |
|-------------------------|-----------|---------------------------------------------------|-----------|
| $T$ (K)                 | $P$ (MPa) | $T$ (K)                                           | $P$ (MPa) |
| 276.77                  | 0.368     | 278.71                                            | 0.643     |
| 277.01                  | 0.377     | 278.75                                            | 0.893     |
| 277.22                  | 0.405     | 278.75                                            | 1.393     |
| 277.36                  | 0.425     | 278.75                                            | 1.891     |
| 277.44                  | 0.433     | 278.78                                            | 1.893     |
| 277.87                  | 0.473     | 278.80                                            | 2.391     |
| 278.01                  | 0.527     | 278.80                                            | 2.891     |
| 278.22                  | 0.483     | 278.79                                            | 2.893     |
| 278.55                  | 0.547     | 278.75                                            | 3.891     |
|                         |           | 278.77                                            | 3.391     |
|                         |           | 278.81                                            | 4.391     |
|                         |           | 278.79                                            | 5.892     |
|                         |           | 278.86                                            | 6.392     |
|                         |           | 278.88                                            | 6.892     |
|                         |           | 278.80                                            | 8.393     |
|                         |           | 278.84                                            | 8.893     |
|                         |           | 278.89                                            | 9.893     |

Ref. 10

Table IIc. Carbon Dioxide Hydrate (Ref. 1)

| $\text{I}_w\text{-H-V}$ |           |         |           |         |           |
|-------------------------|-----------|---------|-----------|---------|-----------|
| $T$ (K)                 | $P$ (MPa) | $T$ (K) | $P$ (MPa) | $T$ (K) | $P$ (MPa) |
| 279.6                   | 2.74      | 282.1   | 4.01      | 282.8   | 4.36      |

| $\text{L}_w\text{-H-L}_{\text{CO}_2}$ |           |         |           |         |           |         |           |
|---------------------------------------|-----------|---------|-----------|---------|-----------|---------|-----------|
| $T$ (K)                               | $P$ (MPa) | $T$ (K) | $P$ (MPa) | $T$ (K) | $P$ (MPa) | $T$ (K) | $P$ (MPa) |
| 282.9                                 | 5.03      | 283.1   | 6.47      | 283.6   | 11.98     | 283.9   | 14.36     |
| 282.9                                 | 5.62      | 283.2   | 9.01      |         |           |         |           |

Ref. 11

Overall feed composition:  
 $x_{\text{H}_2\text{O}} = 0.8668$ ,  $x_{\text{CO}_2} = 0.1332$   
 $\text{Q}_2$  at 283.27 K and 4.48 MPa

| $\text{I}_w\text{-H-V}$ |           | $\text{L}_w\text{-H-L}_{\text{CO}_2}$ |           |
|-------------------------|-----------|---------------------------------------|-----------|
| $T$ (K)                 | $P$ (MPa) | $T$ (K)                               | $P$ (MPa) |
| 276.52                  | 1.82      | 283.33                                | 5.97      |
| 277.85                  | 1.95      | 283.36                                | 7.35      |
| 278.52                  | 2.21      |                                       |           |
| 279.49                  | 2.62      |                                       |           |
| 280.44                  | 2.88      |                                       |           |
| 281.49                  | 3.35      |                                       |           |
| 281.97                  | 3.68      |                                       |           |
| 282.00                  | 3.69      |                                       |           |
| 282.45                  | 3.85      |                                       |           |
| 282.50                  | 4.01      |                                       |           |

Ref. 12

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# PROPERTIES OF SATURATED LIQUID D<sub>2</sub>O

Allan H. Harvey

Properties of saturated liquid heavy water, D<sub>2</sub>O, are given in this table as a function of temperature from the melting point to the critical point. The vapor pressure was calculated from the formulation of Harvey and Lemmon (Ref. 2). The other properties were generated from the NIST REFPROP program (Ref. 1) and are consistent with formulations adopted for general and scientific use by The International Association for the Properties of Water and Steam (IAPWS). The background for the equation of state used for density and heat capacity is given by Hill et al. (Ref. 3), and the background for the transport property correlations is given by Matsunaga and Nagashima (Ref. 4). The unpublished surface tension correlation and the other IAPWS formulations may be found on the IAPWS Web site (<http://www.iapws.org>). The temperature scale is ITS-90. Additional calculations at state points not listed below can be obtained by using the REFPROP program (<http://www.nist.gov/srd/nist23.htm>). The properties are

$P$ : vapor pressure                       $\eta$ : viscosity  
 $\rho$ : density                                 $\lambda$ : thermal conductivity  
 $C_p$ : isobaric heat capacity         $\sigma$ : surface tension

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| $t/^{\circ}\text{C}$ | $P/\text{kPa}$ | $\rho/\text{kg m}^{-3}$ | $C_p/\text{kJ kg}^{-1} \text{K}^{-1}$ | $\eta/\text{mPa s}$ | $\lambda/\text{W m}^{-1} \text{K}^{-1}$ | $\sigma/\text{mN m}^{-1}$ |
|----------------------|----------------|-------------------------|---------------------------------------|---------------------|-----------------------------------------|---------------------------|
| 3.82                 | 0.661          | 1105.5                  | 4.211                                 | 2.086               | 0.565                                   | 74.93                     |
| 10                   | 1.026          | 1106.0                  | 4.231                                 | 1.679               | 0.575                                   | 74.06                     |
| 20                   | 1.999          | 1105.3                  | 4.243                                 | 1.247               | 0.589                                   | 72.61                     |
| 30                   | 3.702          | 1103.2                  | 4.240                                 | 0.972               | 0.600                                   | 71.09                     |
| 40                   | 6.550          | 1099.9                  | 4.232                                 | 0.785               | 0.610                                   | 69.52                     |
| 50                   | 11.12          | 1095.6                  | 4.220                                 | 0.651               | 0.618                                   | 67.89                     |
| 60                   | 18.20          | 1090.5                  | 4.207                                 | 0.552               | 0.625                                   | 66.21                     |
| 70                   | 28.81          | 1084.6                  | 4.194                                 | 0.476               | 0.629                                   | 64.47                     |
| 80                   | 44.24          | 1078.1                  | 4.181                                 | 0.416               | 0.633                                   | 62.67                     |
| 90                   | 66.09          | 1071.0                  | 4.170                                 | 0.368               | 0.635                                   | 60.82                     |
| 100                  | 96.30          | 1063.3                  | 4.161                                 | 0.329               | 0.636                                   | 58.93                     |
| 110                  | 137.1          | 1055.1                  | 4.155                                 | 0.296               | 0.636                                   | 56.98                     |
| 120                  | 191.3          | 1046.4                  | 4.153                                 | 0.269               | 0.635                                   | 54.99                     |
| 130                  | 261.8          | 1037.2                  | 4.155                                 | 0.247               | 0.632                                   | 52.95                     |
| 140                  | 352.0          | 1027.5                  | 4.162                                 | 0.227               | 0.629                                   | 50.87                     |
| 150                  | 465.8          | 1017.2                  | 4.174                                 | 0.210               | 0.625                                   | 48.75                     |
| 160                  | 607.3          | 1006.5                  | 4.190                                 | 0.195               | 0.620                                   | 46.59                     |
| 170                  | 781.1          | 995.2                   | 4.212                                 | 0.182               | 0.614                                   | 44.39                     |
| 180                  | 992.0          | 983.4                   | 4.240                                 | 0.171               | 0.607                                   | 42.16                     |
| 190                  | 1246           | 971.1                   | 4.273                                 | 0.161               | 0.600                                   | 39.90                     |
| 200                  | 1547           | 958.2                   | 4.313                                 | 0.152               | 0.592                                   | 37.61                     |
| 210                  | 1903           | 944.7                   | 4.360                                 | 0.144               | 0.583                                   | 35.29                     |
| 220                  | 2319           | 930.5                   | 4.415                                 | 0.136               | 0.574                                   | 32.95                     |
| 230                  | 2802           | 915.7                   | 4.479                                 | 0.130               | 0.563                                   | 30.59                     |
| 240                  | 3359           | 900.1                   | 4.554                                 | 0.123               | 0.553                                   | 28.22                     |
| 250                  | 3998           | 883.7                   | 4.643                                 | 0.118               | 0.541                                   | 25.84                     |
| 260                  | 4725           | 866.4                   | 4.750                                 | 0.112               | 0.529                                   | 23.45                     |
| 270                  | 5550           | 848.0                   | 4.880                                 | 0.107               | 0.516                                   | 21.07                     |
| 280                  | 6480           | 828.4                   | 5.038                                 | 0.103               | 0.502                                   | 18.69                     |
| 290                  | 7525           | 807.5                   | 5.237                                 | 0.098               | 0.488                                   | 16.33                     |
| 300                  | 8694           | 784.8                   | 5.490                                 | 0.094               | 0.473                                   | 13.99                     |
| 310                  | 9998           | 760.1                   | 5.823                                 | 0.089               | 0.458                                   | 11.68                     |



| $t/^{\circ}\text{C}$ | $P/\text{kPa}$ | $\rho/\text{kg m}^{-3}$ | $C_p/\text{kJ kg}^{-1}\text{ K}^{-1}$ | $\eta/\text{mPa s}$ | $\lambda/\text{W m}^{-1}\text{ K}^{-1}$ | $\sigma/\text{mN m}^{-1}$ |
|----------------------|----------------|-------------------------|---------------------------------------|---------------------|-----------------------------------------|---------------------------|
| 320                  | 11449          | 732.7                   | 6.281                                 | 0.085               | 0.442                                   | 9.428                     |
| 330                  | 13059          | 702.0                   | 6.952                                 | 0.080               | 0.425                                   | 7.238                     |
| 340                  | 14845          | 666.5                   | 8.041                                 | 0.075               | 0.408                                   | 5.141                     |
| 350                  | 16824          | 623.3                   | 10.17                                 | 0.069               | 0.391                                   | 3.173                     |
| 360                  | 19024          | 565.1                   | 16.41                                 | 0.062               | 0.382                                   | 1.405                     |
| 370                  | 21487          | 430.7                   | 268.8                                 | 0.046               | 0.548                                   | 0.0467                    |
| 370.697              | 21671          | 356.0                   |                                       |                     |                                         | 0                         |

## PROPERTIES OF AMINO ACIDS

This table gives selected properties of some important amino acids and closely related compounds. The first part of the table lists the 20 “standard” amino acids that are the basic constituents of proteins. The second part includes other amino acids and related compounds of biochemical importance. Within each part of the table the compounds are listed by name in alphabetical order. Structures are given in the following table.

Symbol: Three-letter symbol for the standard amino acids

$M_r$ : Molecular weight

$t_m$ : Melting point

$pK_a$ ,  $pK_b$ ,  $pK_c$ ,  $pK_d$ : Negative of the logarithm of the acid dissociation constants for the COOH and NH<sub>2</sub> groups (and, in some cases, other groups) in the molecule (at 25 °C)

pI: pH at the isoelectric point

S: Solubility in water in units of grams of compound per kilogram of water; a temperature of 25 °C is understood unless otherwise stated in a superscript. When quantitative data are not available, the notations sl.s. (for slightly soluble), s. (for soluble), and v.s. (for very soluble) are used.

$V_2^0$ : Partial molar volume in aqueous solution at infinite dilution (at 25 °C)

Data on the enthalpy of formation of many of these compounds are included in the table “Standard Thermodynamic Properties of

Chemical Substances” in Section 5 of this *Handbook*. Absorption spectra and optical rotation data can be found in Reference 3. Partial molar volume is taken from Reference 5; other thermodynamic properties, including solubility as a function of temperature, are given in References 3 and 5. Most of the pK values come from References 1, 6, and 7.

## References

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8. Ramasami, P., *J. Chem. Eng. Data*, 47, 1164, 2002.

| Symbol | Name            | Mol. form.                                                    | $M_r$  | $t_m/^\circ\text{C}$ | $pK_a$ | $pK_b$ | $pK_c$ | $pK_d$ | pI    | S/g kg <sup>-1</sup> | $V_2^0/\text{cm}^3\text{mol}^{-1}$ |
|--------|-----------------|---------------------------------------------------------------|--------|----------------------|--------|--------|--------|--------|-------|----------------------|------------------------------------|
| Ala    | L-Alanine       | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                 | 89.09  | 297                  | 2.33   | 9.71   |        |        | 6.00  | 166.9                | 60.54                              |
| Arg    | L-Arginine      | C <sub>6</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub>  | 174.20 | 244                  | 2.03   | 9.00   | 12.10  |        | 10.76 | 182.6                | 127.42                             |
| Asn    | L-Asparagine    | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>   | 132.12 | 235                  | 2.16   | 8.73   |        |        | 5.41  | 25.1                 | 78.0                               |
| Asp    | L-Aspartic acid | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>                 | 133.10 | 270                  | 1.95   | 9.66   | 3.71   |        | 2.77  | 5.04                 | 74.8                               |
| Cys    | L-Cysteine      | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub> S               | 121.16 | 240                  | 1.91   | 10.28  | 8.14   |        | 5.07  | v.s.                 | 73.45                              |
| Gln    | L-Glutamine     | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>  | 146.14 | 185                  | 2.18   | 9.00   |        |        | 5.65  | 42                   |                                    |
| Glu    | L-Glutamic acid | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                 | 147.13 | 160                  | 2.16   | 9.58   | 4.15   |        | 3.22  | 8.6                  | 89.85                              |
| Gly    | Glycine         | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                 | 75.07  | 290                  | 2.34   | 9.58   |        |        | 5.97  | 239                  | 43.26                              |
| His    | L-Histidine     | C <sub>6</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>   | 155.15 | 287                  | 1.70   | 9.09   | 6.04   |        | 7.59  | 43.5                 | 98.3                               |
| Ile    | L-Isoleucine    | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                | 131.17 | 284                  | 2.26   | 9.60   |        |        | 6.02  | 34.2                 | 105.80                             |
| Leu    | L-Leucine       | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                | 131.17 | 293                  | 2.32   | 9.58   |        |        | 5.98  | 23.8                 | 107.77                             |
| Lys    | L-Lysine        | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>  | 146.19 | 224                  | 2.15   | 9.16   | 10.67  |        | 9.74  | 5.8                  | 108.5                              |
| Met    | L-Methionine    | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub> S              | 149.21 | 281                  | 2.16   | 9.08   |        |        | 5.74  | 56                   | 105.57                             |
| Phe    | L-Phenylalanine | C <sub>9</sub> H <sub>9</sub> NO <sub>2</sub>                 | 165.19 | 283                  | 2.18   | 9.09   |        |        | 5.48  | 27.9                 | 121.5                              |
| Pro    | L-Proline       | C <sub>5</sub> H <sub>9</sub> NO <sub>2</sub>                 | 115.13 | 221                  | 1.95   | 10.47  |        |        | 6.30  | 1625                 | 82.76                              |
| Ser    | L-Serine        | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                 | 105.09 | 228                  | 2.13   | 9.05   |        |        | 5.68  | 250                  | 60.62                              |
| Thr    | L-Threonine     | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                 | 119.12 | 256                  | 2.20   | 8.96   |        |        | 5.60  | 90.6                 | 76.90                              |
| Trp    | L-Tryptophan    | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> | 204.23 | 289                  | 2.38   | 9.34   |        |        | 5.89  | 13.2                 | 143.8                              |
| Tyr    | L-Tyrosine      | C <sub>9</sub> H <sub>9</sub> NO <sub>3</sub>                 | 181.19 | 343                  | 2.24   | 9.04   | 10.10  |        | 5.66  | 0.51                 |                                    |
| Val    | L-Valine        | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                | 117.15 | 315                  | 2.27   | 9.52   |        |        | 5.96  | 88                   | 90.75                              |

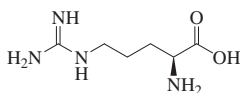
| Name                    | Mol. form.                                                   | $M_r$  | $t_m/^\circ\text{C}$ | $pK_a$ | $pK_b$ | $pK_c$ | $pK_d$ | pI   | S/g kg <sup>-1</sup> | $V_2^0/\text{cm}^3\text{mol}^{-1}$ |
|-------------------------|--------------------------------------------------------------|--------|----------------------|--------|--------|--------|--------|------|----------------------|------------------------------------|
| N-Acetylglutamic acid   | C <sub>7</sub> H <sub>11</sub> NO <sub>5</sub>               | 189.17 | 199                  |        |        |        |        |      | s.                   |                                    |
| N6-Acetyl-L-lysine      | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> | 188.22 | 265                  | 2.12   | 9.51   |        |        |      |                      |                                    |
| β-Alanine               | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                | 89.09  | 200                  | 3.51   | 10.08  |        |        |      | 890                  | 58.28                              |
| 2-Aminoadipic acid      | C <sub>6</sub> H <sub>11</sub> NO <sub>4</sub>               | 161.16 | 207                  | 2.14   | 4.21   | 9.77   |        | 3.18 | 2.2 <sup>40</sup>    |                                    |
| DL-2-Aminobutanoic acid | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 103.12 | 304                  | 2.30   | 9.63   |        |        | 6.06 | 210                  | 75.6                               |
| DL-3-Aminobutanoic acid | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 103.12 | 194.3                | 3.43   | 10.05  |        |        | 7.30 | 1250                 | 76.3                               |
| 4-Aminobutanoic acid    | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 103.12 | 203                  | 4.02   | 10.35  |        |        |      | 971                  | 73.2                               |
| 10-Aminodecanoic acid   | C <sub>10</sub> H <sub>21</sub> NO <sub>2</sub>              | 187.28 | 188.5                |        |        |        |        |      |                      | 167.3                              |

| Name                                       | Mol. form.                                              | $M_r$  | $t_m/^\circ\text{C}$ | $pK_a$ | $pK_b$ | $pK_c$ | $pK_d$ | pI   | $S/\text{g kg}^{-1}$ | $V_2^0/\text{cm}^3 \text{mol}^{-1}$ |
|--------------------------------------------|---------------------------------------------------------|--------|----------------------|--------|--------|--------|--------|------|----------------------|-------------------------------------|
| 7-Aminoheptanoic acid                      | $\text{C}_7\text{H}_{15}\text{NO}_2$                    | 145.20 | 195                  |        |        |        |        |      | v.s.                 | 120.0                               |
| 6-Aminohexanoic acid                       | $\text{C}_6\text{H}_{13}\text{NO}_2$                    | 131.17 | 205                  |        |        |        |        | 7.29 | 850                  | 104.2                               |
| <i>L</i> -3-Amino-2-methylpropanoic acid   | $\text{C}_4\text{H}_9\text{NO}_2$                       | 103.12 | 185                  |        |        |        |        |      | s.                   |                                     |
| 2-Amino-2-methylpropanoic acid             | $\text{C}_4\text{H}_9\text{NO}_2$                       | 103.12 | 335                  | 2.36   | 10.21  |        |        | 5.72 | 137                  | 77.55                               |
| 9-Aminononanoic acid                       | $\text{C}_9\text{H}_{19}\text{NO}_2$                    | 173.26 | 191                  |        |        |        |        |      |                      | 151.3                               |
| 8-Aminooctanoic acid                       | $\text{C}_8\text{H}_{17}\text{NO}_2$                    | 159.23 | 192                  |        |        |        |        |      |                      | 136.1                               |
| 5-Amino-4-oxopentanoic acid                | $\text{C}_5\text{H}_9\text{NO}_3$                       | 131.13 | 118                  | 4.05   | 8.90   |        |        |      |                      |                                     |
| 5-Aminopentanoic acid                      | $\text{C}_5\text{H}_{11}\text{NO}_2$                    | 117.15 | 157 dec              |        |        |        |        |      | s.                   | 87.6                                |
| <i>o</i> -Anthranilic acid                 | $\text{C}_7\text{H}_7\text{NO}_2$                       | 137.14 | 146                  | 2.05   | 4.95   |        |        |      | 3.5 <sup>14</sup>    |                                     |
| Azaserine                                  | $\text{C}_5\text{H}_7\text{N}_3\text{O}_4$              | 173.13 | 150                  |        | 8.55   |        |        |      | v.s.                 |                                     |
| Canavanine                                 | $\text{C}_5\text{H}_{12}\text{N}_4\text{O}_3$           | 176.17 | 172                  | 2.50   | 6.60   | 9.25   |        | 7.93 | v.s.                 |                                     |
| <i>L</i> - $\gamma$ -Carboxyglutamic acid  | $\text{C}_6\text{H}_9\text{NO}_6$                       | 191.14 | 167                  | 1.70   | 9.90   | 4.75   | 3.20   |      |                      |                                     |
| Carnosine                                  | $\text{C}_9\text{H}_{14}\text{N}_4\text{O}_3$           | 226.23 | 260                  | 2.51   | 9.35   | 6.76   |        |      | 322                  |                                     |
| Citrulline                                 | $\text{C}_6\text{H}_{13}\text{N}_3\text{O}_3$           | 175.19 | 222                  | 2.32   | 9.30   |        |        | 5.92 | s.                   |                                     |
| Creatine                                   | $\text{C}_4\text{H}_9\text{N}_3\text{O}_2$              | 131.13 | 303                  | 2.63   | 14.30  |        |        |      | 16                   |                                     |
| <i>L</i> -Cysteic acid                     | $\text{C}_3\text{H}_7\text{NO}_5\text{S}$               | 169.16 | 260                  | 1.89   | 8.70   | 1.30   |        |      | v.s.                 |                                     |
| <i>L</i> -Cystine                          | $\text{C}_6\text{H}_{12}\text{N}_2\text{O}_4\text{S}_2$ | 240.30 | 260                  | 1.50   | 8.80   | 2.05   | 8.03   |      | 0.17                 |                                     |
| 2,4-Diaminobutanoic acid                   | $\text{C}_4\text{H}_{10}\text{N}_2\text{O}_2$           | 118.13 | 118.1                | 1.85   | 8.24   | 10.44  |        | 9.27 | s.                   |                                     |
| 3,5-Dibromo- <i>L</i> -tyrosine            | $\text{C}_9\text{H}_9\text{Br}_2\text{NO}_3$            | 338.98 | 245                  |        |        |        |        |      | 2.72                 |                                     |
| 3,5-Dichloro- <i>L</i> -tyrosine           | $\text{C}_9\text{H}_9\text{Cl}_2\text{NO}_3$            | 250.08 | 247                  |        |        |        |        |      | 1.97                 |                                     |
| 3,5-Diiodo- <i>L</i> -tyrosine             | $\text{C}_9\text{H}_9\text{I}_2\text{NO}_3$             | 432.98 | 213                  | 2.12   | 9.10   | 6.16   |        |      | 0.62                 |                                     |
| Dopamine                                   | $\text{C}_8\text{H}_{11}\text{NO}_2$                    | 153.18 |                      |        | 10.36  | 8.88   |        |      | s.                   |                                     |
| <i>L</i> -Ethionine                        | $\text{C}_6\text{H}_{13}\text{NO}_2\text{S}$            | 163.24 | 273                  | 2.18   | 9.05   | 13.10  |        |      |                      |                                     |
| <i>N</i> -Glycylglycine                    | $\text{C}_4\text{H}_8\text{N}_2\text{O}_3$              | 132.12 | 263                  | 3.13   | 8.10   |        |        |      | 231                  |                                     |
| Guanidinoacetic acid                       | $\text{C}_3\text{H}_7\text{N}_3\text{O}_2$              | 117.11 | 282                  | 2.82   |        |        |        |      | 5                    |                                     |
| Histamine                                  | $\text{C}_5\text{H}_9\text{N}_3$                        | 111.15 | 83                   |        | 9.83   | 6.11   |        |      | v.s.                 |                                     |
| <i>L</i> -Homocysteine                     | $\text{C}_4\text{H}_9\text{NO}_2\text{S}$               | 135.19 | 232                  | 2.15   | 8.57   | 10.38  |        | 5.55 | s.                   |                                     |
| Homocystine                                | $\text{C}_8\text{H}_{16}\text{N}_2\text{O}_4\text{S}_2$ | 268.35 | 264                  | 1.59   | 9.44   | 2.54   | 8.52   |      | 0.2                  |                                     |
| <i>L</i> -Homoserine                       | $\text{C}_4\text{H}_9\text{NO}_3$                       | 119.12 | 203                  | 2.27   | 9.28   |        |        | 6.17 | 1100                 |                                     |
| 3-Hydroxy- <i>DL</i> -glutamic acid        | $\text{C}_5\text{H}_9\text{NO}_5$                       | 163.13 | 209                  |        |        |        |        | 3.28 |                      |                                     |
| 5-Hydroxylysine                            | $\text{C}_6\text{H}_{14}\text{N}_2\text{O}_3$           | 162.19 |                      | 2.13   | 8.85   | 9.83   |        | 9.15 |                      |                                     |
| <i>trans</i> -4-Hydroxy- <i>L</i> -proline | $\text{C}_5\text{H}_9\text{NO}_3$                       | 131.13 | 274                  | 1.82   | 9.47   |        |        | 5.74 | 361                  | 84.49                               |
| <i>L</i> -3-Iodotyrosine                   | $\text{C}_9\text{H}_{10}\text{INO}_3$                   | 307.08 | 205                  | 2.20   | 9.10   | 8.70   |        |      | sl.s.                |                                     |
| <i>L</i> -Kynurenine                       | $\text{C}_{10}\text{H}_{12}\text{N}_2\text{O}_3$        | 208.21 | 194                  |        |        |        |        |      | sl.s.                |                                     |
| <i>L</i> -Lanthionine                      | $\text{C}_6\text{H}_{12}\text{N}_2\text{O}_4\text{S}$   | 208.24 | 294                  |        |        |        |        |      | 1.5                  |                                     |
| Levodopa                                   | $\text{C}_9\text{H}_{11}\text{NO}_4$                    | 197.19 | 277                  | 2.32   | 8.72   | 9.96   | 11.79  |      | 1.65 <sup>20</sup>   |                                     |
| <i>L</i> -1-Methylhistidine                | $\text{C}_7\text{H}_{11}\text{N}_3\text{O}_2$           | 169.18 | 249                  | 1.69   | 8.85   | 6.48   |        |      | 200                  |                                     |
| <i>L</i> -Norleucine                       | $\text{C}_6\text{H}_{13}\text{NO}_2$                    | 131.17 | 301                  | 2.31   | 9.68   |        |        | 6.09 | 15                   | 107.7                               |
| <i>L</i> -Norvaline                        | $\text{C}_5\text{H}_{11}\text{NO}_2$                    | 117.15 | 307                  | 2.31   | 9.65   |        |        |      | 107                  | 91.8                                |
| <i>L</i> -Ornithine                        | $\text{C}_5\text{H}_{12}\text{N}_2\text{O}_2$           | 132.16 | 140                  | 1.94   | 8.78   | 10.52  |        | 9.73 | v.s.                 |                                     |
| <i>O</i> -Phosphoserine                    | $\text{C}_3\text{H}_8\text{NO}_6\text{P}$               | 185.07 | 166                  | 2.14   | 9.80   | 5.70   |        |      |                      |                                     |
| <i>L</i> -Pyroglutamic acid                | $\text{C}_5\text{H}_7\text{NO}_3$                       | 129.12 | 162                  | 3.32   |        |        |        |      |                      |                                     |
| Sarcosine                                  | $\text{C}_3\text{H}_7\text{NO}_2$                       | 89.09  | 212                  | 2.18   | 9.97   |        |        |      | 428                  |                                     |
| Taurine                                    | $\text{C}_2\text{H}_7\text{NO}_3\text{S}$               | 125.15 | 328                  | -0.3   | 9.06   |        |        |      | 105                  |                                     |
| <i>L</i> -Thyroxine                        | $\text{C}_{15}\text{H}_{11}\text{I}_4\text{NO}_4$       | 776.87 | 235                  | 2.20   | 10.01  | 6.45   |        |      | sl.s.                |                                     |

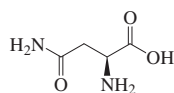
## STRUCTURES OF COMMON AMINO ACIDS



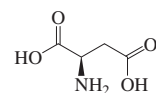
*L*-Alanine (Ala)



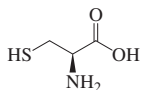
*L*-Arginine (Arg)



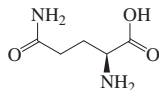
*L*-Asparagine (Asn)



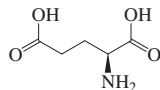
*L*-Aspartic acid (Asp)



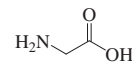
*L*-Cysteine (Cys)



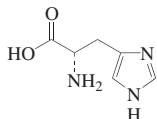
*L*-Glutamine (Gln)



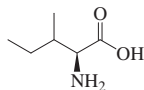
*L*-Glutamic acid (Glu)



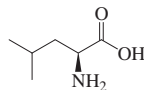
Glycine (Gly)



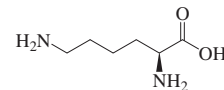
*L*-Histidine (His)



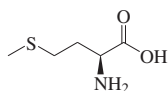
*L*-Isoleucine (Ile)



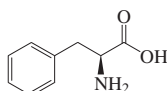
*L*-Leucine (Leu)



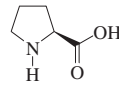
*L*-Lysine (Lys)



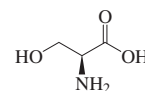
*L*-Methionine (Met)



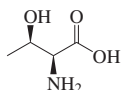
*L*-Phenylalanine (Phe)



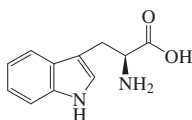
*L*-Proline (Pro)



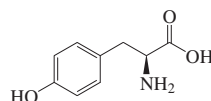
*L*-Serine (Ser)



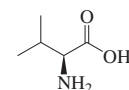
*L*-Threonine (Thr)



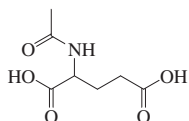
*L*-Tryptophan (Trp)



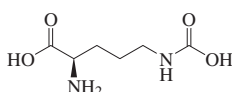
*L*-Tyrosine (Tyr)



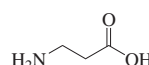
*L*-Valine (Val)



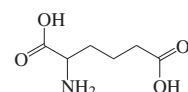
*N*-Acetylglutamic acid



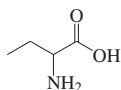
*N*<sub>6</sub>-Acetyl-*L*-lysine



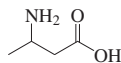
β-Alanine



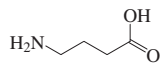
2-Aminoadipic acid



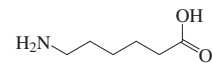
*DL*-2-Aminobutanoic acid



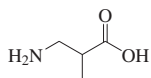
*DL*-3-Aminobutanoic acid



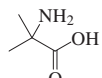
4-Aminobutanoic acid



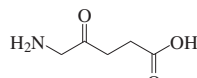
6-Aminohexanoic acid



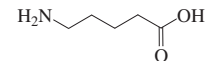
*L*-3-Amino-2-methylpropanoic acid



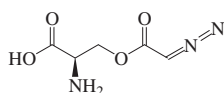
2-Amino-2-methylpropanoic acid



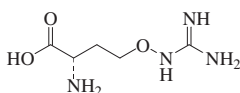
5-Amino-4-oxopentanoic acid



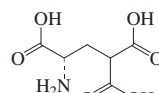
5-Aminopentanoic acid



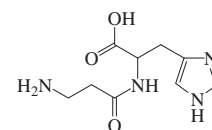
Azaserine



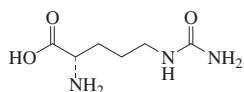
Canavanine



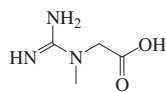
*L*-γ-Carboxyglutamic acid



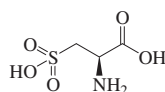
Carnosine



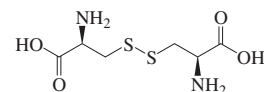
Citrulline



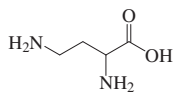
Creatine



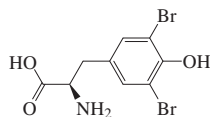
L-Cysteic acid



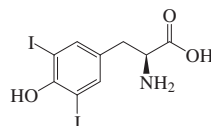
L-Cystine



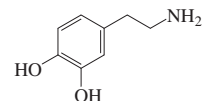
2,4-Diaminobutanoic acid



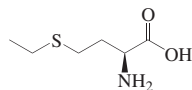
3,5-Dibromo-L-tyrosine



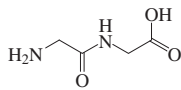
3,5-Diiodo-L-tyrosine



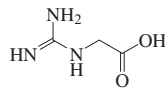
Dopamine



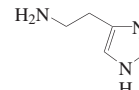
L-Ethionine



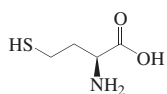
N-Glycylglycine



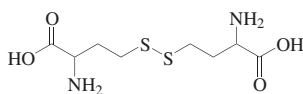
Guanidinoacetic acid



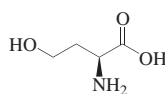
Histamine



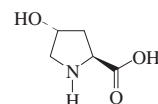
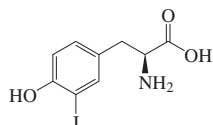
L-Homocysteine



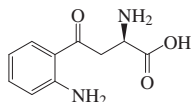
Homocystine



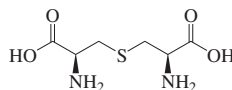
L-Homoserine

*trans*-4-Hydroxy-L-proline

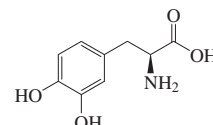
L-3-Iodotyrosine



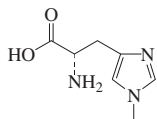
L-Kynurenine



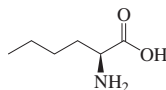
L-Lanthionine



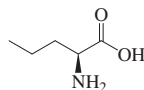
Levodopa



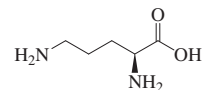
L-1-Methylhistidine



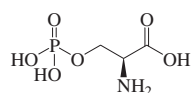
L-Norleucine



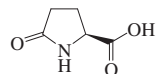
L-Norvaline



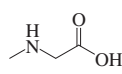
L-Ornithine



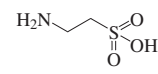
O-Phosphoserine



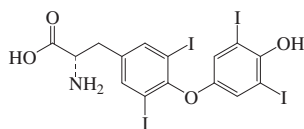
L-Pyrroglutamic acid



Sarcosine



Taurine



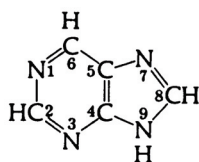
L-Thyroxine

## PROPERTIES OF PURINE AND PYRIMIDINE BASES

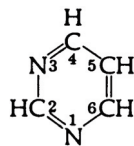
This table lists some of the important purine and pyrimidine bases that occur in nucleic acids. The  $pK_a$  values (negative logarithm of the acid dissociation constant) are given for each ioniza-

tion stage. The last column gives the aqueous solubility  $S$  at the indicated temperature in units of grams per 100 grams of solution.

The numbering system in the rings is:



Purine



Pyrimidine

## References

1. Dawson, R. M. C., et al., *Data for Biochemical Research*, 3rd ed., Clarendon Press, Oxford, 1986.
2. O'Neil, M. J., Ed., *The Merck Index*, 13th ed., Merck and Co., Rahway, NJ, 2001.

| Common name             | Systematic name                              | Mol. form.                                                  | Mol. wt. | pK <sub>a</sub> values |       |      | S/mass % (temp.) |
|-------------------------|----------------------------------------------|-------------------------------------------------------------|----------|------------------------|-------|------|------------------|
| <i>Pyrimidines</i>      |                                              |                                                             |          |                        |       |      |                  |
| Cytosine                | 4-Amino-2-hydroxypyrimidine                  | C <sub>4</sub> H <sub>5</sub> N <sub>3</sub> O              | 111.10   | 4.60                   | 12.16 |      | 0.73 (25°C)      |
| 5-Methylcytosine        | 4-Amino-2-hydroxy-5-methylpyrimidine         | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub> O              | 125.13   | 4.6                    | 12.4  |      | 0.45 (25°C)      |
| 5-Hydroxymethylcytosine | 4-Amino-2-hydroxy-5-hydroxy-methylpyrimidine | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub> | 141.13   | 4.3                    | 13    |      |                  |
| Uracil                  | 2,4-Dihydroxypyrimidine                      | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> | 112.09   | 0.5                    | 9.5   | >13  | 0.27 (25°C)      |
| Thymine                 | 5-Methyluracil                               | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | 126.11   | 9.94                   | >13   |      | 0.35 (25°C)      |
| Orotic acid             | Uracil-6-carboxylic acid                     | C <sub>5</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub> | 156.10   | 2.4                    | 9.5   | >13  | 0.18 (18°C)      |
| <i>Purines</i>          |                                              |                                                             |          |                        |       |      |                  |
| Adenine                 | 6-Aminopurine                                | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub>                | 135.14   | <1                     | 4.3   | 9.83 | 0.104 (25°C)     |
| Guanine                 | 2-Amino-6-hydroxypurine                      | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub> O              | 151.13   | 3.3                    | 9.2   | 12.3 | 0.0068 (40°C)    |
| 7-Methylguanine         | 7-Methyl-2-amino-6-hydroxypurine             | C <sub>6</sub> H <sub>7</sub> N <sub>5</sub> O              | 165.16   | 3.5                    | 9.9   |      |                  |
| Isoguanine              | 6-Amino-2-hydroxypurine                      | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub> O              | 151.13   | 4.5                    | 9.0   |      | 0.006 (25°C)     |
| Xanthine                | 2,6-Dioxopurine                              | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub> | 152.11   | 0.8                    | 7.4   | 11.1 | 0.05 (20°C)      |
| Hypoxanthine            | 6-Hydroxypurine                              | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O              | 136.11   | 2.0                    | 8.9   | 12.1 | 0.07 (19°C)      |
| Uric acid               | 2,6,8-Trihydroxypurine                       | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>3</sub> | 168.11   | 5.4                    | 11.3  |      | 0.002 (20°C)     |

## THE GENETIC CODE

This table gives the correspondence between a messenger RNA codon and the amino acid which it specifies. The symbols for bases in the codon are:

U: uracil  
C: cytosine  
A: adenine  
G: guanine

The amino acid symbols are given in the table entitled "Structures of Common Amino Acids". A chain-initiating codon is indicated by **init** and a chain-terminating codon by **term**.

Example: UCA codes for **Ser**, UAC codes for **Tyr**, etc.

| First position | Second position     |     |             |             | Third position |
|----------------|---------------------|-----|-------------|-------------|----------------|
|                | U                   | C   | A           | G           |                |
| U              | Phe                 | Ser | Tyr         | Cys         | U              |
|                | Phe                 | Ser | Tyr         | Cys         | C              |
|                | Leu                 | Ser | <b>term</b> | <b>term</b> | A              |
|                | Leu                 | Ser | <b>term</b> | Trp         | G              |
| C              | Leu                 | Pro | His         | Arg         | U              |
|                | Leu                 | Pro | His         | Arg         | C              |
|                | Leu                 | Pro | Gln         | Arg         | A              |
|                | Leu                 | Pro | Gln         | Arg         | G              |
| A              | Ile                 | Thr | Asn         | Ser         | U              |
|                | Ile                 | Thr | Asn         | Ser         | C              |
|                | Ile                 | Thr | Lys         | Arg         | A              |
|                | Met ( <b>init</b> ) | Thr | Lys         | Arg         | G              |
| G              | Val                 | Ala | Asp         | Gly         | U              |
|                | Val                 | Ala | Asp         | Gly         | C              |
|                | Val                 | Ala | Glu         | Gly         | A              |
|                | Val ( <b>init</b> ) | Ala | Glu         | Gly         | G              |

## PROPERTIES OF FATTY ACIDS AND THEIR METHYL ESTERS

This table gives the names and selected properties of some important fatty acids and their methyl esters. It includes most of the acids that are significant constituents of naturally occurring oils and fats. Compounds are listed first by number of carbon atoms and, secondly, by the degree of unsaturation. Both the systematic name and the common or trivial name are given, as well as the Chemical Abstracts Service Registry Number and the shorthand acid code that is frequently used. The first number in this code gives the number of carbon atoms; the number following the colon is the number of unsaturated centers (mainly double bonds). The location and orientation of the unsaturated centers follow. The symbols used are: *c* = *cis*; *t* = *trans*; *a* = acetylenic center; *e* = ethylenic center at end of chain; *ep* = *epoxy*. Thus 9c,11t indicates a double bond with *cis* orientation at the No. 9 carbon and another with *trans* orientation at the No. 11 carbon. More details on the codes can be found in Reference 1.

The table gives the molecular weight and melting point of the acid and the melting and boiling points of the methyl ester of the acid when available. A superscript on the boiling point indicates the pressure in mmHg (torr); if there is no superscript, the value refers

to one atmosphere (760 mmHg). The references cover many other fatty acids beyond those listed here and give additional properties.

We are indebted to Frank D. Gunstone for advice on the content of the table.

### References

1. Gunstone, F. D., Harwood, J. L., and Dijkstra, A. J., eds., *The Lipid Handbook, Third Edition*, CRC Press, Boca Raton, FL, 2006.
2. Gunstone, F. D., and Adlof, R. O., *Common (non-systematic) Names for Fatty Acids*, [www.aocs.org/member/division/analytic/fanames.asp](http://www.aocs.org/member/division/analytic/fanames.asp), 2003.
3. Firestone, D., *Physical and Chemical Characteristics of Oils, Fats, and Waxes*, 2nd Edition, AOCS Press, Urbana, IL, 2006.
4. Dawson, R. M. C., Elliott, D. C., Elliott, W. H., and Jones, K. M., *Data for Biochemical Research*, Third Edition, Clarendon Press, Oxford, 1986.
5. Altman, P. L., and Dittmer, D. S., eds., *Biology Data Book*, Second Edition, Vol. 1, Federation of American Societies for Experimental Biology, Bethesda, MD, 1972.
6. Fasman, G. D., Ed., *Practical Handbook of Biochemistry and Molecular Biology*, CRC Press, Boca Raton, FL, 1989.

| Systematic name                                          | Common name               | Mol. form.                                     | Acid code        | CAS RN     | Mol. weight | mp/°C | Methyl ester |                     |
|----------------------------------------------------------|---------------------------|------------------------------------------------|------------------|------------|-------------|-------|--------------|---------------------|
|                                                          |                           |                                                |                  |            |             |       | mp/°C        | bp/°C               |
| Butanoic acid                                            | Butyric acid              | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 4:0              | 107-92-6   | 88.106      | -5.1  | -85.8        | 102.8               |
| Pentanoic acid                                           | Valeric acid              | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | 5:0              | 109-52-4   | 102.132     | -33.6 |              | 127.4               |
| 3-Methylbutanoic acid                                    | Isovaleric acid           | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>  | 4:0 3-Me         | 503-74-2   | 102.132     | -29.3 |              | 116.5               |
| Hexanoic acid                                            | Caproic acid              | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | 6:0              | 142-62-1   | 116.158     | -3    | -71          | 149.5               |
| Heptanoic acid                                           | Enanthic acid             | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>  | 7:0              | 111-14-8   | 130.185     | -7.2  | -56          | 174                 |
| Octanoic acid                                            | Caprylic acid             | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>  | 8:0              | 124-07-2   | 144.212     | 16.5  | -40          | 192.9               |
| Nonanoic acid                                            | Pelargonic acid           | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>  | 9:0              | 112-05-0   | 158.238     | 12.4  |              | 213.5               |
| Decanoic acid                                            | Capric acid               | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub> | 10:0             | 334-48-5   | 172.265     | 31.4  | -18          | 224                 |
| 9-Decenoic acid                                          | Caproleic acid            | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub> | 10:1 9e          | 14436-32-9 | 170.249     | 26.5  |              | 120 <sup>20</sup>   |
| Undecanoic acid                                          |                           | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | 11:0             | 112-37-8   | 186.292     | 28.6  |              | 123 <sup>10</sup>   |
| Dodecanoic acid                                          | Lauric acid               | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub> | 12:0             | 143-07-7   | 200.318     | 43.8  | 5.2          | 267                 |
| <i>cis</i> -9-Dodecenoic acid                            | Lauroleic acid            | C <sub>12</sub> H <sub>22</sub> O <sub>2</sub> | 12:1 9c          | 2382-40-3  | 198.302     |       |              |                     |
| Tridecanoic acid                                         |                           | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub> | 13:0             | 638-53-9   | 214.344     | 41.5  | 6.5          | 92 <sup>1</sup>     |
| Tetradecanoic acid                                       | Myristic acid             | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub> | 14:0             | 544-63-8   | 228.371     | 54.2  | 19           | 295                 |
| <i>cis</i> -9-Tetradecenoic acid                         | Myristoleic acid          | C <sub>14</sub> H <sub>26</sub> O <sub>2</sub> | 14:1 9c          | 13147-06-3 | 226.355     | -4    |              |                     |
| Pentadecanoic acid                                       |                           | C <sub>15</sub> H <sub>30</sub> O <sub>2</sub> | 15:0             | 1002-84-2  | 242.398     | 52.3  | 18.5         | 153.5               |
| Hexadecanoic acid                                        | Palmitic acid             | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub> | 16:0             | 57-10-3    | 256.424     | 62.5  | 30           | 417                 |
| <i>cis</i> -9-Hexadecenoic acid                          | Palmitoleic acid          | C <sub>16</sub> H <sub>30</sub> O <sub>2</sub> | 16:1 9c          | 373-49-9   | 254.408     | 0.5   |              | 140 <sup>5</sup>    |
| Heptadecanoic acid                                       | Margaric acid             | C <sub>17</sub> H <sub>34</sub> O <sub>2</sub> | 17:0             | 506-12-7   | 270.451     | 61.3  | 30           | 185 <sup>9</sup>    |
| Octadecanoic acid                                        | Stearic acid              | C <sub>18</sub> H <sub>36</sub> O <sub>2</sub> | 18:0             | 57-11-4    | 284.478     | 69.3  | 39.1         | 443                 |
| <i>cis</i> -6-Octadecenoic acid                          | Petroselinic acid         | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub> | 18:1 6c          | 593-39-5   | 282.462     | 29.8  |              |                     |
| <i>cis</i> -9-Octadecenoic acid                          | Oleic acid                | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub> | 18:1 9c          | 112-80-1   | 282.462     | 13.4  | -19.9        | 218.5 <sup>20</sup> |
| <i>trans</i> -9-Octadecenoic acid                        | Elaidic acid              | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub> | 18:1 9t          | 112-79-8   | 282.462     | 45    | 13.5         | 218 <sup>24</sup>   |
| <i>cis</i> -11-Octadecenoic acid                         | <i>cis</i> -Vaccenic acid | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub> | 18:1 11c         | 506-17-2   | 282.462     | 15    |              | 163 <sup>0.1</sup>  |
| <i>trans</i> -11-Octadecenoic acid                       | Vaccenic acid             | C <sub>18</sub> H <sub>34</sub> O <sub>2</sub> | 18:1 11t         | 693-72-1   | 282.462     | 44    |              | 172 <sup>3</sup>    |
| <i>cis</i> -12,13-Epoxy- <i>cis</i> -9-octadecenoic acid | Vernolic acid             | C <sub>18</sub> H <sub>32</sub> O <sub>3</sub> | 18:1 12,13-ep,9c | 503-07-1   | 296.445     | 32.5  |              |                     |
| 12-Hydroxy- <i>cis</i> -9-octadecenoic acid              | Ricinoleic acid           | C <sub>18</sub> H <sub>34</sub> O <sub>3</sub> | 18:1 12-OH,9c    | 141-22-0   | 298.461     | 5.5   |              | 226 <sup>15</sup>   |
| <i>cis,trans</i> -9,11-Octadecadienoic acid              | Rumenic (CLA)             | C <sub>18</sub> H <sub>32</sub> O <sub>2</sub> | 18:2 9c,11t      | 1839-11-8  | 280.446     | 20    |              |                     |
| <i>cis,cis</i> -9,12-Octadecadienoic acid                | Linoleic acid             | C <sub>18</sub> H <sub>32</sub> O <sub>2</sub> | 18:2 9c,12c      | 60-33-3    | 280.446     | -7    | -35          | 215 <sup>20</sup>   |



| Systematic name                                                | Common name             | Mol.<br>form.                                  | Acid code                  | CAS RN     | Mol.<br>weight | mp/°C | <u>Methyl ester</u><br>mp/°C bp/°C |                      |
|----------------------------------------------------------------|-------------------------|------------------------------------------------|----------------------------|------------|----------------|-------|------------------------------------|----------------------|
| <i>trans,cis</i> -10,12-Octadecadienoic acid                   | (CLA)                   | C <sub>18</sub> H <sub>32</sub> O <sub>2</sub> | 18:2 10t,12c               | 22880-03-1 | 280.446        | 23    | -12                                |                      |
| <i>cis</i> -9-Octadecen-12-ynoic acid                          | Crepenynic acid         | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:2 9c,12a                | 2277-31-8  | 278.430        |       |                                    |                      |
| <i>cis,cis,cis</i> -5,9,12-Octadecatrienoic acid               | Pinolenic acid          | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 5c,9c,12c             | 27213-43-0 | 278.430        |       |                                    |                      |
| <i>trans,cis,cis</i> -5,9,12-Octadecatrienoic acid             | Columbinic acid         | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 5t,9c,12c             | 2441-53-4  | 278.430        |       |                                    |                      |
| <i>cis,cis,cis</i> -6,9,12-Octadecatrienoic acid               | γ-Linolenic acid        | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 6c,9c,12c             | 506-26-3   | 278.430        |       |                                    | 162 <sup>0.5</sup>   |
| <i>trans,trans,cis</i> -8,10,12-Octadecatrienoic acid          | Calendic acid           | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 8t,10t,12c            | 28872-28-8 | 278.430        | 40    |                                    |                      |
| <i>cis,trans,cis</i> -9,11,13-Octadecatrienoic acid            | Punicic acid            | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 9c,11t,13c            | 544-72-9   | 278.430        | 45    |                                    |                      |
| <i>cis,trans,trans</i> -9,11,13-Octadecatrienoic acid          | α-Eleostearic acid      | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 9c,11t,13t            | 506-23-0   | 278.430        | 49    |                                    | 148 <sup>1</sup>     |
| <i>trans,trans,cis</i> -9,11,13-Octadecatrienoic acid          | Catalpic acid           | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 9t,11t,13c            | 4337-71-7  | 278.430        | 32    |                                    |                      |
| <i>trans,trans,trans</i> -9,11,13-Octadecatrienoic acid        | β-Eleostearic acid      | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 9t,11t,13t            | 544-73-0   | 278.430        | 71.5  | 13                                 | 162 <sup>1</sup>     |
| <i>cis,cis,cis</i> -9,12,15-Octadecatrienoic acid              | α-Linolenic acid        | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | 18:3 9c,12c,15c            | 463-40-1   | 278.430        | -11.3 | -52                                | 109 <sup>0.018</sup> |
| 6,9,12,15-Octadecatetraenoic acid, all <i>cis</i>              | Stearidonic acid        | C <sub>18</sub> H <sub>28</sub> O <sub>2</sub> | 18:4 6c,9c,12c,15c         | 20290-75-9 | 276.414        | -57   |                                    |                      |
| <i>cis,trans,trans,cis</i> -9,11,13,15-Octadecatetraenoic acid | Parinaric acid          | C <sub>18</sub> H <sub>28</sub> O <sub>2</sub> | 18:4 9c,11t,13t,15c        | 593-38-4   | 276.414        | 86    |                                    |                      |
| Nonadecanoic acid                                              |                         | C <sub>19</sub> H <sub>38</sub> O <sub>2</sub> | 19:0                       | 646-30-0   | 298.504        | 69.4  | 41.3                               | 190 <sup>4</sup>     |
| Eicosanoic acid                                                | Arachidic acid          | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub> | 20:0                       | 506-30-9   | 312.531        | 76.5  | 54.5                               | 215 <sup>10</sup>    |
| 3,7,11,15-Tetramethylhexadecanoic acid                         | Phytanic acid           | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub> | 16:0 3,7,11,15-tetramethyl | 14721-66-5 | 312.531        | -65   |                                    |                      |
| <i>cis</i> -5-Eicosenoic acid                                  |                         | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub> | 20:1 5c                    | 7050-07-9  | 310.515        | 27    |                                    |                      |
| <i>cis</i> -9-Eicosenoic acid                                  | Gadoleic acid           | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub> | 20:1 9c                    | 29204-02-2 | 310.515        | 24.5  |                                    |                      |
| <i>cis</i> -11-Eicosenoic acid                                 | Gondoic acid            | C <sub>20</sub> H <sub>38</sub> O <sub>2</sub> | 20:1 11c                   | 2462-94-4  | 310.515        | 24    |                                    |                      |
| <i>cis,cis,cis</i> -8,11,14-Eicosatrienoic acid                | Dihomo-γ-linolenic acid | C <sub>20</sub> H <sub>34</sub> O <sub>2</sub> | 20:3 8c,11c,14c            | 1783-84-2  |                |       |                                    |                      |
| 5,8,11,14-Eicosatetraenoic acid, all <i>cis</i>                | Arachidonic acid        | C <sub>20</sub> H <sub>32</sub> O <sub>2</sub> | 20:4 5c,8c,11c,14c         | 506-32-1   | 304.467        | -49.5 |                                    | 195 <sup>0.7</sup>   |
| 5,8,11,14,17-Eicosapentanoic acid, all <i>cis</i>              | Timnodonic acid, EPA    | C <sub>20</sub> H <sub>30</sub> O <sub>2</sub> | 20:5 5c,8c,11c,14c,17c     | 10417-94-4 | 302.451        | -54   |                                    |                      |
| Heneicosanoic acid                                             |                         | C <sub>21</sub> H <sub>42</sub> O <sub>2</sub> | 21:0                       | 2363-71-5  | 326.557        | 82    | 49                                 | 207 <sup>4</sup>     |
| Docosanoic acid                                                | Behenic acid            | C <sub>22</sub> H <sub>44</sub> O <sub>2</sub> | 22:0                       | 112-85-6   | 340.583        | 81.5  | 54                                 |                      |
| <i>cis</i> -11-Docosenoic acid                                 | Cetolic acid            | C <sub>22</sub> H <sub>42</sub> O <sub>2</sub> | 22:1 11c                   | 506-36-5   | 338.567        | 33    |                                    |                      |
| <i>cis</i> -13-Docosenoic acid                                 | Erucic acid             | C <sub>22</sub> H <sub>42</sub> O <sub>2</sub> | 22:1 13c                   | 112-86-7   | 338.567        | 34.7  |                                    | 221 <sup>5</sup>     |
| <i>trans</i> -13-Docosenoic acid                               | Brassicidic acid        | C <sub>22</sub> H <sub>42</sub> O <sub>2</sub> | 22:1 13t                   | 506-33-2   | 338.567        | 61.9  | 35                                 |                      |
| <i>cis,cis</i> -5,13-Docosadienoic acid                        |                         | C <sub>22</sub> H <sub>40</sub> O <sub>2</sub> | 22:2 5c,13c                | 676-39-1   | 336.552        | -4    |                                    |                      |
| 7,10,13,16,19-Docosapentaenoic acid, all <i>cis</i>            |                         | C <sub>22</sub> H <sub>34</sub> O <sub>2</sub> | 22:5 7c,10c,13c,16c,19c    |            |                |       |                                    |                      |
| 4,7,10,13,16,19-Docosahexaenoic acid, all <i>cis</i>           | Cervonic acid, DHA      | C <sub>22</sub> H <sub>32</sub> O <sub>2</sub> | 22:6 4c,7c,10c,13c,16c,19c | 2091-24-9  |                | -45   |                                    |                      |
| Tricosanoic acid                                               |                         | C <sub>23</sub> H <sub>46</sub> O <sub>2</sub> | 23:0                       | 2433-96-7  |                | 79.6  | 53.4                               |                      |
| Tetracosanoic acid                                             | Lignoceric acid         | C <sub>24</sub> H <sub>48</sub> O <sub>2</sub> | 24:0                       | 557-59-5   | 368.637        | 87.5  | 60                                 |                      |
| <i>cis</i> -15-Tetracosenoic acid                              | Nervonic acid           | C <sub>24</sub> H <sub>46</sub> O <sub>2</sub> | 24:1 15c                   | 506-37-6   | 366.621        | 43    | 15                                 | 165 <sup>0.02</sup>  |
| Pentacosanoic acid                                             |                         | C <sub>25</sub> H <sub>50</sub> O <sub>2</sub> | 25:0                       | 506-38-7   | 382.664        | 77.5  | 62                                 |                      |
| Hexacosanoic acid                                              | Cerotic acid            | C <sub>26</sub> H <sub>52</sub> O <sub>2</sub> | 26:0                       | 506-46-7   | 396.690        | 88.5  | 63.8                               | 286 <sup>15</sup>    |
| Heptacosanoic acid                                             |                         | C <sub>27</sub> H <sub>54</sub> O <sub>2</sub> | 27:0                       | 7138-40-1  |                | 87.6  | 64                                 |                      |
| Octacosanoic acid                                              | Montanic acid           | C <sub>28</sub> H <sub>56</sub> O <sub>2</sub> | 28:0                       | 506-48-9   | 424.744        | 90.9  | 67                                 |                      |
| Nonacosanoic acid                                              |                         | C <sub>29</sub> H <sub>58</sub> O <sub>2</sub> | 29:0                       | 4250-38-8  | 438.770        | 90.3  | 69                                 |                      |
| Triacosanoic acid                                              | Melissic acid           | C <sub>30</sub> H <sub>60</sub> O <sub>2</sub> | 30:0                       | 506-50-3   | 452.796        | 93.6  | 72                                 |                      |
| Hentriacontanoic acid                                          |                         | C <sub>31</sub> H <sub>62</sub> O <sub>2</sub> | 31:0                       | 38232-01-8 | 466.823        | 93.1  |                                    |                      |
| Dotriacontanoic acid                                           | Lacceric acid           | C <sub>32</sub> H <sub>64</sub> O <sub>2</sub> | 32:0                       | 3625-52-3  | 480.849        | 96.2  |                                    | 192 <sup>0.01</sup>  |

## CARBOHYDRATE NAMES AND SYMBOLS

The following table lists the systematic names and symbols for selected carbohydrates and some of their derivatives. The symbols for monosaccharide residues and derivatives are recommended by IUPAC for use in describing the structures of oligosaccharide chains. A more complete list can be found in the reference.

### Reference

McNaught, A. D., *Pure Appl. Chem.*, 68, 1919-2008, 1996.

| Common name                          | Symbol                | Systematic name                                          |
|--------------------------------------|-----------------------|----------------------------------------------------------|
| Abequose                             | Abe                   | 3,6-Dideoxy-D-xylo-hexose                                |
| N-Acetyl-2-deoxyneur-2-enaminic acid | Neu2en5Ac             |                                                          |
| N-Acetylgalactosamine                | GalNAc                |                                                          |
| N-Acetylglucosamine                  | GlcNAc                |                                                          |
| N-Acetylneuraminic acid              | Neu5Ac                |                                                          |
| Allose                               | All                   | <i>allo</i> -Hexose                                      |
| Altrose                              | Alt                   | <i>altro</i> -Hexose                                     |
| Apiose                               | Api                   | 3-C-(Hydroxymethyl)- <i>glycero</i> -tetrose             |
| Arabinitol                           | Ara-ol                | Arabinitol                                               |
| Arabinose                            | Ara                   | <i>arabino</i> -Pentose                                  |
| Arcanose                             |                       | 2,6-Dideoxy-3-C-methyl-3-O-methyl-xylo-hexose            |
| Ascarylose                           |                       | 3,6-Dideoxy-L- <i>arabino</i> -hexose                    |
| Boivinose                            |                       | 2,6-Dideoxy-D-gulose                                     |
| Chalcase                             |                       | 4,6-Dideoxy-3-O-methyl-D-xylo-hexose                     |
| Cladinose                            |                       | 2,6-Dideoxy-3-C-methyl-3-O-methyl-L- <i>ribo</i> -hexose |
| Colitose                             |                       | 3,6-Dideoxy-L-xylo-hexose                                |
| Cymarose                             |                       | 6-Deoxy-3-O-methyl- <i>ribo</i> -hexose                  |
| 3-Deoxy-D-manno-oct-2-ulosonic acid  | Kdo                   |                                                          |
| 2-Deoxyribose                        | dRib                  | 2-Deoxy- <i>erythro</i> -pentose                         |
| 2,3-Diamino-2,3-dideoxy-D-glucose    | GlcN3N                |                                                          |
| Diginose                             |                       | 2,6-Dideoxy-3-O-methyl- <i>lyxo</i> -hexose              |
| Digitalose                           |                       | 6-Deoxy-3-O-methyl-D-galactose                           |
| Digitoxose                           |                       | 2,6-Dideoxy-D- <i>ribo</i> -hexose                       |
| 3,4-Di-O-methylrhamnose              | Rha3,4Me <sub>2</sub> |                                                          |
| Ethyl glucopyranuronate              | Glc <sub>p</sub> A6Et |                                                          |
| Evalose                              |                       | 6-Deoxy-3-C-methyl-D-mannose                             |
| Fructose                             | Fru                   | <i>arabino</i> -Hex-2-ulose                              |
| Fucitol                              | Fuc-ol                | 6-Deoxy-D-galactitol                                     |
| Fucose                               | Fuc                   | 6-Deoxygalactose                                         |
| β-D-Galactopyranose 4-sulfate        | β-D-Galp4S            |                                                          |
| Galactosamine                        | GalN                  | 2-Amino-2-deoxygalactose                                 |
| Galactose                            | Gal                   | <i>galacto</i> -Hexose                                   |
| Glucitol                             | Glc-ol                |                                                          |
| Glucosamine                          | GlcN                  | 2-Amino-2-deoxyglucose                                   |
| Glucose                              | Glc                   | <i>gluco</i> -Hexose                                     |
| Glucuronic acid                      | GlcA                  |                                                          |
| N-Glycoloylneuraminic acid           | Neu5Gc                |                                                          |
| Gulose                               | Gul                   | <i>gulo</i> -Hexose                                      |
| Hamamelose                           |                       | 2-C-(Hydroxymethyl)-D-ribose                             |
| Idose                                | Ido                   | <i>ido</i> -Hexose                                       |
| Iduronic acid                        | IdoA                  |                                                          |
| Lactose                              | Lac                   | β-D-Galactopyranosyl-(1→4)-D-glucose                     |
| Lyxose                               | Lyx                   | <i>lyxo</i> -Pentose                                     |
| Maltose                              |                       | α-D-Glucopyranosyl-(1→4)-D-glucose                       |
| Mannose                              | Man                   | <i>manno</i> -Hexose                                     |
| 2-C-Methylxylose                     | Xyl2CMe               |                                                          |
| Muramic acid                         | Mur                   | 2-Amino-3-O-[(R)-1-carboxyethyl]-2-deoxy-D-glucose       |
| Mycarose                             |                       | 2,6-Dideoxy-3-C-methyl-L- <i>ribo</i> -hexose            |
| Mycinose                             |                       | 6-Deoxy-2,3-di-O-methyl-D-allose                         |

| Common name        | Symbol       | Systematic name                                                                                           |
|--------------------|--------------|-----------------------------------------------------------------------------------------------------------|
| Neuraminic acid    | Neu          | 5-Amino-3,5-dideoxy-D- <i>glycero</i> -D- <i>galacto</i> -non-2-ulosonic acid                             |
| Panose             |              | $\alpha$ -D-Glucopyranosyl-(1 $\rightarrow$ 6)- $\alpha$ -D-glucopyranosyl-(1 $\rightarrow$ 4)-D-glucose  |
| Paratose           |              | 3,6-Dideoxy-D- <i>ribo</i> -hexose                                                                        |
| Primeverose        |              | $\beta$ -D-Xylopyranosyl-(1 $\rightarrow$ 6)-D-glucose                                                    |
| Psicose            | Psi          | <i>ribo</i> -Hex-2-ulose                                                                                  |
| Quinovose          | Qui          | 6-Deoxyglucose                                                                                            |
|                    |              | $\beta$ -D-Fructofuranosyl- $\alpha$ -D-galactopyranosyl-(1 $\rightarrow$ 6)- $\alpha$ -D-glucopyranoside |
| Raffinose          |              | 6-Deoxymannose                                                                                            |
| Rhamnose           | Rha          | 2,3,6-Trideoxy-L- <i>threo</i> -hexose                                                                    |
| Rhodinose          |              |                                                                                                           |
| Ribose             | Rib          | <i>ribo</i> -Pentose                                                                                      |
| Ribose 5-phosphate | Rib5P        |                                                                                                           |
| Ribulose           | Ribulo (Rul) | <i>erythro</i> -Pent-2-ulose                                                                              |
| Rutinose           |              | $\alpha$ -L-Rhamnopyranosyl-(1 $\rightarrow$ 6)-D-glucose                                                 |
| Sarmentose         |              | 2,6-Dideoxy-3- <i>O</i> -methyl-D- <i>xylo</i> -hexose                                                    |
| Sedoheptulose      |              | D- <i>altro</i> -Hept-2-ulose                                                                             |
| Sorbose            | Sor          | <i>xylo</i> -Hex-2-ulose                                                                                  |
| Streptose          |              | 5-Deoxy-3- <i>C</i> -formyl-L-lyxose                                                                      |
| Sucrose            |              | $\beta$ -D-Fructofuranosyl- $\alpha$ -D-glucopyranoside                                                   |
| Tagatose           | Tag          | <i>lyxo</i> -Hex-2-ulose                                                                                  |
| Talose             | Tal          | <i>talo</i> -Hexose                                                                                       |
| Turanose           |              | $\alpha$ -D-Glucopyranosyl-(1 $\rightarrow$ 3)-D-fructose                                                 |
| Tyvelose           | Tyv          | 3,6-Dideoxy-D- <i>arabino</i> -hexose                                                                     |
| Xylose             | Xyl          | <i>xylo</i> -Pentose                                                                                      |
| Xylulose           | Xylulo (Xul) | <i>threo</i> -Pent-2-ulose                                                                                |

## BIOLOGICAL BUFFERS

This table of frequently used buffers gives the  $pK_a$  value at 25°C and the useful pH range of each buffer. The buffers are listed in order of increasing pH.

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| Acronym         | Name                                                                             | Mol. wt. | $pK_a$           | Useful pH range |
|-----------------|----------------------------------------------------------------------------------|----------|------------------|-----------------|
| MES             | 2-( <i>N</i> -Morpholino)ethanesulfonic acid                                     | 195.2    | 6.1              | 5.5–6.7         |
| BIS TRIS        | Bis(2-hydroxyethyl)iminotris(hydroxymethyl)methane                               | 209.2    | 6.5              | 5.8–7.2         |
| ADA             | <i>N</i> -(2-Acetamido)-2-iminodiacetic acid                                     | 190.2    | 6.6              | 6.0–7.2         |
| ACES            | 2-[(2-Amino-2-oxoethyl)amino]ethanesulfonic acid                                 | 182.2    | 6.8              | 6.1–7.5         |
| PIPES           | Piperazine- <i>N,N'</i> -bis(2-ethanesulfonic acid)                              | 302.4    | 6.8              | 6.1–7.5         |
| MOPSO           | 3-( <i>N</i> -Morpholino)-2-hydroxypropanesulfonic acid                          | 225.3    | 6.9              | 6.2–7.6         |
| BIS TRISPROPANE | 1,3-Bis[tris(hydroxymethyl)methylamino]propane                                   | 282.3    | 6.8 <sup>a</sup> | 6.3–9.5         |
| BES             | <i>N,N</i> -Bis(2-hydroxyethyl)-2-aminoethanesulfonic acid                       | 213.2    | 7.1              | 6.4–7.8         |
| MOPS            | 3-( <i>N</i> -Morpholino)propanesulfonic acid                                    | 209.3    | 7.2              | 6.5–7.9         |
| HEPES           | <i>N</i> -(2-Hydroxyethyl)piperazine- <i>N'</i> -(2-ethanesulfonic acid)         | 238.3    | 7.5              | 6.8–8.2         |
| TES             | <i>N</i> -Tris(hydroxymethyl)methyl-2-aminoethanesulfonic acid                   | 229.2    | 7.5              | 6.8–8.2         |
| DIPSO           | 3-[ <i>N,N</i> -Bis(2-hydroxyethyl)amino]-2-hydroxypropanesulfonic acid          | 243.3    | 7.6              | 7.0–8.2         |
| TAPSO           | 3-[ <i>N</i> -Tris(hydroxymethyl)methylamino]-2-hydroxypropanesulfonic acid      | 259.3    | 7.6              | 7.0–8.2         |
| TRIZMA          | Tris(hydroxymethyl)aminomethane                                                  | 121.1    | 8.1              | 7.0–9.1         |
| HEPPSO          | <i>N</i> -(2-hydroxyethyl)piperazine- <i>N'</i> -(2-hydroxypropanesulfonic acid) | 268.3    | 7.8              | 7.1–8.5         |
| POPPO           | Piperazine- <i>N,N'</i> -bis(2-hydroxypropanesulfonic acid)                      | 362.4    | 7.8              | 7.2–8.5         |
| EPPS            | <i>N</i> -(2-Hydroxyethyl)piperazine- <i>N'</i> -(3-propanesulfonic acid)        | 252.3    | 8.0              | 7.3–8.7         |
| TEA             | Triethanolamine                                                                  | 149.2    | 7.8              | 7.3–8.3         |
| TRICINE         | <i>N</i> -Tris(hydroxymethyl)methylglycine                                       | 179.2    | 8.1              | 7.4–8.8         |
| BICINE          | <i>N,N</i> -Bis(2-hydroxyethyl)glycine                                           | 163.2    | 8.3              | 7.6–9.0         |
| TAPS            | <i>N</i> -Tris(hydroxymethyl)methyl-3-aminopropanesulfonic acid                  | 243.3    | 8.4              | 7.7–9.1         |
| AMPSO           | 3-[(1,1-Dimethyl-2-hydroxyethyl)amino]-2-hydroxypropanesulfonic acid             | 227.3    | 9.0              | 8.3–9.7         |
| CHES            | 2-( <i>N</i> -Cyclohexylamino)ethanesulfonic acid                                | 207.3    | 9.3              | 8.6–10.0        |
| CAPSO           | 3-(Cyclohexylamino)-2-hydroxy-1-propanesulfonic acid                             | 237.3    | 9.6              | 8.9–10.3        |
| AMP             | 2-Amino-2-methyl-1-propanol                                                      | 89.1     | 9.7              | 9.0–10.5        |
| CAPS            | 3-(Cyclohexylamino)-1-propanesulfonic acid                                       | 221.3    | 10.4             | 9.7–11.1        |

<sup>a</sup>  $pK_a$  = 9.0 for the second dissociation stage.

## TYPICAL pH VALUES OF BIOLOGICAL MATERIALS AND FOODS

This table gives typical pH ranges for various biological fluids and common foods. All values refer to 25°C.

| Biological Materials     |           |                 |         |
|--------------------------|-----------|-----------------|---------|
| Blood, human             | 7.35–7.45 | Hominy (lye)    | 6.8–8.0 |
| Blood, dog               | 6.9–7.2   | Jams, fruit     | 3.5–4.0 |
| Spinal fluid, human      | 7.3–7.5   | Jellies, fruit  | 2.8–3.4 |
| Saliva, human            | 6.5–7.5   | Lemons          | 2.2–2.4 |
| Gastric contents, human  | 1.0–3.0   | Limes           | 1.8–2.0 |
| Duodenal contents, human | 4.8–8.2   | Maple syrup     | 6.5–7.0 |
| Feces, human             | 4.6–8.4   | Milk, cows      | 6.3–6.6 |
| Urine, human             | 4.8–8.4   | Olives          | 3.6–3.8 |
| Milk, human              | 6.6–7.6   | Oranges         | 3.0–4.0 |
| Bile, human              | 6.8–7.0   | Oysters         | 6.1–6.6 |
| Foods                    |           | Peaches         | 3.4–3.6 |
| Apples                   | 2.9–3.3   | Pears           | 3.6–4.0 |
| Apricots                 | 3.6–4.0   | Peas            | 5.8–6.4 |
| Asparagus                | 5.4–5.8   | Pickles, dill   | 3.2–3.6 |
| Bananas                  | 4.5–4.7   | Pickles, sour   | 3.0–3.4 |
| Beans                    | 5.0–6.0   | Pimento         | 4.6–5.2 |
| Beers                    | 4.0–5.0   | Plums           | 2.8–3.0 |
| Beets                    | 4.9–5.5   | Potatoes        | 5.6–6.0 |
| Blackberries             | 3.2–3.6   | Pumpkin         | 4.8–5.2 |
| Bread, white             | 5.0–6.0   | Raspberries     | 3.2–3.6 |
| Butter                   | 6.1–6.4   | Rhubarb         | 3.1–3.2 |
| Cabbage                  | 5.2–5.4   | Salmon          | 6.1–6.3 |
| Carrots                  | 4.9–5.3   | Sauerkraut      | 3.4–3.6 |
| Cheese                   | 4.8–6.4   | Shrimp          | 6.8–7.0 |
| Cherries                 | 3.2–4.0   | Soft drinks     | 2.0–4.0 |
| Cider                    | 2.9–3.3   | Spinach         | 5.1–5.7 |
| Corn                     | 6.0–6.5   | Squash          | 5.0–5.4 |
| Crackers                 | 6.5–8.5   | Strawberries    | 3.0–3.5 |
| Dates                    | 6.2–6.4   | Sweet potatoes  | 5.3–5.6 |
| Eggs, fresh white        | 7.6–8.0   | Tomatoes        | 4.0–4.4 |
| Flour, wheat             | 5.5–6.5   | Tuna            | 5.9–6.1 |
| Gooseberries             | 2.8–3.0   | Turnips         | 5.2–5.6 |
| Grapefruit               | 3.0–3.3   | Vinegar         | 2.4–3.4 |
| Grapes                   | 3.5–4.5   | Water, drinking | 6.5–8.0 |
|                          |           | Wines           | 2.8–3.8 |

## CHEMICAL COMPOSITION OF THE HUMAN BODY

The elemental composition of the “standard man” of mass 70 kg is given below.

### References

1. Padikal, T. N., and Fivozinsky, S. P., *Medical Physics Data Book, National Bureau of Standards Handbook 138*, U. S. Government Printing Office, Washington, DC, 1981.
2. Snyder, W. S., et al., *Reference Man: Anatomical, Physiological, and Metabolic Characteristics*, Pergamon, New York, 1975.

| Element    | Amount<br>(g)        | Percent of total<br>body mass |
|------------|----------------------|-------------------------------|
| Oxygen     | 43,000               | 61                            |
| Carbon     | 16,000               | 23                            |
| Hydrogen   | 7000                 | 10                            |
| Nitrogen   | 1800                 | 2.6                           |
| Calcium    | 1000                 | 1.4                           |
| Phosphorus | 780                  | 1.1                           |
| Sulfur     | 140                  | 0.20                          |
| Potassium  | 140                  | 0.20                          |
| Sodium     | 100                  | 0.14                          |
| Chlorine   | 95                   | 0.12                          |
| Magnesium  | 19                   | 0.027                         |
| Silicon    | 18                   | 0.026                         |
| Iron       | 4.2                  | 0.006                         |
| Fluorine   | 2.6                  | 0.0037                        |
| Zinc       | 2.3                  | 0.0033                        |
| Rubidium   | 0.32                 | 0.00046                       |
| Strontium  | 0.32                 | 0.00046                       |
| Bromine    | 0.20                 | 0.00029                       |
| Lead       | 0.12                 | 0.00017                       |
| Copper     | 0.072                | 0.00010                       |
| Aluminum   | 0.061                | 0.00009                       |
| Cadmium    | 0.050                | 0.00007                       |
| Boron      | <0.048               | 0.00007                       |
| Barium     | 0.022                | 0.00003                       |
| Tin        | <0.017               | 0.00002                       |
| Manganese  | 0.012                | 0.00002                       |
| Iodine     | 0.013                | 0.00002                       |
| Nickel     | 0.010                | 0.00001                       |
| Gold       | <0.010               | 0.00001                       |
| Molybdenum | <0.0093              | 0.00001                       |
| Chromium   | <0.0018              | 0.000003                      |
| Cesium     | 0.0015               | 0.000002                      |
| Cobalt     | 0.0015               | 0.000002                      |
| Uranium    | 0.00009              | 0.0000001                     |
| Beryllium  | 0.000036             |                               |
| Radium     | $3.1 \cdot 10^{-11}$ |                               |

# STANDARD TRANSFORMED GIBBS ENERGIES OF FORMATION FOR BIOCHEMICAL REACTANTS

Robert N. Goldberg and Robert A. Alberty

This table contains values of the standard transformed Gibbs energies of formation  $\Delta_f G'^{\circ}$  for 130 biochemical reactants. Values of  $\Delta_f G'^{\circ}$  are given at pH 7.0, the temperature 298.15 K, and the pressure 100 kPa for three ionic strengths:  $I = 0$ ,  $I = 0.1$  mol/L and  $I = 0.25$  mol/L. The table can be used for calculating apparent equilibrium constants  $K'$  and standard apparent reduction potentials  $E'^{\circ}$  for biochemical reactions. Such a listing is more compact than tabulating the actual apparent equilibrium constants or standard apparent reduction potentials, which would require a very large number of reactant-product combinations. In the table, all reactants are in aqueous solution unless indicated otherwise.

A biochemical reactant is a sum of species. For example, ATP consists of an equilibrium mixture of the aqueous species  $\text{ATP}^4$ ,  $\text{HATP}^3$ ,  $\text{H}_2\text{ATP}^{2-}$ ,  $\text{MgATP}^{2-}$ , etc. Similarly, phosphate refers to the equilibrium mixture of the aqueous species  $\text{PO}_4^{3-}$ ,  $\text{HPO}_4^{2-}$ ,  $\text{H}_2\text{PO}_4^-$ ,  $\text{H}_3\text{PO}_4$ ,  $\text{MgHPO}_4$ , etc. Biochemical reactions are written using biochemical reactants in terms of an apparent equilibrium constant  $K'$ , which is distinct from the standard equilibrium constant  $K$ . This subject is discussed in an IUPAC report (see Reference 1 below).

The apparent equilibrium constant  $K'$  and the standard transformed Gibbs energy change  $\Delta_r G'^{\circ}$  for a biochemical reaction can be calculated from the  $\Delta_f G'^{\circ}$  values by using the relationship

$$-RT \ln K' = \Delta_r G'^{\circ} = \sum \nu_i' \Delta_f G'^{\circ},$$

where the summation is over all of the biochemical reactants. The quantity  $\nu_i'$  is the stoichiometric number of reactant  $i$  ( $\nu_i'$  is positive for reactants on the right side of the equation and negative for reactants on the left side);  $R$  is the gas constant. As an example, the hydrolysis reaction of ATP is

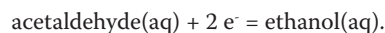


At pH 7.00 and  $I = 0.25$  M,  $\Delta_r G'^{\circ}$  and  $K'$  are calculated as follows:

$$\Delta_r G'^{\circ} = \{-1424.70 - 1059.49 - (-2292.50 - 155.66)\} \cdot (\text{kJ mol}^{-1}) = -36.03 \text{ kJ mol}^{-1}$$

$$K' = \exp[-(-36030 \text{ J mol}^{-1}) / \{(8.3145 \text{ J mol}^{-1} \text{ K}^{-1}) \cdot (298.15 \text{ K})\}] = 2.05 \cdot 10^6$$

An example involving a biochemical half-cell reaction is



At 298.15 K, pH 7.00, and  $I = 0$ , the standard apparent reduction potential  $E'^{\circ}$  can be calculated as follows

$$E'^{\circ} = -(1/nF) \cdot \{\Delta_f G'^{\circ}(\text{ethanol}) - \Delta_f G'^{\circ}(\text{acetaldehyde})\},$$

where  $n$  is the number of electrons in the half-cell reaction and  $F$  is the Faraday constant. Then,

$$E'^{\circ} = [-1 / (2 \cdot 9.6485 \cdot 10^4 \text{ C mol}^{-1})] \cdot (-58.10 \cdot 10^3 \text{ J mol}^{-1} - 20.83 \cdot 10^3 \text{ J mol}^{-1}) = -0.193 \text{ V}$$

## References

1. Alberty, R.A., Cornish-Bowden, A., Gibson, Q.H., Goldberg, R.N., Hammes, G., Jencks, W., Tipton, K.F., Veech, R., Westerhoff, H.V., and Webb, E.C. *Pure Appl. Chem.* 66, 1641-1666, 1994.
2. Alberty, R.A., *Arch. Biochem. Biophys.*, 353, 116-130, 1998; 358, 25-39, 1998.
3. Alberty, R.A., *Thermodynamics of Biochemical Reactions*, Wiley-Interscience, New York, 2003.
4. Alberty, R.A., *BasicBiochemData2: Data and Programs for Biochemical Thermodynamics*, <<http://library.wolfram.com/infocenter/MathSource/797>>.

| Reactant                         | $\Delta_f G'^{\circ}(I = 0)$<br>kJ mol <sup>-1</sup> | $\Delta_f G'^{\circ}(I = 0.1 \text{ M})$<br>kJ mol <sup>-1</sup> | $\Delta_f G'^{\circ}(I = 0.25 \text{ M})$<br>kJ mol <sup>-1</sup> |
|----------------------------------|------------------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------|
| Acetaldehyde                     | 20.83                                                | 23.27                                                            | 24.06                                                             |
| Acetate                          | -249.46                                              | -248.23                                                          | -247.83                                                           |
| Acetone                          | 80.04                                                | 83.71                                                            | 84.90                                                             |
| Acetyl Coenzyme A                | -60.49                                               | -58.65                                                           | -58.06                                                            |
| Acetylphosphate                  | -1109.34                                             | -1107.57                                                         | -1107.02                                                          |
| cis-Aconitate                    | -797.26                                              | -800.93                                                          | -802.12                                                           |
| Adenine                          | 510.45                                               | 513.51                                                           | 514.50                                                            |
| Adenosine                        | 324.93                                               | 332.89                                                           | 335.46                                                            |
| Adenosine 5'-diphosphate (ADP)   | -1428.93                                             | -1425.55                                                         | -1424.70                                                          |
| Adenosine 5'-monophosphate (AMP) | -562.04                                              | -556.53                                                          | -554.83                                                           |
| Adenosine 5'-triphosphate (ATP)  | -2292.61                                             | -2292.16                                                         | -2292.50                                                          |
| D-Alanine                        | -91.31                                               | -87.02                                                           | -85.64                                                            |
| Ammonia                          | 80.50                                                | 82.34                                                            | 82.93                                                             |
| D-Arabinose                      | -342.67                                              | -336.55                                                          | -334.57                                                           |
| L-Asparagine                     | -206.28                                              | -201.38                                                          | -199.80                                                           |
| L-Aspartate                      | -456.14                                              | -453.08                                                          | -452.09                                                           |
| 1,3-Biphosphoglycerate           | -2202.06                                             | -2205.69                                                         | -2207.30                                                          |
| Butanoate                        | -72.94                                               | -69.26                                                           | -68.08                                                            |
| 1-Butanol                        | 227.72                                               | 233.84                                                           | 235.82                                                            |

| Reactant                                               | $\Delta_f G'^{\circ}(I = 0)$<br>kJ mol <sup>-1</sup> | $\Delta_f G'^{\circ}(I = 0.1 \text{ M})$<br>kJ mol <sup>-1</sup> | $\Delta_f G'^{\circ}(I = 0.25 \text{ M})$<br>kJ mol <sup>-1</sup> |
|--------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------|
| Citrate                                                | -963.46                                              | -965.49                                                          | -966.23                                                           |
| Isocitrate                                             | -956.82                                              | -958.84                                                          | -959.58                                                           |
| Coenzyme A (CoA)                                       | -7.98                                                | -7.43                                                            | -7.26                                                             |
| CO(aq)                                                 | -119.90                                              | -119.90                                                          | -119.90                                                           |
| CO(g)                                                  | -137.17                                              | -137.17                                                          | -137.17                                                           |
| CO <sub>2</sub> (aq)[total]                            | -547.33                                              | -547.15                                                          | -547.10                                                           |
| CO <sub>2</sub> (g)                                    | -394.36                                              | -394.36                                                          | -394.36                                                           |
| Creatine                                               | 100.41                                               | 105.92                                                           | 107.69                                                            |
| Creatinine                                             | 256.55                                               | 260.84                                                           | 262.22                                                            |
| L-Cysteine                                             | -59.23                                               | -55.01                                                           | -53.65                                                            |
| L-Cystine                                              | -187.03                                              | -179.69                                                          | -177.32                                                           |
| Cytochrome c [oxidized]                                | 0.00                                                 | -5.51                                                            | -7.29                                                             |
| Cytochrome c [reduced]                                 | -24.51                                               | -26.96                                                           | -27.75                                                            |
| Dihydroxyacetone phosphate                             | -1096.60                                             | -1095.91                                                         | -1095.70                                                          |
| Ethanol                                                | 58.10                                                | 61.77                                                            | 62.96                                                             |
| Ethyl acetate                                          | -18.00                                               | -13.10                                                           | -11.52                                                            |
| Ferredoxin [oxidized]                                  | 0.00                                                 | -0.61                                                            | -0.81                                                             |
| Ferredoxin [reduced]                                   | 38.07                                                | 38.07                                                            | 38.07                                                             |
| Flavine adenine dinucleotide (FAD) [oxidized]          | 1238.65                                              | 1255.17                                                          | 1260.51                                                           |
| Flavine adenine dinucleotide (FAD) [reduced]           | 1279.68                                              | 1297.43                                                          | 1303.16                                                           |
| Flavin adenine dinucleotide-enzyme (FADenz) [oxidized] | 1238.65                                              | 1255.17                                                          | 1260.51                                                           |
| Flavin adenine dinucleotide-enzyme (FADenz) [reduced]  | 1229.96                                              | 1247.71                                                          | 1253.44                                                           |
| Flavin mononucleotide (FMN) [oxidized]                 | 759.17                                               | 768.35                                                           | 771.32                                                            |
| Flavin mononucleotide (FMN) [reduced]                  | 800.20                                               | 810.61                                                           | 813.97                                                            |
| Formate                                                | -311.04                                              | -311.04                                                          | -311.04                                                           |
| D-Fructose                                             | -436.03                                              | -428.69                                                          | -426.32                                                           |
| D-Fructose 1,6-diphosphate                             | -2202.84                                             | -2205.66                                                         | -2206.78                                                          |
| D-Fructose 6-phosphate                                 | -1321.71                                             | -1317.16                                                         | -1315.74                                                          |
| Fumarate                                               | -521.97                                              | -523.19                                                          | -523.58                                                           |
| D-Galactose                                            | -429.45                                              | -422.11                                                          | -419.74                                                           |
| $\alpha$ -D-Galactose 1-phosphate                      | -1317.50                                             | -1313.01                                                         | -1311.60                                                          |
| D-Glucose                                              | -436.42                                              | -429.08                                                          | -426.71                                                           |
| $\alpha$ -D-Glucose 1-phosphate                        | -1318.03                                             | -1313.34                                                         | -1311.89                                                          |
| D-Glucose 6-phosphate                                  | -1325.00                                             | -1320.37                                                         | -1318.92                                                          |
| Glutamate                                              | -377.82                                              | -373.54                                                          | -372.16                                                           |
| D-Glutamine                                            | -128.46                                              | -122.34                                                          | -120.36                                                           |
| Glutathione [oxidized]                                 | 1198.69                                              | 1214.60                                                          | 1219.74                                                           |
| Glutathione [reduced]                                  | 625.75                                               | 634.76                                                           | 637.62                                                            |
| Glutathione-coenzyme A                                 | 563.49                                               | 572.06                                                           | 574.83                                                            |
| D-Glyceraldehyde 3-phosphate                           | -1088.94                                             | -1088.25                                                         | -1088.04                                                          |
| Glycerol                                               | -177.83                                              | -172.93                                                          | -171.35                                                           |
| sn-Glycerol 3-phosphate                                | -1080.22                                             | -1077.83                                                         | -1077.13                                                          |
| Glycine                                                | -180.13                                              | -177.07                                                          | -176.08                                                           |
| Glycolate                                              | -411.08                                              | -409.86                                                          | -409.46                                                           |
| Glycylglycine                                          | -200.55                                              | -195.65                                                          | -194.07                                                           |
| Glyoxylate                                             | -428.64                                              | -428.64                                                          | -428.64                                                           |
| H <sub>2</sub> (aq)                                    | 97.51                                                | 98.74                                                            | 99.13                                                             |
| H <sub>2</sub> (g)                                     | 79.91                                                | 81.14                                                            | 81.53                                                             |
| H <sub>2</sub> O(l)                                    | -157.28                                              | -156.05                                                          | -155.66                                                           |
| H <sub>2</sub> O <sub>2</sub> (aq)                     | -54.12                                               | -52.89                                                           | -52.50                                                            |
| 3-Hydroxypropanoate                                    | -318.62                                              | -316.17                                                          | -315.38                                                           |
| Hypoxanthine                                           | 249.33                                               | 251.77                                                           | 252.56                                                            |
| Indole                                                 | 503.49                                               | 507.78                                                           | 509.16                                                            |
| Lactate                                                | -316.94                                              | -314.49                                                          | -313.70                                                           |
| Lactose                                                | -688.29                                              | -674.83                                                          | -670.48                                                           |
| L-Leucine                                              | 167.18                                               | 175.14                                                           | 177.71                                                            |
| L-Isoleucine                                           | 175.53                                               | 183.49                                                           | 186.06                                                            |
| D-Lyxose                                               | -349.58                                              | -343.46                                                          | -341.48                                                           |
| Malate                                                 | -682.88                                              | -682.85                                                          | -682.85                                                           |
| Maltose                                                | -695.65                                              | -682.19                                                          | -677.84                                                           |



| Reactant                                                      | $\Delta_f G'^{\circ}(I = 0)$<br>kJ mol <sup>-1</sup> | $\Delta_f G'{}^{\circ}(I = 0.1 \text{ M})$<br>kJ mol <sup>-1</sup> | $\Delta_f G'{}^{\circ}(I = 0.25 \text{ M})$<br>kJ mol <sup>-1</sup> |
|---------------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------|---------------------------------------------------------------------|
| <i>D</i> -Mannitol                                            | -383.22                                              | -374.65                                                            | -371.89                                                             |
| Mannose                                                       | -430.52                                              | -423.18                                                            | -420.81                                                             |
| Methane(aq)                                                   | 125.50                                               | 127.94                                                             | 128.73                                                              |
| Methane(g)                                                    | 109.11                                               | 111.55                                                             | 112.34                                                              |
| Methanol                                                      | -15.48                                               | -13.04                                                             | -12.25                                                              |
| <i>L</i> -Methionine                                          | -63.40                                               | -56.67                                                             | -54.49                                                              |
| N <sub>2</sub> (aq)                                           | 18.70                                                | 18.70                                                              | 18.70                                                               |
| N <sub>2</sub> (g)                                            | 0.00                                                 | 0.00                                                               | 0.00                                                                |
| Nicotinamide Adenine Dinucleotide (NAD) [oxidized]            | 1038.86                                              | 1054.17                                                            | 1059.11                                                             |
| Nicotinamide Adenine Dinucleotide (NAD) [reduced]             | 1101.47                                              | 1115.55                                                            | 1120.09                                                             |
| Nicotinamide Adenine Dinucleotide Phosphate (NADP) [oxidized] | 163.73                                               | 173.52                                                             | 176.68                                                              |
| Nicotinamide Adenine Dinucleotide Phosphate (NADP) [reduced]  | 229.67                                               | 235.79                                                             | 237.77                                                              |
| O <sub>2</sub> (aq)                                           | 16.40                                                | 16.40                                                              | 16.40                                                               |
| O <sub>2</sub> (g)                                            | 0.00                                                 | 0.00                                                               | 0.00                                                                |
| Oxalate                                                       | -673.90                                              | -676.35                                                            | -677.14                                                             |
| Oxaloacetate                                                  | -713.38                                              | -714.60                                                            | -715.00                                                             |
| Oxalosuccinate                                                | -979.05                                              | -979.05                                                            | -979.05                                                             |
| 2-Oxoglutarate                                                | -633.58                                              | -633.58                                                            | -633.58                                                             |
| Palmitate                                                     | 979.25                                               | 997.61                                                             | 1003.54                                                             |
| <i>L</i> -Phenylalanine                                       | 232.42                                               | 239.15                                                             | 241.33                                                              |
| Phosphate                                                     | -1058.56                                             | -1059.17                                                           | -1059.49                                                            |
| 2-Phospho- <i>D</i> -glycerate                                | -1340.72                                             | -1341.32                                                           | -1341.79                                                            |
| 3-Phospho- <i>D</i> -glycerate                                | -1346.38                                             | -1347.19                                                           | -1347.73                                                            |
| Phosphoenolpyruvate                                           | -1185.46                                             | -1188.53                                                           | -1189.73                                                            |
| 1-Propanol                                                    | 143.84                                               | 148.74                                                             | 150.32                                                              |
| 2-Propanol                                                    | 134.42                                               | 139.32                                                             | 140.90                                                              |
| Pyrophosphate                                                 | -1934.95                                             | -1939.13                                                           | -1940.66                                                            |
| Pyruvate                                                      | -352.40                                              | -351.18                                                            | -350.78                                                             |
| Retinal                                                       | 1118.78                                              | 1135.91                                                            | 1141.45                                                             |
| Retinol                                                       | 1170.78                                              | 1189.14                                                            | 1195.07                                                             |
| Ribose                                                        | -339.23                                              | -333.11                                                            | -331.13                                                             |
| Ribose 1-phosphate                                            | -1215.87                                             | -1212.24                                                           | -1211.14                                                            |
| Ribose 5-phosphate                                            | -1223.95                                             | -1220.32                                                           | -1219.22                                                            |
| Ribulose                                                      | -336.38                                              | -330.26                                                            | -328.28                                                             |
| <i>L</i> -Serine                                              | -231.18                                              | -226.89                                                            | -225.51                                                             |
| Sorbose                                                       | -432.47                                              | -425.13                                                            | -422.76                                                             |
| Succinate                                                     | -530.72                                              | -530.65                                                            | -530.64                                                             |
| Succinyl Coenzyme A                                           | -349.90                                              | -348.06                                                            | -347.47                                                             |
| Sucrose                                                       | -685.66                                              | -672.20                                                            | -667.85                                                             |
| Thioredoxin [oxidized]                                        | 0.00                                                 | 0.00                                                               | 0.00                                                                |
| Thioredoxin [reduced]                                         | 54.32                                                | 55.41                                                              | 55.74                                                               |
| <i>L</i> -Tryptophan                                          | 364.78                                               | 372.12                                                             | 374.49                                                              |
| <i>L</i> -Tyrosine                                            | 68.82                                                | 75.55                                                              | 77.73                                                               |
| Ubiquinone [oxidized]                                         | 3596.07                                              | 3651.15                                                            | 3668.94                                                             |
| Ubiquinone [reduced]                                          | 3586.06                                              | 3642.37                                                            | 3660.55                                                             |
| Urate                                                         | -206.03                                              | -204.81                                                            | -204.41                                                             |
| Urea                                                          | -42.97                                               | -40.53                                                             | -39.74                                                              |
| Uric acid                                                     | -197.07                                              | -194.63                                                            | -193.84                                                             |
| <i>L</i> -Valine                                              | 80.87                                                | 87.60                                                              | 89.78                                                               |
| <i>D</i> -Xylose                                              | -350.93                                              | -344.81                                                            | -342.83                                                             |
| <i>D</i> -Xylulose                                            | -346.59                                              | -340.47                                                            | -338.49                                                             |

# THERMODYNAMIC QUANTITIES FOR THE IONIZATION REACTIONS OF BUFFERS IN WATER

Robert N. Goldberg, Nand Kishore, and Rebecca M. Lennen

This table contains selected values for the  $pK$ , standard molar enthalpy of reaction  $\Delta_r H^\circ$ , and standard molar heat-capacity change  $\Delta_r C_p^\circ$  for the ionization reactions of 64 buffers many of which are relevant to biochemistry and to biology.<sup>1</sup> The values pertain to the temperature  $T = 298.15$  K and the pressure  $p = 0.1$  MPa. The standard state is the hypothetical ideal solution of unit molality. These data permit one to calculate values of the  $pK$  and of  $\Delta_r H^\circ$  at temperatures in the vicinity  $\{T \approx (274 \text{ K to } 350 \text{ K})\}$  of the reference temperature  $\theta = 298.15$  K by using the following equations<sup>2</sup>

$$\Delta_r G_T^\circ = -RT \ln K_T = \ln(10) \cdot RT \cdot pK_T, \quad (1)$$

$$R \ln K_T = -(\Delta_r G_\theta^\circ / \theta) + \Delta_r H_\theta^\circ \{ (1/\theta) - (1/T) \} + \Delta_r C_{p\theta}^\circ \{ (\theta/T) - 1 + \ln(T/\theta) \}, \quad (2)$$

$$\Delta_r H_T^\circ = \Delta_r H_\theta^\circ + \Delta_r C_{p\theta}^\circ (T - \theta). \quad (3)$$

Here,  $\Delta_r G^\circ$  is the standard molar Gibbs energy change and  $K$  is the equilibrium constant for a reaction;  $R$  is the gas constant (8.314 472 J K<sup>-1</sup> mol<sup>-1</sup>). The subscripts  $T$  and  $\theta$  denote the temperature to which a quantity pertains, the subscript  $p$  denotes constant pres-

sure, and the subscript  $r$  denotes that the quantity refers to a reaction. Combination of equations (1) and (2) yields the following equation that gives  $pK$  as a function of temperature:

$$pK_T = -\{R \ln(10)\}^{-1} [-\{\ln(10) \cdot RT \cdot pK_\theta / \theta\} + \Delta_r H_\theta^\circ \{ (1/\theta) - (1/T) \} + \Delta_r C_{p\theta}^\circ \{ (\theta/T) - 1 + \ln(T/\theta) \}]. \quad (4)$$

The above equations neglect higher order terms that involve temperature derivatives of  $\Delta_r C_p^\circ$ . Also, it is important to recognize that the values of  $pK$  and  $\Delta_r H^\circ$  effectively pertain to ionic strength  $I = 0$ . However, the values of  $pK$  and  $\Delta_r H^\circ$  are almost always dependent on the ionic strength and the actual composition of the solution. These issues are discussed in Reference 1, which also gives an approximate method for making appropriate corrections.

## References

- Goldberg, R. N., Kishore, N., and Lennen, R. M., "Thermodynamic Quantities for the Ionization Reactions of Buffers," *J. Phys. Chem. Ref. Data*, 31, 231, 2002.
- Clarke, E. C. W., and Glew, D. N., *Trans. Faraday Soc.*, 62, 539-547, 1966.

### Selected Values of Thermodynamic Quantities for the Ionization Reactions of Buffers in Water at $T = 298.15$ K and $p = 0.1$ MPa

| Buffer                           | Reaction                                                                                                     | $pK$   | $\Delta_r H^\circ$   | $\Delta_r C_p^\circ$                |
|----------------------------------|--------------------------------------------------------------------------------------------------------------|--------|----------------------|-------------------------------------|
|                                  |                                                                                                              |        | kJ mol <sup>-1</sup> | J mol <sup>-1</sup> K <sup>-1</sup> |
| ACES                             | $HL^\pm = H^+ + L^-$ , (HL = C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub> S)                 | 6.847  | 30.43                | -49                                 |
| Acetate                          | $HL = H^+ + L^-$ , (HL = C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> )                                      | 4.756  | -0.41                | -142                                |
| ADA                              | $H_3L^+ = H^+ + H_2L^+$ , (H <sub>2</sub> L = C <sub>6</sub> H <sub>10</sub> N <sub>2</sub> O <sub>5</sub> ) | 1.59   |                      |                                     |
|                                  | $H_2L^+ = H^+ + HL^-$                                                                                        | 2.48   | 16.7                 |                                     |
|                                  | $HL^- = H^+ + L^{2-}$                                                                                        | 6.844  | 12.23                | -144                                |
|                                  | $HL^+ = H^+ + L$ , (L = C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub> )                                     | 8.801  | 49.85                | -44                                 |
| 2-Amino-2-methyl-1,3-propanediol | $HL^+ = H^+ + L$ , (L = C <sub>4</sub> H <sub>11</sub> NO)                                                   | 9.694  | 54.05                | ≈ -21                               |
| 3-Amino-1-propanesulfonic acid   | $HL = H^+ + L^-$ , (HL = C <sub>3</sub> H <sub>9</sub> NO <sub>3</sub> S)                                    | 10.2   |                      |                                     |
| Ammonia                          | $NH_4^+ = H^+ + NH_3$                                                                                        | 9.245  | 51.95                | 8                                   |
| AMPSO                            | $HL^\pm = H^+ + L^-$ , (HL = C <sub>7</sub> H <sub>17</sub> NO <sub>5</sub> S)                               | 9.138  | 43.19                | -61                                 |
| Arsenate                         | $H_3AsO_4 = H^+ + H_2AsO_4^-$                                                                                | 2.31   | -7.8                 |                                     |
|                                  | $H_2AsO_4^- = H^+ + HAsO_4^{2-}$                                                                             | 7.05   | 1.7                  |                                     |
|                                  | $HAsO_4^{2-} = H^+ + AsO_4^{3-}$                                                                             | 11.9   | 15.9                 |                                     |
|                                  | $H_2L = H^+ + HL^-$ , (H <sub>2</sub> L = C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub> )     | 7.980  | 24.27                | -135                                |
| Barbital                         | $HL^- = H^+ + L^{2-}$                                                                                        | 12.8   |                      |                                     |
| BES                              | $HL^\pm = H^+ + L^-$ , (HL = C <sub>6</sub> H <sub>15</sub> NO <sub>5</sub> S)                               | 7.187  | 24.25                | -2                                  |
| Bicine                           | $H_2L^+ = H^+ + HL^\pm$ , (HL = C <sub>6</sub> H <sub>13</sub> NO <sub>4</sub> )                             | 2.0    |                      |                                     |
|                                  | $HL^\pm = H^+ + L^-$                                                                                         | 8.334  | 26.34                | 0                                   |
| Bis-tris                         | $H_3L^+ = H^+ + H_2L^+$ , (H <sub>2</sub> L = C <sub>8</sub> H <sub>19</sub> NO <sub>5</sub> )               | 6.484  | 28.4                 | 27                                  |
| Bis-tris propane                 | $H_2L^{2+} = H^+ + HL^+$ , (L = C <sub>11</sub> H <sub>26</sub> N <sub>2</sub> O <sub>6</sub> )              | 6.65   |                      |                                     |
|                                  | $HL^+ = H^+ + L$                                                                                             | 9.10   |                      |                                     |
| Borate                           | $H_3BO_3 = H^+ + H_2BO_3^-$                                                                                  | 9.237  | 13.8                 | ≈ -240                              |
| Cacodylate                       | $H_2L^+ = H^+ + HL$ , (HL = C <sub>2</sub> H <sub>6</sub> AsO <sub>2</sub> )                                 | 1.78   | -3.5                 |                                     |
|                                  | $HL = H^+ + L^-$                                                                                             | 6.28   | -3.0                 | -86                                 |
| CAPS                             | $HL^\pm = H^+ + L^-$ , (HL = C <sub>9</sub> H <sub>19</sub> NO <sub>3</sub> S)                               | 10.499 | 48.1                 | 57                                  |
| CAPSO                            | $HL^\pm = H^+ + L^-$ , (HL = C <sub>9</sub> H <sub>19</sub> NO <sub>4</sub> S)                               | 9.825  | 46.67                | 21                                  |
| Carbonate                        | $H_2CO_3 = H^+ + HCO_3^-$                                                                                    | 6.351  | 9.15                 | -371                                |
|                                  | $HCO_3^- = H^+ + CO_3^{2-}$                                                                                  | 10.329 | 14.70                | -249                                |
| CHES                             | $HL^\pm = H^+ + L^-$ , (HL = C <sub>8</sub> H <sub>17</sub> NO <sub>3</sub> S)                               | 9.394  | 39.55                | 9                                   |

| Buffer                | Reaction                                           | pK               | $\Delta_r H^\circ$   | $\Delta_r C_p^\circ$                |
|-----------------------|----------------------------------------------------|------------------|----------------------|-------------------------------------|
|                       |                                                    |                  | kJ mol <sup>-1</sup> | J mol <sup>-1</sup> K <sup>-1</sup> |
| Citrate               | $H_3L = H^+ + H_2L^-, (H_3L = C_6H_8O_7)$          | 3.128            | 4.07                 | -131                                |
|                       | $H_2L^- = H^+ + HL^{2-}$                           | 4.761            | 2.23                 | -178                                |
|                       | $HL^{2-} = H^+ + L^{3-}$                           | 6.396            | -3.38                | -254                                |
| L-Cysteine            | $H_3L^+ = H^+ + H_2L, (H_2L = C_3H_7NO_2S)$        | 1.71             | ≈-0.6                |                                     |
|                       | $H_2L = H^+ + HL^-$                                | 8.36             | 36.1                 | ≈-66                                |
|                       | $HL^- = H^+ + L^{2-}$                              | 10.75            | 34.1                 | ≈-204                               |
| Diethanolamine        | $HL^+ = H^+ + L, (L = C_4H_{11}NO_2)$              | 8.883            | 42.08                | 36                                  |
| Diglycolate           | $H_2L = H^+ + HL^-, (H_2L = C_4H_6O_5)$            | 3.05             | -0.1                 | ≈-142                               |
|                       | $HL^- = H^+ + L^{2-}$                              | 4.37             | -7.2                 | ≈-138                               |
| 3,3-Dimethylglutarate | $H_2L = H^+ + HL^-, (H_2L = C_7H_{12}O_4)$         | 3.70             |                      |                                     |
|                       | $HL^- = H^+ + L^{2-}$                              | 6.34             |                      |                                     |
| DIPSO                 | $HL^\pm = H^+ + L^-, (HL = C_7H_{17}NO_6S)$        | 7.576            | 30.18                | 42                                  |
| Ethanolamine          | $HL^+ = H^+ + L, (L = C_2H_7NO)$                   | 9.498            | 50.52                | 26                                  |
| N-Ethylmorpholine     | $HL^+ = H^+ + L, (L = C_6H_{13}NO)$                | 7.77             | 27.4                 |                                     |
| Glycerol 2-phosphate  | $H_2L = H^+ + HL^-, (H_2L = C_3H_9NO_6P)$          | 1.329            | -12.2                | -330                                |
|                       | $HL^- = H^+ + L^{2-}$                              | 6.650            | -1.85                | -212                                |
| Glycine               | $H_2L^+ = H^+ + HL^\pm, (HL = C_2H_5NO_2)$         | 2.351            | 4.00                 | -139                                |
|                       | $HL^\pm = H^+ + L^-$                               | 9.780            | 44.2                 | -57                                 |
| Glycine amide         | $HL^+ = H^+ + L, (L = C_2H_6N_2O)$                 | 8.04             | 42.9                 |                                     |
| Glycylglycine         | $H_2L^+ = H^+ + HL^\pm, (HL = C_4H_8N_2O_3)$       | 3.140            | 0.11                 | -128                                |
|                       | $HL^\pm = H^+ + L^-$                               | 8.265            | 43.4                 | -16                                 |
| Glycylglycylglycine   | $H_2L^+ = H^+ + HL^\pm, (HL = C_6H_{11}N_3O_4)$    | 3.224            | 0.84                 |                                     |
|                       | $HL^\pm = H^+ + L^-$                               | 8.090            | 41.7                 |                                     |
| HEPES                 | $H_2L^+ = H^+ + HL^\pm, (HL = C_8H_{18}N_2O_4S)$   | ≈3.0             |                      |                                     |
|                       | $HL^\pm = H^+ + L^-$                               | 7.564            | 20.4                 | 47                                  |
| HEPPS                 | $HL^\pm = H^+ + L^-, (HL = C_6H_{20}N_2O_4S)$      | 7.957            | 21.3                 | 48                                  |
| HEPPSO                | $HL^\pm = H^+ + L^-, (HL = C_9H_{20}N_2O_5S)$      | 8.042            | 23.70                | 47                                  |
| L-Histidine           | $H_3L^{2+} = H^+ + H_2L^+, (HL = C_6H_9N_3O_2)$    | 1.5 <sub>4</sub> | 3.6                  |                                     |
|                       | $H_2L^+ = H^+ + HL$                                | 6.07             | 29.5                 | 176                                 |
|                       | $HL = H^+ + L^-$                                   | 9.34             | 43.8                 | -233                                |
| Hydrazine             | $H_2L^{2+} = H^+ + HL^+, (L = H_4N_2)$             | -0.99            | 38.1                 |                                     |
|                       | $HL^+ = H^+ + L$                                   | 8.02             | 41.7                 |                                     |
| Imidazole             | $HL^+ = H^+ + L, (L = C_3H_4N_2)$                  | 6.993            | 36.64                | -9                                  |
| Maleate               | $H_2L = H^+ + HL^-, (H_2L = C_4H_4O_4)$            | 1.92             | 1.1                  | ≈-21                                |
|                       | $HL^- = H^+ + L^{2-}$                              | 6.27             | -3.6                 | ≈-31                                |
| 2-Mercaptoethanol     | $HL = H^+ + L^-, (HL = C_2H_6OS)$                  | 9.7 <sub>5</sub> | 26.2                 |                                     |
| MES                   | $HL^\pm = H^+ + L^-, (HL = C_6H_{13}NO_4S)$        | 6.270            | 14.8                 | 5                                   |
| Methylamine           | $HL^+ = H^+ + L, (L = CH_5N)$                      | 10.645           | 55.34                | 33                                  |
| 2-Methylimidazole     | $HL^+ = H^+ + L, (L = C_4H_6N_2)$                  | 8.0 <sub>1</sub> | 36.8                 |                                     |
| MOPS                  | $HL^\pm = H^+ + L^-, (HL = C_7H_{15}NO_4S)$        | 7.184            | 21.1                 | 25                                  |
| MOPSO                 | $H_2L^+ = H^+ + HL^\pm, (HL = C_7H_{15}NO_5S)$     | 0.060            |                      |                                     |
|                       | $HL^\pm = H^+ + L^-$                               | 6.90             | 25.0                 | ≈38                                 |
| Oxalate               | $H_2L = H^+ + HL^-, (H_2L = C_2H_2O_4)$            | 1.27             | -3.9                 | ≈-231                               |
|                       | $HL^- = H^+ + L^{2-}$                              | 4.266            | 7.00                 | -231                                |
| Phosphate             | $H_3PO_4 = H^+ + H_2PO_4^-$                        | 2.148            | -8.0                 | -141                                |
|                       | $H_2PO_4^- = H^+ + HPO_4^{2-}$                     | 7.198            | 3.6                  | -230                                |
|                       | $HPO_4^{2-} = H^+ + PO_4^{3-}$                     | 12.35            | 16.0                 | -242                                |
| Phthalate             | $H_2L = H^+ + HL^-, (H_2L = C_8H_6O_4)$            | 2.950            | -2.70                | -91                                 |
|                       | $HL^- = H^+ + L^{2-}$                              | 5.408            | -2.17                | -295                                |
| Piperazine            | $H_2L^{2+} = H^+ + HL^+, (L = C_4H_{10}N_2)$       | 5.333            | 31.11                | 86                                  |
|                       | $HL^+ = H^+ + L$                                   | 9.731            | 42.89                | 75                                  |
| PIPES                 | $HL^\pm = H^+ + L^-, (HL = C_8H_{18}N_2O_6S_2)$    | 7.141            | 11.2                 | 22                                  |
| POPSO                 | $HL^\pm = H^+ + L^-, (HL = C_{10}H_{22}N_2O_8S_2)$ | ≈8.0             |                      |                                     |
| Pyrophosphate         | $H_4P_2O_7 = H^+ + H_3P_2O_7^-$                    | 0.83             | -9.2                 | ≈-90                                |
|                       | $H_3P_2O_7^- = H^+ + H_2P_2O_7^{2-}$               | 2.26             | -5.0                 | ≈-130                               |
|                       | $H_2P_2O_7^{2-} = H^+ + HP_2O_7^{3-}$              | 6.72             | 0.5                  | -136                                |
|                       | $HP_2O_7^{3-} = H^+ + P_2O_7^{4-}$                 | 9.46             | 1.4                  | -141                                |
| Succinate             | $H_2L = H^+ + HL^-, (H_2L = C_4H_6O_4)$            | 4.207            | 3.0                  | -121                                |
|                       | $HL^- = H^+ + L^{2-}$                              | 5.636            | -0.5                 | -217                                |
| Sulfate               | $HSO_4^- = H^+ + SO_4^{2-}$                        | 1.987            | -22.4                | -258                                |

| Buffer             | Reaction                                                                                                    | pK    | $\Delta_r H^\circ$   | $\Delta_r C_p^\circ$              |
|--------------------|-------------------------------------------------------------------------------------------------------------|-------|----------------------|-----------------------------------|
|                    |                                                                                                             |       | $\text{kJ mol}^{-1}$ | $\text{J mol}^{-1} \text{K}^{-1}$ |
| Sulfite            | $\text{H}_2\text{SO}_3 = \text{H}^+ + \text{HSO}_3^-$                                                       | 1.857 | -17.80               | -272                              |
|                    | $\text{HSO}_3^- = \text{H}^+ + \text{SO}_3^{2-}$                                                            | 7.172 | -3.65                | -262                              |
| TAPS               | $\text{HL}^\pm = \text{H}^+ + \text{L}^-$ , (HL = $\text{C}_7\text{H}_{17}\text{NO}_6\text{S}$ )            | 8.44  | 40.4                 | 15                                |
| TAPSO              | $\text{HL}^\pm = \text{H}^+ + \text{L}^-$ , (HL = $\text{C}_7\text{H}_{17}\text{NO}_7\text{S}$ )            | 7.635 | 39.09                | -16                               |
| L(+)-Tartaric acid | $\text{H}_2\text{L} = \text{H}^+ + \text{HL}^-$ , ( $\text{H}_2\text{L} = \text{C}_4\text{H}_6\text{O}_6$ ) | 3.036 | 3.19                 | -147                              |
|                    | $\text{HL}^- = \text{H}^+ + \text{L}^{2-}$                                                                  | 4.366 | 0.93                 | -218                              |
| TES                | $\text{HL}^\pm = \text{H}^+ + \text{L}^-$ , (HL = $\text{C}_6\text{H}_{15}\text{NO}_6\text{S}$ )            | 7.550 | 32.13                | 0                                 |
| Tricine            | $\text{H}_2\text{L}^+ = \text{H}^+ + \text{HL}^\pm$ , (HL = $\text{C}_6\text{H}_{13}\text{NO}_5$ )          | 2.023 | 5.85                 | -196                              |
|                    | $\text{HL}^\pm = \text{H}^+ + \text{L}^-$                                                                   | 8.135 | 31.37                | -53                               |
| Triethanolamine    | $\text{HL}^+ = \text{H}^+ + \text{L}$ , (L = $\text{C}_6\text{H}_{15}\text{NO}_3$ )                         | 7.762 | 33.6                 | 50                                |
| Triethylamine      | $\text{HL}^+ = \text{H}^+ + \text{L}$ , (L = $\text{C}_6\text{H}_{15}\text{N}$ )                            | 10.72 | 43.13                | 151                               |
| Tris               | $\text{HL}^+ = \text{H}^+ + \text{L}$ , (L = $\text{C}_4\text{H}_{11}\text{NO}_3$ )                         | 8.072 | 47.45                | -59                               |

## NUTRIENT VALUES OF FOODS

The U. S. Department of Agriculture maintains the USDA National Nutrient Database for Standard Reference, which contains over 7000 food items with data on the energy content, minerals, vitamins, and other properties of nutritional interest. The table here includes about 600 common foods extracted from that database. The properties listed are the energy content (in effect, the enthalpy of combustion); the content of carbohydrates, proteins, and lipids (fats); the cholesterol content; and the amount of sodium, potassium, calcium, magnesium, iron, copper, zinc, manganese, phosphorus, and selenium. All values are given for a 100 gram sample of the food.

To conform with common practice in nutritional science, the energy content is given in kilocalories. For conversion to kilojoules, this number should be multiplied by 4.184. For conversion to the avoirdupois units frequently used in the United States, note that:

1 oz = 28.35 g (thus the 100 g basis in this table is approximately 3.5 oz)

1 lb = 453.6 g

The full USDA database covers specific proprietary brands of many processed foods, and it includes vitamin content as well as the minerals given in this table.

### Reference

U.S. Department of Agriculture, Agricultural Research Service. 2005. USDA National Nutrient Database for Standard Reference, Release 18. Nutrient Data Laboratory Home Page, <http://www.ars.usda.gov/ba/bhnrc/ndl>

| Food description                                                   | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|--------------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Alcoholic beverage, beer, light                                    | 29                       | 1.6                  | 0.2                    | 0.0                | 0                     | 4                  | 21                | 4                 | 5                  | 0.03               | 0.006              | 0.01               | 0.006              | 12                | 0.4                |
| Alcoholic beverage, beer, regular                                  | 43                       | 3.6                  | 0.5                    | 0.0                | 0                     | 4                  | 27                | 4                 | 6                  | 0.02               | 0.005              | 0.01               | 0.008              | 14                | 0.6                |
| Alcoholic beverage, dessert wine, sweet                            | 160                      | 13.7                 | 0.2                    | 0.0                | 0                     | 9                  | 92                | 8                 | 9                  | 0.24               | 0.045              | 0.07               | 0.119              | 9                 | 0.5                |
| Alcoholic beverage, distilled (gin, rum, vodka, whiskey), 80 proof | 231                      | 0.0                  | 0.0                    | 0.0                | 0                     | 1                  | 2                 | 0                 | 0                  | 0.04               | 0.021              | 0.04               | 0.018              | 4                 | 0.0                |
| Alcoholic beverage, distilled (gin, rum, vodka, whiskey), 90 proof | 263                      | 0.0                  | 0.0                    | 0.0                | 0                     | 1                  | 2                 | 0                 | 0                  | 0.04               | 0.021              | 0.04               | 0.018              | 4                 | 0.0                |
| Alcoholic beverage, distilled, all, 100 proof                      | 295                      | 0.0                  | 0.0                    | 0.0                | 0                     | 1                  | 2                 | 0                 | 0                  | 0.04               | 0.021              | 0.04               | 0.018              | 4                 | 0.0                |
| Alcoholic beverage, liqueur, coffee, 63 proof                      | 308                      | 32.2                 | 0.1                    | 0.3                | 0                     | 8                  | 30                | 1                 | 3                  | 0.06               | 0.040              | 0.03               | 0.017              | 6                 | 0.3                |
| Alcoholic beverage, table wine, red                                | 85                       | 2.6                  | 0.1                    | 0.0                | 0                     | 4                  | 127               | 8                 | 12                 | 0.46               | 0.011              | 0.14               | 0.132              | 23                | 0.2                |
| Alcoholic beverage, table wine, white                              | 83                       | 2.6                  | 0.1                    | 0.0                | 0                     | 5                  | 71                | 9                 | 10                 | 0.27               | 0.004              | 0.12               | 0.117              | 18                | 0.1                |
| Almonds, dry roasted, w/o salt                                     | 597                      | 19.3                 | 22.1                   | 52.8               | 0                     | 1                  | 746               | 266               | 286                | 4.51               | 1.170              | 3.54               | 2.620              | 489               | 2.8                |
| Almonds, oil roasted, w/o salt                                     | 607                      | 17.7                 | 21.2                   | 55.2               | 0                     | 1                  | 699               | 291               | 274                | 3.68               | 0.955              | 3.07               | 2.460              | 466               | 2.8                |
| Apple juice, canned or bottled, unsweetened, w/o vitamin C         | 47                       | 11.7                 | 0.1                    | 0.1                | 0                     | 3                  | 119               | 7                 | 3                  | 0.37               | 0.022              | 0.03               | 0.113              | 7                 | 0.1                |
| Apples, raw, w/o skin                                              | 48                       | 12.8                 | 0.3                    | 0.1                | 0                     | 0                  | 90                | 5                 | 4                  | 0.07               | 0.031              | 0.05               | 0.038              | 11                | 0.0                |
| Apples, raw, with skin                                             | 52                       | 13.8                 | 0.3                    | 0.2                | 0                     | 1                  | 107               | 6                 | 5                  | 0.12               | 0.027              | 0.04               | 0.035              | 11                | 0.0                |
| Apricots, dried, sulfured, stewed, w. sugar                        | 113                      | 29.3                 | 1.2                    | 0.2                | 0                     | 3                  | 443               | 15                | 15                 | 1.52               | 0.138              | 0.24               | 0.088              | 38                |                    |
| Apricots, dried, sulfured, stewed, w/o sugar                       | 85                       | 22.2                 | 1.2                    | 0.2                | 0                     | 4                  | 411               | 19                | 11                 | 0.94               | 0.121              | 0.14               | 0.083              | 25                | 0.8                |
| Artichokes, (globe or French), boiled, w/o salt                    | 50                       | 11.2                 | 3.5                    | 0.2                | 0                     | 95                 | 354               | 45                | 60                 | 1.29               | 0.233              | 0.49               | 0.259              | 86                | 0.2                |
| Arugula, raw                                                       | 25                       | 3.7                  | 2.6                    | 0.7                | 0                     | 27                 | 369               | 160               | 47                 | 1.46               | 0.076              | 0.47               | 0.321              | 52                | 0.3                |
| Asparagus, boiled                                                  | 22                       | 4.1                  | 2.4                    | 0.2                | 0                     | 14                 | 224               | 23                | 14                 | 0.91               | 0.165              | 0.60               | 0.154              | 54                | 6.1                |
| Asparagus, raw                                                     | 20                       | 3.9                  | 2.2                    | 0.1                | 0                     | 2                  | 202               | 24                | 14                 | 2.14               | 0.189              | 0.54               | 0.158              | 52                | 2.3                |
| Avocados, raw, all commercial varieties                            | 160                      | 8.5                  | 2.0                    | 14.7               | 0                     | 7                  | 485               | 12                | 29                 | 0.55               | 0.190              | 0.64               | 0.142              | 52                | 0.4                |
| Bagel, plain, toasted, enriched w. calcium propionate              | 257                      | 50.5                 | 10.0                   | 1.6                | 0                     | 448                | 75                | 89                | 22                 | 6.05               | 0.130              | 1.90               | 0.515              | 87                | 22.8               |
| Bagels, cinnamon-raisin, toasted                                   | 294                      | 59.3                 | 10.6                   | 1.8                | 0                     | 346                | 163               | 20                | 23                 | 4.09               | 0.160              | 0.81               | 0.328              | 83                | 33.3               |
| Baked beans, canned, no salt                                       | 105                      | 20.6                 | 4.8                    | 0.4                | 0                     | 1                  | 296               | 50                | 32                 | 0.29               | 0.206              | 1.40               |                    | 104               | 4.5                |
| Bamboo shoots, boiled, w/o salt                                    | 12                       | 1.9                  | 1.5                    | 0.2                | 0                     | 4                  | 533               | 12                | 3                  | 0.24               | 0.082              | 0.47               | 0.113              | 20                | 0.4                |
| Bananas, raw                                                       | 89                       | 22.8                 | 1.1                    | 0.3                | 0                     | 1                  | 358               | 5                 | 27                 | 0.26               | 0.078              | 0.15               | 0.270              | 22                | 1.0                |
| Bass, freshwater, mixed species, cooked, dry heat                  | 146                      | 0.0                  | 24.2                   | 4.7                | 87                    | 90                 | 456               | 103               | 38                 | 1.91               | 0.119              | 0.83               | 1.140              | 256               | 16.2               |
| Bass, striped, cooked, dry heat                                    | 124                      | 0.0                  | 22.7                   | 3.0                | 103                   | 88                 | 328               | 19                | 51                 | 1.08               | 0.040              | 0.51               | 0.019              | 254               | 46.8               |
| Beans, French, mature seeds, boiled, w/o salt                      | 129                      | 24.0                 | 7.1                    | 0.8                | 0                     | 6                  | 370               | 63                | 56                 | 1.08               | 0.115              | 0.64               | 0.382              | 102               | 1.2                |
| Beans, kidney, all types, mature seeds, boiled, w/o salt           | 127                      | 22.8                 | 8.7                    | 0.5                | 0                     | 1                  | 405               | 35                | 42                 | 2.22               | 0.216              | 1.00               | 0.430              | 138               | 1.1                |
| Beans, lima, immature seeds, canned                                | 71                       | 13.3                 | 4.1                    | 0.3                | 0                     | 252                | 285               | 28                | 34                 | 1.61               | 0.162              | 0.64               | 0.700              | 71                | 1.1                |
| Beans, navy, mature seeds, canned                                  | 113                      | 20.5                 | 7.5                    | 0.4                | 0                     | 448                | 288               | 47                | 47                 | 1.85               | 0.208              | 0.77               | 0.375              | 134               | 5.8                |
| Beans, pinto, mature seeds, boiled, w/o salt                       | 143                      | 26.2                 | 9.0                    | 0.7                | 0                     | 1                  | 436               | 46                | 50                 | 2.09               | 0.219              | 0.98               | 0.453              | 147               | 6.2                |

| Food description                                                         | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100 g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|--------------------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Beans, snap, green, boiled, w/o salt                                     | 35                       | 7.9                  | 1.9                    | 0.3                | 0                     | 1                  | 146               | 44                 | 18                 | 0.65               | 0.057              | 0.25               | 0.285              | 29                | 0.2                |
| Beef, bottom sirloin, tri-tip roast, lean & fat, 0" fat, choice, roasted | 218                      | 0.0                  | 25.7                   | 12.4               | 94                    | 50                 | 308               | 17                 | 20                 | 1.70               | 0.083              | 4.52               | 0.009              | 189               | 27.3               |
| Beef, brisket, flat half, lean & fat, 1/8" fat, select, braised          | 280                      | 0.0                  | 29.0                   | 17.4               | 71                    | 49                 | 237               | 17                 | 19                 | 2.40               | 0.090              | 6.92               | 0.010              | 180               | 28.1               |
| Beef, chuck, arm pot roast, lean, 1/8" fat, choice, braised              | 224                      | 0.0                  | 34.7                   | 8.4                | 81                    | 56                 | 275               | 15                 | 23                 | 3.04               | 0.129              | 8.20               | 0.012              | 213               | 34.7               |
| Beef, ground, 75% lean meat / 25% fat, patty, broiled                    | 278                      | 0.0                  | 25.6                   | 18.7               | 89                    | 78                 | 289               | 30                 | 20                 | 2.37               | 0.075              | 6.19               | 0.010              | 189               | 21.4               |
| Beef, ground, 95% lean meat / 5% fat, patty, broiled                     | 171                      | 0.0                  | 26.3                   | 6.6                | 76                    | 65                 | 348               | 7                  | 22                 | 2.83               | 0.096              | 6.43               | 0.014              | 206               | 21.7               |
| Beef, loin, porterhouse steak, lean & fat, 1/4" fat, all grades, broiled | 329                      | 0.0                  | 22.5                   | 25.8               | 72                    | 62                 | 255               | 8                  | 20                 | 2.68               | 0.118              | 4.13               | 0.014              | 177               | 19.3               |
| Beef, loin, T-bone steak, lean & fat, 1/4" fat, all grades, broiled      | 306                      | 0.0                  | 23.5                   | 22.8               | 65                    | 67                 | 282               | 7                  | 22                 | 3.09               | 0.122              | 4.30               | 0.014              | 185               | 11.6               |
| Beef, rib, eye, small end (ribs 10-12), lean, 0" fat, choice, broiled    | 205                      | 0.0                  | 28.9                   | 9.0                | 91                    | 60                 | 363               | 16                 | 25                 | 1.98               | 0.092              | 5.49               | 0.011              | 227               | 33.6               |
| Beef, rib, large end (ribs 6-9), lean & fat, 1/4" fat, choice, roasted   | 383                      | 0.0                  | 22.3                   | 32.0               | 85                    | 63                 | 283               | 10                 | 19                 | 2.27               | 0.086              | 5.58               | 0.013              | 168               | 21.9               |
| Beef, round, bottom round roast, lean, 0" fat, select, roasted           | 169                      | 0.0                  | 28.3                   | 5.3                | 72                    | 38                 | 238               | 6                  | 19                 | 2.35               | 0.079              | 4.92               | 0.010              | 183               | 35.7               |
| Beef, round, bottom round, lean & fat, 1/8" fat, all grades, roasted     | 218                      | 0.0                  | 26.4                   | 11.6               | 75                    | 35                 | 214               | 6                  | 17                 | 2.16               | 0.063              | 4.43               | 0.009              | 164               | 27.0               |
| Beef, round, eye of round, lean & fat, 1/8" fat, all grades, roasted     | 208                      | 0.0                  | 28.3                   | 9.7                | 62                    | 37                 | 227               | 7                  | 18                 | 2.29               | 0.067              | 4.70               | 0.010              | 174               | 28.7               |
| Beef, tenderloin, lean & fat, 1/8" fat, all grades, broiled              | 267                      | 0.0                  | 26.5                   | 17.1               | 90                    | 54                 | 329               | 19                 | 22                 | 1.69               | 0.079              | 4.76               | 0.009              | 205               | 28.6               |
| Beef, top sirloin, lean & fat, 1/8" fat, select, broiled                 | 230                      | 0.0                  | 27.1                   | 12.7               | 67                    | 57                 | 345               | 22                 | 23                 | 1.66               | 0.074              | 4.93               | 0.009              | 217               | 29.3               |
| Beets, boiled                                                            | 44                       | 10.0                 | 1.7                    | 0.2                | 0                     | 77                 | 305               | 16                 | 23                 | 0.79               | 0.074              | 0.35               | 0.326              | 38                | 0.7                |
| Blackberries, raw                                                        | 43                       | 9.6                  | 1.4                    | 0.5                | 0                     | 1                  | 162               | 29                 | 20                 | 0.62               | 0.165              | 0.53               | 0.646              | 22                | 0.4                |
| Blueberries, raw                                                         | 57                       | 14.5                 | 0.7                    | 0.3                | 0                     | 1                  | 77                | 6                  | 6                  | 0.28               | 0.057              | 0.16               | 0.336              | 12                | 0.1                |
| Bluefish, cooked, dry heat                                               | 159                      | 0.0                  | 25.7                   | 5.4                | 76                    | 77                 | 477               | 9                  | 42                 | 0.62               | 0.068              | 1.04               | 0.027              | 291               | 46.8               |
| Bologna, beef                                                            | 314                      | 4.0                  | 10.3                   | 28.2               | 56                    | 1080               | 172               | 31                 | 14                 | 1.10               | 0.068              | 9.10               | 0.044              | 172               | 0.0                |
| Bologna, pork                                                            | 247                      | 0.7                  | 15.3                   | 19.9               | 59                    | 1184               | 281               | 11                 | 14                 | 0.77               | 0.080              | 2.03               | 0.036              | 139               | 12.7               |
| Bratwurst, beef & pork, smoked                                           | 297                      | 2.0                  | 12.2                   | 26.3               | 78                    | 848                | 283               | 7                  | 15                 | 1.00               | 0.080              | 2.47               | 0.041              | 130               | 14.1               |
| Bratwurst, pork, cooked                                                  | 333                      | 2.9                  | 13.7                   | 29.2               | 74                    | 846                | 259               | 28                 | 21                 | 0.53               | 0.079              | 2.49               | 0.012              | 225               | 26.9               |
| Brazil nuts, dried, unblanched                                           | 656                      | 12.3                 | 14.3                   | 66.4               | 0                     | 3                  | 659               | 160                | 376                | 2.43               | 1.743              | 4.06               | 1.223              | 725               | 1917.0             |
| Bread, cracked-wheat                                                     | 260                      | 49.5                 | 8.7                    | 3.9                | 0                     | 538                | 177               | 43                 | 52                 | 2.81               | 0.222              | 1.24               | 1.371              | 153               | 25.3               |
| Bread, Italian                                                           | 271                      | 50.0                 | 8.8                    | 3.5                | 0                     | 584                | 110               | 78                 | 27                 | 2.94               | 0.191              | 0.86               | 0.464              | 103               | 27.2               |
| Bread, mixed-grain, toasted (includes whole-grain, 7-grain)              | 272                      | 50.4                 | 10.9                   | 4.1                | 0                     | 530                | 222               | 99                 | 58                 | 3.77               | 0.276              | 1.38               | 1.615              | 191               | 32.1               |
| Bread, oatmeal                                                           | 269                      | 48.5                 | 8.4                    | 4.4                | 0                     | 599                | 142               | 66                 | 37                 | 2.70               | 0.209              | 1.02               | 0.940              | 126               | 24.6               |
| Bread, pita, white, enriched                                             | 275                      | 55.7                 | 9.1                    | 1.2                | 0                     | 536                | 120               | 86                 | 26                 | 2.62               | 0.168              | 0.84               | 0.481              | 97                | 27.1               |
| Bread, pumpernickel                                                      | 250                      | 47.5                 | 8.7                    | 3.1                | 0                     | 671                | 208               | 68                 | 54                 | 2.87               | 0.287              | 1.48               | 1.305              | 178               | 24.5               |
| Bread, rye                                                               | 259                      | 48.3                 | 8.5                    | 3.3                | 0                     | 660                | 166               | 73                 | 40                 | 2.83               | 0.186              | 1.14               | 0.824              | 125               | 30.9               |
| Bread, white, commercially prepared                                      | 266                      | 50.6                 | 7.6                    | 3.3                | 0                     | 681                | 100               | 151                | 23                 | 3.74               | 0.253              | 0.74               | 0.478              | 99                | 17.3               |
| Bread, whole-wheat, commercially prepared                                | 246                      | 46.1                 | 9.7                    | 4.2                | 0                     | 527                | 252               | 72                 | 86                 | 3.30               | 0.284              | 1.94               | 2.324              | 229               | 36.6               |
| Broccoli, boiled, w/o salt                                               | 35                       | 7.2                  | 2.4                    | 0.4                | 0                     | 41                 | 293               | 40                 | 21                 | 0.67               | 0.061              | 0.45               | 0.194              | 67                | 1.6                |
| Broccoli, raw                                                            | 34                       | 6.6                  | 2.8                    | 0.4                | 0                     | 33                 | 316               | 47                 | 21                 | 0.73               | 0.049              | 0.41               | 0.210              | 66                | 2.5                |
| Brussels sprouts, boiled, w/o salt                                       | 36                       | 7.1                  | 2.6                    | 0.5                | 0                     | 21                 | 317               | 36                 | 20                 | 1.20               | 0.083              | 0.33               | 0.227              | 56                | 1.5                |
| Butter, w. salt                                                          | 717                      | 0.1                  | 0.9                    | 81.1               | 215                   | 576                | 24                | 24                 | 2                  | 0.02               | 0.000              | 0.09               | 0.000              | 24                | 1.0                |
| Butter, w/o salt                                                         | 717                      | 0.1                  | 0.9                    | 81.1               | 215                   | 11                 | 24                | 24                 | 2                  | 0.02               | 0.016              | 0.09               | 0.004              | 24                | 1.0                |
| Cabbage, boiled, w/o salt                                                | 22                       | 4.5                  | 1.0                    | 0.4                | 0                     | 8                  | 97                | 31                 | 8                  | 0.17               | 0.012              | 0.09               | 0.117              | 15                | 0.6                |
| Cabbage, raw                                                             | 24                       | 5.6                  | 1.4                    | 0.1                | 0                     | 18                 | 246               | 47                 | 15                 | 0.59               | 0.023              | 0.18               | 0.159              | 23                | 0.9                |
| Cake, angel food, commercially prepared                                  | 258                      | 57.8                 | 5.9                    | 0.8                | 0                     | 749                | 93                | 140                | 12                 | 0.52               | 0.078              | 0.07               | 0.085              | 32                | 7.3                |
| Cake, carrot, dry mix, pudding-type                                      | 415                      | 79.2                 | 5.1                    | 9.8                | 0                     | 567                | 169               | 172                | 8                  | 1.80               | 0.050              | 0.20               | 0.528              | 247               | 14.9               |
| Cake, fruitcake, commercially prepared                                   | 324                      | 61.6                 | 2.9                    | 9.1                | 5                     | 270                | 153               | 33                 | 16                 | 2.07               | 0.050              | 0.27               | 0.220              | 52                | 2.0                |
| Cake, pound, commercially prepared, butter                               | 388                      | 48.8                 | 5.5                    | 19.9               | 221                   | 398                | 119               | 35                 | 11                 | 1.38               | 0.035              | 0.46               | 0.090              | 137               | 8.8                |
| Cake, white, dry mix                                                     | 426                      | 78.0                 | 4.5                    | 10.9               | 0                     | 664                | 117               | 192                | 11                 | 1.39               | 0.081              | 0.46               | 0.205              | 337               | 8.6                |
| Cake, yellow, dry mix, enriched                                          | 432                      | 78.1                 | 4.4                    | 11.6               | 2                     | 657                | 82                | 135                | 10                 | 1.50               | 0.072              | 0.27               | 0.191              | 310               | 3.0                |
| Candies, fudge, chocolate, prepared-from-recipe                          | 411                      | 76.5                 | 2.4                    | 10.4               | 14                    | 47                 | 131               | 45                 | 36                 | 1.77               | 0.333              | 1.10               | 0.423              | 69                | 2.5                |

| Food description                                                | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|-----------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Candies, gumdrops, starch jelly pieces                          | 396                      | 98.9                 | 0.0                    | 0.0                | 0                     | 44                 | 5                 | 3                 | 1                  | 0.40               | 0.012              | 0.00               | 0.010              | 1                 | 0.8                |
| Candies, hard                                                   | 394                      | 98.0                 | 0.0                    | 0.2                | 0                     | 38                 | 5                 | 3                 | 3                  | 0.30               | 0.029              | 0.01               | 0.010              | 3                 | 0.6                |
| Candies, marshmallows                                           | 318                      | 81.3                 | 1.8                    | 0.2                | 0                     | 80                 | 5                 | 3                 | 2                  | 0.23               | 0.097              | 0.04               | 0.008              | 8                 | 1.7                |
| Candies, milk chocolate                                         | 535                      | 59.4                 | 7.7                    | 29.7               | 23                    | 79                 | 372               | 189               | 63                 | 2.35               | 0.491              | 2.01               | 0.471              | 208               | 4.5                |
| Candies, milk chocolate w. almond bites                         | 550                      | 51.0                 | 9.8                    | 35.7               | 19                    | 74                 | 471               | 220               | 59                 | 1.50               | 0.200              | 1.34               | 0.010              | 227               | 3.4                |
| Candies, peanut brittle, prepared-from-recipe                   | 486                      | 71.2                 | 7.6                    | 19.0               | 12                    | 445                | 168               | 27                | 42                 | 1.22               | 0.254              | 0.87               | 0.593              | 106               | 2.6                |
| Candies, semisweet chocolate                                    | 479                      | 63.1                 | 4.2                    | 30.0               | 0                     | 11                 | 365               | 32                | 115                | 3.13               | 0.700              | 1.62               | 0.800              | 132               | 4.2                |
| Candies, sweet chocolate                                        | 505                      | 59.6                 | 3.9                    | 34.2               | 0                     | 16                 | 290               | 24                | 113                | 2.76               | 0.574              | 1.50               | 0.494              | 147               | 2.8                |
| Candies, white chocolate                                        | 539                      | 59.2                 | 5.9                    | 32.1               | 14                    | 90                 | 286               | 199               | 12                 | 0.24               | 0.060              | 0.74               | 0.008              | 176               | 4.5                |
| Capers, canned                                                  | 23                       | 4.9                  | 2.4                    | 0.9                | 0                     | 2964               | 40                | 40                | 33                 | 1.67               | 0.374              | 0.32               | 0.078              | 10                | 1.2                |
| Carbonated beverage, cola, contains caffeine                    | 37                       | 9.6                  | 0.1                    | 0.0                | 0                     | 4                  | 2                 | 2                 | 0                  | 0.11               | 0.001              | 0.02               | 0.002              | 10                | 0.1                |
| Carbonated beverage, ginger ale                                 | 34                       | 8.8                  | 0.0                    | 0.0                | 0                     | 7                  | 1                 | 3                 | 1                  | 0.18               | 0.018              | 0.05               | 0.013              | 0                 | 0.1                |
| Carbonated beverage, orange                                     | 48                       | 12.3                 | 0.0                    | 0.0                | 0                     | 12                 | 2                 | 5                 | 1                  | 0.06               | 0.015              | 0.10               | 0.013              | 1                 | 0.0                |
| Carbonated beverage, root beer                                  | 41                       | 10.6                 | 0.0                    | 0.0                | 0                     | 13                 | 1                 | 5                 | 1                  | 0.05               | 0.007              | 0.07               | 0.013              | 0                 | 0.1                |
| Carbonated beverage, tonic water                                | 34                       | 8.8                  | 0.0                    | 0.0                | 0                     | 12                 | 0                 | 1                 | 0                  | 0.01               | 0.006              | 0.10               | 0.001              | 0                 | 0.0                |
| Carrots, boiled, w/o salt                                       | 35                       | 8.2                  | 0.8                    | 0.2                | 0                     | 58                 | 235               | 30                | 10                 | 0.34               | 0.017              | 0.20               | 0.155              | 30                | 0.7                |
| Carrots, raw                                                    | 41                       | 9.6                  | 0.9                    | 0.2                | 0                     | 69                 | 320               | 33                | 12                 | 0.30               | 0.045              | 0.24               | 0.143              | 35                | 0.1                |
| Cashew nuts, dry roasted, w. salt                               | 574                      | 32.7                 | 15.3                   | 46.4               | 0                     | 640                | 565               | 45                | 260                | 6.00               | 2.220              | 5.60               | 0.826              | 490               | 11.7               |
| Cashew nuts, oil roasted, w. salt                               | 581                      | 30.2                 | 16.8                   | 47.8               | 0                     | 308                | 632               | 43                | 273                | 6.05               | 2.043              | 5.35               | 1.668              | 531               | 20.3               |
| Cashew nuts, raw                                                | 553                      | 30.2                 | 18.2                   | 43.9               | 0                     | 12                 | 660               | 37                | 292                | 6.68               | 2.195              | 5.78               | 1.655              | 593               | 19.9               |
| Catfish, channel, farmed, cooked, dry heat                      | 152                      | 0.0                  | 18.7                   | 8.0                | 64                    | 80                 | 321               | 9                 | 26                 | 0.82               | 0.122              | 1.05               | 0.020              | 245               | 14.5               |
| Catsup                                                          | 97                       | 25.1                 | 1.7                    | 0.4                | 0                     | 1114               | 382               | 18                | 19                 | 0.51               | 0.181              | 0.26               | 0.128              | 33                | 0.3                |
| Cauliflower, boiled, w/o salt                                   | 23                       | 4.1                  | 1.8                    | 0.5                | 0                     | 15                 | 142               | 16                | 9                  | 0.33               | 0.027              | 0.18               | 0.138              | 32                | 0.5                |
| Cauliflower, raw                                                | 25                       | 5.3                  | 2.0                    | 0.1                | 0                     | 30                 | 303               | 22                | 15                 | 0.44               | 0.042              | 0.28               | 0.156              | 44                | 0.6                |
| Celery, raw                                                     | 14                       | 3.0                  | 0.7                    | 0.2                | 0                     | 80                 | 260               | 40                | 11                 | 0.20               | 0.035              | 0.13               | 0.103              | 24                | 0.4                |
| Cereals, corn grits, white, enriched, cooked w. water, w/o salt | 59                       | 12.9                 | 1.4                    | 0.2                | 0                     | 2                  | 21                | 3                 | 5                  | 0.60               | 0.018              | 0.07               | 0.018              | 11                | 3.1                |
| Chard, Swiss, boiled, w/o salt                                  | 20                       | 4.1                  | 1.9                    | 0.1                | 0                     | 179                | 549               | 58                | 86                 | 2.26               | 0.163              | 0.33               | 0.334              | 33                | 0.9                |
| Chard, Swiss, raw                                               | 19                       | 3.7                  | 1.8                    | 0.2                | 0                     | 213                | 379               | 51                | 81                 | 1.80               | 0.179              | 0.36               | 0.366              | 46                | 0.9                |
| Cheese, American cheddar, imitation                             | 239                      | 11.6                 | 16.7                   | 14.0               | 36                    | 1345               | 242               | 562               | 29                 | 0.33               | 0.033              | 2.59               |                    | 712               | 15.2               |
| Cheese, blue                                                    | 353                      | 2.3                  | 21.4                   | 28.7               | 75                    | 1395               | 256               | 528               | 23                 | 0.31               | 0.040              | 2.66               | 0.009              | 387               | 14.5               |
| Cheese, brie                                                    | 334                      | 0.5                  | 20.8                   | 27.7               | 100                   | 629                | 152               | 184               | 20                 | 0.50               | 0.019              | 2.38               | 0.034              | 188               | 14.5               |
| Cheese, camembert                                               | 300                      | 0.5                  | 19.8                   | 24.3               | 72                    | 842                | 187               | 388               | 20                 | 0.33               | 0.021              | 2.38               | 0.038              | 347               | 14.5               |
| Cheese, cheddar                                                 | 403                      | 1.3                  | 24.9                   | 33.1               | 105                   | 621                | 98                | 721               | 28                 | 0.68               | 0.031              | 3.11               | 0.010              | 512               | 13.9               |
| Cheese, cheshire                                                | 387                      | 4.8                  | 23.4                   | 30.6               | 103                   | 700                | 95                | 643               | 21                 | 0.21               | 0.042              | 2.79               | 0.012              | 464               | 14.5               |
| Cheese, colby                                                   | 394                      | 2.6                  | 23.8                   | 32.1               | 95                    | 604                | 127               | 685               | 26                 | 0.76               | 0.042              | 3.07               | 0.012              | 457               | 14.5               |
| Cheese, cottage, creamed, large or small curd                   | 103                      | 2.7                  | 12.5                   | 4.5                | 15                    | 405                | 84                | 60                | 5                  | 0.14               | 0.028              | 0.37               | 0.003              | 132               | 9.0                |
| Cheese, cottage, low fat, 1% milkfat                            | 72                       | 2.7                  | 12.4                   | 1.0                | 4                     | 406                | 86                | 61                | 5                  | 0.14               | 0.028              | 0.38               | 0.003              | 134               | 9.0                |
| Cheese, cream                                                   | 349                      | 2.7                  | 7.6                    | 34.9               | 110                   | 296                | 119               | 80                | 6                  | 1.20               | 0.016              | 0.54               | 0.004              | 104               | 2.4                |
| Cheese, cream, low fat                                          | 231                      | 7.0                  | 10.6                   | 17.6               | 56                    | 296                | 167               | 112               | 8                  | 1.68               | 0.022              | 0.76               |                    | 146               | 4.0                |
| Cheese, edam                                                    | 357                      | 1.4                  | 25.0                   | 27.8               | 89                    | 965                | 188               | 731               | 30                 | 0.44               | 0.036              | 3.75               | 0.011              | 536               | 14.5               |
| Cheese, feta                                                    | 264                      | 4.1                  | 14.2                   | 21.3               | 89                    | 1116               | 62                | 493               | 19                 | 0.65               | 0.032              | 2.88               | 0.028              | 337               | 15.0               |
| Cheese, gouda                                                   | 356                      | 2.2                  | 24.9                   | 27.4               | 114                   | 819                | 121               | 700               | 29                 | 0.24               | 0.036              | 3.90               | 0.011              | 546               | 14.5               |
| Cheese, gruyere                                                 | 413                      | 0.4                  | 29.8                   | 32.3               | 110                   | 336                | 81                | 1011              | 36                 | 0.17               | 0.032              | 3.90               | 0.017              | 605               | 14.5               |
| Cheese, mozzarella, whole milk                                  | 300                      | 2.2                  | 22.2                   | 22.4               | 79                    | 627                | 76                | 505               | 20                 | 0.44               | 0.011              | 2.92               | 0.030              | 354               | 17.0               |
| Cheese, muenster                                                | 368                      | 1.1                  | 23.4                   | 30.0               | 96                    | 628                | 134               | 717               | 27                 | 0.41               | 0.031              | 2.81               | 0.008              | 468               | 14.5               |
| Cheese, parmesan, grated                                        | 431                      | 4.1                  | 38.5                   | 28.6               | 88                    | 1529               | 125               | 1109              | 38                 | 0.90               | 0.238              | 3.87               | 0.085              | 729               | 17.7               |
| Cheese, pimento                                                 | 375                      | 1.7                  | 22.1                   | 31.2               | 94                    | 1428               | 162               | 614               | 22                 | 0.42               | 0.033              | 2.98               | 0.016              | 744               | 14.5               |
| Cheese, provolone                                               | 351                      | 2.1                  | 25.6                   | 26.6               | 69                    | 876                | 138               | 756               | 28                 | 0.52               | 0.026              | 3.23               | 0.010              | 496               | 14.5               |
| Cheese, Swiss                                                   | 380                      | 5.4                  | 26.9                   | 27.8               | 92                    | 192                | 77                | 791               | 38                 | 0.20               | 0.043              | 4.36               | 0.005              | 567               | 18.2               |
| Cheese, tilsit                                                  | 340                      | 1.9                  | 24.4                   | 26.0               | 102                   | 753                | 65                | 700               | 13                 | 0.23               | 0.026              | 3.50               | 0.013              | 500               | 14.5               |
| Cheesecake, commercially prepared                               | 321                      | 25.5                 | 5.5                    | 22.5               | 55                    | 207                | 90                | 51                | 11                 | 0.63               | 0.020              | 0.51               | 0.140              | 93                | 5.2                |
| Cherries, sour, red, raw                                        | 50                       | 12.2                 | 1.0                    | 0.3                | 0                     | 3                  | 173               | 16                | 9                  | 0.32               | 0.104              | 0.10               | 0.112              | 15                | 0.0                |
| Cherries, sweet, raw                                            | 63                       | 16.0                 | 1.1                    | 0.2                | 0                     | 0                  | 222               | 13                | 11                 | 0.36               | 0.060              | 0.07               | 0.070              | 21                | 0.0                |

| Food description                                                       | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|------------------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Chestnuts, European, boiled & steamed                                  | 131                      | 27.8                 | 2.0                    | 1.4                | 0                     | 27                 | 715               | 46                | 54                 | 1.73               | 0.472              | 0.25               | 0.854              | 99                |                    |
| Chestnuts, European, roasted                                           | 245                      | 53.0                 | 3.2                    | 2.2                | 0                     | 2                  | 592               | 29                | 33                 | 0.91               | 0.507              | 0.57               | 1.180              | 107               | 1.2                |
| Chicken, broilers or fryers, breast, meat & skin, fried                | 222                      | 1.6                  | 31.8                   | 8.9                | 89                    | 76                 | 259               | 16                | 30                 | 1.19               | 0.057              | 1.10               | 0.026              | 233               | 23.9               |
| Chicken, broilers or fryers, breast, meat & skin, roasted              | 197                      | 0.0                  | 29.8                   | 7.8                | 84                    | 71                 | 245               | 14                | 27                 | 1.07               | 0.050              | 1.02               | 0.018              | 214               | 24.7               |
| Chicken, broilers or fryers, breast, meat only, fried                  | 187                      | 0.5                  | 33.4                   | 4.7                | 91                    | 79                 | 276               | 16                | 31                 | 1.14               | 0.054              | 1.08               | 0.021              | 246               | 26.2               |
| Chicken, broilers or fryers, breast, meat only, roasted                | 165                      | 0.0                  | 31.0                   | 3.6                | 85                    | 74                 | 256               | 15                | 29                 | 1.04               | 0.049              | 1.00               | 0.017              | 228               | 27.6               |
| Chicken, broilers or fryers, dark meat, meat only, roasted             | 205                      | 0.0                  | 27.4                   | 9.7                | 93                    | 93                 | 240               | 15                | 23                 | 1.33               | 0.080              | 2.80               | 0.021              | 179               | 18.0               |
| Chicken, broilers or fryers, drumstick, meat & skin, fried             | 245                      | 1.6                  | 27.0                   | 13.7               | 90                    | 89                 | 229               | 12                | 23                 | 1.34               | 0.080              | 2.89               | 0.028              | 176               | 18.4               |
| Chicken, broilers or fryers, thigh, meat & skin, roasted               | 247                      | 0.0                  | 25.1                   | 15.5               | 93                    | 84                 | 222               | 12                | 22                 | 1.34               | 0.078              | 2.36               | 0.021              | 174               | 19.5               |
| Chicken, broilers or fryers, thigh, meat only, roasted                 | 209                      | 0.0                  | 25.9                   | 10.9               | 95                    | 88                 | 238               | 12                | 24                 | 1.31               | 0.081              | 2.57               | 0.021              | 183               | 29.0               |
| Chicken, broilers or fryers, wing, meat & skin, fried                  | 321                      | 2.4                  | 26.1                   | 22.2               | 81                    | 77                 | 177               | 15                | 19                 | 1.25               | 0.061              | 1.76               | 0.028              | 150               | 21.3               |
| Chicken, Cornish game hens, meat & skin, roasted                       | 260                      | 0.0                  | 22.3                   | 18.2               | 131                   | 64                 | 245               | 13                | 18                 | 0.91               | 0.061              | 1.49               | 0.015              | 146               | 15.5               |
| Chicken, Cornish game hens, meat only, roasted                         | 134                      | 0.0                  | 23.3                   | 3.9                | 106                   | 63                 | 250               | 13                | 19                 | 0.77               | 0.059              | 1.53               | 0.015              | 149               | 20.8               |
| Chickpeas, mature seeds, boiled, w/o salt                              | 164                      | 27.4                 | 8.9                    | 2.6                | 0                     | 7                  | 291               | 49                | 48                 | 2.89               | 0.352              | 1.53               | 1.030              | 168               | 3.7                |
| Chicory greens, raw                                                    | 23                       | 4.7                  | 1.7                    | 0.3                | 0                     | 45                 | 420               | 100               | 30                 | 0.90               | 0.295              | 0.42               | 0.429              | 47                | 0.3                |
| Chocolate syrup                                                        | 279                      | 65.1                 | 2.1                    | 1.1                | 0                     | 72                 | 224               | 14                | 65                 | 2.11               | 0.512              | 0.73               | 0.382              | 129               | 2.7                |
| Clam, mixed species, breaded & fried                                   | 202                      | 10.3                 | 14.2                   | 11.2               | 61                    | 364                | 326               | 63                | 14                 | 13.91              | 0.356              | 1.46               | 0.540              | 188               | 28.9               |
| Clam, mixed species, raw                                               | 74                       | 2.6                  | 12.8                   | 1.0                | 34                    | 56                 | 314               | 46                | 9                  | 13.98              | 0.344              | 1.37               | 0.500              | 169               | 24.3               |
| Cocoa, dry powder, unsweetened                                         | 229                      | 54.3                 | 19.6                   | 13.7               | 0                     | 21                 | 1524              | 128               | 499                | 13.86              | 3.788              | 6.81               | 3.837              | 734               | 14.3               |
| Coconut meat, raw                                                      | 354                      | 15.2                 | 3.3                    | 33.5               | 0                     | 20                 | 356               | 14                | 32                 | 2.43               | 0.435              | 1.10               | 1.500              | 113               | 10.1               |
| Cod, Atlantic, cooked, dry heat                                        | 105                      | 0.0                  | 22.8                   | 0.9                | 55                    | 78                 | 244               | 14                | 42                 | 0.49               | 0.036              | 0.58               | 0.020              | 138               | 37.6               |
| Cod, Atlantic, dried & salted                                          | 290                      | 0.0                  | 62.8                   | 2.4                | 152                   | 7027               | 1458              | 160               | 133                | 2.50               | 0.176              | 1.59               | 0.050              | 950               | 147.8              |
| Coffee, brewed from grounds, prep w. tap h2o                           | 1                        | 0.0                  | 0.1                    | 0.0                | 0                     | 2                  | 49                | 2                 | 3                  | 0.01               | 0.002              | 0.02               | 0.023              | 3                 | 0.0                |
| Coffee, brewed, espresso, rest-prep                                    | 2                        | 0.0                  | 0.1                    | 0.2                | 0                     | 14                 | 115               | 2                 | 80                 | 0.13               | 0.050              | 0.05               | 0.050              | 7                 | 0.0                |
| Coleslaw, home-prepared                                                | 69                       | 12.4                 | 1.3                    | 2.6                | 8                     | 23                 | 181               | 45                | 10                 | 0.59               | 0.023              | 0.20               | 0.097              | 32                | 0.7                |
| Collards, boiled, w/o salt                                             | 26                       | 4.9                  | 2.1                    | 0.4                | 0                     | 16                 | 116               | 140               | 20                 | 1.16               | 0.038              | 0.23               | 0.436              | 30                | 0.5                |
| Cookies, brownies, commercially prepared                               | 405                      | 63.9                 | 4.8                    | 16.3               | 17                    | 312                | 149               | 29                | 31                 | 2.25               | 0.224              | 0.72               | 0.128              | 101               | 6.3                |
| Cookies, chocolate chip, commercially prepared, higher fat, unenriched | 481                      | 66.8                 | 5.4                    | 22.6               | 0                     | 315                | 135               | 25                | 31                 | 1.00               | 0.212              | 0.64               | 0.449              | 108               |                    |
| Cookies, chocolate sandwich, w/creme filling                           | 466                      | 71.6                 | 5.3                    | 19.1               | 0                     | 483                | 187               | 21                | 48                 | 3.93               | 0.431              | 0.98               | 0.629              | 92                | 8.1                |
| Cookies, fig bars                                                      | 348                      | 70.9                 | 3.7                    | 7.3                | 0                     | 350                | 207               | 64                | 27                 | 2.90               | 0.147              | 0.39               | 0.343              | 62                | 3.3                |
| Cookies, gingersnaps                                                   | 416                      | 76.9                 | 5.6                    | 9.8                | 0                     | 654                | 346               | 77                | 49                 | 6.40               | 0.305              | 0.55               | 1.555              | 83                | 5.1                |
| Cookies, graham crackers, plain or honey                               | 423                      | 76.8                 | 6.9                    | 10.1               | 0                     | 605                | 135               | 24                | 30                 | 3.73               | 0.202              | 0.81               | 0.804              | 104               | 10.2               |
| Cookies, oatmeal, commercially prepared                                | 450                      | 68.7                 | 6.2                    | 18.1               | 0                     | 383                | 142               | 37                | 33                 | 2.58               | 0.134              | 0.79               | 0.839              | 138               | 9.8                |
| Cookies, peanut butter sandwich, regular                               | 478                      | 65.6                 | 8.8                    | 21.1               | 0                     | 368                | 192               | 53                | 49                 | 2.60               | 0.237              | 1.06               | 0.912              | 188               | 7.7                |
| Cookies, shortbread, commercially prepared, plain                      | 502                      | 64.5                 | 6.1                    | 24.1               | 20                    | 455                | 100               | 35                | 17                 | 2.74               | 0.144              | 0.53               | 0.428              | 108               | 7.3                |
| Cookies, vanilla wafers, higher fat                                    | 473                      | 71.1                 | 4.3                    | 19.4               | 0                     | 306                | 107               | 25                | 12                 | 2.21               | 0.124              | 0.33               | 0.384              | 64                | 11.3               |
| Cookies, vanilla wafers, lower fat                                     | 441                      | 73.6                 | 5.0                    | 15.2               | 51                    | 312                | 97                | 48                | 14                 | 2.38               | 0.100              | 0.36               | 0.262              | 104               | 11.3               |
| Corn, sweet, white, boiled, w. salt                                    | 108                      | 25.1                 | 3.3                    | 1.3                | 0                     | 253                | 249               | 2                 | 32                 | 0.61               | 0.053              | 0.48               | 0.194              | 103               | 0.8                |
| Corn, sweet, yellow, boiled, w. salt                                   | 108                      | 25.1                 | 3.3                    | 1.3                | 0                     | 253                | 249               | 2                 | 32                 | 0.61               | 0.053              | 0.48               | 0.194              | 103               | 0.2                |
| Couscous, cooked                                                       | 112                      | 23.2                 | 3.8                    | 0.2                | 0                     | 5                  | 58                | 8                 | 8                  | 0.38               | 0.041              | 0.26               | 0.084              | 22                | 27.5               |
| Cowpeas (black-eyed), immature seeds, boiled, w. salt                  | 97                       | 20.3                 | 3.2                    | 0.4                | 0                     | 240                | 418               | 128               | 52                 | 1.12               | 0.133              | 1.03               | 0.572              | 51                | 2.5                |
| Crab, Alaska king, cooked, moist heat                                  | 97                       | 0.0                  | 19.4                   | 1.5                | 53                    | 1072               | 262               | 59                | 63                 | 0.76               | 1.182              | 7.62               | 0.040              | 280               | 40.0               |
| Crab, Alaska king, raw                                                 | 84                       | 0.0                  | 18.3                   | 0.6                | 42                    | 836                | 204               | 46                | 49                 | 0.59               | 0.922              | 5.95               | 0.035              | 219               | 36.4               |
| Crab, blue, cooked, moist heat                                         | 102                      | 0.0                  | 20.2                   | 1.8                | 100                   | 279                | 324               | 104               | 33                 | 0.91               | 0.645              | 4.22               | 0.190              | 206               | 40.2               |
| Crab, blue, raw                                                        | 87                       | 0.0                  | 18.1                   | 1.1                | 78                    | 293                | 329               | 89                | 34                 | 0.74               | 0.669              | 3.54               | 0.150              | 229               | 37.4               |
| Crab, Dungeness, cooked, moist heat                                    | 110                      | 1.0                  | 22.3                   | 1.2                | 76                    | 378                | 408               | 59                | 58                 | 0.43               | 0.734              | 5.47               | 0.097              | 175               | 47.6               |
| Crackers, cheese, regular                                              | 503                      | 58.2                 | 10.1                   | 25.3               | 13                    | 995                | 145               | 151               | 36                 | 4.77               | 0.210              | 1.13               | 0.629              | 218               | 8.6                |
| Crackers, matzo, plain                                                 | 395                      | 83.7                 | 10.0                   | 1.4                | 0                     | 2                  | 112               | 13                | 25                 | 3.16               | 0.060              | 0.68               | 0.650              | 89                | 36.9               |
| Crackers, saltines (includes oyster, soda, soup)                       | 428                      | 70.9                 | 9.2                    | 11.4               | 0                     | 1072               | 154               | 68                | 22                 | 5.64               | 0.298              | 0.83               | 0.653              | 101               | 10.3               |



| Food description                                                                       | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100 g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|----------------------------------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Crackers, wheat, regular                                                               | 473                      | 64.9                 | 8.6                    | 20.6               | 0                     | 795                | 183               | 49                 | 62                 | 4.40               | 0.318              | 1.60               | 1.781              | 220               | 6.3                |
| Cranberries, raw                                                                       | 46                       | 12.2                 | 0.4                    | 0.1                | 0                     | 2                  | 85                | 8                  | 6                  | 0.25               | 0.061              | 0.10               | 0.360              | 13                | 0.1                |
| Cranberry juice, unsweetened                                                           | 46                       | 12.2                 | 0.4                    | 0.1                | 0                     | 2                  | 77                | 8                  | 6                  | 0.25               | 0.055              | 0.10               |                    | 13                | 0.1                |
| Crayfish, mixed species, farmed, cooked, moist heat                                    | 87                       | 0.0                  | 17.5                   | 1.3                | 137                   | 97                 | 238               | 51                 | 33                 | 1.11               | 0.580              | 1.48               | 0.217              | 241               | 34.2               |
| Cream, fluid, half and half                                                            | 130                      | 4.3                  | 3.0                    | 11.5               | 37                    | 41                 | 130               | 105                | 10                 | 0.07               | 0.010              | 0.51               | 0.001              | 95                | 1.8                |
| Cream, half & half, fat free                                                           | 59                       | 9.0                  | 2.6                    | 1.4                | 5                     | 144                | 206               | 96                 | 16                 | 0.00               | 0.016              | 0.81               | 0.002              | 151               | 2.9                |
| Cream, sour, cultured                                                                  | 214                      | 4.3                  | 3.2                    | 21.0               | 44                    | 53                 | 144               | 116                | 11                 | 0.06               | 0.019              | 0.27               | 0.003              | 85                | 2.2                |
| Cream, whipped, cream topping, pressurized                                             | 257                      | 12.5                 | 3.2                    | 22.2               | 76                    | 130                | 147               | 101                | 11                 | 0.05               | 0.010              | 0.37               | 0.001              | 89                | 1.4                |
| Croissants, butter                                                                     | 406                      | 45.8                 | 8.2                    | 21.0               | 67                    | 744                | 118               | 37                 | 16                 | 2.03               | 0.080              | 0.75               | 0.330              | 105               | 22.7               |
| Croutons, plain                                                                        | 407                      | 73.5                 | 11.9                   | 6.6                | 0                     | 698                | 124               | 76                 | 31                 | 4.08               | 0.163              | 0.89               | 0.500              | 115               | 37.5               |
| Cucumber, peeled, raw                                                                  | 12                       | 2.2                  | 0.6                    | 0.2                | 0                     | 2                  | 136               | 14                 | 12                 | 0.22               | 0.071              | 0.17               | 0.073              | 21                | 0.1                |
| Cucumber, with peel, raw                                                               | 15                       | 3.6                  | 0.7                    | 0.1                | 0                     | 2                  | 147               | 16                 | 13                 | 0.28               | 0.041              | 0.20               | 0.079              | 24                | 0.3                |
| Curry powder                                                                           | 325                      | 58.2                 | 12.7                   | 13.8               | 0                     | 52                 | 1543              | 478                | 254                | 29.59              | 0.815              | 4.05               | 4.289              | 349               | 17.1               |
| Dandelion greens, boiled, w/o salt                                                     | 33                       | 6.4                  | 2.0                    | 0.6                | 0                     | 44                 | 232               | 140                | 24                 | 1.80               | 0.115              | 0.28               | 0.230              | 42                | 0.3                |
| Dandelion greens, raw                                                                  | 45                       | 9.2                  | 2.7                    | 0.7                | 0                     | 76                 | 397               | 187                | 36                 | 3.10               | 0.171              | 0.41               | 0.342              | 66                | 0.5                |
| Duck, domesticated, meat & skin, roasted                                               | 337                      | 0.0                  | 19.0                   | 28.4               | 84                    | 59                 | 204               | 11                 | 16                 | 2.70               | 0.227              | 1.86               | 0.019              | 156               | 20.0               |
| Duck, domesticated, meat only, roasted                                                 | 201                      | 0.0                  | 23.5                   | 11.2               | 89                    | 65                 | 252               | 12                 | 20                 | 2.70               | 0.231              | 2.60               | 0.019              | 203               | 22.4               |
| Egg, white, raw, fresh                                                                 | 52                       | 0.7                  | 10.9                   | 0.2                | 0                     | 166                | 163               | 7                  | 11                 | 0.08               | 0.023              | 0.03               | 0.011              | 15                | 20.0               |
| Egg, whole, fried                                                                      | 201                      | 0.9                  | 13.6                   | 15.3               | 457                   | 204                | 147               | 59                 | 13                 | 1.98               | 0.111              | 1.20               | 0.041              | 208               | 34.2               |
| Egg, whole, hard-boiled                                                                | 155                      | 1.1                  | 12.6                   | 10.6               | 424                   | 124                | 126               | 50                 | 10                 | 1.19               | 0.013              | 1.05               | 0.026              | 172               | 30.8               |
| Egg, whole, poached                                                                    | 147                      | 0.8                  | 12.5                   | 9.9                | 422                   | 294                | 133               | 53                 | 12                 | 1.83               | 0.102              | 1.10               | 0.039              | 190               | 31.6               |
| Egg, whole, scrambled                                                                  | 166                      | 2.2                  | 11.1                   | 12.2               | 352                   | 280                | 138               | 71                 | 12                 | 1.20               | 0.014              | 1.00               | 0.022              | 170               | 22.5               |
| Egg, yolk, raw, fresh                                                                  | 322                      | 3.6                  | 15.9                   | 26.5               | 1234                  | 48                 | 109               | 129                | 5                  | 2.73               | 0.077              | 2.30               | 0.055              | 390               | 56.0               |
| Eggplant, boiled, w/o salt                                                             | 35                       | 8.7                  | 0.8                    | 0.2                | 0                     | 1                  | 123               | 6                  | 11                 | 0.25               | 0.059              | 0.12               | 0.113              | 15                | 0.1                |
| Eggplant, raw                                                                          | 24                       | 5.7                  | 1.0                    | 0.2                | 0                     | 2                  | 230               | 9                  | 14                 | 0.24               | 0.082              | 0.16               | 0.250              | 25                | 0.3                |
| Endive, raw                                                                            | 17                       | 3.4                  | 1.3                    | 0.2                | 0                     | 22                 | 314               | 52                 | 15                 | 0.83               | 0.099              | 0.79               | 0.420              | 28                | 0.2                |
| English muffins, whole-wheat, toasted                                                  | 221                      | 44.1                 | 9.6                    | 2.3                | 0                     | 692                | 228               | 288                | 77                 | 2.66               | 0.225              | 1.74               | 1.946              | 307               | 43.8               |
| English, muffins, plain, toasted, enriched, w. calcium propionate (includes sourdough) | 270                      | 52.7                 | 10.3                   | 2.0                | 0                     | 477                | 129               | 197                | 28                 | 4.65               | 0.160              | 1.40               | 0.630              | 107               | 26.3               |
| Fat, beef tallow                                                                       | 902                      | 0.0                  | 0.0                    | 100.0              | 109                   | 0                  | 0                 | 0                  | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.2                |
| Fat, chicken                                                                           | 900                      | 0.0                  | 0.0                    | 99.8               | 85                    | 0                  | 0                 | 0                  | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.2                |
| Fat, duck                                                                              | 900                      | 0.0                  | 0.0                    | 99.8               | 100                   | 0                  | 0                 | 0                  | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.2                |
| Fat, goose                                                                             | 900                      | 0.0                  | 0.0                    | 99.8               | 100                   | 0                  | 0                 | 0                  | 0                  | 0.00               |                    | 0.00               |                    | 0                 | 0.2                |
| Fat, turkey                                                                            | 900                      | 0.0                  | 0.0                    | 99.8               | 102                   | 0                  | 0                 | 0                  | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.2                |
| Fennel, bulb, raw                                                                      | 31                       | 7.3                  | 1.2                    | 0.2                | 0                     | 52                 | 414               | 49                 | 17                 | 0.73               | 0.066              | 0.20               | 0.191              | 50                | 0.7                |
| Figs, dried, stewed                                                                    | 107                      | 27.6                 | 1.4                    | 0.4                | 0                     | 4                  | 294               | 70                 | 29                 | 0.88               | 0.124              | 0.24               | 0.220              | 29                | 0.2                |
| Figs, raw                                                                              | 74                       | 19.2                 | 0.8                    | 0.3                | 0                     | 1                  | 232               | 35                 | 17                 | 0.37               | 0.070              | 0.15               | 0.128              | 14                | 0.2                |
| Fish oil, cod liver                                                                    | 902                      | 0.0                  | 0.0                    | 100.0              | 570                   | 0                  | 0                 | 0                  | 0                  | 0.00               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Frankfurter beef                                                                       | 330                      | 4.1                  | 11.2                   | 29.6               | 53                    | 1140               | 156               | 14                 | 14                 | 1.51               | 0.184              | 2.46               | 0.082              | 160               | 8.2                |
| Frankfurter, chick                                                                     | 257                      | 6.8                  | 12.9                   | 19.5               | 101                   | 1370               | 84                | 95                 | 10                 | 2.00               | 0.050              | 1.04               | 0.015              | 107               | 18.4               |
| Frankfurter, pork                                                                      | 269                      | 0.3                  | 12.8                   | 23.7               | 66                    | 816                | 264               | 267                | 15                 | 3.70               | 0.074              | 2.09               | 0.016              | 171               | 27.8               |
| Frankfurter, turkey                                                                    | 226                      | 1.5                  | 14.3                   | 17.7               | 107                   | 1426               | 179               | 106                | 14                 | 1.84               | 0.100              | 3.11               | 0.016              | 134               | 15.4               |
| Game meat, beaver, roasted                                                             | 212                      | 0.0                  | 34.9                   | 7.0                | 117                   | 59                 | 403               | 22                 | 29                 | 10.00              | 0.189              | 2.27               |                    | 292               | 43.1               |
| Game meat, beefalo, roasted                                                            | 188                      | 0.0                  | 30.7                   | 6.3                | 58                    | 82                 | 459               | 24                 |                    | 3.05               |                    | 6.40               |                    | 250               | 13.1               |
| Game meat, bison, lean, roasted                                                        | 143                      | 0.0                  | 28.4                   | 2.4                | 82                    | 57                 | 361               | 8                  | 26                 | 3.42               | 0.107              | 3.68               | 0.008              | 209               | 35.5               |
| Game meat, boar, wild, roasted                                                         | 160                      | 0.0                  | 28.3                   | 4.4                | 77                    | 60                 | 396               | 16                 | 27                 | 1.12               | 0.056              | 3.01               |                    | 134               | 13.0               |
| Game meat, deer, roasted                                                               | 158                      | 0.0                  | 30.2                   | 3.2                | 112                   | 54                 | 335               | 7                  | 24                 | 4.47               | 0.300              | 2.75               | 0.046              | 226               | 12.9               |
| Game meat, elk, roasted                                                                | 146                      | 0.0                  | 30.2                   | 1.9                | 73                    | 61                 | 328               | 5                  | 24                 | 3.63               | 0.142              | 3.16               | 0.013              | 180               | 13.0               |
| Game meat, moose, roasted                                                              | 134                      | 0.0                  | 29.3                   | 1.0                | 78                    | 69                 | 334               | 6                  | 24                 | 4.22               | 0.079              | 3.68               | 0.009              | 176               | 12.8               |
| Game meat, rabbit, domesticated, roasted                                               | 197                      | 0.0                  | 29.1                   | 8.1                | 82                    | 47                 | 383               | 19                 | 21                 | 2.27               | 0.189              | 2.27               | 0.032              | 263               | 38.5               |
| Game meat, raccoon, roasted                                                            | 255                      | 0.0                  | 29.2                   | 14.5               | 97                    | 79                 | 398               | 14                 | 30                 | 7.10               | 0.189              | 2.27               |                    | 261               | 18.0               |
| Game meat, squirrel, roasted                                                           | 173                      | 0.0                  | 30.8                   | 4.7                | 121                   | 119                | 352               | 3                  | 28                 | 6.81               | 0.148              | 1.78               | 0.032              | 211               | 15.1               |
| Goose, domesticated, meat & skin, roasted                                              | 305                      | 0.0                  | 25.2                   | 21.9               | 91                    | 70                 | 329               | 13                 | 22                 | 2.83               | 0.264              | 2.62               | 0.023              | 270               | 21.8               |
| Goose, domesticated, meat only, roasted                                                | 238                      | 0.0                  | 29.0                   | 12.7               | 96                    | 76                 | 388               | 14                 | 25                 | 2.87               | 0.276              | 3.17               | 0.024              | 309               | 25.5               |

| Food description                                                               | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100 g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|--------------------------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Goose, liver, raw                                                              | 133                      | 6.3                  | 16.4                   | 4.3                | 515                   | 140                | 230               | 43                 | 24                 | 30.53              | 7.522              | 3.07               | 0.000              | 261               | 68.1               |
| Gooseberries, raw                                                              | 44                       | 10.2                 | 0.9                    | 0.6                | 0                     | 1                  | 198               | 25                 | 10                 | 0.31               | 0.070              | 0.12               | 0.144              | 27                | 0.6                |
| Grape juice, canned or bottled, unsweetened, w/o vitamin C                     | 61                       | 15.0                 | 0.6                    | 0.1                | 0                     | 3                  | 132               | 9                  | 10                 | 0.24               | 0.028              | 0.05               | 0.360              | 11                | 0.1                |
| Grapefruit juice, white, canned, unsweetened                                   | 38                       | 9.0                  | 0.5                    | 0.1                | 0                     | 1                  | 153               | 7                  | 10                 | 0.20               | 0.038              | 0.09               | 0.020              | 11                | 0.1                |
| Grapefruit, raw, pink & red, all areas                                         | 42                       | 10.7                 | 0.8                    | 0.1                | 0                     | 0                  | 135               | 22                 | 9                  | 0.08               | 0.032              | 0.07               | 0.022              | 18                | 0.1                |
| Grapefruit, raw, white, all areas                                              | 33                       | 8.4                  | 0.7                    | 0.1                | 0                     | 0                  | 148               | 12                 | 9                  | 0.06               | 0.050              | 0.07               | 0.013              | 8                 | 1.4                |
| Grapes, American type (slip skin), raw                                         | 67                       | 17.2                 | 0.6                    | 0.4                | 0                     | 2                  | 191               | 14                 | 5                  | 0.29               | 0.040              | 0.04               | 0.718              | 10                | 0.1                |
| Grouper, mixed species, cooked, dry heat                                       | 118                      | 0.0                  | 24.8                   | 1.3                | 47                    | 53                 | 475               | 21                 | 37                 | 1.14               | 0.045              | 0.51               | 0.012              | 143               | 46.8               |
| Haddock, cooked, dry heat                                                      | 112                      | 0.0                  | 24.2                   | 0.9                | 74                    | 87                 | 399               | 42                 | 50                 | 1.35               | 0.033              | 0.48               | 0.030              | 241               | 40.5               |
| Haddock, smoked                                                                | 116                      | 0.0                  | 25.2                   | 1.0                | 77                    | 763                | 415               | 49                 | 54                 | 1.40               | 0.042              | 0.50               | 0.030              | 251               | 42.9               |
| Halibut, Atlantic & Pacific, cooked, dry heat                                  | 140                      | 0.0                  | 26.7                   | 2.9                | 41                    | 69                 | 576               | 60                 | 107                | 1.07               | 0.035              | 0.53               | 0.020              | 285               | 46.8               |
| Ham, sliced, regular (approx 11% fat)                                          | 163                      | 3.8                  | 16.6                   | 8.6                | 57                    | 1304               | 287               | 24                 | 22                 | 1.02               | 0.089              | 1.35               | 0.557              | 153               | 20.7               |
| Herring, Atlantic, kippered                                                    | 217                      | 0.0                  | 24.6                   | 12.4               | 82                    | 918                | 447               | 84                 | 46                 | 1.51               | 0.135              | 1.36               | 0.050              | 325               | 52.6               |
| Hominy, canned, white or yellow                                                | 72                       | 14.3                 | 1.5                    | 0.9                | 0                     | 210                | 9                 | 10                 | 16                 | 0.62               | 0.030              | 1.05               | 0.070              | 35                | 3.0                |
| Hummus, commercial                                                             | 166                      | 14.3                 | 7.9                    | 9.6                | 0                     | 379                | 228               | 38                 | 71                 | 2.44               | 0.527              | 1.83               | 0.773              | 176               | 2.6                |
| Ice creams, chocolate                                                          | 216                      | 28.2                 | 3.8                    | 11.0               | 34                    | 76                 | 249               | 109                | 29                 | 0.93               | 0.135              | 0.58               | 0.140              | 107               | 2.5                |
| Ice creams, French vanilla, soft-serve                                         | 222                      | 22.2                 | 4.1                    | 13.0               | 91                    | 61                 | 177               | 131                | 12                 | 0.21               | 0.030              | 0.52               | 0.005              | 116               | 3.0                |
| Ice creams, strawberry                                                         | 192                      | 27.6                 | 3.2                    | 8.4                | 29                    | 60                 | 188               | 120                | 14                 | 0.21               | 0.037              | 0.34               | 0.078              | 100               | 1.9                |
| Ice creams, vanilla                                                            | 201                      | 23.6                 | 3.5                    | 11.0               | 44                    | 80                 | 199               | 128                | 14                 | 0.09               | 0.023              | 0.69               | 0.008              | 105               | 1.8                |
| Jams and preserves                                                             | 278                      | 68.9                 | 0.4                    | 0.1                | 0                     | 32                 | 77                | 20                 | 4                  | 0.49               | 0.100              | 0.06               | 0.040              | 19                | 2.0                |
| Jellies                                                                        | 266                      | 70.0                 | 0.2                    | 0.0                | 0                     | 30                 | 54                | 7                  | 6                  | 0.19               | 0.011              | 0.03               | 0.132              | 6                 | 0.4                |
| Kale, boiled, w/o salt                                                         | 28                       | 5.6                  | 1.9                    | 0.4                | 0                     | 23                 | 228               | 72                 | 18                 | 0.90               | 0.156              | 0.24               | 0.416              | 28                | 0.9                |
| Kale, raw                                                                      | 50                       | 10.0                 | 3.3                    | 0.7                | 0                     | 43                 | 447               | 135                | 34                 | 1.70               | 0.290              | 0.44               | 0.774              | 56                | 0.9                |
| Kiwi fruit, (Chinese gooseberries), fresh, raw                                 | 61                       | 14.7                 | 1.1                    | 0.5                | 0                     | 3                  | 312               | 34                 | 17                 | 0.31               | 0.130              | 0.14               | 0.098              | 34                | 0.2                |
| Knockwurst, pork or beef                                                       | 307                      | 3.2                  | 11.1                   | 27.7               | 60                    | 930                | 199               | 11                 | 11                 | 0.66               | 0.060              | 1.66               | 0.021              | 98                | 13.5               |
| Kumquats, raw                                                                  | 71                       | 15.9                 | 1.9                    | 0.9                | 0                     | 10                 | 186               | 62                 | 20                 | 0.86               | 0.095              | 0.17               | 0.135              | 19                | 0.0                |
| Lamb, domestic, composite of retail cuts, lean & fat, 1/4" fat, choice, cooked | 294                      | 0.0                  | 24.5                   | 20.9               | 97                    | 72                 | 310               | 17                 | 23                 | 1.88               | 0.119              | 4.46               | 0.022              | 188               | 26.4               |
| Lamb, domestic, composite of retail cuts, lean & fat, 1/8" fat, choice, cooked | 271                      | 0.0                  | 25.5                   | 18.0               | 96                    | 72                 | 318               | 16                 | 24                 | 1.93               | 0.121              | 4.74               | 0.024              | 193               | 27.2               |
| Lamb, domestic, composite of retail cuts, lean, 1/4" fat, choice, cooked       | 206                      | 0.0                  | 28.2                   | 9.5                | 92                    | 76                 | 344               | 15                 | 26                 | 2.05               | 0.128              | 5.27               | 0.028              | 210               | 26.1               |
| Lamb, domestic, leg, shank half, lean & fat, 1/8" fat, choice, roasted         | 217                      | 0.0                  | 26.7                   | 11.4               | 90                    | 65                 | 329               | 9                  | 25                 | 1.99               | 0.118              | 4.72               | 0.026              | 200               | 29.7               |
| Lamb, domestic, loin, lean & fat, 1/4" fat, choice, roasted                    | 309                      | 0.0                  | 22.6                   | 23.6               | 95                    | 64                 | 246               | 18                 | 23                 | 2.12               | 0.119              | 3.41               | 0.020              | 180               | 24.6               |
| Lamb, domestic, rib, lean & fat, 1/8" fat, choice, roasted                     | 341                      | 0.0                  | 21.8                   | 27.5               | 96                    | 74                 | 277               | 22                 | 20                 | 1.62               | 0.117              | 3.62               | 0.021              | 170               | 22.3               |
| Lamb, ground, broiled                                                          | 283                      | 0.0                  | 24.8                   | 19.7               | 97                    | 81                 | 339               | 22                 | 24                 | 1.79               | 0.128              | 4.67               | 0.024              | 201               | 27.7               |
| Lard                                                                           | 902                      | 0.0                  | 0.0                    | 100.0              | 95                    | 0                  | 0                 | 0                  | 0                  | 0.00               | 0.000              | 0.11               | 0.000              | 0                 | 0.2                |
| Leeks, (bulb & lower leaf-portion), boiled, w/o salt                           | 31                       | 7.6                  | 0.8                    | 0.2                | 0                     | 10                 | 87                | 30                 | 14                 | 1.10               | 0.062              | 0.06               | 0.247              | 17                | 0.5                |
| Lemon juice, canned or bottled                                                 | 21                       | 6.5                  | 0.4                    | 0.3                | 0                     | 21                 | 102               | 11                 | 8                  | 0.13               | 0.037              | 0.06               | 0.020              | 9                 | 0.1                |
| Lemons, raw, with peel                                                         | 20                       | 10.7                 | 1.2                    | 0.3                | 0                     | 3                  | 145               | 61                 | 12                 | 0.70               | 0.260              | 0.10               |                    | 15                |                    |
| Lemons, raw, without peel                                                      | 29                       | 9.3                  | 1.1                    | 0.3                | 0                     | 2                  | 138               | 26                 | 8                  | 0.60               | 0.037              | 0.06               | 0.030              | 16                | 0.4                |
| Lentils, mature seeds, boiled, w. salt                                         | 116                      | 20.1                 | 9.0                    | 0.4                | 0                     | 238                | 369               | 19                 | 36                 | 3.33               | 0.251              | 1.27               | 0.494              | 180               | 2.8                |
| Lentils, sprouted, stir-fried, w. salt                                         | 101                      | 21.3                 | 8.8                    | 0.5                | 0                     | 246                | 284               | 14                 | 35                 | 3.10               | 0.337              | 1.60               | 0.502              | 153               | 0.6                |
| Lettuce, iceberg (includes crisp head types), raw                              | 14                       | 3.0                  | 0.9                    | 0.1                | 0                     | 10                 | 141               | 18                 | 7                  | 0.41               | 0.025              | 0.15               | 0.125              | 20                | 0.1                |
| Lettuce, romaine, raw                                                          | 17                       | 3.3                  | 1.2                    | 0.3                | 0                     | 8                  | 247               | 33                 | 14                 | 0.97               | 0.048              | 0.23               | 0.155              | 30                | 0.4                |
| Lima beans, large, mature seeds, boiled, w/o salt                              | 115                      | 20.9                 | 7.8                    | 0.4                | 0                     | 2                  | 508               | 17                 | 43                 | 2.39               | 0.235              | 0.95               | 0.516              | 111               | 4.5                |
| Lima beans, thin seeded (baby), mature seeds, boiled, w/o salt                 | 126                      | 23.3                 | 8.0                    | 0.4                | 0                     | 3                  | 401               | 29                 | 53                 | 2.40               | 0.215              | 1.03               | 0.585              | 127               | 4.9                |
| Limes, raw                                                                     | 30                       | 10.5                 | 0.7                    | 0.2                | 0                     | 2                  | 102               | 33                 | 6                  | 0.60               | 0.065              | 0.11               | 0.008              | 18                | 0.4                |
| Liverwurst spread                                                              | 305                      | 5.9                  | 12.4                   | 25.5               | 118                   | 700                | 170               | 22                 | 12                 | 8.85               | 0.240              | 2.30               | 0.155              | 230               | 58.0               |
| Lobster, northern, cooked, moist heat                                          | 98                       | 1.3                  | 20.5                   | 0.6                | 72                    | 380                | 352               | 61                 | 35                 | 0.39               | 1.940              | 2.92               | 0.061              | 185               | 42.7               |
| Macadamia nuts, dry roasted, w/o salt                                          | 718                      | 13.4                 | 7.8                    | 76.1               | 0                     | 4                  | 363               | 70                 | 118                | 2.65               | 0.570              | 1.29               | 3.036              | 198               | 3.6                |
| Macaroni, cooked, enriched                                                     | 158                      | 30.9                 | 5.8                    | 0.9                | 0                     | 1                  | 45                | 7                  | 18                 | 1.33               | 0.103              | 0.50               | 0.317              | 58                | 26.4               |
| Mackerel, Atlantic, cooked, dry heat                                           | 262                      | 0.0                  | 23.9                   | 17.8               | 75                    | 83                 | 401               | 15                 | 97                 | 1.57               | 0.094              | 0.94               | 0.020              | 278               | 51.6               |

| Food description                                                       | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|------------------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Mackerel, king, cooked, dry heat                                       | 134                      | 0.0                  | 26.0                   | 2.6                | 68                    | 203                | 558               | 40                | 41                 | 2.28               | 0.033              | 0.72               | 0.006              | 318               | 46.8               |
| Mackerel, Pacific & jack, mixed species, cooked, dry heat              | 201                      | 0.0                  | 25.7                   | 10.1               | 60                    | 110                | 521               | 29                | 36                 | 1.49               | 0.119              | 0.86               | 0.019              | 160               | 46.8               |
| Mackerel, salted                                                       | 305                      | 0.0                  | 18.5                   | 25.1               | 95                    | 4450               | 520               | 66                | 60                 | 1.40               | 0.100              | 1.10               |                    | 254               | 73.4               |
| Mackerel, Spanish, cooked, dry heat                                    | 158                      | 0.0                  | 23.6                   | 6.3                | 73                    | 66                 | 554               | 13                | 38                 | 0.74               | 0.065              | 0.62               | 0.012              | 271               | 40.6               |
| Mangos, raw                                                            | 65                       | 17.0                 | 0.5                    | 0.3                | 0                     | 2                  | 156               | 10                | 9                  | 0.13               | 0.110              | 0.04               | 0.027              | 11                | 0.6                |
| Margarine, regular, hard, corn (hydrogenated)                          | 719                      | 0.9                  | 0.9                    | 80.5               | 0                     | 943                | 42                | 30                | 3                  | 0.00               |                    |                    |                    | 23                | 0.0                |
| Margarine, regular, hard, soybean (hydrogenated) & palm (hydrogenated) | 719                      | 0.9                  | 0.9                    | 80.5               | 0                     | 943                | 42                | 30                | 3                  | 0.00               |                    | 0.00               |                    | 23                | 0.0                |
| Margarine, regular, stick, unsalted, 80% fat                           | 719                      | 0.9                  | 0.9                    | 80.5               | 0                     | 2                  | 25                | 17                | 2                  | 0.00               | 0.000              | 0.00               |                    | 13                | 0.0                |
| Margarine, regular, tub, unsalted, 80% fat                             | 716                      | 0.5                  | 0.8                    | 80.4               | 0                     | 28                 | 38                | 26                | 2                  | 0.00               | 0.000              | 0.00               |                    | 20                | 0.0                |
| Marmalade, orange                                                      | 246                      | 66.3                 | 0.3                    | 0.0                | 0                     | 56                 | 37                | 38                | 2                  | 0.15               | 0.090              | 0.04               | 0.020              | 4                 | 0.6                |
| Mayonnaise dressing, no cholesterol                                    | 688                      | 0.3                  | 0.0                    | 77.8               | 0                     | 486                | 14                | 7                 | 1                  | 0.23               | 0.000              | 0.13               |                    | 25                | 1.6                |
| Mayonnaise, low sodium, diet                                           | 231                      | 16.0                 | 0.3                    | 19.2               | 24                    | 110                | 10                | 0                 | 0                  | 0.00               | 0.000              | 0.11               | 0.000              | 0                 | 1.6                |
| Melons, honeydew, raw                                                  | 36                       | 9.1                  | 0.5                    | 0.1                | 0                     | 18                 | 228               | 6                 | 10                 | 0.17               | 0.024              | 0.09               | 0.027              | 11                | 0.7                |
| Milk, buttermilk, fluid, cultured, reduced fat                         | 56                       | 5.3                  | 4.1                    | 2.0                | 8                     | 86                 | 180               | 143               | 13                 | 0.06               | 0.008              | 0.24               |                    | 82                | 2.3                |
| Milk, goat, fluid                                                      | 69                       | 4.5                  | 3.6                    | 4.1                | 11                    | 50                 | 204               | 134               | 14                 | 0.05               | 0.046              | 0.30               | 0.018              | 111               | 1.4                |
| Milk, low fat, fluid, 1% milkfat, w. vitamin A                         | 42                       | 5.0                  | 3.4                    | 1.0                | 5                     | 44                 | 150               | 119               | 11                 | 0.03               | 0.010              | 0.42               | 0.003              | 95                | 3.3                |
| Milk, low sodium, fluid                                                | 61                       | 4.5                  | 3.1                    | 3.5                | 14                    | 3                  | 253               | 101               | 5                  | 0.05               | 0.010              | 0.38               | 0.004              | 86                | 2.0                |
| Milk, reduced fat, fluid, 2% milkfat, w. added vitamin A               | 50                       | 4.7                  | 3.3                    | 2.0                | 8                     | 41                 | 150               | 117               | 11                 | 0.03               | 0.012              | 0.43               | 0.003              | 94                | 2.5                |
| Muffins, blueberry, commercially prepared                              | 277                      | 48.0                 | 5.5                    | 6.5                | 30                    | 447                | 123               | 57                | 16                 | 1.61               | 0.074              | 0.49               | 0.440              | 197               | 11.2               |
| Muffins, corn, commercially prepared                                   | 305                      | 50.9                 | 5.9                    | 8.4                | 26                    | 521                | 69                | 74                | 32                 | 2.81               | 0.299              | 0.54               | 0.355              | 284               | 15.2               |
| Muffins, oat bran                                                      | 270                      | 48.3                 | 7.0                    | 7.4                | 0                     | 393                | 507               | 63                | 157                | 4.20               | 0.330              | 1.84               | 2.630              | 376               | 11.0               |
| Mullet, striped, cooked, dry heat                                      | 150                      | 0.0                  | 24.8                   | 4.9                | 63                    | 71                 | 458               | 31                | 33                 | 1.41               | 0.141              | 0.88               | 0.022              | 244               | 46.8               |
| Mushrooms, boiled, w/o salt                                            | 28                       | 5.3                  | 2.2                    | 0.5                | 0                     | 2                  | 356               | 6                 | 12                 | 1.74               | 0.504              | 0.87               | 0.115              | 87                | 11.9               |
| Mushrooms, oyster, raw                                                 | 35                       | 6.4                  | 3.3                    | 0.4                | 0                     | 18                 | 420               | 3                 | 18                 | 1.33               | 0.244              | 0.77               | 0.113              | 120               | 2.6                |
| Mushrooms, portabella, grilled                                         | 35                       | 5.1                  | 4.1                    | 0.8                | 0                     | 10                 | 521               | 4                 | 15                 | 0.56               | 0.499              | 0.73               | 0.075              | 150               | 17.7               |
| Mushrooms, raw                                                         | 22                       | 3.3                  | 3.1                    | 0.3                | 0                     | 5                  | 318               | 3                 | 9                  | 0.50               | 0.318              | 0.52               | 0.047              | 86                | 9.3                |
| Mushrooms, shiitake, cooked, w/o salt                                  | 56                       | 14.4                 | 1.6                    | 0.2                | 0                     | 4                  | 117               | 3                 | 14                 | 0.44               | 0.896              | 1.33               | 0.204              | 29                | 24.8               |
| Mussels, blue, cooked, moist heat                                      | 172                      | 7.4                  | 23.8                   | 4.5                | 56                    | 369                | 268               | 33                | 37                 | 6.72               | 0.149              | 2.67               | 6.800              | 285               | 89.6               |
| Mussels, blue, raw                                                     | 86                       | 3.7                  | 11.9                   | 2.2                | 28                    | 286                | 320               | 26                | 34                 | 3.95               | 0.094              | 1.60               | 3.400              | 197               | 44.8               |
| Mustard greens, boiled, w/o salt                                       | 15                       | 2.1                  | 2.3                    | 0.2                | 0                     | 16                 | 202               | 74                | 15                 | 0.70               | 0.084              | 0.11               | 0.274              | 41                | 0.6                |
| Nectarines, raw                                                        | 44                       | 10.6                 | 1.1                    | 0.3                | 0                     | 0                  | 201               | 6                 | 9                  | 0.28               | 0.086              | 0.17               | 0.054              | 26                | 0.0                |
| Noodles, egg, cooked, enriched, w. salt                                | 138                      | 25.2                 | 4.5                    | 2.1                | 29                    | 165                | 38                | 12                | 21                 | 1.47               | 0.098              | 0.65               | 0.315              | 76                | 23.9               |
| Noodles, Japanese, soba, cooked                                        | 99                       | 21.4                 | 5.1                    | 0.1                | 0                     | 60                 | 35                | 4                 | 9                  | 0.48               | 0.008              | 0.12               | 0.374              | 25                |                    |
| Nutmeg, ground                                                         | 525                      | 49.3                 | 5.8                    | 36.3               | 0                     | 16                 | 350               | 184               | 183                | 3.04               | 1.027              | 2.15               | 2.900              | 213               | 1.6                |
| Ocean perch, Atlantic, cooked, dry heat                                | 121                      | 0.0                  | 23.9                   | 2.1                | 54                    | 96                 | 350               | 137               | 39                 | 1.18               | 0.033              | 0.61               | 0.020              | 277               | 55.5               |
| Oil, avocado                                                           | 884                      | 0.0                  | 0.0                    | 100.0              |                       | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Oil, canola                                                            | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Oil, canola and soybean                                                | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.0                |
| Oil, coconut                                                           | 862                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.04               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Oil, corn and canola                                                   | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.0                |
| Oil, mustard                                                           | 884                      | 0.0                  | 0.0                    | 100.0              |                       | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Oil, olive, salad or cooking                                           | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 2                  | 1                 | 1                 | 0                  | 0.56               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Oil, palm                                                              | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.01               | 0.000              | 0.00               |                    | 0                 | 0.0                |
| Oil, palm kernel                                                       | 862                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Oil, peanut, salad or cooking                                          | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.03               | 0.000              | 0.01               |                    | 0                 | 0.0                |
| Oil, safflower, salad or cooking, linoleic >70%                        | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.0                |
| Oil, safflower, salad or cooking, oleic >70%                           | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Oil, sesame, salad or cooking                                          | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.0                |
| Oil, soybean lecithin                                                  | 763                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Oil, soybean, salad or cooking                                         | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.02               | 0.000              | 0.00               |                    | 0                 | 0.0                |
| Oil, sunflower, linoleic, approx. 65%                                  | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               |                    | 0                 | 0.0                |
| Okra, boiled, w/o salt                                                 | 22                       | 4.6                  | 1.9                    | 0.2                | 0                     | 6                  | 135               | 77                | 36                 | 0.28               | 0.085              | 0.43               | 0.294              | 32                | 0.4                |

| Food description                                  | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|---------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Olives, pickled, canned or bottled, green         | 145                      | 3.8                  | 1.0                    | 15.3               | 0                     | 1556               | 42                | 52                | 11                 | 0.49               | 0.120              | 0.04               |                    | 4                 | 0.9                |
| Olives, ripe, canned (small-extra large)          | 115                      | 6.3                  | 0.8                    | 10.7               | 0                     | 872                | 8                 | 88                | 4                  | 3.30               | 0.251              | 0.22               | 0.020              | 3                 | 0.9                |
| Onions, boiled, w/o salt                          | 44                       | 10.2                 | 1.4                    | 0.2                | 0                     | 3                  | 166               | 22                | 11                 | 0.24               | 0.067              | 0.21               | 0.153              | 35                | 0.6                |
| Onions, raw                                       | 42                       | 10.1                 | 0.9                    | 0.1                | 0                     | 3                  | 144               | 22                | 10                 | 0.19               | 0.038              | 0.16               | 0.132              | 27                | 0.5                |
| Orange juice, includes from concentrate           | 44                       | 10.1                 | 0.8                    | 0.3                | 0                     | 1                  | 190               | 10                | 11                 | 0.17               | 0.040              | 0.04               | 0.023              | 11                | 0.1                |
| Oranges, raw, all commercial varieties            | 47                       | 11.8                 | 0.9                    | 0.1                | 0                     | 0                  | 181               | 40                | 10                 | 0.10               | 0.045              | 0.07               | 0.025              | 14                | 0.5                |
| Oranges, raw, California, Valencias               | 49                       | 11.9                 | 1.0                    | 0.3                | 0                     | 0                  | 179               | 40                | 10                 | 0.09               | 0.037              | 0.06               | 0.023              | 17                |                    |
| Oranges, raw, Florida                             | 46                       | 11.5                 | 0.7                    | 0.2                | 0                     | 0                  | 169               | 43                | 10                 | 0.09               | 0.039              | 0.08               | 0.024              | 12                | 0.5                |
| Oranges, raw, navels                              | 49                       | 12.5                 | 0.9                    | 0.2                | 0                     | 1                  | 166               | 43                | 11                 | 0.13               | 0.039              | 0.08               | 0.029              | 23                | 0.0                |
| Ostrich, ground, cooked, pan-broiled              | 175                      | 0.0                  | 26.2                   | 7.1                | 83                    | 80                 | 323               | 8                 | 23                 | 3.43               | 0.136              | 4.33               | 0.017              | 224               | 33.5               |
| Ostrich, inside leg, cooked                       | 141                      | 0.0                  | 29.0                   | 1.9                | 73                    | 83                 | 352               | 6                 | 25                 | 3.12               | 0.148              | 4.71               | 0.018              | 244               | 36.5               |
| Ostrich, top loin, cooked                         | 155                      | 0.0                  | 28.1                   | 3.9                | 93                    | 77                 | 353               | 6                 | 25                 | 3.31               | 0.148              | 4.72               | 0.018              | 245               | 36.6               |
| Oyster, eastern, breaded & fried                  | 197                      | 11.6                 | 8.8                    | 12.6               | 81                    | 417                | 244               | 62                | 58                 | 6.95               | 4.294              | 87.13              | 0.490              | 159               | 66.5               |
| Oyster, eastern, farmed, raw                      | 59                       | 5.5                  | 5.2                    | 1.6                | 25                    | 178                | 124               | 44                | 33                 | 5.78               | 0.738              | 37.92              | 0.394              | 93                | 63.7               |
| Oyster, eastern, wild, raw                        | 68                       | 3.9                  | 7.1                    | 2.5                | 53                    | 211                | 156               | 45                | 47                 | 6.66               | 4.452              | 90.81              | 0.367              | 135               | 63.7               |
| Oyster, Pacific, cooked, moist heat               | 163                      | 9.9                  | 18.9                   | 4.6                | 100                   | 212                | 302               | 16                | 44                 | 9.20               | 2.679              | 33.24              | 1.222              | 243               | 154.0              |
| Oyster, Pacific, raw                              | 81                       | 5.0                  | 9.5                    | 2.3                | 50                    | 106                | 168               | 8                 | 22                 | 5.11               | 1.576              | 16.62              | 0.643              | 162               | 77.0               |
| Palm hearts, raw                                  | 115                      | 25.6                 | 2.7                    | 0.2                | 0                     | 14                 | 1806              | 18                | 10                 | 1.69               | 0.644              | 3.73               |                    | 140               | 0.7                |
| Papayas, raw                                      | 39                       | 9.8                  | 0.6                    | 0.1                | 0                     | 3                  | 257               | 24                | 10                 | 0.10               | 0.016              | 0.07               | 0.011              | 5                 | 0.6                |
| Parsley, raw                                      | 36                       | 6.3                  | 3.0                    | 0.8                | 0                     | 56                 | 554               | 138               | 50                 | 6.20               | 0.149              | 1.07               | 0.160              | 58                | 0.1                |
| Pastrami beef 98% fat-free                        | 95                       | 1.5                  | 19.6                   | 1.2                | 47                    | 1010               | 228               | 9                 | 18                 | 2.78               | 0.079              | 4.26               | 0.013              | 150               | 10.4               |
| Pate de foie gras, canned, smoked                 | 462                      | 4.7                  | 11.4                   | 43.8               | 150                   | 697                | 138               | 70                | 13                 | 5.50               | 0.400              | 0.92               | 0.120              | 200               | 44.0               |
| Pate, liver, not specified, canned                | 319                      | 1.5                  | 14.2                   | 28.0               | 255                   | 697                | 138               | 70                | 13                 | 5.50               | 0.400              | 2.85               | 0.120              | 200               | 41.6               |
| Peaches, raw                                      | 39                       | 9.5                  | 0.9                    | 0.3                | 0                     | 0                  | 190               | 6                 | 9                  | 0.25               | 0.068              | 0.17               | 0.061              | 20                | 0.1                |
| Peanut butter, chunk style, w/o salt              | 589                      | 21.6                 | 24.1                   | 49.9               | 0                     | 17                 | 745               | 45                | 160                | 1.90               | 0.578              | 2.79               | 1.800              | 319               | 8.2                |
| Peanut butter, smooth style, w/o salt             | 588                      | 19.6                 | 25.1                   | 50.4               | 0                     | 17                 | 649               | 43                | 154                | 1.87               | 0.473              | 2.91               | 1.466              | 358               | 5.6                |
| Peanuts, all types, dry-roasted, w. salt          | 585                      | 21.5                 | 23.7                   | 49.7               | 0                     | 813                | 658               | 54                | 176                | 2.26               | 0.671              | 3.31               | 2.083              | 358               | 7.5                |
| Peanuts, all types, oil-roasted, w. salt          | 599                      | 15.3                 | 28.0                   | 52.5               | 0                     | 320                | 726               | 61                | 176                | 1.52               | 0.533              | 3.28               | 1.845              | 397               | 3.3                |
| Pears, raw                                        | 58                       | 15.5                 | 0.4                    | 0.1                | 0                     | 1                  | 119               | 9                 | 7                  | 0.17               | 0.082              | 0.10               | 0.049              | 11                | 0.1                |
| Peas, edible-podded, boiled, w. salt              | 42                       | 7.1                  | 3.3                    | 0.2                | 0                     | 240                | 240               | 42                | 26                 | 1.97               | 0.077              | 0.37               | 0.168              | 55                | 0.7                |
| Peas, edible-podded, raw                          | 42                       | 7.6                  | 2.8                    | 0.2                | 0                     | 4                  | 200               | 43                | 24                 | 2.08               | 0.079              | 0.27               | 0.244              | 53                | 0.7                |
| Peas, green, boiled, w/o salt                     | 84                       | 15.6                 | 5.4                    | 0.2                | 0                     | 3                  | 271               | 27                | 39                 | 1.54               | 0.173              | 1.19               | 0.525              | 117               | 1.9                |
| Pecans, dry roasted, w. salt                      | 710                      | 13.6                 | 9.5                    | 74.3               | 0                     | 383                | 424               | 72                | 132                | 2.80               | 1.167              | 5.07               | 3.933              | 293               | 4.0                |
| Pecans, oil roasted, w. salt                      | 715                      | 13.0                 | 9.2                    | 75.2               | 0                     | 393                | 392               | 67                | 121                | 2.47               | 1.200              | 4.47               | 3.700              | 263               | 6.0                |
| Peppers, hot chili, green, raw                    | 40                       | 9.5                  | 2.0                    | 0.2                | 0                     | 7                  | 340               | 18                | 25                 | 1.20               | 0.174              | 0.30               | 0.237              | 46                | 0.5                |
| Peppers, hot chili, red, raw                      | 40                       | 8.8                  | 1.9                    | 0.4                | 0                     | 9                  | 322               | 14                | 23                 | 1.03               | 0.129              | 0.26               | 0.187              | 43                | 0.5                |
| Peppers, jalapeno, raw                            | 30                       | 5.9                  | 1.4                    | 0.6                | 0                     | 1                  | 215               | 10                | 19                 | 0.70               | 0.133              | 0.23               | 0.250              | 31                | 0.3                |
| Peppers, sweet, green, boiled, w/o salt           | 28                       | 6.7                  | 0.9                    | 0.2                | 0                     | 2                  | 166               | 9                 | 10                 | 0.46               | 0.065              | 0.12               | 0.115              | 18                | 0.3                |
| Peppers, sweet, green, raw                        | 20                       | 4.6                  | 0.9                    | 0.2                | 0                     | 3                  | 175               | 10                | 10                 | 0.34               | 0.066              | 0.13               | 0.122              | 20                | 0.0                |
| Peppers, sweet, red, boiled, w/o salt             | 28                       | 6.7                  | 0.9                    | 0.2                | 0                     | 2                  | 166               | 9                 | 10                 | 0.46               | 0.065              | 0.12               | 0.115              | 18                | 0.3                |
| Peppers, sweet, red, raw                          | 26                       | 6.0                  | 1.0                    | 0.3                | 0                     | 2                  | 211               | 7                 | 12                 | 0.43               | 0.017              | 0.25               | 0.112              | 26                | 0.1                |
| Peppers, sweet, yellow, raw                       | 27                       | 6.3                  | 1.0                    | 0.2                | 0                     | 2                  | 212               | 11                | 12                 | 0.46               | 0.107              | 0.17               | 0.117              | 24                | 0.3                |
| Persimmons, native, raw                           | 127                      | 33.5                 | 0.8                    | 0.4                | 0                     | 1                  | 310               | 27                |                    | 2.50               |                    |                    |                    | 26                |                    |
| Pheasant, cooked, total edible                    | 247                      | 0.0                  | 32.4                   | 12.1               | 89                    | 43                 | 271               | 16                | 22                 | 1.43               | 0.084              | 1.37               |                    | 242               | 20.7               |
| Pickle, cucumber, sour                            | 11                       | 2.3                  | 0.3                    | 0.2                | 0                     | 1208               | 23                | 0                 | 4                  | 0.40               | 0.085              | 0.02               | 0.011              | 14                | 0.0                |
| Pickle, cucumber, sweet                           | 117                      | 31.8                 | 0.4                    | 0.3                | 0                     | 939                | 32                | 4                 | 4                  | 0.59               | 0.105              | 0.08               | 0.015              | 12                | 0.0                |
| Pickles, cucumber, dill                           | 18                       | 4.1                  | 0.6                    | 0.2                | 0                     | 1282               | 116               | 9                 | 11                 | 0.53               | 0.079              | 0.14               | 0.015              | 21                | 0.0                |
| Pie, apple, commercially prepared, enriched flour | 237                      | 34.0                 | 1.9                    | 11.0               | 0                     | 266                | 65                | 11                | 7                  | 0.45               | 0.046              | 0.16               | 0.182              | 24                | 1.0                |
| Pie, blueberry, commercially prepared             | 232                      | 34.9                 | 1.8                    | 10.0               | 0                     | 325                | 50                | 8                 | 5                  | 0.30               | 0.046              | 0.16               | 0.176              | 23                | 1.4                |
| Pie, cherry, commercially prepared                | 260                      | 39.8                 | 2.0                    | 11.0               | 0                     | 246                | 81                | 12                | 8                  | 0.48               | 0.040              | 0.18               | 0.140              | 29                | 1.2                |
| Pie, chocolate creme, commercially prepared       | 304                      | 33.6                 | 2.6                    | 19.4               | 5                     | 136                | 127               | 36                | 21                 | 1.07               | 0.050              | 0.23               | 0.200              | 68                | 7.5                |
| Pie, coconut creme, commercially prepared         | 298                      | 37.2                 | 2.1                    | 16.6               | 0                     | 255                | 65                | 29                | 20                 | 0.80               | 0.068              | 0.47               | 0.438              | 85                | 5.3                |
| Pie, egg custard, commercially prepared           | 210                      | 20.8                 | 5.5                    | 11.6               | 33                    | 240                | 106               | 80                | 11                 | 0.58               | 0.024              | 0.52               | 0.060              | 112               | 7.1                |
| Pie, lemon meringue, commercially prepared        | 268                      | 47.2                 | 1.5                    | 8.7                | 45                    | 146                | 89                | 56                | 15                 | 0.61               | 0.001              | 0.49               | 0.060              | 105               | 3.0                |

| Food description                                                            | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|-----------------------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Pie, mince, prepared from recipe                                            | 289                      | 48.0                 | 2.6                    | 10.8               | 0                     | 254                | 203               | 22                | 14                 | 1.49               | 0.113              | 0.22               | 0.263              | 42                | 6.6                |
| Pie, peach                                                                  | 223                      | 32.9                 | 1.9                    | 10.0               | 0                     | 270                | 125               | 8                 | 6                  | 0.50               | 0.053              | 0.09               | 0.152              | 22                | 1.3                |
| Pie, pecan, commercially prepared                                           | 400                      | 57.2                 | 4.0                    | 18.5               | 32                    | 424                | 74                | 17                | 18                 | 1.04               | 0.195              | 0.57               | 0.789              | 77                | 5.0                |
| Pie, pumpkin, commercially prepared                                         | 210                      | 27.3                 | 3.9                    | 9.5                | 20                    | 282                | 154               | 60                | 15                 | 0.79               | 0.048              | 0.45               | 0.240              | 71                | 2.6                |
| Pike, northern, cooked, dry heat                                            | 113                      | 0.0                  | 24.7                   | 0.9                | 50                    | 49                 | 331               | 73                | 40                 | 0.71               | 0.065              | 0.86               | 0.310              | 282               | 16.2               |
| Pike, walleye, raw                                                          | 93                       | 0.0                  | 19.1                   | 1.2                | 86                    | 51                 | 389               | 110               | 30                 | 1.30               | 0.178              | 0.62               | 0.800              | 210               | 12.6               |
| Pimento, canned                                                             | 23                       | 5.1                  | 1.1                    | 0.3                | 0                     | 14                 | 158               | 6                 | 6                  | 1.68               | 0.049              | 0.19               | 0.092              | 17                | 0.2                |
| Pine nuts, pinyon, dried                                                    | 629                      | 19.3                 | 11.6                   | 61.0               | 0                     | 72                 | 628               | 8                 | 234                | 3.06               | 1.035              | 4.28               | 4.333              | 35                |                    |
| Pineapple juice, canned, unsweetened, w/o vitamin C                         | 53                       | 12.9                 | 0.4                    | 0.1                | 0                     | 2                  | 130               | 13                | 12                 | 0.31               | 0.069              | 0.11               | 0.504              | 8                 | 0.1                |
| Pineapple, raw, all variety                                                 | 48                       | 12.6                 | 0.5                    | 0.1                | 0                     | 1                  | 115               | 13                | 12                 | 0.28               | 0.099              | 0.10               | 1.177              | 8                 | 0.1                |
| Pineapple, raw, traditional variety                                         | 45                       | 11.8                 | 0.6                    | 0.1                |                       | 1                  | 125               | 13                | 12                 | 0.25               | 0.081              | 0.08               | 1.593              | 9                 | 0.0                |
| Pistachio nuts, dry roasted, w/o salt                                       | 571                      | 27.7                 | 21.4                   | 46.0               | 0                     | 10                 | 1042              | 110               | 120                | 4.20               | 1.325              | 2.30               | 1.275              | 485               | 9.3                |
| Plantains, cooked                                                           | 116                      | 31.2                 | 0.8                    | 0.2                | 0                     | 5                  | 465               | 2                 | 32                 | 0.58               | 0.066              | 0.13               |                    | 28                | 1.4                |
| Plums, dried (prunes), uncooked                                             | 240                      | 63.9                 | 2.2                    | 0.4                | 0                     | 2                  | 732               | 43                | 41                 | 0.93               | 0.281              | 0.44               | 0.299              | 69                | 0.3                |
| Plums, raw                                                                  | 46                       | 11.4                 | 0.7                    | 0.3                | 0                     | 0                  | 157               | 6                 | 7                  | 0.17               | 0.057              | 0.10               | 0.052              | 16                | 0.0                |
| Pollock, Atlantic, cooked, dry heat                                         | 118                      | 0.0                  | 24.9                   | 1.3                | 91                    | 110                | 456               | 77                | 86                 | 0.59               | 0.064              | 0.60               | 0.019              | 283               | 46.8               |
| Pollock, walleye, cooked, dry heat                                          | 113                      | 0.0                  | 23.5                   | 1.1                | 96                    | 116                | 387               | 6                 | 73                 | 0.28               | 0.055              | 0.60               | 0.020              | 482               | 43.4               |
| Pomegranates, raw                                                           | 68                       | 17.2                 | 1.0                    | 0.3                | 0                     | 3                  | 259               | 3                 | 3                  | 0.30               | 0.070              | 0.12               |                    | 8                 | 0.6                |
| Pompano, Florida, cooked, dry heat                                          | 211                      | 0.0                  | 23.7                   | 12.1               | 64                    | 76                 | 636               | 43                | 31                 | 0.67               | 0.078              | 0.69               | 0.025              | 341               | 46.8               |
| Popcorn, air-popped                                                         | 387                      | 77.8                 | 12.9                   | 4.5                | 0                     | 8                  | 329               | 7                 | 144                | 3.19               | 0.262              | 3.08               | 1.113              | 358               | 0.0                |
| Pork sausage, fresh, cooked                                                 | 339                      | 0.0                  | 19.4                   | 28.4               | 84                    | 749                | 294               | 13                | 17                 | 1.36               | 0.086              | 2.08               | 0.005              | 163               | 0.0                |
| Pork, cured, bacon, broiled, pan-fried or roasted                           | 541                      | 1.4                  | 37.0                   | 41.8               | 110                   | 2310               | 565               | 11                | 33                 | 1.44               | 0.164              | 3.50               | 0.022              | 533               | 62.0               |
| Pork, cured, breakfast strips, cooked                                       | 459                      | 1.1                  | 29.0                   | 36.7               | 105                   | 2099               | 466               | 14                | 26                 | 1.97               | 0.153              | 3.68               | 0.044              | 265               | 24.7               |
| Pork, cured, Canadian-style bacon, grilled                                  | 185                      | 1.4                  | 24.2                   | 8.4                | 58                    | 1546               | 390               | 10                | 21                 | 0.82               | 0.054              | 1.70               | 0.027              | 296               | 24.7               |
| Pork, cured, ham, boneless, extra lean (approx 5% fat), roasted             | 145                      | 1.5                  | 20.9                   | 5.5                | 53                    | 1203               | 287               | 8                 | 14                 | 1.48               | 0.079              | 2.88               | 0.054              | 196               | 19.5               |
| Pork, cured, ham, boneless, regular (approx 11% fat), roasted               | 178                      | 0.0                  | 22.6                   | 9.0                | 59                    | 1500               | 409               | 8                 | 22                 | 1.34               | 0.145              | 2.47               | 0.041              | 281               | 19.8               |
| Pork, cured, ham, whole, lean & fat, roasted                                | 243                      | 0.0                  | 21.6                   | 16.8               | 62                    | 1187               | 286               | 7                 | 19                 | 0.87               | 0.083              | 2.32               | 0.014              | 214               | 22.7               |
| Pork, cured, salt pork, raw                                                 | 748                      | 0.0                  | 5.1                    | 80.5               | 86                    | 1424               | 66                | 6                 | 7                  | 0.44               | 0.050              | 0.90               | 0.005              | 52                | 5.8                |
| Pork, fresh, composite of retail cuts (leg, loin, & shoulder), lean, cooked | 212                      | 0.0                  | 29.3                   | 9.7                | 86                    | 59                 | 375               | 21                | 26                 | 1.10               | 0.061              | 2.97               | 0.018              | 237               | 45.0               |
| Pork, fresh, leg (ham), rump half, lean & fat, roasted                      | 252                      | 0.0                  | 28.9                   | 14.3               | 96                    | 62                 | 374               | 12                | 27                 | 1.05               | 0.103              | 2.82               | 0.023              | 272               | 46.8               |
| Pork, fresh, leg (ham), shank half, lean & fat, roasted                     | 289                      | 0.0                  | 25.3                   | 20.1               | 92                    | 59                 | 338               | 15                | 22                 | 0.98               | 0.098              | 3.06               | 0.028              | 257               | 43.3               |
| Pork, fresh, loin, blade (chops), bone-in, lean & fat, broiled              | 320                      | 0.0                  | 22.5                   | 24.9               | 86                    | 70                 | 344               | 29                | 22                 | 0.93               | 0.083              | 3.37               | 0.008              | 212               | 37.1               |
| Pork, fresh, loin, center loin (chops), bone-in, lean & fat, broiled        | 240                      | 0.0                  | 28.7                   | 13.1               | 82                    | 58                 | 358               | 33                | 25                 | 0.80               | 0.046              | 2.26               | 0.003              | 232               | 44.3               |
| Pork, fresh, loin, center rib (chops), bone-in, lean, broiled               | 219                      | 0.0                  | 30.8                   | 9.7                | 81                    | 65                 | 420               | 31                | 28                 | 0.82               | 0.070              | 2.38               | 0.020              | 245               | 47.3               |
| Pork, fresh, loin, center rib (chops), boneless, lean & fat, broiled        | 260                      | 0.0                  | 27.6                   | 15.8               | 82                    | 62                 | 401               | 28                | 26                 | 0.77               | 0.068              | 2.26               | 0.018              | 237               | 44.0               |
| Pork, fresh, loin, center rib (roasts), boneless, lean & fat, roasted       | 252                      | 0.0                  | 27.0                   | 15.2               | 81                    | 48                 | 346               | 6                 | 22                 | 0.93               | 0.016              | 2.64               | 0.010              | 214               | 40.3               |
| Pork, fresh, loin, country-style ribs, lean & fat, braised                  | 296                      | 0.0                  | 23.9                   | 21.5               | 87                    | 59                 | 328               | 29                | 17                 | 1.22               | 0.093              | 3.56               | 0.012              | 167               | 39.7               |
| Pork, fresh, loin, sirloin (chops), bone-in, lean & fat, broiled            | 259                      | 0.0                  | 26.7                   | 16.1               | 86                    | 68                 | 383               | 17                | 29                 | 0.99               | 0.058              | 2.57               | 0.010              | 246               | 47.7               |
| Pork, fresh, loin, sirloin (chops), boneless, lean & fat, broiled           | 208                      | 0.0                  | 30.5                   | 8.6                | 91                    | 56                 | 372               | 18                | 27                 | 1.21               | 0.053              | 2.62               | 0.003              | 243               | 50.5               |
| Pork, fresh, loin, tenderloin, lean & fat, broiled                          | 201                      | 0.0                  | 29.9                   | 8.1                | 94                    | 64                 | 444               | 5                 | 35                 | 1.39               | 0.067              | 2.89               | 0.012              | 290               | 47.7               |
| Pork, fresh, spareribs, lean & fat, braised                                 | 397                      | 0.0                  | 29.1                   | 30.3               | 121                   | 93                 | 320               | 47                | 24                 | 1.85               | 0.142              | 4.60               | 0.014              | 261               | 37.4               |
| Potato chips, plain, salted                                                 | 547                      | 49.7                 | 6.6                    | 37.5               | 0                     | 525                | 1642              | 24                | 70                 | 1.61               | 0.398              | 2.39               | 0.664              | 155               | 8.1                |
| Potatoes, baked, flesh & skin, w. salt                                      | 93                       | 21.2                 | 2.5                    | 0.1                | 0                     | 244                | 535               | 15                | 28                 | 1.08               | 0.118              | 0.36               | 0.219              | 70                | 0.4                |
| Potatoes, boiled in skin, flesh, w. salt                                    | 87                       | 20.1                 | 1.9                    | 0.1                | 0                     | 240                | 379               | 5                 | 22                 | 0.31               | 0.188              | 0.30               | 0.138              | 44                | 0.3                |
| Potatoes, boiled w/o skin, flesh, w. salt                                   | 86                       | 20.0                 | 1.7                    | 0.1                | 0                     | 241                | 328               | 8                 | 20                 | 0.31               | 0.167              | 0.27               | 0.140              | 40                | 0.3                |
| Potatoes, French fried, all types, frozen, oven-heated                      | 172                      | 28.7                 | 2.7                    | 5.2                | 0                     | 32                 | 451               | 12                | 26                 | 0.74               | 0.135              | 0.38               | 0.210              | 97                | 0.2                |

| Food description                                              | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100 g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|---------------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Potatoes, hashed brown, home-prepared                         | 265                      | 35.1                 | 3.0                    | 12.5               | 0                     | 342                | 576               | 14                 | 35                 | 0.55               | 0.293              | 0.47               | 0.247              | 70                | 0.5                |
| Potatoes, mashed, home-prepared, whole milk & margarine added | 113                      | 16.9                 | 2.0                    | 4.2                | 1                     | 333                | 328               | 22                 | 19                 | 0.26               | 0.153              | 0.30               | 0.112              | 49                | 0.8                |
| Potatoes, red, flesh & skin, baked                            | 89                       | 19.6                 | 2.3                    | 0.2                | 0                     | 8                  | 545               | 9                  | 28                 | 0.70               | 0.174              | 0.40               | 0.173              | 72                | 0.5                |
| Potatoes, white, flesh & skin, baked                          | 94                       | 21.1                 | 2.1                    | 0.2                | 0                     | 7                  | 544               | 10                 | 27                 | 0.64               | 0.127              | 0.35               | 0.189              | 75                | 0.5                |
| Pretzels, hard, plain, salted                                 | 380                      | 79.8                 | 10.3                   | 2.6                | 0                     | 1357               | 146               | 18                 | 29                 | 5.20               | 0.264              | 1.43               | 1.789              | 113               | 6.0                |
| Prunes, dehydrated (low-moisture), stewed                     | 113                      | 29.7                 | 1.2                    | 0.2                | 0                     | 2                  | 353               | 24                 | 21                 | 1.17               | 0.204              | 0.25               | 0.104              | 37                |                    |
| Pumpkin, boiled, w/o salt                                     | 20                       | 4.9                  | 0.7                    | 0.1                | 0                     | 1                  | 230               | 15                 | 9                  | 0.57               | 0.091              | 0.23               | 0.089              | 30                | 0.2                |
| Pumpkin, raw                                                  | 26                       | 6.5                  | 1.0                    | 0.1                | 0                     | 1                  | 340               | 21                 | 12                 | 0.80               | 0.127              | 0.32               | 0.125              | 44                | 0.3                |
| Quail, cooked, total edible                                   | 234                      | 0.0                  | 25.1                   | 14.1               | 86                    | 52                 | 216               | 15                 | 22                 | 4.43               | 0.592              | 3.10               |                    | 279               | 21.8               |
| Quinces, raw                                                  | 57                       | 15.3                 | 0.4                    | 0.1                | 0                     | 4                  | 197               | 11                 | 8                  | 0.70               | 0.130              | 0.04               |                    | 17                | 0.6                |
| Radicchio, raw                                                | 23                       | 4.5                  | 1.4                    | 0.3                | 0                     | 22                 | 302               | 19                 | 13                 | 0.57               | 0.341              | 0.62               | 0.138              | 40                | 0.9                |
| Radishes, raw                                                 | 16                       | 3.4                  | 0.7                    | 0.1                | 0                     | 39                 | 233               | 25                 | 10                 | 0.34               | 0.050              | 0.28               | 0.069              | 20                | 0.6                |
| Raisins, golden seedless                                      | 302                      | 79.5                 | 3.4                    | 0.5                | 0                     | 12                 | 746               | 53                 | 35                 | 1.79               | 0.363              | 0.32               | 0.308              | 115               | 0.7                |
| Raisins, seeded                                               | 296                      | 78.5                 | 2.5                    | 0.5                | 0                     | 28                 | 825               | 28                 | 30                 | 2.59               | 0.302              | 0.18               | 0.267              | 75                | 0.6                |
| Raisins, seedless                                             | 299                      | 79.2                 | 3.1                    | 0.5                | 0                     | 11                 | 749               | 50                 | 32                 | 1.88               | 0.318              | 0.22               | 0.299              | 101               | 0.6                |
| Raspberries, raw                                              | 52                       | 11.9                 | 1.2                    | 0.7                | 0                     | 1                  | 151               | 25                 | 22                 | 0.69               | 0.090              | 0.42               | 0.670              | 29                | 0.2                |
| Rhubarb, frozen, cooked, w/sugar                              | 116                      | 31.2                 | 0.4                    | 0.1                | 0                     | 1                  | 96                | 145                | 12                 | 0.21               | 0.027              | 0.08               | 0.073              | 8                 | 0.9                |
| Rhubarb, raw                                                  | 21                       | 4.5                  | 0.9                    | 0.2                | 0                     | 4                  | 288               | 86                 | 12                 | 0.22               | 0.021              | 0.10               | 0.196              | 14                | 1.1                |
| Rice, brown, long-grain, cooked                               | 111                      | 23.0                 | 2.6                    | 0.9                | 0                     | 5                  | 43                | 10                 | 43                 | 0.42               | 0.100              | 0.63               | 0.905              | 83                | 9.8                |
| Rice, brown, medium-grain, cooked                             | 112                      | 23.5                 | 2.3                    | 0.8                | 0                     | 1                  | 79                | 10                 | 44                 | 0.53               | 0.081              | 0.62               | 1.097              | 77                |                    |
| Rice, white, glutinous, cooked                                | 97                       | 21.1                 | 2.0                    | 0.2                | 0                     | 5                  | 10                | 2                  | 5                  | 0.14               | 0.049              | 0.41               | 0.262              | 8                 | 5.6                |
| Rice, white, long-grain, regular, cooked                      | 130                      | 28.2                 | 2.7                    | 0.3                | 0                     | 1                  | 35                | 10                 | 12                 | 1.20               | 0.069              | 0.49               | 0.472              | 43                | 7.5                |
| Rice, white, medium-grain, cooked                             | 130                      | 28.6                 | 2.4                    | 0.2                | 0                     | 0                  | 29                | 3                  | 13                 | 1.49               | 0.038              | 0.42               | 0.377              | 37                | 7.5                |
| Rice, white, short-grain, cooked                              | 130                      | 28.7                 | 2.4                    | 0.2                | 0                     | 0                  | 26                | 1                  | 8                  | 1.46               | 0.072              | 0.40               | 0.357              | 33                | 7.5                |
| Rockfish, Pacific, mixed species, cooked, dry heat            | 121                      | 0.0                  | 24.0                   | 2.0                | 44                    | 77                 | 520               | 12                 | 34                 | 0.53               | 0.037              | 0.53               | 0.020              | 228               | 46.8               |
| Rolls, hamburger or hotdog, plain                             | 279                      | 49.5                 | 9.5                    | 4.3                | 0                     | 479                | 94                | 138                | 21                 | 3.32               | 0.220              | 0.66               | 0.272              | 62                | 19.5               |
| Rutabagas, boiled, w/o salt                                   | 39                       | 8.7                  | 1.3                    | 0.2                | 0                     | 20                 | 326               | 48                 | 23                 | 0.53               | 0.041              | 0.35               | 0.174              | 56                | 0.7                |
| Sablefish, cooked, dry heat                                   | 250                      | 0.0                  | 17.2                   | 19.6               | 63                    | 72                 | 459               | 45                 | 71                 | 1.64               | 0.028              | 0.41               | 0.019              | 215               | 46.8               |
| Sablefish, smoked                                             | 257                      | 0.0                  | 17.7                   | 20.1               | 64                    | 737                | 471               | 50                 | 74                 | 1.69               | 0.036              | 0.43               | 0.020              | 222               | 50.2               |
| Salami, cooked, turkey                                        | 152                      | 0.4                  | 15.3                   | 9.4                | 76                    | 1004               | 216               | 40                 | 22                 | 1.25               | 0.190              | 2.32               | 0.020              | 266               | 26.4               |
| Salami, dry or hard, pork                                     | 407                      | 1.6                  | 22.6                   | 33.7               | 79                    | 2260               | 378               | 13                 | 22                 | 1.30               | 0.160              | 4.20               | 0.070              | 229               | 25.4               |
| Salami, dry or hard, pork, beef                               | 385                      | 3.8                  | 23.2                   | 30.1               | 100                   | 2010               | 378               | 8                  | 17                 | 1.51               | 0.080              | 3.23               |                    | 142               | 26.1               |
| Salami, Italian, pork                                         | 425                      | 1.2                  | 21.7                   | 37.0               | 80                    | 1890               | 340               | 10                 | 22                 | 1.52               | 0.160              | 4.20               | 0.070              | 229               | 25.4               |
| Salmon, Atlantic, farmed, cooked, dry heat                    | 206                      | 0.0                  | 22.1                   | 12.4               | 63                    | 61                 | 384               | 15                 | 30                 | 0.34               | 0.049              | 0.43               | 0.016              | 252               | 41.4               |
| Salmon, Atlantic, farmed, raw                                 | 183                      | 0.0                  | 19.9                   | 10.9               | 59                    | 59                 | 362               | 12                 | 28                 | 0.36               | 0.049              | 0.40               | 0.015              | 233               | 36.5               |
| Salmon, Atlantic, wild, cooked, dry heat                      | 182                      | 0.0                  | 25.4                   | 8.1                | 71                    | 56                 | 628               | 15                 | 37                 | 1.03               | 0.321              | 0.82               | 0.021              | 256               | 46.8               |
| Salmon, Atlantic, wild, raw                                   | 142                      | 0.0                  | 19.8                   | 6.3                | 55                    | 44                 | 490               | 12                 | 29                 | 0.80               | 0.250              | 0.64               | 0.016              | 200               | 36.5               |
| Salmon, Chinook, cooked, dry heat                             | 231                      | 0.0                  | 25.7                   | 13.4               | 85                    | 60                 | 505               | 28                 | 122                | 0.91               | 0.053              | 0.56               | 0.019              | 371               | 46.8               |
| Salmon, Chinook, raw                                          | 179                      | 0.0                  | 19.9                   | 10.4               | 50                    | 47                 | 394               | 26                 | 95                 | 0.25               | 0.041              | 0.44               | 0.015              | 289               | 36.5               |
| Salmon, Chinook, smoked                                       | 117                      | 0.0                  | 18.3                   | 4.3                | 23                    | 784                | 175               | 11                 | 18                 | 0.85               | 0.230              | 0.31               | 0.017              | 164               | 32.4               |
| Salmon, Chinook, smoked (lox)                                 | 117                      | 0.0                  | 18.3                   | 4.3                | 23                    | 2000               | 175               | 11                 | 18                 | 0.85               | 0.230              | 0.31               | 0.017              | 164               | 38.1               |
| Salmon, chum, cooked, dry heat                                | 154                      | 0.0                  | 25.8                   | 4.8                | 95                    | 64                 | 550               | 14                 | 28                 | 0.71               | 0.071              | 0.60               | 0.019              | 363               | 46.8               |
| Salmon, coho, farmed, cooked, dry heat                        | 178                      | 0.0                  | 24.3                   | 8.2                | 63                    | 52                 | 460               | 12                 | 34                 | 0.39               | 0.089              | 0.47               | 0.021              | 332               | 14.1               |
| Salmon, coho, farmed, raw                                     | 160                      | 0.0                  | 21.3                   | 7.7                | 51                    | 47                 | 450               | 12                 | 31                 | 0.34               | 0.048              | 0.43               | 0.012              | 292               | 12.6               |
| Salmon, coho, wild, cooked, dry heat                          | 139                      | 0.0                  | 23.5                   | 4.3                | 55                    | 58                 | 434               | 45                 | 33                 | 0.61               | 0.071              | 0.56               | 0.019              | 322               | 38.0               |
| Salmon, coho, wild, raw                                       | 146                      | 0.0                  | 21.6                   | 5.9                | 45                    | 46                 | 423               | 36                 | 31                 | 0.56               | 0.051              | 0.41               | 0.014              | 262               | 36.5               |
| Salmon, pink, cooked, dry heat                                | 149                      | 0.0                  | 25.6                   | 4.4                | 67                    | 86                 | 414               | 17                 | 33                 | 0.99               | 0.099              | 0.71               | 0.019              | 295               | 57.2               |
| Salmon, pink, raw                                             | 116                      | 0.0                  | 19.9                   | 3.5                | 52                    | 67                 | 323               | 13                 | 26                 | 0.77               | 0.077              | 0.55               | 0.015              | 230               | 44.6               |
| Salmon, sockeye, cooked, dry heat                             | 216                      | 0.0                  | 27.3                   | 11.0               | 87                    | 66                 | 375               | 7                  | 31                 | 0.55               | 0.067              | 0.51               | 0.020              | 276               | 37.8               |
| Salmon, sockeye, raw                                          | 168                      | 0.0                  | 21.3                   | 8.6                | 62                    | 47                 | 391               | 6                  | 24                 | 0.47               | 0.052              | 0.54               | 0.014              | 215               | 33.7               |
| Sausage, chicken, beef, pork, skinless, smoked                | 216                      | 8.1                  | 13.6                   | 14.3               | 120                   | 1034               | 246               | 100                | 14                 | 4.80               | 0.063              | 2.68               | 0.015              | 132               | 20.2               |
| Sausage, Italian, pork, cooked                                | 344                      | 4.3                  | 19.1                   | 27.3               | 57                    | 1207               | 304               | 21                 | 18                 | 1.43               | 0.080              | 2.39               |                    | 170               | 22.0               |
| Sausage, Italian, sweet, links                                | 149                      | 2.1                  | 16.1                   | 8.4                | 30                    | 570                | 194               | 25                 | 12                 | 1.19               | 0.040              | 1.52               | 0.007              | 103               | 10.8               |

| Food description                                          | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|-----------------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Sausage, Polish, beef w. chicken, hot                     | 259                      | 3.6                  | 17.6                   | 19.4               | 66                    | 1540               | 237               | 12                | 14                 | 0.88               | 0.090              | 1.93               | 0.049              | 136               | 17.7               |
| Sausage, smoked link sausage, pork & beef                 | 320                      | 2.4                  | 12.0                   | 28.7               | 58                    | 911                | 179               | 12                | 13                 | 0.75               | 0.077              | 1.26               | 0.048              | 121               | 0.0                |
| Sausage, turkey, breakfast links, mild                    | 235                      | 1.6                  | 15.4                   | 18.1               | 60                    | 585                | 197               | 32                | 25                 | 1.07               | 0.111              | 2.13               | 0.066              | 185               | 22.2               |
| Scallops, (bay & sea), steamed                            | 112                      | 0.0                  | 23.2                   | 1.4                | 53                    | 265                | 476               | 115               | 55                 | 3.00               | 0.300              | 3.00               |                    | 338               | 27.9               |
| Scrapple, pork                                            | 213                      | 14.1                 | 8.1                    | 13.9               | 49                    | 659                | 158               | 7                 | 13                 | 1.89               | 0.212              | 1.06               |                    | 76                | 17.4               |
| Sea bass, mixed species, cooked, dry heat                 | 124                      | 0.0                  | 23.6                   | 2.6                | 53                    | 87                 | 328               | 13                | 53                 | 0.37               | 0.024              | 0.52               | 0.020              | 248               | 46.8               |
| Shad, American, cooked, dry heat                          | 252                      | 0.0                  | 21.7                   | 17.7               | 96                    | 65                 | 492               | 60                | 38                 | 1.24               | 0.082              | 0.47               | 0.054              | 349               | 46.8               |
| Shark, mixed species, batter-dipped & fried               | 228                      | 6.4                  | 18.6                   | 13.8               | 59                    | 122                | 155               | 50                | 43                 | 1.11               | 0.042              | 0.48               | 0.050              | 194               | 34.0               |
| Shortening, frying (heavy duty), beef tallow & cottonseed | 900                      | 0.0                  | 0.0                    | 100.0              | 100                   | 0                  | 0                 | 0                 | 0                  | 0.00               |                    | 0.00               |                    | 0                 | 0.0                |
| Shortening, household, soybean (hydrogenated) & palm      | 884                      | 0.0                  | 0.0                    | 100.0              | 0                     | 0                  | 0                 | 0                 | 0                  | 0.00               | 0.000              | 0.00               | 0.000              | 0                 | 0.0                |
| Shrimp, mixed species, cooked, moist heat                 | 99                       | 0.0                  | 20.9                   | 1.1                | 195                   | 224                | 182               | 39                | 34                 | 3.09               | 0.193              | 1.56               | 0.034              | 137               | 39.6               |
| Shrimp, mixed species, imitation, made from surimi        | 101                      | 9.1                  | 12.4                   | 1.5                | 36                    | 705                | 89                | 19                | 43                 | 0.60               | 0.032              | 0.33               | 0.011              | 282               | 22.9               |
| Shrimp, mixed species, raw                                | 106                      | 0.9                  | 20.3                   | 1.7                | 152                   | 148                | 185               | 52                | 37                 | 2.41               | 0.264              | 1.11               | 0.050              | 205               | 38.0               |
| Smelt, rainbow, cooked, dry heat                          | 124                      | 0.0                  | 22.6                   | 3.1                | 90                    | 77                 | 372               | 77                | 38                 | 1.15               | 0.178              | 2.12               | 0.900              | 295               | 46.8               |
| Snails, raw                                               | 90                       | 2.0                  | 16.1                   | 1.4                | 50                    | 70                 | 382               | 10                | 250                | 3.50               | 0.400              | 1.00               |                    | 272               | 27.4               |
| Snapper, mixed species, cooked, dry heat                  | 128                      | 0.0                  | 26.3                   | 1.7                | 47                    | 57                 | 522               | 40                | 37                 | 0.24               | 0.046              | 0.44               | 0.017              | 201               | 49.0               |
| Sour cream, light                                         | 136                      | 7.1                  | 3.5                    | 10.6               | 35                    | 71                 | 212               | 141               | 10                 | 0.07               | 0.016              | 0.50               |                    | 71                | 3.1                |
| Sour cream, reduced fat                                   | 181                      | 7.0                  | 7.0                    | 14.1               | 35                    | 70                 | 211               | 141               | 11                 | 0.06               | 0.010              | 0.27               |                    | 85                | 4.1                |
| Soybeans, green, boiled, w/o salt                         | 141                      | 11.1                 | 12.4                   | 6.4                | 0                     | 14                 | 539               | 145               | 60                 | 2.50               | 0.117              | 0.91               | 0.502              | 158               | 1.4                |
| Soybeans, green, raw                                      | 147                      | 11.1                 | 13.0                   | 6.8                | 0                     | 15                 | 620               | 197               | 65                 | 3.55               | 0.128              | 0.99               | 0.547              | 194               | 1.5                |
| Soybeans, mature cooked, boiled, w/o salt                 | 173                      | 9.9                  | 16.6                   | 9.0                | 0                     | 1                  | 515               | 102               | 86                 | 5.14               | 0.407              | 1.15               | 0.824              | 245               | 7.3                |
| Spaghetti, cooked, enriched, w. salt                      | 157                      | 30.6                 | 5.8                    | 0.9                | 0                     | 128                | 45                | 7                 | 18                 | 1.33               | 0.103              | 0.50               | 0.317              | 58                | 26.4               |
| Spaghetti, whole-wheat, cooked                            | 124                      | 26.5                 | 5.3                    | 0.5                | 0                     | 3                  | 44                | 15                | 30                 | 1.06               | 0.167              | 0.81               | 1.379              | 89                | 25.9               |
| Spinach, boiled, w/o salt                                 | 23                       | 3.8                  | 3.0                    | 0.3                | 0                     | 70                 | 466               | 136               | 87                 | 3.57               | 0.174              | 0.76               | 0.935              | 56                | 1.5                |
| Spinach, raw                                              | 23                       | 3.6                  | 2.9                    | 0.4                | 0                     | 79                 | 558               | 99                | 79                 | 2.71               | 0.130              | 0.53               | 0.897              | 49                | 1.0                |
| Squash, summer, all varieties, boiled, w/o salt           | 20                       | 4.3                  | 0.9                    | 0.3                | 0                     | 1                  | 192               | 27                | 24                 | 0.36               | 0.103              | 0.39               | 0.213              | 39                | 0.2                |
| Squash, summer, all varieties, raw                        | 16                       | 3.4                  | 1.2                    | 0.2                | 0                     | 2                  | 262               | 15                | 17                 | 0.35               | 0.051              | 0.29               | 0.175              | 38                | 0.2                |
| Squash, summer, zucchini, includes skin, boiled, w/o salt | 16                       | 3.9                  | 0.6                    | 0.1                | 0                     | 3                  | 253               | 13                | 22                 | 0.35               | 0.086              | 0.18               | 0.178              | 40                | 0.2                |
| Squash, summer, zucchini, includes skin, raw              | 16                       | 3.4                  | 1.2                    | 0.2                | 0                     | 10                 | 262               | 15                | 17                 | 0.35               | 0.051              | 0.29               | 0.175              | 38                | 0.2                |
| Squash, winter, acorn, baked, w/o salt                    | 56                       | 14.6                 | 1.1                    | 0.1                | 0                     | 4                  | 437               | 44                | 43                 | 0.93               | 0.086              | 0.17               | 0.242              | 45                | 0.7                |
| Squash, winter, butternut, baked, w/o salt                | 40                       | 10.5                 | 0.9                    | 0.1                | 0                     | 4                  | 284               | 41                | 29                 | 0.60               | 0.065              | 0.13               | 0.172              | 27                | 0.5                |
| Squash, winter, Hubbard, baked, w/o salt                  | 50                       | 10.8                 | 2.5                    | 0.6                | 0                     | 8                  | 358               | 17                | 22                 | 0.47               | 0.045              | 0.15               | 0.170              | 23                | 0.6                |
| Squash, zucchini, baby, raw                               | 21                       | 3.1                  | 2.7                    | 0.4                | 0                     | 3                  | 459               | 21                | 33                 | 0.79               | 0.097              | 0.83               | 0.196              | 93                | 0.3                |
| Strawberries, raw                                         | 32                       | 7.7                  | 0.7                    | 0.3                | 0                     | 1                  | 153               | 16                | 13                 | 0.42               | 0.048              | 0.14               | 0.386              | 24                | 0.4                |
| Sturgeon, mixed species, cooked, dry heat                 | 135                      | 0.0                  | 20.7                   | 5.2                | 77                    | 69                 | 364               | 17                | 45                 | 0.90               | 0.053              | 0.54               | 0.030              | 271               | 16.2               |
| Sturgeon, mixed species, raw                              | 105                      | 0.0                  | 16.1                   | 4.0                | 60                    | 54                 | 284               | 13                | 35                 | 0.70               | 0.041              | 0.42               | 0.025              | 211               | 12.6               |
| Sturgeon, mixed species, smoked                           | 173                      | 0.0                  | 31.2                   | 4.4                | 80                    | 739                | 379               | 17                | 47                 | 0.93               | 0.050              | 0.56               | 0.030              | 281               | 20.1               |
| Sugars, brown                                             | 377                      | 97.3                 | 0.0                    | 0.0                | 0                     | 39                 | 346               | 85                | 29                 | 1.91               | 0.298              | 0.18               | 0.320              | 22                | 1.2                |
| Sugars, granulated                                        | 387                      | 100.0                | 0.0                    | 0.0                | 0                     | 0                  | 2                 | 1                 | 0                  | 0.01               | 0.000              | 0.00               | 0.000              | 0                 | 0.6                |
| Sugars, maple                                             | 354                      | 90.9                 | 0.1                    | 0.2                | 0                     | 11                 | 274               | 90                | 19                 | 1.61               | 0.099              | 6.06               | 4.422              | 3                 | 0.8                |
| Sweet potato, baked in skin, w/o salt                     | 90                       | 20.7                 | 2.0                    | 0.2                | 0                     | 36                 | 475               | 38                | 27                 | 0.69               | 0.161              | 0.32               | 0.497              | 54                | 0.2                |
| Sweet potato, boiled, w/o skin                            | 76                       | 17.7                 | 1.4                    | 0.1                | 0                     | 27                 | 230               | 27                | 18                 | 0.72               | 0.094              | 0.20               | 0.266              | 32                | 0.2                |
| Swordfish, cooked, dry heat                               | 155                      | 0.0                  | 25.4                   | 5.1                | 50                    | 115                | 369               | 6                 | 34                 | 1.04               | 0.162              | 1.47               | 0.020              | 337               | 61.7               |
| Swordfish, raw                                            | 121                      | 0.0                  | 19.8                   | 4.0                | 39                    | 90                 | 288               | 4                 | 27                 | 0.81               | 0.126              | 1.15               | 0.019              | 263               | 48.1               |
| Syrups, corn, dark                                        | 286                      | 77.6                 | 0.0                    | 0.0                | 0                     | 155                | 44                | 18                | 8                  | 0.37               | 0.053              | 0.04               | 0.100              | 11                | 2.9                |
| Syrups, corn, high-fructose                               | 281                      | 76.0                 | 0.0                    | 0.0                | 0                     | 2                  | 0                 | 0                 | 0                  | 0.03               | 0.029              | 0.02               | 0.094              | 0                 | 0.7                |
| Syrups, maple                                             | 261                      | 67.1                 | 0.0                    | 0.2                | 0                     | 9                  | 204               | 67                | 14                 | 1.20               | 0.074              | 4.16               | 3.298              | 2                 | 0.6                |
| Syrups, table blends, cane & 15% maple                    | 278                      | 69.5                 | 0.0                    | 0.0                | 0                     | 104                | 53                | 12                | 2                  | 0.19               | 0.017              | 0.63               | 0.495              | 0                 | 0.5                |
| Tangerines, (mandarin oranges), raw                       | 53                       | 13.3                 | 0.8                    | 0.3                | 0                     | 2                  | 166               | 37                | 12                 | 0.15               | 0.042              | 0.07               | 0.039              | 20                | 0.1                |
| Tempeh, cooked                                            | 196                      | 9.4                  | 18.2                   | 11.4               |                       | 14                 | 401               | 96                | 77                 | 2.13               | 0.540              | 1.57               | 1.285              | 253               | 0.0                |
| Tilefish, cooked, dry heat                                | 147                      | 0.0                  | 24.5                   | 4.7                | 64                    | 59                 | 512               | 26                | 33                 | 0.31               | 0.052              | 0.53               | 0.015              | 236               | 51.5               |
| Tilefish, raw                                             | 96                       | 0.0                  | 17.5                   | 2.3                | 50                    | 53                 | 433               | 26                | 28                 | 0.25               | 0.041              | 0.37               | 0.010              | 187               | 36.5               |



| Food description                                    | Energy<br>kcal/<br>100 g | Carb.<br>g/<br>100 g | Protein<br>g/<br>100 g | Fat<br>g/<br>100 g | Chol.<br>mg/<br>100 g | Na<br>mg/<br>100 g | K<br>mg/<br>100 g | Ca<br>mg/<br>100g | Mg<br>mg/<br>100 g | Fe<br>mg/<br>100 g | Cu<br>mg/<br>100 g | Zn<br>mg/<br>100 g | Mn<br>mg/<br>100 g | P<br>mg/<br>100 g | Se<br>µg/<br>100 g |
|-----------------------------------------------------|--------------------------|----------------------|------------------------|--------------------|-----------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|
| Tofu, fried                                         | 271                      | 10.5                 | 17.2                   | 20.2               | 0                     | 16                 | 146               | 372               | 60                 | 4.87               | 0.398              | 1.99               | 1.495              | 287               | 28.5               |
| Tomato juice, canned, w. salt                       | 17                       | 4.2                  | 0.8                    | 0.1                | 0                     | 269                | 229               | 10                | 11                 | 0.43               | 0.061              | 0.15               | 0.070              | 18                | 0.3                |
| Tomatoes, green, raw                                | 23                       | 5.1                  | 1.2                    | 0.2                | 0                     | 13                 | 204               | 13                | 10                 | 0.51               | 0.090              | 0.07               | 0.100              | 28                | 0.4                |
| Tomatoes, orange, raw                               | 16                       | 3.2                  | 1.2                    | 0.2                | 0                     | 42                 | 212               | 5                 | 8                  | 0.47               | 0.062              | 0.14               | 0.088              | 29                | 0.4                |
| Tomatoes, red, ripe, cooked                         | 18                       | 4.0                  | 1.0                    | 0.1                | 0                     | 11                 | 218               | 11                | 9                  | 0.68               | 0.075              | 0.14               | 0.105              | 28                | 0.5                |
| Tomatoes, red, ripe, raw, year-round average        | 18                       | 3.9                  | 0.9                    | 0.2                | 0                     | 5                  | 237               | 10                | 11                 | 0.27               | 0.059              | 0.17               | 0.114              | 24                | 0.0                |
| Tomatoes, sun-dried                                 | 258                      | 55.8                 | 14.1                   | 3.0                | 0                     | 2095               | 3427              | 110               | 194                | 9.09               | 1.423              | 1.99               | 1.846              | 356               | 5.5                |
| Tomatoes, yellow, raw                               | 15                       | 3.0                  | 1.0                    | 0.3                | 0                     | 23                 | 258               | 11                | 12                 | 0.49               | 0.101              | 0.28               | 0.120              | 36                | 0.4                |
| Trout, mixed species, cooked, dry heat              | 190                      | 0.0                  | 26.6                   | 8.5                | 74                    | 67                 | 463               | 55                | 28                 | 1.92               | 0.241              | 0.85               | 1.091              | 314               | 16.2               |
| Trout, rainbow, farmed, cooked, dry heat            | 169                      | 0.0                  | 24.3                   | 7.2                | 68                    | 42                 | 441               | 86                | 32                 | 0.33               | 0.061              | 0.49               | 0.020              | 266               | 15.0               |
| Trout, rainbow, wild, cooked, dry heat              | 150                      | 0.0                  | 22.9                   | 5.8                | 69                    | 56                 | 448               | 86                | 31                 | 0.38               | 0.058              | 0.51               | 0.021              | 269               | 13.2               |
| Tuna, fresh, bluefin, cooked, dry heat              | 184                      | 0.0                  | 29.9                   | 6.3                | 49                    | 50                 | 323               | 10                | 64                 | 1.31               | 0.110              | 0.77               | 0.020              | 326               | 46.8               |
| Tuna, fresh, bluefin, raw                           | 144                      | 0.0                  | 23.3                   | 4.9                | 38                    | 39                 | 252               | 8                 | 50                 | 1.02               | 0.086              | 0.60               | 0.015              | 254               | 36.5               |
| Tuna, fresh, skipjack, raw                          | 103                      | 0.0                  | 22.0                   | 1.0                | 47                    | 37                 | 407               | 29                | 34                 | 1.25               | 0.086              | 0.82               | 0.015              | 222               | 36.5               |
| Tuna, fresh, yellowfin, raw                         | 108                      | 0.0                  | 23.4                   | 1.0                | 45                    | 37                 | 444               | 16                | 50                 | 0.73               | 0.064              | 0.52               | 0.015              | 191               | 36.5               |
| Tuna, skipjack, fresh, cooked, dry heat             | 132                      | 0.0                  | 28.2                   | 1.3                | 60                    | 47                 | 522               | 37                | 44                 | 1.60               | 0.110              | 1.05               | 0.019              | 285               | 46.8               |
| Tuna, white, canned in oil                          | 186                      | 0.0                  | 26.5                   | 8.1                | 31                    | 396                | 333               | 4                 | 34                 | 0.65               | 0.130              | 0.47               | 0.016              | 267               | 60.1               |
| Tuna, white, canned in water                        | 128                      | 0.0                  | 23.6                   | 3.0                | 42                    | 377                | 237               | 14                | 33                 | 0.97               | 0.039              | 0.48               | 0.019              | 217               | 65.7               |
| Tuna, yellowfin, fresh, cooked, dry heat            | 139                      | 0.0                  | 30.0                   | 1.2                | 58                    | 47                 | 569               | 21                | 64                 | 0.94               | 0.082              | 0.67               | 0.019              | 245               | 46.8               |
| Turbot, European, cooked, dry heat                  | 122                      | 0.0                  | 20.6                   | 3.8                | 62                    | 192                | 305               | 23                | 65                 | 0.46               | 0.047              | 0.28               | 0.022              | 165               | 46.8               |
| Turkey breast meat                                  | 104                      | 4.2                  | 17.1                   | 1.7                | 43                    | 1015               | 302               | 8                 | 21                 | 1.44               | 0.057              | 1.33               | 0.018              | 162               | 22.8               |
| Turkey, all classes, breast, meat & skin, roasted   | 189                      | 0.0                  | 28.7                   | 7.4                | 74                    | 63                 | 288               | 21                | 27                 | 1.40               | 0.047              | 2.03               | 0.020              | 210               | 29.1               |
| Turkey, all classes, dark meat, meat & skin, raw    | 160                      | 0.0                  | 18.9                   | 8.8                | 72                    | 71                 | 261               | 17                | 20                 | 1.69               | 0.137              | 2.95               | 0.021              | 170               | 26.4               |
| Turkey, all classes, leg, meat & skin, roasted      | 208                      | 0.0                  | 27.9                   | 9.8                | 85                    | 77                 | 280               | 32                | 23                 | 2.30               | 0.154              | 4.27               | 0.023              | 199               | 37.8               |
| Turkey, all classes, meat only, roasted             | 170                      | 0.0                  | 29.3                   | 5.0                | 76                    | 70                 | 298               | 25                | 26                 | 1.78               | 0.094              | 3.10               | 0.021              | 213               | 36.8               |
| Turkey, all classes, wing, meat & skin, roasted     | 229                      | 0.0                  | 27.4                   | 12.4               | 81                    | 61                 | 266               | 24                | 25                 | 1.46               | 0.056              | 2.10               | 0.020              | 197               | 29.9               |
| Turnip greens, boiled, w/o salt                     | 20                       | 4.4                  | 1.1                    | 0.2                | 0                     | 29                 | 203               | 137               | 22                 | 0.80               | 0.253              | 0.14               | 0.337              | 29                | 0.9                |
| Turnips, boiled, w/o salt                           | 22                       | 5.1                  | 0.7                    | 0.1                | 0                     | 16                 | 177               | 33                | 9                  | 0.18               | 0.002              | 0.12               | 0.071              | 26                | 0.2                |
| Turnips, raw                                        | 28                       | 6.4                  | 0.9                    | 0.1                | 0                     | 67                 | 191               | 30                | 11                 | 0.30               | 0.085              | 0.27               | 0.134              | 27                | 0.7                |
| Veal, composite of retail cuts, fat, cooked         | 642                      | 0.0                  | 9.4                    | 66.7               | 73                    | 57                 | 173               | 4                 | 10                 | 1.00               | 0.044              | 0.87               | 0.012              | 116               | 5.5                |
| Veal, composite of retail cuts, lean & fat, cooked  | 231                      | 0.0                  | 30.1                   | 11.4               | 114                   | 87                 | 325               | 22                | 26                 | 1.15               | 0.114              | 4.76               | 0.036              | 239               | 12.3               |
| Veal, composite of retail cuts, lean, cooked        | 196                      | 0.0                  | 31.9                   | 6.6                | 118                   | 89                 | 338               | 24                | 28                 | 1.16               | 0.120              | 5.10               | 0.038              | 250               | 13.0               |
| Veal, ground, broiled                               | 172                      | 0.0                  | 24.4                   | 7.6                | 103                   | 83                 | 337               | 17                | 24                 | 0.99               | 0.103              | 3.87               | 0.035              | 217               | 13.7               |
| Veal, leg (top round), lean & fat, roasted          | 160                      | 0.0                  | 27.7                   | 4.7                | 103                   | 68                 | 389               | 6                 | 28                 | 0.91               | 0.129              | 3.04               | 0.030              | 234               | 11.2               |
| Veal, loin, lean & fat, roasted                     | 217                      | 0.0                  | 24.8                   | 12.3               | 103                   | 93                 | 325               | 19                | 25                 | 0.87               | 0.110              | 3.03               | 0.029              | 212               | 11.0               |
| Veal, rib, lean & fat, roasted                      | 228                      | 0.0                  | 24.0                   | 14.0               | 110                   | 92                 | 295               | 11                | 22                 | 0.97               | 0.099              | 4.09               | 0.030              | 197               | 10.5               |
| Veal, shoulder, arm, lean & fat, roasted            | 183                      | 0.0                  | 25.5                   | 8.3                | 108                   | 90                 | 348               | 26                | 26                 | 1.15               | 0.141              | 4.18               | 0.030              | 221               | 11.1               |
| Veal, sirloin, lean & fat, roasted                  | 202                      | 0.0                  | 25.1                   | 10.5               | 102                   | 83                 | 351               | 13                | 26                 | 0.92               | 0.129              | 3.35               | 0.029              | 223               | 11.1               |
| Veal, sirloin, lean, roasted                        | 168                      | 0.0                  | 26.3                   | 6.2                | 104                   | 85                 | 365               | 14                | 27                 | 0.91               | 0.136              | 3.54               | 0.030              | 231               | 11.5               |
| Vinegar, distilled                                  | 18                       | 0.0                  | 0.0                    | 0.0                | 0                     | 2                  | 2                 | 6                 | 1                  | 0.03               | 0.006              | 0.01               | 0.055              | 4                 | 0.5                |
| Watercress, raw                                     | 11                       | 1.3                  | 2.3                    | 0.1                | 0                     | 41                 | 330               | 120               | 21                 | 0.20               | 0.077              | 0.11               | 0.244              | 60                | 0.9                |
| Watermelon, raw                                     | 30                       | 7.6                  | 0.6                    | 0.2                | 0                     | 1                  | 112               | 7                 | 10                 | 0.24               | 0.042              | 0.10               | 0.038              | 11                | 0.4                |
| Wheat flour, whole-grain                            | 339                      | 72.6                 | 13.7                   | 1.9                | 0                     | 5                  | 405               | 34                | 138                | 3.88               | 0.382              | 2.93               | 3.799              | 346               | 70.7               |
| Wheat flours, bread, unenriched                     | 361                      | 72.5                 | 12.0                   | 1.7                | 0                     | 2                  | 100               | 15                | 25                 | 0.90               | 0.182              | 0.85               | 0.792              | 97                | 39.7               |
| Wolffish, Atlantic, cooked, dry heat                | 123                      | 0.0                  | 22.4                   | 3.1                | 59                    | 109                | 385               | 8                 | 38                 | 0.12               | 0.037              | 1.00               | 0.019              | 256               | 46.8               |
| Wolffish, Atlantic, raw                             | 96                       | 0.0                  | 17.5                   | 2.4                | 46                    | 85                 | 300               | 6                 | 30                 | 0.09               | 0.029              | 0.78               | 0.015              | 200               | 36.5               |
| Yam, boiled, or baked, w/o salt                     | 116                      | 27.6                 | 1.5                    | 0.1                | 0                     | 8                  | 670               | 14                | 18                 | 0.52               | 0.152              | 0.20               | 0.371              | 49                | 0.7                |
| Yellowtail, mixed species, cooked, dry heat         | 187                      | 0.0                  | 29.7                   | 6.7                | 71                    | 50                 | 538               | 29                | 38                 | 0.63               | 0.058              | 0.67               | 0.019              | 201               | 46.8               |
| Yogurt, fruit varieties, non-fat                    | 94                       | 19.0                 | 4.4                    | 0.2                | 2                     | 58                 | 194               | 152               | 15                 | 0.07               | 0.011              | 0.74               | 0.035              | 119               | 6.0                |
| Yogurt, plain, low fat, 12 grams protein per 8 oz   | 63                       | 7.0                  | 5.3                    | 1.6                | 6                     | 70                 | 234               | 183               | 17                 | 0.08               | 0.013              | 0.89               | 0.004              | 144               | 3.3                |
| Yogurt, plain, skim milk, 13 grams protein per 8 oz | 56                       | 7.7                  | 5.7                    | 0.2                | 2                     | 77                 | 255               | 199               | 19                 | 0.09               | 0.015              | 0.97               | 0.005              | 157               | 3.6                |
| Yogurt, plain, whole milk, 8 grams protein per 8 oz | 61                       | 4.7                  | 3.5                    | 3.3                | 13                    | 46                 | 155               | 121               | 12                 | 0.05               | 0.009              | 0.59               | 0.004              | 95                | 2.2                |



## COMPOSITION AND PROPERTIES OF COMMON OILS AND FATS

This table lists some of the most common naturally occurring oils and fats. The list is separated into those of plant origin, fish and other marine life origin, and land animal origin. The oils and fats consist mainly of esters of glycerol (i.e., triglycerides) with fatty acids of 10 to 22 carbon atoms. The four fatty acids with the highest concentration are given for each oil; concentrations are given in weight percent. Because there is often a wide variation in composition depending on the source of the oil sample, a range (or sometimes an average) is generally given. More complete data on composition, including minor fatty acids, sterols, and tocopherols, can be found in the references.

The acids are labeled by the codes described in the previous table, "Properties of Fatty Acids and Their Methyl Esters," which gives the systematic and common names of the acids. Thus 18:2 9c,12c indicates a C<sub>18</sub> acid with two double bonds in the 9 and 12 positions, both with a *cis* configuration (*cis,cis*-9,12-octadecadienoic acid, or linoleic acid).

The density and refractive index of the oils are typical values; superscripts indicate the temperature in °C.

### Notes:

- The composition figure given for oleic acid (18:1 9c) often includes low levels of other 18:1 isomers.

- In some oils where a concentration is given for 18:2 9c,12c (linoleic acid), other isomers of 18:2 may be included.
- Likewise, where a concentration is given for 18:3 9c,12c,15c ( $\alpha$ -linolenic acid), other isomers of 18:3 may be included.
- The acid 20:5 6c,9c,12c,15c,17c, which is prevalent in many fish oils, is often abbreviated as 20:5  $\omega$ -3 or 20:5 n-3.

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| Type of oil                              | Principal fatty acid components in weight % |        |                 |          | mp/<br>°C | Density/<br>g cm <sup>-3</sup> | Refractive<br>index | Iodine<br>value | Saponification<br>value |
|------------------------------------------|---------------------------------------------|--------|-----------------|----------|-----------|--------------------------------|---------------------|-----------------|-------------------------|
| <i>Plants</i>                            |                                             |        |                 |          |           |                                |                     |                 |                         |
| Almond kernel oil                        | 18:1 9c                                     | 43–70% | 18:2 9c,12c     | 24–30%   |           | 0.910 <sup>25</sup>            | 1.467 <sup>26</sup> | 89–101          | 188–200                 |
|                                          | 16:0                                        | 4–13%  | 18:0            | 1–10%    |           |                                |                     |                 |                         |
| Apricot kernel oil                       | 18:1 9c                                     | 58–66% | 18:2 9c,12c     | 29–33%   |           | 0.910 <sup>25</sup>            | 1.469 <sup>25</sup> | 97–110          | 185–199                 |
|                                          | 16:0                                        | 4.6–6% | 18:0            | 1%       |           |                                |                     |                 |                         |
| Argan seed oil                           | 18:1 9c                                     | 42–55% | 18:2 9c,12c     | 30–34%   |           | 0.912 <sup>20</sup>            | 1.467 <sup>20</sup> | 92–102          | 189–195                 |
|                                          | 16:0                                        | 12–16% | 18:0            | 2–7%     |           |                                |                     |                 |                         |
| Avocado pulp oil                         | 18:1 9c                                     | 56–74% | 18:2 9c,12c     | 10–17%   |           | 0.912 <sup>25</sup>            | 1.466 <sup>25</sup> | 85–90           | 177–198                 |
|                                          | 16:0                                        | 9–18%  | 16:1 9c         | 3–9%     |           |                                |                     |                 |                         |
| Babassu palm oil                         | 12:0                                        | 40–55% | 14:0            | 11–27%   | 24        | 0.914 <sup>25</sup>            | 1.450 <sup>40</sup> | 10–18           | 245–256                 |
|                                          | 18:1 9c                                     | 9–20%  | 16:0            | 5.2–11%  |           |                                |                     |                 |                         |
| Blackcurrant oil                         | 18:2 9c,12c                                 | 45–50% | 18:3 6c,9c,12c  | 14–20%   |           | 0.923 <sup>20</sup>            | 1.480 <sup>20</sup> | 173–182         | 185–195                 |
|                                          | 18:3 9c,12c,15c                             | 12–15% | 18:1 9c         | 9–13%    |           |                                |                     |                 |                         |
| Borage (star-flower) oil                 | 18:2 9c,12c                                 | 36–40% | 18:3 6c,9c,12c  | 17–25%   |           |                                |                     | 141–160         | 189–192                 |
|                                          | 18:1 9c                                     | 14–21% | 16:0            | 9.4–12%  |           |                                |                     |                 |                         |
| Borneo tallow                            | 18:0                                        | 39–43% | 18:1 9c         | 34–37%   | 38        | 0.855 <sup>100</sup>           | 1.456 <sup>40</sup> | 29–38           | 189–200                 |
|                                          | 16:0                                        | 18–21% | 20:0            | 1.0%     |           |                                |                     |                 |                         |
| Cameline oil                             | 18:3 9c,12c,15c                             | 33–38% | 18:2 9c,12c     | 15–16%   |           | 0.924 <sup>15</sup>            | 1.477 <sup>20</sup> | 127–155         | 180–190                 |
|                                          | 20:1 total                                  | 14–16% | 18:1 9c         | 12–24%   |           |                                |                     |                 |                         |
| Canola (rapeseed)<br>oil (low linolenic) | 18:1 9c                                     | 59–66% | 18:2 9c,12c     | 24–29%   | –10       |                                |                     | 91              |                         |
|                                          | 16:0                                        | 4–5%   | 18:3 9c,12c,15c | 2–3%     |           |                                |                     |                 |                         |
| Canola (rapeseed)<br>oil (low erucic)    | 18:1 9c                                     | 52–67% | 18:2 9c,12c     | 16–25%   | –10       | 0.915 <sup>20</sup>            | 1.466 <sup>40</sup> | 110–126         | 182–193                 |
|                                          | 18:3 9c,12c,15c                             | 6–14%  | 16:0            | 3.3–6.0% |           |                                |                     |                 |                         |
| Caraway seed oil                         | 18:1 9c                                     | 40%    | 18:2 9c,12c     | 30%      |           |                                | 1.471 <sup>35</sup> | 128             | 178                     |
|                                          | 18:1 6c                                     | 26%    | 16:0            | 3%       |           |                                |                     |                 |                         |
| Cashew nut oil                           | 18:1 9c                                     | 57–80% | 18:2 9c,12c     | 16–22%   |           | 0.914 <sup>15</sup>            | 1.463 <sup>40</sup> | 79–89           | 180–196                 |
|                                          | 16:0                                        | 4–17%  | 18:0            | 2–12%    |           |                                |                     |                 |                         |

| Type of oil                             | Principal fatty acid components in weight % |           |                 |          | mp/<br>°C | Density/<br>g cm <sup>-3</sup> | Refractive<br>index | Iodine<br>value | Saponification<br>value |
|-----------------------------------------|---------------------------------------------|-----------|-----------------|----------|-----------|--------------------------------|---------------------|-----------------|-------------------------|
| Castor oil                              | 18:1 12-OH,9c                               | 88%       | 18:2 9c,12c     | 3–5%     | –18       | 0.952 <sup>25</sup>            | 1.475 <sup>25</sup> | 81–91           | 176–187                 |
|                                         | 18:1 9c                                     | 2.9–6%    | 22:0            | 2.1%     |           |                                |                     |                 |                         |
| Cherry kernel oil                       | 18:2 9c,12c                                 | 42–45%    | 18:1 9c         | 35–49%   |           | 0.918 <sup>25</sup>            | 1.468 <sup>40</sup> | 110–118         | 190–198                 |
|                                         | 16:0                                        | 4–9%      | 18:3 9c,11t,13t | 3–10%    |           |                                |                     |                 |                         |
| Chinese vegetable tallow                | 16:0                                        | 58–72%    | 18:1 9c         | 20–35%   | 44        | 0.887 <sup>25</sup>            | 1.456 <sup>40</sup> | 16–29           | 200–218                 |
|                                         | 18:0                                        | 1–8%      | 14:0            | 0.5–3.7% |           |                                |                     |                 |                         |
| Cocoa butter                            | 18:0                                        | 31–37%    | 18:1 9c         | 31–35%   | 34        | 0.974 <sup>25</sup>            | 1.457 <sup>40</sup> | 32–40           | 192–200                 |
|                                         | 16:0                                        | 25–27%    | 18:2 9c,12c     | 2.8–4.0% |           |                                |                     |                 |                         |
| Coconut oil                             | 12:0                                        | 45–51%    | 14:0            | 17–21%   | 25        | 0.913 <sup>40</sup>            | 1.449 <sup>40</sup> | 5–13            | 248–265                 |
|                                         | 16:0                                        | 7.7–10.2% | 18:1 9c         | 5.4–9.9% |           |                                |                     |                 |                         |
| Cohune nut oil                          | 12:0                                        | 44–48%    | 14:0            | 16–17%   |           | 0.914 <sup>25</sup>            | 1.450 <sup>40</sup> | 9–14            | 251–260                 |
|                                         | 18:1 9c                                     | 8–10%     | 16:0            | 7–10%    |           |                                |                     |                 |                         |
| Coriander seed oil                      | 18:1 6c                                     | 53%       | 18:1 9c         | 32%      |           | 0.908 <sup>25</sup>            | 1.464 <sup>25</sup> | 86–100          | 182–191                 |
|                                         | 18:2 9c,12c                                 | 7–14%     | 16:0            | 3–8%     |           |                                |                     |                 |                         |
| Corn oil                                | 18:2 9c,12c                                 | 40–66%    | 18:1 9c         | 20–42%   | –20       | 0.919 <sup>20</sup>            | 1.472 <sup>25</sup> | 107–135         | 187–195                 |
|                                         | 16:0                                        | 9–16%     | 18:0            | 0–3%     |           |                                |                     |                 |                         |
| Cottonseed oil                          | 18:2 9c,12c                                 | 47–58%    | 16:0            | 18–26%   | –1        | 0.920 <sup>20</sup>            | 1.462 <sup>40</sup> | 96–115          | 189–198                 |
|                                         | 18:1 9c                                     | 14–22%    | 18:0            | 2.1–3.3% |           |                                |                     |                 |                         |
| Crambe oil                              | 22:1 13c                                    | 55–60%    | 18:1 9c         | 12–15%   |           | 0.906 <sup>25</sup>            | 1.470 <sup>25</sup> | 87–113          |                         |
|                                         | 18:2 9c,12c                                 | 8–10%     | 18:3 9c,12c,15c | 6–7%     |           |                                |                     |                 |                         |
| Cuphea seed oil<br>(caprylic acid rich) | 8:0                                         | 65–78%    | 10:0            | 19–24%   |           |                                |                     |                 |                         |
|                                         | 18:2 9c,12c                                 | 1–4%      | 16:0            | 0.6–3%   |           |                                |                     |                 |                         |
| Euphorbia lagascae<br>seed oil          | 18:1 12,13-ep,9c                            | 64%       | 18:1 other      | 19%      |           | 0.952 <sup>25</sup>            | 1.473 <sup>25</sup> | 102             |                         |
|                                         | 18:2 9c,12c                                 | 9%        | 16:0            | 4%       |           |                                |                     |                 |                         |
| Evening primrose oil                    | 18:2 9c,12c                                 | 65–80%    | 18:3 6c,9c,12c  | 8–14%    |           |                                | 1.479 <sup>20</sup> | 147–155         | 193–198                 |
|                                         | 16:0                                        | 6–10%     | 18:1 9c         | 5–12%    |           |                                |                     |                 |                         |
| Grape seed oil                          | 18:2 9c,12c                                 | 58–78%    | 18:1 9c         | 12–28%   |           | 0.923 <sup>20</sup>            | 1.475 <sup>40</sup> | 130–138         | 188–194                 |
|                                         | 16:0                                        | 5.5–11%   | 18:0            | 3–6%     |           |                                |                     |                 |                         |
| Hazelnut oil (Chilean)                  | 18:1 9c                                     | 39%       | 16:1 11c        | 22.7%    |           |                                |                     |                 |                         |
|                                         | 20:1 total                                  | 9.7%      | 22:1 total      | 9.5%     |           |                                |                     |                 |                         |
| Hazelnut oil (Filbert)                  | 18:1 9c                                     | 72–84%    | 18:2 9c,12c     | 5.7–22%  |           | 0.909 <sup>25</sup>            | 1.473 <sup>25</sup> | 83–90           | 188–197                 |
|                                         | 16:0                                        | 4.1–7.2%  | 18:0            | 1.5–2.4% |           |                                |                     |                 |                         |
| Hempseed oil                            | 18:2 9c,12c                                 | 45–60%    | 18:3 9c,12c,15c | 15–30%   |           | 0.921 <sup>25</sup>            | 1.472 <sup>40</sup> | 145–166         | 190–195                 |
|                                         | 18:1 9c                                     | 11–16%    | 16:0            | 6–12%    |           |                                |                     |                 |                         |
| Illipe (mowrah) butter                  | 18:1 9c                                     | 34%       | 16:0            | 23%      | 27        | 0.862 <sup>100</sup>           | 1.460 <sup>40</sup> | 53–70           | 188–207                 |
|                                         | 18:0                                        | 23%       | 18:2 9c,12c     | 14%      |           |                                |                     |                 |                         |
| Jojoba oil <sup>a</sup>                 | 20:1 total                                  | 66–74%    | 22:1 undefined  | 9–19%    |           |                                |                     |                 |                         |
|                                         | 18:1 9c                                     | 5–12%     | 24:1 15c        | 1–5%     |           |                                |                     |                 |                         |
| Kapok seed oil <sup>b</sup>             | 18:1 9c                                     | 45–65%    | 16:0            | 10–28%   | 30        | 0.926 <sup>15</sup>            | 1.469 <sup>25</sup> | 86–110          | 189–197                 |
|                                         | 18:2 9c,12c                                 | 7–35%     | 18:0            | 2–9%     |           |                                |                     |                 |                         |
| Kokum butter                            | 18:0                                        | 49–56%    | 18:1 9c         | 39–49%   | 41        |                                | 1.456 <sup>40</sup> | 33–37           | 192                     |
|                                         | 16:0                                        | 2–5%      | 18:2 9c,12c     | 1–2%     |           |                                |                     |                 |                         |
| Kusum oil                               | 18:1 9c                                     | 57–62%    | 20:0            | 20–25%   |           |                                | 1.461 <sup>40</sup> | 48–58           | 220–230                 |
|                                         | 16:0                                        | 5–8%      | 18:0            | 2–6%     |           |                                |                     |                 |                         |
| Linola oil                              | 18:2 9c,12c                                 | 72%       | 18:1 9c         | 16%      |           |                                |                     | 142             |                         |
|                                         | 16:0                                        | 5.6%      | 18:0            | 4.0%     |           |                                |                     |                 |                         |
| Linseed oil                             | 18:3 9c,12c,15c                             | 52–58%    | 18:1 9c         | 18–20%   | –24       | 0.924 <sup>25</sup>            | 1.480 <sup>25</sup> | 170–203         | 188–196                 |
|                                         | 18:2 9c,12c                                 | 17%       | 18:2 9c,12c     | 16%      |           |                                |                     |                 |                         |
| Macadamia nut oil                       | 18:1 9c                                     | 56–59%    | 16:1 9c         | 21–22%   |           |                                |                     |                 |                         |
|                                         | 16:0                                        | 8–9%      | 18:0            | 2–4%     |           |                                |                     |                 |                         |

| Type of oil                        | Principal fatty acid components in weight % |           |             |           | mp/<br>°C | Density/<br>g cm <sup>-3</sup> | Refractive<br>index  | Iodine<br>value | Saponification<br>value |
|------------------------------------|---------------------------------------------|-----------|-------------|-----------|-----------|--------------------------------|----------------------|-----------------|-------------------------|
| Mango seed oil                     | 18:1 9c                                     | 38–50%    | 18:0        | 31–49%    |           | 0.912 <sup>15</sup>            | 1.461 <sup>25</sup>  | 39–48           | 188–195                 |
|                                    | 18:2 9c,12c                                 | 3–6%      | 20:0        | 2–6%      |           |                                |                      |                 |                         |
| Meadowfoam seed oil                | 20:1 5c                                     | 58–77%    | 22:1 total  | 8–24%     |           |                                | 1.464 <sup>40</sup>  | 86–91           | 168                     |
|                                    | 22:2 5c,13c                                 | 7–15%     | 18:1 9c     | 1–3%      |           |                                |                      |                 |                         |
| Melon oil                          | 18:2 9c,12c                                 | 67% (av.) | 18:1 9c     | 12% (av.) |           |                                |                      |                 |                         |
|                                    | 16:0                                        | 11% (av.) | 18:0        | 9% (av.)  |           |                                |                      |                 |                         |
| Moringa peregrina seed<br>oil      | 18:1 9c                                     | 70%       | 16:0        | 9%        |           | 0.903 <sup>24</sup>            | 1.460 <sup>40</sup>  | 70              | 185                     |
|                                    | 18:0                                        | 3.8%      | 22:0        | 2.4%      |           |                                |                      |                 |                         |
| Mustard seed oil                   | 22:1 13c                                    | 43%       | 22:1 13c    | 22–50%    |           | 0.913 <sup>20</sup>            | 1.465 <sup>40</sup>  | 92–125          | 170–184                 |
|                                    | 18:3 9c,12c,15c                             | 12%       | 18:2 9c,12c | 10–24%    |           |                                |                      |                 |                         |
| Neem oil                           | 18:1 9c                                     | 49–62%    | 18:0        | 14–24%    | –3        | 0.912 <sup>30</sup>            | 1.462 <sup>40</sup>  | 68–71           | 195–205                 |
|                                    | 16:0                                        | 13–18%    | 18:2 9c,12c | 7–15%     |           |                                |                      |                 |                         |
| Niger seed oil                     | 18:2 9c,12c                                 | 52–78%    | 16:0        | 5–12%     |           | 0.924 <sup>15</sup>            | 1.468 <sup>40</sup>  | 126–135         | 188–193                 |
|                                    | 18:1 9c                                     | 4–10%     | 18:0        | 2–12%     |           |                                |                      |                 |                         |
| Nutmeg butter                      | 14:0                                        | 76–83%    | 18:1 9c     | 5–11%     | 45        |                                | 1.468 <sup>40</sup>  | 48–85           | 170–190                 |
|                                    | 16:0                                        | 4–10%     | 12:0        | 3–6%      |           |                                |                      |                 |                         |
| Oat oil                            | 18:2 9c,12c                                 | 24–48%    | 18:1 9c     | 18–53%    |           | 0.917 <sup>25</sup>            | 1.467 <sup>40</sup>  | 105–116         | 190–199                 |
|                                    | 16:0                                        | 13–39%    | 18:0        | 0.5–4%    |           |                                |                      |                 |                         |
| Oiticica oil                       | 18:3 9c,11t,13t,<br>4-oxo                   | 70–80%    | 16:0        | 7%        |           | 0.972 <sup>20</sup>            | 1.514 <sup>25</sup>  | 140–150         | 188–193                 |
|                                    | 18:0                                        | 5%        | 18:1 9c     | 4–7%      |           |                                |                      |                 |                         |
| Olive oil                          | 18:1 9c                                     | 55–83%    | 18:2 9c,12c | 9%        | –6        | 0.911 <sup>20</sup>            | 1.469 <sup>20</sup>  | 75–94           | 184–196                 |
|                                    | 16:0                                        | 7.5–20%   | 18:2 9c,12c | 3.5–21%   |           |                                |                      |                 |                         |
| Palm kernel oil                    | 12:0                                        | 40–55%    | 14:0        | 14–18%    | 24        | 0.922 <sup>15</sup>            | 1.450 <sup>40</sup>  | 14–21           | 230–250                 |
|                                    | 18:1 9c                                     | 12–21%    | 16:0        | 6.5–10%   |           |                                |                      |                 |                         |
| Palm oil                           | 16:0                                        | 40–48%    | 18:1 9c     | 36–44%    | 35        | 0.914 <sup>15</sup>            | 1.455 <sup>40</sup>  | 49–55           | 190–209                 |
|                                    | 18:2 9c,12c                                 | 6.5–12%   | 18:0        | 3.5–6.5%  |           |                                |                      |                 |                         |
| Palm olein                         | 18:1 9c                                     | 40–44%    | 16:0        | 38–43%    |           | 0.91 <sup>40</sup>             | 1.459 <sup>40</sup>  | >56             | 194–202                 |
|                                    | 18:2 9c,12c                                 | 10–13%    | 18:0        | 3.7–4.8%  |           |                                |                      |                 |                         |
| Palm stearin                       | 16:0                                        | 48–74%    | 18:1 9c     | 16–36%    |           | 0.884 <sup>60</sup>            | 1.449 <sup>40</sup>  | <48             | 193–205                 |
|                                    | 18:0                                        | 3.9–5.6%  | 18:2 9c,12c | 3.2–9.8%  |           |                                |                      |                 |                         |
| Parsley seed oil                   | 18:1 6c                                     | 69–76%    | 18:1 9c     | 12–15%    |           |                                | 1.4800 <sup>40</sup> | 110–120         |                         |
|                                    | 18:2 9c,12c                                 | 6–14%     | 16:0        | 2%        |           |                                |                      |                 |                         |
| Peanut oil                         | 18:1 9c                                     | 36–67%    | 18:2 9c,12c | 14–43%    | 3         | 0.914 <sup>20</sup>            | 1.463 <sup>40</sup>  | 86–107          | 187–196                 |
|                                    | 16:0                                        | 8.3–14%   | 22:0        | 2.1–4.4%  |           |                                |                      |                 |                         |
| Perilla oil                        | 18:3 9c,12c,15c                             | 59%       | 18:2 9c,12c | 14–18%    |           | 0.924 <sup>25</sup>            | 1.477 <sup>25</sup>  | 192–208         | 188–197                 |
|                                    | 18:1 9c                                     | 11–13%    | 16:0        | 6–9%      |           |                                |                      |                 |                         |
| Phulwara butter                    | 16:0                                        | 57–61%    | 18:1 9c     | 30–36%    | 43        | 0.862 <sup>100</sup>           | 1.458 <sup>40</sup>  | 40–51           | 188–200                 |
|                                    | 18:2 9c,12c                                 | 3–4%      | 18:0        | 3–4%      |           |                                |                      |                 |                         |
| Pine nut oil                       | 18:2 9c,12c                                 | 47–51%    | 18:1 9c     | 36–39%    |           | 0.919 <sup>15</sup>            |                      | 118–121         | 193–197                 |
|                                    | 16:0                                        | 6–8%      | 18:0        | 2–3%      |           |                                |                      |                 |                         |
| Poppy seed oil                     | 18:2 9c,12c                                 | 62–73%    | 18:1 9c     | 16–30%    | –15       | 0.916 <sup>25</sup>            | 1.469 <sup>40</sup>  | 132–146         | 188–196                 |
|                                    | 16:0                                        | 7–11%     | 18:0        | 1–4%      |           |                                |                      |                 |                         |
| Rice bran oil                      | 18:1 9c                                     | 38–48%    | 18:2 9c,12c | 16–36%    |           | 0.916 <sup>25</sup>            | 1.472 <sup>25</sup>  | 92–108          | 181–189                 |
|                                    | 16:0                                        | 16–28%    | 18:0        | 2–4%      |           |                                |                      |                 |                         |
| Safflower seed oil                 | 18:2 9c,12c                                 | 68–83%    | 18:1 9c     | 8.4–30%   |           | 0.924 <sup>15</sup>            | 1.474 <sup>25</sup>  | 136–148         | 186–198                 |
|                                    | 16:0                                        | 5.3–8.0%  | 18:0        | 1.9–2.9%  |           |                                |                      |                 |                         |
| Safflower seed oil<br>(high oleic) | 18:1 9c                                     | 74–80%    | 18:2 9c,12c | 13–18%    |           | 0.921 <sup>20</sup>            | 1.470 <sup>25</sup>  | 91–95           |                         |
|                                    | 16:0                                        | 5–6%      | 18:0        | 1.5–2.0%  |           |                                |                      |                 |                         |
| Sal fat                            | 18:0                                        | 33–57%    | 18:1 9c     | 31–52%    | 33        |                                | 1.456 <sup>40</sup>  | 31–45           | 175–192                 |
|                                    | 16:0                                        | 6–23%     | 20:0        | 1–8%      |           |                                |                      |                 |                         |

| Type of oil                             | Principal fatty acid components in weight % |           |                         |          | mp/<br>°C | Density/<br>g cm <sup>−3</sup> | Refractive<br>index | Iodine<br>value | Saponification<br>value |
|-----------------------------------------|---------------------------------------------|-----------|-------------------------|----------|-----------|--------------------------------|---------------------|-----------------|-------------------------|
| Sesame seed oil                         | 18:2 9c,12c                                 | 40–51%    | 18:1 9c                 | 33–44%   | −6        | 0.917 <sup>20</sup>            | 1.467 <sup>40</sup> | 104–120         | 187–195                 |
|                                         | 16:0                                        | 7.9–10.2% | 18:0                    | 4.4–6.7% |           |                                |                     |                 |                         |
| Sheanut butter                          | 18:1 9c                                     | 45–50%    | 18:0                    | 36–41%   | 38        | 0.863 <sup>100</sup>           | 1.465 <sup>40</sup> | 52–66           | 178–198                 |
|                                         | 16:0                                        | 4–8%      | 18:2 9c,12c             | 4–8%     |           |                                |                     |                 |                         |
| Soybean oil                             | 18:2 9c,12c                                 | 50–57%    | 18:1 9c                 | 18–28%   | −16       | 0.920 <sup>20</sup>            | 1.468 <sup>40</sup> | 118–139         | 189–195                 |
|                                         | 16:0                                        | 9–13%     | 18:3 9c,12c,15c         | 5.5–9.5% |           |                                |                     |                 |                         |
| Stillingia seed kernel oil <sup>c</sup> | 18:3 total                                  | 41–54%    | 18:2 9c,12c             | 24–30%   |           | 0.937 <sup>25</sup>            | 1.483 <sup>25</sup> | 169–191         | 202–212                 |
|                                         | 18:1 9c                                     | 7–10%     | 16:0                    | 6–9%     |           |                                |                     |                 |                         |
| Sunflower seed oil                      | 18:2 9c,12c                                 | 48–74%    | 18:1 9c                 | 13–40%   | −17       | 0.919 <sup>20</sup>            | 1.474 <sup>25</sup> | 118–145         | 188–194                 |
|                                         | 16:0                                        | 5–8%      | 18:0                    | 2.5–7.0% |           |                                |                     |                 |                         |
| Sunflower oil, high-oleic<br>(HO)       | 18:1 9c                                     | 80%       | 18:2 9c,12c             | 10%      |           | 0.911 <sup>25</sup>            | 1.468 <sup>25</sup> | 81              |                         |
|                                         | 18:0                                        | 4.4%      | 16:0                    | 3.5%     |           |                                |                     |                 |                         |
| Sunflower oil, mid-Oleic<br>(NuSun oil) | 18:1 9c                                     | 65%       | 18:2, 18:3              | 25%      |           |                                |                     |                 |                         |
|                                         | 16:0, 18:0                                  | 10%       |                         |          |           |                                |                     |                 |                         |
| Tall oil                                | 18:2 9c,12c                                 | 41–52%    | 18:1 9c                 | 41–48%   |           | 0.969 <sup>25</sup>            | 1.494 <sup>25</sup> | 140–180         | 154–180                 |
|                                         | 16:0                                        | 5–6%      | 18:0                    | 2–3%     |           |                                |                     |                 |                         |
| Tung oil                                | 18:3 9c,11t,13t                             | 71–82%    | 18:2 9c,12c             | 8–15%    | −2        | 0.912 <sup>25</sup>            | 1.517 <sup>25</sup> | 160–175         | 189–195                 |
|                                         | 18:1 9c                                     | 4–10%     | 18:0                    | 3%       |           |                                |                     |                 |                         |
| Ucuhuba butter oil                      | 14:0                                        | 64–73%    | 12:0                    | 13–15%   |           | 0.870 <sup>100</sup>           | 1.451 <sup>50</sup> | 11–17           | 221–229                 |
|                                         | 18:1 9c                                     | 6–8%      | 16:0                    | 3–9%     |           |                                |                     |                 |                         |
| Vernonia seed oil                       | 18:1 12,13-ep,9c                            | 62–72%    | 18:2 9c,12c             | 9–17%    |           | 0.901 <sup>30</sup>            | 1.486 <sup>32</sup> | 55              | 176                     |
|                                         | 16:0                                        | 3–7%      | 18:0                    | 2–6%     |           |                                |                     |                 |                         |
| Walnut oil                              | 18:2 9c,12c                                 | 56–60%    | 18:1 9c                 | 17–19%   |           | 0.921 <sup>25</sup>            | 1.474 <sup>25</sup> | 138–162         | 189–197                 |
|                                         | 18:3 9c,12c,15c                             | 13–14%    | 16:0                    | 6–8%     |           |                                |                     |                 |                         |
| Wheatgerm oil                           | 18:2 9c,12c                                 | 50–59%    | 18:1 9c                 | 13–23%   |           | 0.926 <sup>25</sup>            | 1.479 <sup>25</sup> | 100–128         | 179–217                 |
|                                         | 16:0                                        | 12–20%    | 18:3 9c,12c,15c         | 2–9%     |           |                                |                     |                 |                         |
| <i>Marine animals</i>                   |                                             |           |                         |          |           |                                |                     |                 |                         |
| Anchovy oil                             | 20:5                                        | 22%       | 16:0                    | 17%      |           |                                |                     | 163–169         | 191–194                 |
|                                         | 6c,9c,12c,15c,17c                           |           |                         |          |           |                                |                     |                 |                         |
| Capelin oil <sup>d</sup>                | 16:1 undefined                              | 13%       | 18:1 undefined          | 10%      |           |                                | 1.463 <sup>50</sup> | 94–164          | 185–202                 |
|                                         | 20:1 undefined                              | 17%       | 22:1 undefined          | 15%      |           |                                |                     |                 |                         |
| Cod liver oil                           | 18:1 undefined                              | 14%       | 16:0                    | 10%      |           | 0.924 <sup>15</sup>            | 1.482 <sup>25</sup> | 142–176         | 180–192                 |
|                                         | 22:6 4c,7c,10c,13c, 16c,19c                 | 11%       | 16:0                    | 10%      |           |                                |                     |                 |                         |
| Herring oil                             | 22:1 undefined                              | 19%       | 16:0                    | 17%      |           | 0.914 <sup>20</sup>            | 1.474 <sup>25</sup> | 115–160         | 161–192                 |
|                                         | 20:1 undefined                              | 15%       | 18:1 undefined          | 14%      |           |                                |                     |                 |                         |
| Mackerel oil                            | 22:1 undefined                              | 15%       | 16:0                    | 14%      |           | 0.929 <sup>15</sup>            | 1.481 <sup>20</sup> | 136–167         |                         |
|                                         | 18:1 undefined                              | 13%       | 20:1 undefined          | 12%      |           |                                |                     |                 |                         |
| Menhaden oil                            | 16:0                                        | 19%       | 20:5 6c,9c,12c,15c, 17c | 14%      |           | 0.920 <sup>15</sup>            |                     | 150–200         | 192–199                 |
|                                         | 16:1 undefined                              | 12%       | 18:1 undefined          | 11%      |           |                                |                     |                 |                         |
| Salmon oil                              | 22:6 4c,7c,10c,13c, 16c,19c                 | 18%       | 20:5 6c,9c,12c,15c, 17c | 13%      |           | 0.924 <sup>15</sup>            | 1.475 <sup>25</sup> | 130–160         | 183–186                 |
|                                         | 16:0                                        | 9.8%      | 16:1                    | 4.8%     |           |                                |                     |                 |                         |
| Sardine oil                             | 16:0                                        | 18%       | 20:5 6c,9c,12c,15c, 17c | 16%      |           | 0.915 <sup>25</sup>            | 1.464 <sup>65</sup> | 159–192         | 188–199                 |
|                                         | 18:1 undefined                              | 13%       | 16:1 undefined          | 10%      |           |                                |                     |                 |                         |
| Seal blubber oil, harp                  | 18:1 9c                                     | 21%       | 20:1                    | 12%      |           |                                |                     |                 |                         |
|                                         | 22:6 4c,7c,10c,13c, 16c,19c                 | 7.6%      | 20:5 6c,9c,12c,15c, 17c | 6.4%     |           |                                |                     |                 |                         |

| Type of oil              | Principal fatty acid components in weight % |             |                         |             | mp/<br>°C | Density/<br>g cm <sup>-3</sup> | Refractive<br>index | Iodine<br>value | Saponification<br>value |
|--------------------------|---------------------------------------------|-------------|-------------------------|-------------|-----------|--------------------------------|---------------------|-----------------|-------------------------|
| Shark liver oil          | 18:1 undefined                              | 45%         | 16:0                    | 21%         |           | 0.917 <sup>25</sup>            | 1.476 <sup>25</sup> | 150–300         | 170–190                 |
|                          | 20:1                                        | 12%         | 22:1                    | 9%          |           |                                |                     |                 |                         |
| Tuna oil                 | 22:6 4c,7c,10c,13c, 16c,19c                 | 22%         | 16:0                    | 22%         |           |                                |                     |                 |                         |
|                          | 18:1 undefined                              | 21%         | 20:5 6c,9c,12c,15c, 17c | 6%          |           |                                |                     |                 |                         |
| Trout lipids             | 16:0                                        | 21–24%      | 18:1 undefined          | 18–31%      |           |                                |                     |                 |                         |
|                          | 18:2                                        | 7–16%       | 16:1                    | 4–10%       |           |                                |                     |                 |                         |
| Whale oil, minke         | 18:1 undefined                              | 18%         | 20:1                    | 17%         |           |                                |                     |                 |                         |
|                          | 22:1                                        | 11%         | 16:1                    | 9%          |           |                                |                     |                 |                         |
| <b>Land animals</b>      |                                             |             |                         |             |           |                                |                     |                 |                         |
| Beef tallow              | 18:1 undefined                              | 31–50%      | 18:0                    | 25–40%      | 47        | 0.902 <sup>25</sup>            | 1.454 <sup>40</sup> | 33–47           | 190–200                 |
|                          | 16:0                                        | 20–37%      | 14:0                    | 1–6%        |           |                                |                     |                 |                         |
| Butterfat                | 16:0                                        | 28.1% (av.) | 18:1 9c                 | 20.8% (av.) | 32        | 0.934 <sup>15</sup>            | 1.455 <sup>40</sup> | 26–40           | 210–232                 |
|                          | 14:0                                        | 10.8% (av.) | 18:0                    | 10.6% (av.) |           |                                |                     |                 |                         |
| Chicken egg lipids, yolk | 16:0                                        | 28%         | 18:1 9c                 | 25%         |           |                                |                     |                 |                         |
|                          | 18:0                                        | 17%         | 18:2 9c,12c             | 16%         |           |                                |                     |                 |                         |
| Chicken fat              | 18:1 undefined                              | 37%         | 16:0                    | 22%         |           | 0.918 <sup>15</sup>            | 1.456 <sup>40</sup> | 76–80           |                         |
|                          | 18:2                                        | 20%         | 18:0                    | 6%          |           |                                |                     |                 |                         |
| Milk fats, cow           | 16:0                                        | 28.2% (av.) | 18:1 9c                 | 21.4% (av.) |           |                                |                     |                 |                         |
|                          | 18:0                                        | 12.6% (av.) | 14:0                    | 10.6% (av.) |           |                                |                     |                 |                         |
| Milk fats, human         | 18:1 9c                                     | 31.1% (av.) | 16:0                    | 21.6% (av.) |           |                                |                     |                 |                         |
|                          | 18:2 9c,12c                                 | 11.7% (av.) | 14:0                    | 6.6% (av.)  |           |                                |                     |                 |                         |
| Mutton tallow            | 18:1 undefined                              | 30–42%      | 18:0                    | 22–34%      | 48        | 0.946 <sup>15</sup>            | 1.455 <sup>40</sup> | 35–46           |                         |
|                          | 16:0                                        | 20–27%      | 14:0                    | 2–4%        |           |                                |                     |                 |                         |
| Pork lard                | 18:1 undefined                              | 35–62%      | 16:0                    | 20–32%      | 30        | 0.898 <sup>20</sup>            |                     |                 |                         |
|                          | 18:0                                        | 5–24%       | 18:2                    | 3–16%       |           |                                |                     |                 |                         |

<sup>a</sup> Jojoba oil consists primarily of wax esters of the acids listed here and long-chain alcohols.

<sup>b</sup> Kapok oil also contains up to 15% cyclopropene acids.

<sup>c</sup> Stillingia oil also contains 5–10% *trans,cis*-2,4-decadienoic acid (stilingic acid, 10:2 2t,4c).

<sup>d</sup> Capelin oil also contains about 10% 16:1.

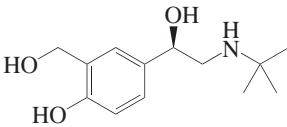
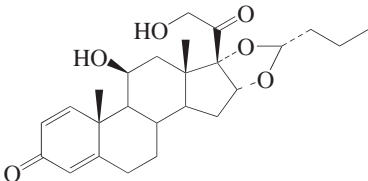
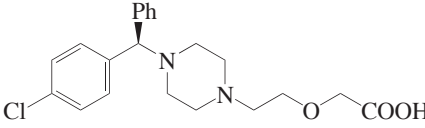
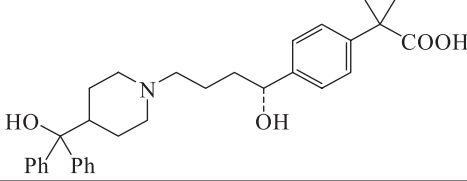
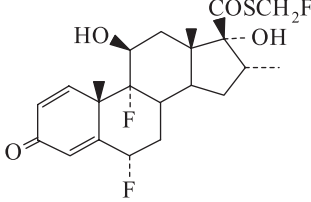
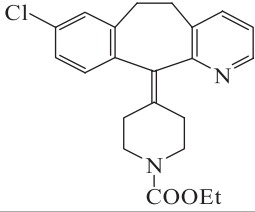
## STRUCTURE AND FUNCTIONS OF SOME COMMON DRUGS

This table lists the names, categories, therapeutic uses, and chemical structures of selected drugs. The generic (chemical) name of each drug is given, along with some of the trade names under which it is sold. When available, physical properties are given in italics in the fourth column. The structure given refers to the active drug, but many of these are packaged as salts or other derivatives. The drugs have been selected to represent a variety of categories; most are widely used throughout the world.

The list is divided into therapeutic categories; within each category the listing is alphabetical by generic name. The index that follows the table can be used to locate a drug by either generic or trade name.

### References

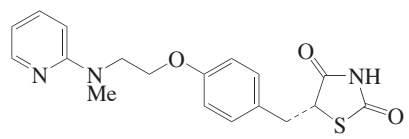
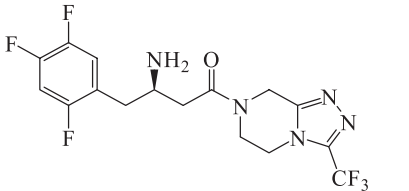
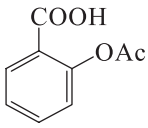
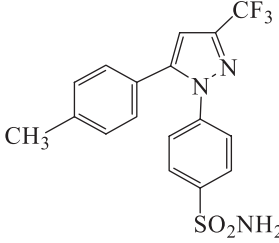
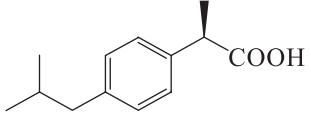
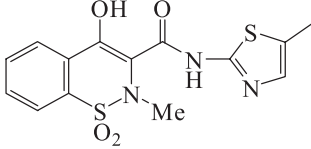
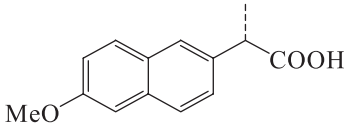
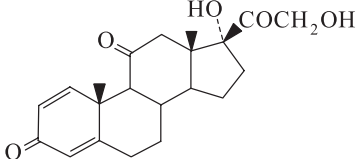
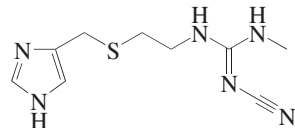
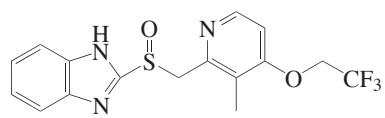
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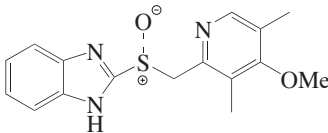
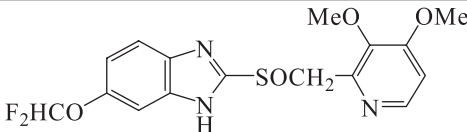
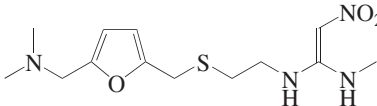
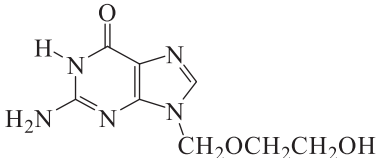
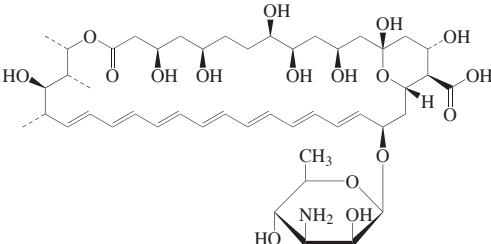
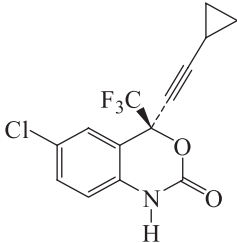
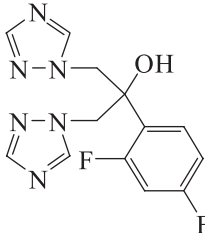
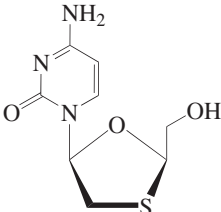
| Generic Name               | Trade Names                                                                | Category and Properties                       | Applications                                                                         | Structure                                                                            |
|----------------------------|----------------------------------------------------------------------------|-----------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Antiallergic Agents</b> |                                                                            |                                               |                                                                                      |                                                                                      |
| 1 Albuterol                | Proventil; Ventolin; Volmax                                                | $\beta_2$ -Andrenergic receptor agonist       | Treatment of troubled breathing caused by asthma, emphysema, and other lung diseases |    |
| 2 Budesonide               | Budeson; Budamax; Rhinocort; Pulmicort; Inflammide                         | Glucocorticoid<br><i>mp</i> 226 °C            | Management of asthma and treatment of inflammatory bowel disease                     |   |
| 3 Cetirizine               | Zyrtec                                                                     | Histamine H <sub>1</sub> -receptor antagonist | Treatment of seasonal allergies and hives                                            |  |
| 4 Fexofenadine             | Carboxyterfenadine; Allegra; Telfast                                       | Histamine H <sub>1</sub> -receptor antagonist | Treatment of allergic rhinitis                                                       |  |
| 5 Fluticasone              | Flovent (as propanoate); Flonase (as propanoate); Advair (with salmeterol) | Anti-inflammatory glucocorticoid              | Treatment of asthma & rhinitis                                                       |  |
| 6 Loratadine               | Claritin; Claratyne; Alavert                                               | Long-acting antihistamine<br><i>mp</i> 132 °C | Relief of allergy symptoms                                                           |  |

| Generic Name         | Trade Names                                   | Category and Properties                                       | Applications                                                                                    | Structure |
|----------------------|-----------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-----------|
| 7 Montelukast        | Singulair                                     | Leukotriene LTD <sub>4</sub> receptor antagonist              | Control of asthma and relief of seasonal allergies                                              |           |
| 8 Salmeterol         | Serevent                                      | β <sub>2</sub> -Adrenergic receptor agonist                   | Treatment of asthma & chronic obstructive pulmonary disease                                     |           |
| 9 Tiotropium bromide | Spiriva                                       | Long-acting antimuscarinic bronchodilator                     | Treatment of chronic obstructive pulmonary disease                                              |           |
| <b>Antibiotics</b>   |                                               |                                                               |                                                                                                 |           |
| 10 Amikacin          | Amikin; Biclin; Chemacin; Flexilite; Negasin  | Aminoglycoside antibiotic                                     | Treatment of serious infections resistant to other antibiotics                                  |           |
| 11 Amoxicillin       | Amoxil; Isimoxin; Ospamox                     | β-Lactam/penicillin                                           | Treatment of a broad spectrum of bacterial infections                                           |           |
| 12 Azithromycin      | Zithromax; Vinzam; Zmax; Azitrocin            | Azalide/macrolide antibiotic<br><i>mp</i> 155 °C              | Treatment of bacterial skin, ear, and respiratory infections                                    |           |
| 13 Cefaclor          | Ceclo; Kefolar; Panacef; Panoral              | β-Lactam/cephalosporin                                        | Treatment of bacterial infections, pneumonia, and urinary tract infections                      |           |
| 14 Ciprofloxacin     | Cipro; Ciproxin; Ciprobay; Flociprin; Uniflox | Fluoroquinolone/broad-spectrum antibiotic<br><i>mp</i> 256 °C | Treatment of urinary & respiratory tract infections, anthrax, and sexually-transmitted diseases |           |

| Generic Name              | Trade Names                                     | Category and Properties                                        | Applications                                                                                                | Structure |
|---------------------------|-------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-----------|
| 15 Doxycycline            | Vibramycin; Adoxa; Doryx; Liviatin; Deoxymykoin | Tetracycline/ broad-spectrum antibiotic                        | Treatment of urinary tract, respiratory tract, and eye infections; anthrax, syphilis, cholera, etc.         |           |
| 16 Erythromycin           | E-Mycin; Erythrocin; Ilosone                    | Macrolide antibiotic<br><i>mp 191 °C</i>                       | Treatment of bacterial infections, including diphtheria, pertussis, rheumatic fever, venereal disease, etc. |           |
| 17 Isoniazid              | Laniazid                                        | Antimycobacterial agent<br><i>mp 171 °C</i>                    | Treatment of tuberculosis; reduction of tremors from multiple sclerosis                                     |           |
| 18 Linezolid              | Zyvox                                           | Oxazolidinone<br><i>mp 182 °C</i>                              | Treatment of serious Gram-positive infections resistant to other antibiotics                                |           |
| 19 Trimethoprim           | Triprim; Proloprim; Monotrim                    | Dihydrofolate reductase inhibitor<br><i>mp 199 °C</i>          | Treatment of urinary tract infections, diarrhea, and ear infections                                         |           |
| <b>Antidiabetic Drugs</b> |                                                 |                                                                |                                                                                                             |           |
| 20 Glipizide              | Glucotrol; Glydiazinamide; Glibenese; Minodiab  | Potassium channel blocker/sulfonylurea<br><i>mp 208 °C</i>     | Treatment of type 2 diabetes by stimulating insulin secretion in pancreas $\beta$ -cells                    |           |
| 21 Metformin              | Glucophage; Diabex; Diaformin; Fortamet         | Antidiabetic biguanide                                         | Treatment of type 2 diabetes by enhancing transport of glucose into muscle cells                            |           |
| 22 Pioglitazone           | Actos                                           | Peroxisome proliferator-activated receptor<br><i>mp 174 °C</i> | Treatment of type 2 diabetes by increasing glucose metabolism and insulin sensitivity                       |           |



| Generic Name                    | Trade Names                               | Category and Properties                                            | Applications                                                                                                              | Structure                                                                            |
|---------------------------------|-------------------------------------------|--------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 23 Rosiglitazone                | Avandia                                   | Thiazolidinedione                                                  | Treatment of type 2 diabetes by increasing insulin sensitivity. Possible adverse effects on patients with heart problems. |    |
| 24 Sitagliptin                  | Januvia                                   | Dipeptidyl peptidase IV inhibitor                                  | Treatment of type 2 diabetes by enhancing the body's ability to lower elevated glucose levels                             |    |
| <b>Anti-Inflammatory Agents</b> |                                           |                                                                    |                                                                                                                           |                                                                                      |
| 25 Acetylsalicylic acid         | Aspirin                                   | NSAID                                                              | Pain and fever relief; anticlotting agent                                                                                 |    |
| 26 Celecoxib                    | Celebrex; Onsenal                         | NSAID (COX-2 inhibitor)<br><i>mp</i> 158 °C                        | Treatment of osteoarthritis and rheumatoid arthritis                                                                      |   |
| 27 Ibuprofen                    | Advil                                     | NSAID (cyclooxygenase inhibitor)<br><i>mp</i> 76 °C                | Relief of inflammation and pain                                                                                           |  |
| 28 Meloxicam                    | Mobic; Metacam; Metacain                  | NSAID (cyclooxygenase inhibitor)<br><i>mp</i> 254 °C               | Treatment of osteoarthritis and rheumatoid arthritis                                                                      |  |
| 29 Naproxen                     | Aleve; Naprelan; Anaprox; Naprogesic      | NSAID<br><i>mp</i> 155 °C                                          | Relief of inflammation and pain                                                                                           |  |
| 30 Prednisone                   | Meticorten; Deltasone                     | Adrenocortical steroid; anti-inflammatory agent; immunosuppressant | Treatment of asthma and other inflammatory diseases                                                                       |  |
| <b>Anti-Ulcer Drugs</b>         |                                           |                                                                    |                                                                                                                           |                                                                                      |
| 31 Cimetidine                   | Tagamet; Cimetimax; Gastromet; Peptimax   | Histamine H <sub>2</sub> -receptor antagonist<br><i>mp</i> 142 °C  | Treatment of peptic ulcer, gastrointestinal bleeding, and gastroesophageal reflux disease                                 |  |
| 32 Lansoprazole                 | Prevacid; SoluTab; Prevpac; Zoton; Prezal | Proton pump inhibitor<br><i>mp</i> 180 °C                          | Treatment of duodenal ulcers & gastroesophageal reflux disease                                                            |  |

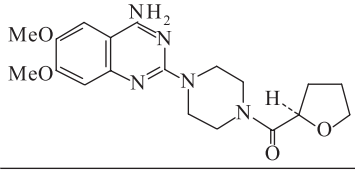
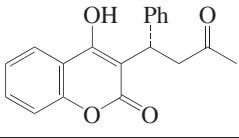
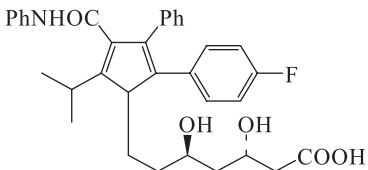
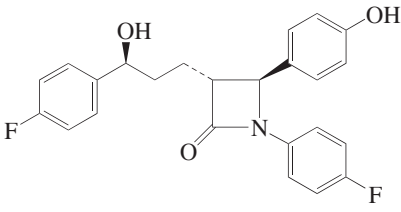
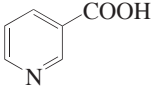
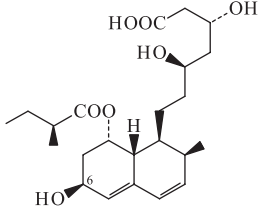
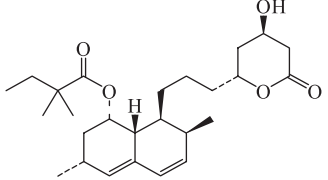
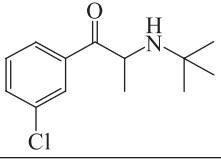
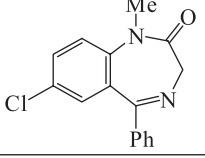
| Generic Name                           | Trade Names                                               | Category and Properties                                                | Applications                                                                              | Structure                                                                            |
|----------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 33 Omeprazole                          | Prilosec; Nexium (Mg salt); Losec; Mepral; Mopral; Zoltum | Proton pump inhibitor<br><i>mp</i> 156 °C                              | Treatment of peptic ulcer, dyspepsia, and gastroesophageal reflux disease                 |    |
| 34 Pantoprazole                        | Protonix; Pantozol; Rifun                                 | Proton pump inhibitor                                                  | Treatment of gastric acid-related conditions                                              |    |
| 35 Ranitidine                          | Zantac; Azantac; Melfax; Rantec; Sostril; Taural          | Histamine H <sub>2</sub> -receptor antagonist<br><i>mp</i> 70 °C       | Treatment of peptic ulcer, gastrointestinal bleeding, and gastroesophageal reflux disease |    |
| <b>Antiviral and Antifungal Agents</b> |                                                           |                                                                        |                                                                                           |                                                                                      |
| 36 Acyclovir                           | Zovirax; Zovir; Avirax; Mirolex                           | Viral DNA synthesis inhibitor<br><i>mp</i> 225 °C                      | Treatment of cold sores, genital herpes, chicken pox, etc.                                |    |
| 37 Amphotericin                        | Fungizone; Amfostet; Amphozone                            | Polyene macrolide antifungal agent<br><i>mp</i> 170 °C                 | Intravenous treatment of systemic fungal infections                                       |   |
| 38 Efavirenz                           | Sustiva                                                   | Non-nucleoside HIV reverse transcriptase inhibitor<br><i>mp</i> 131 °C | Treatment of HIV-1 infections (as part of combination therapy)                            |  |
| 39 Fluconazole                         | Diflucan; Biozolene; Elazor; Triflucan                    | Cytochrome P450 14α-demethylase inhibitor<br><i>mp</i> 139 °C          | Treatment and prevention of superficial & systemic fungal infections                      |  |
| 40 Lamivudine                          | Epivir; Heptodin; Zeffix                                  | HIV reverse transcriptase inhibitor                                    | Treatment of hepatitis B and human immunodeficiency virus                                 |  |

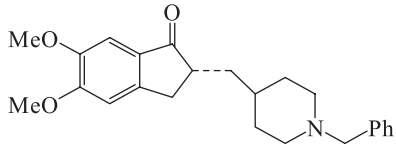
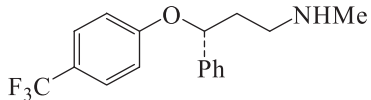
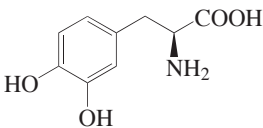
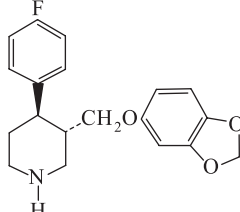
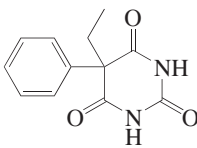
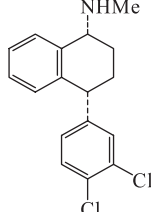
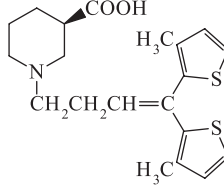
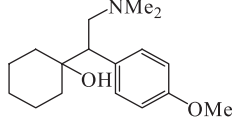
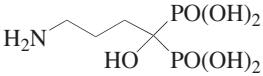
| Generic Name                     | Trade Names                                               | Category and Properties                                                   | Applications                                                            | Structure |
|----------------------------------|-----------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------|-----------|
| 41 Nevirapine                    | Viramune                                                  | Non-nucleoside HIV reverse transcriptase inhibitor<br><i>mp</i> 250 °C    | Treatment of HIV infections (as part of combination therapy)            |           |
| 42 Oseltamivir                   | Tamiflu                                                   | Neuraminidase inhibitor <i>Foam</i>                                       | Prevention & treatment of influenza A and B                             |           |
| 43 Ribavirin                     | Virazole; Rebetol; Copegus; Ribasphere; Viratek; Cotronak | Nucleoside antimetabolite<br><i>mp</i> 175 °C                             | Treatment of hepatitis C                                                |           |
| 44 Terbinafine                   | Lamisil                                                   | Squalene epoxidase inhibitor                                              | Treatment of fungal infections of the skin & nails                      |           |
| 45 Zalcitabine                   | Hivid                                                     | Pyrimidine nucleoside reverse transcriptase inhibitor                     | Treatment of HIV infection & AIDS                                       |           |
| 46 Zidovudine                    | Retrovir; AZT; Azidothymidine; Zidovir                    | Pyrimidine nucleoside reverse transcriptase inhibitor<br><i>mp</i> 121 °C | Treatment of HIV infection & prevention of mother-to-child transmission |           |
| <b>Cancer Chemotherapy Drugs</b> |                                                           |                                                                           |                                                                         |           |
| 47 Anastrozole                   | Arimidex                                                  | Aromatase inhibitor; antineoplastic agent<br><i>mp</i> 81 °C              | Treatment of breast cancer in postmenopausal women                      |           |
| 48 Bicalutamide                  | Casodex                                                   | Antiandrogen<br><i>mp</i> 180 °C                                          | Treatment of advanced prostate cancer                                   |           |

| Generic Name        | Trade Names                                    | Category and Properties                                                    | Applications                                                            | Structure |
|---------------------|------------------------------------------------|----------------------------------------------------------------------------|-------------------------------------------------------------------------|-----------|
| 49 Bortezomib       | Velcade                                        | Proteasome inhibitor                                                       | Treatment of lymphomas and multiple myeloma                             |           |
| 50 Capecitabine     | Xeloda                                         | Antimetabolite                                                             | Treatment of breast & colon cancer                                      |           |
| 51 Carboplatin      | Paraplatin; Carboplat; Erbakar; Nonoplat       | Platinum-based anticancer agent                                            | Treatment of ovarian cancer                                             |           |
| 52 Cyclophosphamide | Cytosan; Neosar; Cytophosphan; Endoxan; Clafen | Oxazaphosphorine alkylating agent ("Nitrogen mustard")<br><i>mp 143 °C</i> | Treatment of lymphomas & leukemias, multiple myeloma, and other cancers |           |
| 53 Docetaxel        | Taxotere                                       | Antineoplastic agent<br><i>mp 232 °C</i>                                   | Treatment of ovarian, breast and bronchial carcinomas                   |           |
| 54 Fluorouracil     | Efudex; Carac; Fluoroplex; Adrucil             | Thymidylate synthesis inhibitor<br><i>mp 243 °C</i>                        | Constituent of several antineoplastic combinations                      |           |
| 55 Gemcitabine      | Gemzar (as hydrochloride)                      | Antineoplastic and antiviral agent<br><i>mp 290 °C</i>                     | Treatment of lung and pancreatic tumors                                 |           |
| 56 Imatinib         | Gleevec; Glivec                                | Protein kinase inhibitor<br><i>mp 212 °C</i>                               | Treatment of myelogenous leukemia and gastrointestinal tumors           |           |

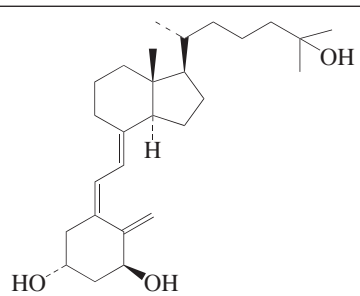
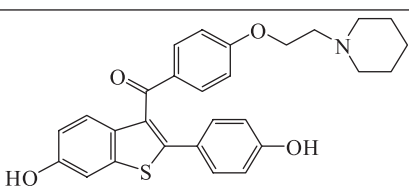
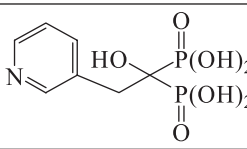
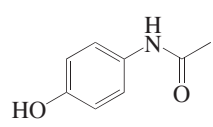
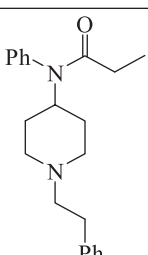
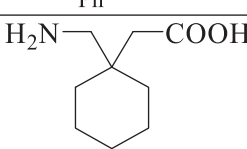
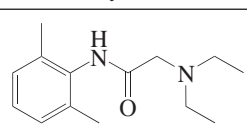
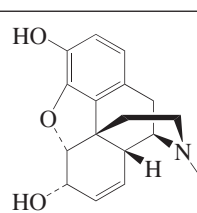
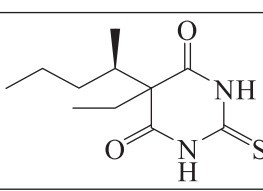
| Generic Name                 | Trade Names                                          | Category and Properties                                   | Applications                                                    | Structure |
|------------------------------|------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------------|-----------|
| 57 Irinotecan                | Camptosar;<br>Camptetin; Topotecin                   | Topoisomerase I inhibitor                                 | Treatment of colorectal cancer                                  |           |
| 58 Paclitaxel                | Taxol; Abraxane;<br>Yewtaxan                         | Microtubule-stabilizing agent<br><i>mp</i> 214 °C         | Treatment of ovarian, breast, and lung cancer                   |           |
| 59 Sunitinib                 | Sutent                                               | Tyrosine kinases inhibitor                                | Treatment of gastrointestinal & kidney tumors                   |           |
| 60 Tamoxifen                 | Nolvadex; Soltamox;<br>Tamaxin; Tamoplex;<br>Valodex | Selective estrogen receptor modulator<br><i>mp</i> 97 °C  | Treatment of breast cancer                                      |           |
| <b>Cardiovascular Agents</b> |                                                      |                                                           |                                                                 |           |
| 61 Aliskiren                 | Tekturna; Rasilex                                    | Renin inhibitor                                           | Treatment of hypertension                                       |           |
| 62 Amlodipine                | Norvasc                                              | Calcium channel blocker                                   | Treatment of hypertension, atrial fibrillation, and angina      |           |
| 63 Atenolol                  | Tenormin                                             | $\beta$ -blocker<br><i>mp</i> 147 °C                      | Treatment of hypertension and excessive heart rate              |           |
| 64 Carvedilol                | Coreg; Dilatrend;<br>Eucardic                        | Calcium channel blocker;<br>$\beta$ -adrenoceptor blocker | Treatment of heart failure and hypertension                     |           |
| 65 Clopidogrel               | Plavix; Isocover;<br>Meilax;<br>Tipidyl              | Antiplatelet agent                                        | Prevention of blood clots after stroke or myocardial infarction |           |

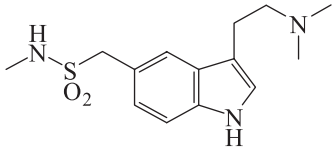
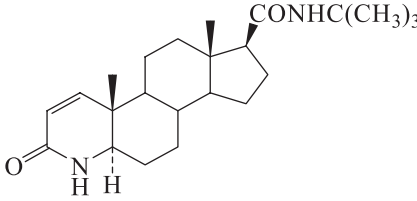
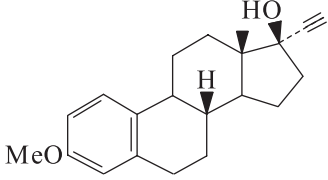
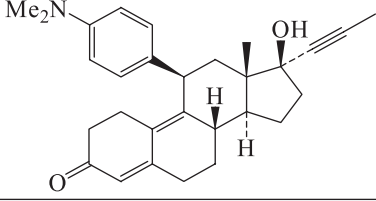
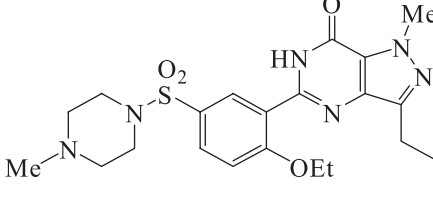
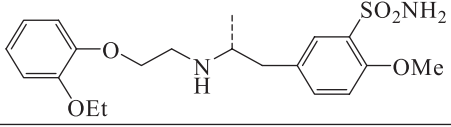
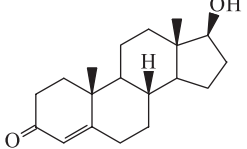
| Generic Name           | Trade Names                                                              | Category and Properties                                                             | Applications                                                             | Structure |
|------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----------|
| 66 Digoxin             | Lanoxin; Davoxin; Digacin; Dilanacin; Rougoxin; Digosin; Cordioxil       | Cardiac glycoside<br><i>mp</i> 249 °C                                               | Treatment of congestive heart failure                                    |           |
| 67 Enalaprilat         | Vasotec                                                                  | Angiotensin-converting enzyme inhibitor; antihypertensive agent<br><i>mp</i> 150 °C | Treatment of hypertension, atherosclerosis, and congestive heart failure |           |
| 68 Glycerol trinitrate | Nitroglycerin                                                            | Cardiac stimulant and vasodilator                                                   | Treatment of angina and congestive heart failure                         |           |
| 69 Irbesartan          | Aprovel; Avapro; Avalide (in combination with hydrochlorothiazide)       | Angiotensin II AT <sub>1</sub> -receptor antagonist<br><i>mp</i> 180 °C             | Treatment of hypertension and diabetes-related kidney disease            |           |
| 70 Lisinopril          | Acecomb; Alapril; Carace; Novatec; Novazyd; Vivatec; Zestoretic; Zestril | Angiotensin-converting enzyme inhibitor; antihypertensive agent<br><i>mp</i> 159 °C | Treatment of hypertension                                                |           |
| 71 Losartan            | Cozaar; Hyzaar (with hydrochlorothiazide)                                | Angiotensin II AT <sub>1</sub> -receptor antagonist<br><i>mp</i> 184 °C             | Treatment of congestive heart failure and hypertension                   |           |
| 72 Metoprolol          | Lopressor; Toprol XL                                                     | β-Adrenergic blocker                                                                | Treatment of angina and hypertension                                     |           |
| 73 Telmisartan         | Micardis                                                                 | Angiotensin II (AT <sub>1</sub> ) receptor antagonist<br><i>mp</i> 262 °C           | Treatment of hypertension                                                |           |

| Generic Name                        | Trade Names                                                          | Category and Properties                                              | Applications                                                                     | Structure                                                                            |
|-------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 74 Terazosin                        | Hytrin; Itrin; Hytrinex; Magnurol; Teraprost; Vasocard; Uroflo; etc. | Antihypertensive agent ( $\alpha_1$ -adrenoceptor antagonist)        | Treatment of hypertension and benign prostatic hyperplasia                       |    |
| 75 Warfarin                         | Coumadin                                                             | Anticlotting agent<br><i>mp</i> 161 °C                               | Reduction of possibility of stroke or coronary                                   |    |
| <b>Cholesterol-Lowering Drugs</b>   |                                                                      |                                                                      |                                                                                  |                                                                                      |
| 76 Atorvastatin                     | Lipitor; Caduet (in combination with amlodipine)                     | HMG-CoA reductase inhibitor (statin)                                 | Reduction of LDL cholesterol levels by inhibiting cholesterol biosynthesis       |    |
| 77 Ezetimibe                        | Zetia                                                                | Selective cholesterol absorption inhibitor<br><i>mp</i> 165 °C       | Reduction of LDL cholesterol levels by inhibiting dietary cholesterol absorption |    |
| 78 Nicotinic acid                   | Niacin                                                               | Lipoprotein synthesis inhibitor                                      | Reduction of LDL cholesterol levels                                              |  |
| 79 Pravastatin                      | Pravochol                                                            | HMG-CoA reductase inhibitor (statin)                                 | Reduction of LDL cholesterol levels by inhibiting cholesterol biosynthesis       |  |
| 80 Simvastatin                      | Zocor; Vytorin (combination with Ezetimibe)                          | HMG-CoA reductase inhibitor (statin)<br><i>mp</i> 136 °C             | Reduction of LDL cholesterol levels by inhibiting cholesterol biosynthesis       |  |
| <b>Depression and Anxiety Drugs</b> |                                                                      |                                                                      |                                                                                  |                                                                                      |
| 81 Bupropion                        | Wellbutrin; Amfebutamone; Zyban                                      | Dopamine reuptake inhibitor<br><i>Pale yellow oil</i>                | Antidepressant; smoking cessation aid                                            |  |
| 82 Diazepam                         | Valium; Stesolid; Seduxen; Antenex; Calmpose; Livotensin             | Benzodiazepine central nervous system depressant<br><i>mp</i> 125 °C | Treatment of anxiety, seizures, muscular spasms, and insomnia                    |  |

| Generic Name              | Trade Names                              | Category and Properties                                        | Applications                                                              | Structure                                                                            |
|---------------------------|------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 83 Donepezil              | Aricept                                  | Acetylcholine esterase inhibitor                               | Treatment of Alzheimer's disease                                          |    |
| 84 Fluoxetine             | Prozac; Sarafem; Adofen; Fontex; Lorient | Selective serotonin reuptake inhibitor                         | Treatment of depression, panic attacks, and obsessive-compulsive disorder |    |
| 85 Levodopa               | L-Dopa; Larodopa; Bendopa; Veldopa       | Precursor to the neurotransmitter dopamine<br><i>mp</i> 277 °C | Treatment of Parkinson's disease                                          |    |
| 86 Paroxetine             | Paxil; Seroxat; Tagonis; Aropax; Motivan | Selective serotonin reuptake inhibitor                         | Treatment of depression, panic attacks, and obsessive-compulsive disorder |    |
| 87 Phenobarbital          | Luminal; Fenemal; Gardenal; Barbivis     | Anticonvulsant<br><i>mp</i> 174 °C                             | Epilepsy control; also used as a sedative                                 |   |
| 88 Sertraline             | Zoloft; Lustral; Serad; Serlain; Tatig   | Selective serotonin reuptake inhibitor                         | Treatment of depression, panic attacks, and obsessive-compulsive disorder |  |
| 89 Tiagabine              | Gabitril                                 | GABA reuptake inhibitor; anticonvulsant                        | Treatment of epileptic seizures                                           |  |
| 90 Venlafaxine            | Effexor; Trewilor; Vandal; Dobupal       | Selective serotonin & norepinephrine reuptake inhibitor        | Treatment of anxiety and panic disorders                                  |  |
| <b>Osteoporosis Drugs</b> |                                          |                                                                |                                                                           |                                                                                      |
| 91 Alendronic acid        | Fosamax; Adronat; Alendros; Dronal       | Farnesyl pyrophosphate synthase inhibitor                      | Prevention and treatment of osteoporosis and Paget's disease              |  |



| Generic Name             | Trade Names                                        | Category and Properties                                        | Applications                                                       | Structure                                                                            |
|--------------------------|----------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 92 Calcitriol            | Rocaltrol; Calcijex                                | Calcium and phosphate metabolism regulator<br><i>mp</i> 170 °C | Treatment of rickets and osteoporosis                              |    |
| 93 Raloxifene            | Evista (as hydrochloride)                          | Selective estrogen receptor modulator                          | Prevention and treatment of osteoporosis                           |    |
| 94 Risedronic acid       | Actonel (as Na salt); Optinate                     | Calcium regulator                                              | Treatment of osteoporosis & Paget's disease                        |    |
| <b>Pain Relief Drugs</b> |                                                    |                                                                |                                                                    |                                                                                      |
| 95 Acetaminophen         | Tylenol; APAP; Paracetamol; Hedrex; Tramil         | Analgesic/antipyretic<br><i>mp</i> 170 °C                      | Relief of musculoskeletal, neuralgic, and other types of pain      |   |
| 96 Fentanyl              | Duragesic; Actiq; Fentora; Sublimaze               | Opioid $\mu$ -receptor agonist<br><i>mp</i> 87.5 °C            | Treatment of severe pain; spinal and epidural anesthesia           |  |
| 97 Gabapentin            | Neurotin; Aclonium                                 | Anticonvulsant/analgesic; CNS depressant<br><i>mp</i> 164 °C   | Treatment of neuralgia, pain from shingles, migraine, and epilepsy |  |
| 98 Lidocaine             | Xylocaine; Xylocard; Lidamantle                    | Aminoamide anesthetic/antiarrhythmic agent                     | Local anesthetic for dental procedures                             |  |
| 99 Morphine              | Avinza; Contin; Kadian; Roxanol; Meconium; Morfine | Opioid analgesic<br><i>mp</i> 255 °C                           | Pain management, especially in malignant diseases                  |  |
| 100 Thiopental           | Pentothal; Penthiobarbital; Thiopentone            | Short-acting barbiturate/anesthetic                            | Induction of presurgical anesthesia                                |  |

|                                              | Generic Name | Trade Names                                             | Category and Properties                                                 | Applications                                                 | Structure                                                                            |
|----------------------------------------------|--------------|---------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 101                                          | Sumatriptan  | Imitrex; Imigrane; Megrelan; Permcran; Sumadol          | Selective 5-HT <sub>1D</sub> receptor agonist                           | Treatment of severe migraine headaches                       |    |
| <b>Reproductive and Urinary System Drugs</b> |              |                                                         |                                                                         |                                                              |                                                                                      |
| 102                                          | Finasteride  | Proscar; Propecia; Andozac; Finastid; Procure; Urprosan | 5 $\alpha$ Reductase inhibitor<br><i>mp</i> 252 °C                      | Treatment of benign prostatic hyperplasia and male hair loss |    |
| 103                                          | Mestranol    | Devocin; Norinyl; Ovastol; Tranel                       | Estrogen, used in combination as oral contraceptive<br><i>mp</i> 151 °C | Prevention of unplanned pregnancy                            |    |
| 104                                          | Mifepristone | Mifeprex; Mifegyne; Corlux; RU 486                      | Progesterone receptor modulator<br><i>mp</i> 150 °C                     | Termination of pregnancy                                     |   |
| 105                                          | Sildenafil   | Viagra; Revatio                                         | Cyclic GMP phosphodiesterase inhibitor                                  | Treatment of erectile dysfunction and pulmonary hypertension |  |
| 106                                          | Tamsulosin   | Flomax; Amsulosin; Harnal; Omix                         | Prostate selective $\alpha_1$ -adrenoceptor antagonist                  | Treatment of benign prostatic hyperplasia                    |  |
| 107                                          | Testosterone | Androderm; Androgel; Testrim; Striant                   | Anabolic steroid hormone                                                | Treatment of male hypogonadism                               |  |

## Index

The index below lists the trade and generic names for the drugs in this table; the generic names are in bold face. Each entry is referred to by its generic name and the identification number in the

table. An asterisk\* beside the trade name indicates a product that is a combination of two drugs.

| Name                        | Generic Name              |
|-----------------------------|---------------------------|
| Abraxane                    | Paclitaxel (58)           |
| Acecomb                     | Lisinopril (70)           |
| <b>Acetaminophen</b>        | Acetaminophen (95)        |
| <b>Acetylsalicylic acid</b> | Acetylsalicylic acid (25) |
| Acлонium                    | Gabapentin (97)           |

| Name      | Generic Name         |
|-----------|----------------------|
| Actiq     | Fentanyl (96)        |
| Actonel   | Risedronic acid (94) |
| Actos     | Pioglitazone (22)    |
| Acyclovir | Acyclovir (36)       |
| Adofen    | Fluoxetine (84)      |

| Name                   | Generic Name              |
|------------------------|---------------------------|
| Adoxa                  | Doxycycline (15)          |
| Adronat                | Alendronic acid (91)      |
| Adrucil                | Fluorouracil (54)         |
| Advair*                | Fluticasone (5)           |
| Advil                  | Ibuprofen (27)            |
| Alapril                | Lisinopril (70)           |
| Alavert                | Loratadine (6)            |
| <b>Albuterol</b>       | Albuterol (1)             |
| <b>Alendronic acid</b> | Alendronic acid (91)      |
| Alendros               | Alendronic acid (91)      |
| Aleve                  | Naproxen (29)             |
| <b>Aliskiren</b>       | Aliskiren (61)            |
| Allegra                | Fexofenadine (4)          |
| Amfebutamone           | Bupropion (81)            |
| Amfostet               | Amphotericin (37)         |
| <b>Amikacin</b>        | Amikacin (10)             |
| Amikin                 | Amikacin (10)             |
| <b>Amlodipine</b>      | Amlodipine (62)           |
| <b>Amoxicillin</b>     | Amoxicillin (11)          |
| Amoxil                 | Amoxicillin (11)          |
| <b>Amphotericin</b>    | Amphotericin (37)         |
| Amphozone              | Amphotericin (37)         |
| Amsulosin              | Tamsulosin (106)          |
| Anaprox                | Naproxen (29)             |
| <b>Anastrozole</b>     | Anastrozole (47)          |
| Andozac                | Finasteride (102)         |
| Androderm              | Testosterone (107)        |
| Androgel               | Testosterone (107)        |
| Antenex                | Diazepam (82)             |
| APAP                   | Acetaminophen (95)        |
| Aprovel                | Irbesartan (69)           |
| Aricept                | Donepezil (83)            |
| Arimidex               | Anastrozole (47)          |
| Aropax                 | Paroxetine (86)           |
| Aspirin                | Acetylsalicylic acid (25) |
| <b>Atenolol</b>        | Atenolol (63)             |
| <b>Atorvastatin</b>    | Atorvastatin (76)         |
| Avalide*               | Irbesartan (69)           |
| Avandia                | Rosiglitazone (23)        |
| Avapro                 | Irbesartan (69)           |
| Avinza                 | Morphine (99)             |
| Avirax                 | Acyclovir (36)            |
| Azantac                | Ranitidine (35)           |
| Azidothymidine         | Zidovudine (46)           |
| <b>Azithromycin</b>    | Azithromycin (12)         |
| Azitrocin              | Azithromycin (12)         |
| AZT                    | Zidovudine (46)           |
| Barbivis               | Phenobarbital (87)        |
| Bendopa                | Levodopa (85)             |
| <b>Bicalutamide</b>    | Bicalutamide (48)         |
| Biclin                 | Amikacin (10)             |
| Biozole                | Fluconazole (39)          |
| <b>Bortezomib</b>      | Bortezomib (49)           |
| Budamax                | Budesonide (2)            |
| Budeson                | Budesonide (2)            |

| Name                    | Generic Name          |
|-------------------------|-----------------------|
| <b>Budesonide</b>       | Budesonide (2)        |
| <b>Bupropion</b>        | Bupropion (81)        |
| Caduet*                 | Atorvastatin (76)     |
| Calcijex                | Calcitriol (92)       |
| <b>Calcitriol</b>       | Calcitriol (92)       |
| Calmpose                | Diazepam (82)         |
| Camptetin               | Irinotecan (57)       |
| Camptosar               | Irinotecan (57)       |
| Capecitabine            | Capecitabine (50)     |
| Carac                   | Fluorouracil (54)     |
| Carace                  | Lisinopril (70)       |
| Carboplat               | Carboplatin (51)      |
| <b>Carboplatin</b>      | Carboplatin (51)      |
| Carboxyterfenadine      | Fexofenadine (4)      |
| <b>Carvedilol</b>       | Carvedilol (64)       |
| Casodex                 | Bicalutamide (48)     |
| Ceclor                  | Cefaclor (13)         |
| <b>Cefaclor</b>         | Cefaclor (13)         |
| Celebrex                | Celecoxib (26)        |
| <b>Celecoxib</b>        | Celecoxib (26)        |
| <b>Cetirizine</b>       | Cetirizine (3)        |
| Chemacin                | Amikacin (10)         |
| <b>Cimetidine</b>       | Cimetidine (31)       |
| Cimetimax               | Cimetidine (31)       |
| Cipro                   | Ciprofloxacin (14)    |
| Ciprobay                | Ciprofloxacin (14)    |
| <b>Ciprofloxacin</b>    | Ciprofloxacin (14)    |
| Ciproxin                | Ciprofloxacin (14)    |
| Clafen                  | Cyclophosphamide (52) |
| Claratyne               | Loratadine (6)        |
| Claritin                | Loratadine (6)        |
| <b>Clopidogrel</b>      | Clopidogrel (65)      |
| Contin                  | Morphine (99)         |
| Copegus                 | Ribavirin (43)        |
| Cordioxil               | Digoxin (66)          |
| Coreg                   | Carvedilol (64)       |
| Corlux                  | Mifepristone (104)    |
| Cotronak                | Ribavirin (43)        |
| Coumadin                | Warfarin (75)         |
| Cozaar                  | Losartan (71)         |
| <b>Cyclophosphamide</b> | Cyclophosphamide (52) |
| Cytosphosphan           | Cyclophosphamide (52) |
| Cytoxan                 | Cyclophosphamide (52) |
| <b>Davoxin</b>          | Digoxin (66)          |
| Deltasone               | Prednisone (30)       |
| Deoxymykoin             | Doxycycline (15)      |
| Devocin                 | Mestranol (103)       |
| Diabex                  | Metformin (21)        |
| Diaformin               | Metformin (21)        |
| <b>Diazepam</b>         | Diazepam (82)         |
| Diflucan                | Fluconazole (39)      |
| Digacin                 | Digoxin (66)          |
| Digosin                 | Digoxin (66)          |
| <b>Digoxin</b>          | Digoxin (66)          |
| Dilanacin               | Digoxin (66)          |

| Name                       | Generic Name             |
|----------------------------|--------------------------|
| Dilatrend                  | Carvedilol (64)          |
| Dobupal                    | Venlafaxine (90)         |
| <b>Docetaxel</b>           | Docetaxel (53)           |
| <b>Donepezil</b>           | Donepezil (83)           |
| Doryx                      | Doxycycline (15)         |
| Doxycycline                | Doxycycline (15)         |
| Dronal                     | Alendronic acid (91)     |
| Duragesic                  | Fentanyl (96)            |
| E-Mycin                    | Erythromycin (16)        |
| <b>Efavirenz</b>           | Efavirenz (38)           |
| Effexor                    | Venlafaxine (90)         |
| Efudex                     | Fluorouracil (54)        |
| Elazor                     | Fluconazole (39)         |
| <b>Enalaprilat</b>         | Enalaprilat (67)         |
| Endoxan                    | Cyclophosphamide (52)    |
| Epivir                     | Lamivudine (40)          |
| Erbakar                    | Carboplatin (51)         |
| Erythrocin                 | Erythromycin (16)        |
| <b>Erythromycin</b>        | Erythromycin (16)        |
| Eucardic                   | Carvedilol (64)          |
| Evista                     | Raloxifene (93)          |
| <b>Ezetimibe</b>           | Ezetimibe (77)           |
| Fenemal                    | Phenobarbital (87)       |
| <b>Fentanyl</b>            | Fentanyl (96)            |
| Fentora                    | Fentanyl (96)            |
| <b>Fexofenadine</b>        | Fexofenadine (4)         |
| <b>Finasteride</b>         | Finasteride (102)        |
| Finastid                   | Finasteride (102)        |
| Flexilite                  | Amikacin (10)            |
| Flociprin                  | Ciprofloxacin (14)       |
| Flomax                     | Tamsulosin (106)         |
| Flonase                    | Fluticasone (5)          |
| Flovent                    | Fluticasone (5)          |
| <b>Fluconazole</b>         | Fluconazole (39)         |
| Fluoroplex                 | Fluorouracil (54)        |
| <b>Fluorouracil</b>        | Fluorouracil (54)        |
| <b>Fluoxetine</b>          | Fluoxetine (84)          |
| <b>Fluticasone</b>         | Fluticasone (5)          |
| Fontex                     | Fluoxetine (84)          |
| Fortamet                   | Metformin (21)           |
| Fosamax                    | Alendronic acid (91)     |
| Fungizone                  | Amphotericin (37)        |
| <b>Gabapentin</b>          | Gabapentin (97)          |
| Gabitril                   | Tiagabine (89)           |
| Gardenal                   | Phenobarbital (87)       |
| Gastromet                  | Cimetidine (31)          |
| <b>Gemcitabine</b>         | Gemcitabine (55)         |
| Gemzar                     | Gemcitabine (55)         |
| Gleevec                    | Imatinib (56)            |
| Glibenese                  | Glipizide (20)           |
| <b>Glipizide</b>           | Glipizide (20)           |
| Glivec                     | Imatinib (56)            |
| Glucophage                 | Metformin (21)           |
| Glucotrol                  | Glipizide (20)           |
| <b>Glycerol trinitrate</b> | Glycerol trinitrate (68) |

| Name                | Generic Name       |
|---------------------|--------------------|
| Glydiazinamide      | Glipizide (20)     |
| Harnal              | Tamsulosin (106)   |
| Hedrex              | Acetaminophen (95) |
| Heptodin            | Lamivudine (40)    |
| Hivid               | Zalcitabine (45)   |
| Hytrin              | Terazosin (74)     |
| Hytrinex            | Terazosin (74)     |
| Hyzaar*             | Losartan (71)      |
| <b>Ibuprofen</b>    | Ibuprofen (27)     |
| Ilosone             | Erythromycin (16)  |
| <b>Imatinib</b>     | Imatinib (56)      |
| Imigrane            | Sumatriptan (101)  |
| Imitrex             | Sumatriptan (101)  |
| Inflammid           | Budesonide (2)     |
| <b>Irbesartan</b>   | Irbesartan (69)    |
| Irinotecan          | Irinotecan (57)    |
| Isimoxin            | Amoxicillin (11)   |
| Isocover            | Clopidogrel (65)   |
| <b>Isoniazid</b>    | Isoniazid (17)     |
| Itrin               | Terazosin (74)     |
| Januvia             | Sitagliptin (24)   |
| Kadian              | Morphine (99)      |
| Kefolar             | Cefaclor (13)      |
| L-Dopa              | Levodopa (85)      |
| Lamisil             | Terbinafine (44)   |
| <b>Lamivudine</b>   | Lamivudine (40)    |
| Laniazid            | Isoniazid (17)     |
| Lanoxin             | Digoxin (66)       |
| <b>Lansoprazole</b> | Lansoprazole (32)  |
| Larodopa            | Levodopa (85)      |
| <b>Levodopa</b>     | Levodopa (85)      |
| Lidamantle          | Lidocaine (98)     |
| <b>Lidocaine</b>    | Lidocaine (98)     |
| <b>Linezolid</b>    | Linezolid (18)     |
| Lipitor             | Atorvastatin (76)  |
| <b>Lisinopril</b>   | Lisinopril (70)    |
| Liviatin            | Doxycycline (15)   |
| Livotensin          | Diazepam (82)      |
| Lopressor           | Metoprolol (72)    |
| <b>Loratadine</b>   | Loratadine (6)     |
| Lorien              | Fluoxetine (84)    |
| <b>Losartan</b>     | Losartan (71)      |
| Losec               | Omeprazole (33)    |
| Luminal             | Phenobarbital (87) |
| Lustral             | Sertraline (88)    |
| Magnurol            | Terazosin (74)     |
| Meconium            | Morphine (99)      |
| Megrelan            | Sumatriptan (101)  |
| Meilax              | Clopidogrel (65)   |
| Melfax              | Ranitidine (35)    |
| <b>Meloxicam</b>    | Meloxicam (28)     |
| Mepral              | Omeprazole (33)    |
| <b>Mestranol</b>    | Mestranol (103)    |
| Metacain            | Meloxicam (28)     |
| Metacam             | Meloxicam (28)     |

| Name                  | Generic Name             |
|-----------------------|--------------------------|
| <b>Metformin</b>      | Metformin (21)           |
| Meticorten            | Prednisone (30)          |
| <b>Metoprolol</b>     | Metoprolol (72)          |
| Micardis              | Telmisartan (73)         |
| Mifegyne              | Mifepristone (104)       |
| Mifeprex              | Mifepristone (104)       |
| <b>Mifepristone</b>   | Mifepristone (104)       |
| Minodiab              | Glipizide (20)           |
| Mirolex               | Acyclovir (36)           |
| Mobic                 | Meloxicam (28)           |
| Monotrim              | Trimethoprim (19)        |
| <b>Montelukast</b>    | Montelukast (7)          |
| Mopral                | Omeprazole (33)          |
| Morfine               | Morphine (99)            |
| <b>Morphine</b>       | Morphine (99)            |
| Motivan               | Paroxetine (86)          |
| Naprelan              | Naproxen (29)            |
| Naprogesic            | Naproxen (29)            |
| <b>Naproxen</b>       | Naproxen (29)            |
| Negasin               | Amikacin (10)            |
| Neosar                | Cyclophosphamide (52)    |
| Neurotin              | Gabapentin (97)          |
| <b>Nevirapine</b>     | Nevirapine (41)          |
| Nexium                | Omeprazole (33)          |
| Niacin                | Nicotinic acid (78)      |
| <b>Nicotinic acid</b> | Nicotinic acid (78)      |
| Nitroglycerin         | Glycerol trinitrate (68) |
| Nolvadex              | Tamoxifen (60)           |
| Nonoplat              | Carboplatin (51)         |
| Norinyl               | Mestranol (103)          |
| Norvasc               | Amlodipine (62)          |
| Novatec               | Lisinopril (70)          |
| Novazyd               | Lisinopril (70)          |
| <b>Omeprazole</b>     | Omeprazole (33)          |
| Omix                  | Tamsulosin (106)         |
| Onsenal               | Celecoxib (26)           |
| Optinate              | Risedronic acid (94)     |
| <b>Oseltamivir</b>    | Oseltamivir (42)         |
| Ospamox               | Amoxicillin (11)         |
| Ovastol               | Mestranol (103)          |
| Paclitaxel            | Paclitaxel (58)          |
| Panacef               | Cefaclor (13)            |
| Panoral               | Cefaclor (13)            |
| <b>Pantoprazole</b>   | Pantoprazole (34)        |
| Pantozol              | Pantoprazole (34)        |
| Paracetamol           | Acetaminophen (95)       |
| Paraplatin            | Carboplatin (51)         |
| <b>Paroxetine</b>     | Paroxetine (86)          |
| Paxil                 | Paroxetine (86)          |
| Penthiobarbital       | Thiopental (100)         |
| Pentothal             | Thiopental (100)         |
| Peptimax              | Cimetidine (31)          |
| Permcran              | Sumatriptan (101)        |
| <b>Phenobarbital</b>  | Phenobarbital (87)       |
| Pioglitazone          | Pioglitazone (22)        |

| Name                   | Generic Name           |
|------------------------|------------------------|
| Plavix                 | Clopidogrel (65)       |
| <b>Pravastatin</b>     | Pravastatin (79)       |
| Pravochol              | Pravastatin (79)       |
| <b>Prednisone</b>      | Prednisone (30)        |
| Prevacid               | Lansoprazole (32)      |
| Prevpac                | Lansoprazole (32)      |
| Prezal                 | Lansoprazole (32)      |
| Prilosec               | Omeprazole (33)        |
| Procure                | Finasteride (102)      |
| Proloprim              | Trimethoprim (19)      |
| Propecia               | Finasteride (102)      |
| Proscar                | Finasteride (102)      |
| Protonix               | Pantoprazole (34)      |
| Proventil              | Albuterol (1)          |
| Prozac                 | Fluoxetine (84)        |
| Pulmicort              | Budesonide (2)         |
| <b>Raloxifene</b>      | Raloxifene (93)        |
| <b>Ranitidine</b>      | Ranitidine (35)        |
| Rantec                 | Ranitidine (35)        |
| Rasilex                | Aliskiren (61)         |
| Rebetol                | Ribavirin (43)         |
| Retrovir               | Zidovudine (46)        |
| Revatio                | Sildenafil (105)       |
| Rhinocort              | Budesonide (2)         |
| Ribasphere             | Ribavirin (43)         |
| <b>Ribavirin</b>       | Ribavirin (43)         |
| Rifun                  | Pantoprazole (34)      |
| <b>Risedronic acid</b> | Risedronic acid (94)   |
| Rocaltrol              | Calcitriol (92)        |
| <b>Rosiglitazone</b>   | Rosiglitazone (23)     |
| Rougoxin               | Digoxin (66)           |
| Roxanol                | Morphine (99)          |
| RU 486                 | Mifepristone (104)     |
| <b>Salmeterol</b>      | Salmeterol (8)         |
| Sarafem                | Fluoxetine (84)        |
| Seduxen                | Diazepam (82)          |
| Serad                  | Sertraline (88)        |
| Serevent               | Salmeterol (8)         |
| Serlain                | Sertraline (88)        |
| Seroxat                | Paroxetine (86)        |
| <b>Sertraline</b>      | Sertraline (88)        |
| <b>Sildenafil</b>      | Sildenafil (105)       |
| <b>Simvastatin</b>     | Simvastatin (80)       |
| Singulair              | Montelukast (7)        |
| <b>Sitagliptin</b>     | Sitagliptin (24)       |
| Soltamox               | Tamoxifen (60)         |
| SoluTab                | Lansoprazole (32)      |
| Sostril                | Ranitidine (35)        |
| Spiriva                | Tiotropium bromide (9) |
| Stesolid               | Diazepam (82)          |
| Striant                | Testosterone (107)     |
| Sublimaze              | Fentanyl (96)          |
| Sumadol                | Sumatriptan (101)      |
| <b>Sumatriptan</b>     | Sumatriptan (101)      |
| <b>Sunitinib</b>       | Sunitinib (59)         |

| Name                | Generic Name           |
|---------------------|------------------------|
| Sustiva             | Efavirenz (38)         |
| Sutent              | Sunitinib (59)         |
| Tagamet             | Cimetidine (31)        |
| Tagonis             | Paroxetine (86)        |
| Tamaxin             | Tamoxifen (60)         |
| Tamiflu             | Oseltamivir (42)       |
| Tamoplex            | Tamoxifen (60)         |
| <b>Tamoxifen</b>    | Tamoxifen (60)         |
| Tamsulosin          | Tamsulosin (106)       |
| Tatig               | Sertraline (88)        |
| Taural              | Ranitidine (35)        |
| Taxol               | Paclitaxel (58)        |
| Taxotere            | Docetaxel (53)         |
| Tekturna            | Aliskiren (61)         |
| Telfast             | Fexofenadine (4)       |
| <b>Telmisartan</b>  | Telmisartan (73)       |
| Tenormin            | Atenolol (63)          |
| Teraprost           | Terazosin (74)         |
| <b>Terazosin</b>    | Terazosin (74)         |
| <b>Terbinafine</b>  | Terbinafine (44)       |
| <b>Testosterone</b> | Testosterone (107)     |
| Testrim             | Testosterone (107)     |
| <b>Thiopental</b>   | Thiopental (100)       |
| Thiopentone         | Thiopental (100)       |
| <b>Tiagabine</b>    | Tiagabine (89)         |
| Tiotropium bromide  | Tiotropium bromide (9) |
| Tipidyl             | Clopidogrel (65)       |
| Topotecin           | Irinotecan (57)        |
| Toprol XL           | Metoprolol (72)        |
| Tramil              | Acetaminophen (95)     |
| Tranel              | Mestranol (103)        |
| Trewilor            | Venlafaxine (90)       |
| Triflucan           | Fluconazole (39)       |
| <b>Trimethoprim</b> | Trimethoprim (19)      |
| Triprim             | Trimethoprim (19)      |
| Tylenol             | Acetaminophen (95)     |
| Uniflox             | Ciprofloxacin (14)     |
| Uroflo              | Terazosin (74)         |
| Urprosan            | Finasteride (102)      |
| Valium              | Diazepam (82)          |
| Valodex             | Tamoxifen (60)         |

| Name               | Generic Name      |
|--------------------|-------------------|
| Vandral            | Venlafaxine (90)  |
| Vasocard           | Terazosin (74)    |
| Vasotec            | Enalaprilat (67)  |
| Velcade            | Bortezomib (49)   |
| Veldopa            | Levodopa (85)     |
| <b>Venlafaxine</b> | Venlafaxine (90)  |
| Ventolin           | Albuterol (1)     |
| Viagra             | Sildenafil (105)  |
| Vibramycin         | Doxycycline (15)  |
| Vinzam             | Azithromycin (12) |
| Viramune           | Nevirapine (41)   |
| Viratek            | Ribavirin (43)    |
| Virazole           | Ribavirin (43)    |
| Vivatec            | Lisinopril (70)   |
| Volmax             | Albuterol (1)     |
| Vytorin*           | Simvastatin (80)  |
| <b>Warfarin</b>    | Warfarin (75)     |
| Wellbutrin         | Bupropion (81)    |
| Xeloda             | Capecitabine (50) |
| Xylocaine          | Lidocaine (98)    |
| Xylocard           | Lidocaine (98)    |
| Yewtaxan           | Paclitaxel (58)   |
| <b>Zalcitabine</b> | Zalcitabine (45)  |
| Zantac             | Ranitidine (35)   |
| Zeffix             | Lamivudine (40)   |
| Zestoretic         | Lisinopril (70)   |
| Zestril            | Lisinopril (70)   |
| Zetia              | Ezetimibe (77)    |
| Zidovir            | Zidovudine (46)   |
| <b>Zidovudine</b>  | Zidovudine (46)   |
| Zithromax          | Azithromycin (12) |
| Zmax               | Azithromycin (12) |
| Zocor              | Simvastatin (80)  |
| Zoloft             | Sertraline (88)   |
| Zoltum             | Omeprazole (33)   |
| Zoton              | Lansoprazole (32) |
| Zovir              | Acyclovir (36)    |
| Zovirax            | Acyclovir (36)    |
| Zyban              | Bupropion (81)    |
| Zyrtec             | Cetirizine (3)    |
| Zyvox              | Linezolid (18)    |

## CHEMICAL CONSTITUENTS OF HUMAN BLOOD

This table lists typical concentrations of some of the chemical constituents of human blood. The table covers elements and compounds of relatively low molecular weight. References 1 and 4 give extensive information on enzymes, hormones, vitamins, and other blood constituents.

The values given for the normal range refer to healthy adults who have not been exposed to unusual environmental agents. In keeping with IUPAC practice, all values refer to a volume of one liter, and thus are stated in units of g/L, mg/L, µg/L or mmol/L. Many clinical test results, especially in the United States, are reported on a deciliter (dL) rather than a liter basis; thus the values in this table should be divided by 10 to place them on a dL basis. The symbols S (for serum), P (plasma), and WB (whole blood) in the second column indicate the nature of the blood sample to which the values apply. In some cases only a single mean value has been reported, rather than a range; these are given in *italics*.

The total volume of blood in a 100 kg (220 lb) adult is 7.5 L for a male and 6.7 L for a female. The corresponding volume of plasma is 4.4 L and 4.3 L, respectively (Reference 1).

Values from Reference 1 are so-called "reference values" against which clinical tests of blood chemistry are compared. In these cases the "normal range" is understood to include about 95% of the population. The remaining 5% may show values outside the normal range without necessarily implying a medical problem. Note that these reference values may vary slightly from one testing laboratory to another, depending on the detailed test procedure.

Accurate measurements on trace elements are very difficult to make, and wide variations can be found in the literature. Preferred measurement methods are discussed in References 2 and 6. Values

for the trace elements can also vary from one country to another, depending on dietary or environmental factors. Thus cadmium levels tend to be higher in Japan because of the prevalence of sea-food in the diet, and lead levels are higher in regions where lead additives are still used in gasoline. Variations with gender, age, geography, and occurrence of diseases are reviewed in Reference 6.

The Critical Values column gives levels that deviate far enough from the normal range to suggest a probable medical issue. Such values from Reference 3 are the Biological Exposure Indexes (BEI) that are specified by the American Council of Government Industrial Hygienists (ACGIH) as danger signals for the levels of pollutants in the workplace.

## References

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3. *2008 TLV's and BEI's*, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-1634, 2008 ([www.acgih.org](http://www.acgih.org)).
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| Component                                    | Unit | Normal Range |      | Critical Values | Ref.           |       |
|----------------------------------------------|------|--------------|------|-----------------|----------------|-------|
|                                              |      | Low          | High |                 |                |       |
| Inorganic                                    |      |              |      |                 |                |       |
| Aluminum                                     | S    | µg/L         | 1    | 10              | >60            | 6,2   |
| Ammonia                                      | P    | µg/L         | 190  | 600             | >700           | 1     |
| Antimony                                     | S,P  | µg/L         |      | 1               |                | 6     |
| Arsenic                                      | S    | µg/L         | 0.5  | 5               |                | 6,2   |
| Barium                                       | S,P  | µg/L         |      | 79              |                | 4,5   |
| Beryllium                                    | S,P  | µg/L         |      | <4              |                | 4,5   |
| Bicarbonate (HCO <sub>3</sub> <sup>-</sup> ) | WB   | mmol/L       | 22   | 28              | <10 or >40     | 1     |
| Bromine                                      | S,P  | mg/L         | 2    | 11              |                | 6,4   |
| Cadmium                                      | S    | µg/L         | 0.1  | 1               | >5             | 6,2,3 |
| Calcium, total                               | S    | mg/L         | 90   | 105             | <65 or >140    | 1     |
| Calcium ion (Ca <sup>++</sup> )              | WB   | mg/L         | 30   | 45              |                | 1     |
| Carbon dioxide                               | P    | mmol/L       | 21   | 30              | <11 or >40     | 1     |
| Carbon monoxide*                             | WB   | %CO-Hb       | 0    | 5%              | 30%            | 1     |
| Cesium                                       | S,P  | µg/L         | 0.5  | 2.0             |                | 6     |
| Chloride (Cl <sup>-</sup> )                  | S    | mmol/L       | 98   | 106             | <80 or >115    | 1     |
| Chromium                                     | S    | µg/L         | 0.1  | 0.4             |                | 6,2   |
| Cobalt                                       | S    | µg/L         | 0.05 | 0.35            | >1             | 6,2,3 |
| Copper                                       | S    | mg/ L        | 0.7  | 1.4             |                | 1,2,6 |
| Fluorine                                     | S,P  | µg/L         | 33   | 236             |                | 6     |
| Hydrogen ion (H <sup>+</sup> )               | WB   | pH           | 7.38 | 7.44            | <7.10 or >7.59 | 1     |
| Iodine (total)                               | S,P  | µg/L         | 59   | 76              |                | 4     |
| Iron                                         | S    | mg/L         | 0.5  | 1.7             |                | 1     |
| Lead                                         | S    | µg/L         | 5    | 100             | >300           | 1,3,6 |



| Component              |     | Unit         | Normal Range |      | Critical Values | Ref.  |
|------------------------|-----|--------------|--------------|------|-----------------|-------|
|                        |     |              | Low          | High |                 |       |
| Lithium                | S,P | µg/L         |              | 8    |                 | 6     |
| Magnesium              | S   | mg/L         | 18           | 30   | <10 or >47      | 1     |
| Manganese              | S   | µg/L         | 0.3          | 1.0  |                 | 6,2   |
| Mercury                | S   | µg/L         | 0.5          | 3    | >15             | 2,3   |
| Molybdenum             | S,P | µg/L         | 0.3          | 1.3  |                 | 6     |
| Nickel                 | S   | µg/L         | 0.1          | 1.3  |                 | 6,2   |
| Oxygen (arterial)      | WB  | % saturation | 96%          | 100% |                 | 1     |
| Oxygen (venous)        | WB  | % saturation | 60%          | 85%  |                 | 1     |
| Phosphorus (inorganic) | S   | mg/L         | 30           | 45   | <11             | 1     |
| Potassium              | S   | mmol/L       | 3.5          | 5.0  | <2.8 or >6.2    | 1     |
|                        |     | mg/L         | 137          | 196  |                 |       |
| Rubidium               | S,P | µg/L         | 100          | 300  |                 | 6     |
| Selenium               | S,P | µg/L         | 40           | 160  |                 | 2,6   |
| Silver                 | S,P | µg/L         |              | 1    |                 | 6     |
| Sodium                 | S   | mmol/L       | 135          | 145  | <120 or >160    | 1     |
|                        |     | g/L          | 3.11         | 3.34 |                 |       |
| Strontium              | S,P | µg/L         |              | 57   |                 | 4,5   |
| Sulfur (total)         | S,P | mg/L         |              | 780  |                 | 4     |
| Tellurium              | S,P | µg/L         |              | 30   |                 | 4,5   |
| Titanium               | S,P | µg/L         |              | 33   |                 | 4,5   |
| Tin                    | S,P | µg/L         |              | 1    |                 | 4,5   |
| Vanadium               | S,P | µg/L         | 0.02         | 1.0  |                 | 6     |
| Zinc                   | S,P | mg/L         | 0.5          | 1.2  |                 | 6,2,4 |
| Zirconium              | S,P | µg/L         |              | 400  |                 | 4,5   |

*Organic*

|                    |     |      |      |        |               |     |
|--------------------|-----|------|------|--------|---------------|-----|
| Acetoacetate ion   | P   | mg/L |      | <10    |               | 1   |
| Acetone            | S,P | mg/L | 3    | 20     |               | 1   |
| Alanine            | S,P | mg/L | 30   | 37     |               | 4   |
| Arginine           | S,P | mg/L | 12   | 19     |               | 4   |
| Asparagine         | S,P | mg/L | 5.4  | 6.5    |               | 4   |
| Cholesterol, total | P   | mg/L | 1000 | 2000** | >2400         | 1,4 |
| HDL Cholesterol    | P   | mg/L | 400  | 600    |               | 1   |
| LDL Cholesterol    | P   | mg/L | 0    | 1000   | >1900         | 1   |
| Citrulline         | S,P | mg/L | 2.1  | 9.7    |               | 4   |
| Creatine           | S,P | mg/L | 2.8  | 6.2    |               | 4   |
| Creatinine         | S   | mg/L | 5    | 15     | >50           | 1   |
| Fructose           | WB  | mg/L | 5    | 50     |               | 4   |
| Glucosamine        | S,P | mg/L | 760  | 1110   |               | 4   |
| Glucose (fasting)  | S   | mg/L | 600  | 1000   | <450 or >1300 | 1   |
| Glutamic acid      | S,P | mg/L | 4.3  | 11.5   |               | 4   |
| Glutamine          | S,P | mg/L | 61   | 102    |               | 4   |
| Glycine            | S,P | mg/L | 13.4 | 17.3   |               | 4   |
| Histidine          | S,P | mg/L | 7.9  | 14.8   |               | 4   |
| Homocysteine       | P   | mg/L | 0.54 | 1.62   |               | 1   |
| Isoleucine         | S,P | mg/L | 6.9  | 12.8   |               | 4   |
| Lactate (venous)   | P   | mg/L | 50   | 150    |               | 1   |
| Leucine            | S,P | mg/L | 14   | 23     |               | 4   |
| Lysine             | S,P | mg/L | 25   | 30     |               | 4   |
| Methionine         | S,P | mg/L | 3.3  | 4.3    |               | 4   |
| Ornithine          | S,P | mg/L | 6.2  | 8.0    |               | 4   |
| Phenylalanine      | S,P | mg/L | 5.8  | 14.0   |               | 1   |
| Proline            | S,P | mg/L | 20   | 33     |               | 4   |
| Serine             | S,P | mg/L | 10.1 | 12.5   |               | 4   |



| Component           |     | Unit        | Normal Range |      | Critical Values | Ref. |
|---------------------|-----|-------------|--------------|------|-----------------|------|
|                     |     |             | Low          | High |                 |      |
| Taurine             | S,P | mg/L        | 4.1          | 8.2  |                 | 4    |
| Threonine           | S,P | mg/L        | 12           | 17   |                 | 4    |
| Triglyceride        | S   | mg/L        | 250          | 1750 |                 | 1    |
| Tyrosine            | S,P | mg/L        | 8.1          | 14.5 |                 | 4    |
| Urea                | S   | mmol/L      | 3.5          | 7.0  | <0.7 or >28     | 1    |
| Urea nitrogen (BUN) | S   | mg/L (of N) | 100          | 200  | <20 or >800     | 1    |
| Uric acid (males)   | S   | mg/L        | 25           | 80   |                 | 1    |
| Uric acid (females) | S   | mg/L        | 13           | 60   |                 | 1    |
| Valine              | S,P | mg/L        | 24           | 37   |                 | 4    |

\* Measured as the percent of hemoglobin bound to CO. Typical value for heavy smokers is 5%–10%. Major symptoms begin around 30%, and respiratory failure sets in at >60%.

\*\* This is the desirable upper limit. Values between 2000 and 2400 mg/L are considered borderline high.

# APPARENT EQUILIBRIUM CONSTANTS FOR ENZYME-CATALYZED REACTIONS

Robert N. Goldberg

This table contains values of apparent equilibrium constants  $K'$  for selected enzyme-catalyzed reactions at specified temperatures  $T$  and pHs. In those cases where the ionic strength  $I$  and/or the pMg ( $\text{pMg} = -\log_{10}[\text{Mg}^{2+}]$ ) have been reported, the values of these quantities are given. The Enzyme Commission numbers [Webb (1992)] of the enzymes that were used to catalyze the reactions are also given.

There are two fundamentally different types of equilibrium constants. This is illustrated by the following example for the hydrolysis of adenosine 5'-triphosphate (ATP) to adenosine 5'-diphosphate (ADP) and phosphate:



The apparent equilibrium constant for the overall biochemical reaction (1) is

$$K' = [\text{ADP}][\text{phosphate}]/([\text{ATP}]c^\circ) \quad (2)$$

The biochemical reactants ATP, ADP, and phosphate each exist in several different ionized and metal bound forms. For example, ATP is an equilibrium mixture of the species  $\text{ATP}^{4-}$ ,  $\text{HATP}^{3-}$ ,  $\text{H}_2\text{ATP}^{2-}$ ,  $\text{MgATP}^{2-}$ ,  $\text{MgHATP}^-$ ,  $\text{Mg}_2\text{ATP}^0$ . Additional species would also have to be considered if  $\text{Ca}^{2+}$  were present. Thus, ATP has often been denoted in the literature as  $\Sigma\text{ATP}$  or as  $(\text{ATP})_{\text{tot}}$ . When it is clear that one is dealing with total amounts of substances, it is not necessary to use either the  $\Sigma$  or "tot." Thus, these designations are not used in this table. In the above equation,  $c^\circ = 1 \text{ mol dm}^{-3}$ ; it is included to make  $K'$  dimensionless. The standard transformed Gibbs energy of reaction  $\Delta_r G'^\circ$  at specified conditions of temperature  $T$ , pressure  $P$ , ionic strength  $I$ , pH, and pMg can be calculated from  $K'$ :

$$\Delta_r G'^\circ = -RT \ln K' \quad (3)$$

The molar gas constant,  $R$ , is equal to  $8.314\,472 \text{ J K}^{-1} \text{ mol}^{-1}$ .  $\Delta_r G'^\circ$  and the apparent equilibrium constant,  $K'$ , can be used to calculate the position of equilibrium of overall biochemical reactions.

It is also possible to choose a chemical reference reaction that involves selected solute species:



The equilibrium constant for this reference reaction is

$$K = [\text{ADP}^{3-}][\text{HPO}_4^{2-}][\text{H}^+]/\{[\text{ATP}^{4-}](c^\circ)^2\} \quad (5)$$

Equations and algorithms that relate these two different types of equilibrium constants have been published [Alberty (1969), Akers and Goldberg (2001), Alberty (2003)]. To calculate the equilibrium constant  $K$  for the reference reaction from the apparent equilibrium constant  $K'$ , or vice versa, one needs the equilibrium constants for the binding of  $\text{H}^+$  and for the relevant metal ions to  $\text{ATP}^{4-}$ ,  $\text{ADP}^{3-}$ , and  $\text{HPO}_4^{2-}$ .

To avoid confusion between the two different types of equilibrium constants ( $K'$  and  $K$ ) and to avoid ambiguity about whether specific species or sums of species are intended, the word "ammonia," for example, rather than  $\text{NH}_3$  or  $\text{NH}_4^+$ , is used for total ammonia, and chemical formulas are used for specific chemical species. Other substances such as carbon dioxide ( $\text{CO}_2$ ,  $\text{HCO}_3^-$ , and  $\text{CO}_3^{2-}$ ), and phosphate ( $\text{H}_2\text{PO}_4^-$ ,  $\text{HPO}_4^{2-}$ , and  $\text{PO}_4^{3-}$ ) are treated in

the same manner. Exceptions are made for water, which is always written as  $\text{H}_2\text{O}$ , and for gaseous hydrogen and oxygen, which are written as  $\text{H}_2(\text{g})$  and  $\text{O}_2(\text{g})$ , respectively.

For symmetrical reactions, there is no concern about the units used to calculate the value of an equilibrium constant. However, care must be exercised for reactions that are not symmetrical. In such cases, the units " $\text{mol dm}^{-3}$ " have been used for all concentrations. As stated above, a  $c^\circ$  ( $1 \text{ mol dm}^{-3}$ ) is then used to make all equilibrium constants dimensionless.

All substances are assumed to be in aqueous solutions unless specified otherwise.

Values of  $\Delta_r G'^\circ$  and  $K'$  can also be calculated for many biochemical reactions by using the table "Standard Transformed Gibbs Energies of Formation for Biochemical Reactants" in Section 7 of this Handbook.

## Abbreviations

|                     |                                                                     |
|---------------------|---------------------------------------------------------------------|
| ADP                 | adenosine 5'-diphosphate                                            |
| AMP                 | adenosine 5'-monophosphate                                          |
| ATP                 | adenosine 5'-triphosphate                                           |
| CoA                 | coenzyme A                                                          |
| GDP                 | guanosine 5'-diphosphate                                            |
| GMP                 | guanosine 5'-monophosphate                                          |
| GTP                 | guanosine 5'-triphosphate                                           |
| IDP                 | inosine 5'-diphosphate                                              |
| IMP                 | inosine 5'-monophosphate                                            |
| ITP                 | inosine 5'-triphosphate                                             |
| NAD <sub>ox</sub>   | $\beta$ -nicotinamide-adenine dinucleotide, oxidized form           |
| NAD <sub>red</sub>  | $\beta$ -nicotinamide-adenine dinucleotide, reduced form            |
| NADP <sub>ox</sub>  | $\beta$ -nicotinamide-adenine dinucleotide phosphate, oxidized form |
| NADP <sub>red</sub> | $\beta$ -nicotinamide-adenine dinucleotide phosphate, reduced form  |
| UDP                 | uridine 5'-diphosphate                                              |
| UTP                 | uridine 5'-triphosphate                                             |

## References

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 See also <www.chem.qmul.ac.uk/iubmb/enzyme/>.

| Reaction                                                                                                         | $K'$                  | Enzyme<br>Commission<br>Number | $\frac{T}{K}$ | pH   | $\frac{I}{\text{mol-dm}^{-3}}$ | pMg  |
|------------------------------------------------------------------------------------------------------------------|-----------------------|--------------------------------|---------------|------|--------------------------------|------|
| benzyl alcohol + NAD <sub>ox</sub> = benzaldehyde + NAD <sub>red</sub>                                           | 9.8·10 <sup>-4</sup>  | 1.1.1.1                        | 298.15        | 7.5  |                                |      |
| 1-butanol + NAD <sub>ox</sub> = butanal + NAD <sub>red</sub>                                                     | 1.8·10 <sup>-3</sup>  | 1.1.1.1                        | 298.15        | 8.3  |                                |      |
| cyclohexanol + NAD <sub>ox</sub> = cyclohexanone + NADH <sub>red</sub>                                           | 0.090                 | 1.1.1.1                        | 298.15        | 7.2  |                                |      |
| 1-hexanol + NAD <sub>ox</sub> = hexanal + NAD <sub>red</sub>                                                     | 2.87·10 <sup>-3</sup> | 1.1.1.1                        | 298.15        | 8.3  |                                |      |
| 1-octanol + NAD <sub>ox</sub> = octanal + NAD <sub>red</sub>                                                     | 1.1·10 <sup>-3</sup>  | 1.1.1.1                        | 298.15        | 8.3  |                                |      |
| L-homoserine + NADP <sub>ox</sub> = L-aspartate 4-semialdehyde + NADP <sub>red</sub>                             | 6.3·10 <sup>-4</sup>  | 1.1.1.3                        | 298.15        | 7.9  |                                |      |
| xylitol + NAD <sub>ox</sub> = L-xylulose + NAD <sub>red</sub>                                                    | 2.97·10 <sup>-4</sup> | 1.1.1.10                       | 298.15        | 7.00 |                                |      |
| D-sorbitol + NAD <sub>ox</sub> = D-fructose + NAD <sub>red</sub>                                                 | 0.032                 | 1.1.1.14                       | 298.15        | 7.0  |                                |      |
| quininate + NAD <sub>ox</sub> = 5-dehydroquininate + NAD <sub>red</sub>                                          | 4.61·10 <sup>-3</sup> | 1.1.1.24                       | 305.15        | 7.2  |                                |      |
| shikimate + NADP <sub>ox</sub> = 5-dehydroshikimate + NADP <sub>red</sub>                                        | 0.036                 | 1.1.1.25                       | 303.15        | 7.0  |                                |      |
| 2-hydroxybutanoate + NAD <sub>ox</sub> = 2-oxobutanoate + NAD <sub>red</sub>                                     | 3.0·10 <sup>-3</sup>  | 1.1.1.27                       | 298.65        | 8.0  |                                |      |
| (R)-3-hydroxybutanoate + NAD <sub>ox</sub> = 3-oxobutanoate + NAD <sub>red</sub>                                 | 1.9·10 <sup>-3</sup>  | 1.1.1.30                       | 298.15        | 7.0  |                                |      |
| D-glucose 6-phosphate + NADP <sub>ox</sub> = D-glucono-1,5-lactone 6-phosphate + NADP <sub>red</sub>             | 1.50                  | 1.1.1.49                       | 301.15        | 6.40 |                                |      |
| 5α-androstane-3α-ol-17-one + NAD <sub>ox</sub> = 5α-androstane-3,17-dione + NAD <sub>red</sub>                   | 0.058                 | 1.1.1.50                       | 298.15        | 7.0  |                                |      |
| 5α-pregnane-3α,17α,21-triol-20-one + NAD <sub>ox</sub> = 5α-pregnane-17α,21-diol-3,20-dione + NAD <sub>red</sub> | 0.0113                | 1.1.1.50                       | 298.15        | 7.0  |                                |      |
| 5α-androstane-3β,17α-diol + NAD <sub>ox</sub> = 5α-androstane-17α-ol-3-one + NAD <sub>red</sub>                  | 0.0211                | 1.1.1.51                       | 298.15        | 7.0  |                                |      |
| 4-androstene-17β-ol-3-one + NAD <sub>ox</sub> = 4-androstene-3,17-dione + NAD <sub>red</sub>                     | 0.378                 | 1.1.1.51                       | 298.15        | 7.0  |                                |      |
| 1,2-propanediol + NADP <sub>ox</sub> = L-lactaldehyde + NADP <sub>red</sub>                                      | 6.0·10 <sup>-5</sup>  | 1.1.1.55                       | 298.15        | 8.4  |                                |      |
| ribitol + NAD <sub>ox</sub> = D-ribulose + NAD <sub>red</sub>                                                    | 3.1·10 <sup>-3</sup>  | 1.1.1.56                       | 310.15        | 7.4  |                                |      |
| 3-hydroxypropanoate + NAD <sub>ox</sub> = 3-oxopropanoate + NAD <sub>red</sub>                                   | 9.0·10 <sup>-3</sup>  | 1.1.1.59                       | 298.15        | 9.0  |                                |      |
| estradiol-17β + NAD <sub>ox</sub> = estrone + NAD <sub>red</sub>                                                 | 0.18                  | 1.1.1.62                       | 298.15        | 7.00 |                                |      |
| benzyl alcohol + NAD <sub>ox</sub> = benzaldehyde + NAD <sub>red</sub>                                           | 0.097                 | 1.1.1.90                       | 300.15        | 9.5  |                                |      |
| L-carnitine + NAD <sub>ox</sub> = 3-dehydrocarnitine + NAD <sub>red</sub>                                        | 1.3·10 <sup>-4</sup>  | 1.1.1.108                      | 303.15        | 7.0  |                                |      |
| L-threonate + NAD <sub>ox</sub> = 3-oxo- L-threonate + NAD <sub>red</sub>                                        | 3.42·10 <sup>-4</sup> | 1.1.1.129                      | 298.15        | 7.0  |                                |      |
| prostaglandin E <sub>1</sub> + NAD <sub>ox</sub> = 15-oxo-prostaglandin E <sub>1</sub> + NAD <sub>red</sub>      | 0.65                  | 1.1.1.141                      | 298.15        | 7.0  |                                |      |
| 7,8-dihydrobiopterin + NADP <sub>ox</sub> = sepiapterin + NADP <sub>red</sub>                                    | 0.045                 | 1.1.1.153                      | 298.15        | 8.0  |                                |      |
| glycine + acetaldehyde = L-threonine                                                                             | 56                    | 2.1.2.1                        | 310.15        | 7.6  |                                |      |
| sedoheptulose 7-phosphate + D-glyceraldehyde 3-phosphate =<br>D-ribose 5-phosphate + D-xylulose 5-phosphate      | 0.48                  | 2.2.1.1                        | 311.15        | 7.0  | 0.25                           | 3.0  |
| acetyl-CoA + choline = CoA + O-acetylcholine                                                                     | 1.60                  | 2.3.1.7                        | 298.15        | 7.0  | 0.25                           |      |
| acetyl-CoA + acyl-carrier protein = CoA + acetyl-[acyl-carrier protein]                                          | 2.09                  | 2.3.1.38                       | 311.15        | 6.5  |                                |      |
| UDPGlucose + D-fructose = UDP + sucrose                                                                          | 6.7                   | 2.4.1.13                       | 298.15        | 7.5  |                                |      |
| cellobiose + orthophosphate = D-glucose + α-D-glucose 1-phosphate                                                | 0.23                  | 2.4.1.20                       | 310.15        | 7.0  |                                |      |
| laminaritriose + orthophosphate = laminaribiose + α-D-glucose 1-phosphate                                        | 0.26                  | 2.4.1.31                       | 310.15        | 6.5  |                                |      |
| α,α-trehalose + orthophosphate = D-glucose + β-D-glucose 1-phosphate                                             | 0.24                  | 2.4.1.64                       | 310.15        | 7.0  |                                |      |
| UDPGlucose + sinapate = UDP + 1-sinapoyl-D-glucose                                                               | 0.21                  | 2.4.1.120                      | 303.15        | 6.0  |                                |      |
| inosine + orthophosphate = hypoxanthine + α-D-ribose 1-phosphate                                                 | 0.0164                | 2.4.2.1                        | 311.15        | 7.0  | 0.25                           | 3.0  |
| xanthosine + orthophosphate = xanthine + α-D-ribose 1-phosphate                                                  | 0.0156                | 2.4.2.1                        | 311.15        | 7.0  | 0.25                           | 3.0  |
| uridine + orthophosphate = uracil + α-D-ribose 1-phosphate                                                       | 0.44                  | 2.4.2.2                        | 310.15        | 7.0  |                                |      |
| adenine + 5-phospho-α-D-ribose 1-diphosphate = AMP + pyrophosphate                                               | 2·10 <sup>3</sup>     | 2.4.2.7                        | 311.15        | 7.4  | 0.25                           | 3.0  |
| GMP + hypoxanthine = IMP + guanine                                                                               | 0.38                  | 2.4.2.8                        | 310.15        | 7.4  |                                |      |
| guanine + 5-phospho-α-D-ribose 1-diphosphate = GMP + pyrophosphate                                               | 1·10 <sup>5</sup>     | 2.4.2.8                        | 311.15        | 7.4  | 0.25                           | 3.0  |
| hypoxanthine + 5-phospho-α-D-ribose 1-diphosphate = IMP + pyrophosphate                                          | 1·10 <sup>5</sup>     | 2.4.2.8                        | 311.15        | 7.4  | 0.25                           | 3.0  |
| ATP + ammonium carbamate = ADP + carbamoyl phosphate                                                             | 0.042                 | 2.7.2.2                        | 283.15        | 9.4  |                                |      |
| ATP + creatine = ADP + phosphocreatine                                                                           | 5.78·10 <sup>-3</sup> | 2.7.3.2                        | 310.15        | 7.11 | 0.25                           | 2.47 |
| ATP + L-arginine = ADP + N <sup>ω</sup> -phospho-L-arginine                                                      | 0.10                  | 2.7.3.3                        | 285.15        | 7.25 |                                |      |
| ATP + sulfate = adenosine 5'-phosphosulfate + pyrophosphate                                                      | 4·10 <sup>-8</sup>    | 2.7.7.4                        | 303.15        | 7.5  |                                |      |
| UTP + α-D-glucose 1-phosphate = pyrophosphate + UDPGlucose                                                       | 0.48                  | 2.7.7.9                        | 310.15        | 8.0  |                                |      |
| succinyl-CoA + acetoacetate = succinate + acetoacetyl-CoA                                                        | 2.8·10 <sup>-3</sup>  | 2.8.3.5                        | 303.15        | 7.0  |                                |      |

| Reaction                                                                                                          | $K'$                  | Enzyme<br>Commission<br>Number | $\frac{T}{K}$ | pH   | $\frac{I}{\text{mol-dm}^{-3}}$ | pMg  |
|-------------------------------------------------------------------------------------------------------------------|-----------------------|--------------------------------|---------------|------|--------------------------------|------|
| acetylcholine + H <sub>2</sub> O = acetate + choline                                                              | 5.38·10 <sup>2</sup>  | 3.1.1.7                        | 296.15        | 5.1  |                                |      |
| IMP + H <sub>2</sub> O = inosine + orthophosphate                                                                 | 1.58·10 <sup>2</sup>  | 3.1.3.1                        | 298.15        | 8.55 | 1.53                           | 4.44 |
| phosphorylcholine + H <sub>2</sub> O = choline + orthophosphate                                                   | 49.9                  | 3.1.3.1                        | 311.15        | 6.90 |                                |      |
| L-O-phosphoserine + H <sub>2</sub> O = L-serine + orthophosphate                                                  | 56                    | 3.1.3.1                        | 308.15        | 7.0  |                                |      |
| cytidine 2':3'-(cyclic)phosphate + H <sub>2</sub> O = cytidine 3'-monophosphate                                   | 1.06·10 <sup>3</sup>  | 3.1.27.5                       | 298.15        | 6.0  |                                |      |
| isomaltose + H <sub>2</sub> O = 2 D-glucose                                                                       | 17.2                  | 3.2.1.3                        | 298.15        | 5.65 |                                |      |
| β-gentiobiose + H <sub>2</sub> O = 2 D-glucose                                                                    | 17.7                  | 3.2.1.21                       | 298.15        | 5.65 |                                |      |
| 3-O-β-D-galactopyranosyl-D-arabinose + H <sub>2</sub> O = D-galactose + D-arabinose                               | 1.04·10 <sup>2</sup>  | 3.2.1.23                       | 298.15        | 5.65 |                                |      |
| lactulose + H <sub>2</sub> O = D-galactose + D-fructose                                                           | 1.28·10 <sup>2</sup>  | 3.2.1.23                       | 298.15        | 5.65 |                                |      |
| 4',5'-anhydroadenosine + H <sub>2</sub> O = adenosine                                                             | 0.48                  | 3.3.1.1                        | 310.15        | 7.0  |                                |      |
| pteroylglutamate + H <sub>2</sub> O = pterate + L-glutamate                                                       | 15.6                  | 3.4.19.9                       | 310.15        | 7.3  |                                |      |
| N-acetyl-L-phenylalanine methyl ester + H <sub>2</sub> O = N-acetyl-L-phenylalanine + methanol                    | 5.88·10 <sup>2</sup>  | 3.4.21.1                       | 293.15        | 5.5  |                                |      |
| hippurylanilide + H <sub>2</sub> O = hippuric acid + aniline                                                      | 11                    | 3.4.22.2                       | 312.15        | 5.0  |                                |      |
| ammonium carbamate + H <sub>2</sub> O = 2 ammonia + carbon dioxide                                                | 1.92·10 <sup>3</sup>  | 3.5.1.5                        | 293.15        | 6.5  |                                |      |
| ampicillin + H <sub>2</sub> O = 6-aminopenicillanic acid + D(-)-α-aminophenylacetic acid                          | 0.013                 | 3.5.1.11                       | 298.15        | 5.0  |                                |      |
| cephalexin + H <sub>2</sub> O = 7-aminodeacetoxycephalosporanic acid + D(-)-α-aminophenylacetic acid              | 0.044                 | 3.5.1.11                       | 298.15        | 5.8  |                                |      |
| cephaloridine + H <sub>2</sub> O = 2-thienylacetic acid + 7-amino-3-(1-pyridyl-methyl)-3-cephem-4-carboxylic acid | 0.015                 | 3.5.1.11                       | 298.15        | 5.0  |                                |      |
| penicillin G + H <sub>2</sub> O = 6-aminopenicillanic acid + phenylacetic acid                                    | 0.445                 | 3.5.1.11                       | 298.15        | 6.71 |                                |      |
| N-acetyl-L-alanine + H <sub>2</sub> O = acetate + L-alanine                                                       | 7                     | 3.5.1.14                       | 298.15        | 6.0  |                                |      |
| ampicillin + H <sub>2</sub> O = ampicillinoic acid                                                                | 95                    | 3.5.2.6                        | 282.35        | 5.55 |                                |      |
| penicillin G + H <sub>2</sub> O = penicillinoic acid                                                              | 2.9                   | 3.5.2.6                        | 298.15        | 6.01 |                                |      |
| cytidine + H <sub>2</sub> O = uridine + ammonia                                                                   | 1.03·10 <sup>4</sup>  | 3.5.4.5                        | 298.15        | 7.00 |                                |      |
| N <sup>3</sup> -methylcytidine + H <sub>2</sub> O = uridine + methylamine                                         | 4.88·10 <sup>2</sup>  | 3.5.4.5                        | 298.15        | 7.50 |                                |      |
| 5,10-methenyltetrahydrofolate + H <sub>2</sub> O = 10-formyltetrahydrofolate                                      | 50                    | 3.5.4.9                        | 298.15        | 7.0  |                                |      |
| ITP + oxaloacetate + H <sub>2</sub> O = IDP + phosphoenolpyruvate + carbon dioxide                                | 12                    | 4.1.1.32                       | 303.15        | 7.6  |                                |      |
| 2-deoxy-D-ribose 5-phosphate = D-glyceraldehyde 3-phosphate + acetaldehyde                                        | 2.5·10 <sup>-4</sup>  | 4.1.2.4                        | 295.15        | 7.5  |                                |      |
| 6-phospho-2-dehydro-3-deoxy-D-gluconate = pyruvate + D-glyceraldehyde 3-phosphate                                 | 1.2·10 <sup>-3</sup>  | 4.1.2.14                       | 298.15        | 8.0  | 0.37                           |      |
| L-fucose 1-phosphate = glyceraldehyde phosphate + (S)-lactaldehyde                                                | 4.6·10 <sup>-4</sup>  | 4.1.2.17                       | 310.15        | 7.2  |                                |      |
| L-rhamnulose 1-phosphate = glyceraldehyde phosphate + (S)-lactaldehyde                                            | 0.083                 | 4.1.2.19                       | 310.15        | 7.5  |                                |      |
| isocitrate = succinate + glyoxylate                                                                               | 2.3·10 <sup>-3</sup>  | 4.1.3.1                        | 303.15        | 7.7  |                                |      |
| (S)-2-methylmalate = acetate + pyruvate                                                                           | 0.151                 | 4.1.3.22                       | 298.15        | 7.4  | 0.845                          |      |
| isocitrate = citrate                                                                                              | 14.7                  | 4.2.1.3                        | 298.15        | 7.4  |                                |      |
| 3-dehydroquinate = 3-dehydroshikimate + H <sub>2</sub> O                                                          | 15                    | 4.2.1.10                       | 302.15        | 7.4  |                                |      |
| (3R)-3-hydroxybutanoyl-CoA = <i>cis</i> -but-2-enoyl-CoA + H <sub>2</sub> O                                       | 0.18                  | 4.2.1.17                       | 298.15        | 7.5  |                                |      |
| indole + D-glyceraldehyde 3-phosphate = 1-(indol-3-yl)glycerol 3-phosphate                                        | 1.2·10 <sup>4</sup>   | 4.2.1.20                       | 298.15        | 7.54 |                                |      |
| (R)-malate = maleate + H <sub>2</sub> O                                                                           | 4.88·10 <sup>-4</sup> | 4.2.1.31                       | 298.15        | 7.00 | 0.10                           |      |
| (R)-2-methylmalate = 2-methylmaleate + H <sub>2</sub> O                                                           | 0.0962                | 4.2.1.35                       | 298.15        | 7.0  | 0.10                           |      |
| D-glutamate = 5-oxo-D-proline + H <sub>2</sub> O                                                                  | 24.3                  | 4.2.1.48                       | 293.4         | 7.9  |                                |      |
| L-threo-3-methylaspartate = 2-methylfumarate + ammonia                                                            | 0.238                 | 4.3.1.2                        | 298.15        | 7.9  |                                |      |
| L-histidine = urocanate + ammonia                                                                                 | 3.01                  | 4.3.1.3                        | 298.25        | 8.41 | 0.167                          |      |
| L-phenylalanine = <i>trans</i> -cinnamate + ammonia                                                               | 2.47                  | 4.3.1.5                        | 298.05        | 7.69 |                                |      |
| ATP = adenosine 3':5'-(cyclic)phosphate + diphosphate                                                             | 0.065                 | 4.6.1.1                        | 298.15        | 7.0  |                                |      |
| L,L-2,6-diaminoheptanedioate = <i>meso</i> -diaminoheptanedioate                                                  | 1.9                   | 5.1.1.7                        | 310.15        | 7.0  |                                |      |
| D-ribose 5-phosphate = D-xylulose 5-phosphate                                                                     | 1.82                  | 5.1.3.1                        | 311.15        | 7.0  | 0.25                           | 3.0  |
| UDPglucose = UDPgalactose                                                                                         | 0.33                  | 5.1.3.2                        | 298.15        | 8.7  |                                |      |
| GDPmannose = GDP-L-galactose                                                                                      | 0.52                  | 5.1.3.18                       | 310.15        | 8.0  |                                |      |
| all- <i>trans</i> -retinal = 11- <i>cis</i> -retinal                                                              | 0.05                  | 5.2.1.3                        | 309.15        | 7.0  |                                |      |

| Reaction                                                                                            | $K'$                | Enzyme<br>Commission<br>Number | $\frac{T}{K}$ | pH   | $\frac{I}{\text{mol-dm}^{-3}}$ | pMg  |
|-----------------------------------------------------------------------------------------------------|---------------------|--------------------------------|---------------|------|--------------------------------|------|
| 9- <i>cis</i> ,12- <i>cis</i> -octadecadienoate = 9- <i>cis</i> ,11- <i>trans</i> -octadecadienoate | 61                  | 5.2.1.5                        | 308.15        | 7.0  |                                |      |
| D-erythrose = D-erythrulose                                                                         | 2.3                 | 5.3.1.2                        | 308.15        | 5.8  |                                |      |
| D-arabinose = D-ribulose                                                                            | 0.146               | 5.3.1.3                        | 320.25        | 7.4  |                                |      |
| L-fucose = L-fuculose                                                                               | 0.12                | 5.3.1.3                        | 310.15        | 8.0  |                                |      |
| L-arabinose = L-ribulose                                                                            | 0.11                | 5.3.1.4                        | 298.15        | 7.0  |                                |      |
| D-psicose = $\beta$ -D-allose                                                                       | 2.15                | 5.3.1.4                        | 317.25        | 7.4  |                                |      |
| D-ribose 5-phosphate = D-ribulose 5-phosphate                                                       | 0.83                | 5.3.1.6                        | 311.15        | 7.0  | 0.25                           | 3.0  |
| D-rhamnose = D-rhamnulose                                                                           | 0.58                | 5.3.1.7                        | 303.15        | 7.4  |                                |      |
| D-mannose 6-phosphate = D-fructose 6-phosphate                                                      | 0.99                | 5.3.1.8                        | 298.15        | 8.50 |                                |      |
| 6-amino-D-glucose 6-phosphate = 6-amino-D-fructose 6-phosphate                                      | 0.202               | 5.3.1.9                        | 278.85        | 8.7  |                                |      |
| D-glucosamine 6-phosphate + H <sub>2</sub> O = D-fructose 6-phosphate + ammonia                     | 0.15                | 5.3.1.10                       | 310.15        | 8.4  |                                |      |
| D-lyxose = D-xylulose                                                                               | 0.23                | 5.3.1.15                       | 298.15        | 7.0  |                                |      |
| D-ribose = D-ribulose                                                                               | 0.391               | 5.3.1.20                       | 313.15        | 7.4  |                                |      |
| <i>keto</i> -phenylpyruvate = <i>enol</i> -phenylpyruvate                                           | 0.1                 | 5.3.2.1                        | 298.15        | 7.8  |                                |      |
| L-lysine = (3 <i>S</i> )-3,6-diaminohexanoate                                                       | 5.3                 | 5.4.3.2                        | 303.15        | 7.7  |                                |      |
| ( <i>R</i> )-methylmalonyl-CoA = succinyl-CoA                                                       | 23.1                | 5.4.99.2                       | 298.15        | 7.4  |                                |      |
| (-)-4-carboxymethyl- $\Delta^{\alpha}$ -but-2-en-4-olide = <i>cis,trans</i> -hexadienedioate        | 4.0                 | 5.5.1.1                        | 303.15        | 8.0  |                                |      |
| ATP + heptanoate + CoA = AMP + diphosphate + <i>n</i> -heptanoyl-CoA                                | 1.11                | 6.2.1.2                        | 311.15        | 8.0  |                                |      |
| GTP + succinate + CoA = GDP + phosphate + succinyl-CoA                                              | 1.68                | 6.2.1.4                        | 298.15        | 7.15 | 0.25                           | 2.91 |
| GTP + IMP + L-aspartate = GDP + phosphate + adenylosuccinate                                        | 2.9                 | 6.3.4.4                        | 310.15        | 8.0  |                                |      |
| ATP + L-citrulline + L-aspartate = AMP + diphosphate + L-arginosuccinate                            | 2.14                | 6.3.4.5                        | 311.15        | 6.91 |                                |      |
| ATP + propanoyl-CoA + carbon dioxide = ADP + phosphate + ( <i>S</i> )-methylmalonyl-CoA             | $8.1 \cdot 10^{-3}$ | 6.4.1.3                        | 310.15        | 8.15 |                                |      |

## PREPARATION OF SPECIAL ANALYTICAL REAGENTS

**Aluminon (qualitative test for aluminum).** Aluminon is a trade name for the ammonium salt of aurintricarboxylic acid. Dissolve 1 g of the salt in 1 L of distilled water. Shake the solution well to insure thorough mixing.

**Bang's reagent (for glucose estimation).** Dissolve 100 g of  $K_2CO_3$ , 66 g of KCl and 160 g of  $KHCO_3$  in the order given in about 700 mL of water at 30°C. Add 4.4 g of  $CuSO_4$  and dilute to 1 L after the  $CO_2$  is evolved. This solution should be shaken only in such a manner as not to allow entry of air. After 24 hours 300 mL are diluted to 1 L with saturated KCl solution, shaken gently and used after 24 hours; 50 mL is equivalent to 10 mg glucose.

**Barfoed's reagent (test for glucose).** See Cupric acetate.

**Baudisch's reagent.** See Cupferron.

**Benedict's solution (qualitative reagent for glucose).** With the aid of heat, dissolve 173 g of sodium citrate and 100 g of  $Na_2CO_3$  in 800 mL of water. Filter, if necessary, and dilute to 850 mL. Dissolve 17.3 g of  $CuSO_4 \cdot 5H_2O$  in 100 mL of water. Pour the latter solution, with constant stirring, into the carbonate-citrate solution, and dilute to 1 L.

**Benzidine hydrochloride solution (for sulfite determination).** Make a paste of 8 g of benzidine hydrochloride ( $C_{12}H_{10}(NH_3)_2 \cdot 2HCl$ ) and 20 mL of water, add 20 mL of HCl (sp. gr. 1.12) and dilute to 1 L with water. Each mL of this solution is equivalent to 0.00357 g of  $H_2SO_4$ .

**Bertrand's reagent (glucose estimation).** Consists of the following solutions:

1. Dissolve 200 g of Rochelle salt and 150 g of NaOH in sufficient water to make 1 L of solution.
2. Dissolve 40 g of  $CuSO_4$  in enough water to make 1 L of solution.
3. Dissolve 50 g of  $Fe_2(SO_4)_3$  and 200 g of  $H_2SO_4$  (sp. gr. 1.84) in sufficient water to make 1 L of solution.
4. Dissolve 5 g of  $KMnO_4$  in sufficient water to make 1 L of solution.

**Bial's reagent (for pentose).** Dissolve 1 g of orcinol (5-methyl-1,3-benzenediol) in 500 mL of 30% HCl to which 30 drops of a 10% solution of  $FeCl_3$  has been added.

**Boutron — Boudet soap solution:**

1. Dissolve 100 g of pure castile soap in about 2.5 L of 56% ethanol.
2. Dissolve 0.59 g of  $Ba(NO_3)_2$  in 1 L of water.

Adjust the castile soap solution so that 2.4 mL of it will give a permanent lather with 40 mL of solution (b). When adjusted, 2.4 mL of soap solution is equivalent to 220 parts per million of hardness (as  $CaCO_3$ ) for a 40 mL sample. See also Soap solution.

**Brucke's reagent (protein precipitation).** See Potassium iodide-mercuric iodide.

**Clarke's soap solution (estimation of hardness in water).**

1. Dissolve 100 g of pure powdered castile soap in 1 L of 80% ethanol and allow to stand over night.
2. Prepare a solution of  $CaCl_2$  by dissolving 0.5 g of  $CaCO_3$  in HCl (sp. gr. 1.19), neutralize with  $NH_4OH$  and make slightly alkaline to litmus, and dilute to 500 mL. One mL is equivalent to 1 mg of  $CaCO_3$ .

Titrate (1) against (2) and dilute (1) with 80% ethanol until 1 mL of the resulting solution is equivalent to 1 mL of (2) after making allowance for the lather factor (the amount of standard soap solution required to produce a permanent lather in 50 mL of distilled water). One mL of the adjusted solution after subtracting the lather factor is equivalent to 1 mg of  $CaCO_3$ . See also Soap solution.

**Cobalticyanide paper (Rinnmann's test for Zn).** Dissolve 4 g of  $K_3Co(CN)_6$  and 1 g of  $KClO_3$  in 100 mL of water. Soak filter paper in solution and dry at 100°C. Apply drop of zinc solution and burn in an evaporating dish. A green disk is obtained if zinc is present.

**Cochineal.** Extract 1 g of cochineal for 4 days with 20 mL of alcohol and 60 mL of distilled water. Filter.

**Congo red.** Dissolve 0.5 g of congo red in 90 mL of distilled water and 10 mL of alcohol.

**Cupferron (Baudisch's reagent for iron analysis).** Dissolve 6 g of the ammonium salt of *N*-hydroxy-*N*-nitrosoaniline (cupferron) in 100 mL of  $H_2O$ . Reagent good for 1 week only and must be kept in the dark.

**Cupric acetate (Barfoed's reagent for reducing monosaccharides).** Dissolve 66 g of cupric acetate and 10 mL of glacial acetic acid in water and dilute to 1 L.

**Cupric oxide, ammoniacal; Schweitzer's reagent (dissolves cotton, linen, and silk, but not wool).**

1. Dissolve 5 g of cupric sulfate in 100 mL of boiling water, and add sodium hydroxide until precipitation is complete. Wash the precipitate well, and dissolve it in a minimum quantity of ammonium hydroxide.
2. Bubble a slow stream of air through 300 mL of strong ammonium hydroxide containing 50 g of fine copper turnings. Continue for 1 hour.

**Cupric sulfate in glycerin-potassium hydroxide (reagent for silk).** Dissolve 10 g of cupric sulfate,  $CuSO_4 \cdot 5H_2O$ , in 100 mL of water and add 5 g of glycerol. Add KOH solution slowly until a deep blue solution is obtained.

**Cupron (precipitates copper).** Dissolve 5 g of benzoinoxime in 100 mL of 95% ethanol.

**Cuprous chloride, acidic (reagent for CO in gas analysis).**

1. Cover the bottom of a 2-L flask with a layer of cupric oxide about 0.5 inch deep, suspend a coil of copper wire so as to reach from the bottom to the top of the solution, and fill the flask with hydrochloric acid (sp. gr. 1.10). Shake occasionally. When the solution becomes nearly colorless, transfer to reagent bottles, which should also contain copper wire. The stock bottle may be refilled with dilute hydrochloric acid until either the cupric oxide or the copper wire is used up. Copper sulfate may be substituted for copper oxide in the above procedure.
2. Dissolve 340 g of  $CuCl_2 \cdot 2H_2O$  in 600 mL of conc. HCl and reduce the cupric chloride by adding 190 mL of a saturated solution of stannous chloride or until the solution is colorless. The stannous chloride is prepared by treating 300 g of metallic tin in a 500 mL flask with conc. HCl until no more tin goes into solution.
3. (Winkler method). Add a mixture of 86 g of CuO and 17 g of finely divided metallic Cu, made by the reduction of CuO with hydrogen, to a solution of HCl, made by dilut-

ing 650 mL of conc. HCl with 325 mL of water. After the mixture has been added slowly and with frequent stirring, a spiral of copper wire is suspended in the bottle, reaching all the way to the bottom. Shake occasionally, and when the solution becomes colorless, it is ready for use.

**Cuprous chloride, ammoniacal (reagent for CO in gas analysis).**

1. The acid solution of cuprous chloride as prepared above is neutralized with ammonium hydroxide until an ammonia odor persists. An excess of metallic copper must be kept in the solution.
2. Pour 800 mL of acidic cuprous chloride, prepared by the Winkler method, into about 4 L of water. Transfer the precipitate to a 250 mL graduate. After several hours, siphon off the liquid above the 50 mL mark and refill with 7.5%  $\text{NH}_4\text{OH}$  solution which may be prepared by diluting 50 mL of conc.  $\text{NH}_4\text{OH}$  with 150 mL of water. The solution is well shaken and allowed to stand for several hours. It should have a faint odor of ammonia.

**Dichlorofluorescein indicator.** Dissolve 1 g in 1 L of 70% alcohol or 1 g of the sodium salt in 1 L of water.

**Dimethylglyoxime, 0.01 N.** Dissolve 0.6 g of dimethylglyoxime (2,3-butanedione oxime) in 500 mL of 95% ethanol. This is an especially sensitive test for nickel, a very definite crimson color being produced.

**Diphenylamine (reagent for rayon).** Dissolve 0.2 g in 100 mL of concentrated sulfuric acid.

**Diphenylamine sulfonate (for titration of iron with  $\text{K}_2\text{Cr}_2\text{O}_7$ ).** Dissolve 0.32 g of the barium salt of diphenylamine sulfonic acid in 100 mL of water, add 0.5 g of sodium sulfate and filter off the precipitate of  $\text{BaSO}_4$ .

**Diphenylcarbazide.** Dissolve 0.2 g of diphenylcarbazide in 10 mL of glacial acetic acid and dilute to 100 mL with 95% ethanol.

**Esbach's reagent (estimation of protein).** To a water solution of 10 g of picric acid and 20 g of citric acid, add sufficient water to make 1 L of solution.

**Eschka's compound.** Two parts of calcined ("light") magnesia are thoroughly mixed with 1 part of anhydrous sodium carbonate.

**Fehling's solution (reagent for reducing sugars.)**

1. Copper sulfate solution. Dissolve 34.66 g of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  in water and dilute to 500 mL.
2. Alkaline tartrate solution. Dissolve 173 g of potassium sodium tartrate (Rochelle salt,  $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$ ) and 50 g of NaOH in water and dilute when cold to 500 mL.

Mix equal volumes of the two solutions at the time of using.

**Ferric-alum indicator.** Dissolve 140 g of ferric ammonium sulfate crystals in 400 mL of hot water. When cool, filter, and make up to a volume of 500 mL with dilute nitric acid.

**Folin's mixture (for uric acid).** To 650 mL of water add 500 g of  $(\text{NH}_4)_2\text{SO}_4$ , 5 g of uranium acetate, and 6 g of glacial acetic acid. Dilute to 1 L.

**Formaldehyde — sulfuric acid (Marquis' reagent for alkaloids).** Add 10 mL of formaldehyde solution to 50 mL of sulfuric acid.

**Froehde's reagent.** See Sulfomolybdic acid.

**Fuchsin (reagent for linen).** Dissolve 1 g of fuchsin in 100 mL of alcohol.

**Fuchsin — sulfurous acid (Schiff's reagent for aldehydes).**

Dissolve 0.5 g of fuchsin and 9 g of sodium bisulfite in 500 mL of water, and add 10 mL of HCl. Keep in well-stoppered bottles and protect from light.

**Gunzberg's reagent (detection of HCl in gastric juice).** Prepare as needed a solution containing 4 g of phloroglucinol (1,3,5-benzenetriol) and 2 g of vanillin in 100 mL of absolute ethanol.

**Hager's reagent.** See Picric acid.

**Hanus solution (for iodine number).** Dissolve 13.2 g of resublimed iodine in 1 L of glacial acetic acid which will pass the dichromate test for reducible matter. Add sufficient bromine to double the halogen content, determined by titration (3 mL is about the proper amount). The iodine may be dissolved by the aid of heat, but the solution should be cold when the bromine is added.

**Iodine, tincture of.** To 50 mL of water add 70 g of  $\text{I}_2$  and 50 g of KI. Dilute to 1 L with alcohol.

**Iodo-potassium iodide (Wagner's reagent for alkaloids).** Dissolve 2 g of iodine and 6 g of KI in 100 mL of water.

**Litmus (indicator).** Extract litmus powder three times with boiling alcohol, each treatment consuming an hour. Reject the alcoholic extract. Treat residue with an equal weight of cold water and filter; then exhaust with five times its weight of boiling water, cool and filter. Combine the aqueous extracts.

**Magnesia mixture (reagent for phosphates and arsenates).** Dissolve 55 g of magnesium chloride and 105 g of ammonium chloride in water, barely acidify with hydrochloric acid, and dilute to 1 L. The ammonium hydroxide may be omitted until just previous to use. The reagent, if completely mixed and stored for any period of time, becomes turbid.

**Magnesium uranyl acetate.** Dissolve 100 g of  $\text{UO}_2(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$  in 60 mL of glacial acetic acid and dilute to 500 mL. Dissolve 330 g of  $\text{Mg}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 4\text{H}_2\text{O}$  in 60 mL of glacial acetic acid and dilute to 200 mL. Heat solutions to the boiling point until clear, pour the magnesium solution into the uranyl solution, cool and dilute to 1 L. Let stand over night and filter if necessary.

**Marme's reagent.** See Potassium-cadmium iodide.

**Marquis' reagent.** See Formaldehyde-sulfuric acid.

**Mayer's reagent (white precipitate with most alkaloids in slightly acid solutions).** Dissolve 1.358 g of  $\text{HgCl}_2$  in 60 mL of water and pour into a solution of 5 g of KI in 10 mL of  $\text{H}_2\text{O}$ . Add sufficient water to make 100 mL.

**Methyl orange indicator.** Dissolve 1 g of methyl orange in 1 L of water. Filter, if necessary.

**Methyl orange, modified.** Dissolve 2 g of methyl orange and 2.8 g of xylene cyanole FF in 1 L of 50% alcohol.

**Methyl red indicator.** Dissolve 1 g of methyl red in 600 mL of alcohol and dilute with 400 mL of water.

**Methyl red, modified.** Dissolve 0.50 g of methyl red and 1.25 g of xylene cyanole FF in 1 L of 90% alcohol. Or, dissolve 1.25 g of methyl red and 0.825 g of methylene blue in 1 L of 90% alcohol.

**Millon's reagent (for albumins and phenols).** Dissolve 1 part of mercury in 1 part of cold fuming nitric acid. Dilute with twice the volume of water and decant the clear solution after several hours.

**Molisch's reagent.** See 1-Naphthol.

**1-Naphthol (Molisch's reagent for wool).** Dissolve 15 g of 1-naphthol in 100 mL of alcohol or chloroform.



**Nessler's reagent (for ammonia).** Dissolve 50 g of KI in the smallest possible quantity of cold water (50 mL). Add a saturated solution of mercuric chloride (about 22 g in 350 mL of water will be needed) until an excess is indicated by the formation of a precipitate. Then add 200 mL of 5 N NaOH and dilute to 1 L. Let settle, and draw off the clear liquid.

**Nickel oxide, ammoniacal (reagent for silk).** Dissolve 5 g of nickel sulfate in 100 mL of water, and add sodium hydroxide solution until nickel hydroxide is completely precipitated. Wash the precipitate well and dissolve in 25 mL of concentrated ammonium hydroxide and 25 mL of water.

**Nitron (detection of nitrate radical).** Dissolve 10 g of nitron (1,4-diphenyl-3-(phenylamino)-1,2,4-triazolium hydroxide) in 5 mL of glacial acetic acid and 95 mL of water. The solution may be filtered with slight suction through an alundum crucible and kept in a dark bottle.

**1-Nitroso-2-naphthol.** Make a saturated solution in 50% acetic acid (1 part of glacial acetic acid with 1 part of water). Does not keep well.

**Nylander's solution (carbohydrates).** Dissolve 20 g of bismuth subnitrate and 40 g of Rochelle salt in 1 L of 8% NaOH solution. Cool and filter.

**Obermayer's reagent (for indoxyl in urine).** Dissolve 4 g of  $\text{FeCl}_3$  in 1 L of HCl (sp. gr. 1.19).

**Oxine.** Dissolve 14 g of 8-hydroxyquinoline in 30 mL of glacial acetic acid. Warm slightly, if necessary. Dilute to 1 L.

**Oxygen absorbent.** Dissolve 300 g of ammonium chloride in 1 L of water and add 1 L of concentrated ammonium hydroxide solution. Shake the solution thoroughly. For use as an oxygen absorbent, a bottle half full of copper turnings is filled nearly full with the  $\text{NH}_4\text{Cl-NH}_4\text{OH}$  solution and the gas passed through.

**Pasteur's salt solution.** To 1 L of distilled water add 2.5 g of potassium phosphate, 0.25 g of calcium phosphate, 0.25 g of magnesium sulfate, and 12.00 g of ammonium tartrate.

**Pavy's solution (glucose reagent).** To 120 mL of Fehling's solution, add 300 mL of  $\text{NH}_4\text{OH}$  (sp. gr. 0.88) and dilute to 1 L with water.

**Phenanthroline ferrous ion indicator.** Dissolve 1.485 g of 1,10-phenanthroline monohydrate in 100 mL of 0.025 M ferrous sulfate solution.

**Phenolphthalein.** Dissolve 1 g of phenolphthalein in 50 mL of alcohol and add 50 mL of water.

**Phenolsulfonic acid (determination of nitrogen as nitrate).** Dissolve 25 g of phenol in 150 mL of conc.  $\text{H}_2\text{SO}_4$ , add 75 mL of fuming  $\text{H}_2\text{SO}_4$  (15%  $\text{SO}_3$ ), stir well and heat for 2 hours at  $100^\circ\text{C}$ .

**Phloroglucinol solution (pentosans).** Make a 3% phloroglucinol (1,3,5-benzenetriol) solution in alcohol. Keep in a dark bottle.

**Phosphomolybdic acid (Sonnenschein's reagent for alkaloids).**

1. Prepare ammonium phosphomolybdate and after washing with water, boil with nitric acid and expel  $\text{NH}_3$ ; evaporate to dryness and dissolve in 2 M nitric acid.
2. Dissolve ammonium molybdate in  $\text{HNO}_3$  and treat with phosphoric acid. Filter, wash the precipitate, and boil with aqua regia until the ammonium salt is decomposed. Evaporate to dryness. The residue dissolved in 10%  $\text{HNO}_3$  constitutes Sonnenschein's reagent.

**Phosphoric acid — sulfuric acid mixture.** Dilute 150 mL of conc.  $\text{H}_2\text{SO}_4$  and 100 mL of conc.  $\text{H}_3\text{PO}_4$  (85%) with water to a volume of 1 L.

**Phosphotungstic acid (Schcibicr's reagent for alkaloids).**

1. Dissolve 20 g of sodium tungstate and 15 g of sodium phosphate in 100 mL of water containing a little nitric acid.
2. The reagent is a 10% solution of phosphotungstic acid in water. The phosphotungstic acid is prepared by evaporating a mixture of 10 g of sodium tungstate dissolved in 5 g of phosphoric acid (sp. gr. 1.13) and enough boiling water to effect solution. Crystals of phosphotungstic acid separate.

**Picric acid (Hager's reagent for alkaloids, wool and silk).**

Dissolve 1 g of picric acid in 100 mL of water.

**Potassium antimonate (reagent for sodium).** Boil 22 g of potassium antimonate with 1 L of water until nearly all of the salt has dissolved, cool quickly, and add 35 mL of 10% potassium hydroxide. Filter after standing overnight.

**Potassium-cadmium iodide (Marme's reagent for alkaloids).**

Add 2 g of  $\text{CdI}_2$  to a boiling solution of 4 g of KI in 12 mL of water, and then mix with 12 mL of saturated KI solution.

**Potassium hydroxide (for  $\text{CO}_2$  absorption).** Dissolve 360 g of KOH in water and dilute to 1 L.

**Potassium iodide — mercuric iodide (Brucke's reagent for proteins).** Dissolve 50 g of KI in 500 mL of water, and saturate with mercuric iodide (about 120 g). Dilute to 1 L.

**Potassium pyrogallate (for oxygen absorption).** For mixtures of gases containing less than 28% oxygen, add 100 mL of KOH solution (50 g of KOH to 100 mL of water) to 5 g of pyrogallol. For mixtures containing more than 28% oxygen the KOH solution should contain 120 g of KOH to 100 mL of water.

**Pyrogallol, alkaline.**

1. Dissolve 75 g of pyrogallol in 75 mL of water.
2. Dissolve 500 g of KOH in 250 mL of water. When cool, adjust until sp. gr. is 1.55.

For use, add 270 mL of solution (2) to 30 mL of solution (1).

**Rosolic acid (indicator).** Dissolve 1 g of rosolic acid in 10 mL of alcohol and add 100 mL of water.

**Scheibler's reagent.** See Phosphotungstic acid.

**Schiff's reagent.** See Fuchsin-sulfurous acid.

**Schweitzer's reagent.** See Cupric oxide, ammoniacal.

**Soap solution (reagent for hardness in water).** Dissolve 100 g of dry castile soap in 1 L of 80% alcohol (5 parts alcohol to 1 part water). Allow to stand several days and dilute with 70% to 80% alcohol until 6.4 mL produces a permanent lather with 20 mL of standard calcium solution. The latter solution is made by dissolving 0.2 g of  $\text{CaCO}_3$  in a small amount of dilute HCl, evaporating to dryness and making up to 1 L.

**Sodium bismuthate (oxidation of manganese).** Heat 20 parts of NaOH nearly to redness in an iron or nickel crucible and add slowly 10 parts of basic bismuth nitrate which has been previously dried. Add 2 parts of sodium peroxide, and pour the brownish-yellow fused mass onto an iron plate to cool. When cold, break up in a mortar, extract with water, and collect on an asbestos filter.

**Sodium hydroxide (for  $\text{CO}_2$  absorption).** Dissolve 330 g of NaOH in water and dilute to 1 L.



**Sodium nitroprusside (reagent for hydrogen sulfide and wool).**

Use a freshly prepared solution of 1 g of sodium nitroferricyanide in 10 mL of water.

**Sodium oxalate (primary standard).** Dissolve 30 g of the commercial salt in 1 L of water, make slightly alkaline with sodium hydroxide, and let stand until perfectly clear. Filter and evaporate the filtrate to 100 mL. Cool and filter. Pulverize the residue and wash it several times with small volumes of water. The procedure is repeated until the mother liquor is free from sulfate and is neutral to phenolphthalein.

**Sodium plumbite (reagent for wool).** Dissolve 5 g of sodium hydroxide in 100 mL of water. Add 5 g of litharge (PbO) and boil until dissolved.

**Sodium polysulfide.** Dissolve 480 g of  $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$  in 500 mL of water, add 40 g of NaOH and 18 g of sulfur. Stir thoroughly and dilute to 1 L with water.

**Sonnenschein's reagent.** See Phosphomolybdic acid.

**Starch solution.**

1. Make a paste with 2 g of soluble starch and 0.01 g of  $\text{HgI}_2$  with a small amount of water. Add the mixture slowly to 1 L of boiling water and boil for a few minutes. Keep in a glass stoppered bottle. If other than soluble starch is used, the solution will not clear on boiling; it should be allowed to stand and the clear liquid decanted.
2. A solution of starch which keeps indefinitely is made as follows: Mix 500 mL of saturated NaCl solution (filtered), 80 mL of glacial acetic acid, 20 mL of water and 3 g of starch. Bring slowly to a boil and boil for 2 minutes.
3. Make a paste with 1 g of soluble starch and 5 mg of  $\text{HgI}_2$ , using as little cold water as possible. Then pour about 200 mL of boiling water on the paste and stir immediately. This will give a clear solution if the paste is prepared correctly and the water actually boiling. Cool and add 4 g of KI. Starch solution decomposes on standing due to bacterial action, but this solution will keep well if stored under a layer of toluene.

**Stoke's reagent.** Dissolve 30 g of  $\text{FeSO}_4$  and 20 g of tartaric acid in water and dilute to 1 L. Just before using, add concentrated  $\text{NH}_4\text{OH}$  until the precipitate first formed is redissolved.

**Sulfanilic acid (reagent for nitrites).** Dissolve 0.5 g of sulfanilic acid in a mixture of 15 mL of glacial acetic acid and 135 mL of recently boiled water.

**Sulfomolybdic acid (Froehde's reagent for alkaloids and glucosides).** Dissolve 10 g of molybdic acid or sodium molybdate in 100 mL of conc.  $\text{H}_2\text{SO}_4$ .

**Tannic acid (reagent for albumin, alkaloids, and gelatin).** Dissolve 10 g of tannic acid in 10 mL of alcohol and dilute with water to 100 mL.

**Titration mixture (residual chlorine in water analysis).** Prepare 1 L of dilute HCl (100 mL of HCl (sp. gr. 1.19) in sufficient water to make 1 L). Dissolve 1 g of *o*-tolidine in 100 mL of the dilute HCl and dilute to 1 L with dilute HCl solution.

**Trinitrophenol solution.** See Picric acid.

**Turmeric tincture (reagent for borates).** Digest ground turmeric root with several quantities of water which are discarded. Dry the residue and digest it several days with six times its weight of alcohol. Filter.

**Uffelmann's reagent (turns yellow in presence of lactic acid).**

To a 2% solution of pure phenol in water, add a water solution of  $\text{FeCl}_3$  until the phenol solution becomes violet in color.

**Wagner's reagent.** See Iodo-potassium iodide.

**Wagner's solution (used in phosphate rock analysis to prevent precipitation of iron and aluminum).** Dissolve 25 g of citric acid and 1 g of salicylic acid in water and dilute to 1 L. Use 50 mL of the reagent.

**Wij's iodine monochloride solution (for iodine number).**

Dissolve 13 g of resublimed iodine in 1 L of glacial acetic acid which will pass the dichromate test for reducible matter. Set aside 25 mL of this solution. Pass into the remainder of the solution dry chlorine gas (dried and washed by passing through  $\text{H}_2\text{SO}_4$  (sp. gr. 1.84)) until the characteristic color of free iodine has been discharged. Now add the iodine solution which was reserved, until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but an excess of chlorine must be avoided. Preserve in well stoppered, amber colored bottles. Avoid use of solutions which have been prepared for more than 30 days.

**Wij's special solution (for iodine number).** To 200 mL of glacial acetic acid that will pass the dichromate test for reducible matter, add 12 g of dichloramine T (*N,N*-dichloro-4-methylbenzenesulfonamide), and 16.6 g of dry KI (in small quantities with continual shaking until all the KI has dissolved). Make up to 1 L with the same quality of acetic acid used above and preserve in a dark colored bottle.

**Zimmermann-Reinhardt reagent (determination of iron).**

Dissolve 70 g of  $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$  in 500 mL of water, add 125 mL of conc.  $\text{H}_2\text{SO}_4$  and 125 mL of 85%  $\text{H}_3\text{PO}_4$ , and dilute to 1 L.

**Zinc chloride solution, basic (reagent for silk).** Dissolve 1000 g of zinc chloride in 850 mL of water, and add 40 g of zinc oxide. Heat until solution is complete.

**Zinc uranyl acetate (reagent for sodium).** Dissolve 10 g of  $\text{UO}_2(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$  in 6 g of 30% acetic acid with heat, if necessary, and dilute to 50 mL. Dissolve 30 g of  $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot \text{H}_2\text{O}$  in 3 g of 30% acetic acid and dilute to 50 mL. Mix the two solutions, add 50 mg of NaCl, allow to stand overnight and filter.

## STANDARD SOLUTIONS OF ACIDS, BASES, AND SALTS

For each compound listed, the last column of this table gives the mass in grams which is contained in 1 liter of a solution whose amount-of-substance concentration divided by the equivalence factor of the compound equals 0.1 mol/L. In the older literature such a solution is often referred to as a "decinormal solution" (0.1 N).

### Reference

*Compendium of Analytical Nomenclature (IUPAC)*, Pergamon Press, Oxford, 1978.

| Name                       | Formula                                                    | Atomic or<br>molecular<br>weight | Equivalence<br>factor | Mass in<br>grams |
|----------------------------|------------------------------------------------------------|----------------------------------|-----------------------|------------------|
| Acetic acid                | $\text{HC}_2\text{H}_3\text{O}_2$                          | 60.0530                          | 1                     | 6.0053           |
| Ammonia                    | $\text{NH}_3$                                              | 17.0306                          | 1                     | 1.7031           |
| Ammonium ion               | $\text{NH}_4^+$                                            | 18.0386                          | 1                     | 1.8039           |
| Ammonium chloride          | $\text{NH}_4\text{Cl}$                                     | 53.4916                          | 1                     | 5.3492           |
| Ammonium sulfate           | $(\text{NH}_4)_2\text{SO}_4$                               | 132.1388                         | 1/2                   | 6.6069           |
| Ammonium thiocyanate       | $\text{NH}_4\text{CNS}$                                    | 76.1204                          | 1                     | 7.6120           |
| Barium                     | Ba                                                         | 137.34                           | 1/2                   | 6.867            |
| Barium carbonate           | $\text{BaCO}_3$                                            | 197.3494                         | 1/2                   | 9.8675           |
| Barium chloride hydrate    | $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$                  | 244.2767                         | 1/2                   | 12.2138          |
| Barium hydroxide           | $\text{Ba}(\text{OH})_2$                                   | 171.3547                         | 1/2                   | 8.5677           |
| Barium oxide               | BaO                                                        | 153.3394                         | 1/2                   | 7.6670           |
| Bromine                    | Br                                                         | 79.909                           | 1                     | 7.9909           |
| Calcium                    | Ca                                                         | 40.08                            | 1/2                   | 2.004            |
| Calcium carbonate          | $\text{CaCO}_3$                                            | 100.0894                         | 1/2                   | 5.0045           |
| Calcium chloride           | $\text{CaCl}_2$                                            | 110.9860                         | 1/2                   | 5.5493           |
| Calcium chloride hydrate   | $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$                  | 219.0150                         | 1/2                   | 10.9508          |
| Calcium hydroxide          | $\text{Ca}(\text{OH})_2$                                   | 74.0947                          | 1/2                   | 3.7047           |
| Calcium oxide              | CaO                                                        | 56.0794                          | 1/2                   | 2.8040           |
| Chlorine                   | Cl                                                         | 35.453                           | 1                     | 3.5453           |
| Citric acid                | $\text{C}_6\text{H}_8\text{O}_7 \cdot \text{H}_2\text{O}$  | 210.1418                         | 1/3                   | 7.0047           |
| Cobalt                     | Co                                                         | 58.9332                          | 1/2                   | 2.9466           |
| Copper                     | Cu                                                         | 63.54                            | 1/2                   | 3.177            |
| Copper oxide (cupric)      | CuO                                                        | 79.5394                          | 1/2                   | 3.9770           |
| Copper sulfate hydrate     | $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$                  | 249.6783                         | 1/2                   | 12.4839          |
| Hydrochloric acid          | HCl                                                        | 36.4610                          | 1                     | 3.6461           |
| Hydrocyanic acid           | HCN                                                        | 27.0258                          | 1                     | 2.7026           |
| Iodine                     | I                                                          | 126.9044                         | 1                     | 12.6904          |
| Lactic acid                | $\text{C}_3\text{H}_6\text{O}_3$                           | 90.0795                          | 1                     | 9.0080           |
| Malic acid                 | $\text{C}_4\text{H}_6\text{O}_5$                           | 134.0894                         | 1/2                   | 6.7045           |
| Magnesium                  | Mg                                                         | 24.312                           | 1/2                   | 1.2156           |
| Magnesium carbonate        | $\text{MgCO}_3$                                            | 84.3214                          | 1/2                   | 4.2161           |
| Magnesium chloride         | $\text{MgCl}_2$                                            | 95.2180                          | 1/2                   | 4.7609           |
| Magnesium chloride hydrate | $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$                  | 203.2370                         | 1/2                   | 10.1623          |
| Magnesium oxide            | MgO                                                        | 40.3114                          | 1/2                   | 2.0156           |
| Manganese                  | Mn                                                         | 54.938                           | 1/2                   | 2.7469           |
| Manganese sulfate          | $\text{MnSO}_4$                                            | 150.9996                         | 1/2                   | 7.5500           |
| Mercuric chloride          | $\text{HgCl}_2$                                            | 271.4960                         | 1/2                   | 13.5748          |
| Nickel                     | Ni                                                         | 58.71                            | 1/2                   | 2.9356           |
| Nitric acid                | $\text{HNO}_3$                                             | 63.0129                          | 1                     | 6.3013           |
| Oxalic acid                | $\text{H}_2\text{C}_2\text{O}_4$                           | 90.0358                          | 1/2                   | 4.5018           |
| Oxalic acid hydrate        | $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ | 126.0665                         | 1/2                   | 6.3033           |
| Oxalic acid anhydride      | $\text{C}_2\text{O}_3$                                     | 72.0205                          | 1/2                   | 3.6010           |
| Phosphoric acid            | $\text{H}_3\text{PO}_4$                                    | 97.9953                          | 1/3                   | 3.2665           |
| Potassium                  | K                                                          | 39.102                           | 1                     | 3.9102           |
| Potassium bicarbonate      | $\text{KHCO}_3$                                            | 100.1193                         | 1                     | 10.0119          |
| Potassium carbonate        | $\text{K}_2\text{CO}_3$                                    | 138.2134                         | 1/2                   | 6.9106           |
| Potassium chloride         | KCl                                                        | 74.5550                          | 1                     | 7.4555           |
| Potassium cyanide          | KCN                                                        | 65.1199                          | 1                     | 6.5120           |
| Potassium hydroxide        | KOH                                                        | 56.1094                          | 1                     | 5.6109           |

| Name                 | Formula              | Atomic or<br>molecular<br>weight | Equivalence<br>factor | Mass in<br>grams |
|----------------------|----------------------|----------------------------------|-----------------------|------------------|
| Potassium oxide      | $K_2O$               | 94.2034                          | 1/2                   | 4.7102           |
| Potassium tartrate   | $K_2H_4C_4O_6$       | 226.2769                         | 1/2                   | 11.3139          |
| Silver               | Ag                   | 107.87                           | 1                     | 10.787           |
| Silver nitrate       | $AgNO_3$             | 169.8749                         | 1                     | 16.9875          |
| Sodium               | Na                   | 22.9898                          | 1                     | 2.2990           |
| Sodium bicarbonate   | $NaHCO_3$            | 84.0071                          | 1                     | 8.4007           |
| Sodium carbonate     | $Na_2CO_3$           | 105.9890                         | 1/2                   | 5.2995           |
| Sodium chloride      | NaCl                 | 58.4428                          | 1                     | 5.8443           |
| Sodium hydroxide     | NaOH                 | 39.9972                          | 1                     | 3.9997           |
| Sodium oxide         | $Na_2O$              | 61.9790                          | 1/2                   | 3.0990           |
| Sodium sulfide       | $Na_2S$              | 78.0436                          | 1/2                   | 3.9022           |
| Succinic acid        | $H_2C_4H_4O_4$       | 118.0900                         | 1/2                   | 5.9045           |
| Sulfuric acid        | $H_2SO_4$            | 98.0775                          | 1/2                   | 4.9039           |
| Tartaric acid        | $C_4H_6O_6$          | 150.0888                         | 1/2                   | 7.5044           |
| Zinc                 | Zn                   | 65.37                            | 1/2                   | 3.269            |
| Zinc sulfate hydrate | $ZnSO_4 \cdot 7H_2O$ | 287.5390                         | 1/2                   | 14.3769          |

## STANDARD SOLUTIONS OF OXIDATION AND REDUCTION REAGENTS

For each reagent listed, the last column of this table gives the mass in grams which is contained in a solution whose amount-of-substance concentration divided by the equivalence factor of the compound equals 0.1 mol/L. The equivalence factor given refers to the most common reactions of the reagent. In the older literature such a solution is often called a "decinormal solution" (0.1 N).

### Reference

*Compendium of Analytical Nomenclature (IUPAC)*, Pergamon Press, Oxford, 1978.

| Name                           | Formula                                                                 | Atomic or<br>molecular<br>weight | Equivalence<br>factor | Mass in<br>grams |
|--------------------------------|-------------------------------------------------------------------------|----------------------------------|-----------------------|------------------|
| Antimony                       | Sb                                                                      | 121.75                           | 1/2                   | 6.0875           |
| Arsenic                        | As                                                                      | 74.9216                          | 1/2                   | 3.7461           |
| Arsenic trisulfide             | As <sub>2</sub> S <sub>3</sub>                                          | 246.0352                         | 1/4                   | 6.1509           |
| Arsenous oxide                 | As <sub>2</sub> O <sub>3</sub>                                          | 197.8414                         | 1/4                   | 4.9460           |
| Barium peroxide                | BaO <sub>2</sub>                                                        | 169.3388                         | 1/2                   | 8.4669           |
| Barium peroxide hydrate        | BaO <sub>2</sub> · 8H <sub>2</sub> O                                    | 313.4615                         | 1/2                   | 15.6730          |
| Calcium                        | Ca                                                                      | 40.08                            | 1/2                   | 2.004            |
| Calcium carbonate              | CaCO <sub>3</sub>                                                       | 100.0894                         | 1/2                   | 5.0045           |
| Calcium hypochlorite           | Ca(OCl) <sub>2</sub>                                                    | 142.9848                         | 1/4                   | 3.5746           |
| Calcium oxide                  | CaO                                                                     | 56.0794                          | 1/2                   | 2.8040           |
| Chlorine                       | Cl                                                                      | 35.453                           | 1                     | 3.5453           |
| Chromium trioxide              | CrO <sub>3</sub>                                                        | 99.9942                          | 1/3                   | 3.3331           |
| Ferrous ammonium sulfate       | FeSO <sub>4</sub> (NH <sub>4</sub> )SO <sub>4</sub> · 6H <sub>2</sub> O | 392.0764                         | 1                     | 39.2076          |
| Hydroferrocyanic acid          | H <sub>4</sub> Fe(CN) <sub>6</sub>                                      | 215.9860                         | 1                     | 21.5986          |
| Hydrogen peroxide              | H <sub>2</sub> O <sub>2</sub>                                           | 34.0147                          | 1/2                   | 1.7007           |
| Hydrogen sulfide               | H <sub>2</sub> S                                                        | 34.0799                          | 1/2                   | 1.7040           |
| Iodine                         | I                                                                       | 126.9044                         | 1                     | 12.6904          |
| Iron                           | Fe                                                                      | 55.847                           | 1                     | 5.5847           |
| Iron oxide (ferrous)           | FeO                                                                     | 71.8464                          | 1                     | 7.1846           |
| Iron oxide (ferric)            | Fe <sub>2</sub> O <sub>3</sub>                                          | 159.6922                         | 1/2                   | 7.9846           |
| Lead peroxide                  | PbO <sub>2</sub>                                                        | 239.1888                         | 1/2                   | 11.9594          |
| Manganese dioxide              | MnO <sub>2</sub>                                                        | 86.9368                          | 1/2                   | 4.3468           |
| Nitric acid                    | HNO <sub>3</sub>                                                        | 63.0129                          | 1/3                   | 2.1004           |
| Nitrogen trioxide              | N <sub>2</sub> O <sub>3</sub>                                           | 76.0116                          | 1/4                   | 1.9002           |
| Nitrogen pentoxide             | N <sub>2</sub> O <sub>5</sub>                                           | 108.0104                         | 1/6                   | 1.8001           |
| Oxalic acid                    | C <sub>2</sub> H <sub>2</sub> O <sub>4</sub>                            | 90.0358                          | 1/2                   | 4.5018           |
| Oxalic acid hydrate            | C <sub>2</sub> H <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O        | 126.0665                         | 1/2                   | 6.3033           |
| Oxygen                         | O                                                                       | 15.9994                          | 1/2                   | 0.8000           |
| Potassium dichromate           | K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>                           | 294.1918                         | 1/6                   | 4.9032           |
| Potassium chlorate             | KClO <sub>3</sub>                                                       | 122.5532                         | 1/6                   | 2.0425           |
| Potassium chromate             | K <sub>2</sub> CrO <sub>4</sub>                                         | 194.1076                         | 1/3                   | 6.4733           |
| Potassium ferrocyanide         | K <sub>4</sub> Fe(CN) <sub>6</sub>                                      | 368.3621                         | 1                     | 36.8362          |
| Potassium ferrocyanide hydrate | K <sub>4</sub> Fe(CN) <sub>6</sub> · 3H <sub>2</sub> O                  | 422.4081                         | 1                     | 42.2408          |
| Potassium iodide               | KI                                                                      | 166.0064                         | 1                     | 16.6006          |
| Potassium nitrate              | KNO <sub>3</sub>                                                        | 101.1069                         | 1/3                   | 3.3702           |
| Potassium perchlorate          | KClO <sub>4</sub>                                                       | 138.5526                         | 1/8                   | 1.7319           |
| Potassium permanganate         | KMnO <sub>4</sub>                                                       | 158.0376                         | 1/5                   | 3.1608           |
| Sodium chlorate                | NaClO <sub>3</sub>                                                      | 106.4410                         | 1/6                   | 1.7740           |
| Sodium nitrate                 | NaNO <sub>3</sub>                                                       | 84.9947                          | 1/3                   | 2.8332           |
| Sodium thiosulfate hydrate     | Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 5H <sub>2</sub> O       | 248.1825                         | 1                     | 24.8183          |
| Stannous chloride              | SnCl <sub>2</sub>                                                       | 189.5960                         | 1/2                   | 9.4798           |
| Stannous oxide                 | SnO                                                                     | 134.6894                         | 1/2                   | 6.7345           |
| Sulfur dioxide                 | SO <sub>2</sub>                                                         | 64.0628                          | 1/2                   | 3.2031           |
| Tin                            | Sn                                                                      | 118.69                           | 1/2                   | 5.935            |

# ORGANIC ANALYTICAL REAGENTS FOR THE DETERMINATION OF INORGANIC SUBSTANCES

**G. Ackermann, L. Sommer, and D. Thorburn Burns**

| Determination | Reagents                                              | Ref.                                                                                                                                            |
|---------------|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Aluminium     | Alizarin Red S                                        | Onishi, Part II a, p 28. (5), Snell, <i>Metals I</i> , p 587. (7)                                                                               |
|               | Aluminon                                              | Fries/Getrost, p 16. (2), Onishi, IIa, p 21. (5), Snell, <i>Metals I</i> , p 590. (7)                                                           |
|               | Aluminon + Cetyltrimethylammonium bromide             | Huaxue Shiji, 8, 85, (1986)                                                                                                                     |
|               | Chrome Azurol S                                       | Onishi, Part IIa, p 26. (5), Snell, <i>Metals I</i> , p 605. (7)                                                                                |
|               | Chrome Azurol S + Cetyltrimethylammonium bromide      | Marczenko, p 133. (3), Snell, <i>Metals I</i> , p 606. (7)                                                                                      |
|               | Chromazol KS + Cetylpyridinium bromide                | <i>Analyst</i> , 107, 428, (1982).                                                                                                              |
|               | Eriochrome Cyanine R                                  | Fries/Getrost, p 19. (2), Onishi, Part IIa, p 25. (5), Snell, <i>Metals I</i> , p 611. (7)                                                      |
|               | Eriochrome Cyanine R + Cetyltrimethylammonium bromide | Snell, <i>Metals I</i> , p 613. (7), <i>Analyst</i> , 107, 1431, (1982).                                                                        |
| Ammonia       | 8-Hydroxyquinoline                                    | Fries/Getrost, p 22. (2), Marczenko, p 131. (3), Onishi, Part IIa, p 31. (5), Snell, <i>Metals I</i> , p 622. (7)                               |
|               | Phenol + Sodium hypochlorite                          | Boltz, p 210 (1), Marczenko, p 413. (3), Snell, <i>Nonmetals</i> , p 604. (9)                                                                   |
|               | Brilliant Green                                       | Onishi, Part IIa, p 102. (5), Snell, <i>Metals I</i> , p 384. (7)                                                                               |
|               | Bromopyrogallol Red                                   | <i>Talanta</i> , 13, 507, (1966).                                                                                                               |
|               | Rhodamine B                                           | Fries/Getrost, p 32. (2), Marczenko, p 141. (3), Onishi, Part IIa, p 93. (5), Snell, <i>Metals I</i> , p 404. (7)                               |
|               | Silver diethyldithiocarbamate                         | Fries/Getrost, p 36. (2)                                                                                                                        |
|               | Silver diethyldithiocarbamate                         | Fries/Getrost, p 41. (2), Marczenko, p 153. (3), Onishi, Part IIa, p 153. (5), Snell, <i>Metals I</i> , p 370. (7)                              |
|               |                                                       | Fries/Getrost, p 46. (2), Snell, <i>Metals II</i> , p 1782. (8), Onishi, Part IIa, p 202. (5)                                                   |
| Barium        | Sulfonazo III                                         | Snell, <i>Metals I</i> , p 667. (7)                                                                                                             |
| Beryllium     | Beryllon II                                           | Marczenko, p 163. (3), Snell, <i>Metals I</i> , p 672. (7)                                                                                      |
|               | Chrome Azurol S                                       | Marczenko, p 164. (3), Snell, <i>Metals I</i> , p 673. (7)                                                                                      |
|               | Chrome Azurol S + Cetyltrimethylammonium bromide      | Snell, <i>Metals I</i> , p 675. (7), <i>Talanta</i> , 31, 249, (1984).                                                                          |
|               | Eriochrome Cyanine R                                  | Zh. Anal. Khim., 33, 1298, (1978).                                                                                                              |
|               | Eriochrome Cyanine R + Cetyltrimethylammonium bromide |                                                                                                                                                 |
| Bismuth       | Dithizone                                             | Onishi, Part IIa, p 262. (5), Snell, <i>Metals I</i> , p 303. (7)                                                                               |
|               | Pyrocatechol Violet                                   | Fres. Z. Anal. Chem., 186, 418, (1962).                                                                                                         |
|               | Pyrocatechol Violet + Cetyltrimethylammonium bromide  | Zh. Anal. Khim., 38, 216, (1983).                                                                                                               |
|               | Thiourea                                              | Onishi, Part IIa, p 260. (5), Snell, <i>Metals I</i> , p 317. (7)                                                                               |
|               | Xylenol Orange                                        | Fries/Getrost, p 57. (2), Marczenko, p 172. (3), Snell, <i>Metals I</i> , p 320. (7)                                                            |
| Boron         | Azomethine H                                          | Snell, <i>Nonmetals</i> , p 165. (9)                                                                                                            |
|               | Carminic acid                                         | Boltz, p 14. (1), Fries/Getrost, p 65. (2), Snell, <i>Nonmetals</i> , p 170. (9), Williams, p 35. (11)                                          |
|               | Curcumin                                              | Boltz, p 8. (1), Fries/Getrost, p 68. (2), Marczenko, p 180. (3), Snell, <i>Nonmetals</i> , p 180. (9), Fres. Z. Anal. Chem., 323, 266, (1986). |
|               | Methylene Blue                                        | Boltz, p 21. (1), Marczenko, p 183. (3), Snell, <i>Nonmetals</i> , p 205. (9), <i>Talanta</i> , 31, 547, (1984).                                |
|               |                                                       |                                                                                                                                                 |
| Bromide       | Fluorescein                                           | Boltz, p 48. (1), Snell, <i>Nonmetals</i> , p 276., Fres. Z. Anal. Chem., 301, 28 (1980).                                                       |
| Cadmium       | Phenol Red                                            | Boltz, p 44. (1), Marczenko, p 190. (3), Snell, <i>Nonmetals</i> , p 28. (9)                                                                    |
|               | 2-(5-Bromo-2-pyridylazo)-5-diethylaminophenol         | Marczenko, p 197. (3)                                                                                                                           |
|               | Cadion                                                | Onishi, Part IIa, p 323. (5)                                                                                                                    |
|               | Dithizone                                             | Fries/Getrost, p 78. (2), Onishi, Part IIa, p 315. (5), Snell, <i>Metals I</i> , p 279. (7), West, p 25. (10).                                  |
| Calcium       | 4-(2-Pyridylazo)resorcinol                            | Fres. Z. Anal. Chem., 310, 51, (1982).                                                                                                          |
|               | Chlorophosphonazo III                                 | Marczenko, p 207. (3), Snell, <i>Metals II</i> , p 1744. (8)                                                                                    |
|               | Glyoxal-bis(2-hydroxyanil)                            | Fries/Getrost, p 86. (2), Onishi, Part IIa, p 352. (5), Snell, <i>Metals I</i> , p 1762. (8)                                                    |
|               | Murexide                                              | Onishi, Part IIa, p 357. (5), Snell, <i>Metals II</i> , p 1769. (8)                                                                             |
| Cerium        | Phthalein Purple                                      | <i>Anal. Chim. Acta</i> , 34, 71 (1966).                                                                                                        |
|               | N-benzoyl-N-phenylhydroxylamine                       | <i>Anal. Chim. Acta</i> , 48, 155, (1969).                                                                                                      |

| Determination | Reagents                                                               | Ref.                                                                                                                 |
|---------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
|               | 8-Hydroxyquinoline                                                     | Fries/Getrost, p 93. (2), Marczenko, p 220. (3), Onishi, Part IIa, p 383. (7)                                        |
| Chlorine      | <i>N,N</i> -Diethyl-1,4-phenylenediamine                               | Boltz, p 92. (1), Fries/Getrost, p 101. (2), Snell, <i>Nonmetals</i> , p 225. (9), <i>Analyst</i> , 90, 187, (1965). |
| Chromium      | 1,5-Diphenylcarbazide                                                  | Fries/Getrost, p 105. (2), Onishi, Part IIa, p 412. (5), Snell, <i>Metals I</i> , p 714. (7), West, p 12. (10)       |
|               | 4-(2-Pyridylazo)resorcinol                                             | Snell, <i>Metals I</i> , p 736. (7), West, p 17. (10)                                                                |
|               | 4-(2-Pyridylazo)resorcinol + Tetradecyldimethylbenzylammonium chloride | West, p 17. (10), <i>Anal. Chim. Acta</i> , 67, 297, (1973).                                                         |
|               | 4-(2-Pyridylazo)resorcinol + Hydrogen peroxide                         | Fres. <i>Z. Anal. Chem.</i> , 304, 382, (1980).                                                                      |
| Cobalt        | Nitroso-R salt                                                         | Fries/Getrost, p 118. (2), Onishi, Part IIa, p 454. (5), Snell, <i>Metals I</i> , p 953. (7)                         |
|               | 1-Nitroso-2-naphthol                                                   | Fries/Getrost, p 111. (2), Marczenko, p 246. (3), Snell, <i>Metals I</i> , p 947. (5)                                |
|               | 2-Nitroso-1-naphthol                                                   | Fries/Getrost, p 113. (2), Onishi, Part IIa, p 459. (5), Snell, <i>Metals I</i> , p 949. (7), West, p 45. (10)       |
|               | 4-(2-Pyridylazo)resorcinol                                             | Snell, <i>Metals I</i> , p 969. (7), West, p 44. (10)                                                                |
|               | 4-(2-Pyridylazo)resorcinol + Diphenylguanidine                         | <i>Zh. Anal. Khim.</i> , 35, 1306, (1980).                                                                           |
| Copper        | Bathocuproine                                                          | Fries/Getrost, p 135. (2), Snell, <i>Metals I</i> , p 148. (7)                                                       |
|               | Bathocuproine disulfonic acid                                          | Fries/Getrost, p 137. (2), West, p 52. (10)                                                                          |
|               | Dithizone                                                              | Marczenko, p 258. (3), Onishi, Part IIa, p 529. (5), Snell, <i>Metals I</i> , p 199. (7)                             |
|               | Neocuproine                                                            | Snell, <i>Metals I</i> , p 217. (5), West, p 51. (10)                                                                |
|               | Cuprizone                                                              | Onishi, Part IIa, p 534. (5), Snell, <i>Metals I</i> , p 157. (7), West, p 53. (10)                                  |
|               | 4-(2-pyridylazo)resorcinol + Tetradecyldimethylbenzylammonium chloride | <i>Anal. Chim. Acta</i> , 138, 321, (1982).                                                                          |
| Cyanide       | Barbituric Acid + Pyridine                                             | Fries/Getrost, p 153. (2), Snell, <i>Nonmetals</i> , p 653. (9)                                                      |
|               | Barbituric Acid + Pyridine-4-carboxylic acid                           | <i>Anal. Chim. Acta</i> , 99, 197, (1978).                                                                           |
| Fluoride      | Alizarin Fluorine blue + Lanthanum(III) ion                            | Boltz, p 129. (1), Fries/Getrost, p 158. (2), Snell, <i>Nonmetals</i> , p 333. (9), Williams, p 354. (11)            |
|               | Eriochrome Cyanine R + Zirconium(IV) ion                               | Boltz, p 119. (1), Snell, <i>Nonmetals</i> , p 359. (2), Williams, p 357. (11)                                       |
| Gallium       | Pyrocatechol violet + Diphenylguanidine                                | Snell, <i>Metals I</i> , p 500. (7)                                                                                  |
|               | 8-Hydroxyquinoline                                                     | Onishi Pt IIa, p 582. (5), Snell, <i>Metals I</i> , p 505. (7)                                                       |
|               | 1-(2-Pyridylazo)-2-naphthol                                            | Snell, <i>Metals I</i> , p 512. (7)                                                                                  |
|               | 4-(2-Pyridylazo)resorcinol                                             | Snell, <i>Metals I</i> , p 513. (7)                                                                                  |
|               | Rhodamine B                                                            | Marczenko, p 284. (3), Onishi, Part IIa, p 578. (5), Snell, <i>Metals I</i> , p 515. (7)                             |
|               | Xylenol Orange                                                         | Fries/Getrost, p 166. (2), Snell, <i>Metals I</i> , p 523. (7)                                                       |
|               | Xylenol Orange + 8-Hydroxyquinoline                                    | <i>Zh. Anal. Khim.</i> , 26, 75, (1971).                                                                             |
| Germanium     | Brilliant Green + Molybdate                                            | Snell, <i>Metals I</i> , p 562. (7)                                                                                  |
|               | Phenylfluorone                                                         | Fries/Getrost, p 168. (2), Marczenko, p 292. (3), Onishi, Part IIa, p 607. (5), Snell, <i>Metals I</i> , p 570. (7)  |
| Gold          | 5-(4-Diethylaminobenzylidene) rhodanine                                | Fries/Getrost, p 173. (2), Onishi, Part IIa, p 631. (5), Snell, <i>Metals II</i> , p 1516. (8)                       |
|               | Rhodamine B                                                            | Fries/Getrost, p 175. (2), Marczenko, p 301. (3), Onishi, Part IIa, p 637. (5), Snell, <i>Metals II</i> , p 513. (8) |
| Hafnium       | Arsenazo III                                                           | Snell, <i>Metals II</i> , p 1184. (8), <i>Talanta</i> , 19, 807, (1972).                                             |
| Indium        | Bromopyrogallol Red                                                    | Snell, <i>Metals I</i> , p 469. (7)                                                                                  |
|               | Chrome Azurol S                                                        | Snell, <i>Metals I</i> , p 474. (7)                                                                                  |
|               | Chrome Azurol S + Cetyltrimethylammonium bromide                       | <i>Anal. Chim. Acta</i> , 67, 107, (1973).                                                                           |
|               | Dithizone                                                              | Fries/Getrost, p 179. (2), Onishi, Part IIa, p 672. (5), Snell, <i>Metals I</i> , p 474. (7)                         |
|               | 8-Hydroxyquinoline                                                     | Onishi, Part IIa, p 670. (5), Snell, <i>Metals I</i> , p 475. (7)                                                    |
|               | 1-(2-Pyridylazo)-2-naphthol                                            | Snell, <i>Metals I</i> , p 480. (7)                                                                                  |
|               | 4-(2-Pyridylazo)resorcinol                                             | Marczenko, p 309. (3), Snell, <i>Metals I</i> , p 480. (7)                                                           |
| Iodide        | Neocuproine + Copper(II)                                               | <i>Anal. Chim. Acta</i> , 69, 321, (1974).                                                                           |
| Iodine        | Starch                                                                 | Boltz, p 162. (1), Marczenko, p 316. (3), Snell, <i>Nonmetals</i> , p 307. (9)                                       |
| Iridium       | Rhodamine 6G + Tin(II)                                                 | Marczenko, p 323. (3)                                                                                                |
|               | <i>N,N</i> -Dimethyl-4-nitrosoaniline                                  | <i>Anal. Chem.</i> , 27, 1776, (1955).                                                                               |
| Iron          | Bathophenanthroline                                                    | Fries/Getrost, p 189. (2), Onishi, Part IIa, p 729. (5), Snell, <i>Metals I</i> , p 763. (7)                         |
|               | Bathophenanthroline disulfonic acid                                    | Fries/Getrost, p 191. (2), Snell, <i>Metals I</i> , p 772. (7)                                                       |

| Determination     | Reagents                                                                      | Ref.                                                                                                                                                       |
|-------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lanthanum<br>Lead | 2,2'-Bipyridyl                                                                | Snell, <i>Metals I</i> , p 750. (7)                                                                                                                        |
|                   | Chrome Azurol S + Cetyltrimethylammonium bromide                              | Snell, <i>Metals I</i> , p 757. (7), <i>Coll. Czech. Chem. Comm.</i> , 45, 2656, (1980).                                                                   |
|                   | 1,10-Phenanthroline                                                           | Fries/Getrost, p 199. (2), Marczenko, p 331. (3), Onishi, Part IIa, p 725. (5), Snell, <i>Metals I</i> , p 795. (7)                                        |
|                   | 1,10-Phenanthroline + Bromothymol Blue                                        | <i>Zh. Anal. Khim.</i> , 25, 1348, (1970).                                                                                                                 |
|                   | Ferrozine                                                                     | Onishi, Part IIa, p 730. (5), Snell, <i>Metals I</i> , p 783. (7)                                                                                          |
|                   | Arsenazo III                                                                  | Marczenko, p 468. (3), Snell, <i>Metals II</i> , p 1910. (8)                                                                                               |
|                   | Dithizone                                                                     | Fries/Getrost, p 207. (2), Onishi, Part IIa, p 824. (5), Snell, <i>Metals I</i> , p 2. (7), West, p 34. (10)                                               |
|                   | Sodium diethyldithiocarbamate                                                 | Fries/Getrost, p 214. (2), Snell, <i>Metals I</i> , p 27. (7)                                                                                              |
|                   | 4-(2-Pyridylazo)resorcinol                                                    | Fries/Getrost, p 220. (2), Marczenko, p 347. (3), Snell, <i>Metals I</i> , p 34. (7)                                                                       |
|                   | Thoron                                                                        | Onishi, Part IIa, p 863. (5), Snell, <i>Metals II</i> , p 1726. (8), <i>Talanta</i> , 30, 587, (1983).                                                     |
| Magnesium         | Eriochrome Black T                                                            | Fries/Getrost, p 226. (2), Marczenko, p 355. (3), Onishi, Part IIb, p 13. (6), Snell, <i>Metals II</i> , p 1932. (8)                                       |
|                   | 8-Hydroxyquinoline                                                            | Onishi, Part IIb, p 11. (6), Snell, <i>Metals II</i> , p 1938. (8)                                                                                         |
|                   | 8-Hydroxyquinoline + Butylamine                                               | Fries/Getrost, p 228. (2), Snell, <i>Metals II</i> , p 1938. (8)                                                                                           |
|                   | Titan Yellow                                                                  | Fries/Getrost, p 234. (2), Marczenko, p 352. (3), Snell, <i>Metals II</i> , p 1945. (8)                                                                    |
|                   | Xylidyl Blue                                                                  | Fries/Getrost, p 231. (2), Onishi, Part IIb, p 14. (6), Snell, <i>Metals II</i> , p 1950. (8)                                                              |
| Manganese         | Formaldehyde                                                                  | Fries/Getrost, p 236. (2), Marczenko, p 364. (3), Onishi Part IIb, p 38. (6), Snell, <i>Metals II</i> , 1010. (8)                                          |
| Mercury           | Dithizone                                                                     | Fries/Getrost, p 243. (2), Marczenko, p 373. (3), Onishi, Part IIb, p 66. (6), Snell, <i>Metals I</i> , p 107. (7), West, p 29. (10)                       |
|                   | Michler's thioketone                                                          | Marczenko, p 375. (3), Snell, <i>Metals I</i> , p 126. (7)                                                                                                 |
| Molybdenum        | Xylenol Orange                                                                | <i>Talanta</i> , 16, 1023, (1969)                                                                                                                          |
|                   | Bromopyrogallol Red + Cetylpyridium chloride                                  | West, p 58. (10)                                                                                                                                           |
|                   | Phenylfluorone                                                                | Snell, <i>Metals II</i> , p 1311. (8), <i>Microchem. J.</i> , 31, 56, (1985).                                                                              |
|                   | Toluene-3,4-dithiol                                                           | Fries/Getrost, p 251. (2), Marczenko, p 384. (3), Onishi, Part IIb, p 96. (6), Snell, <i>Metals II</i> , p 1301. (8)                                       |
| Nickel            | 2-(5-Bromo-2-pyridylazo)-5-diethylaminophenol                                 | Marczenko, p 397. (3), <i>Talanta</i> 28, 189, (1981).                                                                                                     |
|                   | Dimethylglyoxime                                                              | Fries/Getrost, p 263. (2), Marczenko, p 393. (3), Onishi, Part IIb, p 125. (6), Snell, <i>Metals I</i> , p 887. (7)                                        |
|                   | Dimethylglyoxime + Oxidant                                                    | Fries/Getrost, p 263. (2), Onishi, Part IIb, p 125. (6), Snell, <i>Metals I</i> , p 887. (7)                                                               |
|                   | 2,2'-Furildioxime                                                             | Marczenko, p 396. (3), Snell, <i>Metals I</i> , p 904. (7)                                                                                                 |
|                   | 2-(2-Pyridylazo)-2-naphthol                                                   | Snell, <i>Metals I</i> , p 910. (7)                                                                                                                        |
|                   | 4-(2-Pyridylazo)resorcinol                                                    | Snell, <i>Metals I</i> , p 911. (7), West, p 39. (10), <i>Anal. Chim. Acta</i> , 82, 431, (1976).                                                          |
|                   |                                                                               |                                                                                                                                                            |
| Niobium           | <i>N</i> -Benzoyl- <i>N</i> -phenylhydroxylamine                              | Snell, <i>Metals II</i> , p 1425. (8)                                                                                                                      |
|                   | Pyrocatechol + EDTA or 2,2'-Bipyridyl or 1-(2-thenoyl)-3,3,3-trifluoroacetone | Snell, <i>Metals II</i> , p 1427. (8)                                                                                                                      |
|                   | Bromopyrogallol red                                                           | Marczenko, p 407. (3), Snell, <i>Metals II</i> , p 1426. (8)                                                                                               |
|                   | Bromopyrogallol red + Cetylpyridinium chloride                                | <i>Talanta</i> , 32, 189, (1985).                                                                                                                          |
|                   | 4-(2-Pyridylazo)resorcinol                                                    | Fries/Getrost, p 274. (2), Marczenko, p 406. (3), Onishi, Part IIb, p 160. (7), Snell, <i>Metals II</i> , p 1447. (8)                                      |
|                   | Sulfochlorophenol S                                                           | Onishi, Part IIb, p 161. (7), Snell, <i>Metals II</i> , p 1430. (8)                                                                                        |
|                   | Xylenol Orange                                                                | Onishi, Part IIb, p 164. (7)                                                                                                                               |
| Nitrate           | Brucine                                                                       | Boltz, p 227. (1), Fries/Getrost, p 280. (2), Snell, <i>Nonmetals</i> , p 546. (9)                                                                         |
|                   | Chromotropic acid                                                             | Boltz, p 229. (1), Fries/Getrost, p 281. (2), Snell, <i>Nonmetals</i> , p 548. (9), Williams, p 132. (11), <i>Fres. Z. Anal. Chem.</i> , 320, 490, (1985). |
| Nitrite           | Sulfanilamide + <i>N</i> -(1-Naphthyl)ethylenediamine dihydrochloride         | Fries/Getrost, p 279. (2), Snell, <i>Nonmetals</i> , p 559. (9)                                                                                            |
|                   | Sulfanilamide + <i>N</i> -(1-Naphthyl)ethylenediamine dihydrochlorine         | Boltz, p 241. (1), Snell, <i>Nonmetals</i> , p 585. (8), <i>Analyst</i> , 109, 1281, (1984).                                                               |
|                   | Sulfanilic acid + 1-Naphthylamine                                             | Boltz, p 237. (1), Fries/Getrost, p 285. (2), Marczenko, p 419. (3), Snell, <i>Nonmetals</i> , p 586. (9)                                                  |
| Osmium            | 1,5-Diphenylcarbazine                                                         | Marczenko, p 428. (3)                                                                                                                                      |
| Palladium         | 2-(5-Bromo-2-pyridylazo)-5-diethylaminophenol                                 | <i>Talanta</i> , 33, 939, (1986).                                                                                                                          |

| Determination | Reagents                                                   | Ref.                                                                                                                        |
|---------------|------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
|               | Dithizone                                                  | Marczenko, p 440. (3), Onishi, Part IIB, p 227. (6), Snell, <i>Metals II</i> , p 1577. (8)                                  |
|               | 2-Nitroso-1-naphthol                                       | Fries/Getrost, p 294. (2), Onishi, Part IIB, p 226. (6), Snell, <i>Metals II</i> , p 1581. (8)                              |
| Phosphate     | 4-(2-Pyridylazo)resorcinol                                 | Snell, <i>Metals II</i> , p 1583. (8) <i>Analyst</i> , 107, 708, (1982).                                                    |
|               | Rhodamine B + Molybdate                                    | Snell, <i>Nonmetals</i> , p 103. (9)                                                                                        |
|               | Malachite Green + Molybdate                                | Snell, <i>Nonmetals</i> , p 12. (9), <i>Analyst</i> , 108, 361, (1983).                                                     |
| Platinum      | Sulfochlorophenolazorhodamine                              | Onishi, Part IIB, p 253. (6), <i>Talanta</i> , 34, 87, (1987).                                                              |
|               | Dithizone                                                  | Fries/Getrost, p 300. (2), Onishi, Part IIB, p 253. (6), Snell, <i>Metals II</i> , p 1534. (8)                              |
| Rare Earths   | 2-Mercaptobenzothiazole                                    | Fries/Getrost, p 302. (2), <i>Zh. Anal. Khim.</i> , 24, 1172, (1969).                                                       |
|               | Arsenazo I                                                 | Marczenko, p 470. (3), Onishi, Part IIA, p 785. (5), Snell, <i>Metals II</i> , p 1857. (8)                                  |
|               | Arsenazo III                                               | Fries/Getrost, p 309. (2), Marczenko, p 468. (3), Onishi, Part IIA, p 786. (5), Snell, <i>Metals II</i> , p 1862. (8)       |
| Rhenium       | Xylenol Orange                                             | Onishi, Part IIA, p 787. (5), Snell, <i>Metals II</i> , p 1874. (8)                                                         |
|               | 2,2'-Furildioxime                                          | Fries/Getrost, p 310. (2), Marczenko, p 481. (3), Onishi, Part IIB, p 288. (6), Snell, <i>Metals II</i> , p 1659. (8)       |
| Rhodium       | 1-(2-Pyridylazo)-2-naphthol                                | Fries/Getrost, p 311. (2), Snell, <i>Metals II</i> , p 1553. (8)                                                            |
| Ruthenium     | 1,10-Phenanthroline                                        | Onishi, Part IIB, p 331. (6), Snell, <i>Metals II</i> , p 1623. (8)                                                         |
|               | Thiourea                                                   | Fries/Getrost, p 318. (2), Onishi, Part IIB, 329. (6), Snell, <i>Metals II</i> , p 1626. (8)                                |
| Scandium      | 1,4-Diphenylthiosemicarbazide                              | Marczenko, p 493. (3), Onishi, Part IIB, p 330. (8)                                                                         |
|               | Alizarin red S                                             | Fries/Getrost, p 319. (2), Onishi, Part IIB, p 360. (6), Snell, <i>Metals I</i> , p 536. (7)                                |
|               | Arsenazo III                                               | Onishi, Part IIB, p 359. (6), Snell, <i>Metals I</i> , p 539. (7)                                                           |
|               | Chrome Azurol S                                            | Snell, <i>Metals I</i> , p 551. (7), <i>Anal. Chim. Acta</i> , 159, 309, (1984).                                            |
|               | Xylenol Orange                                             | Marczenko, p 501. (3), Onishi, Part IIB, p 357. (6), Snell, <i>Metals I</i> , p 547. (7)                                    |
| Selenium      | 3,3'-Diaminobenzidine                                      | Boltz, p 391. (1), Fries/Getrost, p 323. (2), Marczenko, p 508. (3), Snell, <i>Nonmetals</i> , p 490. (9), West, p 4. (10). |
|               | 2,3-Diaminonaphthalene                                     | Snell, <i>Nonmetals</i> , p 501. (9)                                                                                        |
| Silver        | Dithizone                                                  | Fries/Getrost, p 328. (2), Marczenko, p 524. (3), Onishi, Part IIB, p 379. (6), Snell, <i>Metals I</i> , p 82. (7)          |
|               | Eosin + 1,10-Phenanthroline                                | Snell, <i>Metals I</i> , p 93. (7)                                                                                          |
| Sulfate       | Methylthymol blue + Barium (II)                            | Snell, <i>Nonmetals</i> , p 457. (9)                                                                                        |
| Sulfide       | N,N-Dimethyl-1,4-phenylenediamine                          | Boltz, p 483. (1), Fries/Getrost, p 344. (2), Snell, <i>Nonmetals</i> , p 400. (9), Williams, p 578. (11)                   |
| Sulfite       | Pararosaniline + Formaldehyde                              | Boltz, p 478. (1), Marczenko, p 540. (3), Snell, <i>Nonmetals</i> , p 430. (9), Williams, p 591. (11)                       |
| Tantalum      | Methyl Violet                                              | Marczenko, p 551. (3), Snell, <i>Metals II</i> , p 1485. (8)                                                                |
|               | 4-(2-Pyridylazo)resorcinol                                 | Snell, <i>Metals II</i> , p 1488. (8)                                                                                       |
|               | Phenylfluorone                                             | Onishi, Part IIB, p 166. (6), Snell, <i>Metals II</i> , p 1486. (8)                                                         |
| Tellurium     | Diethyldithiocarbamate                                     | Boltz, p 402. (1), Fries/Getrost, p 348. (2), Snell, <i>Nonmetals</i> , p 533. (9), Williams, p 220. (10)                   |
|               | Bismuthiol II                                              | Boltz, p 401. (1), Marczenko, p 557. (3), Snell, <i>Nonmetals</i> , p 524. (9)                                              |
| Thallium      | Brilliant green                                            | Fries/Getrost, p 352. (2), Marczenko, p 567. (3), Onishi, Part IIB, p 426. (6), Snell, <i>Metals I</i> , p 45. (7)          |
|               | Dithizone                                                  | Fries/Getrost, p 355. (2), Onishi, Part IIB, p 426. (6), Snell, <i>Metals I</i> , p 54. (7)                                 |
|               | Rhodamine B                                                | Fries/Getrost, p 354. (2), Marczenko, p 566. (3), Onishi, Part IIB, p 424. (6), Snell, <i>Metals I</i> , p 63. (7)          |
| Thorium       | Arsenazo III                                               | Fries/Getrost, p 360. (2), Marczenko, p 575. (3), Onishi, Part IIB, p 460. (6), Snell, <i>Metals II</i> , p 1820. (8)       |
|               | Thoron                                                     | Marczenko, p 574. (3), Onishi, Part IIB, p 463. (6), Snell, <i>Metals I</i> , p 1835. (7)                                   |
|               | Xylenol Orange                                             | Snell, <i>Metals I</i> , p 1852. (7)                                                                                        |
|               | Xylenol Orange + Cetyltrimethylammonium bromide            | <i>Talanta</i> , 26, 499, (1979).                                                                                           |
| Tin           | Pyrocatechol violet (and + Cetyltrimethylammonium bromide) | Marczenko, p 585. (3), Onishi, Part IIB, p 501. (6), Snell, <i>Metals I</i> , p 422. (7)                                    |
|               | Gallein                                                    | Onishi, Part IIB, p 507, 510. (6), Snell, <i>Metals I</i> , p 432. (7)                                                      |
|               | Phenylfluorone                                             | Fries/Getrost, p 368. (2), Marczenko, p 582. (3), Onishi, Part IIB, p 497. (6), Snell, <i>Metals I</i> , p 444. (7)         |



| Determination | Reagents                                         | Ref.                                                                                                                  |
|---------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
|               | Toluene-3,4-dithiol + Dispersant                 | Fries/Getrost, p 366. (2), Onishi, Part IIb, p 502. (6), Snell, <i>Metals I</i> , p 427. (7)                          |
| Titanium      | Chromotropic acid                                | Marczenko, p 593. (3), Onishi, Part IIb, p 551. (6), Snell, <i>Metals II</i> , p 1080. (8)                            |
|               | Diantipyrinylmethane                             | Onishi, Part IIb, p 545. (6), Snell, <i>Metals II</i> , 1085. (8)                                                     |
|               | Tiron                                            | Fries/Getrost, p 376. (2), Onishi, Part IIb, p 549. (6), Snell, <i>Metals II</i> , p 1114. (8)                        |
| Tungsten      | Pyrocatechol Violet                              | Snell, <i>Metals II</i> , p 1265. (8)                                                                                 |
|               | Tetraphenylarsonium chloride + Thiocyanate       | Onishi, Part IIb, p 596. (6), Snell, <i>Metals II</i> , p 1278. (8)                                                   |
|               | Toluene-3,5-dithiol                              | Marczenko, p 605. (3), Onishi, Part IIb, p 590. (6), Snell, <i>Metals II</i> , p 1267. (8)                            |
| Uranium       | Arsenazo III                                     | Marczenko, p 611. (3), Onishi, Part IIb, p 627. (6), Snell, <i>Metals II</i> , p 1356. (8)                            |
|               | 2-(5-Bromo-2-pyridylazo)diethylaminophenol       | Fries/Getrost, p 388. (2), Onishi, Part IIb, p 625. (6)                                                               |
|               | Chlorophosphonazo III                            | Snell, <i>Metals II</i> , p 1367. (8), <i>Fres. Z. Anal. Chem.</i> , 306, 110, (1981).                                |
|               | 1-(2-Pyridylazo)-2-naphthol                      | Fries/Getrost, p 386. (2), Onishi, Part IIb, p 625. (6), Snell, <i>Metals II</i> , p 1387. (8)                        |
| Vanadium      | <i>N</i> -Benzoyl- <i>N</i> -phenylhydroxylamine | Fries/Getrost, p 395. (2), Marczenko, p 625. (3), Snell, <i>Metals II</i> , p 1196. (8)                               |
|               | 8-Hydroxyquinoline                               | Marczenko, p 623. (3), Snell, <i>Metals II</i> , p 1209. (8)                                                          |
|               | 4-(2-pyridylazo)resorcinol                       | Fries/Getrost, p 404. (2), Marczenko, p 628. (3), Onishi, Part IIb, p 625. (6), Snell, <i>Metals II</i> , p 1226. (8) |
| Yttrium       | Alizarin Red S                                   | Fries/Getrost, p 406. (2), Onishi, Part IIa, p 784. (5), Snell, <i>Metals II</i> , p 1919. (8)                        |
|               | Arsenazo III                                     | Marczenko, p 468. (3), Onishi, Part IIa, p 786. (5), Snell, <i>Metals II</i> , p 1921. (8)                            |
|               | Xylenol Orange                                   | Fries/Getrost, p 406. (2), Onishi, Part IIa, p 787. (5), Snell, <i>Metals II</i> , p 1923. (8)                        |
| Zinc          | Dithizone                                        | Fries/Getrost, p 408. (2), Marczenko, p 637. (3), Onishi, Part IIb, p 708. (6), Snell, <i>Metals II</i> , p 1042. (8) |
|               | 1-(2-Pyridylazo)-2-naphthol                      | Marczenko, p 639. (3), Onishi, Part IIb, p 719. (6), Snell, <i>Metals II</i> , p 1056. (8)                            |
|               | Xylenol Orange                                   | Fries/Getrost, p 417. (2), Snell, <i>Metals II</i> , p 1062. (8), Talanta, 26, 693, (1979).                           |
|               | Zircon                                           | Fries/Getrost, p 412. (2), Onishi, Part IIb, p 719. (6), Snell, <i>Metals II</i> , p 1063. (8), West, p 23. (10)      |
|               |                                                  | Fries/Getrost, p 421. (2), Marczenko, p 647. (3), Onishi, Part IIb, p 763. (6), Snell, <i>Metals II</i> , p 1136. (8) |
| Zirconium     | Alizarin Red S                                   | Fries/Getrost, p 421. (2), Onishi, Part IIb, p 770. (6), Snell, <i>Metals II</i> , p 1143. (8)                        |
|               | Arsenazo III                                     | Onishi, Part IIb, p 771. (6), Snell, <i>Metals II</i> , p 1149. (8)                                                   |
|               | Pyrocatechol Violet                              | Fries/Getrost, p 424. (2), Onishi, Part IIb, p 765. (6), Snell, <i>Metals II</i> , p 1158. (8)                        |
|               | Morin                                            | Fries/Getrost, p 419. (2), Marczenko, p 648. (3), Onishi, Part IIb, p 767. (6), Snell, <i>Metals II</i> , p 1167. (8) |
|               | Xylenol Orange                                   |                                                                                                                       |

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# ACID-BASE INDICATORS

A. K. Covington

The first part of this table lists some common acid-base indicators in alphabetical order along with the approximate pH range(s) at which a color change occurs. Following this is a table of the same indicators ordered by pH range, which includes the nature of the color change, instructions on preparation of the indicator solution, and the acid dissociation constant  $pK$ , when available.

The color code is:

|               |            |                  |
|---------------|------------|------------------|
| C = colorless | A = amber  | B/G = blue-green |
| Pk = pink     | Y = yellow | V = violet       |
| R = red       | B = blue   | P = purple       |
| O = orange    |            |                  |

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| Indicator                                                                     | pH Range           | Indicator                                             | pH Range         |
|-------------------------------------------------------------------------------|--------------------|-------------------------------------------------------|------------------|
| Alizarin                                                                      | 5.6-7.2; 11.0-12.4 | Ethyl bis(2,4-dimethylphenyl)ethanoate                | 8.4-9.6          |
| Alizarin Red S                                                                | 4.6-6.0            | Ethyl Orange                                          | 3.4-4.8          |
| Alizarin Yellow R                                                             | 10.1-12.0          | Ethyl Red                                             | 4.0-5.8          |
| Benzopurpurine 4B                                                             | 2.2-4.2            | Ethyl Violet                                          | 0.0-2.4          |
| 4,4'-Bis(2-amino-1-naphthylazo)-2,2'-stilbenedisulfonic acid                  | 3.0-4.0            | 5,5'-Indigodisulfonic acid, disodium salt             | 11.4-13.0        |
| 4,4'-Bis(4-amino-1-naphthylazo)-2,2'-stilbenedisulfonic acid                  | 8.0-9.0            | Malachite Green                                       | 0.2-1.8          |
| Brilliant Yellow                                                              | 6.6-7.8            | Metacresol Purple                                     | 1.2-2.8; 7.4-9.0 |
| Bromocresol Green                                                             | 3.8-5.4            | Metanil Yellow                                        | 1.2-2.4          |
| Bromocresol Purple                                                            | 5.2-6.8            | Methyl Green                                          | 0.2-1.8          |
| Bromophenol Blue                                                              | 3.0-4.6            | Methyl Orange                                         | 3.2-4.4          |
| Bromothymol Blue                                                              | 6.0-7.6            | Methyl Red                                            | 4.8-6.0          |
| Chlorophenol Red                                                              | 5.2-6.8            | Methyl Violet                                         | 0.0-1.6          |
| Clayton Yellow                                                                | 12.2-13.2          | <i>p</i> -Naphtholbenzein                             | 8.2-10.0         |
| Congo Red                                                                     | 3.0-5.0            | Neutral Red                                           | 6.8-8.0          |
| <i>o</i> -Cresolphthalein                                                     | 8.2-9.8            | <i>p</i> -Nitrophenol                                 | 5.4-6.6          |
| Cresol Red                                                                    | 0.0-1.0; 7.0-8.8   | <i>m</i> -Nitrophenol                                 | 6.8-8.6          |
| Crystal Violet                                                                | 0.0-1.8            | Orange IV                                             | 1.4-2.8          |
| Curcumin (Turmaric)                                                           | 7.4-8.6            | Paramethyl Red                                        | 1.0-3.0          |
| <i>p</i> -(2,4-Dihydroxyphenylazo) benzenesulfonic acid, sodium salt          | 11.4-12.6          | Phenolphthalein                                       | 8.2-10.0         |
| <i>p</i> -Dimethylaminoazobenzene                                             | 2.8-4.4            | Phenol Red                                            | 6.6-8.0          |
| 4-(4-Dimethylamino-1-naphthylazo)-3-methoxybenzenesulfonic acid               | 3.5-4.8            | 4-Phenylazodiphenylamine                              | 1.2-2.6          |
| 2-( <i>p</i> -Dimethylamino-phenylazo)pyridine                                | 0.2-1.8; 4.4-5.6   | 4-Phenylazo-1-naphthylamine                           | 4.0-5.6          |
| <i>N,N</i> -Dimethyl- <i>p</i> -( <i>m</i> -tolylazo)aniline                  | 2.6-4.8            | Propyl Red                                            | 4.8-6.6          |
| 2,4-Dinitrophenol                                                             | 2.0-4.7            | Quinaldine Red                                        | 1.4-3.2          |
| 2-(2,4-Dinitrophenylazo)-1-naphthol-3,6-disulfonic acid, disodium salt        | 6.0-7.0            | Resazurin                                             | 3.8-6.4          |
| 6,8-Dinitro-2,4-(1 <i>H</i> )quinazolinedione                                 | 6.4-8.0            | Resorcin Blue                                         | 4.4-6.2          |
| Erythrosin, disodium salt                                                     | 2.2-3.6            | Tetrabromophenolphthalein ethyl ester, potassium salt | 3.0-4.2          |
| 4-( <i>p</i> -Ethoxyphenylazo)- <i>m</i> -phenylene-diamine monohydrochloride | 4.4-5.8            | Thymol Blue                                           | 1.2-2.8; 8.0-9.6 |
|                                                                               |                    | Thymolphthalein                                       | 9.4-10.6         |
|                                                                               |                    | 4- <i>o</i> -Tolylazo- <i>o</i> -toluidine            | 1.4-2.8          |
|                                                                               |                    | 1,3,5-Trinitrobenzene                                 | 12.0-14.0        |
|                                                                               |                    | 2,4,6-Trinitrotoluene                                 | 11.5-13.0        |
|                                                                               |                    | Turmaric                                              | 7.4-8.6          |

| pH range | Color change | Indicator                                                                    | pK   | Preparation                                            |
|----------|--------------|------------------------------------------------------------------------------|------|--------------------------------------------------------|
| 0.0-1.0  | R-Y          | Cresol Red                                                                   |      | 0.1 g in 26.2 mL 0.01 M NaOH + 223.8 mL water          |
| 0.0-1.6  | Y-B          | Methyl Violet                                                                |      | 0.01-0.05% in water                                    |
| 0.0-1.8  | Y-B          | Crystal Violet                                                               |      | 0.02% in water                                         |
| 0.0-2.4  | Y-B          | Ethyl Violet                                                                 |      | 0.1 g in 50 mL 50% v/v methanol-water                  |
| 0.2-1.8  | Y-B/G        | Malachite Green                                                              | 1.3  | water                                                  |
| 0.2-1.8  | Y-B          | Methyl Green                                                                 |      | 0.1% in water                                          |
| 0.2-1.8  | Y-R          | 2-( <i>p</i> -Dimethylaminophenylazo)pyridine                                |      | 0.1% in ethanol                                        |
| 1.0-3.0  | R-Y          | Paramethyl Red                                                               |      | ethanol                                                |
| 1.2-2.4  | R-Y          | Metanil Yellow                                                               |      | 0.01% in water                                         |
| 1.2-2.6  | R-Y          | 4-Phenylazodiphenylamine                                                     |      | 0.01 g in 1 mL 1 M HCl + 50 mL ethanol + 49 mL water   |
| 1.2-2.8  | R-Y          | Thymol Blue                                                                  | 1.65 | 0.1 g in 21.5 mL 0.01 M NaOH + 228.5 mL water          |
| 1.2-2.8  | R-Y          | Metacresol Purple                                                            | 1.51 | 0.1 g in 26.2 mL 0.01 M NaOH + 223.8 mL water          |
| 1.4-2.8  | R-Y          | Orange IV                                                                    |      | 0.01% in water                                         |
| 1.4-2.8  | O-Y          | 4- <i>o</i> -Tolylazo- <i>o</i> -toluidine                                   |      | water                                                  |
| 1.4-3.2  | C-R          | Quinaldine Red                                                               | 2.63 | 1% in ethanol                                          |
| 2.0-4.7  | C-Y          | 2,4-Dinitrophenol                                                            | 3.96 | sat. solution in water                                 |
| 2.2-3.6  | O-R          | Erythrosin, disodium salt                                                    |      | 0.1% in water                                          |
| 2.2-4.2  | V-R          | Benzopurpurine 4B                                                            |      | 0.1% in water                                          |
| 2.6-4.8  | R-Y          | <i>N,N</i> -Dimethyl- <i>p</i> -( <i>m</i> -tolylazo)aniline                 |      | 0.1% in water                                          |
| 2.8-4.4  | R-Y          | <i>p</i> -Dimethylaminoazobenzene                                            |      | 0.1 g in 100 mL 90% v/v ethanol-water                  |
| 3.0-4.0  | P-R          | 4,4'-Bis(2-amino-1-naphthylazo)-2,2'-stilbenedisulfonic acid                 |      | 0.1 g in 5.9 mL 0.05 M NaOH + 94.1 mL water            |
| 3.0-4.2  | Y-B          | Tetrabromophenolphthalein ethyl ester, potassium salt                        |      | 0.1% in ethanol                                        |
| 3.0-4.6  | Y-B          | Bromophenol Blue                                                             | 4.10 | 0.1 g in 14.9 mL 0.01 M NaOH + 235.1 mL water          |
| 3.0-5.0  | B-R          | Congo Red                                                                    |      | 0.1% in water                                          |
| 3.2-4.4  | R-Y          | Methyl Orange                                                                | 3.46 | 0.1% in water                                          |
| 3.4-4.8  | R-Y          | Ethyl Orange                                                                 | 4.34 | 0.05-0.2% in water or aqueous ethanol                  |
| 3.5-4.8  | V-Y          | 4-(4-Dimethylamino-1-naphthylazo)-3-methoxybenzenesulfonic acid              |      | 0.1% in 60% ethanol-water                              |
| 3.8-5.4  | Y-B          | Bromocresol Green                                                            | 4.90 | 0.1 g in 14.3 mL 0.01 M NaOH + 235.7 mL water          |
| 3.8-6.4  | O-V          | Resazurin                                                                    |      | water                                                  |
| 4.0-5.6  | R-Y          | 4-Phenylazo-1-naphthylamine                                                  |      | 0.1% in ethanol                                        |
| 4.0-5.8  | C-R          | Ethyl Red                                                                    | 5.42 | 0.1 g in 100 mL 50% v/v methanol-water 0.1% in ethanol |
| 4.4-5.6  | R-Y          | 2-( <i>p</i> -Dimethylaminophenylazo)pyridine                                |      | 0.1% in ethanol                                        |
| 4.4-5.8  | O-Y          | 4-( <i>p</i> -Ethoxyphenylazo)- <i>m</i> -phenylenediamine monohydrochloride |      | 0.1% in water                                          |
| 4.4-6.2  | R-B          | Resorcin Blue                                                                |      | 0.2% in ethanol                                        |
| 4.6-6.0  | Y-R          | Alizarin Red S                                                               |      | water                                                  |
| 4.8-6.0  | R-Y          | Methyl Red                                                                   | 5.00 | 0.02 g in 100 mL 60% v/v ethanol-water                 |
| 4.8-6.6  | R-Y          | Propyl Red                                                                   | 5.48 | ethanol                                                |
| 5.2-6.8  | Y-P          | Bromocresol Purple                                                           | 6.40 | 0.1 g in 18.5 mL 0.01 M NaOH + 231.5 mL water          |
| 5.2-6.8  | Y-R          | Chlorophenol Red                                                             | 6.25 | 0.1 g in 23.6 mL 0.01 M NaOH + 226.4 mL water          |
| 5.4-6.6  | C-Y          | <i>p</i> -Nitrophenol                                                        | 7.15 | 0.1% in water                                          |
| 5.6-7.2  | Y-R          | Alizarin                                                                     |      | 0.1% in methanol                                       |
| 6.0-7.0  | Y-B          | 2-(2,4-Dinitrophenylazo)-1-naphthol-3,6-disulfonic acid, disodium salt       |      | 0.1% in water                                          |
| 6.0-7.6  | Y-B          | Bromothymol Blue                                                             | 7.30 | 0.1 g in 16 mL 0.01 M NaOH + 234 mL water              |
| 6.4-8.0  | C-Y          | 6,8-Dinitro-2,4-(1 <i>H</i> )quinazolin-2-one                                |      | 25 g in 115 mL 1 M NaOH + 50 mL water at 100°C         |
| 6.6-7.8  | Y-R          | Brilliant Yellow                                                             |      | 1% in water                                            |
| 6.6-8.0  | Y-R          | Phenol Red                                                                   | 8.00 | 0.1 g in 28.2 mL 0.01 M NaOH + 221.8 mL water          |
| 6.8-8.0  | R-A          | Neutral Red                                                                  |      | 0.01 g in 100 mL 50% v/v ethanol-water                 |
| 6.8-8.6  | C-Y          | <i>m</i> -Nitrophenol                                                        | 8.28 | 0.3% in water                                          |
| 7.0-8.8  | Y-R          | Cresol Red                                                                   | 8.46 | 0.1 g in 26.2 mL 0.01 M NaOH + 223.8 mL water          |
| 7.4-8.6  | Y-R          | Turmaric (Curcumin)                                                          |      | ethanol                                                |
| 7.4-9.0  | Y-P          | Metacresol Purple                                                            | 8.3  | 0.1 g in 26.2 mL 0.01 M NaOH + 223.8 mL water          |
| 8.0-9.0  | B-R          | 4,4'-Bis(4-amino-1-naphthylazo)-2,2'-stilbenedisulfonic acid                 |      | 0.1 g in 5.9 mL 0.05 M NaOH + 94.1 mL water            |
| 8.0-9.6  | Y-B          | Thymol Blue                                                                  | 9.20 | 0.1 g in 21.5 mL 0.01 M NaOH + 228.5 mL water          |
| 8.2-10.0 | O-B          | <i>p</i> -Naphtholbenzein                                                    |      | 1% in dil. alkali                                      |

| pH range  | Color change | Indicator                                                            | p <i>K</i> | Preparation                            |
|-----------|--------------|----------------------------------------------------------------------|------------|----------------------------------------|
| 8.2-10.0  | C-Pk         | Phenolphthalein                                                      | 9.5        | 0.5 g in 100 mL 50% v/v ethanol-water  |
| 8.2-9.8   | C-R          | <i>o</i> -Cresolphthalein                                            |            | 0.04% in ethanol                       |
| 8.4-9.6   | C-B          | Ethyl bis(2,4-dimethylphenyl)ethanoate                               |            | sat. solution in 50% acetone-ethanol   |
| 9.4-10.6  | C-B          | Thymolphthalein                                                      |            | 0.04 g in 100 mL 50% v/v ethanol-water |
| 10.1-12.0 | Y-R          | Alizarin Yellow R                                                    |            | 0.01% in water                         |
| 11.0-12.4 | R-P          | Alizarin                                                             |            | 0.1% in methanol                       |
| 11.4-12.6 | Y-O          | <i>p</i> -(2,4-Dihydroxyphenylazo) benzenesulfonic acid, sodium salt |            | 0.1% in water                          |
| 11.4-13.0 | B-Y          | 5,5'-Indigodisulfonic acid, disodium salt                            |            | water                                  |
| 11.5-13.0 | C-O          | 2,4,6-Trinitrotoluene                                                |            | 0.1-0.5% in ethanol                    |
| 12.0-14.0 | C-O          | 1,3,5-Trinitrobenzene                                                |            | 0.1-0.5% in ethanol                    |
| 12.2-13.2 | Y-A          | Clayton Yellow                                                       |            | 0.1% in water                          |

# FLUORESCENT INDICATORS

Jack DeMent

Fluorescent indicators are substances that show definite changes in fluorescence with change in pH. Some fluorescent materials are not suitable for indicators since their change in fluorescence is too gradual. Fluorescent indicators find greatest utility in the titration of opaque, highly turbid or deeply colored solutions. A long wavelength ultraviolet ("black light") lamp in a dimly lighted room provides the best environment for titrations involving fluorescent indicators, although bright daylight is sometimes sufficient to evoke a response in the bright green, yellow and orange fluores-

cent indicators. Titrations are carried out in non-fluorescent glassware. One should check the glassware prior to use to make certain that it does not fluoresce due to the wavelengths of light involved in the titration. The meniscus of the liquid in the burette can be followed when a few particles of an insoluble fluorescent solid are dropped onto its surface.

In this table the indicators are arranged by approximate pH range covered. In the case of some of the dyestuffs the end point may vary slightly with the source or manufacturer.

| pH 0 to 2                                 |      |                                              |                        |
|-------------------------------------------|------|----------------------------------------------|------------------------|
| Indicator                                 | C.I. | From pH                                      | To pH                  |
| Benzoflavine                              | —    | 0.3, yellow fl.                              | 1.7, green fl.         |
| 3,6-Dioxypthalimide                       | —    | 0, blue fl.                                  | 2.4, green fl.         |
| Eosine YS                                 | 768  | 0,yellow colored                             | 3.0, yellow fl.        |
| Erythrosine                               | 772  | 0, yellow colored                            | 3.6, yellow fl.        |
| Esculin                                   | —    | 1.5, colorless                               | 2, blue fl.            |
| 4-Ethoxyacridone                          | —    | 1.2, green fl.                               | 3.2, blue fl.          |
| 3,6-Tetramethyldiaminooxanthone           | —    | 1.2, green fl.                               | 3.4, blue fl.          |
| pH 2 to 4                                 |      |                                              |                        |
| Chromotropic acid                         | —    | 3.5, colorless                               | 4.5, blue fl           |
| Fluorescein                               | 766  | 4, colorless                                 | 4.5, green fl.         |
| Magdala Red                               | —    | 3.0, purple colored                          | 4.0, fl                |
| $\alpha$ -Naphthylamine                   | —    | 3.4, colorless                               | 4.8, blue fl.          |
| $\beta$ -Naphthylamine                    | —    | 2.8, colorless                               | 4.4, violet fl.        |
| Phloxine                                  | 774  | 3.4, colorless                               | 5.0, bright yellow fl. |
| Salicylic acid                            | —    | 2.5, colorless                               | 3.5, blue fl.          |
| pH 4 to 6                                 |      |                                              |                        |
| Acridine                                  | 788  | 4.9, green fl.                               | 5.1, violet colored    |
| Dichlorofluorescein                       | —    | 4.0, colorless                               | 5.0, green fl.         |
| 3,6-Dioxyxanthone                         | —    | 5.4, colorless                               | 7.6, blue-violet fl.   |
| Erythrosine                               | 772  | 4.0, colorless                               | 4.5, yellow-green fl.  |
| $\beta$ -Methylesculetin                  | —    | 4.0, colorless                               | 6.2, blue fl           |
| Neville-Winther acid                      | —    | 6.0, colorless                               | 6.5, blue fl.          |
| Resorufin                                 | —    | 4.4, yellow fl                               | 6.4, weak orange fl.   |
| Quininic acid                             | —    | 4.4, yellow colored                          | 5.0, blue fl.          |
| Quinine [first end point]                 | —    | 5.0, blue fl.                                | 6.1, violet fl.        |
| pH 6 to 8                                 |      |                                              |                        |
| Acid R Phosphine                          | —    | (claimed for range pH 6.0–7.0)               |                        |
| Brilliant Diazol Yellow                   | —    | 6.5, colorless                               | 7.5, violet, fl.       |
| Cleves acid                               | —    | 6.5, colorless                               | 7.5, green fl.         |
| Coumaric acid                             | —    | 7.2, colorless                               | 9.0, green fl.         |
| 3,6-Dioxypthalic dinitrile                | —    | 5.8, blue fl.                                | 8.2, green fl.         |
| Magnesium 8-hydroxyquinolate              | —    | 6.5, colorless                               | 7.5, golden fl.        |
| $\beta$ -Methylumbelliferone              | —    | 7.0, colorless                               | 7.5, blue fl.          |
| 1-Naphthol-4-sulfonic acid                | —    | 6.0, colorless                               | 6.5, blue fl.          |
| Orcinaurine                               | —    | 6.5, colorless                               | 8.0, green fl.         |
| Patent Phosphine                          | 789  | (for the range pH 6.0–7.0, green-yellow fl.) |                        |
| Thioflavine                               | 816  | (for the region pH 6.5–7.0, yellow fl.)      |                        |
| Umbelliferone                             | —    | 6.5, colorless                               | 7.6, blue fl.          |
| pH 8 to 10                                |      |                                              |                        |
| Acridine Orange                           | 788  | 8.4, orange colored                          | 10.4, green fl.        |
| Ethoxyphenyl-naphthostilbazonium chloride | —    | 9, green fl.                                 | 11, non-fl.            |

|                                    |     |                     |                             |
|------------------------------------|-----|---------------------|-----------------------------|
| G Salt                             | —   | 9.0, dull blue fl.  | 9.5, bright blue fl.        |
| Naphthazol derivatives             | —   | 8.2, colorless      | 10.0, yellow or green fl.   |
| $\alpha$ -Naphthionic acid         | —   | 9, blue fl.         | 11, green fl.               |
| 2-Naphthol-3,6-disulfonic acid     | —   | 9.5, dark blue fl   | Light blue fl. at higher pH |
| $\beta$ -Naphthol                  | —   | 8.6, colorless      | Blue fl. at higher pH       |
| $\alpha$ -Naphtholsulfonic acid    | —   | 8.0, dark blue fl.  | 9.0, bright violet fl.      |
| 1,4-Naphtholsulfonic acid          | —   | 8.2, dark blue fl.  | Light blue fl. at higher pH |
| Orcinsulfonphthalein               | —   | 8.6, yellow colored | 10.0 fl.                    |
| Quinine [second end point]         | —   | 9.5, violet fl.     | 10.0, colorless             |
| R-Salt                             | —   | 9.0, dull blue fl.  | 9.5, bright blue fl.        |
| Sodium 1-naphthol-2-sulfonate      | —   | 9.0, dark blue fl.  | 10.0, bright violet fl.     |
| <b>pH 10 to 12</b>                 |     |                     |                             |
| Courmarin                          | —   | 9.8, deep green fl. | 12, light green fl.         |
| Eosine BN                          | 771 | 10.5, colorless     | 14.0, yellow fl.            |
| Papaverine (permanganate oxidized) | —   | 9.5, yellow fl.     | 11.0, blue fl.              |
| Schaffers Salt                     | —   | 5.0, violet fl.     | 11.0, green-blue fl.        |
| SS-Acid (sodium salt)              | —   | 10.0, violet fl.    | 12.0, yellow-colored        |
| <b>pH 12 to 14</b>                 |     |                     |                             |
| Cotarnine                          | —   | 12.0, yellow fl.    | 13.0, white fl.             |
| $\alpha$ -Naphthionic acid         | —   | 12, blue fl.        | 13, green fl.               |
| $\beta$ -Naphthionic acid          | —   | 12, blue fl.        | 13, violet fl.              |

## CONVERSION FORMULAS FOR CONCENTRATION OF SOLUTIONS

*A* = Weight percent of solute  
*B* = Molecular weight of solvent  
*E* = Molecular weight of solute  
*F* = Grams of solute per liter of solution

*G* = Molality  
*M* = Molarity  
*N* = Mole fraction  
*R* = Density of solution in grams per milliliter

| Concentration of solute—SOUGHT | Concentration of solute—GIVEN                         |                                                         |                                                     |                                       |                                                |
|--------------------------------|-------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------|---------------------------------------|------------------------------------------------|
|                                | <i>A</i>                                              | <i>N</i>                                                | <i>G</i>                                            | <i>M</i>                              | <i>F</i>                                       |
| <i>A</i>                       | —                                                     | $\frac{100N \times E}{N \times E + (1 - N)B}$           | $\frac{100G \times E}{1000 + G \times E}$           | $\frac{M \times E}{10R}$              | $\frac{F}{10R}$                                |
| <i>N</i>                       | $\frac{\frac{A}{E}}{\frac{A}{E} + \frac{100 - A}{B}}$ | —                                                       | $\frac{B \times G}{B \times G + 1000}$              | $\frac{B \times M}{M(B - E) + 1000R}$ | $\frac{B \times F}{F(B - E) + 1000R \times E}$ |
| <i>G</i>                       | $\frac{1000A}{E(100 - A)}$                            | $\frac{1000N}{B - N \times B}$                          | —                                                   | $\frac{1000M}{1000R - (M \times E)}$  | $\frac{1000F}{E(1000R - F)}$                   |
| <i>M</i>                       | $\frac{10R \times A}{E}$                              | $\frac{1000R \times N}{N \times E + (1 - N)B}$          | $\frac{1000R \times G}{1000 + E \times G}$          | —                                     | $\frac{F}{E}$                                  |
| <i>F</i>                       | $10AR$                                                | $\frac{1000R \times N \times E}{N \times E + (1 - N)B}$ | $\frac{1000R \times G \times E}{1000 + G \times E}$ | $M \times E$                          | —                                              |

## CONVERSION FORMULAS FOR CONCENTRATION OF SOLUTIONS

$A$  = Weight percent of solute  
 $B$  = Molecular weight of solvent  
 $E$  = Molecular weight of solute  
 $F$  = Grams of solute per liter of solution

$G$  = Molality  
 $M$  = Molarity  
 $N$  = Mole fraction  
 $R$  = Density of solution in grams per milliliter

| Concentration of<br>solute—SOUGHT | Concentration of solute—GIVEN                         |                                                         |                                                     |                                       |                                                |
|-----------------------------------|-------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------|---------------------------------------|------------------------------------------------|
|                                   | $A$                                                   | $N$                                                     | $G$                                                 | $M$                                   | $F$                                            |
| $A$                               | —                                                     | $\frac{100N \times E}{N \times E + (1 - N)B}$           | $\frac{100G \times E}{1000 + G \times E}$           | $\frac{M \times E}{10R}$              | $\frac{F}{10R}$                                |
| $N$                               | $\frac{\frac{A}{E}}{\frac{A}{E} + \frac{100 - A}{B}}$ | —                                                       | $\frac{B \times G}{B \times G + 1000}$              | $\frac{B \times M}{M(B - E) + 1000R}$ | $\frac{B \times F}{F(B - E) + 1000R \times E}$ |
| $G$                               | $\frac{1000A}{E(100 - A)}$                            | $\frac{1000N}{B - N \times B}$                          | —                                                   | $\frac{1000M}{1000R - (M \times E)}$  | $\frac{1000F}{E(1000R - F)}$                   |
| $M$                               | $\frac{10R \times A}{E}$                              | $\frac{1000R \times N}{N \times E + (1 - N)B}$          | $\frac{1000R \times G}{1000 + E \times G}$          | —                                     | $\frac{F}{E}$                                  |
| $F$                               | $10AR$                                                | $\frac{1000R \times N \times E}{N \times E + (1 - N)B}$ | $\frac{1000R \times G \times E}{1000 + G \times E}$ | $M \times E$                          | —                                              |

# ELECTROCHEMICAL SERIES

Petr Vanýsek

There are three tables for this electrochemical series. Each table lists standard reduction potentials,  $E^\circ$  values, at 298.15 K (25 °C), and at a pressure of 101.325 kPa (1 atm). Table 1 is an alphabetical listing of the elements, according to the symbol of the elements. Thus, data for silver (Ag) precede those for aluminum (Al). Table 2 lists only those reduction reactions that have  $E^\circ$  values positive in respect to the standard hydrogen electrode. In Table 2, the reactions are listed in the order of increasing positive potential, and they range from 0.0000 V to + 3.4 V. Table 3 lists only those reduction potentials which have  $E^\circ$  negative with respect to the standard hydrogen electrode. In Table 3, the reactions are listed in the order of decreasing potential and range from 0.0000 V to –4.10 V. The reliability of the potentials is not the same for all the data. Typically, the values with fewer significant figures have lower

reliability. The values of reduction potentials, in particular those of less common reactions, are not definite; they are subject to occasional revisions.

*Abbreviations:* ac = acetate; bipy = 2,2'-dipyridine, or bipyridine; en = ethylenediamine; phen = 1,10-phenanthroline.

## References

1. Milazzo, G., Caroli, S., and Sharma, V. K. *Tables of Standard Electrode Potentials*, Wiley, Chichester, 1978.
2. Bard, A. J., Parsons, R., and Jordan, J. *Standard Potentials in Aqueous Solutions*, Marcel Dekker, New York, 1985.
3. Bratsch, S. G. *J. Phys. Chem. Ref. Data*, 18, 1–21, 1989.

TABLE 1. Alphabetical Listing

| Reaction                                                                                                          | $E^\circ/V$ | Reaction                                                                                                        | $E^\circ/V$ |
|-------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------|-------------|
| $\text{Ac}^{3+} + 3 \text{e} \rightleftharpoons \text{Ac}$                                                        | –2.20       | $\text{As} + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{AsH}_3$                                         | –0.608      |
| $\text{Ag}^+ + \text{e} \rightleftharpoons \text{Ag}$                                                             | 0.7996      | $\text{As}_2\text{O}_3 + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons 2 \text{As} + 3 \text{H}_2\text{O}$       | 0.234       |
| $\text{Ag}^{2+} + \text{e} \rightleftharpoons \text{Ag}^+$                                                        | 1.980       | $\text{HAsO}_2 + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{As} + 2 \text{H}_2\text{O}$                 | 0.248       |
| $\text{Ag}(\text{ac}) + \text{e} \rightleftharpoons \text{Ag} + (\text{ac})^-$                                    | 0.643       | $\text{AsO}_2^- + 2 \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{As} + 4 \text{OH}^-$               | –0.68       |
| $\text{AgBr} + \text{e} \rightleftharpoons \text{Ag} + \text{Br}^-$                                               | 0.07133     | $\text{H}_3\text{AsO}_4 + 2 \text{H}^+ + 2 \text{e}^- \rightleftharpoons \text{HAsO}_2 + 2 \text{H}_2\text{O}$  | 0.560       |
| $\text{AgBrO}_3 + \text{e} \rightleftharpoons \text{Ag} + \text{BrO}_3^-$                                         | 0.546       | $\text{AsO}_4^{3-} + 2 \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{AsO}_2^- + 4 \text{OH}^-$       | –0.71       |
| $\text{Ag}_2\text{C}_2\text{O}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{C}_2\text{O}_4^{2-}$         | 0.4647      | $\text{At}_2 + 2 \text{e} \rightleftharpoons 2 \text{At}^-$                                                     | 0.3         |
| $\text{AgCl} + \text{e} \rightleftharpoons \text{Ag} + \text{Cl}^-$                                               | 0.22233     | $\text{Au}^+ + \text{e} \rightleftharpoons \text{Au}$                                                           | 1.692       |
| $\text{AgCN} + \text{e} \rightleftharpoons \text{Ag} + \text{CN}^-$                                               | –0.017      | $\text{Au}^{3+} + 2 \text{e} \rightleftharpoons \text{Au}^+$                                                    | 1.401       |
| $\text{Ag}_2\text{CO}_3 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{CO}_3^{2-}$                           | 0.47        | $\text{Au}^{3+} + 3 \text{e} \rightleftharpoons \text{Au}$                                                      | 1.498       |
| $\text{Ag}_2\text{CrO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{CrO}_4^{2-}$                         | 0.4470      | $\text{Au}^{2+} + \text{e}^- \rightleftharpoons \text{Au}^+$                                                    | 1.8         |
| $\text{AgF} + \text{e} \rightleftharpoons \text{Ag} + \text{F}^-$                                                 | 0.779       | $\text{AuOH}^{2+} + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Au}^+ + \text{H}_2\text{O}$                | 1.32        |
| $\text{Ag}_4[\text{Fe}(\text{CN})_6] + 4 \text{e} \rightleftharpoons 4 \text{Ag} + [\text{Fe}(\text{CN})_6]^{4-}$ | 0.1478      | $\text{AuBr}_2^- + \text{e} \rightleftharpoons \text{Au} + 2 \text{Br}^-$                                       | 0.959       |
| $\text{AgI} + \text{e} \rightleftharpoons \text{Ag} + \text{I}^-$                                                 | –0.15224    | $\text{AuBr}_4^- + 3 \text{e} \rightleftharpoons \text{Au} + 4 \text{Br}^-$                                     | 0.854       |
| $\text{AgIO}_3 + \text{e} \rightleftharpoons \text{Ag} + \text{IO}_3^-$                                           | 0.354       | $\text{AuCl}_4^- + 3 \text{e} \rightleftharpoons \text{Au} + 4 \text{Cl}^-$                                     | 1.002       |
| $\text{Ag}_2\text{MoO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{MoO}_4^{2-}$                         | 0.4573      | $\text{Au}(\text{OH})_3 + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Au} + 3 \text{H}_2\text{O}$        | 1.45        |
| $\text{AgNO}_2 + \text{e} \rightleftharpoons \text{Ag} + 2 \text{NO}_2^-$                                         | 0.564       | $\text{H}_2\text{BO}_3^- + 5 \text{H}_2\text{O} + 8 \text{e} \rightleftharpoons \text{BH}_4^- + 8 \text{OH}^-$  | –1.24       |
| $\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons 2 \text{Ag} + 2 \text{OH}^-$            | 0.342       | $\text{H}_2\text{BO}_3^- + \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{B} + 4 \text{OH}^-$         | –1.79       |
| $\text{Ag}_2\text{O}_3 + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons 2 \text{AgO} + 2 \text{OH}^-$         | 0.739       | $\text{H}_3\text{BO}_3 + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{B} + 3 \text{H}_2\text{O}$          | –0.8698     |
| $\text{Ag}^{3+} + 2 \text{e} \rightleftharpoons \text{Ag}^+$                                                      | 1.9         | $\text{B}(\text{OH})_3 + 7 \text{H}^+ + 8 \text{e} \rightleftharpoons \text{BH}_4^- + 3 \text{H}_2\text{O}$     | –0.481      |
| $\text{Ag}^{3+} + \text{e} \rightleftharpoons \text{Ag}^{2+}$                                                     | 1.8         | $\text{Ba}^{2+} + 2 \text{e} \rightleftharpoons \text{Ba}$                                                      | –2.912      |
| $\text{Ag}_2\text{O}_2 + 4 \text{H}^+ + \text{e} \rightleftharpoons 2 \text{Ag} + 2 \text{H}_2\text{O}$           | 1.802       | $\text{Ba}^{2+} + 2 \text{e} \rightleftharpoons \text{Ba}(\text{Hg})$                                           | –1.570      |
| $2 \text{AgO} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Ag}_2\text{O} + 2 \text{OH}^-$           | 0.607       | $\text{Ba}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Ba} + 2 \text{OH}^-$                              | –2.99       |
| $\text{AgOCN} + \text{e} \rightleftharpoons \text{Ag} + \text{OCN}^-$                                             | 0.41        | $\text{Be}^{2+} + 2 \text{e} \rightleftharpoons \text{Be}$                                                      | –1.847      |
| $\text{Ag}_2\text{S} + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{S}^{2-}$                                 | –0.691      | $\text{Be}_2\text{O}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons 2 \text{Be} + 6 \text{OH}^-$ | –2.63       |
| $\text{Ag}_2\text{S} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{H}_2\text{S}$             | –0.0366     | $p\text{-benzoquinone} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{hydroquinone}$                      | 0.6992      |
| $\text{AgSCN} + \text{e} \rightleftharpoons \text{Ag} + \text{SCN}^-$                                             | 0.08951     | $\text{Bi}^+ + \text{e} \rightleftharpoons \text{Bi}$                                                           | 0.5         |
| $\text{Ag}_2\text{SeO}_3 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{SeO}_4^{2-}$                         | 0.3629      | $\text{Bi}^{3+} + 3 \text{e} \rightleftharpoons \text{Bi}$                                                      | 0.308       |
| $\text{Ag}_2\text{SO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{SO}_4^{2-}$                           | 0.654       | $\text{Bi}^{3+} + 2 \text{e} \rightleftharpoons \text{Bi}^+$                                                    | 0.2         |
| $\text{Ag}_2\text{WO}_4 + 2 \text{e} \rightleftharpoons 2 \text{Ag} + \text{WO}_4^{2-}$                           | 0.4660      | $\text{Bi} + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{BiH}_3$                                         | –0.8        |
| $\text{Al}^{3+} + 3 \text{e} \rightleftharpoons \text{Al}$                                                        | –1.662      | $\text{BiCl}_4^- + 3 \text{e} \rightleftharpoons \text{Bi} + 4 \text{Cl}^-$                                     | 0.16        |
| $\text{Al}(\text{OH})_3 + 3 \text{e} \rightleftharpoons \text{Al} + 3 \text{OH}^-$                                | –2.31       | $\text{Bi}_2\text{O}_3 + 3 \text{H}_2\text{O} + 6 \text{e} \rightleftharpoons 2 \text{Bi} + 6 \text{OH}^-$      | –0.46       |
| $\text{Al}(\text{OH})_4^- + 3 \text{e} \rightleftharpoons \text{Al} + 4 \text{OH}^-$                              | –2.328      | $\text{Bi}_2\text{O}_4 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{BiO}^+ + 2 \text{H}_2\text{O}$    | 1.593       |
| $\text{H}_2\text{AlO}_3^- + \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{Al} + 4 \text{OH}^-$         | –2.33       | $\text{BiO}^+ + 2 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Bi} + \text{H}_2\text{O}$                    | 0.320       |
| $\text{AlF}_6^{3-} + 3 \text{e} \rightleftharpoons \text{Al} + 6 \text{F}^-$                                      | –2.069      | $\text{BiOCl} + 2 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Bi} + \text{Cl}^- + \text{H}_2\text{O}$      | 0.1583      |
| $\text{Am}^{4+} + \text{e} \rightleftharpoons \text{Am}^{3+}$                                                     | 2.60        | $\text{Bk}^{4+} + \text{e} \rightleftharpoons \text{Bk}^{3+}$                                                   | 1.67        |
| $\text{Am}^{2+} + 2 \text{e} \rightleftharpoons \text{Am}$                                                        | –1.9        | $\text{Bk}^{2+} + 2 \text{e} \rightleftharpoons \text{Bk}$                                                      | –1.6        |
| $\text{Am}^{3+} + 3 \text{e} \rightleftharpoons \text{Am}$                                                        | –2.048      | $\text{Bk}^{3+} + \text{e} \rightleftharpoons \text{Bk}^{2+}$                                                   | –2.8        |
| $\text{Am}^{3+} + \text{e} \rightleftharpoons \text{Am}^{2+}$                                                     | –2.3        |                                                                                                                 |             |



| Reaction                                                                                                 | $E^\circ/V$ |
|----------------------------------------------------------------------------------------------------------|-------------|
| $\text{Br}_2(\text{aq}) + 2 \text{e} \rightleftharpoons 2 \text{Br}^-$                                   | 1.0873      |
| $\text{Br}_2(\text{l}) + 2 \text{e} \rightleftharpoons 2 \text{Br}^-$                                    | 1.066       |
| $\text{HBrO} + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Br}^- + \text{H}_2\text{O}$              | 1.331       |
| $\text{HBrO} + \text{H}^+ + \text{e} \rightleftharpoons 1/2 \text{Br}_2(\text{aq}) + \text{H}_2\text{O}$ | 1.574       |
| $\text{HBrO} + \text{H}^+ + \text{e} \rightleftharpoons 1/2 \text{Br}_2(\text{l}) + \text{H}_2\text{O}$  | 1.596       |
| $\text{BrO}^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Br}^- + 2 \text{OH}^-$          | 0.761       |
| $\text{BrO}_3^- + 6 \text{H}^+ + 5 \text{e} \rightleftharpoons 1/2 \text{Br}_2 + 3 \text{H}_2\text{O}$   | 1.482       |
| $\text{BrO}_3^- + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{Br}^- + 3 \text{H}_2\text{O}$       | 1.423       |
| $\text{BrO}_3^- + 3 \text{H}_2\text{O} + 6 \text{e} \rightleftharpoons \text{Br}^- + 6 \text{OH}^-$      | 0.61        |
| $(\text{CN})_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{HCN}$                              | 0.373       |
| $2 \text{HCNO} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons (\text{CN})_2 + 2 \text{H}_2\text{O}$      | 0.330       |
| $(\text{CNS})_2 + 2 \text{e} \rightleftharpoons 2 \text{CNS}^-$                                          | 0.77        |
| $\text{CO}_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{HCOOH}$                                | -0.199      |
| $\text{Ca}^+ + \text{e} \rightleftharpoons \text{Ca}$                                                    | -3.80       |
| $\text{Ca}^{2+} + 2 \text{e} \rightleftharpoons \text{Ca}$                                               | -2.868      |
| $\text{Ca}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Ca} + 2 \text{OH}^-$                       | -3.02       |
| Calomel electrode, 1 molal KCl                                                                           | 0.2800      |
| Calomel electrode, 1 molar KCl (NCE)                                                                     | 0.2801      |
| Calomel electrode, 0.1 molar KCl                                                                         | 0.3337      |
| Calomel electrode, saturated KCl (SCE)                                                                   | 0.2412      |
| Calomel electrode, saturated NaCl (SSCE)                                                                 | 0.2360      |
| $\text{Cd}^{2+} + 2 \text{e} \rightleftharpoons \text{Cd}$                                               | -0.4030     |
| $\text{Cd}^{2+} + 2 \text{e} \rightleftharpoons \text{Cd}(\text{Hg})$                                    | -0.3521     |
| $\text{Cd}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Cd}(\text{Hg}) + 2 \text{OH}^-$            | -0.809      |
| $\text{CdSO}_4 + 2 \text{e} \rightleftharpoons \text{Cd} + \text{SO}_4^{2-}$                             | -0.246      |
| $\text{Cd}(\text{OH})_4^{2-} + 2 \text{e} \rightleftharpoons \text{Cd} + 4 \text{OH}^-$                  | -0.658      |
| $\text{CdO} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Cd} + 2 \text{OH}^-$              | -0.783      |
| $\text{Ce}^{3+} + 3 \text{e} \rightleftharpoons \text{Ce}$                                               | -2.336      |
| $\text{Ce}^{3+} + 3 \text{e} \rightleftharpoons \text{Ce}(\text{Hg})$                                    | -1.4373     |
| $\text{Ce}^{4+} + \text{e} \rightleftharpoons \text{Ce}^{3+}$                                            | 1.72        |
| $\text{CeOH}^{3+} + \text{H}^+ + \text{e} \rightleftharpoons \text{Ce}^{3+} + \text{H}_2\text{O}$        | 1.715       |
| $\text{Ce}^{4+} + \text{e} \rightleftharpoons \text{Ce}^{3+}$                                            | 3.3         |
| $\text{Ce}^{3+} + \text{e} \rightleftharpoons \text{Ce}^{2+}$                                            | -1.6        |
| $\text{Ce}^{3+} + 3 \text{e} \rightleftharpoons \text{Ce}$                                               | -1.94       |
| $\text{Ce}^{2+} + 2 \text{e} \rightleftharpoons \text{Ce}$                                               | -2.12       |
| $\text{Cl}_2(\text{g}) + 2 \text{e} \rightleftharpoons 2 \text{Cl}^-$                                    | 1.35827     |
| $\text{HClO} + \text{H}^+ + \text{e} \rightleftharpoons 1/2 \text{Cl}_2 + \text{H}_2\text{O}$            | 1.611       |
| $\text{HClO} + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Cl}^- + \text{H}_2\text{O}$              | 1.482       |
| $\text{ClO}^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Cl}^- + 2 \text{OH}^-$          | 0.81        |
| $\text{ClO}_2 + \text{H}^+ + \text{e} \rightleftharpoons \text{HClO}_2$                                  | 1.277       |
| $\text{HClO}_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{HClO} + \text{H}_2\text{O}$          | 1.645       |
| $\text{HClO}_2 + 3 \text{H}^+ + 3 \text{e} \rightleftharpoons 1/2 \text{Cl}_2 + 2 \text{H}_2\text{O}$    | 1.628       |
| $\text{HClO}_2 + 3 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Cl}^- + 2 \text{H}_2\text{O}$        | 1.570       |
| $\text{ClO}_2^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{ClO}^- + 2 \text{OH}^-$       | 0.66        |
| $\text{ClO}_2^- + 2 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Cl}^- + 4 \text{OH}^-$      | 0.76        |
| $\text{ClO}_2(\text{aq}) + \text{e} \rightleftharpoons \text{ClO}_2^-$                                   | 0.954       |
| $\text{ClO}_3^- + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{ClO}_2 + \text{H}_2\text{O}$          | 1.152       |
| $\text{ClO}_3^- + 3 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{HClO}_2 + \text{H}_2\text{O}$       | 1.214       |
| $\text{ClO}_3^- + 6 \text{H}^+ + 5 \text{e} \rightleftharpoons 1/2 \text{Cl}_2 + 3 \text{H}_2\text{O}$   | 1.47        |
| $\text{ClO}_3^- + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{Cl}^- + 3 \text{H}_2\text{O}$       | 1.451       |
| $\text{ClO}_3^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{ClO}_2^- + 2 \text{OH}^-$     | 0.33        |
| $\text{ClO}_3^- + 3 \text{H}_2\text{O} + 6 \text{e} \rightleftharpoons \text{Cl}^- + 6 \text{OH}^-$      | 0.62        |
| $\text{ClO}_4^- + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{ClO}_3^- + \text{H}_2\text{O}$      | 1.189       |
| $\text{ClO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons 1/2 \text{Cl}_2 + 4 \text{H}_2\text{O}$   | 1.39        |
| $\text{ClO}_4^- + 8 \text{H}^+ + 8 \text{e} \rightleftharpoons \text{Cl}^- + 4 \text{H}_2\text{O}$       | 1.389       |
| $\text{ClO}_4^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{ClO}_3^- + 2 \text{OH}^-$     | 0.36        |
| $\text{Cm}^{4+} + \text{e} \rightleftharpoons \text{Cm}^{3+}$                                            | 3.0         |
| $\text{Cm}^{3+} + 3 \text{e} \rightleftharpoons \text{Cm}$                                               | -2.04       |
| $\text{Co}^{2+} + 2 \text{e} \rightleftharpoons \text{Co}$                                               | -0.28       |
| $\text{Co}^{3+} + \text{e} \rightleftharpoons \text{Co}^{2+}$                                            | 1.92        |

| Reaction                                                                                                                           | $E^\circ/V$ |
|------------------------------------------------------------------------------------------------------------------------------------|-------------|
| $[\text{Co}(\text{NH}_3)_6]^{3+} + \text{e} \rightleftharpoons [\text{Co}(\text{NH}_3)_6]^{2+}$                                    | 0.108       |
| $\text{Co}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Co} + 2 \text{OH}^-$                                                 | -0.73       |
| $\text{Co}(\text{OH})_3 + \text{e} \rightleftharpoons \text{Co}(\text{OH})_2 + \text{OH}^-$                                        | 0.17        |
| $\text{Cr}^{2+} + 2 \text{e} \rightleftharpoons \text{Cr}$                                                                         | -0.913      |
| $\text{Cr}^{3+} + \text{e} \rightleftharpoons \text{Cr}^{2+}$                                                                      | -0.407      |
| $\text{Cr}^{3+} + 3 \text{e} \rightleftharpoons \text{Cr}$                                                                         | -0.744      |
| $\text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ + 6 \text{e} \rightleftharpoons 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$               | 1.36        |
| $\text{CrO}_2^- + 2 \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{Cr} + 4 \text{OH}^-$                                  | -1.2        |
| $\text{HCrO}_4^- + 7 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Cr}^{3+} + 4 \text{H}_2\text{O}$                             | 1.350       |
| $\text{CrO}_2 + 4 \text{H}^+ + \text{e} \rightleftharpoons \text{Cr}^{3+} + 2 \text{H}_2\text{O}$                                  | 1.48        |
| $\text{Cr}(\text{V}) + \text{e} \rightleftharpoons \text{Cr}(\text{IV})$                                                           | 1.34        |
| $\text{CrO}_4^{2-} + 4 \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{Cr}(\text{OH})_3 + 5 \text{OH}^-$                  | -0.13       |
| $\text{Cr}(\text{OH})_3 + 3 \text{e} \rightleftharpoons \text{Cr} + 3 \text{OH}^-$                                                 | -1.48       |
| $\text{Cs}^+ + \text{e} \rightleftharpoons \text{Cs}$                                                                              | -3.026      |
| $\text{Cu}^+ + \text{e} \rightleftharpoons \text{Cu}$                                                                              | 0.521       |
| $\text{Cu}^{2+} + \text{e} \rightleftharpoons \text{Cu}^+$                                                                         | 0.153       |
| $\text{Cu}^{2+} + 2 \text{e} \rightleftharpoons \text{Cu}$                                                                         | 0.3419      |
| $\text{Cu}^{2+} + 2 \text{e} \rightleftharpoons \text{Cu}(\text{Hg})$                                                              | 0.345       |
| $\text{Cu}^{3+} + \text{e} \rightleftharpoons \text{Cu}^{2+}$                                                                      | 2.4         |
| $\text{Cu}_2\text{O}_3 + 6 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{Cu}^{2+} + 3 \text{H}_2\text{O}$                     | 2.0         |
| $\text{Cu}^{2+} + 2 \text{CN}^- + \text{e} \rightleftharpoons [\text{Cu}(\text{CN})_2]^-$                                          | 1.103       |
| $\text{CuI}_2^- + \text{e} \rightleftharpoons \text{Cu} + 2 \text{I}^-$                                                            | 0.00        |
| $\text{Cu}_2\text{O} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons 2 \text{Cu} + 2 \text{OH}^-$                             | -0.360      |
| $\text{Cu}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Cu} + 2 \text{OH}^-$                                                 | -0.222      |
| $2 \text{Cu}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Cu}_2\text{O} + 2 \text{OH}^- + \text{H}_2\text{O}$                | -0.080      |
| $2 \text{D}^+ + 2 \text{e} \rightleftharpoons \text{D}_2$                                                                          | -0.013      |
| $\text{Dy}^{2+} + 2 \text{e} \rightleftharpoons \text{Dy}$                                                                         | -2.2        |
| $\text{Dy}^{3+} + 3 \text{e} \rightleftharpoons \text{Dy}$                                                                         | -2.295      |
| $\text{Dy}^{3+} + \text{e} \rightleftharpoons \text{Dy}^{2+}$                                                                      | -2.6        |
| $\text{Er}^{2+} + 2 \text{e} \rightleftharpoons \text{Er}$                                                                         | -2.0        |
| $\text{Er}^{3+} + 3 \text{e} \rightleftharpoons \text{Er}$                                                                         | -2.331      |
| $\text{Er}^{3+} + \text{e} \rightleftharpoons \text{Er}^{2+}$                                                                      | -3.0        |
| $\text{Es}^{3+} + \text{e} \rightleftharpoons \text{Es}^{2+}$                                                                      | -1.3        |
| $\text{Es}^{3+} + 3 \text{e} \rightleftharpoons \text{Es}$                                                                         | -1.91       |
| $\text{Es}^{2+} + 2 \text{e} \rightleftharpoons \text{Es}$                                                                         | -2.23       |
| $\text{Eu}^{2+} + 2 \text{e} \rightleftharpoons \text{Eu}$                                                                         | -2.812      |
| $\text{Eu}^{3+} + 3 \text{e} \rightleftharpoons \text{Eu}$                                                                         | -1.991      |
| $\text{Eu}^{3+} + \text{e} \rightleftharpoons \text{Eu}^{2+}$                                                                      | -0.36       |
| $\text{F}_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{HF}$                                                            | 3.053       |
| $\text{F}_2 + 2 \text{e} \rightleftharpoons 2 \text{F}^-$                                                                          | 2.866       |
| $\text{F}_2\text{O} + 2 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{H}_2\text{O} + 2 \text{F}^-$                              | 2.153       |
| $\text{Fe}^{2+} + 2 \text{e} \rightleftharpoons \text{Fe}$                                                                         | -0.447      |
| $\text{Fe}^{3+} + 3 \text{e} \rightleftharpoons \text{Fe}$                                                                         | -0.037      |
| $\text{Fe}^{3+} + \text{e} \rightleftharpoons \text{Fe}^{2+}$                                                                      | 0.771       |
| $2 \text{HFeO}_4^- + 8 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{Fe}_2\text{O}_3 + 5 \text{H}_2\text{O}$                    | 2.09        |
| $\text{HFeO}_4^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{FeOOH} + 2 \text{H}_2\text{O}$                               | 2.08        |
| $\text{HFeO}_4^- + 7 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Fe}^{3+} + 4 \text{H}_2\text{O}$                             | 2.07        |
| $\text{Fe}_2\text{O}_3 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{FeOH}^+ + \text{H}_2\text{O}$                        | 0.16        |
| $[\text{Fe}(\text{CN})_6]^{3-} + \text{e} \rightleftharpoons [\text{Fe}(\text{CN})_6]^{4-}$                                        | 0.358       |
| $\text{FeO}_4^{2-} + 8 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Fe}^{3+} + 4 \text{H}_2\text{O}$                           | 2.20        |
| $[\text{Fe}(\text{bipy})_2]^{3+} + \text{e} \rightleftharpoons [\text{Fe}(\text{bipy})_2]^{2+}$                                    | 0.78        |
| $[\text{Fe}(\text{bipy})_3]^{3+} + \text{e} \rightleftharpoons [\text{Fe}(\text{bipy})_3]^{2+}$                                    | 1.03        |
| $\text{Fe}(\text{OH})_3 + \text{e} \rightleftharpoons \text{Fe}(\text{OH})_2 + \text{OH}^-$                                        | -0.56       |
| $[\text{Fe}(\text{phen})_3]^{3+} + \text{e} \rightleftharpoons [\text{Fe}(\text{phen})_3]^{2+}$                                    | 1.147       |
| $[\text{Fe}(\text{phen})_3]^{3+} + \text{e} \rightleftharpoons [\text{Fe}(\text{phen})_3]^{2+}$ (1 molar $\text{H}_2\text{SO}_4$ ) | 1.06        |
| $[\text{Fericinium}]^+ + \text{e} \rightleftharpoons \text{ferrocene}$                                                             | 0.400       |
| $\text{Fm}^{3+} + \text{e} \rightleftharpoons \text{Fm}^{2+}$                                                                      | -1.1        |
| $\text{Fm}^{3+} + 3 \text{e} \rightleftharpoons \text{Fm}$                                                                         | -1.89       |
| $\text{Fm}^{2+} + 2 \text{e} \rightleftharpoons \text{Fm}$                                                                         | -2.30       |

| Reaction                                                                                         | $E^\circ/V$ |
|--------------------------------------------------------------------------------------------------|-------------|
| $\text{Fr}^+ + e \rightleftharpoons \text{Fr}$                                                   | -2.9        |
| $\text{Ga}^{3+} + 3e \rightleftharpoons \text{Ga}$                                               | -0.549      |
| $\text{Ga}^+ + e \rightleftharpoons \text{Ga}$                                                   | -0.2        |
| $\text{GaOH}^{2+} + \text{H}^+ + 3e \rightleftharpoons \text{Ga} + \text{H}_2\text{O}$           | -0.498      |
| $\text{H}_2\text{GaO}_3^- + \text{H}_2\text{O} + 3e \rightleftharpoons \text{Ga} + 4\text{OH}^-$ | -1.219      |
| $\text{Gd}^{3+} + 3e \rightleftharpoons \text{Gd}$                                               | -2.279      |
| $\text{Ge}^{2+} + 2e \rightleftharpoons \text{Ge}$                                               | 0.24        |
| $\text{Ge}^{4+} + 4e \rightleftharpoons \text{Ge}$                                               | 0.124       |
| $\text{Ge}^{4+} + 2e \rightleftharpoons \text{Ge}^{2+}$                                          | 0.00        |
| $\text{GeO}_2 + 2\text{H}^+ + 2e \rightleftharpoons \text{GeO} + \text{H}_2\text{O}$             | -0.118      |
| $\text{H}_2\text{GeO}_3 + 4\text{H}^+ + 4e \rightleftharpoons \text{Ge} + 3\text{H}_2\text{O}$   | -0.182      |
| $2\text{H}^+ + 2e \rightleftharpoons \text{H}_2$                                                 | 0.00000     |
| $\text{H}_2 + 2e \rightleftharpoons 2\text{H}^-$                                                 | -2.23       |
| $\text{HO}_2 + \text{H}^+ + e \rightleftharpoons \text{H}_2\text{O}_2$                           | 1.495       |
| $2\text{H}_2\text{O} + 2e \rightleftharpoons \text{H}_2 + 2\text{OH}^-$                          | -0.8277     |
| $\text{H}_2\text{O}_2 + 2\text{H}^+ + 2e \rightleftharpoons 2\text{H}_2\text{O}$                 | 1.776       |
| $\text{Hf}^{4+} + 4e \rightleftharpoons \text{Hf}$                                               | -1.55       |
| $\text{HfO}^{2+} + 2\text{H}^+ + 4e \rightleftharpoons \text{Hf} + \text{H}_2\text{O}$           | -1.724      |
| $\text{HfO}_2 + 4\text{H}^+ + 4e \rightleftharpoons \text{Hf} + 2\text{H}_2\text{O}$             | -1.505      |
| $\text{HfO}(\text{OH})_2 + \text{H}_2\text{O} + 4e \rightleftharpoons \text{Hf} + 4\text{OH}^-$  | -2.50       |
| $\text{Hg}^{2+} + 2e \rightleftharpoons \text{Hg}$                                               | 0.851       |
| $2\text{Hg}^{2+} + 2e \rightleftharpoons \text{Hg}_2^{2+}$                                       | 0.920       |
| $\text{Hg}_2^{2+} + 2e \rightleftharpoons 2\text{Hg}$                                            | 0.7973      |
| $\text{Hg}_2(\text{ac})_2 + 2e \rightleftharpoons 2\text{Hg} + 2(\text{ac})^-$                   | 0.51163     |
| $\text{Hg}_2\text{Br}_2 + 2e \rightleftharpoons 2\text{Hg} + 2\text{Br}^-$                       | 0.13923     |
| $\text{Hg}_2\text{Cl}_2 + 2e \rightleftharpoons 2\text{Hg} + 2\text{Cl}^-$                       | 0.26808     |
| $\text{Hg}_2\text{HPO}_4 + 2e \rightleftharpoons 2\text{Hg} + \text{HPO}_4^{2-}$                 | 0.6359      |
| $\text{Hg}_2\text{I}_2 + 2e \rightleftharpoons 2\text{Hg} + 2\text{I}^-$                         | -0.0405     |
| $\text{Hg}_2\text{O} + \text{H}_2\text{O} + 2e \rightleftharpoons 2\text{Hg} + 2\text{OH}^-$     | 0.123       |
| $\text{HgO} + \text{H}_2\text{O} + 2e \rightleftharpoons \text{Hg} + 2\text{OH}^-$               | 0.0977      |
| $\text{Hg}(\text{OH})_2 + 2\text{H}^+ + 2e \rightleftharpoons \text{Hg} + 2\text{H}_2\text{O}$   | 1.034       |
| $\text{Hg}_2\text{SO}_4 + 2e \rightleftharpoons 2\text{Hg} + \text{SO}_4^{2-}$                   | 0.6125      |
| $\text{Ho}^{2+} + 2e \rightleftharpoons \text{Ho}$                                               | -2.1        |
| $\text{Ho}^{3+} + 3e \rightleftharpoons \text{Ho}$                                               | -2.33       |
| $\text{Ho}^{3+} + e \rightleftharpoons \text{Ho}^{2+}$                                           | -2.8        |
| $\text{I}_2 + 2e \rightleftharpoons 2\text{I}^-$                                                 | 0.5355      |
| $\text{I}_3^- + 2e \rightleftharpoons 3\text{I}^-$                                               | 0.536       |
| $\text{H}_3\text{IO}_6^{2-} + 2e \rightleftharpoons \text{IO}_3^- + 3\text{OH}^-$                | 0.7         |
| $\text{H}_5\text{IO}_6 + \text{H}^+ + 2e \rightleftharpoons \text{IO}_3^- + 3\text{H}_2\text{O}$ | 1.601       |
| $2\text{HIO} + 2\text{H}^+ + 2e \rightleftharpoons \text{I}_2 + 2\text{H}_2\text{O}$             | 1.439       |
| $\text{HIO} + \text{H}^+ + 2e \rightleftharpoons \text{I}^- + \text{H}_2\text{O}$                | 0.987       |
| $\text{IO}^- + \text{H}_2\text{O} + 2e \rightleftharpoons \text{I}^- + 2\text{OH}^-$             | 0.485       |
| $2\text{IO}_3^- + 12\text{H}^+ + 10e \rightleftharpoons \text{I}_2 + 6\text{H}_2\text{O}$        | 1.195       |
| $\text{IO}_3^- + 6\text{H}^+ + 6e \rightleftharpoons \text{I}^- + 3\text{H}_2\text{O}$           | 1.085       |
| $\text{IO}_3^- + 2\text{H}_2\text{O} + 4e \rightleftharpoons \text{IO}^- + 4\text{OH}^-$         | 0.15        |
| $\text{IO}_3^- + 3\text{H}_2\text{O} + 6e \rightleftharpoons \text{IO}^- + 6\text{OH}^-$         | 0.26        |
| $\text{In}^+ + e \rightleftharpoons \text{In}$                                                   | -0.14       |
| $\text{In}^{2+} + e \rightleftharpoons \text{In}^+$                                              | -0.40       |
| $\text{In}^{3+} + e \rightleftharpoons \text{In}^{2+}$                                           | -0.49       |
| $\text{In}^{3+} + 2e \rightleftharpoons \text{In}^+$                                             | -0.443      |
| $\text{In}^{3+} + 3e \rightleftharpoons \text{In}$                                               | -0.3382     |
| $\text{In}(\text{OH})_3 + 3e \rightleftharpoons \text{In} + 3\text{OH}^-$                        | -0.99       |
| $\text{In}(\text{OH})_4^- + 3e \rightleftharpoons \text{In} + 4\text{OH}^-$                      | -1.007      |
| $\text{In}_2\text{O}_3 + 3\text{H}_2\text{O} + 6e \rightleftharpoons 2\text{In} + 6\text{OH}^-$  | -1.034      |
| $\text{Ir}^{3+} + 3e \rightleftharpoons \text{Ir}$                                               | 1.156       |
| $[\text{IrCl}_6]^{2-} + e \rightleftharpoons [\text{IrCl}_6]^{3-}$                               | 0.8665      |
| $[\text{IrCl}_6]^{3-} + 3e \rightleftharpoons \text{Ir} + 6\text{Cl}^-$                          | 0.77        |
| $\text{Ir}_2\text{O}_3 + 3\text{H}_2\text{O} + 6e \rightleftharpoons 2\text{Ir} + 6\text{OH}^-$  | 0.098       |
| $\text{K}^+ + e \rightleftharpoons \text{K}$                                                     | -2.931      |
| $\text{La}^{3+} + 3e \rightleftharpoons \text{La}$                                               | -2.379      |

| Reaction                                                                                                            | $E^\circ/V$ |
|---------------------------------------------------------------------------------------------------------------------|-------------|
| $\text{La}(\text{OH})_3 + 3e \rightleftharpoons \text{La} + 3\text{OH}^-$                                           | -2.90       |
| $\text{Li}^+ + e \rightleftharpoons \text{Li}$                                                                      | -3.0401     |
| $\text{Lr}^{3+} + 3e \rightleftharpoons \text{Lr}$                                                                  | -1.96       |
| $\text{Lu}^{3+} + 3e \rightleftharpoons \text{Lu}$                                                                  | -2.28       |
| $\text{Md}^{3+} + e \rightleftharpoons \text{Md}^{2+}$                                                              | -0.1        |
| $\text{Md}^{3+} + 3e \rightleftharpoons \text{Md}$                                                                  | -1.65       |
| $\text{Md}^{2+} + 2e \rightleftharpoons \text{Md}$                                                                  | -2.40       |
| $\text{Mg}^+ + e \rightleftharpoons \text{Mg}$                                                                      | -2.70       |
| $\text{Mg}^{2+} + 2e \rightleftharpoons \text{Mg}$                                                                  | -2.372      |
| $\text{Mg}(\text{OH})_2 + 2e \rightleftharpoons \text{Mg} + 2\text{OH}^-$                                           | -2.690      |
| $\text{Mn}^{2+} + 2e \rightleftharpoons \text{Mn}$                                                                  | -1.185      |
| $\text{Mn}^{3+} + e \rightleftharpoons \text{Mn}^{2+}$                                                              | 1.5415      |
| $\text{MnO}_2 + 4\text{H}^+ + 2e \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$                           | 1.224       |
| $\text{MnO}_4^- + e \rightleftharpoons \text{MnO}_4^{2-}$                                                           | 0.558       |
| $\text{MnO}_4^- + 4\text{H}^+ + 3e \rightleftharpoons \text{MnO}_2 + 2\text{H}_2\text{O}$                           | 1.679       |
| $\text{MnO}_4^- + 8\text{H}^+ + 5e \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$                         | 1.507       |
| $\text{MnO}_4^- + 2\text{H}_2\text{O} + 3e \rightleftharpoons \text{MnO}_2 + 4\text{OH}^-$                          | 0.595       |
| $\text{MnO}_4^{2-} + 2\text{H}_2\text{O} + 2e \rightleftharpoons \text{MnO}_2 + 4\text{OH}^-$                       | 0.60        |
| $\text{Mn}(\text{OH})_2 + 2e \rightleftharpoons \text{Mn} + 2\text{OH}^-$                                           | -1.56       |
| $\text{Mn}(\text{OH})_3 + e \rightleftharpoons \text{Mn}(\text{OH})_2 + \text{OH}^-$                                | 0.15        |
| $\text{Mn}_2\text{O}_3 + 6\text{H}^+ + e \rightleftharpoons 2\text{Mn}^{2+} + 3\text{H}_2\text{O}$                  | 1.485       |
| $\text{Mo}^{3+} + 3e \rightleftharpoons \text{Mo}$                                                                  | -0.200      |
| $\text{MoO}_2 + 4\text{H}^+ + 4e \rightleftharpoons \text{Mo} + 4\text{H}_2\text{O}$                                | -0.152      |
| $\text{H}_3\text{Mo}_7\text{O}_{24}^{3-} + 45\text{H}^+ + 42e \rightleftharpoons 7\text{Mo} + 24\text{H}_2\text{O}$ | 0.082       |
| $\text{MoO}_3 + 6\text{H}^+ + 6e \rightleftharpoons \text{Mo} + 3\text{H}_2\text{O}$                                | 0.075       |
| $\text{N}_2 + 2\text{H}_2\text{O} + 6\text{H}^+ + 6e \rightleftharpoons 2\text{NH}_4\text{OH}$                      | 0.092       |
| $3\text{N}_2 + 2\text{H}^+ + 2e \rightleftharpoons 2\text{HN}_3$                                                    | -3.09       |
| $\text{N}_5^+ + 3\text{H}^+ + 2e \rightleftharpoons 2\text{NH}_4^+$                                                 | 1.275       |
| $\text{N}_2\text{O} + 2\text{H}^+ + 2e \rightleftharpoons \text{N}_2 + \text{H}_2\text{O}$                          | 1.766       |
| $\text{H}_2\text{N}_2\text{O}_2 + 2\text{H}^+ + 2e \rightleftharpoons \text{N}_2 + 2\text{H}_2\text{O}$             | 2.65        |
| $\text{N}_2\text{O}_4 + 2e \rightleftharpoons 2\text{NO}_2^-$                                                       | 0.867       |
| $\text{N}_2\text{O}_4 + 2\text{H}^+ + 2e \rightleftharpoons 2\text{NHO}_2$                                          | 1.065       |
| $\text{N}_2\text{O}_4 + 4\text{H}^+ + 4e \rightleftharpoons 2\text{NO} + 2\text{H}_2\text{O}$                       | 1.035       |
| $2\text{NH}_3\text{OH}^+ + \text{H}^+ + 2e \rightleftharpoons \text{N}_2\text{H}_5^+ + 2\text{H}_2\text{O}$         | 1.42        |
| $2\text{NO} + 2\text{H}^+ + 2e \rightleftharpoons \text{N}_2\text{O} + \text{H}_2\text{O}$                          | 1.591       |
| $2\text{NO} + \text{H}_2\text{O} + 2e \rightleftharpoons \text{N}_2\text{O} + 2\text{OH}^-$                         | 0.76        |
| $\text{HNO}_2 + \text{H}^+ + e \rightleftharpoons \text{NO} + \text{H}_2\text{O}$                                   | 0.983       |
| $2\text{HNO}_2 + 4\text{H}^+ + 4e \rightleftharpoons \text{H}_2\text{N}_2\text{O}_2 + 2\text{H}_2\text{O}$          | 0.86        |
| $2\text{HNO}_2 + 4\text{H}^+ + 4e \rightleftharpoons \text{N}_2\text{O} + 3\text{H}_2\text{O}$                      | 1.297       |
| $\text{NO}_2^- + \text{H}_2\text{O} + e \rightleftharpoons \text{NO} + 2\text{OH}^-$                                | -0.46       |
| $2\text{NO}_2^- + 2\text{H}_2\text{O} + 4e \rightleftharpoons \text{N}_2\text{O}_2^{2-} + 4\text{OH}^-$             | -0.18       |
| $2\text{NO}_2^- + 3\text{H}_2\text{O} + 4e \rightleftharpoons \text{N}_2\text{O} + 6\text{OH}^-$                    | 0.15        |
| $\text{NO}_3^- + 3\text{H}^+ + 2e \rightleftharpoons \text{HNO}_2 + \text{H}_2\text{O}$                             | 0.934       |
| $\text{NO}_3^- + 4\text{H}^+ + 3e \rightleftharpoons \text{NO} + 2\text{H}_2\text{O}$                               | 0.957       |
| $2\text{NO}_3^- + 4\text{H}^+ + 2e \rightleftharpoons \text{N}_2\text{O}_4 + 2\text{H}_2\text{O}$                   | 0.803       |
| $\text{NO}_3^- + \text{H}_2\text{O} + 2e \rightleftharpoons \text{NO}_2^- + 2\text{OH}^-$                           | 0.01        |
| $2\text{NO}_3^- + 2\text{H}_2\text{O} + 2e \rightleftharpoons \text{N}_2\text{O}_4 + 4\text{OH}^-$                  | -0.85       |
| $\text{Na}^+ + e \rightleftharpoons \text{Na}$                                                                      | -2.71       |
| $\text{Nb}^{3+} + 3e \rightleftharpoons \text{Nb}$                                                                  | -1.099      |
| $\text{NbO}_2 + 2\text{H}^+ + 2e \rightleftharpoons \text{NbO} + \text{H}_2\text{O}$                                | -0.646      |
| $\text{NbO}_2 + 4\text{H}^+ + 4e \rightleftharpoons \text{Nb} + 2\text{H}_2\text{O}$                                | -0.690      |
| $\text{NbO} + 2\text{H}^+ + 2e \rightleftharpoons \text{Nb} + \text{H}_2\text{O}$                                   | -0.733      |
| $\text{Nb}_2\text{O}_5 + 10\text{H}^+ + 10e \rightleftharpoons 2\text{Nb} + 5\text{H}_2\text{O}$                    | -0.644      |
| $\text{Nd}^{3+} + 3e \rightleftharpoons \text{Nd}$                                                                  | -2.323      |
| $\text{Nd}^{2+} + 2e \rightleftharpoons \text{Nd}$                                                                  | -2.1        |
| $\text{Nd}^{3+} + e \rightleftharpoons \text{Nd}^{2+}$                                                              | -2.7        |
| $\text{Ni}^{2+} + 2e \rightleftharpoons \text{Ni}$                                                                  | -0.257      |
| $\text{Ni}(\text{OH})_2 + 2e \rightleftharpoons \text{Ni} + 2\text{OH}^-$                                           | -0.72       |
| $\text{NiO}_2 + 4\text{H}^+ + 2e \rightleftharpoons \text{Ni}^{2+} + 2\text{H}_2\text{O}$                           | 1.678       |
| $\text{NiO}_2 + 2\text{H}_2\text{O} + 2e \rightleftharpoons \text{Ni}(\text{OH})_2 + 2\text{OH}^-$                  | -0.490      |

| Reaction                                                                                                       | $E^\circ/V$ | Reaction                                                                                                                           | $E^\circ/V$ |
|----------------------------------------------------------------------------------------------------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------|-------------|
| $\text{No}^{3+} + e \rightleftharpoons \text{No}^{2+}$                                                         | 1.4         | $\text{Pr}^{3+} + e \rightleftharpoons \text{Pr}^{2+}$                                                                             | -3.1        |
| $\text{No}^{3+} + 3 e \rightleftharpoons \text{No}$                                                            | -1.20       | $\text{Pt}^{2+} + 2 e \rightleftharpoons \text{Pt}$                                                                                | 1.18        |
| $\text{No}^{2+} + 2 e \rightleftharpoons \text{No}$                                                            | -2.50       | $[\text{PtCl}_4]^{2-} + 2 e \rightleftharpoons \text{Pt} + 4 \text{Cl}^-$                                                          | 0.755       |
| $\text{Np}^{3+} + 3 e \rightleftharpoons \text{Np}$                                                            | -1.856      | $[\text{PtCl}_6]^{2-} + 2 e \rightleftharpoons [\text{PtCl}_4]^{2-} + 2 \text{Cl}^-$                                               | 0.68        |
| $\text{Np}^{4+} + e \rightleftharpoons \text{Np}^{3+}$                                                         | 0.147       | $\text{Pt}(\text{OH})_2 + 2 e \rightleftharpoons \text{Pt} + 2 \text{OH}^-$                                                        | 0.14        |
| $\text{NpO}_2 + \text{H}_2\text{O} + \text{H}^+ + e \rightleftharpoons \text{Np}(\text{OH})_3$                 | -0.962      | $\text{PtO}_3 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{PtO}_2 + \text{H}_2\text{O}$                                           | 1.7         |
| $\text{O}_2 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{H}_2\text{O}_2$                                      | 0.695       | $\text{PtO}_3 + 4 \text{H}^+ + 2 e \rightleftharpoons \text{Pt}(\text{OH})_2^{2+} + \text{H}_2\text{O}$                            | 1.5         |
| $\text{O}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons 2 \text{H}_2\text{O}$                                      | 1.229       | $\text{PtOH}^+ + \text{H}^+ + 2 e \rightleftharpoons \text{Pt} + \text{H}_2\text{O}$                                               | 1.2         |
| $\text{O}_2 + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{HO}_2^- + \text{OH}^-$                         | -0.076      | $\text{PtO}_2 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{PtO} + \text{H}_2\text{O}$                                             | 1.01        |
| $\text{O}_2 + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{H}_2\text{O}_2 + 2 \text{OH}^-$              | -0.146      | $\text{PtO}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Pt} + 2 \text{H}_2\text{O}$                                            | 1.00        |
| $\text{O}_2 + 2 \text{H}_2\text{O} + 4 e \rightleftharpoons 4 \text{OH}^-$                                     | 0.401       | $\text{Pu}^{3+} + 3 e \rightleftharpoons \text{Pu}$                                                                                | -2.031      |
| $\text{O}_3 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{O}_2 + \text{H}_2\text{O}$                           | 2.076       | $\text{Pu}^{4+} + e \rightleftharpoons \text{Pu}^{3+}$                                                                             | 1.006       |
| $\text{O}_3 + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{O}_2 + 2 \text{OH}^-$                          | 1.24        | $\text{Pu}^{5+} + e \rightleftharpoons \text{Pu}^{4+}$                                                                             | 1.099       |
| $\text{O}(\text{g}) + 2 \text{H}^+ + 2 e \rightleftharpoons \text{H}_2\text{O}$                                | 2.421       | $\text{PuO}_2(\text{OH})_2 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{Pu}(\text{OH})_4$                                         | 1.325       |
| $\text{OH} + e \rightleftharpoons \text{OH}^-$                                                                 | 2.02        | $\text{PuO}_2(\text{OH})_2 + \text{H}^+ + e \rightleftharpoons \text{PuO}_2\text{OH} + \text{H}_2\text{O}$                         | 1.062       |
| $\text{HO}_2^- + \text{H}_2\text{O} + 2 e \rightleftharpoons 3 \text{OH}^-$                                    | 0.878       | $\text{Ra}^{2+} + 2 e \rightleftharpoons \text{Ra}$                                                                                | -2.8        |
| $\text{OsO}_4 + 8 \text{H}^+ + 8 e \rightleftharpoons \text{Os} + 4 \text{H}_2\text{O}$                        | 0.838       | $\text{Rb}^+ + e \rightleftharpoons \text{Rb}$                                                                                     | -2.98       |
| $\text{OsO}_4 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{OsO}_2 + 2 \text{H}_2\text{O}$                     | 1.02        | $\text{Re}^{3+} + 3 e \rightleftharpoons \text{Re}$                                                                                | 0.300       |
| $[\text{Os}(\text{bipy})_2]^{3+} + e \rightleftharpoons [\text{Os}(\text{bipy})_2]^{2+}$                       | 0.81        | $\text{ReO}_4^- + 4 \text{H}^+ + 3 e \rightleftharpoons \text{ReO}_2 + 2 \text{H}_2\text{O}$                                       | 0.510       |
| $[\text{Os}(\text{bipy})_3]^{3+} + e \rightleftharpoons [\text{Os}(\text{bipy})_3]^{2+}$                       | 0.80        | $\text{ReO}_2 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Re} + 2 \text{H}_2\text{O}$                                            | 0.2513      |
| $\text{P}(\text{red}) + 3 \text{H}^+ + 3 e \rightleftharpoons \text{PH}_3(\text{g})$                           | -0.111      | $\text{ReO}_4^- + 2 \text{H}^+ + e \rightleftharpoons \text{ReO}_3 + \text{H}_2\text{O}$                                           | 0.768       |
| $\text{P}(\text{white}) + 3 \text{H}^+ + 3 e \rightleftharpoons \text{PH}_3(\text{g})$                         | -0.063      | $\text{ReO}_4^- + 4 \text{H}_2\text{O} + 7 e \rightleftharpoons \text{Re} + 8 \text{OH}^-$                                         | -0.584      |
| $\text{P} + 3 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{PH}_3(\text{g}) + 3 \text{OH}^-$               | -0.87       | $\text{ReO}_4^- + 8 \text{H}^+ + 7 e \rightleftharpoons \text{Re} + 4 \text{H}_2\text{O}$                                          | 0.368       |
| $\text{H}_2\text{P}_2^- + e \rightleftharpoons \text{P} + 2 \text{OH}^-$                                       | -1.82       | $\text{Rh}^+ + e \rightleftharpoons \text{Rh}$                                                                                     | 0.600       |
| $\text{H}_3\text{PO}_2 + \text{H}^+ + e \rightleftharpoons \text{P} + 2 \text{H}_2\text{O}$                    | -0.508      | $\text{Rh}^{3+} + 3 e \rightleftharpoons \text{Rh}$                                                                                | 0.758       |
| $\text{H}_3\text{PO}_3 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{H}_3\text{PO}_2 + \text{H}_2\text{O}$     | -0.499      | $[\text{RhCl}_6]^{3-} + 3 e \rightleftharpoons \text{Rh} + 6 \text{Cl}^-$                                                          | 0.431       |
| $\text{H}_3\text{PO}_3 + 3 \text{H}^+ + 3 e \rightleftharpoons \text{P} + 3 \text{H}_2\text{O}$                | -0.454      | $\text{RhOH}^{2+} + \text{H}^+ + 3 e \rightleftharpoons \text{Rh} + \text{H}_2\text{O}$                                            | 0.83        |
| $\text{HPO}_3^{2-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{H}_2\text{PO}_2^- + 3 \text{OH}^-$    | -1.65       | $\text{Ru}^{2+} + 2 e \rightleftharpoons \text{Ru}$                                                                                | 0.455       |
| $\text{HPO}_3^{2-} + 2 \text{H}_2\text{O} + 3 e \rightleftharpoons \text{P} + 5 \text{OH}^-$                   | -1.71       | $\text{Ru}^{3+} + e \rightleftharpoons \text{Ru}^{2+}$                                                                             | 0.2487      |
| $\text{H}_3\text{PO}_4 + 2 \text{H}^+ + 2 e \rightleftharpoons \text{H}_3\text{PO}_3 + \text{H}_2\text{O}$     | -0.276      | $\text{RuO}_2 + 4 \text{H}^+ + 2 e \rightleftharpoons \text{Ru}^{2+} + 2 \text{H}_2\text{O}$                                       | 1.120       |
| $\text{PO}_4^{3-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{HPO}_3^{2-} + 3 \text{OH}^-$           | -1.05       | $\text{RuO}_4^- + e \rightleftharpoons \text{RuO}_4^{2-}$                                                                          | 0.59        |
| $\text{Pa}^{3+} + 3 e \rightleftharpoons \text{Pa}$                                                            | -1.34       | $\text{RuO}_4 + e \rightleftharpoons \text{RuO}_4^-$                                                                               | 1.00        |
| $\text{Pa}^{4+} + 4 e \rightleftharpoons \text{Pa}$                                                            | -1.49       | $\text{RuO}_4 + 6 \text{H}^+ + 4 e \rightleftharpoons \text{Ru}(\text{OH})_2^{2+} + 2 \text{H}_2\text{O}$                          | 1.40        |
| $\text{Pa}^{4+} + e \rightleftharpoons \text{Pa}^{3+}$                                                         | -1.9        | $\text{RuO}_4 + 8 \text{H}^+ + 8 e \rightleftharpoons \text{Ru} + 4 \text{H}_2\text{O}$                                            | 1.038       |
| $\text{Pb}^{2+} + 2 e \rightleftharpoons \text{Pb}$                                                            | -0.1262     | $[\text{Ru}(\text{bipy})_3]^{3+} + e^- \rightleftharpoons [\text{Ru}(\text{bipy})_3]^{2+}$                                         | 1.24        |
| $\text{Pb}^{2+} + 2 e \rightleftharpoons \text{Pb}(\text{Hg})$                                                 | -0.1205     | $[\text{Ru}(\text{H}_2\text{O})_6]^{3+} + e^- \rightleftharpoons [\text{Ru}(\text{H}_2\text{O})_6]^{2+}$                           | 0.23        |
| $\text{PbBr}_2 + 2 e \rightleftharpoons \text{Pb} + 2 \text{Br}^-$                                             | -0.284      | $[\text{Ru}(\text{NH}_3)_6]^{3+} + e^- \rightleftharpoons [\text{Ru}(\text{NH}_3)_6]^{2+}$                                         | 0.10        |
| $\text{PbCl}_2 + 2 e \rightleftharpoons \text{Pb} + 2 \text{Cl}^-$                                             | -0.2675     | $[\text{Ru}(\text{en})_3]^{3+} + e^- \rightleftharpoons [\text{Ru}(\text{en})_3]^{2+}$                                             | 0.210       |
| $\text{PbF}_2 + 2 e \rightleftharpoons \text{Pb} + 2 \text{F}^-$                                               | -0.3444     | $[\text{Ru}(\text{CN})_6]^{3-} + e^- \rightleftharpoons [\text{Ru}(\text{CN})_6]^{4-}$                                             | 0.86        |
| $\text{PbHPO}_4 + 2 e \rightleftharpoons \text{Pb} + \text{HPO}_4^{2-}$                                        | -0.465      | $\text{S} + 2 e \rightleftharpoons \text{S}^{2-}$                                                                                  | -0.47627    |
| $\text{PbI}_2 + 2 e \rightleftharpoons \text{Pb} + 2 \text{I}^-$                                               | -0.365      | $\text{S} + 2 \text{H}^+ + 2 e \rightleftharpoons \text{H}_2\text{S}(\text{aq})$                                                   | 0.142       |
| $\text{PbO} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Pb} + 2 \text{OH}^-$                           | -0.580      | $\text{S} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{SH}^- + \text{OH}^-$                                                 | -0.478      |
| $\text{PbO}_2 + 4 \text{H}^+ + 2 e \rightleftharpoons \text{Pb}^{2+} + 2 \text{H}_2\text{O}$                   | 1.455       | $2 \text{S} + 2 e \rightleftharpoons \text{S}_2^{2-}$                                                                              | -0.42836    |
| $\text{HPbO}_2^- + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{Pb} + 3 \text{OH}^-$                      | -0.537      | $\text{S}_2\text{O}_6^{2-} + 4 \text{H}^+ + 2 e \rightleftharpoons 2 \text{H}_2\text{SO}_3$                                        | 0.564       |
| $\text{PbO}_2 + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{PbO} + 2 \text{OH}^-$                        | 0.247       | $\text{S}_2\text{O}_8^{2-} + 2 e \rightleftharpoons 2 \text{SO}_4^{2-}$                                                            | 2.010       |
| $\text{PbO}_2 + \text{SO}_4^{2-} + 4 \text{H}^+ + 2 e \rightleftharpoons \text{PbSO}_4 + 2 \text{H}_2\text{O}$ | 1.6913      | $\text{S}_2\text{O}_8^{2-} + 2 \text{H}^+ + 2 e \rightleftharpoons 2 \text{HSO}_4^-$                                               | 2.123       |
| $\text{PbSO}_4 + 2 e \rightleftharpoons \text{Pb} + \text{SO}_4^{2-}$                                          | -0.3588     | $\text{S}_4\text{O}_6^{2-} + 2 e \rightleftharpoons 2 \text{S}_2\text{O}_3^{2-}$                                                   | 0.08        |
| $\text{PbSO}_4 + 2 e \rightleftharpoons \text{Pb}(\text{Hg}) + \text{SO}_4^{2-}$                               | -0.3505     | $2 \text{H}_2\text{SO}_3 + \text{H}^+ + 2 e \rightleftharpoons \text{HS}_2\text{O}_4^- + 2 \text{H}_2\text{O}$                     | -0.056      |
| $\text{Pd}^{2+} + 2 e \rightleftharpoons \text{Pd}$                                                            | 0.951       | $\text{H}_2\text{SO}_3 + 4 \text{H}^+ + 4 e \rightleftharpoons \text{S} + 3 \text{H}_2\text{O}$                                    | 0.449       |
| $[\text{PdCl}_4]^{2-} + 2 e \rightleftharpoons \text{Pd} + 4 \text{Cl}^-$                                      | 0.591       | $2 \text{SO}_3^{2-} + 2 \text{H}_2\text{O} + 2 e \rightleftharpoons \text{S}_2\text{O}_4^{2-} + 4 \text{OH}^-$                     | -1.12       |
| $[\text{PdCl}_6]^{2-} + 2 e \rightleftharpoons [\text{PdCl}_4]^{2-} + 2 \text{Cl}^-$                           | 1.288       | $2 \text{SO}_3^{2-} + 3 \text{H}_2\text{O} + 4 e \rightleftharpoons \text{S}_2\text{O}_3^{2-} + 6 \text{OH}^-$                     | -0.571      |
| $\text{Pd}(\text{OH})_2 + 2 e \rightleftharpoons \text{Pd} + 2 \text{OH}^-$                                    | 0.07        | $\text{SO}_4^{2-} + 4 \text{H}^+ + 2 e \rightleftharpoons \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$                              | 0.172       |
| $\text{Pm}^{2+} + 2 e \rightleftharpoons \text{Pm}$                                                            | -2.2        | $2 \text{SO}_4^{2-} + 4 \text{H}^+ + 2 e \rightleftharpoons \text{S}_2\text{O}_6^{2-} + \text{H}_2\text{O}$                        | -0.22       |
| $\text{Pm}^{3+} + 3 e \rightleftharpoons \text{Pm}$                                                            | -2.30       | $\text{SO}_4^{2-} + \text{H}_2\text{O} + 2 e \rightleftharpoons \text{SO}_3^{2-} + 2 \text{OH}^-$                                  | -0.93       |
| $\text{Pm}^{3+} + e \rightleftharpoons \text{Pm}^{2+}$                                                         | -2.6        | $\text{Sb} + 3 \text{H}^+ + 3 e \rightleftharpoons \text{SbH}_3$                                                                   | -0.510      |
| $\text{Po}^{4+} + 2 e \rightleftharpoons \text{Po}^{2+}$                                                       | 0.9         | $\text{Sb}_2\text{O}_3 + 6 \text{H}^+ + 6 e \rightleftharpoons 2 \text{Sb} + 3 \text{H}_2\text{O}$                                 | 0.152       |
| $\text{Po}^{4+} + 4 e \rightleftharpoons \text{Po}$                                                            | 0.76        | $\text{Sb}_2\text{O}_5 (\text{senarmontite}) + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Sb}_2\text{O}_3 + 2 \text{H}_2\text{O}$ | 0.671       |
| $\text{Pr}^{4+} + e \rightleftharpoons \text{Pr}^{3+}$                                                         | 3.2         | $\text{Sb}_2\text{O}_5 (\text{valentinite}) + 4 \text{H}^+ + 4 e \rightleftharpoons \text{Sb}_2\text{O}_3 + 2 \text{H}_2\text{O}$  | 0.649       |
| $\text{Pr}^{2+} + 2 e \rightleftharpoons \text{Pr}$                                                            | -2.0        |                                                                                                                                    |             |
| $\text{Pr}^{3+} + 3 e \rightleftharpoons \text{Pr}$                                                            | -2.353      |                                                                                                                                    |             |

| Reaction                                                                                                        | $E^\circ/V$ |
|-----------------------------------------------------------------------------------------------------------------|-------------|
| $\text{Sb}_2\text{O}_5 + 6 \text{H}^+ + 4 \text{e} \rightleftharpoons 2 \text{SbO}^+ + 3 \text{H}_2\text{O}$    | 0.581       |
| $\text{SbO}^+ + 2 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{Sb} + 2 \text{H}_2\text{O}$                  | 0.212       |
| $\text{SbO}_2^- + 2 \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{Sb} + 4 \text{OH}^-$               | -0.66       |
| $\text{SbO}_3^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{SbO}_2^- + 2 \text{OH}^-$            | -0.59       |
| $\text{Sc}^{3+} + 3 \text{e} \rightleftharpoons \text{Sc}$                                                      | -2.077      |
| $\text{Se} + 2 \text{e} \rightleftharpoons \text{Se}^{2-}$                                                      | -0.924      |
| $\text{Se} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{Se(aq)}$                              | -0.399      |
| $\text{H}_2\text{SeO}_3 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Se} + 3 \text{H}_2\text{O}$        | 0.74        |
| $\text{Se} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{Se}$                                  | -0.082      |
| $\text{SeO}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Se} + 6 \text{OH}^-$            | -0.366      |
| $\text{SeO}_4^{2-} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{SeO}_3 + \text{H}_2\text{O}$  | 1.151       |
| $\text{SeO}_4^{2-} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{SeO}_3^{2-} + 2 \text{OH}^-$      | 0.05        |
| $\text{SiF}_6^{2-} + 4 \text{e} \rightleftharpoons \text{Si} + 6 \text{F}^-$                                    | -1.24       |
| $\text{SiO} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Si} + \text{H}_2\text{O}$                      | -0.8        |
| $\text{SiO}_2 \text{ (quartz)} + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Si} + 2 \text{H}_2\text{O}$ | 0.857       |
| $\text{SiO}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Si} + 6 \text{OH}^-$            | -1.697      |
| $\text{Sm}^{3+} + \text{e} \rightleftharpoons \text{Sm}^{2+}$                                                   | -1.55       |
| $\text{Sm}^{3+} + 3 \text{e} \rightleftharpoons \text{Sm}$                                                      | -2.304      |
| $\text{Sm}^{2+} + 2 \text{e} \rightleftharpoons \text{Sm}$                                                      | -2.68       |
| $\text{Sn}^{2+} + 2 \text{e} \rightleftharpoons \text{Sn}$                                                      | -0.1375     |
| $\text{Sn}^{4+} + 2 \text{e} \rightleftharpoons \text{Sn}^{2+}$                                                 | 0.151       |
| $\text{Sn(OH)}_3^+ + 3 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Sn}^{2+} + 3 \text{H}_2\text{O}$        | 0.142       |
| $\text{SnO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Sn}^{2+} + 2 \text{H}_2\text{O}$             | -0.094      |
| $\text{SnO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Sn} + 2 \text{H}_2\text{O}$                  | -0.117      |
| $\text{SnO}_2 + 3 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{SnOH}^+ + \text{H}_2\text{O}$                | -0.194      |
| $\text{SnO}_2 + 2 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Sn} + 4 \text{OH}^-$                 | -0.945      |
| $\text{HSnO}_2^- + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Sn} + 3 \text{OH}^-$                | -0.909      |
| $\text{Sn(OH)}_6^{2-} + 2 \text{e} \rightleftharpoons \text{HSnO}_2^- + 3 \text{OH}^- + \text{H}_2\text{O}$     | -0.93       |
| $\text{Sr}^+ + \text{e} \rightleftharpoons \text{Sr}$                                                           | -4.10       |
| $\text{Sr}^{2+} + 2 \text{e} \rightleftharpoons \text{Sr}$                                                      | -2.899      |
| $\text{Sr}^{2+} + 2 \text{e} \rightleftharpoons \text{Sr(Hg)}$                                                  | -1.793      |
| $\text{Sr(OH)}_2 + 2 \text{e} \rightleftharpoons \text{Sr} + 2 \text{OH}^-$                                     | -2.88       |
| $\text{Ta}_2\text{O}_5 + 10 \text{H}^+ + 10 \text{e} \rightleftharpoons 2 \text{Ta} + 5 \text{H}_2\text{O}$     | -0.750      |
| $\text{Ta}^{3+} + 3 \text{e} \rightleftharpoons \text{Ta}$                                                      | -0.6        |
| $\text{Tc}^{2+} + 2 \text{e} \rightleftharpoons \text{Tc}$                                                      | 0.400       |
| $\text{TcO}_4^- + 4 \text{H}^+ + 3 \text{e} \rightleftharpoons \text{TcO}_2 + 2 \text{H}_2\text{O}$             | 0.782       |
| $\text{Tc}^{3+} + \text{e} \rightleftharpoons \text{Tc}^{2+}$                                                   | 0.3         |
| $\text{TcO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons \text{Tc} + 4 \text{H}_2\text{O}$                | 0.472       |
| $\text{Tb}^{4+} + \text{e} \rightleftharpoons \text{Tb}^{3+}$                                                   | 3.1         |
| $\text{Tb}^{3+} + 3 \text{e} \rightleftharpoons \text{Tb}$                                                      | -2.28       |
| $\text{Te} + 2 \text{e} \rightleftharpoons \text{Te}^{2-}$                                                      | -1.143      |
| $\text{Te} + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{H}_2\text{Te}$                                  | -0.793      |
| $\text{Te}^{4+} + 4 \text{e} \rightleftharpoons \text{Te}$                                                      | 0.568       |
| $\text{TeO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Te} + 2 \text{H}_2\text{O}$                  | 0.593       |
| $\text{TeO}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Te} + 6 \text{OH}^-$            | -0.57       |
| $\text{TeO}_4^- + 8 \text{H}^+ + 7 \text{e} \rightleftharpoons \text{Te} + 4 \text{H}_2\text{O}$                | 0.472       |
| $\text{H}_6\text{TeO}_6 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{TeO}_2 + 4 \text{H}_2\text{O}$     | 1.02        |
| $\text{Th}^{4+} + 4 \text{e} \rightleftharpoons \text{Th}$                                                      | -1.899      |
| $\text{ThO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Th} + 2 \text{H}_2\text{O}$                  | -1.789      |
| $\text{Th(OH)}_4 + 4 \text{e} \rightleftharpoons \text{Th} + 4 \text{OH}^-$                                     | -2.48       |
| $\text{Ti}^{2+} + 2 \text{e} \rightleftharpoons \text{Ti}$                                                      | -1.630      |
| $\text{Ti}^{3+} + \text{e} \rightleftharpoons \text{Ti}^{2+}$                                                   | -0.9        |
| $\text{TiO}_2 + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Ti}^{2+} + 2 \text{H}_2\text{O}$             | -0.502      |
| $\text{Ti}^{3+} + 3 \text{e} \rightleftharpoons \text{Ti}$                                                      | -1.37       |
| $\text{TiOH}^{3+} + \text{H}^+ + \text{e} \rightleftharpoons \text{Ti}^{3+} + \text{H}_2\text{O}$               | -0.055      |

| Reaction                                                                                                                                                     | $E^\circ/V$ |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| $\text{Tl}^+ + \text{e} \rightleftharpoons \text{Tl}$                                                                                                        | -0.336      |
| $\text{Tl}^+ + \text{e} \rightleftharpoons \text{Tl(Hg)}$                                                                                                    | -0.3338     |
| $\text{Tl}^{3+} + 2 \text{e} \rightleftharpoons \text{Tl}^+$                                                                                                 | 1.252       |
| $\text{Tl}^{3+} + 3 \text{e} \rightleftharpoons \text{Tl}$                                                                                                   | 0.741       |
| $\text{TlBr} + \text{e} \rightleftharpoons \text{Tl} + \text{Br}^-$                                                                                          | -0.658      |
| $\text{TlCl} + \text{e} \rightleftharpoons \text{Tl} + \text{Cl}^-$                                                                                          | -0.5568     |
| $\text{TlI} + \text{e} \rightleftharpoons \text{Tl} + \text{I}^-$                                                                                            | -0.752      |
| $\text{Ti}_2\text{O}_3 + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons 2 \text{Ti}^+ + 6 \text{OH}^-$                                                 | 0.02        |
| $\text{TlOH} + \text{e} \rightleftharpoons \text{Tl} + \text{OH}^-$                                                                                          | -0.34       |
| $\text{Ti(OH)}_3 + 2 \text{e} \rightleftharpoons \text{TlOH} + 2 \text{OH}^-$                                                                                | -0.05       |
| $\text{Ti}_2\text{SO}_4 + 2 \text{e} \rightleftharpoons \text{Ti} + \text{SO}_4^{2-}$                                                                        | -0.4360     |
| $\text{Tm}^{3+} + \text{e} \rightleftharpoons \text{Tm}^{2+}$                                                                                                | -2.2        |
| $\text{Tm}^{3+} + 3 \text{e} \rightleftharpoons \text{Tm}$                                                                                                   | -2.319      |
| $\text{Tm}^{2+} + 2 \text{e} \rightleftharpoons \text{Tm}$                                                                                                   | -2.4        |
| $\text{U}^{3+} + 3 \text{e} \rightleftharpoons \text{U}$                                                                                                     | -1.798      |
| $\text{U}^{4+} + \text{e} \rightleftharpoons \text{U}^{3+}$                                                                                                  | -0.607      |
| $\text{UO}_2^+ + 4 \text{H}^+ + \text{e} \rightleftharpoons \text{U}^{4+} + 2 \text{H}_2\text{O}$                                                            | 0.612       |
| $\text{UO}_2^{2+} + \text{e} \rightleftharpoons \text{UO}_2^+$                                                                                               | 0.062       |
| $\text{UO}_2^{2+} + 4 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{U}^{4+} + 2 \text{H}_2\text{O}$                                                       | 0.327       |
| $\text{UO}_2^{2+} + 4 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{U} + 2 \text{H}_2\text{O}$                                                            | -1.444      |
| $\text{V}^{2+} + 2 \text{e} \rightleftharpoons \text{V}$                                                                                                     | -1.175      |
| $\text{V}^{3+} + \text{e} \rightleftharpoons \text{V}^{2+}$                                                                                                  | -0.255      |
| $\text{VO}^{2+} + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{V}^{3+} + \text{H}_2\text{O}$                                                             | 0.337       |
| $\text{VO}_2^+ + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{VO}^{2+} + \text{H}_2\text{O}$                                                             | 0.991       |
| $\text{V}_2\text{O}_5 + 6 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{VO}^{2+} + 3 \text{H}_2\text{O}$                                                | 0.957       |
| $\text{V}_2\text{O}_5 + 10 \text{H}^+ + 10 \text{e} \rightleftharpoons 2 \text{V} + 5 \text{H}_2\text{O}$                                                    | -0.242      |
| $\text{V(OH)}_4^+ + 2 \text{H}^+ + \text{e} \rightleftharpoons \text{VO}^{2+} + 3 \text{H}_2\text{O}$                                                        | 1.00        |
| $\text{V(OH)}_4^+ + 4 \text{H}^+ + 5 \text{e} \rightleftharpoons \text{V} + 4 \text{H}_2\text{O}$                                                            | -0.254      |
| $[\text{V(phen)}_3]^{3+} + \text{e} \rightleftharpoons [\text{V(phen)}_3]^{2+}$                                                                              | 0.14        |
| $\text{W}^{3+} + 3 \text{e} \rightleftharpoons \text{W}$                                                                                                     | 0.1         |
| $\text{W}_2\text{O}_5 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{WO}_2 + \text{H}_2\text{O}$                                                     | -0.031      |
| $\text{WO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{W} + 2 \text{H}_2\text{O}$                                                                 | -0.119      |
| $\text{WO}_3 + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{W} + 3 \text{H}_2\text{O}$                                                                 | -0.090      |
| $\text{WO}_3 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{WO}_2 + \text{H}_2\text{O}$                                                                | 0.036       |
| $2 \text{WO}_3 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{W}_2\text{O}_5 + \text{H}_2\text{O}$                                                     | -0.029      |
| $\text{H}_4\text{XeO}_6 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons \text{XeO}_3 + 3 \text{H}_2\text{O}$                                                  | 2.42        |
| $\text{XeO}_3 + 6 \text{H}^+ + 6 \text{e} \rightleftharpoons \text{Xe} + 3 \text{H}_2\text{O}$                                                               | 2.10        |
| $\text{XeF} + \text{e} \rightleftharpoons \text{Xe} + \text{F}^-$                                                                                            | 3.4         |
| $\text{Y}^{3+} + 3 \text{e} \rightleftharpoons \text{Y}$                                                                                                     | -2.372      |
| $\text{Yb}^{3+} + \text{e} \rightleftharpoons \text{Yb}^{2+}$                                                                                                | -1.05       |
| $\text{Yb}^{3+} + 3 \text{e} \rightleftharpoons \text{Yb}$                                                                                                   | -2.19       |
| $\text{Yb}^{2+} + 2 \text{e} \rightleftharpoons \text{Yb}$                                                                                                   | -2.76       |
| $\text{Zn}^{2+} + 2 \text{e} \rightleftharpoons \text{Zn}$                                                                                                   | -0.7618     |
| $\text{Zn}^{2+} + 2 \text{e} \rightleftharpoons \text{Zn(Hg)}$                                                                                               | -0.7628     |
| $\text{ZnO}_2^{2-} + 2 \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Zn} + 4 \text{OH}^-$                                                         | -1.215      |
| $\text{ZnSO}_4 \cdot 7 \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Zn(Hg)} + \text{SO}_4^{2-} + 7 \text{H}_2\text{O (Saturated ZnSO}_4\text{)}$ | -0.7993     |
| $\text{ZnOH}^+ + \text{H}^+ + 2 \text{e} \rightleftharpoons \text{Zn} + \text{H}_2\text{O}$                                                                  | -0.497      |
| $\text{Zn(OH)}_4^{2-} + 2 \text{e} \rightleftharpoons \text{Zn} + 4 \text{OH}^-$                                                                             | -1.199      |
| $\text{Zn(OH)}_2 + 2 \text{e} \rightleftharpoons \text{Zn} + 2 \text{OH}^-$                                                                                  | -1.249      |
| $\text{ZnO} + \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{Zn} + 2 \text{OH}^-$                                                                  | -1.260      |
| $\text{ZrO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Zr} + 2 \text{H}_2\text{O}$                                                               | -1.553      |
| $\text{ZrO(OH)}_2 + \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Zr} + 4 \text{OH}^-$                                                            | -2.36       |
| $\text{Zr}^{4+} + 4 \text{e} \rightleftharpoons \text{Zr}$                                                                                                   | -1.45       |

TABLE 2. Reduction Reactions Having  $E^\circ$  Values More Positive than That of the Standard Hydrogen Electrode

| Reaction                                                                                                                   | $E^\circ/V$ | Reaction                                                                                                  | $E^\circ/V$ |
|----------------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------------------------------------------------------------------------------------|-------------|
| $2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2$                                                                    | 0.00000     | $\text{Hg}_2\text{Cl}_2 + 2\text{e} \rightleftharpoons 2\text{Hg} + 2\text{Cl}^-$                         | 0.26808     |
| $\text{CuI}_2^- + \text{e} \rightleftharpoons \text{Cu} + 2\text{I}^-$                                                     | 0.00        | Calomel electrode, 1 molal KCl                                                                            | 0.2800      |
| $\text{Ge}^{4+} + 2\text{e} \rightleftharpoons \text{Ge}^{2+}$                                                             | 0.00        | Calomel electrode, 1 molar KCl (NCE)                                                                      | 0.2801      |
| $\text{NO}_3^- + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{NO}_2^- + 2\text{OH}^-$                           | 0.01        | $\text{At}_2 + 2\text{e} \rightleftharpoons 2\text{At}^-$                                                 | 0.3         |
| $\text{Tl}_2\text{O}_3 + 3\text{H}_2\text{O} + 4\text{e} \rightleftharpoons 2\text{Tl}^+ + 6\text{OH}^-$                   | 0.02        | $\text{Re}^{3+} + 3\text{e} \rightleftharpoons \text{Re}$                                                 | 0.300       |
| $\text{SeO}_4^{2-} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{SeO}_3^{2-} + 2\text{OH}^-$                   | 0.05        | $\text{Tc}^{3+} + \text{e} \rightleftharpoons \text{Tc}^{2+}$                                             | 0.3         |
| $\text{WO}_3 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{WO}_2 + \text{H}_2\text{O}$                                | 0.036       | $\text{Bi}^{3+} + 3\text{e} \rightleftharpoons \text{Bi}$                                                 | 0.308       |
| $\text{UO}_2^{2+} + \text{e} \rightleftharpoons \text{UO}_2^+$                                                             | 0.062       | $\text{BiO}^+ + 2\text{H}^+ + 3\text{e} \rightleftharpoons \text{Bi} + \text{H}_2\text{O}$                | 0.320       |
| $\text{Pd}(\text{OH})_2 + 2\text{e} \rightleftharpoons \text{Pd} + 2\text{OH}^-$                                           | 0.07        | $\text{UO}_2^{2+} + 4\text{H}^+ + 2\text{e} \rightleftharpoons \text{U}^{4+} + 2\text{H}_2\text{O}$       | 0.327       |
| $\text{AgBr} + \text{e} \rightleftharpoons \text{Ag} + \text{Br}^-$                                                        | 0.07133     | $\text{ClO}_3^- + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{ClO}_2^- + 2\text{OH}^-$        | 0.33        |
| $\text{MoO}_3 + 6\text{H}^+ + 6\text{e} \rightleftharpoons \text{Mo} + 3\text{H}_2\text{O}$                                | 0.075       | $2\text{HCNO} + 2\text{H}^+ + 2\text{e} \rightleftharpoons (\text{CN})_2 + 2\text{H}_2\text{O}$           | 0.330       |
| $\text{S}_4\text{O}_6^{2-} + 2\text{e} \rightleftharpoons 2\text{S}_2\text{O}_3^{2-}$                                      | 0.08        | Calomel electrode, 0.1 molar KCl                                                                          | 0.3337      |
| $\text{H}_3\text{Mo}_7\text{O}_{24}^{3-} + 45\text{H}^+ + 42\text{e} \rightleftharpoons 7\text{Mo} + 24\text{H}_2\text{O}$ | 0.082       | $\text{VO}^{2+} + 2\text{H}^+ + \text{e} \rightleftharpoons \text{V}^{3+} + \text{H}_2\text{O}$           | 0.337       |
| $\text{AgSCN} + \text{e} \rightleftharpoons \text{Ag} + \text{SCN}^-$                                                      | 0.8951      | $\text{Cu}^{2+} + 2\text{e} \rightleftharpoons \text{Cu}$                                                 | 0.3419      |
| $\text{N}_2 + 2\text{H}_2\text{O} + 6\text{H}^+ + 6\text{e} \rightleftharpoons 2\text{NH}_4\text{OH}$                      | 0.092       | $\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons 2\text{Ag} + 2\text{OH}^-$       | 0.342       |
| $\text{HgO} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Hg} + 2\text{OH}^-$                                  | 0.0977      | $\text{Cu}^{2+} + 2\text{e} \rightleftharpoons \text{Cu}(\text{Hg})$                                      | 0.345       |
| $\text{Ir}_2\text{O}_3 + 3\text{H}_2\text{O} + 6\text{e} \rightleftharpoons 2\text{Ir} + 6\text{OH}^-$                     | 0.098       | $\text{AgIO}_3 + \text{e} \rightleftharpoons \text{Ag} + \text{IO}_3^-$                                   | 0.354       |
| $2\text{NO} + 2\text{e} \rightleftharpoons \text{N}_2\text{O}_2^{2-}$                                                      | 0.10        | $[\text{Fe}(\text{CN})_6]^{3-} + \text{e} \rightleftharpoons [\text{Fe}(\text{CN})_6]^{4-}$               | 0.358       |
| $[\text{Ru}(\text{NH}_3)_6]^{3+} + \text{e} \rightleftharpoons [\text{Ru}(\text{NH}_3)_6]^{2+}$                            | 0.10        | $\text{ClO}_4^- + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{ClO}_3^- + 2\text{OH}^-$        | 0.36        |
| $\text{W}^{3+} + 3\text{e} \rightleftharpoons \text{W}$                                                                    | 0.1         | $\text{Ag}_2\text{SeO}_3 + 2\text{e} \rightleftharpoons 2\text{Ag} + \text{SeO}_3^{2-}$                   | 0.3629      |
| $[\text{Co}(\text{NH}_3)_6]^{3+} + \text{e} \rightleftharpoons [\text{Co}(\text{NH}_3)_6]^{2+}$                            | 0.108       | $\text{ReO}_4^- + 8\text{H}^+ + 7\text{e} \rightleftharpoons \text{Re} + 4\text{H}_2\text{O}$             | 0.368       |
| $\text{Hg}_2\text{O} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons 2\text{Hg} + 2\text{OH}^-$                        | 0.123       | $(\text{CN})_2 + 2\text{H}^+ + 2\text{e} \rightleftharpoons 2\text{HCN}$                                  | 0.373       |
| $\text{Ge}^{4+} + 4\text{e} \rightleftharpoons \text{Ge}$                                                                  | 0.124       | $[\text{Ferricinium}]^+ + \text{e} \rightleftharpoons \text{ferrocene}$                                   | 0.400       |
| $\text{Hg}_2\text{Br}_2 + 2\text{e} \rightleftharpoons 2\text{Hg} + 2\text{Br}^-$                                          | 0.13923     | $\text{Tc}^{2+} + 2\text{e} \rightleftharpoons \text{Tc}$                                                 | 0.400       |
| $\text{Pt}(\text{OH})_2 + 2\text{e} \rightleftharpoons \text{Pt} + 2\text{OH}^-$                                           | 0.14        | $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e} \rightleftharpoons 4\text{OH}^-$                            | 0.401       |
| $[\text{V}(\text{phen})_3]^{3+} + \text{e} \rightleftharpoons [\text{V}(\text{phen})_3]^{2+}$                              | 0.14        | $\text{AgOCN} + \text{e} \rightleftharpoons \text{Ag} + \text{OCN}^-$                                     | 0.41        |
| $\text{S} + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2\text{S}(\text{aq})$                                      | 0.142       | $[\text{RhCl}_6]^{3-} + 3\text{e} \rightleftharpoons \text{Rh} + 6\text{Cl}^-$                            | 0.431       |
| $\text{Sn}(\text{OH})_3^+ + 3\text{H}^+ + 2\text{e} \rightleftharpoons \text{Sn}^{2+} + 3\text{H}_2\text{O}$               | 0.142       | $\text{Ag}_2\text{CrO}_4 + 2\text{e} \rightleftharpoons 2\text{Ag} + \text{CrO}_4^{2-}$                   | 0.4470      |
| $\text{Np}^{4+} + \text{e} \rightleftharpoons \text{Np}^{3+}$                                                              | 0.147       | $\text{H}_2\text{SO}_3 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{S} + 3\text{H}_2\text{O}$       | 0.449       |
| $\text{Ag}_4[\text{Fe}(\text{CN})_6] + 4\text{e} \rightleftharpoons 4\text{Ag} + [\text{Fe}(\text{CN})_6]^{4-}$            | 0.1478      | $\text{Ru}^{2+} + 2\text{e} \rightleftharpoons \text{Ru}$                                                 | 0.455       |
| $\text{IO}_3^- + 2\text{H}_2\text{O} + 4\text{e} \rightleftharpoons \text{IO}^- + 4\text{OH}^-$                            | 0.15        | $\text{Ag}_2\text{MoO}_4 + 2\text{e} \rightleftharpoons 2\text{Ag} + \text{MoO}_4^{2-}$                   | 0.4573      |
| $\text{Mn}(\text{OH})_3 + \text{e} \rightleftharpoons \text{Mn}(\text{OH})_2 + \text{OH}^-$                                | 0.15        | $\text{Ag}_2\text{C}_2\text{O}_4 + 2\text{e} \rightleftharpoons 2\text{Ag} + \text{C}_2\text{O}_4^{2-}$   | 0.4647      |
| $2\text{NO}_2^- + 3\text{H}_2\text{O} + 4\text{e} \rightleftharpoons \text{N}_2\text{O} + 6\text{OH}^-$                    | 0.15        | $\text{Ag}_2\text{WO}_4 + 2\text{e} \rightleftharpoons 2\text{Ag} + \text{WO}_4^{2-}$                     | 0.4660      |
| $\text{Sn}^{4+} + 2\text{e} \rightleftharpoons \text{Sn}^{2+}$                                                             | 0.151       | $\text{Ag}_2\text{CO}_3 + 2\text{e} \rightleftharpoons 2\text{Ag} + \text{CO}_3^{2-}$                     | 0.47        |
| $\text{Sb}_2\text{O}_3 + 6\text{H}^+ + 6\text{e} \rightleftharpoons 2\text{Sb} + 3\text{H}_2\text{O}$                      | 0.152       | $\text{TcO}_4^- + 8\text{H}^+ + 7\text{e} \rightleftharpoons \text{Tc} + 4\text{H}_2\text{O}$             | 0.472       |
| $\text{Cu}^{2+} + \text{e} \rightleftharpoons \text{Cu}^+$                                                                 | 0.153       | $\text{TeO}_4^- + 8\text{H}^+ + 7\text{e} \rightleftharpoons \text{Te} + 4\text{H}_2\text{O}$             | 0.472       |
| $\text{BiOCl} + 2\text{H}^+ + 3\text{e} \rightleftharpoons \text{Bi} + \text{Cl}^- + \text{H}_2\text{O}$                   | 0.1583      | $\text{IO}^- + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{I}^- + 2\text{OH}^-$               | 0.485       |
| $\text{BiCl}_4^- + 3\text{e} \rightleftharpoons \text{Bi} + 4\text{Cl}^-$                                                  | 0.16        | $\text{NiO}_2 + 2\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Ni}(\text{OH})_2 + 2\text{OH}^-$ | 0.490       |
| $\text{Fe}_2\text{O}_3 + 4\text{H}^+ + 2\text{e} \rightleftharpoons 2\text{FeOH}^+ + \text{H}_2\text{O}$                   | 0.16        | $\text{Bi}^+ + \text{e} \rightleftharpoons \text{Bi}$                                                     | 0.5         |
| $\text{Co}(\text{OH})_3 + \text{e} \rightleftharpoons \text{Co}(\text{OH})_2 + \text{OH}^-$                                | 0.17        | $\text{ReO}_4^- + 4\text{H}^+ + 3\text{e} \rightleftharpoons \text{ReO}_2 + 2\text{H}_2\text{O}$          | 0.510       |
| $\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$                 | 0.172       | $\text{Hg}_2(\text{ac})_2 + 2\text{e} \rightleftharpoons 2\text{Hg} + 2(\text{ac})^-$                     | 0.51163     |
| $\text{Bi}^{3+} + 2\text{e} \rightleftharpoons \text{Bi}^+$                                                                | 0.2         | $\text{Cu}^+ + \text{e} \rightleftharpoons \text{Cu}$                                                     | 0.521       |
| $[\text{Ru}(\text{en})_3]^{3+} + \text{e} \rightleftharpoons [\text{Ru}(\text{en})_3]^{2+}$                                | 0.210       | $\text{I}_2 + 2\text{e} \rightleftharpoons 2\text{I}^-$                                                   | 0.5355      |
| $\text{SbO}^+ + 2\text{H}^+ + 3\text{e} \rightleftharpoons \text{Sb} + 2\text{H}_2\text{O}$                                | 0.212       | $\text{I}_3^- + 2\text{e} \rightleftharpoons 3\text{I}^-$                                                 | 0.536       |
| $\text{AgCl} + \text{e} \rightleftharpoons \text{Ag} + \text{Cl}^-$                                                        | 0.22233     | $\text{AgBrO}_3 + \text{e} \rightleftharpoons \text{Ag} + \text{BrO}_3^-$                                 | 0.546       |
| $[\text{Ru}(\text{H}_2\text{O})_6]^{3+} + \text{e} \rightleftharpoons [\text{Ru}(\text{H}_2\text{O})_6]^{2+}$              | 0.23        | $\text{MnO}_4^- + \text{e} \rightleftharpoons \text{MnO}_4^{2-}$                                          | 0.558       |
| $\text{As}_2\text{O}_3 + 6\text{H}^+ + 6\text{e} \rightleftharpoons 2\text{As} + 3\text{H}_2\text{O}$                      | 0.234       | $\text{H}_3\text{AsO}_4 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{HAsO}_2 + 2\text{H}_2\text{O}$ | 0.560       |
| Calomel electrode, saturated NaCl (SSCE)                                                                                   | 0.2360      | $\text{S}_2\text{O}_6^{2-} + 4\text{H}^+ + 2\text{e} \rightleftharpoons 2\text{H}_2\text{SO}_3$           | 0.564       |
| $\text{Ge}^{2+} + 2\text{e} \rightleftharpoons \text{Ge}$                                                                  | 0.24        | $\text{AgNO}_2 + \text{e} \rightleftharpoons \text{Ag} + \text{NO}_2^-$                                   | 0.564       |
| $\text{Ru}^{3+} + \text{e} \rightleftharpoons \text{Ru}^{2+}$                                                              | 0.24        | $\text{Te}^{4+} + 4\text{e} \rightleftharpoons \text{Te}$                                                 | 0.568       |
| Calomel electrode, saturated KCl                                                                                           | 0.2412      | $\text{Sb}_2\text{O}_5 + 6\text{H}^+ + 4\text{e} \rightleftharpoons 2\text{SbO}^+ + 3\text{H}_2\text{O}$  | 0.581       |
| $\text{PbO}_2 + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{PbO} + 2\text{OH}^-$                               | 0.247       | $\text{RuO}_4^- + \text{e} \rightleftharpoons \text{RuO}_4^{2-}$                                          | 0.59        |
| $\text{HAsO}_2 + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{As} + 2\text{H}_2\text{O}$                               | 0.248       | $[\text{PdCl}_4]^{2-} + 2\text{e} \rightleftharpoons \text{Pd} + 4\text{Cl}^-$                            | 0.591       |
| $\text{Ru}^{3+} + \text{e} \rightleftharpoons \text{Ru}^{2+}$                                                              | 0.2487      | $\text{TeO}_2 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{Te} + 2\text{H}_2\text{O}$               | 0.593       |
| $\text{ReO}_2 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{Re} + 2\text{H}_2\text{O}$                                | 0.2513      | $\text{MnO}_4^- + 2\text{H}_2\text{O} + 3\text{e} \rightleftharpoons \text{MnO}_2 + 4\text{OH}^-$         | 0.595       |
| $\text{IO}_3^- + 3\text{H}_2\text{O} + 6\text{e} \rightleftharpoons \text{I}^- + \text{OH}^-$                              | 0.26        | $\text{Rh}^{2+} + 2\text{e} \rightleftharpoons \text{Rh}$                                                 | 0.600       |

| Reaction                                                                                                                       | $E^\circ/V$ | Reaction                                                                                                                                 | $E^\circ/V$ |
|--------------------------------------------------------------------------------------------------------------------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| $\text{Rh}^+ + e \rightleftharpoons \text{Rh}$                                                                                 | 0.600       | $\text{HIO} + \text{H}^+ + 2e \rightleftharpoons \text{I}^- + \text{H}_2\text{O}$                                                        | 0.987       |
| $\text{MnO}_4^{2-} + 2\text{H}_2\text{O} + 2e \rightleftharpoons \text{MnO}_2 + 4\text{OH}^-$                                  | 0.60        | $\text{VO}_2^+ + 2\text{H}^+ + e \rightleftharpoons \text{VO}^{2+} + \text{H}_2\text{O}$                                                 | 0.991       |
| $2\text{AgO} + \text{H}_2\text{O} + 2e \rightleftharpoons \text{Ag}_2\text{O} + 2\text{OH}^-$                                  | 0.607       | $\text{PtO}_2 + 4\text{H}^+ + 4e \rightleftharpoons \text{Pt} + 2\text{H}_2\text{O}$                                                     | 1.00        |
| $\text{BrO}_3^- + 3\text{H}_2\text{O} + 6e \rightleftharpoons \text{Br}^- + 6\text{OH}^-$                                      | 0.61        | $\text{RuO}_4 + e \rightleftharpoons \text{RuO}_4^-$                                                                                     | 1.00        |
| $\text{UO}_2^{+} + 4\text{H}^+ + e \rightleftharpoons \text{U}^{4+} + 2\text{H}_2\text{O}$                                     | 0.612       | $\text{V}(\text{OH})_4^+ + 2\text{H}^+ + e \rightleftharpoons \text{VO}^{2+} + 3\text{H}_2\text{O}$                                      | 1.00        |
| $\text{Hg}_2\text{SO}_4 + 2e \rightleftharpoons 2\text{Hg} + \text{SO}_4^{2-}$                                                 | 0.6125      | $\text{AuCl}_4^- + 3e \rightleftharpoons \text{Au} + 4\text{Cl}^-$                                                                       | 1.002       |
| $\text{ClO}_3^- + 3\text{H}_2\text{O} + 6e \rightleftharpoons \text{Cl}^- + 6\text{OH}^-$                                      | 0.62        | $\text{Pu}^{4+} + e \rightleftharpoons \text{Pu}^{3+}$                                                                                   | 1.006       |
| $\text{Hg}_2\text{HPO}_4 + 2e \rightleftharpoons 2\text{Hg} + \text{HPO}_4^{2-}$                                               | 0.6359      | $\text{PtO}_2 + 2\text{H}^+ + 2e \rightleftharpoons \text{PtO} + \text{H}_2\text{O}$                                                     | 1.01        |
| $\text{Ag}(\text{ac}) + e \rightleftharpoons \text{Ag} + (\text{ac})^-$                                                        | 0.643       | $\text{OsO}_4 + 4\text{H}^+ + 4e \rightleftharpoons \text{OsO}_2 + 2\text{H}_2\text{O}$                                                  | 1.02        |
| $\text{Sb}_2\text{O}_5(\text{valentinite}) + 4\text{H}^+ + 4e \rightleftharpoons \text{Sb}_2\text{O}_3 + 2\text{H}_2\text{O}$  | 0.649       | $\text{H}_6\text{TeO}_6 + 2\text{H}^+ + 2e \rightleftharpoons \text{TeO}_2 + 4\text{H}_2\text{O}$                                        | 1.02        |
| $\text{Ag}_2\text{SO}_4 + 2e \rightleftharpoons 2\text{Ag} + \text{SO}_4^{2-}$                                                 | 0.654       | $[\text{Fe}(\text{bipy})_3]^{3+} + e \rightleftharpoons [\text{Fe}(\text{bipy})_3]^{2+}$                                                 | 1.03        |
| $\text{ClO}_2^- + \text{H}_2\text{O} + 2e \rightleftharpoons \text{ClO}^- + 2\text{OH}^-$                                      | 0.66        | $\text{Hg}(\text{OH})_2 + 2\text{H}^+ + 2e \rightleftharpoons \text{Hg} + 2\text{H}_2\text{O}$                                           | 1.034       |
| $\text{Sb}_2\text{O}_5(\text{senarmontite}) + 4\text{H}^+ + 4e \rightleftharpoons \text{Sb}_2\text{O}_3 + 2\text{H}_2\text{O}$ | 0.671       | $\text{N}_2\text{O}_4 + 4\text{H}^+ + 4e \rightleftharpoons 2\text{NO} + 2\text{H}_2\text{O}$                                            | 1.035       |
| $[\text{PtCl}_6]^{2-} + 2e \rightleftharpoons [\text{PtCl}_4]^{2-} + 2\text{Cl}^-$                                             | 0.68        | $\text{RuO}_4 + 8\text{H}^+ + 8e \rightleftharpoons \text{Ru} + 4\text{H}_2\text{O}$                                                     | 1.038       |
| $\text{O}_2 + 2\text{H}^+ + 2e \rightleftharpoons \text{H}_2\text{O}_2$                                                        | 0.695       | $[\text{Fe}(\text{phen})_3]^{3+} + e \rightleftharpoons [\text{Fe}(\text{phen})_3]^{2+} \text{ (1 molar } \text{H}_2\text{SO}_4\text{)}$ | 1.06        |
| $p\text{-benzoquinone} + 2\text{H}^+ + 2e \rightleftharpoons \text{hydroquinone}$                                              | 0.6992      | $\text{PuO}_2(\text{OH})_2 + \text{H}^+ + e \rightleftharpoons \text{PuO}_2\text{OH} + \text{H}_2\text{O}$                               | 1.062       |
| $\text{H}_3\text{IO}_6^{2-} + 2e \rightleftharpoons \text{IO}_3^- + 3\text{OH}^-$                                              | 0.7         | $\text{N}_2\text{O}_4 + 2\text{H}^+ + 2e \rightleftharpoons 2\text{HNO}_2$                                                               | 1.065       |
| $\text{Ag}_2\text{O}_3 + \text{H}_2\text{O} + 2e \rightleftharpoons 2\text{AgO} + 2\text{OH}^-$                                | 0.739       | $\text{Br}_2(\text{l}) + 2e \rightleftharpoons 2\text{Br}^-$                                                                             | 1.066       |
| $\text{TI}^{3+} + 3e \rightleftharpoons \text{TI}$                                                                             | 0.741       | $\text{IO}_3^- + 6\text{H}^+ + 6e \rightleftharpoons \text{I}^- + 3\text{H}_2\text{O}$                                                   | 1.085       |
| $[\text{PtCl}_4]^{2-} + 2e \rightleftharpoons \text{Pt} + 4\text{Cl}^-$                                                        | 0.755       | $\text{Br}_2(\text{aq}) + 2e \rightleftharpoons 2\text{Br}^-$                                                                            | 1.0873      |
| $\text{Rh}^{3+} + 3e \rightleftharpoons \text{Rh}$                                                                             | 0.758       | $\text{Pu}^{5+} + e \rightleftharpoons \text{Pu}^{4+}$                                                                                   | 1.099       |
| $\text{ClO}_2^- + 2\text{H}_2\text{O} + 4e \rightleftharpoons \text{Cl}^- + 4\text{OH}^-$                                      | 0.76        | $\text{Cu}^{2+} + 2\text{CN}^- + e \rightleftharpoons [\text{Cu}(\text{CN})_2]^-$                                                        | 1.103       |
| $2\text{NO} + \text{H}_2\text{O} + 2e \rightleftharpoons \text{N}_2\text{O} + 2\text{OH}^-$                                    | 0.76        | $\text{RuO}_2 + 4\text{H}^+ + 2e \rightleftharpoons \text{Ru}^{2+} + 2\text{H}_2\text{O}$                                                | 1.120       |
| $\text{Po}^{4+} + 4e \rightleftharpoons \text{Po}$                                                                             | 0.76        | $[\text{Fe}(\text{phen})_3]^{3+} + e \rightleftharpoons [\text{Fe}(\text{phen})_3]^{2+}$                                                 | 1.147       |
| $\text{BrO}^- + \text{H}_2\text{O} + 2e \rightleftharpoons \text{Br}^- + 2\text{OH}^-$                                         | 0.761       | $\text{SeO}_4^{2-} + 4\text{H}^+ + 2e \rightleftharpoons \text{H}_2\text{SeO}_3 + \text{H}_2\text{O}$                                    | 1.151       |
| $\text{ReO}_4^- + 2\text{H}^+ + e \rightleftharpoons \text{ReO}_3 + \text{H}_2\text{O}$                                        | 0.768       | $\text{ClO}_3^- + 2\text{H}^+ + e \rightleftharpoons \text{ClO}_2 + \text{H}_2\text{O}$                                                  | 1.152       |
| $(\text{CNS})_2 + 2e \rightleftharpoons 2\text{CNS}^-$                                                                         | 0.77        | $\text{Ir}^{3+} + 3e \rightarrow \text{Ir}$                                                                                              | 1.156       |
| $[\text{IrCl}_6]^{3-} + 3e \rightleftharpoons \text{Ir} + 6\text{Cl}^-$                                                        | 0.77        | $\text{Pt}^{2+} + 2e \rightleftharpoons \text{Pt}$                                                                                       | 1.18        |
| $\text{Fe}^{3+} + e \rightleftharpoons \text{Fe}^{2+}$                                                                         | 0.771       | $\text{ClO}_4^- + 2\text{H}^+ + 2e \rightleftharpoons \text{ClO}_3^- + \text{H}_2\text{O}$                                               | 1.189       |
| $\text{AgF} + e \rightleftharpoons \text{Ag} + \text{F}^-$                                                                     | 0.779       | $2\text{IO}_3^- + 12\text{H}^+ + 10e \rightleftharpoons \text{I}_2 + 6\text{H}_2\text{O}$                                                | 1.195       |
| $[\text{Fe}(\text{bipy})_2]^{3+} + e \rightleftharpoons [\text{Fe}(\text{bipy})_2]^{2+}$                                       | 0.78        | $\text{PtOH}^+ + \text{H}^+ + 2e \rightleftharpoons \text{Pt} + \text{H}_2\text{O}$                                                      | 1.2         |
| $\text{TcO}_4^- + 4\text{H}^+ + 3e \rightleftharpoons \text{TcO}_2 + 2\text{H}_2\text{O}$                                      | 0.782       | $\text{ClO}_3^- + 3\text{H}^+ + 2e \rightleftharpoons \text{HClO}_2 + \text{H}_2\text{O}$                                                | 1.214       |
| $\text{Hg}_2^{2+} + 2e \rightleftharpoons 2\text{Hg}$                                                                          | 0.7973      | $\text{MnO}_2 + 4\text{H}^+ + 2e \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$                                                | 1.224       |
| $\text{Ag}^+ + e \rightleftharpoons \text{Ag}$                                                                                 | 0.7996      | $\text{O}_2 + 4\text{H}^+ + 4e \rightleftharpoons 2\text{H}_2\text{O}$                                                                   | 1.229       |
| $[\text{Os}(\text{bipy})_3]^{3+} + e \rightleftharpoons [\text{Os}(\text{bipy})_3]^{2+}$                                       | 0.80        | $\text{O}_3 + \text{H}_2\text{O} + 2e \rightleftharpoons \text{O}_2 + 2\text{OH}^-$                                                      | 1.24        |
| $2\text{NO}_3^- + 4\text{H}^+ + 2e \rightleftharpoons \text{N}_2\text{O}_4 + 2\text{H}_2\text{O}$                              | 0.803       | $[\text{Ru}(\text{bipy})_3]^{3+} + e \rightleftharpoons [\text{Ru}(\text{bipy})_3]^{2+}$                                                 | 1.24        |
| $[\text{Os}(\text{bipy})_2]^{3+} + e \rightleftharpoons [\text{Os}(\text{bipy})_2]^{2+}$                                       | 0.81        | $\text{TI}^{3+} + 2e \rightleftharpoons \text{TI}^+$                                                                                     | 1.252       |
| $\text{RhOH}^{2+} + \text{H}^+ + 3e \rightleftharpoons \text{Rh} + \text{H}_2\text{O}$                                         | 0.83        | $\text{N}_2\text{H}_5^+ + 3\text{H}^+ + 2e \rightleftharpoons 2\text{NH}_4^+$                                                            | 1.275       |
| $\text{OsO}_4 + 8\text{H}^+ + 8e \rightleftharpoons \text{Os} + 4\text{H}_2\text{O}$                                           | 0.838       | $\text{ClO}_2 + \text{H}^+ + e \rightleftharpoons \text{HClO}_2$                                                                         | 1.277       |
| $\text{ClO}^- + \text{H}_2\text{O} + 2e \rightleftharpoons \text{Cl}^- + 2\text{OH}^-$                                         | 0.841       | $[\text{PdCl}_6]^{2-} + 2e \rightleftharpoons [\text{PdCl}_4]^{2-} + 2\text{Cl}^-$                                                       | 1.288       |
| $\text{Hg}_2^{2+} + 2e \rightleftharpoons \text{Hg}$                                                                           | 0.851       | $2\text{HNO}_2 + 4\text{H}^+ + 4e \rightleftharpoons \text{N}_2\text{O} + 3\text{H}_2\text{O}$                                           | 1.297       |
| $\text{AuBr}_4^- + 3e \rightleftharpoons \text{Au} + 4\text{Br}^-$                                                             | 0.854       | $\text{AuOH}^{2+} + \text{H}^+ + 2e \rightleftharpoons \text{Au}^+ + \text{H}_2\text{O}$                                                 | 1.32        |
| $\text{SiO}_2(\text{quartz}) + 4\text{H}^+ + 4e \rightleftharpoons \text{Si} + 2\text{H}_2\text{O}$                            | 0.857       | $\text{PuO}_2(\text{OH})_2 + 2\text{H}^+ + 2e \rightleftharpoons \text{Pu}(\text{OH})_4$                                                 | 1.325       |
| $2\text{HNO}_2 + 4\text{H}^+ + 4e \rightleftharpoons \text{H}_2\text{N}_2\text{O}_2 + \text{H}_2\text{O}$                      | 0.86        | $\text{HBrO} + \text{H}^+ + 2e \rightleftharpoons \text{Br}^- + \text{H}_2\text{O}$                                                      | 1.331       |
| $[\text{Ru}(\text{CN})_6]^{3-} + e^- \rightleftharpoons [\text{Ru}(\text{CN})_6]^{4-}$                                         | 0.86        | $\text{Cr(V)} + e \rightleftharpoons \text{Cr(IV)}$                                                                                      | 1.34        |
| $[\text{IrCl}_6]^{2-} + e \rightleftharpoons [\text{IrCl}_6]^{3-}$                                                             | 0.8665      | $\text{HCrO}_4^- + 7\text{H}^+ + 3e \rightleftharpoons \text{Cr}^{3+} + 4\text{H}_2\text{O}$                                             | 1.350       |
| $\text{N}_2\text{O}_4 + 2e \rightleftharpoons 2\text{NO}_2^-$                                                                  | 0.867       | $\text{Cl}_2(\text{g}) + 2e \rightleftharpoons 2\text{Cl}^-$                                                                             | 1.35827     |
| $\text{HO}_2^- + \text{H}_2\text{O} + 2e \rightleftharpoons 3\text{OH}^-$                                                      | 0.878       | $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6e \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$                                | 1.36        |
| $\text{Po}^{4+} + 2e \rightleftharpoons \text{Po}^{2+}$                                                                        | 0.9         | $\text{ClO}_4^- + 8\text{H}^+ + 8e \rightleftharpoons \text{Cl}^- + 4\text{H}_2\text{O}$                                                 | 1.389       |
| $2\text{Hg}_2^{2+} + 2e \rightleftharpoons \text{Hg}_2^{2+}$                                                                   | 0.920       | $\text{ClO}_4^- + 8\text{H}^+ + 7e \rightleftharpoons 1/2\text{Cl}_2 + 4\text{H}_2\text{O}$                                              | 1.39        |
| $\text{NO}_3^- + 3\text{H}^+ + 2e \rightleftharpoons \text{HNO}_2 + \text{H}_2\text{O}$                                        | 0.934       | $\text{No}^{3+} + e \rightleftharpoons \text{No}^{2+}$                                                                                   | 1.4         |
| $\text{Pd}^{2+} + 2e \rightleftharpoons \text{Pd}$                                                                             | 0.951       | $\text{RuO}_4 + 6\text{H}^+ + 4e \rightleftharpoons \text{Ru}(\text{OH})_2^{2+} + 2\text{H}_2\text{O}$                                   | 1.40        |
| $\text{ClO}_2(\text{aq}) + e \rightleftharpoons \text{ClO}_2^-$                                                                | 0.954       | $\text{Au}^{3+} + 2e \rightleftharpoons \text{Au}^+$                                                                                     | 1.401       |
| $\text{NO}_3^- + 4\text{H}^+ + 3e \rightleftharpoons \text{NO} + 2\text{H}_2\text{O}$                                          | 0.957       | $2\text{NH}_3\text{OH}^+ + \text{H}^+ + 2e \rightleftharpoons \text{N}_2\text{H}_5^+ + 2\text{H}_2\text{O}$                              | 1.42        |
| $\text{V}_2\text{O}_5 + 6\text{H}^+ + 2e \rightleftharpoons 2\text{VO}^{2+} + 3\text{H}_2\text{O}$                             | 0.957       | $\text{BrO}_3^- + 6\text{H}^+ + 6e \rightleftharpoons \text{Br}^- + 3\text{H}_2\text{O}$                                                 | 1.423       |
| $\text{AuBr}_2^- + e \rightleftharpoons \text{Au} + 2\text{Br}^-$                                                              | 0.959       | $2\text{HIO} + 2\text{H}^+ + 2e \rightleftharpoons \text{I}_2 + 2\text{H}_2\text{O}$                                                     | 1.439       |
| $\text{HNO}_2 + \text{H}^+ + e \rightleftharpoons \text{NO} + \text{H}_2\text{O}$                                              | 0.983       | $\text{Au}(\text{OH})_3 + 3\text{H}^+ + 3e \rightleftharpoons \text{Au}^- + 3\text{H}_2\text{O}$                                         | 1.45        |



| Reaction                                                                                                             | $E^\circ/V$ | Reaction                                                                                                         | $E^\circ/V$ |
|----------------------------------------------------------------------------------------------------------------------|-------------|------------------------------------------------------------------------------------------------------------------|-------------|
| $3\text{IO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightleftharpoons \text{Cl}^- + 3\text{H}_2\text{O}$                    | 1.451       | $\text{Ag}^{3+} + \text{e}^- \rightleftharpoons \text{Ag}^{2+}$                                                  | 1.8         |
| $\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Pb}^{2+} + 2\text{H}_2\text{O}$                   | 1.455       | $\text{Au}^{2+} + \text{e}^- \rightleftharpoons \text{Au}^+$                                                     | 1.8         |
| $\text{ClO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightleftharpoons 1/2\text{Cl}_2 + 3\text{H}_2\text{O}$                 | 1.47        | $\text{Ag}_2\text{O}_2 + 4\text{H}^+ + \text{e}^- \rightleftharpoons 2\text{Ag} + 2\text{H}_2\text{O}$           | 1.802       |
| $\text{CrO}_2 + 4\text{H}^+ + \text{e}^- \rightleftharpoons \text{Cr}^{3+} + 2\text{H}_2\text{O}$                    | 1.48        | $\text{Co}^{3+} + \text{e}^- \rightleftharpoons \text{Co}^{2+} \text{ (2 molar } \text{H}_2\text{SO}_4\text{)}$  | 1.83        |
| $\text{BrO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightleftharpoons 1/2\text{Br}_2 + 3\text{H}_2\text{O}$                 | 1.482       | $\text{Ag}^{3+} + 2\text{e}^- \rightleftharpoons \text{Ag}^+$                                                    | 1.9         |
| $\text{HClO} + \text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Cl}^- + \text{H}_2\text{O}$                         | 1.482       | $\text{Co}^{3+} + \text{e}^- \rightleftharpoons \text{Co}^{2+}$                                                  | 1.92        |
| $\text{Mn}_2\text{O}_3 + 6\text{H}^+ + \text{e}^- \rightleftharpoons 2\text{Mn}^{2+} + 3\text{H}_2\text{O}$          | 1.485       | $\text{Ag}^{2+} + \text{e}^- \rightleftharpoons \text{Ag}^+$                                                     | 1.980       |
| $\text{HO}_2 + \text{H}^+ + \text{e}^- \rightleftharpoons \text{H}_2\text{O}_2$                                      | 1.495       | $\text{Cu}_2\text{O}_3 + 6\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{Cu}^{2+} + 3\text{H}_2\text{O}$     | 2.0         |
| $\text{Au}^{3+} + 3\text{e}^- \rightleftharpoons \text{Au}$                                                          | 1.498       | $\text{S}_2\text{O}_8^{2-} + 2\text{e}^- \rightleftharpoons 2\text{SO}_4^{2-}$                                   | 2.010       |
| $\text{PtO}_3 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Pt}(\text{OH})_2^{2+} + \text{H}_2\text{O}$       | 1.5         | $\text{OH}^- + \text{e}^- \rightleftharpoons \text{OH}^{2-}$                                                     | 2.02        |
| $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$                 | 1.507       | $\text{HFeO}_4^- + 7\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{Fe}^{3+} + 4\text{H}_2\text{O}$            | 2.07        |
| $\text{Mn}^{3+} + \text{e}^- \rightleftharpoons \text{Mn}^{2+}$                                                      | 1.5415      | $\text{O}_3 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{O}_2 + \text{H}_2\text{O}$                      | 2.076       |
| $\text{HClO}_2 + 3\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{Cl}^- + 2\text{H}_2\text{O}$                     | 1.570       | $\text{HFeO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{FeOOH} + 2\text{H}_2\text{O}$              | 2.08        |
| $\text{HBrO} + \text{H}^+ + \text{e}^- \rightleftharpoons 1/2\text{Br}_2(\text{aq}) + \text{H}_2\text{O}$            | 1.574       | $2\text{HFeO}_4^- + 8\text{H}^+ + 6\text{e}^- \rightleftharpoons \text{Fe}_2\text{O}_3 + 5\text{H}_2\text{O}$    | 2.09        |
| $2\text{NO} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{N}_2\text{O} + \text{H}_2\text{O}$                  | 1.591       | $\text{XeO}_3 + 6\text{H}^+ + 6\text{e}^- \rightleftharpoons \text{Xe} + 3\text{H}_2\text{O}$                    | 2.10        |
| $\text{Bi}_2\text{O}_4 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{BiO}^+ + 2\text{H}_2\text{O}$           | 1.593       | $\text{S}_2\text{O}_8^{2-} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{HSO}_4^-$                       | 2.123       |
| $\text{HBrO} + \text{H}^+ + \text{e}^- \rightleftharpoons 1/2\text{Br}_2(\text{l}) + \text{H}_2\text{O}$             | 1.596       | $\text{F}_2\text{O} + 2\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{H}_2\text{O} + 2\text{F}^-$             | 2.153       |
| $\text{H}_5\text{IO}_6 + \text{H}^+ + 2\text{e}^- \rightleftharpoons \text{IO}_3^- + 3\text{H}_2\text{O}$            | 1.601       | $\text{FeO}_4^{2-} + 8\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{Fe}^{3+} + 4\text{H}_2\text{O}$          | 2.20        |
| $\text{HClO} + \text{H}^+ + \text{e}^- \rightleftharpoons 1/2\text{Cl}_2 + \text{H}_2\text{O}$                       | 1.611       | $\text{Cu}^{3+} + \text{e}^- \rightleftharpoons \text{Cu}^{2+}$                                                  | 2.4         |
| $\text{HClO}_2 + 3\text{H}^+ + 3\text{e}^- \rightleftharpoons 1/2\text{Cl}_2 + 2\text{H}_2\text{O}$                  | 1.628       | $\text{H}_4\text{XeO}_6 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{XeO}_3 + 3\text{H}_2\text{O}$       | 2.42        |
| $\text{HClO}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{HClO} + \text{H}_2\text{O}$                      | 1.645       | $\text{O}(\text{g}) + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}$                           | 2.421       |
| $\text{Bk}^{4+} + \text{e}^- \rightleftharpoons \text{Bk}^{3+}$                                                      | 1.67        | $\text{Am}^{4+} + \text{e}^- \rightleftharpoons \text{Am}^{3+}$                                                  | 2.60        |
| $\text{NiO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Ni}^{2+} + 2\text{H}_2\text{O}$                   | 1.678       | $\text{H}_2\text{N}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{N}_2 + 2\text{H}_2\text{O}$ | 2.65        |
| $\text{MnO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{MnO}_2 + 2\text{H}_2\text{O}$                   | 1.679       | $\text{F}_2 + 2\text{e}^- \rightleftharpoons 2\text{F}^-$                                                        | 2.866       |
| $\text{PbO}_2 + \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{PbSO}_4 + 2\text{H}_2\text{O}$ | 1.6913      | $\text{Cm}^{4+} + \text{e}^- \rightleftharpoons \text{Cm}^{3+}$                                                  | 3.0         |
| $\text{Au}^+ + \text{e}^- \rightleftharpoons \text{Au}$                                                              | 1.692       | $\text{F}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{HF}$                                           | 3.053       |
| $\text{PtO}_3 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{PtO}_2 + \text{H}_2\text{O}$                      | 1.7         | $\text{Tb}^{4+} + \text{e}^- \rightleftharpoons \text{Tb}^{3+}$                                                  | 3.1         |
| $\text{CeOH}^{3+} + \text{H}^+ + \text{e}^- \rightleftharpoons \text{Ce}^{3+} + \text{H}_2\text{O}$                  | 1.715       | $\text{Pr}^{4+} + \text{e}^- \rightleftharpoons \text{Pr}^{3+}$                                                  | 3.2         |
| $\text{Ce}^{4+} + \text{e}^- \rightleftharpoons \text{Ce}^{3+}$                                                      | 1.72        | $\text{Cf}^{4+} + \text{e}^- \rightleftharpoons \text{Cf}^{3+}$                                                  | 3.3         |
| $\text{N}_2\text{O} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{N}_2 + \text{H}_2\text{O}$                  | 1.766       | $\text{XeF} + \text{e}^- \rightleftharpoons \text{Xe} + \text{F}^-$                                              | 3.4         |
| $\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$                            | 1.776       |                                                                                                                  |             |

TABLE 3. Reduction Reactions Having  $E^\circ$  Values More Negative than That of the Standard Hydrogen Electrode

| Reaction                                                                                                             | $E^\circ/V$ | Reaction                                                                                                          | $E^\circ/V$ |
|----------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------------------------|-------------|
| $2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$                                                            | 0.00000     | $\text{WO}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{W} + 2\text{H}_2\text{O}$                       | -0.119      |
| $2\text{D}^+ + 2\text{e}^- \rightleftharpoons \text{D}_2$                                                            | -0.013      | $\text{Pb}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pb}(\text{Hg})$                                            | -0.1205     |
| $\text{AgCN} + \text{e}^- \rightleftharpoons \text{Ag} + \text{CN}^-$                                                | -0.017      | $\text{Pb}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pb}$                                                       | -0.1262     |
| $2\text{WO}_3 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{W}_2\text{O}_5 + \text{H}_2\text{O}$              | -0.029      | $\text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e}^- \rightleftharpoons \text{Cr}(\text{OH})_3 + 5\text{OH}^-$  | -0.13       |
| $\text{W}_2\text{O}_5 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{WO}_2 + \text{H}_2\text{O}$              | -0.031      | $\text{Sn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sn}$                                                       | -0.1375     |
| $\text{Ag}_2\text{S} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{Ag} + \text{H}_2\text{S}$                 | -0.0366     | $\text{In}^+ + \text{e}^- \rightleftharpoons \text{In}$                                                           | -0.14       |
| $\text{Fe}^{3+} + 3\text{e}^- \rightleftharpoons \text{Fe}$                                                          | -0.037      | $\text{O}_2 + 2\text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}_2 + 2\text{OH}^-$           | -0.146      |
| $\text{Hg}_2\text{I}_2 + 2\text{e}^- \rightleftharpoons 2\text{Hg} + 2\text{I}^-$                                    | -0.0405     | $\text{MoO}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{Mo} + 4\text{H}_2\text{O}$                     | -0.152      |
| $\text{Ti}(\text{OH})_3 + 2\text{e}^- \rightleftharpoons \text{TiOH} + 2\text{OH}^-$                                 | -0.05       | $\text{AgI} + \text{e}^- \rightleftharpoons \text{Ag} + \text{I}^-$                                               | -0.15224    |
| $\text{TiOH}^{3+} + \text{H}^+ + \text{e}^- \rightleftharpoons \text{Ti}^{3+} + \text{H}_2\text{O}$                  | -0.055      | $2\text{NO}_2^- + 2\text{H}_2\text{O} + 4\text{e}^- \rightleftharpoons \text{N}_2\text{O}_4^{2-} + 4\text{OH}^-$  | -0.18       |
| $2\text{H}_2\text{SO}_3 + \text{H}^+ + 2\text{e}^- \rightleftharpoons \text{HS}_2\text{O}_3^- + 2\text{H}_2\text{O}$ | -0.056      | $\text{H}_2\text{GeO}_3 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{Ge} + 3\text{H}_2\text{O}$           | -0.182      |
| $\text{P}(\text{white}) + 3\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{PH}_3(\text{g})$                        | -0.063      | $\text{SnO}_2 + 3\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{SnOH}^+ + \text{H}_2\text{O}$                  | -0.194      |
| $\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{HO}_2^- + \text{OH}^-$                       | -0.076      | $\text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{HCOOH}$                                         | -0.199      |
| $2\text{Cu}(\text{OH})_2 + 2\text{e}^- \rightleftharpoons \text{Cu}_2\text{O} + 2\text{OH}^- + \text{H}_2\text{O}$   | -0.080      | $\text{Mo}^{3+} + 3\text{e}^- \rightleftharpoons \text{Mo}$                                                       | -0.200      |
| $\text{Se} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{Se}$                                       | -0.082      | $\text{Ga}^+ + \text{e}^- \rightleftharpoons \text{Ga}$                                                           | -0.2        |
| $\text{WO}_3 + 6\text{H}^+ + 6\text{e}^- \rightleftharpoons \text{W} + 3\text{H}_2\text{O}$                          | -0.090      | $2\text{SO}_2^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{S}_2\text{O}_6^{2-} + \text{H}_2\text{O}$ | -0.22       |
| $\text{SnO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+} + 2\text{H}_2\text{O}$                   | -0.094      | $\text{Cu}(\text{OH})_2 + 2\text{e}^- \rightleftharpoons \text{Cu} + 2\text{OH}^-$                                | -0.222      |
| $\text{Md}^{3+} + \text{e}^- \rightleftharpoons \text{Md}^{2+}$                                                      | -0.1        | $\text{V}_2\text{O}_5 + 10\text{H}^+ + 10\text{e}^- \rightleftharpoons 2\text{V} + 5\text{H}_2\text{O}$           | -0.242      |
| $\text{P}(\text{red}) + 3\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{PH}_3(\text{g})$                          | -0.111      | $\text{CdSO}_4 + 2\text{e}^- \rightleftharpoons \text{Cd} + \text{SO}_4^{2-}$                                     | -0.246      |
| $\text{SnO}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{Sn} + 2\text{H}_2\text{O}$                        | -0.117      | $\text{V}(\text{OH})_4^+ + 4\text{H}^+ + 5\text{e}^- \rightleftharpoons \text{V} + 4\text{H}_2\text{O}$           | -0.254      |
| $\text{GeO}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{GeO} + \text{H}_2\text{O}$                        | -0.118      | $\text{V}^{3+} + \text{e}^- \rightleftharpoons \text{V}^{2+}$                                                     | -0.255      |

| Reaction                                                                                                          | $E^\circ/V$ |
|-------------------------------------------------------------------------------------------------------------------|-------------|
| $\text{Ni}^{2+} + 2\text{e} \rightleftharpoons \text{Ni}$                                                         | -0.257      |
| $\text{PbCl}_2 + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{Cl}^-$                                           | -0.2675     |
| $\text{H}_3\text{PO}_4 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_3\text{PO}_3 + \text{H}_2\text{O}$   | -0.276      |
| $\text{Co}^{2+} + 2\text{e} \rightleftharpoons \text{Co}$                                                         | -0.28       |
| $\text{PbBr}_2 + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{Br}^-$                                           | -0.284      |
| $\text{Tl}^+ + \text{e} \rightleftharpoons \text{Tl(Hg)}$                                                         | -0.3338     |
| $\text{Tl}^+ + \text{e} \rightleftharpoons \text{Tl}$                                                             | -0.336      |
| $\text{In}^{3+} + 3\text{e} \rightleftharpoons \text{In}$                                                         | -0.3382     |
| $\text{TlOH} + \text{e} \rightleftharpoons \text{Tl} + \text{OH}^-$                                               | -0.34       |
| $\text{PbF}_2 + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{F}^-$                                             | -0.3444     |
| $\text{PbSO}_4 + 2\text{e} \rightleftharpoons \text{Pb(Hg)} + \text{SO}_4^{2-}$                                   | -0.3505     |
| $\text{Cd}^{2+} + 2\text{e} \rightleftharpoons \text{Cd(Hg)}$                                                     | -0.3521     |
| $\text{PbSO}_4 + 2\text{e} \rightleftharpoons \text{Pb} + \text{SO}_4^{2-}$                                       | -0.3588     |
| $\text{Cu}_2\text{O} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons 2\text{Cu} + 2\text{OH}^-$               | -0.360      |
| $\text{Eu}^{3+} + \text{e} \rightleftharpoons \text{Eu}^{2+}$                                                     | -0.36       |
| $\text{PbI}_2 + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{I}^-$                                             | -0.365      |
| $\text{SeO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e} \rightleftharpoons \text{Se} + 6\text{OH}^-$                 | -0.366      |
| $\text{Se} + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2\text{Se(aq)}$                                  | -0.399      |
| $\text{In}^{2+} + \text{e} \rightleftharpoons \text{In}^+$                                                        | -0.40       |
| $\text{Cd}^{2+} + 2\text{e} \rightleftharpoons \text{Cd}$                                                         | -0.4030     |
| $\text{Cr}^{3+} + \text{e} \rightleftharpoons \text{Cr}^{2+}$                                                     | -0.407      |
| $2\text{S} + 2\text{e} \rightleftharpoons \text{S}_2^{2-}$                                                        | -0.42836    |
| $\text{Ti}_2\text{SO}_4 + 2\text{e} \rightleftharpoons \text{Ti} + \text{SO}_4^{2-}$                              | -0.4360     |
| $\text{In}^{3+} + 2\text{e} \rightleftharpoons \text{In}^+$                                                       | -0.443      |
| $\text{Fe}^{2+} + 2\text{e} \rightleftharpoons \text{Fe}$                                                         | -0.447      |
| $\text{H}_3\text{PO}_3 + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{P} + 3\text{H}_2\text{O}$               | -0.454      |
| $\text{Bi}_2\text{O}_3 + 3\text{H}_2\text{O} + 6\text{e} \rightleftharpoons 2\text{Bi} + 6\text{OH}^-$            | -0.46       |
| $\text{NO}_2^- + \text{H}_2\text{O} + \text{e} \rightleftharpoons \text{NO} + 2\text{OH}^-$                       | -0.46       |
| $\text{PbHPO}_4 + 2\text{e} \rightleftharpoons \text{Pb} + \text{HPO}_4^{2-}$                                     | -0.465      |
| $\text{S} + 2\text{e} \rightleftharpoons \text{S}^{2-}$                                                           | -0.47627    |
| $\text{S} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{HS}^- + \text{OH}^-$                          | -0.478      |
| $\text{B(OH)}_3 + 7\text{H}^+ + 8\text{e} \rightleftharpoons \text{BH}_4^- + 3\text{H}_2\text{O}$                 | -0.481      |
| $\text{In}^{3+} + \text{e} \rightleftharpoons \text{In}^{2+}$                                                     | -0.49       |
| $\text{ZnOH}^+ + \text{H}^+ + 2\text{e} \rightleftharpoons \text{Zn} + \text{H}_2\text{O}$                        | -0.497      |
| $\text{GaOH}^{2+} + \text{H}^+ + 3\text{e} \rightleftharpoons \text{Ga} + \text{H}_2\text{O}$                     | -0.498      |
| $\text{H}_3\text{PO}_3 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_3\text{PO}_2 + \text{H}_2\text{O}$   | -0.499      |
| $\text{TiO}_2 + 4\text{H}^+ + 2\text{e} \rightleftharpoons \text{Ti}^{2+} + 2\text{H}_2\text{O}$                  | -0.502      |
| $\text{H}_3\text{PO}_2 + \text{H}^+ + \text{e} \rightleftharpoons \text{P} + 2\text{H}_2\text{O}$                 | -0.508      |
| $\text{Sb} + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{SbH}_3$                                             | -0.510      |
| $\text{HPbO}_2^- + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Pb} + 3\text{OH}^-$                    | -0.537      |
| $\text{Ga}^{3+} + 3\text{e} \rightleftharpoons \text{Ga}$                                                         | -0.549      |
| $\text{TlCl} + \text{e} \rightleftharpoons \text{Tl} + \text{Cl}^-$                                               | -0.5568     |
| $\text{Fe(OH)}_3 + \text{e} \rightleftharpoons \text{Fe(OH)}_2 + \text{OH}^-$                                     | -0.56       |
| $\text{TeO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e} \rightleftharpoons \text{Te} + 6\text{OH}^-$                 | -0.57       |
| $2\text{SO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e} \rightleftharpoons \text{S}_2\text{O}_3^{2-} + 6\text{OH}^-$ | -0.571      |
| $\text{PbO} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Pb} + 2\text{OH}^-$                         | -0.580      |
| $\text{ReO}_2^- + 4\text{H}_2\text{O} + 7\text{e} \rightleftharpoons \text{Re} + 8\text{OH}^-$                    | -0.584      |
| $\text{SbO}_3^- + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{SbO}_2^- + 2\text{OH}^-$                | -0.59       |
| $\text{Ta}^{3+} + 3\text{e} \rightleftharpoons \text{Ta}$                                                         | -0.6        |
| $\text{U}^{4+} + \text{e} \rightleftharpoons \text{U}^{3+}$                                                       | -0.607      |
| $\text{As} + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{AsH}_3$                                             | -0.608      |
| $\text{Nb}_2\text{O}_5 + 10\text{H}^+ + 10\text{e} \rightleftharpoons 2\text{Nb} + 5\text{H}_2\text{O}$           | -0.644      |
| $\text{NbO}_2 + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{NbO} + \text{H}_2\text{O}$                       | -0.646      |
| $\text{Cd(OH)}_4^{2-} + 2\text{e} \rightleftharpoons \text{Cd} + 4\text{OH}^-$                                    | -0.658      |
| $\text{TlBr} + \text{e} \rightleftharpoons \text{Tl} + \text{Br}^-$                                               | -0.658      |
| $\text{SbO}_2^- + 2\text{H}_2\text{O} + 3\text{e} \rightleftharpoons \text{Sb} + 4\text{OH}^-$                    | -0.66       |
| $\text{AsO}_2^- + 2\text{H}_2\text{O} + 3\text{e} \rightleftharpoons \text{As} + 4\text{OH}^-$                    | -0.68       |

| Reaction                                                                                                                                                        | $E^\circ/V$ |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| $\text{NbO}_2 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{Nb} + 2\text{H}_2\text{O}$                                                                     | -0.690      |
| $\text{Ag}_2\text{S} + 2\text{e} \rightleftharpoons 2\text{Ag} + \text{S}^{2-}$                                                                                 | -0.691      |
| $\text{AsO}_4^{3-} + 2\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{AsO}_2^- + 4\text{OH}^-$                                                          | -0.71       |
| $\text{Ni(OH)}_2 + 2\text{e} \rightleftharpoons \text{Ni} + 2\text{OH}^-$                                                                                       | -0.72       |
| $\text{Co(OH)}_2 + 2\text{e} \rightleftharpoons \text{Co} + 2\text{OH}^-$                                                                                       | -0.73       |
| $\text{NbO} + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{Nb} + \text{H}_2\text{O}$                                                                        | -0.733      |
| $\text{H}_2\text{SeO}_3 + 4\text{H}^+ + 4\text{e} \rightleftharpoons \text{Se} + 3\text{H}_2\text{O}$                                                           | -0.74       |
| $\text{Cr}^{3+} + 3\text{e} \rightleftharpoons \text{Cr}$                                                                                                       | -0.744      |
| $\text{Ta}_2\text{O}_5 + 10\text{H}^+ + 10\text{e} \rightleftharpoons 2\text{Ta} + 5\text{H}_2\text{O}$                                                         | -0.750      |
| $\text{TlI} + \text{e} \rightleftharpoons \text{Tl} + \text{I}^-$                                                                                               | -0.752      |
| $\text{Zn}^{2+} + 2\text{e} \rightleftharpoons \text{Zn}$                                                                                                       | -0.7618     |
| $\text{Zn}^{2+} + 2\text{e} \rightleftharpoons \text{Zn(Hg)}$                                                                                                   | -0.7628     |
| $\text{CdO} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Cd} + 2\text{OH}^-$                                                                       | -0.783      |
| $\text{Te} + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{H}_2\text{Te}$                                                                                    | -0.793      |
| $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Zn(Hg)} + \text{SO}_4^{2-} + 7\text{H}_2\text{O}$<br>(Saturated $\text{ZnSO}_4$ ) | -0.7993     |
| $\text{Bi} + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{BiH}_3$                                                                                           | -0.8        |
| $\text{SiO} + 2\text{H}^+ + 2\text{e} \rightleftharpoons \text{Si} + \text{H}_2\text{O}$                                                                        | -0.8        |
| $\text{Cd(OH)}_2 + 2\text{e} \rightleftharpoons \text{Cd(Hg)} + 2\text{OH}^-$                                                                                   | -0.809      |
| $2\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{H}_2 + 2\text{OH}^-$                                                                                  | -0.8277     |
| $2\text{NO}_3^- + 2\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{N}_2\text{O}_4 + 4\text{OH}^-$                                                       | -0.85       |
| $\text{H}_3\text{BO}_3 + 3\text{H}^+ + 3\text{e} \rightleftharpoons \text{B} + 3\text{H}_2\text{O}$                                                             | -0.8698     |
| $\text{P} + 3\text{H}_2\text{O} + 3\text{e} \rightleftharpoons \text{PH}_3(\text{g}) + 3\text{OH}^-$                                                            | -0.87       |
| $\text{Ti}^{3+} + \text{e} \rightleftharpoons \text{Ti}^{2+}$                                                                                                   | -0.9        |
| $\text{HSnO}_2^- + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Sn} + 3\text{OH}^-$                                                                  | -0.909      |
| $\text{Cr}^{2+} + 2\text{e} \rightleftharpoons \text{Cr}$                                                                                                       | -0.913      |
| $\text{Se} + 2\text{e} \rightleftharpoons \text{Se}^{2-}$                                                                                                       | -0.924      |
| $\text{SO}_4^{2-} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{SO}_3^{2-} + 2\text{OH}^-$                                                          | -0.93       |
| $\text{Sn(OH)}_6^{2-} + 2\text{e} \rightleftharpoons \text{HSnO}_2^- + 3\text{OH}^- + \text{H}_2\text{O}$                                                       | -0.93       |
| $\text{SnO}_2 + 2\text{H}_2\text{O} + 4\text{e} \rightleftharpoons \text{Sn} + 4\text{OH}^-$                                                                    | -0.945      |
| $\text{In(OH)}_3 + 3\text{e} \rightleftharpoons \text{In} + 3\text{OH}^-$                                                                                       | -0.99       |
| $\text{NpO}_2 + \text{H}_2\text{O} + \text{H}^+ + \text{e} \rightleftharpoons \text{Np(OH)}_3$                                                                  | -0.962      |
| $\text{In(OH)}_4^- + 3\text{e} \rightleftharpoons \text{In} + 4\text{OH}^-$                                                                                     | -1.007      |
| $\text{In}_2\text{O}_3 + 3\text{H}_2\text{O} + 6\text{e} \rightleftharpoons 2\text{In} + 6\text{OH}^-$                                                          | -1.034      |
| $\text{PO}_4^{3-} + 2\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{HPO}_3^{2-} + 3\text{OH}^-$                                                        | -1.05       |
| $\text{Yb}^{3+} + \text{e} \rightleftharpoons \text{Yb}^{2+}$                                                                                                   | -1.05       |
| $\text{Nb}^{3+} + 3\text{e} \rightleftharpoons \text{Nb}$                                                                                                       | -1.099      |
| $\text{Fm}^{3+} + \text{e} \rightleftharpoons \text{Fm}^{2+}$                                                                                                   | -1.1        |
| $2\text{SO}_3^{2-} + 2\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{S}_2\text{O}_4^{2-} + 4\text{OH}^-$                                               | -1.12       |
| $\text{Te} + 2\text{e} \rightleftharpoons \text{Te}^{2-}$                                                                                                       | -1.143      |
| $\text{V}^{2+} + 2\text{e} \rightleftharpoons \text{V}$                                                                                                         | -1.175      |
| $\text{Mn}^{2+} + 2\text{e} \rightleftharpoons \text{Mn}$                                                                                                       | -1.185      |
| $\text{Zn(OH)}_4^{2-} + 2\text{e} \rightleftharpoons \text{Zn} + 4\text{OH}^-$                                                                                  | -1.199      |
| $\text{CrO}_2 + 2\text{H}_2\text{O} + 3\text{e} \rightleftharpoons \text{Cr} + 4\text{OH}^-$                                                                    | -1.2        |
| $\text{No}^{3+} + 3\text{e} \rightleftharpoons \text{No}$                                                                                                       | -1.20       |
| $\text{ZnO}_2^- + 2\text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Zn} + 4\text{OH}^-$                                                                  | -1.215      |
| $\text{H}_2\text{GaO}_3^- + \text{H}_2\text{O} + 3\text{e} \rightleftharpoons \text{Ga} + 4\text{OH}^-$                                                         | -1.219      |
| $\text{H}_2\text{BO}_3^- + 5\text{H}_2\text{O} + 8\text{e} \rightleftharpoons \text{BH}_4^- + 8\text{OH}^-$                                                     | -1.24       |
| $\text{SiF}_6^{2-} + 4\text{e} \rightleftharpoons \text{Si} + 6\text{F}^-$                                                                                      | -1.24       |
| $\text{Zn(OH)}_2 + 2\text{e} \rightleftharpoons \text{Zn} + 2\text{OH}^-$                                                                                       | -1.249      |
| $\text{ZnO} + \text{H}_2\text{O} + 2\text{e} \rightleftharpoons \text{Zn} + 2\text{OH}^-$                                                                       | -1.260      |
| $\text{Es}^{3+} + \text{e} \rightleftharpoons \text{Es}^{2+}$                                                                                                   | -1.3        |
| $\text{Pa}^{3+} + 3\text{e} \rightleftharpoons \text{Pa}$                                                                                                       | -1.34       |
| $\text{Ti}^{3+} + 3\text{e} \rightleftharpoons \text{Ti}$                                                                                                       | -1.37       |
| $\text{Ce}^{3+} + 3\text{e} \rightleftharpoons \text{Ce(Hg)}$                                                                                                   | -1.4373     |
| $\text{UO}_2^{2+} + 4\text{H}^+ + 6\text{e} \rightleftharpoons \text{U} + 2\text{H}_2\text{O}$                                                                  | -1.444      |
| $\text{Zr}^{4+} + 4\text{e} \rightleftharpoons \text{Zr}$                                                                                                       | -1.45       |



| Reaction                                                                                                           | $E^\circ/V$ | Reaction                                                                                                        | $E^\circ/V$ |
|--------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------|-------------|
| $\text{Cr}(\text{OH})_3 + 3 \text{e} \rightleftharpoons \text{Cr} + 3 \text{OH}^-$                                 | -1.48       | $\text{Am}^{3+} + \text{e} \rightleftharpoons \text{Am}^{2+}$                                                   | -2.3        |
| $\text{Pa}^{4+} + 4 \text{e} \rightleftharpoons \text{Pa}$                                                         | -1.49       | $\text{Fm}^{2+} + 2 \text{e} \rightleftharpoons \text{Fm}$                                                      | -2.30       |
| $\text{HfO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Hf} + 2 \text{H}_2\text{O}$                     | -1.505      | $\text{Pm}^{3+} + 3 \text{e} \rightleftharpoons \text{Pm}$                                                      | -2.30       |
| $\text{Hf}^{4+} + 4 \text{e} \rightleftharpoons \text{Hf}$                                                         | -1.55       | $\text{Sm}^{3+} + 3 \text{e} \rightleftharpoons \text{Sm}$                                                      | -2.304      |
| $\text{Sm}^{3+} + \text{e} \rightleftharpoons \text{Sm}^{2+}$                                                      | -1.55       | $\text{Al}(\text{OH})_3 + 3 \text{e} \rightleftharpoons \text{Al} + 3 \text{OH}^-$                              | -2.31       |
| $\text{ZrO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Zr} + 2 \text{H}_2\text{O}$                     | -1.553      | $\text{Tm}^{3+} + 3 \text{e} \rightleftharpoons \text{Tm}$                                                      | -2.319      |
| $\text{Mn}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Mn} + 2 \text{OH}^-$                                 | -1.56       | $\text{Nd}^{3+} + 3 \text{e} \rightleftharpoons \text{Nd}$                                                      | -2.323      |
| $\text{Ba}^{2+} + 2 \text{e} \rightleftharpoons \text{Ba}(\text{Hg})$                                              | -1.570      | $\text{Al}(\text{OH})^- + 3 \text{e} \rightleftharpoons \text{Al} + 4 \text{OH}^-$                              | -2.328      |
| $\text{Bk}^{2+} + 2 \text{e} \rightleftharpoons \text{Bk}$                                                         | -1.6        | $\text{H}_2\text{AlO}_3^- + \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{Al} + 4 \text{OH}^-$       | -2.33       |
| $\text{Cf}^{3+} + \text{e} \rightleftharpoons \text{Cf}^{2+}$                                                      | -1.6        | $\text{Ho}^{3+} + 3 \text{e} \rightleftharpoons \text{Ho}$                                                      | -2.33       |
| $\text{Ti}^{2+} + 2 \text{e} \rightleftharpoons \text{Ti}$                                                         | -1.630      | $\text{Er}^{3+} + 3 \text{e} \rightleftharpoons \text{Er}$                                                      | -2.331      |
| $\text{Md}^{3+} + 3 \text{e} \rightleftharpoons \text{Md}$                                                         | -1.65       | $\text{Ce}^{3+} + 3 \text{e} \rightleftharpoons \text{Ce}$                                                      | -2.336      |
| $\text{HPO}_3^{2-} + 2 \text{H}_2\text{O} + 2 \text{e} \rightleftharpoons \text{H}_2\text{PO}_2^- + 3 \text{OH}^-$ | -1.65       | $\text{Pr}^{3+} + 3 \text{e} \rightleftharpoons \text{Pr}$                                                      | -2.353      |
| $\text{Al}^{3+} + 3 \text{e} \rightleftharpoons \text{Al}$                                                         | -1.662      | $\text{ZrO}(\text{OH})_2 + \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Zr} + 4 \text{OH}^-$        | -2.36       |
| $\text{SiO}_3^{2-} + \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Si} + 6 \text{OH}^-$                 | -1.697      | $\text{Mg}^{2+} + 2 \text{e} \rightleftharpoons \text{Mg}$                                                      | -2.372      |
| $\text{HPO}_3^{2-} + 2 \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{P} + 5 \text{OH}^-$                | -1.71       | $\text{Y}^{3+} + 3 \text{e} \rightleftharpoons \text{Y}$                                                        | -2.372      |
| $\text{HfO}_2 + 2 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Hf} + \text{H}_2\text{O}$                       | -1.724      | $\text{La}^{3+} + 3 \text{e} \rightleftharpoons \text{La}$                                                      | -2.379      |
| $\text{ThO}_2 + 4 \text{H}^+ + 4 \text{e} \rightleftharpoons \text{Th} + 2 \text{H}_2\text{O}$                     | -1.789      | $\text{Tm}^{2+} + 2 \text{e} \rightleftharpoons \text{Tm}$                                                      | -2.4        |
| $\text{H}_2\text{BO}_3^- + \text{H}_2\text{O} + 3 \text{e} \rightleftharpoons \text{B} + 4 \text{OH}^-$            | -1.79       | $\text{Md}^{2+} + 2 \text{e} \rightleftharpoons \text{Md}$                                                      | -2.40       |
| $\text{Sr}^{2+} + 2 \text{e} \rightleftharpoons \text{Sr}(\text{Hg})$                                              | -1.793      | $\text{Th}(\text{OH})_4 + 4 \text{e} \rightleftharpoons \text{Th} + 4 \text{OH}^-$                              | -2.48       |
| $\text{U}^{3+} + 3 \text{e} \rightleftharpoons \text{U}$                                                           | -1.798      | $\text{HfO}(\text{OH})_2 + \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons \text{Hf} + 4 \text{OH}^-$        | -2.50       |
| $\text{H}_2\text{PO}_2^- + \text{e} \rightleftharpoons \text{P} + 2 \text{OH}^-$                                   | -1.82       | $\text{No}^{2+} + 2 \text{e} \rightleftharpoons \text{No}$                                                      | -2.50       |
| $\text{Be}^{2+} + 2 \text{e} \rightleftharpoons \text{Be}$                                                         | -1.847      | $\text{Dy}^{3+} + \text{e} \rightleftharpoons \text{Dy}^{2+}$                                                   | -2.6        |
| $\text{Np}^{3+} + 3 \text{e} \rightleftharpoons \text{Np}$                                                         | -1.856      | $\text{Pm}^{3+} + \text{e} \rightleftharpoons \text{Pm}^{2+}$                                                   | -2.6        |
| $\text{Fm}^{3+} + 3 \text{e} \rightleftharpoons \text{Fm}$                                                         | -1.89       | $\text{Be}_2\text{O}_3^{2-} + 3 \text{H}_2\text{O} + 4 \text{e} \rightleftharpoons 2 \text{Be} + 6 \text{OH}^-$ | -2.63       |
| $\text{Th}^{4+} + 4 \text{e} \rightleftharpoons \text{Th}$                                                         | -1.899      | $\text{Sm}^{2+} + 2 \text{e} \rightleftharpoons \text{Sm}$                                                      | -2.68       |
| $\text{Am}^{2+} + 2 \text{e} \rightleftharpoons \text{Am}$                                                         | -1.9        | $\text{Mg}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Mg} + 2 \text{OH}^-$                              | -2.690      |
| $\text{Pa}^{4+} + \text{e} \rightleftharpoons \text{Pa}^{3+}$                                                      | -1.9        | $\text{Nd}^{3+} + \text{e} \rightleftharpoons \text{Nd}^{2+}$                                                   | -2.7        |
| $\text{Es}^{3+} + 3 \text{e} \rightleftharpoons \text{Es}$                                                         | -1.91       | $\text{Mg}^+ + \text{e} \rightleftharpoons \text{Mg}$                                                           | -2.70       |
| $\text{Cf}^{3+} + 3 \text{e} \rightleftharpoons \text{Cf}$                                                         | -1.94       | $\text{Na}^+ + \text{e} \rightleftharpoons \text{Na}$                                                           | -2.71       |
| $\text{Lr}^{3+} + 3 \text{e} \rightleftharpoons \text{Lr}$                                                         | -1.96       | $\text{Yb}^{2+} + 2 \text{e} \rightleftharpoons \text{Yb}$                                                      | -2.76       |
| $\text{Eu}^{3+} + 3 \text{e} \rightleftharpoons \text{Eu}$                                                         | -1.991      | $\text{Bk}^{3+} + \text{e} \rightleftharpoons \text{Bk}^{2+}$                                                   | -2.8        |
| $\text{Er}^{2+} + 2 \text{e} \rightleftharpoons \text{Er}$                                                         | -2.0        | $\text{Ho}^{3+} + \text{e} \rightleftharpoons \text{Ho}^{2+}$                                                   | -2.8        |
| $\text{Pr}^{2+} + 2 \text{e} \rightleftharpoons \text{Pr}$                                                         | -2.0        | $\text{Ra}^{2+} + 2 \text{e} \rightleftharpoons \text{Ra}$                                                      | -2.8        |
| $\text{Pu}^{3+} + 3 \text{e} \rightleftharpoons \text{Pu}$                                                         | -2.031      | $\text{Eu}^{2+} + 2 \text{e} \rightleftharpoons \text{Eu}$                                                      | -2.812      |
| $\text{Cm}^{3+} + 3 \text{e} \rightleftharpoons \text{Cm}$                                                         | -2.04       | $\text{Ca}^{2+} + 2 \text{e} \rightleftharpoons \text{Ca}$                                                      | -2.868      |
| $\text{Am}^{3+} + 3 \text{e} \rightleftharpoons \text{Am}$                                                         | -2.048      | $\text{Sr}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Sr} + 2 \text{OH}^-$                              | -2.88       |
| $\text{AlF}_6^{3-} + 3 \text{e} \rightleftharpoons \text{Al} + 6 \text{F}^-$                                       | -2.069      | $\text{Sr}^{2+} + 2 \text{e} \rightleftharpoons \text{Sr}$                                                      | -2.899      |
| $\text{Sc}^{3+} + 3 \text{e} \rightleftharpoons \text{Sc}$                                                         | -2.077      | $\text{Fr}^+ + \text{e} \rightleftharpoons \text{Fr}$                                                           | -2.9        |
| $\text{Ho}^{2+} + 2 \text{e} \rightleftharpoons \text{Ho}$                                                         | -2.1        | $\text{La}(\text{OH})_3 + 3 \text{e} \rightleftharpoons \text{La} + 3 \text{OH}^-$                              | -2.90       |
| $\text{Nd}^{2+} + 2 \text{e} \rightleftharpoons \text{Nd}$                                                         | -2.1        | $\text{Ba}^{2+} + 2 \text{e} \rightleftharpoons \text{Ba}$                                                      | -2.912      |
| $\text{Cf}^{2+} + 2 \text{e} \rightleftharpoons \text{Cf}$                                                         | -2.12       | $\text{K}^+ + \text{e} \rightleftharpoons \text{K}$                                                             | -2.931      |
| $\text{Yb}^{3+} + 3 \text{e} \rightleftharpoons \text{Yb}$                                                         | -2.19       | $\text{Rb}^+ + \text{e} \rightleftharpoons \text{Rb}$                                                           | -2.98       |
| $\text{Ac}^{3+} + 3 \text{e} \rightleftharpoons \text{Ac}$                                                         | -2.20       | $\text{Ba}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Ba} + 2 \text{OH}^-$                              | -2.99       |
| $\text{Dy}^{2+} + 2 \text{e} \rightleftharpoons \text{Dy}$                                                         | -2.2        | $\text{Er}^{3+} + \text{e} \rightleftharpoons \text{Er}^{2+}$                                                   | -3.0        |
| $\text{Tm}^{3+} + \text{e} \rightleftharpoons \text{Tm}^{2+}$                                                      | -2.2        | $\text{Ca}(\text{OH})_2 + 2 \text{e} \rightleftharpoons \text{Ca} + 2 \text{OH}^-$                              | -3.02       |
| $\text{Pm}^{2+} + 2 \text{e} \rightleftharpoons \text{Pm}$                                                         | -2.2        | $\text{Cs}^+ + \text{e} \rightleftharpoons \text{Cs}$                                                           | -3.026      |
| $\text{Es}^{2+} + 2 \text{e} \rightleftharpoons \text{Es}$                                                         | -2.23       | $\text{Li}^+ + \text{e} \rightleftharpoons \text{Li}$                                                           | -3.0401     |
| $\text{H}_2 + 2 \text{e} \rightleftharpoons 2 \text{H}^-$                                                          | -2.23       | $3 \text{N}_2 + 2 \text{H}^+ + 2 \text{e} \rightleftharpoons 2 \text{HN}_3$                                     | -3.09       |
| $\text{Gd}^{3+} + 3 \text{e} \rightleftharpoons \text{Gd}$                                                         | -2.279      | $\text{Pr}^{3+} + \text{e} \rightleftharpoons \text{Pr}^{2+}$                                                   | -3.1        |
| $\text{Tb}^{3+} + 3 \text{e} \rightleftharpoons \text{Tb}$                                                         | -2.28       | $\text{Ca}^+ + \text{e} \rightleftharpoons \text{Ca}$                                                           | -3.80       |
| $\text{Lu}^{3+} + 3 \text{e} \rightleftharpoons \text{Lu}$                                                         | -2.28       | $\text{Sr}^+ + \text{e} \rightleftharpoons \text{Sr}$                                                           | -4.10       |
| $\text{Dy}^{3+} + 3 \text{e} \rightleftharpoons \text{Dy}$                                                         | -2.295      |                                                                                                                 |             |

# REDUCTION AND OXIDATION POTENTIALS FOR CERTAIN ION RADICALS

Petr Vanýsek

There are two tables for ion radicals. The first table lists reduction potentials for organic compounds which produce anion radicals during reduction, a process described as  $A + e^- \rightleftharpoons A^-$ . The second table lists oxidation potentials for organic compounds which produce cation radicals during oxidation, a process described as  $A \rightleftharpoons A^+ + e^-$ . To obtain reduction potential for a reverse reaction, the sign for the potential is changed.

Unlike the table of the Electrochemical Series, which lists *standard* potentials, values for radicals are experimental values with experimental conditions given in the second column. Since the measurements leading to potentials for ion radicals are very dependent on conditions, an attempt to report standard potentials for radicals would serve no useful purpose. For the same reason, the potentials are also reported as experimental values, usually a half-wave potential ( $E_{1/2}$  in polarography) or a peak potential ( $E_p$  in cyclic voltammetry). Unless otherwise stated, the values are reported vs. SCE (saturated calomel electrode). To obtain a value vs.

normal hydrogen electrode, 0.241 V has to be added to the SCE values. All the ion radicals chosen for inclusion in the tables result from electrochemically reversible reactions. More detailed data on ion radicals can be found in the *Encyclopedia of Electrochemistry of Elements*, (A. J. Bard, Ed.), Vol. XI and XII in particular, Marcel Dekker, New York, 1978.

Abbreviations are: CV — cyclic voltammetry; DMF — *N,N*-Dimethylformamide;  $E_{swp}$  — potential sweep;  $E^\circ$  — standard potential;  $E_p$  — peak potential;  $E_{p/2}$  — half-peak potential;  $E_{1/2}$  — half wave potential; *M* — mol/L; MeCN — acetonitrile; pol — polarography; rot Pt disk — rotated Pt disk; SCE — saturated calomel electrode; TBABF<sub>4</sub> — tetrabutylammonium tetrafluoroborate; TBAI — tetrabutylammonium iodide; TBAP — tetrabutylammonium perchlorate; TEABr — tetraethylammonium bromide; TEAP — tetraethylammonium perchlorate; THF — tetrahydrofuran; TPACF<sub>3</sub>SO<sub>3</sub> — tetrapropylammonium trifluoromethanesulfite; TPAP — tetrapropylammonium perchlorate; and wr — wire.

## Reduction Potentials (Products are Anion Radicals)

| Substance                    | Conditions/electrode/technique              | Potential<br>V (vs. SCE) |
|------------------------------|---------------------------------------------|--------------------------|
| Acetone                      | DMF, 0.1 <i>M</i> TEABr/Hg/pol              | $E_{1/2} = -2.84$        |
| 1-Naphthylphenylacetylene    | DMF, 0.03 <i>M</i> TBAI/Hg/pol              | $E_{1/2} = -1.91$        |
| 1-Naphthalenecarboxaldehyde  | -/Hg/pol                                    | $E_{1/2} = -0.91$        |
| 2-Naphthalenecarboxaldehyde  | -/Hg/pol                                    | $E_{1/2} = -0.96$        |
| 2-Phenanthrenecarboxaldehyde | -/Hg/pol                                    | $E_{1/2} = -1.00$        |
| 3-Phenanthrenecarboxaldehyde | -/Hg/pol                                    | $E_{1/2} = -0.94$        |
| 9-Phenanthrenecarboxaldehyde | -/Hg/pol                                    | $E_{1/2} = -0.83$        |
| 1-Anthracenecarboxaldehyde   | -/Hg/pol                                    | $E_{1/2} = -0.75$        |
| 1-Pyrenecarboxaldehyde       | -/Hg/pol                                    | $E_{1/2} = -0.76$        |
| 2-Pyrenecarboxaldehyde       | -/Hg/pol                                    | $E_{1/2} = -1.00$        |
| Anthracene                   | DMF, 0.1 <i>M</i> TBAP/Pt disk/CV           | $E_p = -2.00$            |
|                              | DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV | $E_{1/2} = -1.93$        |
|                              | MeCN, 0.1 <i>M</i> TEAP/Hg/CV               | $E_{1/2} = -2.07$        |
|                              | DMF, 0.1 <i>M</i> TBAI/Hg/pol               | $E_{1/2} = -1.92$        |
| 9,10-Dimethylanthracene      | DMF, 0.1 <i>M</i> TBAP/Pt/CV                | $E_p = -2.08$            |
|                              | MeCN, 0.1 <i>M</i> TBAP/Pt/CV               | $E_p = -2.10$            |
| 1-Phenylanthracene           | DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV | $E_{1/2} = -1.91$        |
|                              | DMF, 0.1 <i>M</i> TBAI/Hg/pol               | $E_{1/2} = -1.878$       |
| 2-Phenylanthracene           | DMF, 0.1 <i>M</i> TBAI/Hg/pol               | $E_{1/2} = -1.875$       |
| 8-Phenylanthracene           | DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV | $E_{1/2} = -1.91$        |
| 9-Phenylanthracene           | DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV | $E_{1/2} = -1.93$        |
|                              | DMF, 0.1 <i>M</i> TBAI/Hg/pol               | $E_{1/2} = -1.863$       |
| 1,8-Diphenylanthracene       | DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV | $E_{1/2} = -1.88$        |
| 1,9-Diphenylanthracene       | DMF, 0.1 <i>M</i> TBAI/Hg/pol               | $E_{1/2} = -1.846$       |
| 1,10-Diphenylanthracene      | DMF, 0.1 <i>M</i> TBAI/Hg/pol               | $E_{1/2} = -1.786$       |
| 8,9-Diphenylanthracene       | DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV | $E_{1/2} = -1.90$        |
| 9,10-Diphenylanthracene      | MeCN, 0.1 <i>M</i> TBAP/rot Pt/E swp        | $E_{1/2} = -1.83$        |
|                              | DMF, 0.1 <i>M</i> TBAI/Hg/pol               | $E_{1/2} = -1.835$       |
| 1,8,9-Triphenylanthracene    | DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV | $E_{1/2} = -1.85$        |
| 1,8,10-Triphenylanthracene   | DMF, 0.5 <i>M</i> TBABF <sub>4</sub> /Hg/CV | $E_{1/2} = -1.81$        |
| 9,10-Dibiphenylanthracene    | MeCN, 0.1 <i>M</i> TBAP/rot Pt/E swp        | $E_{1/2} = -1.94$        |
| Benz(a)anthracene            | MeCN, 0.1 <i>M</i> TEAP/Hg/CV               | $E_{1/2} = -2.11$        |
|                              | MeCN, 0.1 <i>M</i> TEAP/Hg/pol              | $E_{1/2} = -2.40^a$      |
| Azulene                      | DMF, 0.1 <i>M</i> TBAI/Hg/pol               | $E_{1/2} = -1.10^c$      |
| Annulene                     | DMF, 0.5 <i>M</i> TBAP 0°C/Hg/pol           | $E_{1/2} = -1.23$        |
| Benzaldehyde                 | DMF, 0.1 <i>M</i> TBAP/Hg/pol               | $E_{1/2} = -1.67$        |
| Benzil                       | DMSO, 0.1 <i>M</i> TBAP/Hg/pol              | $E_{1/2} = -1.04$        |
| Benzophenone                 | -/Hg/pol                                    | $E_{1/2} = -1.80$        |
|                              | DMF/Pt disk/CV                              | $E^\circ = -1.72$        |
| Chrysene                     | MeCN, 0.1 <i>M</i> TEAP/Hg/pol              | $E_{1/2} = -2.73^a$      |
| Fluoranthrene                | DMF, 0.1 <i>M</i> TBAP/Pt disk/CV           | $E_p = -1.76$            |
| Cyclohexanone                | DMF, 0.1 <i>M</i> TEABr/Hg/pol              | $E_{1/2} = -2.79$        |

| Substance                                            | Conditions/electrode/technique                | Potential<br>V (vs. SCE) |
|------------------------------------------------------|-----------------------------------------------|--------------------------|
| 5,5-Dimethyl-3-phenyl-2-cyclohexen-1-one             | DMF, 0.5 M/Hg/pol                             | $E_{1/2} = -1.71$        |
| 1,2,3-Indanetrione hydrate (ninhydrin)               | DMF, 0.2 M NaNO <sub>3</sub> /Hg/pol          | $E_{1/2} = -0.039$       |
| Naphthacene                                          | DMF, 0.1 M TBAI/Hg/pol                        | $E_{1/2} = -1.53$        |
| Naphthalene                                          | DMF, 0.1 M TBAP/Pt dsk/CV                     | $E_p = -2.55$            |
|                                                      | DMF, 0.5 M TBABF <sub>4</sub> /Hg/CV          | $E_{1/2} = -2.56$        |
|                                                      | DMF, MeCN, 0.1 M TEAP/Hg/CV                   | $E_{1/2} = -2.63$        |
|                                                      | DMF, 0.1 M TBAI/Hg/pol                        | $E_{1/2} = -2.50$        |
| 1-Phenylnaphthalene                                  | DMF, 0.5 M TBABF <sub>4</sub> /Hg/CV          | $E_{1/2} = -2.36$        |
| 1,2-Diphenylnaphthalene                              | DMF, 0.5 M TBABF <sub>4</sub> /Hg/CV          | $E_{1/2} = -2.25$        |
| Cyclopentanone                                       | DMF, 0.1 M TEABr/Hg/pol                       | $E_{1/2} = -2.82$        |
| Phenanthrene                                         | MeCN, 0.1 M TBAP/Pt wr/CV                     | $E_{1/2} = -2.47$        |
|                                                      | MeCN, 0.1 M TEAP/Hg/pol                       | $E_{1/2} = -2.88^a$      |
| Pentacene                                            | THF, 0.1 M TBAP/rot Pt dsk/E swp              | $E_{1/2} = -1.40$        |
| Perylene                                             | MeCN, 0.1 M TEAP/Hg/CV                        | $E_{1/2} = -1.73$        |
| 1,3-Diphenyl-1,3-propanedione                        | DMSO, 0.2 M TBAP/Hg/CV                        | $E_{1/2} = -1.42$        |
| 2,2-Dimethyl-1,3-diphenyl-1,3-propanedione           | DMSO, TBAP/Hg/CV                              | $E_{1/2} = -1.80$        |
| Pyrene                                               | DMF, 0.1 M TBAP/Pt/CV                         | $E_p = -2.14$            |
|                                                      | MeCN, 0.1 M TEAP/Hg/pol                       | $E_{1/2} = -2.49^a$      |
| Diphenylsulfone                                      | DMF, TEABr                                    | $E_{1/2} = -2.16$        |
| Triphenylene                                         | MeCN, 0.1 M TEAP/Hg/pol                       | $E_{1/2} = -2.87^a$      |
| 9,10-Anthraquinone                                   | DMF, 0.5 M TBAP, 20°/Pt dsk/CV                | $E_{1/2} = -1.01$        |
| 1,4-Benzoquinone                                     | MeCN, 0.1 M TEAP/Pt/CV                        | $E_p = -0.54$            |
| 1,4-Naphthohydroquinone, dipotassium salt            | DMF, 0.5 M TBAP, 20°/Pt dsk/CV                | $E_{1/2} = -1.55$        |
| Rubrene                                              | DMF, 0.1 M TBAP/Pt dsk/CV                     | $E_p = -1.48$            |
|                                                      | DMF, 0.1 M TBAI/Hg/pol                        | $E_{1/2} = -1.410$       |
| Benzocyclooctatetraene                               | THF, 0.1 M TBAP/Hg/pol                        | $E_{1/2} = -2.13$        |
| <i>sym</i> -Dibenzocyclooctatetraene                 | THF, 0.1 M TBAP/Hg/pol                        | $E_{1/2} = -2.29$        |
| Ubiquinone-6                                         | MeCN, 0.1 M TEAP/Pt/CV                        | $E_p = -1.05^c$          |
| (9-Phenyl-fluorenyl) <sup>+</sup>                    | 10.2 M H <sub>2</sub> SO <sub>4</sub> /Hg/CV  | $E_p = -0.01^b$          |
| (Triphenylcyclopropenyl) <sup>+</sup>                | MeCN, 0.1 M TEAP/Hg/CV                        | $E_p = -1.87$            |
| (Triphenylmethyl) <sup>+</sup>                       | MeCN, 0.1 M TBAP/Hg/pol                       | $E_{1/2} = 0.27$         |
|                                                      | H <sub>2</sub> SO <sub>4</sub> , 10.2 M/Hg/CV | $E_p = -0.58^b$          |
| (Tribiphenylmethyl) <sup>+</sup>                     | MeCN, 0.1 M TBAP/Hg/pol                       | $E_{1/2} = 0.19$         |
| (Tri-4- <i>t</i> -butyl-5-phenylmethyl) <sup>+</sup> | MeCN, 0.1 M TBAP/Hg/pol                       | $E_{1/2} = 0.13$         |
| (Tri-4-isopropylphenylmethyl) <sup>+</sup>           | MeCN, 0.1 M TBAP/Hg/pol                       | $E_{1/2} = 0.07$         |
| (Tri-4-methylphenylmethyl) <sup>+</sup>              | MeCN, 0.1 M TBAP/Hg/pol                       | $E_{1/2} = 0.05$         |
| (Tri-4-cyclopropylphenylmethyl) <sup>+</sup>         | MeCN, 0.1 M TBAP/Hg/pol                       | $E_{1/2} = 0.01$         |
| (Tropylium) <sup>+</sup>                             | MeCN, 0.1 M TBAP/Hg/pol                       | $E_{1/2} = -0.17$        |
|                                                      | DMF, 0.15 M TBAI/Hg/pol                       | $E_{1/2} = -1.55$        |
|                                                      | DMF, 0.15 M TBAI/Hg/pol                       | $E_{1/2} = -1.55$        |
|                                                      | DMF, 0.15 M TBAI/Hg/pol                       | $E_{1/2} = -1.57$        |
|                                                      | DMF, 0.15 M TBAI/Hg/pol                       | $E_{1/2} = -1.60$        |
|                                                      | DMF, 0.15 M TBAI/Hg/pol                       | $E_{1/2} = -1.87$        |
|                                                      | DMF, 0.15 M TBAI/Hg/pol                       | $E_{1/2} = -1.96$        |
|                                                      | DMF, 0.15 M TBAI/Hg/pol                       | $E_{1/2} = -2.05$        |

## Oxidation Potentials (Products are Cation Radicals)

|                        |                                                                                              |                   |
|------------------------|----------------------------------------------------------------------------------------------|-------------------|
| Anthracene             | CH <sub>2</sub> Cl <sub>2</sub> , 0.2 M TBABF <sub>4</sub> , -70°C/Pt dsk/CV                 | $E_p = +0.73^d$   |
| 9,10-Dimethylantracene | MeCN, 0.1 M LiClO <sub>4</sub> /Pt wr/CV                                                     | $E_p = +1.0$      |
| 9,10-Dipropylantracene | MeCN, 0.1 M TEAP/Pt/CV                                                                       | $E_p = +1.08$     |
| 1,8-Diphenylantracene  | CH <sub>2</sub> Cl <sub>2</sub> , 0.2 M TPrACF <sub>3</sub> SO <sub>3</sub> /rot Pt wr/E swp | $E_{1/2} = +1.34$ |
| 8,9-Diphenylantracene  | CH <sub>2</sub> Cl <sub>2</sub> , 0.2 M TPrACF <sub>3</sub> SO <sub>3</sub> /rot Pt wr/E swp | $E_{1/2} = +1.30$ |
| 9,10-Diphenylantracene | MeCN/Pt/CV                                                                                   | $E_p = +1.22$     |
| Perylene               | MeCN, 0.1 M TBAP/Pt/CV                                                                       | $E_p = +1.34$     |
| Pyrene                 | DMF, 0.1 M TBAP/Pt dsk/CV                                                                    | $E_p = +1.25$     |
| Rubrene                | DMF, 0.1 M TBAP/Pt dsk/CV                                                                    | $E_p = +1.10$     |
| Tetracene              | CH <sub>2</sub> Cl <sub>2</sub> , 0.2 M TBABF <sub>4</sub> , -70°C/Pt wr/CV                  | $E_p = +0.35^d$   |
| 1,4-Dithiabenzene      | MeCN, 0.1 M TEAP/Pt dsk/rot                                                                  | $E_{1/2} = +0.69$ |
| 1,4-Dithianaphthalene  | MeCN, 0.1 M TEAP/Pt dsk/rot                                                                  | $E_{1/2} = +0.80$ |
| Thianthrene            | 0.1 M TPAP/Pt/CV                                                                             | $E_{1/2} = +1.28$ |

<sup>a</sup> vs 0.01 M Ag/AgClO<sub>4</sub><sup>b</sup> vs. Hg/Hg<sub>2</sub>SO<sub>4</sub>, 17 M H<sub>2</sub>SO<sub>4</sub><sup>c</sup> vs Hg pool<sup>d</sup> vs Ag/saturated AgNO<sub>3</sub><sup>e</sup> vs Ag/0.01 M Ag<sup>+</sup>

# pH SCALE FOR AQUEOUS SOLUTIONS

A.K. Covington

A Working Party of IUPAC, after extensive considerations over five years, has recently produced a report (1) which sets pH firmly within the International System of Units (SI). A summary of these important developments is given below.

The concept of pH is unique amongst the commonly encountered physicochemical quantities in that, in terms of its definition,

$$\text{pH} = -\lg a_{\text{H}} \quad (1)$$

it involves a single ion quantity, the activity of the hydrogen ion, which is immeasurable by any thermodynamically valid method and requires a convention for its evaluation.

pH was originally defined by Sørensen (2) in terms of the concentration of hydrogen ions (in modern nomenclature) as  $\text{pH} = -\lg (c_{\text{H}}/c^\circ)$  where  $c_{\text{H}}$  is the hydrogen ion concentration in  $\text{mol dm}^{-3}$ , and  $c^\circ = 1 \text{ mol dm}^{-3}$  is the standard amount concentration. Subsequently (3), it was accepted as more satisfactory to define pH in terms of the relative activity of hydrogen ions in solution

$$\text{pH} = -\lg a_{\text{H}} = -\lg (m_{\text{H}}\gamma_{\text{H}}/m^\circ) \quad (2)$$

where  $a_{\text{H}}$  is the relative (molality basis) activity and  $\gamma_{\text{H}}$  is the molal activity coefficient of the hydrogen ion  $\text{H}^+$  at the molality  $m_{\text{H}}$ , and  $m^\circ$  the standard molality. The quantity pH is intended to be a measure of the activity of hydrogen ions in solution. However, since it is defined in terms of a quantity that cannot be measured by a thermodynamically valid method, eqn.(2) can only be considered a *notional definition* of pH.

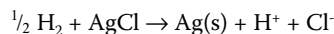
pH being a single ion quantity, it is not determinable in terms of a fundamental (or base) unit of any measurement system, and there is difficulty providing a proper basis for the traceability of pH measurements. A satisfactory approach is now available in that pH determinations can be incorporated into the International System (SI) if they can be traced to measurements made using a method that fulfils the definition of a 'primary method of measurement' (4).

The essential feature of a primary method is that it must operate according to a well-defined measurement equation in which all of the variables can be determined experimentally in terms of SI units. Any limitation in the determination of the experimental variables, or in the theory, must be included within the estimated uncertainty of the method if traceability to the SI is to be established. If a convention were used without an estimate of its uncertainty, true traceability to SI would not be established. The electrochemical cell without liquid junction, known as the Harned cell (5), fulfils the definition of a primary method for the measurement of the acidity function,  $p(a_{\text{H}}\gamma_{\text{Cl}})$ , and subsequently of the pH of buffer solutions.

The Harned cell is written as



and contains a standard buffer, S, with chloride ions, as potassium or sodium chloride, added in order to use the silver-silver chloride electrode as reference electrode. The application of the Nernst equation to the spontaneous cell reaction of Cell I:



yields the potential difference  $E_1$  of the cell (corrected to 1 atm (101.325 kPa), the partial pressure of hydrogen gas used in electrochemistry in preference to 100 kPa) as

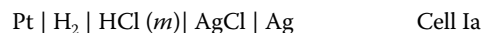
$$E_1 = E^\circ - (RT/F) \ln 10 \lg [(m_{\text{H}}\gamma_{\text{H}}/m^\circ)(m_{\text{Cl}}\gamma_{\text{Cl}}/m^\circ)] \quad (3)$$

which can be rearranged, since  $a_{\text{H}} = m_{\text{H}}\gamma_{\text{H}}/m^\circ$ , to give the acidity function

$$p(a_{\text{H}}\gamma_{\text{Cl}}) = -\lg(a_{\text{H}}\gamma_{\text{Cl}}) = (E_1 - E^\circ)/[(RT/F) \ln 10] + \lg(m_{\text{Cl}}/m^\circ) \quad (4)$$

where  $E^\circ$  is the standard potential difference of the cell, and hence of the silver-silver chloride electrode, and  $\gamma_{\text{Cl}}$  is the activity coefficient of the chloride ion.

The standard potential difference of the silver/silver chloride electrode,  $E^\circ$ , is determined from a Harned cell in which only HCl is present at a fixed molality (e.g.  $m = 0.01 \text{ mol kg}^{-1}$ )



The application of the Nernst equation to the HCl cell (Ia) gives

$$E_{\text{Ia}} = E^\circ - (2RT/F) \ln 10 \lg [(m_{\text{HCl}}/m^\circ)(\gamma_{\pm\text{HCl}})] \quad (5)$$

where  $E_{\text{Ia}}$  has been corrected to 1 atmosphere partial pressure of hydrogen gas (101.325 kPa) and  $\gamma_{\pm\text{HCl}}$  is the mean ionic activity coefficient of HCl.

Values of the activity coefficient ( $\gamma_{\pm\text{HCl}}$ ) at molality  $0.01 \text{ mol kg}^{-1}$  and various temperatures were given by Bates and Robinson (6). The standard potential difference depends on the method of preparation of the electrodes, but individual determinations of the activity coefficient of HCl at  $0.01 \text{ mol kg}^{-1}$  are more uniform than values of  $E^\circ$ . Hence the practical determination of the potential difference of the cell with HCl at  $0.01 \text{ mol kg}^{-1}$  is recommended at 298.15 K at which the mean ionic activity coefficient is 0.904. (It is unnecessary to repeat the measurement of  $E^\circ$  at other temperatures but simply to correct published smoothed values by the observed difference in  $E^\circ$  at 298.15 K)

In national metrology institutes (NMIs), measurements of Cells I and Ia are often done simultaneously in a thermostat bath. Subtracting eqn.(5) from (3) gives

$$\Delta E = E_1 - E_{\text{Ia}} = - (RT/F) \ln 10 \{ \lg [(m_{\text{H}}\gamma_{\text{H}}/m^\circ)(m_{\text{Cl}}\gamma_{\text{Cl}}/m^\circ)] - \lg [(m_{\text{HCl}}/m^\circ)^2 \gamma_{\pm\text{HCl}}] \} \quad (6)$$

which is independent of the standard potential difference. Therefore, the subsequently calculated pH does not depend on the standard potential difference and hence does not depend on the assumption that the standard potential of the hydrogen electrode is zero at all temperatures. Therefore, the Harned cell gives an exact comparison between hydrogen ion activities at different temperatures.

The quantity  $p(a_{\text{H}}\gamma_{\text{Cl}}) = -\lg (a_{\text{H}}\gamma_{\text{Cl}})$ , on the left hand side of (4), is called the acidity function (5). To obtain the quantity pH according to eqn. (2) from the acidity function, it is necessary to evaluate  $\lg \gamma_{\text{Cl}}$  independently. This is done in two steps: (i) the

value of  $\lg(a_{\text{H}}\gamma_{\text{Cl}})$  at zero chloride molality,  $\lg(a_{\text{H}}\gamma_{\text{Cl}})^{\circ}$ , is evaluated and (ii) a value for the activity of the chloride ion  $\gamma_{\text{Cl}}^{\circ}$ , at zero chloride molality (sometimes referred to as the limiting or 'trace' activity coefficient) is calculated using the Bates-Guggenheim convention (7). The value of  $\lg(a_{\text{H}}\gamma_{\text{Cl}})^{\circ}$  corresponding to zero chloride molality is determined by linear extrapolation of measurements using Harned cells with at least three added molalities of sodium or potassium chloride ( $I < 0.1 \text{ mol kg}^{-1}$ ).

The value of  $\lg(a_{\text{H}}\gamma_{\text{Cl}})^{\circ}$  corresponding to zero chloride molality is determined by linear extrapolation of measurements using Harned cells with at least three added molalities of sodium or potassium chloride ( $I < 0.1 \text{ mol kg}^{-1}$ ) in accord with eqn. (7):

$$-\lg(a_{\text{H}}\gamma_{\text{Cl}}) = -\lg(a_{\text{H}}\gamma_{\text{Cl}})^{\circ} + Sm_{\text{Cl}} \quad (7)$$

where  $S$  is an empirical, temperature dependent, constant.

The Bates-Guggenheim convention (7) assumes that the trace activity coefficient of the chloride ion  $\gamma_{\text{Cl}}^{\circ}$  is given by

$$\lg \gamma_{\text{Cl}}^{\circ} = -A I^{1/2} / (1 + Ba I^{1/2}) \quad (8)$$

where  $A$  is the Debye-Hückel temperature dependent constant (limiting slope),  $a$  is the *mean* distance of closest approach of the ions (ion size parameter),  $Ba$  is set equal to  $1.5 (\text{mol kg}^{-1})^{-1/2}$  at all temperatures in the range  $5\text{--}50^{\circ}\text{C}$ , and  $I$  is the ionic strength of the buffer (which for its evaluation requires knowledge of appropriate acid dissociation constants).

The various stages in the assignment of primary standard pH values are combined in eqn. (9), which is derived from eqns. (4), (5) and (8)

$$\text{pH(PS)} = \lim_{m_{\text{Cl}} \rightarrow 0} \{ (E_1 - E^{\circ}) / [(RT/F) \ln 10] + \lg(m_{\text{Cl}}/m^{\circ}) \} - AI^{1/2} / [1 + 1.5 (I/m^{\circ})^{1/2}] \quad (9)$$

In order for a particular buffer solution to be considered a primary buffer solution, it must be of the "highest metrological" quality (4) in accordance with the definition of a primary standard. It is recommended that it have the following attributes (9):

1. High buffer value in the range  $0.016\text{--}0.07 (\text{mol OH}^{-})/\text{pH}$ .
2. Small dilution value at half concentration (change in pH with change in buffer concentration) in the range  $0.01\text{--}0.20$ .
3. Small dependence of pH on temperature less than  $\pm 0.01 \text{ K}^{-1}$ .
4. Low residual liquid junction potential  $< 0.01$  in pH.
5. Ionic strength  $\leq 0.1 \text{ mol kg}^{-1}$  to permit applicability of Bates-Guggenheim convention.
6. NMI certificate for specific batch.
7. Reproducible purity of preparation (lot to lot differences of  $|\Delta\text{pH(PS)}| < 0.003$ ).
8. Long term stability of stored solid material.

Values for the above and other important parameters for the primary and secondary buffer materials are given in Table 1.

### Primary Standard Buffers

As there can be significant variations in the purity of samples of a buffer of the same nominal chemical composition, it is essential that the primary buffer material used has been certified with values that have been measured with Cell I. The Harned cell is used

by many national metrological institutes for accurate measurements of pH of buffer solutions.

Typical values of the pH(PS) of the seven solutions from the six accepted primary standard reference buffers, which meet the conditions stated above, are listed in Table 2. Batch-to-batch variations in purity can result in changes in the pH value of samples of at most 0.003. The typical values in Table 2 should not be used in place of the certified value (from a Harned cell measurement) for a specific batch of buffer material.

The required attributes listed above effectively limit the range of primary buffers available to between pH 3 and 10 (at  $25^{\circ}\text{C}$ ). Calcium hydroxide and potassium tetraoxalate are excluded because the contribution of hydroxide or hydrogen ions to the ionic strength is significant. Also excluded are the nitrogen bases of the type  $\text{BH}^{+}$  (such as tris(hydroxymethyl)aminomethane and piperazine phosphate) and the zwitterionic buffers (e.g. HEPES and MOPS (10)). These do not comply because either the Bates-Guggenheim convention is not applicable, or the liquid junction potentials are high. This means the choice of primary standards is restricted to buffers derived from oxy-carbon, -phosphorus, -boron and mono, di- and tri-protic carboxylic acids. The uncertainties (11) associated with Harned cell measurements are calculated (1) to be 0.004 in pH at NMIs, with typical variation between batches of primary standard buffers of 0.003.

### Secondary Standards

Substances that do not fulfil all the criteria for primary standards, but to which pH values can be assigned using Cell I are considered to be secondary standards (Table 3). Reasons for their exclusion as primary standards include difficulties in achieving consistent and suitable chemical quality (e.g. acetic acid is a liquid), suspected high liquid junction potential, or inappropriateness of the Bates-Guggenheim convention (e.g. other charge-type buffers). The uncertainty is higher (e.g. 0.01) for biological buffers. Certain other substances, which cannot be used in cells containing hydrogen gas electrodes, are also classed as secondary standards.

### Calibration Procedures

#### (a) One-point calibration

A single point calibration is insufficient to determine both slope and one-point parameters. The theoretical value for the slope can be assumed but the practical slope may be up to 5% lower. Alternatively, a value for the practical slope can be assumed from the manufacturer's prior calibration. The one-point calibration therefore yields only an estimate of pH(X). Since both parameters may change with age of the electrodes, this is not a reliable procedure.

#### (b) Two-point calibration [target uncertainty: $0.02\text{--}0.03$ at $25^{\circ}\text{C}$ ]

In the majority of practical applications, glass electrodes cells are calibrated by a two-point calibration, or bracketing, procedure using two standard buffer solutions, with pH values,  $\text{pH}(S_1)$  and  $\text{pH}(S_2)$ , bracketing the unknown  $\text{pH}(X)$ . Bracketing is often taken to mean that the  $\text{pH}(S_1)$  and  $\text{pH}(S_2)$  buffers selected from Table 2 should be those that are immediately above and below  $\text{pH}(X)$ . This may not be appropriate in all situations and choice of a wider range may be better.

- (c) Multi-point calibration [target uncertainty: 0.01-0.03 at 25 °C].

Multi-point calibration is carried out using up to five standard buffers. The use of more than five points yields no significant improvement in the statistical information obtainable.

Details of uncertainty computations (11) have been given (1).

### Measurement of pH and choice of pH Standard Solutions

- 1a) If pH is not required to better than  $\pm 0.05$  any pH standard solution may be selected.
- 1b) If pH is required to  $\pm 0.002$  and interpretation in terms of hydrogen ion concentration or activity is desired, choose a standard solution, pH(PS), to match X as closely as possible in terms of pH, composition and ionic strength.
- 2) Alternatively, a bracketing procedure may be adopted whereby two standard solutions are chosen whose pH values, pH(S1), pH(S2) are on either side of pH(X). Then if the corresponding potential difference measurements are  $E(S1)$ ,  $E(S2)$ ,  $E(X)$ , then pH(X) is obtained from

$$\text{pH}(X) = \text{pH}(S1) + [E(X) - E(S1)] / \%k$$

where  $\%k = 100[E(S2) - E(S1)] / [\text{pH}(S2) - \text{pH}(S1)]$  is the apparent percentage slope. This procedure is very easily done on some pH meters simply by adjusting downwards the slope factor control with the electrodes in S2. The purpose of the bracketing procedure is to compensate for deficiencies in the electrodes and measuring system.

### Information to be given about the measurement of pH(X)

The standard solutions selected for calibration of the pH meter system should be reported with the measurement as follows:

System calibrated with pH(S) = .... at ...K.

System calibrated with two primary standards, pH(PS1) = .... and pH(PS2) = .... at ....K.

System calibrated with  $n$  standards, pH(S1) = ...., pH(S2) = .... etc. at ....K.

### Interpretation of pH(X) in terms of hydrogen ion concentration

The defined pH has no simple interpretation in terms of hydrogen ion concentration but the mean ionic activity coefficient of a typical 1:1 electrolyte can be used to obtain hydrogen ion concentration subject to an uncertainty of 3.9% in concentration, corresponding to 0.02 in pH.

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TABLE 1. Summary of Useful Properties of Some Primary and Secondary Standard Buffer Substances and Solutions

| Salt or solid substance                   | Formula                                                          | Molality/<br>mol kg <sup>-1</sup> | Molar<br>mass/<br>g mol <sup>-1</sup> | Density/<br>g/mL | Amount<br>conc. at<br>20°C/<br>mol dm <sup>-3</sup> | Mass/g<br>to make<br>1 dm <sup>3</sup> | Dilution<br>value<br>$\Delta\text{pH}_{1/2}$ | Buffer<br>value ( $\beta$ )/<br>mol OH <sup>-</sup> /<br>dm <sup>-3</sup> | pH<br>Temperature<br>coefficient/<br>K <sup>-1</sup> |
|-------------------------------------------|------------------------------------------------------------------|-----------------------------------|---------------------------------------|------------------|-----------------------------------------------------|----------------------------------------|----------------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------|
| Potassium tetroxalate dihydrate           | KH <sub>3</sub> C <sub>4</sub> O <sub>8</sub> ·2H <sub>2</sub> O | 0.1                               | 254.191                               | 1.0091           | 0.09875                                             | 25.101                                 |                                              |                                                                           |                                                      |
| Potassium tetraoxalate dihydrate          | KH <sub>3</sub> C <sub>4</sub> O <sub>8</sub> ·2H <sub>2</sub> O | 0.05                              | 254.191                               | 1.0032           | 0.04965                                             | 12.620                                 | 0.186                                        | 0.070                                                                     | 0.001                                                |
| Potassium hydrogen tartrate (sat at 25°C) | KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                   | 0.0341                            | 188.18                                | 1.0036           | 0.034                                               | 6.4                                    | 0.049                                        | 0.027                                                                     | - 0.0014                                             |
| Potassium dihydrogen citrate              | KH <sub>2</sub> C <sub>6</sub> H <sub>5</sub> O <sub>7</sub>     | 0.05                              | 230.22                                | 1.0029           | 0.04958                                             | 11.41                                  | 0.024                                        | 0.034                                                                     | - 0.022                                              |
| Potassium hydrogen phthalate              | KHC <sub>8</sub> H <sub>4</sub> O <sub>4</sub>                   | 0.05                              | 204.44                                | 1.0017           | 0.04958                                             | 10.12                                  | 0.052                                        | 0.016                                                                     | 0.00012                                              |
| Disodium hydrogen orthophosphate +        | Na <sub>2</sub> HPO <sub>4</sub>                                 | 0.025                             | 141.958                               | 1.0038           | 0.02492                                             | 3.5379                                 | 0.080                                        | 0.029                                                                     | - 0.0028                                             |

| Salt or solid substance                | Formula                                                           | Molality/<br>mol kg <sup>-1</sup> | Molar<br>mass/<br>g mol <sup>-1</sup> | Density/<br>g/mL | Amount<br>conc. at<br>20°C/<br>mol dm <sup>-3</sup> | Mass/g<br>to make<br>1 dm <sup>3</sup> | Dilution<br>value<br>ΔpH <sub>1/2</sub> | Buffer<br>value (β)/<br>mol OH <sup>-</sup> /<br>dm <sup>-3</sup> | pH<br>Temperature<br>coefficient/<br>K <sup>-1</sup> |
|----------------------------------------|-------------------------------------------------------------------|-----------------------------------|---------------------------------------|------------------|-----------------------------------------------------|----------------------------------------|-----------------------------------------|-------------------------------------------------------------------|------------------------------------------------------|
| potassium dihydrogen<br>orthophosphate | KH <sub>2</sub> PO <sub>4</sub>                                   | 0.025                             | 136.085                               |                  |                                                     | 3.3912                                 |                                         |                                                                   |                                                      |
| Disodium hydrogen<br>orthophosphate +  | Na <sub>2</sub> HPO <sub>4</sub>                                  | 0.03043                           | 141.959                               | 1.0020           | 0.08665                                             | 4.302                                  | 0.07                                    | 0.016                                                             | - 0.0028                                             |
| potassium dihydrogen<br>orthophosphate | KH <sub>2</sub> PO <sub>4</sub>                                   | 0.00869                           | 136.085                               |                  | 0.03032                                             | 1.179                                  |                                         |                                                                   |                                                      |
| Disodium tetraborate<br>decahydrate    | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O | 0.05                              | 381.367                               | 1.0075           | 0.04985                                             | 19.012                                 |                                         |                                                                   |                                                      |
| Disodium tetraborate<br>decahydrate    | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O | 0.01                              | 381.367                               | 1.0001           | 0.00998                                             | 3.806                                  | 0.01                                    | 0.020                                                             | - 0.0082                                             |
| Sodium hydrogen<br>carbonate +         | NaHCO <sub>3</sub>                                                | 0.025                             | 84.01                                 | 1.0013           | 0.02492                                             | 2.092                                  | 0.079                                   | 0.029                                                             | -0.0096                                              |
| sodium carbonate                       | Na <sub>2</sub> CO <sub>3</sub>                                   | 0.025                             | 105.99                                |                  |                                                     | 2.640                                  |                                         |                                                                   |                                                      |
| Calcium hydroxide (sat. at<br>25°C)    | Ca(OH) <sub>2</sub>                                               | 0.0203                            | 74.09                                 | 0.9991           | 0.02025                                             | 1.5                                    | -0.28                                   | 0.09                                                              | -0.033                                               |

TABLE 2. Typical Values of pH(PS) for Primary Standards at 0–50°C

| Primary standards (PS)                                                                                                           | Temperature in °C |        |        |        |        |        |       |       |       |       |       |
|----------------------------------------------------------------------------------------------------------------------------------|-------------------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|
|                                                                                                                                  | 0                 | 5      | 10     | 15     | 20     | 25     | 30    | 35    | 37    | 40    | 50    |
| Sat. potassium hydrogen tartrate (at<br>25°C)                                                                                    |                   |        |        |        |        | 3.557  | 3.552 | 3.549 | 3.548 | 3.547 | 3.549 |
| 0.05 mol kg <sup>-1</sup> potassium dihydrogen<br>citrate                                                                        | 3.863             | 3.840  | 3.820  | 3.802  | 3.788  | 3.776  | 3.766 | 3.759 | 3.756 | 3.754 | 3.749 |
| 0.05 mol kg <sup>-1</sup> potassium hydrogen<br>phthalate                                                                        | 4.000             | 3.998  | 3.997  | 3.998  | 4.000  | 4.005  | 4.011 | 4.018 | 4.022 | 4.027 | 4.050 |
| 0.025 mol kg <sup>-1</sup> disodium hydrogen<br>phosphate +<br>0.025 mol kg <sup>-1</sup> potassium dihydrogen<br>phosphate      | 6.984             | 6.951  | 6.923  | 6.900  | 6.881  | 6.865  | 6.853 | 6.844 | 6.841 | 6.838 | 6.833 |
| 0.03043 mol kg <sup>-1</sup> disodium hydrogen<br>phosphate +<br>0.008695 mol kg <sup>-1</sup> potassium<br>dihydrogen phosphate | 7.534             | 7.500  | 7.472  | 7.448  | 7.429  | 7.413  | 7.400 | 7.389 | 7.386 | 7.380 | 7.367 |
| 0.01 mol kg <sup>-1</sup> disodium tetraborate                                                                                   | 9.464             | 9.395  | 9.332  | 9.276  | 9.225  | 9.180  | 9.139 | 9.102 | 9.088 | 9.068 | 9.011 |
| 0.025 mol kg <sup>-1</sup> sodium hydrogen<br>carbonate +<br>0.025 mol kg <sup>-1</sup> sodium carbonate                         | 10.317            | 10.245 | 10.179 | 10.118 | 10.062 | 10.012 | 9.966 | 9.926 | 9.910 | 9.889 | 9.828 |

TABLE 3. Values of pH(SS) of Some Secondary Standards from Harned Cell I Measurements

| Secondary standards                                                                           | Temperature in °C |       |       |       |       |       |       |       |       |       |
|-----------------------------------------------------------------------------------------------|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                                                                               | 0                 | 5     | 10    | 15    | 20    | 25    | 30    | 37    | 40    | 50    |
| 0.05 mol kg <sup>-1</sup> potassium tetroxalate <sup>a</sup>                                  | 1.67              | 1.67  | 1.67  | 1.67  | 1.68  | 1.68  | 1.68  | 1.69  | 1.69  | 1.71  |
| 0.05 mol kg <sup>-1</sup> sodium hydrogen diglycolate <sup>b</sup>                            |                   | 3.47  | 3.47  | 3.48  | 3.48  | 3.49  | 3.50  | 3.52  | 3.53  | 3.56  |
| 0.1 mol dm <sup>-3</sup> acetic acid + 0.1 mol dm <sup>-3</sup> sodium acetate                | 4.68              | 4.67  | 4.67  | 4.66  | 4.66  | 4.65  | 4.65  | 4.66  | 4.66  | 4.68  |
| mol dm <sup>-3</sup> acetic acid + 0.1 mol dm <sup>-3</sup> sodium acetate                    | 4.74              | 4.73  | 4.73  | 4.72  | 4.72  | 4.72  | 4.72  | 4.73  | 4.73  | 4.75  |
| 0.02 mol kg <sup>-1</sup> piperazine phosphate <sup>c</sup>                                   | 6.58              | 6.51  | 6.45  | 6.39  | 6.34  | 6.29  | 6.24  | 6.16  | 6.14  | 6.06  |
| 0.05 mol kg <sup>-1</sup> tris hydrochloride + 0.01667 mol kg <sup>-1</sup> tris <sup>c</sup> | 8.47              | 8.30  | 8.14  | 7.99  | 7.84  | 7.70  | 7.56  | 7.38  | 7.31  | 7.07  |
| 0.05 mol kg <sup>-1</sup> disodium tetraborate                                                | 9.51              | 9.43  | 9.36  | 9.30  | 9.25  | 9.19  | 9.15  | 9.09  | 9.07  | 9.01  |
| Saturated (at 25 °C) calcium hydroxide                                                        | 13.42             | 13.21 | 13.00 | 12.81 | 12.63 | 12.45 | 12.29 | 12.07 | 11.98 | 11.71 |

<sup>a</sup> Potassium trihydrogen dioxalate (KH<sub>3</sub>C<sub>4</sub>O<sub>8</sub>)<sup>b</sup> Sodium hydrogen 2,2'-oxydiacetate<sup>c</sup> 2-Amino-2-(hydroxymethyl)-1,3 propanediol or tris(hydroxymethyl)aminomethane



# PRACTICAL pH MEASUREMENTS ON NATURAL WATERS

A. K. Covington and W. Davison

(1) Dilute solutions and freshwater including 'acid-rain' samples ( $I < 0.02 \text{ mol kg}^{-1}$ )

Major problems could be encountered due to errors associated with the liquid junction. It is recommended that either a free diffusion junction is used or it is verified that the junction is working correctly using dilute solutions as follows. For commercial electrodes calibrated with IUPAC aqueous RVS or PS standards, the  $\text{pH(X)}$  of dilute solutions should be within  $\pm 0.02$  of those given in Table 1. The difference in determined  $\text{pH(X)}$  between a stirred and unstirred dilute solution should be  $< 0.02$ . The characteristics of glass electrodes are such that below pH 5 the readings should be stable within 2 min, but for pH 5 to 8.8 or so minutes may be necessary to attain stability. Interpretation of  $\text{pH(X)}$  measured in this way in terms of activity of hydrogen ion,  $a_{\text{H}^+}$ , is subject<sup>1</sup> to an uncertainty of  $\pm 0.02$  in pH.

(2) Seawater

Measurements made by calibration of electrodes with IUPAC aqueous RVS or PS standards to obtain  $\text{pH(X)}$  are perfectly valid. However, the interpretation of  $\text{pH(X)}$  in terms of the activity of hydrogen ion is complicated by the non zero residual liquid junction potential as well as by systematic differences between electrode pairs, principally attributable to the reference electrode. For 35‰ salinity seawater ( $S = 0.035$ )  $a_{\text{H}^+}$  calculated from  $\text{pH(X)}$  is typically 12% too low. Special seawater pH scales have been devised to overcome this problem:

(i) The total hydrogen ion scale,  $\text{pH}_T$ , is defined in terms of the sum of free and complexed (total) hydrogen ion concentrations, where

$$^T C_{\text{H}} = [\text{H}^+] + [\text{HSO}_4^-] + [\text{HF}].$$

$$\text{So, } \text{pH}_T = -\log ^T C_{\text{H}}$$

Calibration of the electrodes with a buffer having a composition similar to that of seawater, to which  $\text{pH}_T$  has been assigned, results in values of  $\text{pH}_T(\text{X})$  (Tables 2, 3) which are accurately interpretable in terms of  $^T C_{\text{H}}$ .

(ii) The free hydrogen ion scale,  $\text{pH}_F$ , is defined, and fully interpretable, in terms of the concentration of free hydrogen ions.

$$\text{pH}_F = -\log [\text{H}^+]$$

Values of  $\text{pH}_F$  as a function of temperature have been assigned to the same set of  $\text{pH}_T$  seawater buffers, and so alternatively can be used for calibration (Tables 2, 3)<sup>2,3</sup>

(3) Estuarine water

Prescriptions for seawater scale buffers are available for a range of salinities. Reliable estuarine pH measurements can be made by calibrating with a buffer of the same salinity as the sample. However, these buffers are difficult to prepare and their use presumes prior knowledge of salinity of the sample. Interpretable measurements of estuarine pH can be made by calibration with IUPAC aqueous RVS or PS standards if the electrode pair is additionally calibrated using a 20‰ salinity seawater buffer.<sup>4</sup> The difference between the assigned  $\text{pH}_{\text{sws}}$  of the seawater buffer and its measured  $\text{pH(X)}$  value using RVS or PS standards is

$$\Delta \text{pH} = \text{pH}_{\text{sws}} - \text{pH(X)}$$

Values of  $\Delta \text{pH}$  should be in the range of 0.08 to 0.18. It empirically corrects for differences between the two pH scales and for measurement errors associated with the electrode pair. The  $\text{pH(X)}$  of samples measured using IUPAC aqueous buffers, can be converted to  $\text{pH}_T$  or  $\text{pH}_F$  using the appropriate measured  $\Delta \text{pH}$ :

$$\text{pH}_T = \text{pH(X)} - \Delta \text{pH}$$

$$\text{or } \text{pH}_F = \text{pH(X)} - \Delta \text{pH}$$

This simple procedure is appropriate to pH measurement at salinities from 2‰ to 35‰. For salinities lower than 2‰ the procedures for freshwaters should be adopted.

## References

1. Davison, W. and Harbinson, T. R., *Analyst*, 113, 709, 1988.
2. Culbertson, C. H., in *Marine Electrochemistry*, Whitfield, M. and Jagner, D., Eds., Wiley, 1981.
3. Millero, F. J., *Limnol. Oceanogr.*, 31, 839, 1986.
4. Covington, A. K., Whalley, P. D., Davison, W., and Whitfield, M., in *The Determination of Trace Metals in Natural Waters*, West, T. S. and Nurnberg, H. W., Eds., Blackwell, Oxford, 1988.
5. Koch, W. F., Marinenko, G., and Paule, R. C., *J. Res. NBS*, 91, 33, 1986.

**TABLE 1. pH of Dilute Solutions at 25°C, Degassed and Equilibrated with Air, Suitable as Quality Control Standards**

|                                                              | Ionic strength<br>mmol kg <sup>-1</sup> | Concentration(x)<br>mmol kg <sup>-1</sup> | pH<br>$p_{\text{CO}_2} = 0$ | pH<br>$p_{\text{CO}_2} = \text{air}$ |
|--------------------------------------------------------------|-----------------------------------------|-------------------------------------------|-----------------------------|--------------------------------------|
| Potassium hydrogen phthalate                                 | 10.7                                    | 10                                        | 4.12                        | 4.12                                 |
|                                                              | 1.1                                     | 1                                         | 4.33                        | 4.33                                 |
| $x\text{KH}_2\text{PO}_4 + x\text{Na}_2\text{HPO}_4$         | 9.9                                     | 2.5                                       | 7.07                        | 7.05                                 |
| $x\text{KH}_2\text{PO}_4 + 3.5x\text{Na}_2\text{HPO}_4$      | 10                                      | 0.87                                      | 7.61                        | 7.58                                 |
| $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ | 10                                      | 5                                         | 9.20                        | —                                    |
| HCl                                                          | 0.1                                     | 0.1                                       | 4.03                        | 4.03                                 |
| SRM2694-I <sup>a</sup>                                       | —                                       | —                                         | 4.30                        | —                                    |
| SRM2694-II <sup>a</sup>                                      | —                                       | —                                         | 3.59                        | —                                    |

Note: The pH of solutions near to pH 4 is virtually independent of temperature over the range of 5 to 30°C.

<sup>a</sup> Simulated rainwater samples are available (Reference 5) from NIST containing sulfate, nitrate, chloride, fluoride, sodium, potassium, calcium and magnesium.

**TABLE 2. Composition of Seawater Buffer of Salinity S = 35‰ at 25°C (Reference 3)**

| Solute                   | mol dm <sup>-3</sup> | mol kg <sup>-1</sup> | g kg <sup>-1</sup> | g dm <sup>-3</sup> |
|--------------------------|----------------------|----------------------|--------------------|--------------------|
| NaCl                     | 0.3666               | 0.3493               | 20.416             | 20.946             |
| $\text{Na}_2\text{SO}_4$ | 0.02926              | 0.02788              | 3.96               | 4.063              |
| KCl                      | 0.01058              | 0.01008              | 0.752              | 0.772              |
| $\text{CaCl}_2$          | 0.01077              | 0.01026              | 1.139              | 1.169              |
| $\text{MgCl}_2$          | 0.05518              | 0.05258              | 5.006              | 5.139              |
| Tris                     | 0.06                 | 0.05717              | 6.926              | 7.106              |
| Tris · HCl               | 0.06                 | 0.05717              | 9.010              | 9.244              |

Tris = tris(hydroxymethyl)aminomethane ( $\text{HOCH}_2)_3\text{CNH}_2$ .

A 20‰ buffer is made by diluting the 35‰ in the ratio 20:35.

**TABLE 3. Assigned Values of 20‰ and 35‰ Buffers on Free and Total Hydrogen Ion Scales. Calculated from Equations Provided by Millero (Reference 3)**

| Temp (°C) | pH <sub>T</sub><br>S = 20‰ | pH <sub>T</sub><br>S = 35‰ | pH <sub>F</sub><br>S = 20‰ | pH <sub>F</sub><br>S = 35‰ |
|-----------|----------------------------|----------------------------|----------------------------|----------------------------|
| 5         | 8.683                      | 8.718                      | 8.759                      | 8.81                       |
| 10        | 8.513                      | 8.542                      | 8.597                      | 8.647                      |
| 15        | 8.351                      | 8.374                      | 8.442                      | 8.491                      |
| 20        | 8.195                      | 8.212                      | 8.292                      | 8.341                      |
| 25        | 8.045                      | 8.057                      | 8.149                      | 8.197                      |
| 30        | 7.901                      | 7.908                      | 8.011                      | 8.059                      |
| 35        | 7.762                      | 7.764                      | 7.879                      | 7.926                      |

## BUFFER SOLUTIONS GIVING ROUND VALUES OF pH AT 25 °C

| A    |          | B    |          | C    |          | D    |          | E    |          |
|------|----------|------|----------|------|----------|------|----------|------|----------|
| pH   | <i>x</i> | pH   | <i>x</i> | pH   | <i>x</i> | pH   | <i>x</i> | pH   | <i>x</i> |
| 1.00 | 67.0     | 2.20 | 49.5     | 4.10 | 1.3      | 5.80 | 3.6      | 7.00 | 46.6     |
| 1.10 | 52.8     | 2.30 | 45.8     | 4.20 | 3.0      | 5.90 | 4.6      | 7.10 | 45.7     |
| 1.20 | 42.5     | 2.40 | 42.2     | 4.30 | 4.7      | 6.00 | 5.6      | 7.20 | 44.7     |
| 1.30 | 33.6     | 2.50 | 38.8     | 4.40 | 6.6      | 6.10 | 6.8      | 7.30 | 43.4     |
| 1.40 | 26.6     | 2.60 | 35.4     | 4.50 | 8.7      | 6.20 | 8.1      | 7.40 | 42.0     |
| 1.50 | 20.7     | 2.70 | 32.1     | 4.60 | 11.1     | 6.30 | 9.7      | 7.50 | 40.3     |
| 1.60 | 16.2     | 2.80 | 28.9     | 4.70 | 13.6     | 6.40 | 11.6     | 7.60 | 38.5     |
| 1.70 | 13.0     | 2.90 | 25.7     | 4.80 | 16.5     | 6.50 | 13.9     | 7.70 | 36.6     |
| 1.80 | 10.2     | 3.00 | 22.3     | 4.90 | 19.4     | 6.60 | 16.4     | 7.80 | 34.5     |
| 1.90 | 8.1      | 3.10 | 18.8     | 5.00 | 22.6     | 6.70 | 19.3     | 7.90 | 32.0     |
| 2.00 | 6.5      | 3.20 | 15.7     | 5.10 | 25.5     | 6.80 | 22.4     | 8.00 | 29.2     |
| 2.10 | 5.10     | 3.30 | 12.9     | 5.20 | 28.8     | 6.90 | 25.9     | 8.10 | 26.2     |
| 2.20 | 3.9      | 3.40 | 10.4     | 5.30 | 31.6     | 7.00 | 29.1     | 8.20 | 22.9     |
|      |          | 3.50 | 8.2      | 5.40 | 34.1     | 7.10 | 32.1     | 8.30 | 19.9     |
|      |          | 3.60 | 6.3      | 5.50 | 36.6     | 7.20 | 34.7     | 8.40 | 17.2     |
|      |          | 3.70 | 4.5      | 5.60 | 38.8     | 7.30 | 37.0     | 8.50 | 14.7     |
|      |          | 3.80 | 2.9      | 5.70 | 40.6     | 7.40 | 39.1     | 8.60 | 12.2     |
|      |          | 3.90 | 1.4      | 5.80 | 42.3     | 7.50 | 40.9     | 8.70 | 10.3     |
|      |          | 4.00 | 0.1      | 5.90 | 43.7     | 7.60 | 42.4     | 8.80 | 8.5      |
|      |          |      |          |      |          | 7.70 | 43.5     | 8.90 | 7.0      |
|      |          |      |          |      |          | 7.80 | 44.5     | 9.00 | 5.7      |
|      |          |      |          |      |          | 7.90 | 45.3     |      |          |
|      |          |      |          |      |          | 8.00 | 46.1     |      |          |

| F    |          | G     |          | H     |          | I     |          | J     |          |
|------|----------|-------|----------|-------|----------|-------|----------|-------|----------|
| pH   | <i>x</i> | pH    | <i>x</i> | pH    | <i>x</i> | pH    | <i>x</i> | pH    | <i>x</i> |
| 8.00 | 20.5     | 9.20  | 0.9      | 9.60  | 5.0      | 10.90 | 3.3      | 12.00 | 6.0      |
| 8.10 | 19.7     | 9.30  | 3.6      | 9.70  | 6.2      | 11.00 | 4.1      | 12.10 | 8.0      |
| 8.20 | 18.8     | 9.40  | 6.2      | 9.80  | 7.6      | 11.10 | 5.1      | 12.20 | 10.2     |
| 8.30 | 17.7     | 9.50  | 8.8      | 9.90  | 9.1      | 11.20 | 6.3      | 12.30 | 12.8     |
| 8.40 | 16.6     | 9.60  | 11.1     | 10.00 | 10.7     | 11.30 | 7.6      | 12.40 | 16.2     |
| 8.50 | 15.2     | 9.70  | 13.1     | 10.10 | 12.2     | 11.40 | 9.1      | 12.50 | 20.4     |
| 8.60 | 13.5     | 9.80  | 15.0     | 10.20 | 13.8     | 11.50 | 11.1     | 12.60 | 25.6     |
| 8.70 | 11.6     | 9.90  | 16.7     | 10.30 | 15.2     | 11.60 | 13.5     | 12.70 | 32.2     |
| 8.80 | 9.6      | 10.00 | 18.3     | 10.40 | 16.5     | 11.70 | 16.2     | 12.80 | 41.2     |
| 8.90 | 7.1      | 10.10 | 19.5     | 10.50 | 17.8     | 11.80 | 19.4     | 12.90 | 53.0     |
| 9.00 | 4.6      | 10.20 | 20.5     | 10.60 | 19.1     | 11.90 | 23.0     | 13.00 | 66.0     |
| 9.10 | 2.0      | 10.30 | 21.3     | 10.70 | 20.2     | 12.00 | 26.9     |       |          |
|      |          | 10.40 | 22.1     | 10.80 | 21.2     |       |          |       |          |
|      |          | 10.50 | 22.7     | 10.90 | 22.0     |       |          |       |          |
|      |          | 10.60 | 23.3     | 11.00 | 22.7     |       |          |       |          |
|      |          | 10.70 | 23.8     |       |          |       |          |       |          |
|      |          | 10.80 | 24.25    |       |          |       |          |       |          |

- A. 25 ml of 0.2 molar KCl + *x* ml of 0.2 molar HCl.  
 B. 50 ml of 0.1 molar potassium hydrogen phthalate + *x* ml of 0.1 molar HCl.  
 C. 50 ml of 0.1 molar potassium hydrogen phthalate + *x* ml of 0.1 molar NaOH.  
 D. 50 ml of 0.1 molar potassium dihydrogen phosphate + *x* ml of 0.1 molar NaOH.  
 E. 50 ml of 0.1 molar tris(hydroxymethyl)aminomethane + *x* ml of 0.1 M HCl.  
 F. 50 ml of 0.025 molar borax + *x* ml of 0.1 molar HCl.  
 G. 50 ml of 0.025 molar borax + *x* ml of 0.1 molar NaOH.  
 H. 50 ml of 0.05 molar sodium bicarbonate + *x* ml of 0.1 molar NaOH.  
 I. 50 ml of 0.05 molar disodium hydrogen phosphate + *x* ml of 0.1 molar NaOH.  
 J. 25 ml of 0.2 molar KCl + *x* ml of 0.2 molar NaOH.

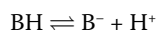
Final volume of mixtures = 100 ml.

## References

1. Bower, V. E., and Bates, R. G., *J. Res. Natl. Bur. Stand.*, 55, 197, 1955 (A–D).
2. Bates, R. G., and Bower, V. E., *Anal. Chem.*, 28, 1322, 1956 (E–J).

## DISSOCIATION CONSTANTS OF INORGANIC ACIDS AND BASES

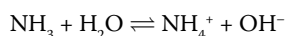
The data in this table are presented as values of  $pK_a$ , defined as the negative logarithm of the acid dissociation constant  $K_a$  for the reaction



Thus  $pK_a = -\log K_a$ , and the hydrogen ion concentration  $[H^+]$  can be calculated from

$$K_a = \frac{[H^+][B^-]}{[BH]}$$

In the case of bases, the entry in the table is for the conjugate acid; e.g., ammonium ion for ammonia. The  $OH^-$  concentration in the system



can be calculated from the equation

$$K_b = K_{\text{water}}/K_a = \frac{[OH^-][NH_4^+]}{[NH_3]}$$

where  $K_{\text{water}} = 1.01 \times 10^{-14}$  at 25 °C. Note that  $pK_a + pK_b = pK_{\text{water}}$ .

All values refer to dilute aqueous solutions at zero ionic strength at the temperature indicated. The table is arranged alphabetically by compound name.

### Reference

1. Perrin, D. D., *Ionization Constants of Inorganic Acids and Bases in Aqueous Solution, Second Edition*, Pergamon, Oxford, 1982.

| Name               | Formula                         | Step | t/°C | pK <sub>a</sub> |
|--------------------|---------------------------------|------|------|-----------------|
| Aluminum(III) ion  | Al <sup>+3</sup>                |      | 25   | 5.0             |
| Ammonia            | NH <sub>3</sub>                 |      | 25   | 9.25            |
| Arsenic acid       | H <sub>3</sub> AsO <sub>4</sub> | 1    | 25   | 2.26            |
|                    |                                 | 2    | 25   | 6.76            |
|                    |                                 | 3    | 25   | 11.29           |
| Arsenious acid     | H <sub>2</sub> AsO <sub>3</sub> |      | 25   | 9.29            |
| Barium(II) ion     | Ba <sup>+2</sup>                |      | 25   | 13.4            |
| Boric acid         | H <sub>3</sub> BO <sub>3</sub>  | 1    | 20   | 9.27            |
|                    |                                 | 2    | 20   | >14             |
| Calcium(II) ion    | Ca <sup>+2</sup>                |      | 25   | 12.6            |
| Carbonic acid      | H <sub>2</sub> CO <sub>3</sub>  | 1    | 25   | 6.35            |
|                    |                                 | 2    | 25   | 10.33           |
| Chlorous acid      | HClO <sub>2</sub>               |      | 25   | 1.94            |
| Chromic acid       | H <sub>2</sub> CrO <sub>4</sub> | 1    | 25   | 0.74            |
|                    |                                 | 2    | 25   | 6.49            |
| Cyanic acid        | HCNO                            |      | 25   | 3.46            |
| Germanic acid      | H <sub>2</sub> GeO <sub>3</sub> | 1    | 25   | 9.01            |
|                    |                                 | 2    | 25   | 12.3            |
| Hydrazine          | N <sub>2</sub> H <sub>4</sub>   |      | 25   | 8.1             |
| Hydrazoic acid     | HN <sub>3</sub>                 |      | 25   | 4.6             |
| Hydrocyanic acid   | HCN                             |      | 25   | 9.21            |
| Hydrofluoric acid  | HF                              |      | 25   | 3.20            |
| Hydrogen peroxide  | H <sub>2</sub> O <sub>2</sub>   |      | 25   | 11.62           |
| Hydrogen selenide  | H <sub>2</sub> Se               | 1    | 25   | 3.89            |
|                    |                                 | 2    | 25   | 11.0            |
| Hydrogen sulfide   | H <sub>2</sub> S                | 1    | 25   | 7.05            |
|                    |                                 | 2    | 25   | 19              |
| Hydrogen telluride | H <sub>2</sub> Te               | 1    | 18   | 2.6             |
|                    |                                 | 2    | 25   | 11              |
| Hydroxylamine      | NH <sub>2</sub> OH              |      | 25   | 5.94            |
| Hypobromous acid   | HBrO                            |      | 25   | 8.55            |
| Hypochlorous acid  | HClO                            |      | 25   | 7.40            |
| Hypoiodous acid    | HIO                             |      | 25   | 10.5            |
| Iodic acid         | HIO <sub>3</sub>                |      | 25   | 0.78            |
| Lithium ion        | Li <sup>+</sup>                 |      | 25   | 13.8            |
| Magnesium(II) ion  | Mg <sup>+2</sup>                |      | 25   | 11.4            |
| Nitrous acid       | HNO <sub>2</sub>                |      | 25   | 3.25            |
| Perchloric acid    | HClO <sub>4</sub>               |      | 20   | -1.6            |
| Periodic acid      | HIO <sub>4</sub>                |      | 25   | 1.64            |
| Phosphoric acid    | H <sub>3</sub> PO <sub>4</sub>  | 1    | 25   | 2.16            |

| Name                  | Formula                          | Step | $t/^{\circ}\text{C}$ | $\text{p}K_{\text{a}}$ |
|-----------------------|----------------------------------|------|----------------------|------------------------|
| Phosphorous acid      | $\text{H}_3\text{PO}_3$          | 2    | 25                   | 7.21                   |
|                       |                                  | 3    | 25                   | 12.32                  |
|                       |                                  | 1    | 20                   | 1.3                    |
| Pyrophosphoric acid   | $\text{H}_4\text{P}_2\text{O}_7$ | 2    | 20                   | 6.70                   |
|                       |                                  | 1    | 25                   | 0.91                   |
|                       |                                  | 2    | 25                   | 2.10                   |
|                       |                                  | 3    | 25                   | 6.70                   |
| Selenic acid          | $\text{H}_2\text{SeO}_4$         | 4    | 25                   | 9.32                   |
| Selenious acid        | $\text{H}_2\text{SeO}_3$         | 2    | 25                   | 1.7                    |
|                       |                                  | 1    | 25                   | 2.62                   |
| Silicic acid          | $\text{H}_4\text{SiO}_4$         | 2    | 25                   | 8.32                   |
|                       |                                  | 1    | 30                   | 9.9                    |
|                       |                                  | 2    | 30                   | 11.8                   |
|                       |                                  | 3    | 30                   | 12                     |
| Sodium ion            | $\text{Na}^+$                    | 4    | 30                   | 12                     |
| Strontium(II) ion     | $\text{Sr}^{+2}$                 |      | 25                   | 14.8                   |
| Sulfamic acid         | $\text{NH}_2\text{SO}_3\text{H}$ |      | 25                   | 13.2                   |
| Sulfuric acid         | $\text{H}_2\text{SO}_4$          | 2    | 25                   | 1.05                   |
| Sulfurous acid        | $\text{H}_2\text{SO}_3$          | 1    | 25                   | 1.99                   |
|                       |                                  | 2    | 25                   | 1.85                   |
| Telluric acid         | $\text{H}_2\text{TeO}_4$         | 1    | 25                   | 7.2                    |
|                       |                                  | 2    | 18                   | 7.68                   |
| Tellurous acid        | $\text{H}_2\text{TeO}_3$         | 1    | 18                   | 11.0                   |
|                       |                                  | 2    | 25                   | 6.27                   |
| Tetrafluoroboric acid | $\text{HBF}_4$                   | 1    | 25                   | 8.43                   |
|                       |                                  | 2    | 25                   | 0.5                    |
| Thiocyanic acid       | $\text{HSCN}$                    |      | 25                   | -1.8                   |
| Water                 | $\text{H}_2\text{O}$             |      | 25                   | 13.995                 |

# DISSOCIATION CONSTANTS OF ORGANIC ACIDS AND BASES

This table lists the dissociation (ionization) constants of over 1070 organic acids, bases, and amphoteric compounds. All data apply to dilute aqueous solutions and are presented as values of  $pK_a$ , which is defined as the negative of the logarithm of the equilibrium constant  $K_a$  for the reaction

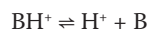


i.e.,

$$K_a = [H^+][A^-]/[HA]$$

where  $[H^+]$ , etc. represent the concentrations of the respective species in mol/L. It follows that  $pK_a = pH + \log[HA] - \log[A^-]$ , so that a solution with 50% dissociation has pH equal to the  $pK_a$  of the acid.

Data for bases are presented as  $pK_a$  values for the conjugate acid, i.e., for the reaction



In older literature, an ionization constant  $K_b$  was used for the reaction  $B + H_2O$

$\rightleftharpoons BH^+ + OH^-$ . This is related to  $K_a$  by

$$pK_a + pK_b = pK_{water} = 14.00 \quad (\text{at } 25^\circ\text{C})$$

Compounds are listed by molecular formula in Hill order.

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| Mol. form.                                                   | Name                   | Step | t/°C | pK <sub>a</sub> |
|--------------------------------------------------------------|------------------------|------|------|-----------------|
| CHNO                                                         | Cyanic acid            |      | 25   | 3.7             |
| CH <sub>2</sub> N <sub>2</sub>                               | Cyanamide              |      | 29   | 1.1             |
| CH <sub>2</sub> O                                            | Formaldehyde           |      | 25   | 13.27           |
| CH <sub>2</sub> O <sub>2</sub>                               | Formic acid            |      | 25   | 3.75            |
| CH <sub>3</sub> NO <sub>2</sub>                              | Nitromethane           |      | 25   | 10.21           |
| CH <sub>3</sub> NS <sub>2</sub>                              | Carbamodithioic acid   |      | 25   | 2.95            |
| CH <sub>4</sub> N <sub>2</sub> O                             | Urea                   |      | 25   | 0.10            |
| CH <sub>4</sub> N <sub>2</sub> S                             | Thiourea               |      | 25   | -1              |
| CH <sub>4</sub> O                                            | Methanol               |      | 25   | 15.5            |
| CH <sub>4</sub> S                                            | Methanethiol           |      | 25   | 10.33           |
| CH <sub>5</sub> N                                            | Methylamine            |      | 25   | 10.66           |
| CH <sub>5</sub> NO                                           | O-Methylhydroxylamine  |      |      | 12.5            |
| CH <sub>5</sub> N <sub>3</sub>                               | Guanidine              |      | 25   | 13.6            |
| C <sub>2</sub> HCl <sub>3</sub> O                            | Trichloroacetaldehyde  |      | 25   | 10.04           |
| C <sub>2</sub> HCl <sub>3</sub> O <sub>2</sub>               | Trichloroacetic acid   |      | 20   | 0.66            |
| C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>                | Trifluoroacetic acid   |      | 25   | 0.52            |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub> | Dichloroacetic acid    |      | 25   | 1.35            |
| C <sub>2</sub> H <sub>2</sub> O <sub>3</sub>                 | Glyoxylic acid         |      | 25   | 3.18            |
| C <sub>2</sub> H <sub>2</sub> O <sub>4</sub>                 | Oxalic acid            | 1    | 25   | 1.25            |
|                                                              |                        | 2    | 25   | 3.81            |
| C <sub>2</sub> H <sub>3</sub> BrO <sub>2</sub>               | Bromoacetic acid       |      | 25   | 2.90            |
| C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>               | Chloroacetic acid      |      | 25   | 2.87            |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> O              | 2,2,2-Trichloroethanol |      | 25   | 12.24           |
| C <sub>2</sub> H <sub>3</sub> FO <sub>2</sub>                | Fluoroacetic acid      |      | 25   | 2.59            |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O               | 2,2,2-Trifluoroethanol |      | 25   | 12.37           |
| C <sub>2</sub> H <sub>3</sub> IO <sub>2</sub>                | Iodoacetic acid        |      | 25   | 3.18            |
| C <sub>2</sub> H <sub>3</sub> NO <sub>4</sub>                | Nitroacetic acid       |      | 24   | 1.48            |
| C <sub>2</sub> H <sub>3</sub> N <sub>3</sub>                 | 1H-1,2,3-Triazole      |      | 20   | 1.17            |
| C <sub>2</sub> H <sub>3</sub> N <sub>3</sub>                 | 1H-1,2,4-Triazole      |      | 20   | 2.27            |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub>                 | Aminoacetonitrile      |      | 25   | 5.34            |
| C <sub>2</sub> H <sub>4</sub> O                              | Acetaldehyde           |      | 25   | 13.57           |
| C <sub>2</sub> H <sub>4</sub> OS                             | Thioacetic acid        |      | 25   | 3.33            |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                 | Acetic acid            |      | 25   | 4.756           |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> S               | Thioglycolic acid      |      | 25   | 3.68            |
| C <sub>2</sub> H <sub>4</sub> O <sub>3</sub>                 | Glycolic acid          |      | 25   | 3.83            |
| C <sub>2</sub> H <sub>5</sub> N                              | Ethyleneimine          |      | 25   | 8.04            |

| Mol. form.                                                  | Name                            | Step | t/°C | pK <sub>a</sub> |
|-------------------------------------------------------------|---------------------------------|------|------|-----------------|
| C <sub>2</sub> H <sub>5</sub> NO                            | Acetamide                       |      | 25   | 15.1            |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>               | Acetohydroxamic acid            |      |      | 8.70            |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>               | Nitroethane                     |      | 25   | 8.46            |
| C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>               | Glycine                         | 1    | 25   | 2.35            |
|                                                             |                                 | 2    | 25   | 9.78            |
| C <sub>2</sub> H <sub>5</sub> N <sub>2</sub>                | Ethanimidamide                  |      | 25   | 12.1            |
| C <sub>2</sub> H <sub>6</sub> O                             | Ethanol                         |      | 25   | 15.5            |
| C <sub>2</sub> H <sub>6</sub> OS                            | 2-Mercaptoethanol               |      | 25   | 9.72            |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>                | Ethyleneglycol                  |      | 25   | 15.1            |
| C <sub>2</sub> H <sub>7</sub> AsO <sub>2</sub>              | Dimethylarsinic acid            | 1    | 25   | 1.57            |
|                                                             |                                 | 2    | 25   | 6.27            |
| C <sub>2</sub> H <sub>7</sub> N                             | Ethylamine                      |      | 25   | 10.65           |
| C <sub>2</sub> H <sub>7</sub> N                             | Dimethylamine                   |      | 25   | 10.73           |
| C <sub>2</sub> H <sub>7</sub> NO                            | Ethanolamine                    |      | 25   | 9.50            |
| C <sub>2</sub> H <sub>7</sub> NO <sub>3</sub> S             | 2-Aminoethanesulfonic acid      | 1    | 25   | 1.5             |
|                                                             |                                 | 2    | 25   | 9.06            |
| C <sub>2</sub> H <sub>7</sub> NS                            | Cysteamine                      | 1    | 25   | 8.27            |
|                                                             |                                 | 2    | 25   | 10.53           |
| C <sub>2</sub> H <sub>7</sub> N <sub>5</sub>                | Biguanide                       | 1    |      | 11.52           |
|                                                             |                                 | 2    |      | 2.93            |
| C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                | 1,2-Ethanediamine               | 1    | 25   | 9.92            |
|                                                             |                                 | 2    | 25   | 6.86            |
| C <sub>2</sub> H <sub>8</sub> O <sub>7</sub> P <sub>2</sub> | 1-Hydroxy-1,1-diphosphonoethane | 1    |      | 1.35            |
|                                                             |                                 | 2    |      | 2.87            |
|                                                             |                                 | 3    |      | 7.03            |
|                                                             |                                 | 4    |      | 11.3            |
| C <sub>3</sub> H <sub>5</sub> O <sub>2</sub>                | 2-Propynoic acid                |      | 25   | 1.84            |
| C <sub>3</sub> H <sub>5</sub> NO                            | Oxazole                         |      | 33   | 0.8             |
| C <sub>3</sub> H <sub>5</sub> NO                            | Isoxazole                       |      | 25   | -2.0            |
| C <sub>3</sub> H <sub>5</sub> NO <sub>2</sub>               | Cyanoacetic acid                |      | 25   | 2.47            |
| C <sub>3</sub> H <sub>5</sub> NS                            | Thiazole                        |      | 25   | 2.52            |
| C <sub>3</sub> H <sub>5</sub> N <sub>3</sub> O <sub>3</sub> | Cyanuric acid                   | 1    |      | 6.88            |
|                                                             |                                 | 2    |      | 11.40           |
|                                                             |                                 | 3    |      | 13.5            |
| C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>                | 1H-Pyrazole                     |      | 25   | 2.49            |
| C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>                | Imidazole                       |      | 25   | 6.99            |

| Mol. form.                                                  | Name                             | Step | t/°C | pK <sub>a</sub> | Mol. form.                                                                 | Name                                     | Step | t/°C | pK <sub>a</sub> |
|-------------------------------------------------------------|----------------------------------|------|------|-----------------|----------------------------------------------------------------------------|------------------------------------------|------|------|-----------------|
| C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> S              | 2-Thiazolamine                   |      | 20   | 5.36            | C <sub>4</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub>                | 5-Nitropyrimidinamine                    |      | 20   | 0.35            |
| C <sub>3</sub> H <sub>4</sub> O                             | Propargyl alcohol                |      | 25   | 13.6            | C <sub>4</sub> H <sub>4</sub> O <sub>2</sub>                               | 2-Butynoic acid                          |      | 25   | 2.62            |
| C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                | Acrylic acid                     |      | 25   | 4.25            | C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                               | Maleic acid                              | 1    | 25   | 1.92            |
| C <sub>3</sub> H <sub>4</sub> O <sub>3</sub>                | Pyruvic acid                     |      | 25   | 2.39            |                                                                            |                                          | 2    | 25   | 6.23            |
| C <sub>3</sub> H <sub>4</sub> O <sub>4</sub>                | Malonic acid                     | 1    | 25   | 2.85            | C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                               | Fumaric acid                             | 1    | 25   | 3.02            |
|                                                             |                                  | 2    | 25   | 5.70            |                                                                            |                                          | 2    | 25   | 4.38            |
| C <sub>3</sub> H <sub>4</sub> O <sub>5</sub>                | Hydroxypropanedioic acid         | 1    |      | 2.42            | C <sub>4</sub> H <sub>4</sub> O <sub>5</sub>                               | Oxaloacetic acid                         | 1    | 25   | 2.55            |
|                                                             |                                  | 2    |      | 4.54            |                                                                            |                                          | 2    | 25   | 4.37            |
| C <sub>3</sub> H <sub>5</sub> BrO <sub>2</sub>              | 3-Bromopropanoic acid            |      | 25   | 4.00            |                                                                            |                                          | 3    | 25   | 13.03           |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>              | 2-Chloropropanoic acid           |      | 25   | 2.83            | C <sub>4</sub> H <sub>5</sub> N                                            | Pyrrole                                  |      | 25   | -3.8            |
| C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>              | 3-Chloropropanoic acid           |      | 25   | 3.98            | C <sub>4</sub> H <sub>5</sub> NO <sub>2</sub>                              | Succinimide                              |      | 25   | 9.62            |
| C <sub>3</sub> H <sub>6</sub> N <sub>2</sub>                | 3-Aminopropanenitrile            |      | 20   | 7.80            | C <sub>4</sub> H <sub>5</sub> N <sub>3</sub>                               | 2-Pyrimidinamine                         |      | 20   | 3.45            |
| C <sub>3</sub> H <sub>6</sub> N <sub>6</sub>                | 1,3,5-Triazine-2,4,6-triamine    |      | 25   | 5.00            | C <sub>4</sub> H <sub>5</sub> N <sub>3</sub>                               | 4-Pyrimidinamine                         |      | 20   | 5.71            |
|                                                             |                                  |      |      |                 | C <sub>4</sub> H <sub>5</sub> N <sub>3</sub> O                             | Cytosine                                 | 1    |      | 4.60            |
| C <sub>3</sub> H <sub>6</sub> O                             | Allyl alcohol                    |      | 25   | 15.5            |                                                                            |                                          | 2    |      | 12.16           |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                | Propanoic acid                   |      | 25   | 4.87            | C <sub>4</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>                | 6-Methyl-1,2,4-triazine-3,5(2H,4H)-dione |      |      | 7.6             |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> S              | (Methylthio)acetic acid          |      | 25   | 3.66            |                                                                            |                                          |      |      |                 |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                | Lactic acid                      |      | 25   | 3.86            | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>                               | 1-Methylimidazol                         |      | 25   | 6.95            |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                | 3-Hydroxypropanoic acid          |      | 25   | 4.51            | C <sub>4</sub> H <sub>6</sub> N <sub>4</sub> O <sub>3</sub>                | Allantoin                                |      | 25   | 8.96            |
| C <sub>3</sub> H <sub>6</sub> O <sub>4</sub>                | Glyceric acid                    |      | 25   | 3.52            | C <sub>4</sub> H <sub>6</sub> N <sub>4</sub> O <sub>3</sub> S <sub>2</sub> | Acetazolamide                            |      |      | 7.2             |
| C <sub>3</sub> H <sub>7</sub> N                             | Allylamine                       |      | 25   | 9.49            | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                               | <i>trans</i> -Crotonic acid              |      | 25   | 4.69            |
| C <sub>3</sub> H <sub>7</sub> N                             | Azetidine                        |      | 25   | 11.29           | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                               | 3-Butenoic acid                          |      | 25   | 4.34            |
| C <sub>3</sub> H <sub>7</sub> NO                            | 2-Propanone oxime                |      | 25   | 12.42           | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                               | Cyclopropanecarboxylic acid              |      | 25   | 4.83            |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | <i>L</i> -Alanine                | 1    | 25   | 2.34            | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                               | 2-Oxobutanoic acid                       |      | 25   | 2.50            |
|                                                             |                                  | 2    | 25   | 9.87            | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                               | Acetoacetic acid                         |      | 25   | 3.6             |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | $\beta$ -Alanine                 | 1    | 25   | 3.55            | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                               | Succinic acid                            | 1    | 25   | 4.21            |
|                                                             |                                  | 2    | 25   | 10.24           |                                                                            |                                          | 2    | 25   | 5.64            |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>               | Sarcosine                        | 1    | 25   | 2.21            | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                               | Methylmalonic acid                       | 1    | 25   | 3.07            |
|                                                             |                                  | 2    | 25   | 10.1            |                                                                            |                                          | 2    | 25   | 5.76            |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub> S             | <i>L</i> -Cysteine               | 1    | 25   | 1.5             | C <sub>4</sub> H <sub>6</sub> O <sub>5</sub>                               | Malic acid                               | 1    | 25   | 3.40            |
|                                                             |                                  | 2    | 25   | 8.7             |                                                                            |                                          | 2    | 25   | 5.11            |
|                                                             |                                  | 3    | 25   | 10.2            | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                               | <i>DL</i> -Tartaric acid                 | 1    | 25   | 3.03            |
| C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>               | <i>L</i> -Serine                 | 1    | 25   | 2.19            |                                                                            |                                          | 2    | 25   | 4.37            |
|                                                             |                                  | 2    | 25   | 9.21            | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                               | <i>meso</i> -Tartaric acid               | 1    | 25   | 3.17            |
| C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub> S             | <i>DL</i> -Cysteic acid          | 1    | 25   | 1.3             |                                                                            |                                          | 2    | 25   | 4.91            |
|                                                             |                                  | 2    | 25   | 1.9             | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                               | <i>L</i> -Tartaric acid                  | 1    | 25   | 2.98            |
|                                                             |                                  | 3    | 25   | 8.70            |                                                                            |                                          | 2    | 25   | 4.34            |
| C <sub>3</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub> | Glycocyanine                     |      | 25   | 2.82            | C <sub>4</sub> H <sub>6</sub> O <sub>8</sub>                               | Dihydroxytartaric acid                   |      | 25   | 1.92            |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                | Ethylene glycol monomethyl ether |      | 25   | 14.8            | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>                             | 2-Chlorobutanoic acid                    |      |      | 2.86            |
| C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>                | Glycerol                         |      | 25   | 14.15           | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>                             | 3-Chlorobutanoic acid                    |      |      | 4.05            |
| C <sub>3</sub> H <sub>9</sub> N                             | Propylamine                      |      | 25   | 10.54           | C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>                             | 4-Chlorobutanoic acid                    |      |      | 4.52            |
| C <sub>3</sub> H <sub>9</sub> N                             | Isopropylamine                   |      | 25   | 10.63           | C <sub>4</sub> H <sub>7</sub> NO <sub>2</sub>                              | 4-Cyanobutanoic acid                     |      | 25   | 2.42            |
| C <sub>3</sub> H <sub>9</sub> N                             | Trimethylamine                   |      | 25   | 9.80            | C <sub>4</sub> H <sub>7</sub> NO <sub>3</sub>                              | <i>N</i> -Acetyl glycine                 |      | 25   | 3.67            |
| C <sub>3</sub> H <sub>9</sub> NO                            | 2-Methoxyethylamine              |      | 25   | 9.40            | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>                              | Iminodiacetic acid                       | 1    |      | 2.98            |
| C <sub>3</sub> H <sub>9</sub> NO                            | Trimethylamine oxide             |      | 20   | 4.65            |                                                                            |                                          | 2    |      | 9.89            |
| C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>               | 1,2-Propanediamine, ( $\pm$ )    | 1    | 25   | 9.82            | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>                              | <i>L</i> -Aspartic acid                  | 1    | 25   | 1.99            |
|                                                             |                                  | 2    | 25   | 6.61            |                                                                            |                                          | 2    | 25   | 3.90            |
| C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>               | 1,3-Propanediamine               | 1    | 25   | 10.55           |                                                                            |                                          | 3    | 25   | 9.90            |
|                                                             |                                  | 2    | 25   | 8.88            | C <sub>4</sub> H <sub>7</sub> N <sub>3</sub> O                             | Creatinine                               | 1    | 25   | 4.8             |
| C <sub>3</sub> H <sub>10</sub> N <sub>2</sub> O             | 1,3-Diamino-2-propanol           | 1    | 20   | 9.69            |                                                                            |                                          | 2    |      | 9.2             |
|                                                             |                                  | 2    | 20   | 7.93            | C <sub>4</sub> H <sub>7</sub> N <sub>5</sub>                               | 2,4,6-Pyrimidinetriamine                 |      | 20   | 6.84            |
| C <sub>3</sub> H <sub>11</sub> N <sub>3</sub>               | 1,2,3-Triaminopropane            | 1    | 20   | 9.59            | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>                | <i>L</i> -Asparagine                     | 1    | 20   | 2.1             |
|                                                             |                                  | 2    | 20   | 7.95            |                                                                            |                                          | 2    | 20   | 8.80            |
| C <sub>4</sub> H <sub>4</sub> FN <sub>3</sub> O             | Flucytosine                      |      |      | 3.26            | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>                | <i>N</i> -Glycylglycine                  | 1    | 25   | 3.14            |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                | Pyrazine                         |      | 20   | 0.65            |                                                                            |                                          | 2    |      | 8.17            |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                | Pyrimidine                       |      | 20   | 1.23            | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                               | Butanoic acid                            |      | 25   | 4.83            |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                | Pyridazine                       |      | 20   | 2.24            | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                               | 2-Methylpropanoic acid                   |      | 20   | 4.84            |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> | Uracil                           |      | 25   | 9.45            | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                               | 3-Hydroxybutanoic acid, ( $\pm$ )        |      | 25   | 4.70            |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>3</sub> | Barbituric acid                  |      | 25   | 4.01            | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                               | 4-Hydroxybutanoic acid                   |      | 25   | 4.72            |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub> | Alloxanic acid                   |      | 25   | 6.64            | C <sub>4</sub> H <sub>8</sub> O <sub>3</sub>                               | Ethoxyacetic acid                        |      | 18   | 3.65            |
|                                                             |                                  |      |      |                 | C <sub>4</sub> H <sub>9</sub> N                                            | Pyrrolidine                              |      | 25   | 11.31           |

| Mol. form.                                                   | Name                                    | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> | Mol. form.                                                                 | Name                                          | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> |
|--------------------------------------------------------------|-----------------------------------------|------|--------------|-------------------------|----------------------------------------------------------------------------|-----------------------------------------------|------|--------------|-------------------------|
| C <sub>4</sub> H <sub>9</sub> NO                             | Morpholine                              |      | 25           | 8.50                    | C <sub>5</sub> H <sub>5</sub> NO <sub>2</sub>                              | 1 <i>H</i> -Pyrrole-3-carboxylic acid         |      | 20           | 5.00                    |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 2-Methylalanine                         | 1    | 25           | 2.36                    | C <sub>5</sub> H <sub>5</sub> N <sub>3</sub> O                             | Pyrazinecarboxamide                           |      |              | 0.5                     |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | <i>N,N</i> -Dimethylglycine             |      | 25           | 9.89                    | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub>                               | Adenine                                       | 1    |              | 4.3                     |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | <i>DL</i> -2-Aminobutanoic acid         | 1    | 25           | 2.29                    |                                                                            |                                               | 2    |              | 9.83                    |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                | 4-Aminobutanoic acid                    | 2    | 25           | 9.83                    | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub> O                             | Guanine                                       |      | 40           | 9.92                    |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub> S              | <i>DL</i> -Homocysteine                 | 1    | 25           | 4.031                   | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                               | 2-Pyridinamine                                |      | 20           | 6.82                    |
|                                                              |                                         | 2    | 25           | 10.556                  | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                               | 3-Pyridinamine                                |      | 25           | 6.04                    |
|                                                              |                                         | 3    | 25           | 10.86                   | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                               | 4-Pyridinamine                                |      | 25           | 9.11                    |
| C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | <i>L</i> -Threonine                     | 1    | 25           | 2.09                    | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                | 2-Methylpyrazine                              |      | 27           | 1.45                    |
| C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                | <i>L</i> -Homoserine                    | 2    | 25           | 9.10                    | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>                | Thymine                                       |      | 25           | 9.94                    |
| C <sub>4</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>  | Creatine                                | 1    | 25           | 2.71                    | C <sub>5</sub> H <sub>6</sub> O <sub>4</sub>                               | 1,1-Cyclopropanedi-carboxylic acid            | 1    | 25           | 1.82                    |
| C <sub>4</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>  |                                         | 2    | 25           | 9.62                    | C <sub>5</sub> H <sub>6</sub> O <sub>4</sub>                               | <i>trans</i> -1-Propene-1,2-dicarboxylic acid | 2    | 25           | 7.43                    |
| C <sub>4</sub> H <sub>10</sub> N <sub>2</sub>                | Piperazine                              | 1    | 25           | 2.63                    | C <sub>5</sub> H <sub>6</sub> O <sub>4</sub>                               | 1-Propene-2,3-dicarboxylic acid               | 1    | 25           | 3.09                    |
| C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | 2,4-Diaminobutanoic acid                | 2    | 25           | 14.3                    | C <sub>5</sub> H <sub>6</sub> O <sub>5</sub>                               | 2-Oxoglutaric acid                            | 2    | 25           | 4.75                    |
|                                                              |                                         | 1    | 25           | 9.73                    |                                                                            |                                               | 1    | 25           | 3.85                    |
|                                                              |                                         | 2    | 25           | 5.33                    |                                                                            |                                               | 2    | 25           | 5.45                    |
|                                                              |                                         | 3    | 25           | 10.44                   | C <sub>5</sub> H <sub>7</sub> NO <sub>3</sub>                              | 5,5-Dimethyl-2,4-oxazolidinedione             | 1    | 25           | 2.47                    |
| C <sub>4</sub> H <sub>10</sub> O <sub>4</sub>                | 1,2,3,4-Butanetetrol                    |      |              | 13.9                    |                                                                            |                                               | 2    | 25           | 4.68                    |
| C <sub>4</sub> H <sub>11</sub> N                             | Butylamine                              |      | 25           | 10.60                   | C <sub>5</sub> H <sub>7</sub> NO <sub>3</sub>                              | <i>L</i> -Pyroglutamic acid                   |      | 37           | 6.13                    |
| C <sub>4</sub> H <sub>11</sub> N                             | <i>sec</i> -Butylamine                  |      | 25           | 10.56                   | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub>                               | 2,5-Pyridinediamine                           |      | 25           | 3.32                    |
| C <sub>4</sub> H <sub>11</sub> N                             | <i>tert</i> -Butylamine                 |      | 25           | 10.68                   | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub>                               | Methylaminopyrazine                           |      | 20           | 6.48                    |
| C <sub>4</sub> H <sub>11</sub> N                             | Diethylamine                            |      | 25           | 10.84                   | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub> O <sub>4</sub>                | Azaserine                                     |      | 25           | 3.39                    |
| C <sub>4</sub> H <sub>11</sub> NO <sub>3</sub>               | Tris(hydroxymethyl)methylamine          |      | 20           | 8.3                     | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub>                               | 2,4-Dimethylimidazole                         |      | 25           | 8.55                    |
| C <sub>4</sub> H <sub>12</sub> N <sub>2</sub>                | 1,4-Butanediamine                       | 1    | 25           | 10.80                   | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub> S <sub>2</sub> | Methazolamide                                 |      |              | 8.36                    |
|                                                              |                                         | 2    | 25           | 9.63                    | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                               | <i>trans</i> -3-Pentenoic acid                |      | 25           | 7.30                    |
| C <sub>5</sub> H <sub>4</sub> BrN                            | 3-Bromopyridine                         |      | 25           | 2.84                    | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                               | Dimethylmalonic acid                          |      | 25           | 4.51                    |
| C <sub>5</sub> H <sub>4</sub> ClN                            | 2-Chloropyridine                        |      | 25           | 0.49                    | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                               | Glutaric acid                                 |      | 25           | 3.15                    |
| C <sub>5</sub> H <sub>4</sub> ClN                            | 3-Chloropyridine                        |      | 25           | 2.81                    |                                                                            |                                               | 1    | 18           | 4.32                    |
| C <sub>5</sub> H <sub>4</sub> ClN                            | 4-Chloropyridine                        |      | 25           | 3.83                    |                                                                            |                                               | 2    | 25           | 5.42                    |
| C <sub>5</sub> H <sub>4</sub> FN                             | 2-Fluoropyridine                        |      | 25           | -0.44                   | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                               | Methylsuccinic acid                           | 1    | 25           | 4.13                    |
| C <sub>5</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>  | 4-Nitropyridine                         |      | 25           | 1.61                    |                                                                            |                                               | 2    | 25           | 5.64                    |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub>                 | 1 <i>H</i> -Purine                      | 1    | 20           | 2.30                    | C <sub>5</sub> H <sub>9</sub> NO <sub>2</sub>                              | <i>L</i> -Proline                             | 1    | 25           | 1.95                    |
|                                                              |                                         | 2    | 20           | 8.96                    |                                                                            |                                               | 2    | 25           | 10.64                   |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O               | Hypoxanthine                            |      | 25           | 8.7                     | C <sub>5</sub> H <sub>9</sub> NO <sub>3</sub>                              | 5-Amino-4-oxopentanoic acid                   | 1    | 25           | 4.05                    |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O               | Allopurinol                             |      |              | 10.2                    |                                                                            |                                               | 2    | 25           | 8.90                    |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>3</sub>  | Uric acid                               |      | 12           | 3.89                    | C <sub>5</sub> H <sub>9</sub> NO <sub>3</sub>                              | <i>trans</i> -4-Hydroxyproline                | 1    | 25           | 1.82                    |
| C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> S               | 1,7-Dihydro-6 <i>H</i> -purine-6-thione | 1    |              | 7.77                    |                                                                            |                                               | 2    | 25           | 9.66                    |
|                                                              |                                         | 2    |              | 11.17                   | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                              | <i>L</i> -Glutamic acid                       | 1    | 25           | 2.13                    |
| C <sub>5</sub> H <sub>4</sub> O <sub>2</sub> S               | 2-Thiophenecarboxylic acid              |      | 25           | 3.49                    |                                                                            |                                               | 2    | 25           | 4.31                    |
| C <sub>5</sub> H <sub>4</sub> O <sub>2</sub> S               | 3-Thiophenecarboxylic acid              |      | 25           | 4.1                     |                                                                            |                                               | 3    |              | 9.67                    |
| C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                 | 2-Furancarboxylic acid                  |      | 25           | 3.16                    | C <sub>5</sub> H <sub>9</sub> N <sub>3</sub>                               | Histamine                                     | 1    | 25           | 6.04                    |
| C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                 | 3-Furancarboxylic acid                  |      | 25           | 3.9                     |                                                                            |                                               | 2    | 25           | 9.75                    |
| C <sub>5</sub> H <sub>5</sub> N                              | Pyridine                                |      | 25           | 5.23                    | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>               | Glycylalanine                                 |      | 25           | 3.15                    |
| C <sub>5</sub> H <sub>5</sub> NO                             | 2-Pyridinol                             | 1    | 20           | 0.75                    | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>               | <i>L</i> -Glutamine                           | 1    | 25           | 2.17                    |
|                                                              |                                         | 2    | 20           | 11.65                   |                                                                            |                                               | 2    | 25           | 9.13                    |
| C <sub>5</sub> H <sub>5</sub> NO                             | 3-Pyridinol                             | 1    | 20           | 4.79                    | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub>               | Glycylserine                                  | 1    | 25           | 2.98                    |
|                                                              |                                         | 2    | 20           | 8.75                    |                                                                            |                                               | 2    | 25           | 8.38                    |
| C <sub>5</sub> H <sub>5</sub> NO                             | 4-Pyridinol                             | 1    | 20           | 3.20                    | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                              | Pentanoic acid                                |      | 20           | 4.83                    |
|                                                              |                                         | 2    | 20           | 11.12                   | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                              | 2-Methylbutanoic acid                         |      | 25           | 4.80                    |
| C <sub>5</sub> H <sub>5</sub> NO                             | 2(1 <i>H</i> )-Pyridinone               | 1    | 20           | 0.75                    | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                              | 3-Methylbutanoic acid                         |      | 25           | 4.77                    |
|                                                              |                                         | 2    | 20           | 11.65                   | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                              | 2,2-Dimethylpropanoic acid                    |      | 20           | 5.03                    |
| C <sub>5</sub> H <sub>5</sub> NO                             | Pyridine-1-oxide                        |      | 24           | 0.79                    | C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>                              | <i>D</i> -2-Deoxyribose                       |      | 25           | 12.61                   |
| C <sub>5</sub> H <sub>5</sub> NO <sub>2</sub>                | 1 <i>H</i> -Pyrrole-2-carboxylic acid   |      | 20           | 4.45                    | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                              | <i>L</i> -Ribose                              |      | 25           | 12.22                   |
|                                                              |                                         |      |              |                         | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                              | <i>D</i> -Xylose                              |      | 18           | 12.14                   |
|                                                              |                                         |      |              |                         | C <sub>5</sub> H <sub>11</sub> N                                           | Piperidine                                    |      | 25           | 11.123                  |
|                                                              |                                         |      |              |                         | C <sub>5</sub> H <sub>11</sub> N                                           | <i>N</i> -Methylpyrrolidine                   |      | 25           | 10.46                   |
|                                                              |                                         |      |              |                         | C <sub>5</sub> H <sub>11</sub> NO                                          | 4-Methylmorpholine                            |      | 25           | 7.38                    |
|                                                              |                                         |      |              |                         | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                             | <i>L</i> -Valine                              | 1    | 25           | 2.29                    |
|                                                              |                                         |      |              |                         |                                                                            |                                               | 2    | 25           | 9.74                    |



| Mol. form.                                                                  | Name                                                  | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> | Mol. form.                                                  | Name                                                 | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> |
|-----------------------------------------------------------------------------|-------------------------------------------------------|------|--------------|-------------------------|-------------------------------------------------------------|------------------------------------------------------|------|--------------|-------------------------|
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                              | <i>DL</i> -Norvaline                                  | 1    |              | 2.36                    |                                                             |                                                      | 3    | 20           | 9.31                    |
|                                                                             |                                                       | 2    |              | 9.72                    | C <sub>6</sub> H <sub>6</sub> BrN                           | 2-Bromoaniline                                       |      | 25           | 2.53                    |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                              | <i>L</i> -Norvaline                                   | 1    | 25           | 2.32                    | C <sub>6</sub> H <sub>6</sub> BrN                           | 3-Bromoaniline                                       |      | 25           | 3.53                    |
|                                                                             |                                                       | 2    | 25           | 9.81                    | C <sub>6</sub> H <sub>6</sub> BrN                           | 4-Bromoaniline                                       |      | 25           | 3.89                    |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                              | <i>N</i> -Propylglycine                               | 1    | 25           | 2.35                    | C <sub>6</sub> H <sub>6</sub> ClN                           | 2-Chloroaniline                                      |      | 25           | 2.66                    |
|                                                                             |                                                       | 2    | 25           | 10.19                   | C <sub>6</sub> H <sub>6</sub> ClN                           | 3-Chloroaniline                                      |      | 25           | 3.52                    |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                              | 5-Aminopentanoic acid                                 | 1    | 25           | 4.27                    | C <sub>6</sub> H <sub>6</sub> ClN                           | 4-Chloroaniline                                      |      | 25           | 3.98                    |
|                                                                             |                                                       | 2    | 25           | 10.77                   | C <sub>6</sub> H <sub>6</sub> FN                            | 2-Fluoroaniline                                      |      | 25           | 3.20                    |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                              | Betaine                                               |      | 0            | 1.83                    | C <sub>6</sub> H <sub>6</sub> FN                            | 3-Fluoroaniline                                      |      | 25           | 3.59                    |
| C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub> S                            | <i>L</i> -Methionine                                  | 1    | 25           | 2.13                    | C <sub>6</sub> H <sub>6</sub> FN                            | 4-Fluoroaniline                                      |      | 25           | 4.65                    |
|                                                                             |                                                       | 2    | 25           | 9.27                    | C <sub>6</sub> H <sub>6</sub> IN                            | 2-Iodoaniline                                        |      | 25           | 2.54                    |
| C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O                             | Tetramethylurea                                       |      |              | 2                       | C <sub>6</sub> H <sub>6</sub> IN                            | 3-Iodoaniline                                        |      | 25           | 3.58                    |
| C <sub>5</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                | <i>L</i> -Ornithine                                   | 1    | 25           | 1.71                    | C <sub>6</sub> H <sub>6</sub> IN                            | 4-Iodoaniline                                        |      | 25           | 3.81                    |
|                                                                             |                                                       | 2    | 25           | 8.69                    | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O              | 3-Pyridinecarboxamide                                |      | 20           | 3.3                     |
|                                                                             |                                                       | 3    | 25           | 10.76                   | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O              | 2-Pyridinecarbox-<br>aldehyde oxime                  | 1    | 20           | 3.59                    |
| C <sub>5</sub> H <sub>13</sub> N                                            | Pentylamine                                           |      | 25           | 10.63                   |                                                             |                                                      | 2    | 20           | 10.18                   |
| C <sub>5</sub> H <sub>13</sub> N                                            | 3-Pentanamine                                         |      | 17           | 10.59                   | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | 2-Nitroaniline                                       |      | 25           | -0.25                   |
| C <sub>5</sub> H <sub>13</sub> N                                            | 3-Methyl-1-butanamine                                 |      | 25           | 10.60                   | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | 3-Nitroaniline                                       |      | 25           | 2.46                    |
| C <sub>5</sub> H <sub>13</sub> N                                            | 2-Methyl-2-butanamine                                 |      | 19           | 10.85                   | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub> | 4-Nitroaniline                                       |      | 25           | 1.02                    |
| C <sub>5</sub> H <sub>13</sub> N                                            | 2,2-Dimethylpropylamine                               |      | 25           | 10.15                   | C <sub>6</sub> H <sub>6</sub> O                             | Phenol                                               |      | 25           | 9.99                    |
| C <sub>5</sub> H <sub>13</sub> N                                            | Diethylmethylamine                                    |      | 25           | 10.35                   | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                | <i>p</i> -Hydroquinone                               | 1    | 25           | 9.85                    |
| C <sub>5</sub> H <sub>14</sub> NO                                           | Choline                                               |      | 25           | 13.9                    |                                                             |                                                      | 2    | 25           | 11.4                    |
| C <sub>5</sub> H <sub>14</sub> N <sub>2</sub>                               | 1,5-Pentanediamine                                    | 1    | 25           | 10.05                   | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                | Pyrocatechol                                         | 1    | 25           | 9.34                    |
|                                                                             |                                                       | 2    | 25           | 10.93                   |                                                             |                                                      | 2    | 25           | 12.6                    |
| C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> N <sub>2</sub> O <sub>2</sub> | 4-Amino-3,5,6-trichloro-<br>2-pyridinecarboxylic acid |      |              | 3.6                     | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                | Resorcinol                                           | 1    | 25           | 9.32                    |
|                                                                             |                                                       |      |              |                         |                                                             |                                                      | 2    | 25           | 11.1                    |
| C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>7</sub>                 | 2,4,6-Trinitrophenol                                  |      | 24           | 0.42                    | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub> S              | Benzenesulfinic acid                                 |      | 20           | 1.3                     |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 2,3-Dichlorophenol                                    |      | 25           | 7.44                    | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub> S              | Benzenesulfonic acid                                 |      | 25           | 0.70                    |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                 | 2,4-Dinitrophenol                                     |      | 25           | 4.07                    | C <sub>6</sub> H <sub>6</sub> O <sub>4</sub>                | 5-Hydroxy-2-(hydroxy-<br>methyl)-4H-pyran-4-one      |      |              | 7.9                     |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>                 | 2,5-Dinitrophenol                                     |      | 15           | 5.15                    |                                                             |                                                      |      |              |                         |
| C <sub>6</sub> H <sub>4</sub> N <sub>4</sub>                                | Pteridine                                             |      | 20           | 4.05                    | C <sub>6</sub> H <sub>6</sub> O <sub>4</sub> S              | 3-Hydroxybenzene-<br>sulfonic acid                   |      | 25           | 9.07                    |
| C <sub>6</sub> H <sub>5</sub> BrO                                           | 2-Bromophenol                                         |      | 25           | 8.45                    | C <sub>6</sub> H <sub>6</sub> O <sub>4</sub> S              | 4-Hydroxybenzene-<br>sulfonic acid                   |      | 25           | 9.11                    |
| C <sub>6</sub> H <sub>5</sub> BrO                                           | 3-Bromophenol                                         |      | 25           | 9.03                    |                                                             |                                                      |      |              |                         |
| C <sub>6</sub> H <sub>5</sub> BrO                                           | 4-Bromophenol                                         |      | 25           | 9.37                    | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                | <i>cis</i> -1-Propene-1,2,3-<br>tricarboxylic acid   |      | 25           | 1.95                    |
| C <sub>6</sub> H <sub>5</sub> Br <sub>2</sub> N                             | 3,5-Dibromoaniline                                    |      | 25           | 2.34                    |                                                             |                                                      |      |              |                         |
| C <sub>6</sub> H <sub>5</sub> ClO                                           | 2-Chlorophenol                                        |      | 25           | 8.56                    | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                | <i>trans</i> -1-Propene-1,2,3-<br>tricarboxylic acid | 1    | 25           | 2.80                    |
| C <sub>6</sub> H <sub>5</sub> ClO                                           | 3-Chlorophenol                                        |      | 25           | 9.12                    |                                                             |                                                      | 2    | 25           | 4.46                    |
| C <sub>6</sub> H <sub>5</sub> ClO                                           | 4-Chlorophenol                                        |      | 25           | 9.41                    | C <sub>6</sub> H <sub>6</sub> S                             | Benzenethiol                                         |      | 25           | 6.62                    |
| C <sub>6</sub> H <sub>5</sub> Cl <sub>2</sub> N                             | 2,4-Dichloroaniline                                   |      | 22           | 2.05                    | C <sub>6</sub> H <sub>7</sub> BO <sub>2</sub>               | Benzeneboronic acid                                  |      |              | 8.83                    |
| C <sub>6</sub> H <sub>5</sub> FO                                            | 2-Fluorophenol                                        |      | 25           | 8.73                    | C <sub>6</sub> H <sub>7</sub> N                             | Aniline                                              |      | 25           | 4.87                    |
| C <sub>6</sub> H <sub>5</sub> FO                                            | 3-Fluorophenol                                        |      | 25           | 9.29                    | C <sub>6</sub> H <sub>7</sub> N                             | 2-Methylpyridine                                     |      | 25           | 6.00                    |
| C <sub>6</sub> H <sub>5</sub> FO                                            | 4-Fluorophenol                                        |      | 25           | 9.89                    | C <sub>6</sub> H <sub>7</sub> N                             | 3-Methylpyridine                                     |      | 25           | 5.70                    |
| C <sub>6</sub> H <sub>5</sub> IO                                            | 2-Iodophenol                                          |      | 25           | 8.51                    | C <sub>6</sub> H <sub>7</sub> N                             | 4-Methylpyridine                                     |      | 25           | 5.99                    |
| C <sub>6</sub> H <sub>5</sub> IO                                            | 3-Iodophenol                                          |      | 25           | 9.03                    | C <sub>6</sub> H <sub>7</sub> NO                            | 2-Aminophenol                                        | 1    | 20           | 4.78                    |
| C <sub>6</sub> H <sub>5</sub> IO                                            | 4-Iodophenol                                          |      | 25           | 9.33                    |                                                             |                                                      | 2    | 20           | 9.97                    |
| C <sub>6</sub> H <sub>5</sub> NO                                            | 2-Pyridinecarboxaldehyde                              |      | 25           | 12.68                   | C <sub>6</sub> H <sub>7</sub> NO                            | 3-Aminophenol                                        | 1    | 20           | 4.37                    |
| C <sub>6</sub> H <sub>5</sub> NO                                            | 4-Pyridinecarboxaldehyde                              |      | 30           | 12.05                   |                                                             |                                                      | 2    | 20           | 9.82                    |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                               | Nitrobenzene                                          |      | 0            | 3.98                    | C <sub>6</sub> H <sub>7</sub> NO                            | 4-Aminophenol                                        | 1    | 25           | 5.48                    |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                               | 2-Pyridinecarboxylic acid                             | 1    | 20           | 0.99                    |                                                             |                                                      | 2    | 25           | 10.30                   |
|                                                                             |                                                       | 2    | 20           | 5.39                    | C <sub>6</sub> H <sub>7</sub> NO                            | 2-Methoxypyridine                                    |      | 20           | 3.28                    |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                               | 3-Pyridinecarboxylic acid                             | 1    | 25           | 2.00                    | C <sub>6</sub> H <sub>7</sub> NO                            | 3-Methoxypyridine                                    |      | 25           | 4.78                    |
|                                                                             |                                                       | 2    | 25           | 4.82                    | C <sub>6</sub> H <sub>7</sub> NO                            | 4-Methoxypyridine                                    |      | 25           | 6.58                    |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                               | 4-Pyridinecarboxylic acid                             | 1    | 25           | 1.77                    | C <sub>6</sub> H <sub>7</sub> NO <sub>3</sub> S             | 2-Aminobenzenesulfonic<br>acid                       |      | 25           | 2.46                    |
|                                                                             |                                                       | 2    | 25           | 4.84                    |                                                             |                                                      |      |              |                         |
| C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                               | 2-Nitrophenol                                         |      | 25           | 7.23                    | C <sub>6</sub> H <sub>7</sub> NO <sub>3</sub> S             | 3-Aminobenzenesulfonic<br>acid                       |      | 25           | 3.74                    |
| C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                               | 3-Nitrophenol                                         |      | 25           | 8.36                    |                                                             |                                                      |      |              |                         |
| C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                               | 4-Nitrophenol                                         |      | 25           | 7.15                    | C <sub>6</sub> H <sub>7</sub> NO <sub>3</sub> S             | 4-Aminobenzenesulfonic<br>acid                       |      | 25           | 3.23                    |
| C <sub>6</sub> H <sub>5</sub> N <sub>3</sub>                                | 1 <i>H</i> -Benzotriazole                             |      | 20           | 1.6                     |                                                             |                                                      |      |              |                         |
| C <sub>6</sub> H <sub>5</sub> N <sub>5</sub> O                              | 2-Amino-4-<br>hydroxypteridine                        | 1    | 20           | 2.27                    | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                | <i>N</i> -Methylpyridinamine                         |      | 20           | 9.65                    |
|                                                                             |                                                       | 2    | 20           | 7.96                    | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                | <i>o</i> -Phenylenediamine                           | 1    | 20           | 4.57                    |
| C <sub>6</sub> H <sub>5</sub> N <sub>5</sub> O <sub>2</sub>                 | Xanthopterin                                          | 2    | 20           | 6.59                    |                                                             |                                                      |      |              |                         |

| Mol. form.                                                                  | Name                                       | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> | Mol. form.                                                    | Name                                            | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> |
|-----------------------------------------------------------------------------|--------------------------------------------|------|--------------|-------------------------|---------------------------------------------------------------|-------------------------------------------------|------|--------------|-------------------------|
|                                                                             |                                            | 2    | 20           | 0.80                    | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                | <i>L</i> -Leucine                               | 1    | 25           | 2.33                    |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                | <i>m</i> -Phenylenediamine                 | 1    | 20           | 5.11                    |                                                               |                                                 | 2    | 25           | 9.74                    |
|                                                                             |                                            | 2    | 20           | 2.50                    | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                | <i>L</i> -Isoleucine                            | 1    | 25           | 2.32                    |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                | <i>p</i> -Phenylenediamine                 | 1    | 20           | 6.31                    |                                                               |                                                 | 2    | 25           | 9.76                    |
|                                                                             |                                            | 2    | 20           | 2.97                    | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                | <i>L</i> -Norleucine                            | 1    | 25           | 2.34                    |
| C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                | Phenylhydrazine                            |      | 15           | 8.79                    |                                                               |                                                 | 2    | 25           | 9.83                    |
| C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                                | 2,4-Hexadienoic acid                       |      | 25           | 4.76                    | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                | 6-Aminohexanoic acid                            | 1    | 25           | 4.37                    |
| C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>                                | 1,3-Cyclohexanedione                       |      | 25           | 5.26                    |                                                               |                                                 | 2    | 25           | 10.80                   |
| C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                                | 2,2-Dimethyl-1,3-dioxane-4,6-dione         |      |              | 5.1                     | C <sub>6</sub> H <sub>13</sub> NO <sub>4</sub>                | <i>N,N</i> -Bis(2-hydroxyethyl)glycine          | 2    | 20           | 8.35                    |
| C <sub>6</sub> H <sub>8</sub> O <sub>6</sub>                                | <i>L</i> -Ascorbic acid                    | 1    | 25           | 4.04                    | C <sub>6</sub> H <sub>13</sub> N <sub>3</sub> O <sub>3</sub>  | Citrulline                                      | 1    | 25           | 2.43                    |
|                                                                             |                                            | 2    | 16           | 11.7                    |                                                               |                                                 | 2    | 25           | 9.69                    |
| C <sub>6</sub> H <sub>8</sub> O <sub>7</sub>                                | Citric acid                                | 1    | 25           | 3.13                    | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                 | <i>cis</i> -1,2-Cyclohexane-diamine             | 1    | 20           | 9.93                    |
|                                                                             |                                            | 2    | 25           | 4.76                    |                                                               |                                                 | 2    | 20           | 6.13                    |
|                                                                             |                                            | 3    | 25           | 6.40                    | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                 | <i>trans</i> -1,2-Cyclohexane-diamine           | 1    | 20           | 9.94                    |
| C <sub>6</sub> H <sub>8</sub> O <sub>7</sub>                                | Isocitric acid                             | 1    | 25           | 3.29                    |                                                               |                                                 | 2    | 20           | 6.47                    |
|                                                                             |                                            | 2    | 25           | 4.71                    | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub>                 | <i>cis</i> -2,5-Dimethylpiperazine              | 1    | 25           | 9.66                    |
|                                                                             |                                            | 3    | 25           | 6.40                    |                                                               |                                                 | 2    | 25           | 5.20                    |
| C <sub>6</sub> H <sub>9</sub> NO <sub>6</sub>                               | Nitrilotriacetic acid                      | 1    | 20           | 3.03                    | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>  | <i>L</i> -Lysine                                | 1    | 25           | 2.16                    |
|                                                                             |                                            | 2    | 20           | 3.07                    |                                                               |                                                 | 2    | 25           | 9.06                    |
|                                                                             |                                            | 3    | 20           | 10.70                   |                                                               |                                                 | 3    | 25           | 10.54                   |
| C <sub>6</sub> H <sub>9</sub> NO <sub>6</sub>                               | <i>L</i> -γ-Carboxyglutamic acid           | 1    | 25           | 1.7                     | C <sub>6</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub>  | <i>L</i> -Arginine                              | 1    | 25           | 1.82                    |
|                                                                             |                                            | 2    | 25           | 3.2                     |                                                               |                                                 | 2    | 25           | 8.99                    |
|                                                                             |                                            | 3    | 25           | 4.75                    |                                                               |                                                 | 3    | 25           | 12.5                    |
|                                                                             |                                            | 4    | 25           | 9.9                     | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                 | <i>D</i> -Mannitol                              |      | 18           | 13.5                    |
| C <sub>6</sub> H <sub>9</sub> N <sub>3</sub>                                | 4,6-Dimethylpyrimidinamine                 |      | 20           | 4.82                    | C <sub>6</sub> H <sub>15</sub> N                              | Hexylamine                                      |      | 25           | 10.56                   |
| C <sub>6</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                 | <i>L</i> -Histidine                        | 1    | 25           | 1.80                    | C <sub>6</sub> H <sub>15</sub> N                              | Diisopropylamine                                |      | 25           | 11.05                   |
|                                                                             |                                            | 2    | 25           | 6.04                    | C <sub>6</sub> H <sub>15</sub> N                              | Triethylamine                                   |      | 25           | 10.75                   |
|                                                                             |                                            | 3    | 25           | 9.33                    | C <sub>6</sub> H <sub>15</sub> NO <sub>3</sub>                | Triethanolamine                                 |      | 25           | 7.76                    |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                               | Cyclopentanecarboxylic acid                |      | 25           | 4.99                    | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                 | 1,6-Hexanediamine                               | 1    | 0            | 11.86                   |
|                                                                             |                                            |      |              |                         |                                                               |                                                 | 2    | 0            | 10.76                   |
| C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                               | Ethyl acetoacetate                         |      | 25           | 10.68                   | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                 | <i>N,N,N',N'</i> -Tetramethyl-1,2-ethanediamine | 1    | 25           | 10.40                   |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                               | 3-Methylglutaric acid                      |      | 25           | 4.24                    |                                                               |                                                 | 2    | 25           | 8.26                    |
| C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                               | Adipic acid                                | 1    | 18           | 4.41                    | C <sub>6</sub> H <sub>19</sub> NSi <sub>2</sub>               | Hexamethyldisilazane                            |      |              | 7.55                    |
|                                                                             |                                            | 2    | 18           | 5.41                    | C <sub>7</sub> HF <sub>5</sub> O <sub>2</sub>                 | Pentafluorobenzoic acid                         |      | 25           | 1.75                    |
| C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>                              | 2-Piperidinecarboxylic acid                | 1    | 25           | 2.28                    | C <sub>7</sub> H <sub>3</sub> Br <sub>2</sub> NO              | 3,5-Dibromo-4-hydroxybenzonitrile               |      |              | 4.06                    |
|                                                                             |                                            | 2    | 25           | 10.72                   |                                                               |                                                 |      |              |                         |
| C <sub>6</sub> H <sub>11</sub> NO <sub>3</sub>                              | Adipamic acid                              |      | 25           | 4.63                    | C <sub>7</sub> H <sub>3</sub> N <sub>3</sub> O <sub>8</sub>   | 2,4,6-Trinitrobenzoic acid                      |      | 25           | 0.65                    |
| C <sub>6</sub> H <sub>11</sub> NO <sub>4</sub>                              | 2-Amino adipic acid                        | 1    | 25           | 2.14                    | C <sub>7</sub> H <sub>4</sub> Cl <sub>3</sub> NO <sub>3</sub> | Triclopyr                                       |      |              | 2.68                    |
|                                                                             |                                            | 2    | 25           | 4.21                    | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>   | 2,4-Dinitrobenzoic acid                         |      | 25           | 1.43                    |
|                                                                             |                                            | 3    | 25           | 9.77                    | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>                | 2-Bromobenzoic acid                             |      | 25           | 2.85                    |
| C <sub>6</sub> H <sub>11</sub> N <sub>3</sub> O <sub>4</sub>                | <i>N</i> -( <i>N</i> -Glycylglycyl)glycine | 1    | 25           | 3.225                   | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>                | 3-Bromobenzoic acid                             |      | 25           | 3.81                    |
|                                                                             |                                            | 2    | 25           | 8.09                    | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>                | 4-Bromobenzoic acid                             |      | 25           | 3.96                    |
| C <sub>6</sub> H <sub>11</sub> N <sub>3</sub> O <sub>4</sub>                | Glycylasparagine                           | 1    | 25           | 2.942                   | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                | 2-Chlorobenzoic acid                            |      | 25           | 2.90                    |
|                                                                             |                                            | 2    | 18           | 8.44                    | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                | 3-Chlorobenzoic acid                            |      | 25           | 3.84                    |
| C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>                               | Triethylenediamine                         | 1    |              | 3.0                     | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                | 4-Chlorobenzoic acid                            |      | 25           | 4.00                    |
|                                                                             |                                            | 2    |              | 8.7                     | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                 | 2-Fluorobenzoic acid                            |      | 25           | 3.27                    |
| C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | <i>L</i> -Cystine                          | 1    |              | 1                       | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                 | 3-Fluorobenzoic acid                            |      | 25           | 3.86                    |
|                                                                             |                                            | 2    |              | 2.1                     | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                 | 4-Fluorobenzoic acid                            |      | 25           | 4.15                    |
|                                                                             |                                            | 3    |              | 8.02                    | C <sub>7</sub> H <sub>5</sub> F <sub>3</sub> O                | 2-(Trifluoromethyl)phenol                       |      | 25           | 8.95                    |
|                                                                             |                                            | 4    |              | 8.71                    | C <sub>7</sub> H <sub>5</sub> F <sub>3</sub> O                | 3-(Trifluoromethyl)phenol                       |      | 25           | 8.68                    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | Hexanoic acid                              |      | 25           | 4.85                    | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                 | 2-Iodobenzoic acid                              |      | 25           | 2.86                    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | 4-Methylpentanoic acid                     |      | 18           | 4.84                    | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                 | 3-Iodobenzoic acid                              |      | 25           | 3.87                    |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                               | β- <i>D</i> -Fructose                      |      | 25           | 12.27                   | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                 | 4-Iodobenzoic acid                              |      | 25           | 4.00                    |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                               | α- <i>D</i> -Glucose                       |      | 25           | 12.46                   | C <sub>7</sub> H <sub>5</sub> NO                              | 2-Hydroxybenzonitrile                           |      | 25           | 6.86                    |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                               | <i>D</i> -Mannose                          |      | 25           | 12.08                   | C <sub>7</sub> H <sub>5</sub> NO                              | 3-Hydroxybenzonitrile                           |      | 25           | 8.61                    |
| C <sub>6</sub> H <sub>13</sub> N                                            | Cyclohexylamine                            |      | 25           | 10.64                   | C <sub>7</sub> H <sub>5</sub> NO                              | 4-Hydroxybenzonitrile                           |      | 25           | 7.97                    |
| C <sub>6</sub> H <sub>13</sub> N                                            | 1-Methylpiperidine                         |      | 25           | 10.38                   | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub> S               | Saccharin                                       |      | 18           | 11.68                   |
| C <sub>6</sub> H <sub>13</sub> N                                            | 1,2-Dimethylpyrrolidine                    |      | 26           | 10.20                   | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                 | 2-Nitrobenzoic acid                             |      | 25           | 2.17                    |
| C <sub>6</sub> H <sub>13</sub> NO                                           | <i>N</i> -Ethylmorpholine                  |      | 25           | 7.67                    | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                 | 3-Nitrobenzoic acid                             |      | 25           | 3.46                    |
|                                                                             |                                            |      |              |                         | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                 | 4-Nitrobenzoic acid                             |      | 25           | 3.43                    |

| Mol. form.                                                                   | Name                          | Step | t/°C | pK <sub>a</sub> | Mol. form.                                                                                | Name                        | Step | t/°C | pK <sub>a</sub> |
|------------------------------------------------------------------------------|-------------------------------|------|------|-----------------|-------------------------------------------------------------------------------------------|-----------------------------|------|------|-----------------|
| C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                                | 2,3-Pyridinedicarboxylic acid | 1    | 25   | 2.43            | C <sub>7</sub> H <sub>9</sub> N                                                           | 2-Methylaniline             |      | 25   | 4.45            |
|                                                                              |                               | 2    | 25   | 4.78            | C <sub>7</sub> H <sub>9</sub> N                                                           | 3-Methylaniline             |      | 25   | 4.71            |
| C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                                | 2,4-Pyridinedicarboxylic acid | 1    | 25   | 2.15            | C <sub>7</sub> H <sub>9</sub> N                                                           | 4-Methylaniline             |      | 25   | 5.08            |
|                                                                              |                               |      |      |                 | C <sub>7</sub> H <sub>9</sub> N                                                           | N-Methylaniline             |      | 25   | 4.85            |
| C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                                | 2,6-Pyridinedicarboxylic acid | 1    | 25   | 2.16            | C <sub>7</sub> H <sub>9</sub> N                                                           | 2-Ethylpyridine             |      | 25   | 5.89            |
|                                                                              |                               | 2    | 25   | 4.76            | C <sub>7</sub> H <sub>9</sub> N                                                           | 2,3-Dimethylpyridine        |      | 25   | 6.57            |
| C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                                | 3,5-Pyridinedicarboxylic acid | 1    | 25   | 2.80            | C <sub>7</sub> H <sub>9</sub> N                                                           | 2,4-Dimethylpyridine        |      | 25   | 6.99            |
|                                                                              |                               |      |      |                 | C <sub>7</sub> H <sub>9</sub> N                                                           | 2,5-Dimethylpyridine        |      | 25   | 6.40            |
|                                                                              | Chlorothiazide                | 1    |      | 6.85            | C <sub>7</sub> H <sub>9</sub> N                                                           | 2,6-Dimethylpyridine        |      | 25   | 6.65            |
| C <sub>7</sub> H <sub>6</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>2</sub> |                               | 2    |      | 9.45            | C <sub>7</sub> H <sub>9</sub> N                                                           | 3,4-Dimethylpyridine        |      | 25   | 6.46            |
| C <sub>7</sub> H <sub>6</sub> F <sub>3</sub> N                               | 3-(Trifluoromethyl)aniline    |      | 25   | 3.49            | C <sub>7</sub> H <sub>9</sub> N                                                           | 3,5-Dimethylpyridine        |      | 25   | 6.15            |
| C <sub>7</sub> H <sub>6</sub> F <sub>3</sub> N                               | 4-(Trifluoromethyl)aniline    |      | 25   | 2.45            | C <sub>7</sub> H <sub>9</sub> NO                                                          | 2-Methoxyaniline            |      | 25   | 4.53            |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                 | 1 <i>H</i> -Benzimidazole     |      | 25   | 5.53            | C <sub>7</sub> H <sub>9</sub> NO                                                          | 3-Methoxyaniline            |      | 25   | 4.20            |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                 | 2-Aminobenzonitrile           |      | 25   | 0.77            | C <sub>7</sub> H <sub>9</sub> NO                                                          | 4-Methoxyaniline            |      | 25   | 5.36            |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                 | 3-Aminobenzonitrile           |      | 25   | 2.75            | C <sub>7</sub> H <sub>9</sub> NS                                                          | 2-(Methylthio)aniline       |      | 25   | 3.45            |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                 | 4-Aminobenzonitrile           |      | 25   | 1.74            | C <sub>7</sub> H <sub>9</sub> NS                                                          | 4-(Methylthio)aniline       |      | 25   | 4.35            |
| C <sub>7</sub> H <sub>6</sub> O                                              | Benzaldehyde                  |      | 25   | 14.90           | C <sub>7</sub> H <sub>9</sub> N <sub>5</sub>                                              | 2-Dimethylaminopurine       | 1    | 20   | 4.00            |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                 | Benzoic acid                  |      | 25   | 4.204           |                                                                                           |                             | 2    | 20   | 10.24           |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                 | Salicylaldehyde               |      | 25   | 8.37            | C <sub>7</sub> H <sub>11</sub> N <sub>3</sub> O <sub>2</sub>                              | <i>L</i> -1-Methylhistidine | 1    | 25   | 1.69            |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                 | 3-Hydroxybenzaldehyde         |      | 25   | 8.98            |                                                                                           |                             | 2    | 25   | 6.48            |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                 | 4-Hydroxybenzaldehyde         |      | 25   | 7.61            |                                                                                           |                             | 3    | 25   | 8.85            |
| C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                                 | 2-Hydroxybenzoic acid         | 1    | 20   | 2.98            | C <sub>7</sub> H <sub>11</sub> N <sub>3</sub> O <sub>2</sub>                              | <i>L</i> -3-Methylhistidine | 1    | 25   | 1.92            |
|                                                                              |                               | 2    | 20   | 13.6            |                                                                                           |                             | 2    | 25   | 6.56            |
| C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                                 | 3-Hydroxybenzoic acid         | 1    | 25   | 4.08            |                                                                                           |                             | 3    | 25   | 8.73            |
|                                                                              |                               | 2    | 19   | 9.92            | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                                             | Cyclohexanecarboxylic acid  |      | 25   | 4.91            |
| C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                                 | 4-Hydroxybenzoic acid         | 1    | 25   | 4.57            | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                                             | Heptanedioic acid           | 1    | 25   | 4.71            |
|                                                                              |                               | 2    | 25   | 9.46            |                                                                                           |                             | 2    | 25   | 5.58            |
| C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                                 | 2,4-Dihydroxybenzoic acid     | 1    | 25   | 3.11            | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                                             | Butylpropanedioic acid      | 1    | 5    | 2.96            |
|                                                                              |                               | 2    | 25   | 8.55            | C <sub>7</sub> H <sub>13</sub> NO <sub>4</sub>                                            | α-Ethylglutamic acid        | 1    | 25   | 3.846           |
|                                                                              |                               | 3    | 25   | 14.0            |                                                                                           |                             | 2    | 25   | 7.838           |
| C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                                 | 2,5-Dihydroxybenzoic acid     | 1    | 25   | 2.97            | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                                             | Heptanoic acid              |      | 25   | 4.89            |
| C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                                 | 3,4-Dihydroxybenzoic acid     | 1    | 25   | 4.48            | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                                             | α-Methylglucoside           |      | 25   | 13.71           |
|                                                                              |                               | 2    | 25   | 8.83            | C <sub>7</sub> H <sub>15</sub> N                                                          | 1-Ethylpiperidine           |      | 23   | 10.45           |
|                                                                              |                               | 3    | 25   | 12.6            | C <sub>7</sub> H <sub>15</sub> N                                                          | 1,2-Dimethylpiperidine,(±)  |      | 25   | 10.22           |
| C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                                 | 3,5-Dihydroxybenzoic acid     | 1    | 25   | 4.04            | C <sub>7</sub> H <sub>15</sub> NO <sub>3</sub>                                            | Carnitine                   |      | 25   | 3.80            |
| C <sub>7</sub> H <sub>6</sub> O <sub>5</sub>                                 | 2,4,6-Trihydroxybenzoic acid  |      | 25   | 1.68            | C <sub>7</sub> H <sub>17</sub> N                                                          | Heptylamine                 |      | 25   | 10.67           |
|                                                                              |                               |      |      |                 | C <sub>7</sub> H <sub>17</sub> N                                                          | 2-Heptanamine               |      | 19   | 10.7            |
| C <sub>7</sub> H <sub>6</sub> O <sub>5</sub>                                 | 3,4,5-Trihydroxybenzoic acid  |      | 25   | 4.41            | C <sub>8</sub> H <sub>5</sub> NO <sub>2</sub>                                             | 3-Cyanobenzoic acid         |      | 25   | 3.60            |
| C <sub>7</sub> H <sub>7</sub> NO                                             | Benzamide                     |      | 25   | 13              | C <sub>8</sub> H <sub>5</sub> NO <sub>2</sub>                                             | 4-Cyanobenzoic acid         |      | 25   | 3.55            |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                | Aniline-2-carboxylic acid     | 1    | 25   | 2.17            | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                                              | Cinnoline                   |      | 20   | 2.37            |
|                                                                              |                               | 2    | 25   | 4.85            | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                                              | Quinazoline                 |      | 29   | 3.43            |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                | Aniline-3-carboxylic acid     | 1    | 25   | 3.07            | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                                              | Quinoxaline                 |      | 20   | 0.56            |
|                                                                              |                               | 2    | 25   | 4.79            | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                                              | Phthalazine                 |      | 20   | 3.47            |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                | Aniline-4-carboxylic acid     | 1    | 25   | 2.50            | C <sub>8</sub> H <sub>6</sub> N <sub>4</sub> O <sub>5</sub>                               | Nitrofurantoin              |      |      | 7.2             |
|                                                                              |                               | 2    | 25   | 4.87            | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                                              | 3-Formylbenzoic acid        |      | 25   | 3.84            |
| C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                                | 4-Amino-2-hydroxybenzoic acid |      |      | 3.25            | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>                                              | 4-Formylbenzoic acid        |      | 25   | 3.77            |
|                                                                              |                               |      |      |                 | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                                              | Phthalic acid               | 1    | 25   | 2.943           |
| C <sub>7</sub> H <sub>8</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | Hydrochlorothiazide           | 1    |      | 7.9             |                                                                                           |                             | 2    | 25   | 5.432           |
|                                                                              |                               | 2    |      | 9.2             | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                                              | Isophthalic acid            | 1    | 25   | 3.70            |
| C <sub>7</sub> H <sub>8</sub> N <sub>4</sub> O <sub>2</sub>                  | Theobromine                   |      | 18   | 7.89            |                                                                                           |                             | 2    | 25   | 4.60            |
| C <sub>7</sub> H <sub>8</sub> N <sub>4</sub> O <sub>2</sub>                  | Theophylline                  | 1    | 25   | 8.77            | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                                              | Terephthalic acid           | 1    | 25   | 3.54            |
| C <sub>7</sub> H <sub>8</sub> O                                              | <i>o</i> -Cresol              |      | 25   | 10.29           |                                                                                           |                             | 2    | 25   | 4.34            |
| C <sub>7</sub> H <sub>8</sub> O                                              | <i>m</i> -Cresol              |      | 25   | 10.09           | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                                            | 2-Chlorobenzeneacetic acid  |      | 25   | 4.07            |
| C <sub>7</sub> H <sub>8</sub> O                                              | <i>p</i> -Cresol              |      | 25   | 10.26           | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                                            | 3-Chlorobenzeneacetic acid  |      | 25   | 4.14            |
| C <sub>7</sub> H <sub>8</sub> OS                                             | 4-(Methylthio)phenol          |      | 25   | 9.53            | C <sub>8</sub> H <sub>7</sub> ClO <sub>2</sub>                                            | 4-Chlorobenzeneacetic acid  |      | 25   | 4.19            |
| C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                                 | 2-Methoxyphenol               |      | 25   | 9.98            | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                                            | 2-Chlorophenoxyacetic acid  |      | 25   | 3.05            |
| C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                                 | 3-Methoxyphenol               |      | 25   | 9.65            | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                                            | 3-Chlorophenoxyacetic acid  |      | 25   | 3.10            |
| C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                                 | 4-Methoxyphenol               |      | 25   | 10.21           | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                                             | 2-Nitrobenzeneacetic acid   |      | 25   | 4.00            |
| C <sub>7</sub> H <sub>8</sub> S                                              | Benzenemethanethiol           |      | 25   | 9.43            | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                                             | 3-Nitrobenzeneacetic acid   |      | 25   | 3.97            |
| C <sub>7</sub> H <sub>9</sub> N                                              | Benzylamine                   |      | 25   | 9.34            | C <sub>8</sub> H <sub>7</sub> NO <sub>4</sub>                                             | 4-Nitrobenzeneacetic acid   |      | 25   | 3.85            |
|                                                                              |                               |      |      |                 | C <sub>8</sub> H <sub>8</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | Hydroflumethiazide          | 1    |      | 8.9             |

| Mol. form.                                                   | Name                                  | Step | t/°C | pK <sub>a</sub> | Mol. form.                                                                  | Name                                               | Step | t/°C | pK <sub>a</sub> |
|--------------------------------------------------------------|---------------------------------------|------|------|-----------------|-----------------------------------------------------------------------------|----------------------------------------------------|------|------|-----------------|
|                                                              |                                       | 2    |      | 9.7             |                                                                             |                                                    | 2    | 25   | 8.2             |
| C <sub>8</sub> H <sub>8</sub> N <sub>2</sub>                 | 2-Methyl-1 <i>H</i> -benzimidazole    | 1    | 25   | 6.19            | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | Homocystine                                        | 1    | 25   | 1.59            |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                 | <i>o</i> -Toluic acid                 |      | 25   | 3.91            |                                                                             |                                                    | 2    | 25   | 2.54            |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                 | <i>m</i> -Toluic acid                 |      | 25   | 4.25            |                                                                             |                                                    | 3    | 25   | 8.52            |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                 | <i>p</i> -Toluic acid                 |      | 25   | 4.37            |                                                                             |                                                    | 4    | 25   | 9.44            |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                 | Benzeneacetic acid                    |      | 25   | 4.31            | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                               | Octanoic acid                                      |      | 25   | 4.89            |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                 | 1-(2-Hydroxyphenyl)ethanone           |      | 25   | 10.06           | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                               | 2-Propylpentanoic acid                             |      |      | 4.6             |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                 | 1-(3-Hydroxyphenyl)ethanone           |      | 25   | 9.19            | C <sub>8</sub> H <sub>17</sub> N                                            | 2-Propylpiperidine,( <i>S</i> )                    |      |      | 10.9            |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                 | 1-(4-Hydroxyphenyl)ethanone           |      | 25   | 8.05            | C <sub>8</sub> H <sub>17</sub> N                                            | 2,2,4-Trimethylpiperidine                          |      | 30   | 11.04           |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | 2-Methoxybenzoic acid                 |      | 25   | 4.08            | C <sub>8</sub> H <sub>17</sub> NO                                           | <i>trans</i> -6-Propyl-3-piperidinol,(3 <i>S</i> ) |      |      | 10.3            |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | 3-Methoxybenzoic acid                 |      | 25   | 4.10            | C <sub>8</sub> H <sub>19</sub> N                                            | Octylamine                                         |      | 25   | 10.65           |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | 4-Methoxybenzoic acid                 |      | 25   | 4.50            | C <sub>8</sub> H <sub>19</sub> N                                            | <i>N</i> -Methyl-2-heptanamine                     |      | 17   | 10.99           |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | Phenoxyacetic acid                    |      | 25   | 3.17            | C <sub>8</sub> H <sub>19</sub> N                                            | Dibutylamine                                       |      | 21   | 11.25           |
| C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | Mandelic acid                         |      | 25   | 3.37            | C <sub>8</sub> H <sub>20</sub> N <sub>2</sub>                               | 1,8-Octanediamine                                  | 1    | 20   | 11.00           |
| C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>                 | 2,5-Hydroxybenzeneacetic acid         |      | 25   | 4.40            |                                                                             |                                                    | 2    | 20   | 10.1            |
| C <sub>8</sub> H <sub>9</sub> NO                             | Acetanilide                           |      | 25   | 0.5             | C <sub>9</sub> H <sub>6</sub> BrN                                           | 3-Bromoquinoline                                   |      | 25   | 2.69            |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                | 2-(Methylamino)benzoic acid           |      | 25   | 5.34            | C <sub>9</sub> H <sub>7</sub> ClO <sub>2</sub>                              | <i>trans</i> - <i>o</i> -Chlorocinnamic acid       |      | 25   | 4.23            |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                | 3-(Methylamino)benzoic acid           |      | 25   | 5.10            | C <sub>9</sub> H <sub>7</sub> ClO <sub>2</sub>                              | <i>trans</i> - <i>m</i> -Chlorocinnamic acid       |      | 25   | 4.29            |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                | 4-(Methylamino)benzoic acid           |      | 25   | 5.04            | C <sub>9</sub> H <sub>7</sub> ClO <sub>2</sub>                              | <i>trans</i> - <i>p</i> -Chlorocinnamic acid       |      | 25   | 4.41            |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                | <i>N</i> -Phenylglycine               | 1    | 25   | 1.83            | C <sub>9</sub> H <sub>7</sub> N                                             | Quinoline                                          |      | 20   | 4.90            |
|                                                              |                                       | 2    |      | 4.39            | C <sub>9</sub> H <sub>7</sub> N                                             | Isoquinoline                                       |      | 20   | 5.40            |
| C <sub>8</sub> H <sub>10</sub> BrN                           | 4-Bromo- <i>N,N</i> -dimethylaniline  |      | 25   | 4.23            | C <sub>9</sub> H <sub>7</sub> NO                                            | 2-Quinolinol                                       | 1    | 20   | -0.31           |
| C <sub>8</sub> H <sub>10</sub> ClN                           | 3-Chloro- <i>N,N</i> -dimethylaniline |      | 20   | 3.83            |                                                                             |                                                    | 2    | 20   | 11.76           |
| C <sub>8</sub> H <sub>10</sub> ClN                           | 4-Chloro- <i>N,N</i> -dimethylaniline |      | 20   | 4.39            | C <sub>9</sub> H <sub>7</sub> NO                                            | 3-Quinolinol                                       | 1    | 20   | 4.28            |
| C <sub>8</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> | <i>N,N</i> -Dimethyl-3-nitroaniline   |      | 25   | 2.62            |                                                                             |                                                    | 2    | 20   | 8.08            |
| C <sub>8</sub> H <sub>11</sub> N                             | <i>N</i> -Ethylaniline                |      | 25   | 5.12            | C <sub>9</sub> H <sub>7</sub> NO                                            | 4-Quinolinol                                       | 1    | 20   | 2.23            |
| C <sub>8</sub> H <sub>11</sub> N                             | <i>N,N</i> -Dimethylaniline           |      | 25   | 5.07            |                                                                             |                                                    | 2    | 20   | 11.28           |
| C <sub>8</sub> H <sub>11</sub> N                             | 2,6-Dimethylaniline                   |      | 25   | 3.89            | C <sub>9</sub> H <sub>7</sub> NO                                            | 6-Quinolinol                                       | 1    | 20   | 5.15            |
| C <sub>8</sub> H <sub>11</sub> N                             | Benzeneethanamine                     |      | 25   | 9.83            |                                                                             |                                                    | 2    | 20   | 8.90            |
| C <sub>8</sub> H <sub>11</sub> N                             | 2,4,6-Trimethylpyridine               |      | 25   | 7.43            | C <sub>9</sub> H <sub>7</sub> NO                                            | 8-Quinolinol                                       | 1    | 25   | 4.91            |
| C <sub>8</sub> H <sub>11</sub> NO                            | 2-Ethoxyaniline                       |      | 28   | 4.43            |                                                                             |                                                    | 2    | 25   | 9.81            |
| C <sub>8</sub> H <sub>11</sub> NO                            | 3-Ethoxyaniline                       |      | 25   | 4.18            | C <sub>9</sub> H <sub>7</sub> NO                                            | 7-Isoquinolinol                                    | 1    | 20   | 5.68            |
| C <sub>8</sub> H <sub>11</sub> NO                            | 4-Ethoxyaniline                       |      | 28   | 5.20            |                                                                             |                                                    | 2    | 20   | 8.90            |
| C <sub>8</sub> H <sub>11</sub> NO                            | 4-(2-Aminoethyl)phenol                | 1    | 25   | 9.74            | C <sub>9</sub> H <sub>7</sub> NO <sub>3</sub>                               | 2-Cyanophenoxyacetic acid                          |      | 25   | 2.98            |
|                                                              |                                       | 2    | 25   | 10.52           | C <sub>9</sub> H <sub>7</sub> NO <sub>3</sub>                               | 3-Cyanophenoxyacetic acid                          |      | 25   | 3.03            |
| C <sub>8</sub> H <sub>11</sub> NO                            | 2-(2-Methoxyethyl)pyridine            |      |      | 5.5             | C <sub>9</sub> H <sub>7</sub> NO <sub>3</sub>                               | 4-Cyanophenoxyacetic acid                          |      | 25   | 2.93            |
| C <sub>8</sub> H <sub>11</sub> NO <sub>2</sub>               | Dopamine                              | 1    | 25   | 8.9             | C <sub>9</sub> H <sub>7</sub> N <sub>2</sub> O <sub>2</sub> S               | Azathioprine                                       |      |      | 8.2             |
|                                                              |                                       | 2    | 25   | 10.6            | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                                | 2-Quinolinamine                                    |      | 20   | 7.34            |
| C <sub>8</sub> H <sub>11</sub> NO <sub>3</sub>               | Norepinephrine                        | 1    | 25   | 8.64            | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                                | 3-Quinolinamine                                    |      | 20   | 4.91            |
|                                                              |                                       | 2    | 25   | 9.70            | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                                | 4-Quinolinamine                                    |      | 20   | 9.17            |
| C <sub>8</sub> H <sub>11</sub> N <sub>3</sub> O <sub>6</sub> | 6-Azauridine                          |      |      | 6.70            | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                                | 1-Isoquinolinamine                                 |      | 20   | 7.62            |
| C <sub>8</sub> H <sub>11</sub> N <sub>5</sub>                | Phenylbiguanide                       | 1    |      | 10.76           | C <sub>9</sub> H <sub>8</sub> N <sub>2</sub>                                | 3-Isoquinolinamine                                 |      | 20   | 5.05            |
|                                                              |                                       | 2    |      | 2.13            | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                                | <i>cis</i> -Cinnamic acid                          |      | 25   | 3.88            |
| C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub> | Barbital                              |      | 25   | 7.43            | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                                | <i>trans</i> -Cinnamic acid                        |      | 25   | 4.44            |
| C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                | 5,5-Dimethyl-1,3-cyclohexanedione     |      | 25   | 5.15            | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                                | α-Methylenebenzeneacetic acid                      |      |      | 4.35            |
| C <sub>8</sub> H <sub>13</sub> NO <sub>2</sub>               | Arecoline                             |      |      | 6.84            | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                                | 2-(Acetyloxy)benzoic acid                          |      | 25   | 3.48            |
| C <sub>8</sub> H <sub>14</sub> O <sub>2</sub> S <sub>2</sub> | Thioctic acid                         |      |      | 5.4             | C <sub>9</sub> H <sub>9</sub> Br <sub>2</sub> NO <sub>3</sub>               | 3,5-Dibromo- <i>L</i> -tyrosine                    | 1    |      | 2.17            |
| C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                | Octanedioic acid                      | 1    | 25   | 4.52            |                                                                             |                                                    | 2    |      | 6.45            |
| C <sub>8</sub> H <sub>15</sub> NO                            | Tropine                               |      | 15   | 3.80            |                                                                             |                                                    | 3    |      | 7.60            |
| C <sub>8</sub> H <sub>15</sub> NO                            | Pseudotropine                         |      | 15   | 3.80            | C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>                              | 3-(2-Chlorophenyl)-propanoic acid                  |      | 25   | 4.58            |
| C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> | <i>N</i> -Glycylleucine               |      | 25   | 3.18            | C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>                              | 3-(3-Chlorophenyl)-propanoic acid                  |      | 25   | 4.59            |
| C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> | <i>N</i> -Leucylglycine               | 1    | 25   | 3.25            | C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>                              | 3-(4-Chlorophenyl)-propanoic acid                  |      | 25   | 4.61            |
|                                                              |                                       |      |      |                 | C <sub>9</sub> H <sub>9</sub> I <sub>2</sub> NO <sub>3</sub>                | <i>L</i> -3,5-Diiodotyrosine                       | 1    | 25   | 2.12            |

| Mol. form.                                                                                  | Name                                 | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> | Mol. form.                                                      | Name                                 | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> |
|---------------------------------------------------------------------------------------------|--------------------------------------|------|--------------|-------------------------|-----------------------------------------------------------------|--------------------------------------|------|--------------|-------------------------|
|                                                                                             |                                      | 2    | 25           | 5.32                    | C <sub>10</sub> H <sub>8</sub> O                                | 1-Naphthol                           |      | 25           | 9.39                    |
|                                                                                             |                                      | 3    | 25           | 9.48                    | C <sub>10</sub> H <sub>8</sub> O                                | 2-Naphthol                           |      | 25           | 9.63                    |
| C <sub>9</sub> H <sub>9</sub> NO <sub>3</sub>                                               | <i>N</i> -Benzoylglycine             |      | 25           | 3.62                    | C <sub>10</sub> H <sub>9</sub> N                                | 1-Naphthylamine                      |      | 25           | 3.92                    |
| C <sub>9</sub> H <sub>9</sub> NO <sub>4</sub>                                               | 3-(2-Nitrophenyl)-propanoic acid     |      | 25           | 4.50                    | C <sub>10</sub> H <sub>9</sub> N                                | 2-Naphthylamine                      |      | 25           | 4.16                    |
| C <sub>9</sub> H <sub>9</sub> NO <sub>4</sub>                                               | 3-(4-Nitrophenyl)-propanoic acid     |      | 25           | 4.47                    | C <sub>10</sub> H <sub>9</sub> N                                | 2-Methylquinoline                    |      | 20           | 5.83                    |
| C <sub>9</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                                 | Carbendazim                          |      |              | 4.48                    | C <sub>10</sub> H <sub>9</sub> N                                | 4-Methylquinoline                    |      | 20           | 5.67                    |
| C <sub>9</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub> S <sub>2</sub>                  | Sulfathiazole                        |      |              | 7.2                     | C <sub>10</sub> H <sub>9</sub> N                                | 5-Methylquinoline                    |      | 20           | 5.20                    |
| C <sub>9</sub> H <sub>10</sub> INO <sub>3</sub>                                             | <i>L</i> -3-Iodotyrosine             | 1    | 25           | 2.2                     | C <sub>10</sub> H <sub>9</sub> NO                               | 5-Amino-1-naphthol                   |      | 25           | 3.97                    |
|                                                                                             |                                      | 2    | 25           | 8.7                     | C <sub>10</sub> H <sub>9</sub> NO                               | 6-Methoxyquinoline                   |      | 20           | 5.03                    |
|                                                                                             |                                      | 3    | 25           | 9.1                     | C <sub>10</sub> H <sub>9</sub> NO <sub>2</sub>                  | 1 <i>H</i> -Indole-3-acetic acid     |      |              | 4.75                    |
| C <sub>9</sub> H <sub>10</sub> N <sub>2</sub>                                               | 2-Ethylbenzimidazole                 |      | 25           | 6.18                    | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                  | <i>o</i> -Methylcinnamic acid        |      | 25           | 4.50                    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                                               | 3,5-Dimethylbenzoic acid             |      | 25           | 4.32                    | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                  | <i>m</i> -Methylcinnamic acid        |      | 25           | 4.44                    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                                               | Benzenepropanoic acid                |      | 25           | 4.66                    | C <sub>10</sub> H <sub>10</sub> O <sub>2</sub>                  | <i>p</i> -Methylcinnamic acid        |      | 25           | 4.56                    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                                               | α-Methylbenzeneacetic acid           |      | 25           | 4.64                    | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub>                  | Tryptamine                           |      | 25           | 10.2                    |
| C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                                               | α-Hydroxy-α-methylbenzeneacetic acid |      | 25           | 3.47                    | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O                | 5-Hydroxytryptamine                  | 1    | 25           | 9.8                     |
|                                                                                             |                                      |      |              |                         |                                                                 |                                      | 2    | 25           | 11.1                    |
| C <sub>9</sub> H <sub>11</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | Methylclothiazide                    |      |              | 9.4                     | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>5</sub>   | Dinoseb                              |      |              | 4.62                    |
| C <sub>9</sub> H <sub>11</sub> N                                                            | <i>N</i> -Allylaniline               |      | 25           | 4.17                    | C <sub>10</sub> H <sub>12</sub> N <sub>4</sub> O <sub>3</sub>   | Dideoxyinosine                       |      |              | 9.12                    |
| C <sub>9</sub> H <sub>11</sub> N                                                            | 1-Indanamine                         |      | 22           | 9.21                    | C <sub>10</sub> H <sub>12</sub> O                               | 5,6,7,8-Tetrahydro-2-naphthalenol    |      | 25           | 10.48                   |
| C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                                              | 4-(Dimethylamino)-benzoic acid       | 1    |              | 6.03                    | C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>                  | Benzenebutanoic acid                 |      | 25           | 4.76                    |
|                                                                                             |                                      | 2    |              | 11.49                   | C <sub>10</sub> H <sub>12</sub> O <sub>5</sub>                  | Propyl 3,4,5-trihydroxybenzoate      |      |              | 8.11                    |
| C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                                              | Ethyl 4-aminobenzoate                |      |              | 2.5                     | C <sub>10</sub> H <sub>13</sub> N <sub>5</sub> O <sub>4</sub>   | Adenosine                            | 1    | 25           | 3.6                     |
| C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                                              | <i>L</i> -Phenylalanine              | 1    | 25           | 2.20                    |                                                                 |                                      | 2    | 25           | 12.4                    |
|                                                                                             |                                      | 2    | 25           | 9.31                    | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub>                  | <i>L</i> -Nicotine                   | 1    |              | 8.02                    |
| C <sub>9</sub> H <sub>11</sub> NO <sub>3</sub>                                              | <i>L</i> -Tyrosine                   | 1    | 25           | 2.20                    |                                                                 |                                      | 2    |              | 3.12                    |
|                                                                                             |                                      | 2    | 25           | 9.11                    | C <sub>10</sub> H <sub>14</sub> N <sub>5</sub> O <sub>7</sub> P | 5'-Adenylic acid                     | 1    |              | 3.8                     |
|                                                                                             |                                      | 3    | 25           | 10.1                    |                                                                 |                                      | 2    |              | 6.2                     |
| C <sub>9</sub> H <sub>11</sub> NO <sub>4</sub>                                              | Levodopa                             | 1    | 25           | 2.32                    | C <sub>10</sub> H <sub>14</sub> O                               | 2- <i>tert</i> -Butylphenol          |      | 25           | 10.62                   |
|                                                                                             |                                      | 2    | 25           | 8.72                    | C <sub>10</sub> H <sub>14</sub> O                               | 3- <i>tert</i> -Butylphenol          |      | 25           | 10.12                   |
|                                                                                             |                                      | 3    | 25           | 9.96                    | C <sub>10</sub> H <sub>14</sub> O                               | 4- <i>tert</i> -Butylphenol          |      | 25           | 10.23                   |
|                                                                                             |                                      | 4    | 25           | 11.79                   | C <sub>10</sub> H <sub>15</sub> N                               | <i>N</i> - <i>tert</i> -Butylaniline |      | 25           | 7.00                    |
| C <sub>9</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>                                | Tyrosineamide                        |      | 25           | 7.33                    | C <sub>10</sub> H <sub>15</sub> N                               | <i>N,N</i> -Diethylaniline           |      | 25           | 6.57                    |
| C <sub>9</sub> H <sub>13</sub> N                                                            | <i>N</i> -Isopropylaniline           |      | 25           | 5.77                    | C <sub>10</sub> H <sub>15</sub> NO                              | <i>d</i> -Ephedrine                  |      | 10           | 10.139                  |
| C <sub>9</sub> H <sub>13</sub> NO <sub>3</sub>                                              | Epinephrine                          | 1    | 25           | 8.66                    | C <sub>10</sub> H <sub>15</sub> NO                              | <i>l</i> -Ephedrine                  |      | 10           | 9.958                   |
|                                                                                             |                                      | 2    | 25           | 9.95                    | C <sub>10</sub> H <sub>17</sub> N <sub>3</sub> O <sub>6</sub> S | <i>l</i> -Glutathione                | 1    | 25           | 2.12                    |
| C <sub>9</sub> H <sub>13</sub> N <sub>2</sub> O <sub>9</sub> P                              | 5'-Uridylic acid                     | 1    |              | 6.4                     |                                                                 |                                      | 2    | 25           | 3.59                    |
|                                                                                             |                                      | 2    |              | 9.5                     |                                                                 |                                      | 3    | 25           | 8.75                    |
| C <sub>9</sub> H <sub>13</sub> N <sub>3</sub> O <sub>5</sub>                                | Cytidine                             | 1    |              | 4.22                    |                                                                 |                                      | 4    | 25           | 9.65                    |
|                                                                                             |                                      | 2    |              | 12.5                    | C <sub>10</sub> H <sub>18</sub> N <sub>4</sub> O <sub>5</sub>   | <i>L</i> -Argininosuccinic acid      | 1    | 25           | 1.62                    |
| C <sub>9</sub> H <sub>14</sub> ClNO                                                         | Phenylpropanolamine hydrochloride    |      |              | 9.44                    |                                                                 |                                      | 2    | 25           | 2.70                    |
|                                                                                             |                                      |      |              |                         |                                                                 |                                      | 3    | 25           | 4.26                    |
| C <sub>9</sub> H <sub>14</sub> N <sub>2</sub> O <sub>3</sub>                                | Metharbital                          |      |              | 8.45                    |                                                                 |                                      | 4    | 25           | 9.58                    |
| C <sub>9</sub> H <sub>14</sub> N <sub>3</sub> O <sub>8</sub> P                              | 3'-Cytidylic acid                    | 1    |              | 0.8                     | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                  | Sebacic acid                         | 1    |              | 4.59                    |
|                                                                                             |                                      | 2    |              | 4.28                    |                                                                 |                                      | 2    |              | 5.59                    |
|                                                                                             |                                      | 3    |              | 6.0                     | C <sub>10</sub> H <sub>19</sub> N                               | Bornylamine                          |      | 25           | 10.17                   |
| C <sub>9</sub> H <sub>14</sub> N <sub>4</sub> O <sub>3</sub>                                | Carnosine                            | 1    | 20           | 2.73                    | C <sub>10</sub> H <sub>19</sub> N                               | Neobornylamine                       |      | 25           | 10.01                   |
|                                                                                             |                                      | 2    | 20           | 6.87                    | C <sub>10</sub> H <sub>21</sub> N                               | Butylcyclohexylamine                 |      | 25           | 11.23                   |
|                                                                                             |                                      | 3    | 20           | 9.73                    | C <sub>10</sub> H <sub>21</sub> N                               | 1,2,2,6,6-Pentamethylpiperidine      |      | 30           | 11.25                   |
| C <sub>9</sub> H <sub>15</sub> NO <sub>3</sub> S                                            | Captopril                            | 1    |              | 3.7                     | C <sub>10</sub> H <sub>23</sub> N                               | Decylamine                           |      | 25           | 10.64                   |
|                                                                                             |                                      | 2    |              | 9.8                     | C <sub>11</sub> H <sub>8</sub> N <sub>2</sub>                   | 1 <i>H</i> -Perimidine               |      | 20           | 6.35                    |
| C <sub>9</sub> H <sub>15</sub> N <sub>5</sub> O                                             | Minoxidil                            |      |              | 4.61                    | C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                   | 1-Naphthalenecarboxylic acid         |      | 25           | 3.69                    |
| C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                                               | Nonanedioic acid                     | 1    | 25           | 4.53                    |                                                                 |                                      |      |              |                         |
|                                                                                             |                                      | 2    | 25           | 5.33                    | C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                   | 2-Naphthalenecarboxylic acid         |      | 25           | 4.16                    |
| C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                                               | Nonanoic acid                        |      | 25           | 4.96                    | C <sub>11</sub> H <sub>11</sub> N                               | Methyl-1-naphthylamine               |      | 27           | 3.67                    |
| C <sub>9</sub> H <sub>19</sub> N                                                            | <i>N</i> -Butylpiperidine            |      | 23           | 10.47                   | C <sub>11</sub> H <sub>12</sub> INO <sub>2</sub>                | Iopanoic acid                        |      |              | 4.8                     |
| C <sub>9</sub> H <sub>19</sub> N                                                            | 2,2,6,6-Tetramethylpiperidine        |      | 25           | 11.07                   | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>   | <i>L</i> -Tryptophan                 | 1    | 25           | 2.46                    |
| C <sub>9</sub> H <sub>21</sub> N                                                            | Nonylamine                           |      | 25           | 10.64                   |                                                                 |                                      | 2    | 25           | 9.41                    |
| C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>                                              | 8-Quinolinescarboxylic acid          |      | 25           | 1.82                    |                                                                 |                                      |      |              |                         |



| Mol. form.                                                                     | Name                                                                                | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> | Mol. form.                                                                    | Name                                     | Step | <i>t</i> /°C | p <i>K</i> <sub>a</sub> |
|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------|--------------|-------------------------|-------------------------------------------------------------------------------|------------------------------------------|------|--------------|-------------------------|
| C <sub>11</sub> H <sub>12</sub> N <sub>4</sub> O <sub>3</sub> S                | Sulfamethoxypyridazine                                                              |      |              | 6.7                     | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub>                                | 2-Phenylbenzoic acid                     |      | 25           | 3.46                    |
| C <sub>11</sub> H <sub>13</sub> F <sub>3</sub> N <sub>2</sub> O <sub>3</sub> S | Mefluidide                                                                          |      |              | 4.6                     | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                                | 2-Phenoxybenzoic acid                    |      | 25           | 3.53                    |
| C <sub>11</sub> H <sub>13</sub> NO <sub>3</sub>                                | Hydrastinine                                                                        |      |              | 11.38                   | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                                | 3-Phenoxybenzoic acid                    |      | 25           | 3.95                    |
| C <sub>11</sub> H <sub>13</sub> N <sub>3</sub> O <sub>3</sub> S                | Sulfisoxazole                                                                       |      |              | 5                       | C <sub>13</sub> H <sub>10</sub> O <sub>3</sub>                                | 4-Phenoxybenzoic acid                    |      | 25           | 4.57                    |
| C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> O                               | Cytisine                                                                            | 1    |              | 6.11                    | C <sub>13</sub> H <sub>11</sub> N <sub>3</sub>                                | 3,6-Acridinediamine                      |      | 20           | 9.65                    |
|                                                                                |                                                                                     | 2    |              | 13.08                   | C <sub>13</sub> H <sub>12</sub> Cl <sub>2</sub> O <sub>4</sub>                | Ethacrynic acid                          |      |              | 3.50                    |
| C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                                 | 2- <i>tert</i> -Butylbenzoic acid                                                   |      | 25           | 3.54                    | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O                              | Harmine                                  |      |              | 7.70                    |
| C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                                 | 3- <i>tert</i> -Butylbenzoic acid                                                   |      | 25           | 4.20                    | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub> S               | Sulfabenzamide                           |      | 25           | 4.57                    |
| C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>                                 | 4- <i>tert</i> -Butylbenzoic acid                                                   |      | 25           | 4.38                    | C <sub>13</sub> H <sub>13</sub> N                                             | 4-Benzylaniline                          |      | 25           | 2.17                    |
| C <sub>11</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>                  | Pilocarpine                                                                         | 1    | 25           | 1.6                     | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub> O <sub>13</sub>                | Harmaline                                |      |              | 4.2                     |
|                                                                                |                                                                                     | 2    | 25           | 6.9                     | C <sub>13</sub> H <sub>15</sub> N <sub>3</sub> O <sub>3</sub>                 | Imazapyr                                 | 1    |              | 1.9                     |
|                                                                                |                                                                                     |      |              | 5.2                     |                                                                               |                                          | 2    |              | 3.6                     |
| C <sub>11</sub> H <sub>16</sub> N <sub>4</sub> O <sub>4</sub>                  | Pentostatin                                                                         |      |              | 5.2                     | C <sub>13</sub> H <sub>16</sub> ClNO                                          | Ketamine                                 |      |              | 7.5                     |
| C <sub>11</sub> H <sub>17</sub> N                                              | <i>N,N</i> -Diethyl-2-methyl-aniline                                                |      | 25           | 7.24                    | C <sub>13</sub> H <sub>19</sub> NO <sub>4</sub> S                             | 4-[(Dipropylamino)-sulfonyl]benzoic acid |      |              | 5.8                     |
| C <sub>11</sub> H <sub>17</sub> NO <sub>3</sub>                                | Isoproterenol                                                                       |      |              | 8.64                    | C <sub>13</sub> H <sub>21</sub> N                                             | 2,6-Di- <i>tert</i> -butylpyridine       |      |              | 3.58                    |
| C <sub>11</sub> H <sub>17</sub> N <sub>3</sub> O <sub>8</sub>                  | Tetrodotoxin                                                                        |      |              | 8.76                    | C <sub>13</sub> H <sub>29</sub> N                                             | (Tridecyl)amine                          |      | 25           | 10.63                   |
| C <sub>11</sub> H <sub>18</sub> ClNO <sub>3</sub>                              | Methoxamine hydrochloride                                                           |      | 25           | 9.2                     | C <sub>14</sub> H <sub>12</sub> F <sub>3</sub> NO <sub>4</sub> S <sub>2</sub> | Perfluidone                              |      |              | 2.5                     |
| C <sub>11</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub>                  | Amobarbital                                                                         |      | 25           | 8.0                     | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub>                                | α-Phenylbenzeneacetic acid               |      | 25           | 3.94                    |
| C <sub>11</sub> H <sub>25</sub> N                                              | Undecylamine                                                                        |      | 25           | 10.63                   | C <sub>14</sub> H <sub>12</sub> O <sub>3</sub>                                | α-Hydroxy-α-phenyl-benzeacetic acid      |      | 25           | 3.04                    |
| C <sub>11</sub> H <sub>26</sub> NO <sub>2</sub> PS                             | Methylphosphonothioic acid S[2-[bis(1-isopropyl)amino]-ethyl], <i>O</i> -ethylester |      |              | 7.9                     | C <sub>14</sub> H <sub>18</sub> N <sub>4</sub> O <sub>3</sub>                 | Trimethoprim                             |      |              | 6.6                     |
| C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub> O <sub>2</sub> S                | Bithionol                                                                           | 1    |              | 4.82                    | C <sub>14</sub> H <sub>19</sub> NO <sub>2</sub>                               | Methylphenidate                          |      |              | 8.9                     |
|                                                                                |                                                                                     | 2    |              | 10.50                   | C <sub>14</sub> H <sub>21</sub> N <sub>3</sub> O <sub>3</sub> S               | Tolazamide                               |      | 25           | 3.6                     |
| C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>                                  | 1,10-Phenanthroline                                                                 |      | 25           | 4.84                    | C <sub>14</sub> H <sub>22</sub> N <sub>2</sub> O <sub>3</sub>                 | Atenolol                                 |      |              | 9.6                     |
| C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>                                  | Phenazine                                                                           |      | 20           | 1.20                    | C <sub>14</sub> H <sub>31</sub> N                                             | Tetradecylamine                          |      | 25           | 10.62                   |
| C <sub>12</sub> H <sub>10</sub> O                                              | 2-Hydroxybiphenyl                                                                   |      | 25           | 10.01                   | C <sub>15</sub> H <sub>10</sub> ClN <sub>3</sub> O <sub>3</sub>               | Clonazepam                               | 1    |              | 1.5                     |
| C <sub>12</sub> H <sub>10</sub> O                                              | 3-Hydroxybiphenyl                                                                   |      | 25           | 9.64                    |                                                                               |                                          | 2    |              | 10.5                    |
| C <sub>12</sub> H <sub>10</sub> O                                              | 4-Hydroxybiphenyl                                                                   |      | 25           | 9.55                    | C <sub>15</sub> H <sub>11</sub> I <sub>4</sub> NO <sub>4</sub>                | <i>L</i> -Thyroxine                      | 1    | 25           | 2.2                     |
| C <sub>12</sub> H <sub>11</sub> N                                              | Diphenylamine                                                                       |      | 25           | 0.79                    |                                                                               |                                          | 2    | 25           | 6.45                    |
| C <sub>12</sub> H <sub>11</sub> N                                              | 2-Aminobiphenyl                                                                     |      | 25           | 3.83                    |                                                                               |                                          | 3    | 25           | 10.1                    |
| C <sub>12</sub> H <sub>11</sub> N                                              | 3-Aminobiphenyl                                                                     |      | 18           | 4.25                    | C <sub>15</sub> H <sub>14</sub> O <sub>3</sub>                                | Fenoprofen                               |      |              | 4.5                     |
| C <sub>12</sub> H <sub>11</sub> N                                              | 4-Aminobiphenyl                                                                     |      | 18           | 4.35                    | C <sub>15</sub> H <sub>15</sub> NO <sub>2</sub>                               | Mefenamic acid                           |      |              | 4.2                     |
| C <sub>12</sub> H <sub>11</sub> N                                              | 2-Benzylpyridine                                                                    |      | 25           | 5.13                    | C <sub>15</sub> H <sub>15</sub> N <sub>3</sub> O <sub>2</sub>                 | Methyl Red                               | 1    |              | 2.5                     |
| C <sub>12</sub> H <sub>11</sub> N <sub>3</sub>                                 | 4-Aminoazobenzene                                                                   |      | 25           | 2.82                    |                                                                               |                                          | 2    |              | 9.5                     |
| C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                                 | <i>p</i> -Benzidine                                                                 | 1    | 20           | 4.65                    | C <sub>15</sub> H <sub>17</sub> ClN <sub>4</sub>                              | NeutralRed                               |      |              | 6.7                     |
|                                                                                |                                                                                     | 2    | 20           | 3.43                    | C <sub>15</sub> H <sub>19</sub> NO <sub>2</sub>                               | Tropacocaine                             |      | 15           | 4.32                    |
| C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>                  | Phenobarbital                                                                       | 1    |              | 7.3                     | C <sub>15</sub> H <sub>19</sub> N <sub>3</sub> O <sub>3</sub>                 | Imazethapyr                              | 1    |              | 2.1                     |
|                                                                                |                                                                                     | 2    |              | 11.8                    |                                                                               |                                          | 2    |              | 3.9                     |
| C <sub>12</sub> H <sub>13</sub> I <sub>3</sub> N <sub>2</sub> O <sub>3</sub>   | Iocetamic acid                                                                      |      |              | 4                       | C <sub>15</sub> H <sub>21</sub> N <sub>3</sub> O <sub>2</sub>                 | Physostigmine                            | 1    |              | 6.12                    |
| C <sub>12</sub> H <sub>13</sub> N                                              | <i>N,N</i> -Dimethyl-1-naphthylamine                                                |      | 25           | 4.83                    |                                                                               |                                          | 2    |              | 12.24                   |
| C <sub>12</sub> H <sub>13</sub> N                                              | <i>N,N</i> -Dimethyl-2-naphthylamine                                                |      | 25           | 4.566                   | C <sub>15</sub> H <sub>26</sub> N <sub>2</sub>                                | Sparteine                                | 1    | 20           | 2.24                    |
|                                                                                |                                                                                     |      |              |                         |                                                                               |                                          | 2    | 20           | 9.46                    |
| C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub> S                | Sulfamethazine                                                                      | 1    |              | 7.4                     | C <sub>15</sub> H <sub>33</sub> N                                             | Pentadecylamine                          |      | 25           | 10.61                   |
|                                                                                |                                                                                     | 2    |              | 2.65                    | C <sub>16</sub> H <sub>13</sub> ClN <sub>2</sub> O                            | Valium                                   |      |              | 3.4                     |
| C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>3</sub> S                | Sulfacytine                                                                         |      |              | 6.9                     | C <sub>16</sub> H <sub>14</sub> ClN <sub>3</sub> O                            | Chlorodiazepoxide                        |      |              | 4.8                     |
| C <sub>12</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub>                  | Agaritine                                                                           | 1    |              | 3.4                     | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub>                 | Lysergic acid                            | 1    |              | 3.44                    |
|                                                                                |                                                                                     | 2    |              | 8.86                    |                                                                               |                                          | 2    |              | 7.68                    |
| C <sub>12</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub>                  | Aspergillilic acid                                                                  |      |              | 5.5                     | C <sub>16</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub> S               | Cephalexin                               | 1    |              | 5.2                     |
| C <sub>12</sub> H <sub>21</sub> N <sub>5</sub> O <sub>2</sub> S <sub>2</sub>   | Nizatidine                                                                          | 1    |              | 2.1                     |                                                                               |                                          | 2    |              | 7.3                     |
|                                                                                |                                                                                     | 2    |              | 6.8                     | C <sub>16</sub> H <sub>19</sub> N <sub>3</sub> O <sub>4</sub> S               | Cephadrine                               | 1    |              | 2.63                    |
|                                                                                |                                                                                     |      |              |                         |                                                                               |                                          | 2    |              | 7.27                    |
| C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                                | Sucrose                                                                             |      | 25           | 12.7                    | C <sub>16</sub> H <sub>22</sub> N <sub>2</sub>                                | Lycodine                                 | 1    |              | 3.97                    |
| C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                                | α-Maltose                                                                           |      | 21           | 12.05                   |                                                                               |                                          | 2    |              | 8.08                    |
| C <sub>12</sub> H <sub>23</sub> N                                              | Dicyclohexylamine                                                                   |      |              | 10.4                    | C <sub>16</sub> H <sub>35</sub> N                                             | Hexadecylamine                           |      | 25           | 10.61                   |
| C <sub>12</sub> H <sub>27</sub> N                                              | Dodecylamine                                                                        |      | 25           | 10.63                   | C <sub>17</sub> H <sub>17</sub> NO <sub>2</sub>                               | Apomorphine                              | 1    |              | 7.0                     |
| C <sub>13</sub> H <sub>9</sub> N                                               | Acridine                                                                            |      | 20           | 5.58                    |                                                                               |                                          | 2    |              | 8.92                    |
| C <sub>13</sub> H <sub>9</sub> N                                               | Phenanthridine                                                                      |      | 20           | 5.58                    | C <sub>17</sub> H <sub>19</sub> NO <sub>3</sub>                               | Piperine                                 |      | 18           | 12.22                   |
| C <sub>13</sub> H <sub>10</sub> N <sub>2</sub>                                 | 9-Acrindamine                                                                       |      | 20           | 9.99                    | C <sub>17</sub> H <sub>19</sub> NO <sub>3</sub>                               | Morphine                                 | 1    | 25           | 8.21                    |
| C <sub>13</sub> H <sub>10</sub> N <sub>2</sub>                                 | 2-Phenylbenzimidazole                                                               | 1    | 25           | 5.23                    |                                                                               |                                          | 2    | 20           | 9.85                    |
|                                                                                |                                                                                     | 2    | 25           | 11.91                   | C <sub>17</sub> H <sub>20</sub> N <sub>4</sub> O <sub>6</sub>                 | Riboflavin                               | 1    |              | 1.7                     |

| Mol. form.                                                                   | Name               | Step | t/°C | pK <sub>a</sub> | Mol. form.                                                       | Name              | Step | t/°C | pK <sub>a</sub> |
|------------------------------------------------------------------------------|--------------------|------|------|-----------------|------------------------------------------------------------------|-------------------|------|------|-----------------|
|                                                                              |                    | 2    | 25   | 9.69            | C <sub>21</sub> H <sub>23</sub> ClFNO <sub>2</sub>               | Haloperidol       |      |      | 8.3             |
| C <sub>17</sub> H <sub>20</sub> O <sub>6</sub>                               | Mycophenolic acid  |      |      | 4.5             | C <sub>21</sub> H <sub>31</sub> NO <sub>4</sub>                  | Furethidine       |      |      | 7.48            |
| C <sub>17</sub> H <sub>23</sub> NO <sub>3</sub>                              | Hyoscyamine        |      | 21   | 9.7             | C <sub>21</sub> H <sub>35</sub> N <sub>3</sub> O <sub>7</sub>    | Lisinopril        | 1    |      | 2.5             |
| C <sub>17</sub> H <sub>27</sub> NO <sub>4</sub>                              | Nadolol            |      |      | 9.67            |                                                                  |                   | 2    |      | 4.0             |
| C <sub>18</sub> H <sub>19</sub> ClN <sub>4</sub>                             | Clozapine          | 1    |      | 3.70            |                                                                  |                   | 3    |      | 6.7             |
|                                                                              |                    | 2    |      | 7.60            |                                                                  |                   | 4    |      | 10.1            |
| C <sub>18</sub> H <sub>21</sub> NO <sub>3</sub>                              | Codeine            |      |      | 8.21            | C <sub>22</sub> H <sub>18</sub> O <sub>4</sub>                   | o-Cresolphthalein |      |      | 9.4             |
| C <sub>18</sub> H <sub>21</sub> N <sub>3</sub> O                             | Dibenzepin         |      |      | 8.25            | C <sub>22</sub> H <sub>22</sub> FN <sub>3</sub> O <sub>2</sub>   | Droperidol        |      |      | 7.64            |
| C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>                               | Linoleic acid      |      | 25   | 4.77            | C <sub>22</sub> H <sub>23</sub> NO <sub>7</sub>                  | Noscapine         |      |      | 7.8             |
| C <sub>18</sub> H <sub>33</sub> ClN <sub>2</sub> O <sub>5</sub> S            | Clindamycin        |      |      | 7.6             | C <sub>22</sub> H <sub>25</sub> NO <sub>6</sub>                  | Colchicine        |      | 20   | 12.36           |
| C <sub>18</sub> H <sub>39</sub> N                                            | Octadecylamine     |      | 25   | 10.60           | C <sub>22</sub> H <sub>25</sub> N <sub>3</sub> O                 | Benzpiperylon     | 1    |      | 6.73            |
| C <sub>19</sub> H <sub>10</sub> Br <sub>4</sub> O <sub>5</sub> S             | Bromophenol Blue   |      |      | 4.0             |                                                                  |                   | 2    |      | 9.13            |
| C <sub>19</sub> H <sub>14</sub> O <sub>5</sub> S                             | Phenol Red         |      |      | 7.9             | C <sub>22</sub> H <sub>33</sub> NO <sub>2</sub>                  | Atisine           |      |      | 12.2            |
| C <sub>19</sub> H <sub>16</sub> ClNO <sub>4</sub>                            | Indomethacin       |      |      | 4.5             | C <sub>23</sub> H <sub>26</sub> N <sub>2</sub> O <sub>4</sub>    | Brucine           | 1    |      | 6.04            |
| C <sub>19</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | Cephaloridine      |      |      | 3.2             |                                                                  |                   | 2    |      | 11.07           |
| C <sub>19</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub>                | Phenylbutazone     |      |      | 4.5             | C <sub>24</sub> H <sub>40</sub> O <sub>4</sub>                   | Deoxycholic acid  |      | 20   | 5.15            |
| C <sub>19</sub> H <sub>21</sub> N                                            | Protriptyline      |      |      | 8.2             | C <sub>24</sub> H <sub>40</sub> O <sub>5</sub>                   | Cholic acid       |      | 20   | 4.98            |
| C <sub>19</sub> H <sub>21</sub> NO <sub>3</sub>                              | Thebaine           |      | 15   | 6.05            | C <sub>25</sub> H <sub>29</sub> I <sub>2</sub> NO <sub>3</sub>   | Amiodarone        |      | 25   | 6.56            |
| C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> O                             | Cinchonine         | 1    |      | 5.85            | C <sub>25</sub> H <sub>41</sub> NO <sub>9</sub>                  | Aconine           |      |      | 9.52            |
|                                                                              |                    | 2    |      | 9.92            | C <sub>26</sub> H <sub>43</sub> NO <sub>6</sub>                  | Glycocholic acid  |      |      | 4.4             |
| C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> O                             | Cinchonidine       | 1    |      | 5.80            | C <sub>26</sub> H <sub>45</sub> NO <sub>7</sub> S                | Taurocholic acid  |      |      | 1.4             |
|                                                                              |                    | 2    |      | 10.03           | C <sub>27</sub> H <sub>28</sub> Br <sub>2</sub> O <sub>5</sub> S | Bromothymol Blue  |      |      | 7.0             |
| C <sub>19</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>                | Cupreine           |      |      | 6.57            | C <sub>27</sub> H <sub>38</sub> N <sub>2</sub> O <sub>4</sub>    | Verapamil         |      |      | 8.6             |
| C <sub>19</sub> H <sub>22</sub> O <sub>6</sub>                               | Gibberellic acid   |      |      | 4.0             | C <sub>29</sub> H <sub>32</sub> O <sub>13</sub>                  | Etoposide         |      |      | 9.8             |
| C <sub>19</sub> H <sub>23</sub> N <sub>3</sub> O <sub>2</sub>                | Ergometrinine      |      |      | 7.3             | C <sub>29</sub> H <sub>40</sub> N <sub>2</sub> O <sub>4</sub>    | Emetine           | 1    |      | 5.77            |
| C <sub>19</sub> H <sub>23</sub> N <sub>3</sub> O <sub>2</sub>                | Ergonovine         |      |      | 6.8             |                                                                  |                   | 2    |      | 6.64            |
| C <sub>20</sub> H <sub>14</sub> O <sub>4</sub>                               | Phenolphthalein    |      | 25   | 9.7             | C <sub>30</sub> H <sub>23</sub> BrO <sub>4</sub>                 | Bromadiolone      |      | 21   | 4.04            |
| C <sub>20</sub> H <sub>21</sub> NO <sub>4</sub>                              | Papaverine         |      |      | 6.4             | C <sub>30</sub> H <sub>48</sub> O <sub>3</sub>                   | Oleanolic acid    |      |      | 2.52            |
| C <sub>20</sub> H <sub>23</sub> N                                            | Amitriptyline      |      |      | 9.4             | C <sub>31</sub> H <sub>36</sub> N <sub>2</sub> O <sub>11</sub>   | Novobiocin        | 1    |      | 4.3             |
| C <sub>20</sub> H <sub>23</sub> N <sub>7</sub> O <sub>7</sub>                | Folinic acid       | 1    |      | 3.1             |                                                                  |                   | 2    |      | 9.1             |
|                                                                              |                    | 2    |      | 4.8             | C <sub>32</sub> H <sub>32</sub> O <sub>13</sub> S                | Teniposide        |      |      | 10.13           |
|                                                                              |                    | 3    |      | 10.4            | C <sub>33</sub> H <sub>40</sub> N <sub>2</sub> O <sub>9</sub>    | Reserpine         |      |      | 6.6             |
| C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>                | Quinine            | 1    | 25   | 8.52            | C <sub>34</sub> H <sub>47</sub> NO <sub>11</sub>                 | Aconitine         |      |      | 5.88            |
|                                                                              |                    | 2    | 25   | 4.13            | C <sub>36</sub> H <sub>51</sub> NO <sub>11</sub>                 | Veratridine       |      |      | 9.54            |
| C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>                | Quinidine          | 1    | 20   | 5.4             | C <sub>37</sub> H <sub>67</sub> NO <sub>13</sub>                 | Erythromycin      |      |      | 8.8             |
|                                                                              |                    | 2    | 20   | 10.0            | C <sub>43</sub> H <sub>58</sub> N <sub>4</sub> O <sub>12</sub>   | Rifampin          | 1    |      | 1.7             |
| C <sub>20</sub> H <sub>26</sub> N <sub>2</sub> O <sub>2</sub>                | Hydroquinine       |      |      | 5.33            |                                                                  |                   | 2    |      | 7.9             |
| C <sub>21</sub> H <sub>14</sub> Br <sub>4</sub> O <sub>5</sub> S             | Bromocresol Green  |      |      | 4.7             | C <sub>45</sub> H <sub>73</sub> NO <sub>15</sub>                 | Solanine          |      | 15   | 6.66            |
| C <sub>21</sub> H <sub>16</sub> Br <sub>2</sub> O <sub>5</sub> S             | Bromocresol Purple |      |      | 6.3             | C <sub>46</sub> H <sub>56</sub> N <sub>4</sub> O <sub>10</sub>   | Vincristine       |      |      | 5.4             |
| C <sub>21</sub> H <sub>18</sub> O <sub>5</sub> S                             | CresolRed          |      |      | 8.3             | C <sub>46</sub> H <sub>58</sub> N <sub>4</sub> O <sub>9</sub>    | Vinblastine       | 1    |      | 5.4             |
| C <sub>21</sub> H <sub>21</sub> NO <sub>6</sub>                              | Hydrastine         |      |      | 7.8             |                                                                  |                   | 2    |      | 7.4             |
| C <sub>21</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>                | Strychnine         |      | 25   | 8.26            |                                                                  |                   |      |      |                 |

# CONCENTRATIVE PROPERTIES OF AQUEOUS SOLUTIONS: DENSITY, REFRACTIVE INDEX, FREEZING POINT DEPRESSION, AND VISCOSITY

This table gives properties of aqueous solutions of 66 substances as a function of concentration. All data refer to a temperature of 20°C. The properties are:

Mass %: Mass of solute divided by total mass of solution, expressed as percent.

$m$  Molality (moles of solute per kg of water).

$c$  Molarity (moles of solute per liter of solution).

$\rho$  Density of solution in g/cm<sup>3</sup>.

$n$  Index of refraction, relative to air, at a wavelength of 589 nm (sodium D line); the index of pure water at 20°C is 1.3330.

$\Delta$  Freezing point depression in °C relative to pure water.

$\eta$  Absolute (dynamic) viscosity in mPa s (equal to centipoise, cP); the viscosity of pure water at 20°C is 1.002 mPa s.

Density data for aqueous solutions over a wider range of temperatures and pressures (and for other compounds) may be found in Reference 2. Solutes are listed in the following order:

|                                                     |                                |                                |
|-----------------------------------------------------|--------------------------------|--------------------------------|
| Acetic acid                                         | Lithium chloride               | 2-Propanol                     |
| Acetone                                             | Magnesium chloride             | Silver nitrate                 |
| Ammonia                                             | Magnesium sulfate              | Sodium acetate                 |
| Ammonium chloride                                   | Maltose                        | Sodium bicarbonate             |
| Ammonium sulfate                                    | Manganese(II) sulfate          | Sodium bromide                 |
| Barium chloride                                     | D-Mannitol                     | Sodium carbonate               |
| Calcium chloride                                    | Methanol                       | Sodium chloride                |
| Cesium chloride                                     | Nitric acid                    | Sodium citrate                 |
| Citric acid                                         | Oxalic acid                    | Sodium hydroxide               |
| Copper sulfate                                      | Phosphoric acid                | Sodium nitrate                 |
| Disodium ethylenediamine tetraacetate (EDTA sodium) | Potassium bicarbonate          | Sodium phosphate               |
| Ethanol                                             | Potassium bromide              | Sodium hydrogen phosphate      |
| Ethylene glycol                                     | Potassium carbonate            | Sodium dihydrogen phosphate    |
| Ferric chloride                                     | Potassium chloride             | Sodium sulfate                 |
| Formic acid                                         | Potassium hydroxide            | Sodium thiosulfate             |
| D-Fructose                                          | Potassium iodide               | Strontium chloride             |
| D-Glucose                                           | Potassium nitrate              | Sucrose                        |
| Glycerol                                            | Potassium permanganate         | Sulfuric acid                  |
| Hydrochloric acid                                   | Potassium hydrogen phosphate   | Trichloroacetic acid           |
| Lactic acid                                         | Potassium dihydrogen phosphate | Tris(hydroxymethyl)methylamine |
| Lactose                                             | Potassium sulfate              | Urea                           |
|                                                     | 1-Propanol                     | Zinc sulfate                   |

## References

1. Wolf, A. V., *Aqueous Solutions and Body Fluids*, Hoeber, 1966.
2. Söhnel, O., and Novotny, P., *Densities of Aqueous Solutions of Inorganic Substances*, Elsevier, Amsterdam, 1985.

| Solute               | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|----------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
| Acetic acid          | 0.5    | 0.084                  | 0.083                 | 0.9989                  | 1.3334 | 0.16                    | 1.012               |
| CH <sub>3</sub> COOH | 1.0    | 0.168                  | 0.166                 | 0.9996                  | 1.3337 | 0.32                    | 1.022               |
|                      | 2.0    | 0.340                  | 0.333                 | 1.0011                  | 1.3345 | 0.63                    | 1.042               |
|                      | 3.0    | 0.515                  | 0.501                 | 1.0025                  | 1.3352 | 0.94                    | 1.063               |
|                      | 4.0    | 0.694                  | 0.669                 | 1.0038                  | 1.3359 | 1.26                    | 1.084               |
|                      | 5.0    | 0.876                  | 0.837                 | 1.0052                  | 1.3366 | 1.58                    | 1.105               |
|                      | 6.0    | 1.063                  | 1.006                 | 1.0066                  | 1.3373 | 1.90                    | 1.125               |
|                      | 7.0    | 1.253                  | 1.175                 | 1.0080                  | 1.3381 | 2.23                    | 1.143               |
|                      | 8.0    | 1.448                  | 1.345                 | 1.0093                  | 1.3388 | 2.56                    | 1.162               |
|                      | 9.0    | 1.647                  | 1.515                 | 1.0107                  | 1.3395 | 2.89                    | 1.186               |
|                      | 10.0   | 1.850                  | 1.685                 | 1.0121                  | 1.3402 | 3.23                    | 1.210               |
|                      | 12.0   | 2.271                  | 2.028                 | 1.0147                  | 1.3416 | 3.91                    | 1.253               |
|                      | 14.0   | 2.711                  | 2.372                 | 1.0174                  | 1.3430 | 4.61                    | 1.298               |
|                      | 16.0   | 3.172                  | 2.718                 | 1.0200                  | 1.3444 | 5.33                    | 1.341               |
|                      | 18.0   | 3.655                  | 3.065                 | 1.0225                  | 1.3458 | 6.06                    | 1.380               |
|                      | 20.0   | 4.163                  | 3.414                 | 1.0250                  | 1.3472 | 6.81                    | 1.431               |
|                      | 22.0   | 4.697                  | 3.764                 | 1.0275                  | 1.3485 | 7.57                    | 1.478               |
|                      | 24.0   | 5.259                  | 4.116                 | 1.0299                  | 1.3498 | 8.36                    | 1.525               |



| Solute                                        | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-----------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                               | 26.0   | 5.851                  | 4.470                 | 1.0323                  | 1.3512 | 9.17                    | 1.572               |
|                                               | 28.0   | 6.476                  | 4.824                 | 1.0346                  | 1.3525 | 10.00                   | 1.613               |
|                                               | 30.0   | 7.137                  | 5.180                 | 1.0369                  | 1.3537 | 10.84                   | 1.669               |
|                                               | 32.0   | 7.837                  | 5.537                 | 1.0391                  | 1.3550 | 11.70                   | 1.715               |
|                                               | 34.0   | 8.579                  | 5.896                 | 1.0413                  | 1.3562 | 12.55                   | 1.762               |
|                                               | 36.0   | 9.367                  | 6.255                 | 1.0434                  | 1.3574 | 13.38                   | 1.812               |
|                                               | 38.0   | 10.207                 | 6.615                 | 1.0454                  | 1.3586 |                         | 1.852               |
|                                               | 40.0   | 11.102                 | 6.977                 | 1.0474                  | 1.3598 |                         | 1.912               |
|                                               | 50.0   | 16.653                 | 8.794                 | 1.0562                  | 1.3653 |                         | 2.158               |
|                                               | 60.0   | 24.979                 | 10.620                | 1.0629                  | 1.3700 |                         | 2.409               |
|                                               | 70.0   | 38.857                 | 12.441                | 1.0673                  | 1.3738 |                         | 2.629               |
|                                               | 80.0   | 66.611                 | 14.228                | 1.0680                  | 1.3767 |                         | 2.720               |
|                                               | 90.0   | 149.875                | 15.953                | 1.0644                  | 1.3771 |                         | 2.386               |
|                                               | 92.0   | 191.507                | 16.284                | 1.0629                  | 1.3766 |                         | 2.240               |
|                                               | 94.0   | 260.894                | 16.602                | 1.0606                  | 1.3759 |                         | 2.036               |
|                                               | 96.0   | 399.667                | 16.911                | 1.0578                  | 1.3748 |                         | 1.813               |
|                                               | 98.0   | 815.987                | 17.198                | 1.0538                  | 1.3734 |                         | 1.535               |
|                                               | 100.0  |                        | 17.447                | 1.0477                  | 1.3716 |                         | 1.223               |
| Acetone<br>(CH <sub>3</sub> ) <sub>2</sub> CO | 0.5    | 0.087                  | 0.086                 | 0.9975                  | 1.3334 | 0.16                    | 1.013               |
|                                               | 1.0    | 0.174                  | 0.172                 | 0.9968                  | 1.3337 | 0.32                    | 1.024               |
|                                               | 2.0    | 0.351                  | 0.343                 | 0.9954                  | 1.3344 | 0.65                    | 1.047               |
|                                               | 3.0    | 0.533                  | 0.513                 | 0.9940                  | 1.3352 | 0.97                    | 1.072               |
|                                               | 4.0    | 0.717                  | 0.684                 | 0.9926                  | 1.3359 | 1.30                    | 1.099               |
|                                               | 5.0    | 0.906                  | 0.853                 | 0.9912                  | 1.3366 | 1.63                    | 1.125               |
|                                               | 6.0    | 1.099                  | 1.023                 | 0.9899                  | 1.3373 | 1.96                    | 1.150               |
|                                               | 7.0    | 1.296                  | 1.191                 | 0.9886                  | 1.3381 | 2.29                    | 1.174               |
|                                               | 8.0    | 1.497                  | 1.360                 | 0.9874                  | 1.3388 | 2.62                    | 1.198               |
|                                               | 9.0    | 1.703                  | 1.528                 | 0.9861                  | 1.3395 | 2.95                    | 1.221               |
|                                               | 10.0   | 1.913                  | 1.696                 | 0.9849                  | 1.3402 | 3.29                    | 1.244               |
| Ammonia<br>NH <sub>3</sub>                    | 0.5    | 0.295                  | 0.292                 | 0.9960                  | 1.3332 | 0.55                    | 1.009               |
|                                               | 1.0    | 0.593                  | 0.584                 | 0.9938                  | 1.3335 | 1.14                    | 1.015               |
|                                               | 2.0    | 1.198                  | 1.162                 | 0.9895                  | 1.3339 | 2.32                    | 1.029               |
|                                               | 3.0    | 1.816                  | 1.736                 | 0.9853                  | 1.3344 | 3.53                    | 1.043               |
|                                               | 4.0    | 2.447                  | 2.304                 | 0.9811                  | 1.3349 | 4.78                    | 1.057               |
|                                               | 5.0    | 3.090                  | 2.868                 | 0.9770                  | 1.3354 | 6.08                    | 1.071               |
|                                               | 6.0    | 3.748                  | 3.428                 | 0.9730                  | 1.3359 | 7.43                    | 1.085               |
|                                               | 7.0    | 4.420                  | 3.983                 | 0.9690                  | 1.3365 | 8.95                    | 1.099               |
|                                               | 8.0    | 5.106                  | 4.533                 | 0.9651                  | 1.3370 | 10.34                   | 1.113               |
|                                               | 9.0    | 5.807                  | 5.080                 | 0.9613                  | 1.3376 | 11.90                   | 1.127               |
|                                               | 10.0   | 6.524                  | 5.622                 | 0.9575                  | 1.3381 | 13.55                   | 1.141               |
|                                               | 12.0   | 8.007                  | 6.695                 | 0.9502                  | 1.3393 | 17.13                   | 1.169               |
|                                               | 14.0   | 9.558                  | 7.753                 | 0.9431                  | 1.3404 | 21.13                   | 1.195               |
|                                               | 16.0   | 11.184                 | 8.794                 | 0.9361                  | 1.3416 | 25.63                   | 1.218               |
|                                               | 18.0   | 12.889                 | 9.823                 | 0.9294                  | 1.3428 | 30.70                   | 1.237               |
|                                               | 20.0   | 14.679                 | 10.837                | 0.9228                  | 1.3440 | 36.42                   | 1.254               |
|                                               | 22.0   | 16.561                 | 11.838                | 0.9164                  | 1.3453 | 43.36                   | 1.268               |
|                                               | 24.0   | 18.542                 | 12.826                | 0.9102                  | 1.3465 | 51.38                   | 1.280               |
|                                               | 26.0   | 20.630                 | 13.801                | 0.9040                  | 1.3477 | 60.77                   | 1.288               |
|                                               | 28.0   | 22.834                 | 14.764                | 0.8980                  | 1.3490 | 71.66                   |                     |
|                                               | 30.0   | 25.164                 | 15.713                | 0.8920                  | 1.3502 | 84.06                   |                     |
| Ammonium<br>chloride<br>NH <sub>4</sub> Cl    | 0.5    | 0.094                  | 0.093                 | 0.9998                  | 1.3340 | 0.32                    | 0.999               |
|                                               | 1.0    | 0.189                  | 0.187                 | 1.0014                  | 1.3349 | 0.64                    | 0.996               |
|                                               | 2.0    | 0.382                  | 0.376                 | 1.0045                  | 1.3369 | 1.27                    | 0.992               |
|                                               | 3.0    | 0.578                  | 0.565                 | 1.0076                  | 1.3388 | 1.91                    | 0.988               |
|                                               | 4.0    | 0.779                  | 0.756                 | 1.0107                  | 1.3407 | 2.57                    | 0.985               |
|                                               | 5.0    | 0.984                  | 0.948                 | 1.0138                  | 1.3426 | 3.25                    | 0.982               |
|                                               | 6.0    | 1.193                  | 1.141                 | 1.0168                  | 1.3445 | 3.94                    | 0.979               |
|                                               | 7.0    | 1.407                  | 1.335                 | 1.0198                  | 1.3464 | 4.66                    | 0.976               |

| Solute                                                                 | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                                        | 8.0    | 1.626                  | 1.529                 | 1.0227                  | 1.3483 | 5.40                    | 0.974               |
|                                                                        | 9.0    | 1.849                  | 1.726                 | 1.0257                  | 1.3502 | 6.16                    | 0.972               |
|                                                                        | 10.0   | 2.077                  | 1.923                 | 1.0286                  | 1.3521 | 6.95                    | 0.970               |
|                                                                        | 12.0   | 2.549                  | 2.320                 | 1.0344                  | 1.3559 | 8.60                    | 0.969               |
|                                                                        | 14.0   | 3.043                  | 2.722                 | 1.0401                  | 1.3596 |                         | 0.969               |
|                                                                        | 16.0   | 3.561                  | 3.128                 | 1.0457                  | 1.3634 |                         | 0.971               |
|                                                                        | 18.0   | 4.104                  | 3.537                 | 1.0512                  | 1.3671 |                         | 0.973               |
|                                                                        | 20.0   | 4.674                  | 3.951                 | 1.0567                  | 1.3708 |                         | 0.978               |
|                                                                        | 22.0   | 5.273                  | 4.368                 | 1.0621                  | 1.3745 |                         | 0.986               |
|                                                                        | 24.0   | 5.903                  | 4.789                 | 1.0674                  | 1.3782 |                         | 0.996               |
| Ammonium<br>sulfate<br>(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 0.5    | 0.038                  | 0.038                 | 1.0012                  | 1.3338 | 0.17                    | 1.008               |
|                                                                        | 1.0    | 0.076                  | 0.076                 | 1.0042                  | 1.3346 | 0.33                    | 1.014               |
|                                                                        | 2.0    | 0.154                  | 0.153                 | 1.0101                  | 1.3363 | 0.63                    | 1.027               |
|                                                                        | 3.0    | 0.234                  | 0.231                 | 1.0160                  | 1.3379 | 0.92                    | 1.041               |
|                                                                        | 4.0    | 0.315                  | 0.309                 | 1.0220                  | 1.3395 | 1.21                    | 1.057               |
|                                                                        | 5.0    | 0.398                  | 0.389                 | 1.0279                  | 1.3411 | 1.49                    | 1.073               |
|                                                                        | 6.0    | 0.483                  | 0.469                 | 1.0338                  | 1.3428 | 1.77                    | 1.090               |
|                                                                        | 7.0    | 0.570                  | 0.551                 | 1.0397                  | 1.3444 | 2.05                    | 1.108               |
|                                                                        | 8.0    | 0.658                  | 0.633                 | 1.0456                  | 1.3460 | 2.33                    | 1.127               |
|                                                                        | 9.0    | 0.748                  | 0.716                 | 1.0515                  | 1.3476 | 2.61                    | 1.147               |
|                                                                        | 10.0   | 0.841                  | 0.800                 | 1.0574                  | 1.3492 | 2.89                    | 1.168               |
|                                                                        | 12.0   | 1.032                  | 0.971                 | 1.0691                  | 1.3523 | 3.47                    | 1.210               |
|                                                                        | 14.0   | 1.232                  | 1.145                 | 1.0808                  | 1.3555 | 4.07                    | 1.256               |
|                                                                        | 16.0   | 1.441                  | 1.323                 | 1.0924                  | 1.3586 | 4.69                    | 1.305               |
|                                                                        | 18.0   | 1.661                  | 1.504                 | 1.1039                  | 1.3616 |                         | 1.359               |
|                                                                        | 20.0   | 1.892                  | 1.688                 | 1.1154                  | 1.3647 |                         | 1.421               |
|                                                                        | 22.0   | 2.134                  | 1.876                 | 1.1269                  | 1.3677 |                         | 1.490               |
|                                                                        | 24.0   | 2.390                  | 2.067                 | 1.1383                  | 1.3707 |                         | 1.566               |
|                                                                        | 26.0   | 2.659                  | 2.262                 | 1.1496                  | 1.3737 |                         | 1.650               |
|                                                                        | 28.0   | 2.943                  | 2.460                 | 1.1609                  | 1.3766 |                         | 1.743               |
|                                                                        | 30.0   | 3.243                  | 2.661                 | 1.1721                  | 1.3795 |                         | 1.847               |
|                                                                        | 32.0   | 3.561                  | 2.866                 | 1.1833                  | 1.3824 |                         | 1.961               |
|                                                                        | 34.0   | 3.898                  | 3.073                 | 1.1945                  | 1.3853 |                         | 2.086               |
|                                                                        | 36.0   | 4.257                  | 3.284                 | 1.2056                  | 1.3881 |                         | 2.222               |
|                                                                        | 38.0   | 4.638                  | 3.499                 | 1.2166                  | 1.3909 |                         | 2.371               |
|                                                                        | 40.0   | 5.045                  | 3.716                 | 1.2277                  | 1.3938 |                         | 2.530               |
| Barium<br>chloride<br>BaCl <sub>2</sub>                                | 0.5    | 0.024                  | 0.024                 | 1.0026                  | 1.3337 | 0.12                    | 1.009               |
|                                                                        | 1.0    | 0.049                  | 0.048                 | 1.0070                  | 1.3345 | 0.23                    | 1.016               |
|                                                                        | 2.0    | 0.098                  | 0.098                 | 1.0159                  | 1.3360 | 0.46                    | 1.026               |
|                                                                        | 3.0    | 0.149                  | 0.148                 | 1.0249                  | 1.3375 | 0.69                    | 1.037               |
|                                                                        | 4.0    | 0.200                  | 0.199                 | 1.0341                  | 1.3391 | 0.93                    | 1.049               |
|                                                                        | 5.0    | 0.253                  | 0.251                 | 1.0434                  | 1.3406 | 1.18                    | 1.062               |
|                                                                        | 6.0    | 0.307                  | 0.303                 | 1.0528                  | 1.3422 | 1.44                    | 1.075               |
|                                                                        | 7.0    | 0.361                  | 0.357                 | 1.0624                  | 1.3438 | 1.70                    | 1.087               |
|                                                                        | 8.0    | 0.418                  | 0.412                 | 1.0721                  | 1.3454 | 1.98                    | 1.101               |
|                                                                        | 9.0    | 0.475                  | 0.468                 | 1.0820                  | 1.3470 | 2.27                    | 1.114               |
|                                                                        | 10.0   | 0.534                  | 0.524                 | 1.0921                  | 1.3487 | 2.58                    | 1.129               |
|                                                                        | 12.0   | 0.655                  | 0.641                 | 1.1128                  | 1.3520 | 3.22                    | 1.161               |
|                                                                        | 14.0   | 0.782                  | 0.763                 | 1.1342                  | 1.3555 | 3.92                    | 1.195               |
|                                                                        | 16.0   | 0.915                  | 0.889                 | 1.1564                  | 1.3591 | 4.69                    | 1.234               |
|                                                                        | 18.0   | 1.054                  | 1.019                 | 1.1793                  | 1.3627 |                         | 1.277               |
|                                                                        | 20.0   | 1.201                  | 1.156                 | 1.2031                  | 1.3664 |                         | 1.325               |
|                                                                        | 22.0   | 1.355                  | 1.297                 | 1.2277                  | 1.3703 |                         | 1.378               |
|                                                                        | 24.0   | 1.517                  | 1.444                 | 1.2531                  | 1.3741 |                         | 1.437               |
|                                                                        | 26.0   | 1.687                  | 1.597                 | 1.2793                  | 1.3781 |                         | 1.503               |
| Calcium<br>chloride<br>CaCl <sub>2</sub>                               | 0.5    | 0.045                  | 0.045                 | 1.0024                  | 1.3342 | 0.22                    | 1.015               |
|                                                                        | 1.0    | 0.091                  | 0.091                 | 1.0065                  | 1.3354 | 0.44                    | 1.028               |
|                                                                        | 2.0    | 0.184                  | 0.183                 | 1.0148                  | 1.3378 | 0.88                    | 1.050               |

| Solute                                  | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-----------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                         | 3.0    | 0.279                  | 0.277                 | 1.0232                  | 1.3402 | 1.33                    | 1.078               |
|                                         | 4.0    | 0.375                  | 0.372                 | 1.0316                  | 1.3426 | 1.82                    | 1.110               |
|                                         | 5.0    | 0.474                  | 0.469                 | 1.0401                  | 1.3451 | 2.35                    | 1.143               |
|                                         | 6.0    | 0.575                  | 0.567                 | 1.0486                  | 1.3475 | 2.93                    | 1.175               |
|                                         | 7.0    | 0.678                  | 0.667                 | 1.0572                  | 1.3500 | 3.57                    | 1.208               |
|                                         | 8.0    | 0.784                  | 0.768                 | 1.0659                  | 1.3525 | 4.28                    | 1.242               |
|                                         | 9.0    | 0.891                  | 0.872                 | 1.0747                  | 1.3549 | 5.04                    | 1.279               |
|                                         | 10.0   | 1.001                  | 0.976                 | 1.0835                  | 1.3575 | 5.86                    | 1.319               |
|                                         | 12.0   | 1.229                  | 1.191                 | 1.1014                  | 1.3625 | 7.70                    | 1.408               |
|                                         | 14.0   | 1.467                  | 1.413                 | 1.1198                  | 1.3677 | 9.83                    | 1.508               |
|                                         | 16.0   | 1.716                  | 1.641                 | 1.1386                  | 1.3730 | 12.28                   | 1.625               |
|                                         | 18.0   | 1.978                  | 1.878                 | 1.1579                  | 1.3784 | 15.11                   | 1.764               |
|                                         | 20.0   | 2.253                  | 2.122                 | 1.1775                  | 1.3839 | 18.30                   | 1.930               |
|                                         | 22.0   | 2.541                  | 2.374                 | 1.1976                  | 1.3895 | 21.70                   | 2.127               |
|                                         | 24.0   | 2.845                  | 2.634                 | 1.2180                  | 1.3951 | 25.30                   | 2.356               |
|                                         | 26.0   | 3.166                  | 2.902                 | 1.2388                  | 1.4008 | 29.70                   | 2.645               |
|                                         | 28.0   | 3.504                  | 3.179                 | 1.2600                  | 1.4066 | 34.70                   | 3.000               |
|                                         | 30.0   | 3.862                  | 3.464                 | 1.2816                  | 1.4124 | 41.00                   | 3.467               |
|                                         | 32.0   | 4.240                  | 3.759                 | 1.3036                  | 1.4183 | 49.70                   | 4.035               |
|                                         | 34.0   | 4.642                  | 4.062                 | 1.3260                  | 1.4242 |                         | 4.820               |
|                                         | 36.0   | 5.068                  | 4.375                 | 1.3488                  | 1.4301 |                         | 5.807               |
|                                         | 38.0   | 5.522                  | 4.698                 | 1.3720                  | 1.4361 |                         | 7.321               |
|                                         | 40.0   | 6.007                  | 5.030                 | 1.3957                  | 1.4420 |                         | 8.997               |
| Cesium<br>chloride<br>CsCl              | 0.5    | 0.030                  | 0.030                 | 1.0020                  | 1.3334 | 0.10                    | 1.000               |
|                                         | 1.0    | 0.060                  | 0.060                 | 1.0058                  | 1.3337 | 0.20                    | 0.997               |
|                                         | 2.0    | 0.121                  | 0.120                 | 1.0135                  | 1.3345 | 0.40                    | 0.992               |
|                                         | 3.0    | 0.184                  | 0.182                 | 1.0214                  | 1.3353 | 0.61                    | 0.988               |
|                                         | 4.0    | 0.247                  | 0.245                 | 1.0293                  | 1.3361 | 0.81                    | 0.984               |
|                                         | 5.0    | 0.313                  | 0.308                 | 1.0374                  | 1.3369 | 1.02                    | 0.980               |
|                                         | 6.0    | 0.379                  | 0.373                 | 1.0456                  | 1.3377 | 1.22                    | 0.977               |
|                                         | 7.0    | 0.447                  | 0.438                 | 1.0540                  | 1.3386 | 1.43                    | 0.974               |
|                                         | 8.0    | 0.516                  | 0.505                 | 1.0625                  | 1.3394 | 1.64                    | 0.971               |
|                                         | 9.0    | 0.587                  | 0.573                 | 1.0711                  | 1.3403 | 1.85                    | 0.969               |
|                                         | 10.0   | 0.660                  | 0.641                 | 1.0798                  | 1.3412 | 2.06                    | 0.966               |
|                                         | 12.0   | 0.810                  | 0.782                 | 1.0978                  | 1.3430 | 2.51                    | 0.961               |
|                                         | 14.0   | 0.967                  | 0.928                 | 1.1163                  | 1.3448 | 2.97                    | 0.955               |
|                                         | 16.0   | 1.131                  | 1.079                 | 1.1355                  | 1.3468 | 3.46                    | 0.950               |
|                                         | 18.0   | 1.304                  | 1.235                 | 1.1552                  | 1.3487 | 3.96                    | 0.945               |
|                                         | 20.0   | 1.485                  | 1.397                 | 1.1756                  | 1.3507 | 4.49                    | 0.939               |
|                                         | 22.0   | 1.675                  | 1.564                 | 1.1967                  | 1.3528 |                         | 0.934               |
|                                         | 24.0   | 1.876                  | 1.737                 | 1.2185                  | 1.3550 |                         | 0.930               |
|                                         | 26.0   | 2.087                  | 1.917                 | 1.2411                  | 1.3572 |                         | 0.926               |
|                                         | 28.0   | 2.310                  | 2.103                 | 1.2644                  | 1.3594 |                         | 0.924               |
|                                         | 30.0   | 2.546                  | 2.296                 | 1.2885                  | 1.3617 |                         | 0.922               |
|                                         | 32.0   | 2.795                  | 2.497                 | 1.3135                  | 1.3641 |                         | 0.922               |
|                                         | 34.0   | 3.060                  | 2.705                 | 1.3393                  | 1.3666 |                         | 0.924               |
|                                         | 36.0   | 3.341                  | 2.921                 | 1.3661                  | 1.3691 |                         | 0.926               |
|                                         | 38.0   | 3.640                  | 3.146                 | 1.3938                  | 1.3717 |                         | 0.930               |
|                                         | 40.0   | 3.960                  | 3.380                 | 1.4226                  | 1.3744 |                         | 0.934               |
|                                         | 42.0   | 4.301                  | 3.624                 | 1.4525                  | 1.3771 |                         | 0.940               |
|                                         | 44.0   | 4.667                  | 3.877                 | 1.4835                  | 1.3800 |                         | 0.947               |
|                                         | 46.0   | 5.060                  | 4.142                 | 1.5158                  | 1.3829 |                         | 0.956               |
|                                         | 48.0   | 5.483                  | 4.418                 | 1.5495                  | 1.3860 |                         | 0.967               |
|                                         | 50.0   | 5.940                  | 4.706                 | 1.5846                  | 1.3892 |                         | 0.981               |
|                                         | 60.0   | 8.910                  | 6.368                 | 1.7868                  | 1.4076 |                         | 1.120               |
|                                         | 64.0   | 10.560                 | 7.163                 | 1.8842                  | 1.4167 |                         | 1.238               |
| Citric acid<br>(HO)C(COOH) <sub>3</sub> | 0.5    | 0.026                  | 0.026                 | 1.0002                  | 1.3336 | 0.05                    | 1.013               |
|                                         | 1.0    | 0.053                  | 0.052                 | 1.0022                  | 1.3343 | 0.11                    | 1.024               |
|                                         | 2.0    | 0.106                  | 0.105                 | 1.0063                  | 1.3356 | 0.21                    | 1.048               |

| Solute                                                      | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-------------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                             | 3.0    | 0.161                  | 0.158                 | 1.0105                  | 1.3368 | 0.32                    | 1.073               |
|                                                             | 4.0    | 0.217                  | 0.211                 | 1.0147                  | 1.3381 | 0.43                    | 1.098               |
|                                                             | 5.0    | 0.274                  | 0.265                 | 1.0189                  | 1.3394 | 0.54                    | 1.125               |
|                                                             | 6.0    | 0.332                  | 0.320                 | 1.0232                  | 1.3407 | 0.65                    | 1.153               |
|                                                             | 7.0    | 0.392                  | 0.374                 | 1.0274                  | 1.3420 | 0.76                    | 1.183               |
|                                                             | 8.0    | 0.453                  | 0.430                 | 1.0316                  | 1.3433 | 0.88                    | 1.214               |
|                                                             | 9.0    | 0.515                  | 0.485                 | 1.0359                  | 1.3446 | 1.00                    | 1.247               |
|                                                             | 10.0   | 0.578                  | 0.541                 | 1.0402                  | 1.3459 | 1.12                    | 1.283               |
|                                                             | 12.0   | 0.710                  | 0.655                 | 1.0490                  | 1.3486 | 1.38                    | 1.357               |
|                                                             | 14.0   | 0.847                  | 0.771                 | 1.0580                  | 1.3514 | 1.66                    | 1.436               |
|                                                             | 16.0   | 0.991                  | 0.889                 | 1.0672                  | 1.3541 | 1.95                    | 1.525               |
|                                                             | 18.0   | 1.143                  | 1.008                 | 1.0764                  | 1.3569 | 2.26                    | 1.625               |
|                                                             | 20.0   | 1.301                  | 1.130                 | 1.0858                  | 1.3598 | 2.57                    | 1.740               |
|                                                             | 22.0   | 1.468                  | 1.254                 | 1.0953                  | 1.3626 | 2.88                    | 1.872               |
|                                                             | 24.0   | 1.644                  | 1.380                 | 1.1049                  | 1.3655 | 3.21                    | 2.017               |
|                                                             | 26.0   | 1.829                  | 1.508                 | 1.1147                  | 1.3684 | 3.55                    | 2.178               |
|                                                             | 28.0   | 2.024                  | 1.639                 | 1.1246                  | 1.3714 | 3.89                    | 2.356               |
|                                                             | 30.0   | 2.231                  | 1.772                 | 1.1346                  | 1.3744 | 4.25                    | 2.549               |
| Copper sulfate                                              | 0.5    | 0.031                  | 0.031                 | 1.0033                  | 1.3339 | 0.08                    | 1.017               |
| $\text{CuSO}_4$                                             | 1.0    | 0.063                  | 0.063                 | 1.0085                  | 1.3348 | 0.14                    | 1.036               |
|                                                             | 2.0    | 0.128                  | 0.128                 | 1.0190                  | 1.3367 | 0.26                    | 1.084               |
|                                                             | 3.0    | 0.194                  | 0.194                 | 1.0296                  | 1.3386 | 0.37                    | 1.129               |
|                                                             | 4.0    | 0.261                  | 0.261                 | 1.0403                  | 1.3405 | 0.48                    | 1.173               |
|                                                             | 5.0    | 0.330                  | 0.329                 | 1.0511                  | 1.3424 | 0.59                    | 1.221               |
|                                                             | 6.0    | 0.400                  | 0.399                 | 1.0620                  | 1.3443 | 0.70                    | 1.276               |
|                                                             | 7.0    | 0.472                  | 0.471                 | 1.0730                  | 1.3462 | 0.82                    | 1.336               |
|                                                             | 8.0    | 0.545                  | 0.543                 | 1.0842                  | 1.3481 | 0.93                    | 1.400               |
|                                                             | 9.0    | 0.620                  | 0.618                 | 1.0955                  | 1.3501 | 1.05                    | 1.469               |
|                                                             | 10.0   | 0.696                  | 0.694                 | 1.1070                  | 1.3520 | 1.18                    | 1.543               |
|                                                             | 12.0   | 0.854                  | 0.850                 | 1.1304                  | 1.3560 | 1.45                    | 1.701               |
|                                                             | 14.0   | 1.020                  | 1.013                 | 1.1545                  | 1.3601 | 1.75                    | 1.889               |
|                                                             | 16.0   | 1.193                  | 1.182                 | 1.1796                  | 1.3644 |                         | 2.136               |
|                                                             | 18.0   | 1.375                  | 1.360                 | 1.2059                  | 1.3689 |                         | 2.449               |
| Disodium ethylenediamine tetraacetate (EDTA sodium)         | 0.5    | 0.015                  | 0.015                 | 1.0009                  | 1.3339 | 0.07                    | 1.017               |
| $\text{Na}_2\text{C}_{10}\text{H}_{14}\text{N}_2\text{O}_8$ | 1.0    | 0.030                  | 0.030                 | 1.0036                  | 1.3348 | 0.14                    | 1.032               |
|                                                             | 1.5    | 0.045                  | 0.045                 | 1.0062                  | 1.3356 | 0.21                    | 1.046               |
|                                                             | 2.0    | 0.061                  | 0.060                 | 1.0089                  | 1.3365 | 0.27                    | 1.062               |
|                                                             | 2.5    | 0.076                  | 0.075                 | 1.0115                  | 1.3374 | 0.33                    | 1.077               |
|                                                             | 3.0    | 0.092                  | 0.090                 | 1.0142                  | 1.3383 | 0.40                    | 1.093               |
|                                                             | 3.5    | 0.108                  | 0.106                 | 1.0169                  | 1.3392 | 0.46                    | 1.109               |
|                                                             | 4.0    | 0.124                  | 0.121                 | 1.0196                  | 1.3400 | 0.52                    | 1.125               |
|                                                             | 4.5    | 0.140                  | 0.137                 | 1.0223                  | 1.3409 | 0.58                    | 1.142               |
|                                                             | 5.0    | 0.157                  | 0.152                 | 1.0250                  | 1.3418 | 0.65                    | 1.160               |
|                                                             | 5.5    | 0.173                  | 0.168                 | 1.0277                  | 1.3427 | 0.71                    | 1.178               |
|                                                             | 6.0    | 0.190                  | 0.184                 | 1.0305                  | 1.3436 | 0.77                    | 1.197               |
| Ethanol                                                     | 0.5    | 0.109                  | 0.108                 | 0.9973                  | 1.3333 | 0.20                    | 1.023               |
| $\text{CH}_3\text{CH}_2\text{OH}$                           | 1.0    | 0.219                  | 0.216                 | 0.9963                  | 1.3336 | 0.40                    | 1.046               |
|                                                             | 2.0    | 0.443                  | 0.432                 | 0.9945                  | 1.3342 | 0.81                    | 1.095               |
|                                                             | 3.0    | 0.671                  | 0.646                 | 0.9927                  | 1.3348 | 1.23                    | 1.140               |
|                                                             | 4.0    | 0.904                  | 0.860                 | 0.9910                  | 1.3354 | 1.65                    | 1.183               |
|                                                             | 5.0    | 1.142                  | 1.074                 | 0.9893                  | 1.3360 | 2.09                    | 1.228               |
|                                                             | 6.0    | 1.385                  | 1.286                 | 0.9878                  | 1.3367 | 2.54                    | 1.279               |
|                                                             | 7.0    | 1.634                  | 1.498                 | 0.9862                  | 1.3374 | 2.99                    | 1.331               |
|                                                             | 8.0    | 1.887                  | 1.710                 | 0.9847                  | 1.3381 | 3.47                    | 1.385               |
|                                                             | 9.0    | 2.147                  | 1.921                 | 0.9833                  | 1.3388 | 3.96                    | 1.442               |
|                                                             | 10.0   | 2.412                  | 2.131                 | 0.9819                  | 1.3395 | 4.47                    | 1.501               |
|                                                             | 12.0   | 2.960                  | 2.551                 | 0.9792                  | 1.3410 | 5.56                    | 1.627               |
|                                                             | 14.0   | 3.534                  | 2.967                 | 0.9765                  | 1.3425 | 6.73                    | 1.761               |

| Solute                                               | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                      | 16.0   | 4.134                  | 3.382                 | 0.9739                  | 1.3440 | 8.01                    | 1.890               |
|                                                      | 18.0   | 4.765                  | 3.795                 | 0.9713                  | 1.3455 | 9.40                    | 2.019               |
|                                                      | 20.0   | 5.427                  | 4.205                 | 0.9687                  | 1.3469 | 10.92                   | 2.142               |
|                                                      | 22.0   | 6.122                  | 4.613                 | 0.9660                  | 1.3484 | 12.60                   | 2.259               |
|                                                      | 24.0   | 6.855                  | 5.018                 | 0.9632                  | 1.3498 | 14.47                   | 2.370               |
|                                                      | 26.0   | 7.626                  | 5.419                 | 0.9602                  | 1.3511 | 16.41                   | 2.476               |
|                                                      | 28.0   | 8.441                  | 5.817                 | 0.9571                  | 1.3524 | 18.43                   | 2.581               |
|                                                      | 30.0   | 9.303                  | 6.212                 | 0.9539                  | 1.3535 | 20.47                   | 2.667               |
|                                                      | 32.0   | 10.215                 | 6.601                 | 0.9504                  | 1.3546 | 22.44                   | 2.726               |
|                                                      | 34.0   | 11.182                 | 6.987                 | 0.9468                  | 1.3557 | 24.27                   | 2.768               |
|                                                      | 36.0   | 12.210                 | 7.370                 | 0.9431                  | 1.3566 | 25.98                   | 2.803               |
|                                                      | 38.0   | 13.304                 | 7.747                 | 0.9392                  | 1.3575 | 27.62                   | 2.829               |
|                                                      | 40.0   | 14.471                 | 8.120                 | 0.9352                  | 1.3583 | 29.26                   | 2.846               |
|                                                      | 42.0   | 15.718                 | 8.488                 | 0.9311                  | 1.3590 | 30.98                   | 2.852               |
|                                                      | 44.0   | 17.055                 | 8.853                 | 0.9269                  | 1.3598 | 32.68                   | 2.850               |
|                                                      | 46.0   | 18.490                 | 9.213                 | 0.9227                  | 1.3604 | 34.36                   | 2.843               |
|                                                      | 48.0   | 20.036                 | 9.568                 | 0.9183                  | 1.3610 | 36.04                   | 2.832               |
|                                                      | 50.0   | 21.706                 | 9.919                 | 0.9139                  | 1.3616 | 37.67                   | 2.813               |
|                                                      | 60.0   | 32.559                 | 11.605                | 0.8911                  | 1.3638 | 44.93                   | 2.547               |
|                                                      | 70.0   | 50.648                 | 13.183                | 0.8676                  | 1.3652 |                         | 2.214               |
|                                                      | 80.0   | 86.824                 | 14.649                | 0.8436                  | 1.3658 |                         | 1.881               |
|                                                      | 90.0   | 195.355                | 15.980                | 0.8180                  | 1.3650 |                         | 1.542               |
|                                                      | 92.0   | 249.620                | 16.225                | 0.8125                  | 1.3646 |                         | 1.475               |
|                                                      | 94.0   | 340.062                | 16.466                | 0.8070                  | 1.3642 |                         | 1.407               |
|                                                      | 96.0   | 520.946                | 16.697                | 0.8013                  | 1.3636 |                         | 1.342               |
|                                                      | 98.0   |                        | 16.920                | 0.7954                  | 1.3630 |                         | 1.273               |
|                                                      | 100.0  |                        | 17.133                | 0.7893                  | 1.3614 |                         | 1.203               |
| Ethylene glycol<br>(CH <sub>2</sub> OH) <sub>2</sub> | 0.5    | 0.081                  | 0.080                 | 0.9988                  | 1.3335 | 0.15                    | 1.010               |
|                                                      | 1.0    | 0.163                  | 0.161                 | 0.9995                  | 1.3339 | 0.30                    | 1.020               |
|                                                      | 2.0    | 0.329                  | 0.322                 | 1.0007                  | 1.3348 | 0.61                    | 1.048               |
|                                                      | 3.0    | 0.498                  | 0.484                 | 1.0019                  | 1.3358 | 0.92                    | 1.074               |
|                                                      | 4.0    | 0.671                  | 0.646                 | 1.0032                  | 1.3367 | 1.24                    | 1.099               |
|                                                      | 5.0    | 0.848                  | 0.809                 | 1.0044                  | 1.3377 | 1.58                    | 1.125               |
|                                                      | 6.0    | 1.028                  | 0.972                 | 1.0057                  | 1.3386 | 1.91                    | 1.153               |
|                                                      | 7.0    | 1.213                  | 1.136                 | 1.0070                  | 1.3396 | 2.26                    | 1.182               |
|                                                      | 8.0    | 1.401                  | 1.299                 | 1.0082                  | 1.3405 | 2.62                    | 1.212               |
|                                                      | 9.0    | 1.593                  | 1.464                 | 1.0095                  | 1.3415 | 2.99                    | 1.243               |
|                                                      | 10.0   | 1.790                  | 1.628                 | 1.0108                  | 1.3425 | 3.37                    | 1.277               |
|                                                      | 12.0   | 2.197                  | 1.959                 | 1.0134                  | 1.3444 | 4.16                    | 1.348               |
|                                                      | 14.0   | 2.623                  | 2.292                 | 1.0161                  | 1.3464 | 5.01                    | 1.424               |
|                                                      | 16.0   | 3.069                  | 2.626                 | 1.0188                  | 1.3484 | 5.91                    | 1.500               |
|                                                      | 18.0   | 3.537                  | 2.962                 | 1.0214                  | 1.3503 | 6.89                    | 1.578               |
|                                                      | 20.0   | 4.028                  | 3.300                 | 1.0241                  | 1.3523 | 7.93                    | 1.661               |
|                                                      | 24.0   | 5.088                  | 3.981                 | 1.0296                  | 1.3564 | 10.28                   | 1.843               |
|                                                      | 28.0   | 6.265                  | 4.669                 | 1.0350                  | 1.3605 | 13.03                   | 2.047               |
|                                                      | 32.0   | 7.582                  | 5.364                 | 1.0405                  | 1.3646 | 16.23                   | 2.280               |
|                                                      | 36.0   | 9.062                  | 6.067                 | 1.0460                  | 1.3687 | 19.82                   | 2.537               |
|                                                      | 40.0   | 10.741                 | 6.776                 | 1.0514                  | 1.3728 | 23.84                   | 2.832               |
|                                                      | 44.0   | 12.659                 | 7.491                 | 1.0567                  | 1.3769 | 28.32                   | 3.166               |
|                                                      | 48.0   | 14.872                 | 8.212                 | 1.0619                  | 1.3811 | 33.30                   | 3.544               |
|                                                      | 52.0   | 17.453                 | 8.939                 | 1.0670                  | 1.3851 | 38.81                   | 3.981               |
|                                                      | 56.0   | 20.505                 | 9.671                 | 1.0719                  | 1.3892 | 44.83                   | 4.475               |
|                                                      | 60.0   | 24.166                 | 10.406                | 1.0765                  | 1.3931 | 51.23                   | 5.026               |
| Ferric chloride<br>FeCl <sub>3</sub>                 | 0.5    | 0.031                  | 0.031                 | 1.0025                  | 1.3344 | 0.21                    | 1.024               |
|                                                      | 1.0    | 0.062                  | 0.062                 | 1.0068                  | 1.3358 | 0.39                    | 1.047               |
|                                                      | 2.0    | 0.126                  | 0.125                 | 1.0153                  | 1.3386 | 0.75                    | 1.093               |
|                                                      | 3.0    | 0.191                  | 0.189                 | 1.0238                  | 1.3413 | 1.15                    | 1.139               |
|                                                      | 4.0    | 0.257                  | 0.255                 | 1.0323                  | 1.3441 | 1.56                    | 1.187               |
|                                                      | 5.0    | 0.324                  | 0.321                 | 1.0408                  | 1.3468 | 2.00                    | 1.238               |

| Solute                                                    | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-----------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                           | 6.0    | 0.394                  | 0.388                 | 1.0493                  | 1.3496 | 2.48                    | 1.292               |
|                                                           | 7.0    | 0.464                  | 0.457                 | 1.0580                  | 1.3524 | 2.99                    | 1.350               |
|                                                           | 8.0    | 0.536                  | 0.526                 | 1.0668                  | 1.3552 | 3.57                    | 1.412               |
|                                                           | 9.0    | 0.610                  | 0.597                 | 1.0760                  | 1.3581 | 4.19                    | 1.480               |
|                                                           | 10.0   | 0.685                  | 0.669                 | 1.0853                  | 1.3611 | 4.85                    | 1.553               |
|                                                           | 12.0   | 0.841                  | 0.817                 | 1.1040                  | 1.3670 | 6.38                    | 1.707               |
|                                                           | 14.0   | 1.004                  | 0.969                 | 1.1228                  | 1.3730 | 8.22                    | 1.879               |
|                                                           | 16.0   | 1.174                  | 1.126                 | 1.1420                  |        | 10.45                   | 2.080               |
|                                                           | 18.0   | 1.353                  | 1.289                 | 1.1615                  |        | 13.08                   | 2.311               |
|                                                           | 20.0   | 1.541                  | 1.457                 | 1.1816                  |        | 16.14                   | 2.570               |
|                                                           | 24.0   | 1.947                  | 1.810                 | 1.2234                  |        | 23.79                   | 3.178               |
|                                                           | 28.0   | 2.398                  | 2.189                 | 1.2679                  |        | 33.61                   | 4.038               |
|                                                           | 32.0   | 2.901                  | 2.595                 | 1.3153                  |        | 49.16                   | 5.274               |
|                                                           | 36.0   | 3.468                  | 3.030                 | 1.3654                  |        |                         | 7.130               |
|                                                           | 40.0   | 4.110                  | 3.496                 | 1.4176                  |        |                         | 9.674               |
| Formic acid<br>HCOOH                                      | 0.5    | 0.109                  | 0.109                 | 0.9994                  | 1.3333 | 0.21                    | 1.006               |
|                                                           | 1.0    | 0.219                  | 0.217                 | 1.0006                  | 1.3336 | 0.42                    | 1.011               |
|                                                           | 2.0    | 0.443                  | 0.436                 | 1.0029                  | 1.3342 | 0.82                    | 1.017               |
|                                                           | 3.0    | 0.672                  | 0.655                 | 1.0053                  | 1.3348 | 1.24                    | 1.195               |
|                                                           | 4.0    | 0.905                  | 0.876                 | 1.0077                  | 1.3354 | 1.67                    | 1.032               |
|                                                           | 5.0    | 1.143                  | 1.097                 | 1.0102                  | 1.3359 | 2.10                    | 1.039               |
|                                                           | 6.0    | 1.387                  | 1.320                 | 1.0126                  | 1.3365 | 2.53                    | 1.046               |
|                                                           | 7.0    | 1.635                  | 1.544                 | 1.0150                  | 1.3371 | 2.97                    | 1.052               |
|                                                           | 8.0    | 1.889                  | 1.768                 | 1.0175                  | 1.3376 | 3.40                    | 1.058               |
|                                                           | 9.0    | 2.149                  | 1.994                 | 1.0199                  | 1.3382 | 3.84                    | 1.064               |
|                                                           | 10.0   | 2.414                  | 2.221                 | 1.0224                  | 1.3387 | 4.27                    | 1.070               |
|                                                           | 12.0   | 2.962                  | 2.678                 | 1.0273                  | 1.3397 | 5.19                    | 1.082               |
|                                                           | 14.0   | 3.537                  | 3.139                 | 1.0322                  | 1.3408 | 6.11                    | 1.094               |
|                                                           | 16.0   | 4.138                  | 3.605                 | 1.0371                  | 1.3418 | 7.06                    | 1.106               |
|                                                           | 18.0   | 4.769                  | 4.074                 | 1.0419                  | 1.3428 | 8.08                    | 1.119               |
|                                                           | 20.0   | 5.431                  | 4.548                 | 1.0467                  | 1.3437 | 9.11                    | 1.132               |
| <i>D</i> -Fructose<br>$\text{C}_6\text{H}_{12}\text{O}_6$ | 28.0   | 8.449                  | 6.481                 | 1.0654                  | 1.3475 | 13.10                   | 1.179               |
|                                                           | 36.0   | 12.220                 | 8.477                 | 1.0839                  | 1.3511 | 17.65                   | 1.227               |
|                                                           | 44.0   | 17.070                 | 10.529                | 1.1015                  | 1.3547 | 22.93                   | 1.281               |
|                                                           | 52.0   | 23.535                 | 12.633                | 1.1183                  | 1.3581 | 29.69                   | 1.340               |
|                                                           | 60.0   | 32.587                 | 14.813                | 1.1364                  | 1.3612 | 38.26                   | 1.410               |
|                                                           | 68.0   | 46.166                 | 17.054                | 1.1544                  | 1.3641 |                         | 1.490               |
|                                                           | 0.5    | 0.028                  | 0.028                 | 1.0002                  | 1.3337 | 0.05                    | 1.015               |
|                                                           | 1.0    | 0.056                  | 0.056                 | 1.0021                  | 1.3344 | 0.10                    | 1.028               |
|                                                           | 2.0    | 0.113                  | 0.112                 | 1.0061                  | 1.3358 | 0.21                    | 1.054               |
|                                                           | 3.0    | 0.172                  | 0.168                 | 1.0101                  | 1.3373 | 0.32                    | 1.080               |
|                                                           | 4.0    | 0.231                  | 0.225                 | 1.0140                  | 1.3387 | 0.43                    | 1.106               |
|                                                           | 5.0    | 0.292                  | 0.283                 | 1.0181                  | 1.3402 | 0.54                    | 1.134               |
|                                                           | 6.0    | 0.354                  | 0.340                 | 1.0221                  | 1.3417 | 0.66                    | 1.165               |
|                                                           | 7.0    | 0.418                  | 0.399                 | 1.0262                  | 1.3431 | 0.78                    | 1.198               |
|                                                           | 8.0    | 0.483                  | 0.458                 | 1.0303                  | 1.3446 | 0.90                    | 1.232               |
|                                                           | 9.0    | 0.549                  | 0.517                 | 1.0344                  | 1.3461 | 1.03                    | 1.270               |
|                                                           | 10.0   | 0.617                  | 0.576                 | 1.0385                  | 1.3476 | 1.16                    | 1.309               |
|                                                           | 12.0   | 0.757                  | 0.697                 | 1.0469                  | 1.3507 | 1.43                    | 1.391               |
|                                                           | 14.0   | 0.904                  | 0.820                 | 1.0554                  | 1.3538 | 1.71                    | 1.483               |
|                                                           | 16.0   | 1.057                  | 0.945                 | 1.0640                  | 1.3569 | 2.01                    | 1.587               |
|                                                           | 18.0   | 1.218                  | 1.072                 | 1.0728                  | 1.3601 | 2.32                    | 1.703               |
|                                                           | 20.0   | 1.388                  | 1.201                 | 1.0816                  | 1.3634 | 2.64                    | 1.837               |
|                                                           | 22.0   | 1.566                  | 1.332                 | 1.0906                  | 1.3667 | 3.05                    | 1.986               |
|                                                           | 24.0   | 1.753                  | 1.465                 | 1.0996                  | 1.3700 | 3.43                    | 2.154               |
|                                                           | 26.0   | 1.950                  | 1.600                 | 1.1089                  | 1.3734 | 3.82                    | 2.348               |
|                                                           | 28.0   | 2.159                  | 1.738                 | 1.1182                  | 1.3768 | 4.20                    | 2.562               |
|                                                           | 30.0   | 2.379                  | 1.878                 | 1.1276                  | 1.3803 |                         | 2.817               |
|                                                           | 32.0   | 2.612                  | 2.020                 | 1.1372                  | 1.3839 |                         | 3.112               |

| Solute                                                   | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|----------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                          | 34.0   | 2.859                  | 2.164                 | 1.1469                  | 1.3874 |                         | 3.462               |
|                                                          | 36.0   | 3.122                  | 2.312                 | 1.1568                  | 1.3911 |                         | 3.899               |
|                                                          | 38.0   | 3.402                  | 2.461                 | 1.1668                  | 1.3948 |                         | 4.418               |
|                                                          | 40.0   | 3.700                  | 2.613                 | 1.1769                  | 1.3985 |                         | 5.046               |
|                                                          | 42.0   | 4.019                  | 2.767                 | 1.1871                  | 1.4023 |                         | 5.773               |
|                                                          | 44.0   | 4.361                  | 2.925                 | 1.1975                  | 1.4062 |                         | 6.644               |
|                                                          | 46.0   | 4.728                  | 3.084                 | 1.2080                  | 1.4101 |                         | 7.753               |
|                                                          | 48.0   | 5.124                  | 3.247                 | 1.2187                  | 1.4141 |                         | 9.060               |
| <i>D</i> -Glucose<br>$\text{C}_6\text{H}_{12}\text{O}_6$ | 0.5    | 0.028                  | 0.028                 | 1.0001                  | 1.3337 | 0.05                    | 1.010               |
|                                                          | 1.0    | 0.056                  | 0.056                 | 1.0020                  | 1.3344 | 0.11                    | 1.021               |
|                                                          | 2.0    | 0.113                  | 0.112                 | 1.0058                  | 1.3358 | 0.21                    | 1.052               |
|                                                          | 3.0    | 0.172                  | 0.168                 | 1.0097                  | 1.3373 | 0.32                    | 1.083               |
|                                                          | 4.0    | 0.231                  | 0.225                 | 1.0136                  | 1.3387 | 0.43                    | 1.113               |
|                                                          | 5.0    | 0.292                  | 0.282                 | 1.0175                  | 1.3402 | 0.55                    | 1.145               |
|                                                          | 6.0    | 0.354                  | 0.340                 | 1.0214                  | 1.3417 | 0.67                    | 1.179               |
|                                                          | 7.0    | 0.418                  | 0.398                 | 1.0254                  | 1.3432 | 0.79                    | 1.214               |
|                                                          | 8.0    | 0.483                  | 0.457                 | 1.0294                  | 1.3447 | 0.91                    | 1.250               |
|                                                          | 9.0    | 0.549                  | 0.516                 | 1.0334                  | 1.3462 | 1.04                    | 1.289               |
|                                                          | 10.0   | 0.617                  | 0.576                 | 1.0375                  | 1.3477 | 1.17                    | 1.330               |
|                                                          | 12.0   | 0.757                  | 0.697                 | 1.0457                  | 1.3508 | 1.44                    | 1.416               |
|                                                          | 14.0   | 0.904                  | 0.819                 | 1.0540                  | 1.3539 | 1.73                    | 1.512               |
|                                                          | 16.0   | 1.057                  | 0.944                 | 1.0624                  | 1.3571 | 2.03                    | 1.625               |
|                                                          | 18.0   | 1.218                  | 1.070                 | 1.0710                  | 1.3603 | 2.35                    | 1.757               |
|                                                          | 20.0   | 1.388                  | 1.199                 | 1.0797                  | 1.3635 | 2.70                    | 1.904               |
|                                                          | 22.0   | 1.566                  | 1.329                 | 1.0884                  | 1.3668 | 3.07                    | 2.063               |
|                                                          | 24.0   | 1.753                  | 1.462                 | 1.0973                  | 1.3702 | 3.48                    | 2.242               |
|                                                          | 26.0   | 1.950                  | 1.597                 | 1.1063                  | 1.3736 | 3.90                    | 2.458               |
|                                                          | 28.0   | 2.159                  | 1.734                 | 1.1154                  | 1.3770 | 4.34                    | 2.707               |
|                                                          | 30.0   | 2.379                  | 1.873                 | 1.1246                  | 1.3805 | 4.79                    | 2.998               |
|                                                          | 32.0   | 2.612                  | 2.014                 | 1.1340                  | 1.3840 |                         | 3.324               |
|                                                          | 34.0   | 2.859                  | 2.158                 | 1.1434                  | 1.3876 |                         | 3.704               |
|                                                          | 36.0   | 3.122                  | 2.304                 | 1.1529                  | 1.3912 |                         | 4.193               |
|                                                          | 38.0   | 3.402                  | 2.452                 | 1.1626                  | 1.3949 |                         | 4.786               |
|                                                          | 40.0   | 3.700                  | 2.603                 | 1.1724                  | 1.3986 |                         | 5.493               |
|                                                          | 42.0   | 4.019                  | 2.756                 | 1.1823                  | 1.4024 |                         | 6.288               |
|                                                          | 44.0   | 4.361                  | 2.912                 | 1.1924                  | 1.4062 |                         | 7.235               |
|                                                          | 46.0   | 4.728                  | 3.071                 | 1.2026                  | 1.4101 |                         | 8.454               |
|                                                          | 48.0   | 5.124                  | 3.232                 | 1.2130                  | 1.4141 |                         | 9.883               |
|                                                          | 50.0   | 5.551                  | 3.396                 | 1.2235                  | 1.4181 |                         | 11.884              |
|                                                          | 52.0   | 6.013                  | 3.562                 | 1.2342                  | 1.4222 |                         | 14.489              |
|                                                          | 54.0   | 6.516                  | 3.732                 | 1.2451                  | 1.4263 |                         | 17.916              |
|                                                          | 56.0   | 7.064                  | 3.905                 | 1.2562                  | 1.4306 |                         | 22.886              |
|                                                          | 58.0   | 7.665                  | 4.081                 | 1.2676                  | 1.4349 |                         | 29.389              |
|                                                          | 60.0   | 8.326                  | 4.261                 | 1.2793                  | 1.4394 |                         | 37.445              |
| Glycerol<br>$\text{CH}_2\text{OHCHOHCH}_2\text{OH}$      | 0.5    | 0.055                  | 0.054                 | 0.9994                  | 1.3336 | 0.07                    | 1.011               |
|                                                          | 1.0    | 0.110                  | 0.109                 | 1.0005                  | 1.3342 | 0.18                    | 1.022               |
|                                                          | 2.0    | 0.222                  | 0.218                 | 1.0028                  | 1.3353 | 0.41                    | 1.048               |
|                                                          | 3.0    | 0.336                  | 0.327                 | 1.0051                  | 1.3365 | 0.63                    | 1.074               |
|                                                          | 4.0    | 0.452                  | 0.438                 | 1.0074                  | 1.3376 | 0.85                    | 1.100               |
|                                                          | 5.0    | 0.572                  | 0.548                 | 1.0097                  | 1.3388 | 1.08                    | 1.127               |
|                                                          | 6.0    | 0.693                  | 0.659                 | 1.0120                  | 1.3400 | 1.32                    | 1.157               |
|                                                          | 7.0    | 0.817                  | 0.771                 | 1.0144                  | 1.3412 | 1.56                    | 1.188               |
|                                                          | 8.0    | 0.944                  | 0.883                 | 1.0167                  | 1.3424 | 1.81                    | 1.220               |
|                                                          | 9.0    | 1.074                  | 0.996                 | 1.0191                  | 1.3436 | 2.06                    | 1.256               |
|                                                          | 10.0   | 1.207                  | 1.109                 | 1.0215                  | 1.3448 | 2.32                    | 1.291               |
|                                                          | 12.0   | 1.481                  | 1.337                 | 1.0262                  | 1.3472 | 2.88                    | 1.365               |
|                                                          | 14.0   | 1.768                  | 1.568                 | 1.0311                  | 1.3496 | 3.47                    | 1.445               |
|                                                          | 16.0   | 2.068                  | 1.800                 | 1.0360                  | 1.3521 | 4.09                    | 1.533               |
|                                                          | 18.0   | 2.384                  | 2.035                 | 1.0409                  | 1.3547 | 4.76                    | 1.630               |

| Solute                   | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|--------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                          | 20.0   | 2.715                  | 2.271                 | 1.0459                  | 1.3572 | 5.46                    | 1.737               |
|                          | 24.0   | 3.429                  | 2.752                 | 1.0561                  | 1.3624 | 7.01                    | 1.988               |
|                          | 28.0   | 4.223                  | 3.242                 | 1.0664                  | 1.3676 | 8.77                    | 2.279               |
|                          | 32.0   | 5.110                  | 3.742                 | 1.0770                  | 1.3730 | 10.74                   | 2.637               |
|                          | 36.0   | 6.108                  | 4.252                 | 1.0876                  | 1.3785 | 12.96                   | 3.088               |
|                          | 40.0   | 7.239                  | 4.771                 | 1.0984                  | 1.3841 | 15.50                   | 3.653               |
|                          | 44.0   | 8.532                  | 5.300                 | 1.1092                  | 1.3897 |                         | 4.443               |
|                          | 48.0   | 10.024                 | 5.838                 | 1.1200                  | 1.3954 |                         | 5.413               |
|                          | 52.0   | 11.764                 | 6.385                 | 1.1308                  | 1.4011 |                         | 6.666               |
|                          | 56.0   | 13.820                 | 6.944                 | 1.1419                  | 1.4069 |                         | 8.349               |
|                          | 60.0   | 16.288                 | 7.512                 | 1.1530                  | 1.4129 |                         | 10.681              |
|                          | 64.0   | 19.305                 | 8.092                 | 1.1643                  | 1.4189 |                         | 13.657              |
|                          | 68.0   | 23.075                 | 8.680                 | 1.1755                  | 1.4249 |                         | 18.457              |
|                          | 72.0   | 27.923                 | 9.277                 | 1.1866                  | 1.4310 |                         | 27.625              |
|                          | 76.0   | 34.387                 | 9.884                 | 1.1976                  | 1.4370 |                         | 40.571              |
|                          | 80.0   | 43.436                 | 10.498                | 1.2085                  | 1.4431 |                         | 59.900              |
|                          | 84.0   | 57.009                 | 11.121                | 1.2192                  | 1.4492 |                         | 84.338              |
|                          | 88.0   | 79.632                 | 11.753                | 1.2299                  | 1.4553 |                         | 147.494             |
|                          | 92.0   | 124.878                | 12.392                | 1.2404                  | 1.4613 |                         | 384.467             |
|                          | 96.0   | 260.615                | 13.039                | 1.2508                  | 1.4674 |                         | 780.458             |
|                          | 100.0  |                        | 13.694                | 1.2611                  | 1.4735 |                         |                     |
| Hydrochloric acid        | 0.5    | 0.138                  | 0.137                 | 1.0007                  | 1.3341 | 0.49                    | 1.008               |
|                          | 1.0    | 0.277                  | 0.275                 | 1.0031                  | 1.3353 | 0.99                    | 1.015               |
| HCl                      | 2.0    | 0.560                  | 0.553                 | 1.0081                  | 1.3376 | 2.08                    | 1.029               |
|                          | 3.0    | 0.848                  | 0.833                 | 1.0130                  | 1.3399 | 3.28                    | 1.044               |
|                          | 4.0    | 1.143                  | 1.117                 | 1.0179                  | 1.3422 | 4.58                    | 1.059               |
|                          | 5.0    | 1.444                  | 1.403                 | 1.0228                  | 1.3445 | 5.98                    | 1.075               |
|                          | 6.0    | 1.751                  | 1.691                 | 1.0278                  | 1.3468 | 7.52                    | 1.091               |
|                          | 7.0    | 2.064                  | 1.983                 | 1.0327                  | 1.3491 | 9.22                    | 1.108               |
|                          | 8.0    | 2.385                  | 2.277                 | 1.0377                  | 1.3515 | 11.10                   | 1.125               |
|                          | 9.0    | 2.713                  | 2.574                 | 1.0426                  | 1.3538 | 13.15                   | 1.143               |
|                          | 10.0   | 3.047                  | 2.873                 | 1.0476                  | 1.3561 | 15.40                   | 1.161               |
|                          | 12.0   | 3.740                  | 3.481                 | 1.0576                  | 1.3607 | 20.51                   | 1.199               |
|                          | 14.0   | 4.465                  | 4.099                 | 1.0676                  | 1.3653 |                         | 1.239               |
|                          | 16.0   | 5.224                  | 4.729                 | 1.0777                  | 1.3700 |                         | 1.282               |
|                          | 18.0   | 6.020                  | 5.370                 | 1.0878                  | 1.3746 |                         | 1.326               |
|                          | 20.0   | 6.857                  | 6.023                 | 1.0980                  | 1.3792 |                         | 1.374               |
|                          | 22.0   | 7.736                  | 6.687                 | 1.1083                  | 1.3838 |                         | 1.426               |
|                          | 24.0   | 8.661                  | 7.362                 | 1.1185                  | 1.3884 |                         | 1.483               |
|                          | 26.0   | 9.636                  | 8.049                 | 1.1288                  | 1.3930 |                         | 1.547               |
|                          | 28.0   | 10.666                 | 8.748                 | 1.1391                  | 1.3976 |                         | 1.620               |
|                          | 30.0   | 11.754                 | 9.456                 | 1.1492                  | 1.4020 |                         | 1.705               |
|                          | 32.0   | 12.907                 | 10.175                | 1.1594                  | 1.4066 |                         | 1.799               |
|                          | 34.0   | 14.129                 | 10.904                | 1.1693                  | 1.4112 |                         | 1.900               |
|                          | 36.0   | 15.427                 | 11.642                | 1.1791                  | 1.4158 |                         | 2.002               |
|                          | 38.0   | 16.810                 | 12.388                | 1.1886                  | 1.4204 |                         | 2.105               |
|                          | 40.0   | 18.284                 | 13.140                | 1.1977                  | 1.4250 |                         |                     |
| Lactic acid              | 0.5    | 0.056                  | 0.055                 | 0.9992                  | 1.3335 | 0.10                    | 1.014               |
| CH <sub>3</sub> CHOHCOOH | 1.0    | 0.112                  | 0.111                 | 1.0002                  | 1.3340 | 0.19                    | 1.027               |
|                          | 2.0    | 0.227                  | 0.223                 | 1.0023                  | 1.3350 | 0.38                    | 1.056               |
|                          | 3.0    | 0.343                  | 0.334                 | 1.0043                  | 1.3360 | 0.57                    | 1.084               |
|                          | 4.0    | 0.463                  | 0.447                 | 1.0065                  | 1.3370 | 0.76                    | 1.110               |
|                          | 5.0    | 0.584                  | 0.560                 | 1.0086                  | 1.3380 | 0.95                    | 1.138               |
|                          | 6.0    | 0.709                  | 0.673                 | 1.0108                  | 1.3390 | 1.16                    | 1.167               |
|                          | 7.0    | 0.836                  | 0.787                 | 1.0131                  | 1.3400 | 1.36                    | 1.198               |
|                          | 8.0    | 0.965                  | 0.902                 | 1.0153                  | 1.3410 | 1.57                    | 1.229               |
|                          | 9.0    | 1.098                  | 1.017                 | 1.0176                  | 1.3420 | 1.79                    | 1.262               |
|                          | 10.0   | 1.233                  | 1.132                 | 1.0199                  | 1.3430 | 2.02                    | 1.296               |
|                          | 12.0   | 1.514                  | 1.365                 | 1.0246                  | 1.3450 | 2.49                    | 1.366               |



| Solute                                    | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                           | 14.0   | 1.807                  | 1.600                 | 1.0294                  | 1.3470 | 2.99                    | 1.441               |
|                                           | 16.0   | 2.115                  | 1.837                 | 1.0342                  | 1.3491 | 3.48                    | 1.522               |
|                                           | 18.0   | 2.437                  | 2.076                 | 1.0390                  | 1.3511 | 3.96                    | 1.607               |
|                                           | 20.0   | 2.775                  | 2.318                 | 1.0439                  | 1.3532 | 4.44                    | 1.699               |
|                                           | 24.0   | 3.506                  | 2.807                 | 1.0536                  | 1.3573 |                         | 1.902               |
|                                           | 28.0   | 4.317                  | 3.305                 | 1.0632                  | 1.3615 |                         | 2.136               |
|                                           | 32.0   | 5.224                  | 3.811                 | 1.0728                  | 1.3657 |                         | 2.414               |
|                                           | 36.0   | 6.244                  | 4.325                 | 1.0822                  | 1.3700 |                         | 2.730               |
|                                           | 40.0   | 7.401                  | 4.847                 | 1.0915                  | 1.3743 |                         | 3.114               |
|                                           | 44.0   | 8.722                  | 5.377                 | 1.1008                  | 1.3786 |                         | 3.566               |
|                                           | 48.0   | 10.247                 | 5.917                 | 1.1105                  | 1.3828 |                         | 4.106               |
|                                           | 52.0   | 12.026                 | 6.466                 | 1.1201                  | 1.3871 |                         | 4.789               |
|                                           | 56.0   | 14.129                 | 7.023                 | 1.1297                  | 1.3914 |                         | 5.579               |
|                                           | 60.0   | 16.652                 | 7.588                 | 1.1392                  | 1.3958 |                         | 6.679               |
|                                           | 64.0   | 19.736                 | 8.161                 | 1.1486                  | 1.4001 |                         | 8.024               |
|                                           | 68.0   | 23.590                 | 8.741                 | 1.1579                  | 1.4045 |                         | 9.863               |
|                                           | 72.0   | 28.546                 | 9.328                 | 1.1670                  | 1.4088 |                         | 12.866              |
|                                           | 76.0   | 35.154                 | 9.922                 | 1.1760                  | 1.4131 |                         | 16.974              |
|                                           | 80.0   | 44.405                 | 10.522                | 1.1848                  | 1.4173 |                         | 22.164              |
| Lactose                                   | 0.5    | 0.015                  | 0.015                 | 1.0002                  | 1.3337 | 0.03                    | 1.013               |
| $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ | 1.0    | 0.030                  | 0.029                 | 1.0021                  | 1.3345 | 0.06                    | 1.026               |
|                                           | 2.0    | 0.060                  | 0.059                 | 1.0061                  | 1.3359 | 0.11                    | 1.058               |
|                                           | 3.0    | 0.090                  | 0.089                 | 1.0102                  | 1.3375 | 0.17                    | 1.089               |
|                                           | 4.0    | 0.122                  | 0.119                 | 1.0143                  | 1.3390 | 0.23                    | 1.120               |
|                                           | 5.0    | 0.154                  | 0.149                 | 1.0184                  | 1.3406 | 0.29                    | 1.154               |
|                                           | 6.0    | 0.186                  | 0.179                 | 1.0225                  | 1.3421 | 0.35                    | 1.191               |
|                                           | 7.0    | 0.220                  | 0.210                 | 1.0267                  | 1.3437 | 0.42                    | 1.232               |
|                                           | 8.0    | 0.254                  | 0.241                 | 1.0308                  | 1.3453 | 0.50                    | 1.276               |
|                                           | 9.0    | 0.289                  | 0.272                 | 1.0349                  | 1.3468 |                         | 1.321               |
|                                           | 10.0   | 0.325                  | 0.304                 | 1.0390                  | 1.3484 |                         | 1.370               |
|                                           | 12.0   | 0.398                  | 0.367                 | 1.0473                  | 1.3515 |                         | 1.476               |
|                                           | 14.0   | 0.476                  | 0.432                 | 1.0558                  | 1.3548 |                         | 1.593               |
|                                           | 16.0   | 0.556                  | 0.498                 | 1.0648                  | 1.3582 |                         | 1.724               |
|                                           | 18.0   | 0.641                  | 0.565                 | 1.0746                  | 1.3619 |                         | 1.869               |
| Lithium chloride                          | 0.5    | 0.119                  | 0.118                 | 1.0012                  | 1.3341 | 0.42                    | 1.019               |
| $\text{LiCl}$                             | 1.0    | 0.238                  | 0.237                 | 1.0041                  | 1.3351 | 0.84                    | 1.037               |
|                                           | 2.0    | 0.481                  | 0.476                 | 1.0099                  | 1.3373 | 1.72                    | 1.072               |
|                                           | 3.0    | 0.730                  | 0.719                 | 1.0157                  | 1.3394 | 2.68                    | 1.108               |
|                                           | 4.0    | 0.983                  | 0.964                 | 1.0215                  | 1.3415 | 3.73                    | 1.146               |
|                                           | 5.0    | 1.241                  | 1.211                 | 1.0272                  | 1.3436 | 4.86                    | 1.185               |
|                                           | 6.0    | 1.506                  | 1.462                 | 1.0330                  | 1.3457 | 6.14                    | 1.226               |
|                                           | 7.0    | 1.775                  | 1.715                 | 1.0387                  | 1.3478 | 7.56                    | 1.269               |
|                                           | 8.0    | 2.051                  | 1.971                 | 1.0444                  | 1.3499 | 9.11                    | 1.313               |
|                                           | 9.0    | 2.333                  | 2.230                 | 1.0502                  | 1.3520 | 10.79                   | 1.360               |
|                                           | 10.0   | 2.621                  | 2.491                 | 1.0560                  | 1.3541 | 12.61                   | 1.411               |
|                                           | 12.0   | 3.217                  | 3.022                 | 1.0675                  | 1.3583 | 16.59                   | 1.522               |
|                                           | 14.0   | 3.840                  | 3.564                 | 1.0792                  | 1.3625 | 21.04                   | 1.647               |
|                                           | 16.0   | 4.493                  | 4.118                 | 1.0910                  | 1.3668 |                         | 1.787               |
|                                           | 18.0   | 5.178                  | 4.683                 | 1.1029                  | 1.3711 |                         | 1.942               |
|                                           | 20.0   | 5.897                  | 5.260                 | 1.1150                  | 1.3755 |                         | 2.128               |
|                                           | 22.0   | 6.653                  | 5.851                 | 1.1274                  | 1.3799 |                         | 2.341               |
|                                           | 24.0   | 7.449                  | 6.453                 | 1.1399                  | 1.3844 |                         | 2.600               |
|                                           | 26.0   | 8.288                  | 7.069                 | 1.1527                  | 1.3890 |                         | 2.925               |
|                                           | 28.0   | 9.173                  | 7.700                 | 1.1658                  | 1.3936 |                         | 3.318               |
|                                           | 30.0   | 10.109                 | 8.344                 | 1.1791                  | 1.3983 |                         | 3.785               |
| Magnesium chloride                        | 0.5    | 0.053                  | 0.053                 | 1.0022                  | 1.3343 | 0.26                    | 1.024               |
| $\text{MgCl}_2$                           | 1.0    | 0.106                  | 0.106                 | 1.0062                  | 1.3356 | 0.52                    | 1.046               |
|                                           | 2.0    | 0.214                  | 0.213                 | 1.0144                  | 1.3381 | 1.06                    | 1.091               |

| Solute                                               | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                      | 3.0    | 0.325                  | 0.322                 | 1.0226                  | 1.3406 | 1.65                    | 1.139               |
|                                                      | 4.0    | 0.438                  | 0.433                 | 1.0309                  | 1.3432 | 2.30                    | 1.188               |
|                                                      | 5.0    | 0.553                  | 0.546                 | 1.0394                  | 1.3457 | 3.01                    | 1.241               |
|                                                      | 6.0    | 0.670                  | 0.660                 | 1.0479                  | 1.3483 |                         | 1.298               |
|                                                      | 7.0    | 0.791                  | 0.777                 | 1.0564                  | 1.3508 |                         | 1.358               |
|                                                      | 8.0    | 0.913                  | 0.895                 | 1.0651                  | 1.3534 |                         | 1.423               |
|                                                      | 9.0    | 1.039                  | 1.015                 | 1.0738                  | 1.3560 |                         | 1.493               |
|                                                      | 10.0   | 1.167                  | 1.137                 | 1.0826                  | 1.3587 |                         | 1.570               |
|                                                      | 12.0   | 1.432                  | 1.387                 | 1.1005                  | 1.3641 |                         | 1.745               |
|                                                      | 14.0   | 1.710                  | 1.645                 | 1.1189                  | 1.3695 |                         | 1.956               |
|                                                      | 16.0   | 2.001                  | 1.911                 | 1.1372                  | 1.3749 |                         | 2.207               |
|                                                      | 18.0   | 2.306                  | 2.184                 | 1.1553                  | 1.3804 |                         | 2.507               |
|                                                      | 20.0   | 2.626                  | 2.467                 | 1.1742                  | 1.3859 |                         | 2.867               |
|                                                      | 22.0   | 2.962                  | 2.758                 | 1.1938                  | 1.3915 |                         | 3.323               |
|                                                      | 24.0   | 3.317                  | 3.060                 | 1.2140                  | 1.3972 |                         | 3.917               |
|                                                      | 26.0   | 3.690                  | 3.371                 | 1.2346                  | 1.4030 |                         | 4.694               |
|                                                      | 28.0   | 4.085                  | 3.692                 | 1.2555                  | 1.4089 |                         | 5.709               |
|                                                      | 30.0   | 4.501                  | 4.022                 | 1.2763                  | 1.4148 |                         | 7.017               |
| Magnesium sulfate<br>$\text{MgSO}_4$                 | 0.5    | 0.042                  | 0.042                 | 1.0033                  | 1.3340 | 0.10                    | 1.027               |
|                                                      | 1.0    | 0.084                  | 0.084                 | 1.0084                  | 1.3350 | 0.19                    | 1.054               |
|                                                      | 2.0    | 0.170                  | 0.169                 | 1.0186                  | 1.3371 | 0.36                    | 1.112               |
|                                                      | 3.0    | 0.257                  | 0.256                 | 1.0289                  | 1.3391 | 0.52                    | 1.177               |
|                                                      | 4.0    | 0.346                  | 0.345                 | 1.0392                  | 1.3411 | 0.69                    | 1.249               |
|                                                      | 5.0    | 0.437                  | 0.436                 | 1.0497                  | 1.3431 | 0.87                    | 1.328               |
|                                                      | 6.0    | 0.530                  | 0.528                 | 1.0602                  | 1.3451 | 1.05                    | 1.411               |
|                                                      | 7.0    | 0.625                  | 0.623                 | 1.0708                  | 1.3471 | 1.24                    | 1.498               |
|                                                      | 8.0    | 0.722                  | 0.719                 | 1.0816                  | 1.3492 | 1.43                    | 1.593               |
|                                                      | 9.0    | 0.822                  | 0.817                 | 1.0924                  | 1.3512 | 1.64                    | 1.702               |
|                                                      | 10.0   | 0.923                  | 0.917                 | 1.1034                  | 1.3532 | 1.85                    | 1.829               |
|                                                      | 12.0   | 1.133                  | 1.122                 | 1.1257                  | 1.3572 | 2.31                    | 2.104               |
|                                                      | 14.0   | 1.352                  | 1.336                 | 1.1484                  | 1.3613 | 2.86                    | 2.412               |
|                                                      | 16.0   | 1.582                  | 1.557                 | 1.1717                  | 1.3654 | 3.67                    | 2.809               |
|                                                      | 18.0   | 1.824                  | 1.788                 | 1.1955                  | 1.3694 |                         | 3.360               |
|                                                      | 20.0   | 2.077                  | 2.027                 | 1.2198                  | 1.3735 |                         | 4.147               |
|                                                      | 22.0   | 2.343                  | 2.275                 | 1.2447                  | 1.3776 |                         | 5.199               |
|                                                      | 24.0   | 2.624                  | 2.532                 | 1.2701                  | 1.3817 |                         | 6.498               |
|                                                      | 26.0   | 2.919                  | 2.800                 | 1.2961                  | 1.3858 |                         | 8.066               |
| Maltose<br>$\text{C}_{12}\text{H}_{22}\text{O}_{11}$ | 0.5    | 0.015                  | 0.015                 | 1.0003                  | 1.3337 | 0.03                    | 1.016               |
|                                                      | 1.0    | 0.030                  | 0.029                 | 1.0023                  | 1.3345 | 0.06                    | 1.030               |
|                                                      | 2.0    | 0.060                  | 0.059                 | 1.0063                  | 1.3359 | 0.11                    | 1.060               |
|                                                      | 3.0    | 0.090                  | 0.089                 | 1.0104                  | 1.3374 | 0.17                    | 1.092               |
|                                                      | 4.0    | 0.122                  | 0.119                 | 1.0144                  | 1.3389 | 0.23                    | 1.126               |
|                                                      | 5.0    | 0.154                  | 0.149                 | 1.0184                  | 1.3404 | 0.29                    | 1.162               |
|                                                      | 6.0    | 0.186                  | 0.179                 | 1.0224                  | 1.3420 | 0.35                    | 1.200               |
|                                                      | 7.0    | 0.220                  | 0.210                 | 1.0265                  | 1.3435 | 0.42                    | 1.239               |
|                                                      | 8.0    | 0.254                  | 0.241                 | 1.0305                  | 1.3450 | 0.48                    | 1.281               |
|                                                      | 9.0    | 0.289                  | 0.272                 | 1.0345                  | 1.3466 | 0.55                    | 1.325               |
|                                                      | 10.0   | 0.325                  | 0.303                 | 1.0385                  | 1.3482 | 0.62                    | 1.372               |
|                                                      | 12.0   | 0.398                  | 0.367                 | 1.0465                  | 1.3513 | 0.77                    | 1.474               |
|                                                      | 14.0   | 0.476                  | 0.431                 | 1.0545                  | 1.3546 | 0.92                    | 1.588               |
|                                                      | 16.0   | 0.556                  | 0.497                 | 1.0629                  | 1.3578 | 1.08                    | 1.715               |
|                                                      | 18.0   | 0.641                  | 0.564                 | 1.0716                  | 1.3612 | 1.25                    | 1.859               |
|                                                      | 20.0   | 0.730                  | 0.631                 | 1.0801                  | 1.3644 | 1.43                    | 2.021               |
|                                                      | 22.0   | 0.824                  | 0.700                 | 1.0894                  | 1.3678 | 1.64                    | 2.216               |
|                                                      | 24.0   | 0.923                  | 0.770                 | 1.0984                  | 1.3714 | 1.85                    | 2.463               |
|                                                      | 26.0   | 1.026                  | 0.842                 | 1.1080                  | 1.3749 | 2.08                    | 2.753               |
|                                                      | 28.0   | 1.136                  | 0.914                 | 1.1171                  | 1.3785 | 2.34                    | 3.066               |
|                                                      | 30.0   | 1.252                  | 0.988                 | 1.1269                  | 1.3821 | 2.62                    | 3.427               |
|                                                      | 40.0   | 1.948                  | 1.375                 | 1.1769                  | 1.4013 | 4.41                    | 6.926               |

| Solute                                           | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|--------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                  | 50.0   | 2.921                  | 1.797                 | 1.2304                  | 1.4217 |                         | 17.786              |
|                                                  | 52.0   | 3.165                  | 1.886                 | 1.2416                  | 1.4260 |                         | 22.034              |
|                                                  | 54.0   | 3.429                  | 1.976                 | 1.2528                  | 1.4308 |                         | 28.757              |
|                                                  | 56.0   | 3.718                  | 2.068                 | 1.2638                  | 1.4350 |                         | 38.226              |
|                                                  | 58.0   | 4.034                  | 2.159                 | 1.2740                  | 1.4394 |                         | 49.298              |
|                                                  | 60.0   | 4.382                  | 2.253                 | 1.2855                  | 1.4440 |                         |                     |
| Manganese(II)                                    | 1.0    | 0.067                  | 0.067                 | 1.0080                  | 1.3348 | 0.16                    | 1.046               |
| sulfate                                          | 2.0    | 0.135                  | 0.135                 | 1.0178                  | 1.3366 | 0.31                    | 1.090               |
| $\text{MnSO}_4$                                  | 3.0    | 0.205                  | 0.204                 | 1.0277                  | 1.3384 | 0.44                    | 1.137               |
|                                                  | 4.0    | 0.276                  | 0.275                 | 1.0378                  | 1.3402 | 0.57                    | 1.187               |
|                                                  | 5.0    | 0.349                  | 0.347                 | 1.0480                  | 1.3420 | 0.70                    | 1.242               |
|                                                  | 6.0    | 0.423                  | 0.421                 | 1.0583                  | 1.3438 | 0.84                    | 1.301               |
|                                                  | 7.0    | 0.498                  | 0.495                 | 1.0688                  | 1.3457 | 0.98                    | 1.363               |
|                                                  | 8.0    | 0.576                  | 0.572                 | 1.0794                  | 1.3475 | 1.12                    | 1.431               |
|                                                  | 9.0    | 0.655                  | 0.650                 | 1.0902                  | 1.3494 | 1.28                    | 1.505               |
|                                                  | 10.0   | 0.736                  | 0.729                 | 1.1012                  | 1.3513 | 1.44                    | 1.587               |
|                                                  | 12.0   | 0.903                  | 0.893                 | 1.1236                  | 1.3551 | 1.80                    | 1.779               |
|                                                  | 14.0   | 1.078                  | 1.063                 | 1.1467                  | 1.3589 | 2.21                    | 2.005               |
|                                                  | 16.0   | 1.261                  | 1.240                 | 1.1705                  | 1.3629 | 2.67                    | 2.272               |
|                                                  | 18.0   | 1.454                  | 1.424                 | 1.1950                  | 1.3668 | 3.19                    | 2.580               |
|                                                  | 20.0   | 1.656                  | 1.616                 | 1.2203                  | 1.3708 | 3.80                    | 2.938               |
| <i>D</i> -Mannitol                               | 0.5    | 0.028                  | 0.027                 | 1.0000                  | 1.3337 | 0.05                    | 1.019               |
| $\text{CH}_2(\text{CHOH})_4\text{CH}_2\text{OH}$ | 1.0    | 0.055                  | 0.055                 | 1.0017                  | 1.3345 | 0.10                    | 1.032               |
|                                                  | 2.0    | 0.112                  | 0.110                 | 1.0053                  | 1.3359 | 0.21                    | 1.057               |
|                                                  | 3.0    | 0.170                  | 0.166                 | 1.0088                  | 1.3374 | 0.32                    | 1.081               |
|                                                  | 4.0    | 0.229                  | 0.222                 | 1.0124                  | 1.3389 | 0.43                    | 1.107               |
|                                                  | 5.0    | 0.289                  | 0.279                 | 1.0159                  | 1.3403 | 0.54                    | 1.135               |
|                                                  | 6.0    | 0.350                  | 0.336                 | 1.0195                  | 1.3418 | 0.66                    | 1.166               |
|                                                  | 7.0    | 0.413                  | 0.393                 | 1.0230                  | 1.3433 | 0.77                    | 1.200               |
|                                                  | 8.0    | 0.477                  | 0.451                 | 1.0266                  | 1.3447 | 0.90                    | 1.236               |
|                                                  | 9.0    | 0.543                  | 0.509                 | 1.0302                  | 1.3462 | 1.02                    | 1.275               |
|                                                  | 10.0   | 0.610                  | 0.567                 | 1.0338                  | 1.3477 | 1.15                    | 1.314               |
|                                                  | 11.0   | 0.678                  | 0.626                 | 1.0375                  | 1.3491 | 1.28                    | 1.355               |
|                                                  | 12.0   | 0.749                  | 0.686                 | 1.0412                  | 1.3506 | 1.41                    | 1.398               |
|                                                  | 13.0   | 0.820                  | 0.746                 | 1.0450                  | 1.3521 | 1.55                    | 1.443               |
|                                                  | 14.0   | 0.894                  | 0.806                 | 1.0489                  | 1.3536 | 1.69                    | 1.489               |
|                                                  | 15.0   | 0.969                  | 0.867                 | 1.0529                  | 1.3552 | 1.84                    | 1.537               |
| Methanol                                         | 0.5    | 0.157                  | 0.156                 | 0.9973                  | 1.3331 | 0.28                    | 1.022               |
| $\text{CH}_3\text{OH}$                           | 1.0    | 0.315                  | 0.311                 | 0.9964                  | 1.3332 | 0.56                    | 1.040               |
|                                                  | 2.0    | 0.637                  | 0.621                 | 0.9947                  | 1.3334 | 1.14                    | 1.070               |
|                                                  | 3.0    | 0.965                  | 0.930                 | 0.9930                  | 1.3336 | 1.75                    | 1.100               |
|                                                  | 4.0    | 1.300                  | 1.238                 | 0.9913                  | 1.3339 | 2.37                    | 1.131               |
|                                                  | 5.0    | 1.643                  | 1.544                 | 0.9896                  | 1.3341 | 3.02                    | 1.163               |
|                                                  | 6.0    | 1.992                  | 1.850                 | 0.9880                  | 1.3343 | 3.71                    | 1.196               |
|                                                  | 7.0    | 2.349                  | 2.155                 | 0.9864                  | 1.3346 | 4.41                    | 1.229               |
|                                                  | 8.0    | 2.714                  | 2.459                 | 0.9848                  | 1.3348 | 5.13                    | 1.264               |
|                                                  | 9.0    | 3.087                  | 2.762                 | 0.9832                  | 1.3351 | 5.85                    | 1.297               |
|                                                  | 10.0   | 3.468                  | 3.064                 | 0.9816                  | 1.3354 | 6.60                    | 1.329               |
|                                                  | 12.0   | 4.256                  | 3.665                 | 0.9785                  | 1.3359 | 8.14                    | 1.389               |
|                                                  | 14.0   | 5.081                  | 4.262                 | 0.9755                  | 1.3365 | 9.72                    | 1.446               |
|                                                  | 16.0   | 5.945                  | 4.856                 | 0.9725                  | 1.3370 | 11.36                   | 1.501               |
|                                                  | 18.0   | 6.851                  | 5.447                 | 0.9695                  | 1.3376 | 13.13                   | 1.554               |
|                                                  | 20.0   | 7.803                  | 6.034                 | 0.9666                  | 1.3381 | 15.02                   | 1.604               |
|                                                  | 22.0   | 8.803                  | 6.616                 | 0.9636                  | 1.3387 | 16.98                   | 1.652               |
|                                                  | 24.0   | 9.856                  | 7.196                 | 0.9606                  | 1.3392 | 19.04                   | 1.697               |
|                                                  | 26.0   | 10.966                 | 7.771                 | 0.9576                  | 1.3397 | 21.23                   | 1.735               |
|                                                  | 28.0   | 12.138                 | 8.341                 | 0.9545                  | 1.3402 | 23.59                   | 1.769               |
|                                                  | 30.0   | 13.376                 | 8.908                 | 0.9514                  | 1.3407 | 25.91                   | 1.795               |

| Solute                                        | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-----------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                               | 32.0   | 14.688                 | 9.470                 | 0.9482                  | 1.3411 | 28.15                   | 1.814               |
|                                               | 34.0   | 16.078                 | 10.028                | 0.9450                  | 1.3415 | 30.48                   | 1.827               |
|                                               | 36.0   | 17.556                 | 10.580                | 0.9416                  | 1.3419 | 32.97                   | 1.835               |
|                                               | 38.0   | 19.129                 | 11.127                | 0.9382                  | 1.3422 | 35.60                   | 1.839               |
|                                               | 40.0   | 20.807                 | 11.669                | 0.9347                  | 1.3425 | 38.60                   | 1.837               |
|                                               | 50.0   | 31.211                 | 14.288                | 0.9156                  | 1.3431 | 54.50                   | 1.761               |
|                                               | 60.0   | 46.816                 | 16.749                | 0.8944                  | 1.3426 | 74.50                   | 1.600               |
|                                               | 70.0   | 72.826                 | 19.040                | 0.8715                  | 1.3411 |                         | 1.368               |
|                                               | 80.0   | 124.844                | 21.144                | 0.8468                  | 1.3385 |                         | 1.128               |
|                                               | 90.0   | 280.899                | 23.045                | 0.8204                  | 1.3348 |                         | 0.861               |
|                                               | 100.0  |                        | 24.710                | 0.7917                  | 1.3290 |                         | 0.586               |
| Nitric acid<br>$\text{HNO}_3$                 | 0.5    | 0.080                  | 0.079                 | 1.0009                  | 1.3336 | 0.28                    | 1.004               |
|                                               | 1.0    | 0.160                  | 0.159                 | 1.0037                  | 1.3343 | 0.56                    | 1.005               |
|                                               | 2.0    | 0.324                  | 0.320                 | 1.0091                  | 1.3356 | 1.12                    | 1.007               |
|                                               | 3.0    | 0.491                  | 0.483                 | 1.0146                  | 1.3368 | 1.70                    | 1.010               |
|                                               | 4.0    | 0.661                  | 0.648                 | 1.0202                  | 1.3381 | 2.32                    | 1.014               |
|                                               | 5.0    | 0.835                  | 0.814                 | 1.0257                  | 1.3394 | 2.96                    | 1.018               |
|                                               | 6.0    | 1.013                  | 0.982                 | 1.0314                  | 1.3407 | 3.63                    | 1.022               |
|                                               | 7.0    | 1.194                  | 1.152                 | 1.0370                  | 1.3421 | 4.33                    | 1.027               |
|                                               | 8.0    | 1.380                  | 1.324                 | 1.0427                  | 1.3434 | 5.05                    | 1.032               |
|                                               | 9.0    | 1.570                  | 1.498                 | 1.0485                  | 1.3447 | 5.81                    | 1.038               |
|                                               | 10.0   | 1.763                  | 1.673                 | 1.0543                  | 1.3460 | 6.60                    | 1.044               |
|                                               | 12.0   | 2.164                  | 2.030                 | 1.0660                  | 1.3487 | 8.27                    | 1.058               |
|                                               | 14.0   | 2.583                  | 2.395                 | 1.0780                  | 1.3514 | 10.08                   | 1.075               |
|                                               | 16.0   | 3.023                  | 2.768                 | 1.0901                  | 1.3541 | 12.04                   | 1.094               |
|                                               | 18.0   | 3.484                  | 3.149                 | 1.1025                  | 1.3569 | 14.16                   | 1.116               |
|                                               | 20.0   | 3.967                  | 3.539                 | 1.1150                  | 1.3596 |                         | 1.141               |
|                                               | 22.0   | 4.476                  | 3.937                 | 1.1277                  | 1.3624 |                         | 1.169               |
|                                               | 24.0   | 5.011                  | 4.344                 | 1.1406                  | 1.3652 |                         | 1.199               |
|                                               | 26.0   | 5.576                  | 4.760                 | 1.1536                  | 1.3680 |                         | 1.233               |
|                                               | 28.0   | 6.172                  | 5.185                 | 1.1668                  | 1.3708 |                         | 1.271               |
|                                               | 30.0   | 6.801                  | 5.618                 | 1.1801                  | 1.3736 |                         | 1.311               |
|                                               | 32.0   | 7.468                  | 6.060                 | 1.1934                  | 1.3763 |                         | 1.354               |
| Oxalic acid<br>$(\text{COOH})_2$              | 34.0   | 8.175                  | 6.512                 | 1.2068                  | 1.3790 |                         | 1.400               |
|                                               | 36.0   | 8.927                  | 6.971                 | 1.2202                  | 1.3817 |                         | 1.450               |
|                                               | 38.0   | 9.727                  | 7.439                 | 1.2335                  | 1.3842 |                         | 1.504               |
|                                               | 40.0   | 10.580                 | 7.913                 | 1.2466                  | 1.3867 |                         | 1.561               |
|                                               | 0.5    | 0.056                  | 0.056                 | 1.0006                  | 1.3336 | 0.16                    | 1.013               |
|                                               | 1.0    | 0.112                  | 0.111                 | 1.0030                  | 1.3342 | 0.30                    | 1.023               |
|                                               | 1.5    | 0.169                  | 0.167                 | 1.0054                  | 1.3347 | 0.44                    | 1.033               |
|                                               | 2.0    | 0.227                  | 0.224                 | 1.0079                  | 1.3353 | 0.57                    | 1.044               |
|                                               | 2.5    | 0.285                  | 0.281                 | 1.0103                  | 1.3359 | 0.71                    | 1.055               |
|                                               | 3.0    | 0.343                  | 0.337                 | 1.0126                  | 1.3364 | 0.84                    | 1.065               |
|                                               | 3.5    | 0.403                  | 0.395                 | 1.0150                  | 1.3370 | 0.97                    | 1.076               |
| Phosphoric<br>acid<br>$\text{H}_3\text{PO}_4$ | 4.0    | 0.463                  | 0.452                 | 1.0174                  | 1.3375 | 1.09                    | 1.086               |
|                                               | 4.5    | 0.523                  | 0.510                 | 1.0197                  | 1.3381 |                         | 1.097               |
|                                               | 5.0    | 0.585                  | 0.568                 | 1.0220                  | 1.3386 |                         | 1.108               |
|                                               | 6.0    | 0.709                  | 0.684                 | 1.0265                  | 1.3397 |                         | 1.129               |
|                                               | 7.0    | 0.836                  | 0.802                 | 1.0310                  | 1.3407 |                         | 1.150               |
|                                               | 8.0    | 0.966                  | 0.920                 | 1.0355                  | 1.3418 |                         | 1.172               |
|                                               | 0.5    | 0.051                  | 0.051                 | 1.0010                  | 1.3335 | 0.12                    | 1.010               |
|                                               | 1.0    | 0.103                  | 0.102                 | 1.0038                  | 1.3340 | 0.24                    | 1.020               |
|                                               | 2.0    | 0.208                  | 0.206                 | 1.0092                  | 1.3349 | 0.46                    | 1.050               |
|                                               | 3.0    | 0.316                  | 0.311                 | 1.0146                  | 1.3358 | 0.69                    | 1.079               |
|                                               | 4.0    | 0.425                  | 0.416                 | 1.0200                  | 1.3367 | 0.93                    | 1.108               |
|                                               | 5.0    | 0.537                  | 0.523                 | 1.0254                  | 1.3376 | 1.16                    | 1.138               |
|                                               | 6.0    | 0.651                  | 0.631                 | 1.0309                  | 1.3385 | 1.38                    | 1.169               |
|                                               | 7.0    | 0.768                  | 0.740                 | 1.0363                  | 1.3394 | 1.62                    | 1.200               |

| Solute                                   | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                          | 8.0    | 0.887                  | 0.850                 | 1.0418                  | 1.3403 | 1.88                    | 1.232               |
|                                          | 9.0    | 1.009                  | 0.962                 | 1.0474                  | 1.3413 | 2.16                    | 1.267               |
|                                          | 10.0   | 1.134                  | 1.075                 | 1.0531                  | 1.3422 | 2.45                    | 1.303               |
|                                          | 12.0   | 1.392                  | 1.304                 | 1.0647                  | 1.3441 | 3.01                    | 1.382               |
|                                          | 14.0   | 1.661                  | 1.538                 | 1.0765                  | 1.3460 | 3.76                    | 1.469               |
|                                          | 16.0   | 1.944                  | 1.777                 | 1.0885                  | 1.3480 | 4.45                    | 1.565               |
|                                          | 18.0   | 2.240                  | 2.022                 | 1.1009                  | 1.3500 | 5.25                    | 1.671               |
|                                          | 20.0   | 2.551                  | 2.273                 | 1.1135                  | 1.3520 | 6.23                    | 1.788               |
|                                          | 22.0   | 2.878                  | 2.529                 | 1.1263                  | 1.3540 | 7.38                    | 1.914               |
|                                          | 24.0   | 3.223                  | 2.791                 | 1.1395                  | 1.3561 | 8.69                    | 2.049               |
|                                          | 26.0   | 3.585                  | 3.059                 | 1.1528                  | 1.3582 | 10.12                   | 2.198               |
|                                          | 28.0   | 3.968                  | 3.333                 | 1.1665                  | 1.3604 | 11.64                   | 2.365               |
|                                          | 30.0   | 4.373                  | 3.614                 | 1.1804                  | 1.3625 | 13.23                   | 2.553               |
|                                          | 32.0   | 4.802                  | 3.901                 | 1.1945                  | 1.3647 | 14.94                   | 2.766               |
|                                          | 34.0   | 5.257                  | 4.194                 | 1.2089                  | 1.3669 | 16.81                   | 3.001               |
|                                          | 36.0   | 5.740                  | 4.495                 | 1.2236                  | 1.3691 | 18.85                   | 3.260               |
|                                          | 38.0   | 6.254                  | 4.803                 | 1.2385                  | 1.3713 | 21.09                   | 3.544               |
|                                          | 40.0   | 6.803                  | 5.117                 | 1.2536                  | 1.3735 | 23.58                   | 3.856               |
| Potassium bicarbonate<br>$\text{KHCO}_3$ | 0.5    | 0.050                  | 0.050                 | 1.0014                  | 1.3335 | 0.18                    | 1.009               |
|                                          | 1.0    | 0.101                  | 0.100                 | 1.0046                  | 1.3341 | 0.34                    | 1.015               |
|                                          | 2.0    | 0.204                  | 0.202                 | 1.0114                  | 1.3353 | 0.67                    | 1.027               |
|                                          | 3.0    | 0.309                  | 0.305                 | 1.0181                  | 1.3365 | 0.98                    | 1.040               |
|                                          | 4.0    | 0.416                  | 0.409                 | 1.0247                  | 1.3376 | 1.29                    | 1.053               |
|                                          | 5.0    | 0.526                  | 0.515                 | 1.0310                  | 1.3386 | 1.60                    | 1.067               |
|                                          | 6.0    | 0.638                  | 0.622                 | 1.0379                  | 1.3397 | 1.91                    | 1.081               |
|                                          | 7.0    | 0.752                  | 0.730                 | 1.0446                  | 1.3409 | 2.22                    | 1.096               |
|                                          | 8.0    | 0.869                  | 0.840                 | 1.0514                  | 1.3419 | 2.53                    | 1.112               |
|                                          | 9.0    | 0.988                  | 0.951                 | 1.0581                  | 1.3430 | 2.84                    | 1.128               |
|                                          | 10.0   | 1.110                  | 1.064                 | 1.0650                  | 1.3441 | 3.16                    | 1.145               |
|                                          | 12.0   | 1.362                  | 1.293                 | 1.0788                  | 1.3462 | 3.79                    | 1.183               |
|                                          | 14.0   | 1.626                  | 1.528                 | 1.0929                  | 1.3484 | 4.41                    | 1.224               |
|                                          | 16.0   | 1.903                  | 1.770                 | 1.1073                  | 1.3506 |                         | 1.270               |
|                                          | 18.0   | 2.193                  | 2.017                 | 1.1221                  | 1.3528 |                         | 1.319               |
|                                          | 20.0   | 2.497                  | 2.272                 | 1.1372                  | 1.3550 |                         | 1.373               |
|                                          | 22.0   | 2.817                  | 2.533                 | 1.1527                  | 1.3572 |                         | 1.432               |
|                                          | 24.0   | 3.154                  | 2.801                 | 1.1685                  | 1.3595 |                         | 1.497               |
| Potassium bromide<br>$\text{KBr}$        | 0.5    | 0.042                  | 0.042                 | 1.0018                  | 1.3336 | 0.15                    | 1.000               |
|                                          | 1.0    | 0.085                  | 0.084                 | 1.0054                  | 1.3342 | 0.29                    | 0.998               |
|                                          | 2.0    | 0.171                  | 0.170                 | 1.0127                  | 1.3354 | 0.59                    | 0.994               |
|                                          | 3.0    | 0.260                  | 0.257                 | 1.0200                  | 1.3366 | 0.88                    | 0.990               |
|                                          | 4.0    | 0.350                  | 0.345                 | 1.0275                  | 1.3379 | 1.18                    | 0.985               |
|                                          | 5.0    | 0.442                  | 0.435                 | 1.0350                  | 1.3391 | 1.48                    | 0.981               |
|                                          | 6.0    | 0.536                  | 0.526                 | 1.0426                  | 1.3403 | 1.78                    | 0.977               |
|                                          | 7.0    | 0.633                  | 0.618                 | 1.0503                  | 1.3416 | 2.10                    | 0.974               |
|                                          | 8.0    | 0.731                  | 0.711                 | 1.0581                  | 1.3429 | 2.42                    | 0.970               |
|                                          | 9.0    | 0.831                  | 0.806                 | 1.0660                  | 1.3441 | 2.74                    | 0.967               |
|                                          | 10.0   | 0.934                  | 0.903                 | 1.0740                  | 1.3454 | 3.07                    | 0.964               |
|                                          | 12.0   | 1.146                  | 1.099                 | 1.0903                  | 1.3481 | 3.76                    | 0.958               |
|                                          | 14.0   | 1.368                  | 1.302                 | 1.1070                  | 1.3507 | 4.49                    | 0.953               |
|                                          | 16.0   | 1.601                  | 1.512                 | 1.1242                  | 1.3535 | 5.25                    | 0.949               |
|                                          | 18.0   | 1.845                  | 1.727                 | 1.1419                  | 1.3562 | 6.04                    | 0.946               |
|                                          | 20.0   | 2.101                  | 1.950                 | 1.1601                  | 1.3591 | 6.88                    | 0.944               |
|                                          | 22.0   | 2.370                  | 2.179                 | 1.1788                  | 1.3620 | 7.76                    | 0.943               |
|                                          | 24.0   | 2.654                  | 2.416                 | 1.1980                  | 1.3650 | 8.70                    | 0.943               |
|                                          | 26.0   | 2.952                  | 2.661                 | 1.2179                  | 1.3680 | 9.68                    | 0.944               |
|                                          | 28.0   | 3.268                  | 2.914                 | 1.2383                  | 1.3711 | 10.72                   | 0.947               |
|                                          | 30.0   | 3.601                  | 3.175                 | 1.2593                  | 1.3743 | 11.82                   | 0.952               |
|                                          | 32.0   | 3.954                  | 3.445                 | 1.2810                  | 1.3776 | 12.98                   | 0.959               |
|                                          | 34.0   | 4.329                  | 3.724                 | 1.3033                  | 1.3809 |                         | 0.968               |

| Solute                                         | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                | 36.0   | 4.727                  | 4.012                 | 1.3263                  | 1.3843 |                         | 0.979               |
|                                                | 38.0   | 5.150                  | 4.311                 | 1.3501                  | 1.3878 |                         | 0.993               |
|                                                | 40.0   | 5.602                  | 4.620                 | 1.3746                  | 1.3914 |                         | 1.010               |
| Potassium carbonate<br>$\text{K}_2\text{CO}_3$ | 0.5    | 0.036                  | 0.036                 | 1.0027                  | 1.3339 | 0.18                    | 1.013               |
|                                                | 1.0    | 0.073                  | 0.073                 | 1.0072                  | 1.3347 | 0.34                    | 1.025               |
|                                                | 2.0    | 0.148                  | 0.147                 | 1.0163                  | 1.3365 | 0.66                    | 1.048               |
|                                                | 3.0    | 0.224                  | 0.223                 | 1.0254                  | 1.3382 | 0.99                    | 1.071               |
|                                                | 4.0    | 0.301                  | 0.299                 | 1.0345                  | 1.3399 | 1.32                    | 1.094               |
|                                                | 5.0    | 0.381                  | 0.378                 | 1.0437                  | 1.3416 | 1.67                    | 1.119               |
|                                                | 6.0    | 0.462                  | 0.457                 | 1.0529                  | 1.3433 | 2.03                    | 1.146               |
|                                                | 7.0    | 0.545                  | 0.538                 | 1.0622                  | 1.3450 | 2.40                    | 1.174               |
|                                                | 8.0    | 0.629                  | 0.620                 | 1.0715                  | 1.3467 | 2.77                    | 1.204               |
|                                                | 9.0    | 0.716                  | 0.704                 | 1.0809                  | 1.3484 | 3.17                    | 1.235               |
|                                                | 10.0   | 0.804                  | 0.789                 | 1.0904                  | 1.3501 | 3.57                    | 1.269               |
|                                                | 12.0   | 0.987                  | 0.963                 | 1.1095                  | 1.3535 | 4.45                    | 1.339               |
|                                                | 14.0   | 1.178                  | 1.144                 | 1.1291                  | 1.3569 | 5.39                    | 1.414               |
|                                                | 16.0   | 1.378                  | 1.330                 | 1.1490                  | 1.3603 | 6.42                    | 1.497               |
|                                                | 18.0   | 1.588                  | 1.523                 | 1.1692                  | 1.3637 | 7.55                    | 1.594               |
|                                                | 20.0   | 1.809                  | 1.722                 | 1.1898                  | 1.3671 | 8.82                    | 1.707               |
|                                                | 24.0   | 2.285                  | 2.139                 | 1.2320                  | 1.3739 | 11.96                   | 1.978               |
|                                                | 28.0   | 2.814                  | 2.584                 | 1.2755                  | 1.3807 | 16.01                   | 2.331               |
|                                                | 32.0   | 3.405                  | 3.057                 | 1.3204                  | 1.3874 | 21.46                   | 2.834               |
|                                                | 36.0   | 4.070                  | 3.559                 | 1.3665                  | 1.3940 | 28.58                   | 3.503               |
|                                                | 40.0   | 4.824                  | 4.093                 | 1.4142                  | 1.4006 | 37.55                   | 4.360               |
|                                                | 50.0   | 7.236                  | 5.573                 | 1.5404                  | 1.4168 |                         | 9.369               |
| Potassium chloride<br>KCl                      | 0.5    | 0.067                  | 0.067                 | 1.0014                  | 1.3337 | 0.23                    | 1.000               |
|                                                | 1.0    | 0.135                  | 0.135                 | 1.0046                  | 1.3343 | 0.46                    | 0.999               |
|                                                | 2.0    | 0.274                  | 0.271                 | 1.0110                  | 1.3357 | 0.92                    | 0.999               |
|                                                | 3.0    | 0.415                  | 0.409                 | 1.0174                  | 1.3371 | 1.38                    | 0.998               |
|                                                | 4.0    | 0.559                  | 0.549                 | 1.0239                  | 1.3384 | 1.85                    | 0.997               |
|                                                | 5.0    | 0.706                  | 0.691                 | 1.0304                  | 1.3398 | 2.32                    | 0.996               |
|                                                | 6.0    | 0.856                  | 0.835                 | 1.0369                  | 1.3411 | 2.80                    | 0.994               |
|                                                | 7.0    | 1.010                  | 0.980                 | 1.0434                  | 1.3425 | 3.29                    | 0.992               |
|                                                | 8.0    | 1.166                  | 1.127                 | 1.0500                  | 1.3438 | 3.80                    | 0.990               |
|                                                | 9.0    | 1.327                  | 1.276                 | 1.0566                  | 1.3452 | 4.30                    | 0.989               |
|                                                | 10.0   | 1.490                  | 1.426                 | 1.0633                  | 1.3466 | 4.81                    | 0.988               |
|                                                | 12.0   | 1.829                  | 1.733                 | 1.0768                  | 1.3493 | 5.88                    | 0.990               |
|                                                | 14.0   | 2.184                  | 2.048                 | 1.0905                  | 1.3521 |                         | 0.994               |
|                                                | 16.0   | 2.555                  | 2.370                 | 1.1043                  | 1.3549 |                         | 0.999               |
|                                                | 18.0   | 2.944                  | 2.701                 | 1.1185                  | 1.3577 |                         | 1.004               |
|                                                | 20.0   | 3.353                  | 3.039                 | 1.1328                  | 1.3606 |                         | 1.012               |
|                                                | 22.0   | 3.783                  | 3.386                 | 1.1474                  | 1.3635 |                         | 1.024               |
|                                                | 24.0   | 4.236                  | 3.742                 | 1.1623                  | 1.3665 |                         | 1.040               |
| Potassium hydroxide<br>KOH                     | 0.5    | 0.090                  | 0.089                 | 1.0025                  | 1.3340 | 0.30                    | 1.010               |
|                                                | 1.0    | 0.180                  | 0.179                 | 1.0068                  | 1.3350 | 0.61                    | 1.019               |
|                                                | 2.0    | 0.364                  | 0.362                 | 1.0155                  | 1.3369 | 1.24                    | 1.038               |
|                                                | 3.0    | 0.551                  | 0.548                 | 1.0242                  | 1.3388 | 1.89                    | 1.058               |
|                                                | 4.0    | 0.743                  | 0.736                 | 1.0330                  | 1.3408 | 2.57                    | 1.079               |
|                                                | 5.0    | 0.938                  | 0.929                 | 1.0419                  | 1.3427 | 3.36                    | 1.102               |
|                                                | 6.0    | 1.138                  | 1.124                 | 1.0509                  | 1.3445 | 4.14                    | 1.126               |
|                                                | 7.0    | 1.342                  | 1.322                 | 1.0599                  | 1.3464 | 4.92                    | 1.151               |
|                                                | 8.0    | 1.550                  | 1.524                 | 1.0690                  | 1.3483 |                         | 1.177               |
|                                                | 9.0    | 1.763                  | 1.729                 | 1.0781                  | 1.3502 |                         | 1.205               |
|                                                | 10.0   | 1.980                  | 1.938                 | 1.0873                  | 1.3520 |                         | 1.233               |
|                                                | 12.0   | 2.431                  | 2.365                 | 1.1059                  | 1.3558 |                         | 1.294               |
|                                                | 14.0   | 2.902                  | 2.806                 | 1.1246                  | 1.3595 |                         | 1.361               |
|                                                | 16.0   | 3.395                  | 3.261                 | 1.1435                  | 1.3632 |                         | 1.436               |
|                                                | 18.0   | 3.913                  | 3.730                 | 1.1626                  | 1.3670 |                         | 1.521               |

| Solute                 | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                        | 20.0   | 4.456                  | 4.213                 | 1.1818                  | 1.3707 |                         | 1.619               |
|                        | 22.0   | 5.027                  | 4.711                 | 1.2014                  | 1.3744 |                         | 1.732               |
|                        | 24.0   | 5.629                  | 5.223                 | 1.2210                  | 1.3781 |                         | 1.861               |
|                        | 26.0   | 6.262                  | 5.750                 | 1.2408                  | 1.3818 |                         | 2.006               |
|                        | 28.0   | 6.931                  | 6.293                 | 1.2609                  | 1.3854 |                         | 2.170               |
|                        | 30.0   | 7.639                  | 6.851                 | 1.2813                  | 1.3889 |                         | 2.357               |
|                        | 40.0   | 11.882                 | 9.896                 | 1.3881                  | 1.4068 |                         | 3.879               |
|                        | 50.0   | 17.824                 | 13.389                | 1.5024                  | 1.4247 |                         | 7.892               |
| Potassium iodide       | 0.5    | 0.030                  | 0.030                 | 1.0019                  | 1.3337 | 0.11                    | 0.999               |
| KI                     | 1.0    | 0.061                  | 0.061                 | 1.0056                  | 1.3343 | 0.22                    | 0.997               |
|                        | 2.0    | 0.123                  | 0.122                 | 1.0131                  | 1.3357 | 0.43                    | 0.991               |
|                        | 3.0    | 0.186                  | 0.184                 | 1.0206                  | 1.3370 | 0.64                    | 0.986               |
|                        | 4.0    | 0.251                  | 0.248                 | 1.0282                  | 1.3384 | 0.86                    | 0.981               |
|                        | 5.0    | 0.317                  | 0.312                 | 1.0360                  | 1.3397 | 1.08                    | 0.976               |
|                        | 6.0    | 0.385                  | 0.377                 | 1.0438                  | 1.3411 | 1.30                    | 0.969               |
|                        | 7.0    | 0.453                  | 0.443                 | 1.0517                  | 1.3425 | 1.53                    | 0.963               |
|                        | 8.0    | 0.524                  | 0.511                 | 1.0598                  | 1.3440 | 1.77                    | 0.957               |
|                        | 9.0    | 0.596                  | 0.579                 | 1.0679                  | 1.3454 | 2.01                    | 0.951               |
|                        | 10.0   | 0.669                  | 0.648                 | 1.0762                  | 1.3469 | 2.26                    | 0.946               |
|                        | 12.0   | 0.821                  | 0.790                 | 1.0931                  | 1.3498 | 2.77                    | 0.937               |
|                        | 14.0   | 0.981                  | 0.937                 | 1.1105                  | 1.3529 | 3.30                    | 0.929               |
|                        | 16.0   | 1.147                  | 1.088                 | 1.1284                  | 1.3560 | 3.87                    | 0.921               |
|                        | 18.0   | 1.322                  | 1.244                 | 1.1469                  | 1.3593 | 4.46                    | 0.915               |
|                        | 20.0   | 1.506                  | 1.405                 | 1.1659                  | 1.3626 | 5.09                    | 0.910               |
|                        | 22.0   | 1.699                  | 1.571                 | 1.1856                  | 1.3661 | 5.76                    | 0.905               |
|                        | 24.0   | 1.902                  | 1.744                 | 1.2060                  | 1.3696 | 6.46                    | 0.901               |
|                        | 26.0   | 2.117                  | 1.922                 | 1.2270                  | 1.3733 | 7.21                    | 0.898               |
|                        | 28.0   | 2.343                  | 2.106                 | 1.2487                  | 1.3771 | 8.01                    | 0.895               |
|                        | 30.0   | 2.582                  | 2.297                 | 1.2712                  | 1.3810 | 8.86                    | 0.892               |
|                        | 32.0   | 2.835                  | 2.495                 | 1.2944                  | 1.3851 | 9.76                    | 0.891               |
|                        | 34.0   | 3.103                  | 2.700                 | 1.3185                  | 1.3893 | 10.72                   | 0.890               |
|                        | 36.0   | 3.388                  | 2.913                 | 1.3434                  | 1.3936 | 11.73                   | 0.890               |
|                        | 38.0   | 3.692                  | 3.134                 | 1.3692                  | 1.3981 | 12.81                   | 0.893               |
|                        | 40.0   | 4.016                  | 3.364                 | 1.3959                  | 1.4027 | 13.97                   | 0.897               |
| Potassium nitrate      | 0.5    | 0.050                  | 0.050                 | 1.0014                  | 1.3335 | 0.17                    | 0.999               |
| KNO <sub>3</sub>       | 1.0    | 0.100                  | 0.099                 | 1.0045                  | 1.3339 | 0.33                    | 0.996               |
|                        | 2.0    | 0.202                  | 0.200                 | 1.0108                  | 1.3349 | 0.64                    | 0.990               |
|                        | 3.0    | 0.306                  | 0.302                 | 1.0171                  | 1.3358 | 0.94                    | 0.986               |
|                        | 4.0    | 0.412                  | 0.405                 | 1.0234                  | 1.3368 | 1.22                    | 0.983               |
|                        | 5.0    | 0.521                  | 0.509                 | 1.0298                  | 1.3377 | 1.50                    | 0.980               |
|                        | 6.0    | 0.631                  | 0.615                 | 1.0363                  | 1.3386 | 1.76                    | 0.977               |
|                        | 7.0    | 0.744                  | 0.722                 | 1.0428                  | 1.3396 | 2.02                    | 0.975               |
|                        | 8.0    | 0.860                  | 0.830                 | 1.0494                  | 1.3405 | 2.27                    | 0.973               |
|                        | 9.0    | 0.978                  | 0.940                 | 1.0560                  | 1.3415 | 2.52                    | 0.971               |
|                        | 10.0   | 1.099                  | 1.051                 | 1.0627                  | 1.3425 | 2.75                    | 0.970               |
|                        | 12.0   | 1.349                  | 1.277                 | 1.0762                  | 1.3444 |                         | 0.970               |
|                        | 14.0   | 1.610                  | 1.509                 | 1.0899                  | 1.3463 |                         | 0.972               |
|                        | 16.0   | 1.884                  | 1.747                 | 1.1039                  | 1.3482 |                         | 0.976               |
|                        | 18.0   | 2.171                  | 1.991                 | 1.1181                  | 1.3502 |                         | 0.982               |
|                        | 20.0   | 2.473                  | 2.240                 | 1.1326                  | 1.3521 |                         | 0.990               |
|                        | 22.0   | 2.790                  | 2.497                 | 1.1473                  | 1.3541 |                         | 0.999               |
|                        | 24.0   | 3.123                  | 2.759                 | 1.1623                  | 1.3561 |                         | 1.010               |
| Potassium permanganate | 0.5    | 0.032                  | 0.032                 | 1.0017                  |        | 0.11                    | 1.001               |
| KMnO <sub>4</sub>      | 1.0    | 0.064                  | 0.064                 | 1.0051                  |        | 0.22                    | 1.000               |
|                        | 1.5    | 0.096                  | 0.096                 | 1.0085                  |        | 0.32                    | 0.999               |
|                        | 2.0    | 0.129                  | 0.128                 | 1.0118                  |        | 0.43                    | 0.998               |
|                        | 3.0    | 0.196                  | 0.193                 | 1.0186                  |        |                         | 0.995               |
|                        | 4.0    | 0.264                  | 0.260                 | 1.0254                  |        |                         | 0.992               |

| Solute                                       | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|----------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                              | 5.0    | 0.333                  | 0.327                 | 1.0322                  |        |                         | 0.989               |
|                                              | 6.0    | 0.404                  | 0.394                 | 1.0390                  |        |                         | 0.985               |
| Potassium                                    | 0.5    | 0.029                  | 0.029                 | 1.0025                  | 1.3338 | 0.13                    | 1.013               |
| hydrogen                                     | 1.0    | 0.058                  | 0.058                 | 1.0068                  | 1.3345 | 0.25                    | 1.023               |
| phosphate                                    | 1.5    | 0.087                  | 0.087                 | 1.0110                  | 1.3353 | 0.37                    | 1.034               |
| $\text{K}_2\text{HPO}_4$                     | 2.0    | 0.117                  | 0.117                 | 1.0153                  | 1.3361 | 0.49                    | 1.046               |
|                                              | 2.5    | 0.147                  | 0.146                 | 1.0195                  | 1.3368 | 0.61                    | 1.057               |
|                                              | 3.0    | 0.178                  | 0.176                 | 1.0238                  | 1.3376 | 0.73                    | 1.069               |
|                                              | 3.5    | 0.208                  | 0.207                 | 1.0281                  | 1.3384 | 0.86                    | 1.081               |
|                                              | 4.0    | 0.239                  | 0.237                 | 1.0324                  | 1.3392 | 0.97                    | 1.094               |
|                                              | 4.5    | 0.271                  | 0.268                 | 1.0368                  | 1.3399 | 1.10                    | 1.107               |
|                                              | 5.0    | 0.302                  | 0.299                 | 1.0412                  | 1.3407 | 1.22                    | 1.120               |
|                                              | 6.0    | 0.366                  | 0.362                 | 1.0500                  | 1.3422 | 1.46                    | 1.147               |
|                                              | 7.0    | 0.432                  | 0.426                 | 1.0590                  | 1.3438 | 1.70                    | 1.177               |
|                                              | 8.0    | 0.499                  | 0.491                 | 1.0680                  | 1.3453 | 1.95                    | 1.209               |
| Potassium                                    | 0.5    | 0.037                  | 0.037                 | 1.0018                  | 1.3336 | 0.13                    | 1.010               |
| dihydrogen                                   | 1.0    | 0.074                  | 0.074                 | 1.0053                  | 1.3342 | 0.25                    | 1.019               |
| phosphate                                    | 1.5    | 0.112                  | 0.111                 | 1.0089                  | 1.3348 | 0.37                    | 1.028               |
| $\text{KH}_2\text{PO}_4$                     | 2.0    | 0.150                  | 0.149                 | 1.0125                  | 1.3354 | 0.49                    | 1.038               |
|                                              | 3.0    | 0.227                  | 0.225                 | 1.0197                  | 1.3365 | 0.72                    | 1.060               |
|                                              | 4.0    | 0.306                  | 0.302                 | 1.0269                  | 1.3377 | 0.96                    | 1.083               |
|                                              | 5.0    | 0.387                  | 0.380                 | 1.0342                  | 1.3388 | 1.19                    | 1.108               |
|                                              | 6.0    | 0.469                  | 0.459                 | 1.0414                  | 1.3400 | 1.41                    | 1.133               |
|                                              | 7.0    | 0.553                  | 0.539                 | 1.0486                  | 1.3411 | 1.63                    | 1.160               |
|                                              | 8.0    | 0.639                  | 0.621                 | 1.0558                  | 1.3422 | 1.84                    | 1.187               |
|                                              | 9.0    | 0.727                  | 0.703                 | 1.0630                  | 1.3434 | 2.04                    | 1.215               |
|                                              | 10.0   | 0.816                  | 0.786                 | 1.0703                  | 1.3445 | 2.23                    | 1.245               |
| Potassium                                    | 0.5    | 0.029                  | 0.029                 | 1.0022                  | 1.3336 | 0.14                    | 1.006               |
| sulfate                                      | 1.0    | 0.058                  | 0.058                 | 1.0062                  | 1.3343 | 0.26                    | 1.011               |
| $\text{K}_2\text{SO}_4$                      | 2.0    | 0.117                  | 0.116                 | 1.0143                  | 1.3355 | 0.50                    | 1.021               |
|                                              | 3.0    | 0.177                  | 0.176                 | 1.0224                  | 1.3368 | 0.73                    | 1.033               |
|                                              | 4.0    | 0.239                  | 0.237                 | 1.0306                  | 1.3380 | 0.95                    | 1.045               |
|                                              | 5.0    | 0.302                  | 0.298                 | 1.0388                  | 1.3393 | 1.17                    | 1.058               |
|                                              | 6.0    | 0.366                  | 0.360                 | 1.0470                  | 1.3405 |                         | 1.072               |
|                                              | 7.0    | 0.432                  | 0.424                 | 1.0553                  | 1.3417 |                         | 1.087               |
|                                              | 8.0    | 0.499                  | 0.488                 | 1.0637                  | 1.3428 |                         | 1.102               |
|                                              | 9.0    | 0.568                  | 0.554                 | 1.0721                  | 1.3440 |                         | 1.117               |
|                                              | 10.0   | 0.638                  | 0.620                 | 1.0806                  | 1.3452 |                         | 1.132               |
| 1-Propanol                                   | 1.0    | 0.168                  | 0.166                 | 0.9963                  | 1.3339 | 0.31                    | 1.051               |
| $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ | 2.0    | 0.340                  | 0.331                 | 0.9946                  | 1.3348 | 0.61                    | 1.100               |
|                                              | 3.0    | 0.515                  | 0.496                 | 0.9928                  | 1.3357 | 0.93                    | 1.152               |
|                                              | 4.0    | 0.693                  | 0.660                 | 0.9911                  | 1.3366 | 1.24                    | 1.208               |
|                                              | 5.0    | 0.876                  | 0.823                 | 0.9896                  | 1.3376 | 1.57                    | 1.267               |
|                                              | 6.0    | 1.062                  | 0.987                 | 0.9882                  | 1.3385 | 1.91                    | 1.325               |
|                                              | 7.0    | 1.252                  | 1.149                 | 0.9868                  | 1.3394 | 2.26                    | 1.387               |
|                                              | 8.0    | 1.447                  | 1.312                 | 0.9855                  | 1.3404 | 2.61                    | 1.449               |
|                                              | 9.0    | 1.646                  | 1.474                 | 0.9842                  | 1.3414 | 2.99                    | 1.514               |
|                                              | 10.0   | 1.849                  | 1.635                 | 0.9829                  | 1.3423 | 3.36                    | 1.577               |
|                                              | 12.0   | 2.269                  | 1.958                 | 0.9804                  | 1.3442 | 4.09                    | 1.710               |
|                                              | 14.0   | 2.709                  | 2.278                 | 0.9779                  | 1.3460 | 4.91                    | 1.849               |
|                                              | 16.0   | 3.169                  | 2.595                 | 0.9749                  | 1.3477 | 5.78                    | 1.986               |
|                                              | 18.0   | 3.652                  | 2.911                 | 0.9719                  | 1.3494 | 6.67                    | 2.106               |
|                                              | 20.0   | 4.160                  | 3.223                 | 0.9686                  | 1.3510 | 7.76                    | 2.218               |
|                                              | 24.0   | 5.254                  | 3.838                 | 0.9612                  | 1.3539 | 9.12                    | 2.432               |
|                                              | 28.0   | 6.471                  | 4.441                 | 0.9533                  | 1.3566 | 10.17                   | 2.612               |
|                                              | 32.0   | 7.830                  | 5.033                 | 0.9452                  | 1.3592 | 10.66                   | 2.765               |
|                                              | 36.0   | 9.359                  | 5.613                 | 0.9370                  | 1.3614 |                         | 2.900               |



| Solute                       | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                              | 40.0   | 11.093                 | 6.182                 | 0.9288                  | 1.3635 |                         | 3.010               |
|                              | 60.0   | 24.958                 | 8.860                 | 0.8875                  | 1.3734 |                         | 3.186               |
|                              | 80.0   | 66.556                 | 11.275                | 0.8470                  | 1.3812 |                         | 2.822               |
|                              | 100.0  |                        | 13.368                | 0.8034                  | 1.3852 |                         | 2.227               |
| 2-Propanol                   | 1.0    | 0.168                  | 0.166                 | 0.9960                  | 1.3338 | 0.30                    | 1.056               |
| $\text{CH}_3\text{CHOHCH}_3$ | 2.0    | 0.340                  | 0.331                 | 0.9939                  | 1.3346 | 0.60                    | 1.112               |
|                              | 3.0    | 0.515                  | 0.495                 | 0.9920                  | 1.3355 | 0.93                    | 1.166               |
|                              | 4.0    | 0.693                  | 0.659                 | 0.9902                  | 1.3364 | 1.26                    | 1.225               |
|                              | 5.0    | 0.876                  | 0.822                 | 0.9884                  | 1.3373 | 1.61                    | 1.287               |
|                              | 6.0    | 1.062                  | 0.985                 | 0.9871                  | 1.3382 | 1.96                    | 1.352               |
|                              | 7.0    | 1.252                  | 1.148                 | 0.9855                  | 1.3392 | 2.32                    | 1.417               |
|                              | 8.0    | 1.447                  | 1.310                 | 0.9843                  | 1.3400 | 2.68                    | 1.485               |
|                              | 9.0    | 1.646                  | 1.472                 | 0.9831                  | 1.3410 | 3.06                    | 1.553               |
|                              | 10.0   | 1.849                  | 1.633                 | 0.9816                  | 1.3420 | 3.48                    | 1.629               |
|                              | 12.0   | 2.269                  | 1.955                 | 0.9793                  | 1.3439 | 4.43                    | 1.794               |
|                              | 14.0   | 2.709                  | 2.276                 | 0.9772                  | 1.3459 | 5.29                    | 1.970               |
|                              | 16.0   | 3.169                  | 2.596                 | 0.9751                  | 1.3478 | 6.36                    | 2.160               |
|                              | 18.0   | 3.652                  | 2.913                 | 0.9725                  | 1.3496 | 7.40                    | 2.352               |
|                              | 20.0   | 4.160                  | 3.227                 | 0.9696                  | 1.3514 | 8.52                    | 2.550               |
|                              | 40.0   | 11.093                 | 6.191                 | 0.9302                  | 1.3642 |                         |                     |
|                              | 60.0   | 24.958                 | 8.809                 | 0.8824                  | 1.3717 |                         |                     |
|                              | 80.0   | 66.556                 | 11.103                | 0.8341                  | 1.3742 |                         |                     |
|                              | 100.0  |                        | 13.058                | 0.7848                  | 1.3776 |                         |                     |
| Silver                       | 0.5    | 0.030                  | 0.030                 | 1.0027                  | 1.3336 | 0.10                    | 1.003               |
| nitrate                      | 1.0    | 0.059                  | 0.059                 | 1.0070                  | 1.3342 | 0.20                    | 1.005               |
| $\text{AgNO}_3$              | 2.0    | 0.120                  | 0.120                 | 1.0154                  | 1.3352 | 0.40                    | 1.009               |
|                              | 3.0    | 0.182                  | 0.181                 | 1.0239                  | 1.3363 | 0.59                    | 1.013               |
|                              | 4.0    | 0.245                  | 0.243                 | 1.0327                  | 1.3374 | 0.78                    | 1.016               |
|                              | 5.0    | 0.310                  | 0.307                 | 1.0417                  | 1.3385 | 0.96                    | 1.020               |
|                              | 6.0    | 0.376                  | 0.371                 | 1.0506                  | 1.3396 | 1.15                    | 1.024               |
|                              | 7.0    | 0.443                  | 0.437                 | 1.0597                  | 1.3407 | 1.33                    | 1.027               |
|                              | 8.0    | 0.512                  | 0.503                 | 1.0690                  | 1.3419 | 1.51                    | 1.031               |
|                              | 9.0    | 0.582                  | 0.571                 | 1.0785                  | 1.3431 | 1.69                    | 1.035               |
|                              | 10.0   | 0.654                  | 0.641                 | 1.0882                  | 1.3443 | 1.87                    | 1.039               |
|                              | 12.0   | 0.803                  | 0.783                 | 1.1079                  | 1.3467 | 2.21                    | 1.049               |
|                              | 14.0   | 0.958                  | 0.930                 | 1.1284                  | 1.3493 | 2.55                    | 1.060               |
|                              | 16.0   | 1.121                  | 1.083                 | 1.1496                  | 1.3519 | 2.86                    | 1.072               |
|                              | 18.0   | 1.292                  | 1.241                 | 1.1715                  | 1.3546 |                         | 1.086               |
|                              | 20.0   | 1.472                  | 1.406                 | 1.1942                  | 1.3574 |                         | 1.101               |
|                              | 22.0   | 1.660                  | 1.577                 | 1.2177                  | 1.3602 |                         | 1.117               |
|                              | 24.0   | 1.859                  | 1.755                 | 1.2420                  | 1.3632 |                         | 1.135               |
|                              | 26.0   | 2.068                  | 1.940                 | 1.2672                  | 1.3662 |                         | 1.154               |
|                              | 28.0   | 2.289                  | 2.132                 | 1.2933                  | 1.3694 |                         | 1.176               |
|                              | 30.0   | 2.523                  | 2.332                 | 1.3204                  | 1.3726 |                         | 1.200               |
|                              | 32.0   | 2.770                  | 2.541                 | 1.3487                  | 1.3760 |                         | 1.227               |
|                              | 34.0   | 3.033                  | 2.758                 | 1.3780                  | 1.3795 |                         | 1.257               |
|                              | 36.0   | 3.311                  | 2.985                 | 1.4087                  | 1.3832 |                         | 1.290               |
|                              | 38.0   | 3.608                  | 3.223                 | 1.4407                  | 1.3871 |                         | 1.326               |
|                              | 40.0   | 3.925                  | 3.472                 | 1.4743                  | 1.3911 |                         | 1.366               |
| Sodium                       | 0.5    | 0.061                  | 0.061                 | 1.0008                  | 1.3337 | 0.22                    | 1.021               |
| acetate                      | 1.0    | 0.123                  | 0.122                 | 1.0034                  | 1.3344 | 0.43                    | 1.040               |
| $\text{CH}_3\text{COONa}$    | 2.0    | 0.249                  | 0.246                 | 1.0085                  | 1.3358 | 0.88                    | 1.080               |
|                              | 3.0    | 0.377                  | 0.371                 | 1.0135                  | 1.3372 | 1.34                    | 1.124               |
|                              | 4.0    | 0.508                  | 0.497                 | 1.0184                  | 1.3386 | 1.82                    | 1.171               |
|                              | 5.0    | 0.642                  | 0.624                 | 1.0234                  | 1.3400 | 2.32                    | 1.222               |
|                              | 6.0    | 0.778                  | 0.752                 | 1.0283                  | 1.3414 | 2.85                    | 1.278               |
|                              | 7.0    | 0.918                  | 0.882                 | 1.0334                  | 1.3428 | 3.40                    | 1.337               |
|                              | 8.0    | 1.060                  | 1.013                 | 1.0386                  | 1.3442 | 3.98                    | 1.401               |

| Solute                                       | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|----------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                              | 9.0    | 1.206                  | 1.145                 | 1.0440                  | 1.3456 | 4.57                    | 1.468               |
|                                              | 10.0   | 1.354                  | 1.279                 | 1.0495                  | 1.3470 |                         | 1.539               |
|                                              | 12.0   | 1.662                  | 1.552                 | 1.0607                  | 1.3498 |                         | 1.688               |
|                                              | 14.0   | 1.984                  | 1.829                 | 1.0718                  | 1.3526 |                         | 1.855               |
|                                              | 16.0   | 2.322                  | 2.112                 | 1.0830                  | 1.3554 |                         | 2.054               |
|                                              | 18.0   | 2.676                  | 2.400                 | 1.0940                  | 1.3583 |                         | 2.284               |
|                                              | 20.0   | 3.047                  | 2.694                 | 1.1050                  | 1.3611 |                         | 2.567               |
|                                              | 22.0   | 3.438                  | 2.993                 | 1.1159                  | 1.3639 |                         | 2.948               |
|                                              | 24.0   | 3.849                  | 3.297                 | 1.1268                  | 1.3666 |                         | 3.400               |
|                                              | 26.0   | 4.283                  | 3.606                 | 1.1377                  | 1.3693 |                         | 3.877               |
|                                              | 28.0   | 4.741                  | 3.921                 | 1.1488                  | 1.3720 |                         | 4.388               |
|                                              | 30.0   | 5.224                  | 4.243                 | 1.1602                  | 1.3748 |                         | 4.940               |
| Sodium bicarbonate<br>$\text{NaHCO}_3$       | 0.5    | 0.060                  | 0.060                 | 1.0018                  | 1.3337 | 0.20                    | 1.015               |
|                                              | 1.0    | 0.120                  | 0.120                 | 1.0054                  | 1.3344 | 0.40                    | 1.028               |
|                                              | 1.5    | 0.181                  | 0.180                 | 1.0089                  | 1.3351 | 0.59                    | 1.042               |
|                                              | 2.0    | 0.243                  | 0.241                 | 1.0125                  | 1.3357 | 0.78                    | 1.057               |
|                                              | 2.5    | 0.305                  | 0.302                 | 1.0160                  | 1.3364 | 0.98                    | 1.071               |
|                                              | 3.0    | 0.368                  | 0.364                 | 1.0196                  | 1.3370 | 1.16                    | 1.086               |
|                                              | 3.5    | 0.432                  | 0.426                 | 1.0231                  | 1.3377 | 1.35                    | 1.102               |
|                                              | 4.0    | 0.496                  | 0.489                 | 1.0266                  | 1.3383 | 1.54                    | 1.118               |
|                                              | 4.5    | 0.561                  | 0.552                 | 1.0301                  | 1.3390 | 1.72                    | 1.134               |
|                                              | 5.0    | 0.627                  | 0.615                 | 1.0337                  | 1.3396 | 1.90                    | 1.151               |
|                                              | 5.5    | 0.693                  | 0.679                 | 1.0372                  | 1.3403 | 2.08                    | 1.168               |
|                                              | 6.0    | 0.760                  | 0.743                 | 1.0408                  | 1.3409 | 2.26                    | 1.185               |
| Sodium bromide<br>$\text{NaBr}$              | 0.5    | 0.049                  | 0.049                 | 1.0021                  | 1.3337 | 0.17                    | 1.004               |
|                                              | 1.0    | 0.098                  | 0.098                 | 1.0060                  | 1.3344 | 0.34                    | 1.007               |
|                                              | 2.0    | 0.198                  | 0.197                 | 1.0139                  | 1.3358 | 0.69                    | 1.012               |
|                                              | 3.0    | 0.301                  | 0.298                 | 1.0218                  | 1.3372 | 1.04                    | 1.017               |
|                                              | 4.0    | 0.405                  | 0.400                 | 1.0298                  | 1.3386 | 1.39                    | 1.022               |
|                                              | 5.0    | 0.512                  | 0.504                 | 1.0380                  | 1.3401 | 1.76                    | 1.028               |
|                                              | 6.0    | 0.620                  | 0.610                 | 1.0462                  | 1.3415 | 2.14                    | 1.034               |
|                                              | 7.0    | 0.732                  | 0.717                 | 1.0546                  | 1.3430 | 2.53                    | 1.040               |
|                                              | 8.0    | 0.845                  | 0.826                 | 1.0630                  | 1.3445 | 2.93                    | 1.046               |
|                                              | 9.0    | 0.961                  | 0.937                 | 1.0716                  | 1.3460 | 3.34                    | 1.053               |
|                                              | 10.0   | 1.080                  | 1.050                 | 1.0803                  | 1.3475 | 3.77                    | 1.060               |
|                                              | 12.0   | 1.325                  | 1.281                 | 1.0981                  | 1.3506 | 4.67                    | 1.077               |
|                                              | 14.0   | 1.582                  | 1.519                 | 1.1164                  | 1.3538 | 5.65                    | 1.096               |
|                                              | 16.0   | 1.851                  | 1.765                 | 1.1352                  | 1.3570 | 6.74                    | 1.119               |
|                                              | 18.0   | 2.133                  | 2.020                 | 1.1546                  | 1.3604 |                         | 1.144               |
|                                              | 20.0   | 2.430                  | 2.283                 | 1.1745                  | 1.3638 |                         | 1.174               |
|                                              | 22.0   | 2.741                  | 2.555                 | 1.1951                  | 1.3673 |                         | 1.207               |
|                                              | 24.0   | 3.069                  | 2.837                 | 1.2163                  | 1.3708 |                         | 1.244               |
|                                              | 26.0   | 3.415                  | 3.129                 | 1.2382                  | 1.3745 |                         | 1.287               |
|                                              | 28.0   | 3.780                  | 3.431                 | 1.2608                  | 1.3783 |                         | 1.336               |
|                                              | 30.0   | 4.165                  | 3.744                 | 1.2842                  | 1.3822 |                         | 1.395               |
|                                              | 32.0   | 4.574                  | 4.069                 | 1.3083                  | 1.3862 |                         | 1.465               |
|                                              | 34.0   | 5.007                  | 4.406                 | 1.3333                  | 1.3903 |                         | 1.546               |
|                                              | 36.0   | 5.467                  | 4.755                 | 1.3592                  | 1.3946 |                         | 1.639               |
|                                              | 38.0   | 5.957                  | 5.119                 | 1.3860                  | 1.3990 |                         | 1.745               |
|                                              | 40.0   | 6.479                  | 5.496                 | 1.4138                  | 1.4035 |                         | 1.866               |
| Sodium carbonate<br>$\text{Na}_2\text{CO}_3$ | 0.5    | 0.047                  | 0.047                 | 1.0034                  | 1.3341 | 0.22                    | 1.025               |
|                                              | 1.0    | 0.095                  | 0.095                 | 1.0086                  | 1.3352 | 0.43                    | 1.049               |
|                                              | 2.0    | 0.193                  | 0.192                 | 1.0190                  | 1.3375 | 0.75                    | 1.102               |
|                                              | 3.0    | 0.292                  | 0.291                 | 1.0294                  | 1.3397 | 1.08                    | 1.159               |
|                                              | 4.0    | 0.393                  | 0.392                 | 1.0398                  | 1.3419 | 1.42                    | 1.222               |
|                                              | 5.0    | 0.497                  | 0.495                 | 1.0502                  | 1.3440 | 1.77                    | 1.292               |
|                                              | 6.0    | 0.602                  | 0.600                 | 1.0606                  | 1.3462 | 2.13                    | 1.367               |
|                                              | 7.0    | 0.710                  | 0.707                 | 1.0711                  | 1.3483 |                         | 1.448               |

| Solute                                         | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                | 8.0    | 0.820                  | 0.816                 | 1.0816                  | 1.3504 |                         | 1.538               |
|                                                | 9.0    | 0.933                  | 0.927                 | 1.0922                  | 1.3525 |                         | 1.638               |
|                                                | 10.0   | 1.048                  | 1.041                 | 1.1029                  | 1.3547 |                         | 1.754               |
|                                                | 11.0   | 1.166                  | 1.156                 | 1.1136                  | 1.3568 |                         | 1.884               |
|                                                | 12.0   | 1.287                  | 1.273                 | 1.1244                  | 1.3589 |                         | 2.028               |
|                                                | 13.0   | 1.410                  | 1.392                 | 1.1353                  | 1.3610 |                         | 2.186               |
|                                                | 14.0   | 1.536                  | 1.514                 | 1.1463                  | 1.3631 |                         | 2.361               |
|                                                | 15.0   | 1.665                  | 1.638                 | 1.1574                  | 1.3652 |                         | 2.551               |
| Sodium<br>chloride<br>NaCl                     | 0.5    | 0.086                  | 0.086                 | 1.0018                  | 1.3339 | 0.30                    | 1.011               |
|                                                | 1.0    | 0.173                  | 0.172                 | 1.0053                  | 1.3347 | 0.59                    | 1.020               |
|                                                | 2.0    | 0.349                  | 0.346                 | 1.0125                  | 1.3365 | 1.19                    | 1.036               |
|                                                | 3.0    | 0.529                  | 0.523                 | 1.0196                  | 1.3383 | 1.79                    | 1.052               |
|                                                | 4.0    | 0.713                  | 0.703                 | 1.0268                  | 1.3400 | 2.41                    | 1.068               |
|                                                | 5.0    | 0.901                  | 0.885                 | 1.0340                  | 1.3418 | 3.05                    | 1.085               |
|                                                | 6.0    | 1.092                  | 1.069                 | 1.0413                  | 1.3435 | 3.70                    | 1.104               |
|                                                | 7.0    | 1.288                  | 1.256                 | 1.0486                  | 1.3453 | 4.38                    | 1.124               |
|                                                | 8.0    | 1.488                  | 1.445                 | 1.0559                  | 1.3470 | 5.08                    | 1.145               |
|                                                | 9.0    | 1.692                  | 1.637                 | 1.0633                  | 1.3488 | 5.81                    | 1.168               |
|                                                | 10.0   | 1.901                  | 1.832                 | 1.0707                  | 1.3505 | 6.56                    | 1.193               |
|                                                | 12.0   | 2.333                  | 2.229                 | 1.0857                  | 1.3541 | 8.18                    | 1.250               |
|                                                | 14.0   | 2.785                  | 2.637                 | 1.1008                  | 1.3576 | 9.94                    | 1.317               |
|                                                | 16.0   | 3.259                  | 3.056                 | 1.1162                  | 1.3612 | 11.89                   | 1.388               |
|                                                | 18.0   | 3.756                  | 3.486                 | 1.1319                  | 1.3648 | 14.04                   | 1.463               |
|                                                | 20.0   | 4.278                  | 3.928                 | 1.1478                  | 1.3684 | 16.46                   | 1.557               |
|                                                | 22.0   | 4.826                  | 4.382                 | 1.1640                  | 1.3721 | 19.18                   | 1.676               |
|                                                | 24.0   | 5.403                  | 4.847                 | 1.1804                  | 1.3757 |                         | 1.821               |
|                                                | 26.0   | 6.012                  | 5.326                 | 1.1972                  | 1.3795 |                         | 1.990               |
| Sodium<br>citrate<br>(HO)C(COONa) <sub>3</sub> | 1.0    | 0.039                  | 0.039                 | 1.0049                  | 1.3348 | 0.20                    | 1.043               |
|                                                | 2.0    | 0.079                  | 0.078                 | 1.0120                  | 1.3366 | 0.39                    | 1.081               |
|                                                | 3.0    | 0.120                  | 0.118                 | 1.0186                  | 1.3383 | 0.59                    | 1.122               |
|                                                | 4.0    | 0.161                  | 0.159                 | 1.0260                  | 1.3401 | 0.79                    | 1.166               |
|                                                | 5.0    | 0.204                  | 0.200                 | 1.0331                  | 1.3419 | 0.97                    | 1.210               |
|                                                | 6.0    | 0.247                  | 0.242                 | 1.0405                  | 1.3437 | 1.17                    | 1.263               |
|                                                | 7.0    | 0.292                  | 0.284                 | 1.0482                  | 1.3455 | 1.36                    | 1.314               |
|                                                | 8.0    | 0.337                  | 0.327                 | 1.0557                  | 1.3473 | 1.57                    | 1.371               |
|                                                | 9.0    | 0.383                  | 0.371                 | 1.0632                  | 1.3491 | 1.77                    | 1.427               |
|                                                | 10.0   | 0.431                  | 0.415                 | 1.0708                  | 1.3509 | 1.96                    | 1.499               |
|                                                | 12.0   | 0.528                  | 0.505                 | 1.0861                  | 1.3546 | 2.38                    | 1.649               |
|                                                | 14.0   | 0.631                  | 0.598                 | 1.1019                  | 1.3583 | 2.82                    | 1.832               |
|                                                | 16.0   | 0.738                  | 0.693                 | 1.1173                  | 1.3618 | 3.27                    | 2.045               |
|                                                | 18.0   | 0.851                  | 0.790                 | 1.1327                  | 1.3656 | 3.82                    | 2.290               |
|                                                | 20.0   | 0.969                  | 0.891                 | 1.1492                  | 1.3693 | 4.39                    | 2.596               |
|                                                | 24.0   | 1.224                  | 1.099                 | 1.1813                  | 1.3767 |                         | 3.409               |
|                                                | 28.0   | 1.507                  | 1.318                 | 1.2151                  | 1.3845 |                         | 4.586               |
|                                                | 32.0   | 1.823                  | 1.548                 | 1.2487                  | 1.3923 |                         | 6.541               |
|                                                | 36.0   | 2.180                  | 1.792                 | 1.2843                  | 1.4001 |                         | 9.788               |
| Sodium<br>hydroxide<br>NaOH                    | 0.5    | 0.126                  | 0.125                 | 1.0039                  | 1.3344 | 0.43                    | 1.027               |
|                                                | 1.0    | 0.253                  | 0.252                 | 1.0095                  | 1.3358 | 0.86                    | 1.054               |
|                                                | 2.0    | 0.510                  | 0.510                 | 1.0207                  | 1.3386 | 1.74                    | 1.112               |
|                                                | 3.0    | 0.773                  | 0.774                 | 1.0318                  | 1.3414 | 2.64                    | 1.176               |
|                                                | 4.0    | 1.042                  | 1.043                 | 1.0428                  | 1.3441 | 3.59                    | 1.248               |
|                                                | 5.0    | 1.316                  | 1.317                 | 1.0538                  | 1.3467 | 4.57                    | 1.329               |
|                                                | 6.0    | 1.596                  | 1.597                 | 1.0648                  | 1.3494 | 5.60                    | 1.416               |
|                                                | 7.0    | 1.882                  | 1.883                 | 1.0758                  | 1.3520 | 6.69                    | 1.510               |
|                                                | 8.0    | 2.174                  | 2.174                 | 1.0869                  | 1.3546 | 7.87                    | 1.616               |
|                                                | 9.0    | 2.473                  | 2.470                 | 1.0979                  | 1.3572 | 9.12                    | 1.737               |
|                                                | 10.0   | 2.778                  | 2.772                 | 1.1089                  | 1.3597 | 10.47                   | 1.882               |
|                                                | 12.0   | 3.409                  | 3.393                 | 1.1309                  | 1.3648 | 13.42                   | 2.201               |

| Solute                                                    | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-----------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                           | 14.0   | 4.070                  | 4.036                 | 1.1530                  | 1.3697 | 16.76                   | 2.568               |
|                                                           | 15.0   | 4.412                  | 4.365                 | 1.1640                  | 1.3722 |                         | 2.789               |
|                                                           | 16.0   | 4.762                  | 4.701                 | 1.1751                  | 1.3746 |                         | 3.043               |
|                                                           | 18.0   | 5.488                  | 5.387                 | 1.1971                  | 1.3793 |                         | 3.698               |
|                                                           | 20.0   | 6.250                  | 6.096                 | 1.2192                  | 1.3840 |                         | 4.619               |
|                                                           | 22.0   | 7.052                  | 6.827                 | 1.2412                  | 1.3885 |                         | 5.765               |
|                                                           | 24.0   | 7.895                  | 7.579                 | 1.2631                  | 1.3929 |                         | 7.100               |
|                                                           | 26.0   | 8.784                  | 8.352                 | 1.2848                  | 1.3971 |                         | 8.744               |
|                                                           | 28.0   | 9.723                  | 9.145                 | 1.3064                  | 1.4012 |                         | 10.832              |
|                                                           | 30.0   | 10.715                 | 9.958                 | 1.3277                  | 1.4051 |                         | 13.517              |
|                                                           | 32.0   | 11.766                 | 10.791                | 1.3488                  | 1.4088 |                         | 16.844              |
|                                                           | 34.0   | 12.880                 | 11.643                | 1.3697                  | 1.4123 |                         | 20.751              |
|                                                           | 36.0   | 14.064                 | 12.512                | 1.3901                  | 1.4156 |                         | 25.290              |
|                                                           | 38.0   | 15.324                 | 13.398                | 1.4102                  | 1.4186 |                         | 30.461              |
|                                                           | 40.0   | 16.668                 | 14.300                | 1.4299                  | 1.4215 |                         | 36.312              |
| Sodium<br>nitrate<br>$\text{NaNO}_3$                      | 0.5    | 0.059                  | 0.059                 | 1.0016                  | 1.3336 | 0.20                    | 1.004               |
|                                                           | 1.0    | 0.119                  | 0.118                 | 1.0050                  | 1.3341 | 0.40                    | 1.007               |
|                                                           | 2.0    | 0.240                  | 0.238                 | 1.0117                  | 1.3353 | 0.79                    | 1.012               |
|                                                           | 3.0    | 0.364                  | 0.359                 | 1.0185                  | 1.3364 | 1.18                    | 1.018               |
|                                                           | 4.0    | 0.490                  | 0.483                 | 1.0254                  | 1.3375 | 1.56                    | 1.025               |
|                                                           | 5.0    | 0.619                  | 0.607                 | 1.0322                  | 1.3387 | 1.94                    | 1.032               |
|                                                           | 6.0    | 0.751                  | 0.734                 | 1.0392                  | 1.3398 | 2.32                    | 1.040               |
|                                                           | 7.0    | 0.886                  | 0.862                 | 1.0462                  | 1.3409 | 2.70                    | 1.049               |
|                                                           | 8.0    | 1.023                  | 0.991                 | 1.0532                  | 1.3421 | 3.08                    | 1.059               |
|                                                           | 9.0    | 1.164                  | 1.123                 | 1.0603                  | 1.3432 | 3.46                    | 1.069               |
|                                                           | 10.0   | 1.307                  | 1.256                 | 1.0674                  | 1.3443 | 3.84                    | 1.081               |
|                                                           | 12.0   | 1.604                  | 1.527                 | 1.0819                  | 1.3466 | 4.60                    | 1.107               |
|                                                           | 14.0   | 1.915                  | 1.806                 | 1.0967                  | 1.3489 | 5.37                    | 1.138               |
|                                                           | 18.0   | 2.583                  | 2.387                 | 1.1272                  | 1.3536 | 6.98                    | 1.215               |
|                                                           | 20.0   | 2.941                  | 2.689                 | 1.1429                  | 1.3559 | 7.81                    | 1.263               |
|                                                           | 30.0   | 5.042                  | 4.326                 | 1.2256                  | 1.3678 |                         | 1.609               |
|                                                           | 40.0   | 7.844                  | 6.200                 | 1.3175                  | 1.3802 |                         | 2.226               |
| Sodium<br>phosphate<br>$\text{Na}_3\text{PO}_4$           | 0.5    | 0.031                  | 0.031                 | 1.0042                  | 1.3343 | 0.19                    | 1.033               |
|                                                           | 1.0    | 0.062                  | 0.062                 | 1.0100                  | 1.3356 | 0.37                    | 1.064               |
|                                                           | 1.5    | 0.093                  | 0.093                 | 1.0158                  | 1.3369 | 0.53                    | 1.094               |
|                                                           | 2.0    | 0.124                  | 0.125                 | 1.0216                  | 1.3381 | 0.67                    | 1.126               |
|                                                           | 2.5    | 0.156                  | 0.157                 | 1.0275                  | 1.3394 | 0.79                    | 1.161               |
|                                                           | 3.0    | 0.189                  | 0.189                 | 1.0335                  | 1.3406 |                         | 1.198               |
|                                                           | 3.5    | 0.221                  | 0.222                 | 1.0395                  | 1.3419 |                         | 1.238               |
|                                                           | 4.0    | 0.254                  | 0.255                 | 1.0456                  | 1.3432 |                         | 1.281               |
|                                                           | 4.5    | 0.287                  | 0.289                 | 1.0517                  | 1.3444 |                         | 1.327               |
|                                                           | 5.0    | 0.321                  | 0.323                 | 1.0579                  | 1.3457 |                         | 1.375               |
|                                                           | 5.5    | 0.355                  | 0.357                 | 1.0642                  | 1.3470 |                         | 1.426               |
|                                                           | 6.0    | 0.389                  | 0.392                 | 1.0705                  | 1.3482 |                         | 1.480               |
|                                                           | 6.5    | 0.424                  | 0.427                 | 1.0768                  | 1.3495 |                         | 1.538               |
|                                                           | 7.0    | 0.459                  | 0.462                 | 1.0832                  | 1.3507 |                         | 1.598               |
|                                                           | 7.5    | 0.495                  | 0.498                 | 1.0896                  | 1.3519 |                         | 1.662               |
|                                                           | 8.0    | 0.530                  | 0.535                 | 1.0961                  | 1.3532 |                         | 1.729               |
| Sodium hydrogen<br>phosphate<br>$\text{Na}_2\text{HPO}_4$ | 0.5    | 0.035                  | 0.035                 | 1.0032                  | 1.3340 | 0.17                    | 1.021               |
|                                                           | 1.0    | 0.071                  | 0.071                 | 1.0082                  | 1.3349 | 0.32                    | 1.042               |
|                                                           | 1.5    | 0.107                  | 0.107                 | 1.0131                  | 1.3358 | 0.46                    | 1.064               |
|                                                           | 2.0    | 0.144                  | 0.143                 | 1.0180                  | 1.3368 |                         | 1.088               |
|                                                           | 2.5    | 0.181                  | 0.180                 | 1.0229                  | 1.3377 |                         | 1.113               |
|                                                           | 3.0    | 0.218                  | 0.217                 | 1.0279                  | 1.3386 |                         | 1.138               |
|                                                           | 3.5    | 0.255                  | 0.255                 | 1.0328                  | 1.3396 |                         | 1.165               |
|                                                           | 4.0    | 0.293                  | 0.292                 | 1.0378                  | 1.3405 |                         | 1.193               |
|                                                           | 4.5    | 0.332                  | 0.331                 | 1.0428                  | 1.3414 |                         | 1.223               |
|                                                           | 5.0    | 0.371                  | 0.369                 | 1.0478                  | 1.3424 |                         | 1.254               |

| Solute                            | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-----------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                   | 5.5    | 0.410                  | 0.408                 | 1.0528                  | 1.3433 |                         | 1.286               |
| Sodium                            | 0.5    | 0.042                  | 0.042                 | 1.0019                  | 1.3336 | 0.14                    | 1.018               |
| dihydrogen                        | 1.0    | 0.084                  | 0.084                 | 1.0056                  | 1.3343 | 0.28                    | 1.035               |
| phosphate                         | 1.5    | 0.127                  | 0.126                 | 1.0094                  | 1.3349 | 0.42                    | 1.051               |
| $\text{NaH}_2\text{PO}_4$         | 2.0    | 0.170                  | 0.169                 | 1.0131                  | 1.3356 | 0.56                    | 1.068               |
|                                   | 2.5    | 0.214                  | 0.212                 | 1.0168                  | 1.3362 | 0.70                    | 1.085               |
|                                   | 3.0    | 0.258                  | 0.255                 | 1.0206                  | 1.3369 | 0.84                    | 1.103               |
|                                   | 3.5    | 0.302                  | 0.299                 | 1.0244                  | 1.3375 | 0.98                    | 1.121               |
|                                   | 4.0    | 0.347                  | 0.343                 | 1.0281                  | 1.3382 | 1.12                    | 1.140               |
|                                   | 4.5    | 0.393                  | 0.387                 | 1.0319                  | 1.3388 | 1.25                    | 1.160               |
|                                   | 5.0    | 0.439                  | 0.432                 | 1.0358                  | 1.3395 | 1.39                    | 1.180               |
|                                   | 6.0    | 0.532                  | 0.522                 | 1.0434                  | 1.3408 | 1.65                    | 1.223               |
|                                   | 7.0    | 0.627                  | 0.613                 | 1.0511                  | 1.3421 | 1.89                    | 1.270               |
|                                   | 8.0    | 0.725                  | 0.706                 | 1.0589                  | 1.3434 | 2.12                    | 1.319               |
|                                   | 9.0    | 0.824                  | 0.800                 | 1.0668                  | 1.3447 | 2.35                    | 1.371               |
|                                   | 10.0   | 0.926                  | 0.896                 | 1.0747                  | 1.3460 | 2.58                    | 1.428               |
|                                   | 12.0   | 1.137                  | 1.091                 | 1.0907                  | 1.3486 | 3.06                    | 1.552               |
|                                   | 14.0   | 1.357                  | 1.292                 | 1.1070                  | 1.3512 | 3.53                    | 1.694               |
|                                   | 16.0   | 1.588                  | 1.499                 | 1.1236                  | 1.3538 | 4.03                    | 1.861               |
|                                   | 18.0   | 1.830                  | 1.711                 | 1.1404                  | 1.3565 | 4.55                    | 2.050               |
|                                   | 20.0   | 2.084                  | 1.930                 | 1.1576                  | 1.3592 | 5.10                    | 2.283               |
|                                   | 22.0   | 2.351                  | 2.155                 | 1.1752                  | 1.3618 |                         | 2.550               |
|                                   | 24.0   | 2.632                  | 2.387                 | 1.1931                  | 1.3646 |                         | 2.850               |
|                                   | 26.0   | 2.929                  | 2.625                 | 1.2113                  | 1.3673 |                         | 3.214               |
|                                   | 28.0   | 3.242                  | 2.870                 | 1.2299                  | 1.3700 |                         | 3.682               |
|                                   | 30.0   | 3.572                  | 3.123                 | 1.2488                  | 1.3728 |                         | 4.300               |
|                                   | 32.0   | 3.923                  | 3.383                 | 1.2682                  | 1.3756 |                         | 5.079               |
|                                   | 34.0   | 4.294                  | 3.650                 | 1.2879                  | 1.3784 |                         | 6.008               |
|                                   | 36.0   | 4.689                  | 3.925                 | 1.3080                  | 1.3812 |                         | 7.098               |
|                                   | 38.0   | 5.109                  | 4.208                 | 1.3285                  | 1.3840 |                         | 8.363               |
|                                   | 40.0   | 5.557                  | 4.499                 | 1.3493                  | 1.3869 |                         | 9.814               |
| Sodium                            | 0.5    | 0.035                  | 0.035                 | 1.0027                  | 1.3338 | 0.17                    | 1.013               |
| sulfate                           | 1.0    | 0.071                  | 0.071                 | 1.0071                  | 1.3345 | 0.32                    | 1.026               |
| $\text{Na}_2\text{SO}_4$          | 2.0    | 0.144                  | 0.143                 | 1.0161                  | 1.3360 | 0.61                    | 1.058               |
|                                   | 3.0    | 0.218                  | 0.217                 | 1.0252                  | 1.3376 | 0.87                    | 1.091               |
|                                   | 4.0    | 0.293                  | 0.291                 | 1.0343                  | 1.3391 | 1.13                    | 1.126               |
|                                   | 5.0    | 0.371                  | 0.367                 | 1.0436                  | 1.3406 | 1.36                    | 1.163               |
|                                   | 6.0    | 0.449                  | 0.445                 | 1.0526                  | 1.3420 | 1.56                    | 1.202               |
|                                   | 7.0    | 0.530                  | 0.523                 | 1.0619                  | 1.3435 |                         | 1.244               |
|                                   | 8.0    | 0.612                  | 0.603                 | 1.0713                  | 1.3449 |                         | 1.289               |
|                                   | 9.0    | 0.696                  | 0.685                 | 1.0808                  | 1.3464 |                         | 1.337               |
|                                   | 10.0   | 0.782                  | 0.768                 | 1.0905                  | 1.3479 |                         | 1.390               |
|                                   | 12.0   | 0.960                  | 0.938                 | 1.1101                  | 1.3509 |                         | 1.508               |
|                                   | 14.0   | 1.146                  | 1.114                 | 1.1301                  | 1.3539 |                         | 1.646               |
|                                   | 16.0   | 1.341                  | 1.296                 | 1.1503                  | 1.3567 |                         | 1.812               |
|                                   | 18.0   | 1.545                  | 1.483                 | 1.1705                  | 1.3595 |                         | 2.005               |
|                                   | 20.0   | 1.760                  | 1.677                 | 1.1907                  | 1.3620 |                         | 2.227               |
|                                   | 22.0   | 1.986                  | 1.875                 | 1.2106                  | 1.3643 |                         | 2.481               |
| Sodium                            | 0.5    | 0.032                  | 0.032                 | 1.0024                  | 1.3340 | 0.14                    | 1.012               |
| thiosulfate                       | 1.0    | 0.064                  | 0.064                 | 1.0065                  | 1.3351 | 0.28                    | 1.023               |
| $\text{Na}_2\text{S}_2\text{O}_3$ | 2.0    | 0.129                  | 0.128                 | 1.0148                  | 1.3371 | 0.57                    | 1.044               |
|                                   | 3.0    | 0.196                  | 0.194                 | 1.0231                  | 1.3392 | 0.84                    | 1.066               |
|                                   | 4.0    | 0.264                  | 0.261                 | 1.0315                  | 1.3413 | 1.09                    | 1.090               |
|                                   | 5.0    | 0.333                  | 0.329                 | 1.0399                  | 1.3434 | 1.34                    | 1.115               |
|                                   | 6.0    | 0.404                  | 0.398                 | 1.0483                  | 1.3454 | 1.59                    | 1.141               |
|                                   | 7.0    | 0.476                  | 0.468                 | 1.0568                  | 1.3475 | 1.83                    | 1.169               |
|                                   | 8.0    | 0.550                  | 0.539                 | 1.0654                  | 1.3496 | 2.06                    | 1.199               |
|                                   | 9.0    | 0.626                  | 0.611                 | 1.0740                  | 1.3517 | 2.30                    | 1.231               |

| Solute                                    | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|-------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                           | 10.0   | 0.703                  | 0.685                 | 1.0827                  | 1.3538 | 2.55                    | 1.267               |
|                                           | 12.0   | 0.862                  | 0.835                 | 1.1003                  | 1.3581 | 3.06                    | 1.345               |
|                                           | 14.0   | 1.030                  | 0.990                 | 1.1182                  | 1.3624 | 3.60                    | 1.435               |
|                                           | 16.0   | 1.205                  | 1.150                 | 1.1365                  | 1.3667 | 4.17                    | 1.537               |
|                                           | 18.0   | 1.388                  | 1.315                 | 1.1551                  | 1.3711 | 4.76                    | 1.657               |
|                                           | 20.0   | 1.581                  | 1.485                 | 1.1740                  | 1.3756 | 5.37                    | 1.798               |
|                                           | 30.0   | 2.711                  | 2.417                 | 1.2739                  | 1.3987 |                         | 2.903               |
|                                           | 40.0   | 4.216                  | 3.498                 | 1.3827                  | 1.4229 |                         | 5.758               |
| Strontium chloride                        | 0.5    | 0.032                  | 0.032                 | 1.0027                  | 1.3339 | 0.16                    | 1.012               |
|                                           | 1.0    | 0.064                  | 0.064                 | 1.0071                  | 1.3348 | 0.31                    | 1.021               |
| $\text{SrCl}_2$                           | 2.0    | 0.129                  | 0.128                 | 1.0161                  | 1.3366 | 0.62                    | 1.039               |
|                                           | 3.0    | 0.195                  | 0.194                 | 1.0252                  | 1.3384 | 0.93                    | 1.057               |
|                                           | 4.0    | 0.263                  | 0.261                 | 1.0344                  | 1.3402 | 1.26                    | 1.076               |
|                                           | 5.0    | 0.332                  | 0.329                 | 1.0437                  | 1.3421 | 1.61                    | 1.096               |
|                                           | 6.0    | 0.403                  | 0.399                 | 1.0532                  | 1.3440 | 1.98                    | 1.116               |
|                                           | 7.0    | 0.475                  | 0.469                 | 1.0628                  | 1.3459 | 2.38                    | 1.136               |
|                                           | 8.0    | 0.549                  | 0.541                 | 1.0726                  | 1.3478 | 2.80                    | 1.157               |
|                                           | 9.0    | 0.624                  | 0.615                 | 1.0825                  | 1.3498 | 3.25                    | 1.180               |
|                                           | 10.0   | 0.701                  | 0.689                 | 1.0925                  | 1.3518 | 3.74                    | 1.204               |
|                                           | 12.0   | 0.860                  | 0.843                 | 1.1131                  | 1.3558 | 4.81                    | 1.258               |
|                                           | 14.0   | 1.027                  | 1.002                 | 1.1342                  | 1.3599 | 6.03                    | 1.317               |
|                                           | 16.0   | 1.202                  | 1.167                 | 1.1558                  | 1.3641 | 7.41                    | 1.383               |
|                                           | 18.0   | 1.385                  | 1.338                 | 1.1780                  | 1.3684 | 8.98                    | 1.460               |
|                                           | 20.0   | 1.577                  | 1.515                 | 1.2008                  | 1.3728 | 10.74                   | 1.549               |
|                                           | 22.0   | 1.779                  | 1.699                 | 1.2241                  | 1.3772 | 12.74                   | 1.650               |
|                                           | 24.0   | 1.992                  | 1.890                 | 1.2481                  | 1.3817 | 14.99                   | 1.765               |
|                                           | 26.0   | 2.216                  | 2.087                 | 1.2728                  | 1.3864 |                         | 1.897               |
|                                           | 28.0   | 2.453                  | 2.293                 | 1.2983                  | 1.3911 |                         | 2.056               |
|                                           | 30.0   | 2.703                  | 2.507                 | 1.3248                  | 1.3961 |                         | 2.245               |
|                                           | 32.0   | 2.968                  | 2.730                 | 1.3523                  | 1.4013 |                         | 2.527               |
|                                           | 34.0   | 3.250                  | 2.962                 | 1.3811                  | 1.4067 |                         | 2.846               |
|                                           | 36.0   | 3.548                  | 3.205                 | 1.4114                  | 1.4124 |                         | 3.206               |
| Sucrose                                   | 0.5    | 0.015                  | 0.015                 | 1.0002                  | 1.3337 | 0.03                    | 1.015               |
| $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ | 1.0    | 0.030                  | 0.029                 | 1.0021                  | 1.3344 | 0.06                    | 1.028               |
|                                           | 2.0    | 0.060                  | 0.059                 | 1.0060                  | 1.3359 | 0.11                    | 1.055               |
|                                           | 3.0    | 0.090                  | 0.089                 | 1.0099                  | 1.3373 | 0.17                    | 1.084               |
|                                           | 4.0    | 0.122                  | 0.118                 | 1.0139                  | 1.3388 | 0.23                    | 1.114               |
|                                           | 5.0    | 0.154                  | 0.149                 | 1.0178                  | 1.3403 | 0.29                    | 1.146               |
|                                           | 6.0    | 0.186                  | 0.179                 | 1.0218                  | 1.3418 | 0.35                    | 1.179               |
|                                           | 7.0    | 0.220                  | 0.210                 | 1.0259                  | 1.3433 | 0.42                    | 1.215               |
|                                           | 8.0    | 0.254                  | 0.241                 | 1.0299                  | 1.3448 | 0.49                    | 1.254               |
|                                           | 9.0    | 0.289                  | 0.272                 | 1.0340                  | 1.3463 | 0.55                    | 1.294               |
|                                           | 10.0   | 0.325                  | 0.303                 | 1.0381                  | 1.3478 | 0.63                    | 1.336               |
|                                           | 12.0   | 0.398                  | 0.367                 | 1.0465                  | 1.3509 | 0.77                    | 1.429               |
|                                           | 14.0   | 0.476                  | 0.431                 | 1.0549                  | 1.3541 | 0.93                    | 1.534               |
|                                           | 16.0   | 0.556                  | 0.497                 | 1.0635                  | 1.3573 | 1.10                    | 1.653               |
|                                           | 18.0   | 0.641                  | 0.564                 | 1.0722                  | 1.3606 | 1.27                    | 1.790               |
|                                           | 20.0   | 0.730                  | 0.632                 | 1.0810                  | 1.3639 | 1.47                    | 1.945               |
|                                           | 22.0   | 0.824                  | 0.700                 | 1.0899                  | 1.3672 | 1.67                    | 2.124               |
|                                           | 24.0   | 0.923                  | 0.771                 | 1.0990                  | 1.3706 | 1.89                    | 2.331               |
|                                           | 26.0   | 1.026                  | 0.842                 | 1.1082                  | 1.3741 | 2.12                    | 2.573               |
|                                           | 28.0   | 1.136                  | 0.914                 | 1.1175                  | 1.3776 | 2.37                    | 2.855               |
|                                           | 30.0   | 1.252                  | 0.988                 | 1.1270                  | 1.3812 | 2.64                    | 3.187               |
|                                           | 32.0   | 1.375                  | 1.063                 | 1.1366                  | 1.3848 | 2.94                    | 3.762               |
|                                           | 34.0   | 1.505                  | 1.139                 | 1.1464                  | 1.3885 | 3.27                    | 4.052               |
|                                           | 36.0   | 1.643                  | 1.216                 | 1.1562                  | 1.3922 | 3.63                    | 4.621               |
|                                           | 38.0   | 1.791                  | 1.295                 | 1.1663                  | 1.3960 | 4.02                    | 5.315               |
|                                           | 40.0   | 1.948                  | 1.375                 | 1.1765                  | 1.3999 | 4.45                    | 6.162               |
|                                           | 42.0   | 2.116                  | 1.456                 | 1.1868                  | 1.4038 | 4.93                    | 7.234               |

| Solute                                               | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                      | 44.0   | 2.295                  | 1.539                 | 1.1972                  | 1.4078 |                         | 8.596               |
|                                                      | 46.0   | 2.489                  | 1.623                 | 1.2079                  | 1.4118 |                         | 10.301              |
|                                                      | 48.0   | 2.697                  | 1.709                 | 1.2186                  | 1.4159 |                         | 12.515              |
|                                                      | 50.0   | 2.921                  | 1.796                 | 1.2295                  | 1.4201 |                         | 15.431              |
|                                                      | 60.0   | 4.382                  | 2.255                 | 1.2864                  | 1.4419 |                         | 58.487              |
|                                                      | 70.0   | 6.817                  | 2.755                 | 1.3472                  | 1.4654 |                         | 481.561             |
|                                                      | 80.0   | 11.686                 | 3.299                 | 1.4117                  | 1.4906 |                         |                     |
| Sulfuric acid<br>$\text{H}_2\text{SO}_4$             | 0.5    | 0.051                  | 0.051                 | 1.0016                  | 1.3336 | 0.21                    | 1.010               |
|                                                      | 1.0    | 0.103                  | 0.102                 | 1.0049                  | 1.3342 | 0.42                    | 1.019               |
|                                                      | 2.0    | 0.208                  | 0.206                 | 1.0116                  | 1.3355 | 0.80                    | 1.036               |
|                                                      | 3.0    | 0.315                  | 0.311                 | 1.0183                  | 1.3367 | 1.17                    | 1.059               |
|                                                      | 4.0    | 0.425                  | 0.418                 | 1.0250                  | 1.3379 | 1.60                    | 1.085               |
|                                                      | 5.0    | 0.537                  | 0.526                 | 1.0318                  | 1.3391 | 2.05                    | 1.112               |
|                                                      | 6.0    | 0.651                  | 0.635                 | 1.0385                  | 1.3403 | 2.50                    | 1.136               |
|                                                      | 7.0    | 0.767                  | 0.746                 | 1.0453                  | 1.3415 | 2.95                    | 1.159               |
|                                                      | 8.0    | 0.887                  | 0.858                 | 1.0522                  | 1.3427 | 3.49                    | 1.182               |
|                                                      | 9.0    | 1.008                  | 0.972                 | 1.0591                  | 1.3439 | 4.08                    | 1.206               |
|                                                      | 10.0   | 1.133                  | 1.087                 | 1.0661                  | 1.3451 | 4.64                    | 1.230               |
|                                                      | 12.0   | 1.390                  | 1.322                 | 1.0802                  | 1.3475 | 5.93                    | 1.282               |
|                                                      | 14.0   | 1.660                  | 1.563                 | 1.0947                  | 1.3500 | 7.49                    | 1.337               |
|                                                      | 16.0   | 1.942                  | 1.810                 | 1.1094                  | 1.3525 | 9.26                    | 1.399               |
|                                                      | 18.0   | 2.238                  | 2.064                 | 1.1245                  | 1.3551 | 11.29                   | 1.470               |
|                                                      | 20.0   | 2.549                  | 2.324                 | 1.1398                  | 1.3576 | 13.64                   | 1.546               |
|                                                      | 22.0   | 2.876                  | 2.592                 | 1.1554                  | 1.3602 | 16.48                   | 1.624               |
|                                                      | 24.0   | 3.220                  | 2.866                 | 1.1714                  | 1.3628 | 19.85                   | 1.706               |
|                                                      | 26.0   | 3.582                  | 3.147                 | 1.1872                  | 1.3653 | 24.29                   | 1.797               |
|                                                      | 28.0   | 3.965                  | 3.435                 | 1.2031                  | 1.3677 | 29.65                   | 1.894               |
|                                                      | 30.0   | 4.370                  | 3.729                 | 1.2191                  | 1.3701 | 36.21                   | 2.001               |
|                                                      | 32.0   | 4.798                  | 4.030                 | 1.2353                  | 1.3725 | 44.76                   | 2.122               |
|                                                      | 34.0   | 5.252                  | 4.339                 | 1.2518                  | 1.3749 | 55.28                   | 2.255               |
|                                                      | 36.0   | 5.735                  | 4.656                 | 1.2685                  | 1.3773 |                         | 2.392               |
|                                                      | 38.0   | 6.249                  | 4.981                 | 1.2855                  | 1.3797 |                         | 2.533               |
|                                                      | 40.0   | 6.797                  | 5.313                 | 1.3028                  | 1.3821 |                         | 2.690               |
|                                                      | 42.0   | 7.383                  | 5.655                 | 1.3205                  | 1.3846 |                         | 2.872               |
|                                                      | 44.0   | 8.011                  | 6.005                 | 1.3386                  | 1.3870 |                         | 3.073               |
|                                                      | 46.0   | 8.685                  | 6.364                 | 1.3570                  | 1.3895 |                         | 3.299               |
|                                                      | 48.0   | 9.411                  | 6.734                 | 1.3759                  | 1.3920 |                         | 3.546               |
|                                                      | 50.0   | 10.196                 | 7.113                 | 1.3952                  | 1.3945 |                         | 3.826               |
|                                                      | 52.0   | 11.045                 | 7.502                 | 1.4149                  | 1.3971 |                         | 4.142               |
|                                                      | 54.0   | 11.969                 | 7.901                 | 1.4351                  | 1.3997 |                         | 4.499               |
|                                                      | 56.0   | 12.976                 | 8.312                 | 1.4558                  | 1.4024 |                         | 4.906               |
|                                                      | 58.0   | 14.080                 | 8.734                 | 1.4770                  | 1.4050 |                         | 5.354               |
|                                                      | 60.0   | 15.294                 | 9.168                 | 1.4987                  | 1.4077 |                         | 5.917               |
|                                                      | 70.0   | 23.790                 | 11.494                | 1.6105                  |        |                         |                     |
|                                                      | 80.0   | 40.783                 | 14.088                | 1.7272                  |        |                         |                     |
|                                                      | 90.0   | 91.762                 | 16.649                | 1.8144                  |        |                         |                     |
|                                                      | 92.0   | 117.251                | 17.109                | 1.8240                  |        |                         |                     |
|                                                      | 94.0   | 159.734                | 17.550                | 1.8312                  |        |                         |                     |
|                                                      | 96.0   | 244.698                | 17.966                | 1.8355                  |        |                         |                     |
|                                                      | 98.0   | 499.592                | 18.346                | 1.8361                  |        |                         |                     |
|                                                      | 100.0  |                        | 18.663                | 1.8305                  |        |                         |                     |
| Trichloroacetic<br>acid<br>$\text{CCl}_3\text{COOH}$ | 0.5    | 0.031                  | 0.031                 | 1.0008                  | 1.3337 | 0.11                    | 1.011               |
|                                                      | 1.0    | 0.062                  | 0.061                 | 1.0034                  | 1.3343 | 0.21                    | 1.021               |
|                                                      | 2.0    | 0.125                  | 0.123                 | 1.0083                  | 1.3356 | 0.42                    | 1.044               |
|                                                      | 3.0    | 0.189                  | 0.186                 | 1.0133                  | 1.3369 | 0.64                    | 1.069               |
|                                                      | 4.0    | 0.255                  | 0.249                 | 1.0182                  | 1.3381 | 0.86                    | 1.096               |
|                                                      | 5.0    | 0.322                  | 0.313                 | 1.0230                  | 1.3394 | 1.08                    | 1.123               |
|                                                      | 6.0    | 0.391                  | 0.377                 | 1.0279                  | 1.3406 | 1.30                    | 1.150               |
|                                                      | 7.0    | 0.461                  | 0.442                 | 1.0328                  | 1.3418 | 1.53                    | 1.177               |

| Solute                                                                                   | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^\circ\text{C}$ | $\eta/\text{mPa s}$ |
|------------------------------------------------------------------------------------------|--------|------------------------|-----------------------|-------------------------|--------|-------------------------|---------------------|
|                                                                                          | 8.0    | 0.532                  | 0.508                 | 1.0378                  | 1.3431 | 1.76                    | 1.204               |
|                                                                                          | 9.0    | 0.605                  | 0.574                 | 1.0428                  | 1.3444 | 1.99                    | 1.233               |
|                                                                                          | 10.0   | 0.680                  | 0.641                 | 1.0479                  | 1.3456 | 2.23                    | 1.263               |
|                                                                                          | 12.0   | 0.835                  | 0.777                 | 1.0583                  | 1.3483 | 2.73                    | 1.326               |
|                                                                                          | 14.0   | 0.996                  | 0.916                 | 1.0692                  | 1.3510 | 3.26                    | 1.393               |
|                                                                                          | 16.0   | 1.166                  | 1.058                 | 1.0806                  | 1.3539 | 3.82                    | 1.462               |
|                                                                                          | 18.0   | 1.343                  | 1.203                 | 1.0921                  | 1.3568 |                         | 1.533               |
|                                                                                          | 20.0   | 1.530                  | 1.351                 | 1.1035                  | 1.3597 |                         | 1.608               |
|                                                                                          | 24.0   | 1.933                  | 1.654                 | 1.1260                  | 1.3652 |                         | 1.768               |
|                                                                                          | 28.0   | 2.380                  | 1.968                 | 1.1485                  | 1.3705 |                         | 1.935               |
|                                                                                          | 32.0   | 2.880                  | 2.294                 | 1.1713                  | 1.3759 |                         | 2.118               |
|                                                                                          | 36.0   | 3.443                  | 2.632                 | 1.1947                  | 1.3813 |                         | 2.320               |
|                                                                                          | 40.0   | 4.080                  | 2.984                 | 1.2188                  | 1.3868 |                         | 1.543               |
|                                                                                          | 44.0   | 4.809                  | 3.349                 | 1.2435                  | 1.3923 |                         | 2.797               |
|                                                                                          | 48.0   | 5.650                  | 3.726                 | 1.2682                  | 1.3977 |                         | 3.076               |
| Tris<br>(hydroxymethyl)-<br>methylamine<br>$\text{H}_2\text{NC}(\text{CH}_2\text{OH})_3$ | 0.5    | 0.041                  | 0.041                 | 0.9994                  | 1.3337 | 0.08                    | 1.014               |
|                                                                                          | 1.0    | 0.083                  | 0.083                 | 1.0006                  | 1.3344 | 0.16                    | 1.027               |
|                                                                                          | 2.0    | 0.168                  | 0.166                 | 1.0030                  | 1.3359 | 0.31                    | 1.054               |
|                                                                                          | 3.0    | 0.255                  | 0.249                 | 1.0054                  | 1.3374 | 0.47                    | 1.083               |
|                                                                                          | 4.0    | 0.344                  | 0.333                 | 1.0078                  | 1.3388 | 0.64                    | 1.115               |
|                                                                                          | 5.0    | 0.434                  | 0.417                 | 1.0103                  | 1.3403 | 0.80                    | 1.148               |
|                                                                                          | 6.0    | 0.527                  | 0.502                 | 1.0128                  | 1.3418 | 0.97                    | 1.182               |
|                                                                                          | 7.0    | 0.621                  | 0.587                 | 1.0153                  | 1.3433 | 1.15                    | 1.218               |
|                                                                                          | 8.0    | 0.718                  | 0.672                 | 1.0179                  | 1.3448 | 1.33                    | 1.256               |
|                                                                                          | 9.0    | 0.816                  | 0.758                 | 1.0204                  | 1.3463 | 1.51                    | 1.295               |
|                                                                                          | 10.0   | 0.917                  | 0.844                 | 1.0230                  | 1.3478 | 1.70                    | 1.337               |
|                                                                                          | 12.0   | 1.126                  | 1.019                 | 1.0282                  | 1.3508 | 2.08                    | 1.427               |
|                                                                                          | 14.0   | 1.344                  | 1.194                 | 1.0335                  | 1.3539 | 2.47                    | 1.527               |
|                                                                                          | 16.0   | 1.572                  | 1.372                 | 1.0389                  | 1.3570 | 2.90                    | 1.642               |
|                                                                                          | 18.0   | 1.812                  | 1.552                 | 1.0443                  | 1.3601 | 3.36                    | 1.772               |
|                                                                                          | 20.0   | 2.064                  | 1.733                 | 1.0498                  | 1.3633 | 3.85                    | 1.920               |
|                                                                                          | 30.0   | 3.538                  | 2.670                 | 1.0781                  | 1.3797 |                         | 2.998               |
|                                                                                          | 40.0   | 5.503                  | 3.657                 | 1.1076                  | 1.3970 |                         | 5.208               |
| Urea<br>$(\text{NH}_2)_2\text{CO}$                                                       | 0.5    | 0.084                  | 0.083                 | 0.9995                  | 1.3337 | 0.16                    | 1.007               |
|                                                                                          | 1.0    | 0.168                  | 0.167                 | 1.0007                  | 1.3344 | 0.31                    | 1.010               |
|                                                                                          | 2.0    | 0.340                  | 0.334                 | 1.0033                  | 1.3358 | 0.62                    | 1.012               |
|                                                                                          | 3.0    | 0.515                  | 0.502                 | 1.0058                  | 1.3372 | 0.93                    | 1.017               |
|                                                                                          | 4.0    | 0.694                  | 0.672                 | 1.0085                  | 1.3387 | 1.24                    | 1.025               |
|                                                                                          | 5.0    | 0.876                  | 0.842                 | 1.0111                  | 1.3401 | 1.55                    | 1.033               |
|                                                                                          | 6.0    | 1.063                  | 1.013                 | 1.0138                  | 1.3416 | 1.88                    | 1.041               |
|                                                                                          | 7.0    | 1.253                  | 1.185                 | 1.0165                  | 1.3431 | 2.22                    | 1.049               |
|                                                                                          | 8.0    | 1.448                  | 1.358                 | 1.0192                  | 1.3446 | 2.56                    | 1.057               |
|                                                                                          | 9.0    | 1.647                  | 1.531                 | 1.0220                  | 1.3461 | 2.91                    | 1.065               |
|                                                                                          | 10.0   | 1.850                  | 1.706                 | 1.0248                  | 1.3476 | 3.26                    | 1.074               |
|                                                                                          | 12.0   | 2.270                  | 2.059                 | 1.0304                  | 1.3506 | 3.95                    | 1.091               |
|                                                                                          | 14.0   | 2.710                  | 2.415                 | 1.0360                  | 1.3537 | 4.66                    | 1.109               |
|                                                                                          | 16.0   | 3.171                  | 2.775                 | 1.0417                  | 1.3568 | 5.40                    | 1.130               |
|                                                                                          | 18.0   | 3.655                  | 3.139                 | 1.0473                  | 1.3599 | 6.19                    | 1.153               |
|                                                                                          | 20.0   | 4.163                  | 3.506                 | 1.0530                  | 1.3629 | 7.00                    | 1.178               |
|                                                                                          | 22.0   | 4.696                  | 3.878                 | 1.0586                  | 1.3661 | 7.81                    | 1.205               |
|                                                                                          | 24.0   | 5.258                  | 4.253                 | 1.0643                  | 1.3692 | 8.64                    | 1.235               |
|                                                                                          | 26.0   | 5.850                  | 4.632                 | 1.0699                  | 1.3723 | 9.52                    | 1.266               |
|                                                                                          | 28.0   | 6.475                  | 5.014                 | 1.0756                  | 1.3754 | 10.45                   | 1.298               |
|                                                                                          | 30.0   | 7.136                  | 5.401                 | 1.0812                  | 1.3785 | 11.40                   | 1.332               |
|                                                                                          | 32.0   | 7.835                  | 5.791                 | 1.0869                  | 1.3817 | 12.34                   | 1.371               |
|                                                                                          | 34.0   | 8.577                  | 6.185                 | 1.0926                  | 1.3848 | 13.27                   | 1.413               |
|                                                                                          | 36.0   | 9.366                  | 6.584                 | 1.0984                  | 1.3881 | 14.20                   | 1.459               |
|                                                                                          | 38.0   | 10.205                 | 6.988                 | 1.1044                  | 1.3913 | 15.11                   | 1.509               |
|                                                                                          | 40.0   | 11.100                 | 7.397                 | 1.1106                  | 1.3947 | 15.99                   | 1.565               |



| Solute            | Mass % | $m/\text{mol kg}^{-1}$ | $c/\text{mol L}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $n$    | $\Delta/^{\circ}\text{C}$ | $\eta/\text{mPa s}$ |
|-------------------|--------|------------------------|-----------------------|-------------------------|--------|---------------------------|---------------------|
|                   | 42.0   | 12.057                 | 7.812                 | 1.1171                  | 1.3982 | 16.83                     | 1.629               |
|                   | 44.0   | 13.082                 | 8.234                 | 1.1239                  | 1.4018 | 17.62                     | 1.700               |
|                   | 46.0   | 14.183                 | 8.665                 | 1.1313                  | 1.4056 |                           | 1.780               |
| Zinc sulfate      | 0.5    | 0.031                  | 0.031                 | 1.0034                  | 1.3339 | 0.08                      | 1.021               |
| ZnSO <sub>4</sub> | 1.0    | 0.063                  | 0.062                 | 1.0085                  | 1.3348 | 0.15                      | 1.040               |
|                   | 2.0    | 0.126                  | 0.126                 | 1.0190                  | 1.3366 | 0.28                      | 1.081               |
|                   | 3.0    | 0.192                  | 0.191                 | 1.0296                  | 1.3384 | 0.41                      | 1.126               |
|                   | 4.0    | 0.258                  | 0.258                 | 1.0403                  | 1.3403 | 0.53                      | 1.175               |
|                   | 5.0    | 0.326                  | 0.326                 | 1.0511                  | 1.3421 | 0.65                      | 1.227               |
|                   | 6.0    | 0.395                  | 0.395                 | 1.0620                  | 1.3439 | 0.77                      | 1.283               |
|                   | 7.0    | 0.466                  | 0.465                 | 1.0730                  | 1.3457 | 0.89                      | 1.341               |
|                   | 8.0    | 0.539                  | 0.537                 | 1.0842                  | 1.3475 | 1.01                      | 1.403               |
|                   | 9.0    | 0.613                  | 0.611                 | 1.0956                  | 1.3494 | 1.14                      | 1.470               |
|                   | 10.0   | 0.688                  | 0.686                 | 1.1071                  | 1.3513 | 1.27                      | 1.545               |
|                   | 12.0   | 0.845                  | 0.840                 | 1.1308                  | 1.3551 | 1.55                      | 1.716               |
|                   | 14.0   | 1.008                  | 1.002                 | 1.1553                  | 1.3590 | 1.89                      | 1.918               |
|                   | 16.0   | 1.180                  | 1.170                 | 1.1806                  | 1.3630 | 2.31                      | 2.152               |

# ION PRODUCT OF WATER SUBSTANCE

William L. Marshall and E. U. Franck

| Pressure<br>(bars) | Temperature (°C) |        |        |        |        |        |        |        |        |
|--------------------|------------------|--------|--------|--------|--------|--------|--------|--------|--------|
|                    | 0                | 25     | 50     | 75     | 100    | 150    | 200    | 250    | 300    |
| Saturated vapor    | 14.938           | 13.995 | 13.275 | 12.712 | 12.265 | 11.638 | 11.289 | 11.191 | 11.406 |
| 250                | 14.83            | 13.90  | 13.19  | 12.63  | 12.18  | 11.54  | 11.16  | 11.01  | 11.14  |
| 500                | 14.72            | 13.82  | 13.11  | 12.55  | 12.10  | 11.45  | 11.05  | 10.85  | 10.86  |
| 750                | 14.62            | 13.73  | 13.04  | 12.48  | 12.03  | 11.36  | 10.95  | 10.72  | 10.66  |
| 1,000              | 14.53            | 13.66  | 12.96  | 12.41  | 11.96  | 11.29  | 10.86  | 10.60  | 10.50  |
| 1,500              | 14.34            | 13.53  | 12.85  | 12.29  | 11.84  | 11.16  | 10.71  | 10.43  | 10.26  |
| 2,000              | 14.21            | 13.40  | 12.73  | 12.18  | 11.72  | 11.04  | 10.57  | 10.27  | 10.08  |
| 2,500              | 14.08            | 13.28  | 12.62  | 12.07  | 11.61  | 10.92  | 10.45  | 10.12  | 9.91   |
| 3,000              | 13.97            | 13.18  | 12.53  | 11.98  | 11.53  | 10.83  | 10.34  | 9.99   | 9.76   |
| 3,500              | 13.87            | 13.09  | 12.44  | 11.90  | 11.44  | 10.74  | 10.24  | 9.88   | 9.63   |
| 4,000              | 13.77            | 13.00  | 12.35  | 11.82  | 11.37  | 10.66  | 10.16  | 9.79   | 9.52   |
| 5,000              | 13.60            | 12.83  | 12.19  | 11.66  | 11.22  | 10.52  | 10.00  | 9.62   | 9.34   |
| 6,000              | 13.44            | 12.68  | 12.05  | 11.53  | 11.09  | 10.39  | 9.87   | 9.48   | 9.18   |
| 7,000              | 13.31            | 12.55  | 11.93  | 11.41  | 10.97  | 10.27  | 9.75   | 9.35   | 9.04   |
| 8,000              | 13.18            | 12.43  | 11.82  | 11.30  | 10.86  | 10.17  | 9.64   | 9.24   | 8.93   |
| 9,000              | 13.04            | 12.31  | 11.71  | 11.20  | 10.77  | 10.07  | 9.54   | 9.13   | 8.82   |
| 10,000             | 12.91            | 12.21  | 11.62  | 11.11  | 10.68  | 9.98   | 9.45   | 9.04   | 8.71   |

| Pressure<br>(bars) | Temperature (°C) |       |       |       |       |       |       |       |       |
|--------------------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                    | 350              | 400   | 450   | 500   | 600   | 700   | 800   | 900   | 1000  |
| Saturated vapor    | 12.30            | —     | —     | —     | —     | —     | —     | —     | —     |
| 250                | 11.77            | 19.43 | 21.59 | 22.40 | 23.27 | 23.81 | 24.23 | 24.59 | 24.93 |
| 500                | 11.14            | 11.88 | 13.74 | 16.13 | 18.30 | 19.29 | 19.92 | 20.39 | 20.80 |
| 750                | 10.79            | 11.17 | 11.89 | 13.01 | 15.25 | 16.55 | 17.35 | 17.93 | 18.39 |
| 1,000              | 10.54            | 10.77 | 11.19 | 11.81 | 13.40 | 14.70 | 15.58 | 16.22 | 16.72 |
| 1,500              | 10.22            | 10.29 | 10.48 | 10.77 | 11.59 | 12.50 | 13.30 | 13.97 | 14.50 |
| 2,000              | 9.98             | 9.98  | 10.07 | 10.23 | 10.73 | 11.36 | 11.98 | 12.54 | 12.97 |
| 2,500              | 9.79             | 9.74  | 9.77  | 9.86  | 10.18 | 10.63 | 11.11 | 11.59 | 12.02 |
| 3,000              | 9.61             | 9.54  | 9.53  | 9.57  | 9.78  | 10.11 | 10.49 | 10.89 | 11.24 |
| 3,500              | 9.47             | 9.37  | 9.33  | 9.34  | 9.48  | 9.71  | 10.02 | 10.35 | 10.62 |
| 4,000              | 9.34             | 9.22  | 9.16  | 9.15  | 9.23  | 9.41  | 9.65  | 9.93  | 10.13 |
| 5,000              | 9.13             | 8.99  | 8.90  | 8.85  | 8.85  | 8.95  | 9.11  | 9.30  | 9.42  |
| 6,000              | 8.96             | 8.80  | 8.69  | 8.62  | 8.57  | 8.61  | 8.72  | 8.86  | 8.97  |
| 7,000              | 8.81             | 8.64  | 8.51  | 8.42  | 8.34  | 8.34  | 8.40  | 8.51  | 8.64  |
| 8,000              | 8.68             | 8.50  | 8.36  | 8.25  | 8.13  | 8.10  | 8.13  | 8.21  | 8.38  |
| 9,000              | 8.57             | 8.37  | 8.22  | 8.10  | 7.95  | 7.89  | 7.89  | 7.95  | 8.12  |
| 10,000             | 8.46             | 8.25  | 8.09  | 7.96  | 7.78  | 7.70  | 7.68  | 7.70  | 7.85  |

Data in this table were calculated from the equation,  $\log_{10} K_w^* = A + B/T + C/T^2 + D/T^3 + (E + F/T + G/T^2) \log_{10} \rho_w^*$ , where  $K_w^* = K_w/(\text{mol kg}^{-1})$ , and  $\rho_w^* = \rho_w/(\text{g cm}^{-3})$ . The parameters are:

A = -4.098                      E = +13.957  
 B = -3245.2 K                F = 1262.3 K  
 C = +2.2362  $\times 10^5$  K<sup>2</sup>      G = +8.5641  $\times 10^5$  K<sup>2</sup>  
 D = -3.984  $\times 10^7$  K<sup>3</sup>

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## IONIZATION CONSTANT OF NORMAL AND HEAVY WATER

This table gives the ionization constant in molality terms for H<sub>2</sub>O and D<sub>2</sub>O at temperatures from 0 to 100°C at the saturated vapor pressure. The quantity tabulated is  $-\log K_w$ , where  $K_w$  is defined by

$$K_w = m_+ \times m_-$$

and  $m_+$  and  $m_-$  are the molalities, in mol/kg of water, for H<sup>+</sup> and OH<sup>-</sup>, respectively.

### References

1. Marshall W. L., and Franck, E. U., *J. Phys. Chem. Ref. Data*, 10, 295, 1981.
2. Mesmer R. E., and Herting, D. L., *J. Solution Chem.*, 7, 901, 1978.

| <i>t</i> /°C | $-\log K_w$      |                  |
|--------------|------------------|------------------|
|              | H <sub>2</sub> O | D <sub>2</sub> O |
| 0            | 14.938           | 15.972           |
| 5            | 14.727           | 15.743           |
| 10           | 14.528           | 15.527           |
| 15           | 14.340           | 15.324           |
| 20           | 14.163           | 15.132           |
| 25           | 13.995           | 14.951           |
| 30           | 13.836           | 14.779           |
| 35           | 13.685           | 14.616           |
| 40           | 13.542           | 14.462           |
| 45           | 13.405           | 14.316           |
| 50           | 13.275           | 14.176           |
| 55           | 13.152           | 14.044           |
| 60           | 13.034           | 13.918           |
| 65           | 12.921           | 13.798           |
| 70           | 12.814           | 13.683           |
| 75           | 12.712           | 13.574           |
| 80           | 12.613           | 13.470           |
| 85           | 12.520           | 13.371           |
| 90           | 12.428           | 13.276           |
| 95           | 12.345           | 13.186           |
| 100          | 12.265           | 13.099           |

# SOLUBILITY OF SELECTED GASES IN WATER

L. H. Gevantman

The values in this table are taken almost exclusively from the International Union of Pure and Applied Chemistry "Solubility Data Series". Unless noted, they comprise evaluated data fitted to a smoothing equation. The data at each temperature are then derived from the smoothing equation which expresses the mole fraction solubility  $X_1$  of the gas in solution as:

$$\ln X_1 = A + B/T^* + C \ln T^*$$

where

$$T^* = T/100 \text{ K}$$

All values refer to a partial pressure of the gas of 101.325 kPa (one atmosphere).

The equation constants, the standard deviation for  $\ln X_1$  (except where noted), and the temperature range over which the equation applies are given in the column headed Equation constants. There are two exceptions. The equation for methane has an added term,  $DT^*$ . The equation for  $\text{H}_2\text{Se}$  and  $\text{H}_2\text{S}$  takes the form,

$$\ln X_1 = A + B/T + C \ln T + DT$$

where  $T$  is the temperature in kelvin.

Solubilities given for those gases which react with water, namely ozone, nitrogen oxides, chlorine and its oxides, carbon dioxide, hydrogen sulfide, hydrogen selenide and sulfur dioxide, are recorded as bulk solubilities; i.e., all chemical species of the gas and its reaction products with water are included.

| Gas                                          | T/K    | Solubility ( $X_1$ )              | Equation constants           | Ref. |
|----------------------------------------------|--------|-----------------------------------|------------------------------|------|
| Hydrogen ( $\text{H}_2$ )<br>$M_r = 2.01588$ | 288.15 | $1.510 \times 10^{-5}$            | $A = -48.1611$               | 1    |
|                                              | 293.15 | $1.455 \times 10^{-5}$            | $B = 55.2845$                |      |
|                                              | 298.15 | $1.411 \times 10^{-5}$            | $C = 16.8893$                |      |
|                                              | 303.15 | $1.377 \times 10^{-5}$            | Std. dev. = $\pm 0.54\%$     |      |
|                                              | 308.15 | $1.350 \times 10^{-5}$            | Temp. range = 273.15—353.15  |      |
| Deuterium ( $\text{D}_2$ )<br>$M_r = 4.0282$ | 283.15 | $1.675 \times 10^{-5} \pm 0.57\%$ | Averaged experimental values | 1    |
|                                              | 288.15 | $1.595 \times 10^{-5} \pm 0.57\%$ |                              |      |
|                                              | 293.15 | $1.512 \times 10^{-5} \pm 0.78\%$ | Temp. range = 278.15—303.15  |      |
|                                              | 298.15 | $1.460 \times 10^{-5} \pm 0.52\%$ |                              |      |
|                                              | 303.15 | $1.395 \times 10^{-5} \pm 0.37\%$ |                              |      |
| Helium (He)<br>$A_r = 4.0026$                | 288.15 | $7.123 \times 10^{-6}$            | $A = -41.4611$               | 2    |
|                                              | 293.15 | $7.044 \times 10^{-6}$            | $B = 42.5962$                |      |
|                                              | 298.15 | $6.997 \times 10^{-6}$            | $C = 14.0094$                |      |
|                                              | 303.15 | $6.978 \times 10^{-6}$            | Std. dev. = $\pm 0.54\%$     |      |
|                                              | 308.15 | $6.987 \times 10^{-6}$            | Temp. range = 273.15—348.15  |      |
| Neon (Ne)<br>$A_r = 20.1797$                 | 288.15 | $8.702 \times 10^{-6}$            | $A = -52.8573$               | 2    |
|                                              | 293.15 | $8.395 \times 10^{-6}$            | $B = 61.0494$                |      |
|                                              | 298.15 | $8.152 \times 10^{-6}$            | $C = 18.9157$                |      |
|                                              | 303.15 | $7.966 \times 10^{-6}$            | Std. dev. = $\pm 0.47\%$     |      |
|                                              | 308.15 | $7.829 \times 10^{-6}$            | Temp. range = 273.15—348.15  |      |
| Argon (Ar)<br>$A_r = 39.948$                 | 288.15 | $3.025 \times 10^{-5}$            | $A = -57.6661$               | 3    |
|                                              | 293.15 | $2.748 \times 10^{-5}$            | $B = 74.7627$                |      |
|                                              | 298.15 | $2.519 \times 10^{-5}$            | $C = 20.1398$                |      |
|                                              | 303.15 | $2.328 \times 10^{-5}$            | Std. dev. = $\pm 0.26\%$     |      |
|                                              | 308.15 | $2.169 \times 10^{-5}$            | Temp. range = 273.15—348.15  |      |
| Krypton (Kr)<br>$A_r = 83.80$                | 288.15 | $5.696 \times 10^{-5}$            | $A = -66.9928$               | 4    |
|                                              | 293.15 | $5.041 \times 10^{-5}$            | $B = 91.0166$                |      |
|                                              | 298.15 | $4.512 \times 10^{-5}$            | $C = 24.2207$                |      |
|                                              | 303.15 | $4.079 \times 10^{-5}$            | Std. dev. = $\pm 0.32\%$     |      |
|                                              | 308.15 | $3.725 \times 10^{-5}$            | Temp. range = 273.15—353.15  |      |
| Xenon (Xe)<br>$A_r = 131.29$                 | 288.15 | $10.519 \times 10^{-5}$           | $A = -74.7398$               | 4    |
|                                              | 293.15 | $9.051 \times 10^{-5}$            | $B = 105.210$                |      |
|                                              | 298.15 | $7.890 \times 10^{-5}$            | $C = 27.4664$                |      |
|                                              | 303.15 | $6.961 \times 10^{-5}$            | Std. dev. = $\pm 0.35\%$     |      |
|                                              | 308.15 | $6.212 \times 10^{-5}$            | Temp. range = 273.15—348.15  |      |

| Gas                                   | T/K    | Solubility ( $X_1$ )            | Equation constants                   | Ref. |
|---------------------------------------|--------|---------------------------------|--------------------------------------|------|
| Radon-222( <sup>222</sup> Rn)         | 288.15 | $2.299 \times 10^{-4}$          | $A = -90.5481$                       |      |
| $A_r = 222$                           | 293.15 | $1.945 \times 10^{-4}$          | $B = 130.026$                        |      |
|                                       | 298.15 | $1.671 \times 10^{-4}$          | $C = 35.0047$                        |      |
|                                       | 303.15 | $1.457 \times 10^{-4}$          | Std. dev. = $\pm 1.02\%$             |      |
|                                       | 308.15 | $1.288 \times 10^{-4}$          | Temp. range = 273.15—373.15          |      |
| Oxygen (O <sub>2</sub> )              | 288.15 | $2.756 \times 10^{-5}$          | $A = -66.7354$                       | 5    |
| $M_r = 31.9988$                       | 293.15 | $2.501 \times 10^{-5}$          | $B = 87.4755$                        |      |
|                                       | 298.15 | $2.293 \times 10^{-5}$          | $C = 24.4526$                        |      |
|                                       | 303.15 | $2.122 \times 10^{-5}$          | Std. dev. = $\pm 0.36\%$             |      |
|                                       | 308.15 | $1.982 \times 10^{-5}$          | Temp. range = 273.15—348.15          |      |
| Ozone (O <sub>3</sub> )               | 293.15 | $1.885 \times 10^{-6} \pm 10\%$ | Experimental value derived           | 5    |
| $M_r = 47.9982$                       |        | pH = 7.0                        | from Henry's Law Constant Equation   |      |
| Nitrogen (N <sub>2</sub> )            | 288.15 | $1.386 \times 10^{-5}$          | $A = -67.3877$                       | 6    |
| $M_r = 28.0134$                       | 293.15 | $1.274 \times 10^{-5}$          | $B = 86.3213$                        |      |
|                                       | 298.15 | $1.183 \times 10^{-5}$          | $C = 24.7981$                        |      |
|                                       | 303.15 | $1.108 \times 10^{-5}$          | Std. dev. = $\pm 0.72\%$             |      |
|                                       | 308.15 | $1.047 \times 10^{-5}$          | Temp. range = 273.15—348.15          |      |
| Nitrous oxide (N <sub>2</sub> O)      | 288.15 | $5.948 \times 10^{-4}$          | $A = -60.7467$                       | 7    |
| $M_r = 44.0129$                       | 293.15 | $5.068 \times 10^{-4}$          | $B = 88.8280$                        |      |
|                                       | 298.15 | $4.367 \times 10^{-4}$          | $C = 21.2531$                        |      |
|                                       | 303.15 | $3.805 \times 10^{-4}$          | Std. dev. = $\pm 1.2\%$              |      |
|                                       | 308.15 | $3.348 \times 10^{-4}$          | Temp. range = 273.15—313.15          |      |
| Nitric oxide (NO)                     | 288.15 | $4.163 \times 10^{-5}$          | $A = -62.8086$                       | 7    |
| $M_r = 30.0061$                       | 293.15 | $3.786 \times 10^{-5}$          | $B = 82.3420$                        |      |
|                                       | 298.15 | $3.477 \times 10^{-5}$          | $C = 22.8155$                        |      |
|                                       | 303.15 | $3.222 \times 10^{-5}$          | Std. dev. = $\pm 0.76\%$             |      |
|                                       | 308.15 | $3.012 \times 10^{-5}$          | Temp. range = 273.15—358.15          |      |
| Carbon monoxide (CO)                  | 288.15 | $2.095 \times 10^{-5}$          | Derived from Henry's                 | 8    |
| $M_r = 28.0104$                       | 293.15 | $1.918 \times 10^{-5}$          | Law Constant Equation                |      |
|                                       | 298.15 | $1.774 \times 10^{-5}$          | Std. dev. = $\pm 0.043\%$            |      |
|                                       | 303.15 | $1.657 \times 10^{-5}$          | Temp. range = 273.15—328.15          |      |
|                                       | 308.15 | $1.562 \times 10^{-5}$          |                                      |      |
| Carbon dioxide (CO <sub>2</sub> )     | 288.15 | $8.21 \times 10^{-4}$           | Derived from Henry's                 | 9    |
| $M_r = 44.0098$                       | 293.15 | $7.07 \times 10^{-4}$           | Law Constant Equation                |      |
|                                       | 298.15 | $6.15 \times 10^{-4}$           | Std. dev. = $\pm 1.1\%$              |      |
|                                       | 303.15 | $5.41 \times 10^{-4}$           | Temp. range = 273.15—353.15          |      |
|                                       | 308.15 | $4.80 \times 10^{-4}$           |                                      |      |
| Hydrogen selenide (H <sub>2</sub> Se) | 288.15 | $1.80 \times 10^{-3}$           | $A = 9.15$                           | 10   |
| $M_r = 80.976$                        | 298.15 | $1.49 \times 10^{-3}$           | $B = 974$                            |      |
|                                       | 308.15 | $1.24 \times 10^{-3}$           | $C = -3.542$                         |      |
|                                       |        |                                 | $D = 0.0042$                         |      |
|                                       |        |                                 | Std. dev. = $\pm 2.3 \times 10^{-5}$ |      |
|                                       |        |                                 | Temp. range = 288.15—343.15          |      |
| Hydrogen sulfide (H <sub>2</sub> S)   | 288.15 | $2.335 \times 10^{-3}$          | $A = -24.912$                        | 10   |
| $M_r = 34.082$                        | 293.15 | $2.075 \times 10^{-3}$          | $B = 3477$                           |      |
|                                       | 298.15 | $1.85 \times 10^{-3}$           | $C = 0.3993$                         |      |
|                                       | 303.15 | $1.66 \times 10^{-3}$           | $D = 0.0157$                         |      |
|                                       | 308.15 | $1.51 \times 10^{-3}$           | Std. dev. = $\pm 6.5 \times 10^{-5}$ |      |
|                                       |        |                                 | Temp. range = 283.15—603.15          |      |
| Sulfur dioxide (SO <sub>2</sub> )     | 288.15 | $3.45 \times 10^{-2}$           | $A = -25.2629$                       | 11   |
| $M_r = 64.0648$                       | 293.15 | $2.90 \times 10^{-2}$           | $B = 45.7552$                        |      |

| Gas                                         | $T/K$  | Solubility ( $X_1$ )           | Equation constants                                       | Ref. |
|---------------------------------------------|--------|--------------------------------|----------------------------------------------------------|------|
|                                             | 298.15 | $2.46 \times 10^{-2}$          | $C = 5.6855$                                             |      |
|                                             | 303.15 | $2.10 \times 10^{-2}$          | Std. dev. = $\pm 1.8\%$                                  |      |
|                                             | 308.15 | $1.80 \times 10^{-2}$          | Temp. range = 278.15—328.15                              |      |
| Chlorine ( $\text{Cl}_2$ )                  | 283.15 | $2.48 \times 10^{-3} \pm 2\%$  | Experimental data                                        | 11   |
| $M_r = 70.9054$                             | 293.15 | $1.88 \times 10^{-3} \pm 2\%$  | Temp. range = 283.15—333.15                              |      |
|                                             | 303.15 | $1.50 \times 10^{-3} \pm 2\%$  |                                                          |      |
|                                             | 313.15 | $1.23 \times 10^{-3} \pm 2\%$  |                                                          |      |
| Chlorine monoxide ( $\text{Cl}_2\text{O}$ ) | 273.15 | $5.25 \times 10^{-1} \pm 1\%$  | Experimental data                                        | 11   |
| $M_r = 86.9048$                             | 276.61 | $4.54 \times 10^{-1} \pm 1\%$  | Temp. range = 273.15—293.15                              |      |
|                                             | 283.15 | $4.273 \times 10^{-1} \pm 1\%$ |                                                          |      |
|                                             | 293.15 | $3.353 \times 10^{-1} \pm 1\%$ |                                                          |      |
| Chlorine dioxide ( $\text{ClO}_2$ )         | 288.15 | $2.67 \times 10^{-2}$          | $A = 7.9163$                                             | 11   |
| $M_r = 67.4515$                             | 293.15 | $2.20 \times 10^{-2}$          | $B = 0.4791$                                             |      |
|                                             | 298.15 | $1.823 \times 10^{-2}$         | $C = 11.0593$                                            |      |
|                                             | 303.15 | $1.513 \times 10^{-2}$         | Std. dev. = $\pm 4.6\%$                                  |      |
|                                             | 308.15 | $1.259 \times 10^{-2}$         | Temp. range = 283.15—333.15                              |      |
| Methane ( $\text{CH}_4$ )                   | 288.15 | $3.122 \times 10^{-5}$         | $A = -115.6477$                                          | 12   |
| $M_r = 16.0428$                             | 293.15 | $2.806 \times 10^{-5}$         | $B = 155.5756$                                           |      |
|                                             | 298.15 | $2.552 \times 10^{-5}$         | $C = 65.2553$                                            |      |
|                                             | 303.15 | $2.346 \times 10^{-5}$         | $D = -6.1698$                                            |      |
|                                             | 308.15 | $2.180 \times 10^{-5}$         | Std. dev. = $\pm 0.056\%$<br>Temp. range = 273.15—328.15 |      |
| Ethane ( $\text{C}_2\text{H}_6$ )           | 288.15 | $4.556 \times 10^{-5}$         | $A = -90.8225$                                           | 13   |
| $M_r = 30.0696$                             | 293.15 | $3.907 \times 10^{-5}$         | $B = 126.9559$                                           |      |
|                                             | 298.15 | $3.401 \times 10^{-5}$         | $C = 34.7413$                                            |      |
|                                             | 303.15 | $3.002 \times 10^{-5}$         | Std. dev. = $\pm 0.13\%$                                 |      |
|                                             | 308.15 | $2.686 \times 10^{-5}$         | Temp. range = 273.15—323.15                              |      |
| Propane ( $\text{C}_3\text{H}_8$ )          | 288.15 | $3.813 \times 10^{-5}$         | $A = -102.044$                                           | 14   |
| $M_r = 44.097$                              | 293.15 | $3.200 \times 10^{-5}$         | $B = 144.345$                                            |      |
|                                             | 298.15 | $2.732 \times 10^{-5}$         | $C = 39.4740$                                            |      |
|                                             | 303.15 | $2.370 \times 10^{-5}$         | Std. dev. = $\pm 0.012\%$                                |      |
|                                             | 308.15 | $2.088 \times 10^{-5}$         | Temp. range = 273.15—347.15                              |      |
| Butane ( $\text{C}_4\text{H}_{10}$ )        | 288.15 | $3.274 \times 10^{-5}$         | $A = -102.029$                                           | 14   |
| $M_r = 58.123$                              | 293.15 | $2.687 \times 10^{-5}$         | $B = 146.040$                                            |      |
|                                             | 298.15 | $2.244 \times 10^{-5}$         | $C = 38.7599$                                            |      |
|                                             | 303.15 | $1.906 \times 10^{-5}$         | Std. dev. = $\pm 0.026\%$                                |      |
|                                             | 308.15 | $1.645 \times 10^{-5}$         | Temp. range = 273.15—349.15                              |      |
| 2-Methyl propane (Isobutane)                | 288.15 | $2.333 \times 10^{-5}$         | $A = -129.714$                                           | 14   |
| ( $\text{C}_4\text{H}_{10}$ )               | 293.15 | $1.947 \times 10^{-5}$         | $B = 183.044$                                            |      |
| $M_r = 58.123$                              | 298.15 | $1.659 \times 10^{-5}$         | $C = 53.4651$                                            |      |
|                                             | 303.15 | $1.443 \times 10^{-5}$         | Std. dev. = $\pm 0.034\%$                                |      |
|                                             | 308.15 | $1.278 \times 10^{-5}$         | Temp. range = 278.15—318.15                              |      |

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# SOLUBILITY OF CARBON DIOXIDE IN WATER AT VARIOUS TEMPERATURES AND PRESSURES

The solubility of CO<sub>2</sub> in water, expressed as mole fraction of CO<sub>2</sub> in the liquid phase, is given for pressures up to atmospheric and temperatures of 0 to 100 °C. Note that 1 standard atmosphere equals 101.325 kPa. The references give data over a wider range of temperature and pressure. The estimated uncertainty is about 2%.

## References

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| 1000 × mole fraction of CO <sub>2</sub> in liquid phase |                                            |       |       |       |       |       |       |
|---------------------------------------------------------|--------------------------------------------|-------|-------|-------|-------|-------|-------|
| t/°C                                                    | Partial pressure of CO <sub>2</sub> in kPa |       |       |       |       |       |       |
|                                                         | 5                                          | 10    | 20    | 30    | 40    | 50    | 100   |
| 0                                                       | 0.067                                      | 0.135 | 0.269 | 0.404 | 0.538 | 0.671 | 1.337 |
| 5                                                       | 0.056                                      | 0.113 | 0.226 | 0.338 | 0.451 | 0.564 | 1.123 |
| 10                                                      | 0.048                                      | 0.096 | 0.191 | 0.287 | 0.382 | 0.477 | 0.950 |
| 15                                                      | 0.041                                      | 0.082 | 0.164 | 0.245 | 0.327 | 0.409 | 0.814 |
| 20                                                      | 0.035                                      | 0.071 | 0.141 | 0.212 | 0.283 | 0.353 | 0.704 |
| 25                                                      | 0.031                                      | 0.062 | 0.123 | 0.185 | 0.247 | 0.308 | 0.614 |
| 30                                                      | 0.027                                      | 0.054 | 0.109 | 0.163 | 0.218 | 0.271 | 0.541 |
| 35                                                      | 0.024                                      | 0.048 | 0.097 | 0.145 | 0.193 | 0.242 | 0.481 |
| 40                                                      | 0.022                                      | 0.043 | 0.087 | 0.130 | 0.173 | 0.216 | 0.431 |
| 45                                                      | 0.020                                      | 0.039 | 0.078 | 0.117 | 0.156 | 0.196 | 0.389 |
| 50                                                      | 0.018                                      | 0.036 | 0.071 | 0.107 | 0.142 | 0.178 | 0.354 |
| 55                                                      | 0.016                                      | 0.033 | 0.065 | 0.098 | 0.131 | 0.163 | 0.325 |
| 60                                                      | 0.015                                      | 0.030 | 0.060 | 0.090 | 0.121 | 0.150 | 0.300 |
| 65                                                      | 0.014                                      | 0.028 | 0.056 | 0.084 | 0.112 | 0.140 | 0.279 |
| 70                                                      | 0.013                                      | 0.026 | 0.052 | 0.079 | 0.105 | 0.131 | 0.261 |
| 75                                                      | 0.012                                      | 0.025 | 0.049 | 0.074 | 0.099 | 0.123 | 0.245 |
| 80                                                      | 0.012                                      | 0.023 | 0.047 | 0.070 | 0.093 | 0.116 | 0.232 |
| 85                                                      | 0.011                                      | 0.022 | 0.044 | 0.067 | 0.089 | 0.111 | 0.221 |
| 90                                                      | 0.011                                      | 0.021 | 0.042 | 0.064 | 0.085 | 0.106 | 0.211 |
| 95                                                      | 0.010                                      | 0.020 | 0.041 | 0.061 | 0.082 | 0.102 | 0.203 |
| 100                                                     | 0.010                                      | 0.020 | 0.039 | 0.059 | 0.079 | 0.098 | 0.196 |



## AQUEOUS SOLUBILITY AND HENRY'S LAW CONSTANTS OF ORGANIC COMPOUNDS

The solubility in water of about 1300 organic compounds, including many compounds of environmental interest, is tabulated here. When data are available, values are given at several temperatures between 0 °C and 100 °C. Solids, liquids, and gases are included; additional data on gases can be found in the table "Solubility of Selected Gases in Water" in Section 8.

Solubility of solids is defined as the concentration of the compound in a solution that is in equilibrium with the solid phase at the specified temperature and one atmosphere pressure. For liquids whose water mixtures separate into two phases, the solubility given here is the concentration of the specified compound in the water-rich phase at equilibrium. In the case of gases (i.e., compounds whose vapor pressure at the specified temperature exceeds one atmosphere) the solubility is defined here as the concentration in the water phase when the partial pressure of the compound above the solution is 101.325 kPa (1 atm). Values for gases are marked with an asterisk.

The solubility values in this table are expressed as mass percent of solute,  $s = 100w_2$ , where the mass fraction  $w_2$  is defined as

$$w_2 = m_2 / (m_1 + m_2)$$

where  $m_2$  is the mass of solute and  $m_1$  the mass of water. For convenience, the solubility expressed in grams of solute that will dissolve in 1 kilogram of water is tabulated in the adjacent column to mass percent. For compounds with low solubility (e.g.,  $s < 1\%$ ), that column is, to a high approximation, numerically identical to the solubility expressed in grams of solute per liter of solution.

The mass fraction  $w_2$  is related to other common measures of solubility as follows:

|                                                  |                                                           |
|--------------------------------------------------|-----------------------------------------------------------|
| Molality:                                        | $m_2 = 1000 w_2 / M_2 (1 - w_2)$                          |
| Molarity:                                        | $c_2 = 1000 \rho w_2 / M_2$                               |
| Mole fraction:                                   | $x_2 = (w_2 / M_2) / \{ (w_2 / M_2) + (1 - w_2) / M_1 \}$ |
| Mass of solute per<br>100 g of H <sub>2</sub> O: | $100w_2 / (1 - w_2)$                                      |
| Mass of solute per<br>liter of solution:         | $1000 \rho w_2$                                           |

Here,  $M_2$  is the molar mass of the solute,  $M_1 = 18.015$  g/mol is the molar mass of water, and  $\rho$  is the density of the solution in g/mL.

Data have been selected from evaluated sources wherever possible, in particular the *IUPAC Solubility Data Series*. Many values come from experimental measurements reported in the *Journal of Chemical and Engineering Data* and the *Journal of Chemical Thermodynamics*, as well as critical review papers in the *Journal of Physical and Chemical Reference Data*. The primary source for each value is listed in the column following the solubility values; additional references of interest are sometimes given. Many of the references contain solubility data at other temperatures and pH values and in the presence of other compounds. The user is cautioned that wide variations of data are found in the literature for the lower solubility compounds. The references should be consulted for more information on these compounds.

The table also contains values of the Henry's Law constant  $k_H$ , which provides a measure of the partition of a substance between the atmosphere and the aqueous phase. Here,  $k_H$  is defined as the limit of  $p_2/c_2$  as the concentration approaches zero, where  $p_2$  is the

partial pressure of the solute above the solution and  $c_2$  is the concentration in the solution at equilibrium (other formulations of Henry's Law are often used; see Reference 5). The values of  $k_H$  listed here are based on direct experimental measurement whenever available, but many of them are simply calculated as the ratio of the pure compound vapor pressure to the solubility. This approximation is reliable only for compounds of very low solubility. In fact, values of  $k_H$  found in the literature frequently differ by a factor of two or three, and variations over an order of magnitude are not unusual (Reference 5). Therefore, the data given here should be taken only as a rough indication of the true Henry's Law constant, which is difficult to measure precisely.

All values of  $k_H$  refer to 25 °C. If the vapor pressure of the compound at 25 °C is greater than one atmosphere, it can be assumed that the  $k_H$  value has been calculated as  $101.325/c_2$ . The source of the Henry's Law data is given in the last column. The air-water partition coefficient (i.e., ratio of air concentration to water concentration when both are expressed in the same units) is equal to  $k_H/RT$  or  $k_H/2.48$  in the units used here.

Compounds are listed by systematic name. To locate a compound by molecular formula or CAS Registry Number, use the indexes to the table "Physical Constants of Organic Compounds" in Section 3, which point to the entry in that table from which the name can be determined.

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\* Indicates a value of  $s$  for a gas at a partial pressure of 101.325 kPa (1 atm) in equilibrium with the solution.

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| Name                                               | Mol. Form.                                                                 | Mol. Wt. | t/°C | Solubility, s     |                           |      | Henry Const., $k_H$                  |      |
|----------------------------------------------------|----------------------------------------------------------------------------|----------|------|-------------------|---------------------------|------|--------------------------------------|------|
|                                                    |                                                                            |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref. | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Acenaphthene                                       | C <sub>12</sub> H <sub>10</sub>                                            | 154.207  | 0    | 0.00015           | 0.0015                    | 4    |                                      |      |
|                                                    |                                                                            |          | 25   | 0.000380          | 0.00380                   | 22   | 0.01217                              | 22   |
|                                                    |                                                                            |          | 50   | 0.00092           | 0.0092                    | 4    |                                      |      |
| Acenaphthylene                                     | C <sub>12</sub> H <sub>8</sub>                                             | 152.192  | 20   | 0.0016            | 0.016                     | 28   | 0.012                                | 28   |
| Acephate                                           | C <sub>4</sub> H <sub>10</sub> NO <sub>3</sub> PS                          | 183.166  | 20   | ≈28               | ≈390                      | 40   |                                      |      |
| Acetamide                                          | C <sub>2</sub> H <sub>5</sub> NO                                           | 59.067   | 20   | 40.8              | 689                       | 10   |                                      |      |
| Acetanilide                                        | C <sub>8</sub> H <sub>9</sub> NO                                           | 135.163  | 20   | 0.52              | 5.2                       | 27   |                                      |      |
|                                                    |                                                                            |          | 70   | 2.7               | 28                        | 27   |                                      |      |
| Acetazolamide                                      | C <sub>4</sub> H <sub>6</sub> N <sub>4</sub> O <sub>3</sub> S <sub>2</sub> | 222.246  | 30   | 0.10              | 1.0                       | 40   |                                      |      |
| Acetohexamide                                      | C <sub>15</sub> H <sub>20</sub> N <sub>2</sub> O <sub>4</sub> S            | 324.396  | 37   | 0.0013            | 0.013                     | 40   |                                      |      |
| Acetonitrile                                       | C <sub>2</sub> H <sub>3</sub> N                                            | 41.052   | -3   | 40.5              | 681                       | 39   |                                      |      |
|                                                    |                                                                            |          | -10  | 31.7              | 464                       | 39   |                                      |      |
| Acetophenone                                       | C <sub>8</sub> H <sub>8</sub> O                                            | 120.149  | 20   | 0.67              | 6.7                       | 84   | 0.00108                              | 28   |
|                                                    |                                                                            |          | 50   | 0.81              | 8.2                       | 84   | 0.00108                              | 28   |
|                                                    |                                                                            |          | 80   | 1.16              | 11.7                      | 84   | 0.00108                              | 28   |
| Acetylene                                          | C <sub>2</sub> H <sub>2</sub>                                              | 26.037   | 25   | 0.108*            | 1.08*                     | 19   |                                      |      |
| 2-(Acetyloxy)benzoic acid                          | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                               | 180.158  |      | 0.25              | 2.5                       | 27   |                                      |      |
| 2-(Acetyloxy)-5-bromobenzoic acid                  | C <sub>9</sub> H <sub>7</sub> BrO <sub>4</sub>                             | 259.054  |      | 0.07              | 0.7                       | 30   |                                      |      |
| Acridine                                           | C <sub>13</sub> H <sub>9</sub> N                                           | 179.217  | 25   | 0.00466           | 0.0466                    | 6    |                                      |      |
| Acrolein                                           | C <sub>3</sub> H <sub>4</sub> O                                            | 56.063   | 20   | 20.8              | 263                       | 10   |                                      |      |
| Acrylamide                                         | C <sub>3</sub> H <sub>5</sub> NO                                           | 71.078   | 20   | ≈27               | ≈370                      | 40   |                                      |      |
| Acrylonitrile                                      | C <sub>3</sub> H <sub>3</sub> N                                            | 53.063   | 20   | 7.35              | 79.3                      | 10   |                                      |      |
| Adenine                                            | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub>                               | 135.128  | 25   | 0.104             | 1.04                      | 29   |                                      |      |
| Adenosine                                          | C <sub>10</sub> H <sub>13</sub> N <sub>5</sub> O <sub>4</sub>              | 267.242  | 25   | 0.51              | 5.1                       | 29   |                                      |      |
| Alachlor                                           | C <sub>14</sub> H <sub>20</sub> ClNO <sub>2</sub>                          | 269.768  | 23   | 0.024             | 0.24                      | 40   |                                      |      |
| L-Alanine                                          | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                              | 89.094   | 25   | 14.30             | 167                       | 26   |                                      |      |
| β-Alanine                                          | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                              | 89.094   | 25   | 47.1              | 890                       | 26   |                                      |      |
| Aldicarb                                           | C <sub>7</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub> S             | 190.263  | 20   | 0.60              | 6.0                       | 40   |                                      |      |
| Aldrin                                             | C <sub>12</sub> H <sub>8</sub> Cl <sub>6</sub>                             | 364.910  | 25   | 0.00002           | 0.0002                    | 67   |                                      |      |
| Allopurinol                                        | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O                             | 136.112  | 25   | 0.057             | 0.57                      | 40   |                                      |      |
| Ametryn                                            | C <sub>9</sub> H <sub>17</sub> N <sub>5</sub> S                            | 227.330  | 20   | 0.0190            | 0.190                     | 40   |                                      |      |
| 2-Amino-9,10-anthracenedione                       | C <sub>14</sub> H <sub>9</sub> NO <sub>2</sub>                             | 223.227  | 25   | 0.000016          | 0.00016                   | 40   |                                      |      |
| 4-Aminoazobenzene                                  | C <sub>12</sub> H <sub>11</sub> N <sub>3</sub>                             | 197.235  | 25   | 0.0030            | 0.030                     | 40   |                                      |      |
|                                                    |                                                                            |          | 97   | 0.068             | 0.68                      | 40   |                                      |      |
| 4-Aminobenzenesulfonamide                          | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> S              | 172.205  | 20   | 0.71              | 7.2                       | 40   |                                      |      |
| 4-Aminobenzenesulfonic acid                        | C <sub>6</sub> H <sub>7</sub> NO <sub>3</sub> S                            | 173.190  | 7    | 0.59              | 5.9                       | 27   |                                      |      |
| DL-2-Aminobutanoic acid                            | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                              | 103.120  | 25   | 17.4              | 211                       | 26   |                                      |      |
| DL-3-Aminobutanoic acid                            | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                              | 103.120  | 25   | 55.6              | 1250                      | 26   |                                      |      |
| 4-Amino-N-[(butylamino)carbonyl]benzenesulfonamide | C <sub>11</sub> H <sub>17</sub> N <sub>3</sub> O <sub>3</sub> S            | 271.336  | 37   | 0.053             | 0.53                      | 40   |                                      |      |
| 3-Amino-2,5-dichlorobenzoic acid                   | C <sub>7</sub> H <sub>5</sub> Cl <sub>2</sub> NO <sub>2</sub>              | 206.027  | 25   | 0.070             | 0.70                      | 40   |                                      |      |
| 6-Amino-1,3-dihydro-2H-purin-2-one                 | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub> O                             | 151.127  | 25   | 0.006             | 0.06                      | 26   |                                      |      |
| 4-(2-Aminoethyl)phenol                             | C <sub>8</sub> H <sub>11</sub> NO                                          | 137.179  | 15   | 1.03              | 10.4                      | 40   |                                      |      |
| 6-Aminohexanoic acid                               | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                             | 131.173  | 25   | 46                | 852                       | 29   |                                      |      |
| 4-Amino-2-hydroxybenzoic acid                      | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                              | 153.136  | 20   | 0.20              | 2.0                       | 40   |                                      |      |
| 2-Amino-2-methylpropanoic acid                     | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                              | 103.120  | 25   | 12.1              | 138                       | 26   |                                      |      |
| 4-Amino-5-methyl-2(1H)-pyrimidinone                | C <sub>5</sub> H <sub>7</sub> N <sub>3</sub> O                             | 125.129  | 25   | 0.45              | 4.5                       | 26   |                                      |      |
| 2-Aminophenol                                      | C <sub>6</sub> H <sub>7</sub> NO                                           | 109.126  | 20   | 1.92              | 19.6                      | 40   |                                      |      |
| 3-Aminophenol                                      | C <sub>6</sub> H <sub>7</sub> NO                                           | 109.126  | 20   | 2.56              | 26.3                      | 40   |                                      |      |

| Name                      | Mol. Form.                                                                    | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>                 |                           |       | Henry Const., <i>k<sub>H</sub></i>      |      |
|---------------------------|-------------------------------------------------------------------------------|----------|--------------|--------------------------------------|---------------------------|-------|-----------------------------------------|------|
|                           |                                                                               |          |              | 100 <i>w</i> <sub>2</sub><br>(mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
|                           |                                                                               |          | 70           | ≈24                                  | ≈320                      | 40    |                                         |      |
| 4-Aminophenol             | C <sub>6</sub> H <sub>7</sub> NO                                              | 109.126  | 20           | 1.55                                 | 15.7                      | 40    |                                         |      |
| Aminopyrine               | C <sub>13</sub> H <sub>17</sub> N <sub>3</sub> O                              | 231.293  | 25           | 4.8                                  | 50                        | 40    |                                         |      |
| Amitriptyline             | C <sub>20</sub> H <sub>23</sub> N                                             | 277.404  | 24           | 0.00097                              | 0.0097                    | 40    |                                         |      |
| Amobarbital               | C <sub>11</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub>                 | 226.272  | 25           | 0.06                                 | 0.6                       | 40    |                                         |      |
| Anilazine                 | C <sub>9</sub> H <sub>5</sub> Cl <sub>3</sub> N <sub>4</sub>                  | 275.522  | 20           | 0.001                                | 0.01                      | 40    |                                         |      |
| Aniline                   | C <sub>6</sub> H <sub>7</sub> N                                               | 93.127   | 25           | 3.38                                 | 35.0                      | 10    | 14                                      | 15   |
| Aniline-2-carboxylic acid | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                 | 137.137  | 20           | 0.349                                | 3.49                      | 40    |                                         |      |
| Aniline-4-carboxylic acid | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                 | 137.137  | 25           | 0.54                                 | 5.4                       | 40    |                                         |      |
| Aniline hydrochloride     | C <sub>6</sub> H <sub>8</sub> ClN                                             | 129.588  | 15           | 15.1                                 | 178                       | 27    |                                         |      |
| Anisole                   | C <sub>7</sub> H <sub>8</sub> O                                               | 108.138  | 20           | 0.203                                | 2.03                      | 20    | 0.025                                   | 13   |
|                           |                                                                               |          | 40           | 0.184                                | 1.84                      | 20    | 0.025                                   | 13   |
|                           |                                                                               |          | 81           | 0.294                                | 2.95                      | 20    | 0.025                                   | 13   |
| Anthracene                | C <sub>14</sub> H <sub>10</sub>                                               | 178.229  | 0            | 0.0000022                            | 0.000022                  | 42,4  |                                         |      |
|                           |                                                                               |          | 25           | 0.0000044                            | 0.000044                  | 42,22 | 0.00396                                 | 22   |
|                           |                                                                               |          | 50           | 0.000029                             | 0.00029                   | 42    |                                         |      |
| 9,10-Anthracenedione      | C <sub>14</sub> H <sub>8</sub> O <sub>2</sub>                                 | 208.213  | 25           | 0.00014                              | 0.0014                    | 40    |                                         |      |
| Apomorphine               | C <sub>17</sub> H <sub>17</sub> NO <sub>2</sub>                               | 267.323  | 25           | 2.0                                  | 20                        | 40    |                                         |      |
| <i>L</i> -Arginine        | C <sub>6</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub>                  | 174.201  | 25           | 15.44                                | 183                       | 26    |                                         |      |
| <i>L</i> -Ascorbic acid   | C <sub>6</sub> H <sub>8</sub> O <sub>6</sub>                                  | 176.124  | 25           | 25.2                                 | 337                       | 33    |                                         |      |
|                           |                                                                               |          | 50           | 41.0                                 | 695                       | 33    |                                         |      |
| <i>L</i> -Asparagine      | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>                   | 132.118  | 25           | 2.45                                 | 25.1                      | 26    |                                         |      |
| <i>L</i> -Aspartic acid   | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>                                 | 133.104  | 10           | 0.29                                 | 2.9                       | 77    |                                         |      |
|                           |                                                                               |          | 25           | 0.49                                 | 4.9                       | 77    |                                         |      |
|                           |                                                                               |          | 50           | 1.31                                 | 13.3                      | 77    |                                         |      |
| Atrazine                  | C <sub>8</sub> H <sub>14</sub> ClN <sub>5</sub>                               | 215.684  | 25           | 0.007                                | 0.07                      | 26    |                                         |      |
| Atropine                  | C <sub>17</sub> H <sub>23</sub> NO <sub>3</sub>                               | 289.370  | 20           | 0.3                                  | 3                         | 40    |                                         |      |
| Azinphos-methyl           | C <sub>10</sub> H <sub>12</sub> N <sub>3</sub> O <sub>3</sub> PS <sub>2</sub> | 317.324  | 20           | 0.00209                              | 0.0209                    | 40    |                                         |      |
| <i>trans</i> -Azobenzene  | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub>                                | 182.220  | 20           | 0.03                                 | 0.3                       | 27    |                                         |      |
| Bayleton                  | C <sub>14</sub> H <sub>16</sub> ClN <sub>3</sub> O <sub>2</sub>               | 293.749  | 20           | 0.026                                | 0.26                      | 40    |                                         |      |
| Bendiocarb                | C <sub>11</sub> H <sub>13</sub> NO <sub>4</sub>                               | 223.226  | 25           | 0.004                                | 0.04                      | 40    |                                         |      |
| Bentazon                  | C <sub>10</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub> S               | 240.278  | 20           | 0.050                                | 0.50                      | 40    |                                         |      |
| Benzaldehyde              | C <sub>7</sub> H <sub>6</sub> O                                               | 106.122  | 20           | 0.3                                  | 3                         | 10    |                                         |      |
| Benzamide                 | C <sub>7</sub> H <sub>7</sub> NO                                              | 121.137  | 12           | 0.577                                | 5.77                      | 27    |                                         |      |
| Benz[a]anthracene         | C <sub>18</sub> H <sub>12</sub>                                               | 228.288  | 10           | 0.00000038                           | 0.0000038                 | 42    |                                         |      |
|                           |                                                                               |          | 25           | 0.00000093                           | 0.0000093                 | 42,22 | 0.00058                                 | 22   |
| Benzene                   | C <sub>6</sub> H <sub>6</sub>                                                 | 78.112   | 10           | 0.174                                | 1.74                      | 22    |                                         |      |
|                           |                                                                               |          | 20           | 0.177                                | 1.77                      | 22    |                                         |      |
|                           |                                                                               |          | 30           | 0.183                                | 1.83                      | 22    |                                         |      |
|                           |                                                                               |          | 40           | 0.192                                | 1.92                      | 22    |                                         |      |
|                           |                                                                               |          | 50           | 0.206                                | 2.06                      | 22    |                                         |      |
|                           |                                                                               |          | 70           | 0.249                                | 2.50                      | 65    |                                         |      |
|                           |                                                                               |          | 101          | 0.398                                | 4.00                      | 65    |                                         |      |
| Benzeneacetic acid        | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                                  | 136.149  | 25           | 1.71                                 | 17.4                      | 27    |                                         |      |
| 1,2-Benzenediamine        | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                  | 108.141  | 20           | 3.02                                 | 31.1                      | 40    |                                         |      |
| 1,3-Benzenediamine        | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                  | 108.141  | 20           | 3.48                                 | 36.1                      | 40    |                                         |      |
| 1,4-Benzenediamine        | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                  | 108.141  | 24           | 3.45                                 | 35.7                      | 40    |                                         |      |
| 1,2-Benzenedicarboxamide  | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                   | 164.162  | 30           | 0.59                                 | 5.9                       | 40    |                                         |      |
| Benzeneethanol            | C <sub>8</sub> H <sub>10</sub> O                                              | 122.164  | 25           | 1.72                                 | 17.5                      | 40    |                                         |      |

| Name                                | Mol. Form.                                     | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|-------------------------------------|------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                                     |                                                |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Benzenhexacarboxylic acid           | C <sub>12</sub> H <sub>6</sub> O <sub>12</sub> | 342.169  | 25           | 49.3                              | 972                       | 76    |                                      |      |
| Benzenepentacarboxylic acid         | C <sub>11</sub> H <sub>6</sub> O <sub>10</sub> | 298.160  | 10           | 11.9                              | 135                       | 76    |                                      |      |
|                                     |                                                |          | 25           | 21.1                              | 267                       | 76    |                                      |      |
|                                     |                                                |          | 50           | 36.2                              | 567                       | 76    |                                      |      |
| 1,2,3,4-Benzenetetracarboxylic acid | C <sub>10</sub> H <sub>6</sub> O <sub>8</sub>  | 254.150  | 10           | 11.0                              | 124                       | 76    |                                      |      |
|                                     |                                                |          | 25           | 20.9                              | 264                       | 76    |                                      |      |
|                                     |                                                |          | 50           | 39.5                              | 653                       | 76    |                                      |      |
| 1,2,3,5-Benzenetetracarboxylic acid | C <sub>10</sub> H <sub>6</sub> O <sub>8</sub>  | 254.150  | 10           | 7.50                              | 81.1                      | 76    |                                      |      |
|                                     |                                                |          | 25           | 10.1                              | 112                       | 76    |                                      |      |
|                                     |                                                |          | 50           | 15.8                              | 188                       | 76    |                                      |      |
| 1,2,4,5-Benzenetetracarboxylic acid | C <sub>10</sub> H <sub>6</sub> O <sub>8</sub>  | 254.150  | 10           | 0.51                              | 5.1                       | 76    |                                      |      |
|                                     |                                                |          | 25           | 1.06                              | 10.7                      | 76    |                                      |      |
|                                     |                                                |          | 50           | 3.82                              | 39.7                      | 76    |                                      |      |
| 1,2,3-Benzenetricarboxylic acid     | C <sub>9</sub> H <sub>6</sub> O <sub>6</sub>   | 210.140  | 10           | 2.39                              | 24.5                      | 76    |                                      |      |
|                                     |                                                |          | 25           | 4.78                              | 50.2                      | 76    |                                      |      |
|                                     |                                                |          | 50           | 17.4                              | 211                       | 76    |                                      |      |
| 1,2,4-Benzenetricarboxylic acid     | C <sub>9</sub> H <sub>6</sub> O <sub>6</sub>   | 210.140  | 10           | 1.02                              | 10.3                      | 76    |                                      |      |
|                                     |                                                |          | 25           | 1.92                              | 19.6                      | 76    |                                      |      |
|                                     |                                                |          | 50           | 5.45                              | 57.6                      | 76    |                                      |      |
| 1,3,5-Benzenetricarboxylic acid     | C <sub>9</sub> H <sub>6</sub> O <sub>6</sub>   | 210.140  | 10           | 0.110                             | 1.10                      | 76    |                                      |      |
|                                     |                                                |          | 25           | 0.207                             | 2.07                      | 76    |                                      |      |
|                                     |                                                |          | 50           | 0.598                             | 6.02                      | 76    |                                      |      |
| 1,2,3-Benzenetriol                  | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>   | 126.110  | 25           | 38.5                              | 626                       | 27    |                                      |      |
| 1,3,5-Benzenetriol                  | C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>   | 126.110  | 20           | 1.12                              | 11.3                      | 27    |                                      |      |
| <i>p</i> -Benzidine                 | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> | 184.236  | 24           | 0.0360                            | 0.360                     | 40    |                                      |      |
| 1 <i>H</i> -Benzimidazole           | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>   | 118.136  | 15           | 0.33                              | 3.3                       | 54    |                                      |      |
|                                     |                                                |          | 20           | 0.201                             | 2.01                      | 6     |                                      |      |
| 1,3-Benzodioxole-5-carboxaldehyde   | C <sub>8</sub> H <sub>6</sub> O <sub>3</sub>   | 150.132  | 20           | 0.35                              | 3.5                       | 40    |                                      |      |
| Benzo[b]fluoranthene                | C <sub>20</sub> H <sub>12</sub>                | 252.309  | 20           | 0.0000002                         | 0.000002                  | 40    |                                      |      |
| Benzo[k]fluoranthene                | C <sub>20</sub> H <sub>12</sub>                | 252.309  |              | 0.00000008                        | 0.0000008                 | 40    |                                      |      |
| 11 <i>H</i> -Benzo[a]fluorene       | C <sub>17</sub> H <sub>12</sub>                | 216.277  | 25           | 0.0000045                         | 0.000045                  | 42,4  |                                      |      |
| 11 <i>H</i> -Benzo[b]fluorene       | C <sub>17</sub> H <sub>12</sub>                | 216.277  | 25           | 0.0000002                         | 0.000002                  | 42,4  |                                      |      |
| Benzoic acid                        | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>   | 122.122  | 10           | 0.209                             | 2.09                      | 76    |                                      |      |
|                                     |                                                |          | 25           | 0.343                             | 3.44                      | 76    |                                      |      |
|                                     |                                                |          | 50           | 0.842                             | 8.49                      | 76    |                                      |      |
| Benzoin                             | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub> | 212.244  | 25           | 0.03                              | 0.3                       | 40    |                                      |      |
| Benzonitrile                        | C <sub>7</sub> H <sub>5</sub> N                | 103.122  | 25           | 0.2                               | 2                         | 10    |                                      |      |
| Benzo[ghi]perylene                  | C <sub>22</sub> H <sub>12</sub>                | 276.330  | 25           | 0.000000026                       | 0.00000026                | 42,4  | 0.000075                             | 12   |
| Benzophenone                        | C <sub>13</sub> H <sub>10</sub> O              | 182.217  | 20           | 0.0075                            | 0.075                     | 40    |                                      |      |
| 2 <i>H</i> -1-Benzopyran-2-one      | C <sub>9</sub> H <sub>6</sub> O <sub>2</sub>   | 146.143  | 20           | 0.190                             | 1.90                      | 40    |                                      |      |
|                                     |                                                |          | 60           | 0.69                              | 6.9                       | 40    |                                      |      |
| Benzo[a]pyrene                      | C <sub>20</sub> H <sub>12</sub>                | 252.309  | 25           | 0.00000043                        | 0.0000043                 | 42,22 | 0.0000465                            | 22   |
| Benzo[e]pyrene                      | C <sub>20</sub> H <sub>12</sub>                | 252.309  | 8            | 0.00000032                        | 0.0000032                 | 42    |                                      |      |
|                                     |                                                |          | 17           | 0.00000044                        | 0.0000044                 | 42,22 | 0.0000467                            | 22   |
|                                     |                                                |          | 25           | 0.00000048                        | 0.0000048                 | 42    |                                      |      |
| Benzo[f]quinoline                   | C <sub>13</sub> H <sub>9</sub> N               | 179.217  | 25           | 0.0079                            | 0.079                     | 6     |                                      |      |
| <i>p</i> -Benzoquinone              | C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>   | 108.095  | 25           | 1.36                              | 13.8                      | 27    |                                      |      |
| Benzo[b]thiophene                   | C <sub>8</sub> H <sub>6</sub> S                | 134.199  | 20           | 0.0130                            | 0.130                     | 6     |                                      |      |
| Benzo[b]triphenylene                | C <sub>22</sub> H <sub>14</sub>                | 278.346  | 25           | 0.0000027                         | 0.000027                  | 4     |                                      |      |



| Name                                           | Mol. Form.                                                      | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|------------------------------------------------|-----------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                                                |                                                                 |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Benzoxazole                                    | C <sub>7</sub> H <sub>5</sub> NO                                | 119.121  | 20           | 0.834                             | 8.34                      | 6     |                                      |      |
| <i>N</i> -Benzoylglycine                       | C <sub>9</sub> H <sub>9</sub> NO <sub>3</sub>                   | 179.172  | 25           | 0.37                              | 3.7                       | 29    |                                      |      |
| Benzoyl peroxide                               | C <sub>14</sub> H <sub>10</sub> O <sub>4</sub>                  | 242.227  | 20           | 0.000016                          | 0.00016                   | 40    |                                      |      |
| <i>N</i> -Benzoyl- <i>L</i> -phenylalanine     | C <sub>16</sub> H <sub>15</sub> NO <sub>3</sub>                 | 269.295  | 25           | 0.085                             | 0.85                      | 29    |                                      |      |
| Benzyl acetate                                 | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                   | 150.174  | 25           | 0.150                             | 1.50                      | 40    |                                      |      |
| Benzyl alcohol                                 | C <sub>7</sub> H <sub>8</sub> O                                 | 108.138  | 20           | 0.08                              | 0.8                       | 10    |                                      |      |
| Benzyl formate                                 | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                    | 136.149  | 20           | 1.07                              | 10.8                      | 20    |                                      |      |
|                                                |                                                                 |          | 80           | 1.43                              | 14.5                      | 20    |                                      |      |
| Bifenthrin                                     | C <sub>23</sub> H <sub>22</sub> ClF <sub>3</sub> O <sub>2</sub> | 422.868  | 25           | 0.00001                           | 0.0001                    | 32    |                                      |      |
| Biotin                                         | C <sub>10</sub> H <sub>16</sub> N <sub>2</sub> O <sub>3</sub> S | 244.310  | 25           | 0.035                             | 0.35                      | 40    |                                      |      |
| Biphenyl                                       | C <sub>12</sub> H <sub>10</sub>                                 | 154.207  | 0            | 0.000272                          | 0.00272                   | 4     |                                      |      |
|                                                |                                                                 |          | 25           | 0.00054                           | 0.0054                    | 58,22 | 0.0280                               | 22   |
|                                                |                                                                 |          | 50           | 0.0022                            | 0.022                     | 4     |                                      |      |
| 2,2'-Bipyridine                                | C <sub>10</sub> H <sub>8</sub> N <sub>2</sub>                   | 156.184  | 25           | 0.61                              | 6.1                       | 40    |                                      |      |
| 2,2'-Biquinoline                               | C <sub>18</sub> H <sub>12</sub> N <sub>2</sub>                  | 256.301  | 24           | 0.000102                          | 0.00102                   | 6     |                                      |      |
| Bis(4-aminophenyl) sulfone                     | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub> S | 248.300  | 25           | 0.016                             | 0.16                      | 40    |                                      |      |
| Bis(2-chloroethyl) ether                       | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O                 | 143.012  | 20           | 1.04                              | 10.5                      | 20    | 0.003                                | 13   |
|                                                |                                                                 |          | 81           | 1.26                              | 12.8                      | 20    |                                      |      |
| 1,1-Bis(4-chlorophenyl)-2,2,2-trichloroethanol | C <sub>14</sub> H <sub>9</sub> Cl <sub>5</sub> O                | 370.485  | 25           | 0.00013                           | 0.0013                    | 40    |                                      |      |
| Bis(2-ethylhexyl) phthalate                    | C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                  | 390.557  | 25           | 0.000027                          | 0.00027                   | 40    |                                      |      |
| 2,2-Bis(4-hydroxyphenyl)propane                | C <sub>15</sub> H <sub>16</sub> O <sub>2</sub>                  | 228.287  | 25           | 0.0300                            | 0.30                      | 49    |                                      |      |
| 1,3-Bis(trifluoromethyl)benzene                | C <sub>8</sub> H <sub>4</sub> F <sub>6</sub>                    | 214.108  | 25           | 0.0041                            | 0.041                     | 2     |                                      |      |
| Borneol                                        | C <sub>10</sub> H <sub>18</sub> O                               | 154.249  | 25           | 0.046                             | 0.46                      | 52    |                                      |      |
| Bromacil                                       | C <sub>9</sub> H <sub>13</sub> BrN <sub>2</sub> O <sub>2</sub>  | 261.115  | 25           | 0.082                             | 0.82                      | 40    |                                      |      |
| Bromobenzene                                   | C <sub>6</sub> H <sub>5</sub> Br                                | 157.008  | 10           | 0.0387                            | 0.387                     | 2     |                                      |      |
|                                                |                                                                 |          | 25           | 0.0445                            | 0.445                     | 2     | 0.250                                | 28   |
|                                                |                                                                 |          | 40           | 0.0516                            | 0.516                     | 2     |                                      |      |
| 2-Bromobenzoic acid                            | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>                  | 201.018  | 25           | 0.185                             | 1.85                      | 27    |                                      |      |
| 3-Bromobenzoic acid                            | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>                  | 201.018  | 25           | 0.040                             | 0.40                      | 27    |                                      |      |
| 4-Bromobenzoic acid                            | C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub>                  | 201.018  | 25           | 0.0056                            | 0.056                     | 27    |                                      |      |
| 1-Bromobutane                                  | C <sub>4</sub> H <sub>9</sub> Br                                | 137.018  | 25           | 0.087                             | 0.87                      | 35    | 1.2                                  | 13   |
| 4-Bromo-1-butene                               | C <sub>4</sub> H <sub>7</sub> Br                                | 135.003  | 25           | 0.076                             | 0.76                      | 35    |                                      |      |
| 1-Bromo-2-chlorobenzene                        | C <sub>6</sub> H <sub>4</sub> BrCl                              | 191.453  | 25           | 0.0124                            | 0.124                     | 2     |                                      |      |
| 1-Bromo-3-chlorobenzene                        | C <sub>6</sub> H <sub>4</sub> BrCl                              | 191.453  | 25           | 0.0118                            | 0.118                     | 2     |                                      |      |
| 1-Bromo-4-chlorobenzene                        | C <sub>6</sub> H <sub>4</sub> BrCl                              | 191.453  | 25           | 0.00442                           | 0.0442                    | 2     |                                      |      |
| 1-Bromo-2-chloroethane                         | C <sub>2</sub> H <sub>4</sub> BrCl                              | 143.410  | 30           | 0.683                             | 6.83                      | 25    |                                      |      |
| Bromochloromethane                             | CH <sub>2</sub> BrCl                                            | 129.384  | 25           | 1.7                               | 17                        | 10    | 0.18                                 | 13   |
| 1-Bromo-3-chloropropane                        | C <sub>3</sub> H <sub>6</sub> BrCl                              | 157.437  | 25           | 0.223                             | 2.23                      | 35    |                                      |      |
| 2-Bromo-2-chloro-1,1,1-trifluoroethane         | C <sub>2</sub> HBrClF <sub>3</sub>                              | 197.381  | 10           | 0.52                              | 5.2                       | 25    |                                      |      |
|                                                |                                                                 |          | 25           | 0.41                              | 4.1                       | 25    |                                      |      |
|                                                |                                                                 |          | 40           | 0.40                              | 4.0                       | 25    |                                      |      |
| Bromodichloromethane                           | CHBrCl <sub>2</sub>                                             | 163.829  | 30           | 0.300                             | 3.00                      | 40    |                                      |      |
| Bromoethane                                    | C <sub>2</sub> H <sub>5</sub> Br                                | 108.965  | 0            | 1.05                              | 10.6                      | 25    |                                      |      |
|                                                |                                                                 |          | 25           | 0.90                              | 9.0                       | 25    | 1.23                                 | 13   |
| 1-Bromoheptane                                 | C <sub>7</sub> H <sub>15</sub> Br                               | 179.098  | 25           | 0.00067                           | 0.0067                    | 35    |                                      |      |
| 1-Bromohexane                                  | C <sub>6</sub> H <sub>13</sub> Br                               | 165.071  | 25           | 0.00258                           | 0.0258                    | 35    |                                      |      |
| 1-Bromo-4-iodobenzene                          | C <sub>6</sub> H <sub>4</sub> BrI                               | 282.904  | 25           | 0.000794                          | 0.00794                   | 2     |                                      |      |
| Bromomethane                                   | CH <sub>3</sub> Br                                              | 94.939   | 20           | 1.80*                             | 18.3*                     | 5     | 0.63                                 | 13   |
| 1-Bromo-3-methylbutane                         | C <sub>5</sub> H <sub>11</sub> Br                               | 151.045  | 16           | 0.020                             | 0.20                      | 35    |                                      |      |

| Name                          | Mol. Form.                                                    | Mol. Wt. | t/°C | Solubility, s        |                           |       | Henry Const., $k_H$                     |      |
|-------------------------------|---------------------------------------------------------------|----------|------|----------------------|---------------------------|-------|-----------------------------------------|------|
|                               |                                                               |          |      | 100 $w_2$<br>(mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 1-Bromo-2-methylpropane       | C <sub>4</sub> H <sub>9</sub> Br                              | 137.018  | 18   | 0.051                | 0.51                      | 35    |                                         |      |
| 1-Bromooctane                 | C <sub>8</sub> H <sub>17</sub> Br                             | 193.125  | 25   | 0.000167             | 0.00167                   | 35    |                                         |      |
| 1-Bromopentane                | C <sub>5</sub> H <sub>11</sub> Br                             | 151.045  | 25   | 0.0127               | 0.127                     | 35    |                                         |      |
| 4-Bromophenol                 | C <sub>6</sub> H <sub>5</sub> BrO                             | 173.007  | 25   | 1.86                 | 19.0                      | 2     |                                         |      |
| 1-Bromopropane                | C <sub>3</sub> H <sub>7</sub> Br                              | 122.992  | 0    | 0.298                | 2.98                      | 35    |                                         |      |
|                               |                                                               |          | 25   | 0.234                | 2.34                      | 35    | 3.8                                     | 13   |
| 2-Bromopropane                | C <sub>3</sub> H <sub>7</sub> Br                              | 122.992  | 20   | 0.32                 | 3.2                       | 35    | 1.27                                    | 13   |
| 3-Bromopropene                | C <sub>3</sub> H <sub>5</sub> Br                              | 120.976  | 25   | 0.38                 | 3.8                       | 35    |                                         |      |
| 4-Bromotoluene                | C <sub>7</sub> H <sub>7</sub> Br                              | 171.035  | 25   | 0.011                | 0.11                      | 2     |                                         |      |
| Bromotrifluoromethane         | CBrF <sub>3</sub>                                             | 148.910  | 25   | 0.032*               | 0.32*                     | 14    |                                         |      |
| 5-Bromouracil                 | C <sub>4</sub> H <sub>3</sub> BrN <sub>2</sub> O <sub>2</sub> | 190.983  | 25   | 0.288                | 2.89                      | 72    |                                         |      |
| Brucine                       | C <sub>23</sub> H <sub>26</sub> N <sub>2</sub> O <sub>4</sub> | 394.463  | 20   | 0.012                | 0.12                      | 27    |                                         |      |
| 1,3-Butadiene                 | C <sub>4</sub> H <sub>6</sub>                                 | 54.091   | 25   | 0.0735*              | 0.735*                    | 5     | 20.7                                    | 13   |
| Butanal                       | C <sub>4</sub> H <sub>8</sub> O                               | 72.106   | 25   | 7.1                  | 76                        | 10    |                                         |      |
| Butanamide                    | C <sub>4</sub> H <sub>9</sub> NO                              | 87.120   | 25   | ≈19                  | ≈230                      | 40    |                                         |      |
| Butane                        | C <sub>4</sub> H <sub>10</sub>                                | 58.122   | 25   | 0.00724*             | 0.0724*                   | 18    | 95.9                                    | 5    |
| 2,3-Butanedione               | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                  | 86.090   | 20   | 31.7                 | 464                       | 20    |                                         |      |
|                               |                                                               |          | 80   | 21.8                 | 279                       | 20    |                                         |      |
| Butanenitrile                 | C <sub>4</sub> H <sub>7</sub> N                               | 69.106   | 20   | 3.3                  | 34                        | 10    |                                         |      |
| 1,2,3,4-Butanetetrol          | C <sub>4</sub> H <sub>10</sub> O <sub>4</sub>                 | 122.120  | 20   | 38.0                 | 613                       | 27    |                                         |      |
| 1-Butanethiol                 | C <sub>4</sub> H <sub>10</sub> S                              | 90.187   | 20   | 0.0597               | 0.597                     | 10    |                                         |      |
| 1-Butanol                     | C <sub>4</sub> H <sub>10</sub> O                              | 74.121   | 0    | 10.5                 | 117                       | 78,1  |                                         |      |
|                               |                                                               |          | 25   | 7.3                  | 79                        | 78,1  |                                         |      |
|                               |                                                               |          | 50   | 6.4                  | 68                        | 78,1  |                                         |      |
|                               |                                                               |          | 100  | 8.8                  | 96                        | 78    |                                         |      |
| 2-Butanol                     | C <sub>4</sub> H <sub>10</sub> O                              | 74.121   | 10   | 23.9                 | 314                       | 1,87  |                                         |      |
|                               |                                                               |          | 25   | 18.1                 | 221                       | 1,87  |                                         |      |
|                               |                                                               |          | 50   | 14.0                 | 163                       | 1,87  |                                         |      |
| 2-Butanone                    | C <sub>4</sub> H <sub>8</sub> O                               | 72.106   | 0    | 35.9                 | 560                       | 82    |                                         |      |
|                               |                                                               |          | 25   | 25.6                 | 344                       | 82    |                                         |      |
|                               |                                                               |          | 40   | 21.5                 | 274                       | 82    |                                         |      |
|                               |                                                               |          | 70   | 18.1                 | 221                       | 20    |                                         |      |
|                               |                                                               |          | 100  | 19.3                 | 239                       | 82    |                                         |      |
| <i>trans</i> -2-Butenal       | C <sub>4</sub> H <sub>6</sub> O                               | 70.090   | 20   | 15.6                 | 185                       | 10    |                                         |      |
| 1-Butene                      | C <sub>4</sub> H <sub>8</sub>                                 | 56.107   | 25   | 0.0222*              | 0.222*                    | 5     | 25.6                                    | 13   |
| <i>trans</i> -2-Butenoic acid | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                  | 86.090   | 20   | 7.1                  | 76                        | 26    |                                         |      |
| <i>cis</i> -2-Buten-1-ol      | C <sub>4</sub> H <sub>8</sub> O                               | 72.106   | 20   | 16.6                 | 199                       | 10    |                                         |      |
| 3-Buten-2-one                 | C <sub>4</sub> H <sub>6</sub> O                               | 70.090   | 28   | 54.3                 | 1190                      | 82    |                                         |      |
|                               |                                                               |          | 50   | 35.6                 | 553                       | 82    |                                         |      |
|                               |                                                               |          | 80   | 37.6                 | 603                       | 82    |                                         |      |
| Butyl acetate                 | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 116.158  | 20   | 0.68                 | 6.8                       | 10    |                                         |      |
| <i>sec</i> -Butyl acetate     | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                 | 116.158  | 20   | 0.62                 | 6.2                       | 10    |                                         |      |
| Butyl 4-aminobenzoate         | C <sub>11</sub> H <sub>15</sub> NO <sub>2</sub>               | 193.243  | 25   | 0.018                | 0.18                      | 40    |                                         |      |
| Butylbenzene                  | C <sub>10</sub> H <sub>14</sub>                               | 134.218  | 25   | 0.00138              | 0.0138                    | 22,89 | 1.33                                    | 22   |
| <i>sec</i> -Butylbenzene      | C <sub>10</sub> H <sub>14</sub>                               | 134.218  | 25   | 0.0014               | 0.014                     | 4,89  | 1.89                                    | 11   |
| <i>tert</i> -Butylbenzene     | C <sub>10</sub> H <sub>14</sub>                               | 134.218  | 25   | 0.0032               | 0.032                     | 4     | 1.28                                    | 11   |
| Butyl ethyl ether             | C <sub>6</sub> H <sub>14</sub> O                              | 102.174  | 20   | 0.65                 | 6.5                       | 20    |                                         |      |
|                               |                                                               |          | 70   | 0.39                 | 3.9                       | 20    |                                         |      |
| Butyl 4-hydroxybenzoate       | C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>                | 194.227  | 25   | 0.020                | 0.20                      | 40    |                                         |      |

| Name                         | Mol. Form.                                                                    | Mol. Wt. | t/°C | Solubility, s     |                           |      | Henry Const., $k_H$                  |      |
|------------------------------|-------------------------------------------------------------------------------|----------|------|-------------------|---------------------------|------|--------------------------------------|------|
|                              |                                                                               |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref. | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Butyl methyl ether           | C <sub>5</sub> H <sub>12</sub> O                                              | 88.148   | 0    | 2.51              | 25.7                      | 79   |                                      |      |
|                              |                                                                               |          | 25   | 0.89              | 9.0                       | 79   |                                      |      |
| 4- <i>tert</i> -Butylphenol  | C <sub>10</sub> H <sub>14</sub> O                                             | 150.217  | 25   | 0.058             | 0.58                      | 40   |                                      |      |
| Butyl propanoate             | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                                 | 130.185  | 22   | 0.572             | 5.72                      | 27   |                                      |      |
| Butyl stearate               | C <sub>22</sub> H <sub>44</sub> O <sub>2</sub>                                | 340.583  | 25   | 0.2               | 2                         | 10   |                                      |      |
| Butyl vinyl ether            | C <sub>6</sub> H <sub>12</sub> O                                              | 100.158  | 20   | 0.3               | 3                         | 10   |                                      |      |
| 1-Butyne                     | C <sub>4</sub> H <sub>6</sub>                                                 | 54.091   | 25   | 0.287*            | 2.87*                     | 5    | 1.91                                 | 5    |
| Caffeine                     | C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub>                  | 194.191  | 25   | 2.12              | 21.7                      | 29   |                                      |      |
| Camphor, (+)                 | C <sub>10</sub> H <sub>16</sub> O                                             | 152.233  | 20   | 0.01              | 0.1                       | 10   |                                      |      |
| <i>trans</i> -Camphoric acid | C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>                                | 200.232  | 25   | 0.8               | 8                         | 27   |                                      |      |
| Cantharidin                  | C <sub>10</sub> H <sub>12</sub> O <sub>4</sub>                                | 196.200  | 20   | 0.003             | 0.03                      | 40   |                                      |      |
| Caprolactam                  | C <sub>6</sub> H <sub>11</sub> NO                                             | 113.157  | 25   | 84.0              | 5250                      | 10   |                                      |      |
| Captafol                     | C <sub>10</sub> H <sub>9</sub> Cl <sub>4</sub> NO <sub>2</sub> S              | 349.061  | 20   | 0.000142          | 0.00142                   | 40   |                                      |      |
| Captan                       | C <sub>9</sub> H <sub>8</sub> Cl <sub>3</sub> NO <sub>2</sub> S               | 300.590  | 20   | 0.00005           | 0.0005                    | 40   |                                      |      |
| Carbaryl                     | C <sub>12</sub> H <sub>11</sub> NO <sub>2</sub>                               | 201.221  | 20   | 0.0102            | 0.102                     | 40   |                                      |      |
| Carbazole                    | C <sub>12</sub> H <sub>9</sub> N                                              | 167.206  | 22   | 0.000120          | 0.00120                   | 6    |                                      |      |
| Carbofuran                   | C <sub>12</sub> H <sub>15</sub> NO <sub>3</sub>                               | 221.252  | 20   | 0.032             | 0.32                      | 40   |                                      |      |
| Carbon dioxide               | CO <sub>2</sub>                                                               | 44.010   | 25   | 0.150*            | 1.50*                     | 18   |                                      |      |
| Carbon disulfide             | CS <sub>2</sub>                                                               | 76.141   | 20   | 0.210             | 2.10                      | 10   |                                      |      |
| Carbon monoxide              | CO                                                                            | 28.010   | 25   | 0.00276*          | 0.0276*                   | 18   |                                      |      |
| Carboxin                     | C <sub>12</sub> H <sub>13</sub> NO <sub>2</sub> S                             | 235.302  | 25   | 0.017             | 0.17                      | 40   |                                      |      |
| Carminic acid                | C <sub>22</sub> H <sub>20</sub> O <sub>13</sub>                               | 492.386  | 20   | 0.13              | 1.3                       | 40   |                                      |      |
| Carnosine                    | C <sub>9</sub> H <sub>14</sub> N <sub>4</sub> O <sub>3</sub>                  | 226.232  | 25   | 24.4              | 323                       | 26   |                                      |      |
| Carvenol                     | C <sub>10</sub> H <sub>16</sub> O                                             | 152.233  | 25   | 0.29              | 2.9                       | 52   |                                      |      |
| Carvenone, (S)-              | C <sub>10</sub> H <sub>16</sub> O                                             | 152.233  | 15   | 0.22              | 2.2                       | 27   |                                      |      |
| Carvone                      | C <sub>10</sub> H <sub>14</sub> O                                             | 150.217  | 15   | 0.13              | 1.3                       | 27   |                                      |      |
| (S)-Carvone                  | C <sub>10</sub> H <sub>14</sub> O                                             | 150.217  | 25   | 0.13              | 1.3                       | 52   |                                      |      |
| Cephalexin                   | C <sub>16</sub> H <sub>17</sub> N <sub>3</sub> O <sub>4</sub> S               | 347.389  | 25   | 1.2               | 12                        | 40   |                                      |      |
| Chloramphenicol              | C <sub>11</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>5</sub> | 323.129  | 25   | 0.38              | 3.8                       | 40   |                                      |      |
| Chlordane                    | C <sub>10</sub> H <sub>6</sub> Cl <sub>8</sub>                                | 409.779  | 25   | 0.00006           | 0.0006                    | 67   |                                      |      |
| 2-Chloroaniline              | C <sub>6</sub> H <sub>6</sub> ClN                                             | 127.572  | 25   | 0.876             | 8.76                      | 10   |                                      |      |
| 3-Chloroaniline              | C <sub>6</sub> H <sub>6</sub> ClN                                             | 127.572  | 20   | 0.54              | 5.4                       | 40   |                                      |      |
| 4-Chloroaniline              | C <sub>6</sub> H <sub>6</sub> ClN                                             | 127.572  | 20   | 0.275             | 2.75                      | 40   |                                      |      |
| Chlorobenzene                | C <sub>6</sub> H <sub>5</sub> Cl                                              | 112.557  | 5    | 0.050             | 0.50                      | 61   |                                      |      |
|                              |                                                                               |          | 25   | 0.050             | 0.50                      | 61   |                                      |      |
|                              |                                                                               |          | 45   | 0.055             | 0.55                      | 61,2 |                                      |      |
| Chlorobenzilate              | C <sub>16</sub> H <sub>14</sub> Cl <sub>2</sub> O <sub>3</sub>                | 325.186  | 20   | 0.001             | 0.01                      | 32   |                                      |      |
| 2-Chlorobenzoic acid         | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                                | 156.567  | 25   | 0.209             | 2.09                      | 27   |                                      |      |
| 3-Chlorobenzoic acid         | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                                | 156.567  | 25   | 0.040             | 0.40                      | 27   |                                      |      |
| 4-Chlorobenzoic acid         | C <sub>7</sub> H <sub>5</sub> ClO <sub>2</sub>                                | 156.567  | 25   | 0.072             | 0.72                      | 27   |                                      |      |
| 2-Chlorobiphenyl             | C <sub>12</sub> H <sub>9</sub> Cl                                             | 188.652  | 25   | 0.00055           | 0.0055                    | 7    | 0.0701                               | 7    |
| 1-Chlorobutane               | C <sub>4</sub> H <sub>9</sub> Cl                                              | 92.567   | 1    | 0.062             | 0.62                      | 35   |                                      |      |
|                              |                                                                               |          | 25   | 0.087             | 0.87                      | 35   | 1.54                                 | 13   |
| 2-Chlorobutane               | C <sub>4</sub> H <sub>9</sub> Cl                                              | 92.567   | 0    | 0.107             | 1.07                      | 35   |                                      |      |
|                              |                                                                               |          | 25   | 0.092             | 0.92                      | 35   |                                      |      |
| 3-Chloro-2-butanone          | C <sub>4</sub> H <sub>7</sub> ClO                                             | 106.551  | 19   | 2.80              | 28.8                      | 20   |                                      |      |
|                              |                                                                               |          | 92   | 3.38              | 35.0                      | 20   |                                      |      |
| Chlorodiazepoxide            | C <sub>16</sub> H <sub>14</sub> ClN <sub>3</sub> O                            | 299.754  | 20   | 0.2               | 2                         | 40   |                                      |      |
| Chlorodibromomethane         | CHBr <sub>2</sub> Cl                                                          | 208.280  | 30   | 0.251             | 2.51                      | 40   |                                      |      |



| Name                                     | Mol. Form.                                                    | Mol. Wt. | t/°C | Solubility, s     |                           |         | Henry Const., $k_H$                  |      |
|------------------------------------------|---------------------------------------------------------------|----------|------|-------------------|---------------------------|---------|--------------------------------------|------|
|                                          |                                                               |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref.    | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Chlorodifluoromethane                    | CHClF <sub>2</sub>                                            | 86.469   | 25   | 0.30*             | 3.0*                      | 10      | 3.0                                  | 13   |
| 4-Chloro-2,5-dimethylphenol              | C <sub>8</sub> H <sub>9</sub> ClO                             | 156.609  | 25   | 0.89              | 8.9                       | 2       |                                      |      |
| 4-Chloro-2,6-dimethylphenol              | C <sub>8</sub> H <sub>9</sub> ClO                             | 156.609  | 25   | 0.52              | 5.2                       | 2       |                                      |      |
| 4-Chloro-3,5-dimethylphenol              | C <sub>8</sub> H <sub>9</sub> ClO                             | 156.609  | 25   | 0.34              | 3.4                       | 2       |                                      |      |
| 1-Chloro-2,4-dinitrobenzene              | C <sub>6</sub> H <sub>3</sub> ClN <sub>2</sub> O <sub>4</sub> | 202.552  | 25   | 0.00092           | 0.0092                    | 40      |                                      |      |
| Chloroethane                             | C <sub>2</sub> H <sub>5</sub> Cl                              | 64.514   | 0    | 0.45              | 4.5                       | 25      |                                      |      |
|                                          |                                                               |          | 25   | 0.67*             | 6.7*                      | 25      | 1.02                                 | 13   |
| Chloroethene                             | C <sub>2</sub> H <sub>3</sub> Cl                              | 62.498   | 25   | 0.27*             | 2.7*                      | 5       | 2.68                                 | 13   |
| 1-Chloro-2-fluorobenzene                 | C <sub>6</sub> H <sub>4</sub> ClF                             | 130.547  | 25   | 0.0502            | 0.502                     | 40      |                                      |      |
| Chlorofluoromethane                      | CH <sub>2</sub> ClF                                           | 68.478   | 25   | 1.05*             | 10.6*                     | 14      |                                      |      |
| 1-Chloroheptane                          | C <sub>7</sub> H <sub>15</sub> Cl                             | 134.647  | 25   | 0.00136           | 0.0136                    | 35      |                                      |      |
| 1-Chlorohexane                           | C <sub>6</sub> H <sub>13</sub> Cl                             | 120.620  | 5    | 0.0047            | 0.047                     | 35      |                                      |      |
|                                          |                                                               |          | 25   | 0.0064            | 0.064                     | 35      |                                      |      |
| 2-Chloro-4-hydroxy-5-methoxybenzaldehyde | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                | 186.593  | 25   | 0.013             | 0.13                      | 8       |                                      |      |
| 3-Chloro-4-hydroxy-5-methoxybenzaldehyde | C <sub>8</sub> H <sub>7</sub> ClO <sub>3</sub>                | 186.593  | 25   | 0.093             | 0.93                      | 8       |                                      |      |
| 1-Chloro-2-iodobenzene                   | C <sub>6</sub> H <sub>4</sub> ClI                             | 238.453  | 25   | 0.00689           | 0.0689                    | 2       |                                      |      |
| 1-Chloro-3-iodobenzene                   | C <sub>6</sub> H <sub>4</sub> ClI                             | 238.453  | 25   | 0.00674           | 0.0674                    | 2       |                                      |      |
| 1-Chloro-4-iodobenzene                   | C <sub>6</sub> H <sub>4</sub> ClI                             | 238.453  | 25   | 0.00311           | 0.0311                    | 2       |                                      |      |
| Chloromethane                            | CH <sub>3</sub> Cl                                            | 50.488   | 25   | 0.535*            | 5.35*                     | 5       | 0.98                                 | 13   |
| 1-Chloro-2-methoxyethane                 | C <sub>3</sub> H <sub>7</sub> ClO                             | 94.540   | 20   | 7.79              | 84.5                      | 20      |                                      |      |
|                                          |                                                               |          | 70   | 6.31              | 67.3                      | 20      |                                      |      |
| (Chloromethyl)benzene                    | C <sub>7</sub> H <sub>7</sub> Cl                              | 126.584  | 20   | 0.0493            | 0.493                     | 10      |                                      |      |
| 3-(Chloromethyl)heptane                  | C <sub>8</sub> H <sub>17</sub> Cl                             | 148.674  | 20   | 0.01              | 0.1                       | 10      |                                      |      |
| 2-Chloro-6-methylphenol                  | C <sub>7</sub> H <sub>7</sub> ClO                             | 142.583  | 25   | 0.36              | 3.6                       | 2       |                                      |      |
| 4-Chloro-2-methylphenol                  | C <sub>7</sub> H <sub>7</sub> ClO                             | 142.583  | 25   | 0.68              | 6.8                       | 2       |                                      |      |
| 4-Chloro-3-methylphenol                  | C <sub>7</sub> H <sub>7</sub> ClO                             | 142.583  | 25   | 0.40              | 4.0                       | 2       |                                      |      |
| (4-Chloro-2-methylphenoxy)acetic acid    | C <sub>9</sub> H <sub>9</sub> ClO <sub>3</sub>                | 200.618  | 25   | 0.117             | 1.17                      | 40      |                                      |      |
| 1-Chloro-2-methylpropane                 | C <sub>4</sub> H <sub>9</sub> Cl                              | 92.567   | 25   | 0.92              | 9.2                       | 35      |                                      |      |
| 2-Chloro-2-methylpropane                 | C <sub>4</sub> H <sub>9</sub> Cl                              | 92.567   | 15   | 0.29              | 2.9                       | 35      |                                      |      |
| 1-Chloro-2-methylpropene                 | C <sub>4</sub> H <sub>7</sub> Cl                              | 90.552   | 25   | 0.916             | 9.16                      | 5       | 0.12                                 | 5    |
| 1-Chloronaphthalene                      | C <sub>10</sub> H <sub>7</sub> Cl                             | 162.616  | 25   | 0.00224           | 0.0224                    | 5       | 0.0363                               | 28   |
| 2-Chloronaphthalene                      | C <sub>10</sub> H <sub>7</sub> Cl                             | 162.616  | 25   | 0.00117           | 0.0117                    | 5       | 0.0335                               | 28   |
| 1-Chloro-2-nitrobenzene                  | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>               | 157.555  | 20   | 0.0441            | 0.441                     | 40      |                                      |      |
| 1-Chloro-3-nitrobenzene                  | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>               | 157.555  | 20   | 0.0273            | 0.273                     | 40      |                                      |      |
| 1-Chloro-4-nitrobenzene                  | C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>               | 157.555  | 20   | 0.0453            | 0.453                     | 40      |                                      |      |
| 3-Chloro-2-nitrobenzoic acid             | C <sub>7</sub> H <sub>4</sub> ClNO <sub>4</sub>               | 201.565  | 25   | 0.047             | 0.47                      | 27      |                                      |      |
| 5-Chloro-2-nitrobenzoic acid             | C <sub>7</sub> H <sub>4</sub> ClNO <sub>4</sub>               | 201.565  | 25   | 0.96              | 9.6                       | 27      |                                      |      |
| 1-Chlorooctane                           | C <sub>8</sub> H <sub>17</sub> Cl                             | 148.674  | 25   | 0.0345            | 0.345                     | 35      |                                      |      |
| Chloropentafluoroethane                  | C <sub>2</sub> ClF <sub>5</sub>                               | 154.466  | 25   | 0.006*            | 0.06*                     | 10      | 260                                  | 13   |
| 1-Chloropentane                          | C <sub>5</sub> H <sub>11</sub> Cl                             | 106.594  | 5    | 0.020             | 0.20                      | 35      |                                      |      |
|                                          |                                                               |          | 25   | 0.0201            | 0.201                     | 35      | 2.37                                 | 13   |
| 3-Chloropentane                          | C <sub>5</sub> H <sub>11</sub> Cl                             | 106.594  | 25   | 0.025             | 0.25                      | 35      |                                      |      |
| 5-Chloro-2-pentanone                     | C <sub>5</sub> H <sub>9</sub> ClO                             | 120.577  | 22   | 4.7               | 49                        | 20      |                                      |      |
|                                          |                                                               |          | 71   | 13.5              | 156                       | 20      |                                      |      |
| 2-Chlorophenol                           | C <sub>6</sub> H <sub>5</sub> ClO                             | 128.556  | 25   | 2.27              | 23.2                      | 48,51,2 |                                      |      |
| 3-Chlorophenol                           | C <sub>6</sub> H <sub>5</sub> ClO                             | 128.556  | 25   | 2.2               | 22                        | 2       |                                      |      |
| 4-Chlorophenol                           | C <sub>6</sub> H <sub>5</sub> ClO                             | 128.556  | 25   | 2.55              | 26.2                      | 48,51,2 |                                      |      |
| N'-(4-Chlorophenyl)-N,N-dimethylurea     | C <sub>9</sub> H <sub>11</sub> ClN <sub>2</sub> O             | 198.648  | 25   | 0.023             | 0.23                      | 26      |                                      |      |
| 1-Chloropropane                          | C <sub>3</sub> H <sub>7</sub> Cl                              | 78.541   | 25   | 0.250             | 2.50                      | 35      | 1.41                                 | 13   |

| Name                            | Mol. Form.                                                                   | Mol. Wt. | t/°C | Solubility, s     |                           |       | Henry Const., $k_H$                  |      |
|---------------------------------|------------------------------------------------------------------------------|----------|------|-------------------|---------------------------|-------|--------------------------------------|------|
|                                 |                                                                              |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 2-Chloropropane                 | C <sub>3</sub> H <sub>7</sub> Cl                                             | 78.541   | 0    | 0.44              | 4.4                       | 35    |                                      |      |
|                                 |                                                                              |          | 20   | 0.30              | 3.0                       | 35    |                                      |      |
| 3-Chloropropene                 | C <sub>3</sub> H <sub>5</sub> Cl                                             | 76.525   | 25   | 0.40              | 4.0                       | 35    | 1.10                                 | 5    |
|                                 |                                                                              |          | 50   | 0.13              | 1.3                       | 35    |                                      |      |
| Chloropropham                   | C <sub>10</sub> H <sub>12</sub> ClNO <sub>2</sub>                            | 213.661  | 25   | 0.0080            | 0.080                     | 40    |                                      |      |
| 1-Chlorotetradecane             | C <sub>14</sub> H <sub>29</sub> Cl                                           | 232.833  | 25   | 0.0232            | 0.232                     | 35    |                                      |      |
| Chlorothalonil                  | C <sub>8</sub> Cl <sub>4</sub> N <sub>2</sub>                                | 265.911  | 25   | 0.00006           | 0.0006                    | 40    |                                      |      |
| Chlorothiazide                  | C <sub>7</sub> H <sub>6</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 295.724  | 25   | 0.0283            | 0.283                     | 40    |                                      |      |
| 2-Chlorotoluene                 | C <sub>7</sub> H <sub>7</sub> Cl                                             | 126.584  | 25   | 0.0117            | 0.117                     | 61    |                                      |      |
| 3-Chlorotoluene                 | C <sub>7</sub> H <sub>7</sub> Cl                                             | 126.584  | 25   | 0.0117            | 0.117                     | 61    |                                      |      |
| 4-Chlorotoluene                 | C <sub>7</sub> H <sub>7</sub> Cl                                             | 126.584  | 25   | 0.0123            | 0.123                     | 61    |                                      |      |
| Chlorotrifluoromethane          | CClF <sub>3</sub>                                                            | 104.459  | 25   | 0.009*            | 0.09*                     | 10    | 6.9                                  | 13   |
| 3-Chloro-1,1,1-trifluoropropane | C <sub>3</sub> H <sub>4</sub> ClF <sub>3</sub>                               | 132.512  | 20   | 0.133             | 1.33                      | 35    |                                      |      |
| 2-Chloro-1,3,5-trinitrobenzene  | C <sub>6</sub> H <sub>2</sub> ClN <sub>3</sub> O <sub>6</sub>                | 247.549  | 15   | 0.018             | 0.18                      | 40    |                                      |      |
| 5-Chlorouracil                  | C <sub>4</sub> H <sub>3</sub> ClN <sub>2</sub> O <sub>2</sub>                | 146.532  | 25   | 0.250             | 2.51                      | 72    |                                      |      |
| Chlorpyrifos                    | C <sub>9</sub> H <sub>11</sub> Cl <sub>3</sub> NO <sub>3</sub> PS            | 350.586  | 20   | 0.000073          | 0.00073                   | 40    |                                      |      |
| Chlorsulfuron                   | C <sub>12</sub> H <sub>12</sub> ClN <sub>5</sub> O <sub>4</sub> S            | 357.773  | 25   | 2.71              | 27.9                      | 32    |                                      |      |
| Cholic acid                     | C <sub>24</sub> H <sub>40</sub> O <sub>5</sub>                               | 408.572  | 20   | 0.028             | 0.28                      | 26    |                                      |      |
| Chrysene                        | C <sub>18</sub> H <sub>12</sub>                                              | 228.288  | 7    | 0.00000007        | 0.0000007                 | 42    |                                      |      |
|                                 |                                                                              |          | 25   | 0.00000019        | 0.0000019                 | 42,22 | 0.000065                             | 22   |
| <i>trans</i> -Cinnamaldehyde    | C <sub>9</sub> H <sub>8</sub> O                                              | 132.159  | 25   | 0.135             | 1.35                      | 40    |                                      |      |
| <i>trans</i> -Cinnamic acid     | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>                                 | 148.159  | 20   | 0.1               | 1                         | 26    |                                      |      |
|                                 |                                                                              |          | 98   | 0.59              | 5.9                       | 26    |                                      |      |
| Citric acid                     | C <sub>6</sub> H <sub>8</sub> O <sub>7</sub>                                 | 192.124  | 20   | 59                | 1440                      | 26    |                                      |      |
| Clopyralid                      | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>                | 192.000  | 20   | 0.1               | 1                         | 40    |                                      |      |
| Clorophene                      | C <sub>13</sub> H <sub>11</sub> ClO                                          | 218.678  | 20   | 0.42              | 4.2                       | 40    |                                      |      |
| Cocaine                         | C <sub>17</sub> H <sub>21</sub> NO <sub>4</sub>                              | 303.354  | 25   | 0.17              | 1.7                       | 27    |                                      |      |
| Codeine                         | C <sub>18</sub> H <sub>21</sub> NO <sub>3</sub>                              | 299.365  | 25   | 0.79              | 7.9                       | 27    |                                      |      |
| Colchicine                      | C <sub>22</sub> H <sub>25</sub> NO <sub>6</sub>                              | 399.437  | 20   | 4                 | 42                        | 26    |                                      |      |
| Coronene                        | C <sub>24</sub> H <sub>12</sub>                                              | 300.352  | 25   | 0.000000014       | 0.00000014                | 42,4  |                                      |      |
| Creatine                        | C <sub>4</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                  | 131.133  | 25   | 1.6               | 16                        | 26    |                                      |      |
| <i>o</i> -Cresol                | C <sub>7</sub> H <sub>8</sub> O                                              | 108.138  | 40   | 3.08              | 31.8                      | 10    |                                      |      |
| <i>m</i> -Cresol                | C <sub>7</sub> H <sub>8</sub> O                                              | 108.138  | 40   | 2.51              | 25.7                      | 10    |                                      |      |
| <i>p</i> -Cresol                | C <sub>7</sub> H <sub>8</sub> O                                              | 108.138  | 40   | 2.26              | 23.1                      | 10    |                                      |      |
| Crufomate                       | C <sub>12</sub> H <sub>19</sub> ClNO <sub>3</sub> P                          | 291.711  | 20   | 0.50              | 5.0                       | 40    |                                      |      |
| Cyanazine                       | C <sub>9</sub> H <sub>13</sub> ClN <sub>6</sub>                              | 240.692  | 25   | 0.0171            | 0.171                     | 40    |                                      |      |
| 2-Cyanoacetamide                | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> O                               | 84.076   | 20   | 11.5              | 130                       | 40    |                                      |      |
| Cyanogen                        | C <sub>2</sub> N <sub>2</sub>                                                | 52.034   | 25   | 0.8*              | 8*                        | 30    |                                      |      |
| Cyanogen chloride               | CClN                                                                         | 61.471   | 0    | 5.7               | 60                        | 40    |                                      |      |
| Cyanoguanidine                  | C <sub>2</sub> H <sub>4</sub> N <sub>4</sub>                                 | 84.080   | 25   | 3.8               | 40                        | 40    |                                      |      |
| Cyanuric acid                   | C <sub>3</sub> H <sub>3</sub> N <sub>3</sub> O <sub>3</sub>                  | 129.074  | 25   | 0.259             | 2.59                      | 40    |                                      |      |
| Cycloheptane                    | C <sub>7</sub> H <sub>14</sub>                                               | 98.186   | 25   | 0.0030            | 0.030                     | 3     | 9.59                                 | 13   |
| Cycloheptanone                  | C <sub>7</sub> H <sub>12</sub> O                                             | 112.169  | 20   | 3.61              | 37.5                      | 20    |                                      |      |
|                                 |                                                                              |          | 92   | 2.82              | 29.0                      | 20    |                                      |      |
| 1,3,5-Cycloheptatriene          | C <sub>7</sub> H <sub>8</sub>                                                | 92.139   | 25   | 0.064             | 0.64                      | 3     | 0.47                                 | 13   |
| Cycloheptene                    | C <sub>7</sub> H <sub>12</sub>                                               | 96.170   | 25   | 0.0066            | 0.066                     | 3     | 4.9                                  | 13   |
| 1,4-Cyclohexadiene              | C <sub>6</sub> H <sub>8</sub>                                                | 80.128   | 25   | 0.08              | 0.8                       | 3     | 1.03                                 | 13   |
| Cyclohexane                     | C <sub>6</sub> H <sub>12</sub>                                               | 84.159   | 25   | 0.0058            | 0.058                     | 3     | 19.4                                 | 13   |
|                                 |                                                                              |          | 70   | 0.0092            | 0.092                     | 65    |                                      |      |

| Name                               | Mol. Form.                                                                  | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |      | Henry Const., <i>k<sub>H</sub></i>   |      |
|------------------------------------|-----------------------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|------|--------------------------------------|------|
|                                    |                                                                             |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref. | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
|                                    |                                                                             |          | 100          | 0.0163                            | 0.163                     | 65   |                                      |      |
| Cyclohexanecarboxylic acid         | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                               | 128.169  | 15           | 0.201                             | 2.01                      | 27   |                                      |      |
| Cyclohexanol                       | C <sub>6</sub> H <sub>12</sub> O                                            | 100.158  | 10           | 4.62                              | 48.4                      | 1    |                                      |      |
|                                    |                                                                             |          | 25           | 3.8                               | 40                        | 1    |                                      |      |
|                                    |                                                                             |          | 40           | 3.30                              | 34.1                      | 1    |                                      |      |
| Cyclohexanone                      | C <sub>6</sub> H <sub>10</sub> O                                            | 98.142   | 10           | 12.2                              | 139                       | 83   |                                      |      |
|                                    |                                                                             |          | 25           | 9.5                               | 105                       | 83   |                                      |      |
|                                    |                                                                             |          | 50           | 7.6                               | 82                        | 83   |                                      |      |
|                                    |                                                                             |          | 80           | 6.8                               | 73                        | 20   |                                      |      |
| Cyclohexanone oxime                | C <sub>6</sub> H <sub>11</sub> NO                                           | 113.157  | 25           | 1.57                              | 16.0                      | 40   |                                      |      |
| Cyclohexene                        | C <sub>6</sub> H <sub>10</sub>                                              | 82.143   | 25           | 0.016                             | 0.16                      | 3    | 4.57                                 | 13   |
| Cyclohexyl butanoate               | C <sub>10</sub> H <sub>18</sub> O <sub>2</sub>                              | 170.249  | 20           | 0.11                              | 1.1                       | 20   |                                      |      |
|                                    |                                                                             |          | 90           | 0.09                              | 0.90                      | 20   |                                      |      |
| Cyclooctane                        | C <sub>8</sub> H <sub>16</sub>                                              | 112.213  | 25           | 0.00079                           | 0.0079                    | 4    | 10.7                                 | 13   |
| 1,3-Cyclopentadiene                | C <sub>5</sub> H <sub>6</sub>                                               | 66.102   | 25           | 0.068                             | 0.68                      | 3    |                                      |      |
| Cyclopentane                       | C <sub>5</sub> H <sub>10</sub>                                              | 70.133   | 25           | 0.0157                            | 0.157                     | 3    | 19.1                                 | 13   |
| Cyclopentanol                      | C <sub>5</sub> H <sub>10</sub> O                                            | 86.132   | 19           | 10.6                              | 119                       | 88   |                                      |      |
|                                    |                                                                             |          | 50           | 8.3                               | 91                        | 88   |                                      |      |
|                                    |                                                                             |          | 90           | 9.2                               | 101                       | 88   |                                      |      |
| Cyclopentanone                     | C <sub>5</sub> H <sub>8</sub> O                                             | 84.117   | 0            | 37.7                              | 605                       | 20   |                                      |      |
|                                    |                                                                             |          | 20           | 31.0                              | 449                       | 20   |                                      |      |
|                                    |                                                                             |          | 80           | 24.8                              | 330                       | 20   |                                      |      |
| Cyclopentene                       | C <sub>5</sub> H <sub>8</sub>                                               | 68.118   | 25           | 0.054                             | 0.54                      | 3    | 6.56                                 | 13   |
| Cyclopropane                       | C <sub>3</sub> H <sub>6</sub>                                               | 42.080   | 25           | 0.0484*                           | 0.484*                    | 19   |                                      |      |
| Cyfluthrin                         | C <sub>22</sub> H <sub>18</sub> Cl <sub>2</sub> FNO <sub>3</sub>            | 434.287  | 20           | 0.0000002                         | 0.000002                  | 32   |                                      |      |
| Cygon                              | C <sub>5</sub> H <sub>12</sub> NO <sub>3</sub> PS <sub>2</sub>              | 229.258  | 20           | 2.6                               | 27                        | 40   |                                      |      |
| Cyhalothrin                        | C <sub>23</sub> H <sub>19</sub> ClF <sub>3</sub> NO <sub>3</sub>            | 449.850  | 20           | 0.0000005                         | 0.000005                  | 32   |                                      |      |
| Cypermethrin                       | C <sub>22</sub> H <sub>19</sub> Cl <sub>2</sub> NO <sub>3</sub>             | 416.297  | 20           | 0.000001                          | 0.00001                   | 32   |                                      |      |
| <i>L</i> -Cystine                  | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub> | 240.300  | 25           | 0.0166                            | 0.166                     | 62   |                                      |      |
| Cytisine                           | C <sub>11</sub> H <sub>14</sub> N <sub>2</sub> O                            | 190.241  | 16           | ≈30                               | ≈430                      | 40   |                                      |      |
| Cytosine                           | C <sub>4</sub> H <sub>5</sub> N <sub>3</sub> O                              | 111.102  | 25           | 0.73                              | 7.3                       | 29   |                                      |      |
| Daminozide                         | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>                | 160.170  | 25           | 9.1                               | 100                       | 40   |                                      |      |
| Dazomet                            | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> S <sub>2</sub>                | 162.276  | 25           | 0.12                              | 1.2                       | 40   |                                      |      |
| Decabromobiphenyl ether            | C <sub>12</sub> Br <sub>10</sub> O                                          | 959.167  | 25           | 0.0000025                         | 0.000025                  | 40   |                                      |      |
| Decachlorobiphenyl                 | C <sub>12</sub> Cl <sub>10</sub>                                            | 498.658  | 25           | 0.00000000012                     | 0.0000000012              | 7    | 0.0208                               | 7    |
| <i>cis</i> -Decahydronaphthalene   | C <sub>10</sub> H <sub>18</sub>                                             | 138.250  | 25           | 0.000089                          | 0.00089                   | 37   |                                      |      |
| <i>trans</i> -Decahydronaphthalene | C <sub>10</sub> H <sub>18</sub>                                             | 138.250  | 25           | 0.000089                          | 0.00089                   | 4    | 3                                    | 13   |
| Decane                             | C <sub>10</sub> H <sub>22</sub>                                             | 142.282  | 0            | 0.0000015                         | 0.000015                  | 4    | 479                                  | 13   |
| Decanedioic acid                   | C <sub>10</sub> H <sub>18</sub> O <sub>4</sub>                              | 202.248  | 20           | 0.10                              | 1.0                       | 40   |                                      |      |
| Decanoic acid                      | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                              | 172.265  | 20           | 0.015                             | 0.15                      | 26   |                                      |      |
| 1-Decanol                          | C <sub>10</sub> H <sub>22</sub> O                                           | 158.281  | 25           | 0.0037                            | 0.037                     | 1    |                                      |      |
| 2-Decanone                         | C <sub>10</sub> H <sub>20</sub> O                                           | 156.265  | 25           | 0.0079                            | 0.079                     | 84   |                                      |      |
| 4-Decanone                         | C <sub>10</sub> H <sub>20</sub> O                                           | 156.265  | 20           | 0.0238                            | 0.238                     | 20   |                                      |      |
|                                    |                                                                             |          | 80           | 0.0064                            | 0.064                     | 20   |                                      |      |
| 1-Decene                           | C <sub>10</sub> H <sub>20</sub>                                             | 140.266  | 25           | 0.00057                           | 0.0057                    | 4    |                                      |      |
| 2'-Deoxyadenosine                  | C <sub>10</sub> H <sub>13</sub> N <sub>5</sub> O <sub>3</sub>               | 251.242  | 25           | 0.67                              | 6.7                       | 29   |                                      |      |
| Dexamethasone                      | C <sub>22</sub> H <sub>29</sub> FO <sub>5</sub>                             | 392.460  | 25           | 0.009                             | 0.09                      | 40   |                                      |      |
| Dibenz[a,j]acridine                | C <sub>21</sub> H <sub>13</sub> N                                           | 279.335  | 25           | 0.000016                          | 0.00016                   | 6    |                                      |      |
| Dibenz[a,h]anthracene              | C <sub>22</sub> H <sub>14</sub>                                             | 278.346  | 25           | 0.00000005                        | 0.0000005                 | 42,4 |                                      |      |

| Name                                                | Mol. Form.                                                     | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>                 |                           |         | Henry Const., <i>k<sub>H</sub></i>      |      |
|-----------------------------------------------------|----------------------------------------------------------------|----------|--------------|--------------------------------------|---------------------------|---------|-----------------------------------------|------|
|                                                     |                                                                |          |              | 100 <i>w</i> <sub>2</sub><br>(mass%) | g per kg H <sub>2</sub> O | Ref.    | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Dibenz[a,j]anthracene                               | C <sub>22</sub> H <sub>14</sub>                                | 278.346  | 27           | 0.0000012                            | 0.000012                  | 42,4    |                                         |      |
| 13 <i>H</i> -Dibenzo[a,i]carbazole                  | C <sub>20</sub> H <sub>13</sub> N                              | 267.324  | 24           | 0.00000104                           | 0.0000104                 | 6       |                                         |      |
| Dibenzo[b,e][1,4]dioxin                             | C <sub>12</sub> H <sub>8</sub> O <sub>2</sub>                  | 184.191  | 25           | 0.000126                             | 0.00126                   | 68      |                                         |      |
| Dibenzofuran                                        | C <sub>12</sub> H <sub>8</sub> O                               | 168.191  | 25           | 0.000475                             | 0.00475                   | 41      | 0.011                                   | 12   |
| Dibenzothiophene                                    | C <sub>12</sub> H <sub>8</sub> S                               | 184.257  | 25           | 0.000103                             | 0.00103                   | 6       |                                         |      |
| Dibenzyl ether                                      | C <sub>14</sub> H <sub>14</sub> O                              | 198.260  | 35           | 0.0040                               | 0.040                     | 10      |                                         |      |
| <i>o</i> -Dibromobenzene                            | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>                  | 235.904  | 25           | 0.00748                              | 0.0748                    | 2       |                                         |      |
| <i>m</i> -Dibromobenzene                            | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>                  | 235.904  | 25           | 0.0064                               | 0.064                     | 2       |                                         |      |
| <i>p</i> -Dibromobenzene                            | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub>                  | 235.904  | 25           | 0.0020                               | 0.020                     | 2       |                                         |      |
| 1,4-Dibromobutane                                   | C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>                  | 215.915  | 25           | 0.035                                | 0.35                      | 35      |                                         |      |
| 1,2-Dibromo-1-chloroethane                          | C <sub>2</sub> H <sub>3</sub> Br <sub>2</sub> Cl               | 222.306  | 20           | 0.060                                | 0.60                      | 25      |                                         |      |
| 1,2-Dibromo-3-chloropropane                         | C <sub>3</sub> H <sub>5</sub> Br <sub>2</sub> Cl               | 236.333  | 20           | 0.123                                | 1.23                      | 35      |                                         |      |
| 1,2-Dibromo-1,2-dichloroethane                      | C <sub>2</sub> H <sub>2</sub> Br <sub>2</sub> Cl <sub>2</sub>  | 256.751  | 20           | 0.070                                | 0.70                      | 25      |                                         |      |
| 1,2-Dibromoethane                                   | C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>                  | 187.861  | 20           | 0.412                                | 4.14                      | 20      |                                         |      |
|                                                     |                                                                |          | 50           | 0.493                                | 4.95                      | 20      | 0.066                                   | 13   |
|                                                     |                                                                |          | 80           | 0.572                                | 5.75                      | 20      |                                         |      |
| 1,2-Dibromo-1,1,2,3,3,3-hexafluoropropane           | C <sub>3</sub> BrF <sub>6</sub>                                | 309.830  | 21           | 0.0068                               | 0.068                     | 35      |                                         |      |
| 3,5-Dibromo-4-hydroxybenzonitrile                   | C <sub>7</sub> H <sub>3</sub> Br <sub>2</sub> NO               | 276.913  | 25           | 0.013                                | 0.13                      | 40      |                                         |      |
| Dibromomethane                                      | CH <sub>2</sub> Br <sub>2</sub>                                | 173.835  | 20           | 1.28                                 | 13.0                      | 20      | 0.086                                   | 13   |
|                                                     |                                                                |          | 90           | 1.51                                 | 15.3                      | 20      |                                         |      |
| 2,4-Dibromophenol                                   | C <sub>6</sub> H <sub>4</sub> Br <sub>2</sub> O                | 251.903  | 25           | 0.2                                  | 2                         | 2       |                                         |      |
| 1,2-Dibromopropane                                  | C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>                  | 201.888  | 25           | 0.143                                | 1.43                      | 10      |                                         |      |
| 1,3-Dibromopropane                                  | C <sub>3</sub> H <sub>6</sub> Br <sub>2</sub>                  | 201.888  | 25           | 0.169                                | 1.69                      | 35      |                                         |      |
| 1,2-Dibromotetrafluoroethane                        | C <sub>2</sub> Br <sub>2</sub> F <sub>4</sub>                  | 259.823  | 25           | 0.00030                              | 0.0030                    | 25      |                                         |      |
| Dibutylamine                                        | C <sub>8</sub> H <sub>19</sub> N                               | 129.244  | 20           | 0.47                                 | 4.7                       | 10      |                                         |      |
| Dibutyl ether                                       | C <sub>8</sub> H <sub>18</sub> O                               | 130.228  | 0            | 0.040                                | 0.40                      | 20      | 0.48                                    | 13   |
|                                                     |                                                                |          | 20           | 0.023                                | 0.23                      | 20      | 0.48                                    | 13   |
|                                                     |                                                                |          | 90           | 0.010                                | 0.10                      | 20      |                                         |      |
| Dibutyl phthalate                                   | C <sub>16</sub> H <sub>22</sub> O <sub>4</sub>                 | 278.344  | 25           | 0.00112                              | 0.0112                    | 15      |                                         |      |
| Dibutyl sebacate                                    | C <sub>18</sub> H <sub>34</sub> O <sub>4</sub>                 | 314.461  | 20           | 0.004                                | 0.04                      | 10      |                                         |      |
| <i>o</i> -Dichlorobenzene                           | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                  | 147.002  | 5            | 0.012                                | 0.12                      | 61,58,2 |                                         |      |
|                                                     |                                                                |          | 25           | 0.015                                | 0.15                      | 61,58,2 |                                         |      |
|                                                     |                                                                |          | 45           | 0.020                                | 0.20                      | 61,58,2 |                                         |      |
| <i>m</i> -Dichlorobenzene                           | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                  | 147.002  | 10           | 0.0103                               | 0.103                     | 41,2    |                                         |      |
|                                                     |                                                                |          | 25           | 0.0120                               | 0.120                     | 41,2    | 0.376                                   | 11   |
|                                                     |                                                                |          | 45           | 0.0141                               | 0.141                     | 61,2    |                                         |      |
| <i>p</i> -Dichlorobenzene                           | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                  | 147.002  | 10           | 0.00512                              | 0.0512                    | 2       |                                         |      |
|                                                     |                                                                |          | 25           | 0.0080                               | 0.080                     | 41      | 0.244                                   | 28   |
|                                                     |                                                                |          | 50           | 0.0167                               | 0.167                     | 2       |                                         |      |
| 3,5-Dichloro-1,2-benzenediol                        | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>   | 179.001  | 25           | 0.78                                 | 7.8                       | 8       |                                         |      |
| 4,5-Dichloro-1,2-benzenediol                        | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>   | 179.001  | 25           | 1.19                                 | 12.0                      | 8       |                                         |      |
| 3,3'-Dichloro- <i>p</i> -benzidine                  | C <sub>12</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> | 253.126  | 25           | 0.00031                              | 0.0031                    | 40      |                                         |      |
| 2,5-Dichlorobiphenyl                                | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub>                 | 223.098  | 25           | 0.0002                               | 0.002                     | 7       | 0.0201                                  | 7    |
| 2,6-Dichlorobiphenyl                                | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub>                 | 223.098  | 25           | 0.00014                              | 0.0014                    | 7       |                                         |      |
| 1,1-Dichloro-2,2-bis( <i>p</i> -chlorophenyl)ethane | C <sub>14</sub> H <sub>10</sub> Cl <sub>4</sub>                | 320.041  | 25           | 0.000009                             | 0.00009                   | 40      |                                         |      |
|                                                     |                                                                |          | 45           | 0.000024                             | 0.00024                   | 40      |                                         |      |
| 1,1-Dichlorobutane                                  | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 127.013  | 25           | 0.050                                | 0.50                      | 35      |                                         |      |
| 1,4-Dichlorobutane                                  | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 127.013  | 25           | 0.16                                 | 1.6                       | 35      |                                         |      |
| 2,3-Dichlorobutane                                  | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                  | 127.013  | 20           | 0.056                                | 0.56                      | 35      |                                         |      |

| Name                                       | Mol. Form.                                                                  | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>                 |                           |          | Henry Const., <i>k<sub>H</sub></i>      |      |
|--------------------------------------------|-----------------------------------------------------------------------------|----------|--------------|--------------------------------------|---------------------------|----------|-----------------------------------------|------|
|                                            |                                                                             |          |              | 100 <i>w</i> <sub>2</sub><br>(mass%) | g per kg H <sub>2</sub> O | Ref.     | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 2,7-Dichlorodibenzo- <i>p</i> -dioxin      | C <sub>12</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>2</sub>               | 253.081  | 25           | 0.00000041                           | 0.0000041                 | 68       |                                         |      |
| 1,2-Dichloro-1,1-difluoroethane            | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>                | 134.940  | 24           | 0.49                                 | 4.9                       | 25       |                                         |      |
| Dichlorodifluoromethane                    | CCl <sub>2</sub> F <sub>2</sub>                                             | 120.914  | 20           | 0.028*                               | 0.28*                     | 5        | 41                                      | 13   |
| 1,3-Dichloro-5,5-dimethyl hydantoin        | C <sub>5</sub> H <sub>6</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 197.019  | 20           | 0.050                                | 0.50                      | 40       |                                         |      |
| 1,1-Dichloroethane                         | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 98.959   | 0            | 0.62                                 | 6.2                       | 25       |                                         |      |
|                                            |                                                                             |          | 25           | 0.50                                 | 5.0                       | 25       | 0.63                                    | 13   |
|                                            |                                                                             |          | 50           | 0.50                                 | 5.0                       | 25       |                                         |      |
| 1,2-Dichloroethane                         | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 98.959   | 0            | 0.92                                 | 9.2                       | 25       |                                         |      |
|                                            |                                                                             |          | 25           | 0.86                                 | 8.6                       | 25       | 0.14                                    | 13   |
|                                            |                                                                             |          | 50           | 1.05                                 | 10.6                      | 25       |                                         |      |
|                                            |                                                                             |          | 100          | 2.17                                 | 22.2                      | 25       |                                         |      |
| 1,1-Dichloroethene                         | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                               | 96.943   | 5            | 0.310                                | 3.10                      | 25       |                                         |      |
|                                            |                                                                             |          | 25           | 0.242                                | 2.42                      | 25       | 2.62                                    | 13   |
|                                            |                                                                             |          | 50           | 0.225                                | 2.25                      | 25       |                                         |      |
|                                            |                                                                             |          | 90           | 0.355                                | 3.55                      | 25       |                                         |      |
| <i>cis</i> -1,2-Dichloroethene             | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                               | 96.943   | 10           | 0.76                                 | 7.6                       | 25       |                                         |      |
|                                            |                                                                             |          | 25           | 0.64                                 | 6.4                       | 25       | 0.46                                    | 13   |
|                                            |                                                                             |          | 40           | 0.66                                 | 6.6                       | 25       |                                         |      |
| <i>trans</i> -1,2-Dichloroethene           | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                               | 96.943   | 10           | 0.53                                 | 5.3                       | 25       |                                         |      |
|                                            |                                                                             |          | 25           | 0.45                                 | 4.5                       | 25       | 0.96                                    | 13   |
|                                            |                                                                             |          | 40           | 0.41                                 | 4.1                       | 25       |                                         |      |
| 1,1-Dichloro-1-fluoroethane                | C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> F                             | 116.949  | 25           | 0.042                                | 0.42                      | 25       |                                         |      |
| Dichlorofluoromethane                      | CHCl <sub>2</sub> F                                                         | 102.923  | 25           | 0.95*                                | 9.5*                      | 10       |                                         |      |
| 1,2-Dichloro-1,1,2,3,3,3-hexafluoropropane | C <sub>3</sub> ClF <sub>6</sub>                                             | 220.928  | 21           | 0.0096                               | 0.096                     | 35       |                                         |      |
| 1,4-Dichloro-5-isopropyl-2-methylbenzene   | C <sub>10</sub> H <sub>12</sub> Cl <sub>2</sub>                             | 203.108  | 25           | 0.00049                              | 0.0049                    | 23       |                                         |      |
| Dichloromethane                            | CH <sub>2</sub> Cl <sub>2</sub>                                             | 84.933   | 25           | 1.73                                 | 17.6                      | 20       | 0.30                                    | 13   |
| 3,6-Dichloro-2-methoxybenzoic acid         | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>3</sub>                | 221.038  | 25           | 0.45                                 | 4.5                       | 40       |                                         |      |
| (Dichloromethyl)benzene                    | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 161.029  | 30           | 0.025                                | 0.25                      | 10       |                                         |      |
| 2,3-Dichloro-2-methylbutane                | C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 141.038  | 25           | 0.029                                | 0.29                      | 35       |                                         |      |
| 2,4-Dichloro-6-methylphenol                | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                             | 177.028  | 25           | 0.0283                               | 0.283                     | 2        |                                         |      |
| 2,6-Dichloro-4-methylphenol                | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub> O                             | 177.028  | 25           | 0.0673                               | 0.673                     | 2        |                                         |      |
| 2,3-Dichloro-1,4-naphthalenedione          | C <sub>10</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>               | 227.044  | 25           | 0.00001                              | 0.0001                    | 40       |                                         |      |
| 1,2-Dichloro-4-nitrobenzene                | C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 192.000  | 20           | 0.0121                               | 0.121                     | 40       |                                         |      |
| 1,2-Dichloropentane                        | C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 141.038  | 25           | 0.029                                | 0.29                      | 35       |                                         |      |
| 1,5-Dichloropentane                        | C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 141.038  | 19           | 0.02                                 | 0.2                       | 35       |                                         |      |
| 2,3-Dichloropentane                        | C <sub>5</sub> H <sub>10</sub> Cl <sub>2</sub>                              | 141.038  | 25           | 0.029                                | 0.29                      | 35       |                                         |      |
| Dichlorophene                              | C <sub>13</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>2</sub>              | 269.123  | 25           | 0.003                                | 0.03                      | 40       |                                         |      |
| 2,3-Dichlorophenol                         | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 163.001  | 25           | 0.82                                 | 8.3                       | 40       |                                         |      |
| 2,4-Dichlorophenol                         | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 163.001  | 25           | 0.55                                 | 5.5                       | 48,51,24 |                                         |      |
| 2,6-Dichlorophenol                         | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O                             | 163.001  | 25           | 0.262                                | 2.62                      | 40       |                                         |      |
| (2,4-Dichlorophenoxy)acetic acid           | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>3</sub>                | 221.038  | 25           | 0.07                                 | 0.7                       | 40       |                                         |      |
| 4-(2,4-Dichlorophenoxy)butanoic acid       | C <sub>10</sub> H <sub>10</sub> Cl <sub>2</sub> O <sub>3</sub>              | 249.090  | 25           | 0.0046                               | 0.046                     | 40       |                                         |      |
| 2-(2,4-Dichlorophenoxy)propanoic acid      | C <sub>9</sub> H <sub>8</sub> Cl <sub>2</sub> O <sub>3</sub>                | 235.064  | 25           | 0.083                                | 0.83                      | 40       |                                         |      |
| 1,2-Dichloropropane                        | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 112.986  | 5            | 0.270                                | 2.70                      | 35       |                                         |      |
|                                            |                                                                             |          | 25           | 0.274                                | 2.74                      | 35       | 0.29                                    | 13   |
|                                            |                                                                             |          | 40           | 0.297                                | 2.97                      | 35       |                                         |      |
| 1,3-Dichloropropane                        | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 112.986  | 5            | 0.218                                | 2.18                      | 35       |                                         |      |
|                                            |                                                                             |          | 25           | 0.280                                | 2.80                      | 35       |                                         |      |
| <i>cis</i> -1,3-Dichloropropene            | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 110.970  | 20           | 0.27                                 | 2.7                       | 5        | 0.24                                    | 5    |

| Name                                                      | Mol. Form.                                                                    | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>                 |                           |      | Henry Const., <i>k<sub>H</sub></i>      |      |
|-----------------------------------------------------------|-------------------------------------------------------------------------------|----------|--------------|--------------------------------------|---------------------------|------|-----------------------------------------|------|
|                                                           |                                                                               |          |              | 100 <i>w</i> <sub>2</sub><br>(mass%) | g per kg H <sub>2</sub> O | Ref. | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| <i>trans</i> -1,3-Dichloropropene                         | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                                 | 110.970  | 20           | 0.28                                 | 2.8                       | 5    | 0.18                                    | 5    |
| 2,3-Dichloropropene                                       | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                                 | 110.970  | 25           | 0.215                                | 2.15                      | 5    | 0.36                                    | 5    |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane                    | C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>                                 | 170.921  | 25           | 0.013*                               | 0.13*                     | 10   | 127                                     | 13   |
| 2,4-Dichlorotoluene                                       | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                                 | 161.029  | 25           | 0.00260                              | 0.0260                    | 61   |                                         |      |
| 2,6-Dichlorotoluene                                       | C <sub>7</sub> H <sub>6</sub> Cl <sub>2</sub>                                 | 161.029  | 25           | 0.00233                              | 0.0233                    | 61   |                                         |      |
| 2,2-Dichloro-1,1,1-trifluoroethane                        | C <sub>2</sub> HCl <sub>2</sub> F <sub>3</sub>                                | 152.930  | 25           | 0.46                                 | 4.6                       | 25   |                                         |      |
| Diclofop-methyl                                           | C <sub>16</sub> H <sub>14</sub> Cl <sub>2</sub> O <sub>4</sub>                | 341.186  | 20           | 0.0003                               | 0.003                     | 32   |                                         |      |
| Dieldrin                                                  | C <sub>12</sub> H <sub>8</sub> Cl <sub>6</sub> O                              | 380.909  | 25           | 0.000020                             | 0.00020                   | 67   |                                         |      |
| Diethanolamine                                            | C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>                                | 105.136  | 20           | 95.4                                 | 20700                     | 10   |                                         |      |
| 1,1-Diethoxyethane                                        | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                                 | 118.174  | 25           | 5                                    | 53                        | 10   |                                         |      |
| 1,2-Diethoxyethane                                        | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                                 | 118.174  | 20           | 21.0                                 | 266                       | 10   |                                         |      |
| 2-(Diethylamino)- <i>N</i> -(2,6-dimethylphenyl)acetamide | C <sub>14</sub> H <sub>22</sub> N <sub>2</sub> O                              | 234.337  | 25           | 0.38                                 | 3.8                       | 40   |                                         |      |
| <i>o</i> -Diethylbenzene                                  | C <sub>10</sub> H <sub>14</sub>                                               | 134.218  | 20           | 0.0071                               | 0.071                     | 40   |                                         |      |
| <i>p</i> -Diethylbenzene                                  | C <sub>10</sub> H <sub>14</sub>                                               | 134.218  | 20           | 0.0025                               | 0.025                     | 40   |                                         |      |
| Diethyl carbonate                                         | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>                                 | 118.131  | 20           | 1.8                                  | 18                        | 40   |                                         |      |
| Diethyl ether                                             | C <sub>4</sub> H <sub>10</sub> O                                              | 74.121   | 0            | 12.5                                 | 143                       | 79   | 0.088                                   | 13   |
|                                                           |                                                                               |          | 25           | 5.9                                  | 63                        | 79   | 0.088                                   | 13   |
|                                                           |                                                                               |          | 38           | 4.6                                  | 48                        | 79   | 0.088                                   | 13   |
|                                                           |                                                                               |          | 82           | 3.1                                  | 32                        | 79   | 0.088                                   | 13   |
| Diethyl glutarate                                         | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                                 | 188.221  | 30           | 1.20                                 | 12.1                      | 20   |                                         |      |
|                                                           |                                                                               |          | 91           | 0.91                                 | 9.2                       | 20   |                                         |      |
| Diethyl maleate                                           | C <sub>8</sub> H <sub>12</sub> O <sub>4</sub>                                 | 172.179  | 20           | 1.56                                 | 15.8                      | 20   |                                         |      |
|                                                           |                                                                               |          | 91           | 1.75                                 | 17.8                      | 20   |                                         |      |
| Diethyl malonate                                          | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                                 | 160.168  | 20           | 2.26                                 | 23.1                      | 20   |                                         |      |
|                                                           |                                                                               |          | 91           | 2.47                                 | 25.3                      | 20   |                                         |      |
| Diethyl phthalate                                         | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                                | 222.237  | 25           | 0.12                                 | 1.2                       | 40   |                                         |      |
| <i>trans</i> -Diethylstilbestrol                          | C <sub>18</sub> H <sub>20</sub> O <sub>2</sub>                                | 268.351  | 20           | 0.01                                 | 0.1                       | 40   |                                         |      |
| Diethyl succinate                                         | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                                 | 174.195  | 20           | 0.19                                 | 1.9                       | 40   |                                         |      |
| Diethyl sulfide                                           | C <sub>4</sub> H <sub>10</sub> S                                              | 90.187   | 25           | 0.307                                | 3.07                      | 40   |                                         |      |
| Diflubenzuron                                             | C <sub>14</sub> H <sub>9</sub> ClF <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 310.683  | 20           | 0.00002                              | 0.0002                    | 40   |                                         |      |
| <i>o</i> -Difluorobenzene                                 | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                                  | 114.093  | 25           | 0.114                                | 1.14                      | 2    |                                         |      |
| <i>m</i> -Difluorobenzene                                 | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                                  | 114.093  | 25           | 0.114                                | 1.14                      | 2    |                                         |      |
| <i>p</i> -Difluorobenzene                                 | C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                                  | 114.093  | 25           | 0.122                                | 1.22                      | 2    |                                         |      |
| 1,1-Difluoroethane                                        | C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>                                  | 66.050   | 20           | 0.29*                                | 2.9*                      | 50   |                                         |      |
| Digitoxin                                                 | C <sub>41</sub> H <sub>64</sub> O <sub>13</sub>                               | 764.939  | 25           | 0.0004                               | 0.004                     | 40   |                                         |      |
| Diglycolic acid                                           | C <sub>4</sub> H <sub>6</sub> O <sub>5</sub>                                  | 134.088  | 24           | 40.0                                 | 667                       | 34   |                                         |      |
|                                                           |                                                                               |          | 50           | 59.9                                 | 1490                      | 34   |                                         |      |
| Digoxin                                                   | C <sub>41</sub> H <sub>64</sub> O <sub>14</sub>                               | 780.939  | 25           | 0.0059                               | 0.059                     | 40   |                                         |      |
| Dihexyl ether                                             | C <sub>12</sub> H <sub>26</sub> O                                             | 186.333  | 20           | 0.019                                | 0.19                      | 20   |                                         |      |
|                                                           |                                                                               |          | 90           | 0.019                                | 0.19                      | 20   |                                         |      |
| 1,2-Dihydrobenz[j]aceanthrylene                           | C <sub>20</sub> H <sub>14</sub>                                               | 254.325  | 27           | 0.00000035                           | 0.0000035                 | 42,6 |                                         |      |
| 1,3-Dihydro-2 <i>H</i> -benzimidazol-2-one                | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O                                | 134.135  | 24           | 0.37                                 | 3.7                       | 54   |                                         |      |
| 1,2-Dihydro-3-methylbenz[j]aceanthrylene                  | C <sub>21</sub> H <sub>16</sub>                                               | 268.352  | 25           | 0.00000022                           | 0.0000022                 | 42,6 |                                         |      |
|                                                           |                                                                               |          | 27           | 0.00000028                           | 0.0000028                 | 42   |                                         |      |
| 2,3-Dihydro-6-propyl-2-thioxo-4(1 <i>H</i> )-pyrimidinone | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub> OS                              | 170.231  | 25           | 0.120                                | 1.20                      | 40   |                                         |      |
| 1,7-Dihydro-6 <i>H</i> -purine-6-thione                   | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> S                                | 152.178  | 25           | 0.0124                               | 0.124                     | 40   |                                         |      |
| 3,4-Dihydro-2 <i>H</i> -pyran                             | C <sub>5</sub> H <sub>8</sub> O                                               | 84.117   | 20           | 1.04                                 | 10.5                      | 20   |                                         |      |
|                                                           |                                                                               |          | 82           | 2.26                                 | 23.1                      | 20   |                                         |      |

| Name                                           | Mol. Form.                                                    | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |      | Henry Const., <i>k<sub>H</sub></i>   |      |
|------------------------------------------------|---------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|------|--------------------------------------|------|
|                                                |                                                               |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref. | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 1,4-Dihydroxy-9,10-anthracenedione             | C <sub>14</sub> H <sub>8</sub> O <sub>4</sub>                 | 240.212  | 25           | 0.0000096                         | 0.000096                  | 40   |                                      |      |
| 3,4-Dihydroxybenzoic acid                      | C <sub>7</sub> H <sub>6</sub> O <sub>4</sub>                  | 154.121  | 14           | 1.8                               | 18                        | 26   |                                      |      |
|                                                |                                                               |          | 80           | 21.3                              | 271                       | 26   |                                      |      |
| 3,12-Dihydroxycholan-24-oic acid, (3α,5β,12α)  | C <sub>24</sub> H <sub>40</sub> O <sub>4</sub>                | 392.573  | 20           | 0.001                             | 0.01                      | 40   |                                      |      |
| 17,21-Dihydroxypregna-1,4-diene-3,11,20-trione | C <sub>21</sub> H <sub>26</sub> O <sub>5</sub>                | 358.428  | 25           | 0.012                             | 0.12                      | 40   |                                      |      |
| 17,21-Dihydroxypregn-4-ene-3,11,20-trione      | C <sub>21</sub> H <sub>28</sub> O <sub>5</sub>                | 360.444  | 25           | 0.028                             | 0.28                      | 30   |                                      |      |
| <i>o</i> -Diiodobenzene                        | C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                  | 329.905  | 25           | 0.00192                           | 0.0192                    | 2    |                                      |      |
| <i>m</i> -Diiodobenzene                        | C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                  | 329.905  | 25           | 0.000185                          | 0.00185                   | 2    |                                      |      |
| <i>p</i> -Diiodobenzene                        | C <sub>6</sub> H <sub>4</sub> I <sub>2</sub>                  | 329.905  | 25           | 0.000893                          | 0.00893                   | 2    |                                      |      |
| <i>cis</i> -1,2-Diiodoethene                   | C <sub>2</sub> H <sub>2</sub> I <sub>2</sub>                  | 279.846  | 25           | 0.046                             | 0.46                      | 25   |                                      |      |
| <i>trans</i> -1,2-Diiodoethene                 | C <sub>2</sub> H <sub>2</sub> I <sub>2</sub>                  | 279.846  | 25           | 0.015                             | 0.15                      | 25   |                                      |      |
| Diiodomethane                                  | CH <sub>2</sub> I <sub>2</sub>                                | 267.836  | 30           | 0.124                             | 1.24                      | 10   | 0.032                                | 13   |
| 3,5-Diiodo- <i>L</i> -tyrosine                 | C <sub>9</sub> H <sub>9</sub> I <sub>2</sub> NO <sub>3</sub>  | 432.981  | 25           | 0.062                             | 0.62                      | 26   |                                      |      |
| Diisopentyl ether                              | C <sub>10</sub> H <sub>22</sub> O                             | 158.281  | 20           | 0.02                              | 0.2                       | 10   |                                      |      |
| Diisopropyl ether                              | C <sub>6</sub> H <sub>14</sub> O                              | 102.174  | 20           | 0.79                              | 8.0                       | 20   | 0.26                                 | 13   |
|                                                |                                                               |          | 61           | 0.22                              | 2.2                       | 20   |                                      |      |
| 1,2-Dimethoxybenzene                           | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                 | 138.164  | 20           | 0.716                             | 7.21                      | 20   |                                      |      |
|                                                |                                                               |          | 92           | 1.073                             | 10.85*                    | 20   |                                      |      |
| 3,3'-Dimethoxybenzidine                        | C <sub>14</sub> H <sub>16</sub> N <sub>2</sub> O <sub>2</sub> | 244.289  | 25           | 0.006                             | 0.06                      | 40   |                                      |      |
| Dimethoxymethane                               | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                  | 76.095   | 16           | 24.4                              | 323                       | 10   |                                      |      |
| 4-(Dimethylamino)azobenzene                    | C <sub>14</sub> H <sub>15</sub> N <sub>3</sub>                | 225.289  | 20           | 0.00014                           | 0.0014                    | 40   |                                      |      |
| 2',3-Dimethyl-4-aminoazobenzene                | C <sub>14</sub> H <sub>15</sub> N <sub>3</sub>                | 225.289  | 37           | 0.0007                            | 0.007                     | 40   |                                      |      |
| 2,5-Dimethylaniline                            | C <sub>8</sub> H <sub>11</sub> N                              | 121.180  | 20           | 0.66                              | 6.6                       | 27   |                                      |      |
| <i>N,N</i> -Dimethylaniline                    | C <sub>8</sub> H <sub>11</sub> N                              | 121.180  | 25           | 0.111                             | 1.11                      | 40   |                                      |      |
| 9,10-Dimethylantracene                         | C <sub>16</sub> H <sub>14</sub>                               | 206.282  | 25           | 0.0000056                         | 0.000056                  | 42,4 |                                      |      |
| Dimethylarsinic acid                           | C <sub>2</sub> H <sub>7</sub> AsO <sub>2</sub>                | 137.998  | 25           | ≈41                               | ≈700                      | 40   |                                      |      |
| 7,12-Dimethylbenz[a]anthracene                 | C <sub>20</sub> H <sub>16</sub>                               | 256.341  | 25           | 0.0000061                         | 0.000061                  | 42   |                                      |      |
| 2,2-Dimethylbutane                             | C <sub>6</sub> H <sub>14</sub>                                | 86.175   | 25           | 0.0021                            | 0.021                     | 3    | 199                                  | 13   |
| 2,3-Dimethylbutane                             | C <sub>6</sub> H <sub>14</sub>                                | 86.175   | 25           | 0.0021                            | 0.021                     | 3    | 144                                  | 13   |
| 2,2-Dimethyl-1-butanol                         | C <sub>6</sub> H <sub>14</sub> O                              | 102.174  | 25           | 0.78                              | 7.9                       | 78,1 |                                      |      |
| 2,3-Dimethyl-2-butanol                         | C <sub>6</sub> H <sub>14</sub> O                              | 102.174  | 25           | 4.2                               | 44                        | 1    |                                      |      |
| 3,3-Dimethyl-2-butanol                         | C <sub>6</sub> H <sub>14</sub> O                              | 102.174  | 25           | 2.4                               | 25                        | 1    |                                      |      |
| 3,3-Dimethyl-2-butanone                        | C <sub>6</sub> H <sub>12</sub> O                              | 100.158  | 0            | 2.92                              | 30.1                      | 83   |                                      |      |
|                                                |                                                               |          | 19           | 1.97                              | 20.1                      | 20   |                                      |      |
|                                                |                                                               |          | 25           | 1.85                              | 18.8                      | 83   |                                      |      |
|                                                |                                                               |          | 50           | 1.46                              | 14.8                      | 83   |                                      |      |
|                                                |                                                               |          | 90           | 1.14                              | 11.5                      | 20   |                                      |      |
| 2,3-Dimethyl-1-butene                          | C <sub>6</sub> H <sub>12</sub>                                | 84.159   | 30           | 0.046                             | 0.46                      | 3    |                                      |      |
| <i>cis</i> -1,2-Dimethylcyclohexane            | C <sub>8</sub> H <sub>16</sub>                                | 112.213  | 25           | 0.00060                           | 0.0060                    | 4    | 36                                   | 5    |
| <i>trans</i> -1,2-Dimethylcyclohexane          | C <sub>8</sub> H <sub>16</sub>                                | 112.213  | 30           | 0.00050                           | 0.0050                    | 57,4 | 88.2                                 | 5    |
|                                                |                                                               |          | 100          | 0.00293                           | 0.0293                    | 57,4 |                                      |      |
| Dimethyl ether                                 | C <sub>2</sub> H <sub>6</sub> O                               | 46.068   | 25           | 35.3*                             | 546                       | 79   |                                      |      |
|                                                |                                                               |          | 50           | 29.2*                             | 412                       | 79   |                                      |      |
| Dimethylglyoxime                               | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>   | 116.119  | 20           | 0.06                              | 0.6                       | 40   |                                      |      |
| 3,5-Dimethyl-4-heptanol                        | C <sub>9</sub> H <sub>20</sub> O                              | 144.254  | 15           | 0.072                             | 0.72                      | 1    |                                      |      |
| 2,6-Dimethyl-4-heptanone                       | C <sub>9</sub> H <sub>18</sub> O                              | 142.238  | 21           | 0.045                             | 0.45                      | 20   |                                      |      |
|                                                |                                                               |          | 91           | 0.037                             | 0.37                      | 20   |                                      |      |
| 1,2-Dimethyl-1 <i>H</i> -imidazole             | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub>                  | 96.131   | 19           | 94.3                              | 16500                     | 54   |                                      |      |
| Dimethyl maleate                               | C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>                  | 144.126  | 25           | 8.0                               | 87                        | 10   |                                      |      |



| Name                                                             | Mol. Form.                                                      | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|------------------------------------------------------------------|-----------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                                                                  |                                                                 |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Dimethyl malonate                                                | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                    | 132.116  | 19           | 14.9                              | 175                       | 20    |                                      |      |
|                                                                  |                                                                 |          | 90           | 29.8                              | 425                       | 20    |                                      |      |
| 1,3-Dimethylnaphthalene                                          | C <sub>12</sub> H <sub>12</sub>                                 | 156.223  | 25           | 0.0008                            | 0.008                     | 4     |                                      |      |
| 1,4-Dimethylnaphthalene                                          | C <sub>12</sub> H <sub>12</sub>                                 | 156.223  | 25           | 0.00114                           | 0.0114                    | 4     |                                      |      |
| 1,5-Dimethylnaphthalene                                          | C <sub>12</sub> H <sub>12</sub>                                 | 156.223  | 25           | 0.00031                           | 0.0031                    | 4     | 0.036                                | 28   |
| 2,3-Dimethylnaphthalene                                          | C <sub>12</sub> H <sub>12</sub>                                 | 156.223  | 25           | 0.00025                           | 0.0025                    | 4     |                                      |      |
| 2,6-Dimethylnaphthalene                                          | C <sub>12</sub> H <sub>12</sub>                                 | 156.223  | 25           | 0.00017                           | 0.0017                    | 4     |                                      |      |
| Dimethyl oxalate                                                 | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                    | 118.089  | 20           | 5.82                              | 61.8                      | 27    |                                      |      |
| 2,2-Dimethylpentane                                              | C <sub>7</sub> H <sub>16</sub>                                  | 100.202  | 25           | 0.00044                           | 0.0044                    | 3     | 318                                  | 5    |
| 2,3-Dimethylpentane                                              | C <sub>7</sub> H <sub>16</sub>                                  | 100.202  | 25           | 0.00052                           | 0.0052                    | 3     | 175                                  | 5    |
| 2,4-Dimethylpentane                                              | C <sub>7</sub> H <sub>16</sub>                                  | 100.202  | 25           | 0.00042                           | 0.0042                    | 3     | 323                                  | 13   |
| 3,3-Dimethylpentane                                              | C <sub>7</sub> H <sub>16</sub>                                  | 100.202  | 25           | 0.00059                           | 0.0059                    | 3     | 186                                  | 5    |
| 2,3-Dimethyl-2-pentanol                                          | C <sub>7</sub> H <sub>16</sub> O                                | 116.201  | 25           | 1.5                               | 15                        | 1     |                                      |      |
| 2,4-Dimethyl-2-pentanol                                          | C <sub>7</sub> H <sub>16</sub> O                                | 116.201  | 25           | 1.3                               | 13                        | 1     |                                      |      |
| 2,2-Dimethyl-3-pentanol                                          | C <sub>7</sub> H <sub>16</sub> O                                | 116.201  | 25           | 0.82                              | 8.2                       | 1     |                                      |      |
| 2,3-Dimethyl-3-pentanol                                          | C <sub>7</sub> H <sub>16</sub> O                                | 116.201  | 25           | 1.6                               | 16                        | 1     |                                      |      |
| 2,4-Dimethyl-3-pentanol                                          | C <sub>7</sub> H <sub>16</sub> O                                | 116.201  | 25           | 0.70                              | 7.0                       | 1     |                                      |      |
| 2,4-Dimethyl-3-pentanone                                         | C <sub>7</sub> H <sub>14</sub> O                                | 114.185  | 20           | 0.52                              | 5.2                       | 20    |                                      |      |
|                                                                  |                                                                 |          | 90           | 0.30                              | 3.0                       | 20    |                                      |      |
| <i>N,N</i> -Dimethyl- <i>N'</i> -phenylurea                      | C <sub>9</sub> H <sub>12</sub> N <sub>2</sub> O                 | 164.203  | 25           | 0.32                              | 3.2                       | 40    |                                      |      |
| Dimethyl phthalate                                               | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                  | 194.184  | 25           | 0.40                              | 4.0                       | 15    |                                      |      |
| 2,2-Dimethyl-1-propanol                                          | C <sub>5</sub> H <sub>12</sub> O                                | 88.148   | 12           | 3.87                              | 40.3                      | 78,1  |                                      |      |
|                                                                  |                                                                 |          | 25           | 3.26                              | 33.7                      | 78,1  |                                      |      |
|                                                                  |                                                                 |          | 80           | 2.84                              | 29.2                      | 78,1  |                                      |      |
| 4-(1,1-Dimethylpropyl)phenol                                     | C <sub>11</sub> H <sub>16</sub> O                               | 164.244  | 25           | 0.017                             | 0.17                      | 40    |                                      |      |
| Dimethyl succinate                                               | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                   | 146.141  | 21           | 12.4                              | 142                       | 20    |                                      |      |
|                                                                  |                                                                 |          | 92           | 17.1                              | 206                       | 20    |                                      |      |
| Dimethyl sulfate                                                 | C <sub>2</sub> H <sub>6</sub> O <sub>4</sub> S                  | 126.132  | 18           | 2.7                               | 28                        | 27    |                                      |      |
| Dimethyl sulfide                                                 | C <sub>2</sub> H <sub>6</sub> S                                 | 62.134   | 25           | 2                                 | 20                        | 10    |                                      |      |
| Dimethyl sulfoxide                                               | C <sub>2</sub> H <sub>6</sub> OS                                | 78.133   | 25           | 25.3                              | 339                       | 10    |                                      |      |
| Dimethyl terephthalate                                           | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                  | 194.184  | 25           | 0.00328                           | 0.0328                    | 40    |                                      |      |
| Dimethyl tetrachloroterephthalate                                | C <sub>10</sub> H <sub>6</sub> Cl <sub>4</sub> O <sub>4</sub>   | 331.965  | 25           | 0.00005                           | 0.0005                    | 40    |                                      |      |
| <i>N,N</i> -Dimethyl- <i>N'</i> -[3-(trifluoromethyl)phenyl]urea | C <sub>10</sub> H <sub>11</sub> F <sub>3</sub> N <sub>2</sub> O | 232.201  | 20           | 0.0105                            | 0.105                     | 40    |                                      |      |
| 2,4-Dinitroaniline                                               | C <sub>6</sub> H <sub>5</sub> N <sub>3</sub> O <sub>4</sub>     | 183.122  | 25           | 0.0078                            | 0.078                     | 40    |                                      |      |
| 1,2-Dinitrobenzene                                               | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>     | 168.107  | 20           | 0.21                              | 2.1                       | 27    |                                      |      |
| 1,3-Dinitrobenzene                                               | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>     | 168.107  | 20           | 2.09                              | 21.3                      | 27    |                                      |      |
| 1,4-Dinitrobenzene                                               | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>     | 168.107  | 20           | 1.30                              | 13.2                      | 27    |                                      |      |
| 3,5-Dinitrobenzoic acid                                          | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>     | 212.116  | 25           | 0.134                             | 1.34                      | 27    |                                      |      |
| 2,4-Dinitrophenol                                                | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>5</sub>     | 184.106  | 25           | 0.069                             | 0.69                      | 48,51 |                                      |      |
|                                                                  |                                                                 |          | 35           | 0.098                             | 0.98                      | 48,51 |                                      |      |
| Dipentyl ether                                                   | C <sub>10</sub> H <sub>22</sub> O                               | 158.281  | 25           | 0.11                              | 1.1                       | 81    |                                      |      |
| Diphenamid                                                       | C <sub>16</sub> H <sub>17</sub> NO                              | 239.312  | 27           | 0.026                             | 0.26                      | 32    |                                      |      |
| Diphenylamine                                                    | C <sub>12</sub> H <sub>11</sub> N                               | 169.222  | 20           | 0.0055                            | 0.055                     | 40    |                                      |      |
|                                                                  |                                                                 |          | 50           | 0.0058                            | 0.058                     | 40    |                                      |      |
| 1,2-Diphenylethane                                               | C <sub>14</sub> H <sub>14</sub>                                 | 182.261  | 25           | 0.00044                           | 0.0044                    | 6     | 0.017                                | 12   |
| Diphenyl ether                                                   | C <sub>12</sub> H <sub>10</sub> O                               | 170.206  | 25           | 0.0018                            | 0.0180                    | 6     | 0.027                                | 13   |
| Diphenylmethane                                                  | C <sub>13</sub> H <sub>12</sub>                                 | 168.234  | 25           | 0.00014                           | 0.0014                    | 42,4  | 0.001                                | 12   |
| Diphenyl phthalate                                               | C <sub>20</sub> H <sub>14</sub> O <sub>4</sub>                  | 318.323  | 24           | 0.000008                          | 0.00008                   | 40    |                                      |      |
| 1,3-Diphenyl-1-triazene                                          | C <sub>12</sub> H <sub>11</sub> N <sub>3</sub>                  | 197.235  | 20           | 0.050                             | 0.50                      | 40    |                                      |      |



| Name                                           | Mol. Form.                                                      | Mol. Wt. | t/°C | Solubility, s     |                           |       | Henry Const., $k_H$                  |      |
|------------------------------------------------|-----------------------------------------------------------------|----------|------|-------------------|---------------------------|-------|--------------------------------------|------|
|                                                |                                                                 |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| <i>N,N'</i> -Diphenylurea                      | C <sub>13</sub> H <sub>12</sub> N <sub>2</sub> O                | 212.246  | 20   | 0.015             | 0.15                      | 40    |                                      |      |
| Dipropylamine                                  | C <sub>6</sub> H <sub>15</sub> N                                | 101.190  | 20   | 2.5               | 26                        | 10    |                                      |      |
| Dipropyl ether                                 | C <sub>6</sub> H <sub>14</sub> O                                | 102.174  | 0    | 2.67              | 27.4                      | 80    | 0.26                                 | 13   |
|                                                |                                                                 |          | 25   | 0.91              | 9.2                       | 80    | 0.26                                 | 13   |
| Diuron                                         | C <sub>9</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> O | 233.093  | 25   | 0.0042            | 0.042                     | 40    |                                      |      |
| Docosane                                       | C <sub>22</sub> H <sub>46</sub>                                 | 310.600  | 22   | 0.0000006         | 0.000006                  | 37    |                                      |      |
| Dodecane                                       | C <sub>12</sub> H <sub>26</sub>                                 | 170.334  | 25   | 0.00000037        | 0.0000037                 | 4     | 750                                  | 5    |
| Dodecanedioic acid                             | C <sub>12</sub> H <sub>22</sub> O <sub>4</sub>                  | 230.301  | 20   | 0.004             | 0.04                      | 40    |                                      |      |
| Dodecanoic acid                                | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                  | 200.318  | 20   | 0.0055            | 0.055                     | 26    |                                      |      |
| 1-Dodecanol                                    | C <sub>12</sub> H <sub>26</sub> O                               | 186.333  | 25   | 0.0004            | 0.004                     | 1     |                                      |      |
| Droperidol                                     | C <sub>22</sub> H <sub>22</sub> FN <sub>3</sub> O <sub>2</sub>  | 379.427  | 30   | 0.00041           | 0.0041                    | 40    |                                      |      |
| Eicosane                                       | C <sub>20</sub> H <sub>42</sub>                                 | 282.547  | 25   | 0.00000019        | 0.0000019                 | 42,4  |                                      |      |
| Emetine                                        | C <sub>29</sub> H <sub>40</sub> N <sub>2</sub> O <sub>4</sub>   | 480.639  | 15   | 0.096             | 0.96                      | 40    |                                      |      |
| Endrin                                         | C <sub>12</sub> H <sub>8</sub> Cl <sub>6</sub> O                | 380.909  | 25   | 0.000025          | 0.00025                   | 67    |                                      |      |
| <i>l</i> -Ephedrine                            | C <sub>10</sub> H <sub>15</sub> NO                              | 165.232  | 25   | 0.57              | 5.7                       | 40    |                                      |      |
| Epichlorohydrin                                | C <sub>3</sub> H <sub>5</sub> ClO                               | 92.524   | 20   | 6.58              | 70.4                      | 10    | 0.003                                | 13   |
|                                                |                                                                 |          | 65   | 7.2               | 78                        | 40    |                                      |      |
| Epinephrine                                    | C <sub>9</sub> H <sub>13</sub> NO <sub>3</sub>                  | 183.204  | 20   | 0.018             | 0.18                      | 40    |                                      |      |
| 1,2-Epoxy-4-(epoxyethyl)cyclohexane            | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                   | 140.180  | 20   | 13.4              | 155                       | 40    |                                      |      |
| 2,3-Epoxy- $\alpha$ -pinane                    | C <sub>10</sub> H <sub>16</sub> O                               | 152.233  | 25   | 0.039             | 0.39                      | 52    |                                      |      |
| Erythromycin                                   | C <sub>37</sub> H <sub>67</sub> NO <sub>13</sub>                | 733.927  | 30   | 0.12              | 1.2                       | 40    |                                      |      |
|                                                |                                                                 |          | 80   | 0.04              | 0.4                       | 40    |                                      |      |
| Estra-1,3,5(10)-triene-3,17-diol (17 $\beta$ ) | C <sub>18</sub> H <sub>24</sub> O <sub>2</sub>                  | 272.383  | 25   | 0.000151          | 0.00151                   | 49    |                                      |      |
| Estrone                                        | C <sub>18</sub> H <sub>22</sub> O <sub>2</sub>                  | 270.367  | 25   | 0.000130          | 0.00130                   | 49    |                                      |      |
| Ethane                                         | C <sub>2</sub> H <sub>6</sub>                                   | 30.069   | 25   | 0.00568*          | 0.0568*                   | 18    | 50.6                                 | 5    |
| 1,2-Ethandiol, diacetate                       | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                   | 146.141  | 25   | 13.3              | 153                       | 40    |                                      |      |
| Ethinylestradiol                               | C <sub>20</sub> H <sub>24</sub> O <sub>2</sub>                  | 296.404  | 25   | 0.000921          | 0.00921                   | 49    |                                      |      |
| Ethoxybenzene                                  | C <sub>8</sub> H <sub>10</sub> O                                | 122.164  | 25   | 0.12              | 1.2                       | 10    |                                      |      |
| 2-Ethoxyethyl acetate                          | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                   | 132.157  |      | 14                | 163                       | 30    |                                      |      |
| <i>N</i> -(4-Ethoxyphenyl)acetamide            | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>                 | 179.216  | 25   | 0.0502            | 0.502                     | 40    |                                      |      |
| Ethyl acetate                                  | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                    | 88.106   | 25   | 8.08              | 87.9                      | 10    |                                      |      |
| Ethyl acetoacetate                             | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                   | 130.141  | 25   | 12                | 136                       | 10    |                                      |      |
| Ethyl acrylate                                 | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                    | 100.117  | 25   | 1.50              | 15.2                      | 10    |                                      |      |
| Ethylbenzene                                   | C <sub>8</sub> H <sub>10</sub>                                  | 106.165  | 0    | 0.020             | 0.20                      | 4,89  |                                      |      |
|                                                |                                                                 |          | 25   | 0.0161            | 0.161                     | 22,89 | 0.843                                | 22   |
|                                                |                                                                 |          | 40   | 0.0200            | 0.200                     | 4,89  |                                      |      |
| Ethyl benzoate                                 | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                   | 150.174  | 25   | 0.083             | 0.83                      | 20    |                                      |      |
| Ethyl butanoate                                | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                   | 116.158  | 20   | 0.49              | 4.9                       | 10    |                                      |      |
| 2-Ethyl-1-butanol                              | C <sub>6</sub> H <sub>14</sub> O                                | 102.174  | 20   | 0.92              | 9.3                       | 78    |                                      |      |
|                                                |                                                                 |          | 50   | 0.80              | 8.1                       | 78    |                                      |      |
| Ethyl carbamate                                | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                   | 89.094   | 15   | 48                | 920                       | 27    |                                      |      |
| Ethyl cyanoacetate                             | C <sub>5</sub> H <sub>7</sub> NO <sub>2</sub>                   | 113.116  | 20   | 25.9              | 350                       | 10    |                                      |      |
| Ethylcyclohexane                               | C <sub>8</sub> H <sub>16</sub>                                  | 112.213  | 30   | 0.00061           | 0.0061                    | 57,4  |                                      |      |
|                                                |                                                                 |          | 100  | 0.00212           | 0.0212                    | 57,4  |                                      |      |
| Ethylcyclopentane                              | C <sub>7</sub> H <sub>14</sub>                                  | 98.186   | 20   | 0.012             | 0.12                      | 3     |                                      |      |
| Ethyl decanoate                                | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>                  | 200.318  | 20   | 0.0015            | 0.015                     | 27    |                                      |      |
| Ethylene                                       | C <sub>2</sub> H <sub>4</sub>                                   | 28.053   | 25   | 0.01336*          | 0.1336*                   | 19    | 21.7                                 | 5    |
| Ethyleneimine                                  | C <sub>2</sub> H <sub>5</sub> N                                 | 43.068   | 20   | 0.90              | 9.1                       | 40    |                                      |      |
| Ethyl formate                                  | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                    | 74.079   | 25   | 11.8              | 134                       | 10    |                                      |      |

| Name                                                                    | Mol. Form.                                                     | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>                 |                           |       | Henry Const., <i>k<sub>H</sub></i>      |      |
|-------------------------------------------------------------------------|----------------------------------------------------------------|----------|--------------|--------------------------------------|---------------------------|-------|-----------------------------------------|------|
|                                                                         |                                                                |          |              | 100 <i>w</i> <sub>2</sub><br>(mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Ethyl heptanoate                                                        | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                  | 158.238  | 20           | 0.029                                | 0.29                      | 27    |                                         |      |
| Ethyl hexanoate                                                         | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                  | 144.212  | 20           | 0.063                                | 0.63                      | 27    |                                         |      |
| 2-Ethyl-1-hexanol                                                       | C <sub>8</sub> H <sub>18</sub> O                               | 130.228  | 25           | 0.071                                | 0.71                      | 78    |                                         |      |
|                                                                         |                                                                |          | 50           | 0.074                                | 0.74                      | 78    |                                         |      |
| 2-Ethylhexylamine                                                       | C <sub>8</sub> H <sub>19</sub> N                               | 129.244  | 20           | 0.25                                 | 2.5                       | 10    |                                         |      |
| Ethyl 4-hydroxybenzoate                                                 | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>                  | 166.173  | 25           | 0.0080                               | 0.080                     | 40    |                                         |      |
| Ethyl isopropyl ether                                                   | C <sub>5</sub> H <sub>12</sub> O                               | 88.148   | 25           | 0.52                                 | 5.2                       | 79    |                                         |      |
| Ethyl 2-methylbutanoate, (+)                                            | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 130.185  | 19           | 0.257                                | 2.58                      | 20    |                                         |      |
|                                                                         |                                                                |          | 91           | 0.151                                | 1.51                      | 20    |                                         |      |
| Ethyl 3-methylbutanoate                                                 | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 130.185  | 20           | 0.2                                  | 2                         | 10    |                                         |      |
| Ethyl <i>N</i> -methylcarbamate                                         | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                  | 103.120  | 15           | 69                                   | 2230                      | 27    |                                         |      |
| 1-Ethyl-naphthalene                                                     | C <sub>12</sub> H <sub>12</sub>                                | 156.223  | 25           | 0.00101                              | 0.0101                    | 4     | 0.039                                   | 12   |
| 2-Ethyl-naphthalene                                                     | C <sub>12</sub> H <sub>12</sub>                                | 156.223  | 25           | 0.00080                              | 0.0080                    | 4     | 0.078                                   | 12   |
| <i>O</i> -Ethyl <i>O</i> - <i>p</i> -nitrophenyl benzenethiophosphonate | C <sub>14</sub> H <sub>14</sub> NO <sub>4</sub> PS             | 323.304  | 22           | 0.00031                              | 0.0031                    | 40    |                                         |      |
| <i>N</i> -Ethyl- <i>N</i> -nitrosourea                                  | C <sub>3</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>    | 117.107  | 20           | 1.3                                  | 13                        | 40    |                                         |      |
| Ethyl nonanoate                                                         | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>                 | 186.292  | 20           | 0.003                                | 0.03                      | 27    |                                         |      |
| Ethyl octanoate                                                         | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                 | 172.265  | 20           | 0.007                                | 0.07                      | 27    |                                         |      |
| Ethyl pentanoate                                                        | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 130.185  | 25           | 0.3                                  | 3                         | 27    |                                         |      |
| 3-Ethyl-3-pentanol                                                      | C <sub>7</sub> H <sub>16</sub> O                               | 116.201  | 25           | 1.7                                  | 17                        | 1     |                                         |      |
| 4-Ethylphenol                                                           | C <sub>8</sub> H <sub>10</sub> O                               | 122.164  | 20           | 0.59                                 | 5.9                       | 40    |                                         |      |
| Ethyl propanoate                                                        | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                  | 102.132  | 20           | 1.92                                 | 19.6                      | 10    |                                         |      |
| Ethyl <i>N</i> -propylcarbamate                                         | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                 | 131.173  | 15           | 7.70                                 | 83.4                      | 27    |                                         |      |
| Ethyl propyl ether                                                      | C <sub>5</sub> H <sub>12</sub> O                               | 88.148   | 25           | 1.87                                 | 19.2                      | 79    |                                         |      |
| 2-Ethyltoluene                                                          | C <sub>9</sub> H <sub>12</sub>                                 | 120.191  | 25           | 0.0075                               | 0.075                     | 89,5  | 0.529                                   | 13   |
| 4-Ethyltoluene                                                          | C <sub>9</sub> H <sub>12</sub>                                 | 120.191  | 25           | 0.0094                               | 0.094                     | 5     | 0.500                                   | 13   |
| Ethyl vinyl ether                                                       | C <sub>4</sub> H <sub>8</sub> O                                | 72.106   | 20           | 0.9                                  | 9                         | 10    |                                         |      |
| Etoposide                                                               | C <sub>29</sub> H <sub>32</sub> O <sub>13</sub>                | 588.556  | 20           | 0.02                                 | 0.2                       | 40    |                                         |      |
| Eucalyptol                                                              | C <sub>10</sub> H <sub>18</sub> O                              | 154.249  | 21           | 0.379                                | 3.79                      | 40    |                                         |      |
|                                                                         |                                                                |          | 50           | 0.170                                | 1.70                      | 40    |                                         |      |
| Fenamiphos                                                              | C <sub>13</sub> H <sub>22</sub> NO <sub>3</sub> PS             | 303.358  | 20           | 0.0329                               | 0.329                     | 40    |                                         |      |
| Fenbutatin oxide                                                        | C <sub>60</sub> H <sub>78</sub> OSn <sub>2</sub>               | 1052.68  | 23           | 0.0000005                            | 0.000005                  | 32    |                                         |      |
| α-Fenchol, (+)-                                                         | C <sub>10</sub> H <sub>18</sub> O                              | 154.249  | 25           | 0.083                                | 0.83                      | 52    |                                         |      |
| Fenchone                                                                | C <sub>10</sub> H <sub>16</sub> O                              | 152.233  | 20           | 0.2                                  | 2                         | 84    |                                         |      |
| Fenoxycarb                                                              | C <sub>17</sub> H <sub>19</sub> NO <sub>4</sub>                | 301.338  | 20           | 0.0006                               | 0.006                     | 32    |                                         |      |
| Ferbam                                                                  | C <sub>9</sub> H <sub>18</sub> FeN <sub>3</sub> S <sub>6</sub> | 416.494  | 20           | 0.013                                | 0.13                      | 40    |                                         |      |
| Fluoranthene                                                            | C <sub>16</sub> H <sub>10</sub>                                | 202.250  | 20           | 0.000017                             | 0.00017                   | 42    |                                         |      |
|                                                                         |                                                                |          | 25           | 0.000021                             | 0.00021                   | 42,22 | 0.00096                                 | 22   |
| 9 <i>H</i> -Fluorene                                                    | C <sub>13</sub> H <sub>10</sub>                                | 166.218  | 0            | 0.00007                              | 0.0007                    | 42,4  |                                         |      |
|                                                                         |                                                                |          | 25           | 0.00019                              | 0.0019                    | 42,22 | 0.00787                                 | 22   |
|                                                                         |                                                                |          | 50           | 0.00063                              | 0.0063                    | 42,4  |                                         |      |
| Fluorescein                                                             | C <sub>20</sub> H <sub>12</sub> O <sub>5</sub>                 | 332.306  | 20           | 0.005                                | 0.05                      | 27    |                                         |      |
| Fluorobenzene                                                           | C <sub>6</sub> H <sub>5</sub> F                                | 96.102   | 19           | 0.170                                | 1.70                      | 20    | 0.70                                    | 11   |
|                                                                         |                                                                |          | 80           | 0.188                                | 1.88                      | 20    | 0.70                                    | 11   |
| 2-Fluorobenzoic acid                                                    | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                  | 140.112  | 25           | 0.72                                 | 7.2                       | 27    |                                         |      |
| 3-Fluorobenzoic acid                                                    | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                  | 140.112  | 25           | 0.15                                 | 1.5                       | 27    |                                         |      |
| 4-Fluorobenzoic acid                                                    | C <sub>7</sub> H <sub>5</sub> FO <sub>2</sub>                  | 140.112  | 25           | 0.12                                 | 1.2                       | 27    |                                         |      |
| Fluoroethane                                                            | C <sub>2</sub> H <sub>5</sub> F                                | 48.059   | 25           | 0.216*                               | 2.16*                     | 14    |                                         |      |
| Fluoromethane                                                           | CH <sub>3</sub> F                                              | 34.033   | 0            | 0.420*                               | 4.20*                     | 50    |                                         |      |
|                                                                         |                                                                |          | 25           | 0.201*                               | 2.01*                     | 50    |                                         |      |

| Name                                 | Mol. Form.                                                      | Mol. Wt. | t/°C | Solubility, s     |                           |       | Henry Const., $k_H$                  |      |
|--------------------------------------|-----------------------------------------------------------------|----------|------|-------------------|---------------------------|-------|--------------------------------------|------|
|                                      |                                                                 |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
|                                      |                                                                 |          | 80   | 0.082*            | 0.82*                     | 50    |                                      |      |
| 1-Fluoropropane                      | C <sub>3</sub> H <sub>7</sub> F                                 | 62.086   | 14   | 0.386*            | 3.86*                     | 14    |                                      |      |
| 2-Fluoropropane                      | C <sub>3</sub> H <sub>7</sub> F                                 | 62.086   | 15   | 0.366*            | 3.66*                     | 14    |                                      |      |
| 5-Fluorouracil                       | C <sub>4</sub> H <sub>3</sub> FN <sub>2</sub> O <sub>2</sub>    | 130.077  | 25   | 1.77              | 18.0                      | 72    |                                      |      |
| Folic acid                           | C <sub>19</sub> H <sub>19</sub> N <sub>7</sub> O <sub>6</sub>   | 441.397  | 0    | 0.001             | 0.01                      | 26    |                                      |      |
|                                      |                                                                 |          | 100  | 0.05              | 0.5                       | 26    |                                      |      |
| Folpet                               | C <sub>9</sub> H <sub>4</sub> Cl <sub>3</sub> NO <sub>2</sub> S | 296.558  | 20   | 0.00010           | 0.0010                    | 40    |                                      |      |
| β-D-Fructose                         | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                   | 180.155  | 20   | ≈31               | ≈450                      | 40    |                                      |      |
| Furan                                | C <sub>4</sub> H <sub>4</sub> O                                 | 68.074   | 25   | 1                 | 10                        | 10    | 0.54                                 | 13   |
| 2-Furancarboxylic acid               | C <sub>5</sub> H <sub>4</sub> O <sub>3</sub>                    | 112.084  | 25   | 4.76              | 50.0                      | 33    |                                      |      |
|                                      |                                                                 |          | 50   | 25.2              | 337                       | 33    |                                      |      |
| Furfural                             | C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                    | 96.085   | 20   | 8.2               | 89                        | 10    |                                      |      |
| Galactaric acid                      | C <sub>6</sub> H <sub>10</sub> O <sub>8</sub>                   | 210.138  | 14   | 0.33              | 3.3                       | 40    |                                      |      |
| D-Galactose                          | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                   | 180.155  | 20   | 40.6              | 684                       | 27    |                                      |      |
| D-Glucitol                           | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                   | 182.171  | 20   | ≈41               | ≈700                      | 40    |                                      |      |
| α-D-Glucose                          | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                   | 180.155  | 15   | 45.0              | 818                       | 27    |                                      |      |
|                                      |                                                                 |          | 30   | 54.6              | 1200                      | 27    |                                      |      |
|                                      |                                                                 |          | 80   | 81.5              | 4400                      | 27    |                                      |      |
| DL-Glutamic acid                     | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                   | 147.130  | 25   | 2.30              | 23.5                      | 29    |                                      |      |
| L-Glutamic acid                      | C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub>                   | 147.130  | 10   | 0.444             | 4.46                      | 75    |                                      |      |
|                                      |                                                                 |          | 25   | 0.824             | 8.31                      | 75    |                                      |      |
|                                      |                                                                 |          | 50   | 2.13              | 21.8                      | 75    |                                      |      |
| L-Glutamine                          | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>3</sub>    | 146.144  | 25   | 4.0               | 42                        | 26    |                                      |      |
| Glycerol triacetate                  | C <sub>9</sub> H <sub>14</sub> O <sub>6</sub>                   | 218.203  | 25   | 5.8               | 62                        | 10    |                                      |      |
| Glycine                              | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                   | 75.067   | 25   | 18.5              | 227                       | 70    |                                      |      |
|                                      |                                                                 |          | 36   | 22.1              | 284                       | 70    |                                      |      |
|                                      |                                                                 |          | 50   | 26.1              | 353                       | 70    |                                      |      |
| Glycolic acid                        | C <sub>2</sub> H <sub>4</sub> O <sub>3</sub>                    | 76.051   | 25   | 71.2              | 2470                      | 34    |                                      |      |
|                                      |                                                                 |          | 55   | 77.9              | 3520                      | 34    |                                      |      |
| N-Glycylglycine                      | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>3</sub>     | 132.118  | 25   | 18.8              | 232                       | 47,29 |                                      |      |
| Glyphosate                           | C <sub>3</sub> H <sub>8</sub> NO <sub>5</sub> P                 | 169.074  | 25   | 1.2               | 12                        | 32    |                                      |      |
| Guanidinoacetic acid                 | C <sub>3</sub> H <sub>7</sub> N <sub>3</sub> O <sub>2</sub>     | 117.107  | 25   | 0.5               | 5                         | 26    |                                      |      |
| Guanine                              | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub> O                  | 151.127  | 25   | 0.0068            | 0.068                     | 29    |                                      |      |
| Guanosine                            | C <sub>10</sub> H <sub>13</sub> N <sub>5</sub> O <sub>5</sub>   | 283.241  | 25   | 0.0500            | 0.500                     | 29    |                                      |      |
| Haloperidol                          | C <sub>21</sub> H <sub>23</sub> ClFNO <sub>2</sub>              | 375.865  | 30   | 0.0003            | 0.003                     | 40    |                                      |      |
| Heptachlor                           | C <sub>10</sub> H <sub>5</sub> Cl <sub>7</sub>                  | 373.318  | 25   | 0.000018          | 0.00018                   | 67    |                                      |      |
| 2,2',3,3',4,4',6-Heptachlorobiphenyl | C <sub>12</sub> H <sub>3</sub> Cl <sub>7</sub>                  | 395.323  | 25   | 0.0000002         | 0.000002                  | 7     | 0.0054                               | 7    |
| Heptadecanoic acid                   | C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>                  | 270.451  | 20   | 0.00042           | 0.0042                    | 26    |                                      |      |
| 1,6-Heptadiyne                       | C <sub>7</sub> H <sub>8</sub>                                   | 92.139   | 25   | 0.125             | 1.25                      | 3     |                                      |      |
| Heptanal                             | C <sub>7</sub> H <sub>14</sub> O                                | 114.185  | 11   | 0.124             | 1.24                      | 27    |                                      |      |
| Heptane                              | C <sub>7</sub> H <sub>16</sub>                                  | 100.202  | 25   | 0.000242          | 0.00242                   | 46    |                                      |      |
|                                      |                                                                 |          | 50   | 0.000341          | 0.00341                   | 46    | 209                                  | 13   |
|                                      |                                                                 |          | 75   | 0.000570          | 0.00570                   | 46    |                                      |      |
|                                      |                                                                 |          | 100  | 0.00108           | 0.0108                    | 46    |                                      |      |
| Heptanedioic acid                    | C <sub>7</sub> H <sub>12</sub> O <sub>4</sub>                   | 160.168  | 25   | 6.347             | 67.77                     | 33    |                                      |      |
|                                      |                                                                 |          | 50   | 42.80             | 748                       | 33    |                                      |      |
| Heptanoic acid                       | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                   | 130.185  | 15   | 0.24              | 2.4                       | 27    |                                      |      |
| 1-Heptanol                           | C <sub>7</sub> H <sub>16</sub> O                                | 116.201  | 0    | 0.236             | 2.37                      | 78    |                                      |      |
|                                      |                                                                 |          | 25   | 0.164             | 1.64                      | 78,1  | 0.00562                              | 28   |

| Name                                                                                                          | Mol. Form.                                                  | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>                 |                           |       | Henry Const., <i>k<sub>H</sub></i>      |      |
|---------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|----------|--------------|--------------------------------------|---------------------------|-------|-----------------------------------------|------|
|                                                                                                               |                                                             |          |              | 100 <i>w</i> <sub>2</sub><br>(mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
|                                                                                                               |                                                             |          |              |                                      |                           |       |                                         |      |
|                                                                                                               |                                                             |          | 50           | 0.164                                | 1.64                      | 78,1  |                                         |      |
|                                                                                                               |                                                             |          | 90           | 0.245                                | 2.46                      | 78    |                                         |      |
| 2-Heptanol                                                                                                    | C <sub>7</sub> H <sub>16</sub> O                            | 116.201  | 30           | 0.33                                 | 3.3                       | 1     |                                         |      |
| 3-Heptanol, (S)-                                                                                              | C <sub>7</sub> H <sub>16</sub> O                            | 116.201  | 25           | 0.43                                 | 4.3                       | 1     |                                         |      |
| 4-Heptanol                                                                                                    | C <sub>7</sub> H <sub>16</sub> O                            | 116.201  | 25           | 0.47                                 | 4.7                       | 1     |                                         |      |
| 2-Heptanone                                                                                                   | C <sub>7</sub> H <sub>14</sub> O                            | 114.185  | 25           | 0.435                                | 4.37                      | 20    | 0.0171                                  | 28   |
|                                                                                                               |                                                             |          | 90           | 0.353                                | 3.53                      | 20    | 0.0171                                  | 28   |
| 3-Heptanone                                                                                                   | C <sub>7</sub> H <sub>14</sub> O                            | 114.185  | 20           | 0.479                                | 4.81                      | 20    |                                         |      |
|                                                                                                               |                                                             |          | 90           | 0.309                                | 3.10                      | 20    |                                         |      |
| 4-Heptanone                                                                                                   | C <sub>7</sub> H <sub>14</sub> O                            | 114.185  | 20           | 0.457                                | 4.57                      | 20    |                                         |      |
|                                                                                                               |                                                             |          | 90           | 0.316                                | 3.16                      | 20    |                                         |      |
| 1-Heptene                                                                                                     | C <sub>7</sub> H <sub>14</sub>                              | 98.186   | 25           | 0.032                                | 0.32                      | 3     | 40.3                                    | 13   |
| <i>trans</i> -2-Heptene                                                                                       | C <sub>7</sub> H <sub>14</sub>                              | 98.186   | 25           | 0.015                                | 0.15                      | 3     | 42.2                                    | 13   |
| Heptyl butanoate                                                                                              | C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>              | 186.292  | 20           | 0.028                                | 0.28                      | 20    |                                         |      |
|                                                                                                               |                                                             |          | 80           | 0.020                                | 0.20                      | 20    |                                         |      |
| 1-Heptyne                                                                                                     | C <sub>7</sub> H <sub>12</sub>                              | 96.170   | 25           | 0.0094                               | 0.094                     | 3     | 4.47                                    | 13   |
| Hesperetin                                                                                                    | C <sub>16</sub> H <sub>14</sub> O <sub>6</sub>              | 302.278  | 15           | 0.00004                              | 0.0004                    | 71    |                                         |      |
|                                                                                                               |                                                             |          | 25           | 0.00014                              | 0.0014                    | 71    |                                         |      |
|                                                                                                               |                                                             |          | 35           | 0.00052                              | 0.0052                    | 71    |                                         |      |
| Hexachlorobenzene                                                                                             | C <sub>6</sub> Cl <sub>6</sub>                              | 284.782  | 25           | 0.00000096                           | 0.0000096                 | 58    | 0.131                                   | 11   |
|                                                                                                               |                                                             |          | 35           | 0.0000018                            | 0.000018                  | 58    |                                         |      |
|                                                                                                               |                                                             |          | 55           | 0.0000038                            | 0.000038                  | 58    |                                         |      |
| 2,2',3,3',4,4'-Hexachlorobiphenyl                                                                             | C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub>              | 360.878  | 25           | 0.00000006                           | 0.0000006                 | 7     | 0.0354                                  | 31   |
| 2,2',4,4',6,6'-Hexachlorobiphenyl                                                                             | C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub>              | 360.878  | 25           | 0.0000003                            | 0.000003                  | 41    | 0.818                                   | 7    |
| 2,2',3,3',6,6'-Hexachlorobiphenyl                                                                             | C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub>              | 360.878  | 25           | 0.0000004                            | 0.000004                  | 41    |                                         |      |
| Hexachloro-1,3-butadiene                                                                                      | C <sub>4</sub> Cl <sub>6</sub>                              | 260.761  | 25           | 0.41                                 | 4.1                       | 35    |                                         |      |
| 1,2,3,4,5,6-Hexachlorocyclohexane,<br>(1 $\alpha$ ,2 $\alpha$ ,3 $\beta$ ,4 $\alpha$ ,5 $\alpha$ ,6 $\beta$ ) | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub>               | 290.830  | 25           | 0.00078                              | 0.0078                    | 60    |                                         |      |
|                                                                                                               |                                                             |          | 45           | 0.0015                               | 0.015                     | 60    |                                         |      |
| 1,2,3,4,5,6-Hexachlorocyclohexane,<br>(1 $\alpha$ ,2 $\alpha$ ,3 $\beta$ ,4 $\alpha$ ,5 $\beta$ ,6 $\beta$ )  | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub>               | 290.830  | 25           | 0.00018                              | 0.0018                    | 60    |                                         |      |
| 1,2,3,4,5,6-Hexachlorocyclohexane,<br>(1 $\alpha$ ,2 $\beta$ ,3 $\alpha$ ,4 $\beta$ ,5 $\alpha$ ,6 $\beta$ )  | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub>               | 290.830  | 25           | 0.00002                              | 0.0002                    | 60    |                                         |      |
| Hexachloroethane                                                                                              | C <sub>2</sub> Cl <sub>6</sub>                              | 236.739  | 25           | 0.005                                | 0.05                      | 25    | 0.85                                    | 13   |
| Hexachloropropene                                                                                             | C <sub>3</sub> Cl <sub>6</sub>                              | 248.750  | 20           | 0.00118                              | 0.0118                    | 35    |                                         |      |
| Hexacosafuorododecane                                                                                         | C <sub>12</sub> F <sub>26</sub>                             | 638.086  | 20           | 0.00000096                           | 0.0000096                 | 35    |                                         |      |
| Hexacosane                                                                                                    | C <sub>26</sub> H <sub>54</sub>                             | 366.707  | 25           | 0.00000017                           | 0.0000017                 | 42,37 |                                         |      |
| Hexadecane                                                                                                    | C <sub>16</sub> H <sub>34</sub>                             | 226.441  | 25           | 0.0000004                            | 0.000004                  | 42,37 |                                         |      |
| Hexadecanoic acid                                                                                             | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>              | 256.424  | 20           | 0.00072                              | 0.0072                    | 26    |                                         |      |
| 1-Hexadecanol                                                                                                 | C <sub>16</sub> H <sub>34</sub> O                           | 242.440  | 25           | 0.000003                             | 0.00003                   | 1     |                                         |      |
| 1,5-Hexadiene                                                                                                 | C <sub>6</sub> H <sub>10</sub>                              | 82.143   | 25           | 0.017                                | 0.17                      | 3     |                                         |      |
| Hexafluorobenzene                                                                                             | C <sub>6</sub> F <sub>6</sub>                               | 186.054  | 8            | 0.0778                               | 0.778                     | 53    |                                         |      |
|                                                                                                               |                                                             |          | 28           | 0.0616                               | 0.616                     | 53    |                                         |      |
|                                                                                                               |                                                             |          | 67           | 0.0636                               | 0.636                     | 53    |                                         |      |
| Hexahydro-1,3,5-trinitro-1,3,5-triazine                                                                       | C <sub>3</sub> H <sub>6</sub> N <sub>6</sub> O <sub>6</sub> | 222.116  | 3            | 0.0014                               | 0.014                     | 59    |                                         |      |
|                                                                                                               |                                                             |          | 20           | 0.0037                               | 0.037                     | 59    |                                         |      |
|                                                                                                               |                                                             |          | 25           | 0.0060                               | 0.060                     | 17    |                                         |      |
|                                                                                                               |                                                             |          | 34           | 0.0086                               | 0.086                     | 59    |                                         |      |
| Hexamethylenetetramine                                                                                        | C <sub>6</sub> H <sub>12</sub> N <sub>4</sub>               | 140.186  | 12           | 44.8                                 | 812                       | 27    |                                         |      |
| Hexane                                                                                                        | C <sub>6</sub> H <sub>14</sub>                              | 86.175   | 25           | 0.00098                              | 0.0098                    | 46    |                                         |      |

| Name                                | Mol. Form.                                                                                | Mol. Wt. | t/°C | Solubility, s     |                           |       | Henry Const., $k_H$                  |      |
|-------------------------------------|-------------------------------------------------------------------------------------------|----------|------|-------------------|---------------------------|-------|--------------------------------------|------|
|                                     |                                                                                           |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
|                                     |                                                                                           |          | 50   | 0.00114           | 0.0114                    | 46    |                                      |      |
|                                     |                                                                                           |          | 75   | 0.00167           | 0.0167                    | 46    | 183                                  | 13   |
|                                     |                                                                                           |          | 100  | 0.00291           | 0.0291                    | 46    |                                      |      |
| 1,6-Hexanediamine                   | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                                             | 116.204  | 5    | ≈42               | ≈720                      | 40    |                                      |      |
| Hexanedinitrile                     | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                              | 108.141  | 20   | 0.80              | 8.0                       | 16    |                                      |      |
| 1,6-Hexanedioic acid                | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                                             | 146.141  | 15   | 1.48              | 15.0                      | 26    |                                      |      |
|                                     |                                                                                           |          | 100  | 61.5              | 1600                      | 26    |                                      |      |
| Hexanoic acid                       | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                                             | 116.158  | 25   | 1.01              | 10.2                      | 64    |                                      |      |
|                                     |                                                                                           |          | 35   | 1.09              | 11.0                      | 64    |                                      |      |
|                                     |                                                                                           |          | 60   | 1.16              | 11.7                      | 26    |                                      |      |
| 1-Hexanol                           | C <sub>6</sub> H <sub>14</sub> O                                                          | 102.174  | 0    | 0.79              | 7.9                       | 1     |                                      |      |
|                                     |                                                                                           |          | 10   | 0.70              | 7.0                       | 78    |                                      |      |
|                                     |                                                                                           |          | 25   | 0.59              | 5.9                       | 78,1  |                                      |      |
|                                     |                                                                                           |          | 50   | 0.55              | 5.5                       | 78,1  |                                      |      |
| 2-Hexanol                           | C <sub>6</sub> H <sub>14</sub> O                                                          | 102.174  | 25   | 1.4               | 14                        | 1     |                                      |      |
| 3-Hexanol                           | C <sub>6</sub> H <sub>14</sub> O                                                          | 102.174  | 25   | 1.6               | 16                        | 1     |                                      |      |
| 2-Hexanone                          | C <sub>6</sub> H <sub>12</sub> O                                                          | 100.158  | 10   | 1.91              | 19.5                      | 83    |                                      |      |
|                                     |                                                                                           |          | 25   | 1.49              | 15.1                      | 83    |                                      |      |
|                                     |                                                                                           |          | 50   | 1.17              | 11.8                      | 83    |                                      |      |
| 3-Hexanone                          | C <sub>6</sub> H <sub>12</sub> O                                                          | 100.158  | 25   | 1.47              | 14.9                      | 83    |                                      |      |
| Hexatriacontane                     | C <sub>36</sub> H <sub>74</sub>                                                           | 506.973  | 25   | 0.00000017        | 0.0000017                 | 42,37 |                                      |      |
| Hexazinone                          | C <sub>12</sub> H <sub>20</sub> N <sub>4</sub> O <sub>2</sub>                             | 252.313  | 25   | 3.2               | 33                        | 40    |                                      |      |
| 1-Hexene                            | C <sub>6</sub> H <sub>12</sub>                                                            | 84.159   | 25   | 0.0053            | 0.053                     | 3     | 41.8                                 | 5    |
| <i>trans</i> -2-Hexene              | C <sub>6</sub> H <sub>12</sub>                                                            | 84.159   | 25   | 0.0067            | 0.067                     | 3     |                                      |      |
| 1-Hexen-3-ol                        | C <sub>6</sub> H <sub>12</sub> O                                                          | 100.158  | 25   | 2.52              | 25.9                      | 1     |                                      |      |
| 4-Hexen-2-ol                        | C <sub>6</sub> H <sub>12</sub> O                                                          | 100.158  | 25   | 3.81              | 39.6                      | 1     |                                      |      |
| Hexyl acetate                       | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                                             | 144.212  | 20   | 0.02              | 0.2                       | 10    |                                      |      |
| <i>sec</i> -Hexyl acetate           | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                                             | 144.212  | 20   | 0.13              | 1.3                       | 10    |                                      |      |
| Hexylbenzene                        | C <sub>12</sub> H <sub>18</sub>                                                           | 162.271  | 25   | 0.00021           | 0.0021                    | 4     |                                      |      |
| 4-Hexyl-1,3-benzenediol             | C <sub>12</sub> H <sub>18</sub> O <sub>2</sub>                                            | 194.270  | 18   | 0.05              | 0.5                       | 40    |                                      |      |
| Hexyl butanoate                     | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                                            | 172.265  | 29   | 0.021             | 0.21                      | 20    |                                      |      |
| 1-Hexyne                            | C <sub>6</sub> H <sub>10</sub>                                                            | 82.143   | 25   | 0.036             | 0.36                      | 3     | 4.14                                 | 13   |
| <i>L</i> -Histidine                 | C <sub>6</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub>                               | 155.154  | 25   | 4.17              | 43.5                      | 26    |                                      |      |
| Homocystine                         | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub> S <sub>2</sub>               | 268.354  | 25   | 0.02              | 0.2                       | 26    |                                      |      |
| <i>L</i> -Homoserine                | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                                             | 119.119  | 25   | 52.4              | 1100                      | 26    |                                      |      |
| Hydramethylnon                      | C <sub>25</sub> H <sub>24</sub> F <sub>6</sub> N <sub>4</sub>                             | 494.476  | 20   | 0.0000006         | 0.000006                  | 32    |                                      |      |
| Hydrochlorothiazide                 | C <sub>7</sub> H <sub>8</sub> ClN <sub>3</sub> O <sub>4</sub> S <sub>2</sub>              | 297.740  | 25   | 0.007             | 0.07                      | 40    |                                      |      |
| Hydrocortisone                      | C <sub>21</sub> H <sub>30</sub> O <sub>5</sub>                                            | 362.460  | 25   | 0.029             | 0.29                      | 40    |                                      |      |
| Hydroflumethiazide                  | C <sub>8</sub> H <sub>8</sub> F <sub>3</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 331.293  | 37   | 0.068             | 0.68                      | 40    |                                      |      |
| <i>p</i> -Hydroquinone              | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                                              | 110.111  | 25   | 7.42              | 80.1                      | 27    |                                      |      |
| 17-Hydroxyandrost-4-en-3-one, (17β) | C <sub>19</sub> H <sub>28</sub> O <sub>2</sub>                                            | 288.424  | 25   | 0.0024            | 0.024                     | 40    |                                      |      |
| 4-Hydroxybenzaldehyde               | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                                              | 122.122  | 30   | 1.27              | 12.9                      | 40    |                                      |      |
| 2-Hydroxybenzamide                  | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                                             | 137.137  | 10   | 0.122             | 1.22                      | 44    |                                      |      |
|                                     |                                                                                           |          | 25   | 0.241             | 2.42                      | 44    |                                      |      |
|                                     |                                                                                           |          | 50   | 0.737             | 7.42                      | 44    |                                      |      |
| α-Hydroxybenzeneacetic acid         | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                                              | 152.148  | 25   | 11.3              | 127                       | 27    |                                      |      |
| 2-Hydroxybenzoic acid               | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                                              | 138.121  | 10   | 0.119             | 1.19                      | 43,33 |                                      |      |
|                                     |                                                                                           |          | 25   | 0.189             | 1.89                      | 43,33 |                                      |      |
|                                     |                                                                                           |          | 50   | 0.521             | 5.24                      | 43,33 |                                      |      |

| Name                                                    | Mol. Form.                                                                    | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |      | Henry Const., <i>k<sub>H</sub></i>   |      |
|---------------------------------------------------------|-------------------------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|------|--------------------------------------|------|
|                                                         |                                                                               |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref. | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 4-Hydroxybenzoic acid                                   | C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>                                  | 138.121  | 15           | 0.8                               | 8                         | 26   |                                      |      |
|                                                         |                                                                               |          | 75           | 2.5                               | 26                        | 27   |                                      |      |
| 2-Hydroxybiphenyl                                       | C <sub>12</sub> H <sub>10</sub> O                                             | 170.206  | 25           | 0.07                              | 0.7                       | 40   |                                      |      |
| 4-Hydroxybiphenyl                                       | C <sub>12</sub> H <sub>10</sub> O                                             | 170.206  | 25           | 0.0056                            | 0.056                     | 40   |                                      |      |
| 4-Hydroxy-3-methoxybenzaldehyde                         | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                                  | 152.148  | 25           | 0.247                             | 2.47                      | 8    |                                      |      |
| 3-Hydroxy-4-oxo-4 <i>H</i> -pyran-2,6-dicarboxylic acid | C <sub>7</sub> H <sub>4</sub> O <sub>7</sub>                                  | 200.103  | 25           | 0.84                              | 8.4                       | 27   |                                      |      |
| <i>N</i> -(4-Hydroxyphenyl)acetamide                    | C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                                 | 151.163  | 25           | 1.3                               | 13                        | 40   |                                      |      |
| <i>trans</i> -4-Hydroxy- <i>L</i> -proline              | C <sub>5</sub> H <sub>9</sub> NO <sub>3</sub>                                 | 131.130  | 25           | 26.5                              | 361                       | 26   |                                      |      |
| Hyoscyamine                                             | C <sub>17</sub> H <sub>23</sub> NO <sub>3</sub>                               | 289.370  | 20           | 0.36                              | 3.6                       | 40   |                                      |      |
| Hypoxanthine                                            | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O                                | 136.112  | 25           | 0.070                             | 0.70                      | 29   |                                      |      |
| Ibuprofen                                               | C <sub>13</sub> H <sub>18</sub> O <sub>2</sub>                                | 206.281  | 25           | 0.0011                            | 0.011                     | 40   |                                      |      |
|                                                         |                                                                               |          | 60           | 0.0048                            | 0.048                     | 40   |                                      |      |
| Imazaquin                                               | C <sub>17</sub> H <sub>17</sub> N <sub>3</sub> O <sub>3</sub>                 | 311.335  | 20           | 0.009                             | 0.09                      | 32   |                                      |      |
| Imidacloprid                                            | C <sub>9</sub> H <sub>10</sub> ClN <sub>5</sub> O <sub>2</sub>                | 255.66   | 30           | 0.038                             | 0.38                      | 73   |                                      |      |
|                                                         |                                                                               |          | 51           | 0.117                             | 1.17                      | 73   |                                      |      |
| Imidazole                                               | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>                                  | 68.077   | 19           | 67.3                              | 2060                      | 54   |                                      |      |
| 2,4-Imidazolidinedione                                  | C <sub>3</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>                   | 100.076  | 25           | 3.93                              | 40.9                      | 29   |                                      |      |
| Imidodicarbonic diamide                                 | C <sub>2</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>                   | 103.080  | 15           | 1.5                               | 15                        | 40   |                                      |      |
| Iminodiacetic acid                                      | C <sub>4</sub> H <sub>7</sub> NO <sub>4</sub>                                 | 133.104  | 5            | 2.32                              | 23.8                      | 40   |                                      |      |
| Indan                                                   | C <sub>9</sub> H <sub>10</sub>                                                | 118.175  | 25           | 0.010                             | 0.10                      | 4    |                                      |      |
| 1 <i>H</i> -Indazole                                    | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub>                                  | 118.136  | 20           | 0.0827                            | 0.827                     | 6    |                                      |      |
| Indeno[1,2,3- <i>cd</i> ]pyrene                         | C <sub>22</sub> H <sub>12</sub>                                               | 276.330  | 20           | 0.00000002                        | 0.0000002                 | 40   |                                      |      |
| 1 <i>H</i> -Indole                                      | C <sub>8</sub> H <sub>7</sub> N                                               | 117.149  | 20           | 0.187                             | 1.87                      | 6    |                                      |      |
| Indomethacin                                            | C <sub>19</sub> H <sub>16</sub> ClNO <sub>4</sub>                             | 357.788  | 25           | 0.001                             | 0.01                      | 40   |                                      |      |
| Inosine                                                 | C <sub>10</sub> H <sub>12</sub> N <sub>4</sub> O <sub>5</sub>                 | 268.226  | 20           | 1.6                               | 16                        | 29   |                                      |      |
| Iodobenzene                                             | C <sub>6</sub> H <sub>5</sub> I                                               | 204.008  | 10           | 0.0193                            | 0.193                     | 2    |                                      |      |
|                                                         |                                                                               |          | 25           | 0.0226                            | 0.226                     | 2    | 0.078                                | 11   |
|                                                         |                                                                               |          | 45           | 0.0279                            | 0.279                     | 2    |                                      |      |
| 2-Iodobenzoic acid                                      | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                                 | 248.018  | 25           | 0.095                             | 0.95                      | 27   |                                      |      |
| 3-Iodobenzoic acid                                      | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                                 | 248.018  | 25           | 0.016                             | 0.16                      | 27   |                                      |      |
| 4-Iodobenzoic acid                                      | C <sub>7</sub> H <sub>5</sub> IO <sub>2</sub>                                 | 248.018  | 25           | 0.0027                            | 0.027                     | 27   |                                      |      |
| 1-Iodobutane                                            | C <sub>4</sub> H <sub>9</sub> I                                               | 184.018  | 17           | 0.021                             | 0.21                      | 10   | 1.87                                 | 13   |
| Iodoethane                                              | C <sub>2</sub> H <sub>5</sub> I                                               | 155.965  | 0            | 0.44                              | 4.4                       | 25   |                                      |      |
|                                                         |                                                                               |          | 25           | 0.40                              | 4.0                       | 25   | 0.52                                 | 13   |
| 1-Iodoheptane                                           | C <sub>7</sub> H <sub>15</sub> I                                              | 226.098  | 25           | 0.00035                           | 0.0035                    | 35   |                                      |      |
| Iodomethane                                             | CH <sub>3</sub> I                                                             | 141.939  | 20           | 1.4                               | 14                        | 10   | 0.54                                 | 13   |
| 1-Iodopropane                                           | C <sub>3</sub> H <sub>7</sub> I                                               | 169.992  | 0            | 0.114                             | 1.14                      | 35   |                                      |      |
|                                                         |                                                                               |          | 20           | 0.100                             | 1.00                      | 35   | 0.93                                 | 13   |
| 2-Iodopropane                                           | C <sub>3</sub> H <sub>7</sub> I                                               | 169.992  | 0            | 0.167                             | 1.67                      | 35   |                                      |      |
|                                                         |                                                                               |          | 20           | 0.140                             | 1.40                      | 35   |                                      |      |
| 5-Iodouracil                                            | C <sub>4</sub> H <sub>3</sub> IN <sub>2</sub> O <sub>2</sub>                  | 237.983  | 25           | 0.49                              | 4.9                       | 72   |                                      |      |
| <i>trans</i> -β-Ionone                                  | C <sub>13</sub> H <sub>20</sub> O                                             | 192.297  | 25           | 0.017                             | 0.17                      | 52   |                                      |      |
| Ipanoic acid                                            | C <sub>11</sub> H <sub>12</sub> INO <sub>2</sub>                              | 570.932  | 37           | 0.034                             | 0.34                      | 40   |                                      |      |
| Iprodione                                               | C <sub>13</sub> H <sub>13</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>3</sub> | 330.166  | 20           | 0.0013                            | 0.013                     | 40   |                                      |      |
| Isobutanal                                              | C <sub>4</sub> H <sub>8</sub> O                                               | 72.106   | 20           | 9.1                               | 100                       | 10   |                                      |      |
| Isobutane                                               | C <sub>4</sub> H <sub>10</sub>                                                | 58.122   | 25           | 0.00535*                          | 0.0535*                   | 18   | 120                                  | 5    |
| Isobutene                                               | C <sub>4</sub> H <sub>8</sub>                                                 | 56.107   | 25           | 0.0263*                           | 0.263*                    | 5    | 21.6                                 | 13   |
| Isobutyl acetate                                        | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                                 | 116.158  | 20           | 0.63                              | 6.3                       | 10   |                                      |      |
| Isobutylbenzene                                         | C <sub>10</sub> H <sub>14</sub>                                               | 134.218  | 25           | 0.0010                            | 0.010                     | 4    | 3.32                                 | 11   |

| Name                                         | Mol. Form.                                                                    | Mol. Wt. | t/°C | Solubility, s     |                           |      | Henry Const., $k_H$                  |      |
|----------------------------------------------|-------------------------------------------------------------------------------|----------|------|-------------------|---------------------------|------|--------------------------------------|------|
|                                              |                                                                               |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref. | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Isobutyl formate                             | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                                 | 102.132  | 22   | 1.0               | 10                        | 10   |                                      |      |
| Isobutyl isobutanoate                        | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                                 | 144.212  | 20   | 0.5               | 5                         | 10   |                                      |      |
| Isobutyl propanoate                          | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                                 | 130.185  | 19   | 0.225             | 2.26                      | 20   |                                      |      |
|                                              |                                                                               |          | 91   | 0.142             | 1.42                      | 20   |                                      |      |
| 1 <i>H</i> -Isoindole-1,3(2 <i>H</i> )-dione | C <sub>8</sub> H <sub>5</sub> NO <sub>2</sub>                                 | 147.132  | 25   | 0.036             | 0.36                      | 40   |                                      |      |
| <i>L</i> -Isoleucine                         | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                                | 131.173  | 25   | 3.31              | 34.2                      | 26   |                                      |      |
| Isoniazid                                    | C <sub>6</sub> H <sub>7</sub> N <sub>3</sub> O                                | 137.139  | 25   | 11.0              | 124                       | 40   |                                      |      |
| Isopentane                                   | C <sub>5</sub> H <sub>12</sub>                                                | 72.149   | 25   | 0.00485           | 0.0485                    | 3    | 479                                  | 13   |
| Isopentyl acetate                            | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                                 | 130.185  | 20   | 0.2               | 2                         | 10   |                                      |      |
| Isopentyl formate                            | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                                 | 116.158  | 22   | 0.3               | 3                         | 27   |                                      |      |
| Isophorone                                   | C <sub>9</sub> H <sub>14</sub> O                                              | 138.206  | 20   | 1.57              | 16.0                      | 20   |                                      |      |
|                                              |                                                                               |          | 80   | 1.27              | 12.9                      | 20   |                                      |      |
| Isophthalic acid                             | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                                  | 166.132  | 10   | 0.0062            | 0.062                     | 76   |                                      |      |
|                                              |                                                                               |          | 25   | 0.0154            | 0.154                     | 56   |                                      |      |
|                                              |                                                                               |          | 50   | 0.0395            | 0.395                     | 56   |                                      |      |
|                                              |                                                                               |          | 80   | 0.123             | 1.23                      | 56   |                                      |      |
| Isopropenylbenzene                           | C <sub>9</sub> H <sub>10</sub>                                                | 118.175  | 20   | 0.0116            | 0.116                     | 40   |                                      |      |
| Isopropyl acetate                            | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                                 | 102.132  | 20   | 2.9               | 30                        | 10   |                                      |      |
| Isopropylbenzene                             | C <sub>9</sub> H <sub>12</sub>                                                | 120.191  | 25   | 0.0050            | 0.050                     | 22   | 1.466                                | 22   |
| 1-Isopropyl-2-methylbenzene                  | C <sub>10</sub> H <sub>14</sub>                                               | 134.218  | 25   | 0.00482           | 0.0482                    | 23   |                                      |      |
| 1-Isopropyl-3-methylbenzene                  | C <sub>10</sub> H <sub>14</sub>                                               | 134.218  | 25   | 0.00425           | 0.0425                    | 23   |                                      |      |
| 1-Isopropyl-4-methylbenzene                  | C <sub>10</sub> H <sub>14</sub>                                               | 134.218  | 25   | 0.0051            | 0.051                     | 23   | 0.80                                 | 5    |
| Isopropyl phenylcarbamate                    | C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub>                               | 179.216  | 20   | 0.01              | 0.1                       | 40   |                                      |      |
| Isoquinoline                                 | C <sub>9</sub> H <sub>7</sub> N                                               | 129.159  | 20   | 0.452             | 4.52                      | 6    |                                      |      |
| Isosorbide dinitrate                         | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub> O <sub>8</sub>                   | 236.136  | 25   | 0.055             | 0.55                      | 40   |                                      |      |
| Kepone                                       | C <sub>10</sub> Cl <sub>10</sub> O                                            | 490.636  | 100  | 0.4               | 4                         | 40   |                                      |      |
| <i>L</i> -Lanthionine                        | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> O <sub>4</sub> S                | 208.235  | 25   | 0.15              | 1.5                       | 26   |                                      |      |
| Lasiocarpine                                 | C <sub>21</sub> H <sub>33</sub> NO <sub>7</sub>                               | 411.490  | 20   | 0.67              | 6.7                       | 40   |                                      |      |
| <i>L</i> -Leucine                            | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                                | 131.173  | 25   | 2.32              | 23.8                      | 62   |                                      |      |
| Levodopa                                     | C <sub>9</sub> H <sub>11</sub> NO <sub>4</sub>                                | 197.188  | 20   | 0.165             | 1.65                      | 63   |                                      |      |
| <i>d</i> -Limonene                           | C <sub>10</sub> H <sub>16</sub>                                               | 136.234  | 0    | 0.001             | 0.01                      | 4    |                                      |      |
|                                              |                                                                               |          | 25   | 0.0020            | 0.020                     | 52   |                                      |      |
| Linalol                                      | C <sub>10</sub> H <sub>18</sub> O                                             | 154.249  | 25   | 0.156             | 1.56                      | 52   |                                      |      |
| Linuron                                      | C <sub>9</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub>  | 249.093  | 25   | 0.0075            | 0.075                     | 40   |                                      |      |
| <i>L</i> -Lysine                             | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>2</sub>                  | 146.187  | 25   | 0.58              | 5.8                       | 26   |                                      |      |
| Maleic acid                                  | C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                                  | 116.073  | 25   | 44.1              | 789                       | 26   |                                      |      |
| Malic acid                                   | C <sub>4</sub> H <sub>6</sub> O <sub>5</sub>                                  | 134.088  | 26   | 59                | 1440                      | 26   |                                      |      |
| Malonic acid                                 | C <sub>3</sub> H <sub>4</sub> O <sub>4</sub>                                  | 104.062  | 0    | 37.9              | 610                       | 26   |                                      |      |
|                                              |                                                                               |          | 20   | 42.4              | 736                       | 26   |                                      |      |
|                                              |                                                                               |          | 50   | 48.1              | 927                       | 26   |                                      |      |
| Malononitrile                                | C <sub>3</sub> H <sub>2</sub> N <sub>2</sub>                                  | 66.061   | 20   | 10.6              | 119                       | 40   |                                      |      |
| $\alpha$ -Maltose                            | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                               | 342.296  | 20   | 51.9              | 1080                      | 27   |                                      |      |
| <i>D</i> -Mannitol                           | C <sub>6</sub> H <sub>14</sub> O <sub>6</sub>                                 | 182.171  | 25   | 17.7              | 215                       | 27   |                                      |      |
| Mefenamic acid                               | C <sub>15</sub> H <sub>15</sub> NO <sub>2</sub>                               | 241.286  | 20   | 0.0026            | 0.026                     | 40   |                                      |      |
| Melphalan                                    | C <sub>13</sub> H <sub>18</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 305.200  | 30   | 0.44              | 4.4                       | 40   |                                      |      |
| Mercury(II) phenyl acetate                   | C <sub>8</sub> H <sub>8</sub> HgO <sub>2</sub>                                | 336.74   | 20   | 0.2               | 2                         | 30   |                                      |      |
| Mesityl oxide                                | C <sub>6</sub> H <sub>10</sub> O                                              | 98.142   | 20   | 2.8               | 29                        | 83   |                                      |      |
| Methacrylic acid                             | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                  | 86.090   | 20   | 8.9               | 98                        | 10   |                                      |      |
| Methane                                      | CH <sub>4</sub>                                                               | 16.043   | 25   | 0.00227*          | 0.0227*                   | 18   | 67.4                                 | 5    |

| Name                               | Mol. Form.                                                                                  | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>                 |                           |       | Henry Const., <i>k<sub>H</sub></i>      |      |
|------------------------------------|---------------------------------------------------------------------------------------------|----------|--------------|--------------------------------------|---------------------------|-------|-----------------------------------------|------|
|                                    |                                                                                             |          |              | 100 <i>w</i> <sub>2</sub><br>(mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Methazolamide                      | C <sub>5</sub> H <sub>8</sub> N <sub>4</sub> O <sub>3</sub> S <sub>2</sub>                  | 236.273  | 15           | 0.0472                               | 0.472                     | 40    |                                         |      |
| Methazole                          | C <sub>9</sub> H <sub>6</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>3</sub>                 | 261.061  | 24           | 0.00015                              | 0.0015                    | 40    |                                         |      |
| Methidathion                       | C <sub>6</sub> H <sub>11</sub> N <sub>2</sub> O <sub>4</sub> PS <sub>3</sub>                | 302.330  | 20           | 0.0187                               | 0.187                     | 40    |                                         |      |
| <i>L</i> -Methionine               | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub> S                                            | 149.212  | 25           | 5.3                                  | 56                        | 26    |                                         |      |
| Methomyl                           | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> S                              | 162.210  | 25           | 5.5                                  | 58                        | 40    |                                         |      |
| Methoxsalen                        | C <sub>12</sub> H <sub>8</sub> O <sub>4</sub>                                               | 216.190  | 30           | 0.0048                               | 0.048                     | 40    |                                         |      |
| 2-Methoxyaniline                   | C <sub>7</sub> H <sub>9</sub> NO                                                            | 123.152  | 25           | 1.24                                 | 12.6                      | 40    |                                         |      |
| 4-Methoxyaniline                   | C <sub>7</sub> H <sub>9</sub> NO                                                            | 123.152  | 20           | 1.14                                 | 11.5                      | 40    |                                         |      |
| 4-Methoxybenzaldehyde              | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                                                | 136.149  | 25           | 0.429                                | 4.29                      | 40    |                                         |      |
| 4-Methoxybenzoic acid              | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                                                | 152.148  | 25           | 0.023                                | 0.23                      | 27    |                                         |      |
| Methoxychlor                       | C <sub>16</sub> H <sub>15</sub> Cl <sub>3</sub> O <sub>2</sub>                              | 345.648  | 25           | 0.000005                             | 0.00005                   | 40    |                                         |      |
| 2-Methoxy-2-methylbutane           | C <sub>6</sub> H <sub>14</sub> O                                                            | 102.174  | 20           | 1.10                                 | 11.1                      | 20    |                                         |      |
|                                    |                                                                                             |          | 79           | 0.36                                 | 3.6                       | 20    |                                         |      |
| 4-Methoxyphenol                    | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                                                | 124.138  | 20           | 2.51                                 | 25.7                      | 40    |                                         |      |
| Methyclothiazide                   | C <sub>9</sub> H <sub>11</sub> Cl <sub>2</sub> N <sub>3</sub> O <sub>4</sub> S <sub>2</sub> | 360.237  | 20           | 0.005                                | 0.05                      | 40    |                                         |      |
| Methyl acetate                     | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                                                | 74.079   | 20           | 24.5                                 | 325                       | 10    |                                         |      |
| Methyl acrylate                    | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                                                | 86.090   | 25           | 4.94                                 | 52.0                      | 10    |                                         |      |
| 2-Methylacrylonitrile              | C <sub>4</sub> H <sub>5</sub> N                                                             | 67.090   | 20           | 2.57                                 | 26.4                      | 10    |                                         |      |
| 2-Methylaniline                    | C <sub>7</sub> H <sub>9</sub> N                                                             | 107.153  | 20           | 1.66                                 | 16.9                      | 10    |                                         |      |
| 4-Methylaniline                    | C <sub>7</sub> H <sub>9</sub> N                                                             | 107.153  | 21           | 7.35                                 | 79.3                      | 10    |                                         |      |
| <i>N</i> -Methylaniline            | C <sub>7</sub> H <sub>9</sub> N                                                             | 107.153  | 25           | 0.56                                 | 5.6                       | 40    |                                         |      |
| 2-Methylanthracene                 | C <sub>15</sub> H <sub>12</sub>                                                             | 192.256  | 6            | 0.0000007                            | 0.000007                  | 42    |                                         |      |
|                                    |                                                                                             |          | 25           | 0.0000021                            | 0.000021                  | 42,22 |                                         |      |
| 9-Methylanthracene                 | C <sub>15</sub> H <sub>12</sub>                                                             | 192.256  | 25           | 0.000026                             | 0.00026                   | 42,4  |                                         |      |
| 9-Methylbenz[a]anthracene          | C <sub>19</sub> H <sub>14</sub>                                                             | 242.314  | 27           | 0.0000066                            | 0.000066                  | 42,4  |                                         |      |
| 10-Methylbenz[a]anthracene         | C <sub>19</sub> H <sub>14</sub>                                                             | 242.314  | 25           | 0.0000055                            | 0.000055                  | 42,4  |                                         |      |
| 2-Methylbenzenesulfonamide         | C <sub>7</sub> H <sub>9</sub> NO <sub>2</sub> S                                             | 171.217  | 25           | 0.162                                | 1.62                      | 27    |                                         |      |
| 3-Methylbenzenesulfonamide         | C <sub>7</sub> H <sub>9</sub> NO <sub>2</sub> S                                             | 171.217  | 25           | 0.78                                 | 7.8                       | 27    |                                         |      |
| 4-Methylbenzenesulfonamide         | C <sub>7</sub> H <sub>9</sub> NO <sub>2</sub> S                                             | 171.217  | 25           | 0.316                                | 3.16                      | 27    |                                         |      |
| 2-Methyl-1 <i>H</i> -benzimidazole | C <sub>8</sub> H <sub>8</sub> N <sub>2</sub>                                                | 132.163  | 20           | 0.145                                | 1.45                      | 6     |                                         |      |
| Methyl benzoate                    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                                                | 136.149  | 20           | 0.21                                 | 2.1                       | 10    |                                         |      |
| 2-Methyl-1,3-butadiene             | C <sub>5</sub> H <sub>8</sub>                                                               | 68.118   | 25           | 0.061                                | 0.61                      | 3     | 7.78                                    | 5    |
|                                    |                                                                                             |          | 50           | 0.076*                               | 0.76*                     | 3     |                                         |      |
| Methyl butanoate                   | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                                               | 102.132  |              | 1.6                                  | 16                        | 30    |                                         |      |
| 3-Methylbutanoic acid              | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                                               | 102.132  | 20           | 4.0                                  | 42                        | 26    |                                         |      |
| 2-Methyl-1-butanol                 | C <sub>5</sub> H <sub>12</sub> O                                                            | 88.148   | 10           | 3.38                                 | 35.0                      | 78    |                                         |      |
|                                    |                                                                                             |          | 25           | 2.75                                 | 28.3                      | 78    |                                         |      |
|                                    |                                                                                             |          | 50           | 2.35                                 | 24.1                      | 78    |                                         |      |
| 3-Methyl-1-butanol                 | C <sub>5</sub> H <sub>12</sub> O                                                            | 88.148   | 10           | 3.17                                 | 32.7                      | 78,1  |                                         |      |
|                                    |                                                                                             |          | 25           | 2.59                                 | 26.6                      | 78,1  |                                         |      |
|                                    |                                                                                             |          | 70           | 2.24                                 | 22.9                      | 78,1  |                                         |      |
| 2-Methyl-2-butanol                 | C <sub>5</sub> H <sub>12</sub> O                                                            | 88.148   | 25           | 11.0                                 | 124                       | 88,1  |                                         |      |
|                                    |                                                                                             |          | 60           | 6.6                                  | 71                        | 88,1  |                                         |      |
| 3-Methyl-2-butanol                 | C <sub>5</sub> H <sub>12</sub> O                                                            | 88.148   | 25           | 5.6                                  | 59                        | 1     |                                         |      |
| 3-Methyl-2-butanone                | C <sub>5</sub> H <sub>10</sub> O                                                            | 86.132   | 0            | 9.4                                  | 104                       | 82    |                                         |      |
|                                    |                                                                                             |          | 25           | 6.1                                  | 65                        | 82    |                                         |      |
|                                    |                                                                                             |          | 40           | 5.2                                  | 55                        | 82    |                                         |      |
| 3-Methyl-1-butene                  | C <sub>5</sub> H <sub>10</sub>                                                              | 70.133   | 25           | 0.013*                               | 0.13*                     | 3     | 54.7                                    | 5    |



| Name                                                     | Mol. Form.                                                  | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |      | Henry Const., <i>k<sub>H</sub></i>   |      |
|----------------------------------------------------------|-------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|------|--------------------------------------|------|
|                                                          |                                                             |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref. | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 2-Methyl-2-butene                                        | C <sub>5</sub> H <sub>10</sub>                              | 70.133   | 25           | 0.041                             | 0.41                      | 3    |                                      |      |
| 2-Methyl-3-buten-2-ol                                    | C <sub>5</sub> H <sub>10</sub> O                            | 86.132   | 18           | 27.4                              | 377                       | 88   |                                      |      |
|                                                          |                                                             |          | 29           | 18.4                              | 225                       | 88   |                                      |      |
| Methyl <i>tert</i> -butyl ether                          | C <sub>5</sub> H <sub>12</sub> O                            | 88.148   | 0            | 7.72                              | 83.7                      | 79   |                                      |      |
|                                                          |                                                             |          | 25           | 3.25                              | 33.6                      | 79   |                                      |      |
|                                                          |                                                             |          | 35           | 2.56                              | 26.3                      | 79   |                                      |      |
|                                                          |                                                             |          | 70           | 1.64                              | 16.7                      | 79   |                                      |      |
| Methyl carbamate                                         | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>               | 75.067   | 15           | 69                                | 2230                      | 27   |                                      |      |
| 5-Methylchrysene                                         | C <sub>19</sub> H <sub>14</sub>                             | 242.314  | 27           | 0.0000062                         | 0.000062                  | 42,4 |                                      |      |
| Methylcyclohexane                                        | C <sub>7</sub> H <sub>14</sub>                              | 98.186   | 26           | 0.00161                           | 0.0161                    | 3    | 43.3                                 | 13   |
|                                                          |                                                             |          | 100          | 0.00548                           | 0.0548                    | 3    |                                      |      |
| 2-Methylcyclohexanone                                    | C <sub>7</sub> H <sub>12</sub> O                            | 112.169  | 0            | 2.93                              | 30.2                      | 84   |                                      |      |
|                                                          |                                                             |          | 20           | 1.98                              | 20.2                      | 20   |                                      |      |
|                                                          |                                                             |          | 31           | 1.72                              | 17.5                      | 84   |                                      |      |
|                                                          |                                                             |          | 60           | 1.44                              | 14.6                      | 84   |                                      |      |
|                                                          |                                                             |          | 90           | 1.54                              | 15.6                      | 20   |                                      |      |
| 4-Methylcyclohexanone                                    | C <sub>7</sub> H <sub>12</sub> O                            | 112.169  | 20           | 2.43                              | 24.9                      | 20   |                                      |      |
|                                                          |                                                             |          | 80           | 1.95                              | 19.9                      | 20   |                                      |      |
| 1-Methylcyclohexene                                      | C <sub>7</sub> H <sub>12</sub>                              | 96.170   | 25           | 0.0052                            | 0.052                     | 3    |                                      |      |
| Methylcyclopentane                                       | C <sub>6</sub> H <sub>12</sub>                              | 84.159   | 25           | 0.0043                            | 0.043                     | 3    | 36.7                                 | 5    |
| 1-Methyl-2,4-dinitrobenzene                              | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub> | 182.134  | 12           | 0.0130                            | 0.130                     | 55   |                                      |      |
|                                                          |                                                             |          | 32           | 0.0270                            | 0.270                     | 85   |                                      |      |
|                                                          |                                                             |          | 62           | 0.098                             | 0.98                      | 85   |                                      |      |
| 2-Methyl-4,6-dinitrophenol                               | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>5</sub> | 198.133  |              | 0.0130                            | 0.130                     | 40   |                                      |      |
| Methyl formate                                           | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                | 60.052   | 25           | 23                                | 300                       | 10   |                                      |      |
| 3-Methylheptane                                          | C <sub>8</sub> H <sub>18</sub>                              | 114.229  | 25           | 0.000079                          | 0.00079                   | 4    | 376                                  | 5    |
| 2-Methyl-2-heptanol                                      | C <sub>8</sub> H <sub>18</sub> O                            | 130.228  | 30           | 0.25                              | 2.5                       | 1    |                                      |      |
| 5-Methyl-3-heptanone                                     | C <sub>8</sub> H <sub>16</sub> O                            | 128.212  | 20           | 0.192                             | 1.92                      | 20   |                                      |      |
|                                                          |                                                             |          | 90           | 0.131                             | 1.31                      | 20   |                                      |      |
| 2-Methylhexane                                           | C <sub>7</sub> H <sub>16</sub>                              | 100.202  | 25           | 0.00025                           | 0.0025                    | 3    | 346                                  | 5    |
| 3-Methylhexane                                           | C <sub>7</sub> H <sub>16</sub>                              | 100.202  | 25           | 0.00026                           | 0.0026                    | 3    | 249                                  | 13   |
| 2-Methyl-2-hexanol                                       | C <sub>7</sub> H <sub>16</sub> O                            | 116.201  | 25           | 1.0                               | 10                        | 1    |                                      |      |
| 5-Methyl-2-hexanol                                       | C <sub>7</sub> H <sub>16</sub> O                            | 116.201  | 25           | 0.49                              | 4.9                       | 1    |                                      |      |
| 3-Methyl-3-hexanol                                       | C <sub>7</sub> H <sub>16</sub> O                            | 116.201  | 25           | 1.2                               | 12                        | 1    |                                      |      |
| 5-Methyl-2-hexanone                                      | C <sub>7</sub> H <sub>14</sub> O                            | 114.185  | 19           | 0.537                             | 5.40                      | 20   |                                      |      |
|                                                          |                                                             |          | 90           | 0.417                             | 4.19                      | 20   |                                      |      |
| 5-Methyl-3-hexanone                                      | C <sub>7</sub> H <sub>14</sub> O                            | 114.185  | 20           | 0.47                              | 4.7                       | 20   |                                      |      |
|                                                          |                                                             |          | 81           | 0.32                              | 3.2                       | 20   |                                      |      |
| Methyl 4-hydroxybenzoate                                 | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                | 152.148  | 25           | 0.24                              | 2.4                       | 40   |                                      |      |
| 2-Methyl-1 <i>H</i> -imidazole                           | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>                | 82.104   | 18           | 23.2                              | 302                       | 54   |                                      |      |
| 3-Methyl-1 <i>H</i> -indole                              | C <sub>9</sub> H <sub>9</sub> N                             | 131.174  | 20           | 0.050                             | 0.50                      | 6    |                                      |      |
| 3-Methylisoquinoline                                     | C <sub>10</sub> H <sub>9</sub> N                            | 143.185  | 20           | 0.092                             | 0.92                      | 6    |                                      |      |
| Methyl isothiocyanate                                    | C <sub>2</sub> H <sub>3</sub> NS                            | 73.117   | 20           | 0.75                              | 7.6                       | 40   |                                      |      |
| Methylmalonic acid                                       | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | 118.089  | 0            | 30.1                              | 431                       | 26   |                                      |      |
|                                                          |                                                             |          | 20           | 40                                | 670                       | 26   |                                      |      |
| Methyl methacrylate                                      | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                | 100.117  | 20           | 1.56                              | 15.8                      | 10   |                                      |      |
| 2-Methyl-3-(2-methylphenyl)-4(3 <i>H</i> )-quinazolinone | C <sub>16</sub> H <sub>14</sub> N <sub>2</sub> O            | 250.294  | 23           | 0.03                              | 0.3                       | 40   |                                      |      |
| 1-Methylnaphthalene                                      | C <sub>11</sub> H <sub>10</sub>                             | 142.197  | 25           | 0.00281                           | 0.0281                    | 22   | 0.045                                | 22   |

| Name                                                | Mol. Form.                                                   | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|-----------------------------------------------------|--------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                                                     |                                                              |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 2-Methylnaphthalene                                 | C <sub>11</sub> H <sub>10</sub>                              | 142.197  | 25           | 0.0025                            | 0.025                     | 4     | 0.051                                | 12   |
| 2-Methyl-1,4-naphthalenedione                       | C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                | 172.181  | 25           | 0.016                             | 0.16                      | 40    |                                      |      |
| <i>N</i> -Methyl- <i>N</i> -nitrosoarea             | C <sub>2</sub> H <sub>5</sub> N <sub>3</sub> O <sub>2</sub>  | 103.080  | 14           | 2.3                               | 24                        | 40    |                                      |      |
| 4-Methyloctane                                      | C <sub>9</sub> H <sub>20</sub>                               | 128.255  | 25           | 0.0000115                         | 0.000115                  | 4     | 1000                                 | 5    |
| Methyloxirane                                       | C <sub>3</sub> H <sub>6</sub> O                              | 58.079   | 20           | 40.5                              | 681                       | 10    | 0.0087                               | 13   |
| Methyl parathion                                    | C <sub>8</sub> H <sub>10</sub> NO <sub>5</sub> PS            | 263.208  | 10           | 0.00218                           | 0.0218                    | 40    |                                      |      |
|                                                     |                                                              |          | 20           | 0.00380                           | 0.0380                    | 40    |                                      |      |
|                                                     |                                                              |          | 30           | 0.0059                            | 0.059                     | 40    |                                      |      |
| 2-Methylpentane                                     | C <sub>6</sub> H <sub>14</sub>                               | 86.175   | 25           | 0.00137                           | 0.0137                    | 3     | 176                                  | 13   |
| 3-Methylpentane                                     | C <sub>6</sub> H <sub>14</sub>                               | 86.175   | 25           | 0.00129                           | 0.0129                    | 3     | 170                                  | 13   |
| 2-Methyl-1-pentanol                                 | C <sub>6</sub> H <sub>14</sub> O                             | 102.174  | 25           | 0.76                              | 7.7                       | 78,1  |                                      |      |
|                                                     |                                                              |          | 50           | 0.70                              | 7.0                       | 78    |                                      |      |
| 4-Methyl-1-pentanol                                 | C <sub>6</sub> H <sub>14</sub> O                             | 102.174  | 25           | 0.76                              | 7.6                       | 1     |                                      |      |
| 2-Methyl-2-pentanol                                 | C <sub>6</sub> H <sub>14</sub> O                             | 102.174  | 25           | 3.2                               | 33                        | 1     |                                      |      |
| 3-Methyl-2-pentanol                                 | C <sub>6</sub> H <sub>14</sub> O                             | 102.174  | 25           | 1.9                               | 19                        | 1     |                                      |      |
| 4-Methyl-2-pentanol                                 | C <sub>6</sub> H <sub>14</sub> O                             | 102.174  | 27           | 1.5                               | 15                        | 1     |                                      |      |
| 2-Methyl-3-pentanol                                 | C <sub>6</sub> H <sub>14</sub> O                             | 102.174  | 25           | 2.0                               | 20                        | 1     |                                      |      |
| 3-Methyl-3-pentanol                                 | C <sub>6</sub> H <sub>14</sub> O                             | 102.174  | 25           | 4.3                               | 45                        | 1     |                                      |      |
| 4-Methyl-2-pentanone                                | C <sub>6</sub> H <sub>12</sub> O                             | 100.158  | 0            | 2.92                              | 30.1                      | 83    |                                      |      |
|                                                     |                                                              |          | 25           | 1.85                              | 18.8                      | 83    |                                      |      |
|                                                     |                                                              |          | 50           | 1.46                              | 14.8                      | 83    |                                      |      |
| 2-Methyl-3-pentanone                                | C <sub>6</sub> H <sub>12</sub> O                             | 100.158  | 25           | 1.5                               | 15                        | 83    |                                      |      |
| 2-Methyl-1-pentene                                  | C <sub>6</sub> H <sub>12</sub>                               | 84.159   | 25           | 0.0078                            | 0.078                     | 3     | 28.1                                 | 5    |
| 4-Methyl-1-pentene                                  | C <sub>6</sub> H <sub>12</sub>                               | 84.159   | 25           | 0.0048                            | 0.048                     | 3     | 63.2                                 | 5    |
| 1-Methylphenanthrene                                | C <sub>15</sub> H <sub>12</sub>                              | 192.256  | 7            | 0.0000095                         | 0.000095                  | 42    |                                      |      |
|                                                     |                                                              |          | 25           | 0.0000269                         | 0.000269                  | 42,4  |                                      |      |
| Methylprednisolone                                  | C <sub>22</sub> H <sub>30</sub> O <sub>5</sub>               | 374.470  | 25           | 0.012                             | 0.12                      | 40    |                                      |      |
| Methyl propanoate                                   | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                 | 88.106   |              | 6                                 | 60                        | 30    |                                      |      |
| 2-Methylpropanoic acid                              | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                 | 88.106   | 20           | 22.8                              | 295                       | 10    |                                      |      |
| 2-Methyl-1-propanol                                 | C <sub>4</sub> H <sub>10</sub> O                             | 74.121   | 0            | 12.2                              | 139                       | 78,1  |                                      |      |
|                                                     |                                                              |          | 25           | 8.1                               | 88                        | 78,1  | 0.00273                              | 28   |
|                                                     |                                                              |          | 50           | 7.0                               | 70                        | 78,1  |                                      |      |
| Methyl propyl ether                                 | C <sub>4</sub> H <sub>10</sub> O                             | 74.121   | 0            | 5.4                               | 57                        | 79    |                                      |      |
|                                                     |                                                              |          | 25           | 3.0                               | 31                        | 79    |                                      |      |
| 2-Methyl-2-propyl-1,3-propanediol dicarbamate       | C <sub>9</sub> H <sub>18</sub> N <sub>2</sub> O <sub>4</sub> | 218.250  | 25           | 0.33                              | 3.3                       | 40    |                                      |      |
| Methyl salicylate                                   | C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>                 | 152.148  | 30           | 0.74                              | 7.4                       | 10    |                                      |      |
| 17-Methyltestosterone                               | C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>               | 302.451  | 25           | 0.0033                            | 0.033                     | 40    |                                      |      |
| 2-Methyltetrahydrofuran                             | C <sub>5</sub> H <sub>10</sub> O                             | 86.132   | 19           | 14.4                              | 168                       | 20    | 0.67                                 | 13   |
|                                                     |                                                              |          | 71           | 6.0                               | 64                        | 20    |                                      |      |
| <i>N</i> -Methyl- <i>N</i> ,2,4,6-tetranitroaniline | C <sub>7</sub> H <sub>5</sub> N <sub>5</sub> O <sub>8</sub>  | 287.144  | 20           | 0.0074                            | 0.074                     | 40    |                                      |      |
| Methylthiouracil                                    | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub> OS              | 142.179  | 25           | 0.0533                            | 0.533                     | 40    |                                      |      |
| 1-Methyl-2,3,4-trinitrobenzene                      | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>6</sub>  | 227.131  | 14           | 0.0091                            | 0.091                     | 85,59 |                                      |      |
|                                                     |                                                              |          | 23           | 0.0116                            | 0.116                     | 85,59 |                                      |      |
|                                                     |                                                              |          | 61           | 0.0643                            | 0.643                     | 85,59 |                                      |      |
| Metronidazole                                       | C <sub>6</sub> H <sub>9</sub> N <sub>3</sub> O <sub>3</sub>  | 171.153  | 20           | 0.93                              | 9.4                       | 40    |                                      |      |
| Mirex                                               | C <sub>10</sub> Cl <sub>12</sub>                             | 545.543  | 25           | 0.0000085                         | 0.000085                  | 40    |                                      |      |
| Morphine                                            | C <sub>17</sub> H <sub>19</sub> NO <sub>3</sub>              | 285.338  | 20           | 0.015                             | 0.15                      | 27    |                                      |      |
| β-Myrcene                                           | C <sub>10</sub> H <sub>16</sub>                              | 136.234  | 25           | 0.030                             | 0.30                      | 52    |                                      |      |
| Naphthacene                                         | C <sub>18</sub> H <sub>12</sub>                              | 228.288  | 25           | 0.00000007                        | 0.0000007                 | 42,4  | 0.000004                             | 12   |

| Name                                 | Mol. Form.                                                     | Mol. Wt. | t/°C | Solubility, s     |                           |       | Henry Const., $k_H$                  |      |
|--------------------------------------|----------------------------------------------------------------|----------|------|-------------------|---------------------------|-------|--------------------------------------|------|
|                                      |                                                                |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Naphthalene                          | C <sub>10</sub> H <sub>8</sub>                                 | 128.171  | 10   | 0.0019            | 0.019                     | 4     | 0.043                                | 22   |
|                                      |                                                                |          | 25   | 0.00316           | 0.0316                    | 22    |                                      |      |
|                                      |                                                                |          | 50   | 0.0082            | 0.082                     | 4     |                                      |      |
| 1-Naphthaleneacetic acid             | C <sub>12</sub> H <sub>10</sub> O <sub>2</sub>                 | 186.206  | 25   | 0.0415            | 0.415                     | 40    |                                      |      |
| 1-Naphthalenecarboxylic acid         | C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>                  | 172.181  | 25   | 0.0058            | 0.058                     | 27    |                                      |      |
| 1-Naphthalenylthiourea               | C <sub>11</sub> H <sub>10</sub> N <sub>2</sub> S               | 202.275  | 20   | 0.06              | 0.6                       | 40    |                                      |      |
| 1-Naphthol                           | C <sub>10</sub> H <sub>8</sub> O                               | 144.170  | 20   | 0.111             | 1.11                      | 40    |                                      |      |
| 2-Naphthol                           | C <sub>10</sub> H <sub>8</sub> O                               | 144.170  | 20   | 0.064             | 0.64                      | 40    |                                      |      |
|                                      |                                                                |          | 80   | 0.67              | 6.7                       | 40    |                                      |      |
| 1-Naphthylamine                      | C <sub>10</sub> H <sub>9</sub> N                               | 143.185  | 20   | 0.17              | 1.7                       | 40    |                                      |      |
| 2-Naphthylamine                      | C <sub>10</sub> H <sub>9</sub> N                               | 143.185  | 20   | 0.0189            | 0.189                     | 40    |                                      |      |
| Narceine                             | C <sub>23</sub> H <sub>27</sub> NO <sub>8</sub>                | 445.462  | 13   | 0.078             | 0.78                      | 27    |                                      |      |
| Neopentane                           | C <sub>5</sub> H <sub>12</sub>                                 | 72.149   | 25   | 0.00332*          | 0.0332*                   | 3     | 220                                  | 13   |
| Nitrapyrin                           | C <sub>6</sub> H <sub>3</sub> Cl <sub>4</sub> N                | 230.907  | 20   | 0.0040            | 0.040                     | 40    |                                      |      |
| 2-Nitroaniline                       | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>    | 138.124  | 30   | 1.47              | 14.9                      | 27    |                                      |      |
| 3-Nitroaniline                       | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>    | 138.124  | 30   | 0.121             | 1.21                      | 27    |                                      |      |
| 4-Nitroaniline                       | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>    | 138.124  | 30   | 0.073             | 0.73                      | 27    |                                      |      |
| 2-Nitroanisole                       | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                  | 153.136  | 30   | 0.169             | 1.69                      | 10    |                                      |      |
| 4-Nitroanisole                       | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                  | 153.136  | 30   | 0.059             | 0.59                      | 27    |                                      |      |
| 3-Nitrobenzaldehyde                  | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub>                  | 151.120  | 25   | 0.16              | 1.6                       | 27    |                                      |      |
| 4-Nitrobenzaldehyde                  | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub>                  | 151.120  | 25   | 0.23              | 2.3                       | 27    |                                      |      |
| Nitrobenzene                         | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                  | 123.110  | 25   | 0.21              | 2.1                       | 17    |                                      |      |
| 3-Nitro-1,2-benzenedicarboxylic acid | C <sub>8</sub> H <sub>5</sub> NO <sub>6</sub>                  | 211.129  | 25   | 1.63              | 16.6                      | 69    |                                      |      |
|                                      |                                                                |          | 40   | 2.97              | 30.6                      | 69    |                                      |      |
| 4-Nitro-1,2-benzenedicarboxylic acid | C <sub>8</sub> H <sub>5</sub> NO <sub>6</sub>                  | 211.129  | 25   | 60.9              | 1560                      | 69    |                                      |      |
|                                      |                                                                |          | 40   | 68.0              | 2125                      | 69    |                                      |      |
| 2-Nitrobenzoic acid                  | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                  | 167.120  | 25   | 0.55              | 5.5                       | 40    |                                      |      |
| 3-Nitrobenzoic acid                  | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                  | 167.120  | 10   | 0.197             | 1.97                      | 75    |                                      |      |
|                                      |                                                                |          | 25   | 0.313             | 3.14                      | 75    |                                      |      |
|                                      |                                                                |          | 50   | 0.90              | 9.1                       | 75    |                                      |      |
| 4-Nitrobenzoic acid                  | C <sub>7</sub> H <sub>5</sub> NO <sub>4</sub>                  | 167.120  | 25   | 0.0422            | 0.422                     | 40    |                                      |      |
| Nitroethane                          | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>                  | 75.067   | 25   | 4.4               | 46                        | 38    |                                      |      |
|                                      |                                                                |          | 50   | 5.3               | 56                        | 38    |                                      |      |
| Nitrofen                             | C <sub>12</sub> H <sub>7</sub> Cl <sub>2</sub> NO <sub>3</sub> | 284.095  | 22   | 0.00095           | 0.0095                    | 40    |                                      |      |
| Nitrofurantoin                       | C <sub>8</sub> H <sub>6</sub> N <sub>4</sub> O <sub>5</sub>    | 238.158  | 30   | 0.011             | 0.11                      | 40    |                                      |      |
| Nitrofurazone                        | C <sub>6</sub> H <sub>6</sub> N <sub>4</sub> O <sub>4</sub>    | 198.137  | 20   | 0.0238            | 0.238                     | 40    |                                      |      |
| Nitroguanidine                       | CH <sub>4</sub> N <sub>4</sub> O <sub>2</sub>                  | 104.069  | 25   | 1.2               | 12                        | 40    |                                      |      |
| Nitromethane                         | CH <sub>3</sub> NO <sub>2</sub>                                | 61.041   | 0    | 9.2               | 101                       | 36    |                                      |      |
|                                      |                                                                |          | 25   | 11.0              | 124                       | 36    |                                      |      |
|                                      |                                                                |          | 50   | 14.8              | 174                       | 36    |                                      |      |
| 1-Nitronaphthalene                   | C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>                 | 173.169  | 18   | 0.005             | 0.05                      | 40    |                                      |      |
| 2-Nitrophenol                        | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                  | 139.109  | 25   | 0.170             | 1.70                      | 48,51 |                                      |      |
| 3-Nitrophenol                        | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                  | 139.109  | 20   | 2.14              | 21.9                      | 27    |                                      |      |
| 4-Nitrophenol                        | C <sub>6</sub> H <sub>5</sub> NO <sub>3</sub>                  | 139.109  | 20   | 1.56              | 15.8                      | 48,51 |                                      |      |
| 1-Nitropropane                       | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                  | 89.094   | 25   | 1.54              | 15.6                      | 38    |                                      |      |
|                                      |                                                                |          | 90   | 2.29              | 23.4                      | 20    |                                      |      |
| 2-Nitropropane                       | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                  | 89.094   | 25   | 1.75              | 17.8                      | 38    |                                      |      |
|                                      |                                                                |          | 90   | 2.36              | 24.2                      | 20    |                                      |      |
| N-Nitrosodiethylamine                | C <sub>4</sub> H <sub>10</sub> N <sub>2</sub> O                | 102.134  | 24   | 9.6               | 106                       | 40    |                                      |      |

| Name                                     | Mol. Form.                                                       | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|------------------------------------------|------------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                                          |                                                                  |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| <i>N</i> -Nitrosodiphenylamine           | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> O                 | 198.219  | 25           | 0.0035                            | 0.035                     | 17    |                                      |      |
| 2-Nitrotoluene                           | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                    | 137.137  | 30           | 0.065                             | 0.65                      | 27    |                                      |      |
| 3-Nitrotoluene                           | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                    | 137.137  | 30           | 0.050                             | 0.50                      | 27    |                                      |      |
| 4-Nitrotoluene                           | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                    | 137.137  | 30           | 0.044                             | 0.44                      | 27    |                                      |      |
| 2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl | C <sub>12</sub> HCl <sub>9</sub>                                 | 464.213  | 25           | 0.0000000018                      | 0.000000018               | 7     |                                      |      |
| 1,8-Nonadiyne                            | C <sub>9</sub> H <sub>12</sub>                                   | 120.191  | 25           | 0.0125                            | 0.125                     | 4     |                                      |      |
| Nonane                                   | C <sub>9</sub> H <sub>20</sub>                                   | 128.255  | 25           | 0.000017                          | 0.00017                   | 4     | 333                                  | 13   |
|                                          |                                                                  |          | 50           | 0.000022                          | 0.00022                   | 4     |                                      |      |
| Nonanedioic acid                         | C <sub>9</sub> H <sub>16</sub> O <sub>4</sub>                    | 188.221  | 25           | 0.1780                            | 1.780                     | 34    |                                      |      |
|                                          |                                                                  |          | 65           | 1.322                             | 13.40                     | 34    |                                      |      |
| Nonanoic acid                            | C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>                    | 158.238  | 20           | 0.0284                            | 0.284                     | 26    |                                      |      |
| 1-Nonanol                                | C <sub>9</sub> H <sub>20</sub> O                                 | 144.254  | 25           | 0.0129                            | 0.129                     | 78,1  |                                      |      |
|                                          |                                                                  |          | 90           | 0.0291                            | 0.291                     | 78    |                                      |      |
| 2-Nonanol                                | C <sub>9</sub> H <sub>20</sub> O                                 | 144.254  | 15           | 0.026                             | 0.26                      | 1     |                                      |      |
| 3-Nonanol                                | C <sub>9</sub> H <sub>20</sub> O                                 | 144.254  | 15           | 0.032                             | 0.32                      | 1     |                                      |      |
| 4-Nonanol                                | C <sub>9</sub> H <sub>20</sub> O                                 | 144.254  | 15           | 0.0026                            | 0.026                     | 1     |                                      |      |
| 5-Nonanol                                | C <sub>9</sub> H <sub>20</sub> O                                 | 144.254  | 15           | 0.0032                            | 0.032                     | 1     |                                      |      |
| 2-Nonanone                               | C <sub>9</sub> H <sub>18</sub> O                                 | 142.238  | 20           | 0.038                             | 0.38                      | 20    |                                      |      |
|                                          |                                                                  |          | 70           | 0.034                             | 0.34                      | 20    |                                      |      |
| 3-Nonanone                               | C <sub>9</sub> H <sub>18</sub> O                                 | 142.238  | 30           | 0.056                             | 0.56                      | 20    |                                      |      |
|                                          |                                                                  |          | 80           | 0.046                             | 0.46                      | 20    |                                      |      |
| 5-Nonanone                               | C <sub>9</sub> H <sub>18</sub> O                                 | 142.238  | 20           | 0.054                             | 0.54                      | 20    |                                      |      |
|                                          |                                                                  |          | 80           | 0.029                             | 0.29                      | 20    |                                      |      |
| 1-Nonene                                 | C <sub>9</sub> H <sub>18</sub>                                   | 126.239  | 25           | 0.000112                          | 0.00112                   | 40    |                                      |      |
| Nonyl formate                            | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                   | 172.265  | 10           | 0.012                             | 0.12                      | 20    |                                      |      |
|                                          |                                                                  |          | 90           | 0.039                             | 0.39                      | 20    |                                      |      |
| 4-Nonylphenol                            | C <sub>15</sub> H <sub>24</sub> O                                | 220.351  | 25           | 0.000636                          | 0.00636                   | 40    |                                      |      |
| 1-Nonyne                                 | C <sub>9</sub> H <sub>16</sub>                                   | 124.223  | 25           | 0.00072                           | 0.0072                    | 4     |                                      |      |
| Norethisterone                           | C <sub>20</sub> H <sub>26</sub> O <sub>2</sub>                   | 298.419  | 25           | 0.00063                           | 0.0063                    | 40    |                                      |      |
| Norflurazon                              | C <sub>12</sub> H <sub>9</sub> ClF <sub>3</sub> N <sub>3</sub> O | 303.666  | 25           | 0.0028                            | 0.028                     | 40    |                                      |      |
| <i>L</i> -Norleucine                     | C <sub>6</sub> H <sub>13</sub> NO <sub>2</sub>                   | 131.173  | 25           | 1.5                               | 15                        | 26    |                                      |      |
| <i>L</i> -Norvaline                      | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                   | 117.147  | 25           | 9.7                               | 107                       | 26    |                                      |      |
| Noscapine                                | C <sub>22</sub> H <sub>23</sub> NO <sub>7</sub>                  | 413.421  | 25           | 0.03                              | 0.3                       | 40    |                                      |      |
| 2,2',3,3',5,5',6,6'-Octachlorobiphenyl   | C <sub>12</sub> H <sub>2</sub> Cl <sub>8</sub>                   | 429.768  | 25           | 0.00000015                        | 0.0000015                 | 41    | 0.0381                               | 7    |
| Octachlorodibenzo- <i>p</i> -dioxin      | C <sub>12</sub> Cl <sub>8</sub> O <sub>2</sub>                   | 459.751  | 25           | 2.3•10 <sup>-11</sup>             | 2.3•10 <sup>-10</sup>     | 68    |                                      |      |
| Octachloro-1,3-pentadiene                | C <sub>5</sub> Cl <sub>8</sub>                                   | 343.678  | 20           | 0.000020                          | 0.00020                   | 35    |                                      |      |
| Octacosane                               | C <sub>28</sub> H <sub>58</sub>                                  | 394.761  | 22           | 0.0000006                         | 0.000006                  | 37    |                                      |      |
| Octadecane                               | C <sub>18</sub> H <sub>38</sub>                                  | 254.495  | 25           | 0.00000021                        | 0.0000021                 | 42,37 |                                      |      |
| 1-Octadecanol                            | C <sub>18</sub> H <sub>38</sub> O                                | 270.494  | 34           | 0.000011                          | 0.00011                   | 1     |                                      |      |
| Octane                                   | C <sub>8</sub> H <sub>18</sub>                                   | 114.229  | 25           | 0.000073                          | 0.00073                   | 46    | 311                                  | 13   |
|                                          |                                                                  |          | 50           | 0.000102                          | 0.00102                   | 47    |                                      |      |
|                                          |                                                                  |          | 75           | 0.000179                          | 0.00179                   | 46    |                                      |      |
|                                          |                                                                  |          | 100          | 0.000377                          | 0.00377                   | 46    |                                      |      |
| Octanedioic acid                         | C <sub>8</sub> H <sub>14</sub> O <sub>4</sub>                    | 174.195  | 25           | 0.242                             | 2.43                      | 34    |                                      |      |
|                                          |                                                                  |          | 50           | 0.557                             | 5.570                     | 34    |                                      |      |
| Octanoic acid                            | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                    | 144.212  | 25           | 0.080                             | 0.80                      | 26    |                                      |      |
| 1-Octanol                                | C <sub>8</sub> H <sub>18</sub> O                                 | 130.228  | 25           | 0.0460                            | 0.460                     | 78    |                                      |      |
|                                          |                                                                  |          | 60           | 0.0536                            | 0.536                     | 78    |                                      |      |
| 2-Octanol                                | C <sub>8</sub> H <sub>18</sub> O                                 | 130.228  | 25           | 0.4                               | 4                         | 1     |                                      |      |

| Name                                          | Mol. Form.                                                      | Mol. Wt. | t/°C | Solubility, s     |                           |          | Henry Const., $k_H$                  |      |
|-----------------------------------------------|-----------------------------------------------------------------|----------|------|-------------------|---------------------------|----------|--------------------------------------|------|
|                                               |                                                                 |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref.     | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 2-Octanone                                    | C <sub>8</sub> H <sub>16</sub> O                                | 128.212  | 20   | 0.134             | 1.34                      | 84       |                                      |      |
|                                               |                                                                 |          | 50   | 0.098             | 0.98                      | 84       |                                      |      |
|                                               |                                                                 |          | 80   | 0.091             | 0.91                      | 84       |                                      |      |
| 3-Octanone                                    | C <sub>8</sub> H <sub>16</sub> O                                | 128.212  | 20   | 0.137             | 1.37                      | 20       |                                      |      |
|                                               |                                                                 |          | 91   | 0.106             | 1.06                      | 20       |                                      |      |
| 1-Octene                                      | C <sub>8</sub> H <sub>16</sub>                                  | 112.213  | 25   | 0.00027           | 0.0027                    | 4        | 96.3                                 | 13   |
| Octyl acetate                                 | C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>                  | 172.265  | 19   | 0.020             | 0.20                      | 20       |                                      |      |
|                                               |                                                                 |          | 92   | 0.012             | 0.12                      | 20       |                                      |      |
| 1-Octyne                                      | C <sub>8</sub> H <sub>14</sub>                                  | 110.197  | 25   | 0.0024            | 0.024                     | 4        | 7.87                                 | 13   |
| Orotic acid                                   | C <sub>5</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>     | 156.097  | 18   | 0.18              | 1.8                       | 26       |                                      |      |
| Oryzalin                                      | C <sub>12</sub> H <sub>18</sub> N <sub>4</sub> O <sub>6</sub> S | 346.359  | 25   | 0.00024           | 0.0024                    | 40       |                                      |      |
| Ouabain                                       | C <sub>29</sub> H <sub>44</sub> O <sub>12</sub>                 | 584.652  | 25   | 1.3               | 13                        | 40       |                                      |      |
| Oxalic acid                                   | C <sub>2</sub> H <sub>2</sub> O <sub>4</sub>                    | 90.035   | 20   | 8.69              | 95.2                      | 27       |                                      |      |
|                                               |                                                                 |          | 80   | 45.8              | 845                       | 27       |                                      |      |
| Oxamyl                                        | C <sub>7</sub> H <sub>13</sub> N <sub>3</sub> O <sub>3</sub> S  | 219.261  | 25   | ≈21               | ≈270                      | 40       |                                      |      |
| 4-Oxopentanoic acid                           | C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>                    | 116.116  | 10   | 63.6              | 1750                      | 34       |                                      |      |
|                                               |                                                                 |          | 25   | 84.0              | 5250                      | 34       |                                      |      |
| 4-Oxo-4 <i>H</i> -pyran-2,6-dicarboxylic acid | C <sub>7</sub> H <sub>4</sub> O <sub>6</sub>                    | 184.103  | 25   | 1.45              | 14.7                      | 27       |                                      |      |
| Papaverine                                    | C <sub>20</sub> H <sub>21</sub> NO <sub>4</sub>                 | 339.386  | 37   | 0.0037            | 0.037                     | 40       |                                      |      |
| Paraldehyde                                   | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                   | 132.157  | 25   | 11                | 124                       | 30       |                                      |      |
| Parathion                                     | C <sub>10</sub> H <sub>14</sub> NO <sub>5</sub> PS              | 291.261  | 20   | 0.00129           | 0.0129                    | 40       |                                      |      |
| Pendimethalin                                 | C <sub>13</sub> H <sub>19</sub> N <sub>3</sub> O <sub>4</sub>   | 281.308  | 20   | 0.00003           | 0.0003                    | 40       |                                      |      |
| Pentachlorobenzene                            | C <sub>6</sub> HCl <sub>5</sub>                                 | 250.337  | 25   | 0.000050          | 0.00050                   | 41       | 0.085                                | 11   |
| 2,3,4,5,6-Pentachlorobiphenyl                 | C <sub>12</sub> H <sub>5</sub> Cl <sub>5</sub>                  | 326.433  | 25   | 0.0000008         | 0.000008                  | 7        |                                      |      |
| 2,2',4,5,5'-Pentachlorobiphenyl               | C <sub>12</sub> H <sub>5</sub> Cl <sub>5</sub>                  | 326.433  | 25   | 0.000001          | 0.00001                   | 7        | 0.0421                               | 31   |
| Pentachloroethane                             | C <sub>2</sub> HCl <sub>5</sub>                                 | 202.294  | 25   | 0.049             | 0.49                      | 25       | 0.25                                 | 13   |
| Pentachloronitrobenzene                       | C <sub>6</sub> Cl <sub>5</sub> NO <sub>2</sub>                  | 295.335  | 20   | 0.000044          | 0.00044                   | 40       |                                      |      |
| Pentachlorophenol                             | C <sub>6</sub> HCl <sub>5</sub> O                               | 266.336  | 25   | 0.0021            | 0.021                     | 48,51,24 |                                      |      |
| 2,3,4,5,6-Pentachlorotoluene                  | C <sub>7</sub> H <sub>3</sub> Cl <sub>5</sub>                   | 264.364  | 25   | 0.0000028         | 0.000028                  | 61       |                                      |      |
| Pentadecanoic acid                            | C <sub>15</sub> H <sub>30</sub> O <sub>2</sub>                  | 242.398  | 20   | 0.0012            | 0.012                     | 26       |                                      |      |
| 1-Pentadecanol                                | C <sub>15</sub> H <sub>32</sub> O                               | 228.414  | 25   | 0.000010          | 0.00010                   | 1        |                                      |      |
| 1,4-Pentadiene                                | C <sub>5</sub> H <sub>8</sub>                                   | 68.118   | 25   | 0.056             | 0.56                      | 3        | 12                                   | 5    |
| Pentaerythritol                               | C <sub>5</sub> H <sub>12</sub> O <sub>4</sub>                   | 136.147  | 15   | 5.3               | 56                        | 30       |                                      |      |
| Pentaerythritol tetranitrate                  | C <sub>5</sub> H <sub>8</sub> N <sub>4</sub> O <sub>12</sub>    | 316.138  | 20   | 0.0002            | 0.002                     | 40       |                                      |      |
| Pentanal                                      | C <sub>5</sub> H <sub>10</sub> O                                | 86.132   | 25   | 1.2               | 12                        | 40       |                                      |      |
| Pentane                                       | C <sub>5</sub> H <sub>12</sub>                                  | 72.149   | 25   | 0.0041            | 0.041                     | 3        | 128                                  | 13   |
|                                               |                                                                 |          |      |                   |                           |          |                                      |      |
| Pentanedioic acid                             | C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                    | 132.116  | 25   | 58.3              | 1400                      | 33       |                                      |      |
|                                               |                                                                 |          | 50   | 78.1              | 3570                      | 33       |                                      |      |
| 2,4-Pentanedione                              | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                    | 100.117  | 20   | 16.1              | 192                       | 20       |                                      |      |
|                                               |                                                                 |          | 80   | 32.2              | 475                       | 20       |                                      |      |
| Pentanoic acid                                | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                   | 102.132  | 16   | 3.6               | 37                        | 26       |                                      |      |
|                                               |                                                                 |          | 25   | 4.32              | 45.2                      | 90       |                                      |      |
|                                               |                                                                 |          | 35   | 5.26              | 55.5                      | 90       |                                      |      |
| 1-Pentanol                                    | C <sub>5</sub> H <sub>12</sub> O                                | 88.148   | 0    | 3.23              | 33.4                      | 78,1     |                                      |      |
|                                               |                                                                 |          | 25   | 2.14              | 21.9                      | 78,1     |                                      |      |
|                                               |                                                                 |          | 50   | 1.83              | 18.6                      | 78,1     |                                      |      |
|                                               |                                                                 |          | 90   | 2.12              | 21.7                      | 78       |                                      |      |
| 2-Pentanol                                    | C <sub>5</sub> H <sub>12</sub> O                                | 88.148   | 25   | 4.3               | 45                        | 21       |                                      |      |
| 3-Pentanol                                    | C <sub>5</sub> H <sub>12</sub> O                                | 88.148   | 25   | 5.6               | 59                        | 21       |                                      |      |

| Name                                     | Mol. Form.                                                     | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|------------------------------------------|----------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                                          |                                                                |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 2-Pentanone                              | C <sub>5</sub> H <sub>10</sub> O                               | 86.132   | 0            | 8.7                               | 95                        | 20    | 0.00847                              | 28   |
|                                          |                                                                |          | 25           | 5.5                               | 58                        | 20    | 0.00847                              | 28   |
|                                          |                                                                |          | 80           | 3.8                               | 40                        | 20    | 0.00847                              | 28   |
| 3-Pentanone                              | C <sub>5</sub> H <sub>10</sub> O                               | 86.132   | 0            | 7.6                               | 82                        | 82    |                                      |      |
|                                          |                                                                |          | 25           | 4.9                               | 52                        | 82    |                                      |      |
|                                          |                                                                |          | 80           | 3.6                               | 37                        | 82    |                                      |      |
| 1-Pentene                                | C <sub>5</sub> H <sub>10</sub>                                 | 70.133   | 25           | 0.0148                            | 0.148                     | 3     | 40.3                                 | 5    |
| <i>cis</i> -2-Pentene                    | C <sub>5</sub> H <sub>10</sub>                                 | 70.133   | 25           | 0.0203                            | 0.203                     | 3     | 22.8                                 | 5    |
| Pentyl acetate                           | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 130.185  | 20           | 0.17                              | 1.7                       | 10    |                                      |      |
| <i>sec</i> -Pentyl acetate ( <i>S</i> )- | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 130.185  | 25           | 0.2                               | 2                         | 27    |                                      |      |
| Pentylbenzene                            | C <sub>11</sub> H <sub>16</sub>                                | 148.245  | 25           | 0.00043                           | 0.0043                    | 89,5  | 1.69                                 | 11   |
| Pentylcyclopentane                       | C <sub>10</sub> H <sub>20</sub>                                | 140.266  | 25           | 0.0000115                         | 0.000115                  | 4     | 185                                  | 5    |
| Pentyl propanoate                        | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                  | 144.212  | 20           | 0.1                               | 1                         | 27    |                                      |      |
| 1-Pentyne                                | C <sub>5</sub> H <sub>8</sub>                                  | 68.118   | 25           | 0.157                             | 1.57                      | 3     | 2.5                                  | 5    |
| Perfluorocyclobutane                     | C <sub>4</sub> F <sub>8</sub>                                  | 200.030  | 5            | 0.00638*                          | 0.0638*                   | 50    |                                      |      |
|                                          |                                                                |          | 25           | 0.00247*                          | 0.0247*                   | 50    |                                      |      |
|                                          |                                                                |          | 45           | 0.00158*                          | 0.0158*                   | 50    |                                      |      |
| Perfluorodecane                          | C <sub>10</sub> F <sub>22</sub>                                | 538.072  | 20           | 0.000031                          | 0.00031                   | 35    |                                      |      |
| Perfluoroheptane                         | C <sub>7</sub> F <sub>16</sub>                                 | 388.049  | 25           | 0.0000013                         | 0.000013                  | 35    |                                      |      |
| Perfluorohexane                          | C <sub>6</sub> F <sub>14</sub>                                 | 338.042  | 25           | 0.0000098                         | 0.000098                  | 35    |                                      |      |
| Perfluoro-2-methylpentane                | C <sub>6</sub> F <sub>14</sub>                                 | 338.042  | 25           | 0.000017                          | 0.00017                   | 35    |                                      |      |
| Perfluorooctane                          | C <sub>8</sub> F <sub>18</sub>                                 | 438.057  | 25           | 0.00000017                        | 0.0000017                 | 35    |                                      |      |
| Perfluoropentane                         | C <sub>5</sub> F <sub>12</sub>                                 | 288.035  | 25           | 0.00012                           | 0.0012                    | 35    |                                      |      |
| Perfluoropropane                         | C <sub>3</sub> F <sub>8</sub>                                  | 188.019  | 15           | 0.0015*                           | 0.015*                    | 14    |                                      |      |
| Perfluoropropene                         | C <sub>3</sub> F <sub>6</sub>                                  | 150.022  | 25           | 0.0194*                           | 0.194*                    | 14    |                                      |      |
| Permethrin                               | C <sub>21</sub> H <sub>20</sub> Cl <sub>2</sub> O <sub>3</sub> | 391.288  | 20           | 0.00002                           | 0.0002                    | 32    |                                      |      |
| Perylene                                 | C <sub>20</sub> H <sub>12</sub>                                | 252.309  | 25           | 0.00000004                        | 0.0000004                 | 42,4  | 0.000003                             | 12   |
| Phenanthrene                             | C <sub>14</sub> H <sub>10</sub>                                | 178.229  | 0            | 0.000039                          | 0.00039                   | 42    |                                      |      |
|                                          |                                                                |          | 10           | 0.000047                          | 0.00047                   | 42,4  |                                      |      |
|                                          |                                                                |          | 25           | 0.00012                           | 0.0012                    | 42,22 | 0.00324                              | 22   |
|                                          |                                                                |          | 50           | 0.00042                           | 0.0042                    | 42,4  |                                      |      |
| Phenmedipham                             | C <sub>16</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub>  | 300.309  | 25           | 0.00047                           | 0.0047                    | 32    |                                      |      |
| Phenobarbital                            | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> O <sub>3</sub>  | 232.234  | 25           | 0.12                              | 1.2                       | 40    |                                      |      |
|                                          |                                                                |          | 45           | 0.26                              | 2.6                       | 40    |                                      |      |
| Phenol                                   | C <sub>6</sub> H <sub>6</sub> O                                | 94.111   | 15           | 7.60                              | 82.3                      | 48,51 |                                      |      |
|                                          |                                                                |          | 25           | 8.40                              | 91.7                      | 48,51 |                                      |      |
|                                          |                                                                |          | 35           | 9.31                              | 102.7                     | 48,51 |                                      |      |
| Phenolphthalein                          | C <sub>20</sub> H <sub>14</sub> O <sub>4</sub>                 | 318.323  | 20           | 0.018                             | 0.18                      | 27    |                                      |      |
| 10 <i>H</i> -Phenothiazine               | C <sub>12</sub> H <sub>9</sub> NS                              | 199.271  | 25           | 0.00016                           | 0.0016                    | 40    |                                      |      |
| 2-Phenoxyethanol                         | C <sub>8</sub> H <sub>10</sub> O <sub>2</sub>                  | 138.164  | 20           | 2.53                              | 26.0                      | 40    |                                      |      |
| Phenyl acetate                           | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                   | 136.149  | 20           | 0.59                              | 5.9                       | 20    |                                      |      |
|                                          |                                                                |          | 91           | 0.91                              | 9.2                       | 20    |                                      |      |
| <i>DL</i> -Phenylalanine                 | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                 | 165.189  | 25           | 1.40                              | 14.2                      | 29    |                                      |      |
| <i>L</i> -Phenylalanine                  | C <sub>9</sub> H <sub>11</sub> NO <sub>2</sub>                 | 165.189  | 25           | 2.71                              | 27.9                      | 26    |                                      |      |
| Phenylbutazone                           | C <sub>19</sub> H <sub>20</sub> N <sub>2</sub> O <sub>2</sub>  | 308.374  | 25           | 0.0034                            | 0.034                     | 40    |                                      |      |
| 1-Phenyl-1-propanone                     | C <sub>9</sub> H <sub>10</sub> O                               | 134.174  | 19           | 0.32                              | 3.2                       | 20    |                                      |      |
|                                          |                                                                |          | 80           | 0.24                              | 2.4                       | 20    |                                      |      |
| Phenylthiourea                           | C <sub>7</sub> H <sub>8</sub> N <sub>2</sub> S                 | 152.217  | 25           | 2.55                              | 26.2                      | 27    |                                      |      |
| Phenytoin                                | C <sub>15</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>  | 252.268  | 37           | 0.0038                            | 0.038                     | 40    |                                      |      |

| Name                                             | Mol. Form.                                                        | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|--------------------------------------------------|-------------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                                                  |                                                                   |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Phosalone                                        | C <sub>12</sub> H <sub>15</sub> ClNO <sub>4</sub> PS <sub>2</sub> | 367.808  | 20           | 0.00026                           | 0.0026                    | 40    |                                      |      |
| Phosmet                                          | C <sub>11</sub> H <sub>12</sub> NO <sub>4</sub> PS <sub>2</sub>   | 317.321  | 25           | 0.0025                            | 0.025                     | 40    |                                      |      |
| Phthalic acid                                    | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                      | 166.132  | 10           | 0.464                             | 4.66                      | 76    |                                      |      |
|                                                  |                                                                   |          | 25           | 0.719                             | 7.24                      | 76    |                                      |      |
|                                                  |                                                                   |          | 50           | 1.76                              | 17.9                      | 76    |                                      |      |
|                                                  |                                                                   |          | 65           | 3.57                              | 37.0                      | 33    |                                      |      |
| Phthalic anhydride                               | C <sub>8</sub> H <sub>4</sub> O <sub>3</sub>                      | 148.116  | 27           | 0.62                              | 6.20                      | 40    |                                      |      |
| Picene                                           | C <sub>22</sub> H <sub>14</sub>                                   | 278.346  | 27           | 0.00000025                        | 0.0000025                 | 42,4  |                                      |      |
| α-Pinene, (-)                                    | C <sub>10</sub> H <sub>16</sub>                                   | 136.234  | 25           | 0.00050                           | 0.0050                    | 52    |                                      |      |
| β-Pinene, (1S)-                                  | C <sub>10</sub> H <sub>16</sub>                                   | 136.234  | 25           | 0.00110                           | 0.0110                    | 52    |                                      |      |
| 2,5-Piperazinedione                              | C <sub>4</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>       | 114.103  | 25           | 1.64                              | 16.7                      | 29    |                                      |      |
| 2-Pivaloyl-1,3-indandione                        | C <sub>14</sub> H <sub>14</sub> O <sub>3</sub>                    | 230.259  | 25           | 0.0018                            | 0.018                     | 40    |                                      |      |
| Prednisolone                                     | C <sub>21</sub> H <sub>28</sub> O <sub>5</sub>                    | 360.444  | 25           | 0.03                              | 0.3                       | 40    |                                      |      |
| Progesterone                                     | C <sub>21</sub> H <sub>30</sub> O <sub>2</sub>                    | 314.462  | 25           | 0.00088                           | 0.0088                    | 40    |                                      |      |
|                                                  |                                                                   |          | 41           | 0.00206                           | 0.0206                    | 40    |                                      |      |
| <i>L</i> -Proline                                | C <sub>5</sub> H <sub>9</sub> NO <sub>2</sub>                     | 115.131  | 25           | 61.9                              | 1625                      | 26    |                                      |      |
| Prometone                                        | C <sub>10</sub> H <sub>19</sub> N <sub>5</sub> O                  | 225.291  | 20           | 0.075                             | 0.75                      | 40    |                                      |      |
| Prometryn                                        | C <sub>10</sub> H <sub>19</sub> N <sub>5</sub> S                  | 241.357  | 20           | 0.0048                            | 0.048                     | 32    |                                      |      |
| Propachlor                                       | C <sub>11</sub> H <sub>14</sub> ClNO                              | 211.688  | 20           | 0.07                              | 0.7                       | 40    |                                      |      |
| Propanal                                         | C <sub>3</sub> H <sub>6</sub> O                                   | 58.079   | 25           | 30.6                              | 441                       | 10    |                                      |      |
| Propane                                          | C <sub>3</sub> H <sub>8</sub>                                     | 44.096   | 25           | 0.00669*                          | 0.0669*                   | 18    | 71.6                                 | 5    |
| Propanenitrile                                   | C <sub>3</sub> H <sub>5</sub> N                                   | 55.079   | 25           | 10.3                              | 115                       | 10    |                                      |      |
| Propanil                                         | C <sub>9</sub> H <sub>9</sub> Cl <sub>2</sub> NO                  | 218.079  | 20           | 0.013                             | 0.13                      | 40    |                                      |      |
| Propazine                                        | C <sub>9</sub> H <sub>16</sub> ClN <sub>5</sub>                   | 229.710  | 20           | 0.00086                           | 0.0086                    | 40    |                                      |      |
| Propene                                          | C <sub>3</sub> H <sub>6</sub>                                     | 42.080   | 25           | 0.0200*                           | 0.200*                    | 5     | 21.3                                 | 5    |
| 1-Propene-2,3-dicarboxylic acid                  | C <sub>5</sub> H <sub>6</sub> O <sub>4</sub>                      | 130.100  | 20           | 7.7                               | 83                        | 26    |                                      |      |
| <i>trans</i> -1-Propene-1,2,3-tricarboxylic acid | C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>                      | 174.108  | 25           | 20.9                              | 264                       | 26    |                                      |      |
|                                                  |                                                                   |          | 90           | 52.5                              | 1105                      | 26    |                                      |      |
| Propoxur                                         | C <sub>11</sub> H <sub>15</sub> NO <sub>3</sub>                   | 209.242  | 20           | 0.193                             | 1.93                      | 40    |                                      |      |
| Propyl acetate                                   | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                     | 102.132  | 20           | 2.3                               | 24                        | 10    |                                      |      |
| Propylbenzene                                    | C <sub>9</sub> H <sub>12</sub>                                    | 120.191  | 25           | 0.0052                            | 0.052                     | 22    | 1.041                                | 22   |
| Propyl butanoate                                 | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                     | 130.185  | 17           | 0.162                             | 1.62                      | 27    |                                      |      |
| Propylcyclopentane                               | C <sub>8</sub> H <sub>16</sub>                                    | 112.213  | 25           | 0.00020                           | 0.0020                    | 4     | 90.2                                 | 5    |
| Propyl formate                                   | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                      | 88.106   | 22           | 2.05                              | 20.9                      | 10    |                                      |      |
| Propyl 4-hydroxybenzoate                         | C <sub>10</sub> H <sub>12</sub> O <sub>3</sub>                    | 180.200  | 25           | 0.04                              | 0.4                       | 40    |                                      |      |
| Propyl propanoate                                | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                     | 116.158  | 25           | 0.6                               | 6                         | 27    |                                      |      |
| Propyne                                          | C <sub>3</sub> H <sub>4</sub>                                     | 40.064   | 25           | 0.364*                            | 3.64*                     | 5     | 1.11                                 | 5    |
| Propyzamide                                      | C <sub>12</sub> H <sub>11</sub> Cl <sub>2</sub> NO                | 256.127  | 25           | 0.0015                            | 0.015                     | 32    |                                      |      |
| Pyrene                                           | C <sub>16</sub> H <sub>10</sub>                                   | 202.250  | 0            | 0.0000049                         | 0.000049                  | 42    |                                      |      |
|                                                  |                                                                   |          | 15           | 0.0000069                         | 0.000069                  | 42    |                                      |      |
|                                                  |                                                                   |          | 25           | 0.0000139                         | 0.000139                  | 42,22 | 0.00092                              | 22   |
|                                                  |                                                                   |          | 50           | 0.000053                          | 0.00053                   | 42,4  |                                      |      |
|                                                  |                                                                   |          | 75           | 0.000231                          | 0.00231                   | 42    |                                      |      |
| 3-Pyridinecarboxamide                            | C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O                    | 122.124  | 20           | ≈33                               | ≈490                      | 40    |                                      |      |
| 3-Pyridinecarboxylic acid                        | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                     | 123.110  | 24           | 1.63                              | 16.6                      | 66    |                                      |      |
|                                                  |                                                                   |          | 52           | 3.40                              | 35.2                      | 66    |                                      |      |
|                                                  |                                                                   |          | 72           | 5.20                              | 54.9                      | 66    |                                      |      |
| Pyrocatechol                                     | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                      | 110.111  | 20           | 31.1                              | 451                       | 27    |                                      |      |
| Pyrrole                                          | C <sub>4</sub> H <sub>5</sub> N                                   | 67.090   | 25           | 4.5                               | 47                        | 10    |                                      |      |

| Name                     | Mol. Form.                                                                 | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|--------------------------|----------------------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                          |                                                                            |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Quinic acid              | C <sub>7</sub> H <sub>12</sub> O <sub>6</sub>                              | 192.166  | 9            | 29                                | 410                       | 26    |                                      |      |
| Quinidine                | C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>              | 324.417  | 20           | 0.020                             | 0.20                      | 27    |                                      |      |
| Quinine                  | C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub>              | 324.417  | 25           | 0.057                             | 0.57                      | 27    |                                      |      |
| Quinoline                | C <sub>9</sub> H <sub>7</sub> N                                            | 129.159  | 20           | 0.633                             | 6.33                      | 6     |                                      |      |
| 8-Quinolinol             | C <sub>9</sub> H <sub>7</sub> NO                                           | 145.158  | 25           | 0.065                             | 0.65                      | 40    |                                      |      |
| Quinoxaline              | C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>                               | 130.147  | 50           | 54                                | 1170                      | 6     |                                      |      |
| Raffinose                | C <sub>18</sub> H <sub>32</sub> O <sub>16</sub>                            | 504.437  | 20           | 12.5                              | 143                       | 27    |                                      |      |
| Reserpine                | C <sub>33</sub> H <sub>40</sub> N <sub>2</sub> O <sub>9</sub>              | 608.679  | 30           | 0.0073                            | 0.073                     | 40    |                                      |      |
| Resorcinol               | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                               | 110.111  | 20           | 63.7                              | 1750                      | 27    |                                      |      |
| Riboflavin               | C <sub>17</sub> H <sub>20</sub> N <sub>4</sub> O <sub>6</sub>              | 376.364  | 25           | 0.0075                            | 0.075                     | 40    |                                      |      |
| Ronnel                   | C <sub>8</sub> H <sub>8</sub> Cl <sub>3</sub> O <sub>3</sub> PS            | 321.546  | 20           | 0.00011                           | 0.0011                    | 40    |                                      |      |
| Rotenone                 | C <sub>23</sub> H <sub>22</sub> O <sub>6</sub>                             | 394.417  | 25           | 0.000017                          | 0.00017                   | 40    |                                      |      |
| Saccharin                | C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub> S                            | 183.185  | 25           | 0.40                              | 4.0                       | 27    |                                      |      |
|                          |                                                                            |          | 100          | 4.0                               | 42                        | 27    |                                      |      |
| Salicylaldehyde          | C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                               | 122.122  | 86           | 1.68                              | 17.1                      | 10    |                                      |      |
| Sarcosine                | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>                              | 89.094   | 25           | 30.0                              | 429                       | 26    |                                      |      |
| <i>L</i> -Serine         | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                              | 105.093  | 25           | 20                                | 250                       | 26    |                                      |      |
| Shikimic acid            | C <sub>7</sub> H <sub>10</sub> O <sub>5</sub>                              | 174.151  |              | 15                                | 176                       | 26    |                                      |      |
| Silvex                   | C <sub>9</sub> H <sub>7</sub> Cl <sub>3</sub> O <sub>3</sub>               | 269.509  | 25           | 0.014                             | 0.14                      | 40    |                                      |      |
| Solanine                 | C <sub>45</sub> H <sub>73</sub> NO <sub>15</sub>                           | 868.060  | 15           | 0.0026                            | 0.026                     | 40    |                                      |      |
| <i>L</i> -Sorbose        | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                              | 180.155  | 17           | ≈26                               | ≈350                      | 40    |                                      |      |
| Stearic acid             | C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>                             | 284.478  | 20           | 0.00029                           | 0.0029                    | 26    |                                      |      |
| <i>trans</i> -Stilbene   | C <sub>14</sub> H <sub>12</sub>                                            | 180.245  | 25           | 0.000029                          | 0.00029                   | 42,4  | 0.040                                | 12   |
| Streptozotocin           | C <sub>8</sub> H <sub>15</sub> N <sub>3</sub> O <sub>7</sub>               | 265.221  | 25           | 0.50                              | 5.0                       | 40    |                                      |      |
| Strychnine               | C <sub>21</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>              | 334.412  | 20           | 0.013                             | 0.13                      | 27    |                                      |      |
| Styrene                  | C <sub>8</sub> H <sub>8</sub>                                              | 104.150  | 25           | 0.032                             | 0.32                      | 22    | 0.286                                | 22   |
|                          |                                                                            |          | 50           | 0.046                             | 0.46                      | 4,89  | 0.30                                 | 13   |
| Succinamide              | C <sub>4</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub>                | 116.119  | 50           | 18.4                              | 225                       | 27    |                                      |      |
| Succinic acid            | C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                               | 118.089  | 25           | 7.71                              | 83.5                      | 27    |                                      |      |
|                          |                                                                            |          | 100          | 55                                | 1220                      | 27    |                                      |      |
| Succinonitrile           | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>                               | 80.088   | 25           | 11.5                              | 130                       | 10    |                                      |      |
| Sucrose                  | C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>                            | 342.296  | 20           | 67.1                              | 2040                      | 27    |                                      |      |
|                          |                                                                            |          | 50           | 72.3                              | 2610                      | 27    |                                      |      |
|                          |                                                                            |          | 100          | 83.0                              | 4880                      | 27    |                                      |      |
| Sulfamethazine           | C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>2</sub> S            | 278.330  | 20           | 0.053                             | 0.53                      | 40    |                                      |      |
| Sulfamethoxazole         | C <sub>10</sub> H <sub>11</sub> N <sub>3</sub> O <sub>3</sub> S            | 253.277  | 25           | 0.0281                            | 0.281                     | 40    |                                      |      |
| Sulfathiazole            | C <sub>9</sub> H <sub>9</sub> N <sub>3</sub> O <sub>2</sub> S <sub>2</sub> | 255.316  | 20           | 0.048                             | 0.48                      | 40    |                                      |      |
| Sulfisoxazole            | C <sub>11</sub> H <sub>13</sub> N <sub>3</sub> O <sub>3</sub> S            | 267.304  | 37           | 0.03                              | 0.3                       | 40    |                                      |      |
| <i>DL</i> -Tartaric acid | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                               | 150.087  | 0            | 8.95                              | 98.3                      | 26    |                                      |      |
|                          |                                                                            |          | 20           | 17.1                              | 206                       | 26    |                                      |      |
|                          |                                                                            |          | 100          | 65                                | 1860                      | 26    |                                      |      |
| <i>L</i> -Tartaric acid  | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>                               | 150.087  | 20           | 58                                | 1380                      | 26    |                                      |      |
|                          |                                                                            |          | 100          | 77                                | 3350                      | 26    |                                      |      |
| Tebuthiuron              | C <sub>9</sub> H <sub>16</sub> N <sub>4</sub> OS                           | 228.314  | 20           | 0.23                              | 2.3                       | 40    |                                      |      |
| Terbacil                 | C <sub>9</sub> H <sub>13</sub> ClN <sub>2</sub> O <sub>2</sub>             | 216.664  | 25           | 0.071                             | 0.71                      | 40    |                                      |      |
| Terephthalic acid        | C <sub>8</sub> H <sub>6</sub> O <sub>4</sub>                               | 166.132  | 10           | 0.0082                            | 0.082                     | 76    |                                      |      |
|                          |                                                                            |          | 25           | 0.0065                            | 0.065                     | 76    |                                      |      |
|                          |                                                                            |          | 50           | 0.0074                            | 0.074                     | 76    |                                      |      |
| <i>o</i> -Terphenyl      | C <sub>18</sub> H <sub>14</sub>                                            | 230.304  | 25           | 0.000124                          | 0.00124                   | 42,40 |                                      |      |



| Name                                                   | Mol. Form.                                                    | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |       | Henry Const., <i>k<sub>H</sub></i>   |      |
|--------------------------------------------------------|---------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|-------|--------------------------------------|------|
|                                                        |                                                               |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| <i>m</i> -Terphenyl                                    | C <sub>18</sub> H <sub>14</sub>                               | 230.304  | 25           | 0.000152                          | 0.00152                   | 42,40 |                                      |      |
| <i>p</i> -Terphenyl                                    | C <sub>18</sub> H <sub>14</sub>                               | 230.304  | 25           | 0.00000180                        | 0.000018                  | 42,40 |                                      |      |
| α-Terpineol                                            | C <sub>10</sub> H <sub>18</sub> O                             | 154.249  | 25           | 0.189                             | 1.89                      | 52    |                                      |      |
| 1,2,4,5-Tetrabromobenzene                              | C <sub>6</sub> H <sub>2</sub> Br <sub>4</sub>                 | 393.696  | 25           | 0.00000434                        | 0.0000434                 | 2     |                                      |      |
| 1,1,2,2-Tetrabromoethane                               | C <sub>2</sub> H <sub>2</sub> Br <sub>4</sub>                 | 345.653  | 0            | 0.052                             | 0.52                      | 25    |                                      |      |
|                                                        |                                                               |          | 25           | 0.068                             | 0.68                      | 25    |                                      |      |
|                                                        |                                                               |          | 50           | 0.106                             | 1.06                      | 25    |                                      |      |
|                                                        |                                                               |          | 100          | 0.307                             | 3.07                      | 25    |                                      |      |
| Tetrabromomethane                                      | CBr <sub>4</sub>                                              | 331.627  | 30           | 0.024                             | 0.24                      | 14    |                                      |      |
| 1,2,3,4-Tetrachlorobenzene                             | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 215.892  | 25           | 0.0007                            | 0.007                     | 41    | 0.144                                | 11   |
| 1,2,3,5-Tetrachlorobenzene                             | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 215.892  | 25           | 0.00035                           | 0.0035                    | 41    | 0.59                                 | 11   |
| 1,2,4,5-Tetrachlorobenzene                             | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 215.892  | 25           | 0.000060                          | 0.00060                   | 41    | 0.122                                | 11   |
| 3,4,5,6-Tetrachloro-1,2-benzenediol                    | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub> O <sub>2</sub>  | 247.891  | 25           | 0.071                             | 0.71                      | 8     |                                      |      |
| 2,2',4',5-Tetrachlorobiphenyl                          | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub>                | 291.988  | 25           | 0.0000016                         | 0.000016                  | 9     |                                      |      |
| 2,3,4,5-Tetrachlorobiphenyl                            | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub>                | 291.988  | 25           | 0.000002                          | 0.00002                   | 7     |                                      |      |
| 2,3,5,6-Tetrachloro-2,5-cyclohexadiene-1,4-dione       | C <sub>6</sub> Cl <sub>4</sub> O <sub>2</sub>                 | 245.875  | 20           | 0.025                             | 0.25                      | 40    |                                      |      |
| 2,3,7,8-Tetrachlorodibenzo- <i>p</i> -dioxin           | C <sub>12</sub> H <sub>4</sub> Cl <sub>4</sub> O <sub>2</sub> | 321.971  | 22           | 0.0000000019                      | 0.000000019               | 40    |                                      |      |
| 1,1,2,2-Tetrachloro-1,2-difluoroethane                 | C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>                 | 203.830  | 27           | 0.016                             | 0.16                      | 25    |                                      |      |
| 1,1,1,2-Tetrachloroethane                              | C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 167.849  | 0            | 0.120                             | 1.20                      | 25    |                                      |      |
|                                                        |                                                               |          | 25           | 0.107                             | 1.07                      | 25    | 0.24                                 | 13   |
|                                                        |                                                               |          | 50           | 0.123                             | 1.23                      | 25    |                                      |      |
| 1,1,2,2-Tetrachloroethane                              | C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                 | 167.849  | 5            | 0.302                             | 3.02                      | 25    |                                      |      |
|                                                        |                                                               |          | 25           | 0.283                             | 2.83                      | 25    | 0.026                                | 13   |
|                                                        |                                                               |          | 50           | 0.318                             | 3.18                      | 25    |                                      |      |
| Tetrachloroethene                                      | C <sub>2</sub> Cl <sub>4</sub>                                | 165.833  | 0            | 0.0273                            | 0.273                     | 20    |                                      |      |
|                                                        |                                                               |          | 20           | 0.0286                            | 0.286                     | 20    | 1.73                                 | 13   |
|                                                        |                                                               |          | 80           | 0.0380                            | 0.380                     | 20    |                                      |      |
| Tetrachloromethane                                     | CCl <sub>4</sub>                                              | 153.823  | 25           | 0.065                             | 0.65                      | 20    | 2.99                                 | 13   |
|                                                        |                                                               |          | 75           | 0.115                             | 1.15                      | 20    | 2.99                                 | 13   |
| 2,3,4,6-Tetrachloro-5-methylphenol                     | C <sub>7</sub> H <sub>4</sub> Cl <sub>4</sub> O               | 245.918  | 25           | 0.00061                           | 0.0061                    | 2     |                                      |      |
| 2,3,4,6-Tetrachlorophenol                              | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub> O               | 231.891  | 25           | 0.017                             | 0.17                      | 24    |                                      |      |
| 1,1,1,3-Tetrachloro-2,2,3,3-tetrafluoropropane         | C <sub>3</sub> Cl <sub>4</sub> F <sub>4</sub>                 | 253.838  | 21           | 0.0052                            | 0.052                     | 35    |                                      |      |
| Tetracosane                                            | C <sub>24</sub> H <sub>50</sub>                               | 338.654  | 22           | 0.0000004                         | 0.000004                  | 37    |                                      |      |
| Tetradecane                                            | C <sub>14</sub> H <sub>30</sub>                               | 198.388  | 25           | 0.00000023                        | 0.0000023                 | 42,5  |                                      |      |
| Tetradecanoic acid                                     | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>                | 228.371  | 20           | 0.0020                            | 0.020                     | 26    |                                      |      |
| 1-Tetradecanol                                         | C <sub>14</sub> H <sub>30</sub> O                             | 214.387  | 25           | 0.000031                          | 0.00031                   | 1     |                                      |      |
| Tetraethylsilane                                       | C <sub>8</sub> H <sub>20</sub> Si                             | 144.331  | 25           | 0.0000325                         | 0.000325                  | 10    |                                      |      |
| Tetrafluoroethene                                      | C <sub>2</sub> F <sub>4</sub>                                 | 100.015  | 25           | 0.0158*                           | 0.158*                    | 19,50 |                                      |      |
|                                                        |                                                               |          | 70           | 0.0090*                           | 0.090*                    | 50    |                                      |      |
| Tetrafluoromethane                                     | CF <sub>4</sub>                                               | 88.005   | 0            | 0.00390*                          | 0.0390*                   | 50    |                                      |      |
|                                                        |                                                               |          | 25           | 0.00185*                          | 0.0185*                   | 50,19 |                                      |      |
|                                                        |                                                               |          | 50           | 0.00134*                          | 0.0134*                   | 50    |                                      |      |
| Tetrahydro-2,5-dimethoxyfuran                          | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                 | 132.157  | 21           | 32                                | 470                       | 20    |                                      |      |
|                                                        |                                                               |          | 90           | 19                                | 235                       | 20    |                                      |      |
| 1,2,3,4-Tetrahydronaphthalene                          | C <sub>10</sub> H <sub>12</sub>                               | 132.202  | 20           | 0.0045                            | 0.045                     | 40    |                                      |      |
| Tetrahydropyran                                        | C <sub>5</sub> H <sub>10</sub> O                              | 86.132   | 20           | 8.57                              | 93.7                      | 20    |                                      |      |
|                                                        |                                                               |          | 81           | 4.29                              | 44.8                      | 20    |                                      |      |
| 1,2,4,5-Tetramethylbenzene                             | C <sub>10</sub> H <sub>14</sub>                               | 134.218  | 25           | 0.000348                          | 0.00348                   | 4     | 2.55                                 | 11   |
| <i>N,N,N',N'</i> -Tetramethyl-4,4'-diaminobenzophenone | C <sub>17</sub> H <sub>20</sub> N <sub>2</sub> O              | 268.353  | 20           | 0.04                              | 0.4                       | 40    |                                      |      |

| Name                              | Mol. Form.                                                      | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>                 |                           |       | Henry Const., <i>k<sub>H</sub></i>      |      |
|-----------------------------------|-----------------------------------------------------------------|----------|--------------|--------------------------------------|---------------------------|-------|-----------------------------------------|------|
|                                   |                                                                 |          |              | 100 <i>w</i> <sub>2</sub><br>(mass%) | g per kg H <sub>2</sub> O | Ref.  | kPa<br>m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| Tetramethylsilane                 | C <sub>4</sub> H <sub>12</sub> Si                               | 88.224   | 25           | 0.00196                              | 0.0196                    | 10    |                                         |      |
| Theophylline                      | C <sub>7</sub> H <sub>8</sub> N <sub>4</sub> O <sub>2</sub>     | 180.165  | 20           | 0.52                                 | 5.2                       | 29    |                                         |      |
| Thioacetamide                     | C <sub>2</sub> H <sub>5</sub> NS                                | 75.133   | 25           | 12.3                                 | 140                       | 40    |                                         |      |
| Thiourea                          | CH <sub>4</sub> N <sub>2</sub> S                                | 76.121   | 20           | 10.6                                 | 119                       | 40    |                                         |      |
|                                   |                                                                 |          | 80           | ≈37                                  | ≈590                      | 40    |                                         |      |
| 2-Thioxo-4-thiazolidinone         | C <sub>3</sub> H <sub>3</sub> NOS <sub>2</sub>                  | 133.192  | 25           | 0.225                                | 2.25                      | 40    |                                         |      |
| Thiram                            | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> S <sub>4</sub>    | 240.432  | 20           | 0.003                                | 0.03                      | 40    |                                         |      |
| <i>DL</i> -Threonine              | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                   | 119.119  | 10           | 14.34                                | 167                       | 45    |                                         |      |
|                                   |                                                                 |          | 20           | 15.69                                | 186                       | 45    |                                         |      |
|                                   |                                                                 |          | 40           | 19.84                                | 248                       | 45    |                                         |      |
| <i>L</i> -Threonine               | C <sub>4</sub> H <sub>9</sub> NO <sub>3</sub>                   | 119.119  | 10           | 7.34                                 | 79.2                      | 45    |                                         |      |
|                                   |                                                                 |          | 20           | 8.31                                 | 90.6                      | 45    |                                         |      |
|                                   |                                                                 |          | 40           | 10.78                                | 121                       | 45    |                                         |      |
| Thymidine                         | C <sub>10</sub> H <sub>14</sub> N <sub>2</sub> O <sub>5</sub>   | 242.228  | 25           | 5.1                                  | 54                        | 29    |                                         |      |
| Thymine                           | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>     | 126.114  | 25           | 0.35                                 | 3.5                       | 29    |                                         |      |
| Thymol                            | C <sub>10</sub> H <sub>14</sub> O                               | 150.217  |              | 0.1                                  | 1                         | 30    |                                         |      |
| Tolazamide                        | C <sub>14</sub> H <sub>21</sub> N <sub>3</sub> O <sub>3</sub> S | 311.400  | 30           | 0.0065                               | 0.065                     | 40    |                                         |      |
| Tolbutamide                       | C <sub>12</sub> H <sub>18</sub> N <sub>2</sub> O <sub>3</sub> S | 270.347  | 25           | 0.011                                | 0.11                      | 40    |                                         |      |
| <i>o</i> -Tolidine                | C <sub>14</sub> H <sub>16</sub> N <sub>2</sub>                  | 212.290  | 25           | 0.13                                 | 1.3                       | 40    |                                         |      |
| Toluene                           | C <sub>7</sub> H <sub>8</sub>                                   | 92.139   | 5            | 0.054                                | 0.54                      | 61    |                                         |      |
|                                   |                                                                 |          | 25           | 0.0519                               | 0.519                     | 61,22 | 0.660                                   | 22   |
|                                   |                                                                 |          | 45           | 0.063                                | 0.63                      | 61    |                                         |      |
|                                   |                                                                 |          | 90           | 0.12                                 | 1.2                       | 22    |                                         |      |
| <i>p</i> -Toluenesulfonic acid    | C <sub>7</sub> H <sub>8</sub> O <sub>3</sub> S                  | 172.202  | 40           | ≈33                                  | ≈490                      | 40    |                                         |      |
| <i>o</i> -Toluic acid             | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                    | 136.149  | 25           | 0.118                                | 1.18                      | 27    |                                         |      |
| <i>m</i> -Toluic acid             | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                    | 136.149  | 25           | 0.098                                | 0.98                      | 27    |                                         |      |
| <i>p</i> -Toluic acid             | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>                    | 136.149  | 10           | 0.030                                | 0.30                      | 75    |                                         |      |
|                                   |                                                                 |          | 25           | 0.036                                | 0.36                      | 75    |                                         |      |
|                                   |                                                                 |          | 50           | 0.089                                | 0.89                      | 75    |                                         |      |
| 1,3,5-Triazine-2,4,6-triamine     | C <sub>3</sub> H <sub>6</sub> N <sub>6</sub>                    | 126.120  | 20           | 0.323                                | 3.23                      | 40    |                                         |      |
|                                   |                                                                 |          | 95           | 4.2                                  | 44                        | 40    |                                         |      |
| 1 <i>H</i> -1,2,4-Triazol-3-amine | C <sub>2</sub> H <sub>4</sub> N <sub>4</sub>                    | 84.080   | 23           | 22                                   | 280                       | 26    |                                         |      |
| 1,2,4-Tribromobenzene             | C <sub>6</sub> H <sub>3</sub> Br <sub>3</sub>                   | 314.800  | 25           | 0.0010                               | 0.010                     | 2     |                                         |      |
| 1,3,5-Tribromobenzene             | C <sub>6</sub> H <sub>3</sub> Br <sub>3</sub>                   | 314.800  | 25           | 0.0000789                            | 0.000789                  | 2     |                                         |      |
| 1,1,2-Tribromoethane              | C <sub>2</sub> H <sub>3</sub> Br <sub>3</sub>                   | 266.757  | 20           | 0.050                                | 0.50                      | 25    |                                         |      |
| Tribromofluoromethane             | CBr <sub>3</sub> F                                              | 270.721  | 25           | 0.040                                | 0.40                      | 14    |                                         |      |
| Tribromomethane                   | CHBr <sub>3</sub>                                               | 252.731  | 25           | 0.30                                 | 3.0                       | 5     | 0.047                                   | 13   |
| 2,4,6-Tribromophenol              | C <sub>6</sub> H <sub>3</sub> Br <sub>3</sub> O                 | 330.799  | 15           | 0.0007                               | 0.007                     | 2     |                                         |      |
| Tributylamine                     | C <sub>12</sub> H <sub>27</sub> N                               | 185.349  | 25           | 0.0142                               | 0.142                     | 40    |                                         |      |
| Tributyl phosphate                | C <sub>12</sub> H <sub>27</sub> O <sub>4</sub> P                | 266.313  | 25           | 0.039                                | 0.39                      | 10    |                                         |      |
| Tributyrin                        | C <sub>15</sub> H <sub>26</sub> O <sub>6</sub>                  | 302.363  | 20           | 0.010                                | 0.10                      | 40    |                                         |      |
| Trichloroacetaldehyde             | C <sub>2</sub> HCl <sub>3</sub> O                               | 147.387  | 25           | ≈39                                  | ≈640                      | 40    |                                         |      |
| Trichloroacetic acid              | C <sub>2</sub> HCl <sub>3</sub> O <sub>2</sub>                  | 163.387  | 25           | 92.3                                 | 11990                     | 27    |                                         |      |
| 1,2,3-Trichlorobenzene            | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>                   | 181.447  | 25           | 0.0021                               | 0.021                     | 41    | 0.242                                   | 11   |
| 1,2,4-Trichlorobenzene            | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>                   | 181.447  | 15           | 0.0029                               | 0.029                     | 61    |                                         |      |
|                                   |                                                                 |          | 25           | 0.0037                               | 0.037                     | 61,41 | 0.277                                   | 11   |
|                                   |                                                                 |          | 45           | 0.0047                               | 0.047                     | 61    |                                         |      |
| 1,3,5-Trichlorobenzene            | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>                   | 181.447  | 25           | 0.0008                               | 0.008                     | 41    | 1.1                                     | 11   |
| 3,4,5-Trichloro-1,2-benzenediol   | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O <sub>2</sub>    | 213.446  | 25           | 0.051                                | 0.51                      | 8     |                                         |      |

| Name                                          | Mol. Form.                                                    | Mol. Wt. | t/°C | Solubility, s     |                           |          | Henry Const., $k_H$                  |      |
|-----------------------------------------------|---------------------------------------------------------------|----------|------|-------------------|---------------------------|----------|--------------------------------------|------|
|                                               |                                                               |          |      | 100 $w_2$ (mass%) | g per kg H <sub>2</sub> O | Ref.     | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 2,4,5-Trichlorobiphenyl                       | C <sub>12</sub> H <sub>7</sub> Cl <sub>3</sub>                | 257.543  | 25   | 0.000014          | 0.00014                   | 7        | 0.0379                               | 31   |
| 2,4,6-Trichlorobiphenyl                       | C <sub>12</sub> H <sub>7</sub> Cl <sub>3</sub>                | 257.543  | 25   | 0.00002           | 0.0002                    | 7        | 0.0495                               | 7    |
| 1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane | C <sub>14</sub> H <sub>9</sub> Cl <sub>5</sub>                | 354.486  | 25   | 0.0000004         | 0.000004                  | 67       |                                      |      |
| 2,4,6-Trichloro-3,5-dimethylphenol            | C <sub>8</sub> H <sub>7</sub> Cl <sub>3</sub> O               | 225.500  | 25   | 0.00050           | 0.0050                    | 2        |                                      |      |
| 1,1,1-Trichloroethane                         | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                 | 133.404  | 0    | 0.134             | 1.34                      | 25       |                                      |      |
|                                               |                                                               |          | 25   | 0.129             | 1.29                      | 25       | 1.76                                 | 13   |
|                                               |                                                               |          | 50   | 0.138             | 1.38                      | 25       |                                      |      |
| 1,1,2-Trichloroethane                         | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                 | 133.404  | 0    | 0.425             | 4.25                      | 25       |                                      |      |
|                                               |                                                               |          | 25   | 0.459             | 4.59                      | 25       | 0.092                                | 13   |
|                                               |                                                               |          | 50   | 0.536             | 5.36                      | 25       |                                      |      |
| Trichloroethene                               | C <sub>2</sub> HCl <sub>3</sub>                               | 131.388  | 0    | 0.145             | 1.45                      | 25       |                                      |      |
|                                               |                                                               |          | 25   | 0.128             | 1.28                      | 25       | 1.03                                 | 13   |
|                                               |                                                               |          | 60   | 0.133             | 1.33                      | 25       |                                      |      |
| Trichlorofluoromethane                        | CCl <sub>3</sub> F                                            | 137.368  | 20   | 0.11              | 1.1                       | 5        | 10.2                                 | 13   |
| Trichloromethane                              | CHCl <sub>3</sub>                                             | 119.378  | 25   | 0.80              | 8.0                       | 20       | 0.43                                 | 13   |
|                                               |                                                               |          | 59   | 0.79              | 7.9                       | 20       | 0.43                                 | 13   |
| 1,2,4-Trichloro-5-methylbenzene               | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub>                 | 195.474  | 25   | 0.00023           | 0.0023                    | 61       |                                      |      |
| (Trichloromethyl)benzene                      | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub>                 | 195.474  | 5    | 0.0053            | 0.053                     | 10       |                                      |      |
| 2,4,6-Trichloro-3-methylphenol                | C <sub>7</sub> H <sub>5</sub> Cl <sub>3</sub> O               | 211.473  | 25   | 0.0112            | 0.112                     | 2        |                                      |      |
| Trichloronitromethane                         | CCl <sub>3</sub> NO <sub>2</sub>                              | 164.376  | 0    | 0.227             | 2.27                      | 40       |                                      |      |
|                                               |                                                               |          | 25   | 0.162             | 1.62                      | 40       |                                      |      |
| 1,1,1-Trichloro-2,2,3,3,3-pentafluoropropane  | C <sub>3</sub> Cl <sub>3</sub> F <sub>5</sub>                 | 237.383  | 21   | 0.0058            | 0.058                     | 35       |                                      |      |
| 2,4,5-Trichlorophenol                         | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O               | 197.446  | 25   | 0.1               | 1                         | 2        |                                      |      |
| 2,4,6-Trichlorophenol                         | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> O               | 197.446  | 25   | 0.069             | 0.69                      | 48,51,24 |                                      |      |
| 2,4,5-Trichlorophenoxyacetic acid             | C <sub>8</sub> H <sub>5</sub> Cl <sub>3</sub> O <sub>3</sub>  | 255.483  | 25   | 0.028             | 0.28                      | 40       |                                      |      |
| 1,2,3-Trichloropropane                        | C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>                 | 147.431  | 10   | 0.14              | 1.4                       | 35       |                                      |      |
|                                               |                                                               |          | 25   | 0.20              | 2.0                       | 35       | 0.038                                | 13   |
| 1,1,2-Trichloro-1,2,2-trifluoroethane         | C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>                 | 187.375  | 25   | 0.017             | 0.17                      | 25       | 32                                   | 13   |
| Tri- <i>p</i> -cresyl phosphate               | C <sub>21</sub> H <sub>21</sub> O <sub>4</sub> P              | 368.363  | 25   | 0.00004           | 0.0004                    | 40       |                                      |      |
| Tridecane                                     | C <sub>13</sub> H <sub>28</sub>                               | 184.361  | 25   | 0.000000033       | 0.00000033                | 37       |                                      |      |
| Tridecanoic acid                              | C <sub>13</sub> H <sub>26</sub> O <sub>2</sub>                | 214.344  | 20   | 0.0033            | 0.033                     | 26       |                                      |      |
| Triethylamine                                 | C <sub>6</sub> H <sub>15</sub> N                              | 101.190  | 20   | 5.5               | 58                        | 10       |                                      |      |
| Triethylamine hydrochloride                   | C <sub>6</sub> H <sub>16</sub> ClN                            | 137.651  | 25   | 57.8              | 1370                      | 27       |                                      |      |
| Trifluoromethane                              | CHF <sub>3</sub>                                              | 70.014   | 25   | 0.15*             | 1.5*                      | 50,14    |                                      |      |
| 3,4,5-Trihydroxybenzoic acid                  | C <sub>7</sub> H <sub>6</sub> O <sub>5</sub>                  | 170.120  | 25   | 1.52              | 15.4                      | 74       |                                      |      |
|                                               |                                                               |          | 50   | 3.82              | 39.7                      | 74       |                                      |      |
|                                               |                                                               |          | 100  | 25.0              | 333                       | 27       |                                      |      |
| Triiodomethane                                | CHI <sub>3</sub>                                              | 393.732  | 25   | 0.012             | 0.12                      | 14       |                                      |      |
| Trimethoprim                                  | C <sub>14</sub> H <sub>18</sub> N <sub>4</sub> O <sub>3</sub> | 290.318  | 25   | 0.04              | 0.4                       | 40       |                                      |      |
| 1,2,3-Trimethylbenzene                        | C <sub>9</sub> H <sub>12</sub>                                | 120.191  | 25   | 0.0070            | 0.070                     | 22       | 0.343                                | 22   |
| 1,2,4-Trimethylbenzene                        | C <sub>9</sub> H <sub>12</sub>                                | 120.191  | 25   | 0.0057            | 0.057                     | 22       | 0.569                                | 22   |
| 1,3,5-Trimethylbenzene                        | C <sub>9</sub> H <sub>12</sub>                                | 120.191  | 25   | 0.0050            | 0.050                     | 22       | 0.781                                | 22   |
| 2,3,3-Trimethyl-2-butanol                     | C <sub>7</sub> H <sub>16</sub> O                              | 116.201  | 40   | 2.2               | 22                        | 1        |                                      |      |
| 1,1,3-Trimethylcyclohexane                    | C <sub>9</sub> H <sub>18</sub>                                | 126.239  | 25   | 0.000177          | 0.00177                   | 4        | 105                                  | 13   |
| 1,1,3-Trimethylcyclopentane                   | C <sub>8</sub> H <sub>16</sub>                                | 112.213  | 25   | 0.00037           | 0.0037                    | 4        | 159                                  | 5    |
| 2,2,5-Trimethylhexane                         | C <sub>9</sub> H <sub>20</sub>                                | 128.255  | 25   | 0.00008           | 0.0008                    | 4        | 246                                  | 13   |
| 1,4,5-Trimethylnaphthalene                    | C <sub>13</sub> H <sub>14</sub>                               | 170.250  | 25   | 0.00021           | 0.0021                    | 42,4     |                                      |      |
| 2,6,8-Trimethyl-4-nonanone                    | C <sub>12</sub> H <sub>24</sub> O                             | 184.318  | 10   | 0.012             | 0.12                      | 20       |                                      |      |
|                                               |                                                               |          | 80   | 0.014             | 0.14                      | 20       |                                      |      |

| Name                                                    | Mol. Form.                                                      | Mol. Wt. | <i>t</i> /°C | Solubility, <i>s</i>              |                           |      | Henry Const., <i>k<sub>H</sub></i>   |      |
|---------------------------------------------------------|-----------------------------------------------------------------|----------|--------------|-----------------------------------|---------------------------|------|--------------------------------------|------|
|                                                         |                                                                 |          |              | 100 <i>w</i> <sub>2</sub> (mass%) | g per kg H <sub>2</sub> O | Ref. | kPa m <sup>3</sup> mol <sup>-1</sup> | Ref. |
| 2,2,4-Trimethylpentane                                  | C <sub>8</sub> H <sub>18</sub>                                  | 114.229  | 25           | 0.00022                           | 0.0022                    | 4    | 307                                  | 13   |
| 2,3,4-Trimethylpentane                                  | C <sub>8</sub> H <sub>18</sub>                                  | 114.229  | 25           | 0.00018                           | 0.0018                    | 4    | 206                                  | 13   |
| Trimethyl phosphate                                     | C <sub>3</sub> H <sub>9</sub> O <sub>4</sub> P                  | 140.074  | 25           | ≈33                               | ≈490                      | 40   |                                      |      |
| 1,3,5-Trinitrobenzene                                   | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>6</sub>     | 213.104  | 15           | 0.028                             | 0.28                      | 40   |                                      |      |
| 2,4,6-Trinitrobenzoic acid                              | C <sub>7</sub> H <sub>3</sub> N <sub>3</sub> O <sub>8</sub>     | 257.114  | 23           | 1.97                              | 20.1                      | 40   |                                      |      |
| Trinitroglycerol                                        | C <sub>3</sub> H <sub>5</sub> N <sub>3</sub> O <sub>9</sub>     | 227.087  | 25           | 0.13                              | 1.3                       | 40   |                                      |      |
|                                                         |                                                                 |          | 80           | 0.34                              | 3.4                       | 40   |                                      |      |
| 2,4,6-Trinitrophenol                                    | C <sub>6</sub> H <sub>3</sub> N <sub>3</sub> O <sub>7</sub>     | 229.104  | 25           | 1.25                              | 12.7                      | 40   |                                      |      |
|                                                         |                                                                 |          | 90           | 4.9                               | 52                        | 40   |                                      |      |
| 2,4,6-Trinitrotoluene                                   | C <sub>7</sub> H <sub>5</sub> N <sub>3</sub> O <sub>6</sub>     | 227.131  | 20           | 0.012                             | 0.12                      | 40   |                                      |      |
|                                                         |                                                                 |          | 100          | 0.15                              | 1.5                       | 40   |                                      |      |
| 2,4,6-Trinitro- <i>N</i> -(2,4,6-trinitrophenyl)aniline | C <sub>12</sub> H <sub>5</sub> N <sub>7</sub> O <sub>12</sub>   | 439.208  | 17           | 0.0060                            | 0.060                     | 40   |                                      |      |
| 1,3,5-Trioxane                                          | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>                    | 90.078   | 25           | 17.4                              | 211                       | 30   |                                      |      |
| Triphenylene                                            | C <sub>18</sub> H <sub>12</sub>                                 | 228.288  | 25           | 0.0000043                         | 0.000043                  | 42,4 | 0.00001                              | 12   |
| Triphenyl phosphate                                     | C <sub>18</sub> H <sub>15</sub> O <sub>4</sub> P                | 326.283  | 24           | 0.000073                          | 0.00073                   | 40   |                                      |      |
| Triphenyltin hydroxide                                  | C <sub>18</sub> H <sub>16</sub> OSn                             | 367.029  | 20           | 0.0001                            | 0.001                     | 32   |                                      |      |
| Tris(hydroxymethyl)methylamine                          | C <sub>4</sub> H <sub>11</sub> NO <sub>3</sub>                  | 121.135  | 25           | ≈41                               | ≈700                      | 40   |                                      |      |
| <i>L</i> -Tryptophan                                    | C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>   | 204.225  | 25           | 1.30                              | 13.2                      | 26   |                                      |      |
| <i>DL</i> -Tyrosine                                     | C <sub>9</sub> H <sub>11</sub> NO <sub>3</sub>                  | 181.188  | 25           | 0.35                              | 3.5                       | 30   |                                      |      |
| <i>L</i> -Tyrosine                                      | C <sub>9</sub> H <sub>11</sub> NO <sub>3</sub>                  | 181.188  | 25           | 0.0507                            | 0.507                     | 62   |                                      |      |
| Undecane                                                | C <sub>11</sub> H <sub>24</sub>                                 | 156.309  | 25           | 0.0000004                         | 0.000004                  | 37   |                                      |      |
| Uracil                                                  | C <sub>4</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>     | 112.087  | 25           | 0.460                             | 4.62                      | 72   |                                      |      |
| Urea                                                    | CH <sub>4</sub> N <sub>2</sub> O                                | 60.055   | 5            | 44                                | 790                       | 26   |                                      |      |
|                                                         |                                                                 |          | 25           | 54.4                              | 1200                      | 26   |                                      |      |
| Uric acid                                               | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>3</sub>     | 168.111  | 20           | 0.002                             | 0.02                      | 26   |                                      |      |
| <i>L</i> -Valine                                        | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>                  | 117.147  | 25           | 8.13                              | 88.5                      | 26   |                                      |      |
| Valium                                                  | C <sub>16</sub> H <sub>13</sub> ClN <sub>2</sub> O              | 284.739  | 25           | 0.005                             | 0.05                      | 40   |                                      |      |
| Vidarabine                                              | C <sub>10</sub> H <sub>15</sub> N <sub>5</sub> O <sub>5</sub>   | 285.257  | 20           | 0.051                             | 0.51                      | 40   |                                      |      |
| Vinclozolin                                             | C <sub>12</sub> H <sub>9</sub> Cl <sub>2</sub> NO <sub>3</sub>  | 286.110  | 20           | 0.1                               | 1                         | 32   |                                      |      |
| Vinyl acetate                                           | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                    | 86.090   | 20           | 2.0                               | 20                        | 10   |                                      |      |
| 4-Vinylcyclohexene                                      | C <sub>8</sub> H <sub>12</sub>                                  | 108.181  | 25           | 0.005                             | 0.05                      | 4    |                                      |      |
| Warfarin                                                | C <sub>19</sub> H <sub>16</sub> O <sub>4</sub>                  | 308.328  | 20           | 0.004                             | 0.04                      | 40   |                                      |      |
| Xanthine                                                | C <sub>5</sub> H <sub>4</sub> N <sub>4</sub> O <sub>2</sub>     | 152.112  | 20           | 0.05                              | 0.5                       | 26   |                                      |      |
| <i>o</i> -Xylene                                        | C <sub>8</sub> H <sub>10</sub>                                  | 106.165  | 25           | 0.0171                            | 0.171                     | 22   | 0.551                                | 22   |
|                                                         |                                                                 |          | 45           | 0.021                             | 0.21                      | 4    |                                      |      |
| <i>m</i> -Xylene                                        | C <sub>8</sub> H <sub>10</sub>                                  | 106.165  | 0            | 0.0203                            | 0.203                     | 4    |                                      |      |
|                                                         |                                                                 |          | 25           | 0.0161                            | 0.161                     | 22   | 0.730                                | 22   |
|                                                         |                                                                 |          | 40           | 0.022                             | 0.22                      | 4    |                                      |      |
| <i>p</i> -Xylene                                        | C <sub>8</sub> H <sub>10</sub>                                  | 106.165  | 0            | 0.0160                            | 0.160                     | 4    |                                      |      |
|                                                         |                                                                 |          | 25           | 0.0181                            | 0.181                     | 22   | 0.690                                | 22   |
|                                                         |                                                                 |          | 40           | 0.022                             | 0.22                      | 4    |                                      |      |
| 2,3-Xylenol                                             | C <sub>8</sub> H <sub>10</sub> O                                | 122.164  | 25           | 0.457                             | 4.57                      | 40   |                                      |      |
| 2,4-Xylenol                                             | C <sub>8</sub> H <sub>10</sub> O                                | 122.164  | 25           | 0.787                             | 7.87                      | 10   |                                      |      |
| 2,5-Xylenol                                             | C <sub>8</sub> H <sub>10</sub> O                                | 122.164  | 25           | 0.354                             | 3.54                      | 40   |                                      |      |
| 2,6-Xylenol                                             | C <sub>8</sub> H <sub>10</sub> O                                | 122.164  | 25           | 0.60                              | 6.0                       | 40   |                                      |      |
| 3,4-Xylenol                                             | C <sub>8</sub> H <sub>10</sub> O                                | 122.164  | 25           | 0.477                             | 4.77                      | 40   |                                      |      |
| 3,5-Xylenol                                             | C <sub>8</sub> H <sub>10</sub> O                                | 122.164  | 29           | 0.62                              | 6.2                       | 10   |                                      |      |
| <i>D</i> -Xylose                                        | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                   | 150.130  | 25           | ≈30                               | ≈430                      | 40   |                                      |      |
| Ziram                                                   | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub> S <sub>4</sub> Zn | 305.841  | 20           | 0.0065                            | 0.065                     | 40   |                                      |      |

# AQUEOUS SOLUBILITY OF INORGANIC COMPOUNDS AT VARIOUS TEMPERATURES

The solubility of over 300 common inorganic compounds in water is tabulated here as a function of temperature. Solubility is defined as the concentration of the compound in a solution that is in equilibrium with a solid phase at the specified temperature. In this table the solid phase is generally the most stable crystalline phase at the temperature in question. An asterisk \* on solubility values in adjacent columns indicates that the solid phase changes between those two temperatures (usually from one hydrated phase to another or from a hydrate to the anhydrous solid). In such cases the slope of the solubility vs. temperature curve may show a discontinuity.

All solubility values are expressed as mass percent of solute,  $100w_2$ , where

$$w_2 = m_2 / (m_1 + m_2)$$

and  $m_2$  is the mass of solute and  $m_1$  the mass of water. This quantity is related to other common measures of solubility as follows:

Molarity:  $c_2 = 1000 \rho w_2 / M_2$

Molality:  $m_2 = 1000 w_2 / M_2 (1 - w_2)$

Mole fraction:  $x_2 = (w_2 / M_2) / \{ (w_2 / M_2) + (1 - w_2) / M_1 \}$

Mass of solute per 100 g of  $H_2O$ :  $r_2 = 100 w_2 / (1 - w_2)$

Here  $M_2$  is the molar mass of the solute and  $M_1 = 18.015$  g/mol is the molar mass of water.  $\rho$  is the density of the solution in  $g\ cm^{-3}$ .

The data in the table have been derived from the references indicated; in many cases the data have been refitted or interpolated in order to present solubility at rounded values of temperature. Where available, values were taken from the IUPAC *Solubility Data Series* (Reference 1) or the related papers in the *Journal of Physical and Chemical Reference Data* (References 2 to 5), which present carefully evaluated data.

The solubility of sparingly soluble compounds that do not appear in this table may be calculated from the data in the table "Solubility Product Constants". Solubility of inorganic gases may be found in the table "Solubility of Selected Gases in Water".

Compounds are listed alphabetically by chemical formula in the most commonly used form (e.g., NaCl,  $NH_4NO_3$ , etc.).

## References

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| Compound                                                       | 0°C   | 10°C  | 20°C  | 25°C  | 30°C  | 40°C  | 50°C  | 60°C  | 70°C  | 80°C  | 90°C  | 100°C | Ref. |
|----------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
| AgBrO <sub>3</sub>                                             |       |       |       | 0.193 |       |       |       |       |       |       | 1.32  |       | 7    |
| AgClO <sub>2</sub>                                             | 0.17  | 0.31  | 0.47  | 0.55  | 0.64  | 0.82  | 1.02  | 1.22  | 1.44  | 1.66  | 1.88  | 2.11  | 7    |
| AgClO <sub>3</sub>                                             |       |       |       | 15    |       |       |       |       |       |       |       |       | 7    |
| AgClO <sub>4</sub>                                             | 81.6  | 83.0  | 84.2  | 84.8  | 85.3  | 86.3  | 86.9  | 87.5  | 87.9  | 88.3  | 88.6  | 88.8  | 6    |
| AgNO <sub>2</sub>                                              | 0.155 |       |       | 0.413 |       |       |       |       |       |       |       |       | 7    |
| AgNO <sub>3</sub>                                              | 55.9  | 62.3  | 67.8  | 70.1  | 72.3  | 76.1  | 79.2  | 81.7  | 83.8  | 85.4  | 86.7  | 87.8  | 6    |
| Ag <sub>2</sub> SO <sub>4</sub>                                | 0.56  | 0.67  | 0.78  | 0.83  | 0.88  | 0.97  | 1.05  | 1.13  | 1.20  | 1.26  | 1.32  | 1.39  | 7    |
| AlCl <sub>3</sub>                                              | 30.84 | 30.91 | 31.03 | 31.10 | 31.18 | 31.37 | 31.60 | 31.87 | 32.17 | 32.51 | 32.90 | 33.32 | 7    |
| Al(ClO <sub>4</sub> ) <sub>3</sub>                             | 54.9  |       |       |       |       |       |       |       |       |       | 64.4  |       | 7    |
| AlF <sub>3</sub>                                               | 0.25  | 0.34  | 0.44  | 0.50  | 0.56  | 0.68  | 0.81  | 0.96  | 1.11  | 1.28  | 1.45  | 1.64  | 7    |
| Al(NO <sub>3</sub> ) <sub>3</sub>                              | 37.0  | 38.2  | 39.9  | 40.8  | 42.0  | 44.5  | 47.3  | 50.4  | 53.8* |       |       | 61.5* | 6    |
| Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>                | 27.5  |       |       | 27.8  | 28.2  | 29.2  | 30.7  | 32.6  | 34.9  | 37.6  | 40.7  | 44.2  | 7    |
| As <sub>2</sub> O <sub>3</sub>                                 | 1.19  | 1.48  | 1.80  | 2.01  | 2.27  | 2.86  | 3.43  | 4.11  | 4.89  | 5.77  | 6.72  | 7.71  | 10   |
| BaBr <sub>2</sub>                                              | 47.6  | 48.5  | 49.5  | 50.0  | 50.4  | 51.4  | 52.5  | 53.5  | 54.5  | 55.5  | 56.6  | 57.6  | 6    |
| Ba(BrO <sub>3</sub> ) <sub>2</sub>                             | 0.285 | 0.442 | 0.656 | 0.788 | 0.935 | 1.30  | 1.74  | 2.27  | 2.90  | 3.61  | 4.40  | 5.25  | 1:14 |
| Ba(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> | 37.0  |       |       | 44.2  |       |       |       |       |       |       |       |       | 7    |
| BaCl <sub>2</sub>                                              | 23.30 | 24.88 | 26.33 | 27.03 | 27.70 | 29.00 | 30.27 | 31.53 | 32.81 | 34.14 | 35.54 | 37.05 | 8    |
| Ba(ClO <sub>2</sub> ) <sub>2</sub>                             | 30.5  |       |       | 31.3  |       |       |       |       |       |       |       | 44.7  | 7    |
| Ba(ClO <sub>3</sub> ) <sub>2</sub>                             | 16.90 | 21.23 | 23.66 | 27.50 | 29.43 | 33.16 | 36.69 | 40.05 | 43.04 | 45.90 | 48.70 | 51.17 | 1:14 |
| Ba(ClO <sub>4</sub> ) <sub>2</sub>                             | 67.30 | 70.96 | 74.30 | 75.75 | 77.05 | 79.23 | 80.92 | 82.21 | 83.16 | 83.88 | 84.43 | 84.90 | 7    |
| BaF <sub>2</sub>                                               |       | 0.158 |       | 0.161 |       |       |       |       |       |       |       |       | 7    |
| BaI <sub>2</sub>                                               | 62.5  | 64.7  | 67.3  | 68.8  | 69.1  | 69.5  | 70.1  | 70.7  | 71.3  | 72.0  | 72.7  | 73.4  | 6    |

| Compound                           | 0°C    | 10°C   | 20°C   | 25°C   | 30°C   | 40°C   | 50°C   | 60°C   | 70°C   | 80°C   | 90°C   | 100°C  | Ref. |
|------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|------|
| Ba(IO <sub>3</sub> ) <sub>2</sub>  | 0.0182 | 0.0262 | 0.0342 | 0.0396 | 0.045* | 0.058* | 0.073  | 0.090  | 0.109  | 0.131  | 0.156  | 0.182  | 1:14 |
| Ba(NO <sub>2</sub> ) <sub>2</sub>  | 31.1   | 36.6   | 41.8   | 44.3   | 46.8   | 51.6   | 56.2   | 60.5   | 64.6   | 68.5   | 72.1   | 75.6   | 10   |
| Ba(NO <sub>3</sub> ) <sub>2</sub>  | 4.7    | 6.3    | 8.2    | 9.3    | 10.2   | 12.4   | 14.7   | 17.0   | 19.3   | 21.5   | 23.5   | 25.5   | 6    |
| Ba(OH) <sub>2</sub>                | 1.67   |        |        | 4.68   | 8.4    | 19     | 33     | 52     | 74     | 100    |        |        | 7    |
| BaS                                | 2.79   | 4.78   | 6.97   | 8.21   | 9.58   | 12.67  | 16.18  | 20.05  | 24.19  | 28.55  | 33.04  | 37.61  | 7    |
| Ba(SCN) <sub>2</sub>               |        |        |        | 62.6   |        |        |        |        |        |        |        |        | 7    |
| BaSO <sub>3</sub>                  |        |        |        | 0.0011 |        |        |        |        |        |        |        |        | 1:26 |
| BeCl <sub>2</sub>                  | 40.5   |        |        | 41.7   |        |        |        |        |        |        |        |        | 7    |
| Be(ClO <sub>4</sub> ) <sub>2</sub> |        |        |        | 59.5   |        |        |        |        |        |        |        |        | 7    |
| BeSO <sub>4</sub>                  | 26.69  | 27.58  | 28.61  | 29.22  | 29.90  | 31.51  | 33.39  | 35.50  | 37.78  | 40.21  | 42.72  | 45.28  | 7    |
| CaBr <sub>2</sub>                  | 55     | 56     | 59     | 61     | 63     | 68     | 71     | 73     |        |        |        |        | 10   |
| CaCl <sub>2</sub>                  | 36.70  | 39.19  | 42.13  | 44.83* | 49.12* | 52.85* | 56.05* | 56.73  | 57.44  | 58.21  | 59.04  | 59.94  | 8    |
| Ca(ClO <sub>3</sub> ) <sub>2</sub> | 63.2   | 64.2   | 65.5   | 66.3   | 67.2   | 69.0   | 71.0   | 73.2   | 75.5*  | 77.4*  | 77.7   | 78.0   | 1:14 |
| Ca(ClO <sub>4</sub> ) <sub>2</sub> |        |        |        | 65.3   |        |        |        |        |        |        |        |        | 7    |
| CaF <sub>2</sub>                   | 0.0013 |        |        | 0.0016 |        |        |        |        |        |        |        |        | 10   |
| CaI <sub>2</sub>                   | 64.6   | 66.0   | 67.6   | 68.3   | 69.0   | 70.8   | 72.4   | 74.0   | 76.0   | 78.0   | 79.6   | 81.0   | 7    |
| Ca(IO <sub>3</sub> ) <sub>2</sub>  | 0.082  | 0.155  | 0.243  | 0.305  | 0.384* | 0.517* | 0.590  | 0.652  | 0.811* | 0.665* | 0.668  |        | 1:14 |
| Ca(NO <sub>2</sub> ) <sub>2</sub>  | 38.6   | 39.5   | 44.5   | 48.6   |        |        |        |        |        |        |        |        | 7    |
| Ca(NO <sub>3</sub> ) <sub>2</sub>  | 50.1   | 53.1   | 56.7   | 59.0   | 60.9   | 65.4   | 77.8   | 78.1   | 78.2   | 78.3   | 78.4   | 78.5   | 6    |
| CaSO <sub>3</sub>                  |        |        | 0.0059 | 0.0054 | 0.0049 | 0.0041 | 0.0035 | 0.0030 | 0.0026 | 0.0023 | 0.0020 | 0.0019 | 1:26 |
| CaSO <sub>4</sub>                  | 0.174  | 0.191  | 0.202  | 0.205  | 0.208  | 0.210  | 0.207  | 0.201  | 0.193  | 0.184  | 0.173  | 0.163  | 9    |
| CdBr <sub>2</sub>                  | 36.0   | 43.0   | 49.9   | 53.4   | 56.4   | 60.3*  | 60.3*  | 60.5   | 60.7   | 60.9   | 61.3   | 61.6   | 6    |
| CdC <sub>2</sub> O <sub>4</sub>    |        |        |        | 0.0060 |        |        |        |        |        |        |        |        | 5    |
| CdCl <sub>2</sub>                  | 47.2   | 50.1   | 53.2   | 54.6   | 56.3*  | 57.3*  | 57.5   | 57.8   | 58.1   | 58.51  | 58.98  | 59.5   | 6    |
| Cd(ClO <sub>4</sub> ) <sub>2</sub> |        |        |        | 58.7   |        |        |        |        |        |        |        | 66.9   | 7    |
| CdF <sub>2</sub>                   |        | 5.82   | 4.65   | 4.18   | 3.76   |        |        |        |        |        |        |        | 5    |
| CdI <sub>2</sub>                   | 44.1   | 44.9   | 45.8   | 46.3   | 46.8   | 47.9   | 49.0   | 50.2   | 51.5   | 52.7   | 54.1   | 55.4   | 6    |
| Cd(IO <sub>3</sub> ) <sub>2</sub>  |        |        |        | 0.091  |        |        |        |        |        |        |        |        | 5    |
| Cd(NO <sub>3</sub> ) <sub>2</sub>  | 55.4   | 57.1   | 59.6   | 61.0   | 62.8   | 66.5   | 70.6   | 86.1   | 86.5   | 86.8   | 87.1   | 87.4   | 6    |
| CdSO <sub>4</sub>                  | 43.1   | 43.1   | 43.2   | 43.4   | 43.6   | 44.1   | 43.5   | 42.5   | 41.4   | 40.2   | 38.5   | 36.7   | 6    |
| CdSeO <sub>4</sub>                 | 42.04  | 40.59  | 39.02  | 38.18  | 37.29  | 35.35  | 33.15  | 30.65  | 27.84  | 24.69  | 21.24  | 17.49  | 5    |
| Ce(NO <sub>3</sub> ) <sub>3</sub>  | 57.99  | 59.80  | 61.89  | 63.05  | 64.31* | 67.0*  | 68.6   | 71.1*  | 74.9*  | 79.2   | 80.9   | 83.1   | 1:13 |
| CoCl <sub>2</sub>                  | 30.30  | 32.60  | 34.87  | 35.99  | 37.10  | 39.27  | 41.38  | 43.46  | 45.50  | 47.51  | 49.51  | 51.50  | 7    |
| Co(ClO <sub>4</sub> ) <sub>2</sub> | 50.0   |        |        | 53.0   |        |        |        |        |        |        |        |        | 7    |
| CoF <sub>2</sub>                   |        |        |        | 1.4    |        |        |        |        |        |        |        |        | 7    |
| CoI <sub>2</sub>                   | 58.00  | 61.78  | 65.35  | 66.99  | 68.51  | 71.17  | 73.41  | 75.29  | 76.89  | 78.28  | 79.52  | 80.70  | 7    |
| Co(NO <sub>2</sub> ) <sub>2</sub>  | 0.076  |        |        | 0.49   |        |        |        |        |        |        |        |        | 7    |
| Co(NO <sub>3</sub> ) <sub>2</sub>  | 45.5   | 47.0   | 49.4   | 50.8   | 52.4   | 56.0   | 60.1   | 62.6   | 64.9   | 67.7   |        |        | 6    |
| CoSO <sub>4</sub>                  | 19.9   | 23.0   | 26.1   | 27.7   | 29.2   | 32.3   | 34.4   | 35.9   | 35.5   | 33.2   | 30.6   | 27.8   | 6    |
| Co(SCN) <sub>2</sub>               |        |        |        | 50.7   |        |        |        |        |        |        |        |        | 7    |
| CrO <sub>3</sub>                   | 62.2   | 62.3   | 62.6   | 62.8   | 63.0   | 63.5   | 64.1   | 64.7   | 65.5   | 66.2   | 67.1   | 67.9   | 6    |
| CsBr                               |        |        |        | 55.2   |        |        |        |        |        |        |        |        | 7    |
| CsBrO <sub>3</sub>                 | 1.16   | 1.93   | 3.01   | 3.69   | 4.46   | 6.32   | 8.60   | 11.32  | 14.45  | 17.96  | 21.83  | 25.98  | 1:30 |
| CsCl                               | 61.83  | 63.48  | 64.96  | 65.64  | 66.29  | 67.50  | 68.60  | 69.61  | 70.54  | 71.40  | 72.21  | 72.96  | 1:47 |
| CsClO <sub>3</sub>                 | 2.40   | 3.87   | 5.94   | 7.22   | 8.69   | 12.15  | 16.33  | 21.14  | 26.45  | 32.10  | 37.89  | 43.42  | 1:30 |
| CsClO <sub>4</sub>                 | 0.79   | 1.01   | 1.51   | 1.96   | 2.57   | 4.28   | 6.55   | 9.29   | 12.41  | 15.80  | 19.39  | 23.07  | 7    |
| CsI                                | 30.9   | 37.2   | 43.2   | 45.9   | 48.6   | 53.3   | 57.3   | 60.7   | 63.6   | 65.9   | 67.7   | 69.2   | 6    |
| CsIO <sub>3</sub>                  | 1.08   | 1.58   | 2.21   | 2.59   | 3.02   | 3.96   | 5.06   | 6.29   | 7.70   | 9.20   | 10.79  | 12.45  | 1:30 |
| CsNO <sub>3</sub>                  | 8.46   | 13.0   | 18.6   | 21.8   | 25.1   | 32.0   | 39.0   | 45.7   | 51.9   | 57.3   | 62.1   | 66.2   | 6    |
| CsOH                               |        |        |        | 75     |        |        |        |        |        |        |        |        | 7    |
| Cs <sub>2</sub> SO <sub>4</sub>    | 62.6   | 63.4   | 64.1   | 64.5   | 64.8   | 65.5   | 66.1   | 66.7   | 67.3   | 67.8   | 68.3   | 68.8   | 6    |
| CuBr <sub>2</sub>                  |        |        |        | 55.8   |        |        |        |        |        |        |        |        | 7    |
| CuCl <sub>2</sub>                  | 40.8   | 41.7   | 42.6   | 43.1   | 43.7   | 44.8   | 46.0   | 47.2   | 48.5   | 49.9   | 51.3   | 52.7   | 6    |
| Cu(ClO <sub>4</sub> ) <sub>2</sub> | 54.3   |        |        | 59.3   |        |        |        |        |        |        |        |        | 7    |
| CuF <sub>2</sub>                   |        |        |        | 0.075  |        |        |        |        |        |        |        |        | 7    |
| Cu(NO <sub>3</sub> ) <sub>2</sub>  | 45.2   | 49.8   | 56.3   | 59.2   | 61.1   | 62.0   | 63.1   | 64.5   | 65.9   | 67.5   | 69.2   | 71.0   | 6    |
| CuSO <sub>4</sub>                  | 12.4   | 14.4   | 16.7   | 18.0   | 19.3   | 22.2   | 25.4   | 28.8   | 32.4   | 36.3   | 40.3   | 43.5   | 6    |
| CuSeO <sub>4</sub>                 | 10.6   |        |        | 16.0   |        |        |        |        |        |        |        |        | 7    |
| Dy(NO <sub>3</sub> ) <sub>3</sub>  | 58.79  | 59.99  | 61.49  | 62.35  | 63.29  | 65.43  | 68.04  | 71.58  |        |        |        |        | 1:13 |
| Er(NO <sub>3</sub> ) <sub>3</sub>  | 61.58  | 63.15  | 64.84  | 65.75  | 66.69  | 68.70  | 70.96  | 73.64  | 77.75  |        |        |        | 1:13 |
| Eu(NO <sub>3</sub> ) <sub>3</sub>  | 55.2   | 56.7   | 58.5   | 59.4   | 60.4   | 62.5   | 64.6   |        |        |        |        |        | 1:13 |

| Compound                                         | 0°C   | 10°C   | 20°C   | 25°C   | 30°C   | 40°C   | 50°C   | 60°C   | 70°C  | 80°C  | 90°C   | 100°C  | Ref. |
|--------------------------------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-------|-------|--------|--------|------|
| FeBr <sub>2</sub>                                |       |        |        | 54.6   |        |        |        |        |       |       |        | 64.8*  | 7    |
| FeCl <sub>2</sub>                                | 33.2* |        |        | 39.4*  |        |        |        |        |       |       |        | 48.7*  | 7    |
| FeCl <sub>3</sub>                                | 42.7  | 44.9   | 47.9   | 47.7   | 51.6   | 74.8   | 76.7   | 84.6   | 84.3  | 84.3  | 84.4   | 84.7   | 6    |
| Fe(ClO <sub>4</sub> ) <sub>2</sub>               | 63.39 |        |        | 67.76  |        |        |        |        |       |       |        |        | 7    |
| FeF <sub>3</sub>                                 |       |        |        | 5.59   |        |        |        |        |       |       |        |        | 7    |
| Fe(NO <sub>3</sub> ) <sub>3</sub>                | 40.15 |        |        | 46.57  |        |        |        |        |       |       |        |        | 7    |
| Fe(NO <sub>3</sub> ) <sub>2</sub>                | 41.44 |        |        | 46.67  |        |        |        |        |       |       |        |        | 7    |
| FeSO <sub>4</sub>                                | 13.5  | 17.0   | 20.8   | 22.8   | 24.8   | 28.8   | 32.8   | 35.5   | 33.6  | 30.4  | 27.1   | 24.0   | 6    |
| Gd(NO <sub>3</sub> ) <sub>3</sub>                | 56.3  | 57.7   | 59.2   | 60.1   | 61.0   | 62.9   | 65.2   | 67.9   | 71.5  |       |        |        | 1:13 |
| HIO <sub>3</sub>                                 | 73.45 | 74.10  | 74.98  | 75.48  | 76.03  | 77.20  | 78.46  | 79.78  | 81.13 | 82.48 | 83.82  | 85.14  | 1:30 |
| H <sub>3</sub> BO <sub>3</sub>                   | 2.61  | 3.57   | 4.77   | 5.48   | 6.27   | 8.10   | 10.3   | 12.9   | 15.9  | 19.3  | 23.1   | 27.3   | 6    |
| HgBr <sub>2</sub>                                | 0.26  | 0.37   | 0.52   | 0.61   | 0.72   | 0.96   | 1.26   | 1.63   | 2.08  | 2.61  | 3.23   | 3.95   | 4    |
| Hg(CN) <sub>2</sub>                              | 6.57  | 7.83   | 9.33   | 10.2   | 11.1   | 13.1   | 15.5   | 18.2   | 21.2  | 24.6  | 28.3   | 32.3   | 6    |
| HgCl <sub>2</sub>                                | 4.24  | 5.05   | 6.17   | 6.81   | 7.62   | 9.53   | 12.02  | 15.18  | 19.16 | 24.06 | 29.90  | 36.62  | 4    |
| HgI <sub>2</sub>                                 |       |        | 0.0041 | 0.0055 | 0.0072 | 0.0122 | 0.0199 |        |       |       |        |        | 4    |
| Hg(SCN) <sub>2</sub>                             |       |        |        | 0.070  |        |        |        |        |       |       |        |        | 4    |
| Hg <sub>2</sub> Cl <sub>2</sub>                  |       |        |        | 0.0004 |        |        |        |        |       |       |        |        | 3    |
| Hg <sub>2</sub> (ClO <sub>4</sub> ) <sub>2</sub> | 73.8  |        |        | 79.8*  |        |        |        |        |       |       |        | 85.3*  | 7    |
| Hg <sub>2</sub> SO <sub>4</sub>                  | 0.038 | 0.043  | 0.048  | 0.051  | 0.054  | 0.059  | 0.065  | 0.070  | 0.076 | 0.082 | 0.088  | 0.093  | 4    |
| Ho(NO <sub>3</sub> ) <sub>3</sub>                |       |        |        | 63.8   |        |        |        |        |       |       |        |        | 1:13 |
| KBF <sub>4</sub>                                 | 0.28  | 0.34   | 0.45   | 0.55   | 0.75   | 1.38   | 2.09   | 2.82   | 3.58  | 4.34  | 5.12   | 5.90   | 10   |
| KBr                                              | 35.0  | 37.3   | 39.4   | 40.4   | 41.4   | 43.2   | 44.8   | 46.2   | 47.6  | 48.8  | 49.8   | 50.8   | 6    |
| KBrO <sub>3</sub>                                | 2.97  | 4.48   | 6.42   | 7.55   | 8.79   | 11.57  | 14.71  | 18.14  | 21.79 | 25.57 | 29.42  | 33.28  | 1:30 |
| KC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>    | 68.40 | 70.29  | 72.09  | 72.92  | 73.70  | 75.08  | 76.27  | 77.31  | 78.22 | 79.04 | 79.80  | 80.55  | 7    |
| KCl                                              | 21.74 | 23.61  | 25.39  | 26.22  | 27.04  | 28.59  | 30.04  | 31.40  | 32.66 | 33.86 | 34.99  | 36.05  | 1:47 |
| KClO <sub>3</sub>                                | 3.03  | 4.67   | 6.74   | 7.93   | 9.21   | 12.06  | 15.26  | 18.78  | 22.65 | 26.88 | 31.53  | 36.65  | 1:30 |
| KClO <sub>4</sub>                                | 0.70  | 1.10   | 1.67   | 2.04   | 2.47   | 3.54   | 4.94   | 6.74   | 8.99  | 11.71 | 14.94  | 18.67  | 6    |
| KF                                               | 30.90 | 39.8   | 47.3   | 50.41  | 53.2   |        |        |        |       | 60.0  |        |        | 7    |
| KHCO <sub>3</sub>                                | 18.62 | 21.73  | 24.92  | 26.6   | 28.13  | 31.32  | 34.46  | 37.51  | 40.45 |       |        |        | 6    |
| KHSO <sub>4</sub>                                | 27.1  | 29.7   | 32.3   | 33.6   | 35.0   | 37.8   | 40.5   | 43.4   | 46.2  | 49.02 | 51.82  | 54.6   | 6    |
| KH <sub>2</sub> PO <sub>4</sub>                  | 11.74 | 14.91  | 18.25  | 19.97  | 21.77  | 25.28  | 28.95  | 32.76  | 36.75 | 40.96 | 45.41  | 50.12  | 1:31 |
| KI                                               | 56.0  | 57.6   | 59.0   | 59.7   | 60.4   | 61.6   | 62.8   | 63.8   | 64.8  | 65.7  | 66.6   | 67.4   | 6    |
| KIO <sub>3</sub>                                 | 4.53  | 5.96   | 7.57   | 8.44   | 9.34   | 11.09  | 13.22  | 15.29  | 17.41 | 19.58 | 21.78  | 24.03  | 1:30 |
| KIO <sub>4</sub>                                 | 0.16  | 0.22   | 0.37   | 0.51   | 0.70   | 1.24   | 1.96   | 2.83   | 3.82  | 4.89  | 6.02   | 7.17   | 7    |
| KMnO <sub>4</sub>                                | 2.74  | 4.12   | 5.96   | 7.06   | 8.28   | 11.11  | 14.42  | 18.16  |       |       |        |        | 6    |
| KNO <sub>2</sub>                                 | 73.7  | 74.6   | 75.3   | 75.7   | 76.0   | 76.7   | 77.4   | 78.0   | 78.5  | 79.1  | 79.6   | 80.1   | 6    |
| KNO <sub>3</sub>                                 | 12.0  | 17.6   | 24.2   | 27.7   | 31.3   | 38.6   | 45.7   | 52.2   | 58.0  | 63.0  | 67.3   | 70.8   | 6    |
| KOH                                              | 48.7  | 50.8   | 53.2   | 54.7   | 56.1   | 57.9   | 58.6   | 59.5   | 60.6  | 61.8  | 63.1   | 64.6   | 6    |
| KSCN                                             | 63.8  | 66.4   | 69.1   | 70.4   | 71.6   | 74.1   | 76.5   | 78.9   | 81.1  | 83.3  | 85.3   | 87.3   | 6    |
| K <sub>2</sub> CO <sub>3</sub>                   | 51.3  | 51.7   | 52.3   | 52.7   | 53.1   | 54.0   | 54.9   | 56.0   | 57.2  | 58.4  | 59.6   | 61.0   | 6    |
| K <sub>2</sub> CrO <sub>4</sub>                  | 37.1  | 38.1   | 38.9   | 39.4   | 39.8   | 40.5   | 41.3   | 41.9   | 42.6  | 43.2  | 43.8   | 44.3   | 6    |
| K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>    | 4.30  | 7.12   | 10.9   | 13.1   | 15.5   | 20.8   | 26.3   | 31.7   | 36.9  | 41.5  | 45.5   | 48.9   | 6    |
| K <sub>2</sub> HAsO <sub>4</sub>                 | 48.5* |        |        | 63.6*  |        |        |        |        |       |       |        | 79.8*  | 7    |
| K <sub>2</sub> HPO <sub>4</sub>                  | 57.0  | 59.1   | 61.5   | 62.7   | 64.1   | 67.7*  |        | 72.7*  |       |       |        |        | 1:31 |
| K <sub>2</sub> MoO <sub>4</sub>                  |       |        |        | 64.7   |        |        |        |        |       |       | 66.5   |        | 7    |
| K <sub>2</sub> SO <sub>3</sub>                   | 51.30 | 51.39  | 51.49  | 51.55  | 51.62  | 51.76  | 51.93  | 52.11  | 52.32 | 52.54 | 52.79  | 53.06  | 1:26 |
| K <sub>2</sub> SO <sub>4</sub>                   | 7.11  | 8.46   | 9.95   | 10.7   | 11.4   | 12.9   | 14.2   | 15.5   | 16.7  | 17.7  | 18.6   | 19.3   | 6    |
| K <sub>2</sub> S <sub>2</sub> O <sub>3</sub>     | 49.0* |        |        | 62.3*  |        |        |        |        |       |       | 75.7*  |        | 7    |
| K <sub>2</sub> S <sub>2</sub> O <sub>5</sub>     | 22.1  | 26.7   | 31.1   | 33.1   | 35.2   | 39.0   | 42.6   | 46.0   | 49.1  | 52.0  | 54.6   |        | 1:26 |
| K <sub>2</sub> SeO <sub>3</sub>                  | 68.4* |        |        | 68.5*  |        |        |        |        |       |       |        | 68.5*  | 7    |
| K <sub>2</sub> SeO <sub>4</sub>                  | 52.70 | 52.93  | 53.17  | 53.30  | 53.43  | 53.70  | 53.99  | 54.30  | 54.61 | 54.94 | 55.26  | 55.60  | 7    |
| K <sub>3</sub> AsO <sub>4</sub>                  | 51.5* |        |        | 55.6*  |        |        |        |        |       |       |        | 73*    | 7    |
| K <sub>3</sub> Fe(CN) <sub>6</sub>               | 23.9  | 27.6   | 31.1   | 32.8   | 34.3   | 37.2   | 39.6   | 41.7   | 43.5  | 45.0  | 46.1   | 47.0   | 6    |
| K <sub>3</sub> PO <sub>4</sub>                   | 44.3  |        |        | 51.4   |        |        |        |        |       |       |        |        | 7    |
| K <sub>4</sub> Fe(CN) <sub>6</sub>               | 12.5  | 17.3   | 22.0   | 23.9   | 25.6   | 29.2   | 32.5   | 35.5   | 38.2  | 40.6  | 41.4   | 43.1   | 6    |
| LaCl <sub>3</sub>                                | 49.0  | 48.5   | 48.6   | 48.9   | 49.3   | 50.5   | 52.1   | 54.0   | 56.3  | 58.9  | 61.7   |        | 6    |
| La(NO <sub>3</sub> ) <sub>3</sub>                | 55.0  | 56.9   | 58.9   | 60.0   | 61.1   | 63.6   | 66.3   | 69.9*  | 74.1* |       |        |        | 1:13 |
| LiBr                                             | 58.4  | 60.1   | 62.7   | 64.4   | 65.9   | 67.8   | 68.3   | 69.0   | 69.8  | 70.7  | 71.7   | 72.8   | 6    |
| LiBrO <sub>3</sub>                               | 61.03 | 62.62  | 64.44  | 65.44  | 66.51  | 68.90  | 71.68* | 73.24* | 74.43 | 75.66 | 76.93  | 78.32  | 1:30 |
| LiC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>   | 23.76 | 26.49  | 29.42  | 31.02  | 32.72  | 36.48  | 40.65  | 45.15  | 49.93 | 54.91 | 60.04  | 65.26  | 7    |
| LiCl                                             | 40.45 | 42.46* | 45.29* | 45.81  | 46.25  | 47.30  | 48.47  | 49.78  | 51.27 | 52.98 | 54.98* | 56.34* | 1:47 |

| Compound                                                       | 0°C    | 10°C  | 20°C  | 25°C   | 30°C   | 40°C   | 50°C  | 60°C  | 70°C  | 80°C  | 90°C  | 100°C | Ref. |
|----------------------------------------------------------------|--------|-------|-------|--------|--------|--------|-------|-------|-------|-------|-------|-------|------|
| LiClO <sub>3</sub>                                             | 73.2   | 75.6* | 80.8* | 82.1   | 83.4   | 85.9*  | 87.1* | 88.2  | 89.6  | 91.3  | 93.4  | 95.7  | 1:30 |
| LiClO <sub>4</sub>                                             | 30.1   | 32.6  | 35.5  | 37.0   | 38.6   | 41.9   | 45.5  | 49.2  | 53.2  | 57.2  | 61.3  | 71.4  | 6    |
| LiF                                                            | 0.120  | 0.126 | 0.131 | 0.134  |        |        |       |       |       |       |       |       | 7    |
| LiH <sub>2</sub> PO <sub>4</sub>                               | 55.8   |       |       |        |        |        |       |       |       |       |       |       | 7    |
| LiI                                                            | 59.4   | 60.5  | 61.7  | 62.3   | 63.0   | 64.3   | 65.8  | 67.3  | 68.8  | 81.3  | 81.7  | 82.6  | 6    |
| LiIO <sub>3</sub>                                              |        |       |       | 43.8   |        |        |       |       |       |       |       |       | 1:30 |
| LiNO <sub>2</sub>                                              | 41     | 45    | 49    | 51     | 53     | 56     | 60    | 63    | 66    | 68    |       |       | 10   |
| LiNO <sub>3</sub>                                              | 34.8   | 37.6  | 42.7  | 50.5   | 57.9   | 60.1   | 62.2  | 64.0  | 65.7  | 67.2  | 68.5  | 69.7  | 6    |
| LiOH                                                           | 10.8   | 10.8  | 11.0  | 11.1   | 11.3   | 11.7   | 12.2  | 12.7  | 13.4  | 14.2  | 15.1  | 16.1  | 6    |
| LiSCN                                                          |        |       |       | 54.5   |        |        |       |       |       |       |       |       | 7    |
| Li <sub>2</sub> CO <sub>3</sub>                                | 1.54   | 1.43  | 1.33  | 1.28   | 1.24   | 1.15   | 1.07  | 0.99  | 0.92  | 0.85  | 0.78  | 0.72  | 7    |
| Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub>                  |        |       |       | 5.87   |        |        |       |       |       |       |       |       | 7    |
| Li <sub>2</sub> HPO <sub>3</sub>                               | 9.07   | 8.40  | 7.77  | 7.47   | 7.18   | 6.64   | 6.16  | 5.71  | 5.30  | 4.91  | 4.53  | 4.16  | 7    |
| Li <sub>2</sub> SO <sub>4</sub>                                | 26.3   | 25.9  | 25.6  | 25.5   | 25.3   | 25.0   | 24.8  | 24.5  | 24.3  | 24.0  | 23.8  | 23.6  | 6    |
| Li <sub>3</sub> PO <sub>4</sub>                                |        |       |       | 0.027  |        |        |       |       |       |       |       |       | 1:31 |
| Lu(NO <sub>3</sub> ) <sub>3</sub>                              |        |       |       | 71.1   |        |        |       |       |       |       |       |       | 1:13 |
| MgBr <sub>2</sub>                                              | 49.3   | 49.8  | 50.3  | 50.6   | 50.9   | 51.5   | 52.1  | 52.8  | 53.5  | 54.2  | 55.0  | 55.7  | 6    |
| Mg(BrO <sub>3</sub> ) <sub>2</sub>                             | 43.0   | 45.2  | 48.0  | 49.4   | 51.0   | 54.3   | 57.9  | 61.6  | 65.3  | 69.0* | 70.9* | 71.7  | 1:14 |
| Mg(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> | 36.18  | 37.55 | 38.92 | 39.61  |        |        |       |       |       |       |       |       | 7    |
| MgC <sub>2</sub> O <sub>4</sub>                                |        |       |       | 0.038  |        |        |       |       |       |       |       |       | 7    |
| MgCl <sub>2</sub>                                              | 33.96  | 34.85 | 35.58 | 35.90  | 36.20  | 36.77  | 37.34 | 37.97 | 38.71 | 39.62 | 40.75 | 42.15 | 8    |
| Mg(ClO <sub>3</sub> ) <sub>2</sub>                             | 53.35  | 54.40 | 56.81 | 58.66  | 60.91* | 65.46* | 67.33 | 69.27 | 71.01 | 72.44 | 73.48 |       | 1:14 |
| Mg(ClO <sub>4</sub> ) <sub>2</sub>                             | 47.8   | 48.7  | 49.6  | 50.1   | 50.5   | 51.3   | 52.1  |       |       |       |       |       | 6    |
| MgCrO <sub>4</sub>                                             | 32.06* |       |       | 35.39* |        |        |       |       |       |       |       |       | 7    |
| MgCr <sub>2</sub> O <sub>7</sub>                               |        |       |       | 58.9   |        |        |       |       |       | 67.0  |       |       | 7    |
| MgF <sub>2</sub>                                               |        |       |       | 0.013  |        |        |       |       |       |       |       |       | 7    |
| MgI <sub>2</sub>                                               | 54.7   | 56.1  | 58.2  | 59.4   | 60.8   | 63.9   | 65.0  | 65.0  | 65.0  | 65.0  | 65.1  | 65.2  | 6    |
| Mg(IO <sub>3</sub> ) <sub>2</sub>                              | 3.19*  | 6.70* | 7.92  | 8.52   | 9.11   | 10.45  | 11.99 | 13.7  | 15.6  | 17.6  | 19.6  |       | 1:14 |
| Mg(NO <sub>2</sub> ) <sub>2</sub>                              |        |       |       | 47     |        |        |       |       |       |       |       |       | 7    |
| Mg(NO <sub>3</sub> ) <sub>2</sub>                              | 38.4   | 39.5  | 40.8  | 41.6   | 42.4   | 44.1   | 45.9  | 47.9  | 50.0  | 52.2  | 70.6  | 72.0  | 6    |
| MgSO <sub>3</sub>                                              | 0.32   | 0.37  | 0.46  | 0.52   | 0.61   | 0.87*  | 0.85* | 0.76  | 0.69  | 0.64  | 0.62  | 0.60  | 1:26 |
| MgSO <sub>4</sub>                                              | 18.2   | 21.7  | 25.1  | 26.3   | 28.2   | 30.9   | 33.4  | 35.6  | 36.9  | 35.9  | 34.7  | 33.3  | 6    |
| MgS <sub>2</sub> O <sub>3</sub>                                | 30.7   |       |       | 34.1   |        |        |       |       |       |       |       |       | 7    |
| MgSeO <sub>4</sub>                                             | 31.4*  |       |       | 35.7*  |        |        |       |       |       |       |       | 47*   | 7    |
| MnBr <sub>2</sub>                                              | 56.00  | 57.72 | 59.39 | 60.19  | 60.96  | 62.41  | 63.75 | 65.01 | 66.19 | 67.32 | 68.42 | 69.50 | 7    |
| MnCl <sub>2</sub>                                              | 38.7   | 40.6  | 42.5  | 43.6   | 44.7   | 47.0   | 49.4  | 54.1  | 54.7  | 55.2  | 55.7  | 56.1  | 6    |
| MnF <sub>2</sub>                                               | 0.80*  |       |       | 1.01*  |        |        |       |       |       |       |       | 0.48  | 7    |
| Mn(IO <sub>3</sub> ) <sub>2</sub>                              |        |       |       | 0.27   |        |        |       |       |       |       | 0.34  |       | 7    |
| Mn(NO <sub>3</sub> ) <sub>2</sub>                              | 50.5   |       |       | 61.7   |        |        |       |       |       |       |       |       | 7    |
| MnSO <sub>4</sub>                                              | 34.6   | 37.3  | 38.6  | 38.9   | 38.9   | 37.7   | 36.3  | 34.6  | 32.8  | 30.8  | 28.8  | 26.7  | 6    |
| NH <sub>4</sub> Br                                             | 37.5   | 40.2  | 42.7  | 43.9   | 45.1   | 47.3   | 49.4  | 51.3  | 53.0  | 54.6  | 56.1  | 57.4  | 7    |
| NH <sub>4</sub> Cl                                             | 22.92  | 25.12 | 27.27 | 28.34  | 29.39  | 31.46  | 33.50 | 35.49 | 37.46 | 39.40 | 41.33 | 43.24 | 1:47 |
| NH <sub>4</sub> ClO <sub>4</sub>                               | 10.8   | 14.1  | 17.8  | 19.7   | 21.7   | 25.8   | 29.8  | 33.6  | 37.3  | 40.7  | 43.8  | 46.6  | 6    |
| NH <sub>4</sub> F                                              | 41.7   | 43.2  | 44.7  | 45.5   | 46.3   | 47.8   | 49.3  | 50.9  | 52.5  | 54.1  |       |       | 7    |
| NH <sub>4</sub> HCO <sub>3</sub>                               | 10.6   | 13.7  | 17.6  | 19.9   | 22.4   | 27.9   | 34.2  | 41.4  | 49.3  | 58.1  | 67.6  | 78.0  | 7    |
| NH <sub>4</sub> H <sub>2</sub> AsO <sub>4</sub>                | 25.2   | 29.0  | 32.7  | 34.5   | 36.3   | 39.7   | 43.1  | 46.2  | 49.3  | 52.2  | 55.0  |       | 7    |
| NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>                 | 17.8   | 22.0  | 26.4  | 28.8   | 31.2   | 36.2   | 41.6  | 47.2  | 53.0  | 59.2  | 65.7  | 72.4  | 7    |
| NH <sub>4</sub> I                                              | 60.7   | 62.1  | 63.4  | 64.0   | 64.6   | 65.8   | 66.8  | 67.8  | 68.7  | 69.6  | 70.4  | 71.1  | 6    |
| NH <sub>4</sub> IO <sub>3</sub>                                |        |       |       | 3.70   | 4.20   | 5.64   | 7.63  |       |       |       |       |       | 1:30 |
| NH <sub>4</sub> NO <sub>2</sub>                                | 55.7   | 59.0  | 64.9  | 68.8   |        |        |       |       |       |       |       |       | 7    |
| NH <sub>4</sub> NO <sub>3</sub>                                | 54.0   | 60.1  | 65.5  | 68.0   | 70.3   | 74.3   | 77.7  | 80.8  | 83.4  | 85.8  | 88.2  | 90.3  | 6    |
| NH <sub>4</sub> SCN                                            |        |       |       | 64.4   |        |        |       |       | 81.1  |       |       |       | 7    |
| (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>  | 2.31   | 3.11  | 4.25  | 4.94   | 5.73   | 7.56   | 9.73  | 12.2  | 15.1  | 18.3  | 21.8  | 25.7  | 7    |
| (NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>               | 36.4   | 38.2  | 40.0  | 41.0   | 42.0   | 44.1   | 46.2  | 48.5  | 50.9  | 53.3  | 55.9  | 58.6  | 7    |
| (NH <sub>4</sub> ) <sub>2</sub> S <sub>2</sub> O <sub>5</sub>  | 65.5   | 67.9  | 69.8  | 70.5   | 71.3   | 72.3   | 72.9  | 73.1  |       |       |       |       | 1:26 |
| (NH <sub>4</sub> ) <sub>2</sub> S <sub>2</sub> O <sub>8</sub>  | 37.00  | 40.45 | 43.84 | 45.49  | 47.11  | 50.25  | 53.28 | 56.23 | 59.13 | 62.00 |       |       | 7    |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>3</sub>                | 32.2   | 34.9  | 37.7  | 39.1   | 40.6   | 43.7   | 47.0  | 50.6  | 54.5  | 58.9  |       |       | 1:26 |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>                | 41.3   | 42.1  | 42.9  | 43.3   | 43.8   | 44.7   | 45.6  | 46.6  | 47.5  | 48.5  | 49.5  | 50.5  | 6    |
| (NH <sub>4</sub> ) <sub>2</sub> SeO <sub>3</sub>               | 49.0   | 51.1  | 53.4  | 54.7   | 56.0   | 58.9   | 62.0  | 65.4  | 69.1  |       |       |       | 7    |
| (NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub>               |        |       |       | 54.02  |        |        |       |       |       |       |       |       | 7    |
| (NH <sub>4</sub> ) <sub>3</sub> PO <sub>4</sub>                |        |       |       | 15.5   |        |        |       |       |       |       |       |       | 7    |

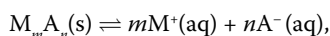


| Compound                                       | 0°C    | 10°C   | 20°C   | 25°C   | 30°C   | 40°C   | 50°C   | 60°C  | 70°C   | 80°C  | 90°C  | 100°C | Ref. |
|------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|-------|--------|-------|-------|-------|------|
| NaBr                                           | 44.4   | 45.9   | 47.7   | 48.6   | 49.6   | 51.6   | 53.7   | 54.1  | 54.3   | 54.5  | 54.7  | 54.9  | 6    |
| NaBrO <sub>3</sub>                             | 20.0   | 23.22  | 26.65  | 28.28  | 29.86  | 32.83  | 35.55  | 38.05 | 40.37  | 42.52 |       |       | 1:30 |
| NaCHO <sub>2</sub>                             | 30.8   | 37.9   | 45.7   | 48.7   | 50.6   | 52.0   | 53.5   | 55.0  |        |       |       |       | 6    |
| NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> | 26.5   | 28.8   | 31.8   | 33.5   | 35.5   | 39.9   | 45.1   | 58.3  | 59.3   | 60.5  | 61.7  | 62.9  | 6    |
| NaCl                                           | 26.28  | 26.32  | 26.41  | 26.45  | 26.52  | 26.67  | 26.84  | 27.03 | 27.25  | 27.50 | 27.78 | 28.05 | 1:47 |
| NaClO                                          | 22.7   |        |        | 44.4   |        |        |        |       |        |       |       |       | 7    |
| NaClO <sub>2</sub>                             |        |        |        | 97.0*  |        |        |        | 95.3* |        |       |       |       | 7    |
| NaClO <sub>3</sub>                             | 44.27  | 46.67  | 49.3   | 50.1   | 51.2   | 53.6   | 55.5   | 57.0  | 58.5   | 60.5  | 63.3  | 67.1  | 1:30 |
| NaClO <sub>4</sub>                             | 61.9   | 64.1   | 66.2   | 67.2   | 68.3   | 70.4   | 72.5   | 74.1  | 74.7   | 75.4  | 76.1  | 76.7  | 6    |
| NaF                                            | 3.52   | 3.72   | 3.89   | 3.97   | 4.05   | 4.20   | 4.34   | 4.46  | 4.57   | 4.66  | 4.75  | 4.82  | 6    |
| NaHCO <sub>3</sub>                             | 6.48   | 7.59   | 8.73   | 9.32   | 9.91   | 11.13  | 12.40  | 13.70 | 15.02  | 16.37 | 17.73 | 19.10 | 7    |
| NaHSO <sub>4</sub>                             |        |        |        | 22.2   |        |        |        |       |        |       |       | 33.3  | 10   |
| NaH <sub>2</sub> PO <sub>4</sub>               | 36.54  | 41.07  | 46.00  | 48.68  | 51.54  | 57.89* | 61.7*  | 62.3* | 65.9   | 68.7  |       |       | 1:31 |
| NaI                                            | 61.2   | 62.4   | 63.9   | 64.8   | 65.7   | 67.7   | 69.8   | 72.0  | 74.7   | 74.8  | 74.9  | 75.1  | 6    |
| NaIO <sub>3</sub>                              | 2.43   | 4.40   | 7.78*  | 8.65*  | 9.60   | 11.67  | 13.99  | 16.52 | 19.25* | 21.1* | 22.9  | 24.7  | 1:30 |
| NaIO <sub>4</sub>                              |        |        |        | 12.62  |        |        |        |       |        |       |       |       | 7    |
| NaNO <sub>2</sub>                              | 41.9   | 43.4   | 45.1   | 45.9   | 46.8   | 48.7   | 50.7   | 52.8  | 55.0   | 57.2  | 59.5  | 61.8  | 6    |
| NaNO <sub>3</sub>                              | 42.2   | 44.4   | 46.6   | 47.7   | 48.8   | 51.0   | 53.2   | 55.3  | 57.5   | 59.6  | 61.7  | 63.8  | 6    |
| NaOH                                           | 30     | 39     | 46     | 50     | 53     | 58     | 63     | 67    | 71     | 74    | 76    | 79    | 10   |
| NaSCN                                          |        | 52.9   | 57.1   | 60.2   | 62.7   | 63.5   | 64.2   | 65.0  | 65.9   | 66.9  | 67.9  | 69.0  | 6    |
| Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub>  | 1.23   | 1.71   | 2.50   | 3.07   | 3.82   | 6.02   | 9.7    | 14.9  | 17.1   | 19.9  | 23.5  | 28.0  | 6    |
| Na <sub>2</sub> CO <sub>3</sub>                | 6.44   | 10.8   | 17.9   | 23.5   | 28.7   | 32.8   | 32.2   | 31.7  | 31.3   | 31.1  | 30.9  | 30.9  | 6    |
| Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>  | 2.62   | 2.95   | 3.30   | 3.48   | 3.65   | 4.00   | 4.36   | 4.71  | 5.06   | 5.41  | 5.75  | 6.08  | 6    |
| Na <sub>2</sub> CrO <sub>4</sub>               | 22.6   | 32.3   | 44.6   | 46.7   | 46.9   | 48.9   | 51.0   | 53.4  | 55.3   | 55.5  | 55.8  | 56.1  | 6    |
| Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> | 62.1   | 63.1   | 64.4   | 65.2   | 66.1   | 68.0   | 70.1   | 72.3  | 74.6   | 77.0  | 79.6  | 80.7  | 6    |
| Na <sub>2</sub> HAsO <sub>4</sub>              | 5.6*   |        |        | 29.3*  |        |        |        |       |        |       |       | 67*   | 7    |
| Na <sub>2</sub> HPO <sub>4</sub>               | 1.66   | 4.19   | 7.51   | 10.55  | 16.34* | 35.17* | 44.64* | 45.20 | 46.81  | 48.78 | 50.52 | 51.53 | 1:31 |
| Na <sub>2</sub> MoO <sub>4</sub>               | 30.6   | 38.8   | 39.4   | 39.4   | 39.8   | 40.3   | 41.0   | 41.7  | 42.6   | 43.5  | 44.5  | 45.5  | 6    |
| Na <sub>2</sub> S                              | 11.1   | 13.2   | 15.7   | 17.1   | 18.6   | 22.1   | 26.7   | 28.1  | 30.2   | 33.0  | 36.4  | 41.0  | 6    |
| Na <sub>2</sub> SO <sub>3</sub>                | 12.0   | 16.1   | 20.9   | 23.5   | 26.3*  | 27.3*  | 25.9   | 24.8  | 23.7   | 22.8  | 22.1  | 21.5  | 1:26 |
| Na <sub>2</sub> SO <sub>4</sub>                |        |        | 16.13  | 21.94  | 29.22* | 32.35* | 31.55  | 30.90 | 30.39  | 30.02 | 29.79 | 29.67 | 8    |
| Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>  | 33.1   | 36.3   | 40.6   | 43.3   | 45.9   | 52.0   | 62.3   | 65.7  | 68.8   | 69.4  | 70.1  | 71.0  | 6    |
| Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub>  |        | 38.4   | 39.5   | 40.0   | 40.6   | 41.8   | 43.0   | 44.2  | 45.5   | 46.8  | 48.1  | 49.5  | 1:26 |
| Na <sub>2</sub> SeO <sub>3</sub>               |        |        |        | 47.3*  |        |        |        |       |        |       |       | 45*   | 7    |
| Na <sub>2</sub> SeO <sub>4</sub>               | 11.7   |        |        | 36.9*  |        |        |        |       |        |       |       | 42.1* | 7    |
| Na <sub>2</sub> WO <sub>4</sub>                | 41.6   | 41.9   | 42.3   | 42.6   | 42.9   | 43.6   | 44.4   | 45.3  | 46.2   | 47.3  | 48.4  | 49.5  | 6    |
| Na <sub>3</sub> PO <sub>4</sub>                | 4.28   | 7.30   | 10.8   | 12.6   | 14.1   | 16.6   | 22.9   | 28.4  | 32.4   | 37.6  | 40.4  | 43.5  | 6    |
| Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub>  | 2.23   | 3.28   | 4.81   | 6.62   | 7.00   | 10.10  | 14.38  | 20.07 | 27.31  | 36.03 | 32.37 | 30.67 | 6    |
| NdCl <sub>3</sub>                              | 49.0   | 49.3   | 49.7   | 50.0   | 50.4   | 51.2   | 52.2   | 53.3  | 54.5   | 55.8  | 57.1  | 58.5  | 6    |
| Nd(NO <sub>3</sub> ) <sub>3</sub>              | 55.76  | 57.49  | 59.37  | 60.38  | 61.43  | 63.69  | 66.27  | 69.47 |        |       |       |       | 1:13 |
| NiCl <sub>2</sub>                              | 34.7   | 36.1   | 38.5   | 40.3   | 41.7   | 42.1   | 43.2   | 45.0  | 46.1   | 46.2  | 46.4  | 46.6  | 6    |
| Ni(ClO <sub>4</sub> ) <sub>2</sub>             | 51.1   |        |        | 52.8   |        |        |        |       |        |       |       |       | 7    |
| NiF <sub>2</sub>                               |        |        |        | 2.50   |        |        |        |       |        |       | 2.52  |       | 7    |
| NiI <sub>2</sub>                               | 55.40  | 57.68  | 59.78  | 60.69  | 61.50  | 62.80  | 63.73  | 64.38 | 64.80  | 65.09 | 65.30 |       | 7    |
| Ni(NO <sub>3</sub> ) <sub>2</sub>              | 44.1   | 46.0   | 48.4   | 49.8   | 51.3   | 54.6   | 58.3   | 61.0  | 63.1   | 65.6  | 67.9  | 69.0  | 6    |
| NiSO <sub>4</sub>                              | 21.4   | 24.4   | 27.4   | 28.8   | 30.3*  | 32.0*  | 34.1   | 35.8  | 37.7   | 39.9  | 42.3  | 44.8  | 6    |
| Ni(SCN) <sub>2</sub>                           |        |        |        | 35.48  |        |        |        |       |        |       |       |       | 7    |
| NiSeO <sub>4</sub>                             | 21.6   |        | 26.2*  |        |        |        |        |       |        |       |       | 45.6* | 7    |
| PbBr <sub>2</sub>                              | 0.449  | 0.620  | 0.841  | 0.966  | 1.118  | 1.46   | 1.89   |       |        |       |       |       | 2    |
| PbCl <sub>2</sub>                              | 0.66   | 0.81   | 0.98   | 1.07   | 1.17   | 1.39   | 1.64   | 1.93  | 2.24   | 2.60  | 2.99  | 3.42  | 2    |
| Pb(ClO <sub>4</sub> ) <sub>2</sub>             |        |        |        | 81.5   |        |        |        |       |        |       |       |       | 7    |
| PbF <sub>2</sub>                               |        | 0.0603 | 0.0649 | 0.0670 | 0.0693 |        |        |       |        |       |       |       | 2    |
| PbI <sub>2</sub>                               | 0.041  | 0.052  | 0.067  | 0.076  | 0.086  | 0.112  | 0.144  | 0.187 | 0.243  | 0.315 |       |       | 2    |
| Pb(IO <sub>3</sub> ) <sub>2</sub>              |        |        |        | 0.0025 |        |        |        |       |        |       |       |       | 7    |
| Pb(NO <sub>3</sub> ) <sub>2</sub>              | 28.46  | 32.13  | 35.67  | 37.38  | 39.05  | 42.22  | 45.17  | 47.90 | 50.42  | 52.72 | 54.82 | 56.75 | 2    |
| PbSO <sub>4</sub>                              | 0.0033 | 0.0038 | 0.0042 | 0.0044 | 0.0047 | 0.0052 | 0.0058 |       |        |       |       |       | 2    |
| PrCl <sub>3</sub>                              | 48.0   | 48.1   | 48.6   | 49.0   | 49.5   | 50.8   | 52.3   | 54.1  | 56.1   | 58.3  |       |       | 6    |
| Pr(NO <sub>3</sub> ) <sub>3</sub>              | 57.50  | 59.20  | 61.16  | 62.24  | 63.40* | 65.7*  | 67.8   | 70.2  | 73.4   |       |       |       | 1:13 |
| RbBr                                           | 47.4   | 50.1   | 52.6   | 53.8   | 54.9   | 57.0   | 58.8   | 60.6  | 62.1   | 63.5  | 64.8  | 65.9  | 6    |
| RbBrO <sub>3</sub>                             | 0.97   | 1.55   | 2.36   | 2.87   | 3.45   | 4.87   | 6.64   | 8.78  | 11.29  | 14.15 | 17.32 | 20.76 | 1:30 |
| RbCl                                           | 43.58  | 45.65  | 47.53  | 48.42  | 49.27  | 50.86  | 52.34  | 53.67 | 54.92  | 56.08 | 57.16 | 58.15 | 1:47 |

| Compound                                        | 0°C    | 10°C   | 20°C   | 25°C   | 30°C   | 40°C   | 50°C   | 60°C   | 70°C   | 80°C  | 90°C  | 100°C | Ref. |
|-------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|-------|------|
| RbClO <sub>3</sub>                              | 2.10   | 3.38   | 5.14   | 6.22   | 7.45   | 10.35  | 13.85  | 17.93  | 22.53  | 27.57 | 32.96 | 38.60 | 1:30 |
| RbClO <sub>4</sub>                              | 1      |        |        | 1.5    |        |        |        |        |        |       |       | 17    | 7    |
| RbF                                             |        |        | 75     |        |        |        |        |        |        |       |       |       | 7    |
| RbHCO <sub>3</sub>                              |        |        | 53.7   |        |        |        |        |        |        |       |       |       | 7    |
| RbI                                             | 55.8   | 58.6   | 61.1   | 62.3   | 63.4   | 65.4   | 67.2   | 68.8   | 70.3   | 71.6  | 72.7  | 73.8  | 6    |
| RbIO <sub>3</sub>                               | 1.09   | 1.53   | 2.07   | 2.38   | 2.74   | 3.52   | 4.41   | 5.42   | 6.52   | 7.74  | 9.00  | 10.36 | 1:30 |
| RbNO <sub>3</sub>                               | 16.4   | 25.0   | 34.6   | 39.4   | 44.2   | 53.1   | 60.8   | 67.2   | 72.2   | 76.1  | 79.0  | 81.2  | 6    |
| RbOH                                            |        |        |        |        | 63.4   |        |        |        |        |       |       |       | 7    |
| Rb <sub>2</sub> CrO <sub>4</sub>                | 38.27  |        |        | 43.26  |        |        |        |        |        |       |       |       | 7    |
| Rb <sub>2</sub> SO <sub>4</sub>                 | 27.3   | 30.0   | 32.5   | 33.7   | 34.8   | 36.9   | 38.7   | 40.3   | 41.8   | 43.0  | 44.1  | 44.9  | 6    |
| SbCl <sub>3</sub>                               | 85.7   |        |        | 90.8   |        |        |        |        |        |       |       |       | 7    |
| SbF <sub>3</sub>                                | 79.4   |        |        | 83.1   |        |        |        |        |        |       |       |       | 7    |
| Sc(NO <sub>3</sub> ) <sub>3</sub>               | 57.0   | 59.3   | 61.6   | 62.8   | 63.9   | 66.2   | 68.5   |        |        |       |       |       | 1:13 |
| Sm(NO <sub>3</sub> ) <sub>3</sub>               | 54.83  | 56.33  | 58.08  | 59.05  | 60.08  | 62.38  | 65.05* | 68.1*  | 70.8   | 74.2  |       |       | 1:13 |
| SmCl <sub>3</sub>                               |        | 48.0   | 48.2   | 48.4   | 48.6   | 49.2   | 50.0   |        |        |       |       |       | 6    |
| SnCl <sub>2</sub>                               | 46     | 64     |        |        |        |        |        |        |        |       |       |       | 7    |
| SnI <sub>2</sub>                                |        |        | 0.97   |        |        |        |        |        |        |       |       | 3.87  | 7    |
| SrBr <sub>2</sub>                               | 46.0   | 48.3   | 50.6   | 51.7   | 52.9   | 55.2   | 57.6   | 59.9   | 62.3   | 64.6  | 66.8  | 69.0  | 6    |
| Sr(BrO <sub>3</sub> ) <sub>2</sub>              | 18.53  | 22.00  | 25.39  | 27.02  | 28.59  | 31.55  | 34.21  | 36.57  | 38.64* | 40.2* | 40.8  | 41.0  | 1:14 |
| SrCl <sub>2</sub>                               | 31.94  | 32.93  | 34.43  | 35.37  | 36.43  | 38.93  | 41.94  | 45.44* | 46.81* | 47.69 | 48.70 | 49.87 | 8    |
| Sr(ClO <sub>2</sub> ) <sub>2</sub>              | 13.0   | 13.6   | 14.1   | 14.3   | 14.5   | 14.9   | 15.3   | 15.6   | 15.9   |       |       |       | 7    |
| Sr(ClO <sub>3</sub> ) <sub>2</sub>              | 63.29  | 63.42  | 63.64  | 63.77  | 63.93  | 64.29  | 64.70  | 65.16  | 65.65  | 66.18 | 66.74 | 67.31 | 1:14 |
| Sr(ClO <sub>4</sub> ) <sub>2</sub>              | 70.04* |        |        | 75.35* |        | 78.44* |        |        |        |       |       |       | 7    |
| SrF <sub>2</sub>                                | 0.011  |        |        | 0.021  |        |        |        |        |        |       |       |       | 7    |
| SrI <sub>2</sub>                                | 62.5   | 62.8   | 63.5   | 63.9   | 64.5   | 65.8   | 67.3   | 69.0   | 70.8   | 72.7  | 74.7  | 79.2  | 6    |
| Sr(IO <sub>3</sub> ) <sub>2</sub>               | 0.102  | 0.126  | 0.152  | 0.165  | 0.179  | 0.206  | 0.233  | 0.259  | 0.284  | 0.307 | 0.328 | 0.346 | 1:14 |
| Sr(MnO <sub>4</sub> ) <sub>2</sub>              | 2.5    |        |        |        |        |        |        |        |        |       |       |       | 7    |
| Sr(NO <sub>2</sub> ) <sub>2</sub>               |        |        |        |        | 41.9   | 44.3   |        |        |        |       |       | 58.6  | 7    |
| Sr(NO <sub>3</sub> ) <sub>2</sub>               | 28.2   | 34.6   | 41.0   | 44.5   | 47.0   | 47.4   | 47.9   | 48.4   | 48.9   | 49.5  | 50.1  | 50.7  | 6    |
| Sr(OH) <sub>2</sub>                             | 0.9    |        |        | 2.2    |        |        |        |        |        |       |       |       | 7    |
| SrSO <sub>3</sub>                               |        |        |        | 0.0015 |        |        |        |        |        |       |       |       | 1:26 |
| SrSO <sub>4</sub>                               |        |        |        | 0.0135 |        |        |        |        |        |       |       |       | 7    |
| SrS <sub>2</sub> O <sub>3</sub>                 | 8.8    | 13.2   | 17.7   | 20.0   | 22.2   | 26.8   |        |        |        |       |       |       | 7    |
| Tb(NO <sub>3</sub> ) <sub>3</sub>               |        |        | 60.6   | 61.02  |        |        |        |        |        |       |       |       | 1:13 |
| Tl <sub>2</sub> SO <sub>4</sub>                 | 2.65   | 3.56   | 4.61   | 5.19   | 5.80   | 7.09   | 8.46   | 9.89   | 11.33  | 12.77 | 14.18 | 15.53 | 6    |
| Tm(NO <sub>3</sub> ) <sub>3</sub>               |        |        |        | 67.9   |        |        |        |        |        |       |       |       | 1:13 |
| UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> | 49.52  | 51.82  | 54.42  | 55.85  | 57.55  | 61.59  | 67.07  |        |        |       |       |       | 1:55 |
| Y(NO <sub>3</sub> ) <sub>3</sub>                | 55.57  | 56.93  | 58.75  | 59.86  | 61.11* | 63.3*  | 64.9   | 67.9   | 72.5   |       |       |       | 1:13 |
| Yb(NO <sub>3</sub> ) <sub>3</sub>               |        |        |        | 70.5   |        |        |        |        |        |       |       |       | 1:13 |
| ZnBr <sub>2</sub>                               | 79.3   | 80.1   | 81.8   | 83.0   | 84.1   | 85.6   | 85.8   | 86.1   | 86.3   | 86.6  | 86.8  | 87.1  | 6    |
| ZnC <sub>2</sub> O <sub>4</sub>                 |        | 0.0010 | 0.0019 | 0.0026 |        |        |        |        |        |       |       |       | 5    |
| ZnCl <sub>2</sub>                               |        | 76.6   | 79.0   | 80.3   | 81.4   | 81.8   | 82.4   | 83.0   | 83.7   | 84.4  | 85.2  | 86.0  | 6    |
| Zn(ClO <sub>4</sub> ) <sub>2</sub>              | 44.29* |        |        | 46.27* |        |        | 48.70  |        |        |       |       |       | 7    |
| ZnF <sub>2</sub>                                |        |        |        | 1.53   |        |        |        |        |        |       |       |       | 5    |
| ZnI <sub>2</sub>                                | 81.1   | 81.2   | 81.3   | 81.4   | 81.5   | 81.7   | 82.0   | 82.3   | 82.6   | 83.0  | 83.3  | 83.7  | 6    |
| Zn(IO <sub>3</sub> ) <sub>2</sub>               |        |        | 0.58   | 0.64   | 0.69   | 0.77   | 0.82   |        |        |       |       |       | 5    |
| Zn(NO <sub>3</sub> ) <sub>2</sub>               | 47.8   | 50.8   | 54.4   | 54.6   | 58.5   | 79.1   | 80.1   | 87.5   | 89.9   |       |       |       | 6    |
| ZnSO <sub>3</sub>                               |        |        | 0.1786 | 0.1790 | 0.1794 | 0.1803 | 0.1812 |        |        |       |       |       | 5    |
| ZnSO <sub>4</sub>                               | 29.1   | 32.0   | 35.0   | 36.6   | 38.2   | 41.3   | 43.0   | 42.1   | 41.0   | 39.9  | 38.8  | 37.6  | 6    |
| ZnSeO <sub>4</sub>                              | 33.06  | 34.98  | 37.38  | 38.79  | 40.34  |        |        |        |        |       |       |       | 5    |

# SOLUBILITY PRODUCT CONSTANTS

The solubility product constant  $K_{sp}$  is a useful parameter for calculating the aqueous solubility of sparingly soluble compounds under various conditions. It may be determined by direct measurement or calculated from the standard Gibbs energies of formation  $\Delta_f G^\circ$  of the species involved at their standard states. Thus if  $K_{sp} = [M^+]^m [A^-]^n$  is the equilibrium constant for the reaction



where  $M_m A_n$  is the slightly soluble substance and  $M^+$  and  $A^-$  are the ions produced in solution by the dissociation of  $M_m A_n$ , then the Gibbs energy change is

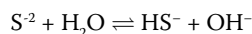
$$\Delta G^\circ = m \Delta_f G^\circ (M^+, aq) + n \Delta_f G^\circ (A^-, aq) - \Delta_f G^\circ (M_m A_n, s)$$

The solubility product constant is calculated from the equation

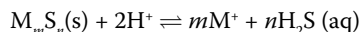
$$\ln K_{sp} = -\Delta G^\circ / RT$$

The first table below gives selected values of  $K_{sp}$  at 25°C. Many of these have been calculated from standard state thermodynamic data in References 1 and 2; other values are taken from publications of the IUPAC Solubility Data Project (References 3 to 7).

The above formulation is not convenient for treating sulfides because the  $S^{2-}$  ion is usually not present in significant concentrations (see Reference 8). This is due to the hydrolysis reaction



which is strongly shifted to the right except in very basic solutions. Furthermore, the equilibrium constant for this reaction, which depends on the second ionization constant of  $H_2S$ , is poorly known. Therefore it is more useful in the case of sulfides to define a different solubility product  $K_{spa}$  based on the reaction



Values of  $K_{spa}$ , taken from Reference 8, are given for several sulfides in the auxiliary table following the main table. Additional discussion of sulfide equilibria may be found in References 7 and 9.

## References

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| Compound                     | Formula                 | $K_{sp}$              |
|------------------------------|-------------------------|-----------------------|
| Aluminum phosphate           | $AlPO_4$                | $9.84 \cdot 10^{-21}$ |
| Barium bromate               | $Ba(BrO_3)_2$           | $2.43 \cdot 10^{-4}$  |
| Barium carbonate             | $BaCO_3$                | $2.58 \cdot 10^{-9}$  |
| Barium chromate              | $BaCrO_4$               | $1.17 \cdot 10^{-10}$ |
| Barium fluoride              | $BaF_2$                 | $1.84 \cdot 10^{-7}$  |
| Barium hydroxide octahydrate | $Ba(OH)_2 \cdot 8H_2O$  | $2.55 \cdot 10^{-4}$  |
| Barium iodate                | $Ba(IO_3)_2$            | $4.01 \cdot 10^{-9}$  |
| Barium iodate monohydrate    | $Ba(IO_3)_2 \cdot H_2O$ | $1.67 \cdot 10^{-9}$  |
| Barium molybdate             | $BaMoO_4$               | $3.54 \cdot 10^{-8}$  |
| Barium nitrate               | $Ba(NO_3)_2$            | $4.64 \cdot 10^{-3}$  |
| Barium selenate              | $BaSeO_4$               | $3.40 \cdot 10^{-8}$  |
| Barium sulfate               | $BaSO_4$                | $1.08 \cdot 10^{-10}$ |
| Barium sulfite               | $BaSO_3$                | $5.0 \cdot 10^{-10}$  |
| Beryllium hydroxide          | $Be(OH)_2$              | $6.92 \cdot 10^{-22}$ |
| Bismuth arsenate             | $BiAsO_4$               | $4.43 \cdot 10^{-10}$ |
| Bismuth iodide               | $BiI_3$                 | $7.71 \cdot 10^{-19}$ |
| Cadmium arsenate             | $Cd_3(AsO_4)_2$         | $2.2 \cdot 10^{-33}$  |
| Cadmium carbonate            | $CdCO_3$                | $1.0 \cdot 10^{-12}$  |
| Cadmium fluoride             | $CdF_2$                 | $6.44 \cdot 10^{-3}$  |
| Cadmium hydroxide            | $Cd(OH)_2$              | $7.2 \cdot 10^{-15}$  |
| Cadmium iodate               | $Cd(IO_3)_2$            | $2.5 \cdot 10^{-8}$   |
| Cadmium oxalate trihydrate   | $CdC_2O_4 \cdot 3H_2O$  | $1.42 \cdot 10^{-8}$  |
| Cadmium phosphate            | $Cd_3(PO_4)_2$          | $2.53 \cdot 10^{-33}$ |
| Calcium carbonate (calcite)  | $CaCO_3$                | $3.36 \cdot 10^{-9}$  |
| Calcium fluoride             | $CaF_2$                 | $3.45 \cdot 10^{-11}$ |
| Calcium hydroxide            | $Ca(OH)_2$              | $5.02 \cdot 10^{-6}$  |

| Compound                      | Formula                  | $K_{sp}$              |
|-------------------------------|--------------------------|-----------------------|
| Calcium iodate                | $Ca(IO_3)_2$             | $6.47 \cdot 10^{-6}$  |
| Calcium iodate hexahydrate    | $Ca(IO_3)_2 \cdot 6H_2O$ | $7.10 \cdot 10^{-7}$  |
| Calcium molybdate             | $CaMoO_4$                | $1.46 \cdot 10^{-8}$  |
| Calcium oxalate monohydrate   | $CaC_2O_4 \cdot H_2O$    | $2.32 \cdot 10^{-9}$  |
| Calcium phosphate             | $Ca_3(PO_4)_2$           | $2.07 \cdot 10^{-33}$ |
| Calcium sulfate               | $CaSO_4$                 | $4.93 \cdot 10^{-5}$  |
| Calcium sulfate dihydrate     | $CaSO_4 \cdot 2H_2O$     | $3.14 \cdot 10^{-5}$  |
| Calcium sulfite hemihydrate   | $CaSO_3 \cdot 0.5H_2O$   | $3.1 \cdot 10^{-7}$   |
| Cesium perchlorate            | $CsClO_4$                | $3.95 \cdot 10^{-3}$  |
| Cesium periodate              | $CsIO_4$                 | $5.16 \cdot 10^{-6}$  |
| Cobalt(II) arsenate           | $Co_3(AsO_4)_2$          | $6.80 \cdot 10^{-29}$ |
| Cobalt(II) hydroxide (blue)   | $Co(OH)_2$               | $5.92 \cdot 10^{-15}$ |
| Cobalt(II) iodate dihydrate   | $Co(IO_3)_2 \cdot 2H_2O$ | $1.21 \cdot 10^{-2}$  |
| Cobalt(II) phosphate          | $Co_3(PO_4)_2$           | $2.05 \cdot 10^{-35}$ |
| Copper(I) bromide             | $CuBr$                   | $6.27 \cdot 10^{-9}$  |
| Copper(I) chloride            | $CuCl$                   | $1.72 \cdot 10^{-7}$  |
| Copper(I) cyanide             | $CuCN$                   | $3.47 \cdot 10^{-20}$ |
| Copper(I) iodide              | $CuI$                    | $1.27 \cdot 10^{-12}$ |
| Copper(I) thiocyanate         | $CuSCN$                  | $1.77 \cdot 10^{-13}$ |
| Copper(II) arsenate           | $Cu_3(AsO_4)_2$          | $7.95 \cdot 10^{-36}$ |
| Copper(II) iodate monohydrate | $Cu(IO_3)_2 \cdot H_2O$  | $6.94 \cdot 10^{-8}$  |
| Copper(II) oxalate            | $CuC_2O_4$               | $4.43 \cdot 10^{-10}$ |
| Copper(II) phosphate          | $Cu_3(PO_4)_2$           | $1.40 \cdot 10^{-37}$ |
| Europium(III) hydroxide       | $Eu(OH)_3$               | $9.38 \cdot 10^{-27}$ |
| Gallium(III) hydroxide        | $Ga(OH)_3$               | $7.28 \cdot 10^{-36}$ |
| Iron(II) carbonate            | $FeCO_3$                 | $3.13 \cdot 10^{-11}$ |

| Compound                         | Formula                                            | $K_{sp}$              |
|----------------------------------|----------------------------------------------------|-----------------------|
| Iron(II) fluoride                | $\text{FeF}_2$                                     | $2.36 \cdot 10^{-6}$  |
| Iron(II) hydroxide               | $\text{Fe}(\text{OH})_2$                           | $4.87 \cdot 10^{-17}$ |
| Iron(III) hydroxide              | $\text{Fe}(\text{OH})_3$                           | $2.79 \cdot 10^{-39}$ |
| Iron(III) phosphate dihydrate    | $\text{FePO}_4 \cdot 2\text{H}_2\text{O}$          | $9.91 \cdot 10^{-16}$ |
| Lanthanum iodate                 | $\text{La}(\text{IO}_3)_3$                         | $7.50 \cdot 10^{-12}$ |
| Lead(II) bromide                 | $\text{PbBr}_2$                                    | $6.60 \cdot 10^{-6}$  |
| Lead(II) carbonate               | $\text{PbCO}_3$                                    | $7.40 \cdot 10^{-14}$ |
| Lead(II) chloride                | $\text{PbCl}_2$                                    | $1.70 \cdot 10^{-5}$  |
| Lead(II) fluoride                | $\text{PbF}_2$                                     | $3.3 \cdot 10^{-8}$   |
| Lead(II) hydroxide               | $\text{Pb}(\text{OH})_2$                           | $1.43 \cdot 10^{-20}$ |
| Lead(II) iodate                  | $\text{Pb}(\text{IO}_3)_2$                         | $3.69 \cdot 10^{-13}$ |
| Lead(II) iodide                  | $\text{PbI}_2$                                     | $9.8 \cdot 10^{-9}$   |
| Lead(II) selenate                | $\text{PbSeO}_4$                                   | $1.37 \cdot 10^{-7}$  |
| Lead(II) sulfate                 | $\text{PbSO}_4$                                    | $2.53 \cdot 10^{-8}$  |
| Lithium carbonate                | $\text{Li}_2\text{CO}_3$                           | $8.15 \cdot 10^{-4}$  |
| Lithium fluoride                 | $\text{LiF}$                                       | $1.84 \cdot 10^{-3}$  |
| Lithium phosphate                | $\text{Li}_3\text{PO}_4$                           | $2.37 \cdot 10^{-11}$ |
| Magnesium carbonate              | $\text{MgCO}_3$                                    | $6.82 \cdot 10^{-6}$  |
| Magnesium carbonate trihydrate   | $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$          | $2.38 \cdot 10^{-6}$  |
| Magnesium carbonate pentahydrate | $\text{MgCO}_3 \cdot 5\text{H}_2\text{O}$          | $3.79 \cdot 10^{-6}$  |
| Magnesium fluoride               | $\text{MgF}_2$                                     | $5.16 \cdot 10^{-11}$ |
| Magnesium hydroxide              | $\text{Mg}(\text{OH})_2$                           | $5.61 \cdot 10^{-12}$ |
| Magnesium oxalate dihydrate      | $\text{MgC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ | $4.83 \cdot 10^{-6}$  |
| Magnesium phosphate              | $\text{Mg}_3(\text{PO}_4)_2$                       | $1.04 \cdot 10^{-24}$ |
| Manganese(II) carbonate          | $\text{MnCO}_3$                                    | $2.24 \cdot 10^{-11}$ |
| Manganese(II) iodate             | $\text{Mn}(\text{IO}_3)_2$                         | $4.37 \cdot 10^{-7}$  |
| Manganese(II) oxalate dihydrate  | $\text{MnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ | $1.70 \cdot 10^{-7}$  |
| Mercury(I) bromide               | $\text{Hg}_2\text{Br}_2$                           | $6.40 \cdot 10^{-23}$ |
| Mercury(I) carbonate             | $\text{Hg}_2\text{CO}_3$                           | $3.6 \cdot 10^{-17}$  |
| Mercury(I) chloride              | $\text{Hg}_2\text{Cl}_2$                           | $1.43 \cdot 10^{-18}$ |
| Mercury(I) fluoride              | $\text{Hg}_2\text{F}_2$                            | $3.10 \cdot 10^{-6}$  |
| Mercury(I) iodide                | $\text{Hg}_2\text{I}_2$                            | $5.2 \cdot 10^{-29}$  |
| Mercury(I) oxalate               | $\text{Hg}_2\text{C}_2\text{O}_4$                  | $1.75 \cdot 10^{-13}$ |
| Mercury(I) sulfate               | $\text{Hg}_2\text{SO}_4$                           | $6.5 \cdot 10^{-7}$   |
| Mercury(I) thiocyanate           | $\text{Hg}_2(\text{SCN})_2$                        | $3.2 \cdot 10^{-20}$  |
| Mercury(II) bromide              | $\text{HgBr}_2$                                    | $6.2 \cdot 10^{-20}$  |
| Mercury(II) iodide               | $\text{HgI}_2$                                     | $2.9 \cdot 10^{-29}$  |
| Neodymium carbonate              | $\text{Nd}_2(\text{CO}_3)_3$                       | $1.08 \cdot 10^{-33}$ |
| Nickel(II) carbonate             | $\text{NiCO}_3$                                    | $1.42 \cdot 10^{-7}$  |
| Nickel(II) hydroxide             | $\text{Ni}(\text{OH})_2$                           | $5.48 \cdot 10^{-16}$ |
| Nickel(II) iodate                | $\text{Ni}(\text{IO}_3)_2$                         | $4.71 \cdot 10^{-5}$  |
| Nickel(II) phosphate             | $\text{Ni}_3(\text{PO}_4)_2$                       | $4.74 \cdot 10^{-32}$ |
| Palladium(II) thiocyanate        | $\text{Pd}(\text{SCN})_2$                          | $4.39 \cdot 10^{-23}$ |
| Potassium hexachloroplatinate    | $\text{K}_2\text{PtCl}_6$                          | $7.48 \cdot 10^{-6}$  |
| Potassium perchlorate            | $\text{KClO}_4$                                    | $1.05 \cdot 10^{-2}$  |
| Potassium periodate              | $\text{KIO}_4$                                     | $3.71 \cdot 10^{-4}$  |
| Praseodymium hydroxide           | $\text{Pr}(\text{OH})_3$                           | $3.39 \cdot 10^{-24}$ |

| Compound                     | Formula                                              | $K_{sp}$              |
|------------------------------|------------------------------------------------------|-----------------------|
| Radium iodate                | $\text{Ra}(\text{IO}_3)_2$                           | $1.16 \cdot 10^{-9}$  |
| Radium sulfate               | $\text{RaSO}_4$                                      | $3.66 \cdot 10^{-11}$ |
| Rubidium perchlorate         | $\text{RbClO}_4$                                     | $3.00 \cdot 10^{-3}$  |
| Scandium fluoride            | $\text{ScF}_3$                                       | $5.81 \cdot 10^{-24}$ |
| Scandium hydroxide           | $\text{Sc}(\text{OH})_3$                             | $2.22 \cdot 10^{-31}$ |
| Silver(I) acetate            | $\text{AgCH}_3\text{COO}$                            | $1.94 \cdot 10^{-3}$  |
| Silver(I) arsenate           | $\text{Ag}_3\text{AsO}_4$                            | $1.03 \cdot 10^{-22}$ |
| Silver(I) bromate            | $\text{AgBrO}_3$                                     | $5.38 \cdot 10^{-5}$  |
| Silver(I) bromide            | $\text{AgBr}$                                        | $5.35 \cdot 10^{-13}$ |
| Silver(I) carbonate          | $\text{Ag}_2\text{CO}_3$                             | $8.46 \cdot 10^{-12}$ |
| Silver(I) chloride           | $\text{AgCl}$                                        | $1.77 \cdot 10^{-10}$ |
| Silver(I) chromate           | $\text{Ag}_2\text{CrO}_4$                            | $1.12 \cdot 10^{-12}$ |
| Silver(I) cyanide            | $\text{AgCN}$                                        | $5.97 \cdot 10^{-17}$ |
| Silver(I) iodate             | $\text{AgIO}_3$                                      | $3.17 \cdot 10^{-8}$  |
| Silver(I) iodide             | $\text{AgI}$                                         | $8.52 \cdot 10^{-17}$ |
| Silver(I) oxalate            | $\text{Ag}_2\text{C}_2\text{O}_4$                    | $5.40 \cdot 10^{-12}$ |
| Silver(I) phosphate          | $\text{Ag}_3\text{PO}_4$                             | $8.89 \cdot 10^{-17}$ |
| Silver(I) sulfate            | $\text{Ag}_2\text{SO}_4$                             | $1.20 \cdot 10^{-5}$  |
| Silver(I) sulfite            | $\text{Ag}_2\text{SO}_3$                             | $1.50 \cdot 10^{-14}$ |
| Silver(I) thiocyanate        | $\text{AgSCN}$                                       | $1.03 \cdot 10^{-12}$ |
| Strontium arsenate           | $\text{Sr}_3(\text{AsO}_4)_2$                        | $4.29 \cdot 10^{-19}$ |
| Strontium carbonate          | $\text{SrCO}_3$                                      | $5.60 \cdot 10^{-10}$ |
| Strontium fluoride           | $\text{SrF}_2$                                       | $4.33 \cdot 10^{-9}$  |
| Strontium iodate             | $\text{Sr}(\text{IO}_3)_2$                           | $1.14 \cdot 10^{-7}$  |
| Strontium iodate monohydrate | $\text{Sr}(\text{IO}_3)_2 \cdot \text{H}_2\text{O}$  | $3.77 \cdot 10^{-7}$  |
| Strontium iodate hexahydrate | $\text{Sr}(\text{IO}_3)_2 \cdot 6\text{H}_2\text{O}$ | $4.55 \cdot 10^{-7}$  |
| Strontium sulfate            | $\text{SrSO}_4$                                      | $3.44 \cdot 10^{-7}$  |
| Thallium(I) bromate          | $\text{TlBrO}_3$                                     | $1.10 \cdot 10^{-4}$  |
| Thallium(I) bromide          | $\text{TlBr}$                                        | $3.71 \cdot 10^{-6}$  |
| Thallium(I) chloride         | $\text{TlCl}$                                        | $1.86 \cdot 10^{-4}$  |
| Thallium(I) chromate         | $\text{Tl}_2\text{CrO}_4$                            | $8.67 \cdot 10^{-13}$ |
| Thallium(I) iodate           | $\text{TlIO}_3$                                      | $3.12 \cdot 10^{-6}$  |
| Thallium(I) iodide           | $\text{TlI}$                                         | $5.54 \cdot 10^{-8}$  |
| Thallium(I) thiocyanate      | $\text{TlSCN}$                                       | $1.57 \cdot 10^{-4}$  |
| Thallium(III) hydroxide      | $\text{Tl}(\text{OH})_3$                             | $1.68 \cdot 10^{-44}$ |
| Tin(II) hydroxide            | $\text{Sn}(\text{OH})_2$                             | $5.45 \cdot 10^{-27}$ |
| Yttrium carbonate            | $\text{Y}_2(\text{CO}_3)_3$                          | $1.03 \cdot 10^{-31}$ |
| Yttrium fluoride             | $\text{YF}_3$                                        | $8.62 \cdot 10^{-21}$ |
| Yttrium hydroxide            | $\text{Y}(\text{OH})_3$                              | $1.00 \cdot 10^{-22}$ |
| Yttrium iodate               | $\text{Y}(\text{IO}_3)_3$                            | $1.12 \cdot 10^{-10}$ |
| Zinc arsenate                | $\text{Zn}_3(\text{AsO}_4)_2$                        | $2.8 \cdot 10^{-28}$  |
| Zinc carbonate               | $\text{ZnCO}_3$                                      | $1.46 \cdot 10^{-10}$ |
| Zinc carbonate monohydrate   | $\text{ZnCO}_3 \cdot \text{H}_2\text{O}$             | $5.42 \cdot 10^{-11}$ |
| Zinc fluoride                | $\text{ZnF}_2$                                       | $3.04 \cdot 10^{-2}$  |
| Zinc hydroxide               | $\text{Zn}(\text{OH})_2$                             | $3 \cdot 10^{-17}$    |
| Zinc iodate dihydrate        | $\text{Zn}(\text{IO}_3)_2 \cdot 2\text{H}_2\text{O}$ | $4.1 \cdot 10^{-6}$   |
| Zinc oxalate dihydrate       | $\text{ZnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$   | $1.38 \cdot 10^{-9}$  |
| Zinc selenide                | $\text{ZnSe}$                                        | $3.6 \cdot 10^{-26}$  |
| Zinc selenite monohydrate    | $\text{ZnSeO}_3 \cdot \text{H}_2\text{O}$            | $1.59 \cdot 10^{-7}$  |

*Sulfides*

| Compound                      | Formula           | $K_{\text{spa}}$   |
|-------------------------------|-------------------|--------------------|
| Cadmium sulfide               | CdS               | $8 \cdot 10^{-7}$  |
| Copper(II) sulfide            | CuS               | $6 \cdot 10^{-16}$ |
| Iron(II) sulfide              | FeS               | $6 \cdot 10^{-2}$  |
| Lead(II) sulfide              | PbS               | $3 \cdot 10^{-7}$  |
| Manganese(II) sulfide (green) | MnS               | $3 \cdot 10^{-7}$  |
| Mercury(II) sulfide (red)     | HgS               | $4 \cdot 10^{-33}$ |
| Mercury(II) sulfide (black)   | HgS               | $2 \cdot 10^{-32}$ |
| Silver(I) sulfide             | Ag <sub>2</sub> S | $6 \cdot 10^{-30}$ |
| Tin(II) sulfide               | SnS               | $1 \cdot 10^{-5}$  |
| Zinc sulfide (sphalerite)     | ZnS               | $2 \cdot 10^{-4}$  |
| Zinc sulfide (wurtzite)       | ZnS               | $3 \cdot 10^{-2}$  |

# SOLUBILITY CHART

Abbreviations: **W**, soluble in water; **A**, insoluble in water but soluble in acids; **w**, sparingly soluble in water but soluble in acids; **a**, insoluble in water and only sparingly soluble in acids; **I**, insoluble in water and acids; **d**, decomposes in water. \* Indicates two modifications of the salt.

| No. |                                                  | Al                                              | NH <sub>4</sub>                                 | Sb                                              | Ba                                              | Bi                                              | Cd                                              | Ca                                              | Cr                                              | Co                                              | Cu                                              | Au (I)            | Au (II)                        | H                                               | Fe (II)                           | Fe (III)                          |
|-----|--------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------|--------------------------------|-------------------------------------------------|-----------------------------------|-----------------------------------|
| 1   | Acetate                                          | W                                               | W                                               |                                                 | W                                               | W                                               | W                                               | W                                               | W                                               | W                                               | W                                               | W                 | W                              | W                                               |                                   |                                   |
|     | —(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) | Al(—) <sub>3</sub>                              | NH <sub>4</sub> (—)                             |                                                 | Ba(—) <sub>2</sub>                              | Bi(—) <sub>3</sub>                              | Cd(—) <sub>2</sub>                              | Ca(—) <sub>2</sub>                              | Cr(—) <sub>3</sub>                              | Co(—) <sub>2</sub>                              | Cu(—) <sub>2</sub>                              |                   |                                | C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>    | Fe(—) <sub>2</sub>                | Fe <sub>2</sub> (—) <sub>6</sub>  |
| 2   | Arsenate                                         | a                                               | W                                               | A                                               | w                                               | A                                               | A                                               | w                                               |                                                 | A                                               | A                                               |                   |                                | W                                               | A                                 | A                                 |
|     | —(AsO <sub>4</sub> )                             | Al(—)                                           | (NH <sub>4</sub> ) <sub>3</sub> (—)             | Sb(—)                                           | Ba <sub>3</sub> (—) <sub>2</sub>                | Bi(—)                                           | Cd <sub>3</sub> (—) <sub>2</sub>                | Ca <sub>3</sub> (—) <sub>2</sub>                |                                                 | Co <sub>3</sub> (—) <sub>2</sub>                | Cu <sub>3</sub> (—) <sub>2</sub>                |                   |                                | H <sub>3</sub> AsO <sub>4</sub>                 | Fe <sub>3</sub> (—) <sub>2</sub>  | Fe(—)                             |
| 3   | Arsenite                                         |                                                 | W                                               | A                                               |                                                 |                                                 |                                                 | w                                               |                                                 | A                                               | A                                               |                   |                                |                                                 |                                   |                                   |
|     | —(AsO <sub>3</sub> )                             |                                                 | NH <sub>4</sub> AsO <sub>2</sub>                | Sb(—)                                           |                                                 |                                                 |                                                 | Ca <sub>3</sub> (—) <sub>2</sub>                |                                                 | Co <sub>3</sub> H <sub>6</sub> (—) <sub>4</sub> | CuH(—)                                          |                   |                                |                                                 |                                   |                                   |
| 4   | Benzoate                                         |                                                 | W                                               |                                                 | W                                               | A                                               | W                                               | W                                               |                                                 | W                                               | w                                               |                   |                                | W                                               | W                                 | A                                 |
|     | —(C <sub>6</sub> H <sub>5</sub> O <sub>2</sub> ) |                                                 | NH <sub>4</sub> (—)                             |                                                 | Ba(—) <sub>2</sub>                              | Bi(—) <sub>3</sub>                              | Cd(—) <sub>2</sub>                              | Ca(—) <sub>2</sub>                              |                                                 | Co(—) <sub>2</sub>                              | Cu(—) <sub>2</sub>                              |                   |                                | C <sub>7</sub> H <sub>5</sub> O <sub>2</sub>    | Fe(—) <sub>2</sub>                | Fe <sub>2</sub> (—) <sub>6</sub>  |
| 5   | Bromide                                          | W                                               | W                                               | d                                               | W                                               | d                                               | W                                               | W                                               | W(I)*                                           | W                                               | W                                               | w                 | W                              | W                                               | W                                 | W                                 |
|     |                                                  | AlBr <sub>2</sub>                               | NH <sub>4</sub> Br                              | SbBr <sub>3</sub>                               | BaBr <sub>2</sub>                               | BiBr <sub>3</sub>                               | CdBr <sub>2</sub>                               | CaBr <sub>2</sub>                               | CrBr <sub>3</sub>                               | CoBr <sub>2</sub>                               | CuBr <sub>2</sub>                               | AuBr              | AuBr <sub>3</sub>              | HBr                                             | FeBr <sub>2</sub>                 | FeBr <sub>3</sub>                 |
| 6   | Carbonate                                        |                                                 | W                                               |                                                 | w                                               |                                                 | A                                               | w                                               | W                                               | A                                               |                                                 |                   |                                |                                                 | w                                 |                                   |
|     |                                                  |                                                 | (NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> |                                                 | BaCO <sub>3</sub>                               |                                                 | CdCO <sub>3</sub>                               | CaCO <sub>3</sub>                               | CrCO <sub>3</sub>                               | CoCO <sub>3</sub>                               |                                                 |                   |                                |                                                 | FeCO <sub>3</sub>                 |                                   |
| 7   | Chlorate                                         | W                                               | W                                               |                                                 | W                                               | W                                               | W                                               | W                                               |                                                 | W                                               | W                                               |                   |                                | W                                               | W                                 | W                                 |
|     | —(ClO <sub>3</sub> )                             | Al(—) <sub>3</sub>                              | NH <sub>4</sub> (—)                             |                                                 | Ba(—) <sub>2</sub>                              | Bi(—) <sub>3</sub>                              | Cd(—) <sub>2</sub>                              | Ca(—) <sub>2</sub>                              |                                                 | Co(—) <sub>2</sub>                              | Cu(—) <sub>2</sub>                              |                   |                                | HClO <sub>3</sub>                               | Fe(—) <sub>2</sub>                | Fe(—) <sub>3</sub>                |
| 8   | Chloride                                         | W                                               | W                                               | W                                               | W                                               | d                                               | W                                               | W                                               | I                                               | W                                               | W                                               | w                 | W                              | W                                               | W                                 | W                                 |
|     |                                                  | AlCl <sub>3</sub>                               | NH <sub>4</sub> Cl                              | SbCl <sub>3</sub>                               | BaCl <sub>2</sub>                               | BiCl <sub>3</sub>                               | CdCl <sub>2</sub>                               | CaCl <sub>2</sub>                               | CrCl <sub>3</sub>                               | CoCl <sub>2</sub>                               | CuCl <sub>2</sub>                               | AuCl              | AuCl <sub>3</sub>              | HCl                                             | FeCl <sub>2</sub>                 | FeCl <sub>3</sub>                 |
| 9   | Chromate                                         |                                                 | W                                               |                                                 | A                                               |                                                 | A                                               | W                                               |                                                 | A                                               |                                                 |                   |                                |                                                 |                                   | A                                 |
|     | —(CrO <sub>4</sub> )                             |                                                 | (NH <sub>4</sub> ) <sub>2</sub> (—)             |                                                 | Ba(—)                                           |                                                 | Cd(—)                                           | Ca(—)                                           |                                                 | Co(—)                                           |                                                 |                   |                                |                                                 |                                   | Fe <sub>2</sub> (—) <sub>3</sub>  |
| 10  | Citrate                                          | W                                               | W                                               |                                                 | w                                               | A                                               | A                                               | w                                               |                                                 | w                                               |                                                 |                   |                                | W                                               |                                   | W                                 |
|     | —(C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) | Al(—)                                           | (NH <sub>4</sub> ) <sub>3</sub> (—)             |                                                 | Ba <sub>3</sub> (—) <sub>2</sub>                | Bi(—)                                           | Cd <sub>3</sub> (—) <sub>2</sub>                | Ca <sub>3</sub> (—) <sub>2</sub>                |                                                 | Co <sub>3</sub> (—) <sub>2</sub>                |                                                 |                   |                                | C <sub>6</sub> H <sub>5</sub> O <sub>7</sub>    |                                   | Fe(—)                             |
| 11  | Cyanide                                          |                                                 | W                                               |                                                 | W                                               | w                                               | W                                               | W                                               | A                                               | A                                               | A                                               | w                 | W                              | W                                               | a                                 |                                   |
|     |                                                  |                                                 | NH <sub>4</sub> CN                              |                                                 | Ba(CN) <sub>2</sub>                             | Bi(CN) <sub>3</sub>                             | Cd(CN) <sub>2</sub>                             | Ca(CN) <sub>2</sub>                             | Cr(CN) <sub>3</sub>                             | Co(CN) <sub>2</sub>                             | Cu(CN) <sub>2</sub>                             | AuCN              | Au(CN) <sub>3</sub>            | HCN                                             | Fe(CN) <sub>2</sub>               |                                   |
| 12  | Ferricyde                                        |                                                 | W                                               |                                                 | w                                               |                                                 | A                                               | W                                               |                                                 | I                                               | I                                               |                   |                                | W                                               | I                                 |                                   |
|     | —(Fe(CN) <sub>6</sub> )                          |                                                 | (NH <sub>4</sub> ) <sub>3</sub> (—)             |                                                 | Ba <sub>3</sub> (—) <sub>2</sub>                |                                                 | Cd <sub>3</sub> (—) <sub>2</sub>                | Ca <sub>3</sub> (—) <sub>2</sub>                |                                                 | Co <sub>3</sub> (—) <sub>2</sub>                | Cu <sub>3</sub> (—) <sub>2</sub>                |                   |                                | H <sub>3</sub> (—)                              | Fe <sub>3</sub> (—) <sub>2</sub>  |                                   |
| 13  | Ferrocide                                        | w                                               | W                                               |                                                 | W                                               |                                                 | A                                               | W                                               |                                                 | I                                               | I                                               |                   |                                | W                                               | I                                 | a                                 |
|     | —(Fe(CN) <sub>6</sub> )                          | Al <sub>4</sub> (—) <sub>3</sub>                | (NH <sub>4</sub> ) <sub>4</sub> (—)             |                                                 | Ba <sub>2</sub> (—)                             |                                                 | Cd <sub>2</sub> (—)                             | Ca <sub>2</sub> (—)                             |                                                 | Co <sub>2</sub> (—)                             | Cu <sub>2</sub> (—)                             |                   |                                | H <sub>4</sub> (—)                              | Fe <sub>2</sub> (—)               | Fe <sub>4</sub> (—) <sub>3</sub>  |
| 14  | Fluoride                                         | W                                               | W                                               | W                                               | w                                               | W                                               | W                                               | w                                               | W(a)*                                           | W                                               | w                                               |                   |                                | W                                               | w                                 | w                                 |
|     |                                                  | AlF <sub>3</sub>                                | NH <sub>4</sub> F                               | SbF <sub>3</sub>                                | BaF <sub>2</sub>                                | BiF <sub>3</sub>                                | CdF <sub>2</sub>                                | CaF <sub>2</sub>                                | CrF <sub>3</sub>                                | CoF <sub>2</sub>                                | CuF <sub>2</sub>                                |                   |                                | HF                                              | FeF <sub>2</sub>                  | FeF <sub>3</sub>                  |
| 15  | Formate                                          | W                                               | W                                               |                                                 | W                                               |                                                 | W                                               | W                                               |                                                 | W                                               | W                                               |                   |                                | W                                               | W                                 | W                                 |
|     | —(CHO <sub>2</sub> )                             | Al(—) <sub>3</sub>                              | NH <sub>4</sub> (—)                             |                                                 | Ba(—) <sub>2</sub>                              | Bi(—) <sub>3</sub>                              | Cd(—) <sub>2</sub>                              | Ca(—) <sub>2</sub>                              |                                                 | Co(—) <sub>2</sub>                              | Cu(—) <sub>2</sub>                              |                   |                                | CH <sub>2</sub> O <sub>2</sub>                  | Fe(—) <sub>2</sub>                | Fe(—) <sub>3</sub>                |
| 16  | Hydroxide                                        | A                                               | W                                               |                                                 | W                                               | A                                               | A                                               | W                                               | A                                               | A                                               | A                                               | W                 | A                              |                                                 | A                                 | A                                 |
|     |                                                  | Al(OH) <sub>3</sub>                             | NH <sub>4</sub> OH                              |                                                 | Ba(OH) <sub>2</sub>                             | Bi(OH) <sub>3</sub>                             | Cd(OH) <sub>2</sub>                             | Ca(OH) <sub>2</sub>                             | Cr(OH) <sub>3</sub>                             | Co(OH) <sub>2</sub>                             | Cu(OH) <sub>2</sub>                             | AuOH              | Au(OH) <sub>3</sub>            |                                                 | Fe(OH) <sub>2</sub>               | Fe(OH) <sub>3</sub>               |
| 17  | Iodide                                           | W                                               | W                                               | d                                               | W                                               | A                                               | W                                               | W                                               | W                                               | W                                               | a                                               | a                 | a                              | W                                               | W                                 | W                                 |
|     |                                                  | AlI <sub>3</sub>                                | NH <sub>4</sub> I                               | SbI <sub>3</sub>                                | BaI <sub>2</sub>                                | BiI <sub>3</sub>                                | CdI <sub>2</sub>                                | CaI <sub>2</sub>                                | CrI <sub>3</sub>                                | CoI <sub>2</sub>                                | CuI                                             | AuI               | AuI <sub>3</sub>               | HI                                              | FeI <sub>2</sub>                  | FeI <sub>3</sub>                  |
| 18  | Nitrate                                          | W                                               | W                                               |                                                 | W                                               | d                                               | W                                               | W                                               | W                                               | W                                               | W                                               |                   |                                | W                                               | W                                 | W                                 |
|     |                                                  | Al(NO <sub>3</sub> ) <sub>3</sub>               | NH <sub>4</sub> NO <sub>3</sub>                 |                                                 | Ba(NO <sub>3</sub> ) <sub>2</sub>               | Bi(NO <sub>3</sub> ) <sub>3</sub>               | Cd(NO <sub>3</sub> ) <sub>2</sub>               | Ca(NO <sub>3</sub> ) <sub>2</sub>               | Cr(NO <sub>3</sub> ) <sub>3</sub>               | Co(NO <sub>3</sub> ) <sub>2</sub>               | Cu(NO <sub>3</sub> ) <sub>2</sub>               |                   |                                | HNO <sub>3</sub>                                | Fe(NO <sub>3</sub> ) <sub>2</sub> | Fe(NO <sub>3</sub> ) <sub>3</sub> |
| 19  | Oxalate                                          | A                                               | W                                               |                                                 | w                                               | A                                               | w                                               | A                                               | W                                               | A                                               | A                                               |                   |                                | W                                               | A                                 | W                                 |
|     | —(C <sub>2</sub> O <sub>4</sub> )                | Al <sub>2</sub> (—) <sub>3</sub>                | (NH <sub>4</sub> ) <sub>2</sub> (—)             |                                                 | Ba(—)                                           | Bi <sub>2</sub> (—) <sub>3</sub>                | Cd(—)                                           | Ca(—)                                           | Cr(—)                                           | Co(—)                                           | Cu(—)                                           |                   |                                | C <sub>2</sub> H <sub>2</sub> O <sub>4</sub>    | Fe(—)                             | Fe <sub>2</sub> (—) <sub>3</sub>  |
| 20  | Oxide                                            | a                                               |                                                 | w                                               | W                                               | A                                               | A                                               | w                                               | a                                               | A                                               | A                                               |                   | A                              | W                                               | A                                 | A                                 |
|     |                                                  | Al <sub>2</sub> O <sub>3</sub>                  |                                                 | Sb <sub>2</sub> O <sub>3</sub>                  | BaO                                             | Bi <sub>2</sub> O <sub>3</sub>                  | CdO                                             | CaO                                             | Cr <sub>2</sub> O <sub>3</sub>                  | CoO                                             | CuO                                             | Au <sub>2</sub> O | Au <sub>2</sub> O <sub>3</sub> | H <sub>2</sub> O <sub>2</sub>                   | FeO                               | Fe <sub>2</sub> O <sub>3</sub>    |
| 21  | Phosphate                                        | A                                               | W                                               |                                                 | A                                               | A                                               | A                                               | w                                               | w                                               | A                                               | A                                               |                   |                                | W                                               | A                                 | w                                 |
|     |                                                  | AlPO <sub>4</sub>                               | NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>  |                                                 | Ba <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | BiPO <sub>4</sub>                               | Cd <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | Cr <sub>2</sub> (PO <sub>4</sub> ) <sub>2</sub> | Co <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | Cu <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> |                   | H <sub>3</sub> PO <sub>4</sub> | Fe <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | FePO <sub>4</sub>                 |                                   |
| 22  | Silicate                                         | I                                               |                                                 |                                                 | W                                               |                                                 | A                                               | w                                               |                                                 | A                                               | A                                               |                   |                                | I                                               |                                   |                                   |
|     | —(SiO <sub>3</sub> )                             | Al <sub>2</sub> (—) <sub>3</sub>                |                                                 |                                                 | Ba(—)                                           |                                                 | Cd(—)                                           | Ca(—)                                           |                                                 | Co <sub>2</sub> SiO <sub>4</sub>                | Cu(—)                                           |                   |                                | H <sub>2</sub> SiO <sub>3</sub>                 |                                   |                                   |
| 23  | Sulfate                                          | W                                               | W                                               | A                                               | a                                               | d                                               | W                                               | w                                               | W(I)*                                           | W                                               | W                                               |                   |                                | W                                               | W                                 | w                                 |
|     |                                                  | Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | Sb <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> | BaSO <sub>4</sub>                               | Bi <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> | CdSO <sub>4</sub>                               | CaSO <sub>4</sub>                               | Cr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> | CoSO <sub>4</sub>                               | CuSO <sub>4</sub>                               |                   |                                | H <sub>2</sub> SO <sub>4</sub>                  | FeSO <sub>4</sub>                 | Fe(SO <sub>4</sub> ) <sub>3</sub> |
| 24  | Sulfide                                          | d                                               | W                                               | A                                               | d                                               | A                                               | A                                               | w                                               | d                                               | A                                               | A                                               | I                 | I                              | W                                               | A                                 | d                                 |
|     |                                                  | Al <sub>2</sub> S <sub>3</sub>                  | (NH <sub>4</sub> ) <sub>2</sub> S               | Sb <sub>2</sub> S <sub>3</sub>                  | BaS                                             | Bi <sub>2</sub> S <sub>3</sub>                  | CdS                                             | CaS                                             | Cr <sub>2</sub> S <sub>3</sub>                  | CoS                                             | CuS                                             | Au <sub>2</sub> S | Au <sub>2</sub> S <sub>3</sub> | H <sub>2</sub> S                                | FeS                               | Fe <sub>2</sub> S <sub>3</sub>    |
| 25  | Tartrate                                         | w                                               | W                                               | W                                               | w                                               | A                                               | A                                               | w                                               | d                                               | A                                               | A                                               | I                 | I                              | W                                               | A                                 | d                                 |
|     | —(C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ) | Al <sub>2</sub> (—) <sub>3</sub>                | (NH <sub>4</sub> ) <sub>2</sub> (—)             | Sb <sub>2</sub> (—) <sub>3</sub>                | Ba(—)                                           | Bi <sub>2</sub> (—) <sub>3</sub>                | Cd(—)                                           | Ca(—)                                           |                                                 | Co(—)                                           | Cu(—)                                           |                   |                                | C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>    | Fe(—)                             | Fe <sub>2</sub> (—) <sub>3</sub>  |
| 26  | Thiocyete                                        |                                                 | W                                               |                                                 | W                                               |                                                 |                                                 | W                                               |                                                 | W                                               | d                                               |                   |                                | W                                               | W                                 |                                   |
|     |                                                  |                                                 | NH <sub>4</sub> CNS                             |                                                 | Ba(CNS) <sub>2</sub>                            |                                                 |                                                 | Ca(CNS)                                         |                                                 | Co(CNS) <sub>2</sub>                            | CuCNS                                           |                   |                                | CNSH                                            | Fe(CNS) <sub>2</sub>              | Fe(CNS) <sub>3</sub>              |

| No. |                                                  | Pb                                              | Mg                                              | Mn                                              | Hg (I)                           | Hg (II)                                         | Ni                                              | K                               | Pt                                | Ag                              | Na                              | Sn (IV)                           | Sn (II)                            | Sr                                              | Zn                                              |
|-----|--------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|----------------------------------|-------------------------------------------------|-------------------------------------------------|---------------------------------|-----------------------------------|---------------------------------|---------------------------------|-----------------------------------|------------------------------------|-------------------------------------------------|-------------------------------------------------|
| 1   | Acetate                                          | W                                               | W                                               | W                                               | w                                | W                                               | W                                               | W                               |                                   | w                               | W                               | W                                 | d                                  | W                                               | W                                               |
|     | —(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) | Pb(—) <sub>2</sub>                              | Mg(—) <sub>2</sub>                              | Mn(—) <sub>2</sub>                              | Hg(—)                            | Hg(—) <sub>2</sub>                              | Ni(—) <sub>2</sub>                              | K(—)                            |                                   | Ag(—)                           | Na(—)                           | Sn(—) <sub>4</sub>                | Sn(—) <sub>2</sub>                 | Sr(—) <sub>2</sub>                              | Zn(—) <sub>2</sub>                              |
| 2   | Arsenate                                         | A                                               | A                                               | w                                               | A                                | w                                               | A                                               | W                               |                                   | A                               | W                               |                                   |                                    | w                                               | A                                               |
|     | —(AsO <sub>4</sub> )                             | PbH(—)                                          | Mg <sub>3</sub> (—)                             | MnH(—)                                          | Hg <sub>3</sub> (—)              | Hg <sub>3</sub> (—) <sub>2</sub>                | Ni <sub>3</sub> (—) <sub>2</sub>                | K <sub>3</sub> (—)              |                                   | Ag <sub>3</sub> (—)             | Na <sub>3</sub> (—)             |                                   |                                    | SrH(—)                                          | Zn <sub>3</sub> (—) <sub>2</sub>                |
| 3   | Arsenite                                         |                                                 | W                                               | A                                               | A                                | A                                               | A                                               | W                               |                                   | A                               | W                               |                                   | A                                  | w                                               |                                                 |
|     | —(AsO <sub>3</sub> )                             |                                                 | Mg <sub>3</sub> (—) <sub>2</sub>                | Mn <sub>3</sub> H <sub>6</sub> (—) <sub>4</sub> | Hg <sub>3</sub> (—)              | Hg <sub>3</sub> (—)                             | Ni <sub>3</sub> H <sub>6</sub> (—) <sub>4</sub> | K <sub>3</sub> AsO <sub>3</sub> |                                   | Ag <sub>3</sub> (—)             | Na <sub>2</sub> H(—)            |                                   | Sn <sub>3</sub> (—) <sub>2</sub>   | Sr <sub>3</sub> (—) <sub>2</sub>                |                                                 |
| 4   | Benzoate                                         | w                                               | W                                               | W                                               | A                                | w                                               | w                                               | W                               |                                   | w                               | W                               |                                   |                                    |                                                 | W                                               |
|     | —(C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> ) | Pb(—) <sub>2</sub>                              | Mg(—) <sub>2</sub>                              | Mn(—) <sub>2</sub>                              | Hg <sub>2</sub> (—) <sub>2</sub> | Hg(—) <sub>2</sub>                              | Ni(—) <sub>2</sub>                              | K(—)                            |                                   | Ag(—)                           | Na(—)                           |                                   |                                    |                                                 | Zn(—) <sub>2</sub>                              |
| 5   | Bromide                                          | W                                               | W                                               | W                                               | A                                | W                                               | W                                               | W                               | w                                 | a                               | W                               | W                                 | W                                  | W                                               | W                                               |
|     |                                                  | PbBr <sub>2</sub>                               | MgBr <sub>2</sub>                               | MnBr <sub>2</sub>                               | HgBr                             | HgBr <sub>2</sub>                               | NiBr <sub>2</sub>                               | KBr                             | PtBr <sub>4</sub>                 | AgBr                            | NaBr                            | SnBr <sub>4</sub>                 | SnBr <sub>2</sub>                  | SrBr <sub>2</sub>                               | ZnBr <sub>2</sub>                               |
| 6   | Carbonate                                        | A                                               | w                                               | w                                               | A                                |                                                 | w                                               | W                               |                                   | A                               | W                               |                                   |                                    | w                                               | w                                               |
|     |                                                  | PbCO <sub>3</sub>                               | MgCO <sub>3</sub>                               | MnCO <sub>3</sub>                               | Hg <sub>2</sub> CO <sub>3</sub>  |                                                 | NiCO <sub>3</sub>                               | K <sub>2</sub> CO <sub>3</sub>  |                                   | Ag <sub>2</sub> CO <sub>3</sub> | Na <sub>2</sub> CO <sub>3</sub> |                                   |                                    | SrCO <sub>3</sub>                               | ZnCO <sub>3</sub>                               |
| 7   | Chlorate                                         | W                                               | W                                               | W                                               | W                                | W                                               | W                                               | W                               |                                   | W                               | W                               |                                   | W                                  | W                                               | W                                               |
|     | —(ClO <sub>3</sub> )                             | Pb(—) <sub>2</sub>                              | Mg(—) <sub>2</sub>                              | Mn(—) <sub>2</sub>                              | Hg(—)                            | Hg(—) <sub>2</sub>                              | Ni(—) <sub>2</sub>                              | K(—)                            |                                   | Ag(—)                           | Na(—)                           |                                   | Sn(—) <sub>2</sub>                 | Sr(—) <sub>2</sub>                              | Zn(—) <sub>2</sub>                              |
| 8   | Chloride                                         | W                                               | W                                               | W                                               | a                                | W                                               | W                                               | W                               | W                                 | a                               | W                               | W                                 | W                                  | W                                               | W                                               |
|     |                                                  | PbCl <sub>2</sub>                               | MgCl <sub>2</sub>                               | MnCl <sub>2</sub>                               | HgCl                             | HgCl <sub>2</sub>                               | NiCl <sub>2</sub>                               | KCl                             | PtCl <sub>4</sub>                 | AgCl                            | NaCl                            | SnCl <sub>4</sub>                 | SnCl <sub>2</sub>                  | SrCl <sub>2</sub>                               | ZnCl <sub>2</sub>                               |
| 9   | Chromate                                         | A                                               | W                                               |                                                 | w                                | w                                               | A                                               | W                               |                                   | w                               | W                               | W                                 | A                                  | w                                               | w                                               |
|     | —(CrO <sub>4</sub> )                             | Pb(—)                                           | Mg(—)                                           |                                                 | Hg <sub>2</sub> (—)              | Hg(—)                                           | Ni(—)                                           | K <sub>2</sub> (—)              |                                   | Ag <sub>2</sub> (—)             | Ma <sub>2</sub> (—)             | Sn(—) <sub>2</sub>                | Sn(—)                              | Sr(—)                                           | Zn(—)                                           |
| 10  | Citrate                                          | W                                               | W                                               | w                                               | w                                |                                                 | W                                               | W                               |                                   | w                               | W                               |                                   |                                    | A                                               | w                                               |
|     | —(C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> ) | Pb <sub>3</sub> (—) <sub>2</sub>                | Mg <sub>3</sub> (—) <sub>2</sub>                | MnH(—)                                          | Hg <sub>3</sub> (—)              |                                                 | Ni <sub>3</sub> (—) <sub>2</sub>                | K <sub>3</sub> (—)              |                                   | Ag <sub>3</sub> (—)             | Na <sub>3</sub> (—)             |                                   |                                    | SrH(—)                                          | Zn <sub>3</sub> (—) <sub>2</sub>                |
| 11  | Cyanide                                          | w                                               | W                                               |                                                 | A                                | W                                               | a                                               | W                               | I                                 | a                               | W                               |                                   |                                    | W                                               | A                                               |
|     |                                                  | Pb(CN) <sub>2</sub>                             | Mg(CN) <sub>2</sub>                             |                                                 | HgCN                             | Hg(CN) <sub>2</sub>                             | Ni(CN) <sub>2</sub>                             | KCN                             | Pt(CN) <sub>2</sub>               | AgCN                            | NaCN                            |                                   |                                    | Sr(CN) <sub>2</sub>                             | Zn(CN) <sub>2</sub>                             |
| 12  | Ferricy'de                                       | w                                               | W                                               |                                                 |                                  | A                                               | I                                               | W                               |                                   | I                               | W                               |                                   | A                                  | W                                               | A                                               |
|     | —Fe(CN) <sub>6</sub>                             | Pb <sub>3</sub> (—) <sub>2</sub>                | Mg <sub>3</sub> (—) <sub>2</sub>                |                                                 |                                  | Hg <sub>3</sub> (—) <sub>2</sub>                | Ni <sub>3</sub> (—) <sub>2</sub>                | K <sub>3</sub> (—)              |                                   | Ag <sub>3</sub> (—)             | Na <sub>3</sub> (—)             |                                   | Sn <sub>3</sub> (—) <sub>2</sub>   | Sr <sub>3</sub> (—) <sub>2</sub>                | Zn <sub>3</sub> (—) <sub>2</sub>                |
| 13  | Ferroc'yde                                       | a                                               | W                                               | A                                               |                                  | I                                               | I                                               | W                               |                                   | I                               | W                               |                                   | a                                  | W                                               | I                                               |
|     | —Fe(CN) <sub>6</sub>                             | Pb <sub>2</sub> (—)                             | Mg <sub>2</sub> (—)                             | Mn <sub>2</sub> (—)                             |                                  | Hg <sub>2</sub> (—)                             | Ni <sub>2</sub> (—)                             | K <sub>4</sub> (—)              |                                   | Ag <sub>4</sub> (—)             | Na <sub>4</sub> (—)             |                                   | Sn <sub>2</sub> (—)                | Sr <sub>2</sub> (—)                             | Zn <sub>2</sub> (—)                             |
| 14  | Fluoride                                         | w                                               | w                                               | A                                               | d                                | d                                               | w                                               | W                               | W                                 | W                               | W                               | W                                 | W                                  | w                                               | w                                               |
|     |                                                  | PbF <sub>2</sub>                                | MgF <sub>2</sub>                                | MnF <sub>2</sub>                                | HgF                              | HgF <sub>2</sub>                                | NiF <sub>2</sub>                                | KF                              | PtF <sub>4</sub>                  | AgF                             | NaF                             | SnF <sub>4</sub>                  | SnF <sub>2</sub>                   | SrF <sub>2</sub>                                | ZnF <sub>2</sub>                                |
| 15  | Formate                                          | W                                               | W                                               | W                                               | w                                | W                                               | W                                               | W                               |                                   | W                               | W                               |                                   |                                    | W                                               | W                                               |
|     | —(CHO <sub>2</sub> )                             | Pb(—) <sub>2</sub>                              | Mg(—) <sub>2</sub>                              | Mn(—) <sub>2</sub>                              | Hg(—)                            | Hg(—) <sub>2</sub>                              | Ni(—) <sub>2</sub>                              | K(—)                            |                                   | Ag(—)                           | Na(—)                           |                                   |                                    | Sr(—) <sub>2</sub>                              | Zn(—) <sub>2</sub>                              |
| 16  | Hydroxide                                        | w                                               | A                                               | A                                               |                                  | A                                               | w                                               | W                               | A                                 |                                 | W                               | w                                 | A                                  | W                                               | A                                               |
|     |                                                  | Pb(OH) <sub>2</sub>                             | Mg(OH) <sub>2</sub>                             | Mn(OH) <sub>2</sub>                             |                                  | Hg(OH) <sub>2</sub>                             | Ni(OH) <sub>2</sub>                             | KOH                             | Pt(OH) <sub>4</sub>               |                                 | NaOH                            | Sn(OH) <sub>4</sub>               | Sn(OH) <sub>2</sub>                | Sr(OH) <sub>2</sub>                             | Zn(OH) <sub>2</sub>                             |
| 17  | Iodide                                           | w                                               | W                                               | W                                               | A                                | w                                               | W                                               | W                               | I                                 | I                               | W                               | d                                 | W                                  | W                                               | W                                               |
|     |                                                  | PbI <sub>2</sub>                                | MgI <sub>2</sub>                                | MnI <sub>2</sub>                                | HgI                              | HgI <sub>2</sub>                                | NiI <sub>2</sub>                                | KI                              | PtI <sub>2</sub>                  | AgI                             | NaI                             | SnI <sub>4</sub>                  | SnI <sub>2</sub>                   | SrI <sub>2</sub>                                | ZnI <sub>2</sub>                                |
| 18  | Nitrate                                          | W                                               | W                                               | W                                               | W                                | W                                               | W                                               | W                               | W                                 | W                               | W                               |                                   | d                                  | W                                               | W                                               |
|     |                                                  | Pb(NO <sub>3</sub> ) <sub>2</sub>               | Mg(NO <sub>3</sub> ) <sub>2</sub>               | Mn(NO <sub>3</sub> ) <sub>2</sub>               | HgNO <sub>3</sub>                | Hg(NO <sub>3</sub> ) <sub>2</sub>               | Ni(NO <sub>3</sub> ) <sub>2</sub>               | KNO <sub>3</sub>                | Pt(NO <sub>3</sub> ) <sub>4</sub> | AgNO <sub>3</sub>               | NaNO <sub>3</sub>               |                                   | Sn(NO <sub>3</sub> ) <sub>2</sub>  | Sr(NO <sub>3</sub> ) <sub>2</sub>               | Zn(NO <sub>3</sub> ) <sub>2</sub>               |
| 19  | Oxalate                                          | A                                               | w                                               | w                                               | a                                | A                                               | A                                               | W                               |                                   | a                               | W                               |                                   | A                                  | w                                               | A                                               |
|     | —(C <sub>2</sub> O <sub>4</sub> )                | Pb(—)                                           | Mg(—)                                           | Mn(—)                                           | Hg <sub>2</sub> (—)              | Hg(—)                                           | Ni(—)                                           | K <sub>2</sub> (—)              |                                   | Ag <sub>2</sub> (—)             | Na <sub>2</sub> (—)             |                                   | Sn(—)                              | Sr(—)                                           | Zn(—)                                           |
| 20  | Oxide                                            | w                                               | A                                               | A                                               | A                                | A                                               | A                                               | W                               | A                                 | w                               | d                               | A                                 | A                                  | W                                               | w                                               |
|     |                                                  | PbO                                             | MgO                                             | MnO                                             | Hg <sub>2</sub> O                | HgO                                             | NiO                                             | K <sub>2</sub> O                | PtO                               | Ag <sub>2</sub> O               | Na <sub>2</sub> O               | SnO <sub>2</sub>                  | SnO                                | SrO                                             | ZnO                                             |
| 21  | Phosphate                                        | A                                               | w                                               | w                                               | A                                | A                                               | A                                               | W                               |                                   | A                               | W                               |                                   | A                                  | A                                               | A                                               |
|     |                                                  | Pb <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | Mg <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | Mn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | Hg <sub>3</sub> PO <sub>4</sub>  | Hg <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | Ni <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | K <sub>3</sub> PO <sub>4</sub>  |                                   | Ag <sub>3</sub> PO <sub>4</sub> | Na <sub>3</sub> PO <sub>4</sub> |                                   | Sn <sub>3</sub> (PO <sub>4</sub> ) | Sr <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | Zn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> |
| 22  | Silicate                                         | A                                               | A                                               | I                                               |                                  |                                                 |                                                 | W                               |                                   |                                 | W                               |                                   |                                    | A                                               | A                                               |
|     | —(SiO <sub>3</sub> )                             | Pb(—)                                           | Mg(—)                                           | Mn(—)                                           |                                  |                                                 |                                                 | K <sub>2</sub> (—)              |                                   |                                 | Na <sub>2</sub> (—)             |                                   |                                    | Sr(—)                                           | Zn(—)                                           |
| 23  | Sulfate                                          | w                                               | W                                               | W                                               | w                                | d                                               | W                                               | W                               | W                                 | w                               | W                               | W                                 | W                                  | w                                               | W                                               |
|     |                                                  | PbSO <sub>4</sub>                               | MgSO <sub>4</sub>                               | MnSO <sub>4</sub>                               | Hg <sub>2</sub> SO <sub>4</sub>  | HgSO <sub>4</sub>                               | NiSO <sub>4</sub>                               | K <sub>2</sub> SO <sub>4</sub>  | Pt(SO <sub>4</sub> ) <sub>2</sub> | Ag <sub>2</sub> SO <sub>4</sub> | Na <sub>2</sub> SO <sub>4</sub> | Sn(SO <sub>4</sub> ) <sub>2</sub> | SnSO <sub>4</sub>                  | SrSO <sub>4</sub>                               | ZnSO <sub>4</sub>                               |
| 24  | Sulfide                                          | A                                               | d                                               | A                                               | I                                | I                                               | A                                               | W                               | I                                 | A                               | W                               | A                                 | A                                  | W                                               | A                                               |
|     |                                                  | PbS                                             | MgS                                             | MnS                                             | Hg <sub>2</sub> S                | HgS                                             | NiS                                             | K <sub>2</sub> S                | PtS                               | Ag <sub>2</sub> S               | Na <sub>2</sub> S               | SnS <sub>2</sub>                  | SnS                                | SrS                                             | ZnS                                             |
| 25  | Tartrate                                         | A                                               | w                                               | w                                               | I                                | I                                               | A                                               | W                               | I                                 | A                               | W                               | A                                 | A                                  | W                                               | A                                               |
|     | —(C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ) | Pb(—)                                           | Mg(—)                                           | Mn(—)                                           | Hg <sub>2</sub> (—)              |                                                 | Ni(—)                                           | K <sub>2</sub> (—)              |                                   | Ag <sub>2</sub> (—)             | Na <sub>2</sub> (—)             |                                   | Sn(—)                              | Sr(—)                                           | Zn(—)                                           |
| 26  | Thiocy'te                                        | w                                               | W                                               | W                                               | A                                | w                                               |                                                 | W                               |                                   | I                               | W                               |                                   |                                    | W                                               | W                                               |
|     |                                                  | Pb(CNS) <sub>2</sub>                            | Mg(CNS) <sub>2</sub>                            | Mn(CNS) <sub>2</sub>                            | HgCNS                            | Hg(CNS) <sub>2</sub>                            |                                                 | KCNS                            |                                   | AgCNS                           | NaCNS                           |                                   |                                    | Sr(CNS) <sub>2</sub>                            | Zn(CNS) <sub>2</sub>                            |

## REDUCTION OF WEIGHINGS IN AIR TO VACUO

When the mass  $M$  of a body is determined in air, a correction is necessary for the buoyancy of the air. The corrected mass is given by  $M + kM/1000$ , where  $k$  is a function of the material used for the weights, given by

$$k = 1000\rho_{\text{air}}(1/\rho_{\text{body}} - 1/\rho_{\text{weight}})$$

and  $\rho$  is density. The table below is computed for an air density of 0.0012 g/cm<sup>3</sup> and for densities of three common weights:

| Density of<br>body (g/cm <sup>3</sup> ) | Value of $k$ for weights of: |       |              |
|-----------------------------------------|------------------------------|-------|--------------|
|                                         | Pt-Ir                        | Brass | Quartz or Al |
| 0.5                                     | 2.34                         | 2.26  | 1.95         |
| 0.6                                     | 1.94                         | 1.86  | 1.55         |
| 0.7                                     | 1.66                         | 1.57  | 1.26         |
| 0.8                                     | 1.44                         | 1.36  | 1.05         |
| 0.9                                     | 1.28                         | 1.19  | 0.88         |
| 1.0                                     | 1.14                         | 1.06  | 0.75         |
| 1.1                                     | 1.04                         | 0.95  | 0.64         |
| 1.2                                     | 0.94                         | 0.86  | 0.55         |
| 1.3                                     | 0.87                         | 0.78  | 0.47         |
| 1.4                                     | 0.80                         | 0.72  | 0.40         |
| 1.5                                     | 0.74                         | 0.66  | 0.35         |
| 1.6                                     | 0.69                         | 0.61  | 0.30         |
| 1.7                                     | 0.65                         | 0.56  | 0.25         |

platinum-iridium (21.6 g/cm<sup>3</sup>), brass (8.5 g/cm<sup>3</sup>), and aluminum or quartz (2.65 g/cm<sup>3</sup>).

### References

1. Kaye, G. W. C., and Laby, T. H., *Tables of Physical and Chemical Constants, 16th Edition*, pp. 25-28, Longman, London, 1995.
2. Giacomo, P., *Metrologia*, 18, 33, 1982.
3. Davis, R. S., *Metrologia*, 29, 67, 1992.

| Density of<br>body (g/cm <sup>3</sup> ) | Value of $k$ for weights of: |       |              |
|-----------------------------------------|------------------------------|-------|--------------|
|                                         | Pt-Ir                        | Brass | Quartz or Al |
| 1.8                                     | 0.61                         | 0.53  | 0.21         |
| 1.9                                     | 0.58                         | 0.49  | 0.18         |
| 2.0                                     | 0.54                         | 0.46  | 0.15         |
| 2.5                                     | 0.42                         | 0.34  | 0.03         |
| 3.0                                     | 0.34                         | 0.26  | -0.05        |
| 4.0                                     | 0.24                         | 0.16  | -0.15        |
| 6.0                                     | 0.14                         | 0.06  | -0.25        |
| 8.0                                     | 0.09                         | 0.01  | -0.30        |
| 10.0                                    | 0.06                         | -0.02 | -0.33        |
| 15.0                                    | 0.02                         | -0.06 | -0.37        |
| 20.0                                    | 0.00                         | -0.08 | -0.39        |
| 22.0                                    | 0.00                         | -0.09 | -0.40        |

For a more accurate calculation, use the following values of the density of air (assuming 50% relative humidity and 0.04% CO<sub>2</sub>):

| $P/\text{kPa}$ | Air temperature |          |          |
|----------------|-----------------|----------|----------|
|                | 10°C            | 20°C     | 30°C     |
| 85             | 0.001043        | 0.001005 | 0.000968 |
| 90             | 0.001105        | 0.001065 | 0.001025 |
| 95             | 0.001166        | 0.001124 | 0.001083 |
| 100            | 0.001228        | 0.001184 | 0.001140 |
| 105            | 0.001290        | 0.001243 | 0.001198 |

Formulas for calculating the density of air over more extended ranges of temperature, pressure, and humidity may be found in the references.



## VOLUME OF ONE GRAM OF WATER

The following table, which is designed for gravimetric calibration of volumetric apparatus, gives the specific volume of water at standard atmospheric pressure as a function of temperature.

### Reference

Marsh, K. N., Ed., *Recommended Reference Materials for the Realization of Physicochemical Properties*, pp. 25-27, Blackwell Scientific Publications, Oxford, 1987.

| t/°C | Volume of 1 g<br>H <sub>2</sub> O in cm <sup>3</sup> |
|------|------------------------------------------------------|
| 10   | 1.0002980                                            |
| 11   | 1.0003928                                            |
| 12   | 1.0005007                                            |
| 13   | 1.0006212                                            |
| 14   | 1.0007542                                            |
| 15   | 1.0008992                                            |
| 16   | 1.0010561                                            |
| 17   | 1.0012246                                            |
| 18   | 1.0014044                                            |
| 19   | 1.0015952                                            |
| 20   | 1.0017969                                            |
| 21   | 1.0020092                                            |
| 22   | 1.0022320                                            |
| 23   | 1.0024649                                            |
| 24   | 1.0027079                                            |
| 25   | 1.0029607                                            |
| 26   | 1.0032234                                            |
| 27   | 1.0034956                                            |
| 28   | 1.0037771                                            |
| 29   | 1.0040679                                            |
| 30   | 1.0043679                                            |

## PROPERTIES OF CARRIER GASES FOR GAS CHROMATOGRAPHY

The following is a list of carrier gases sometimes used in gas chromatography, with properties relevant to the design of chromatographic systems. All data refer to normal atmospheric pressure (101.325 kPa).

$M_r$ : Molecular weight (relative molar mass)  
 $\rho_{25}$ : Density at 25 °C in g/L  
 $\lambda$ : Thermal conductivity in mW/m °C  
 $\eta$ : Viscosity in  $\mu\text{Pa s}$  (equal to  $10^{-3}$  cP)  
 $c_p$ : Specific heat at 25 °C in J/g °C

### References

1. Lide, D. R., and Kehiaian, H. V., *CRC Handbook of Thermophysical and Thermochemical Data*, CRC Press, Boca Raton, FL, 1994.
2. Bruno, T. J., and Svoronos, P. D. N., *CRC Handbook of Basic Tables for Chemical Analysis*, CRC Press, Boca Raton, FL, 1989.

| Gas                 | $M_r$  | $\rho_{25}$<br>g L <sup>-1</sup> | At 25 °C             |                            | At 250 °C            |                            | $c_p$ (25 °C)<br>J/g °C |
|---------------------|--------|----------------------------------|----------------------|----------------------------|----------------------|----------------------------|-------------------------|
|                     |        |                                  | $\lambda$<br>mW/m °C | $\eta$<br>$\mu\text{Pa s}$ | $\lambda$<br>mW/m °C | $\eta$<br>$\mu\text{Pa s}$ |                         |
| Hydrogen            | 2.016  | 0.0824                           | 185.9                | 8.9                        | 280                  | 13.1                       | 14.3                    |
| Helium              | 4.003  | 0.1636                           | 154.6                | 19.9                       | 230                  | 29.5                       | 5.20                    |
| Argon               | 39.95  | 1.6329                           | 17.8                 | 22.7                       | 27.7                 | 35.3                       | 0.521                   |
| Nitrogen            | 28.01  | 1.1449                           | 25.9                 | 17.9                       | 39.6                 | 26.8                       | 1.039                   |
| Oxygen              | 32.00  | 1.3080                           | 26.2                 | 20.7                       | 42.6                 | 31.8                       | 0.919                   |
| Carbon monoxide     | 28.01  | 1.1449                           | 24.8                 | 17.8                       | 40.7                 | 26.5                       | 1.039                   |
| Carbon dioxide      | 44.01  | 1.7989                           | 16.7                 | 14.9                       | 35.5                 | 24.9                       | 0.843                   |
| Sulfur hexafluoride | 146.05 | 5.9696                           | 13.1                 | 28.1                       | 15.3                 | 24.8                       | 0.664                   |
| Methane             | 16.04  | 0.6556                           | 34.5                 | 11.1                       | 75.0                 | 17.6                       | 2.23                    |
| Ethane              | 30.07  | 1.2291                           | 20.9                 | 9.4                        | 57.7                 | 15.5                       | 1.75                    |
| Ethylene            | 28.05  | 1.1465                           | 20.5                 | 10.3                       | 53.8                 | 17.2                       | 1.53                    |
| Propane             | 44.10  | 1.8025                           | 17.9                 | 8.3                        | 49.2                 | 14.0                       | 1.67                    |

## SOLVENTS FOR ULTRAVIOLET SPECTROPHOTOMETRY

This table lists some solvents commonly used for sample preparation for ultraviolet spectrophotometry. The properties given are:

- $\lambda_c$ : cutoff wavelength, below which the solvent absorption becomes excessive.  
 $\epsilon$ : dielectric constant (relative permittivity); the temperature in °C is given as a superscript.  
 $t_b$ : normal boiling point.

### References

1. Bruno, T. J., and Svoronos, P. D. N., *CRC Handbook of Basic Tables for Chemical Analysis*, CRC Press, Boca Raton, FL, 1989.
2. *Landolt-Börnstein, Numerical Data and Functional Relationships in Science and Technology, New Series, IV/6, Static Dielectric Constants of Pure Liquids and Binary Liquid Mixtures*, Springer-Verlag, Heidelberg, 1991.

| Name                                  | $\lambda_c/\text{nm}$ | $\epsilon$          | $t_b/^\circ\text{C}$ |
|---------------------------------------|-----------------------|---------------------|----------------------|
| Acetic acid                           | 260                   | 6.20 <sup>20</sup>  | 117.9                |
| Acetone                               | 330                   | 21.01 <sup>20</sup> | 56.0                 |
| Acetonitrile                          | 190                   | 36.64 <sup>20</sup> | 81.6                 |
| Benzene                               | 280                   | 2.28 <sup>20</sup>  | 80.0                 |
| 2-Butanol                             | 260                   | 17.26 <sup>20</sup> | 99.5                 |
| Butyl acetate                         | 254                   | 5.07 <sup>20</sup>  | 126.1                |
| Carbon disulfide                      | 380                   | 2.63 <sup>20</sup>  | 46                   |
| Carbon tetrachloride                  | 265                   | 2.24 <sup>20</sup>  | 76.8                 |
| 1-Chlorobutane                        | 220                   | 7.28 <sup>20</sup>  | 78.6                 |
| Chloroform                            | 245                   | 4.81 <sup>20</sup>  | 61.1                 |
| Cyclohexane                           | 210                   | 2.02 <sup>20</sup>  | 80.7                 |
| 1,2-Dichloroethane                    | 226                   | 10.42 <sup>20</sup> | 83.5                 |
| Dichloromethane                       | 235                   | 8.93 <sup>25</sup>  | 40                   |
| Diethyl ether                         | 218                   | 4.27 <sup>20</sup>  | 34.5                 |
| <i>N,N</i> -Dimethylacetamide         | 268                   | 38.85 <sup>21</sup> | 165                  |
| <i>N,N</i> -Dimethylformamide         | 270                   | 38.25 <sup>20</sup> | 153                  |
| Dimethyl sulfoxide                    | 265                   | 47.24 <sup>20</sup> | 189                  |
| 1,4-Dioxane                           | 215                   | 2.22 <sup>20</sup>  | 101.5                |
| Ethanol                               | 210                   | 25.3 <sup>20</sup>  | 78.2                 |
| Ethyl acetate                         | 255                   | 6.08 <sup>20</sup>  | 77.1                 |
| Ethylene glycol dimethyl ether        | 240                   | 7.30 <sup>24</sup>  | 85                   |
| Ethylene glycol monoethyl ether       | 210                   | 13.38 <sup>25</sup> | 135                  |
| Ethylene glycol monomethyl ether      | 210                   | 17.2 <sup>25</sup>  | 124.1                |
| Glycerol                              | 207                   | 46.53 <sup>20</sup> | 290                  |
| Heptane                               | 197                   | 1.92 <sup>20</sup>  | 98.5                 |
| Hexadecane                            | 200                   | 2.05 <sup>20</sup>  | 286.8                |
| Hexane                                | 210                   | 1.89 <sup>20</sup>  | 68.7                 |
| Methanol                              | 210                   | 33.0 <sup>20</sup>  | 64.6                 |
| Methylcyclohexane                     | 210                   | 2.02 <sup>20</sup>  | 100.9                |
| Methyl ethyl ketone                   | 330                   | 18.56 <sup>20</sup> | 79.5                 |
| Methyl isobutyl ketone                | 335                   | 13.11 <sup>20</sup> | 116.5                |
| 2-Methyl-1-propanol                   | 230                   | 17.93 <sup>20</sup> | 107.8                |
| <i>N</i> -Methyl-2-pyrrolidone        | 285                   | 32.55 <sup>20</sup> | 202                  |
| Nitromethane                          | 380                   | 37.27 <sup>20</sup> | 101.1                |
| Pentane                               | 210                   | 1.84 <sup>20</sup>  | 36.0                 |
| Pentyl acetate                        | 212                   | 4.79 <sup>20</sup>  | 149.2                |
| 1-Propanol                            | 210                   | 20.8 <sup>20</sup>  | 97.2                 |
| 2-Propanol                            | 210                   | 20.18 <sup>20</sup> | 82.3                 |
| Pyridine                              | 330                   | 13.26 <sup>20</sup> | 115.2                |
| Tetrachloroethylene                   | 290                   | 2.27 <sup>30</sup>  | 121.3                |
| Tetrahydrofuran                       | 220                   | 7.52 <sup>22</sup>  | 65                   |
| Toluene                               | 286                   | 2.38 <sup>23</sup>  | 110.6                |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 231                   | 2.41 <sup>25</sup>  | 47.7                 |
| 2,2,4-Trimethylpentane                | 215                   | 1.94 <sup>20</sup>  | 99.2                 |
| Water                                 | 191                   | 80.10 <sup>20</sup> | 100.0                |
| <i>o</i> -Xylene                      | 290                   | 2.56 <sup>20</sup>  | 144.5                |
| <i>m</i> -Xylene                      | 290                   | 2.36 <sup>20</sup>  | 139.1                |
| <i>p</i> -Xylene                      | 290                   | 2.27 <sup>20</sup>  | 138.3                |

## $^{13}\text{C}$ CHEMICAL SHIFTS OF USEFUL NMR SOLVENTS

The following table gives the expected carbon-13 chemical shifts, relative to tetramethylsilane, for various useful NMR solvents. In some solvents, slight changes can occur with change of concentration.<sup>2,3</sup>

### References

1. Bruno, T. J., and Svoronos, P. D. N., *CRC Handbook of Basic Tables for Chemical Analysis*, CRC Press, Boca Raton, FL, 1989.
2. Silverstein, R. M., Bassler, G. C., and Morrill, T. C., *Spectrometric Identification of Organic Compounds*, John Wiley & Sons, New York, 1981.
3. Rahman, A. U., *Nuclear Magnetic Resonance. Basic Principles*, Springer-Verlag, New York, 1986.
4. Pretsch, E., Clerc, T., Seibl, J., and Simon, W., *Spectral Data for Structure Determination of Organic Compounds, Second Edition*, Springer-Verlag, Heidelberg, 1989.

| Solvent                          | Formula                             | Chemical shift (ppm)                                                 |
|----------------------------------|-------------------------------------|----------------------------------------------------------------------|
| Acetic acid- $d_4$               | $\text{CD}_3\text{COOD}$            | 20.0 ( $\text{CD}_3$ ) 205.8 (C=O)                                   |
| Acetone                          | $(\text{CH}_3)_2\text{C}=\text{O}$  | 30.7 ( $\text{CH}_3$ ) 206.7 (C=O)                                   |
| Acetone- $d_6$                   | $(\text{CD}_3)_2\text{C}=\text{O}$  | 29.2 ( $\text{CD}_3$ ) 204.1 (C=O)                                   |
| Acetonitrile- $d_3$              | $\text{CD}_3\text{C}\equiv\text{N}$ | 1.3 ( $\text{CD}_3$ ) 117.1 (C $\equiv$ N)                           |
| Benzene                          | $\text{C}_6\text{H}_6$              | 128.5                                                                |
| Benzene- $d_6$                   | $\text{C}_6\text{D}_6$              | 128.4                                                                |
| Carbon disulfide                 | $\text{CS}_2$                       | 192.3                                                                |
| Carbon tetrachloride             | $\text{CCl}_4$                      | 96.0                                                                 |
| Chloroform                       | $\text{CHCl}_3$                     | 77.2                                                                 |
| Chloroform- $d_3$                | $\text{CDCl}_3$                     | 77.05                                                                |
| Cyclohexane- $d_{12}$            | $\text{C}_6\text{D}_{12}$           | 27.5                                                                 |
| Dichloromethane- $d_2$           | $\text{CD}_2\text{Cl}_2$            | 53.6                                                                 |
| Dimethylformamide- $d_7$         | $(\text{CD}_3)_2\text{NCDO}$        | 31 ( $\text{CD}_3$ ) 36 ( $\text{CD}_3$ ) 162.4 (C=O)                |
| Dimethylsulfoxide- $d_6$         | $(\text{CD}_3)_2\text{S}=\text{O}$  | 39.6                                                                 |
| Dioxane- $d_8$                   | $\text{C}_4\text{D}_8\text{O}_2$    | 67.4                                                                 |
| Formic acid- $d_2$               | $\text{DCOOD}$                      | 165.5                                                                |
| Methanol- $d_4$                  | $\text{CD}_3\text{OD}$              | 49.3                                                                 |
| Nitromethane- $d_3$              | $\text{CD}_3\text{NO}_2$            | 57.3                                                                 |
| Pyridine                         | $\text{C}_5\text{H}_5\text{N}$      | 123.6 ( $\text{C}_3$ ) 135.7 ( $\text{C}_4$ ) 149.8 ( $\text{C}_2$ ) |
| Pyridine- $d_5$                  | $\text{C}_5\text{D}_5\text{N}$      | 123.9 ( $\text{C}_3$ ) 135.9 ( $\text{C}_4$ ) 150.2 ( $\text{C}_2$ ) |
| 1,1,2,2-Tetrachloroethane- $d_2$ | $\text{CDCl}_2\text{CDCl}_2$        | 75.5                                                                 |
| Tetrahydrofuran- $d_8$           | $\text{C}_4\text{D}_8\text{O}$      | 25.8 ( $\text{C}_2$ ) 67.9 ( $\text{C}_1$ )                          |
| Trichlorofluoromethane           | $\text{CFCl}_3$                     | 117.6                                                                |

## MASS SPECTRAL PEAKS OF COMMON ORGANIC SOLVENTS

The strongest peaks in the mass spectra of 375 important organic solvents and other liquid reagents are listed in this table. The *e/m* value for each peak is followed by the relative intensity in parentheses, with the strongest peak assigned an intensity of 100. The peaks for each compound are listed in order of decreasing intensity. Compounds are listed by the name used in this *Handbook*, with other common names given in parentheses.

Data on the physical properties of the same compounds may be found in Section 15 in the table *Laboratory Solvents and Other Liquid Reagents*.

## References

1. NIST/EPA/NIH Mass Spectral Database, National Institute of Standards and Technology, Gaithersburg, MD, 20899.
2. Lide, D. R., and Milne, G. W. A., Editors, *Handbook of Data on Organic Compounds, Third Edition*, CRC Press, Boca Raton, FL, 1994. (Also available as a CD-ROM database.)
3. Lide, D. R., Editor, *Properties of Organic Compounds*, <www.chem-netbase.com/scripts/pocweb.exe>.

| Compound                                                        | <i>e/m</i> (intensity) |         |         |         |         |         |         |         |         |        |
|-----------------------------------------------------------------|------------------------|---------|---------|---------|---------|---------|---------|---------|---------|--------|
| Acetic acid                                                     | 43(100)                | 45(87)  | 60(57)  | 15(42)  | 42(14)  | 29(13)  | 14(13)  | 28(7)   | 18(6)   | 16(6)  |
| Acetic anhydride                                                | 43(100)                | 42(35)  | 45(29)  | 60(18)  | 29(9)   | 41(8)   | 40(2)   | 26(2)   | 87(1)   | 61(1)  |
| Acetone                                                         | 43(100)                | 15(34)  | 58(23)  | 27(9)   | 14(9)   | 42(8)   | 26(7)   | 29(5)   | 28(5)   | 39(4)  |
| Acetonitrile                                                    | 41(100)                | 40(46)  | 39(13)  | 14(9)   | 38(6)   | 28(4)   | 26(4)   | 25(3)   | 42(2)   | 27(2)  |
| Acrolein (2-Propenal)                                           | 27(100)                | 56(74)  | 28(65)  | 26(54)  | 55(52)  | 29(37)  | 25(8)   | 53(5)   | 38(5)   | 57(4)  |
| Acrylonitrile                                                   | 53(100)                | 26(85)  | 52(79)  | 51(34)  | 27(13)  | 50(8)   | 25(7)   | 38(5)   | 54(3)   | 37(3)  |
| Allyl alcohol                                                   | 57(100)                | 31(34)  | 29(32)  | 28(31)  | 58(25)  | 39(22)  | 27(20)  | 30(16)  | 32(14)  | 26(11) |
| Allylamine                                                      | 30(100)                | 56(80)  | 28(76)  | 57(33)  | 39(21)  | 29(20)  | 27(18)  | 26(13)  | 41(8)   | 18(8)  |
| 2-Amino-2-methyl-1-propanol (2-Aminoisobutanol)                 | 58(100)                | 41(18)  | 18(17)  | 42(13)  | 28(11)  | 56(10)  | 30(10)  | 29(8)   | 43(6)   | 59(5)  |
| Aniline (Benzenamine)                                           | 93(100)                | 66(32)  | 65(16)  | 39(13)  | 92(10)  | 94(7)   | 41(5)   | 40(5)   | 67(4)   | 64(3)  |
| Anisole (Methoxybenzene)                                        | 108(100)               | 65(76)  | 78(60)  | 39(44)  | 51(21)  | 77(20)  | 93(16)  | 79(14)  | 50(13)  | 63(12) |
| Benzaldehyde                                                    | 51(100)                | 77(81)  | 50(55)  | 106(44) | 105(43) | 52(26)  | 78(16)  | 39(13)  | 27(10)  | 74(8)  |
| Benzene                                                         | 78(100)                | 77(20)  | 52(19)  | 51(17)  | 50(15)  | 39(12)  | 79(6)   | 76(5)   | 74(4)   | 38(4)  |
| Benzeneacetonitrile (Benzyl cyanide)                            | 117(100)               | 90(43)  | 116(35) | 89(22)  | 51(13)  | 39(11)  | 63(10)  | 118(9)  | 91(8)   | 50(8)  |
| Benzenethiol (Phenyl mercaptan)                                 | 110(100)               | 66(28)  | 109(23) | 39(15)  | 77(14)  | 51(14)  | 84(13)  | 69(11)  | 50(11)  | 45(11) |
| Benzonitrile                                                    | 103(100)               | 76(34)  | 50(13)  | 104(9)  | 75(7)   | 51(7)   | 77(5)   | 52(4)   | 39(4)   | 74(3)  |
| Benzyl acetate                                                  | 108(100)               | 43(76)  | 91(60)  | 90(48)  | 79(27)  | 107(17) | 77(17)  | 65(15)  | 51(15)  | 89(14) |
| Benzyl alcohol                                                  | 79(100)                | 108(83) | 77(74)  | 107(66) | 51(35)  | 105(23) | 106(22) | 50(17)  | 78(16)  | 39(16) |
| Bis(2-aminoethyl)amine (Diethylenetriamine)                     | 44(100)                | 73(59)  | 30(35)  | 19(18)  | 56(16)  | 28(16)  | 27(16)  | 42(11)  | 99(8)   | 43(8)  |
| Bis(2-chloroethyl) ether                                        | 93(100)                | 63(74)  | 27(38)  | 95(32)  | 65(24)  | 31(9)   | 49(4)   | 28(4)   | 94(3)   | 62(3)  |
| Bis(2-ethylhexyl) phthalate                                     | 149(100)               | 57(32)  | 167(29) | 71(21)  | 43(21)  | 70(18)  | 150(11) | 113(10) | 55(10)  | 41(9)  |
| Bis(2-hydroxyethyl) sulfide                                     | 61(100)                | 45(68)  | 31(38)  | 104(36) | 91(34)  | 47(26)  | 44(26)  | 27(24)  | 60(18)  | 43(17) |
| Bromobenzene                                                    | 77(100)                | 158(64) | 156(64) | 51(39)  | 50(17)  | 78(8)   | 76(6)   | 75(6)   | 28(5)   | 159(4) |
| 1-Bromobutane (Butyl bromide)                                   | 57(100)                | 41(56)  | 29(45)  | 27(29)  | 56(13)  | 39(12)  | 28(12)  | 55(7)   | 43(7)   | 138(6) |
| 2-Bromobutane (sec-Butyl bromide)                               | 57(100)                | 41(60)  | 29(57)  | 27(34)  | 39(20)  | 28(9)   | 26(9)   | 136(1)  |         |        |
| 1-Bromo-2-chloroethane                                          | 63(100)                | 27(85)  | 65(31)  | 26(23)  | 144(8)  | 81(8)   | 79(8)   | 28(7)   | 142(6)  | 93(6)  |
| Bromochloromethane                                              | 49(100)                | 130(67) | 128(52) | 51(31)  | 93(23)  | 81(20)  | 79(20)  | 95(17)  | 132(16) | 47(8)  |
| 1-Bromodecane (Decyl bromide)                                   | 43(100)                | 135(94) | 137(91) | 57(81)  | 41(58)  | 55(56)  | 71(38)  | 69(36)  | 85(33)  | 29(27) |
| Bromoethane (Ethyl bromide)                                     | 108(100)               | 110(97) | 29(62)  | 27(51)  | 28(35)  | 26(14)  | 93(6)   | 32(6)   | 95(5)   | 81(5)  |
| 2-Bromo-2-methylpropane (tert-Butyl bromide)                    | 57(100)                | 41(67)  | 29(45)  | 39(30)  | 27(18)  | 28(8)   | 40(5)   | 38(5)   | 58(4)   | 55(4)  |
| 1-Bromonaphthalene                                              | 44(100)                | 206(39) | 127(39) | 208(37) | 36(31)  | 69(29)  | 131(13) | 29(13)  | 126(12) | 63(12) |
| 1-Bromopentane (Pentyl bromide)                                 | 43(100)                | 71(80)  | 41(56)  | 27(51)  | 42(37)  | 29(34)  | 55(33)  | 39(30)  | 28(12)  | 26(9)  |
| 1-Bromopropane (Propyl bromide)                                 | 43(100)                | 41(77)  | 28(69)  | 27(60)  | 39(49)  | 124(42) | 122(41) | 42(34)  | 32(20)  | 29(15) |
| 2-Bromopropane (Isopropyl bromide)                              | 43(100)                | 27(47)  | 41(43)  | 39(22)  | 124(8)  | 122(8)  | 26(7)   | 81(6)   | 79(6)   | 38(6)  |
| 2-Bromopropene                                                  | 41(100)                | 39(58)  | 122(37) | 120(36) | 38(12)  | 37(8)   | 40(6)   | 81(5)   | 79(5)   | 42(4)  |
| Butanal                                                         | 44(100)                | 43(74)  | 72(57)  | 41(56)  | 27(55)  | 29(48)  | 57(23)  | 39(22)  | 28(15)  | 42(11) |
| Butanenitrile                                                   | 41(100)                | 29(62)  | 27(37)  | 28(10)  | 39(9)   | 26(7)   | 40(5)   | 42(4)   | 38(4)   | 15(4)  |
| 1-Butanethiol (Butyl mercaptan)                                 | 56(100)                | 41(74)  | 90(66)  | 47(43)  | 27(43)  | 28(36)  | 29(33)  | 57(17)  | 39(16)  | 61(15) |
| Butanoic acid                                                   | 60(100)                | 27(50)  | 73(27)  | 42(25)  | 41(24)  | 43(22)  | 29(21)  | 45(19)  | 39(15)  | 28(11) |
| Butanoic anhydride                                              | 71(100)                | 43(59)  | 27(26)  | 41(19)  | 42(10)  | 39(10)  | 73(9)   | 28(7)   | 72(5)   | 55(5)  |
| 1-Butanol (Butyl alcohol)                                       | 31(100)                | 56(81)  | 41(62)  | 43(60)  | 27(50)  | 42(31)  | 29(31)  | 28(17)  | 39(16)  | 55(12) |
| 2-Butanol (sec-Butyl alcohol)                                   | 45(100)                | 31(22)  | 27(22)  | 59(20)  | 29(18)  | 43(13)  | 41(12)  | 44(8)   | 18(8)   | 28(5)  |
| 2-Butanone (Methyl ethyl ketone)                                | 43(100)                | 72(24)  | 29(19)  | 27(12)  | 57(7)   | 42(5)   | 26(4)   | 28(3)   | 44(2)   | 39(2)  |
| trans-2-Butenal (trans-Crotonaldehyde)                          | 41(100)                | 39(97)  | 70(82)  | 69(65)  | 27(49)  | 29(39)  | 42(30)  | 38(29)  | 40(27)  | 37(18) |
| 2-Butoxyethanol (Ethylene glycol monobutyl ether)               | 57(100)                | 45(38)  | 29(35)  | 41(31)  | 87(16)  | 27(12)  | 56(11)  | 31(9)   | 75(7)   | 28(7)  |
| 2-Butoxyethyl acetate (Ethylene glycol monobutyl ether acetate) | 57(100)                | 43(86)  | 56(50)  | 87(33)  | 41(26)  | 29(22)  | 85(18)  | 88(11)  | 44(11)  | 27(7)  |
| Butyl acetate                                                   | 43(100)                | 56(34)  | 41(17)  | 27(16)  | 29(15)  | 73(11)  | 61(10)  | 28(7)   | 55(6)   | 39(6)  |

| Compound                                                    | <i>m/z</i> (intensity) |         |         |         |         |         |         |         |         |         |
|-------------------------------------------------------------|------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <i>sec</i> -Butyl acetate                                   | 43(100)                | 56(21)  | 87(15)  | 41(14)  | 29(8)   | 57(6)   | 73(4)   | 61(4)   | 55(4)   | 27(4)   |
| Butylamine                                                  | 30(100)                | 73(10)  | 28(5)   | 41(3)   | 27(3)   | 18(3)   | 44(2)   | 42(2)   | 31(2)   | 29(2)   |
| <i>tert</i> -Butylamine                                     | 58(100)                | 41(21)  | 42(15)  | 18(9)   | 30(8)   | 15(8)   | 39(7)   | 57(6)   | 28(6)   | 59(4)   |
| Butylbenzene                                                | 91(100)                | 92(55)  | 134(20) | 65(13)  | 27(10)  | 39(9)   | 105(8)  | 51(7)   | 78(6)   | 41(6)   |
| <i>sec</i> -Butylbenzene                                    | 105(100)               | 134(18) | 91(14)  | 77(10)  | 27(9)   | 106(9)  | 51(7)   | 79(7)   |         |         |
| <i>tert</i> -Butylbenzene                                   | 119(100)               | 91(65)  | 41(40)  | 134(24) | 39(15)  | 79(14)  | 77(13)  | 51(13)  | 120(11) | 65(7)   |
| Butyl butanoate                                             | 43(100)                | 71(90)  | 56(80)  | 89(69)  | 41(67)  | 27(52)  | 29(47)  | 57(29)  | 39(22)  | 60(19)  |
| Butyl formate                                               | 56(100)                | 41(60)  | 31(58)  | 29(53)  | 27(45)  | 43(34)  | 28(21)  | 39(19)  | 55(11)  | 42(11)  |
| 1- <i>tert</i> -Butyl-4-methylbenzene                       | 133(100)               | 105(38) | 41(23)  | 148(18) | 93(16)  | 91(14)  | 115(13) | 134(11) | 39(11)  | 116(10) |
| Butyl vinyl ether                                           | 29(100)                | 41(74)  | 56(56)  | 57(43)  | 27(42)  | 44(26)  | 15(16)  | 85(14)  | 39(14)  | 43(13)  |
| $\gamma$ -Butyrolactone                                     | 28(100)                | 42(74)  | 29(48)  | 27(33)  | 41(27)  | 56(25)  | 86(24)  | 26(18)  | 85(10)  | 39(10)  |
| Caprolactam                                                 | 55(100)                | 113(87) | 30(81)  | 56(66)  | 84(60)  | 85(57)  | 42(51)  | 41(33)  | 28(26)  | 43(17)  |
| Carbon disulfide                                            | 76(100)                | 32(22)  | 44(17)  | 78(9)   | 38(6)   | 28(5)   | 77(3)   | 64(1)   | 46(1)   | 39(1)   |
| 2-Chloroaniline                                             | 127(100)               | 129(32) | 92(17)  | 65(16)  | 128(10) | 91(9)   | 64(9)   | 39(8)   | 63(7)   | 99(6)   |
| Chlorobenzene                                               | 112(100)               | 77(63)  | 114(33) | 51(29)  | 50(14)  | 75(8)   | 113(7)  | 78(5)   | 76(5)   | 28(4)   |
| 1-Chlorobutane (Butyl chloride)                             | 56(100)                | 41(65)  | 27(50)  | 43(35)  | 29(24)  | 39(18)  | 28(16)  | 26(11)  | 55(8)   | 15(8)   |
| 2-Chlorobutane ( <i>sec</i> -Butyl chloride)                | 56(100)                | 57(100) | 41(90)  | 27(77)  | 29(57)  | 63(46)  | 39(34)  | 92(1)   |         |         |
| 1-Chloro-1,1-difluoroethane                                 | 65(100)                | 45(31)  | 85(14)  | 31(10)  | 64(8)   | 44(7)   | 35(6)   | 26(6)   | 87(5)   | 81(4)   |
| Chloroethane (Ethyl chloride)                               | 64(100)                | 28(91)  | 29(84)  | 27(75)  | 66(32)  | 26(28)  | 49(25)  | 51(8)   | 63(6)   | 65(4)   |
| 2-Chloroethanol (Ethylene chlorohydrin)                     | 31(100)                | 15(13)  | 29(10)  | 28(10)  | 27(9)   | 43(8)   | 44(7)   | 26(5)   | 18(5)   | 14(5)   |
| (Chloromethyl)benzene (Benzyl chloride)                     | 91(100)                | 126(20) | 65(14)  | 92(9)   | 39(9)   | 63(8)   | 128(6)  | 45(6)   | 89(5)   | 125(3)  |
| 1-Chloro-3-methylbutane (Isopentyl chloride)                | 43(100)                | 55(56)  | 41(55)  | 27(51)  | 70(49)  | 42(37)  | 29(34)  | 57(30)  | 39(30)  | 56(15)  |
| 1-Chloro-2-methylpropane (Isobutyl chloride)                | 43(100)                | 41(67)  | 42(50)  | 27(33)  | 39(26)  | 15(11)  | 29(10)  | 56(7)   | 49(6)   | 38(5)   |
| 2-Chloro-2-methylpropane ( <i>tert</i> -Butyl chloride)     | 57(100)                | 41(80)  | 77(44)  | 29(26)  | 39(24)  | 79(14)  | 27(14)  | 59(7)   | 56(7)   | 38(6)   |
| 1-Chloronaphthalene                                         | 162(100)               | 127(36) | 164(30) | 126(20) | 163(10) | 77(8)   | 101(6)  | 75(6)   | 128(5)  | 28(4)   |
| 1-Chlorooctane (Octyl chloride)                             | 91(100)                | 41(83)  | 43(76)  | 27(62)  | 29(56)  | 55(55)  | 39(34)  | 93(32)  | 57(32)  | 69(29)  |
| Chloropentafluoroethane                                     | 85(100)                | 69(61)  | 31(38)  | 87(32)  | 50(17)  | 35(8)   | 119(6)  | 66(4)   | 100(3)  | 47(3)   |
| 1-Chloropentane (Pentyl chloride)                           | 42(100)                | 41(90)  | 70(89)  | 55(87)  | 27(73)  | 29(55)  | 43(40)  | 39(40)  | 28(19)  | 57(18)  |
| 1-Chloropropane (Propyl chloride)                           | 42(100)                | 29(46)  | 27(37)  | 41(23)  | 28(15)  | 43(14)  | 39(12)  | 78(6)   | 63(6)   | 49(5)   |
| 3-Chloropropene (Allyl chloride)                            | 41(100)                | 39(73)  | 76(28)  | 38(16)  | 37(13)  | 40(12)  | 27(12)  | 26(11)  | 78(9)   | 49(5)   |
| 2-Chlorotoluene                                             | 91(100)                | 126(68) | 89(23)  | 128(22) | 90(18)  | 65(17)  | 125(15) | 92(13)  | 127(10) | 63(6)   |
| 3-Chlorotoluene                                             | 91(100)                | 126(27) | 63(15)  | 65(12)  | 89(11)  | 39(11)  | 128(9)  | 125(8)  | 92(8)   | 62(6)   |
| Cyclohexane                                                 | 56(100)                | 84(71)  | 41(70)  | 27(37)  | 55(36)  | 39(35)  | 42(30)  | 69(23)  | 28(18)  | 43(14)  |
| Cyclohexanol                                                | 57(100)                | 44(68)  | 41(68)  | 39(51)  | 32(40)  | 43(38)  | 31(32)  | 42(22)  | 67(18)  | 82(16)  |
| Cyclohexanone                                               | 55(100)                | 42(85)  | 41(34)  | 27(33)  | 98(31)  | 39(27)  | 69(26)  | 70(20)  | 43(14)  | 28(14)  |
| Cyclohexene                                                 | 67(100)                | 54(72)  | 82(37)  | 41(35)  | 39(33)  | 27(15)  | 53(12)  | 81(9)   | 51(8)   | 79(6)   |
| Cyclohexylamine                                             | 56(100)                | 43(23)  | 28(17)  | 99(10)  | 70(8)   | 57(6)   | 30(6)   | 93(5)   | 54(4)   | 41(4)   |
| Cyclopentane                                                | 42(100)                | 70(30)  | 55(29)  | 41(29)  | 39(22)  | 27(15)  | 40(7)   | 29(5)   | 28(4)   | 43(3)   |
| Cyclopentanone                                              | 55(100)                | 28(50)  | 84(42)  | 41(38)  | 56(29)  | 27(24)  | 39(19)  | 42(15)  | 26(9)   | 29(7)   |
| <i>cis</i> -Decahydronaphthalene ( <i>cis</i> -Decalin)     | 67(100)                | 81(87)  | 41(81)  | 138(67) | 96(62)  | 82(62)  | 39(50)  | 55(45)  | 27(44)  | 95(42)  |
| <i>trans</i> -Decahydronaphthalene ( <i>trans</i> -Decalin) | 41(100)                | 68(91)  | 67(88)  | 82(67)  | 27(65)  | 96(61)  | 95(55)  | 138(51) | 81(51)  | 29(51)  |
| Decane                                                      | 43(100)                | 57(90)  | 41(41)  | 71(33)  | 29(30)  | 85(24)  | 27(20)  | 56(17)  | 55(14)  | 42(14)  |
| Diacetone alcohol                                           | 43(100)                | 59(41)  | 58(17)  | 101(10) | 41(9)   | 31(9)   | 83(6)   | 56(6)   | 55(6)   | 29(6)   |
| 1,2-Dibromoethane                                           | 27(100)                | 107(77) | 109(72) | 26(24)  | 28(10)  | 81(5)   | 79(5)   | 25(5)   | 95(4)   | 93(4)   |
| Dibromofluoromethane                                        | 111(100)               | 113(98) | 192(29) | 43(16)  | 41(16)  | 190(15) | 194(14) | 81(9)   | 79(9)   | 122(7)  |
| Dibromomethane                                              | 174(100)               | 93(96)  | 95(84)  | 172(53) | 176(50) | 91(11)  | 81(9)   | 79(9)   | 94(5)   | 65(5)   |
| 1,2-Dibromopropane                                          | 41(100)                | 121(66) | 123(65) | 39(48)  | 27(28)  | 107(11) | 38(10)  | 26(10)  | 109(9)  | 42(9)   |
| 1,2-Dibromotetrafluoroethane                                | 179(100)               | 181(97) | 129(34) | 131(33) | 100(17) | 31(13)  | 260(12) | 50(8)   | 69(7)   | 262(6)  |
| Dibutylamine                                                | 86(100)                | 72(52)  | 30(48)  | 44(40)  | 29(31)  | 57(24)  | 41(21)  | 73(15)  | 28(15)  | 43(13)  |
| Dibutyl ether                                               | 57(100)                | 41(34)  | 29(30)  | 56(25)  | 87(21)  | 27(9)   | 58(8)   | 55(6)   | 39(5)   | 28(5)   |
| Dibutyl oxalate                                             | 57(100)                | 41(61)  | 56(24)  | 44(9)   | 55(8)   | 43(7)   | 58(5)   | 42(4)   | 103(2)  | 73(2)   |
| Dibutyl phthalate                                           | 149(100)               | 86(18)  | 57(18)  | 223(17) | 205(17) | 150(17) | 104(17) | 56(17)  | 41(17)  | 65(16)  |
| Dibutyl sebacate                                            | 241(100)               | 185(71) | 41(37)  | 56(35)  | 55(32)  | 57(31)  | 242(23) | 143(21) | 98(21)  | 125(20) |
| <i>o</i> -Dichlorobenzene                                   | 146(100)               | 148(64) | 111(38) | 75(23)  | 113(12) | 74(12)  | 50(11)  | 150(10) | 73(9)   | 147(7)  |
| <i>m</i> -Dichlorobenzene                                   | 146(100)               | 148(65) | 111(36) | 75(25)  | 50(19)  | 74(16)  | 150(11) | 113(11) | 73(11)  | 147(8)  |
| 1,1-Dichloroethane                                          | 63(100)                | 27(71)  | 65(31)  | 26(19)  | 83(11)  | 85(7)   | 61(7)   | 35(6)   | 98(5)   | 62(5)   |
| 1,2-Dichloroethane                                          | 62(100)                | 27(91)  | 49(40)  | 64(32)  | 26(31)  | 63(19)  | 98(14)  | 51(13)  | 61(12)  | 100(9)  |
| 1,1-Dichloroethene                                          | 61(100)                | 96(61)  | 98(38)  | 63(32)  | 26(16)  | 60(15)  | 62(7)   | 25(7)   | 100(6)  | 35(6)   |
| <i>cis</i> -1,2-Dichloroethene                              | 61(100)                | 96(73)  | 98(47)  | 63(32)  | 26(30)  | 60(21)  | 25(13)  | 35(12)  | 62(9)   | 100(8)  |
| <i>trans</i> -1,2-Dichloroethene                            | 61(100)                | 96(67)  | 98(43)  | 26(34)  | 63(32)  | 60(24)  | 25(15)  | 62(10)  | 100(7)  | 47(7)   |
| Dichlorofluoromethane                                       | 67(100)                | 69(32)  | 47(13)  | 35(13)  | 31(9)   | 32(8)   | 48(7)   | 83(5)   | 102(4)  | 49(4)   |

| Compound                                                        | <i>m/z</i> (intensity) |         |         |         |         |         |         |        |         |         |
|-----------------------------------------------------------------|------------------------|---------|---------|---------|---------|---------|---------|--------|---------|---------|
| Dichloromethane (Methylene chloride)                            | 49(100)                | 84(64)  | 86(39)  | 51(31)  | 47(14)  | 48(8)   | 88(6)   | 50(3)  | 85(2)   | 83(2)   |
| (Dichloromethyl)benzene (Benzal chloride)                       | 125(100)               | 127(32) | 160(14) | 89(13)  | 162(9)  | 63(9)   | 126(8)  | 62(7)  | 105(5)  | 39(5)   |
| 1,2-Dichloropropane                                             | 63(100)                | 62(71)  | 27(57)  | 41(49)  | 39(32)  | 65(31)  | 76(27)  | 64(25) | 49(13)  | 77(12)  |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane                          | 85(100)                | 135(52) | 87(33)  | 137(17) | 101(9)  | 31(9)   | 103(6)  | 100(6) | 50(5)   | 69(4)   |
| 2,4-Dichlorotoluene                                             | 125(100)               | 160(61) | 162(40) | 127(32) | 89(23)  | 159(16) | 161(14) | 63(13) | 62(11)  | 126(10) |
| 3,4-Dichlorotoluene                                             | 125(100)               | 160(47) | 127(32) | 162(31) | 89(15)  | 159(11) | 161(10) | 63(10) | 126(8)  | 62(8)   |
| Diethanolamine                                                  | 30(100)                | 74(82)  | 28(77)  | 56(69)  | 18(50)  | 42(46)  | 29(36)  | 27(34) | 45(30)  | 43(19)  |
| 1,1-Diethoxyethane (Acetal)                                     | 44(100)                | 43(92)  | 29(77)  | 31(76)  | 45(74)  | 27(52)  | 72(48)  | 73(23) | 28(17)  | 46(15)  |
| 1,2-Diethoxyethane (Ethylene glycol diethyl ether)              | 31(100)                | 59(71)  | 29(58)  | 45(43)  | 27(33)  | 74(27)  | 43(15)  | 15(14) | 28(12)  | 44(10)  |
| Diethylamine                                                    | 30(100)                | 58(81)  | 44(28)  | 73(18)  | 29(18)  | 28(17)  | 72(12)  | 42(11) | 27(11)  | 59(4)   |
| Diethyl carbonate                                               | 29(100)                | 45(70)  | 31(53)  | 27(39)  | 91(24)  | 28(15)  | 63(11)  | 26(10) | 30(6)   | 43(5)   |
| Diethylene glycol                                               | 45(100)                | 75(23)  | 31(20)  | 44(16)  | 27(14)  | 76(12)  | 29(12)  | 43(11) | 42(9)   | 41(4)   |
| Diethylene glycol dimethyl ether (Diglyme)                      | 59(100)                | 58(43)  | 31(34)  | 29(32)  | 45(28)  | 28(19)  | 89(15)  | 43(9)  | 27(5)   | 60(4)   |
| Diethylene glycol monobutyl ether acetate                       | 43(100)                | 87(93)  | 57(82)  | 41(28)  | 45(25)  | 56(18)  | 29(18)  | 72(14) | 85(12)  | 101(10) |
| Diethylene glycol monoethyl ether (Carbitol)                    | 45(100)                | 59(56)  | 72(37)  | 73(22)  | 60(14)  | 31(13)  | 75(11)  | 44(9)  | 104(8)  | 103(7)  |
| Diethylene glycol monoethyl ether acetate                       | 43(100)                | 29(51)  | 31(42)  | 45(40)  | 59(24)  | 72(18)  | 44(10)  | 73(9)  | 42(9)   | 30(6)   |
| Diethylene glycol monomethyl ether                              | 45(100)                | 31(42)  | 59(41)  | 29(38)  | 28(32)  | 58(21)  | 43(14)  | 27(13) | 44(11)  | 32(10)  |
| Diethyl ether                                                   | 31(100)                | 29(63)  | 59(40)  | 27(35)  | 45(33)  | 74(23)  | 15(17)  | 43(9)  | 28(9)   | 26(9)   |
| Diethyl oxalate                                                 | 29(100)                | 31(16)  | 45(14)  | 27(14)  | 74(11)  | 28(9)   | 43(4)   | 30(4)  | 73(3)   | 75(2)   |
| Diethyl sulfide                                                 | 75(100)                | 47(81)  | 90(73)  | 62(60)  | 29(55)  | 61(54)  | 27(48)  | 28(23) | 46(17)  | 45(17)  |
| Diisopropylamine                                                | 44(100)                | 86(30)  | 58(14)  | 42(13)  | 28(13)  | 41(12)  | 43(11)  | 27(11) | 15(11)  | 39(6)   |
| Diisopropyl ether                                               | 45(100)                | 43(39)  | 87(15)  | 41(12)  | 59(10)  | 27(8)   | 39(4)   | 69(3)  | 42(3)   | 31(3)   |
| 1,2-Dimethoxybenzene (Veratrole)                                | 138(100)               | 95(65)  | 77(48)  | 123(44) | 52(42)  | 41(33)  | 65(30)  | 51(29) | 39(19)  | 63(17)  |
| 1,2-Dimethoxyethane (Ethylene glycol dimethyl ether)            | 45(100)                | 60(13)  | 29(13)  | 90(7)   | 58(6)   | 31(5)   | 28(5)   | 43(4)  | 59(3)   | 46(2)   |
| Dimethoxymethane (Methylal)                                     | 45(100)                | 75(61)  | 29(59)  | 31(13)  | 30(6)   | 15(6)   | 47(5)   | 76(2)  | 46(2)   | 44(2)   |
| <i>N,N</i> -Dimethylacetamide                                   | 44(100)                | 87(69)  | 43(46)  | 45(23)  | 42(19)  | 72(15)  | 15(11)  | 30(8)  | 28(5)   | 88(4)   |
| Dimethylamine                                                   | 44(100)                | 45(81)  | 18(32)  | 28(30)  | 43(19)  | 42(15)  | 15(9)   | 46(5)  | 41(5)   | 27(5)   |
| 2,4-Dimethylaniline (2,4-Xylydine)                              | 121(100)               | 120(78) | 106(57) | 77(15)  | 28(15)  | 91(12)  | 122(9)  | 18(8)  | 93(6)   | 118(5)  |
| 2,2-Dimethylbutane (Neohexane)                                  | 43(100)                | 57(98)  | 71(73)  | 41(61)  | 29(51)  | 27(36)  | 56(29)  | 39(25) | 55(15)  | 15(12)  |
| 2,3-Dimethylbutane                                              | 43(100)                | 42(97)  | 41(27)  | 71(25)  | 27(11)  | 86(10)  | 39(9)   | 29(6)  | 55(5)   | 44(4)   |
| Dimethyl disulfide                                              | 94(100)                | 45(63)  | 79(59)  | 46(38)  | 47(26)  | 15(18)  | 48(14)  | 61(12) | 64(11)  | 96(9)   |
| <i>N,N</i> -Dimethylformamide                                   | 73(100)                | 44(86)  | 42(36)  | 30(22)  | 28(20)  | 29(8)   | 43(7)   | 72(6)  | 58(5)   | 74(4)   |
| Dimethyl glutarate                                              | 59(100)                | 100(51) | 55(49)  | 42(33)  | 129(32) | 101(32) | 41(26)  | 43(22) | 128(19) | 87(15)  |
| 2,6-Dimethyl-4-heptanone (Isovalerone)                          | 57(100)                | 85(82)  | 41(46)  | 43(39)  | 58(33)  | 28(30)  | 26(30)  | 39(22) | 42(12)  | 142(11) |
| 2,5-Dimethylhexane                                              | 57(100)                | 43(93)  | 42(31)  | 41(26)  | 99(19)  | 71(19)  | 29(11)  | 70(10) | 55(9)   | 27(9)   |
| Dimethyl maleate                                                | 113(100)               | 59(83)  | 26(72)  | 29(40)  | 85(37)  | 54(31)  | 114(25) | 53(24) | 55(13)  | 82(9)   |
| 2,2-Dimethylpentane                                             | 57(100)                | 43(73)  | 41(46)  | 56(40)  | 85(34)  | 29(31)  | 27(23)  | 39(15) | 15(7)   | 55(6)   |
| 2,4-Dimethylpentane                                             | 43(100)                | 57(73)  | 56(41)  | 41(35)  | 42(24)  | 85(17)  | 29(16)  | 27(12) | 39(9)   | 58(3)   |
| 2,4-Dimethyl-3-pentanone (Diisopropyl ketone)                   | 43(100)                | 71(31)  | 41(13)  | 27(9)   | 70(6)   | 39(6)   | 114(5)  | 42(5)  | 44(3)   | 72(2)   |
| 2,4-Dimethylpyridine (2,4-Lutidine)                             | 107(100)               | 106(63) | 79(44)  | 92(22)  | 65(22)  | 51(19)  | 77(17)  | 80(12) | 52(11)  | 50(11)  |
| 2,6-Dimethylpyridine (2,6-Lutidine)                             | 107(100)               | 39(39)  | 106(29) | 66(22)  | 92(18)  | 65(18)  | 38(12)  | 27(11) | 79(9)   | 63(9)   |
| Dimethyl sulfoxide                                              | 63(100)                | 78(70)  | 15(40)  | 45(35)  | 29(16)  | 61(13)  | 46(12)  | 31(11) | 48(10)  | 47(10)  |
| 1,4-Dioxane                                                     | 28(100)                | 29(37)  | 88(31)  | 58(24)  | 31(17)  | 15(17)  | 27(15)  | 30(13) | 43(11)  | 26(9)   |
| 1,3-Dioxolane                                                   | 73(100)                | 29(56)  | 44(53)  | 45(28)  | 28(21)  | 43(20)  | 27(13)  | 31(7)  | 74(5)   | 42(3)   |
| Dipentene                                                       | 68(100)                | 93(50)  | 67(44)  | 94(22)  | 39(22)  | 107(18) | 92(18)  | 53(18) | 136(16) | 79(16)  |
| Dipentyl ether (Amyl ether)                                     | 71(100)                | 43(92)  | 29(43)  | 70(40)  | 41(36)  | 27(34)  | 42(23)  | 69(17) | 55(16)  | 39(16)  |
| Dipropylamine                                                   | 30(100)                | 72(79)  | 44(40)  | 43(32)  | 27(25)  | 28(24)  | 41(22)  | 86(11) | 58(10)  | 42(10)  |
| Dodecane                                                        | 57(100)                | 43(91)  | 71(53)  | 41(45)  | 85(31)  | 29(27)  | 55(19)  | 56(18) | 28(16)  | 42(14)  |
| 1-Dodecene                                                      | 43(100)                | 56(83)  | 55(83)  | 41(75)  | 69(62)  | 70(58)  | 57(57)  | 83(47) | 29(38)  | 84(33)  |
| Epichlorohydrin                                                 | 57(100)                | 27(39)  | 29(32)  | 49(25)  | 31(22)  | 62(18)  | 28(16)  | 92(1)  |         |         |
| 1,2-Epoxybutane (Ethylloxirane)                                 | 43(100)                | 44(58)  | 27(52)  | 29(50)  | 45(46)  | 26(27)  | 28(27)  | 72(5)  |         |         |
| 1,2-Ethanediamine                                               | 30(100)                | 18(13)  | 42(6)   | 43(5)   | 27(5)   | 44(4)   | 29(4)   | 17(4)  | 15(4)   | 41(3)   |
| 1,2-Ethandiol (Ethylene glycol)                                 | 31(100)                | 33(35)  | 29(13)  | 32(11)  | 43(6)   | 27(5)   | 28(4)   | 62(3)  | 30(3)   | 44(2)   |
| 1,2-Ethandiol, diacetate (Ethylene glycol diacetate)            | 43(100)                | 86(11)  | 42(7)   | 15(7)   | 116(4)  | 73(4)   | 44(3)   | 29(3)  | 103(2)  | 45(2)   |
| Ethanol                                                         | 31(100)                | 45(44)  | 46(18)  | 27(18)  | 29(15)  | 43(14)  | 30(6)   | 42(3)  | 19(3)   | 14(3)   |
| Ethanolamine                                                    | 30(100)                | 18(30)  | 28(15)  | 42(7)   | 31(6)   | 17(6)   | 61(5)   | 15(5)  | 43(3)   | 29(3)   |
| Ethoxybenzene (Phenetole)                                       | 94(100)                | 122(39) | 28(12)  | 66(11)  | 39(9)   | 77(8)   | 95(7)   | 65(7)  | 51(7)   | 29(6)   |
| 2-Ethoxyethanol (Ethylene glycol monoethyl ether; Cellosolve)   | 31(100)                | 29(52)  | 59(50)  | 27(27)  | 45(26)  | 72(14)  | 43(14)  | 15(14) | 28(8)   | 26(6)   |
| 2-Ethoxyethyl acetate (Ethylene glycol monoethyl ether acetate) | 43(100)                | 31(34)  | 59(31)  | 72(28)  | 44(25)  | 29(24)  | 45(12)  | 27(11) | 15(11)  | 87(7)   |
| Ethyl acetate                                                   | 43(100)                | 29(46)  | 27(33)  | 45(32)  | 61(28)  | 28(25)  | 42(18)  | 73(11) | 88(10)  | 70(10)  |
| Ethyl acetoacetate                                              | 43(100)                | 29(24)  | 88(18)  | 28(16)  | 85(14)  | 27(12)  | 42(11)  | 60(9)  | 130(6)  | 45(6)   |

| Compound                                            | <i>m/z</i> (intensity) |         |         |         |         |         |        |         |         |         |
|-----------------------------------------------------|------------------------|---------|---------|---------|---------|---------|--------|---------|---------|---------|
| Ethyl acrylate (Ethyl propenoate)                   | 55(100)                | 27(32)  | 29(15)  | 56(12)  | 45(9)   | 73(8)   | 28(8)  | 26(6)   | 99(5)   | 85(5)   |
| Ethylamine                                          | 30(100)                | 28(32)  | 44(20)  | 45(19)  | 27(13)  | 15(10)  | 42(9)  | 29(8)   | 41(5)   | 40(5)   |
| Ethylbenzene                                        | 91(100)                | 106(31) | 51(14)  | 39(10)  | 77(8)   | 65(8)   | 105(7) | 92(7)   | 78(7)   | 27(6)   |
| Ethyl benzoate                                      | 105(100)               | 77(65)  | 122(34) | 51(34)  | 27(17)  | 150(16) | 29(14) | 50(13)  | 106(12) | 78(6)   |
| Ethyl butanoate                                     | 43(100)                | 71(88)  | 29(83)  | 27(43)  | 88(40)  | 41(28)  | 60(22) | 45(20)  | 73(17)  | 42(17)  |
| Ethyl cyanoacetate                                  | 29(100)                | 68(59)  | 27(34)  | 40(21)  | 28(16)  | 41(14)  | 15(13) | 45(10)  | 43(9)   | 26(9)   |
| Ethylcyclohexane                                    | 83(100)                | 55(65)  | 82(42)  | 41(36)  | 112(23) | 56(11)  | 67(10) | 39(10)  | 42(9)   | 84(8)   |
| Ethylene carbonate                                  | 29(100)                | 44(62)  | 43(54)  | 88(40)  | 30(16)  | 28(11)  | 45(7)  | 58(6)   | 42(6)   | 73(4)   |
| Ethyl formate                                       | 31(100)                | 28(73)  | 27(51)  | 29(38)  | 45(34)  | 26(17)  | 74(11) | 43(9)   | 47(8)   | 56(4)   |
| 2-Ethyl-1,3-hexanediol                              | 56(100)                | 55(71)  | 41(60)  | 43(55)  | 29(46)  | 27(44)  | 31(34) | 57(33)  | 73(32)  | 39(20)  |
| 2-Ethyl-1-hexanol                                   | 57(100)                | 43(41)  | 41(40)  | 29(29)  | 55(28)  | 83(27)  | 56(23) | 70(20)  | 27(17)  | 31(13)  |
| <i>N</i> -Ethyl- <i>N</i> -isopropyl-2-propanamine  | 72(100)                | 114(77) | 44(41)  | 129(22) | 42(21)  | 30(20)  | 43(18) | 41(17)  | 27(15)  | 70(11)  |
| Ethyl 3-methylbutanoate                             | 29(100)                | 41(52)  | 27(51)  | 57(43)  | 43(42)  | 60(39)  | 88(38) | 85(38)  | 61(26)  | 45(24)  |
| 3-Ethyl-2-methylpentane                             | 43(100)                | 70(50)  | 41(27)  | 71(25)  | 29(19)  | 27(19)  | 85(18) | 55(18)  | 57(15)  | 42(14)  |
| Ethyl propanoate                                    | 57(100)                | 29(84)  | 102(17) | 27(17)  | 75(15)  | 28(14)  | 45(13) | 74(12)  | 73(7)   | 43(6)   |
| Fluorobenzene                                       | 96(100)                | 70(17)  | 97(7)   | 95(6)   | 75(6)   | 50(6)   | 51(4)  | 39(4)   | 69(3)   | 57(3)   |
| 2-Fluorotoluene                                     | 109(100)               | 110(55) | 83(18)  | 57(11)  | 63(10)  | 39(9)   | 51(6)  | 50(6)   | 107(5)  | 62(5)   |
| 3-Fluorotoluene                                     | 109(100)               | 110(54) | 83(11)  | 57(5)   | 111(4)  | 107(4)  | 63(3)  | 39(3)   | 108(2)  | 89(2)   |
| 4-Fluorotoluene                                     | 109(100)               | 110(60) | 83(13)  | 57(10)  | 108(8)  | 39(8)   | 63(7)  | 107(5)  | 51(5)   | 50(5)   |
| Furan                                               | 68(100)                | 39(64)  | 40(9)   | 38(9)   | 42(6)   | 29(6)   | 37(5)  | 69(4)   | 34(2)   | 67(1)   |
| Furfural                                            | 39(100)                | 96(55)  | 95(52)  | 38(38)  | 29(35)  | 37(29)  | 40(11) | 97(9)   | 50(7)   | 42(7)   |
| Furfuryl alcohol                                    | 98(100)                | 41(65)  | 39(59)  | 81(55)  | 53(53)  | 97(51)  | 42(49) | 69(39)  | 70(36)  | 29(28)  |
| Glycerol                                            | 61(100)                | 43(90)  | 31(57)  | 44(54)  | 29(38)  | 18(32)  | 27(12) | 42(11)  | 60(10)  | 45(10)  |
| Glycerol triacetate (Triacetin)                     | 43(100)                | 103(44) | 145(34) | 116(17) | 115(13) | 44(10)  | 86(9)  | 28(8)   | 73(7)   | 42(7)   |
| Heptane                                             | 43(100)                | 41(56)  | 29(49)  | 57(47)  | 27(46)  | 71(45)  | 56(27) | 42(26)  | 39(23)  | 70(18)  |
| 1-Heptanol                                          | 41(100)                | 70(87)  | 56(86)  | 31(78)  | 43(72)  | 29(70)  | 55(67) | 27(65)  | 42(54)  | 69(41)  |
| 3-Heptanol                                          | 59(100)                | 69(73)  | 87(37)  | 41(37)  | 29(33)  | 55(30)  | 31(24) | 116(0)  |         |         |
| 2-Heptanone (Methyl pentyl ketone)                  | 43(100)                | 58(60)  | 71(14)  | 41(11)  | 27(11)  | 59(9)   | 39(8)  | 29(8)   | 42(5)   | 114(4)  |
| 3-Heptanone (Ethyl butyl ketone)                    | 57(100)                | 29(76)  | 41(32)  | 85(29)  | 72(22)  | 43(15)  | 39(11) | 114(10) | 27(7)   | 55(5)   |
| 1-Heptene                                           | 41(100)                | 56(88)  | 29(70)  | 55(59)  | 42(52)  | 27(45)  | 39(41) | 70(37)  | 69(27)  | 57(27)  |
| Hexane                                              | 57(100)                | 43(78)  | 41(77)  | 29(61)  | 27(57)  | 56(45)  | 42(39) | 39(27)  | 28(16)  | 86(14)  |
| Hexanedinitrile (Adiponitrile)                      | 41(100)                | 68(50)  | 54(42)  | 40(21)  | 55(20)  | 27(17)  | 39(16) | 28(13)  | 52(7)   | 42(6)   |
| Hexanenitrile                                       | 41(100)                | 54(68)  | 27(59)  | 55(55)  | 29(44)  | 39(35)  | 57(30) | 43(30)  | 68(24)  | 28(22)  |
| Hexanoic acid (Caproic acid)                        | 60(100)                | 73(42)  | 27(36)  | 41(33)  | 43(27)  | 29(26)  | 45(20) | 39(16)  | 42(15)  | 55(14)  |
| 1-Hexanol                                           | 56(100)                | 43(78)  | 31(74)  | 41(71)  | 27(64)  | 29(59)  | 55(58) | 42(53)  | 39(37)  | 69(27)  |
| 2-Hexanone (Butyl methyl ketone)                    | 43(100)                | 58(60)  | 57(17)  | 100(16) | 29(15)  | 41(13)  | 85(8)  | 27(8)   | 71(7)   | 59(5)   |
| Hexyl acetate                                       | 43(100)                | 56(66)  | 41(38)  | 55(37)  | 61(35)  | 42(33)  | 84(31) | 69(19)  | 73(17)  | 57(7)   |
| 3-Hydroxypropanenitrile (Hydracrylonitrile)         | 41(100)                | 31(97)  | 29(20)  | 42(17)  | 52(15)  | 40(13)  | 53(10) | 51(9)   | 39(7)   | 26(7)   |
| Iodobenzene                                         | 204(100)               | 77(82)  | 51(32)  | 50(20)  | 127(8)  | 205(6)  | 78(6)  | 74(6)   | 102(5)  | 76(5)   |
| 1-Iodobutane (Butyl iodide)                         | 57(100)                | 29(78)  | 41(56)  | 27(39)  | 184(36) | 39(17)  | 28(16) | 26(7)   | 127(6)  | 55(6)   |
| 2-Iodobutane ( <i>sec</i> -Butyl iodide)            | 57(100)                | 29(36)  | 184(36) | 41(36)  | 27(10)  | 39(9)   | 127(6) | 58(4)   |         |         |
| Iodoethane (Ethyl iodide)                           | 156(100)               | 29(75)  | 27(63)  | 127(31) | 26(14)  | 28(9)   | 128(8) | 141(2)  | 25(2)   | 140(1)  |
| Iodomethane (Methyl iodide)                         | 142(100)               | 127(38) | 141(14) | 15(13)  | 139(5)  | 140(4)  | 128(3) | 14(1)   | 13(1)   | 71(0)   |
| 1-Iodopropane (Propyl iodide)                       | 43(100)                | 170(68) | 41(35)  | 27(26)  | 127(14) | 39(11)  | 44(4)  | 141(3)  | 128(3)  | 42(3)   |
| 2-Iodopropane (Isopropyl iodide)                    | 43(100)                | 170(46) | 41(45)  | 27(44)  | 39(19)  | 127(17) | 42(4)  | 38(4)   | 128(3)  | 44(3)   |
| Isobutanal (2-Methyl-1-propanal)                    | 43(100)                | 41(84)  | 27(47)  | 72(46)  | 39(30)  | 29(25)  | 42(10) | 70(5)   | 38(5)   | 28(5)   |
| Isobutyl acetate                                    | 43(100)                | 56(26)  | 73(15)  | 41(10)  | 29(5)   | 71(3)   | 57(3)  | 39(3)   | 27(3)   | 86(2)   |
| Isobutylamine                                       | 30(100)                | 28(9)   | 41(6)   | 73(5)   | 27(5)   | 39(4)   | 29(3)  | 15(3)   | 58(2)   | 56(2)   |
| Isobutylbenzene                                     | 91(100)                | 92(58)  | 43(22)  | 134(20) | 65(12)  | 41(12)  | 39(11) | 27(8)   | 51(7)   | 93(5)   |
| Isobutyl formate                                    | 43(100)                | 56(82)  | 41(78)  | 31(65)  | 29(64)  | 27(53)  | 60(39) | 39(36)  | 42(26)  | 15(14)  |
| Isobutyl isobutanoate                               | 43(100)                | 41(94)  | 56(76)  | 71(70)  | 57(68)  | 27(62)  | 29(59) | 89(37)  | 39(32)  | 42(17)  |
| Isopentyl acetate                                   | 43(100)                | 70(49)  | 55(38)  | 61(15)  | 42(15)  | 41(14)  | 27(12) | 87(11)  | 29(10)  | 73(9)   |
| Isophorone                                          | 82(100)                | 39(20)  | 138(17) | 54(13)  | 27(12)  | 41(10)  | 53(8)  | 83(7)   | 29(7)   | 55(6)   |
| Isopropyl acetate                                   | 43(100)                | 61(17)  | 41(14)  | 87(9)   | 59(8)   | 27(8)   | 42(7)  | 39(4)   | 45(3)   | 44(2)   |
| Isopropylbenzene (Cumene)                           | 105(100)               | 120(25) | 77(13)  | 51(12)  | 79(10)  | 106(9)  | 39(9)  | 27(8)   | 103(6)  | 91(5)   |
| 1-Isopropyl-4-methylbenzene ( <i>p</i> -Cymene)     | 119(100)               | 91(42)  | 134(33) | 39(27)  | 41(20)  | 117(18) | 65(18) | 77(17)  | 27(16)  | 120(15) |
| Isoquinoline                                        | 129(100)               | 102(26) | 51(20)  | 128(18) | 50(11)  | 130(10) | 75(10) | 76(9)   | 103(8)  | 74(7)   |
| <i>d</i> -Limonene (Citrene)                        | 68(100)                | 93(50)  | 67(49)  | 41(22)  | 94(21)  | 79(21)  | 39(21) | 136(20) | 53(19)  | 121(16) |
| Mesityl oxide                                       | 55(100)                | 83(89)  | 43(73)  | 29(42)  | 98(36)  | 39(32)  | 27(28) | 53(11)  | 41(10)  | 56(5)   |
| Methanol                                            | 31(100)                | 29(72)  | 32(67)  | 15(42)  | 28(12)  | 14(10)  | 30(9)  | 13(6)   | 12(3)   | 16(2)   |
| 2-Methoxyethanol (Ethylene glycol monomethyl ether) | 45(100)                | 31(15)  | 29(14)  | 28(11)  | 47(9)   | 76(6)   | 43(6)  | 58(4)   | 46(4)   | 27(4)   |



| Compound                                                          | <i>e/m</i> (intensity) |         |         |         |        |         |         |         |         |        |
|-------------------------------------------------------------------|------------------------|---------|---------|---------|--------|---------|---------|---------|---------|--------|
| 2-Methoxyethyl acetate (Ethylene glycol monomethyl ether acetate) | 43(100)                | 45(48)  | 58(42)  | 29(10)  | 42(4)  | 31(4)   | 73(3)   | 27(3)   | 59(2)   | 26(2)  |
| Methyl acetate                                                    | 43(100)                | 74(52)  | 28(38)  | 42(19)  | 59(17) | 44(8)   | 32(8)   | 29(6)   | 31(4)   | 75(2)  |
| 2-Methylacrylonitrile                                             | 41(100)                | 39(54)  | 67(44)  | 40(26)  | 38(24) | 52(23)  | 27(23)  | 37(20)  | 66(17)  | 51(12) |
| Methylamine                                                       | 30(100)                | 31(87)  | 28(56)  | 29(19)  | 32(15) | 15(12)  | 27(9)   |         |         |        |
| 2-Methylaniline ( <i>o</i> -Toluidine)                            | 106(100)               | 107(83) | 77(17)  | 79(13)  | 39(12) | 53(10)  | 52(10)  | 54(9)   | 51(9)   | 28(9)  |
| 3-Methylaniline ( <i>m</i> -Toluidine)                            | 106(100)               | 107(84) | 79(17)  | 77(17)  | 108(7) | 78(6)   | 80(5)   | 89(4)   | 65(4)   | 53(4)  |
| <i>N</i> -Methylaniline                                           | 106(100)               | 107(79) | 77(23)  | 51(12)  | 79(11) | 65(9)   | 39(9)   | 78(8)   | 108(7)  | 50(6)  |
| Methyl benzoate                                                   | 105(100)               | 77(81)  | 51(45)  | 136(24) | 50(18) | 106(8)  | 78(6)   | 28(6)   | 39(5)   | 27(5)  |
| Methyl butanoate                                                  | 43(100)                | 74(90)  | 71(66)  | 41(32)  | 27(31) | 59(28)  | 87(19)  | 42(15)  | 28(15)  | 39(14) |
| 3-Methylbutanoic acid (Isovaleric acid)                           | 60(100)                | 43(61)  | 41(54)  | 27(33)  | 45(31) | 29(27)  | 74(24)  | 39(24)  | 87(21)  | 57(20) |
| 3-Methyl-1-butanol (Isopentyl alcohol)                            | 55(100)                | 42(90)  | 43(82)  | 41(81)  | 70(71) | 31(61)  | 29(59)  | 27(59)  | 39(44)  | 57(31) |
| Methyl <i>tert</i> -butyl ether                                   | 41(100)                | 73(78)  | 57(71)  | 29(60)  | 43(48) | 39(34)  | 28(28)  | 56(23)  | 55(18)  | 45(16) |
| Methyl cyanoacetate                                               | 59(100)                | 15(65)  | 68(60)  | 40(38)  | 28(17) | 29(16)  | 55(11)  | 54(10)  | 39(10)  | 67(8)  |
| Methylcyclohexane                                                 | 83(100)                | 55(82)  | 41(60)  | 98(44)  | 42(35) | 56(30)  | 27(29)  | 39(27)  | 69(23)  | 70(22) |
| <i>cis</i> -4-Methylcyclohexanol                                  | 57(100)                | 58(54)  | 70(38)  | 81(36)  | 96(33) | 55(25)  | 41(23)  | 114(17) | 71(15)  | 56(12) |
| <i>N</i> -Methylformamide                                         | 59(100)                | 30(54)  | 28(34)  | 29(13)  | 58(8)  | 15(7)   | 60(3)   | 41(3)   | 27(3)   | 31(2)  |
| Methyl formate                                                    | 31(100)                | 29(63)  | 32(34)  | 60(28)  | 30(7)  | 28(7)   | 44(2)   | 18(2)   | 61(1)   | 59(1)  |
| 2-Methylheptane                                                   | 43(100)                | 57(91)  | 42(39)  | 41(27)  | 29(16) | 70(15)  | 27(13)  | 71(12)  | 99(10)  | 55(9)  |
| 4-Methylheptane                                                   | 43(100)                | 71(53)  | 70(46)  | 41(27)  | 29(23) | 27(23)  | 55(15)  | 57(14)  | 42(14)  | 39(10) |
| 6-Methyl-1-heptanol (Isooctyl alcohol)                            | 41(100)                | 55(94)  | 43(93)  | 69(84)  | 57(81) | 56(73)  | 29(50)  | 84(48)  | 70(47)  | 27(46) |
| 2-Methylhexane                                                    | 43(100)                | 42(38)  | 41(35)  | 85(32)  | 57(26) | 29(22)  | 27(22)  | 56(20)  | 39(11)  | 55(5)  |
| 5-Methyl-2-hexanone (Methyl isopentyl ketone)                     | 43(100)                | 58(34)  | 27(14)  | 41(13)  | 15(13) | 57(11)  | 39(9)   | 71(8)   | 59(8)   | 29(8)  |
| Methyl methacrylate (Methyl 2-methyl-2-propenoate)                | 41(100)                | 69(66)  | 39(40)  | 100(34) | 15(20) | 40(10)  | 59(8)   | 99(6)   | 38(6)   | 55(5)  |
| 2-Methyloctane                                                    | 43(100)                | 57(51)  | 41(35)  | 71(28)  | 42(28) | 29(23)  | 27(21)  | 85(17)  | 56(15)  | 84(13) |
| 2-Methylpentane                                                   | 43(100)                | 42(53)  | 41(35)  | 27(31)  | 71(29) | 39(20)  | 29(18)  | 57(11)  | 15(10)  | 70(7)  |
| 3-Methylpentane                                                   | 57(100)                | 56(76)  | 41(68)  | 29(60)  | 27(40) | 43(29)  | 39(22)  | 55(9)   | 15(9)   | 28(8)  |
| 2-Methyl-2,4-pentanediol (Hexylene glycol)                        | 59(100)                | 43(61)  | 56(25)  | 45(17)  | 41(16) | 57(13)  | 42(13)  | 85(11)  | 61(10)  | 31(10) |
| 4-Methylpentanenitrile                                            | 55(100)                | 41(52)  | 43(46)  | 27(39)  | 39(29) | 57(27)  | 54(26)  | 29(22)  | 82(13)  | 28(12) |
| 4-Methyl-2-pentanol                                               | 45(100)                | 43(47)  | 69(30)  | 41(27)  | 27(19) | 39(13)  | 29(12)  | 87(11)  | 84(10)  | 57(10) |
| 3-Methyl-3-pentanol                                               | 73(100)                | 55(38)  | 43(35)  | 45(28)  | 27(25) | 29(21)  | 41(12)  | 87(11)  | 31(11)  | 15(9)  |
| 4-Methyl-2-pentanone (Methyl isobutyl ketone)                     | 43(100)                | 58(84)  | 29(65)  | 41(56)  | 57(44) | 27(42)  | 39(31)  | 85(19)  | 100(14) | 42(14) |
| 2-Methylpropanenitrile (Isobutyronitrile)                         | 42(100)                | 68(45)  | 28(45)  | 54(26)  | 41(26) | 27(26)  | 29(25)  | 26(15)  | 39(13)  | 15(13) |
| Methyl propanoate                                                 | 57(100)                | 29(72)  | 59(31)  | 88(26)  | 27(18) | 28(9)   | 31(5)   | 44(4)   | 26(4)   | 58(3)  |
| 2-Methylpropanoic acid (Isobutyric acid)                          | 43(100)                | 41(42)  | 27(40)  | 73(22)  | 39(15) | 45(14)  | 42(11)  | 29(9)   | 88(7)   | 28(6)  |
| 2-Methyl-1-propanol (Isobutyl alcohol)                            | 43(100)                | 33(73)  | 31(72)  | 41(66)  | 42(60) | 27(43)  | 29(18)  | 39(17)  | 28(8)   | 74(6)  |
| 2-Methyl-2-propanol ( <i>tert</i> -Butyl alcohol)                 | 59(100)                | 31(33)  | 41(22)  | 43(18)  | 29(13) | 27(11)  | 57(10)  | 42(4)   | 60(3)   | 28(3)  |
| 2-Methylpyridine (2-Picoline)                                     | 93(100)                | 66(41)  | 39(31)  | 92(20)  | 78(19) | 51(19)  | 65(16)  | 38(13)  | 50(12)  | 52(11) |
| 3-Methylpyridine (3-Picoline)                                     | 93(100)                | 39(51)  | 66(46)  | 92(31)  | 65(29) | 40(19)  | 38(18)  | 67(13)  | 63(11)  | 51(11) |
| <i>N</i> -Methyl-2-pyrrolidinone                                  | 99(100)                | 44(89)  | 98(80)  | 42(60)  | 41(38) | 43(17)  | 28(17)  | 71(13)  | 39(11)  | 70(10) |
| Methyl salicylate                                                 | 120(100)               | 92(59)  | 152(47) | 121(32) | 65(22) | 39(22)  | 93(15)  | 64(14)  | 18(14)  | 63(13) |
| 2-Methylthiophene                                                 | 97(100)                | 98(57)  | 45(22)  | 39(14)  | 53(9)  | 99(8)   | 27(8)   | 69(6)   | 58(6)   | 59(5)  |
| Morpholine                                                        | 57(100)                | 29(100) | 87(69)  | 28(69)  | 30(38) | 56(33)  | 86(28)  | 31(28)  | 27(12)  | 15(7)  |
| Nitrobenzene                                                      | 77(100)                | 51(59)  | 123(42) | 50(25)  | 30(15) | 65(14)  | 39(10)  | 93(9)   | 74(7)   | 78(6)  |
| Nitroethane                                                       | 29(100)                | 30(12)  | 28(11)  | 26(9)   | 27(8)  | 43(5)   | 41(5)   | 14(5)   | 15(3)   | 46(2)  |
| Nitromethane                                                      | 30(100)                | 61(64)  | 46(39)  | 28(30)  | 45(8)  | 27(8)   | 44(7)   | 29(7)   | 60(5)   | 43(4)  |
| 1-Nitropropane                                                    | 43(100)                | 27(93)  | 41(90)  | 39(34)  | 30(25) | 44(20)  | 42(20)  | 26(20)  | 28(13)  | 54(12) |
| 2-Nitropropane                                                    | 43(100)                | 41(73)  | 27(71)  | 39(30)  | 30(18) | 15(11)  | 42(9)   | 28(8)   | 26(8)   | 38(6)  |
| Nonane                                                            | 43(100)                | 57(75)  | 41(29)  | 84(26)  | 85(22) | 29(22)  | 71(18)  | 56(16)  | 27(13)  | 42(12) |
| Octane                                                            | 43(100)                | 57(30)  | 85(25)  | 41(25)  | 71(19) | 29(17)  | 56(14)  | 70(10)  | 42(10)  | 27(10) |
| 1-Octanol                                                         | 41(100)                | 56(85)  | 43(82)  | 55(81)  | 31(69) | 27(69)  | 29(68)  | 42(62)  | 70(53)  | 69(48) |
| 2-Octanone (Hexyl methyl ketone)                                  | 43(100)                | 58(79)  | 41(56)  | 59(52)  | 71(49) | 27(46)  | 29(36)  | 39(27)  | 57(18)  | 55(17) |
| 1-Octene                                                          | 43(100)                | 41(82)  | 55(80)  | 56(67)  | 42(67) | 70(54)  | 29(44)  | 27(31)  | 69(30)  | 39(29) |
| Pentachloroethane                                                 | 167(100)               | 165(91) | 117(90) | 119(89) | 83(58) | 169(54) | 130(43) | 132(42) | 60(40)  | 85(37) |
| Pentane                                                           | 43(100)                | 42(55)  | 41(45)  | 27(42)  | 29(26) | 39(19)  | 57(13)  | 28(9)   | 15(9)   | 72(8)  |
| 1,5-Pentanediol (Pentamethylene glycol)                           | 31(100)                | 56(85)  | 41(67)  | 57(59)  | 55(51) | 44(45)  | 29(37)  | 43(31)  | 68(29)  | 27(26) |
| 2,4-Pentanedione (Acetylacetone)                                  | 43(100)                | 85(31)  | 100(20) | 27(12)  | 42(10) | 29(10)  | 41(7)   | 39(7)   | 31(5)   | 26(5)  |
| Pentanenitrile (Valeronitrile)                                    | 41(100)                | 43(97)  | 54(54)  | 27(34)  | 55(21) | 28(19)  | 29(16)  | 39(15)  | 42(5)   | 26(5)  |
| Pentanoic acid (Valeric acid)                                     | 60(100)                | 73(34)  | 27(33)  | 29(28)  | 41(21) | 43(17)  | 45(16)  | 28(14)  | 42(12)  | 39(12) |
| 1-Pentanol (Amyl alcohol)                                         | 42(100)                | 70(72)  | 55(65)  | 41(56)  | 31(47) | 29(41)  | 27(26)  | 57(22)  | 28(22)  | 43(21) |
| 2-Pentanol (sec-Amyl alcohol)                                     | 45(100)                | 43(20)  | 55(18)  | 27(17)  | 29(11) | 41(9)   | 31(9)   | 15(9)   | 44(8)   | 39(8)  |
| 3-Pentanol (Diethyl carbinol)                                     | 59(100)                | 31(83)  | 41(42)  | 27(35)  | 29(34) | 58(15)  | 43(15)  | 57(14)  | 39(12)  | 15(9)  |

| Compound                                    | <i>m/z</i> (intensity) |          |         |         |         |         |         |         |         |         |
|---------------------------------------------|------------------------|----------|---------|---------|---------|---------|---------|---------|---------|---------|
| 2-Pentanone (Methyl propyl ketone)          | 43(100)                | 41(17)   | 86(12)  | 42(12)  | 27(11)  | 39(8)   | 71(7)   | 58(7)   | 45(7)   | 44(3)   |
| 3-Pentanone (Diethyl ketone)                | 57(100)                | 29(50)   | 86(26)  | 27(13)  | 58(4)   | 56(4)   | 28(4)   | 26(3)   | 43(2)   | 42(2)   |
| Pentyl acetate (Amyl acetate)               | 43(100)                | 70(90)   | 42(52)  | 28(51)  | 61(50)  | 55(41)  | 73(21)  | 41(20)  | 29(14)  | 69(11)  |
| Pentylamine (Amylamine)                     | 30(100)                | 87(8)    | 41(4)   | 28(4)   | 45(3)   | 42(3)   | 27(3)   | 56(2)   | 44(2)   | 43(2)   |
| Pentyl lactate                              | 43(100)                | 70(44)   | 71(32)  | 55(28)  | 41(22)  | 29(20)  | 27(15)  | 45(12)  | 42(9)   | 57(7)   |
| $\alpha$ -Pinene                            | 93(100)                | 92(30)   | 39(24)  | 41(23)  | 77(22)  | 91(21)  | 27(21)  | 79(18)  | 121(13) | 53(10)  |
| $\beta$ -Pinene                             | 93(100)                | 41(64)   | 69(47)  | 39(33)  | 27(31)  | 79(20)  | 77(18)  | 53(14)  | 94(13)  | 91(13)  |
| Piperidine                                  | 84(100)                | 85(53)   | 56(46)  | 57(43)  | 28(41)  | 29(37)  | 44(34)  | 42(30)  | 30(30)  | 43(25)  |
| Propanal                                    | 29(100)                | 58(59)   | 28(58)  | 27(39)  | 57(20)  | 31(4)   | 30(4)   | 42(3)   | 39(3)   | 59(2)   |
| 1,2-Propanediol (1,2-Propylene glycol)      | 45(100)                | 18(46)   | 29(21)  | 43(19)  | 31(18)  | 27(17)  | 28(11)  | 19(8)   | 44(6)   | 61(5)   |
| 1,3-Propanediol (Trimethylene glycol)       | 28(100)                | 58(93)   | 31(76)  | 57(70)  | 29(40)  | 27(26)  | 45(24)  | 43(23)  | 19(18)  | 30(17)  |
| Propanenitrile                              | 28(100)                | 54(63)   | 26(20)  | 27(17)  | 52(11)  | 55(10)  | 51(9)   | 15(9)   | 53(7)   | 25(7)   |
| Propanoic acid                              | 28(100)                | 29(84)   | 74(79)  | 27(62)  | 45(56)  | 73(48)  | 57(30)  | 26(21)  | 55(17)  | 56(16)  |
| Propanoic anhydride                         | 57(100)                | 29(55)   | 28(20)  | 27(20)  | 74(19)  | 73(12)  | 45(11)  | 26(5)   | 30(4)   | 58(3)   |
| 1-Propanol (Propyl alcohol)                 | 31(100)                | 27(19)   | 29(18)  | 59(11)  | 42(9)   | 60(7)   | 41(7)   | 28(7)   | 43(3)   | 32(3)   |
| 2-Propanol (Isopropyl alcohol)              | 45(100)                | 43(19)   | 27(17)  | 29(12)  | 41(7)   | 31(6)   | 19(6)   | 42(5)   | 44(4)   | 59(3)   |
| Propargyl alcohol (3-Hydroxy-1-propyne)     | 55(100)                | 39(25)   | 28(20)  | 27(19)  | 29(16)  | 38(14)  | 26(11)  | 37(8)   | 53(6)   | 56(4)   |
| Propyl acetate                              | 43(100)                | 61(19)   | 31(18)  | 27(15)  | 42(11)  | 73(9)   | 41(9)   | 29(9)   | 59(5)   | 39(5)   |
| Propylamine                                 | 30(100)                | 28(13)   | 59(8)   | 27(7)   | 41(5)   | 42(3)   | 39(3)   | 29(3)   | 26(3)   | 18(3)   |
| Propylbenzene                               | 91(100)                | 120(21)  | 92(10)  | 38(10)  | 65(9)   | 78(6)   | 51(6)   | 27(5)   | 63(4)   | 105(3)  |
| Propylene carbonate                         | 28(100)                | 57(69)   | 43(66)  | 29(51)  | 27(45)  | 30(42)  | 26(19)  | 42(17)  | 31(16)  | 58(13)  |
| Propyl formate                              | 27(100)                | 29(92)   | 31(81)  | 42(60)  | 41(53)  | 43(29)  | 39(29)  | 26(28)  | 47(22)  | 30(16)  |
| Pyridine                                    | 79(100)                | 52(62)   | 51(31)  | 50(19)  | 78(11)  | 53(7)   | 39(7)   | 80(6)   | 27(3)   | 77(2)   |
| Pyrrole                                     | 67(100)                | 41(58)   | 39(58)  | 40(51)  | 28(42)  | 38(20)  | 37(12)  | 66(7)   | 68(5)   | 27(3)   |
| Pyrrolidine                                 | 43(100)                | 28(52)   | 70(33)  | 71(26)  | 42(22)  | 41(20)  | 27(16)  | 39(15)  | 29(10)  | 30(9)   |
| 2-Pyrrolidone                               | 85(100)                | 42(43)   | 41(36)  | 28(33)  | 30(29)  | 56(16)  | 84(14)  | 40(12)  | 27(12)  | 29(9)   |
| Quinoline                                   | 129(100)               | 51(28)   | 76(25)  | 128(24) | 44(24)  | 50(20)  | 32(19)  | 75(18)  | 74(12)  | 103(11) |
| Salicylaldehyde (2-Hydroxybenzaldehyde)     | 28(100)                | 122(98)  | 121(92) | 39(79)  | 65(52)  | 76(31)  | 32(31)  | 44(30)  | 93(26)  | 38(23)  |
| Styrene                                     | 104(100)               | 103(41)  | 78(32)  | 51(28)  | 77(23)  | 105(12) | 50(12)  | 52(11)  | 39(11)  | 102(10) |
| Sulfolane                                   | 41(100)                | 28(94)   | 56(82)  | 55(72)  | 120(37) | 27(32)  | 39(19)  | 29(17)  | 26(11)  | 48(5)   |
| $\alpha$ -Terpinene                         | 121(100)               | 93(85)   | 136(43) | 91(40)  | 77(34)  | 39(33)  | 27(33)  | 79(27)  | 41(26)  | 43(18)  |
| 1,1,1,2-Tetrachloro-2,2-difluoroethane      | 167(100)               | 169(96)  | 117(85) | 119(82) | 171(31) | 85(29)  | 121(26) | 82(14)  | 47(14)  | 101(13) |
| 1,1,2,2-Tetrachloro-1,2-difluoroethane      | 101(100)               | 103(64)  | 167(54) | 169(52) | 117(19) | 119(18) | 171(17) | 105(11) | 31(11)  | 132(9)  |
| 1,1,1,2-Tetrachloroethane                   | 131(100)               | 133(96)  | 117(76) | 119(73) | 95(34)  | 135(31) | 121(23) | 97(23)  | 61(19)  | 60(18)  |
| 1,1,2,2-Tetrachloroethane                   | 83(100)                | 85(63)   | 95(11)  | 87(10)  | 168(8)  | 133(8)  | 131(8)  | 96(8)   | 61(8)   | 60(8)   |
| Tetrachloroethene                           | 166(100)               | 164(82)  | 131(71) | 129(71) | 168(45) | 94(38)  | 47(31)  | 96(24)  | 133(20) | 59(17)  |
| Tetrachloromethane (Carbon tetrachloride)   | 117(100)               | 119(98)  | 121(31) | 82(24)  | 47(23)  | 84(16)  | 35(14)  | 49(8)   | 28(8)   | 36(6)   |
| Tetraethylene glycol                        | 45(100)                | 89(10)   | 44(8)   | 43(6)   | 31(6)   | 29(6)   | 27(6)   | 101(5)  | 75(5)   | 28(5)   |
| Tetrahydrofuran                             | 42(100)                | 41(52)   | 27(33)  | 72(29)  | 71(27)  | 39(24)  | 43(22)  | 29(22)  | 40(13)  | 15(10)  |
| 1,2,3,4-Tetrahydronaphthalene               | 104(100)               | 132(53)  | 91(43)  | 51(17)  | 39(17)  | 131(15) | 117(15) | 115(14) | 78(13)  | 77(13)  |
| Tetrahydropyran                             | 41(100)                | 28(64)   | 56(57)  | 45(57)  | 29(51)  | 27(49)  | 85(47)  | 86(42)  | 39(28)  | 55(23)  |
| Tetrahydrothiophene                         | 60(100)                | 88(54)   | 45(37)  | 46(32)  | 47(26)  | 27(24)  | 59(18)  | 87(16)  | 39(14)  | 54(13)  |
| Tetramethylsilane                           | 73(100)                | 43(14)   | 45(12)  | 74(8)   | 29(7)   | 15(5)   | 75(4)   | 44(4)   | 42(4)   | 31(4)   |
| Tetramethylurea                             | 72(100)                | 44(27)   | 116(24) | 42(13)  | 15(13)  | 17(7)   | 28(5)   | 73(4)   | 56(4)   | 18(4)   |
| 1 <i>H</i> -Tetrazole                       | 42(100)                | 28(60)   | 27(25)  | 29(24)  | 41(13)  | 43(11)  | 70(8)   | 26(7)   | 40(2)   | 38(2)   |
| Thiophene                                   | 84(100)                | 58(65)   | 45(58)  | 39(29)  | 57(13)  | 38(8)   | 69(7)   | 37(7)   | 83(6)   | 50(6)   |
| Toluene                                     | 91(100)                | 92(73)   | 39(20)  | 65(14)  | 63(11)  | 51(11)  | 50(7)   | 27(6)   | 93(5)   | 90(5)   |
| Tribromomethane (Bromoform)                 | 173(100)               | 171(50)  | 175(49) | 93(22)  | 91(22)  | 79(18)  | 81(17)  | 94(13)  | 92(13)  | 254(11) |
| Tributylamine                               | 142(100)               | 100(19)  | 143(11) | 29(8)   | 185(7)  | 57(6)   | 44(6)   | 41(6)   | 30(5)   | 86(4)   |
| 1,2,4-Trichlorobenzene                      | 180(100)               | 182(96)  | 184(30) | 145(30) | 109(26) | 147(19) | 75(11)  | 74(9)   | 111(8)  | 181(7)  |
| 1,1,1-Trichloroethane                       | 97(100)                | 99(64)   | 61(58)  | 26(31)  | 27(24)  | 117(19) | 63(19)  | 119(18) | 35(17)  | 62(11)  |
| 1,1,2-Trichloroethane                       | 97(100)                | 83(95)   | 99(62)  | 85(60)  | 61(58)  | 26(23)  | 96(21)  | 63(19)  | 27(17)  | 98(15)  |
| Trichloroethene                             | 95(100)                | 130(90)  | 132(85) | 60(65)  | 97(64)  | 35(40)  | 134(27) | 47(26)  | 62(21)  | 59(13)  |
| Trichloroethylsilane                        | 135(100)               | 133(100) | 126(67) | 128(46) | 137(37) | 98(22)  | 63(21)  | 35(16)  | 100(14) | 127(11) |
| Trichlorofluoromethane                      | 101(100)               | 103(66)  | 66(13)  | 105(11) | 35(11)  | 47(9)   | 31(8)   | 82(4)   | 68(4)   | 37(4)   |
| Trichloromethane (Chloroform)               | 83(100)                | 85(64)   | 47(35)  | 35(19)  | 48(16)  | 49(12)  | 87(10)  | 37(6)   | 50(5)   | 84(4)   |
| (Trichloromethyl)benzene (Benzotrifluoride) | 159(100)               | 161(64)  | 89(14)  | 163(11) | 28(10)  | 63(9)   | 160(8)  | 123(8)  | 62(8)   | 124(6)  |
| 1,2,3-Trichloropropane                      | 75(100)                | 39(58)   | 49(42)  | 110(38) | 61(34)  | 77(33)  | 112(22) | 27(16)  | 97(15)  | 38(15)  |
| 1,1,2-Trichloro-1,2,2-trifluoroethane       | 101(100)               | 151(68)  | 103(64) | 85(45)  | 31(45)  | 153(44) | 35(20)  | 66(19)  | 47(18)  | 87(14)  |
| Tridecane                                   | 57(100)                | 43(91)   | 71(51)  | 41(34)  | 85(24)  | 29(23)  | 56(14)  | 55(12)  | 27(11)  | 42(10)  |
| Triethanolamine                             | 118(100)               | 56(69)   | 45(60)  | 42(56)  | 44(27)  | 43(25)  | 41(14)  | 116(8)  | 57(8)   | 86(7)   |

| Compound                                    | <i>e/m</i> (intensity) |         |         |         |         |         |         |         |         |         |
|---------------------------------------------|------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|                                             |                        |         |         |         |         |         |         |         |         |         |
| Triethylamine                               | 86(100)                | 30(68)  | 58(37)  | 28(24)  | 29(23)  | 27(19)  | 44(18)  | 101(17) | 42(16)  | 56(8)   |
| Triethylene glycol                          | 45(100)                | 58(11)  | 89(9)   | 31(8)   | 29(8)   | 75(7)   | 44(7)   | 43(7)   | 27(7)   | 28(5)   |
| Triethyl phosphate                          | 99(100)                | 81(71)  | 155(56) | 82(45)  | 45(45)  | 109(44) | 127(41) | 43(24)  | 125(16) | 111(14) |
| Trifluoroacetic acid                        | 45(100)                | 69(70)  | 51(36)  | 28(28)  | 50(15)  | 44(11)  | 43(7)   | 97(5)   | 31(5)   | 29(5)   |
| 2,2,2-Trifluoroethanol                      | 31(100)                | 33(24)  | 61(19)  | 29(19)  | 51(16)  | 69(9)   | 32(6)   | 49(5)   | 83(4)   | 81(4)   |
| (Trifluoromethyl)benzene (Benzotrifluoride) | 146(100)               | 145(40) | 127(34) | 96(28)  | 77(10)  | 51(10)  | 147(8)  | 75(6)   | 50(6)   | 128(3)  |
| Trimethylamine                              | 58(100)                | 59(47)  | 30(29)  | 42(26)  | 44(17)  | 15(14)  | 28(10)  | 18(10)  | 43(8)   | 57(7)   |
| 1,2,3-Trimethylbenzene (Hemimellitene)      | 105(100)               | 120(47) | 39(22)  | 77(17)  | 91(14)  | 51(14)  | 27(14)  | 79(12)  | 119(11) | 106(9)  |
| 1,2,4-Trimethylbenzene (Pseudocumene)       | 105(100)               | 120(56) | 119(17) | 77(15)  | 39(15)  | 51(11)  | 91(10)  | 27(10)  | 106(9)  | 79(7)   |
| 1,3,5-Trimethylbenzene (Mesitylene)         | 105(100)               | 120(64) | 119(15) | 77(13)  | 39(11)  | 106(9)  | 91(9)   | 51(8)   | 27(7)   | 121(6)  |
| 2,2,3-Trimethylbutane (Triptane)            | 57(100)                | 43(71)  | 56(63)  | 41(53)  | 85(30)  | 29(26)  | 27(18)  | 39(14)  | 15(6)   | 55(5)   |
| 2,2,5-Trimethylhexane                       | 57(100)                | 56(35)  | 71(18)  | 41(17)  | 43(14)  | 29(8)   | 70(4)   | 58(4)   | 113(3)  | 55(3)   |
| 2,2,4-Trimethylpentane (Isooctane)          | 57(100)                | 41(31)  | 56(28)  | 43(24)  | 29(16)  | 27(9)   | 39(7)   | 58(4)   | 55(4)   | 99(2)   |
| 2,3,3-Trimethylpentane                      | 43(100)                | 71(45)  | 70(36)  | 57(36)  | 41(29)  | 85(25)  | 27(18)  | 55(16)  | 29(16)  | 39(11)  |
| 2,3,4-Trimethylpentane                      | 43(100)                | 71(62)  | 70(41)  | 41(25)  | 27(18)  | 55(17)  | 57(16)  | 29(14)  | 39(10)  | 42(7)   |
| Trimethyl phosphate                         | 110(100)               | 109(35) | 79(34)  | 95(25)  | 80(23)  | 15(20)  | 140(18) | 47(10)  | 31(7)   | 139(5)  |
| 2,4,6-Trimethylpyridine (2,4,6-Collidine)   | 121(100)               | 39(27)  | 79(26)  | 120(24) | 106(17) | 27(16)  | 77(13)  | 51(11)  | 42(11)  | 122(10) |
| 1-Undecene                                  | 41(100)                | 43(87)  | 55(80)  | 70(67)  | 56(67)  | 69(55)  | 29(55)  | 83(51)  | 57(50)  | 27(46)  |
| Vinyl acetate                               | 43(100)                | 28(45)  | 42(26)  | 44(24)  | 86(20)  | 31(10)  | 32(7)   | 29(7)   | 45(2)   | 41(2)   |
| <i>o</i> -Xylene                            | 91(100)                | 106(40) | 39(21)  | 105(17) | 51(17)  | 77(15)  | 27(12)  | 65(10)  | 92(8)   | 79(8)   |
| <i>m</i> -Xylene                            | 91(100)                | 106(65) | 105(29) | 39(18)  | 51(15)  | 77(14)  | 27(10)  | 92(8)   | 79(8)   | 78(8)   |
| <i>p</i> -Xylene                            | 91(100)                | 106(62) | 105(30) | 51(16)  | 39(16)  | 77(13)  | 27(11)  | 92(7)   | 78(7)   | 65(7)   |

## SOLUBILITY OF COMMON SALTS AT AMBIENT TEMPERATURES

This table gives the aqueous solubility of selected salts at temperatures from 10°C to 40°C. Values are given in molality terms.

### References

1. Apelblat, A., *J. Chem. Thermodynamics*, 24, 619, 1992.
2. Apelblat, A., *J. Chem. Thermodynamics*, 25, 63, 1993.
3. Apelblat, A., *J. Chem. Thermodynamics*, 25, 1513, 1993.
4. Apelblat, A. and Korin, E., *J. Chem. Thermodynamics*, 30, 59, 1998.

| Salt                                            | 10°C   | 15°C   | 20°C   | 25°C   | 30°C   | 35°C   | 40°C   | Ref. |
|-------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|------|
| BaCl <sub>2</sub>                               | 1.603  | 1.659  | 1.716  | 1.774  | 1.834  | 1.895  | 1.958  | 1    |
| Ca(NO <sub>3</sub> ) <sub>2</sub>               | 6.896  | 7.398  | 7.986  | 8.675  | 9.480  | 10.421 |        | 1    |
| CuSO <sub>4</sub>                               | 1.055  | 1.153  | 1.260  | 1.376  | 1.502  | 1.639  |        | 3    |
| FeSO <sub>4</sub>                               | 1.352  | 1.533  | 1.729  | 1.940  | 2.165  | 2.405  |        | 3    |
| KBr                                             | 5.002  | 5.237  | 5.471  | 5.703  | 5.932  | 6.157  |        | 3    |
| KIO <sub>3</sub>                                | 0.291  | 0.333  | 0.378  | 0.426  | 0.478  | 0.534  | 0.593  | 4    |
| K <sub>2</sub> CO <sub>3</sub>                  | 7.756  | 7.846  | 7.948  | 8.063  | 8.191  | 8.331  | 8.483  | 1    |
| LiCl                                            | 19.296 | 19.456 | 19.670 | 19.935 |        |        |        | 2    |
| Mg(NO <sub>3</sub> ) <sub>2</sub>               | 4.403  | 4.523  | 4.656  | 4.800  | 4.958  | 5.130  | 5.314  | 1    |
| MnCl <sub>2</sub>                               | 5.421  | 5.644  | 5.884  | 6.143  | 6.422  | 6.721  |        | 3    |
| NH <sub>4</sub> Cl                              | 6.199  | 6.566  | 6.943  | 7.331  |        |        |        | 2    |
| NH <sub>4</sub> NO <sub>3</sub>                 | 18.809 | 21.163 | 23.721 | 26.496 |        |        |        | 2    |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 5.494  | 5.589  | 5.688  | 5.790  | 5.896  | 6.005  |        | 3    |
| NaBr                                            | 8.258  | 8.546  | 8.856  | 9.191  | 9.550  | 9.937  | 10.351 | 4    |
| NaCl                                            | 6.110  | 6.121  | 6.136  | 6.153  | 6.174  | 6.197  | 6.222  | 4    |
| NaNO <sub>2</sub>                               | 11.111 | 11.484 | 11.883 | 12.310 | 12.766 | 13.253 | 13.772 | 4    |
| NaNO <sub>3</sub>                               | 9.395  | 9.819  | 10.261 | 10.723 | 11.204 | 11.706 | 12.230 | 4    |
| RbCl                                            | 6.911  | 7.180  | 7.449  | 7.717  | 7.986  | 8.253  | 8.520  | 4    |
| ZnSO <sub>4</sub>                               | 2.911  | 3.116  | 3.336  | 3.573  | 3.827  | 4.099  | 4.194  | 1    |

## FLAME AND BEAD TESTS

### Flame Colorations

#### Violet

Potassium compounds. Purple red through blue glass. Easily obscured by sodium flame. Bluish-green through green glass. Rubidium and cesium compounds impart same flame as potassium compounds.

#### Blues

Azure — Copper chloride. Copper bromide gives azure blue followed by green. Other copper compounds give same coloration when moistened with hydrochloric acid.

Light blue — Lead, arsenic, selenium.

#### Greens

Emerald — Copper compounds except the halides, and when not moistened with hydrochloric acid.

Pure green — Compounds of thallium and tellurium.

Yellowish — Barium compounds. Some molybdenum compounds. Borates, especially when treated with sulfuric acid or when burned with alcohol.

Bluish — Phosphates with sulfuric acid.

Feeble — Antimony compounds. Ammonium compounds.

Whitish — Zinc.

#### Reds

Carmine — Lithium compounds. Violet through blue glass.

Invisible through green glass. Masked by barium flame.

Scarlet — Strontium compounds. Violet through blue glass.

Yellowish through green glass. Masked by barium flame.

Yellowish — Calcium compounds. Greenish through blue glass.

Green through green glass. Masked by barium flame.

#### Yellow

Yellow — All sodium compounds. Invisible with blue glass.

### Bead Tests

Abbreviations employed: s = saturated; ss = supersaturated; ns = not saturated; h = hot; c = cold

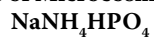
#### Borax Beads

| Substance  | Oxidizing flame                       | Reducing flame                      |
|------------|---------------------------------------|-------------------------------------|
| Aluminum   | Colorless (h, c, ns); opaque (ss)     | Colorless; opaque (s)               |
| Antimony   | Colorless; yellow or brownish (h, ss) | Gray and opaque                     |
| Barium     | Colorless (ns)                        |                                     |
| Bismuth    | Colorless; yellow or brownish (h, ss) | Gray and opaque                     |
| Cadmium    | Colorless                             | Gray and opaque                     |
| Calcium    | Colorless (ns)                        |                                     |
| Cerium     | Red (h)                               | Colorless (h, c)                    |
| Chromium   | Green (c)                             | Green                               |
| Cobalt     | Blue (h, c)                           | Blue (h, c)                         |
| Copper     | Green (h); blue (c)                   | Red (c); opaque (ss); colorless (h) |
| Iron       | Yellow or brownish red (h, ns)        | Green (ss)                          |
| Lead       | Colorless; yellow or brownish (h, ss) | Gray and opaque                     |
| Magnesium  | Colorless (ns)                        |                                     |
| Manganese  | Violet (h, c)                         | Colorless (h, c)                    |
| Molybdenum | Colorless                             | Yellow or brown (h)                 |
| Nickel     | Brown; red (c)                        | Gray and opaque                     |
| Silicon    | Colorless (h, c); opaque (ss)         | Colorless; opaque (s)               |
| Silver     | Colorless (ns)                        | Gray and opaque                     |
| Strontium  | Colorless (ns)                        |                                     |
| Tin        | Colorless (h, c); opaque (ss)         | Colorless; opaque (s)               |
| Titanium   | Colorless                             | Yellow (h); violet (c)              |
| Tungsten   | Colorless                             | Brown                               |
| Uranium    | Yellow or brownish (h, ns)            | Green                               |
| Vanadium   | Colorless                             | Green                               |

#### Beads of Microcosmic Salt



| Substance | Oxidizing flame       | Reducing flame            |
|-----------|-----------------------|---------------------------|
| Aluminum  | Colorless; opaque (s) | Colorless; not clear (ss) |
| Antimony  | Colorless (ns)        | Gray and opaque           |
| Barium    | Colorless; opaque (s) | Colorless; not clear (ss) |
| Bismuth   | Colorless (ns)        | Gray and opaque           |
| Cadmium   | Colorless (ns)        | Gray and opaque           |
| Calcium   | Colorless; opaque (s) | Colorless; not clear (ss) |

**Beads of Microcosmic Salt**

| <b>Substance</b> | <b>Oxidizing flame</b>        | <b>Reducing flame</b>                |
|------------------|-------------------------------|--------------------------------------|
| Cerium           | Yellow or brownish red (h, s) | Colorless                            |
| Chromium         | Red (h, s); green (c)         | Green (c)                            |
| Cobalt           | Blue (h, c)                   | Blue (h, c)                          |
| Copper           | Blue (c); green (h)           | Red and opaque (c)                   |
| Iron             | Yellow or brown (h, s)        | Colorless; yellow or brownish (h)    |
| Lead             | Colorless (ns)                | Gray and opaque                      |
| Magnesium        | Colorless; opaque (s)         | Colorless; not clear (ss)            |
| Manganese        | Violet (h, c)                 | Colorless                            |
| Molybdenum       | Colorless; green (h)          | Green (h)                            |
| Nickel           | Yellow (c); red (h, s)        | Yellow (c); red (h); gray and opaque |
| Silver           |                               | Gray and opaque                      |
| Strontium        | Colorless; opaque (s)         | Colorless; not clear (ss)            |
| Tin              | Colorless; opaque (s)         | Colorless                            |
| Titanium         | Colorless (ns)                | Violet (c); yellow or brownish (h)   |
| Uranium          | Green; yellow or brownish     | Green (h) (h, s)                     |
| Vanadium         | Yellow                        | Green                                |
| Zinc             | Colorless (ns)                | Gray and opaque                      |

**Sodium Carbonate Bead**

| <b>Substance</b> | <b>Oxidizing flame</b> | <b>Reducing flame</b> |
|------------------|------------------------|-----------------------|
| Manganese        | Green                  | Colorless             |

## SOLUBILITY OF HYDROCARBONS IN SEAWATER

Concern about pollution of the oceans has stimulated measurements of the solubility of organic compounds in seawater. This table gives the solubility of several hydrocarbons in seawater. The data are derived from a review in the IUPAC Solubility Data Series (Reference 1).

Solubility is expressed in this table as parts per million by mass, i.e.,

$$S/\text{ppm}(\text{mass}) = 10^6 \times w_2 = 10^6 \times m_2/(m_1 + m_2)$$

where  $m_1$  and  $m_2$  are the masses of solvent (seawater) and solute, respectively, under saturation conditions, and  $w_2$  is the mass fraction. Since the solubilities in this table are very low, the value of  $S$  is effectively the mass of hydrocarbon in grams per 1000 kg of seawater.

The temperature and salinity of each measurement are given in the table. Salinity is a standardized measure of the concentration of dissolved salts, as explained in the table "Properties of Seawater" in Section 14. Salinity values in the open oceans at mid-latitude typically fall between 34 and 36.

Reference 1 gives details of the method of measurement and an indication of the reliability of the measurements.

### Reference

1. Shaw, David G., and Maczynski, A., IUPAC-NIST Solubility Data Series 81. Hydrocarbons with Water and Seawater — Revised and Updated. Part 12.  $C_5$ - $C_{26}$  Hydrocarbons with Seawater, *J. Phys. Chem. Ref. Data* 35, 785, 2006.

| Name                  | Mol. Form.     | Salinity | $t/^\circ\text{C}$ | $S/\text{ppm}(\text{mass})$ |
|-----------------------|----------------|----------|--------------------|-----------------------------|
| Acenaphthene          | $C_{12}H_{10}$ | 35       | 15                 | 0.21                        |
| Acenaphthene          | $C_{12}H_{10}$ | 35       | 25                 | 1.8                         |
| Anthracene            | $C_{14}H_{10}$ | 35       | 25                 | 0.031                       |
| Benz[a]anthracene     | $C_{18}H_{12}$ | 35       | 25                 | 0.0056                      |
| Benzene               | $C_6H_6$       | 34.4     | 0                  | 1320                        |
| Benzene               | $C_6H_6$       | 35       | 25                 | 1360                        |
| Benzo[ghi]perylene    | $C_{22}H_{12}$ | 6        | 25                 | 0.00021                     |
| Benzo[a]pyrene        | $C_{20}H_{12}$ | 6        | 25                 | 0.00013                     |
| Benzo[e]pyrene        | $C_{20}H_{12}$ | 30       | 25                 | 0.0033                      |
| Benzo[b]triphenylene  | $C_{22}H_{14}$ | 6        | 25                 | 0.027                       |
| Biphenyl              | $C_{12}H_{10}$ | 35       | 25                 | 4.76                        |
| Butylbenzene          | $C_{10}H_{14}$ | 34.5     | 25                 | 7.1                         |
| sec-Butylbenzene      | $C_{10}H_{14}$ | 34.5     | 25                 | 12                          |
| tert-Butylbenzene     | $C_{10}H_{14}$ | 34.5     | 25                 | 21                          |
| Chrysene              | $C_{18}H_{12}$ | 35       | 25                 | 0.0011                      |
| Dibenz[a,h]anthracene | $C_{22}H_{14}$ | 6        | 25                 | 0.021                       |
| Dibenz[a,j]anthracene | $C_{22}H_{14}$ | 6        | 25                 | 0.010                       |
| Dodecane              | $C_{12}H_{26}$ | 35       | 25                 | 0.0029                      |
| Eicosane              | $C_{20}H_{42}$ | 35       | 25                 | 0.0008                      |
| Ethylbenzene          | $C_8H_{10}$    | 34.4     | 0                  | 140                         |
| Ethylbenzene          | $C_8H_{10}$    | 34.4     | 10                 | 129                         |
| Ethylbenzene          | $C_8H_{10}$    | 34.4     | 25                 | 111                         |
| Fluoranthene          | $C_{16}H_{10}$ | 35       | 25                 | 0.124                       |
| 9H-Fluorene           | $C_{13}H_{10}$ | 35       | 25                 | 1.2                         |
| Heptane               | $C_7H_{16}$    | 6        | 25                 | 10.3                        |
| Hexacosane            | $C_{26}H_{54}$ | 35       | 25                 | 0.0001                      |
| Hexadecane            | $C_{16}H_{34}$ | 35       | 25                 | 0.0004                      |
| Hexane                | $C_6H_{14}$    | 35.3     | 25                 | 7.9                         |
| Isopropylbenzene      | $C_9H_{12}$    | 34.5     | 25                 | 43                          |
| 2-Methylanthracene    | $C_{15}H_{12}$ | 35       | 25                 | 0.013                       |
| Methylcyclopentane    | $C_6H_{12}$    | 34.5     | 25                 | 29                          |
| 1-Methylnaphthalene   | $C_{11}H_{10}$ | 30       | 25                 | 23                          |
| 1-Methylphenanthrene  | $C_{15}H_{12}$ | 35       | 25                 | 0.20                        |
| Naphthalene           | $C_{10}H_8$    | 35       | 25                 | 22.8                        |
| Nonane                | $C_9H_{20}$    | 6        | 25                 | 0.43                        |
| Octadecane            | $C_{18}H_{38}$ | 35       | 25                 | 0.0008                      |
| Pentane               | $C_5H_{12}$    | 34.5     | 25                 | 28                          |
| Phenanthrene          | $C_{14}H_{10}$ | 34       | 25                 | 0.69                        |

| Name                   | Mol. Form.                      | Salinity | <i>t</i> /°C | <i>S</i> /ppm (mass) |
|------------------------|---------------------------------|----------|--------------|----------------------|
| Pyrene                 | C <sub>16</sub> H <sub>10</sub> | 35       | 25           | 0.086                |
| Tetradecane            | C <sub>14</sub> H <sub>30</sub> | 35       | 25           | 0.0017               |
| Toluene                | C <sub>7</sub> H <sub>8</sub>   | 34.4     | 0            | 450                  |
| Toluene                | C <sub>7</sub> H <sub>8</sub>   | 35       | 25           | 387                  |
| 1,2,3-Trimethylbenzene | C <sub>9</sub> H <sub>12</sub>  | 34.5     | 25           | 49                   |
| 1,2,4-Trimethylbenzene | C <sub>9</sub> H <sub>12</sub>  | 34.5     | 25           | 40                   |
| 1,3,5-Trimethylbenzene | C <sub>9</sub> H <sub>12</sub>  | 34.5     | 25           | 31                   |
| Undecane               | C <sub>11</sub> H <sub>24</sub> | 6        | 25           | 0.01                 |
| <i>o</i> -Xylene       | C <sub>8</sub> H <sub>10</sub>  | 34.5     | 25           | 130                  |
| <i>m</i> -Xylene       | C <sub>8</sub> H <sub>10</sub>  | 34.5     | 25           | 106                  |
| <i>p</i> -Xylene       | C <sub>8</sub> H <sub>10</sub>  | 34.5     | 25           | 111                  |



# SOLUBILITY OF ORGANIC COMPOUNDS IN PRESSURIZED HOT WATER

Liquid water at elevated temperatures and pressures, but still in the subcritical region, is of interest as a solvent in various laboratory and industrial processes. In effect, this means water at a temperature between about 100°C and 373°C, the critical temperature, and at pressures up to 400 bar or greater. Since the dielectric constant of water decreases with increasing temperature, the solubility of many compounds, especially non-polar compounds, increases dramatically at higher temperature. The fact that solubility can be fine-tuned by controlling temperature and pressure makes pressurized hot water a useful tool in various extraction and reaction processes.

This table gives a sample of the variations of solubility with temperature and pressure for several compounds, mostly hydrocarbons. The solubility is expressed in both mole fraction of solute,  $x_2$ , and mass percent,  $100w_2$ , where  $w_2$  is the mass fraction. More information is available in the references.

## References

1. *Solubility Data Series, International Union of Pure and Applied Chemistry, Vol. 38*, Pergamon Press, Oxford, 1988.
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| Name              | Mol. Form.                        | $t/^\circ\text{C}$ | $p/\text{bar}$ | Solubility |            | Ref. |
|-------------------|-----------------------------------|--------------------|----------------|------------|------------|------|
|                   |                                   |                    |                | $10^3x_2$  | Mass%      |      |
| Acenaphthene      | $\text{C}_{12}\text{H}_{10}$      | 25                 | 1              | 0.000444   | 0.000380   | 13   |
|                   |                                   | 250                | 50             | 1.25       | 1.06       | 11   |
| Anthracene        | $\text{C}_{14}\text{H}_{10}$      | 25                 | 1              | 0.0000074  | 0.0000044  | 2    |
|                   |                                   | 50                 | 50             | 0.000017   | 0.000017   | 5    |
|                   |                                   | 100                | 45             | 0.00032    | 0.00032    | 5    |
|                   |                                   | 100                | 39             | 0.000457   | 0.00045    | 12   |
|                   |                                   | 150                | 50             | 0.0102     | 0.0101     | 11   |
|                   |                                   | 200                | 77             | 0.13       | 0.13       | 12   |
|                   |                                   | 250                | 50             | 0.497      | 0.49       | 11   |
| Benz[a]anthracene | $\text{C}_{18}\text{H}_{12}$      | 300                | 100            | 3.78       | 3.62       | 11   |
|                   |                                   | 25                 | 1              | 0.00000073 | 0.00000093 | 2    |
|                   |                                   | 60                 | 50             | 0.00000846 | 0.0000107  | 12   |
|                   |                                   | 100                | 50             | 0.000113   | 0.000143   | 12   |
|                   |                                   | 120                | 52             | 0.000418   | 0.00053    | 12   |
| Benzene           | $\text{C}_6\text{H}_6$            | 150                | 49             | 0.00296    | 0.00375    | 12   |
|                   |                                   | 25                 | 1              | 0.40       | 0.178      | 13   |
|                   |                                   | 25                 | 65             | 0.40       | 0.173      | 6    |
|                   |                                   | 25                 | 400            | 0.33       | 0.143      | 6    |
|                   |                                   | 50                 | 65             | 0.47       | 0.203      | 6    |
|                   |                                   | 100                | 65             | 0.89       | 0.38       | 6    |
|                   |                                   | 150                | 65             | 2.2        | 0.95       | 6    |
| Carbazole         | $\text{C}_{12}\text{H}_9\text{N}$ | 200                | 65             | 5.0        | 2.13       | 6    |
|                   |                                   | 200                | 400            | 4.1        | 1.75       | 6    |
|                   |                                   | 25                 | 1              | 0.00013    | 0.00012    | 5    |
|                   |                                   | 25                 | 54             | 0.00011    | 0.000102   | 5    |
|                   |                                   | 50                 | 56             | 0.00045    | 0.00042    | 5    |
| Chrysene          | $\text{C}_{18}\text{H}_{12}$      | 100                | 54             | 0.0099     | 0.0092     | 5    |
|                   |                                   | 150                | 54             | 0.162      | 0.150      | 5    |
|                   |                                   | 200                | 52             | 1.9        | 1.74       | 5    |
|                   |                                   | 25                 | 1              | 0.00000016 | 0.00000019 | 2    |

| Name                                  | Mol. Form.                                    | <i>t</i> /°C | <i>p</i> /bar | Solubility                            |            | Ref. |
|---------------------------------------|-----------------------------------------------|--------------|---------------|---------------------------------------|------------|------|
|                                       |                                               |              |               | 10 <sup>3</sup> <i>x</i> <sub>2</sub> | Mass%      |      |
| <i>o</i> -Dichlorobenzene             | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> | 25           | 32            | 0.00000063                            | 0.0000008  | 5    |
|                                       |                                               | 50           | 36            | 0.000001                              | 0.0000013  | 5    |
|                                       |                                               | 100          | 38            | 0.000013                              | 0.000016   | 5    |
|                                       |                                               | 150          | 43            | 0.00060                               | 0.00076    | 5    |
|                                       |                                               | 200          | 45            | 0.0158                                | 0.020      | 5    |
|                                       |                                               | 225          | 62            | 0.0758                                | 0.096      | 5    |
|                                       |                                               | 25           | 1             | 0.018                                 | 0.0094     | 9    |
|                                       |                                               | 50           | 65            | 0.023                                 | 0.019      | 6    |
|                                       |                                               | 100          | 65            | 0.055                                 | 0.045      | 6    |
|                                       |                                               | 150          | 65            | 0.18                                  | 0.15       | 6    |
| <i>trans</i> -1,2-Dimethylcyclohexane | C <sub>8</sub> H <sub>16</sub>                | 200          | 65            | 0.57                                  | 0.46       | 6    |
|                                       |                                               | 25           | 1             | 0.008                                 | 0.00050    | 10   |
|                                       |                                               | 101          | 7             | 0.0047                                | 0.0029     | 10   |
|                                       |                                               | 131          | 7             | 0.0108                                | 0.0067     | 10   |
|                                       |                                               | 151          | 7             | 0.0223                                | 0.0139     | 10   |
| Ethylcyclohexane                      | C <sub>8</sub> H <sub>16</sub>                | 170          | 7             | 0.0356                                | 0.0222     | 10   |
|                                       |                                               | 25           | 1             | 0.00098                               | 0.00061    | 10   |
|                                       |                                               | 100          | 7             | 0.00340                               | 0.00212    | 10   |
|                                       |                                               | 131          | 7             | 0.0085                                | 0.0053     | 10   |
|                                       |                                               | 151          | 7             | 0.01665                               | 0.0104     | 10   |
| Heptane                               | C <sub>7</sub> H <sub>16</sub>                | 171          | 7             | 0.0334                                | 0.0208     | 10   |
|                                       |                                               | 25           | 1             | 0.0004352                             | 0.000242   | 8    |
|                                       |                                               | 50           | 7             | 0.000613                              | 0.00034096 | 8    |
|                                       |                                               | 100          | 7             | 0.001938                              | 0.00108    | 8    |
|                                       |                                               | 125          | 7             | 0.00400                               | 0.00222    | 8    |
| Hexane                                | C <sub>6</sub> H <sub>14</sub>                | 150          | 7             | 0.00878                               | 0.00488    | 8    |
|                                       |                                               | 170          | 7             | 0.01701                               | 0.00946    | 8    |
|                                       |                                               | 25           | 1             | 0.002045                              | 0.00098    | 8    |
|                                       |                                               | 100          | 7             | 0.006074                              | 0.0029     | 8    |
|                                       |                                               | 125          | 7             | 0.01192                               | 0.0057     | 8    |
| 1-Isopropyl-4-methylbenzene           | C <sub>10</sub> H <sub>14</sub>               | 150          | 7             | 0.02555                               | 0.0122     | 8    |
|                                       |                                               | 170          | 7             | 0.04935                               | 0.0236     | 8    |
|                                       |                                               | 25           | 1             | 0.0030                                | 0.0051     | 4    |
|                                       |                                               | 50           | 60            | 0.0040                                | 0.0030     | 6    |
|                                       |                                               | 100          | 60            | 0.011                                 | 0.0082     | 6    |
| Methylcyclohexane                     | C <sub>7</sub> H <sub>14</sub>                | 150          | 60            | 0.043                                 | 0.032      | 6    |
|                                       |                                               | 200          | 60            | 0.20                                  | 0.15       | 6    |
|                                       |                                               | 25           | 1             | 0.00293                               | 0.00151    | 10   |
|                                       |                                               | 100          | 7             | 0.01006                               | 0.0055     | 10   |
|                                       |                                               | 131          | 7             | 0.0244                                | 0.0133     | 10   |
| Naphthalene                           | C <sub>10</sub> H <sub>8</sub>                | 151          | 7             | 0.0423                                | 0.0231     | 10   |
|                                       |                                               | 171          | 7             | 0.0708                                | 0.0386     | 10   |
|                                       |                                               | 25           | 1             | 0.00444                               | 0.00316    | 13   |
|                                       |                                               | 40           | 50            | 0.00692                               | 0.0049     | 12   |
|                                       |                                               | 50           | 50            | 0.0114                                | 0.0081     | 12   |
| Octane                                | C <sub>8</sub> H <sub>18</sub>                | 65           | 50            | 0.0264                                | 0.0188     | 12   |
|                                       |                                               | 75           | 50            | 0.0435                                | 0.0309     | 12   |
|                                       |                                               | 25           | 1             | 0.0001158                             | 0.000073   | 8    |
|                                       |                                               | 100          | 7             | 0.0005943                             | 0.000377   | 8    |
|                                       |                                               | 125          | 7             | 0.0014163                             | 0.000898   | 8    |
| Perylene                              | C <sub>20</sub> H <sub>12</sub>               | 150          | 7             | 0.0036957                             | 0.00234    | 8    |
|                                       |                                               | 170          | 7             | 0.0083483                             | 0.00529    | 8    |
|                                       |                                               | 200          | 65            | 0.029                                 | 0.018      | 6    |
|                                       |                                               | 25           | 1             | 0.00000003                            | 0.00000004 | 2    |

| Name                   | Mol. Form.                   | $t/^{\circ}\text{C}$ | $p/\text{bar}$ | Solubility |            | Ref. |
|------------------------|------------------------------|----------------------|----------------|------------|------------|------|
|                        |                              |                      |                | $10^3 x_2$ | Mass%      |      |
| Pyrene                 | $\text{C}_{16}\text{H}_{10}$ | 50                   | 50             | 0.00000029 | 0.0000004  | 5    |
|                        |                              | 100                  | 45             | 0.00000210 | 0.00000294 | 5    |
|                        |                              | 150                  | 47             | 0.000120   | 0.000168   | 5    |
|                        |                              | 200                  | 48             | 0.0050     | 0.0070     | 5    |
|                        |                              | 25                   | 1              | 0.000012   | 0.0000139  | 2    |
|                        |                              | 100                  | 50             | 0.000637   | 0.00072    | 11   |
|                        |                              | 100                  | 200            | 0.00078    | 0.00087    | 5    |
|                        |                              | 140                  | 50             | 0.0054     | 0.0061     | 11   |
|                        |                              | 200                  | 50             | 0.0492     | 0.055      | 11   |
|                        |                              | 250                  | 50             | 0.205      | 0.23       | 11   |
| <i>p</i> -Terphenyl    | $\text{C}_{18}\text{H}_{14}$ | 300                  | 50             | 1.41       | 1.56       | 11   |
|                        |                              | 25                   | 1              | 0.00000141 | 0.00000180 | 2    |
|                        |                              | 100                  | 49             | 0.0000219  | 0.000028   | 12   |
|                        |                              | 140                  | 51             | 0.000372   | 0.000476   | 12   |
|                        |                              | 180                  | 55             | 0.00626    | 0.0080     | 12   |
|                        |                              | 200                  | 53             | 0.0241     | 0.0308     | 12   |
| Tetrachloroethene      | $\text{C}_2\text{Cl}_4$      | 210                  | 54             | 0.0393     | 0.0502     | 12   |
|                        |                              | 25                   | 1              | 0.0285     | 0.0286     | 3    |
|                        |                              | 50                   | 65             | 0.027      | 0.025      | 6    |
|                        |                              | 100                  | 65             | 0.059      | 0.054      | 6    |
|                        |                              | 150                  | 65             | 0.18       | 0.17       | 6    |
| Toluene                | $\text{C}_7\text{H}_8$       | 200                  | 65             | 0.59       | 0.54       | 6    |
|                        |                              | 25                   | 1              | 0.107      | 0.0519     | 7,13 |
|                        |                              | 50                   | 50             | 0.125      | 0.064      | 6    |
|                        |                              | 100                  | 50             | 0.27       | 0.138      | 6    |
|                        |                              | 150                  | 50             | 0.66       | 0.337      | 6    |
| 2,2,4-Trimethylpentane | $\text{C}_8\text{H}_{18}$    | 200                  | 50             | 1.9        | 0.96       | 6    |
|                        |                              | 25                   | 1              | 0.00035    | 0.00022    | 1    |
|                        |                              | 50                   | 65             | 0.00052    | 0.00033    | 6    |
|                        |                              | 100                  | 65             | 0.0020     | 0.00127    | 6    |
|                        |                              | 150                  | 65             | 0.0102     | 0.0065     | 6    |
| Triphenylene           | $\text{C}_{18}\text{H}_{12}$ | 200                  | 65             | 0.061      | 0.0387     | 6    |
|                        |                              | 25                   | 1              | 0.0000034  | 0.0000043  | 2    |
|                        |                              | 100                  | 51             | 0.0000899  | 0.000114   | 12   |
|                        |                              | 140                  | 50             | 0.00126    | 0.00160    | 12   |
|                        |                              | 180                  | 64             | 0.0123     | 0.0156     | 12   |
| <i>m</i> -Xylene       | $\text{C}_8\text{H}_{10}$    | 195                  | 60             | 0.0283     | 0.0359     | 12   |
|                        |                              | 25                   | 1              | 0.028      | 0.0161     | 13   |
|                        |                              | 50                   | 60             | 0.036      | 0.021      | 6    |
|                        |                              | 100                  | 60             | 0.085      | 0.050      | 6    |
|                        |                              | 150                  | 60             | 0.27       | 0.159      | 6    |
|                        |                              | 200                  | 60             | 0.88       | 0.516      | 6    |

## PROTON NMR SHIFTS OF COMMON ORGANIC SOLVENTS

The table below lists the  $^1\text{H}$  chemical shifts for over 300 organic solvents and liquid reagents. The solvent in which the shift was measured is given in the second column. Shifts are given in parts per million relative to tetramethylsilane (TMS) and are listed in order of smallest to largest shift. In many cases the peaks show additional small splittings. Compounds are listed by the name used in this *Handbook*, with other common names given in parentheses.

### References

1. Lide, D. R., Editor, *Properties of Organic Compounds*, <www.chem-netbase.com/scripts/pocweb.exe>; Lide, D. R., and Milne, G. W. A., Editors, *Handbook of Data on Organic Compounds, Third Edition*, CRC Press, Boca Raton, FL, 1993.
2. Spectral Database for Organic Compounds, SDBS, National Institute of Advanced Industrial Science and Technology (AIST), Japan, <riodb01.ibase.aist.go.jp>.
3. NMRShiftDB, <nmrshiftdb.ice.mpg.de>.

| Compound                                              | Solvent         | HNMR shifts (ppm relative to TMS) |      |      |      |     | Ref. |
|-------------------------------------------------------|-----------------|-----------------------------------|------|------|------|-----|------|
|                                                       |                 |                                   |      |      |      |     |      |
| Acetic acid                                           | $\text{CDCl}_3$ | 2.10                              | 11.4 |      |      |     | 2    |
| Acetic anhydride                                      | $\text{CCl}_4$  | 2.2                               |      |      |      |     | 1    |
| Acetone                                               | $\text{CDCl}_3$ | 2.1                               |      |      |      |     | 1    |
| Acetonitrile                                          | $\text{CCl}_4$  | 1.9                               |      |      |      |     | 1    |
| Acrolein (2-Propenal)                                 | $\text{CDCl}_3$ | 6.4                               | 9.5  |      |      |     | 1    |
| Acrylonitrile                                         | $\text{CDCl}_3$ | 6.3                               |      |      |      |     | 1    |
| Allyl alcohol                                         | $\text{CDCl}_3$ | 3.6                               | 4.1  | 5.1  | 5.3  | 6.0 | 1    |
| Allylamine                                            | $\text{CDCl}_3$ | 1.5                               | 3.3  | 5.0  | 5.1  | 5.9 | 1    |
| 2-Amino-2-methyl-1-propanol (2-Aminoisobutanol)       | $\text{CCl}_4$  | 1.1                               | 2.8  | 3.2  |      |     | 1    |
| Aniline (Benzenamine)                                 | $\text{CCl}_4$  | 3.3                               | 6.4  | 6.6  | 7.0  |     | 1    |
| Anisole (Methoxybenzene)                              | $\text{CDCl}_3$ | 3.8                               | 7.1  |      |      |     | 1    |
| Benzaldehyde                                          | $\text{CDCl}_3$ | 7.7                               | 10.0 |      |      |     | 1    |
| Benzene                                               | $\text{CDCl}_3$ | 7.34                              |      |      |      |     | 2    |
| Benzeneacetonitrile (Benzyl cyanide)                  | $\text{CCl}_4$  | 0.8                               | 0.9  | 1.6  | 2.3  |     | 1    |
| Benzenethiol (Phenyl mercaptan)                       | $\text{CCl}_4$  | 3.2                               | 6.9  |      |      |     | 1    |
| Benzonitrile                                          | $\text{CCl}_4$  | 7.5                               |      |      |      |     | 1    |
| Benzyl acetate                                        | $\text{CDCl}_3$ | 2.1                               | 5.1  | 7.3  |      |     | 1    |
| Benzyl alcohol                                        | $\text{CDCl}_3$ | 2.4                               | 4.6  | 7.3  |      |     | 1    |
| Bis(2-aminoethyl)amine (Diethylenetriamine)           | $\text{CDCl}_3$ | 1.23                              | 2.69 | 2.79 |      |     | 2    |
| Bis(2-chloroethyl) ether                              | $\text{CDCl}_3$ | 3.66                              | 3.77 |      |      |     | 2    |
| Bis(2-ethylhexyl) phthalate                           | $\text{CCl}_4$  | 0.9                               | 1.5  | 4.2  | 7.4  | 7.7 | 1    |
| Bis(2-hydroxyethyl) sulfide                           | $\text{CDCl}_3$ | 2.8                               | 3.8  | 4.2  |      |     | 1    |
| Bromobenzene                                          | $\text{CCl}_4$  | 7.1                               | 7.4  |      |      |     | 1    |
| 1-Bromobutane (Butyl bromide)                         | $\text{CCl}_4$  | 1.0                               | 1.4  | 1.8  | 3.4  |     | 1    |
| 2-Bromobutane ( <i>sec</i> -Butyl bromide)            | $\text{CDCl}_3$ | 1.1                               | 1.7  | 1.8  | 4.1  |     | 1    |
| 1-Bromo-2-chloroethane                                | $\text{CDCl}_3$ | 3.3                               | 4.0  |      |      |     | 1    |
| Bromochloromethane                                    | $\text{CCl}_4$  | 5.2                               |      |      |      |     | 1    |
| 1-Bromodecane (Decyl bromide)                         | $\text{CCl}_4$  | 0.9                               | 1.8  | 3.3  |      |     | 1    |
| Bromoethane (Ethyl bromide)                           | $\text{CDCl}_3$ | 1.7                               | 3.4  |      |      |     | 1    |
| 2-Bromo-2-methylpropane ( <i>tert</i> -Butyl bromide) | $\text{CCl}_4$  | 1.8                               |      |      |      |     | 1    |
| 1-Bromonaphthalene                                    | $\text{CCl}_4$  | 7.4                               | 8.1  |      |      |     | 1    |
| 1-Bromopentane (Pentyl bromide)                       | $\text{CCl}_4$  | 0.9                               | 1.4  | 1.9  | 3.3  |     | 1    |
| 1-Bromopropane (Propyl bromide)                       | $\text{CCl}_4$  | 1.0                               | 1.9  | 3.4  |      |     | 1    |
| 2-Bromopropane (Isopropyl bromide)                    | $\text{CDCl}_3$ | 1.7                               | 4.3  |      |      |     | 1    |
| 2-Bromopropene                                        | $\text{CDCl}_3$ | 2.3                               | 5.3  | 5.5  |      |     | 1    |
| Butanal                                               | $\text{CDCl}_3$ | 1.0                               | 1.7  | 2.4  | 9.7  |     | 1    |
| Butanenitrile                                         | $\text{CCl}_4$  | 1.1                               | 1.7  | 2.3  |      |     | 1    |
| 1-Butanethiol (Butyl mercaptan)                       | $\text{CDCl}_3$ | 0.9                               | 1.2  | 1.5  | 2.5  |     | 1    |
| Butanoic acid                                         | $\text{CCl}_4$  | 0.9                               | 1.7  | 2.3  | 12.0 |     | 1    |
| Butanoic anhydride                                    | $\text{CCl}_4$  | 1.0                               | 1.7  | 2.4  |      |     | 1    |

| Compound                                                    | Solvent           | HNMR shifts (ppm relative to TMS) |      |      |      |      |     | Ref. |
|-------------------------------------------------------------|-------------------|-----------------------------------|------|------|------|------|-----|------|
|                                                             |                   |                                   |      |      |      |      |     |      |
| 1-Butanol (Butyl alcohol)                                   | CDCl <sub>3</sub> | 0.94                              | 1.39 | 1.53 | 2.24 | 3.63 |     | 2    |
| 2-Butanol ( <i>sec</i> -Butyl alcohol)                      | CDCl <sub>3</sub> | 0.93                              | 1.17 | 1.46 | 2.37 | 3.71 |     | 2    |
| 2-Butanone (Methyl ethyl ketone)                            | CDCl <sub>3</sub> | 1.06                              | 2.14 | 2.45 |      |      |     | 2    |
| <i>trans</i> -2-Butenal ( <i>trans</i> -Crotonaldehyde)     | CDCl <sub>3</sub> | 2.0                               | 6.1  | 6.9  | 9.5  |      |     | 1    |
| 2-Butoxyethanol (Ethylene glycol monobutyl ether)           | CCl <sub>4</sub>  | 0.9                               | 1.3  | 3.3  | 3.7  |      |     | 1    |
| Butyl acetate                                               | CDCl <sub>3</sub> | 0.9                               | 1.4  | 2.0  | 4.1  |      |     | 1    |
| Butylamine                                                  | CDCl <sub>3</sub> | 0.92                              | 1.33 | 1.43 | 1.77 | 2.68 |     | 2    |
| <i>tert</i> -Butylamine                                     | CDCl <sub>3</sub> | 1.1                               | 1.2  |      |      |      |     | 1    |
| Butylbenzene                                                | CCl <sub>4</sub>  | 0.9                               | 1.4  | 2.6  | 7.1  |      |     | 1    |
| <i>sec</i> -Butylbenzene                                    | CCl <sub>4</sub>  | 0.8                               | 1.2  | 1.6  | 2.5  | 7.1  |     | 1    |
| <i>tert</i> -Butylbenzene                                   | CCl <sub>4</sub>  | 1.3                               | 7.2  |      |      |      |     | 1    |
| Butyl formate                                               | CDCl <sub>3</sub> | 0.9                               | 1.5  | 4.2  | 8.1  |      |     | 1    |
| 1- <i>tert</i> -Butyl-4-methylbenzene                       | CDCl <sub>3</sub> | 1.30                              | 2.31 | 7.11 | 7.26 |      |     | 2    |
| Butyl vinyl ether                                           | CCl <sub>4</sub>  | 0.9                               | 1.4  | 3.6  | 3.8  | 4.0  | 6.3 | 1    |
| $\gamma$ -Butyrolactone                                     | CDCl <sub>3</sub> | 4.4                               |      |      |      |      |     | 1    |
| Caprolactam                                                 | CDCl <sub>3</sub> | 1.7                               | 2.4  | 3.2  | 7.8  |      |     | 1    |
| 2-Chloroaniline                                             | CCl <sub>4</sub>  | 3.8                               | 6.8  |      |      |      |     | 1    |
| Chlorobenzene                                               | CDCl <sub>3</sub> | 7.3                               |      |      |      |      |     | 2    |
| 2-Chlorobutane ( <i>sec</i> -Butyl chloride)                | CCl <sub>4</sub>  | 1.1                               | 1.5  | 1.7  | 3.9  |      |     | 1    |
| Chloroethane (Ethyl chloride)                               | CDCl <sub>3</sub> | 1.5                               | 3.6  |      |      |      |     | 1    |
| 2-Chloroethanol (Ethylene chlorohydrin)                     | CDCl <sub>3</sub> | 2.8                               | 3.7  | 3.8  |      |      |     | 1    |
| (Chloromethyl)benzene (Benzyl chloride)                     | CCl <sub>4</sub>  | 4.5                               | 7.3  |      |      |      |     | 1    |
| 1-Chloro-3-methylbutane (Isopentyl chloride)                | CDCl <sub>3</sub> | 0.9                               | 1.7  | 3.6  |      |      |     | 1    |
| 1-Chloro-2-methylpropane (Isobutyl chloride)                | CCl <sub>4</sub>  | 1.0                               | 1.9  | 3.3  |      |      |     | 1    |
| 2-Chloro-2-methylpropane ( <i>tert</i> -Butyl chloride)     | CCl <sub>4</sub>  | 1.6                               |      |      |      |      |     | 1    |
| 1-Chloronaphthalene                                         | CCl <sub>4</sub>  | 7.1                               | 7.5  | 8.2  |      |      |     | 1    |
| 1-Chlorooctane (Octyl chloride)                             | CCl <sub>4</sub>  | 0.9                               | 1.3  | 1.8  | 3.5  |      |     | 1    |
| 1-Chloropentane (Pentyl chloride)                           | CCl <sub>4</sub>  | 0.9                               | 1.6  | 3.4  |      |      |     | 1    |
| 1-Chloropropane (Propyl chloride)                           | CCl <sub>4</sub>  | 1.0                               | 1.8  | 3.4  |      |      |     | 1    |
| 3-Chloropropene (Allyl chloride)                            | CCl <sub>4</sub>  | 4.0                               | 5.2  | 5.3  | 5.9  |      |     | 1    |
| 2-Chlorotoluene                                             | CDCl <sub>3</sub> | 2.4                               | 7.2  |      |      |      |     | 1    |
| 3-Chlorotoluene                                             | CCl <sub>4</sub>  | 2.3                               | 7.1  |      |      |      |     | 1    |
| Cyclohexane                                                 | CDCl <sub>3</sub> | 1.43                              |      |      |      |      |     | 2    |
| Cyclohexanol                                                | CCl <sub>4</sub>  | 1.6                               | 3.5  | 4.2  |      |      |     | 1    |
| Cyclohexanone                                               | CCl <sub>4</sub>  | 1.8                               | 2.3  |      |      |      |     | 1    |
| Cyclohexene                                                 | CCl <sub>4</sub>  | 1.6                               | 2.0  | 5.6  |      |      |     | 1    |
| Cyclohexylamine                                             | CCl <sub>4</sub>  | 1.4                               | 1.5  | 2.6  |      |      |     | 1    |
| Cyclopentane                                                | CCl <sub>4</sub>  | 1.5                               |      |      |      |      |     | 1    |
| Cyclopentanone                                              | CCl <sub>4</sub>  | 2.0                               |      |      |      |      |     | 1    |
| <i>cis</i> -Decahydronaphthalene ( <i>cis</i> -Decalin)     | CDCl <sub>3</sub> | 1.42                              | 1.62 |      |      |      |     | 2    |
| <i>trans</i> -Decahydronaphthalene ( <i>trans</i> -Decalin) | CDCl <sub>3</sub> | 0.87                              | 0.93 | 1.23 | 1.54 | 1.67 |     | 2    |
| Decane                                                      | CCl <sub>4</sub>  | 0.9                               | 1.3  |      |      |      |     | 1    |
| Diacetone alcohol                                           | CDCl <sub>3</sub> | 1.3                               | 2.2  | 2.6  | 3.7  |      |     | 1    |
| 1,2-Dibromoethane                                           | CDCl <sub>3</sub> | 3.65                              |      |      |      |      |     | 2    |
| Dibromomethane                                              | CCl <sub>4</sub>  | 4.9                               |      |      |      |      |     | 1    |
| 1,2-Dibromopropane                                          | CCl <sub>4</sub>  | 1.8                               | 3.5  | 3.8  | 4.2  |      |     | 1    |
| Dibutylamine                                                | CCl <sub>4</sub>  | 0.5                               | 0.9  | 1.4  | 2.5  |      |     | 1    |
| Dibutyl ether                                               | CCl <sub>4</sub>  | 0.9                               | 1.4  | 3.3  |      |      |     | 1    |
| Dibutyl sebacate                                            | CCl <sub>4</sub>  | 1.0                               | 1.5  | 2.2  | 4.0  |      |     | 1    |
| <i>o</i> -Dichlorobenzene                                   | CCl <sub>4</sub>  | 7.2                               |      |      |      |      |     | 1    |
| <i>m</i> -Dichlorobenzene                                   | CCl <sub>4</sub>  | 7.2                               | 7.4  |      |      |      |     | 1    |
| 1,1-Dichloroethane                                          | CDCl <sub>3</sub> | 2.06                              | 5.90 |      |      |      |     | 2    |

| Compound                                             | Solvent                            | HNMR shifts (ppm relative to TMS) |      |      |      |      | Ref. |
|------------------------------------------------------|------------------------------------|-----------------------------------|------|------|------|------|------|
|                                                      |                                    |                                   |      |      |      |      |      |
| 1,2-Dichloroethane                                   | CCl <sub>4</sub>                   | 3.7                               |      |      |      |      | 1    |
| 1,1-Dichloroethene                                   | CCl <sub>4</sub>                   | 5.5                               |      |      |      |      | 1    |
| <i>cis</i> -1,2-Dichloroethene                       | CDCl <sub>3</sub>                  | 6.28                              |      |      |      |      | 2    |
| <i>trans</i> -1,2-Dichloroethene                     | (CH <sub>3</sub> ) <sub>4</sub> Si | 6.24                              |      |      |      |      | 2    |
| Dichloromethane (Methylene chloride)                 | CCl <sub>4</sub>                   | 5.3                               |      |      |      |      | 1    |
| (Dichloromethyl)benzene (Benzal chloride)            | CCl <sub>4</sub>                   | 6.6                               | 7.4  |      |      |      | 1    |
| 1,2-Dichloropropane                                  | CDCl <sub>3</sub>                  | 1.61                              | 3.59 | 3.74 | 4.14 |      | 2    |
| 2,4-Dichlorotoluene                                  | CCl <sub>4</sub>                   | 2.3                               | 7.0  | 7.3  |      |      | 1    |
| 3,4-Dichlorotoluene                                  | CCl <sub>4</sub>                   | 2.3                               | 7.0  |      |      |      | 1    |
| Diethanolamine                                       | D <sub>2</sub> O                   | 2.7                               | 3.7  |      |      |      | 1    |
| 1,1-Diethoxyethane (Acetal)                          | CDCl <sub>3</sub>                  | 1.2                               | 1.3  | 3.5  | 3.7  | 4.7  | 2    |
| 1,2-Diethoxyethane (Ethylene glycol diethyl ether)   | CDCl <sub>3</sub>                  | 1.22                              | 3.54 | 3.58 |      |      | 1    |
| Diethylamine                                         | CCl <sub>4</sub>                   | 0.9                               | 1.0  | 2.6  |      |      | 1    |
| Diethyl carbonate                                    | CDCl <sub>3</sub>                  | 1.3                               | 4.2  |      |      |      | 1    |
| Diethylene glycol                                    | CDCl <sub>3</sub>                  | 3.7                               | 4.2  |      |      |      | 1    |
| Diethylene glycol dimethyl ether (Diglyme)           | CDCl <sub>3</sub>                  | 3.3                               | 3.5  |      |      |      | 1    |
| Diethylene glycol monoethyl ether (Carbitol)         | CCl <sub>4</sub>                   | 1.2                               | 3.1  | 3.5  | 3.6  |      | 1    |
| Diethylene glycol monoethyl ether acetate            | CDCl <sub>3</sub>                  | 1.22                              | 2.08 | 3.54 | 3.71 | 4.23 | 2    |
| Diethylene glycol monomethyl ether                   | CDCl <sub>3</sub>                  | 3.3                               | 3.4  | 3.6  |      |      | 1    |
| Diethyl ether                                        | CDCl <sub>3</sub>                  | 1.21                              | 3.47 |      |      |      | 2    |
| Diethyl sulfide                                      | CCl <sub>4</sub>                   | 1.2                               | 2.5  |      |      |      | 1    |
| Diisopropylamine                                     | CCl <sub>4</sub>                   | 0.7                               | 1.0  | 2.9  |      |      | 1    |
| Diisopropyl ether                                    | CCl <sub>4</sub>                   | 1.0                               | 3.5  |      |      |      | 1    |
| 1,2-Dimethoxybenzene (Veratrole)                     | CCl <sub>4</sub>                   | 3.7                               | 6.8  |      |      |      | 1    |
| 1,2-Dimethoxyethane (Ethylene glycol dimethyl ether) | CCl <sub>4</sub>                   | 3.3                               | 3.4  |      |      |      | 1    |
| Dimethoxymethane (Methylal)                          | CCl <sub>4</sub>                   | 3.2                               | 4.4  |      |      |      | 1    |
| <i>N,N</i> -Dimethylacetamide                        | CDCl <sub>3</sub>                  | 2.1                               | 2.9  | 3.0  |      |      | 1    |
| 2,4-Dimethylaniline (2,4-Xylidine)                   | CCl <sub>4</sub>                   | 2.0                               | 2.2  | 3.4  | 6.4  | 6.7  | 1    |
| 2,2-Dimethylbutane (Neohexane)                       | CCl <sub>4</sub>                   | 0.9                               | 1.1  | 1.3  | 1.1  | 1.3  | 1    |
| 2,3-Dimethylbutane                                   | CCl <sub>4</sub>                   | 0.9                               | 1.5  |      |      |      | 1    |
| Dimethyl disulfide                                   |                                    | 2.45                              |      |      |      |      | 3    |
| <i>N,N</i> -Dimethylformamide                        | CDCl <sub>3</sub>                  | 2.9                               | 3.0  | 8.0  |      |      | 1    |
| Dimethyl glutarate                                   | CDCl <sub>3</sub>                  | 2.0                               | 2.4  | 3.7  |      |      | 1    |
| 2,6-Dimethyl-4-heptanone (Isovalerone)               | CCl <sub>4</sub>                   | 0.9                               | 2.1  |      |      |      | 1    |
| 2,5-Dimethylhexane                                   | CCl <sub>4</sub>                   | 0.9                               | 1.4  |      |      |      | 1    |
| Dimethyl maleate                                     | CCl <sub>4</sub>                   | 3.7                               | 6.2  |      |      |      | 1    |
| 2,2-Dimethylpentane                                  | CDCl <sub>3</sub>                  | 0.9                               | 0.9  | 1.2  |      |      | 1    |
| 2,4-Dimethylpentane                                  | CCl <sub>4</sub>                   | 0.9                               | 1.1  | 1.6  |      |      | 1    |
| 2,4-Dimethyl-3-pentanone (Diisopropyl ketone)        | CCl <sub>4</sub>                   | 1.0                               | 2.6  |      |      |      | 1    |
| 2,4-Dimethylpyridine (2,4-Lutidine)                  | CDCl <sub>3</sub>                  | 2.3                               | 2.5  | 7.0  | 7.0  | 8.4  | 1    |
| 2,6-Dimethylpyridine (2,6-Lutidine)                  | CDCl <sub>3</sub>                  | 2.51                              | 6.93 | 7.42 |      |      | 2    |
| Dimethyl sulfoxide                                   | CDCl <sub>3</sub>                  | 2.62                              |      |      |      |      | 2    |
| 1,4-Dioxane                                          | CDCl <sub>3</sub>                  | 3.69                              |      |      |      |      | 2    |
| 1,3-Dioxolane                                        | CDCl <sub>3</sub>                  | 3.88                              | 4.90 |      |      |      | 2    |
| Dipentyl ether (Amyl ether)                          | CDCl <sub>3</sub>                  | 0.9                               | 1.4  | 3.4  |      |      | 1    |
| Dipropylamine                                        | CDCl <sub>3</sub>                  | 1.5                               | 2.6  |      |      |      | 1    |
| Dodecane                                             | CCl <sub>4</sub>                   | 0.9                               | 1.3  |      |      |      | 1    |
| 1-Dodecene                                           | CCl <sub>4</sub>                   | 0.9                               | 1.3  | 2.0  | 5.4  |      | 1    |
| Epichlorohydrin                                      | CCl <sub>4</sub>                   | 2.6                               | 2.8  | 3.2  | 3.5  | 3.6  | 1    |
| 1,2-Epoxybutane (Ethloxirane)                        | CCl <sub>4</sub>                   | 1.0                               | 1.5  | 2.3  | 2.6  | 2.7  | 1    |
| 1,2-Ethanediamine                                    | CCl <sub>4</sub>                   | 1.2                               | 2.6  |      |      |      | 1    |
| 1,2-Ethanediol (Ethylene glycol)                     | D <sub>2</sub> O                   | 3.7                               |      |      |      |      | 1    |

| Compound                                                        | Solvent           | HNMR shifts (ppm relative to TMS) |      |      |      |      |     | Ref. |
|-----------------------------------------------------------------|-------------------|-----------------------------------|------|------|------|------|-----|------|
|                                                                 |                   |                                   |      |      |      |      |     |      |
| 1,2-Ethanediol, diacetate (Ethylene glycol diacetate)           | CCl <sub>4</sub>  | 2.0                               | 4.2  |      |      |      |     | 1    |
| Ethanol                                                         | CDCl <sub>3</sub> | 1.23                              | 2.61 | 3.69 |      |      |     | 2    |
| Ethanolamine                                                    | CDCl <sub>3</sub> | 2.7                               | 2.8  | 3.5  |      |      |     | 1    |
| Ethoxybenzene (Phenetole)                                       | CCl <sub>4</sub>  | 1.3                               | 3.9  | 6.9  |      |      |     | 1    |
| 2-Ethoxyethanol (Ethylene glycol monoethyl ether (Cellosolve))  | CDCl <sub>3</sub> | 1.22                              | 2.70 | 3.55 | 3.72 |      |     | 2    |
| 2-Ethoxyethyl acetate (Ethylene glycol monoethyl ether acetate) | CCl <sub>4</sub>  | 1.2                               | 2.0  | 3.4  | 3.5  | 4.1  |     | 1    |
| Ethyl acetate                                                   | CDCl <sub>3</sub> | 1.26                              | 2.04 | 4.12 |      |      |     | 2    |
| Ethyl acetoacetate                                              | CDCl <sub>3</sub> | 1.3                               | 1.9  | 2.2  | 3.3  | 4.1  | 4.9 | 1    |
| Ethyl acrylate (Ethyl propenoate)                               | CCl <sub>4</sub>  | 1.3                               | 4.1  | 5.7  | 6.1  | 6.3  |     | 1    |
| Ethylamine                                                      | D <sub>2</sub> O  | 1.1                               | 2.6  |      |      |      |     | 1    |
| Ethylbenzene                                                    | CDCl <sub>3</sub> | 1.3                               | 2.7  | 7.2  |      |      |     | 1    |
| Ethyl benzoate                                                  | CCl <sub>4</sub>  | 1.3                               | 4.3  | 7.4  | 8.0  |      |     | 1    |
| Ethyl butanoate                                                 | CCl <sub>4</sub>  | 0.9                               | 1.2  | 1.7  | 2.2  | 4.1  |     | 1    |
| Ethyl cyanoacetate                                              | CCl <sub>4</sub>  | 1.3                               | 3.4  | 4.3  |      |      |     | 1    |
| Ethylcyclohexane                                                | CDCl <sub>3</sub> | 0.9                               | 1.9  | 1.4  |      |      |     | 1    |
| Ethylene carbonate                                              | CDCl <sub>3</sub> | 4.5                               |      |      |      |      |     | 1    |
| Ethyl formate                                                   | CCl <sub>4</sub>  | 1.3                               | 4.2  | 7.9  |      |      |     | 1    |
| 2-Ethyl-1,3-hexanediol                                          | CDCl <sub>3</sub> | 1.0                               | 1.4  | 3.8  |      |      |     | 1    |
| 2-Ethyl-1-hexanol                                               | CDCl <sub>3</sub> | 0.9                               | 1.3  | 1.8  | 3.5  |      |     | 1    |
| Ethyl 3-methylbutanoate                                         | CDCl <sub>3</sub> | 1.0                               | 1.3  | 1.9  | 4.1  |      |     | 1    |
| 3-Ethyl-2-methylpentane                                         | CCl <sub>4</sub>  | 0.9                               | 0.9  | 1.5  |      |      |     | 1    |
| Fluorobenzene                                                   | CCl <sub>4</sub>  | 7.0                               |      |      |      |      |     | 1    |
| 2-Fluorotoluene                                                 | CCl <sub>4</sub>  | 2.2                               | 6.9  |      |      |      |     | 1    |
| 3-Fluorotoluene                                                 | CCl <sub>4</sub>  | 2.3                               | 6.9  |      |      |      |     | 1    |
| 4-Fluorotoluene                                                 | CCl <sub>4</sub>  | 2.2                               | 6.8  | 7.0  |      |      |     | 1    |
| Furan                                                           | CDCl <sub>3</sub> | 6.38                              | 7.44 |      |      |      |     | 2    |
| Furfural                                                        | CDCl <sub>3</sub> | 6.6                               | 7.3  | 7.7  | 9.7  |      |     | 1    |
| Furfuryl alcohol                                                | CDCl <sub>3</sub> | 2.8                               | 4.6  | 6.3  | 7.4  |      |     | 1    |
| Glycerol                                                        | D <sub>2</sub> O  | 3.6                               |      |      |      |      |     | 1    |
| Glycerol triacetate (Triacetin)                                 | CDCl <sub>3</sub> | 2.1                               | 4.2  | 4.3  | 5.2  |      |     | 1    |
| Heptane                                                         | CDCl <sub>3</sub> | 0.88                              | 1.27 | 1.30 |      |      |     | 2    |
| 1-Heptanol                                                      | CCl <sub>4</sub>  | 0.9                               | 1.4  | 3.4  | 3.5  |      |     | 1    |
| 3-Heptanol                                                      | CCl <sub>4</sub>  | 0.9                               | 1.4  | 2.3  | 3.4  |      |     | 1    |
| 2-Heptanone (Methyl pentyl ketone)                              | CCl <sub>4</sub>  | 0.9                               | 1.3  | 2.0  | 2.3  |      |     | 1    |
| 3-Heptanone (Ethyl butyl ketone)                                | CCl <sub>4</sub>  | 1.0                               | 1.4  | 2.3  |      |      |     | 1    |
| 1-Heptene                                                       | CCl <sub>4</sub>  | 0.9                               | 1.4  | 2.0  | 4.9  | 5.7  |     | 1    |
| Hexane                                                          | CDCl <sub>3</sub> | 0.89                              | 1.27 | 1.29 |      |      |     | 2    |
| Hexanedinitrile (Adiponitrile)                                  | CDCl <sub>3</sub> | 1.8                               | 2.5  |      |      |      |     | 1    |
| Hexanenitrile                                                   | CDCl <sub>3</sub> | 0.9                               | 1.5  | 2.3  |      |      |     | 1    |
| Hexanoic acid (Caproic acid)                                    | CDCl <sub>3</sub> | 0.9                               | 1.4  | 2.4  | 11.4 |      |     | 1    |
| 1-Hexanol                                                       | CDCl <sub>3</sub> | 0.90                              | 1.32 | 1.56 | 1.79 | 3.62 |     | 2    |
| Hexyl acetate                                                   | CCl <sub>4</sub>  | 0.9                               | 1.4  | 2.0  | 4.0  |      |     | 1    |
| 3-Hydroxypropanenitrile (Hydracrylonitrile)                     | CDCl <sub>3</sub> | 2.6                               | 3.4  | 3.9  |      |      |     | 1    |
| Iodobenzene                                                     | CCl <sub>4</sub>  | 6.8                               | 7.5  | 7.7  |      |      |     | 1    |
| 1-Iodobutane (Butyl iodide)                                     | CDCl <sub>3</sub> | 1.0                               | 1.7  | 1.9  | 4.2  |      |     | 1    |
| 2-Iodobutane ( <i>sec</i> -Butyl iodide)                        | CDCl <sub>3</sub> | 1.0                               | 1.7  | 1.9  | 4.2  |      |     | 1    |
| Iodoethane (Ethyl iodide)                                       | CDCl <sub>3</sub> | 1.2                               | 2.6  | 3.7  |      |      |     | 1    |
| Iodomethane (Methyl iodide)                                     | CDCl <sub>3</sub> | 2.2                               |      |      |      |      |     | 1    |
| 1-Iodopropane (Propyl iodide)                                   | CCl <sub>4</sub>  | 1.0                               | 1.8  | 3.2  |      |      |     | 1    |
| 2-Iodopropane (Isopropyl iodide)                                | CDCl <sub>3</sub> | 1.9                               | 4.3  |      |      |      |     | 1    |
| Isobutanal (2-Methyl-1-propanal)                                | CCl <sub>4</sub>  | 1.1                               | 2.4  | 9.6  |      |      |     | 1    |
| Isobutyl acetate                                                | CCl <sub>4</sub>  | 0.9                               | 1.9  | 2.0  | 3.8  |      |     | 1    |

| Compound                                                          | Solvent           | HNMR shifts (ppm relative to TMS) |      |      |      |     |      |     |     | Ref. |
|-------------------------------------------------------------------|-------------------|-----------------------------------|------|------|------|-----|------|-----|-----|------|
|                                                                   |                   |                                   |      |      |      |     |      |     |     |      |
| Isobutylbenzene                                                   | CCl <sub>4</sub>  | 0.9                               | 1.9  | 2.4  | 7.1  |     |      |     |     | 1    |
| Isobutyl formate                                                  | CDCl <sub>3</sub> | 1.0                               | 2.0  | 3.9  | 8.0  |     |      |     |     | 1    |
| Isobutyl isobutanoate                                             | CCl <sub>4</sub>  | 0.9                               | 1.2  | 1.9  | 2.5  | 3.8 |      |     |     | 1    |
| Isopentyl acetate                                                 | CDCl <sub>3</sub> | 0.9                               | 1.5  | 2.0  | 4.0  |     |      |     |     | 1    |
| Isophorone                                                        | CDCl <sub>3</sub> | 1.04                              | 1.95 | 2.19 | 5.88 |     |      |     |     | 2    |
| Isopropyl acetate                                                 | CDCl <sub>3</sub> | 0.9                               | 1.4  | 1.6  | 2.4  |     |      |     |     | 1    |
| Isopropylbenzene (Cumene)                                         | CDCl <sub>3</sub> | 1.3                               | 2.4  | 2.9  | 7.3  |     |      |     |     | 1    |
| 1-Isopropyl-4-methylbenzene ( <i>p</i> -Cymene)                   | CDCl <sub>3</sub> | 1.2                               | 2.3  | 2.9  | 7.1  |     |      |     |     | 1    |
| Isoquinoline                                                      | CDCl <sub>3</sub> | 8.5                               | 9.3  |      |      |     |      |     |     | 1    |
| <i>d</i> -Limonene (Citrene)                                      | CCl <sub>4</sub>  | 1.4                               | 1.7  | 1.9  | 4.6  | 5.3 |      |     |     | 1    |
| Mesityl oxide                                                     | CDCl <sub>3</sub> | 1.89                              | 2.14 | 2.16 | 6.09 |     |      |     |     | 2    |
| Methanol                                                          | CDCl <sub>3</sub> | 3.43                              | 3.66 |      |      |     |      |     |     | 2    |
| 2-Methoxyethanol (Ethylene glycol monomethyl ether)               | CDCl <sub>3</sub> | 2.5                               | 3.4  | 3.5  | 3.7  | 3.5 | 3.7  |     |     | 1    |
| 2-Methoxyethyl acetate (Ethylene glycol monomethyl ether acetate) | CDCl <sub>3</sub> | 2.09                              | 3.39 | 3.59 | 4.22 |     |      |     |     | 2    |
| Methyl acetate                                                    | CCl <sub>4</sub>  | 2.0                               | 3.7  |      |      |     |      |     |     | 1    |
| 2-Methylacrylonitrile                                             | CDCl <sub>3</sub> | 2.0                               | 5.7  | 5.8  |      |     |      |     |     | 1    |
| 2-Methylaniline ( <i>o</i> -Toluidine)                            | CCl <sub>4</sub>  | 2.0                               | 3.2  | 6.7  |      |     |      |     |     | 1    |
| 3-Methylaniline ( <i>m</i> -Toluidine)                            | CCl <sub>4</sub>  | 2.2                               | 3.3  | 6.4  | 6.9  |     |      |     |     | 1    |
| <i>N</i> -Methylaniline                                           | CCl <sub>4</sub>  | 2.7                               | 3.3  | 6.4  | 6.6  | 7.1 |      |     |     | 1    |
| Methyl benzoate                                                   | CCl <sub>4</sub>  | 3.8                               | 7.4  | 8.0  |      |     |      |     |     | 1    |
| 3-Methylbutanoic acid (Isovaleric acid)                           | CCl <sub>4</sub>  | 1.0                               | 2.2  | 11.0 |      |     |      |     |     | 1    |
| 3-Methyl-1-butanol (Isopentyl alcohol)                            | CCl <sub>4</sub>  | 0.9                               | 1.5  | 3.5  | 4.1  |     |      |     |     | 1    |
| Methyl cyanoacetate                                               | CDCl <sub>3</sub> | 3.5                               | 3.8  |      |      |     |      |     |     | 1    |
| Methylcyclohexane                                                 | CCl <sub>4</sub>  | 0.9                               | 1.4  |      |      |     |      |     |     | 1    |
| <i>cis</i> -4-Methylcyclohexanol                                  | CDCl <sub>3</sub> | 0.9                               | 1.5  | 2.9  | 3.9  |     |      |     |     | 1    |
| <i>N</i> -Methylformamide                                         | CDCl <sub>3</sub> | 2.82                              | 7.4  | 8.16 |      |     |      |     |     | 2    |
| Methyl formate                                                    | CDCl <sub>3</sub> | 3.76                              | 8.07 |      |      |     |      |     |     | 2    |
| 2-Methylheptane                                                   | CCl <sub>4</sub>  | 0.9                               | 1.3  |      |      |     |      |     |     | 1    |
| 4-Methylheptane                                                   | CDCl <sub>3</sub> | 0.8                               | 0.9  | 1.4  |      |     |      |     |     | 1    |
| 2-Methylhexane                                                    | CDCl <sub>3</sub> | 0.9                               | 0.9  | 1.4  |      |     |      |     |     | 1    |
| 5-Methyl-2-hexanone (Methyl isopentyl ketone)                     | CCl <sub>4</sub>  | 0.9                               | 1.4  | 2.0  | 2.3  |     |      |     |     | 1    |
| Methyl methacrylate (Methyl 2-methyl-2-propenoate)                | CDCl <sub>3</sub> | 2.0                               | 3.8  | 5.6  | 6.1  |     |      |     |     | 1    |
| 2-Methyloctane                                                    | CCl <sub>4</sub>  | 0.9                               | 1.0  | 1.3  |      |     |      |     |     | 1    |
| 2-Methylpentane                                                   | CCl <sub>4</sub>  | 0.8                               | 0.9  | 1.5  |      |     |      |     |     | 1    |
| 3-Methylpentane                                                   | CCl <sub>4</sub>  | 0.8                               | 1.5  |      |      |     |      |     |     | 1    |
| 2-Methyl-2,4-pentanediol (Hexylene glycol)                        | CCl <sub>4</sub>  | 1.1                               | 1.2  | 1.3  | 1.4  | 1.6 | 4.2  | 4.7 | 4.9 | 1    |
| 4-Methylpentanenitrile                                            | CCl <sub>4</sub>  | 1.0                               | 1.6  | 2.3  |      |     |      |     |     | 1    |
| 4-Methyl-2-pentanol                                               | CCl <sub>4</sub>  | 0.9                               | 1.1  | 1.3  | 1.8  | 3.5 | 3.7  |     |     | 1    |
| 3-Methyl-3-pentanol                                               | CCl <sub>4</sub>  | 0.9                               | 1.1  | 1.4  | 1.8  |     |      |     |     | 1    |
| 4-Methyl-2-pentanone (Methyl isobutyl ketone)                     | CDCl <sub>3</sub> | 0.9                               | 2.1  | 2.3  |      |     |      |     |     | 1    |
| 2-Methylpropanenitrile (Isobutyronitrile)                         | CDCl <sub>3</sub> | 1.3                               | 2.7  |      |      |     |      |     |     | 1    |
| 2-Methylpropanoic acid (Isobutyric acid)                          | CCl <sub>4</sub>  | 1.2                               | 2.6  |      |      |     |      |     |     | 1    |
| 2-Methyl-1-propanol (Isobutyl alcohol)                            | CCl <sub>4</sub>  | 0.9                               | 1.7  | 3.3  | 4.0  |     |      |     |     | 1    |
| 2-Methyl-2-propanol ( <i>tert</i> -Butyl alcohol)                 | CDCl <sub>3</sub> | 1.3                               | 1.4  |      |      |     |      |     |     | 1    |
| 2-Methylpyridine (2-Picoline)                                     | CCl <sub>4</sub>  | 2.5                               | 6.9  | 7.4  | 8.4  |     |      |     |     | 1    |
| 3-Methylpyridine (3-Picoline)                                     | CCl <sub>4</sub>  | 2.3                               | 7.0  | 7.4  | 8.4  |     |      |     |     | 1    |
| <i>N</i> -Methyl-2-pyrrolidinone                                  | CDCl <sub>3</sub> | 2.1                               | 2.4  | 2.8  | 3.4  |     |      |     |     | 1    |
| Methyl salicylate                                                 | CCl <sub>4</sub>  | 3.9                               | 6.7  | 6.9  | 7.3  | 7.7 | 10.6 |     |     | 1    |
| 2-Methylthiophene                                                 | CDCl <sub>3</sub> | 2.5                               | 6.7  | 6.9  | 7.0  |     |      |     |     | 1    |
| Morpholine                                                        | CDCl <sub>3</sub> | 2.59                              | 2.86 | 3.67 |      |     |      |     |     | 2    |
| Nitrobenzene                                                      | CCl <sub>4</sub>  | 7.52                              | 7.65 | 8.19 |      |     |      |     |     | 2    |
| Nitroethane                                                       | CDCl <sub>3</sub> | 1.6                               | 4.3  |      |      |     |      |     |     | 1    |



| Compound                                | Solvent                       | HNMR shifts (ppm relative to TMS) |      |      |      |      |      |      |      | Ref. |
|-----------------------------------------|-------------------------------|-----------------------------------|------|------|------|------|------|------|------|------|
|                                         |                               |                                   |      |      |      |      |      |      |      |      |
| Nitromethane                            | CCl <sub>4</sub>              | 4.2                               |      |      |      |      |      |      |      | 1    |
| 1-Nitropropane                          | CDCl <sub>3</sub>             | 1.0                               | 2.1  | 4.4  |      |      |      |      |      | 1    |
| 2-Nitropropane                          |                               | 1.55                              | 4.70 |      |      |      |      |      |      | 3    |
| Nonane                                  | CDCl <sub>3</sub>             | 0.9                               | 1.3  |      |      |      |      |      |      | 1    |
| Octane                                  | CDCl <sub>3</sub>             | 0.88                              | 1.26 |      |      |      |      |      |      | 1    |
| 1-Octanol                               | CDCl <sub>3</sub>             | 0.88                              | 1.29 | 1.5  | 2.40 | 3.60 |      |      |      | 2    |
| 2-Octanone (Hexyl methyl ketone)        | CCl <sub>4</sub>              | 0.9                               | 1.4  | 2.1  | 2.4  |      |      |      |      | 1    |
| 1-Octene                                | CCl <sub>4</sub>              | 0.9                               | 1.3  | 2.1  | 4.8  | 4.9  | 5.7  |      |      | 1    |
| Pentane                                 | CDCl <sub>3</sub>             | 0.88                              | 1.26 | 1.30 |      |      |      |      |      | 2    |
| 1,5-Pentanediol (Pentamethylene glycol) | D <sub>2</sub> O              | 1.5                               | 3.6  |      |      |      |      |      |      | 1    |
| 2,4-Pentanedione (Acetylacetone)        | CCl <sub>4</sub>              | 2.0                               | 2.2  | 3.5  | 5.4  | 14.7 |      |      |      | 1    |
| Pentanenitrile (Valeronitrile)          | CCl <sub>4</sub>              | 1.0                               | 1.6  | 2.3  |      |      |      |      |      | 1    |
| Pentanoic acid (Valeric acid)           | CCl <sub>4</sub>              | 0.9                               | 1.5  | 2.3  | 11.7 |      |      |      |      | 1    |
| 1-Pentanol (Amyl alcohol)               | CCl <sub>4</sub>              | 0.9                               | 1.4  | 3.5  | 4.4  |      |      |      |      | 1    |
| 2-Pentanol ( <i>sec</i> -Amyl alcohol)  | CDCl <sub>3</sub>             | 0.9                               | 1.2  | 1.3  | 2.2  | 3.7  |      |      |      | 1    |
| 3-Pentanol (Diethyl carbinol)           | CCl <sub>4</sub>              | 0.9                               | 1.4  | 3.3  | 3.4  |      |      |      |      | 1    |
| 2-Pentanone (Methyl propyl ketone)      | CCl <sub>4</sub>              | 0.9                               | 1.6  | 2.0  | 2.3  |      |      |      |      | 1    |
| 3-Pentanone (Diethyl ketone)            | CCl <sub>4</sub>              | 1.0                               | 2.4  |      |      |      |      |      |      | 1    |
| Pentyl acetate (Amyl acetate)           | CCl <sub>4</sub>              | 0.9                               | 1.4  | 2.0  | 4.0  |      |      |      |      | 1    |
| Pentylamine (Amylamine)                 | CDCl <sub>3</sub>             | 0.9                               | 1.4  | 2.7  |      |      |      |      |      | 1    |
| α-Pinene                                | CDCl <sub>3</sub>             | 0.84                              | 1.16 | 1.27 | 1.66 | 1.93 | 2.19 | 2.33 | 5.19 | 2    |
| Piperidine                              | CDCl <sub>3</sub>             | 1.53                              | 2.18 | 2.79 |      |      |      |      |      | 2    |
| Propanal                                | CDCl <sub>3</sub>             | 1.1                               | 2.4  | 9.8  |      |      |      |      |      | 1    |
| 1,2-Propanediol (1,2-Propylene glycol)  | CDCl <sub>3</sub>             | 1.1                               | 3.4  | 3.9  | 4.3  |      |      |      |      | 1    |
| 1,3-Propanediol (Trimethylene glycol)   | D <sub>2</sub> O              | 1.8                               | 3.7  |      |      |      |      |      |      | 1    |
| Propanenitrile                          | CCl <sub>4</sub>              | 1.3                               | 2.3  |      |      |      |      |      |      | 1    |
| Propanoic acid                          | CDCl <sub>3</sub>             | 1.1                               | 2.4  | 10.5 |      |      |      |      |      | 1    |
| Propanoic anhydride                     | CCl <sub>4</sub>              | 1.2                               | 2.4  |      |      |      |      |      |      | 1    |
| 1-Propanol (Propyl alcohol)             | CDCl <sub>3</sub>             | 0.9                               | 1.6  | 2.3  | 3.6  |      |      |      |      | 1    |
| 2-Propanol (Isopropyl alcohol)          | CDCl <sub>3</sub>             | 1.2                               | 1.6  | 4.0  |      |      |      |      |      | 1    |
| Propargyl alcohol (3-Hydroxy-1-propyne) | CDCl <sub>3</sub>             | 2.5                               | 2.8  | 4.3  |      |      |      |      |      | 1    |
| Propyl acetate                          | CCl <sub>4</sub>              | 0.9                               | 1.6  | 2.0  | 4.0  |      |      |      |      | 1    |
| Propylamine                             | CCl <sub>4</sub>              | 0.9                               | 1.5  | 2.1  | 2.7  |      |      |      |      | 1    |
| Propylbenzene                           | CDCl <sub>3</sub>             | 0.9                               | 1.6  | 2.6  |      |      |      |      |      | 1    |
| Propyl formate                          | CCl <sub>4</sub>              | 1.0                               | 1.7  | 4.1  | 7.9  |      |      |      |      | 1    |
| Pyridine                                | CDCl <sub>3</sub>             | 7.23                              | 7.62 | 8.59 |      |      |      |      |      | 2    |
| Pyrrole                                 | CDCl <sub>3</sub>             | 6.2                               | 6.7  | 8.0  |      |      |      |      |      | 1    |
| Pyrrolidine                             | C <sub>6</sub> H <sub>6</sub> | 1.5                               | 2.4  | 2.7  |      |      |      |      |      | 1    |
| 2-Pyrrolidone                           | CDCl <sub>3</sub>             | 2.2                               | 3.4  | 7.7  |      |      |      |      |      | 1    |
| Quinoline                               | CCl <sub>4</sub>              | 7.1                               | 7.8  | 8.8  |      |      |      |      |      | 1    |
| Salicylaldehyde (2-Hydroxybenzaldehyde) | CDCl <sub>3</sub>             | 7.0                               | 7.4  | 9.8  | 11.0 |      |      |      |      | 1    |
| Styrene                                 | CCl <sub>4</sub>              | 5.1                               | 5.6  | 6.6  | 7.2  |      |      |      |      | 1    |
| Sulfolane                               | CDCl <sub>3</sub>             | 2.2                               | 3.0  |      |      |      |      |      |      | 1    |
| α-Terpinene                             | CDCl <sub>3</sub>             | 1.02                              | 1.77 | 2.09 | 2.28 | 5.59 | 5.62 |      |      | 2    |
| 1,1,1,2-Tetrachloroethane               | CDCl <sub>3</sub>             | 4.29                              |      |      |      |      |      |      |      | 2    |
| 1,1,2,2-Tetrachloroethane               | CDCl <sub>3</sub>             | 5.91                              |      |      |      |      |      |      |      | 2    |
| Tetraethylene glycol                    | CCl <sub>4</sub>              | 3.5                               | 3.6  |      |      |      |      |      |      | 1    |
| Tetrahydrofuran                         | CDCl <sub>3</sub>             | 1.84                              | 3.73 |      |      |      |      |      |      | 2    |
| 1,2,3,4-Tetrahydronaphthalene           | CDCl <sub>3</sub>             | 1.8                               | 2.8  | 7.1  |      |      |      |      |      | 1    |
| Tetrahydropyran                         | CCl <sub>4</sub>              | 1.6                               | 3.6  |      |      |      |      |      |      | 1    |
| Tetrahydrothiophene                     | CDCl <sub>3</sub>             | 1.9                               | 2.8  |      |      |      |      |      |      | 1    |
| Tetramethylsilane                       | CCl <sub>4</sub>              | 0.0                               |      |      |      |      |      |      |      | 1    |

| Compound                                    | Solvent           | HNMR shifts (ppm relative to TMS) |      |      |     |     |     |  | Ref. |
|---------------------------------------------|-------------------|-----------------------------------|------|------|-----|-----|-----|--|------|
|                                             |                   |                                   |      |      |     |     |     |  |      |
| Tetramethylurea                             | CCl <sub>4</sub>  | 2.8                               |      |      |     |     |     |  | 1    |
| Thiophene                                   | CDCl <sub>3</sub> | 7.1                               | 7.3  |      |     |     |     |  | 1    |
| Toluene                                     | CDCl <sub>3</sub> | 2.34                              | 7.18 |      |     |     |     |  | 2    |
| Tribromomethane (Bromoform)                 | CCl <sub>4</sub>  | 6.8                               |      |      |     |     |     |  | 1    |
| Tributylamine                               | CCl <sub>4</sub>  | 0.9                               | 1.3  | 2.3  |     |     |     |  | 1    |
| 1,1,1-Trichloroethane                       | CCl <sub>4</sub>  | 2.7                               |      |      |     |     |     |  | 1    |
| 1,1,2-Trichloroethane                       | CDCl <sub>3</sub> | 4.0                               | 5.8  |      |     |     |     |  | 1    |
| Trichloroethene                             | CCl <sub>4</sub>  | 6.5                               |      |      |     |     |     |  | 1    |
| Trichloroethylsilane                        | CCl <sub>4</sub>  | 1.3                               |      |      |     |     |     |  | 1    |
| Trichloromethane (Chloroform)               | CCl <sub>4</sub>  | 7.2                               |      |      |     |     |     |  | 1    |
| (Trichloromethyl)benzene (Benzotrichloride) | CCl <sub>4</sub>  | 7.3                               | 7.8  |      |     |     |     |  | 1    |
| Tridecane                                   | CCl <sub>4</sub>  | 0.9                               | 1.3  |      |     |     |     |  | 1    |
| Triethanolamine                             | D <sub>2</sub> O  | 2.7                               | 3.6  |      |     |     |     |  | 1    |
| Triethylamine                               | CCl <sub>4</sub>  | 1.0                               | 2.4  |      |     |     |     |  | 1    |
| Triethylene glycol                          | CDCl <sub>3</sub> | 3.5                               | 3.7  |      |     |     |     |  | 1    |
| Triethyl phosphate                          | CDCl <sub>3</sub> | 1.4                               | 4.1  |      |     |     |     |  | 1    |
| 2,2,2-Trifluoroethanol                      | CDCl <sub>3</sub> | 3.4                               | 3.9  |      |     |     |     |  | 1    |
| (Trifluoromethyl)benzene (Benzotrifluoride) | CCl <sub>4</sub>  | 7.5                               |      |      |     |     |     |  | 1    |
| Trimethylamine                              | CCl <sub>4</sub>  | 2.12                              |      |      |     |     |     |  | 2    |
| 1,2,3-Trimethylbenzene (Hemimellitene)      | CDCl <sub>3</sub> | 2.2                               | 2.3  | 7.0  |     |     |     |  | 1    |
| 1,2,4-Trimethylbenzene (Pseudocumene)       | CCl <sub>4</sub>  | 2.2                               | 6.8  |      |     |     |     |  | 1    |
| 1,3,5-Trimethylbenzene (Mesitylene)         | CDCl <sub>3</sub> | 2.3                               | 6.8  |      |     |     |     |  | 1    |
| 2,2,3-Trimethylbutane (Triptane)            | CCl <sub>4</sub>  | 0.8                               | 1.3  |      |     |     |     |  | 1    |
| 2,2,5-Trimethylhexane                       | CCl <sub>4</sub>  | 0.9                               | 1.2  |      |     |     |     |  | 1    |
| 2,3,3-Trimethylpentane                      | CCl <sub>4</sub>  | 0.8                               | 0.8  | 1.4  |     |     |     |  | 1    |
| 2,3,4-Trimethylpentane                      | CCl <sub>4</sub>  | 0.8                               | 1.9  |      |     |     |     |  | 1    |
| Trimethyl phosphate                         | CDCl <sub>3</sub> | 3.78                              |      |      |     |     |     |  | 2    |
| 2,4,6-Trimethylpyridine (2,4,6-Collidine)   | CCl <sub>4</sub>  | 2.2                               | 2.4  | 6.6  |     |     |     |  | 1    |
| 1-Undecene                                  | CCl <sub>4</sub>  | 0.9                               | 1.3  | 2.0  | 4.8 | 4.9 | 5.6 |  | 1    |
| Vinyl acetate                               | CDCl <sub>3</sub> | 2.1                               | 4.6  | 4.9  | 7.3 |     |     |  | 1    |
| <i>o</i> -Xylene                            | CDCl <sub>3</sub> | 2.22                              | 7.07 |      |     |     |     |  | 2    |
| <i>m</i> -Xylene                            | CDCl <sub>3</sub> | 2.28                              | 6.95 | 7.11 |     |     |     |  | 2    |
| <i>p</i> -Xylene                            | CDCl <sub>3</sub> | 2.30                              | 7.05 |      |     |     |     |  | 2    |

# BOND LENGTHS IN CRYSTALLINE ORGANIC COMPOUNDS

The following table gives average interatomic distances for bonds between the elements H, B, C, N, O, F, Si, P, S, Cl, As, Se, Br, Te, and I as determined from X-ray and neutron diffraction measurements on organic crystals. The table has been derived from an analysis of high-precision structure data on about 10,000 crystals contained in the 1985 version of the Cambridge Structural Database, which is maintained by the Cambridge Crystallographic Data Center. The explanation of the columns is:

Column 4:  $m$  is the median in Å units of all values.  
 Column 5:  $\sigma$  is the standard deviation in the sample.  
 Column 6:  $q_1$  is the lower quartile for the sample (i.e., 25% of values are less than  $q_1$  and 75% exceed it).  
 Column 7:  $q_u$  is the upper quartile for the sample.  
 Column 8:  $n$  is number of observations in the sample.  
 Column 9: Notes refer to the footnotes in Appendix 1.

Column 1: Specification of elements in the bond, with coordination number given in parentheses, and bond type (single, double, etc.). For carbon, the hybridization state is given.  
 Column 2: Substructure in which the bond is found. The target bond is set in boldface. Where X is not specified, it denotes any element type. C# indicates any sp<sup>3</sup> carbon atom, and C\* denotes an sp<sup>3</sup> carbon whose bonds, in addition to those specified in the linear formulation, are to C and H atoms only.  
 Column 3:  $d$  is the unweighted mean in Å units of all the values for that bond length found in the sample.

References to special cases are given in a shorthand form and listed in Appendix 2. Further information on the method of analysis of the data may be found in the reference cited below.

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## Reference

Frank H. Allen, Olga Kennard, David G. Watson, Lee Brammer, A. Guy Orpen, and Robin Taylor, *J. Chem. Soc. Perkin Trans. II*, S1–S19, 1987.

| Bond        | Substructure                                             | $d$   | $m$   | $\sigma$ | $q_1$ | $q_u$ | $n$ | Note |
|-------------|----------------------------------------------------------|-------|-------|----------|-------|-------|-----|------|
| As(3)–As(3) | X <sub>2</sub> – <b>As–As</b> –X <sub>2</sub>            | 2.459 | 2.457 | 0.011    | 2.456 | 2.466 | 8   |      |
| As–B        | see CUDLOC (2.065), CUDLUI (2.041)                       |       |       |          |       |       |     |      |
| As–BR       | see CODDEE, CODDII (2.346–3.203)                         |       |       |          |       |       |     |      |
| As(4)–C     | X <sub>3</sub> – <b>As–CH<sub>3</sub></b>                | 1.903 | 1.907 | 0.016    | 1.893 | 1.916 | 12  |      |
|             | (X) <sub>2</sub> (C,O,S)= <b>As–Csp<sup>3</sup></b>      | 1.927 | 1.929 | 0.017    | 1.921 | 1.937 | 16  |      |
|             | <b>As–Car</b> in Ph <sub>4</sub> As <sup>+</sup>         | 1.905 | 1.909 | 0.012    | 1.897 | 1.912 | 108 |      |
|             | (X) <sub>2</sub> (C,O,S)= <b>As–Car</b>                  | 1.922 | 1.927 | 0.016    | 1.908 | 1.934 | 36  |      |
| As(3)–C     | X <sub>2</sub> – <b>As–Csp<sup>3</sup></b>               | 1.963 | 1.965 | 0.017    | 1.948 | 1.978 | 6   |      |
|             | X <sub>2</sub> – <b>As–Car</b>                           | 1.956 | 1.956 | 0.015    | 1.944 | 1.964 | 41  |      |
| As(3)–Cl    | X <sub>2</sub> – <b>As–Cl</b>                            | 2.268 | 2.256 | 0.039    | 2.247 | 2.281 | 10  |      |
| As(6)–F     | in <b>AsF<sub>6</sub><sup>–</sup></b>                    | 1.678 | 1.676 | 0.020    | 1.659 | 1.695 | 36  |      |
| As(3)–I     | see OPIMAS (2.579, 2.590)                                |       |       |          |       |       |     |      |
| As(3)–N(3)  | X <sub>2</sub> – <b>As–N–X<sub>2</sub></b>               | 1.858 | 1.858 | 0.029    | 1.839 | 1.873 | 19  |      |
| As(4)=N(2)  | see TPASSN (1.837)                                       |       |       |          |       |       |     |      |
| As(4)–O     | (X) <sub>2</sub> (O=) <b>As–OH</b>                       | 1.710 | 1.712 | 0.017    | 1.695 | 1.726 | 6   |      |
| As(3)–O     | see ASAZOC, PHASOC01 (1.787–1.845)                       |       |       |          |       |       |     |      |
| As(4)=O     | X <sub>3</sub> – <b>As=O</b>                             | 1.661 | 1.661 | 0.016    | 1.652 | 1.667 | 9   |      |
| As(3)=P(3)  | see BELNIP (2.350, 2.362)                                |       |       |          |       |       |     | †    |
| As(3)–P(3)  | see BUTHAZ10 (2.124)                                     |       |       |          |       |       |     | †    |
| As(3)–S     | X <sub>2</sub> – <b>As–S</b>                             | 2.275 | 2.266 | 0.032    | 2.247 | 2.298 | 14  |      |
| As(4)=S     | X <sub>3</sub> – <b>As=S</b>                             | 2.083 | 2.082 | 0.004    | 2.080 | 2.086 | 9   |      |
| As(3)–Se(2) | see COSDIX, ESEARS (2.355–2.401)                         |       |       |          |       |       |     | †    |
| As(3)–Si(4) | see BICGEZ, MESIAD (2.351–2.365)                         |       |       |          |       |       |     | †    |
| As(3)–Te(2) | see ETEARS (2.571, 2.576)                                |       |       |          |       |       |     | †    |
| B(n)–B(n)   | $n = 5–7$ in boron cages                                 | 1.775 | 1.773 | 0.031    | 1.763 | 1.786 | 688 |      |
| B(4)–B(4)   | see CETTAW (2.041)                                       |       |       |          |       |       |     |      |
| B(4)–B(3)   | see COFVOI (1.698)                                       |       |       |          |       |       |     |      |
| B(3)–B(3)   | X <sub>2</sub> – <b>B–B–X<sub>2</sub></b>                | 1.701 | 1.700 | 0.014    | 1.691 | 1.712 | 8   |      |
| B(6)–BR     |                                                          | 1.967 | 1.971 | 0.014    | 1.954 | 1.979 | 7   | †    |
| B(4)–BR     |                                                          | 2.017 | 2.008 | 0.031    | 1.990 | 2.044 | 15  | †    |
| B(n)–C      | $n = 5–7$ : <b>B–C</b> in cages                          | 1.716 | 1.717 | 0.020    | 1.707 | 1.728 | 96  |      |
|             | $n = 3–4$ : <b>B–Csp<sup>3</sup></b> not cages           | 1.597 | 1.599 | 0.022    | 1.585 | 1.611 | 29  | 1    |
|             | $n = 4$ : <b>B–Car</b>                                   | 1.606 | 1.607 | 0.012    | 1.596 | 1.615 | 41  |      |
|             | $n = 4$ : <b>B–Car</b> in Ph <sub>4</sub> B <sup>–</sup> | 1.643 | 1.643 | 0.006    | 1.641 | 1.645 | 16  |      |
| B(n)–C      | $n = 3$ : <b>B–Car</b>                                   | 1.556 | 1.552 | 0.015    | 1.546 | 1.566 | 24  |      |
| B(n)–Cl     | <b>B(5)–Cl</b> and <b>B(3)–Cl</b>                        | 1.751 | 1.751 | 0.011    | 1.743 | 1.761 | 14  |      |

| Bond                                   | Substructure                                                                                                                                            | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>0</sub> | <i>n</i> | Note |
|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|------|
|                                        | <b>B(4)–Cl</b>                                                                                                                                          | 1.833    | 1.833    | 0.013    | 1.821                 | 1.843                 | 22       |      |
| B(4)–F                                 | <b>B–F</b> (B neutral)                                                                                                                                  | 1.366    | 1.368    | 0.017    | 1.356                 | 1.375                 | 25       |      |
|                                        | <b>B<sup>+</sup>–F</b> in BF <sub>4</sub> <sup>–</sup>                                                                                                  | 1.365    | 1.372    | 0.029    | 1.352                 | 1.390                 | 84       |      |
| B(4)–I                                 | see TMPBTI (2.220, 2.253)                                                                                                                               |          |          |          |                       |                       |          |      |
| B(4)–N(3)                              | X <sub>3</sub> – <b>B–N</b> (=C)(X)                                                                                                                     | 1.611    | 1.617    | 0.013    | 1.601                 | 1.625                 | 8        |      |
|                                        | in pyrazaboles                                                                                                                                          | 1.549    | 1.552    | 0.015    | 1.536                 | 1.560                 | 10       |      |
| B(3)–N(3)                              | X <sub>2</sub> – <b>B–N–C<sub>2</sub>: all coplanar<br/>for <math>\tau(\text{BN}) &gt; 30^\circ</math> see BOGSUL, BUSHAY, CILRUK<br/>(1.434–1.530)</b> | 1.404    | 1.404    | 0.014    | 1.389                 | 1.408                 | 40       | 2    |
|                                        | S <sub>2</sub> – <b>B–N–X<sub>2</sub></b>                                                                                                               | 1.447    | 1.443    | 0.013    | 1.435                 | 1.470                 | 14       |      |
| B(4)–O                                 | <b>B<sup>+</sup>–O</b> in BO <sub>4</sub> <sup>–</sup>                                                                                                  | 1.468    | 1.468    | 0.022    | 1.453                 | 1.479                 | 24       |      |
|                                        | for neutral B–O see Note 3                                                                                                                              |          |          |          |                       |                       |          | 3    |
| B(3)–O(2)                              | X <sub>2</sub> – <b>B–O–X</b>                                                                                                                           | 1.367    | 1.367    | 0.024    | 1.349                 | 1.382                 | 35       |      |
| B( <i>n</i> )–P                        | <i>n</i> = 4: <b>B–P</b>                                                                                                                                | 1.922    | 1.927    | 0.027    | 1.900                 | 1.954                 | 10       |      |
|                                        | <i>n</i> = 3: see BUPSI10 (1.892, 1.893)                                                                                                                |          |          |          |                       |                       |          |      |
| B(4)–S                                 | <b>B(4)–S(3)</b>                                                                                                                                        | 1.930    | 1.927    | 0.009    | 1.925                 | 1.934                 | 10       |      |
|                                        | <b>B(4)–S(2)</b>                                                                                                                                        | 1.896    | 1.896    | 0.004    | 1.893                 | 1.899                 | 6        |      |
| B(3)–S                                 | N– <b>B–S<sub>2</sub></b>                                                                                                                               | 1.806    | 1.806    | 0.010    | 1.799                 | 1.816                 | 28       |      |
|                                        | (=X–)(N–) <b>B–S</b>                                                                                                                                    | 1.851    | 1.854    | 0.013    | 1.842                 | 1.859                 | 10       |      |
| Br–Br                                  | see BEPZEB, TPASTB                                                                                                                                      | 2.542    | 2.548    | 0.015    | 2.526                 | 2.551                 | 4        |      |
| Br–C                                   | <b>Br–C<sup>*</sup></b>                                                                                                                                 | 1.966    | 1.967    | 0.029    | 1.951                 | 1.983                 | 100      | 4    |
|                                        | <b>Br–Csp<sup>3</sup></b> (cyclopropane)                                                                                                                | 1.910    | 1.910    | 0.010    | 1.900                 | 1.914                 | 8        |      |
|                                        | <b>Br–Csp<sup>2</sup></b>                                                                                                                               | 1.883    | 1.881    | 0.015    | 1.874                 | 1.894                 | 31       | 4    |
|                                        | <b>Br–Car</b> (mono-Br + <i>m.p.</i> -Br <sub>2</sub> )                                                                                                 | 1.899    | 1.899    | 0.012    | 1.892                 | 1.906                 | 119      | 4    |
|                                        | <b>Br–Car</b> (o-Br <sub>2</sub> )                                                                                                                      | 1.875    | 1.872    | 0.011    | 1.864                 | 1.884                 | 8        | 4    |
| –Br(2)–Cl                              | see TEACBR (2.362–2.402)                                                                                                                                |          |          |          |                       |                       |          | †    |
| Br–I                                   | see DTHIBR10 (2.646), TPHOSI (2.695)                                                                                                                    |          |          |          |                       |                       |          |      |
| Br–N                                   | see NBBZAM (1.843)                                                                                                                                      |          |          |          |                       |                       |          |      |
| Br–O                                   | see CIYFOF                                                                                                                                              | 1.581    | 1.581    | 0.007    | 1.574                 | 1.587                 | 4        |      |
| Br–P                                   | see CISTED (2.366)                                                                                                                                      |          |          |          |                       |                       |          |      |
| Br–S(2)                                | see BEMLIO (2.206)                                                                                                                                      |          |          |          |                       |                       |          | †    |
| Br–S(3)                                | see CIWYIQ (2.435, 2.453)                                                                                                                               |          |          |          |                       |                       |          | †    |
| Br–S(3) <sup>+</sup>                   | see THINBR (2.321)                                                                                                                                      |          |          |          |                       |                       |          | †    |
| Br–SE                                  | see CIFZUM (2.508, 2.619)                                                                                                                               |          |          |          |                       |                       |          |      |
| Br–Si                                  | see BIZJAV (2.284)                                                                                                                                      |          |          |          |                       |                       |          |      |
| Br–Te                                  | In <b>Br<sub>6</sub>Te<sup>2–</sup></b> see CUGBAH (2.692–2.716)                                                                                        |          |          |          |                       |                       |          |      |
|                                        | <b>Br–Te(4)</b> see BETUTE10 (3.079, 3.015)                                                                                                             |          |          |          |                       |                       |          |      |
|                                        | <b>Br–Te(3)</b> see BTUPTE (2.835)                                                                                                                      |          |          |          |                       |                       |          |      |
| <b>Csp<sup>3</sup>–Csp<sup>3</sup></b> | C#– <b>CH<sub>2</sub>–CH<sub>3</sub></b>                                                                                                                | 1.513    | 1.514    | 0.014    | 1.507                 | 1.523                 | 192      |      |
|                                        | (C#) <sub>2</sub> – <b>CH–CH<sub>3</sub></b>                                                                                                            | 1.524    | 1.526    | 0.015    | 1.518                 | 1.534                 | 226      |      |
|                                        | (C#) <sub>3</sub> – <b>C–CH<sub>3</sub></b>                                                                                                             | 1.534    | 1.534    | 0.011    | 1.527                 | 1.541                 | 825      |      |
|                                        | C#– <b>CH<sub>2</sub>–CH<sub>2</sub>–C#</b>                                                                                                             | 1.524    | 1.524    | 0.014    | 1.516                 | 1.532                 | 2459     |      |
|                                        | (C#) <sub>2</sub> – <b>CH–CH<sub>2</sub>–C#</b>                                                                                                         | 1.531    | 1.531    | 0.012    | 1.524                 | 1.538                 | 1217     |      |
|                                        | (C#) <sub>3</sub> – <b>C–CH<sub>2</sub>–C#</b>                                                                                                          | 1.538    | 1.539    | 0.010    | 1.533                 | 1.544                 | 330      |      |
|                                        | (C#) <sub>2</sub> – <b>CH–CH–(C#)<sub>2</sub></b>                                                                                                       | 1.542    | 1.542    | 0.011    | 1.536                 | 1.549                 | 321      |      |
|                                        | (C#) <sub>3</sub> – <b>C–CH–(C#)<sub>2</sub></b>                                                                                                        | 1.556    | 1.556    | 0.011    | 1.549                 | 1.562                 | 215      |      |
|                                        | (C#) <sub>3</sub> – <b>C–C–(C#)<sub>3</sub></b>                                                                                                         | 1.588    | 1.580    | 0.025    | 1.566                 | 1.610                 | 21       |      |
|                                        | <b>C*–C*</b> (overall)                                                                                                                                  | 1.530    | 1.530    | 0.015    | 1.521                 | 1.539                 | 5777     | 5,6  |
|                                        | in cyclopropane (any subst.)                                                                                                                            | 1.510    | 1.509    | 0.026    | 1.497                 | 1.523                 | 888      | 7    |
|                                        | in cyclobutane (any subst.)                                                                                                                             | 1.554    | 1.553    | 0.021    | 1.540                 | 1.567                 | 679      | 8    |
|                                        | in cyclopentane (C,H-subst.)                                                                                                                            | 1.543    | 1.543    | 0.018    | 1.532                 | 1.554                 | 1641     |      |
|                                        | in cyclohexane (C,H-subst.)                                                                                                                             | 1.535    | 1.535    | 0.016    | 1.525                 | 1.545                 | 2814     |      |
|                                        | cyclopropyl– <b>C*</b> (exocyclic)                                                                                                                      | 1.518    | 1.518    | 0.019    | 1.505                 | 1.531                 | 366      | 7    |
|                                        | cyclobutyl– <b>C*</b> (exocyclic)                                                                                                                       | 1.529    | 1.529    | 0.016    | 1.519                 | 1.539                 | 376      | 8    |
|                                        | cyclopentyl– <b>C*</b> (exocyclic)                                                                                                                      | 1.540    | 1.541    | 0.017    | 1.527                 | 1.549                 | 956      |      |
|                                        | cyclohexyl– <b>C*</b> (exocyclic)                                                                                                                       | 1.539    | 1.538    | 0.016    | 1.529                 | 1.549                 | 2682     |      |
|                                        | in cyclobutene (any subst.)                                                                                                                             | 1.573    | 1.574    | 0.017    | 1.566                 | 1.586                 | 25       | 8    |
|                                        | in cyclopentene (C,H-subst.)                                                                                                                            | 1.541    | 1.539    | 0.015    | 1.532                 | 1.549                 | 208      |      |
|                                        | in cyclohexene (C,H-subst.)                                                                                                                             | 1.541    | 1.541    | 0.020    | 1.528                 | 1.554                 | 586      |      |
|                                        | in oxirane (epoxide)                                                                                                                                    | 1.466    | 1.466    | 0.015    | 1.458                 | 1.474                 | 249      | 9    |
|                                        | in aziridine                                                                                                                                            | 1.480    | 1.481    | 0.021    | 1.465                 | 1.496                 | 67       | 9    |

| Bond                                   | Substructure                                          | <i>d</i> | <i>m</i> | $\sigma$ | $q_1$ | $q_u$ | <i>n</i> | Note  |
|----------------------------------------|-------------------------------------------------------|----------|----------|----------|-------|-------|----------|-------|
| <i>Csp<sup>3</sup>-Csp<sup>2</sup></i> | in oxetane                                            | 1.541    | 1.541    | 0.019    | 1.527 | 1.557 | 16       |       |
|                                        | in azetidine                                          | 1.548    | 1.543    | 0.018    | 1.536 | 1.558 | 22       |       |
|                                        | oxiranyl-C* (exocyclic)                               | 1.509    | 1.507    | 0.018    | 1.497 | 1.519 | 333      | 9     |
|                                        | aziridinyl-C* (exocyclic)                             | 1.512    | 1.512    | 0.018    | 1.496 | 1.526 | 13       | 9     |
|                                        | <b>CH<sub>3</sub>-C=C</b>                             | 1.503    | 1.504    | 0.011    | 1.497 | 1.509 | 215      |       |
|                                        | <b>C#-CH<sub>2</sub>-C=C</b>                          | 1.502    | 1.502    | 0.013    | 1.494 | 1.510 | 483      |       |
|                                        | <b>(C#)<sub>2</sub>-CH-C=C</b>                        | 1.510    | 1.510    | 0.014    | 1.501 | 1.518 | 564      |       |
| <i>Csp<sup>3</sup>-Csp<sup>2</sup></i> | <b>(C#)<sub>3</sub>-C-C=C</b>                         | 1.522    | 1.522    | 0.016    | 1.511 | 1.533 | 193      |       |
|                                        | <b>C*-C=C (overall)</b>                               | 1.507    | 1.507    | 0.015    | 1.499 | 1.517 | 1456     | 5     |
|                                        | <b>C*-C=C (endocyclic)</b>                            |          |          |          |       |       |          |       |
|                                        | in cyclopropene                                       | 1.509    | 1.508    | 0.016    | 1.500 | 1.516 | 20       | 10    |
|                                        | in cyclobutene                                        | 1.513    | 1.512    | 0.018    | 1.500 | 1.525 | 50       | 8     |
|                                        | in cyclopentene                                       | 1.512    | 1.512    | 0.014    | 1.502 | 1.521 | 208      |       |
|                                        | in cyclohexene                                        | 1.506    | 1.505    | 0.016    | 1.495 | 1.516 | 391      |       |
|                                        | in cyclopentadiene                                    | 1.502    | 1.503    | 0.019    | 1.490 | 1.515 | 18       |       |
|                                        | in cyclohexa-1,3-diene                                | 1.504    | 1.504    | 0.017    | 1.491 | 1.517 | 56       |       |
|                                        | <b>C*-C=C (exocyclic):</b>                            |          |          |          |       |       |          |       |
|                                        | cyclopropenyl-C*                                      | 1.478    | 1.475    | 0.012    | 1.470 | 1.485 | 7        | 10    |
|                                        | cyclobutenyl-C*                                       | 1.489    | 1.483    | 0.015    | 1.479 | 1.496 | 11       | 8     |
|                                        | cyclopentenyl-C*                                      | 1.504    | 1.506    | 0.012    | 1.495 | 1.512 | 115      |       |
|                                        | cyclohexenyl-C*                                       | 1.511    | 1.511    | 0.013    | 1.502 | 1.519 | 292      |       |
|                                        | <b>C*CH=O in aldehydes</b>                            | 1.510    | 1.510    | 0.008    | 1.501 | 1.518 | 7        |       |
|                                        | <b>(C*)<sub>2</sub>-C=O</b>                           |          |          |          |       |       |          |       |
|                                        | in ketones                                            | 1.511    | 1.511    | 0.015    | 1.501 | 1.521 | 952      | 11    |
|                                        | in cyclobutanone                                      | 1.529    | 1.530    | 0.016    | 1.514 | 1.545 | 18       |       |
|                                        | in cyclopentanone                                     | 1.514    | 1.514    | 0.016    | 1.505 | 1.523 | 312      |       |
|                                        | acyclic and 6 + rings                                 | 1.509    | 1.509    | 0.016    | 1.499 | 1.519 | 626      |       |
|                                        | <b>C*-COOH in carboxylic acids</b>                    | 1.502    | 1.502    | 0.014    | 1.495 | 1.510 | 176      |       |
|                                        | <b>C*-COO<sup>-</sup> in carboxylate anions</b>       | 1.520    | 1.521    | 0.011    | 1.516 | 1.528 | 57       |       |
|                                        | <b>C*-C(=O)(-OC*)</b>                                 |          |          |          |       |       |          |       |
|                                        | in acyclic esters                                     | 1.497    | 1.496    | 0.018    | 1.484 | 1.509 | 553      | 12    |
|                                        | in β-lactones                                         | 1.519    | 1.519    | 0.020    | 1.500 | 1.538 | 4        | 13    |
|                                        | in γ-lactones                                         | 1.512    | 1.512    | 0.015    | 1.501 | 1.521 | 110      | 12    |
|                                        | in δ-lactones                                         | 1.504    | 1.502    | 0.013    | 1.495 | 1.517 | 27       | 12    |
|                                        | cyclopropyl (C)-C=O in ketones, acids and esters      | 1.486    | 1.485    | 0.018    | 1.474 | 1.497 | 105      | 7     |
|                                        | <b>C*-C(=O)(-NH<sub>2</sub>) in acyclic amides</b>    | 1.514    | 1.512    | 0.016    | 1.506 | 1.526 | 32       | 14    |
|                                        | <b>C*-C(=O)(-NHC*) in acyclic amides</b>              | 1.506    | 1.505    | 0.012    | 1.498 | 1.515 | 78       | 14    |
|                                        | <b>C*-C(=O)[-N(C*)<sub>2</sub>] in acyclic amides</b> | 1.505    | 1.505    | 0.011    | 1.496 | 1.517 | 15       | 14    |
| <i>Csp<sup>3</sup>-Car</i>             | <b>CH<sub>3</sub>-Car</b>                             | 1.506    | 1.507    | 0.011    | 1.501 | 1.513 | 454      |       |
|                                        | <b>C#-CH<sub>2</sub>-Car</b>                          | 1.510    | 1.510    | 0.009    | 1.505 | 1.516 | 674      |       |
|                                        | <b>(C#)<sub>2</sub>-CH-Car</b>                        | 1.515    | 1.515    | 0.011    | 1.508 | 1.522 | 363      |       |
|                                        | <b>(C#)<sub>3</sub>-C-Car</b>                         | 1.527    | 1.530    | 0.016    | 1.517 | 1.539 | 308      |       |
|                                        | <b>C*-Car (overall)</b>                               | 1.513    | 1.513    | 0.014    | 1.505 | 1.521 | 1813     |       |
|                                        | <b>cyclopropyl (C)-Car</b>                            | 1.490    | 1.490    | 0.015    | 1.479 | 1.503 | 90       | 7     |
|                                        | <b>C*-C≡C</b>                                         | 1.466    | 1.465    | 0.010    | 1.460 | 1.469 | 21       | 15    |
| <i>Csp<sup>3</sup>-Csp<sup>1</sup></i> | <b>C#-C≡C</b>                                         | 1.472    | 1.472    | 0.012    | 1.464 | 1.481 | 88       | 15    |
|                                        | <b>C*-C≡N</b>                                         | 1.470    | 1.469    | 0.013    | 1.463 | 1.479 | 106      | 7b    |
|                                        | <b>cyclopropyl (C)-C≡N</b>                            | 1.444    | 1.447    | 0.010    | 1.436 | 1.451 | 38       | 7     |
| <i>Csp<sup>2</sup>-Csp<sup>2</sup></i> | <b>C=C-C=C</b>                                        |          |          |          |       |       |          |       |
|                                        | (conjugated)                                          | 1.455    | 1.455    | 0.011    | 1.447 | 1.463 | 30       | 16,18 |
|                                        | (unconjugated)                                        | 1.478    | 1.476    | 0.012    | 1.470 | 1.479 | 8        | 17,18 |
|                                        | (overall)                                             | 1.460    | 1.460    | 0.015    | 1.450 | 1.470 | 38       |       |
|                                        | <b>C=C-C=C-C=C</b>                                    | 1.443    | 1.445    | 0.013    | 1.431 | 1.454 | 29       | 18    |
|                                        | <b>C=C-C=C (endocyclic in TCNQ)</b>                   | 1.432    | 1.433    | 0.012    | 1.424 | 1.441 | 280      | 19    |
|                                        | <b>C=C-C(=O)(-C*)</b>                                 |          |          |          |       |       |          |       |
|                                        | (conjugated)                                          | 1.464    | 1.462    | 0.018    | 1.453 | 1.476 | 211      | 16,18 |
|                                        | (unconjugated)                                        | 1.484    | 1.486    | 0.017    | 1.475 | 1.497 | 14       | 17,18 |
|                                        | (overall)                                             | 1.465    | 1.462    | 0.018    | 1.453 | 1.478 | 226      |       |
|                                        | <b>C=C-C(=O)-C=C</b>                                  |          |          |          |       |       |          |       |
|                                        | in benzoquinone (C,H-subst. only)                     | 1.478    | 1.476    | 0.011    | 1.469 | 1.488 | 28       |       |
|                                        | in benzoquinone (any subst.)                          | 1.478    | 1.478    | 0.031    | 1.464 | 1.498 | 172      |       |

| Bond                                              | Substructure                                                                                             | <i>d</i> | <i>m</i> | $\sigma$ | $q_1$ | $q_u$ | <i>n</i> | Note  |
|---------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------|----------|----------|-------|-------|----------|-------|
|                                                   | non-quinonoid                                                                                            | 1.456    | 1.455    | 0.012    | 1.447 | 1.464 | 28       |       |
|                                                   | C=C-COOH                                                                                                 | 1.475    | 1.476    | 0.015    | 1.461 | 1.488 | 22       |       |
|                                                   | C=C-COOC*                                                                                                | 1.488    | 1.489    | 0.014    | 1.478 | 1.497 | 113      |       |
|                                                   | C=C-COO <sup>-</sup>                                                                                     | 1.502    | 1.499    | 0.017    | 1.488 | 1.510 | 11       |       |
|                                                   | HOOC-COOH                                                                                                | 1.538    | 1.537    | 0.007    | 1.535 | 1.541 | 9        |       |
|                                                   | HOOC-COO <sup>-</sup>                                                                                    | 1.549    | 1.552    | 0.009    | 1.546 | 1.553 | 13       |       |
|                                                   | <sup>-</sup> OOC-COO <sup>-</sup>                                                                        | 1.564    | 1.559    | 0.022    | 1.554 | 1.568 | 9        |       |
|                                                   | formal <i>Csp</i> <sup>2</sup> - <i>Csp</i> <sup>2</sup> single bond in selected non-fused heterocycles: |          |          |          |       |       |          |       |
|                                                   | in 1 <i>H</i> -pyrrole (C3-C4)                                                                           | 1.412    | 1.410    | 0.016    | 1.401 | 1.427 | 29       |       |
|                                                   | in furan (C3-C4)                                                                                         | 1.423    | 1.423    | 0.016    | 1.412 | 1.433 | 62       |       |
|                                                   | in thiophene (C3-C4)                                                                                     | 1.424    | 1.425    | 0.015    | 1.415 | 1.433 | 40       |       |
|                                                   | in pyrazole (C3-C4)                                                                                      | 1.410    | 1.412    | 0.016    | 1.400 | 1.418 | 20       |       |
|                                                   | in isoxazole (C3-C4)                                                                                     | 1.425    | 1.425    | 0.016    | 1.413 | 1.438 | 9        |       |
|                                                   | in furazan (C3-C4)                                                                                       | 1.428    | 1.427    | 0.007    | 1.422 | 1.435 | 6        |       |
|                                                   | in furoxan (C3-C4)                                                                                       | 1.417    | 1.417    | 0.006    | 1.412 | 1.422 | 14       |       |
| <i>Csp</i> <sup>2</sup> - <i>Car</i>              | C=C- <i>Car</i>                                                                                          |          |          |          |       |       |          |       |
|                                                   | (conjugated)                                                                                             | 1.470    | 1.470    | 0.015    | 1.463 | 1.480 | 37       | 16,18 |
| <i>Csp</i> <sup>2</sup> - <i>Car</i>              |                                                                                                          | 1.488    | 1.490    | 0.012    | 1.480 | 1.496 | 87       | 17,18 |
|                                                   | (overall)                                                                                                | 1.483    | 1.483    | 0.015    | 1.472 | 1.494 | 124      |       |
|                                                   | cyclopropenyl (C=C)- <i>Car</i>                                                                          | 1.447    | 1.448    | 0.006    | 1.441 | 1.452 | 8        | 10    |
|                                                   | <i>Car</i> -C(=O)-C*                                                                                     | 1.488    | 1.489    | 0.016    | 1.478 | 1.500 | 84       |       |
|                                                   | <i>Car</i> -C(=O)- <i>Car</i>                                                                            | 1.480    | 1.481    | 0.017    | 1.468 | 1.494 | 58       |       |
|                                                   | <i>Car</i> -COOH                                                                                         | 1.484    | 1.485    | 0.014    | 1.474 | 1.491 | 75       |       |
|                                                   | <i>Car</i> -C(=O)(-OC*)                                                                                  | 1.487    | 1.487    | 0.012    | 1.480 | 1.494 | 218      |       |
|                                                   | <i>Car</i> -COO <sup>-</sup>                                                                             | 1.504    | 1.509    | 0.014    | 1.495 | 1.512 | 26       |       |
|                                                   | <i>Car</i> -C(-O)-NH <sub>2</sub>                                                                        | 1.500    | 1.503    | 0.020    | 1.498 | 1.510 | 19       |       |
|                                                   | <i>Car</i> -C=N-C#                                                                                       |          |          |          |       |       |          |       |
|                                                   | (conjugated)                                                                                             | 1.476    | 1.478    | 0.014    | 1.466 | 1.486 | 27       | 16    |
|                                                   | (unconjugated)                                                                                           | 1.491    | 1.490    | 0.008    | 1.485 | 1.496 | 48       | 17    |
|                                                   | (overall)                                                                                                | 1.485    | 1.487    | 0.013    | 1.481 | 1.493 | 75       |       |
|                                                   | in indole (C3-C3a)                                                                                       | 1.434    | 1.434    | 0.011    | 1.428 | 1.439 | 40       |       |
| <i>Csp</i> <sup>2</sup> - <i>Csp</i> <sup>1</sup> | C=C-C≡C                                                                                                  | 1.431    | 1.427    | 0.014    | 1.425 | 1.441 | 11       | 7b    |
|                                                   | C=C-C≡N in TCNQ                                                                                          | 1.427    | 1.427    | 0.010    | 1.420 | 1.433 | 280      | 19    |
| <i>Car</i> - <i>Car</i>                           | in biphenyls ( <i>ortho</i> subst. all <b>H</b> )                                                        | 1.487    | 1.488    | 0.007    | 1.484 | 1.493 | 30       |       |
|                                                   | (≥1 non- <b>H</b> <i>ortho</i> -subst.)                                                                  | 1.490    | 1.491    | 0.010    | 1.486 | 1.495 | 212      |       |
| <i>Car</i> - <i>Csp</i> <sup>1</sup>              | <i>Car</i> -C≡C                                                                                          | 1.434    | 1.436    | 0.006    | 1.430 | 1.437 | 37       |       |
|                                                   | <i>Car</i> -C≡N                                                                                          | 1.443    | 1.444    | 0.008    | 1.436 | 1.448 | 31       |       |
| <i>Csp</i> <sup>1</sup> - <i>Csp</i> <sup>1</sup> | C≡C-C=C                                                                                                  | 1.377    | 1.378    | 0.012    | 1.374 | 1.384 | 21       |       |
| <i>Csp</i> <sup>2</sup> = <i>Csp</i> <sup>2</sup> | C*-CH=CH <sub>2</sub>                                                                                    | 1.299    | 1.300    | 0.027    | 1.280 | 1.311 | 42       |       |
|                                                   | (C*) <sub>2</sub> -C=CH <sub>2</sub>                                                                     | 1.321    | 1.321    | 0.013    | 1.313 | 1.328 | 77       |       |
|                                                   | C*-CH=CH-C*                                                                                              |          |          |          |       |       |          |       |
|                                                   | ( <i>cis</i> )                                                                                           | 1.317    | 1.318    | 0.013    | 1.310 | 1.323 | 106      |       |
|                                                   | ( <i>trans</i> )                                                                                         | 1.312    | 1.311    | 0.011    | 1.304 | 1.320 | 19       |       |
|                                                   | (overall)                                                                                                | 1.316    | 1.317    | 0.015    | 1.309 | 1.323 | 127      |       |
|                                                   | (C*) <sub>2</sub> -C=CH-C*                                                                               | 1.326    | 1.328    | 0.011    | 1.319 | 1.334 | 168      |       |
|                                                   | (C*) <sub>2</sub> -C=C-(C*) <sub>2</sub>                                                                 | 1.331    | 1.330    | 0.009    | 1.326 | 1.334 | 89       |       |
|                                                   | (C*,H) <sub>2</sub> -C=C-(C*,H) <sub>2</sub> (overall)                                                   | 1.322    | 1.323    | 0.014    | 1.315 | 1.331 | 493      | 5     |
|                                                   | in cyclopropene (any subst.)                                                                             | 1.294    | 1.288    | 0.017    | 1.284 | 1.302 | 10       | 10    |
|                                                   | in cyclobutene (any subst.)                                                                              | 1.335    | 1.335    | 0.019    | 1.324 | 1.347 | 25       | 8     |
|                                                   | in cyclopentene (C,H-subst.)                                                                             | 1.323    | 1.324    | 0.013    | 1.314 | 1.331 | 104      |       |
|                                                   | in cyclohexene (C,H-subst.)                                                                              | 1.326    | 1.325    | 0.012    | 1.318 | 1.334 | 196      |       |
|                                                   | C=C=C (allenes, any subst.)                                                                              | 1.307    | 1.307    | 0.005    | 1.303 | 1.310 | 18       |       |
|                                                   | C=C-C=C (C,H subst., conjugated)                                                                         | 1.330    | 1.330    | 0.014    | 1.322 | 1.338 | 76       | 16    |
|                                                   | C=C-C=C-C=C (C,H subst., conjugated)                                                                     | 1.345    | 1.345    | 0.012    | 1.337 | 1.350 | 58       | 16    |
|                                                   | C=C- <i>Car</i> (C,H subst., conjugated)                                                                 | 1.339    | 1.340    | 0.011    | 1.334 | 1.346 | 124      | 16    |
|                                                   | C=C in cyclopenta-1,3-diene (any subst.)                                                                 | 1.341    | 1.341    | 0.017    | 1.328 | 1.356 | 18       |       |
|                                                   | C=C in cyclohexa-1,3-diene (any subst.)                                                                  | 1.332    | 1.332    | 0.013    | 1.323 | 1.341 | 56       |       |
|                                                   | in C=C-C=O                                                                                               |          |          |          |       |       |          |       |
|                                                   | (C,H subst., conjugated)                                                                                 | 1.340    | 1.340    | 0.013    | 1.332 | 1.348 | 211      | 16,18 |
|                                                   | (C,H subst., unconjugated)                                                                               | 1.331    | 1.330    | 0.008    | 1.326 | 1.339 | 14       | 17,18 |

| Bond                                                     | Substructure                                            | <i>d</i> | <i>m</i> | $\sigma$ | $q_1$ | $q_u$ | <i>n</i> | Note |
|----------------------------------------------------------|---------------------------------------------------------|----------|----------|----------|-------|-------|----------|------|
|                                                          | (C,H subst., overall)                                   | 1.340    | 1.339    | 0.013    | 1.332 | 1.348 | 226      |      |
|                                                          | in cyclohexa-2,5-dien-1-ones                            | 1.329    | 1.327    | 0.011    | 1.321 | 1.335 | 28       |      |
|                                                          | in <i>p</i> -benzoquinones                              |          |          |          |       |       |          |      |
|                                                          | (C*,H subst.)                                           | 1.333    | 1.337    | 0.011    | 1.325 | 1.338 | 14       |      |
|                                                          | (any subst.)                                            | 1.349    | 1.339    | 0.030    | 1.330 | 1.364 | 86       |      |
|                                                          | in TCNQ                                                 |          |          |          |       |       |          |      |
|                                                          | (endocyclic)                                            | 1.352    | 1.353    | 0.010    | 1.345 | 1.358 | 142      | 19   |
|                                                          | (exocyclic)                                             | 1.392    | 1.391    | 0.017    | 1.379 | 1.405 | 139      | 19   |
|                                                          | C=C–OH in enol tautomers                                | 1.362    | 1.360    | 0.020    | 1.349 | 1.370 | 54       |      |
|                                                          | in heterocycles (any subst.):                           |          |          |          |       |       |          |      |
|                                                          | 1 <i>H</i> -pyrrole (C2–C3, C4–C5)                      | 1.375    | 1.377    | 0.018    | 1.361 | 1.388 | 58       |      |
|                                                          | furan (C2–C3, C4–C5)                                    | 1.341    | 1.342    | 0.021    | 1.329 | 1.351 | 125      |      |
|                                                          | thiophene (C2–C3, C4–C5)                                | 1.362    | 1.359    | 0.025    | 1.346 | 1.377 | 60       |      |
|                                                          | pyrazole (C4–C5)                                        | 1.369    | 1.372    | 0.019    | 1.362 | 1.383 | 20       |      |
|                                                          | imidazole (C4–C5)                                       | 1.360    | 1.361    | 0.014    | 1.352 | 1.367 | 44       |      |
|                                                          | isoxazole (C4–C5)                                       | 1.341    | 1.336    | 0.012    | 1.331 | 1.355 | 9        |      |
|                                                          | indole (C2–C3)                                          | 1.364    | 1.363    | 0.012    | 1.355 | 1.371 | 40       |      |
| <i>Car</i> $\simeq$ <i>Car</i>                           | in phenyl rings with C*, H subst. only                  |          |          |          |       |       |          |      |
|                                                          | H–C $\simeq$ C–H                                        | 1.380    | 1.381    | 0.013    | 1.372 | 1.388 | 2191     |      |
|                                                          | C*–C $\simeq$ C–H                                       | 1.387    | 1.388    | 0.010    | 1.382 | 1.393 | 891      |      |
|                                                          | C*–C $\simeq$ C–C*                                      | 1.397    | 1.397    | 0.009    | 1.392 | 1.403 | 182      |      |
|                                                          | C $\simeq$ C (overall)                                  | 1.384    | 1.384    | 0.013    | 1.375 | 1.391 | 3264     |      |
|                                                          | F–C $\simeq$ C–F                                        | 1.372    | 1.374    | 0.011    | 1.366 | 1.380 | 84       | 4    |
|                                                          | Cl–C $\simeq$ C–Cl                                      | 1.388    | 1.389    | 0.014    | 1.380 | 1.398 | 152      | 4    |
|                                                          | in naphthalene (D <sub>2h</sub> , any subst.)           |          |          |          |       |       |          |      |
|                                                          | C1–C2                                                   | 1.364    | 1.364    | 0.014    | 1.356 | 1.373 | 440      |      |
|                                                          | C2–C3                                                   | 1.406    | 1.406    | 0.014    | 1.397 | 1.415 | 218      |      |
|                                                          | C1–C8a                                                  | 1.420    | 1.419    | 0.012    | 1.412 | 1.426 | 440      |      |
|                                                          | C4a–C8a                                                 | 1.422    | 1.424    | 0.011    | 1.417 | 1.429 | 109      |      |
| <i>Car</i> $\simeq$ <i>Car</i>                           | in anthracene (D <sub>2h</sub> , any subst.)            |          |          |          |       |       |          |      |
|                                                          | C1–C2                                                   | 1.356    | 1.356    | 0.009    | 1.350 | 1.360 | 56       |      |
|                                                          | C2–C3                                                   | 1.410    | 1.410    | 0.010    | 1.401 | 1.416 | 34       |      |
|                                                          | C1–C9a                                                  | 1.430    | 1.430    | 0.006    | 1.426 | 1.434 | 56       |      |
|                                                          | C4a–C9a                                                 | 1.435    | 1.436    | 0.007    | 1.429 | 1.440 | 34       |      |
|                                                          | C9–C9a                                                  | 1.400    | 1.402    | 0.009    | 1.395 | 1.406 | 68       |      |
|                                                          | in pyridine (C,H subst.)                                | 1.379    | 1.381    | 0.012    | 1.371 | 1.387 | 276      | 20   |
|                                                          | (any subst.)                                            | 1.380    | 1.380    | 0.015    | 1.371 | 1.389 | 537      | 20   |
|                                                          | in pyridinium cation                                    |          |          |          |       |       |          |      |
|                                                          | (N <sup>+</sup> –H; C,H subst. on C)                    |          |          |          |       |       |          |      |
|                                                          | C2–C3                                                   | 1.373    | 1.375    | 0.012    | 1.368 | 1.380 | 30       |      |
|                                                          | C3–C4                                                   | 1.379    | 1.380    | 0.011    | 1.371 | 1.388 | 30       |      |
|                                                          | (N <sup>+</sup> –X; C,H subst. on C)                    |          |          |          |       |       |          |      |
|                                                          | C2–C3                                                   | 1.373    | 1.372    | 0.019    | 1.362 | 1.382 | 151      |      |
|                                                          | C3–C4                                                   | 1.383    | 1.385    | 0.019    | 1.372 | 1.394 | 151      |      |
|                                                          | in pyrazine (H subst. on C)                             | 1.379    | 1.377    | 0.010    | 1.370 | 1.388 | 10       |      |
|                                                          | (any subst. on C)                                       | 1.405    | 1.405    | 0.024    | 1.388 | 1.420 | 60       |      |
|                                                          | in pyrimidine (C,H subst. on C)                         | 1.387    | 1.389    | 0.018    | 1.379 | 1.400 | 28       |      |
| <i>Csp</i> <sup>1</sup> $\equiv$ <i>Csp</i> <sup>1</sup> | X–C $\equiv$ C–X                                        | 1.183    | 1.183    | 0.014    | 1.174 | 1.193 | 119      | 15   |
|                                                          | C,H–C $\equiv$ C–C,H                                    | 1.181    | 1.181    | 0.014    | 1.173 | 1.192 | 104      | 15   |
|                                                          | in C $\equiv$ C–C( <i>sp</i> <sup>2</sup> , <i>ar</i> ) | 1.189    | 1.193    | 0.010    | 1.181 | 1.195 | 38       | 15   |
|                                                          | in C $\equiv$ C–C $\equiv$ C                            | 1.192    | 1.192    | 0.010    | 1.187 | 1.197 | 42       | 15   |
|                                                          | in CH $\equiv$ C–C#                                     | 1.174    | 1.174    | 0.011    | 1.167 | 1.180 | 42       | 15   |
| <i>Csp</i> <sup>3</sup> –Cl                              | Omitting 1,2-dichlorides:                               |          |          |          |       |       |          |      |
|                                                          | C–CH <sub>2</sub> –Cl                                   | 1.790    | 1.790    | 0.007    | 1.783 | 1.795 | 13       | 4    |
|                                                          | C <sub>2</sub> –CH–Cl                                   | 1.803    | 1.802    | 0.003    | 1.800 | 1.807 | 8        | 4    |
|                                                          | C <sub>3</sub> –C–Cl                                    | 1.849    | 1.856    | 0.011    | 1.837 | 1.858 | 5        | 4    |
|                                                          | X–CH <sub>2</sub> –Cl (X = C,H,N,O)                     | 1.790    | 1.791    | 0.011    | 1.783 | 1.797 | 37       | 4    |
|                                                          | X <sub>2</sub> –CH–Cl (X = C,H,N,O)                     | 1.805    | 1.803    | 0.014    | 1.800 | 1.812 | 26       | 4    |
|                                                          | X <sub>3</sub> –C–Cl (X = C,H,N,O)                      | 1.843    | 1.838    | 0.014    | 1.835 | 1.858 | 7        | 4    |
|                                                          | X <sub>2</sub> –C–Cl <sub>2</sub> (X = C,H,N,O)         | 1.779    | 1.776    | 0.015    | 1.769 | 1.790 | 18       | 4    |
|                                                          | X–C–Cl <sub>3</sub> (X = C,H,N,O)                       | 1.768    | 1.765    | 0.011    | 1.761 | 1.776 | 33       | 4    |

| Bond                          | Substructure                                                     | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>u</sub> | <i>n</i> | Note |
|-------------------------------|------------------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|------|
| <i>Csp</i> <sup>2</sup> -Cl   | Cl-CH(-C)-CH(-C)-Cl                                              | 1.793    | 1.793    | 0.013    | 1.786                 | 1.800                 | 66       | 4    |
|                               | Cl-C(-C <sub>2</sub> )-C(-C <sub>2</sub> )-Cl                    | 1.762    | 1.760    | 0.010    | 1.757                 | 1.765                 | 54       | 4    |
|                               | cyclopropyl-Cl                                                   | 1.755    | 1.756    | 0.011    | 1.749                 | 1.763                 | 64       |      |
|                               | C=C-Cl (C,H,N,O subst. on C)                                     | 1.734    | 1.729    | 0.019    | 1.719                 | 1.748                 | 63       | 4    |
|                               | C=C-Cl <sub>2</sub> (C,H,N,O subst. on C)                        | 1.720    | 1.716    | 0.013    | 1.708                 | 1.729                 | 20       | 4    |
| <i>Car</i> -Cl                | Cl-C=C-Cl                                                        | 1.713    | 1.711    | 0.011    | 1.705                 | 1.720                 | 80       | 4    |
|                               | <i>Car</i> -Cl (mono-Cl + m,p-Cl <sub>2</sub> )                  | 1.739    | 1.741    | 0.010    | 1.734                 | 1.745                 | 340      | 4    |
|                               | <i>Car</i> -Cl ( <i>o</i> -Cl <sub>2</sub> )                     | 1.720    | 1.720    | 0.010    | 1.713                 | 1.717                 | 364      | 4    |
| <i>Csp</i> <sup>1</sup> Cl    | see HCLENE10 (1.634, 1.646)                                      |          |          |          |                       |                       |          |      |
| <i>Csp</i> <sup>3</sup> -F    | Omitting 1,2-difluorides                                         |          |          |          |                       |                       |          |      |
|                               | C-CH <sub>2</sub> -F and C <sub>2</sub> -CH-F                    | 1.399    | 1.399    | 0.017    | 1.389                 | 1.408                 | 25       | 4    |
|                               | C <sub>3</sub> -C-F                                              | 1.428    | 1.431    | 0.009    | 1.421                 | 1.435                 | 11       | 4    |
|                               | (C*,H) <sub>2</sub> -C-F <sub>2</sub>                            | 1.349    | 1.347    | 0.012    | 1.342                 | 1.356                 | 58       | 4    |
|                               | C*-C-F <sub>3</sub>                                              | 1.336    | 1.334    | 0.007    | 1.330                 | 1.344                 | 12       | 4    |
|                               | F-C*-C*-F                                                        | 1.371    | 1.374    | 0.007    | 1.362                 | 1.375                 | 26       | 4    |
|                               | X <sub>3</sub> -C-F (X = C,H,N,O)                                | 1.386    | 1.389    | 0.033    | 1.373                 | 1.408                 | 70       | 4    |
|                               | X <sub>2</sub> -C-F <sub>2</sub> (X = C,H,N,O)                   | 1.351    | 1.349    | 0.013    | 1.342                 | 1.356                 | 58       | 4    |
|                               | X-C-F <sub>3</sub> (X = C,H,N,O)                                 | 1.322    | 1.323    | 0.015    | 1.314                 | 1.332                 | 309      | 4    |
|                               | F-C(-X) <sub>2</sub> -C(-X) <sub>2</sub> -F (X = C,H,N,O)        | 1.373    | 1.374    | 0.009    | 1.362                 | 1.377                 | 30       | 4    |
|                               | F-C(-X) <sub>2</sub> -NO <sub>2</sub> (X = any subst.)           | 1.320    | 1.319    | 0.009    | 1.312                 | 1.327                 | 18       |      |
| <i>Csp</i> <sup>2</sup> -F    | C=C-F (C,H,N,O subst. on C)                                      | 1.340    | 1.340    | 0.013    | 1.334                 | 1.346                 | 34       | 4    |
| <i>Car</i> -F                 | <i>Car</i> -F (mono-F + m,p-F <sub>2</sub> )                     | 1.363    | 1.362    | 0.008    | 1.357                 | 1.368                 | 38       | 4    |
|                               | <i>Car</i> -F ( <i>o</i> -F <sub>2</sub> )                       | 1.340    | 1.340    | 0.009    | 1.336                 | 1.344                 | 167      | 4    |
| <i>Csp</i> <sup>3</sup> -H    | C-C-H <sub>3</sub> (methyl)                                      | 1.059    | 1.061    | 0.030    | 1.039                 | 1.083                 | 83       | 21   |
|                               | C <sub>2</sub> -C-H <sub>2</sub> (primary)                       | 1.092    | 1.095    | 0.013    | 1.088                 | 1.099                 | 100      | 21   |
|                               | C <sub>3</sub> -C-H (secondary)                                  | 1.099    | 1.097    | 0.004    | 1.095                 | 1.103                 | 14       | 21   |
|                               | C <sub>2,3</sub> -C-H (primary and secondary)                    | 1.093    | 1.095    | 0.012    | 1.089                 | 1.100                 | 118      | 21   |
|                               | X-C-H <sub>3</sub> (methyl)                                      | 1.066    | 1.074    | 0.028    | 1.049                 | 1.087                 | 160      | 21   |
|                               | X <sub>2</sub> -C-H <sub>2</sub> (primary)                       | 1.092    | 1.095    | 0.012    | 1.088                 | 1.099                 | 230      | 21   |
|                               | X <sub>3</sub> -C-H (secondary)                                  | 1.099    | 1.099    | 0.007    | 1.095                 | 1.103                 | 117      | 21   |
|                               | X <sub>2,3</sub> -C-H (primary and secondary)                    | 1.094    | 1.096    | 0.011    | 1.091                 | 1.100                 | 348      | 21   |
| <i>Csp</i> <sup>2</sup> -H    | C=C=C-H                                                          | 1.077    | 1.079    | 0.012    | 1.074                 | 1.085                 | 14       | 21   |
| <i>Car</i> -H                 | <i>Car</i> -H                                                    | 1.083    | 1.083    | 0.011    | 1.080                 | 1.087                 | 218      | 21   |
| <i>Csp</i> <sup>3</sup> -I    | C*-I                                                             | 2.162    | 2.159    | 0.015    | 2.149                 | 2.179                 | 15       | 4    |
| <i>Car</i> -I                 | <i>Car</i> -I                                                    | 2.095    | 2.095    | 0.015    | 2.089                 | 2.104                 | 51       | 4    |
| <i>Csp</i> <sup>3</sup> -N(4) | C*-NH <sub>3</sub> <sup>+</sup>                                  | 1.488    | 1.488    | 0.013    | 1.482                 | 1.495                 | 298      |      |
|                               | (C*) <sub>2</sub> -NH <sub>2</sub> <sup>+</sup>                  | 1.494    | 1.493    | 0.016    | 1.484                 | 1.503                 | 249      |      |
|                               | (C*) <sub>3</sub> -NH <sup>+</sup>                               | 1.502    | 1.502    | 0.015    | 1.491                 | 1.512                 | 509      |      |
|                               | (C*) <sub>4</sub> -N <sup>+</sup>                                | 1.510    | 1.509    | 0.020    | 1.496                 | 1.523                 | 319      |      |
|                               | C*-N <sup>+</sup> (overall)                                      | 1.499    | 1.498    | 0.018    | 1.488                 | 1.510                 | 1370     |      |
|                               | C*-N <sup>+</sup> in N-subst. pyridinium                         | 1.485    | 1.484    | 0.009    | 1.477                 | 1.490                 | 32       |      |
|                               | C*-NH <sub>2</sub> ( <i>Nsp</i> <sup>3</sup> : pyramidal)        | 1.469    | 1.470    | 0.010    | 1.462                 | 1.474                 | 19       | 22   |
|                               | (C*) <sub>2</sub> -NH ( <i>Nsp</i> <sup>3</sup> : pyramidal)     | 1.469    | 1.467    | 0.012    | 1.461                 | 1.477                 | 152      | 5,22 |
|                               | (C*) <sub>3</sub> -N ( <i>Nsp</i> <sup>3</sup> : pyramidal)      | 1.469    | 1.468    | 0.014    | 1.460                 | 1.476                 | 1042     | 5,22 |
|                               | C*- <i>Nsp</i> <sup>3</sup> (overall)                            | 1.469    | 1.468    | 0.014    | 1.460                 | 1.476                 | 1201     |      |
| <i>Csp</i> <sup>3</sup> -N(3) | <i>Csp</i> <sup>3</sup> - <i>Nsp</i> <sup>3</sup>                |          |          |          |                       |                       |          |      |
|                               | in aziridine                                                     | 1.472    | 1.471    | 0.016    | 1.464                 | 1.482                 | 134      |      |
|                               | in azetidine                                                     | 1.484    | 1.481    | 0.018    | 1.472                 | 1.495                 | 21       |      |
|                               | in tetrahydropyrrole                                             | 1.475    | 1.473    | 0.016    | 1.464                 | 1.483                 | 66       |      |
|                               | in piperidine                                                    | 1.473    | 1.473    | 0.013    | 1.460                 | 1.479                 | 240      |      |
|                               | <i>Csp</i> <sup>3</sup> - <i>Nsp</i> <sup>2</sup> (N planar) in: |          |          |          |                       |                       |          | 23   |
|                               | acyclic amides C*-NH-C=O                                         | 1.454    | 1.451    | 0.011    | 1.446                 | 1.461                 | 78       | 14   |
|                               | β-lactams C*-N(-X)-C=O (endo)                                    | 1.464    | 1.465    | 0.012    | 1.458                 | 1.475                 | 23       | 13   |
|                               | γ-lactams                                                        |          |          |          |                       |                       |          |      |
|                               | C*-NH-C=O (endo)                                                 | 1.457    | 1.458    | 0.011    | 1.449                 | 1.465                 | 20       | 13   |
|                               | C*-N(-C*)-C=O (endo)                                             | 1.462    | 1.461    | 0.010    | 1.453                 | 1.466                 | 15       | 13   |
|                               | C*-N(-C*)-C=O (exo)                                              | 1.458    | 1.456    | 0.014    | 1.448                 | 1.465                 | 15       | 13   |
|                               | δ-lactams                                                        |          |          |          |                       |                       |          |      |
|                               | C*-NH-C=O (endo)                                                 | 1.478    | 1.472    | 0.016    | 1.467                 | 1.491                 | 6        | 14   |
|                               | C*-N(-C*)-C=O (endo)                                             | 1.479    | 1.476    | 0.007    | 1.475                 | 1.482                 | 15       | 14   |
|                               | C*-N(-C*)-C=O (exo)                                              | 1.468    | 1.471    | 0.009    | 1.462                 | 1.477                 | 15       | 14   |



| Bond                   | Substructure                                                             | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>u</sub> | <i>n</i> | Note  |
|------------------------|--------------------------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|-------|
|                        | nitro compounds (1,2-dinitro omitted):                                   |          |          |          |                       |                       |          |       |
|                        | C-CH <sub>2</sub> -NO <sub>2</sub>                                       | 1.485    | 1.483    | 0.020    | 1.478                 | 1.502                 | 8        |       |
|                        | C <sub>2</sub> -CH-NO <sub>2</sub>                                       | 1.509    | 1.509    | 0.011    | 1.502                 | 1.511                 | 12       |       |
|                        | C <sub>3</sub> -C-NO <sub>2</sub>                                        | 1.533    | 1.533    | 0.013    | 1.530                 | 1.539                 | 17       |       |
|                        | C <sub>2</sub> -C-(NO <sub>2</sub> ) <sub>2</sub>                        | 1.537    | 1.536    | 0.016    | 1.525                 | 1.550                 | 19       |       |
|                        | 1,2-dinitro: NO <sub>2</sub> -C*-C*-NO <sub>2</sub>                      | 1.552    | 1.550    | 0.023    | 1.536                 | 1.572                 | 32       |       |
| Csp <sup>3</sup> -N(2) | C#-N=N                                                                   | 1.493    | 1.493    | 0.020    | 1.477                 | 1.506                 | 54       |       |
|                        | C*-N=C-Car                                                               | 1.465    | 1.468    | 0.011    | 1.461                 | 1.472                 | 75       |       |
| Csp <sup>2</sup> -N(3) | C=C-NH <sub>2</sub> Nsp <sup>2</sup> planar                              | 1.336    | 1.344    | 0.017    | 1.317                 | 1.348                 | 10       | 23    |
|                        | C=C-NH-C# Nsp <sup>2</sup> planar                                        | 1.339    | 1.340    | 0.016    | 1.327                 | 1.351                 | 17       | 23    |
|                        | C=C-N-(C#) <sub>2</sub>                                                  |          |          |          |                       |                       |          |       |
|                        | Nsp <sup>2</sup> planar                                                  | 1.355    | 1.358    | 0.014    | 1.341                 | 1.363                 | 22       | 23    |
|                        | Nsp <sup>3</sup> pyramidal                                               | 1.416    | 1.418    | 0.018    | 1.397                 | 1.432                 | 18       | 22    |
|                        | Csp <sup>2</sup> -Nsp <sup>2</sup> (N planar) in:                        |          |          |          |                       |                       |          | 23    |
|                        | acyclic amides                                                           |          |          |          |                       |                       |          |       |
|                        | NH <sub>2</sub> -C=O                                                     | 1.325    | 1.323    | 0.009    | 1.318                 | 1.331                 | 32       | 14    |
|                        | C*-NH-C=O                                                                | 1.334    | 1.333    | 0.011    | 1.326                 | 1.343                 | 78       | 14    |
|                        | (C*) <sub>2</sub> -N-C=O                                                 | 1.346    | 1.342    | 0.011    | 1.339                 | 1.356                 | 5        | 14    |
|                        | β-lactams C*-NH-C=O                                                      | 1.385    | 1.388    | 0.019    | 1.374                 | 1.396                 | 23       | 13    |
|                        | γ-lactams                                                                |          |          |          |                       |                       |          |       |
|                        | C*-NH-C=O                                                                | 1.331    | 1.331    | 0.011    | 1.326                 | 1.337                 | 20       | 13    |
|                        | C*-N(-C*)-C=O                                                            | 1.347    | 1.344    | 0.014    | 1.335                 | 1.359                 | 15       | 13    |
|                        | δ-lactams                                                                |          |          |          |                       |                       |          |       |
|                        | C*-NH-C=O                                                                | 1.334    | 1.334    | 0.006    | 1.330                 | 1.339                 | 6        | 14    |
|                        | (C*)-N(-C*)-C=O                                                          | 1.352    | 1.353    | 0.010    | 1.344                 | 1.356                 | 15       | 14    |
|                        | peptides C#-N(-X)-C(-C#)(=O)                                             | 1.333    | 1.334    | 0.013    | 1.326                 | 1.340                 | 380      | 24    |
|                        | ureas                                                                    |          |          |          |                       |                       |          |       |
|                        | (NH <sub>2</sub> ) <sub>2</sub> -C=O                                     | 1.334    | 1.334    | 0.008    | 1.329                 | 1.339                 | 48       | 25,26 |
|                        | (C#-NH) <sub>2</sub> -C=O                                                | 1.347    | 1.345    | 0.010    | 1.341                 | 1.354                 | 26       | 25    |
|                        | [(C#) <sub>n</sub> -N] <sub>2</sub> -C=O                                 | 1.363    | 1.359    | 0.014    | 1.354                 | 1.370                 | 40       | 25,27 |
|                        | thioureas                                                                | 1.346    | 1.343    | 0.023    | 1.328                 | 1.361                 | 192      |       |
|                        | (X <sub>2</sub> N) <sub>2</sub> -C=S                                     |          |          |          |                       |                       |          |       |
|                        | imides                                                                   |          |          |          |                       |                       |          |       |
|                        | [C#-C(=O)] <sub>2</sub> -NH                                              | 1.376    | 1.377    | 0.012    | 1.369                 | 1.383                 | 64       |       |
|                        | [C#-C(=O)] <sub>2</sub> -N-C#                                            | 1.389    | 1.383    | 0.017    | 1.376                 | 1.404                 | 38       |       |
|                        | [Csp <sup>2</sup> -C(=O)] <sub>2</sub> -N-C#                             | 1.396    | 1.396    | 0.010    | 1.389                 | 1.403                 | 46       |       |
|                        | [Csp <sup>2</sup> -C(=O)] <sub>2</sub> -N-Csp <sup>2</sup>               | 1.409    | 1.406    | 0.020    | 1.391                 | 1.419                 | 28       |       |
|                        | guanidinium [C-(NH <sub>2</sub> ) <sub>3</sub> ] <sup>+</sup> (unsubst.) | 1.321    | 1.320    | 0.008    | 1.314                 | 1.327                 | 39       |       |
|                        | (any subst.)                                                             | 1.328    | 1.325    | 0.015    | 1.317                 | 1.333                 | 140      |       |
|                        | in heterocyclic systems (any subst.)                                     |          |          |          |                       |                       |          |       |
|                        | 1H-pyrrole (N1-C2, N1-C5)                                                | 1.372    | 1.374    | 0.016    | 1.363                 | 1.384                 | 58       |       |
|                        | indole (N1-C2)                                                           | 1.370    | 1.370    | 0.012    | 1.364                 | 1.377                 | 40       |       |
|                        | pyrazole (N1-C5)                                                         | 1.357    | 1.359    | 0.012    | 1.347                 | 1.365                 | 20       |       |
|                        | imidazole (N1-C2)                                                        | 1.349    | 1.349    | 0.018    | 1.338                 | 1.358                 | 44       |       |
|                        | imidazole (N1-C5)                                                        | 1.370    | 1.370    | 0.010    | 1.365                 | 1.377                 | 44       |       |
| Csp <sup>2</sup> -N(2) | in imidazole (N3-C4)                                                     | 1.376    | 1.377    | 0.011    | 1.369                 | 1.384                 | 44       |       |
| Car-N(4)               | Car-N <sup>+</sup> -(C,H) <sub>3</sub>                                   | 1.465    | 1.466    | 0.007    | 1.461                 | 1.470                 | 23       |       |
| Car-N(3)               | Car-NH <sub>2</sub>                                                      |          |          |          |                       |                       |          |       |
|                        | (Nsp <sup>2</sup> ; planar)                                              | 1.355    | 1.360    | 0.020    | 1.340                 | 1.372                 | 33       | 23    |
|                        | (Nsp <sup>3</sup> ; pyramidal)                                           | 1.394    | 1.396    | 0.011    | 1.385                 | 1.403                 | 25       | 22    |
|                        | (overall)                                                                | 1.375    | 1.377    | 0.025    | 1.363                 | 1.394                 | 98       | 28    |
| Car-N(3)               | Car-NH-C#                                                                |          |          |          |                       |                       |          |       |
|                        | (Nsp <sup>2</sup> ; planar)                                              | 1.353    | 1.353    | 0.007    | 1.347                 | 1.359                 | 16       | 23    |
|                        | (Nsp <sup>3</sup> ; pyramidal)                                           | 1.419    | 1.423    | 0.017    | 1.412                 | 1.432                 | 8        | 22    |
|                        | (overall)                                                                | 1.380    | 1.364    | 0.032    | 1.353                 | 1.412                 | 31       | 28    |
|                        | Car-N-(C#) <sub>2</sub>                                                  |          |          |          |                       |                       |          |       |
|                        | (Nsp <sup>2</sup> ; planar)                                              | 1.371    | 1.370    | 0.016    | 1.363                 | 1.382                 | 41       | 23    |
|                        | (Nsp <sup>3</sup> ; pyramidal)                                           | 1.426    | 1.425    | 0.011    | 1.421                 | 1.431                 | 22       | 22    |
|                        | (overall)                                                                | 1.390    | 1.385    | 0.030    | 1.366                 | 1.420                 | 69       | 28    |
|                        | in indole (N1-C7a)                                                       | 1.372    | 1.372    | 0.007    | 1.367                 | 1.376                 | 40       |       |
|                        | Car-NO <sub>2</sub>                                                      | 1.468    | 1.469    | 0.014    | 1.460                 | 1.476                 | 556      |       |

| Bond                                  | Substructure                                             | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>0</sub> | <i>n</i> | Note  |
|---------------------------------------|----------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|-------|
| <i>Car</i> -N(2)                      | <i>Car</i> -N=N                                          | 1.431    | 1.435    | 0.020    | 1.422                 | 1.442                 | 26       |       |
| <i>Csp</i> <sup>2</sup> =N(3)         | in furoxan ( <sup>+</sup> N2=C3)                         | 1.316    | 1.316    | 0.009    | 1.311                 | 1.324                 | 14       |       |
| <i>Csp</i> <sup>2</sup> =N(2)         | <i>Car</i> -C=N-C#                                       | 1.279    | 1.279    | 0.008    | 1.275                 | 1.285                 | 75       |       |
|                                       | (C,H) <sub>2</sub> -C=N-OH in oximes                     | 1.281    | 1.280    | 0.013    | 1.273                 | 1.288                 | 67       |       |
|                                       | S-C=N-X                                                  | 1.302    | 1.302    | 0.021    | 1.285                 | 1.319                 | 36       |       |
|                                       | in pyrazole (N2=C3)                                      | 1.329    | 1.331    | 0.014    | 1.315                 | 1.339                 | 20       |       |
|                                       | in imidazole (C2=N3)                                     | 1.313    | 1.314    | 0.011    | 1.307                 | 1.319                 | 44       |       |
|                                       | in isoxazole (N2=C3)                                     | 1.314    | 1.315    | 0.009    | 1.305                 | 1.320                 | 9        |       |
|                                       | in furazan (N2=C3, C4=N5)                                | 1.298    | 1.299    | 0.006    | 1.294                 | 1.303                 | 12       |       |
|                                       | in furoxan (C4=N5)                                       | 1.304    | 1.306    | 0.008    | 1.300                 | 1.308                 | 14       |       |
| <i>Car</i> $\simeq$ N(3)              | C $\simeq$ N <sup>+</sup> -H (pyrimidinium)              | 1.335    | 1.334    | 0.015    | 1.325                 | 1.342                 | 30       |       |
|                                       | C $\simeq$ N <sup>+</sup> -C* (pyrimidinium)             | 1.346    | 1.346    | 0.010    | 1.340                 | 1.352                 | 64       |       |
|                                       | C $\simeq$ N <sup>+</sup> -O <sup>-</sup> (pyrimidinium) | 1.362    | 1.359    | 0.013    | 1.353                 | 1.369                 | 56       |       |
| <i>Car</i> $\simeq$ N(2)              | C $\simeq$ N (pyridine)                                  | 1.337    | 1.338    | 0.012    | 1.330                 | 1.344                 | 269      |       |
|                                       | C $\simeq$ N (pyrazine)                                  | 1.336    | 1.335    | 0.022    | 1.319                 | 1.347                 | 120      |       |
|                                       | C $\simeq$ N $\simeq$ C (pyrimidine)                     | 1.339    | 1.338    | 0.015    | 1.333                 | 1.342                 | 28       |       |
|                                       | N $\simeq$ C $\simeq$ N (pyrimidine)                     | 1.333    | 1.335    | 0.013    | 1.326                 | 1.337                 | 28       |       |
|                                       | C $\simeq$ N (pyrimidine) (overall)                      | 1.336    | 1.337    | 0.014    | 1.331                 | 1.339                 | 56       |       |
|                                       | in any 6-membered N-containing aromatic ring:            |          |          |          |                       |                       |          |       |
|                                       | H-C $\simeq$ N $\simeq$ C-H                              | 1.334    | 1.334    | 0.014    | 1.327                 | 1.341                 | 146      |       |
|                                       | H-C $\simeq$ N $\simeq$ C-C*                             | 1.339    | 1.341    | 0.013    | 1.336                 | 1.345                 | 38       |       |
|                                       | C*-C $\simeq$ N $\simeq$ C-C*                            | 1.345    | 1.345    | 0.008    | 1.342                 | 1.348                 | 24       |       |
|                                       | C $\simeq$ N $\simeq$ C (overall)                        | 1.336    | 1.337    | 0.014    | 1.329                 | 1.344                 | 204      |       |
| <i>Csp</i> <sup>1</sup> $\equiv$ N(2) | X-S-N $\equiv$ C <sup>-</sup> (isothiocyanide)           | 1.144    | 1.147    | 0.006    | 1.140                 | 1.148                 | 6        |       |
| <i>Csp</i> <sup>1</sup> $\equiv$ N(1) | C*-C $\equiv$ N                                          | 1.136    | 1.137    | 0.010    | 1.131                 | 1.142                 | 140      |       |
|                                       | C=C-C $\equiv$ N in TCNQ                                 | 1.144    | 1.144    | 0.008    | 1.139                 | 1.149                 | 284      | 19    |
|                                       | <i>Car</i> -C $\equiv$ N                                 | 1.138    | 1.138    | 0.007    | 1.133                 | 1.143                 | 31       |       |
|                                       | X-C $\equiv$ N                                           | 1.144    | 1.141    | 0.012    | 1.138                 | 1.151                 | 10       |       |
|                                       | (S-C $\equiv$ N) <sup>-</sup>                            | 1.155    | 1.156    | 0.012    | 1.147                 | 1.165                 | 14       |       |
| <i>Csp</i> <sup>3</sup> -O(2)         | in alcohols                                              |          |          |          |                       |                       |          |       |
|                                       | CH <sub>3</sub> -OH                                      | 1.413    | 1.414    | 0.018    | 1.395                 | 1.425                 | 17       |       |
|                                       | C-CH <sub>2</sub> -OH                                    | 1.426    | 1.426    | 0.011    | 1.420                 | 1.431                 | 75       |       |
|                                       | C <sub>2</sub> -CH-OH                                    | 1.432    | 1.431    | 0.011    | 1.425                 | 1.439                 | 266      |       |
|                                       | C <sub>3</sub> -C-OH                                     | 1.440    | 1.440    | 0.012    | 1.432                 | 1.449                 | 106      |       |
|                                       | C*-OH (overall)                                          | 1.432    | 1.431    | 0.013    | 1.424                 | 1.441                 | 464      |       |
|                                       | in dialkyl ethers                                        |          |          |          |                       |                       |          | 29    |
|                                       | CH <sub>3</sub> -O-C*                                    | 1.416    | 1.418    | 0.016    | 1.405                 | 1.426                 | 110      |       |
|                                       | C-CH <sub>2</sub> -O-C*                                  | 1.426    | 1.424    | 0.011    | 1.418                 | 1.435                 | 34       |       |
|                                       | C <sub>2</sub> -CH-O-C*                                  | 1.429    | 1.430    | 0.010    | 1.420                 | 1.437                 | 53       |       |
|                                       | C <sub>3</sub> -C-O-C*                                   | 1.452    | 1.450    | 0.011    | 1.445                 | 1.458                 | 39       |       |
|                                       | C*-O-C* (overall)                                        | 1.426    | 1.425    | 0.019    | 1.414                 | 1.437                 | 236      | 5     |
|                                       | in aryl alkyl ethers                                     |          |          |          |                       |                       |          | 29    |
|                                       | CH <sub>3</sub> -O- <i>Car</i>                           | 1.424    | 1.424    | 0.012    | 1.417                 | 1.431                 | 616      |       |
|                                       | C-CH <sub>2</sub> -O- <i>Car</i>                         | 1.431    | 1.430    | 0.013    | 1.422                 | 1.438                 | 188      |       |
|                                       | C <sub>2</sub> -CH-O- <i>Car</i>                         | 1.447    | 1.446    | 0.020    | 1.435                 | 1.466                 | 58       |       |
|                                       | C <sub>3</sub> -C-O- <i>Car</i>                          | 1.470    | 1.469    | 0.018    | 1.456                 | 1.483                 | 55       |       |
|                                       | C*-O- <i>Car</i> (overall)                               | 1.429    | 1.427    | 0.018    | 1.419                 | 1.436                 | 917      |       |
|                                       | in alkyl esters of carboxylic acids                      |          |          |          |                       |                       |          | 12,29 |
|                                       | CH <sub>3</sub> -O-C(=O)-C*                              | 1.448    | 1.449    | 0.010    | 1.442                 | 1.455                 | 200      |       |
|                                       | C-CH <sub>2</sub> -O-C(=O)-C*                            | 1.452    | 1.453    | 0.009    | 1.445                 | 1.458                 | 32       |       |
|                                       | C <sub>2</sub> -CH-O-C(=O)-C*                            | 1.460    | 1.460    | 0.010    | 1.454                 | 1.465                 | 78       |       |
|                                       | C <sub>3</sub> -C-O-C(=O)-C*                             | 1.477    | 1.475    | 0.008    | 1.472                 | 1.484                 | 6        |       |
|                                       | C*-O-C(=O)-C* (overall)                                  | 1.450    | 1.451    | 0.014    | 1.442                 | 1.459                 | 314      |       |
|                                       | in alkyl esters of $\alpha,\beta$ -unsaturated acids:    |          |          |          |                       |                       |          |       |
|                                       | C*-O-C(=O)-C=C (overall)                                 | 1.453    | 1.452    | 0.013    | 1.444                 | 1.459                 | 112      |       |
|                                       | in alkyl esters of benzoic acid                          |          |          |          |                       |                       |          |       |
|                                       | C*-O-C(=O)-C(phenyl) (overall)                           | 1.454    | 1.454    | 0.012    | 1.446                 | 1.463                 | 219      |       |
|                                       | in ring systems                                          |          |          |          |                       |                       |          |       |
|                                       | oxirane (epoxides) (any subst.)                          | 1.446    | 1.446    | 0.014    | 1.438                 | 1.456                 | 498      | 9     |
|                                       | oxetane (any subst.)                                     | 1.463    | 1.460    | 0.015    | 1.451                 | 1.474                 | 16       |       |
|                                       | tetrahydrofuran (C,H subst.)                             | 1.442    | 1.441    | 0.017    | 1.430                 | 1.451                 | 154      |       |

| Bond                          | Substructure                                                                                     | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>0</sub> | <i>n</i> | Note  |
|-------------------------------|--------------------------------------------------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|-------|
| <i>Csp</i> <sup>3</sup> –O(2) | tetrahydropyran (C,H subst.)                                                                     | 1.441    | 1.442    | 0.015    | 1.431                 | 1.451                 | 22       |       |
|                               | β-lactones: C*–O–C(=O)                                                                           | 1.492    | 1.494    | 0.010    | 1.481                 | 1.501                 | 4        | 16    |
|                               | γ-lactones: C*–O–C(=O)                                                                           | 1.464    | 1.464    | 0.012    | 1.455                 | 1.473                 | 110      | 12    |
|                               | δ-lactones: C*–O–C(=O)                                                                           | 1.461    | 1.464    | 0.017    | 1.452                 | 1.473                 | 27       | 12    |
|                               | O–C–O system in <i>gem</i> -diols, and pyranose and furanose sugars:                             |          |          |          |                       |                       |          | 30,31 |
|                               | HO–C*–OH                                                                                         | 1.397    | 1.401    | 0.012    | 1.388                 | 1.405                 | 18       |       |
|                               | C <sub>5</sub> –O <sub>5</sub> –C <sub>1</sub> –O <sub>1</sub> H in pyranoses                    |          |          |          |                       |                       |          |       |
|                               | O <sub>1</sub> axial (α):                                                                        |          |          |          |                       |                       |          |       |
|                               | C <sub>5</sub> –O <sub>5</sub>                                                                   | 1.439    | 1.440    | 0.008    | 1.432                 | 1.445                 | 29       |       |
|                               | O <sub>5</sub> –C <sub>1</sub>                                                                   | 1.427    | 1.426    | 0.012    | 1.421                 | 1.432                 | 29       |       |
|                               | C <sub>1</sub> –O <sub>1</sub>                                                                   | 1.403    | 1.400    | 0.012    | 1.391                 | 1.412                 | 29       |       |
|                               | O <sub>1</sub> equatorial (β):                                                                   |          |          |          |                       |                       |          |       |
|                               | C <sub>5</sub> –O <sub>5</sub>                                                                   | 1.435    | 1.436    | 0.008    | 1.429                 | 1.440                 | 17       |       |
|                               | O <sub>5</sub> –C <sub>1</sub>                                                                   | 1.430    | 1.431    | 0.010    | 1.424                 | 1.436                 | 17       |       |
|                               | C <sub>1</sub> –O <sub>1</sub>                                                                   | 1.393    | 1.393    | 0.007    | 1.386                 | 1.399                 | 17       |       |
|                               | α + β (overall):                                                                                 |          |          |          |                       |                       |          |       |
|                               | C <sub>5</sub> –O <sub>5</sub>                                                                   | 1.439    | 1.440    | 0.008    | 1.432                 | 1.446                 | 60       |       |
|                               | O <sub>5</sub> –C <sub>1</sub>                                                                   | 1.430    | 1.429    | 0.012    | 1.421                 | 1.436                 | 60       |       |
|                               | C <sub>1</sub> –O <sub>1</sub>                                                                   | 1.401    | 1.399    | 0.011    | 1.392                 | 1.407                 | 60       |       |
|                               | C <sub>4</sub> –O <sub>4</sub> –C <sub>1</sub> –O <sub>1</sub> H in furanoses (overall values)   |          |          |          |                       |                       |          |       |
|                               | C <sub>4</sub> –O <sub>4</sub>                                                                   | 1.442    | 1.446    | 0.012    | 1.436                 | 1.449                 | 18       |       |
|                               | O <sub>4</sub> –C <sub>1</sub>                                                                   | 1.432    | 1.432    | 0.012    | 1.421                 | 1.443                 | 18       |       |
|                               | C <sub>1</sub> –O <sub>1</sub>                                                                   | 1.404    | 1.405    | 0.013    | 1.397                 | 1.409                 | 18       |       |
|                               | C <sub>5</sub> –O <sub>5</sub> –C <sub>1</sub> –O <sub>1</sub> –C* in pyranoses                  |          |          |          |                       |                       |          |       |
|                               | O <sub>1</sub> axial (α):                                                                        |          |          |          |                       |                       |          |       |
|                               | C <sub>5</sub> –O <sub>5</sub>                                                                   | 1.439    | 1.438    | 0.010    | 1.433                 | 1.446                 | 67       |       |
|                               | O <sub>5</sub> –C <sub>1</sub>                                                                   | 1.417    | 1.417    | 0.009    | 1.410                 | 1.424                 | 67       |       |
|                               | C <sub>1</sub> –O <sub>1</sub>                                                                   | 1.409    | 1.409    | 0.014    | 1.401                 | 1.417                 | 67       |       |
|                               | O <sub>1</sub> –C*                                                                               | 1.435    | 1.435    | 0.013    | 1.427                 | 1.443                 | 67       |       |
|                               | O <sub>1</sub> equatorial (β):                                                                   |          |          |          |                       |                       |          |       |
|                               | C <sub>5</sub> –O <sub>5</sub>                                                                   | 1.434    | 1.435    | 0.006    | 1.429                 | 1.439                 | 39       |       |
|                               | O <sub>5</sub> –C <sub>1</sub>                                                                   | 1.424    | 1.424    | 0.008    | 1.418                 | 1.431                 | 39       |       |
|                               | C <sub>1</sub> –O <sub>1</sub>                                                                   | 1.390    | 1.390    | 0.011    | 1.381                 | 1.400                 | 39       |       |
|                               | O <sub>1</sub> –C*                                                                               | 1.437    | 1.438    | 0.013    | 1.428                 | 1.445                 | 39       |       |
|                               | α + β (overall):                                                                                 |          |          |          |                       |                       |          |       |
|                               | C <sub>5</sub> –O <sub>5</sub>                                                                   | 1.436    | 1.436    | 0.009    | 1.431                 | 1.442                 | 126      |       |
|                               | O <sub>5</sub> –C <sub>1</sub>                                                                   | 1.419    | 1.419    | 0.011    | 1.412                 | 1.426                 | 126      |       |
|                               | C <sub>1</sub> –O <sub>1</sub>                                                                   | 1.402    | 1.403    | 0.016    | 1.391                 | 1.413                 | 126      |       |
|                               | O <sub>1</sub> –C*                                                                               | 1.436    | 1.436    | 0.013    | 1.428                 | 1.445                 | 126      |       |
|                               | C <sub>4</sub> –O <sub>4</sub> –C <sub>1</sub> –O <sub>1</sub> –C* in furanoses (overall values) |          |          |          |                       |                       |          |       |
|                               | C <sub>4</sub> –O <sub>4</sub>                                                                   | 1.443    | 1.445    | 0.013    | 1.429                 | 1.453                 | 23       |       |
|                               | O <sub>4</sub> –C <sub>1</sub>                                                                   | 1.421    | 1.418    | 0.012    | 1.413                 | 1.431                 | 23       |       |
|                               | C <sub>1</sub> –O <sub>1</sub>                                                                   | 1.410    | 1.409    | 0.014    | 1.401                 | 1.420                 | 23       |       |
|                               | O <sub>1</sub> –C*                                                                               | 1.439    | 1.437    | 0.014    | 1.429                 | 1.449                 | 23       |       |
|                               | Miscellaneous:                                                                                   |          |          |          |                       |                       |          |       |
|                               | C#–O–SiX <sub>3</sub>                                                                            | 1.416    | 1.416    | 0.017    | 1.405                 | 1.428                 | 29       |       |
|                               | C*–O–SO <sub>2</sub> –C                                                                          | 1.465    | 1.461    | 0.014    | 1.454                 | 1.475                 | 33       |       |
| <i>Csp</i> <sup>2</sup> –O(2) | in enols: C=C–OH                                                                                 | 1.333    | 1.331    | 0.017    | 1.324                 | 1.342                 | 53       |       |
|                               | in enol esters: C=C–O–C*                                                                         | 1.354    | 1.353    | 0.016    | 1.341                 | 1.363                 | 40       |       |
|                               | in acids:                                                                                        |          |          |          |                       |                       |          |       |
|                               | C*–C(=O)–OH                                                                                      | 1.308    | 1.311    | 0.019    | 1.298                 | 1.320                 | 174      |       |
|                               | C=C–C(=O)–OH                                                                                     | 1.293    | 1.295    | 0.019    | 1.279                 | 1.307                 | 22       |       |
|                               | Car–C(=O)–OH                                                                                     | 1.305    | 1.311    | 0.020    | 1.291                 | 1.317                 | 75       |       |
|                               | in esters:                                                                                       |          |          |          |                       |                       |          |       |
|                               | C*–C(=O)–O–C*                                                                                    | 1.336    | 1.337    | 0.014    | 1.328                 | 1.346                 | 551      | 12,29 |
|                               | C=C–C(=O)–O–C*                                                                                   | 1.332    | 1.331    | 0.011    | 1.324                 | 1.339                 | 112      |       |
|                               | Car–C(=O)–O–C*                                                                                   | 1.337    | 1.335    | 0.013    | 1.329                 | 1.344                 | 219      | 12    |
|                               | C*–C(=O)–O–C=C                                                                                   | 1.362    | 1.359    | 0.018    | 1.351                 | 1.374                 | 26       |       |
|                               | C*–C(=O)–O–C=C                                                                                   | 1.407    | 1.405    | 0.017    | 1.394                 | 1.420                 | 26       |       |

| Bond                   | Substructure                                                  | <i>d</i> | <i>m</i> | $\sigma$ | $q_1$ | $q_u$ | <i>n</i> | Note  |
|------------------------|---------------------------------------------------------------|----------|----------|----------|-------|-------|----------|-------|
|                        | C <sup>*</sup> –C(=O)–O–Car                                   | 1.360    | 1.359    | 0.011    | 1.355 | 1.367 | 40       | 12    |
|                        | in anhydrides: O=C–O–C=O                                      | 1.386    | 1.386    | 0.011    | 1.379 | 1.393 | 70       |       |
|                        | in ring systems:                                              |          |          |          |       |       |          |       |
|                        | furan (O1–C2, O1–C5)                                          | 1.368    | 1.369    | 0.015    | 1.359 | 1.377 | 125      |       |
|                        | isoxazole (O1–C5)                                             | 1.354    | 1.354    | 0.010    | 1.345 | 1.360 | 9        |       |
|                        | β-lactones: C <sup>*</sup> –C(=O)–O–C <sup>*</sup>            | 1.359    | 1.359    | 0.013    | 1.348 | 1.371 | 4        | 13    |
|                        | γ-lactones: C <sup>*</sup> –C(=O)–O–C <sup>*</sup>            | 1.350    | 1.349    | 0.012    | 1.342 | 1.359 | 110      | 12    |
|                        | δ-lactones: C <sup>*</sup> –C(=O)–O–C <sup>*</sup>            | 1.339    | 1.339    | 0.016    | 1.332 | 1.347 | 27       | 12    |
| Car–O(2)               | in phenols: Car–OH                                            | 1.362    | 1.364    | 0.015    | 1.353 | 1.373 | 551      |       |
|                        | in aryl alkyl ethers: Car–O–C <sup>*</sup>                    | 1.370    | 1.370    | 0.011    | 1.363 | 1.377 | 920      | 29,32 |
| Car–O(2)               | in diaryl ethers: Car–O–Car                                   | 1.384    | 1.381    | 0.014    | 1.375 | 1.391 | 132      |       |
|                        | in esters: Car–O–C(=O)–C <sup>*</sup>                         | 1.401    | 1.401    | 0.010    | 1.394 | 1.408 | 40       | 12    |
| Csp <sup>2</sup> =O(1) | in aldehydes and ketones:                                     |          |          |          |       |       |          |       |
|                        | C <sup>*</sup> –CH=O                                          | 1.192    | 1.192    | 0.005    | 1.188 | 1.197 | 7        |       |
|                        | (C <sup>*</sup> ) <sub>2</sub> –C=O                           | 1.210    | 1.210    | 0.008    | 1.206 | 1.215 | 474      | 5     |
|                        | (C#) <sub>2</sub> –C=O                                        |          |          |          |       |       |          |       |
|                        | in cyclobutanones                                             | 1.198    | 1.198    | 0.007    | 1.194 | 1.204 | 12       |       |
|                        | in cyclopentanones                                            | 1.208    | 1.208    | 0.007    | 1.203 | 1.212 | 155      |       |
|                        | in cyclohexanones                                             | 1.211    | 1.211    | 0.009    | 1.207 | 1.216 | 312      |       |
|                        | C=C–C=O                                                       | 1.222    | 1.222    | 0.010    | 1.216 | 1.229 | 225      |       |
|                        | (C=C) <sub>2</sub> –C=O                                       | 1.233    | 1.229    | 0.010    | 1.226 | 1.242 | 28       |       |
|                        | Car–C=O                                                       | 1.221    | 1.218    | 0.014    | 1.212 | 1.229 | 85       |       |
|                        | (Car) <sub>2</sub> –C=O                                       | 1.230    | 1.226    | 0.015    | 1.220 | 1.238 | 66       |       |
|                        | C=O in benzoquinones                                          | 1.222    | 1.220    | 0.013    | 1.211 | 1.231 | 86       |       |
|                        | delocalized double bonds in carboxylate anions:               |          |          |          |       |       |          |       |
|                        | H–C ≃ O <sub>2</sub> <sup>–</sup> (formate)                   | 1.242    | 1.243    | 0.012    | 1.234 | 1.252 | 24       |       |
|                        | C <sup>*</sup> –C ≃ O <sub>2</sub> <sup>–</sup>               | 1.254    | 1.253    | 0.010    | 1.247 | 1.261 | 114      |       |
|                        | C=C–C ≃ O <sub>2</sub> <sup>–</sup>                           | 1.250    | 1.248    | 0.017    | 1.238 | 1.261 | 52       |       |
|                        | Car–C ≃ O <sub>2</sub> <sup>–</sup>                           | 1.255    | 1.253    | 0.010    | 1.249 | 1.262 | 22       |       |
|                        | HOOC–C ≃ O <sub>2</sub> <sup>–</sup> (hydrogen oxalate)       | 1.243    | 1.247    | 0.015    | 1.232 | 1.256 | 26       |       |
|                        | –O <sub>2</sub> ≃ C–C ≃ O <sub>2</sub> <sup>–</sup> (oxalate) | 1.251    | 1.251    | 0.007    | 1.248 | 1.254 | 18       |       |
|                        | in carboxylic acids (X–COOH)                                  |          |          |          |       |       |          |       |
|                        | C <sup>*</sup> –C(=O)–OH                                      | 1.214    | 1.214    | 0.019    | 1.203 | 1.224 | 175      |       |
|                        | C=C–C(=O)–OH                                                  | 1.229    | 1.226    | 0.017    | 1.218 | 1.237 | 22       |       |
|                        | Car–C(=O)–OH                                                  | 1.226    | 1.223    | 0.020    | 1.211 | 1.241 | 75       |       |
|                        | in esters:                                                    |          |          |          |       |       |          |       |
|                        | C <sup>*</sup> –C(=O)–O–C <sup>*</sup>                        | 1.196    | 1.196    | 0.010    | 1.190 | 1.202 | 551      | 12    |
|                        | C=C–C(=O)–O–C <sup>*</sup>                                    | 1.199    | 1.198    | 0.009    | 1.193 | 1.203 | 113      |       |
|                        | Car–C(=O)–O–C <sup>*</sup>                                    | 1.202    | 1.201    | 0.009    | 1.196 | 1.207 | 218      | 12    |
|                        | C <sup>*</sup> –C(=O)–O–C=C                                   | 1.190    | 1.190    | 0.014    | 1.184 | 1.198 | 26       |       |
|                        | C <sup>*</sup> –C(=O)–O–Car                                   | 1.187    | 1.188    | 0.011    | 1.181 | 1.195 | 40       | 12    |
|                        | in anhydrides: O=C–O–C=O                                      | 1.187    | 1.187    | 0.010    | 1.184 | 1.193 | 70       |       |
|                        | in β-lactones: C <sup>*</sup> –C(=O)–O–C <sup>*</sup>         | 1.193    | 1.193    | 0.006    | 1.187 | 1.198 | 4        | 13    |
|                        | γ-lactones: C <sup>*</sup> –C(=O)–O–C <sup>*</sup>            | 1.201    | 1.202    | 0.009    | 1.196 | 1.206 | 109      | 12    |
|                        | δ-lactones: C <sup>*</sup> –C(=O)–O–C <sup>*</sup>            | 1.205    | 1.207    | 0.008    | 1.201 | 1.209 | 27       | 12    |
|                        | in amides:                                                    |          |          |          |       |       |          |       |
|                        | NH <sub>2</sub> –C(–C <sup>*</sup> )=O                        | 1.234    | 1.233    | 0.012    | 1.225 | 1.243 | 32       | 14    |
|                        | (C <sup>*</sup> –)(C <sup>*</sup> ,H–)N–C(–C <sup>*</sup> )=O | 1.231    | 1.231    | 0.012    | 1.224 | 1.238 | 378      | 14    |
|                        | β-lactams: C <sup>*</sup> –NH–C=O                             | 1.198    | 1.200    | 0.012    | 1.193 | 1.204 | 23       | 13    |
|                        | γ-lactams:                                                    |          |          |          |       |       |          |       |
|                        | C <sup>*</sup> –NH–C=O                                        | 1.235    | 1.235    | 0.008    | 1.232 | 1.240 | 20       | 13    |
|                        | C <sup>*</sup> –N(–C <sup>*</sup> )–C=O                       | 1.225    | 1.226    | 0.011    | 1.217 | 1.233 | 15       | 13    |
|                        | δ-lactams:                                                    |          |          |          |       |       |          |       |
|                        | C <sup>*</sup> –NH–C=O                                        | 1.240    | 1.241    | 0.003    | 1.237 | 1.243 | 6        | 14    |
|                        | C <sup>*</sup> –N(–C <sup>*</sup> )–C=O                       | 1.233    | 1.233    | 0.007    | 1.229 | 1.239 | 15       | 14    |
|                        | in ureas:                                                     |          |          |          |       |       |          |       |
|                        | (NH) <sub>2</sub> –C=O                                        | 1.256    | 1.256    | 0.007    | 1.249 | 1.261 | 24       | 25,26 |
|                        | (C#–NH) <sub>2</sub> –C=O                                     | 1.241    | 1.237    | 0.011    | 1.235 | 1.245 | 13       | 25    |
|                        | [(C#) <sub>n</sub> –N] <sub>2</sub> –C=O                      | 1.230    | 1.230    | 0.007    | 1.224 | 1.234 | 20       | 25,27 |
| Csp <sup>3</sup> –P(4) | C <sub>3</sub> –P <sup>+</sup> –C <sup>*</sup>                | 1.800    | 1.802    | 0.015    | 1.790 | 1.812 | 35       | 33    |
|                        | C <sub>2</sub> –P(=O)–CH <sub>3</sub>                         | 1.791    | 1.790    | 0.006    | 1.786 | 1.795 | 10       |       |

| Bond                    | Substructure                                                      | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>u</sub> | <i>n</i> | Note |
|-------------------------|-------------------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|------|
|                         | C <sub>2</sub> -P(=O)-CH <sub>2</sub> -C                          | 1.806    | 1.806    | 0.009    | 1.801                 | 1.813                 | 45       |      |
|                         | C <sub>2</sub> -P(=O)-CH-C <sub>2</sub>                           | 1.821    | 1.821    | 0.009    | 1.815                 | 1.828                 | 15       |      |
|                         | C <sub>2</sub> -P(=O)-C-C <sub>3</sub>                            | 1.841    | 1.842    | 0.008    | 1.835                 | 1.847                 | 14       |      |
|                         | C <sub>2</sub> -P(=O)-C* (overall)                                | 1.813    | 1.811    | 0.017    | 1.800                 | 1.822                 | 84       |      |
| Csp <sup>3</sup> -P(3)  | C <sub>2</sub> -P-C*                                              | 1.855    | 1.857    | 0.019    | 1.840                 | 1.870                 | 23       |      |
| Car-P(4)                | C <sub>3</sub> -P <sup>+</sup> -Car                               | 1.793    | 1.792    | 0.011    | 1.786                 | 1.800                 | 276      |      |
|                         | C <sub>2</sub> -P(=O)-Car                                         | 1.801    | 1.802    | 0.011    | 1.796                 | 1.807                 | 98       |      |
|                         | Ph <sub>3</sub> -P=N <sup>+</sup> =P-Ph <sub>3</sub>              | 1.795    | 1.795    | 0.008    | 1.789                 | 1.800                 | 197      |      |
| Car-P(3)                | C <sub>2</sub> -P-Car                                             | 1.836    | 1.837    | 0.010    | 1.830                 | 1.844                 | 102      |      |
|                         | (N $\simeq$ ) <sub>2</sub> P-Car (P $\simeq$ N aromatic)          | 1.795    | 1.793    | 0.011    | 1.788                 | 1.803                 | 43       |      |
| Csp <sup>3</sup> -S(4)  | C*-SO <sub>2</sub> -C (C* = CH <sub>3</sub> excluded)             | 1.786    | 1.782    | 0.018    | 1.774                 | 1.797                 | 75       |      |
|                         | C*-SO <sub>2</sub> -C (overall)                                   | 1.779    | 1.778    | 0.020    | 1.764                 | 1.790                 | 94       |      |
|                         | C*-SO <sub>2</sub> -O-X                                           | 1.745    | 1.744    | 0.009    | 1.738                 | 1.754                 | 7        | 34   |
|                         | C*-SO <sub>2</sub> -N-X <sub>2</sub>                              | 1.758    | 1.756    | 0.018    | 1.746                 | 1.773                 | 17       | 34   |
| Csp <sup>3</sup> -S(3)  | C*-S(=O)-C (C* = CH <sub>3</sub> excluded)                        | 1.818    | 1.814    | 0.024    | 1.802                 | 1.829                 | 69       |      |
|                         | C*-S(=O)-C (overall)                                              | 1.809    | 1.806    | 0.025    | 1.793                 | 1.820                 | 88       |      |
|                         | CH <sub>3</sub> -S <sup>+</sup> -X <sub>2</sub>                   | 1.786    | 1.787    | 0.007    | 1.779                 | 1.792                 | 21       |      |
|                         | C*-S <sup>+</sup> -X <sub>2</sub> (C* = CH <sub>3</sub> excluded) | 1.823    | 1.820    | 0.016    | 1.812                 | 1.834                 | 18       |      |
|                         | C*-S <sup>+</sup> -X <sub>2</sub> (overall)                       | 1.804    | 1.794    | 0.025    | 1.788                 | 1.820                 | 41       |      |
| Csp <sup>3</sup> -S(2)  | C*-SH                                                             | 1.808    | 1.805    | 0.010    | 1.800                 | 1.819                 | 6        |      |
|                         | CH <sub>3</sub> -S-C*                                             | 1.789    | 1.787    | 0.008    | 1.784                 | 1.794                 | 9        |      |
| Csp <sup>3</sup> -S(2)  | C-CH <sub>2</sub> -S-C*                                           | 1.817    | 1.816    | 0.013    | 1.808                 | 1.824                 | 92       |      |
|                         | C <sub>2</sub> -CH-S-C*                                           | 1.819    | 1.819    | 0.011    | 1.811                 | 1.825                 | 32       |      |
|                         | C <sub>3</sub> -C-S-C*                                            | 1.856    | 1.860    | 0.011    | 1.854                 | 1.863                 | 26       |      |
|                         | C*-S-C* (overall)                                                 | 1.819    | 1.817    | 0.019    | 1.809                 | 1.827                 | 242      |      |
|                         | in thiirane                                                       | 1.834    | 1.835    | 0.025    | 1.810                 | 1.858                 | 4        | 9    |
|                         | in thiirane: see ZCMXSP (1.817, 1.844)                            |          |          |          |                       |                       |          |      |
|                         | in tetrahydrothiophene                                            | 1.827    | 1.826    | 0.018    | 1.811                 | 1.837                 | 20       |      |
|                         | in tetrahydrothiopyran                                            | 1.823    | 1.821    | 0.014    | 1.812                 | 1.832                 | 24       |      |
|                         | C-CH <sub>2</sub> -S-S-X                                          | 1.823    | 1.820    | 0.014    | 1.813                 | 1.832                 | 41       |      |
|                         | C <sub>3</sub> -C-S-S-X                                           | 1.863    | 1.865    | 0.015    | 1.848                 | 1.878                 | 11       |      |
|                         | C*-S-S-X (overall)                                                | 1.833    | 1.828    | 0.022    | 1.818                 | 1.848                 | 59       |      |
| Csp <sup>2</sup> -S(2)  | C=C-S-C*                                                          | 1.751    | 1.755    | 0.017    | 1.740                 | 1.764                 | 61       |      |
|                         | C=C-S-C=C (in tetrathiafulvalene)                                 | 1.741    | 1.741    | 0.011    | 1.733                 | 1.750                 | 88       |      |
|                         | C=C-S-C=C (in thiophene)                                          | 1.712    | 1.712    | 0.013    | 1.703                 | 1.722                 | 60       |      |
|                         | O=C-S-C#                                                          | 1.762    | 1.759    | 0.018    | 1.747                 | 1.778                 | 20       |      |
| Car-S(4)                | Car-SO <sub>2</sub> -C                                            | 1.763    | 1.764    | 0.009    | 1.756                 | 1.769                 | 96       |      |
|                         | Car-SO <sub>2</sub> -O-X                                          | 1.752    | 1.750    | 0.008    | 1.749                 | 1.756                 | 27       |      |
|                         | Car-SO <sub>2</sub> -N-X <sub>2</sub>                             | 1.758    | 1.759    | 0.013    | 1.749                 | 1.765                 | 106      | 35   |
| Car-S(3)                | Car-S(=O)-C                                                       | 1.790    | 1.790    | 0.010    | 1.783                 | 1.798                 | 41       |      |
|                         | Car-S <sup>+</sup> -X <sub>2</sub>                                | 1.778    | 1.779    | 0.010    | 1.771                 | 1.787                 | 10       |      |
| Car-S(2)                | Car-S-C*                                                          | 1.773    | 1.774    | 0.009    | 1.765                 | 1.779                 | 44       |      |
|                         | Car-S-Car                                                         | 1.768    | 1.767    | 0.010    | 1.762                 | 1.774                 | 158      |      |
|                         | Car-S-Car (in phenothiazine)                                      | 1.764    | 1.764    | 0.008    | 1.760                 | 1.769                 | 48       |      |
|                         | Car-S-S-X                                                         | 1.777    | 1.777    | 0.012    | 1.767                 | 1.785                 | 47       |      |
| Csp <sup>1</sup> -S(2)  | N $\equiv$ C-S-X                                                  | 1.679    | 1.683    | 0.026    | 1.645                 | 1.698                 | 10       |      |
| Csp <sup>1</sup> -S(1)  | (N $\equiv$ C-S) <sup>-</sup>                                     | 1.630    | 1.630    | 0.014    | 1.619                 | 1.641                 | 14       |      |
| Csp <sup>2</sup> =S(1)  | (C*) <sub>2</sub> -C=S: see IPMUDS (1.599)                        |          |          |          |                       |                       |          |      |
|                         | (Car) <sub>2</sub> -C=S: see CELDOM (1.611)                       |          |          |          |                       |                       |          |      |
|                         | (X) <sub>2</sub> -C=S (X = C, N, O, S)                            | 1.671    | 1.675    | 0.024    | 1.656                 | 1.689                 | 245      |      |
|                         | X <sub>2</sub> N-C(=S)-S-X                                        | 1.660    | 1.660    | 0.016    | 1.648                 | 1.674                 | 38       |      |
|                         | (X <sub>2</sub> N) <sub>2</sub> -C=S (thioureas)                  | 1.681    | 1.684    | 0.020    | 1.669                 | 1.693                 | 96       |      |
|                         | N-C( $\simeq$ S) <sub>2</sub>                                     | 1.720    | 1.721    | 0.012    | 1.709                 | 1.731                 | 20       |      |
| Csp <sup>3</sup> -Se    | C#-Se                                                             | 1.970    | 1.967    | 0.032    | 1.948                 | 1.998                 | 21       |      |
| Csp <sup>2</sup> -Se(2) | C=C-Se-C=C (in tetraselenafulvalene)                              | 1.893    | 1.895    | 0.013    | 1.882                 | 1.902                 | 32       |      |
| Car-Se(3)               | Ph <sub>3</sub> -Se <sup>+</sup>                                  | 1.930    | 1.929    | 0.006    | 1.924                 | 1.936                 | 13       |      |
| Csp <sup>3</sup> -Si(5) | C#-Si <sup>+</sup> -X <sub>4</sub>                                | 1.874    | 1.876    | 0.015    | 1.859                 | 1.884                 | 9        |      |
| Csp <sup>3</sup> -Si(4) | CH <sub>3</sub> -Si-X <sub>3</sub>                                | 1.857    | 1.857    | 0.018    | 1.848                 | 1.869                 | 552      |      |
|                         | C*-Si-X <sub>3</sub> (C* = CH <sub>3</sub> excluded)              | 1.888    | 1.887    | 0.023    | 1.872                 | 1.905                 | 124      |      |
|                         | C*-Si-X <sub>3</sub> (overall)                                    | 1.863    | 1.861    | 0.024    | 1.850                 | 1.875                 | 681      |      |
| Car-Si(4)               | Car-Si-X <sub>3</sub>                                             | 1.868    | 1.868    | 0.014    | 1.857                 | 1.878                 | 178      |      |

| Bond                    | Substructure                                                                                                                                                   | <i>d</i> | <i>m</i> | $\sigma$ | $q_1$ | $q_u$ | <i>n</i> | Note  |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|----------|-------|-------|----------|-------|
| Csp <sup>1</sup> -Si(4) | C≡C-Si-X <sub>3</sub>                                                                                                                                          | 1.837    | 1.840    | 0.012    | 1.824 | 1.849 | 8        |       |
| Csp <sup>3</sup> -Te    | C#-Te                                                                                                                                                          | 2.158    | 2.159    | 0.030    | 2.128 | 2.177 | 13       |       |
| Car-Te                  | Car-Te                                                                                                                                                         | 2.116    | 2.115    | 0.020    | 2.104 | 2.130 | 72       |       |
| Csp <sup>2</sup> =Te    | see CEDCUJ (2.044)                                                                                                                                             |          |          |          |       |       |          |       |
| Cl-Cl                   | see PHASCL (2.306, 2.227)                                                                                                                                      |          |          |          |       |       |          |       |
| Cl-I                    | see CMBIDZ (2.563), HXPASC (2.541, 2.513),<br>METAMM (2.552), BQUINI<br>(2.416, 2.718)                                                                         |          |          |          |       |       |          |       |
| Cl-N                    | see BECTAE (1.743-1.757), BOGPOC (1.705)                                                                                                                       |          |          |          |       |       |          |       |
| Cl-O(1)                 | in ClO <sub>4</sub> <sup>-</sup>                                                                                                                               | 1.414    | 1.419    | 0.026    | 1.403 | 1.431 | 252      |       |
| Cl-P                    | (N≃) <sub>2</sub> P-Cl (N ≃ P aromatic)                                                                                                                        | 1.997    | 1.994    | 0.015    | 1.989 | 2.004 | 46       |       |
|                         | Cl-P (overall)                                                                                                                                                 | 2.008    | 2.001    | 0.035    | 1.986 | 2.028 | 111      |       |
| Cl-S                    | Cl-S (overall)                                                                                                                                                 | 2.072    | 2.079    | 0.023    | 2.047 | 2.091 | 6        |       |
|                         | see also longer bonds in CILSAR (2.283), BIHXIZ<br>(2.357), CANLUI (2.749)                                                                                     |          |          |          |       |       |          |       |
| Cl-Se                   | see BIRGUE10, BIRHAL10, CTCNSE<br>(2.234-2.851)                                                                                                                |          |          |          |       |       |          |       |
| Cl-Si(4)                | Cl-Si-X <sub>3</sub> (monochloro)                                                                                                                              | 2.072    | 2.075    | 0.009    | 2.066 | 2.078 | 5        |       |
|                         | Cl <sub>2</sub> -Si-X <sub>2</sub> and Cl <sub>3</sub> -Si-X                                                                                                   | 2.020    | 2.012    | 0.015    | 2.007 | 2.036 | 5        |       |
| Cl-Te                   | Cl-Te in range 2.34-2.60                                                                                                                                       | 2.520    | 2.515    | 0.034    | 2.493 | 2.537 | 22       | 36    |
|                         | see also longer bonds in BARRIV, BOJPUL, CETUTE,<br>EPHTEA, OPNTEC10<br>(2.73-2.94)                                                                            |          |          |          |       |       |          |       |
| F-N(3)                  | F-N-C <sub>2</sub> and F <sub>2</sub> -N-C                                                                                                                     | 1.406    | 1.404    | 0.016    | 1.395 | 1.416 | 9        |       |
| F-P(6)                  | in hexafluorophosphate, PF <sub>6</sub> <sup>-</sup>                                                                                                           | 1.579    | 1.587    | 0.025    | 1.563 | 1.598 | 72       |       |
| F-P(3)                  | (N≃) <sub>2</sub> P-F (N ≃ P aromatic)                                                                                                                         | 1.495    | 1.497    | 0.016    | 1.481 | 1.510 | 10       |       |
| F-S                     | 43 observations in range 1.409-1.770 in a wide variety<br>of environments; F-S(6) in<br>F <sub>2</sub> -SO <sub>2</sub> -C <sub>2</sub> (see FPSULF10, BETJOZ) | 1.640    | 1.646    | 0.011    | 1.626 | 1.649 | 6        |       |
|                         | F-S(4) in F <sub>2</sub> -S(=O)-N (see BUDTEZ)                                                                                                                 | 1.527    | 1.528    | 0.004    | 1.524 | 1.530 | 24       | 37    |
| F-Si(6)                 | in SiF <sub>6</sub> <sup>2-</sup>                                                                                                                              | 1.694    | 1.701    | 0.013    | 1.677 | 1.703 | 6        |       |
| F-Si(5)                 | F-Si-X <sub>4</sub>                                                                                                                                            | 1.636    | 1.639    | 0.035    | 1.602 | 1.657 | 10       |       |
| F-Si(4)                 | F-Si-X <sub>3</sub>                                                                                                                                            | 1.588    | 1.587    | 0.014    | 1.581 | 1.599 | 24       |       |
| F-Te                    | see CUCPLZ (F-Te(6) = 1.942, 1.937), FPHTL(F-<br>Te(4) = 2.006)                                                                                                |          |          |          |       |       |          |       |
| H-N(4)                  | X <sub>3</sub> -N <sup>+</sup> -H                                                                                                                              | 1.033    | 1.036    | 0.022    | 1.026 | 1.045 | 87       | 21    |
| H-N(3)                  | X <sub>3</sub> -N-H                                                                                                                                            | 1.009    | 1.010    | 0.019    | 0.997 | 1.023 | 95       | 21    |
| H-O(2)                  | in alcohols C*-O-H                                                                                                                                             | 0.967    | 0.969    | 0.010    | 0.959 | 0.974 | 63       | 21    |
|                         | C#-O-H                                                                                                                                                         | 0.967    | 0.970    | 0.010    | 0.959 | 0.974 | 73       | 21    |
|                         | in acids O=C-O-H                                                                                                                                               | 1.015    | 1.017    | 0.017    | 1.001 | 1.031 | 16       | 21,38 |
| I-I                     | in I <sub>3</sub>                                                                                                                                              | 2.917    | 2.918    | 0.011    | 2.907 | 2.927 | 6        |       |
| I-N                     | see BZPRIB, CMBIDZ, HMTITI, HMTNTI,<br>IFORAM, IODMAM (2.042-2.475)                                                                                            |          |          |          |       |       |          |       |
| I-O                     | X-I-O (see BZPRIB, CAJMAB, IBZDAC11)<br>for IO <sub>6</sub> <sup>-</sup> see BOVMEE (1.829-1.912)                                                              | 2.144    | 2.144    | 0.028    | 2.127 | 2.164 | 6        |       |
| I-P(3)                  | see CEHKAB (2.490-2.493)                                                                                                                                       |          |          |          |       |       |          | †     |
| I-S                     | see DTHIBR10 (2.687), ISUREA10 (2.629), BZTPPI<br>(3.251)                                                                                                      |          |          |          |       |       |          |       |
| I-Te(4)                 | I-Te-X <sub>3</sub>                                                                                                                                            | 2.926    | 2.928    | 0.026    | 2.902 | 2.944 | 8        |       |
| N(4)-N(3)               | X <sub>3</sub> -N <sup>+</sup> -N <sup>0</sup> -X <sub>2</sub> (N <sup>0</sup> planar)                                                                         | 1.414    | 1.414    | 0.005    | 1.412 | 1.418 | 13       |       |
| N(3)-N(3)               | (C)(C,H)-N <sub>a</sub> -N <sub>b</sub> (C)(C,H)                                                                                                               |          |          |          |       |       |          | 5,39  |
|                         | N <sub>a</sub> , N <sub>b</sub> pyramidal                                                                                                                      | 1.454    | 1.452    | 0.021    | 1.444 | 1.457 | 44       | 40    |
|                         | N <sub>a</sub> pyramidal, N <sub>b</sub> planar                                                                                                                | 1.420    | 1.420    | 0.015    | 1.407 | 1.433 | 68       | 40    |
|                         | N <sub>a</sub> , N <sub>b</sub> planar                                                                                                                         | 1.401    | 1.401    | 0.018    | 1.384 | 1.418 | 40       | 40    |
|                         | overall                                                                                                                                                        | 1.425    | 1.425    | 0.027    | 1.407 | 1.443 | 139      |       |
| N(3)-N(2)               | in pyrazole (N1-N2)                                                                                                                                            | 1.366    | 1.366    | 0.019    | 1.350 | 1.375 | 20       |       |
|                         | in pyridazinium (N1 <sup>+</sup> ≃N2)                                                                                                                          | 1.350    | 1.349    | 0.010    | 1.345 | 1.361 | 7        |       |
| N(2) ≃ N(2)             | N ≃ N (aromatic) in pyridazine                                                                                                                                 |          |          |          |       |       |          |       |
|                         | with C,H as <i>ortho</i> substituents                                                                                                                          | 1.304    | 1.300    | 0.019    | 1.287 | 1.326 | 6        |       |
|                         | with N,Cl as <i>ortho</i> substituents                                                                                                                         | 1.368    | 1.373    | 0.011    | 1.362 | 1.375 | 9        |       |

| Bond               | Substructure                                                                           | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>u</sub> | <i>n</i> | Note |
|--------------------|----------------------------------------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|------|
| N(2)=N(2)          | C#-N=N-C#                                                                              |          |          |          |                       |                       |          |      |
|                    | <i>cis</i>                                                                             | 1.245    | 1.244    | 0.009    | 1.239                 | 1.252                 | 21       |      |
|                    | <i>trans</i>                                                                           | 1.222    | 1.222    | 0.006    | 1.218                 | 1.227                 | 6        |      |
|                    | (overall)                                                                              | 1.240    | 1.241    | 0.012    | 1.230                 | 1.251                 | 27       |      |
|                    | <i>Car</i> -N=N- <i>Car</i>                                                            | 1.255    | 1.253    | 0.016    | 1.247                 | 1.262                 | 13       |      |
|                    | X-N=N=N (azides)                                                                       | 1.216    | 1.226    | 0.028    | 1.202                 | 1.237                 | 19       |      |
| N(2)=N(1)          | X-N=N=N (azides)                                                                       | 1.124    | 1.128    | 0.015    | 1.114                 | 1.137                 | 19       |      |
| N(3)-O(2)          | (C,H) <sub>2</sub> -N-OH (N <i>sp</i> <sup>2</sup> : planar)                           | 1.396    | 1.394    | 0.012    | 1.390                 | 1.401                 | 28       |      |
|                    | C <sub>2</sub> -N-O-C                                                                  |          |          |          |                       |                       |          |      |
|                    | (N <i>sp</i> <sup>3</sup> : pyramidal)                                                 | 1.463    | 1.465    | 0.012    | 1.457                 | 1.468                 | 22       |      |
|                    | (N <i>sp</i> <sup>2</sup> : planar)                                                    | 1.397    | 1.394    | 0.011    | 1.388                 | 1.409                 | 12       |      |
|                    | in furoxan (N2-O1)                                                                     | 1.438    | 1.436    | 0.009    | 1.430                 | 1.447                 | 14       |      |
| N(3)-O(1)          | (C $\simeq$ ) <sub>2</sub> N <sup>+</sup> -O <sup>-</sup> in pyridine <i>N</i> -oxides | 1.304    | 1.299    | 0.015    | 1.291                 | 1.316                 | 11       |      |
|                    | in furoxan ( <sup>+</sup> N2-O6 <sup>-</sup> )                                         | 1.234    | 1.234    | 0.008    | 1.228                 | 1.240                 | 14       |      |
| N(2)-O(2)          | in oximes                                                                              |          |          |          |                       |                       |          |      |
|                    | (C#) <sub>2</sub> -C=N-OH                                                              | 1.416    | 1.418    | 0.006    | 1.416                 | 1.420                 | 7        |      |
|                    | (H)(C <i>sp</i> <sup>2</sup> )-C=N-OH                                                  | 1.390    | 1.390    | 0.011    | 1.380                 | 1.401                 | 20       |      |
|                    | (C#)(C <i>sp</i> <sup>2</sup> )-C=N-OH                                                 | 1.402    | 1.403    | 0.010    | 1.393                 | 1.410                 | 18       |      |
|                    | (C <i>sp</i> <sup>2</sup> ) <sub>2</sub> -C=N-OH                                       | 1.378    | 1.377    | 0.017    | 1.365                 | 1.393                 | 16       |      |
|                    | (C,H) <sub>2</sub> -C=N-OH (overall)                                                   | 1.394    | 1.395    | 0.018    | 1.379                 | 1.408                 | 67       |      |
|                    | in furazan (O1-N2, O1-N5)                                                              | 1.385    | 1.383    | 0.013    | 1.378                 | 1.392                 | 12       |      |
|                    | in furoxan (O1-N5)                                                                     | 1.380    | 1.380    | 0.011    | 1.370                 | 1.388                 | 14       |      |
|                    | in isoxazole (O1-N2)                                                                   | 1.425    | 1.425    | 0.010    | 1.417                 | 1.434                 | 9        |      |
| N(3)=O(1)          | in nitrate ions NO <sub>3</sub> <sup>-</sup>                                           | 1.239    | 1.240    | 0.020    | 1.227                 | 1.251                 | 105      |      |
|                    | in nitro groups                                                                        |          |          |          |                       |                       |          |      |
|                    | C <sup>*</sup> -NO <sub>2</sub>                                                        | 1.212    | 1.214    | 0.012    | 1.206                 | 1.221                 | 84       |      |
|                    | C#-NO <sub>2</sub>                                                                     | 1.210    | 1.210    | 0.011    | 1.203                 | 1.218                 | 251      |      |
|                    | <i>Car</i> -NO <sub>2</sub>                                                            | 1.217    | 1.218    | 0.011    | 1.211                 | 1.215                 | 1116     |      |
|                    | C-NO <sub>2</sub> (overall)                                                            | 1.218    | 1.219    | 0.013    | 1.210                 | 1.226                 | 1733     |      |
| N(3)-P(4)          | X <sub>2</sub> -P(=X)-NX <sub>2</sub>                                                  |          |          |          |                       |                       |          |      |
|                    | N <i>sp</i> <sup>2</sup> : planar                                                      | 1.652    | 1.651    | 0.024    | 1.634                 | 1.670                 | 205      |      |
|                    | N <i>sp</i> <sup>3</sup> : pyramidal                                                   | 1.683    | 1.683    | 0.005    | 1.680                 | 1.686                 | 6        |      |
|                    | (overall)                                                                              | 1.662    | 1.662    | 0.029    | 1.639                 | 1.682                 | 358      |      |
|                    | subsets of this group are:                                                             |          |          |          |                       |                       |          |      |
|                    | O <sub>2</sub> -P(=S)-NX <sub>2</sub>                                                  | 1.628    | 1.624    | 0.015    | 1.615                 | 1.634                 | 9        |      |
|                    | C-P(=S)-(NX <sub>2</sub> ) <sub>2</sub>                                                | 1.691    | 1.694    | 0.018    | 1.678                 | 1.703                 | 28       |      |
|                    | O-P(=S)-(NX <sub>2</sub> ) <sub>2</sub>                                                | 1.652    | 1.654    | 0.014    | 1.642                 | 1.664                 | 28       |      |
|                    | P(=O)-(NX <sub>2</sub> ) <sub>3</sub>                                                  | 1.663    | 1.668    | 0.026    | 1.640                 | 1.679                 | 78       |      |
| N(3)-P(3)          | -NX-P(-X)-NX-P(-X)-(P <sub>2</sub> N <sub>2</sub> ring)                                | 1.730    | 1.721    | 0.017    | 1.716                 | 1.748                 | 20       |      |
|                    | -NX-P(=S)-NX-P(=S)-(P <sub>2</sub> N <sub>2</sub> ring)                                | 1.697    | 1.697    | 0.015    | 1.690                 | 1.703                 | 44       |      |
|                    | in P-substituted phosphazenes:                                                         |          |          |          |                       |                       |          |      |
|                    | (N $\simeq$ ) <sub>2</sub> P-N (amino)                                                 | 1.637    | 1.638    | 0.014    | 1.625                 | 1.651                 | 16       |      |
|                    | (aziridinyl)                                                                           | 1.672    | 1.674    | 0.010    | 1.665                 | 1.676                 | 15       |      |
| N(2)=P(4)          | Ph <sub>3</sub> -P=N <sup>+</sup> =P-Ph <sub>3</sub>                                   | 1.571    | 1.573    | 0.013    | 1.563                 | 1.580                 | 66       |      |
| N(2)=P(3)          | Ph <sub>3</sub> -P=N-C,S                                                               | 1.599    | 1.597    | 0.018    | 1.580                 | 1.615                 | 7        |      |
| N(2) $\simeq$ P(3) | N $\simeq$ P aromatic                                                                  |          |          |          |                       |                       |          |      |
|                    | in phosphazenes                                                                        | 1.582    | 1.582    | 0.019    | 1.571                 | 1.594                 | 126      |      |
|                    | in P $\simeq$ N $\simeq$ S                                                             | 1.604    | 1.606    | 0.009    | 1.594                 | 1.612                 | 36       |      |
| N(3)-S(4)          | C-SO <sub>2</sub> -NH <sub>2</sub>                                                     | 1.600    | 1.601    | 0.012    | 1.591                 | 1.610                 | 14       | 35   |
|                    | C-SO <sub>2</sub> -NH-C#                                                               | 1.633    | 1.633    | 0.019    | 1.615                 | 1.652                 | 47       | 35   |
|                    | C-SO <sub>2</sub> -N-C(#) <sub>2</sub>                                                 | 1.642    | 1.641    | 0.024    | 1.623                 | 1.659                 | 38       | 35   |
| N(3)-S(2)          | C-S-NX <sub>2</sub> N <i>sp</i> <sup>2</sup> : planar                                  | 1.710    | 1.707    | 0.019    | 1.698                 | 1.722                 | 22       | 23   |
|                    | (for N <i>sp</i> <sup>3</sup> pyramidal see MODIAZ: 1.765)                             |          |          |          |                       |                       |          |      |
|                    | X-S-NX <sub>2</sub> N <i>sp</i> <sup>2</sup> : planar                                  | 1.707    | 1.705    | 0.012    | 1.699                 | 1.715                 | 30       | 23   |
| N(2)-S(2)          | C=N-S-X                                                                                | 1.656    | 1.663    | 0.027    | 1.632                 | 1.677                 | 36       |      |
| N(2) $\simeq$ S(2) | N $\simeq$ S aromatic in P $\simeq$ N $\simeq$ S                                       | 1.560    | 1.558    | 0.011    | 1.554                 | 1.563                 | 37       |      |
| N(2)=S(2)          | N=S in N=S=N and N=S=S                                                                 | 1.541    | 1.546    | 0.022    | 1.521                 | 1.558                 | 37       |      |
| N(3)-SE            | see COJCUZ (1.830), DSEMOR10 (1.846, 1.852),<br>MORTS10 (1.841)                        |          |          |          |                       |                       |          |      |
| N(2)-Se            | see SEBZQI (1.805), NAPSEZ10 (1.809, 1.820)                                            |          |          |          |                       |                       |          |      |
| N(2)=Se            | see CISMUM (1.790, 1.791)                                                              |          |          |          |                       |                       |          |      |

| Bond       | Substructure                                                                                       | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>0</sub> | <i>n</i> | Note |
|------------|----------------------------------------------------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|------|
| N(3)–Si(5) | see DMESIP01, BOJLER, CASSAQ, CASYOK, CECXEN, CINTEY, CIPBUY, FMESIB, MNPSIL, PNPOSI (1.973–2.344) |          |          |          |                       |                       |          |      |
| N(3)–Si(4) | X <sub>3</sub> –Si–NX <sub>2</sub> (overall)                                                       | 1.748    | 1.746    | 0.022    | 1.735                 | 1.757                 | 170      |      |
|            | subsets of this group are:                                                                         |          |          |          |                       |                       |          |      |
|            | X <sub>3</sub> –Si–NHX                                                                             | 1.714    | 1.719    | 0.014    | 1.702                 | 1.727                 | 16       |      |
|            | X <sub>3</sub> –Si–NX–Si–X <sub>3</sub> acyclic                                                    | 1.743    | 1.744    | 0.016    | 1.731                 | 1.755                 | 45       |      |
|            | N–Si–N in 4-membered rings                                                                         | 1.742    | 1.742    | 0.009    | 1.735                 | 1.748                 | 53       |      |
|            | N–Si–N in 5-membered rings                                                                         | 1.741    | 1.742    | 0.019    | 1.726                 | 1.749                 | 33       |      |
| N(2)–Si(4) | X <sub>3</sub> –Si–N <sup>–</sup> –Si–X <sub>3</sub>                                               | 1.711    | 1.712    | 0.019    | 1.693                 | 1.729                 | 15       |      |
| N–Te       | see ACLTEP (2.402), BIBLAZ (1.980), CESSAU (2.023)                                                 |          |          |          |                       |                       |          |      |
| O(2)–O(2)  | C*–O–O–C*,H                                                                                        |          |          |          |                       |                       |          |      |
|            | τ(OO) = 70–85°                                                                                     | 1.464    | 1.464    | 0.009    | 1.458                 | 1.472                 | 12       |      |
|            | τ(OO) <i>ca.</i> 180°                                                                              | 1.482    | 1.480    | 0.005    | 1.478                 | 1.486                 | 5        |      |
|            | overall                                                                                            | 1.469    | 1.471    | 0.012    | 1.461                 | 1.478                 | 17       |      |
|            | O=C–O–O–C=O see ACBZPO01 (1.446), CEYLUN (1.452), CIMHIP (1.454)                                   |          |          |          |                       |                       |          |      |
|            | Si–O–O–Si                                                                                          | 1.496    | 1.499    | 0.005    | 1.490                 | 1.499                 | 10       |      |
| O(2)–P(5)  | X–P–(OX) <sub>4</sub>                                                                              |          |          |          |                       |                       |          | 41   |
|            | trigonal bipyramidal:                                                                              |          |          |          |                       |                       |          |      |
|            | axial                                                                                              | 1.689    | 1.685    | 0.024    | 1.675                 | 1.712                 | 20       |      |
|            | equatorial                                                                                         | 1.619    | 1.622    | 0.024    | 1.604                 | 1.628                 | 20       |      |
|            | square pyramidal                                                                                   | 1.662    | 1.661    | 0.020    | 1.649                 | 1.673                 | 28       |      |
| O(2)–P(4)  | C–O–P(≈ O) <sub>3</sub> <sup>2–</sup>                                                              | 1.621    | 1.622    | 0.007    | 1.615                 | 1.628                 | 12       |      |
|            | (H–O) <sub>2</sub> –P(≈ O) <sub>2</sub> <sup>–</sup>                                               | 1.560    | 1.561    | 0.009    | 1.555                 | 1.566                 | 16       |      |
|            | (C–O) <sub>2</sub> –P(≈ O) <sub>2</sub> <sup>–</sup>                                               | 1.608    | 1.607    | 0.013    | 1.599                 | 1.615                 | 16       |      |
|            | (C#–O) <sub>3</sub> –P=O                                                                           | 1.558    | 1.554    | 0.011    | 1.550                 | 1.564                 | 30       |      |
|            | (Car–O) <sub>3</sub> –P=O                                                                          | 1.587    | 1.588    | 0.014    | 1.572                 | 1.599                 | 19       |      |
|            | X–O–P(=O)–(C,N) <sub>2</sub>                                                                       | 1.590    | 1.585    | 0.016    | 1.577                 | 1.601                 | 33       |      |
|            | (X–O) <sub>2</sub> –P(=O)–(C,N)                                                                    | 1.571    | 1.572    | 0.013    | 1.563                 | 1.579                 | 70       |      |
| O(2)–P(3)  | (N≈) <sub>2</sub> P–O–C (N ≈ P aromatic)                                                           | 1.573    | 1.573    | 0.011    | 1.563                 | 1.584                 | 16       |      |
| O(1)=P(4)  | C–O–P(≈ O) <sub>3</sub> <sup>2–</sup> (delocalized)                                                | 1.513    | 1.512    | 0.008    | 1.508                 | 1.518                 | 42       |      |
|            | (H–O) <sub>2</sub> –P(≈ O) <sub>2</sub> <sup>–</sup> (delocalized)                                 | 1.503    | 1.503    | 0.005    | 1.499                 | 1.508                 | 16       |      |
|            | (C–O) <sub>2</sub> –P(≈ O) <sub>2</sub> <sup>–</sup> (delocalized)                                 | 1.483    | 1.485    | 0.008    | 1.474                 | 1.490                 | 16       |      |
|            | (C–O) <sub>3</sub> –P=O                                                                            | 1.449    | 1.448    | 0.007    | 1.446                 | 1.452                 | 18       |      |
|            | C <sub>3</sub> –P=O                                                                                | 1.489    | 1.486    | 0.010    | 1.481                 | 1.496                 | 72       |      |
|            | N <sub>3</sub> –P=O                                                                                | 1.461    | 1.462    | 0.014    | 1.449                 | 1.470                 | 26       |      |
|            | (C) <sub>2</sub> (N)–P=O                                                                           | 1.487    | 1.489    | 0.007    | 1.479                 | 1.493                 | 5        |      |
|            | (C,N) <sub>2</sub> (O)–P=O                                                                         | 1.467    | 1.462    | 0.007    | 1.462                 | 1.472                 | 33       |      |
|            | (C,N)(O) <sub>2</sub> –P=O                                                                         | 1.457    | 1.458    | 0.009    | 1.454                 | 1.462                 | 35       |      |
| O(2)–S(4)  | C–O–SO <sub>2</sub> –C                                                                             | 1.577    | 1.576    | 0.015    | 1.566                 | 1.584                 | 41       |      |
|            | C–O–SO <sub>2</sub> –CH <sub>3</sub>                                                               | 1.569    | 1.569    | 0.013    | 1.556                 | 1.582                 | 7        |      |
|            | C–O–SO <sub>2</sub> –Car                                                                           | 1.580    | 1.578    | 0.015    | 1.571                 | 1.588                 | 27       |      |
| O(1)=S(4)  | C–SO <sub>2</sub> –C                                                                               | 1.436    | 1.437    | 0.010    | 1.431                 | 1.442                 | 316      | 42   |
|            | X–SO <sub>2</sub> –NX <sub>2</sub>                                                                 | 1.428    | 1.428    | 0.010    | 1.422                 | 1.434                 | 326      |      |
|            | C–SO <sub>2</sub> –N–(C,H) <sub>2</sub>                                                            | 1.430    | 1.430    | 0.009    | 1.425                 | 1.435                 | 206      |      |
|            | C–SO <sub>2</sub> –O–C                                                                             | 1.423    | 1.423    | 0.008    | 1.418                 | 1.428                 | 82       |      |
|            | in SO <sub>4</sub> <sup>2–</sup>                                                                   | 1.472    | 1.473    | 0.013    | 1.463                 | 1.481                 | 104      |      |
| O(1)=S(3)  | C–S(=O)–C                                                                                          | 1.497    | 1.498    | 0.013    | 1.489                 | 1.505                 | 90       | 5    |
| O–Se       | see BAPPA, BIRGUE10, BIRHAL10, CXMSEO, DGLYSE, SPSEBU (1.597 for O=Se to 1.974 for O–Se)           |          |          |          |                       |                       |          |      |
| O(2)–Si(5) | (X–O) <sub>3</sub> –Si–(N)(C)                                                                      | 1.663    | 1.658    | 0.023    | 1.650                 | 1.665                 | 21       |      |
| O(2)–Si(4) | X <sub>3</sub> –Si–O–X (overall)                                                                   | 1.631    | 1.630    | 0.022    | 1.617                 | 1.646                 | 191      |      |
| O(2)–Si(4) | subsets of this group are:                                                                         |          |          |          |                       |                       |          |      |
|            | X <sub>3</sub> –Si–O–C#                                                                            | 1.645    | 1.647    | 0.012    | 1.634                 | 1.652                 | 29       |      |
|            | X <sub>3</sub> –Si–O–Si–X <sub>3</sub>                                                             | 1.622    | 1.625    | 0.014    | 1.614                 | 1.631                 | 70       |      |
|            | X <sub>3</sub> –Si–O–O–Si–X <sub>3</sub>                                                           | 1.680    | 1.676    | 0.008    | 1.673                 | 1.688                 | 10       |      |
| O(2)–Te(6) | (X–O) <sub>6</sub> –Te                                                                             | 1.927    | 1.927    | 0.020    | 1.908                 | 1.942                 | 16       |      |
| O(2)–Te(4) | (X–O) <sub>2</sub> –Te–X <sub>2</sub>                                                              | 2.133    | 2.136    | 0.054    | 2.078                 | 2.177                 | 12       |      |
| P(4)–P(4)  | X <sub>3</sub> –P–P–X <sub>3</sub>                                                                 | 2.256    | 2.259    | 0.025    | 2.243                 | 2.277                 | 6        |      |



| Bond        | Substructure                                                                                                            | <i>d</i> | <i>m</i> | $\sigma$ | <i>q</i> <sub>1</sub> | <i>q</i> <sub>u</sub> | <i>n</i> | Note |
|-------------|-------------------------------------------------------------------------------------------------------------------------|----------|----------|----------|-----------------------|-----------------------|----------|------|
| P(4)–P(3)   | see CECHEX (2.197), COZPIQ (2.249)                                                                                      |          |          |          |                       |                       |          |      |
| P(3)–P(3)   | X <sub>2</sub> –P–P–X <sub>2</sub>                                                                                      | 2.214    | 2.210    | 0.022    | 2.200                 | 2.224                 | 41       |      |
| P(4)=P(4)   | see BUTSUE (2.054)                                                                                                      |          |          |          |                       |                       |          |      |
| P(3)=P(3)   | see BALXOB (2.034)                                                                                                      |          |          |          |                       |                       |          |      |
| P(4)=S(1)   | C <sub>3</sub> –P=S                                                                                                     | 1.954    | 1.952    | 0.005    | 1.950                 | 1.957                 | 13       |      |
|             | (N,O) <sub>2</sub> (C)–P=S                                                                                              | 1.922    | 1.924    | 0.014    | 1.913                 | 1.927                 | 26       |      |
|             | (N,O) <sub>3</sub> –P=S                                                                                                 | 1.913    | 1.914    | 0.014    | 1.906                 | 1.921                 | 50       |      |
| P(4)=Se(1)  | X <sub>3</sub> –P=Se                                                                                                    | 2.093    | 2.099    | 0.019    | 2.075                 | 2.108                 | 12       |      |
| P(3)–Si(4)  | X <sub>2</sub> –P–Si–X <sub>3</sub> : 3- and 4-rings<br>excluded (see BOPFER, BOPFIV, CASTOF10,<br>COZVIW: 2.201–2.317) | 2.264    | 2.260    | 0.019    | 2.249                 | 2.283                 | 22       |      |
| P(4)=Te(1)  | see MOPHTE (2.356), TTEBPZ (2.327)                                                                                      |          |          |          |                       |                       |          |      |
| S(2)–S(2)   | C–S–S–C                                                                                                                 |          |          |          |                       |                       |          |      |
|             | τ(SS) = 75–105°                                                                                                         | 2.031    | 2.029    | 0.015    | 2.021                 | 2.038                 | 46       |      |
|             | τ(SS) = 0–20°                                                                                                           | 2.070    | 2.068    | 0.022    | 2.057                 | 2.077                 | 28       |      |
|             | (overall)                                                                                                               | 2.048    | 2.045    | 0.026    | 2.028                 | 2.068                 | 99       |      |
|             | in polysulphide chain–S–S–S–                                                                                            | 2.051    | 2.050    | 0.022    | 2.037                 | 2.065                 | 126      |      |
| S(2)–S(1)   | X–N=S–S                                                                                                                 | 1.897    | 1.896    | 0.012    | 1.887                 | 1.908                 | 5        |      |
| S–Se(4)     | see BUWZUO (2.264, 2.269)                                                                                               |          |          |          |                       |                       |          |      |
| S–Se(2)     | X–Se–S (any)                                                                                                            | 2.193    | 2.195    | 0.015    | 2.174                 | 2.207                 | 9        |      |
| S(2)–Si(4)  | X <sub>3</sub> –Si–S–X                                                                                                  | 2.145    | 2.138    | 0.020    | 2.130                 | 2.158                 | 19       |      |
| S(2)–Te     | X–S–Te (any)                                                                                                            | 2.405    | 2.406    | 0.022    | 2.383                 | 2.424                 | 10       |      |
|             | X=S–Te (any)                                                                                                            | 2.682    | 2.686    | 0.035    | 2.673                 | 2.694                 | 28       |      |
| Se(2)–Se(2) | X–Se–Se–X                                                                                                               | 2.340    | 2.340    | 0.024    | 2.315                 | 2.361                 | 15       |      |
| Se(2)–Te(2) | see BAWFUA, BAWGAH (2.524–2.561)                                                                                        |          |          |          |                       |                       |          | †    |
| Si(4)–Si(4) | X <sub>3</sub> –Si–Si–X <sub>3</sub> 3-membered rings excluded:<br>see CIHRAM (2.511)                                   | 2.359    | 2.359    | 0.012    | 2.349                 | 2.366                 | 42       |      |
| Te–Te       | see CAHJOK (2.751, 2.704)                                                                                               |          |          |          |                       |                       |          |      |

## Appendix 1. (Footnotes to Table)

- Sample dominated by B–CH<sub>3</sub>. For longer bonds in B–CH<sub>3</sub> see LITMEB10 [B(4)–CH<sub>3</sub> = 1.621–1.644 Å].
- p(π)–p(π) Bonding with Bsp<sup>2</sup> and Nsp<sup>2</sup> coplanar (τBN = 0 ± 15°) predominates. See G. Schmidt, R. Boese, and D. Bläser, *Z. Naturforsch.*, 1982, **37b**, 1230.
- 84 observations range from 1.38 to 1.61 Å and individual values depend on substituents on B and O. For a discussion of borinic acid adducts see S. J. Rettig and J. Trotter, *Can. J. Chem.*, 1982, **60**, 2957.
- See M. Kaftory in 'The Chemistry of Functional Groups. Supplement D: The Chemistry of Halides, Pseudohalides, and Azides', S. Patai and Z. Rappoport, Eds., Wiley: New York, 1983, Part 2, ch. 24.
- Bonds which are endocyclic or exocyclic to any 3- or 4-membered rings have been omitted from all averages in this section.
- The overall average given here is for Csp<sup>3</sup>–Csp<sup>3</sup> bonds which carry only C or H substituents. The value cited reflects the relative abundance of each 'substitution' group. The 'mean of means' for the 9 subgroups is 1.538 (σ = 0.022) Å.
- See F. H. Allen, (a) *Acta Crystallogr.*, 1980, **B36**, 81; (b) 1981, **B37**, 890.
- See F. H. Allen, *Acta Crystallogr.*, 1984, **B40**, 64.
- See F. H. Allen, *Tetrahedron*, 1982, **38**, 2843.
- See F. H. Allen, *Tetrahedron*, 1982, **38**, 645.
- Cyclopropanones and cyclobutanones excluded.
- See W. B. Schweizer and J. D. Dunitz, *Helv. Chim. Acta*, 1982, **65**, 1547.
- See L. Nørskov-Lauritsen, H.-B. Bürgi, P. Hoffmann, and H. R. Schmidt, *Helv. Chim. Acta*, 1985, **68**, 76.
- See P. Chakrabarti and J. D. Dunitz, *Helv. Chim. Acta*, 1982, **65**, 1555.
- See J. L. Hencher in 'The Chemistry of the C≡C Triple Bond', S. Patai, Ed., Wiley, New York, 1978, ch. 2.
- Conjugated: torsion angle about central C–C single bond is 0 ± 20° (*cis*) or 180 ± 20° (*trans*).
- Unconjugated: torsion angle about central C–C single bond is 20–160°.
- Other conjugative substituents excluded.
- TCNQ is tetracyanoquinodimethane.
- No difference detected between C2 ≈ C3 and C3 ≈ C4 bonds.
- Derived from neutron diffraction results only.
- Nsp<sup>3</sup>: pyramidal; mean valence angle at N is in range 108–114°.
- Nsp<sup>2</sup>: planar; mean valence angle at N is ≥ 117.5°.
- Cyclic and acyclic peptides.
- See R. H. Blessing, *J. Am. Chem. Soc.*, 1983, **105**, 2776.
- See L. Lebioda, *Acta Crystallogr.*, 1980, **B36**, 271.
- n* = 3 or 4, i.e. tri- or tetra-substituted ureas.
- Overall value also includes structures with mean valence angle at N in the range 115–118°.
- See F. H. Allen and A. J. Kirby, *J. Am. Chem. Soc.*, 1984, **106**, 6197.
- See A. J. Kirby, 'The Anomeric Effect and Related Stereoelectronic Effects at Oxygen', Springer, Berlin, 1983.
- See B. Fuchs, L. Schleifer, and E. Tartakovsky, *Nouv. J. Chim.*, 1984, **8**, 275.
- See S. C. Nyburg and C. H. Faerman, *J. Mol. Struct.*, 1986, **140**, 347.
- Sample dominated by P–CH<sub>3</sub> and P–CH<sub>2</sub>–C.
- Sample dominated by C\* = methyl.
- See A. Kalman, M. Czugler, and G. Argay, *Acta Crystallogr.*, 1981, **B37**, 868.
- Bimodal distribution resolved into 22 'short' bonds and 5 longer outliers.
- All 24 observations come from BUDTEZ.
- 'Long' O–H bonds in centrosymmetric O---H---O H-bonded dimers are excluded.
- N–N bond length also dependent on torsion angle about N–N bond and on nature of substituent C atoms; these effects are ignored here.
- N pyramidal has average angle at N in range 100–113.5°; N planar has average angle of ≥ 117.5°.
- See R. R. Holmes and J. A. Deiters, *J. Amer. Chem. Soc.*, 1977, **99**, 3318.
- No detectable variation in S=O bond length with type of C-substituent.

## Appendix 2

Short-form references to individual CSD entries cited by reference code in the Table. A full list of CSD bibliographic entries is given in SUP 56701.

|          |                                                              |          |                                                             |
|----------|--------------------------------------------------------------|----------|-------------------------------------------------------------|
| ACBZPO01 | <i>J. Am. Chem. Soc.</i> , 1975, <b>97</b> , 6729.           | CIWYIQ   | <i>Inorg. Chem.</i> , 1984, <b>23</b> , 1946.               |
| ACLTEP   | <i>J. Organomet. Chem.</i> , 1980, <b>184</b> , 417.         | CIYFOF   | <i>Inorg. Chem.</i> , 1984, <b>23</b> , 1790.               |
| ASAZOC   | <i>Dokl. Akad. Nauk SSSR</i> , 1979, <b>249</b> , 120.       | CMBIDZ   | <i>J. Org. Chem.</i> , 1979, <b>44</b> , 1447.              |
| BALXOB   | <i>J. Am. Chem. Soc.</i> , 1981, <b>103</b> , 4587.          | CODDEE   | <i>Z. Naturforsch., Teil B</i> , 1984, <b>39</b> , 1257.    |
| BAPPAJ   | <i>Inorg. Chem.</i> , 1981, <b>20</b> , 3071.                | CODDII   | <i>Z. Naturforsch., Teil B</i> , 1984, <b>39</b> , 1257.    |
| BARRIV   | <i>Acta Chem. Scand., Ser. A</i> , 1981, <b>35</b> , 443.    | COFVOI   | <i>Z. Naturforsch., Teil B</i> , 1984, <b>39</b> , 1027.    |
| BAWFUA   | <i>Cryst. Struct. Commun.</i> , 1981, <b>10</b> , 1345.      | COJCUZ   | <i>Chem. Ber.</i> , 1984, <b>117</b> , 2686.                |
| BAWGAH   | <i>Cryst. Struct. Commun.</i> , 1981, <b>10</b> , 1353.      | COSDIX   | <i>Z. Naturforsch., Teil B</i> , 1984, <b>39</b> , 1344.    |
| BECTAE   | <i>J. Org. Chem.</i> , 1981, <b>46</b> , 5048, 1981.         | COZPIQ   | <i>Chem. Ber.</i> , 1984, <b>117</b> , 2063.                |
| BELNIP   | <i>Z. Naturforsch., Teil B</i> , 1982, <b>37</b> , 299.      | COZVIW   | <i>Z. Anorg. Allg. Chem.</i> , 1984, <b>515</b> , 7.        |
| BEMLIO   | <i>Chem. Ber.</i> , 1982, <b>115</b> , 1126.                 | CTCNSE   | <i>J. Am. Chem. Soc.</i> , 1980, <b>102</b> , 5430.         |
| BEPZEB   | <i>Cryst. Struct. Commun.</i> , 1982, <b>11</b> , 175.       | CUCPIZ   | <i>J. Am. Chem. Soc.</i> , 1984, <b>106</b> , 7529.         |
| BETJOZ   | <i>J. Am. Chem. Soc.</i> , 1982, <b>104</b> , 1683.          | CUDLOC   | <i>J. Cryst. Spectrosc.</i> , 1985, <b>15</b> , 53.         |
| BETUTE10 | <i>Acta Chem. Scand., Ser. A</i> , 1976, <b>30</b> , 719.    | CUDLUI   | <i>J. Cryst. Spectrosc.</i> , 1985, <b>15</b> , 53.         |
| BIBLAZ   | <i>Zh. Strukt. Khim.</i> , 1981, <b>22</b> , 118.            | CUGBAH   | <i>Acta Crystallogr., Sect. C</i> , 1985, <b>41</b> , 476.  |
| BICGEZ   | <i>Z. Anorg. Allg. Chem.</i> , 1982, <b>486</b> , 90.        | CXMSEO   | <i>Acta Crystallogr., Sect. B</i> , 1973, <b>29</b> , 595.  |
| BIHXIZ   | <i>J. Chem. Soc., Chem. Commun.</i> , 1982, 982.             | DGLYSE   | <i>Acta Crystallogr., Sect. B</i> , 1975, <b>31</b> , 1785. |
| BIRGUE10 | <i>Z. Naturforsch., Teil B</i> , 1983, <b>38</b> , 20.       | DMESIP01 | <i>Acta Crystallogr., Sect. C</i> , 1984, <b>40</b> , 895.  |
| BIRHAL10 | <i>Z. Naturforsch., Teil B</i> , 1982, <b>37</b> , 1410.     | DSEMOR10 | <i>J. Chem. Soc., Dalton Trans.</i> , 1980, 628.            |
| BIZJAV   | <i>J. Organomet. Chem.</i> , 1982, <b>238</b> , C1.          | DTHIBR10 | <i>Inorg. Chem.</i> , 1971, <b>10</b> , 697.                |
| BOGPOC   | <i>Z. Naturforsch., Teil B</i> , 1982, <b>37</b> , 1402.     | EPHTEA   | <i>Inorg. Chem.</i> , 1980, <b>19</b> , 2487.               |
| BOGSUL   | <i>Z. Naturforsch., Teil B</i> , 1982, <b>37</b> , 1230.     | ESEARS   | <i>J. Chem. Soc. C</i> , 1971, 1511.                        |
| BOJLER   | <i>Z. Anorg. Allg. Chem.</i> , 1982, <b>493</b> , 53.        | ETEARS   | <i>J. Chem. Soc. C</i> , 1971, 1511.                        |
| BOJPUL   | <i>Acta Chem. Scand., Ser. A</i> , 1982, <b>36</b> , 829.    | FMESIB   | <i>J. Organomet. Chem.</i> , 1980, <b>197</b> , 275.        |
| BOPFER   | <i>Chem. Ber.</i> , 1983, <b>116</b> , 146.                  | FPHTEL   | <i>J. Chem. Soc., Dalton Trans.</i> , 1980, 2306.           |
| BOPFIV   | <i>Chem. Ber.</i> , 1983, <b>116</b> , 146.                  | FPSULF10 | <i>J. Am. Chem. Soc.</i> , 1982, <b>104</b> , 1683.         |
| BOVMEE   | <i>Acta Crystallogr., Sect. B</i> , 1982, <b>38</b> , 1048.  | HCLENE10 | <i>Acta Crystallogr., Sect. B</i> , 1982, <b>38</b> , 3139. |
| BQUINI   | <i>Acta Crystallogr., Sect. B</i> , 1979, <b>35</b> , 1930.  | HMTITI   | <i>Acta Crystallogr., Sect. B</i> , 1975, <b>31</b> , 1505. |
| BTUPTE   | <i>Acta Chem. Scand., Ser. A</i> , 1975, <b>29</b> , 738.    | HMTNTI   | <i>Z. Anorg. Allg. Chem.</i> , 1974, <b>409</b> , 237.      |
| BUDTEZ   | <i>Z. Naturforsch., Teil B</i> , 1983, <b>38</b> , 454.      | HXPASC   | <i>J. Chem. Soc., Dalton Trans.</i> , 1975, 1381.           |
| BUPSIB10 | <i>Z. Anorg. Allg. Chem.</i> , 1981, <b>474</b> , 31.        | IBZDAC11 | <i>J. Chem. Soc., Dalton Trans.</i> , 1979, 854.            |
| BUSHAY   | <i>Z. Naturforsch., Teil B</i> , 1983, <b>38</b> , 692.      | IFORAM   | <i>Monatsh. Chem.</i> , 1974, <b>105</b> , 621.             |
| BUTHAZ10 | <i>Inorg. Chem.</i> , 1984, <b>23</b> , 2582.                | IODMAM   | <i>Acta Crystallogr., Sect. B</i> , 1977, <b>33</b> , 3209. |
| BUTSUE   | <i>J. Chem. Soc., Chem. Commun.</i> , 1983, 862.             | IPMUDS   | <i>Acta Crystallogr., Sect. B</i> , 1973, <b>29</b> , 2128. |
| BUWZUO   | <i>Acta Chem. Scand., Ser. A</i> , 1983, <b>37</b> , 219.    | ISUREA10 | <i>Acta Crystallogr., Sect. B</i> , 1972, <b>28</b> , 643.  |
| BZPRIB   | <i>Z. Naturforsch., Teil B</i> , 1981, <b>36</b> , 922.      | LITMEB10 | <i>J. Am. Chem. Soc.</i> , 1975, <b>97</b> , 6401.          |
| BZTPPI   | <i>Inorg. Chem.</i> , 1978, <b>17</b> , 894.                 | MESIAD   | <i>Z. Naturforsch., Teil B</i> , 1980, <b>35</b> , 789.     |
| CAHJOK   | <i>Inorg. Chem.</i> , 1983, <b>22</b> , 1809.                | METAMM   | <i>Acta Crystallogr.</i> , 1964, <b>17</b> , 1336.          |
| CAJMAB   | <i>Chem. Z.</i> , 1983, <b>107</b> , 169.                    | MNPSIL   | <i>J. Am. Chem. Soc.</i> , 1969, <b>91</b> , 4134.          |
| CANLUY   | <i>Tetrahedron Lett.</i> , 1983, <b>24</b> , 4337.           | MODIAZ   | <i>J. Heterocycl. Chem.</i> , 1980, <b>17</b> , 1217.       |
| CASSAQ   | <i>J. Struct. Chem.</i> , 1983, <b>2</b> , 101.              | MOPHTE   | <i>Acta Chem. Scand., Ser. A</i> , 1980, <b>34</b> , 333.   |
| CASTOF10 | <i>Acta Crystallogr., Sect. C</i> , 1984, <b>40</b> , 1879.  | MORTRS10 | <i>J. Chem. Soc., Dalton Trans.</i> , 1980, 628.            |
| CASYOK   | <i>J. Struct. Chem.</i> , 1983, <b>2</b> , 107.              | NAPSEZ10 | <i>J. Am. Chem. Soc.</i> , 1980, <b>102</b> , 5070.         |
| CECHEX   | <i>Z. Anorg. Allg. Chem.</i> , 1984, <b>508</b> , 61.        | NBBZAM   | <i>Z. Naturforsch., Teil B</i> , 1977, <b>32</b> , 1416.    |
| CECXEN   | <i>J. Struct. Chem.</i> , 1983, <b>2</b> , 207.              | OPIMAS   | <i>Aust. J. Chem.</i> , 1977, <b>30</b> , 2417.             |
| CEDCUJ   | <i>J. Org. Chem.</i> , 1983, <b>48</b> , 5149.               | OPNTEC10 | <i>J. Chem. Soc., Dalton Trans.</i> , 1982, 251.            |
| CEHKAB   | <i>Z. Naturforsch., Teil B</i> , 1984, <b>39</b> , 139.      | PHASCL   | <i>Acta Crystallogr., Sect. B</i> , 1981, <b>37</b> , 1357. |
| CELDOM   | <i>Acta Crystallogr., Sect. C</i> , 1984, <b>40</b> , 556.   | PHASOC01 | <i>Aust. J. Chem.</i> , 1975, <b>28</b> , 15.               |
| CESSAU   | <i>Acta Crystallogr., Sect. C</i> , 1984, <b>40</b> , 653.   | PNPOSI   | <i>J. Am. Chem. Soc.</i> , 1968, <b>90</b> , 5102.          |
| CETTAW   | <i>Chem. Ber.</i> , 1984, <b>117</b> , 1089.                 | SEBZQI   | <i>J. Chem. Soc., Chem. Commun.</i> , 1977, 325.            |
| CETUTE   | <i>Acta Chem. Scand., Ser. A</i> , 1975, <b>29</b> , 763.    | SPSEBU   | <i>Acta Chem. Scand., Ser. A</i> , 1979, <b>33</b> , 403.   |
| CEYLUN   | <i>Izv. Akad. Nauk SSSR, Ser. Khim.</i> , 1983, 2744.        | TEACBR   | <i>Cryst. Struct. Commun.</i> , 1974, <b>3</b> , 753.       |
| CIFZUM   | <i>Acta Chem. Scand., Ser. A</i> , 1984, <b>38</b> , 289.    | THINBR   | <i>J. Am. Chem. Soc.</i> , 1970, <b>92</b> , 4002.          |
| CIHRAM   | <i>Angew. Chem., Int. Ed. Engl.</i> , 1984, <b>23</b> , 302. | TMPBTI   | <i>Acta Crystallogr., Sect. B</i> , 1975, <b>31</b> , 1116. |
| CILRUK   | <i>J. Chem. Soc., Chem. Commun.</i> , 1984, 1023.            | TPASSN   | <i>J. Chem. Soc., Dalton Trans.</i> , 1977, 514.            |
| CILSAR   | <i>J. Chem. Soc., Chem. Commun.</i> , 1984, 1021.            | TPASTB   | <i>Cryst. Struct. Commun.</i> , 1976, <b>5</b> , 39.        |
| CIMHIP   | <i>Acta Crystallogr., C</i> , 1984, <b>40</b> , 1458.        | TPHOSI   | <i>Z. Naturforsch., Teil B</i> , 1979, <b>34</b> , 1064.    |
| CINTEY   | <i>Dokl. Akad. Nauk SSSR</i> , 1984, <b>274</b> , 615.       | TTEBPZ   | <i>Z. Naturforsch., Teil B</i> , 1979, <b>34</b> , 256.     |
| CIPBUY   | <i>J. Struct. Chem.</i> , 1983, <b>2</b> , 281.              | ZCMXSP   | <i>Cryst. Struct. Commun.</i> , 1977, <b>6</b> , 93.        |
| CISMUM   | <i>Z. Naturforsch., Teil B</i> , 1984, <b>39</b> , 485.      |          |                                                             |
| CISTED   | <i>Z. Anorg. Allg. Chem.</i> , 1984, <b>511</b> , 95.        |          |                                                             |

## STRUCTURE OF FREE MOLECULES IN THE GAS PHASE

This table gives information on the geometric structure of selected molecules in the gas phase, including the overall geometry, interatomic distances, and bond angles. The molecules have been chosen to provide data on a wide variety of chemical bonds and to illustrate the influence of molecular environment on bond distances and angles. The table is restricted to molecules with conventional covalent or ionic bonds, but it should be pointed out that structure data on many loosely bonded complexes of the van der Waals type have recently become available. The references below contain data on many molecules that are not included here and give additional information such as uncertainties and isotopic variations.

The two techniques for gas phase structure determination are spectroscopy and electron diffraction. The following codes are used to indicate the method used for each set of data:

ED – Gas phase electron diffraction  
MW – Microwave spectroscopy, including both measurements in bulk gases and molecular beams  
IR – Infrared spectroscopy  
R – Raman spectroscopy  
UV – Electronic spectroscopy in the ultraviolet and visible regions, including fluorescence measurements  
ESR – Electron spin resonance.

In some cases data from two sources have been combined to derive the structure; these are labeled by “ED, MW,” for example.

Because of the internal vibrations that are present in all molecules, even in their lowest energy state, the definition of interatomic distance is not a simple matter. The ideal measure is the equilibrium distance in the hypothetical non-vibrating state, designated by  $r_e$ . This is the value of the separation of the atoms at the minimum of the potential function that describes the forces between the two atoms. All other measures represent some form of average, generally complex, over the vibrational motions. Since the potential function is asymmetric and less steep at distances beyond the potential minimum, the average distance is normally greater than  $r_e$ . Distances determined by electron diffraction (ED) represent an average over all vibrational states that are populated at the temperature of the measurement; the most common measure is designated  $r_g$ . Distances determined by spectroscopy (MW, IR, R, or UV) through measurements on the ground vibrational state of the molecule, designated by  $r_0$ , describe some form of average, not easily defined, over the zero-point vibrations. Another measure that is frequently used in microwave spectroscopy is the “substitution” distance  $r_s$ , which is operationally defined through a series of measurements on different isotopic species. In simple cases,  $r_s$  often lies between  $r_0$  and  $r_e$  and is therefore a closer approximation to  $r_e$ . Several other types of averages have been used; good discussions can be found in Volumes II/25 and II/28 of the *Landolt-Börnstein* series (Reference 1) and in References 4 and 5.

Unless otherwise specified, distances and angles given in this table are  $r_0$  values if the method is spectroscopic and  $r_g$  values if the method is electron diffraction. When given, equilibrium and substitution distances are designated by  $r_e$  and  $r_s$ , respectively.

Many interatomic distances and angles calculated by *ab initio* techniques have been reported in the recent literature. However, it should be emphasized that all data in this table are obtained from direct experimental measurements. In a few cases, *ab initio* calculations of vibration-rotation interaction constants have been combined with the primary experimental measurements to derive  $r_e$  values in the table.

The number of significant figures in the values is an indication of the precision of the measurement; thus a distance quoted to three decimal places is probably reliable to about 0.005 Å or better. However, discrepancies between  $r_e$ ,  $r_0$ , and  $r_g$  values for the same bond are often the order of 0.01 Å because of vibrational averaging considerations, so care must be taken in comparing bond distances in different molecules. Some distances in simple molecules are given here to four or five decimal places, but little chemical significance can be attached to differences beyond the third decimal place.

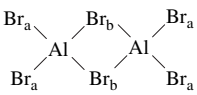
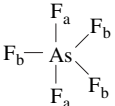
The table is presented in two parts: Part A covers molecules that do not contain carbon while Part B lists carbon-containing molecules. Because many of the entries in Part A are free radicals or other transient species whose systematic chemical names are unfamiliar, the listing in Part A is in order of chemical formula. Part B is ordered by name. In both parts the second column gives information on the overall configuration of the molecule, often indicated by the point group of the equilibrium geometry. Columns 3 through 8 give the values of the bond distances and angles, and the last column indicates the experimental method. Distances are given in Å units, where 1 Å =  $10^{-10}$  m or 0.1 nm. Angles are given in degrees.

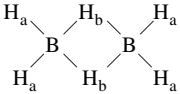
The efforts of Kozo Kuchitsu in preparing an earlier version of this table and in giving advice on the new version are gratefully acknowledged.

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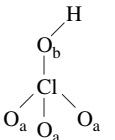
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II/25C, *Molecules Containing Three or Four Carbon Atoms*, 2000  
II/25D, *Molecules Containing Five or More Carbon Atoms*, 2003  
II/28A, *Inorganic Molecules*, 2006  
II/28B, *Molecules Containing One or Two Carbon Atoms*, 2006  
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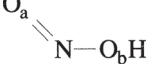
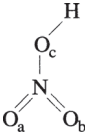
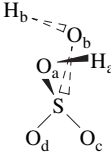
## Part 1 Molecules Not Containing Carbon

| Formula                         | Structure                                                                           | Bond distances in Å and angles in degrees                |               |                                                          |              |       |              | Method |
|---------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------|---------------|----------------------------------------------------------|--------------|-------|--------------|--------|
| AgBr                            |                                                                                     | Ag—Br ( $r_e$ )                                          | 2.3931        |                                                          |              |       |              | MW     |
| AgCl                            |                                                                                     | Ag—Cl ( $r_e$ )                                          | 2.2808        |                                                          |              |       |              | MW     |
| AgF                             |                                                                                     | Ag—F ( $r_e$ )                                           | 1.9832        |                                                          |              |       |              | MW     |
| AgH                             |                                                                                     | Ag—H ( $r_e$ )                                           | 1.617         |                                                          |              |       |              | UV     |
| AgI                             |                                                                                     | Ag—I ( $r_e$ )                                           | 2.5446        |                                                          |              |       |              | MW     |
| AgLi                            |                                                                                     | Ag—Li                                                    | 2.41          |                                                          |              |       |              | UV     |
| AgO                             |                                                                                     | Ag—O ( $r_e$ )                                           | 2.0030        |                                                          |              |       |              | UV     |
| AgOH                            | bent                                                                                | Ag—O                                                     | 2.016         | O—H                                                      | 0.952        | ∠HOAg | 108.3 (ass.) | MW     |
| AlBr                            |                                                                                     | Al—Br ( $r_e$ )                                          | 2.295         |                                                          |              |       |              | UV     |
| AlBr <sub>3</sub>               | D <sub>3h</sub>                                                                     | Al—Br                                                    | 2.221         |                                                          |              |       |              | ED     |
| AlCa                            |                                                                                     | Al—Ca                                                    | 3.148         |                                                          |              |       |              | UV     |
| AlCl                            |                                                                                     | Al—Cl ( $r_e$ )                                          | 2.1301        |                                                          |              |       |              | MW     |
| AlCl <sub>3</sub>               | D <sub>3h</sub>                                                                     | Al—Cl                                                    | 2.063         |                                                          |              |       |              | ED     |
| AlCo                            |                                                                                     | Al—Co                                                    | 2.283         |                                                          |              |       |              | UV     |
| AlCu                            |                                                                                     | Al—Cu                                                    | 2.339         |                                                          |              |       |              | UV     |
| AlF                             |                                                                                     | Al—F ( $r_e$ )                                           | 1.6544        |                                                          |              |       |              | MW     |
| AlF <sub>3</sub>                | D <sub>3h</sub>                                                                     | Al—F                                                     | 1.633         |                                                          |              |       |              | ED     |
| AlH                             |                                                                                     | Al—H ( $r_e$ )                                           | 1.6482        |                                                          |              |       |              | UV     |
| AlI                             |                                                                                     | Al—I ( $r_e$ )                                           | 2.5371        |                                                          |              |       |              | MW     |
| AlI <sub>3</sub>                | D <sub>3h</sub>                                                                     | Al—I                                                     | 2.461         |                                                          |              |       |              | ED     |
| AlK                             |                                                                                     | Al—K                                                     | 3.88          |                                                          |              |       |              | UV     |
| AlMn                            |                                                                                     | Al—Mn                                                    | 2.638         |                                                          |              |       |              | UV     |
| AlNi                            |                                                                                     | Al—Ni                                                    | 2.321         |                                                          |              |       |              | UV     |
| AlO                             |                                                                                     | Al—O ( $r_e$ )                                           | 1.6176        |                                                          |              |       |              | UV     |
| AlS                             |                                                                                     | Al—S ( $r_e$ )                                           | 2.029         |                                                          |              |       |              | UV     |
| AlV                             |                                                                                     | Al—V                                                     | 2.620         |                                                          |              |       |              | UV     |
| AlZn                            |                                                                                     | Al—Zn                                                    | 2.696         |                                                          |              |       |              | UV     |
| Al <sub>2</sub>                 |                                                                                     | Al—Al ( $r_e$ )                                          | 2.701         |                                                          |              |       |              | UV     |
| Al <sub>2</sub> Br <sub>6</sub> |  | Al—Br <sub>a</sub><br>∠Br <sub>b</sub> AlBr <sub>b</sub> | 2.234<br>91.6 | Al—Br <sub>b</sub><br>∠Br <sub>a</sub> AlBr <sub>a</sub> | 2.433<br>122 |       |              | ED     |
|                                 | D <sub>2h</sub>                                                                     |                                                          |               |                                                          |              |       |              |        |
| Al <sub>2</sub> Cl <sub>6</sub> | See Al <sub>2</sub> Br <sub>6</sub>                                                 | Al—Cl <sub>a</sub><br>∠Cl <sub>b</sub> AlCl <sub>b</sub> | 2.061<br>90.0 | Al—Cl <sub>b</sub><br>∠Cl <sub>a</sub> AlCl <sub>a</sub> | 2.250<br>122 |       |              | ED     |
|                                 | D <sub>2h</sub>                                                                     |                                                          |               |                                                          |              |       |              |        |
| AsBr <sub>3</sub>               | C <sub>3v</sub>                                                                     | As—Br                                                    | 2.324         | ∠BrAsBr                                                  | 99.6         |       |              | ED     |
| AsCl <sub>3</sub>               | C <sub>3v</sub>                                                                     | As—Cl                                                    | 2.165         | ∠ClAsCl                                                  | 98.6         |       |              | ED, MW |
| AsF <sub>3</sub>                | C <sub>3v</sub>                                                                     | As—F                                                     | 1.710         | ∠FAsF                                                    | 95.9         |       |              | ED, MW |
| AsF <sub>5</sub>                |  | As—F <sub>a</sub>                                        | 1.711         | As—F <sub>b</sub>                                        | 1.656        |       |              | ED     |
|                                 | D <sub>3h</sub>                                                                     |                                                          |               |                                                          |              |       |              |        |
| AsH                             |                                                                                     | As—H ( $r_e$ )                                           | 1.5232        |                                                          |              |       |              | UV     |
| AsH <sub>3</sub>                | C <sub>3v</sub>                                                                     | As—H ( $r_e$ )                                           | 1.511         | ∠HASH ( $\theta_e$ )                                     | 92.1         |       |              | MW, IR |
| AsI <sub>3</sub>                | C <sub>3v</sub>                                                                     | As—I                                                     | 2.557         | ∠IASI                                                    | 100.2        |       |              | ED     |
| AsN                             |                                                                                     | As—N ( $r_e$ )                                           | 1.6184        |                                                          |              |       |              | UV     |
| AsO                             |                                                                                     | As—O ( $r_e$ )                                           | 1.6236        |                                                          |              |       |              | UV     |
| AsP                             |                                                                                     | As—P ( $r_e$ )                                           | 1.99954       |                                                          |              |       |              | MW     |
| As <sub>2</sub>                 |                                                                                     | As—As ( $r_e$ )                                          | 2.1026        |                                                          |              |       |              | UV     |
| AuH                             |                                                                                     | Au—H ( $r_e$ )                                           | 1.5237        |                                                          |              |       |              | UV     |
| Au <sub>2</sub>                 |                                                                                     | Au—Au ( $r_e$ )                                          | 2.4719        |                                                          |              |       |              | UV     |
| BBr                             |                                                                                     | B—Br ( $r_e$ )                                           | 1.888         |                                                          |              |       |              | UV     |
| BBr <sub>3</sub>                | D <sub>3h</sub>                                                                     | B—Br                                                     | 1.893         |                                                          |              |       |              | ED     |
| BCl                             |                                                                                     | B—Cl ( $r_e$ )                                           | 1.7153        |                                                          |              |       |              | UV     |
| BClF <sub>2</sub>               | C <sub>2v</sub>                                                                     | B—Cl ( $r_s$ )                                           | 1.728         | B—F                                                      | 1.315        | ∠FBF  | 118.1        | MW     |

| Formula                                      | Structure                                                                         | Bond distances in Å and angles in degrees                                                                  |                            |                                                                                          |                  |                                                               |                  | Method |
|----------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------------------------------------------------------------|------------------|---------------------------------------------------------------|------------------|--------|
| BCl <sub>3</sub>                             | D <sub>3h</sub>                                                                   | B—Cl                                                                                                       | 1.742                      |                                                                                          |                  |                                                               |                  | ED     |
| BF                                           |                                                                                   | B—F ( <i>r<sub>e</sub></i> )                                                                               | 1.2626                     |                                                                                          |                  |                                                               |                  | UV     |
| BF <sub>2</sub> H                            |                                                                                   | B—H                                                                                                        | 1.189                      | B—F                                                                                      | 1.311            | ∠FBF                                                          | 118.3            | MW     |
| BF <sub>2</sub> OH                           | F <sub>a</sub> F <sub>b</sub> BOH<br>planar<br>F <sub>a</sub> <i>cis</i> to OH    | B—F <sub>a</sub> ( <i>r<sub>e</sub></i> )<br>∠FBF ( <i>θ<sub>e</sub></i> )<br>O—H ( <i>r<sub>e</sub></i> ) | 1.3229<br>118.36<br>0.9574 | B—F <sub>b</sub> ( <i>r<sub>e</sub></i> )<br>∠F <sub>a</sub> BO ( <i>θ<sub>e</sub></i> ) | 1.3129<br>122.25 | B—O ( <i>r<sub>e</sub></i> )<br>∠BOH ( <i>θ<sub>e</sub></i> ) | 1.3448<br>113.14 | MW     |
| BF <sub>3</sub>                              | D <sub>3h</sub>                                                                   | B—F                                                                                                        | 1.313                      |                                                                                          |                  |                                                               |                  | ED, IR |
| BH                                           |                                                                                   | B—H ( <i>r<sub>e</sub></i> )                                                                               | 1.2325                     |                                                                                          |                  |                                                               |                  | UV     |
| BH <sub>2</sub> NH <sub>2</sub>              | planar                                                                            | B—N<br>∠HBH                                                                                                | 1.391<br>122.2             | B—H<br>∠HNNH                                                                             | 1.195<br>114.2   | N—H                                                           | 1.004            | MW     |
| BH <sub>3</sub>                              | planar                                                                            | B—H                                                                                                        | 1.1900                     |                                                                                          |                  |                                                               |                  | IR     |
| BH <sub>3</sub> PH <sub>3</sub>              | staggered form                                                                    | B—P<br>∠PBH<br>∠HPH                                                                                        | 1.937<br>103.6<br>101.3    | B—H<br>∠BPH                                                                              | 1.212<br>116.9   | P—H<br>∠HBH                                                   | 1.399<br>114.6   | MW     |
| BI <sub>3</sub>                              | D <sub>3h</sub>                                                                   | B—I                                                                                                        | 2.118                      |                                                                                          |                  |                                                               |                  | ED     |
| BN                                           |                                                                                   | B—N ( <i>r<sub>e</sub></i> )                                                                               | 1.281                      |                                                                                          |                  |                                                               |                  | UV     |
| BO                                           |                                                                                   | B—O ( <i>r<sub>e</sub></i> )                                                                               | 1.2045                     |                                                                                          |                  |                                                               |                  | EPR    |
| BO <sub>2</sub>                              | linear                                                                            | B—O                                                                                                        | 1.265                      |                                                                                          |                  |                                                               |                  | UV     |
| BS                                           |                                                                                   | B—S                                                                                                        | 1.6091                     |                                                                                          |                  |                                                               |                  | UV     |
| B <sub>2</sub>                               |                                                                                   | B—B ( <i>r<sub>e</sub></i> )                                                                               | 1.590                      |                                                                                          |                  |                                                               |                  | UV     |
| B <sub>2</sub> H <sub>6</sub>                |  | B—H <sub>a</sub><br>∠H <sub>a</sub> BH <sub>a</sub>                                                        | 1.19<br>122                | B—H <sub>b</sub><br>∠H <sub>b</sub> BH <sub>b</sub>                                      | 1.33<br>97       | B...B                                                         | 1.77             | IR, ED |
| B <sub>3</sub> H <sub>3</sub> O <sub>3</sub> |                                                                                   | B—O                                                                                                        | 1.376                      | ∠BOB                                                                                     | 120              | ∠OBO                                                          | 120              | ED     |
| B <sub>3</sub> H <sub>6</sub> N <sub>3</sub> | C <sub>2</sub>                                                                    | B—N<br>∠BNB                                                                                                | 1.435<br>121               | B—H<br>∠NBN                                                                              | 1.26<br>118      | N—H                                                           | 1.05             | ED     |
| BaBr                                         |                                                                                   | Ba—Br ( <i>r<sub>e</sub></i> )                                                                             | 2.8445                     |                                                                                          |                  |                                                               |                  | UV     |
| BaBr <sub>2</sub>                            |                                                                                   | Ba—Br                                                                                                      | 2.912                      | ∠BrBaBr                                                                                  | 137.0            |                                                               |                  | ED     |
| BaCl                                         |                                                                                   | Ba—Cl ( <i>r<sub>e</sub></i> )                                                                             | 2.6828                     |                                                                                          |                  |                                                               |                  | UV     |
| BaF                                          |                                                                                   | Ba—F ( <i>r<sub>e</sub></i> )                                                                              | 2.163                      |                                                                                          |                  |                                                               |                  | UV     |
| BaH                                          |                                                                                   | Ba—H ( <i>r<sub>e</sub></i> )                                                                              | 2.2318                     |                                                                                          |                  |                                                               |                  | UV     |
| BaI                                          |                                                                                   | Ba—I ( <i>r<sub>e</sub></i> )                                                                              | 3.0848                     |                                                                                          |                  |                                                               |                  | UV     |
| BaI <sub>2</sub>                             |                                                                                   | Ba—I                                                                                                       | 3.150                      | ∠IBaI                                                                                    | 137.6            |                                                               |                  | ED     |
| BaO                                          |                                                                                   | Ba—O ( <i>r<sub>e</sub></i> )                                                                              | 1.9397                     |                                                                                          |                  |                                                               |                  | MW     |
| BaOH                                         | linear                                                                            | Ba—O                                                                                                       | 2.200                      | O—H                                                                                      | 0.927            |                                                               |                  | UV     |
| BaS                                          |                                                                                   | Ba—S ( <i>r<sub>e</sub></i> )                                                                              | 2.5074                     |                                                                                          |                  |                                                               |                  | MBE    |
| BeCl <sub>2</sub>                            | linear                                                                            | Be—Cl ( <i>r<sub>e</sub></i> )                                                                             | 1.791                      |                                                                                          |                  |                                                               |                  | ED, IR |
| BeF                                          |                                                                                   | Be—F ( <i>r<sub>e</sub></i> )                                                                              | 1.3609                     |                                                                                          |                  |                                                               |                  | UV     |
| BeF <sub>2</sub>                             | linear                                                                            | Be—F ( <i>r<sub>e</sub></i> )                                                                              | 1.3730                     |                                                                                          |                  |                                                               |                  | IR     |
| BeH                                          |                                                                                   | Be—H ( <i>r<sub>e</sub></i> )                                                                              | 1.3431                     |                                                                                          |                  |                                                               |                  | UV     |
| BeH <sub>2</sub>                             | linear                                                                            | Be—H( <i>r<sub>e</sub></i> )                                                                               | 1.3264                     |                                                                                          |                  |                                                               |                  | IR     |
| BeO                                          |                                                                                   | Be—O ( <i>r<sub>e</sub></i> )                                                                              | 1.3308                     |                                                                                          |                  |                                                               |                  | UV     |
| BeS                                          |                                                                                   | Be—S ( <i>r<sub>e</sub></i> )                                                                              | 1.7415                     |                                                                                          |                  |                                                               |                  | UV     |
| BiBr                                         |                                                                                   | Bi—Br ( <i>r<sub>e</sub></i> )                                                                             | 2.6095                     |                                                                                          |                  |                                                               |                  | MW     |
| BiBr <sub>3</sub>                            | C <sub>3v</sub>                                                                   | Bi—Br                                                                                                      | 2.577                      | ∠BrBiBr                                                                                  | 98.6             |                                                               |                  | ED     |
| BiCl                                         |                                                                                   | Bi—Cl ( <i>r<sub>e</sub></i> )                                                                             | 2.4716                     |                                                                                          |                  |                                                               |                  | MW     |
| BiCl <sub>3</sub>                            | C <sub>3v</sub>                                                                   | Bi—Cl                                                                                                      | 2.424                      | ∠ClBiCl                                                                                  | 97.5             |                                                               |                  | ED     |
| BiF                                          |                                                                                   | Bi—F ( <i>r<sub>e</sub></i> )                                                                              | 2.0516                     |                                                                                          |                  |                                                               |                  | MW     |
| BiF <sub>3</sub>                             | C <sub>3v</sub>                                                                   | Bi—F                                                                                                       | 1.987                      | ∠FBiF                                                                                    | 96.1             |                                                               |                  | ED     |
| BiH                                          |                                                                                   | Bi—H ( <i>r<sub>e</sub></i> )                                                                              | 1.805                      |                                                                                          |                  |                                                               |                  | UV     |
| BiI                                          |                                                                                   | Bi—I ( <i>r<sub>e</sub></i> )                                                                              | 2.8005                     |                                                                                          |                  |                                                               |                  | MW     |
| BiI <sub>3</sub>                             | C <sub>3v</sub>                                                                   | Bi—I                                                                                                       | 2.807                      | ∠IBiI                                                                                    | 99.5             |                                                               |                  | ED     |
| BiO                                          |                                                                                   | Bi—O ( <i>r<sub>e</sub></i> )                                                                              | 1.934                      |                                                                                          |                  |                                                               |                  | UV     |
| BiP                                          |                                                                                   | Bi—P ( <i>r<sub>e</sub></i> )                                                                              | 2.29345                    |                                                                                          |                  |                                                               |                  | IR     |
| Bi <sub>2</sub>                              |                                                                                   | Bi—Bi ( <i>r<sub>e</sub></i> )                                                                             | 2.6596                     |                                                                                          |                  |                                                               |                  | UV     |
| BrCl                                         |                                                                                   | Br—Cl ( <i>r<sub>e</sub></i> )                                                                             | 2.1361                     |                                                                                          |                  |                                                               |                  | MW     |
| BrF                                          |                                                                                   | Br—F ( <i>r<sub>e</sub></i> )                                                                              | 1.7590                     |                                                                                          |                  |                                                               |                  | MW     |
| BrF <sub>3</sub>                             | F <sub>a</sub> —Br—F <sub>a</sub><br> <br>F <sub>b</sub><br><br>C <sub>2v</sub>   | Br—F <sub>a</sub><br>Br—F <sub>b</sub>                                                                     | 1.810<br>1.721             | ∠F <sub>ax</sub> BrF <sub>eq</sub>                                                       | 85.1             | ∠F <sub>a</sub> BrF <sub>b</sub>                              | 86.2             | MW     |

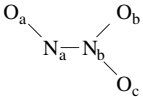
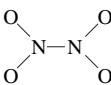
| Formula           | Structure                                                | Bond distances in Å and angles in degrees |                       |                                               |                |                                    |       | Method |
|-------------------|----------------------------------------------------------|-------------------------------------------|-----------------------|-----------------------------------------------|----------------|------------------------------------|-------|--------|
| BrF <sub>5</sub>  | C <sub>4v</sub>                                          | Br—F (av.)                                | 1.753                 | (Br—F <sub>eq</sub> ) – (Br—F <sub>ax</sub> ) | 0.069          | ∠F <sub>ax</sub> BrF <sub>eq</sub> | 85.1  | ED, MW |
| BrN <sub>3</sub>  | BrN <sub>a</sub> N <sub>b</sub> N <sub>c</sub><br>planar | N <sub>a</sub> —N <sub>b</sub><br>∠NNN    | 1.113 (ass.)<br>170.7 | N <sub>b</sub> —N <sub>c</sub><br>∠BrNN       | 1.247<br>109.7 | N <sub>a</sub> —Br                 | 1.899 | ED     |
| BrO               |                                                          | Br—O ( <i>r<sub>e</sub></i> )             | 1.7172                |                                               |                |                                    |       | MW     |
| BrO <sub>2</sub>  | C <sub>2v</sub>                                          | Br—O ( <i>r<sub>e</sub></i> )             | 1.644                 | ∠OBrO ( <i>θ<sub>e</sub></i> )                | 114.3          |                                    |       | MW     |
| Br <sub>2</sub>   |                                                          | Br—Br ( <i>r<sub>e</sub></i> )            | 2.2811                |                                               |                |                                    |       | R      |
| CaBr <sub>2</sub> | linear                                                   | Ca—Br                                     | 2.62                  |                                               |                |                                    |       | ED     |
| CaCl              |                                                          | Ca—Cl ( <i>r<sub>e</sub></i> )            | 2.43676               |                                               |                |                                    |       | UV     |
| CaCl <sub>2</sub> | linear                                                   | Ca—Cl                                     | 2.483                 |                                               |                |                                    |       | ED     |
| CaF               |                                                          | Ca—F ( <i>r<sub>e</sub></i> )             | 1.967                 |                                               |                |                                    |       | UV     |
| CaH               |                                                          | Ca—H ( <i>r<sub>e</sub></i> )             | 2.002                 |                                               |                |                                    |       | UV     |
| CaI               |                                                          | Ca—I ( <i>r<sub>e</sub></i> )             | 2.8286                |                                               |                |                                    |       | UV     |
| CaI <sub>2</sub>  | linear                                                   | Ca—I                                      | 2.840                 |                                               |                |                                    |       | ED     |
| CaO               |                                                          | Ca—O ( <i>r<sub>e</sub></i> )             | 1.8221                |                                               |                |                                    |       | UV     |
| CaOH              | linear                                                   | Ca—O                                      | 1.985                 | O—H                                           | 0.921          |                                    |       | UV     |
| CaS               |                                                          | Ca—S ( <i>r<sub>e</sub></i> )             | 2.3178                |                                               |                |                                    |       | UV     |
| CdH               |                                                          | Cd—H ( <i>r<sub>e</sub></i> )             | 1.781                 |                                               |                |                                    |       | EPR    |
| CdH <sub>2</sub>  | linear                                                   | Cd—H                                      | 1.6792                |                                               |                |                                    |       | IR     |
| CdBr <sub>2</sub> | linear                                                   | Cd—Br                                     | 2.394                 |                                               |                |                                    |       | ED     |
| CdCl <sub>2</sub> | linear                                                   | Cd—Cl                                     | 2.284                 |                                               |                |                                    |       | ED     |
| CdI <sub>2</sub>  | linear                                                   | Cd—I                                      | 2.582                 |                                               |                |                                    |       | ED     |
| CeF <sub>4</sub>  | T <sub>d</sub>                                           | Ce—F                                      | 2.036                 |                                               |                |                                    |       | ED     |
| CeI <sub>3</sub>  | quasiplanar                                              | Ce—I                                      | 2.948                 |                                               |                |                                    |       | ED     |
| ClBS              | linear                                                   | B—Cl                                      | 1.681                 | B—S                                           | 1.606          |                                    |       | MW     |
| ClF               |                                                          | Cl—F ( <i>r<sub>e</sub></i> )             | 1.6283                |                                               |                |                                    |       | MW     |
| ClF <sub>3</sub>  | F <sub>a</sub> —Cl—F <sub>a</sub><br> <br>F <sub>b</sub> | Cl—F <sub>a</sub>                         | 1.698                 | Cl—F <sub>b</sub>                             | 1.598          | ∠F <sub>a</sub> ClF <sub>b</sub>   | 87.5  | MW     |
| ClN <sub>3</sub>  | ClN <sub>a</sub> N <sub>b</sub> N <sub>c</sub><br>planar | N <sub>a</sub> —N <sub>b</sub><br>∠NNN    | 1.253<br>171.0        | N <sub>b</sub> —N <sub>c</sub><br>∠ClNN       | 1.113<br>108.7 | N <sub>a</sub> —Cl                 | 1.746 | MW     |
| ClO               |                                                          | Cl—O ( <i>r<sub>e</sub></i> )             | 1.5696                |                                               |                |                                    |       | MW, UV |
| ClO <sub>2</sub>  | C <sub>2v</sub>                                          | Cl—O                                      | 1.470                 | ∠OClO                                         | 117.38         |                                    |       | MW     |
| Cl <sub>2</sub>   |                                                          | Cl—Cl ( <i>r<sub>e</sub></i> )            | 1.9878                |                                               |                |                                    |       | UV     |
| Cl <sub>2</sub> O | C <sub>2v</sub>                                          | Cl—O                                      | 1.6959                | ∠ClOCl                                        | 110.89         |                                    |       | MW     |
| CoBr <sub>2</sub> | linear                                                   | Co—Br                                     | 2.241                 |                                               |                |                                    |       | ED     |
| CoCl <sub>2</sub> | linear                                                   | Co—Cl                                     | 2.113                 |                                               |                |                                    |       | ED     |
| CoF <sub>2</sub>  | linear                                                   | Co—F                                      | 1.754                 | [Co—F ( <i>r<sub>e</sub></i> )]               | 1.738          |                                    |       | ED     |
| CoF <sub>3</sub>  | D <sub>3h</sub>                                          | Co—F                                      | 1.732                 |                                               |                |                                    |       | ED     |
| CoH               |                                                          | Co—H ( <i>r<sub>e</sub></i> )             | 1.542                 |                                               |                |                                    |       | UV     |
| CrF <sub>2</sub>  | linear                                                   | Cr—F                                      | 1.795                 |                                               |                |                                    |       | ED     |
| CrF <sub>3</sub>  | D <sub>3h</sub>                                          | Cr—F                                      | 1.732                 |                                               |                |                                    |       | ED     |
| CrF <sub>4</sub>  | T <sub>d</sub>                                           | Cr—F                                      | 1.706                 |                                               |                |                                    |       | ED     |
| CrH               |                                                          | Cr—H ( <i>r<sub>e</sub></i> )             | 1.656                 |                                               |                |                                    |       | UV     |
| CrO               |                                                          | Cr—O ( <i>r<sub>e</sub></i> )             | 1.615                 |                                               |                |                                    |       | UV     |
| CsBr              |                                                          | Cs—Br ( <i>r<sub>e</sub></i> )            | 3.0723                |                                               |                |                                    |       | MW     |
| CsCl              |                                                          | Cs—Cl ( <i>r<sub>e</sub></i> )            | 2.9063                |                                               |                |                                    |       | MW     |
| CsF               |                                                          | Cs—F ( <i>r<sub>e</sub></i> )             | 2.3454                |                                               |                |                                    |       | MW     |
| CsH               |                                                          | Cs—H ( <i>r<sub>e</sub></i> )             | 2.4938                |                                               |                |                                    |       | UV     |
| CsI               |                                                          | Cs—I ( <i>r<sub>e</sub></i> )             | 3.3152                |                                               |                |                                    |       | MW     |
| CsO               |                                                          | Cs—O ( <i>r<sub>e</sub></i> )             | 2.3007                |                                               |                |                                    |       | MW     |
| CsOH              | linear; large amplitude bending mode                     | Cs—O ( <i>r<sub>e</sub></i> )             | 2.395                 | O—H ( <i>r<sub>e</sub></i> )                  | 0.97           |                                    |       | MW     |
| Cs <sub>2</sub>   |                                                          | Cs—Cs ( <i>r<sub>e</sub></i> )            | 4.47                  |                                               |                |                                    |       | UV     |
| CuBr              |                                                          | Cu—Br ( <i>r<sub>e</sub></i> )            | 2.1734                |                                               |                |                                    |       | MW     |
| CuCl              |                                                          | Cu—Cl ( <i>r<sub>e</sub></i> )            | 2.0512                |                                               |                |                                    |       | MW     |
| CuF               |                                                          | Cu—F ( <i>r<sub>e</sub></i> )             | 1.7449                |                                               |                |                                    |       | MW     |
| CuF <sub>2</sub>  | linear                                                   | Cu—F                                      | 1.713                 |                                               |                |                                    |       | ED     |
| CuH               |                                                          | Cu—H ( <i>r<sub>e</sub></i> )             | 1.4626                |                                               |                |                                    |       | UV     |
| CuI               |                                                          | Cu—I ( <i>r<sub>e</sub></i> )             | 2.3383                |                                               |                |                                    |       | MW     |
| CuLi              |                                                          | Cu—Li                                     | 2.26                  |                                               |                |                                    |       | UV     |
| CuO               |                                                          | Cu—O ( <i>r<sub>e</sub></i> )             | 1.7244                |                                               |                |                                    |       | UV     |

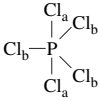
| Formula                         | Structure                                                                           | Bond distances in Å and angles in degrees  |        |                                            |       |                   |                       | Method |
|---------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------|--------|--------------------------------------------|-------|-------------------|-----------------------|--------|
| CuOH                            | bent                                                                                | Cu—O ( $r_s$ )                             | 1.769  | O—H                                        | 0.952 | $\angle$ HOCu     | 110.24 ( $\theta_s$ ) | MW     |
| CuS                             |                                                                                     | Cu—S                                       | 2.051  |                                            |       |                   |                       | UV     |
| Cu <sub>2</sub>                 |                                                                                     | Cu—Cu ( $r_e$ )                            | 2.2197 |                                            |       |                   |                       | UV     |
| DyBr <sub>3</sub>               | quasiplanar                                                                         | Dy—Br                                      | 2.609  |                                            |       |                   |                       | ED     |
| DyCl <sub>3</sub>               | quasiplanar                                                                         | Dy—Cl                                      | 2.461  |                                            |       |                   |                       | ED     |
| FN <sub>3</sub>                 | planar                                                                              | N <sub>a</sub> —N <sub>b</sub>             | 1.253  | N <sub>b</sub> —N <sub>c</sub>             | 1.132 | N <sub>a</sub> —F | 1.439                 | MW     |
|                                 |                                                                                     | $\angle$ NNN                               | 170.3  | $\angle$ FNN                               | 103.8 |                   |                       |        |
| F <sub>2</sub>                  |                                                                                     | F—F ( $r_e$ )                              | 1.4119 |                                            |       |                   |                       | R      |
| FeBr <sub>2</sub>               | linear                                                                              | Fe—Br                                      | 2.294  |                                            |       |                   |                       | ED     |
| FeCl <sub>2</sub>               | linear                                                                              | Fe—Cl                                      | 2.132  |                                            |       |                   |                       | UV,ED  |
| FeF <sub>2</sub>                | linear                                                                              | Fe—F                                       | 1.769  | [Fe—F ( $r_e$ )]                           | 1.755 |                   |                       | ED     |
| FeF <sub>3</sub>                | D <sub>3h</sub>                                                                     | Fe—F                                       | 1.763  |                                            |       |                   |                       | ED     |
| FeH                             |                                                                                     | Fe—H                                       | 1.620  |                                            |       |                   |                       | IR     |
| FeO                             |                                                                                     | Fe—O                                       | 1.444  |                                            |       |                   |                       | UV     |
| FeS                             |                                                                                     | Fe—S                                       | 2.017  |                                            |       |                   |                       | MW     |
| GaBr                            |                                                                                     | Ga—Br ( $r_e$ )                            | 2.3525 |                                            |       |                   |                       | MW     |
| GaBr <sub>3</sub>               | D <sub>3h</sub>                                                                     | Ga—Br                                      | 2.249  |                                            |       |                   |                       | ED     |
| GaCl                            |                                                                                     | Ga—Cl ( $r_e$ )                            | 2.2017 |                                            |       |                   |                       | MW     |
| GaCl <sub>3</sub>               | D <sub>3h</sub>                                                                     | Ga—Cl                                      | 2.110  |                                            |       |                   |                       | ED     |
| GaF                             |                                                                                     | Ga—F ( $r_e$ )                             | 1.7744 |                                            |       |                   |                       | MW     |
| GaF <sub>3</sub>                | D <sub>3h</sub>                                                                     | Ga—F                                       | 1.725  |                                            |       |                   |                       | ED     |
| GaH                             |                                                                                     | Ga—H ( $r_e$ )                             | 1.663  |                                            |       |                   |                       | UV     |
| GaI                             |                                                                                     | Ga—I ( $r_e$ )                             | 2.5747 |                                            |       |                   |                       | MW     |
| GaI <sub>3</sub>                | D <sub>3h</sub>                                                                     | Ga—I                                       | 2.458  |                                            |       |                   |                       | ED     |
| GaO                             |                                                                                     | Ga—O                                       | 1.744  |                                            |       |                   |                       | UV     |
| Ga <sub>2</sub> Br <sub>6</sub> | See Al <sub>2</sub> Br <sub>6</sub>                                                 | Ga—Br <sub>a</sub>                         | 2.250  | Ga—Br <sub>b</sub>                         | 2.453 |                   |                       | ED     |
|                                 | D <sub>2h</sub>                                                                     | $\angle$ Br <sub>a</sub> GaBr <sub>a</sub> | 92.7   | $\angle$ Br <sub>b</sub> GaBr <sub>b</sub> | 123   |                   |                       |        |
| Ga <sub>2</sub> Cl <sub>6</sub> | See Al <sub>2</sub> Br <sub>6</sub>                                                 | Ga—Cl <sub>a</sub>                         | 2.116  | Ga—Cl <sub>b</sub>                         | 2.305 |                   |                       | ED     |
|                                 | D <sub>2h</sub>                                                                     | $\angle$ Cl <sub>a</sub> GaCl <sub>a</sub> | 90     | $\angle$ Cl <sub>b</sub> GaCl <sub>b</sub> | 124.5 |                   |                       |        |
| GdBr <sub>3</sub>               | C <sub>3v</sub>                                                                     | Gd—Br                                      | 2.641  |                                            |       |                   |                       | ED     |
| GdCl <sub>3</sub>               | C <sub>3v</sub>                                                                     | Gd—Cl                                      | 2.488  |                                            |       |                   |                       | ED     |
| GdF <sub>3</sub>                | C <sub>3v</sub>                                                                     | Gd—F                                       | 2.053  |                                            |       |                   |                       | ED     |
| GdI <sub>3</sub>                | C <sub>3v</sub>                                                                     | Gd—I                                       | 2.840  | $\angle$ IGdI                              | 108   |                   |                       | ED     |
| GeBrH <sub>3</sub>              | C <sub>3v</sub>                                                                     | Ge—H                                       | 1.526  | Ge—Br                                      | 2.299 | $\angle$ HGeH     | 106.2                 | MW, IR |
| GeBr <sub>2</sub>               |                                                                                     | Ge—Br ( $r_e$ )                            | 2.359  | $\angle$ BrGeBr                            | 101.0 |                   |                       | ED     |
| GeBr <sub>4</sub>               | T <sub>d</sub>                                                                      | Ge—Br                                      | 2.272  |                                            |       |                   |                       | ED     |
| GeClH <sub>3</sub>              | C <sub>3v</sub>                                                                     | Ge—H                                       | 1.537  | Ge—Cl                                      | 2.150 | $\angle$ HGeH     | 111.0                 | IR, MW |
| GeCl <sub>2</sub>               |                                                                                     | Ge—Cl ( $r_e$ )                            | 2.186  | $\angle$ ClGeCl                            | 100.3 |                   |                       | ED     |
| GeCl <sub>4</sub>               | T <sub>d</sub>                                                                      | Ge—Cl                                      | 2.113  |                                            |       |                   |                       | ED     |
| GeFH <sub>3</sub>               | C <sub>3v</sub>                                                                     | Ge—H                                       | 1.522  | Ge—F                                       | 1.732 | $\angle$ HGeH     | 113.0                 | MW, IR |
| GeF <sub>2</sub>                |                                                                                     | Ge—F ( $r_e$ )                             | 1.7321 | $\angle$ FGeF ( $\theta_s$ )               | 97.15 |                   |                       | MW     |
| GeH                             |                                                                                     | Ge—H ( $r_e$ )                             | 1.5880 |                                            |       |                   |                       | UV     |
| GeHI                            |                                                                                     | Ge—I                                       | 2.525  | Ge—H                                       | 1.593 | $\angle$ HGeI     | 93.5                  | UV     |
| GeH <sub>4</sub>                | T <sub>d</sub>                                                                      | Ge—H                                       | 1.5251 |                                            |       |                   |                       | IR, R  |
| GeI <sub>2</sub>                |                                                                                     | Ge—I                                       | 2.540  | $\angle$ IGeI                              | 102.1 |                   |                       | ED     |
| GeI <sub>4</sub>                | T <sub>d</sub>                                                                      | Ge—I                                       | 2.515  |                                            |       |                   |                       | ED     |
| GeO                             |                                                                                     | Ge—O ( $r_e$ )                             | 1.6246 |                                            |       |                   |                       | MW     |
| GeS                             |                                                                                     | Ge—S ( $r_e$ )                             | 2.0121 |                                            |       |                   |                       | MW     |
| GeSe                            |                                                                                     | Ge—Se ( $r_e$ )                            | 2.1346 |                                            |       |                   |                       | MW     |
| GeTe                            |                                                                                     | Ge—Te ( $r_e$ )                            | 2.3402 |                                            |       |                   |                       | MW     |
| Ge <sub>2</sub> H <sub>6</sub>  |                                                                                     | Ge—Ge                                      | 2.403  | Ge—H                                       | 1.541 |                   |                       | ED     |
|                                 |                                                                                     | $\angle$ HGeH                              | 106.4  | $\angle$ GeGeH                             | 112.5 |                   |                       |        |
| HBr                             |                                                                                     | H—Br ( $r_e$ )                             | 1.4145 |                                            |       |                   |                       | MW     |
| HCl                             |                                                                                     | H—Cl ( $r_e$ )                             | 1.2746 |                                            |       |                   |                       | MW     |
| HClO                            | CLOH (bent)                                                                         | Cl—O                                       | 1.690  | O—H                                        | 0.975 | $\angle$ HOCl     | 102.5                 | MW, IR |
| HClO <sub>4</sub>               |  | Cl—O <sub>a</sub>                          | 1.407  | Cl—O <sub>b</sub>                          | 1.639 |                   |                       | ED     |
|                                 |                                                                                     | $\angle$ O <sub>a</sub> ClO <sub>a</sub>   | 114.3  | $\angle$ O <sub>a</sub> ClO <sub>b</sub>   | 104.1 |                   |                       |        |

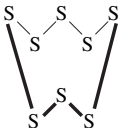
| Formula                        | Structure                                                                          | Bond distances in Å and angles in degrees                                                            |         |                                                                                                     |        |                                                                                                      |        | Method |
|--------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|---------|-----------------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------------------------------|--------|--------|
| HF                             |                                                                                    | H—F ( $r_e$ )                                                                                        | 0.9169  |                                                                                                     |        |                                                                                                      |        | MW     |
| HFO                            | FOH (bent)                                                                         | F—O                                                                                                  | 1.442   | O—H                                                                                                 | 0.96   | $\angle$ HOF                                                                                         | 97.2   | MW     |
| HI                             |                                                                                    | H—I ( $r_e$ )                                                                                        | 1.6090  |                                                                                                     |        |                                                                                                      |        | MW     |
| HIO                            | IOH (bent)                                                                         | I—O                                                                                                  | 1.9941  | O—H                                                                                                 | 0.967  | $\angle$ HOI                                                                                         | 103.9  | MW     |
| HNO                            | bent                                                                               | N—O                                                                                                  | 1.212   | N—H                                                                                                 | 1.063  | $\angle$ HNO                                                                                         | 108.6  | UV     |
| HNO <sub>2</sub>               |   | <i>s-trans</i> conformer                                                                             |         | <i>s-cis</i> conformer                                                                              |        |                                                                                                      |        | MW     |
|                                |                                                                                    | O <sub>b</sub> —H                                                                                    | 0.958   | O <sub>b</sub> —H                                                                                   | 0.98   |                                                                                                      |        |        |
|                                |                                                                                    | N—O <sub>b</sub>                                                                                     | 1.432   | N—O <sub>b</sub>                                                                                    | 1.39   |                                                                                                      |        |        |
|                                |                                                                                    | N—O <sub>a</sub>                                                                                     | 1.170   | N—O <sub>a</sub>                                                                                    | 1.19   |                                                                                                      |        |        |
|                                |                                                                                    | $\angle$ O <sub>a</sub> NO <sub>b</sub>                                                              | 110.7   | $\angle$ O <sub>a</sub> NO <sub>b</sub>                                                             | 114    |                                                                                                      |        |        |
|                                |                                                                                    | $\angle$ NO <sub>b</sub> H                                                                           | 102.1   | $\angle$ NO <sub>b</sub> H                                                                          | 104    |                                                                                                      |        |        |
| HNO <sub>3</sub>               |   | N—O <sub>a</sub>                                                                                     | 1.20    | N—O <sub>b</sub>                                                                                    | 1.21   | N—O <sub>c</sub>                                                                                     | 1.41   | MW     |
|                                |                                                                                    | O <sub>c</sub> —H                                                                                    | 0.96    | $\angle$ O <sub>c</sub> NO <sub>b</sub>                                                             | 115.9  | $\angle$ HO <sub>c</sub> N                                                                           | 102.2  |        |
|                                |                                                                                    | $\angle$ O <sub>c</sub> NO <sub>a</sub>                                                              | 113.9   |                                                                                                     |        |                                                                                                      |        |        |
| HNSO                           | planar<br>planar <i>cis</i>                                                        | N—S                                                                                                  | 1.512   | S—O                                                                                                 | 1.451  | N—H                                                                                                  | 1.029  | MW     |
|                                |                                                                                    | $\angle$ NSO                                                                                         | 120.4   | $\angle$ HNS                                                                                        | 115.8  |                                                                                                      |        |        |
| HN <sub>3</sub>                | HN <sub>a</sub> N <sub>b</sub> N <sub>c</sub><br>planar                            | N <sub>a</sub> —N <sub>b</sub>                                                                       | 1.245   | N <sub>b</sub> —N <sub>c</sub>                                                                      | 1.134  | N <sub>a</sub> —H                                                                                    | 1.015  | MW     |
|                                |                                                                                    | $\angle$ NNN                                                                                         | 171.8   | $\angle$ HNN                                                                                        | 109.2  |                                                                                                      |        |        |
| HPO                            |                                                                                    | P—O                                                                                                  | 1.4843  | P—H                                                                                                 | 1.473  | $\angle$ HPO                                                                                         | 104.57 | MW     |
| H <sub>2</sub>                 |                                                                                    | H—H ( $r_e$ )                                                                                        | 0.74144 |                                                                                                     |        |                                                                                                      |        | UV     |
| H <sub>2</sub> O               | C <sub>2v</sub>                                                                    | O—H ( $r_e$ )                                                                                        | 0.9575  | $\angle$ HOH ( $\theta_e$ )                                                                         | 104.51 |                                                                                                      |        | MW, IR |
| H <sub>2</sub> O <sub>2</sub>  | C <sub>2</sub>                                                                     | O—O                                                                                                  | 1.475   | $\angle$ OOH                                                                                        | 94.8   | dihedral angle                                                                                       | 119.8  | IR     |
| H <sub>2</sub> S               | C <sub>2v</sub>                                                                    | H—S ( $r_e$ )                                                                                        | 1.3356  | $\angle$ HSH ( $\theta_e$ )                                                                         | 92.12  |                                                                                                      |        | MW, IR |
| H <sub>2</sub> SO <sub>4</sub> |  | O—H                                                                                                  | 0.97    | S—O <sub>a</sub>                                                                                    | 1.574  | S—O <sub>c</sub>                                                                                     | 1.422  | MW     |
|                                |                                                                                    | $\angle$ O <sub>a</sub> SO <sub>b</sub>                                                              | 101.3   | $\angle$ O <sub>c</sub> SO <sub>d</sub>                                                             | 123.3  | $\angle$ O <sub>a</sub> SO <sub>c</sub>                                                              | 108.6  |        |
|                                |                                                                                    | $\angle$ O <sub>a</sub> SO <sub>d</sub>                                                              | 106.4   | $\angle$ H <sub>a</sub> O <sub>a</sub> S                                                            | 108.5  | dihedral angle                                                                                       | 20.8   |        |
|                                |                                                                                    | dihedral angle between the H <sub>a</sub> O <sub>a</sub> S and O <sub>a</sub> SO <sub>b</sub> planes | 90.9    | dihedral angle between the H <sub>b</sub> SO <sub>b</sub> and O <sub>c</sub> SO <sub>d</sub> planes | 88.4   | dihedral angle between the H <sub>a</sub> O <sub>a</sub> S and O <sub>a</sub> SO <sub>c</sub> planes |        |        |
| H <sub>2</sub> S <sub>2</sub>  | C <sub>2</sub>                                                                     | S—S                                                                                                  | 2.055   | S—H                                                                                                 | 1.327  | $\angle$ SSH                                                                                         | 91.3   | ED, MW |
|                                | C <sub>2</sub>                                                                     | dihedral angle                                                                                       | 90.6    |                                                                                                     |        |                                                                                                      |        |        |
| HfBr <sub>4</sub>              | T <sub>d</sub>                                                                     | Hf—Br                                                                                                | 2.450   |                                                                                                     |        |                                                                                                      |        | ED     |
| HfCl <sub>4</sub>              | T <sub>d</sub>                                                                     | Hf—Cl                                                                                                | 2.316   |                                                                                                     |        |                                                                                                      |        | ED     |
| HfF                            |                                                                                    | Hf—F                                                                                                 | 1.8596  |                                                                                                     |        |                                                                                                      |        | UV     |
| HfF <sub>4</sub>               | T <sub>d</sub>                                                                     | Hf—F                                                                                                 | 1.909   |                                                                                                     |        |                                                                                                      |        | ED     |
| HfI <sub>4</sub>               | T <sub>d</sub>                                                                     | Hf—I                                                                                                 | 2.662   |                                                                                                     |        |                                                                                                      |        | ED     |
| HgBr <sub>2</sub>              | linear                                                                             | Hg—Br                                                                                                | 2.384   |                                                                                                     |        |                                                                                                      |        | ED     |
| HgCl <sub>2</sub>              | linear                                                                             | Hg—Cl                                                                                                | 2.252   |                                                                                                     |        |                                                                                                      |        | ED     |
| HgH                            |                                                                                    | Hg—H ( $r_e$ )                                                                                       | 1.7404  |                                                                                                     |        |                                                                                                      |        | UV     |
| HgI <sub>2</sub>               | linear                                                                             | Hg—I                                                                                                 | 2.568   |                                                                                                     |        |                                                                                                      |        | ED     |
| HoCl <sub>3</sub>              |                                                                                    | Ho—Cl                                                                                                | 2.462   |                                                                                                     |        |                                                                                                      |        | ED     |
| HoF <sub>3</sub>               |                                                                                    | Ho—F                                                                                                 | 2.007   |                                                                                                     |        |                                                                                                      |        | ED     |
| HoO                            |                                                                                    | Ho—O                                                                                                 | 1.797   |                                                                                                     |        |                                                                                                      |        | UV     |
| IBr                            |                                                                                    | I—Br ( $r_e$ )                                                                                       | 2.4691  |                                                                                                     |        |                                                                                                      |        | MW     |
| ICl                            |                                                                                    | I—Cl ( $r_e$ )                                                                                       | 2.3210  |                                                                                                     |        |                                                                                                      |        | MW     |
| IF                             |                                                                                    | I—F ( $r_e$ )                                                                                        | 1.9098  |                                                                                                     |        |                                                                                                      |        | UV     |
| IF <sub>5</sub>                | C <sub>4v</sub>                                                                    | I—F (av.)                                                                                            | 1.860   | (I—F <sub>eq</sub> ) — (I—F <sub>ax</sub> )                                                         | 0.03   | $\angle$ F <sub>ax</sub> IF <sub>eq</sub>                                                            | 82.1   | ED, MW |
| IO                             |                                                                                    | I—O ( $r_e$ )                                                                                        | 1.8676  |                                                                                                     |        |                                                                                                      |        | MW     |
| I <sub>2</sub>                 |                                                                                    | I—I ( $r_e$ )                                                                                        | 2.6663  |                                                                                                     |        |                                                                                                      |        | R      |
| InBr                           |                                                                                    | In—Br ( $r_e$ )                                                                                      | 2.5432  |                                                                                                     |        |                                                                                                      |        | MW     |
| InCl                           |                                                                                    | In—Cl ( $r_e$ )                                                                                      | 2.4012  |                                                                                                     |        |                                                                                                      |        | MW     |
| InCl <sub>3</sub>              |                                                                                    | In—Cl                                                                                                | 2.291   |                                                                                                     |        |                                                                                                      |        | ED     |
| InF                            |                                                                                    | In—F ( $r_e$ )                                                                                       | 1.9854  |                                                                                                     |        |                                                                                                      |        | MW     |
| InH                            |                                                                                    | In—H ( $r_e$ )                                                                                       | 1.8376  |                                                                                                     |        |                                                                                                      |        | UV     |



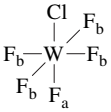
| Formula                         | Structure                                                                           | Bond distances in Å and angles in degrees |         |                  |       |         |       | Method |
|---------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------|---------|------------------|-------|---------|-------|--------|
| InI                             |                                                                                     | In—I ( $r_e$ )                            | 2.7537  |                  |       |         |       | MW     |
| IrF <sub>6</sub>                | O <sub>h</sub>                                                                      | Ir—F                                      | 1.831   |                  |       |         |       | ED     |
| KBH <sub>4</sub>                | H <sub>a</sub> (BH <sub>3</sub> )K (C <sub>3v</sub> )                               | B—H (BH <sub>3</sub> )                    | 1.272   | B—H <sub>a</sub> | 1.233 | K—B     | 2.656 | MW     |
| KBr                             |                                                                                     | K—Br ( $r_e$ )                            | 2.8208  |                  |       |         |       | MW     |
| KCl                             |                                                                                     | K—Cl ( $r_e$ )                            | 2.6667  |                  |       |         |       | MW     |
| KF                              |                                                                                     | K—F ( $r_e$ )                             | 2.1716  |                  |       |         |       | MW     |
| KH                              |                                                                                     | K—H ( $r_e$ )                             | 2.244   |                  |       |         |       | UV     |
| KI                              |                                                                                     | K—I ( $r_e$ )                             | 3.0478  |                  |       |         |       | MW     |
| KOH                             | linear; large amplitude bending mode                                                | K—O                                       | 2.212   | O—H              | 0.91  |         |       | MW     |
| K <sub>2</sub>                  |                                                                                     | K—K ( $r_e$ )                             | 3.9051  |                  |       |         |       | UV     |
| KrF <sub>2</sub>                | linear                                                                              | Kr—F                                      | 1.89    |                  |       |         |       | ED     |
| LaBr                            |                                                                                     | La—Br ( $r_e$ )                           | 2.65208 |                  |       |         |       | MW     |
| LaBr <sub>3</sub>               | C <sub>3v</sub>                                                                     | La—Br                                     | 2.742   |                  |       |         |       | ED     |
| LaCl                            |                                                                                     | La—Cl ( $r_e$ )                           | 2.49804 |                  |       |         |       | MW     |
| LaCl <sub>3</sub>               | C <sub>3v</sub>                                                                     | La—Cl                                     | 2.589   |                  |       |         |       | ED     |
| LaF                             |                                                                                     | La—F ( $r_e$ )                            | 2.02338 |                  |       |         |       | MW     |
| LaI                             |                                                                                     | La—I ( $r_e$ )                            | 2.87885 |                  |       |         |       | MW     |
| LaO                             |                                                                                     | La—O ( $r_e$ )                            | 1.82591 |                  |       |         |       | UV     |
| LiBH <sub>4</sub>               | H <sub>a</sub> (BH <sub>3</sub> )Li (C <sub>3v</sub> )                              | B—H (H <sub>3</sub> )                     | 1.257   | B—H <sub>a</sub> | 1.218 | Li—B    | 1.939 | MW     |
| LiBr                            |                                                                                     | Li—Br ( $r_e$ )                           | 2.1704  |                  |       |         |       | MW     |
| LiCl                            |                                                                                     | Li—Cl ( $r_e$ )                           | 2.0207  |                  |       |         |       | MW     |
| LiF                             |                                                                                     | Li—F ( $r_e$ )                            | 1.5639  |                  |       |         |       | MW     |
| LiH                             |                                                                                     | Li—H ( $r_e$ )                            | 1.5949  |                  |       |         |       | MW     |
| LiI                             |                                                                                     | Li—I ( $r_e$ )                            | 2.3919  |                  |       |         |       | MW     |
| LiO                             |                                                                                     | Li—O ( $r_e$ )                            | 1.68822 |                  |       |         |       | UV     |
| LiOH                            | linear                                                                              | Li—O ( $r_e$ )                            | 1.5776  | O—H ( $r_e$ )    | 0.949 |         |       | MW     |
| Li <sub>2</sub>                 |                                                                                     | Li—Li ( $r_e$ )                           | 2.6729  |                  |       |         |       | UV     |
| Li <sub>2</sub> Cl <sub>2</sub> |  | Li—Cl                                     | 2.23    | Cl—Cl            | 3.61  | ∠ClLiCl | 108   | ED     |
| Li <sub>2</sub> O               | linear                                                                              | Li—O                                      | 1.606   |                  |       |         |       | UV     |
| LuBr <sub>3</sub>               | C <sub>3v</sub>                                                                     | Lu—Br                                     | 2.557   |                  |       |         |       | ED     |
| LuCl <sub>3</sub>               | C <sub>3v</sub>                                                                     | Lu—Cl                                     | 2.417   | ∠ClLuCl          | 112   |         |       | ED     |
| LuI <sub>3</sub>                | C <sub>3v</sub>                                                                     | Lu—I                                      | 2.768   |                  |       |         |       | ED     |
| MgBr                            |                                                                                     | Mg—Br ( $r_e$ )                           | 2.34742 |                  |       |         |       | MW     |
| MgCl                            |                                                                                     | Mg—Cl ( $r_e$ )                           | 2.1964  |                  |       |         |       | UV     |
| MgCl <sub>2</sub>               | linear                                                                              | Mg—Cl                                     | 2.179   |                  |       |         |       | ED     |
| MgF                             |                                                                                     | Mg—F ( $r_e$ )                            | 1.7500  |                  |       |         |       | UV     |
| MgF <sub>2</sub>                | linear                                                                              | Mg—F                                      | 1.771   |                  |       |         |       | ED     |
| MgH                             |                                                                                     | Mg—H ( $r_e$ )                            | 1.7297  |                  |       |         |       | UV     |
| MgO                             |                                                                                     | Mg—O ( $r_e$ )                            | 1.749   |                  |       |         |       | UV     |
| MgOH                            | linear                                                                              | Mg—O                                      | 1.770   | O—H              | 0.912 |         |       | UV     |
| Mg <sub>2</sub>                 |                                                                                     | Mg—Mg ( $r_e$ )                           | 3.891   |                  |       |         |       | UV     |
| MnBr <sub>2</sub>               | linear                                                                              | Mn—Br                                     | 2.344   |                  |       |         |       | ED     |
| MnCl <sub>2</sub>               | linear                                                                              | Mn—Cl                                     | 2.202   |                  |       |         |       | ED     |
| MnF <sub>2</sub>                | linear                                                                              | Mn—F                                      | 1.811   | [Mn—F ( $r_e$ )] | 1.797 |         |       | ED     |
| MnH                             |                                                                                     | Mn—H ( $r_e$ )                            | 1.7308  |                  |       |         |       | UV     |
| MnI <sub>2</sub>                | linear                                                                              | Mn—I                                      | 2.538   |                  |       |         |       | ED     |
| MoCl <sub>4</sub> O             | C <sub>4v</sub>                                                                     | Mo—Cl                                     | 2.279   | Mo—O             | 1.658 |         |       | ED     |
|                                 |                                                                                     | ∠ClMoCl                                   | 87.2    |                  |       |         |       |        |
| MoF <sub>4</sub>                |                                                                                     | Mo—F                                      | 1.851   |                  |       |         |       | ED     |
| MoF <sub>6</sub>                | O <sub>h</sub>                                                                      | Mo—F                                      | 1.821   |                  |       |         |       | ED     |
| NBr                             |                                                                                     | N—Br ( $r_e$ )                            | 1.79    |                  |       |         |       | UV     |
| NCl                             |                                                                                     | N—Cl ( $r_e$ )                            | 1.6107  |                  |       |         |       | UV     |
| NClH <sub>2</sub>               |                                                                                     | N—H                                       | 1.017   | N—Cl             | 1.748 |         |       | MW, IR |
|                                 |                                                                                     | ∠HNCI                                     | 103.7   | ∠HNNH            | 107   |         |       |        |
| NCl <sub>3</sub>                |                                                                                     | N—Cl                                      | 1.759   | ∠ClNCI           | 107.1 |         |       | ED     |

| Formula                           | Structure                                                                                                        | Bond distances in Å and angles in degrees                          |              |                                               |        |                                               |        | Method |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|--------------|-----------------------------------------------|--------|-----------------------------------------------|--------|--------|
| NF                                |                                                                                                                  | N—F ( $r_e$ )                                                      | 1.3170       |                                               |        |                                               |        | UV     |
| NF <sub>2</sub>                   |                                                                                                                  | N—F                                                                | 1.3528       | ∠FNF                                          | 103.18 |                                               |        | MW     |
| NH <sub>2</sub>                   |                                                                                                                  | N—H                                                                | 1.024        | ∠HNH                                          | 103.3  |                                               |        | UV     |
| NH <sub>2</sub> NO <sub>2</sub>   |                                                                                                                  | N—N                                                                | 1.427        | N—H                                           | 1.005  |                                               |        | MW     |
|                                   |                                                                                                                  | dihedral angle between NH <sub>2</sub> and NNO <sub>2</sub> planes | 128.2        | ∠HNH                                          | 115.2  | ∠ONO                                          | 130.1  |        |
| NH <sub>3</sub>                   | C <sub>3v</sub>                                                                                                  | N—H ( $r_e$ )                                                      | 1.012        | ∠HNH ( $\theta_e$ )                           | 106.7  |                                               |        | IR     |
| NH <sub>4</sub> Cl                | H <sub>3</sub> N...HCl (C <sub>3v</sub> )                                                                        | N—Cl                                                               | 3.136        |                                               |        |                                               |        | MW     |
| NH                                |                                                                                                                  | N—H ( $r_e$ )                                                      | 1.0362       |                                               |        |                                               |        | LMR    |
| NH <sub>2</sub> OH                | bisector of HNH angle is <i>trans</i> to OH bond                                                                 | N—O                                                                | 1.453        | N—H                                           | 1.02   | O—H                                           | 0.962  | MW     |
|                                   |                                                                                                                  | ∠HNO                                                               | 103.3        | ∠HNH                                          | 107    | ∠NOH                                          | 101.4  |        |
| NO                                |                                                                                                                  | N—O ( $r_e$ )                                                      | 1.1506       |                                               |        |                                               |        | IR     |
| NOCl                              |                                                                                                                  | N—O                                                                | 1.14         | N—Cl                                          | 1.975  | ∠ONCl                                         | 113    | MW     |
| NOF                               |                                                                                                                  | N—O                                                                | 1.136        | N—F                                           | 1.512  | ∠FNO                                          | 110.1  | MW     |
| NO <sub>2</sub>                   |                                                                                                                  | N—O                                                                | 1.193        | ∠ONO                                          | 134.1  |                                               |        | MW     |
| NO <sub>2</sub> Cl                | C <sub>2v</sub>                                                                                                  | N—O                                                                | 1.202        | N—Cl                                          | 1.840  | ∠ONO                                          | 130.6  | MW     |
| NO <sub>2</sub> F                 | C <sub>2v</sub>                                                                                                  | N—O                                                                | 1.1798       | N—F                                           | 1.467  | ∠ONO                                          | 136    | MW     |
| NS                                |                                                                                                                  | N—S ( $r_e$ )                                                      | 1.4940       |                                               |        |                                               |        | IR     |
| N <sub>2</sub>                    |                                                                                                                  | N—N ( $r_e$ )                                                      | 1.0977       |                                               |        |                                               |        | UV     |
| N <sub>2</sub> H <sub>4</sub>     | H <sub>a</sub> atom is closer to the C <sub>2</sub> axis, H <sub>b</sub> is farther from the C <sub>2</sub> axis | N—N                                                                | 1.449        | N—H                                           | 1.021  | ∠NNH <sub>b</sub>                             | 106    | ED, MW |
|                                   |                                                                                                                  | ∠HNH                                                               | 106.6 (ass.) | ∠NNH <sub>a</sub>                             | 112    |                                               |        |        |
|                                   |                                                                                                                  | dihedral angle of internal rotation                                | 91           |                                               |        |                                               |        |        |
| N <sub>2</sub> O                  |                                                                                                                  | N—N ( $r_e$ )                                                      | 1.1284       | N—O ( $r_e$ )                                 | 1.1841 |                                               |        | MW, IR |
| N <sub>2</sub> O <sub>3</sub>     |                                | N <sub>a</sub> —N <sub>b</sub>                                     | 1.864        | N <sub>a</sub> —O <sub>a</sub>                | 1.142  |                                               |        | MW     |
|                                   |                                                                                                                  | N <sub>b</sub> —O <sub>b</sub>                                     | 1.202        | N <sub>b</sub> —O <sub>c</sub>                | 1.217  |                                               |        |        |
|                                   |                                                                                                                  | ∠O <sub>a</sub> N <sub>a</sub> N <sub>b</sub>                      | 105.05       | ∠N <sub>a</sub> N <sub>b</sub> O <sub>b</sub> | 112.72 | ∠N <sub>a</sub> N <sub>b</sub> O <sub>c</sub> | 117.47 |        |
| N <sub>2</sub> O <sub>4</sub>     |                               | N—N                                                                | 1.782        | N—O                                           | 1.190  | ∠ONO                                          | 135.4  | ED     |
| NaBH <sub>4</sub>                 | D <sub>2h</sub><br>H <sub>a</sub> (BH <sub>3</sub> )Na (C <sub>3v</sub> )                                        | B—H (BH <sub>3</sub> )                                             | 1.278        | B—H <sub>a</sub>                              | 1.238  | Na—B                                          | 2.308  | MW     |
| NaBr                              |                                                                                                                  | Na—Br ( $r_e$ )                                                    | 2.5020       |                                               |        |                                               |        | MW     |
| NaCl                              |                                                                                                                  | Na—Cl ( $r_e$ )                                                    | 2.3609       |                                               |        |                                               |        | MW     |
| NaF                               |                                                                                                                  | Na—F ( $r_e$ )                                                     | 1.9260       |                                               |        |                                               |        | MW     |
| NaH                               |                                                                                                                  | Na—H ( $r_e$ )                                                     | 1.8873       |                                               |        |                                               |        | UV     |
| NaI                               |                                                                                                                  | Na—I ( $r_e$ )                                                     | 2.7115       |                                               |        |                                               |        | MW     |
| NaO                               |                                                                                                                  | Na—O ( $r_e$ )                                                     | 2.05155      |                                               |        |                                               |        | UV     |
| Na <sub>2</sub>                   |                                                                                                                  | Na—Na ( $r_e$ )                                                    | 3.0789       |                                               |        |                                               |        | UV     |
| NbCl <sub>4</sub>                 | T <sub>d</sub>                                                                                                   | Nb—Cl                                                              | 2.279        |                                               |        |                                               |        | ED     |
| NbCl <sub>5</sub>                 | D <sub>3h</sub>                                                                                                  | Nb—Cl <sub>ax</sub>                                                | 2.307        | Nb—Cl <sub>eq</sub>                           | 2.276  |                                               |        | ED     |
| NbO                               |                                                                                                                  | Nb—O ( $r_e$ )                                                     | 1.691        |                                               |        |                                               |        | UV     |
| NdI <sub>3</sub>                  | C <sub>3v</sub>                                                                                                  | Nd—I                                                               | 2.879        |                                               |        |                                               |        | ED     |
| NiBr                              |                                                                                                                  | Ni—Br                                                              | 2.1963       |                                               |        |                                               |        | UV     |
| NiBr <sub>2</sub>                 | linear                                                                                                           | Ni—Br                                                              | 2.201        |                                               |        |                                               |        | ED     |
| NiCl <sub>2</sub>                 | linear                                                                                                           | Ni—Cl                                                              | 2.076        |                                               |        |                                               |        | ED     |
| NiF <sub>2</sub>                  | linear                                                                                                           | Ni—F                                                               | 1.729        | [Ni—F ( $r_e$ )]                              | 1.715  |                                               |        | ED     |
| NiH                               |                                                                                                                  | Ni—H ( $r_e$ )                                                     | 1.476        |                                               |        |                                               |        | UV     |
| NiI                               |                                                                                                                  | Ni—I                                                               | 2.348        |                                               |        |                                               |        | UV     |
| NpF <sub>6</sub>                  | O <sub>h</sub>                                                                                                   | Np—F                                                               | 1.982        |                                               |        |                                               |        | ED     |
| OF                                |                                                                                                                  | O—F ( $r_e$ )                                                      | 1.3579       |                                               |        |                                               |        | LMR    |
| OF <sub>2</sub>                   | C <sub>2v</sub>                                                                                                  | O—F ( $r_e$ )                                                      | 1.4053       | ∠FOF ( $\theta_e$ )                           | 103.07 |                                               |        | MW     |
| OH                                |                                                                                                                  | O—H ( $r_e$ )                                                      | 0.96966      |                                               |        |                                               |        | UV     |
| O(SiH <sub>3</sub> ) <sub>2</sub> |                                                                                                                  | Si—H                                                               | 1.486        | Si—O                                          | 1.634  | ∠SiOSi                                        | 144.1  | ED     |
| O <sub>2</sub>                    |                                                                                                                  | O—O ( $r_e$ )                                                      | 1.2074       |                                               |        |                                               |        | MW     |

| Formula                       | Structure                                                                         | Bond distances in Å and angles in degrees |         |                               |        |        |       | Method                        |
|-------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------|---------|-------------------------------|--------|--------|-------|-------------------------------|
| O <sub>2</sub> F <sub>2</sub> | C <sub>2</sub>                                                                    | O—O                                       | 1.217   | F—O                           | 1.575  | ∠OOF   | 109.5 | MW                            |
|                               |                                                                                   | dihedral angle of internal rotation       | 87.5    |                               |        |        |       |                               |
| O <sub>3</sub>                | C <sub>2v</sub>                                                                   | O—O ( <i>r<sub>e</sub></i> )              | 1.2716  | ∠OOO ( <i>θ<sub>e</sub></i> ) | 117.47 |        |       | MW                            |
| OsF <sub>6</sub>              | O <sub>h</sub>                                                                    | Os—F                                      | 1.832   |                               |        |        |       | ED                            |
| OsO <sub>4</sub>              | T <sub>d</sub>                                                                    | Os—O                                      | 1.712   |                               |        |        |       | ED                            |
| PBr <sub>3</sub>              | C <sub>3v</sub>                                                                   | P—Br                                      | 2.220   | ∠BrPBr                        | 101.0  |        |       | ED                            |
| PCl                           |                                                                                   | P—Cl ( <i>r<sub>e</sub></i> )             | 2.01461 |                               |        |        |       | UV                            |
| PCl <sub>3</sub>              | C <sub>3v</sub>                                                                   | P—Cl                                      | 2.039   | ∠ClPCl                        | 100.27 |        |       | ED                            |
| PCl <sub>5</sub>              |  | P—Cl <sub>a</sub>                         | 2.124   | P—Cl <sub>b</sub>             | 2.020  |        |       | ED                            |
|                               | D <sub>3h</sub>                                                                   |                                           |         |                               |        |        |       |                               |
| PF                            |                                                                                   | P—F ( <i>r<sub>e</sub></i> )              | 1.5896  |                               |        |        |       | UV                            |
| PF <sub>3</sub>               | C <sub>3v</sub>                                                                   | P—F                                       | 1.570   | ∠FPF                          | 97.8   |        |       | ED, MW                        |
| PF <sub>5</sub>               | D <sub>3h</sub>                                                                   | P—F <sub>eq</sub>                         | 1.534   | P—F <sub>ax</sub>             | 1.577  |        |       | ED                            |
| PH                            |                                                                                   | P—H ( <i>r<sub>e</sub></i> )              | 1.4223  |                               |        |        |       | LMR                           |
| PH <sub>2</sub>               |                                                                                   | P—H                                       | 1.418   | ∠HPH                          | 91.70  |        |       | UV                            |
| PH <sub>3</sub>               | C <sub>3v</sub>                                                                   | P—H                                       | 1.4200  | ∠HPH                          | 93.345 |        |       | MW                            |
| PN                            |                                                                                   | N—P ( <i>r<sub>e</sub></i> )              | 1.49087 |                               |        |        |       | MW                            |
| PO                            |                                                                                   | O—P ( <i>r<sub>e</sub></i> )              | 1.4759  |                               |        |        |       | UV                            |
| POCl <sub>3</sub>             | C <sub>3v</sub>                                                                   | P—O                                       | 1.449   | P—Cl                          | 1.993  | ∠ClPCl | 103.3 | ED                            |
| POF <sub>3</sub>              | C <sub>3v</sub>                                                                   | P—O                                       | 1.436   | P—F                           | 1.524  | ∠FPF   | 101.3 | ED, MW                        |
| P <sub>2</sub>                |                                                                                   | P—P ( <i>r<sub>e</sub></i> )              | 1.8931  |                               |        |        |       | UV                            |
| P <sub>2</sub> F <sub>4</sub> | <i>trans conformer</i>                                                            | P—F                                       | 1.587   | P—P                           | 2.281  | ∠FPF   | 99.1  | P <sub>2</sub> F <sub>4</sub> |
|                               |                                                                                   | ∠PPF                                      | 95.4    |                               |        |        |       |                               |
| P <sub>4</sub>                | T <sub>d</sub>                                                                    | P—P                                       | 2.21    |                               |        |        |       | ED                            |
| P <sub>4</sub> O <sub>6</sub> | T <sub>d</sub>                                                                    | P—O                                       | 1.638   | ∠POP                          | 126.4  |        |       | ED                            |
| PbBr <sub>2</sub>             | bent                                                                              | Pb—Br ( <i>r<sub>e</sub></i> )            | 2.598   |                               |        |        |       | ED                            |
| PbCl <sub>2</sub>             | bent                                                                              | Pb—Cl ( <i>r<sub>e</sub></i> )            | 2.444   |                               |        |        |       | ED                            |
| PbCl <sub>4</sub>             | T <sub>d</sub>                                                                    | Pb—Cl                                     | 2.369   |                               |        |        |       | ED                            |
| PbF                           |                                                                                   | Pb—F ( <i>r<sub>e</sub></i> )             | 2.0575  |                               |        |        |       | UV                            |
| PbF <sub>2</sub>              | bent                                                                              | Pb—F ( <i>r<sub>e</sub></i> )             | 2.041   |                               |        |        |       | ED                            |
| PbH                           |                                                                                   | Pb—H ( <i>r<sub>e</sub></i> )             | 1.839   |                               |        |        |       | UV                            |
| PbI <sub>2</sub>              | bent                                                                              | Pb—I ( <i>r<sub>e</sub></i> )             | 2.807   |                               |        |        |       | ED                            |
| PbO                           |                                                                                   | Pb—O ( <i>r<sub>e</sub></i> )             | 1.9218  |                               |        |        |       | MW                            |
| PbS                           |                                                                                   | Pb—S ( <i>r<sub>e</sub></i> )             | 2.2869  |                               |        |        |       | MW                            |
| PbSe                          |                                                                                   | Pb—Se ( <i>r<sub>e</sub></i> )            | 2.4022  |                               |        |        |       | MW                            |
| PbTe                          |                                                                                   | Pb—Te ( <i>r<sub>e</sub></i> )            | 2.5950  |                               |        |        |       | MW                            |
| PrCl <sub>3</sub>             | C <sub>3v</sub>                                                                   | Pr—Cl                                     | 2.554   |                               |        |        |       | ED                            |
| PrF <sub>3</sub>              | C <sub>3v</sub>                                                                   | Pr—F                                      | 2.091   |                               |        |        |       | ED                            |
| PrI <sub>3</sub>              | C <sub>3v</sub>                                                                   | Pr—I                                      | 2.901   | ∠IPrI                         | 113    |        |       | ED                            |
| PtC                           |                                                                                   | Pt—C ( <i>r<sub>e</sub></i> )             | 1.6767  |                               |        |        |       | UV                            |
| PtH                           |                                                                                   | Pt—H ( <i>r<sub>e</sub></i> )             | 1.52852 |                               |        |        |       | UV                            |
| PtN                           |                                                                                   | Pt—N ( <i>r<sub>e</sub></i> )             | 1.682   |                               |        |        |       | MW                            |
| PtO                           |                                                                                   | Pt—O ( <i>r<sub>e</sub></i> )             | 1.7273  |                               |        |        |       | UV                            |
| PtS                           |                                                                                   | Pt—S ( <i>r<sub>e</sub></i> )             | 2.03983 |                               |        |        |       | MW                            |
| PtSi                          |                                                                                   | Pt—Si ( <i>r<sub>e</sub></i> )            | 2.0612  |                               |        |        |       | MW                            |
| PuF <sub>6</sub>              | O <sub>h</sub>                                                                    | Pu—F                                      | 1.972   |                               |        |        |       | ED                            |
| RbBr                          |                                                                                   | Rb—Br ( <i>r<sub>e</sub></i> )            | 2.9447  |                               |        |        |       | MW                            |
| RbCl                          |                                                                                   | Rb—Cl ( <i>r<sub>e</sub></i> )            | 2.7869  |                               |        |        |       | MW                            |
| RbF                           |                                                                                   | Rb—F ( <i>r<sub>e</sub></i> )             | 2.2703  |                               |        |        |       | MW                            |
| RbH                           |                                                                                   | Rb—H ( <i>r<sub>e</sub></i> )             | 2.367   |                               |        |        |       | UV                            |
| RbI                           |                                                                                   | Rb—I ( <i>r<sub>e</sub></i> )             | 3.1768  |                               |        |        |       | MW                            |
| RbO                           |                                                                                   | Rb—O ( <i>r<sub>e</sub></i> )             | 2.25420 |                               |        |        |       | UV                            |
| RbOH                          | linear; large amplitude bending mode                                              | Rb—O                                      | 2.301   | O—H                           | 0.957  |        |       | MW                            |
| ReClO <sub>3</sub>            | C <sub>3v</sub>                                                                   | Re—O                                      | 1.702   | Re—Cl                         | 2.229  | ∠ClReO | 109.4 | MW                            |

| Formula                           | Structure                                                                           | Bond distances in Å and angles in degrees |         |                                 |         |                    |       | Method |
|-----------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------|---------|---------------------------------|---------|--------------------|-------|--------|
| ReClO <sub>4</sub>                | C <sub>4v</sub>                                                                     | Re—O                                      | 1.663   | Re—Cl                           | 2.270   | ∠ClReO             | 105.5 | ED     |
| ReCl <sub>5</sub>                 | D <sub>3h</sub>                                                                     | Re—Cl <sub>eq</sub>                       | 2.238   | Re—Cl <sub>ax</sub>             | 2.263   |                    |       | ED     |
| ReF <sub>6</sub>                  | O <sub>h</sub>                                                                      | Re—F                                      | 1.832   |                                 |         |                    |       | ED     |
| ReF <sub>7</sub>                  | pseudorotation                                                                      | Re—F                                      | 1.835   |                                 |         |                    |       | ED     |
| RhB                               |                                                                                     | Rh—B                                      | 1.691   |                                 |         |                    |       | UV     |
| RhC                               |                                                                                     | Rh—C                                      | 1.614   |                                 |         |                    |       | UV     |
| RhS                               |                                                                                     | Rh—S                                      | 2.059   |                                 |         |                    |       | UV     |
| RuO <sub>4</sub>                  | T <sub>d</sub>                                                                      | Ru—O                                      | 1.706   |                                 |         |                    |       | ED     |
| SCl <sub>2</sub>                  | C <sub>2v</sub>                                                                     | S—Cl                                      | 2.006   | ∠ClSCl                          | 103.0   |                    |       | ED     |
| SF                                |                                                                                     | S—F ( <i>r<sub>e</sub></i> )              | 1.6006  |                                 |         |                    |       | MW     |
| SF <sub>2</sub>                   |                                                                                     | S—F                                       | 1.5921  | ∠FSF                            | 98.20   |                    |       | MW     |
| SF <sub>6</sub>                   | O <sub>h</sub>                                                                      | S—F                                       | 1.561   |                                 |         |                    |       | ED     |
| SH                                |                                                                                     | S—H ( <i>r<sub>e</sub></i> )              | 1.34066 |                                 |         |                    |       | UV     |
| SO                                |                                                                                     | S—O ( <i>r<sub>e</sub></i> )              | 1.4811  |                                 |         |                    |       | MW     |
| SOCl <sub>2</sub>                 |                                                                                     | S—O                                       | 1.44    | S—Cl                            | 2.072   |                    |       | MW     |
|                                   |                                                                                     | ∠ClSCl                                    | 97.2    | ∠OSCl                           | 108.0   |                    |       |        |
| SOF <sub>2</sub>                  |                                                                                     | S—O                                       | 1.420   | S—F                             | 1.583   |                    |       | ED     |
|                                   |                                                                                     | ∠FSF                                      | 92.2    | ∠OSF                            | 106.2   |                    |       |        |
| SOF <sub>4</sub>                  |    | S—O                                       | 1.403   | S—F <sub>a</sub>                | 1.575   | S—F <sub>b</sub>   | 1.552 | ED     |
|                                   |                                                                                     | ∠OSF <sub>a</sub>                         | 90.7    | ∠OSF <sub>b</sub>               | 124.9   |                    |       |        |
|                                   |                                                                                     | ∠F <sub>a</sub> SF <sub>b</sub>           | 89.6    | ∠F <sub>b</sub> SF <sub>b</sub> | 110.2   |                    |       |        |
|                                   | C <sub>2v</sub>                                                                     |                                           |         |                                 |         |                    |       |        |
| SO <sub>2</sub>                   |                                                                                     | S—O ( <i>r<sub>e</sub></i> )              | 1.4308  | ∠OSO ( <i>θ<sub>e</sub></i> )   | 119.329 |                    |       | MW     |
| SO <sub>2</sub> Cl <sub>2</sub>   | C <sub>2v</sub>                                                                     | S—Cl                                      | 2.011   | S—O                             | 1.404   |                    |       | ED     |
|                                   |                                                                                     | ∠ClSCl                                    | 100.0   | ∠OSO                            | 123.5   |                    |       |        |
| SO <sub>2</sub> F <sub>2</sub>    | C <sub>2v</sub>                                                                     | S—F                                       | 1.530   | S—O                             | 1.397   |                    |       | ED     |
|                                   |                                                                                     | ∠FSF                                      | 97      | ∠OSO                            | 123     |                    |       |        |
| SO <sub>3</sub>                   | D <sub>3h</sub>                                                                     | S—O                                       | 1.4198  |                                 |         |                    |       | IR     |
| S(SiH <sub>3</sub> ) <sub>2</sub> |                                                                                     | Si—S                                      | 2.136   | Si—H                            | 1.494   | ∠SiSSi             | 97.4  | ED     |
| S <sub>2</sub>                    |                                                                                     | S—S ( <i>r<sub>e</sub></i> )              | 1.8892  |                                 |         |                    |       | R      |
| S <sub>2</sub> Br <sub>2</sub>    | C <sub>2</sub>                                                                      | S—Br                                      | 2.24    | S—S                             | 1.98    | ∠SSBr              | 105   | ED     |
|                                   |                                                                                     | dihedral angle of internal rotation       | 83.5    |                                 |         |                    |       |        |
| S <sub>2</sub> Cl <sub>2</sub>    | C <sub>2</sub>                                                                      | S—Cl                                      | 2.057   | S—S                             | 1.931   | ∠SSCl              | 108.2 | ED     |
|                                   |                                                                                     | dihedral angle of internal rotation       | 84.1    |                                 |         |                    |       |        |
| S <sub>2</sub> O <sub>2</sub>     | planar <i>cis</i> form                                                              | S—S                                       | 2.025   | S—O                             | 1.458   | ∠OSS               | 112.8 | MW     |
| S <sub>8</sub>                    |  | S—S                                       | 2.07    | ∠SSS                            | 105     | (D <sub>4d</sub> ) |       | ED     |
| SbBr <sub>3</sub>                 | C <sub>3v</sub>                                                                     | Sb—Br                                     | 2.490   | ∠BrSbBr                         | 98.2    |                    |       | ED     |
| SbCl <sub>3</sub>                 | C <sub>3v</sub>                                                                     | Sb—Cl                                     | 2.334   | ∠ClSbCl                         | 97.1    |                    |       | ED     |
| SbCl <sub>5</sub>                 | D <sub>3h</sub>                                                                     | Sb—Cl <sub>eq</sub>                       | 2.277   | Sb—Cl <sub>ax</sub>             | 2.338   |                    |       | ED     |
| SbF                               |                                                                                     | Sb—F ( <i>r<sub>e</sub></i> )             | 1.918   |                                 |         |                    |       | UV     |
| SbF <sub>3</sub>                  | C <sub>3v</sub>                                                                     | Sb—F                                      | 1.880   | ∠FSbF                           | 94.9    |                    |       | ED     |
| SbH                               |                                                                                     | Sb—H                                      | 1.723   |                                 |         |                    |       | UV     |
| SbH <sub>3</sub>                  | C <sub>3v</sub>                                                                     | Sb—H                                      | 1.704   | ∠HSbH                           | 91.6    |                    |       | MW     |
| SbI <sub>3</sub>                  | C <sub>3v</sub>                                                                     | Sb—I                                      | 2.721   | ∠ISbI                           | 99.0    |                    |       | ED     |
| SbO                               |                                                                                     | Sb—O ( <i>r<sub>e</sub></i> )             | 1.826   |                                 |         |                    |       | UV     |
| SbP                               |                                                                                     | Sb—P ( <i>r<sub>e</sub></i> )             | 2.20544 |                                 |         |                    |       | MW     |
| ScCl <sub>3</sub>                 | D <sub>3h</sub>                                                                     | Sc—Cl                                     | 2.291   |                                 |         |                    |       | ED     |
| ScF                               |                                                                                     | Sc—F ( <i>r<sub>e</sub></i> )             | 1.788   |                                 |         |                    |       | UV     |
| ScF <sub>3</sub>                  | D <sub>3h</sub>                                                                     | Sc—F                                      | 1.847   |                                 |         |                    |       | ED     |
| SeF                               |                                                                                     | Se—F                                      | 1.742   |                                 |         |                    |       | MW     |
| SeF <sub>6</sub>                  | O <sub>h</sub>                                                                      | Se—F                                      | 1.69    |                                 |         |                    |       | ED     |
| SeH                               |                                                                                     | Se—H ( <i>r<sub>e</sub></i> )             | 1.48    |                                 |         |                    |       | UV     |
| SeO                               |                                                                                     | Se—O ( <i>r<sub>e</sub></i> )             | 1.6393  |                                 |         |                    |       | MW     |

| Formula                         | Structure                                 | Bond distances in Å and angles in degrees |        |                                |        |                                |        | Method |
|---------------------------------|-------------------------------------------|-------------------------------------------|--------|--------------------------------|--------|--------------------------------|--------|--------|
| SeOF <sub>2</sub>               |                                           | Se—O                                      | 1.576  | Se—F                           | 1.730  |                                |        | MW     |
|                                 |                                           | ∠OSeF                                     | 104.82 | ∠FSeF                          | 92.22  |                                |        |        |
| SeO <sub>2</sub>                |                                           | Se—O ( <i>r<sub>e</sub></i> )             | 1.6076 | ∠OSeO ( <i>θ<sub>e</sub></i> ) | 113.83 |                                |        | MW     |
| SeO <sub>3</sub>                | D <sub>3h</sub>                           | Se—O                                      | 1.69   |                                |        |                                |        | ED     |
| Se <sub>2</sub>                 |                                           | Se—Se ( <i>r<sub>e</sub></i> )            | 2.1660 |                                |        |                                |        | UV     |
| Se <sub>6</sub>                 | six-membered ring with chair conformation | Se—Se                                     | 2.34   | ∠SeSeSe                        | 102    |                                |        | ED     |
| SiBrF <sub>3</sub>              | C <sub>3v</sub>                           | Si—F                                      | 1.559  | Si—Br                          | 2.156  | ∠FSiBr                         | 108.5  | MW     |
| SiBrH <sub>3</sub>              | C <sub>3v</sub>                           | Si—Br                                     | 2.210  | Si—H                           | 1.486  | ∠HSiBr                         | 107.8  | MW     |
| SiCl                            |                                           | Si—Cl ( <i>r<sub>e</sub></i> )            | 2.058  |                                |        |                                |        | UV     |
| SiClH <sub>3</sub>              | C <sub>3v</sub>                           | Si—Cl                                     | 2.049  | Si—H                           | 1.486  | ∠HSiCl                         | 107.9  | MW     |
| SiCl <sub>4</sub>               | T <sub>d</sub>                            | Si—Cl                                     | 2.019  |                                |        |                                |        | ED     |
| SiF                             |                                           | Si—F                                      | 1.6008 |                                |        |                                |        | UV     |
| SiFH <sub>3</sub>               | C <sub>3v</sub>                           | Si—F                                      | 1.593  | Si—H                           | 1.486  | ∠HSiH                          | 110.63 | MW, IR |
| SiF <sub>2</sub>                |                                           | Si—F ( <i>r<sub>e</sub></i> )             | 1.590  | ∠FSiF ( <i>θ<sub>e</sub></i> ) | 100.8  |                                |        | MW     |
| SiF <sub>3</sub> H              | C <sub>3v</sub>                           | Si—H ( <i>r<sub>e</sub></i> )             | 1.4468 | Si—F ( <i>r<sub>e</sub></i> )  | 1.5624 | ∠HSiF ( <i>θ<sub>e</sub></i> ) | 110.64 | MW     |
| SiF <sub>4</sub>                | T <sub>d</sub>                            | Si—F                                      | 1.553  |                                |        |                                |        | ED     |
| SiH                             |                                           | Si—H ( <i>r<sub>e</sub></i> )             | 1.5201 |                                |        |                                |        | UV     |
| SiH <sub>3</sub> I              | C <sub>3v</sub>                           | Si—I                                      | 2.437  | Si—H                           | 1.486  | ∠HSH                           | 107.8  | MW     |
| SiH <sub>4</sub>                | T <sub>d</sub>                            | Si—H                                      | 1.4798 |                                |        |                                |        | IR     |
| SiN                             |                                           | Si—N ( <i>r<sub>e</sub></i> )             | 1.572  |                                |        |                                |        | UV     |
| SiO                             |                                           | Si—O ( <i>r<sub>e</sub></i> )             | 1.5097 |                                |        |                                |        | MW     |
| SiS                             |                                           | Si—S ( <i>r<sub>e</sub></i> )             | 1.9293 |                                |        |                                |        | MW     |
| SiSe                            |                                           | Si—Se ( <i>r<sub>e</sub></i> )            | 2.0583 |                                |        |                                |        | MW     |
| Si <sub>2</sub>                 |                                           | Si—Si ( <i>r<sub>e</sub></i> )            | 2.246  |                                |        |                                |        | UV     |
| Si <sub>2</sub> Cl <sub>6</sub> |                                           | Si—Si                                     | 2.32   | Si—Cl                          | 2.009  | ∠ClSiCl                        | 109.7  | ED     |
| Si <sub>2</sub> F <sub>6</sub>  |                                           | Si—Si                                     | 2.317  | Si—F                           | 1.564  | ∠FSiF                          | 108.6  | ED     |
| Si <sub>2</sub> H <sub>6</sub>  |                                           | Si—Si                                     | 2.331  | Si—H                           | 1.492  |                                |        | ED     |
|                                 |                                           | ∠SiSiH                                    | 110.3  | ∠HSiH                          | 108.6  |                                |        |        |
| SnBr <sub>2</sub>               |                                           | Sn—Br ( <i>r<sub>e</sub></i> )            | 2.501  | ∠BrSnBr                        | 100.0  |                                |        | ED     |
| SnCl                            |                                           | Sn—Cl ( <i>r<sub>e</sub></i> )            | 2.361  |                                |        |                                |        | UV     |
| SnCl <sub>2</sub>               |                                           | Sn—Cl ( <i>r<sub>e</sub></i> )            | 2.335  | ∠ClSnCl                        | 99.1   |                                |        | ED     |
| SnCl <sub>4</sub>               | T <sub>d</sub>                            | Sn—Cl                                     | 2.281  |                                |        |                                |        | ED     |
| SnF                             |                                           | Sn—F ( <i>r<sub>e</sub></i> )             | 1.944  |                                |        |                                |        | UV     |
| SnH                             |                                           | Sn—H ( <i>r<sub>e</sub></i> )             | 1.7815 |                                |        |                                |        | UV     |
| SnH <sub>4</sub>                | T <sub>d</sub>                            | Sn—H                                      | 1.711  |                                |        |                                |        | R, IR  |
| SnI <sub>2</sub>                |                                           | Sn—I ( <i>r<sub>e</sub></i> )             | 2.688  |                                |        |                                |        | ED     |
| SnO                             |                                           | Sn—O ( <i>r<sub>e</sub></i> )             | 1.8325 |                                |        |                                |        | MW, UV |
| SnS                             |                                           | Sn—S ( <i>r<sub>e</sub></i> )             | 2.2090 |                                |        |                                |        | MW     |
| SnSe                            |                                           | Sn—Se ( <i>r<sub>e</sub></i> )            | 2.3256 |                                |        |                                |        | MW     |
| SnTe                            |                                           | Sn—Te ( <i>r<sub>e</sub></i> )            | 2.5228 |                                |        |                                |        | MW     |
| SrBr                            |                                           | Sr—Br ( <i>r<sub>e</sub></i> )            | 2.7352 |                                |        |                                |        | UV     |
| SrBr <sub>2</sub>               | quasilinear                               | Sr—Br                                     | 2.783  |                                |        |                                |        | ED     |
| SrCl <sub>2</sub>               |                                           | Sr—Cl                                     | 2.630  | ∠ClSrCl                        | 155    |                                |        | ED     |
| SrF                             |                                           | Sr—F ( <i>r<sub>e</sub></i> )             | 2.0754 |                                |        |                                |        | UV     |
| SrH                             |                                           | Sr—H ( <i>r<sub>e</sub></i> )             | 2.1456 |                                |        |                                |        | UV     |
| SrI                             |                                           | Sr—I ( <i>r<sub>e</sub></i> )             | 2.9436 |                                |        |                                |        | UV     |
| SrI <sub>2</sub>                | linear                                    | Sr—I                                      | 3.01   |                                |        |                                |        | ED     |
| SrO                             |                                           | Sr—O ( <i>r<sub>e</sub></i> )             | 1.9198 |                                |        |                                |        | MW     |
| SrOH                            |                                           | Sr—O                                      | 2.111  | O—H                            | 0.922  |                                |        | UV     |
| SrS                             |                                           | Sr—S ( <i>r<sub>e</sub></i> )             | 2.4405 |                                |        |                                |        | UV     |
| TaBr <sub>5</sub>               | D <sub>3h</sub>                           | Ta—Br <sub>eq</sub>                       | 2.412  | Ta—Br <sub>ax</sub>            | 2.473  |                                |        | ED     |
| TaCl <sub>5</sub>               | D <sub>3h</sub>                           | Ta—Cl <sub>eq</sub>                       | 2.268  | Ta—Cl <sub>ax</sub>            | 2.315  |                                |        | ED     |
| TaO                             |                                           | Ta—O ( <i>r<sub>e</sub></i> )             | 1.6875 |                                |        |                                |        | UV     |
| TbCl <sub>3</sub>               | C <sub>3v</sub>                           | Tb—Cl                                     | 2.476  |                                |        |                                |        | ED     |
| TeF <sub>6</sub>                | O <sub>h</sub>                            | Te—F                                      | 1.815  |                                |        |                                |        | ED     |
| TeH                             |                                           | Te—H                                      | 1.74   |                                |        |                                |        | UV     |
| TeO                             |                                           | Te—O ( <i>r<sub>e</sub></i> )             | 1.825  |                                |        |                                |        | UV     |
| Te <sub>2</sub>                 |                                           | Te—Te ( <i>r<sub>e</sub></i> )            | 2.5574 |                                |        |                                |        | UV     |
| ThCl <sub>4</sub>               | T <sub>d</sub>                            | Th—Cl                                     | 2.567  |                                |        |                                |        | ED     |

| Formula            | Structure                                                                           | Bond distances in Å and angles in degrees |         |                                 |       |                                 |       | Method |
|--------------------|-------------------------------------------------------------------------------------|-------------------------------------------|---------|---------------------------------|-------|---------------------------------|-------|--------|
| ThF <sub>4</sub>   | T <sub>d</sub>                                                                      | Th—F                                      | 2.124   |                                 |       |                                 |       | ED     |
| ThO                |                                                                                     | Th—O ( <i>r<sub>e</sub></i> )             | 1.84032 |                                 |       |                                 |       | UV     |
| TiBr <sub>4</sub>  | T <sub>d</sub>                                                                      | Ti—Br                                     | 2.339   |                                 |       |                                 |       | ED     |
| TiCl <sub>3</sub>  | D <sub>3h</sub>                                                                     | Ti—Cl                                     | 2.208   |                                 |       |                                 |       | ED     |
| TiCl <sub>4</sub>  | T <sub>d</sub>                                                                      | Ti—Cl                                     | 2.170   |                                 |       |                                 |       | ED     |
| TiF                |                                                                                     | Ti—F                                      | 1.8342  |                                 |       |                                 |       | MW     |
| TiF <sub>4</sub>   | T <sub>d</sub>                                                                      | Ti—F                                      | 1.756   |                                 |       |                                 |       | ED     |
| TiI <sub>3</sub>   | D <sub>3h</sub>                                                                     | Ti—I                                      | 2.568   |                                 |       |                                 |       | ED     |
| TiI <sub>4</sub>   | T <sub>d</sub>                                                                      | Ti—I                                      | 2.546   |                                 |       |                                 |       | ED     |
| TiO                |                                                                                     | Ti—O ( <i>r<sub>e</sub></i> )             | 1.620   |                                 |       |                                 |       | UV     |
| TiS                |                                                                                     | Ti—S ( <i>r<sub>e</sub></i> )             | 2.0825  |                                 |       |                                 |       | UV     |
| TlBr               |                                                                                     | Tl—Br ( <i>r<sub>e</sub></i> )            | 2.6182  |                                 |       |                                 |       | MW     |
| TlCl               |                                                                                     | Tl—Cl ( <i>r<sub>e</sub></i> )            | 2.4848  |                                 |       |                                 |       | MW     |
| TlF                |                                                                                     | Tl—F ( <i>r<sub>e</sub></i> )             | 2.0844  |                                 |       |                                 |       | MW     |
| TlH                |                                                                                     | Tl—H ( <i>r<sub>e</sub></i> )             | 1.870   |                                 |       |                                 |       | UV     |
| TlI                |                                                                                     | Tl—I ( <i>r<sub>e</sub></i> )             | 2.8137  |                                 |       |                                 |       | MW     |
| UCl <sub>4</sub>   | T <sub>d</sub>                                                                      | U—Cl                                      | 2.506   |                                 |       |                                 |       | ED     |
| UCl <sub>6</sub>   | O <sub>h</sub>                                                                      | U—F                                       | 2.46    |                                 |       |                                 |       | ED     |
| UF <sub>4</sub>    | T <sub>d</sub>                                                                      | U—F                                       | 2.059   |                                 |       |                                 |       | ED     |
| UF <sub>6</sub>    | O <sub>h</sub>                                                                      | U—F                                       | 2.000   |                                 |       |                                 |       | ED     |
| UI <sub>3</sub> O  | C <sub>3v</sub>                                                                     | U—I                                       | 2.88    |                                 |       |                                 |       | ED     |
| VCl <sub>3</sub> O | C <sub>3v</sub>                                                                     | V—O                                       | 1.570   | V—Cl                            | 2.142 | ∠ClVCl                          | 111.3 | ED, MW |
| VBr <sub>4</sub>   | T <sub>d</sub> (Jahn-Teller effect)                                                 | V—Br                                      | 2.276   |                                 |       |                                 |       | ED     |
| VCl <sub>4</sub>   | T <sub>d</sub> (Jahn-Teller effect)                                                 | V—Cl                                      | 2.138   |                                 |       |                                 |       | ED     |
| VF <sub>3</sub>    | D <sub>3h</sub>                                                                     | V—F                                       | 1.751   |                                 |       |                                 |       | ED     |
| VF <sub>5</sub>    |                                                                                     | V—F <sub>eq</sub>                         | 1.709   | V—F <sub>ax</sub>               | 1.736 |                                 |       | ED     |
| VMo                |                                                                                     | V—Mo                                      | 1.876   |                                 |       |                                 |       | UV     |
| VO                 |                                                                                     | V—O ( <i>r<sub>e</sub></i> )              | 1.5893  |                                 |       |                                 |       | UV     |
| WClF <sub>5</sub>  |  | W—F (av.)                                 | 1.836   | W—Cl                            | 2.251 | ∠F <sub>a</sub> WF <sub>b</sub> | 88.7  | MW     |
| WCl <sub>5</sub>   | D <sub>3h</sub>                                                                     | W—Cl <sub>eq</sub>                        | 2.243   | W—Cl <sub>ax</sub>              | 2.293 |                                 |       | ED     |
| WCl <sub>6</sub>   | O <sub>h</sub>                                                                      | W—Cl                                      | 2.290   |                                 |       |                                 |       | ED     |
| WF <sub>4</sub> O  | C <sub>4v</sub>                                                                     | W—O                                       | 1.666   | W—F                             | 1.847 | ∠FWF                            | 86.2  | ED     |
| WF <sub>6</sub>    | O <sub>h</sub>                                                                      | W—F                                       | 1.833   |                                 |       |                                 |       | ED     |
| XeF <sub>2</sub>   | linear                                                                              | Xe—F                                      | 1.977   |                                 |       |                                 |       | IR     |
| XeF <sub>4</sub>   | D <sub>4h</sub>                                                                     | Xe—F                                      | 1.94    |                                 |       |                                 |       | ED     |
| XeF <sub>6</sub>   | O <sub>h</sub>                                                                      | Xe—F                                      | 1.890   |                                 |       |                                 |       | ED     |
| XeO <sub>4</sub>   | T <sub>d</sub>                                                                      | Xe—O                                      | 1.736   |                                 |       |                                 |       | ED     |
| YCl                |                                                                                     | Y—Cl                                      | 2.385   |                                 |       |                                 |       | UV     |
| YCl <sub>3</sub>   |                                                                                     | Y—Cl                                      | 2.437   |                                 |       |                                 |       | ED     |
| YF                 |                                                                                     | Y—F ( <i>r<sub>e</sub></i> )              | 1.9257  |                                 |       |                                 |       | UV     |
| YI <sub>3</sub>    |                                                                                     | Y—I                                       | 2.817   |                                 |       |                                 |       | ED     |
| YO                 |                                                                                     | Y—O ( <i>r<sub>e</sub></i> )              | 1.790   |                                 |       |                                 |       | UV     |
| YbBr               |                                                                                     | Yb—Br ( <i>r<sub>e</sub></i> )            | 2.6454  |                                 |       |                                 |       | UV     |
| YbH                |                                                                                     | Yb—H ( <i>r<sub>e</sub></i> )             | 2.0526  |                                 |       |                                 |       | UV     |
| ZnBr <sub>2</sub>  | linear                                                                              | Zn—Br                                     | 2.204   |                                 |       |                                 |       | ED     |
| ZnCl <sub>2</sub>  | linear                                                                              | Zn—Cl                                     | 2.072   |                                 |       |                                 |       | ED     |
| ZnF                |                                                                                     | Zn—F ( <i>r<sub>e</sub></i> )             | 1.7677  |                                 |       |                                 |       | MW     |
| ZnF <sub>2</sub>   | linear                                                                              | Zn—F                                      | 1.742   | [Zn—F ( <i>r<sub>e</sub></i> )] | 1.729 |                                 |       | ED     |
| ZnH                |                                                                                     | Zn—H ( <i>r<sub>e</sub></i> )             | 1.5949  |                                 |       |                                 |       | UV     |
| ZnI <sub>2</sub>   | linear                                                                              | Zn—I                                      | 2.401   |                                 |       |                                 |       | ED     |
| ZrBr <sub>4</sub>  | T <sub>d</sub>                                                                      | Zr—Br                                     | 2.465   |                                 |       |                                 |       | ED     |
| ZrCl <sub>4</sub>  | T <sub>d</sub>                                                                      | Zr—Cl                                     | 2.328   |                                 |       |                                 |       | ED     |
| ZrF <sub>4</sub>   | T <sub>d</sub>                                                                      | Zr—F                                      | 1.902   |                                 |       |                                 |       | ED     |
| ZrI <sub>4</sub>   | T <sub>d</sub>                                                                      | Zr—I                                      | 2.660   |                                 |       |                                 |       | ED     |
| ZrO                |                                                                                     | Zr—O ( <i>r<sub>e</sub></i> )             | 1.7116  |                                 |       |                                 |       | UV     |

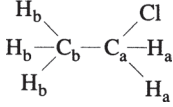
## Part 2. Molecules containing carbon

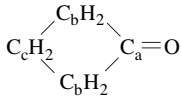
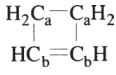
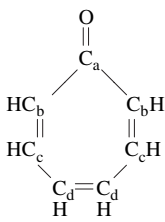
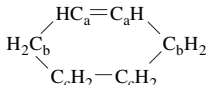
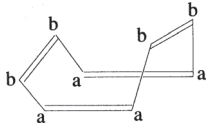
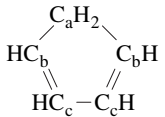
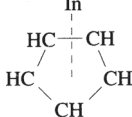
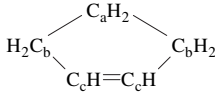
| Compound                      | Structure                                                                                                  | Bond distances in Å and angles in degrees     |        |                                                           |           |                                               |       | Method |
|-------------------------------|------------------------------------------------------------------------------------------------------------|-----------------------------------------------|--------|-----------------------------------------------------------|-----------|-----------------------------------------------|-------|--------|
| Acetaldehyde                  |                                                                                                            | C <sub>a</sub> —O                             | 1.210  | C <sub>a</sub> —C <sub>b</sub>                            | 1.515     |                                               |       | ED, MW |
|                               |                                                                                                            | C <sub>a</sub> —H                             | 1.128  | C <sub>b</sub> —H                                         | 1.107     |                                               |       |        |
|                               |                                                                                                            | ∠C <sub>b</sub> C <sub>a</sub> O              | 124.1  | ∠C <sub>b</sub> C <sub>a</sub> H                          | 115.3     | ∠HC <sub>b</sub> H                            | 109.8 |        |
| Acetamide                     | CH <sub>3</sub> CONH <sub>2</sub>                                                                          | C—O                                           | 1.220  | C—N                                                       | 1.380     |                                               |       | ED     |
|                               |                                                                                                            | C—C                                           | 1.519  | N—H                                                       | 1.022     | C—H                                           | 1.124 |        |
|                               |                                                                                                            | ∠CCN                                          | 115.1  | ∠NCO                                                      | 122.0     |                                               |       |        |
| Acetic acid                   |                                                                                                            | C—C                                           | 1.520  | C—O <sub>a</sub>                                          | 1.214     | C—O <sub>b</sub>                              | 1.364 | ED     |
|                               |                                                                                                            | C—H                                           | 1.10   | ∠CCO <sub>a</sub>                                         | 126.6     | ∠CCO <sub>b</sub>                             | 110.6 |        |
| Acetone                       | (CH <sub>3</sub> ) <sub>2</sub> CO<br>Symmetry axis of each CH <sub>3</sub> is tilted 2° from the C—C bond | C—C                                           | 1.520  | C—O                                                       | 1.213     | C—H                                           | 1.103 | ED, MW |
|                               |                                                                                                            | ∠CCC                                          | 116.0  | ∠HCH                                                      | 108.5     |                                               |       |        |
| Acetonitrile                  | CH <sub>3</sub> CN (C <sub>3v</sub> )                                                                      | C—N                                           | 1.159  | C—C                                                       | 1.468     | C—H                                           | 1.107 | ED, MW |
|                               |                                                                                                            | ∠CCH                                          | 109.7  |                                                           |           |                                               |       |        |
| Acetonitrile- <i>N</i> -oxide | CH <sub>3</sub> CNO (C <sub>3v</sub> )                                                                     | C—C                                           | 1.442  | C—N                                                       | 1.169     | N—O                                           | 1.217 | MW     |
| Acetyl chloride               | CH <sub>3</sub> COCl                                                                                       | C—C                                           | 1.506  | C—O                                                       | 1.187     | C—H                                           | 1.105 | ED, MW |
|                               |                                                                                                            | C—Cl                                          | 1.798  | ∠HCH                                                      | 108.6     | ∠OCCl                                         | 121.2 |        |
|                               |                                                                                                            | ∠CCCl                                         | 111.6  |                                                           |           |                                               |       |        |
| Acetylene                     | HC≡CH                                                                                                      | C—C ( <i>r<sub>e</sub></i> )                  | 1.203  | C—H ( <i>r<sub>e</sub></i> )                              | 1.060     |                                               |       | IR     |
| Acrolein                      |                                                                                                            | C <sub>a</sub> —C <sub>b</sub>                | 1.345  | C <sub>b</sub> —C <sub>c</sub>                            | 1.484     | C <sub>c</sub> —O                             | 1.217 | ED, MW |
|                               |                                                                                                            | C <sub>a</sub> —H                             | 1.10   | C <sub>c</sub> —H                                         | 1.13      | ∠HC <sub>c</sub> C <sub>b</sub>               | 114   |        |
|                               |                                                                                                            | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub> | 120.3  | ∠C <sub>b</sub> C <sub>c</sub> O                          | 123.3     | Other CCH (av.)                               | 122   |        |
|                               | (planar <i>s-trans</i> form)                                                                               |                                               |        |                                                           |           |                                               |       |        |
| Acrylonitrile                 |                                                                                                            | C <sub>a</sub> —C <sub>b</sub>                | 1.343  | C <sub>b</sub> —C <sub>c</sub>                            | 1.438     | C <sub>c</sub> —N                             | 1.167 | ED, MW |
|                               |                                                                                                            | C <sub>a</sub> —H                             | 1.114  | ∠C <sub>b</sub> C <sub>c</sub> N                          | 178       | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub> | 121.7 |        |
|                               |                                                                                                            | ∠HCC                                          | 120    |                                                           |           |                                               |       |        |
| Allene                        | CH <sub>2</sub> =C=CH <sub>2</sub>                                                                         | C—C                                           | 1.3084 | C—H                                                       | 1.087     | ∠HCH                                          | 118.2 | IR     |
| Aniline                       | C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>                                                              | C—C                                           | 1.392  | C—N                                                       | 1.431     | N—H                                           | 0.998 | MW     |
|                               |                                                                                                            | ∠HNH                                          | 113.9  | dihedral angle between NH <sub>2</sub> plane and N—C bond | 140.6     |                                               |       |        |
| Azetidine                     |                                                                                                            | C—N                                           | 1.482  | C—C                                                       | 1.553     |                                               |       | ED     |
|                               |                                                                                                            | C—H                                           | 1.107  | N—H                                                       | 1.03      |                                               |       |        |
|                               |                                                                                                            | ∠CCC                                          | 86.9   | ∠CCN                                                      | 85.8      | ∠CNC                                          | 92.2  |        |
|                               |                                                                                                            | dihedral angle between CCC and CNC planes     | 147    |                                                           |           |                                               |       |        |
| Benzamide                     | C <sub>6</sub> H <sub>5</sub> —C <sub>a</sub> ONH <sub>2</sub>                                             | C—C (ring)                                    | 1.401  | C (ring)—C <sub>a</sub>                                   | 1.511     | C <sub>a</sub> —O                             | 1.225 | ED     |
|                               |                                                                                                            | C—H                                           | 1.112  | C—N                                                       | 1.380     |                                               |       |        |
|                               |                                                                                                            | ∠CCN                                          | 117.8  | ∠CCC (ring)                                               | 120(ass.) | ∠CCO                                          | 121.2 |        |
| Benzene                       | C <sub>6</sub> H <sub>6</sub>                                                                              | C—C                                           | 1.399  | C—H                                                       | 1.101     |                                               |       | ED, IR |
| <i>p</i> -Benzoquinone        |                                                                                                            | C <sub>a</sub> —O                             | 1.225  | C <sub>a</sub> —C <sub>b</sub>                            | 1.481     | C <sub>b</sub> —C <sub>b</sub>                | 1.344 | ED     |
|                               |                                                                                                            | ∠C <sub>b</sub> C <sub>a</sub> C <sub>b</sub> | 118.1  |                                                           |           |                                               |       |        |

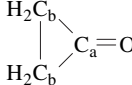
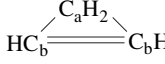
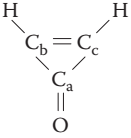
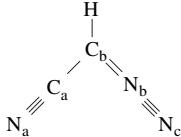
| Compound                        | Structure                                                                                         | Bond distances in Å and angles in degrees                                                                      |                                                            |                                                |                         |                                                           |                        | Method |
|---------------------------------|---------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------|-------------------------|-----------------------------------------------------------|------------------------|--------|
| Bicyclo[1.1.0]butane            |                                                                                                   | $C_a-C_a$<br>$C_b-H_b$<br>$\angle C_b C_a H_a$<br>dihedral angle<br>between the<br>two $C_a C_a C_b$<br>planes | 1.497<br>1.093<br>130.4<br>121.7                           | $C_a-C_b$<br>$C_b-H_c$<br>$\angle C_a C_a H_a$ | 1.498<br>1.093<br>128.4 | $C_a-H_a$<br>$\angle H_b C_b H_c$<br>$\angle C_a C_b C_a$ | 1.071<br>115.6<br>60.0 | MW     |
| Bicyclo[2.2.1]heptane           | See preceding structure<br>$C_7H_{12}$                                                            | $C_a-C_b$<br>$C-C$ (av.)<br>dihedral angle<br>between the<br>two $C_a C_b C_b C_a$<br>planes                   | 1.54<br>1.549<br>113.1                                     | $C_b-C_b$<br>$\angle C_a C_c C_a$              | 1.56<br>93.1            | $C_a-C_c$                                                 | 1.56                   | ED     |
| Bicyclo[2.2.0]hexa-2,5-diene    |                                                                                                   | $C_b-C_b$<br>dihedral angle<br>between the<br>two $C_a C_b C_b C_a$<br>planes                                  | 1.345<br>117.3                                             | $C_a-C_a$                                      | 1.574                   | $C_a-C_b$                                                 | 1.524                  | ED     |
| Bicyclo[2.2.2]octane            | $HC_a(C_bH_2C_bH_2)_3C_aH$<br>large-amplitude torsional<br>motion about $D_{3h}$ symmetry<br>axis | $C_a-C_b$<br>$\angle C_a C_b C_b$                                                                              | 1.54<br>109.7                                              | $C_b-C_b$                                      | 1.55                    | $C-C$ (av.)                                               | 1.542                  | ED     |
| Bicyclo[1.1.1]pentane           | $C_5H_8$                                                                                          | $C-C$                                                                                                          | 1.557                                                      | $\angle CCC$                                   | 74.2                    |                                                           |                        | ED     |
| Bicyclo[2.1.0]pentane           |                                                                                                   | $C_a-C_a$<br>$C_a-C_b$<br>dihedral angle<br>between the<br>$C_a C_a C_b C_b$ and<br>$C_a C_a C_c$ planes       | 1.536<br>1.528<br>112.7                                    | $C_b-C_b$                                      | 1.565                   | $C_a-C_c$                                                 | 1.507                  | MW     |
| Biphenyl                        |                                                                                                   | $C-C$ (intra-<br>ring)<br>torsional<br>dihedral angle<br>between the<br>two rings                              | 1.396<br>$\approx 40$                                      | $C-C$ (inter-<br>ring)                         | 1.49                    |                                                           |                        | ED     |
| 4,4'-Bipyridyl                  |                                                                                                   | $C-C$ (inter-<br>ring)<br>torsional<br>dihedral angle<br>between the<br>two rings                              | 1.465<br>$\approx 37$                                      | $C-C$ (intra-<br>ring)                         | 1.375                   | $C-N$ (intra-<br>ring)                                    | 1.375                  | ED     |
| Bis(cyclopentadienyl) beryllium | $(C_5H_5)_2Be$ ( $D_{5v}$ )                                                                       | $Be-(cyclopentadienyl$ plane)                                                                                  | 1.470,<br>1.92                                             | $C-C$                                          | 1.423                   |                                                           |                        | ED     |
| Bis(cyclopentadienyl) iron      | $(C_5H_5)_2Fe$ ( $D_{5h}$ )                                                                       | $Fe-C$                                                                                                         | 2.064                                                      | $C-C$                                          | 1.440                   | $C-H$                                                     | 1.104                  | ED     |
| Bis(cyclopentadienyl) lead      | $(C_5H_5)_2Pb$ ( $D_{5h}$ )                                                                       | $Pb-C$<br>dihedral angle<br>between the<br>two $C_5H_5$ planes                                                 | 2.79<br>40~50<br>(The two<br>rings are<br>not<br>parallel) | $C-C$                                          | 1.430                   |                                                           |                        | ED     |
| Bis(cyclopentadienyl) manganese | $(C_5H_5)_2Mn$ ( $D_{5h}$ )                                                                       | $Mn-C$                                                                                                         | 2.383                                                      | $C-C$                                          | 1.429                   |                                                           |                        | ED     |
| Bis(cyclopentadienyl) nickel    | $(C_5H_5)_2Ni$ ( $D_{5h}$ )                                                                       | $Ni-C$                                                                                                         | 2.196                                                      | $C-C$                                          | 1.430                   |                                                           |                        | ED     |
| Bis(cyclopentadienyl) ruthenium | $(C_5H_5)_2Ru$ ( $D_{5h}$ )                                                                       | $Ru-C$                                                                                                         | 2.196                                                      | $C-C$                                          | 1.439                   |                                                           |                        | ED     |
| Bis(cyclopentadienyl) tin       | $(C_5H_5)_2Sn$ ( $D_{5h}$ )                                                                       | $Sn-C$                                                                                                         | 2.71                                                       | $C-C$                                          | 1.431                   | $C-H$                                                     | 1.14                   | ED     |
| Borane carbonyl                 | $BH_3CO$ ( $C_{3v}$ )                                                                             | $C-O$<br>$\angle BCO$                                                                                          | 1.131<br>180                                               | $B-C$<br>$\angle HBH$                          | 1.540<br>113.9          | $B-H$                                                     | 1.194                  | MW     |



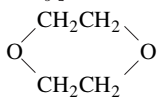
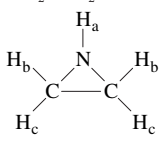
| Compound                    | Structure                                                 | Bond distances in Å and angles in degrees                              |                               |                                                                        |                             |                                                           |                     | Method |
|-----------------------------|-----------------------------------------------------------|------------------------------------------------------------------------|-------------------------------|------------------------------------------------------------------------|-----------------------------|-----------------------------------------------------------|---------------------|--------|
| Bromobenzene                |                                                           | $C_a-C_b$<br>$C-Br$                                                    | 1.42<br>1.85                  | $C_b-C_c$<br>$C-H$                                                     | 1.375<br>1.072              | $C_c-C_d$<br>$\angle C_b C_a C_b$                         | 1.401<br>117.4      | MW     |
| Bromochloroacetylene        | $ClC\equiv CBr$                                           | $C-Cl$                                                                 | 1.636                         | $C-Br$                                                                 | 1.784                       | $C-C$                                                     | 1.206               | ED     |
| Bromoiodoacetylene          | $IC\equiv CBr$                                            | $C-I$                                                                  | 1.972                         | $C-Br$                                                                 | 1.795                       | $C-C$                                                     | 1.206               | ED     |
| Bromomethane                | $CH_3Br$                                                  | $C-Br$ ( $r_e$ )                                                       | 1.933                         | $C-H$ ( $r_e$ )                                                        | 1.086                       | $\angle HCH$ ( $\theta_e$ )                               | 111.2               | MW, IR |
| Bromomethyl                 | $CH_2Br$ (planar)                                         | $C-Br$                                                                 | 1.848                         | $C-H$                                                                  | 1.084                       | $\angle HCH$ (ass.)                                       | 124.5               | MW     |
| Bromomethylene              | $CHBr$ (bent)                                             | $C-Br$                                                                 | 1.857                         | $C-H$                                                                  | 1.110                       | $\angle HCH$                                              | 101.0               | UV     |
| Bromomethylmercury          | $CH_3HgBr$ ( $C_{3v}$ )                                   | $C-Hg$                                                                 | 2.07                          | $Hg-Br$                                                                | 2.406                       |                                                           |                     | MW     |
| 1,3-Butadiene               |                                                           | $C_a-C_b$<br>$\angle CCC$                                              | 1.349<br>124.4                | $C_b-C_c$<br>$\angle C_b C_a H$                                        | 1.467<br>120.9              | $C-H$ (av.)                                               | 1.108               | ED     |
| 1,3-Butadiyne               | $(C_{2h})$<br>$HC\equiv C_b C_b \equiv C_a H$<br>(linear) | $C_a-C_b$                                                              | 1.218                         | $C_b-C_b$                                                              | 1.384                       | $C-H$                                                     | 1.09                | ED     |
| Butane                      | $CH_3CH_2CH_2CH_3$                                        | $C-C$<br>$\angle CCH$                                                  | 1.531<br>111.0                | $C-H$<br>dihedral angle<br>for the <i>gauche</i><br>conformer          | 1.117<br>65                 | $\angle CCC$                                              | 113.8               | ED     |
| 2,3-Butanedione             | $CH_3COCOCH_3$<br><i>trans</i> conformer                  | $C-O$<br>$\angle CCC$                                                  | 1.215<br>116.2                | $C-C$ (av.)<br>$\angle CCO$                                            | 1.524<br>119.5              | $C-H$                                                     | 1.108               | ED     |
| 2-Butanone                  |                                                           | $C-C$ (av.)                                                            | 1.518                         | $C_c-O$                                                                | 1.219                       | $C-H$ (av.)                                               | 1.102               | ED     |
| 1,2,3-Butatriene            | $H_2C_a=C_b=C_c=C_aH_2$ ( $D_{2h}$ )                      | $\angle C_a C_b C_c$<br>$C_a-C_b$                                      | 113.5<br>1.32                 | $\angle C_b C_c O$<br>$C_b-C_b$                                        | 121.9<br>1.28               | $\angle C_d C_c O$<br>$C-H$                               | 121.9<br>1.08       | ED     |
| <i>cis</i> -2-Butene        | $C_aH_3C_bH=C_bHC_aH_3$                                   | $C_a-C_b$                                                              | 1.506                         | $C_b-C_b$                                                              | 1.346                       | $\angle C_a C_b C_b$                                      | 125.4               | ED     |
| <i>trans</i> -2-Butene      | $C_aH_3C_bH=C_bHC_aH_3$                                   | $C_a-C_b$                                                              | 1.508                         | $C_b-C_b$                                                              | 1.347                       | $\angle C_a C_b C_b$                                      | 123.8               | ED     |
| 1-Buten-3-yne               |                                                           | $C_a-C_b$<br>$C_a-H_a$<br>$\angle C_a C_b C_c$<br>$\angle H_b C_a C_b$ | 1.344<br>1.11<br>123.1<br>122 | $C_b-C_c$<br>$C_d-H_d$<br>$\angle C_b C_c C_d$<br>$\angle H_c C_b C_a$ | 1.434<br>1.09<br>178<br>122 | $C_c-C_d$<br>$\angle H_a C_a C_b$<br>$\angle C_c C_d H_d$ | 1.215<br>119<br>182 | ED, MW |
| <i>tert</i> -Butyl chloride | $(CH_3)_3CCl$                                             | $C-C$<br>$\angle CCCl$                                                 | 1.528<br>107.3                | $C-Cl$<br>$\angle CCH$                                                 | 1.828<br>110.8              | $C-H$<br>$\angle CCC$                                     | 1.102<br>111.6      | ED, MW |
| 2-Butyne                    | $C_aH_3-C_b\equiv C_b-C_aH_3$                             | $C_b-C_b$<br>$\angle C_b C_a H$                                        | 1.214<br>110.7                | $C_a-C_b$                                                              | 1.468                       | $C-H$                                                     | 1.116               | ED     |
| Carbon dimer                | $C_2$                                                     | $C-C$ ( $r_e$ )                                                        | 1.2425                        |                                                                        |                             |                                                           |                     | UV     |
| Carbon trimer               | $C_3$ (linear)                                            | $C-C$                                                                  | 1.277                         |                                                                        |                             |                                                           |                     | UV     |
| Carbon dioxide              | $CO_2$ (linear)                                           | $C-O$ ( $r_e$ )                                                        | 1.1600                        |                                                                        |                             |                                                           |                     | IR     |
| Carbon disulfide            | $CS_2$ (linear)                                           | $C-S$ ( $r_e$ )                                                        | 1.5526                        |                                                                        |                             |                                                           |                     | IR     |
| Carbon monobromide          | $CBr$                                                     | $C-Br$                                                                 | 1.8209                        |                                                                        |                             |                                                           |                     | UV     |
| Carbon monoselenide         | $CSe$                                                     | $C-Se$ ( $r_e$ )                                                       | 1.67609                       |                                                                        |                             |                                                           |                     | UV     |
| Carbon monosulfide          | $CS$                                                      | $C-S$ ( $r_e$ )                                                        | 1.5349                        |                                                                        |                             |                                                           |                     | MW     |
| Carbon monoxide             | $CO$                                                      | $C-O$ ( $r_e$ )                                                        | 1.1283                        |                                                                        |                             |                                                           |                     | MW     |
| Carbon oxyselenide          | $OCSe$ (linear)                                           | $C-O$                                                                  | 1.159                         | $C-Se$                                                                 | 1.709                       |                                                           |                     | MW     |
| Carbon oxysulfide           | $OCS$ (linear)                                            | $C-O$ ( $r_e$ )                                                        | 1.1578                        | $C-S$ ( $r_e$ )                                                        | 1.5601                      |                                                           |                     | MW     |
| Carbon phosphide            | $CP$                                                      | $C-P$ ( $r_e$ )                                                        | 1.562                         |                                                                        |                             |                                                           |                     | UV     |
| Carbon sulfide selenide     | $SCSe$ (linear)                                           | $C-S$                                                                  | 1.553                         | $C-Se$                                                                 | 1.693                       |                                                           |                     | MW     |
| Carbon sulfide telluride    | $SCTe$ (linear)                                           | $C-S$                                                                  | 1.557                         | $C-Te$                                                                 | 1.904                       |                                                           |                     | MW     |
| Carbon suboxide             | $OCCCO$ (linear)                                          | $C-C$                                                                  | 1.289                         | $C-O$                                                                  | 1.163                       |                                                           |                     | ED     |

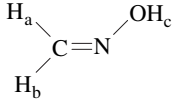
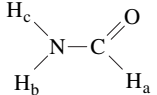
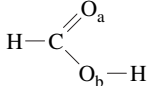
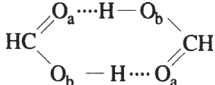
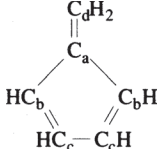
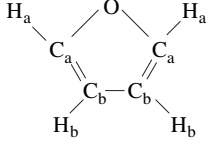
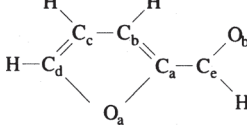
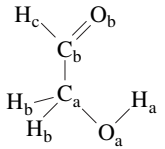
| Compound                   | Structure                                                                         | Bond distances in Å and angles in degrees     |              |                                                                        |              |                                               |             | Method |
|----------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------|--------------|------------------------------------------------------------------------|--------------|-----------------------------------------------|-------------|--------|
| Carbonyl bromide           | COBr <sub>2</sub>                                                                 | C—O                                           | 1.178        | C—Br                                                                   | 1.923        | ∠BrCBr                                        | 112.3       | ED, MW |
| Carbonyl chloride          | COCl <sub>2</sub>                                                                 | C—O                                           | 1.179        | C—Cl                                                                   | 1.742        | ∠ClCCl                                        | 111.8       | ED, MW |
| Carbonyl chloride fluoride | COCIF                                                                             | C—O                                           | 1.173        | C—F                                                                    | 1.334        | C—Cl                                          | 1.725       | ED, MW |
|                            |                                                                                   | ∠ClCO                                         | 127.5        | ∠FCCl                                                                  | 108.8        |                                               |             |        |
| Carbonyl dicyanide         | CO(CN) <sub>2</sub>                                                               | C—O                                           | 1.209        | C—C                                                                    | 1.466        | C—N                                           | 1.153       | ED, MW |
|                            |                                                                                   | ∠CCC                                          | 115          | ∠CCN                                                                   | 180          |                                               |             |        |
| Carbonyl fluoride          | COF <sub>2</sub>                                                                  | C—O                                           | 1.172        | C—F                                                                    | 1.3157       | ∠FCF                                          | 107.71      | ED, MW |
| Chloroacetylene            | HC≡CCl                                                                            | C—Cl                                          | 1.6368       | C—C                                                                    | 1.2033       | C—H                                           | 1.0550      | MW     |
| Chlorobenzene              | C <sub>6</sub> H <sub>5</sub> Cl                                                  | C—C                                           | 1.400        | C—Cl                                                                   | 1.737        | C—H                                           | 1.083       | ED     |
| Chlorocyanoacetylene       | ClC≡C—CN                                                                          | C—Cl                                          | 1.624        | C—N                                                                    | 1.160        | C—C                                           | 1.205       | ED     |
|                            |                                                                                   | C—CN                                          | 1.362        |                                                                        |              |                                               |             |        |
| Chloroethane               |  | C—C                                           | 1.528        | C—Cl                                                                   | 1.802        | C—H                                           | 1.103       | ED, MW |
|                            |                                                                                   | ∠CCCl                                         | 110.7        | ∠H <sub>b</sub> C <sub>b</sub> H <sub>b</sub>                          | 109.8        | ∠H <sub>a</sub> C <sub>a</sub> H <sub>a</sub> | 109.2       |        |
|                            |                                                                                   | ∠C <sub>b</sub> C <sub>a</sub> H <sub>a</sub> | 110.6        | C <sub>a</sub> —H <sub>a</sub> = C <sub>b</sub> —H <sub>b</sub> (ass.) |              |                                               |             |        |
| 2-Chloroethanol            | ClCH <sub>2</sub> CH <sub>2</sub> OH<br>(gauche)                                  | C—O                                           | 1.413        | C—C                                                                    | 1.519        | C—Cl                                          | 1.801       | ED     |
|                            |                                                                                   | O—H                                           | 1.033        | C—H                                                                    | 1.093        |                                               |             |        |
|                            |                                                                                   | ∠CCCl                                         | 110.7        | ∠CCO                                                                   | 113.8        | dihedral angle of internal rotation           | 62.4        |        |
| Chloroiodoacetylene        | ClC≡CI                                                                            | C—Cl                                          | 1.63         | C—I                                                                    | 1.99         | C—C                                           | 1.209 (ass) | MW     |
| Chloromethane              | CH <sub>3</sub> Cl                                                                | C—Cl                                          | 1.785        | C—H                                                                    | 1.090        | ∠HCH                                          | 110.8       | MW, IR |
| Chloromethyldiyne          | CCl                                                                               | C—Cl                                          | 1.6512       |                                                                        |              |                                               |             | UV     |
| Chloromethylmercury        | CH <sub>3</sub> HgCl (C <sub>3v</sub> )                                           | C—Hg                                          | 2.06         | Hg—Cl                                                                  | 2.282        |                                               |             | MW     |
| trans-1-Chloropropene      | CH <sub>3</sub> CH=CHCl                                                           | C—Cl                                          | 1.728        | ∠CCCl                                                                  | 121.9        |                                               |             | MW     |
| 3-Chloropropene            | CH <sub>2</sub> ClCH=CH <sub>2</sub><br>cis conformer                             | C—Cl                                          | 1.811        | ∠CCCl                                                                  | 115.2        |                                               |             | MW     |
|                            | skew conformer                                                                    | C—Cl                                          | 1.809        | ∠CCCl                                                                  | 109.6        | dihedral angle of internal rotation           | 122.4       |        |
| Chlorotrifluoromethane     | CClF <sub>3</sub> (C <sub>3v</sub> )                                              | C—Cl                                          | 1.752        | C—F                                                                    | 1.325        | ∠FCF                                          | 108.6       | ED, MW |
| Chromium carbonyl          | Cr(CO) <sub>6</sub>                                                               | Cr—C                                          | 1.92         | C—O                                                                    | 1.16         | ∠CrCO                                         | 180         | ED     |
| Cobalt cyanide             | CoC≡N                                                                             | Co—C                                          | 1.883        | C—N                                                                    | 1.131        |                                               |             | MW     |
| Copper cyanide             | CuC≡N                                                                             | Cu—C                                          | 1.832        | C—N                                                                    | 1.158        |                                               |             | MW     |
| Cyanamide                  | H <sub>2</sub> N <sub>a</sub> CN <sub>b</sub>                                     | N <sub>a</sub> —C                             | 1.346        | C—N <sub>b</sub>                                                       | 1.160        | N—H                                           | 1.00        | MW     |
|                            |                                                                                   | ∠HNH                                          | 114          | dihedral angle between NH <sub>2</sub> plane and N—C bond              | 142          |                                               |             |        |
| Cyanide                    | CN                                                                                | C—N (r <sub>e</sub> )                         | 1.1718       |                                                                        |              |                                               |             | MW     |
| Cyanoacetylene             | HC≡C <sub>b</sub> —C <sub>c</sub> N                                               | C <sub>a</sub> —C <sub>b</sub>                | 1.205        | C <sub>b</sub> —C <sub>c</sub>                                         | 1.378        | C—H                                           | 1.058       | MW     |
|                            |                                                                                   | C <sub>c</sub> —N                             | 1.159        |                                                                        |              |                                               |             |        |
| Cyanocyclopropane          | C <sub>3</sub> H <sub>5</sub> C <sub>a</sub> N                                    | C—C (ring)                                    | 1.513        | C—C <sub>a</sub>                                                       | 1.472        | C <sub>a</sub> —N                             | 1.157       | MW     |
|                            |                                                                                   | C—H                                           | 1.107        | ∠C <sub>a</sub> CH                                                     | 119.6        | ∠HCH                                          | 114.6       |        |
| Cyanogen                   | N≡C—C≡N (linear)                                                                  | C—N                                           | 1.163        | C—C                                                                    | 1.393        |                                               |             | ED     |
| Cyanogen azide             | N≡C—N=N≡N<br>(planar)                                                             | C—N                                           | 1.312        | N=N                                                                    | 1.252        | N≡N                                           | 1.133       | MW     |
|                            |                                                                                   | C≡N                                           | 1.164        | ∠CNN                                                                   | 120.2        | ∠NCN                                          | 176.0       |        |
| Cyanogen bromide           | BrCN (linear)                                                                     | C—N (r <sub>e</sub> )                         | 1.157        | C—Br (r <sub>e</sub> )                                                 | 1.790        |                                               |             | MW     |
| Cyanogen chloride          | ClCN (linear)                                                                     | C—Cl (r <sub>e</sub> )                        | 1.629        | C—N (r <sub>e</sub> )                                                  | 1.160        |                                               |             | MW     |
| Cyanogen fluoride          | FCN (linear)                                                                      | C—F                                           | 1.262        | C—N                                                                    | 1.159        |                                               |             | MW     |
| Cyanogen iodide            | ICN (linear)                                                                      | C—I                                           | 1.995        | C—N                                                                    | 1.159        |                                               |             | MW     |
| 1-Cyano-2-propyne          | HC≡C <sub>b</sub> C <sub>c</sub> H <sub>2</sub> C <sub>d</sub> ≡N                 | C <sub>a</sub> —C <sub>b</sub>                | 1.207 (ass.) | C <sub>b</sub> —C <sub>c</sub> (ass.)                                  | 1.465        | C <sub>c</sub> —C <sub>d</sub>                | 1.454       | MW     |
|                            |                                                                                   | C <sub>d</sub> —N                             | 1.159 (ass.) | C <sub>a</sub> —H (ass.)                                               | 1.057        | C <sub>c</sub> —H (ass.)                      | 1.090       |        |
|                            |                                                                                   | ∠C <sub>b</sub> C <sub>c</sub> C <sub>d</sub> | 113.4        | ∠HC <sub>c</sub> H                                                     | 109.4 (ass.) | ∠C <sub>b</sub> C <sub>c</sub> H              | 111.3       |        |

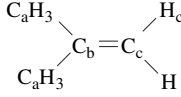
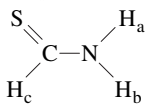
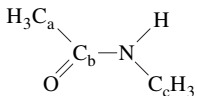
| Compound                    | Structure                                                                                                                                               | Bond distances in Å and angles in degrees                                                                                                                 |       |                                               |       |                                                                                      |       | Method |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------------------------------------------|-------|--------------------------------------------------------------------------------------|-------|--------|
| Cyclobutane                 | (CH <sub>2</sub> ) <sub>4</sub>                                                                                                                         | C—C                                                                                                                                                       | 1.555 | C—H                                           | 1.113 |                                                                                      |       | ED     |
|                             |                                                                                                                                                         | dihedral angle between the two CCC planes                                                                                                                 | 145   |                                               |       |                                                                                      |       |        |
| Cyclobutanone               |                                                                        | C <sub>a</sub> —C <sub>b</sub>                                                                                                                            | 1.527 | C <sub>b</sub> —C <sub>c</sub>                | 1.556 |                                                                                      |       | MW     |
|                             |                                                                                                                                                         | ∠C <sub>b</sub> C <sub>a</sub> C <sub>b</sub>                                                                                                             | 93.1  | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub> | 88.0  |                                                                                      |       |        |
| Cyclobutene                 |                                                                        | C <sub>a</sub> —C <sub>a</sub>                                                                                                                            | 1.566 | C <sub>b</sub> —C <sub>b</sub>                | 1.342 | C <sub>a</sub> —C <sub>b</sub>                                                       | 1.517 | MW     |
|                             |                                                                                                                                                         | C <sub>a</sub> —H                                                                                                                                         | 1.094 | C <sub>b</sub> —H                             | 1.083 |                                                                                      |       |        |
|                             |                                                                                                                                                         | ∠C <sub>a</sub> C <sub>b</sub> C <sub>b</sub>                                                                                                             | 94.2  | ∠C <sub>b</sub> C <sub>b</sub> H              | 133.5 | ∠HC <sub>a</sub> H                                                                   | 109.2 |        |
|                             |                                                                                                                                                         | ∠C <sub>a</sub> C <sub>a</sub> H                                                                                                                          | 114.5 | ∠C <sub>a</sub> C <sub>a</sub> C <sub>b</sub> | 85.8  | dihedral angle between CH <sub>2</sub> plane and C <sub>a</sub> —C <sub>a</sub> bond | 135.8 |        |
| 2,4,6-Cycloheptatrien-1-one |                                                                        | C <sub>a</sub> —C <sub>b</sub>                                                                                                                            | 1.45  | C <sub>b</sub> —C <sub>c</sub>                | 1.36  | C <sub>c</sub> —C <sub>d</sub>                                                       | 1.46  | ED     |
|                             |                                                                                                                                                         | C <sub>d</sub> —C <sub>d</sub>                                                                                                                            | 1.34  | C <sub>a</sub> —O                             | 1.23  | ∠C <sub>b</sub> C <sub>a</sub> C <sub>b</sub>                                        | 122   |        |
|                             |                                                                                                                                                         | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub>                                                                                                             | 133   | ∠C <sub>b</sub> C <sub>c</sub> C <sub>d</sub> | 126   | ∠C <sub>c</sub> C <sub>d</sub> C <sub>d</sub>                                        | 130   |        |
| Cyclohexane                 | (C <sub>2v</sub> )<br>C <sub>6</sub> H <sub>12</sub> (chair form)                                                                                       | C—C                                                                                                                                                       | 1.536 | C—H                                           | 1.119 | ∠CCC                                                                                 | 111.3 | ED     |
| Cyclohexene                 |                                                                       | C <sub>a</sub> —C <sub>a</sub>                                                                                                                            | 1.334 | C <sub>a</sub> —C <sub>b</sub>                | 1.50  | C <sub>b</sub> —C <sub>c</sub>                                                       | 1.52  | ED     |
|                             |                                                                                                                                                         | C <sub>c</sub> —C <sub>c</sub>                                                                                                                            | 1.54  | ∠C <sub>a</sub> C <sub>a</sub> C <sub>b</sub> | 123.4 | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub>                                        | 112.0 |        |
|                             |                                                                                                                                                         | ∠C <sub>b</sub> C <sub>c</sub> C <sub>c</sub>                                                                                                             | 110.9 |                                               |       |                                                                                      |       |        |
| Cyclooctatetraene           | half-chair form (C <sub>2</sub> )<br><br>tub form (D <sub>2d</sub> ) | C <sub>a</sub> —C <sub>b</sub>                                                                                                                            | 1.476 | C <sub>a</sub> —C <sub>a</sub>                | 1.340 | C <sub>b</sub> —C <sub>b</sub>                                                       | 1.340 | ED     |
|                             |                                                                                                                                                         | C—H                                                                                                                                                       | 1.100 | ∠C <sub>b</sub> C <sub>a</sub> C <sub>a</sub> | 126.1 | ∠C <sub>a</sub> C <sub>b</sub> C <sub>b</sub>                                        | 126.1 |        |
|                             |                                                                                                                                                         | dihedral angle between C <sub>a</sub> C <sub>a</sub> C <sub>a</sub> C <sub>a</sub> and C <sub>a</sub> C <sub>b</sub> C <sub>b</sub> C <sub>a</sub> planes | 136.9 |                                               |       |                                                                                      |       |        |
| 1,3-Cyclopentadiene         |                                                                      | C <sub>a</sub> —C <sub>b</sub>                                                                                                                            | 1.509 | C <sub>b</sub> —C <sub>c</sub>                | 1.342 | C <sub>c</sub> —C <sub>c</sub>                                                       | 1.469 | MW     |
|                             |                                                                                                                                                         | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub>                                                                                                             | 109.3 | ∠C <sub>b</sub> C <sub>c</sub> C <sub>c</sub> | 109.4 | ∠C <sub>b</sub> C <sub>a</sub> C <sub>b</sub>                                        | 102.8 |        |
| Cyclopentadienylindium      |                                                                      | C—In                                                                                                                                                      | 2.621 | C—C                                           | 1.426 | (C <sub>5v</sub> )                                                                   |       | ED     |
| Cyclopentane                | (CH <sub>2</sub> ) <sub>5</sub>                                                                                                                         | C—C                                                                                                                                                       | 1.546 | C—H                                           | 1.114 | ∠CCH                                                                                 | 111.7 | ED     |
| Cyclopentene                |                                                                      | C <sub>a</sub> —C <sub>b</sub>                                                                                                                            | 1.546 | C <sub>b</sub> —C <sub>c</sub>                | 1.519 | C <sub>c</sub> —C <sub>c</sub>                                                       | 1.342 | ED     |
|                             |                                                                                                                                                         | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub>                                                                                                             | 103.0 | ∠C <sub>b</sub> C <sub>c</sub> C <sub>c</sub> | 110.0 | ∠C <sub>b</sub> C <sub>a</sub> C <sub>b</sub>                                        | 104.0 |        |
|                             |                                                                                                                                                         | dihedral angle between C <sub>b</sub> C <sub>a</sub> C <sub>b</sub> and C <sub>b</sub> C <sub>c</sub> C <sub>c</sub> planes                               | 151.2 |                                               |       |                                                                                      |       |        |
| Cyclopropane                | (CH <sub>2</sub> ) <sub>3</sub>                                                                                                                         | C—C                                                                                                                                                       | 1.512 | C—H                                           | 1.083 | ∠HCH                                                                                 | 114.0 | R      |

| Compound                              | Structure                                                                         | Bond distances in Å and angles in degrees                                                                               |                          |                                                 |                         |                                           |                 | Method |
|---------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|--------------------------|-------------------------------------------------|-------------------------|-------------------------------------------|-----------------|--------|
| Cyclopropanone                        |  | $C_a-C_b$<br>$C-H$<br>dihedral angle<br>between $CH_2$<br>plane<br>and $C_b-C_b$<br>bond                                | 1.475<br>1.086<br>151    | $C_b-C_b$<br>$\angle C_a C_b C_b$               | 1.575<br>57.7           | $C_a-O$<br>$\angle HC_b H$                | 1.191<br>114    | MW     |
| Cyclopropene                          |  | $C_a-C_b$<br>$C_b-H$                                                                                                    | 1.505<br>1.072           | $C_b-C_b$<br>$\angle C_b C_b H$                 | 1.293<br>150            | $C_a-H$<br>$\angle HC_a H$                | 1.085<br>114.3  | MW     |
| Cyclopropenone                        |  | $C_a-C_b (r_s)$<br>$C-H (r_s)$                                                                                          | 1.423<br>1.079           | $C_b-C_c (r_s)$<br>$\angle HC_b C_c (\theta_s)$ | 1.349<br>144.3          | $C_a-O (r_s)$<br>$C_b C_a C_c (\theta_s)$ | 1.212<br>56.6   | MW     |
| Decalin                               | $C_{2v}$<br>$C_{10}H_{18}$                                                        | $C-C$ (av.)                                                                                                             | 1.530                    | $C-H$ (av.)                                     | 1.113                   | $\angle CCC$ (av.)                        | 111.4           | ED     |
| Diazirine                             |  | $C-N$<br>$\angle HCH$                                                                                                   | 1.482<br>117             | $N-N$                                           | 1.228                   | $C-H$                                     | 1.09            | MW     |
| Diazoacetonitrile                     |  | $C_a-C_b$<br>$N_b-N_c$<br>$\angle C_a C_b H$                                                                            | 1.424<br>1.132<br>117    | $C_a-N_a$<br>$C-H$<br>$\angle C_a C_b N_b$      | 1.165<br>1.082<br>119.5 | $C_b-N_b$                                 | 1.280           | MW     |
| Diazomethane                          | $CH_2N_2$                                                                         | $C-N$<br>$\angle HCH$                                                                                                   | 1.32<br>126.0            | $N-N$                                           | 1.12                    | $C-H$                                     | 1.075           | MW, IR |
| 1,2-Dibromoethane                     | $CH_2BrCH_2Br$                                                                    | $C-C$<br>$\angle CCB$                                                                                                   | 1.506<br>109.5           | $C-Br$<br>$\angle CCH$                          | 1.950<br>110            | $C-H$                                     | 1.108           | ED     |
| Dibromomethane                        | $CH_2Br_2$                                                                        | $C-Br$<br>$\angle BrCB$                                                                                                 | 1.924<br>113.2           | $C-H$                                           | 1.08                    | $\angle HCB$                              | 109             | ED     |
| 2,2'-Dichlorobiphenyl                 | $C_6H_4Cl-C_6H_4Cl$                                                               | $C-C$ (rings)<br><br>$C-Cl$<br>dihedral angle<br>between the<br>two rings<br>(defined as 0 for<br><i>cis</i> conformer) | 1.398<br><br>1.732<br>74 | $C-C$ (inter-<br>ring)<br><br>$\angle CCCl$     | 1.495<br><br>121.4      | $C-H$<br><br>$\angle CCH$                 | 1.10<br><br>126 | ED     |
| <i>trans</i> -1,4-Dichlorocyclohexane | $C_6H_{10}Cl_2$                                                                   | $C-C$<br>$\angle CCC$                                                                                                   | 1.530<br>111.5           | $C-Cl$                                          | 1.810                   | $C-H$                                     | 1.102           | ED     |
|                                       | <i>equatorial:</i>                                                                | $\angle CClCl$                                                                                                          | 108.6                    | $\angle HCCl$                                   | 111.5                   |                                           |                 |        |
|                                       | <i>axial:</i>                                                                     | $\angle CClCl$                                                                                                          | 110.6                    | $\angle HCCl$                                   | 107.6                   |                                           |                 |        |
| 1,1-Dichloroethane                    | $CHCl_2CH_3$                                                                      | $C-C$<br>$\angle ClCCl$                                                                                                 | 1.540<br>112.0           | $C-Cl$<br>$\angle CClCl$                        | 1.766<br>111.0          |                                           |                 | MW     |
| 1,2-Dichloroethane                    | $CH_2ClCH_2Cl$                                                                    | $C-C$<br>$\angle CClCl$                                                                                                 | 1.531<br>109.0           | $C-Cl$<br>$\angle CCH$                          | 1.790<br>113            | $C-H$                                     | 1.11            | ED     |
| 1,1-Dichloroethene                    | $CH_2=CCl_2$ ( $C_{2v}$ )                                                         | $C-C$<br>$\angle ClCC$                                                                                                  | 1.32 (ass.)<br>123       | $C-Cl$                                          | 1.73                    |                                           |                 | MW     |
| <i>cis</i> -1,2-Dichloroethene        | $CHCl=CHCl$                                                                       | $C-C$<br>$\angle ClCC$                                                                                                  | 1.354<br>123.8           | $C-Cl$                                          | 1.718                   |                                           |                 | ED     |
| Dichloromethane                       | $CH_2Cl_2$                                                                        | $C-Cl$ ( $r_e$ )<br>$\angle ClCCl$ ( $\theta_e$ )                                                                       | 1.765<br>112.0           | $C-H$ ( $r_e$ )<br>$\angle HCH$ ( $\theta_e$ )  | 1.087<br>111.5          |                                           |                 | MW, IR |

| Compound               | Structure | Bond distances in Å and angles in degrees                                  |                                 |                                                                       |                                 |                                                                          |                                  | Method |
|------------------------|-----------|----------------------------------------------------------------------------|---------------------------------|-----------------------------------------------------------------------|---------------------------------|--------------------------------------------------------------------------|----------------------------------|--------|
| 1,2-Dicyanocyclobutene |           | $C_a-C_{a'}$<br>$C_a-C_c$<br>$\angle C_a C_a' C_b$<br>$\angle C_b C_a C_c$ | 1.361<br>1.420<br>93.9<br>133.3 | $C_a-C_b$<br>$C_c-N$<br>$\angle C_a C_b C_{b'}$<br>$\angle C_a C_b H$ | 1.515<br>1.157<br>86.1<br>114.7 | $C_b-C_{b'}$<br>$C_b-H$<br>$\angle C_a C_c N$<br>$\angle C_a C_a' C_b H$ | 1.567<br>1.088<br>178.2<br>115.8 | MW     |
| Difluorocyanamide      |           | $C-N_a$<br>$\angle N_a C N_b$                                              | 1.158<br>174                    | $C-N_b$<br>$\angle C N_b F$                                           | 1.386<br>105.4                  | $N_b-F$<br>$\angle F N_b F$                                              | 1.399<br>102.8                   | MW     |
| Difluorocyclopropenone |           | $C_a-C_b$<br>$C-F$                                                         | 1.453<br>1.314                  | $C_b-C_c$<br>$\angle F C_b C_c$                                       | 1.324<br>145.7                  | $C_a-O$                                                                  | 1.192                            | MW     |
| Difluorodimethylsilane |           | $C-Si$<br>$\angle C Si C$                                                  | 1.844<br>115.2                  | $Si-F$<br>$\angle F Si F$                                             | 1.585<br>106.1                  | $C-H$ (ass.)<br>$\angle Si C H$ (ass.)                                   | 1.093<br>110.8                   | MW     |
| 1,1-Difluoroethane     |           | $C-C$<br>$\angle CCF$                                                      | 1.498<br>110.7                  | $C-F$<br>$\angle CCH$ (av.)                                           | 1.364<br>111.0                  | $C-H$ (av.)<br>dihedral angle between CCF planes                         | 1.081<br>118.9                   | ED     |
| 1,2-Difluoroethane     |           | $C-C$<br>$\angle CCF$                                                      | 1.503<br>110.3                  | $C-F$<br>$\angle CCH$                                                 | 1.389<br>111                    | $C-H$<br>dihedral angle of internal rotation                             | 1.103<br>109                     | ED     |
| 1,1-Difluoroethene     |           | $C-C$<br>$\angle CCF$                                                      | 1.340<br>124.7                  | $C-F$<br>$\angle CCH$                                                 | 1.315<br>119.0                  | $C-H$                                                                    | 1.091                            | ED, MW |
| cis-1,2-Difluoroethene |           | $C-C$<br>$\angle CCF$                                                      | 1.33<br>122.0                   | $C-F$<br>$\angle CCH$                                                 | 1.342<br>124.1                  | $C-H$                                                                    | 1.099                            | ED, MW |
| Difluoromethane        |           | $C-F$<br>$\angle FCF$                                                      | 1.357<br>108.3                  | $C-H$<br>$\angle HCH$                                                 | 1.093<br>113.7                  |                                                                          |                                  | MW     |
| Dimethoxymethane       |           | $C_a-O$<br>$\angle COC$                                                    | 1.432<br>114.6                  | $C_b-O$<br>$\angle OCO$                                               | 1.382<br>114.3                  | $C-H$ (av.)<br>$\angle OCH$                                              | 1.108<br>110.3                   | ED     |
| Dimethylamine          |           | $C-N$<br>$\angle CNC$<br>$\angle HCH$                                      | 1.455<br>111.8<br>107           | $N-H$<br>$\angle CNH$                                                 | 1.00<br>107                     | $C-H$<br>$\angle NCH$                                                    | 1.106<br>112                     | ED     |
| Dimethylberyllium      |           | $C-Be$                                                                     | 1.698                           | $C-H$                                                                 | 1.127                           | $\angle BeCH$                                                            | 113.9                            | ED     |
| Dimethyl cadmium       |           | $C-Cd$                                                                     | 2.112                           | $\angle HCH$                                                          | 108.4                           |                                                                          |                                  | R      |
| Dimethyl carbonate     |           | $C_b-O_b$<br>$\angle O_a C_b O_a$                                          | 1.209<br>107                    | $C_b-O_a$<br>$\angle C_b O_a C_a$                                     | 1.34<br>114.5                   | $C_a-O_a$                                                                | 1.42                             | ED     |
| Dimethylcyanamide      |           | $C_b-N_b$<br>$C-N$<br>$\angle C_a N C_a$                                   | 1.161<br>1.482<br>115.5         | $C_a-N_a$<br>$N-N$<br>$\angle C_a N C_b$                              | 1.463<br>1.247<br>116.0         | $C_b-N_a$<br>$\angle CNN$                                                | 1.338<br>112.3                   | ED     |
| trans-Dimethyldiazene  |           | $B-B$<br>$B-H_b$ (cis)<br>$\angle BBC$ (cis)                               | 1.799<br>1.358<br>122.6         | $B-C$<br>$B-H_b$ (trans)<br>$\angle BBC$ (trans)                      | 1.580<br>1.365<br>121.8         | $B-H_t$                                                                  | 1.24                             | ED     |
| 1,2-Dimethyldiborane   |           | $C-Se$<br>$\angle CSeSe$                                                   | 1.95<br>98.9                    | $Se-Se$<br>$\angle HCSe$                                              | 2.326<br>108                    | $C-H$<br>$CSeSeC$ dihedral angle                                         | 1.13<br>88                       | ED     |
| Dimethyl diselenide    |           | $C-S$<br>$\angle SSC$                                                      | 1.816<br>103.2                  | $S-S$<br>$\angle SCH$                                                 | 2.029<br>111.3                  | $C-H$<br>$CSSC$ dihedral angle                                           | 1.105<br>85                      | ED     |
| Dimethyl disulfide     |           |                                                                            |                                 |                                                                       |                                 |                                                                          |                                  |        |

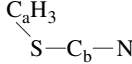
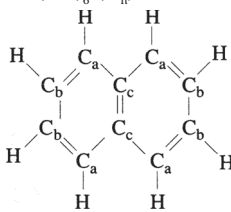
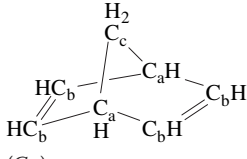
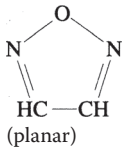
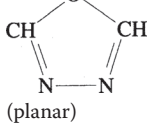
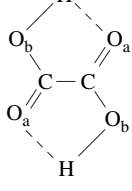
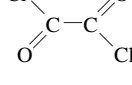
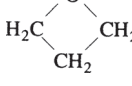
| Compound                              | Structure                                                                                                | Bond distances in Å and angles in degrees                                       |                                          |                                                             |                                  |                                             |                        | Method |
|---------------------------------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|------------------------------------------|-------------------------------------------------------------|----------------------------------|---------------------------------------------|------------------------|--------|
| <i>S,S'</i> -Dimethyl dithiocarbonate | $C_aH_3SC_bSC_aH_3$<br> | $C_a-S$<br>$\angle OCS$                                                         | 1.802<br>124.9                           | $C_b-S$<br>$\angle CSC$                                     | 1.777<br>99.3                    | $C_b-O$                                     | 1.206                  | ED     |
| Dimethyl ether                        | <i>syn-syn</i> conformer<br>$(CH_3)_2O$                                                                  | $C-O$<br>$\angle COC$                                                           | 1.416<br>112                             | $C-H$<br>$\angle HCH$                                       | 1.121<br>108                     |                                             |                        | ED     |
| <i>N,N'</i> -Dimethylhydrazine        | $CH_3NH-NHCH_3$                                                                                          | $C-N$<br>$C-H$                                                                  | 1.46<br>1.12                             | $N-N$<br>$\angle NNC$                                       | 1.42<br>112                      | $N-H$<br>CNCN<br>dihedral<br>angle          | 1.03<br>90             | ED     |
| Dimethyl mercury                      | $(CH_3)_2Hg$                                                                                             | $C-Hg$                                                                          | 2.083                                    | $C-H$                                                       | 1.160<br>(ass.)                  | $Hg\cdots H$                                | 2.71                   | ED     |
| Dimethylphosphine                     | $(CH_3)_2PH$                                                                                             | $C-P$<br>$\angle CPC$                                                           | 1.848<br>99.7                            | $P-H$<br>$\angle CPH$                                       | 1.419<br>97.0                    |                                             |                        | MW     |
| 2,2-Dimethylpropanenitrile            | $(C_cH_3)_3C_b-C_a\equiv N$                                                                              | $C_a-C_b$<br>$\angle C_cC_bC_c$                                                 | 1.495<br>110.5                           | $C_b-C_c$                                                   | 1.536                            | $C_a-N$                                     | 1.159                  | MW     |
| Dimethyl selenide                     | $(CH_3)_2Se$                                                                                             | $C-Se$<br>$\angle CSeC$                                                         | 1.943<br>96.2                            | $C-H$<br>$\angle SeCH$                                      | 1.093<br>108.7                   | $\angle HCH$                                | 110.3                  | MW     |
| Dimethyl silane                       | $(CH_3)_2SiH_2$                                                                                          | $C-Si$<br>$\angle CSiC$<br>$\angle HSiH$                                        | 1.868<br>110.9<br>107.8                  | $C-H$<br>$\angle CSiH$                                      | 1.089<br>109.5                   | $Si-H$<br>$\angle SiCH$                     | 1.482<br>110.9         | MW     |
| Dimethyl sulfide                      | $(CH_3)_2S$                                                                                              | $C-S$<br>$\angle CSC$                                                           | 1.802<br>98.80                           | $C-H$<br>$\angle HCH$                                       | 1.090<br>109.3                   |                                             |                        | ED, MW |
| Dimethyl sulfone                      | $(CH_3)_2SO_2$                                                                                           | $C-S$<br>$\angle CSC$                                                           | 1.771<br>102                             | $S-O$<br>$\angle OSO$                                       | 1.435<br>121                     | $C-H$                                       | 1.114                  | ED     |
| Dimethyl sulfoxide                    | $(CH_3)_2SO$                                                                                             | $C-S$<br>$\angle CSC$<br>dihedral angle<br>between SCC<br>plane and S—O<br>bond | 1.799<br>96.6<br>115.5                   | $S-O$<br>$\angle CSO$                                       | 1.485<br>106.7                   | $C-H$<br>$\angle HCH$                       | 1.081<br>110.3         | MW     |
| Dimethyl zinc                         | $(CH_3)_2Zn$                                                                                             | $C-Zn$                                                                          | 1.929                                    | $\angle HCH$                                                | 107.7                            |                                             |                        | R      |
| 1,4-Dioxane                           | <br>chair form        | $C-C$<br>$\angle CCO$                                                           | 1.523<br>109.2                           | $C-O$<br>$\angle COC$                                       | 1.423<br>112.45                  | $C-H$                                       | 1.112                  | ED     |
| Ethane                                | $C_2H_6$<br>staggered conformation                                                                       | $C-C$<br>$C-C (r_e)$                                                            | 1.5351<br>1.522                          | $C-H$                                                       | 1.0940                           | $\angle CCH$                                | 111.17                 | MW     |
| 1,2-Ethanediamine                     | $H_2NCH_2CH_2NH_2$<br><i>gauche</i> conformer                                                            | $C-C$<br>$\angle CCN$                                                           | 1.545<br>110.2                           | $C-N$<br>dihedral angle<br>between NCC<br>and CCN<br>planes | 1.469<br>64                      | $C-H$                                       | 1.11                   | ED     |
| Ethanethiol                           | $C_bH_3-C_aH_2-SH$                                                                                       | $C_a-C_b$<br>$C_a-H$<br>$\angle C_bC_aS$                                        | 1.530<br>1.090<br>108.3                  | $C_a-S$<br>$C_b-H$<br>$\angle C_bC_aH$                      | 1.829<br>1.093<br>109.6          | $S-H$<br>$\angle C_aSH$<br>$\angle C_aC_bH$ | 1.350<br>96.4<br>109.7 | MW     |
| Ethanol                               | $C_bH_3C_aH_2OH$<br>staggered conformation                                                               | $C-C$<br>$C_a-H$<br>$\angle CCO$                                                | 1.512<br>1.10<br>107.8                   | $C-O$<br>$C_b-H$<br>$\angle C_bC_aH$                        | 1.431<br>1.09<br>111             | $O-H$<br>$\angle COH$<br>$\angle C_aC_bH$   | 0.971<br>105<br>110    | MW     |
| Ethylene                              | $CH_2=CH_2$                                                                                              | $C-C (r_s)$                                                                     | 1.329                                    | $C-H (r_s)$                                                 | 1.082                            | $\angle HCH (\theta_s)$                     | 117.2                  | MW, IR |
| Ethyleneimine                         |                       | $C-C$<br>$C-H$<br>$\angle CNC$<br>$\angle H_bCC$<br>$\angle H_cCN$              | 1.481<br>1.084<br>60.3<br>117.8<br>114.3 | $N-C$<br>$N-H$<br>$\angle H_aNC$<br>$\angle H_bCN$          | 1.475<br>1.016<br>109.3<br>118.3 | $\angle H_bCH_c$<br>$\angle H_cCC$          | 115.7<br>119.3         | MW     |
| Ethyl methyl ether                    | $C_2H_5OCH_3$                                                                                            | $C-C$<br>$\angle COC$                                                           | 1.520<br>111.9                           | $C-O$ (av.)<br>$\angle OCC$                                 | 1.418<br>109.4                   | $C-H$ (av.)<br>$\angle HCH$                 | 1.118<br>109.0         | ED     |

| Compound                      | Structure                                                                           | Bond distances in Å and angles in degrees                                           |        |                                |       |                                  |        | Method |
|-------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------|--------------------------------|-------|----------------------------------|--------|--------|
| Ethyl methyl sulfide          | $C_2H_5SCH_3$<br><i>gauche conformer</i>                                            | C—C                                                                                 | 1.536  | C—S (av.)                      | 1.813 | C—H                              | 1.111  | ED     |
|                               |                                                                                     | $\angle CSC$                                                                        | 97     | $\angle SCC$                   | 114.0 | $\angle HCH$                     | 110    |        |
| Fluoroketene                  | $HFC=C=O$                                                                           | C—C                                                                                 | 1.317  | C—O                            | 1.167 | C—F                              | 1.360  | MW     |
|                               |                                                                                     | C—H                                                                                 | 1.102  | $\angle CCO$                   | 178.0 | $\angle CCF$                     | 119.5  |        |
|                               |                                                                                     | $\angle CCH$                                                                        | 122.3  |                                |       |                                  |        |        |
| Fluoromethane                 | $CH_3F$                                                                             | C—F ( $r_e$ )                                                                       | 1.382  | C—H ( $r_e$ )                  | 1.095 | $\angle HCH$ ( $\theta_e$ )      | 110.45 | MW, IR |
| Fluoromethylidyne             | $CF$                                                                                | C—F ( $r_e$ )                                                                       | 1.2718 |                                |       |                                  |        | UV     |
| (Fluoromethylidyne) phosphine | $FC\equiv P$                                                                        | C—F                                                                                 | 1.285  | C—P                            | 1.541 |                                  |        | MW     |
| 2-Fluoropropane               | $CH_3CHFCH_3$                                                                       | C—C                                                                                 | 1.522  | C—F                            | 1.398 |                                  |        | MW     |
|                               |                                                                                     | $\angle CCC$                                                                        | 113.4  | $\angle CCF$                   | 108.2 |                                  |        |        |
| Formaldehyde                  | $H_2CO$                                                                             | C—O                                                                                 | 1.208  | C—H                            | 1.116 | $\angle HCH$                     | 116.5  | MW     |
| Formaldehyde azine            | $H_2C=N=N=CH_2$<br><i>trans conformer</i>                                           | C—N                                                                                 | 1.277  | N—N                            | 1.418 | C—H                              | 1.094  | ED     |
|                               |                                                                                     | $\angle CNN$                                                                        | 111.4  | $\angle HCN$                   | 120.7 |                                  |        |        |
| Formaldehyde oxime            |    | C—N                                                                                 | 1.276  | N—O                            | 1.408 | O—H <sub>c</sub>                 | 0.956  | MW     |
|                               |                                                                                     | C—H <sub>a</sub>                                                                    | 1.085  | C—H <sub>b</sub>               | 1.086 | $\angle CNO$                     | 110.2  |        |
|                               |                                                                                     | $\angle H_aCN$                                                                      | 121.8  | $\angle H_bCN$                 | 115.6 | $\angle NOH_c$                   | 102.7  |        |
| Formamide                     |    | C—N                                                                                 | 1.368  | C—O                            | 1.212 | C—H <sub>a</sub>                 | 1.125  | ED, MW |
|                               |                                                                                     | N—H                                                                                 | 1.027  | $\angle CNH$ (av.)             | 119.2 | $\angle NCO$                     | 125.0  |        |
| Formic acid                   |    | C—O <sub>a</sub>                                                                    | 1.202  | C—O <sub>b</sub>               | 1.343 | O <sub>b</sub> —H                | 0.972  | MW     |
|                               |                                                                                     | C—H                                                                                 | 1.097  |                                |       |                                  |        |        |
|                               |                                                                                     | $\angle O_aCO_b$                                                                    | 124.9  | $\angle HCO_a$                 | 124.1 | $\angle CO_bH$                   | 106.3  |        |
|                               | (planar)                                                                            |                                                                                     |        |                                |       |                                  |        |        |
| Formic acid dimer             |   | C—O <sub>a</sub>                                                                    | 1.220  | C—O <sub>b</sub>               | 1.323 | O <sub>a</sub> ...O <sub>b</sub> | 2.703  | ED     |
|                               |                                                                                     | $\angle O_aCO_b$                                                                    | 126.2  | $\angle CO_aO_b$               | 108.5 |                                  |        |        |
| Formyl radical                | $HC=O$                                                                              | C—O                                                                                 | 1.1712 | C—H                            | 1.110 | $\angle HCO$                     | 127.43 | MW     |
| Fulvene                       |  | C <sub>a</sub> —C <sub>d</sub>                                                      | 1.349  | C <sub>a</sub> —C <sub>b</sub> | 1.470 | C <sub>b</sub> —C <sub>c</sub>   | 1.355  | MW     |
|                               |                                                                                     | C <sub>c</sub> —C <sub>c</sub>                                                      | 1.476  | C <sub>b</sub> —H              | 1.078 | C <sub>c</sub> —H                | 1.080  |        |
|                               |                                                                                     | C <sub>d</sub> —H                                                                   | 1.13   | $\angle C_bC_aC_b$             | 106.6 | $\angle C_bC_cC_c$               | 109    |        |
|                               |                                                                                     | $\angle C_aC_bC_c$                                                                  | 107.7  | $\angle C_aC_bH$               | 124.7 | $\angle C_bC_cH$                 | 126.4  |        |
|                               |                                                                                     | $\angle HC_dH$                                                                      | 117    |                                |       |                                  |        |        |
| Furan                         |  | C <sub>a</sub> —C <sub>b</sub>                                                      | 1.361  | C <sub>b</sub> —C <sub>b</sub> | 1.431 | C <sub>a</sub> —O                | 1.362  | MW     |
|                               |                                                                                     | C <sub>a</sub> —H <sub>a</sub>                                                      | 1.075  | C <sub>b</sub> —H <sub>b</sub> | 1.077 |                                  |        |        |
|                               |                                                                                     | $\angle C_aC_bC_b$                                                                  | 106.1  | $\angle C_bC_aO$               | 110.7 | $\angle C_aOC_a$                 | 106.6  |        |
|                               |                                                                                     | $\angle C_bC_bH_b$                                                                  | 128.0  | $\angle OC_aH_a$               | 115.9 |                                  |        |        |
| Furfural                      |  | C <sub>a</sub> —C <sub>c</sub>                                                      | 1.458  | C <sub>c</sub> —O <sub>b</sub> | 1.250 | C <sub>c</sub> —H                | 1.088  | MW     |
|                               |                                                                                     | $\angle C_aC_eO$                                                                    | 121.6  | $\angle C_eC_aC_b$             | 133.9 | $\angle C_aC_eH$                 | 116.9  |        |
|                               |                                                                                     | <i>trans conformer</i><br>(with respect to O <sub>a</sub> and O <sub>b</sub> atoms) |        |                                |       |                                  |        |        |
| Glycolaldehyde                |  | C <sub>a</sub> —C <sub>b</sub>                                                      | 1.499  | C <sub>a</sub> —O <sub>a</sub> | 1.437 | C <sub>b</sub> —O <sub>b</sub>   | 1.209  | MW     |
|                               |                                                                                     | C <sub>a</sub> —H <sub>b</sub>                                                      | 1.093  | C <sub>b</sub> —H <sub>c</sub> | 1.102 | O <sub>a</sub> —H <sub>a</sub>   | 1.051  |        |
|                               |                                                                                     | $\angle C_aC_bO_b$                                                                  | 122.7  | $\angle C_bC_aO_a$             | 111.5 |                                  |        |        |
|                               |                                                                                     | $\angle C_aC_bH_c$                                                                  | 115.3  | $\angle C_bC_aH_b$             | 109.2 | $\angle H_bC_aH_b$               | 107.6  |        |
|                               |                                                                                     | $\angle C_aO_aH_a$                                                                  | 101.6  | $\angle H_bC_aO_a$             | 109.7 |                                  |        |        |
| Glyoxal                       | $CHOCHO$<br><i>trans conformer</i>                                                  | C—C                                                                                 | 1.526  | C—O                            | 1.212 | C—H                              | 1.132  | ED, UV |
|                               |                                                                                     | $\angle CCO$                                                                        | 121.2  | $\angle HCO$                   | 112   |                                  |        |        |
| Hexachloroethane              | $Cl_3CCl_3$                                                                         | C—C                                                                                 | 1.56   | C—Cl                           | 1.769 | $\angle CCCl$                    | 110.0  | ED     |
| 2,4-Hexadiyne                 | $C_aH_3C_b\equiv C_cC_c\equiv C_dC_eH_3$                                            | C <sub>a</sub> —C <sub>b</sub>                                                      | 1.450  | C <sub>b</sub> —C <sub>c</sub> | 1.208 | C <sub>c</sub> —C <sub>c</sub>   | 1.377  | ED     |
|                               |                                                                                     | C <sub>a</sub> —H                                                                   | 1.09   |                                |       |                                  |        |        |
| Hexafluoroethane              | $F_3CCF_3$                                                                          | C—C                                                                                 | 1.545  | CF                             | 1.326 | $\angle CCF$                     | 109.8  | ED     |

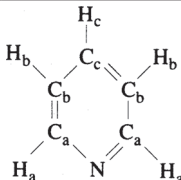
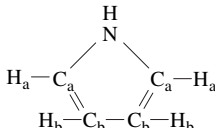
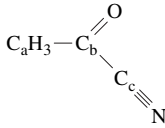
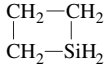
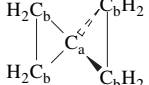
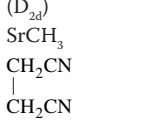
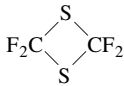
| Compound               | Structure                                                                                               | Bond distances in Å and angles in degrees |        |                                                |                 |                                                                        |                 | Method |
|------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------|--------|------------------------------------------------|-----------------|------------------------------------------------------------------------|-----------------|--------|
| Hexafluoropropene      | $\text{CF}_2=\text{CFCF}_3$                                                                             | C—C                                       | 1.513  | C=C                                            | 1.329<br>(ass.) | C—F                                                                    | 1.329<br>(ass.) | ED     |
|                        |                                                                                                         | $\angle\text{CCC}$                        | 127.8  | $\angle\text{FCC}(\text{CF})$                  | 120             | $\angle\text{FCC}(\text{CF}_2)$                                        | 124             |        |
| trans-1,3,5-Hexatriene | $\text{H}_2\text{C}_a=\text{C}_b\text{HC}_c\text{H}=\text{C}_c\text{HC}_b\text{H}=\text{C}_a\text{H}_2$ | $\text{C}_a-\text{C}_b$                   | 1.337  | $\text{C}_b-\text{C}_c$                        | 1.458           | $\text{C}_c-\text{C}_c$                                                | 1.368           | ED     |
|                        |                                                                                                         | $\angle\text{C}_a\text{C}_b\text{C}_c$    | 121.7  | $\angle\text{C}_b\text{C}_c\text{C}_c$         | 124.4           |                                                                        |                 |        |
| Hydrogen cyanide       | HCN (linear)                                                                                            | C—H ( $r_e$ )                             | 1.0655 | C—N ( $r_e$ )                                  | 1.1532          |                                                                        |                 | MW, IR |
| Iminocyanide radical   | HNCN                                                                                                    | N—H                                       | 1.034  | N...N                                          | 2.470           |                                                                        |                 | UV     |
|                        |                                                                                                         | $\angle\text{HNC}$                        | 116.5  | $\angle\text{NCN}$                             | ~180            |                                                                        |                 |        |
| Iodoacetylene          | $\text{IC}\equiv\text{CH}$                                                                              | C—C                                       | 1.218  | C—I                                            | 1.980           | C—H                                                                    | 1.059           | IR     |
| Iodocynoacetylene      | $\text{IC}_a\equiv\text{C}_b\text{C}_c\equiv\text{N}$<br>(linear)                                       | $\text{C}_a-\text{C}_b$                   | 1.207  | $\text{C}_b-\text{C}_c$                        | 1.370           | $\text{C}_c-\text{N}$                                                  | 1.160           | MW     |
|                        |                                                                                                         | $\text{C}_a-\text{I}$                     | 1.985  |                                                |                 |                                                                        |                 |        |
| Iodomethane            | $\text{CH}_3\text{I}$                                                                                   | C—I ( $r_e$ )                             | 2.132  | C—H ( $r_e$ )                                  | 1.084           | $\angle\text{HCH}(\theta_e)$                                           | 111.2           | MW, IR |
| Iron pentacarbonyl     | $\text{Fe}(\text{CO})_5$ ( $\text{D}_{3h}$ )                                                            | Fe—C (av.)                                | 1.821  | (Fe—C) <sub>eq</sub> —<br>(Fe—C) <sub>ax</sub> | 0.020           | C—O (av.)                                                              | 1.153           | ED     |
| Isobutane              | $(\text{C}_b\text{H}_3)_3\text{C}_a\text{H}$                                                            | $\text{C}_a-\text{C}_b$                   | 1.535  | $\text{C}_a-\text{H}$                          | 1.122           | $\text{C}_b-\text{H}$                                                  | 1.113           | ED, MW |
|                        |                                                                                                         | $\angle\text{C}_a\text{C}_b\text{C}_b$    | 110.8  | $\angle\text{C}_a\text{C}_b\text{H}$           | 111.4           |                                                                        |                 |        |
| Isobutene              |                        | $\text{C}_a-\text{C}_b$                   | 1.508  | $\text{C}_b-\text{C}_c$                        | 1.342           | $\text{C}_a-\text{H}$                                                  | 1.119           | ED, MW |
|                        |                                                                                                         | $\text{C}_c-\text{H}_c$                   | 1.10   |                                                |                 |                                                                        |                 |        |
|                        |                                                                                                         | $\angle\text{C}_a\text{C}_b\text{C}_a$    | 115.6  | $\angle\text{C}_a\text{C}_b\text{C}_c$         | 122.2           | $\angle\text{C}_b\text{C}_c\text{H}$                                   | 121             |        |
|                        |                                                                                                         | $\angle\text{HC}_a\text{C}_b$ (av.)       | 111.4  | $\angle\text{HC}_a\text{H}$                    | 107.9           | $\angle\text{H}_c\text{C}_c\text{H}_c$                                 | 118.5           |        |
| Isocyanic acid         | HNCO (bent)                                                                                             | N—C                                       | 1.209  | C—O                                            | 1.166           | N—H                                                                    | 0.986           | MW     |
|                        |                                                                                                         | $\angle\text{NCO}$                        | 180    | $\angle\text{HNC}$                             | 128.0           |                                                                        |                 |        |
| Isocyanomethane        | $\text{C}_a\text{H}_3-\text{N}\equiv\text{C}_b$                                                         | $\text{C}_a-\text{N}$                     | 1.424  | N—C <sub>b</sub>                               | 1.166           | $\text{C}_a-\text{H}$                                                  | 1.102           | MW     |
|                        |                                                                                                         | $\angle\text{NC}_a\text{H}$               | 109.12 |                                                |                 |                                                                        |                 |        |
|                        |                                                                                                         | $\angle\text{HCH}$                        | 123.0  |                                                |                 |                                                                        |                 |        |
| Isofulminic acid       | HCNO (linear)                                                                                           | C—N                                       | 1.161  | N—O                                            | 1.207           | H—C                                                                    | 1.027           | MW     |
| Isothiocyanic acid     | HNCS                                                                                                    | N—C                                       | 1.216  | C—S                                            | 1.561           | N—H                                                                    | 0.989           | MW     |
|                        |                                                                                                         | $\angle\text{NCS}$                        | 180    | $\angle\text{HNC}$                             | 135.0           |                                                                        |                 |        |
| Ketene                 | $\text{H}_2\text{C}=\text{C}=\text{O}$                                                                  | C—C                                       | 1.315  | C—O                                            | 1.163           |                                                                        |                 | MW     |
|                        |                                                                                                         | C—H                                       | 1.090  | $\angle\text{HCH}$                             | 123.5           |                                                                        |                 |        |
| Malononitrile          | $\text{CH}_2(\text{CN})_2$                                                                              | C—C                                       | 1.480  | C—N                                            | 1.147           | C—H                                                                    | 1.091           | MW     |
|                        |                                                                                                         | $\angle\text{CCC}$                        | 110.4  | $\angle\text{CCN}$                             | 176.6           | $\angle\text{HCH}$                                                     | 108.4           |        |
| Methane                | $\text{CH}_4$                                                                                           | C—H ( $r_e$ )                             | 1.0870 |                                                |                 |                                                                        |                 | IR     |
| Methanethioamide       |                      | C—S                                       | 1.626  | C—N                                            | 1.358           | C—H <sub>c</sub>                                                       | 1.10            | MW     |
|                        |                                                                                                         | N—H <sub>a</sub>                          | 1.002  | N—H <sub>b</sub>                               | 1.007           |                                                                        |                 |        |
|                        |                                                                                                         | $\angle\text{NCS}$                        | 125.3  | $\angle\text{H}_a\text{NC}$                    | 117.9           | $\angle\text{H}_b\text{NC}$                                            | 120.4           |        |
|                        |                                                                                                         | $\angle\text{SCH}_c$                      | 127    | $\angle\text{H}_a\text{NH}_b$                  | 121.7           | $\angle\text{NCH}_c$                                                   | 108             |        |
| Methanethiol           | $\text{CH}_3\text{SH}$                                                                                  | C—S                                       | 1.819  | S—H                                            | 1.34            | C—H                                                                    | 1.09            | MW     |
|                        |                                                                                                         | $\angle\text{HSC}$                        | 96.5   | $\angle\text{HCH}$                             | 109.8           | angle<br>between<br>$\text{CH}_3$<br>symmetry<br>axis and C—<br>S bond | 2.2             |        |
| Methanol               | $\text{CH}_3\text{OH}$                                                                                  | C—O                                       | 1.4246 | C—H                                            | 1.0936          | O—H                                                                    | 0.9451          | MW     |
|                        |                                                                                                         | $\angle\text{COH}$                        | 108.53 | $\angle\text{HCH}$                             | 108.63          | angle<br>between<br>$\text{CH}_3$<br>symmetry<br>axis and C—<br>O bond | 3.27            |        |
| Methyl                 | $\cdot\text{CH}_3$ planar ( $\text{D}_{3h}$ )                                                           | C—H                                       | 1.076  |                                                |                 |                                                                        |                 | R      |
| N-Methylacetamide      |                      | $\text{C}_a-\text{C}_b$                   | 1.520  | $\text{C}_b-\text{N}$                          | 1.386           | $\text{C}_c-\text{N}$                                                  | 1.469           | ED     |
|                        |                                                                                                         | $\text{C}_b-\text{O}$                     | 1.225  | C—H                                            | 1.107           |                                                                        |                 |        |
|                        |                                                                                                         | $\angle\text{C}_b\text{NC}_c$             | 119.7  | $\angle\text{NC}_b\text{O}$                    | 121.8           | $\angle\text{C}_a\text{C}_b\text{N}$                                   | 114.1           |        |



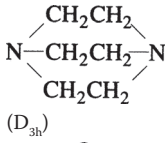
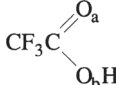
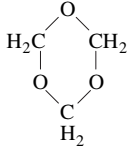
| Compound                    | Structure                                                                      | Bond distances in Å and angles in degrees                |              |                                                                                                    |           |                                                                                                     |           | Method |
|-----------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------|--------------|----------------------------------------------------------------------------------------------------|-----------|-----------------------------------------------------------------------------------------------------|-----------|--------|
| Methylamine                 | CH <sub>3</sub> NH <sub>2</sub>                                                | C—N                                                      | 1.471        | N—H                                                                                                | 1.019     | C—H                                                                                                 | 1.095     | MW     |
|                             |                                                                                | ∠HNC                                                     | 110.3        | ∠HNH                                                                                               | 106.6     | ∠HCH                                                                                                | 108.1     |        |
|                             |                                                                                | angle between CH <sub>3</sub> symmetry axis and C—N bond | 4.3          |                                                                                                    |           |                                                                                                     |           |        |
| Methyl azide                | CH <sub>3</sub> —N <sub>a</sub> —N <sub>b</sub> —N <sub>c</sub>                | C—N <sub>a</sub>                                         | 1.468        | N <sub>a</sub> —N <sub>b</sub>                                                                     | 1.216     | N <sub>b</sub> —N <sub>c</sub>                                                                      | 1.113     | ED     |
|                             | NNN linear                                                                     | C—H                                                      | 1.09         | ∠CN <sub>a</sub> N <sub>b</sub>                                                                    | 116.8     |                                                                                                     |           |        |
| 3-Methyl-3H-diazirine       | CH <sub>3</sub> CH—N                                                           | C—C                                                      | 1.501        | C—N                                                                                                | 1.481     | N—N                                                                                                 | 1.235     | MW     |
|                             |                                                                                | ∠NCN                                                     | 49.3         | dihedral angle between CNN plane and C—C bond                                                      | 122.3     |                                                                                                     |           |        |
| Methylene                   | :CH <sub>2</sub>                                                               | C—H ( <i>r<sub>e</sub></i> )                             | 1.0748       | ∠HCH ( <i>θ<sub>e</sub></i> )                                                                      | 133.84    |                                                                                                     |           | IR,MW  |
| Methylenecyclopropane       | C <sub>c</sub> H <sub>2</sub> —C <sub>b</sub> =C <sub>a</sub> H <sub>2</sub>   | C <sub>a</sub> —C <sub>b</sub>                           | 1.332        | C <sub>b</sub> —C <sub>c</sub>                                                                     | 1.457     | C <sub>c</sub> —C <sub>c</sub>                                                                      | 1.542     | MW     |
|                             |                                                                                | C <sub>c</sub> —H                                        | 1.09         | ∠C <sub>c</sub> C <sub>b</sub> C <sub>c</sub>                                                      | 63.9      | ∠HC <sub>a</sub> H                                                                                  | 114.3     |        |
|                             |                                                                                | ∠HC <sub>c</sub> H                                       | 113.5        | dihedral angle between C <sub>c</sub> H <sub>2</sub> plane and C <sub>c</sub> —C <sub>b</sub> bond | 150.8     |                                                                                                     |           |        |
| 3-Methyleneoxetane          | O—C <sub>c</sub> H <sub>2</sub> —C <sub>b</sub> =C <sub>a</sub> H <sub>2</sub> | C <sub>a</sub> —C <sub>b</sub>                           | 1.33         | C <sub>b</sub> —C <sub>c</sub>                                                                     | 1.52      | C <sub>c</sub> —O                                                                                   | 1.45      | MW     |
|                             |                                                                                | C—H                                                      | 1.09 (ass)   | ∠HC <sub>c</sub> H                                                                                 | 114 (ass) | ∠HC <sub>a</sub> H                                                                                  | 120 (ass) |        |
|                             |                                                                                | ∠C <sub>c</sub> C <sub>b</sub> C <sub>c</sub>            | 87           |                                                                                                    |           |                                                                                                     |           |        |
| Methylenephosphine          | CH <sub>c</sub> H <sub>t</sub> =PH planar                                      | C—P                                                      | 1.673        | C—H <sub>c</sub>                                                                                   | 1.09      | C—H <sub>t</sub>                                                                                    | 1.09      | MW     |
|                             |                                                                                | P—H                                                      | 1.420        | ∠CPH                                                                                               | 97.4      |                                                                                                     |           |        |
|                             |                                                                                | ∠HCH                                                     | 117.2        | ∠PCH <sub>c</sub>                                                                                  | 124.4     | ∠PCH <sub>t</sub>                                                                                   | 118.4     |        |
| Methyl formate              | C <sub>a</sub> H <sub>3</sub> —O <sub>a</sub> —C <sub>b</sub> =O <sub>b</sub>  | C <sub>b</sub> —O <sub>b</sub>                           | 1.206        | C—O (av.)                                                                                          | 1.393     | C <sub>a</sub> —H                                                                                   | 1.08      | ED     |
|                             |                                                                                | C <sub>b</sub> —H                                        | 1.101 (ass.) |                                                                                                    |           |                                                                                                     |           |        |
|                             |                                                                                | ∠COC                                                     | 114          | ∠O <sub>a</sub> C <sub>b</sub> O <sub>b</sub>                                                      | 127       | ∠O <sub>a</sub> C <sub>a</sub> H                                                                    | 110       |        |
| Methylgermane               | CH <sub>3</sub> GeH <sub>3</sub>                                               | C—Ge                                                     | 1.945        | Ge—H                                                                                               | 1.529     | C—H                                                                                                 | 1.083     | MW     |
|                             |                                                                                | ∠HGeH                                                    | 109.3        | ∠HCH                                                                                               | 108.4     |                                                                                                     |           |        |
| Methyl hypochlorite         | CH <sub>3</sub> OCl                                                            | C—O                                                      | 1.389        | O—Cl                                                                                               | 1.674     | C—H                                                                                                 | 1.103     | MW     |
|                             |                                                                                | ∠COCl                                                    | 112.8        | ∠HCH                                                                                               | 109.6     |                                                                                                     |           |        |
| Methyldiyne                 | :CH                                                                            | C—H ( <i>r<sub>e</sub></i> )                             | 1.1198       |                                                                                                    |           |                                                                                                     |           | UV     |
| Methyldynephosphine         | HCP                                                                            | C—P ( <i>r<sub>e</sub></i> )                             | 1.5398       | C—H ( <i>r<sub>e</sub></i> )                                                                       | 1.0692    |                                                                                                     |           | MW     |
| Methylketene                | C <sub>c</sub> H <sub>3</sub> —C <sub>b</sub> =C <sub>a</sub> =O               | C <sub>a</sub> —C <sub>b</sub>                           | 1.306        | C <sub>b</sub> —C <sub>c</sub>                                                                     | 1.518     | C <sub>a</sub> —O                                                                                   | 1.171     | MW     |
|                             |                                                                                | C <sub>b</sub> —H                                        | 1.083        | C <sub>c</sub> —H                                                                                  | 1.10      |                                                                                                     |           |        |
|                             |                                                                                | ∠OC <sub>a</sub> C <sub>b</sub>                          | 180.5        | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub>                                                      | 122.6     | ∠C <sub>a</sub> C <sub>b</sub> H                                                                    | 113.7     |        |
|                             |                                                                                | ∠C <sub>c</sub> C <sub>b</sub> H                         | 123.7        | ∠HCH                                                                                               | 109.2     |                                                                                                     |           |        |
| Methyl nitrate              | H <sub>a</sub> —C—O—N=O <sub>a</sub>                                           | C—O                                                      | 1.437        | C—H <sub>a</sub>                                                                                   | 1.10      | C—H <sub>b</sub>                                                                                    | 1.09      | MW     |
|                             |                                                                                | O—N                                                      | 1.402        | N—O <sub>a</sub>                                                                                   | 1.205     | N—O <sub>b</sub>                                                                                    | 1.208     |        |
|                             |                                                                                | ∠CON                                                     | 112.7        | ∠ONO <sub>a</sub>                                                                                  | 118.1     | ∠ONO <sub>b</sub>                                                                                   | 112.4     |        |
|                             |                                                                                | ∠OCH <sub>a</sub>                                        | 110          | ∠OCH <sub>b</sub>                                                                                  | 103       |                                                                                                     |           |        |
| Methyloxirane               | C <sub>a</sub> H <sub>3</sub> C <sub>b</sub> H—C <sub>c</sub> H <sub>2</sub>   | C <sub>a</sub> —C <sub>b</sub>                           | 1.51         | ∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub>                                                      | 121.0     | dihedral angle between C <sub>b</sub> C <sub>c</sub> O plane and C <sub>a</sub> C <sub>b</sub> bond | 123.8     | MW     |
| Methylphosphine             | CH <sub>3</sub> PH <sub>2</sub>                                                | C—P                                                      | 1.858        | C—H                                                                                                | 1.094     |                                                                                                     |           | ED     |
| Methylphosphonic difluoride | CH <sub>3</sub> POF <sub>2</sub>                                               | C—P                                                      | 1.770        | P—O                                                                                                | 1.444     | P—F                                                                                                 | 1.545     | ED,MW  |
|                             |                                                                                | ∠OPC                                                     | 117.8        | ∠FPC                                                                                               | 103.7     | ∠FPF                                                                                                | 99.2      |        |
| Methylsilane                | CH <sub>3</sub> SiH <sub>3</sub>                                               | C—Si                                                     | 1.867        | Si—H                                                                                               | 1.485     | C—H                                                                                                 | 1.093     | MW     |
|                             |                                                                                | ∠HCH                                                     | 107.7        | ∠HSiH                                                                                              | 108.3     |                                                                                                     |           |        |
| Methylstannane              | CH <sub>3</sub> SnH <sub>3</sub>                                               | C—Sn                                                     | 2.143        | Sn—H                                                                                               | 1.700     |                                                                                                     |           | MW     |

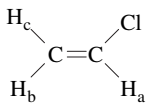
| Compound               | Structure                                                                           | Bond distances in Å and angles in degrees                                                         |       |                                               |       |                                               |              | Method |
|------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------|-----------------------------------------------|-------|-----------------------------------------------|--------------|--------|
| Methyl thiocyanate     |    | S—C <sub>a</sub>                                                                                  | 1.824 | S—C <sub>b</sub>                              | 1.684 | C <sub>b</sub> —N                             | 1.170        | MW     |
|                        |                                                                                     | C—H                                                                                               | 1.081 |                                               |       |                                               |              |        |
|                        |                                                                                     | ∠C <sub>a</sub> SC <sub>b</sub>                                                                   | 99.0  | ∠HCH                                          | 110.6 | ∠HCS                                          | 108.3        |        |
| Methyltrioxorhenium    | CH <sub>3</sub> ReO <sub>3</sub>                                                    | Re—C                                                                                              | 2.074 | Re—O                                          | 1.703 | C—H                                           | 1.088        | MW     |
|                        |                                                                                     | ∠ReCH                                                                                             | 108.9 | ∠CReO                                         | 106.4 |                                               |              |        |
| Molybdenum carbide     | MoC                                                                                 | Mo—C                                                                                              | 1.676 |                                               |       |                                               |              | UV     |
| Molybdenum carbonyl    | Mo(CO) <sub>6</sub> (O <sub>h</sub> )                                               | Mo—C                                                                                              | 2.063 | C—O                                           | 1.145 |                                               |              | ED     |
| Naphthalene            |    | C <sub>a</sub> —C <sub>b</sub>                                                                    | 1.37  | C <sub>b</sub> —C <sub>b</sub>                | 1.41  | C <sub>a</sub> —C <sub>c</sub>                | 1.42         | ED     |
|                        |                                                                                     | C <sub>c</sub> —C <sub>c</sub>                                                                    | 1.42  | C—C (av.)                                     | 1.40  | ∠C <sub>a</sub> C <sub>c</sub> C <sub>c</sub> | 119.4        |        |
| Neopentane             | C(CH <sub>3</sub> ) <sub>4</sub>                                                    | C—C                                                                                               | 1.537 | C—H                                           | 1.114 | ∠CCH                                          | 112          | ED     |
| Nickel carbonyl        | Ni(CO) <sub>4</sub> (T <sub>d</sub> )                                               | Ni—C                                                                                              | 1.839 | C—O                                           | 1.121 |                                               |              | IR     |
| Nickel monocarbonyl    | NiCO (linear)                                                                       | Ni—C                                                                                              | 1.64  | C—O                                           | 1.19  |                                               |              | IR     |
| Nickel cyanide         | NiC≡N (linear)                                                                      | Ni—C                                                                                              | 1.828 | C—N                                           | 1.158 |                                               |              | MW     |
| Nitromethane           | CH <sub>3</sub> NO <sub>2</sub>                                                     | C—N                                                                                               | 1.489 | N—O                                           | 1.224 | C—H                                           | 1.088 (ass.) | MW     |
|                        |                                                                                     | ∠ONO                                                                                              | 125.3 | ∠NCH                                          | 107   |                                               |              |        |
| N-Nitrosodimethylamine | (CH <sub>3</sub> ) <sub>2</sub> NNO                                                 | C—N                                                                                               | 1.461 | N—O                                           | 1.235 | N—N                                           | 1.344        | ED     |
|                        |                                                                                     | ∠CNC                                                                                              | 123.2 | ∠CNN                                          | 116.4 | ∠ONN                                          | 113.6        |        |
| Nitrosomethane         | CH <sub>3</sub> NO                                                                  | C—N                                                                                               | 1.49  | N—O                                           | 1.22  | C—H                                           | 1.084        | MW     |
|                        |                                                                                     | ∠CNO                                                                                              | 112.6 | ∠NCH                                          | 109.0 |                                               |              |        |
| 2,5-Norbornadiene      |   | C <sub>a</sub> —C <sub>b</sub>                                                                    | 1.535 | C <sub>b</sub> —C <sub>b</sub>                | 1.343 | C <sub>a</sub> —C <sub>c</sub>                | 1.573        | ED     |
|                        |                                                                                     | C—H                                                                                               | 1.12  | ∠C <sub>a</sub> C <sub>c</sub> C <sub>a</sub> | 94    |                                               |              |        |
|                        |                                                                                     | dihedral angle between the two C <sub>a</sub> C <sub>b</sub> C <sub>b</sub> C <sub>a</sub> planes | 115.6 |                                               |       |                                               |              |        |
| 1,2,5-Oxadiazole       |  | C—C                                                                                               | 1.421 | C—N                                           | 1.300 | O—N                                           | 1.380        | MW     |
|                        |                                                                                     | C—H                                                                                               | 1.076 | ∠CCH                                          | 130.2 | ∠NCH                                          | 120.9        |        |
|                        |                                                                                     | ∠CCN                                                                                              | 109.0 | ∠NON                                          | 110.4 | ∠ONC                                          | 105.8        |        |
| 1,3,4-Oxadiazole       |  | C—O                                                                                               | 1.348 | C—N                                           | 1.297 | N—N                                           | 1.399        | MW     |
|                        |                                                                                     | C—H                                                                                               | 1.075 | ∠OCH                                          | 118.1 | ∠NCH                                          | 128.5        |        |
|                        |                                                                                     | ∠CNN                                                                                              | 105.6 | ∠COC                                          | 102.0 | ∠OCN                                          | 113.4        |        |
| Oxalic acid            |  | C—C                                                                                               | 1.544 | C—O <sub>a</sub>                              | 1.205 | C—O <sub>b</sub>                              | 1.336        | ED     |
|                        |                                                                                     | O <sub>b</sub> —H                                                                                 | 1.05  |                                               |       |                                               |              |        |
|                        |                                                                                     | ∠CCO <sub>a</sub>                                                                                 | 123.1 | ∠O <sub>a</sub> CO <sub>b</sub>               | 125.0 | ∠CO <sub>b</sub> H                            | 104          |        |
| Oxalyl chloride        |  | C—C                                                                                               | 1.534 | C—O                                           | 1.182 | C—Cl                                          | 1.744        | ED     |
|                        |                                                                                     | ∠CCO                                                                                              | 124.2 | ∠CCCl                                         | 111.7 | 68% trans, 32% gauche at 0 °C                 |              |        |
| Oxetane                |  | C—C                                                                                               | 1.546 | C—O                                           | 1.448 | C—H (av.)                                     | 1.090        | MW     |
|                        |                                                                                     | ∠CCC                                                                                              | 85    | ∠COC                                          | 92    | ∠OCC                                          | 92           |        |
|                        |                                                                                     | ∠HCH (av.)                                                                                        | 109.9 |                                               |       |                                               |              |        |

| Compound             | Structure                                                                                  | Bond distances in Å and angles in degrees                                                                                                |                                   |                                                                                                                       |                                             |                                                                                                        |                      | Method |
|----------------------|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------|--------------------------------------------------------------------------------------------------------|----------------------|--------|
| Oxirane              |                                                                                            | C—C<br>∠HCH                                                                                                                              | 1.466<br>116.6                    | C—O<br>dihedral angle between NH <sub>2</sub> plane and N—C bond                                                      | 1.431<br>158.0                              | C—H                                                                                                    | 1.085                | MW     |
| Phenol               |                                                                                            | C—C (av.)<br>C <sub>b</sub> —H<br>∠COH                                                                                                   | 1.397<br>1.084<br>109.0           | C <sub>a</sub> —O<br>C <sub>c</sub> —H                                                                                | 1.364<br>1.076                              | O—H<br>C <sub>d</sub> —H                                                                               | 0.956<br>1.082       | MW     |
| Phosphirane          |                                                                                            | C—C<br>C—H<br>∠HCH                                                                                                                       | 1.502<br>1.09<br>114.4            | C—P<br>∠CPC<br>∠CCH                                                                                                   | 1.867<br>47.4<br>118                        | P—H<br>∠HPC<br>dihedral angle between PCC plane and PH bond                                            | 1.43<br>95.2<br>95.7 | MW     |
| Piperazine           |                                                                                            | C—C<br>∠CNC                                                                                                                              | 1.540<br>109.0                    | C—N<br>∠CCN                                                                                                           | 1.467<br>110.4                              | C—H                                                                                                    | 1.110                | ED     |
| Palladium carbide    | (C <sub>2h</sub> )<br>PdC                                                                  | Pd—C                                                                                                                                     | 1.712                             |                                                                                                                       |                                             |                                                                                                        |                      | UV     |
| Platinum carbide     | PtC                                                                                        | Pt—C ( <i>r<sub>e</sub></i> )                                                                                                            | 1.6767                            |                                                                                                                       |                                             |                                                                                                        |                      | UV     |
| Potassium carbide    | KC                                                                                         | K—C                                                                                                                                      | 2.528                             |                                                                                                                       |                                             |                                                                                                        |                      | MW     |
| Propane              | C <sub>3</sub> H <sub>8</sub>                                                              | C—C<br>∠CCC                                                                                                                              | 1.532<br>112                      | C—H<br>∠HCH                                                                                                           | 1.107<br>107                                |                                                                                                        |                      | ED     |
| Propene              |                                                                                            | C <sub>a</sub> —C <sub>b</sub><br>C <sub>a</sub> —H <sub>a</sub><br>∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub>                        | 1.341<br>1.104<br>124.3           | C <sub>b</sub> —C <sub>c</sub><br>C <sub>c</sub> —H <sub>d</sub><br>∠C <sub>b</sub> C <sub>a</sub> H <sub>a,b,c</sub> | 1.506<br>1.117<br>121.3                     | ∠C <sub>b</sub> C <sub>c</sub> H <sub>d</sub>                                                          | 110.7                | ED, MW |
| 2-Propenoyl chloride |                                                                                            | C <sub>a</sub> —C <sub>b</sub><br>C <sub>c</sub> —O<br>∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub><br>∠C <sub>a</sub> C <sub>b</sub> H | 1.35<br>1.19<br>123<br>120 (ass.) | C <sub>b</sub> —C <sub>c</sub><br>C—H<br>∠C <sub>b</sub> C <sub>c</sub> Cl<br>∠C <sub>b</sub> C <sub>a</sub> H        | 1.48<br>1.086 (ass.)<br>116<br>121.5 (ass.) | C <sub>c</sub> —Cl<br>∠C <sub>b</sub> C <sub>c</sub> O                                                 | 1.82<br>127          | MW     |
| 2-Propynal           | H <sub>a</sub> C <sub>a</sub> ≡C <sub>b</sub> —C <sub>c</sub> H <sub>c</sub> O<br>(planar) | C <sub>a</sub> —C <sub>b</sub><br>C <sub>a</sub> —H <sub>a</sub><br>∠C <sub>a</sub> C <sub>b</sub> C <sub>c</sub>                        | 1.211<br>1.085<br>178.6           | C <sub>b</sub> —C <sub>c</sub><br>C <sub>c</sub> —H <sub>c</sub><br>∠C <sub>b</sub> C <sub>c</sub> O                  | 1.453<br>1.130<br>124.2                     | C <sub>c</sub> —O<br>∠C <sub>b</sub> C <sub>c</sub> H <sub>c</sub>                                     | 1.214<br>113.7       | ED, MW |
| Propyne              | H <sub>3</sub> C <sub>c</sub> —C <sub>b</sub> ≡C <sub>a</sub> H                            | C <sub>c</sub> —C <sub>b</sub><br>C <sub>a</sub> —H                                                                                      | 1.459<br>1.056                    | C <sub>b</sub> —C <sub>a</sub><br>C <sub>c</sub> —H                                                                   | 1.206<br>1.105                              | ∠HC <sub>c</sub> C <sub>b</sub>                                                                        | 110.2                | MW     |
| Propynal isocyanide  | H <sub>3</sub> C <sub>c</sub> —C <sub>b</sub> ≡C <sub>a</sub> —N≡C                         | C <sub>c</sub> —C <sub>b</sub> ( <i>r<sub>s</sub></i> )<br>N—C ( <i>r<sub>s</sub></i> )                                                  | 1.456<br>1.175                    | C <sub>b</sub> —C <sub>a</sub> ( <i>r<sub>s</sub></i> )<br>C <sub>c</sub> —H ( <i>r<sub>s</sub></i> )                 | 1.206<br>1.090                              | C <sub>a</sub> —N ( <i>r<sub>s</sub></i> )<br>∠HC <sub>c</sub> C <sub>b</sub> ( <i>θ<sub>s</sub></i> ) | 1.316<br>110.7       | MW     |
| Pyrazine             |                                                                                            | C—C<br>∠CCH                                                                                                                              | 1.339<br>123.9                    | C—N<br>∠CCN                                                                                                           | 1.403<br>115.6                              | C—H                                                                                                    | 1.115                | ED     |
| Pyridazine           |                                                                                            | C <sub>a</sub> —C <sub>b</sub><br>N—N                                                                                                    | 1.393<br>1.330                    | C <sub>b</sub> —C <sub>b</sub><br>∠NCC                                                                                | 1.375<br>123.7                              | C <sub>a</sub> —N<br>∠NNC                                                                              | 1.341<br>119.3       | ED, MW |

| Compound                             | Structure                                                                                                | Bond distances in Å and angles in degrees                            |                                  |                                                                                     |                                  |                                                                                             |                                  | Method   |
|--------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------|-------------------------------------------------------------------------------------|----------------------------------|---------------------------------------------------------------------------------------------|----------------------------------|----------|
| Pyridine                             |                         | $C_a-C_b$<br>$C_a-H_a$<br>$\angle C_a C_b C_c$<br>$\angle C_a N C_a$ | 1.395<br>1.084<br>118.5<br>116.8 | $C_b-C_c$<br>$C_b-H_b$<br>$\angle C_b C_c C_a$<br>$\angle N C_a C_b$                | 1.394<br>1.081<br>118.3<br>123.9 | $C_a-N$<br>$C_c-H_c$<br>$\angle C_c C_b H_b$<br>$\angle N C_a H_a$                          | 1.340<br>1.077<br>121.3<br>115.9 | MW       |
| Pyrimidine                           | <br>( $C_{2v}$ assumed) | $C-C$<br>$\angle N C N$                                              | 1.393<br>127.6                   | $C-N$<br>$\angle C N C$                                                             | 1.340<br>115.5                   |                                                                                             |                                  | ED       |
| Pyrrole                              |                         | $C_a-C_b$<br>$C_a-H_a$<br>$\angle C_a C_b C_c$<br>$\angle C_b C_c H$ | 1.382<br>1.076<br>107.4<br>127.1 | $C_b-C_c$<br>$C_b-H_b$<br>$\angle C_a N C_a$<br>$\angle N C_a H_a$                  | 1.417<br>1.077<br>109.8<br>121.5 | $C_a-N$<br>$N-H$<br>$\angle N C_a C_b$                                                      | 1.370<br>0.996<br>107.7          | MW       |
| Pyruvonitrile                        |                         | $C_a-C_b$<br>$C-N$<br>$\angle C_a C_b C_c$                           | 1.518<br>1.17<br>114.2           | $C_b-C_c$<br>$C-O$<br>$\angle C_a C_b O$                                            | 1.477<br>1.208<br>124.5          | $C-H$<br>$\angle H C H$<br>$\angle C C N$                                                   | 1.12<br>109.2<br>179             | ED, MW   |
| Ruthenium carbide<br>Silacyclobutane |                         | $Ru-C$<br>$C-C$<br>$Si-H$<br>$\angle Si C C$                         | 1.607<br>1.571<br>1.47<br>84.8   | $C-Si$<br>$\angle C C C$<br>dihedral angle<br>between $CCC$<br>and $CSiC$<br>planes | 1.885<br>99.8<br>146             | $C-H$<br>$\angle CSiC$                                                                      | 1.100<br>77.2                    | UV<br>ED |
| Silaethene                           | $H_2Si=CH_2$                                                                                             | $Si-C(r_e)$<br>$\angle H C Si$                                       | 1.704<br>122.0                   | $Si-H(r_e)$<br>$\angle H Si C$                                                      | 1.467<br>122.4                   | $C-H(r_e)$                                                                                  | 1.082                            | MW       |
| Silicon dicarbide                    | $CSiC$ (ring)                                                                                            | $C-C(r_s)$                                                           | 1.269                            | $Si-C(r_s)$                                                                         | 1.832                            | $\angle CSiC(\theta_s)$                                                                     | 40.5                             | MW       |
| Silylchloroacetylene                 | $SiH_3C\equiv CCl$                                                                                       | $C-C$<br>$Si-H$                                                      | 1.234<br>1.488                   | $Si-C$<br>$\angle H Si C$                                                           | 1.812<br>109.4                   | $C-Cl$                                                                                      | 1.620                            | ED       |
| Silyl cyanide                        | $SiH_3C\equiv N$                                                                                         | $Si-C$<br>$\angle H Si C$                                            | 1.850<br>107.25                  | $C-N$                                                                               | 1.156                            | $Si-H$                                                                                      | 1.487                            | ED, MW   |
| Sodium carbide                       | $NaC$                                                                                                    | $Na-C$                                                               | 2.232                            |                                                                                     |                                  |                                                                                             |                                  | MW       |
| Spiro[2.2]pentane                    |                       | $C_b-C_b$<br>$\angle C_b C_a C_b$                                    | 1.52<br>62                       | $C_a-C_b$<br>$\angle H C H$                                                         | 1.47<br>118                      | $C-H$                                                                                       | 1.09                             | ED       |
| Strontium methyl<br>Succinonitrile   |                       | $Sr-C$<br>$C-C$<br>$C-H$                                             | 2.487<br>1.561<br>1.09           | $C-H$ (ass.)<br>$C-C(N)$<br>$\angle C C C$                                          | 1.104<br>1.465<br>110.4          | $\angle H C H$<br>$C-N$<br>dihedral<br>angle of<br>$CCCC$ for<br><i>gauche</i><br>conformer | 105.8<br>1.161<br>75             | UV<br>ED |
| Tetrabromomethane                    | $CBr_4$ ( $T_d$ )                                                                                        | $C-Br$                                                               | 1.935                            |                                                                                     |                                  |                                                                                             |                                  | ED       |
| Tetrachloroethene                    | $CCl_2=CCl_2$                                                                                            | $C-C$                                                                | 1.354                            | $C-Cl$                                                                              | 1.718                            | $\angle Cl C Cl$                                                                            | 115.7                            | ED       |
| Tetrachloromethane                   | $CCl_4$ ( $T_d$ )                                                                                        | $C-Cl$                                                               | 1.767                            |                                                                                     |                                  |                                                                                             |                                  | ED       |
| Tetracyanoethene                     | $(CN)_2C=C(CN)_2$                                                                                        | $C-C$<br>$\angle CC=C$                                               | 1.435<br>121.1                   | $C=C$                                                                               | 1.357                            | $C-N$                                                                                       | 1.162                            | ED       |
| 2,2,4,4-Tetrafluoro-1,3-dithietane   |                       | $C-S$<br>$\angle F C S$                                              | 1.785<br>113.7                   | $C-F$                                                                               | 1.314                            | $\angle C S C$                                                                              | 83.2                             | ED       |
| Tetrafluoroethene                    | $CF_2=CF_2$                                                                                              | $C-C$                                                                | 1.31                             | $C-F$                                                                               | 1.319                            | $\angle C C F$                                                                              | 123.8                            | ED       |
| Tetrafluoromethane                   | $CF_4$ ( $T_d$ )                                                                                         | $C-F$                                                                | 1.323                            |                                                                                     |                                  |                                                                                             |                                  | ED       |

| Compound              | Structure                                      | Bond distances in Å and angles in degrees                                                                                                            |                                  |                                                                                                                                                      |                                 |                                                        |                              | Method |
|-----------------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------------------------------------------|------------------------------|--------|
| Tetrahydrofuran       |                                                | C—C                                                                                                                                                  | 1.536                            | C—O                                                                                                                                                  | 1.428                           | C—H                                                    | 1.115                        | ED     |
| Tetrahydropyran       |                                                | C—C<br>∠COC<br>∠CCC (O)                                                                                                                              | 1.531<br>111.5<br>111            | C—O<br>∠OCC                                                                                                                                          | 1.420<br>111.8                  | C—H<br>∠CCC (C)                                        | 1.116<br>108                 | ED     |
| Tetrahydrothiophene   |                                                | C—C<br>∠CCC                                                                                                                                          | 1.536<br>105.0                   | C—S<br>∠CSC                                                                                                                                          | 1.839<br>93.4                   | C—H<br>∠SCC                                            | 1.120<br>106.1               | ED     |
| Tetraiodomethane      | CI <sub>4</sub> (T <sub>d</sub> )              | C—I                                                                                                                                                  | 2.15                             |                                                                                                                                                      |                                 |                                                        |                              | ED     |
| Tetramethylgermane    | (CH <sub>3</sub> ) <sub>4</sub> Ge             | C—Ge                                                                                                                                                 | 1.945                            | C—H                                                                                                                                                  | 1.12                            | ∠GeCH                                                  | 108                          | ED     |
| Tetramethyl lead      | (CH <sub>3</sub> ) <sub>4</sub> Pb             | C—Pb                                                                                                                                                 | 2.238                            |                                                                                                                                                      |                                 |                                                        |                              | ED     |
| Tetramethylsilane     | (CH <sub>3</sub> ) <sub>4</sub> Si             | C—Si                                                                                                                                                 | 1.875                            | C—H                                                                                                                                                  | 1.115                           | ∠HCH                                                   | 109.8                        | ED     |
| Tetramethylstannane   | (CH <sub>3</sub> ) <sub>4</sub> Sn             | C—Sn                                                                                                                                                 | 2.144                            | C—H                                                                                                                                                  | 1.12                            |                                                        |                              | ED     |
| 1,2,5-Thiadiazole     |                                                | C—C<br>C—H<br>∠CCN                                                                                                                                   | 1.420<br>1.079<br>113.8          | C—N<br>∠NSN                                                                                                                                          | 1.328<br>99.6                   | S—N<br>∠CCH                                            | 1.631<br>126.2               | MW     |
| 1,3,4-Thiadiazole     |                                                | C—S<br>C—H<br>∠CCN                                                                                                                                   | 1.721<br>1.08<br>112.2           | C—N<br>∠CSC<br>∠NCH                                                                                                                                  | 1.302<br>86.4<br>123.5          | N—N<br>∠SCN<br>∠SCH                                    | 1.371<br>114.6<br>121.9      | MW     |
| Thietane              |                                                | C—C<br>∠CSC                                                                                                                                          | 1.549<br>76.8                    | C—S<br>∠HCH (av.)                                                                                                                                    | 1.847<br>112                    | C—H (av.)<br>dihedral angle between CCC and CSC planes | 1.100<br>154                 | ED, MW |
| Thiirane              |                                                | C—C<br>∠CSC<br>dihedral angle between CH <sub>2</sub> plane and C—C bond                                                                             | 1.484<br>48.3<br>152             | C—S<br>∠CCS                                                                                                                                          | 1.815<br>65.9                   | C—H<br>∠HCH                                            | 1.083<br>116                 | MW     |
| Thioacetaldehyde      |                                                | C <sub>a</sub> —S (r <sub>s</sub> )<br>C <sub>a</sub> —H (r <sub>s</sub> )<br>∠C <sub>b</sub> C <sub>a</sub> S (θ <sub>s</sub> )                     | 1.610<br>1.089<br>125.3          | C <sub>a</sub> —C <sub>b</sub> (r <sub>s</sub> )<br>C <sub>b</sub> —H (r <sub>s</sub> )<br>∠C <sub>b</sub> C <sub>a</sub> H (θ <sub>s</sub> )        | 1.506<br>1.094 (av.)<br>119.4   |                                                        | 110.6 (av.)                  | MW     |
| Thiocarbonyl fluoride | F <sub>2</sub> CS                              | C—S                                                                                                                                                  | 1.589                            | C—F                                                                                                                                                  | 1.315                           | ∠FCF                                                   | 107.1                        | MW     |
| Thioformaldehyde      | CH <sub>2</sub> S                              | C—S                                                                                                                                                  | 1.611                            | C—H                                                                                                                                                  | 1.093                           | ∠HCH                                                   | 116.9                        | MW     |
| Thioketene            | H <sub>2</sub> C=C=S                           | C—C (r <sub>s</sub> )<br>∠HCH (θ <sub>s</sub> )                                                                                                      | 1.314<br>119.8                   | C—S (r <sub>s</sub> )                                                                                                                                | 1.554                           | C—H (r <sub>s</sub> )                                  | 1.080                        | IR     |
| Thiophene             |                                                | C <sub>a</sub> —C <sub>b</sub><br>C <sub>a</sub> —H <sub>a</sub><br>∠C <sub>a</sub> C <sub>b</sub> C <sub>b</sub><br>∠SC <sub>a</sub> H <sub>a</sub> | 1.370<br>1.078<br>112.5<br>119.9 | C <sub>b</sub> —C <sub>b</sub><br>C <sub>b</sub> —H <sub>b</sub><br>∠C <sub>b</sub> SC <sub>a</sub><br>∠C <sub>b</sub> C <sub>b</sub> H <sub>b</sub> | 1.423<br>1.081<br>92.2<br>124.3 | C <sub>a</sub> —S<br>∠SC <sub>a</sub> C <sub>b</sub>   | 1.714<br>115.5               | MW     |
| Toluene               | C <sub>6</sub> H <sub>5</sub> —CH <sub>3</sub> | C—C (ring)                                                                                                                                           | 1.399                            | C—CH <sub>3</sub>                                                                                                                                    | 1.524                           | C—H (av.)                                              | 1.11                         | ED     |
| 1,1,1-Tribromoethane  | CH <sub>3</sub> CBr <sub>3</sub>               | C—C<br>∠BrCBr                                                                                                                                        | 1.51 (ass.)<br>111               | C—Br<br>∠CCBr                                                                                                                                        | 1.93<br>108                     | C—H<br>∠CCH                                            | 1.095 (ass.)<br>109.0 (ass.) | MW     |

| Compound                               | Structure                                                                                                | Bond distances in Å and angles in degrees |       |                         |              |                                                      |       | Method |
|----------------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------|-------|-------------------------|--------------|------------------------------------------------------|-------|--------|
| Tribromomethane                        | $\text{CHBr}_3$ ( $\text{C}_{3v}$ )                                                                      | C—Br                                      | 1.924 | C—H                     | 1.11         | $\angle\text{BrCBr}$                                 | 111.7 | ED, MW |
| Tri- <i>tert</i> -butyl methane        | $\text{HC}_a[\text{C}_b(\text{C}_c\text{H}_3)_3]_3$                                                      | $\text{C}_a\text{—C}_b$                   | 1.611 | $\text{C}_b\text{—C}_c$ | 1.548        | C—H                                                  | 1.111 | ED     |
|                                        |                                                                                                          | $\angle\text{C}_a\text{C}_b\text{C}_c$    | 113.0 |                         |              |                                                      |       |        |
| Trichloroacetonitrile                  | $\text{CCl}_3\text{CN}$                                                                                  | C—C                                       | 1.460 | C—N                     | 1.165        | C—Cl                                                 | 1.763 | ED     |
|                                        |                                                                                                          | $\angle\text{ClCCl}$                      | 110.0 |                         |              |                                                      |       |        |
| 1,1,1-Trichloroethane                  | $\text{CH}_3\text{CCl}_3$                                                                                | C—C                                       | 1.541 | C—Cl                    | 1.771        | C—H                                                  | 1.090 | MW     |
|                                        |                                                                                                          | $\angle\text{CCCl}$                       | 109.6 | $\angle\text{ClCCl}$    | 109.4        | $\angle\text{HCH}$                                   | 110.0 |        |
|                                        |                                                                                                          | $\angle\text{CCH}$                        | 108.9 |                         |              |                                                      |       |        |
| Trichlorofluoromethane                 | $\text{CCl}_3\text{F}$                                                                                   | C—Cl                                      | 1.754 | C—F                     | 1.362        | $\angle\text{ClCCl}$                                 | 111   | MW     |
| Trichloromethane                       | $\text{CHCl}_3$                                                                                          | C—Cl                                      | 1.758 | C—H                     | 1.100        | $\angle\text{ClCCl}$                                 | 111.3 | MW     |
| Trichloromethylgermane                 | $\text{CH}_3\text{GeCl}_3$                                                                               | C—Ge                                      | 1.89  | Ge—Cl                   | 2.132        | C—H                                                  | 1.103 | ED, MW |
|                                        |                                                                                                          | $\angle\text{ClGeCl}$                     | 106.4 | $\angle\text{GeCH}$     | 110.5 (ass.) |                                                      |       |        |
| Trichloromethylsilane                  | $\text{CH}_3\text{SiCl}_3$                                                                               | C—Si                                      | 1.876 | Si—Cl                   | 2.021        |                                                      |       | MW     |
| Trichloromethylstannane                | $\text{CH}_3\text{SnCl}_3$                                                                               | C—Sn                                      | 2.10  | Sn—Cl                   | 2.304        | C—H                                                  | 1.100 | ED     |
| 1,1,1-Trichloro-2,2,2-trifluoroethane  | $\text{CF}_3\text{CCl}_3$<br>(staggered configuration)                                                   | C—C                                       | 1.54  | C—F                     | 1.33         | C—Cl                                                 | 1.77  | MW     |
|                                        |                                                                                                          | $\angle\text{CCF}$                        | 110   | $\angle\text{CCCl}$     | 109.6        |                                                      |       |        |
|                                        |                                                                                                          | $\angle\text{CSnCl}$                      | 113.9 | $\angle\text{ClSnCl}$   | 104.7        | $\angle\text{SnCH}$                                  | 108   |        |
| Triethylenediamine                     | <br>( $\text{D}_{3h}$ ) | C—C                                       | 1.562 | C—N                     | 1.472        | $\angle\text{CNC}$                                   | 108.7 | ED     |
|                                        |                                                                                                          | $\angle\text{NCC}$                        | 110.2 |                         |              |                                                      |       |        |
| Trifluoroacetic acid                   |                         | C—C                                       | 1.546 | C—O <sub>a</sub>        | 1.192        | C—O <sub>b</sub>                                     | 1.35  | ED     |
|                                        |                                                                                                          | C—F                                       | 1.325 | O—H                     | 0.96 (ass.)  |                                                      |       |        |
|                                        |                                                                                                          | $\angle\text{CCO}_a$                      | 126.8 | $\angle\text{CCO}_b$    | 111.1        | $\angle\text{CCF}$                                   | 109.5 |        |
| 1,1,1-Trifluoroethane                  | $\text{CH}_3\text{CF}_3$                                                                                 | C—C                                       | 1.494 | C—F                     | 1.340        | C—H                                                  | 1.081 | ED     |
| Trifluoroiodomethane                   | $\text{CF}_3\text{I}$ ( $\text{C}_{3v}$ )                                                                | C—F                                       | 1.330 | C—I                     | 2.138        | $\angle\text{FCF}$                                   | 108.1 | ED, MW |
| Trifluoromethane                       | $\text{CHF}_3$ ( $\text{C}_{3v}$ )                                                                       | C—F                                       | 1.332 | C—H                     | 1.098        | $\angle\text{FCF}$                                   | 108.8 | MW     |
| Trifluoromethanesulfonyl fluoride      | $\text{CF}_3\text{SO}_2\text{F}_a$                                                                       | C—S                                       | 1.835 | C—F (av.)               | 1.325        | S—O                                                  | 1.410 | ED     |
|                                        |                                                                                                          | S—F <sub>a</sub>                          | 1.543 | $\angle\text{CSF}_a$    | 95.4         | $\angle\text{CSO}$                                   | 108.5 |        |
|                                        |                                                                                                          | $\angle\text{OSO}$                        | 124.1 | $\angle\text{FCF}$      | 109.8        |                                                      |       |        |
| Trifluoromethylimino-sulfur difluoride | $\text{CF}_3\text{N}=\text{SF}_2$                                                                        | C—N                                       | 1.409 | S—N                     | 1.477        | S—F                                                  | 1.594 | ED, MW |
|                                        |                                                                                                          | C—F                                       | 1.331 | $\angle\text{CNS}$      | 127.2        | $\angle\text{NSF}$                                   | 112.7 |        |
|                                        |                                                                                                          | $\angle\text{FSF}$                        | 92.8  | $\angle\text{FCF}$      | 108.1        |                                                      |       |        |
| Trifluoromethyl peroxide               | $\text{CF}_3\text{OOCF}_3$                                                                               | O—O                                       | 1.42  | C—O                     | 1.399        | C—F                                                  | 1.320 | ED     |
|                                        |                                                                                                          | $\angle\text{COO}$                        | 107   | $\angle\text{FCF}$      | 109.0        | COOC<br>dihedral<br>angle of<br>internal<br>rotation | 123   |        |
|                                        |                                                                                                          | $\angle\text{CCF}$                        | 119.2 | $\angle\text{CCH}$      | 112          |                                                      |       |        |
| Trimethyl aluminium                    | $(\text{CH}_3)_3\text{Al}$                                                                               | C—Al                                      | 1.957 | C—H                     | 1.113        |                                                      |       | ED     |
|                                        |                                                                                                          | $\angle\text{CAIC}$                       | 120   | $\angle\text{AlCH}$     | 111.7        |                                                      |       |        |
| Trimethylamine                         | $(\text{CH}_3)_3\text{N}$                                                                                | C—N                                       | 1.458 | C—H                     | 1.100        |                                                      |       | ED     |
|                                        |                                                                                                          | $\angle\text{CNC}$                        | 110.9 | $\angle\text{HCH}$      | 110          |                                                      |       |        |
| Trimethylarsine                        | $(\text{CH}_3)_3\text{As}$                                                                               | C—As                                      | 1.979 | $\angle\text{CAsC}$     | 98.8         | $\angle\text{AsCH}$                                  | 111.4 | ED     |
| Trimethyl bismuth                      | $(\text{CH}_3)_3\text{Bi}$                                                                               | C—Bi                                      | 2.263 | C—H                     | 1.07         | $\angle\text{CBiC}$                                  | 97.1  | ED     |
| Trimethylborane                        | $(\text{CH}_3)_3\text{B}$                                                                                | C—B                                       | 1.578 | C—H                     | 1.114        |                                                      |       | ED     |
|                                        |                                                                                                          | $\angle\text{CBC}$                        | 120   | $\angle\text{BCH}$      | 112.5        |                                                      |       |        |
| Trimethylphosphine                     | $(\text{CH}_3)_3\text{P}$                                                                                | C—P                                       | 1.847 | C—H                     | 1.091        |                                                      |       | ED     |
|                                        |                                                                                                          | $\angle\text{CPC}$                        | 98.6  | $\angle\text{PCH}$      | 110.7        |                                                      |       |        |
| 1,3,5-Trioxane                         |                       | C—O                                       | 1.422 | $\angle\text{OCO}$      | 112.2        | $\angle\text{COC}$                                   | 110.3 | MW     |

| Compound          | Structure                                                                         | Bond distances in Å and angles in degrees |        |                   |        |                   |        | Method |
|-------------------|-----------------------------------------------------------------------------------|-------------------------------------------|--------|-------------------|--------|-------------------|--------|--------|
| Triphenylamine    | (C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub> N (C <sub>3</sub> )                 | C—C                                       | 1.392  | C—N               | 1.42   | ∠CNC              | 116    | ED     |
|                   |                                                                                   | torsional                                 | 47     |                   |        |                   |        |        |
|                   |                                                                                   | dihedral angle                            |        |                   |        |                   |        |        |
|                   |                                                                                   | of phenyl rings                           |        |                   |        |                   |        |        |
| Tungsten carbide  | WC                                                                                | W—C                                       | 1.7135 |                   |        |                   |        | UV     |
| Tungsten carbonyl | W(CO) <sub>6</sub> (O <sub>h</sub> )                                              | W—C                                       | 2.059  | C—O               | 1.149  |                   |        | ED     |
| Vanadium carbonyl | V(CO) <sub>6</sub> (O <sub>h</sub> , involving<br>dynamic Jahn-Teller effect)     | V—C                                       | 2.015  | C—O               | 1.138  |                   |        | ED     |
| Vinyl bromide     | See Vinyl chloride                                                                | C—C                                       | 1.3256 | C—Br              | 1.8835 | C—H <sub>a</sub>  | 1.0780 | MW     |
|                   |                                                                                   | C—H <sub>b</sub>                          | 1.0804 | C—H <sub>c</sub>  | 1.0794 | ∠CCBr             | 122.62 |        |
|                   |                                                                                   | ∠CCH <sub>a</sub>                         | 124.34 | ∠CCH <sub>b</sub> | 119.28 | ∠CCH <sub>c</sub> | 122.03 |        |
| Vinyl chloride    |  | C—C                                       | 1.3262 | C—Cl              | 1.7263 | C—H <sub>a</sub>  | 1.0783 | MW     |
|                   |                                                                                   | C—H <sub>b</sub>                          | 1.0796 | C—H <sub>c</sub>  | 1.0796 | ∠CCCl             | 122.75 |        |
|                   |                                                                                   | ∠CCH <sub>a</sub>                         | 123.91 | ∠CCH <sub>b</sub> | 119.28 | ∠CCH <sub>c</sub> | 121.77 |        |
| Vinyl fluoride    | See Vinyl chloride                                                                | C—C                                       | 1.3210 | C—F               | 1.3428 | C—H <sub>a</sub>  | 1.0796 | MW     |
|                   |                                                                                   | C—H <sub>b</sub>                          | 1.0774 | C—H <sub>c</sub>  | 1.0789 | ∠CCF              | 121.70 |        |
|                   |                                                                                   | ∠CCH <sub>a</sub>                         | 125.95 | ∠CCH <sub>b</sub> | 118.97 | ∠CCH <sub>c</sub> | 121.34 |        |
| Vinyl iodide      | See Vinyl chloride                                                                | C—C                                       | 1.3276 | C—I               | 2.0830 | C—H <sub>a</sub>  | 1.0787 | MW     |
|                   |                                                                                   | C—H <sub>b</sub>                          | 1.0823 | C—H <sub>c</sub>  | 1.0799 | ∠CCI              | 122.97 |        |
|                   |                                                                                   | ∠CCH <sub>a</sub>                         | 123.54 | ∠CCH <sub>b</sub> | 119.36 | ∠CCH <sub>c</sub> | 122.30 |        |
| Zinc cyanide      | ZnC≡N (linear)                                                                    | Zn—C                                      | 1.955  | C—N               | 1.146  |                   |        | MW     |

## DIPOLE MOMENTS

This table gives selected values of the electric dipole moment for over 800 molecules. When available, values determined by microwave spectroscopy, molecular beam electric resonance, and other high-resolution spectroscopic techniques were selected. Otherwise, the values come from measurements of the dielectric constant in the gas phase or, if these do not exist, in the liquid phase. Entries are listed alphabetically; compounds not containing carbon are listed first, followed by compounds containing carbon.

The dipole moment is given in debye units (D). The conversion factor to SI units is  $1 \text{ D} = 3.33564 \times 10^{-30} \text{ C m}$ .

Dipole moments of individual conformers (rotational isomers) are given when they have been measured. The conformers are designated as *gauche*, *trans*, *axial*, etc. The meaning of these terms can be found in the references. In some cases an average value, obtained from measurements on the bulk gas, is also given. Other information on molecules that have been studied by spectroscopy, such as the components of the dipole moment in the molecular framework and the variation with vibrational state and isotopic species, is given in the references.

When the accuracy of a value is explicitly stated (i.e.,  $1.234 \pm 0.005$ ), the stated uncertainty generally indicates two or three standard deviations. When no uncertainty is given, the value may be assumed to be precise to a few units in the last decimal place. However, if more than three decimal places are given, the exact interpretation of the final digits may require analysis of the vibrational averaging.

Values measured in the gas phase that are questionable because of undetermined error sources are indicated as approximate ( $\approx$ ). Values obtained by liquid phase measurements, which sometimes have large errors because of association effects, are enclosed in brackets, e.g., [1.8].

## References

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| Name                                   | Mol. Form.                        | $\mu/D$         | Ref. | Name                                        | Mol. Form.                    | $\mu/D$         | Ref. |
|----------------------------------------|-----------------------------------|-----------------|------|---------------------------------------------|-------------------------------|-----------------|------|
| <b>Compounds not containing carbon</b> |                                   |                 |      | Hydrazine                                   | H <sub>4</sub> N <sub>2</sub> | 1.75 ± 0.09     | 1    |
| Aluminum monofluoride                  | AlF                               | 1.53 ± 0.15     | 1    | Hydrazoic acid                              | HN <sub>3</sub>               | 1.70 ± 0.09     | 3    |
| Ammonia                                | H <sub>3</sub> N                  | 1.4718 ± 0.0002 | 5    | Hydrogen bromide                            | BrH                           | 0.8272 ± 0.0003 | 3    |
| Arsenic(III) chloride                  | AsCl <sub>3</sub>                 | 1.59 ± 0.08     | 1    | Hydrogen chloride                           | ClH                           | 1.1086 ± 0.0003 | 3    |
| Arsenic(III) fluoride                  | AsF <sub>3</sub>                  | 2.59 ± 0.05     | 1    | Hydrogen fluoride                           | FH                            | 1.826178        | 2    |
| Arsine                                 | AsH <sub>3</sub>                  | 0.217 ± 0.003   | 5    | Hydrogen iodide                             | HI                            | 0.448 ± 0.001   | 2    |
| Barium oxide                           | BaO                               | 7.954 ± 0.003   | 5    | Hydrogen peroxide                           | H <sub>2</sub> O <sub>2</sub> | 1.573 ± 0.001   | 65   |
| Barium sulfide                         | BaS                               | 10.86 ± 0.02    | 3    | Hydrogen sulfide                            | H <sub>2</sub> S              | 0.97833         | 5    |
| Bromine chloride                       | BrCl                              | 0.519 ± 0.004   | 3    | Hydroxyl                                    | HO                            | 1.655 ± 0.001   | 5    |
| Bromine dioxide                        | BrO <sub>2</sub>                  | 2.8 ± 0.1       | 18   | Hydroxylamine                               | H <sub>3</sub> NO             | 0.59 ± 0.05     | 2    |
| Bromine fluoride                       | BrF                               | 1.422 ± 0.016   | 3    | Hypochlorous acid                           | ClHO                          | ≈1.3            | 2    |
| Bromine oxide                          | BrO                               | 1.76 ± 0.04     | 2    | Hypofluorous acid                           | FHO                           | 2.23 ± 0.11     | 3    |
| Bromine pentafluoride                  | BrF <sub>5</sub>                  | 1.51 ± 0.15     | 1    | Imidogen                                    | HN                            | 1.39 ± 0.07     | 3    |
| Bromosilane                            | BrH <sub>3</sub> Si               | 1.319           | 3    | Indium(I) chloride                          | ClIn                          | 3.79 ± 0.19     | 2    |
| Bromotrifluorosilane                   | BrF <sub>3</sub> Si               | 0.835 ± 0.007   | 64   | Indium(I) fluoride                          | FIn                           | 3.40 ± 0.07     | 2    |
| Calcium monochloride                   | CaCl                              | ≈3.6            | 4    | Iodine bromide                              | BrI                           | 0.726 ± 0.003   | 5    |
| Cesium chloride                        | ClCs                              | 10.387 ± 0.004  | 2    | Iodine chloride                             | ClI                           | 1.24 ± 0.02     | 2    |
| Cesium fluoride                        | CsF                               | 7.884 ± 0.001   | 2    | Iodine fluoride                             | FI                            | 1.948 ± 0.020   | 3    |
| Cesium sodium                          | CsNa                              | 4.75 ± 0.20     | 2    | Iodine monoxide                             | IO                            | 2.45 ± 0.05     | 2    |
| Chlorine fluoride                      | ClF                               | 0.888061        | 5    | Iodine pentafluoride                        | F <sub>5</sub> I              | 2.18 ± 0.11     | 1    |
| Chlorine oxide                         | ClO                               | 1.297 ± 0.001   | 5    | Lanthanum monoxide                          | LaO                           | 3.207 ± 0.011   | 26   |
| Chlorine trifluoride                   | ClF <sub>3</sub>                  | 0.6 ± 0.1       | 1    | Lead(II) oxide                              | OPb                           | 4.64 ± 0.50     | 2    |
| Chloroborane                           | BClH <sub>2</sub>                 | 0.75 ± 0.05     | 14   | Lead(II) sulfide                            | PbS                           | 3.59 ± 0.18     | 2    |
| Chlorogermane                          | ClGeH <sub>3</sub>                | 2.13 ± 0.02     | 1    | Lithium bromide                             | BrLi                          | 7.268 ± 0.001   | 2    |
| Chlorosilane                           | ClH <sub>3</sub> Si               | 1.31 ± 0.01     | 1    | Lithium chloride                            | CLi                           | 7.12887         | 2    |
| Chlorosyl fluoride                     | ClFO                              | 1.93 ± 0.02     | 55   | Lithium fluoride                            | FLi                           | 6.3274 ± 0.0002 | 3    |
| Chlorotrifluorosilane                  | ClF <sub>3</sub> Si               | 0.636 ± 0.004   | 5    | Lithium fluoride–sodium<br>fluoride complex | FLi•FNa                       | 2.62 ± 0.02     | 51   |
| Chromium monoxide                      | CrO                               | 3.88 ± 0.13     | 5    | Lithium hydride                             | HLi                           | 5.884 ± 0.001   | 2    |
| Copper(I) fluoride                     | CuF                               | 5.77 ± 0.29     | 2    | Lithium hydroxide                           | HLiO                          | 4.754 ± 0.002   | 3    |
| Copper(II) oxide                       | CuO                               | 4.5 ± 0.5       | 5    | Lithium iodide                              | ILi                           | 7.428 ± 0.001   | 2    |
| Dichlorosilane                         | Cl <sub>2</sub> H <sub>2</sub> Si | 1.17 ± 0.02     | 1    | Lithium monoxide                            | LiO                           | 6.84 ± 0.03     | 2    |
| Difluoramine                           | F <sub>2</sub> HN                 | 1.92 ± 0.02     | 1    | Lithium potassium                           | KLi                           | 3.45 ± 0.20     | 2    |
| Difluorine dioxide                     | F <sub>2</sub> O <sub>2</sub>     | 1.44 ± 0.07     | 1    | Lithium rubidium                            | LiRb                          | 4.0 ± 0.1       | 2    |
| Difluoroborane                         | BF <sub>2</sub> H                 | 0.971 ± 0.010   | 8    | Lithium sodium                              | LiNa                          | 0.463 ± 0.002   | 2    |
| cis-Difluorodiazine                    | F <sub>2</sub> N <sub>2</sub>     | 0.16 ± 0.01     | 1    | Magnesium oxide                             | MgO                           | 6.2 ± 0.6       | 5    |
| Difluorosilane                         | F <sub>2</sub> H <sub>2</sub> Si  | 1.55 ± 0.02     | 1    | Mercapto                                    | HS                            | 0.7580 ± 0.0001 | 3    |
| Difluorosilylene                       | F <sub>2</sub> Si                 | 1.23 ± 0.02     | 2    | Nitric acid                                 | HNO <sub>3</sub>              | 2.17 ± 0.02     | 1    |
| Disiloxane                             | H <sub>6</sub> OSi <sub>2</sub>   | 0.24 ± 0.02     | 1    | Nitric oxide                                | NO                            | 0.15872         | 2    |
| Fluoramine                             | FH <sub>2</sub> N                 | 2.27 ± 0.18     | 5    | Nitrogen dioxide                            | NO <sub>2</sub>               | 0.316 ± 0.010   | 1    |
| Fluorine azide                         | FN <sub>3</sub>                   | ≈1.3            | 5    | Nitrogen sulfide                            | NS                            | 1.81 ± 0.02     | 2    |
| Fluorine monoxide                      | F <sub>2</sub> O                  | 0.308180        | 5    | Nitrogen trichloride                        | Cl <sub>3</sub> N             | 0.39 ± 0.01     | 3    |
| Fluorine oxide                         | FO                                | 0.0043 ± 0.0004 | 5    | Nitrogen trifluoride                        | F <sub>3</sub> N              | 0.235 ± 0.004   | 1    |
| Fluoroborane                           | BF                                | ≈0.5            | 2    | Nitrogen trioxide                           | N <sub>2</sub> O <sub>3</sub> | 2.122 ± 0.010   | 2    |
| Fluorogermane                          | FGeH <sub>3</sub>                 | 2.33 ± 0.12     | 2    | Nitrosyl bromide                            | BrNO                          | ≈1.8            | 1    |
| Fluorosilane                           | FH <sub>3</sub> Si                | 1.2969 ± 0.0006 | 5    | Nitrosyl fluoride                           | FNO                           | 1.730 ± 0.003   | 3    |
| Gallium monofluoride                   | FGa                               | 2.45 ± 0.05     | 2    | Nitrosyl hydride                            | HNO                           | 1.62 ± 0.03     | 3    |
| Germanium(II) fluoride                 | F <sub>2</sub> Ge                 | 2.61 ± 0.02     | 2    | Nitrous acid (cis)                          | HNO <sub>2</sub>              | 1.423 ± 0.005   | 2    |
| Germanium(II) oxide                    | GeO                               | 3.2823 ± 0.0001 | 2    | Nitrous acid (trans)                        | HNO <sub>2</sub>              | 1.855 ± 0.016   | 2    |
| Germanium(II) selenide                 | GeSe                              | 1.65 ± 0.05     | 2    | Nitrous oxide                               | N <sub>2</sub> O              | 0.16083         | 3    |
| Germanium(II) sulfide                  | GeS                               | 2.00 ± 0.06     | 2    | Nitryl chloride                             | ClNO <sub>2</sub>             | 0.53            | 1    |
| Germanium(II) telluride                | GeTe                              | 1.06 ± 0.07     | 2    | Nitryl fluoride                             | FNO <sub>2</sub>              | 0.466 ± 0.005   | 2    |
| Germylazide                            | GeH <sub>3</sub> N <sub>3</sub>   | 2.58 ± 0.02     | 25   | Ozone                                       | O <sub>3</sub>                | 0.53373         | 3    |
| Hafnium monoxide                       | HfO                               | 3.431 ± 0.005   | 26   | Pentaborane(9)                              | B <sub>5</sub> H <sub>9</sub> | 2.13 ± 0.04     | 1    |
| Hafnium(IV) oxide                      | HfO <sub>2</sub>                  | 7.92 ± 0.01     | 39   | Perchloryl fluoride                         | ClFO <sub>3</sub>             | 0.023 ± 0.001   | 3    |
| Hexaborane(10)                         | B <sub>6</sub> H <sub>10</sub>    | 2.50 ± 0.05     | 3    | Peroxynitrous acid                          | HNO <sub>3</sub>              | 1.07 ± 0.002    | 46   |

| Name                                   | Mol. Form.                         | $\mu/D$         | Ref. | Name                                       | Mol. Form.                                                                  | $\mu/D$         | Ref. |
|----------------------------------------|------------------------------------|-----------------|------|--------------------------------------------|-----------------------------------------------------------------------------|-----------------|------|
| Peroxyntoric acid                      | HNO <sub>4</sub>                   | 1.99 ± 0.02     | 67   | Tin(II) oxide                              | OSn                                                                         | 4.32 ± 0.22     | 2    |
| Phosphine                              | H <sub>3</sub> P                   | 0.5740 ± 0.0003 | 3    | Tin(II) sulfide                            | SSn                                                                         | 3.18 ± 0.16     | 2    |
| Phosphorothioc trifluoride             | F <sub>3</sub> PS                  | 0.64 ± 0.02     | 1    | Titanium(II) oxide                         | OTi                                                                         | 2.96 ± 0.05     | 5    |
| Phosphorus(III) chloride               | Cl <sub>3</sub> P                  | 0.56 ± 0.02     | 2    | Trichlorofluorosilane                      | Cl <sub>3</sub> FSi                                                         | 0.49 ± 0.01     | 2    |
| Phosphorus(III) fluoride               | F <sub>3</sub> P                   | 1.03 ± 0.01     | 1    | Trichlorosilane                            | Cl <sub>3</sub> HSi                                                         | 0.86 ± 0.01     | 2    |
| Phosphorus monoxide                    | OP                                 | 1.88 ± 0.07     | 5    | Trifluoramine oxide                        | F <sub>3</sub> NO                                                           | 0.0390 ± 0.0004 | 9    |
| Phosphorus nitride                     | NP                                 | 2.7470 ± 0.0001 | 2    | 1,1,1-Trifluorodisilane                    | F <sub>3</sub> H <sub>3</sub> Si <sub>2</sub>                               | 2.03 ± 0.10     | 3    |
| Phosphoryl chloride                    | Cl <sub>3</sub> OP                 | 2.54 ± 0.05     | 2    | Trifluoriodosilane                         | F <sub>3</sub> ISi                                                          | 1.11 ± 0.03     | 5    |
| Phosphoryl fluoride                    | F <sub>3</sub> OP                  | 1.8685 ± 0.0001 | 3    | Trifluorosilane                            | F <sub>3</sub> HSi                                                          | 1.27 ± 0.03     | 1    |
| Potassium bromide                      | BrK                                | 10.628 ± 0.001  | 2    | Water                                      | H <sub>2</sub> O                                                            | 1.8546 ± 0.0040 | 3    |
| Potassium chloride                     | ClK                                | 10.269 ± 0.001  | 2    | Water dimer–hydrogen bromide complex       | H <sub>4</sub> O <sub>2</sub> •BrH                                          | 2.281 ± 0.003   | 48   |
| Potassium fluoride                     | FK                                 | 8.585 ± 0.003   | 2    | Water dimer–hydrogen chloride complex      | H <sub>4</sub> O <sub>2</sub> •ClH                                          | 2.328 ± 0.003   | 48   |
| Potassium hydroxide                    | HKO                                | 7.415 ± 0.002   | 16   | Ytterbium monofluoride                     | FYb                                                                         | 3.91 ± 0.04     | 45   |
| Potassium iodide                       | IK                                 | ≈10.8           | 2    | Yttrium monoxide                           | OY                                                                          | 4.524 ± 0.007   | 26   |
| Potassium sodium                       | KNa                                | 2.693 ± 0.014   | 3    | Zirconium(II) oxide                        | OZr                                                                         | 2.55 ± 0.01     | 26   |
| Rubidium bromide                       | BrRb                               | ≈10.9           | 2    | Zirconium(IV) oxide                        | O <sub>2</sub> Zr                                                           | 7.80 ± 0.02     | 19   |
| Rubidium chloride                      | ClRb                               | 10.510 ± 0.005  | 2    | <b>Compounds containing carbon</b>         |                                                                             |                 |      |
| Rubidium fluoride                      | FRb                                | 8.5465 ± 0.0005 | 2    | Acenaphthene                               | C <sub>12</sub> H <sub>10</sub>                                             | ≈0.85           | 1    |
| Rubidium iodide                        | IRb                                | ≈11.5           | 2    | Acetaldehyde                               | C <sub>2</sub> H <sub>4</sub> O                                             | 2.750 ± 0.006   | 3    |
| Rubidium sodium                        | NaRb                               | 3.1 ± 0.3       | 2    | Acetamide                                  | C <sub>2</sub> H <sub>5</sub> NO                                            | 3.68 ± 0.03     | 5    |
| Selenium dioxide                       | O <sub>2</sub> Se                  | 2.62 ± 0.05     | 2    | Acetic acid                                | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                                | 1.70 ± 0.03     | 2    |
| Selenium tetrafluoride                 | F <sub>4</sub> Se                  | 1.78 ± 0.09     | 2    | Acetic anhydride                           | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                                | ≈2.8            | 1    |
| Silicon monosulfide                    | SSi                                | 1.73 ± 0.09     | 2    | Acetone                                    | C <sub>3</sub> H <sub>6</sub> O                                             | 2.88 ± 0.03     | 1    |
| Silicon monoxide                       | OSi                                | 3.0982          | 2    | Acetonitrile                               | C <sub>2</sub> H <sub>3</sub> N                                             | 3.92519         | 5    |
| Silver(I) bromide                      | AgBr                               | 5.62 ± 0.03     | 5    | Acetophenone                               | C <sub>8</sub> H <sub>8</sub> O                                             | 3.02 ± 0.06     | 1    |
| Silver(I) chloride                     | AgCl                               | 6.08 ± 0.06     | 5    | Acetyl chloride                            | C <sub>2</sub> H <sub>3</sub> ClO                                           | 2.72 ± 0.14     | 1    |
| Silver(I) fluoride                     | AgF                                | 6.22 ± 0.30     | 2    | Acetylene–carbon dioxide complex           | C <sub>2</sub> H <sub>2</sub> •CO <sub>2</sub>                              | 0.161 ± 0.001   | 22   |
| Silver(I) iodide                       | AgI                                | 4.55 ± 0.05     | 5    | Acetylene–carbon monoxide complex          | C <sub>2</sub> H <sub>2</sub> •CO                                           | 0.311 ± 0.001   | 32   |
| Sodium bromide                         | BrNa                               | 9.1183 ± 0.0006 | 2    | Acetylene–carbon oxysulfide trimer complex | C <sub>2</sub> H <sub>2</sub> •C <sub>3</sub> O <sub>3</sub> S <sub>3</sub> | 1.23 ± 0.02     | 53   |
| Sodium chloride                        | ClNa                               | 9.00117         | 2    | Acetylene–hydrogen cyanide complex         | C <sub>2</sub> H <sub>2</sub> •CHN                                          | 3.29 ± 0.03     | 32   |
| Sodium fluoride                        | FNa                                | 8.156 ± 0.001   | 2    | Acetyl fluoride                            | C <sub>2</sub> H <sub>3</sub> FO                                            | 2.96 ± 0.03     | 1    |
| Sodium iodide                          | INa                                | 9.236 ± 0.003   | 2    | Acrolein ( <i>cis</i> )                    | C <sub>3</sub> H <sub>4</sub> O                                             | 2.552 ± 0.003   | 5    |
| Stibine                                | H <sub>3</sub> Sb                  | 0.12 ± 0.05     | 1    | Acrolein ( <i>trans</i> )                  | C <sub>3</sub> H <sub>4</sub> O                                             | 3.117 ± 0.004   | 5    |
| Strontium oxide                        | OSr                                | 8.900 ± 0.003   | 2    | Acrylonitrile                              | C <sub>3</sub> H <sub>3</sub> N                                             | 3.92 ± 0.07     | 5    |
| Sulfur dichloride                      | Cl <sub>2</sub> S                  | 0.36 ± 0.01     | 3    | Allyl alcohol ( <i>gauche</i> )            | C <sub>3</sub> H <sub>6</sub> O                                             | 1.55 ± 0.08     | 3    |
| Sulfur difluoride                      | F <sub>2</sub> S                   | 1.05 ± 0.05     | 2    | Allyl alcohol ( <i>average</i> )           | C <sub>3</sub> H <sub>6</sub> O                                             | 1.60 ± 0.08     | 1    |
| Sulfur dioxide                         | O <sub>2</sub> S                   | 1.63305         | 3    | Allylamine                                 | C <sub>3</sub> H <sub>7</sub> N                                             | ≈1.2            | 1    |
| Sulfur monofluoride                    | FS                                 | 0.794 ± 0.02    | 3    | Aniline                                    | C <sub>6</sub> H <sub>7</sub> N                                             | 1.13 ± 0.02     | 3    |
| Sulfur monoxide                        | OS                                 | 1.55 ± 0.02     | 1    | Anisole                                    | C <sub>7</sub> H <sub>8</sub> O                                             | 1.38 ± 0.07     | 1    |
| Sulfur oxide (SSO)                     | OS <sub>2</sub>                    | 1.47 ± 0.03     | 1    | Azulene                                    | C <sub>10</sub> H <sub>8</sub>                                              | 0.80 ± 0.02     | 1    |
| Sulfur tetrafluoride                   | F <sub>4</sub> S                   | 0.632 ± 0.003   | 1    | Benzaldehyde                               | C <sub>7</sub> H <sub>6</sub> O                                             | [3.0]           | 7    |
| Sulfuryl chloride                      | Cl <sub>2</sub> O <sub>2</sub> S   | 1.81 ± 0.04     | 1    | Benzeneacetoneitrile                       | C <sub>8</sub> H <sub>7</sub> N                                             | [3.5]           | 7    |
| Sulfuryl fluoride                      | F <sub>2</sub> O <sub>2</sub> S    | 1.12 ± 0.02     | 1    | Benzene–hydrogen sulfide complex           | C <sub>6</sub> H <sub>6</sub> •H <sub>2</sub> S                             | 1.14 ± 0.02     | 40   |
| Tetraborane(10)                        | B <sub>4</sub> H <sub>10</sub>     | 0.486 ± 0.002   | 3    | Benzene–krypton complex                    | C <sub>6</sub> H <sub>6</sub> •Kr                                           | 0.136 ± 0.002   | 58   |
| Tetrafluorohydrazine ( <i>gauche</i> ) | F <sub>4</sub> N <sub>2</sub>      | 0.257 ± 0.002   | 5    | Benzene–sulfur dioxide complex             | C <sub>6</sub> H <sub>6</sub> •O <sub>2</sub> S                             | 2.061 ± 0.002   | 33   |
| Tetrafluorosilane–ammonia complex      | F <sub>4</sub> Si•H <sub>3</sub> N | 5.61 ± 0.02     | 31   | Benzenethiol                               | C <sub>6</sub> H <sub>6</sub> S                                             | [1.23]          | 7    |
| Thallium(I) bromide                    | BrTl                               | 4.49 ± 0.05     | 2    | Benzonitrile                               | C <sub>7</sub> H <sub>5</sub> N                                             | 4.18 ± 0.08     | 1    |
| Thallium(I) chloride                   | ClTl                               | 4.54299         | 2    | Benzyl acetate                             | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                               | [1.22]          | 7    |
| Thallium(I) fluoride                   | FTl                                | 4.2282 ± 0.0008 | 2    | Benzyl alcohol                             | C <sub>7</sub> H <sub>8</sub> O                                             | 1.71 ± 0.09     | 1    |
| Thallium(I) iodide                     | ITl                                | 4.61 ± 0.07     | 2    |                                            |                                                                             |                 |      |
| Thionitrosyl chloride (NSCl)           | ClNS                               | 1.87 ± 0.02     | 2    |                                            |                                                                             |                 |      |
| Thionitrosyl fluoride (NSF)            | FNS                                | 1.902 ± 0.012   | 2    |                                            |                                                                             |                 |      |
| Thionyl chloride                       | Cl <sub>2</sub> OS                 | 1.45 ± 0.03     | 1    |                                            |                                                                             |                 |      |
| Thionyl fluoride                       | F <sub>2</sub> OS                  | 1.63 ± 0.01     | 1    |                                            |                                                                             |                 |      |

| Name                            | Mol. Form.        | $\mu/D$             | Ref. | Name                                           | Mol. Form.          | $\mu/D$             | Ref. |
|---------------------------------|-------------------|---------------------|------|------------------------------------------------|---------------------|---------------------|------|
| Benzyl benzoate                 | $C_{14}H_{12}O_2$ | [2.06]              | 7    | Butyl vinyl ether                              | $C_6H_{12}O$        | [1.25]              | 7    |
| Bis(2-aminoethyl)amine          | $C_4H_{13}N_3$    | [1.89]              | 7    | 1-Butyne                                       | $C_4H_6$            | $0.782 \pm 0.004$   | 5    |
| Bis(2-chloroethyl) ether        | $C_4H_8Cl_2O$     | [2.58]              | 7    | $\gamma$ -Butyrolactone                        | $C_4H_6O_2$         | $4.27 \pm 0.03$     | 3    |
| Bis(2-ethylhexyl) phthalate     | $C_{24}H_{38}O_4$ | [2.84]              | 7    | Calcium methoxide                              | $CH_3CaO$           | $1.58 \pm 0.08$     | 43   |
| Borane carbonyl                 | $CH_3BO$          | $1.698 \pm 0.020$   | 3    | Camphor, (+)                                   | $C_{10}H_{16}O$     | [3.1]               | 7    |
| Bromoacetylene                  | $C_2HBr$          | 0.22962             | 5    | Caprolactam                                    | $C_6H_{11}NO$       | [3.9]               | 7    |
| Bromobenzene                    | $C_6H_5Br$        | $1.70 \pm 0.03$     | 1    | Carboimidic difluoride                         | $CHF_2N$            | $1.393 \pm 0.001$   | 5    |
| 1-Bromobutane                   | $C_4H_9Br$        | $2.08 \pm 0.10$     | 1    | Carbon dioxide dimer–water complex             | $C_2O_4 \cdot H_2O$ | $1.989 \pm 0.002$   | 23   |
| 2-Bromobutane                   | $C_4H_9Br$        | $2.23 \pm 0.11$     | 1    | Carbon dioxide–mercury complex                 | $CO_2 \cdot Hg$     | $0.107 \pm 0.003$   | 29   |
| 1-Bromo-2-chloroethane          | $C_2H_4BrCl$      | [1.2]               | 7    | Carbon dioxide–water dimer complex             | $CO_2 \cdot H_4O_2$ | $1.746 \pm 0.010$   | 28   |
| Bromochlorofluoromethane        | $CHBrClF$         | $1.5 \pm 0.3$       | 17   | Carbon disulfide–sulfur dioxide complex        | $CO_2 \cdot O_2S$   | $1.096 \pm 0.001$   | 42   |
| Bromochloromethane              | $CH_2BrCl$        | [1.66]              | 7    | Carbon monoselenide                            | $CSe$               | $1.99 \pm 0.04$     | 3    |
| 1-Bromodecane                   | $C_{10}H_{21}Br$  | [1.93]              | 7    | Carbon monosulfide                             | $CS$                | $1.958 \pm 0.005$   | 2    |
| Bromoethane                     | $C_2H_5Br$        | $2.04 \pm 0.02$     | 5    | Carbon monoxide                                | $CO$                | 0.10980             | 3    |
| Bromoethene                     | $C_2H_3Br$        | $1.42 \pm 0.03$     | 1    | Carbon monoxide dimer–water complex            | $C_2O_2 \cdot H_2O$ | $1.57 \pm 0.05$     | 36   |
| Bromofluoroacetylene            | $C_2BrF$          | $0.448 \pm 0.002$   | 5    | Carbon oxyselenide                             | $COSe$              | $0.73 \pm 0.02$     | 1    |
| 1-Bromoheptane                  | $C_7H_{15}Br$     | $2.16 \pm 0.11$     | 1    | Carbon oxysulfide                              | $COS$               | 0.715189            | 5    |
| Bromomethane                    | $CH_3Br$          | $1.8203 \pm 0.0004$ | 5    | Carbon oxysulfide–carbon dioxide dimer complex | $COS \cdot C_2O_4$  | $0.69 \pm 0.05$     | 44   |
| 2-Bromo-2-methylpropane         | $C_4H_9Br$        | [2.17]              | 7    | Carbon oxysulfide–water complex                | $COS \cdot H_2O$    | $2.668 \pm 0.003$   | 37   |
| 1-Bromonaphthalene              | $C_{10}H_7Br$     | [1.55]              | 7    | Carbonyl chloride                              | $CCl_2O$            | $1.17 \pm 0.01$     | 1    |
| 1-Bromopentane                  | $C_5H_{11}Br$     | $2.20 \pm 0.11$     | 1    | Carbonyl fluoride                              | $CF_2O$             | $0.95 \pm 0.01$     | 1    |
| 1-Bromopropane                  | $C_3H_7Br$        | $2.18 \pm 0.11$     | 1    | Chloroacetyl chloride                          | $C_2H_2Cl_2O$       | $2.23 \pm 0.11$     | 1    |
| 2-Bromopropane                  | $C_3H_7Br$        | $2.21 \pm 0.11$     | 1    | Chloroacetylene                                | $C_2HCl$            | 0.44408             | 5    |
| 2-Bromopropene                  | $C_3H_5Br$        | [1.51]              | 7    | 2-Chloroaniline                                | $C_6H_6ClN$         | [1.77]              | 7    |
| 3-Bromopropene                  | $C_3H_5Br$        | $\approx 1.9$       | 1    | Chlorobenzene                                  | $C_6H_5Cl$          | $1.69 \pm 0.03$     | 1    |
| Bromotrifluoromethane           | $CBrF_3$          | $0.65 \pm 0.05$     | 1    | 1-Chlorobutane                                 | $C_4H_9Cl$          | $2.05 \pm 0.04$     | 1    |
| 1,2-Butadiene                   | $C_4H_6$          | $0.403 \pm 0.002$   | 1    | 2-Chlorobutane                                 | $C_4H_9Cl$          | $2.04 \pm 0.10$     | 1    |
| Butanal                         | $C_4H_8O$         | $2.72 \pm 0.05$     | 1    | Chlorocyclohexane ( <i>axial</i> )             | $C_6H_{11}Cl$       | $1.91 \pm 0.02$     | 5    |
| 1,4-Butanediol                  | $C_4H_{10}O_2$    | [2.58]              | 7    | Chlorocyclohexane ( <i>equatorial</i> )        | $C_6H_{11}Cl$       | $2.44 \pm 0.07$     | 5    |
| Butanenitrile ( <i>gauche</i> ) | $C_4H_7N$         | $3.91 \pm 0.04$     | 5    | 1-Chloro-1,1-difluoroethane                    | $C_2H_3ClF_2$       | $2.14 \pm 0.04$     | 1    |
| Butanenitrile ( <i>anti</i> )   | $C_4H_7N$         | $3.73 \pm 0.06$     | 5    | Chlorodifluoromethane                          | $CHClF_2$           | $1.42 \pm 0.03$     | 1    |
| 1-Butanethiol                   | $C_4H_{10}S$      | [1.53]              | 7    | Chloroethane                                   | $C_2H_5Cl$          | $2.05 \pm 0.02$     | 1    |
| Butanoic acid                   | $C_4H_8O_2$       | [1.65]              | 7    | 2-Chloroethanol                                | $C_2H_5ClO$         | $1.78 \pm 0.09$     | 1    |
| 1-Butanol                       | $C_4H_{10}O$      | $1.66 \pm 0.03$     | 1    | Chloroethene                                   | $C_2H_3Cl$          | $1.45 \pm 0.03$     | 1    |
| 2-Butanone                      | $C_4H_8O$         | $2.779 \pm 0.015$   | 2    | 1-Chloro-4-fluorobenzene                       | $C_6H_4ClF$         | $0.12 \pm 0.01$     | 66   |
| <i>trans</i> -2-Butenal         | $C_4H_6O$         | $3.67 \pm 0.07$     | 1    | 1-Chloro-1-fluoroethane                        | $C_2H_4ClF$         | $2.068 \pm 0.014$   | 3    |
| 1-Butene ( <i>cis</i> )         | $C_4H_8$          | $0.438 \pm 0.007$   | 2    | Chlorofluoromethane                            | $CH_2ClF$           | $1.82 \pm 0.04$     | 1    |
| 1-Butene ( <i>skew</i> )        | $C_4H_8$          | $0.359 \pm 0.011$   | 2    | Chloromethane                                  | $CH_3Cl$            | $1.8963 \pm 0.0002$ | 5    |
| <i>cis</i> -2-Butene            | $C_4H_8$          | $0.253 \pm 0.005$   | 2    | (Chloromethyl)benzene                          | $C_7H_7Cl$          | [1.82]              | 7    |
| <i>cis</i> -2-Butene-1,4-diol   | $C_4H_8O_2$       | [2.48]              | 7    | 1-Chloro-3-methylbutane                        | $C_5H_{11}Cl$       | [1.92]              | 7    |
| <i>trans</i> -2-Butene-1,4-diol | $C_4H_8O_2$       | [2.45]              | 7    | 1-Chloro-2-methylpropane                       | $C_4H_9Cl$          | $2.00 \pm 0.10$     | 1    |
| <i>trans</i> -2-Butenoic acid   | $C_4H_6O_2$       | [2.13]              | 7    | 2-Chloro-2-methylpropane                       | $C_4H_9Cl$          | $2.13 \pm 0.04$     | 1    |
| <i>cis</i> -2-Buten-1-ol        | $C_4H_8O$         | $1.96 \pm 0.03$     | 5    | 1-Chloronaphthalene                            | $C_{10}H_7Cl$       | [1.57]              | 7    |
| <i>trans</i> -2-Buten-1-ol      | $C_4H_8O$         | $1.90 \pm 0.02$     | 5    | 1-Chloro-2-nitrobenzene                        | $C_6H_4ClNO_2$      | $4.64 \pm 0.09$     | 1    |
| 1-Buten-3-yne                   | $C_4H_4$          | $0.22 \pm 0.02$     | 3    | 1-Chloro-3-nitrobenzene                        | $C_6H_4ClNO_2$      | $3.73 \pm 0.07$     | 1    |
| 2-Butoxyethanol                 | $C_6H_{14}O_2$    | [2.08]              | 7    | 1-Chloro-4-nitrobenzene                        | $C_6H_4ClNO_2$      | $2.83 \pm 0.06$     | 1    |
| Butyl acetate                   | $C_6H_{12}O_2$    | [1.87]              | 7    | 1-Chlorooctane                                 | $C_8H_{17}Cl$       | [2.00]              | 7    |
| <i>sec</i> -Butyl acetate       | $C_6H_{12}O_2$    | [1.87]              | 7    | Chloropentafluoroethane                        | $C_2ClF_5$          | $0.52 \pm 0.05$     | 1    |
| Butylamine                      | $C_4H_{11}N$      | $\approx 1.0$       | 1    | 1-Chloropentane                                | $C_5H_{11}Cl$       | $2.16 \pm 0.11$     | 1    |
| <i>sec</i> -Butylamine          | $C_4H_{11}N$      | [1.28]              | 7    | 4-Chlorophenol                                 | $C_6H_5ClO$         | $2.11 \pm 0.11$     | 1    |
| <i>tert</i> -Butylamine         | $C_4H_{11}N$      | [1.29]              | 7    |                                                |                     |                     |      |
| <i>tert</i> -Butylbenzene       | $C_{10}H_{14}$    | $\approx 0.83$      | 1    |                                                |                     |                     |      |
| Butyl ethyl ether               | $C_6H_{14}O$      | [1.24]              | 7    |                                                |                     |                     |      |
| Butyl formate                   | $C_5H_{10}O_2$    | [2.03]              | 7    |                                                |                     |                     |      |
| Butyl stearate                  | $C_{22}H_{44}O_2$ | [1.88]              | 7    |                                                |                     |                     |      |

| Name                                | Mol. Form.          | $\mu/D$             | Ref. | Name                                      | Mol. Form.      | $\mu/D$             | Ref. |
|-------------------------------------|---------------------|---------------------|------|-------------------------------------------|-----------------|---------------------|------|
| 1-Chloropropane ( <i>gauche</i> )   | $C_3H_7Cl$          | $2.02 \pm 0.03$     | 5    | Dibutyl sulfide                           | $C_8H_{18}S$    | [1.61]              | 7    |
| 1-Chloropropane ( <i>trans</i> )    | $C_3H_7Cl$          | $1.95 \pm 0.02$     | 5    | <i>o</i> -Dichlorobenzene                 | $C_6H_4Cl_2$    | $2.50 \pm 0.05$     | 1    |
| 1-Chloropropane ( <i>average</i> )  | $C_3H_7Cl$          | $2.05 \pm 0.04$     | 1    | <i>m</i> -Dichlorobenzene                 | $C_6H_4Cl_2$    | $1.72 \pm 0.09$     | 1    |
| 2-Chloropropane                     | $C_3H_7Cl$          | $2.17 \pm 0.11$     | 1    | 1,4-Dichlorobutane                        | $C_4H_8Cl_2$    | $2.22 \pm 0.11$     | 1    |
| <i>cis</i> -1-Chloropropene         | $C_3H_5Cl$          | $1.67 \pm 0.08$     | 1    | 1,1-Dichloro-2,2-difluoroethene           | $C_2Cl_2F_2$    | 0.50                | 7    |
| <i>trans</i> -1-Chloropropene       | $C_3H_5Cl$          | $1.97 \pm 0.10$     | 1    | Dichlorodifluoromethane                   | $CCl_2F_2$      | $0.51 \pm 0.05$     | 1    |
| 2-Chloropropene                     | $C_3H_5Cl$          | $1.647 \pm 0.010$   | 3    | 1,1-Dichloroethane                        | $C_2H_4Cl_2$    | $2.06 \pm 0.04$     | 1    |
| 3-Chloropropene                     | $C_3H_5Cl$          | $1.94 \pm 0.10$     | 1    | 1,2-Dichloroethane                        | $C_2H_4Cl_2$    | [1.83]              | 7    |
| 4-Chloropyridine                    | $C_5H_4ClN$         | $0.756 \pm 0.005$   | 3    | 1,1-Dichloroethene                        | $C_2H_2Cl_2$    | $1.34 \pm 0.01$     | 1    |
| 2-Chlorotoluene                     | $C_7H_7Cl$          | $1.56 \pm 0.08$     | 1    | <i>cis</i> -1,2-Dichloroethene            | $C_2H_2Cl_2$    | $1.90 \pm 0.04$     | 1    |
| 3-Chlorotoluene                     | $C_7H_7Cl$          | [1.82]              | 7    | Dichlorofluoromethane                     | $CHCl_2F$       | $1.29 \pm 0.03$     | 1    |
| 4-Chlorotoluene                     | $C_7H_7Cl$          | $2.21 \pm 0.04$     | 1    | 1,1-Dichloro-2-fluoropropene              | $C_3H_3Cl_2F$   | $2.43 \pm 0.02$     | 3    |
| Chlorotrifluoroethene               | $C_2ClF_3$          | $0.40 \pm 0.10$     | 1    | Dichloromethane                           | $CH_2Cl_2$      | $1.60 \pm 0.03$     | 1    |
| Chlorotrifluoromethane              | $CClF_3$            | $0.50 \pm 0.01$     | 1    | (Dichloromethyl)benzene                   | $C_7H_6Cl_2$    | [2.07]              | 7    |
| <i>o</i> -Cresol                    | $C_7H_8O$           | [1.45]              | 7    | Dichloromethylborane                      | $CH_3BCl_2$     | $1.419 \pm 0.013$   | 5    |
| <i>m</i> -Cresol                    | $C_7H_8O$           | [1.48]              | 7    | 1,2-Dichloropropane                       | $C_3H_6Cl_2$    | [1.85]              | 7    |
| <i>p</i> -Cresol                    | $C_7H_8O$           | [1.48]              | 7    | 1,3-Dichloropropane                       | $C_3H_6Cl_2$    | $2.08 \pm 0.04$     | 1    |
| Cyanamide                           | $CH_2N_2$           | $4.28 \pm 0.10$     | 5    | 1,2-Dichloro-1,1,2,2-tetrafluoroethane    | $C_2Cl_2F_4$    | $\approx 0.5$       | 1    |
| Cyanoacetylene                      | $C_3HN$             | 3.73172             | 5    | 2,4-Dichlorotoluene                       | $C_7H_6Cl_2$    | [1.70]              | 7    |
| Cyanoformamide                      | $C_2H_2N_2O$        | $4.10 \pm 0.12$     | 47   | 3,4-Dichlorotoluene                       | $C_7H_6Cl_2$    | [2.95]              | 7    |
| Cyanogen azide (NCN <sub>3</sub> )  | $CN_4$              | $2.96 \pm 0.07$     | 60   | Diethanolamine                            | $C_4H_{11}NO_2$ | [2.8]               | 7    |
| Cyanogen chloride                   | $CClN$              | $2.8331 \pm 0.0002$ | 3    | 1,1-Diethoxyethane                        | $C_6H_{14}O_2$  | [1.38]              | 7    |
| Cyanogen fluoride                   | $CFN$               | $2.120 \pm 0.001$   | 3    | Diethylamine                              | $C_4H_{11}N$    | $0.92 \pm 0.05$     | 1    |
| Cyanogen iodide                     | $CIN$               | $3.67 \pm 0.02$     | 5    | Diethyl carbonate                         | $C_5H_{10}O_3$  | $1.10 \pm 0.06$     | 1    |
| Cyanomethylmercury                  | $C_2H_5HgN$         | $4.7 \pm 0.1$       | 12   | Diethylene glycol                         | $C_4H_{10}O_3$  | [2.31]              | 7    |
| Cyclobutanecarbonitrile             | $C_5H_5N$           | $4.04 \pm 0.04$     | 5    | Diethylene glycol dimethyl ether          | $C_6H_{14}O_3$  | [1.97]              | 7    |
| Cyclobutanone                       | $C_4H_6O$           | $2.89 \pm 0.03$     | 2    | Diethylene glycol monoethyl ether         | $C_6H_{14}O_3$  | [1.6]               | 7    |
| Cyclobutene                         | $C_4H_6$            | $0.132 \pm 0.001$   | 1    | Diethylene glycol monoethyl ether acetate | $C_8H_{16}O_4$  | [1.8]               | 7    |
| 1,3-Cycloheptadiene                 | $C_7H_{10}$         | 0.740               | 3    | Diethylene glycol monomethyl ether        | $C_5H_{12}O_3$  | [1.6]               | 7    |
| 2,4,6-Cycloheptatrien-1-one         | $C_7H_6O$           | $4.1 \pm 0.3$       | 3    | Diethyl ether                             | $C_4H_{10}O$    | $1.098 \pm 0.001$   | 38   |
| 3,5-Cyclohexadiene-1,2-dione        | $C_6H_4O_2$         | $4.23 \pm 0.02$     | 3    | Diethyl malonate                          | $C_7H_{12}O_4$  | [2.54]              | 7    |
| Cyclohexanone                       | $C_6H_{10}O$        | $3.246 \pm 0.006$   | 5    | Diethyl oxalate                           | $C_6H_{10}O_4$  | [2.49]              | 7    |
| Cyclohexene ( <i>half-chair</i> )   | $C_6H_{10}$         | $0.332 \pm 0.012$   | 2    | Diethyl sulfide ( <i>trans-trans</i> )    | $C_4H_{10}S$    | $1.556 \pm 0.004$   | 54   |
| Cyclohexylamine                     | $C_6H_{13}N$        | [1.26]              | 7    | Diethyl sulfide ( <i>trans-gauche</i> )   | $C_4H_{10}S$    | $1.591 \pm 0.009$   | 54   |
| 1,3-Cyclopentadiene                 | $C_5H_6$            | $0.419 \pm 0.004$   | 1    | Diethyl sulfide ( <i>gauche-gauche</i> )  | $C_4H_{10}S$    | $1.645 \pm 0.001$   | 54   |
| 2,4-Cyclopentadien-1-one            | $C_5H_4O$           | $3.132 \pm 0.007$   | 3    | <i>o</i> -Difluorobenzene                 | $C_6H_4F_2$     | $2.46 \pm 0.05$     | 2    |
| Cyclopentanone                      | $C_5H_8O$           | $\approx 3.3$       | 1    | <i>m</i> -Difluorobenzene                 | $C_6H_4F_2$     | $1.51 \pm 0.02$     | 2    |
| Cyclopentene                        | $C_5H_8$            | $0.20 \pm 0.02$     | 1    | 1,1-Difluorocyclohexane                   | $C_6H_{10}F_2$  | $2.556 \pm 0.010$   | 3    |
| 3-Cyclopenten-1-one                 | $C_5H_6O$           | $2.79 \pm 0.03$     | 3    | 3,3-Difluorocyclopropene                  | $C_3H_2F_2$     | $2.98 \pm 0.02$     | 3    |
| Cyclopropane-sulfur dioxide complex | $C_3H_6 \cdot O_2S$ | $1.681 \pm 0.001$   | 30   | 1,1-Difluoroethane                        | $C_2H_4F_2$     | $2.27 \pm 0.05$     | 1    |
| Cyclopropanone                      | $C_3H_4O$           | $2.67 \pm 0.13$     | 2    | 1,2-Difluoroethane ( <i>gauche</i> )      | $C_2H_4F_2$     | $2.67 \pm 0.13$     | 2    |
| Cyclopropene                        | $C_3H_4$            | $0.454 \pm 0.010$   | 1    | 1,1-Difluoroethene                        | $C_2H_2F_2$     | $1.3893 \pm 0.0002$ | 5    |
| Cyclopropylamine                    | $C_3H_7N$           | $1.19 \pm 0.01$     | 2    | <i>cis</i> -1,2-Difluoroethene            | $C_2H_2F_2$     | $2.42 \pm 0.02$     | 1    |
| Cyclopropyl methyl ketone           | $C_5H_8O$           | $2.62 \pm 0.25$     | 2    | Difluoromethane                           | $CH_2F_2$       | $1.9785 \pm 0.02$   | 3    |
| Diacetone alcohol                   | $C_6H_{12}O_2$      | [3.24]              | 7    | Difluoromethylborane                      | $CH_3BF_2$      | $1.668 \pm 0.003$   | 3    |
| Diazomethane                        | $CH_2N_2$           | $1.50 \pm 0.01$     | 1    | Difluoromethylene                         | $CF_2$          | $0.47 \pm 0.02$     | 3    |
| Dibromodifluoromethane              | $CBr_2F_2$          | $0.66 \pm 0.05$     | 1    | 1,1-Difluoro-1-propene                    | $C_3H_4F_2$     | $0.889 \pm 0.007$   | 2    |
| 1,2-Dibromoethane                   | $C_2H_4Br_2$        | [1.19]              | 7    | 2,3-Dihydro-1,4-dioxin                    | $C_4H_6O_2$     | $0.939 \pm 0.008$   | 3    |
| Dibromomethane                      | $CH_2Br_2$          | $1.43 \pm 0.03$     | 1    | 3,6-Dihydro-1,2-dioxin                    | $C_4H_6O_2$     | $2.329 \pm 0.001$   | 3    |
| 1,2-Dibromopropane                  | $C_3H_6Br_2$        | [1.2]               | 7    |                                           |                 |                     |      |
| Dibutylamine                        | $C_8H_{19}N$        | [0.98]              | 7    |                                           |                 |                     |      |
| Dibutyl ether                       | $C_8H_{18}O$        | $1.17 \pm 0.06$     | 1    |                                           |                 |                     |      |
| Dibutyl phthalate                   | $C_{16}H_{22}O_4$   | [2.82]              | 7    |                                           |                 |                     |      |
| Dibutyl sebacate                    | $C_{18}H_{34}O_4$   | [2.48]              | 7    |                                           |                 |                     |      |

| Name                            | Mol. Form.      | $\mu/D$           | Ref. | Name                                   | Mol. Form.          | $\mu/D$             | Ref. |
|---------------------------------|-----------------|-------------------|------|----------------------------------------|---------------------|---------------------|------|
| 2,3-Dihydrofuran                | $C_4H_6O$       | $1.32 \pm 0.03$   | 2    | Ethoxybenzene                          | $C_8H_{10}O$        | $1.45 \pm 0.15$     | 1    |
| 2,5-Dihydrofuran                | $C_4H_6O$       | $1.63 \pm 0.01$   | 5    | 2-Ethoxyethanol                        | $C_4H_{10}O_2$      | [2.08]              | 7    |
| Dihydro-3-methyl-2(3H)-furanone | $C_5H_8O_2$     | $4.56 \pm 0.02$   | 5    | 2-Ethoxyethyl acetate                  | $C_6H_{12}O_3$      | [2.25]              | 7    |
| Dihydro-5-methyl-2(3H)-furanone | $C_5H_8O_2$     | $4.71 \pm 0.05$   | 5    | Ethyl acetate                          | $C_4H_8O_2$         | $1.78 \pm 0.09$     | 1    |
| 3,4-Dihydro-2H-pyran            | $C_5H_8O$       | $1.400 \pm 0.008$ | 5    | Ethyl acrylate                         | $C_5H_8O_2$         | [1.96]              | 7    |
| 3,6-Dihydro-2H-pyran            | $C_5H_8O$       | $1.283 \pm 0.005$ | 3    | Ethylamine ( <i>gauche</i> )           | $C_2H_7N$           | $1.210 \pm 0.015$   | 5    |
| 2,3-Dihydrothiophene            | $C_4H_6S$       | $1.61 \pm 0.20$   | 5    | Ethylamine ( <i>trans</i> )            | $C_2H_7N$           | $1.304 \pm 0.011$   | 5    |
| 2,5-Dihydrothiophene            | $C_4H_6S$       | $1.75 \pm 0.01$   | 3    | Ethylamine ( <i>average</i> )          | $C_2H_7N$           | $1.22 \pm 0.10$     | 1    |
| Diiodomethane                   | $CH_2I_2$       | [1.08]            | 7    | Ethylbenzene                           | $C_8H_{10}$         | $0.59 \pm 0.05$     | 1    |
| Diisopentyl ether               | $C_{10}H_{22}O$ | [1.23]            | 7    | Ethyl benzoate                         | $C_9H_{10}O_2$      | $2.00 \pm 0.10$     | 1    |
| Diisopropylamine                | $C_6H_{15}N$    | [1.15]            | 7    | Ethyl butanoate                        | $C_6H_{12}O_2$      | [1.74]              | 7    |
| Diisopropyl ether               | $C_6H_{14}O$    | $1.13 \pm 0.10$   | 1    | Ethyl <i>trans</i> -cinnamate          | $C_{11}H_{12}O_2$   | [1.84]              | 7    |
| Diketene                        | $C_4H_4O_2$     | $3.53 \pm 0.07$   | 1    | Ethyl cyanate                          | $C_3H_5NO$          | $4.72 \pm 0.09$     | 5    |
| 1,2-Dimethoxybenzene            | $C_8H_{10}O_2$  | [1.29]            | 7    | Ethyl cyanoacetate                     | $C_5H_7NO_2$        | [2.17]              | 7    |
| Dimethoxymethane                | $C_3H_8O_2$     | [0.74]            | 7    | Ethylene carbonate                     | $C_3H_4O_3$         | [4.9]               | 7    |
| <i>N,N</i> -Dimethylacetamide   | $C_4H_9NO$      | [3.7]             | 7    | Ethylene glycol ( <i>average</i> )     | $C_2H_6O_2$         | $2.36 \pm 0.10$     | 5    |
| Dimethylamine                   | $C_2H_7N$       | $1.01 \pm 0.02$   | 2    | Ethyleneimine                          | $C_2H_5N$           | $1.90 \pm 0.01$     | 1    |
| <i>N,N</i> -Dimethylaniline     | $C_8H_{11}N$    | $1.68 \pm 0.17$   | 1    | Ethylene-sulfur dioxide complex        | $C_2H_4 \cdot O_2S$ | $1.650 \pm 0.003$   | 27   |
| 2,4-Dimethylaniline             | $C_8H_{11}N$    | [1.40]            | 7    | Ethylene-water complex                 | $C_2H_4 \cdot H_2O$ | $1.10 \pm 0.01$     | 56   |
| 2,6-Dimethylaniline             | $C_8H_{11}N$    | [1.63]            | 7    | Ethyl formate ( <i>gauche</i> )        | $C_3H_6O_2$         | $1.81 \pm 0.02$     | 2    |
| 3,3-Dimethyl-1-butyne           | $C_6H_{10}$     | $0.661 \pm 0.004$ | 1    | Ethyl formate ( <i>trans</i> )         | $C_3H_6O_2$         | $1.98 \pm 0.02$     | 2    |
| 1,1-Dimethylcyclopropane        | $C_5H_{10}$     | $0.142 \pm 0.001$ | 3    | Ethyl formate ( <i>average</i> )       | $C_3H_6O_2$         | 1.93                | 1    |
| 3,3-Dimethylcyclopropene        | $C_5H_8$        | $0.287 \pm 0.003$ | 3    | 2-Ethyl-1-hexanol                      | $C_8H_{18}O$        | [1.74]              | 7    |
| Dimethyl disulfide              | $C_2H_6S_2$     | [1.85]            | 7    | 2-Ethylhexyl acetate                   | $C_{10}H_{20}O_2$   | [1.8]               | 7    |
| Dimethyl ether                  | $C_2H_6O$       | $1.30 \pm 0.01$   | 1    | Ethyl lactate                          | $C_5H_{10}O_3$      | [2.4]               | 7    |
| <i>N,N</i> -Dimethylformamide   | $C_3H_7NO$      | $3.82 \pm 0.08$   | 1    | Ethyl methyl ether ( <i>trans</i> )    | $C_3H_8O$           | $1.17 \pm 0.02$     | 3    |
| 2,6-Dimethyl-4-heptanone        | $C_9H_{18}O$    | [2.66]            | 7    | Ethyl methyl sulfide ( <i>gauche</i> ) | $C_3H_8S$           | $1.593 \pm 0.004$   | 5    |
| Dimethyl maleate                | $C_6H_8O_4$     | [2.48]            | 7    | Ethyl methyl sulfide ( <i>trans</i> )  | $C_3H_8S$           | $1.56 \pm 0.03$     | 3    |
| 2,4-Dimethyl-3-pentanone        | $C_7H_{14}O$    | [2.74]            | 7    | Ethyl propanoate                       | $C_5H_{10}O_2$      | [1.74]              | 7    |
| 2,2-Dimethylpropanal            | $C_5H_{10}O$    | $2.66 \pm 0.05$   | 2    | Ethyl vinyl ether                      | $C_4H_8O$           | [1.26]              | 7    |
| 2,2-Dimethylpropanenitrile      | $C_5H_9N$       | $3.95 \pm 0.04$   | 1    | Fluoroacetylene                        | $C_2HF$             | $0.7207 \pm 0.0003$ | 3    |
| 2,4-Dimethylpyridine            | $C_7H_9N$       | [2.30]            | 7    | Fluorobenzene                          | $C_6H_5F$           | $1.60 \pm 0.08$     | 1    |
| 2,6-Dimethylpyridine            | $C_7H_9N$       | [1.66]            | 7    | Fluorocyclohexane                      | $C_6H_{11}F$        | $2.11 \pm 0.04$     | 2    |
| Dimethyl sulfide                | $C_2H_6S$       | $1.554 \pm 0.004$ | 3    | ( <i>equatorial</i> )                  |                     |                     |      |
| Dimethyl sulfoxide              | $C_2H_6OS$      | $3.96 \pm 0.04$   | 1    | Fluorocyclohexane ( <i>axial</i> )     | $C_6H_{11}F$        | $1.81 \pm 0.04$     | 2    |
| 1,3-Dioxane                     | $C_4H_8O_2$     | $2.06 \pm 0.04$   | 2    | 1-Fluorocyclohexene                    | $C_6H_9F$           | $1.942 \pm 0.010$   | 5    |
| 1,3-Dioxolane                   | $C_3H_6O_2$     | $1.19 \pm 0.06$   | 3    | Fluoroethane                           | $C_2H_5F$           | $1.937 \pm 0.007$   | 5    |
| Dipentyl ether                  | $C_{10}H_{22}O$ | [1.20]            | 7    | Fluoroethene                           | $C_2H_3F$           | $1.468 \pm 0.003$   | 5    |
| Diphenyl ether                  | $C_{12}H_{10}O$ | $\approx 1.3$     | 1    | Fluoromethane                          | $CH_3F$             | $1.858 \pm 0.002$   | 3    |
| Dipropylamine                   | $C_6H_{15}N$    | [1.03]            | 7    | Fluoromethylidyne                      | $CF$                | $0.645 \pm 0.005$   | 3    |
| Dipropyl ether                  | $C_6H_{14}O$    | $1.21 \pm 0.06$   | 1    | (Fluoromethylidyne) phosphine (FCP)    | $CFP$               | $0.279 \pm 0.001$   | 62   |
| 1,3-Dithiane                    | $C_4H_8S_2$     | $2.14 \pm 0.04$   | 5    | Fluoromethylsilane                     | $CH_3FSi$           | $1.700 \pm 0.008$   | 5    |
| Divinyl ether                   | $C_4H_6O$       | $0.78 \pm 0.05$   | 2    | 1-Fluoro-4-nitrobenzene                | $C_6H_4FNO_2$       | $2.87 \pm 0.06$     | 1    |
| Epichlorohydrin                 | $C_3H_5ClO$     | [1.8]             | 7    | 1-Fluoropropane ( <i>gauche</i> )      | $C_3H_7F$           | $1.90 \pm 0.10$     | 1    |
| 1,2-Epoxybutane                 | $C_4H_8O$       | $1.891 \pm 0.011$ | 3    | 1-Fluoropropane ( <i>trans</i> )       | $C_3H_7F$           | $2.05 \pm 0.04$     | 1    |
| 1,2-Ethanediamine               | $C_2H_8N_2$     | $1.99 \pm 0.10$   | 1    | 2-Fluoropropane                        | $C_3H_7F$           | $1.958 \pm 0.001$   | 5    |
| 1,2-Ethanediol, diacetate       | $C_6H_{10}O_4$  | [2.34]            | 7    | <i>cis</i> -1-Fluoropropene            | $C_3H_5F$           | $1.46 \pm 0.03$     | 1    |
| 1,2-Ethanedithiol               | $C_2H_6S_2$     | $2.03 \pm 0.08$   | 5    | <i>trans</i> -1-Fluoropropene          | $C_3H_5F$           | $\approx 1.9$       | 1    |
| Ethanethiol ( <i>gauche</i> )   | $C_2H_6S$       | $1.61 \pm 0.08$   | 3    | 2-Fluoropropene                        | $C_3H_5F$           | $1.61 \pm 0.03$     | 1    |
| Ethanethiol ( <i>trans</i> )    | $C_2H_6S$       | $1.58 \pm 0.08$   | 3    | 3-Fluoropropene ( <i>gauche</i> )      | $C_3H_5F$           | $1.939 \pm 0.015$   | 1    |
| Ethanol ( <i>gauche</i> )       | $C_2H_6O$       | $1.68 \pm 0.03$   | 3    | 3-Fluoropropene ( <i>cis</i> )         | $C_3H_5F$           | $1.765 \pm 0.014$   | 1    |
| Ethanol ( <i>trans</i> )        | $C_2H_6O$       | $1.44 \pm 0.03$   | 2    | 3-Fluoropropyne                        | $C_3H_3F$           | $1.73 \pm 0.02$     | 5    |
| Ethanol ( <i>average</i> )      | $C_2H_6O$       | $1.69 \pm 0.03$   | 1    | 3-Fluoropyridine                       | $C_5H_4FN$          | $2.09 \pm 0.26$     | 3    |
| Ethanolamine                    | $C_2H_7NO$      | [2.27]            | 7    | 2-Fluorotoluene                        | $C_7H_7F$           | $1.37 \pm 0.07$     | 1    |

| Name                                      | Mol. Form.       | $\mu/D$             | Ref. | Name                                | Mol. Form.          | $\mu/D$           | Ref. |
|-------------------------------------------|------------------|---------------------|------|-------------------------------------|---------------------|-------------------|------|
| 3-Fluorotoluene                           | $C_7H_7F$        | $1.82 \pm 0.04$     | 2    | 2-Isocyanopropane                   | $C_4H_7N$           | $4.055 \pm 0.001$ | 5    |
| 4-Fluorotoluene                           | $C_7H_7F$        | $2.00 \pm 0.10$     | 1    | Isopentane                          | $C_5H_{12}$         | $0.13 \pm 0.05$   | 1    |
| Formaldehyde                              | $CH_2O$          | $2.332 \pm 0.002$   | 3    | Isopentyl acetate                   | $C_7H_{14}O_2$      | [1.86]            | 7    |
| Formaldehyde dimer                        | $C_2H_4O_2$      | $0.858 \pm 0.005$   | 57   | Isopropylamine                      | $C_3H_9N$           | $1.19 \pm 0.06$   | 3    |
| Formamide                                 | $CH_3NO$         | $3.73 \pm 0.07$     | 1    | Isopropylbenzene                    | $C_9H_{12}$         | $\approx 0.79$    | 1    |
| Formic acid                               | $CH_2O_2$        | $1.425 \pm 0.002$   | 5    | Isopropyl methyl ether              | $C_4H_{10}O$        | $1.247 \pm 0.003$ | 5    |
| Formyl fluoride                           | $CHFO$           | $2.081 \pm 0.001$   | 5    | Isoquinoline                        | $C_9H_7N$           | $2.73 \pm 0.14$   | 1    |
| Fulminic acid                             | $CHNO$           | 3.09934             | 5    | Isoxazole                           | $C_3H_3NO$          | $2.95 \pm 0.04$   | 3    |
| Fulvene                                   | $C_6H_6$         | $0.4236 \pm 0.013$  | 2    | Isoxazole-carbon monoxide complex   | $C_3H_3NO \cdot CO$ | $2.873 \pm 0.004$ | 52   |
| Furan                                     | $C_4H_4O$        | $0.66 \pm 0.01$     | 1    | Ketene                              | $C_2H_2O$           | 1.42215           | 3    |
| Furfural                                  | $C_5H_4O_2$      | [3.54]              | 7    | Mesityl oxide                       | $C_6H_{10}O$        | [2.79]            | 7    |
| Furfuryl alcohol                          | $C_5H_6O_2$      | [1.92]              | 7    | Methacrylic acid                    | $C_4H_6O_2$         | [1.65]            | 7    |
| Glycerol                                  | $C_3H_8O_3$      | [2.56]              | 7    | Methanethiol                        | $CH_4S$             | $1.52 \pm 0.08$   | 1    |
| Glycine (Conformer I)                     | $C_2H_5NO_2$     | $1.147 \pm 0.005$   | 49   | Methanol                            | $CH_4O$             | $1.70 \pm 0.02$   | 1    |
| Glycine (Conformer II)                    | $C_2H_5NO_2$     | $5.45 \pm 0.05$     | 49   | 2-Methoxyethanol ( <i>gauche</i> )  | $C_3H_8O_2$         | $2.36 \pm 0.05$   | 2    |
| Glycolaldehyde                            | $C_2H_4O_2$      | $2.73 \pm 0.05$     | 2    | 2-Methoxyethyl acetate              | $C_5H_{10}O_3$      | [2.13]            | 7    |
| Glyoxal ( <i>cis</i> )                    | $C_2H_2O_2$      | $4.8 \pm 0.2$       | 2    | 1-Methoxy-1,2-propadiene            | $C_4H_6O$           | $0.963 \pm 0.020$ | 5    |
| 2-Heptanol                                | $C_7H_{16}O$     | [1.71]              | 7    | <i>N</i> -Methylacetamide           | $C_3H_7NO$          | [4.3]             | 7    |
| 3-Heptanol                                | $C_7H_{16}O$     | [1.71]              | 7    | Methyl acetate                      | $C_3H_6O_2$         | $1.72 \pm 0.09$   | 1    |
| 2-Heptanone                               | $C_7H_{14}O$     | [2.59]              | 7    | Methyl acrylate                     | $C_4H_6O_2$         | [1.77]            | 7    |
| 3-Heptanone                               | $C_7H_{14}O$     | [2.78]              | 7    | 2-Methylacrylonitrile               | $C_4H_5N$           | $3.69 \pm 0.18$   | 1    |
| Hexamethylphosphoric triamide             | $C_6H_{18}N_3OP$ | [5.5]               | 7    | Methylamine                         | $CH_5N$             | $1.31 \pm 0.03$   | 1    |
| Hexanoic acid                             | $C_6H_{12}O_2$   | [1.13]              | 7    | 2-Methylaniline                     | $C_7H_9N$           | [1.60]            | 7    |
| 2-Hexanone                                | $C_6H_{12}O$     | [2.66]              | 7    | 3-Methylaniline                     | $C_7H_9N$           | [1.45]            | 7    |
| <i>sec</i> -Hexyl acetate                 | $C_8H_{16}O_2$   | [1.9]               | 7    | 4-Methylaniline                     | $C_7H_9N$           | [1.52]            | 7    |
| 1-Hexyne                                  | $C_6H_{10}$      | $0.83 \pm 0.05$     | 1    | Methyl azide                        | $CH_3N_3$           | $2.17 \pm 0.04$   | 2    |
| Hydrogen cyanide                          | $CHN$            | 2.985188            | 5    | Methyl benzoate                     | $C_8H_8O_2$         | [1.94]            | 7    |
| Hydrogen cyanide trimer                   | $C_3H_3N_3$      | 10.6                | 21   | 2-Methyl-1,3-butadiene              | $C_5H_8$            | $0.25 \pm 0.01$   | 1    |
| Hydrogen isocyanide                       | $CHN$            | $3.05 \pm 0.15$     | 3    | 3-Methylbutanoic acid               | $C_5H_{10}O_2$      | [0.63]            | 7    |
| <i>p</i> -Hydroquinone                    | $C_6H_6O_2$      | $2.38 \pm 0.05$     | 15   | 2-Methyl-1-butanol                  | $C_5H_{12}O$        | [1.88]            | 7    |
| 3-Hydroxypropanenitrile ( <i>gauche</i> ) | $C_3H_5NO$       | $3.17 \pm 0.02$     | 5    | 2-Methyl-2-butanol                  | $C_5H_{12}O$        | [1.82]            | 7    |
| Imidazole                                 | $C_3H_4N_2$      | $3.8 \pm 0.4$       | 2    | 3-Methyl-1-butene ( <i>gauche</i> ) | $C_5H_{10}$         | $0.398 \pm 0.004$ | 3    |
| Iodoacetylene                             | $C_2HI$          | 0.02525             | 5    | 3-Methyl-1-butene ( <i>trans</i> )  | $C_5H_{10}$         | $0.320 \pm 0.010$ | 3    |
| Iodobenzene                               | $C_6H_5I$        | $1.70 \pm 0.09$     | 1    | 3-Methyl-2-butenenitrile            | $C_5H_7N$           | $4.61 \pm 0.13$   | 10   |
| 1-Iodobutane                              | $C_4H_9I$        | [1.93]              | 7    | 2-Methyl-1-buten-3-yne              | $C_5H_6$            | $0.513 \pm 0.02$  | 2    |
| 2-Iodobutane                              | $C_4H_9I$        | $2.12 \pm 0.11$     | 1    | Methyl cyanate                      | $C_2H_3NO$          | $4.26 \pm 0.18$   | 5    |
| Iodoethane                                | $C_2H_5I$        | $1.976 \pm 0.002$   | 5    | <i>cis</i> -3-Methylcyclohexanol    | $C_7H_{14}O$        | [1.91]            | 7    |
| Iodoethene                                | $C_2H_3I$        | $1.311 \pm 0.005$   | 5    | <i>trans</i> -3-Methylcyclohexanol  | $C_7H_{14}O$        | [1.75]            | 7    |
| Iodomethane                               | $CH_3I$          | $1.6406 \pm 0.0004$ | 5    | 3-Methylcyclopentanone              | $C_6H_{10}O$        | $3.14 \pm 0.03$   | 5    |
| 1-Iodo-2-methylpropane                    | $C_4H_9I$        | [1.87]              | 7    | 3-Methyl-2-cyclopenten-1-one        | $C_6H_8O$           | $4.33 \pm 0.002$  | 5    |
| Iodomethylsilane                          | $CH_3Si$         | $1.862 \pm 0.005$   | 5    | Methylcyclopropane                  | $C_4H_8$            | $0.139 \pm 0.004$ | 2    |
| 1-Iodopropane                             | $C_3H_7I$        | $2.04 \pm 0.10$     | 1    | Methyldiborane(6)                   | $CH_8B_2$           | $0.566 \pm 0.006$ | 3    |
| 2-Iodopropane                             | $C_3H_7I$        | [1.95]              | 7    | Methyldifluorophosphine             | $CH_3F_2P$          | $2.056 \pm 0.006$ | 3    |
| Isobutanal ( <i>gauche</i> )              | $C_4H_8O$        | $2.69 \pm 0.01$     | 5    | Methylenecyclohexane                | $C_7H_{12}$         | $0.62 \pm 0.01$   | 5    |
| Isobutanal ( <i>trans</i> )               | $C_4H_8O$        | $2.86 \pm 0.01$     | 5    | Methylenecyclopropene               | $C_4H_4$            | $1.90 \pm 0.01$   | 5    |
| Isobutane                                 | $C_4H_{10}$      | $0.132 \pm 0.002$   | 1    | Methylenephosphine ( $CH_2 = PH$ )  | $CH_3P$             | $0.869 \pm 0.003$ | 61   |
| Isobutene                                 | $C_4H_8$         | $0.503 \pm 0.010$   | 1    | <i>N</i> -Methylformamide           | $C_2H_5NO$          | $3.83 \pm 0.08$   | 1    |
| Isobutyl acetate                          | $C_6H_{12}O_2$   | [1.86]              | 7    | Methyl formate                      | $C_2H_4O_2$         | $1.77 \pm 0.04$   | 1    |
| Isobutylamine                             | $C_4H_{11}N$     | [1.27]              | 7    | 2-Methylfuran                       | $C_5H_6O$           | $0.65 \pm 0.05$   | 2    |
| Isobutyl formate                          | $C_5H_{10}O_2$   | [1.88]              | 7    | 3-Methylfuran                       | $C_5H_6O$           | $1.03 \pm 0.02$   | 2    |
| Isobutyl isobutanoate                     | $C_8H_{16}O_2$   | [1.9]               | 7    | 5-Methyl-2(3 <i>H</i> )-furanone    | $C_5H_6O_2$         | $4.08 \pm 0.02$   | 5    |
| Isocyanic acid (HNCO)                     | $CHNO$           | $\approx 1.6$       | 2    | Methyl hydroperoxide                | $CH_4O_2$           | $\approx 0.65$    | 13   |
| Isocyanobenzene                           | $C_7H_5N$        | $4.018 \pm 0.003$   | 5    | Methylidyne                         | $CH$                | $\approx 1.46$    | 2    |
| Isocyanocyclopropane                      | $C_4H_5N$        | $4.03 \pm 0.10$     | 3    |                                     |                     |                   |      |

| Name                                       | Mol. Form.        | $\mu/D$             | Ref. | Name                              | Mol. Form.          | $\mu/D$           | Ref. |
|--------------------------------------------|-------------------|---------------------|------|-----------------------------------|---------------------|-------------------|------|
| Methyl isocyanate                          | $C_2H_3NO$        | $\approx 2.8$       | 1    | Pentachloroethane                 | $C_2HCl_5$          | $0.92 \pm 0.05$   | 1    |
| Methyl isothiocyanate                      | $C_2H_3NS$        | $3.453 \pm 0.003$   | 5    | <i>cis</i> -1,3-Pentadiene        | $C_5H_8$            | $0.500 \pm 0.015$ | 2    |
| 4-Methylisoxazole                          | $C_4H_5NO$        | $3.583 \pm 0.005$   | 5    | <i>trans</i> -1,3-Pentadiene      | $C_5H_8$            | $0.585 \pm 0.010$ | 2    |
| Methyl methacrylate                        | $C_5H_8O_2$       | [1.67]              | 7    | 1,3-Pentadiyne                    | $C_5H_4$            | $1.207 \pm 0.001$ | 5    |
| 2-Methyloxazole                            | $C_4H_5NO$        | $1.37 \pm 0.07$     | 5    | 1,5-Pentanediol                   | $C_5H_{12}O_2$      | [2.5]             | 7    |
| 4-Methyloxazole                            | $C_4H_5NO$        | $1.08 \pm 0.05$     | 5    | 2,4-Pentanedione                  | $C_5H_8O_2$         | [2.78]            | 7    |
| 5-Methyloxazole                            | $C_4H_5NO$        | $2.16 \pm 0.04$     | 5    | Pentanenitrile                    | $C_5H_9N$           | $4.12 \pm 0.08$   | 1    |
| Methyloxirane                              | $C_3H_6O$         | $2.01 \pm 0.02$     | 1    | Pentanoic acid                    | $C_5H_{10}O_2$      | [1.61]            | 7    |
| 2-Methyl-2,4-pentanediol                   | $C_6H_{14}O_2$    | [2.9]               | 7    | 1-Pentanol                        | $C_5H_{12}O$        | [1.7]             | 7    |
| 4-Methylpentanenitrile                     | $C_6H_{11}N$      | [3.5]               | 7    | 2-Pentanol                        | $C_5H_{12}O$        | [1.66]            | 7    |
| Methylphosphonic difluoride                | $CH_3F_2OP$       | $3.69 \pm 0.26$     | 3    | 3-Pentanol                        | $C_5H_{12}O$        | [1.64]            | 7    |
| <i>N</i> -Methylpropanamide                | $C_4H_9NO$        | 3.61                | 7    | 2-Pentanone                       | $C_5H_{10}O$        | [2.70]            | 7    |
| 2-Methylpropanenitrile                     | $C_4H_7N$         | $4.29 \pm 0.09$     | 3    | 3-Pentanone                       | $C_5H_{10}O$        | [2.82]            | 7    |
| 2-Methyl-2-propanethiol                    | $C_4H_{10}S$      | $1.66 \pm 0.03$     | 3    | 1,2,3-Pentatriene                 | $C_5H_6$            | $0.51 \pm 0.05$   | 11   |
| 2-Methylpropanoic acid                     | $C_4H_8O_2$       | [1.08]              | 7    | 1-Pentene                         | $C_5H_{10}$         | $\approx 0.5$     | 1    |
| 2-Methyl-1-propanol                        | $C_4H_{10}O$      | $1.64 \pm 0.08$     | 1    | 1-Penten-3-yne                    | $C_5H_6$            | $0.66 \pm 0.02$   | 2    |
| 2-Methyl-2-propanol                        | $C_4H_{10}O$      | [1.66]              | 7    | <i>cis</i> -3-Penten-1-yne        | $C_5H_6$            | $0.78 \pm 0.02$   | 2    |
| 2-Methylpropenal                           | $C_4H_6O$         | $2.68 \pm 0.13$     | 1    | <i>trans</i> -3-Penten-1-yne      | $C_5H_6$            | $1.06 \pm 0.05$   | 2    |
| 2-Methyl-2-propenol ( <i>skew</i> )        | $C_4H_8O$         | $1.295 \pm 0.022$   | 5    | Pentyl acetate                    | $C_7H_{14}O_2$      | $1.75 \pm 0.10$   | 1    |
| Methyl propyl ether ( <i>trans-trans</i> ) | $C_4H_{10}O$      | $1.107 \pm 0.013$   | 3    | Pentyl formate                    | $C_6H_{12}O_2$      | $1.90 \pm 0.10$   | 1    |
| 2-Methylpyridine                           | $C_6H_7N$         | $1.85 \pm 0.04$     | 2    | 1-Pentyne ( <i>gauche</i> )       | $C_5H_8$            | $0.769 \pm 0.028$ | 2    |
| 3-Methylpyridine                           | $C_6H_7N$         | [2.40]              | 7    | 1-Pentyne ( <i>trans</i> )        | $C_5H_8$            | $0.842 \pm 0.010$ | 2    |
| 4-Methylpyridine                           | $C_6H_7N$         | $2.70 \pm 0.02$     | 2    | Perfluoropyridine                 | $C_5F_5N$           | $0.98 \pm 0.08$   | 3    |
| 2-Methylpyrimidine                         | $C_5H_6N_2$       | $1.676 \pm 0.010$   | 3    | Phenol                            | $C_6H_6O$           | $1.224 \pm 0.008$ | 3    |
| 5-Methylpyrimidine                         | $C_5H_6N_2$       | $2.881 \pm 0.006$   | 3    | Phenylacetylene                   | $C_8H_6$            | $0.656 \pm 0.005$ | 3    |
| <i>N</i> -Methylpyrrolidine                | $C_5H_{11}N$      | $0.572 \pm 0.003$   | 5    | Phenylsilane                      | $C_6H_5Si$          | $0.845 \pm 0.012$ | 3    |
| <i>N</i> -Methyl-2-pyrrolidinone           | $C_5H_9NO$        | [4.1]               | 7    | 1-Phosphapropyne ( $CH_3CP$ )     | $C_2H_3P$           | $1.499 \pm 0.001$ | 63   |
| Methyl salicylate                          | $C_8H_8O_3$       | [2.47]              | 7    | Piperidine ( <i>equatorial</i> )  | $C_5H_{11}N$        | $0.82 \pm 0.02$   | 3    |
| Methylsilane                               | $CH_6Si$          | 0.73456             | 5    | Piperidine ( <i>axial</i> )       | $C_5H_{11}N$        | $1.19 \pm 0.02$   | 3    |
| Methyl silyl ether                         | $CH_6OSi$         | $1.15 \pm 0.02$     | 2    | Piperidine ( <i>average</i> )     | $C_5H_{11}N$        | [1.19]            | 3    |
| 3-Methylthietane                           | $C_4H_8S$         | $2.046 \pm 0.009$   | 5    | Propanal ( <i>gauche</i> )        | $C_3H_6O$           | $2.86 \pm 0.01$   | 5    |
| 2-Methylthiophene                          | $C_5H_6S$         | $0.674 \pm 0.005$   | 2    | Propanal ( <i>cis</i> )           | $C_3H_6O$           | $2.52 \pm 0.05$   | 1    |
| 3-Methylthiophene                          | $C_5H_6S$         | $0.914 \pm 0.015$   | 3    | Propanal ( <i>average</i> )       | $C_3H_6O$           | 2.72              | 1    |
| Methyl vinyl ether                         | $C_3H_6O$         | $0.965 \pm 0.002$   | 5    | Propane                           | $C_3H_8$            | $0.084 \pm 0.001$ | 1    |
| Morpholine                                 | $C_4H_9NO$        | $1.55 \pm 0.03$     | 3    | 1,2-Propanediol                   | $C_3H_8O_2$         | [2.25]            | 7    |
| 2-Nitroanisole                             | $C_7H_7NO_3$      | [5.0]               | 7    | 1,3-Propanediol                   | $C_3H_8O_2$         | [2.55]            | 7    |
| Nitrobenzene                               | $C_6H_5NO_2$      | $4.22 \pm 0.08$     | 1    | Propanenitrile                    | $C_3H_5N$           | $4.05 \pm 0.03$   | 3    |
| Nitroethane                                | $C_2H_5NO_2$      | $3.23 \pm 0.03$     | 2    | 1-Propanethiol ( <i>gauche</i> )  | $C_3H_7S$           | $1.683 \pm 0.010$ | 3    |
| Nitromethane                               | $CH_3NO_2$        | $3.46 \pm 0.02$     | 1    | 1-Propanethiol ( <i>trans</i> )   | $C_3H_7S$           | $1.60 \pm 0.08$   | 3    |
| 1-Nitropropane                             | $C_3H_7NO_2$      | $3.66 \pm 0.07$     | 1    | 2-Propanethiol ( <i>gauche</i> )  | $C_3H_7S$           | $1.53 \pm 0.03$   | 3    |
| 2-Nitropropane                             | $C_3H_7NO_2$      | $3.73 \pm 0.07$     | 1    | 2-Propanethiol ( <i>trans</i> )   | $C_3H_7S$           | $1.61 \pm 0.03$   | 3    |
| Nonanoic acid                              | $C_9H_{18}O_2$    | [0.79]              | 7    | Propanoic acid ( <i>cis</i> )     | $C_3H_6O_2$         | $1.46 \pm 0.07$   | 2    |
| 2,5-Norbornadiene                          | $C_7H_8$          | $0.0587 \pm 0.0001$ | 5    | Propanoic acid ( <i>average</i> ) | $C_3H_6O_2$         | $1.75 \pm 0.09$   | 1    |
| <i>cis</i> -9-Octadecenoic acid            | $C_{18}H_{34}O_2$ | [1.18]              | 7    | 1-Propanol ( <i>gauche</i> )      | $C_3H_8O$           | $1.58 \pm 0.03$   | 2    |
| Octanoic acid                              | $C_8H_{16}O_2$    | [1.15]              | 7    | 1-Propanol ( <i>trans</i> )       | $C_3H_8O$           | $1.55 \pm 0.03$   | 2    |
| 1-Octanol                                  | $C_8H_{18}O$      | [1.76]              | 7    | 2-Propanol ( <i>trans</i> )       | $C_3H_8O$           | $1.58 \pm 0.03$   | 2    |
| 2-Octanol                                  | $C_8H_{18}O$      | [1.71]              | 7    | Propargyl alcohol                 | $C_3H_4O$           | $1.13 \pm 0.06$   | 2    |
| 2-Octanone                                 | $C_8H_{16}O$      | [2.70]              | 7    | Propene                           | $C_3H_6$            | $0.366 \pm 0.001$ | 1    |
| 1,4-Oxathiane                              | $C_4H_8OS$        | $0.295 \pm 0.003$   | 3    | Propene-sulfur dioxide complex    | $C_3H_6 \cdot O_2S$ | $1.34 \pm 0.003$  | 35   |
| Oxazole                                    | $C_3H_3NO$        | $1.503 \pm 0.030$   | 3    | Propyl acetate                    | $C_5H_{10}O_2$      | [1.78]            | 7    |
| Oxetane                                    | $C_3H_6O$         | $1.94 \pm 0.01$     | 1    | Propylamine                       | $C_3H_9N$           | $1.17 \pm 0.06$   | 1    |
| 2-Oxetanone                                | $C_3H_4O_2$       | $4.18 \pm 0.03$     | 1    | Propylene carbonate               | $C_4H_6O_3$         | [4.9]             | 7    |
| 3-Oxetanone                                | $C_3H_4O_2$       | $0.887 \pm 0.005$   | 2    | Propyleneimine ( <i>cis</i> )     | $C_3H_7N$           | $1.77 \pm 0.09$   | 2    |
| Oxirane                                    | $C_2H_4O$         | $1.89 \pm 0.01$     | 1    | Propyleneimine ( <i>trans</i> )   | $C_3H_7N$           | $1.57 \pm 0.03$   | 2    |
| Paraldehyde                                | $C_6H_{12}O_3$    | $1.43 \pm 0.07$     | 1    | Propyl formate                    | $C_4H_8O_2$         | [1.89]            | 7    |

| Name                               | Mol. Form.        | $\mu/D$             | Ref. | Name                            | Mol. Form.          | $\mu/D$             | Ref. |
|------------------------------------|-------------------|---------------------|------|---------------------------------|---------------------|---------------------|------|
| 2-Propynal                         | $C_3H_2O$         | $2.78 \pm 0.02$     | 5    | Toluene                         | $C_7H_8$            | $0.375 \pm 0.010$   | 3    |
| Propyne                            | $C_3H_4$          | $0.784 \pm 0.001$   | 3    | Toluene-sulfur dioxide complex  | $C_7H_8 \cdot O_2S$ | $1.87 \pm 0.03$     | 34   |
| Propyne-argon complex              | $C_3H_4 \cdot Ar$ | $0.730 \pm 0.005$   | 20   | 1 <i>H</i> -1,2,4-Triazole      | $C_2H_3N_3$         | $2.7 \pm 0.1$       | 3    |
| 4 <i>H</i> -Pyran-4-one            | $C_5H_4O_2$       | $3.79 \pm 0.02$     | 5    | Tribromomethane                 | $CHBr_3$            | $0.99 \pm 0.02$     | 1    |
| 4 <i>H</i> -Pyran-4-thione         | $C_5H_4OS$        | $3.95 \pm 0.05$     | 5    | Tributylamine                   | $C_{12}H_{27}N$     | [0.78]              | 7    |
| 1 <i>H</i> -Pyrazole               | $C_3H_4N_2$       | $2.20 \pm 0.01$     | 3    | Tributyl borate                 | $C_{12}H_{27}BO_3$  | [0.77]              | 7    |
| Pyridazine                         | $C_4H_4N_2$       | $4.22 \pm 0.02$     | 2    | Tributyl phosphate              | $C_{12}H_{27}O_4P$  | [3.07]              | 7    |
| Pyridine                           | $C_5H_5N$         | $2.215 \pm 0.010$   | 3    | Tricarbon monosulfide           | $C_3S$              | $3.704 \pm 0.009$   | 50   |
| 2-Pyridinecarbonitrile             | $C_6H_4N_2$       | $5.78 \pm 0.11$     | 3    | 1,1,1-Trichloroethane           | $C_2H_3Cl_3$        | $1.755 \pm 0.015$   | 2    |
| 3-Pyridinecarbonitrile             | $C_6H_4N_2$       | $3.66 \pm 0.11$     | 3    | 1,1,2-Trichloroethane           | $C_2H_3Cl_3$        | [1.4]               | 7    |
| 4-Pyridinecarbonitrile             | $C_6H_4N_2$       | $1.96 \pm 0.03$     | 3    | Trichloroethene                 | $C_2HCl_3$          | [0.8]               | 7    |
| 3-Pyridinecarboxaldehyde           | $C_6H_5NO$        | 1.44                | 3    | Trichloroethylsilane            | $C_2H_5Cl_3Si$      | [2.04]              | 7    |
| 4-Pyridinecarboxaldehyde           | $C_6H_5NO$        | 1.66                | 3    | Trichlorofluoromethane          | $CCl_3F$            | $0.46 \pm 0.02$     | 2    |
| 2-Pyridinecarboxaldehyde           | $C_6H_5NO$        | $3.56 \pm 0.07$     | 3    | Trichloromethane                | $CHCl_3$            | $1.04 \pm 0.02$     | 2    |
| Pyrimidine                         | $C_4H_4N_2$       | $2.334 \pm 0.010$   | 2    | (Trichloromethyl)benzene        | $C_7H_5Cl_3$        | [2.03]              | 7    |
| Pyrrole                            | $C_4H_5N$         | $1.767 \pm 0.001$   | 5    | Trichloromethylsilane           | $CH_3Cl_3Si$        | $1.91 \pm 0.01$     | 2    |
| Pyrrolidine                        | $C_4H_9N$         | [1.57]              | 7    | Tri- <i>o</i> -cresyl phosphate | $C_{21}H_{21}O_4P$  | [2.87]              | 7    |
| 2-Pyrrolidone                      | $C_4H_7NO$        | [3.5]               | 7    | Tri- <i>m</i> -cresyl phosphate | $C_{21}H_{21}O_4P$  | [3.05]              | 7    |
| Quinoline                          | $C_9H_7N$         | $2.29 \pm 0.11$     | 1    | Tri- <i>p</i> -cresyl phosphate | $C_{21}H_{21}O_4P$  | [3.18]              | 7    |
| Salicylaldehyde                    | $C_7H_6O_2$       | [2.86]              | 7    | Triethanolamine                 | $C_6H_{15}NO_3$     | [3.57]              | 7    |
| Selenoformaldehyde                 | $CH_2Se$          | $1.41 \pm 0.01$     | 5    | Triethylamine                   | $C_6H_{15}N$        | $0.66 \pm 0.05$     | 1    |
| Silicon dicarbide                  | $C_2Si$           | $2.393 \pm 0.006$   | 24   | Triethyl phosphate              | $C_6H_{15}O_4P$     | [3.12]              | 7    |
| Silicon methylidyne                | $CHSi$            | $0.066 \pm 0.002$   | 41   | Trifluoroacetic acid            | $C_2HF_3O_2$        | $2.28 \pm 0.25$     | 1    |
| Styrene                            | $C_8H_8$          | $0.123 \pm 0.003$   | 5    | Trifluoroacetonitrile           | $C_2F_3N$           | $1.262 \pm 0.010$   | 3    |
| Succinonitrile                     | $C_4H_4N_2$       | [3.7]               | 7    | 1,2,4-Trifluorobenzene          | $C_6H_3F_3$         | $1.402 \pm 0.009$   | 5    |
| Sulfolane                          | $C_4H_8O_2S$      | [4.8]               | 7    | 1,1,1-Trifluoroethane           | $C_2H_3F_3$         | $2.347 \pm 0.005$   | 3    |
| 1,1,2,2-Tetrabromoethane           | $C_2H_2Br_4$      | [1.38]              | 7    | Trifluoroethene                 | $C_2HF_3$           | $1.32 \pm 0.03$     | 2    |
| 1,1,2,2-Tetrachloroethane          | $C_2H_2Cl_4$      | $1.32 \pm 0.07$     | 1    | Trifluoroiodomethane            | $CF_3I$             | $1.048 \pm 0.003$   | 3    |
| 1,2,3,4-Tetrafluorobenzene         | $C_6H_2F_4$       | $2.42 \pm 0.05$     | 3    | Trifluoroisocyanomethane        | $C_2F_3N$           | $1.153 \pm 0.010$   | 5    |
| 1,2,3,5-Tetrafluorobenzene         | $C_6H_2F_4$       | $1.46 \pm 0.06$     | 3    | Trifluoromethane                | $CHF_3$             | 1.65150             | 3    |
| 1,1,1,2-Tetrafluoroethane          | $C_2H_2F_4$       | $1.80 \pm 0.22$     | 5    | (Trifluoromethyl)benzene        | $C_7H_5F_3$         | $2.86 \pm 0.06$     | 1    |
| Tetrahydrofuran                    | $C_4H_8O$         | $1.75 \pm 0.04$     | 2    | Trifluoromethylsilane           | $CH_3F_3Si$         | $2.3394 \pm 0.0002$ | 5    |
| Tetrahydrofurfuryl alcohol         | $C_5H_{10}O_2$    | [2.1]               | 7    | (Trifluoromethyl)silane         | $CH_3F_3Si$         | $2.32 \pm 0.02$     | 5    |
| Tetrahydropyran ( <i>chair</i> )   | $C_5H_{10}O$      | $1.58 \pm 0.03$     | 3    | 3,3,3-Trifluoropropene          | $C_3H_3F_3$         | $2.45 \pm 0.05$     | 1    |
| Tetrahydro-4 <i>H</i> -pyran-4-one | $C_5H_8O_2$       | $1.720 \pm 0.003$   | 3    | 3,3,3-Trifluoro-1-propyne       | $C_3HF_3$           | $2.317 \pm 0.013$   | 5    |
| 1,2,5,6-Tetrahydropyridine         | $C_5H_7N$         | $1.007 \pm 0.003$   | 3    | Trimethylamine                  | $C_3H_9N$           | $0.612 \pm 0.003$   | 1    |
| Tetrahydrothiophene                | $C_4H_8S$         | [1.90]              | 7    | Trimethyl phosphate             | $C_3H_9O_4P$        | [3.18]              | 7    |
| Tetramethylurea                    | $C_5H_{12}N_2O$   | [3.5]               | 7    | 2,4,6-Trimethylpyridine         | $C_8H_{11}N$        | [2.05]              | 7    |
| 1 <i>H</i> -Tetrazole              | $CH_2N_4$         | $2.19 \pm 0.05$     | 3    | 1,3,5-Trioxane                  | $C_3H_6O_3$         | $2.08 \pm 0.02$     | 1    |
| Thiacyclohexane                    | $C_5H_{10}S$      | $1.781 \pm 0.010$   | 3    | Vinyl acetate                   | $C_4H_6O_2$         | [1.79]              | 7    |
| 1,2,5-Thiadiazole                  | $C_2H_2N_2S$      | $1.579 \pm 0.007$   | 3    | Vinyl formate                   | $C_3H_4O_2$         | $1.49 \pm 0.01$     | 1    |
| Thietane                           | $C_3H_6S$         | $1.85 \pm 0.09$     | 1    | 2-Vinylfuran                    | $C_6H_6O$           | $0.69 \pm 0.07$     | 5    |
| Thietane 1,1-dioxide               | $C_3H_6O_2S$      | $4.8 \pm 0.1$       | 5    | Vinylsilane                     | $C_2H_6Si$          | $0.657 \pm 0.002$   | 5    |
| Thioacetaldehyde                   | $C_2H_4S$         | $2.33 \pm 0.02$     | 68   | <i>o</i> -Xylene                | $C_8H_{10}$         | $0.640 \pm 0.005$   | 2    |
| Thiocarbonyl fluoride              | $CF_2S$           | 0.080               | 59   | 2,4-Xylenol                     | $C_8H_{10}O$        | [1.4]               | 7    |
| Thioformaldehyde                   | $CH_2S$           | $1.6491 \pm 0.0004$ | 3    | 2,5-Xylenol                     | $C_8H_{10}O$        | [1.45]              | 7    |
| Thiophene                          | $C_4H_4S$         | $0.55 \pm 0.01$     | 2    | 2,6-Xylenol                     | $C_8H_{10}O$        | [1.40]              | 7    |
| 2-Thiophenecarbonitrile            | $C_5H_3NS$        | $4.59 \pm 0.02$     | 3    | 3,4-Xylenol                     | $C_8H_{10}O$        | [1.56]              | 7    |
| 3-Thiophenecarbonitrile            | $C_5H_3NS$        | $4.13 \pm 0.02$     | 3    | 3,5-Xylenol                     | $C_8H_{10}O$        | [1.55]              | 7    |
| 4 <i>H</i> -Thiopyran-4-thione     | $C_5H_4S_2$       | $3.9 \pm 0.2$       | 5    |                                 |                     |                     |      |



# BOND DISSOCIATION ENERGIES

Yu-Ran Luo

The bond dissociation energy (enthalpy) is also referred to as bond disruption energy, bond energy, bond strength, or binding energy (abbreviation: BDE, BE, or D). It is defined as the standard enthalpy change of the following fission:  $R-X \rightarrow R + X$ . The BDE, denoted by  $D^\circ(R-X)$ , is usually derived by the thermochemical equation,  $D^\circ(R-X) = \Delta_f H^\circ(R) + \Delta_f H^\circ(X) - \Delta_f H^\circ(RX)$ . The enthalpy of formation  $\Delta_f H^\circ$  of a large number of atoms, free radicals, ions, clusters and compounds is available from the websites of NIST, NASA, CODATA, and IUPAC. Most authors prefer to use the BDE values at 298.15 K.

The following seven tables provide essential information of experimental BDE values of  $R-X$  and  $R^+-X$  bonds.

- (1) Table 1: Bond Dissociation Energies in Diatomic Molecules
- (2) Table 2: Enthalpy of Formation of Gaseous Atoms
- (3) Table 3: Bond Dissociation Energies in Polyatomic Molecules
- (4) Table 4: Enthalpies of Formation of Free Radicals and Other Transient Species
- (5) Table 5: Bond Dissociation Energies of Common Organic Molecules
- (6) Table 6: Bond Dissociation Energies in Diatomic Cations
- (7) Table 7: Bond Dissociation Energies in Polyatomic Cations

The data in these tables have been revised through September 2008.

**TABLE 1. Bond Dissociation Energies in Diatomic Molecules**

The BDEs in diatomic species have usually been measured by spectroscopy or mass spectrometry. In the absence of data on the enthalpy function, the values at 0 K,  $D^\circ(A-B)$ , are converted to  $D^\circ_{298}$  by the approximate equation:

$$D^\circ_{298}(A-B) \approx D^\circ(A-B) + (3/2)RT = D^\circ(A-B) + 3.7181 \text{ kJ mol}^{-1}$$

This table has been arranged in an alphabetical order of the atoms A in the diatomics A-B.

| A-B   | $D^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. |
|-------|------------------------------------|------|-------|------------------------------------|------|-------|------------------------------------|------|-------|------------------------------------|------|
| Ac-O  | 794                                | 1    | Ag-Sn | 136 ± 21                           | 1    | Al-Sb | 216.3 ± 6                          | 1    | Ar-Si | 5.86                               | 1    |
| Ag-Ag | 162.9 ± 2.9                        | 1    | Ag-Te | 195.8 ± 14.6                       | 1    | Al-Se | 318 ± 13                           | 1    | Ar-Sn | <5.1                               | 1    |
| Ag-Al | 183.7 ± 9.2                        | 1    | Al-Al | 264.3 ± 0.5                        | 1    | Al-Si | 246.9 ± 12.6                       | 1    | Ar-Tl | 4.09                               | 1    |
| Ag-Au | 202.5 ± 9.6                        | 1    | Al-Ar | 5.69                               | 1    | Al-Te | 268 ± 13                           | 1    | Ar-Xe | 5.28                               | 1    |
| Ag-Bi | 192 ± 42                           | 1    | Al-As | 202.7 ± 7.1                        | 1    | Al-Ti | 263.4                              | 1    | Ar-Zn | 5.0                                | 1    |
| Ag-Br | 280.3 ± 1.3                        | 1    | Al-Au | 325.9 ± 6.3                        | 1    | Al-U  | 326 ± 29                           | 1    | As-As | 385.8 ± 10.5                       | 1    |
| Ag-Cl | 279.1 ± 8.4                        | 1    | Al-Br | 429.2 ± 5.8                        | 1    | Al-V  | 147.4 ± 1.0                        | 1    | As-Cl | 448                                | 1    |
| Ag-Cu | 171.5 ± 9.6                        | 1    | Al-C  | 267.7                              | 1    | Al-Xe | 7.39                               | 1    | As-D  | 270.3                              | 1    |
| Ag-D  | 226.8                              | 1    | Al-Ca | 52.7                               | 1    | Am-O  | 553 ± 36                           | 1    | As-F  | 410                                | 1    |
| Ag-Dy | 130 ± 19                           | 1    | Al-Cl | 502                                | 1    | Ar-Ar | 4.91                               | 1    | As-Ga | 202.5 ± 4.8                        | 1    |
| Ag-Eu | 127 ± 13                           | 1    | Al-Co | 181.6 ± 0.2                        | 1    | Ar-B  | 4.62                               | 1    | As-H  | 274.0 ± 2.9                        | 1    |
| Ag-F  | 356.9 ± 5.8                        | 1    | Al-Cr | 222.9 ± 0.9                        | 1    | Ar-Br | ~5.0                               | 1    | As-I  | 296.6 ± 24                         | 1    |
| Ag-Ga | 159 ± 17                           | 1    | Al-Cu | 227.1 ± 1.2                        | 1    | Ar-C  | 5.158                              | 1    | As-In | 201 ± 10                           | 1    |
| Ag-Ge | 174.5 ± 21                         | 1    | Al-D  | 290.4                              | 1    | Ar-Ca | 4.44 ± 0.60                        | 1    | As-N  | 489 ± 2.1                          | 1    |
| Ag-H  | 202.4 ± 9.1                        | 1    | Al-F  | 675                                | 1    | Ar-Cd | 5.57 ± 0.05                        | 1    | As-O  | 484 ± 8                            | 1    |
| Ag-Ho | 124 ± 19                           | 1    | Al-H  | 288 ± 13                           | 1    | Ar-Ga | 3.96                               | 1    | As-P  | 433.5 ± 12.6                       | 1    |
| Ag-I  | 234 ± 29                           | 1    | Al-I  | 369.9 ± 2.1                        | 1    | Ar-Ge | <5.4                               | 1    | As-S  | 379.5 ± 6.3                        | 1    |
| Ag-In | 166.5 ± 4.9                        | 1    | Al-Kr | 6.05                               | 1    | Ar-He | 3.96                               | 1    | As-Sb | 330.5 ± 5.4                        | 1    |
| Ag-Li | 186.1                              | 1    | Al-Li | 76.1                               | 1    | Ar-Hg | 5.32                               | 1    | As-Se | 96                                 | 1    |
| Ag-Mn | 99.2 ± 21                          | 1    | Al-N  | ≤368 ± 15                          | 1    | Ar-I  | ~5.3                               | 1    | As-Tl | 198.3 ± 14.6                       | 1    |
| Ag-Na | 133.1 ± 12.6                       | 1    | Al-Ne | 3.9                                | 1    | Ar-In | 4.18                               | 1    | Au-Au | 226.2 ± 0.5                        | 1    |
| Ag-Nd | <213                               | 1    | Al-Ni | 224.7 ± 4.8                        | 1    | Ar-Kr | 5.11                               | 1    | Au-B  | 367.8 ± 10.5                       | 1    |
| Ag-O  | 221 ± 21                           | 1    | Al-O  | 501.9 ± 10.6                       | 1    | Ar-Li | ~7.82                              | 1    | Au-Ba | 254.8 ± 10.0                       | 1    |
| Ag-S  | 216.7 ± 14.6                       | 1    | Al-P  | 216.7 ± 12.6                       | 1    | Ar-Mg | ~3.7                               | 1    | Au-Be | 237.7 ± 4.0                        | 1    |
| Ag-Se | 210.0 ± 14.6                       | 1    | Al-Pd | 254.4 ± 12.1                       | 1    | Ar-Na | ~4.2                               | 1    | Au-Bi | 293 ± 8.4                          | 1    |
| Ag-Si | 185.1 ± 9.6                        | 1    | Al-S  | 332 ± 10                           | 1    | Ar-Ne | 4.27                               | 1    | Au-Br | 213 ± 21                           | 1    |

| A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|
| Au-Ca | 250.4 ± 4.0                          | 1    | B-H   | 345.2 ± 2.5                          | 1    | Bi-O  | 337.2 ± 12.6                         | 1    | Br-Sb | 314 ± 59                             | 1    |
| Au-Ce | 322 ± 18                             | 1    | B-I   | 361                                  | 1    | Bi-P  | 281.7 ± 13                           | 1    | Br-Sc | 444 ± 63                             | 1    |
| Au-Cl | 280 ± 13                             | 1    | B-Ir  | 512.2 ± 17                           | 1    | Bi-Pb | 142.4 ± 3.0                          | 1    | Br-Se | 297 ± 84                             | 1    |
| Au-Co | 218.0 ± 16.4                         | 1    | B-La  | 335 ± 63                             | 1    | Bi-S  | 315.5 ± 4.6                          | 1    | Br-Si | 358.2 ± 8.4                          | 1    |
| Au-Cr | 223.7 ± 28.9                         | 1    | B-N   | 377.9 ± 8.7                          | 1    | Bi-Sb | 252.7 ± 3.9                          | 1    | Br-Sm | 331.4                                | 1    |
| Au-Cs | 253 ± 3.5                            | 1    | B-Ne  | 3.97                                 | 1    | Bi-Se | 280.3 ± 5.9                          | 1    | Br-Sn | 337 ± 13                             | 1    |
| Au-Cu | 227.1 ± 1.2                          | 1    | B-O   | 809                                  | 1    | Bi-Sn | 193 ± 13                             | 1    | Br-Sr | 365                                  | 1    |
| Au-D  | 322.2                                | 1    | B-P   | 347 ± 16.7                           | 1    | Bi-Te | 232.2 ± 11.3                         | 1    | Br-T  | 372.77                               | 1    |
| Au-Dy | 259 ± 24                             | 1    | B-Pd  | 351.5 ± 16.7                         | 1    | Bi-Tl | 120.9 ± 12.6                         | 1    | Br-Tb | 382.8                                | 1    |
| Au-Eu | 245 ± 12                             | 1    | B-Pt  | 477.8 ± 16.7                         | 1    | Bk-O  | 598                                  | 1    | Br-Th | 364                                  | 1    |
| Au-F  | 294.1                                | 1    | B-Rh  | 475.8 ± 21                           | 1    | Br-Br | 193.859 ± 0.120                      | 1    | Br-Ti | 373                                  | 1    |
| Au-Fe | 187.0 ± 19.3                         | 1    | B-Ru  | 446.9 ± 21                           | 1    | Br-C  | 318.0 ± 8.4                          | 1    | Br-Tl | 331 ± 21                             | 1    |
| Au-Ga | 290 ± 15                             | 1    | B-S   | 577 ± 9.2                            | 1    | Br-Ca | 339                                  | 1    | Br-Tm | 299.1                                | 1    |
| Au-Ge | 273.2 ± 14.6                         | 1    | B-Sc  | 272 ± 63                             | 1    | Br-Cd | 159 ± 96                             | 1    | Br-U  | 377 ± 15                             | 1    |
| Au-H  | 300.5 ± 2.6                          | 4    | B-Se  | 462 ± 14.6                           | 1    | Br-Ce | 373.2                                | 1    | Br-V  | 439 ± 42                             | 1    |
| Au-Ho | 267 ± 35                             | 1    | B-Si  | 317 ± 12                             | 1    | Br-Cl | 219.32 ± 0.05                        | 1    | Br-W  | 329.3                                | 1    |
| Au-I  | 276                                  | 1    | B-Te  | 354 ± 20                             | 1    | Br-Co | 326 ± 42                             | 1    | Br-Xe | 5.94 ± 0.02                          | 1    |
| Au-In | 286.0 ± 5.7                          | 1    | B-Th  | 297 ± 33                             | 1    | Br-Cr | 328.0 ± 24.3                         | 1    | Br-Y  | 481 ± 84                             | 1    |
| Au-La | 457 ± 28                             | 1    | B-Ti  | 272 ± 63                             | 1    | Br-Cs | 389.1 ± 4.2                          | 1    | Br-Yb | 295.4                                | 1    |
| Au-Li | 284.5 ± 6.7                          | 1    | B-U   | 322 ± 33                             | 1    | Br-Cu | 331 ± 25                             | 1    | Br-Zn | 138 ± 29                             | 1    |
| Au-Lu | 332 ± 19                             | 1    | B-Y   | 289 ± 63                             | 1    | Br-D  | 370.74                               | 1    | Br-Zr | 420                                  | 1    |
| Au-Mg | 179.1 ± 2.7                          | 1    | Ba-Br | 402                                  | 1    | Br-Dy | 339.3 ± 10.5                         | 1    | C-C   | 618.3 ± 15.4                         | 1    |
| Au-Mn | 197.7 ± 21                           | 1    | Ba-Cl | 443                                  | 1    | Br-Er | 361.3                                | 1    | C-Ce  | 443 ± 30                             | 1    |
| Au-Na | 215.1 ± 12.6                         | 1    | Ba-D  | ≤193.7                               | 1    | Br-Eu | 548                                  | 1    | C-Cl  | 394.9 ± 13.4                         | 1    |
| Au-Nd | 294 ± 29                             | 1    | Ba-F  | 580.6                                | 1    | Br-F  | 280 ± 12                             | 1    | C-D   | 341.4                                | 1    |
| Au-Ni | 247 ± 16.4                           | 1    | Ba-H  | 192.0                                | 1    | Br-Fe | 243 ± 84                             | 1    | C-F   | 513.8 ± 10.0                         | 1    |
| Au-O  | 223 ± 21                             | 1    | Ba-I  | 322.6 ± 6.3                          | 1    | Br-Ga | 402 ± 13                             | 1    | C-Fe  | 376.3 ± 28.9                         | 1    |
| Au-Pb | 133 ± 42                             | 1    | Ba-O  | 562 ± 13.4                           | 1    | Br-Gd | 372.0                                | 1    | C-Ge  | 455.7 ± 11                           | 1    |
| Au-Pd | 142.7 ± 21                           | 1    | Ba-Pd | 221.8 ± 5.0                          | 1    | Br-Ge | 347 ± 8                              | 1    | C-H   | 338.4 ± 1.2                          | 1    |
| Au-Pr | 311 ± 25                             | 1    | Ba-Rh | 259.4 ± 25                           | 1    | Br-H  | 366.16 ± 0.20                        | 1    | C-Hf  | 540 ± 25                             | 1    |
| Au-Rb | 243 ± 3.5                            | 1    | Ba-S  | 418 ± 21                             | 1    | Br-Hg | 74.9                                 | 1    | C-I   | 253.1 ± 35.6                         | 1    |
| Au-Rh | 232.6 ± 29                           | 1    | Be-Be | 59                                   | 1    | Br-Ho | 321.8                                | 1    | C-Ir  | 631 ± 5                              | 1    |
| Au-S  | 253.6 ± 14.6                         | 1    | Be-Br | 316                                  | 1    | Br-I  | 179.1 ± 0.4                          | 1    | C-La  | 463 ± 20                             | 1    |
| Au-Sc | 280 ± 40                             | 1    | Be-Cl | 434                                  | 1    | Br-In | 409 ± 10                             | 1    | C-Mo  | 482 ± 16                             | 1    |
| Au-Se | 251.0 ± 14.6                         | 1    | Be-D  | 203.1                                | 1    | Br-K  | 379.1 ± 4.2                          | 1    | C-N   | 750.0 ± 2.9                          | 1    |
| Au-Si | 304.6 ± 6.0                          | 1    | Be-F  | 573                                  | 1    | Br-La | 446.2                                | 1    | C-Nb  | 523.8 ± 14.5                         | 1    |
| Au-Sn | 256.5 ± 7.2                          | 1    | Be-H  | 221                                  | 1    | Br-Li | 418.8 ± 4.2                          | 1    | C-Ni  | 337.0                                | 1    |
| Au-Sr | 264 ± 42                             | 1    | Be-I  | 261                                  | 1    | Br-Lu | 301.5                                | 1    | C-O   | 1076.38 ± 0.67                       | 1    |
| Au-Tb | 285 ± 33                             | 1    | Be-O  | 437                                  | 1    | Br-Mg | 317.96                               | 1    | C-Os  | 608 ± 25                             | 1    |
| Au-Te | 237.2 ± 14.6                         | 1    | Be-S  | 372 ± 59                             | 1    | Br-Mn | 314.2 ± 9.6                          | 1    | C-P   | 507.5 ± 8.8                          | 1    |
| Au-U  | 318 ± 29                             | 1    | Be-T  | 204.4                                | 1    | Br-Mo | 313.4                                | 1    | C-Pd  | 436 ± 20                             | 1    |
| Au-V  | 246.0 ± 8.7                          | 1    | Bi-Bi | 204.4                                | 1    | Br-N  | 280.8 ± 21                           | 1    | C-Pt  | 577.8 ± 6.8                          | 13   |
| Au-Y  | 310 ± 12                             | 1    | Bi-Br | 240.2                                | 1    | Br-Na | 363.1 ± 4.2                          | 1    | C-Rh  | 580 ± 4                              | 1    |
| B-B   | 290                                  | 1    | Bi-Cl | 300.4 ± 4.2                          | 1    | Br-Nd | 339.7                                | 1    | C-Ru  | 648 ± 13                             | 1    |
| B-Br  | 390.9 ± 0.5                          | 1    | Bi-D  | 283.7                                | 1    | Br-Ni | 360 ± 13                             | 1    | C-S   | 713.3 ± 1.2                          | 1    |
| B-C   | 448 ± 29                             | 1    | Bi-F  | 366.5 ± 12.5                         | 1    | Br-O  | 237.6 ± 0.4                          | 1    | C-Sc  | 444 ± 21                             | 1    |
| B-Cd  | 301.0                                | 1    | Bi-Ga | 158.6 ± 16.7                         | 1    | Br-P  | ≤329                                 | 1    | C-Se  | 590.4 ± 5.9                          | 1    |
| B-Ce  | 305 ± 21                             | 1    | Bi-H  | ≤283.3                               | 1    | Br-Pb | 248.5 ± 14.6                         | 1    | C-Si  | 447                                  | 1    |
| B-Cl  | 427                                  | 1    | Bi-I  | 186.1 ± 5.8                          | 1    | Br-Pr | 344.5                                | 1    | C-Tc  | 564 ± 29                             | 1    |
| B-D   | 341.0 ± 6.3                          | 1    | Bi-In | 153.6 ± 1.7                          | 1    | Br-Rb | 380.7 ± 4.2                          | 1    | C-Th  | 453 ± 17                             | 1    |
| B-F   | 732                                  | 1    | Bi-Li | 149.4                                | 1    | Br-S  | 218 ± 17                             | 1    | C-Ti  | 423 ± 30                             | 1    |

| A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|
| C-U   | 455 ± 15                             | 1    | Cl-Cu | 377.8 ± 7.5                          | 1    | Cl-Yb | 374.5                                | 1    | Cu-In | 187.4 ± 7.9                          | 1    |
| C-V   | 423 ± 24                             | 1    | Cl-D  | 436.303 ± 0.011                      | 1    | Cl-Zn | 229 ± 8                              | 1    | Cu-Li | 191.9                                | 1    |
| C-Y   | 418 ± 14                             | 1    | Cl-Dy | 392.4                                | 1    | Cl-Zr | 530                                  | 1    | Cu-Na | 176.1 ± 16.7                         | 1    |
| C-Zr  | 495.8 ± 38.6                         | 1    | Cl-Er | 448.6                                | 1    | Cm-O  | 732                                  | 1    | Cu-Ni | 201.7 ± 9.6                          | 1    |
| Ca-Ca | 16.52 ± 0.11                         | 1    | Cl-Eu | 405.5                                | 1    | Co-Co | <127                                 | 1    | Cu-O  | 287.4 ± 11.6                         | 1    |
| Ca-Cl | 409 ± 8.7                            | 1    | Cl-F  | 260.83                               | 1    | Co-Cu | 161.1 ± 16.4                         | 1    | Cu-S  | 274.5 ± 14.6                         | 1    |
| Ca-D  | ≤169.9                               | 1    | Cl-Fe | 335.5                                | 11   | Co-D  | 270.2 ± 5.8                          | 1    | Cu-Se | 255.2 ± 14.6                         | 1    |
| Ca-F  | 529                                  | 1    | Cl-Ga | 463 ± 13                             | 1    | Co-F  | 431 ± 63                             | 1    | Cu-Si | 221.3 ± 6.3                          | 1    |
| Ca-H  | 223.8                                | 1    | Cl-Gd | 451.0                                | 1    | Co-Ge | 230 ± 21                             | 1    | Cu-Sn | 170 ± 10                             | 1    |
| Ca-I  | 284.7 ± 8.4                          | 1    | Cl-Ge | 390.8 ± 9.6                          | 1    | Co-H  | 244.9 ± 4.8                          | 1    | Cu-Tb | 191 ± 18                             | 1    |
| Ca-Kr | 5.15 ± 0.72                          | 1    | Cl-H  | 431.361 ± 0.013                      | 1    | Co-I  | 280 ± 21                             | 1    | Cu-Te | 230.5 ± 14.6                         | 1    |
| Ca-Li | 84.9 ± 8.4                           | 1    | Cl-Hg | 92.0 ± 9.2                           | 1    | Co-Mn | 50 ± 8                               | 1    | D-D   | 443.3197 ± 0.0003                    | 1    |
| Ca-O  | 383.3 ± 5.0                          | 1    | Cl-Ho | 409.1                                | 1    | Co-Nb | 267.02 ± 0.10                        | 1    | D-F   | 576.236 ± 0.011                      | 1    |
| Ca-Pd | 347 - 360                            | 1    | Cl-I  | 211.3 ± 0.4                          | 1    | Co-O  | 397.4 ± 8.7                          | 1    | D-Ga  | <276.5                               | 1    |
| Ca-S  | 335 ± 21                             | 1    | Cl-In | 436 ± 8                              | 1    | Co-S  | 331                                  | 1    | D-Ge  | ≤322                                 | 1    |
| Ca-Xe | 7.31 ± 0.96                          | 1    | Cl-K  | 433.0 ± 8.4                          | 1    | Co-Sc | 240.1                                | 7    | D-H   | 439.2223 ± 0.0002                    | 1    |
| Cd-Cd | 7.36                                 | 1    | Cl-La | 521.6                                | 1    | Co-Si | 274.4 ± 17                           | 1    | D-Hg  | 42.05                                | 1    |
| Cd-Cl | 208.4                                | 1    | Cl-Li | 469 ± 13                             | 1    | Co-Ti | 235.37 ± 0.10                        | 1    | D-I   | 302.33                               | 1    |
| Cd-F  | 305 ± 21                             | 1    | Cl-Lu | 325.7 ± 2                            | 1    | Co-Y  | 253.71 ± 0.10                        | 1    | D-In  | 246                                  | 1    |
| Cd-H  | 69.0 ± 0.4                           | 1    | Cl-Mg | 312                                  | 1    | Co-Zr | 306.39 ± 0.10                        | 1    | D-K   | 182.4                                | 1    |
| Cd-I  | 97.2 ± 2.1                           | 1    | Cl-Mn | 337.6                                | 11   | Cr-Cr | 152.0 ± 6                            | 1    | D-Li  | 240.24                               | 1    |
| Cd-In | 134                                  | 1    | Cl-N  | 333.9 ± 9.6                          | 1    | Cr-Cu | 154.4 ± 14.5                         | 1    | D-Lu  | 302                                  | 1    |
| Cd-K  | 7.3                                  | 1    | Cl-Na | 412.1 ± 8.4                          | 1    | Cr-F  | 523 ± 19                             | 1    | D-Mg  | 161.33 ± 0.32                        | 1    |
| Cd-Kr | 5.17                                 | 1    | Cl-Nd | 418.7                                | 1    | Cr-Fe | ~75                                  | 1    | D-Mn  | 312 ± 6                              | 1    |
| Cd-Na | 10.2                                 | 1    | Cl-Ni | 372.3                                | 11   | Cr-Ge | 154 ± 7                              | 1    | D-N   | 341.6                                | 1    |
| Cd-Ne | 3.97                                 | 1    | Cl-O  | 267.47 ± 0.08                        | 1    | Cr-H  | 189.9 ± 6.7                          | 1    | D-Ni  | ≤302.9                               | 1    |
| Cd-O  | 236 ± 84                             | 1    | Cl-P  | ≤376                                 | 1    | Cr-I  | 287.0 ± 24.3                         | 1    | D-O   | 429.64                               | 1    |
| Cd-S  | 208.5 ± 20.9                         | 1    | Cl-Pb | 301 ± 50                             | 1    | Cr-N  | 377.8 ± 18.8                         | 1    | D-P   | 299.0                                | 1    |
| Cd-Se | 127.6 ± 25.1                         | 1    | Cl-Pr | 423.5                                | 1    | Cr-Nb | 295.72 ± 0.06                        | 1    | D-Pt  | ≤350.2                               | 1    |
| Cd-Te | 100.0 ± 15.1                         | 1    | Cl-Ra | 343 ± 75                             | 1    | Cr-O  | 461 ± 8.7                            | 1    | D-S   | 350.62 ± 1.20                        | 1    |
| Cd-Xe | 6.54                                 | 1    | Cl-Rb | 427.6 ± 8.4                          | 1    | Cr-Pb | 105 ± 2                              | 1    | D-Si  | 302.5                                | 1    |
| Ce-Ce | 251.7                                | 1    | Cl-S  | 241.8                                | 1    | Cr-S  | 331                                  | 1    | D-Sr  | 167.7                                | 1    |
| Ce-Cl | 457.0                                | 1    | Cl-Sb | 360 ± 50                             | 1    | Cr-Sn | 141 ± 3                              | 1    | D-T   | 444.91                               | 1    |
| Ce-F  | 582 ± 42                             | 1    | Cl-Sc | 331                                  | 1    | Cs-Cs | 43.919 ± 0.010                       | 1    | D-Tl  | 193.0                                | 1    |
| Ce-I  | 333.8                                | 1    | Cl-Se | 322                                  | 1    | Cs-F  | 517.1 ± 7.7                          | 1    | D-Zn  | 88.7                                 | 1    |
| Ce-Ir | 575 ± 9                              | 1    | Cl-Si | 416.7 ± 6.3                          | 1    | Cs-H  | 175.364                              | 1    | Dy-Dy | 70.3                                 | 1    |
| Ce-N  | 519 ± 21                             | 1    | Cl-Sm | 418.7                                | 1    | Cs-Hg | 8                                    | 1    | Dy-F  | 531                                  | 1    |
| Ce-O  | 790                                  | 1    | Cl-Sn | 350 ± 8                              | 1    | Cs-I  | 338.5 ± 2.1                          | 1    | Dy-I  | 269.0 ± 8.4                          | 1    |
| Ce-Os | 524 ± 20                             | 1    | Cl-Sr | 409                                  | 1    | Cs-Li | 72.9 ± 1.2                           | 5    | Dy-O  | 615                                  | 1    |
| Ce-Pd | 319 ± 21                             | 1    | Cl-T  | 438.64                               | 1    | Cs-Na | 63.2 ± 1.3                           | 1    | Dy-S  | 414 ± 42                             | 1    |
| Ce-Pt | 550 ± 5                              | 1    | Cl-Ta | 544                                  | 1    | Cs-O  | 293 ± 25                             | 1    | Dy-Se | 322 ± 20                             | 1    |
| Ce-Rh | 545 ± 7                              | 1    | Cl-Tb | 470.1                                | 1    | Cs-Rb | 49.57 ± 0.01                         | 1    | Dy-Te | 234 ± 20                             | 1    |
| Ce-Ru | 494 ± 12                             | 1    | Cl-Th | 489                                  | 1    | Cu-Cu | 201                                  | 1    | Er-Er | 75 ± 29                              | 1    |
| Ce-S  | 569                                  | 1    | Cl-Ti | 405.4 ± 10.5                         | 1    | Cu-D  | 270.3                                | 1    | Er-F  | 565 ± 17                             | 1    |
| Ce-Se | 494.5 ± 14.6                         | 1    | Cl-Tl | 372.8 ± 2.1                          | 1    | Cu-Dy | 144 ± 18                             | 1    | Er-I  | 315.8                                | 1    |
| Ce-Te | 189.4 ± 12.6                         | 1    | Cl-Tm | 378.0                                | 1    | Cu-F  | 414                                  | 1    | Er-O  | 606                                  | 1    |
| Cf-O  | 498                                  | 1    | Cl-U  | 439                                  | 1    | Cu-Ga | 215.9 ± 15                           | 1    | Er-S  | 418 ± 21                             | 1    |
| Cl-Cl | 436.303 ± 0.011                      | 8    | Cl-V  | 477 ± 63                             | 1    | Cu-Ge | 208.8 ± 21                           | 1    | Er-Se | 326 ± 20                             | 1    |
| Cl-Co | 343.9                                | 11   | Cl-W  | 419                                  | 1    | Cu-H  | 254.8 ± 6                            | 1    | Er-Te | 238 ± 20                             | 1    |
| Cl-Cr | 380.3                                | 11   | Cl-Xe | 7.08                                 | 1    | Cu-Ho | 144 ± 19                             | 1    | Es-O  | 460                                  | 1    |
| Cl-Cs | 445.7 ± 7.7                          | 1    | Cl-Y  | 523 ± 84                             | 1    | Cu-I  | 289 ± 63                             | 1    | Eu-Eu | 45.2                                 | 1    |

| A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|
| Eu-F  | 544                                  | 1    | F-Ti  | 569 ± 33                             | 1    | H-Hg  | 39.844                               | 1    | Hg-T  | 43.14                                | 1    |
| Eu-I  | 288.3                                | 1    | F-Tl  | 439 ± 21                             | 1    | H-I   | 298.26 ± 0.10                        | 1    | Hg-Te | <142                                 | 1    |
| Eu-Li | 268.1 ± 12.6                         | 1    | F-Tm  | 510                                  | 1    | H-In  | 243.1                                | 1    | Hg-Tl | 2.9                                  | 1    |
| Eu-O  | 473                                  | 1    | F-U   | 648                                  | 1    | H-K   | 174.576                              | 1    | Hg-Xe | 6.65                                 | 1    |
| Eu-Rh | 238 ± 34                             | 1    | F-V   | 590 ± 63                             | 1    | H-Li  | 238.039 ± 0.006                      | 1    | Hg-Zn | 7.3                                  | 1    |
| Eu-S  | 365.7 ± 13.4                         | 1    | F-W   | ≤544                                 | 1    | H-Mg  | 127.18 ± 0.006                       | 10   | Ho-Ho | 70.3                                 | 1    |
| Eu-Se | 302.9 ± 14.6                         | 1    | F-Xe  | 14.18                                | 1    | H-Mn  | 251 ± 5                              | 1    | Ho-I  | 275.1                                | 1    |
| Eu-Te | 251.0 ± 14.6                         | 1    | F-Y   | 685.3 ± 13.4                         | 1    | H-Mo  | 202.5 ± 18.3                         | 9    | Ho-O  | 606                                  | 1    |
| F-F   | 158.670 ± 0.096                      | 1    | F-Yb  | ≥517.6 ± 9.6                         | 1    | H-N   | ≤338.9                               | 1    | Ho-S  | 428.4 ± 14.6                         | 1    |
| F-Fe  | 447                                  | 1    | F-Zn  | 364 ± 63                             | 1    | H-Na  | 185.69 ± 0.29                        | 1    | Ho-Se | 333 ± 15                             | 1    |
| F-Ga  | 584 ± 13                             | 1    | F-Zr  | 627.2 ± 10.5                         | 1    | H-Nb  | >221.9 ± 9.6                         | 1    | Ho-Te | ≤259 ± 15                            | 1    |
| F-Gd  | 590 ± 17                             | 1    | Fe-Fe | 118                                  | 1    | H-Ni  | 240 ± 8                              | 1    | I-I   | 152.25 ± 0.57                        | 1    |
| F-Ge  | 523 ± 13                             | 1    | Fe-Ge | 210.9 ± 29                           | 1    | H-O   | 429.91 ± 0.29                        | 1    | I-In  | 306.9 ± 1.1                          | 1    |
| F-H   | 569.680 ± 0.011                      | 1    | Fe-H  | 148 ± 3                              | 1    | H-P   | 297.0 ± 2.1                          | 1    | I-K   | 322.5 ± 2.1                          | 1    |
| F-Hf  | 650 ± 15                             | 1    | Fe-I  | 123                                  | 1    | H-Pb  | ≤157                                 | 1    | I-Kr  | 5.67                                 | 1    |
| F-Hg  | ~180                                 | 1    | Fe-O  | 407.0 ± 1.0                          | 1    | H-Pd  | 234 ± 25                             | 1    | I-La  | 411.7                                | 1    |
| F-Ho  | 540                                  | 1    | Fe-S  | 328.9 ± 14.6                         | 1    | H-Pt  | 330                                  | 1    | I-Li  | 345.2 ± 4.2                          | 1    |
| F-I   | ≤271.5                               | 1    | Fe-Si | 297 ± 25                             | 1    | H-Rb  | 172.6                                | 1    | I-Lu  | 263.2                                | 1    |
| F-In  | 516 ± 13                             | 1    | Fm-O  | 443                                  | 1    | H-Rh  | 241.0 ± 5.9                          | 1    | I-Mg  | 229                                  | 1    |
| F-K   | 489.2                                | 1    | Ga-Ga | <106.4                               | 1    | H-Ru  | 223 ± 15                             | 1    | I-Mn  | 282.8 ± 9.6                          | 1    |
| F-Kr  | 6.6                                  | 1    | Ga-H  | 265.9 ± 5.9                          | 4    | H-S   | 353.57 ± 0.30                        | 1    | I-Mo  | 266.9                                | 1    |
| F-La  | 659.0 ± 17.2                         | 1    | Ga-I  | 334 ± 13                             | 1    | H-Sb  | 239.7 ± 4.2                          | 1    | I-N   | 159 ± 17                             | 1    |
| F-Li  | 577 ± 21                             | 1    | Ga-In | 94.0 ± 3                             | 1    | H-Sc  | 205 ± 17                             | 1    | I-Na  | 304.2 ± 2.1                          | 1    |
| F-Lu  | 405 ± 19                             | 1    | Ga-Kr | 4.08                                 | 1    | H-Se  | 312.5                                | 1    | I-Nd  | 301.5                                | 1    |
| F-Mg  | 463                                  | 1    | Ga-Li | 133.1 ± 14.6                         | 1    | H-Si  | 293.3 ± 1.9                          | 1    | I-Ni  | 293 ± 21                             | 1    |
| F-Mn  | 445.2 ± 7.5                          | 1    | Ga-O  | 374 ± 21                             | 1    | H-Sn  | 264 ± 17                             | 1    | I-O   | 233.4 ± 1.3                          | 12   |
| F-Mo  | 464                                  | 1    | Ga-P  | 229.7 ± 12.6                         | 1    | H-Sr  | 164 ± 8                              | 1    | I-Pb  | 194 ± 38                             | 1    |
| F-N   | ≤349                                 | 1    | Ga-Sb | 192.0 ± 12.6                         | 1    | H-T   | 440.49                               | 1    | I-Pr  | 306.2                                | 1    |
| F-Na  | 477.3                                | 1    | Ga-Te | 265 ± 21                             | 1    | H-Te  | 270.7 ± 1.7                          | 1    | I-Rb  | 318.8 ± 2.1                          | 1    |
| F-Nd  | 545.2 ± 12.6                         | 1    | Ga-Xe | 5.27                                 | 1    | H-Ti  | 204.6 ± 8.8                          | 1    | I-Si  | 243.1 ± 8.4                          | 1    |
| F-Ni  | 439.7 ± 5.9                          | 2    | Gd-Gd | 206.3 ± 67.5                         | 1    | H-Tl  | 195.4 ± 4                            | 1    | I-Sm  | 293.1                                | 1    |
| F-Np  | 430 ± 50                             | 1    | Gd-I  | 333.8                                | 1    | H-V   | 209.3 ± 6.8                          | 1    | I-Sn  | 235 ± 3                              | 1    |
| F-O   | 220                                  | 1    | Gd-O  | 715                                  | 1    | H-Yb  | 183.1 ± 2.0                          | 1    | I-Sr  | 301                                  | 1    |
| F-P   | ≤405                                 | 1    | Gd-S  | 526.8 ± 10.5                         | 1    | H-Zn  | 85.8 ± 2                             | 1    | I-Tb  | 336.2                                | 1    |
| F-Pb  | 355 ± 13                             | 1    | Gd-Se | 430 ± 15                             | 1    | He-He | 3.809                                | 1    | I-Te  | 192 ± 42                             | 1    |
| F-Pr  | 582 ± 46                             | 1    | Gd-Te | 341 ± 15                             | 1    | He-Hg | 3.8                                  | 1    | I-Th  | 361 ± 25                             | 1    |
| F-Pu  | 538 ± 29                             | 1    | Ge-Ge | 264.4 ± 6.8                          | 1    | He-Xe | 3.8                                  | 1    | I-Ti  | 306                                  | 1    |
| F-Rb  | 494 ± 21                             | 1    | Ge-H  | 263.2 ± 4.8                          | 1    | Hf-Hf | 328 ± 58                             | 1    | I-Tl  | 285 ± 21                             | 1    |
| F-Ru  | 402                                  | 1    | Ge-I  | 268 ± 25                             | 1    | Hf-N  | 535 ± 30                             | 1    | I-Tm  | 260.8                                | 1    |
| F-S   | 343.5 ± 6.7                          | 1    | Ge-Ni | 290.3 ± 10.9                         | 1    | Hf-O  | 801 ± 13                             | 1    | I-U   | 299 ± 27                             | 1    |
| F-Sb  | 439 ± 96                             | 1    | Ge-O  | 657.5 ± 4.6                          | 4    | Hg-Hg | 8.10 ± 0.18                          | 1    | I-Xe  | ~6.9                                 | 1    |
| F-Sc  | 599.1 ± 13.4                         | 1    | Ge-Pb | 145.3 ± 6.9                          | 6    | Hg-I  | 34.69 ± 0.96                         | 1    | I-Y   | 422.6 ± 12.5                         | 1    |
| F-Se  | 339 ± 42                             | 1    | Ge-Pd | 254.7 ± 10.5                         | 1    | Hg-K  | 8.8                                  | 1    | I-Yb  | 257.3                                | 1    |
| F-Si  | 576.4 ± 17                           | 1    | Ge-S  | 534 ± 3                              | 1    | Hg-Kr | 5.75                                 | 1    | I-Zn  | 153.1 ± 6.3                          | 1    |
| F-Sm  | 565                                  | 1    | Ge-Sc | 270 ± 11                             | 1    | Hg-Li | 13.16 ± 0.38                         | 1    | I-Zr  | 127                                  | 1    |
| F-Sn  | 476 ± 8                              | 1    | Ge-Se | 484.7 ± 1.7                          | 1    | Hg-Na | 10.8                                 | 1    | In-In | 82.0 ± 5.7                           | 1    |
| F-Sr  | 538                                  | 1    | Ge-Si | 297                                  | 1    | Hg-Ne | 4.14                                 | 1    | In-Kr | 4.85                                 | 1    |
| F-T   | 579.009 ± 0.108                      | 1    | Ge-Sn | 230.1 ± 13                           | 1    | Hg-O  | 269                                  | 1    | In-Li | 92.5 ± 14.6                          | 1    |
| F-Ta  | 573 ± 13                             | 1    | Ge-Te | 396.7 ± 3.3                          | 1    | Hg-Rb | 8.4                                  | 1    | In-O  | 346 ± 30                             | 1    |
| F-Tb  | 561 ± 42                             | 1    | Ge-Y  | 279 ± 11                             | 1    | Hg-S  | 217.3 ± 22.2                         | 1    | In-P  | 197.9 ± 8.4                          | 1    |
| F-Th  | 652                                  | 1    | H-H   | 435.7799 ± 0.0001                    | 1    | Hg-Se | 144.3 ± 30.1                         | 1    | In-S  | 287.9 ± 14.6                         | 1    |

| A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|
| In-Sb | 151.9 ± 10.5                         | 1    | Lr-O  | 665                                  | 1    | Nd-Te | 305 ± 15                             | 1    | O-Zr  | 766.1 ± 10.6                         | 1    |
| In-Se | 245.2 ± 14.6                         | 1    | Lu-Lu | 142 ± 33                             | 1    | Ne-Ne | 4.070                                | 1    | Os-Os | 415 ± 77                             | 1    |
| In-Te | 215.5 ± 14.6                         | 1    | Lu-O  | 669                                  | 1    | Ne-Xe | 4.31                                 | 1    | P-P   | 489.1                                | 1    |
| In-Xe | 6.48                                 | 1    | Lu-Pt | 402 ± 34                             | 1    | Ne-Zn | 3.92                                 | 1    | P-Pt  | ≤416.7 ± 16.7                        | 1    |
| In-Zn | 32.2                                 | 1    | Lu-S  | 508.4 ± 14.4                         | 1    | Ni-Ni | 204                                  | 1    | P-Rh  | 353.1 ± 16.7                         | 1    |
| Ir-Ir | 361 ± 68                             | 1    | Lu-Se | 418 ± 15                             | 1    | Ni-O  | 366 ± 30                             | 1    | P-S   | 442 ± 10                             | 1    |
| Ir-La | 577 ± 12                             | 1    | Lu-Te | 325 ± 15                             | 1    | Ni-Pd | 140.9                                | 1    | P-Sb  | 356.9 ± 4.2                          | 1    |
| Ir-Nb | 465 ± 25                             | 1    | Md-O  | 418                                  | 1    | Ni-Pt | 273.7 ± 0.3                          | 1    | P-Se  | 363.7 ± 10.0                         | 1    |
| Ir-O  | 414 ± 42                             | 1    | Mg-Mg | 11.3                                 | 1    | Ni-S  | 356 ± 21                             | 1    | P-Si  | 363.6                                | 1    |
| Ir-Si | 462.8 ± 21                           | 1    | Mg-Ne | ~4.1                                 | 1    | Ni-Si | 318 ± 17                             | 1    | P-Te  | 297.9 ± 10.0                         | 1    |
| Ir-Th | 574 ± 42                             | 1    | Mg-O  | 358.2 ± 7.2                          | 1    | Ni-V  | 206.3 ± 0.2                          | 1    | P-Th  | 372 ± 29                             | 1    |
| Ir-Ti | 422 ± 13                             | 1    | Mg-S  | 234                                  | 1    | Ni-Y  | 283.92 ± 0.10                        | 1    | P-Tl  | 209 ± 13                             | 1    |
| Ir-Y  | 457 ± 15                             | 1    | Mg-Xe | 9.70 ± 1.79                          | 1    | Ni-Zr | 279.8 ± 0.1                          | 1    | P-U   | 293 ± 21                             | 1    |
| K-K   | 56.96                                | 1    | Mn-Mn | 61.6 ± 9.6                           | 1    | No-O  | 268                                  | 1    | P-W   | 305 ± 4                              | 1    |
| K-Kr  | 4.6                                  | 1    | Mn-O  | 362 ± 25                             | 1    | Np-O  | 731                                  | 1    | Pb-Pb | 86.6 ± 0.8                           | 1    |
| K-Li  | 82.0 ± 4.2                           | 1    | Mn-S  | 301 ± 17                             | 1    | O-O   | 498.36 ± 0.17                        | 1    | Pb-S  | 398                                  | 1    |
| K-Na  | 65.994 ± 0.008                       | 1    | Mn-Se | 239.3 ± 9.2                          | 1    | O-Os  | 575                                  | 1    | Pb-Sb | 161.5 ± 10.5                         | 1    |
| K-Zn  | 6.5                                  | 1    | Mo-Mo | 435.5 ± 1.0                          | 1    | O-P   | 589                                  | 1    | Pb-Se | 302.9 ± 4.2                          | 1    |
| K-O   | 271.5 ± 12.6                         | 1    | Mo-Nb | 452 ± 25                             | 1    | O-Pa  | 792                                  | 1    | Pb-Si | 168.8 ± 7.3                          | 6    |
| K-Rb  | 53.723 ± 0.005                       | 1    | Mo-O  | 502                                  | 1    | O-Pb  | 382.4 ± 3.3                          | 4    | Pb-Te | 249.8 ± 10.5                         | 1    |
| K-Xe  | 5.0                                  | 1    | N-N   | 944.84 ± 0.10                        | 1    | O-Pd  | 238.1 ± 12.6                         | 1    | Pd-Pd | >136                                 | 1    |
| Kr-Kr | 5.39                                 | 1    | N-O   | 631.62 ± 0.18                        | 1    | O-Pr  | 740                                  | 1    | Pd-Pt | 191.0                                | 1    |
| Kr-Li | ~12.1                                | 1    | N-P   | 617.1 ± 20.9                         | 1    | O-Pt  | 418.6 ± 11.6                         | 13   | Pd-Si | 261 ± 12                             | 1    |
| Kr-Mg | 6.71 ± 0.96                          | 1    | N-Pt  | 374.2 ± 9.6                          | 1    | O-Pu  | 656.1                                | 1    | Pd-Y  | 241 ± 15                             | 1    |
| Kr-Na | ~4.53                                | 1    | N-Pu  | 469 ± 63                             | 1    | O-Rb  | 276 ± 12.6                           | 1    | Po-Po | 187                                  | 1    |
| Kr-Ne | 4.31                                 | 1    | N-S   | 467 ± 24                             | 1    | O-Re  | 627 ± 84                             | 1    | Pr-Pr | 129.1                                | 1    |
| Kr-O  | <8                                   | 1    | N-Sb  | 460 ± 84                             | 1    | O-Rh  | 405 ± 42                             | 1    | Pr-S  | 492.5 ± 4.6                          | 1    |
| Kr-Tl | 4.14                                 | 1    | N-Sc  | 464 ± 84                             | 1    | O-Ru  | 528 ± 42                             | 1    | Pr-Se | 446.4 ± 23.0                         | 1    |
| Kr-Xe | 5.66                                 | 1    | N-Si  | 437.1 ± 9.9                          | 1    | O-S   | 517.90 ± 0.05                        | 1    | Pr-Te | 326 ± 20                             | 1    |
| Kr-Zn | 5.0                                  | 1    | N-Ta  | 607 ± 84                             | 1    | O-Sb  | 434 ± 42                             | 1    | Pt-Pt | 306.7 ± 1.9                          | 1    |
| La-La | 244.9                                | 1    | N-Th  | 577 ± 33                             | 1    | O-Sc  | 671.4 ± 1.0                          | 1    | Pt-Si | 501 ± 18                             | 1    |
| La-N  | 519 ± 42                             | 1    | N-Ti  | 476 ± 33                             | 1    | O-Se  | 429.7 ± 6.3                          | 1    | Pt-Th | 551 ± 42                             | 1    |
| La-O  | 798                                  | 1    | N-U   | 531 ± 21                             | 1    | O-Si  | 799.6 ± 13.4                         | 1    | Pt-Ti | 397.5 ± 10.6                         | 1    |
| La-Pt | 505 ± 12                             | 1    | N-V   | 523 ± 38                             | 1    | O-Sm  | 573                                  | 1    | Pt-Y  | 474 ± 12                             | 1    |
| La-Rh | 550 ± 12                             | 1    | N-Xe  | 26.9                                 | 1    | O-Sn  | 528                                  | 1    | Rb-Rb | 48.898 ± 0.005                       | 1    |
| La-S  | 573.4 ± 1.7                          | 1    | N-Y   | 477 ± 63                             | 1    | O-Sr  | 426.3 ± 6.3                          | 1    | Re-Re | 432 ± 30                             | 1    |
| La-Se | 485.7 ± 14.6                         | 1    | N-Zr  | 565 ± 25                             | 1    | O-Ta  | 839                                  | 1    | Rh-Rh | 235.85 ± 0.05                        | 1    |
| La-Te | 385.6 ± 15                           | 1    | Na-Na | 74.805 ± 0.586                       | 1    | O-Tb  | 694                                  | 1    | Rh-Sc | 444 ± 11                             | 1    |
| La-Y  | 197 ± 21                             | 1    | Na-Ne | ~3.8                                 | 1    | O-Tc  | 548                                  | 1    | Rh-Si | 395.0 ± 18.0                         | 1    |
| Li-Li | 105.0                                | 1    | Na-O  | 270 ± 4                              | 1    | O-Te  | 377 ± 21                             | 1    | Rh-Th | 513 ± 21                             | 1    |
| Li-Mg | 67.4 ± 6.3                           | 1    | Na-Rb | 63.887 ± 0.024                       | 1    | O-Th  | 877                                  | 1    | Rh-Ti | 390.8 ± 14.6                         | 1    |
| Li-Na | 87.181 ± 0.001                       | 1    | Na-Xe | ~5.12                                | 1    | O-Ti  | 666.5 ± 5.6                          | 1    | Rh-U  | 519 ± 17                             | 1    |
| Li-O  | 340.5 ± 6.3                          | 1    | Nb-Nb | 513                                  | 1    | O-Tl  | 213 ± 84                             | 1    | Rh-V  | 364 ± 29                             | 1    |
| Li-Pb | 78.7 ± 8                             | 1    | Nb-Ni | 271.9 ± 0.1                          | 1    | O-Tm  | 514                                  | 1    | Rh-Y  | 446 ± 11                             | 1    |
| Li-S  | 312.5 ± 7.5                          | 1    | Nb-O  | 726.5 ± 10.6                         | 1    | O-U   | 755                                  | 1    | Ru-Ru | 193.0 ± 19.3                         | 1    |
| Li-Sb | 169.0 ± 10.0                         | 1    | Nb-Ti | 302.0 ± 0.1                          | 1    | O-V   | 637                                  | 1    | Ru-Si | 397.1 ± 21                           | 1    |
| Li-Si | 149                                  | 1    | Nb-V  | 369.3 ± 0.1                          | 1    | O-W   | 720 ± 71                             | 1    | Ru-Th | 592 ± 42                             | 1    |
| Li-Sm | 193.3 ± 18.8                         | 1    | Nd-Nd | 82.8                                 | 1    | O-Xe  | 36.4                                 | 1    | Ru-V  | 414 ± 29                             | 1    |
| Li-Tm | 276.1 ± 14.6                         | 1    | Nd-O  | 703                                  | 1    | O-Y   | 714.1 ± 10.2                         | 1    | S-S   | 425.30                               | 1    |
| Li-Xe | ~12.1                                | 1    | Nd-S  | 471.5 ± 14.6                         | 1    | O-Yb  | 387.7 ± 10                           | 1    | S-Sb  | 378.7                                | 1    |
| Li-Yb | 143.5 ± 12.6                         | 1    | Nd-Se | 393.9                                | 1    | O-Zn  | ≤250                                 | 1    | S-Sc  | 478.2 ± 12.6                         | 1    |

| A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | A-B   | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|-------|--------------------------------------|------|
| S-Se  | 371.1 ± 6.7                          | 1    | Sb-Tl | 126.7 ± 10.5                         | 1    | Si-Te | 429.2                                | 3    | Ti-Ti | 117.6                                | 1    |
| S-Si  | 617 ± 5                              | 1    | Sc-Sc | 163 ± 21                             | 1    | Si-Y  | 258 ± 17                             | 1    | Ti-V  | 203.2 ± 0.1                          | 1    |
| S-Sm  | 389                                  | 1    | Sc-Se | 385 ± 17                             | 1    | Sm-Sm | 54 ± 21                              | 1    | Ti-Zr | 214.3 ± 0.1                          | 1    |
| S-Sn  | 467                                  | 1    | Sc-Si | 227.2 ± 14                           | 1    | Sm-Te | 272.4 ± 14.6                         | 1    | Tl-Tl | 59.4                                 | 1    |
| S-Sr  | 338.5 ± 16.7                         | 1    | Sc-Te | 289 ± 17                             | 1    | Sn-Sn | 187.1 ± 0.3                          | 1    | Tl-Xe | 4.18                                 | 1    |
| S-Ta  | 669.5 ± 13.5                         | 1    | Se-Se | 330.5                                | 1    | Sn-Te | 338.1 ± 6.3                          | 1    | Tm-Tm | 54 ± 17                              | 1    |
| S-Tb  | 515 ± 42                             | 1    | Se-Si | 538 ± 13                             | 1    | Sr-Sr | 16.64 ± 1.12                         | 1    | U-U   | 222 ± 21                             | 1    |
| S-Te  | 335 ± 42                             | 1    | Se-Sm | 331.0 ± 14.6                         | 1    | T-T   | 446.67                               | 1    | V-V   | 269.3 ± 0.1                          | 1    |
| S-Ti  | 418 ± 3                              | 1    | Se-Sn | 401.2 ± 5.9                          | 1    | Ta-Ta | 390 ± 96                             | 1    | V-Zr  | 260.6 ± 0.3                          | 1    |
| S-Tm  | 368 ± 21                             | 1    | Se-Sr | 251.0 ± 12.6                         | 1    | Tb-Tb | 138.8                                | 1    | W-W   | 666                                  | 1    |
| S-U   | 528.4 ± 10.5                         | 1    | Se-Tb | 423 ± 20                             | 1    | Tb-Te | 339 ± 42                             | 1    | Xe-Xe | 6.023                                | 1    |
| S-V   | 449.4 ± 14.6                         | 1    | Se-Te | 293.3                                | 1    | Tc-Tc | 330                                  | 1    | Y-Y   | ~270 ± 39                            | 1    |
| S-Y   | 528.4 ± 10.5                         | 1    | Se-Ti | 381 ± 42                             | 1    | Te-Te | 257.6 ± 4.1                          | 1    | Yb-Yb | 16.3                                 | 1    |
| S-Yb  | 167                                  | 1    | Se-Tm | 274 ± 40                             | 1    | Te-Ti | 289 ± 17                             | 1    | Zn-Zn | 22.2 ± 6.3                           | 1    |
| S-Zn  | 224.8 ± 12.6                         | 1    | Se-V  | 347 ± 21                             | 1    | Te-Tm | 182 ± 40                             | 1    | Zr-Zr | 298.2 ± 0.1                          | 1    |
| S-Zr  | 572.0 ± 11.6                         | 1    | Se-Y  | 435 ± 13                             | 1    | Te-Y  | 339 ± 13                             | 1    |       |                                      |      |
| Sb-Sb | 301.7 ± 6.3                          | 1    | Se-Zn | 170.7 ± 25.9                         | 1    | Te-Zn | 117.6 ± 18.0                         | 1    |       |                                      |      |
| Sb-Te | 277.4 ± 3.8                          | 1    | Si-Si | 310                                  | 1    | Th-Th | ≤289 ± 33                            | 1    |       |                                      |      |

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TABLE 2. Enthalpy of Formation of Gaseous Atoms

| Atom | $\Delta_f H_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Atom | $\Delta_f H_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Atom | $\Delta_f H_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Atom | $\Delta_f H_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|------|-----------------------------------------------|------|------|-----------------------------------------------|------|------|-----------------------------------------------|------|------|-----------------------------------------------|------|
| Ac   | 406                                           | 5    | Cr   | 397.48 ± 4.2                                  | 3    | La   | 431.0 ± 2.1                                   | 4    | Pu   | 345                                           | 6    |
| Ag   | 284.9 ± 0.8                                   | 2    | Cs   | 76.5 ± 1.0                                    | 2    | Li   | 159.3 ± 1.0                                   | 2    | Ra   | 159                                           | 5    |
| Al   | 330.9 ± 4.0                                   | 2    | Cu   | 337.4 ± 1.2                                   | 2    | Lu   | 427.6 ± 2.1                                   | 4    | Rb   | 80.9 ± 0.8                                    | 2    |
| Am   | 284                                           | 6    | Dy   | 290.4 ± 2.1                                   | 4    | Mg   | 147.1 ± 0.8                                   | 2    | Re   | 774 ± 6.3                                     | 1    |
| As   | 302.5 ± 13                                    | 1    | Er   | 316.4 ± 2.1                                   | 4    | Mn   | 283.3 ± 4.2                                   | 3    | Rh   | 556 ± 4                                       | 1    |
| Au   | 368.2 ± 2.1                                   | 1    | Es   | 133                                           | 6    | Mo   | 658.98 ± 3.8                                  | 3    | Ru   | 650.6 ± 6.3                                   | 1    |
| B    | 565 ± 5                                       | 2    | Eu   | 177.4 ± 2.1                                   | 4    | N    | 472.68 ± 0.40                                 | 2    | S    | 277.17 ± 0.15                                 | 2    |
| Ba   | 179.1 ± 5.0                                   | 3    | F    | 79.38 ± 0.30                                  | 2    | Na   | 107.5 ± 0.7                                   | 3    | Sb   | 264.4 ± 2.5                                   | 1    |
| Be   | 324 ± 5                                       | 2    | Fe   | 415.5 ± 1.3                                   | 3    | Nb   | 733.0 ± 8                                     | 3    | Sc   | 377.8 ± 4                                     | 1    |
| Bi   | 209.6 ± 2.1                                   | 1    | Ga   | 271.96 ± 2.1                                  | 3    | Nd   | 326.9 ± 2.1                                   | 4    | Se   | 227.2 ± 4                                     | 1    |
| Bk   | 310                                           | 6    | Gd   | 397.5 ± 2.1                                   | 4    | Ni   | 430.1 ± 8.4                                   | 3    | Si   | 450.0 ± 8                                     | 2    |
| Br   | 111.87 ± 0.12                                 | 3    | Ge   | 372 ± 3                                       | 2    | Np   | 464.8                                         | 6    | Sm   | 206.7 ± 2.1                                   | 4    |
| C    | 716.68 ± 0.45                                 | 2    | H    | 217.998 ± 0.006                               | 2    | O    | 249.229 ± 0.002                               | 7    | Sn   | 301.2 ± 1.5                                   | 2    |
| Ca   | 177.8 ± 0.8                                   | 2    | Hf   | 618.4 ± 6.3                                   | 3    | Os   | 787 ± 6.3                                     | 1    | Sr   | 164.0 ± 1.7                                   | 3    |
| Cd   | 111.80 ± 0.20                                 | 2    | Hg   | 61.38 ± 0.04                                  | 2    | P    | 316.5 ± 1.0                                   | 2    | Ta   | 782.0 ± 2.5                                   | 1    |
| Ce   | 420.1 ± 2.1                                   | 4    | Ho   | 300.6 ± 2.1                                   | 4    | Pa   | 563                                           | 5    | Tb   | 388.7 ± 2.1                                   | 4    |
| Cf   | 196                                           | 6    | I    | 106.76 ± 0.04                                 | 2    | Pb   | 195.2 ± 0.8                                   | 2    | Tc   | 678                                           | 5    |
| Cl   | 121.301 ± 0.008                               | 2    | In   | 243 ± 4                                       | 1    | Pd   | 376.6 ± 2.1                                   | 1    | Te   | 196.6 ± 2.1                                   | 1    |
| Cm   | 386                                           | 6    | Ir   | 669 ± 4                                       | 1    | Pr   | 356.9 ± 2.1                                   | 4    | Th   | 602 ± 6                                       | 2    |
| Co   | 426.7                                         | 3    | K    | 89.0 ± 0.8                                    | 2    | Pt   | 565.7 ± 1.3                                   | 1    | Ti   | 473 ± 3                                       | 2    |



| Atom | $\Delta_f H^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. | Atom | $\Delta_f H^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. | Atom | $\Delta_f H^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. | Atom | $\Delta_f H^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. |
|------|---------------------------------------------|------|------|---------------------------------------------|------|------|---------------------------------------------|------|------|---------------------------------------------|------|
| Tl   | $182.2 \pm 0.4$                             | 1    | U    | $533 \pm 8$                                 | 2    | W    | $851.0 \pm 6.3$                             | 3    | Yb   | $155.6 \pm 2.1$                             | 4    |
| Tm   | $232.2 \pm 2.1$                             | 4    | V    | $515.5 \pm 8$                               | 3    | Y    | $424.7 \pm 2.1$                             | 4    | Zn   | $130.40 \pm 0.40$                           | 2    |
|      |                                             |      |      |                                             |      |      |                                             |      | Zr   | $610.0 \pm 8.4$                             | 3    |

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### TABLE 3. Bond Dissociation Energies in Polyatomic Molecules

The  $D^\circ_{298}$  values in polyatomic molecules are notoriously difficult to measure accurately since the mechanism of the kinetic systems involved in many of the measurements are seldom straightforward. Thus, much lively controversy has taken place in the literature and is likely to continue for some time to come. We will continue updating and presenting our assessment of the most reliable BDE data every year.

The references relating to each of the  $D^\circ_{298}$  values listed in Table 3 are contained in the *Comprehensive Handbook of Chemical Bond Energies*, by Yu-Ran Luo, CRC Press, 2007. Many  $D^\circ_{298}$  in Table 3 are derived from the equation

$$D^\circ_{298}(\text{R-X}) = \Delta_f H^\circ(\text{R}) + \Delta_f H^\circ(\text{X}) - \Delta_f H^\circ(\text{RX})$$

Here, the enthalpies of formation of the atoms and radicals are taken from Tables 2 and 4, respectively, and the enthalpies of formation of the molecules are from reference sources listed in the above *Comprehensive Handbook of Chemical Bond Energies*.

Table 3 presents H-C, C-C, C-halogen, O-, N-, S-, Si-, Ge-, Sn-, Pb-, P-, As-, Sb-, Bi-, Se-, Te-, and metal-X BDEs. The **boldface** in the species indicates the dissociated fragment. The **metal-X** BDEs are arranged on the basis of the Periodic Table with the new IUPAC notation for Groups 1 to 18, see inside front cover of this *Handbook*.

| Bond                                                        | $D^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                               | $D^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                             | $D^\circ_{298}/\text{kJ mol}^{-1}$ | Ref. |
|-------------------------------------------------------------|------------------------------------|------|--------------------------------------------------------------------|------------------------------------|------|------------------------------------------------------------------|------------------------------------|------|
| <b>(1) C-H BDEs</b>                                         |                                    |      | $\text{CH}_2=\text{CHCCCH}_2\text{-H}$                             | 363.3                              | 1    | <b>H-cyclo-C<sub>5</sub>H<sub>9</sub></b>                        | $400.0 \pm 4.2$                    | 1    |
| $\text{CH}_3\text{-H}$                                      | $439.3 \pm 0.4$                    | 1    | $\text{CH}_3\text{CCCH}_2\text{CH}_3$                              | $365.3 \pm 9.6$                    | 1    | <b>H-cyclo-C<sub>6</sub>H<sub>11</sub></b>                       | 416.3                              | 1    |
| $\text{CH}_3\text{CH}_2\text{-H}$                           | $420.5 \pm 1.3$                    | 1    | $\text{HCCCH}_2\text{CH}_2\text{CH}_3$                             | $349.8 \pm 8.4$                    | 1    | <b>H-C<sub>6</sub>H<sub>5</sub></b>                              | $472.2 \pm 2.2$                    | 1    |
| $\text{CH}_3\text{CH}_2\text{CH}_2\text{-H}$                | $422.2 \pm 2.1$                    | 1    | $\text{HCCCH}(\text{CH}_3)_2$                                      | $345.2 \pm 8.4$                    | 1    | <b>H-CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub></b>                | $375.5 \pm 5.0$                    | 1    |
| $\text{CH}_3\text{CH}_2\text{CH}_3$                         | $410.5 \pm 2.9$                    | 1    | $\text{CH}_3\text{CCCH}(\text{CH}_3)_2$                            | $344.3 \pm 11.3$                   | 1    | <b>H-CH(CH<sub>3</sub>)C<sub>6</sub>H<sub>5</sub></b>            | $357.3 \pm 6.3$                    | 1    |
| $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{-H}$     | 421.3                              | 1    | $\text{HCCCCC-H}$                                                  | $\sim 543 \pm 13$                  | 1    | <b>H-CH(C<sub>6</sub>H<sub>5</sub>)<sub>2</sub></b>              | $353.5 \pm 2.1$                    | 1    |
| $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$              | $411.1 \pm 2.2$                    | 1    | $\text{H}_2\text{C=CH-H}$                                          | $464.2 \pm 2.5$                    | 1    | <b>H-CH(C<sub>6</sub>H<sub>4</sub>-p-OH)<sub>2</sub></b>         | $375.8 \pm 4.7$                    | 1    |
| $(\text{CH}_3)_2\text{CHCH}_2\text{-H}$                     | $419.2 \pm 4.2$                    | 1    | $\text{CH}_2=\text{C=CH-H}$                                        | $371.1 \pm 12.6$                   | 1    | <b>H-C(CH<sub>3</sub>)<sub>2</sub>C<sub>6</sub>H<sub>5</sub></b> | $348.1 \pm 4.2$                    | 1    |
| $(\text{CH}_3)_3\text{C-H}$                                 | $400.4 \pm 2.9$                    | 1    | $\text{CH}_3\text{CH=CH-H}$                                        | 464.8                              | 1    | <b>H-C(C<sub>6</sub>H<sub>5</sub>)<sub>3</sub></b>               | $338.9 \pm 8.4$                    | 1    |
| $(\text{CH}_3)_3\text{CCH}_2\text{-H}$                      | $419.7 \pm 4.2$                    | 1    | $\text{CH}_2=\text{CHCH}_2\text{-H}$                               | $369 \pm 3$                        | 1    | <b>1-H-C<sub>10</sub>H<sub>7</sub></b>                           | $469.4 \pm 5.4$                    | 1    |
| $(\text{CH}_3\text{CH}_2)\text{CH}(\text{CH}_3)_2$          | 400.8                              | 1    | $\text{CH}_2=\text{CH-CH}_2\text{CH}_2\text{-H}$                   | 410.5                              | 1    | <b>2-H-C<sub>10</sub>H<sub>7</sub></b>                           | $468.2 \pm 5.9$                    | 1    |
| $\text{CH}_3\text{CH}_2(\text{CH}_2)_2\text{CH}_3$          | 415.1                              | 1    | $\text{CH}_2=\text{CHCH}_2\text{CH}_3$                             | 350.6                              | 1    | <b>H-CF<sub>3</sub></b>                                          | $445.2 \pm 2.9$                    | 1    |
| $(\text{C}_3\text{H}_7)\text{CH}(\text{CH}_3)_2$            | $396.2 \pm 8.4$                    | 1    | $\text{CH}_2=\text{C}(\text{CH}_3)\text{CH}_2\text{-H}$            | 372.8                              | 1    | <b>H-CHF<sub>2</sub></b>                                         | $431.8 \pm 4.2$                    | 1    |
| $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)_2$ | $399.2 \pm 13.0$                   | 1    | $\text{CH}_2=\text{CHCH=CHCH}_2\text{-H}$                          | $347.3 \pm 12.6$                   | 1    | <b>H-CH<sub>2</sub>F</b>                                         | $423.8 \pm 4.2$                    | 1    |
| $\text{CH}_3\text{CH}_2(\text{CH}_2)_3\text{CH}_3$          | 410                                | 1    | $(\text{CH}_2=\text{CH})_2\text{CH-H}$                             | $320.5 \pm 4.2$                    | 1    | <b>H-CClF<sub>2</sub></b>                                        | $421.3 \pm 8.4$                    | 1    |
| $\text{CH}_3\text{CH}_2(\text{CH}_2)_4\text{CH}_3$          | 410                                | 1    | $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{CH}_3$                  | 348.8                              | 1    | <b>H-CCl<sub>2</sub>F</b>                                        | $410.9 \pm 8.4$                    | 1    |
| $\text{HCC-H}$                                              | $557.81 \pm 0.30$                  | 1    | $\text{CH}_2=\text{CHCH}(\text{CH}_3)_2$                           | $332.6 \pm 7.1$                    | 1    | <b>H-CBrF<sub>2</sub></b>                                        | $415.5 \pm 12.6$                   | 1    |
| $\text{HCCCC-H}$                                            | $539 \pm 12$                       | 1    | $\text{CH}_2=\text{C}(\text{CH}_3\text{CH}_2)\text{CH}_2\text{-H}$ | $356.1 \pm 8.4$                    | 1    | <b>H-CHClF</b>                                                   | $421.7 \pm 10.0$                   | 1    |
| $\text{CHCCH}_2\text{-H}$                                   | $384.1 \pm 4.2$                    | 1    | $(\text{CH}_2=\text{CH})_2\text{C}(\text{CH}_3)\text{-H}$          | 322.2                              | 1    | <b>H-CCl<sub>3</sub></b>                                         | $392.5 \pm 2.5$                    | 1    |
| $\text{CH}_3\text{CCCH}_2\text{-H}$                         | 379.5                              | 1    | <b>H-cyclo-C<sub>3</sub>H<sub>5</sub></b>                          | $444.8 \pm 1.0$                    | 1    | <b>H-CHCl<sub>2</sub></b>                                        | $400.6 \pm 2.0$                    | 1    |
| $\text{HCCCH}_2\text{CH}_3$                                 | 373.0                              | 1    | <b>H-CH<sub>2</sub>-cyclo-C<sub>3</sub>H<sub>5</sub></b>           | $407.5 \pm 6.7$                    | 1    | <b>H-CH<sub>2</sub>Cl</b>                                        | $419.0 \pm 2.3$                    | 1    |
|                                                             |                                    |      | <b>H-cyclo-C<sub>4</sub>H<sub>7</sub></b>                          | $409.2 \pm 1.3$                    | 1    | <b>H-CFClBr</b>                                                  | $413 \pm 21$                       | 1    |

| Bond                                               | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                           | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|----------------------------------------------------|--------------------------------------|------|---------------------------------------------------------------------|--------------------------------------|------|--------------------------------------------------------------------------------|--------------------------------------|------|
| H-CHClBr                                           | 406.0 ± 2.4                          | 1    | (CH <sub>2</sub> OH) <sub>2</sub>                                   | 385.3                                | 1    | Me <sub>2</sub> CHC(O)OEt                                                      | 387.4                                | 1    |
| H-CCl <sub>2</sub> Br                              | 387 ± 21                             | 1    | HOCH <sub>2</sub> (CH <sub>2</sub> ) <sub>2</sub>                   | 399.2                                | 1    | PhCHMe(C(O)OEt)                                                                | 358.2                                | 1    |
| H-CClBr <sub>2</sub>                               | 371 ± 21                             | 1    | (OH)CH-H                                                            |                                      |      | H-furaylmethyl                                                                 | 361.9 ± 8.4                          | 1    |
| H-CBr <sub>3</sub>                                 | 399.2 ± 8.4                          | 1    | CH <sub>3</sub> OCH <sub>3</sub>                                    | 402.1                                | 1    | CH <sub>3</sub> NH <sub>2</sub>                                                | 392.9 ± 8.4                          | 1    |
| H-CHBr <sub>2</sub>                                | 412.6 ± 2.7                          | 3    | CHF <sub>2</sub> OCF <sub>3</sub>                                   | 443.5 ± 4.2                          | 1    | CH <sub>3</sub> N=CH <sub>2</sub>                                              | 407.9 ± 14.6                         | 1    |
| H-CH <sub>2</sub> Br                               | 427.2 ± 2.4                          | 1    | CHF <sub>2</sub> OCHF <sub>2</sub>                                  | 435.1 ± 4.2                          | 1    | CH <sub>3</sub> CH <sub>2</sub> NH <sub>2</sub>                                | 377.0 ± 8.4                          | 1    |
| H-Cl <sub>3</sub>                                  | 423 ± 29                             | 1    | CH <sub>3</sub> OCF <sub>3</sub>                                    | 426.8 ± 4.2                          | 1    | C <sub>2</sub> H <sub>5</sub> CH <sub>2</sub> NH <sub>2</sub>                  | 380.7 ± 8.4                          | 1    |
| H-CHI <sub>2</sub>                                 | 431.0 ± 8.4                          | 1    | CH <sub>3</sub> OCH <sub>2</sub> CH <sub>3</sub>                    | 389.1                                | 1    | C <sub>3</sub> H <sub>7</sub> CH <sub>2</sub> NH <sub>2</sub>                  | 393.3 ± 8.4                          | 1    |
| H-CH <sub>2</sub> I                                | 431.6 ± 2.8                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> COC(CH <sub>3</sub> ) <sub>3</sub>  | 402.1                                | 1    | C <sub>4</sub> H <sub>9</sub> CH <sub>2</sub> NH <sub>2</sub>                  | 387.7 ± 8.4                          | 1    |
| CF <sub>3</sub> CF <sub>2</sub> -H                 | 429.7 ± 2.1                          | 1    | CH <sub>3</sub> CH <sub>2</sub> OCH <sub>2</sub> CH <sub>3</sub>    | 389.1                                | 1    | HOCH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub>                              | 379.5 ± 8.4                          | 1    |
| CHF <sub>2</sub> CF <sub>2</sub> -H                | 431.0 ± 18.8                         | 1    | CH <sub>3</sub> CH <sub>2</sub> Ot-C(CH <sub>3</sub> ) <sub>3</sub> | 405.4                                | 1    | (CH <sub>3</sub> CH <sub>2</sub> ) <sub>2</sub> NH                             | 370.7 ± 8.4                          | 1    |
| CH <sub>2</sub> FCF <sub>2</sub> -H                | 433.0 ± 14.6                         | 1    | CH <sub>3</sub> OPh                                                 | 385.0                                | 1    | (C <sub>3</sub> H <sub>7</sub> CH <sub>2</sub> ) <sub>2</sub> NH               | 379.9 ± 8.4                          | 1    |
| CHF <sub>2</sub> CFH-H                             | 426.8 ± 14.6                         | 1    | H-2-oxiran-2-yl                                                     | 420.5 ± 6.5                          | 1    | (C <sub>4</sub> H <sub>9</sub> CH <sub>2</sub> ) <sub>2</sub> NH               | 384.5 ± 8.4                          | 1    |
| CF <sub>3</sub> CH <sub>2</sub> -H                 | 446.4 ± 4.5                          | 1    | H-tetrahydrofuran-2-yl                                              | 385.3 ± 6.7                          | 1    | (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> NCH <sub>2</sub> CH <sub>3</sub> | 379.5 ± 1.7                          | 1    |
| CH <sub>3</sub> CF <sub>2</sub> -H                 | 416.3 ± 4.2                          | 1    | HC(O)-H                                                             | 368.40 ± 0.67                        | 1    | (C <sub>2</sub> H <sub>5</sub> CH <sub>2</sub> ) <sub>3</sub> N                | 376.6 ± 8.4                          | 1    |
| CH <sub>2</sub> FCHF-H                             | 413.4 ± 12.6                         | 1    | FC(O)-H                                                             | 423.0                                | 1    | ((CH <sub>3</sub> ) <sub>2</sub> CCH <sub>2</sub> ) <sub>3</sub> N             | 388.3 ± 8.4                          | 1    |
| CHF <sub>2</sub> CH <sub>2</sub> -H                | 433.0 ± 14.6                         | 1    | CH <sub>3</sub> C(O)-H                                              | 374.0 ± 1.3                          | 1    | (Bu) <sub>2</sub> NCH <sub>2</sub> (nPr)                                       | 381 ± 10.0                           | 1    |
| CH <sub>2</sub> FCH <sub>2</sub> -H                | 433.5 ± 8.4                          | 1    | CF <sub>3</sub> C(O)-H                                              | 390.4                                | 1    | ((CH <sub>3</sub> ) <sub>2</sub> CH) <sub>3</sub> N                            | 387.0 ± 8.4                          | 1    |
| CH <sub>3</sub> CHF-H                              | 410.9 ± 8.4                          | 1    | C <sub>2</sub> H <sub>5</sub> C(O)-H                                | 374.5                                | 1    | (CH <sub>3</sub> ) <sub>2</sub> CHNH <sub>2</sub>                              | 372.0 ± 8.4                          | 1    |
| CF <sub>3</sub> CHCl-H                             | 425.9 ± 6.3                          | 1    | CH <sub>2</sub> =CHC(O)-H                                           | 372.8                                | 1    | CH <sub>3</sub> NHCH <sub>3</sub>                                              | 364.0 ± 8.4                          | 1    |
| CF <sub>3</sub> CClBr-H                            | 404.2 ± 6.3                          | 1    | C <sub>3</sub> H <sub>7</sub> C(O)-H                                | 371.2                                | 1    | (CH <sub>3</sub> ) <sub>3</sub> N                                              | 380.7 ± 8.4                          | 1    |
| CClF <sub>2</sub> CHF-H                            | 412.1 ± 2.1                          | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> C(O)-H                    | 364.5                                | 1    | <i>tert</i> -BuN(CH <sub>3</sub> ) <sub>2</sub>                                | 376.6 ± 8.4                          | 1    |
| CCl <sub>3</sub> CCl <sub>2</sub> -H               | 397.5 ± 8.4                          | 1    | C <sub>4</sub> H <sub>9</sub> C(O)-H                                | 372.0                                | 1    | ((HOCH <sub>2</sub> CH <sub>2</sub> ) <sub>2</sub> (CH <sub>3</sub> ))N        | 364.4 ± 8.4                          | 1    |
| CHCl <sub>2</sub> CCl <sub>2</sub> -H              | 393.3 ± 8.4                          | 1    | (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> C(O)-H            | 362.5                                | 1    | (HOCH <sub>2</sub> CH <sub>2</sub> ) <sub>3</sub> N                            | 379.9 ± 8.4                          | 1    |
| CH <sub>3</sub> CCl <sub>2</sub> -H                | 397.9 ± 5.0                          | 1    | C <sub>2</sub> H <sub>5</sub> CH(CH <sub>3</sub> )C(O)-H            | 360.8                                | 1    | ((HOCH <sub>2</sub> )CH(CH <sub>3</sub> )) <sub>3</sub> N                      | 379.9 ± 8.4                          | 1    |
| CH <sub>3</sub> CHCl-H                             | 406.6 ± 1.5                          | 1    | <i>tert</i> -BuC(O)-H                                               | 375.1                                | 1    | PhCH <sub>2</sub> NH <sub>2</sub>                                              | 368.2                                | 1    |
| CH <sub>2</sub> ClCH <sub>2</sub> -H               | 423.1 ± 2.4                          | 1    | EtCHC(O)-H                                                          | 367.2                                | 1    | PhN(CH <sub>2</sub> CH <sub>3</sub> ) <sub>2</sub>                             | 383.3 ± 4.2                          | 1    |
| CH <sub>3</sub> CBr <sub>2</sub> -H                | 397.1 ± 5.0                          | 1    | CH <sub>3</sub> (CH <sub>2</sub> ) <sub>8</sub> C(O)-H              | 373.3                                | 1    | Ph <sub>2</sub> NCH <sub>3</sub>                                               | 379.5 ± 1.7                          | 1    |
| CH <sub>2</sub> BrCH <sub>2</sub> -H               | 415.1 ± 8.4                          | 1    | C <sub>6</sub> H <sub>5</sub> C(O)-H                                | 371.1 ± 10.9                         | 1    | PhN(CH <sub>2</sub> Ph) <sub>2</sub>                                           | 357.3 ± 8.8                          | 1    |
| CH <sub>3</sub> CHBr-H                             | 415.0 ± 2.7                          | 3    | PhCH <sub>2</sub> C(O)-H                                            | 362.0                                | 1    | N(CH <sub>2</sub> Ph) <sub>3</sub>                                             | 372.8 ± 2.5                          | 1    |
| CF <sub>2</sub> =CF-H                              | 464.4 ± 8.4                          | 1    | PhC(CH <sub>3</sub> ) <sub>2</sub> C(O)-H                           | 362.9                                | 1    | PhN(CH <sub>2</sub> CH=CH <sub>2</sub> ) <sub>2</sub>                          | 339.3 ± 2.9                          | 1    |
| CF <sub>3</sub> CF <sub>2</sub> CF <sub>2</sub> -H | 432.2                                | 1    | H-CH=C=O                                                            | 448.1                                | 1    | N(CH <sub>2</sub> CH=CH <sub>2</sub> ) <sub>3</sub>                            | 345.6 ± 3.3                          | 1    |
| CH <sub>3</sub> CH <sub>2</sub> CHCl-H             | 407.0 ± 3.5                          | 1    | CH <sub>3</sub> C(O)H                                               | 394.5 ± 9.2                          | 1    | H <sub>2</sub> NNH(CH <sub>3</sub> )                                           | 410                                  | 1    |
| CH <sub>2</sub> =CH-CHF-H                          | 370.7 ± 4.6                          | 1    | CH <sub>3</sub> C(O)Cl                                              | ≤423.4                               | 1    | HNN(CH <sub>3</sub> ) <sub>2</sub>                                             | 410                                  | 1    |
| CH <sub>2</sub> =CHCHCl-H                          | 370.7 ± 4.6                          | 1    | CH <sub>3</sub> CH <sub>2</sub> C(O)H                               | 383.7                                | 1    | (CH <sub>3</sub> ) <sub>2</sub> NC <sub>6</sub> H <sub>5</sub>                 | 383.7 ± 5.4                          | 1    |
| CH <sub>2</sub> =CHCHBr-H                          | 374.0 ± 4.6                          | 1    | CH <sub>3</sub> COCH <sub>3</sub>                                   | 401.2 ± 2.9                          | 1    | H-CN                                                                           | 528.5 ± 0.8                          | 1    |
| H-C <sub>6</sub> F <sub>5</sub>                    | 487.4                                | 1    | CF <sub>3</sub> C(O)CH <sub>3</sub>                                 | 465.6                                | 1    | CH <sub>3</sub> CN                                                             | 405.8 ± 4.2                          | 1    |
| H-CH <sub>2</sub> OH                               | 401.92 ± 0.63                        | 1    | CH <sub>3</sub> COCH <sub>2</sub> CH <sub>3</sub>                   | 403.8                                | 1    | CH <sub>3</sub> CH <sub>2</sub> CN                                             | 393.3 ± 12.6                         | 1    |
| CH <sub>2</sub> CHOH                               | 467 ± 11                             | 1    | MeCOCH <sub>2</sub> Me                                              | 386.2 ± 7.1                          | 1    | PhCH <sub>2</sub> CN                                                           | 344.3                                | 1    |
| CH <sub>3</sub> CH <sub>2</sub> OH                 | 401.2 ± 4.2                          | 1    | EtCOCH <sub>2</sub> Me                                              | 396.5 ± 2.8                          | 1    | C <sub>6</sub> F <sub>5</sub> CH <sub>2</sub> CN                               | 350.6                                | 1    |
| CH <sub>3</sub> CH <sub>2</sub> OH                 | 421.7 ± 8                            | 1    | CH <sub>3</sub> CH <sub>2</sub> COC <sub>6</sub> H <sub>5</sub>     | 402.8 ± 3.6                          | 1    | CH <sub>2</sub> (CN) <sub>2</sub>                                              | 366.5                                | 1    |
| CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH | 392                                  | 1    | MeCH <sub>2</sub> COPh                                              | 388.7                                | 1    | CH <sub>2</sub> (CN)(NH <sub>2</sub> )                                         | 355.2                                | 1    |
| CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH | 394.6 ± 8.4                          | 1    | H-C(O)OH                                                            | 404.2                                | 1    | (CH <sub>3</sub> ) <sub>2</sub> CHCN                                           | 384.5                                | 1    |
| CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH | 406.3 ± 8.4                          | 1    | CH <sub>3</sub> C(O)OH                                              | 398.7 ± 12.1                         | 1    | CH <sub>3</sub> NC                                                             | 389.1 ± 12.6                         | 1    |
| (CH <sub>3</sub> ) <sub>2</sub> CHOH               | 383.7 ± 8.4                          | 1    | ClCH <sub>2</sub> C(O)OH                                            | 398.9                                | 1    | H-HCNN                                                                         | 405.8 ± 8.4                          | 1    |
| (CH <sub>3</sub> ) <sub>2</sub> CHOH               | 394.6 ± 8.4                          | 1    | H-C(O)OCH <sub>3</sub>                                              | 399.2 ± 8.4                          | 1    | H-CNN                                                                          | 331 ± 17                             | 1    |
| CH <sub>2</sub> =CHCH <sub>2</sub> OH              | 341.4 ± 7.5                          | 1    | CH <sub>3</sub> C(O)OCH <sub>3</sub>                                | 406.3 ± 10.5                         | 1    | CH <sub>3</sub> NO <sub>2</sub>                                                | 415.4                                | 1    |
| (CH <sub>3</sub> ) <sub>3</sub> COH                | 418.4 ± 8.4                          | 1    | CH <sub>3</sub> C(O)OCH <sub>3</sub>                                | 404.6                                | 1    | CH <sub>3</sub> CH <sub>2</sub> NO <sub>2</sub>                                | 410.5                                | 1    |
| (CH <sub>2</sub> =CH) <sub>2</sub> CHOH            | 288.7                                | 1    | CH <sub>3</sub> C(O)OCH <sub>2</sub> CH <sub>3</sub>                | 401.7                                | 1    | C <sub>2</sub> H <sub>5</sub> CH <sub>2</sub> NO <sub>2</sub>                  | 410.5                                | 1    |
| Ph <sub>2</sub> CHOH                               | 326                                  | 1    | CH <sub>3</sub> C(O)OPh                                             | 419.2 ± 5.4                          | 1    | Me <sub>2</sub> CHNO <sub>2</sub>                                              | 394.9                                | 1    |
| CH <sub>3</sub> CH(OH) <sub>2</sub>                | ~385                                 | 1    | CH <sub>3</sub> CH <sub>2</sub> C(O)OEt                             | 400                                  | 1    | C <sub>6</sub> H <sub>5</sub> C(NO <sub>2</sub> )CHCH <sub>3</sub>             | 357.3                                | 1    |
|                                                    |                                      |      | PhCH <sub>2</sub> C(O)OEt                                           | 370.7                                | 1    |                                                                                |                                      |      |



| Bond                                                                                    | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                                         | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                 | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-----------------------------------------------------------------------------------------|--------------------------------------|------|----------------------------------------------------------------------------------------------|--------------------------------------|------|----------------------------------------------------------------------|--------------------------------------|------|
| H-C(S)H                                                                                 | 399.6 ± 5.0                          | 1    | CH <sub>3</sub> -CHCH <sub>2</sub>                                                           | 426.3 ± 6.3                          | 1    | CCl <sub>3</sub> -CH <sub>2</sub> Cl                                 | 323.8 ± 8.4                          | 1    |
| CH <sub>3</sub> SH                                                                      | 392.9 ± 8.4                          | 1    | CH <sub>3</sub> -CH=CCH <sub>2</sub>                                                         | 359.8 ± 5.9                          | 1    | CCl <sub>3</sub> -CH <sub>3</sub>                                    | 362.3 ± 6.3                          | 1    |
| CH <sub>3</sub> SCH <sub>3</sub>                                                        | 392.0 ± 5.9                          | 1    | CH <sub>3</sub> -cyclopro-en-1-yl                                                            | 340.6 ± 20.9                         | 1    | CHCl <sub>2</sub> -CHCl <sub>2</sub>                                 | 326.9 ± 4.1                          | 1    |
| PhSCH <sub>3</sub>                                                                      | 389.1                                | 1    | CH <sub>3</sub> -CH <sub>2</sub> CH=CH <sub>2</sub>                                          | 317.6 ± 3.8                          | 1    | CHCl <sub>2</sub> -CH <sub>2</sub> Cl                                | 352.2 ± 5.9                          | 1    |
| PhCH <sub>2</sub> SPh                                                                   | 352.3                                | 1    | CH <sub>3</sub> -CH <sub>2</sub> C(CH <sub>3</sub> )=CH <sub>2</sub>                         | 310.0 ± 4.2                          | 1    | CHCl <sub>2</sub> -CH <sub>3</sub>                                   | 361.3 ± 2.5                          | 1    |
| (PhS) <sub>2</sub> CHPh                                                                 | 341.0                                | 1    | CH <sub>3</sub> -CH(CH <sub>3</sub> )CH=CH <sub>2</sub>                                      | 302.5 ± 6.3                          | 1    | CHBrCl-CH <sub>3</sub>                                               | 384.5                                | 1    |
| PhSCHPh <sub>2</sub>                                                                    | 344.8                                | 1    | CH <sub>3</sub> -C(CH <sub>3</sub> ) <sub>2</sub> CH=CH <sub>2</sub>                         | 282.4 ± 6.3                          | 1    | CHClBr-CHClBr                                                        | 317.1 ± 12.6                         | 1    |
| CH <sub>3</sub> SOCH <sub>3</sub>                                                       | 393.3                                | 1    | CH <sub>3</sub> -cyclo-C <sub>5</sub> H <sub>7</sub>                                         | 299.2 ± 8.4                          | 1    | CH <sub>2</sub> Cl-CH <sub>2</sub> Cl                                | 360.7 ± 8.4                          | 1    |
| CH <sub>3</sub> SO <sub>2</sub> CH <sub>3</sub>                                         | 414.2                                | 1    | CH <sub>3</sub> -C <sub>6</sub> H <sub>5</sub>                                               | 426.8 ± 4.2                          | 1    | CH <sub>2</sub> Cl-CH <sub>3</sub>                                   | 375.7 ± 9.2                          | 1    |
| CH <sub>3</sub> SO <sub>2</sub> CF <sub>3</sub>                                         | 431.0                                | 1    | HCC-C <sub>6</sub> H <sub>5</sub>                                                            | 590.8 ± 5.9                          | 1    | Br <sub>3</sub> C-CH <sub>3</sub>                                    | 356.9 ± 12.6                         | 1    |
| CH <sub>3</sub> SO <sub>2</sub> Ph                                                      | 414.2                                | 1    | C <sub>2</sub> H <sub>3</sub> -C <sub>6</sub> H <sub>5</sub>                                 | 482.0 ± 5.4                          | 1    | Br <sub>3</sub> C-CBr <sub>3</sub>                                   | 278.7 ± 16.7                         | 1    |
| PhCH <sub>2</sub> SO <sub>2</sub> Me                                                    | 380.7                                | 1    | CH <sub>3</sub> -CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>                               | 325.1 ± 4.2                          | 1    | CHBr <sub>2</sub> -CH <sub>3</sub>                                   | 372.8                                | 1    |
| PhCH <sub>2</sub> SO <sub>2</sub> CF <sub>3</sub>                                       | 372.4                                | 1    | CH <sub>3</sub> -CH(CH <sub>3</sub> )C <sub>6</sub> H <sub>5</sub>                           | 318.8 ± 8.4                          | 1    | CH <sub>2</sub> Br-CH <sub>2</sub> Cl                                | 378.2                                | 1    |
| PhCH <sub>2</sub> SO <sub>2</sub> tBu                                                   | 376.6                                | 1    | CH <sub>3</sub> -C(CH <sub>3</sub> ) <sub>2</sub> C <sub>6</sub> H <sub>5</sub>              | 303.3 ± 8.4                          | 1    | CH <sub>2</sub> Br-CH <sub>2</sub> Br                                | 379.9 ± 8.4                          | 1    |
| Ph <sub>2</sub> CHSO <sub>2</sub> Ph                                                    | 365.3                                | 1    | CH <sub>3</sub> -CH <sub>2</sub> CHCHPh                                                      | 295.4                                | 1    | CH <sub>2</sub> I-CH <sub>2</sub> I                                  | 387.0 ± 10.5                         | 1    |
| CH <sub>2</sub> (SPh) <sub>2</sub>                                                      | 372.4                                | 1    | CH <sub>3</sub> -CH(C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub>                             | 315.9 ± 6.3                          | 1    | CH <sub>3</sub> -CH <sub>2</sub> Br                                  | 381.6 ± 8.4                          | 1    |
| H-CH <sub>2</sub> SiMe <sub>3</sub>                                                     | 418 ± 6.3                            | 1    | CH <sub>3</sub> -C(CH <sub>3</sub> )(C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub>            | 290.8 ± 8.4                          | 1    | CH <sub>3</sub> -CH <sub>2</sub> I                                   | 384.5 ± 8.4                          | 1    |
| H-CH <sub>2</sub> C(CH <sub>3</sub> ) <sub>2</sub> SiMe <sub>3</sub>                    | 409 ± 5                              | 1    | C <sub>6</sub> H <sub>5</sub> -C <sub>6</sub> H <sub>5</sub>                                 | 478.6 ± 6.3                          | 1    | CF <sub>3</sub> -CF <sub>2</sub> CF <sub>3</sub>                     | 424.3 ± 13.6                         | 1    |
| H-CH <sub>2</sub> SiMe <sub>2</sub> Ph                                                  | 410.1                                | 1    | C <sub>6</sub> H <sub>5</sub> -CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>                 | 383.7 ± 8.4                          | 1    | CF <sub>3</sub> -CF=CF <sub>2</sub>                                  | 420.5                                | 1    |
| H-CH((CH <sub>3</sub> ) <sub>3</sub> Si) <sub>2</sub>                                   | 397 ± 13                             | 1    | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> -CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub> | 272.8 ± 9.2                          | 1    | CH <sub>3</sub> -CH <sub>2</sub> CH <sub>2</sub> Cl                  | 371.4 ± 2.8                          | 1    |
| H-CH <sub>2</sub> B(RO) <sub>2</sub>                                                    | 412.5                                | 1    | C <sub>6</sub> H <sub>5</sub> -CH(C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub>               | 361.1 ± 8.4                          | 1    | CH <sub>3</sub> -CHClCH <sub>3</sub>                                 | 367.5 ± 2.0                          | 1    |
| H-CH((CH <sub>3</sub> ) <sub>2</sub> P) <sub>2</sub>                                    | 385 ± 13                             | 1    | C <sub>6</sub> H <sub>5</sub> -C(C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub>                | 324.3 ± 12.6                         | 1    | CH <sub>2</sub> Cl-CHClCH <sub>3</sub>                               | 356.5 ± 8.4                          | 1    |
| (2) C-C BDEs                                                                            |                                      |      | Ph <sub>2</sub> CH-CHPh <sub>2</sub>                                                         | 247.3 ± 8.4                          | 1    | CH <sub>2</sub> Cl-CH <sub>2</sub> CClH <sub>2</sub>                 | 369.0 ± 8.4                          | 1    |
| CH <sub>3</sub> -CH <sub>3</sub>                                                        | 377.4 ± 0.8                          | 1    | PhCH <sub>2</sub> -CPh <sub>3</sub>                                                          | 234.7 ± 14.6                         | 1    | CH <sub>3</sub> -CCl <sub>2</sub> CH <sub>3</sub>                    | 362.8 ± 8.4                          | 1    |
| CH <sub>3</sub> -C <sub>2</sub> H <sub>5</sub>                                          | 370.3 ± 2.1                          | 1    | R-R, $\pi$ -dimer, R = phenalenyl                                                            | 42                                   | 1    | CH <sub>2</sub> Br-CHBrCH <sub>3</sub>                               | 369.4 ± 8.4                          | 1    |
| CH <sub>3</sub> -C <sub>3</sub> H <sub>7</sub>                                          | 372.0 ± 2.9                          | 1    | R-R, $\sigma$ -dimer, R = phenalenyl                                                         | 42.7                                 | 1    | CH <sub>2</sub> ClCH <sub>2</sub> -CHClCH <sub>3</sub>               | 364.4 ± 8.4                          | 1    |
| CH <sub>3</sub> - <i>iso</i> -C <sub>3</sub> H <sub>7</sub>                             | 369.0 ± 3.8                          | 1    | R-R, R = 9-phenylfluorenyl                                                                   | 63.6                                 | 1    | CH <sub>2</sub> ClCH <sub>2</sub> -CH <sub>2</sub> CClH <sub>2</sub> | 369.0 ± 8.4                          | 1    |
| CH <sub>3</sub> -C <sub>4</sub> H <sub>9</sub>                                          | 371.5 ± 2.9                          | 1    | CF <sub>3</sub> -CF <sub>3</sub>                                                             | 413.0 ± 5.0                          | 1    | CH <sub>3</sub> CHBr-CHBrCH <sub>3</sub>                             | 355.6 ± 8.4                          | 1    |
| CH <sub>3</sub> - <i>iso</i> -C <sub>4</sub> H <sub>9</sub>                             | 370.3 ± 4.6                          | 1    | CF <sub>3</sub> -CHF <sub>2</sub>                                                            | 399.6 ± 8.4                          | 1    | CF <sub>3</sub> -C <sub>6</sub> H <sub>5</sub>                       | 463.2 ± 12.6                         | 1    |
| CH <sub>3</sub> - <i>sec</i> -C <sub>4</sub> H <sub>9</sub>                             | 368.2 ± 2.9                          | 1    | CF <sub>3</sub> -CClF <sub>2</sub>                                                           | 373.6 ± 12.5                         | 1    | CCl <sub>3</sub> -C <sub>6</sub> H <sub>5</sub>                      | 388.7 ± 8.4                          | 1    |
| CH <sub>3</sub> - <i>tert</i> -C <sub>4</sub> H <sub>9</sub>                            | 363.6 ± 2.9                          | 1    | CF <sub>3</sub> -CH <sub>2</sub> F                                                           | 397.5 ± 8.4                          | 1    | CH <sub>3</sub> -C <sub>6</sub> F <sub>5</sub>                       | 439.3                                | 1    |
| CH <sub>3</sub> -C <sub>5</sub> H <sub>11</sub>                                         | 368.4 ± 6.3                          | 1    | CF <sub>3</sub> -CCl <sub>3</sub>                                                            | 332.2 ± 5.4                          | 1    | CF <sub>3</sub> -C <sub>6</sub> F <sub>5</sub>                       | 435.1                                | 1    |
| CH <sub>3</sub> -CH(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>                        | 365.7 ± 4.2                          | 1    | CF <sub>3</sub> -CHBrCl                                                                      | 377.0 ± 10.5                         | 1    | CF <sub>3</sub> -CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>       | 365.7 ± 12.6                         | 1    |
| CH <sub>3</sub> -C(CH <sub>3</sub> ) <sub>2</sub> (CH <sub>2</sub> CH <sub>3</sub> )    | 360.9 ± 6.3                          | 1    | CF <sub>3</sub> -CH <sub>2</sub> Br                                                          | 399.6 ± 8.4                          | 1    | C <sub>6</sub> F <sub>5</sub> -C <sub>6</sub> F <sub>5</sub>         | 488.3                                | 1    |
| CH <sub>3</sub> -C <sub>6</sub> H <sub>13</sub>                                         | 368.2 ± 6.3                          | 1    | CF <sub>3</sub> -CH <sub>2</sub> I                                                           | 408.4 ± 10.5                         | 1    | CF <sub>3</sub> -CHPh <sub>2</sub>                                   | 352.3 ± 16.7                         | 1    |
| C <sub>2</sub> H <sub>5</sub> -C <sub>2</sub> H <sub>5</sub>                            | 363.2 ± 2.5                          | 1    | CF <sub>3</sub> -CH <sub>3</sub>                                                             | 429.3 ± 5.0                          | 1    | CF <sub>3</sub> -CPh <sub>3</sub>                                    | 290.8 ± 16.7                         | 1    |
| C <sub>3</sub> H <sub>7</sub> -C <sub>3</sub> H <sub>7</sub>                            | 366.1 ± 3.3                          | 1    | CHF <sub>2</sub> -CHF <sub>2</sub>                                                           | 382.4 ± 15.5                         | 1    | CF <sub>2</sub> CF-CF <sub>2</sub>                                   | 558.1 ± 12.6                         | 1    |
| <i>iso</i> -C <sub>3</sub> H <sub>7</sub> - <i>iso</i> -C <sub>3</sub> H <sub>7</sub>   | 353.5 ± 4.6                          | 1    | CClF <sub>2</sub> -CClF <sub>2</sub>                                                         | 378.7 ± 12.6                         | 1    | CH <sub>2</sub> FCH <sub>2</sub> -CPh <sub>3</sub>                   | 274.9 ± 16.7                         | 1    |
| C <sub>4</sub> H <sub>9</sub> -C <sub>4</sub> H <sub>9</sub>                            | 364.0 ± 3.8                          | 1    | CF <sub>2</sub> Cl-CFCl <sub>2</sub>                                                         | 358.6 ± 12.6                         | 1    | CHF <sub>2</sub> CH <sub>2</sub> -CPh <sub>3</sub>                   | 264.0 ± 16.7                         | 1    |
| <i>iso</i> -C <sub>4</sub> H <sub>9</sub> - <i>iso</i> -C <sub>4</sub> H <sub>9</sub>   | 362.3 ± 6.3                          | 1    | CHF <sub>2</sub> -CH <sub>2</sub> F                                                          | 394.1 ± 16.7                         | 1    | CH <sub>3</sub> -CH <sub>2</sub> OH                                  | 364.8 ± 4.2                          | 1    |
| <i>sec</i> -C <sub>4</sub> H <sub>9</sub> - <i>sec</i> -C <sub>4</sub> H <sub>9</sub>   | 348.5 ± 3.3                          | 1    | CH <sub>2</sub> F-CH <sub>2</sub> F                                                          | 368.2 ± 8.4                          | 1    | CF <sub>3</sub> -CH <sub>2</sub> OH                                  | 405.4 ± 6.3                          | 1    |
| <i>tert</i> -C <sub>4</sub> H <sub>9</sub> - <i>tert</i> -C <sub>4</sub> H <sub>9</sub> | 322.6 ± 4.2                          | 1    | CHF <sub>2</sub> -CH <sub>3</sub>                                                            | 405.0 ± 8.4                          | 1    | C <sub>2</sub> H <sub>5</sub> -CH <sub>2</sub> OH                    | 356.9 ± 5.0                          | 1    |
| CH <sub>3</sub> -cyclo-C <sub>5</sub> H <sub>9</sub>                                    | 358.2 ± 5.0                          | 1    | CH <sub>2</sub> F-CH <sub>3</sub>                                                            | 388.3 ± 8.4                          | 1    | C <sub>3</sub> H <sub>7</sub> -CH <sub>2</sub> OH                    | 357.3 ± 3.3                          | 1    |
| CH <sub>3</sub> -cyclo-C <sub>6</sub> H <sub>11</sub>                                   | 377.0 ± 7.5                          | 1    | CHClF-CH <sub>3</sub>                                                                        | 399.6 ± 12.6                         | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> -CH <sub>2</sub> OH        | 354.8 ± 4.2                          | 1    |
| cyclo-C <sub>6</sub> H <sub>11</sub> -cyclo-C <sub>6</sub> H <sub>11</sub>              | 369.0 ± 8.4                          | 1    | CF <sub>2</sub> Br-CHClF                                                                     | 369.4                                | 1    | C <sub>4</sub> H <sub>9</sub> -CH <sub>2</sub> OH                    | 355.6 ± 4.2                          | 1    |
| CH <sub>3</sub> -CH <sub>2</sub> C≡CH                                                   | 320.5 ± 5.0                          | 1    | CF <sub>2</sub> Br-CH <sub>3</sub>                                                           | 396.6 ± 15.1                         | 1    | <i>sec</i> -C <sub>4</sub> H <sub>9</sub> -CH <sub>2</sub> OH        | 352.7 ± 4.2                          | 1    |
| CH <sub>3</sub> -CH <sub>2</sub> C≡CCH <sub>3</sub>                                     | 308.4 ± 6.3                          | 1    | CCl <sub>3</sub> -CCl <sub>3</sub>                                                           | 285.8 ± 6.3                          | 1    | <i>iso</i> -C <sub>4</sub> H <sub>9</sub> -CH <sub>2</sub> OH        | 354.0 ± 5.4                          | 1    |
| CH <sub>3</sub> -CH(CH <sub>3</sub> )C≡CH                                               | 305.4 ± 8.4                          | 1    | CCl <sub>3</sub> -CClF <sub>2</sub>                                                          | 282.0 ± 12.6                         | 1    | C <sub>6</sub> H <sub>5</sub> -CH <sub>2</sub> OH                    | 413.4 ± 5.4                          | 1    |
| CH <sub>3</sub> -CH(CH <sub>3</sub> )C≡CCH <sub>3</sub>                                 | 320.9 ± 6.3                          | 1    | CCl <sub>3</sub> -CHCl <sub>2</sub>                                                          | 303.3 ± 6.3                          | 1    | HOH <sub>2</sub> C-CH <sub>2</sub> OH                                | 358.2 ± 6.3                          | 1    |
| CH <sub>3</sub> -C(CH <sub>3</sub> ) <sub>2</sub> C≡CH                                  | 295.8 ± 6.3                          | 1    |                                                                                              |                                      |      | NH <sub>2</sub> CH <sub>2</sub> -CH <sub>2</sub> OH                  | 335.6 ± 10.5                         | 1    |
| CH <sub>3</sub> -C(CH <sub>3</sub> ) <sub>2</sub> C≡CCH <sub>3</sub>                    | 303.3 ± 6.3                          | 1    |                                                                                              |                                      |      | CH <sub>3</sub> -CH <sub>2</sub> OCH <sub>3</sub>                    | 363.2 ± 5.0                          | 1    |

| Bond                                                  | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                 | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                       | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-------------------------------------------------------|--------------------------------------|------|--------------------------------------|--------------------------------------|------|------------------------------------------------------------|--------------------------------------|------|
| $\text{CH}_3\text{OCH}_2\text{--CH}_2\text{OCH}_3$    | $338.9 \pm 10.5$                     | 1    | $\text{C}_{58}\text{--C}_2$          | $955.2 \pm 14.5$                     | 1    | $\text{Cl--CF}_2\text{CF}_2\text{Cl}$                      | $331.4 \pm 20.9$                     | 1    |
| $\text{CH}_3\text{--C(O)H}$                           | $354.8 \pm 1.7$                      | 1    | <b>(3) C--halogen BDEs</b>           |                                      |      | $\text{Cl--CCl}_2\text{CF}_3$                              | 307.9                                | 1    |
| $\text{CCl}_3\text{--C(O)H}$                          | $309.2 \pm 5.0$                      | 1    | $\text{F--CN}$                       | 482.8                                | 1    | $\text{Cl--CCl}_2\text{CCl}_3$                             | 303.8                                | 1    |
| $\text{CH}_3\text{--C(O)F}$                           | $417.6 \pm 6.3$                      | 1    | $\text{F--CF}_3$                     | $546.8 \pm 2.1$                      | 1    | $\text{Cl--CHClCCl}_3$                                     | $330.5 \pm 4.2$                      | 1    |
| $\text{CH}_3\text{--C(O)Cl}$                          | $367.8 \pm 6.3$                      | 1    | $\text{F--CHF}_2$                    | $533.9 \pm 5.9$                      | 1    | $\text{Cl--CCl}_2\text{CHCl}_2$                            | 311.7                                | 1    |
| $\text{CCl}_3\text{--C(O)Cl}$                         | $289.1 \pm 6.3$                      | 1    | $\text{F--CH}_2\text{F}$             | $496.2 \pm 8.8$                      | 1    | $\text{Cl--CHClCH}_3$                                      | $327.9 \pm 1.8$                      | 1    |
| $\text{CHCl}_2\text{--C(O)Cl}$                        | $312.5 \pm 8.4$                      | 1    | $\text{F--CF}_2\text{Cl}$            | 511.7                                | 1    | $\text{Cl--CH}_2\text{CH}_2\text{Cl}$                      | $345.1 \pm 5.0$                      | 1    |
| $\text{CClH}_2\text{--C(O)Cl}$                        | $340.2 \pm 8.4$                      | 1    | $\text{F--CFCl}_2$                   | $482.0 \pm 10.5$                     | 1    | $\text{Cl--CHBrCH}_3$                                      | $331.8 \pm 8.4$                      | 1    |
| $\text{C}_6\text{H}_5\text{--C(O)H}$                  | $408.4 \pm 4.2$                      | 1    | $\text{F--CHFCl}$                    | $462.3 \pm 10.0$                     | 1    | $\text{Cl--CH}_2\text{CH}_3$                               | $352.3 \pm 3.3$                      | 1    |
| $\text{C}_6\text{H}_5\text{--C(O)Cl}$                 | $417.6 \pm 6.3$                      | 1    | $\text{F--CCl}_3$                    | $439.3 \pm 4$                        | 1    | $\text{Cl--CH}_2\text{CH=CH}_2$                            | $298.3 \pm 5.0$                      | 1    |
| $\text{CH}_3\text{--C(O)CH}_3$                        | $351.9 \pm 2.1$                      | 1    | $\text{F--CH}_2\text{Cl}$            | $465.3 \pm 9.6$                      | 1    | $\text{Cl--C}_3\text{H}_7$                                 | $352.7 \pm 4.2$                      | 1    |
| $\text{C}_2\text{H}_5\text{--C(O)CH}_3$               | $347.3 \pm 2.9$                      | 1    | $\text{F--CH}_3$                     | $460.2 \pm 8.4$                      | 1    | $\text{Cl--CH}_2\text{CH}_2\text{CH}_2\text{Cl}$           | 348.9                                | 1    |
| $\text{C}_3\text{H}_7\text{--C(O)CH}_3$               | $348.5 \pm 2.9$                      | 1    | $\text{F--C}\equiv\text{CH}$         | 521.3                                | 1    | $\text{Cl--iso-C}_3\text{H}_7$                             | $354.0 \pm 6.3$                      | 1    |
| <i>iso</i> - $\text{C}_3\text{H}_7\text{--C(O)CH}_3$  | $340.2 \pm 3.8$                      | 1    | $\text{F--C}\equiv\text{CF}$         | $519 \pm 21$                         | 1    | $\text{Cl--CH}_2\text{CHCH=CH}_2$                          | 342.7                                | 1    |
| $\text{C}_4\text{H}_7\text{--C(O)CH}_3$               | $346.9 \pm 5.4$                      | 1    | $\text{F--CF=CF}_2$                  | $546.4 \pm 12.6$                     | 1    | $\text{Cl--C}_4\text{H}_9$                                 | $350.6 \pm 6.3$                      | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9\text{--C(O)CH}_3$ | $329.3 \pm 4.2$                      | 1    | $\text{F--CF}_2\text{CF}_3$          | $532.2 \pm 6.3$                      | 1    | $\text{Cl--sec-C}_4\text{H}_9$                             | $350.2 \pm 6.3$                      | 1    |
| $\text{C}_6\text{H}_5\text{--C(O)CH}_3$               | $406.7 \pm 4.6$                      | 1    | $\text{F--CH}_2\text{CF}_3$          | 457.7                                | 1    | $\text{Cl--tert-C}_4\text{H}_9$                            | $351.9 \pm 6.3$                      | 1    |
| $\text{C}_6\text{H}_5\text{CH}_2\text{--C(O)CH}_3$    | $299.7 \pm 8.4$                      | 1    | $\text{F--CF}_2\text{CH}_3$          | $522.2 \pm 8.4$                      | 1    | $\text{CH}_2\text{CHCHCl(CH}_3\text{)}$                    | $300.0 \pm 6.3$                      | 1    |
| $\text{HC(O)--C(O)H}$                                 | $295.8 \pm 6.3$                      | 1    | $\text{F--C}_2\text{H}_3$            | $517.6 \pm 12.6$                     | 1    | $\text{Cl--C}_5\text{H}_{11}$                              | $350.6 \pm 6.3$                      | 1    |
| $\text{ClC(O)--C(O)Cl}$                               | $292.5 \pm 8.4$                      | 1    | $\text{F--C}_2\text{H}_5$            | $467.4 \pm 8.4$                      | 1    | $\text{Cl--C(CH}_3\text{)}_2\text{(C}_2\text{H}_5\text{)}$ | $352.7 \pm 6.3$                      | 1    |
| $\text{CH}_3\text{C(O)--C(O)H}$                       | $302.5 \pm 8.4$                      | 1    | $\text{F--C}_3\text{H}_7$            | $474.9 \pm 8.4$                      | 1    | $\text{Cl--cyclo-C}_6\text{H}_{11}$                        | $360.2 \pm 6.5$                      | 1    |
| $\text{CH}_3\text{C(O)--C(O)CH}_3$                    | $307.1 \pm 4.2$                      | 1    | $\text{F--iso-C}_3\text{H}_7$        | $483.8 \pm 8.4$                      | 1    | $\text{Cl--C}_6\text{H}_5$                                 | $399.6 \pm 6.3$                      | 1    |
| $\text{C}_6\text{H}_5\text{C(O)--C(O)C}_6\text{H}_5$  | $288.3 \pm 16.7$                     | 1    | $\text{F--tert-C}_4\text{H}_9$       | $495.8 \pm 8.4$                      | 1    | $\text{Cl--C}_6\text{F}_5$                                 | $383.3 \pm 8.4$                      | 1    |
| $\text{CH}_3\text{--C(O)OH}$                          | $384.9 \pm 8.4$                      | 1    | $\text{F--C}_6\text{H}_5$            | $525.5 \pm 8.4$                      | 1    | $\text{Cl--CH}_2\text{C}_6\text{H}_5$                      | $299.9 \pm 4.3$                      | 1    |
| $\text{CF}_3\text{--C(O)OH}$                          | $370.7 \pm 8.4$                      | 1    | $\text{F--C}_6\text{F}_5$            | $485 \pm 25$                         | 1    | $\text{Cl--C(O)Cl}$                                        | $318.8 \pm 8.4$                      | 1    |
| $\text{CCl}_3\text{--C(O)OH}$                         | $310.5 \pm 12.6$                     | 1    | $\text{F--CH}_2\text{C}_6\text{H}_5$ | $412.8 \pm 4.2$                      | 1    | $\text{Cl--COF}$                                           | 376.6                                | 1    |
| $\text{CClH}_2\text{--C(O)OH}$                        | $357.7 \pm 8.4$                      | 1    | $\text{F--COH}$                      | $497.9 \pm 10.5$                     | 1    | $\text{Cl--C(O)CH}_3$                                      | $354.0 \pm 8.4$                      | 1    |
| $\text{CH}_2\text{Br--C(O)OH}$                        | $358.2 \pm 8.4$                      | 1    | $\text{F--COF}$                      | 510.3                                | 1    | $\text{Cl--C(O)CH}_2\text{CH}_3$                           | $353.3 \pm 6.3$                      | 1    |
| $\text{NH}_2\text{CH}_2\text{--C(O)OH}$               | $349.4 \pm 8.4$                      | 1    | $\text{F--COCl}$                     | 484.5                                | 1    | $\text{Cl--C(O)C}_6\text{H}_5$                             | $341.0 \pm 8.4$                      | 1    |
| $\text{CH}_3\text{NHCH}_2\text{--C(O)OH}$             | $300.4 \pm 8.4$                      | 1    | $\text{F--C(O)CH}_3$                 | $511.7 \pm 12.6$                     | 1    | $\text{Cl--CH}_2\text{C(O)C}_6\text{H}_5$                  | 309                                  | 1    |
| $\text{C}_6\text{H}_5\text{--C(O)OH}$                 | $429.7 \pm 8.4$                      | 1    | $\text{Cl--CN}$                      | $422.6 \pm 8.4$                      | 1    | $\text{Cl--CH}_2\text{C(O)OH}$                             | $310.9 \pm 2.2$                      | 1    |
| $\text{C}_6\text{F}_5\text{--C(O)OH}$                 | $470.0 \pm 10.5$                     | 1    | $\text{Cl--CF}_3$                    | $365.3 \pm 3.8$                      | 1    | $\text{Cl--C(O)OC}_6\text{H}_5$                            | 364                                  | 1    |
| $\text{HOCH}_2\text{--C(O)OH}$                        | $371.5 \pm 5.4$                      | 1    | $\text{Cl--CHF}_2$                   | $364 \pm 8$                          | 1    | $\text{Cl--C(NO}_2\text{)}_3$                              | 302.1                                | 1    |
| $\text{HOC(O)--C(O)OH}$                               | $334.7 \pm 6.3$                      | 1    | $\text{Cl--CH}_2\text{F}$            | $354.4 \pm 11.7$                     | 1    | $\text{Br--CN}$                                            | $364.8 \pm 4.2$                      | 1    |
| $\text{CH}_3\text{NHCH}_2\text{--C(O)OH}$             | $301.2 \pm 16.7$                     | 1    | $\text{Cl--CF}_2\text{Cl}$           | $333.9 \pm 10.5$                     | 1    | $\text{Br--CF}_3$                                          | $296.2 \pm 1.3$                      | 1    |
| $\text{CH}_3\text{CH(NH}_2\text{)--C(O)OH}$           | $331.4 \pm 16.7$                     | 1    | $\text{Cl--CFCl}_2$                  | $320.9 \pm 8.4$                      | 1    | $\text{Br--CHF}_2$                                         | $288.7 \pm 8.4$                      | 1    |
| $\text{NH}_2\text{CH}_2\text{--CH}_2\text{C(O)OH}$    | $325.5 \pm 16.7$                     | 1    | $\text{Cl--CHFCl}$                   | $346.0 \pm 13.4$                     | 1    | $\text{Br--CF}_2\text{Cl}$                                 | $269.9 \pm 6.3$                      | 1    |
| $\text{CN--CN}$                                       | $571.9 \pm 6.7$                      | 1    | $\text{Cl--CCl}_3$                   | 296.6                                | 1    | $\text{Br--CCl}_3$                                         | $231.4 \pm 4.2$                      | 1    |
| $\text{HC(O)--CN}$                                    | $455.2 \pm 8.4$                      | 1    | $\text{Cl--CHCl}_2$                  | $311.1 \pm 2.0$                      | 1    | $\text{Br--CH}_2\text{Cl}$                                 | $277.3 \pm 3.6$                      | 1    |
| $\text{HC(S)--CN}$                                    | $530.1 \pm 8.4$                      | 1    | $\text{Cl--CH}_2\text{Cl}$           | $338.0 \pm 3.3$                      | 1    | $\text{Br--CBr}_3$                                         | $242.3 \pm 8.4$                      | 1    |
| $\text{CF}_3\text{--CN}$                              | $469.0 \pm 4.2$                      | 1    | $\text{Cl--CBrCl}_2$                 | $287 \pm 10.5$                       | 1    | $\text{Br--CHBr}_2$                                        | $274.9 \pm 13.0$                     | 1    |
| $\text{CH}_3\text{--CN}$                              | $521.7 \pm 9.2$                      | 1    | $\text{Cl--CH}_2\text{Br}$           | $332.8 \pm 4.6$                      | 1    | $\text{Br--CH}_2\text{Br}$                                 | $276.1 \pm 5.3$                      | 1    |
| $\text{NCC--CN}$                                      | 462.3                                | 1    | $\text{Cl--CH}_2\text{I}$            | $328.2 \pm 6.9$                      | 1    | $\text{Br--CH}_2\text{I}$                                  | $274.5 \pm 7.5$                      | 1    |
| $\text{C}_2\text{H}_5\text{--CN}$                     | $506.7 \pm 7.5$                      | 1    | $\text{Cl--CH}_3$                    | $350.2 \pm 1.7$                      | 1    | $\text{Br--CH}_3$                                          | $294.1 \pm 2.1$                      | 1    |
| $\text{CH}_3\text{--CH}_2\text{CN}$                   | $348.1 \pm 12.6$                     | 1    | $\text{Cl--C}\equiv\text{CCl}$       | $443 \pm 50$                         | 1    | $\text{Br--C}\equiv\text{CH}$                              | 410.5                                | 1    |
| $\text{C}_6\text{H}_5\text{--CH}_2\text{CN}$          | $386.6 \pm 8.4$                      | 1    | $\text{Cl--C}\equiv\text{CH}$        | $435.6 \pm 8.4$                      | 1    | $\text{Br--CH=CH}_2$                                       | $338.3 \pm 3.1$                      | 1    |
| $\text{CH}_3\text{--CH(CH}_3\text{)CN}$               | $332.6 \pm 8.4$                      | 1    | $\text{Cl--CH}_2\text{CN}$           | 267.4                                | 1    | $\text{Br--CF}_2\text{CF}_3$                               | $283.3 \pm 6.3$                      | 1    |
| $\text{CH}_3\text{--C(CH}_3\text{)}_2\text{CN}$       | $340.6 \pm 16.7$                     | 1    | $\text{Cl--CCl=CCl}_2$               | 383.7                                | 1    | $\text{Br--CClBrCF}_3$                                     | $251.0 \pm 6.3$                      | 1    |
| $\text{CH}_3\text{--C(CH}_3\text{)(CN)C}_6\text{H}_5$ | 250.6                                | 1    | $\text{Cl--CH=CH}_2$                 | $394.1 \pm 3.1$                      | 2    | $\text{Br--CF}_2\text{CF}_2\text{Br}$                      | $282.8 \pm 6.7$                      | 1    |
| $(\text{Ph})_2(\text{CN})\text{C--C(CN)(Ph)}_2$       | 109.6                                | 1    | $\text{Cl--CF=CF}_2$                 | $434.7 \pm 8.4$                      | 1    | $\text{Br--CHClCF}_3$                                      | $274.9 \pm 6.3$                      | 1    |
| $(\text{NO}_2)_3\text{C--C(NO}_2)_3$                  | 308.8                                | 1    | $\text{Cl--CF}_2\text{CF}_3$         | $346.0 \pm 7.1$                      | 1    | $\text{Br--CF}_2\text{CH}_3$                               | $287.0 \pm 5.4$                      | 1    |

| Bond                                                  | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                              | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                                     | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-------------------------------------------------------|--------------------------------------|------|---------------------------------------------------|--------------------------------------|------|------------------------------------------------------------------------------------------|--------------------------------------|------|
| Br-CH <sub>2</sub> CH <sub>2</sub> Cl                 | 292.5 ± 8.4                          | 1    | I-2-naphthyl                                      | 272.0 ± 10.5                         | 1    | C <sub>6</sub> H <sub>5</sub> OO-H                                                       | 384                                  | 1    |
| Br-CHClCH <sub>3</sub>                                | 272.0 ± 8.4                          | 1    | I-CH <sub>2</sub> CN                              | 187.0 ± 8.4                          | 1    | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> OO-H                                       | 363                                  | 1    |
| Br-C <sub>2</sub> H <sub>5</sub>                      | 292.9 ± 4.2                          | 1    | I-CH <sub>2</sub> OCH <sub>3</sub>                | 229.4 ± 8.4                          | 1    | (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> CHOO-H                                     | 370                                  | 1    |
| Br-CH <sub>2</sub> CH=CH <sub>2</sub>                 | 237.2 ± 5.0                          | 1    | I-CH <sub>2</sub> SCH <sub>3</sub>                | 216.8 ± 6.3                          | 1    | CH <sub>3</sub> C(O)OO-H                                                                 | 386                                  | 1    |
| Br-C <sub>3</sub> H <sub>7</sub>                      | 298.3 ± 4.2                          | 1    | I-C(O)CH <sub>3</sub>                             | 223.0 ± 8.4                          | 1    | CCl <sub>2</sub> (CN)OO-H                                                                | 384                                  | 1    |
| Br- <i>iso</i> -C <sub>3</sub> H <sub>7</sub>         | 299.2 ± 6.3                          | 1    | I-C(O)C <sub>6</sub> H <sub>5</sub>               | 212.1 ± 8.4                          | 1    | OHCH <sub>2</sub> OO-H                                                                   | 368                                  | 1    |
| Br-CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> Br | 324.7                                | 1    | I-CH <sub>2</sub> C(O)OH                          | 197.5 ± 2.7                          | 1    | H-ONO                                                                                    | 330.7                                | 1    |
| Br-CF <sub>2</sub> CF <sub>2</sub> CF <sub>3</sub>    | 278.2 ± 10.5                         | 1    | I-C(NO <sub>2</sub> ) <sub>3</sub>                | 144.8                                | 1    | H-OONO                                                                                   | 299.2                                | 1    |
| CF <sub>3</sub> CFBrCF <sub>3</sub>                   | 274.2 ± 4.6                          | 1    |                                                   |                                      |      | H-ONH <sub>2</sub>                                                                       | 318                                  | 1    |
| Br-C <sub>4</sub> H <sub>9</sub>                      | 296.6 ± 4.2                          | 1    | (4) O-X BDEs                                      |                                      |      | H-ONO <sub>2</sub>                                                                       | 426.8                                | 1    |
| Br- <i>sec</i> -C <sub>4</sub> H <sub>9</sub>         | 300.0 ± 4.2                          | 1    | HO-H                                              | 497.10 ± 0.29                        | 1    | H-ONNOH                                                                                  | 189                                  | 1    |
| Br- <i>tert</i> -C <sub>4</sub> H <sub>9</sub>        | 292.9 ± 6.3                          | 1    | FO-H                                              | 425.1                                | 1    | H-OPO <sub>2</sub>                                                                       | 465.7 ± 12.6                         | 1    |
| Br-C <sub>6</sub> H <sub>5</sub>                      | 336.4 ± 6.3                          | 1    | ClO-H                                             | 393.7                                | 1    | H-OSO <sub>2</sub> OH                                                                    | 441.4 ± 14.6                         | 1    |
| Br-C <sub>6</sub> F <sub>5</sub>                      | ~328                                 | 1    | BrO-H                                             | 405                                  | 1    | H-OSiMe <sub>3</sub>                                                                     | 495                                  | 1    |
| Br-CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>      | 239.3 ± 6.3                          | 1    | IO-H                                              | 403.3                                | 1    | (CH <sub>3</sub> )CHNO-H                                                                 | 354.4                                | 1    |
| Br-CH <sub>2</sub> C <sub>6</sub> F <sub>5</sub>      | 225.1 ± 6.3                          | 1    | CH <sub>3</sub> O-H                               | 440.2 ± 3                            | 1    | (CH <sub>3</sub> ) <sub>2</sub> CNO-H                                                    | 354.0                                | 1    |
| Br-1-C <sub>10</sub> H <sub>7</sub>                   | 339.7                                | 1    | CF <sub>3</sub> O-H                               | 497.1                                | 1    | (C <sub>6</sub> H <sub>5</sub> )CHNO-H                                                   | 368.6                                | 1    |
| Br-2-C <sub>10</sub> H <sub>7</sub>                   | 341.8                                | 1    | HC≡CO-H                                           | 443.1                                | 1    | PhO-H                                                                                    | 362.8 ± 2.9                          | 1    |
| Br-anthracenyl                                        | 322.6                                | 1    | C <sub>2</sub> H <sub>5</sub> O-H                 | 441.0 ± 5.9                          | 1    | α-tocopherol RO-H                                                                        | 323.4                                | 1    |
| Br-C(O)CH <sub>3</sub>                                | 292.0 ± 8.4                          | 1    | CH <sub>2</sub> =CHO-H                            | 355.6                                | 1    | β-tocopherol RO-H                                                                        | 335.6                                | 1    |
| Br-C(O)C <sub>6</sub> H <sub>5</sub>                  | 276.6 ± 8.4                          | 1    | CF <sub>3</sub> CH <sub>2</sub> O-H               | 447.7 ± 10.5                         | 1    | γ-tocopherol RO-H                                                                        | 335.1                                | 1    |
| Br-CH <sub>2</sub> C(O)CH <sub>3</sub>                | 257.9 ± 10.5                         | 1    | C <sub>3</sub> H <sub>7</sub> O-H                 | ≤433 ± 2                             | 1    | δ-tocopherol RO-H                                                                        | 342.8                                | 1    |
| Br-CH <sub>2</sub> C(O)C <sub>6</sub> H <sub>5</sub>  | 271                                  | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> O-H     | 442.3 ± 2.8                          | 1    | p-C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> -C <sub>6</sub> H <sub>4</sub> O-H       | 356.2                                | 1    |
| Br-CH <sub>2</sub> C(O)OH                             | 257.4 ± 3.7                          | 1    | C <sub>4</sub> H <sub>9</sub> O-H                 | 432.3                                | 1    | O-O <sub>2</sub>                                                                         | 106.6                                | 1    |
| Br-C(NO <sub>2</sub> ) <sub>3</sub>                   | 218.4                                | 1    | <i>sec</i> -C <sub>4</sub> H <sub>9</sub> O-H     | 441.4 ± 4.2                          | 1    | HO-OH                                                                                    | 210.66 ± 0.42                        | 1    |
| I-CN                                                  | 320.1                                | 1    | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> O-H    | 444.9 ± 2.8                          | 1    | HO-OF                                                                                    | 199.7 ± 8.4                          | 1    |
| I-CF <sub>3</sub>                                     | 227.2 ± 1.3                          | 1    | <i>tert</i> -BuCH <sub>2</sub> O-H                | 436.1                                | 1    | HO-OCi                                                                                   | ~146                                 | 1    |
| I-CCl <sub>3</sub>                                    | 168 ± 42                             | 1    | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> O-H | 442.7 ± 8.8                          | 1    | HO-OBri                                                                                  | 138.5 ± 8.4                          | 1    |
| I-CH <sub>2</sub> Cl                                  | 221.8 ± 4.2                          | 1    | CH <sub>3</sub> C(OH)O-H                          | 446.9 ± 6.3                          | 1    | FO-OF                                                                                    | 199.6                                | 1    |
| I-CH <sub>2</sub> Br                                  | 219.2 ± 5.4                          | 1    | (CH <sub>3</sub> ) <sub>2</sub> C(OH)O-H          | 450.6 ± 6.3                          | 1    | ClO-OCi                                                                                  | 72.4 ± 2.8                           | 1    |
| I-CH <sub>2</sub> I                                   | 216.9 ± 7.9                          | 1    | HC(O)O-H                                          | 468.6 ± 12.6                         | 1    | IO-Oi                                                                                    | 74.9 ± 17                            | 1    |
| I-CH <sub>3</sub>                                     | 238.9 ± 2.1                          | 1    | CH <sub>3</sub> C(O)O-H                           | 468.6 ± 12.6                         | 1    | <i>trans-perp</i> -HO-ONO                                                                | ≤67.8 ± 0.4                          | 1    |
| I-CH <sub>2</sub> CN                                  | 187.0 ± 6.3                          | 1    | C <sub>2</sub> H <sub>5</sub> C(O)O-H             | 472.8                                | 1    | <i>cis-cis</i> -HO-ONO                                                                   | 83.3 ± 2.1                           | 1    |
| I-CF <sub>2</sub> CF <sub>3</sub>                     | 219.2 ± 2.1                          | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> C(O)O-H | 472.8                                | 1    | HO-ONO <sub>2</sub>                                                                      | 163.2 ± 8.4                          | 1    |
| I-CF <sub>2</sub> CF <sub>2</sub> I                   | 217.6 ± 6.7                          | 1    | C <sub>6</sub> H <sub>5</sub> C(O)O-H             | 464.4 ± 16.7                         | 1    | HO-OCH <sub>3</sub>                                                                      | 189.1 ± 4.2                          | 1    |
| I-CH <sub>2</sub> CF <sub>3</sub>                     | 235.6 ± 4.2                          | 1    | HOO-H                                             | 366.06 ± 0.29                        | 1    | HO-OCF <sub>3</sub>                                                                      | 201.3 ± 20.9                         | 1    |
| I-CHFCClF <sub>2</sub>                                | 202 ± 2                              | 1    | CH <sub>3</sub> OO-H                              | 370.3 ± 2.1                          | 1    | HO-OC <sub>2</sub> H <sub>5</sub>                                                        | 178.7 ± 6.3                          | 1    |
| I-CF <sub>2</sub> CH <sub>3</sub>                     | 217.6 ± 4.2                          | 1    | CF <sub>3</sub> OO-H                              | 383                                  | 1    | HO-O- <i>iso</i> -C <sub>3</sub> H <sub>7</sub>                                          | 185.8 ± 6.3                          | 1    |
| I-CFICH <sub>3</sub>                                  | 218.0 ± 4.2                          | 1    | CH <sub>2</sub> FOO-H                             | 379                                  | 1    | HO-O- <i>tert</i> -C <sub>4</sub> H <sub>9</sub>                                         | 186.2 ± 4.2                          | 1    |
| CF <sub>3</sub> CFICF <sub>3</sub>                    | 215.1                                | 1    | CCl <sub>3</sub> OO-H                             | 386                                  | 1    | HO-OC(O)CH <sub>3</sub>                                                                  | 169.9 ± 2.1                          | 1    |
| I-CH=CH <sub>2</sub>                                  | 259.0 ± 4.2                          | 1    | CHCl <sub>2</sub> OO-H                            | 383                                  | 1    | HO-OC(O)C <sub>2</sub> H <sub>5</sub>                                                    | 169.9 ± 2.1                          | 1    |
| I-C <sub>2</sub> H <sub>5</sub>                       | 233.5 ± 6.3                          | 1    | CH <sub>2</sub> ClOO-H                            | 379                                  | 1    | CH <sub>3</sub> O-OCH <sub>3</sub>                                                       | 167.4 ± 6.3                          | 1    |
| I-CH <sub>2</sub> CH=CH <sub>2</sub>                  | 185.8 ± 6.3                          | 1    | CBr <sub>3</sub> OO-H                             | 383                                  | 1    | CF <sub>3</sub> O-OCF <sub>3</sub>                                                       | 198.7 ± 2.1                          | 1    |
| I-C <sub>3</sub> H <sub>7</sub>                       | 236.8 ± 4.2                          | 1    | CH <sub>2</sub> BrOO-H                            | 379                                  | 1    | C <sub>2</sub> H <sub>5</sub> O-OC <sub>2</sub> H <sub>5</sub>                           | 166.1                                | 1    |
| I- <i>iso</i> -C <sub>3</sub> H <sub>7</sub>          | 234.7 ± 6.3                          | 1    | C <sub>2</sub> H <sub>5</sub> OO-H                | 354.8 ± 9.2                          | 1    | C <sub>3</sub> H <sub>7</sub> O-OC <sub>3</sub> H <sub>7</sub>                           | 155.2 ± 4.2                          | 1    |
| I-C <sub>4</sub> F <sub>9</sub>                       | 205.8                                | 1    | CH <sub>3</sub> CHClOO-H                          | 377                                  | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> O-O- <i>iso</i> -C <sub>3</sub> H <sub>7</sub> | 157.7                                | 1    |
| I- <i>tert</i> -C <sub>4</sub> H <sub>9</sub>         | 227.2 ± 6.3                          | 1    | CH <sub>3</sub> CCl <sub>2</sub> OO-H             | 383                                  | 1    | <i>sec</i> -C <sub>4</sub> H <sub>9</sub> O-O- <i>sec</i> -C <sub>4</sub> H <sub>9</sub> | 152.3 ± 4.2                          | 1    |
| I-C <sub>6</sub> H <sub>5</sub>                       | 272.0 ± 4.2                          | 1    | CF <sub>3</sub> CHClOO-H                          | 384                                  | 1    | <i>tert</i> -BuO-O- <i>tert</i> -Bu                                                      | 162.8 ± 2.1                          | 1    |
| I-C <sub>6</sub> F <sub>5</sub>                       | <301.7                               | 1    | C <sub>2</sub> Cl <sub>5</sub> OO-H               | 383                                  | 1    | <i>tert</i> -BuCH <sub>2</sub> O-OCH <sub>2</sub> - <i>tert</i> -Bu                      | 152.3                                | 1    |
| I-CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>       | 187.8 ± 4.8                          | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> OO-H    | 356                                  | 1    | EtC(Me) <sub>2</sub> O-OC(Me) <sub>2</sub> Et                                            | 164.4 ± 4.2                          | 1    |
| I-1-naphthyl                                          | 274.5 ± 10.5                         | 1    | CH <sub>2</sub> =CHCH <sub>2</sub> OO-H           | 372.4                                | 1    | (CF <sub>3</sub> ) <sub>3</sub> CO-OC(CF <sub>3</sub> ) <sub>3</sub>                     | 148.5 ± 4.6                          | 1    |
|                                                       |                                      |      | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> OO-H   | 352.3 ± 8.8                          | 1    |                                                                                          |                                      |      |

| Bond                                                                                     | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                             | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                                       | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|------------------------------------------------------------------------------------------|--------------------------------------|------|----------------------------------------------------------------------------------|--------------------------------------|------|--------------------------------------------------------------------------------------------|--------------------------------------|------|
| $\text{Ph}_3\text{CO}-\text{OCPh}_3$                                                     | 131.4                                | 1    | $\text{CH}_3\text{O}-\text{C}_4\text{H}_9$                                       | $346.0 \pm 6.3$                      | 1    | $\text{O}_2\text{N}-\text{ONO}_2$                                                          | $95.4 \pm 1.5$                       | 1    |
| $\text{SF}_5\text{O}-\text{OSF}_5$                                                       | 155.6                                | 1    | $\text{CH}_3\text{O}-\text{tert-C}_4\text{H}_9$                                  | $353.1 \pm 6.3$                      | 1    | <i>cis</i> -HO-NO                                                                          | 207.0                                | 1    |
| $\text{SF}_5\text{O}-\text{OOSF}_5$                                                      | 126.8                                | 1    | $\text{C}_6\text{H}_5-\text{OCH}_3$                                              | $418.8 \pm 5.9$                      | 1    | <i>trans</i> -HO-NO                                                                        | $200.64 \pm 0.19$                    | 1    |
| $(\text{CH}_3)_3\text{CO}-\text{OSi}(\text{CH}_3)_3$                                     | 196.6                                | 1    | $\text{C}_6\text{H}_5\text{CH}(\text{CH}_3)-\text{OCH}_3$                        | $313.4 \pm 9.6$                      | 1    | FO-NO                                                                                      | $132.5 \pm 17$                       | 1    |
| <i>tert</i> -BuO-GeEt <sub>3</sub>                                                       | 192.5                                | 1    | $\text{C}_6\text{H}_5-\text{OC}_6\text{H}_5$                                     | $326.8 \pm 4.2$                      | 1    | <i>cis</i> -ClO-NO                                                                         | $127.6 \pm 8.4$                      | 1    |
| <i>tert</i> -BuO-SnEt <sub>3</sub>                                                       | 192.5                                | 1    | $\text{CH}_3-\text{OC}(\text{O})\text{H}$                                        | $383.7 \pm 12.6$                     | 1    | <i>trans</i> -ClO-NO                                                                       | $116.6 \pm 8.4$                      | 1    |
| $\text{CF}_3\text{OO}-\text{OCF}_3$                                                      | $126.8 \pm 8.4$                      | 1    | $\text{HC}(\text{O})-\text{OH}$                                                  | $457.7 \pm 2.1$                      | 1    | <i>cis</i> -BrO-NO                                                                         | $138.1 \pm 8.4$                      | 1    |
| $\text{HC}(\text{O})\text{O}-\text{OH}$                                                  | $199.2 \pm 8.4$                      | 1    | $\text{CH}_3\text{C}(\text{O})-\text{OH}$                                        | $459.4 \pm 4.2$                      | 1    | <i>trans</i> -BrO-NO                                                                       | $121.6 \pm 8.4$                      | 1    |
| $\text{FC}(\text{O})\text{O}-\text{OC}(\text{O})\text{F}$                                | 96.2                                 | 1    | $\text{C}_6\text{H}_5\text{C}(\text{O})-\text{OH}$                               | $447.7 \pm 10.5$                     | 1    | <i>trans-perp</i> -HOO-NO                                                                  | $114.2 \pm 4$                        | 1    |
| $\text{CH}_3\text{C}(\text{O})\text{O}-\text{ONO}_2$                                     | $131.4 \pm 8.4$                      | 1    | $\text{HO}-\text{CH}_2\text{C}(\text{O})\text{OH}$                               | $368.2 \pm 10.5$                     | 1    | $\text{CH}_3\text{O}-\text{NO}$                                                            | $176.6 \pm 3.3$                      | 1    |
| $\text{CH}_3\text{C}(\text{O})\text{O}-\text{OC}(\text{O})\text{CH}_3$                   | $140.2 \pm 21$                       | 1    | $\text{CH}_3-\text{OC}(\text{O})\text{CH}_3$                                     | $380.3 \pm 12.6$                     | 1    | $\text{C}_2\text{H}_5\text{O}-\text{NO}$                                                   | $185.4 \pm 4.2$                      | 1    |
| $\text{CF}_3\text{C}(\text{O})\text{O}-\text{OC}(\text{O})\text{CF}_3$                   | 125.5                                | 1    | $\text{HC}(\text{O})-\text{OCH}_3$                                               | $423.8 \pm 4.2$                      | 1    | $\text{C}_3\text{H}_7\text{O}-\text{NO}$                                                   | $179.1 \pm 6.3$                      | 1    |
| $\text{CF}_3\text{OC}(\text{O})\text{O}-\text{OC}(\text{O})\text{F}$                     | $121.3 \pm 4.2$                      | 1    | $\text{CH}_3\text{C}(\text{O})-\text{OCH}_3$                                     | $424.3 \pm 6.3$                      | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> O-NO                                             | $175.3 \pm 4.2$                      | 1    |
| $\text{CF}_3\text{OC}(\text{O})\text{O}-\text{OCF}_3$                                    | $142.3 \pm 2.9$                      | 1    | $\text{C}_6\text{H}_5\text{C}(\text{O})-\text{OCH}_3$                            | $421.3 \pm 12.6$                     | 1    | $\text{C}_4\text{H}_9\text{O}-\text{NO}$                                                   | $177.8 \pm 6.5$                      | 1    |
| $\text{CF}_3\text{OC}(\text{O})\text{O}-\text{OC}(\text{O})\text{OCF}_3$                 | 119.2                                | 1    | $\text{C}_6\text{H}_5\text{C}(\text{O})-\text{OC}_6\text{H}_5$                   | $307.5 \pm 8.4$                      | 1    | <i>iso</i> -C <sub>4</sub> H <sub>9</sub> O-NO                                             | $175.7 \pm 6.5$                      | 1    |
| $\text{C}_2\text{H}_5\text{C}(\text{O})\text{O}-\text{OC}(\text{O})\text{C}_2\text{H}_5$ | 150.6                                | 1    | $\text{CH}_3\text{OCH}_2-\text{OCH}_3$                                           | $367.5 \pm 8.4$                      | 1    | <i>sec</i> -C <sub>4</sub> H <sub>9</sub> O-NO                                             | $173.6 \pm 3.3$                      | 1    |
| $\text{C}_3\text{H}_7\text{C}(\text{O})\text{O}-\text{OC}(\text{O})\text{C}_3\text{H}_7$ | 150.6                                | 1    | $\text{CH}_3\text{C}(\text{O})-\text{OC}(\text{O})\text{CH}_3$                   | $382.4 \pm 12.6$                     | 1    | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> O-NO                                            | $176.1 \pm 5.9$                      | 1    |
| $\text{FS}(\text{O})_2\text{O}-\text{OS}(\text{O})_2\text{F}$                            | 92–100                               | 1    | $\text{C}_6\text{H}_5\text{C}(\text{O})-\text{OC}(\text{O})\text{C}_6\text{H}_5$ | $384.9 \pm 16.7$                     | 1    | <i>tert</i> -AmO-NO                                                                        | $171.1 \pm 0.4$                      | 1    |
| HO-CF <sub>3</sub>                                                                       | $\leq 482.0 \pm 1.3$                 | 1    | $\text{CH}_3-\text{OOH}$                                                         | $300.4 \pm 12.6$                     | 1    | $\text{C}_6\text{H}_5\text{O}-\text{NO}$                                                   | 87.0                                 | 1    |
| FO-CF <sub>3</sub>                                                                       | $408 \pm 17$                         | 1    | $\text{C}_2\text{H}_5-\text{OOH}$                                                | $332.2 \pm 20.9$                     | 1    | HO-NO <sub>2</sub>                                                                         | 205.4                                | 1    |
| HO-CH <sub>3</sub>                                                                       | $384.93 \pm 0.71$                    | 1    | $\text{C}_3\text{H}_7-\text{OOH}$                                                | 364.4                                | 1    | FO-NO <sub>2</sub>                                                                         | $131.8 \pm 12.6$                     | 1    |
| HO-C <sub>2</sub> H <sub>5</sub>                                                         | $391.2 \pm 2.9$                      | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> -OOH                                   | 298.3                                | 1    | ClO-NO <sub>2</sub>                                                                        | $111.8 \pm 2.1$                      | 1    |
| HO-CH <sub>2</sub> CF <sub>3</sub>                                                       | $408.4 \pm 8.4$                      | 1    | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> -OOH                                  | $309.2 \pm 4.2$                      | 1    | BrO-NO <sub>2</sub>                                                                        | $118.0 \pm 6.3$                      | 1    |
| HO-CH <sub>2</sub> CH=CH <sub>2</sub>                                                    | $332.6 \pm 4.2$                      | 1    | $\text{CH}_3-\text{OOCH}_3$                                                      | $292.5 \pm 8.4$                      | 1    | IO-NO <sub>2</sub>                                                                         | ~100                                 | 1    |
| HO-C <sub>3</sub> H <sub>7</sub>                                                         | $392.0 \pm 2.9$                      | 1    | $\text{CF}_3-\text{OOCF}_3$                                                      | $361.5 \pm 8.4$                      | 1    | $\text{CH}_3\text{O}-\text{NO}_2$                                                          | $176.1 \pm 4.2$                      | 1    |
| HO- <i>iso</i> -C <sub>3</sub> H <sub>7</sub>                                            | $397.9 \pm 4.2$                      | 1    | $\text{CH}_3-\text{OO}$                                                          | $137.0 \pm 3.8$                      | 1    | $\text{C}_2\text{H}_5\text{O}-\text{NO}_2$                                                 | $174.5 \pm 4.2$                      | 1    |
| HO-C <sub>4</sub> H <sub>9</sub>                                                         | $389.9 \pm 4.2$                      | 1    | $\text{CF}_3-\text{OO}$                                                          | 169.0                                | 1    | $\text{C}_3\text{H}_7\text{O}-\text{NO}_2$                                                 | $177.0 \pm 4.2$                      | 1    |
| HO- <i>sec</i> -C <sub>4</sub> H <sub>9</sub>                                            | $396.1 \pm 4.2$                      | 1    | $\text{CClF}_2-\text{OO}$                                                        | 127.6                                | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> O-NO <sub>2</sub>                                | $175.7 \pm 4.2$                      | 1    |
| HO- <i>iso</i> -C <sub>4</sub> H <sub>9</sub>                                            | $394.1 \pm 4.2$                      | 1    | $\text{CCl}_2\text{F}-\text{OO}$                                                 | 124.7                                | 1    | HOO-NO <sub>2</sub>                                                                        | $99.2 \pm 4.6$                       | 1    |
| HO- <i>tert</i> -C <sub>4</sub> H <sub>9</sub>                                           | $398.3 \pm 4.2$                      | 1    | $\text{CH}_2\text{Cl}-\text{OO}$                                                 | $122.4 \pm 10.5$                     | 1    | $\text{CH}_3\text{OO}-\text{NO}_2$                                                         | $86.6 \pm 8.4$                       | 1    |
| HO-CH(CH <sub>3</sub> )(nC <sub>3</sub> H <sub>7</sub> )                                 | $398.3 \pm 4.2$                      | 1    | $\text{CHCl}_2-\text{OO}$                                                        | $108.2 \pm 8.2$                      | 1    | $\text{CF}_3\text{OO}-\text{NO}_2$                                                         | 105                                  | 1    |
| HO-CH(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>                                       | $399.2 \pm 4.2$                      | 1    | $\text{CCl}_3-\text{OO}$                                                         | $92.0 \pm 6.4$                       | 1    | $\text{CF}_2\text{ClOO}-\text{NO}_2$                                                       | 106.7                                | 1    |
| HO-C(CH <sub>3</sub> ) <sub>2</sub> (C <sub>2</sub> H <sub>5</sub> )                     | $395.8 \pm 6.3$                      | 1    | $\text{HC}(\text{O})-\text{OOH}$                                                 | 290.0                                | 1    | $\text{CFCl}_2\text{OO}-\text{NO}_2$                                                       | 106.7                                | 1    |
| HO-C <sub>6</sub> H <sub>5</sub>                                                         | $463.6 \pm 4.2$                      | 1    | $\text{CH}_3\text{C}(\text{O})-\text{OOC}(\text{O})\text{CH}_3$                  | 315.1                                | 1    | $\text{CCl}_3\text{OO}-\text{NO}_2$                                                        | 95.8                                 | 1    |
| HO-C <sub>6</sub> F <sub>5</sub>                                                         | $446.9 \pm 9.2$                      | 1    | $\text{ClO}-\text{CF}_3$                                                         | $\leq 369.9 \pm 1.3$                 | 1    | $\text{CH}_3\text{N}(\text{O})-\text{O}$                                                   | $305.3 \pm 4.4$                      | 1    |
| HO-CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>                                         | $334.1 \pm 2.6$                      | 1    | $\text{CH}_3-\text{ONO}$                                                         | 245.2                                | 1    | $\text{C}_6\text{H}_5\text{N}(\text{O})-\text{O}$                                          | $392 \pm 8$                          | 1    |
| HO-C(CH <sub>3</sub> ) <sub>2</sub> C <sub>6</sub> H <sub>5</sub>                        | $339.3 \pm 6.3$                      | 1    | $\text{C}_2\text{H}_5-\text{ONO}$                                                | 260.2                                | 1    | $\text{C}_5\text{H}_5\text{N}-\text{O}$                                                    | $264.9 \pm 2.0$                      | 1    |
| <i>cyclo</i> -C <sub>5</sub> H <sub>9</sub> -OH                                          | $385.8 \pm 6.3$                      | 1    | $\text{C}_3\text{H}_7-\text{ONO}$                                                | $249.4 \pm 6.3$                      | 1    | $\text{C}_6\text{H}_5\text{N}=\text{N}(\text{O})(\text{C}_6\text{H}_5)-\text{O}$           | $309.4 \pm 3.5$                      | 1    |
| 1-C <sub>10</sub> H <sub>7</sub> -OH                                                     | $468.6 \pm 6.3$                      | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> -ONO                                   | $254.4 \pm 6.3$                      | 1    | $\text{C}_6\text{H}_5(\text{O})\text{N}=\text{N}(\text{O})(\text{C}_6\text{H}_5)-\text{O}$ | $309.4 \pm 3.6$                      | 1    |
| 2-C <sub>10</sub> H <sub>7</sub> -OH                                                     | $467.8 \pm 6.3$                      | 1    | $\text{C}_4\text{H}_9-\text{ONO}$                                                | $256.5 \pm 6.3$                      | 1    | O-SO                                                                                       | 551.1                                | 1    |
| (CH <sub>3</sub> ) <sub>2</sub> (NH <sub>2</sub> )C-OH                                   | $310.4 \pm 6.3$                      | 1    | <i>iso</i> -C <sub>4</sub> H <sub>9</sub> -ONO                                   | $254.0 \pm 6.3$                      | 1    | O-SOF <sub>2</sub>                                                                         | 513.3                                | 1    |
| $\text{CH}_3\text{C}(\text{O})-\text{OH}$                                                | $459.4 \pm 4.2$                      | 1    | <i>sec</i> -C <sub>4</sub> H <sub>9</sub> -ONO                                   | $253.6 \pm 6.3$                      | 1    | O-SOCl <sub>2</sub>                                                                        | 398.5                                | 1    |
| $\text{HOCH}_2-\text{OH}$                                                                | 411.3                                | 1    | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> -ONO                                  | $252.7 \pm 6.3$                      | 1    | O-S(OH) <sub>2</sub>                                                                       | $493.7 \pm 25$                       | 1    |
| $\text{CH}_3-\text{OCH}_3$                                                               | $351.9 \pm 4.2$                      | 1    | (C <sub>2</sub> H <sub>5</sub> )(CH <sub>3</sub> ) <sub>2</sub> C-ONO            | $254.0 \pm 8.4$                      | 1    | HO-SH                                                                                      | $293.3 \pm 16.7$                     | 1    |
| $\text{ICH}_2-\text{OCH}_3$                                                              | $373.2 \pm 12.6$                     | 1    | $\text{CH}_3-\text{ONO}_2$                                                       | 340.2                                | 1    | HO-SOH                                                                                     | $313.4 \pm 12.6$                     | 1    |
| $\text{CH}_3\text{O}-\text{C}_2\text{H}_5$                                               | $355.2 \pm 5.4$                      | 1    | $\text{C}_2\text{H}_5-\text{ONO}_2$                                              | 344.8                                | 1    | HO-S(OH)O <sub>2</sub>                                                                     | $384.9 \pm 8.4$                      | 1    |
| $\text{CH}_3\text{O}-\text{CHClCH}_3$                                                    | $370.3 \pm 8.4$                      | 1    | $\text{CH}_3\text{O}-\text{CH}_2\text{CN}$                                       | 393.3                                | 1    | HO-SCH <sub>3</sub>                                                                        | $303.8 \pm 12.6$                     | 1    |
| $\text{CH}_3\text{O}-\text{C}_3\text{H}_7$                                               | $358.6 \pm 6.3$                      | 1    | O-N <sub>2</sub>                                                                 | $167.4 \pm 0.4$                      | 1    | HO-SO <sub>2</sub> CH <sub>3</sub>                                                         | $360.2 \pm 12.6$                     | 1    |
| $\text{CH}_3\text{O}-\text{iso-C}_3\text{H}_7$                                           | $360.7 \pm 4.2$                      | 1    | O-NO                                                                             | $306.21 \pm 0.13$                    | 1    | F-OH                                                                                       | 215.1                                | 1    |
|                                                                                          |                                      |      | O-NO <sub>2</sub>                                                                | 206.3                                | 1    | F-OF                                                                                       | 164.1                                | 1    |
|                                                                                          |                                      |      | NO-NO                                                                            | $40.6 \pm 2.1$                       | 1    |                                                                                            |                                      |      |

| Bond                                                          | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                           | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                               | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|---------------------------------------------------------------|--------------------------------------|------|----------------------------------------------------------------|--------------------------------------|------|--------------------------------------------------------------------|--------------------------------------|------|
| F-OCF <sub>3</sub>                                            | 200.8 ± 4.2                          | 1    | ON-NO <sub>2</sub>                                             | 42.5                                 | 1    | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> -NH <sub>2</sub>     | 306.7 ± 6.3                          | 1    |
| F-OCH <sub>3</sub>                                            | >196.6                               | 1    | O <sub>2</sub> N-NO <sub>2</sub>                               | 57.3 ± 1                             | 1    | C <sub>6</sub> H <sub>5</sub> CH(CH <sub>3</sub> )-NH <sub>2</sub> | 307.5 ± 9.6                          | 1    |
| F-ONO <sub>2</sub>                                            | 143.1                                | 1    | H <sub>2</sub> N-NH <sub>2</sub>                               | 277.0 ± 1.3                          | 1    | HC(O)-NH <sub>2</sub>                                              | 421.7 ± 8.4                          | 1    |
| Cl-OH                                                         | 233.5                                | 1    | F <sub>2</sub> N-NF <sub>2</sub>                               | 92.9 ± 12.6                          | 1    | CH <sub>3</sub> C(O)-NH <sub>2</sub>                               | 414.6 ± 8.4                          | 1    |
| Cl-OCi                                                        | 142                                  | 1    | H <sub>2</sub> N-NHCH <sub>3</sub>                             | 275.8 ± 8.4                          | 1    | HS-NO                                                              | 138.9                                | 1    |
| Cl-OCF <sub>3</sub>                                           | ≤220.9 ± 8.4                         | 1    | H <sub>2</sub> N-N(CH <sub>3</sub> ) <sub>2</sub>              | 259.8 ± 8.4                          | 1    | CH <sub>3</sub> S-NO                                               | 104.6 ± 4.2                          | 1    |
| Cl-OCH <sub>3</sub>                                           | 200.8                                | 1    | H <sub>2</sub> N-NHC <sub>6</sub> H <sub>5</sub>               | 227.6 ± 8.4                          | 1    | <i>tert</i> -BuS-NO                                                | 115.1                                | 1    |
| Cl-O- <i>tert</i> -C <sub>4</sub> H <sub>9</sub>              | 198.3                                | 1    | H <sub>2</sub> N-NO <sub>2</sub>                               | 230                                  | 1    | PhCH <sub>2</sub> S-NO                                             | 120.5                                | 1    |
| Cl-OOCl                                                       | 91.2                                 | 1    | H <sub>2</sub> NN(CH <sub>3</sub> )-NO                         | 179.6                                | 1    | C <sub>6</sub> H <sub>5</sub> S-NO                                 | 81.2 ± 5.4                           | 1    |
| Cl-ONO <sub>2</sub>                                           | 172.0                                | 1    | (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> N-NO             | 94.6                                 | 1    | SCN-SCN                                                            | 255.6                                | 1    |
| Br-OH                                                         | 209.6 ± 4.2                          | 1    | N <sub>3</sub> -CH <sub>3</sub>                                | 335.1 ± 20.5                         | 1    | FSO <sub>2</sub> -NF <sub>2</sub>                                  | 163                                  | 1    |
| Br-OBBr                                                       | 125                                  | 1    | N <sub>3</sub> -C <sub>6</sub> H <sub>5</sub>                  | 375.7 ± 20.9                         | 1    | F-NO                                                               | 235.26                               | 1    |
| Br-O- <i>tert</i> -C <sub>4</sub> H <sub>9</sub>              | 183.3                                | 1    | N <sub>3</sub> -CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>  | 211.3 ± 14.2                         | 1    | F-NO <sub>2</sub>                                                  | 221.3                                | 1    |
| Br-ONO <sub>2</sub>                                           | 143.1 ± 6.3                          | 1    | CH <sub>3</sub> -NC                                            | 413.0 ± 3.3                          | 1    | F-NF <sub>2</sub>                                                  | 254.0                                | 1    |
| I-OH                                                          | 213.4                                | 1    | C <sub>2</sub> H <sub>5</sub> -NC                              | 413.4 ± 8.4                          | 1    | F-NH <sub>2</sub>                                                  | 286.6                                | 1    |
| I-OI                                                          | 130.1                                | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> -NC                  | 423.0 ± 8.4                          | 1    | Cl-NO                                                              | 158.8 ± 0.8                          | 1    |
| I-ONO <sub>2</sub>                                            | >140.6                               | 1    | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> -NC                 | 399.6 ± 5.4                          | 1    | Cl-NO <sub>2</sub>                                                 | 141.8 ± 1.3                          | 1    |
| (5) N-X BDEs                                                  |                                      |      | NC-NO                                                          | 204.4                                | 1    | Cl-NF <sub>2</sub>                                                 | ~134                                 | 1    |
| H-NH <sub>2</sub>                                             | 450.08 ± 0.24                        | 1    | CH <sub>3</sub> -NO                                            | 172                                  | 1    | Cl-NH <sub>2</sub>                                                 | 253.1                                | 1    |
| H-NF <sub>2</sub>                                             | 316.7 ± 10.5                         | 1    | CF <sub>3</sub> -NO                                            | 167                                  | 1    | Br-NO                                                              | 120.1 ± 0.8                          | 1    |
| H-NNH                                                         | 254.4                                | 1    | CCl <sub>3</sub> -NO                                           | 125                                  | 1    | Br-NO <sub>2</sub>                                                 | 82.0 ± 7.1                           | 1    |
| H-N <sub>3</sub>                                              | ≤389                                 | 1    | C <sub>2</sub> H <sub>5</sub> -NO                              | 171.5                                | 1    | Br-NF <sub>2</sub>                                                 | <227.2                               | 1    |
| H-N=CH <sub>2</sub>                                           | 364 ± 25                             | 1    | CH <sub>2</sub> CHCH <sub>2</sub> -NO                          | 110                                  | 1    | I-NO                                                               | 75.6 ± 4                             | 1    |
| H-NO                                                          | 199.5                                | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> -NO                  | 152.7 ± 12.6                         | 1    | I-NO <sub>2</sub>                                                  | 79.6 ± 4                             | 1    |
| H-NHOH                                                        | 341                                  | 1    | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> -NO                 | 167                                  | 1    | (6) S-X BDEs                                                       |                                      |      |
| H-NCO                                                         | 460.7 ± 2.1                          | 1    | C <sub>6</sub> H <sub>5</sub> -NO                              | 226.8 ± 2.1                          | 1    | H-SH                                                               | 381.18 ± 0.05                        | 1    |
| H-NCS                                                         | ≤396.6 ± 4.6                         | 1    | C <sub>6</sub> F <sub>5</sub> -NO                              | 211.3 ± 4.2                          | 1    | H-SCH <sub>3</sub>                                                 | 365.7 ± 2.1                          | 1    |
| H-NCS                                                         | 347.3 ± 8.4                          | 1    | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> -NO              | 123                                  | 1    | H-SCHCH <sub>2</sub>                                               | 351.5 ± 8.4                          | 1    |
| CH <sub>3</sub> NH <sub>2</sub>                               | 425.1 ± 8.4                          | 1    | CH <sub>3</sub> -NO <sub>2</sub>                               | 260.7 ± 2.1                          | 1    | H-SC <sub>2</sub> H <sub>5</sub>                                   | 365.3                                | 1    |
| <i>tert</i> -BuNH <sub>2</sub>                                | 397.5 ± 8.4                          | 1    | C <sub>2</sub> H <sub>5</sub> -NO <sub>2</sub>                 | 254.4                                | 1    | H-SC <sub>3</sub> H <sub>7</sub>                                   | 365.7                                | 1    |
| C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> NH <sub>2</sub> | 418.4                                | 1    | C <sub>3</sub> H <sub>7</sub> -NO <sub>2</sub>                 | 256.5                                | 1    | H-S- <i>iso</i> -C <sub>3</sub> H <sub>7</sub>                     | 369.9 ± 8.4                          | 1    |
| (CH <sub>3</sub> ) <sub>2</sub> NH                            | 395.8 ± 8.4                          | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> -NO <sub>2</sub>     | 259.8                                | 1    | H-S- <i>tert</i> -C <sub>4</sub> H <sub>9</sub>                    | 362.3 ± 9.2                          | 1    |
| H-NHNH(CH <sub>3</sub> )                                      | 276 ± 21                             | 1    | C <sub>4</sub> H <sub>9</sub> -NO <sub>2</sub>                 | 254.8                                | 1    | H-SOH                                                              | 330.5 ± 14.6                         | 1    |
| H-NHN(CH <sub>3</sub> ) <sub>2</sub>                          | 356 ± 21                             | 1    | <i>sec</i> -C <sub>4</sub> H <sub>9</sub> -NO <sub>2</sub>     | 263.2                                | 1    | H-SCOCH <sub>3</sub>                                               | 370.7                                | 1    |
| NH <sub>2</sub> CN                                            | 414.2                                | 1    | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> -NO <sub>2</sub>    | 258.6                                | 1    | H-SCOPh                                                            | 364                                  | 1    |
| (NH <sub>2</sub> ) <sub>2</sub> C=O                           | 464.4                                | 1    | C <sub>6</sub> H <sub>5</sub> -NO <sub>2</sub>                 | 295.8 ± 4.2                          | 1    | H-SO <sub>2</sub> CH <sub>3</sub>                                  | ≤397                                 | 1    |
| (NH <sub>2</sub> ) <sub>2</sub> C=S                           | 389.1                                | 1    | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> -NO <sub>2</sub> | 210.3 ± 6.3                          | 1    | H-SSCH <sub>3</sub>                                                | 330.5 ± 14.6                         | 1    |
| CH <sub>3</sub> CSNH <sub>2</sub>                             | 380.7                                | 1    | (NO <sub>2</sub> )CH <sub>2</sub> -NO <sub>2</sub>             | 207.1                                | 1    | H-SPh                                                              | 349.4 ± 4.5                          | 1    |
| PhCSNH <sub>2</sub>                                           | 380.7                                | 1    | (NO <sub>2</sub> ) <sub>3</sub> C-NO <sub>2</sub>              | 176.1                                | 1    | H-SSH                                                              | 318.0 ± 14.6                         | 1    |
| (PhNH) <sub>2</sub> C=S                                       | 364.0                                | 1    | CF <sub>3</sub> -NF <sub>2</sub>                               | 280.7                                | 1    | H-SSSH                                                             | 292.9 ± 6.5                          | 1    |
| (NH <sub>2</sub> ) <sub>2</sub> C=NH                          | 435.1                                | 1    | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> -NF <sub>2</sub> | 237.2 ± 14.6                         | 1    | HS-SH                                                              | 270.7 ± 8.4                          | 1    |
| Ph <sub>2</sub> C=NH                                          | 489.5                                | 1    | CH <sub>3</sub> -NH <sub>2</sub>                               | 356.1 ± 2.1                          | 1    | FS-SF                                                              | 362.3                                | 1    |
| H-N(SiMe <sub>3</sub> ) <sub>2</sub>                          | 464                                  | 1    | C <sub>2</sub> H <sub>5</sub> -NH <sub>2</sub>                 | 352.3 ± 6.3                          | 1    | ClS-SCl                                                            | 329.7                                | 1    |
| H-NHPh                                                        | 375.3                                | 1    | C <sub>3</sub> H <sub>7</sub> -NH <sub>2</sub>                 | 356.1 ± 2.9                          | 1    | HS-SCH <sub>3</sub>                                                | 272.0                                | 1    |
| C <sub>6</sub> H <sub>5</sub> NHOH                            | 292                                  | 1    | <i>iso</i> -C <sub>3</sub> H <sub>7</sub> -NH <sub>2</sub>     | 357.7 ± 3.8                          | 1    | HS-SPh                                                             | 255.2 ± 6.3                          | 1    |
| C <sub>6</sub> H <sub>5</sub> NH(CONMe <sub>2</sub> )         | 387.9                                | 1    | C <sub>4</sub> H <sub>9</sub> -NH <sub>2</sub>                 | 356.1 ± 2.9                          | 1    | CH <sub>3</sub> S-SCH <sub>3</sub>                                 | 272.8 ± 3.8                          | 1    |
| H-NPh <sub>2</sub>                                            | 364.8                                | 1    | <i>sec</i> -C <sub>4</sub> H <sub>9</sub> -NH <sub>2</sub>     | 359.0 ± 2.9                          | 1    | C <sub>2</sub> H <sub>5</sub> S-SC <sub>2</sub> H <sub>5</sub>     | 276.6                                | 1    |
| HN-N <sub>2</sub>                                             | 63                                   | 1    | <i>iso</i> -C <sub>4</sub> H <sub>9</sub> -NH <sub>2</sub>     | 254.8 ± 5.0                          | 1    | MeS-SPh                                                            | 272.0 ± 6.3                          | 1    |
| ON-N                                                          | 480.7 ± 0.4                          | 1    | <i>tert</i> -C <sub>4</sub> H <sub>9</sub> -NH <sub>2</sub>    | 355.6 ± 6.3                          | 1    | C <sub>6</sub> H <sub>5</sub> S-SC <sub>6</sub> H <sub>5</sub>     | 214.2 ± 12.6                         | 1    |
| ON-NO                                                         | 8.49 ± 0.12                          | 1    | pyridin-2-yl-NH <sub>2</sub>                                   | 431                                  | 1    | F <sub>5</sub> S-SF <sub>5</sub>                                   | 305 ± 21                             | 1    |
|                                                               |                                      |      | C <sub>6</sub> H <sub>5</sub> -NH <sub>2</sub>                 | 429.3 ± 4.2                          | 1    |                                                                    |                                      |      |



| Bond                                               | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                                           | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                                                               | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|----------------------------------------------------|--------------------------------------|------|------------------------------------------------------------------------------------------------|--------------------------------------|------|--------------------------------------------------------------------------------------------------------------------|--------------------------------------|------|
| HS-CH <sub>3</sub>                                 | 312.5 ± 4.2                          | 1    | SiH <sub>3</sub> -Br                                                                           | 376 ± 9                              | 1    | MgO-H                                                                                                              | 441                                  | 1    |
| HS-C <sub>2</sub> H <sub>5</sub>                   | 307.9 ± 2.1                          | 1    | SiH <sub>3</sub> -I                                                                            | 299 ± 8                              | 1    | Mg(OH)-OH                                                                                                          | 349                                  | 1    |
| HS-C <sub>3</sub> H <sub>7</sub>                   | 310.5 ± 2.9                          | 1    | GeH <sub>3</sub> -H                                                                            | 348.9 ± 8.4                          | 1    | BrMg-CH <sub>3</sub>                                                                                               | 253                                  | 1    |
| HS- <i>iso</i> -C <sub>3</sub> H <sub>7</sub>      | 307.1 ± 3.8                          | 1    | Me <sub>3</sub> Ge-H                                                                           | 364.0                                | 1    | BrMg-CH <sub>2</sub> CH <sub>3</sub>                                                                               | 205                                  | 1    |
| HS-C <sub>4</sub> H <sub>9</sub>                   | 309.2 ± 2.9                          | 1    | Ph <sub>3</sub> Ge-H                                                                           | 359.8                                | 1    | BrMg- <i>i</i> -C <sub>3</sub> H <sub>7</sub>                                                                      | 184                                  | 1    |
| HS- <i>sec</i> -C <sub>4</sub> H <sub>9</sub>      | 307.5 ± 2.9                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> Ge-Ge(CH <sub>3</sub> ) <sub>3</sub>                           | 280.3                                | 1    | BrMg- <i>t</i> -C <sub>4</sub> H <sub>9</sub>                                                                      | 174                                  | 1    |
| HS- <i>iso</i> -C <sub>4</sub> H <sub>9</sub>      | 310.0 ± 4.6                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> Ge-CH <sub>3</sub>                                             | 288.7                                | 1    | BrMg-C <sub>6</sub> H <sub>5</sub>                                                                                 | 289                                  | 1    |
| HS- <i>tert</i> -C <sub>4</sub> H <sub>9</sub>     | 301.2 ± 3.8                          | 1    | Me <sub>3</sub> Sn-H                                                                           | 326.4                                | 1    | BrMg-CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>                                                                 | 201                                  | 1    |
| HS-C <sub>6</sub> H <sub>5</sub>                   | 360.7 ± 6.3                          | 1    | Ph <sub>3</sub> Sn-H                                                                           | 294.6                                | 1    | BrMg-C(C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub>                                                                | 180                                  | 1    |
| HS-CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>   | 258.2 ± 6.3                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> Sn-Sn(CH <sub>3</sub> ) <sub>3</sub>                           | 257.7                                | 1    | Ca(OH)-OH                                                                                                          | 409                                  | 1    |
| HS-C(O)H                                           | 309.6 ± 8.4                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> Sn-Cl                                                          | 425 ± 17                             | 1    | Sr(OH)-OH                                                                                                          | 407                                  | 1    |
| HS-C(O)CH <sub>3</sub>                             | 307.9 ± 6.3                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> Pb-Pb(CH <sub>3</sub> ) <sub>3</sub>                           | 228.4                                | 1    | Ba(OH)-OH                                                                                                          | 443                                  | 1    |
| CH <sub>3</sub> S-CH <sub>3</sub>                  | 307.9 ± 3.3                          | 1    | Cl <sub>3</sub> Pb-Cl                                                                          | 271 ± 84                             | 1    |                                                                                                                    |                                      |      |
| HOS-CH <sub>3</sub>                                | 284.9 ± 12.6                         | 1    | (CH <sub>3</sub> ) <sub>3</sub> Pb-CH <sub>3</sub>                                             | 238 ± 21                             | 1    |                                                                                                                    |                                      |      |
| CH <sub>3</sub> SO-CH <sub>3</sub>                 | 221.8 ± 8.4                          | 1    |                                                                                                |                                      |      | (10.3) Group 3                                                                                                     |                                      |      |
| HOSO <sub>2</sub> -CH <sub>3</sub>                 | 324.3 ± 12.6                         | 1    | (8) P-, As-, Sb-, Bi-X BDEs                                                                    |                                      |      | Sc-CH <sub>3</sub>                                                                                                 | 116 ± 29                             | 1    |
| CH <sub>3</sub> SO <sub>2</sub> -CH <sub>3</sub>   | 279.5                                | 1    | H <sub>2</sub> P-H                                                                             | 351.0 ± 2.1                          | 1    | Sc-C <sub>6</sub> H <sub>6</sub>                                                                                   | 60.8                                 | 1    |
| F <sub>3</sub> S-CF <sub>3</sub>                   | 392 ± 43                             | 1    | CH <sub>3</sub> PH-H                                                                           | 322.2 ± 12.6                         | 1    | La(η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> -CH(SiMe <sub>3</sub> ) <sub>2</sub>              | 278.7 ± 10.5                         | 1    |
| F-SF <sub>5</sub>                                  | 391.6                                | 1    | H <sub>2</sub> P-PH <sub>2</sub>                                                               | 256.1                                | 1    | Nd(η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> -CH(SiMe <sub>3</sub> ) <sub>2</sub>              | 236.8 ± 10.5                         | 1    |
| F-SO <sub>2</sub> (F)                              | 379                                  | 1    | (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> P-P(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> | 359.8                                | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Sm-H                                                | 226.8 ± 12.6                         | 1    |
| Cl-SF <sub>5</sub>                                 | <272                                 | 1    | F <sub>2</sub> P-F                                                                             | 549                                  | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Sm-OCH <sub>3</sub>                                 | 343.1                                | 1    |
| Cl-SO <sub>2</sub> CH <sub>3</sub>                 | 293                                  | 1    | Cl <sub>2</sub> P-Cl                                                                           | 356 ± 8                              | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Sm-(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ) | 188.3 ± 6.3                          | 1    |
| Cl-SO <sub>2</sub> Ph                              | 297                                  | 1    | Br <sub>2</sub> P-Br                                                                           | <259                                 | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Sm-S-nC <sub>3</sub> H <sub>7</sub>                 | 295.4 ± 10.0                         | 1    |
| Br-SBr                                             | 259 ± 17                             | 1    | I <sub>2</sub> P-I                                                                             | 217                                  | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Sm-N(CH <sub>3</sub> ) <sub>2</sub>                 | 201.7 ± 7.5                          | 1    |
| Br-SF <sub>5</sub>                                 | <230                                 | 1    | H <sub>2</sub> P-SiH <sub>3</sub>                                                              | 331.4                                | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Sm-SiH(SiMe <sub>3</sub> ) <sub>2</sub>             | 179.9 ± 21                           | 1    |
| I-SH                                               | 206.7 ± 8.4                          | 1    | H <sub>2</sub> As-H                                                                            | 319.2 ± 0.8                          | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Sm-P(Et) <sub>2</sub>                               | 136.4 ± 8.4                          | 1    |
| I-SCH <sub>3</sub>                                 | 206.3 ± 7.1                          | 1    | H <sub>2</sub> Sb-H                                                                            | 288.3 ± 2.1                          | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Eu-I                                                | 238.9 ± 8.4                          | 1    |
|                                                    |                                      |      | F <sub>2</sub> Bi-F                                                                            | 435 ± 19                             | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> Yb-I                                                | 256.1 ± 6.3                          | 1    |
| (7) Si-, Ge-, Sn-, and Pb-X BDEs                   |                                      |      | Br <sub>2</sub> Bi-Br                                                                          | >297.1                               | 1    |                                                                                                                    |                                      |      |
| SiH <sub>3</sub> -H                                | 383.7 ± 2.1                          | 1    |                                                                                                |                                      |      | Lu(η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> -CH(SiMe <sub>3</sub> ) <sub>2</sub>              | 279.1 ± 10.5                         | 1    |
| Me <sub>3</sub> Si-H                               | 396 ± 7                              | 1    | (9) Se- and Te-X BDEs                                                                          |                                      |      | (η <sup>5</sup> -C <sub>5</sub> H <sub>4</sub> SiMe <sub>3</sub> ) <sub>3</sub> Th-H                               | 277 ± 6                              | 1    |
| H <sub>2</sub> Si <sub>2</sub> -H                  | 373 ± 8                              | 1    | H-SeH                                                                                          | 334.93 ± 0.75                        | 1    | (η <sup>5</sup> -C <sub>5</sub> H <sub>4</sub> SiMe <sub>3</sub> ) <sub>3</sub> Th-O                               | 371 ± 24                             | 1    |
| (C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> Si-H | 396 ± 4                              | 1    | H-SeC <sub>6</sub> H <sub>5</sub>                                                              | 326.4 ± 16.7                         | 1    | (η <sup>5</sup> -C <sub>5</sub> H <sub>3</sub> ) <sub>3</sub> Th-CH <sub>3</sub>                                   | 375 ± 9                              | 1    |
| C <sub>6</sub> H <sub>5</sub> SiH <sub>2</sub> -H  | 382 ± 5                              | 1    | PhSe-SePh                                                                                      | 280 ± 19                             | 1    | (η <sup>5</sup> -C <sub>5</sub> H <sub>2</sub> ) <sub>3</sub> Th-CH <sub>2</sub> Si(CH <sub>3</sub> ) <sub>3</sub> | 369 ± 12                             | 1    |
| (CH <sub>3</sub> S) <sub>3</sub> Si-H              | 364.0                                | 1    | H-TeH                                                                                          | 277.0 ± 5.0                          | 1    | (C <sub>6</sub> H <sub>7</sub> ) <sub>3</sub> Th-CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>                     | 342 ± 9                              | 1    |
| (iPrS) <sub>3</sub> Si-H                           | 376.6                                | 1    | H-TeC <sub>6</sub> H <sub>5</sub>                                                              | ≤264                                 | 1    | (η <sup>5</sup> -C <sub>5</sub> H <sub>4</sub> tBu) <sub>3</sub> U-H                                               | 249.7 ± 5.7                          | 1    |
| PhMe <sub>2</sub> Si-H                             | 377 ± 7                              | 1    | PhTe-TePh                                                                                      | 138.1 ± 12.6                         | 1    | (η <sup>5</sup> -C <sub>5</sub> H <sub>4</sub> SiMe <sub>3</sub> ) <sub>3</sub> U-H                                | 253.7 ± 5.1                          | 1    |
| Ph <sub>2</sub> SiH-H                              | 379 ± 7                              | 1    |                                                                                                |                                      |      | [HB(3,5-Me <sub>2</sub> Pz) <sub>3</sub> ]<br>U(Cl) <sub>2</sub> -Cl                                               | 422.6                                | 1    |
| Ph <sub>2</sub> MeSi-H                             | 361 ± 10                             | 1    | (10) Metal-Centered BDEs                                                                       |                                      |      | (η <sup>5</sup> -C <sub>5</sub> H <sub>4</sub> SiMe <sub>3</sub> ) <sub>3</sub> U-I                                | 265.6 ± 4.3                          | 1    |
| SiF <sub>3</sub> -H                                | 432 ± 5                              | 1    | Arranged by the Periodic Table                                                                 |                                      |      | (η <sup>5</sup> -C <sub>5</sub> H <sub>4</sub> tBu) <sub>3</sub> U-O                                               | 307 ± 9                              | 1    |
| SiCl <sub>3</sub> -H                               | 395 ± 5                              | 1    |                                                                                                |                                      |      | (η <sup>5</sup> -C <sub>5</sub> H <sub>4</sub> SiMe <sub>3</sub> ) <sub>3</sub> U-CO                               | 43.1 ± 0.8                           | 1    |
| SiBr <sub>3</sub> -H                               | 334 ± 8                              | 1    | (10.1) Group 1                                                                                 |                                      |      | (C <sub>9</sub> H <sub>7</sub> ) <sub>3</sub> U-CH <sub>3</sub>                                                    | 196.3 ± 6.6                          | 1    |
| SiH <sub>3</sub> -SiH <sub>3</sub>                 | 321 ± 4                              | 1    | Li-OH                                                                                          | 431.0                                | 1    | (η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> U(Cl)-C <sub>6</sub> H <sub>5</sub>                 | 358 ± 11                             | 1    |
| SiH <sub>3</sub> -Si <sub>2</sub> H <sub>5</sub>   | 313 ± 8                              | 1    | Li-C <sub>2</sub> H <sub>5</sub>                                                               | 214.6 ± 8.4                          | 1    | (η <sup>5</sup> -C <sub>5</sub> H <sub>4</sub> SiMe <sub>3</sub> ) <sub>3</sub> U-THF                              | 41.0 ± 0.8                           | 1    |
| Ph <sub>3</sub> Si-SiPh <sub>3</sub>               | 368.2                                | 1    | Li-nC <sub>4</sub> H <sub>9</sub>                                                              | 197.9 ± 16.3                         | 1    |                                                                                                                    |                                      |      |
| F <sub>3</sub> Si-SiF <sub>3</sub>                 | 453.1 ± 25                           | 1    | Na-OH                                                                                          | 342.3                                | 1    | (10.4) Group 4                                                                                                     |                                      |      |
| SiH <sub>3</sub> -CH <sub>3</sub>                  | 375 ± 5                              | 1    | Na-O <sub>2</sub>                                                                              | <200                                 | 1    | Ti(η <sup>5</sup> -C <sub>5</sub> H <sub>5</sub> ) <sub>2</sub> -Cl                                                | 471                                  | 1    |
| SiF <sub>3</sub> -CH <sub>3</sub>                  | 355.6                                | 1    | K-OH                                                                                           | 359                                  | 1    | Ti(Cl)(η <sup>5</sup> -C <sub>5</sub> H <sub>5</sub> ) <sub>2</sub> -Cl                                            | 390                                  | 1    |
| H <sub>3</sub> Si-NO                               | 158.2 ± 5.7                          | 1    | Rb-OH                                                                                          | 356.2 ± 4.2                          | 1    | Ti(η <sup>5</sup> -C <sub>5</sub> Me <sub>5</sub> ) <sub>2</sub> -I                                                | 219                                  | 1    |
| H <sub>3</sub> Si-PH <sub>2</sub>                  | 331.4                                | 1    | Cs-OH                                                                                          | 373                                  | 1    |                                                                                                                    |                                      |      |
| SiH <sub>3</sub> -F                                | 638 ± 5                              | 1    |                                                                                                |                                      |      |                                                                                                                    |                                      |      |
| SiH <sub>3</sub> -Cl                               | 458 ± 7                              | 1    | (10.2) Group 2                                                                                 |                                      |      |                                                                                                                    |                                      |      |
|                                                    |                                      |      | BeO-H                                                                                          | 469                                  | 1    |                                                                                                                    |                                      |      |
|                                                    |                                      |      | Be(OH)-OH                                                                                      | 476                                  | 1    |                                                                                                                    |                                      |      |

| Bond                                                                                                | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                                                     | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                                     | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|-----------------------------------------------------------------------------------------------------|--------------------------------------|------|----------------------------------------------------------------------------------------------------------|--------------------------------------|------|------------------------------------------------------------------------------------------|--------------------------------------|------|
| Ti( $\eta^5\text{-C}_5\text{H}_5$ ) <sub>2</sub> -CO                                                | 174                                  | 1    | Cr(C <sub>6</sub> H <sub>6</sub> )-C <sub>6</sub> H <sub>6</sub>                                         | 268.2 ± 15.4                         | 1    | Fe-CH <sub>3</sub>                                                                       | 135 ± 29                             | 1    |
| Ti(CO)( $\eta^5\text{-C}_5\text{H}_5$ ) <sub>2</sub> -CO                                            | 170                                  | 1    | Cr(CO) <sub>5</sub> -C <sub>6</sub> H <sub>6</sub>                                                       | 57.3 ± 3.3                           | 1    | Fe(C <sub>2</sub> H <sub>4</sub> )(CO) <sub>3</sub> -C <sub>2</sub> H <sub>4</sub>       | 89.1 ± 8                             | 1    |
| Ti-CH <sub>3</sub>                                                                                  | 174 ± 29                             | 1    | (P(C <sub>6</sub> H <sub>11</sub> ) <sub>3</sub> ) <sub>2</sub> (CO) <sub>3</sub> Cr-P(OMe) <sub>3</sub> | 68.6 ± 2.5                           | 1    | Fe-C <sub>3</sub> H <sub>5</sub>                                                         | 218                                  | 1    |
| Ti(Cl)( $\eta^5\text{-C}_5\text{H}_5$ ) <sub>2</sub> -CH <sub>3</sub>                               | 276                                  | 1    | ( $\eta^5\text{-C}_5\text{H}_5$ )Mo(CO) <sub>3</sub> -H                                                  | 290                                  | 1    | Fe-C <sub>3</sub> H <sub>6</sub>                                                         | 79                                   | 1    |
| Ti(Cl)( $\eta^5\text{-C}_5\text{H}_5$ ) <sub>2</sub> -C <sub>6</sub> H <sub>5</sub>                 | 292                                  | 1    | Mo( $\eta^5\text{-C}_5\text{H}_5$ )-H                                                                    | 246                                  | 1    | Fe(CO) <sub>5</sub> -Ni(CO) <sub>4</sub>                                                 | 37.7                                 | 1    |
| Ti(C <sub>6</sub> H <sub>6</sub> )-C <sub>6</sub> H <sub>5</sub>                                    | 308.7                                | 1    | Mo(H)( $\eta^5\text{-C}_5\text{H}_5$ )-H                                                                 | 256.9 ± 8.4                          | 1    | Fe(CO) <sub>5</sub> -( $\eta^3\text{-C}_3\text{H}_5$ )                                   | 176                                  | 1    |
| Zr( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> -H                                                | 351.0 ± 7.5                          | 1    | Mo(CO) <sub>3</sub> ( $\eta^5\text{-C}_5\text{H}_5$ )-I                                                  | 216.7 ± 4.2                          | 1    | Fe(C <sub>3</sub> H <sub>6</sub> )(CO) <sub>3</sub> -C <sub>3</sub> H <sub>6</sub>       | ~79.5                                | 1    |
| Zr(H)( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> -H                                             | 326.4 ± 4                            | 1    | ( $\eta^5\text{-C}_5\text{Me}_5$ )Mo-O                                                                   | 272                                  | 1    | (CO) <sub>2</sub> ( $\eta^5\text{-C}_5\text{H}_5$ )Ru-H                                  | 272                                  | 1    |
| Zr( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> -Cl                                               | 481.2                                | 1    | (P(C <sub>6</sub> H <sub>11</sub> ) <sub>3</sub> ) <sub>2</sub> (CO) <sub>3</sub> Mo-H <sub>2</sub>      | 27.2 ± 0.8                           | 1    | (PMe <sub>3</sub> ) <sub>2</sub> ( $\eta^5\text{-C}_5\text{Me}_5$ )Ru-H                  | 167.4                                | 1    |
| Zr( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> -Br                                               | 410.0                                | 1    | (P(C <sub>6</sub> H <sub>11</sub> ) <sub>3</sub> ) <sub>2</sub> (CO) <sub>3</sub> Mo-N <sub>2</sub>      | 37.7 ± 2.5                           | 1    | (CO) <sub>2</sub> ( $\eta^5\text{-C}_5\text{Me}_5$ )Ru-Cl                                | 337.6                                | 1    |
| Zr(I)( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> -I                                             | 336.4 ± 2.1                          | 1    | Mo(CO) <sub>5</sub> -CO                                                                                  | 169.5 ± 8.4                          | 1    | ( $\eta^5\text{-C}_5\text{Me}_5$ )(PMe <sub>3</sub> ) <sub>2</sub> Ru-Cl                 | <138                                 | 1    |
| Zr( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> (Ph)-OH                                           | 482.4 ± 6.3                          | 1    | Mo(CO) <sub>3</sub> ( $\eta^5\text{-C}_5\text{H}_5$ )-CH <sub>3</sub>                                    | 203 ± 8                              | 1    | ( $\eta^5\text{-C}_5\text{Me}_5$ )(PMe <sub>3</sub> ) <sub>2</sub> Ru-OH                 | 204.6                                | 1    |
| Zr( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> (Ph)(OH)-OH                                       | 482.8 ± 10.5                         | 1    | W(CO) <sub>5</sub> -Xe                                                                                   | 35.1 ± 0.8                           | 1    | (CO) <sub>4</sub> Ru-CO                                                                  | 115 ± 1.7                            | 1    |
| Zr( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> (NH <sub>2</sub> )H-NH <sub>2</sub>               | 421.3 ± 15.1                         | 1    | W(CO) <sub>3</sub> ( $\eta^5\text{-C}_5\text{H}_5$ )-H                                                   | 303                                  | 1    | ( $\eta^5\text{-C}_5\text{Me}_5$ )(PMe <sub>3</sub> ) <sub>2</sub> Ru-CH <sub>3</sub>    | 142.3                                | 1    |
| Zr( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> -CH <sub>3</sub>                                  | 276 ± 10                             | 1    | W(H)( $\eta^5\text{-C}_5\text{H}_5$ ) <sub>2</sub> -H                                                    | 310.9 ± 4.2                          | 1    | Os(H)(CO) <sub>4</sub> -H                                                                | 326.4                                | 1    |
| Zr( $\eta^5\text{-C}_5\text{H}_5$ )(C <sub>6</sub> H <sub>5</sub> )-C <sub>6</sub> H <sub>5</sub>   | 300 ± 10                             | 1    | W(I)( $\eta^5\text{-C}_5\text{H}_5$ ) <sub>2</sub> -H                                                    | 273 ± 14                             | 1    | (CO) <sub>4</sub> Os-CO                                                                  | 133 ± 2.6                            | 1    |
| Zr( $\eta^5\text{-C}_5\text{H}_5$ )(Si(SiMe <sub>3</sub> ) <sub>3</sub> )-SiMe <sub>3</sub>         | 188 ± 30                             | 1    | (CO) <sub>5</sub> W-H <sub>2</sub>                                                                       | ≥67                                  | 1    | Os(C <sub>2</sub> H <sub>2</sub> )(CO) <sub>4</sub> -CO                                  | 99.5 ± 0.8                           | 1    |
| Hf(H)( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> -H                                             | 346.0 ± 7.9                          | 1    | (P(C <sub>6</sub> H <sub>11</sub> ) <sub>3</sub> )(CO) <sub>3</sub> W-( $\eta^2\text{-H}_2$ )            | 28.5 ± 2.1                           | 1    | <b>(10.9) Group 9</b>                                                                    |                                      |      |
| Hf( $\eta^5\text{-C}_5\text{Me}_5$ )(C <sub>4</sub> H <sub>9</sub> )-C <sub>4</sub> H <sub>9</sub>  | 274 ± 10                             | 1    | W(CO) <sub>5</sub> -CO                                                                                   | 192.5 ± 8.48.4                       | 1    | (CO) <sub>4</sub> Co-Co(CO) <sub>4</sub>                                                 | 83 ± 29                              | 1    |
| <b>(10.5) Group 5</b>                                                                               |                                      |      | W(CH <sub>3</sub> )( $\eta^5\text{-C}_5\text{H}_5$ )-CH <sub>3</sub>                                     | 220.9 ± 4                            | 1    | (CO) <sub>4</sub> Co-Mn(CO) <sub>5</sub>                                                 | 96 ± 12                              | 1    |
| ( $\eta^5\text{-C}_5\text{H}_5$ )(CO) <sub>3</sub> V- $\eta^2\text{H}_2$                            | 90 ± 20                              | 1    | <b>(10.7) Group 7</b>                                                                                    |                                      |      | (CO) <sub>4</sub> Co-Re(CO) <sub>5</sub>                                                 | 113 ± 15                             | 1    |
| ( $\eta^5\text{-C}_5\text{H}_5$ )(CO) <sub>3</sub> V-CO                                             | 146 ± 21                             | 1    | F <sub>3</sub> Mn-MnF <sub>3</sub>                                                                       | 210.9 ± 2.5                          | 1    | Co(CO) <sub>4</sub> -H                                                                   | 278                                  | 1    |
| V-CH <sub>3</sub>                                                                                   | 169 ± 18                             | 1    | (CO) <sub>5</sub> Mn-Mn(CO) <sub>5</sub>                                                                 | 185 ± 8                              | 1    | Co(CO) <sub>3</sub> (PPh <sub>3</sub> )-H                                                | 272                                  | 1    |
| V-C <sub>6</sub> H <sub>6</sub>                                                                     | 76.2                                 | 1    | (CO) <sub>5</sub> Mn-H                                                                                   | 284.5                                | 1    | (CO) <sub>3</sub> HCo-CO                                                                 | ~54                                  | 1    |
| V(C <sub>6</sub> H <sub>6</sub> )-C <sub>6</sub> H <sub>6</sub>                                     | 307.8                                | 1    | (PPh <sub>3</sub> )Mn(CO) <sub>4</sub> -H                                                                | 286.2                                | 1    | ( $\eta^5\text{-C}_5\text{H}_5$ )Co(CO)-CO                                               | 184.3 ± 4.8                          | 1    |
| Nb( $\eta^5\text{-C}_5\text{H}_5$ ) <sub>2</sub> H <sub>3</sub> -TFE                                | 18.8 ± 1.3                           | 1    | MnBr(CO) <sub>4</sub> -CO                                                                                | 184                                  | 1    | Co-CH <sub>2</sub>                                                                       | 331 ± 38                             | 1    |
| Ta(CH <sub>3</sub> )-CH <sub>3</sub>                                                                | 261 ± 5                              | 1    | ( $\eta^5\text{-C}_5\text{H}_5$ )(CO) <sub>2</sub> Mn-CO                                                 | 195.8 ± 9.2                          | 1    | Co-CH <sub>3</sub>                                                                       | 178 ± 8                              | 1    |
| (Me <sub>3</sub> SiCH <sub>2</sub> ) <sub>4</sub> Ta-(CH <sub>2</sub> SiMe <sub>3</sub> )           | 184.1 ± 8.4                          | 1    | Mn-CH <sub>3</sub>                                                                                       | >35 ± 12                             | 1    | cobalamin-CH <sub>3</sub>                                                                | 150.6                                | 1    |
| <b>(10.6) Group 6</b>                                                                               |                                      |      | Mn(CO) <sub>5</sub> -CH <sub>3</sub>                                                                     | 187.0 ± 3.8                          | 1    | cobinamide-iC <sub>4</sub> H <sub>9</sub>                                                | 104                                  | 1    |
| [Cr(CO) <sub>3</sub> ( $\eta^5\text{-C}_5\text{Me}_5$ ) <sub>2</sub> ]-Hg                           | 61.5                                 | 1    | Mn(CO) <sub>5</sub> -C <sub>6</sub> H <sub>5</sub>                                                       | 207 ± 11                             | 1    | Co-C bonds in B <sub>12</sub>                                                            | 123.8 ± 6.3                          | 1    |
| [Cr(CO) <sub>3</sub> ( $\eta^5\text{-C}_5\text{Me}_5$ )]-Hg                                         | 111.3                                | 1    | (CO) <sub>5</sub> Mn-Re(CO) <sub>5</sub>                                                                 | 149 ± 11                             | 1    | Cl(CO) <sub>2</sub> Rh-Rh(CO) <sub>2</sub> Cl                                            | 94.6                                 | 1    |
| Cr(CO) <sub>5</sub> -Xe                                                                             | 37.7 ± 3.8                           | 1    | ( $\eta^5\text{-C}_5\text{H}_5$ )Mn(CO) <sub>2</sub> -PhMe                                               | 59.4 ± 3.3                           | 1    | HRh(m-xylyl)Rh-H                                                                         | 255.6 ± 1.7                          | 1    |
| (CO) <sub>2</sub> (PPh <sub>3</sub> )( $\eta^5\text{-C}_5\text{H}_5$ )Cr-H                          | 250.2 ± 4.2                          | 1    | (CO) <sub>3</sub> Tc-Tc(CO) <sub>5</sub>                                                                 | 177.5 ± 1.9                          | 1    | (PiPr <sub>3</sub> ) <sub>2</sub> (Cl)Rh-H <sub>2</sub>                                  | 136.0                                | 1    |
| ( $\eta^5\text{-C}_5\text{H}_5$ )Cr(CO) <sub>3</sub> -H                                             | 257                                  | 1    | (CO) <sub>3</sub> Re-Re(CO) <sub>5</sub>                                                                 | 187 ± 4.8                            | 1    | (PiPr <sub>3</sub> ) <sub>2</sub> (Cl)Rh-N <sub>2</sub>                                  | 69.0                                 | 1    |
| Cr(CO) <sub>5</sub> -H <sub>2</sub>                                                                 | 78 ± 4                               | 1    | (CO) <sub>3</sub> Re-H                                                                                   | 313                                  | 1    | (PiPr <sub>3</sub> ) <sub>2</sub> (Cl)Rh-CO                                              | 201.7                                | 1    |
| (P(C <sub>6</sub> H <sub>11</sub> ) <sub>3</sub> ) <sub>2</sub> (CO) <sub>3</sub> Cr-H <sub>2</sub> | 30.5 ± 0.4                           | 1    | (CO) <sub>5</sub> Re-CH <sub>3</sub>                                                                     | 220 ± 8                              | 1    | HRh(m-xylyl)Rh-CH <sub>2</sub> OH                                                        | 195.4 ± 7.5                          | 1    |
| ( $\eta^6\text{-C}_6\text{H}_6$ )(CO) <sub>3</sub> Cr-H <sub>2</sub>                                | 251 ± 17                             | 1    | <b>(10.8) Group 8</b>                                                                                    |                                      |      | Ir(Cl)(CO)(PMe <sub>3</sub> ) <sub>2</sub> -H                                            | 251                                  | 1    |
| Cr(CO) <sub>5</sub> -N <sub>2</sub>                                                                 | 81 ± 4                               | 1    | (CO) <sub>4</sub> Fe-Fe(CO) <sub>5</sub>                                                                 | 171.5                                | 1    | Ir(H)( $\eta^5\text{-C}_5\text{Me}_5$ )(PMe <sub>3</sub> )-H                             | 310.5 ± 21                           | 1    |
| (P(C <sub>6</sub> H <sub>11</sub> ) <sub>3</sub> ) <sub>2</sub> (CO) <sub>3</sub> Cr-N <sub>2</sub> | 38.9 ± 0.8                           | 1    | (CO) <sub>4</sub> Fe(H) <sub>x</sub> -H                                                                  | 259.4 ± 8.4                          | 1    | Ir(Cl)(H)(CO)(PEt <sub>3</sub> ) <sub>2</sub> -H                                         | 243.1                                | 1    |
| ( $\eta^5\text{-C}_5\text{Me}_5$ )(CO) <sub>3</sub> Cr-SH                                           | 193                                  | 1    | ( $\eta^5\text{-C}_5\text{H}_5$ )(CO) <sub>2</sub> Fe-H                                                  | 239                                  | 1    | Ir(Cl)(H)(CO)(PPh <sub>3</sub> ) <sub>2</sub> -H                                         | 246.9                                | 1    |
| Cr(CO) <sub>5</sub> -CO                                                                             | 154.0 ± 8.4                          | 1    | Fe(CO) <sub>3</sub> (N <sub>2</sub> )-N <sub>2</sub>                                                     | 37.7 ± 19.2                          | 1    | (Cl)(CO)(PPh <sub>3</sub> ) <sub>2</sub> Ir-H <sub>2</sub>                               | 62.8                                 | 1    |
| Cr(CO) <sub>5</sub> -CH <sub>4</sub>                                                                | ~33.5 ± 8                            | 1    | Fe(C <sub>2</sub> H <sub>2</sub> )(CO) <sub>4</sub> -CO                                                  | 88 ± 2.3                             | 1    | (Cl)(CO)(PPh <sub>3</sub> ) <sub>2</sub> Ir-CO                                           | 45.2                                 | 1    |
| Cr-C <sub>6</sub> H <sub>6</sub>                                                                    | 9.6 ± 5.8                            | 1    | Fe(CO) <sub>2</sub> (PMe <sub>3</sub> )-CO                                                               | >125                                 | 1    | Ir(H)( $\eta^5\text{-C}_5\text{Me}_5$ )(PMe <sub>3</sub> )-C <sub>6</sub> H <sub>5</sub> | 321                                  | 1    |
|                                                                                                     |                                      |      | Fe(CO) <sub>3</sub> (PPh <sub>3</sub> )-CO                                                               | <177.8 ± 5                           | 1    | <b>(10.10) Group 10</b>                                                                  |                                      |      |
|                                                                                                     |                                      |      | Fe-NH <sub>3</sub>                                                                                       | 31.4 ± 4.2                           | 1    | Ni-H <sub>2</sub> O                                                                      | ~29                                  | 1    |
|                                                                                                     |                                      |      | Fe-CH <sub>2</sub>                                                                                       | 364 ± 29                             | 1    | Ni(CO) <sub>3</sub> -N <sub>2</sub>                                                      | ~42                                  | 1    |

| Bond                                                                                               | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                             | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                              | $D_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|----------------------------------------------------------------------------------------------------|--------------------------------------|------|------------------------------------------------------------------|--------------------------------------|------|-----------------------------------------------------------------------------------|--------------------------------------|------|
| Ni(CO) <sub>3</sub> -CO                                                                            | 104.6 ± 8.4                          | 1    | Cu(C <sub>6</sub> H <sub>6</sub> )-C <sub>6</sub> H <sub>6</sub> | 27.0 ± 19.3                          | 1    | <b>(10.13) Group 13</b>                                                           |                                      |      |
| Ni-CH <sub>3</sub>                                                                                 | 208 ± 8                              | 1    | Ag-CH <sub>3</sub>                                               | 134.1 ± 6.8                          | 1    | H <sub>3</sub> B-BH <sub>3</sub>                                                  | 172                                  | 1    |
| Ni-C <sub>2</sub> H <sub>2</sub>                                                                   | 193 ± 25                             | 1    | Ag-NH <sub>3</sub>                                               | 8 ± 13                               | 1    | H <sub>3</sub> B-NH <sub>3</sub>                                                  | 130.1 ± 4.2                          | 1    |
| Ni-C <sub>2</sub> H <sub>4</sub>                                                                   | 147.3 ± 17.6                         | 1    | Ag(NH <sub>3</sub> )-NH <sub>3</sub>                             | 62.8 ± 4.2                           | 1    | (CH <sub>3</sub> ) <sub>3</sub> B-NH <sub>3</sub>                                 | 57.7 ± 1.3                           | 1    |
| Ni-propyne                                                                                         | 155 ± 21                             | 1    | Au-OH                                                            | >262                                 | 1    | F <sub>3</sub> B-N(CH <sub>3</sub> ) <sub>3</sub>                                 | 130 ± 4.6                            | 1    |
| Ni-2-butyne                                                                                        | 121 ± 21                             | 1    | Au-NH <sub>3</sub>                                               | 76 ± 6                               | 1    | Cl <sub>3</sub> B-N(CH <sub>3</sub> ) <sub>3</sub>                                | 127.6                                | 1    |
| Pd-OH                                                                                              | 213                                  | 1    | Au-CH <sub>3</sub>                                               | ≥191.6                               | 1    | F <sub>2</sub> B-CH <sub>3</sub>                                                  | 397 - 418                            | 1    |
| trans-Pt(PPh <sub>3</sub> ) <sub>2</sub> (Cl)-H                                                    | 307 ± 37                             | 1    | Au-C <sub>6</sub> H <sub>6</sub>                                 | 8.4                                  | 1    | Al-OH                                                                             | 547 ± 13                             | 1    |
| [Ph <sub>2</sub> PCH <sub>2</sub> ] <sub>2</sub> MePt-H                                            | 104.6                                | 1    | <b>(10.12) Group 12</b>                                          |                                      |      | Al-C <sub>2</sub> H <sub>2</sub>                                                  | >54                                  | 1    |
| [Ph <sub>2</sub> PCH <sub>2</sub> ] <sub>2</sub> MePt-OH                                           | 167.4                                | 1    | Zn-CH <sub>3</sub>                                               | 70 ± 10                              | 1    | Cl <sub>3</sub> Al-N(CH <sub>3</sub> ) <sub>3</sub>                               | 198.7 ± 8.4                          | 1    |
| [Ph <sub>2</sub> PCH <sub>2</sub> ] <sub>2</sub> MePt-SH                                           | 90.0                                 | 1    | Zn(CH <sub>3</sub> )-CH <sub>3</sub>                             | 266.5 ± 6.3                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> Al-N(CH <sub>3</sub> ) <sub>3</sub>               | 130                                  | 1    |
| Pt(η <sup>5</sup> -C <sub>5</sub> H <sub>5</sub> )(CH <sub>3</sub> ) <sub>2</sub> -CH <sub>3</sub> | 163 ± 21                             | 1    | Zn-C <sub>2</sub> H <sub>5</sub>                                 | 92.0 ± 17.6                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> Al-O(CH <sub>3</sub> ) <sub>2</sub>               | 92                                   | 1    |
| cis-Pt(PEt <sub>3</sub> ) <sub>2</sub> (CH <sub>3</sub> )-CH <sub>3</sub>                          | 269 ± 13                             | 1    | Zn(C <sub>2</sub> H <sub>5</sub> )-C <sub>2</sub> H <sub>5</sub> | 219.2 ± 8.4                          | 1    | (CH <sub>3</sub> ) <sub>3</sub> Ga-O(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> | 50.6 ± 0.8                           | 1    |
| <b>(10.11) Group 11</b>                                                                            |                                      |      | Cd-CH <sub>3</sub>                                               | 63.6 ± 10.0                          | 1    | Cl <sub>3</sub> Ga-S(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>                 | 235.1                                | 1    |
| Cu-OH                                                                                              | >406                                 | 1    | Cd(CH <sub>3</sub> )-CH <sub>3</sub>                             | 234.3 ± 6.3                          | 1    | In-CH <sub>3</sub>                                                                | 216.3                                | 1    |
| Cu-CO                                                                                              | 25 ± 5                               | 1    | Hg-CH <sub>3</sub>                                               | 22.6 ± 12.6                          | 1    | In(CH <sub>3</sub> ) <sub>1</sub> -CH <sub>3</sub>                                | 318.8                                | 1    |
| Cu-CH <sub>3</sub>                                                                                 | 223 ± 5                              | 1    | Hg(CH <sub>3</sub> )-CH <sub>3</sub>                             | 239.3 ± 6.3                          | 1    | In(CH <sub>3</sub> ) <sub>2</sub> -CH <sub>3</sub>                                | 587.4                                | 1    |
| Cu-NH <sub>3</sub>                                                                                 | 47 ± 15                              | 1    | ClHg-CH <sub>3</sub>                                             | 280.0 ± 12.6                         | 1    | (CH <sub>3</sub> ) <sub>3</sub> In-N(CH <sub>3</sub> ) <sub>3</sub>               | 83.3 ± 2.1                           | 1    |
| Cu(NH <sub>3</sub> )-NH <sub>3</sub>                                                               | 83.7 ± 4.2                           | 1    | BrHg-CH <sub>3</sub>                                             | 270 ± 38                             | 1    | Tl-OH                                                                             | 330 ± 30                             | 1    |
| Cu-C <sub>6</sub> H <sub>6</sub>                                                                   | 16.4 ± 12.5                          | 1    | IHg-CH <sub>3</sub>                                              | 258.6 ± 12.6                         | 1    |                                                                                   |                                      |      |

## References

1. Luo, Y.R., *Comprehensive Handbook of Chemical Bond Energies*, CRC Press, 2007.
2. Shuman, N.S., et al., *J. Phys. Chem. A* 112, 5647-5652, 2008.
3. Seetula, J.A., et al., *Chem. Phys.* 351, 141-146, 2008.

TABLE 4. Enthalpies of Formation of Free Radicals and Other Transient Species

References: Yu-Ran Luo, *Comprehensive Handbook of Chemical Bond Energies*, CRC Press, 2007.

| Radical                                                                        | $\Delta H_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. | Radical                                                                                                      | $\Delta H_{298}^{\circ}/\text{kJ mol}^{-1}$ | Ref. |
|--------------------------------------------------------------------------------|---------------------------------------------|------|--------------------------------------------------------------------------------------------------------------|---------------------------------------------|------|
| <b>(1) Carbon-Centered Species</b>                                             |                                             |      | n-C <sub>3</sub> H <sub>7</sub> •, n-propyl, CH <sub>3</sub> CH <sub>2</sub> C•H <sub>2</sub>                | 100 ± 2                                     | 1    |
| CH                                                                             | 595.8 ± 0.6                                 | 1    | i-C <sub>3</sub> H <sub>7</sub> •, i-propyl, CH <sub>3</sub> C•HCH <sub>3</sub>                              | 88 ± 3                                      | 1    |
| CH <sub>2</sub> (triplet)                                                      | 391.2 ± 1.6                                 | 1    | *n-C <sub>4</sub> H <sub>9</sub> , CH≡CCH=C•H                                                                | 547.3                                       | 1    |
| CH <sub>2</sub> (singlet)                                                      | 428.8 ± 1.6                                 | 1    | *i-C <sub>4</sub> H <sub>9</sub> , CH <sub>2</sub> =C•C≡CH                                                   | 499.2                                       | 1    |
| *CH <sub>3</sub> , methyl                                                      | 146.7 ± 0.3                                 | 1    | *C <sub>4</sub> H <sub>9</sub> , CH <sub>3</sub> C≡CC•H <sub>2</sub>                                         | 304.5                                       | 1    |
| *C <sub>2</sub> H, acetynyl, CH≡C•                                             | 567.4 ± 2.1                                 | 1    | *C <sub>4</sub> H <sub>9</sub> , CH≡CC•HCH <sub>3</sub>                                                      | 316.5                                       | 1    |
| *C <sub>2</sub> H <sub>2</sub> , vinylidene CH <sub>2</sub> =C••               | 419.7 ± 16.7                                | 1    | *C <sub>4</sub> H <sub>9</sub> , •CH=CHCHCH <sub>2</sub>                                                     | 364.4                                       | 1    |
| *C <sub>2</sub> H <sub>3</sub> , vinyl, CH <sub>2</sub> =C•H                   | 299.6 ± 3.3                                 | 1    | *C <sub>4</sub> H <sub>9</sub> , CH <sub>2</sub> =CHC•HCH <sub>2</sub>                                       | 313.3                                       | 1    |
| *C <sub>2</sub> H <sub>5</sub> , ethyl, CH <sub>3</sub> C•H <sub>2</sub>       | 118.8 ± 1.3                                 | 1    | *C <sub>4</sub> H <sub>7</sub> , CH <sub>3</sub> CH=CHC•H <sub>2</sub>                                       | 146 ± 8                                     | 1    |
| *C <sub>3</sub> H <sub>3</sub> , propargyl, CH≡CC•H <sub>2</sub>               | 351.9                                       | 2    | *C <sub>4</sub> H <sub>7</sub> , CH <sub>2</sub> =CHCH <sub>2</sub> C•H <sub>2</sub>                         | 192.5                                       | 1    |
| *C <sub>3</sub> H <sub>3</sub> , CH <sub>3</sub> C≡C•                          | 515 ± 13                                    | 1    | *C <sub>4</sub> H <sub>7</sub> , CH <sub>2</sub> =C(CH <sub>3</sub> )C•H <sub>2</sub>                        | 137.9                                       | 1    |
| *C <sub>3</sub> H <sub>3</sub> , CH <sub>2</sub> =C=CH• ↔ CH≡CC•H <sub>2</sub> | 351.9                                       | 2    | *C <sub>4</sub> H <sub>7</sub> , CH <sub>2</sub> =CHC•HCH <sub>3</sub>                                       | 136.2                                       | 1    |
| *C <sub>3</sub> H <sub>3</sub> , cyclopro-2-en-1-yl                            | 439.7 ± 17.2                                | 1    | *C <sub>4</sub> H <sub>7</sub> , cyclopropylmethyl                                                           | 213.8 ± 6.7                                 | 1    |
| *C <sub>3</sub> H <sub>5</sub> , allyl, CH <sub>2</sub> =CHC•H <sub>2</sub>    | 171.0 ± 3.0                                 | 1    | *C <sub>4</sub> H <sub>7</sub> , cyclobutyl                                                                  | 219.2 ± 4.2                                 | 1    |
| *C <sub>3</sub> H <sub>5</sub> , CH <sub>3</sub> CH=C•H                        | 267 ± 6                                     | 1    | n-C <sub>4</sub> H <sub>9</sub> •, n-butyl, CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> C•H <sub>2</sub> | 77.8 ± 2.1                                  | 1    |
| *C <sub>3</sub> H <sub>5</sub> , CH <sub>3</sub> C•=CH <sub>2</sub>            | 231.4                                       | 1    | i-C <sub>4</sub> H <sub>9</sub> •, i-butyl, (CH <sub>3</sub> ) <sub>2</sub> CHC•H <sub>2</sub>               | 70 ± 4                                      | 1    |
| *C <sub>3</sub> H <sub>5</sub> , cyclopropyl                                   | 279.9 ± 10.5                                | 1    | s-C <sub>4</sub> H <sub>9</sub> •, s-butyl, CH <sub>3</sub> C•HCH <sub>2</sub> CH <sub>3</sub>               | 67.8 ± 2.1                                  | 1    |
|                                                                                |                                             |      | t-C <sub>4</sub> H <sub>9</sub> •, t-butyl, (CH <sub>3</sub> ) <sub>3</sub> C•                               | 48 ± 3                                      | 1    |



| Radical                                                                                                            | $\Delta_f H^\circ / \text{kJ mol}^{-1}$ | Ref. | Radical                                                                                                              | $\Delta_f H^\circ / \text{kJ mol}^{-1}$ | Ref. |
|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------|------|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------|------|
| $\cdot\text{C}_5\text{H}_3$ , $\text{CH}\equiv\text{C}-\text{C}\equiv\text{CC}\cdot\text{H}_2$                     | 579.1                                   | 1    | $\cdot\text{C}_7\text{H}_9$ , $(\text{CH}_2=\text{CH})_3\text{C}\cdot$                                               | 274.0                                   | 1    |
| $\cdot\text{C}_5\text{H}_3$ , $(\text{CH}\equiv\text{C})_2\text{C}\cdot\text{H}$                                   | 573.2                                   | 1    | $\cdot\text{C}_7\text{H}_{11}$ , norborn-1-yl                                                                        | 136.4 $\pm$ 10.5                        | 1    |
| $\cdot\text{C}_5\text{H}_5$ , $\text{CH}_2=\text{CHC}\equiv\text{CC}\cdot\text{H}_2$                               | 351.5                                   | 1    | $\cdot\text{C}_7\text{H}_{11}$ , cycloheptenyl                                                                       | 119.2                                   | 1    |
| $\cdot\text{C}_5\text{H}_5$ , $\text{CH}_2=\text{CH}-\text{C}\cdot\text{H}-\text{C}\equiv\text{CH}$                | 372.4                                   | 1    | $\cdot\text{C}_7\text{H}_{13}$ , cycloheptyl                                                                         | 50.6 $\pm$ 4.2                          | 1    |
| $\cdot\text{C}_5\text{H}_5$ , cyclopenta-1,3-dien-5-yl                                                             | 274.1 $\pm$ 7.3                         | 1    | $\cdot\text{C}_7\text{H}_{13}$ , cyclo-[ $\text{C}\cdot(\text{CH}_3)(\text{CH}_2)_5$ ]                               | 22.6                                    | 1    |
| $\cdot\text{C}_5\text{H}_7$ , $\text{CH}_3\text{C}\equiv\text{CC}\cdot\text{HCH}_3$                                | 272.8 $\pm$ 9.2                         | 1    | $\cdot\text{C}_7\text{H}_{13}$ , cyclo-[ $\text{C}\cdot(\text{CH}_2\text{CH}_3)(\text{CH}_2)_4$ ]                    | 47.0                                    | 1    |
| $\cdot\text{C}_5\text{H}_7$ , $\text{CH}\equiv\text{CC}\cdot\text{HC}_2\text{H}_5$                                 | 277.0 $\pm$ 8.4                         | 1    | $\cdot\text{C}_7\text{H}_{15}$ , $(\text{nC}_5\text{H}_{11})(\text{CH}_3)\text{CH}\cdot$                             | 8.4                                     | 1    |
| $\cdot\text{C}_5\text{H}_7$ , $\text{CH}\equiv\text{CC}\cdot(\text{CH}_3)_2$                                       | 257.3 $\pm$ 9.2                         | 1    | $\cdot\text{C}_7\text{H}_{15}$ , $(\text{CH}_3)_2\text{CHCHC}\cdot(\text{CH}_3)_2$                                   | -21.8 $\pm$ 5.2                         | 1    |
| $\cdot\text{C}_5\text{H}_7$ , $\text{CH}_2=\text{CHCH}=\text{CHC}\cdot\text{H}_2$                                  | 205.0 $\pm$ 12.6                        | 1    | $\cdot\text{C}_8\text{H}_7$ , cubyl                                                                                  | 831.0 $\pm$ 16.7                        | 1    |
| $\cdot\text{C}_5\text{H}_7$ , $(\text{CH}_2=\text{CH})_2\text{C}\cdot\text{H}$                                     | 208.0 $\pm$ 4.2                         | 1    | $\cdot\text{C}_8\text{H}_7$ , $\text{C}_6\text{H}_5\text{C}\cdot=\text{CH}_2$                                        | 309.6                                   | 1    |
| $\cdot\text{C}_5\text{H}_7$ , $\text{CH}_3\text{CH}=\text{C}=\text{CHC}\cdot\text{H}_2$                            | 278.0                                   | 1    | $\cdot\text{C}_8\text{H}_7$ , $\text{C}_6\text{H}_5\text{CH}=\text{CH}\cdot$                                         | 387.0                                   | 1    |
| $\cdot\text{C}_5\text{H}_7$ , spiropentyl                                                                          | 380.7 $\pm$ 4.2                         | 1    | $\cdot\text{C}_8\text{H}_9$ , $\text{C}_6\text{H}_5\text{C}\cdot\text{H}(\text{CH}_3)$                               | 175.7 $\pm$ 7.5                         | 1    |
| $\cdot\text{C}_5\text{H}_7$ , cyclopent-1-en-3-yl                                                                  | 160.7 $\pm$ 4.2                         | 1    | $\cdot\text{C}_8\text{H}_9$ , $\text{C}_6\text{H}_5\text{CH}_2\text{C}\cdot\text{H}_2$                               | 236.0 $\pm$ 7.5                         | 1    |
| $\cdot\text{C}_5\text{H}_9$ , cyclopentyl                                                                          | 105.9 $\pm$ 4.2                         | 1    | $\cdot\text{C}_8\text{H}_9$ , p- $\text{CH}_3\text{C}_6\text{H}_4\text{C}\cdot\text{H}_2$                            | 167.4                                   | 1    |
| $\cdot\text{C}_5\text{H}_9$ , $\text{CH}_2=\text{CHC}\cdot\text{HCH}_2\text{CH}_3$                                 | 109.6 $\pm$ 8.4                         | 1    | $\cdot\text{C}_8\text{H}_9$ , m- $\text{CH}_3\text{C}_6\text{H}_4\text{C}\cdot\text{H}_2$                            | 167.4                                   | 1    |
| $\cdot\text{C}_5\text{H}_9$ , $\text{CH}_3\text{CH}=\text{CHC}\cdot\text{H}(\text{CH}_3)$                          | 92                                      | 1    | $\cdot\text{C}_8\text{H}_9$ , o- $\text{CH}_3\text{C}_6\text{H}_4\text{C}\cdot\text{H}_2$                            | 167.4                                   | 1    |
| $\cdot\text{C}_5\text{H}_9$ , $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{C}\cdot\text{H}_2$                  | 92.0                                    | 1    | $\cdot\text{C}_8\text{H}_9$ , 1-vinyl-cyclohexa-2,4-dienyl                                                           | 247.7 $\pm$ 14.2                        | 1    |
| $\cdot\text{C}_5\text{H}_9$ , $\text{CH}_2=\text{CHC}\cdot(\text{CH}_3)_2$                                         | 87.0 $\pm$ 8.4                          | 1    | $\cdot\text{C}_8\text{H}_9$ , 2-vinyl-cyclohexa-2,4-dienyl                                                           | 249.8 $\pm$ 14.2                        | 1    |
| $\cdot\text{C}_5\text{H}_9$ , $\text{CH}_2=\text{C}(\text{CH}_3)\text{C}\cdot\text{H}(\text{CH}_3)$                | 93.7                                    | 1    | $\cdot\text{C}_8\text{H}_9$ , 3-vinyl-cyclohexa-2,4-dienyl                                                           | 269.4 $\pm$ 14.2                        | 1    |
| $\cdot\text{C}_5\text{H}_9$ , $\text{CH}_2=\text{C}(\text{C}\cdot\text{H}_2)\text{CH}_2\text{CH}_3$                | 114.2                                   | 1    | $\cdot\text{C}_8\text{H}_9$ , 6-vinyl-cyclohexa-2,4-dienyl                                                           | 284.5 $\pm$ 14.2                        | 1    |
| $\cdot\text{C}_5\text{H}_9$ , $\text{CH}_2=\text{CH}(\text{CH}_2)_2\text{C}\cdot\text{H}_2$                        | 179.5                                   | 1    | $\cdot\text{C}_8\text{H}_{13}$ , $\text{CH}_2=\text{CHCH}=\text{CHC}\cdot\text{H}(\text{CH}_2)_2\text{CH}_3$         | 130.5                                   | 1    |
| $\text{nC}_5\text{H}_{11}\cdot$ , $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{C}\cdot\text{H}_2$            | 54.4                                    | 1    | $\cdot\text{C}_8\text{H}_{13}$ , $\text{CH}_2=\text{CHC}\cdot\text{H}(\text{CH}_2)_3\text{CH}=\text{CH}_2$           | 130.5                                   | 1    |
| $\cdot\text{C}_5\text{H}_{11}$ , $(\text{C}_2\text{H}_5)_2\text{C}\cdot\text{H}$                                   | 47.0                                    | 1    | $\cdot\text{C}_8\text{H}_{13}$ , bicyclooct-1-yl                                                                     | 92.0                                    | 1    |
| $\cdot\text{C}_5\text{H}_{11}$ , $(\text{nC}_3\text{H}_7)(\text{CH}_3)\text{C}\cdot\text{H}$                       | 50.2                                    | 1    | $\cdot\text{C}_8\text{H}_{15}$ , $\text{CH}_2=\text{CHC}\cdot\text{H}(\text{CH}_2)_4\text{CH}_3$                     | 49.8                                    | 1    |
| $\cdot\text{C}_5\text{H}_{11}$ , $(\text{CH}_3)_3\text{C}\cdot\text{CH}_2$                                         | 36.4 $\pm$ 8.4                          | 1    | $\cdot\text{C}_8\text{H}_{15}$ , (E)- $\text{CH}_3\text{CH}=\text{C}\cdot(\text{CH}_2)_4\text{CH}_3$                 | 29.7                                    | 1    |
| $\cdot\text{C}_5\text{H}_{11}$ , $(\text{C}_2\text{H}_5)(\text{CH}_3)_2\text{C}\cdot$                              | 29                                      | 1    | $\cdot\text{C}_8\text{H}_{15}$ , (Z)- $(\text{CH}_3)_2\text{C}\cdot\text{CH}=\text{CHCH}(\text{CH}_3)_2$             | 9.2                                     | 1    |
| $\cdot\text{C}_6\text{H}_5$ , phenyl                                                                               | 330.1 $\pm$ 3.3                         | 1    | $\cdot\text{C}_8\text{H}_{15}$ , cyclooctanyl                                                                        | 59.4                                    | 1    |
| $\cdot\text{C}_6\text{H}_7$ , cyclohexa-1,3-dien-5-yl                                                              | 199.2                                   | 1    | $\cdot\text{C}_8\text{H}_{15}$ , cyclo-[ $\text{C}\cdot(\text{CH}_2\text{CH}_3)(\text{CH}_2)_5$ ]                    | 10.0                                    | 1    |
| $\cdot\text{C}_6\text{H}_7$ , cyclohexa-1,4-dien-3-yl                                                              | 201.7 $\pm$ 5.0                         | 1    | $\cdot\text{C}_9\text{H}_7$ , indenyl                                                                                | 297.1                                   | 1    |
| $\cdot\text{C}_6\text{H}_9$ , $\text{CH}_3\text{C}\equiv\text{CC}\cdot(\text{CH}_3)_2$                             | 221.8 $\pm$ 9.2                         | 1    | $\cdot\text{C}_9\text{H}_9$ , indanyl-1                                                                              | 204.2 $\pm$ 8.4                         | 1    |
| $\cdot\text{C}_6\text{H}_9$ , $(\text{CH}_2=\text{CH})_2\text{C}\cdot(\text{CH}_3)$                                | 193.7                                   | 1    | $\cdot\text{C}_9\text{H}_{11}$ , 2,6-dimethylbenzyl                                                                  | 124.7                                   | 1    |
| $\cdot\text{C}_6\text{H}_9$ , cyclohexa-1-en-3-yl                                                                  | 119.7                                   | 1    | $\cdot\text{C}_9\text{H}_{11}$ , 3,6-dimethylbenzyl                                                                  | 124.7                                   | 1    |
| $\cdot\text{C}_6\text{H}_{11}$ , $\text{CH}_2=\text{CH}(\text{CH}_2)_3\text{C}\cdot\text{H}_2$                     | 158.6                                   | 1    | $\cdot\text{C}_9\text{H}_{11}$ , 3,5-dimethylbenzyl                                                                  | 124.7                                   | 1    |
| $\cdot\text{C}_6\text{H}_{11}$ , $\text{CH}_2=\text{CHC}\cdot\text{H}(\text{CH}_2)_2\text{CH}_3$                   | 89.0                                    | 1    | $\cdot\text{C}_9\text{H}_{11}$ , $\text{C}_6\text{H}_5\text{C}\cdot(\text{CH}_3)_2$                                  | 133.9 $\pm$ 4.2                         | 1    |
| $\cdot\text{C}_6\text{H}_{11}$ , $\text{CH}_2=\text{C}(\text{CH}_3)\text{C}\cdot(\text{CH}_3)_2$                   | 37.7 $\pm$ 6.3                          | 1    | $\cdot\text{C}_9\text{H}_{11}$ , o- $\cdot\text{C}_6\text{H}_4\text{C}_2\text{H}_5$                                  | 279.5 $\pm$ 7.5                         | 1    |
| $\cdot\text{C}_6\text{H}_{11}$ , $(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_3)\text{C}\cdot\text{H}_2$            | 39.7 $\pm$ 6.3                          | 1    | $\cdot\text{C}_9\text{H}_{17}$ , cyclononanyl                                                                        | 52.3                                    | 1    |
| $\cdot\text{C}_6\text{H}_{11}$ , $(\text{CH}_3)_2\text{C}=\text{CHC}\cdot\text{H}(\text{CH}_3)$                    | 47.3                                    | 1    | $\cdot\text{C}_{10}\text{H}_7$ , naphth-1-yl                                                                         | 401.7 $\pm$ 5.4                         | 1    |
| $\cdot\text{C}_6\text{H}_{11}$ , (Z)- $\text{CH}_3\text{CH}=\text{CHC}\cdot(\text{CH}_3)_2$                        | 54.4                                    | 1    | $\cdot\text{C}_{10}\text{H}_7$ , naphth-2-yl                                                                         | 400.4 $\pm$ 5.9                         | 1    |
| $\cdot\text{C}_6\text{H}_{11}$ , cyclohexyl                                                                        | 75.3 $\pm$ 6.3                          | 1    | $\cdot\text{C}_{10}\text{H}_{11}$ , tetralin-1-yl                                                                    | 154.8 $\pm$ 5.0                         | 1    |
| $\text{nC}_6\text{H}_{13}\cdot$ , $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{C}\cdot\text{H}_2$ | 33.5                                    | 1    | $\cdot\text{C}_{10}\text{H}_{13}$ , 1-phenyl-but-4-yl                                                                | 192.0                                   | 1    |
| $\cdot\text{C}_6\text{H}_{13}$ , $(\text{nC}_4\text{H}_9)(\text{CH}_3)\text{C}\cdot\text{H}$                       | 29.3                                    | 1    | $\cdot\text{C}_{10}\text{H}_{13}$ , $(\text{C}_6\text{H}_5\text{CH}_2)(\text{C}_2\text{H}_5)\text{C}\cdot\text{H}$   | 184.5                                   | 1    |
| $\cdot\text{C}_6\text{H}_{13}$ , 2-methyl-2-pentyl                                                                 | 3.3 $\pm$ 8.4                           | 1    | $\cdot\text{C}_{10}\text{H}_{13}$ , $(\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2)(\text{CH}_3)\text{C}\cdot\text{H}$ | 184.5                                   | 1    |
| $\cdot\text{C}_6\text{H}_{13}$ , 3-methyl-3-pentyl                                                                 | 14.2                                    | 1    | $\cdot\text{C}_{10}\text{H}_{13}$ , $(\text{C}_6\text{H}_5\text{C}\cdot\text{HCH}_2\text{CH}_2\text{CH}_3)$          | 134.7                                   | 1    |
| $\cdot\text{C}_6\text{H}_{13}$ , 2,3-dimethyl-2-butyl                                                              | 3.1 $\pm$ 10                            | 1    | $\cdot\text{C}_{10}\text{H}_{15}$ , 1-adamantyl                                                                      | 51.5                                    | 1    |
| $\cdot\text{C}_7\text{H}_3$ , $(\text{CH}\equiv\text{C})_3\text{C}\cdot$                                           | 784.5                                   | 1    | $\cdot\text{C}_{10}\text{H}_{15}$ , 2-adamantyl                                                                      | 61.9                                    | 1    |
| $\cdot\text{C}_7\text{H}_7$ , benzyl, $\text{C}_6\text{H}_5\text{C}\cdot\text{H}_2$                                | 208.0 $\pm$ 1.7                         | 1    | $\cdot\text{C}_{10}\text{H}_{19}$ , cyclodecanyl                                                                     | 32.2                                    | 1    |
| $\cdot\text{C}_7\text{H}_7$ , quadricyclolan-5-yl                                                                  | 578.6 $\pm$ 5.4                         | 1    | $\cdot\text{C}_{11}\text{H}_9$ , 1-naphthylmethyl                                                                    | 252.7                                   | 1    |
| $\cdot\text{C}_7\text{H}_7$ , quadricyclolan-4-yl                                                                  | 587.4 $\pm$ 5.4                         | 1    | $\cdot\text{C}_{11}\text{H}_{21}$ , cycloundecanyl                                                                   | 7.5                                     | 1    |
| $\cdot\text{C}_7\text{H}_7$ , norborna-2,5-dien-7-yl                                                               | 511.7 $\pm$ 7.9                         | 1    | $\cdot\text{C}_{12}\text{H}_{23}$ , cyclododecanyl                                                                   | -38.5                                   | 1    |
| $\cdot\text{C}_7\text{H}_7$ , cyclohepta-1,3,5-trien-7-yl                                                          | 285.3 $\pm$ 12.6                        | 1    | $\cdot\text{C}_{13}\text{H}_9$ , 9-fluorenyl                                                                         | 297.5                                   | 1    |
| $\cdot\text{C}_7\text{H}_9$ , $\text{CH}_2=\text{CH}(\text{CH}=\text{CH})_2\text{CC}\cdot\text{H}_2$               | 251.0                                   | 1    | $\cdot\text{C}_{13}\text{H}_{11}$ , $(\text{C}_6\text{H}_5)_2\text{C}\cdot\text{H}$                                  | 302.1 $\pm$ 4.2                         | 1    |

| Radical                                                                                                | $\Delta_f H^\circ / \text{kJ mol}^{-1}$ | Ref. | Radical                                                                                         | $\Delta_f H^\circ / \text{kJ mol}^{-1}$ | Ref. |
|--------------------------------------------------------------------------------------------------------|-----------------------------------------|------|-------------------------------------------------------------------------------------------------|-----------------------------------------|------|
| $\cdot\text{C}_{13}\text{H}_{11}$ , 9-methyl-9-fluorenyl                                               | 268.2                                   | 1    | $\cdot\text{C}_2\text{HF}_4$ , $\text{CHF}_2\text{C}\cdot\text{F}_2$                            | -664.8                                  | 1    |
| $\cdot\text{C}_{14}\text{H}_{11}$ , 9,10-dihydroanthracen-9-yl                                         | 261.0                                   | 1    | $\cdot\text{C}_2\text{H}_2\text{F}_3$ , $\text{CF}_3\text{C}\cdot\text{H}_2$                    | -517.1 $\pm$ 8.4                        | 1    |
| $\cdot\text{C}_{15}\text{H}_{11}$ , 9-anthracenylmethyl                                                | 337.6                                   | 1    | $\cdot\text{C}_2\text{H}_2\text{F}_3$ , $\text{CHF}_2\text{C}\cdot\text{HF}$                    | -456.0                                  | 1    |
| $\cdot\text{C}_{15}\text{H}_{11}$ , 9-phenanthrenylmethyl                                              | 311.3                                   | 1    | $\cdot\text{C}_2\text{H}_2\text{F}_3$ , $\text{CH}_2\text{FC}\cdot\text{F}_2$                   | -449.8                                  | 1    |
| $\cdot\text{C}_{16}\text{H}_{31}$ , $\text{CH}_2=\text{CHC}\cdot\text{H}(\text{CH}_2)_{12}\text{CH}_3$ | -118.8                                  | 1    | $\cdot\text{C}_2\text{H}_2\text{F}_2\text{Cl}$ , $\text{CF}_2\text{ClC}\cdot\text{H}_2$         | -310.9 $\pm$ 7.0                        | 1    |
| $\cdot\text{C}_{19}\text{H}_{15}$ , trityl, $(\text{C}_6\text{H}_5)_3\text{C}\cdot$                    | 392.0 $\pm$ 8.4                         | 1    | $\cdot\text{C}_2\text{H}_3\text{F}_2$ , $\text{CH}_3\text{C}\cdot\text{F}_2$                    | -302.5 $\pm$ 8.4                        | 1    |
| $\cdot\text{C}_{35}\text{H}_{25}$ , pentamethylcyclopentadienyl                                        | 67.4                                    | 1    | $\cdot\text{C}_2\text{H}_3\text{F}_2$ , $\text{CHF}_2\text{C}\cdot\text{H}_2$                   | -285.8                                  | 1    |
| CF                                                                                                     | 255.2 $\pm$ 8                           | 1    | $\cdot\text{C}_2\text{H}_3\text{F}_2$ , $\text{CH}_2\text{FC}\cdot\text{HF}$                    | -238.5                                  | 1    |
| $\text{CF}_2$                                                                                          | -182.0 $\pm$ 6.3                        | 1    | $\cdot\text{C}_2\text{H}_4\text{F}$ , $\text{CH}_3\text{C}\cdot\text{HF}$                       | -70.3 $\pm$ 8.4                         | 1    |
| $\text{FC}\cdot(\text{O})$                                                                             | -161.2 $\pm$ 8.4                        | 1    | $\cdot\text{C}_2\text{H}_4\text{F}$ , $\text{CH}_2\text{FC}\cdot\text{H}_2$                     | -59.4 $\pm$ 8.4                         | 1    |
| CHF                                                                                                    | 143.0 $\pm$ 12.6                        | 1    | $\cdot\text{C}_2\text{H}_2\text{F}_2\text{Cl}$ , $\text{CF}_2\text{ClC}\cdot\text{H}_2$         | -315.2 $\pm$ 6                          | 1    |
| CClF                                                                                                   | 31.0 $\pm$ 13.4                         | 1    | $\cdot\text{C}_2\text{F}_4\text{Cl}$ , $\text{CF}_2\text{ClC}\cdot\text{F}_2$                   | -686.0                                  | 1    |
| CCl                                                                                                    | 443.1 $\pm$ 13.0                        | 1    | $\cdot\text{C}_2\text{HF}_3\text{Cl}$ , $\text{CClF}_2\text{C}\cdot\text{HF}$                   | -450.6 $\pm$ 12.6                       | 1    |
| $\text{CCl}_2$                                                                                         | 226                                     | 1    | $\cdot\text{C}_2\text{F}_4\text{Cl}$ , $\text{CF}_3\text{C}\cdot\text{FCl}$                     | -728.0                                  | 1    |
| $\text{ClC}\cdot(\text{O})$                                                                            | -21.8 $\pm$ 2.5                         | 1    | $\cdot\text{C}_2\text{F}_3\text{Cl}_2$ , $\text{CF}_3\text{C}\cdot\text{Cl}_2$                  | -564.0                                  | 1    |
| CHCl                                                                                                   | 326.4 $\pm$ 8.4                         | 1    | $\cdot\text{C}_2\text{F}_3\text{ClBr}$ , $\text{CF}_3\text{C}\cdot\text{ClBr}$                  | -504.2 $\pm$ 8.4                        | 1    |
| CClBr                                                                                                  | 267                                     | 1    | $\cdot\text{C}_2\text{Cl}$ , $\text{ClC}\equiv\text{C}\cdot$                                    | 534 $\pm$ 50                            | 1    |
| CBr                                                                                                    | 510 $\pm$ 63                            | 1    | $\cdot\text{C}_2\text{Cl}_3$ , $\text{CCl}_2\text{C}\cdot\text{Cl}$                             | 190 $\pm$ 50                            | 1    |
| CHBr                                                                                                   | 373 $\pm$ 18                            | 1    | $\cdot\text{C}_2\text{Cl}_5$ , $\text{CCl}_3\text{C}\cdot\text{Cl}_2$                           | 35.1 $\pm$ 5.4                          | 1    |
| $\text{CBr}_2$                                                                                         | 343.5                                   | 1    | $\cdot\text{C}_2\text{HCl}_4$ , $\text{CHCl}_2\text{C}\cdot\text{Cl}_2$                         | 23.4 $\pm$ 8.4                          | 1    |
| Cl                                                                                                     | 570 $\pm$ 35                            | 1    | $\cdot\text{C}_2\text{HCl}_4$ , $\text{CCl}_3\text{C}\cdot\text{HCl}$                           | 51.0                                    | 1    |
| $\text{Cl}_2$                                                                                          | 468 $\pm$ 60                            | 1    | $\cdot\text{C}_2\text{H}_2\text{Cl}_3$ , $\text{CH}_2\text{ClC}\cdot\text{Cl}_2$                | 26.4                                    | 1    |
| $\cdot\text{CF}_3$                                                                                     | -465.7 $\pm$ 2.1                        | 1    | $\cdot\text{C}_2\text{H}_2\text{Cl}_3$ , $\text{CHCl}_2\text{C}\cdot\text{HCl}$                 | 46.4                                    | 1    |
| $\cdot\text{CHF}_2$                                                                                    | -238.9 $\pm$ 4.2                        | 1    | $\cdot\text{C}_2\text{H}_2\text{Cl}_3$ , $\text{CCl}_3\text{C}\cdot\text{H}_2$                  | 71.5 $\pm$ 8                            | 1    |
| $\cdot\text{CH}_2\text{F}$                                                                             | -31.8 $\pm$ 4.2                         | 1    | $\cdot\text{C}_2\text{H}_3\text{Cl}_2$ , $\text{CH}_3\text{C}\cdot\text{Cl}_2$                  | 42.5 $\pm$ 1.7                          | 1    |
| $\cdot\text{CClF}_2$                                                                                   | -279.0 $\pm$ 8.4                        | 1    | $\cdot\text{C}_2\text{H}_3\text{Cl}_2$ , $\text{CH}_2\text{ClC}\cdot\text{ClH}$                 | 65.3                                    | 1    |
| $\cdot\text{CCl}_2\text{F}$                                                                            | -89.0 $\pm$ 8.4                         | 1    | $\cdot\text{C}_2\text{H}_3\text{Cl}_2$ , $\text{CHCl}_2\text{C}\cdot\text{H}_2$                 | 90.1 $\pm$ 0.8                          | 1    |
| $\cdot\text{CBrClF}$                                                                                   | -35.5 $\pm$ 6.3                         | 1    | $\cdot\text{C}_2\text{H}_4\text{Cl}$ , $\text{CH}_3\text{C}\cdot\text{HCl}$                     | 76.5 $\pm$ 1.6                          | 1    |
| $\cdot\text{CHClF}$                                                                                    | -60.7 $\pm$ 10.0                        | 1    | $\cdot\text{C}_2\text{H}_4\text{Cl}$ , $\text{CH}_2\text{ClC}\cdot\text{H}_2$                   | 93.0 $\pm$ 2.4                          | 1    |
| $\cdot\text{CBrF}_2$                                                                                   | -224.7 $\pm$ 12.6                       | 1    | $\cdot\text{C}_2\text{H}_3\text{Br}_2$ , $\text{CH}_3\text{C}\cdot\text{Br}_2$                  | 140.2 $\pm$ 5.4                         | 1    |
| $\cdot\text{CCl}_3$                                                                                    | 71.1 $\pm$ 2.5                          | 1    | $\cdot\text{C}_2\text{H}_4\text{Br}$ , $\text{BrCH}_2\text{C}\cdot\text{H}_2$                   | 135.1                                   | 1    |
| $\cdot\text{CHCl}_2$                                                                                   | 87.1 $\pm$ 1.6                          | 1    | $\cdot\text{C}_2\text{H}_4\text{Br}$ , $\text{CH}_3\text{C}\cdot\text{HBr}$                     | 133.4 $\pm$ 3.4                         | 3    |
| $\cdot\text{CH}_2\text{Cl}$                                                                            | 117.2 $\pm$ 2.9                         | 1    | $\cdot\text{C}_2\text{Br}$ , $\text{CBrC}\cdot$                                                 | 623.8                                   | 1    |
| $\cdot\text{CHBrCl}$                                                                                   | 140 $\pm$ 4                             | 1    | $\cdot\text{C}_2\text{Br}_3$ , $\text{CBr}_2\text{C}\cdot\text{Br}$                             | 385.3                                   | 1    |
| $\cdot\text{CHBr}_2$                                                                                   | 199.1 $\pm$ 2.7                         | 3    | $\cdot\text{C}_2\text{Br}_5$ , $\text{CBr}_3\text{C}\cdot\text{Br}_2$                           | 283.3                                   | 1    |
| $\cdot\text{CBr}_2\text{Cl}$                                                                           | 163 $\pm$ 8                             | 1    | $\cdot\text{C}_3\text{H}_6\text{Cl}$ , $\text{CH}_3\text{CH}_2\text{C}\cdot\text{HCl}$          | 56.6                                    | 1    |
| $\cdot\text{CBrCl}_2$                                                                                  | 124 $\pm$ 8                             | 1    | $\cdot\text{C}_3\text{H}_6\text{Cl}$ , $\text{CH}_3\text{C}\cdot\text{ClCH}_3$                  | 29.9 $\pm$ 0.6                          | 1    |
| $\cdot\text{CBr}_3$                                                                                    | 214.8                                   | 1    | $\cdot\text{C}_3\text{H}_6\text{Br}$ , $\text{C}\cdot\text{H}_2\text{CH}_2\text{CH}_2\text{Br}$ | 120.1 $\pm$ 1.3                         | 1    |
| $\cdot\text{CH}_2\text{Br}$                                                                            | 171.1 $\pm$ 2.7                         | 1    | $\cdot\text{C}_3\text{H}_6\text{Br}$ , $\text{CH}_3\text{C}\cdot\text{HCH}_2\text{Br}$          | 96.7 $\pm$ 5.9                          | 1    |
| $\cdot\text{Cl}_3$                                                                                     | 424.9 $\pm$ 2.8                         | 1    | $\cdot\text{C}_3\text{H}_6\text{Br}$ , $\text{CH}_3\text{CH}_2\text{C}\cdot\text{HBr}$          | 107.5 $\pm$ 2.5                         | 1    |
| $\cdot\text{CHI}_2$                                                                                    | 314.4 $\pm$ 3.3                         | 1    | $\cdot\text{C}_6\text{F}_5$                                                                     | -547.7 $\pm$ 8.4                        | 1    |
| $\cdot\text{CH}_2\text{I}$                                                                             | 229.7 $\pm$ 8.4                         | 1    | $\cdot\text{CH}_3\text{O}$ , $\text{HOC}\cdot\text{H}_2$                                        | -17.0 $\pm$ 0.7                         | 1    |
| $\cdot\text{C}_2\text{F}$ , $\text{FC}\equiv\text{C}\cdot$                                             | 460.0 $\pm$ 21.0                        | 1    | $\cdot\text{CH}_2\text{ClO}$ , $\text{HOC}\cdot\text{ClH}$                                      | -60.7 $\pm$ 7.5                         | 1    |
| $\cdot\text{C}_2\text{Cl}$ , $\text{ClC}\equiv\text{C}\cdot$                                           | 568 $\pm$ 26                            | 1    | $\cdot\text{CHCl}_2\text{O}$ , $\text{HOC}\cdot\text{Cl}_2$                                     | -94.1 $\pm$ 7.5                         | 1    |
| $\cdot\text{C}_2\text{F}_3$ , $\text{CF}_2=\text{C}\cdot\text{F}$                                      | -192.0 $\pm$ 8.4                        | 1    | $\cdot\text{CH}_2\text{ClO}$ , $\text{ClOC}\cdot\text{H}_2$                                     | 135.6 $\pm$ 9.2                         | 1    |
| $\cdot\text{C}_2\text{F}_2\text{H}$ , $\text{CF}_2=\text{C}\cdot\text{H}$                              | -92.9 $\pm$ 8.4                         | 1    | $\cdot\text{CH}_2\text{BrO}$ , $\text{BrOC}\cdot\text{H}_2$                                     | 151 $\pm$ 16                            | 1    |
| $\cdot\text{C}_2\text{F}_2\text{H}$ , $\text{CHF}=\text{C}\cdot\text{F}$                               | -50.6 $\pm$ 8.4                         | 1    | $\cdot\text{C}_2\text{H}_3\text{O}$ , $\text{C}\cdot\text{H}=\text{CHOH}$                       | 121 $\pm$ 11                            | 1    |
| $\cdot\text{CCl}_2\text{H}$ , $\text{CHCl}=\text{C}\cdot\text{Cl}$                                     | 234.7 $\pm$ 8.4                         | 1    | $\cdot\text{C}_2\text{H}_3\text{O}$ , $\text{C}\cdot\text{H}_2\text{CHO}$                       | 13.0 $\pm$ 2                            | 1    |
| $\cdot\text{CClH}_2$ , $\text{CH}_2=\text{C}\cdot\text{Cl}$                                            | >251                                    | 1    | $\cdot\text{C}_2\text{H}_5\text{O}$ , $\text{CH}_3\text{C}\cdot\text{HOH}$                      | -54.0                                   | 1    |
| $\cdot\text{C}_2\text{F}_5$ , $\text{CF}_3\text{C}\cdot\text{F}_2$                                     | -892.9 $\pm$ 4.2                        | 1    | $\cdot\text{C}_2\text{H}_4\text{ClO}$ , $\text{CH}_3\text{C}\cdot\text{ClOH}$                   | -108.4 $\pm$ 8.8                        | 1    |
| $\cdot\text{C}_2\text{HF}_4$ , $\text{CF}_3\text{C}\cdot\text{HF}$                                     | -680.8 $\pm$ 9.6                        | 1    | $\cdot\text{C}_2\text{H}_4\text{ClO}$ , $\text{C}\cdot\text{H}_2\text{CHClOH}$                  | -73.2 $\pm$ 8.8                         | 1    |

| Radical                                                                                        | $\Delta_f H^\circ / \text{kJ mol}^{-1}$ | Ref. | Radical                                                                                         | $\Delta_f H^\circ / \text{kJ mol}^{-1}$ | Ref. |
|------------------------------------------------------------------------------------------------|-----------------------------------------|------|-------------------------------------------------------------------------------------------------|-----------------------------------------|------|
| $\cdot\text{C}_2\text{H}_3\text{Cl}_2\text{O}$ , $\text{C}^*\text{H}_2\text{CCl}_2\text{OH}$   | $-99.6 \pm 8.8$                         | 1    | $\text{iPrC}(\text{O})\text{C}^*(\text{CH}_3)_2$                                                | $-173.6 \pm 20.9$                       | 1    |
| $\cdot\text{C}_2\text{H}_5\text{O}$ , $\text{C}^*\text{H}_2\text{CH}_2\text{OH}$               | $-31 \pm 7$                             | 1    | $\text{tC}_4\text{H}_9\text{C}(\text{O})\text{C}^*\text{H}_2$                                   | $-115.5 \pm 12.6$                       | 1    |
| $\cdot\text{C}_2\text{H}_3\text{O}$ , oxiran-2-yl                                              | $149.8 \pm 6.3$                         | 1    | $\text{PhC}(\text{O})\text{C}^*\text{H}_2$                                                      | $84.5 \pm 12.6$                         | 1    |
| $\cdot\text{C}_3\text{H}_5\text{O}$ , $\text{CH}_2=\text{CHC}^*\text{HOH}$                     | $0 \pm 8.4$                             | 1    | $\text{PhC}(\text{O})\text{C}^*\text{HCH}_3$                                                    | $41.4 \pm 20.9$                         | 1    |
| $\cdot\text{C}_3\text{H}_7\text{O}$ , $\text{CH}_3\text{CH}_2\text{C}^*\text{HOH}$             | $-81 \pm 4$                             | 1    | $\text{PhC}^*\text{HC}(\text{O})\text{CH}_2\text{Ph}$                                           | $134.3 \pm 20.9$                        | 1    |
| $\cdot\text{C}_3\text{H}_7\text{O}$ , $(\text{CH}_3)_2\text{C}^*\text{HCH}_2\text{OH}$         | $-78.7 \pm 8.4$                         | 1    | $\text{PhC}(\text{O})\text{OC}^*\text{H}_2$                                                     | $-69.9$                                 | 1    |
| $\cdot\text{C}_3\text{H}_7\text{O}$ , $\text{HOCH}_2\text{CH}_2\text{C}^*\text{H}_2$           | $-66.9 \pm 8.4$                         | 1    | $\cdot\text{C}(\text{O})\text{OH-trans}$                                                        | $\geq -194.6 \pm 2.9$                   | 1    |
| $\cdot\text{C}_3\text{H}_7\text{O}$ , $(\text{CH}_3)_2\text{C}^*\text{OH}$                     | $-96.4$                                 | 1    | $\cdot\text{C}(\text{O})\text{OH-cis}$                                                          | $-219.7$                                | 1    |
| $\cdot\text{C}_3\text{H}_7\text{O}$ , $\cdot\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$        | $-62.8 \pm 11.7$                        | 1    | $\cdot\text{C}(\text{O})\text{OCH}_3$                                                           | $-161.5$                                | 1    |
| $\cdot\text{C}_4\text{H}_9\text{O}$ , $\cdot\text{CH}_2\text{C}(\text{OH})(\text{CH}_3)_2$     | $-147.3 \pm 8.4$                        | 1    | $\text{C}^*\text{H}_2\text{C}(\text{O})\text{OH}$                                               | $-248.9 \pm 12.0$                       | 1    |
| $\cdot\text{C}_2\text{H}_5\text{O}_2$ , $\text{C}^*\text{H}_2\text{OCH}_2\text{OOH}$           | $109.6 \pm 4.2$                         | 1    | $\text{C}^*\text{H}(\text{CH}_3)\text{C}(\text{O})\text{OH}$                                    | $-293 \pm 3$                            | 1    |
| $\text{PhCH}^*\text{OH}$                                                                       | $29.3 \pm 8.4$                          | 1    | $\text{C}^*\text{H}_2\text{C}(\text{O})\text{OCH}_3$                                            | $-236.8 \pm 8.4$                        | 1    |
| $\text{Ph}_2\text{C}^*\text{OH}$                                                               | $152.3 \pm 6.3$                         | 1    | $\text{C}^*\text{H}_2\text{C}(\text{O})\text{OCH}_2\text{CH}_3$                                 | $-260.2 \pm 12.6$                       | 1    |
| $\cdot\text{C}_2\text{H}_5\text{O}$ , $\text{CH}_3\text{OC}^*\text{H}_2$                       | $0 \pm 4.2$                             | 1    | $\text{C}^*\text{H}_2\text{C}(\text{O})\text{OPh}$                                              | $-28.0$                                 | 1    |
| $\cdot\text{C}_3\text{H}_7\text{O}$ , $\text{CH}_3\text{OC}^*\text{HCH}_3$                     | $-57.7 \pm 8.4$                         | 1    | $\cdot\text{C}_4\text{H}_7\text{O}$ , tetrahydrofuran-2-yl                                      | $-18.0 \pm 6.3$                         | 1    |
| $\cdot\text{C}_3\text{H}_7\text{O}$ , $\text{CH}_3\text{CH}_2\text{OC}^*\text{H}_2$            | $-45.2 \pm 8.4$                         | 1    | $\cdot\text{C}_4\text{H}_8\text{O}$ , cyclopentanone-2-yl                                       | $-41.8 \pm 12.6$                        | 1    |
| $\cdot\text{C}_3\text{H}_7\text{O}$ , $\text{C}^*\text{H}_2\text{CH}_2\text{OCH}_3$            | $-7.1 \pm 4.2$                          | 1    | $\cdot\text{C}_4\text{H}_7\text{O}_2$ , 1,4-dioxan-2-yl                                         | $-131.8 \pm 12.6$                       | 1    |
| $\cdot\text{C}_4\text{H}_9\text{O}$ , $(\text{CH}_3)_2\text{CHOC}^*\text{H}_2$                 | $-70.3 \pm 7.1$                         | 1    | $\cdot\text{C}_6\text{H}_5\text{O}_2$ , 2-C(O)OH- $\cdot\text{C}_6\text{H}_4$                   | $-33.0$                                 | 1    |
| $\cdot\text{C}_4\text{H}_9\text{O}$ , $\text{CH}_3\text{CH}_2\text{OC}^*\text{HCH}_3$          | $-81.2 \pm 4.2$                         | 1    | $\cdot\text{C}_6\text{H}_5\text{O}_2$ , 3-C(O)OH- $\cdot\text{C}_6\text{H}_4$                   | $-35.0$                                 | 1    |
| $\cdot\text{C}_4\text{H}_9\text{O}$ , $\text{C}^*\text{H}_2\text{CH}(\text{CH}_3)\text{OCH}_3$ | $-42.3 \pm 3.8$                         | 1    | $\cdot\text{C}_6\text{H}_5\text{O}_2$ , 4-C(O)OH- $\cdot\text{C}_6\text{H}_4$                   | $-36.0$                                 | 1    |
| $\cdot\text{C}_4\text{H}_9\text{O}$ , $(\text{CH}_3)_2\text{C}^*\text{OCH}_3$                  | $-72.4 \pm 10$                          | 1    | $\cdot\text{CH}_3\text{O}_2$ , $\text{C}^*\text{H}_2\text{OOH}$                                 | $66.1$                                  | 1    |
| $\cdot\text{C}_5\text{H}_{11}\text{O}$ , $(\text{CH}_3)_3\text{COC}^*\text{H}_2$               | $-102.5 \pm 8.4$                        | 1    | $\cdot\text{C}_2\text{H}_5\text{O}_2$ , $\text{C}^*\text{H}_2\text{CH}_2\text{OOH}$             | $46.0 \pm 4.6$                          | 1    |
| $\cdot\text{C}_2\text{H}_5\text{O}_2$ , $\text{HOCH}_2\text{C}^*\text{HOH}$                    | $-220.1 \pm 8.4$                        | 1    | $\cdot\text{C}_2\text{H}_5\text{O}_2$ , $\text{CH}_3\text{CH}^*\text{OOH}$                      | $26.9$                                  | 1    |
| $\text{C}^*\text{H}=\text{C}=\text{O}$ , ketenyl                                               | $177.5 \pm 8.8$                         | 1    | $\cdot\text{C}_3\text{H}_7\text{O}_2$ , $\text{CH}_3\text{CH}^*\text{CH}_2\text{OOH}$           | $10.9 \pm 5.4$                          | 1    |
| $\text{HC}^*(\text{O})$                                                                        | $42.5 \pm 0.5$                          | 1    | $\cdot\text{C}_3\text{H}_7\text{O}_2$ , $\text{C}^*\text{H}_2\text{CH}(\text{OOH})\text{CH}_3$  | $2.9 \pm 6.3$                           | 1    |
| $\text{C}^*\text{CO}$                                                                          | $381.2 \pm 2.1$                         | 1    | $\cdot\text{C}_4\text{H}_9\text{O}_2$ , $(\text{CH}_3)_2\text{C}^*\text{CH}_2\text{OOH}$        | $-30.1 \pm 5.4$                         | 1    |
| $\text{CH}_3\text{C}^*(\text{O})$                                                              | $-10.3 \pm 1.8$                         | 1    | $\cdot\text{C}_4\text{H}_9\text{O}_2$ , $\text{C}^*\text{H}_2\text{C}(\text{CH}_3)_2\text{OOH}$ | $-26.8 \pm 5.4$                         | 1    |
| $\text{CF}_3\text{C}^*(\text{O})$                                                              | $-608.7$                                | 1    | $\cdot\text{C}_2\text{H}_3\text{O}_3$ , $\text{C}^*\text{H}_2\text{C}(\text{O})\text{OOH}$      | $-137.9$                                | 1    |
| $\text{CH}_2\text{ClC}^*(\text{O})$                                                            | $-21 \pm 12.6$                          | 1    | $\cdot\text{CHN}_2$                                                                             | $494.5$                                 | 1    |
| $\text{CHCl}_2\text{C}^*(\text{O})$                                                            | $-17.6 \pm 23$                          | 1    | $\cdot\text{CH}_2\text{N}=\text{CH}_2$                                                          | $263.6 \pm 12.6$                        | 1    |
| $\text{CCl}_3\text{C}^*(\text{O})$                                                             | $-19.7$                                 | 1    | $\cdot\text{CH}_2\text{NH}_2$                                                                   | $151.9 \pm 8.4$                         | 1    |
| $\text{CH}_3\text{CH}_2\text{C}^*(\text{O})$                                                   | $-31.7 \pm 3.4$                         | 1    | $\text{CH}_3\text{C}^*\text{HNNH}_2$                                                            | $111.7 \pm 8.4$                         | 1    |
| $\text{CH}_2\text{CHC}^*(\text{O})$                                                            | $88.5$                                  | 1    | $(\text{CH}_3)_2\text{C}^*\text{NH}_2$                                                          | $69.9 \pm 8.4$                          | 1    |
| $\text{CH}_2\text{C}(\text{CH}_3)\text{C}^*(\text{O})$                                         | $58.6 \pm 16.7$                         | 1    | $\cdot\text{CH}_2\text{NHCH}_3$                                                                 | $156.6$                                 | 1    |
| $\text{CH}_3\text{CH}_2\text{CH}_2\text{C}^*(\text{O})$                                        | $54.4 \pm 4.2$                          | 1    | $\cdot\text{CH}_2\text{N}(\text{CH}_3)_2$                                                       | $148.0$                                 | 1    |
| $(\text{CH}_3)_2\text{CHC}^*(\text{O})$                                                        | $-64.0 \pm 3.8$                         | 1    | $(\text{C}_2\text{H}_5)_2\text{NC}^*\text{HCH}_3$                                               | $68.6 \pm 2.1$                          | 1    |
| $(\text{CH}_3)_3\text{CC}^*(\text{O})$                                                         | $-102.9 \pm 6.3$                        | 1    | $\cdot\text{CH}_2\text{N}(\text{CH}_3)\text{Ph}$                                                | $266.0 \pm 12.6$                        | 1    |
| $\text{C}_6\text{H}_5\text{C}^*(\text{O})$                                                     | $116.3 \pm 10.9$                        | 1    | $\cdot\text{CN}$                                                                                | $439.3 \pm 2.9$                         | 1    |
| $\text{HC}(\text{O})\text{CH}_2\cdot$                                                          | $10.5 \pm 9.2$                          | 1    | $\cdot\text{CH}_2\text{CN}$                                                                     | $252.6 \pm 4$                           | 1    |
| $\text{ClC}(\text{O})\text{CH}_2\cdot$                                                         | $-52.7 \pm 13$                          | 1    | $\text{CH}_3\text{C}^*\text{HCN}$                                                               | $226.7 \pm 12.6$                        | 1    |
| $\text{E-C}^*\text{HClC}(\text{O})\text{H}$                                                    | $-27.2 \pm 10.5$                        | 1    | $\cdot\text{CH}_2\text{CH}_2\text{CN}$                                                          | $245.4 \pm 12.6$                        | 1    |
| $\text{Z-C}^*\text{HClC}(\text{O})\text{H}$                                                    | $-23.4 \pm 10.5$                        | 1    | $(\text{CH}_3)_2\text{C}^*\text{CN}$                                                            | $190.4 \pm 12.6$                        | 1    |
| $\text{C}^*\text{Cl}_2\text{C}(\text{O})\text{H}$                                              | $-55.6 \pm 14.2$                        | 1    | $\text{Ph}(\text{CH}_3)\text{C}^*\text{CN}$                                                     | $248.5 \pm 8.4$                         | 1    |
| $\text{E-C}^*\text{HClC}(\text{O})\text{Cl}$                                                   | $-88.7 \pm 15.1$                        | 1    | $\text{NCC}^*\text{HCH}_2\text{CN}$                                                             | $381.8 \pm 12.6$                        | 1    |
| $\text{C}^*\text{H}_2\text{C}(\text{O})\text{F}$                                               | $-273.0 \pm 5.8$                        | 1    | $\cdot\text{CH}_2\text{NC}$                                                                     | $334.7 \pm 16.7$                        | 1    |
| $\text{Z-C}^*\text{HClC}(\text{O})\text{Cl}$                                                   | $-84.9 \pm 13.8$                        | 1    | $\cdot\text{C}(\text{O})\text{NC}$                                                              | $210.0 \pm 10$                          | 1    |
| $\text{C}^*\text{Cl}_2\text{C}(\text{O})\text{Cl}$                                             | $-101.7 \pm 15.5$                       | 1    | $\cdot\text{C}(\text{O})\text{NH}_2$                                                            | $-15.1 \pm 4$                           | 1    |
| $\text{CH}_3\text{C}(\text{O})\text{CH}_2\cdot$                                                | $-34 \pm 3$                             | 1    | $\text{C}^*\text{NN}$                                                                           | $569 \pm 21$                            | 1    |
| $\text{CH}_3\text{C}(\text{O})\text{C}^*\text{HCH}_3$                                          | $-70.3 \pm 7.1$                         | 1    | $\text{HC}^*\text{NN}$                                                                          | $460 \pm 8$                             | 1    |
| $\text{CH}_3\text{C}(\text{O})\text{C}^*=\text{CH}_2$                                          | $113.4$                                 | 1    | $\text{H}_2\text{C}^*\text{NN}$                                                                 | $292.5 \pm 2.1$                         | 1    |
| $\text{C}_2\text{H}_5\text{C}(\text{O})\text{C}^*\text{HCH}_3$                                 | $-107.5 \pm 20.9$                       | 1    | $\cdot\text{CH}_2\text{NO}$                                                                     | $157 \pm 4$                             | 1    |

| Radical                                                                                                              | $\Delta_f H^\circ_{298} / \text{kJ mol}^{-1}$ | Ref. |
|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------|
| $\cdot\text{CH}_2\text{NO}_2$                                                                                        | 115.1 $\pm$ 12.6                              | 1    |
| $\text{CH}_3\text{C}\cdot\text{HNO}_2$                                                                               | 61.9 $\pm$ 12.6                               | 1    |
| $(\text{CH}_3)_2\text{C}\cdot\text{NO}_2$                                                                            | 6.3 $\pm$ 12.6                                | 1    |
| $\text{PhC}\cdot\text{HNO}_2$                                                                                        | 169.0 $\pm$ 12.6                              | 1    |
| $\cdot\text{C}_6\text{H}_6\text{N}$ , 3-NH <sub>2</sub> -C <sub>6</sub> H <sub>4</sub>                               | 320.1                                         | 1    |
| $\cdot\text{C}_6\text{H}_6\text{N}$ , 4-NH <sub>2</sub> -C <sub>6</sub> H <sub>4</sub>                               | 327.8                                         | 1    |
| $\cdot\text{C}_6\text{H}_4\text{NO}_2$ , 3-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub>                            | 340.6 $\pm$ 10.0                              | 1    |
| $\cdot\text{C}_6\text{H}_4\text{NO}_2$ , 4-NO <sub>2</sub> -C <sub>6</sub> H <sub>4</sub>                            | 302.7                                         | 1    |
| $\cdot\text{C}_6\text{H}_4\text{CH}_3$ , 2-Me-C <sub>6</sub> H <sub>4</sub>                                          | 315.1 $\pm$ 10.5                              | 1    |
| $\cdot\text{C}_6\text{H}_4\text{CH}_3$ , 4-Me-C <sub>6</sub> H <sub>4</sub>                                          | 296.6 $\pm$ 9.6                               | 1    |
| $\cdot\text{C}_6\text{H}_3\text{N}_2\text{O}_4$ , 3,5-(NO <sub>2</sub> ) <sub>2</sub> -C <sub>6</sub> H <sub>3</sub> | 305.4                                         | 1    |
| $\cdot\text{C}_7\text{H}_6\text{NO}_2$ , 2-Me-4-NO <sub>2</sub> -C <sub>6</sub> H <sub>3</sub>                       | 295.4 $\pm$ 8.4                               | 1    |
| $\cdot\text{C}_4\text{H}_3\text{N}$ , pyrrol-2-yl                                                                    | 385.8                                         | 1    |
| $\cdot\text{C}_4\text{H}_3\text{N}$ , pyrrol-3-yl                                                                    | 385.8                                         | 1    |
| $\cdot\text{C}_4\text{H}_8\text{N}$ , pyrrolidin-2-yl                                                                | 142.7 $\pm$ 12.6                              | 1    |
| $\cdot\text{C}_5\text{H}_4\text{N}$ , pyrid-2-yl                                                                     | 362.0                                         | 1    |
| $\cdot\text{C}_5\text{H}_4\text{N}$ , pyrid-3-yl                                                                     | 391.0                                         | 1    |
| $\cdot\text{C}_5\text{H}_4\text{N}$ , pyrid-4-yl                                                                     | 391.0                                         | 1    |
| $\cdot\text{C}_4\text{H}_7\text{N}_2$ , piperad-2-yl                                                                 | 119.7                                         | 1    |
| $\cdot\text{C}_4\text{H}_3\text{N}_2$ , pyrazin-2-yl                                                                 | 409.2 $\pm$ 12.6                              | 1    |
| $\cdot\text{C}_4\text{H}_3\text{N}_2$ , pyrimid-2-yl                                                                 | 388.0 $\pm$ 12.6                              | 1    |
| $\cdot\text{C}_4\text{H}_3\text{N}_2$ , pyrimid-4-yl                                                                 | 409.0 $\pm$ 12.6                              | 1    |
| $\cdot\text{C}_4\text{H}_3\text{N}_2$ , pyrimid-5-yl                                                                 | 446.4 $\pm$ 12.6                              | 1    |
| $\cdot\text{CH}(\text{NO}_2)_2$                                                                                      | 139.1                                         | 1    |
| $\cdot\text{C}(\text{NO}_2)_3$                                                                                       | 201.2                                         | 1    |
| $\cdot\text{CH}_2\text{C}(\text{NO}_2)_3$                                                                            | 150.6                                         | 1    |
| $\cdot\text{CH}_2\text{CH}(\text{NO}_2)_2$                                                                           | 103.3                                         | 1    |
| $\cdot\text{CH}_2\text{CH}_2\text{C}(\text{NO}_2)_3$                                                                 | 133.9                                         | 1    |
| $\cdot\text{CH}_2\text{N}(\text{NO}_2)\text{CH}_2\text{C}(\text{NO}_2)_3$                                            | 173.6                                         | 1    |
| $\cdot\text{CH}_2\text{N}(\text{NO}_2)\text{CH}_2\text{CH}(\text{NO}_2)_2$                                           | 126.4                                         | 1    |
| $\cdot\text{CH}_2\text{CH}_2\text{N}(\text{NO}_2)\text{CH}_2\text{C}(\text{NO}_2)_3$                                 | 168.6                                         | 1    |
| $\cdot\text{CH}_2\text{CH}_2\text{ONO}_2$                                                                            | 37.7                                          | 1    |
| $\cdot\text{CH}_2(\text{ONO}_2)\text{CHCH}_2\text{ONO}_2$                                                            | -25.5                                         | 1    |
| $\cdot\text{CH}(\text{CH}_2\text{ONO}_2)_2$                                                                          | -57.3                                         | 1    |
| $\cdot\text{CH}_2\text{C}(\text{CH}_2\text{ONO}_2)_3$                                                                | -158.2                                        | 1    |
| $\cdot\text{CH}_2\text{NHNO}_2$                                                                                      | 164.8                                         | 1    |
| $\cdot\text{CH}_2\text{N}(\text{NO}_2)\text{CH}_3$                                                                   | 149.4                                         | 1    |
| $\cdot\text{CH}_2\text{N}(\text{NO}_2)_2$                                                                            | 210.5                                         | 1    |
| $\cdot\text{CH}_2\text{CH}_2\text{N}(\text{NO}_2)\text{CH}_3$                                                        | 144.3                                         | 1    |
| $\cdot\text{CH}_2\text{N}(\text{NO}_2)\text{CH}_2\text{N}(\text{NO}_2)\text{CH}_3$                                   | 202.1                                         | 1    |
| $\cdot\text{CH}_2\text{N}(\text{NO}_2)(\text{CH}_2)\text{N}(\text{NO}_2)\text{CH}_3$                                 | 173.2                                         | 1    |
| $\text{C}\cdot(\text{S})\text{H}$                                                                                    | 300.4 $\pm$ 8.4                               | 1    |
| $\cdot\text{CH}_2\text{SH}$                                                                                          | 151.9 $\pm$ 8.4                               | 1    |
| $\cdot\text{CH}_2\text{SCH}_3$                                                                                       | 136.8 $\pm$ 5.9                               | 1    |
| $\cdot\text{CH}_2\text{SPh}$                                                                                         | 268.6 $\pm$ 12.6                              | 1    |
| $\cdot\text{CH}_2\text{SOCH}_3$                                                                                      | 23.8 $\pm$ 12.6                               | 1    |
| $\text{HOC}\cdot(\text{S})\text{S}$                                                                                  | 110.5                                         | 1    |
| $\cdot\text{CH}_2\text{SO}_2\text{CH}_3$                                                                             | -177.0 $\pm$ 12.6                             | 1    |
| $\cdot\text{CH}_2\text{SO}_2\text{Ph}$                                                                               | -57.3 $\pm$ 12.6                              | 1    |
| $\text{PhC}\cdot\text{HSO}_2\text{CH}_3$                                                                             | -109.2 $\pm$ 12.6                             | 1    |
| $\text{PhC}\cdot\text{HSO}_2\text{Ph}$                                                                               | 7 $\pm$ 12.6                                  | 1    |

| Radical                                                | $\Delta_f H^\circ_{298} / \text{kJ mol}^{-1}$ | Ref. |
|--------------------------------------------------------|-----------------------------------------------|------|
| $\text{Ph}_2\text{C}\cdot\text{SO}_2\text{Ph}$         | 102 $\pm$ 12.6                                | 1    |
| $\text{Ph}_2\text{C}\cdot\text{SPh}$                   | 435.6 $\pm$ 12.6                              | 1    |
| $\text{NC}\cdot(\text{O})$                             | 127.2                                         | 1    |
| $\cdot\text{CNH}$                                      | 207.9 $\pm$ 12.1                              | 1    |
| $\cdot\text{CNO}$                                      | 323 $\pm$ 30                                  | 1    |
| $\cdot\text{CH}_2\text{SiMe}_3$                        | -32 $\pm$ 6                                   | 1    |
| $\cdot\text{CH}_2\text{C}(\text{CH}_3)_2\text{SiMe}_3$ | -125                                          | 1    |
| $\cdot\text{CP}$                                       | 450 $\pm$ 9                                   | 1    |
| (2) Oxygen-Centered Species                            |                                               |      |
| $\text{HO}\cdot$                                       | 37.36 $\pm$ 0.13                              | 1    |
| $\text{FO}\cdot$                                       | 109 $\pm$ 10                                  | 1    |
| $\text{ClO}\cdot$                                      | 101.63 $\pm$ 0.1                              | 1    |
| $\text{BrO}\cdot$                                      | 126.2 $\pm$ 1.7                               | 1    |
| $\text{IO}\cdot$                                       | 115.9 $\pm$ 5.0                               | 1    |
| $\text{HOO}\cdot$                                      | 12.30 $\pm$ 0.25                              | 1    |
| $\text{FOO}\cdot$                                      | 25.4 $\pm$ 2                                  | 1    |
| $\text{ClOO}\cdot$                                     | 98.0 $\pm$ 4                                  | 1    |
| $\text{BrOO}\cdot$                                     | 108 $\pm$ 40                                  | 1    |
| $\text{IOO}\cdot$                                      | 96.6 $\pm$ 15                                 | 1    |
| $\text{OFO}\cdot$                                      | 378.6 $\pm$ 20                                | 1    |
| $\text{OCIO}\cdot$                                     | 95.4                                          | 1    |
| $\text{ClOOCIO}\cdot$                                  | 142 $\pm$ 12                                  | 1    |
| $\text{ClICIO}\cdot$                                   | 90 $\pm$ 30                                   | 1    |
| $\text{NCO}\cdot$                                      | 184.1                                         | 1    |
| $\text{CNO}\cdot$                                      | 386.6                                         | 1    |
| $\text{HONNO}\cdot$                                    | 172                                           | 1    |
| $\text{sym-ClO}_3$                                     | 217.2 $\pm$ 21                                | 1    |
| $\text{HSO}\cdot$                                      | -21.8 $\pm$ 2.1                               | 1    |
| $\text{HSOO}\cdot$                                     | 112                                           | 1    |
| $\text{CH}_3\text{SOO}\cdot$                           | 76                                            | 1    |
| $\text{CF}_3\text{SO}_2\text{O}\cdot$                  | -912                                          | 1    |
| $\text{NCO}\cdot$                                      | 184.0                                         | 1    |
| $\text{O}_2\text{NO}\cdot$                             | 73.7 $\pm$ 1.4                                | 1    |
| $\text{ONOO}\cdot$                                     | 82.8                                          | 1    |
| $\text{HOS}(\text{O})_2\text{O}\cdot$                  | -511.7                                        | 1    |
| $\text{CH}_3\text{O}\cdot$                             | 21.0 $\pm$ 2.1                                | 1    |
| $\text{CF}_3\text{O}\cdot$                             | -635.1 $\pm$ 7.1                              | 1    |
| $\text{CCl}_3\text{O}\cdot$                            | -38.1 $\pm$ 9.2                               | 1    |
| $\text{CH}_2\text{ClO}\cdot$                           | -21.3 $\pm$ 9.2                               | 1    |
| $\text{CHCl}_2\text{O}\cdot$                           | -32.2 $\pm$ 9.2                               | 1    |
| $\text{CH}_2=\text{CH-O}\cdot$                         | 18.4 $\pm$ 1.3                                | 1    |
| $\text{CF}_3\text{CHFO}\cdot$                          | -851.0                                        | 1    |
| $\text{C}_2\text{H}_5\text{O}\cdot$                    | -13.6 $\pm$ 3.3                               | 1    |
| $\text{CH}_3\text{CHClO}\cdot$                         | -61.9 $\pm$ 12.1                              | 1    |
| $\text{CH}_3\text{CCl}_2\text{O}\cdot$                 | -91.6 $\pm$ 11.7                              | 1    |
| $\text{nC}_3\text{H}_7\text{O}\cdot$                   | -30.1 $\pm$ 8.4                               | 1    |
| $\text{iC}_3\text{H}_7\text{O}\cdot$                   | -48.5 $\pm$ 3.3                               | 1    |
| $(\text{CH}_3)_2\text{CClO}\cdot$                      | -108.4 $\pm$ 8.4                              | 1    |
| $\text{nC}_4\text{H}_9\text{O}\cdot$                   | -62.8                                         | 1    |
| $\text{sC}_4\text{H}_9\text{O}\cdot$                   | -69.5                                         | 1    |
| $\text{tC}_4\text{H}_9\text{O}\cdot$                   | -85.8 $\pm$ 3.8                               | 1    |

| Radical                                                                                         | $\Delta_f H^\circ / \text{kJ mol}^{-1}$ | Ref. | Radical                                                                  | $\Delta_f H^\circ / \text{kJ mol}^{-1}$ | Ref. |
|-------------------------------------------------------------------------------------------------|-----------------------------------------|------|--------------------------------------------------------------------------|-----------------------------------------|------|
| $\text{CH}_2=\text{CHCH}_2\text{O}^\bullet$                                                     | 87.0                                    | 1    | $\bullet\text{NNH}$                                                      | 249.5                                   | 1    |
| $\text{C}_6\text{H}_5\text{O}^\bullet$                                                          | $48.5 \pm 2.9$                          | 1    | $\bullet\text{NCO}$                                                      | 131.8                                   | 1    |
| $\text{o-Cl-C}_6\text{H}_4\text{O}^\bullet$                                                     | 30.6                                    | 1    | $\bullet\text{N}_3$                                                      | $414.2 \pm 20.9$                        | 1    |
| $\text{C}_6\text{Cl}_5\text{O}^\bullet$                                                         | $\sim 63$                               | 1    | $\bullet\text{N}_2\text{H}_3$                                            | 243.5                                   | 1    |
| $\text{p-Cl-C}_6\text{H}_4\text{O}^\bullet$                                                     | $\sim 9$                                | 1    | $(\text{Z})\text{-N}_2\text{H}_2$                                        | $213.0 \pm 10.9$                        | 1    |
| $\text{o-OH-C}_6\text{H}_4\text{O}^\bullet$                                                     | -186.3                                  | 1    | NF                                                                       | 209.2                                   | 1    |
| $\text{p-OH-C}_6\text{H}_4\text{O}^\bullet$                                                     | -143.6                                  | 1    | $\bullet\text{NF}_2$                                                     | $42.3 \pm 8$                            | 1    |
| $\text{o-CH}_3\text{O-C}_6\text{H}_4\text{O}^\bullet$                                           | -125.5                                  | 1    | $\bullet\text{NHF}$                                                      | $112 \pm 15$                            | 1    |
| $\text{p-CH}_3\text{O-C}_6\text{H}_4\text{O}^\bullet$                                           | -81.1                                   | 1    | NBr                                                                      | $301 \pm 21$                            | 1    |
| $\text{C}_6\text{H}_5\text{CH}_2\text{O}^\bullet$                                               | $136.0 \pm 12.6$                        | 1    | HNO                                                                      | $107.1 \pm 2.5$                         | 1    |
| $\text{C}_{10}\text{H}_7\text{O}^\bullet$ , naphthoxy-1                                         | 165.3                                   | 1    | FNO                                                                      | $-65.7 \pm 1.7$                         | 1    |
| $\text{C}_{10}\text{H}_7\text{O}^\bullet$ , naphthoxy-2                                         | 174.1                                   | 1    | ClNO                                                                     | $51.71 \pm 0.42$                        | 1    |
| $\text{HC(O)O}^\bullet$                                                                         | $-129.7 \pm 12.6$                       | 1    | BrNO                                                                     | $82.13 \pm 0.8$                         | 1    |
| $\text{FC(O)O}^\bullet$                                                                         | 368.0                                   | 1    | INO                                                                      | $112.1 \pm 20.9$                        | 1    |
| $\text{CH}_3\text{C(O)O}^\bullet$                                                               | $-179.9 \pm 12.6$                       | 1    | NCO                                                                      | 120.9                                   | 1    |
| $\text{CF}_3\text{C(O)O}^\bullet$                                                               | -797.0                                  | 1    | NCN                                                                      | $464.8 \pm 2.9$                         | 1    |
| $\text{CF}_3\text{OC(O)O}^\bullet$                                                              | $-958.1 \pm 16.7$                       | 1    | NSi                                                                      | $372 \pm 63$                            | 1    |
| $\text{C}_6\text{H}_5\text{C(O)O}^\bullet$                                                      | $-50.2 \pm 16.7$                        | 1    | $\text{NH}_2\text{C(O)N}^\bullet\text{H}$                                | $0.8 \pm 12.6$                          | 1    |
| $\text{CH}_3\text{OO}^\bullet$                                                                  | $20.1 \pm 5.1$                          | 1    | $\text{CH}_3\text{C(O)N}^\bullet\text{H}$                                | $-6.7 \pm 12.6$                         | 1    |
| $\text{C}_2\text{H}_3\text{OO}^\bullet$ , $\text{CH}_2=\text{CHOO}^\bullet$                     | $101.7 \pm 1.7$                         | 1    | $\text{NH}_2\text{C(S)N}^\bullet\text{H}$                                | $194 \pm 12.6$                          | 1    |
| $\text{C}_2\text{H}_5\text{OO}^\bullet$                                                         | $-28.5 \pm 9.6$                         | 1    | $\text{CH}_3\text{C(S)N}^\bullet\text{H}$                                | $173 \pm 12.6$                          | 1    |
| $\text{C}_3\text{H}_5\text{OO}^\bullet$ , $\text{CH}_2=\text{CHCH}_2\text{OO}^\bullet$          | 88.7                                    | 1    | PhC(S)N <sup>•</sup> H                                                   | $307 \pm 12.6$                          | 1    |
| $\text{iC}_3\text{H}_7\text{OO}^\bullet$                                                        | $-65.4 \pm 11.3$                        | 1    | HCON <sup>•</sup> H                                                      | $49.8 \pm 12.6$                         | 1    |
| $\text{C}_4\text{H}_7\text{OO}^\bullet$ , $\text{CH}_3\text{CH}=\text{CHCH}_2\text{OO}^\bullet$ | $82.6 \pm 5.3$                          | 1    | $\text{NH}_2\text{C(NH)N}^\bullet\text{H}$                               | $250.6 \pm 12.6$                        | 1    |
| $\text{tC}_4\text{H}_9\text{OO}^\bullet$                                                        | $-101.5 \pm 9.2$                        | 1    | $\bullet\text{NHCN}$                                                     | $319.2 \pm 2.9$                         | 1    |
| neo-C <sub>5</sub> H <sub>11</sub> OO <sup>•</sup>                                              | -115.5                                  | 1    | $\text{CH}_2\text{N}^\bullet\text{H}$                                    | $104.6 \pm 12.6$                        | 1    |
| $\text{HOCH}_2\text{OO}^\bullet$                                                                | -162.1                                  | 1    | $\text{CH}_3\text{N}^\bullet\text{H}$                                    | $184.1 \pm 8.4$                         | 1    |
| $\text{HOOCH}_2\text{CH}_2\text{OO}^\bullet$                                                    | 100                                     | 1    | tBuN <sup>•</sup> H                                                      | $95.4 \pm 12.6$                         | 1    |
| $\text{C}_6\text{H}_5\text{CH}_2\text{OO}^\bullet$                                              | $114.6 \pm 4.2$                         | 1    | $\text{C}_6\text{H}_5\text{CH}_2\text{N}^\bullet\text{H}$                | $288.3 \pm 12.6$                        | 1    |
| c-C <sub>6</sub> H <sub>11</sub> OO <sup>•</sup>                                                | $-25.0 \pm 10.5$                        | 1    | $\text{C}_6\text{H}_5\text{N}^\bullet\text{H}$                           | $244.3 \pm 4.2$                         | 1    |
| $(\text{C}_2\text{H}_5)\text{N}(\text{CH}_3)\text{CHOO}^\bullet$                                | $-36.0 \pm 12.6$                        | 1    | $(\text{CH}_3)_2\text{N}^\bullet$                                        | $158.2 \pm 4.2$                         | 1    |
| $\text{CF}_3\text{OO}^\bullet$                                                                  | -635.0                                  | 1    | $(\text{C}_6\text{H}_5)(\text{CH}_3)\text{N}^\bullet$                    | $241.0 \pm 6.3$                         | 1    |
| $\text{CF}_2\text{ClOO}^\bullet$                                                                | $-406.7 \pm 14.6$                       | 1    | $(\text{C}_6\text{H}_5)_2\text{N}^\bullet$                               | $366.0 \pm 6.3$                         | 1    |
| $\text{CFCl}_2\text{OO}^\bullet$                                                                | -213.7                                  | 1    | 1-pyrrolyl                                                               | $269.2 \pm 12.6$                        | 1    |
| $\text{CH}_2\text{ClOO}^\bullet$                                                                | $-5.1 \pm 13.6$                         | 1    | 1-pyrazolyl                                                              | $413.0 \pm 2.1$                         | 1    |
| $\text{CHCl}_2\text{OO}^\bullet$                                                                | $-19.2 \pm 11.2$                        | 1    | carbazol-9-yl                                                            | $383.3 \pm 8.4$                         | 1    |
| $\text{CCl}_3\text{OO}^\bullet$                                                                 | $-20.9 \pm 8.9$                         | 1    | $\text{CH}_3\text{N}_2^\bullet$                                          | $215.5 \pm 7.5$                         | 1    |
| $\text{CH}_3\text{CHClOO}^\bullet$                                                              | $-54.7 \pm 3.4$                         | 1    | $\text{C}_2\text{H}_5\text{N}_2^\bullet$                                 | $187.4 \pm 10.5$                        | 1    |
| $\text{CH}_3\text{CCl}_2\text{OO}^\bullet$                                                      | $-63.8 \pm 9.8$                         | 1    | iC <sub>3</sub> H <sub>7</sub> N <sub>2</sub> <sup>•</sup>               | $146.0 \pm 8.4$                         | 1    |
| $\text{CH}_3\text{OCH}_2\text{OO}^\bullet$                                                      | $-142.2 \pm 4.2$                        | 1    | nC <sub>4</sub> H <sub>9</sub> N <sub>2</sub> <sup>•</sup>               | $140.6 \pm 8.4$                         | 1    |
| $\text{CH}_3\text{C(O)CH}_2\text{OO}^\bullet$                                                   | $-142.1 \pm 4$                          | 1    | tC <sub>4</sub> H <sub>9</sub> N <sub>2</sub> <sup>•</sup>               | $97.5 \pm 4.2$                          | 1    |
| $\text{CH}_3\text{C(O)OO}^\bullet$                                                              | $-154.4 \pm 5.8$                        | 1    | $(\text{NO}_2)\text{HN}^\bullet$                                         | 162.3                                   | 1    |
| HOOO <sup>•</sup>                                                                               | $29.7 \pm 8.4$                          | 1    | $(\text{CH}_3)(\text{NO}_2)\text{N}^\bullet$                             | 139.0                                   | 1    |
| $\text{CH}_3\text{OOO}^\bullet$                                                                 | $33.4 \pm 12.6$                         | 1    | $(\text{NO}_2)_2\text{N}^\bullet$                                        | 200.0                                   | 1    |
| $\text{C}_2\text{H}_5\text{OOO}^\bullet$                                                        | $5.4 \pm 12.6$                          | 1    | $\text{CH}_3\text{N}^\bullet\text{CH}_2\text{N}(\text{NO}_2)\text{CH}_3$ | 185.4                                   | 1    |
| (3) Nitrogen-Centered Species                                                                   |                                         |      | (4) Sulfur-Centered Species                                              |                                         |      |
| ON                                                                                              | $91.04 \pm 0.08$                        | 1    | HOS <sup>•</sup>                                                         | $-6.7 \pm 2.1$                          | 1    |
| NO <sub>2</sub>                                                                                 | $33.97 \pm 0.08$                        | 1    | HC(O)S <sup>•</sup>                                                      | 56.5                                    | 1    |
| N <sub>2</sub> O                                                                                | $82.05 \pm 0.4$                         | 1    | HS <sup>•</sup> O <sub>2</sub>                                           | -221.8                                  | 1    |
| NH                                                                                              | $357 \pm 1$                             | 1    | HOS <sup>•</sup> O <sub>2</sub>                                          | -384.9                                  | 1    |
| $\bullet\text{NH}_2$                                                                            | $186.2 \pm 1.0$                         | 1    | NCS <sup>•</sup>                                                         | $300 \pm 8$                             | 1    |

| Radical                                          | $\Delta_f H^\circ_{298} / \text{kJ mol}^{-1}$ | Ref. | Radical                                          | $\Delta_f H^\circ_{298} / \text{kJ mol}^{-1}$ | Ref. |
|--------------------------------------------------|-----------------------------------------------|------|--------------------------------------------------|-----------------------------------------------|------|
| HS•                                              | 143.0 ± 0.8                                   | 1    | H <sub>3</sub> SiSi•H <sub>2</sub>               | 234 ± 6                                       | 1    |
| CH <sub>3</sub> S•                               | 124.7 ± 1.7                                   | 1    | C <sub>6</sub> H <sub>5</sub> Si•H <sub>2</sub>  | 274                                           | 1    |
| C <sub>2</sub> H <sub>5</sub> S•                 | 101                                           | 1    | H <sub>3</sub> SiSi•H                            | 312 ± 8                                       | 1    |
| nC <sub>3</sub> H <sub>7</sub> S•                | 80                                            | 1    | MeSi•                                            | 302.2                                         | 1    |
| iC <sub>3</sub> H <sub>7</sub> S•                | 74.9 ± 8.4                                    | 1    | MeSi•H                                           | 202 ± 6                                       | 1    |
| tC <sub>4</sub> H <sub>9</sub> S•                | 43.9 ± 8.4                                    | 1    | Me <sub>2</sub> Si•                              | 135 ± 8                                       | 1    |
| C <sub>6</sub> H <sub>5</sub> S•                 | 242.7 ± 4.6                                   | 1    | SiN                                              | 313.8 ± 42                                    | 1    |
| C <sub>6</sub> Cl <sub>5</sub> S•                | ~184                                          | 1    | •GeH <sub>3</sub>                                | 221.8 ± 8.4                                   | 1    |
| C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> S• | 246                                           | 1    | GeF                                              | -71 ± 10                                      | 1    |
| CH <sub>3</sub> S•O                              | -67 ± 10                                      | 1    | GeF <sub>2</sub>                                 | -574 ± 20                                     | 1    |
| CH <sub>3</sub> S•O <sub>2</sub>                 | -239.3                                        | 1    | •GeF <sub>3</sub>                                | -807 ± 50                                     | 1    |
| HSS•                                             | 115.5 ± 14.6                                  | 1    | GeCl                                             | 69 ± 18                                       | 1    |
| CH <sub>3</sub> SS•                              | 68.6 ± 8.4                                    | 1    | GeCl <sub>2</sub>                                | -171 ± 5                                      | 1    |
| C <sub>2</sub> H <sub>5</sub> SS•                | 43.5 ± 8.4                                    | 1    | •GeCl <sub>3</sub>                               | -268 ± 50                                     | 1    |
| iC <sub>3</sub> H <sub>7</sub> SS•               | 13.8 ± 8.4                                    | 1    | GeBr                                             | 137 ± 5                                       | 1    |
| tC <sub>4</sub> H <sub>9</sub> SS•               | -19.2 ± 8.4                                   | 1    | GeBr <sub>2</sub>                                | -61 ± 5                                       | 1    |
| HOC(S)S•                                         | 110.5 ± 4.6                                   | 1    | •GeBr <sub>3</sub>                               | -119 ± 50                                     | 1    |
| HC(O)S•                                          | 56.5                                          | 1    | GeI                                              | 211 ± 25                                      | 1    |
| SF                                               | 13.0 ± 6.3                                    | 1    | GeI <sub>2</sub>                                 | 50.2 ± 4                                      | 1    |
| SF <sub>2</sub>                                  | -296.7 ± 16.7                                 | 1    | •GeI <sub>3</sub>                                | 42 ± 50                                       | 1    |
| SF <sub>3</sub>                                  | -503.0 ± 33.5                                 | 1    | SnF                                              | -95 ± 7.2                                     | 1    |
| SF <sub>4</sub>                                  | -763.2 ± 20.9                                 | 1    | SnF <sub>2</sub>                                 | -511 ± 9.2                                    | 1    |
| SF <sub>5</sub>                                  | -879.9 ± 15.1                                 | 1    | •SnF <sub>3</sub>                                | -647 ± 50                                     | 1    |
| ClS•                                             | 156.5 ± 16.7                                  | 1    | SnCl                                             | 35 ± 12                                       | 1    |
| SN                                               | 263.6 ± 105                                   | 1    | SnCl <sub>2</sub>                                | -202.6 ± 7.1                                  | 1    |
| SCI                                              | 156.5 ± 16.7                                  | 1    | •SnCl <sub>3</sub>                               | -292 ± 50                                     | 1    |
| <b>(5) Si-, Ge-, Sn-, Pb-Centered Species</b>    |                                               |      | SnBr                                             | 76 ± 12                                       | 1    |
| SiF                                              | -20.1 ± 12.6                                  | 1    | SnBr <sub>2</sub>                                | -119 ± 2.8                                    | 1    |
| SiF <sub>2</sub>                                 | -638 ± 6                                      | 1    | •SnBr <sub>3</sub>                               | -159 ± 50                                     | 1    |
| •SiF <sub>3</sub>                                | -987 ± 20                                     | 1    | SnI                                              | 173 ± 12                                      | 1    |
| SiCl                                             | 198.3 ± 6.7                                   | 1    | SnI <sub>2</sub>                                 | -8.1 ± 4.2                                    | 1    |
| SiCl <sub>2</sub>                                | -169 ± 3                                      | 1    | •SnI <sub>3</sub>                                | -8 ± 50                                       | 1    |
| •SiCl <sub>3</sub>                               | 322 ± 8                                       | 1    | •Sn(CH <sub>3</sub> ) <sub>3</sub>               | 132.2                                         | 1    |
| SiBr                                             | 235 ± 46                                      | 1    | •Sn(C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub> | 518.8 ± 21                                    | 1    |
| SiBr <sub>2</sub>                                | 46 ± 8                                        | 1    | PbH                                              | 236.2 ± 19.2                                  | 1    |
| •SiBr <sub>3</sub>                               | -201.7 ± 63                                   | 1    | PbF                                              | -80.3 ± 10.5                                  | 1    |
| SiI                                              | 313.8 ± 42                                    | 1    | PbF <sub>2</sub>                                 | -435.1 ± 8.4                                  | 1    |
| SiI <sub>2</sub>                                 | 92.5 ± 8.4                                    | 1    | •PbF <sub>3</sub>                                | -490 ± 60                                     | 1    |
| •SiI <sub>3</sub>                                | 35.3 ± 63                                     | 1    | PbCl                                             | 15.1 ± 50                                     | 1    |
| SiH                                              | 376.6 ± 8.4                                   | 1    | PbCl <sub>2</sub>                                | -174.1 ± 1.3                                  | 1    |
| SiH <sub>2</sub> ( <sup>1</sup> A <sub>1</sub> ) | 273 ± 2                                       | 1    | •PbCl <sub>3</sub>                               | -178 ± 80                                     | 1    |
| SiH <sub>3</sub> ( <sup>3</sup> B <sub>1</sub> ) | 360.7                                         | 1    | PbBr                                             | 70.9 ± 42                                     | 1    |
| •SiH <sub>3</sub>                                | 200.4 ± 2.5                                   | 1    | PbBr <sub>2</sub>                                | -104.4 ± 6.3                                  | 1    |
| MeSi•H <sub>2</sub>                              | 141 ± 6                                       | 1    | •PbBr <sub>3</sub>                               | -104 ± 80                                     | 1    |
| Me <sub>2</sub> Si•H                             | 78 ± 6                                        | 1    | PbI                                              | 107.4 ± 37.7                                  | 1    |
| Me <sub>3</sub> Si•                              | 15 ± 7                                        | 1    | PbI <sub>2</sub>                                 | -3.2 ± 4.2                                    | 1    |
| •Si <sub>2</sub> H <sub>3</sub>                  | ~402                                          | 1    | •PbI <sub>3</sub>                                | 22 ± 80                                       | 1    |

## References

1. Luo, Y.R., *Comprehensive Handbook of Chemical Bond Energies*, CRC Press, 2007.
2. Wheeler, S.E., et al., *J. Phys. Chem. A* 111, 3819–3830, 2007.
3. Seetula, J.A., et al., *Chem. Phys.* 351, 141–146, 2008.

**TABLE 5. Bond Dissociation Energies of Some Organic Molecules**

$D_{298}^{\circ}(\text{R-X})/\text{kJ mol}^{-1}$  of some organic compounds are listed below. All data are from Tables 1 and 3.

|                                               | X=H      | F       | Cl      | Br     | I      | OH     | OCH <sub>3</sub> | NH <sub>2</sub> | NO    | CH <sub>3</sub> | COCH <sub>3</sub> | CF <sub>3</sub> | CCl <sub>3</sub> |
|-----------------------------------------------|----------|---------|---------|--------|--------|--------|------------------|-----------------|-------|-----------------|-------------------|-----------------|------------------|
| R=H                                           | 435.7799 | 569.658 | 431.361 | 366.16 | 298.26 | 497.10 | 440.2            | 450.08          | 199.5 | 439.3           | 374.0             | 445.2           | 392.5            |
| CH <sub>3</sub>                               | 439.3    | 460.2   | 350.2   | 294.1  | 238.9  | 384.93 | 351.9            | 356.1           | 172.0 | 377.4           | 351.9             | 429.3           | 362.3            |
| C <sub>2</sub> H <sub>5</sub>                 | 420.5    | 447.4   | 352.3   | 292.9  | 233.5  | 391.2  | 355.2            | 352.3           | 171.5 | 370.3           | 347.3             | —               | —                |
| i-C <sub>3</sub> H <sub>7</sub>               | 410.5    | 483.8   | 354.0   | 299.2  | 234.7  | 397.9  | 360.7            | 357.7           | 152.7 | 369.0           | 340.2             | —               | —                |
| t-C <sub>4</sub> H <sub>9</sub>               | 400.4    | 495.8   | 351.9   | 292.9  | 227.2  | 398.3  | 353.1            | 355.6           | 167   | 363.6           | 329.3             | —               | —                |
| C <sub>6</sub> H <sub>5</sub>                 | 472.2    | 525.5   | 399.6   | 336.4  | 272.0  | 463.6  | 418.8            | 429.3           | 226.8 | 426.8           | 406.7             | 463.2           | 388.7            |
| C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> | 375.5    | 412.8   | 299.9   | 239.3  | 187.8  | 334.1  | —                | 306.7           | 123   | 325.1           | 299.7             | 365.7           | —                |
| CCl <sub>3</sub>                              | 392.5    | 439.3   | 296.6   | 231.4  | 168    | —      | —                | —               | 125   | 362.3           | —                 | 332.2           | 285.8            |
| CF <sub>3</sub>                               | 445.2    | 546.8   | 365.3   | 296.2  | 227.2  | ≤482.0 | —                | —               | 167   | 429.3           | —                 | 413.0           | 332.2            |
| C <sub>2</sub> F <sub>5</sub>                 | 429.7    | 532.2   | 346.0   | 283.3  | 219.2  | —      | —                | —               | —     | —               | —                 | 424.3           | —                |
| CH <sub>3</sub> CO                            | 374.0    | 511.7   | 354.0   | 292.0  | 223.0  | 459.4  | 424.3            | 414.6           | —     | 351.9           | 307.1             | —               | —                |
| CN                                            | 528.5    | 482.8   | 422.6   | 364.8  | 320.1  | —      | —                | —               | 204.4 | 521.7           | —                 | 469.0           | —                |
| C <sub>6</sub> F <sub>5</sub>                 | 487.4    | 485     | 383.3   | ~328   | <301.7 | 446.9  | —                | —               | 211.3 | 439.3           | —                 | 435.1           | —                |

**TABLE 6. Bond Dissociation Energies in Diatomic Cations**

From thermochemistry, we have

$$D_{298}^{\circ}(\text{A}^+-\text{B}) \equiv \Delta_f H^{\circ}(\text{A}^+) + \Delta_f H^{\circ}(\text{B}) - \Delta_f H^{\circ}(\text{AB}^+) = D_{298}^{\circ}(\text{A}-\text{B}) + IP(\text{A}) - IP(\text{AB})$$

Thus,  $D_{298}^{\circ}(\text{A}^+-\text{B})$  may be derived using the Table 1 and the ionization potentials of species A and AB. The following Table has been arranged in an alphabetical order of the atoms. The **boldface** in the species indicates the dissociated fragment.

| A <sup>+</sup> -B          | $D_{298}^{\circ}$ kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> -B          | $D_{298}^{\circ}$ kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> -B          | $D_{298}^{\circ}$ kJ/mol <sup>-1</sup> | Ref. |
|----------------------------|----------------------------------------|------|----------------------------|----------------------------------------|------|----------------------------|----------------------------------------|------|
| <b>Ag</b> <sup>+</sup> -Ag | 167.9 ± 8.7                            | 1    | <b>Au</b> <sup>+</sup> -B  | 329 ± 50                               | 1    | <b>Ba</b> <sup>+</sup> -I  | 335 ± 10                               | 1    |
| <b>Ag</b> <sup>+</sup> -Cl | 32 ± 30                                | 1    | <b>Au</b> <sup>+</sup> -Be | 401 ± 29                               | 1    | <b>Ba</b> <sup>+</sup> -O  | 441.4 ± 15                             | 1    |
| <b>Ag</b> <sup>+</sup> -F  | 24 ± 27                                | 1    | <b>Au</b> <sup>+</sup> -C  | 311.5 ± 7.7                            | 4    | <b>Be</b> <sup>+</sup> -Ar | 49.0 ± 2.4                             | 1    |
| <b>Ag</b> <sup>+</sup> -H  | 43.5 ± 5.9                             | 1    | <b>Au</b> <sup>+</sup> -F  | 79                                     | 1    | <b>Be</b> <sup>+</sup> -Au | 410 ± 29                               | 1    |
| <b>Ag</b> <sup>+</sup> -O  | 123 ± 5                                | 1    | <b>Au</b> <sup>+</sup> -Ge | 292 ± 24                               | 1    | <b>Be</b> <sup>+</sup> -Be | 187.0                                  | 1    |
| <b>Ag</b> <sup>+</sup> -S  | 123 ± 13                               | 1    | <b>Au</b> <sup>+</sup> -H  | 213.1 ± 7.7                            | 4    | <b>Be</b> <sup>+</sup> -Cl | 417 ± 50                               | 1    |
| <b>Al</b> <sup>+</sup> -Al | 121                                    | 1    | <b>Au</b> <sup>+</sup> -I  | 230~280                                | 1    | <b>Be</b> <sup>+</sup> -F  | 575 ± 98                               | 1    |
| <b>Al</b> <sup>+</sup> -Ar | 15.47                                  | 1    | <b>Au</b> <sup>+</sup> -Xe | 130 ± 13                               | 1    | <b>Be</b> <sup>+</sup> -H  | 307.3 ± 5.0                            | 1    |
| <b>Al</b> <sup>+</sup> -Ca | 148.5                                  | 1    | <b>B</b> <sup>+</sup> -Ar  | 32.7                                   | 1    | <b>Be</b> <sup>+</sup> -O  | 362.0 ± 6.2                            | 1    |
| <b>Al</b> <sup>+</sup> -Cl | 173 ± 42                               | 1    | <b>B</b> <sup>+</sup> -B   | 187                                    | 1    | <b>Bi</b> <sup>+</sup> -Bi | 199 ± 10                               | 1    |
| <b>Al</b> <sup>+</sup> -F  | 314 ± 21                               | 1    | <b>B</b> <sup>+</sup> -Br  | 164 ± 21                               | 1    | <b>Bi</b> <sup>+</sup> -O  | 174                                    | 1    |
| <b>Al</b> <sup>+</sup> -Kr | 5.54                                   | 1    | <b>B</b> <sup>+</sup> -C   | 284 ± 58                               | 1    | <b>Bi</b> <sup>+</sup> -S  | 179 ± 50                               | 1    |
| <b>Al</b> <sup>+</sup> -O  | 166.7 ± 12.0                           | 1    | <b>B</b> <sup>+</sup> -Cl  | 308 ± 21                               | 1    | <b>Bi</b> <sup>+</sup> -Se | 184 ± 29                               | 1    |
| <b>Al</b> <sup>+</sup> -Se | 114 ± 49                               | 1    | <b>B</b> <sup>+</sup> -F   | 460 ± 10                               | 1    | <b>Bi</b> <sup>+</sup> -Te | 125 ± 50                               | 1    |
| <b>Ar</b> <sup>+</sup> -Ar | 130.323 ± 0.087                        | 1    | <b>B</b> <sup>+</sup> -H   | 198 ± 5                                | 1    | <b>Bi</b> <sup>+</sup> -Tl | 100 ± 42                               | 1    |
| <b>Ar</b> <sup>+</sup> -He | 2.9 ± 0.8                              | 1    | <b>B</b> <sup>+</sup> -O   | 326 ± 48                               | 1    | <b>Bk</b> <sup>+</sup> -O  | 610                                    | 1    |
| <b>Ar</b> <sup>+</sup> -Ne | 7.5 ± 0.8                              | 1    | <b>B</b> <sup>+</sup> -Pt  | 314 ± 98                               | 1    | <b>Br</b> <sup>+</sup> -Br | 318.858 ± 0.024                        | 1    |
| <b>As</b> <sup>+</sup> -As | 364 ± 22                               | 1    | <b>B</b> <sup>+</sup> -Se  | 298 ± 98                               | 1    | <b>Br</b> <sup>+</sup> -C  | 451.5 ± 8.6                            | 1    |
| <b>As</b> <sup>+</sup> -H  | 290.8 ± 3.0                            | 1    | <b>B</b> <sup>+</sup> -Si  | 365 ± 15                               | 1    | <b>Br</b> <sup>+</sup> -Cl | 303.000 ± 0.048                        | 1    |
| <b>As</b> <sup>+</sup> -O  | 495                                    | 1    | <b>Ba</b> <sup>+</sup> -Ar | 11.85                                  | 1    | <b>Br</b> <sup>+</sup> -F  | 251.5 ± 12.6                           | 1    |
| <b>As</b> <sup>+</sup> -P  | 367 ± 59                               | 1    | <b>Ba</b> <sup>+</sup> -Br | 418 ± 10                               | 1    | <b>Br</b> <sup>+</sup> -H  | 379.26 ± 2.89                          | 1    |
| <b>As</b> <sup>+</sup> -S  | 433.2 ± 12.5                           | 1    | <b>Ba</b> <sup>+</sup> -Cl | 468.2 ± 10                             | 1    | <b>Br</b> <sup>+</sup> -O  | 365.7 ± 3.1                            | 1    |
| <b>Au</b> <sup>+</sup> -Al | 170 ± 30                               | 1    | <b>Ba</b> <sup>+</sup> -D  | 245.2 ± 9.6                            | 1    | <b>C</b> <sup>+</sup> -Ar  | 72.3                                   | 1    |
| <b>Au</b> <sup>+</sup> -Au | 234.5                                  | 1    | <b>Ba</b> <sup>+</sup> -F  | 640 ± 29                               | 1    | <b>C</b> <sup>+</sup> -Br  | 398 ± 8.6                              | 1    |

| A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. |
|---------------------|----------------------------------------------------|------|---------------------|----------------------------------------------------|------|---------------------|----------------------------------------------------|------|
| C <sup>+</sup> -C   | 601.9 ± 19.3                                       | 1    | Co <sup>+</sup> -H  | 195 ± 6                                            | 1    | Dy <sup>+</sup> -I  | 279.9                                              | 1    |
| C <sup>+</sup> -Cl  | 614                                                | 1    | Co <sup>+</sup> -He | 16.4 ± 0.4                                         | 1    | Dy <sup>+</sup> -O  | 597 ± 15                                           | 1    |
| C <sup>+</sup> -F   | 721 ± 40                                           | 1    | Co <sup>+</sup> -I  | 211.7 ± 8.4                                        | 1    | Er <sup>+</sup> -Br | 315.8                                              | 1    |
| C <sup>+</sup> -H   | 397.848 ± 0.013                                    | 1    | Co <sup>+</sup> -Kr | 68.37 ± 0.18                                       | 1    | Er <sup>+</sup> -Cl | 406.7                                              | 1    |
| C <sup>+</sup> -N   | 524.5 ± 4.2                                        | 1    | Co <sup>+</sup> -Ne | 12.8 ± 0.4                                         | 1    | Er <sup>+</sup> -F  | 546 ± 34                                           | 1    |
| C <sup>+</sup> -O   | 810.7 ± 0.8                                        | 1    | Co <sup>+</sup> -O  | 317.3 ± 4.8                                        | 1    | Er <sup>+</sup> -I  | 271.6                                              | 1    |
| C <sup>+</sup> -P   | 587 ± 50                                           | 1    | Co <sup>+</sup> -S  | 288.3 ± 8.7                                        | 1    | Er <sup>+</sup> -O  | 583 ± 15                                           | 1    |
| C <sup>+</sup> -S   | 706.6 ± 2.1                                        | 1    | Co <sup>+</sup> -Si | 317.1 ± 6.7                                        | 1    | Es <sup>+</sup> -O  | 470 ± 60                                           | 1    |
| C <sup>+</sup> -Se  | 587 ± 50                                           | 1    | Co <sup>+</sup> -Xe | 85.7 ± 6.8                                         | 1    | Eu <sup>+</sup> -Ag | 85 ± 50                                            | 1    |
| Ca <sup>+</sup> -Al | 144.7                                              | 1    | Cr <sup>+</sup> -Ar | 31.7 ± 3.9                                         | 1    | Eu <sup>+</sup> -Au | 252 ± 97                                           | 1    |
| Ca <sup>+</sup> -Ar | 12.99 ± 0.60                                       | 1    | Cr <sup>+</sup> -C  | 277 ± 24                                           | 1    | Eu <sup>+</sup> -Br | 333.8                                              | 1    |
| Ca <sup>+</sup> -Au | 306 ± 29                                           | 1    | Cr <sup>+</sup> -Cl | >211                                               | 1    | Eu <sup>+</sup> -Cl | 430.7                                              | 1    |
| Ca <sup>+</sup> -Br | 417.6 ± 10                                         | 1    | Cr <sup>+</sup> -Cr | 129                                                | 1    | Eu <sup>+</sup> -F  | 543 ± 29                                           | 1    |
| Ca <sup>+</sup> -Ca | 104.1                                              | 1    | Cr <sup>+</sup> -D  | 135 ± 9                                            | 1    | Eu <sup>+</sup> -I  | 290.7                                              | 1    |
| Ca <sup>+</sup> -Cl | 433.4 ± 12                                         | 1    | Cr <sup>+</sup> -F  | 279 ± 42                                           | 1    | Eu <sup>+</sup> -O  | 393 ± 15                                           | 1    |
| Ca <sup>+</sup> -F  | 556.5 ± 8.4                                        | 1    | Cr <sup>+</sup> -H  | 136 ± 9                                            | 1    | Eu <sup>+</sup> -S  | 257 ± 32                                           | 1    |
| Ca <sup>+</sup> -H  | 284.2 ± 10                                         | 1    | Cr <sup>+</sup> -He | 7.8 ± 0.4                                          | 1    | F <sup>+</sup> -Ar  | 161.1                                              | 1    |
| Ca <sup>+</sup> -I  | 293.7 ± 10.8                                       | 1    | Cr <sup>+</sup> -Ne | 9.5 ± 0.4                                          | 1    | F <sup>+</sup> -F   | 325.393 ± 0.096                                    | 1    |
| Ca <sup>+</sup> -Kr | 18.60 ± 0.72                                       | 1    | Cr <sup>+</sup> -O  | 359                                                | 1    | F <sup>+</sup> -He  | 181.62 ± 0.08                                      | 1    |
| Ca <sup>+</sup> -Ne | 4.95 ± 0.06                                        | 1    | Cr <sup>+</sup> -S  | 258.6 ± 16.4                                       | 1    | F <sup>+</sup> -Kr  | 152.4                                              | 1    |
| Ca <sup>+</sup> -O  | 348 ± 5                                            | 1    | Cr <sup>+</sup> -Si | 203 ± 15                                           | 1    | F <sup>+</sup> -Xe  | 188                                                | 1    |
| Ca <sup>+</sup> -Xe | 25.38 ± 0.96                                       | 1    | Cr <sup>+</sup> -Xe | 71.9 ± 10.0                                        | 1    | Fe <sup>+</sup> -Ar | 14.2 ± 7.7                                         | 1    |
| Cd <sup>+</sup> -Cd | 122.5 ± 10                                         | 1    | Cs <sup>+</sup> -Ar | 8.2                                                | 1    | Fe <sup>+</sup> -Br | >293                                               | 1    |
| Cd <sup>+</sup> -H  | 179.5                                              | 1    | Cs <sup>+</sup> -Br | 60.5 ± 10                                          | 1    | Fe <sup>+</sup> -C  | 356.1 ± 17.2                                       | 1    |
| Ce <sup>+</sup> -Au | 278 ± 34                                           | 1    | Cs <sup>+</sup> -Cl | 107.4 ± 10                                         | 1    | Fe <sup>+</sup> -Cl | >343                                               | 1    |
| Ce <sup>+</sup> -Br | 341.0                                              | 1    | Cs <sup>+</sup> -Cs | 62.6 ± 9.6                                         | 1    | Fe <sup>+</sup> -Co | 259 ± 21                                           | 1    |
| Ce <sup>+</sup> -C  | 254 ± 96                                           | 1    | Cs <sup>+</sup> -F  | 43.7 ± 10                                          | 1    | Fe <sup>+</sup> -Cr | 209 ± 29                                           | 1    |
| Ce <sup>+</sup> -Ce | 207 ± 42                                           | 1    | Cs <sup>+</sup> -He | 5.1                                                | 1    | Fe <sup>+</sup> -Cu | 222 ± 29                                           | 1    |
| Ce <sup>+</sup> -Cl | 429.5                                              | 1    | Cs <sup>+</sup> -I  | 29.3 ± 10                                          | 1    | Fe <sup>+</sup> -D  | 227                                                | 1    |
| Ce <sup>+</sup> -F  | 586 ± 63                                           | 1    | Cs <sup>+</sup> -Kr | 15.1                                               | 1    | Fe <sup>+</sup> -F  | 360 - 423                                          | 1    |
| Ce <sup>+</sup> -I  | 295.5                                              | 1    | Cs <sup>+</sup> -Na | 48.1 ± 4.2                                         | 1    | Fe <sup>+</sup> -Fe | 272                                                | 1    |
| Ce <sup>+</sup> -Ir | 530 ± 96                                           | 1    | Cs <sup>+</sup> -Ne | 6.11                                               | 1    | Fe <sup>+</sup> -H  | 211.2 ± 9.6                                        | 1    |
| Ce <sup>+</sup> -N  | 494 ± 63                                           | 1    | Cs <sup>+</sup> -O  | 59                                                 | 1    | Fe <sup>+</sup> -I  | >239                                               | 1    |
| Ce <sup>+</sup> -O  | 852 ± 15                                           | 1    | Cs <sup>+</sup> -Rb | 68.3 ± 10                                          | 1    | Fe <sup>+</sup> -Kr | 33.5 ± 6.7                                         | 1    |
| Ce <sup>+</sup> -Pd | 255 ± 53                                           | 1    | Cs <sup>+</sup> -Xe | 14.7                                               | 1    | Fe <sup>+</sup> -N  | 485                                                | 1    |
| Ce <sup>+</sup> -Pt | 467 ± 96                                           | 1    | Cu <sup>+</sup> -Ar | 51.9 ± 6.8                                         | 1    | Fe <sup>+</sup> -Nb | 285 ± 21                                           | 1    |
| Ce <sup>+</sup> -Rh | 423 ± 96                                           | 1    | Cu <sup>+</sup> -Cl | 91 ± 10                                            | 1    | Fe <sup>+</sup> -Ni | 268 ± 21                                           | 1    |
| Ce <sup>+</sup> -S  | 524 ± 59                                           | 1    | Cu <sup>+</sup> -Cu | 155.2 ± 7.7                                        | 1    | Fe <sup>+</sup> -O  | 343.3 ± 1.9                                        | 1    |
| Cl <sup>+</sup> -Ar | 169                                                | 1    | Cu <sup>+</sup> -F  | 117 ± 21                                           | 1    | Fe <sup>+</sup> -S  | 295.2 ± 5.8                                        | 1    |
| Cl <sup>+</sup> -Cl | 385.746 ± 0.096                                    | 6    | Cu <sup>+</sup> -Ge | 231 ± 23                                           | 1    | Fe <sup>+</sup> -Sc | 200 ± 21                                           | 1    |
| Cl <sup>+</sup> -D  | 457.284 ± 0.017                                    | 1    | Cu <sup>+</sup> -H  | 93 ± 13                                            | 1    | Fe <sup>+</sup> -Si | 277 ± 9                                            | 1    |
| Cl <sup>+</sup> -F  | 291 ± 10                                           | 1    | Cu <sup>+</sup> -Kr | 24.3 ± 0.8                                         | 1    | Fe <sup>+</sup> -Ta | 301 ± 21                                           | 1    |
| Cl <sup>+</sup> -H  | 452.714 ± 0.018                                    | 1    | Cu <sup>+</sup> -O  | 133.9 ± 11.6                                       | 1    | Fe <sup>+</sup> -Ti | 251 ± 25                                           | 1    |
| Cl <sup>+</sup> -N  | 650 ± 10                                           | 1    | Cu <sup>+</sup> -S  | 203.3 ± 14.5                                       | 1    | Fe <sup>+</sup> -V  | 314 ± 21                                           | 1    |
| Cl <sup>+</sup> -O  | 468.0 ± 2.1                                        | 1    | Cu <sup>+</sup> -Si | 260 ± 8                                            | 1    | Fe <sup>+</sup> -Xe | 46.0 ± 5.8                                         | 1    |
| Co <sup>+</sup> -Ar | 52.89 ± 0.06                                       | 1    | Cu <sup>+</sup> -Xe | 102.1 ± 5.8                                        | 1    | Ga <sup>+</sup> -Bi | 62 ± 98                                            | 1    |
| Co <sup>+</sup> -Br | >289                                               | 1    | D <sup>+</sup> -D   | 263.4405 ± 0.0003                                  | 1    | Ga <sup>+</sup> -Br | 56.5 ± 16                                          | 1    |
| Co <sup>+</sup> -C  | 351 ± 29                                           | 1    | Dy <sup>+</sup> -Br | 324.2                                              | 1    | Ga <sup>+</sup> -Cl | 86 ± 21                                            | 1    |
| Co <sup>+</sup> -Cl | 285 ± 12                                           | 1    | Dy <sup>+</sup> -Cl | 407.9                                              | 1    | Ga <sup>+</sup> -F  | 136 ± 15                                           | 1    |
| Co <sup>+</sup> -Co | 269                                                | 1    | Dy <sup>+</sup> -Cu | 196 ± 42                                           | 1    | Ga <sup>+</sup> -Ga | 126.3                                              | 1    |
| Co <sup>+</sup> -D  | 199.6 ± 5.8                                        | 1    | Dy <sup>+</sup> -F  | 535 ± 24                                           | 1    | Ga <sup>+</sup> -I  | 41.6 ± 15                                          | 1    |



| A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. |
|---------------------|----------------------------------------------------|------|---------------------|----------------------------------------------------|------|---------------------|----------------------------------------------------|------|
| Ga <sup>+</sup> -O  | 46 ± 50                                            | 1    | Ir <sup>+</sup> -C  | 635.8 ± 4.8                                        | 3    | Lu <sup>+</sup> -H  | 204 ± 15                                           | 1    |
| Ga <sup>+</sup> -Sb | 38 ± 96                                            | 1    | Ir <sup>+</sup> -D  | 302.8 ± 5.8                                        | 1    | Lu <sup>+</sup> -I  | 40.7                                               | 1    |
| Ga <sup>+</sup> -Te | 19 ± 29                                            | 1    | Ir <sup>+</sup> -H  | 305.7 ± 5.8                                        | 1    | Lu <sup>+</sup> -O  | 524 ± 15                                           | 1    |
| Gd <sup>+</sup> -Cd | 122.5 ± 10                                         | 1    | Ir <sup>+</sup> -O  | 247                                                | 1    | Lu <sup>+</sup> -Si | 107 ± 13                                           | 1    |
| Gd <sup>+</sup> -H  | 179.5                                              | 1    | K <sup>+</sup> -Ar  | 14 ± 7                                             | 1    | Mg <sup>+</sup> -Ar | 19.20                                              | 1    |
| Ge <sup>+</sup> -Br | 398 ± 42                                           | 1    | K <sup>+</sup> -Br  | 35.7 ± 10.5                                        | 1    | Mg <sup>+</sup> -Au | 267 ± 29                                           | 1    |
| Ge <sup>+</sup> -C  | 223 ± 31                                           | 1    | K <sup>+</sup> -Cl  | 51 ± 19                                            | 1    | Mg <sup>+</sup> -Cl | 327 ± 6.5                                          | 1    |
| Ge <sup>+</sup> -Cl | 473 ± 50                                           | 1    | K <sup>+</sup> -He  | 6.00                                               | 1    | Mg <sup>+</sup> -D  | 203.6 ± 0.8                                        | 1    |
| Ge <sup>+</sup> -F  | 565 ± 21                                           | 1    | K <sup>+</sup> -I   | 18 ± 45                                            | 1    | Mg <sup>+</sup> -F  | 477 ± 50                                           | 1    |
| Ge <sup>+</sup> -Ge | 274 ± 10                                           | 1    | K <sup>+</sup> -K   | 83.86 ± 0.15                                       | 1    | Mg <sup>+</sup> -H  | 190.8 ± 5.8                                        | 1    |
| Ge <sup>+</sup> -H  | 377 ± 84                                           | 1    | K <sup>+</sup> -Kr  | 15.8                                               | 1    | Mg <sup>+</sup> -Kr | 25.39                                              | 1    |
| Ge <sup>+</sup> -O  | 344 ± 21                                           | 1    | K <sup>+</sup> -Li  | 59.9 ± 5.9                                         | 1    | Mg <sup>+</sup> -Mg | 125                                                | 1    |
| Ge <sup>+</sup> -S  | 283 ± 21                                           | 1    | K <sup>+</sup> -Na  | 58.69 ± 0.08                                       | 1    | Mg <sup>+</sup> -Ne | 4.9 ± 0.6                                          | 1    |
| Ge <sup>+</sup> -Se | 234 ± 10                                           | 1    | K <sup>+</sup> -Ne  | 7.79                                               | 1    | Mg <sup>+</sup> -O  | 245.2 ± 10                                         | 1    |
| Ge <sup>+</sup> -Si | 268 ± 21                                           | 1    | K <sup>+</sup> -O   | 13                                                 | 1    | Mg <sup>+</sup> -Xe | 53.74                                              | 1    |
| Ge <sup>+</sup> -Te | 233 ± 19                                           | 1    | K <sup>+</sup> -Xe  | 19.5                                               | 1    | Mn <sup>+</sup> -Cl | >211                                               | 1    |
| H <sup>+</sup> -D   | 261.1021 ± 0.0002                                  | 1    | Kr <sup>+</sup> -Ar | 55.31 ± 0.14                                       | 1    | Mn <sup>+</sup> -F  | 321 ± 24                                           | 1    |
| H <sup>+</sup> -H   | 259.4659 ± 0.0002                                  | 1    | Kr <sup>+</sup> -H  | 464                                                | 1    | Mn <sup>+</sup> -H  | 202.5 ± 5.9                                        | 1    |
| He <sup>+</sup> -H  | 123.9                                              | 1    | Kr <sup>+</sup> -He | 2.1 ± 0.8                                          | 1    | Mn <sup>+</sup> -I  | >211                                               | 1    |
| He <sup>+</sup> -He | 229.687 ± 0.019                                    | 1    | Kr <sup>+</sup> -Kr | 110.967 ± 0.033                                    | 1    | Mn <sup>+</sup> -Mn | 129                                                | 1    |
| Hf <sup>+</sup> -H  | 193.8 ± 10.6                                       | 2    | Kr <sup>+</sup> -N  | 136.9 ± 13                                         | 1    | Mn <sup>+</sup> -O  | 285 ± 13                                           | 1    |
| Hf <sup>+</sup> -O  | 724 ± 21                                           | 1    | Kr <sup>+</sup> -Ne | 3.8 ± 0.8                                          | 1    | Mn <sup>+</sup> -S  | 247 ± 23                                           | 1    |
| Hg <sup>+</sup> -Ar | 22.2 ± 1.2                                         | 1    | La <sup>+</sup> -Au | 436 ± 97                                           | 1    | Mn <sup>+</sup> -Se | 165 ± 50                                           | 1    |
| Hg <sup>+</sup> -H  | 207                                                | 1    | La <sup>+</sup> -Br | 425.9                                              | 1    | Mo <sup>+</sup> -C  | 442.7 ± 13.5                                       | 1    |
| Hg <sup>+</sup> -Hg | 134                                                | 1    | La <sup>+</sup> -C  | 427 ± 33                                           | 1    | Mo <sup>+</sup> -F  | 376 ± 29                                           | 1    |
| Hg <sup>+</sup> -Kr | 37.9 ± 1.3                                         | 1    | La <sup>+</sup> -Cl | 503.6                                              | 1    | Mo <sup>+</sup> -H  | 170 ± 6                                            | 1    |
| Hg <sup>+</sup> -Xe | 72.2 ± 1.3                                         | 1    | La <sup>+</sup> -F  | 589 ± 34                                           | 1    | Mo <sup>+</sup> -Mo | 449.4 ± 1.0                                        | 1    |
| Ho <sup>+</sup> -Ag | 155 ± 61                                           | 1    | La <sup>+</sup> -H  | 243 ± 9                                            | 1    | Mo <sup>+</sup> -O  | 488.2 ± 1.9                                        | 1    |
| Ho <sup>+</sup> -Au | 250 ± 60                                           | 1    | La <sup>+</sup> -I  | 392.4                                              | 1    | Mo <sup>+</sup> -S  | 355.1 ± 5.8                                        | 1    |
| Ho <sup>+</sup> -Br | 320.6                                              | 1    | La <sup>+</sup> -Ir | 356 ± 97                                           | 1    | Mo <sup>+</sup> -Xe | >53.1 ± 6.8                                        | 1    |
| Ho <sup>+</sup> -Cl | 410.3                                              | 1    | La <sup>+</sup> -O  | 875 ± 25                                           | 1    | N <sup>+</sup> -Ar  | 208.4 ± 9.6                                        | 1    |
| Ho <sup>+</sup> -Cu | 214 ± 35                                           | 1    | La <sup>+</sup> -Pt | 522 ± 78                                           | 1    | N <sup>+</sup> -F   | 584 ± 42                                           | 1    |
| Ho <sup>+</sup> -F  | 542 ± 50                                           | 1    | La <sup>+</sup> -Rh | 345 ± 97                                           | 1    | N <sup>+</sup> -H   | ≥435.67 ± 0.77                                     | 1    |
| Ho <sup>+</sup> -Ho | 88 ± 96                                            | 1    | La <sup>+</sup> -S  | 629 ± 96                                           | 1    | N <sup>+</sup> -N   | 843.85 ± 0.10                                      | 1    |
| Ho <sup>+</sup> -I  | 270.4                                              | 1    | La <sup>+</sup> -Si | 277.0 ± 9.6                                        | 1    | N <sup>+</sup> -O   | 115                                                | 1    |
| Ho <sup>+</sup> -O  | 551 ± 25                                           | 1    | Li <sup>+</sup> -Ar | 33 ± 14                                            | 1    | Na <sup>+</sup> -Ar | 19 ± 8                                             | 1    |
| I <sup>+</sup> -Br  | 184.90 ± 0.02                                      | 1    | Li <sup>+</sup> -Bi | 91 ± 50                                            | 1    | Na <sup>+</sup> -Br | 58.2 ± 10.6                                        | 1    |
| I <sup>+</sup> -Cl  | 247.5 ± 0.4                                        | 1    | Li <sup>+</sup> -Br | 41.8 ± 10.6                                        | 1    | Na <sup>+</sup> -Cl | 20.3 ± 10                                          | 1    |
| I <sup>+</sup> -F   | 262.9 ± 2.1                                        | 1    | Li <sup>+</sup> -Cl | 66 ± 15                                            | 1    | Na <sup>+</sup> -He | 7.55                                               | 1    |
| I <sup>+</sup> -H   | 304.70 ± 0.10                                      | 1    | Li <sup>+</sup> -F  | 7 ± 21                                             | 1    | Na <sup>+</sup> -I  | 64.9 ± 3.0                                         | 1    |
| I <sup>+</sup> -I   | 262.90 ± 0.04                                      | 1    | Li <sup>+</sup> -He | 10.66                                              | 1    | Na <sup>+</sup> -Kr | ~24.9                                              | 1    |
| I <sup>+</sup> -O   | 316.3 ± 10.5                                       | 1    | Li <sup>+</sup> -I  | 51.1 ± 6.3                                         | 1    | Na <sup>+</sup> -Li | 95.8 ± 3.9                                         | 1    |
| In <sup>+</sup> -Br | 65.2 ± 12.6                                        | 1    | Li <sup>+</sup> -Kr | 48.1                                               | 1    | Na <sup>+</sup> -Na | 98.64 ± 0.29                                       | 1    |
| In <sup>+</sup> -Cl | 193 ± 21                                           | 1    | Li <sup>+</sup> -Li | 137.3 ± 6.3                                        | 1    | Na <sup>+</sup> -Na | 6.4                                                | 1    |
| In <sup>+</sup> -F  | 148 ± 50                                           | 1    | Li <sup>+</sup> -Ne | 15.32                                              | 1    | Na <sup>+</sup> -Ne | ~9.04                                              | 1    |
| In <sup>+</sup> -I  | 51.5 ± 21                                          | 1    | Li <sup>+</sup> -O  | 38.9 ± 9.6                                         | 1    | Na <sup>+</sup> -O  | 37 ± 19                                            | 1    |
| In <sup>+</sup> -In | 81 ± 30                                            | 1    | Li <sup>+</sup> -Sb | 129.6 ± 13.9                                       | 1    | Na <sup>+</sup> -Xe | ~28.6                                              | 1    |
| In <sup>+</sup> -S  | 171 ± 50                                           | 1    | Li <sup>+</sup> -Xe | 56.4                                               | 1    | Nb <sup>+</sup> -Ar | 40.87 ± 0.13                                       | 1    |
| In <sup>+</sup> -Sb | 73 ± 50                                            | 1    | Lu <sup>+</sup> -Br | 86.1                                               | 1    | Nb <sup>+</sup> -C  | 509 ± 15                                           | 1    |
| In <sup>+</sup> -Se | 118 ± 50                                           | 1    | Lu <sup>+</sup> -Cl | 180.6                                              | 1    | Nb <sup>+</sup> -Fe | >251                                               | 1    |
| In <sup>+</sup> -Te | 41 ± 50                                            | 1    | Lu <sup>+</sup> -F  | 376.8                                              | 1    | Nb <sup>+</sup> -H  | 220 ± 7                                            | 1    |

| A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> -B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. |
|---------------------|----------------------------------------------------|------|---------------------|----------------------------------------------------|------|---------------------|----------------------------------------------------|------|
| Nb <sup>+</sup> -Nb | 576.8 ± 9.6                                        | 1    | Pb <sup>+</sup> -S  | 293 ± 50                                           | 1    | S <sup>+</sup> -N   | 516 ± 34                                           | 1    |
| Nb <sup>+</sup> -O  | 688 ± 11                                           | 1    | Pb <sup>+</sup> -Se | 169.4 ± 6.3                                        | 1    | S <sup>+</sup> -O   | 524.3 ± 0.4                                        | 1    |
| Nb <sup>+</sup> -S  | 501.7 ± 20.3                                       | 1    | Pb <sup>+</sup> -Te | 163 ± 63                                           | 1    | S <sup>+</sup> -P   | 573 ± 21                                           | 1    |
| Nb <sup>+</sup> -V  | 404.7 ± 0.2                                        | 1    | Pd <sup>+</sup> -C  | 528 ± 5                                            | 1    | S <sup>+</sup> -S   | 522.4 ± 0.5                                        | 1    |
| Nb <sup>+</sup> -Xe | 73.28 ± 0.12                                       | 1    | Pd <sup>+</sup> -H  | 208.4 ± 8.7                                        | 1    | Sc <sup>+</sup> -C  | 326 ± 6                                            | 1    |
| Nd <sup>+</sup> -Au | 267 ± 84                                           | 1    | Pd <sup>+</sup> -O  | 145 ± 11                                           | 1    | Sc <sup>+</sup> -Cl | 410 ± 42                                           | 1    |
| Nd <sup>+</sup> -Br | 352.9                                              | 1    | Pd <sup>+</sup> -Pd | 197 ± 29                                           | 1    | Sc <sup>+</sup> -F  | 605 ± 32                                           | 1    |
| Nd <sup>+</sup> -Cl | 441.4                                              | 1    | Pd <sup>+</sup> -S  | 197 ± 6                                            | 1    | Sc <sup>+</sup> -Fe | 201 ± 21                                           | 1    |
| Nd <sup>+</sup> -F  | 309.6                                              | 1    | Pd <sup>+</sup> -Si | 289 ± 50                                           | 1    | Sc <sup>+</sup> -H  | 235 ± 8                                            | 1    |
| Nd <sup>+</sup> -I  | 596 ± 32                                           | 1    | Pr <sup>+</sup> -Au | 317 ± 81                                           | 1    | Sc <sup>+</sup> -O  | 689 ± 5                                            | 1    |
| Nd <sup>+</sup> -O  | 753 ± 15                                           | 1    | Pr <sup>+</sup> -Br | 357.7                                              | 1    | Sc <sup>+</sup> -S  | 529.7 ± 17.4                                       | 1    |
| Ne <sup>+</sup> -H  | 1239                                               | 1    | Pr <sup>+</sup> -Cl | 445.0                                              | 1    | Sc <sup>+</sup> -Se | 475.8 ± 8.4                                        | 1    |
| Ne <sup>+</sup> -He | 13.0 ± 0.8                                         | 1    | Pr <sup>+</sup> -F  | 557 ± 63                                           | 1    | Sc <sup>+</sup> -Si | 242.3 ± 10.5                                       | 1    |
| Ne <sup>+</sup> -Ne | 125.29 ± 1.93                                      | 1    | Pr <sup>+</sup> -I  | 317.0                                              | 1    | Se <sup>+</sup> -F  | 364 ± 42                                           | 1    |
| Ni <sup>+</sup> -Ar | 53.9                                               | 1    | Pr <sup>+</sup> -O  | 796 ± 15                                           | 1    | Se <sup>+</sup> -H  | 304                                                | 1    |
| Ni <sup>+</sup> -Br | >289                                               | 1    | Pt <sup>+</sup> -Ar | 36.4 ± 8.7                                         | 1    | Se <sup>+</sup> -P  | 514 ± 25                                           | 1    |
| Ni <sup>+</sup> -C  | 418                                                | 1    | Pt <sup>+</sup> -B  | 398 ± 105                                          | 1    | Se <sup>+</sup> -S  | 392 ± 19                                           | 1    |
| Ni <sup>+</sup> -Cl | 192 ± 4                                            | 1    | Pt <sup>+</sup> -C  | 530.5 ± 4.8                                        | 1    | Se <sup>+</sup> -Se | 413 ± 19                                           | 1    |
| Ni <sup>+</sup> -D  | 166.0 ± 7.7                                        | 1    | Pt <sup>+</sup> -Cl | 249.8 ± 14.5                                       | 1    | Si <sup>+</sup> -Au | 175 ± 50                                           | 1    |
| Ni <sup>+</sup> -F  | ≥456                                               | 1    | Pt <sup>+</sup> -H  | 275 ± 5                                            | 1    | Si <sup>+</sup> -B  | 351 ± 15                                           | 1    |
| Ni <sup>+</sup> -H  | 158.1 ± 7.7                                        | 1    | Pt <sup>+</sup> -N  | 326.9 ± 9.6                                        | 1    | Si <sup>+</sup> -Br | 276 ± 96                                           | 1    |
| Ni <sup>+</sup> -He | 12.4 ± 0.4                                         | 1    | Pt <sup>+</sup> -O  | 318.4 ± 6.7                                        | 1    | Si <sup>+</sup> -C  | 365 ± 50                                           | 1    |
| Ni <sup>+</sup> -I  | >297                                               | 1    | Pt <sup>+</sup> -Pt | 318 ± 23                                           | 1    | Si <sup>+</sup> -Cl | 591.0 ± 0.6                                        | 1    |
| Ni <sup>+</sup> -Ne | 9.9 ± 0.4                                          | 1    | Pt <sup>+</sup> -Si | 515 ± 50                                           | 1    | Si <sup>+</sup> -F  | 684.1 ± 5.4                                        | 1    |
| Ni <sup>+</sup> -Ni | 208                                                | 1    | Pt <sup>+</sup> -Xe | 86.6 ± 28.9                                        | 1    | Si <sup>+</sup> -H  | 316.6 ± 2.1                                        | 1    |
| Ni <sup>+</sup> -O  | 275.9 ± 7.7                                        | 1    | Pu <sup>+</sup> -F  | 562 ± 50                                           | 1    | Si <sup>+</sup> -O  | 478 ± 13.4                                         | 1    |
| Ni <sup>+</sup> -S  | 241.0 ± 3.9                                        | 1    | Pu <sup>+</sup> -O  | 655                                                | 1    | Si <sup>+</sup> -P  | 272 ± 50                                           | 1    |
| Ni <sup>+</sup> -Si | 326 ± 6.7                                          | 1    | Rb <sup>+</sup> -Ar | 12.0                                               | 1    | Si <sup>+</sup> -Pd | 237 ± 50                                           | 1    |
| Np <sup>+</sup> -F  | 730 ± 100                                          | 1    | Rb <sup>+</sup> -Br | 17.6v5.1                                           | 1    | Si <sup>+</sup> -Pt | 525 ± 50                                           | 1    |
| Np <sup>+</sup> -O  | ≥752                                               | 1    | Rb <sup>+</sup> -Cl | 10.5 ± 10.5                                        | 1    | Si <sup>+</sup> -S  | 387.5 ± 6.0                                        | 1    |
| O <sup>+</sup> -Ar  | 33.8                                               | 1    | Rb <sup>+</sup> -I  | 27 ± 42                                            | 1    | Si <sup>+</sup> -Si | 334 ± 19                                           | 1    |
| O <sup>+</sup> -F   | 301.8 ± 8.4                                        | 1    | Rb <sup>+</sup> -Kr | 14.9                                               | 1    | Si <sup>+</sup> -Te | 347 ± 50                                           | 1    |
| O <sup>+</sup> -H   | 487.9 ± 0.34                                       | 1    | Rb <sup>+</sup> -Na | 50.1 ± 3.9                                         | 1    | Sm <sup>+</sup> -Br | 343.3                                              | 1    |
| O <sup>+</sup> -N   | 1050.64 ± 0.13                                     | 1    | Rb <sup>+</sup> -Ne | 6.95                                               | 1    | Sm <sup>+</sup> -Cl | 435.4                                              | 1    |
| O <sup>+</sup> -O   | 647.75 ± 0.17                                      | 1    | Rb <sup>+</sup> -O  | 29                                                 | 1    | Sm <sup>+</sup> -F  | 620.9                                              | 1    |
| Os <sup>+</sup> -H  | 238.9                                              | 1    | Rb <sup>+</sup> -Rb | 75.6 ± 9.6                                         | 1    | Sm <sup>+</sup> -I  | 299.1                                              | 1    |
| Os <sup>+</sup> -O  | 418 ± 50                                           | 1    | Rb <sup>+</sup> -Xe | 21.5                                               | 1    | Sm <sup>+</sup> -O  | 569 ± 15                                           | 1    |
| P <sup>+</sup> -C   | 512 ± 42                                           | 1    | Re <sup>+</sup> -C  | 497.7 ± 3.9                                        | 1    | Sn <sup>+</sup> -Br | 335 ± 50                                           | 1    |
| P <sup>+</sup> -Cl  | 289                                                | 1    | Re <sup>+</sup> -H  | 224.7 ± 6.7                                        | 1    | Sn <sup>+</sup> -Cu | 184 ± 96                                           | 1    |
| P <sup>+</sup> -F   | 490.6 ± 8.4                                        | 1    | Re <sup>+</sup> -O  | 435 ± 59                                           | 1    | Sn <sup>+</sup> -F  | 364 ± 29                                           | 1    |
| P <sup>+</sup> -H   | 329.6 ± 2.1                                        | 1    | Rh <sup>+</sup> -C  | 414 ± 17                                           | 1    | Sn <sup>+</sup> -O  | 281 ± 10                                           | 1    |
| P <sup>+</sup> -N   | 483 ± 21                                           | 1    | Rh <sup>+</sup> -H  | 164.8 ± 3.8                                        | 1    | Sn <sup>+</sup> -S  | 240 ± 19                                           | 1    |
| P <sup>+</sup> -O   | 791.3 ± 8.4                                        | 1    | Rh <sup>+</sup> -O  | 295.0 ± 5.8                                        | 1    | Sn <sup>+</sup> -Se | 174 ± 6.3                                          | 1    |
| P <sup>+</sup> -P   | 481 ± 50                                           | 1    | Rh <sup>+</sup> -S  | 226 ± 13                                           | 1    | Sn <sup>+</sup> -Sn | 193                                                | 1    |
| P <sup>+</sup> -S   | 606 ± 34                                           | 1    | Ru <sup>+</sup> -C  | 453.5 ± 10.6                                       | 1    | Sn <sup>+</sup> -Te | 168.7 ± 8.4                                        | 1    |
| Pa <sup>+</sup> -O  | ~800                                               | 1    | Ru <sup>+</sup> -H  | 160.2 ± 5.0                                        | 1    | Sr <sup>+</sup> -Ar | 13.32 ± 2.92                                       | 1    |
| Pb <sup>+</sup> -Br | 260 ± 63                                           | 1    | Ru <sup>+</sup> -O  | 372 ± 5                                            | 1    | Sr <sup>+</sup> -Br | 378.1 ± 8.4                                        | 1    |
| Pb <sup>+</sup> -Cl | 285 ± 63                                           | 1    | Ru <sup>+</sup> -S  | 288 ± 6                                            | 1    | Sr <sup>+</sup> -Cl | 427 ± 8.4                                          | 1    |
| Pb <sup>+</sup> -F  | 347 ± 32                                           | 1    | S <sup>+</sup> -C   | 620.8 ± 1.3                                        | 1    | Sr <sup>+</sup> -F  | 615 ± 50                                           | 1    |
| Pb <sup>+</sup> -O  | 247 ± 8.4                                          | 1    | S <sup>+</sup> -F   | 343.5 ± 4.8                                        | 1    | Sr <sup>+</sup> -H  | 209 ± 5                                            | 1    |
| Pb <sup>+</sup> -Pb | 214 ± 29                                           | 1    | S <sup>+</sup> -H   | 348.2 ± 1.7                                        | 1    | Sr <sup>+</sup> -I  | 308.2                                              | 1    |

| A <sup>+</sup> –B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> –B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. | A <sup>+</sup> –B   | D <sub>298</sub> <sup>o</sup> kJ/mol <sup>-1</sup> | Ref. |
|---------------------|----------------------------------------------------|------|---------------------|----------------------------------------------------|------|---------------------|----------------------------------------------------|------|
| Sr <sup>+</sup> –Kr | 18.13 ± 6.94                                       | 1    | Tl <sup>+</sup> –I  | 133 ± 21                                           | 1    | Xe <sup>+</sup> –H  | 355                                                | 1    |
| Sr <sup>+</sup> –Ne | 4.52 ± 9.6                                         | 1    | Tl <sup>+</sup> –Tl | 22 ± 50                                            | 1    | Xe <sup>+</sup> –Kr | 41.65 ± 0.08                                       | 1    |
| Sr <sup>+</sup> –O  | 298.7                                              | 1    | Tm <sup>+</sup> –Br | 312.2                                              | 1    | Xe <sup>+</sup> –N  | 66.4 ± 9.6                                         | 1    |
| Sr <sup>+</sup> –Sr | 108.5 ± 1.6                                        | 1    | Tm <sup>+</sup> –Cl | 407.9                                              | 1    | Xe <sup>+</sup> –Ne | 2.1 ± 0.8                                          | 1    |
| Ta <sup>+</sup> –H  | 230 ± 6                                            | 1    | Tm <sup>+</sup> –F  | 537 ± 16                                           | 1    | Xe <sup>+</sup> –Xe | 99.6                                               | 1    |
| Ta <sup>+</sup> –O  | 787 ± 63                                           | 1    | Tm <sup>+</sup> –I  | 266.8                                              | 1    | Y <sup>+</sup> –C   | 281 ± 12                                           | 1    |
| Ta <sup>+</sup> –Ta | 666                                                | 1    | Tm <sup>+</sup> –O  | 482 ± 15                                           | 1    | Y <sup>+</sup> –F   | 677 ± 21                                           | 1    |
| Tb <sup>+</sup> –Cu | 245 ± 34                                           | 1    | U <sup>+</sup> –Br  | 345 ± 29                                           | 1    | Y <sup>+</sup> –H   | 260.5 ± 5.8                                        | 1    |
| Tb <sup>+</sup> –O  | 722 ± 15                                           | 1    | U <sup>+</sup> –C   | 300 ± 96                                           | 1    | Y <sup>+</sup> –O   | 718 ± 25                                           | 1    |
| Tc <sup>+</sup> –H  | 197.5                                              | 1    | U <sup>+</sup> –Cl  | 431 ± 34                                           | 1    | Y <sup>+</sup> –Pt  | 466 ± 192                                          | 1    |
| Tc <sup>+</sup> –O  | >167                                               | 1    | U <sup>+</sup> –D   | 283.4 ± 9.6                                        | 1    | Y <sup>+</sup> –S   | 533.9 ± 8                                          | 1    |
| Te <sup>+</sup> –H  | 305 ± 12                                           | 1    | U <sup>+</sup> –F   | 668 ± 29                                           | 1    | Y <sup>+</sup> –Si  | 243 ± 13                                           | 1    |
| Te <sup>+</sup> –O  | 339 ± 50                                           | 1    | U <sup>+</sup> –H   | 284 ± 8                                            | 1    | Y <sup>+</sup> –Te  | 360 ± 96                                           | 1    |
| Te <sup>+</sup> –P  | 415 ± 97                                           | 1    | U <sup>+</sup> –N   | ~485                                               | 1    | Y <sup>+</sup> –Y   | 281 ± 21                                           | 1    |
| Te <sup>+</sup> –Se | 342 ± 19                                           | 1    | U <sup>+</sup> –O   | 757 ± 42                                           | 1    | Yb <sup>+</sup> –Br | 307.4                                              | 1    |
| Te <sup>+</sup> –Si | 339.6                                              | 5    | U <sup>+</sup> –P   | 186                                                | 1    | Yb <sup>+</sup> –Cl | 399.6                                              | 1    |
| Te <sup>+</sup> –Te | 278 ± 29                                           | 1    | U <sup>+</sup> –S   | 518 ± 29                                           | 1    | Yb <sup>+</sup> –F  | 557.5 ± 14.4                                       | 1    |
| Th <sup>+</sup> –Cl | 499 ± 29                                           | 1    | V <sup>+</sup> –Ar  | 39.39 ± 0.12                                       | 1    | Yb <sup>+</sup> –I  | 262.0                                              | 1    |
| Th <sup>+</sup> –F  | 682 ± 29                                           | 1    | V <sup>+</sup> –C   | 373 ± 13.5                                         | 1    | Yb <sup>+</sup> –O  | 376 ± 15                                           | 1    |
| Th <sup>+</sup> –O  | 875 ± 16                                           | 1    | V <sup>+</sup> –D   | 202 ± 6                                            | 1    | Yb <sup>+</sup> –Yb | 238 ± 96                                           | 1    |
| Th <sup>+</sup> –Pt | 388 ± 193                                          | 1    | V <sup>+</sup> –Fe  | 314 ± 21                                           | 1    | Zn <sup>+</sup> –Ar | 28.7 ± 1.2                                         | 1    |
| Th <sup>+</sup> –Rh | 504 ± 67                                           | 1    | V <sup>+</sup> –H   | 202 ± 6                                            | 1    | Zn <sup>+</sup> –H  | 216 ± 15                                           | 1    |
| Ti <sup>+</sup> –C  | 395 ± 23                                           | 1    | V <sup>+</sup> –Kr  | 49.46 ± 0.18                                       | 1    | Zn <sup>+</sup> –O  | 161.1 ± 4.8                                        | 1    |
| Ti <sup>+</sup> –Cl | 426.8                                              | 1    | V <sup>+</sup> –N   | 448.6 ± 5.8                                        | 1    | Zn <sup>+</sup> –S  | 198 ± 12                                           | 1    |
| Ti <sup>+</sup> –F  | ≥456                                               | 1    | V <sup>+</sup> –Nb  | 403.5 ± 0.2                                        | 1    | Zn <sup>+</sup> –Si | 274.1 ± 9.6                                        | 1    |
| Ti <sup>+</sup> –H  | 226.6 ± 10.6                                       | 1    | V <sup>+</sup> –O   | 581.6 ± 9.6                                        | 1    | Zn <sup>+</sup> –Zn | 60 ± 19                                            | 1    |
| Ti <sup>+</sup> –N  | 501 ± 13                                           | 1    | V <sup>+</sup> –S   | 358.9 ± 8.7                                        | 1    | Zr <sup>+</sup> –Ar | 36.09 ± 0.24                                       | 1    |
| Ti <sup>+</sup> –O  | 667 ± 7                                            | 1    | V <sup>+</sup> –Si  | 229 ± 15                                           | 1    | Zr <sup>+</sup> –C  | 445.8 ± 15.4                                       | 1    |
| Ti <sup>+</sup> –Pt | 82 ± 96                                            | 1    | V <sup>+</sup> –V   | 302                                                | 1    | Zr <sup>+</sup> –H  | 218.8 ± 9.6                                        | 1    |
| Ti <sup>+</sup> –S  | 461.1 ± 6.8                                        | 1    | V <sup>+</sup> –Xe  | 66.4 ± 0.6                                         | 1    | Zr <sup>+</sup> –N  | 443 ± 46                                           | 1    |
| Ti <sup>+</sup> –Si | 249 ± 16                                           | 1    | W <sup>+</sup> –C   | 483 ± 21                                           | 1    | Zr <sup>+</sup> –O  | 753 ± 11                                           | 1    |
| Ti <sup>+</sup> –Ti | 229                                                | 1    | W <sup>+</sup> –F   | 444 ± 96                                           | 1    | Zr <sup>+</sup> –S  | 549.0 ± 9.6                                        | 1    |
| Tl <sup>+</sup> –Br | 52 ± 50                                            | 1    | W <sup>+</sup> –H   | 222.5 ± 5                                          | 1    | Zr <sup>+</sup> –Zr | 407.0 ± 9.6                                        | 1    |
| Tl <sup>+</sup> –Cl | 26 ± 4                                             | 1    | W <sup>+</sup> –O   | 695 ± 42                                           | 1    |                     |                                                    |      |
| Tl <sup>+</sup> –F  | 13 ± 21                                            | 1    | Xe <sup>+</sup> –Ar | 13.4                                               | 1    |                     |                                                    |      |

## References

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TABLE 7. Bond Dissociation Energies in Polyatomic Cations

This Table has been arranged on the basis of the Periodic Table with the IUPAC notation for Groups 1 to 18, see inside front cover of this *Handbook*. The **boldface** in the species indicates the dissociated fragment.

| Bond                                                             | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                                       | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. |
|------------------------------------------------------------------|--------------------------------|------|--------------------------------------------------------------------------------------------|--------------------------------|------|
| <b>(1) Group 1</b>                                               |                                |      | <b>K<sup>+</sup>–adenine</b>                                                               |                                |      |
| <b>Li<sup>+</sup>–H<sub>2</sub></b>                              | 27.2                           | 1    | <b>K<sup>+</sup>–indole</b>                                                                | 104.6 ± 12.6                   | 1    |
| <b>Li<sup>+</sup>–CO</b>                                         | 57 ± 13                        | 1    | <b>K<sup>+</sup>–Phe (phenylalanine)</b>                                                   | 150.5 ± 5.8                    | 1    |
| <b>Li<sup>+</sup>–H<sub>2</sub>O</b>                             | 139 ± 8                        | 1    | <b>K<sup>+</sup>–Tyr (tyrosine)</b>                                                        | 165.0 ± 5.8                    | 1    |
| <b>Li<sup>+</sup>–NH<sub>3</sub></b>                             | 156 ± 8                        | 1    | <b>Rb<sup>+</sup>–H<sub>2</sub>O</b>                                                       | 66.9 ± 12.6                    | 1    |
| <b>Li<sup>+</sup>–CH<sub>4</sub></b>                             | 130                            | 1    | <b>Rb<sup>+</sup>–NH<sub>3</sub></b>                                                       | 78.2                           | 1    |
| <b>Li<sup>+</sup>–CH<sub>3</sub>OH</b>                           | 156 ± 8                        | 1    | <b>Rb<sup>+</sup>–CH<sub>3</sub>CN</b>                                                     | 86.6 ± 1.3                     | 1    |
| <b>Li<sup>+</sup>–CH<sub>3</sub>OCH<sub>3</sub></b>              | 167 ± 10                       | 1    | <b>Rb<sup>+</sup>–C<sub>6</sub>H<sub>5</sub>OH</b>                                         | 70.2 ± 3.7                     | 1    |
| <b>Li<sup>+</sup>–pyridine</b>                                   | 183.0 ± 14.5                   | 1    | <b>Cs<sup>+</sup>–H<sub>2</sub>O</b>                                                       | 57.3                           | 1    |
| <b>Li<sup>+</sup>–Gly (glycine)</b>                              | 220 ± 9                        | 1    | <b>Cs<sup>+</sup>–C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub></b>                             | 70.8 ± 4.5                     | 1    |
| <b>Na<sup>+</sup>–H<sub>2</sub></b>                              | 10.4 ± 0.8                     | 1    | <b>(2) Group 2</b>                                                                         |                                |      |
| <b>Na<sup>+</sup>–N<sub>2</sub></b>                              | 33.5                           | 1    | <b>CH<sub>3</sub>Be<sup>+</sup>–CH<sub>3</sub></b>                                         | 192.9 ± 13.4                   | 1    |
| <b>Na<sup>+</sup>–CO</b>                                         | 31 ± 8                         | 1    | <b>tert-C(CH<sub>3</sub>)<sub>3</sub>Be<sup>+</sup>–tert-C(CH<sub>3</sub>)<sub>3</sub></b> | 121.8 ± 13.4                   | 1    |
| <b>Na<sup>+</sup>–CO<sub>2</sub></b>                             | 66.5                           | 1    | <b>Mg<sup>+</sup>–OH</b>                                                                   | 314 ± 33                       | 1    |
| <b>Na<sup>+</sup>–SO<sub>2</sub></b>                             | 79.1                           | 1    | <b>Mg<sup>+</sup>–CO</b>                                                                   | 43.1 ± 5.8                     | 1    |
| <b>Na<sup>+</sup>–O<sub>3</sub></b>                              | 52.3                           | 1    | <b>Mg<sup>+</sup>–CO<sub>2</sub></b>                                                       | 58.4 ± 5.8                     | 1    |
| <b>Na<sup>+</sup>–H<sub>2</sub>O</b>                             | 91.2 ± 6.3                     | 1    | <b>Mg<sup>+</sup>–H<sub>2</sub>O</b>                                                       | 122.5 ± 12.5                   | 1    |
| <b>Na<sup>+</sup>(H<sub>2</sub>O)–H<sub>2</sub>O</b>             | 82.0 ± 5.8                     | 1    | <b>Mg<sup>+</sup>–NH<sub>3</sub></b>                                                       | 158.9 ± 11.6                   | 1    |
| <b>Na<sup>+</sup>(H<sub>2</sub>O)<sub>2</sub>–H<sub>2</sub>O</b> | 66.1                           | 1    | <b>Mg<sup>+</sup>–CH<sub>4</sub></b>                                                       | 29.8 ± 6.8                     | 1    |
| <b>Na<sup>+</sup>(H<sub>2</sub>O)<sub>3</sub>–H<sub>2</sub>O</b> | 52.7 ± 0.8                     | 1    | <b>Mg<sup>+</sup>–MeOH</b>                                                                 | 147.6 ± 6.8                    | 1    |
| <b>Na<sup>+</sup>(glycine)–H<sub>2</sub>O</b>                    | 75.1 ± 5.3                     | 1    | <b>Mg<sup>+</sup>–C<sub>6</sub>H<sub>6</sub></b>                                           | 155.2                          | 1    |
| <b>Na<sup>+</sup>(glutamine)–H<sub>2</sub>O</b>                  | 52 ± 1                         | 1    | <b>Mg<sup>+</sup>–pyridine</b>                                                             | 200.0 ± 6.4                    | 1    |
| <b>Na<sup>+</sup>–NH<sub>3</sub></b>                             | 106.2 ± 5.4                    | 1    | <b>Mg<sup>+</sup>–imidazole</b>                                                            | 243.9 ± 10.4                   | 1    |
| <b>Na<sup>+</sup>–HNO<sub>3</sub></b>                            | 86.2                           | 1    | <b>Mg<sup>2+</sup>(H<sub>2</sub>O)<sub>5</sub>–H<sub>2</sub>O</b>                          | 101.3                          | 1    |
| <b>Na<sup>+</sup>–CH<sub>4</sub></b>                             | 30.1                           | 1    | <b>Mg<sup>2+</sup>(Me<sub>2</sub>CO)<sub>5</sub>–Me<sub>2</sub>CO</b>                      | 93.3                           | 1    |
| <b>Na<sup>+</sup>–CH<sub>3</sub>OH</b>                           | 98.8 ± 5.7                     | 1    | <b>Ca<sup>+</sup>–OH</b>                                                                   | 435.1 ± 14.5                   | 1    |
| <b>Na<sup>+</sup>–CH<sub>3</sub>CN</b>                           | 125.5 ± 9.6                    | 1    | <b>Ca<sup>+</sup>–H<sub>2</sub>O</b>                                                       | 117.2                          | 1    |
| <b>Na<sup>+</sup>–C<sub>2</sub>H<sub>4</sub></b>                 | 44.6 ± 4.4                     | 1    | <b>Ca<sup>+</sup>–C<sub>6</sub>H<sub>6</sub></b>                                           | 134                            | 1    |
| <b>Na<sup>+</sup>–CH<sub>3</sub>OCH<sub>3</sub></b>              | 101.4 ± 5.7                    | 1    | <b>Ca<sup>+</sup>–imidazole</b>                                                            | 186.3 ± 3.9                    | 1    |
| <b>Na<sup>+</sup>–CH<sub>3</sub>C(O)H</b>                        | 114.4 ± 3.4                    | 1    | <b>Ca<sup>2+</sup>(H<sub>2</sub>O)<sub>4</sub>–H<sub>2</sub>O</b>                          | 110.0 ± 5.9                    | 1    |
| <b>Na<sup>+</sup>– MeCOMe</b>                                    | 131.3 ± 4.1                    | 1    | <b>Ca<sup>2+</sup>(Me<sub>2</sub>CO)<sub>5</sub>–Me<sub>2</sub>CO</b>                      | 101.3                          | 1    |
| <b>Na<sup>+</sup>–C<sub>6</sub>H<sub>6</sub></b>                 | 97.0 ± 5.9                     | 1    | <b>Sr<sup>+</sup>–CO</b>                                                                   | 20.3                           | 1    |
| <b>Na<sup>+</sup>–pyrrole</b>                                    | 103.7 ± 4.8                    | 1    | <b>Sr<sup>+</sup>–CO<sub>2</sub></b>                                                       | 41.9                           | 1    |
| <b>Na<sup>+</sup>–Gly (glycine)</b>                              | 166.7 ± 5.1                    | 1    | <b>Sr<sup>+</sup>–H<sub>2</sub>O</b>                                                       | 144.3                          | 1    |
| <b>Na<sup>+</sup>–Ala (alanine)</b>                              | 167 ± 4                        | 1    | <b>Sr<sup>+</sup>–C<sub>6</sub>H<sub>6</sub></b>                                           | 117                            | 1    |
| <b>Na<sup>+</sup>–GlyGly (glycylglycine)</b>                     | 203 ± 8                        | 1    | <b>Sr<sup>2+</sup>(H<sub>2</sub>O)<sub>5</sub>–H<sub>2</sub>O</b>                          | 87.4                           | 1    |
| <b>K<sup>+</sup>–H<sub>2</sub></b>                               | 6.1 ± 0.8                      | 1    | <b>Ba<sup>+</sup>–OH</b>                                                                   | 530.7 ± 19.3                   | 1    |
| <b>K<sup>+</sup>–CO<sub>2</sub></b>                              | 35.6                           | 1    | <b>Ba<sup>2+</sup>(H<sub>2</sub>O)<sub>4</sub>–H<sub>2</sub>O</b>                          | 90.8                           | 1    |
| <b>K<sup>+</sup>–H<sub>2</sub>O</b>                              | 74.9                           | 1    | <b>(3) Group 3</b>                                                                         |                                |      |
| <b>K<sup>+</sup>(H<sub>2</sub>O)<sub>2</sub>–H<sub>2</sub>O</b>  | 67.4                           | 1    | <b>Sc<sup>+</sup>–H<sub>2</sub></b>                                                        | 23.0 ± 1.3                     | 1    |
| <b>K<sup>+</sup>(H<sub>2</sub>O)<sub>3</sub>–H<sub>2</sub>O</b>  | 55.2                           | 1    | <b>Sc<sup>+</sup>–CH<sub>2</sub></b>                                                       | 412 ± 22                       | 1    |
| <b>K<sup>+</sup>(H<sub>2</sub>O)<sub>4</sub>–H<sub>2</sub>O</b>  | 11.8                           | 1    | <b>Sc<sup>+</sup>–CH<sub>3</sub></b>                                                       | 233 ± 10                       | 1    |
| <b>K<sup>+</sup>(H<sub>2</sub>O)<sub>5</sub>–H<sub>2</sub>O</b>  | 44.8                           | 1    | <b>Sc<sup>+</sup>–C<sub>2</sub>H<sub>2</sub></b>                                           | 240 ± 20                       | 1    |
| <b>K<sup>+</sup>(H<sub>2</sub>O)<sub>6</sub>–H<sub>2</sub>O</b>  | 41.8                           | 1    | <b>Sc<sup>+</sup>–C<sub>2</sub>H<sub>4</sub></b>                                           | ≥131                           | 1    |
| <b>K<sup>+</sup>–NH<sub>3</sub></b>                              | 79 ± 7                         | 1    | <b>Sc<sup>+</sup>–C<sub>6</sub>H<sub>6</sub></b>                                           | 222 ± 21                       | 1    |
| <b>K<sup>+</sup>–C<sub>6</sub>H<sub>6</sub></b>                  | 80.3                           | 1    | <b>Sc<sup>+</sup>–H<sub>2</sub>O</b>                                                       | 131                            | 1    |

| Bond                               | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                        | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. |
|------------------------------------|--------------------------------|------|-----------------------------------------------------------------------------|--------------------------------|------|
| $\text{Sc}^+-\text{NH}$            | $483 \pm 10$                   | 1    | $\text{V}^+-\text{CH}$                                                      | $470 \pm 5$                    | 1    |
| $\text{Sc}^+-\text{NH}_2$          | $347 \pm 5$                    | 1    | $\text{V}^+-\text{CH}_2$                                                    | $326 \pm 6$                    | 1    |
| $\text{Sc}^+-\text{pyridine}$      | $231.5 \pm 10.3$               | 1    | $\text{V}^+-\text{CH}_3$                                                    | $193 \pm 7$                    | 1    |
| $\text{Y}^+-\text{CH}_2$           | $398 \pm 13$                   | 1    | $\text{V}^+-\text{C}_2\text{H}_2$                                           | $172 \pm 8$                    | 1    |
| $\text{Y}^+-\text{CH}_3$           | $249 \pm 5.0$                  | 1    | $\text{V}^+-\text{C}_2\text{H}_4$                                           | $124 \pm 8$                    | 1    |
| $\text{Y}^+-\text{C}_2\text{H}_2$  | $218 \pm 13$                   | 1    | $\text{V}^+(\eta^5\text{-C}_5\text{H}_5)$                                   | 530.7                          | 1    |
| $\text{Y}^+-\text{C}_2\text{H}_4$  | >138                           | 1    | $\text{V}^+-\text{C}_6\text{H}_6$                                           | $234 \pm 10$                   | 1    |
| $\text{Y}^+-\text{CO}$             | $29.9 \pm 10.6$                | 1    | $\text{V}^+-\text{CO}$                                                      | $114.8 \pm 2.9$                | 1    |
| $\text{Y}^+-\text{CS}$             | $137.0 \pm 7.7$                | 1    | $\text{V}^+-\text{CO}_2$                                                    | $72.4 \pm 3.8$                 | 1    |
| $\text{Y}^+(\text{O})-\text{CO}_2$ | $86 \pm 5$                     | 1    | $\text{V}^+-\text{H}_2\text{O}$                                             | $149.8 \pm 5.0$                | 1    |
| $\text{La}^+-\text{CH}$            | $523 \pm 33$                   | 1    | $\text{V}^+-\text{NH}$                                                      | $423 \pm 29$                   | 1    |
| $\text{La}^+-\text{CH}_2$          | $401 \pm 7$                    | 1    | $\text{V}^+-\text{NH}_2$                                                    | $293 \pm 6$                    | 1    |
| $\text{La}^+-\text{CH}_3$          | $217 \pm 15$                   | 1    | $\text{V}^+-\text{NH}_3$                                                    | $192 \pm 11$                   | 1    |
| $\text{La}^+-\text{C}_2\text{H}_2$ | $262 \pm 30$                   | 1    | $\text{V}^+-\text{pyridine}$                                                | $218.7 \pm 13.5$               | 1    |
| $\text{La}^+-\text{C}_2\text{H}_4$ | 192.5                          | 1    | $\text{V}^+-\text{imidazole}$                                               | $\leq 243.4 \pm 8.0$           | 1    |
| $\text{Lu}^+-\text{CH}_2$          | $>230 \pm 6$                   | 1    | $\text{Nb}^+-\text{H}_2$                                                    | 61.9                           | 1    |
| $\text{Lu}^+-\text{CH}_3$          | $176 \pm 20$                   | 1    | $\text{Nb}^+-\text{CH}$                                                     | $581 \pm 19$                   | 1    |
| $\text{U}^+(\text{F})-\text{F}$    | $552 \pm 44$                   | 1    | $\text{Nb}^+-\text{CH}_2$                                                   | $428.4 \pm 8.7$                | 1    |
| $\text{U}^+(\text{F})_2-\text{F}$  | $523 \pm 38$                   | 1    | $\text{Nb}^+-\text{CH}_3$                                                   | $198.8 \pm 10.6$               | 1    |
| $\text{U}^+(\text{F})_3-\text{F}$  | $381 \pm 19$                   | 1    | $\text{Nb}^+-\text{CH}_3\text{NH}_2$                                        | 134                            | 1    |
| $\text{U}^+(\text{F})_4-\text{F}$  | $243 \pm 17$                   | 1    | $\text{Nb}^+-\text{C}_3\text{H}_6$                                          | 117.7                          | 1    |
| $\text{U}^+(\text{F})_5-\text{F}$  | $26 \pm 11$                    | 1    | $(\text{NbFe})^+-\text{C}_3\text{H}_4$                                      | >163                           | 1    |
| <b>(4) Group 4</b>                 |                                |      | $\text{Nb}^+-\text{CO}$                                                     | $95.5 \pm 4.8$                 | 1    |
| $\text{Ti}^+-\text{CH}$            | $478 \pm 5$                    | 1    | $\text{Nb}^+-\text{CS}$                                                     | $242.2 \pm 10.6$               | 1    |
| $\text{Ti}^+-\text{CH}_2$          | $391 \pm 15$                   | 1    | $\text{Nb}_7^+-\text{N}_2$                                                  | <215                           | 1    |
| $\text{Ti}^+-\text{CH}_3$          | $213.8 \pm 3$                  | 1    | $\text{Ta}^+-\text{CH}$                                                     | $561.5 \pm 15.4$               | 6    |
| $\text{Ti}^+-\text{CH}_4$          | $70.3 \pm 2.5$                 | 1    | $\text{Ta}^+-\text{CH}_2$                                                   | $464.1 \pm 2.9$                | 6    |
| $\text{Ti}^+-\text{C}_2\text{H}_2$ | $213 \pm 13$                   | 1    | $\text{Ta}^+-\text{CH}_3$                                                   | $259.5 \pm 13.5$               | 6    |
| $\text{Ti}^+-\text{C}_2\text{H}_4$ | $146 \pm 11$                   | 1    | $\text{Ta}^+-\text{C}_6\text{H}_6$                                          | 251~301                        | 1    |
| $\text{Ti}^+-\text{C}_6\text{H}_6$ | $259 \pm 9$                    | 1    | <b>(6) Group 6</b>                                                          |                                |      |
| $\text{Ti}^+-\text{CO}$            | $117.7 \pm 5.8$                | 1    | $(\text{CO})_6\text{Cr}^+-\text{H}$                                         | $230 \pm 10$                   | 1    |
| $\text{Ti}^+-\text{H}_2\text{O}$   | $157.7 \pm 5.9$                | 1    | $(\eta^5\text{-C}_5\text{H}_5)(\text{NO})(\text{CO})_2\text{Cr}^+-\text{H}$ | $207.1 \pm 14$                 | 1    |
| $\text{Ti}^+-\text{NH}$            | $466 \pm 12$                   | 1    | $\text{Cr}^+-\text{H}_2$                                                    | $31.8 \pm 2.1$                 | 1    |
| $\text{Ti}^+-\text{NH}_2$          | $356 \pm 13$                   | 1    | $\text{Cr}^+-\text{CH}$                                                     | $294 \pm 29$                   | 1    |
| $\text{Ti}^+-\text{NH}_3$          | $197 \pm 7$                    | 1    | $\text{Cr}^+-\text{CH}_2$                                                   | $216 \pm 4$                    | 1    |
| $\text{Ti}^+-\text{pyridine}$      | $217.2 \pm 9.3$                | 1    | $\text{Cr}^+-\text{CH}_3$                                                   | $110 \pm 4$                    | 1    |
| $\text{Ti}^+-\text{imidazole}$     | $\leq 232.4 \pm 8.2$           | 1    | $\text{Cr}^+-\text{C}_6\text{H}_6$                                          | $170 \pm 10$                   | 1    |
| $\text{Zr}^+-\text{CH}$            | $568 \pm 13$                   | 1    | $\text{Cr}^+-\text{indole}$                                                 | $196.6 \pm 16.7$               | 1    |
| $\text{Zr}^+-\text{CH}_2$          | $444.8 \pm 5$                  | 1    | $\text{Cr}^+-\text{CO}$                                                     | $89.7 \pm 5.8$                 | 1    |
| $\text{Zr}^+-\text{CH}_3$          | $227.7 \pm 9.6$                | 1    | $\text{Cr}^+-\text{OH}$                                                     | $298 \pm 14$                   | 1    |
| $\text{Zr}^+-\text{C}_2\text{H}_2$ | $273 \pm 14$                   | 1    | $\text{Cr}^+-\text{H}_2\text{O}$                                            | $132.6 \pm 8.8$                | 1    |
| $\text{Zr}^+-\text{CO}$            | $77 \pm 10$                    | 1    | $\text{Cr}^+-\text{N}_2$                                                    | $59 \pm 4$                     | 1    |
| $\text{Zr}^+-\text{CS}$            | $257.6 \pm 10.6$               | 1    | $\text{Cr}^+-\text{NH}_3$                                                   | $183 \pm 10$                   | 1    |
| $\text{Hf}^+-\text{CH}$            | $492.1 \pm 14.5$               | 2    | $(\text{CO})_6\text{Mo}^+-\text{H}$                                         | $260 \pm 9$                    | 1    |
| $\text{Hf}^+-\text{CH}_2$          | $421.6 \pm 6.8$                | 2    | $\text{Mo}^+-\text{CH}$                                                     | $513.3 \pm 13.5$               | 1    |
| $\text{Hf}^+-\text{CH}_3$          | $204.5 \pm 25.1$               | 2    | $\text{Mo}^+-\text{CH}_2$                                                   | $344.4 \pm 10$                 | 1    |
| $\text{Hf}^+-\text{C}_2\text{H}_2$ | 150.6                          | 1    | $\text{Mo}^+-\text{CH}_3$                                                   | $151.5 \pm 8.7$                | 1    |
| <b>(5) Group 5</b>                 |                                |      | $\text{Mo}^+-\text{CO}$                                                     | $193.9 \pm 9.6$                | 1    |
| $(\text{CO})_6\text{V}^+-\text{H}$ | $220 \pm 14$                   | 1    | $\text{Mo}^+-\text{CO}_2$                                                   | $49.2 \pm 7$                   | 1    |
| $\text{V}^+-\text{H}_2$            | $42.7 \pm 2.1$                 | 1    | $\text{Mo}^+-\text{CS}$                                                     | $162 \pm 18$                   | 1    |
|                                    |                                |      | $\text{Mo}^+-\text{CS}_2$                                                   | $67.5 \pm 12.5$                | 1    |

| Bond                                                | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                             | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. |
|-----------------------------------------------------|--------------------------------|------|----------------------------------------------------------------------------------|--------------------------------|------|
| $\text{Mo}^+-\text{NH}$                             | <385                           | 1    | $\text{Fe}^+-\text{N}_2$                                                         | $53 \pm 4$                     | 1    |
| $\text{Mo}^+-\text{pyrrole}$                        | >289                           | 1    | $\text{Fe}^+-\text{NH}_3$                                                        | $184 \pm 12$                   | 1    |
| $(\text{CO})_6\text{W}^+-\text{H}$                  | $257 \pm 9$                    | 1    | $\text{Fe}^+-\text{CS}_2$                                                        | $166.1 \pm 4.6$                | 1    |
| $\text{W}^+-\text{CH}$                              | $580 \pm 27$                   | 1    | $\text{Fe}^+-\text{imidazole}$                                                   | $246.1 \pm 13.8$               | 1    |
| $\text{W}^+-\text{CH}_2$                            | $456.4 \pm 5.8$                | 1    | $\text{Fe}^+-\text{SiH}$                                                         | $254 \pm 13$                   | 1    |
| $\text{W}^+-\text{CH}_3$                            | $\sim 222.9 \pm 9.6$           | 1    | $\text{Fe}^+-\text{SiH}_2$                                                       | $181 \pm 9$                    | 1    |
| $(\text{PMe}_3)_3(\text{CO})_3\text{W}^+-\text{H}$  | 259.4                          | 1    | $\text{Fe}^+-\text{SiH}_3$                                                       | $183 \pm 9$                    | 1    |
| $\text{W}^+-\text{pyrrole}$                         | >209                           | 1    | $\text{Ru}^+(\eta^5\text{-C}_5\text{H}_5)_2\text{-H}$                            | $292 \pm 16$                   | 1    |
| (7) Group 7                                         |                                |      | $(\eta^5\text{-C}_5\text{Me}_5)_2\text{Ru}^+-\text{H}$                           | 284.5                          | 1    |
| $(\text{CO})_5\text{Mn}^+-\text{H}$                 | $172 \pm 10$                   | 1    | $\text{Ru}^+-\text{CH}$                                                          | $501.7 \pm 11.6$               | 1    |
| $\text{Mn}^+-\text{H}_2$                            | $7.9 \pm 1.7$                  | 1    | $\text{Ru}^+-\text{CH}_2$                                                        | $344.4 \pm 4.8$                | 1    |
| $\text{Mn}^+-\text{CH}_2$                           | $295 \pm 13$                   | 1    | $\text{Ru}^+-\text{CH}_3$                                                        | $160.2 \pm 5.8$                | 1    |
| $\text{Mn}^+-\text{CH}_3$                           | $215 \pm 10$                   | 1    | $\text{Ru}^+-\text{CS}$                                                          | $253 \pm 20$                   | 1    |
| $\text{Mn}^+(\text{CO})_5\text{-CH}_3$              | $132 \pm 15$                   | 1    | $\text{OsO}_4^+-\text{H}$                                                        | $552 \pm 13$                   | 1    |
| $\text{Mn}^+(\text{CO})_5\text{-CH}_4$              | >30                            | 1    | (9) Group 9                                                                      |                                |      |
| $\text{Mn}^+-\text{C}_5\text{H}_5$                  | $326.1 \pm 9.6$                | 1    | $(\eta^5\text{-C}_5\text{H}_5)(\text{CO})_2\text{Co}^+-\text{H}$                 | $245 \pm 12$                   | 1    |
| $\text{Mn}^+-\text{C}_6\text{H}_6$                  | $145 \pm 10$                   | 1    | $(\text{CH}_3\text{OD})\text{Co}^+-\text{H}$                                     | $147.6 \pm 7.7$                | 1    |
| $\text{Mn}^+-\text{OH}$                             | $332 \pm 24$                   | 1    | $\text{Co}^+-\text{H}_2$                                                         | $76.1 \pm 4.2$                 | 1    |
| $\text{Mn}^+-\text{CO}$                             | $25 \pm 10$                    | 1    | $(\eta^5\text{-C}_5\text{H}_5)\text{Co}^+-\text{H}_2$                            | 67.8                           | 1    |
| $\text{Mn}^+-\text{H}_2\text{O}$                    | $121.8 \pm 5.9$                | 1    | $\text{Co}^+-\text{CH}$                                                          | $420 \pm 37$                   | 1    |
| $\text{Mn}^+-\text{CH}_3\text{OH}$                  | $134 \pm 29$                   | 1    | $\text{Co}^+-\text{CH}_2$                                                        | $317 \pm 5$                    | 1    |
| $\text{Mn}^+-\text{OC}(\text{CH}_3)_2$              | $159 \pm 14$                   | 1    | $\text{Co}^+-\text{CH}_3$                                                        | $203 \pm 4$                    | 1    |
| $\text{Mn}^+-\text{CS}$                             | $80.0 \pm 21$                  | 1    | $\text{Co}^+-\text{CH}_4$                                                        | 96.7                           | 1    |
| $\text{Mn}^+-\text{NH}_2$                           | $254 \pm 20$                   | 1    | $\text{Co}^+-\text{C}_{60}$                                                      | $243 \pm 67$                   | 1    |
| $\text{Mn}^+-\text{NH}_3$                           | $147 \pm 8$                    | 1    | $\text{Co}^+-\text{CO}$                                                          | $173.7 \pm 6.7$                | 1    |
| $\text{Tc}^+-\text{CH}_2$                           | <464                           | 1    | $\text{Co}^+-\text{H}_2\text{O}$                                                 | $164.4 \pm 5.9$                | 1    |
| $\text{Tc}^+-\text{C}_2\text{H}_2$                  | <320                           | 1    | $\text{Co}^+-\text{CS}$                                                          | $259 \pm 33$                   | 1    |
| $\text{Re}^+(\text{CH}_3)(\text{CO})_5\text{-H}$    | $294 \pm 13$                   | 1    | $\text{Co}^+-\text{N}_2$                                                         | $96.2 \pm 7.1$                 | 1    |
| $(\text{PMe}_3)(\text{CO})_2\text{Re}^+-\text{H}$   | 300.4                          | 1    | $\text{Co}^+-\text{NH}_2$                                                        | $247 \pm 7$                    | 1    |
| (8) Group 8                                         |                                |      | $\text{Co}^+-\text{NH}_3$                                                        | $219 \pm 16$                   | 1    |
| $\text{Fe}^+(\text{O})-\text{H}$                    | $444 \pm 17$                   | 1    | $\text{Co}^+-\text{CH}_3\text{CN}$                                               | >255 $\pm 17$                  | 1    |
| $\text{Fe}^+(\text{CO})-\text{H}$                   | $120 \pm 23$                   | 1    | $\text{Co}^+-\text{P}(\text{CH}_3)_3$                                            | $278 \pm 11$                   | 1    |
| $\text{Fe}^+(\text{H}_2\text{O})-\text{H}$          | $215 \pm 14$                   | 1    | $\text{Co}^+-\text{P}(\text{C}_2\text{H}_5)_3$                                   | $339 \pm 16$                   | 1    |
| $\text{Fe}^+(\eta^5\text{-C}_5\text{H}_5)-\text{H}$ | $193 \pm 21$                   | 1    | $(\text{CH})\text{Rh}^+-\text{H}$                                                | $372 \pm 21$                   | 1    |
| $(\text{CO})_2\text{Fe}^+-\text{H}$                 | $299 \pm 15$                   | 1    | $(\eta^5\text{-C}_5\text{H}_5)(\text{CO})_2\text{Rh}^+-\text{H}$                 | $287 \pm 12$                   | 1    |
| $\text{Fe}^+-\text{H}_2$                            | $45.2 \pm 2.5$                 | 1    | $\text{Rh}^+-\text{CH}$                                                          | $444 \pm 12$                   | 1    |
| $\text{Fe}^+-\text{CH}$                             | $423 \pm 29$                   | 1    | $\text{Rh}^+-\text{CH}_2$                                                        | $356 \pm 8$                    | 1    |
| $\text{Fe}^+-\text{CH}_2$                           | $\leq 342 \pm 2$               | 1    | $\text{Rh}^+-\text{CH}_3$                                                        | $142 \pm 6$                    | 1    |
| $\text{Fe}^+-\text{CH}_3$                           | $229 \pm 5$                    | 1    | $\text{Rh}^+-\text{NO}$                                                          | $167 \pm 21$                   | 1    |
| $\text{Fe}^+-\text{CH}_4$                           | 73.2                           | 1    | $\text{Rh}^+-\text{CS}$                                                          | $234 \pm 19$                   | 1    |
| $\text{Fe}^+-\text{C}_2\text{H}_2$                  | $159.0 \pm 2.1$                | 1    | $(\text{CO})(\eta^5\text{-C}_5\text{H}_5)(\text{PPh}_3)\text{Ir}^+-\text{H}$     | 313.4                          | 1    |
| $\text{Fe}^+-\text{C}_2\text{H}_3$                  | $238 \pm 10$                   | 1    | $(\text{CO})_2(\eta^5\text{-C}_5\text{Me}_5)\text{Ir}^+-\text{H}$                | 298.3                          | 1    |
| $\text{Fe}^+-\text{C}_2\text{H}_4$                  | $145 \pm 11$                   | 1    | $\text{Ir}^+-\text{CH}$                                                          | $666.7 \pm 22.2$               | 3    |
| $\text{Fe}^+-\text{C}_2\text{H}_5$                  | $233 \pm 9$                    | 1    | $\text{Ir}^+-\text{CH}_2$                                                        | $474.7 \pm 2.9$                | 3    |
| $\text{Fe}^+-\text{C}_2\text{H}_6$                  | $64 \pm 6$                     | 1    | $\text{Ir}^+-\text{CH}_3$                                                        | $313.6 \pm 17.4$               | 3    |
| $\text{Fe}^+-\text{OH}$                             | $366 \pm 12$                   | 1    | $\text{Ir}^+-\text{C}_2\text{H}_4$                                               | 234.3                          | 1    |
| $\text{Fe}^+-\text{CO}$                             | $129.3 \pm 3.9$                | 1    | (10) Group 10                                                                    |                                |      |
| $\text{Fe}^+\text{D}-\text{CO}$                     | $53 \pm 13$                    | 1    | $(\text{CO})_4\text{Ni}^+-\text{H}$                                              | $248 \pm 9$                    | 1    |
| $\text{Fe}^+-\text{CO}_2$                           | $74.3 \pm 7.7$                 | 1    | $(\eta^5\text{-C}_5\text{H}_5)(\text{NO})\text{Ni}^+-\text{H}$                   | $315 \pm 14$                   | 1    |
| $\text{Fe}^+-\text{H}_2\text{O}$                    | $128.9 \pm 0.8$                | 1    | $(\eta^5\text{-C}_5\text{H}_5)(\eta^5\text{-C}_5\text{H}_5)\text{Ni}^+-\text{H}$ | $215 \pm 13$                   | 1    |

| Bond                                           | $Do^{\circ}_{98}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                            | $Do^{\circ}_{98}/\text{kJ mol}^{-1}$ | Ref. |
|------------------------------------------------|--------------------------------------|------|-----------------------------------------------------------------|--------------------------------------|------|
| Ni <sup>+</sup> -H <sub>2</sub>                | 72.4 ± 1.3                           | 1    | Ag <sup>+</sup> -O <sub>2</sub>                                 | 29.7 ± 0.8                           | 1    |
| Ni <sup>+</sup> -CH                            | 301.0 ± 11.6                         | 1    | Ag <sup>+</sup> -CO                                             | 89 ± 5                               | 1    |
| Ni <sup>+</sup> -CH <sub>2</sub>               | 306 ± 4                              | 1    | Ag <sup>+</sup> -H <sub>2</sub> O                               | 134 ± 8                              | 1    |
| Ni <sup>+</sup> -CH <sub>3</sub>               | 169.8 ± 6.8                          | 1    | Ag <sup>+</sup> -CS                                             | 152 ± 20                             | 1    |
| Ni <sup>+</sup> -CH <sub>4</sub>               | 96.5 ± 4                             | 1    | Ag <sup>+</sup> -NH <sub>3</sub>                                | 170 ± 13                             | 1    |
| Ni <sup>+</sup> -OH                            | 235 ± 19                             | 1    | Au <sup>+</sup> -CH <sub>2</sub>                                | 357.0 ± 6.8                          | 5    |
| Ni <sup>+</sup> -CO                            | 175 ± 11                             | 1    | Au <sup>+</sup> -CH <sub>3</sub>                                | 209.4 ± 23.2                         | 5    |
| Ni <sup>+</sup> -CO <sub>2</sub>               | 104 ± 1                              | 1    | Au <sup>+</sup> -C <sub>2</sub> H <sub>4</sub>                  | 344.5                                | 1    |
| Ni <sup>+</sup> -H <sub>2</sub> O              | 183.7 ± 3.3                          | 1    | Au <sup>+</sup> -C <sub>6</sub> H <sub>6</sub>                  | 289 ± 29                             | 1    |
| Ni <sup>+</sup> -CS                            | 234.5 ± 9.6                          | 1    | Au <sup>+</sup> -CO                                             | 201 ± 8                              | 1    |
| Ni <sup>+</sup> -N <sub>2</sub>                | 110.9 ± 10.5                         | 1    | Au <sup>+</sup> -H <sub>2</sub> O                               | 164.0 ± 9.6                          | 1    |
| Ni <sup>+</sup> -NO                            | 227.6 ± 7.5                          | 1    | Au <sup>+</sup> -H <sub>2</sub> S                               | 230 ± 25                             | 1    |
| Ni <sup>+</sup> -NH <sub>2</sub>               | 232.5 ± 7.7                          | 1    | Au <sup>+</sup> -NH <sub>3</sub>                                | 297 ± 29                             | 1    |
| Ni <sup>+</sup> -NH <sub>3</sub>               | 238 ± 19                             | 1    | Au <sup>+</sup> -PH <sub>3</sub>                                | 402 ± 33                             | 1    |
| Pd <sup>+</sup> -CH                            | 536 ± 10                             | 1    | (12) Group 12                                                   |                                      |      |
| Pd <sup>+</sup> -CH <sub>2</sub>               | 463 ± 3                              | 1    | Zn <sup>+</sup> -H <sub>2</sub>                                 | 15.7 ± 1.7                           | 1    |
| Pd <sup>+</sup> -CH <sub>3</sub>               | 258 ± 8                              | 1    | Zn <sup>+</sup> -CH <sub>3</sub>                                | 280 ± 7                              | 1    |
| Pd <sup>+</sup> -CH <sub>4</sub>               | 170.8 ± 7.7                          | 1    | Zn <sup>+</sup> -OH                                             | 127.2                                | 1    |
| Pd <sup>+</sup> -CS                            | 200 ± 14                             | 1    | Zn <sup>+</sup> -H <sub>2</sub> O                               | 163                                  | 1    |
| Pd <sup>+</sup> -C <sub>2</sub> H <sub>2</sub> | >28.9 ± 4.8                          | 1    | Zn <sup>+</sup> -NO                                             | 76.2 ± 9.6                           | 1    |
| Pt <sup>+</sup> -H <sub>2</sub>                | 146.7 ± 11.6                         | 1    | Zn <sup>+</sup> -pyrimidine                                     | 209.6 ± 7.7                          | 1    |
| Pt <sup>+</sup> -CH                            | 536.4 ± 9.6                          | 1    | Zn <sup>+</sup> -CS                                             | 149 ± 23                             | 1    |
| Pt <sup>+</sup> -CH <sub>2</sub>               | 471                                  | 1    | Cd <sup>+</sup> -CH <sub>3</sub>                                | 228 ± 3                              | 1    |
| Pt <sup>+</sup> -CH <sub>3</sub>               | 257.6 ± 7.7                          | 1    | Cd <sup>+</sup> (CH <sub>3</sub> )-CH <sub>3</sub>              | 109 ± 3                              | 1    |
| Pt <sup>+</sup> -CH <sub>4</sub>               | 170.8 ± 7.7                          | 1    | Cd <sup>+</sup> -C <sub>6</sub> H <sub>6</sub>                  | 136 ± 19                             | 1    |
| Pt <sup>+</sup> -O <sub>2</sub>                | 64.6 ± 4.8                           | 1    | Hg <sup>+</sup> -CH <sub>3</sub>                                | 285 ± 3                              | 1    |
| Pt <sup>+</sup> -CO                            | 218.1 ± 8.7                          | 1    | Hg <sup>+</sup> (CH <sub>3</sub> )-CH <sub>3</sub>              | 96 ± 3                               | 1    |
| Pt <sup>+</sup> -CO <sub>2</sub>               | 59.8 ± 4.8                           | 1    | (13) Group 13                                                   |                                      |      |
| Pt <sup>+</sup> -NH <sub>3</sub>               | 274 ± 12                             | 1    | B <sup>+</sup> -H <sub>2</sub>                                  | 15.9 ± 0.8                           | 1    |
| Pt <sup>+</sup> -C <sub>2</sub> H <sub>4</sub> | 229.7                                | 1    | HB <sup>+</sup> -H <sub>2</sub>                                 | 61.5 ± 2.1                           | 1    |
| (11) Group 11                                  |                                      |      | (CH <sub>3</sub> ) <sub>2</sub> B <sup>+</sup> -CH <sub>3</sub> | 32.6 ± 4.2                           | 1    |
| Cu <sup>+</sup> -H <sub>2</sub>                | 51.9 ± 0.4                           | 1    | Al <sup>+</sup> -H <sub>2</sub>                                 | 5.6 ± 0.6                            | 1    |
| Cu <sup>+</sup> -CH <sub>2</sub>               | 267.3 ± 6.8                          | 1    | Al <sup>+</sup> -N <sub>2</sub>                                 | 5.6                                  | 1    |
| Cu <sup>+</sup> -CH <sub>3</sub>               | 111 ± 7                              | 1    | Al <sup>+</sup> -CO <sub>2</sub>                                | ≥29.3                                | 1    |
| Cu <sup>+</sup> -C <sub>2</sub> H <sub>2</sub> | >21.2 ± 9.6                          | 1    | Al <sup>+</sup> -H <sub>2</sub> O                               | 104 ± 15                             | 1    |
| Cu <sup>+</sup> -C <sub>2</sub> H <sub>4</sub> | 176 ± 14                             | 1    | Al <sup>+</sup> -MeOH                                           | 139.7                                | 1    |
| Cu <sup>+</sup> -C <sub>6</sub> H <sub>6</sub> | 218.0 ± 9.6                          | 1    | Al <sup>+</sup> -EtC(O)Et                                       | 191.2                                | 1    |
| Cu <sup>+</sup> -CO                            | 149 ± 7                              | 1    | Al <sup>+</sup> -C <sub>6</sub> H <sub>6</sub>                  | 147.3 ± 8.4                          | 1    |
| Cu <sup>+</sup> -N <sub>2</sub>                | 89 ± 30                              | 1    | Al <sup>+</sup> -pyridine                                       | 190.3 ± 10.3                         | 1    |
| Cu <sup>+</sup> -NO                            | 109.0 ± 4.8                          | 1    | Al <sup>+</sup> -phenol                                         | 154.8 ± 16.7                         | 1    |
| Cu <sup>+</sup> -H <sub>2</sub> O              | 160.7 ± 7.5                          | 1    | Al <sup>+</sup> -imidazole                                      | 232.4 ± 8.2                          | 1    |
| Cu <sup>+</sup> -NH <sub>2</sub>               | 192 ± 13                             | 1    | Ga <sup>+</sup> -NH <sub>3</sub>                                | 122.5                                | 1    |
| Cu <sup>+</sup> -NH <sub>3</sub>               | 237 ± 15                             | 1    | In <sup>+</sup> -NH <sub>3</sub>                                | 111.0                                | 1    |
| Cu <sup>+</sup> -CS                            | 238.3 ± 11.6                         | 1    | (14) Group 14                                                   |                                      |      |
| Cu <sup>+</sup> -SiH                           | 246 ± 27                             | 1    | C <sub>58</sub> <sup>+</sup> -C <sub>2</sub>                    | 955 ± 15                             | 1    |
| Cu <sup>+</sup> -SiH <sub>2</sub>              | ≥231 ± 7                             | 1    | C <sub>60</sub> <sup>+</sup> -C <sub>2</sub>                    | 822.0 ± 12.5                         | 1    |
| Cu <sup>+</sup> -SiH <sub>3</sub>              | 97 ± 25                              | 1    | C <sub>62</sub> <sup>+</sup> -C <sub>2</sub>                    | 846.2 ± 10.6                         | 1    |
| Ag <sup>+</sup> -CH <sub>2</sub>               | ≥107 ± 4                             | 1    | C <sub>78</sub> <sup>+</sup> -C <sub>2</sub>                    | 938.8 ± 10.6                         | 1    |
| Ag <sup>+</sup> -CH <sub>3</sub>               | 66.6 ± 4.8                           | 1    | HC <sub>2</sub> <sup>+</sup> -H                                 | 574.749                              | 1    |
| Ag <sup>+</sup> -C <sub>2</sub> H <sub>5</sub> | 65.7 ± 7.5                           | 1    | C <sub>6</sub> H <sub>5</sub> <sup>+</sup> -H                   | 376.3 ± 4.8                          | 1    |
| Ag <sup>+</sup> -C <sub>6</sub> H <sub>6</sub> | 167 ± 19                             | 1    |                                                                 |                                      |      |

| Bond                                                                   | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                          | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. |
|------------------------------------------------------------------------|--------------------------------|------|---------------------------------------------------------------|--------------------------------|------|
| $\text{C}_2\text{H}_3^+-\text{Cl}$                                     | $249 \pm 1.0$                  | 7    | $\text{C}_6\text{F}_6^+-\text{C}_6\text{F}_6$                 | $30.1 \pm 4$                   | 1    |
| $\text{C}_2\text{H}_5^+-\text{Br}$                                     | $206.3 \pm 1.0$                | 7    | $\text{C}_{60}^+-\text{C}_{60}$                               | $35.89 \pm 7.72$               | 1    |
| $\text{C}_6\text{H}_5^+-\text{Br}$                                     | 266.3                          | 1    | $\text{PhSiH}_2^+-\text{H}$                                   | 159                            | 1    |
| $\text{C}_2\text{H}_3^+-\text{I}$                                      | $196.2 \pm 1.4$                | 7    | $\text{Si}^+(\text{CH}_3)_3-\text{Cl}$                        | $178.5 \pm 1.9$                | 1    |
| $\text{CH}_3^+-\text{H}_2$                                             | 186                            | 1    | $\text{SiH}_3^+-\text{CO}$                                    | $\geq 151$                     | 1    |
| $\text{CH}_5^+-\text{H}_2$                                             | $7.9 \pm 0.4$                  | 1    | $\text{SiF}_3^+-\text{CO}$                                    | $174.1 \pm 1.3$                | 1    |
| $\text{C}_2\text{H}_5^+-\text{H}_2$                                    | 17                             | 1    | $(\text{CH}_3)_3\text{Si}^+-\text{H}_2\text{O}$               | $125.9 \pm 7.9$                | 1    |
| $\text{CH}_3^+-\text{O}_2$                                             | $80 \pm 7$                     | 4    | $(\text{CH}_3)_3\text{Si}^+-\text{NH}_3$                      | 194.6                          | 1    |
| $\text{CO}^+-\text{N}_2$                                               | $67.5 \pm 19.3$                | 1    | $\text{Si}^+(\text{CH}_3)(\text{Cl})_2-\text{CH}_3$           | $60.8 \pm 2.9$                 | 1    |
| $\text{H}_2\text{CH}^+-\text{N}_2$                                     | 31.8                           | 1    | $\text{Si}^+(\text{CH}_3)_2(\text{Cl})-\text{CH}_3$           | $41.5 \pm 1.9$                 | 1    |
| $\text{CO}^+-\text{CO}$                                                | $173.7 \pm 14.6$               | 1    | $\text{Si}^+-\text{CH}_3$                                     | $413.9 \pm 5.8$                | 1    |
| $\text{CO}^+(\text{CO})-\text{CO}$                                     | 52.3                           | 1    | $\text{Si}^+(\text{CH}_3)-\text{CH}_3$                        | $123 \pm 48$                   | 1    |
| $\text{CO}^+(\text{CO})_2-\text{CO}$                                   | 30.2                           | 1    | $\text{Si}^+(\text{CH}_3)_2-\text{CH}_3$                      | $513 \pm 27$                   | 1    |
| $\text{CO}^+(\text{CO})_3-\text{CO}$                                   | 18.4                           | 1    | $\text{Si}^+(\text{CH}_3)_3-\text{CH}_3$                      | $66.6 \pm 5.8$                 | 1    |
| $(\text{CO}_2)^+-\text{CO}_2$                                          | 70.3                           | 1    | $(\text{CH}_3)_3\text{Si}^+-\text{CH}_3\text{OH}$             | 164.0                          | 1    |
| $(\text{CO}_2)^+(\text{CO}_2)-\text{CO}_2$                             | 34.7                           | 1    | $(\text{CH}_3)_3\text{Si}^+-(\text{C}_2\text{H}_5)_2\text{O}$ | 184.9                          | 1    |
| $(\text{CO}_2)^+(\text{CO}_2)_2-\text{CO}_2$                           | 21.3                           | 1    | $(\text{CH}_3)_3\text{Si}^+-\text{C}_6\text{H}_6$             | 100.0                          | 1    |
| $(\text{CO}_2)^+(\text{CO}_2)_3-\text{CO}_2$                           | $20.1 \pm 1.3$                 | 1    | $(\text{CH}_3)_3\text{Si}^+-\text{CH}_3\text{NH}_2$           | 231.8                          | 1    |
| $\text{CH}_3^+-\text{N}_2\text{O}$                                     | 221.3                          | 1    | $(\text{CH}_3)_3\text{Ge}^+-\text{H}_2\text{O}$               | $119.7 \pm 2.1$                | 1    |
| $\text{CH}_3^+-\text{SO}_2$                                            | 253.6                          | 1    | $(\text{C}_2\text{H}_5)_3\text{Ge}^+-\text{H}_2\text{O}$      | $104.2 \pm 2.1$                | 1    |
| $\text{CH}_3^+-\text{OCS}$                                             | 239.3                          | 1    | $(\text{CH}_3)_3\text{Sn}^+-\text{NH}_3$                      | 154                            | 1    |
| $\text{CH}_3^+-\text{CS}_2$                                            | 251.9                          | 1    | $(\text{CH}_3)_3\text{Sn}^+-\text{H}_2\text{O}$               | 108                            | 1    |
| $\text{CH}_3^+-\text{H}_2\text{O}$                                     | 279                            | 1    | $(\text{CH}_3)_3\text{Sn}^+-\text{CH}_3)_2\text{CO}$          | 157                            | 1    |
| $\text{CH}_3^+(\text{H}_2\text{O})-\text{H}_2\text{O}$                 | 106.3                          | 1    | $(\text{CH}_3)_3\text{Sn}^+-\text{C}_3\text{H}_7\text{SH}$    | 143                            | 1    |
| $\text{CH}_3^+(\text{H}_2\text{O})_2-\text{H}_2\text{O}$               | 87.9                           | 1    | $\text{Pb}^+-\text{H}_2\text{O}$                              | 93.7                           | 1    |
| $\text{CH}_3^+(\text{H}_2\text{O})_3-\text{H}_2\text{O}$               | 61.9                           | 1    | $\text{Pb}^+-\text{NH}_3$                                     | $118.4 \pm 0.8$                | 1    |
| $\text{CH}_3^+(\text{H}_2\text{O})_4-\text{H}_2\text{O}$               | 48.5                           | 1    | $\text{Pb}^+-\text{CH}_3\text{OH}$                            | $97.5 \pm 0.8$                 | 1    |
| $\text{CH}_3^+-\text{H}_2\text{S}$                                     | 344.8                          | 1    | $\text{Pb}^+-\text{CH}_3\text{NH}_2$                          | $148.1 \pm 1.3$                | 1    |
| $\text{CH}_2^+-\text{CH}_2\text{O}$                                    | $303.0 \pm 2.9$                | 1    | $\text{Pb}^+-\text{C}_6\text{H}_6$                            | $110 \pm 2$                    | 1    |
| $\text{CH}_3^+-\text{NH}_3$                                            | 431.4                          | 1    |                                                               |                                |      |
| $(\text{CH}_3)^+-\text{CH}_3$                                          | $209.2 \pm 4.2$                | 1    | <b>(15) Group 15</b>                                          |                                |      |
| $\text{CH}_3^+-\text{CH}_4$                                            | 166.5                          | 1    | $\text{H}_2\text{N}^+-\text{H}$                               | $544.43 \pm 0.10$              | 1    |
| $\text{CF}_3^+-\text{CH}_4$                                            | 19.0                           | 1    | $\text{H}_3\text{N}^+-\text{H}$                               | 515.1                          | 1    |
| $(\text{CH}_5)^+-\text{CH}_4$                                          | $28.7 \pm 1.3$                 | 1    | $\text{Me}_3\text{N}^+-\text{H}$                              | 376                            | 1    |
| $\text{C}_6\text{H}_6^+-\text{CH}_4$                                   | 12.0                           | 1    | $\text{Et}_3\text{N}^+-\text{H}$                              | 362                            | 1    |
| $\text{CH}_3^+-\text{CH}_3\text{F}$                                    | 230                            | 1    | $(\text{imidazole})^+-\text{Zn}$                              | $216.1 \pm 3.9$                | 1    |
| $\text{CH}_3^+-\text{CF}_3\text{Cl}$                                   | 221                            | 1    | $\text{N}_2\text{H}^+-\text{H}_2$                             | $24.7 \pm 0.8$                 | 1    |
| $\text{CH}_3^+-\text{CH}_3\text{Cl}$                                   | 259                            | 1    | $\text{ON}^+-\text{O}_2$                                      | 14.2                           | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{CH}_3\text{OH}$            | 63                             | 1    | $\text{N}^+-\text{N}_2$                                       | 303.8                          | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{CH}_3\text{CN}$            | 85                             | 1    | $\text{ON}^+-\text{N}_2$                                      | 21.3                           | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{SO}_2\text{F}_2$           | 43.5                           | 1    | $\text{N}_2^+-\text{N}_2$                                     | $102.3 \pm 14.6$               | 1    |
| $\text{CH}_3^+-\text{C}_2\text{H}_3\text{O}$                           | $338.7 \pm 2.9$                | 1    | $\text{HN}_2^+-\text{N}_2$                                    | 60.7                           | 1    |
| $\text{CH}_3^+-\text{CF}_3\text{ClOCl}$                                | 252                            | 1    | $\text{N}_3^+-\text{N}_2$                                     | $18.8 \pm 1.3$                 | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{CH}_3)_2\text{S}$          | 185                            | 1    | $\text{O}_2\text{N}^+-\text{N}_2$                             | $19.2 \pm 1.3$                 | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{C}_2\text{H}_5\text{OH}$   | 85                             | 1    | $\text{H}_4\text{N}^+-\text{N}_2$                             | $54 \pm 21$                    | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{C}_3\text{H}_8$            | 27.6                           | 1    | $\text{ON}^+-\text{NO}$                                       | $59.4 \pm 0.8$                 | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{t-C}_4\text{H}_9\text{Cl}$ | 339                            | 1    | $\text{ON}^+-\text{CO}$                                       | $27.2 \pm 1.3$                 | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{CH}_3)_3\text{CH}$         | 30.1                           | 1    | $\text{ON}^+-\text{O}_3$                                      | <58                            | 1    |
| <i>tert</i> - $\text{C}_4\text{H}_9^+-\text{C}_6\text{H}_6$            | 92                             | 1    | $\text{ON}^+-\text{CO}_2$                                     | 32.2                           | 1    |
| $(\text{C}_6\text{H}_6)^+-\text{C}_6\text{H}_6$                        | 73.6                           | 1    | $\text{N}_2\text{O}^+-\text{ON}_2$                            | $72.8 \pm 6.3$                 | 1    |
| $(\text{C}_6\text{H}_6)^+-text{indole}$                                | 54.8                           | 1    | $\text{NO}^+-\text{ON}_2$                                     | $36.4 \pm 0.8$                 | 1    |
|                                                                        |                                |      | $(\text{HON}_2)^+-\text{ON}_2$                                | $69.9 \pm 4$                   | 1    |



| Bond                                                            | $Do^{\circ}_{98}/\text{kJ mol}^{-1}$ | Ref. | Bond                                                                            | $Do^{\circ}_{98}/\text{kJ mol}^{-1}$ | Ref. |
|-----------------------------------------------------------------|--------------------------------------|------|---------------------------------------------------------------------------------|--------------------------------------|------|
| $\text{ON}^+-\text{H}_2\text{O}$                                | 95                                   | 1    | $(\text{H}_3\text{O})^+-\text{CO}_2$                                            | 64.0                                 | 1    |
| $\text{ON}^+(\text{H}_2\text{O})-\text{H}_2\text{O}$            | 67.4                                 | 1    | $(\text{H}_3\text{O})^+(\text{CO}_2)-\text{CO}_2$                               | 51.9                                 | 1    |
| $\text{ON}^+(\text{H}_2\text{O})_2-\text{H}_2\text{O}$          | 56.5                                 | 1    | $(\text{H}_3\text{O})^+(\text{CO}_2)_2-\text{CO}_2$                             | 43.9                                 | 1    |
| $\text{H}_4\text{N}^+-\text{H}_2\text{O}$                       | $86.2 \pm 4.2$                       | 1    | $(\text{H}_3\text{O})^+(\text{CO}_2)_3-\text{CO}_2$                             | 18.0                                 | 1    |
| $\text{H}_4\text{N}^+(\text{H}_2\text{O})-\text{H}_2\text{O}$   | $72.8 \pm 4.2$                       | 1    | $\text{O}_2^+-\text{ON}_2$                                                      | $56.1 \pm 4$                         | 1    |
| $\text{H}_4\text{N}^+(\text{H}_2\text{O})_2-\text{H}_2\text{O}$ | $57.3 \pm 4.2$                       | 1    | $(\text{H}_3\text{O})^+-\text{ON}_2$                                            | $70.7 \pm 6.5$                       | 1    |
| $\text{H}_4\text{N}^+(\text{H}_2\text{O})_3-\text{H}_2\text{O}$ | 51.0                                 | 1    | $(\text{H}_3\text{O})^+(\text{H}_2\text{O})-\text{ON}_2$                        | $50.6 \pm 2.1$                       | 1    |
| $\text{H}_4\text{N}^+(\text{H}_2\text{O})_4-\text{H}_2\text{O}$ | 44.4                                 | 1    | $(\text{H}_3\text{O})^+(\text{H}_2\text{O})_2-\text{ON}_2$                      | $42.7 \pm 2.1$                       | 1    |
| $(\text{glycine})\text{H}^+-\text{H}_2\text{O}$                 | $77.2 \pm 11.0$                      | 1    | $\text{O}_3^+-\text{O}_3$                                                       | $67.5 \pm 39$                        | 1    |
| $(\text{tryptophan})\text{H}^+-\text{H}_2\text{O}$              | $31.2 \pm 2.5$                       | 1    | $\text{OCIO}^+-\text{OCIO}$                                                     | $246 \pm 48$                         | 1    |
| $(\text{tryptophanylglycine})\text{H}^+-\text{H}_2\text{O}$     | $56.0 \pm 5.3$                       | 1    | $\text{O}_2^+-\text{H}_2\text{O}$                                               | >67                                  | 1    |
| $\text{H}_4\text{N}^+-\text{H}_2\text{S}$                       | 47.7                                 | 1    | $(\text{OH})^+(\text{H}_2\text{O})_2-\text{H}_2\text{O}$                        | 87.4                                 | 1    |
| $\text{H}^+(\text{NH}_3)-\text{NH}_3$                           | 108.8                                | 1    | $(\text{OH})^+(\text{H}_2\text{SO}_4)(\text{H}_2\text{O})_4-\text{H}_2\text{O}$ | 56.9                                 | 1    |
| $\text{H}^+(\text{NH}_3)_2-\text{NH}_3$                         | 69.5                                 | 1    | $(\text{OH})^+(\text{H}_2\text{SO}_4)(\text{H}_2\text{O})_5-\text{H}_2\text{O}$ | 49.8                                 | 1    |
| $\text{H}^+(\text{NH}_3)_3-\text{NH}_3$                         | 57.3                                 | 1    | $(\text{OH})^+(\text{H}_2\text{SO}_4)(\text{H}_2\text{O})_6-\text{H}_2\text{O}$ | 44.8                                 | 1    |
| $\text{H}^+(\text{NH}_3)_4-\text{NH}_3$                         | 49.0                                 | 1    | $(\text{H}_2\text{O})^+-\text{H}_2\text{O}$                                     | 164.0                                | 1    |
| $\text{H}^+(\text{NH}_3)_5-\text{NH}_3$                         | 29.3                                 | 1    | $(\text{H}_3\text{O})^+-\text{H}_2\text{O}$                                     | 140.2                                | 1    |
| $\text{H}^+(\text{NH}_3)_6-\text{NH}_3$                         | 27.2                                 | 1    | $(\text{H}_3\text{O})^+(\text{H}_2\text{O})-\text{H}_2\text{O}$                 | 93.3                                 | 1    |
| $\text{NH}_4^+-\text{CH}_4$                                     | 15.0                                 | 1    | $(\text{H}_3\text{O})^+(\text{H}_2\text{O})_2-\text{H}_2\text{O}$               | 71.1                                 | 1    |
| $\text{ON}^+-\text{CH}_3\text{OH}$                              | 97.6                                 | 1    | $(\text{H}_3\text{O})^+(\text{H}_2\text{O})_3-\text{H}_2\text{O}$               | 64.0                                 | 1    |
| $\text{O}_2\text{N}^+-\text{CH}_3\text{OH}$                     | $80.3 \pm 9.6$                       | 1    | $(\text{H}_3\text{O})^+(\text{H}_2\text{O})_4-\text{H}_2\text{O}$               | 54.4                                 | 1    |
| $(\text{CH}_3\text{CNH})^+-\text{CH}_3\text{CN}$                | $130.1 \pm 9.6$                      | 1    | $(\text{H}_3\text{O})^+(\text{H}_2\text{O})_5-\text{H}_2\text{O}$               | 49.0                                 | 1    |
| $(\text{pyridineH})^+-\text{pyridine}$                          | $105.4 \pm 4$                        | 1    | $(\text{H}_3\text{O})^+(\text{H}_2\text{O})_6-\text{H}_2\text{O}$               | 43.1                                 | 1    |
| $(\text{valine H})^+-\text{valine}$                             | $86.6 \pm 8.4$                       | 1    | $(\text{HCOOH})\text{H}^+-\text{H}_2\text{O}$                                   | 100.8                                | 1    |
| $(\text{betainH})^+-\text{betaine}$                             | $139.9 \pm 4.8$                      | 1    | $\text{CH}_3\text{OH}_2^+-\text{H}_2\text{O}$                                   | 115.6                                | 1    |
| $\text{H}_4\text{P}^+-\text{H}_2\text{O}$                       | 54.4                                 | 1    | $\text{CH}_3\text{CHOH}^+-\text{H}_2\text{O}$                                   | 104.6                                | 1    |
| $(\text{H}_4\text{P})^+-\text{PH}_3$                            | 48.1                                 | 1    | $(\text{CH}_3)_2\text{OH}^+-\text{H}_2\text{O}$                                 | 100.4                                | 1    |
| $\text{AsH}_2^+-\text{H}$                                       | 257                                  | 1    | $(\text{tetrahydrofuranH})^+-\text{H}_2\text{O}$                                | 82.8                                 | 1    |
| $\text{I}_2\text{As}^+-\text{acetone}$                          | $106 \pm 17$                         | 1    | $(\text{furanH})^+-\text{H}_2\text{O}$                                          | 43.5                                 | 1    |
| $\text{I}_2\text{As}^+-\text{benzene}$                          | $77 \pm 17$                          | 1    | $\text{furane}^+-\text{H}_2\text{O}$                                            | 41.0                                 | 1    |
| $\text{Bi}^+-\text{H}_2\text{O}$                                | 95.4                                 | 1    | $(\text{phenol})^+-\text{H}_2\text{O}$                                          | 78.0                                 | 1    |
| $\text{Bi}^+-\text{NH}_3$                                       | 149                                  | 1    | $(1\text{-naphthol})^+-\text{H}_2\text{O}$                                      | 66.4                                 | 1    |
| $\text{Bi}^+-\text{C}_6\text{H}_6$                              | $\leq 149$                           | 1    | $\text{H}_3\text{O}^+-\text{HC(O)H}$                                            | 137.7                                | 1    |
| <b>(16) Group 16</b>                                            |                                      |      | $\text{H}_3\text{O}^+-\text{NH}_3$                                              | 229.3                                | 1    |
| $(\text{H}_3\text{O})^+-\text{H}_2$                             | $14.6 \pm 2.1$                       | 1    | $\text{H}_3\text{O}^+(\text{NH}_3)-\text{NH}_3$                                 | 77.0                                 | 1    |
| $\text{O}^+-\text{O}_2$                                         | 179.5                                | 1    | $\text{H}_3\text{O}^+(\text{NH}_3)_2-\text{NH}_3$                               | 71.5                                 | 1    |
| $\text{O}^+(\text{O}_2)_1-\text{O}_2$                           | 28.9                                 | 1    | $\text{H}_3\text{O}^+(\text{NH}_3)_3-\text{NH}_3$                               | 62.8                                 | 1    |
| $\text{O}^+(\text{O}_2)_2-\text{O}_2$                           | 3.9                                  | 1    | $\text{H}_3\text{O}^+-\text{PH}_3$                                              | 144                                  | 1    |
| $\text{O}_2^+-\text{O}_2$                                       | $38.3 \pm 2.1$                       | 1    | $\text{H}_3\text{O}^+-\text{SO}_3$                                              | 74                                   | 1    |
| $\text{O}_2^+(\text{O}_2)-\text{O}_2$                           | $24.6 \pm 1.3$                       | 1    | $(\text{HCOOH})^+-\text{HCOOH}$                                                 | $96.5 \pm 9.6$                       | 1    |
| $\text{O}_2^+(\text{O}_2)_2-\text{O}_2$                         | $10.4 \pm 0.8$                       | 1    | $\text{H}_3\text{O}^+-\text{CH}_4$                                              | 33.5                                 | 1    |
| $\text{O}_2^+(\text{O}_2)_3-\text{O}_2$                         | $9.0 \pm 0.8$                        | 1    | $(\text{CH}_3\text{OH})^+-\text{CH}_3\text{OH}$                                 | $115.8 \pm 19.3$                     | 1    |
| $\text{O}_2^+(\text{O}_2)_4-\text{O}_2$                         | $8.0 \pm 0.8$                        | 1    | $\text{CH}_3\text{OH}_2^+-\text{CH}_3\text{OH}$                                 | 136.4                                | 1    |
| $\text{O}_2^+(\text{O}_2)_5-\text{O}_2$                         | $7.9 \pm 1.3$                        | 1    | $\text{H}_3\text{O}^+-\text{CH}_3\text{CN}$                                     | 195.4                                | 1    |
| $\text{O}^+-\text{N}_2$                                         | 231.4                                | 1    | $\text{furan}^+-\text{furan}$                                                   | 94.1                                 | 1    |
| $\text{O}_2^+-\text{N}_2$                                       | 22.6                                 | 1    | $\text{BH}^+-\text{B}$ , B = tetrahydrofuran                                    | 125.1                                | 1    |
| $(\text{H}_3\text{O})^+-\text{N}_2$                             | $22.2 \pm 2.1$                       | 1    | $\text{S}^+-\text{CS}_2$                                                        | 166                                  | 1    |
| $\text{O}_4^+-\text{N}_2$                                       | 12.3                                 | 1    | $\text{CS}^+-\text{CS}_2$                                                       | 150.6                                | 1    |
| $\text{O}_2^+-\text{CO}$                                        | 31.8                                 | 1    | $\text{CS}_2^+-\text{CS}_2$                                                     | 104.2                                | 1    |
| $\text{O}_2^+-\text{CO}_2$                                      | $41.0 \pm 2.1$                       | 1    | $\text{HCS}_2^+-\text{CS}_2$                                                    | 46.4                                 | 1    |
| $\text{CO}_2^+-\text{CO}_2$                                     | $65.3 \pm 4$                         | 1    | $\text{OS}^+-\text{SO}_2$                                                       | 57.7                                 | 1    |

| Bond                                                     | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. | Bond                                             | $Do^2_{98}/\text{kJ mol}^{-1}$ | Ref. |
|----------------------------------------------------------|--------------------------------|------|--------------------------------------------------|--------------------------------|------|
| $\text{O}_2\text{S}^+-\text{SO}_2$                       | 63.6                           | 1    | $\text{He}^+(\text{He})_2-\text{He}$             | $2.7 \pm 0.6$                  | 1    |
| $\text{OCS}^+-\text{OCS}$                                | 100.0                          | 1    | $\text{Ne}^+(\text{Ne})-\text{Ne}$               | $10.3 \pm 0.6$                 | 1    |
| $\text{OCS}^+-\text{CO}_2$                               | 72.0                           | 1    | $\text{Ne}^+(\text{Ne})_2-\text{Ne}$             | $3.3 \pm 0.6$                  | 1    |
| $\text{SO}_2^+-\text{CO}_2$                              | 42.7                           | 1    | $\text{Ar}^+(\text{Ar})-\text{Ar}$               | $20.4 \pm 0.6$                 | 1    |
| $\text{H}_3\text{S}^+-\text{H}_2\text{O}$                | 91.6                           | 1    | $\text{Ar}^+(\text{Ar})_2-\text{Ar}$             | $7.0 \pm 0.6$                  | 1    |
| <b>thiophene</b> $\text{H}^+-\text{H}_2\text{O}$         | 42.7                           | 1    | $\text{Ar}^+(\text{N}_2)-\text{Ar}$              | 25.1                           | 1    |
| $\text{H}_3\text{S}^+-\text{H}_2\text{S}$                | $53.6 \pm 6.3$                 | 1    | $\text{Ar}^+(\text{N}_2)(\text{Ar})-\text{Ar}$   | 7.1                            | 1    |
| $\text{H}_3\text{S}^+-\text{CH}_4$                       | 16.3                           | 1    | $\text{Ar}^+(\text{N}_2)(\text{Ar})_2-\text{Ar}$ | 7.1                            | 1    |
| $(\text{CH}_3)_2\text{Se}^{++}-\text{Se}(\text{CH}_3)_2$ | $\sim 95 \pm 3$                | 1    | $\text{Kr}^+(\text{Kr})-\text{Kr}$               | $23.3 \pm 0.6$                 | 1    |
| $(\text{CH}_3)_2\text{Te}^{++}-\text{Te}(\text{CH}_3)_2$ | $97 \pm 2$                     | 1    | $\text{Kr}^+(\text{Kr})_2-\text{Kr}$             | $9.0 \pm 0.6$                  | 1    |
| <b>(17) Group 17</b>                                     |                                |      | $\text{Xe}^+(\text{Xe})-\text{Xe}$               | $25.2 \pm 0.6$                 | 1    |
| $\text{HF}^+-\text{HF}$                                  | $\geq 138$                     | 1    | $\text{Xe}^+(\text{Xe})_2-\text{Xe}$             | $11.0 \pm 0.6$                 | 1    |
| $(\text{H}_2\text{Cl})^+-\text{Cl}$                      | 39.6                           | 1    | $\text{Ar}^+-\text{H}_2$                         | 93.7                           | 1    |
| $\text{HCl}^+-\text{HCl}$                                | 83.9                           | 1    | $\text{Ar}^+-\text{N}_2$                         | 127.6                          | 1    |
| $\text{Cl}^+-\text{CCl}_3$                               | $446.7 \pm 9.6$                | 1    | $\text{Ar}^+(\text{N}_2)-\text{N}_2$             | 31.0                           | 1    |
| $\text{Cl}^+-\text{C}_2\text{H}_3$                       | $685.0 \pm 4.8$                | 1    | $\text{Ar}^+(\text{N}_2)_2-\text{N}_2$           | 10.9                           | 1    |
| $\text{HBr}^+-\text{HBr}$                                | 96                             | 1    | $\text{Ar}^+-\text{CO}$                          | $75 \pm 17$                    | 1    |
| $\text{I}^+-\text{CH}_3$                                 | 330.0                          | 1    | $\text{Ar}^+(\text{CO})-\text{CO}$               | 13                             | 1    |
| $\text{I}^+(\text{CH}_3\text{I})-\text{CH}_3$            | 51.1                           | 1    | $\text{Kr}^+-\text{CO}$                          | $103.3 \pm 7.5$                | 1    |
| $\text{I}^+(\text{CH}_3\text{I})_2-\text{CH}_3$          | 112.9                          | 1    | $\text{Kr}^+-\text{CO}_2$                        | $79.1 \pm 2.9$                 | 1    |
| <b>(18) Group 18</b>                                     |                                |      |                                                  |                                |      |
| $\text{He}^+(\text{He})_1-\text{He}$                     | 17.6                           | 1    |                                                  |                                |      |

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## ELECTRONEGATIVITY

Electronegativity is a parameter originally introduced by Pauling which describes, on a relative basis, the tendency of an atom in a molecule to attract bonding electrons. While electronegativity is not a precisely defined molecular property, the electronegativity difference between two atoms provides a useful measure of the polarity and ionic character of the bond between them. This table gives the electronegativity  $X$ , on the Pauling scale, for the most common oxidation state. Other scales are described in the references.

## References

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| $Z$ | Symbol | $X$  | $Z$ | Symbol | $X$  | $Z$ | Symbol | $X$  |
|-----|--------|------|-----|--------|------|-----|--------|------|
| 1   | H      | 2.20 | 33  | As     | 2.18 | 65  | Tb     | —    |
| 2   | He     | —    | 34  | Se     | 2.55 | 66  | Dy     | 1.22 |
| 3   | Li     | 0.98 | 35  | Br     | 2.96 | 67  | Ho     | 1.23 |
| 4   | Be     | 1.57 | 36  | Kr     | —    | 68  | Er     | 1.24 |
| 5   | B      | 2.04 | 37  | Rb     | 0.82 | 69  | Tm     | 1.25 |
| 6   | C      | 2.55 | 38  | Sr     | 0.95 | 70  | Yb     | —    |
| 7   | N      | 3.04 | 39  | Y      | 1.22 | 71  | Lu     | 1.0  |
| 8   | O      | 3.44 | 40  | Zr     | 1.33 | 72  | Hf     | 1.3  |
| 9   | F      | 3.98 | 41  | Nb     | 1.6  | 73  | Ta     | 1.5  |
| 10  | Ne     | —    | 42  | Mo     | 2.16 | 74  | W      | 1.7  |
| 11  | Na     | 0.93 | 43  | Tc     | 2.10 | 75  | Re     | 1.9  |
| 12  | Mg     | 1.31 | 44  | Ru     | 2.2  | 76  | Os     | 2.2  |
| 13  | Al     | 1.61 | 45  | Rh     | 2.28 | 77  | Ir     | 2.2  |
| 14  | Si     | 1.90 | 46  | Pd     | 2.20 | 78  | Pt     | 2.2  |
| 15  | P      | 2.19 | 47  | Ag     | 1.93 | 79  | Au     | 2.4  |
| 16  | S      | 2.58 | 48  | Cd     | 1.69 | 80  | Hg     | 1.9  |
| 17  | Cl     | 3.16 | 49  | In     | 1.78 | 81  | Tl     | 1.8  |
| 18  | Ar     | —    | 50  | Sn     | 1.96 | 82  | Pb     | 1.8  |
| 19  | K      | 0.82 | 51  | Sb     | 2.05 | 83  | Bi     | 1.9  |
| 20  | Ca     | 1.00 | 52  | Te     | 2.1  | 84  | Po     | 2.0  |
| 21  | Sc     | 1.36 | 53  | I      | 2.66 | 85  | At     | 2.2  |
| 22  | Ti     | 1.54 | 54  | Xe     | 2.60 | 86  | Rn     | —    |
| 23  | V      | 1.63 | 55  | Cs     | 0.79 | 87  | Fr     | 0.7  |
| 24  | Cr     | 1.66 | 56  | Ba     | 0.89 | 88  | Ra     | 0.9  |
| 25  | Mn     | 1.55 | 57  | La     | 1.10 | 89  | Ac     | 1.1  |
| 26  | Fe     | 1.83 | 58  | Ce     | 1.12 | 90  | Th     | 1.3  |
| 27  | Co     | 1.88 | 59  | Pr     | 1.13 | 91  | Pa     | 1.5  |
| 28  | Ni     | 1.91 | 60  | Nd     | 1.14 | 92  | U      | 1.7  |
| 29  | Cu     | 1.90 | 61  | Pm     | —    | 93  | Np     | 1.3  |
| 30  | Zn     | 1.65 | 62  | Sm     | 1.17 | 94  | Pu     | 1.3  |
| 31  | Ga     | 1.81 | 63  | Eu     | —    |     |        |      |
| 32  | Ge     | 2.01 | 64  | Gd     | 1.20 |     |        |      |

## FORCE CONSTANTS FOR BOND STRETCHING

Representative force constants ( $f$ ) for stretching of chemical bonds are listed in this table. Except where noted, all force constants are derived from values of the harmonic vibrational frequencies  $\omega_e$ . Values derived from the observed vibrational fundamentals  $\nu$ , which are noted by a, are lower than the harmonic force constants, typically by 2 to 3% in the case of heavy atoms (often by 5 to 10% if one of the atoms is hydrogen). Values are given in the SI unit newton per centimeter (N/cm), which is identical to the commonly used cgs unit mdyn/Å.

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| Bond | Molecule                          | $f$ /(N/cm) | Note  | Bond  | Molecule                        | $f$ /(N/cm) | Note |
|------|-----------------------------------|-------------|-------|-------|---------------------------------|-------------|------|
| H-H  | H <sub>2</sub>                    | 5.75        |       |       | OCS                             | 7.44        |      |
| Be-H | BeH                               | 2.27        |       | C-N   | CN                              | 16.29       |      |
| B-H  | BH                                | 3.05        |       |       | HCN                             | 18.78       |      |
| C-H  | CH                                | 4.48        |       |       | CH <sub>3</sub> CN              | 18.33       |      |
|      | CH <sub>4</sub>                   | 5.44        | b     |       | CH <sub>3</sub> NH <sub>2</sub> | 5.12        | a,c  |
|      | C <sub>2</sub> H <sub>6</sub>     | 4.83        | a,b,c | C-P   | CP                              | 7.83        |      |
|      | CH <sub>3</sub> CN                | 5.33        | b     | Si-Si | Si <sub>2</sub>                 | 2.15        |      |
|      | CH <sub>3</sub> Cl                | 5.02        | a,b,c | Si-O  | SiO                             | 9.24        |      |
|      | CCl <sub>2</sub> =CH <sub>2</sub> | 5.57        | b     | Si-F  | SiF                             | 4.90        |      |
|      | HCN                               | 6.22        |       | Si-Cl | SiCl                            | 2.63        |      |
| N-H  | NH                                | 5.97        |       | N-N   | N <sub>2</sub>                  | 22.95       |      |
| O-H  | OH                                | 7.80        |       |       | N <sub>2</sub> O                | 18.72       |      |
|      | H <sub>2</sub> O                  | 8.45        |       | N-O   | NO                              | 15.95       |      |
| P-H  | PH                                | 3.22        |       |       | N <sub>2</sub> O                | 11.70       |      |
| S-H  | SH                                | 4.23        |       | P-P   | P <sub>2</sub>                  | 5.56        |      |
|      | H <sub>2</sub> S                  | 4.28        |       | P-O   | PO                              | 9.45        |      |
| F-H  | HF                                | 9.66        |       | O-O   | O <sub>2</sub>                  | 11.77       |      |
| Cl-H | HCl                               | 5.16        |       |       | O <sub>3</sub>                  | 5.74        | a    |
| Br-H | HBr                               | 4.12        |       | S-O   | SO                              | 8.30        |      |
| I-H  | HI                                | 3.14        |       |       | SO <sub>2</sub>                 | 10.33       | a    |
| Li-H | LiH                               | 1.03        |       | S-S   | S <sub>2</sub>                  | 4.96        |      |
| Na-H | NaH                               | 0.78        |       | F-F   | F <sub>2</sub>                  | 4.70        |      |
| K-H  | KH                                | 0.56        |       | Cl-F  | ClF                             | 4.48        |      |
| Rb-H | RbH                               | 0.52        |       | Br-F  | BrF                             | 4.06        |      |
| Cs-H | CsH                               | 0.47        |       | Cl-Cl | Cl <sub>2</sub>                 | 3.23        |      |
| C-C  | C <sub>2</sub>                    | 12.16       |       | Br-Cl | BrCl                            | 2.82        |      |
|      | CCl <sub>2</sub> =CH <sub>2</sub> | 8.43        |       | Br-Br | Br <sub>2</sub>                 | 2.46        |      |
|      | C <sub>2</sub> H <sub>6</sub>     | 4.50        | a,c   | I-I   | I <sub>2</sub>                  | 1.72        |      |
|      | CH <sub>3</sub> CN                | 5.16        |       | Li-Li | Li <sub>2</sub>                 | 0.26        |      |
| C-F  | CF                                | 7.42        |       | Li-Na | LiNa                            | 0.21        |      |
|      | CH <sub>3</sub> F                 | 5.71        | a,c   | Na-Na | Na <sub>2</sub>                 | 0.17        |      |
| C-Cl | CCl                               | 3.95        |       | Li-F  | LiF                             | 2.50        |      |
|      | CH <sub>3</sub> Cl                | 3.44        | a,c   | Li-Cl | LiCl                            | 1.43        |      |
|      | CCl <sub>2</sub> =CH <sub>2</sub> | 4.02        | b     | Li-Br | LiBr                            | 1.20        |      |
| C-Br | CH <sub>3</sub> Br                | 2.89        | a,c   | Li-I  | LiI                             | 0.97        |      |
| C-I  | CH <sub>3</sub> I                 | 2.34        | a,c   | Na-F  | NaF                             | 1.76        |      |
| C-O  | CO                                | 19.02       |       | Na-Cl | NaCl                            | 1.09        |      |
|      | CO <sub>2</sub>                   | 16.00       |       | Na-Br | NaBr                            | 0.94        |      |
|      | OCS                               | 16.14       |       | Na-I  | NaI                             | 0.76        |      |
|      | CH <sub>3</sub> OH                | 5.42        | a,c   | Be-O  | BeO                             | 7.51        |      |
| C-S  | CS                                | 8.49        |       | Mg-O  | MgO                             | 3.48        |      |
|      | CS <sub>2</sub>                   | 7.88        |       | Ca-O  | CaO                             | 3.61        |      |

<sup>a</sup> Derived from fundamental frequency, without anharmonicity correction.

<sup>b</sup> Average of symmetric and antisymmetric (or degenerate) modes.

<sup>c</sup> Calculated from Local Symmetry Force Field (see Reference 2).

# FUNDAMENTAL VIBRATIONAL FREQUENCIES OF SMALL MOLECULES

This table lists the fundamental vibrational frequencies of selected three-, four-, and five-atom molecules. Both stable molecules and transient free radicals are included. The data have been taken from evaluated sources. In general, the selected values are based on gas-phase infrared, Raman, or ultraviolet spectra; when these were not available, liquid-phase or matrix-isolation spectra were used.

Molecules are grouped by structural type. Within each group, related molecules appear together for convenient comparison.

The vibrational modes are described by their approximate character in terms of stretching, bending, deformation, etc. However, it should be emphasized that most such descriptions are only approximate, and that the true normal mode usually involves a mixture of motions. Abbreviations are:

|          |               |
|----------|---------------|
| sym.     | symmetric     |
| antisym. | antisymmetric |
| str.     | stretch       |
| deform.  | deformation   |
| scis.    | scissors      |
| rock.    | rocking       |
| deg.     | degenerate    |

In the case of free radicals, strong interactions may exist between the electronic and bending vibrational motions. Details can be found in References 3 and 4. The references should be consulted for information on the accuracy of the data and for data on other molecules not listed here.

All fundamental frequencies (more precisely, wavenumbers) are given in units of  $\text{cm}^{-1}$ .

## XY<sub>2</sub> Molecules

### Point groups D<sub>∞h</sub> (linear) and C<sub>2v</sub> (bent)

| Molecule          | Structure | Sym. str. | Bend | Antisym. str. |
|-------------------|-----------|-----------|------|---------------|
| CO <sub>2</sub>   | Linear    | 1333      | 667  | 2349          |
| CS <sub>2</sub>   | Linear    | 658       | 397  | 1535          |
| C <sub>3</sub>    | Linear    | 1224      | 63   | 2040          |
| CNC               | Linear    |           | 321  | 1453          |
| NCN               | Linear    | 1197      | 423  | 1476          |
| BO <sub>2</sub>   | Linear    | 1056      | 447  | 1278          |
| BS <sub>2</sub>   | Linear    | 510       | 120  | 1015          |
| KrF <sub>2</sub>  | Linear    | 449       | 233  | 590           |
| XeF <sub>2</sub>  | Linear    | 515       | 213  | 555           |
| XeCl <sub>2</sub> | Linear    | 316       |      | 481           |
| H <sub>2</sub> O  | Bent      | 3657      | 1595 | 3756          |
| D <sub>2</sub> O  | Bent      | 2671      | 1178 | 2788          |
| F <sub>2</sub> O  | Bent      | 928       | 461  | 831           |
| Cl <sub>2</sub> O | Bent      | 639       | 296  | 686           |
| O <sub>3</sub>    | Bent      | 1103      | 701  | 1042          |
| H <sub>2</sub> S  | Bent      | 2615      | 1183 | 2626          |
| D <sub>2</sub> S  | Bent      | 1896      | 855  | 1999          |
| SF <sub>2</sub>   | Bent      | 838       | 357  | 813           |
| SCl <sub>2</sub>  | Bent      | 525       | 208  | 535           |
| SO <sub>2</sub>   | Bent      | 1151      | 518  | 1362          |
| H <sub>2</sub> Se | Bent      | 2345      | 1034 | 2358          |
| D <sub>2</sub> Se | Bent      | 1630      | 745  | 1696          |

## XY<sub>2</sub> Molecules

### Point groups D<sub>∞h</sub> (linear) and C<sub>2v</sub> (bent)

| Molecule          | Structure | Sym. str. | Bend | Antisym. str. |
|-------------------|-----------|-----------|------|---------------|
| NH <sub>2</sub>   | Bent      | 3219      | 1497 | 3301          |
| NO <sub>2</sub>   | Bent      | 1318      | 750  | 1618          |
| NF <sub>2</sub>   | Bent      | 1075      | 573  | 942           |
| ClO <sub>2</sub>  | Bent      | 945       | 445  | 1111          |
| CH <sub>2</sub>   | Bent      |           | 963  |               |
| CD <sub>2</sub>   | Bent      |           | 752  |               |
| CF <sub>2</sub>   | Bent      | 1225      | 667  | 1114          |
| CCl <sub>2</sub>  | Bent      | 721       | 333  | 748           |
| CBr <sub>2</sub>  | Bent      | 595       | 196  | 641           |
| SiH <sub>2</sub>  | Bent      | 2032      | 990  | 2022          |
| SiD <sub>2</sub>  | Bent      | 1472      | 729  | 1468          |
| SiF <sub>2</sub>  | Bent      | 855       | 345  | 870           |
| SiCl <sub>2</sub> | Bent      | 515       |      | 505           |
| SiBr <sub>2</sub> | Bent      | 403       |      | 400           |
| GeH <sub>2</sub>  | Bent      | 1887      | 920  | 1864          |
| GeCl <sub>2</sub> | Bent      | 399       | 159  | 374           |
| SnF <sub>2</sub>  | Bent      | 593       | 197  | 571           |
| SnCl <sub>2</sub> | Bent      | 352       | 120  | 334           |
| SnBr <sub>2</sub> | Bent      | 244       | 80   | 231           |
| PbF <sub>2</sub>  | Bent      | 531       | 165  | 507           |
| PbCl <sub>2</sub> | Bent      | 314       | 99   | 299           |
| ClF <sub>2</sub>  | Bent      | 500       |      | 576           |

## XYZ Molecules

### Point Groups C<sub>∞v</sub> (linear) and C<sub>s</sub> (bent)

| Molecule | Structure | XY str. | Bend | YZ str. |
|----------|-----------|---------|------|---------|
| HCN      | Linear    | 3311    | 712  | 2097    |
| DCN      | Linear    | 2630    | 569  | 1925    |
| FCN      | Linear    | 1077    | 451  | 2323    |
| ClCN     | Linear    | 744     | 378  | 2216    |
| BrCN     | Linear    | 575     | 342  | 2198    |
| ICN      | Linear    | 486     | 305  | 2188    |
| CCN      | Linear    | 1060    | 230  | 1917    |
| CCO      | Linear    | 1063    | 379  | 1967    |
| HCO      | Bent      | 2485    | 1081 | 1868    |
| HCC      | Linear    | 3612    |      | 1848    |
| OCS      | Linear    | 2062    | 520  | 859     |
| NCO      | Linear    | 1270    | 535  | 1921    |

## XYZ Molecules

### Point Groups C<sub>∞v</sub> (linear) and C<sub>s</sub> (bent)

| Molecule | Structure | XY str. | Bend | YZ str. |
|----------|-----------|---------|------|---------|
| NNO      | Linear    | 2224    | 589  | 1285    |
| HNB      | Linear    | 3675    |      | 2035    |
| HNC      | Linear    | 3653    |      | 2032    |
| HNSi     | Linear    | 3583    | 523  | 1198    |
| HBO      | Linear    |         | 754  | 1817    |
| FBO      | Linear    |         | 500  | 2075    |
| CIBO     | Linear    | 676     | 404  | 1958    |
| BrBO     | Linear    | 535     | 374  | 1937    |
| FNO      | Bent      | 766     | 520  | 1844    |
| ClNO     | Bent      | 596     | 332  | 1800    |
| BrNO     | Bent      | 542     | 266  | 1799    |
| HNF      | Bent      |         | 1419 | 1000    |

## XYZ Molecules

Point Groups  $C_{\infty v}$  (linear) and  $C_s$  (bent)

| Molecule | Structure | XY str. | Bend | YZ str. |
|----------|-----------|---------|------|---------|
| HNO      | Bent      | 2684    | 1501 | 1565    |
| HPO      | Bent      | 2095    | 983  | 1179    |
| HOF      | Bent      | 3537    | 886  | 1393    |
| HOCl     | Bent      | 3609    | 1242 | 725     |
| HOO      | Bent      | 3436    | 1392 | 1098    |
| FOO      | Bent      | 579     | 376  | 1490    |
| CIOO     | Bent      | 407     | 373  | 1443    |
| BrOO     | Bent      |         |      | 1487    |
| HSO      | Bent      |         | 1063 | 1009    |

## XYZ Molecules

Point Groups  $C_{\infty v}$  (linear) and  $C_s$  (bent)

| Molecule | Structure | XY str. | Bend | YZ str. |
|----------|-----------|---------|------|---------|
| NSF      | Bent      | 1372    | 366  | 640     |
| NSCl     | Bent      | 1325    | 273  | 414     |
| HCF      | Bent      |         | 1407 | 1181    |
| HCCl     | Bent      |         | 1201 | 815     |
| HSiF     | Bent      | 1913    | 860  | 834     |
| HSiCl    | Bent      |         | 808  | 522     |
| HSiBr    | Bent      | 1548    | 774  | 408     |

Symmetric  $XY_3$  MoleculesPoint Groups  $D_{3h}$  (planar) and  $C_{3v}$  (pyramidal)

| Molecule          | Structure | Sym. str. | Sym. deform. | Deg. str. | Deg. deform. |
|-------------------|-----------|-----------|--------------|-----------|--------------|
| NH <sub>3</sub>   | Pyram.    | 3337      | 950          | 3444      | 1627         |
| ND <sub>3</sub>   | Pyram.    | 2420      | 748          | 2564      | 1191         |
| PH <sub>3</sub>   | Pyram.    | 2323      | 992          | 2328      | 1118         |
| AsH <sub>3</sub>  | Pyram.    | 2116      | 906          | 2123      | 1003         |
| SbH <sub>3</sub>  | Pyram.    | 1891      | 782          | 1894      | 831          |
| NF <sub>3</sub>   | Pyram.    | 1032      | 647          | 907       | 492          |
| PF <sub>3</sub>   | Pyram.    | 892       | 487          | 860       | 344          |
| AsF <sub>3</sub>  | Pyram.    | 741       | 337          | 702       | 262          |
| PCl <sub>3</sub>  | Pyram.    | 504       | 252          | 482       | 198          |
| PI <sub>3</sub>   | Pyram.    | 303       | 111          | 325       | 79           |
| AsI <sub>3</sub>  | Pyram.    | 219       | 94           | 224       | 71           |
| AlCl <sub>3</sub> | Pyram.    | 375       | 183          | 595       | 150          |
| SO <sub>3</sub>   | Planar    | 1065      | 498          | 1391      | 530          |
| BF <sub>3</sub>   | Planar    | 888       | 691          | 1449      | 480          |
| BH <sub>3</sub>   | Planar    |           | 1125         | 2808      | 1640         |
| CH <sub>3</sub>   | Planar    |           | 606          | 3161      | 1396         |
| CD <sub>3</sub>   | Planar    |           | 453          | 2369      | 1029         |
| CF <sub>3</sub>   | Pyram.    | 1090      | 701          | 1260      | 510          |
| SiF <sub>3</sub>  | Pyram.    | 830       | 427          | 937       | 290          |

## Linear XXXX Molecules

Point Group  $D_{\infty h}$ 

| Molecule                      | Sym. XY str. | Antisym. XY str. | YY str. | Bend | Bend |
|-------------------------------|--------------|------------------|---------|------|------|
| C <sub>2</sub> H <sub>2</sub> | 3374         | 3289             | 1974    | 612  | 730  |
| C <sub>2</sub> D <sub>2</sub> | 2701         | 2439             | 1762    | 505  | 537  |
| C <sub>2</sub> N <sub>2</sub> | 2330         | 2158             | 851     | 507  | 233  |

Planar X<sub>2</sub>YZ MoleculesPoint Group  $C_{2v}$ 

| Molecule           | Sym. XY str. | YZ str. | YX <sub>2</sub> scis. | Antisym. XY str. | YX <sub>2</sub> rock | YX <sub>2</sub> wag |
|--------------------|--------------|---------|-----------------------|------------------|----------------------|---------------------|
| H <sub>2</sub> CO  | 2783         | 1746    | 1500                  | 2843             | 1249                 | 1167                |
| D <sub>2</sub> CO  | 2056         | 1700    | 1106                  | 2160             | 990                  | 938                 |
| F <sub>2</sub> CO  | 965          | 1928    | 584                   | 1249             | 626                  | 774                 |
| Cl <sub>2</sub> CO | 567          | 1827    | 285                   | 849              | 440                  | 580                 |
| O <sub>2</sub> NF  | 1310         | 822     | 568                   | 1792             | 560                  | 742                 |
| O <sub>2</sub> NCl | 1286         | 793     | 370                   | 1685             | 408                  | 652                 |

Tetrahedral XY<sub>4</sub> Molecules

| Molecule          | Sym. str. | Point Group T <sub>d</sub> |                 | Deg.<br>deform.(f) |
|-------------------|-----------|----------------------------|-----------------|--------------------|
|                   |           | Deg.<br>deform.(e)         | Deg.<br>str.(f) |                    |
| CH <sub>4</sub>   | 2917      | 1534                       | 3019            | 1306               |
| CD <sub>4</sub>   | 2109      | 1092                       | 2259            | 996                |
| CF <sub>4</sub>   | 909       | 435                        | 1281            | 632                |
| CCl <sub>4</sub>  | 459       | 217                        | 776             | 314                |
| CBr <sub>4</sub>  | 267       | 122                        | 672             | 182                |
| Cl <sub>4</sub>   | 178       | 90                         | 555             | 125                |
| SiH <sub>4</sub>  | 2187      | 975                        | 2191            | 914                |
| SiD <sub>4</sub>  | 1558      | 700                        | 1597            | 681                |
| SiF <sub>4</sub>  | 800       | 268                        | 1032            | 389                |
| SiCl <sub>4</sub> | 424       | 150                        | 621             | 221                |
| GeH <sub>4</sub>  | 2106      | 931                        | 2114            | 819                |
| GeD <sub>4</sub>  | 1504      | 665                        | 1522            | 596                |
| GeCl <sub>4</sub> | 396       | 134                        | 453             | 172                |
| SnCl <sub>4</sub> | 366       | 104                        | 403             | 134                |
| TiCl <sub>4</sub> | 389       | 114                        | 498             | 136                |
| ZrCl <sub>4</sub> | 377       | 98                         | 418             | 113                |
| HfCl <sub>4</sub> | 382       | 102                        | 390             | 112                |
| RuO <sub>4</sub>  | 885       | 322                        | 921             | 336                |
| OsO <sub>4</sub>  | 965       | 333                        | 960             | 329                |

## References

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# SPECTROSCOPIC CONSTANTS OF DIATOMIC MOLECULES

This table lists the leading spectroscopic constants and equilibrium internuclear distance  $r_e$  in the ground electronic state for selected diatomic molecules. The constants are those describing the vibrational and rotational energy through the expressions:

$$E_{\text{vib}}/hc = \omega_e(v + 1/2) - \omega_e x_e(v + 1/2)^2 + \dots$$

$$E_{\text{rot}}/hc = B_v J(J + 1) - D_v [J(J + 1)]^2 + \dots$$

where

$$B_v = B_e - \alpha_e(v + 1/2) + \dots$$

$$D_v = D_e + \dots$$

Here  $v$  and  $J$  are the vibrational and rotational quantum numbers, respectively,  $h$  is Planck's constant, and  $c$  is the speed of light. In this customary formulation the constants  $\omega_e$ ,  $B_e$ , etc. have dimensions of inverse length; in this table they are given in units of  $\text{cm}^{-1}$ .

Users should note that higher order terms in the above energy expressions are required for very precise calculations; constants for many of these terms can be found in the references. Also, if the ground electronic state is not  $^1\Sigma$ , additional terms are needed to account for the interaction between electronic and pure rotational angular momentum. For some molecules in the table the data have been analyzed in terms of the Dunham series expansion:

$$E/hc = \sum_{lm} Y_{lm}(v + 1/2)^l J^m(J + 1)^m$$

In such cases it has been assumed that  $Y_{10} = \omega_e$ ,  $Y_{01} = B_e$ , etc., although in the highest approximations these identities are not precisely correct. Some of the values of  $r_e$  in the table have been corrected for breakdown of the Born-Oppenheimer approximation, which can affect the last decimal place. Because of differences in the method of data analysis and limitations in the model, care should be taken in comparing  $r_e$  values for different molecules to a precision beyond 0.001 Å.

Molecules are listed in alphabetical order by formula as written in the most common form. In most cases this form places the more electropositive element first, but there are exceptions such as OH, NH, CH, etc.

\* Indicates a value for the interval between  $v = 0$  and  $v = 1$  states instead of a value of  $\omega_e$ .

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| Molecule                           | State                                    | $\omega_e$<br>$\text{cm}^{-1}$ | $\omega_e x_e$<br>$\text{cm}^{-1}$ | $B_e$<br>$\text{cm}^{-1}$ | $\alpha_e$<br>$\text{cm}^{-1}$ | $D_e$<br>$10^{-6}\text{cm}^{-1}$ | $r_e$<br>Å |
|------------------------------------|------------------------------------------|--------------------------------|------------------------------------|---------------------------|--------------------------------|----------------------------------|------------|
| <sup>107</sup> Ag <sup>79</sup> Br | <sup>1</sup> Σ <sup>+</sup>              | 249.57                         | 0.63                               | 0.064833                  | 0.0002361                      | 0.0175                           | 2.39311    |
| <sup>107</sup> Ag <sup>35</sup> Cl | <sup>1</sup> Σ <sup>+</sup>              | 343.49                         | 1.17                               | 0.12298388                | 0.00059541                     | 0.06305                          | 2.28079    |
| <sup>107</sup> Ag <sup>19</sup> F  | <sup>1</sup> Σ <sup>+</sup>              | 513.45                         | 2.59                               | 0.2657020                 | 0.0019206                      | 0.284                            | 1.98318    |
| <sup>107</sup> Ag <sup>1</sup> H   | <sup>1</sup> Σ <sup>+</sup>              | 1759.9                         | 34.06                              | 6.449                     | 0.201                          | 344                              | 1.618      |
| <sup>107</sup> Ag <sup>2</sup> H   | <sup>1</sup> Σ <sup>+</sup>              | 1250.70                        | 17.17                              | 3.2572                    | 0.0722                         | 85.9                             | 1.6180     |
| <sup>107</sup> Ag <sup>127</sup> I | <sup>1</sup> Σ <sup>+</sup>              | 206.50                         | 0.46                               | 0.04486821                | 0.0001414                      | 0.00847                          | 2.54463    |
| <sup>107</sup> Ag <sup>16</sup> O  | <sup>2</sup> Π <sub>1/2</sub>            | 490.2                          | 3.1                                | 0.3020                    | 0.0025                         | 0.45                             | 2.003      |
| <sup>27</sup> Al <sub>2</sub>      | <sup>3</sup> Π <sub>u</sub>              | 285.8                          | 0.9                                | 0.17127                   | 0.0008                         |                                  | 2.701      |
| <sup>27</sup> Al <sup>79</sup> Br  | <sup>1</sup> Σ <sup>+</sup>              | 378.0                          | 1.28                               | 0.15919713                | 0.00086045                     | 0.11285                          | 2.29481    |
| <sup>27</sup> Al <sup>35</sup> Cl  | <sup>1</sup> Σ <sup>+</sup>              | 481.30                         | 1.95                               | 0.24393012                | 0.00161113                     | 0.2503                           | 2.13011    |
| <sup>27</sup> Al <sup>19</sup> F   | <sup>1</sup> Σ <sup>+</sup>              | 802.3                          | 4.77                               | 0.5524798                 | 0.0049841                      | 1.0464                           | 1.65437    |
| <sup>27</sup> Al <sup>1</sup> H    | <sup>1</sup> Σ <sup>+</sup>              | 1682.56                        | 29.09                              | 6.3907                    | 0.1858                         | 356.5                            | 1.6478     |
| <sup>27</sup> Al <sup>2</sup> H    | <sup>1</sup> Σ <sup>+</sup>              | 1211.95                        | 15.14                              | 3.3186                    | 0.0697                         | 97                               | 1.6463     |
| <sup>27</sup> Al <sup>127</sup> I  | <sup>1</sup> Σ <sup>+</sup>              | 316.1                          | 1.0                                | 0.11769985                | 0.00055859                     |                                  | 2.53710    |
| <sup>27</sup> Al <sup>16</sup> O   | <sup>2</sup> Σ <sup>+</sup>              | 979.23                         | 6.97                               | 0.6414                    | 0.0058                         | 1.08                             | 1.6179     |
| <sup>27</sup> Al <sup>32</sup> S   | <sup>2</sup> Σ <sup>+</sup>              | 617.1                          | 3.33                               | 0.2799                    | 0.0018                         | 0.22                             | 2.029      |
| <sup>75</sup> As <sub>2</sub>      | <sup>1</sup> Σ <sub>g</sub> <sup>+</sup> | 429.55                         | 1.12                               | 0.10179                   | 0.000333                       |                                  | 2.1026     |
| <sup>75</sup> As <sup>1</sup> H    | <sup>3</sup> Σ <sup>-</sup>              | 2130*                          |                                    | 7.3067                    | 0.2117                         | 327                              | 1.52315    |
| <sup>75</sup> As <sup>2</sup> H    | <sup>3</sup> Σ <sup>-</sup>              | 1484*                          |                                    | 3.6688                    |                                | 90                               | 1.5306     |
| <sup>75</sup> As <sup>14</sup> N   | <sup>1</sup> Σ <sup>+</sup>              | 1068.54                        | 5.41                               | 0.54551                   | 0.003366                       | 0.53                             | 1.6184     |
| <sup>75</sup> As <sup>16</sup> O   | <sup>2</sup> Π <sub>1/2</sub>            | 967.08                         | 4.85                               | 0.48482                   | 0.003299                       | 0.49                             | 1.6236     |
| <sup>197</sup> Au <sub>2</sub>     | <sup>1</sup> Σ <sub>g</sub> <sup>+</sup> | 190.9                          | 0.42                               | 0.028013                  | 0.0000723                      | 0.00250                          | 2.4719     |
| <sup>197</sup> Au <sup>1</sup> H   | <sup>1</sup> Σ <sup>+</sup>              | 2305.01                        | 43.12                              | 7.2401                    | 0.2136                         | 279                              | 1.5239     |
| <sup>197</sup> Au <sup>2</sup> H   | <sup>1</sup> Σ <sup>+</sup>              | 1634.98                        | 21.65                              | 3.6415                    | 0.07614                        | 70.9                             | 1.5238     |
| <sup>11</sup> B <sub>2</sub>       | <sup>3</sup> Σ <sub>g</sub> <sup>-</sup> | 1051.3                         | 9.35                               | 1.212                     | 0.014                          |                                  | 1.590      |
| <sup>11</sup> B <sup>79</sup> Br   | <sup>1</sup> Σ <sup>+</sup>              | 684.31                         | 3.52                               | 0.4894                    | 0.0035                         | 1.00                             | 1.888      |
| <sup>11</sup> B <sup>35</sup> Cl   | <sup>1</sup> Σ <sup>+</sup>              | 840.29                         | 5.49                               | 0.684282                  | 0.006812                       | 1.84                             | 1.71528    |
| <sup>11</sup> B <sup>19</sup> F    | <sup>1</sup> Σ <sup>+</sup>              | 1402.1                         | 11.8                               | 1.516950                  | 0.019056                       | 7.105                            | 1.26267    |
| <sup>11</sup> B <sup>1</sup> H     | <sup>1</sup> Σ <sup>+</sup>              | 2366.9                         | 49.40                              | 12.021                    | 0.412                          | 1242                             | 1.2324     |
| <sup>11</sup> B <sup>2</sup> H     | <sup>1</sup> Σ <sup>+</sup>              | 1703.3                         | 28                                 | 6.54                      | 0.17                           | 400                              | 1.2324     |
| <sup>11</sup> B <sup>14</sup> N    | <sup>3</sup> Π                           | 1514.6                         | 12.3                               | 1.666                     | 0.025                          | 8.1                              | 1.281      |
| <sup>11</sup> B <sup>16</sup> O    | <sup>2</sup> Σ <sup>+</sup>              | 1885.69                        | 11.81                              | 1.7820                    | 0.0166                         | 6.32                             | 1.2045     |



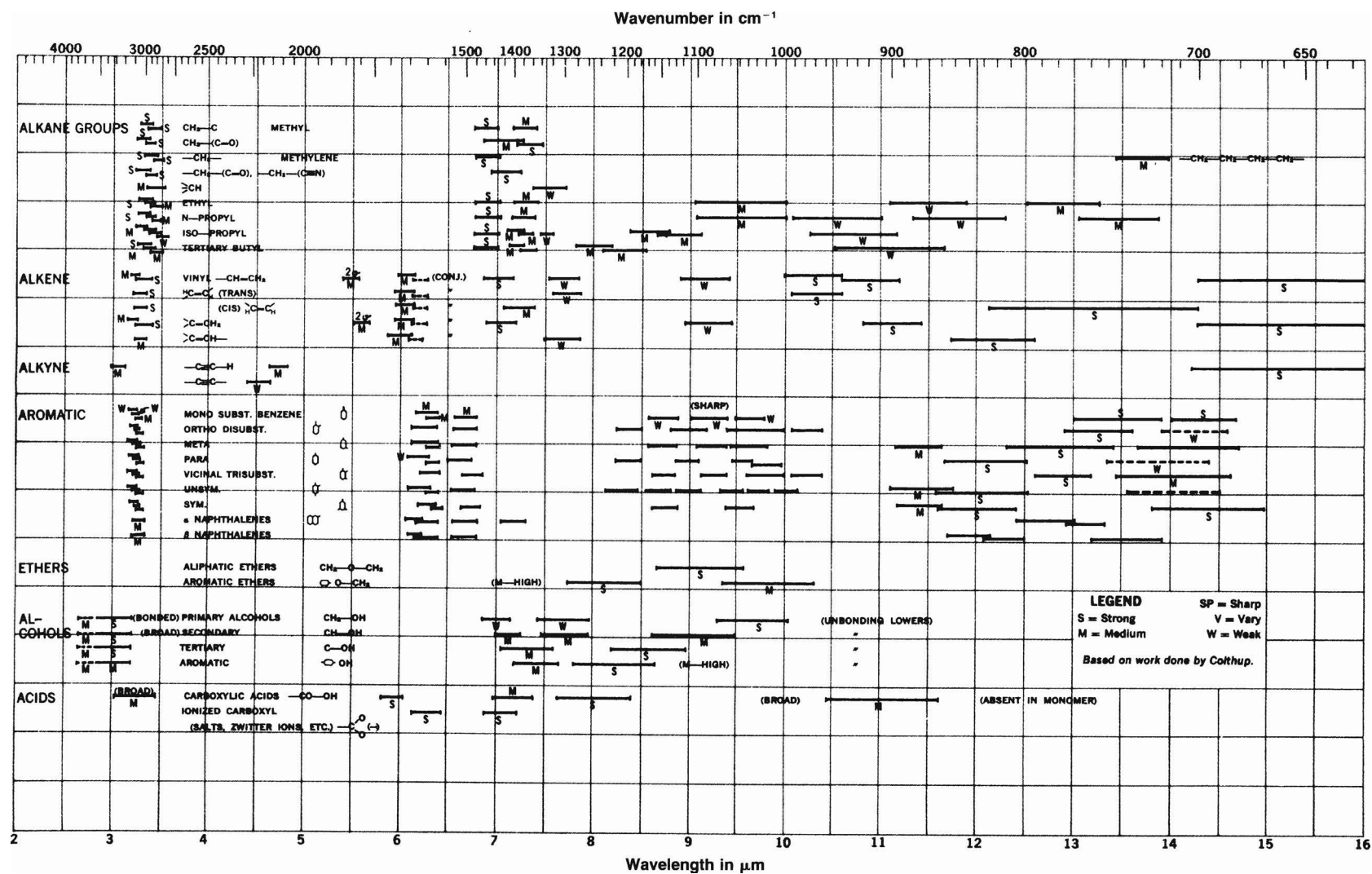
| Molecule                        | State         | $\omega_e$<br>$\text{cm}^{-1}$ | $\omega_e x_e$<br>$\text{cm}^{-1}$ | $B_e$<br>$\text{cm}^{-1}$ | $\alpha_e$<br>$\text{cm}^{-1}$ | $D_e$<br>$10^{-6}\text{cm}^{-1}$ | $r_e$<br>$\text{\AA}$ |
|---------------------------------|---------------|--------------------------------|------------------------------------|---------------------------|--------------------------------|----------------------------------|-----------------------|
| $^{11}\text{B}^{32}\text{S}$    | $2\Sigma^+$   | 1180.17                        | 6.31                               | 0.7949                    | 0.0061                         | 1.40                             | 1.6092                |
| $^{138}\text{Ba}^{79}\text{Br}$ | $2\Sigma^+$   | 193.77                         | 0.41                               | 0.0415082                 | 0.0001219                      | 0.00762                          | 2.84449               |
| $^{138}\text{Ba}^{35}\text{Cl}$ | $2\Sigma^+$   | 279.92                         | 0.82                               | 0.08396717                | 0.00033429                     | 0.03022                          | 2.68276               |
| $^{138}\text{Ba}^{19}\text{F}$  | $2\Sigma^+$   | 468.9                          | 1.79                               | 0.2159                    | 0.0012                         | 0.175                            | 2.163                 |
| $^{138}\text{Ba}^1\text{H}$     | $2\Sigma^+$   | 1168.31                        | 14.50                              | 3.38285                   | 0.06599                        | 112.67                           | 2.23175               |
| $^{138}\text{Ba}^2\text{H}$     | $2\Sigma^+$   | 829.77                         | 7.32                               | 1.7071                    | 0.02363                        | 28.77                            | 2.2304                |
| $^{138}\text{Ba}^{127}\text{I}$ | $2\Sigma^+$   | 152.14                         | 0.27                               | 0.02680587                | 0.00006634                     | 0.00333                          | 3.08476               |
| $^{138}\text{Ba}^{16}\text{O}$  | $1\Sigma^+$   | 669.76                         | 2.03                               | 0.3126140                 | 0.0013921                      | 0.2724                           | 1.93969               |
| $^{138}\text{Ba}^{32}\text{S}$  | $1\Sigma^+$   | 379.42                         | 0.88                               | 0.10331                   | 0.0003188                      | 0.0306                           | 2.5074                |
| $^9\text{Be}^{19}\text{F}$      | $2\Sigma^+$   | 1247.36                        | 9.12                               | 1.4889                    | 0.0176                         | 8.28                             | 1.3610                |
| $^9\text{Be}^1\text{H}$         | $2\Sigma^+$   | 2060.78                        | 36.31                              | 10.3164                   | 0.3030                         | 1022.1                           | 1.3426                |
| $^9\text{Be}^2\text{H}$         | $2\Sigma^+$   | 1530.32                        | 20.71                              | 5.6872                    | 0.1225                         | 313.8                            | 1.3419                |
| $^9\text{Be}^{16}\text{O}$      | $1\Sigma^+$   | 1487.32                        | 11.83                              | 1.6510                    | 0.0190                         | 8.20                             | 1.3309                |
| $^9\text{Be}^{32}\text{S}$      | $1\Sigma^+$   | 997.94                         | 6.14                               | 0.79059                   | 0.00664                        | 2.00                             | 1.7415                |
| $^{209}\text{Bi}_2$             | $1\Sigma_g^+$ | 172.71                         | 0.34                               | 0.022781                  | 0.000055                       | 0.00150                          | 2.6596                |
| $^{209}\text{Bi}^1\text{H}$     | $3\Sigma^-$   | 1635.73                        | 31.6                               | 5.137                     | 0.148                          | 183                              | 1.805                 |
| $^{209}\text{Bi}^2\text{H}$     | $3\Sigma^-$   | 1173.32                        | 16.1                               | 2.592                     | 0.054                          | 50.6                             | 1.804                 |
| $^{79}\text{Br}_2$              | $1\Sigma_g^+$ | 325.32                         | 1.08                               | 0.082107                  | 0.0003187                      | 0.02092                          | 2.2811                |
| $^{79}\text{Br}^{35}\text{Cl}$  | $1\Sigma^+$   | 444.28                         | 1.84                               | 0.152470                  | 0.000770                       | 0.07183                          | 2.13607               |
| $^{79}\text{Br}^{19}\text{F}$   | $1\Sigma^+$   | 670.75                         | 4.05                               | 0.35584                   | 0.00261                        | 0.401                            | 1.75894               |
| $^{79}\text{Br}^{16}\text{O}$   | $2\Pi_{3/2}$  | 779                            | 6.8                                | 0.429598                  | 0.003639                       | 0.523                            | 1.717                 |
| $^{12}\text{C}_2$               | $1\Sigma_g^+$ | 1854.71                        | 13.34                              | 1.8198                    | 0.0177                         | 6.92                             | 1.2425                |
| $^{12}\text{C}^{35}\text{Cl}$   | $2\Pi_{1/2}$  | 866.72*                        | 6.2                                | 0.6936                    | 0.00672                        | 1.9                              | 1.6450                |
| $^{12}\text{C}^{19}\text{F}$    | $2\Pi_{1/2}$  | 1308.1                         | 11.10                              | 1.4172                    | 0.0184                         | 6.5                              | 1.2718                |
| $^{12}\text{C}^1\text{H}$       | $2\Pi_{1/2}$  | 2858.5                         | 63.0                               | 14.457                    | 0.534                          | 1450                             | 1.1199                |
| $^{12}\text{C}^2\text{H}$       | $2\Pi_{1/2}$  | 2099.8                         | 34.02                              | 7.806                     | 0.208                          | 420                              | 1.1190                |
| $^{12}\text{C}^{14}\text{N}$    | $2\Sigma^+$   | 2068.59                        | 13.09                              | 1.8997830                 | 0.0173717                      | 6.4034                           | 1.17181               |
| $^{12}\text{C}^{16}\text{O}$    | $1\Sigma^+$   | 2169.81                        | 13.29                              | 1.93128075                | 0.01750390                     | 6.1216                           | 1.12823               |
| $^{12}\text{C}^{31}\text{P}$    | $2\Sigma^+$   | 1239.67                        | 6.86                               | 0.7986                    | 0.00597                        | 1.33                             | 1.562                 |
| $^{12}\text{C}^{32}\text{S}$    | $1\Sigma^+$   | 1285.15                        | 6.50                               | 0.8200434                 | 0.0059182                      | 1.336                            | 1.53482               |
| $^{12}\text{C}^{80}\text{Se}$   | $1\Sigma^+$   | 1035.36                        | 4.86                               | 0.5750                    | 0.00379                        | 0.71                             | 1.67609               |
| $^{40}\text{Ca}^{35}\text{Cl}$  | $2\Sigma^+$   | 367.53                         | 1.31                               | 0.1522302                 | 0.0007990                      | 0.1029                           | 2.43676               |
| $^{40}\text{Ca}^{19}\text{F}$   | $2\Sigma^+$   | 581.1                          | 2.74                               | 0.339                     | 0.0026                         | 0.45                             | 1.967                 |
| $^{40}\text{Ca}^1\text{H}$      | $2\Sigma^+$   | 1298.34                        | 19.10                              | 4.2766                    | 0.0970                         | 183.7                            | 2.0025                |
| $^{40}\text{Ca}^2\text{H}$      | $2\Sigma^+$   | 910*                           |                                    | 2.1769                    | 0.035                          | 47.9                             | 2.002                 |
| $^{40}\text{Ca}^{127}\text{I}$  | $2\Sigma^+$   | 238.70                         | 0.63                               | 0.0693263                 | 0.0002634                      | 0.0234                           | 2.82859               |
| $^{40}\text{Ca}^{16}\text{O}$   | $1\Sigma^+$   | 732.03                         | 4.83                               | 0.444441                  | 0.003282                       | 0.6541                           | 1.8221                |
| $^{40}\text{Ca}^{32}\text{S}$   | $1\Sigma^+$   | 462.23                         | 1.78                               | 0.1766757                 | 0.0008270                      | 0.1032                           | 2.31775               |
| $^{114}\text{Cd}^1\text{H}$     | $2\Sigma^+$   | 1337.1*                        |                                    | 5.323                     |                                | 314                              | 1.781                 |
| $^{114}\text{Cd}^2\text{H}$     | $2\Sigma^+$   |                                |                                    | 2.704                     |                                | 76                               | 1.775                 |
| $^{35}\text{Cl}_2$              | $1\Sigma_g^+$ | 559.7                          | 2.68                               | 0.2440                    | 0.0015                         | 0.186                            | 1.988                 |
| $^{35}\text{Cl}^{19}\text{F}$   | $1\Sigma^+$   | 786.15                         | 6.16                               | 0.516479                  | 0.004358                       | 0.88                             | 1.62831               |
| $^{35}\text{Cl}^{16}\text{O}$   | $2\Pi_{3/2}$  | 853.8                          | 5.5                                | 0.62345                   | 0.0058                         | 1.33                             | 1.56963               |
| $^{52}\text{Cr}^1\text{H}$      | $6\Sigma^+$   | 1581*                          | 32                                 | 6.220                     | 0.179                          | 347                              | 1.656                 |
| $^{52}\text{Cr}^2\text{H}$      | $6\Sigma^+$   | 1182*                          |                                    | 3.14                      |                                | 88.8                             | 1.664                 |
| $^{52}\text{Cr}^{16}\text{O}$   | $5\Pi$        | 898.4                          | 6.8                                | 0.5231                    | 0.0070                         |                                  | 1.615                 |
| $^{133}\text{Cs}_2$             | $1\Sigma_g^+$ | 42.02                          | 0.08                               | 0.0127                    | 0.0000264                      | 0.00464                          | 4.47                  |
| $^{133}\text{Cs}^{79}\text{Br}$ | $1\Sigma^+$   | 149.66                         | 0.37                               | 0.03606925                | 0.00012401                     | 0.00838                          | 3.07225               |
| $^{133}\text{Cs}^{35}\text{Cl}$ | $1\Sigma^+$   | 214.17                         | 0.73                               | 0.07209149                | 0.00033756                     | 0.03268                          | 2.90627               |
| $^{133}\text{Cs}^{19}\text{F}$  | $1\Sigma^+$   | 352.56                         | 1.62                               | 0.18436969                | 0.0011756                      | 0.20168                          | 2.34535               |
| $^{133}\text{Cs}^1\text{H}$     | $1\Sigma^+$   | 891.0                          | 12.9                               | 2.7099                    | 0.0579                         | 113                              | 2.4938                |
| $^{133}\text{Cs}^2\text{H}$     | $1\Sigma^+$   | 619.1*                         |                                    | 1.354                     |                                | 20                               | 2.505                 |
| $^{133}\text{Cs}^{127}\text{I}$ | $1\Sigma^+$   | 119.18                         | 0.25                               | 0.02362736                | 0.00006826                     | 0.00371                          | 3.31519               |
| $^{133}\text{Cs}^{16}\text{O}$  | $2\Sigma^+$   | 357.5*                         |                                    | 0.223073                  | 0.001303                       | 0.348                            | 2.3007                |
| $^{63}\text{Cu}_2$              | $1\Sigma_g^+$ | 264.55                         | 1.02                               | 0.10874                   | 0.000614                       | 0.0716                           | 2.2197                |
| $^{63}\text{Cu}^{79}\text{Br}$  | $1\Sigma^+$   | 314.8                          | 0.96                               | 0.10192625                | 0.00045214                     | 0.04274                          | 2.17344               |
| $^{63}\text{Cu}^{35}\text{Cl}$  | $1\Sigma^+$   | 415.29                         | 1.58                               | 0.17628802                | 0.00099647                     | 0.12706                          | 2.05118               |
| $^{63}\text{Cu}^{19}\text{F}$   | $1\Sigma^+$   | 622.7                          | 3.95                               | 0.3794029                 | 0.0032298                      | 0.563                            | 1.74493               |
| $^{63}\text{Cu}^1\text{H}$      | $1\Sigma^+$   | 1941.26                        | 37.51                              | 7.9441                    | 0.2563                         | 520                              | 1.46263               |
| $^{63}\text{Cu}^2\text{H}$      | $1\Sigma^+$   | 1384.14                        | 18.97                              | 4.0381                    | 0.0917                         | 136.2                            | 1.4626                |

| Molecule                           | State                        | $\omega_e$<br>cm <sup>-1</sup> | $\omega_e x_e$<br>cm <sup>-1</sup> | $B_e$<br>cm <sup>-1</sup> | $\alpha_e$<br>cm <sup>-1</sup> | $D_e$<br>10 <sup>-6</sup> cm <sup>-1</sup> | $r_e$<br>Å |
|------------------------------------|------------------------------|--------------------------------|------------------------------------|---------------------------|--------------------------------|--------------------------------------------|------------|
| <sup>63</sup> Cu <sup>127</sup> I  | 1Σ <sup>+</sup>              | 264.5                          | 0.60                               | 0.07328742                | 0.00028390                     | 0.02244                                    | 2.33832    |
| <sup>63</sup> Cu <sup>16</sup> O   | 2Π <sub>3/2</sub>            | 640.17                         | 4.43                               | 0.44454                   | 0.00456                        | 0.85                                       | 1.7244     |
| <sup>63</sup> Cu <sup>32</sup> S   | 2Π <sub>3/2</sub>            | 415.0                          | 1.75                               | 0.1891                    |                                | 0.18                                       | 2.051      |
| <sup>19</sup> F <sub>2</sub>       | 1Σ <sub>g</sub> <sup>+</sup> | 916.64                         | 11.24                              | 0.89019                   | 0.013847                       | 3.3                                        | 1.41193    |
| <sup>56</sup> Fe <sup>16</sup> O   | 5Δ                           | 965*                           |                                    | 0.650                     |                                | 0.72                                       | 1.444      |
| <sup>69</sup> Ga <sup>81</sup> Br  | 1Σ <sup>+</sup>              | 263.0                          | 0.81                               | 0.081839                  | 0.0003207                      | 0.032                                      | 2.35248    |
| <sup>69</sup> Ga <sup>35</sup> Cl  | 1Σ <sup>+</sup>              | 365.67                         | 1.25                               | 0.1499046                 | 0.0007936                      | 0.1008                                     | 2.20169    |
| <sup>69</sup> Ga <sup>19</sup> F   | 1Σ <sup>+</sup>              | 622.2                          | 3.2                                | 0.3595161                 | 0.0028642                      | 0.50                                       | 1.77437    |
| <sup>69</sup> Ga <sup>1</sup> H    | 1Σ <sup>+</sup>              | 1604.52                        | 28.77                              | 6.137                     | 0.181                          | 342                                        | 1.663      |
| <sup>69</sup> Ga <sup>2</sup> H    | 1Σ <sup>+</sup>              |                                |                                    | 3.083                     | 0.06                           | 84                                         | 1.663      |
| <sup>69</sup> Ga <sup>127</sup> I  | 1Σ <sup>+</sup>              | 216.38                         | 0.47                               | 0.0569359                 | 0.0001897                      | 0.015770                                   | 2.57464    |
| <sup>69</sup> Ga <sup>16</sup> O   | 2Σ                           | 767.5                          | 6.24                               | 0.4271                    |                                | 0.37                                       | 1.744      |
| <sup>74</sup> Ge <sup>79</sup> Br  | 2Π <sub>1/2</sub>            | 295                            | 0.7                                |                           |                                |                                            |            |
| <sup>74</sup> Ge <sup>35</sup> Cl  | 2Π <sub>1/2</sub>            | 407.6                          | 1.36                               |                           |                                |                                            |            |
| <sup>72</sup> Ge <sup>1</sup> H    | 2Π <sub>1/2</sub>            | 1833.77                        | 37                                 | 6.726                     | 0.192                          | 326                                        | 1.5880     |
| <sup>72</sup> Ge <sup>2</sup> H    | 2Π <sub>1/2</sub>            | 1320.09                        | 19                                 | 3.415                     | 0.070                          | 83.2                                       | 1.5874     |
| <sup>74</sup> Ge <sup>16</sup> O   | 1Σ <sup>+</sup>              | 986.49                         | 4.47                               | 0.4856981                 | 0.0030787                      | 0.4709                                     | 1.62464    |
| <sup>74</sup> Ge <sup>32</sup> S   | 1Σ <sup>+</sup>              | 575.8                          | 1.80                               | 0.18656576                | 0.00074910                     | 0.07883                                    | 2.01209    |
| <sup>74</sup> Ge <sup>80</sup> Se  | 1Σ <sup>+</sup>              | 408.7                          | 1.36                               | 0.09634051                | 0.00028904                     | 0.02207                                    | 2.13463    |
| <sup>74</sup> Ge <sup>130</sup> Te | 1Σ <sup>+</sup>              | 323.9                          | 0.75                               | 0.06533821                | 0.00017246                     | 0.012                                      | 2.34017    |
| <sup>1</sup> H <sub>2</sub>        | 1Σ <sub>g</sub> <sup>+</sup> | 4401.21                        | 121.34                             | 60.853                    | 3.062                          | 47100                                      | 0.74144    |
| <sup>2</sup> H <sub>2</sub>        | 1Σ <sub>g</sub> <sup>+</sup> | 3115.50                        | 61.82                              | 30.444                    | 1.0786                         | 11410                                      | 0.74152    |
| <sup>3</sup> H <sub>2</sub>        | 1Σ <sub>g</sub> <sup>+</sup> | 2546.5                         | 41.23                              | 20.335                    | 0.5887                         |                                            | 0.74142    |
| <sup>1</sup> H <sup>81</sup> Br    | 1Σ <sup>+</sup>              | 2648.97                        | 45.22                              | 8.46488                   | 0.23328                        | 345.8                                      | 1.41444    |
| <sup>2</sup> H <sup>81</sup> Br    | 1Σ <sup>+</sup>              | 1884.75                        | 22.72                              | 4.245596                  | 0.084                          | 88.32                                      | 1.4145     |
| <sup>1</sup> H <sup>35</sup> Cl    | 1Σ <sup>+</sup>              | 2990.95                        | 52.82                              | 10.59342                  | 0.30718                        | 531.94                                     | 1.27455    |
| <sup>2</sup> H <sup>35</sup> Cl    | 1Σ <sup>+</sup>              | 2145.16                        | 27.18                              | 5.448796                  | 0.113292                       | 140                                        | 1.27458    |
| <sup>1</sup> H <sup>19</sup> F     | 1Σ <sup>+</sup>              | 4138.32                        | 89.88                              | 20.9557                   | 0.798                          | 2151                                       | 0.91681    |
| <sup>2</sup> H <sup>19</sup> F     | 1Σ <sup>+</sup>              | 2998.19                        | 45.76                              | 11.0102                   | 0.3017                         | 594                                        | 0.91694    |
| <sup>1</sup> H <sup>127</sup> I    | 1Σ <sup>+</sup>              | 2309.01                        | 39.64                              | 6.4263650                 | 0.1689                         | 206.9                                      | 1.60916    |
| <sup>202</sup> Hg <sup>1</sup> H   | 2Σ <sup>+</sup>              | 1203.24*                       |                                    | 5.3888                    |                                | 395.3                                      | 1.7662     |
| <sup>202</sup> Hg <sup>2</sup> H   | 2Σ <sup>+</sup>              | 896.12*                        |                                    | 2.739                     |                                | 91                                         | 1.757      |
| <sup>127</sup> I <sub>2</sub>      | 1Σ <sub>g</sub> <sup>+</sup> | 214.50                         | 0.61                               | 0.03737                   | 0.000114                       | 0.0043                                     | 2.666      |
| <sup>127</sup> I <sup>79</sup> Br  | 1Σ <sup>+</sup>              | 268.64                         | 0.81                               | 0.0568325                 | 0.0001969                      | 0.0102                                     | 2.46899    |
| <sup>127</sup> I <sup>35</sup> Cl  | 1Σ <sup>+</sup>              | 384.29                         | 1.50                               | 0.1141587                 | 0.0005354                      | 0.0403                                     | 2.32088    |
| <sup>127</sup> I <sup>19</sup> F   | 1Σ <sup>+</sup>              | 610.24                         | 3.12                               | 0.2797111                 | 0.0018738                      | 0.2356                                     | 1.90976    |
| <sup>127</sup> I <sup>16</sup> O   | 2Π <sub>3/2</sub>            | 681.5                          | 4.3                                | 0.34026                   | 0.00270                        | 0.36                                       | 1.8676     |
| <sup>115</sup> In <sup>81</sup> Br | 1Σ <sup>+</sup>              | 221.0                          | 0.65                               | 0.05489468                | 0.00018672                     | 0.01350                                    | 2.54315    |
| <sup>115</sup> In <sup>35</sup> Cl | 1Σ <sup>+</sup>              | 317.39                         | 1.03                               | 0.1090583                 | 0.0005177                      | 0.0515                                     | 2.40117    |
| <sup>115</sup> In <sup>19</sup> F  | 1Σ <sup>+</sup>              | 535.4                          | 2.6                                | 0.2623241                 | 0.0018798                      | 0.252                                      | 1.98540    |
| <sup>115</sup> In <sup>1</sup> H   | 1Σ <sup>+</sup>              | 1476.0                         | 25.61                              | 4.995                     | 0.143                          | 223                                        | 1.8380     |
| <sup>115</sup> In <sup>2</sup> H   | 1Σ <sup>+</sup>              | 1048.2                         | 12.4                               | 2.523                     | 0.051                          | 58                                         | 1.837      |
| <sup>115</sup> In <sup>127</sup> I | 1Σ <sup>+</sup>              | 177.08                         | 0.34                               | 0.03686702                | 0.00010411                     | 0.00639                                    | 2.75364    |
| <sup>39</sup> K <sub>2</sub>       | 1Σ <sub>g</sub> <sup>+</sup> | 92.02                          | 0.28                               | 0.056743                  | 0.000165                       | 0.0863                                     | 3.9051     |
| <sup>39</sup> K <sup>79</sup> Br   | 1Σ <sup>+</sup>              | 213                            | 0.80                               | 0.08122109                | 0.00040481                     | 0.04462                                    | 2.82078    |
| <sup>39</sup> K <sup>35</sup> Cl   | 1Σ <sup>+</sup>              | 281                            | 1.30                               | 0.1286348                 | 0.0007899                      | 0.1087                                     | 2.66665    |
| <sup>39</sup> K <sup>19</sup> F    | 1Σ <sup>+</sup>              | 426.26                         | 2.45                               | 0.27993741                | 0.00233492                     | 0.4829                                     | 2.17146    |
| <sup>39</sup> K <sup>1</sup> H     | 1Σ <sup>+</sup>              | 983.6                          | 14.3                               | 3.416400                  | 0.085313                       | 163.55                                     | 2.243      |
| <sup>39</sup> K <sup>2</sup> H     | 1Σ <sup>+</sup>              | 707                            | 7.7                                | 1.754                     | 0.0318                         | 50                                         | 2.240      |
| <sup>39</sup> K <sup>127</sup> I   | 1Σ <sup>+</sup>              | 186.53                         | 0.57                               | 0.06087473                | 0.00026776                     | 0.02593                                    | 3.04784    |
| <sup>139</sup> La <sup>16</sup> O  | 2Σ <sup>+</sup>              | 812.8                          | 2.22                               | 0.35252001                | 0.00142365                     | 0.2626                                     | 1.82591    |
| <sup>7</sup> Li <sub>2</sub>       | 1Σ <sub>g</sub> <sup>+</sup> | 351.43                         | 2.61                               | 0.67264                   | 0.00704                        | 9.87                                       | 2.6729     |
| <sup>7</sup> Li <sup>79</sup> Br   | 1Σ <sup>+</sup>              | 563.2                          | 3.5                                | 0.555399                  | 0.005644                       | 2.159                                      | 2.17043    |
| <sup>7</sup> Li <sup>35</sup> Cl   | 1Σ <sup>+</sup>              | 642.95                         | 4.47                               | 0.7065225                 | 0.0080102                      | 3.409                                      | 2.02067    |
| <sup>7</sup> Li <sup>19</sup> F    | 1Σ <sup>+</sup>              | 910.57                         | 8.21                               | 1.3452583                 | 0.0202887                      | 11.745                                     | 1.56386    |
| <sup>7</sup> Li <sup>1</sup> H     | 1Σ <sup>+</sup>              | 1405.65                        | 23.20                              | 7.51373                   | 0.21665                        | 862                                        | 1.59490    |
| <sup>7</sup> Li <sup>2</sup> H     | 1Σ <sup>+</sup>              | 1054.80                        | 12.94                              | 4.23310                   | 0.09155                        | 276                                        | 1.5941     |
| <sup>7</sup> Li <sup>127</sup> I   | 1Σ <sup>+</sup>              | 496.85                         | 2.85                               | 0.4431766                 | 0.0040862                      | 1.4104                                     | 2.39192    |
| <sup>7</sup> Li <sup>16</sup> O    | 2Π                           | 814.62                         | 7.78                               | 1.212830                  | 0.017899                       | 0.1079                                     | 1.68822    |
| <sup>24</sup> Mg <sub>2</sub>      | 1Σ <sub>g</sub> <sup>+</sup> | 51.12                          | 1.64                               | 0.09287                   | 0.00378                        | 1.22                                       | 3.891      |

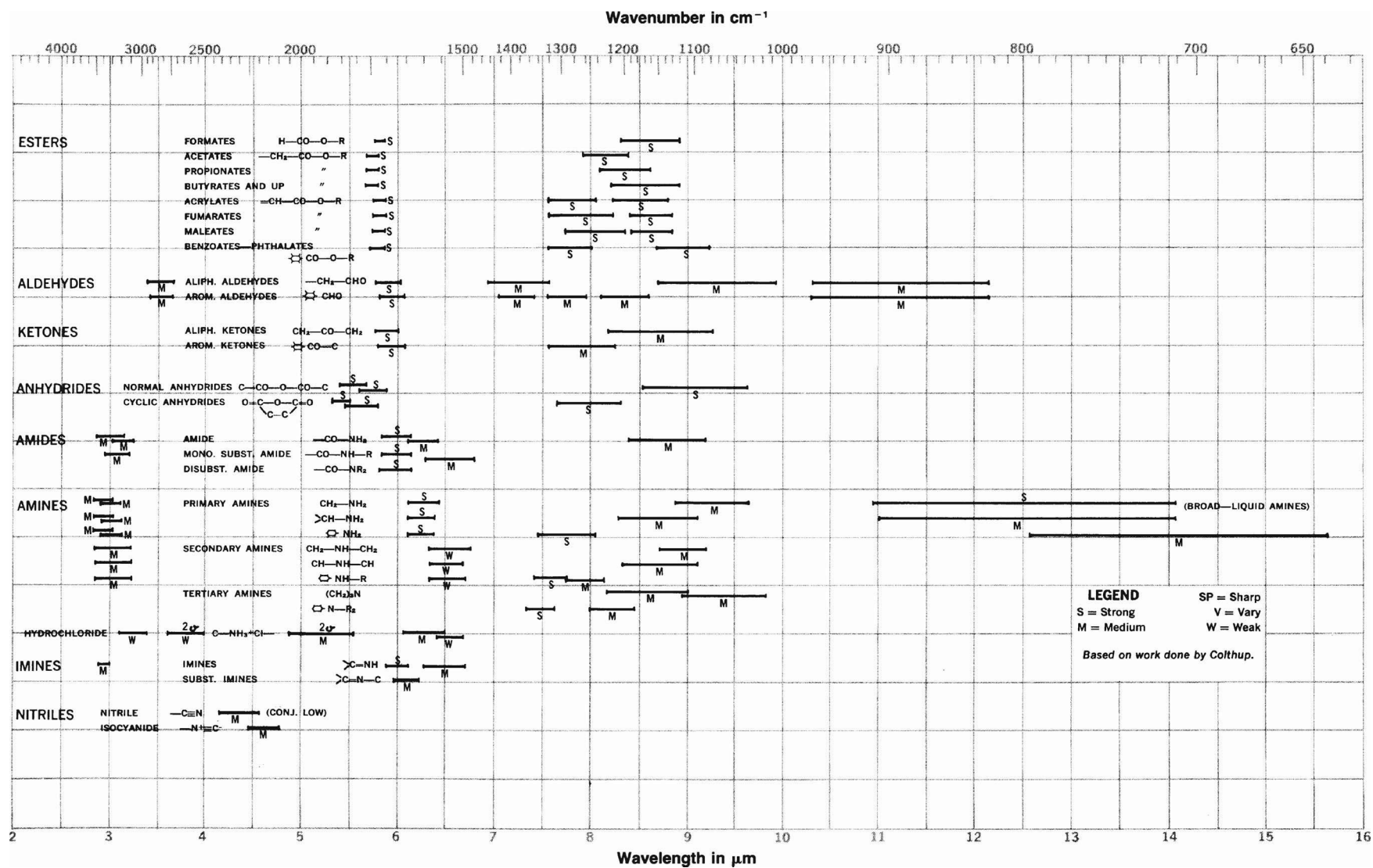
| Molecule                            | State                                    | $\omega_e$<br>cm <sup>-1</sup> | $\omega_e x_e$<br>cm <sup>-1</sup> | $B_e$<br>cm <sup>-1</sup> | $\alpha_e$<br>cm <sup>-1</sup> | $D_e$<br>10 <sup>-6</sup> cm <sup>-1</sup> | $r_e$<br>Å |
|-------------------------------------|------------------------------------------|--------------------------------|------------------------------------|---------------------------|--------------------------------|--------------------------------------------|------------|
| <sup>24</sup> Mg <sup>35</sup> Cl   | <sup>2</sup> Σ <sup>+</sup>              | 462.12*                        | 2.1                                | 0.2456154                 | 0.0016204                      | 0.2723                                     | 2.19639    |
| <sup>24</sup> Mg <sup>19</sup> F    | <sup>2</sup> Σ <sup>+</sup>              | 711.69*                        | 4.9                                | 0.51922                   | 0.00470                        | 1.080                                      | 1.7500     |
| <sup>24</sup> Mg <sup>1</sup> H     | <sup>2</sup> Σ <sup>+</sup>              | 1495.20                        | 31.89                              | 5.8257                    | 0.1859                         | 344                                        | 1.7297     |
| <sup>24</sup> Mg <sup>2</sup> H     | <sup>2</sup> Σ <sup>+</sup>              | 1077.9                         | 16.1                               | 3.0306                    | 0.06289                        | 92                                         | 1.7302     |
| <sup>24</sup> Mg <sup>16</sup> O    | <sup>1</sup> Σ <sup>+</sup>              | 784.78                         | 5.26                               | 0.57470436                | 0.00532377                     | 1.2328                                     | 1.74838    |
| <sup>55</sup> Mn <sup>1</sup> H     | <sup>7</sup> Σ                           | 1548.0                         | 28.8                               | 5.6841                    | 0.1570                         | 303.9                                      | 1.7311     |
| <sup>55</sup> Mn <sup>2</sup> H     | <sup>7</sup> Σ                           | 1103                           | 13.9                               | 2.8957                    | 0.051                          | 79.5                                       | 1.7310     |
| <sup>14</sup> N <sub>2</sub>        | <sup>1</sup> Σ <sub>g</sub> <sup>+</sup> | 2358.57                        | 14.32                              | 1.99824                   | 0.017318                       | 5.76                                       | 1.09769    |
| <sup>14</sup> N <sup>79</sup> Br    | <sup>3</sup> Σ <sup>-</sup>              | 691.75                         | 4.72                               | 0.444                     | 0.0040                         |                                            | 1.79       |
| <sup>14</sup> N <sup>35</sup> Cl    | <sup>3</sup> Σ <sup>-</sup>              | 827.96                         | 5.30                               | 0.649770                  | 0.006414                       | 1.598                                      | 1.61071    |
| <sup>14</sup> N <sup>19</sup> F     | <sup>3</sup> Σ <sup>-</sup>              | 1141.37                        | 8.99                               | 1.2057                    | 0.01492                        | 5.39                                       | 1.3170     |
| <sup>14</sup> N <sup>1</sup> H      | <sup>3</sup> Σ <sup>-</sup>              | 3282.3                         | 78.4                               | 16.6993                   | 0.6490                         | 1709.7                                     | 1.0362     |
| <sup>14</sup> N <sup>2</sup> H      | <sup>3</sup> Σ <sup>-</sup>              | 2398                           | 42                                 | 8.7913                    | 0.2531                         | 490.4                                      | 1.0361     |
| <sup>14</sup> N <sup>16</sup> O     | <sup>2</sup> Π <sub>1/2</sub>            | 1904.20                        | 14.07                              | 1.67195                   | 0.0171                         | 0.5                                        | 1.15077    |
| <sup>14</sup> N <sup>32</sup> S     | <sup>2</sup> Π <sub>1/2</sub>            | 1218.7                         | 7.28                               | 0.769602                  | 0.0064                         | 1.2                                        | 1.4940     |
| <sup>23</sup> Na <sub>2</sub>       | <sup>1</sup> Σ <sub>g</sub> <sup>+</sup> | 159.13                         | 0.72                               | 0.154707                  | 0.008736                       | 0.581                                      | 3.0789     |
| <sup>23</sup> Na <sup>79</sup> Br   | <sup>1</sup> Σ <sup>+</sup>              | 302                            | 1.5                                | 0.1512533                 | 0.0009410                      | 0.1554                                     | 2.50204    |
| <sup>23</sup> Na <sup>35</sup> Cl   | <sup>1</sup> Σ <sup>+</sup>              | 366                            | 2.05                               | 0.2180631                 | 0.0016248                      | 0.3120                                     | 2.36080    |
| <sup>23</sup> Na <sup>19</sup> F    | <sup>1</sup> Σ <sup>+</sup>              | 535.66                         | 3.57                               | 0.4369011                 | 0.0045580                      | 1.163                                      | 1.92595    |
| <sup>23</sup> Na <sup>1</sup> H     | <sup>1</sup> Σ <sup>+</sup>              | 1172.2                         | 19.72                              | 4.9033634                 | 0.1370919                      | 343.40                                     | 1.88654    |
| <sup>23</sup> Na <sup>2</sup> H     | <sup>1</sup> Σ <sup>+</sup>              | 826.1*                         |                                    | 2.557089                  | 0.051600                       | 93.46                                      | 1.88654    |
| <sup>23</sup> Na <sup>127</sup> I   | <sup>1</sup> Σ <sup>+</sup>              | 258                            | 1.1                                | 0.1178056                 | 0.0006478                      | 0.0973                                     | 2.71145    |
| <sup>23</sup> Na <sup>16</sup> O    | <sup>2</sup> Π                           | 492.3                          |                                    | 0.424630                  | 0.004506                       | 1.2638                                     | 2.05155    |
| <sup>93</sup> Nb <sup>16</sup> O    | <sup>4</sup> Σ <sup>-</sup>              | 989.0                          | 3.8                                | 0.4321                    | 0.0021                         | 0.22                                       | 1.691      |
| <sup>58</sup> Ni <sup>1</sup> H     | <sup>2</sup> Δ <sub>5/2</sub>            | 1926.6                         | 38                                 | 7.700                     | 0.23                           | 481                                        | 1.476      |
| <sup>58</sup> Ni <sup>2</sup> H     | <sup>2</sup> Δ <sub>5/2</sub>            | 1390.1                         | 19                                 | 3.992                     | 0.092                          | 130                                        | 1.465      |
| <sup>16</sup> O <sub>2</sub>        | <sup>3</sup> Σ <sub>g</sub> <sup>-</sup> | 1580.19                        | 11.98                              | 1.44563                   | 0.0159                         | 4.839                                      | 1.20752    |
| <sup>16</sup> O <sup>1</sup> H      | <sup>2</sup> Π <sub>3/2</sub>            | 3737.76                        | 84.88                              | 18.911                    | 0.7242                         | 1938                                       | 0.96966    |
| <sup>16</sup> O <sup>2</sup> H      | <sup>2</sup> Π <sub>3/2</sub>            | 2720.24                        | 44.05                              | 10.021                    | 0.276                          | 537.4                                      | 0.9698     |
| <sup>31</sup> P <sub>2</sub>        | <sup>1</sup> Σ <sub>g</sub> <sup>+</sup> | 780.77                         | 2.84                               | 0.30362                   | 0.00149                        | 0.188                                      | 1.8934     |
| <sup>31</sup> P <sup>35</sup> Cl    | <sup>3</sup> Σ <sup>-</sup>              | 551.38                         | 2.23                               | 0.2528748                 | 0.0015119                      | 0.2124                                     | 2.01461    |
| <sup>31</sup> P <sup>19</sup> F     | <sup>3</sup> Σ <sup>-</sup>              | 846.75                         | 4.49                               | 0.5665                    | 0.00456                        |                                            | 1.58938    |
| <sup>31</sup> P <sup>1</sup> H      | <sup>3</sup> Σ <sup>-</sup>              | 2365.2                         | 44.5                               | 8.5371                    | 0.2514                         | 436                                        | 1.42140    |
| <sup>31</sup> P <sup>2</sup> H      | <sup>3</sup> Σ <sup>-</sup>              | 1699.2                         | 23.0                               | 4.4081                    | 0.0928                         | 116                                        | 1.4220     |
| <sup>31</sup> P <sup>14</sup> N     | <sup>1</sup> Σ <sup>+</sup>              | 1337.24                        | 6.98                               | 0.7864854                 | 0.0055364                      | 1.091                                      | 1.49087    |
| <sup>31</sup> P <sup>16</sup> O     | <sup>2</sup> Π <sub>1/2</sub>            | 1233.34                        | 6.56                               | 0.7337                    | 0.0055                         | 1.3                                        | 1.4759     |
| <sup>208</sup> Pb <sub>2</sub>      |                                          | 110.5                          | 0.35                               |                           |                                |                                            |            |
| <sup>208</sup> Pb <sup>79</sup> Br  | <sup>2</sup> Π <sub>1/2</sub>            | 207.5                          | 0.50                               |                           |                                |                                            |            |
| <sup>208</sup> Pb <sup>35</sup> Cl  | <sup>2</sup> Π <sub>1/2</sub>            | 303.9                          | 0.88                               |                           |                                |                                            |            |
| <sup>208</sup> Pb <sup>19</sup> F   | <sup>2</sup> Π <sub>1/2</sub>            | 502.73                         | 2.28                               | 0.22875                   | 0.001473                       | 0.183                                      | 2.0575     |
| <sup>208</sup> Pb <sup>1</sup> H    | <sup>2</sup> Π <sub>1/2</sub>            | 1564.1                         | 29.75                              | 4.971                     | 0.144                          | 201                                        | 1.839      |
| <sup>208</sup> Pb <sup>16</sup> O   | <sup>1</sup> Σ <sup>+</sup>              | 720.96                         | 3.52                               | 0.30730373                | 0.00190977                     | 0.2138                                     | 1.92181    |
| <sup>208</sup> Pb <sup>32</sup> S   | <sup>1</sup> Σ <sup>+</sup>              | 429.17                         | 1.26                               | 0.11632307                | 0.00043510                     | 0.03418                                    | 2.28678    |
| <sup>208</sup> Pb <sup>80</sup> Se  | <sup>1</sup> Σ <sup>+</sup>              | 277.6                          | 0.51                               | 0.05059953                | 0.00012993                     | 0.0070                                     | 2.40218    |
| <sup>208</sup> Pb <sup>130</sup> Te | <sup>1</sup> Σ <sup>+</sup>              | 212.0                          | 0.43                               | 0.03130774                | 0.00006743                     | 0.0027                                     | 2.59492    |
| <sup>195</sup> Pt <sup>12</sup> C   | <sup>1</sup> Σ <sup>+</sup>              | 1051.13                        | 4.86                               | 0.53044                   | 0.003273                       | 0.546                                      | 1.6767     |
| <sup>195</sup> Pt <sup>1</sup> H    | <sup>2</sup> Δ <sub>5/2</sub>            | 2294.68*                       | 46                                 | 7.1963                    | 0.1996                         | 261                                        | 1.52852    |
| <sup>195</sup> Pt <sup>2</sup> H    | <sup>2</sup> Δ <sub>5/2</sub>            | 1644.3*                        | 23                                 | 3.640                     | 0.071                          | 66                                         | 1.524      |
| <sup>85</sup> Rb <sup>79</sup> Br   | <sup>1</sup> Σ <sup>+</sup>              | 169.46                         | 0.46                               | 0.04752798                | 0.00018596                     | 0.01496                                    | 2.94474    |
| <sup>85</sup> Rb <sup>35</sup> Cl   | <sup>1</sup> Σ <sup>+</sup>              | 228                            | 0.92                               | 0.0876404                 | 0.0004537                      | 0.04947                                    | 2.78673    |
| <sup>85</sup> Rb <sup>19</sup> F    | <sup>1</sup> Σ <sup>+</sup>              | 376                            | 1.9                                | 0.2106640                 | 0.0015228                      | 0.2684                                     | 2.27033    |
| <sup>85</sup> Rb <sup>1</sup> H     | <sup>1</sup> Σ <sup>+</sup>              | 936.9                          | 14.21                              | 3.020                     | 0.072                          | 123                                        | 2.367      |
| <sup>85</sup> Rb <sup>127</sup> I   | <sup>1</sup> Σ <sup>+</sup>              | 138.51                         | 0.33                               | 0.03283293                | 0.00010946                     | 0.00738                                    | 3.17688    |
| <sup>85</sup> Rb <sup>16</sup> O    | <sup>2</sup> Σ <sup>+</sup>              | 388.4*                         |                                    | 0.246481                  | 0.002174                       | 0.397                                      | 2.25420    |
| <sup>32</sup> S <sub>2</sub>        | <sup>3</sup> Σ <sub>g</sub> <sup>-</sup> | 725.65                         | 2.84                               | 0.2955                    | 0.001570                       | 0.19                                       | 1.8892     |
| <sup>32</sup> S <sup>19</sup> F     | <sup>2</sup> Π <sub>3/2</sub>            |                                |                                    | 0.552174                  |                                |                                            | 1.60058    |
| <sup>32</sup> S <sup>1</sup> H      | <sup>2</sup> Π <sub>3/2</sub>            | 2711.6                         | 59.9                               | 9.5995                    | 0.2785                         | 480.6                                      | 1.34066    |
| <sup>32</sup> S <sup>2</sup> H      | <sup>2</sup> Π <sub>3/2</sub>            | 1885                           | 31                                 | 4.95130                   | 0.10308                        | 130                                        | 1.34049    |
| <sup>32</sup> S <sup>16</sup> O     | <sup>3</sup> Σ <sup>-</sup>              | 1149.2                         | 5.6                                | 0.7208171                 | 0.005737                       | 1.134                                      | 1.48109    |
| <sup>121</sup> Sb <sup>35</sup> Cl  | <sup>3</sup> Σ <sup>-</sup>              | 374.7                          | 0.6                                |                           |                                |                                            |            |

| Molecule                         | State           | $\omega_e$<br>$\text{cm}^{-1}$ | $\omega_e x_e$<br>$\text{cm}^{-1}$ | $B_e$<br>$\text{cm}^{-1}$ | $\alpha_e$<br>$\text{cm}^{-1}$ | $D_e$<br>$10^{-6}\text{cm}^{-1}$ | $r_e$<br>$\text{\AA}$ |
|----------------------------------|-----------------|--------------------------------|------------------------------------|---------------------------|--------------------------------|----------------------------------|-----------------------|
| $^{121}\text{Sb}^{19}\text{F}$   | $3\Sigma^-$     | 605.0                          | 2.6                                | 0.2792                    | 0.0020                         | 0.23                             | 1.918                 |
| $^{121}\text{Sb}^1\text{H}$      | $3\Sigma^-$     |                                |                                    | 5.684                     |                                | 240                              | 1.723                 |
| $^{121}\text{Sb}^2\text{H}$      | $3\Sigma^-$     |                                |                                    | 2.8782                    |                                | 45                               | 1.7194                |
| $^{121}\text{Sb}^{14}\text{N}$   | $1\Sigma^+$     | 942.0                          | 5.6                                |                           |                                |                                  |                       |
| $^{121}\text{Sb}^{16}\text{O}$   | $2\Pi_{1/2}$    | 816                            | 4.2                                | 0.3580                    | 0.0022                         | 0.270                            | 1.826                 |
| $^{45}\text{Sc}^{19}\text{F}$    | $1\Sigma^+$     | 735.6                          | 3.8                                | 0.3950                    | 0.00266                        |                                  | 1.788                 |
| $^{80}\text{Se}_2$               | $3\Sigma^-_g$   | 385.30                         | 0.96                               | 0.08992                   | 0.000288                       | 0.024                            | 2.166                 |
| $^{80}\text{Se}^1\text{H}$       | $2\Pi_{3/2}$    | 2400*                          |                                    | 8.02                      | 0.23                           | 330                              | 1.48                  |
| $^{80}\text{Se}^2\text{H}$       | $2\Pi_{3/2}$    | 1708*                          |                                    | 3.94                      |                                |                                  | 1.48                  |
| $^{80}\text{Se}^{16}\text{O}$    | $3\Sigma^-$     | 914.69                         | 4.52                               | 0.4655                    | 0.00323                        | 0.5                              | 1.648                 |
| $^{28}\text{Si}_2$               | $3\Sigma^-_g$   | 510.98                         | 2.02                               | 0.2390                    | 0.0014                         | 0.21                             | 2.246                 |
| $^{28}\text{Si}^{35}\text{Cl}$   | $2\Pi_{1/2}$    | 535.60                         | 2.17                               | 0.2561                    | 0.0016                         | 0.25                             | 2.058                 |
| $^{28}\text{Si}^{19}\text{F}$    | $2\Pi_{1/2}$    | 857.19                         | 4.73                               | 0.5812                    | 0.00494                        | 1.07                             | 1.6011                |
| $^{28}\text{Si}^1\text{H}$       | $2\Pi_{1/2}$    | 2041.80                        | 35.51                              | 7.4996                    | 0.2190                         | 397                              | 1.5201                |
| $^{28}\text{Si}^2\text{H}$       | $2\Pi_{1/2}$    | 1469.32                        | 18.23                              | 3.8840                    | 0.0781                         | 105.4                            | 1.5199                |
| $^{28}\text{Si}^{14}\text{N}$    | $2\Sigma^+$     | 1151.4                         | 6.47                               | 0.7311                    | 0.00565                        | 1.2                              | 1.572                 |
| $^{28}\text{Si}^{16}\text{O}$    | $1\Sigma^+$     | 1241.54                        | 5.97                               | 0.7267521                 | 0.0050379                      | 0.9923                           | 1.50975               |
| $^{28}\text{Si}^{32}\text{S}$    | $1\Sigma^+$     | 749.64                         | 2.58                               | 0.30352788                | 0.00147308                     | 0.201                            | 1.92926               |
| $^{28}\text{Si}^{80}\text{Se}$   | $1\Sigma^+$     | 580.0                          | 1.78                               | 0.1920117                 | 0.0007767                      | 0.0842                           | 2.05832               |
| $^{120}\text{Sn}^{79}\text{Br}$  | $2\Pi_{1/2}$    | 247.2                          | 0.6                                |                           |                                |                                  |                       |
| $^{120}\text{Sn}^{35}\text{Cl}$  | $2\Pi_{1/2}$    | 351.1                          | 1.06                               | 0.1117                    | 0.0004                         |                                  | 2.361                 |
| $^{118}\text{Sn}^{19}\text{F}$   | $2\Pi_{1/2}$    | 577.6                          | 2.69                               | 0.2727                    | 0.0014                         | 0.26                             | 1.944                 |
| $^{120}\text{Sn}^1\text{H}$      | $2\Pi_{1/2}$    |                                |                                    | 5.31488                   |                                | 207.5                            | 1.78146               |
| $^{120}\text{Sn}^2\text{H}$      | $2\Pi_{1/2}$    | 1188.0*                        |                                    | 2.6950                    | 0.049                          | 53.4                             | 1.7770                |
| $^{120}\text{Sn}^{127}\text{I}$  | $2\Pi_{1/2}$    | 199.0                          | 0.6                                |                           |                                |                                  |                       |
| $^{120}\text{Sn}^{16}\text{O}$   | $1\Sigma^+$     | 822.13                         | 3.72                               | 0.35571998                | 0.00214432                     | 0.26638                          | 1.83251               |
| $^{120}\text{Sn}^{32}\text{S}$   | $1\Sigma^+$     | 487.26                         | 1.36                               | 0.13686139                | 0.00050563                     | 0.0424                           | 2.20898               |
| $^{120}\text{Sn}^{80}\text{Se}$  | $1\Sigma^+$     | 331.2                          | 0.74                               | 0.0649978                 | 0.0001705                      | 0.011                            | 2.32557               |
| $^{120}\text{Sn}^{130}\text{Te}$ | $1\Sigma^+$     | 259.5                          | 0.50                               | 0.04247917                | 0.00009543                     | 0.0055                           | 2.52280               |
| $^{88}\text{Sr}^{79}\text{Br}$   | $2\Sigma^+$     | 216.60                         | 0.52                               | 0.0541847                 | 0.0001827                      | 0.01356                          | 2.73522               |
| $^{88}\text{Sr}^{35}\text{Cl}$   | $2\Sigma^+$     | 302.3                          | 0.95                               |                           |                                |                                  |                       |
| $^{88}\text{Sr}^{19}\text{F}$    | $2\Sigma^+$     | 502.4                          | 2.3                                | 0.2505346                 | 0.0015513                      | 0.2498                           | 2.07537               |
| $^{88}\text{Sr}^1\text{H}$       | $2\Sigma^+$     | 1206.2                         | 17.0                               | 3.6751                    | 0.0814                         | 135                              | 2.1456                |
| $^{88}\text{Sr}^2\text{H}$       | $2\Sigma^+$     | 841                            | 8.6                                | 1.8609                    | 0.0292                         | 34.7                             | 2.1449                |
| $^{88}\text{Sr}^{127}\text{I}$   | $2\Sigma^+$     | 173.77                         | 0.35                               | 0.0367097                 | 0.0001060                      | 0.00655                          | 2.94364               |
| $^{88}\text{Sr}^{16}\text{O}$    | $1\Sigma^+$     | 653.5                          | 3.96                               | 0.33798                   | 0.00219                        | 0.36                             | 1.91983               |
| $^{181}\text{Ta}^{16}\text{O}$   | $2\Delta_{3/2}$ | 1028.69                        | 3.51                               | 0.40284                   | 0.00182                        | 0.2450                           | 1.68746               |
| $^{130}\text{Te}_2$              | $3\Sigma^-_g$   | 247.07                         | 0.51                               | 0.039681                  | 0.000106                       | 0.0044                           | 2.5574                |
| $^{130}\text{Te}^1\text{H}$      | $2\Pi_{3/2}$    |                                |                                    | 5.56                      |                                |                                  | 1.74                  |
| $^{130}\text{Te}^{16}\text{O}$   | $0^+$           | 797.11                         | 4.00                               | 0.3554                    | 0.00237                        | 0.27                             | 1.825                 |
| $^{232}\text{Th}^{16}\text{O}$   | $1\Sigma^+$     | 895.77                         | 2.39                               | 0.332644                  | 0.001302                       | 0.1833                           | 1.84032               |
| $^{48}\text{Ti}^{16}\text{O}$    | $3\Delta_1$     | 1009.02                        | 4.50                               | 0.53541                   | 0.00301                        | 0.603                            | 1.6202                |
| $^{205}\text{Tl}^{81}\text{Br}$  | $1\Sigma^+$     | 192.10                         | 0.39                               | 0.0423899                 | 0.0001276                      | 0.0083                           | 1.61817               |
| $^{205}\text{Tl}^{35}\text{Cl}$  | $1\Sigma^+$     | 284.71                         | 0.86                               | 0.09139702                | 0.00039784                     | 0.0377                           | 2.48483               |
| $^{205}\text{Tl}^{19}\text{F}$   | $1\Sigma^+$     | 476.86                         | 2.24                               | 0.22315014                | 0.00150380                     | 0.1955                           | 2.08439               |
| $^{205}\text{Tl}^1\text{H}$      | $1\Sigma^+$     | 1390.7                         | 22.7                               | 4.806                     | 0.154                          | 254                              | 1.870                 |
| $^{205}\text{Tl}^2\text{H}$      | $1\Sigma^+$     | 987.7                          | 12.04                              | 2.419                     | 0.057                          | 60                               | 1.869                 |
| $^{205}\text{Tl}^{127}\text{I}$  | $1\Sigma^+$     | 150*                           |                                    | 0.0271676                 | 0.0000664                      | 0.0036                           | 2.81361               |
| $^{51}\text{V}^{16}\text{O}$     | $4\Sigma^-$     | 1011.3                         | 4.86                               | 0.54825                   | 0.00352                        | 0.6                              | 1.5893                |
| $^{89}\text{Y}^{35}\text{Cl}$    | $1\Sigma$       | 380.7                          | 1.3                                | 0.1160                    | 0.0003                         | 0.09                             | 2.41                  |
| $^{89}\text{Y}^{19}\text{F}$     | $1\Sigma^+$     | 631.29                         | 2.50                               | 0.29042                   | 0.00163                        | 0.237                            | 1.9257                |
| $^{89}\text{Y}^{16}\text{O}$     | $2\Sigma^+$     | 861.0                          | 2.9                                | 0.3881                    | 0.0018                         | 0.32                             | 1.790                 |
| $^{174}\text{Yb}^1\text{H}$      | $2\Sigma^+$     | 1249.54                        | 21.06                              | 3.9931                    | 0.0957                         | 161.8                            | 2.0526                |
| $^{174}\text{Yb}^2\text{H}$      | $2\Sigma^+$     | 886.6                          | 10.57                              | 2.01162                   | 0.03425                        | 41.60                            | 2.0516                |
| $^{64}\text{Zn}^{35}\text{Cl}$   | $2\Sigma$       | 390.5                          | 1.6                                |                           |                                |                                  |                       |
| $^{64}\text{Zn}^{19}\text{F}$    | $2\Sigma$       | 628                            | 3.5                                |                           |                                |                                  |                       |
| $^{64}\text{Zn}^1\text{H}$       | $2\Sigma^+$     | 1607.6                         | 55.14                              | 6.6794                    | 0.2500                         | 466                              | 1.5949                |
| $^{64}\text{Zn}^2\text{H}$       | $2\Sigma^+$     | 1072                           | 28                                 | 3.350                     |                                | 124                              | 1.6054                |
| $^{64}\text{Zn}^{127}\text{I}$   | $2\Sigma$       | 223.4                          | 0.6                                |                           |                                |                                  |                       |
| $^{90}\text{Zr}^{16}\text{O}$    | $1\Sigma^+$     | 969.8                          | 4.9                                | 0.42263                   | 0.0023                         | 0.319                            | 1.7116                |

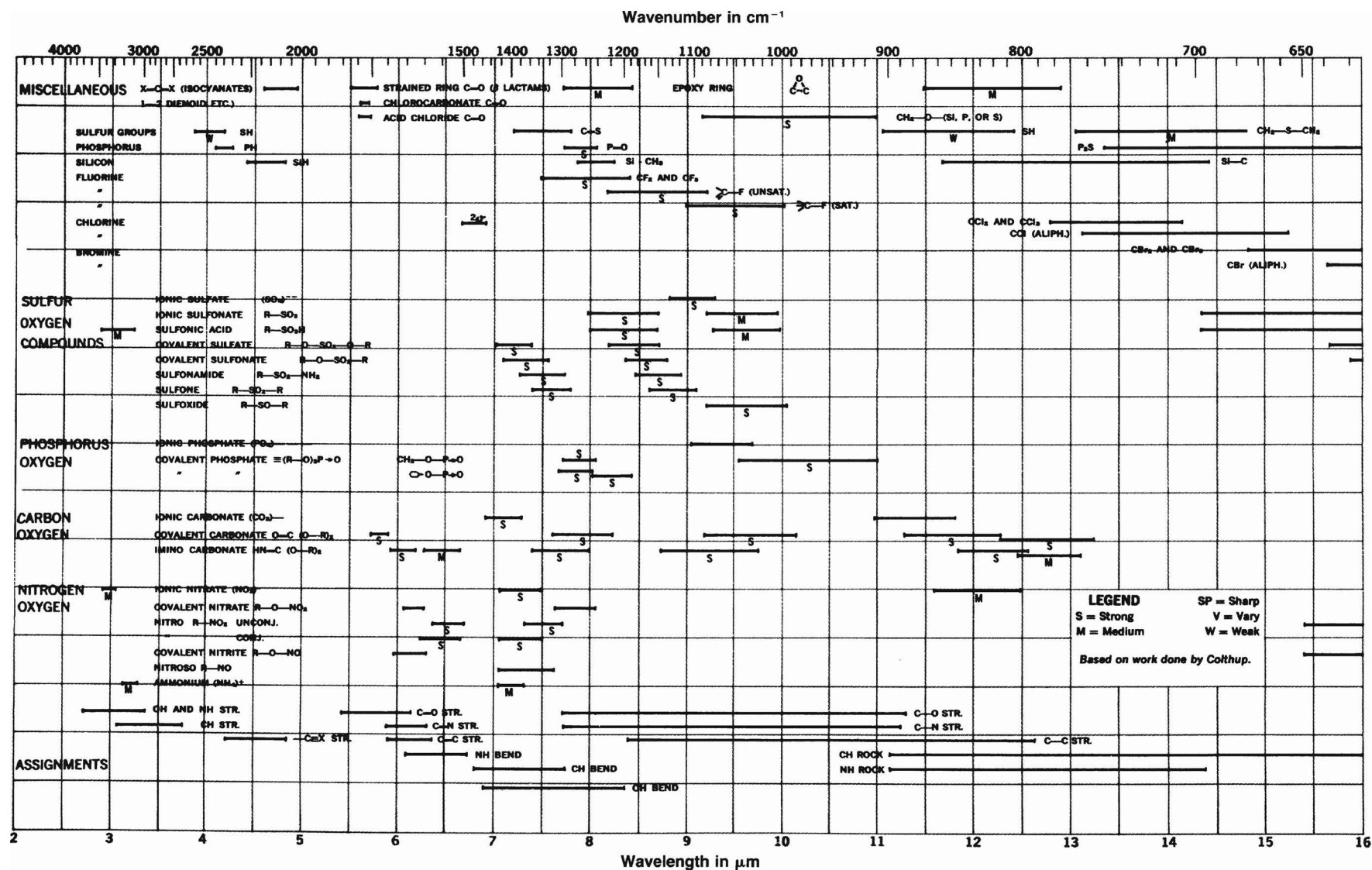
# INFRARED CORRELATION CHARTS



# INFRARED CORRELATION CHARTS

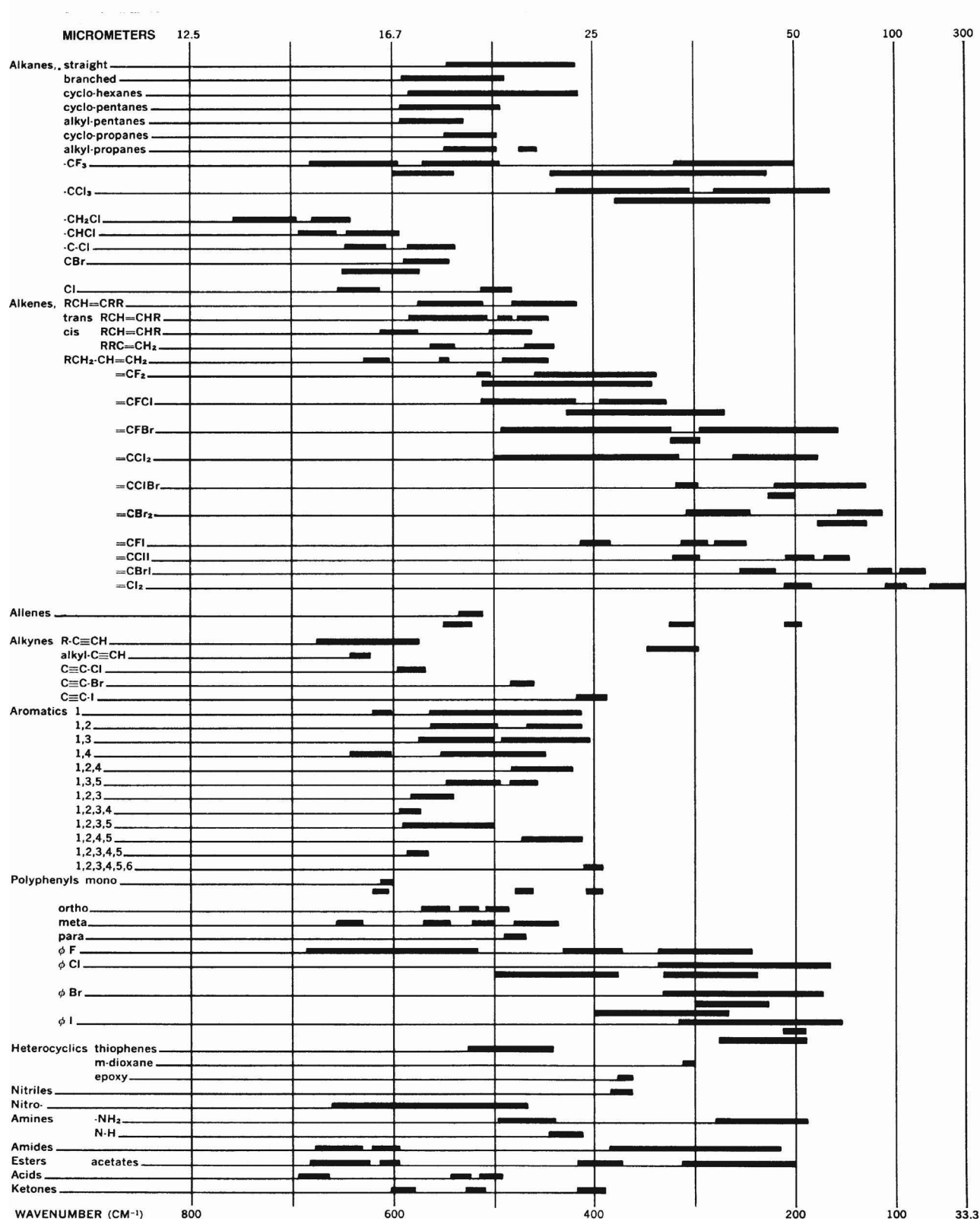


# INFRARED CORRELATION CHARTS

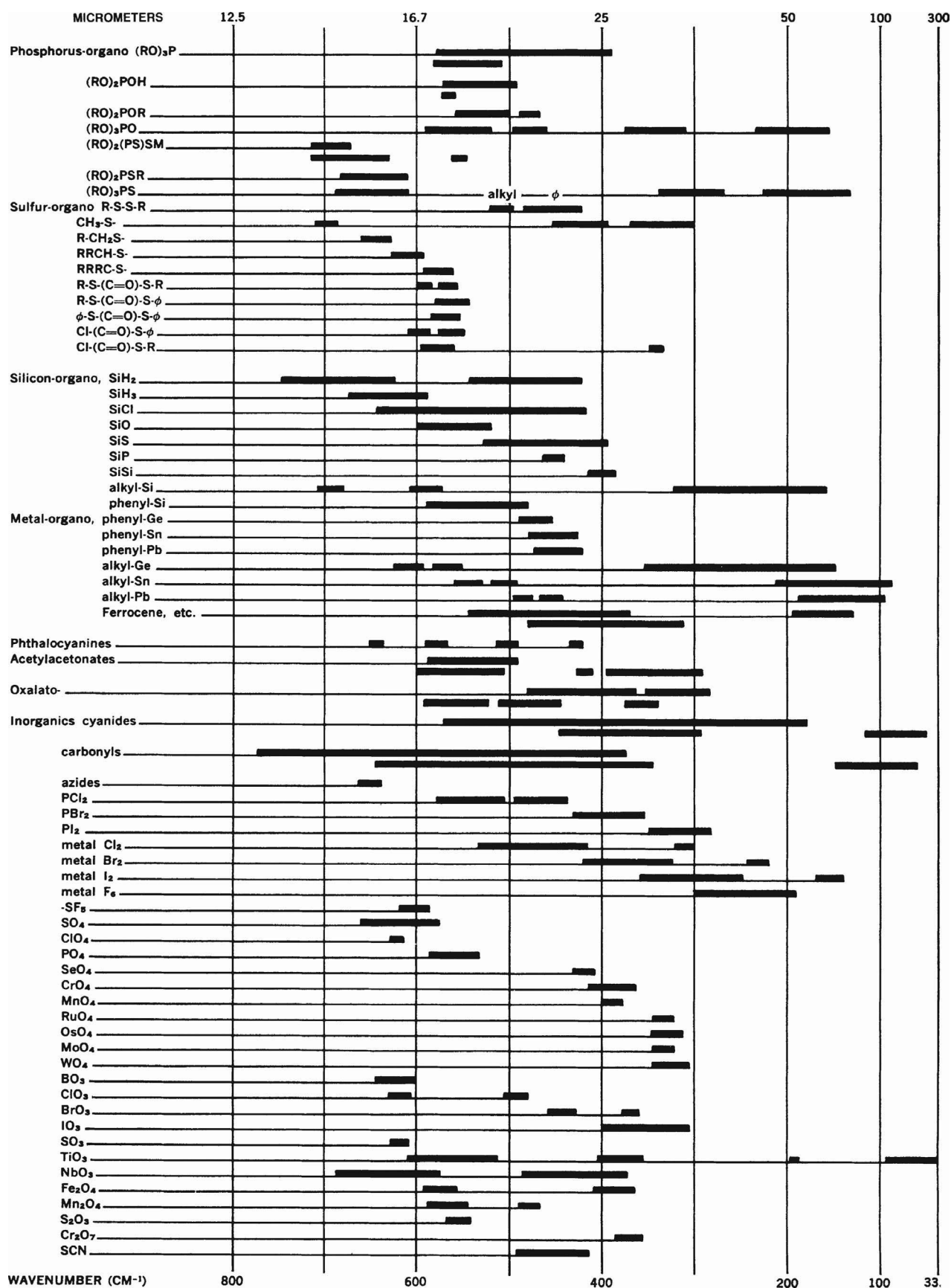




## Far Infrared Region







# NUCLEAR SPINS, MOMENTS, AND OTHER DATA RELATED TO NMR SPECTROSCOPY

This table presents the following data relevant to nuclear magnetic resonance spectroscopy:

**Z:** Atomic number

**Isotope:** Element symbol and mass number

**Abundance:** Natural abundance of the isotope in percent. An \* indicates a radioactive nuclide; if no value is given, the nuclide is not present in nature or its abundance is highly variable.

**I:** Nuclear spin

**$\nu$ :** Resonant frequency in megahertz for an applied field  $H_0$  of 1 tesla (in cgs units, 10 kilogauss). The resonant frequency scales with  $H_0$ .

**Relative sensitivity:** Sensitivity relative to  $^1\text{H}$  (=1) assuming an equal number of nuclei and constant temperature. Values were calculated from the expressions:

For constant  $H_0$ :  $0.0076508(\mu/\mu_N)^3(I+1)/I^2$

For constant  $\nu$ :  $0.23871(\mu/\mu_N)(I+1)$

**$\mu/\mu_N$ :** Nuclear magnetic moment in units of the nuclear magneton  $\mu_N$

**Q:** Nuclear quadrupole moment in units of femtometers squared ( $1 \text{ fm}^2 = 10^{-2} \text{ barn}$ ). Because the determination of quadrupole moments requires knowledge of the electron configuration

near the nucleus, values of Q in the literature tend to scatter considerably. The values quoted here come mainly from the review of Pykkö (Ref. 3), otherwise from Ref. 1.

The table includes all stable nuclides of non-zero spin for which spin and magnetic moment values have been measured, as well as selected radioactive nuclides of current or potential interest. At least one isotope is included for each element through  $Z = 95$  for which data are available. See Reference 1 for a complete listing of spins and moments.

The assistance of P. Pykkö in providing data on nuclear quadrupole moments is gratefully acknowledged.

## References

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2. Raghavan, P., *At. Data Nuc. Data Tables*, 42, 189, 1989.
3. Pykkö, P., *Mol. Phys.* 106, 1965, 2008.
4. Stone, N. J., *At. Data Nucl. Data Tables*, 90, 75, 2005.
5. IUPAC Commission on Physicochemical Symbols, Terminology and Units, *Quantities, Units, and Symbols in Physical Chemistry, Third Edition*, Royal Society of Chemistry, Cambridge, 2007.

| Z  | Isotope          | Abundance<br>% | I   | $\nu$ /MHz for<br>$H_0 = 1 \text{ T}$ | Relative Sensitivity |              | $\mu/\mu_N$  | Q/fm <sup>2</sup> |
|----|------------------|----------------|-----|---------------------------------------|----------------------|--------------|--------------|-------------------|
|    |                  |                |     |                                       | Const. $H_0$         | Const. $\nu$ |              |                   |
| 1  | $^1\text{n}$     |                | 1/2 | 29.1647                               | 0.32139              | 0.6850       | -1.91304272  |                   |
| 1  | $^1\text{H}$     | 99.9885        | 1/2 | 42.5775                               | 1.00000              | 1.0000       | +2.792847337 |                   |
| 1  | $^2\text{H}$     | 0.0115         | 1   | 6.5359                                | 0.00965              | 0.4094       | +0.857438228 | +0.2860           |
| 1  | $^3\text{H}$     | *              | 1/2 | 45.4148                               | 1.21354              | 1.0667       | +2.9789625   |                   |
| 2  | $^3\text{He}$    | 0.000134       | 1/2 | 32.4380                               | 0.44220              | 0.7619       | -2.127750    |                   |
| 3  | $^6\text{Li}$    | 7.59           | 1   | 6.2661                                | 0.00850              | 0.3925       | +0.8220467   | -0.0808           |
| 3  | $^7\text{Li}$    | 92.41          | 3/2 | 16.5483                               | 0.29356              | 1.9434       | +3.25644     | -4.01             |
| 4  | $^9\text{Be}$    | 100            | 3/2 | 5.9842                                | 0.01388              | 0.7028       | -1.1776      | +5.288            |
| 5  | $^{10}\text{B}$  | 19.9           | 3   | 4.5752                                | 0.01985              | 1.7193       | +1.800645    | +8.459            |
| 5  | $^{11}\text{B}$  | 80.1           | 3/2 | 13.6630                               | 0.16522              | 1.6045       | +2.688649    | +4.059            |
| 6  | $^{13}\text{C}$  | 1.07           | 1/2 | 10.7084                               | 0.01591              | 0.2515       | +0.7024118   |                   |
| 7  | $^{14}\text{N}$  | 99.636         | 1   | 3.0777                                | 0.00101              | 0.1928       | +0.4037610   | +2.044            |
| 7  | $^{15}\text{N}$  | 0.364          | 1/2 | 4.3173                                | 0.00104              | 0.1014       | -0.2831888   |                   |
| 8  | $^{17}\text{O}$  | 0.038          | 5/2 | 5.7742                                | 0.02910              | 1.5822       | -1.89379     | -2.558            |
| 9  | $^{19}\text{F}$  | 100            | 1/2 | 40.0776                               | 0.83400              | 0.9413       | +2.628868    |                   |
| 10 | $^{21}\text{Ne}$ | 0.27           | 3/2 | 3.3631                                | 0.00246              | 0.3949       | -0.661797    | +10.155           |
| 11 | $^{23}\text{Na}$ | 100            | 3/2 | 11.2688                               | 0.09270              | 1.3234       | +2.217522    | +10.4             |
| 12 | $^{25}\text{Mg}$ | 10.00          | 5/2 | 2.6083                                | 0.00268              | 0.7147       | -0.85545     | +19.94            |
| 13 | $^{27}\text{Al}$ | 100            | 5/2 | 11.1031                               | 0.20689              | 3.0424       | +3.641507    | +14.66            |
| 14 | $^{29}\text{Si}$ | 4.685          | 1/2 | 8.4655                                | 0.00786              | 0.1988       | -0.55529     |                   |
| 15 | $^{31}\text{P}$  | 100            | 1/2 | 17.2515                               | 0.06652              | 0.4052       | +1.13160     |                   |
| 16 | $^{33}\text{S}$  | 0.75           | 3/2 | 3.2717                                | 0.00227              | 0.3842       | +0.6438212   | -6.78             |
| 17 | $^{35}\text{Cl}$ | 75.76          | 3/2 | 4.1765                                | 0.00472              | 0.4905       | +0.8218743   | -8.165            |
| 17 | $^{37}\text{Cl}$ | 24.24          | 3/2 | 3.4765                                | 0.00272              | 0.4083       | +0.6841236   | -6.435            |
| 18 | $^{37}\text{Ar}$ | *              | 3/2 | 5.819                                 | 0.01276              | 0.6833       | +1.145       | +7.6              |
| 18 | $^{39}\text{Ar}$ | *              | 7/2 | 3.46                                  | 0.01130              | 1.7080       | -1.59        | -12               |
| 19 | $^{39}\text{K}$  | 93.2581        | 3/2 | 1.9893                                | 0.00051              | 0.2336       | +0.3914662   | +5.85             |
| 19 | $^{40}\text{K}$  | 0.0117         | 4   | 2.4737                                | 0.00523              | 1.5493       | -1.298100    | -7.3              |
| 19 | $^{41}\text{K}$  | 6.7302         | 3/2 | 1.0919                                | 0.00008              | 0.1282       | +0.2148701   | +7.11             |

| Z  | Isotope           | Abundance | I   | v/MHz for<br>$H_0 = 1 \text{ T}$ | Relative Sensitivity |          | $\mu/\mu_N$ | Q/fm <sup>2</sup> |
|----|-------------------|-----------|-----|----------------------------------|----------------------|----------|-------------|-------------------|
|    |                   | %         |     |                                  | Const. $H_0$         | Const. v |             |                   |
| 20 | <sup>43</sup> Ca  | 0.135     | 7/2 | 2.8697                           | 0.00643              | 1.4154   | -1.317643   | -4.08             |
| 21 | <sup>45</sup> Sc  | 100       | 7/2 | 10.3591                          | 0.30244              | 5.1094   | +4.756487   | -22.0             |
| 22 | <sup>47</sup> Ti  | 7.44      | 5/2 | 2.4041                           | 0.00210              | 0.6588   | -0.78848    | +30.2             |
| 22 | <sup>49</sup> Ti  | 5.41      | 7/2 | 2.4048                           | 0.00378              | 1.1861   | -1.10417    | +24.7             |
| 23 | <sup>50</sup> V   | 0.250     | 6   | 4.2505                           | 0.05571              | 5.5905   | +3.345689   | +21               |
| 23 | <sup>51</sup> V   | 99.750    | 7/2 | 11.2133                          | 0.38360              | 5.5307   | +5.1487057  | -5.2              |
| 24 | <sup>53</sup> Cr  | 9.501     | 3/2 | 2.4115                           | 0.00091              | 0.2832   | -0.47454    | -15               |
| 25 | <sup>55</sup> Mn  | 100       | 5/2 | 10.5763                          | 0.17881              | 2.8981   | +3.46872    | +33               |
| 26 | <sup>57</sup> Fe  | 2.119     | 1/2 | 1.3816                           | 0.00003              | 0.0324   | +0.0906230  | +16               |
| 27 | <sup>59</sup> Co  | 100       | 7/2 | 10.077                           | 0.27841              | 4.9703   | +4.627      | +42               |
| 28 | <sup>61</sup> Ni  | 1.1399    | 3/2 | 3.8114                           | 0.00359              | 0.4476   | -0.75002    | +16.2             |
| 29 | <sup>63</sup> Cu  | 69.15     | 3/2 | 11.3188                          | 0.09393              | 1.3292   | +2.2273456  | -22.0             |
| 29 | <sup>65</sup> Cu  | 30.85     | 3/2 | 12.1027                          | 0.11484              | 1.4213   | +2.38161    | -20.4             |
| 30 | <sup>67</sup> Zn  | 4.102     | 5/2 | 2.6685                           | 0.00287              | 0.7312   | +0.875205   | +15.0             |
| 31 | <sup>69</sup> Ga  | 60.108    | 3/2 | 10.2478                          | 0.06971              | 1.2035   | +2.01659    | +17.1             |
| 31 | <sup>71</sup> Ga  | 39.892    | 3/2 | 13.0208                          | 0.14300              | 1.5291   | +2.56227    | +10.7             |
| 32 | <sup>73</sup> Ge  | 7.76      | 9/2 | 1.4897                           | 0.00141              | 1.1547   | -0.8794677  | -19.6             |
| 33 | <sup>75</sup> As  | 100       | 3/2 | 7.3150                           | 0.02536              | 0.8590   | +1.439475   | +31.4             |
| 34 | <sup>77</sup> Se  | 7.63      | 1/2 | 8.1568                           | 0.00703              | 0.1916   | +0.5350422  |                   |
| 35 | <sup>79</sup> Br  | 50.69     | 3/2 | 10.7042                          | 0.07945              | 1.2570   | +2.106400   | +31.3             |
| 35 | <sup>81</sup> Br  | 49.31     | 3/2 | 11.5384                          | 0.09951              | 1.3550   | +2.270562   | +26.2             |
| 36 | <sup>83</sup> Kr  | 11.500    | 9/2 | 1.6442                           | 0.00190              | 1.2744   | -0.970669   | +25.9             |
| 37 | <sup>85</sup> Rb  | 72.17     | 5/2 | 4.1253                           | 0.01061              | 1.1304   | +1.35298    | +27.6             |
| 37 | <sup>87</sup> Rb  | 27.83     | 3/2 | 13.9814                          | 0.17704              | 1.6419   | +2.75131    | +13.35            |
| 38 | <sup>87</sup> Sr  | 7.00      | 9/2 | 1.8525                           | 0.00272              | 1.4358   | -1.093603   | +30.5             |
| 39 | <sup>89</sup> Y   | 100       | 1/2 | 2.0949                           | 0.00012              | 0.0492   | -0.1374154  |                   |
| 40 | <sup>91</sup> Zr  | 11.22     | 5/2 | 3.9748                           | 0.00949              | 1.0892   | -1.30362    | -17.6             |
| 41 | <sup>93</sup> Nb  | 100       | 9/2 | 10.4523                          | 0.48821              | 8.1013   | +6.1705     | -32               |
| 42 | <sup>95</sup> Mo  | 15.90     | 5/2 | 2.7874                           | 0.00327              | 0.7638   | -0.9142     | -2.2              |
| 42 | <sup>97</sup> Mo  | 9.56      | 5/2 | 2.8463                           | 0.00349              | 0.7799   | -0.9335     | +25.5             |
| 43 | <sup>99</sup> Tc  | *         | 9/2 | 9.6294                           | 0.38174              | 7.4635   | +5.6847     | -12.9             |
| 44 | <sup>99</sup> Ru  | 12.76     | 5/2 | 1.9553                           | 0.00113              | 0.5358   | -0.6413     | +7.9              |
| 44 | <sup>101</sup> Ru | 17.06     | 5/2 | 2.1916                           | 0.00159              | 0.6005   | -0.7188     | +45.7             |
| 45 | <sup>103</sup> Rh | 100       | 1/2 | 1.3477                           | 0.00003              | 0.0317   | -0.08840    |                   |
| 46 | <sup>105</sup> Pd | 22.33     | 5/2 | 1.957                            | 0.00113              | 0.5364   | -0.642      | +66.0             |
| 47 | <sup>107</sup> Ag | 51.839    | 1/2 | 1.7331                           | 0.00007              | 0.0407   | -0.1136796  |                   |
| 47 | <sup>109</sup> Ag | 48.161    | 1/2 | 1.9924                           | 0.00010              | 0.0468   | -0.1306906  |                   |
| 48 | <sup>111</sup> Cd | 12.80     | 1/2 | 9.0692                           | 0.00966              | 0.2130   | -0.5948861  |                   |
| 48 | <sup>113</sup> Cd | 12.22     | 1/2 | 9.4871                           | 0.01106              | 0.2228   | -0.6223009  |                   |
| 49 | <sup>113</sup> In | 4.29      | 9/2 | 9.3655                           | 0.35121              | 7.2589   | +5.5289     | +75.9             |
| 49 | <sup>115</sup> In | 95.71     | 9/2 | 9.3856                           | 0.35348              | 7.2745   | +5.5408     | +77.0             |
| 50 | <sup>115</sup> Sn | 0.34      | 1/2 | 14.0077                          | 0.03561              | 0.3290   | -0.91883    |                   |
| 50 | <sup>117</sup> Sn | 7.68      | 1/2 | 15.2610                          | 0.04605              | 0.3584   | -1.00104    |                   |
| 50 | <sup>119</sup> Sn | 8.59      | 1/2 | 15.9660                          | 0.05273              | 0.3750   | -1.04728    |                   |
| 51 | <sup>121</sup> Sb | 57.21     | 5/2 | 10.2551                          | 0.16302              | 2.8101   | +3.3634     | -54.3             |
| 51 | <sup>123</sup> Sb | 42.79     | 7/2 | 5.5532                           | 0.04659              | 2.7390   | +2.5498     | -69.2             |
| 52 | <sup>123</sup> Te | 0.89      | 1/2 | 11.2349                          | 0.01837              | 0.2639   | -0.7369478  |                   |
| 52 | <sup>125</sup> Te | 7.07      | 1/2 | 13.5446                          | 0.03219              | 0.3181   | -0.8884509  |                   |
| 53 | <sup>127</sup> I  | 100       | 5/2 | 8.5778                           | 0.09540              | 2.3504   | +2.813273   | -69.6             |
| 54 | <sup>129</sup> Xe | 26.4006   | 1/2 | 11.8604                          | 0.02162              | 0.2786   | -0.7779763  |                   |
| 54 | <sup>131</sup> Xe | 21.2324   | 3/2 | 3.5159                           | 0.00282              | 0.4129   | +0.6918619  | -11.4             |
| 55 | <sup>133</sup> Cs | 100       | 7/2 | 5.6234                           | 0.04838              | 2.7736   | +2.582025   | -0.343            |
| 56 | <sup>135</sup> Ba | 6.592     | 3/2 | 4.2617                           | 0.00501              | 0.5005   | +0.838627   | +16.0             |
| 56 | <sup>137</sup> Ba | 11.232    | 3/2 | 4.7634                           | 0.00700              | 0.5594   | +0.937365   | +24.5             |
| 57 | <sup>138</sup> La | 0.090     | 5   | 5.6615                           | 0.09404              | 5.3189   | +3.713646   | +45               |

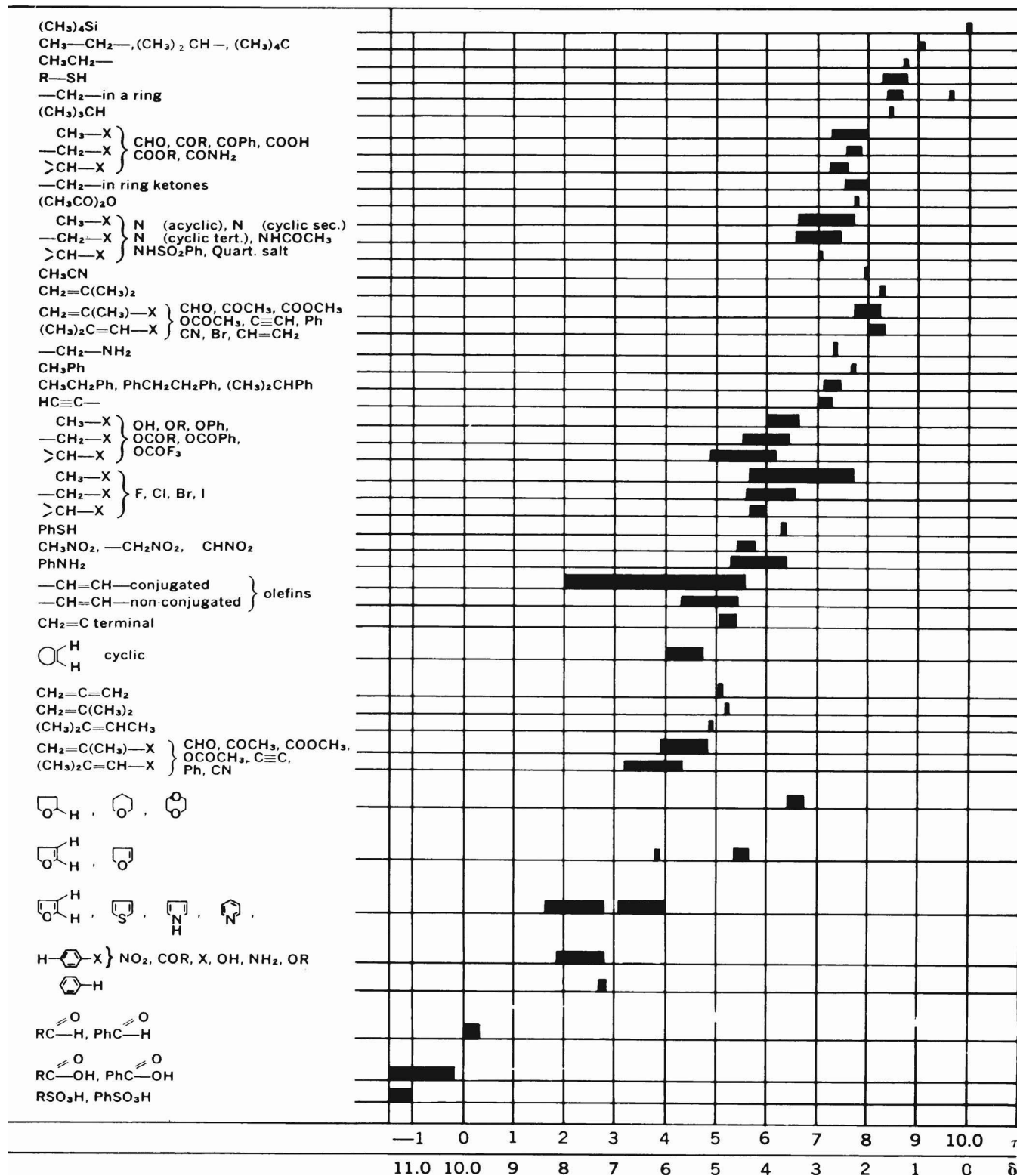
| Z  | Isotope           | Abundance | I   | v/MHz for<br>$H_0 = 1 \text{ T}$ | Relative Sensitivity |          | $\mu/\mu_N$ | Q/fm <sup>2</sup> |
|----|-------------------|-----------|-----|----------------------------------|----------------------|----------|-------------|-------------------|
|    |                   | %         |     |                                  | Const. $H_0$         | Const. v |             |                   |
| 57 | <sup>139</sup> La | 99.910    | 7/2 | 6.0612                           | 0.06058              | 2.9895   | +2.7830455  | +20.0             |
| 58 | <sup>137</sup> Ce | *         | 3/2 | 4.88                             | 0.00752              | 0.5729   | 0.96        |                   |
| 58 | <sup>139</sup> Ce | *         | 3/2 | 5.39                             | 0.01012              | 0.6326   | 1.06        |                   |
| 58 | <sup>141</sup> Ce | *         | 7/2 | 2.37                             | 0.00364              | 1.1709   | 1.09        |                   |
| 59 | <sup>141</sup> Pr | 100       | 5/2 | 13.0359                          | 0.33483              | 3.5720   | +4.2754     | -5.9              |
| 60 | <sup>143</sup> Nd | 12.2      | 7/2 | 2.319                            | 0.00339              | 1.1440   | -1.065      | -63               |
| 60 | <sup>145</sup> Nd | 8.3       | 7/2 | 1.429                            | 0.00079              | 0.7047   | -0.656      | -33               |
| 61 | <sup>143</sup> Pm | *         | 5/2 | 11.59                            | 0.23510              | 3.1748   | +3.80       |                   |
| 61 | <sup>147</sup> Pm | *         | 7/2 | 5.62                             | 0.04827              | 2.7714   | +2.58       | +74               |
| 62 | <sup>147</sup> Sm | 14.99     | 7/2 | 1.7748                           | 0.00152              | 0.8754   | -0.8149     | -26               |
| 62 | <sup>149</sup> Sm | 13.82     | 7/2 | 1.4631                           | 0.00085              | 0.7216   | -0.6718     | +7.4              |
| 63 | <sup>151</sup> Eu | 47.81     | 5/2 | 10.5856                          | 0.17929              | 2.9006   | +3.4718     | +90.3             |
| 63 | <sup>153</sup> Eu | 52.19     | 5/2 | 4.6745                           | 0.01544              | 1.2809   | +1.5331     | +241              |
| 64 | <sup>155</sup> Gd | 14.80     | 3/2 | 1.312                            | 0.00015              | 0.1541   | -0.2582     | +127              |
| 64 | <sup>157</sup> Gd | 15.65     | 3/2 | 1.720                            | 0.00033              | 0.2020   | -0.3385     | +135              |
| 65 | <sup>159</sup> Tb | 100       | 3/2 | 10.23                            | 0.06945              | 1.2019   | +2.014      | +143.2            |
| 66 | <sup>161</sup> Dy | 18.889    | 5/2 | 1.4654                           | 0.00048              | 0.4015   | -0.4806     | +250.7            |
| 66 | <sup>163</sup> Dy | 24.896    | 5/2 | 2.0508                           | 0.00130              | 0.5619   | +0.6726     | +265              |
| 67 | <sup>165</sup> Ho | 100       | 7/2 | 9.0883                           | 0.20423              | 4.4826   | +4.173      | +358              |
| 68 | <sup>167</sup> Er | 22.869    | 7/2 | 1.2281                           | 0.00050              | 0.6057   | -0.5639     | +356.5            |
| 69 | <sup>169</sup> Tm | 100       | 1/2 | 3.531                            | 0.00057              | 0.0829   | -0.2316     | -120              |
| 70 | <sup>171</sup> Yb | 14.28     | 1/2 | 7.5261                           | 0.00552              | 0.1768   | +0.49367    |                   |
| 70 | <sup>173</sup> Yb | 16.13     | 5/2 | 2.0730                           | 0.00135              | 0.5680   | -0.67989    | +280              |
| 71 | <sup>175</sup> Lu | 97.41     | 7/2 | 4.8626                           | 0.03128              | 2.3984   | +2.2327     | +349              |
| 71 | <sup>176</sup> Lu | 2.59      | 7   | 3.451                            | 0.03975              | 6.0518   | +3.169      | +497              |
| 72 | <sup>177</sup> Hf | 18.60     | 7/2 | 1.7282                           | 0.00140              | 0.8524   | +0.7935     | +336.5            |
| 72 | <sup>179</sup> Hf | 13.62     | 9/2 | 1.0856                           | 0.00055              | 0.8414   | -0.6409     | +379.3            |
| 73 | <sup>181</sup> Ta | 99.988    | 7/2 | 5.1627                           | 0.03744              | 2.5464   | +2.3705     | +317              |
| 74 | <sup>183</sup> W  | 14.31     | 1/2 | 1.7957                           | 0.00008              | 0.0422   | +0.1177848  |                   |
| 75 | <sup>185</sup> Re | 37.40     | 5/2 | 9.7176                           | 0.13870              | 2.6628   | +3.1871     | +218              |
| 75 | <sup>187</sup> Re | 62.60     | 5/2 | 9.8170                           | 0.14300              | 2.6900   | +3.2197     | +207              |
| 76 | <sup>187</sup> Os | 1.96      | 1/2 | 0.9856                           | 0.00001              | 0.0231   | +0.06465189 |                   |
| 76 | <sup>189</sup> Os | 16.15     | 3/2 | 3.3536                           | 0.00244              | 0.3938   | +0.659933   | +85.6             |
| 77 | <sup>191</sup> Ir | 37.3      | 3/2 | 0.7658                           | 0.00003              | 0.0899   | +0.1507     | +81.6             |
| 77 | <sup>193</sup> Ir | 62.7      | 3/2 | 0.8319                           | 0.00004              | 0.0977   | +0.1637     | +75.1             |
| 78 | <sup>195</sup> Pt | 33.832    | 1/2 | 9.2922                           | 0.01039              | 0.2182   | +0.60952    |                   |
| 79 | <sup>197</sup> Au | 100       | 3/2 | 0.7406                           | 0.00003              | 0.0870   | +0.145746   | +54.7             |
| 80 | <sup>199</sup> Hg | 16.87     | 1/2 | 7.7123                           | 0.00594              | 0.1811   | +0.5058855  |                   |
| 80 | <sup>201</sup> Hg | 13.18     | 3/2 | 2.8469                           | 0.00149              | 0.3343   | -0.5602257  | +38.7             |
| 81 | <sup>203</sup> Tl | 29.52     | 1/2 | 24.7316                          | 0.19598              | 0.5809   | +1.6222579  |                   |
| 81 | <sup>205</sup> Tl | 70.48     | 1/2 | 24.9749                          | 0.20182              | 0.5866   | +1.6382146  |                   |
| 82 | <sup>207</sup> Pb | 22.1      | 1/2 | 9.0340                           | 0.00955              | 0.2122   | +0.59258    |                   |
| 83 | <sup>209</sup> Bi | 100       | 9/2 | 6.9630                           | 0.14433              | 5.3968   | +4.1106     | -51.6             |
| 84 | <sup>209</sup> Po | *         | 1/2 | 11.7                             | 0.02096              | 0.2757   | +0.77       |                   |
| 86 | <sup>211</sup> Rn | *         | 1/2 | 9.16                             | 0.00997              | 0.2152   | +0.601      |                   |
| 87 | <sup>223</sup> Fr | *         | 3/2 | 5.95                             | 0.01362              | 0.6982   | +1.17       | +117              |
| 88 | <sup>223</sup> Ra | *         | 3/2 | 1.3746                           | 0.00017              | 0.1614   | +0.2705     | +121              |
| 88 | <sup>225</sup> Ra | *         | 1/2 | 11.187                           | 0.01814              | 0.2627   | -0.7338     |                   |
| 89 | <sup>227</sup> Ac | *         | 3/2 | 5.6                              | 0.01131              | 0.6565   | +1.1        | +170              |
| 90 | <sup>229</sup> Th | *         | 5/2 | 1.40                             | 0.00042              | 0.3843   | +0.46       | +430              |
| 91 | <sup>231</sup> Pa | 100       | 3/2 | 10.2                             | 0.06903              | 1.1995   | 2.01        | -172              |
| 92 | <sup>235</sup> U  | 0.7204    | 7/2 | 0.83                             | 0.00015              | 0.4082   | -0.38       | +493.6            |
| 93 | <sup>237</sup> Np | *         | 5/2 | 9.57                             | 0.13264              | 2.6234   | +3.14       | +388.6            |
| 94 | <sup>239</sup> Pu | *         | 1/2 | 3.09                             | 0.00038              | 0.0727   | +0.203      |                   |
| 95 | <sup>243</sup> Am | *         | 5/2 | 4.6                              | 0.01446              | 1.2532   | +1.5        | +421              |

# PROTON NMR CHEMICAL SHIFTS FOR CHARACTERISTIC ORGANIC STRUCTURES

The chart below summarizes the range of chemical shifts for protons in several classes of organic compounds and substituent groups. The chemical shifts  $\delta$  are given in parts per million relative to tetramethylsilane.

## Reference

Mohacsi, E., *J. Chem. Edu.*, 41, 38, 1964 (with permission)



## $^{13}\text{C}$ -NMR ABSORPTIONS OF MAJOR FUNCTIONAL GROUPS

The table below lists the range of  $^{13}\text{C}$  chemical shifts  $\delta$  in parts per million relative to tetramethylsilane, in descending order, for various functional groups. Examples of simple compounds for each family are given to illustrate the correlations. The shifts for the carbons of interest, which are italicized, are given in parentheses; when two or more values appear, they refer to the sequence of italicized carbon atoms from left to right in the formula.

### References

1. Yoder, C. H. and Schaeffer, C. D., Jr., *Introduction to Multinuclear NMR: Theory and Application*, Benjamin/Cummings, Menlo Park, CA, 1987.
2. Silverstein, R. M., Bassler, G. C., and Morrill, T. C., *Spectrometric Identification of Organic Compounds*, John Wiley & Sons, New York, 1981.
3. Brown, D. W., A Short Set of  $^{13}\text{C}$  NMR Correlation Tables, *J. Chem. Educ.*, 62, 209, 1985.

| $\delta$ (ppm) | Group                   | Family                      | Example<br>( $\delta$ of italicized carbon)               |                    |
|----------------|-------------------------|-----------------------------|-----------------------------------------------------------|--------------------|
| 220-165        | $>\text{C}=\text{O}$    | Ketones                     | $(\text{CH}_3)_2\text{CO}$                                | (206.0)            |
|                |                         |                             | $(\text{CH}_3)_2\text{CHCOCH}_3$                          | (212.1)            |
|                |                         | Aldehydes                   | $\text{CH}_3\text{CHO}$                                   | (199.7)            |
|                |                         | $\alpha,\beta$ -Unsaturated | $\text{CH}_3\text{CH}=\text{CHCHO}$                       | (192.4)            |
|                |                         | carbonyls                   | $\text{CH}_2=\text{CHCOCH}_3$                             | (169.9)            |
|                |                         | Carboxylic acids            | $\text{HCO}_2\text{H}$                                    | (166.0)            |
|                |                         |                             | $\text{CH}_3\text{CO}_2\text{H}$                          | (178.1)            |
|                |                         | Amides                      | $\text{HCONH}_2$                                          | (165.0)            |
|                |                         |                             | $\text{CH}_3\text{CONH}_2$                                | (172.7)            |
|                |                         | Esters                      | $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3$            | (170.3)            |
|                |                         |                             | $\text{CH}_2=\text{CHCO}_2\text{CH}_3$                    | (165.5)            |
|                |                         |                             | $\text{C}_6\text{H}_6$                                    | (128.5)            |
| 140-120        | $>\text{C}=\text{C}<$   | Aromatic                    |                                                           |                    |
|                |                         | Alkenes                     | $\text{CH}_2=\text{CH}_2$                                 | (123.2)            |
|                |                         |                             | $\text{CH}_2=\text{CHCH}_3$                               | (115.9, 136.2)     |
|                |                         |                             | $\text{CH}_2=\text{CHCH}_2\text{Cl}$                      | (117.5, 133.7)     |
|                |                         |                             | $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$           | (132.7)            |
| 125-115        | $-\text{CN}$            | Nitriles                    | $\text{CH}_3-\text{CN}$                                   | (117.7)            |
| 80-70          | $-\text{CC}-$           | Alkynes                     | $\text{HCCH}$                                             | (71.9)             |
|                |                         |                             | $\text{CH}_3\text{CCH}_3$                                 | (73.9)             |
| 70-45          | $-\text{C}-\text{O}$    | Esters                      | $\text{CH}_3\text{OOCH}_2\text{CH}_3$                     | (57.6, 67.9)       |
|                |                         | Alcohols                    | $\text{HOCH}_3$                                           | (49.0)             |
|                |                         |                             | $\text{HOCH}_2\text{CH}_3$                                | (57.0)             |
| 40-20          | $-\text{C}-\text{NH}_2$ | Amines                      | $\text{CH}_3\text{NH}_2$                                  | (26.9)             |
|                |                         |                             | $\text{CH}_3\text{CH}_2\text{NH}_2$                       | (35.9)             |
| 30-15          | $-\text{S}-\text{CH}_3$ | Sulfides (thioethers)       | $\text{C}_6\text{H}_5-\text{S}-\text{CH}_3$               | 15.6               |
| 30-(-2.3)      | $-\text{C}-\text{H}$    | Alkanes, cycloalkanes       | $\text{CH}_4$                                             | (-2.3)             |
|                |                         |                             | $\text{CH}_3\text{CH}_3$                                  | (5.7)              |
|                |                         |                             | $\text{CH}_3\text{CH}_2\text{CH}_3$                       | (15.8, 16.3)       |
|                |                         |                             | $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$            | (13.4, 25.2)       |
|                |                         |                             | $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ | (13.9, 22.8, 34.7) |
|                |                         | Cyclohexane                 |                                                           | (26.9)             |

## BOND LENGTHS IN ORGANOMETALLIC COMPOUNDS

This table summarizes the average values of interatomic distances of representative metal–ligand bonds. Sigma bonds between *d*- and *f*-block metals and the elements C, N, O, P, S, and As are included. The values are extracted from a much larger list in Reference 1. The tabulated values are the unweighted means of reported measurements on compounds in each category. If four or more measurements are available, the standard deviation is given in parentheses. All values are in Ångstrom units ( $10^{-10}$  m).

The first part of the table covers metal-carbon bonds in different ligand categories, while the second part covers metal bonds to

other elements. R stands for any alkyl group; Me for a  $\text{CH}_3$  group;  $\text{C}_6\text{R}_5$  indicates an aryl group; and  $\text{C}(=\text{O})\text{R}$  an acyl group. Metals are listed in atomic number order.

### Reference

1. Orpen, A. G., Brammer, L., Allen, F.H., Kennard, O., Watson, D. G., and Taylor, R., *J. Chem. Soc. Dalton Trans.*, 1989, S1-S83.

| M  | M-CH <sub>3</sub> | M-CH <sub>2</sub> R | M-CR=CR <sub>2</sub> | M-C <sub>6</sub> R <sub>5</sub> | M-C(=O)R     |
|----|-------------------|---------------------|----------------------|---------------------------------|--------------|
| Ti |                   | 2.167               | 2.215(0.042)         | 2.148                           |              |
| V  |                   |                     |                      | 2.114(0.012)                    |              |
| Cr | 2.168             |                     | 2.035(0.009)         | 2.075(0.019)                    |              |
| Mn | 2.095(0.030)      | 2.176(0.024)        | 2.007                | 2.064(0.021)                    | 2.044        |
| Fe | 2.074             | 2.091(0.030)        | 1.991(0.039)         | 2.031(0.062)                    | 1.997(0.033) |
| Co | 2.014(0.023)      | 2.039(0.032)        | 1.934(0.019)         | 1.974                           | 1.990        |
| Ni | 2.029             | 1.964               | 1.892(0.017)         | 1.917(0.038)                    | 1.850(0.059) |
| Cu |                   |                     |                      | 2.020                           |              |
| Zn |                   | 1.964               |                      |                                 |              |
| Zr | 2.292(0.049)      |                     | 2.257                |                                 |              |
| Nb | 2.336             | 1.319               |                      |                                 |              |
| Mo | 2.254(0.065)      | 2.250(0.061)        | 2.204(0.049)         | 2.193(0.054)                    | 2.109        |
| Ru | 2.179(0.045)      | 2.036(0.010)        | 2.063                | 2.092(0.057)                    | 2.091        |
| Rh | 2.092(0.027)      | 2.100               | 2.040(0.054)         | 2.011(0.026)                    | 1.995(0.031) |
| Pd |                   | 2.028               | 2.000(0.024)         | 1.981(0.032)                    | 1.982(0.029) |
| Hf | 2.275(0.049)      |                     | 2.205                |                                 |              |
| Ta | 2.217(0.035)      | 2.225(0.056)        |                      | 2.199(0.073)                    |              |
| W  | 2.189(0.039)      | 2.175               | 2.224                |                                 |              |
| Re | 2.173(0.051)      | 2.290               |                      | 2.027                           | 2.190(0.027) |
| Os |                   | 2.221               | 2.052                | 2.090(0.032)                    | 2.161        |
| Ir | 2.175             |                     | 2.071(0.044)         | 2.070(0.038)                    | 2.019        |
| Pt | 2.083(0.045)      | 2.062(0.031)        | 2.024(0.037)         | 2.049(0.046)                    | 1.991(0.025) |
| Au | 2.066(0.045)      |                     | 2.042                | 2.059(0.024)                    |              |
| Hg | 2.072(0.026)      | 2.125               |                      | 2.086(0.040)                    |              |
| Th | 2.567             |                     |                      |                                 |              |

| M  | M-NH <sub>3</sub> | M-OH <sub>2</sub> | M-PMe <sub>3</sub> | M-SR         | M-AsR <sub>3</sub> |
|----|-------------------|-------------------|--------------------|--------------|--------------------|
| Ti |                   | 2.066(0.052)      |                    | 2.369        | 2.686              |
| V  |                   | 2.129(0.131)      | 2.510(0.010)       | 2.378(0.007) |                    |
| Cr | 2.069(0.008)      | 1.997(0.070)      | 2.389(0.069)       | 2.362        | 2.460(0.040)       |
| Mn |                   | 2.189(0.040)      | 2.455(0.164)       | 2.366(0.054) | 2.400(0.013)       |
| Fe |                   | 2.085(0.066)      | 2.246(0.042)       | 2.271(0.028) | 2.352(0.043)       |
| Co | 1.965(0.021)      | 2.085(0.064)      | 2.217(0.043)       | 2.254(0.025) | 2.323(0.021)       |
| Ni | 2.074(0.093)      | 2.079(0.038)      | 2.204(0.031)       | 2.187(0.007) | 2.333(0.035)       |
| Cu | 1.987(0.017)      | 2.186(0.215)      |                    |              | 2.367(0.016)       |
| Zn | 2.044             | 2.090(0.061)      |                    | 2.295        |                    |
| Y  |                   | 2.398(0.068)      |                    |              |                    |
| Zr |                   |                   | 2.692              |              |                    |
| Nb |                   | 2.248(0.137)      |                    |              | 2.741(0.008)       |
| Mo | 2.217             | 2.201(0.094)      | 2.462(0.046)       | 2.401(0.050) | 2.582(0.036)       |
| Ru | 2.126(0.024)      | 2.074(0.051)      | 2.307(0.050)       |              | 2.446(0.031)       |
| Rh | 2.114(0.018)      | 2.190(0.096)      | 2.266(0.036)       |              | 2.416(0.039)       |
| Pd | 2.032             | 2.200             | 2.287(0.018)       |              | 2.386(0.052)       |
| Ag |                   | 2.350             |                    |              |                    |
| Cd |                   | 2.318(0.065)      |                    | 2.444        |                    |
| La |                   | 2.556(0.062)      |                    |              |                    |
| Ce |                   | 2.565(0.063)      |                    |              |                    |
| Pr |                   | 2.518(0.038)      |                    |              |                    |
| Nd |                   | 2.533(0.058)      |                    |              |                    |
| Sm |                   | 2.459(0.050)      |                    |              |                    |
| Eu |                   | 2.441(0.055)      |                    |              |                    |
| Gd |                   | 2.443(0.074)      |                    |              |                    |
| Tb |                   | 2.455             |                    |              |                    |
| Dy |                   | 2.409(0.074)      |                    |              |                    |
| Ho |                   | 2.407(0.069)      |                    |              |                    |
| Er |                   | 2.404(0.083)      |                    |              |                    |
| Yb |                   | 2.353(0.066)      |                    |              |                    |
| Lu |                   | 2.404(0.116)      |                    |              |                    |
| Ta |                   |                   | 2.589(0.044)       |              |                    |
| W  |                   | 2.115(0.065)      | 2.485(0.039)       |              |                    |
| Re | 2.253             | 2.199(0.091)      | 2.369(0.065)       |              | 2.575(0.006)       |
| Os | 2.136             | 2.166             | 2.328(0.029)       |              |                    |
| Ir | 2.050(0.021)      |                   | 2.323(0.028)       | 2.461        |                    |
| Pt |                   |                   | 2.295(0.036)       | 2.320(0.015) | 2.366(0.058)       |
| Au |                   | 2.157             |                    | 2.293        |                    |
| Hg |                   | 2.690(0.083)      |                    | 2.402(0.065) |                    |
| Th |                   | 2.483(0.032)      |                    |              |                    |
| U  |                   | 2.455(0.047)      |                    |              |                    |



## CHARACTERISTIC BOND LENGTHS IN FREE MOLECULES

This is a summary of typical bond lengths in gas-phase molecules. The value given for each bond is near the mid-range of values found in simple molecules. Bond lengths usually vary by 1 or 2%, and often by more, depending on the nature of the other bonds attached to the two atoms in question. References 1 and 2 give bond lengths in individual gas-phase molecules, as determined by spectroscopic and electron diffraction methods.

All bond distances are given in Å (1 Å = 10<sup>-10</sup> m).

### References

1. "Bond Lengths and Angles in Gas-Phase Molecules", *CRC Handbook of Chemistry and Physics*, 86th Edition, 2005, p. 9-19.
2. Harmony, M. D., Laurie, V. W., Kuczkowski, R. L., Schwendeman, R. H., Ramsay, D. A., Lovas, F. J., Lafferty, W. J., and Maki, A. G., Molecular structure of gas-phase polyatomic molecules determined by spectroscopic methods, *J. Phys. Chem. Ref. Data* 8, 619, 1979.
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### A. Characteristic lengths of single bonds.

|    | As   | Br   | C    | Cl   | F    | Ge   | H    | I    | N    | O    | P    | S    | Sb | Se   | Si   |
|----|------|------|------|------|------|------|------|------|------|------|------|------|----|------|------|
| As | 2.10 |      |      |      |      |      |      |      |      |      |      |      |    |      |      |
| Br | 2.32 | 2.28 |      |      |      |      |      |      |      |      |      |      |    |      |      |
| C  | 1.96 | 1.94 | 1.53 |      |      |      |      |      |      |      |      |      |    |      |      |
| Cl | 2.17 | 2.14 | 1.79 | 1.99 |      |      |      |      |      |      |      |      |    |      |      |
| F  | 1.71 | 1.76 | 1.39 | 1.63 | 1.41 |      |      |      |      |      |      |      |    |      |      |
| Ge |      | 2.30 | 1.95 | 2.15 | 1.73 | 2.40 |      |      |      |      |      |      |    |      |      |
| H  | 1.51 | 1.41 | 1.09 | 1.28 | 0.92 | 1.53 | 0.74 |      |      |      |      |      |    |      |      |
| I  |      | 2.47 | 2.13 | 2.32 | 1.91 | 2.51 | 1.61 | 2.67 |      |      |      |      |    |      |      |
| N  |      |      | 1.46 | 1.90 | 1.37 |      | 1.02 |      | 1.45 |      |      |      |    |      |      |
| O  |      |      | 1.42 | 1.70 | 1.42 |      | 0.96 |      | 1.43 | 1.48 |      |      |    |      |      |
| P  |      | 2.22 | 1.85 | 2.04 | 1.57 |      | 1.42 |      | 1.65 |      | 2.25 |      |    |      |      |
| S  |      | 2.24 | 1.82 | 2.05 | 1.56 |      | 1.34 |      |      |      |      | 2.00 |    |      |      |
| Sb |      |      |      | 2.33 |      |      | 1.70 |      |      |      |      |      |    |      |      |
| Se |      |      | 1.95 |      | 1.71 |      | 1.47 |      |      |      |      |      |    | 2.33 |      |
| Si |      | 2.21 | 1.87 | 2.05 | 1.58 |      | 1.48 | 2.44 |      | 1.63 |      | 2.14 |    |      | 2.33 |
| Sn |      |      | 2.14 | 2.28 |      |      | 1.71 | 2.67 |      |      |      |      |    |      |      |
| Te |      |      |      |      | 1.82 |      | 1.66 |      |      |      |      |      |    |      |      |

### B. Lengths of multiple bonds (non-ring molecules).

|     |      |
|-----|------|
| C=C | 1.34 |
| C≡C | 1.20 |
| C=N | 1.21 |
| C≡N | 1.16 |
| C=O | 1.21 |
| C=S | 1.61 |
| N=N | 1.24 |
| N≡N | 1.13 |
| N=O | 1.18 |
| O=O | 1.21 |

### C. Effect of environment on carbon-carbon single bonds (other single bonds not shown). From Reference 3.

| Configuration | C-C length | Examples of molecules                  |
|---------------|------------|----------------------------------------|
| C-C           | 1.526      | H <sub>3</sub> C-CH <sub>3</sub>       |
| C-C=          | 1.501      | H <sub>3</sub> C-CH=CH <sub>2</sub>    |
| C-C≡          | 1.459      | H <sub>3</sub> C-C≡CH                  |
| =C-C=         | 1.467      | H <sub>2</sub> C=CH-CH=CH <sub>2</sub> |
| ≡C-C=         | 1.445      | HC≡C-CH=CH <sub>2</sub>                |
| ≡C-C≡         | 1.378      | HC≡C-C≡CH                              |

### D. Some metal-carbon bond lengths in gas-phase molecules.

|      |      |      |      |      |      |
|------|------|------|------|------|------|
| Al-C | 1.96 | Bi-C | 2.26 | Pb-C | 2.24 |
| B-C  | 1.58 | Cd-C | 2.11 | Sn-C | 2.14 |
| Be-C | 1.70 | Hg-C | 2.08 | Zn-C | 1.93 |

## ATOMIC RADII OF THE ELEMENTS

The simple model of an atom as a hard sphere that can approach only to a fixed distance from another atom to which it is not bonded has proved useful in interpreting crystal structures and other molecular properties. The term van der Waals radius,  $r_{\text{vdw}}$ , was originally introduced by Pauling as a measure of this atomic size. Thus in a closely packed structure two non-bonded atoms A and B will be separated by the sum of their van der Waals radii  $r_{\text{vdw}}$  (A) and  $r_{\text{vdw}}$  (B). The set of van der Waals radii proposed by Pauling was refined by Bondi (Reference 1) based on crystallographic data, gas kinetic collision cross sections, and liquid state properties. The non-bonded contact distances predicted from the recommended  $r_{\text{vdw}}$  of Bondi have been compared with actual data in the collection of the Cambridge Crystallographic Data Center by Rowland and Taylor (Reference 2) and modified slightly. Their recommended van der Waals radii are given in the third column of this table.

The Cambridge Crystallographic Data Center also makes use of a set of "covalent radii" to determine which atoms in a crystal are bonded to each other. Thus two atoms A and B are judged to be connected by a covalent bond if their separation falls within a tolerance of  $\pm 0.4 \text{ \AA}$  of the sum  $r_{\text{cov}}$  (A) +  $r_{\text{cov}}$  (B). The covalent radii are given in the fourth column of the table.

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| Element     | Symbol | $r_{\text{vdw}}/\text{\AA}$ | $r_{\text{cov}}/\text{\AA}$ | Element      | Symbol | $r_{\text{vdw}}/\text{\AA}$ | $r_{\text{cov}}/\text{\AA}$ | Element      | Symbol | $r_{\text{vdw}}/\text{\AA}$ | $r_{\text{cov}}/\text{\AA}$ |
|-------------|--------|-----------------------------|-----------------------------|--------------|--------|-----------------------------|-----------------------------|--------------|--------|-----------------------------|-----------------------------|
| Actinium    | Ac     |                             | 1.88                        | Hafnium      | Hf     |                             | 1.57                        | Promethium   | Pm     |                             | 1.80                        |
| Aluminum    | Al     |                             | 1.35                        | Helium       | He     | 1.40                        |                             | Protactinium | Pa     |                             | 1.61                        |
| Americium   | Am     |                             | 1.51                        | Holmium      | Ho     |                             | 1.74                        | Radium       | Ra     |                             | 1.90                        |
| Antimony    | Sb     |                             | 1.46                        | Hydrogen     | H      | 1.09                        | 0.23                        | Rhenium      | Re     |                             | 1.35                        |
| Argon       | Ar     | 1.88                        | 1.51                        | Indium       | In     | 1.93                        | 1.63                        | Rhodium      | Rh     |                             | 1.45                        |
| Arsenic     | As     | 1.85                        | 1.21                        | Iodine       | I      | 1.98                        | 1.40                        | Rubidium     | Rb     |                             | 1.47                        |
| Astatine    | At     |                             | 1.21                        | Iridium      | Ir     |                             | 1.32                        | Ruthenium    | Ru     |                             | 1.40                        |
| Barium      | Ba     |                             | 1.34                        | Iron         | Fe     |                             | 1.34                        | Samarium     | Sm     |                             | 1.80                        |
| Berkelium   | Bk     |                             | 1.54                        | Krypton      | Kr     | 2.02                        |                             | Scandium     | Sc     |                             | 1.44                        |
| Beryllium   | Be     |                             | 0.35                        | Lanthanum    | La     |                             | 1.87                        | Selenium     | Se     | 1.90                        | 1.22                        |
| Bismuth     | Bi     |                             | 1.54                        | Lead         | Pb     | 2.02                        | 1.54                        | Silicon      | Si     | 2.10                        | 1.20                        |
| Boron       | B      |                             | 0.83                        | Lithium      | Li     | 1.82                        | 0.68                        | Silver       | Ag     | 1.72                        | 1.59                        |
| Bromine     | Br     | 1.85                        | 1.21                        | Lutetium     | Lu     |                             | 1.72                        | Sodium       | Na     | 2.27                        | 0.97                        |
| Cadmium     | Cd     | 1.58                        | 1.69                        | Magnesium    | Mg     | 1.73                        | 1.10                        | Strontium    | Sr     |                             | 1.12                        |
| Cesium      | Cs     |                             | 1.67                        | Manganese    | Mn     |                             | 1.35                        | Sulfur       | S      | 1.80                        | 1.02                        |
| Calcium     | Ca     |                             | 0.99                        | Mercury      | Hg     | 1.55                        | 1.70                        | Tantalum     | Ta     |                             | 1.43                        |
| Californium | Cf     |                             | 1.83                        | Molybdenum   | Mo     |                             | 1.47                        | Technetium   | Tc     |                             | 1.35                        |
| Carbon      | C      | 1.70                        | 0.68                        | Neodymium    | Nd     |                             | 1.81                        | Tellurium    | Te     | 2.06                        | 1.47                        |
| Cerium      | Ce     |                             | 1.83                        | Neon         | Ne     | 1.54                        |                             | Terbium      | Tb     |                             | 1.76                        |
| Chlorine    | Cl     | 1.75                        | 0.99                        | Neptunium    | Np     |                             | 1.55                        | Thallium     | Tl     | 1.96                        | 1.55                        |
| Chromium    | Cr     |                             | 1.35                        | Nickel       | Ni     | 1.63                        |                             | Thorium      | Th     |                             | 1.79                        |
| Cobalt      | Co     |                             | 1.33                        | Niobium      | Nb     |                             | 1.48                        | Thulium      | Tm     |                             | 1.72                        |
| Copper      | Cu     | 1.40                        | 1.52                        | Nitrogen     | N      | 1.55                        | 0.68                        | Tin          | Sn     | 2.17                        | 1.46                        |
| Curium      | Cm     |                             | 0.99                        | Osmium       | Os     |                             | 1.37                        | Titanium     | Ti     |                             | 1.47                        |
| Dysprosium  | Dy     |                             | 1.75                        | Oxygen       | O      | 1.52                        | 0.68                        | Tungsten     | W      |                             | 1.37                        |
| Erbium      | Er     |                             | 1.73                        | Palladium    | Pd     | 1.63                        |                             | Uranium      | U      | 1.86                        | 1.58                        |
| Europium    | Eu     |                             | 1.99                        | Phosphorus   | P      | 1.80                        | 1.05                        | Vanadium     | V      |                             | 1.33                        |
| Fluorine    | F      | 1.47                        | 0.64                        | Platinum     | Pt     | 1.72                        |                             | Xenon        | Xe     | 2.16                        |                             |
| Gadolinium  | Gd     |                             | 1.79                        | Plutonium    | Pu     |                             | 1.53                        | Ytterbium    | Yb     |                             | 1.94                        |
| Gallium     | Ga     | 1.87                        | 1.22                        | Polonium     | Po     |                             | 1.68                        | Yttrium      | Y      |                             | 1.78                        |
| Germanium   | Ge     |                             | 1.17                        | Potassium    | K      | 2.75                        | 1.33                        | Zinc         | Zn     | 1.39                        | 1.45                        |
| Gold        | Au     | 1.66                        |                             | Praseodymium | Pr     |                             | 1.82                        | Zirconium    | Zr     |                             | 1.56                        |

# HINDERED INTERNAL ROTATION

I. Ozier and N. Moazzen-Ahmadi

In asymmetric tops like methyl alcohol,  $\text{CH}_3\text{OH}$ , and symmetric rotors like  $\text{CH}_3\text{SiH}_3$ , the methyl group can undergo internal rotation relative to the rest of the molecule, traditionally called the frame (LS59, OM07). Although various different tops are considered here, all have three-fold symmetry. In such cases, the potential  $V$  hindering the internal rotation can be written:

$$V(\alpha) = V_3(\frac{1}{2})(1 - \cos 3\alpha) + V_6(\frac{1}{2})(1 - \cos 6\alpha) + V_9(\frac{1}{2})(1 - \cos 9\alpha) + \dots,$$

where  $\alpha$  is the deviation from equilibrium of the angle between the top and frame that measures the torsional motion. If only the first two terms are retained, then  $V_3$  is the height of the hindering potential and  $V_6$  is the shape parameter. For symmetric tops like  $\text{CH}_3\text{CH}_3$  where the top and frame are identical,  $\alpha$  is replaced by  $2\gamma$  and the origin for  $\gamma$  is often taken as the eclipsed configuration. In the expansion,  $-\cos 6n\gamma$  is then replaced by  $(-1)^{n+1}\cos 6n\gamma$ , where  $n = 1, 2, \dots$ . In cases where different forms of the expansion have been used in the original works, the values of the parameters published there have been converted to the conventions defined here.

In Tables 1 and 2, values are given for  $V_3$  for a selection of asymmetric and symmetric tops, respectively. In cases where the higher order parameters have been determined, these are given in the Comments column. Where appropriate, this column also indicates the specific top, isomer, state, and/or isotopomer that has been studied. For ethane, three symmetric top isotopomer are listed to illustrate the isotopic dependence of  $V_3$  and  $V_6$ . In all other cases, only one isotopomer is listed, even if several have been studied. In all but one of these cases, the isotopomer reported is the one with the highest natural abundance. However,  $\text{CH}_3\text{OCDO}$  is listed because the results obtained are more precise than for  $\text{CH}_3\text{OCHO}$ . The molecules are listed alphabetically in Hill order according to the molecular formula.

The determinations listed for the potential parameters are effective values that incorporate to varying degrees effects from other molecular parameters. For example, the apparent value of  $V_3$  can be changed significantly if the reduced rotational constant  $F$  is calculated from the structure, rather than being determined independently (LS59). Other examples include such mechanisms as coupling to excited skeletal vibrations (OM07) and redundancies connecting some of the torsional parameters (LB68, MO87). The experimental uncertainties quoted are taken from the original works; no attempt has been made to standardize the definitions. All the potential parameters are given in  $\text{cm}^{-1}$ . Where the original work has reported these values in other units, the conversion to  $\text{cm}^{-1}$  has been carried out using standard factors (LB02):

$$\begin{aligned} 1 \text{ calorie} &= 4.1868 \text{ joules;} \\ 1 \text{ calorie/mole} &= 0.34998915 \text{ cm}^{-1}. \end{aligned}$$

A variety of different methods have been used to measure  $V_3$ ,  $V_6$ , and  $V_9$  (LS59, OM07); only a few of the more important will be discussed here. For *asymmetric rotors*, both the pure rotational spectrum and its torsion-rotation counterpart are electric dipole allowed and are affected in lowest order by the leading terms in the torsional Hamiltonian. Both types of spectra have been used extensively to determine  $V_3$  (LS59). For *symmetric tops* with a single torsional degree of freedom, either the permanent electric dipole moment vanishes, as in  $\text{CH}_3\text{CH}_3$ , or the normal rotational spectrum is independent of  $V_3$  in lowest order, as in  $\text{CH}_3\text{SiH}_3$ . In

the latter case, the molecular beam avoided crossing method can often be used (OM07). The torsion-rotation spectrum is forbidden in lowest order, but becomes weakly allowed through interactions with the infrared active skeletal vibrations (OM07). By employing long absorption path lengths, this spectrum has been used to determine  $V_3$  in a number of molecules. For both asymmetric and symmetric tops, the most precise determinations of the molecular parameters have been made in cases where both rotational and torsion-rotation spectra have been investigated.

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TABLE 1. Asymmetric Top Potential Parameters

| Name                            | Molecular Formula                               |                                                  | Line Formula | Ref.  | $V_3/\text{cm}^{-1}$ | Comments                                          |
|---------------------------------|-------------------------------------------------|--------------------------------------------------|--------------|-------|----------------------|---------------------------------------------------|
| 1 Trifluoromethanethiol         | CHF <sub>3</sub> S                              | CF <sub>3</sub> SH                               |              | LB02  | 500.83 ± 0.03        |                                                   |
| 2 Methylphosphonic difluoride   | CH <sub>3</sub> F <sub>2</sub> OP               | CH <sub>3</sub> P(=O)F <sub>2</sub>              |              | SL06  | 676 ± 25             |                                                   |
| 3 Methanol                      | CH <sub>4</sub> O                               | CH <sub>3</sub> OH                               |              | LB02  | 373.594 ± 0.007      | $V_6 = -1.597 \pm 0.051$<br>$V_9 = 1.04 \pm 0.20$ |
| 4 Methanethiol                  | CH <sub>4</sub> S                               | CH <sub>3</sub> SH                               |              | SH86  | 443.029 ± 0.070      | $V_6 = -1.6451 \pm 0.0144$                        |
| 5 Methylsulfane                 | CH <sub>4</sub> S <sub>2</sub>                  | CH <sub>3</sub> SSH                              |              | TH86  | 609.0 ± 14.0         |                                                   |
| 6 Trifluoromethyl isocyanate    | C <sub>2</sub> F <sub>3</sub> NO                | CF <sub>3</sub> N=C=O                            |              | LB02  | 47.8769 ± 0.0051     |                                                   |
| 7 Trifluoroacetaldehyde         | C <sub>2</sub> HF <sub>3</sub> O                | CF <sub>3</sub> C(H)=O                           |              | DG87  | 298 ± 10             |                                                   |
| 8 Pentafluoroethane             | C <sub>2</sub> HF <sub>5</sub>                  | CF <sub>3</sub> CHF <sub>2</sub>                 |              | EG96  | 1190 ± 4             |                                                   |
| 9 Acetyl bromide                | C <sub>2</sub> H <sub>3</sub> BrO               | CH <sub>3</sub> C(Br)=O                          |              | K60   | 456.7 ± 10.5         |                                                   |
| 10 1-Chloro-1,1-difluoroethane  | C <sub>2</sub> H <sub>3</sub> ClF <sub>2</sub>  | CH <sub>3</sub> CClF <sub>2</sub>                |              | ALB97 | 1311.8 ± 1.4         |                                                   |
| 11 Acetyl chloride              | C <sub>2</sub> H <sub>3</sub> ClO               | CH <sub>3</sub> C(Cl)=O                          |              | LB02  | 442.74 ± 1.05        | <sup>35</sup> Cl                                  |
| 12 Acetyl fluoride              | C <sub>2</sub> H <sub>3</sub> FO                | CH <sub>3</sub> C(F)=O                           |              | PK59  | 364.3 ± 2.1          |                                                   |
| 13 Methyl fluoroformate         | C <sub>2</sub> H <sub>3</sub> FO <sub>2</sub>   | CH <sub>3</sub> OC(F)=O                          |              | LB02  | 374.1 ± 0.2          |                                                   |
| 14 Methyl trifluoromethyl ether | C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O  | CH <sub>3</sub> OCF <sub>3</sub>                 |              | LB02  | 382 ± 10             | CH <sub>3</sub>                                   |
| 15 Acetyl iodide                | C <sub>2</sub> H <sub>3</sub> IO                | CH <sub>3</sub> C(=O)I                           |              | MK66  | 455.3 ± 10.5         |                                                   |
| 16 Methyl cyanate               | C <sub>2</sub> H <sub>3</sub> NO                | CH <sub>3</sub> OC≡N                             |              | LB02  | 399.0 ± 17.5         |                                                   |
| 17 1-Chloro-1-fluoroethane      | C <sub>2</sub> H <sub>4</sub> ClF               | CH <sub>3</sub> CHClF                            |              | LB02  | 1334.9 ± 3.8         |                                                   |
| 18 1,1-Difluoroethane           | C <sub>2</sub> H <sub>4</sub> F <sub>2</sub>    | CH <sub>3</sub> CHF <sub>2</sub>                 |              | LB02  | 1163.0 ± 2.5         |                                                   |
| 19 Acetaldehyde                 | C <sub>2</sub> H <sub>4</sub> O                 | CH <sub>3</sub> C(H)=O                           |              | KH96  | 407.716 ± 0.010      | $V_6 = -12.068 \pm 0.037$                         |
| 20 Thioacetaldehyde S-oxide     | C <sub>2</sub> H <sub>4</sub> OS                | CH <sub>3</sub> C(H)=S=O                         |              | LB02  | 285.6 ± 0.3          | Z isomer                                          |
| 21 Acetic acid                  | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>    | CH <sub>3</sub> COOH                             |              | IA03  | 170.1742 ± 0.0002    | $V_6 = -6.4725 \pm 0.0001$                        |
| 22 Methyl formate               | C <sub>2</sub> H <sub>3</sub> DO <sub>2</sub>   | CH <sub>3</sub> OC(D)=O                          |              | LB02  | 400.60 ± 0.03        | deuterated                                        |
| 23 Fluoroethane                 | C <sub>2</sub> H <sub>5</sub> F                 | CH <sub>3</sub> CH <sub>2</sub> F                |              | FD83  | 1172.1 ± 1.4         |                                                   |
| 24 Nitrosoethane                | C <sub>2</sub> H <sub>5</sub> NO                | CH <sub>3</sub> CH <sub>2</sub> N=O              |              | LB02  | 903 ± 25             | gauche conformer                                  |
|                                 | C <sub>2</sub> H <sub>5</sub> NO                | CH <sub>3</sub> CH <sub>2</sub> N=O              |              | LB02  | 911 ± 25             | cis conformer                                     |
| 25 Acetamide                    | C <sub>2</sub> H <sub>5</sub> NO                | CH <sub>3</sub> C(NH <sub>2</sub> )=O            |              | LB02  | 24.949 ± 0.008       |                                                   |
| 26 Difluorodimethylsilane       | C <sub>2</sub> H <sub>6</sub> F <sub>2</sub> Si | (CH <sub>3</sub> ) <sub>2</sub> SiF <sub>2</sub> |              | SG05  | 439.4 ± 2.5          |                                                   |

| Name                                 | Molecular Formula                        | Line Formula                                                                | Ref.  | $V_3/\text{cm}^{-1}$ | Comments                            |
|--------------------------------------|------------------------------------------|-----------------------------------------------------------------------------|-------|----------------------|-------------------------------------|
| 27 <i>N</i> -Nitrosodimethylamine    | $\text{C}_2\text{H}_6\text{N}_2\text{O}$ | $(\text{CH}_3)_2\text{NN}=\text{O}$                                         | LB02  | $145.8 \pm 0.25$     | <i>cis</i> $\text{CH}_3$            |
|                                      | $\text{C}_2\text{H}_6\text{N}_2\text{O}$ | $(\text{CH}_3)_2\text{NN}=\text{O}$                                         | LB02  | $737.4 \pm 13.3$     | <i>trans</i> $\text{CH}_3$          |
| 28 Ethanol                           | $\text{C}_2\text{H}_6\text{O}$           | $\text{CH}_3\text{CH}_2\text{OH}$                                           | LB02  | $1173.76 \pm 2.20$   | <i>trans</i> isomer                 |
| 29 Dimethyl ether                    | $\text{C}_2\text{H}_6\text{O}$           | $(\text{CH}_3)_2\text{O}$                                                   | NH04  | $926.0 \pm 3.5$      |                                     |
| 30 Dimethyl sulfide                  | $\text{C}_2\text{H}_6\text{S}$           | $(\text{CH}_3)_2\text{S}$                                                   | NH04  | $751.1 \pm 4.8$      |                                     |
| 31 Vinylsilane                       | $\text{C}_2\text{H}_6\text{Si}$          | $\text{SiH}_3\text{C}(\text{H})=\text{CH}_2$                                | SH82  | $520.1 \pm 1.8$      |                                     |
| 32 Dimethyl disulfide                | $\text{C}_2\text{H}_6\text{S}_2$         | $\text{CH}_3\text{SSCH}_3$                                                  | LB02  | $535.1 \pm 1.8$      |                                     |
| 33 Dimethyl diselenide               | $\text{C}_2\text{H}_6\text{Se}_2$        | $\text{CH}_3\text{SeSeCH}_3$                                                | GG04  | $395 \pm 2$          |                                     |
| 34 Dimethylsilane                    | $\text{C}_2\text{H}_8\text{Si}$          | $(\text{CH}_3)_2\text{SiH}_2$                                               | NH04  | $578.0 \pm 3.5$      |                                     |
| 35 3,3,3-Trifluoropropene            | $\text{C}_3\text{H}_3\text{F}_3$         | $\text{CF}_3\text{C}(\text{H})=\text{CH}_2$                                 | ALL97 | $653.06 \pm 0.83$    |                                     |
| 36 Methyl cyanofornate               | $\text{C}_3\text{H}_3\text{NO}_2$        | $\text{CH}_3\text{OC}(\text{C}\equiv\text{N})=\text{O}$                     | LB02  | $406.6 \pm 1.1$      | <i>s-trans</i> conformer            |
| 37 (Methylthio)acetylene             | $\text{C}_3\text{H}_4\text{S}$           | $\text{CH}_3\text{SC}\equiv\text{CH}$                                       | DM87  | $592.0 \pm 3.3$      |                                     |
| 38 1,1,1-Trifluoropropane            | $\text{C}_3\text{H}_5\text{F}_3$         | $\text{CH}_3\text{CH}_2\text{CF}_3$                                         | ALA97 | $922.2 \pm 1.4$      |                                     |
| 39 2-Iodopropene                     | $\text{C}_3\text{H}_5\text{I}$           | $\text{CH}_3\text{C}(\text{I})=\text{CH}_2$                                 | LB02  | $905.8 \pm 4.2$      |                                     |
| 40 Ethyl isocyanide                  | $\text{C}_3\text{H}_5\text{N}$           | $\text{CH}_3\text{CH}_2\text{N}\equiv\text{C}$                              | LB02  | $1167.6 \pm 18.2$    |                                     |
| 41 Propene                           | $\text{C}_3\text{H}_6$                   | $\text{CH}_3\text{C}(\text{H})=\text{CH}_2$                                 | LB02  | $697.499 \pm 0.048$  | $V_6 = -13.0$ (fixed)               |
| 42 Propanal                          | $\text{C}_3\text{H}_6\text{O}$           | $\text{CH}_3\text{CH}_2\text{C}(\text{H})=\text{O}$                         | BW64  | $798 \pm 39$         | <i>cis</i> conformer                |
| 43 Acetone                           | $\text{C}_3\text{H}_6\text{O}$           | $(\text{CH}_3)_2\text{C}=\text{O}$                                          | G00   | $251.4 \pm 2.6$      | $V_6 = -6.92 \pm 0.65$              |
| 44 (Methylthio)ethene                | $\text{C}_3\text{H}_6\text{S}$           | $\text{CH}_3\text{SC}(\text{H})=\text{CH}_2$                                | MM01  | $1138 \pm 13$        |                                     |
| 45 Propanoic acid                    | $\text{C}_3\text{H}_6\text{O}_2$         | $\text{CH}_3\text{CH}_2\text{COOH}$                                         | S75   | $819.0 \pm 10.5$     | <i>cis</i> conformer                |
| 46 Methyl mercaptoacetate            | $\text{C}_3\text{H}_6\text{O}_2\text{S}$ | $\text{CH}_3\text{OC}(\text{H})\text{C}(\text{H}_2)\text{SH}$               | LB02  | $411 \pm 8$          | state 0 <sup>+</sup>                |
|                                      | $\text{C}_3\text{H}_6\text{O}_2\text{S}$ | $\text{CH}_3\text{OC}(\text{H})\text{C}(\text{H}_2)\text{SH}$               | LB02  | $412 \pm 9$          | state 0 <sup>-</sup>                |
| 47 2-Bromopropane                    | $\text{C}_3\text{H}_7\text{Br}$          | $(\text{CH}_3)_2\text{CHBr}$                                                | LB02  | $1437.0 \pm 2.5$     | <sup>79</sup> Br                    |
| 48 1-Chloropropane                   | $\text{C}_3\text{H}_7\text{Cl}$          | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{Cl}$              | LE97  | $1017.8 \pm 1.4$     | <i>gauche</i> conformer             |
|                                      | $\text{C}_3\text{H}_7\text{Cl}$          | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{Cl}$              | LE97  | $966.0 \pm 7.0$      | <i>trans</i> conformer              |
| 49 2-Chloropropane                   | $\text{C}_3\text{H}_7\text{Cl}$          | $(\text{CH}_3)_2\text{CHCl}$                                                | LB02  | $1374.03 \pm 1.00$   | <sup>35</sup> Cl                    |
| 50 1-Fluoropropane                   | $\text{C}_3\text{H}_7\text{F}$           | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{F}$               | KD86  | $965.3 \pm 12.2$     | <i>gauche</i> conformer             |
|                                      | $\text{C}_3\text{H}_7\text{F}$           | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{F}$               | KD86  | $948.5 \pm 2.8$      | <i>trans</i> conformer              |
| 51 2-Fluoropropane                   | $\text{C}_3\text{H}_7\text{F}$           | $(\text{CH}_3)_2\text{CHF}$                                                 | LB02  | $1162.79 \pm 0.84$   |                                     |
| 52 Butanenitrile                     | $\text{C}_4\text{H}_7\text{N}$           | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{C}\equiv\text{N}$ | VD88  | $1087.4 \pm 8.4$     | <i>gauche</i> conformer             |
|                                      | $\text{C}_4\text{H}_7\text{N}$           | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{C}\equiv\text{N}$ | VD88  | $1088.5 \pm 13.3$    | <i>trans</i> conformer              |
| 53 Propanamide                       | $\text{C}_3\text{H}_7\text{NO}$          | $\text{CH}_3\text{CH}_2\text{C}(\text{H})\text{C}(\text{H})\text{NH}_2$     | MM96  | $761 \pm 42$         | <i>syn</i> conformer                |
| 54 <i>N,N</i> -Dimethylformamide     | $\text{C}_3\text{H}_7\text{NO}$          | $(\text{CH}_3)_2\text{NC}(\text{H})=\text{O}$                               | LB02  | $366.04 \pm 0.26$    | <i>cis</i> $\text{CH}_3$            |
|                                      | $\text{C}_3\text{H}_7\text{NO}$          | $(\text{CH}_3)_2\text{NC}(\text{H})=\text{O}$                               | LB02  | $772.4 \pm 7.4$      | <i>trans</i> $\text{CH}_3$          |
| 55 Propane                           | $\text{C}_3\text{H}_8$                   | $(\text{CH}_3)_2\text{CH}_2$                                                | BL85  | $1108.1 \pm 9.5$     |                                     |
| 56 Cyclopropylgermane                | $\text{C}_3\text{H}_8\text{Ge}$          | $\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{C}(\text{H})(\text{GeH}_3)$  | LB02  | $466.6 \pm 16.7$     | $\text{GeH}_3$                      |
| 57 <i>N</i> -Nitrosoethylmethylamine | $\text{C}_3\text{H}_8\text{N}_2\text{O}$ | $\text{CH}_3\text{CH}_2\text{N}(\text{CH}_3)\text{N}=\text{O}$              | LB02  | $310 \pm 30$         | <i>N</i> -methyl top, OGM conformer |
| 58 1-Propanol                        | $\text{C}_3\text{H}_8\text{O}$           | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{OH}$              | DS81  | $956 \pm 21$         | <i>trans</i> conformer              |
| 59 Cyclopropylsilane                 | $\text{C}_3\text{H}_8\text{Si}$          | $\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{C}(\text{H})(\text{SiH}_3)$  | TB86  | $670.9 \pm 1.5$      |                                     |
| 60 Dimethyl(methylene)silane         | $\text{C}_3\text{H}_8\text{Si}$          | $(\text{CH}_3)_2\text{Si}=\text{CH}_2$                                      | LB02  | $351.4 \pm 5.9$      |                                     |
| 61 Dimethyl methylphosphonate        | $\text{C}_3\text{H}_9\text{O}_3\text{P}$ | $(\text{OCH}_3)_2\text{P}(\text{H})\text{CH}_3$                             | SL02  | $662 \pm 6$          | <i>P</i> -methyl top                |
|                                      | $\text{C}_3\text{H}_9\text{O}_3\text{P}$ | $(\text{OCH}_3)_2\text{P}(\text{H})\text{CH}_3$                             | OH07  | $278.82 \pm 0.06$    | <i>O</i> -methyl top #1             |
|                                      | $\text{C}_3\text{H}_9\text{O}_3\text{P}$ | $(\text{OCH}_3)_2\text{P}(\text{H})\text{CH}_3$                             | OH07  | $181.82 \pm 0.01$    | <i>O</i> -methyl top #2             |
| 62 But-2-ynoyl fluoride              | $\text{C}_4\text{H}_3\text{FO}$          | $\text{CH}_3\text{C}\equiv\text{CC}(\text{F})=\text{O}$                     | LB02  | $2.20 \pm 0.12$      |                                     |
| 63 <i>cis</i> -2-Butenenitrile       | $\text{C}_4\text{H}_5\text{N}$           | $\text{CH}_3\text{C}(\text{H})=\text{C}(\text{H})\text{C}\equiv\text{N}$    | LB02  | $485.50 \pm 0.25$    |                                     |
| 64 2-Methylacrylonitrile             | $\text{C}_4\text{H}_5\text{N}$           | $\text{CH}_2=\text{C}(\text{CH}_3)\text{C}\equiv\text{N}$                   | LB02  | $695.2 \pm 2.1$      |                                     |
| 65 2-Methyloxazole                   | $\text{C}_4\text{H}_5\text{NO}$          | $\text{N}=\text{C}(\text{CH}_3)\text{OC}(\text{H})=\text{C}(\text{H})$      | LB02  | $251.70 \pm 1.17$    |                                     |
| 66 4-Methyloxazole                   | $\text{C}_4\text{H}_5\text{NO}$          | $\text{N}=\text{C}(\text{H})\text{OC}(\text{H})=\text{C}(\text{CH}_3)$      | LB02  | $429.44 \pm 0.33$    |                                     |

| Name                                               | Molecular Formula                            | Line Formula                                                                                                          | Ref. | $V_3/\text{cm}^{-1}$ | Comments                              |
|----------------------------------------------------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|------|----------------------|---------------------------------------|
| 67 5-Methyloxazole                                 | $\text{C}_4\text{H}_5\text{NO}$              | $\text{N}=\text{C}(\text{H})\text{OC}(\text{CH}_3)=\text{C}(\text{H})$                                                | LB02 | $477.90 \pm 1.34$    |                                       |
| 68 5-Methylisoxazole                               | $\text{C}_4\text{H}_5\text{NO}$              | $\text{C}(\text{H})=\text{NOC}(\text{CH}_3)=\text{C}(\text{H})$                                                       | LB02 | $272.05 \pm 1.00$    |                                       |
| 69 2-Methylthiazole                                | $\text{C}_4\text{H}_5\text{NS}$              | $\text{N}=\text{C}(\text{CH}_3)\text{SC}(\text{H})=\text{C}(\text{H})$                                                | GH02 | $34.938 \pm 0.020$   |                                       |
| 70 4-Methylisothiazole                             | $\text{C}_4\text{H}_5\text{NS}$              | $\text{N}=\text{C}(\text{H})\text{C}(\text{CH}_3)=\text{C}(\text{H})\text{S}$                                         | LB02 | $105.767 \pm 0.043$  |                                       |
| 71 4-Methyl-2-oxetanone                            | $\text{C}_4\text{H}_6\text{O}_2$             | $\text{OC}(=\text{O})\text{C}(\text{H}_2)\text{C}(\text{H})(\text{CH}_3)$                                             | LB02 | $1256.5 \pm 10.5$    |                                       |
| 72 <i>trans</i> -1-Fluoro-2-butene                 | $\text{C}_4\text{H}_7\text{F}$               | $\text{CH}_3\text{C}(\text{H})=\text{C}(\text{H})\text{CH}_2\text{F}$                                                 | LB02 | $596 \pm 7$          | anticlinal conformer                  |
| 73 1-Isocyanopropane                               | $\text{C}_4\text{H}_7\text{N}$               | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{N}=\text{C}$                                                | LB02 | $1012.3 \pm 8.4$     | <i>gauche</i> conformer               |
|                                                    | $\text{C}_4\text{H}_7\text{N}$               | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{N}=\text{C}$                                                | LB02 | $1033.8 \pm 7.7$     | <i>trans</i> conformer                |
| 74 Isobutene                                       | $\text{C}_4\text{H}_8$                       | $(\text{CH}_3)_2\text{C}=\text{CH}_2$                                                                                 | LB02 | $761.58 \pm 1.05$    |                                       |
| 75 <i>cis</i> -2-Butene                            | $\text{C}_4\text{H}_8$                       | $\text{CH}_3\text{CH}=\text{CHCH}_3$                                                                                  | LB02 | $259.89 \pm 0.42$    |                                       |
| 76 3-Methoxy-1-propene                             | $\text{C}_4\text{H}_8\text{O}$               | $\text{CH}_3\text{OC}(\text{H}_2)\text{C}(\text{H})=\text{CH}_2$                                                      | LB02 | $728.0 \pm 10.5$     | <i>skew-gauche</i> conformer          |
|                                                    | $\text{C}_4\text{H}_8\text{O}$               | $\text{CH}_3\text{OC}(\text{H}_2)\text{C}(\text{H})=\text{CH}_2$                                                      | LB02 | $829.5 \pm 10.5$     | <i>syn-trans</i> conformer            |
| 77 2,2-Dimethyloxirane                             | $\text{C}_4\text{H}_8\text{O}$               | $\text{OC}(\text{CH}_3)(\text{CH}_3)\text{C}(\text{H}_2)$                                                             | LB02 | $945.61 \pm 0.75$    |                                       |
| 78 <i>cis</i> -2,3-Dimethyloxirane                 | $\text{C}_4\text{H}_8\text{O}$               | $\text{OC}(\text{H})(\text{CH}_3)\text{C}(\text{H})(\text{CH}_3)$                                                     | LB02 | $577.80 \pm 1.84$    | <i>cis</i> conformer                  |
|                                                    | $\text{C}_4\text{H}_8\text{O}$               | $\text{OC}(\text{H})(\text{CH}_3)\text{C}(\text{H})(\text{CH}_3)$                                                     | LB02 | $862.52 \pm 1.84$    | <i>trans</i> conformer                |
| 79 2-Methyloxetane                                 | $\text{C}_4\text{H}_8\text{O}$               | $\text{OC}(\text{H}_2)\text{C}(\text{H}_2)\text{C}(\text{H})(\text{CH}_3)$                                            | LB02 | $1166.5 \pm 4.9$     |                                       |
| 80 3-Methyloxetane                                 | $\text{C}_4\text{H}_8\text{O}$               | $\text{OC}(\text{H}_2)\text{C}(\text{H})(\text{CH}_3)\text{C}(\text{H}_2)$                                            | LB02 | $1149.4 \pm 4.2$     |                                       |
| 81 3-Methoxythietane                               | $\text{C}_4\text{H}_8\text{OS}$              | $\text{SC}(\text{H}_2)\text{C}(\text{H})(\text{OCH}_3)\text{C}(\text{H}_2)$                                           | LB02 | $1071.0 \pm 10.5$    |                                       |
| 82 3-(Methylthio)-1-propene                        | $\text{C}_4\text{H}_8\text{S}$               | $\text{CH}_3\text{SC}(\text{H}_2)\text{C}(\text{H})=\text{CH}_2$                                                      | LB02 | $619 \pm 28$         |                                       |
| 83 2,2-Dimethylthiirane                            | $\text{C}_4\text{H}_8\text{S}$               | $\text{SC}(\text{CH}_3)(\text{CH}_3)\text{C}(\text{H}_2)$                                                             | LB02 | $1268.3 \pm 3.0$     |                                       |
| 84 Butane                                          | $\text{C}_4\text{H}_{10}$                    | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{CH}_3$                                                      | LB02 | $948 \pm 24$         |                                       |
| 85 <i>N</i> -Methyl- <i>N</i> -nitrosopropylamine  | $\text{C}_4\text{H}_{10}\text{N}_2\text{O}$  | $\text{CH}_3\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{N}(\text{CH}_3)\text{N}=\text{O}$                           | LB02 | $320 \pm 30$         | <i>N</i> -methyl top, conformer OMGA  |
| 86 Dihydro-3-methyl-2(3 <i>H</i> )-furanone        | $\text{C}_5\text{H}_8\text{O}_2$             | $\text{OC}(=\text{O})\text{C}(\text{H})(\text{CH}_3)\text{C}(\text{H}_2)\text{C}(\text{H}_2)$                         | LB02 | $913.8 \pm 2.5$      |                                       |
| 87 Dihydro-4-methyl-2(3 <i>H</i> )-furanone        | $\text{C}_5\text{H}_8\text{O}_2$             | $\text{OC}(=\text{O})\text{C}(\text{H}_2)\text{C}(\text{H})(\text{CH}_3)\text{C}(\text{H}_2)$                         | CA96 | $1437.8 \pm 8.4$     |                                       |
| 88 Dihydro-5-methyl-2(3 <i>H</i> )-furanone        | $\text{C}_5\text{H}_8\text{O}_2$             | $\text{OC}(=\text{O})\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{C}(\text{H})(\text{CH}_3)$                         | CA96 | $1233.0 \pm 4.2$     |                                       |
| 89 <i>tert</i> -Butyl isocyanate                   | $\text{C}_5\text{H}_9\text{NO}$              | $(\text{CH}_3)_3\text{C}\equiv\text{N}=\text{C}=\text{O}$                                                             | LB02 | $41.510 \pm 0.015$   | $(\text{CH}_3)_3\text{C}$ group       |
| 90 Methyl <i>tert</i> -butyl ether                 | $\text{C}_5\text{H}_{12}\text{O}$            | $(\text{CH}_3)_3\text{COCH}_3$                                                                                        | LB02 | $498.6 \pm 1.5$      | <i>O</i> -methyl top                  |
| 91 2-Methylcyclopentanone                          | $\text{C}_6\text{H}_{10}\text{O}$            | $\text{C}(=\text{O})\text{C}(\text{H})(\text{CH}_3)\text{C}(\text{H}_2)\text{C}(\text{H}_2)\text{C}(\text{H}_2)$      | LB02 | $844.2 \pm 2.4$      |                                       |
| 92 3-Methylcyclopentanone                          | $\text{C}_6\text{H}_{10}\text{O}$            | $\text{C}(=\text{O})\text{C}(\text{H}_2)\text{C}(\text{H})(\text{CH}_3)\text{C}(\text{H}_2)\text{C}(\text{H}_2)$      | LB02 | $1233.8 \pm 1.7$     |                                       |
| 93 <i>tert</i> -Butyl ethyl ether                  | $\text{C}_6\text{H}_{14}\text{O}$            | $(\text{CH}_3)_3\text{COC}(\text{H}_2)\text{CH}_3$                                                                    | LB02 | $1025 \pm 3$         | ethyl $\text{CH}_3$                   |
| 94 2,4-Difluorotoluene                             | $\text{C}_7\text{H}_6\text{F}_2$             | $\text{C}(\text{H})=\text{C}(\text{CH}_3)\text{C}(\text{F})=\text{C}(\text{H})\text{C}(\text{F})=\text{C}(\text{H})$  | LB02 | $204.04 \pm 0.23$    |                                       |
| 95 2-Chlorotoluene                                 | $\text{C}_7\text{H}_7\text{Cl}$              | $\text{C}(\text{H})=\text{C}(\text{H})\text{C}(\text{Cl})=\text{C}(\text{CH}_3)\text{C}(\text{H})=\text{C}(\text{H})$ | ND06 | $513.8 \pm 2.7$      | $^{35}\text{Cl}$                      |
| 96 2,6-Dimethylpyridine                            | $\text{C}_7\text{H}_9\text{N}$               | $\text{C}(\text{H})=\text{C}(\text{H})\text{C}(\text{CH}_3)=\text{NC}(\text{CH}_3)=\text{C}(\text{H})$                | LB02 | $98.24 \pm 0.27$     |                                       |
| 97 1,2,2-Trimethylpropyl methylphosphonofluoridate | $\text{C}_7\text{H}_{16}\text{FO}_2\text{P}$ | $(\text{CH}_3)_3\text{CC}(\text{H})(\text{CH}_3)\text{OP}(\text{O})(\text{F})\text{CH}_3$                             | SD04 | $821 \pm 5$          | <i>P</i> -methyl top, conformer GD-I  |
|                                                    | $\text{C}_7\text{H}_{16}\text{FO}_2\text{P}$ | $(\text{CH}_3)_3\text{CC}(\text{H})(\text{CH}_3)\text{OP}(\text{O})(\text{F})\text{CH}_3$                             | SD04 | $738 \pm 5$          | <i>P</i> -methyl top, conformer GD-II |
| 98 Germyl azide                                    | $\text{GeH}_3\text{N}_3$                     | $\text{GeH}_3\text{-N}=\text{N}=\text{N}$                                                                             | GA89 | $86.598 \pm 0.062$   |                                       |
| 99 Silylphospine                                   | $\text{H}_5\text{PSi}$                       | $\text{SiH}_3\text{PH}_2$                                                                                             | VR75 | $537.2 \pm 14.0$     |                                       |

TABLE 2. Symmetric Top Potential Parameters

|    | Name                                  | Molecular<br>Formula               | Line<br>Formula                            | Ref. | $V_3/\text{cm}^{-1}$  | Comments                                                |
|----|---------------------------------------|------------------------------------|--------------------------------------------|------|-----------------------|---------------------------------------------------------|
| 1  | Phosphine-trifluoroborane             | $\text{BF}_3\text{H}_3\text{P}$    | $\text{H}_3\text{PBF}_3$                   | OK75 | $1169 \pm 123$        |                                                         |
| 2  | Trihydro(phosphorus trifluoride)boron | $\text{BF}_3\text{H}_3\text{P}$    | $\text{F}_3\text{PBH}_3$                   | KL67 | $1134 \pm 53$         |                                                         |
| 3  | Trihydro(phosphine)boron              | $\text{BH}_6\text{P}$              | $\text{H}_3\text{PBH}_3$                   | DL73 | $864.5 \pm 17.5$      |                                                         |
| 4  | Trifluoro(trifluoromethyl)silane      | $\text{CF}_6\text{Si}$             | $\text{CF}_3\text{SiF}_3$                  | LJ72 | $489 \pm 50$          |                                                         |
| 5  | Trifluoromethylgermane                | $\text{CH}_3\text{F}_3\text{Ge}$   | $\text{CF}_3\text{GeH}_3$                  | KW74 | $448 \pm 53$          |                                                         |
| 6  | Trifluoromethylsilane                 | $\text{CH}_3\text{F}_3\text{Si}$   | $\text{CH}_3\text{SiF}_3$                  | ST06 | $414.147 \pm 0.030$   |                                                         |
| 7  | Methylgermane                         | $\text{CH}_6\text{Ge}$             | $\text{CH}_3\text{GeH}_3$                  | L59  | $433.6 \pm 8.8$       |                                                         |
| 8  | Methylsilane                          | $\text{CH}_6\text{Si}$             | $\text{CH}_3\text{SiH}_3$                  | OM07 | $603.3878 \pm 0.0037$ |                                                         |
| 9  | Methylstannane                        | $\text{CH}_6\text{Sn}$             | $\text{CH}_3\text{SnH}_3$                  | CB61 | $227 \pm 10$          |                                                         |
| 10 | 1,1,1-Trifluoroethane                 | $\text{C}_2\text{H}_3\text{F}_3$   | $\text{CH}_3\text{CF}_3$                   | WA02 | $1112.24 \pm 0.16$    |                                                         |
| 11 | Ethane                                | $\text{C}_2\text{H}_6$             | $\text{CH}_3\text{CH}_3$                   | OM07 | $1013.28 \pm 0.10$    | $V_6 = 8.798 \pm 0.041$                                 |
| 12 | Ethane-1,1,1- $d_3$                   | $\text{C}_2\text{H}_3\text{D}_3$   | $\text{CH}_3\text{CD}_3$                   | OM07 | $1001.876 \pm 0.023$  | $V_6 = 9.328 \pm 0.018$                                 |
| 13 | Ethane- $d_6$                         | $\text{C}_2\text{D}_6$             | $\text{CD}_3\text{CD}_3$                   | OM07 | $989.946 \pm 0.090$   | $V_6 = 9.51 \pm 0.10$                                   |
| 14 | 1-Silylpropyne                        | $\text{C}_3\text{H}_6\text{Si}$    | $\text{CH}_3\text{C}\equiv\text{CSiH}_3$   | NY85 | $3.77 \pm 0.70$       |                                                         |
| 15 | Trimethylchlorosilane                 | $\text{C}_3\text{H}_9\text{ClSi}$  | $(\text{CH}_3)_3\text{SiCl}$               | MS02 | $576.9 \pm 0.9$       |                                                         |
| 16 | 2-Butyne                              | $\text{C}_4\text{H}_6$             | $\text{CH}_3\text{C}\equiv\text{CCH}_3$    | LB97 | $6.067 \pm 0.040$     | $V_6 = 0.1240 \pm 0.0144$<br>$V_9 = -0.0916 \pm 0.0180$ |
| 17 | Ethynyltrimethylgermane               | $\text{C}_5\text{H}_{10}\text{Ge}$ | $(\text{CH}_3)_3\text{GeC}\equiv\text{CH}$ | VG96 | $376.2 \pm 16.7$      |                                                         |
| 18 | Disilane                              | $\text{H}_6\text{Si}_2$            | $\text{SiH}_3\text{SiH}_3$                 | BM07 | $412.033 \pm 0.010$   |                                                         |

# LINE SPECTRA OF THE ELEMENTS

Joseph Reader and Charles H. Corliss

The original tables from which this table was derived were prepared under the auspices of the Committee on Line Spectra of the Elements of the National Academy of Sciences-National Research Council. The table contains the outstanding spectral lines of neutral (I) and singly ionized (II) atoms of the elements from hydrogen through plutonium ( $Z = 1-94$ ); selected strong lines from doubly ionized (III), triply ionized (IV), and quadruply ionized (V) atoms are also included. Listed are lines that appear in emission from the vacuum ultraviolet to the far infrared. These lines were selected from much larger lists in such a way as to include the stronger observed lines in each spectral region. A more extensive list may be found in Reference 1.

The data were compiled by the following contributors.

J. G. Conway — Lawrence Berkeley Laboratory  
C. H. Corliss — National Bureau of Standards  
R. D. Cowan — Los Alamos Scientific Laboratory  
C. R. Cowley — University of Michigan  
Henry M. and Hannah Crosswhite — Argonne National Laboratory  
S. P. Davis — University of California, Berkeley  
V. Kaufman — National Bureau of Standards  
R. L. Kelly — Naval Postgraduate School  
J. F. Kielkopf — University of Louisville  
W. C. Martin — National Bureau of Standards  
T. K. McCubbin — Pennsylvania State University  
L. J. Radziemski — Los Alamos Scientific Laboratory  
J. Reader — National Bureau of Standards  
C. J. Sansonetti — National Bureau of Standards  
G. V. Shalimoff — Lawrence Berkeley Laboratory  
R. W. Stanley — Purdue University  
J. O. Stoner, Jr. — University of Arizona  
H. H. Stroke — New York University  
D. R. Wood — Wright State University  
E. F. Worden — Lawrence Livermore Laboratory  
J. J. Wynne — International Business Machines Corporation  
R. Zalubas — National Bureau of Standards

All wavelengths are given in Ångstrom units ( $10^{-10}$  m). Below 2000 Å the wavelengths are in vacuum (except for the Cu II line at 1999.698 Å, which is in air); above 2000 Å the wavelengths are in air. Wavelengths given to three decimal places have an uncertainty of less than 0.001 Å and are therefore suitable for calibration purposes. In the air region, the elements used most commonly for calibration are Ne, Ar, Kr, Fe, Th, and Hg; in the vacuum region, the most common are C, N, O, Si, Cu.

All data refer to natural isotopic abundance of the elements except that Kr I and Kr II lines below 11,000 Å given to three decimal

places are for  $^{86}\text{Kr}$ . A separate table for  $^{198}\text{Hg}$  contains accurately known wavelengths that are frequently used for calibration.

A large number of the lines for neutral and singly ionized atoms were extracted from the National Bureau of Standards (NBS) *Tables of Spectral-Line Intensities* (Reference 2). The intensities of these lines represent quantitative estimates of relative line strengths that take account of varying detection sensitivity at different wavelengths. They are on a linear scale. For nearly all of the other lines the intensities represent qualitative estimates of the relative strengths of lines not greatly separated in wavelength. Because different observers frequently use different scales for their intensity estimates, these intensities are useful only as a rough indication of the appearance of a spectrum. In some cases the intensity scale is not intended to be linear. In the first and second spectra the intensities of the lines of the singly ionized atom (II) relative to those of the neutral atom (I) should be used with caution, inasmuch as the concentration of ions in a light source depends greatly on the excitation conditions.

Descriptive symbols that follow the wavelength have the following meanings:

c — complex  
d — line consists of two unresolved lines  
h — hazy  
l — shaded to longer wavelengths  
s — shaded to shorter wavelengths  
p — perturbed by a close line  
r — easily reversed  
w — wide

The table is arranged alphabetically by element name (not symbol); for each element the lines are listed by wavelength. References to the sources of data for each element are given at the end of the table, starting on page 10-89.

## General References

1. Reader, J., Corliss, C. H., Wiese, W. L., and Martin, G. A., *Tables of Line Spectra of the Elements, Part 1. Wavelengths and Intensities*, Nat. Stand. Ref. Data Sys.- Nat. Bur. Standards (U.S.), No. 68, 1980.
2. Meggers, W. F., Corliss, C. H., and Scribner, B. F., *Tables of Spectral Line Intensities, Part 1. Arranged by Elements*, Nat. Bur. Stand. (U.S.), Monograph 145, 1975.
3. Fuhr, J. R., Martin, W. C., Musgrove, A., Sugar, J., and Wiese, W. L., "NIST Atomic Spectroscopic Database" ver. 1.1, January 1996. *NIST Physical Reference Data*, National Institute of Standards and Technology, Gaithersburg, MD. Available at the WWW address: <http://physics.nist.gov/PhysRefData/contents.html>



| Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                 | Wavelength/Å |     |
|---------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|---------------------------|--------------|-----|
| <b>Actinium Ac Z = 89</b> |              |     | 900       | 1582.04      | IV  | 110       | 2368.11      | I   | 290                       | 6068.43      | II  |
| 2000 h                    | 2952.55      | III | 800       | 1584.46      | IV  | 180       | 2369.30      | I   | 110                       | 6068.53      | II  |
| 2000 h                    | 3392.78      | III | 125       | 1596.059     | II  | 140       | 2370.22      | I   | 450                       | 6073.23      | II  |
| 3000                      | 3487.59      | III | 700       | 1605.766     | III | 160       | 2372.07      | I   | 110                       | 6181.57      | II  |
| 2000 s                    | 3863.12      | II  | 100       | 1611.814     | III | 850       | 2373.12      | I   | 150                       | 6181.68      | II  |
| 3000 s                    | 4088.44      | II  | 800       | 1611.874     | III | 170       | 2373.35      | I   | 290                       | 6182.28      | II  |
| 3000 s                    | 4168.40      | II  | 150       | 1625.627     | II  | 110       | 2373.57      | I   | 220                       | 6182.45      | II  |
| 100                       | 4179.98      | I   | 800       | 1639.06      | IV  | 240       | 2567.98      | I   | 450 h                     | 6183.42      | II  |
| 20                        | 4183.12      | I   | 100       | 1644.235     | II  | 480       | 2575.10      | I   | 450                       | 6201.52      | II  |
| 20                        | 4194.40      | I   | 100       | 1644.809     | II  | 110       | 2637.70      | II  | 360                       | 6201.70      | II  |
| 20 l                      | 4384.53      | I   | 1000      | 1670.787     | II  | 150       | 2652.48      | I   | 290                       | 6226.18      | II  |
| 20                        | 4396.71      | I   | 100       | 1686.250     | II  | 200       | 2660.39      | I   | 360                       | 6231.78      | II  |
| 2000 h                    | 4413.09      | III | 800       | 1719.440     | II  | 160       | 2669.17      | II  | 450                       | 6243.36      | II  |
| 20                        | 4462.73      | I   | 500       | 1721.244     | II  | 650       | 2816.19      | II  | 450                       | 6335.74      | II  |
| 3000 h                    | 4569.87      | III | 900       | 1721.271     | II  | 150       | 3041.28      | II  | 360                       | 6696.02      | I   |
| 1000                      | 5910.85      | II  | 500       | 1724.952     | II  | 360       | 3050.07      | I   | 230                       | 6698.67      | I   |
| 20                        | 6359.86      | I   | 900       | 1724.984     | II  | 450       | 3057.14      | I   | 110                       | 7361.57      | I   |
| 20 l                      | 6691.27      | I   | 350       | 1760.104     | II  | 150       | 3074.64      | II  | 140                       | 7362.30      | I   |
| <b>Aluminum Al Z = 13</b> |              |     | 300       | 1761.975     | II  | 4500 r    | 3082.153     | I   | 230                       | 7835.31      | I   |
| 900                       | 125.53       | V   | 290       | 1763.00      | I   | 7200 r    | 3092.710     | I   | 290                       | 7836.13      | I   |
| 800                       | 126.07       | V   | 500       | 1763.869     | II  | 1800 r    | 3092.839     | I   | 110                       | 8075.35      | I   |
| 800                       | 130.41       | V   | 700       | 1763.952     | II  | 150       | 3428.92      | II  | 290                       | 8640.70      | II  |
| 1000                      | 130.85       | V   | 450       | 1765.64      | I   | 150       | 3443.64      | I   | 360                       | 8772.87      | I   |
| 900                       | 131.00       | V   | 300       | 1765.815     | II  | 900       | 3492.23      | IV  | 450                       | 8773.90      | I   |
| 900                       | 131.44       | V   | 450       | 1766.38      | I   | 800       | 3508.46      | IV  | 110                       | 8828.91      | I   |
| 800                       | 160.07       | IV  | 400       | 1767.731     | II  | 450       | 3586.56      | II  | 180                       | 8841.28      | I   |
| 1000                      | 278.69       | V   | 450       | 1769.14      | I   | 360       | 3587.07      | II  | 140                       | 8923.56      | I   |
| 900                       | 281.39       | V   | 1000      | 1818.56      | IV  | 290       | 3587.45      | II  | 150                       | 9290.65      | II  |
| 70                        | 486.884      | III | 600       | 1828.588     | II  | 870       | 3601.63      | III | 110                       | 9290.75      | II  |
| 30                        | 486.912      | III | 400       | 1832.837     | II  | 220       | 3651.06      | II  | 150                       | 10076.29     | II  |
| 250                       | 511.138      | III | 250       | 1834.808     | II  | 110       | 3651.10      | II  | 110                       | 10768.36     | I   |
| 150                       | 511.191      | III | 1000      | 1854.716     | III | 150       | 3654.98      | II  | 140                       | 10782.04     | I   |
| 500                       | 560.317      | III | 300       | 1855.929     | II  | 290       | 3655.00      | II  | 110                       | 10872.98     | I   |
| 200                       | 560.433      | III | 700       | 1858.026     | II  | 450       | 3900.68      | II  | 230                       | 10891.73     | I   |
| 100                       | 670.068      | III | 120       | 1859.980     | II  | 4500 r    | 3944.006     | I   | 450                       | 11253.19     | I   |
| 200                       | 671.118      | III | 1000      | 1862.311     | II  | 9000 r    | 3961.520     | I   | 570                       | 11254.88     | I   |
| 500                       | 695.829      | III | 600       | 1862.790     | III | 110       | 3995.86      | II  | 570                       | 13123.41     | I   |
| 400                       | 696.217      | III | 200       | 1929.978     | II  | 290       | 4226.81      | II  | 450                       | 13150.76     | I   |
| 200                       | 725.683      | III | 150       | 1931.048     | II  | 870       | 4529.19      | III | 230                       | 16718.96     | I   |
| 300                       | 726.915      | III | 200       | 1932.377     | II  | 150       | 4585.82      | II  | 300                       | 16750.56     | I   |
| 400                       | 855.034      | III | 400       | 1934.503     | II  | 110       | 4588.19      | II  | 140                       | 16763.36     | I   |
| 500                       | 856.746      | III | 150       | 1934.713     | II  | 550       | 4666.80      | II  | 300                       | 21093.04     | I   |
| 400                       | 892.024      | III | 300       | 1935.840     | III | 110       | 4898.76      | II  | 360                       | 21163.75     | I   |
| 50                        | 893.887      | III | 200       | 1935.949     | III | 110       | 4902.77      | II  | <b>Antimony Sb Z = 51</b> |              |     |
| 450                       | 893.897      | III | 150       | 1936.907     | II  | 150       | 5280.21      | II  | 15                        | 722.86       | III |
| 800                       | 1042.17      | IV  | 220       | 1939.261     | II  | 290       | 5283.77      | II  | 15                        | 732.33       | III |
| 50                        | 1191.812     | II  | 700       | 1990.531     | II  | 150       | 5285.85      | II  |                           | 861.5        | IV  |
| 900                       | 1237.19      | IV  | 150       | 2016.052     | II  | 110       | 5312.32      | II  | 4                         | 876.84       | II  |
| 900                       | 1257.62      | IV  | 150       | 2016.234     | II  | 220       | 5316.07      | II  | 4                         | 921.07       | II  |
| 800                       | 1264.18      | IV  | 100       | 2016.368     | II  | 150       | 5371.84      | II  | 6                         | 983.57       | II  |
| 1000                      | 1272.76      | IV  | 200       | 2074.008     | II  | 180       | 5557.06      | I   | 15                        | 999.62       | III |
| 150                       | 1350.18      | II  | 700       | 2094.264     | II  | 110       | 5557.95      | I   | 6                         | 1001.13      | II  |
| 800                       | 1384.13      | III | 150       | 2094.744     | II  | 450       | 5593.23      | II  | 6                         | 1009.43      | II  |
| 800                       | 1447.51      | IV  | 300       | 2094.791     | II  | 1200      | 5696.60      | III | 40                        | 1011.94      | III |
| 800                       | 1494.79      | IV  | 100       | 2095.104     | II  | 1000      | 5722.73      | III | 6                         | 1052.21      | II  |
| 1000                      | 1526.14      | V   | 200       | 2095.141     | II  | 110       | 5853.62      | II  | 8                         | 1056.27      | II  |
| 800                       | 1537.54      | IV  | 400       | 2269.10      | I   | 220       | 5971.94      | II  | 8                         | 1057.32      | II  |
| 800                       | 1539.830     | II  | 120       | 2269.22      | I   | 290       | 6001.76      | II  | 40                        | 1065.90      | III |
| 1000                      | 1557.25      | IV  | 140       | 2321.56      | I   | 220       | 6001.88      | II  | 6                         | 1073.81      | II  |
| 100                       | 1569.385     | II  | 460       | 2367.05      | I   | 450       | 6006.42      | II  | 30                        | 1075.82      | III |
|                           |              |     | 110       | 2367.61      | I   | 150       | 6061.11      | II  |                           | 1087.6       | IV  |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity              | Wavelength/Å |    | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|------------------------|--------------|----|-----------|--------------|-----|
| 8         | 1104.32      | V   | 100 r     | 2139.69      | I   | 15                     | 4514.50      | II | 4         | 447.53       | V   |
| 30        | 1151.49      | III | 10        | 2141.80      | II  | 30                     | 4596.90      | II | 18        | 449.06       | V   |
| 40        | 1157.74      | III | 50 r      | 2141.83      | I   | 20                     | 4599.09      | II | 4         | 449.49       | V   |
|           | 1199.1       | IV  | 100 r     | 2144.86      | I   | 15                     | 4604.77      | II | 3         | 458.12       | V   |
| 50        | 1205.20      | III | 1500 r    | 2175.81      | I   | 30                     | 4647.32      | II | 2         | 458.98       | V   |
| 50        | 1210.64      | III | 250 r     | 2179.19      | I   | 20                     | 4675.74      | II | 6 p       | 461.23       | V   |
| 12        | 1226.00      | V   | 200 r     | 2201.32      | I   | 40                     | 4711.26      | II | 3         | 462.42       | V   |
| 6         | 1230.30      | II  | 300 r     | 2208.45      | I   | 20                     | 4757.81      | II | 7         | 463.94       | V   |
| 8         | 1274.98      | II  | 150 r     | 2220.73      | I   | 20                     | 4765.36      | II | 30        | 487.227      | II  |
| 20        | 1306.69      | III | 100       | 2221.98      | I   | 30                     | 4784.03      | II | 50        | 490.650      | II  |
| 8         | 1327.40      | II  | 120 r     | 2224.93      | I   | 20                     | 4802.01      | II | 30        | 490.701      | II  |
| 6         | 1358.04      | II  | 300 r     | 2262.51      | I   | 20                     | 4832.82      | II | 30        | 519.327      | II  |
| 8         | 1384.70      | II  | 120       | 2288.98      | I   | 20                     | 4877.24      | II | 3         | 522.09       | V   |
| 20        | 1404.18      | III | 150 r     | 2293.44      | I   | 15                     | 4947.40      | II | 5         | 524.19       | V   |
| 6         | 1407.83      | II  | 300 r     | 2306.46      | I   | 15                     | 5044.56      | II | 6         | 527.69       | V   |
| 8         | 1436.49      | II  | 2500 r    | 2311.47      | I   | 20                     | 5238.94      | II | 30        | 542.912      | II  |
| 20 r      | 1486.57      | I   | 150       | 2315.89      | I   | 20                     | 5354.24      | II | 200       | 543.203      | II  |
| 40 h      | 1491.36      | I   | 400 h     | 2373.67      | I   | 40 h                   | 5556.10      | I  | 70        | 547.461      | II  |
|           | 1499.2       | IV  | 300 h     | 2383.64      | I   | 100 l                  | 5632.02      | I  | 2         | 554.50       | V   |
| 12        | 1505.70      | V   | 100       | 2395.22      | I   | 30                     | 5639.75      | II | 70        | 556.817      | II  |
| 50 r      | 1512.57      | I   | 150       | 2422.13      | I   | 60 h                   | 5830.34      | I  | 5         | 558.48       | V   |
| 12        | 1524.47      | V   | 250       | 2426.35      | I   | 100                    | 6005.21      | II | 70        | 573.362      | II  |
| 120 r     | 1532.74      | I   | 400 r     | 2445.51      | I   | 20                     | 6053.41      | II | 30        | 576.736      | II  |
| 80 r      | 1535.06      | I   | 400       | 2478.32      | I   | 30                     | 6079.80      | II | 70        | 580.263      | II  |
| 6         | 1565.51      | II  | 150       | 2480.44      | I   | 50                     | 6130.04      | II | 30        | 583.437      | II  |
| 8         | 1576.11      | II  | 100       | 2510.54      | I   | 20                     | 6154.94      | II | 70        | 597.700      | II  |
| 7         | 1581.36      | II  | 2000 r    | 2528.52      | I   | 20                     | 6611.49      | I  | 30        | 602.858      | II  |
| 80 r      | 1599.96      | I   | 15        | 2528.54      | II  | 30                     | 6647.44      | II | 30        | 612.372      | II  |
| 10        | 1606.98      | II  | 10        | 2567.75      | II  | 30 h                   | 7648.28      | I  | 6         | 623.77       | IV  |
| 200 w     | 1612.8       | I   | 150       | 2574.06      | I   | 80                     | 7844.44      | I  | 3         | 635.12       | V   |
| 100 w     | 1623.3       | I   | 15        | 2590.13      | III | 200                    | 7924.65      | I  | 500       | 661.867      | II  |
| 20        | 1657.04      | II  | 1500 r    | 2598.05      | I   | 60                     | 8411.69      | I  | 30        | 664.562      | II  |
| 100 w     | 1662.6       | I   | 500 r     | 2598.09      | I   | 150                    | 8572.64      | I  | 200       | 666.011      | II  |
| 15        | 1673.89      | III | 300 r     | 2612.31      | I   | 100                    | 8619.55      | I  | 1000      | 670.946      | II  |
| 15        | 1711.84      | III | 12        | 2617.17      | III | 400                    | 9518.68      | I  | 3000      | 671.851      | II  |
| 80 r      | 1716.93      | I   | 200 r     | 2652.60      | I   | 400                    | 9949.14      | I  | 70        | 676.242      | II  |
| 150 r     | 1717.45      | I   | 20        | 2669.39      | III | 200                    | 10078.49     | I  | 30        | 677.952      | II  |
| 150 r     | 1723.43      | I   | 300 r     | 2670.64      | I   | 300                    | 10261.01     | I  | 30        | 679.218      | II  |
| 15        | 1725.33      | III | 200 r     | 2682.76      | I   | 200                    | 10585.60     | I  | 200       | 679.401      | II  |
| 100 r     | 1736.19      | I   | 120       | 2692.25      | I   | 1000                   | 10677.41     | I  | 10        | 683.28       | IV  |
| 100 h     | 1765.76      | I   | 150 r     | 2718.90      | I   | 800                    | 10741.94     | I  | 7         | 688.39       | IV  |
| 100 r     | 1780.87      | I   | 400 r     | 2769.95      | I   | 80                     | 10794.11     | I  | 12 p      | 689.01       | IV  |
| 100 r     | 1788.24      | I   | 1000 r    | 2877.92      | I   | 600                    | 10839.73     | I  | 6         | 699.41       | IV  |
| 150       | 1800.18      | I   | 15        | 2980.96      | II  | 200                    | 10868.58     | I  | 8         | 700.28       | IV  |
| 50 r      | 1810.50      | I   | 500 r     | 3029.83      | I   | 400                    | 10879.55     | I  | 3         | 705.35       | V   |
| 80 r      | 1814.20      | I   | 600 r     | 3232.52      | I   | 300                    | 11012.79     | I  | 5         | 709.20       | V   |
| 100       | 1829.50      | I   | 20        | 3241.28      | II  | 150                    | 11266.23     | I  | 4         | 715.60       | V   |
| 50 r      | 1868.17      | I   | 700 r     | 3267.51      | I   | 5                      | 12116.06     | I  | 3         | 715.65       | V   |
| 300 r     | 1871.15      | I   | 15        | 3498.46      | II  | <i>Argon Ar Z = 18</i> |              |    | 200       | 718.090      | II  |
| 150 r     | 1882.56      | I   | 25        | 3637.80      | II  | 3                      | 336.56       | V  | 3000      | 723.361      | II  |
| 100       | 1927.08      | I   | 250       | 3637.83      | I   | 3                      | 337.56       | V  | 2         | 725.11       | V   |
| 200 r     | 1950.39      | I   | 20        | 3722.78      | II  | 6                      | 338.00       | V  | 500       | 725.548      | II  |
| 60 r      | 2029.49      | I   | 200 r     | 3722.79      | I   | 2                      | 338.43       | V  | 70        | 730.930      | II  |
| 70 r      | 2039.77      | I   | 20        | 3850.22      | II  | 2                      | 339.01       | V  | 200       | 740.269      | II  |
| 150 r     | 2049.57      | I   | 200       | 4033.55      | I   | 3                      | 339.89       | V  | 200       | 744.925      | II  |
| 1000 r    | 2068.33      | I   | 20        | 4033.56      | II  | 3                      | 350.88       | V  | 70        | 745.322      | II  |
| 100       | 2079.56      | I   | 20        | 4133.63      | II  | 4                      | 396.87       | IV | 4         | 754.20       | IV  |
| 50 r      | 2098.41      | I   | 15        | 4140.54      | II  | 4                      | 398.55       | IV | 5         | 761.47       | IV  |
| 80 r      | 2118.48      | I   | 15        | 4195.17      | II  | 2                      | 436.67       | V  | 12        | 769.15       | III |
| 100 r     | 2127.39      | I   | 20        | 4219.07      | II  | 5                      | 446.00       | V  | 5         | 800.57       | IV  |
| 50 r      | 2137.05      | I   | 20        | 4314.32      | II  | 8                      | 446.95       | V  | 10        | 801.09       | IV  |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 10        | 801.41       | IV  | 12        | 2293.03      | III | 12        | 2913.00      | IV  | 35        | 3718.206     | II  |
| 5         | 801.91       | IV  | 4         | 2299.72      | IV  | 11        | 2926.33      | IV  | 70        | 3729.309     | II  |
| 20        | 802.859      | I   | 10        | 2300.85      | III | 200       | 2942.893     | II  | 50        | 3737.889     | II  |
| 100       | 806.471      | I   | 15        | 2302.17      | III | 100       | 2979.050     | II  | 150       | 3765.270     | II  |
| 60        | 806.869      | I   | 9         | 2317.00      | III | 10        | 3010.02      | III | 50        | 3766.119     | II  |
| 30        | 807.218      | I   | 15        | 2317.47      | III | 12        | 3024.05      | III | 20        | 3770.369     | I   |
| 40        | 807.653      | I   | 12        | 2318.04      | III | 50        | 3033.508     | II  | 20        | 3770.520     | II  |
| 50        | 809.927      | I   | 10        | 2319.13      | III | 6         | 3037.98      | IV  | 25        | 3780.840     | II  |
| 120       | 816.232      | I   | 10        | 2319.37      | III | 12        | 3054.82      | III | 20        | 3795.37      | III |
| 70        | 816.464      | I   | 9         | 2345.17      | III | 10        | 3064.77      | III | 25        | 3803.172     | II  |
| 80        | 820.124      | I   | 7         | 2351.67      | III | 8         | 3077.40      | IV  | 50        | 3809.456     | II  |
| 4         | 822.16       | V   | 9         | 2360.26      | III | 10        | 3078.15      | III | 7         | 3834.679     | I   |
| 120       | 825.346      | I   | 10        | 2395.63      | III | 50        | 3093.402     | II  | 70        | 3850.581     | II  |
| 120       | 826.365      | I   | 12        | 2399.15      | III | 7         | 3110.41      | III | 10        | 3858.32      | III |
| 5         | 827.05       | V   | 10        | 2413.20      | III | 7         | 3127.90      | III | 35        | 3868.528     | II  |
| 3         | 827.35       | V   | 7         | 2415.61      | III | 8         | 3200.37      | I   | 7         | 3907.84      | III |
| 150       | 834.392      | I   | 10        | 2418.82      | III | 20        | 3243.689     | II  | 35        | 3925.719     | II  |
| 4 p       | 834.88       | V   | 5         | 2420.456     | II  | 25        | 3285.85      | III | 50        | 3928.623     | II  |
| 100       | 835.002      | I   | 12        | 2423.52      | III | 25        | 3293.640     | II  | 25        | 3932.547     | II  |
| 2         | 836.13       | V   | 12        | 2423.93      | III | 20        | 3301.88      | III | 70        | 3946.097     | II  |
| 15        | 840.03       | IV  | 7         | 2443.69      | III | 20        | 3307.228     | II  | 7         | 3947.505     | I   |
| 100       | 842.805      | I   | 8         | 2447.71      | IV  | 15        | 3311.25      | III | 35        | 3948.979     | I   |
| 20        | 843.77       | IV  | 8         | 2472.95      | III | 7         | 3319.34      | I   | 8         | 3960.53      | III |
| 25        | 850.60       | IV  | 7         | 2476.10      | III | 7         | 3323.59      | III | 20        | 3979.356     | II  |
| 180       | 866.800      | I   | 12        | 2488.86      | III | 25        | 3336.13      | III | 35        | 3994.792     | II  |
| 150       | 869.754      | I   | 12        | 2513.28      | IV  | 20        | 3344.72      | III | 50        | 4013.857     | II  |
| 10        | 871.10       | III | 10        | 2516.789     | II  | 25        | 3350.924     | II  | 6         | 4023.60      | III |
| 9         | 875.53       | III | 6         | 2518.40      | IV  | 15        | 3358.49      | III | 50        | 4033.809     | II  |
| 180 r     | 876.058      | I   | 9         | 2525.69      | IV  | 7         | 3361.28      | III | 20        | 4035.460     | II  |
| 12        | 878.73       | III | 10        | 2534.709     | II  | 7         | 3373.47      | I   | 150       | 4042.894     | II  |
| 8         | 879.62       | III | 15        | 2562.087     | II  | 25        | 3376.436     | II  | 50        | 4044.418     | I   |
| 180 r     | 879.947      | I   | 12        | 2562.17      | IV  | 25        | 3388.531     | II  | 100       | 4052.921     | II  |
| 9         | 883.18       | III | 10        | 2568.07      | IV  | 15        | 3391.85      | III | 200       | 4072.005     | II  |
| 10        | 887.40       | III | 7         | 2569.53      | IV  | 7         | 3393.73      | I   | 70        | 4072.385     | II  |
| 150       | 894.310      | I   | 12        | 2599.47      | IV  | 7         | 3417.49      | III | 25        | 4076.628     | II  |
| 5         | 900.36       | IV  | 10        | 2608.06      | IV  | 9         | 3424.25      | III | 35        | 4079.574     | II  |
| 9         | 901.17       | IV  | 7         | 2608.44      | IV  | 8         | 3438.04      | III | 25        | 4082.387     | II  |
| 1000      | 919.781      | II  | 12        | 2615.68      | IV  | 7         | 3461.07      | I   | 150       | 4103.912     | II  |
| 1000      | 932.054      | II  | 6         | 2619.98      | IV  | 9         | 3471.32      | III | 300       | 4131.724     | II  |
| 1000 r    | 1048.220     | I   | 12        | 2621.36      | IV  | 70        | 3476.747     | II  | 5         | 4146.70      | III |
| 500 r     | 1066.660     | I   | 12        | 2624.92      | IV  | 20        | 3478.232     | II  | 35        | 4156.086     | II  |
| 7         | 1669.67      | III | 7         | 2631.90      | III | 20        | 3480.55      | III | 400       | 4158.590     | I   |
| 7         | 1673.42      | III | 15        | 2640.34      | IV  | 50        | 3491.244     | II  | 50        | 4164.180     | I   |
| 7         | 1675.48      | III | 10        | 2654.63      | III | 100       | 3491.536     | II  | 35        | 4179.297     | II  |
| 9         | 1914.40      | III | 8         | 2674.02      | III | 12        | 3499.67      | III | 50        | 4181.884     | I   |
| 7         | 1915.56      | III | 9         | 2678.38      | III | 15        | 3503.58      | III | 100       | 4190.713     | I   |
| 10        | 2125.16      | III | 9         | 2682.63      | IV  | 70        | 3509.778     | II  | 50        | 4191.029     | I   |
| 15        | 2133.87      | III | 10        | 2724.84      | III | 8         | 3511.12      | III | 200       | 4198.317     | I   |
| 10        | 2138.59      | III | 14        | 2757.92      | IV  | 70        | 3514.388     | II  | 400       | 4200.674     | I   |
| 10        | 2148.73      | III | 7         | 2762.23      | III | 70        | 3545.596     | II  | 25        | 4218.665     | II  |
| 15        | 2166.19      | III | 10        | 2776.26      | IV  | 70        | 3545.845     | II  | 25        | 4222.637     | II  |
| 10        | 2168.26      | III | 12        | 2784.47      | IV  | 7         | 3554.306     | I   | 25        | 4226.988     | II  |
| 20        | 2170.23      | III | 14        | 2788.96      | IV  | 100       | 3559.508     | II  | 100       | 4228.158     | II  |
| 25        | 2177.22      | III | 7         | 2797.11      | IV  | 100       | 3561.030     | II  | 100       | 4237.220     | II  |
| 8         | 2184.06      | III | 16        | 2809.44      | IV  | 70        | 3576.616     | II  | 25        | 4251.185     | I   |
| 10        | 2188.22      | III | 10        | 2830.25      | IV  | 25        | 3581.608     | II  | 200       | 4259.362     | I   |
| 15        | 2192.06      | III | 7         | 2842.88      | III | 50        | 3582.355     | II  | 100       | 4266.286     | I   |
| 7         | 2248.73      | III | 8         | 2855.29      | III | 70        | 3588.441     | II  | 70        | 4266.527     | II  |
| 10        | 2279.10      | III | 6         | 2874.40      | IV  | 7         | 3606.522     | I   | 150       | 4272.169     | I   |
| 7         | 2281.22      | III | 9         | 2884.12      | III | 25        | 3622.138     | II  | 550       | 4277.528     | II  |
| 7         | 2282.21      | III | 25        | 2891.612     | II  | 20        | 3639.833     | II  | 20        | 4282.898     | II  |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity                | Wavelength/Å |     |
|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|--------------------------|--------------|-----|
| 100       | 4300.101     | I  | 25        | 5165.773     | II | 7         | 6951.478     | I  | 200                      | 10673.565    | I   |
| 25        | 4300.650     | II | 20        | 5187.746     | I  | 7         | 6960.250     | I  | 11                       | 10681.773    | I   |
| 70        | 4309.239     | II | 20        | 5216.814     | II | 10000     | 6965.431     | I  | 7                        | 10683.034    | II  |
| 200       | 4331.200     | II | 7         | 5221.271     | I  | 150       | 7030.251     | I  | 30                       | 10733.87     | I   |
| 50        | 4332.030     | II | 5         | 5421.352     | I  | 10000     | 7067.218     | I  | 30                       | 10759.16     | I   |
| 100       | 4333.561     | I  | 10        | 5451.652     | I  | 100       | 7068.736     | I  | 7                        | 10812.896    | II  |
| 50        | 4335.338     | I  | 25        | 5495.874     | I  | 25        | 7107.478     | I  | 11                       | 11078.869    | I   |
| 25        | 4345.168     | I  | 5         | 5506.113     | I  | 25        | 7125.820     | I  | 30                       | 11106.46     | I   |
| 800       | 4348.064     | II | 25        | 5558.702     | I  | 1000      | 7147.042     | I  | 12                       | 11441.832    | I   |
| 50        | 4352.205     | II | 10        | 5572.541     | I  | 15        | 7158.839     | I  | 400                      | 11488.109    | I   |
| 25        | 4362.066     | II | 35        | 5606.733     | I  | 70        | 7206.980     | I  | 200                      | 11668.710    | I   |
| 50        | 4367.832     | II | 20        | 5650.704     | I  | 15        | 7265.172     | I  | 12                       | 11719.488    | I   |
| 200       | 4370.753     | II | 10        | 5739.520     | I  | 7         | 7270.664     | I  | 200                      | 12112.326    | I   |
| 70        | 4371.329     | II | 5         | 5834.263     | I  | 2000      | 7272.936     | I  | 50                       | 12139.738    | I   |
| 50        | 4375.954     | II | 10        | 5860.310     | I  | 35        | 7311.716     | I  | 50                       | 12343.393    | I   |
| 150       | 4379.667     | II | 15        | 5882.624     | I  | 25        | 7316.005     | I  | 200                      | 12402.827    | I   |
| 50        | 4385.057     | II | 25        | 5888.584     | I  | 5         | 7350.814     | I  | 200                      | 12439.321    | I   |
| 70        | 4400.097     | II | 50        | 5912.085     | I  | 70        | 7353.293     | I  | 100                      | 12456.12     | I   |
| 200       | 4400.986     | II | 15        | 5928.813     | I  | 200       | 7372.118     | I  | 200                      | 12487.663    | I   |
| 400       | 4426.001     | II | 5         | 5942.669     | I  | 20        | 7380.426     | II | 150                      | 12702.281    | I   |
| 150       | 4430.189     | II | 7         | 5987.302     | I  | 10000     | 7383.980     | I  | 30                       | 12733.418    | I   |
| 50        | 4430.996     | II | 5         | 5998.999     | I  | 20        | 7392.980     | I  | 12                       | 12746.232    | I   |
| 50        | 4433.838     | II | 5         | 6025.150     | I  | 15        | 7412.337     | I  | 200                      | 12802.739    | I   |
| 20        | 4439.461     | II | 70        | 6032.127     | I  | 10        | 7425.294     | I  | 50                       | 12933.195    | I   |
| 35        | 4448.879     | II | 35        | 6043.223     | I  | 25        | 7435.368     | I  | 500                      | 12956.659    | I   |
| 100       | 4474.759     | II | 10        | 6052.723     | I  | 10        | 7436.297     | I  | 200                      | 13008.264    | I   |
| 200       | 4481.811     | II | 20        | 6059.372     | I  | 20000     | 7503.869     | I  | 200                      | 13213.99     | I   |
| 100       | 4510.733     | I  | 7         | 6098.803     | I  | 15000     | 7514.652     | I  | 200                      | 13228.107    | I   |
| 20        | 4522.323     | I  | 10        | 6105.635     | I  | 25000     | 7635.106     | I  | 100                      | 13230.90     | I   |
| 20        | 4530.552     | II | 100       | 6114.923     | II | 15000     | 7723.761     | I  | 500                      | 13272.64     | I   |
| 400       | 4545.052     | II | 10        | 6145.441     | I  | 10000     | 7724.207     | I  | 1000                     | 13313.210    | I   |
| 20        | 4564.405     | II | 7         | 6170.174     | I  | 10        | 7891.075     | I  | 1000                     | 13367.111    | I   |
| 400       | 4579.350     | II | 150       | 6172.278     | II | 20000     | 7948.176     | I  | 30                       | 13499.41     | I   |
| 400       | 4589.898     | II | 10        | 6173.096     | I  | 20000     | 8006.157     | I  | 1000                     | 13504.191    | I   |
| 15        | 4596.097     | I  | 10        | 6212.503     | I  | 25000     | 8014.786     | I  | 11                       | 13573.617    | I   |
| 550       | 4609.567     | II | 5         | 6215.938     | I  | 7         | 8053.308     | I  | 30                       | 13599.333    | I   |
| 7         | 4628.441     | I  | 25        | 6243.120     | II | 20000     | 8103.693     | I  | 400                      | 13622.659    | I   |
| 35        | 4637.233     | II | 7         | 6296.872     | I  | 35000     | 8115.311     | I  | 200                      | 13678.550    | I   |
| 400       | 4657.901     | II | 15        | 6307.657     | I  | 10000     | 8264.522     | I  | 1000                     | 13718.577    | I   |
| 15        | 4702.316     | I  | 7         | 6369.575     | I  | 20        | 8392.27      | I  | 10                       | 13825.715    | I   |
| 20        | 4721.591     | II | 20        | 6384.717     | I  | 15000     | 8408.210     | I  | 10                       | 13907.478    | I   |
| 550       | 4726.868     | II | 70        | 6416.307     | I  | 20000     | 8424.648     | I  | 200                      | 14093.640    | I   |
| 50        | 4732.053     | II | 25        | 6483.082     | II | 15000     | 8521.442     | I  | 100                      | 15046.50     | I   |
| 300       | 4735.906     | II | 15        | 6538.112     | I  | 7         | 8605.776     | I  | 25                       | 15172.69     | I   |
| 800       | 4764.865     | II | 15        | 6604.853     | I  | 4500      | 8667.944     | I  | 10                       | 15329.34     | I   |
| 550       | 4806.020     | II | 25        | 6638.221     | II | 20        | 8771.860     | II | 30                       | 15989.49     | I   |
| 150       | 4847.810     | II | 20        | 6639.740     | II | 180       | 8849.91      | I  | 30                       | 16519.86     | I   |
| 50        | 4865.910     | II | 50        | 6643.698     | II | 20        | 9075.394     | I  | 500                      | 16940.58     | I   |
| 800       | 4879.864     | II | 5         | 6660.676     | I  | 35000     | 9122.967     | I  | 12                       | 18427.76     | I   |
| 70        | 4889.042     | II | 5         | 6664.051     | I  | 550       | 9194.638     | I  | 50                       | 20616.23     | I   |
| 20        | 4904.752     | II | 25        | 6666.359     | II | 15000     | 9224.499     | I  | 30                       | 20986.11     | I   |
| 35        | 4933.209     | II | 100       | 6677.282     | I  | 400       | 9291.531     | I  | 20                       | 23133.20     | I   |
| 200       | 4965.080     | II | 35        | 6684.293     | II | 1600      | 9354.220     | I  | 20                       | 23966.52     | I   |
| 50        | 5009.334     | II | 150       | 6752.834     | I  | 25000     | 9657.786     | I  | <i>Arsenic As Z = 33</i> |              |     |
| 70        | 5017.163     | II | 5         | 6756.163     | I  | 4500      | 9784.503     | I  | 510                      | 871.7        | III |
| 70        | 5062.037     | II | 15        | 6766.612     | I  | 180       | 10052.06     | I  | 325                      | 889.0        | III |
| 20        | 5090.495     | II | 20        | 6861.269     | II | 30        | 10332.72     | I  | 325                      | 927.5        | III |
| 100       | 5141.783     | II | 150       | 6871.289     | I  | 100       | 10467.177    | II | 325                      | 937.2        | III |
| 70        | 5145.308     | II | 5         | 6879.582     | I  | 1600      | 10470.054    | I  | 325                      | 953.6        | III |
| 5         | 5151.391     | I  | 10        | 6888.174     | I  | 13        | 10478.034    | I  | 325                      | 963.8        | III |
| 15        | 5162.285     | I  | 50        | 6937.664     | I  | 180       | 10506.50     | I  | 250                      | 987.7        | V   |

| Intensity | Wavelength/Å |    | Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|---------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 340       | 1021.96      | II | 300                       | 2831.164     | II  | 14        | 587.57       | III | 10        | 3193.91      | I   |
| 250       | 1029.5       | V  | 100 r                     | 2860.44      | I   | 18        | 647.27       | III | 25 h      | 3203.70      | I   |
| 340       | 1082.35      | II | 300                       | 2884.406     | II  | 300       | 719.86       | V   | 30        | 3221.63      | I   |
| 500       | 1139.40      | II | 80                        | 2926.3       | III | 150       | 721.85       | V   | 40        | 3222.19      | I   |
| 615       | 1149.31      | II | 615                       | 2959.572     | II  | 1000      | 766.87       | V   | 50        | 3261.96      | I   |
| 555       | 1181.51      | II | 300                       | 3003.819     | II  | 40000     | 794.89       | IV  | 60 r      | 3262.34      | I   |
| 555       | 1189.87      | II | 300                       | 3116.516     | II  | 300       | 877.41       | V   | 40        | 3281.50      | I   |
| 615       | 1196.38      | II | 340                       | 3842.60      | II  | 50000     | 923.74       | IV  | 15        | 3281.77      | I   |
| 615       | 1196.56      | II | 325                       | 3922.6       | III | 200       | 946.26       | V   | 50        | 3322.80      | I   |
| 340       | 1207.44      | II | 715                       | 4190.082     | II  | 200       | 1486.72      | II  | 80 h      | 3356.80      | I   |
| 800       | 1211.17      | II | 615                       | 4197.40      | II  | 400       | 1504.01      | II  | 50        | 3368.18      | III |
| 800       | 1218.10      | II | 615                       | 4242.982     | II  | 300       | 1554.38      | II  | 60 r      | 3377.08      | I   |
| 340       | 1223.15      | II | 500                       | 4315.657     | II  | 200       | 1572.73      | II  | 20        | 3377.39      | I   |
| 760       | 1241.31      | II | 500                       | 4323.867     | II  |           | 1573.92      | II  | 70 r      | 3420.32      | I   |
| 965       | 1243.08      | II | 500                       | 4336.64      | II  |           | 1630.40      | II  | 25        | 3421.01      | I   |
| 870       | 1245.67      | II | 500                       | 4352.145     | II  | 100       | 1674.51      | II  | 30 h      | 3421.48      | I   |
| 800       | 1258.58      | II | 425                       | 4352.864     | II  | 400       | 1694.37      | II  | 40        | 3463.74      | I   |
| 965       | 1263.77      | II | 375                       | 4371.17      | II  |           | 1697.16      | II  | 200 r     | 3501.11      | I   |
| 800       | 1266.34      | II | 615                       | 4427.106     | II  |           | 1761.75      | II  | 80 h      | 3524.97      | I   |
| 800       | 1267.59      | II | 615                       | 4431.562     | II  |           | 1771.03      | II  | 30 h      | 3531.35      | I   |
| 715       | 1280.99      | II | 715                       | 4458.469     | II  |           | 1786.93      | II  | 80 h      | 3544.66      | I   |
| 715       | 1287.54      | II | 340                       | 4461.075     | II  | 100       | 1904.15      | II  | 20 h      | 3547.68      | I   |
| 715       | 1305.70      | II | 715                       | 4466.348     | II  | 500       | 1924.70      | II  | 100       | 3552.45      | II  |
| 340       | 1307.74      | II | 500                       | 4474.46      | II  |           | 1985.60      | II  | 200       | 3567.73      | II  |
| 760       | 1333.15      | II | 800                       | 4494.230     | II  | 300       | 1999.54      | II  | 100       | 3576.28      | II  |
| 965       | 1341.55      | II | 850                       | 4507.659     | II  | 10        | 2001.30      | III | 30        | 3577.62      | I   |
| 760       | 1355.93      | II | 615                       | 4539.74      | II  |           | 2009.20      | II  | 80 h      | 3579.67      | I   |
| 965       | 1369.77      | II | 715                       | 4543.483     | II  | 400       | 2023.95      | II  | 200       | 3596.57      | II  |
| 800       | 1373.65      | II | 615                       | 4602.427     | II  |           | 2052.68      | II  | 40        | 3630.64      | I   |
| 1000      | 1375.07      | II | 340                       | 4629.787     | II  |           | 2054.57      | II  | 40 h      | 3636.83      | I   |
| 760       | 1375.78      | II | 340                       | 4707.586     | II  | 500       | 2214.7       | II  | 20 h      | 3688.47      | I   |
| 800       | 1394.64      | II | 340                       | 4730.67      | II  | 800       | 2245.61      | II  | 400       | 3735.75      | II  |
| 800       | 1400.31      | II | 340                       | 4888.557     | II  | 1000      | 2254.73      | II  | 200       | 3816.69      | II  |
| 500       | 1448.59      | II | 340                       | 5105.58      | II  | 1400      | 2304.24      | II  | 200       | 3842.80      | II  |
| 500       | 1558.88      | II | 500                       | 5107.55      | II  | 60        | 2331.10      | III | 100       | 3854.76      | II  |
| 500       | 1570.99      | II | 425                       | 5231.38      | II  | 2000      | 2335.27      | II  | 20        | 3889.33      | I   |
| 100 r     | 1593.60      | I  | 500                       | 5331.23      | II  | 190       | 2347.58      | II  | 1400 l    | 3891.78      | II  |
| 500       | 1660.55      | II | 340                       | 5497.727     | II  | 40        | 2512.28      | III | 20        | 3892.65      | I   |
| 340       | 1860.34      | II | 425                       | 5558.09      | II  | 40        | 2523.83      | III | 40        | 3909.91      | I   |
| 1000 r    | 1890.42      | I  | 425                       | 5651.32      | II  | 60        | 2528.51      | II  | 500       | 3914.73      | II  |
| 500       | 1912.94      | II | 425                       | 6110.07      | II  | 50        | 2559.54      | III | 25        | 3926.85      | III |
| 800 r     | 1937.59      | I  | 500                       | 6170.27      | II  | 8 h       | 2596.64      | I   | 50        | 3935.72      | I   |
| 585 r     | 1972.62      | I  | 300                       | 6511.74      | II  | 100       | 2634.78      | II  | 20        | 3937.87      | I   |
| 170 r     | 1990.35      | I  | 300                       | 7092.27      | II  | 40        | 2681.89      | III | 200       | 3939.67      | II  |
| 100 r     | 1991.13      | I  | 300                       | 7102.72      | II  | 8         | 2702.63      | I   | 500       | 3949.51      | II  |
| 100 r     | 1995.43      | I  | 340                       | 7990.53      | II  | 18        | 2771.36      | II  | 25        | 3993.06      | III |
| 230 r     | 2003.34      | I  | 300                       | 8174.51      | II  | 15        | 2785.28      | I   | 80        | 3993.40      | I   |
| 100 r     | 2009.19      | I  | 200                       | 9300.61      | I   | 100 r     | 3071.58      | I   | 30        | 3995.66      | I   |
| 200       | 2263.2       | IV | 230                       | 9597.95      | I   | 40        | 3079.14      | III | 300       | 4036.26      | II  |
| 350 r     | 2288.12      | I  | 290                       | 9626.70      | I   | 10 h      | 3108.21      | I   | 200       | 4083.77      | II  |
| 200       | 2301.0       | IV | 230                       | 9833.76      | I   | 8         | 3132.60      | I   | 30 h      | 4084.86      | I   |
| 350 r     | 2349.84      | I  | 170                       | 9915.71      | I   | 8 h       | 3135.72      | I   | 1500 h    | 4130.66      | II  |
| 100 r     | 2370.77      | I  | 290                       | 9923.05      | I   | 10        | 3137.70      | I   | 20        | 4132.43      | I   |
| 135 r     | 2381.18      | I  | 290                       | 10024.04     | I   | 10        | 3155.34      | I   | 200       | 4166.00      | II  |
| 250       | 2417.5       | IV | 170                       | 10614.07     | I   | 10        | 3155.67      | I   | 500       | 4216.04      | II  |
| 250       | 2454.0       | IV | <i>Astatine At Z = 85</i> |              |     | 12        | 3158.05      | I   | 800       | 4267.95      | II  |
| 170 r     | 2456.53      | I  | 8                         | 2162.25      | I   | 12 h      | 3158.54      | I   | 100       | 4283.10      | I   |
| 200       | 2461.4       | IV | 10                        | 2244.01      | I   | 25        | 3165.60      | I   | 300       | 4287.80      | II  |
| 340       | 2602.00      | II | <i>Barium Ba Z = 56</i>   |              |     | 15 h      | 3173.69      | I   | 200       | 4297.60      | II  |
| 170 r     | 2780.22      | I  | 14                        | 555.48       | III | 30        | 3183.16      | I   | 800       | 4309.32      | II  |
| 300       | 2830.359     | II |                           |              |     | 15        | 3183.96      | I   | 20 h      | 4323.00      | I   |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|-----------|--------------|-----|---------------------------|--------------|-----|-----------|--------------|-----|
| 600       | 4325.73      | II | 300       | 6110.78      | I   | 120 h                     | 11697.45     | I   |           | 107.38       | I   |
| 200       | 4326.74      | II | 400       | 6135.83      | II  | 120                       | 13207.30     | I   | 3         | 509.99       | III |
| 300       | 4329.62      | II | 20000     | 6141.72      | II  | 120                       | 13810.50     | I   | 2         | 549.31       | III |
| 80        | 4350.33      | I  | 150       | 6341.68      | I   | 120                       | 14077.90     | I   | 6         | 582.08       | III |
| 60        | 4402.54      | I  | 500       | 6378.91      | II  | 120                       | 15000.40     | I   | 4         | 661.32       | III |
| 400       | 4405.23      | II | 10        | 6383.76      | III | 120                       | 20712.00     | I   | 8         | 675.59       | III |
| 40        | 4431.89      | I  | 90        | 6450.85      | I   | 150                       | 25515.70     | I   |           | 714.0        | II  |
| 60 h      | 4488.98      | I  | 150       | 6482.91      | I   | 150                       | 29223.90     | I   | 4         | 725.59       | III |
| 50 h      | 4493.64      | I  | 12000     | 6496.90      | II  | <i>Beryllium Be Z = 4</i> |              |     | 5         | 725.71       | II  |
| 40        | 4505.92      | I  | 300       | 6498.76      | I   |                           | 58.13        | IV  | 5         | 743.58       | II  |
| 200       | 4509.63      | II | 150       | 6527.31      | I   |                           | 58.57        | IV  | 7         | 746.23       | III |
| 60 h      | 4523.17      | I  | 3000      | 6595.33      | I   |                           | 59.32        | IV  | 2         | 767.75       | III |
| 130       | 4524.93      | II | 150       | 6654.10      | I   |                           | 60.74        | IV  | 8         | 775.37       | II  |
| 65000     | 4554.03      | II | 1500      | 6675.27      | I   |                           | 64.06        | IV  | 20        | 842.06       | II  |
| 40        | 4573.85      | I  | 1800      | 6693.84      | I   |                           | 75.93        | IV  |           | 865.3        | II  |
| 80        | 4579.64      | I  | 1000      | 6769.62      | II  | 1 h                       | 76.10        | III | 2         | 925.25       | II  |
| 30        | 4599.75      | I  | 600       | 6865.69      | I   | 2                         | 76.48        | III | 10        | 943.56       | II  |
| 20 h      | 4619.92      | I  | 300 h     | 6867.85      | I   | 3                         | 78.53        | III | 10        | 973.27       | II  |
| 25 h      | 4628.33      | I  | 1000      | 6874.09      | II  | 4                         | 78.66        | III |           | 981.4        | II  |
| 300       | 4644.10      | II | 6000      | 7059.94      | I   | 1 h                       | 78.92        | III |           | 1020.1       | II  |
| 30        | 4673.62      | I  | 2400 hs   | 7120.33      | I   | 5                         | 81.89        | III | 8         | 1026.93      | II  |
| 35        | 4691.62      | I  | 600       | 7195.24      | I   | 10                        | 82.38        | III | 5         | 1036.32      | II  |
| 20        | 4700.43      | I  | 600 hl    | 7228.84      | I   |                           | 82.58        | II  | 15        | 1048.23      | II  |
| 800       | 4708.94      | II | 3000      | 7280.30      | I   | 20                        | 83.20        | III | 1         | 1114.69      | III |
| 40        | 4726.44      | I  | 1200      | 7392.41      | I   |                           | 83.66        | II  | 20        | 1143.03      | II  |
| 800       | 4843.46      | II | 300       | 7417.53      | I   | 30                        | 84.76        | III |           | 1155.9       | II  |
| 300       | 4847.14      | II | 900 hl    | 7459.78      | I   | 50                        | 88.31        | III | 60        | 1197.19      | II  |
| 200       | 4850.84      | II | 600       | 7488.08      | I   |                           | 89.16        | I   | 2         | 1213.12      | III |
| 30 h      | 4877.65      | I  | 450 hl    | 7636.90      | I   |                           | 89.80        | II  | 1         | 1214.32      | III |
| 400       | 4899.97      | II | 600 hl    | 7642.91      | I   |                           | 90.04        | II  | 2         | 1362.25      | III |
| 15        | 4902.90      | I  | 1800      | 7672.09      | I   |                           | 90.21        | I   | 1         | 1401.52      | III |
| 20000     | 4934.09      | II | 1200      | 7780.48      | I   |                           | 90.67        | I   | 10        | 1421.26      | III |
| 8         | 4947.35      | I  | 180 h     | 7839.57      | I   |                           | 91.06        | II  | 5         | 1422.86      | III |
| 1000      | 4957.15      | II | 1500      | 7905.75      | I   |                           | 91.36        | II  |           | 1426.12      | I   |
| 300       | 4997.81      | II | 600       | 7911.34      | I   |                           | 91.74        | II  | 1         | 1435.17      | III |
| 1000      | 5013.00      | II | 900 h     | 8210.24      | I   |                           | 92.19        | I   | 2         | 1440.77      | III |
| 20 h      | 5159.94      | I  | 8         | 8308.69      | III |                           | 92.61        | II  |           | 1491.76      | I   |
| 20        | 5267.03      | I  | 1800 h    | 8559.97      | I   |                           | 93.14        | II  | 20        | 1512.30      | II  |
| 800       | 5361.35      | II | 100       | 8710.74      | II  |                           | 93.42        | II  | 60        | 1512.43      | II  |
| 1000      | 5391.60      | II | 100       | 8737.71      | II  |                           | 93.93        | II  | 100       | 1661.49      | I   |
| 200       | 5421.05      | II | 300 h     | 8799.76      | I   |                           | 94.78        | II  | 2 h       | 1754.69      | III |
| 100       | 5424.55      | I  | 300       | 8860.98      | I   |                           | 95.76        | II  | 15        | 1776.12      | II  |
| 200       | 5428.79      | II | 450       | 8914.99      | I   |                           | 96.29        | I   | 20        | 1776.34      | II  |
| 300       | 5480.30      | II | 300       | 9219.69      | I   |                           | 97.24        | I   |           | 1907.        | I   |
| 200       | 5519.05      | I  | 300       | 9308.08      | I   |                           | 97.44        | I   |           | 1909.0       | II  |
| 1000 r    | 5535.48      | I  | 300 h     | 9324.58      | I   |                           | 97.86        | I   |           | 1912.        | I   |
| 20 h      | 5620.40      | I  | 1500      | 9370.06      | I   |                           | 97.97        | I   | 3         | 1917.03      | III |
| 10        | 5680.18      | I  | 300       | 9455.92      | I   |                           | 98.12        | I   |           | 1919.        | I   |
| 400       | 5777.62      | I  | 8         | 9521.76      | III |                           | 98.37        | I   | 5         | 1929.67      | I   |
| 800       | 5784.18      | II | 450       | 9589.37      | I   |                           | 98.66        | I   | 10        | 1943.68      | I   |
| 100       | 5800.23      | I  | 900       | 9608.88      | I   |                           | 98.94        | I   | 60 h      | 1954.97      | III |
| 20        | 5805.69      | I  | 300 h     | 9645.72      | I   |                           | 99.19        | I   |           | 1956.        | I   |
| 150       | 5826.28      | I  | 1500 hl   | 9830.37      | I   | 100                       | 100.25       | III | 50        | 1964.59      | I   |
| 2800      | 5853.68      | II | 900       | 10001.08     | I   |                           | 100.86       | I   | 5         | 1985.13      | I   |
| 15        | 5907.64      | I  | 600       | 10032.10     | I   |                           | 101.20       | I   |           | 1997.95      | I   |
| 100       | 5971.70      | I  | 1200 h    | 10233.23     | I   |                           | 102.13       | I   |           | 1997.98      | I   |
| 800       | 5981.25      | II | 300       | 10471.26     | I   |                           | 102.49       | II  | 60        | 1998.01      | I   |
| 100       | 5997.09      | I  | 120 hl    | 10791.25     | I   |                           | 104.40       | II  |           | 2033.25      | I   |
| 300       | 5999.85      | II | 180 hl    | 11012.69     | I   |                           | 104.67       | I   |           | 2033.28      | I   |
| 100       | 6019.47      | I  | 150 h     | 11114.42     | I   |                           | 105.80       | I   |           | 2033.38      | I   |
| 200       | 6063.12      | I  | 240       | 11303.04     | I   |                           | 107.26       | I   | 50        | 2055.90      | I   |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|--------------------------|--------------|-----|
| 100       | 2056.01      | I   |           | 3163.        | I   | 64        | 5270.28      | II  | 60                       | 14644.75     | I   |
| 75 h      | 2076.94      | III |           | 3168.        | I   | 500       | 5270.81      | II  | 200                      | 16157.72     | I   |
| 60 h      | 2080.38      | III |           | 3180.7       | II  | 20        | 5403.04      | II  | 80                       | 17855.38     | I   |
| 25        | 2118.56      | III |           | 3187.        | I   | 20        | 5410.21      | II  | 120                      | 17856.63     | I   |
| 15 h      | 2122.27      | III | 20        | 3193.81      | I   |           | 5558.        | I   | 100                      | 18143.54     | I   |
| 10        | 2125.57      | I   | 20        | 3197.10      | II  | 140 h     | 6142.01      | III | 160                      | 31775.05     | I   |
| 20        | 2125.68      | I   | 30        | 3197.15      | II  | 10        | 6229.11      | I   | 200                      | 31778.70     | I   |
| 15 h      | 2127.20      | III | 20        | 3208.60      | I   | 16        | 6279.43      | II  | <b>Bismuth Bi Z = 83</b> |              |     |
| 5         | 2137.25      | III |           | 3220.        | I   | 30        | 6279.73      | II  | 6                        | 420.7        | IV  |
| 25        | 2145.        | I   | 60        | 3229.63      | I   | 30        | 6473.54      | I   | 6                        | 431.2        | IV  |
| 55        | 2174.99      | I   | 2         | 3233.52      | II  | 60        | 6547.89      | II  | 2                        | 488.39       | V   |
| 55        | 2175.10      | I   | 10        | 3241.62      | II  | 60        | 6558.36      | II  | 3                        | 563.62       | V   |
| 5         | 2191.57      | III | 30        | 3241.83      | II  | 30        | 6564.52      | I   | 5                        | 670.76       | III |
|           | 2273.5       | II  | 15        | 3269.02      | I   | 2 h       | 6636.44      | II  | 6                        | 686.88       | V   |
|           | 2324.6       | II  | 100       | 3274.58      | II  | 1         | 6756.72      | II  | 5                        | 730.71       | V   |
|           | 2337.0       | I   | 30        | 3274.67      | II  | 2         | 6757.13      | II  | 10                       | 738.17       | V   |
| 950       | 2348.61      | I   | 30        | 3282.91      | I   | 30        | 6786.56      | I   | 4                        | 775.16       | III |
| 20        | 2350.66      | I   | 30        | 3321.01      | I   | 1 h       | 6884.22      | I   | 6                        | 790.5        | IV  |
| 60        | 2350.71      | I   | 30        | 3321.09      | I   | 6 h       | 6884.44      | I   | 6                        | 790.6        | IV  |
| 200       | 2350.83      | I   | 220       | 3321.34      | I   | 100       | 6982.75      | I   | 8                        | 792.5        | IV  |
| 2         | 2413.34      | II  | 20        | 3345.43      | I   | 6 h       | 7154.40      | I   | 10                       | 820.3        | IV  |
| 16        | 2413.46      | II  | 60        | 3367.63      | I   | 40 h      | 7154.65      | I   | 9                        | 822.9        | IV  |
| 20        | 2453.84      | II  |           | 3405.6       | II  | 100       | 7209.13      | I   | 12                       | 824.9        | IV  |
|           | 2480.6       | I   | 5         | 3451.37      | I   | 3         | 7401.20      | II  | 15 d                     | 864.45       | V   |
| 35        | 2494.54      | I   | 300       | 3455.18      | I   | 2         | 7401.43      | II  | 15                       | 872.6        | IV  |
| 35        | 2494.58      | I   | 20        | 3476.56      | I   | 10        | 7551.90      | I   | 12                       | 923.9        | IV  |
| 100       | 2494.73      | I   | 300       | 3515.54      | I   | 10 h      | 7618.68      | I   | 15                       | 943.3        | IV  |
| 16        | 2507.43      | II  | 10        | 3555.        | I   | 20 h      | 7618.88      | I   | 25                       | 1039.99      | III |
| 5         | 2617.99      | II  | 100       | 3720.36      | III | 60        | 8090.06      | I   | 50 h                     | 1045.76      | III |
| 20        | 2618.13      | II  |           | 3720.92      | III | 5 h       | 8158.99      | I   | 30                       | 1051.81      | III |
| 100       | 2650.45      | I   |           | 3722.98      | III | 10 h      | 8159.24      | I   | 15                       | 1058.88      | II  |
| 60        | 2650.55      | I   | 100       | 3736.30      | I   | 4         | 8254.07      | I   | 20                       | 1085.47      | II  |
| 200       | 2650.62      | I   | 700       | 3813.45      | I   | 10 h      | 8287.07      | I   | 10                       | 1099.20      | II  |
| 60        | 2650.69      | I   | 40        | 3865.13      | I   | 30        | 8547.36      | I   | 24                       | 1103.4       | IV  |
| 100       | 2650.76      | I   | 80        | 3865.42      | I   | 60        | 8547.67      | I   | 20                       | 1139.01      | III |
| 5         | 2697.46      | II  | 1         | 3865.51      | I   | 300       | 8801.37      | I   | 50                       | 1224.64      | III |
| 20        | 2697.58      | II  | 6         | 3865.72      | I   | 6         | 8882.18      | I   | 10                       | 1225.43      | II  |
| 20        | 2728.88      | II  | 100       | 3866.03      | I   | 40        | 9190.45      | I   | 15                       | 1232.78      | II  |
| 30        | 2738.05      | I   | 90 h      | 4249.14      | III | 20 h      | 9243.92      | I   | 10                       | 1241.05      | II  |
|           | 2764.2       | II  | 100       | 4253.05      | I   | 1 h       | 9343.89      | II  | 10                       | 1265.35      | II  |
| 20        | 2898.13      | I   | 60        | 4253.76      | I   | 40        | 9392.74      | I   | 15                       | 1283.73      | II  |
| 10        | 2898.19      | I   | 300       | 4360.66      | II  | 2         | 9476.43      | II  | 10                       | 1306.18      | II  |
| 20        | 2898.25      | I   | 500       | 4360.99      | II  | 16        | 9477.03      | II  | 60                       | 1317.0       | IV  |
| 30        | 2986.06      | I   | 400       | 4407.94      | I   | 20        | 9847.32      | I   | 20                       | 1325.46      | II  |
| 10        | 2986.42      | I   | 2         | 4485.52      | III | 10 h      | 9895.63      | I   | 40                       | 1326.84      | III |
| 60        | 3019.33      | I   | 100 h     | 4487.30      | III | 20 h      | 9895.96      | I   | 20                       | 1329.47      | II  |
| 30        | 3019.49      | I   | 1         | 4495.09      | III | 80        | 9939.78      | I   | 60                       | 1346.12      | III |
| 30        | 3019.53      | I   | 140 h     | 4497.8       | III | 16        | 10095.52     | II  | 20                       | 1350.07      | II  |
| 20        | 3019.60      | I   |           | 4526.6       | I   | 20        | 10095.73     | II  | 25                       | 1372.61      | II  |
| 10        | 3046.52      | II  |           | 4548.        | I   | 60        | 10119.92     | II  | 15                       | 1376.02      | II  |
| 30        | 3046.69      | II  | 12        | 4572.66      | I   | 80        | 10331.03     | I   | 20                       | 1393.92      | II  |
|           | 3090.3       | I   | 700       | 4673.33      | II  | 30        | 11066.46     | I   | 35                       | 1423.33      | III |
| 10        | 3110.81      | I   | 1000      | 4673.42      | II  |           | 11173.       | II  | 35                       | 1423.52      | III |
| 10        | 3110.92      | I   | 6         | 4709.37      | I   | 1         | 11173.73     | II  | 45                       | 1436.83      | II  |
| 20        | 3110.99      | I   | 200       | 4828.16      | II  | 120       | 11496.39     | I   | 25                       | 1447.94      | II  |
|           | 3120.        | I   | 40        | 4849.16      | I   | 2 h       | 11625.16     | II  | 50                       | 1455.11      | II  |
| 480       | 3130.42      | II  | 2 h       | 4858.22      | II  |           | 11659.       | II  | 60 h                     | 1461.00      | III |
| 320       | 3131.07      | II  | 80        | 5087.75      | I   | 2         | 11660.25     | II  | 25                       | 1462.14      | II  |
|           | 3136.        | I   | 8         | 5218.12      | II  | 100       | 12095.36     | II  | 35                       | 1486.93      | II  |
|           | 3150.        | I   | 20        | 5218.33      | II  | 30        | 12098.18     | II  | 20                       | 1502.50      | II  |
|           | 3160.6       | I   | 3         | 5255.86      | II  | 100       | 14643.92     | I   | 40                       | 1520.57      | II  |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity            | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|----------------------|--------------|-----|
| 40        | 1533.17      | II  | 100       | 2924.        | IV  | 60 h      | 5144.3       | II  | <i>Boron B Z = 5</i> |              |     |
| 30        | 1536.77      | II  | 100       | 2933.        | IV  | 20        | 5201.5       | II  |                      | 41.00        | V   |
| 35        | 1538.06      | II  | 100       | 2936.        | IV  | 75 h      | 5209.2       | II  | 30                   | 48.59        | V   |
| 20        | 1563.67      | II  | 15        | 2936.7       | II  | 40 h      | 5270.3       | II  | 10                   | 52.68        | IV  |
| 40        | 1573.70      | II  | 3200      | 2938.30      | I   | 10        | 5397.8       | II  | 30                   | 60.31        | IV  |
| 60        | 1591.79      | II  | 20        | 2950.4       | II  | 10 c      | 5552.35      | I   |                      | 194.37       | V   |
| 25        | 1601.58      | II  | 12        | 2963.4       | II  | 3         | 5599.41      | I   |                      | 262.37       | V   |
| 60 h      | 1606.40      | III | 2800      | 2989.03      | I   | 20        | 5655.2       | II  | 160                  | 344.0        | IV  |
| 40        | 1609.70      | II  | 700       | 2993.34      | I   | 40 h      | 5719.2       | II  | 450                  | 385.0        | IV  |
| 40        | 1611.38      | II  | 100       | 3012.        | IV  | 6         | 5742.55      | I   | 40                   | 411.80       | III |
| 20        | 1652.81      | II  | 2400      | 3024.64      | I   | 12        | 5818.3       | II  | 285                  | 418.7        | IV  |
| 20        | 1749.29      | II  | 60        | 3034.87      | I   | 20        | 5860.2       | II  | 20                   | 510.77       | III |
| 80        | 1777.11      | II  | 100       | 3042.        | IV  | 20        | 5973.0       | II  | 40                   | 510.85       | III |
| 60        | 1787.47      | II  | 9000 c    | 3067.72      | I   | 15        | 6059.1       | II  |                      | 512.53       | V   |
| 70        | 1791.93      | II  | 140       | 3076.66      | I   | 15        | 6128.0       | II  | 150                  | 518.24       | III |
| 70        | 1823.80      | II  | 35        | 3115.0       | III | 6         | 6134.82      | I   | 75                   | 518.27       | III |
| 100       | 1902.41      | II  | 100       | 3239.        | IV  | 3         | 6475.73      | I   | 110                  | 677.00       | III |
| 9000      | 1954.53      | I   | 550 c     | 3397.21      | I   | 3         | 6476.24      | I   | 160                  | 677.14       | III |
| 7000      | 1960.13      | I   | 10        | 3430.83      | II  | 15        | 6497.7       | II  | 40                   | 693.95       | II  |
| 25        | 1989.35      | II  | 12        | 3431.23      | II  | 10        | 6577.2       | II  | 40                   | 731.36       | II  |
| 7000      | 2021.21      | I   | 40 h      | 3451.0       | III | 40 h      | 6600.2       | II  | 40                   | 731.44       | II  |
| 9000      | 2061.70      | I   | 40        | 3473.8       | III | 50 h      | 6808.6       | II  |                      | 749.74       | V   |
| 45 h      | 2068.9       | II  | 35        | 3485.5       | III | 4 h       | 6991.12      | I   | 40                   | 758.48       | III |
| 4600      | 2110.26      | I   | 500 c     | 3510.85      | I   | 12        | 7033.        | II  | 70                   | 758.67       | III |
| 2500      | 2133.63      | I   | 380 c     | 3596.11      | I   | 2         | 7036.15      | I   | 110                  | 882.54       | II  |
| 15        | 2143.40      | II  | 45        | 3613.4       | III | 10 h      | 7381.        | II  | 110                  | 882.68       | II  |
| 15        | 2143.46      | II  | 100       | 3643.        | IV  | 2         | 7502.33      | I   | 40                   | 984.67       | II  |
| 60        | 2186.9       | II  | 12        | 3654.2       | II  | 10 h      | 7637.        | II  | 110                  | 1081.88      | II  |
| 40 h      | 2214.0       | II  | 100       | 3682.        | IV  | 10        | 7750.        | II  | 110                  | 1082.07      | II  |
| 360       | 2228.25      | I   | 50        | 3695.32      | III | 3         | 7838.70      | I   | 70                   | 1112.2       | IV  |
| 1700      | 2230.61      | I   | 50        | 3695.68      | III | 2         | 7840.33      | I   | 450                  | 1168.9       | IV  |
| 340       | 2276.58      | I   | 100       | 3734.        | IV  | 20        | 7965.        | II  | 70                   | 1170.9       | IV  |
| 100       | 2311.        | IV  | 70 h      | 3792.5       | II  | 40        | 8008.        | III | 110                  | 1230.16      | II  |
| 100       | 2326.        | IV  | 12        | 3811.1       | II  | 12 h      | 8050.        | II  | 220                  | 1362.46      | II  |
| 16        | 2368.12      | II  | 20        | 3815.8       | II  | 50        | 8070.        | III | 70                   | 1600.46      | I   |
| 12        | 2368.25      | II  | 10        | 3845.8       | II  | 15        | 8328.        | II  | 120                  | 1600.73      | I   |
| 100       | 2376.        | IV  | 30        | 3863.9       | II  | 15        | 8388.        | II  | 160                  | 1623.58      | II  |
| 190       | 2400.88      | I   | 100       | 3868.        | IV  | 30        | 8532.        | II  | 110                  | 1623.77      | II  |
| 75 h      | 2414.6       | III | 40 h      | 4079.1       | II  | 2         | 8544.54      | I   | 220                  | 1624.02      | II  |
| 10        | 2501.0       | II  | 10        | 4097.2       | II  | 1         | 8579.74      | I   | 70                   | 1624.16      | II  |
| 25        | 2515.69      | I   | 140       | 4121.53      | I   | 25        | 8653.        | II  | 160                  | 1624.34      | II  |
| 70        | 2524.49      | I   | 140       | 4121.86      | I   | 2         | 8754.88      | I   | 100                  | 1663.04      | I   |
| 20 h      | 2544.5       | II  | 75 h      | 4259.4       | II  | 3         | 8761.54      | I   | 150                  | 1666.87      | I   |
| 700       | 2627.91      | I   | 25        | 4272.0       | II  | 25        | 8863.        | II  | 200                  | 1667.29      | I   |
| 100       | 2629.        | IV  | 70 h      | 4301.7       | II  | 2         | 8907.81      | I   | 150                  | 1817.86      | I   |
| 100       | 2677.        | IV  | 12 h      | 4339.8       | II  | 2000 d    | 9657.04      | I   | 200                  | 1818.37      | I   |
| 12        | 2693.0       | II  | 25 h      | 4340.5       | II  | 40        | 9827.78      | I   | 300                  | 1825.91      | I   |
| 280 c     | 2696.76      | I   | 12 h      | 4379.4       | II  | 20        | 10104.5      | I   | 300                  | 1826.41      | I   |
| 20        | 2713.3       | II  | 25 h      | 4476.8       | II  | 15        | 10138.8      | I   | 110                  | 1842.81      | II  |
| 140 d     | 2730.50      | I   | 60 h      | 4705.3       | II  | 20        | 10300.6      | I   | 20                   | 1953.83      | III |
| 100       | 2767.        | IV  | 600 c     | 4722.52      | I   | 20        | 10536.19     | I   | 550                  | 2065.78      | III |
| 100       | 2772.        | IV  | 30        | 4730.3       | II  | 50        | 11072.44     | I   | 250                  | 2066.38      | I   |
| 360       | 2780.52      | I   | 20        | 4749.7       | II  | 1500 d    | 11710.37     | I   | 250                  | 2066.65      | I   |
| 100       | 2786.        | IV  | 40 h      | 4797.4       | III | 40        | 11999.49     | I   | 100                  | 2066.93      | I   |
| 15        | 2803.42      | II  | 12        | 4908.2       | II  | 200       | 12165.08     | I   | 300                  | 2067.19      | I   |
| 11        | 2803.70      | II  | 10        | 4916.6       | II  | 200       | 12690.04     | I   | 450                  | 2067.23      | III |
| 12        | 2805.3       | II  | 12        | 4969.7       | II  | 100       | 12817.8      | I   | 160                  | 2077.09      | III |
| 140 c     | 2809.62      | I   | 20        | 4993.6       | II  | 200       | 14330.5      | I   | 500                  | 2088.91      | I   |
| 100       | 2842.        | IV  | 45 h      | 5079.3       | III | 50        | 16001.5      | I   | 500                  | 2089.57      | I   |
| 80 h      | 2855.6       | III | 10        | 5091.6       | II  | 60        | 22551.6      | I   | 70                   | 2220.30      | II  |
| 4000      | 2897.98      | I   | 50 h      | 5124.3       | II  |           |              |     | 40                   | 2234.09      | III |



| Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |   |
|--------------------------|--------------|-----|-----------|--------------|----|-----------|--------------|-----|-----------|--------------|---|
| 70                       | 2234.59      | III | 1000      | 619.87       | IV | 500       | 3041.18      | IV  | 1200      | 7827.23      | I |
| 40                       | 2323.03      | II  | 1000      | 630.14       | IV | 500       | 3074.42      | III | 2500 s    | 7881.45      | I |
| 40                       | 2328.67      | II  | 1000      | 642.23       | IV | 500       | 3349.64      | III | 2500      | 7881.57      | I |
| 40                       | 2393.20      | II  | 1000      | 661.53       | IV | 500       | 3380.56      | IV  | 2500      | 7925.81      | I |
| 220                      | 2395.05      | II  | 1000      | 683.51       | IV | 500       | 3540.16      | III | 30000 c   | 7938.68      | I |
| 40                       | 2459.69      | II  | 1000      | 697.72       | IV | 500       | 3562.43      | III | 3000      | 7947.94      | I |
| 40                       | 2459.90      | II  | 1000      | 715.39       | IV | 1200      | 3815.65      | I   | 3000      | 7950.18      | I |
| 1000                     | 2496.77      | I   | 1000      | 731.00       | IV | 1500      | 3992.36      | I   | 8000      | 7978.44      | I |
| 1000                     | 2497.73      | I   | 1000      | 800.12       | IV | 1000      | 4223.89      | II  | 10000     | 7978.57      | I |
| 70                       | 2524.7       | IV  | 700       | 812.95       | V  | 2000      | 4365.14      | I   | 30000     | 7989.94      | I |
| 160                      | 2530.3       | IV  | 1000      | 813.66       | IV | 1000      | 4365.60      | II  | 2000      | 8026.35      | I |
| 450                      | 2821.68      | IV  | 1000      | 850.81       | V  | 1500      | 4425.14      | I   | 2500      | 8026.54      | I |
| 70                       | 2824.57      | IV  | 1000      | 889.23       | II | 10000     | 4441.74      | I   | 30000     | 8131.52      | I |
| 285                      | 2825.85      | IV  | 1000      | 948.97       | II | 10000     | 4472.61      | I   | 1000 c    | 8152.65      | I |
| 160                      | 2918.08      | II  | 1000      | 1015.54      | II | 20000     | 4477.72      | I   | 10000     | 8153.75      | I |
| 110                      | 3032.26      | II  | 1000      | 1049.00      | II | 1000      | 4490.42      | I   | 25000     | 8154.00      | I |
| 70                       | 3179.33      | II  | 1000      | 1069.15      | V  | 3000      | 4513.44      | I   | 5000      | 8246.86      | I |
| 110                      | 3323.18      | II  | 900       | 1112.13      | V  | 15000     | 4525.59      | I   | 15000     | 8264.96      | I |
| 110                      | 3323.60      | II  | 1000      | 1143.56      | V  | 3000      | 4575.74      | I   | 75000 c   | 8272.44      | I |
| 450                      | 3451.29      | II  | 1000      | 1189.28      | I  | 2500      | 4614.58      | I   | 20000     | 8334.70      | I |
| 285                      | 4121.93      | II  | 1000      | 1189.50      | I  | 2500      | 4752.28      | I   | 10000     | 8343.70      | I |
| 110                      | 4194.79      | II  | 1000      | 1210.73      | I  | 4000      | 4780.31      | I   | 1200      | 8384.04      | I |
| 40                       | 4242.98      | III | 1000      | 1221.13      | I  | 1600      | 4785.19      | I   | 40000     | 8446.55      | I |
| 70                       | 4243.61      | III | 1000      | 1223.24      | I  | 4000      | 4979.76      | I   | 4000      | 8477.45      | I |
| 110                      | 4472.10      | II  | 1200      | 1224.41      | I  | 1200      | 5395.48      | I   | 1500      | 8513.38      | I |
| 110                      | 4472.85      | II  | 1200      | 1226.90      | I  | 1200      | 5466.22      | I   | 1000      | 8557.73      | I |
| 220                      | 4487.05      | III | 7500      | 1232.43      | I  | 1800      | 5852.08      | I   | 1000      | 8566.28      | I |
| 360                      | 4497.73      | III | 1200      | 1243.90      | I  | 1600      | 5940.48      | I   | 20000     | 8638.66      | I |
| 70                       | 4784.21      | II  | 1500      | 1251.66      | I  | 2400      | 6122.14      | I   | 4000      | 8698.53      | I |
| 110                      | 4940.38      | II  | 1000      | 1255.80      | I  | 40000     | 6148.60      | I   | 10000 c   | 8793.47      | I |
| 110                      | 6080.44      | II  | 1500      | 1259.20      | I  | 2000      | 6177.39      | I   | 15000     | 8819.96      | I |
| 70                       | 6285.47      | II  | 1200      | 1261.66      | I  | 1500      | 6335.48      | I   | 25000     | 8825.22      | I |
| 70                       | 7030.20      | II  | 1200      | 1266.20      | I  | 60000     | 6350.73      | I   | 4000      | 8888.98      | I |
| 40                       | 7031.90      | II  | 1000      | 1279.48      | I  | 2500      | 6410.32      | I   | 30000     | 8897.62      | I |
| 110                      | 7835.25      | III | 1000      | 1286.26      | I  | 1800      | 6483.56      | I   | 6000      | 8932.40      | I |
| 70                       | 7841.41      | III | 3000      | 1309.91      | I  | 1000      | 6514.62      | I   | 1800      | 8949.39      | I |
| 20                       | 8667.22      | I   | 3000      | 1316.74      | I  | 20000     | 6544.57      | I   | 9000      | 8964.00      | I |
| 70                       | 8668.57      | I   | 1000      | 1317.37      | I  | 1500      | 6548.09      | I   | 30000     | 9166.06      | I |
| 800                      | 11660.04     | I   | 2000      | 1317.70      | I  | 50000 c   | 6559.80      | I   | 15000     | 9173.63      | I |
| 570                      | 11662.47     | I   | 12000     | 1384.60      | I  | 1000      | 6571.31      | I   | 20000     | 9178.16      | I |
| 125                      | 15629.08     | I   | 3000      | 1449.90      | I  | 1800      | 6579.14      | I   | 40000     | 9265.42      | I |
| 200                      | 16240.38     | I   | 50000     | 1488.45      | I  | 20000     | 6582.17      | I   | 15000     | 9320.86      | I |
| 250                      | 16244.67     | I   | 30000     | 1531.74      | I  | 1500      | 6620.47      | I   | 6000      | 9793.48      | I |
| 235                      | 18994.33     | I   | 25000     | 1540.65      | I  | 50000 c   | 6631.62      | I   | 10000     | 9896.40      | I |
| <b>Bromine Br Z = 35</b> |              |     | 30000     | 1574.84      | I  | 20000     | 6682.28      | I   | 3000      | 10140.08     | I |
| 700                      | 379.73       | IV  | 20000     | 1576.39      | I  | 10000     | 6692.13      | I   | 6000      | 10237.74     | I |
| 700                      | 400.37       | IV  | 25000     | 1582.31      | I  | 8000      | 6728.28      | I   | 1000      | 10299.62     | I |
| 800                      | 482.11       | V   | 75000     | 1633.40      | I  | 2000      | 6760.06      | I   | 1500      | 10377.65     | I |
| 900                      | 531.97       | V   | 1000      | 2133.79      | IV | 2000      | 6779.48      | I   | 30000     | 10457.96     | I |
| 1000                     | 545.43       | IV  | 1000      | 2145.02      | IV | 2200      | 6786.74      | I   | 1000      | 10742.14     | I |
| 1000                     | 547.90       | V   | 1000      | 2257.21      | IV | 6500      | 6790.04      | I   | 3000      | 10755.92     | I |
| 1000                     | 559.76       | IV  | 1000      | 2272.73      | IV | 1600 c    | 6791.48      | I   | 1700      | 13217.17     | I |
| 1000                     | 569.19       | IV  | 1000      | 2307.40      | IV | 1800      | 6861.15      | I   | 1800      | 14354.57     | I |
| 1000                     | 576.59       | IV  | 1000      | 2408.16      | IV | 10000     | 7005.19      | I   | 1250      | 14888.70     | I |
| 1000                     | 585.10       | IV  | 1000      | 2411.58      | IV | 2000      | 7260.45      | I   | 1800      | 16731.19     | I |
| 1000                     | 586.71       | IV  | 700       | 2491.14      | IV | 10000     | 7348.51      | I   | 1200      | 18568.31     | I |
| 1000                     | 597.51       | IV  | 1000      | 2581.19      | IV | 40000     | 7512.96      | I   | 3500      | 19733.62     | I |
| 1000                     | 600.09       | IV  | 600       | 2661.40      | IV | 1600      | 7591.61      | I   | 1000      | 20281.73     | I |
| 1000                     | 601.27       | IV  | 1000      | 2842.88      | IV | 1800      | 7595.07      | I   | 1000      | 20624.67     | I |
| 1000                     | 607.03       | IV  | 1100 h    | 2907.71      | IV | 2000      | 7616.41      | I   | 1200      | 21787.24     | I |
| 1000                     | 617.85       | IV  | 500 h     | 2972.26      | II | 30000     | 7803.02      | I   | 4000      | 22865.65     | I |

| Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity                | Wavelength/Å |    |
|--------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|--------------------------|--------------|----|
| 1000                     | 23513.15     | I   | 75        | 1793.40      | III | 30        | 2823.19      | II | 1000                     | 5378.13      | II |
| 500                      | 28346.50     | I   | 40        | 1823.41      | III | 200       | 2836.900     | I  | 200                      | 5381.89      | II |
| 500                      | 30380.85     | I   | 100       | 1827.70      | II  | 25        | 2856.46      | II | 40                       | 5843.30      | II |
| 600                      | 31630.13     | I   | 50        | 1844.66      | III | 100       | 2868.180     | I  | 50                       | 5880.22      | II |
| 150                      | 38345.75     | I   | 40        | 1851.13      | III | 200 r     | 2880.767     | I  | 300                      | 6099.142     | I  |
| 120                      | 39964.36     | I   | 40        | 1855.85      | III | 50 r      | 2881.224     | I  | 100                      | 6111.49      | I  |
| <i>Cadmium Cd Z = 48</i> |              |     | 200       | 1856.67      | III | 200       | 2914.67      | II | 100                      | 6325.166     | I  |
| 50                       | 427.01       | IV  | 150       | 1874.08      | III | 50        | 2927.87      | II | 30                       | 6330.013     | I  |
| 50                       | 447.85       | IV  | 300       | 1922.23      | II  | 200       | 2929.27      | II | 400                      | 6354.72      | II |
| 60                       | 480.90       | IV  | 100       | 1943.54      | II  | 1000 r    | 2980.620     | I  | 500                      | 6359.98      | II |
| 70                       | 493.00       | IV  | 40        | 1965.54      | II  | 200 r     | 2981.362     | I  | 2000                     | 6438.470     | I  |
| 70                       | 495.13       | IV  | 30        | 1986.89      | II  | 50        | 2981.845     | I  | 400                      | 6464.94      | II |
| 70                       | 498.14       | IV  | 200       | 1995.43      | II  | 50        | 3030.60      | II | 25                       | 6567.65      | II |
| 70                       | 498.53       | IV  | 100       | 2007.49      | II  | 150       | 3080.822     | I  | 500                      | 6725.78      | II |
| 80                       | 504.09       | IV  | 50        | 2032.45      | II  | 25        | 3081.48      | II | 100                      | 6759.19      | II |
| 70                       | 504.20       | IV  | 75        | 2036.23      | II  | 30        | 3082.593     | I  | 30                       | 6778.116     | I  |
| 70                       | 504.50       | IV  | 40        | 2039.83      | III | 100       | 3092.34      | II | 50                       | 7237.01      | II |
| 80                       | 506.31       | IV  | 50        | 2045.61      | III | 200       | 3133.167     | I  | 100                      | 7284.38      | II |
| 60                       | 508.01       | IV  | 75        | 2087.91      | III | 50        | 3146.79      | II | 1000                     | 7345.670     | I  |
| 50                       | 508.95       | IV  | 150       | 2096.00      | II  | 150       | 3250.33      | II | 50                       | 8066.99      | II |
| 70                       | 509.55       | IV  | 50        | 2111.60      | III | 300       | 3252.524     | I  | 5                        | 8200.309     | I  |
| 70                       | 511.40       | IV  | 1000 r    | 2144.41      | II  | 300       | 3261.055     | I  | 20                       | 9289.        | I  |
| 80                       | 513.00       | IV  | 50        | 2155.06      | II  | 50        | 3343.21      | II | 15                       | 11652.       | I  |
| 70                       | 514.50       | IV  | 100       | 2187.79      | II  | 50        | 3385.49      | II | 35                       | 14487.       | I  |
| 60                       | 519.42       | IV  | 1000      | 2194.56      | II  | 30        | 3388.88      | II | 80                       | 15708.       | I  |
| 80                       | 524.41       | IV  | 1000      | 2265.02      | II  | 800       | 3403.652     | I  | 55 d                     | 19120.       | I  |
| 70                       | 524.47       | IV  | 1500 r    | 2288.022     | I   | 50        | 3417.49      | II | 25                       | 24371.       | I  |
| 70                       | 525.10       | IV  | 1000      | 2312.77      | II  | 50        | 3442.42      | II | 35                       | 25448.       | I  |
| 60                       | 525.19       | IV  | 200       | 2321.07      | II  | 100       | 3464.43      | II | <i>Calcium Ca Z = 20</i> |              |    |
| 70                       | 527.07       | IV  | 40        | 2376.82      | II  | 1000      | 3466.200     | I  | 250                      | 190.46       | V  |
| 80                       | 531.09       | IV  | 50        | 2418.69      | II  | 800       | 3467.655     | I  | 250                      | 196.97       | V  |
| 80                       | 531.51       | IV  | 50        | 2469.73      | II  | 25        | 3483.08      | II | 300                      | 199.55       | V  |
| 70                       | 534.29       | IV  | 40        | 2487.93      | II  | 150       | 3495.44      | II | 250                      | 200.51       | V  |
| 70                       | 536.77       | IV  | 40        | 2495.58      | II  | 25        | 3499.952     | I  | 265                      | 257.98       | V  |
| 60                       | 540.90       | IV  | 50        | 2509.11      | II  | 100       | 3524.11      | II | 400                      | 267.77       | V  |
| 70                       | 541.74       | IV  | 30        | 2516.22      | II  | 100       | 3535.69      | II | 300                      | 270.31       | V  |
| 80                       | 542.60       | IV  | 25 h      | 2525.196     | I   | 1000      | 3610.508     | I  | 400                      | 280.99       | V  |
| 80                       | 546.55       | IV  | 50        | 2544.613     | I   | 800       | 3612.873     | I  | 300                      | 284.98       | V  |
| 60                       | 553.06       | IV  | 50        | 2551.98      | II  | 60        | 3614.453     | I  | 450 c                    | 286.96       | V  |
| 80                       | 554.05       | IV  | 25        | 2553.465     | I   | 20        | 3649.558     | I  | 500                      | 322.17       | V  |
| 60                       | 567.01       | IV  | 3         | 2565.789     | I   | 10        | 3981.926     | I  | 300                      | 323.22       | V  |
| 150                      | 1118.16      | IV  | 500       | 2572.93      | II  | 100       | 4029.12      | II | 300                      | 330.94       | V  |
| 100                      | 1164.65      | IV  | 50        | 2580.106     | I   | 200       | 4134.77      | II | 300                      | 334.55       | V  |
| 100                      | 1183.40      | IV  | 30        | 2592.026     | I   | 50        | 4141.49      | II | 250 c                    | 342.45       | IV |
| 100                      | 1256.00      | II  | 25 h      | 2602.048     | I   | 100       | 4285.08      | II | 250                      | 343.93       | IV |
| 150                      | 1296.43      | II  | 50        | 2628.979     | I   | 8         | 4306.672     | I  | 450                      | 352.92       | V  |
| 100                      | 1326.50      | II  | 40        | 2632.190     | I   | 100       | 4412.41      | II | 250                      | 377.18       | V  |
| 60                       | 1370.48      | IV  | 75        | 2639.420     | I   | 3         | 4412.989     | I  | 200                      | 387.08       | V  |
| 150                      | 1370.91      | II  | 40        | 2659.23      | II  | 1000      | 4415.63      | II | 750                      | 425.00       | V  |
| 60                       | 1418.89      | IV  | 50 h      | 2660.325     | I   | 30        | 4440.45      | II | 600                      | 434.57       | IV |
| 200                      | 1514.26      | II  | 25        | 2668.20      | II  | 8         | 4662.352     | I  | 250                      | 437.77       | IV |
| 50                       | 1545.17      | III | 50        | 2672.62      | II  | 200       | 4678.149     | I  | 750                      | 443.82       | IV |
| 200                      | 1571.58      | II  | 100       | 2677.540     | I   | 30        | 4744.69      | II | 500                      | 450.57       | IV |
| 100                      | 1668.60      | II  | 25        | 2677.748     | I   | 300       | 4799.912     | I  | 500                      | 558.60       | V  |
| 50                       | 1702.47      | II  | 50        | 2707.00      | II  | 50        | 4881.72      | II | 400                      | 637.93       | V  |
| 40                       | 1707.16      | III | 75        | 2712.505     | I   | 50        | 5025.50      | II | 300                      | 643.12       | V  |
| 40                       | 1722.95      | III | 50        | 2733.820     | I   | 1000 h    | 5085.822     | I  | 400                      | 646.57       | V  |
| 50                       | 1724.41      | II  | 1000      | 2748.54      | II  | 6         | 5154.660     | I  | 750                      | 656.00       | IV |
| 40                       | 1747.67      | III | 100 h     | 2763.894     | I   | 100       | 5268.01      | II | 300                      | 656.76       | V  |
| 40                       | 1773.06      | III | 50 h      | 2764.230     | I   | 100       | 5271.60      | II | 500                      | 669.70       | IV |
| 100                      | 1785.84      | II  | 50        | 2774.958     | I   | 1000      | 5337.48      | II | 24                       | 1341.89      | II |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity             | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------------------|--------------|-----|-----------|--------------|-----|
| 12        | 1342.54      | II  | 20        | 4489.18      | II  | 40                    | 7820.78      | II  | 250       | 371.75       | III |
| 20        | 1433.75      | II  | 19        | 4499.88      | III | 60                    | 7843.38      | II  | 150       | 371.78       | III |
| 20        | 1545.29      | III | 23        | 4526.94      | I   | 20                    | 8017.50      | II  | 650       | 384.03       | IV  |
| 60        | 1649.86      | II  | 22        | 4578.55      | I   | 20                    | 8020.50      | II  | 700       | 384.18       | IV  |
| 20        | 1807.34      | II  | 23        | 4581.40      | I   | 70                    | 8133.05      | II  | 500       | 386.203      | III |
| 40        | 1814.50      | II  | 23        | 4581.47      | I   | 100                   | 8201.72      | II  | 400       | 419.52       | IV  |
| 40        | 1838.01      | II  | 24        | 4585.87      | I   | 110                   | 8248.80      | II  | 500       | 419.71       | IV  |
| 60        | 1840.06      | II  | 24        | 4585.96      | I   | 70                    | 8254.73      | II  | 200       | 450.734      | III |
| 20        | 1843.09      | II  | 20        | 4685.27      | I   | 130                   | 8498.02      | II  | 400       | 459.46       | III |
| 40        | 1850.69      | II  | 30        | 4716.74      | II  | 170                   | 8542.09      | II  | 500       | 459.52       | III |
| 17        | 2123.03      | III | 40        | 4721.03      | II  | 160                   | 8662.14      | II  | 570       | 459.63       | III |
| 16        | 2152.43      | III | 40        | 4799.97      | II  | 100                   | 8912.07      | II  | 250       | 511.522      | III |
| 16        | 2687.76      | III | 25        | 4878.13      | I   | 110                   | 8927.36      | II  | 250       | 535.288      | III |
| 19        | 2881.78      | III | 70        | 5001.48      | II  | 110                   | 9213.90      | II  | 300       | 538.080      | III |
| 21        | 2899.79      | III | 80        | 5019.97      | II  | 90                    | 9312.00      | II  | 350       | 538.149      | III |
| 19        | 2924.33      | III | 40        | 5021.14      | II  | 100                   | 9319.56      | II  | 400       | 538.312      | III |
| 20        | 2988.63      | III | 23        | 5041.62      | I   | 110                   | 9320.65      | II  | 350       | 574.281      | III |
| 10        | 3006.86      | I   | 25        | 5188.85      | I   | 25                    | 9416.97      | I   | 9         | 595.022      | II  |
| 15        | 3028.59      | III | 22        | 5261.71      | I   | 100                   | 9567.97      | II  | 30        | 687.053      | II  |
| 3         | 3055.32      | I   | 23        | 5262.24      | I   | 110                   | 9599.24      | II  | 50        | 687.345      | II  |
| 19        | 3119.67      | III | 22        | 5264.24      | I   | 80                    | 9601.82      | II  | 10        | 858.092      | II  |
| 170       | 3158.87      | II  | 24        | 5265.56      | I   | 80                    | 9854.74      | II  | 20        | 858.559      | II  |
| 180       | 3179.33      | II  | 25        | 5270.27      | I   | 110                   | 9890.63      | II  | 30        | 903.624      | II  |
| 150       | 3181.28      | II  | 60        | 5285.27      | II  | 90                    | 9931.39      | II  | 60        | 903.962      | II  |
| 20        | 3316.51      | II  | 70        | 5307.22      | II  | 100                   | 10223.04     | II  | 150       | 904.142      | II  |
| 12        | 3361.92      | I   | 50        | 5339.19      | II  | 20                    | 10343.81     | I   | 30        | 904.480      | II  |
| 19        | 3372.67      | III | 27        | 5349.47      | I   | 20                    | 11838.99     | II  | 800       | 977.03       | III |
| 20        | 3461.87      | II  | 23        | 5512.98      | I   | 25                    | 12816.04     | I   | 9         | 1009.86      | II  |
| 13        | 3487.60      | I   | 25        | 5581.97      | I   | 24                    | 12823.86     | I   | 10        | 1010.08      | II  |
| 18        | 3537.77      | III | 27        | 5588.76      | I   | 25                    | 12909.10     | I   | 10        | 1010.37      | II  |
| 20        | 3644.41      | I   | 24        | 5590.12      | I   | 30                    | 13033.57     | I   | 80        | 1036.337     | II  |
| 30        | 3683.70      | II  | 26        | 5594.47      | I   | 21                    | 13086.44     | I   | 150       | 1037.018     | II  |
| 40        | 3694.11      | II  | 25        | 5598.49      | I   | 24                    | 13134.95     | I   | 150       | 1157.910     | I   |
| 170       | 3706.03      | II  | 24        | 5601.29      | I   | 20                    | 16150.77     | I   | 150       | 1158.019     | I   |
| 180       | 3736.90      | II  | 24        | 5602.85      | I   | 22                    | 16157.36     | I   | 150       | 1158.035     | I   |
| 20        | 3755.67      | II  | 30        | 5857.45      | I   | 21                    | 16197.04     | I   | 370       | 1174.93      | III |
| 30        | 3758.39      | II  | 27        | 6102.72      | I   | 20                    | 18925.47     | I   | 350       | 1175.26      | III |
| 230       | 3933.66      | II  | 29        | 6122.22      | I   | 24                    | 18970.14     | I   | 330       | 1175.59      | III |
| 220       | 3968.47      | II  | 22        | 6161.29      | I   | 30                    | 19046.14     | I   | 500       | 1175.71      | III |
| 50        | 4097.10      | II  | 30        | 6162.17      | I   | 48                    | 19309.20     | I   | 350       | 1175.99      | III |
| 60        | 4109.82      | II  | 22        | 6163.76      | I   | 49                    | 19452.99     | I   | 370       | 1176.37      | III |
| 30        | 4110.28      | II  | 24        | 6166.44      | I   | 47                    | 19505.72     | I   | 150       | 1188.992     | I   |
| 40        | 4206.18      | II  | 26        | 6169.06      | I   | 50                    | 19776.79     | I   | 150       | 1189.447     | I   |
| 50        | 4220.07      | II  | 28        | 6169.56      | I   | 35                    | 19853.10     | I   | 200       | 1189.631     | I   |
| 50        | 4226.73      | I   | 35        | 6439.07      | I   | 34                    | 19862.22     | I   | 300       | 1193.009     | I   |
| 24        | 4283.01      | I   | 30        | 6449.81      | I   | 23                    | 19917.19     | I   | 300       | 1193.031     | I   |
| 22        | 4289.36      | I   | 22        | 6455.60      | I   | 24                    | 19933.70     | I   | 300       | 1193.240     | I   |
| 22        | 4298.99      | I   | 80        | 6456.87      | II  | 25                    | 22624.93     | I   | 300       | 1193.264     | I   |
| 25        | 4302.53      | I   | 34        | 6462.57      | I   | 30                    | 22651.23     | I   | 100       | 1193.393     | I   |
| 20        | 4302.81      | III | 29        | 6471.66      | I   | <i>Carbon C Z = 6</i> |              |     | 150       | 1193.649     | I   |
| 23        | 4307.74      | I   | 32        | 6493.78      | I   | 110                   | 34.973       | V   | 150       | 1193.679     | I   |
| 22        | 4318.65      | I   | 28        | 6499.65      | I   | 450                   | 40.268       | V   | 100       | 1194.064     | I   |
| 20        | 4355.08      | I   | 23        | 6572.78      | I   | 110                   | 227.19       | V   | 100       | 1194.488     | I   |
| 19        | 4399.59      | III | 30        | 6717.69      | I   | 250                   | 244.91       | IV  | 100       | 1261.552     | I   |
| 25        | 4425.44      | I   | 33        | 7148.15      | I   | 160                   | 248.66       | V   | 250       | 1277.245     | I   |
| 26        | 4434.96      | I   | 31        | 7202.19      | I   | 160                   | 248.74       | V   | 250       | 1277.282     | I   |
| 25        | 4435.69      | I   | 33        | 7326.15      | I   | 200                   | 289.14       | IV  | 300       | 1277.513     | I   |
| 30        | 4454.78      | I   | 30        | 7575.81      | II  | 250                   | 289.23       | IV  | 300       | 1277.550     | I   |
| 28        | 4455.89      | I   | 60        | 7581.11      | II  | 570                   | 312.42       | IV  | 200       | 1280.333     | I   |
| 20        | 4456.61      | I   | 80        | 7601.30      | II  | 500                   | 312.46       | IV  | 100       | 1311.363     | I   |
| 20        | 4472.04      | II  | 20        | 7602.32      | II  | 250                   | 371.69       | III | 9         | 1323.951     | II  |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity               | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-------------------------|--------------|-----|-----------|--------------|-----|
| 120       | 1329.578     | I   | 1000      | 4267.26      | II  | 250                     | 9620.80      | I   | 40000     | 3085.10      | III |
| 120       | 1329.600     | I   | 200       | 4325.56      | III | 300                     | 9658.44      | I   | 20000     | 3106.98      | III |
| 150       | 1334.532     | II  | 600       | 4647.42      | III | 200                     | 10683.08     | I   | 30000     | 3110.53      | III |
| 300       | 1335.708     | II  | 520       | 4650.25      | III | 300                     | 10691.25     | I   | 30000     | 3121.56      | III |
| 100       | 1354.288     | I   | 375       | 4651.47      | III | 12                      | 11619.29     | I   | 20000     | 3141.29      | III |
| 150       | 1355.84      | I   | 200 w     | 4658.30      | IV  | 23                      | 11628.83     | I   | 20000     | 3143.96      | III |
| 120       | 1364.164     | I   | 200       | 4665.86      | III | 13                      | 11658.85     | I   | 20000     | 3147.06      | III |
| 100       | 1459.032     | I   | 200       | 4771.75      | I   | 47                      | 11659.68     | I   | 710       | 3194.83      | II  |
| 200       | 1463.336     | I   | 200       | 4932.05      | I   | 24                      | 11669.63     | I   | 990       | 3201.71      | II  |
| 120       | 1467.402     | I   | 5         | 4943.88      | V   | 85                      | 11748.22     | I   | 710       | 3218.94      | II  |
| 150       | 1481.764     | I   | 5         | 4944.56      | V   | 142                     | 11753.32     | I   | 880       | 3221.17      | II  |
| 1000      | 1548.202     | IV  | 200       | 5052.17      | I   | 114                     | 11754.76     | I   | 710       | 3227.11      | II  |
| 900       | 1550.774     | IV  | 350       | 5132.94      | II  | 11                      | 11777.54     | I   | 20000     | 3228.57      | III |
| 150       | 1560.310     | I   | 350       | 5133.28      | II  | 17                      | 11892.91     | I   | 710       | 3234.16      | II  |
| 400       | 1560.683     | I   | 350       | 5143.49      | II  | 30                      | 11895.75     | I   | 990       | 3272.25      | II  |
| 400       | 1560.708     | I   | 570       | 5145.16      | II  | 26                      | 12614.10     | I   | 20000     | 3353.29      | III |
| 100       | 1561.341     | I   | 400       | 5151.09      | II  | 20                      | 13502.27     | I   | 10000     | 3395.77      | III |
| 400       | 1561.438     | I   | 300       | 5380.34      | I   | 38                      | 14399.65     | I   | 30000     | 3427.36      | III |
| 150       | 1656.266     | I   | 250       | 5648.07      | II  | 16                      | 14403.25     | I   | 40000     | 3443.63      | III |
| 120       | 1656.928     | I   | 350       | 5662.47      | II  | 61                      | 14420.12     | I   | 30000     | 3454.39      | III |
| 300       | 1657.008     | I   | 450       | 5695.92      | III | 12                      | 14429.03     | I   | 40000     | 3459.39      | III |
| 120       | 1657.380     | I   | 250       | 5801.33      | IV  | 13                      | 14442.24     | I   | 60000     | 3470.92      | III |
| 120       | 1657.907     | I   | 200       | 5811.98      | IV  | 12                      | 16559.66     | I   | 710       | 3485.05      | II  |
| 150       | 1658.122     | I   | 150       | 5826.42      | III | 50                      | 16890.38     | I   | 50000     | 3497.81      | III |
| 500       | 1751.823     | I   | 570       | 5889.77      | II  | 10                      | 17338.56     | I   | 60000     | 3504.64      | III |
| 1000      | 1930.905     | I   | 350       | 5891.59      | II  | 11                      | 17448.60     | I   | 770       | 3539.08      | II  |
| 250       | 2162.94      | III | 200       | 6001.13      | I   | 13                      | 18139.80     | I   | 50000     | 3544.07      | III |
| 40        | 2270.91      | V   | 250       | 6006.03      | I   | 23                      | 19721.99     | I   | 1200      | 3560.80      | II  |
| 5         | 2277.25      | V   | 110       | 6007.18      | I   | <i>Cerium Ce Z = 58</i> |              |     | 1000      | 3577.45      | II  |
| 20        | 2277.92      | V   | 150       | 6010.68      | I   | 300                     | 399.36       | V   | 1800      | 3655.85      | II  |
| 800       | 2296.87      | III | 300       | 6013.22      | I   | 200                     | 482.96       | V   | 880       | 3660.64      | II  |
| 800       | 2478.56      | I   | 250       | 6014.84      | I   | 40                      | 741.79       | IV  | 880       | 3667.98      | II  |
| 250       | 2509.12      | II  | 800       | 6578.05      | II  | 30                      | 754.60       | IV  | 1000      | 3709.29      | II  |
| 350       | 2512.06      | II  | 570       | 6582.88      | II  | 75                      | 1332.16      | IV  | 1000      | 3709.93      | II  |
| 200 l     | 2524.41      | IV  | 200       | 6587.61      | I   | 75                      | 1372.72      | IV  | 1400      | 3716.37      | II  |
| 300 s     | 2529.98      | IV  | 150       | 6744.38      | III | 100                     | 2000.42      | IV  | 800       | 3728.42      | II  |
| 250 h     | 2574.83      | II  | 250       | 6783.90      | II  | 100                     | 2009.94      | IV  | 860       | 3786.63      | II  |
| 150       | 2697.75      | III | 150 h     | 7037.25      | III | 10000                   | 2318.64      | III | 2500      | 3801.52      | II  |
| 110 l     | 2724.85      | III | 250       | 7113.18      | I   | 10000                   | 2372.34      | III | 800       | 3803.09      | II  |
| 150 l     | 2725.30      | III | 250       | 7115.19      | I   | 10000                   | 2380.12      | III | 1000      | 3808.11      | II  |
| 150 l     | 2725.90      | III | 250       | 7115.63      | II  | 10000                   | 2431.45      | III | 1100      | 3838.54      | II  |
| 350 l     | 2741.28      | II  | 200       | 7116.99      | I   | 15000                   | 2439.80      | III | 860       | 3848.59      | II  |
| 250       | 2746.49      | II  | 350       | 7119.90      | II  | 10000                   | 2454.32      | III | 860       | 3853.15      | II  |
| 1000      | 2836.71      | II  | 800       | 7231.32      | II  | 10000                   | 2469.95      | III | 1200      | 3854.18      | II  |
| 800       | 2837.60      | II  | 1000      | 7236.42      | II  | 10000                   | 2483.82      | III | 1200      | 3854.31      | II  |
| 200       | 2982.11      | III | 150       | 7612.65      | III | 10000                   | 2497.50      | III | 1100      | 3878.36      | II  |
| 800 h     | 2992.62      | II  | 90 w      | 7726.2       | IV  | 20000                   | 2531.99      | III | 1500      | 3882.45      | II  |
| 350       | 3876.19      | II  | 200       | 7860.89      | I   | 10000                   | 2603.59      | III | 1000      | 3889.98      | II  |
| 350       | 3876.41      | II  | 200       | 8058.62      | I   | 340                     | 2651.01      | II  | 770       | 3907.29      | II  |
| 350       | 3876.66      | II  | 300 h     | 8196.48      | III | 270                     | 2830.90      | II  | 980       | 3912.44      | II  |
| 570       | 3918.98      | II  | 150       | 8332.99      | III | 250                     | 2874.14      | II  | 770       | 3918.28      | II  |
| 800       | 3920.69      | II  | 520       | 8335.15      | I   | 10000                   | 2923.81      | III | 770       | 3931.09      | II  |
| 150       | 4056.06      | III | 300       | 8500.32      | III | 10000                   | 2931.54      | III | 770       | 3940.34      | II  |
| 200       | 4067.94      | III | 250       | 9061.43      | I   | 400                     | 2976.91      | II  | 2000      | 3942.15      | II  |
| 250       | 4068.91      | III | 200       | 9062.47      | I   | 10000                   | 3022.75      | III | 2700      | 3942.75      | II  |
| 250       | 4070.26      | III | 200       | 9078.28      | I   | 50000                   | 3031.58      | III | 770       | 3943.89      | II  |
| 250       | 4074.52      | II  | 250       | 9088.51      | I   | 95000                   | 3055.59      | III | 3100      | 3952.54      | II  |
| 350 l     | 4075.85      | II  | 450       | 9094.83      | I   | 20000                   | 3056.56      | III | 980       | 3956.28      | II  |
| 150       | 4162.86      | III | 300       | 9111.80      | I   | 40000                   | 3057.23      | III | 770       | 3960.91      | II  |
| 250 h     | 4186.90      | III | 800       | 9405.73      | I   | 20000                   | 3057.58      | III | 770       | 3967.05      | II  |
| 800       | 4267.00      | II  | 150       | 9603.03      | I   | 680                     | 3063.01      | II  | 770       | 3978.65      | II  |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity               | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|-----------|--------------|-----|-------------------------|--------------|-----|-----------|--------------|-----|
| 770       | 3984.68      | II | 280       | 5159.69      | I   | 25                      | 7329.91      | I   | 630       | 2845.70      | III |
| 700       | 3992.39      | II | 280       | 5161.48      | I   | 25                      | 7397.77      | I   | 3100      | 2859.32      | III |
| 910       | 3993.82      | II | 370       | 5187.46      | II  | 25                      | 7616.11      | II  | 200       | 2893.85      | III |
| 2800      | 3999.24      | II | 260       | 5223.46      | I   | 25                      | 7689.17      | II  | 180       | 2921.13      | III |
| 910       | 4003.77      | II | 260       | 5245.92      | I   | 22                      | 7844.94      | II  | 3200      | 2976.86      | III |
| 2700      | 4012.39      | II | 340       | 5274.23      | II  | 22                      | 7857.54      | II  | 210       | 3001.28      | III |
| 910       | 4014.90      | II | 450       | 5353.53      | II  | 30                      | 8025.56      | II  | 1700      | 3066.59      | III |
| 840       | 4024.49      | II | 300       | 5393.40      | II  | 25                      | 8772.14      | II  | 1100 c    | 3149.36      | III |
| 840       | 4028.41      | II | 280       | 5409.23      | II  | 30                      | 8891.20      | II  | 1400      | 3152.36      | III |
| 840       | 4031.34      | II | 260       | 5512.08      | II  | <i>Cesium Ce Z = 55</i> |              |     | 8400      | 3268.32      | III |
| 2100      | 4040.76      | II | 300       | 5696.99      | I   | 10000                   | 614.01       | III | 1300      | 3315.51      | III |
| 910       | 4042.58      | II | 370       | 5699.23      | I   | 2000                    | 638.17       | III | 550       | 3340.60      | III |
| 700       | 4053.51      | II | 240       | 5719.03      | I   | 2500                    | 666.25       | III | 430       | 3344.02      | III |
| 1100      | 4071.81      | II | 230       | 5940.86      | I   | 5000                    | 691.60       | III | 1200      | 3349.46      | III |
| 1800      | 4073.48      | II | 55        | 6001.90      | I   | 3500                    | 703.89       | III | 400       | 3463.45      | III |
| 1500      | 4075.71      | II | 55        | 6005.86      | I   | 15000                   | 718.14       | II  | 580       | 3476.83      | III |
| 1500      | 4075.85      | II | 55        | 6006.82      | I   | 20000                   | 721.79       | III | 480       | 3559.82      | III |
| 910       | 4083.23      | II | 75        | 6013.42      | I   | 20000                   | 722.20       | III | 7200      | 3597.45      | III |
| 770       | 4118.14      | II | 110       | 6024.20      | I   | 5000                    | 731.56       | III | 1300      | 3608.31      | III |
| 980       | 4123.87      | II | 10000     | 6032.54      | III | 12000                   | 740.29       | III | 2300      | 3618.19      | III |
| 980       | 4127.37      | II | 110       | 6043.39      | II  | 15000                   | 808.76       | II  | 300 c     | 3641.34      | III |
| 2700      | 4133.80      | II | 55        | 6047.40      | I   | 15000                   | 813.84       | II  | 520       | 3651.08      | III |
| 2000      | 4137.65      | II | 10000     | 6060.91      | III | 7500                    | 830.39       | III | 4800      | 3661.40      | III |
| 770       | 4142.40      | II | 45        | 6098.34      | II  | 35000                   | 901.27       | II  | 640       | 3699.50      | III |
| 980       | 4149.94      | II | 45        | 6123.67      | I   | 15000                   | 920.35       | III | 430       | 3837.46      | III |
| 1400      | 4151.97      | II | 35        | 6143.36      | II  | 40000                   | 926.66       | II  | 2100 c    | 3876.15      | I   |
| 1300      | 4165.61      | II | 35        | 6186.17      | I   | 25000 c                 | 1054.79      | III | 2900      | 3888.37      | III |
| 3500      | 4186.60      | II | 35        | 6208.98      | I   | 17 c                    | 1673.99      | III | 600 c     | 3888.61      | I   |
| 840       | 4198.72      | II | 35        | 6228.94      | I   | 12                      | 1705.25      | III | 2700      | 3925.60      | III |
| 910       | 4202.94      | II | 23        | 6232.45      | II  | 10                      | 1801.83      | III | 680 c     | 4001.70      | III |
| 1500      | 4222.60      | II | 28        | 6237.45      | I   | 20 c                    | 1822.40      | III | 3100      | 4006.55      | III |
| 770       | 4227.75      | II | 45        | 6272.05      | II  | 11                      | 1823.93      | III | 420       | 4006.78      | III |
| 980       | 4239.92      | II | 35        | 6295.58      | I   | 12                      | 1824.70      | III | 520       | 4043.42      | III |
| 1100      | 4248.68      | II | 28        | 6299.51      | II  | 12                      | 1841.80      | III | 14000     | 4264.70      | II  |
| 2000      | 4289.94      | II | 23        | 6300.21      | I   | 25                      | 1915.50      | III | 18000 w   | 4277.13      | II  |
| 1500      | 4296.67      | II | 35        | 6310.01      | I   | 25 c                    | 1923.29      | III | 370       | 4403.86      | III |
| 770       | 4300.33      | II | 35        | 6343.95      | II  | 12                      | 1961.33      | III | 1200      | 4410.22      | III |
| 770       | 4306.72      | II | 35        | 6371.11      | II  | 17                      | 1996.56      | III | 940       | 4425.68      | III |
| 980       | 4337.77      | II | 28        | 6386.84      | I   | 710                     | 2035.11      | III | 530       | 4471.48      | III |
| 700       | 4349.79      | II | 23        | 6393.02      | II  | 120                     | 2056.43      | III | 12000     | 4501.55      | II  |
| 910       | 4364.66      | II | 35        | 6430.07      | I   | 330                     | 2076.43      | III | 1200      | 4506.72      | III |
| 910       | 4382.17      | II | 23        | 6436.40      | I   | 540                     | 2077.30      | III | 590       | 4522.86      | III |
| 700       | 4386.84      | II | 35        | 6458.03      | I   | 410                     | 2088.68      | III | 20000     | 4526.74      | II  |
| 1700      | 4391.66      | II | 28        | 6467.39      | I   | 210                     | 2101.63      | III | 1000 c    | 4555.28      | I   |
| 980       | 4418.78      | II | 35        | 6473.72      | I   | 200                     | 2141.47      | III | 460 c     | 4593.17      | I   |
| 770       | 4449.34      | II | 23        | 6513.59      | II  | 1000                    | 2316.88      | III | 99900     | 4603.79      | III |
| 2400      | 4460.21      | II | 45        | 6555.65      | I   | 230                     | 2325.95      | III | 420 h     | 4620.61      | II  |
| 1400      | 4471.24      | II | 23        | 6579.10      | I   | 390                     | 2340.49      | III | 210       | 4665.52      | III |
| 700       | 4479.36      | II | 22        | 6612.06      | I   | 1600                    | 2455.81      | III | 25000     | 4830.19      | II  |
| 700       | 4483.90      | II | 30        | 6628.93      | I   | 1600                    | 2477.57      | III | 140       | 4851.59      | III |
| 840       | 4486.91      | II | 22        | 6652.72      | II  | 890                     | 2485.45      | III | 19000     | 4870.04      | II  |
| 770       | 4523.08      | II | 26        | 6700.66      | I   | 410                     | 2495.07      | III | 37000     | 4952.85      | II  |
| 840       | 4527.35      | II | 35        | 6704.27      | I   | 1400                    | 2525.67      | III | 370       | 5035.72      | III |
| 840       | 4528.47      | II | 30        | 6774.28      | II  | 430                     | 2573.05      | III | 27000     | 5043.80      | II  |
| 840       | 4539.75      | II | 35        | 6775.59      | I   | 16000                   | 2596.86      | III | 75000     | 5227.04      | II  |
| 2100      | 4562.36      | II | 30        | 6924.81      | I   | 390                     | 2610.12      | III | 29000     | 5249.38      | II  |
| 1100      | 4572.28      | II | 30        | 6986.02      | I   | 6200                    | 2630.51      | III | 11000     | 5274.05      | II  |
| 840       | 4593.93      | II | 35        | 7061.75      | II  | 370                     | 2700.32      | III | 10000 c   | 5349.13      | II  |
| 1700      | 4628.16      | II | 35        | 7086.35      | II  | 710                     | 2701.20      | III | 22000     | 5370.99      | II  |
| 310       | 4737.28      | II | 22        | 7238.36      | II  | 390                     | 2776.44      | III | 230       | 5380.79      | III |
| 470       | 5079.68      | II | 25        | 7252.75      | I   | 270                     | 2810.87      | III | 60 c      | 5465.94      | I   |

| Intensity | Wavelength/Å |     | Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|---------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 37        | 5502.88      | I   | 1500                      | 17012.32     | I   | 2500      | 728.951      | II  | 12000     | 1396.527     | I   |
| 39000     | 5563.02      | II  | 760                       | 20138.47     | I   | 2000      | 777.562      | II  | 500       | 1441.470     | II  |
| 100       | 5635.21      | I   | 880                       | 22811.86     | I   | 5000      | 787.580      | II  | 500       | 1528.569     | II  |
| 210 c     | 5664.02      | I   | 1100                      | 23037.98     | I   | 5000      | 788.740      | II  | 500       | 1542.942     | II  |
| 27        | 5745.72      | I   | 3900                      | 23344.47     | I   | 5000      | 793.342      | II  | 500       | 1558.144     | II  |
| 24000     | 5831.14      | II  | 4400                      | 24251.21     | I   | 500       | 834.84       | IV  | 500       | 1565.050     | II  |
| 59 c      | 5838.83      | I   | 850                       | 24374.96     | I   | 500       | 834.97       | IV  | 600       | 1822.50      | III |
| 300       | 5845.14      | I   | 890 d                     | 25763.51     | I   | 6000      | 839.297      | II  | 500       | 1828.40      | III |
| 51000     | 5925.63      | II  | 500                       | 25764.73     | I   | 8000      | 839.599      | II  | 500       | 1857.488     | II  |
| 140       | 5950.14      | III | 680 c                     | 29310.06     | I   | 600       | 840.93       | IV  | 500       | 1901.61      | III |
| 110       | 5979.97      | III | 2800                      | 30103.27     | I   | 5000      | 851.691      | II  | 500       | 1983.61      | III |
| 640 c     | 6010.49      | I   | 610 c                     | 30953.06     | I   | 2000      | 888.026      | II  | 450 h     | 1997.370     | II  |
| 86        | 6034.09      | I   | 1100                      | 34900.13     | I   | 2000      | 893.549      | II  | 450       | 2032.116     | II  |
| 150       | 6043.99      | III | 190                       | 36131.00     | I   | 2000      | 961.499      | II  | 350 h     | 2088.583     | II  |
| 870       | 6079.86      | III | 2 c                       | 39177.28     | I   | 500       | 973.21       | IV  | 350 h     | 2091.458     | II  |
| 9800      | 6128.61      | II  | 2 d                       | 39421.25     | I   | 600       | 977.56       | IV  | 700       | 2253.07      | III |
| 330       | 6150.42      | III | 1                         | 39424.11     | I   | 40        | 978.284      | I   | 500       | 2268.95      | III |
| 1000      | 6213.10      | I   | <i>Chlorine Cl Z = 17</i> |              |     | 700       | 984.95       | IV  | 500       | 2278.34      | III |
| 170       | 6217.60      | I   | 500                       | 392.43       | V   | 25        | 998.372      | I   | 700       | 2283.93      | III |
| 450       | 6242.96      | III | 800                       | 486.17       | IV  | 25        | 998.432      | I   | 600       | 2323.50      | III |
| 320 c     | 6354.55      | I   | 800                       | 534.73       | IV  | 75        | 1002.346     | I   | 500       | 2336.45      | III |
| 510       | 6456.33      | III | 700                       | 535.67       | IV  | 500       | 1005.28      | III | 600       | 2340.64      | III |
| 8300      | 6495.53      | II  | 600                       | 536.15       | IV  | 600       | 1008.78      | III | 600       | 2359.67      | III |
| 10000 w   | 6536.44      | II  | 900                       | 537.61       | IV  | 150       | 1013.664     | I   | 600       | 2370.37      | III |
| 490       | 6586.51      | I   | 500                       | 538.03       | V   | 700       | 1015.02      | III | 700       | 2416.42      | III |
| 97        | 6628.66      | I   | 600                       | 538.12       | IV  | 90        | 1025.553     | I   | 600       | 2447.14      | III |
| 8800      | 6646.57      | II  | 800                       | 542.23       | V   | 6000      | 1063.831     | II  | 600       | 2448.58      | III |
| 3300 c    | 6723.28      | I   | 600                       | 542.30       | V   | 3000      | 1067.945     | II  | 500       | 2486.91      | III |
| 9600      | 6724.47      | II  | 1000                      | 545.11       | V   | 9000      | 1071.036     | II  | 500       | 2532.48      | III |
| 400       | 6753.12      | III | 600                       | 546.33       | V   | 6000      | 1071.767     | II  | 600       | 2580.67      | III |
| 200       | 6824.65      | I   | 1000                      | 547.63       | V   | 5000      | 1075.230     | II  | 500       | 2603.59      | III |
| 300       | 6870.45      | I   | 500                       | 549.22       | IV  | 5000      | 1079.080     | II  | 500       | 2632.67      | III |
| 37000     | 6955.50      | II  | 700                       | 552.02       | IV  | 200       | 1084.667     | I   | 500       | 2633.18      | III |
| 4800      | 6973.30      | I   | 600                       | 553.30       | IV  | 200       | 1085.171     | I   | 600       | 2665.54      | III |
| 16000     | 6979.67      | II  | 700                       | 554.62       | IV  | 250       | 1085.304     | I   | 700       | 2710.37      | III |
| 980       | 6983.49      | I   | 600                       | 556.23       | III | 400       | 1088.06      | I   | 500       | 2724.03      | IV  |
| 13000 w   | 7149.54      | II  | 700                       | 556.61       | III | 350       | 1090.271     | I   | 500       | 2751.23      | IV  |
| 1900 c    | 7219.60      | III | 700                       | 557.12       | III | 250       | 1090.982     | I   | 700       | 2782.47      | IV  |
| 790       | 7228.53      | I   | 350                       | 559.305      | II  | 250       | 1092.437     | I   | 600       | 2965.56      | III |
| 130       | 7279.90      | I   | 700                       | 561.53       | III | 400       | 1094.769     | I   | 500       | 3063.13      | IV  |
| 1100      | 7279.96      | I   | 700                       | 561.68       | III | 350       | 1095.148     | I   | 600       | 3076.68      | IV  |
| 2600 c    | 7608.90      | I   | 700                       | 561.74       | III | 350       | 1095.662     | I   | 600       | 3104.46      | III |
| 3300      | 7943.88      | I   | 400                       | 571.904      | II  | 400       | 1095.797     | I   | 800       | 3139.34      | III |
| 22000     | 7997.44      | II  | 800                       | 574.406      | II  | 250       | 1096.810     | I   | 900       | 3191.45      | III |
| 3500      | 8015.73      | I   | 500                       | 601.50       | IV  | 300       | 1097.369     | I   | 700       | 3289.80      | III |
| 510       | 8078.94      | I   | 500                       | 604.59       | IV  | 200       | 1098.068     | I   | 700       | 3320.57      | III |
| 4500      | 8079.04      | I   | 500                       | 606.35       | III | 200       | 1099.523     | I   | 800       | 3329.06      | III |
| 59000 c   | 8521.13      | I   | 700                       | 618.057      | II  | 500       | 1107.528     | I   | 900       | 3340.42      | III |
| 15000 c   | 8761.41      | I   | 600                       | 619.982      | II  | 800       | 1139.214     | II  | 800       | 3392.89      | III |
| 61000 c   | 8943.47      | I   | 800                       | 620.298      | II  | 800       | 1167.148     | I   | 800       | 3393.45      | III |
| 18000     | 9172.32      | I   | 700                       | 626.735      | II  | 3000      | 1179.293     | I   | 900       | 3530.03      | III |
| 5200      | 9208.53      | I   | 800                       | 635.881      | II  | 1200      | 1188.774     | I   | 800       | 3560.68      | III |
| 19000     | 10024.36     | I   | 1000                      | 636.626      | II  | 900       | 1201.353     | I   | 900       | 3602.10      | III |
| 4800      | 10123.41     | I   | 1000                      | 650.894      | II  | 3000      | 1335.726     | I   | 800       | 3612.85      | III |
| 26000     | 10123.60     | I   | 1000                      | 659.811      | II  | 10000     | 1347.240     | I   | 700       | 3622.69      | III |
| 2900      | 13424.31     | I   | 1300                      | 661.841      | II  | 5000      | 1351.657     | I   | 700       | 3656.95      | III |
| 38000 c   | 13588.29     | I   | 2000                      | 663.074      | II  | 12000     | 1363.447     | I   | 700       | 3670.28      | III |
| 8400      | 13602.56     | I   | 1500                      | 682.053      | II  | 2500      | 1373.116     | I   | 700       | 3682.05      | III |
| 5700      | 13758.81     | I   | 1500                      | 687.656      | II  | 20000     | 1379.528     | I   | 600       | 3705.45      | III |
| 55000 c   | 14694.91     | I   | 1500                      | 693.594      | II  | 25000     | 1389.693     | I   | 600       | 3707.34      | III |
| 820       | 16535.63     | I   | 2000                      | 725.271      | II  | 20000     | 1389.957     | I   | 800       | 3720.45      | III |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |   | Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |    |
|-----------|--------------|-----|-----------|--------------|---|---------------------------|--------------|-----|-----------|--------------|----|
| 800       | 3748.81      | III | 2300      | 7899.31      | I | 310                       | 13296.0      | I   | 130       | 2383.33      | I  |
| 500       | 3779.35      | III | 1800      | 7915.08      | I | 550                       | 13346.8      | I   | 140       | 2408.62      | I  |
| 10000     | 3850.99      | II  | 3000      | 7924.645     | I | 525                       | 13821.7      | I   | 170       | 2496.31      | I  |
| 25000     | 3860.83      | II  | 2100      | 7933.89      | I | 294                       | 14931.7      | I   | 110       | 2502.53      | I  |
| 500       | 3925.87      | III | 1700      | 7935.012     | I | 269                       | 15108.0      | I   | 190       | 2504.31      | I  |
| 700       | 3991.50      | III | 650       | 7952.52      | I | 381                       | 15465.1      | I   | 110       | 2516.92      | I  |
| 600       | 4018.50      | III | 1500      | 7974.72      | I | 1094                      | 15520.3      | I   | 390       | 2519.52      | I  |
| 600       | 4059.07      | III | 1300      | 7976.97      | I | 1487                      | 15730.1      | I   | 190       | 2527.12      | I  |
| 500       | 4104.23      | III | 600       | 7980.60      | I | 2780                      | 15869.7      | I   | 160       | 2549.54      | I  |
| 500       | 4106.83      | III | 2900      | 7997.85      | I | 277                       | 15883.3      | I   | 130       | 2560.69      | I  |
| 10000 h   | 4132.50      | II  | 2200      | 8015.61      | I | 342                       | 15928.9      | I   | 150       | 2571.74      | I  |
| 500       | 4608.21      | III | 1100      | 8023.33      | I | 735                       | 15960.0      | I   | 100       | 2577.65      | I  |
| 40        | 4623.938     | I   | 400       | 8051.07      | I | 283                       | 15970.5      | I   | 380       | 2591.85      | I  |
| 50        | 4654.040     | I   | 1700      | 8084.51      | I | 259                       | 16198.5      | I   | 250       | 2653.59      | II |
| 80        | 4661.208     | I   | 2200      | 8085.56      | I | 717                       | 19755.3      | I   | 250       | 2658.59      | II |
| 45        | 4691.523     | I   | 3000      | 8086.67      | I | 100                       | 24470.0      | I   | 320       | 2663.42      | II |
| 40        | 4721.255     | I   | 1300      | 8087.73      | I |                           | 39716.0      | I   | 440       | 2666.02      | II |
| 45        | 4740.729     | I   | 2500      | 8194.42      | I |                           | 40085.5      | I   | 280       | 2668.71      | II |
| 13000     | 4781.32      | II  | 2200      | 8199.13      | I |                           | 40089.5      | I   | 350       | 2671.81      | II |
| 99000     | 4794.55      | II  | 2200      | 8200.21      | I |                           | 40532.2      | I   | 280       | 2672.83      | II |
| 29000     | 4810.06      | II  | 800       | 8203.78      | I | <i>Chromium Cr Z = 24</i> |              |     | 1800      | 2677.16      | II |
| 16000     | 4819.47      | II  | 18000     | 8212.04      | I | 100                       | 438.62       | V   | 320       | 2678.79      | II |
| 81000     | 4896.77      | II  | 3000      | 8220.45      | I | 100                       | 464.02       | V   | 230       | 2687.09      | II |
| 47000     | 4904.78      | II  | 20000     | 8221.74      | I | 100                       | 620.66       | IV  | 280       | 2691.04      | II |
| 26000     | 4917.73      | II  | 18000     | 8333.31      | I | 100                       | 629.26       | IV  | 180       | 2698.41      | II |
| 10000     | 4995.48      | II  | 99900     | 8375.94      | I | 80                        | 630.30       | IV  | 180       | 2698.69      | II |
| 26000     | 5078.26      | II  | 400       | 8406.199     | I | 100                       | 666.55       | IV  | 110       | 2701.99      | I  |
| 30        | 5099.789     | I   | 15000     | 8428.25      | I | 100                       | 693.92       | IV  | 140       | 2712.31      | II |
| 56000     | 5217.94      | II  | 2200      | 8467.34      | I | 60                        | 1030.47      | III | 170       | 2722.75      | II |
| 23000     | 5221.36      | II  | 2200      | 8550.44      | I | 100                       | 1033.69      | III | 420 h     | 2726.51      | I  |
| 15000     | 5392.12      | II  | 20000     | 8575.24      | I | 100                       | 1036.03      | III | 280 h     | 2731.91      | I  |
| 99000     | 5423.23      | II  | 750       | 8578.02      | I | 80                        | 1055.89      | IV  | 170 h     | 2736.47      | I  |
| 10000     | 5423.51      | II  | 75000     | 8585.97      | I | 80                        | 1068.41      | III | 250       | 2743.64      | II |
| 19000     | 5443.37      | II  | 450       | 8628.54      | I | 100                       | 1116.48      | V   | 110 h     | 2748.29      | I  |
| 10000     | 5444.21      | II  | 300       | 8641.71      | I | 150                       | 1121.07      | V   | 330       | 2748.98      | II |
| 40        | 5532.162     | I   | 3500      | 8686.26      | I | 150                       | 1127.63      | V   | 390       | 2750.73      | II |
| 50 d      | 5796.305     | I   | 2200      | 8912.92      | I | 100                       | 1263.50      | V   | 280       | 2751.87      | II |
| 45        | 5799.914     | I   | 3000      | 8948.06      | I | 100                       | 1417.42      | IV  | 110 h     | 2752.88      | I  |
| 30        | 5856.742     | I   | 2000      | 9038.982     | I | 100                       | 1465.86      | V   | 150       | 2757.10      | I  |
| 50        | 6019.812     | I   | 2500      | 9045.43      | I | 150                       | 1497.97      | V   | 350       | 2757.72      | II |
| 200       | 6140.245     | I   | 1000      | 9069.656     | I | 150                       | 1519.03      | V   | 750       | 2762.59      | II |
| 160       | 6194.757     | I   | 2000      | 9073.17      | I | 220                       | 1579.70      | V   | 750       | 2766.54      | II |
| 150       | 6434.833     | I   | 7500      | 9121.15      | I | 170                       | 1591.72      | V   | 250 h     | 2769.92      | I  |
| 300       | 6932.903     | I   | 3000      | 9191.731     | I | 150                       | 1603.19      | V   | 610       | 2780.70      | I  |
| 300       | 6981.886     | I   | 500       | 9197.596     | I | 120                       | 1672.66      | IV  | 180       | 2822.37      | II |
| 600       | 7086.814     | I   | 4000      | 9288.86      | I | 120                       | 1758.51      | IV  | 180       | 2830.47      | II |
| 7500      | 7256.62      | I   | 1500      | 9393.862     | I | 140                       | 1802.72      | IV  | 2500      | 2835.63      | II |
| 5000      | 7414.11      | I   | 3500      | 9452.10      | I | 130                       | 1812.41      | IV  | 110       | 2840.02      | II |
| 550       | 7462.370     | I   | 500       | 9486.964     | I | 200                       | 1837.44      | V   | 1700      | 2843.25      | II |
| 550       | 7489.47      | I   | 1000      | 9584.801     | I | 140                       | 1873.89      | IV  | 1200      | 2849.84      | II |
| 700       | 7492.118     | I   | 3500      | 9592.22      | I | 140                       | 1967.18      | IV  | 120       | 2851.36      | II |
| 11000     | 7547.072     | I   | 250       | 9632.509     | I | 120                       | 1972.07      | IV  | 880       | 2855.68      | II |
| 2300      | 7672.42      | I   | 1000      | 9702.439     | I | 19000                     | 2055.52      | II  | 610       | 2858.91      | II |
| 450       | 7702.828     | I   | 250       | 9744.426     | I | 14000                     | 2061.49      | II  | 440       | 2860.93      | II |
| 7000      | 7717.581     | I   | 200       | 9807.057     | I | 8900                      | 2065.42      | II  | 790       | 2862.57      | II |
| 10000     | 7744.97      | I   | 400       | 9875.970     | I | 200                       | 2226.72      | III | 750       | 2865.11      | II |
| 2200      | 7769.16      | I   | 331       | 10392.549    | I | 200                       | 2235.91      | III | 610       | 2866.74      | II |
| 650       | 7771.09      | I   | 300       | 11123.05     | I | 150                       | 2237.59      | III | 480       | 2867.65      | II |
| 2200      | 7821.36      | I   | 269       | 11409.69     | I | 150                       | 2244.10      | III | 210       | 2870.44      | II |
| 1700      | 7830.75      | I   | 1000      | 11436.33     | I | 150                       | 2284.44      | III | 110       | 2871.63      | I  |
| 3000      | 7878.22      | I   | 350       | 13243.8      | I | 150                       | 2324.88      | III | 160       | 2873.48      | II |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |   |
|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|-----------|--------------|---|
| 320       | 2875.99      | II | 220       | 3197.08      | II | 110       | 3807.93      | I  | 110       | 4374.16      | I |
| 230       | 2876.24      | II | 170       | 3209.18      | II | 180       | 3815.43      | I  | 530       | 4384.98      | I |
| 180       | 2877.98      | II | 140       | 3217.40      | II | 180       | 3819.56      | I  | 110       | 4458.54      | I |
| 120       | 2879.27      | I  | 120       | 3245.54      | I  | 130       | 3826.42      | I  | 660       | 4496.86      | I |
| 170       | 2887.00      | I  | 130       | 3251.84      | I  | 130       | 3830.03      | I  | 380       | 4526.47      | I |
| 700       | 2889.29      | I  | 130       | 3257.82      | I  | 380       | 3841.28      | I  | 380       | 4530.74      | I |
| 370       | 2893.25      | I  | 130       | 3339.80      | II | 190       | 3848.98      | I  | 240       | 4535.72      | I |
| 190       | 2894.17      | I  | 110       | 3342.59      | II | 140       | 3849.36      | I  | 240       | 4540.50      | I |
| 210       | 2896.75      | I  | 170       | 3358.50      | II | 290       | 3850.04      | I  | 240       | 4540.72      | I |
| 180       | 2905.49      | I  | 160       | 3360.30      | II | 140       | 3852.22      | I  | 140       | 4544.62      | I |
| 260       | 2909.05      | I  | 430       | 3368.05      | II | 190       | 3854.22      | I  | 600       | 4545.96      | I |
| 260       | 2910.90      | I  | 140       | 3382.68      | II | 110       | 3855.29      | I  | 120       | 4565.51      | I |
| 250       | 2911.14      | I  | 170       | 3403.32      | II | 140       | 3855.57      | I  | 120       | 4571.68      | I |
| 480       | 2967.64      | I  | 360       | 3408.76      | II | 260       | 3857.63      | I  | 360       | 4580.06      | I |
| 480       | 2971.11      | I  | 210       | 3421.21      | II | 660       | 3883.29      | I  | 360       | 4591.39      | I |
| 210       | 2971.91      | II | 270       | 3422.74      | II | 570       | 3885.22      | I  | 480       | 4600.75      | I |
| 480       | 2975.48      | I  | 140       | 3433.31      | II | 380       | 3886.79      | I  | 240       | 4613.37      | I |
| 190       | 2979.74      | II | 270       | 3433.60      | I  | 260       | 3894.04      | I  | 600       | 4616.14      | I |
| 350       | 2980.79      | I  | 160       | 3436.19      | I  | 360       | 3902.92      | I  | 550       | 4626.19      | I |
| 110       | 2985.32      | II | 140       | 3441.44      | I  | 960       | 3908.76      | I  | 1600      | 4646.17      | I |
| 480       | 2985.85      | I  | 170       | 3445.62      | I  | 120 hd    | 3911.82      | I  | 570       | 4651.28      | I |
| 1500      | 2986.00      | I  | 170       | 3447.43      | I  | 120       | 3915.84      | I  | 840       | 4652.16      | I |
| 2100      | 2986.47      | I  | 190       | 3453.33      | I  | 190       | 3916.24      | I  | 240 d     | 4698.46      | I |
| 660       | 2988.65      | I  | 130       | 3455.60      | I  | 1900      | 3919.16      | I  | 190       | 4708.04      | I |
| 160       | 2989.19      | II | 100       | 3460.43      | I  | 600       | 3921.02      | I  | 240       | 4718.43      | I |
| 480       | 2991.89      | I  | 120       | 3550.64      | I  | 600       | 3928.64      | I  | 120       | 4730.71      | I |
| 230       | 2994.07      | I  | 130       | 3566.16      | I  | 410       | 3941.49      | I  | 140       | 4737.35      | I |
| 300       | 2995.10      | I  | 130       | 3573.64      | I  | 1900      | 3963.69      | I  | 340       | 4756.11      | I |
| 700       | 2996.58      | I  | 330 h     | 3574.80      | I  | 120       | 3969.06      | I  | 190       | 4789.32      | I |
| 210       | 2998.79      | I  | 19000     | 3578.69      | I  | 1600      | 3969.75      | I  | 120       | 4801.03      | I |
| 1100      | 3000.89      | I  | 160 h     | 3584.33      | I  | 1600      | 3976.66      | I  | 110       | 4829.38      | I |
| 750       | 3005.06      | I  | 130       | 3585.30      | II | 960       | 3983.91      | I  | 140       | 4870.80      | I |
| 140       | 3013.03      | I  | 17000     | 3593.49      | I  | 190       | 3984.34      | I  | 130       | 4887.01      | I |
| 710       | 3013.71      | I  | 350       | 3601.67      | I  | 160       | 3989.99      | I  | 260       | 4922.27      | I |
| 710       | 3014.76      | I  | 13000     | 3605.33      | I  | 960       | 3991.12      | I  | 110       | 4936.33      | I |
| 1400      | 3014.92      | I  | 130       | 3632.84      | I  | 160       | 3991.67      | I  | 70        | 4942.50      | I |
| 710       | 3015.19      | I  | 350       | 3636.59      | I  | 190       | 3992.84      | I  | 110       | 4954.81      | I |
| 2800      | 3017.57      | I  | 630       | 3639.80      | I  | 160       | 4001.44      | I  | 60        | 5013.32      | I |
| 430       | 3018.50      | I  | 220       | 3641.83      | I  | 120       | 4012.47      | II | 70        | 5166.23      | I |
| 240       | 3018.82      | I  | 220       | 3649.00      | I  | 120       | 4026.17      | I  | 70        | 5184.59      | I |
| 430       | 3020.67      | I  | 170       | 3653.91      | I  | 190       | 4039.10      | I  | 70        | 5192.00      | I |
| 2800      | 3021.56      | I  | 220       | 3656.26      | I  | 160       | 4048.78      | I  | 85        | 5196.44      | I |
| 1100      | 3024.35      | I  | 130       | 3663.21      | I  | 120       | 4058.77      | I  | 5300      | 5204.52      | I |
| 170       | 3029.16      | I  | 120       | 3685.55      | I  | 140       | 4126.52      | I  | 8400      | 5206.04      | I |
| 710       | 3030.24      | I  | 130       | 3686.80      | I  | 120       | 4153.82      | I  | 11000     | 5208.44      | I |
| 140       | 3031.35      | I  | 130       | 3687.25      | I  | 140       | 4163.62      | I  | 85        | 5224.94      | I |
| 390       | 3034.19      | I  | 130       | 3730.81      | I  | 170       | 4174.80      | I  | 290       | 5247.56      | I |
| 550       | 3037.04      | I  | 150       | 3732.03      | I  | 170       | 4179.26      | I  | 530       | 5264.15      | I |
| 550       | 3040.85      | I  | 480       | 3743.58      | I  | 110       | 4209.37      | I  | 180       | 5265.72      | I |
| 110       | 3050.14      | II | 570       | 3743.88      | I  | 20000     | 4254.35      | I  | 95 h      | 5275.17      | I |
| 710       | 3053.88      | I  | 340       | 3749.00      | I  | 110       | 4263.14      | I  | 70 h      | 5276.03      | I |
| 240       | 3118.65      | II | 230       | 3757.66      | I  | 16000     | 4274.80      | I  | 340       | 5296.69      | I |
| 430       | 3120.37      | II | 260       | 3768.24      | I  | 10000     | 4289.72      | I  | 70 h      | 5297.36      | I |
| 470       | 3124.94      | II | 130       | 3791.38      | I  | 780       | 4337.57      | I  | 660       | 5298.27      | I |
| 120       | 3128.70      | II | 130       | 3792.14      | I  | 1100      | 4339.45      | I  | 85        | 5300.75      | I |
| 590       | 3132.06      | II | 120       | 3793.29      | I  | 380       | 4339.72      | I  | 340 h     | 5328.34      | I |
| 140       | 3136.68      | II | 130       | 3793.88      | I  | 1900      | 4344.51      | I  | 70 h      | 5329.17      | I |
| 140       | 3147.23      | II | 140       | 3797.13      | I  | 380       | 4351.05      | I  | 780       | 5345.81      | I |
| 100       | 3155.15      | I  | 200       | 3797.72      | I  | 2300      | 4351.77      | I  | 380       | 5348.32      | I |
| 100       | 3163.76      | I  | 530       | 3804.80      | I  | 570       | 4359.63      | I  | 40        | 5400.61      | I |
| 240       | 3180.70      | II | 110       | 3806.83      | I  | 530       | 4371.28      | I  | 1400      | 5409.79      | I |



| Intensity               | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-------------------------|--------------|-----|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 24                      | 5628.64      | I   | 1800      | 1955.17      | I  | 200       | 2347.39      | II | 800       | 2580.32      | II |
| 7                       | 5642.36      | I   | 1500      | 1958.55      | I  | 1600      | 2352.85      | I  | 300 d     | 2582.22      | II |
| 24                      | 5664.04      | I   | 1500      | 1961.59      | I  | 200 d     | 2353.41      | II | 500       | 2587.22      | II |
| 24                      | 5694.73      | I   | 1500 h    | 1968.69      | I  | 2000      | 2353.42      | I  | 500       | 2587.52      | II |
| 40                      | 5698.33      | I   | 1500 h    | 1968.93      | I  | 500       | 2363.80      | II | 200       | 2588.91      | II |
| 24                      | 5702.31      | I   | 3000      | 1970.71      | I  | 400       | 2378.62      | II | 100 p     | 2605.71      | II |
| 24                      | 5712.78      | I   | 1800 h    | 1971.16      | I  | 1400      | 2380.48      | I  | 100       | 2612.50      | II |
| 24 h                    | 5783.11      | I   | 1800 h    | 1972.52      | I  | 200       | 2381.76      | II | 100       | 2614.36      | II |
| 30 h                    | 5783.93      | I   | 1500      | 1973.85      | I  | 300 p     | 2383.45      | II | 100 p     | 2628.77      | II |
| 24 h                    | 5785.00      | I   | 1800      | 1976.97      | I  | 1400      | 2384.86      | I  | 100       | 2632.26      | II |
| 19 h                    | 5785.82      | I   | 2400 h    | 1980.89      | I  | 200       | 2386.36      | II | 100       | 2636.07      | II |
| 60 h                    | 5787.99      | I   | 1500      | 1989.80      | I  | 500       | 2388.92      | II | 310       | 2646.42      | I  |
| 180 h                   | 5791.00      | I   | 1800      | 1990.34      | I  | 200       | 2397.38      | II | 770       | 2648.64      | I  |
| 35                      | 6330.10      | I   | 1500 l    | 1998.49      | I  | 1100 d    | 2402.06      | I  | 100       | 2653.72      | II |
| 22                      | 6362.87      | I   | 1500      | 2002.32      | I  | 200 p     | 2404.16      | II | 100       | 2663.53      | II |
| 19                      | 6661.08      | I   | 900       | 2008.04      | I  | 5300      | 2407.25      | I  | 200       | 2666.73      | II |
| 21 h                    | 6883.03      | I   | 50        | 2011.51      | II | 5300      | 2411.62      | I  | 100       | 2675.85      | II |
| 27 h                    | 6924.13      | I   | 1200 h    | 2014.58      | I  | 1600      | 2412.76      | I  | 100       | 2684.42      | II |
| 30 h                    | 6978.48      | I   | 900       | 2016.17      | I  | 4800      | 2414.46      | I  | 100       | 2702.02      | II |
| 85                      | 7355.90      | I   | 50        | 2022.35      | II | 4800      | 2415.30      | I  | 200       | 2706.62      | II |
| 130                     | 7400.21      | I   | 50        | 2027.04      | II | 300       | 2417.65      | II | 200       | 2707.35      | II |
| 150                     | 7462.31      | I   | 900       | 2031.96      | I  | 4100      | 2424.93      | I  | 190       | 2715.99      | I  |
| 40                      | 8947.15      | I   | 1500      | 2039.95      | I  | 3300      | 2432.21      | I  | 100       | 2727.78      | II |
| 19                      | 8976.83      | I   | 1200      | 2041.11      | I  | 2900      | 2436.66      | I  | 80        | 2734.54      | II |
| <i>Cobalt Co Z = 27</i> |              |     | 50        | 2065.54      | II | 2400      | 2439.05      | I  | 190       | 2745.10      | I  |
| 20                      | 355.52       | V   | 1500 h    | 2077.76      | I  | 200       | 2442.63      | II | 100       | 2753.22      | II |
| 18                      | 355.88       | V   | 900       | 2085.67      | I  | 200 d     | 2446.03      | II | 190       | 2764.19      | I  |
| 12                      | 356.06       | V   | 900       | 2087.55      | I  | 200 p     | 2447.69      | II | 100       | 2766.70      | II |
| 66                      | 609.16       | IV  | 900       | 2089.35      | I  | 200       | 2450.00      | II | 100       | 2774.97      | II |
| 70                      | 609.21       | IV  | 900       | 2093.40      | I  | 200       | 2464.20      | II | 100       | 2791.00      | II |
| 64                      | 609.28       | IV  | 900       | 2094.86      | I  | 200       | 2486.44      | II | 100       | 2793.73      | II |
| 10                      | 1018.36      | V   | 900       | 2095.77      | I  | 200       | 2498.82      | II | 150       | 2815.56      | I  |
| 10                      | 1021.14      | V   | 1200      | 2097.51      | I  | 570       | 2504.52      | I  | 80        | 2835.63      | II |
| 15                      | 1231.73      | V   | 1500      | 2104.73      | I  | 500       | 2506.46      | II | 80        | 2847.35      | II |
| 50                      | 1277.01      | V   | 1500      | 2106.80      | I  | 360       | 2506.88      | I  | 80        | 2871.22      | II |
| 80                      | 1299.58      | II  | 900       | 2108.98      | I  | 200       | 2511.16      | II | 190       | 2886.44      | I  |
| 80                      | 1306.95      | II  | 900 s     | 2117.68      | I  | 860       | 2517.87      | I  | 100       | 2918.38      | II |
| 50                      | 1345.67      | V   | 900       | 2137.78      | I  | 500       | 2519.82      | II | 100       | 2930.24      | II |
| 1000                    | 1696.01      | III | 900       | 2138.97      | I  | 4300      | 2521.36      | I  | 100       | 2954.73      | II |
| 800                     | 1697.99      | III | 900       | 2163.03      | I  | 200 h     | 2524.65      | II | 690       | 2987.16      | I  |
| 1000                    | 1707.35      | III | 1100      | 2174.60      | I  | 300       | 2524.97      | II | 690       | 2989.59      | I  |
| 5000                    | 1760.35      | III | 200       | 2193.60      | II | 500       | 2528.62      | II | 60        | 3022.59      | II |
| 5000                    | 1773.57      | III | 200       | 2256.73      | II | 2900      | 2528.97      | I  | 3100      | 3044.00      | I  |
| 2000                    | 1780.05      | III | 150       | 2260.00      | II | 200 p     | 2530.09      | II | 1700      | 3061.82      | I  |
| 3000                    | 1782.97      | III | 200       | 2283.52      | II | 720       | 2530.13      | I  | 80        | 3387.70      | II |
| 1000                    | 1787.08      | III | 1000      | 2286.15      | II | 860       | 2532.18      | I  | 1100      | 3388.17      | I  |
| 1000                    | 1789.07      | III | 200       | 2291.98      | II | 200 d     | 2533.82      | II | 2200      | 3395.38      | I  |
| 1000                    | 1823.08      | III | 300 d     | 2293.38      | II | 2900      | 2535.96      | I  | 11000     | 3405.12      | I  |
| 2000                    | 1830.09      | III | 300       | 2301.40      | II | 860       | 2536.49      | I  | 4500      | 3409.18      | I  |
| 2000                    | 1831.44      | III | 800 d     | 2307.85      | II | 300       | 2541.94      | II | 6700      | 3412.34      | I  |
| 5000                    | 1835.00      | III | 2600      | 2309.02      | I  | 1700      | 2544.25      | I  | 2200      | 3412.63      | I  |
| 1500                    | 1842.34      | I   | 500       | 2311.60      | II | 200       | 2546.74      | II | 2700      | 3417.16      | I  |
| 1800                    | 1847.89      | I   | 500       | 2314.05      | II | 340       | 2548.34      | I  | 50        | 3423.84      | II |
| 1800                    | 1852.71      | I   | 300       | 2314.96      | II | 310       | 2553.37      | I  | 2500      | 3431.58      | I  |
| 2400                    | 1855.05      | I   | 200 p     | 2317.06      | II | 310       | 2555.07      | I  | 4500      | 3433.04      | I  |
| 2000                    | 1863.83      | III | 2400      | 2323.14      | I  | 300       | 2559.41      | II | 1600      | 3442.93      | I  |
| 1500                    | 1878.28      | I   | 300 p     | 2324.31      | II | 200       | 2560.03      | II | 8800      | 3443.64      | I  |
| 1800                    | 1936.58      | I   | 200 d     | 2326.11      | II | 960       | 2562.15      | I  | 50        | 3446.39      | II |
| 1500                    | 1946.79      | I   | 500       | 2326.47      | II | 500       | 2564.04      | II | 4100      | 3449.17      | I  |
| 1500                    | 1951.90      | I   | 1400      | 2335.99      | I  | 1100      | 2567.35      | I  | 2100      | 3449.44      | I  |
| 1800                    | 1954.22      | I   | 1600      | 2338.67      | I  | 960       | 2574.35      | I  | 21000     | 3453.50      | I  |

| Intensity | Wavelength/Å |    | Intensity               | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|-------------------------|--------------|----|-----------|--------------|-----|-----------|--------------|-----|
| 1000      | 3455.23      | I  | 90                      | 4549.66      | I  | 200       | 974.759      | II  | 250       | 1418.426     | II  |
| 5100      | 3462.80      | I  | 140                     | 4565.59      | I  | 250       | 977.567      | II  | 250       | 1421.759     | II  |
| 5100      | 3465.80      | I  | 190                     | 4581.60      | I  | 100       | 987.657      | II  | 200       | 1427.829     | II  |
| 8000      | 3474.02      | I  | 120                     | 4629.38      | I  | 250       | 992.953      | II  | 400       | 1430.243     | II  |
| 1900      | 3483.41      | I  | 85                      | 4663.41      | I  | 300       | 1004.055     | II  | 250       | 1434.904     | II  |
| 4800      | 3489.40      | I  | 110                     | 4792.86      | I  | 300       | 1008.569     | II  | 150       | 1436.236     | II  |
| 2400      | 3495.69      | I  | 100                     | 4840.27      | I  | 300       | 1008.728     | II  | 150       | 1442.139     | II  |
| 50        | 3501.72      | II | 150                     | 4867.88      | I  | 300       | 1010.269     | II  | 200       | 1445.984     | II  |
| 9600      | 3502.28      | I  | 80 h                    | 4964.18      | II | 250       | 1012.597     | II  | 200       | 1449.058     | II  |
| 7000      | 3506.32      | I  | 50                      | 5212.71      | I  | 500       | 1018.707     | II  | 250       | 1450.304     | II  |
| 50        | 3507.77      | II | 50                      | 5230.22      | I  | 500       | 1027.831     | II  | 200       | 1452.294     | II  |
| 2900      | 3509.84      | I  | 50                      | 5247.93      | I  | 250       | 1028.328     | II  | 300       | 1458.002     | II  |
| 1400      | 3510.43      | I  | 50                      | 5342.71      | I  | 200       | 1030.263     | II  | 250       | 1459.412     | II  |
| 4800      | 3512.64      | I  | 50                      | 5352.05      | I  | 600       | 1036.470     | II  | 200       | 1463.752     | II  |
| 3800      | 3513.48      | I  | <i>Copper Cu Z = 29</i> |              |    | 600       | 1039.348     | II  | 400       | 1463.838     | II  |
| 4800      | 3518.35      | I  | 80                      | 685.141      | II | 600       | 1039.582     | II  | 200       | 1466.070     | II  |
| 1300      | 3520.08      | I  | 100                     | 709.313      | II | 800       | 1044.519     | II  | 400       | 1470.697     | II  |
| 2700      | 3521.57      | I  | 100                     | 718.179      | II | 800       | 1044.744     | II  | 200       | 1472.395     | II  |
| 3800      | 3523.43      | I  | 150                     | 724.489      | II | 500       | 1049.755     | II  | 250       | 1473.978     | II  |
| 60        | 3523.51      | II | 200                     | 735.520      | II | 600       | 1054.690     | II  | 200       | 1474.935     | II  |
| 6400      | 3526.85      | I  | 250                     | 736.032      | II | 400       | 1055.797     | II  | 150       | 1476.059     | II  |
| 2700      | 3529.03      | I  | 80                      | 779.295      | II | 600       | 1056.955     | II  | 300 r     | 1481.23      | III |
| 7300      | 3529.81      | I  | 100                     | 797.455      | II | 400       | 1058.799     | II  | 200       | 1481.544     | II  |
| 1900      | 3533.36      | I  | 150                     | 810.998      | II | 600       | 1059.096     | II  | 200       | 1485.328     | II  |
| 50        | 3545.03      | II | 200                     | 813.883      | II | 600       | 1060.634     | II  | 750       | 1488.831     | II  |
| 1100      | 3560.89      | I  | 300                     | 826.996      | II | 600       | 1063.005     | II  | 300       | 1492.834     | II  |
| 80        | 3561.07      | II | 150                     | 848.808      | II | 200       | 1065.782     | II  | 250       | 1493.366     | II  |
| 8800      | 3569.38      | I  | 250                     | 851.303      | II | 200       | 1066.134     | II  | 250       | 1495.430     | II  |
| 50        | 3574.95      | II | 250                     | 858.487      | II | 500       | 1069.195     | II  | 350       | 1496.687     | II  |
| 1600      | 3574.96      | I  | 400                     | 861.994      | II | 300       | 1073.745     | II  | 150       | 1503.368     | II  |
| 60        | 3575.32      | II | 400                     | 865.390      | II | 200       | 1088.395     | II  | 250       | 1504.757     | II  |
| 2500      | 3575.36      | I  | 250                     | 869.336      | II | 300       | 1094.402     | II  | 200       | 1505.388     | II  |
| 60        | 3577.96      | II | 150                     | 873.263      | II | 250       | 1097.053     | II  | 300       | 1508.632     | II  |
| 1000      | 3585.16      | I  | 200                     | 876.723      | II | 150       | 1119.947     | II  | 350       | 1510.506     | II  |
| 6700      | 3587.19      | I  | 250                     | 877.012      | II | 200       | 1142.640     | II  | 200       | 1512.465     | II  |
| 1900      | 3594.87      | I  | 200                     | 877.555      | II | 300       | 1144.856     | II  | 200       | 1513.366     | II  |
| 1600      | 3602.08      | I  | 500                     | 878.699      | II | 100       | 1250.048     | II  | 500       | 1514.492     | II  |
| 100       | 3621.21      | II | 100                     | 884.133      | II | 150       | 1265.506     | II  | 200       | 1517.631     | II  |
| 1000      | 3627.81      | I  | 250                     | 885.847      | II | 300       | 1275.572     | II  | 500       | 1519.492     | II  |
| 80        | 3643.61      | II | 600                     | 886.943      | II | 150       | 1282.455     | II  | 600       | 1519.837     | II  |
| 60        | 3681.35      | II | 600                     | 890.567      | II | 150       | 1287.468     | II  | 200       | 1520.540     | II  |
| 1100      | 3745.50      | I  | 500                     | 892.414      | II | 150       | 1298.395     | II  | 200       | 1524.860     | II  |
| 1400      | 3842.05      | I  | 800                     | 893.678      | II | 300       | 1308.297     | II  | 150       | 1525.764     | II  |
| 6900      | 3845.47      | I  | 400                     | 894.227      | II | 300       | 1314.337     | II  | 500       | 1531.856     | II  |
| 5500      | 3873.12      | I  | 600                     | 896.759      | II | 100       | 1320.686     | II  | 300       | 1532.131     | II  |
| 2800      | 3873.96      | I  | 400                     | 896.976      | II | 100       | 1326.395     | II  | 250       | 1533.986     | II  |
| 7900      | 3894.08      | I  | 600                     | 901.073      | II | 150       | 1350.594     | II  | 250       | 1535.002     | II  |
| 1500      | 3935.97      | I  | 400                     | 906.113      | II | 250       | 1351.837     | II  | 500       | 1537.559     | II  |
| 80 h      | 3963.10      | II | 800                     | 914.213      | II | 150       | 1355.305     | II  | 200       | 1540.239     | II  |
| 6000      | 3995.31      | I  | 600                     | 922.019      | II | 300       | 1358.773     | II  | 300       | 1540.389     | II  |
| 970       | 3997.91      | I  | 500                     | 924.239      | II | 200       | 1359.009     | II  | 300       | 1540.588     | II  |
| 350       | 4020.90      | I  | 400                     | 935.232      | II | 200       | 1362.600     | II  | 750       | 1541.703     | II  |
| 370       | 4045.39      | I  | 600                     | 935.898      | II | 250       | 1367.951     | II  | 400       | 1544.677     | II  |
| 350       | 4066.37      | I  | 600                     | 943.335      | II | 200       | 1371.840     | II  | 100       | 1547.958     | II  |
| 830       | 4092.39      | I  | 600                     | 945.525      | II | 300 r     | 1376.79      | III | 300       | 1550.653     | II  |
| 550       | 4110.54      | I  | 500                     | 945.965      | II | 200 r     | 1377.49      | III | 300       | 1551.389     | II  |
| 2800      | 4118.77      | I  | 200                     | 954.383      | II | 100       | 1393.128     | II  | 500       | 1552.646     | II  |
| 4400      | 4121.32      | I  | 250                     | 956.290      | II | 100       | 1398.642     | II  | 250       | 1553.896     | II  |
| 90        | 4190.71      | I  | 400                     | 958.154      | II | 150       | 1402.777     | II  | 400       | 1555.134     | II  |
| 90        | 4469.56      | I  | 200                     | 960.414      | II | 150       | 1407.169     | II  | 500       | 1555.703     | II  |
| 690       | 4530.96      | I  | 250                     | 968.042      | II | 100       | 1414.898     | II  | 300       | 1558.345     | II  |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|-----|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 400       | 1565.924     | II  | 900       | 2135.981     | II | 800       | 2769.669     | II | 500       | 4043.751     | II |
| 400       | 1566.415     | II  | 400       | 2148.984     | II | 200       | 2791.795     | II | 2000      | 4062.64      | I  |
| 100       | 1569.416     | II  | 150       | 2161.320     | II | 170       | 2799.528     | II | 120       | 4068.106     | II |
| 300       | 1579.492     | II  | 1300 r    | 2165.09      | I  | 100       | 2810.804     | II | 500       | 4131.363     | II |
| 300       | 1580.626     | II  | 250       | 2174.982     | II | 1250 r    | 2824.37      | I  | 200       | 4143.017     | II |
| 400       | 1581.995     | II  | 1600 r    | 2178.94      | I  | 350       | 2837.368     | II | 300       | 4153.623     | II |
| 500       | 1583.682     | II  | 700       | 2179.410     | II | 100       | 2857.748     | II | 500       | 4161.140     | II |
| 400       | 1590.165     | II  | 1700 r    | 2181.72      | I  | 600       | 2877.100     | II | 370       | 4164.284     | II |
| 600       | 1593.556     | II  | 700       | 2189.630     | II | 270       | 2884.196     | II | 400       | 4171.851     | II |
| 500 r     | 1593.75      | III | 900       | 2192.268     | II | 2500 r    | 2961.16      | I  | 500       | 4179.512     | II |
| 400       | 1598.402     | II  | 400       | 2195.683     | II | 100       | 2986.335     | II | 500       | 4211.866     | II |
| 400       | 1602.388     | II  | 1700 r    | 2199.58      | I  | 2000      | 2997.36      | I  | 320       | 4230.449     | II |
| 200       | 1604.848     | II  | 1300 r    | 2199.75      | I  | 2000      | 3010.84      | I  | 200       | 4255.635     | II |
| 300       | 1605.281     | II  | 100       | 2200.509     | II | 2500      | 3036.10      | I  | 950       | 4275.11      | I  |
| 400       | 1606.834     | II  | 200       | 2209.806     | II | 2500      | 3063.41      | I  | 300       | 4279.962     | II |
| 250       | 1608.639     | II  | 750       | 2210.268     | II | 1400      | 3073.80      | I  | 500       | 4292.470     | II |
| 150       | 1610.296     | II  | 1600 r    | 2214.58      | I  | 1500      | 3093.99      | I  | 400       | 4365.370     | II |
| 200       | 1617.915     | II  | 250       | 2215.106     | II | 1250      | 3099.93      | I  | 100       | 4444.831     | II |
| 600       | 1621.426     | II  | 1000 r    | 2215.65      | I  | 2000      | 3108.60      | I  | 400       | 4506.002     | II |
| 400       | 1622.428     | II  | 750       | 2218.108     | II | 1400 h    | 3126.11      | I  | 150       | 4516.049     | II |
| 250       | 1630.268     | II  | 2100 r    | 2225.70      | I  | 1500      | 3194.10      | I  | 150       | 4541.032     | II |
| 100       | 1636.605     | II  | 150       | 2226.780     | II | 1400      | 3208.23      | I  | 500       | 4555.920     | II |
| 1000 r    | 1642.21      | III | 1600 r    | 2227.78      | I  | 1500 h    | 3243.16      | I  | 100       | 4596.906     | II |
| 250       | 1649.458     | II  | 350       | 2228.868     | II | 10000 r   | 3247.54      | I  | 120       | 4649.271     | II |
| 30 r      | 1655.32      | I   | 2500 r    | 2230.08      | I  | 10000 r   | 3273.96      | I  | 2000      | 4651.12      | I  |
| 200       | 1656.322     | II  | 1100 r    | 2238.45      | I  | 1400 h    | 3282.72      | I  | 120       | 4661.363     | II |
| 200       | 1660.001     | II  | 900       | 2242.618     | II | 400       | 3290.418     | II | 320       | 4671.702     | II |
| 300       | 1663.002     | II  | 2300 r    | 2244.26      | I  | 1500 h    | 3290.54      | I  | 300       | 4673.577     | II |
| 100       | 1672.776     | II  | 1000      | 2247.002     | II | 110       | 3300.881     | II | 450       | 4681.994     | II |
| 30        | 1688.09      | I   | 1300 r    | 2260.53      | I  | 250       | 3301.229     | II | 100       | 4758.433     | II |
| 30        | 1691.08      | I   | 2200 r    | 2263.08      | I  | 2500 h    | 3307.95      | I  | 400       | 4812.948     | II |
| 30 r      | 1703.84      | I   | 150       | 2263.786     | II | 200       | 3316.276     | II | 120       | 4851.262     | II |
| 50 r      | 1713.36      | I   | 200       | 2276.258     | II | 1500      | 3337.84      | I  | 300       | 4854.988     | II |
| 150       | 1717.721     | II  | 100       | 2286.645     | II | 150       | 3338.648     | II | 100       | 4873.304     | II |
| 50 r      | 1725.66      | I   | 2500 r    | 2293.84      | I  | 200       | 3365.648     | II | 150       | 4901.427     | II |
| 100       | 1736.551     | II  | 170       | 2294.368     | II | 450       | 3370.454     | II | 1000      | 4909.734     | II |
| 50 r      | 1741.57      | I   | 1000      | 2303.12      | I  | 300       | 3374.952     | II | 500       | 4918.376     | II |
| 150       | 1753.281     | II  | 150       | 2369.890     | II | 200       | 3380.712     | II | 200       | 4926.424     | II |
| 200 r     | 1774.82      | I   | 2500 r    | 2392.63      | I  | 100       | 3384.945     | II | 900       | 4931.698     | II |
| 100 r     | 1825.35      | I   | 120       | 2403.337     | II | 1250 h    | 3483.76      | I  | 120       | 4943.026     | II |
| 250       | 1929.751     | II  | 1500      | 2406.66      | I  | 1250      | 3524.23      | I  | 700       | 4953.724     | II |
| 250       | 1944.597     | II  | 1000 r    | 2441.64      | I  | 2000      | 3530.38      | I  | 500       | 4985.506     | II |
| 100       | 1946.493     | II  | 100       | 2485.792     | II | 1400      | 3599.13      | I  | 400       | 5006.801     | II |
| 200       | 1957.518     | II  | 2000 r    | 2492.15      | I  | 1400      | 3602.03      | I  | 350       | 5009.851     | II |
| 150       | 1970.495     | II  | 150       | 2506.273     | II | 1000      | 3686.555     | II | 400       | 5012.620     | II |
| 150       | 1977.027     | II  | 120       | 2526.593     | II | 150       | 3786.270     | II | 350       | 5021.279     | II |
| 500       | 1979.956     | II  | 300       | 2544.805     | II | 170       | 3797.849     | II | 200       | 5039.016     | II |
| 300       | 1989.855     | II  | 100       | 2571.756     | II | 100       | 3818.879     | II | 300       | 5047.348     | II |
| 250       | 1999.698     | II  | 150       | 2590.529     | II | 140       | 3826.921     | II | 900       | 5051.793     | II |
| 270       | 2035.854     | II  | 200       | 2600.270     | II | 160       | 3864.137     | II | 400       | 5058.910     | II |
| 250       | 2037.127     | II  | 2500 r    | 2618.37      | I  | 280       | 3884.131     | II | 500       | 5065.459     | II |
| 350       | 2043.802     | II  | 200       | 2666.291     | II | 150       | 3892.924     | II | 450       | 5067.094     | II |
| 300       | 2054.980     | II  | 750       | 2689.300     | II | 170       | 3903.177     | II | 350       | 5072.302     | II |
| 100       | 2078.663     | II  | 700       | 2700.962     | II | 140       | 3920.654     | II | 450       | 5088.277     | II |
| 110       | 2098.398     | II  | 650       | 2703.184     | II | 120       | 3933.268     | II | 420       | 5093.816     | II |
| 320       | 2104.797     | II  | 700       | 2713.508     | II | 120       | 3987.024     | II | 350       | 5100.067     | II |
| 300       | 2112.100     | II  | 650       | 2718.778     | II | 150       | 3993.302     | II | 1500      | 5105.54      | I  |
| 320       | 2117.310     | II  | 300       | 2721.677     | II | 140       | 4003.476     | II | 250       | 5124.476     | II |
| 350       | 2122.980     | II  | 120       | 2737.342     | II | 1250      | 4022.63      | I  | 2000      | 5153.24      | I  |
| 350       | 2126.044     | II  | 270       | 2745.271     | II | 100       | 4032.647     | II | 100       | 5158.093     | II |
| 420       | 2134.341     | II  | 2500 r    | 2766.37      | I  | 600       | 4043.484     | II | 100       | 5183.367     | II |

| Intensity | Wavelength/Å |    | Intensity                   | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|----|-----------------------------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 2500      | 5218.20      | I  | 270                         | 6879.404     | II | 1200      | 3156.52      | II | 830       | 3577.98      | II |
| 100       | 5269.991     | II | 220                         | 6937.553     | II | 670       | 3162.83      | II | 440       | 3580.04      | II |
| 100       | 5276.525     | II | 150                         | 6952.871     | II | 1000      | 3169.99      | II | 3300      | 3585.06      | II |
| 1650      | 5292.52      | I  | 150                         | 6977.572     | II | 470       | 3215.19      | II | 1400      | 3585.78      | II |
| 100       | 5368.383     | II | 200                         | 7022.860     | II | 830       | 3216.63      | II | 560       | 3586.11      | II |
| 1500      | 5700.24      | I  | 300                         | 7194.896     | II | 490       | 3235.89      | II | 1100      | 3591.41      | II |
| 1500      | 5782.13      | I  | 400                         | 7326.008     | II | 490       | 3245.12      | II | 560       | 3591.81      | II |
| 150       | 5805.989     | II | 300                         | 7331.694     | II | 1200      | 3251.27      | II | 560       | 3592.11      | II |
| 100       | 5833.515     | II | 250                         | 7382.277     | II | 890       | 3280.09      | II | 1800      | 3595.04      | II |
| 200       | 5897.971     | II | 1000                        | 7404.354     | II | 490       | 3282.77      | II | 560       | 3600.38      | II |
| 120       | 5937.577     | II | 270                         | 7434.156     | II | 1100      | 3308.88      | II | 1800      | 3606.12      | II |
| 400       | 5941.196     | II | 500                         | 7562.015     | II | 780       | 3316.32      | II | 440       | 3618.51      | II |
| 100       | 5993.260     | II | 700                         | 7652.333     | II | 1000      | 3319.88      | II | 560       | 3620.16      | II |
| 650       | 6000.120     | II | 1000                        | 7664.648     | II | 780       | 3341.00      | II | 470       | 3624.27      | II |
| 100       | 6023.264     | II | 150                         | 7681.788     | II | 510       | 3353.58      | II | 1100      | 3629.42      | II |
| 250       | 6072.218     | II | 450                         | 7744.097     | II | 510       | 3368.11      | II | 4000      | 3630.24      | II |
| 150       | 6080.343     | II | 800                         | 7778.738     | II | 5300      | 3385.02      | II | 440       | 3632.78      | II |
| 150       | 6099.990     | II | 750                         | 7805.184     | II | 610       | 3388.85      | II | 1100      | 3640.25      | II |
| 160       | 6107.412     | II | 1500                        | 7807.659     | II | 3800      | 3393.57      | II | 11000     | 3645.40      | II |
| 300       | 6114.493     | II | 1000                        | 7825.654     | II | 1300      | 3396.16      | II | 1000      | 3648.78      | II |
| 600       | 6150.384     | II | 350                         | 7860.577     | II | 5300      | 3407.80      | II | 700       | 3664.62      | II |
| 750       | 6154.222     | II | 300                         | 7890.567     | II | 1300      | 3413.78      | II | 990       | 3672.30      | II |
| 500       | 6172.037     | II | 700                         | 7902.553     | II | 530       | 3414.82      | II | 420       | 3672.70      | II |
| 550       | 6186.884     | II | 1500                        | 7933.13      | I  | 780       | 3419.63      | II | 1400      | 3674.08      | II |
| 400       | 6188.676     | II | 400                         | 7944.438     | II | 530       | 3425.06      | II | 2200      | 3676.59      | II |
| 300       | 6198.092     | II | 400                         | 7972.033     | II | 1900      | 3434.37      | II | 640       | 3678.51      | I  |
| 470       | 6204.261     | II | 1200                        | 7988.163     | II | 560       | 3440.93      | II | 820       | 3684.85      | I  |
| 450       | 6208.457     | II | 2000                        | 8092.63      | I  | 1300      | 3441.45      | II | 1300      | 3685.78      | I  |
| 750       | 6216.939     | II | 500                         | 8277.560     | II | 3800      | 3445.57      | II | 4700      | 3694.81      | II |
| 700       | 6219.844     | II | 800                         | 8283.160     | II | 830       | 3446.99      | II | 990       | 3698.21      | II |
| 500       | 6261.848     | II | 250                         | 8503.396     | II | 2700      | 3454.32      | II | 540       | 3701.63      | II |
| 1000      | 6273.349     | II | 750                         | 8511.061     | II | 1300      | 3456.56      | II | 440       | 3707.57      | II |
| 350       | 6288.696     | II | 200                         | 8609.134     | II | 4400      | 3460.97      | II | 440       | 3708.22      | II |
| 900       | 6301.009     | II | 500                         | 9813.213     | II | 720       | 3468.43      | II | 420       | 3710.07      | II |
| 550       | 6305.972     | II | 250                         | 9827.978     | II | 560       | 3471.14      | II | 1600      | 3724.45      | II |
| 400       | 6312.492     | II | 200                         | 9830.798     | II | 560 d     | 3471.53      | II | 930       | 3739.34      | I  |
| 120       | 6326.466     | II | 600                         | 9861.280     | II | 1300      | 3477.07      | II | 1200      | 3747.82      | II |
| 400       | 6373.268     | II | 600                         | 9864.137     | II | 4400      | 3494.49      | II | 1400      | 3753.51      | II |
| 750       | 6377.840     | II | 200                         | 9883.969     | II | 560       | 3496.34      | II | 1400      | 3753.75      | II |
| 400       | 6403.384     | II | 550                         | 9916.419     | II | 830       | 3498.71      | II | 1200      | 3757.05      | I  |
| 850       | 6423.884     | II | 500                         | 9917.954     | II | 830       | 3504.53      | II | 4700      | 3757.37      | II |
| 200       | 6442.965     | II | 550                         | 9925.594     | II | 830       | 3505.45      | II | 640       | 3767.63      | I  |
| 750       | 6448.559     | II | 450                         | 9938.998     | II | 1300      | 3506.81      | II | 640       | 3773.05      | I  |
| 170       | 6466.246     | II | 500                         | 9960.354     | II | 560       | 3517.26      | II | 420       | 3781.47      | I  |
| 950       | 6470.168     | II | 450                         | 10006.588    | II | 4400      | 3523.98      | II | 3300      | 3786.18      | II |
| 750       | 6481.437     | II | 550                         | 10022.969    | II | 22000     | 3531.70      | II | 1600      | 3788.44      | II |
| 400       | 6484.421     | II | 550                         | 10038.093    | II | 4400      | 3534.96      | II | 700       | 3791.87      | II |
| 220       | 6517.317     | II | 650                         | 10054.938    | II | 5500      | 3536.02      | II | 510       | 3804.14      | II |
| 400       | 6530.083     | II | 450                         | 10080.354    | II | 4400      | 3538.52      | II | 580       | 3806.27      | II |
| 120       | 6551.286     | II |                             |              |    | 1700      | 3542.33      | II | 470       | 3812.27      | I  |
| 200       | 6577.080     | II | <i>Dysprosium Dy Z = 66</i> |              |    | 1400      | 3546.83      | II | 470       | 3813.67      | II |
| 750       | 6624.292     | II | 260                         | 2356.91      | II | 4400      | 3550.22      | II | 1400      | 3816.76      | II |
| 800       | 6641.396     | II | 240                         | 2410.01      | II | 2200      | 3551.62      | II | 700       | 3825.68      | II |
| 450       | 6660.962     | II | 260                         | 2439.84      | II | 440 h     | 3558.23      | II | 2300      | 3836.50      | II |
| 100       | 6770.362     | II | 220                         | 2585.30      | I  | 440       | 3559.30      | II | 1400      | 3841.31      | II |
| 300       | 6806.216     | II | 440                         | 2634.80      | II | 2200      | 3563.15      | II | 420       | 3846.34      | II |
| 400       | 6809.647     | II | 220                         | 2755.75      | II | 560       | 3563.69      | II | 420       | 3847.02      | I  |
| 320       | 6823.202     | II | 300                         | 2816.39      | II | 780       | 3573.83      | II | 1200      | 3853.03      | II |
| 250       | 6844.157     | II | 390                         | 2913.95      | II | 1400      | 3574.15      | II | 420       | 3858.40      | I  |
| 320       | 6868.791     | II | 610                         | 3038.28      | II | 4400      | 3576.24      | II | 560       | 3868.45      | II |
| 270       | 6872.231     | II | 830                         | 3135.38      | II | 1700      | 3576.87      | II | 1600      | 3868.81      | I  |
|           |              |    | 500                         | 3141.14      | II |           |              |    |           |              |    |

| Intensity | Wavelength/Å |    | Intensity               | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|-------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 820       | 3869.86      | II | 990                     | 4612.26      | I   | 1000      | 3070.40      | III | 3200      | 3944.42      | I   |
| 7000      | 3872.11      | II | 170                     | 4731.84      | II  | 610       | 3073.34      | II  | 2700      | 3973.04      | I   |
| 1200      | 3873.99      | II | 120 h                   | 4775.79      | I   | 720       | 3082.08      | II  | 3200      | 3973.58      | I   |
| 470       | 3879.11      | II | 480                     | 4957.34      | II  | 610       | 3084.02      | II  | 1400      | 3974.72      | II  |
| 5800      | 3898.53      | II | 70                      | 5022.12      | I   | 770       | 3122.72      | II  | 810       | 3977.02      | I   |
| 540       | 3914.87      | II | 160                     | 5042.63      | I   | 1500      | 3166.25      | III | 1100      | 3982.33      | I   |
| 540       | 3915.59      | II | 95                      | 5070.68      | I   | 870       | 3181.92      | II  | 810       | 3987.66      | I   |
| 540 d     | 3917.29      | I  | 120                     | 5077.67      | I   | 870       | 3220.73      | II  | 14000     | 4007.96      | I   |
| 420       | 3927.86      | I  | 80                      | 5090.38      | II  | 610       | 3223.31      | II  | 1100      | 4012.58      | I   |
| 540       | 3930.14      | I  | 80                      | 5110.32      | I   | 2300      | 3230.58      | II  | 3000      | 4020.51      | I   |
| 2100      | 3931.52      | II | 130 h                   | 5120.04      | I   | 2700      | 3264.78      | II  | 1000      | 4046.96      | I   |
| 10000     | 3944.68      | II | 190                     | 5139.60      | II  | 720       | 3279.33      | II  | 940       | 4055.47      | II  |
| 800       | 3957.79      | II | 110                     | 5169.69      | II  | 720       | 3280.22      | II  | 690       | 4059.78      | II  |
| 14000     | 3968.39      | II | 80                      | 5185.30      | I   | 2000      | 3301.23      | III | 3500      | 4087.63      | I   |
| 2700      | 3978.57      | II | 290                     | 5192.86      | II  | 2300      | 3312.42      | II  | 1100      | 4098.10      | I   |
| 1400      | 3981.92      | II | 95                      | 5197.66      | II  | 770       | 3323.19      | II  | 6900      | 4151.11      | I   |
| 1600      | 3983.65      | II | 70                      | 5259.88      | I   | 770       | 3332.70      | II  | 1000      | 4190.70      | I   |
| 800       | 3984.21      | II | 130                     | 5260.56      | I   | 1300      | 3346.04      | II  | 1400      | 4218.43      | I   |
| 540       | 3991.32      | II | 65                      | 5267.11      | I   | 1400      | 3364.08      | II  | 690       | 4286.56      | I   |
| 1600      | 3996.69      | II | 55                      | 5282.07      | I   | 1400 d    | 3368.02      | II  | 40000     | 4290.06      | III |
| 8000      | 4000.45      | II | 160                     | 5301.58      | I   | 7700      | 3372.71      | II  | 20000     | 4386.86      | III |
| 420       | 4005.84      | I  | 65                      | 5340.30      | I   | 970       | 3374.17      | II  | 810       | 4409.34      | I   |
| 540       | 4011.29      | II | 85                      | 5389.58      | II  | 1700      | 3385.08      | II  | 1000      | 4606.61      | I   |
| 540       | 4013.82      | I  | 80                      | 5419.13      | I   | 2300      | 3392.00      | II  | 570       | 4675.62      | II  |
| 540       | 4014.70      | II | 70                      | 5423.32      | I   | 770       | 3441.13      | II  | 15000     | 4735.56      | III |
| 420       | 4027.78      | II | 95                      | 5451.11      | I   | 970       | 3471.71      | II  | 2000      | 4783.12      | III |
| 520 d     | 4028.32      | II | 65                      | 5547.27      | I   | 610       | 3479.41      | II  | 250       | 5007.25      | I   |
| 520       | 4032.47      | II | 100                     | 5639.50      | I   | 970       | 3485.85      | II  | 200       | 5035.94      | I   |
| 420       | 4033.65      | II | 55 h                    | 5645.99      | I   | 6700      | 3499.10      | II  | 210       | 5042.05      | II  |
| 420       | 4036.32      | II | 80                      | 5652.01      | I   | 610       | 3502.78      | I   | 120       | 5124.56      | I   |
| 12000     | 4045.97      | I  | 70 h                    | 5718.46      | I   | 610       | 3524.91      | II  | 130       | 5127.41      | II  |
| 1600      | 4050.56      | II | 55                      | 5745.53      | I   | 820       | 3549.84      | II  | 120       | 5131.53      | I   |
| 520       | 4055.14      | II | 55 h                    | 5868.11      | II  | 1500      | 3558.02      | I   | 130       | 5133.83      | II  |
| 2500      | 4073.12      | II | 70                      | 5945.80      | I   | 1000      | 3559.90      | II  | 170       | 5164.77      | II  |
| 7400      | 4077.96      | II | 120                     | 5974.49      | I   | 920       | 3570.75      | II  | 130       | 5172.78      | I   |
| 3900      | 4103.30      | II | 140                     | 5988.56      | I   | 1000      | 3580.52      | II  | 160       | 5188.90      | II  |
| 860       | 4103.87      | I  | 140                     | 6088.26      | I   | 610       | 3590.76      | I   | 150       | 5206.52      | I   |
| 1500      | 4111.34      | II | 100                     | 6168.43      | I   | 610       | 3599.50      | II  | 140       | 5255.93      | II  |
| 490       | 4124.63      | II | 270                     | 6259.09      | I   | 1000      | 3599.83      | II  | 80        | 5272.91      | I   |
| 990       | 4129.42      | II | 160                     | 6579.37      | I   | 3100      | 3616.56      | II  | 90        | 5348.06      | I   |
| 1200      | 4143.10      | II | 75                      | 6667.86      | I   | 720       | 3628.04      | I   | 60        | 5414.63      | II  |
| 990       | 4146.06      | I  | 180                     | 6835.42      | I   | 1000      | 3633.54      | II  | 180       | 5456.62      | I   |
| 5700      | 4167.97      | I  | 80                      | 6852.96      | I   | 1600      | 3638.68      | I   | 90        | 5468.32      | I   |
| 930       | 4183.72      | I  | 65                      | 6899.32      | II  | 900       | 3645.94      | II  | 80        | 5485.97      | II  |
| 12000     | 4186.82      | I  | 55                      | 7426.86      | II  | 7900      | 3692.65      | II  | 80        | 5593.46      | I   |
| 2200      | 4191.64      | I  | 55                      | 7543.73      | I   | 1300      | 3729.52      | II  | 60        | 5611.82      | I   |
| 6800      | 4194.84      | I  | 80                      | 7662.36      | I   | 900       | 3742.64      | II  | 70        | 5622.01      | I   |
| 800       | 4198.02      | I  | 100                     | 8201.57      | II  | 900       | 3747.43      | I   | 80        | 5626.53      | II  |
| 680       | 4201.30      | I  | 45                      | 8791.39      | II  | 1800      | 3786.84      | II  | 90        | 5640.36      | I   |
| 680       | 4202.24      | I  | <i>Erbium Er Z = 68</i> |              |     | 1600      | 3810.33      | I   | 70        | 5664.95      | I   |
| 16000     | 4211.72      | I  | 600                     | 2277.65      | III | 4000      | 3816.78      | III | 70        | 5719.55      | I   |
| 1800      | 4213.18      | I  | 290                     | 2586.73      | II  | 3600      | 3830.48      | II  | 100       | 5739.19      | I   |
| 3700      | 4215.16      | I  | 490                     | 2670.26      | II  | 680       | 3855.90      | I   | 290       | 5762.80      | I   |
| 4400      | 4218.09      | I  | 500                     | 2739.27      | III | 7500      | 3862.85      | I   | 70        | 5784.66      | I   |
| 4400      | 4221.11      | I  | 610                     | 2755.63      | II  | 1500      | 3880.61      | II  | 70        | 5800.79      | I   |
| 2700      | 4225.16      | I  | 1000                    | 2904.47      | II  | 1200      | 3882.89      | II  | 430       | 5826.79      | I   |
| 1000      | 4308.63      | II | 1500                    | 2910.36      | II  | 4200      | 3892.68      | I   | 100       | 5850.07      | I   |
| 540       | 4409.38      | II | 1500                    | 2964.52      | II  | 5200      | 3896.23      | II  | 120       | 5855.31      | I   |
| 740       | 4449.70      | II | 1200                    | 3002.41      | II  | 11000     | 3906.31      | II  | 140       | 5872.35      | I   |
| 420       | 4577.78      | I  | 1000                    | 3055.10      | III | 3200      | 3937.01      | I   | 120       | 5881.14      | I   |
| 2100      | 4589.36      | I  |                         |              |     | 2100      | 3938.63      | II  | 8000      | 5903.30      | III |

| Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity               | Wavelength/Å |     |
|---------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|-------------------------|--------------|-----|
| 70                        | 6022.56      | I   | 140       | 2893.03      | I   | 9800      | 4627.22      | I  | 230                     | 6303.41      | II  |
| 70                        | 6061.25      | I   | 360       | 2893.83      | I   | 8300      | 4661.88      | I  | 120 cw                  | 6350.04      | I   |
| 60                        | 6076.45      | II  | 3200      | 2906.68      | II  | 110       | 4867.62      | I  | 120 cw                  | 6400.93      | I   |
| 360                       | 6221.02      | I   | 160       | 2908.99      | I   | 150       | 4907.18      | I  | 180                     | 6410.04      | I   |
| 55                        | 6262.56      | I   | 850       | 2925.04      | II  | 180       | 4911.40      | I  | 140                     | 6411.32      | I   |
| 60                        | 6268.87      | I   | 200 cw    | 2952.68      | II  | 180       | 5013.17      | I  | 830                     | 6437.64      | II  |
| 130                       | 6308.77      | I   | 260       | 2960.21      | II  | 170       | 5022.91      | I  | 120                     | 6457.96      | I   |
| 55                        | 6326.13      | I   | 300       | 2991.33      | II  | 110       | 5029.54      | I  | 1400                    | 6645.11      | II  |
| 55                        | 6492.35      | I   | 100 c     | 3023.93      | III | 170       | 5114.37      | I  | 50                      | 6666.35      | III |
| 60                        | 6583.48      | I   | 200 c     | 3026.79      | III | 170       | 5129.10      | I  | 140                     | 6802.72      | I   |
| 70                        | 6601.11      | I   | 320 cw    | 3054.94      | II  | 210       | 5133.52      | I  | 360                     | 6864.54      | I   |
| 70                        | 6759.87      | I   | 120       | 3058.98      | I   | 270       | 5160.07      | I  | 120                     | 7040.20      | I   |
| 35                        | 6790.92      | I   | 220       | 3077.36      | II  | 210       | 5166.70      | I  | 330                     | 7077.10      | II  |
| 70                        | 6848.10      | I   | 120       | 3097.45      | II  | 200       | 5199.85      | I  | 570                     | 7194.81      | II  |
| 55                        | 6865.13      | I   | 320       | 3106.18      | I   | 110       | 5200.96      | I  | 570                     | 7217.55      | II  |
| 55                        | 7459.55      | I   | 950       | 3111.43      | I   | 120       | 5206.44      | I  | 540                     | 7301.17      | II  |
| 120                       | 7469.51      | I   | 120       | 3130.73      | II  | 750       | 5215.10      | I  | 720                     | 7370.22      | II  |
| 35                        | 7680.01      | I   | 50 c      | 3171.00      | III | 300       | 5223.49      | I  | 300                     | 7426.57      | II  |
| 35                        | 7797.47      | I   | 50 c      | 3183.78      | III | 120       | 5239.24      | I  | 160                     | 7583.91      | I   |
| 35                        | 7921.85      | I   | 420       | 3210.57      | I   | 200       | 5266.40      | I  | 60 cw                   | 7742.57      | I   |
| 30                        | 7937.84      | I   | 1000      | 3212.81      | I   | 390       | 5271.96      | I  | 70                      | 7746.19      | I   |
| 35                        | 8312.82      | I   | 420       | 3213.75      | I   | 110       | 5272.48      | I  | 35                      | 7887.99      | I   |
| 55                        | 8409.90      | I   | 150       | 3272.77      | II  | 150       | 5282.82      | I  | 24 cw                   | 8209.80      | I   |
| 9                         | 8866.84      | II  | 210       | 3277.78      | II  | 120       | 5291.26      | I  | 21 cw                   | 8642.67      | I   |
| <b>Europium Eu Z = 63</b> |              |     | 150       | 3301.95      | II  | 120       | 5294.64      | I  | 18                      | 8870.30      | I   |
| 30                        | 2124.69      | III | 140       | 3308.02      | II  | 540       | 5357.61      | I  | <b>Fluorine F Z = 9</b> |              |     |
| 200                       | 2350.51      | III | 140       | 3313.33      | II  | 120       | 5361.61      | I  | 50                      | 148.00       | V   |
| 4000                      | 2375.46      | III | 950       | 3334.33      | I   | 110       | 5376.94      | I  | 50                      | 163.56       | V   |
| 100 d                     | 2435.14      | III | 110       | 3350.40      | I   | 120       | 5392.94      | I  | 90                      | 165.98       | V   |
| 1000                      | 2444.38      | III | 140       | 3369.06      | II  | 450       | 5402.77      | I  | 100                     | 166.18       | V   |
| 4000                      | 2445.99      | III | 190       | 3391.99      | II  | 380       | 5451.51      | I  | 50                      | 186.84       | V   |
| 2000                      | 2513.76      | III | 280       | 3396.58      | II  | 260       | 5452.94      | I  | 60                      | 190.57       | V   |
| 200                       | 2522.14      | III | 150       | 3425.02      | II  | 120       | 5488.65      | I  | 70                      | 190.84       | V   |
| 160                       | 2564.17      | II  | 150       | 3441.00      | II  | 120       | 5510.52      | I  | 50                      | 196.39       | IV  |
| 110                       | 2568.17      | II  | 130       | 3461.38      | II  | 200       | 5547.44      | I  | 60                      | 196.45       | IV  |
| 230                       | 2577.14      | II  | 470 cw    | 3521.09      | II  | 150       | 5570.33      | I  | 70                      | 200.09       | IV  |
| 1000                      | 2638.77      | II  | 150       | 3542.15      | II  | 200       | 5577.14      | I  | 80                      | 201.16       | IV  |
| 380                       | 2641.27      | II  | 180       | 3552.52      | II  | 120       | 5580.03      | I  | 90                      | 208.25       | IV  |
| 640                       | 2668.34      | II  | 150       | 3603.20      | II  | 210       | 5645.80      | I  | 90                      | 240.08       | IV  |
| 110                       | 2673.42      | II  | 6400      | 3688.42      | II  | 330       | 5765.20      | I  | 100                     | 251.03       | IV  |
| 250                       | 2678.29      | II  | 20000 cw  | 3724.94      | II  | 180       | 5783.69      | I  | 140                     | 419.65       | IV  |
| 250                       | 2685.66      | II  | 350       | 3741.31      | II  | 170       | 5818.74      | II | 150                     | 420.05       | IV  |
| 550                       | 2692.03      | II  | 260       | 3761.12      | II  | 600 cw    | 5830.98      | I  | 160                     | 420.73       | IV  |
| 700                       | 2701.14      | II  | 39000 cw  | 3819.67      | II  | 330       | 5966.07      | II | 100                     | 429.51       | III |
| 800                       | 2701.90      | II  | 140       | 3844.23      | II  | 480 cw    | 5967.10      | I  | 110                     | 430.15       | III |
| 240                       | 2705.28      | II  | 190       | 3865.57      | I   | 170       | 5972.75      | I  | 150                     | 430.76       | IV  |
| 180                       | 2709.99      | I   | 150       | 3884.75      | I   | 240       | 5992.83      | I  | 90                      | 464.29       | III |
| 700                       | 2716.98      | II  | 28000 cw  | 3907.10      | II  | 110       | 6012.56      | I  | 120                     | 465.98       | V   |
| 4200                      | 2727.78      | II  | 32000 cw  | 3930.48      | II  | 420       | 6018.15      | I  | 130                     | 490.57       | IV  |
| 160                       | 2740.62      | II  | 30000 cw  | 3971.96      | II  | 170       | 6029.00      | I  | 160                     | 491.00       | IV  |
| 120                       | 2744.26      | II  | 180       | 4011.69      | II  | 420       | 6049.51      | II | 50                      | 497.38       | IV  |
| 480                       | 2781.89      | II  | 150       | 4017.58      | II  | 140       | 6057.36      | I  | 60                      | 497.83       | IV  |
| 1900                      | 2802.84      | II  | 120       | 4039.19      | I   | 240       | 6083.84      | I  | 70                      | 498.80       | IV  |
| 220                       | 2811.75      | II  | 120       | 4085.38      | II  | 240       | 6099.35      | I  | 90                      | 506.16       | V   |
| 3400                      | 2813.94      | II  | 33000 cw  | 4129.70      | II  | 120       | 6118.78      | I  | 100                     | 508.08       | V   |
| 550                       | 2816.18      | II  | 60000 cw  | 4205.05      | II  | 330       | 6173.05      | II | 120                     | 508.39       | III |
| 2000                      | 2820.78      | II  | 150       | 4298.73      | I   | 110       | 6178.76      | I  | 60                      | 514.08       | V   |
| 400 cw                    | 2828.72      | II  | 240       | 4355.09      | II  | 260 cw    | 6188.13      | I  | 90                      | 525.29       | V   |
| 260                       | 2859.67      | II  | 14000 cw  | 4435.56      | II  | 140       | 6195.07      | I  | 100                     | 526.30       | V   |
| 280                       | 2862.57      | II  | 3000      | 4522.57      | II  | 240       | 6262.25      | I  | 120                     | 567.69       | III |
| 200                       | 2892.54      | I   | 11000     | 4594.03      | I   | 170       | 6299.77      | I  | 110                     | 567.75       | III |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                 | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|---------------------------|--------------|-----|
| 140       | 570.64       | IV  | 110       | 1839.30      | III | 270       | 3847.09      | II  | 8000                      | 6870.22      | I   |
| 140       | 571.30       | IV  | 120       | 1839.97      | III | 260       | 3849.99      | II  | 15000                     | 6902.48      | I   |
| 150       | 571.39       | IV  | 110       | 1840.14      | III | 250       | 3851.67      | II  | 6000                      | 6909.82      | I   |
| 160       | 572.66       | IV  | 100       | 2027.44      | III | 5         | 3898.48      | I   | 4000                      | 6966.35      | I   |
| 90        | 605.67       | II  | 120       | 2030.32      | III | 8         | 3930.69      | I   | 45000                     | 7037.47      | I   |
| 100       | 606.80       | II  | 120       | 2217.17      | III | 5         | 3934.26      | I   | 30000                     | 7127.89      | I   |
| 90        | 630.20       | III | 50        | 2298.29      | IV  | 5         | 3948.56      | I   | 15000                     | 7202.36      | I   |
| 100       | 647.77       | V   | 40        | 2451.58      | IV  | 240       | 4024.73      | II  | 1000                      | 7309.03      | I   |
| 110       | 647.87       | V   | 120       | 2452.07      | III | 220       | 4025.01      | II  | 15000                     | 7311.02      | I   |
| 130       | 654.03       | V   | 50        | 2456.92      | IV  | 230       | 4025.49      | II  | 700                       | 7314.30      | I   |
| 120       | 656.12       | III | 130       | 2464.85      | III | 200       | 4103.51      | II  | 5000                      | 7331.96      | I   |
| 130       | 656.87       | III | 130       | 2470.29      | III | 200       | 4246.23      | II  | 120                       | 7336.77      | III |
| 110       | 657.23       | V   | 120       | 2478.73      | III | 200       | 4299.17      | II  | 130                       | 7354.94      | III |
| 140       | 657.33       | V   | 150       | 2484.37      | III | 140 h     | 4420.30      | III | 10000                     | 7398.69      | I   |
| 140       | 658.33       | III | 120       | 2542.77      | III | 120 h     | 4427.35      | III | 4000                      | 7425.65      | I   |
| 140       | 676.12       | IV  | 120       | 2580.04      | III | 120 h     | 4432.32      | III | 2200                      | 7482.72      | I   |
| 130       | 677.15       | IV  | 130       | 2583.81      | III | 140 h     | 4479.99      | III | 2500                      | 7489.16      | I   |
| 150       | 677.22       | IV  | 120       | 2593.23      | III | 6         | 4960.65      | I   | 900                       | 7514.92      | I   |
| 130       | 678.99       | IV  | 130       | 2595.53      | III | 150       | 5012.54      | III | 5000                      | 7552.24      | I   |
| 160       | 679.21       | IV  | 140       | 2599.28      | III | 160       | 5110.99      | III | 5000                      | 7573.38      | I   |
| 60        | 757.04       | V   | 130       | 2625.01      | III | 15        | 5230.41      | I   | 7000                      | 7607.17      | I   |
| 150       | 806.96       | I   | 140       | 2629.70      | III | 12        | 5279.01      | I   | 18000                     | 7754.70      | I   |
| 125       | 809.60       | I   | 120       | 2656.44      | III | 18        | 5540.52      | I   | 15000                     | 7800.21      | I   |
| 500       | 951.87       | I   | 130       | 2755.55      | III | 12        | 5552.43      | I   | 300                       | 7879.18      | I   |
| 1000      | 954.83       | I   | 160       | 2759.63      | III | 10        | 5577.33      | I   | 500                       | 7898.59      | I   |
| 750       | 955.55       | I   | 120       | 2788.15      | III | 20        | 5624.06      | I   | 350                       | 7936.31      | I   |
| 500       | 958.52       | I   | 160       | 2811.45      | III | 12        | 5626.93      | I   | 300                       | 7956.32      | I   |
| 20        | 972.40       | I   | 40        | 2820.74      | IV  | 15        | 5659.15      | I   | 80                        | 8016.01      | II  |
| 350       | 973.90       | I   | 50        | 2826.13      | IV  | 40        | 5667.53      | I   | 1000                      | 8040.93      | I   |
| 100       | 976.22       | I   | 140       | 2833.99      | III | 90        | 5671.67      | I   | 900                       | 8075.52      | I   |
| 40        | 976.51       | I   | 150       | 2835.63      | III | 18        | 5689.14      | I   | 350                       | 8077.52      | I   |
| 100       | 977.75       | I   | 150       | 2860.33      | III | 25        | 5700.82      | I   | 350                       | 8126.56      | I   |
| 60        | 1082.31      | V   | 120       | 2862.86      | III | 25        | 5707.31      | I   | 600                       | 8129.26      | I   |
| 70        | 1088.39      | V   | 140       | 2887.58      | III | 140       | 5753.17      | III | 300                       | 8159.51      | I   |
| 80        | 1219.03      | III | 150       | 2889.45      | III | 120       | 5761.20      | III | 600                       | 8179.34      | I   |
| 80        | 1266.87      | III | 120       | 2905.30      | III | 12        | 5950.15      | I   | 300                       | 8191.24      | I   |
| 90        | 1267.71      | III | 140       | 2913.29      | III | 25        | 5959.19      | I   | 350                       | 8208.63      | I   |
| 70        | 1297.54      | III | 160       | 2916.34      | III | 70        | 5965.28      | I   | 2500                      | 8214.73      | I   |
| 70        | 1359.92      | III | 140       | 2932.49      | III | 50        | 5994.43      | I   | 3000                      | 8230.77      | I   |
| 110       | 1498.93      | III | 140       | 2994.28      | III | 150       | 6015.83      | I   | 500                       | 8232.19      | I   |
| 120       | 1502.01      | III | 120 h     | 2997.21      | III | 80        | 6038.04      | I   | 1500                      | 8274.62      | I   |
| 110       | 1504.18      | III | 130       | 2997.53      | III | 900       | 6047.54      | I   | 2000                      | 8298.58      | I   |
| 140       | 1504.79      | III | 120       | 2999.47      | III | 100       | 6080.11      | I   | 600                       | 8302.40      | I   |
| 130       | 1506.30      | III | 130       | 3039.25      | III | 150       | 6091.82      | III | 900                       | 8807.58      | I   |
| 110       | 1506.77      | III | 120       | 3039.75      | III | 140       | 6125.50      | III | 1000                      | 8900.92      | I   |
| 100       | 1553.02      | III | 160       | 3042.80      | III | 800       | 6149.76      | I   | 300                       | 8912.78      | I   |
| 110       | 1557.59      | III | 150       | 3049.14      | III | 400       | 6210.87      | I   | 350                       | 9025.49      | I   |
| 100       | 1563.73      | III | 140       | 3113.62      | III | 130       | 6233.57      | III | 400                       | 9042.10      | I   |
| 100       | 1565.54      | III | 160       | 3115.70      | III | 13000     | 6239.65      | I   | 350                       | 9178.68      | I   |
| 100       | 1623.40      | III | 180       | 3121.54      | III | 10000     | 6348.51      | I   | 200                       | 9433.67      | I   |
| 100       | 1650.76      | III | 140       | 3124.79      | III | 140       | 6363.05      | III | 25                        | 9505.30      | I   |
| 130       | 1670.39      | III | 140       | 3134.23      | III | 8000      | 6413.65      | I   | 12                        | 9662.04      | I   |
| 140       | 1677.40      | III | 140       | 3146.99      | III | 450       | 6569.69      | I   | 25                        | 9734.34      | I   |
| 100       | 1716.99      | III | 180       | 3174.17      | III | 300       | 6580.39      | I   | 15                        | 9822.11      | I   |
| 120       | 1770.09      | III | 170       | 3174.76      | III | 400       | 6650.41      | I   | 12                        | 9902.65      | I   |
| 150       | 1770.67      | III | 120       | 3214.00      | III | 1800      | 6690.48      | I   | 80 h                      | 10047.98     | II  |
| 110       | 1772.93      | III | 200       | 3501.45      | II  | 400       | 6708.28      | I   | 15                        | 10285.45     | I   |
| 140       | 1773.36      | III | 200       | 3501.57      | II  | 7000      | 6773.98      | I   | 20                        | 10862.31     | I   |
| 160       | 1791.65      | III | 200       | 3502.96      | II  | 1500      | 6795.53      | I   | <i>Francium Fr Z = 87</i> |              |     |
| 110       | 1803.03      | III | 6         | 3594.10      | I   | 9000      | 6834.26      | I   |                           |              |     |
| 170       | 1805.90      | III | 12        | 3668.17      | I   | 50000     | 6856.03      | I   | 7177.                     |              | I   |

| Intensity                   | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity                | Wavelength/Å |     |
|-----------------------------|--------------|-----|-----------|--------------|----|-----------|--------------|-----|--------------------------|--------------|-----|
| <b>Gadolinium Gd Z = 64</b> |              |     | 2000      | 3684.13      | I  | 700       | 4694.33      | I   | 50                       | 6752.67      | II  |
| 1200                        | 1007.24      | IV  | 3100      | 3687.74      | II | 410       | 4743.65      | I   | 26                       | 6786.33      | II  |
| 1200                        | 1063.84      | IV  | 2000      | 3697.73      | II | 470       | 4767.24      | I   | 100                      | 6828.25      | I   |
| 1600                        | 1476.98      | IV  | 1300      | 3699.73      | II | 300       | 4784.62      | I   | 100                      | 6916.57      | I   |
| 1500                        | 1705.03      | IV  | 2700      | 3712.70      | II | 320       | 4821.69      | I   | 50                       | 6985.89      | II  |
| 1600                        | 1706.01      | IV  | 2000      | 3713.57      | I  | 280       | 4934.12      | I   | 75                       | 6991.92      | I   |
| 2000                        | 1736.24      | IV  | 1400      | 3716.36      | II | 750       | 5015.04      | I   | 60                       | 6996.76      | II  |
| 1500                        | 1815.32      | IV  | 2000      | 3717.48      | I  | 75        | 5039.09      | I   | 45                       | 7006.16      | II  |
| 2200                        | 1975.24      | III | 1800 d    | 3719.45      | II | 5000      | 5091.70      | III | 35                       | 7122.57      | I   |
| 3400                        | 2018.07      | III | 1500      | 3730.84      | II | 130       | 5098.38      | II  | 170                      | 7168.37      | I   |
| 2800                        | 2359.31      | III | 4500      | 3743.47      | II | 910       | 5103.45      | I   | 28                       | 7189.57      | II  |
| 1400                        | 2397.87      | IV  | 1400      | 3758.31      | II | 180       | 5108.91      | II  | 28                       | 7262.66      | I   |
| 2800                        | 2697.39      | III | 8700      | 3768.39      | II | 120       | 5125.56      | II  | 35                       | 7441.85      | I   |
| 2800                        | 2703.28      | III | 1400      | 3770.69      | II | 860       | 5155.84      | I   | 40                       | 7464.36      | I   |
| 2700                        | 2727.89      | III | 2900      | 3783.05      | I  | 190       | 5176.28      | II  | 55                       | 7562.97      | I   |
| 9000                        | 2904.73      | III | 5100      | 3796.37      | II | 410       | 5197.77      | I   | 80                       | 7733.50      | I   |
| 9500                        | 2955.53      | III | 3700      | 3813.97      | II | 280       | 5219.40      | I   | 35                       | 7846.35      | II  |
| 1200                        | 2999.04      | II  | 3300      | 3850.69      | II | 130       | 5233.93      | I   | 35                       | 7856.93      | I   |
| 2100                        | 3010.13      | II  | 5100      | 3850.97      | II | 320       | 5251.18      | I   | 25                       | 7930.25      | II  |
| 1900                        | 3027.60      | II  | 4300      | 3852.45      | II | 120       | 5252.14      | II  | 18                       | 8146.15      | I   |
| 2100                        | 3032.84      | II  | 1600      | 3866.99      | I  | 140       | 5255.80      | I   | 21                       | 8668.63      | I   |
| 1600                        | 3034.05      | II  | 1500      | 3894.70      | II | 280       | 5283.08      | I   | 21 h                     | 8832.06      | II  |
| 2100                        | 3081.99      | II  | 2200      | 3916.51      | II | 280       | 5301.67      | I   | 14 h                     | 8849.14      | I   |
| 3500                        | 3100.50      | II  | 1200      | 3934.79      | I  | 220       | 5302.76      | I   | 18 h                     | 8867.31      | I   |
| 930                         | 3145.00      | II  | 1400      | 3945.54      | I  | 280       | 5307.30      | I   | 5000                     | 14332.88     | III |
| 980                         | 3156.53      | II  | 1200      | 3957.67      | II | 130       | 5321.50      | I   | <b>Gallium Ga Z = 31</b> |              |     |
| 980                         | 3161.37      | II  | 1100      | 4023.14      | I  | 280       | 5321.78      | I   | 14                       | 294.53       | IV  |
| 4000                        | 3176.66      | III | 1100      | 4028.15      | I  | 110       | 5327.32      | I   | 61                       | 295.67       | IV  |
| 1400                        | 3331.38      | II  | 1400      | 4037.33      | II | 170       | 5333.30      | I   | 30                       | 298.44       | V   |
| 1100                        | 3336.18      | II  | 1600      | 4045.01      | I  | 300       | 5343.00      | I   | 30                       | 300.01       | V   |
| 5400                        | 3350.47      | II  | 1300      | 4049.43      | II | 200       | 5348.67      | I   | 30                       | 302.86       | V   |
| 4300                        | 3358.62      | II  | 2200      | 4049.86      | II | 300       | 5350.38      | I   | 41                       | 304.99       | IV  |
| 5400                        | 3362.23      | II  | 2600      | 4053.64      | I  | 240       | 5353.26      | I   | 30                       | 307.03       | V   |
| 1100                        | 3392.53      | II  | 2600      | 4058.22      | I  | 3000      | 5365.96      | III | 30                       | 308.26       | V   |
| 1100 d                      | 3407.56      | II  | 1900      | 4063.39      | II | 150       | 5370.63      | I   | 30                       | 311.79       | V   |
| 6900                        | 3422.47      | II  | 1300      | 4078.44      | II | 4000      | 5553.30      | III | 30                       | 313.68       | V   |
| 1700                        | 3439.21      | II  | 2800      | 4078.70      | I  | 3000      | 5587.88      | III | 30                       | 319.41       | V   |
| 2700                        | 3439.99      | II  | 1500      | 4085.56      | II | 190       | 5617.91      | I   | 40                       | 322.31       | V   |
| 1400                        | 3450.38      | II  | 1100      | 4092.71      | I  | 110       | 5632.25      | I   | 40                       | 322.99       | V   |
| 1100                        | 3451.23      | II  | 2600      | 4098.61      | II | 260       | 5643.24      | I   | 50                       | 322.99       | V   |
| 2700                        | 3463.98      | II  | 2200      | 4130.37      | II | 3000      | 5658.98      | III | 30                       | 323.10       | V   |
| 1700                        | 3467.27      | II  | 1100      | 4132.28      | II | 390       | 5696.22      | I   | 40                       | 324.25       | V   |
| 1700                        | 3468.99      | II  | 2400      | 4175.54      | I  | 120       | 5733.86      | II  | 40                       | 324.95       | V   |
| 1400                        | 3473.22      | II  | 2400      | 4184.25      | II | 240       | 5791.38      | I   | 40                       | 326.14       | V   |
| 2200                        | 3481.28      | II  | 2200      | 4190.78      | I  | 220       | 5851.63      | I   | 30                       | 326.77       | V   |
| 1700                        | 3481.80      | II  | 1300      | 4212.00      | II | 280       | 5856.22      | I   | 30                       | 328.65       | V   |
| 1700                        | 3494.40      | II  | 4800      | 4225.85      | I  | 110       | 5904.56      | I   | 25                       | 423.18       | IV  |
| 1400                        | 3505.51      | II  | 1700      | 4251.73      | II | 170       | 5911.45      | II  | 16                       | 439.92       | IV  |
| 1100                        | 3512.50      | II  | 1600      | 4262.09      | I  | 85        | 5930.29      | I   | 50                       | 620.00       | III |
| 4300                        | 3545.80      | II  | 1100      | 4306.34      | I  | 85        | 5936.84      | I   | 40                       | 622.01       | III |
| 3900                        | 3549.36      | II  | 1800      | 4313.84      | I  | 65        | 5937.71      | I   | 90                       | 806.51       | III |
| 1400                        | 3557.05      | II  | 2600 d    | 4325.57      | II | 110 h     | 5988.02      | I   | 90                       | 817.30       | III |
| 5400                        | 3584.96      | II  | 1900      | 4327.12      | I  | 430       | 6114.07      | I   | 50                       | 828.70       | III |
| 1100                        | 3592.71      | II  | 1000      | 4344.30      | II | 75        | 6305.15      | II  | 20                       | 878.17       | V   |
| 1100                        | 3604.87      | I   | 2200      | 4346.46      | I  | 40        | 6331.35      | I   | 40                       | 973.21       | V   |
| 6100                        | 3646.19      | II  | 1400      | 4401.86      | I  | 40        | 6380.95      | II  | 40                       | 989.75       | V   |
| 3900                        | 3654.62      | II  | 1400      | 4422.41      | I  | 40 h      | 6538.15      | I   | 90                       | 1014.47      | V   |
| 3100                        | 3656.15      | II  | 1100      | 4430.63      | I  | 55        | 6564.78      | I   | 90                       | 1019.71      | V   |
| 1400                        | 3662.26      | II  | 1100      | 4519.66      | I  | 50        | 6634.36      | II  | 120                      | 1050.48      | V   |
| 2700                        | 3664.60      | II  | 910       | 4537.81      | I  | 35        | 6681.23      | II  | 80                       | 1054.56      | V   |
| 2000                        | 3671.20      | II  | 520       | 4614.50      | I  | 85        | 6730.73      | I   | 90                       | 1058.12      | V   |
|                             |              |     |           |              |    |           |              |     | 80                       | 1066.69      | V   |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                  | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|----------------------------|--------------|-----|-----------|--------------|-----|
| 60        | 1069.60      | V   | 85        | 1338.09      | IV  | <i>Germanium Ge Z = 32</i> |              |     | 100       | 1742.195     | I   |
| 80        | 1073.77      | V   | 77        | 1347.03      | IV  | 700                        | 294.51       | V   | 50        | 1746.065     | I   |
| 90        | 1078.83      | V   | 76        | 1351.06      | IV  | 1000                       | 295.64       | V   | 200       | 1750.043     | I   |
| 110       | 1079.60      | V   | 70        | 1353.92      | III | 200                        | 304.98       | V   | 100       | 1758.279     | I   |
| 60        | 1080.99      | V   | 74        | 1364.63      | IV  | 20                         | 621.52       | V   | 100 h     | 1764.185     | I   |
| 80        | 1085.00      | III | 60        | 1395.54      | IV  | 50                         | 724.21       | V   | 100 h     | 1765.284     | I   |
| 250       | 1085.01      | V   | 77        | 1402.55      | IV  | 60                         | 746.88       | V   | 50 h      | 1766.433     | I   |
| 80        | 1087.37      | V   | 70        | 1405.32      | IV  | 60                         | 760.05       | V   | 200       | 1774.176     | I   |
| 90        | 1091.71      | V   | 73        | 1465.87      | IV  | 10                         | 862.234      | II  | 200       | 1785.046     | I   |
| 100       | 1094.36      | V   | 90        | 1495.07      | III | 15                         | 875.493      | II  | 100 h     | 1793.071     | I   |
| 80        | 1095.10      | V   | 50        | 1534.46      | III | 15                         | 905.977      | II  | 75 h      | 1801.432     | I   |
| 160       | 1102.83      | V   | 10        | 1813.98      | II  | 20                         | 920.554      | II  | 200 h     | 1841.328     | I   |
| 140       | 1103.03      | V   | 15        | 1845.30      | II  | 300                        | 971.35       | V   | 200 h     | 1842.410     | I   |
| 60        | 1105.61      | III | 20        | 2091.34      | II  | 300                        | 990.66       | V   | 100 h     | 1844.410     | I   |
| 75        | 1105.62      | V   | 90        | 2417.70      | III | 50                         | 999.101      | II  | 100 h     | 1845.872     | I   |
| 70        | 1106.17      | V   | 90        | 2423.98      | III | 300                        | 1004.38      | V   | 100 h     | 1846.958     | I   |
| 80        | 1118.34      | V   | 15        | 2424.36      | III | 100                        | 1016.638     | II  | 200       | 1853.134     | I   |
| 120       | 1126.40      | V   | 10        | 2632.66      | I   | 900                        | 1045.71      | V   | 500 r     | 1860.086     | I   |
| 130       | 1128.10      | V   | 10        | 2665.05      | I   | 700                        | 1072.66      | V   | 100       | 1865.052     | I   |
| 120       | 1128.53      | V   | 20        | 2700.47      | II  | 100                        | 1075.072     | II  | 300 r     | 1874.256     | I   |
| 100       | 1129.94      | V   | 15        | 2780.15      | II  | 300                        | 1085.51      | II  | 100       | 1895.197     | I   |
| 130       | 1136.07      | V   | 50        | 3521.77      | III | 40                         | 1088.45      | III | 500 r     | 1904.702     | I   |
| 67        | 1137.06      | IV  | 80        | 3581.19      | III | 800                        | 1089.49      | V   | 50 h      | 1908.434     | I   |
| 130       | 1150.23      | V   | 100       | 3589.34      | III | 200                        | 1098.71      | II  | 30        | 1912.409     | I   |
| 90        | 1150.27      | III | 10        | 3731.10      | III | 500                        | 1106.74      | II  | 300 r     | 1917.592     | I   |
| 70        | 1156.10      | IV  | 10        | 3806.60      | III | 1000                       | 1116.94      | V   | 100 h     | 1923.467     | I   |
| 120       | 1156.51      | V   | 10        | 4032.99      | I   | 500                        | 1120.46      | II  | 500 r     | 1929.826     | I   |
| 35        | 1157.74      | V   | 10        | 4172.04      | I   | 700                        | 1163.39      | V   | 10 h      | 1934.048     | I   |
| 70        | 1163.60      | IV  | 15        | 4251.16      | II  | 200                        | 1164.27      | II  | 100 r     | 1937.483     | I   |
| 25        | 1169.40      | V   | 10 h      | 4254.04      | II  | 500                        | 1181.19      | II  | 500       | 1938.008     | II  |
| 75        | 1170.58      | IV  | 10        | 4255.77      | II  | 500                        | 1181.65      | II  | 100 r     | 1938.300     | I   |
| 48        | 1171.71      | IV  | 40        | 4262.00      | II  | 200                        | 1188.73      | II  | 500       | 1938.891     | II  |
| 40        | 1178.95      | V   | 100       | 4380.69      | III | 20                         | 1188.99      | IV  | 30 s      | 1944.116     | I   |
| 68        | 1185.23      | IV  | 150       | 4381.76      | III | 300                        | 1191.26      | II  | 200       | 1944.731     | I   |
| 40        | 1186.06      | IV  | 100       | 4863.00      | III | 700                        | 1222.30      | V   | 200       | 1955.115     | I   |
| 73        | 1190.89      | IV  | 150       | 4993.78      | III | 20                         | 1229.81      | IV  | 500       | 1962.013     | I   |
| 73        | 1193.02      | IV  | 10        | 5808.28      | III | 500                        | 1237.059     | II  | 30 h      | 1963.373     | I   |
| 75        | 1195.02      | IV  | 20        | 5848.25      | III | 500                        | 1261.905     | II  | 30        | 1965.383     | I   |
| 69        | 1201.54      | IV  | 15        | 5993.51      | III | 100                        | 1264.710     | II  | 200       | 1970.880     | I   |
| 72        | 1206.89      | IV  | 10        | 6334.2       | II  | 200                        | 1401.24      | II  | 200       | 1979.274     | II  |
| 80        | 1213.17      | V   | 2000      | 6396.56      | I   | 200                        | 1538.091     | II  | 300 h     | 1987.849     | I   |
| 63        | 1216.15      | IV  | 1000      | 6413.44      | I   | 500                        | 1576.855     | II  | 300       | 1988.267     | I   |
| 50        | 1228.03      | IV  | 10 h      | 7251.4       | I   | 75                         | 1581.070     | II  | 500 r     | 1998.887     | I   |
| 60        | 1236.38      | IV  | 20 h      | 7403.0       | I   | 100                        | 1602.486     | II  | 200       | 2011.29      | I   |
| 60        | 1238.59      | IV  | 30 h      | 7464.0       | I   | 3 r                        | 1615.57      | I   | 1700      | 2019.068     | I   |
| 75        | 1245.53      | IV  | 10 h      | 7620.5       | I   | 2 r                        | 1624.130     | I   | 2400 r    | 2041.712     | I   |
| 83        | 1258.77      | IV  | 50 h      | 7734.77      | I   | 2 r                        | 1630.173     | I   | 1600 r    | 2043.770     | I   |
| 81        | 1264.66      | IV  | 100 h     | 7800.01      | I   | 3 r                        | 1636.31      | I   | 420       | 2054.461     | I   |
| 82        | 1267.15      | IV  | 15 h      | 8002.55      | I   | 4 r                        | 1639.730     | I   | 220 h     | 2057.238     | I   |
| 90        | 1267.16      | III | 20 h      | 8074.25      | I   | 2                          | 1647.531     | I   | 750 r     | 2065.215     | I   |
| 81        | 1279.24      | IV  | 100 h     | 8311.86      | I   | 200                        | 1649.194     | II  | 2600 r    | 2068.656     | I   |
| 15        | 1283.64      | V   | 200 h     | 8386.49      | I   | 2                          | 1651.528     | I   | 420       | 2086.021     | I   |
| 80        | 1285.33      | IV  | 200 h     | 9492.92      | I   | 4 r                        | 1651.955     | I   | 2000 r    | 2094.258     | I   |
| 80        | 1293.46      | III | 200 h     | 9493.12      | I   | 3                          | 1661.345     | I   | 25        | 2104.45      | III |
| 60        | 1295.36      | III | 300 h     | 9589.36      | I   | 4 r                        | 1663.539     | I   | 240       | 2105.824     | I   |
| 82        | 1295.86      | IV  | 100 h     | 10905.95     | I   | 10 h                       | 1665.275     | I   | 95 h      | 2124.744     | I   |
| 83        | 1299.46      | IV  | 400       | 11949.12     | I   | 4                          | 1667.802     | I   | 50 h      | 2186.451     | I   |
| 82        | 1303.53      | IV  | 200       | 12109.78     | I   | 3 r                        | 1670.608     | I   | 340 r     | 2198.714     | I   |
| 80        | 1309.68      | IV  | 60        | 14996.64     | I   | 100 r                      | 1691.090     | I   | 15        | 2220.375     | I   |
| 80        | 1314.82      | IV  | 60        | 22016.81     | I   | 200 r                      | 1716.784     | I   | 18        | 2256.001     | I   |
| 60        | 1323.15      | III | 70        | 22568.71     | I   | 100 h                      | 1739.102     | I   | 18        | 2314.201     | I   |

| Intensity | Wavelength/Å |     | Intensity             | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 24        | 2327.918     | I   | 1000                  | 5893.389     | II  | 60        | 1368.62      | I   | 100       | 1624.34      | I   |
| 15        | 2359.233     | I   | 500                   | 6021.041     | II  | 70        | 1374.82      | I   | 300 d     | 1629.13      | III |
| 20        | 2379.144     | I   | 75                    | 6283.452     | II  | 50        | 1375.76      | I   | 250       | 1638.88      | III |
| 10        | 2389.472     | I   | 100                   | 6336.377     | II  | 180       | 1377.73      | III | 50        | 1639.90      | I   |
| 15        | 2397.885     | I   | 100                   | 6484.181     | II  | 150       | 1378.69      | III | 100       | 1644.17      | III |
| 130       | 2417.367     | I   | 6                     | 6557.488     | I   | 150       | 1379.98      | III | 150       | 1646.67      | I   |
| 30        | 2436.412     | I   | 50                    | 7049.369     | II  | 125       | 1380.53      | III | 250       | 1652.74      | III |
| 30        | 2488.25      | IV  | 30                    | 7145.390     | II  | 200       | 1381.36      | III | 250       | 1664.77      | III |
| 90        | 2497.962     | I   | 5                     | 7353.334     | I   | 80        | 1382.75      | I   | 100       | 1665.76      | I   |
| 500       | 2500.54      | II  | 7                     | 7384.208     | I   | 50        | 1385.33      | I   | 100       | 1668.11      | III |
| 70        | 2533.230     | I   | 10                    | 7833.575     | I   | 300       | 1385.79      | III | 125       | 1673.93      | III |
| 20        | 2542.44      | IV  | 10                    | 8031.039     | I   | 100       | 1389.41      | III | 1000      | 1693.94      | III |
| 3         | 2556.298     | I   | 6                     | 8044.165     | I   | 180       | 1391.46      | III | 150       | 1697.09      | III |
| 28        | 2589.188     | I   | 10                    | 8256.013     | I   | 60        | 1392.27      | I   | 200       | 1698.98      | III |
| 500       | 2592.534     | I   | 10                    | 8482.21      | I   | 180       | 1396.00      | III | 200       | 1699.34      | I   |
| 8         | 2644.184     | I   | 9                     | 8700.60      | I   | 50        | 1402.12      | I   | 200       | 1700.00      | III |
| 1200      | 2651.172     | I   | 5                     | 9068.785     | I   | 100       | 1402.91      | III | 200       | 1702.25      | III |
| 500       | 2651.568     | I   | 5                     | 9095.957     | I   | 70        | 1407.38      | I   | 100       | 1707.53      | III |
| 500       | 2691.341     | I   | 6                     | 9398.868     | I   | 100       | 1408.45      | I   | 250       | 1710.16      | III |
| 850       | 2709.624     | I   | 20                    | 9474.993     | II  | 225       | 1409.50      | III | 200       | 1715.69      | III |
| 400       | 2729.78      | II  | 20                    | 9475.645     | II  | 250       | 1413.80      | III | 100       | 1716.71      | III |
| 40        | 2740.426     | I   | 4                     | 9492.559     | I   | 100       | 1414.27      | III | 300       | 1717.83      | III |
| 650       | 2754.588     | I   | 7                     | 9625.664     | I   | 100       | 1417.09      | III | 500       | 1727.31      | III |
| 70        | 2793.925     | I   | 5                     | 10039.436    | I   | 125       | 1417.39      | III | 100 d     | 1733.17      | III |
| 80        | 2829.008     | I   | 4                     | 10200.952    | I   | 150       | 1427.42      | III | 300       | 1738.48      | III |
| 1000      | 2831.843     | II  | 10                    | 10382.427    | I   | 300       | 1428.93      | III | 150       | 1744.39      | III |
| 1000      | 2845.527     | II  | 10                    | 10404.913    | I   | 80        | 1429.19      | I   | 500       | 1746.10      | III |
| 750       | 3039.067     | I   | 8                     | 10734.068    | I   | 250       | 1430.06      | III | 500       | 1756.92      | III |
| 600       | 3067.021     | I   | 8                     | 10947.416    | I   | 275       | 1433.37      | III | 500       | 1761.95      | III |
| 20        | 3124.816     | I   | 10                    | 11125.130    | I   | 50        | 1435.79      | I   | 300       | 1767.42      | III |
| 35        | 3211.86      | III | 230                   | 11252.83     | I   | 250       | 1435.81      | III | 100       | 1774.42      | III |
| 40        | 3255.05      | III | 600                   | 11714.76     | I   | 300       | 1439.12      | III | 800       | 1775.17      | III |
| 110       | 3269.489     | I   | 1300                  | 12069.20     | I   | 200       | 1441.21      | III | 200       | 1776.40      | III |
| 40        | 3434.03      | III | 1050                  | 12391.58     | I   | 150       | 1446.37      | III | 100       | 1780.57      | III |
| 300       | 3499.21      | II  | 235                   | 13107.61     | I   | 250       | 1448.42      | III | 60        | 1783.22      | II  |
| 60        | 3554.19      | IV  | 470                   | 14822.38     | I   | 250       | 1454.95      | III | 300       | 1786.11      | III |
| 50        | 3676.65      | IV  | 150                   | 16759.79     | I   | 100       | 1464.72      | III | 150       | 1792.65      | III |
| 200       | 4178.96      | III | 135                   | 17214.34     | I   | 150       | 1471.28      | III | 500       | 1793.76      | III |
| 70        | 4226.562     | I   | 70                    | 18811.86     | I   | 100       | 1474.73      | III | 200       | 1801.98      | III |
| 200       | 4260.85      | III | 62                    | 19279.24     | I   | 150       | 1481.10      | III | 400       | 1805.24      | III |
| 150       | 4291.71      | III | 28                    | 20673.64     | I   | 100       | 1481.76      | I   | 100       | 1809.81      | III |
| 10        | 4685.829     | I   | <i>Gold Au Z = 79</i> |              |     | 300       | 1487.15      | III | 400       | 1821.17      | III |
| 1000      | 4741.806     | II  | 100                   | 843.44       | III | 250       | 1487.91      | III | 400       | 1844.89      | III |
| 1000      | 4814.608     | II  | 100                   | 845.14       | III | 200       | 1489.47      | III | 150       | 1848.83      | III |
| 50        | 4824.097     | II  | 200                   | 945.10       | III | 250       | 1500.37      | III | 500       | 1861.80      | III |
| 100       | 5131.752     | II  | 100                   | 1040.63      | III | 200       | 1502.47      | III | 150       | 1871.92      | III |
| 200       | 5178.648     | II  | 80                    | 1044.49      | III | 200       | 1503.74      | III | 100       | 1879.83      | I   |
| 3         | 5194.583     | I   | 80                    | 1046.81      | III | 100       | 1542.00      | III | 150       | 1918.28      | III |
| 6         | 5265.892     | I   | 100 h                 | 1239.96      | III | 100       | 1548.50      | III | 100       | 1932.04      | III |
| 6         | 5513.263     | I   | 100                   | 1278.51      | III | 200       | 1567.54      | III | 100       | 1935.42      | III |
| 8         | 5564.741     | I   | 100                   | 1314.84      | III | 200       | 1574.85      | III | 200       | 1948.79      | III |
| 8         | 5607.010     | I   | 100 h                 | 1328.37      | I   | 200       | 1579.44      | III | 100       | 1958.47      | III |
| 6         | 5616.135     | I   | 200                   | 1336.72      | III | 150       | 1584.10      | III | 400       | 1989.63      | III |
| 7         | 5621.426     | I   | 180                   | 1341.68      | III | 200       | 1587.16      | I   | 150       | 1996.85      | III |
| 6         | 5664.226     | I   | 100                   | 1348.89      | III | 200       | 1589.56      | III | 11000     | 2012.00      | I   |
| 5         | 5664.842     | I   | 150                   | 1350.32      | III | 150       | 1593.41      | III | 2600      | 2021.38      | I   |
| 9         | 5691.954     | I   | 150                   | 1355.61      | III | 70        | 1598.24      | I   | 150       | 2082.09      | II  |
| 6         | 5701.776     | I   | 150                   | 1356.13      | III | 200       | 1600.51      | III | 300       | 2083.09      | III |
| 5         | 5717.877     | I   | 50                    | 1363.98      | I   | 250       | 1617.16      | III | 60        | 2110.68      | II  |
| 6         | 5801.029     | I   | 500                   | 1365.40      | III | 100       | 1617.78      | III | 100       | 2159.08      | III |
| 9         | 5802.093     | I   | 200                   | 1367.17      | III | 500       | 1621.93      | III | 80        | 2167.33      | III |

| Intensity | Wavelength/Å |     | Intensity                | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|--------------------------|--------------|----|-----------|--------------|-----|-----------|--------------|-----|
| 200       | 2172.20      | III | 100                      | 3927.69      | I  | 370       | 1437.27      | V   | 200       | 2537.33      | II  |
| 100       | 2184.11      | III | 400                      | 4040.93      | I  | 500       | 1437.73      | V   | 320       | 2551.40      | II  |
| 500       | 2188.97      | III | 700                      | 4065.07      | I  | 370       | 1445.40      | V   | 400 h     | 2560.74      | III |
| 70        | 2248.56      | II  | 100                      | 4084.10      | I  | 270       | 1457.91      | V   | 250       | 2563.61      | II  |
| 80        | 2263.62      | II  | 100                      | 4241.80      | I  | 100       | 1717.21      | IV  | 300 h     | 2567.46      | III |
| 300       | 2322.27      | III | 200                      | 4315.11      | I  | 270       | 1719.32      | V   | 890       | 2571.67      | II  |
| 180       | 2352.65      | I   | 120 h                    | 4437.27      | I  | 550       | 1729.08      | V   | 320       | 2573.90      | II  |
| 100       | 2382.40      | III | 250                      | 4488.25      | I  | 750       | 1731.83      | V   | 320       | 2576.82      | II  |
| 120       | 2387.75      | I   | 900 h                    | 4607.51      | I  | 750       | 1733.96      | V   | 300       | 2578.14      | II  |
| 150       | 2402.71      | III | 100 h                    | 4620.56      | I  | 440       | 1741.74      | V   | 320       | 2582.54      | II  |
| 150       | 2405.12      | III | 500                      | 4792.58      | I  | 1000      | 1749.11      | V   | 390       | 2606.37      | II  |
| 2600      | 2427.95      | I   | 100                      | 4811.60      | I  | 1000      | 1750.19      | V   | 450       | 2607.03      | II  |
| 60        | 2533.52      | II  | 100                      | 5147.44      | I  | 500       | 1760.89      | V   | 230       | 2613.60      | II  |
| 250       | 2641.48      | I   | 300                      | 5230.26      | I  | 370       | 1765.62      | V   | 450       | 2622.74      | II  |
| 3400      | 2675.95      | I   | 100 h                    | 5261.76      | I  | 270       | 1774.02      | V   | 160       | 2637.00      | I   |
| 1100      | 2748.25      | I   | 100                      | 5655.77      | I  | 6200      | 2012.78      | II  | 1100      | 2638.71      | II  |
| 100       | 2780.82      | I   | 100 h                    | 5721.36      | I  | 8500      | 2028.18      | II  | 1100      | 2641.41      | II  |
| 1000      | 2802.04      | II  | 300                      | 5837.37      | I  | 300       | 2070.94      | III | 160       | 2642.75      | I   |
| 300       | 2819.79      | II  | 100 h                    | 5862.93      | I  | 1200      | 2096.18      | II  | 670       | 2647.29      | II  |
| 100       | 2822.55      | II  | 300 h                    | 5956.96      | I  | 200 h     | 2099.30      | III | 160       | 2657.84      | II  |
| 100 h     | 2825.44      | II  | 600                      | 6278.17      | I  | 200 h     | 2110.31      | III | 210       | 2661.88      | II  |
| 300       | 2837.85      | II  | 100                      | 6562.68      | I  | 200       | 2155.66      | III | 290       | 2683.35      | II  |
| 100       | 2846.92      | II  | 600                      | 7510.73      | I  | 200       | 2183.50      | III | 200       | 2687.22      | III |
| 100       | 2856.74      | II  | 10                       | 8145.06      | I  | 200       | 2195.44      | III | 670       | 2705.61      | I   |
| 300       | 2883.45      | I   | 10                       | 9254.28      | I  | 540       | 2210.82      | II  | 210       | 2712.42      | II  |
| 300       | 2891.96      | I   | <i>Hafnium Hf Z = 72</i> |              |    | 200       | 2234.59      | III | 250       | 2718.59      | I   |
| 100       | 2893.25      | II  | 220                      | 545.41       | V  | 320       | 2254.01      | II  | 710       | 2738.76      | II  |
| 100       | 2907.04      | II  | 180                      | 600.00       | V  | 160       | 2255.15      | II  | 200       | 2743.64      | I   |
| 300       | 2913.52      | II  | 200                      | 618.27       | IV | 250       | 2266.83      | II  | 360       | 2751.81      | II  |
| 300       | 2918.24      | II  | 200                      | 644.54       | IV | 620       | 2277.16      | II  | 500       | 2753.60      | III |
| 100       | 2954.22      | II  | 400                      | 647.39       | IV | 200 h     | 2313.44      | III | 450       | 2761.63      | I   |
| 100 h     | 2990.27      | II  | 600                      | 665.65       | IV | 230       | 2321.14      | II  | 160       | 2766.96      | I   |
| 300       | 2994.80      | II  | 200                      | 673.49       | IV | 580       | 2322.47      | II  | 170       | 2773.02      | I   |
| 320       | 3029.20      | I   | 270                      | 867.25       | V  | 300       | 2323.25      | II  | 980       | 2773.36      | II  |
| 300       | 3065.42      | I   | 180                      | 875.88       | V  | 300       | 2324.89      | II  | 180       | 2774.02      | II  |
| 100       | 3122.50      | II  | 180                      | 885.58       | V  | 200       | 2332.97      | II  | 390       | 2779.37      | I   |
| 1600      | 3122.78      | I   | 180                      | 896.14       | V  | 300       | 2336.47      | III | 230       | 2808.00      | II  |
| 100       | 3194.72      | I   | 180                      | 901.54       | V  | 200       | 2337.33      | II  | 230       | 2813.86      | II  |
| 100       | 3227.99      | III | 180                      | 919.10       | V  | 230       | 2343.32      | II  | 170       | 2814.48      | II  |
| 300       | 3230.63      | I   | 270                      | 921.67       | V  | 320       | 2347.44      | II  | 230       | 2817.68      | I   |
| 300       | 3308.30      | I   | 245                      | 951.62       | V  | 540       | 2351.22      | II  | 200       | 2819.74      | I   |
| 300       | 3309.64      | I   | 180                      | 960.12       | V  | 250       | 2380.30      | II  | 1200      | 2820.22      | II  |
| 100       | 3309.86      | III | 180                      | 964.74       | V  | 250       | 2383.540     | III | 490       | 2822.68      | II  |
| 100       | 3320.12      | I   | 160                      | 971.51       | V  | 170       | 2393.18      | II  | 180       | 2833.28      | I   |
| 100       | 3355.15      | I   | 160                      | 1092.76      | V  | 450       | 2393.36      | II  | 410       | 2845.83      | I   |
| 100 h     | 3391.31      | I   | 160                      | 1201.76      | V  | 670       | 2393.83      | II  | 270       | 2849.21      | II  |
| 100       | 3395.40      | I   | 270                      | 1232.03      | V  | 540       | 2405.42      | II  | 270       | 2850.96      | I   |
| 100       | 3467.21      | I   | 200                      | 1233.59      | V  | 370       | 2410.14      | II  | 180       | 2851.21      | II  |
| 300       | 3557.36      | I   | 160                      | 1237.42      | V  | 320       | 2417.69      | II  | 180       | 2860.56      | I   |
| 300       | 3586.73      | I   | 160                      | 1239.53      | V  | 390       | 2447.25      | II  | 760       | 2861.01      | II  |
| 100       | 3611.57      | I   | 160                      | 1244.46      | V  | 450       | 2460.49      | II  | 760       | 2861.70      | II  |
| 100 h     | 3631.31      | I   | 440                      | 1396.66      | V  | 400       | 2461.74      | III | 2100      | 2866.37      | I   |
| 300       | 3637.90      | I   | 270                      | 1400.09      | V  | 430       | 2464.19      | II  | 210       | 2887.14      | I   |
| 100 h     | 3645.02      | I   | 160                      | 1401.70      | V  | 210       | 2469.18      | II  | 800       | 2889.62      | I   |
| 100       | 3650.74      | I   | 370                      | 1407.17      | V  | 2000      | 2495.16      | III | 1800      | 2898.26      | I   |
| 100       | 3709.62      | I   | 370                      | 1408.38      | V  | 290       | 2496.99      | II  | 1200      | 2904.41      | I   |
| 100       | 3796.01      | I   | 270                      | 1412.28      | V  | 580       | 2512.69      | II  | 890       | 2904.75      | I   |
| 100       | 3874.73      | I   | 270                      | 1413.51      | V  | 580       | 2513.03      | II  | 2000      | 2916.48      | I   |
| 100 h     | 3892.26      | I   | 160                      | 1421.96      | V  | 1000      | 2515.16      | III | 580       | 2918.58      | I   |
| 400       | 3897.86      | I   | 220                      | 1422.53      | V  | 890       | 2516.88      | II  | 320       | 2919.59      | II  |
| 300       | 3909.38      | I   | 370                      | 1433.43      | V  | 340       | 2531.19      | II  | 180       | 2924.62      | I   |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity              | Wavelength/Å |    |
|-----------|--------------|-----|-----------|--------------|----|-----------|--------------|----|------------------------|--------------|----|
| 490       | 2929.63      | II  | 670       | 3312.86      | I  | 650       | 3793.37      | II | 160                    | 5719.18      | I  |
| 450       | 2929.90      | I   | 180       | 3317.99      | II | 850 d     | 3800.38      | I  | 95                     | 6098.67      | I  |
| 710       | 2937.80      | II  | 890       | 3332.73      | I  | 320       | 3811.78      | I  | 95                     | 6185.13      | I  |
| 2000      | 2940.77      | I   | 370       | 3352.06      | II | 1300      | 3820.73      | I  | 85                     | 6789.27      | I  |
| 160       | 2944.71      | I   | 230       | 3358.91      | I  | 280       | 3830.02      | I  | 160                    | 6818.94      | I  |
| 1200      | 2950.68      | I   | 180       | 3360.06      | I  | 800       | 3849.18      | I  | 160                    | 7063.83      | I  |
| 1100      | 2954.20      | I   | 180       | 3378.93      | I  | 600       | 3858.31      | I  | 570                    | 7131.81      | I  |
| 540       | 2958.02      | I   | 230       | 3384.70      | II | 230       | 3860.91      | I  | 650                    | 7237.10      | I  |
| 1400      | 2964.88      | I   | 170       | 3386.21      | I  | 200       | 3872.55      | II | 410                    | 7240.87      | I  |
| 620       | 2966.93      | I   | 800       | 3389.83      | II | 160       | 3877.10      | II | 360                    | 7624.40      | I  |
| 710       | 2968.81      | II  | 230       | 3392.81      | I  | 380       | 3880.82      | II | 110                    | 7740.17      | I  |
| 890       | 2975.88      | II  | 230       | 3394.59      | II | 200       | 3882.52      | I  | 310                    | 7845.35      | I  |
| 1100      | 2980.81      | I   | 230       | 3397.26      | I  | 200       | 3889.23      | I  | 130                    | 7920.71      | I  |
| 210       | 2982.72      | I   | 230       | 3397.60      | I  | 200       | 3889.33      | I  | 250                    | 7994.73      | I  |
| 170       | 3000.10      | II  | 2300      | 3399.80      | II | 620       | 3899.94      | I  | 130                    | 8204.58      | I  |
| 800       | 3005.56      | I   | 170       | 3400.21      | I  | 620       | 3918.09      | II | 150                    | 8546.48      | I  |
| 1100      | 3012.90      | II  | 180       | 3402.51      | I  | 200       | 3923.90      | II | 160                    | 8640.06      | I  |
| 540       | 3016.78      | I   | 230       | 3410.17      | II | 320       | 3931.38      | I  | 40                     | 8711.24      | I  |
| 1100      | 3016.94      | II  | 230       | 3417.34      | I  | 410       | 3951.83      | I  | 65                     | 9004.73      | I  |
| 980       | 3018.31      | I   | 410       | 3419.18      | I  | 160       | 3968.01      | I  | <i>Helium He Z = 2</i> |              |    |
| 1200      | 3020.53      | I   | 200       | 3428.37      | II | 200       | 3973.48      | I  | 15                     | 231.454      | II |
| 410       | 3031.16      | II  | 250       | 3438.24      | II | 180       | 4032.27      | I  | 20                     | 232.584      | II |
| 710       | 3050.76      | I   | 710       | 3472.40      | I  | 230       | 4062.84      | I  | 30                     | 234.347      | II |
| 1100      | 3057.02      | I   | 200       | 3478.99      | II | 180       | 4083.35      | I  | 50                     | 237.331      | II |
| 850       | 3067.41      | I   | 480       | 3479.28      | II | 540       | 4093.16      | II | 100                    | 243.027      | II |
| 2100      | 3072.88      | I   | 250       | 3495.75      | II | 1100      | 4174.34      | I  | 300                    | 256.317      | II |
| 170       | 3074.10      | I   | 250       | 3497.16      | I  | 160       | 4206.58      | II | 1000                   | 303.780      | II |
| 250       | 3074.79      | I   | 980       | 3497.49      | I  | 190       | 4209.70      | I  | 500                    | 303.786      | II |
| 430       | 3080.84      | I   | 1200      | 3505.23      | II | 170       | 4228.08      | I  | 10                     | 320.293      | I  |
| 200       | 3096.76      | I   | 980       | 3523.02      | I  | 170       | 4232.44      | II | 2                      | 505.500      | I  |
| 340       | 3101.40      | II  | 980       | 3535.54      | II | 170       | 4260.98      | I  | 3                      | 505.684      | I  |
| 710       | 3109.12      | II  | 760       | 3536.62      | I  | 200       | 4263.39      | I  | 4                      | 505.912      | I  |
| 710       | 3131.81      | I   | 180       | 3548.81      | I  | 170       | 4272.85      | II | 5                      | 506.200      | I  |
| 850       | 3134.72      | II  | 540       | 3552.70      | II | 320       | 4294.79      | I  | 7                      | 506.570      | I  |
| 170       | 3139.65      | II  | 1300      | 3561.66      | II | 160       | 4330.27      | I  | 10                     | 507.058      | I  |
| 220       | 3145.32      | II  | 270       | 3567.36      | I  | 180       | 4336.66      | II | 15                     | 507.718      | I  |
| 220       | 3148.41      | I   | 1100      | 3569.04      | II | 250       | 4356.33      | I  | 20                     | 508.643      | I  |
| 450       | 3156.63      | I   | 210       | 3597.42      | II | 180       | 4370.97      | II | 25                     | 509.998      | I  |
| 270       | 3159.82      | I   | 540       | 3599.87      | I  | 160       | 4417.91      | I  | 35                     | 512.098      | I  |
| 710       | 3162.61      | II  | 800       | 3616.89      | I  | 200       | 4438.04      | I  | 50                     | 515.616      | I  |
| 450       | 3168.39      | I   | 320       | 3630.87      | II | 250       | 4565.94      | I  | 100                    | 522.213      | I  |
| 890       | 3172.94      | I   | 800       | 3644.36      | II | 500 d     | 4598.80      | I  | 400                    | 537.030      | I  |
| 450       | 3176.86      | II  | 320       | 3649.10      | I  | 230       | 4620.86      | I  | 1000                   | 584.334      | I  |
| 220       | 3181.01      | I   | 200       | 3651.84      | I  | 210       | 4655.19      | I  | 50                     | 591.412      | I  |
| 360       | 3193.53      | II  | 220       | 3665.35      | II | 120       | 4699.01      | I  | 5                      | 958.70       | II |
| 670       | 3194.19      | II  | 200       | 3672.27      | I  | 160       | 4782.74      | I  | 6                      | 972.11       | II |
| 200       | 3196.93      | I   | 480       | 3675.74      | I  | 310       | 4800.50      | I  | 8                      | 992.36       | II |
| 310       | 3206.11      | I   | 2200      | 3682.24      | I  | 130       | 4859.24      | I  | 15                     | 1025.27      | II |
| 180       | 3210.98      | I   | 280       | 3696.51      | I  | 120       | 4975.25      | I  | 30                     | 1084.94      | II |
| 180       | 3217.30      | II  | 240       | 3699.72      | II | 95        | 5018.20      | I  | 35                     | 1215.09      | II |
| 180       | 3220.61      | II  | 340       | 3701.15      | II | 95        | 5047.45      | I  | 50                     | 1215.17      | II |
| 360       | 3247.66      | I   | 1000      | 3717.80      | I  | 75        | 5170.18      | I  | 120                    | 1640.34      | II |
| 220       | 3249.53      | I   | 650       | 3719.28      | II | 230       | 5181.86      | I  | 180                    | 1640.47      | II |
| 890       | 3253.70      | II  | 160       | 3729.10      | I  | 110       | 5243.99      | I  | 7                      | 2385.40      | II |
| 270       | 3255.28      | II  | 460       | 3733.79      | I  | 120       | 5294.87      | I  | 9                      | 2511.20      | II |
| 180       | 3273.66      | II  | 160       | 3737.88      | II | 110       | 5354.73      | I  | 50                     | 2577.6       | I  |
| 200 h     | 3279.67      | III | 400       | 3746.80      | I  | 110       | 5373.86      | I  | 1                      | 2723.19      | I  |
| 270       | 3279.98      | II  | 170       | 3766.92      | II | 75        | 5452.92      | I  | 12                     | 2733.30      | II |
| 160       | 3291.05      | I   | 200       | 3768.25      | I  | 230       | 5550.60      | I  | 2                      | 2763.80      | I  |
| 210       | 3306.12      | I   | 1400      | 3777.64      | I  | 230       | 5552.12      | I  | 10                     | 2818.2       | I  |
| 340       | 3310.27      | I   | 1400      | 3785.46      | I  | 95        | 5613.27      | I  | 4                      | 2829.08      | I  |

| Intensity | Wavelength/Å |    | Intensity                | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|----|--------------------------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 10        | 2945.11      | I  | 2000                     | 10830.34     | I  | 1600      | 3461.97      | II | 1300      | 4125.65      | I  |
| 40        | 3013.7       | I  | 9                        | 10913.05     | I  | 810 c     | 3473.91      | II | 4300      | 4127.16      | I  |
| 20        | 3187.74      | I  | 3                        | 10917.10     | I  | 5400 c    | 3474.26      | II | 1500      | 4136.22      | I  |
| 3         | 3202.96      | II | 4                        | 11626.4      | II | 6300      | 3484.84      | II | 980 cw    | 4152.61      | II |
| 15        | 3203.10      | II | 30                       | 11969.12     | I  | 2500 c    | 3494.76      | II | 8100      | 4163.03      | I  |
| 1         | 3354.55      | I  | 20                       | 12527.52     | I  | 810 c     | 3498.88      | II | 2500      | 4173.23      | I  |
| 2         | 3447.59      | I  | 50                       | 12784.99     | I  | 810       | 3510.73      | I  | 540       | 4194.35      | I  |
| 1         | 3587.27      | I  | 20                       | 12790.57     | I  | 4100 c    | 3515.59      | II | 2000      | 4227.04      | I  |
| 3         | 3613.64      | I  | 7                        | 12845.96     | I  | 410 c     | 3519.94      | II | 1300 cw   | 4254.43      | I  |
| 2         | 3634.23      | I  | 10                       | 12968.45     | I  | 630       | 3540.76      | II | 490       | 4264.05      | I  |
| 3         | 3705.00      | I  | 2                        | 12984.89     | I  | 1600      | 3546.05      | II | 1300      | 4350.73      | I  |
| 1         | 3732.86      | I  | 12                       | 15083.64     | I  | 1100 c    | 3556.78      | II | 300       | 4477.64      | II |
| 10        | 3819.607     | I  | 200                      | 17002.47     | I  | 410       | 3560.15      | II | 290       | 4629.10      | II |
| 1         | 3819.76      | I  | 1                        | 18555.55     | I  | 410 c     | 3573.24      | II | 80        | 4701.69      | II |
| 500       | 3888.65      | I  | 6                        | 18636.8      | II | 630 c     | 3574.80      | II | 130       | 4709.84      | II |
| 20        | 3964.729     | I  | 500                      | 18685.34     | I  | 810       | 3579.12      | I  | 130 c     | 4717.52      | I  |
| 1         | 4009.27      | I  | 200                      | 18697.23     | I  | 410       | 3580.75      | II | 290       | 4742.04      | II |
| 50        | 4026.191     | I  | 100                      | 19089.38     | I  | 410       | 3581.83      | II | 100 c     | 4757.01      | I  |
| 5         | 4026.36      | I  | 20                       | 19543.08     | I  | 630 c     | 3592.23      | II | 65        | 4782.92      | I  |
| 12        | 4120.82      | I  | 1000                     | 20581.30     | I  | 1100 cw   | 3598.77      | II | 290       | 4939.01      | I  |
| 2         | 4120.99      | I  | 80                       | 21120.07     | I  | 540 c     | 3600.95      | II | 250 c     | 4967.21      | II |
| 3         | 4143.76      | I  | 10                       | 21121.43     | I  | 410       | 3618.43      | I  | 220       | 4979.97      | I  |
| 10        | 4387.929     | I  | 20                       | 21132.03     | I  | 430 c     | 3626.69      | II | 90        | 4995.05      | I  |
| 3         | 4437.55      | I  | 3                        | 30908.5      | II | 490       | 3627.25      | II | 130       | 5042.37      | I  |
| 200       | 4471.479     | I  | 4                        | 40478.90     | I  | 430 c     | 3631.76      | II | 80        | 5093.07      | I  |
| 25        | 4471.68      | I  | <i>Holmium Ho Z = 67</i> |              |    | 430 c     | 3638.30      | II | 140       | 5127.81      | I  |
| 6         | 4685.4       | II | 170                      | 2502.91      | II | 1600 c    | 3662.29      | I  | 130       | 5142.59      | II |
| 30        | 4685.7       | II | 170                      | 2533.80      | I  | 1400      | 3667.97      | I  | 110       | 5143.22      | II |
| 30        | 4713.146     | I  | 190                      | 2605.86      | II | 720       | 3679.19      | I  | 160       | 5149.59      | II |
| 4         | 4713.38      | I  | 270                      | 2750.35      | II | 670       | 3679.70      | I  | 90 c      | 5167.88      | I  |
| 20        | 4921.931     | I  | 270                      | 2769.89      | II | 720       | 3682.65      | I  | 130 c     | 5182.11      | I  |
| 100       | 5015.678     | I  | 300                      | 2824.20      | II | 580       | 3690.65      | I  | 90        | 5190.11      | II |
| 10        | 5047.74      | I  | 270 c                    | 2831.69      | II | 410       | 3700.04      | I  | 65        | 5251.82      | I  |
| 5         | 5411.52      | II | 270                      | 2849.10      | II | 490 c     | 3702.35      | II | 90        | 5301.25      | I  |
| 500       | 5875.62      | I  | 360                      | 2880.26      | II | 430       | 3712.88      | I  | 80        | 5330.11      | I  |
| 100       | 5875.97      | I  | 460                      | 2880.98      | II | 450       | 3720.72      | I  | 90        | 5359.99      | I  |
| 8         | 6560.10      | II | 570 c                    | 2909.41      | II | 1100      | 3731.40      | I  | 100       | 5407.08      | I  |
| 100       | 6678.15      | I  | 410 c                    | 2979.63      | II | 810       | 3736.35      | I  | 70        | 5566.52      | I  |
| 3         | 6867.48      | I  | 410                      | 2987.64      | II | 3200 cw   | 3748.17      | II | 65        | 5627.60      | I  |
| 200       | 7065.19      | I  | 480 c                    | 3049.38      | II | 8900 c    | 3796.75      | II | 140       | 5659.58      | I  |
| 30        | 7065.71      | I  | 410 c                    | 3054.00      | II | 8900 c    | 3810.73      | II | 140 c     | 5691.47      | I  |
| 50        | 7281.35      | I  | 500 c                    | 3057.45      | II | 410 c     | 3835.35      | II | 140 c     | 5696.57      | I  |
| 1         | 7816.15      | I  | 500 c                    | 3082.34      | II | 1300 cw   | 3837.51      | II | 140 c     | 5860.28      | I  |
| 2         | 8361.69      | I  | 910                      | 3084.36      | II | 410 c     | 3842.05      | II | 70 c      | 5882.99      | I  |
| 2         | 9063.27      | I  | 430 c                    | 3086.54      | II | 1100      | 3843.86      | II | 70        | 5921.76      | I  |
| 2         | 9210.34      | I  | 760                      | 3118.50      | II | 490 c     | 3846.73      | II | 70 cw     | 5948.03      | I  |
| 10        | 9463.61      | I  | 580 c                    | 3166.62      | II | 1800 c    | 3854.07      | II | 70        | 5972.76      | I  |
| 4         | 9516.60      | I  | 810                      | 3173.78      | II | 2700 c    | 3861.68      | II | 90        | 5973.52      | I  |
| 3         | 9526.17      | I  | 810 c                    | 3181.50      | II | 3000 c    | 3888.96      | II | 230 c     | 5982.90      | I  |
| 1         | 9529.27      | I  | 980 c                    | 3281.97      | II | 13000 c   | 3891.02      | II | 120       | 6081.79      | I  |
| 1         | 9603.42      | I  | 630 c                    | 3337.23      | II | 1300 cw   | 3905.68      | II | 70        | 6208.65      | I  |
| 3         | 9702.60      | I  | 980 c                    | 3343.58      | II | 580       | 3955.73      | I  | 70 c      | 6305.36      | I  |
| 6         | 10027.73     | I  | 8100 c                   | 3398.98      | II | 490       | 3959.68      | I  | 70        | 6550.97      | I  |
| 2         | 10031.16     | I  | 810 c                    | 3410.26      | II | 2700      | 4040.81      | I  | 260       | 6604.94      | I  |
| 15        | 10123.6      | II | 1400 c                   | 3414.90      | II | 5400 c    | 4045.44      | II | 120       | 6628.99      | I  |
| 1         | 10138.50     | I  | 5400                     | 3416.46      | II | 8100      | 4053.93      | I  | 55 cw     | 6694.32      | I  |
| 10        | 10311.23     | I  | 1200                     | 3421.63      | II | 1700      | 4065.09      | II | 55 c      | 6785.43      | I  |
| 2         | 10311.54     | I  | 2000 c                   | 3425.34      | II | 720       | 4068.05      | I  | 40 cw     | 6939.49      | I  |
| 3         | 10667.65     | I  | 2000 c                   | 3428.13      | II | 8900      | 4103.84      | I  | 45 cw     | 6950.39      | I  |
| 300       | 10829.09     | I  | 3200                     | 3453.14      | II | 2900      | 4108.62      | I  | 140       | 7555.09      | I  |
| 1000      | 10830.25     | I  | 16000 c                  | 3456.00      | II | 1500      | 4120.20      | I  | 40 c      | 7628.42      | I  |

| Intensity               | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 50 c                    | 7693.15      | I   | 82        | 1096.81      | IV  | 80        | 2865.68      | II  | 380 c     | 4638.16      | II  |
| 60 cw                   | 7815.48      | I   | 84        | 1097.18      | IV  | 120 d     | 2890.18      | II  | 220 c     | 4644.58      | II  |
| 60                      | 7894.64      | I   | 85        | 1116.10      | IV  | 1100      | 2932.63      | I   | 360 c     | 4655.62      | II  |
| 50                      | 8512.94      | I   | 80        | 1124.06      | IV  | 100       | 2941.05      | II  | 320 w     | 4656.74      | II  |
| 40                      | 8670.19      | I   | 90        | 1131.46      | IV  | 100       | 2982.80      | III | 190 c     | 4681.11      | II  |
| 90                      | 8915.98      | II  | 85        | 1144.43      | IV  | 110 c     | 2999.40      | II  | 450 w     | 4684.8       | II  |
| <i>Hydrogen H Z = 1</i> |              |     |           |              |     |           |              |     |           |              |     |
| 15                      | 926.226      | I   | 80        | 1145.41      | IV  | 100       | 3008.08      | III | 90 d      | 4907.06      | II  |
| 20                      | 930.748      | I   | 89        | 1146.62      | IV  | 8000      | 3039.36      | I   | 150 c     | 4973.77      | II  |
| 30                      | 937.803      | I   | 83        | 1154.11      | IV  | 110 d     | 3099.80      | II  | 80 h      | 5109.36      | II  |
| 50                      | 949.743      | I   | 84        | 1154.60      | IV  | 180 c     | 3101.8       | II  | 100 w     | 5115.14      | II  |
| 100                     | 972.537      | I   | 90        | 1157.71      | IV  | 130 c     | 3138.60      | II  | 140 c     | 5117.40      | II  |
| 300                     | 1025.722     | I   | 90        | 1157.82      | IV  | 80 c      | 3142.75      | II  | 270 c     | 5120.80      | II  |
| 1000                    | 1215.668     | I   | 85        | 1159.78      | IV  | 130 d     | 3146.70      | II  | 200 w     | 5121.75      | II  |
| 500                     | 1215.674     | I   | 88        | 1176.50      | IV  | 150       | 3155.77      | II  | 80 d      | 5129.85      | II  |
| 5                       | 3835.384     | I   | 85        | 1191.58      | IV  | 100 c     | 3158.40      | II  | 240 c     | 5175.42      | II  |
| 6                       | 3889.049     | I   | 83        | 1204.87      | IV  | 90 c      | 3176.30      | II  | 140 c     | 5184.44      | II  |
| 8                       | 3970.072     | I   | 90        | 1206.55      | IV  | 90 d      | 3198.11      | II  | 200       | 5248.77      | III |
| 15                      | 4101.74      | I   | 88        | 1221.50      | IV  | 13000     | 3256.09      | I   | 150 c     | 5309.45      | II  |
| 30                      | 4340.47      | I   | 85        | 1221.90      | IV  | 3000      | 3258.56      | I   | 80        | 5411.41      | II  |
| 80                      | 4861.33      | I   | 85        | 1233.58      | IV  | 90 c      | 3338.50      | II  | 140 c     | 5418.45      | II  |
| 120                     | 6562.72      | I   | 87        | 1235.84      | IV  | 100 c     | 3404.28      | II  | 220 w     | 5436.70      | II  |
| 180                     | 6562.852     | I   | 90        | 1373.20      | IV  | 110 d     | 3438.40      | II  | 130 c     | 5497.50      | II  |
| 5                       | 9545.97      | I   | 88        | 1398.77      | IV  | 180 c     | 3693.91      | II  | 140 c     | 5507.08      | II  |
| 7                       | 10049.4      | I   | 81        | 1412.09      | IV  | 95 c      | 3708.13      | II  | 320 c     | 5513.00      | II  |
| 12                      | 10938.1      | I   | 100       | 1625.42      | III | 380 w     | 3716.14      | II  | 250 w     | 5523.28      | II  |
| 20                      | 12818.1      | I   | 100       | 1748.83      | III | 120 c     | 3718.30      | II  | 130 c     | 5536.50      | II  |
| 40                      | 18751.0      | I   | 30        | 1842.41      | III | 160 c     | 3718.72      | II  | 190 w     | 5555.45      | II  |
| 5                       | 21655.3      | I   | 40        | 1850.30      | III | 160 c     | 3723.40      | II  | 240 c     | 5576.90      | II  |
| 8                       | 26251.5      | I   | 30        | 2154.08      | III | 170 w     | 3795.21      | II  | 200 w     | 5636.70      | II  |
| 15                      | 40511.6      | I   | 50        | 2205.28      | II  | 230 c     | 3799.21      | II  | 100       | 5645.15      | III |
| 4                       | 46525.1      | I   | 40        | 2281.64      | II  | 250 c     | 3834.65      | II  | 160 c     | 5708.50      | II  |
| 6                       | 74578.       | I   | 100 c     | 2306.05      | II  | 200 c     | 3842.18      | II  | 100 c     | 5721.80      | II  |
| <i>Indium In Z = 49</i> |              |     |           |              |     |           |              |     |           |              |     |
| 17                      | 378.61       | V   | 90 d      | 2313.21      | II  | 100       | 3852.82      | III | 100       | 5819.50      | III |
| 17                      | 386.21       | V   | 70 d      | 2327.95      | II  | 100       | 3889.78      | II  | 210 c     | 5853.15      | II  |
| 14                      | 388.91       | V   | 80 h      | 2334.57      | II  | 100 c     | 3902.07      | II  | 490 w     | 5903.4       | II  |
| 25                      | 393.89       | V   | 110 d     | 2382.63      | II  | 250 w     | 3962.35      | II  | 260 w     | 5915.4       | II  |
| 25                      | 400.57       | V   | 70 h      | 2427.20      | II  | 120 c     | 4004.66      | II  | 120 c     | 5918.78      | II  |
| 25                      | 402.39       | V   | 100       | 2447.90      | II  | 140 d     | 4013.92      | II  | 130 c     | 6062.9       | II  |
| 622                     | 472.71       | IV  | 110 d     | 2488.62      | II  | 100       | 4023.77      | III | 250 c     | 6095.95      | II  |
| 689                     | 479.39       | IV  | 90        | 2488.95      | II  | 150       | 4032.32      | III | 210 c     | 6108.66      | II  |
| 709                     | 498.62       | IV  | 80        | 2498.59      | II  | 410 w     | 4056.94      | II  | 180 w     | 6115.9       | II  |
| 10                      | 882.24       | III | 100       | 2499.60      | II  | 100       | 4071.57      | III | 230 w     | 6128.7       | II  |
| 10                      | 890.84       | III | 90 d      | 2500.99      | II  | 100       | 4072.93      | III | 240 w     | 6129.4       | II  |
| 10                      | 915.87       | III | 110 d     | 2512.31      | II  | 17000     | 4101.76      | I   | 320 w     | 6132.1       | II  |
| 85                      | 954.67       | IV  | 100       | 2521.37      | I   | 140 c     | 4205.14      | II  | 150 c     | 6140.0       | II  |
| 87                      | 973.50       | IV  | 100       | 2527.41      | III | 100 d     | 4213.04      | II  | 90        | 6143.23      | II  |
| 86                      | 991.60       | IV  | 160 d     | 2554.44      | II  | 110 d     | 4219.66      | II  | 140 c     | 6148.10      | II  |
| 89                      | 1024.68      | IV  | 1100      | 2560.15      | I   | 100       | 4252.68      | III | 190 w     | 6149.5       | II  |
| 85                      | 1024.79      | IV  | 200       | 2601.76      | I   | 150 d     | 4372.87      | II  | 80        | 6161.15      | II  |
| 88                      | 1031.45      | IV  | 90 d      | 2654.70      | II  | 150 c     | 4500.78      | II  | 180 w     | 6162.45      | II  |
| 82                      | 1031.98      | IV  | 100 d     | 2662.63      | II  | 18000     | 4511.31      | I   | 200       | 6197.72      | III |
| 80                      | 1054.43      | IV  | 140 d     | 2668.65      | II  | 110 c     | 4549.01      | II  | 100 c     | 6224.28      | II  |
| 84                      | 1063.03      | IV  | 140 d     | 2674.56      | II  | 140 c     | 4570.85      | II  | 280 w     | 6228.3       | II  |
| 83                      | 1068.25      | IV  | 80        | 2683.12      | II  | 180 w     | 4578.02      | II  | 140 w     | 6231.1       | II  |
| 82                      | 1069.82      | IV  | 1600      | 2710.26      | I   | 180 w     | 4578.40      | II  | 270 w     | 6304.8       | II  |
| 86                      | 1077.64      | IV  | 300       | 2713.94      | I   | 140 c     | 4616.08      | II  | 290 w     | 6362.3       | II  |
| 90                      | 1082.10      | IV  | 80        | 2726.15      | III | 170 c     | 4617.17      | II  | 300 w     | 6469.0       | II  |
| 83                      | 1086.33      | IV  | 130 d     | 2749.75      | II  | 250 c     | 4620.14      | II  | 210 c     | 6541.20      | II  |
|                         |              |     | 700       | 2753.88      | I   | 150 w     | 4620.70      | II  | 190 c     | 6751.88      | II  |
|                         |              |     | 90 d      | 2818.97      | II  | 170 c     | 4627.30      | II  | 180 c     | 6765.9       | II  |
|                         |              |     | 180 c     | 2836.92      | I   | 140 c     | 4637.04      | II  | 100 c     | 6783.72      | II  |



| Intensity              | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |   |
|------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|-----------|--------------|---|
| 320 w                  | 6891.5       | II  | 600       | 1267.60      | I   | 10000     | 5119.29      | I  | 800 c     | 8169.38      | I |
| 380 w                  | 7182.9       | II  | 1500      | 1275.26      | I   | 3000 c    | 5161.20      | II | 500 d     | 8222.57      | I |
| 180 c                  | 7255.0       | II  | 3000      | 1289.40      | I   | 1000      | 5234.57      | I  | 4000      | 8240.05      | I |
| 210 c                  | 7276.5       | II  | 10000     | 1300.34      | I   | 3000 c    | 5245.71      | II | 10000 c   | 8393.30      | I |
| 180 c                  | 7303.4       | II  | 3000      | 1302.98      | I   | 10000     | 5338.22      | II | 1000      | 8486.11      | I |
| 320 c                  | 7350.6       | II  | 3000      | 1313.95      | I   | 5000 c    | 5345.15      | II | 1500 c    | 8664.95      | I |
| 100 c                  | 7632.7       | II  | 3000      | 1317.54      | I   | 600 c     | 5427.06      | I  | 500 c     | 8700.80      | I |
| 100 c                  | 7682.9       | II  | 2000      | 1330.19      | I   | 3000      | 5435.83      | II | 250 d     | 8748.22      | I |
| 210 c                  | 7740.7       | II  | 20000     | 1336.52      | II  | 2000 c    | 5464.62      | II | 1000      | 8853.24      | I |
| 100 c                  | 7776.96      | II  | 5000      | 1355.10      | I   | 10000     | 5625.69      | II | 2000      | 8853.80      | I |
| 180 c                  | 7789.0       | II  | 3000      | 1357.97      | I   | 2000 c    | 5690.91      | II | 3000      | 8857.50      | I |
| 90 c                   | 7840.9       | II  | 5000      | 1360.97      | I   | 4000 c    | 5710.53      | II | 1000 d    | 8898.50      | I |
| 240 c                  | 8227.0       | II  | 3000      | 1361.11      | I   | 1000 d    | 5764.33      | I  | 400       | 8964.69      | I |
| 100 w                  | 8813.5       | II  | 2500      | 1367.71      | I   | 2000      | 5894.03      | I  | 400       | 8993.13      | I |
| 80 c                   | 8832.6       | II  | 2500      | 1368.22      | I   | 5000      | 5950.25      | II | 5000      | 9022.40      | I |
| 120 c                  | 9197.7       | II  | 4000      | 1383.23      | I   | 300       | 5984.86      | I  | 15000     | 9058.33      | I |
| 120 c                  | 9202.0       | II  | 3000      | 1390.75      | I   | 2000 d    | 6024.08      | I  | 1000      | 9098.86      | I |
| 220 w                  | 9213.0       | II  | 2000      | 1392.90      | I   | 2000 c    | 6074.98      | II | 12000     | 9113.91      | I |
| 160 d                  | 9241.1       | II  | 2000      | 1400.01      | I   | 1000      | 6082.43      | I  | 600       | 9128.03      | I |
| 100                    | 9977.86      | I   | 8000      | 1425.49      | I   | 2000 c    | 6127.49      | II | 600       | 9227.74      | I |
| 200                    | 10257.03     | I   | 5000      | 1446.26      | I   | 800       | 6191.88      | I  | 1000      | 9335.05      | I |
| 100 h                  | 10744.31     | I   | 5000      | 1453.18      | I   | 500       | 6213.10      | I  | 4000      | 9426.71      | I |
| 20                     | 11334.72     | I   | 5000      | 1457.39      | I   | 800       | 6244.48      | I  | 3000      | 9427.15      | I |
| 20                     | 11731.48     | I   | 5000      | 1457.47      | I   | 1000      | 6293.98      | I  | 2000      | 9598.22      | I |
| 10                     | 12912.59     | I   | 10000     | 1457.98      | I   | 500       | 6313.13      | I  | 2000      | 9649.61      | I |
| 9                      | 13429.96     | I   | 2500      | 1458.79      | I   | 800       | 6330.37      | I  | 3000 d    | 9653.06      | I |
| 7                      | 14719.08     | I   | 4000      | 1459.15      | I   | 400       | 6333.50      | I  | 5000      | 9731.73      | I |
| 6                      | 22291.06     | I   | 2500      | 1465.83      | I   | 2000      | 6337.85      | I  | 500       | 10003.05     | I |
| 7                      | 23879.13     | I   | 1000      | 1485.92      | I   | 1000      | 6339.44      | I  | 750       | 10131.16     | I |
| <b>Iodine I Z = 53</b> |              |     | 5000      | 1492.89      | I   | 500       | 6359.16      | I  | 1000      | 10238.82     | I |
| 30                     | 363.78       | V   | 5000      | 1507.04      | I   | 1000      | 6566.49      | I  | 400       | 10375.20     | I |
| 36                     | 380.74       | V   | 5000      | 1514.68      | I   | 2000      | 6583.75      | I  | 400       | 10391.74     | I |
| 45                     | 565.53       | V   | 15000     | 1518.05      | I   | 1000      | 6585.27      | I  | 5000      | 10466.54     | I |
| 50                     | 607.57       | V   | 2500      | 1526.45      | I   | 5000      | 6619.66      | I  | 400       | 11236.56     | I |
| 6                      | 612.46       | IV  | 5000      | 1593.58      | I   | 500       | 6661.11      | I  | 350       | 11558.46     | I |
| 6                      | 666.81       | III | 5000      | 1617.60      | I   | 500 c     | 6697.29      | I  | 320       | 11778.34     | I |
| 8                      | 705.11       | III | 2500      | 1640.78      | I   | 400       | 6732.03      | I  | 450       | 11996.86     | I |
| 7                      | 784.64       | III | 15000     | 1702.07      | I   | 4000      | 6812.57      | II | 300       | 12033.69     | I |
| 7                      | 784.80       | III | 12000     | 1782.76      | I   | 500       | 6989.78      | I  | 150       | 12304.58     | I |
| 8                      | 795.52       | III | 5000      | 1799.09      | I   | 500       | 7120.05      | I  | 60        | 13149.16     | I |
| 7                      | 919.28       | IV  | 75000     | 1830.38      | I   | 1200      | 7122.05      | I  | 140       | 13958.27     | I |
| 10000                  | 1034.66      | II  | 15000     | 1844.45      | I   | 2000      | 7142.06      | I  | 200       | 14287.02     | I |
| 8                      | 1094.20      | III | 2000      | 2061.63      | I   | 1000      | 7164.79      | I  | 100       | 14460.00     | I |
| 10000                  | 1139.80      | II  | 7         | 2361.13      | IV  | 400 d     | 7191.66      | I  | 225       | 15032.57     | I |
| 10000                  | 1160.56      | II  | 6         | 2372.45      | IV  | 700       | 7227.30      | I  | 105       | 15528.65     | I |
| 20000                  | 1166.48      | II  | 7         | 2376.46      | IV  | 1000      | 7236.78      | I  | 150       | 16037.33     | I |
| 10000                  | 1178.65      | II  | 8         | 2387.11      | IV  | 500       | 7237.84      | I  | 15        | 18275.71     | I |
| 15000                  | 1187.34      | II  | 9         | 2426.10      | IV  | 5000      | 7402.06      | I  | 20        | 18348.52     | I |
| 10000                  | 1190.85      | II  | 8         | 2475.35      | IV  | 1000      | 7410.50      | I  | 15        | 18982.41     | I |
| 200                    | 1218.41      | I   | 8         | 2519.74      | IV  | 500       | 7416.48      | I  | 35        | 19070.17     | I |
| 20000                  | 1220.89      | II  | 8         | 2545.67      | IV  | 5000      | 7468.99      | I  | 110       | 19105.12     | I |
| 600                    | 1224.05      | I   | 7         | 2545.71      | III | 500 c     | 7490.52      | I  | 50        | 19370.02     | I |
| 600                    | 1224.08      | I   | 8         | 2652.23      | IV  | 2000      | 7554.18      | I  | 10        | 20648.69     | I |
| 500                    | 1228.89      | I   | 5000      | 3078.75      | II  | 500 d     | 7556.65      | I  | 220       | 22183.03     | I |
| 20000                  | 1234.06      | II  | 200       | 4102.23      | I   | 2000 c    | 7700.20      | I  | 150       | 22226.53     | I |
| 600                    | 1251.34      | I   | 200       | 4129.21      | I   | 600       | 7897.98      | I  | 30        | 22309.21     | I |
| 8                      | 1252.35      | III | 100 d     | 4134.15      | I   | 500       | 7969.48      | I  | 32        | 24420.82     | I |
| 2500                   | 1259.15      | I   | 500 d     | 4321.84      | I   | 1000      | 8003.63      | I  | 12        | 27365.42     | I |
| 3000                   | 1259.51      | I   | 250       | 4763.31      | I   | 99000     | 8043.74      | I  | 9         | 27573.05     | I |
| 800                    | 1261.27      | I   | 1000      | 4862.32      | I   | 300 d     | 8065.70      | I  | 10        | 30361.93     | I |
| 600                    | 1267.57      | I   | 200       | 4916.94      | I   | 1000      | 8090.76      | I  | 8         | 30383.88     | I |

| Intensity                | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |   | Intensity | Wavelength/Å |    |
|--------------------------|--------------|----|-----------|--------------|----|-----------|--------------|---|-----------|--------------|----|
| 10                       | 34295.73     | I  | 540       | 2333.30      | I  | 230       | 2572.70      | I | 330       | 3039.26      | I  |
| 9                        | 34513.11     | I  | 740       | 2333.84      | I  | 740       | 2577.26      | I | 300       | 3047.16      | I  |
| 3                        | 40228.54     | I  | 580       | 2334.50      | I  | 740       | 2592.06      | I | 300       | 3049.44      | I  |
| 2                        | 41633.80     | I  | 1600      | 2343.18      | I  | 740       | 2599.04      | I | 300       | 3057.28      | I  |
| <i>Iridium Ir Z = 77</i> |              |    | 740       | 2343.61      | I  | 700       | 2608.25      | I | 1600      | 3068.89      | I  |
| 9900                     | 2010.65      | I  | 580       | 2355.00      | I  | 1800      | 2611.30      | I | 320       | 3083.22      | I  |
| 8700                     | 2022.35      | I  | 230       | 2357.53      | II | 210       | 2614.98      | I | 240       | 3086.44      | I  |
| 15000                    | 2033.57      | I  | 410       | 2358.16      | I  | 330       | 2617.78      | I | 390       | 3088.04      | I  |
| 6200                     | 2052.22      | I  | 500       | 2360.73      | I  | 210       | 2619.88      | I | 510       | 3100.29      | I  |
| 5000                     | 2060.64      | I  | 2500      | 2363.04      | I  | 250       | 2625.32      | I | 510       | 3100.45      | I  |
| 3700                     | 2083.22      | I  | 370       | 2368.04      | II | 700       | 2634.17      | I | 340       | 3120.76      | I  |
| 3100                     | 2085.74      | I  | 3500      | 2372.77      | I  | 250       | 2639.42      | I | 200       | 3121.78      | I  |
| 17000                    | 2088.82      | I  | 290       | 2375.09      | II | 3500      | 2639.71      | I | 3400      | 3133.32      | I  |
| 14000                    | 2092.63      | I  | 250       | 2377.28      | I  | 210       | 2644.19      | I | 490       | 3168.88      | I  |
| 2700                     | 2112.68      | I  | 250       | 2377.98      | I  | 1800      | 2661.98      | I | 370       | 3177.58      | I  |
| 1800                     | 2119.54      | I  | 500       | 2379.38      | I  | 350       | 2662.63      | I | 370       | 3198.92      | I  |
| 2000                     | 2125.44      | I  | 540       | 2381.62      | I  | 2700      | 2664.79      | I | 610       | 3212.12      | I  |
| 4500                     | 2126.81      | II | 210       | 2383.17      | I  | 520       | 2669.91      | I | 370       | 3219.51      | I  |
| 2000                     | 2127.52      | I  | 1300      | 2386.89      | I  | 520       | 2671.84      | I | 5100      | 3220.78      | I  |
| 4500                     | 2127.94      | I  | 2500      | 2390.62      | I  | 330       | 2673.61      | I | 300       | 3229.28      | I  |
| 3700                     | 2148.22      | I  | 2700      | 2391.18      | I  | 270       | 2692.34      | I | 470       | 3241.52      | I  |
| 2500                     | 2150.54      | I  | 230       | 2407.59      | I  | 3000      | 2694.23      | I | 200       | 3262.01      | I  |
| 3500                     | 2152.68      | II | 290       | 2409.37      | I  | 330       | 2772.46      | I | 390       | 3266.44      | I  |
| 2900                     | 2155.81      | I  | 290       | 2410.17      | I  | 250       | 2775.55      | I | 200       | 3322.60      | I  |
| 7900                     | 2158.05      | I  | 290       | 2410.73      | I  | 520       | 2781.29      | I | 560       | 3368.48      | I  |
| 2100                     | 2162.88      | I  | 540       | 2413.31      | I  | 330       | 2785.22      | I | 660       | 3437.02      | I  |
| 5800                     | 2169.42      | II | 370       | 2415.86      | I  | 540       | 2797.35      | I | 410       | 3448.97      | I  |
| 4500                     | 2175.24      | I  | 620       | 2418.11      | I  | 1600      | 2797.70      | I | 3200      | 3513.64      | I  |
| 2700                     | 2178.17      | I  | 210       | 2424.89      | I  | 380       | 2798.18      | I | 220       | 3515.95      | I  |
| 1600                     | 2187.43      | II | 370       | 2424.99      | I  | 410       | 2800.82      | I | 410       | 3522.03      | I  |
| 1100                     | 2190.38      | II | 290       | 2425.66      | I  | 680       | 2823.18      | I | 320       | 3558.99      | I  |
| 740                      | 2191.64      | I  | 540       | 2427.61      | I  | 1200      | 2824.45      | I | 1200      | 3573.72      | I  |
| 910                      | 2208.09      | II | 540       | 2431.24      | I  | 820       | 2836.40      | I | 320       | 3594.39      | I  |
| 1300                     | 2220.37      | I  | 1300      | 2431.94      | I  | 1100      | 2839.16      | I | 220       | 3609.77      | I  |
| 790                      | 2221.07      | II | 270       | 2435.14      | I  | 820       | 2840.22      | I | 660       | 3628.67      | I  |
| 2500                     | 2242.68      | II | 250       | 2445.34      | I  | 3800      | 2849.72      | I | 220       | 3636.20      | I  |
| 620                      | 2245.76      | II | 250       | 2447.76      | I  | 380       | 2875.60      | I | 300       | 3661.71      | I  |
| 2100                     | 2253.38      | I  | 910       | 2452.81      | I  | 380       | 2875.98      | I | 300       | 3664.62      | I  |
| 2100                     | 2255.10      | I  | 1300      | 2455.61      | I  | 270       | 2877.68      | I | 320       | 3674.98      | I  |
| 1400                     | 2255.81      | I  | 230       | 2455.87      | I  | 820       | 2882.64      | I | 200       | 3687.08      | I  |
| 350                      | 2258.51      | I  | 210       | 2457.03      | I  | 650       | 2897.15      | I | 200       | 3731.36      | II |
| 1400                     | 2258.86      | I  | 210       | 2457.23      | I  | 260       | 2901.95      | I | 530       | 3747.20      | I  |
| 830                      | 2264.61      | I  | 870       | 2467.30      | I  | 260       | 2904.80      | I | 3100      | 3800.12      | I  |
| 1100                     | 2266.33      | I  | 3300      | 2475.12      | I  | 200       | 2907.24      | I | 230       | 3817.24      | I  |
| 1000                     | 2268.90      | I  | 210       | 2478.11      | I  | 440       | 2916.36      | I | 480       | 3902.51      | I  |
| 660                      | 2280.00      | I  | 2100      | 2481.18      | I  | 230       | 2918.57      | I | 480       | 3915.38      | I  |
| 950                      | 2281.02      | II | 620       | 2493.08      | I  | 4400      | 2924.79      | I | 400       | 3934.84      | I  |
| 660                      | 2281.91      | I  | 210       | 2496.27      | I  | 1200      | 2934.64      | I | 590       | 3976.31      | I  |
| 330                      | 2284.60      | I  | 250       | 2502.63      | I  | 880       | 2936.68      | I | 460       | 3992.12      | I  |
| 330                      | 2295.08      | I  | 4100      | 2502.98      | I  | 250       | 2938.47      | I | 350       | 4033.76      | I  |
| 790                      | 2298.05      | I  | 210       | 2513.71      | I  | 2700      | 2943.15      | I | 370       | 4069.92      | I  |
| 460                      | 2299.53      | I  | 990       | 2533.13      | I  | 230       | 2946.97      | I | 150       | 4070.68      | I  |
| 910                      | 2300.50      | I  | 1100      | 2534.46      | I  | 200       | 2949.76      | I | 100       | 4092.61      | I  |
| 2700                     | 2304.22      | I  | 580       | 2537.22      | I  | 1200      | 2951.22      | I | 140       | 4115.78      | I  |
| 410                      | 2305.47      | I  | 580       | 2542.02      | I  | 200       | 2974.95      | I | 90        | 4172.56      | I  |
| 210                      | 2307.27      | I  | 7900      | 2543.97      | I  | 440       | 2980.65      | I | 260       | 4268.10      | I  |
| 910                      | 2308.93      | I  | 790       | 2546.03      | I  | 300       | 2996.08      | I | 220       | 4311.50      | I  |
| 460                      | 2315.38      | I  | 210       | 2551.40      | I  | 220       | 3002.25      | I | 160       | 4399.47      | I  |
| 410                      | 2321.45      | I  | 210       | 2555.35      | I  | 600       | 3003.63      | I | 65        | 4403.78      | I  |
| 410                      | 2321.58      | I  | 910       | 2564.18      | I  | 270       | 3017.31      | I | 110       | 4426.27      | I  |
| 210                      | 2327.98      | I  | 210       | 2569.88      | I  | 380       | 3029.36      | I | 55        | 4478.48      | I  |



| Intensity             | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 55                    | 4545.68      | I   | 10        | 844.28       | III | 500       | 1479.47      | V   | 15        | 1651.58      | IV  |
| 30                    | 4548.48      | I   | 10 p      | 861.83       | III | 10 h      | 1505.17      | III | 15        | 1652.90      | IV  |
| 35                    | 4568.09      | I   | 10        | 891.17       | III | 13        | 1526.60      | IV  | 13        | 1653.41      | IV  |
| 75                    | 4616.39      | I   | 10        | 950.33       | III | 13        | 1530.26      | IV  | 13        | 1656.11      | IV  |
| 26                    | 4656.18      | I   | 10        | 981.37       | III | 14        | 1532.63      | IV  | 15        | 1656.65      | IV  |
| 50                    | 4728.86      | I   | 10 w      | 983.88       | III | 13        | 1532.91      | IV  | 14        | 1660.10      | IV  |
| 26                    | 4756.46      | I   | 12        | 1055.27      | II  | 15        | 1533.86      | IV  | 13        | 1662.32      | IV  |
| 65                    | 4778.16      | I   | 15        | 1068.36      | II  | 13        | 1533.95      | IV  | 13        | 1662.52      | IV  |
| 30                    | 4795.67      | I   | 15        | 1071.60      | II  | 14        | 1536.58      | IV  | 13        | 1663.54      | IV  |
| 50                    | 4938.09      | I   | 15        | 1096.89      | II  | 10 h      | 1538.63      | III | 13        | 1668.09      | IV  |
| 26                    | 4970.48      | I   | 12        | 1099.12      | II  | 13        | 1542.16      | IV  | 12        | 1670.74      | II  |
| 25                    | 4999.74      | I   | 18        | 1112.09      | II  | 14        | 1542.70      | IV  | 14        | 1671.04      | IV  |
| 25                    | 5002.74      | I   | 12        | 1121.99      | II  | 12 h      | 1550.20      | III | 13        | 1673.68      | IV  |
| 30                    | 5014.98      | I   | 12        | 1122.86      | II  | 13        | 1566.26      | IV  | 14        | 1675.66      | IV  |
| 30                    | 5123.66      | I   | 12        | 1128.07      | II  | 14        | 1568.27      | IV  | 13        | 1681.36      | IV  |
| 35                    | 5364.32      | I   | 12        | 1130.43      | II  | 13        | 1591.51      | IV  | 15        | 1687.69      | IV  |
| 75                    | 5449.50      | I   | 15        | 1133.41      | II  | 13        | 1592.05      | IV  | 15        | 1698.88      | IV  |
| 45                    | 5625.55      | I   | 12        | 1133.68      | II  | 13        | 1598.01      | IV  | 12        | 1702.04      | II  |
| 35                    | 5894.06      | I   | 12        | 1138.64      | II  | 13        | 1600.58      | IV  | 13        | 1709.81      | IV  |
| 20                    | 6110.67      | I   | 12        | 1142.33      | II  | 10 h      | 1601.21      | III | 15        | 1711.41      | IV  |
| 12                    | 6288.28      | I   | 12        | 1143.23      | II  | 13        | 1601.67      | IV  | 14        | 1712.76      | IV  |
| 10                    | 6686.08      | I   | 18        | 1144.95      | II  | 13        | 1603.18      | IV  | 14        | 1717.90      | IV  |
| 6                     | 7834.32      | I   | 12        | 1147.41      | II  | 13        | 1603.73      | IV  | 14        | 1718.16      | IV  |
| <i>Iron Fe Z = 26</i> |              |     | 15        | 1148.29      | II  | 13        | 1604.88      | IV  | 14        | 1719.46      | IV  |
| 350                   | 386.16       | V   | 12        | 1151.16      | II  | 13        | 1605.68      | IV  | 14        | 1722.71      | IV  |
| 350                   | 386.88       | V   | 12        | 1267.44      | II  | 15        | 1605.97      | IV  | 14        | 1724.06      | IV  |
| 400                   | 387.20       | V   | 12        | 1272.00      | II  | 13        | 1606.98      | IV  | 16        | 1725.63      | IV  |
| 400                   | 387.50       | V   | 400       | 1317.86      | V   | 17        | 1609.10      | IV  | 13        | 1761.08      | IV  |
| 400                   | 387.76       | V   | 400       | 1323.27      | V   | 14        | 1609.83      | IV  | 12        | 1761.38      | II  |
| 400                   | 387.78       | V   | 400       | 1330.40      | V   | 13        | 1610.47      | IV  | 20        | 1785.26      | II  |
| 400                   | 395.90       | V   | 400       | 1359.01      | V   | 13        | 1611.20      | IV  | 20        | 1786.74      | II  |
| 400                   | 404.62       | V   | 600       | 1361.82      | V   | 13        | 1613.64      | IV  | 18        | 1788.07      | II  |
| 400                   | 405.50       | V   | 700       | 1373.59      | V   | 15        | 1614.02      | IV  | 13        | 1792.10      | IV  |
| 800                   | 407.42       | V   | 600       | 1373.67      | V   | 13        | 1614.64      | IV  | 13        | 1796.93      | IV  |
| 600                   | 407.44       | V   | 500       | 1376.34      | V   | 13        | 1615.00      | IV  | 13        | 1827.98      | IV  |
| 400                   | 407.49       | V   | 500       | 1378.56      | V   | 16        | 1616.68      | IV  | 10        | 1869.83      | III |
| 500                   | 407.75       | V   | 800       | 1387.94      | V   | 14        | 1617.68      | IV  | 12        | 1877.99      | III |
| 400                   | 409.71       | V   | 400       | 1397.97      | V   | 12        | 1618.47      | II  | 10        | 1882.05      | III |
| 400                   | 410.20       | V   | 600       | 1400.24      | V   | 14        | 1619.02      | IV  | 12        | 1886.76      | III |
| 600                   | 411.55       | V   | 800       | 1402.39      | V   | 13        | 1621.16      | IV  | 13        | 1890.67      | III |
| 700                   | 417.39       | V   | 400       | 1406.67      | V   | 14        | 1621.57      | IV  | 11        | 1893.98      | III |
| 700                   | 418.04       | V   | 500       | 1406.82      | V   | 13        | 1623.38      | IV  | 20        | 1895.46      | III |
| 500                   | 418.47       | V   | 400       | 1407.25      | V   | 13        | 1623.53      | IV  | 10 s      | 1907.58      | III |
| 700                   | 421.06       | V   | 600       | 1409.45      | V   | 15        | 1626.47      | IV  | 19        | 1914.06      | III |
| 500                   | 421.78       | V   | 400       | 1415.20      | V   | 14        | 1626.90      | IV  | 15        | 1915.08      | III |
| 500                   | 422.31       | V   | 600       | 1420.46      | V   | 13        | 1628.54      | IV  | 15        | 1922.79      | III |
| 500                   | 426.06       | V   | 800       | 1430.57      | V   | 13        | 1630.18      | IV  | 10 p      | 1926.01      | III |
| 500                   | 426.11       | V   | 13        | 1431.43      | IV  | 17        | 1631.08      | IV  | 18        | 1926.30      | III |
| 350                   | 426.97       | V   | 800       | 1440.53      | V   | 15        | 1631.12      | II  | 15        | 1930.39      | III |
| 17                    | 525.69       | IV  | 400       | 1442.22      | V   | 14        | 1632.40      | IV  | 14        | 1931.51      | III |
| 15                    | 526.29       | IV  | 800       | 1446.62      | V   | 13        | 1634.01      | IV  | 30        | 1934.538     | I   |
| 13                    | 526.63       | IV  | 700       | 1448.85      | V   | 18        | 1635.40      | II  | 25        | 1937.269     | I   |
| 14                    | 536.61       | IV  | 400       | 1449.93      | V   | 15        | 1636.32      | II  | 14        | 1937.34      | III |
| 15                    | 537.10       | IV  | 700       | 1456.16      | V   | 15        | 1639.40      | II  | 10 l      | 1938.90      | III |
| 13                    | 537.26       | IV  | 500       | 1459.83      | V   | 14        | 1639.40      | IV  | 14 s      | 1943.48      | III |
| 14                    | 537.79       | IV  | 400       | 1460.73      | V   | 16        | 1640.04      | IV  | 12        | 1945.34      | III |
| 13                    | 537.94       | IV  | 500       | 1462.63      | V   | 14        | 1640.16      | IV  | 50        | 1946.988     | I   |
| 13                    | 552.14       | IV  | 700       | 1464.68      | V   | 12        | 1641.76      | II  | 10        | 1950.33      | III |
| 14                    | 607.53       | IV  | 500       | 1465.38      | V   | 15        | 1641.87      | IV  | 12        | 1951.01      | III |
| 13                    | 608.80       | IV  | 400       | 1466.65      | V   | 15        | 1647.09      | IV  | 25        | 1951.571     | I   |
| 10                    | 813.38       | III | 500       | 1469.00      | V   | 12        | 1647.16      | II  | 30        | 1952.59      | I   |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|-----------|--------------|----|
| 11        | 1952.65      | III | 60        | 2264.389     | I   | 80        | 2406.97      | II | 500       | 2493.26      | II |
| 30        | 1953.005     | I   | 80        | 2267.085     | I   | 300       | 2410.52      | II | 60        | 2494.000     | I  |
| 13        | 1953.32      | III | 10        | 2267.42      | III | 200       | 2411.07      | II | 50        | 2494.251     | I  |
| 10        | 1953.49      | III | 80        | 2267.469     | I   | 150       | 2413.31      | II | 100       | 2495.87      | I  |
| 10 w      | 1954.22      | III | 50        | 2270.862     | I   | 80        | 2417.87      | II | 600       | 2496.533     | I  |
| 60        | 1957.823     | I   | 150       | 2272.070     | I   | 60        | 2420.396     | I  | 150       | 2498.90      | I  |
| 11        | 1958.58      | III | 150       | 2276.026     | I   | 60        | 2423.089     | I  | 1000      | 2501.132     | I  |
| 60        | 1960.144     | I   | 80        | 2279.937     | I   | 150       | 2424.14      | II | 50        | 2501.693     | I  |
| 13        | 1960.32      | III | 150       | 2284.086     | I   | 120       | 2428.36      | II | 80        | 2506.09      | II |
| 30        | 1961.25      | I   | 150       | 2287.250     | I   | 120       | 2430.08      | II | 500       | 2507.900     | I  |
| 50        | 1962.111     | I   | 300       | 2292.524     | I   | 80        | 2432.26      | II | 50        | 2508.753     | I  |
| 12        | 1963.11      | II  | 10        | 2293.06      | III | 60        | 2438.182     | I  | 1000      | 2510.835     | I  |
| 15        | 1987.50      | III | 15        | 2295.86      | III | 150       | 2439.30      | II | 120       | 2511.76      | II |
| 14        | 1991.61      | III | 200       | 2297.787     | I   | 150       | 2439.74      | I  | 80        | 2512.275     | I  |
| 13        | 1994.07      | III | 600       | 2298.169     | I   | 100       | 2442.57      | I  | 400       | 2512.365     | I  |
| 12        | 1995.56      | III | 80        | 2299.220     | I   | 250       | 2443.872     | I  | 80        | 2516.570     | I  |
| 12        | 1996.42      | III | 300       | 2300.142     | I   | 100       | 2444.51      | II | 300       | 2517.661     | I  |
| 10        | 2061.55      | III | 50        | 2301.684     | I   | 50        | 2445.212     | I  | 800       | 2518.102     | I  |
| 12        | 2068.24      | III | 100       | 2303.424     | I   | 100       | 2445.57      | II | 150       | 2519.629     | I  |
| 14        | 2078.99      | III | 150       | 2303.581     | I   | 60        | 2447.709     | I  | 50        | 2522.480     | I  |
| 100       | 2084.122     | I   | 120       | 2308.999     | I   | 100       | 2453.476     | I  | 4000      | 2522.849     | I  |
| 10        | 2084.35      | III | 150       | 2313.104     | I   | 1500      | 2457.598     | I  | 200       | 2523.66      | I  |
| 12        | 2090.14      | III | 10 p      | 2317.70      | III | 150       | 2458.78      | II | 500       | 2524.293     | I  |
| 15        | 2097.48      | III | 10        | 2319.22      | III | 80        | 2461.28      | II | 100       | 2525.02      | I  |
| 12        | 2097.69      | III | 200       | 2320.358     | I   | 100       | 2461.86      | II | 200       | 2525.39      | II |
| 12        | 2103.80      | III | 10 p      | 2321.71      | III | 100       | 2462.181     | I  | 300       | 2526.29      | II |
| 10        | 2107.32      | III | 10        | 2326.95      | III | 1500      | 2462.647     | I  | 2000      | 2527.435     | I  |
| 15        | 2151.78      | III | 100       | 2327.40      | II  | 50        | 2463.730     | I  | 800       | 2529.135     | I  |
| 12        | 2157.71      | III | 100       | 2331.31      | II  | 800       | 2465.149     | I  | 250       | 2529.55      | II |
| 50        | 2157.794     | I   | 300       | 2332.80      | II  | 60        | 2467.732     | I  | 150       | 2529.836     | I  |
| 12        | 2158.47      | III | 10 p      | 2336.77      | III | 600       | 2468.879     | I  | 200       | 2530.687     | I  |
| 10        | 2161.27      | III | 200       | 2338.01      | II  | 80        | 2470.67      | II | 120       | 2533.63      | II |
| 40        | 2166.773     | I   | 10        | 2338.96      | III | 80        | 2470.965     | I  | 100       | 2534.42      | II |
| 12        | 2166.95      | III | 600       | 2343.49      | II  | 800       | 2472.336     | I  | 120       | 2535.49      | II |
| 12        | 2171.04      | III | 80        | 2343.96      | II  | 1000      | 2472.895     | I  | 400       | 2535.607     | I  |
| 15        | 2174.66      | III | 150       | 2344.28      | II  | 200       | 2473.16      | I  | 200       | 2536.792     | I  |
| 300       | 2178.118     | I   | 200       | 2348.11      | II  | 600       | 2474.814     | I  | 200       | 2536.80      | II |
| 12        | 2180.41      | III | 250       | 2348.30      | II  | 60        | 2476.657     | I  | 100       | 2538.80      | II |
| 250       | 2186.486     | I   | 200       | 2359.12      | II  | 120       | 2479.480     | I  | 100       | 2538.91      | II |
| 60        | 2186.892     | I   | 150       | 2360.00      | II  | 1200      | 2479.776     | I  | 150       | 2538.99      | II |
| 120       | 2187.195     | I   | 120       | 2360.29      | II  | 100       | 2480.16      | II | 50        | 2539.357     | I  |
| 250       | 2191.839     | I   | 200       | 2364.83      | II  | 80        | 2482.12      | II | 200       | 2540.66      | II |
| 150       | 2196.043     | I   | 80        | 2365.76      | II  | 100       | 2482.66      | II | 600       | 2540.972     | I  |
| 80        | 2200.390     | I   | 80        | 2368.59      | II  | 10000     | 2483.271     | I  | 80        | 2541.10      | II |
| 80        | 2200.724     | I   | 80        | 2369.456     | I   | 300       | 2483.533     | I  | 300       | 2542.10      | I  |
| 15        | 2208.41      | II  | 80        | 2369.95      | II  | 1000      | 2484.185     | I  | 250       | 2543.92      | I  |
| 10 p      | 2208.85      | III | 120       | 2371.430     | I   | 50        | 2485.990     | I  | 150       | 2544.70      | I  |
| 20        | 2213.65      | II  | 300       | 2373.624     | I   | 800       | 2486.373     | I  | 800       | 2545.978     | I  |
| 12        | 2218.26      | II  | 150       | 2373.74      | II  | 100       | 2486.691     | I  | 80        | 2546.67      | II |
| 20        | 2220.38      | II  | 120       | 2374.518     | I   | 100       | 2487.066     | I  | 100       | 2548.74      | II |
| 10        | 2221.83      | III | 120       | 2376.43      | II  | 120       | 2487.370     | I  | 80        | 2549.08      | II |
| 10        | 2229.27      | III | 80        | 2379.27      | II  | 4000      | 2488.143     | I  | 80        | 2549.39      | II |
| 10        | 2232.43      | III | 120       | 2380.76      | II  | 100       | 2488.945     | I  | 600       | 2549.613     | I  |
| 10        | 2232.69      | III | 150       | 2381.835     | I   | 80        | 2489.48      | II | 400       | 2562.53      | II |
| 10        | 2235.91      | III | 1000      | 2382.04      | II  | 1000      | 2489.750     | I  | 200       | 2563.48      | II |
| 10        | 2238.16      | III | 300       | 2388.63      | II  | 50        | 2489.913     | I  | 150       | 2574.36      | II |
| 12 p      | 2241.54      | III | 200       | 2389.973     | I   | 3000      | 2490.644     | I  | 300       | 2576.691     | I  |
| 50        | 2250.790     | I   | 1000      | 2395.62      | II  | 100       | 2490.71      | II | 100       | 2582.58      | II |
| 60        | 2251.874     | I   | 300       | 2399.24      | II  | 2000      | 2491.155     | I  | 1500      | 2584.54      | I  |
| 300       | 2259.511     | I   | 800       | 2404.88      | II  | 100       | 2491.40      | II | 650       | 2585.88      | II |
| 12        | 2261.59      | III | 250       | 2406.66      | II  | 100       | 2493.18      | II | 90        | 2591.54      | II |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 90        | 2593.73      | II  | 80        | 2744.527     | I   | 500       | 2999.512     | I   | 80        | 3246.005     | I   |
| 650       | 2598.37      | II  | 300       | 2746.48      | II  | 120       | 3000.451     | I   | 80        | 3265.046     | I   |
| 2000      | 2599.40      | II  | 100       | 2749.32      | II  | 800       | 3000.948     | I   | 50        | 3265.617     | I   |
| 300       | 2599.57      | I   | 500       | 2749.48      | II  | 12        | 3001.62      | III | 13        | 3266.88      | III |
| 60        | 2605.657     | I   | 1200      | 2750.140     | I   | 60        | 3001.655     | I   | 50        | 3271.000     | I   |
| 300       | 2606.51      | II  | 80        | 2753.29      | II  | 12 h      | 3007.28      | III | 11        | 3276.08      | III |
| 800       | 2606.827     | I   | 150       | 2754.032     | I   | 200       | 3007.282     | I   | 150       | 3286.75      | I   |
| 650       | 2607.09      | II  | 100       | 2754.426     | I   | 500       | 3008.14      | I   | 10        | 3288.81      | III |
| 600       | 2611.87      | II  | 800       | 2755.73      | II  | 120       | 3009.569     | I   | 120       | 3305.97      | I   |
| 320       | 2613.82      | II  | 250       | 2756.328     | I   | 15        | 3013.17      | III | 200       | 3306.343     | I   |
| 320       | 2617.62      | II  | 100       | 2757.316     | I   | 60        | 3017.627     | I   | 400       | 3355.227     | I   |
| 250       | 2618.018     | I   | 120       | 2761.780     | I   | 60        | 3018.983     | I   | 80        | 3355.517     | I   |
| 90        | 2620.41      | II  | 150       | 2761.81      | II  | 500       | 3020.491     | I   | 60        | 3369.546     | I   |
| 400       | 2623.53      | I   | 150       | 2762.026     | I   | 1500      | 3020.639     | I   | 120       | 3370.783     | I   |
| 200       | 2625.67      | II  | 120       | 2762.772     | I   | 600       | 3021.073     | I   | 50        | 3378.678     | I   |
| 150       | 2628.29      | II  | 120       | 2763.109     | I   | 500       | 3024.032     | I   | 50        | 3380.110     | I   |
| 250       | 2631.05      | II  | 80        | 2766.910     | I   | 150       | 3025.638     | I   | 60        | 3383.978     | I   |
| 250       | 2631.32      | II  | 250       | 2767.522     | I   | 500       | 3025.842     | I   | 50        | 3392.304     | I   |
| 100       | 2632.237     | I   | 300       | 2772.07      | I   | 80        | 3030.148     | I   | 150       | 3392.651     | I   |
| 300       | 2635.809     | I   | 600       | 2778.220     | I   | 60        | 3031.214     | I   | 150       | 3399.333     | I   |
| 50        | 2641.646     | I   | 3000      | 2788.10      | I   | 60        | 3034.484     | I   | 80        | 3404.353     | I   |
| 200       | 2643.998     | I   | 200       | 2797.78      | I   | 800       | 3037.389     | I   | 500       | 3407.458     | I   |
| 300       | 2666.812     | I   | 400       | 2804.521     | I   | 80        | 3041.637     | I   | 250       | 3413.131     | I   |
| 60        | 2666.965     | I   | 1500      | 2806.98      | I   | 800       | 3047.604     | I   | 60        | 3424.284     | I   |
| 600       | 2679.062     | I   | 10 p      | 2813.24      | III | 600       | 3057.446     | I   | 500       | 3427.119     | I   |
| 500       | 2684.75      | II  | 2500      | 2813.287     | I   | 1000      | 3059.086     | I   | 60        | 3428.748     | I   |
| 400       | 2689.212     | I   | 300       | 2823.276     | I   | 250       | 3067.244     | I   | 6000      | 3440.606     | I   |
| 10 h      | 2695.13      | III | 600       | 2825.56      | I   | 120       | 3075.719     | I   | 2500      | 3440.989     | I   |
| 200       | 2699.106     | I   | 50        | 2825.687     | I   | 120       | 3091.577     | I   | 1000      | 3443.876     | I   |
| 80        | 2706.012     | I   | 120       | 2828.808     | I   | 80        | 3098.189     | I   | 200       | 3445.149     | I   |
| 400       | 2706.582     | I   | 1500      | 2832.436     | I   | 100       | 3099.895     | I   | 1200      | 3465.860     | I   |
| 60        | 2708.571     | I   | 120       | 2835.950     | I   | 100       | 3099.968     | I   | 2000      | 3475.450     | I   |
| 200       | 2711.655     | I   | 200       | 2838.119     | I   | 60        | 3100.303     | I   | 500       | 3476.702     | I   |
| 80        | 2714.41      | II  | 200       | 2843.631     | I   | 100       | 3100.665     | I   | 2500      | 3490.574     | I   |
| 50        | 2716.257     | I   | 1000      | 2843.977     | I   | 10 p      | 3136.43      | III | 500       | 3497.840     | I   |
| 50        | 2717.786     | I   | 100       | 2845.594     | I   | 10        | 3174.09      | III | 10        | 3501.76      | III |
| 250       | 2718.436     | I   | 800       | 2851.797     | I   | 80        | 3175.445     | I   | 250       | 3513.817     | I   |
| 4000      | 2719.027     | I   | 50        | 2869.307     | I   | 10        | 3175.99      | III | 300       | 3521.261     | I   |
| 100       | 2719.420     | I   | 50        | 2872.334     | I   | 10        | 3178.01      | III | 400       | 3526.040     | I   |
| 50        | 2720.197     | I   | 80        | 2874.172     | I   | 150       | 3184.895     | I   | 100       | 3526.166     | I   |
| 1500      | 2720.903     | I   | 50        | 2894.504     | I   | 250       | 3191.659     | I   | 60        | 3526.237     | I   |
| 400       | 2723.578     | I   | 12        | 2904.43      | III | 500       | 3193.226     | I   | 60        | 3526.381     | I   |
| 150       | 2724.953     | I   | 10        | 2907.50      | III | 800       | 3193.299     | I   | 60        | 3526.467     | I   |
| 50        | 2726.235     | I   | 12        | 2907.70      | III | 200       | 3196.928     | I   | 100       | 3533.199     | I   |
| 80        | 2727.54      | II  | 120       | 2912.157     | I   | 80        | 3199.500     | I   | 200       | 3536.556     | I   |
| 200       | 2728.020     | I   | 120       | 2929.007     | I   | 50        | 3205.398     | I   | 300       | 3541.083     | I   |
| 50        | 2728.820     | I   | 1200      | 2936.903     | I   | 100       | 3211.88      | I   | 250       | 3542.075     | I   |
| 80        | 2728.90      | II  | 60        | 2941.343     | I   | 200       | 3214.011     | I   | 80        | 3553.739     | I   |
| 1000      | 2733.581     | I   | 1000      | 2947.876     | I   | 200       | 3214.396     | I   | 400       | 3554.925     | I   |
| 60        | 2734.005     | I   | 600       | 2953.940     | I   | 60        | 3215.938     | I   | 200       | 3556.878     | I   |
| 50        | 2734.268     | I   | 250       | 2957.364     | I   | 50        | 3217.377     | I   | 400       | 3558.515     | I   |
| 500       | 2735.475     | I   | 150       | 2965.254     | I   | 80        | 3219.583     | I   | 1000      | 3565.379     | I   |
| 50        | 2735.612     | I   | 1500      | 2966.898     | I   | 60        | 3219.766     | I   | 1200      | 3570.097     | I   |
| 500       | 2737.310     | I   | 120       | 2969.36      | I   | 300       | 3222.045     | I   | 800       | 3570.25      | I   |
| 120       | 2737.83      | I   | 800       | 2970.099     | I   | 600       | 3225.78      | I   | 120       | 3571.996     | I   |
| 400       | 2739.55      | II  | 1200      | 2973.132     | I   | 80        | 3227.796     | I   | 100       | 3573.393     | I   |
| 250       | 2742.254     | I   | 500       | 2973.235     | I   | 50        | 3233.967     | I   | 60        | 3573.829     | I   |
| 800       | 2742.405     | I   | 600       | 2981.445     | I   | 120       | 3234.613     | I   | 60        | 3573.888     | I   |
| 200       | 2743.20      | II  | 1000      | 2983.570     | I   | 300       | 3236.222     | I   | 4000      | 3581.19      | I   |
| 150       | 2743.565     | I   | 1000      | 2994.427     | I   | 100       | 3239.433     | I   | 150       | 3582.199     | I   |
| 200       | 2744.068     | I   | 250       | 2994.502     | I   | 80        | 3244.187     | I   | 150       | 3584.660     | I   |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |   | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|---|-----------|--------------|-----|-----------|--------------|-----|
| 120       | 3584.929     | I   | 6000      | 3737.131     | I | 1200      | 3927.920     | I   | 40        | 4195.329     | I   |
| 300       | 3585.319     | I   | 100       | 3738.306     | I | 2000      | 3930.296     | I   | 150       | 4198.304     | I   |
| 150       | 3585.705     | I   | 400       | 3743.362     | I | 60        | 3948.774     | I   | 40        | 4199.095     | I   |
| 10        | 3586.04      | III | 6000      | 3745.561     | I | 60        | 3949.953     | I   | 300       | 4202.029     | I   |
| 200       | 3586.103     | I   | 1200      | 3745.899     | I | 50        | 3951.164     | I   | 40        | 4203.984     | I   |
| 400       | 3586.984     | I   | 3000      | 3748.262     | I | 50        | 3952.601     | I   | 80        | 4206.696     | I   |
| 100       | 3594.633     | I   | 80        | 3748.964     | I | 16        | 3954.33      | III | 80        | 4210.343     | I   |
| 11        | 3600.94      | III | 3000      | 3749.485     | I | 60        | 3956.454     | I   | 400       | 4216.183     | I   |
| 150       | 3603.204     | I   | 1500      | 3758.232     | I | 250       | 3956.68      | I   | 100       | 4219.360     | I   |
| 11        | 3603.88      | III | 400       | 3760.05      | I | 60        | 3966.614     | I   | 50        | 4222.212     | I   |
| 200       | 3605.454     | I   | 1500      | 3763.788     | I | 11        | 3968.72      | III | 11        | 4222.27      | III |
| 500       | 3606.680     | I   | 400       | 3765.54      | I | 100       | 3969.257     | I   | 50        | 4225.956     | I   |
| 1500      | 3608.859     | I   | 600       | 3767.191     | I | 80        | 3977.741     | I   | 200       | 4227.423     | I   |
| 250       | 3610.16      | I   | 60        | 3776.452     | I | 10 w      | 3979.42      | III | 100       | 4233.602     | I   |
| 60        | 3612.068     | I   | 250       | 3785.95      | I | 40        | 3981.771     | I   | 13        | 4235.56      | III |
| 150       | 3617.788     | I   | 100       | 3786.68      | I | 50        | 3983.956     | I   | 250       | 4235.936     | I   |
| 1500      | 3618.768     | I   | 250       | 3787.880     | I | 60        | 3994.114     | I   | 50        | 4238.809     | I   |
| 200       | 3621.462     | I   | 250       | 3790.092     | I | 200       | 3997.392     | I   | 12        | 4243.75      | III |
| 150       | 3622.004     | I   | 150       | 3794.34      | I | 40        | 3998.053     | I   | 50        | 4247.425     | I   |
| 150       | 3623.19      | I   | 400       | 3795.002     | I | 400       | 4005.241     | I   | 200       | 4250.118     | I   |
| 100       | 3631.096     | I   | 120       | 3797.518     | I | 60        | 4009.713     | I   | 300       | 4250.787     | I   |
| 1200      | 3631.463     | I   | 250       | 3798.511     | I | 100       | 4021.867     | I   | 40        | 4258.315     | I   |
| 60        | 3632.041     | I   | 400       | 3799.547     | I | 10        | 4035.42      | III | 800       | 4260.473     | I   |
| 100       | 3638.298     | I   | 200       | 3805.345     | I | 50        | 4040.638     | I   | 250       | 4271.153     | I   |
| 200       | 3640.389     | I   | 80        | 3806.696     | I | 4000      | 4045.813     | I   | 1200      | 4271.759     | I   |
| 80        | 3643.717     | I   | 600       | 3812.964     | I | 11        | 4053.11      | III | 12 h      | 4273.40      | III |
| 1500      | 3647.842     | I   | 60        | 3813.059     | I | 1500      | 4063.594     | I   | 12        | 4279.72      | III |
| 250       | 3649.506     | I   | 1500      | 3815.840     | I | 50        | 4066.975     | I   | 1200      | 4282.402     | I   |
| 80        | 3650.279     | I   | 2500      | 3820.425     | I | 50        | 4067.977     | I   | 14 h      | 4286.16      | III |
| 200       | 3651.467     | I   | 150       | 3821.179     | I | 1200      | 4071.737     | I   | 80        | 4291.462     | I   |
| 120       | 3670.024     | I   | 80        | 3824.306     | I | 40        | 4076.629     | I   | 16 h      | 4296.85      | III |
| 150       | 3670.089     | I   | 2500      | 3824.444     | I | 12        | 4081.00      | III | 250       | 4299.234     | I   |
| 100       | 3676.311     | I   | 1500      | 3825.880     | I | 40        | 4100.737     | I   | 18 h      | 4304.78      | III |
| 150       | 3677.629     | I   | 1200      | 3827.823     | I | 40        | 4107.489     | I   | 1200      | 4307.901     | I   |
| 1500      | 3679.913     | I   | 1000      | 3834.222     | I | 150       | 4118.544     | I   | 20 h      | 4310.36      | III |
| 200       | 3682.242     | I   | 120       | 3839.257     | I | 10        | 4120.90      | III | 150       | 4315.084     | I   |
| 120       | 3683.054     | I   | 500       | 3840.437     | I | 11        | 4122.02      | III | 1500      | 4325.761     | I   |
| 150       | 3684.107     | I   | 800       | 3841.047     | I | 11        | 4122.78      | III | 80        | 4352.734     | I   |
| 120       | 3685.998     | I   | 120       | 3843.256     | I | 40        | 4127.608     | I   | 80        | 4369.771     | I   |
| 500       | 3687.456     | I   | 80        | 3846.800     | I | 400       | 4132.058     | I   | 11 h      | 4372.31      | III |
| 120       | 3689.477     | I   | 200       | 3849.96      | I | 80        | 4134.676     | I   | 14 h      | 4372.53      | III |
| 150       | 3694.008     | I   | 120       | 3850.817     | I | 40        | 4136.997     | I   | 18 h      | 4372.81      | III |
| 120       | 3695.051     | I   | 2500      | 3856.372     | I | 15        | 4137.76      | III | 800       | 4375.929     | I   |
| 150       | 3701.086     | I   | 150       | 3859.212     | I | 13        | 4139.35      | III | 3000      | 4383.544     | I   |
| 80        | 3704.462     | I   | 10000     | 3859.911     | I | 200       | 4143.415     | I   | 1200      | 4404.750     | I   |
| 1200      | 3705.566     | I   | 150       | 3865.523     | I | 800       | 4143.869     | I   | 300       | 4415.122     | I   |
| 60        | 3707.041     | I   | 60        | 3867.215     | I | 40        | 4153.898     | I   | 12        | 4419.60      | III |
| 150       | 3707.821     | I   | 250       | 3872.501     | I | 50        | 4154.500     | I   | 600       | 4427.299     | I   |
| 300       | 3707.919     | I   | 150       | 3873.761     | I | 60        | 4156.799     | I   | 400       | 4461.652     | I   |
| 600       | 3709.246     | I   | 250       | 3878.018     | I | 18        | 4164.73      | III | 120       | 4466.551     | I   |
| 120       | 3716.442     | I   | 2000      | 3878.573     | I | 13        | 4166.84      | III | 80        | 4476.017     | I   |
| 8000      | 3719.935     | I   | 4000      | 3886.282     | I | 50        | 4172.744     | I   | 80        | 4482.169     | I   |
| 1500      | 3722.563     | I   | 200       | 3887.048     | I | 13        | 4174.26      | III | 200       | 4482.252     | I   |
| 120       | 3724.377     | I   | 300       | 3888.513     | I | 60        | 4174.912     | I   | 50        | 4489.739     | I   |
| 60        | 3725.491     | I   | 800       | 3895.656     | I | 50        | 4175.635     | I   | 50        | 4528.613     | I   |
| 60        | 3727.093     | I   | 1200      | 3899.707     | I | 50        | 4177.593     | I   | 30        | 4647.433     | I   |
| 500       | 3727.619     | I   | 400       | 3902.945     | I | 120       | 4181.754     | I   | 30        | 4736.771     | I   |
| 150       | 3732.396     | I   | 250       | 3906.479     | I | 50        | 4184.891     | I   | 50        | 4859.741     | I   |
| 1200      | 3733.317     | I   | 80        | 3916.731     | I | 120       | 4187.038     | I   | 120       | 4871.317     | I   |
| 5000      | 3734.864     | I   | 600       | 3920.258     | I | 120       | 4187.795     | I   | 60        | 4872.136     | I   |
| 120       | 3735.324     | I   | 1200      | 3922.911     | I | 80        | 4191.430     | I   | 30        | 4878.208     | I   |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|--------------------------|--------------|-----|-----------|--------------|-----|
| 100       | 4890.754     | I   | 10        | 5368.06      | III | 80                       | 7187.313     | I   | 50        | 625.02       | III |
| 250       | 4891.492     | I   | 400       | 5371.489     | I   | 30                       | 7207.381     | I   | 30        | 625.76       | III |
| 30        | 4903.309     | I   | 11 I      | 5375.47      | III | 30                       | 7445.746     | I   | 45        | 628.59       | III |
| 150       | 4918.992     | I   | 40        | 5393.167     | I   | 40                       | 7495.059     | I   | 50        | 630.04       | III |
| 500       | 4920.502     | I   | 300       | 5397.127     | I   | 60                       | 7511.045     | I   | 35        | 633.09       | III |
| 1500      | 4957.597     | I   | 250       | 5405.774     | I   | 80                       | 7937.131     | I   | 120       | 637.87       | V   |
| 80        | 5001.862     | I   | 250       | 5429.695     | I   | 60                       | 7945.984     | I   | 50        | 639.98       | III |
| 30        | 5005.711     | I   | 100       | 5434.523     | I   | 80                       | 7998.939     | I   | 60        | 646.41       | III |
| 100       | 5006.117     | I   | 200       | 5446.871     | I   | 60                       | 8046.047     | I   | 50        | 651.20       | III |
| 60        | 5012.067     | I   | 120       | 5455.609     | I   | 50                       | 8085.176     | I   | 50        | 659.72       | III |
| 30        | 5014.941     | I   | 25        | 5497.516     | I   | 150                      | 8220.41      | I   | 30        | 664.86       | III |
| 150       | 5041.755     | I   | 20        | 5501.464     | I   | 120                      | 8327.053     | I   | 40        | 672.34       | III |
| 30        | 5049.819     | I   | 30        | 5506.778     | I   | 20                       | 8331.908     | I   | 35        | 672.85       | III |
| 30        | 5051.634     | I   | 30        | 5569.618     | I   | 120                      | 8387.770     | I   | 35        | 676.57       | III |
| 25        | 5074.748     | I   | 60        | 5572.841     | I   | 30                       | 8468.404     | I   | 35        | 680.13       | III |
| 150       | 5110.357     | I   | 120       | 5586.755     | I   | 15                       | 8514.069     | I   | 35        | 683.68       | III |
| 40        | 5139.251     | I   | 200       | 5615.644     | I   | 60                       | 8661.898     | I   | 45        | 686.25       | III |
| 100       | 5139.462     | I   | 20        | 5624.541     | I   | 150                      | 8688.621     | I   | 45        | 687.98       | III |
| 25        | 5151.910     | I   | 50        | 5662.515     | I   | 52                       | 11422.32     | I   |           | 690.86       | V   |
| 12        | 5156.12      | III | 11        | 5719.88      | III | 87                       | 11439.12     | I   |           | 691.75       | V   |
| 80        | 5166.281     | I   | 10        | 5756.38      | III | 91                       | 11593.59     | I   | 45        | 691.93       | III |
| 2500      | 5167.487     | I   | 20        | 5762.990     | I   | 255                      | 11607.57     | I   | 50        | 695.61       | III |
| 80        | 5168.897     | I   | 18        | 5833.93      | III | 160                      | 11638.26     | I   | 30        | 698.05       | III |
| 500       | 5171.595     | I   | 10        | 5854.62      | III | 230                      | 11689.98     | I   | 50        | 708.36       | III |
| 50        | 5191.454     | I   | 30        | 5862.353     | I   | 160                      | 11783.26     | I   | 600       | 708.85       | V   |
| 80        | 5192.343     | I   | 15        | 5891.91      | III | 580                      | 11882.84     | I   | 50        | 714.00       | III |
| 200       | 5194.941     | I   | 30        | 5914.114     | I   | 225                      | 11884.08     | I   | 100 p     | 722.04       | III |
| 10        | 5199.08      | III | 10 p      | 5920.13      | III | 1030                     | 11973.05     | I   | 60        | 729.40       | II  |
| 30        | 5204.582     | I   | 18 p      | 5929.69      | III | 96                       | 14400.56     | I   | 30        | 746.70       | III |
| 25        | 5215.179     | I   | 10        | 5952.31      | III | 72                       | 14512.23     | I   | 200       | 761.18       | II  |
| 150       | 5216.274     | I   | 14        | 5953.62      | III | 50                       | 14555.06     | I   | 100       | 763.98       | II  |
| 60        | 5226.862     | I   | 12        | 5979.32      | III | 40                       | 14826.43     | I   | 60        | 766.20       | II  |
| 1000      | 5227.150     | I   | 30        | 5986.956     | I   | 94                       | 15294.58     | I   | 200       | 771.03       | II  |
| 250       | 5232.939     | I   | 12 h      | 5989.08      | III | 41                       | 15769.42     | I   | 60 p      | 773.69       | II  |
| 10        | 5235.66      | III | 18        | 5999.54      | III | 105                      | 18856.65     | I   | 200       | 782.10       | II  |
| 18        | 5243.31      | III | 16        | 6032.59      | III | <i>Krypton Kr Z = 36</i> |              |     | 100       | 783.72       | II  |
| 13 I      | 5260.34      | III | 13        | 6036.56      | III | 30                       | 467.35       | III | 60        | 785.97       | III |
| 100       | 5266.555     | I   | 11        | 6048.72      | III | 150                      | 472.16       | V   |           | 793.44       | IV  |
| 1200      | 5269.537     | I   | 11        | 6054.18      | III | 100                      | 484.39       | V   |           | 794.11       | IV  |
| 800       | 5270.357     | I   | 40        | 6065.482     | I   | 250                      | 496.25       | V   | 7         | 805.76       | IV  |
| 14        | 5272.98      | III | 30        | 6102.159     | I   | 120                      | 500.77       | V   |           | 810.70       | V   |
| 15        | 5276.48      | III | 40        | 6136.614     | I   | 200                      | 507.20       | V   | 18        | 816.82       | IV  |
| 30        | 5281.789     | I   | 40        | 6137.694     | I   | 30                       | 540.86       | III | 60        | 818.15       | II  |
| 16        | 5282.30      | III | 40        | 6191.558     | I   | 60                       | 548.04       | V   | 60        | 830.38       | II  |
| 60        | 5283.621     | I   | 30        | 6213.429     | I   | 30                       | 565.64       | III | 50        | 837.66       | III |
| 12        | 5284.83      | III | 30        | 6219.279     | I   | 30                       | 569.16       | III | 22        | 842.04       | IV  |
| 11        | 5298.12      | III | 40        | 6230.726     | I   | 30                       | 571.98       | III | 100       | 844.06       | II  |
| 12        | 5299.93      | III | 20        | 6246.317     | I   | 30                       | 579.83       | III | 50        | 854.73       | III |
| 25        | 5302.299     | I   | 80        | 6247.56      | II  | 30                       | 579.83       | III | 60        | 862.58       | III |
| 14 w      | 5302.60      | III | 30        | 6252.554     | I   | 30                       | 585.14       | III | 60        | 864.82       | II  |
| 10        | 5306.76      | III | 20        | 6393.602     | I   | 30                       | 585.96       | III | 60        | 868.87       | II  |
| 10        | 5322.74      | III | 30        | 6399.999     | I   | 30                       | 593.70       | III | 60        | 868.87       | II  |
| 150       | 5324.178     | I   | 20        | 6411.647     | I   | 30                       | 594.10       | III | 40        | 870.84       | III |
| 800       | 5328.038     | I   | 20        | 6421.349     | I   | 30                       | 596.41       | III | 50        | 876.08       | III |
| 300       | 5328.531     | I   | 30        | 6430.844     | I   | 40                       | 600.17       | III | 200       | 884.14       | II  |
| 100       | 5332.899     | I   | 200       | 6456.38      | II  | 30                       | 603.67       | III | 1000      | 886.30       | II  |
| 80        | 5339.928     | I   | 60        | 6494.981     | I   | 50                       | 605.86       | III | 400       | 891.01       | II  |
| 500       | 5341.023     | I   | 20        | 6546.239     | I   | 35                       | 606.47       | III | 75        | 897.81       | III |
| 11        | 5346.88      | III | 20        | 6592.913     | I   | 50                       | 611.12       | III | 200       | 911.39       | II  |
| 12        | 5353.77      | III | 40        | 6677.989     | I   | 35                       | 616.72       | III | 2000      | 917.43       | II  |
| 12        | 5363.76      | III | 25        | 7164.443     | I   | 40                       | 621.45       | III | 50        | 945.44       | I   |
|           |              |     |           |              |     | 45                       | 622.80       | III | 50        | 946.54       | I   |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 20        | 951.06       | I   | 60        | 2992.22      | III | 300       | 4057.037     | II  | 200       | 5468.17      | II  |
| 50        | 953.40       | I   | 50        | 3022.30      | III | 300       | 4065.128     | II  | 10        | 5501.43      | III |
| 50        | 963.37       | I   | 80        | 3024.45      | III | 50        | 4067.37      | III | 500       | 5562.224     | I   |
| 2000      | 964.97       | II  | 50        | 3046.93      | III | 500       | 4088.337     | II  | 2000      | 5570.288     | I   |
| 50        | 987.29       | III | 30        | 3056.72      | III | 250       | 4098.729     | II  | 80        | 5580.386     | I   |
| 100       | 1001.06      | I   | 60        | 3063.13      | III | 100       | 4109.248     | II  | 100       | 5649.561     | I   |
| 100       | 1003.55      | I   | 40        | 3097.16      | III | 40        | 4131.33      | III | 400       | 5681.89      | II  |
| 100       | 1030.02      | I   | 60        | 3112.25      | III | 250       | 4145.122     | II  | 200 h     | 5690.35      | II  |
| 30        | 1158.74      | III | 30        | 3120.61      | III | 40        | 4154.46      | III | 100       | 5832.855     | I   |
| 200       | 1164.87      | I   | 100       | 3124.39      | III | 150       | 4250.580     | II  | 3000      | 5870.914     | I   |
| 650       | 1235.84      | I   | 60        | 3141.35      | III | 1000      | 4273.969     | I   | 200       | 5992.22      | II  |
| 6         | 1638.82      | III | 3         | 3142.01      | IV  | 100       | 4282.967     | I   | 60        | 5993.849     | I   |
| 6         | 1914.09      | III | 100       | 3189.11      | III | 600       | 4292.923     | II  | 10 h      | 6037.17      | III |
| 3         | 2237.34      | IV  | 80        | 3191.21      | III | 200       | 4300.49      | II  | 60        | 6056.125     | I   |
| 6         | 2291.26      | IV  | 6         | 3224.99      | IV  | 500 h     | 4317.81      | II  | 10 h      | 6078.38      | III |
| 3         | 2329.3       | IV  | 40        | 3239.52      | III | 400       | 4318.551     | I   | 10        | 6310.22      | III |
| 4         | 2336.75      | IV  | 40        | 3240.44      | III | 1000      | 4319.579     | I   | 300       | 6420.18      | II  |
| 4         | 2348.27      | IV  | 300       | 3245.69      | III | 150 h     | 4322.98      | II  | 100       | 6421.026     | I   |
| 3         | 2358.5       | IV  | 3         | 3261.70      | IV  | 100       | 4351.359     | I   | 200       | 6456.288     | I   |
| 3         | 2388.05      | IV  | 150       | 3264.81      | III | 3000      | 4355.477     | II  | 150       | 6570.07      | II  |
| 40        | 2393.94      | III | 100       | 3268.48      | III | 500       | 4362.641     | I   | 60        | 6699.228     | I   |
| 4         | 2416.9       | IV  | 30        | 3271.65      | III | 200       | 4369.69      | II  | 100       | 6904.678     | I   |
| 3         | 2428.04      | IV  | 30        | 3285.89      | III | 800       | 4376.121     | I   | 250       | 7213.13      | II  |
| 5         | 2442.68      | IV  | 30        | 3304.75      | III | 300 h     | 4386.54      | II  | 100       | 7224.104     | I   |
| 4         | 2451.7       | IV  | 50        | 3311.47      | III | 200       | 4399.965     | I   | 80        | 7287.258     | I   |
| 6         | 2459.74      | IV  | 200       | 3325.75      | III | 100       | 4425.189     | I   | 400       | 7289.78      | II  |
| 100 h     | 2464.77      | II  | 60        | 3330.76      | III | 500       | 4431.685     | II  | 400       | 7407.02      | II  |
| 5         | 2474.06      | IV  | 50        | 3342.48      | III | 600       | 4436.812     | II  | 60        | 7425.541     | I   |
| 60        | 2492.48      | II  | 100       | 3351.93      | III | 600       | 4453.917     | I   | 200       | 7435.78      | II  |
| 40        | 2494.01      | III | 40        | 3374.96      | III | 800       | 4463.689     | I   | 100       | 7486.862     | I   |
| 4         | 2517.0       | IV  | 100       | 3439.46      | III | 800       | 4475.014     | II  | 300       | 7524.46      | II  |
| 5         | 2518.02      | IV  | 70        | 3474.65      | III | 400 h     | 4489.88      | II  | 1000      | 7587.411     | I   |
| 6         | 2519.38      | IV  | 100       | 3488.59      | III | 600       | 4502.353     | I   | 2000      | 7601.544     | I   |
| 5         | 2524.5       | IV  | 200       | 3507.42      | III | 400 h     | 4523.14      | II  | 150       | 7641.16      | II  |
| 5         | 2546.0       | IV  | 100       | 3564.23      | III | 200 h     | 4556.61      | II  | 1000      | 7685.244     | I   |
| 6         | 2547.0       | IV  | 100 h     | 3607.88      | II  | 800       | 4577.209     | II  | 1200      | 7694.538     | I   |
| 4         | 2558.08      | IV  | 200       | 3631.889     | II  | 300       | 4582.978     | II  | 250       | 7735.69      | II  |
| 30        | 2563.25      | III | 30        | 3641.34      | III | 150 h     | 4592.80      | II  | 150       | 7746.827     | I   |
| 3         | 2586.9       | IV  | 250       | 3653.928     | II  | 500       | 4615.292     | II  | 800       | 7854.821     | I   |
| 5         | 2606.17      | IV  | 80        | 3665.324     | I   | 1000      | 4619.166     | II  | 200       | 7913.423     | I   |
| 10        | 2609.5       | IV  | 150       | 3669.01      | II  | 800       | 4633.885     | II  | 180       | 7928.597     | I   |
| 8         | 2615.3       | IV  | 100       | 3679.559     | I   | 2000      | 4658.876     | II  | 200       | 7933.22      | II  |
| 7         | 2621.11      | IV  | 80        | 3686.182     | II  | 500       | 4680.406     | II  | 120       | 7973.62      | II  |
| 60        | 2639.76      | III | 30        | 3690.65      | III | 100       | 4691.301     | II  | 100       | 7982.401     | I   |
| 30        | 2680.32      | III | 300 h     | 3718.02      | II  | 200       | 4694.360     | II  | 1500      | 8059.503     | I   |
| 40        | 2681.19      | III | 200       | 3718.595     | II  | 3000      | 4739.002     | II  | 4000      | 8104.364     | I   |
| 80 h      | 2712.40      | II  | 150       | 3721.350     | II  | 300       | 4762.435     | II  | 6000      | 8112.899     | I   |
| 3         | 2730.55      | IV  | 200       | 3741.638     | II  | 1000      | 4765.744     | II  | 60        | 8132.967     | I   |
| 8         | 2748.18      | IV  | 150       | 3744.80      | II  | 300       | 4811.76      | II  | 3000      | 8190.054     | I   |
| 6         | 2774.70      | IV  | 80        | 3754.245     | II  | 300       | 4825.18      | II  | 200       | 8202.72      | II  |
| 3         | 2829.60      | IV  | 500       | 3778.089     | II  | 800       | 4832.077     | II  | 80        | 8218.365     | I   |
| 100       | 2833.00      | II  | 500       | 3783.095     | II  | 700       | 4846.612     | II  | 3000      | 8263.240     | I   |
| 3         | 2836.08      | IV  | 3         | 3809.30      | IV  | 150       | 4857.20      | II  | 100       | 8272.353     | I   |
| 30        | 2841.00      | III | 5         | 3860.58      | IV  | 300       | 4945.59      | II  | 1500      | 8281.050     | I   |
| 30        | 2851.16      | III | 40 h      | 3868.70      | III | 20 h      | 5016.45      | III | 5000      | 8298.107     | I   |
| 5         | 2853.0       | IV  | 150 h     | 3875.44      | II  | 200       | 5022.40      | II  | 100       | 8412.430     | I   |
| 3         | 2859.3       | IV  | 150       | 3906.177     | II  | 250       | 5086.52      | II  | 3000      | 8508.870     | I   |
| 50        | 2870.61      | III | 200       | 3920.081     | II  | 400 h     | 5125.73      | II  | 150       | 8764.110     | I   |
| 100       | 2892.18      | III | 5         | 3934.29      | IV  | 500       | 5208.32      | II  | 6000      | 8776.748     | I   |
| 30        | 2909.17      | III | 100       | 3994.840     | II  | 200       | 5308.66      | II  | 2000      | 8928.692     | I   |
| 50        | 2952.56      | III | 100 h     | 3997.793     | II  | 500       | 5333.41      | II  | 500       | 9238.48      | II  |

| Intensity | Wavelength/Å |    | Intensity                  | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|----------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 500 hl    | 9293.82      | II | 2600                       | 18167.315    | I   | 10000     | 1523.79      | III | 410       | 4619.88      | II  |
| 200 h     | 9320.99      | II | 100                        | 18399.786    | I   | 4000      | 1808.66      | IV  | 540       | 4655.50      | II  |
| 300       | 9361.95      | II | 150                        | 18580.896    | I   | 5000      | 1902.97      | IV  | 360       | 4662.51      | II  |
| 100       | 9362.082     | I  | 300                        | 18696.294    | I   | 4000 c    | 2197.45      | IV  | 230       | 4692.50      | II  |
| 200 h     | 9402.82      | II | 170                        | 18785.460    | I   | 770       | 2256.76      | II  | 230       | 4728.42      | II  |
| 200 h     | 9470.93      | II | 200                        | 18797.703    | I   | 25000 w   | 2417.58      | IV  | 500       | 4740.28      | II  |
| 500       | 9577.52      | II | 140                        | 20209.878    | I   | 50000     | 2532.75      | IV  | 390       | 4743.09      | II  |
| 500 h     | 9605.80      | II | 300                        | 20423.964    | I   | 45000     | 2582.05      | IV  | 320       | 4748.73      | II  |
| 400 h     | 9619.61      | II | 140                        | 20446.971    | I   | 95000 w   | 2597.50      | IV  | 320       | 4860.91      | II  |
| 200       | 9663.34      | II | 600                        | 21165.471    | I   | 70000 w   | 2662.75      | IV  | 850       | 4899.92      | II  |
| 200 h     | 9711.60      | II | 1800                       | 21902.513    | I   | 420       | 2808.39      | II  | 1000      | 4920.98      | II  |
| 2000      | 9751.758     | I  | 120                        | 22485.775    | I   | 50000 w   | 2848.30      | IV  | 1000      | 4921.79      | II  |
| 500       | 9803.14      | II | 180                        | 23340.416    | I   | 30000 c   | 2962.58      | IV  | 370       | 4949.77      | I   |
| 500       | 9856.314     | I  | 120                        | 24260.506    | I   | 70000 w   | 3009.51      | IV  | 340       | 4970.39      | II  |
| 1000      | 10221.46     | II | 180                        | 24292.221    | I   | 90000 c   | 3056.68      | IV  | 370       | 4986.83      | II  |
| 100       | 11187.108    | I  | 600                        | 25233.820    | I   | 1000      | 3171.63      | III | 720       | 4999.47      | II  |
| 200       | 11257.711    | I  | 180                        | 28610.55     | I   | 1500      | 3171.74      | III | 210       | 5050.57      | I   |
| 150       | 11259.126    | I  | 1000                       | 28655.72     | I   | 510       | 3245.13      | II  | 470       | 5114.56      | II  |
| 500       | 11457.481    | I  | 150                        | 28769.71     | I   | 550       | 3265.67      | II  | 470       | 5122.99      | II  |
| 150       | 11792.425    | I  | 140                        | 28822.49     | I   | 800       | 3303.11      | II  | 450       | 5145.42      | I   |
| 1500      | 11819.377    | I  | 300                        | 29236.69     | I   | 1500      | 3337.49      | II  | 290       | 5158.69      | I   |
| 600       | 11997.105    | I  | 300                        | 30663.54     | I   | 870       | 3344.56      | II  | 580       | 5177.31      | I   |
| 160       | 12077.224    | I  | 300                        | 30979.16     | I   | 1500      | 3380.91      | II  | 850       | 5183.42      | II  |
| 100       | 12861.892    | I  | 500                        | 39300.6      | I   | 320       | 3628.83      | II  | 260       | 5188.22      | II  |
| 1100      | 13177.412    | I  | 1100                       | 39486.52     | I   | 1000      | 3645.42      | II  | 720       | 5211.86      | I   |
| 1000      | 13622.415    | I  | 220                        | 39557.25     | I   | 550       | 3713.54      | II  | 520       | 5234.27      | I   |
| 2400      | 13634.220    | I  | 100                        | 39572.60     | I   | 2400      | 3759.08      | II  | 340       | 5253.46      | I   |
| 800       | 13658.394    | I  | 1400                       | 39588.4      | I   | 3700      | 3790.83      | II  | 370       | 5271.19      | I   |
| 200       | 13711.036    | I  | 1100                       | 39589.6      | I   | 3900      | 3794.78      | II  | 370       | 5301.98      | II  |
| 600       | 13738.851    | I  | 500                        | 39954.8      | I   | 600       | 3840.72      | II  | 180       | 5303.55      | II  |
| 150       | 13974.027    | I  | 300                        | 39966.6      | I   | 1600      | 3849.02      | II  | 500       | 5455.15      | I   |
| 550       | 14045.657    | I  | 1300                       | 40306.1      | I   | 3400      | 3871.64      | II  | 470       | 5501.34      | I   |
| 140       | 14104.298    | I  | 250                        | 40685.16     | I   | 1700      | 3886.37      | II  | 240       | 5648.25      | I   |
| 180       | 14402.22     | I  | <i>Lanthanum La Z = 57</i> |              |     | 1300      | 3916.05      | II  | 180       | 5740.66      | I   |
| 2000      | 14426.793    | I  | 100                        | 344.12       | IV  | 1100      | 3921.54      | II  | 370       | 5769.34      | I   |
| 100       | 14517.84     | I  | 400                        | 390.72       | V   | 2200      | 3929.22      | II  | 320       | 5789.24      | I   |
| 1600      | 14734.436    | I  | 1000                       | 432.11       | V   | 9000      | 3949.10      | II  | 450       | 5791.34      | I   |
| 550       | 14762.672    | I  | 2500                       | 435.28       | V   | 4400      | 3988.52      | II  | 140       | 5821.99      | I   |
| 450       | 14765.472    | I  | 10000                      | 463.14       | IV  | 3600      | 3995.75      | II  | 320       | 5930.62      | I   |
| 400       | 14961.894    | I  | 5000                       | 482.16       | V   | 2800      | 4031.69      | II  | 720       | 6249.93      | I   |
| 120       | 15005.307    | I  | 7000                       | 498.08       | V   | 3000      | 4042.91      | II  | 260 d     | 6262.30      | II  |
| 140       | 15209.526    | I  | 15000                      | 499.54       | IV  | 850       | 4067.39      | II  | 450       | 6394.23      | I   |
| 1700      | 15239.615    | I  | 10000                      | 503.58       | V   | 2800      | 4077.35      | II  | 250       | 6455.99      | I   |
| 130       | 15326.480    | I  | 12000                      | 526.76       | V   | 5500      | 4086.72      | II  | 180       | 6709.50      | I   |
| 1500      | 15334.958    | I  | 10000                      | 531.07       | V   | 4400      | 4123.23      | II  | 110       | 7045.96      | I   |
| 700       | 15372.037    | I  | 15000                      | 533.23       | V   | 550       | 4141.74      | II  | 160       | 7066.23      | II  |
| 200       | 15474.026    | I  | 8000                       | 547.44       | V   | 1100      | 4151.97      | II  | 50        | 7161.25      | I   |
| 180       | 15681.02     | I  | 40000                      | 552.02       | IV  | 1500      | 4196.55      | II  | 110 w     | 7282.34      | II  |
| 120       | 15820.09     | I  | 5000                       | 600.24       | V   | 1600      | 4238.38      | II  | 110 w     | 7334.18      | I   |
| 200       | 16726.513    | I  | 30000                      | 631.26       | IV  | 480       | 4269.50      | II  | 75 cw     | 7483.50      | II  |
| 2000      | 16785.128    | I  | 400                        | 796.99       | III | 600       | 4286.97      | II  | 50        | 7498.83      | I   |
| 1000      | 16853.488    | I  | 2000                       | 870.40       | III | 600       | 4296.05      | II  | 85        | 7539.23      | I   |
| 2400      | 16890.441    | I  | 1000                       | 882.34       | III | 440       | 4322.51      | II  | 40        | 7964.83      | I   |
| 1600      | 16896.753    | I  | 400                        | 942.86       | III | 4600      | 4333.74      | II  | 75        | 8086.05      | I   |
| 1800      | 16935.806    | I  | 50000                      | 1081.61      | III | 550       | 4354.40      | II  | 85        | 8324.69      | I   |
| 600       | 17098.771    | I  | 95000                      | 1099.73      | III | 2000      | 4429.90      | II  | 95        | 8346.53      | I   |
| 700       | 17367.606    | I  | 2000                       | 1255.63      | III | 850       | 4522.37      | II  | 65        | 8545.44      | I   |
| 120       | 17404.443    | I  | 10000                      | 1349.18      | III | 420       | 4526.12      | II  | 300       | 8583.45      | III |
| 150       | 17616.854    | I  | 25000                      | 1368.04      | IV  | 400       | 4558.46      | II  | 40        | 8674.43      | I   |
| 650       | 17842.737    | I  | 20000                      | 1463.47      | IV  | 400       | 4574.88      | II  | 35        | 8825.82      | I   |
| 700       | 18002.229    | I  | 15000                      | 1507.87      | IV  | 410       | 4613.39      | II  | 120       | 9184.38      | III |



| Intensity             | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity               | Wavelength/Å |     |
|-----------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-------------------------|--------------|-----|
| 100                   | 9212.63      | III | 15        | 1056.53      | IV  | 20        | 2259.01      | V   | 100                     | 5006.572     | I   |
| 140                   | 10284.79     | III | 10        | 1060.66      | II  | 150       | 2332.418     | I   | 50                      | 5089.484     | I   |
| <b>Lead Pb Z = 82</b> |              |     | 12        | 1072.09      | IV  | 16        | 2359.53      | IV  | 10                      | 5107.242     | I   |
| 10                    | 496.38       | IV  | 18        | 1080.81      | IV  | 180       | 2388.797     | I   | 2000                    | 5201.437     | I   |
| 12                    | 499.94       | IV  | 20        | 1084.17      | IV  | 550 r     | 2393.792     | I   | 10                      | 5372.099     | II  |
| 14                    | 529.78       | IV  | 10        | 1088.86      | V   | 140       | 2399.597     | I   | 40                      | 5692.346     | I   |
| 20                    | 570.16       | IV  | 10        | 1103.94      | II  | 320 r     | 2401.940     | I   | 200                     | 5895.624     | I   |
| 10                    | 648.50       | IV  | 10        | 1108.43      | II  | 320 r     | 2411.734     | I   | 2000                    | 6001.862     | I   |
| 20                    | 703.73       | V   | 10        | 1109.84      | II  | 16        | 2417.61      | IV  | 500                     | 6011.667     | I   |
| 12                    | 749.46       | V   | 20        | 1116.08      | IV  | 15        | 2424.81      | V   | 500                     | 6059.356     | I   |
| 10                    | 752.52       | V   | 10        | 1119.57      | II  | 150 r     | 2443.829     | I   | 40                      | 6081.409     | II  |
| 10                    | 761.09       | IV  | 10        | 1121.36      | II  | 160 r     | 2446.181     | I   | 50                      | 6110.520     | I   |
| 18                    | 767.45       | V   | 10        | 1133.14      | II  | 130 r     | 2476.378     | I   | 100                     | 6235.266     | I   |
| 18                    | 769.49       | V   | 18        | 1137.84      | IV  | 80 r      | 2577.260     | I   | 50 c                    | 6660.20      | II  |
| 14                    | 771.42       | V   | 14        | 1144.93      | IV  | 500 r     | 2613.655     | I   | 20000                   | 7228.965     | I   |
| 14                    | 782.79       | V   | 12        | 1157.88      | V   | 900 r     | 2614.175     | I   | 10                      | 7346.676     | I   |
| 15                    | 797.02       | V   | 14        | 1185.43      | V   | 160       | 2628.262     | I   | 20                      | 7809.259     | I   |
| 18                    | 802.07       | IV  | 20        | 1189.95      | IV  | 4         | 2634.256     | II  | 5                       | 7896.737     | I   |
| 12                    | 802.82       | IV  | 10        | 1203.63      | II  | 10        | 2657.094     | I   | 10                      | 8168.001     | I   |
| 18                    | 809.63       | V   | 10        | 1231.20      | II  | 700       | 2663.154     | I   | 6                       | 8191.886     | I   |
| 10                    | 812.59       | IV  | 11        | 1233.50      | V   | 10        | 2697.541     | I   | 5                       | 8217.711     | I   |
| 10                    | 827.41       | IV  | 10        | 1291.10      | IV  | 25000 r   | 2801.995     | I   | 40                      | 8272.690     | I   |
| 12                    | 832.60       | IV  | 20        | 1313.05      | IV  | 100       | 2822.58      | I   | 20                      | 8409.384     | I   |
| 12                    | 845.94       | IV  | 10        | 1331.65      | II  | 14000 r   | 2823.189     | I   | 10                      | 8478.492     | I   |
| 18                    | 857.64       | IV  | 10        | 1335.20      | II  | 35000 r   | 2833.053     | I   | 5                       | 8722.810     | I   |
| 16                    | 862.33       | IV  | 12        | 1343.06      | IV  | 6         | 2840.557     | II  | 10                      | 8857.457     | I   |
| 20                    | 863.97       | V   | 10        | 1348.37      | II  | 14000 r   | 2873.311     | I   | 8                       | 9293.476     | I   |
| 14                    | 870.44       | IV  | 16        | 1388.94      | IV  | 3         | 2914.442     | II  | 15                      | 9438.05      | I   |
| 6                     | 873.71       | II  | 18        | 1400.26      | IV  | 15        | 2966.460     | I   | 15                      | 9604.297     | I   |
| 12                    | 879.96       | IV  | 10        | 1404.34      | IV  | 15        | 2972.991     | I   | 15                      | 9674.351     | I   |
| 18                    | 883.90       | V   | 10        | 1433.96      | II  | 15        | 2980.157     | I   | 200                     | 10290.458    | I   |
| 14                    | 884.96       | IV  | 10        | 1512.42      | II  | 4         | 2986.876     | II  | 100                     | 10498.965    | I   |
| 14                    | 884.99       | IV  | 14        | 1535.71      | IV  | 10        | 3043.85      | III | 50                      | 10649.249    | I   |
| 14                    | 888.37       | V   | 20        | 1553.1       | III | 150       | 3118.894     | I   | 15                      | 10886.688    | I   |
| 8                     | 889.68       | II  | 10        | 1671.53      | II  | 10        | 3137.81      | III | 40                      | 10969.53     | I   |
| 16                    | 890.72       | IV  | 10        | 1682.15      | II  | 10        | 3176.50      | III |                         | 13512.6      | I   |
| 14                    | 894.40       | V   | 20        | 1726.75      | II  | 600       | 3220.528     | I   |                         | 14743.0      | I   |
| 12                    | 896.08       | V   | 10        | 1796.670     | II  | 100       | 3229.613     | I   |                         | 15349.6      | I   |
| 12                    | 908.51       | IV  | 10        | 1822.050     | II  | 400       | 3240.186     | I   |                         | 39039.4      | I   |
| 14                    | 915.71       | V   | 10        | 1904.77      | I   | 200       | 3262.355     | I   | <b>Lithium Li Z = 3</b> |              |     |
| 12                    | 917.90       | IV  | 7         | 1921.471     | II  | 35000     | 3572.729     | I   |                         | 102.9        | III |
| 12                    | 918.09       | V   | 12        | 1959.34      | IV  | 50000 r   | 3639.568     | I   |                         | 103.4        | III |
| 12                    | 920.28       | V   | 16        | 1973.16      | IV  | 20000     | 3671.491     | I   |                         | 104.1        | III |
| 12                    | 920.66       | V   | 10        | 1998.83      | V   | 70000 r   | 3683.462     | I   |                         | 105.5        | III |
| 10                    | 922.12       | IV  | 5 r       | 2022.02      | I   | 10        | 3713.982     | II  |                         | 108.0        | III |
| 12                    | 922.49       | IV  | 10        | 2042.58      | IV  | 25000     | 3739.935     | I   |                         | 113.9        | III |
| 10                    | 927.64       | IV  | 12        | 2049.34      | IV  | 12        | 3854.08      | III |                         | 125.5        | II  |
| 14                    | 932.20       | IV  | 8 r       | 2053.28      | I   | 15000     | 4019.632     | I   |                         | 135.0        | III |
| 12                    | 954.35       | V   | 12        | 2079.22      | IV  | 95000     | 4057.807     | I   |                         | 136.5        | II  |
| 10                    | 967.23       | II  | 6         | 2111.758     | I   | 14000     | 4062.136     | I   |                         | 140.5        | II  |
| 10                    | 986.71       | II  | 10        | 2115.066     | I   | 10        | 4157.814     | I   |                         | 167.21       | II  |
| 10                    | 995.89       | II  | 15        | 2154.01      | IV  | 10000     | 4168.033     | I   |                         | 168.74       | II  |
| 10                    | 1016.61      | II  | 500 r     | 2170.00      | I   | 8         | 4272.66      | III |                         | 171.58       | II  |
| 14                    | 1028.61      | IV  | 7         | 2175.580     | I   | 200       | 4340.413     | I   |                         | 178.02       | II  |
| 20                    | 1032.05      | IV  | 12        | 2177.46      | IV  | 10        | 4496.15      | IV  |                         | 199.28       | II  |
| 16                    | 1041.24      | IV  | 7         | 2187.888     | I   | 6         | 4499.34      | III |                         | 207.5        | II  |
| 18                    | 1044.14      | IV  | 8         | 2189.603     | I   | 16        | 4534.60      | IV  |                         | 456.         | II  |
| 12                    | 1048.9       | III | 10        | 2203.534     | II  | 7         | 4571.21      | III |                         | 483.         | II  |
| 10                    | 1049.82      | II  | 20        | 2237.425     | I   | 10        | 4579.051     | II  |                         | 540.         | II  |
| 10                    | 1050.77      | II  | 20        | 2246.86      | I   | 6         | 4761.12      | III |                         | 540.0        | III |
| 10                    | 1051.26      | V   | 25        | 2246.89      | I   | 1000      | 5005.416     | I   |                         | 729.         | II  |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å              |     |
|-----------|--------------|-----|-----------|--------------|----|-----------|--------------|----|-----------|---------------------------|-----|
|           | 729.1        | III |           | 2313.49      | I  | 5         | 3199.33      | II | 48        | 8126.23                   | I   |
|           | 800.         | II  |           | 2315.08      | I  | 2         | 3199.43      | II | 48        | 8126.45                   | I   |
|           | 820.         | II  |           | 2316.95      | I  | 17        | 3232.66      | I  |           | 8517.37                   | II  |
|           | 861.         | II  |           | 2319.18      | I  |           | 3249.87      | II |           | 9581.42                   | II  |
|           | 905.5        | II  |           | 2321.88      | I  |           | 3306.28      | II |           | 10120.                    | II  |
|           | 917.5        | II  |           | 2325.11      | I  |           | 3488.        | I  |           | 12232.                    | I   |
|           | 936.         | II  |           | 2329.02      | I  |           | 3579.8       | I  |           | 12782.                    | I   |
|           | 945.         | II  |           | 2329.84      | II |           | 3618.        | I  |           | 13566.                    | I   |
|           | 965.         | II  |           | 2333.94      | I  |           | 3662.        | I  |           | 17552.                    | I   |
|           | 972.         | II  | 3         | 2336.88      | II |           | 3684.32      | II |           | 18697.                    | I   |
|           | 988.         | II  | 5         | 2336.91      | II | 1         | 3714.00      | II |           | 19290.                    | I   |
|           | 1018.        | II  | 2         | 2337.00      | II | 5         | 3714.16      | II |           | 24467.                    | I   |
|           | 1032.        | II  |           | 2340.15      | I  | 6 d       | 3714.27      | II |           | 40475.                    | I   |
|           | 1036.        | II  |           | 2348.22      | I  | 8         | 3714.29      | II |           |                           |     |
|           | 1093.        | II  |           | 2358.93      | I  | 7 d       | 3714.40      | II |           | <i>Lutetium Lu Z = 71</i> |     |
|           | 1103.        | II  |           | 2373.54      | I  | 10        | 3714.41      | II | 100       | 563.72                    | V   |
|           | 1109.        | II  |           | 2381.54      | II | 1         | 3714.51      | II | 500       | 810.73                    | III |
|           | 1116.        | II  |           | 2383.20      | II |           | 3714.58      | II | 2000      | 832.28                    | III |
|           | 1132.1       | II  | 1         | 2394.39      | I  | 3         | 3718.7       | I  | 100       | 861.92                    | V   |
|           | 1141.        | II  |           | 2402.33      | II | 6         | 3794.72      | I  | 400       | 876.80                    | IV  |
|           | 1166.4       | II  |           | 2410.84      | II | 20        | 3915.30      | I  | 100       | 880.32                    | V   |
|           | 1198.09      | II  | 3         | 2425.43      | I  | 20        | 3915.35      | I  | 100       | 891.81                    | V   |
|           | 1215.        | II  |           | 2429.81      | II | 10        | 3985.48      | I  | 100       | 914.72                    | V   |
|           | 1238.        | II  |           | 2460.2       | I  | 10        | 3985.54      | I  | 400       | 1001.18                   | III |
|           | 1253.8       | II  | 10        | 2475.06      | I  | 40        | 4132.56      | I  | 100       | 1272.42                   | IV  |
|           | 1420.89      | II  |           | 2506.94      | II | 40        | 4132.62      | I  | 800       | 1333.79                   | IV  |
|           | 1424.        | II  |           | 2508.78      | II |           | 4196.        | I  | 400       | 1429.38                   | IV  |
| 3         | 1492.93      | II  |           | 2518.        | I  | 20        | 4273.07      | I  | 200       | 1441.76                   | V   |
| 5         | 1492.97      | II  |           | 2539.49      | II | 20        | 4273.13      | I  | 200       | 1453.35                   | V   |
| 1         | 1493.04      | II  | 24        | 2551.7       | II | 5         | 4325.42      | II | 200       | 1468.99                   | V   |
|           | 1555.        | II  |           | 2559.        | II | 5         | 4325.47      | II | 400       | 1472.12                   | V   |
| 3         | 1653.08      | II  | 15        | 2562.31      | I  | 1         | 4325.54      | II | 200       | 1473.71                   | V   |
| 5         | 1653.13      | II  |           | 2605.08      | II |           | 4516.45      | II | 200       | 1485.58                   | V   |
| 1         | 1653.21      | II  | 2         | 2657.29      | II | 13        | 4602.83      | I  | 400       | 1511.26                   | IV  |
|           | 1681.66      | II  | 3         | 2657.30      | II | 13        | 4602.89      | I  | 600       | 1772.57                   | IV  |
|           | 1755.33      | II  |           | 2674.46      | II |           | 4607.34      | II | 100 c     | 1786.25                   | V   |
|           | 2009.        | II  |           | 2728.24      | II |           | 4671.51      | II | 1000      | 1854.57                   | III |
|           | 2039.        | I   | 5         | 2728.29      | II | 6         | 4671.65      | II | 1500      | 2065.35                   | III |
|           | 2068.        | II  | 2         | 2728.32      | II | 2         | 4671.70      | II | 1500 c    | 2070.56                   | III |
|           | 2131.        | II  | 3         | 2730.47      | II | 3         | 4678.06      | II | 600 c     | 2086.47                   | IV  |
|           | 2164.        | II  | 1         | 2730.55      | II | 1         | 4678.29      | II | 1000 c    | 2104.41                   | IV  |
|           | 2173.4       | I   | 5         | 2741.20      | I  |           | 4760.        | I  | 1000 c    | 2108.31                   | IV  |
|           | 2183.        | II  |           | 2766.99      | II |           | 4763.        | II | 1700 h    | 2195.54                   | II  |
|           | 2214.        | II  |           | 2790.31      | II |           | 4788.36      | II | 1000      | 2236.14                   | III |
|           | 2222.        | II  |           | 2801.        | I  |           | 4843.0       | II | 2000      | 2236.22                   | III |
|           | 2237.        | II  |           | 2846.        | I  | 4         | 4881.32      | II | 95        | 2276.94                   | II  |
| h         | 2249.21      | II  |           | 2868.        | I  | 4         | 4881.39      | II | 190       | 2297.41                   | II  |
|           | 2286.82      | II  |           | 2895.        | I  | 1         | 4881.49      | II | 1300      | 2392.19                   | II  |
|           | 2302.57      | II  | 2         | 2934.02      | II | 8         | 4971.66      | I  | 120       | 2399.14                   | II  |
|           | 2303.33      | II  | 2         | 2934.07      | II | 8         | 4971.75      | I  | 80        | 2419.21                   | II  |
|           | 2304.59      | I   | 5         | 2934.12      | II |           | 5037.92      | II | 130       | 2459.64                   | II  |
|           | 2304.92      | I   | 1         | 2934.25      | II |           | 5271.        | I  | 370       | 2536.95                   | II  |
|           | 2305.36      | I   |           | 2968.        | I  |           | 5315.        | I  | 930       | 2571.23                   | II  |
|           | 2305.83      | I   | 3         | 3029.12      | II |           | 5395.        | I  | 1700      | 2578.79                   | II  |
|           | 2306.29      | I   | 3         | 3029.14      | II |           | 5440.        | I  | 4500 c    | 2603.35                   | III |
|           | 2306.82      | I   |           | 3144.        | I  | 600 c     | 5483.55      | II | 1800      | 2613.40                   | II  |
|           | 2307.44      | I   | 3         | 3155.31      | II | 600 c     | 5485.65      | II | 18000     | 2615.42                   | II  |
|           | 2308.97      | I   | 4         | 3155.33      | II | 320       | 6103.54      | I  | 1800      | 2619.26                   | II  |
|           | 2309.88      | I   | 1         | 3196.26      | II | 320       | 6103.65      | I  | 2700      | 2657.80                   | II  |
|           | 2310.94      | I   | 9         | 3196.33      | II | 3600      | 6707.76      | I  | 570 h     | 2685.08                   | I   |
|           | 2312.11      | I   | 4         | 3196.36      | II | 3600      | 6707.91      | I  | 4200      | 2701.71                   | II  |
|           |              |     |           |              |    |           |              |    | 180 d     | 2719.09                   | I   |

| Intensity | Wavelength/Å |     | Intensity                  | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    |
|-----------|--------------|-----|----------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|
| 480 h     | 2728.95      | I   | 250                        | 4281.03      | I   | 3000      | 323.31       | IV  | 1         | 2613.36      | I  |
| 3600      | 2754.17      | II  | 330 d                      | 4295.97      | I   | 30        | 353.09       | V   | 2         | 2614.73      | I  |
| 750 h     | 2765.74      | I   | 150                        | 4309.57      | I   | 150       | 857.29       | IV  | 3         | 2617.51      | I  |
| 2000      | 2772.55      | III | 190 c                      | 4430.48      | I   | 50        | 919.03       | IV  | 3         | 2628.66      | I  |
| 2700      | 2796.63      | II  | 190                        | 4450.81      | I   | 250       | 1037.41      | IV  | 6         | 2630.05      | I  |
| 270 c     | 2834.35      | II  | 3300                       | 4518.57      | I   | 300       | 1210.99      | IV  | 8         | 2632.87      | I  |
| 330 h     | 2845.13      | I   | 100 h                      | 4648.21      | I   | 300       | 1342.19      | IV  | 2         | 2644.80      | I  |
| 3000      | 2847.51      | II  | 1000                       | 4658.02      | I   | 800       | 1346.57      | IV  | 3         | 2646.21      | I  |
| 570 h     | 2885.14      | I   | 85 h                       | 4659.03      | I   | 300       | 1346.68      | IV  | 4         | 2649.06      | I  |
| 6300      | 2894.84      | II  | 150                        | 4785.42      | II  | 600       | 1352.05      | IV  | 8         | 2660.76      | II |
| 4500      | 2900.30      | II  | 85                         | 4815.05      | I   | 900       | 1384.46      | IV  | 8         | 2660.82      | II |
| 300       | 2903.05      | I   | 460                        | 4904.88      | I   | 500       | 1385.77      | IV  | 6         | 2668.12      | I  |
| 9000      | 2911.39      | II  | 180                        | 4942.34      | I   | 800       | 1387.53      | IV  | 8         | 2669.55      | I  |
| 270 h     | 2949.73      | I   | 800                        | 4994.13      | II  | 300       | 1404.68      | IV  | 10        | 2672.46      | I  |
| 1200      | 2951.69      | II  | 800                        | 5001.14      | I   | 1000      | 1409.36      | IV  | 3         | 2693.72      | I  |
| 4200      | 2963.32      | II  | 140                        | 5134.05      | I   | 500       | 1437.53      | IV  | 5         | 2695.18      | I  |
| 2400      | 2969.82      | II  | 2700                       | 5135.09      | I   | 1000      | 1437.64      | IV  | 6         | 2698.14      | I  |
| 1800      | 2989.27      | I   | 170                        | 5196.61      | I   | 300       | 1447.42      | IV  | 8         | 2731.99      | I  |
| 3000      | 3020.54      | II  | 500                        | 5402.57      | I   | 300       | 1459.54      | IV  | 10        | 2733.49      | I  |
| 2100      | 3056.72      | II  | 140 c                      | 5421.90      | I   | 400       | 1459.62      | IV  | 12        | 2736.53      | I  |
| 1000      | 3057.86      | III | 100                        | 5437.88      | I   | 400       | 1481.51      | IV  | 5         | 2765.22      | I  |
| 7500      | 3077.60      | II  | 2100                       | 5476.69      | II  | 350       | 1490.45      | IV  | 7         | 2768.34      | I  |
| 390       | 3080.11      | I   | 550                        | 5736.55      | I   | 300       | 1495.50      | IV  | 38        | 2776.69      | I  |
| 5100 h    | 3081.47      | I   | 80                         | 5800.59      | I   | 300       | 1607.11      | IV  | 32        | 2778.27      | I  |
| 3000      | 3118.43      | I   | 690 cw                     | 5983.9       | II  | 5         | 1668.43      | I   | 90        | 2779.83      | I  |
| 2400      | 3171.36      | I   | 140                        | 5997.13      | I   | 500       | 1683.02      | IV  | 8         | 2781.29      | I  |
| 260       | 3191.80      | II  | 1400                       | 6004.52      | I   | 10        | 1683.41      | I   | 32        | 2781.42      | I  |
| 1400      | 3198.12      | II  | 440                        | 6055.03      | I   | 400       | 1698.81      | IV  | 36        | 2782.97      | I  |
| 4800      | 3254.31      | II  | 150                        | 6159.94      | II  | 15        | 1707.06      | I   | 1000      | 2795.53      | II |
| 3800      | 3278.97      | I   | 600                        | 6198.13      | III | 40        | 1734.84      | II  | 600       | 2802.70      | II |
| 7600      | 3281.74      | I   | 160                        | 6199.66      | II  | 50        | 1737.62      | II  | 3         | 2809.76      | I  |
| 6200      | 3312.11      | I   | 2100                       | 6221.87      | II  | 20        | 1747.80      | I   | 2         | 2811.11      | I  |
| 7600      | 3359.56      | I   | 80                         | 6235.36      | II  | 40        | 1750.65      | II  | 1         | 2811.78      | I  |
| 6200      | 3376.50      | I   | 160                        | 6242.34      | II  | 50        | 1753.46      | II  | 12        | 2846.72      | I  |
| 950       | 3385.50      | I   | 70 h                       | 6345.35      | I   | 30        | 1827.93      | I   | 12        | 2846.75      | I  |
| 160 h     | 3391.55      | I   | 1100                       | 6463.12      | II  | 300       | 1844.17      | IV  | 14        | 2848.34      | I  |
| 1400      | 3396.82      | I   | 29                         | 6477.67      | I   | 9         | 2025.82      | I   | 14        | 2848.42      | I  |
| 4100      | 3397.07      | II  | 55 c                       | 6523.18      | I   | 25        | 2064.90      | III | 16        | 2851.65      | I  |
| 4800      | 3472.48      | II  | 35 cw                      | 6611.28      | II  | 20        | 2091.96      | III | 16        | 2851.66      | I  |
| 8300 c    | 3507.39      | II  | 23 c                       | 6677.14      | I   | 20        | 2177.70      | III | 6000      | 2852.13      | I  |
| 1600      | 3508.42      | I   | 30 c                       | 6793.77      | I   | 3         | 2329.58      | II  | 2         | 2902.92      | I  |
| 4800      | 3554.43      | II  | 45                         | 6917.31      | I   | 20        | 2395.15      | III | 4         | 2906.36      | I  |
| 4800      | 3567.84      | I   | 23                         | 7031.24      | I   | 6         | 2449.57      | II  | 3         | 2915.45      | I  |
| 340       | 3596.34      | I   | 45                         | 7125.84      | II  | 1         | 2557.23      | I   | 10        | 2936.74      | I  |
| 800       | 3623.99      | II  | 14 ch                      | 7237.98      | I   | 1         | 2560.94      | I   | 12        | 2938.47      | I  |
| 680       | 3636.25      | I   | 11 c                       | 7441.52      | I   | 1         | 2562.26      | I   | 2         | 2942.00      | I  |
| 2600      | 3647.77      | I   | 9 c                        | 8178.16      | I   | 1         | 2564.94      | I   | 13        | 2942.00      | I  |
| 110       | 3756.70      | I   | 17                         | 8382.08      | I   | 1         | 2570.91      | I   | 20        | 3091.08      | I  |
| 110       | 3756.79      | I   | 35                         | 8459.19      | II  | 1         | 2572.25      | I   | 22        | 3092.99      | I  |
| 150       | 3800.67      | I   | 10 d                       | 8478.50      | I   | 2         | 2574.94      | I   | 14        | 3096.90      | I  |
| 2700      | 3841.18      | I   | 29 c                       | 8508.08      | I   | 1         | 2577.89      | I   | 9         | 3104.71      | II |
| 530       | 3876.65      | II  | 35 c                       | 8610.98      | I   | 1         | 2580.59      | I   | 8         | 3104.81      | II |
| 50        | 3918.86      | I   | <i>Magnesium Mg Z = 12</i> |              |     | 1         | 2584.22      | I   | 6         | 3168.98      | II |
| 480       | 3968.46      | I   | 400                        | 146.95       | IV  | 2         | 2585.56      | I   | 6         | 3172.71      | II |
| 670       | 4054.45      | I   | 20                         | 186.51       | III | 3         | 2588.28      | I   | 7         | 3175.78      | II |
| 310       | 4122.49      | I   | 20                         | 187.20       | III | 1         | 2591.89      | I   | 2         | 3197.62      | I  |
| 3100      | 4124.73      | I   | 10                         | 188.53       | III | 1         | 2593.23      | I   | 17        | 3329.93      | I  |
| 150 c     | 4131.79      | I   | 100                        | 231.73       | III | 2         | 2595.97      | I   | 6         | 3332.15      | I  |
| 460       | 4154.08      | I   | 80                         | 234.26       | III | 2         | 2602.50      | I   | 9         | 3336.68      | I  |
| 1600      | 4184.25      | II  | 35                         | 276.58       | V   | 4         | 2603.85      | I   | 7         | 3535.04      | II |
| 150       | 4277.50      | I   | 4000                       | 320.99       | IV  | 5         | 2606.62      | I   | 8         | 3538.86      | II |

| Intensity | Wavelength/Å |    | Intensity                  | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|----------------------------|--------------|----|-----------|--------------|-----|-----------|--------------|-----|
| 7         | 3549.52      | II | 12                         | 8712.69      | I  | 90        | 1264.41      | IV  | 500       | 2066.38      | III |
| 8         | 3553.37      | II | 13                         | 8717.83      | I  | 500       | 1283.58      | III | 1000      | 2069.02      | III |
| 140       | 3829.30      | I  | 10                         | 8734.99      | II | 400       | 1287.59      | III | 30        | 2076.21      | II  |
| 300       | 3832.30      | I  | 17                         | 8736.02      | I  | 300       | 1291.62      | III | 900       | 2077.38      | III |
| 500       | 3838.29      | I  | 11                         | 8745.66      | II | 1000      | 1360.72      | III | 800       | 2084.23      | III |
| 8         | 3848.24      | II | 14                         | 8806.76      | I  | 800       | 1365.20      | III | 600       | 2090.05      | III |
| 7         | 3850.40      | II | 10                         | 8824.32      | II | 500 h     | 1609.17      | III | 1500      | 2092.16      | I   |
| 3         | 3878.31      | I  | 11                         | 8835.08      | II | 1000      | 1614.14      | III | 500       | 2094.78      | III |
| 3         | 3895.57      | I  | 20                         | 8923.57      | I  | 2000      | 1620.60      | III | 20        | 2097.46      | II  |
| 4         | 3903.86      | I  | 10                         | 8997.16      | I  | 500       | 1633.80      | III | 500       | 2097.93      | III |
| 6         | 3938.40      | I  | 14                         | 9218.25      | II | 80        | 1667.00      | IV  | 500       | 2099.97      | III |
| 8         | 3986.75      | I  | 13                         | 9244.27      | II | 80        | 1698.30      | IV  | 20        | 2102.50      | II  |
| 10        | 4057.50      | I  | 12                         | 9246.50      | I  | 20        | 1726.47      | II  | 1700      | 2109.58      | I   |
| 15        | 4167.27      | I  | 30                         | 9255.78      | I  | 30        | 1732.70      | II  | 30        | 2113.96      | II  |
| 20        | 4351.91      | I  | 10                         | 9327.54      | II | 50        | 1733.55      | II  | 1000      | 2169.78      | III |
| 9         | 4384.64      | II | 10                         | 9340.54      | II | 40        | 1734.49      | II  | 700       | 2174.15      | III |
| 10        | 4390.59      | II | 25                         | 9414.96      | I  | 30        | 1737.93      | II  | 900       | 2176.87      | III |
| 8         | 4428.00      | II | 17                         | 9429.81      | I  | 20        | 1740.16      | II  | 800       | 2181.86      | III |
| 9         | 4433.99      | II | 19                         | 9432.76      | I  | 20        | 1742.00      | II  | 800       | 2184.87      | III |
| 14        | 4481.16      | II | 20                         | 9438.78      | I  | 85        | 1742.10      | IV  | 290       | 2208.81      | I   |
| 13        | 4481.33      | II | 12                         | 9631.89      | II | 85        | 1766.27      | IV  | 540       | 2213.85      | I   |
| 28        | 4571.10      | I  | 11                         | 9632.43      | II | 80        | 1795.65      | IV  | 900       | 2220.55      | III |
| 10        | 4730.03      | I  | 15                         | 9953.20      | I  | 80        | 1795.79      | IV  | 770       | 2221.84      | I   |
| 7         | 4851.10      | II | 15                         | 9983.20      | I  | 30        | 1853.27      | II  | 1000      | 2227.42      | III |
| 75        | 5167.33      | I  | 17                         | 9986.47      | I  | 20        | 1857.92      | II  | 20        | 2373.36      | II  |
| 220       | 5172.68      | I  | 18                         | 9993.21      | I  | 50        | 1902.95      | II  | 20        | 2427.38      | II  |
| 400       | 5183.61      | I  | 14                         | 10092.16     | II | 20        | 1907.84      | II  | 50        | 2427.72      | II  |
| 8         | 5264.21      | II | 35                         | 10811.08     | I  | 75        | 1910.25      | IV  | 30        | 2427.94      | II  |
| 7         | 5264.37      | II | 11                         | 10914.23     | II | 30        | 1911.41      | II  | 30        | 2437.37      | II  |
| 9         | 5401.54      | II | 10                         | 10951.78     | II | 20 d      | 1914.68      | II  | 20        | 2437.84      | II  |
| 6         | 5528.41      | I  | 25                         | 10953.32     | I  | 100       | 1915.10      | II  | 30        | 2452.49      | II  |
| 30        | 5711.09      | I  | 27                         | 10957.30     | I  | 20        | 1918.64      | II  | 50        | 2499.00      | II  |
| 10        | 6318.72      | I  | 28                         | 10965.45     | I  | 30        | 1919.64      | II  | 30        | 2507.60      | II  |
| 9         | 6319.24      | I  | 15                         | 11032.10     | I  | 80        | 1921.25      | II  | 20        | 2516.60      | II  |
| 7         | 6319.49      | I  | 14                         | 11033.66     | I  | 20        | 1923.07      | II  | 30        | 2516.74      | II  |
| 10        | 6346.74      | II | 45                         | 11828.18     | I  | 20        | 1923.34      | II  | 20        | 2521.66      | II  |
| 9         | 6346.96      | II | 30                         | 12083.66     | I  | 30        | 1925.52      | II  | 20        | 2530.72      | II  |
| 11        | 6545.97      | II | 28                         | 14877.62     | I  | 50        | 1926.59      | II  | 20        | 2531.80      | II  |
| 7         | 6781.45      | II | 35                         | 15024.99     | I  | 30        | 1931.40      | II  | 50        | 2532.78      | II  |
| 8         | 6787.85      | II | 30                         | 15040.24     | I  | 500       | 1941.28      | III | 50        | 2533.33      | II  |
| 7         | 6812.86      | II | 25                         | 15047.70     | I  | 800       | 1943.21      | III | 30        | 2534.10      | II  |
| 8         | 6819.27      | II | 10                         | 15765.84     | I  | 20        | 1945.15      | II  | 80        | 2534.22      | II  |
| 10        | 7193.17      | I  | 30                         | 17108.66     | I  | 20        | 1947.93      | II  | 100       | 2535.66      | II  |
| 10        | 7291.06      | I  | 5                          | 26392.90     | I  | 20        | 1950.14      | II  | 30        | 2535.98      | II  |
| 12        | 7387.69      | I  | <i>Manganese Mn Z = 25</i> |              |    | 500       | 1952.36      | III | 100       | 2537.92      | II  |
| 20        | 7657.60      | I  | 600                        | 410.30       | V  | 1000      | 1952.52      | III | 50        | 2541.11      | II  |
| 19        | 7659.15      | I  | 600                        | 410.60       | V  | 30        | 1953.23      | II  | 80        | 2542.92      | II  |
| 17        | 7659.90      | I  | 600                        | 415.62       | V  | 20 d      | 1954.81      | II  | 50        | 2543.45      | II  |
| 15        | 7691.55      | I  | 650                        | 415.98       | V  | 30        | 1959.25      | II  | 100       | 2548.75      | II  |
| 12        | 7877.05      | II | 600                        | 428.59       | V  | 20        | 1969.24      | II  | 50        | 2551.85      | II  |
| 13        | 7896.37      | II | 600                        | 435.67       | V  | 500       | 1978.95      | III | 30        | 2553.27      | II  |
| 10        | 8098.72      | I  | 1000                       | 441.72       | V  | 30        | 1994.23      | II  | 75        | 2556.57      | II  |
| 9         | 8115.22      | II | 850                        | 442.49       | V  | 9700      | 1996.06      | I   | 30        | 2556.89      | II  |
| 8         | 8120.43      | II | 60                         | 579.79       | IV | 14000     | 1999.51      | I   | 95        | 2558.59      | II  |
| 10        | 8209.84      | I  | 60                         | 581.44       | IV | 18000     | 2003.85      | I   | 30        | 2559.41      | II  |
| 20        | 8213.03      | I  | 60                         | 581.65       | IV | 1000 w    | 2027.83      | III | 150       | 2563.65      | II  |
| 10        | 8213.99      | II | 60                         | 585.21       | IV | 500 w     | 2028.14      | III | 30        | 2565.22      | II  |
| 11        | 8234.64      | II | 90                         | 1242.25      | IV | 50        | 2037.31      | II  | 580       | 2572.76      | I   |
| 10        | 8310.26      | I  | 90                         | 1244.50      | IV | 40        | 2037.64      | II  | 480       | 2575.51      | I   |
| 15        | 8346.12      | I  | 95                         | 1251.93      | IV | 40        | 2039.97      | II  | 12000     | 2576.10      | II  |
| 10        | 8710.18      | I  | 95                         | 1257.28      | IV | 500       | 2049.68      | III | 550       | 2584.31      | I   |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |     |
|-----------|--------------|----|-----------|--------------|-----|-----------|--------------|----|-----------|--------------|-----|
| 30        | 2588.97      | II | 70        | 2886.68      | II  | 290       | 3619.28      | I  | 800       | 4451.59      | I   |
| 45        | 2589.71      | II | 160       | 2889.58      | II  | 220       | 3623.79      | I  | 160       | 4453.00      | I   |
| 250       | 2592.94      | I  | 55        | 2892.39      | II  | 140       | 3629.74      | I  | 130       | 4455.01      | I   |
| 6200      | 2593.73      | II | 50        | 2898.70      | II  | 100       | 3660.40      | I  | 160       | 4455.32      | I   |
| 250       | 2595.76      | I  | 80        | 2900.16      | II  | 280       | 3693.67      | I  | 110       | 4455.82      | I   |
| 95        | 2598.90      | II | 140 h     | 2914.60      | I   | 180       | 3696.57      | I  | 210       | 4457.55      | I   |
| 30        | 2602.72      | II | 190 h     | 2925.57      | I   | 210       | 3706.08      | I  | 270       | 4458.26      | I   |
| 45        | 2603.72      | II | 1100      | 2933.06      | II  | 130       | 3718.93      | I  | 150       | 4461.08      | I   |
| 4300      | 2605.69      | II | 1500      | 2939.30      | II  | 130       | 3731.93      | I  | 510       | 4462.02      | I   |
| 190       | 2610.20      | II | 250 h     | 2940.39      | I   | 260       | 3790.22      | I  | 290       | 4464.68      | I   |
| 500       | 2618.14      | II | 1900      | 2949.20      | II  | 110       | 3800.55      | I  | 200       | 4470.14      | I   |
| 140       | 2622.90      | I  | 30        | 3019.92      | II  | 3200      | 3806.72      | I  | 130       | 4472.79      | I   |
| 150       | 2624.04      | I  | 55        | 3031.06      | II  | 700       | 3809.59      | I  | 170       | 4490.08      | I   |
| 40        | 2624.80      | II | 30        | 3035.35      | II  | 2100      | 3823.51      | I  | 240       | 4498.90      | I   |
| 200       | 2625.58      | II | 330       | 3044.57      | I   | 390       | 3823.89      | I  | 240       | 4502.22      | I   |
| 190       | 2632.35      | II | 120       | 3045.59      | I   | 200       | 3829.68      | I  | 160       | 4709.72      | I   |
| 130       | 2638.17      | II | 200       | 3047.04      | I   | 480       | 3833.86      | I  | 180       | 4727.48      | I   |
| 80        | 2639.84      | II | 30        | 3050.65      | II  | 1300      | 3834.36      | I  | 130       | 4739.11      | I   |
| 27        | 2650.99      | II | 250       | 3054.36      | I   | 350       | 3839.78      | I  | 1000      | 4754.04      | I   |
| 60        | 2655.91      | II | 140       | 3062.12      | I   | 670       | 3841.08      | I  | 180       | 4761.53      | I   |
| 30        | 2666.77      | II | 170       | 3066.02      | I   | 350       | 3843.98      | I  | 750       | 4762.38      | I   |
| 30        | 2667.03      | II | 170       | 3070.27      | I   | 120       | 3926.47      | I  | 300       | 4765.86      | I   |
| 110       | 2672.59      | II | 160       | 3073.13      | I   | 130       | 3982.58      | I  | 500       | 4766.43      | I   |
| 55        | 2673.37      | II | 140 h     | 3178.50      | I   | 150       | 3985.24      | I  | 940       | 4783.42      | I   |
| 55        | 2674.43      | II | 220       | 3212.88      | I   | 190       | 3986.83      | I  | 1000      | 4823.52      | I   |
| 45        | 2680.34      | II | 1000      | 3228.09      | I   | 150       | 3987.10      | I  | 19        | 5004.91      | I   |
| 30        | 2680.68      | II | 300       | 3230.72      | I   | 1500      | 4018.10      | I  | 30        | 5074.79      | I   |
| 30        | 2681.25      | II | 850       | 3236.78      | I   | 150       | 4026.44      | I  | 200       | 5079.20      | III |
| 55        | 2684.55      | II | 330       | 3243.78      | I   | 27000     | 4030.76      | I  | 150       | 5100.03      | III |
| 55        | 2685.94      | II | 650       | 3248.52      | I   | 19000     | 4033.07      | I  | 60        | 5117.94      | I   |
| 110       | 2688.25      | II | 100       | 3251.14      | I   | 11000     | 4034.49      | I  | 50        | 5150.89      | I   |
| 27        | 2693.19      | II | 310       | 3252.95      | I   | 1500      | 4035.73      | I  | 50        | 5196.59      | I   |
| 55        | 2695.36      | II | 310       | 3256.14      | I   | 5600      | 4041.36      | I  | 85        | 5255.32      | I   |
| 27        | 2698.97      | II | 220       | 3258.41      | I   | 210 d     | 4045.13      | I  | 160       | 5341.06      | I   |
| 85        | 2701.00      | II | 180       | 3260.23      | I   | 1100      | 4048.76      | I  | 19        | 5349.88      | I   |
| 50        | 2701.17      | II | 180       | 3264.71      | I   | 150       | 4055.21      | I  | 95        | 5377.63      | I   |
| 160       | 2701.70      | II | 200       | 3330.78      | II  | 1900      | 4055.54      | I  | 95        | 5394.67      | I   |
| 100       | 2703.98      | II | 720       | 3441.99      | II  | 210       | 4057.95      | I  | 50        | 5399.49      | I   |
| 130       | 2705.74      | II | 50        | 3460.03      | II  | 1100      | 4058.93      | I  | 95        | 5407.42      | I   |
| 80        | 2707.53      | II | 360       | 3460.33      | II  | 150       | 4059.39      | I  | 35        | 5413.69      | I   |
| 110       | 2708.45      | II | 360 h     | 3474.04      | II  | 730       | 4061.74      | I  | 85        | 5420.36      | I   |
| 45        | 2709.96      | II |           | 3474.13      | II  | 730       | 4063.53      | I  | 35        | 5432.55      | I   |
| 80        | 2710.33      | II | 290       | 3482.91      | II  | 290       | 4070.28      | I  | 150       | 5454.07      | III |
| 110       | 2711.58      | II | 180       | 3488.68      | II  | 730       | 4079.24      | I  | 12        | 5457.47      | I   |
| 30        | 2716.80      | II | 140       | 3495.84      | II  | 730       | 4079.42      | I  | 60        | 5470.64      | I   |
| 30        | 2717.53      | II | 50        | 3496.81      | II  | 1100      | 4082.94      | I  | 200       | 5474.68      | III |
| 30        | 2719.01      | II | 100       | 3497.54      | II  | 1100      | 4083.63      | I  | 40        | 5481.40      | I   |
| 50        | 2719.74      | II | 360       | 3531.85      | I   | 200       | 4110.90      | I  | 30        | 5505.87      | I   |
| 30        | 2722.10      | II | 1100      | 3532.12      | I   | 150       | 4131.12      | I  | 50        | 5516.77      | I   |
| 30        | 2724.46      | II | 1300      | 3547.80      | I   | 120       | 4135.04      | I  | 40        | 5537.76      | I   |
| 55        | 2728.61      | II | 1100      | 3548.03      | I   | 150       | 4176.60      | I  | 21        | 5551.98      | I   |
| 6200      | 2794.82      | I  | 390       | 3548.20      | I   | 120       | 4189.99      | I  | 200       | 5946.65      | III |
| 5100      | 2798.27      | I  | 2200      | 3569.49      | I   | 370       | 4235.14      | I  | 140       | 6013.50      | I   |
| 220       | 2799.84      | I  | 720       | 3569.80      | I   | 510       | 4235.29      | I  | 200       | 6016.64      | I   |
| 3700      | 2801.06      | I  | 1400      | 3577.88      | I   | 190       | 4239.72      | I  | 290       | 6021.80      | I   |
| 110       | 2809.11      | I  | 720       | 3586.54      | I   | 290       | 4257.66      | I  | 200       | 6231.21      | III |
| 60        | 2815.02      | II | 290       | 3595.12      | I   | 290       | 4265.92      | I  | 17        | 6440.97      | I   |
| 30        | 2816.33      | II | 150       | 3601.72      | III | 270       | 4281.10      | I  | 24        | 6491.71      | I   |
| 60        | 2870.08      | II | 420       | 3607.54      | I   | 50        | 4323.63      | II | 14 h      | 6942.52      | I   |
| 30        | 2872.94      | II | 420       | 3608.49      | I   | 350       | 4414.88      | I  | 12        | 6989.96      | I   |
| 80        | 2879.49      | II | 360       | 3610.30      | I   | 210       | 4436.35      | I  | 14        | 7069.84      | I   |

| Intensity                    | Wavelength/Å |    | Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|------------------------------|--------------|----|--------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 12                           | 7184.25      | I  | 30                       | 3801.660     | I   | 40        | 1783.70      | II  | 50        | 2698.83      | I   |
| 24 h                         | 7283.82      | I  | 20                       | 3901.867     | I   | 30        | 1796.22      | II  | 50        | 2699.38      | I   |
| 35 h                         | 7302.89      | I  | 60                       | 3906.372     | I   | 200       | 1796.90      | II  | 80        | 2705.36      | II  |
| 50                           | 7326.51      | I  | 200                      | 3983.839     | II  | 60        | 1798.74      | II  | 70        | 2724.43      | III |
| 12                           | 7680.20      | I  | 1800                     | 4046.572     | I   | 30        | 1803.89      | II  | 80        | 2752.78      | I   |
| 12 h                         | 8672.06      | I  | 150                      | 4077.838     | I   | 40        | 1808.29      | II  | 20        | 2759.71      | I   |
| 12 h                         | 8701.05      | I  | 40                       | 4108.057     | I   | 400       | 1820.34      | II  | 6         | 2769.22      | III |
| 17 h                         | 8703.76      | I  | 250                      | 4339.224     | I   | 5         | 1832.74      | I   | 40        | 2803.46      | I   |
| 30 h                         | 8740.93      | I  | 400                      | 4347.496     | I   | 1000      | 1849.50      | I   | 30        | 2804.43      | I   |
| <i>Mercury 198 Hg Z = 80</i> |              |    | 4000                     | 4358.337     | I   | 160       | 1869.23      | II  | 2         | 2805.34      | I   |
| 80                           | 1250.564     | I  | 80                       | 4916.068     | I   | 300       | 1870.55      | II  | 2         | 2806.77      | I   |
| 8                            | 1259.242     | I  | 1100                     | 5460.753     | I   | 200       | 1875.54      | II  | 150       | 2814.93      | II  |
| 100                          | 1268.825     | I  | 160                      | 5675.922     | I   | 1         | 1894.77      | III | 3         | 2844.76      | III |
| 5                            | 1307.751     | I  | 240                      | 5769.598     | I   | 20        | 1900.28      | II  | 750       | 2847.68      | II  |
| 20                           | 1402.619     | I  | 280                      | 5790.663     | I   | 30        | 1927.60      | II  | 50        | 2856.94      | I   |
| 10                           | 1435.503     | I  | 20                       | 6072.713     | I   | 300       | 1942.27      | II  | 150       | 2893.60      | I   |
| 1000                         | 1849.492     | I  | 30                       | 6234.402     | I   | 100       | 1972.94      | II  | 150       | 2916.27      | II  |
| 60                           | 2262.210     | II | 160                      | 6716.429     | I   | 200       | 1973.89      | II  | 60        | 2925.41      | I   |
| 20                           | 2302.065     | I  | 250                      | 6907.461     | I   | 150       | 1987.98      | II  | 150       | 2935.94      | II  |
| 20                           | 2345.440     | I  | 240                      | 11287.407    | I   | 90        | 2026.97      | II  | 400       | 2947.08      | II  |
| 100                          | 2378.325     | I  | <i>Mercury Hg Z = 80</i> |              |     | 90        | 2052.93      | II  | 1200      | 2967.28      | I   |
| 20                           | 2380.004     | I  | 3                        | 621.44       | III | 70        | 2148.00      | II  | 300       | 3021.50      | I   |
| 40                           | 2399.349     | I  | 2                        | 679.68       | III | 5         | 2247.55      | I   | 120       | 3023.47      | I   |
| 20                           | 2399.729     | I  | 2                        | 878.59       | III | 60        | 2262.23      | II  | 30        | 3025.61      | I   |
| 20                           | 2446.900     | I  | 1                        | 886.48       | III | 20        | 2302.06      | I   | 50        | 3027.49      | I   |
| 15                           | 2464.064     | I  | 400                      | 893.08       | II  | 7         | 2314.15      | III | 15        | 3090.05      | III |
| 40                           | 2481.999     | I  | 300                      | 915.83       | II  | 15        | 2323.20      | I   | 400       | 3125.67      | I   |
| 30                           | 2482.713     | I  | 150                      | 923.39       | II  | 5         | 2340.57      | I   | 320       | 3131.55      | I   |
| 40                           | 2483.821     | I  | 200                      | 940.80       | II  | 20        | 2345.43      | I   | 320       | 3131.84      | I   |
| 90                           | 2534.769     | I  | 100                      | 962.74       | II  | 20        | 2352.48      | I   | 400       | 3208.20      | II  |
| 15000                        | 2536.506     | I  | 50                       | 969.13       | II  | 100       | 2378.32      | I   | 400       | 3264.06      | II  |
| 25                           | 2563.861     | I  | 1                        | 988.89       | III | 20        | 2380.00      | I   | 5         | 3283.02      | III |
| 25                           | 2576.290     | I  | 2                        | 1009.29      | III | 4         | 2380.55      | III | 12        | 3312.28      | III |
| 250                          | 2652.043     | I  | 5                        | 1068.03      | III | 40        | 2399.38      | I   | 80        | 3341.48      | I   |
| 400                          | 2653.683     | I  | 800                      | 1099.26      | II  | 20        | 2399.73      | I   | 100       | 3385.25      | II  |
| 100                          | 2655.130     | I  | 2                        | 1161.95      | III | 10        | 2400.49      | I   | 8         | 3389.01      | III |
| 50                           | 2698.831     | I  | 80                       | 1250.58      | I   | 60        | 2407.35      | II  | 5         | 3450.77      | III |
| 80                           | 2752.783     | I  | 8                        | 1259.24      | I   | 50        | 2414.13      | II  | 400       | 3451.69      | II  |
| 20                           | 2759.710     | I  | 100                      | 1268.82      | I   | 8         | 2431.65      | III | 3         | 3500.35      | III |
| 40                           | 2803.471     | I  | 5                        | 1307.75      | I   | 5         | 2441.06      | I   | 4         | 3538.88      | III |
| 30                           | 2804.438     | I  | 300                      | 1307.93      | II  | 20        | 2446.90      | I   | 200       | 3549.42      | II  |
| 750                          | 2847.675     | II | 400                      | 1321.71      | II  | 15        | 2464.06      | I   | 5         | 3557.24      | III |
| 50                           | 2856.939     | I  | 400                      | 1331.74      | II  | 5         | 2480.56      | III | 2800      | 3650.15      | I   |
| 150                          | 2893.598     | I  | 80                       | 1350.07      | II  | 40        | 2482.00      | I   | 300       | 3654.84      | I   |
| 150                          | 2916.227     | II | 200                      | 1361.27      | II  | 30        | 2482.72      | I   | 80        | 3662.88      | I   |
| 60                           | 2925.413     | I  | 20                       | 1402.62      | I   | 40        | 2483.82      | I   | 240       | 3663.28      | I   |
| 1200                         | 2967.283     | I  | 200                      | 1414.43      | II  | 7         | 2484.50      | III | 30        | 3701.44      | I   |
| 300                          | 3021.500     | I  | 10                       | 1435.51      | I   | 90        | 2534.77      | I   | 35        | 3704.17      | I   |
| 120                          | 3023.476     | I  | 15                       | 1619.46      | II  | 15000     | 2536.52      | I   | 30        | 3801.66      | I   |
| 30                           | 3025.608     | I  | 120                      | 1623.95      | II  | 25        | 2563.86      | I   | 15        | 3803.51      | III |
| 50                           | 3027.490     | I  | 20                       | 1628.25      | II  | 25        | 2576.29      | I   | 100       | 3806.38      | II  |
| 400                          | 3125.670     | I  | 150                      | 1649.94      | II  | 5         | 2578.91      | I   | 20        | 3901.87      | I   |
| 320                          | 3131.551     | I  | 50                       | 1653.64      | II  | 2         | 2612.92      | III | 60        | 3906.37      | I   |
| 320                          | 3131.842     | I  | 200                      | 1672.41      | II  | 4         | 2617.97      | III | 100       | 3918.92      | II  |
| 80                           | 3341.481     | I  | 9                        | 1681.40      | III | 15        | 2625.19      | I   | 200       | 3983.96      | II  |
| 2800                         | 3650.157     | I  | 100                      | 1702.73      | II  | 5         | 2639.78      | I   | 1800      | 4046.56      | I   |
| 300                          | 3654.839     | I  | 100                      | 1707.40      | II  | 250       | 2652.04      | I   | 150       | 4077.83      | I   |
| 80                           | 3662.883     | I  | 120                      | 1727.18      | II  | 400       | 2653.69      | I   | 40        | 4108.05      | I   |
| 240                          | 3663.281     | I  | 250                      | 1732.14      | II  | 100       | 2655.13      | I   | 70        | 4122.07      | III |
| 30                           | 3701.432     | I  | 15                       | 1759.75      | III | 3         | 2670.49      | III | 10        | 4140.34      | III |
| 35                           | 3704.170     | I  | 20                       | 1775.68      | I   | 5         | 2674.91      | I   | 100       | 4216.74      | III |

| Intensity | Wavelength/Å |     | Intensity                   | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 250       | 4339.22      | I   | 120                         | 13209.95     | I   | 150       | 2269.71      | III | 80        | 2834.39      | II  |
| 400       | 4347.49      | I   | 140                         | 13426.57     | I   | 200       | 2294.97      | III | 80        | 2835.33      | II  |
| 4000      | 4358.33      | I   | 60                          | 13468.38     | I   | 160       | 2304.25      | II  | 160       | 2842.15      | II  |
| 100       | 4398.62      | II  | 80                          | 13505.58     | I   | 160       | 2306.97      | II  | 1700      | 2848.23      | II  |
| 15        | 4470.58      | III | 500                         | 13570.21     | I   | 150       | 2330.93      | III | 370       | 2853.23      | II  |
| 12        | 4552.84      | III | 450                         | 13673.51     | I   | 110       | 2332.12      | II  | 370       | 2863.81      | II  |
| 90        | 4660.28      | II  | 200                         | 13950.55     | I   | 190       | 2341.59      | II  | 220       | 2866.69      | II  |
| 50        | 4797.01      | III | 500                         | 15295.82     | I   | 100       | 2359.76      | III | 1700      | 2871.51      | II  |
| 80        | 4855.72      | II  | 100                         | 16881.48     | I   | 110       | 2389.20      | II  | 85        | 2872.88      | II  |
| 10        | 4869.85      | III | 400                         | 16920.16     | I   | 140       | 2403.61      | II  | 220       | 2879.05      | II  |
| 5         | 4883.00      | I   | 300                         | 16942.00     | I   | 120       | 2413.01      | II  | 65        | 2888.15      | II  |
| 5         | 4889.91      | I   | 500                         | 17072.79     | I   | 85        | 2498.28      | II  | 1300      | 2890.99      | II  |
| 80        | 4916.07      | I   | 400                         | 17109.93     | I   | 200       | 2506.19      | III | 95        | 2891.28      | II  |
| 5         | 4970.37      | I   | 20                          | 17116.75     | I   | 440       | 2538.46      | II  | 190       | 2892.81      | II  |
| 80        | 4973.57      | III | 20                          | 17198.67     | I   | 330       | 2542.67      | II  | 950       | 2894.45      | II  |
| 5         | 4980.64      | I   | 20                          | 17213.20     | I   | 80        | 2558.88      | II  | 140       | 2897.63      | II  |
| 20        | 5102.70      | I   | 70                          | 17329.41     | I   | 85        | 2564.34      | II  | 70        | 2900.80      | II  |
| 40        | 5120.64      | I   | 30                          | 17436.18     | I   | 250       | 2593.70      | II  | 290       | 2903.07      | II  |
| 100       | 5128.45      | II  | 50                          | 18130.38     | I   | 250       | 2602.80      | II  | 80        | 2907.12      | II  |
| 20        | 5137.94      | I   | 40                          | 19700.17     | I   | 400       | 2616.78      | I   | 600       | 2909.12      | II  |
| 30        | 5210.82      | III |                             | 22493.28     | I   | 440       | 2629.85      | I   | 1100      | 2911.92      | II  |
| 20        | 5290.74      | I   | 250                         | 23253.07     | I   | 330       | 2636.67      | II  | 120       | 2918.83      | II  |
| 5         | 5316.78      | I   |                             | 32148.06     | I   | 720       | 2638.76      | II  | 1300      | 2923.39      | II  |
| 60        | 5354.05      | I   |                             | 36303.03     | I   | 410       | 2640.99      | I   | 140       | 2924.32      | II  |
| 30        | 5384.63      | I   | <i>Molybdenum Mo Z = 42</i> |              |     | 600       | 2644.35      | II  | 1100      | 2930.50      | II  |
| 1100      | 5460.74      | I   | 50                          | 867.92       | IV  | 370       | 2646.49      | II  | 800       | 2934.30      | II  |
| 30        | 5549.63      | I   | 100                         | 884.19       | IV  | 640       | 2649.46      | I   | 95        | 2940.10      | II  |
| 160       | 5675.86      | I   | 60                          | 886.05       | IV  | 480       | 2653.35      | II  | 110       | 2941.22      | II  |
| 6         | 5695.71      | III | 50                          | 891.74       | IV  | 560 h     | 2655.03      | I   | 150       | 2944.82      | II  |
| 240       | 5769.60      | I   | 100                         | 1169.33      | III | 640       | 2660.58      | II  | 140       | 2946.69      | II  |
| 100       | 5789.66      | I   | 100                         | 1254.93      | III | 720       | 2672.84      | II  | 95        | 2947.28      | II  |
| 280       | 5790.66      | I   | 100                         | 1258.52      | III | 250       | 2673.27      | II  | 125       | 2947.32      | III |
| 140       | 5803.78      | I   | 100                         | 1262.21      | III | 1000      | 2679.85      | I   | 95        | 2955.84      | II  |
| 60        | 5859.25      | I   | 100                         | 1263.74      | III | 95        | 2681.36      | II  | 240       | 2956.06      | II  |
| 60        | 5871.73      | II  | 100                         | 1274.37      | III | 640       | 2683.23      | II  | 70        | 2956.90      | II  |
| 20        | 5871.98      | I   | 100                         | 1276.40      | III | 880       | 2684.14      | II  | 95        | 2960.24      | II  |
| 20        | 6072.72      | I   | 100                         | 1277.40      | III | 560       | 2687.99      | II  | 250       | 2963.79      | II  |
| 1000      | 6149.50      | II  | 200                         | 1277.58      | III | 480       | 2701.42      | II  | 210       | 2965.27      | II  |
| 25        | 6220.35      | III | 200                         | 1278.40      | III | 190       | 2713.51      | II  | 70        | 2971.91      | II  |
| 30        | 6234.40      | I   | 150                         | 1281.90      | III | 290       | 2717.35      | II  | 250       | 2972.61      | II  |
| 35        | 6418.98      | III | 150                         | 1283.60      | III | 85        | 2726.97      | II  | 80        | 2975.40      | II  |
| 40        | 6501.38      | III | 100                         | 1854.73      | III | 140       | 2729.68      | II  | 95        | 2992.84      | II  |
| 80        | 6521.13      | II  | 80                          | 1926.26      | IV  | 80        | 2730.20      | II  | 95        | 3027.77      | II  |
| 10        | 6584.26      | III | 100                         | 1929.24      | IV  | 330       | 2732.88      | II  | 100       | 3060.78      | II  |
| 6         | 6610.12      | III | 80                          | 1971.06      | IV  | 160       | 2736.96      | II  | 800       | 3064.28      | I   |
| 30        | 6709.29      | III | 70                          | 2010.92      | IV  | 80 h      | 2737.88      | II  | 250       | 3065.04      | II  |
| 160       | 6716.43      | I   | 19000                       | 2015.11      | II  | 290       | 2746.30      | II  | 800       | 3074.37      | I   |
| 250       | 6907.52      | I   | 40000                       | 2020.30      | II  | 110       | 2756.07      | II  | 85        | 3077.66      | II  |
| 250       | 7081.90      | I   | 21000                       | 2038.44      | II  | 220       | 2763.62      | II  | 800       | 3085.62      | I   |
| 200       | 7091.86      | I   | 17000                       | 2045.98      | II  | 240       | 2769.76      | II  | 270       | 3087.62      | II  |
| 40        | 7346.37      | II  | 50                          | 2060.38      | IV  | 160       | 2773.78      | II  | 190       | 3092.07      | II  |
| 100       | 7485.87      | II  | 4800                        | 2081.68      | II  | 190       | 2774.39      | II  | 560       | 3094.66      | I   |
| 12        | 7517.46      | III | 2400                        | 2089.52      | II  | 1700      | 2775.40      | II  | 560       | 3101.34      | I   |
| 20        | 7728.82      | I   | 2200                        | 2092.50      | II  | 65        | 2777.86      | II  | 1400      | 3112.12      | I   |
| 7         | 7808.10      | III | 4000                        | 2093.11      | II  | 880       | 2780.04      | II  | 290       | 3122.00      | II  |
| 100       | 7944.66      | II  | 2700                        | 2100.84      | II  | 400       | 2784.99      | II  | 14000     | 3132.59      | I   |
| 25        | 7946.75      | III | 1500                        | 2104.29      | II  | 100       | 2807.74      | III | 110       | 3138.72      | II  |
| 50        | 7984.51      | III | 1400                        | 2108.02      | II  | 400       | 2807.76      | II  | 220       | 3152.82      | II  |
| 5         | 8151.64      | III | 100                         | 2184.37      | III | 1700      | 2816.15      | II  | 55        | 3155.64      | II  |
| 2000      | 10139.75     | I   | 100                         | 2211.02      | III | 220       | 2817.44      | II  | 6000      | 3158.16      | I   |
| 240       | 11287.40     | I   | 400                         | 2269.69      | II  | 80        | 2827.74      | II  | 8700      | 3170.35      | I   |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity                  | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|-----|-----------|--------------|----|----------------------------|--------------|----|-----------|--------------|----|
| 95        | 3172.03      | II  | 580       | 3886.82      | I  | 65                         | 5279.65      | I  | 95        | 3007.97      | II |
| 160       | 3172.74      | II  | 19000     | 3902.96      | I  | 210                        | 5280.86      | I  | 95        | 3014.19      | II |
| 120 d     | 3187.59      | II  | 65        | 3941.48      | II | 55                         | 5292.08      | I  | 95        | 3018.35      | II |
| 7600      | 3193.97      | I   | 1400      | 4062.08      | I  | 55                         | 5295.47      | I  | 140       | 3056.71      | II |
| 880       | 3205.88      | I   | 2300      | 4069.88      | I  | 55                         | 5313.89      | I  | 130       | 3069.73      | II |
| 3000      | 3208.83      | I   | 1300      | 4081.44      | I  | 80                         | 5354.88      | I  | 160       | 3075.38      | II |
| 560       | 3215.07      | I   | 940       | 4084.38      | I  | 65                         | 5356.48      | I  | 240       | 3092.92      | II |
| 880       | 3228.22      | I   | 730       | 4107.47      | I  | 560 hl                     | 5360.56      | I  | 260       | 3115.18      | II |
| 600       | 3229.79      | I   | 630       | 4120.10      | I  | 110 hl                     | 5364.28      | I  | 290       | 3133.60      | II |
| 1100      | 3233.14      | I   | 2900      | 4143.55      | I  | 65                         | 5394.52      | I  | 220       | 3134.90      | II |
| 950       | 3237.08      | I   | 480       | 4185.82      | I  | 50                         | 5400.47      | I  | 170       | 3141.46      | II |
| 65        | 3240.71      | II  | 2500      | 4188.32      | I  | 55                         | 5435.68      | I  | 170       | 3142.44      | II |
| 950       | 3256.21      | I   | 1500      | 4232.59      | I  | 65                         | 5437.75      | I  | 150       | 3203.47      | II |
| 480       | 3264.40      | I   | 890       | 4276.91      | I  | 50                         | 5501.54      | I  | 220       | 3259.24      | II |
| 800       | 3270.90      | I   | 1200      | 4277.24      | I  | 7800                       | 5506.49      | I  | 220       | 3265.12      | II |
| 200       | 3271.69      | III | 1400      | 4288.64      | I  | 5200                       | 5533.05      | I  | 320       | 3275.22      | II |
| 1100      | 3289.02      | I   | 680       | 4292.13      | I  | 50                         | 5543.12      | I  | 290       | 3285.10      | II |
| 950       | 3290.82      | I   | 890       | 4293.21      | I  | 55                         | 5556.28      | I  | 410       | 3328.28      | II |
| 190       | 3292.31      | II  | 840       | 4326.14      | I  | 2500                       | 5570.45      | I  | 320       | 3353.59      | II |
| 100       | 3313.62      | II  | 1900      | 4381.64      | I  | 100                        | 5610.93      | I  | 410       | 3560.75      | II |
| 190       | 3320.90      | II  | 2500      | 4411.57      | I  | 330                        | 5632.47      | I  | 470       | 3587.51      | II |
| 640       | 3323.95      | I   | 990       | 4434.95      | I  | 50                         | 5634.86      | I  | 370       | 3615.82      | II |
| 1300      | 3344.75      | I   | 480       | 4457.36      | I  | 230                        | 5650.13      | I  | 410       | 3653.15      | II |
| 95        | 3346.40      | II  | 630       | 4474.56      | I  | 55                         | 5674.47      | I  | 470       | 3662.26      | II |
| 1600      | 3358.12      | I   | 400       | 4536.80      | I  | 460                        | 5689.14      | I  | 540       | 3665.18      | II |
| 950       | 3363.78      | I   | 460       | 4626.47      | I  | 80                         | 5705.72      | I  | 540       | 3672.36      | II |
| 950       | 3379.97      | I   | 640       | 4707.26      | I  | 210                        | 5722.74      | I  | 580       | 3673.54      | II |
| 1900      | 3384.62      | I   | 700       | 4731.44      | I  | 620                        | 5751.40      | I  | 1200      | 3685.80      | II |
| 130       | 3395.36      | II  | 770       | 4760.19      | I  | 520                        | 5791.85      | I  | 440       | 3687.30      | II |
| 640       | 3404.34      | I   | 410       | 4819.25      | I  | 55 h                       | 5849.73      | I  | 410       | 3689.69      | II |
| 1300      | 3405.94      | I   | 410       | 4830.51      | I  | 50 h                       | 5851.52      | I  | 410       | 3697.56      | II |
| 640       | 3437.22      | I   | 180       | 5014.60      | I  | 520                        | 5858.27      | I  | 470       | 3713.70      | II |
| 130       | 3446.08      | II  | 80        | 5029.00      | I  | 50                         | 5869.33      | I  | 640 d     | 3714.73      | II |
| 3200      | 3447.12      | I   | 65        | 5030.78      | I  | 820                        | 5888.33      | I  | 470       | 3715.68      | II |
| 640       | 3449.07      | I   | 100       | 5047.71      | I  | 50 h                       | 5893.38      | I  | 410       | 3718.54      | II |
| 950       | 3456.39      | I   | 50        | 5055.00      | I  | 160 h                      | 5928.88      | I  | 410       | 3721.35      | II |
| 640       | 3460.78      | I   | 200       | 5059.88      | I  | 35                         | 6025.49      | I  | 780       | 3723.50      | II |
| 800       | 3504.41      | I   | 100       | 5080.02      | I  | 1300                       | 6030.66      | I  | 410       | 3724.87      | II |
| 560       | 3508.12      | I   | 100       | 5096.65      | I  | 40                         | 6101.87      | I  | 710       | 3728.13      | II |
| 480       | 3521.41      | I   | 130       | 5097.52      | I  | 40                         | 6357.22      | I  | 470       | 3730.58      | II |
| 640       | 3537.28      | I   | 130       | 5109.71      | I  | 35                         | 6401.07      | I  | 1000 d    | 3735.54      | II |
| 520       | 3558.10      | I   | 80        | 5114.97      | I  | 100                        | 6424.37      | I  | 440       | 3737.10      | II |
| 400       | 3563.14      | I   | 150       | 5145.38      | I  | 230                        | 6619.13      | I  | 1000      | 3738.06      | II |
| 1400      | 3581.89      | I   | 110       | 5147.39      | I  | 50                         | 6650.38      | I  | 580       | 3752.49      | II |
| 1400      | 3624.46      | I   | 80        | 5163.19      | I  | 110                        | 6733.98      | I  | 510       | 3757.82      | II |
| 1000      | 3635.43      | I   | 100       | 5167.76      | I  | 50                         | 6746.27      | I  | 930       | 3758.95      | II |
| 400       | 3657.35      | I   | 160 d     | 5171.08      | I  | 35                         | 6753.97      | I  | 930       | 3763.47      | II |
| 540       | 3664.81      | I   | 230 h     | 5172.94      | I  | 40                         | 6838.88      | I  | 510       | 3769.65      | II |
| 590       | 3672.82      | I   | 160 h     | 5174.18      | I  | 35                         | 6914.01      | I  | 1400      | 3775.50      | II |
| 1300      | 3680.60      | I   | 110       | 5200.17      | I  | 110                        | 7109.87      | I  | 710       | 3779.47      | II |
| 65        | 3688.31      | II  | 50        | 5200.74      | I  | 150                        | 7242.50      | I  | 580       | 3780.40      | II |
| 180       | 3692.64      | II  | 50        | 5211.86      | I  | 40                         | 7245.85      | I  | 510       | 3781.32      | II |
| 1400      | 3694.94      | I   | 80        | 5219.40      | I  | 40                         | 7391.36      | I  | 2400      | 3784.25      | II |
| 500       | 3727.69      | I   | 65        | 5231.06      | I  | 140                        | 7485.74      | I  | 370       | 3801.12      | II |
| 80        | 3744.37      | II  | 100       | 5234.26      | I  | 27                         | 7720.77      | I  | 1200      | 3803.47      | II |
| 29000     | 3798.25      | I   | 460 h     | 5238.20      | I  | 40 h                       | 8328.44      | I  | 2500      | 3805.36      | II |
| 520       | 3826.70      | I   | 230 h     | 5240.88      | I  | 45 h                       | 8389.32      | I  | 470       | 3807.23      | II |
| 940       | 3828.87      | I   | 110 h     | 5242.81      | I  | 45 h                       | 8483.39      | I  | 540       | 3808.77      | II |
| 1700      | 3833.75      | I   | 100       | 5245.51      | I  | <i>Neodymium Nd Z = 60</i> |              |    | 440       | 3809.06      | II |
| 29000     | 3864.11      | I   | 150       | 5259.04      | I  | 75                         | 2764.98      | I  | 580       | 3810.49      | II |
| 580       | 3869.08      | I   | 65        | 5261.14      | I  | 80                         | 2993.20      | II | 710       | 3814.73      | II |



| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity             | Wavelength/Å |    |
|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|-----------------------|--------------|----|
| 410       | 3822.47      | II | 1000      | 4021.78      | II | 240       | 4719.02      | I  | 20                    | 7192.01      | II |
| 1200      | 3826.42      | II | 1200      | 4023.00      | II | 240       | 4811.34      | II | 15                    | 7236.54      | II |
| 540       | 3828.85      | II | 410       | 4030.47      | II | 350       | 4825.48      | II | 12                    | 7316.81      | II |
| 440       | 3829.16      | II | 1200      | 4031.82      | II | 280       | 4859.02      | II | 10                    | 7406.62      | II |
| 510       | 3830.47      | II | 3000      | 4040.80      | II | 350       | 4883.81      | I  | 10                    | 7418.18      | II |
| 740       | 3836.54      | II | 410       | 4043.59      | II | 220       | 4890.70      | II | 12                    | 7511.16      | II |
| 1700      | 3838.98      | II | 410       | 4048.81      | II | 240       | 4891.07      | I  | 17                    | 7513.73      | II |
| 410 d     | 3841.82      | II | 850       | 4051.15      | II | 280       | 4896.93      | I  | 12                    | 7528.99      | II |
| 1700 d    | 3848.24      | II | 850       | 4059.96      | II | 210       | 4901.84      | I  | 10                    | 7538.26      | II |
| 1500      | 3848.52      | II | 4700      | 4061.09      | II | 330       | 4920.68      | II | 12                    | 7696.56      | II |
| 470       | 3850.22      | II | 1100      | 4069.28      | II | 470       | 4924.53      | I  | 10                    | 7750.95      | II |
| 2400 d    | 3851.66      | II | 710       | 4075.12      | II | 260       | 4944.83      | I  | 10                    | 7808.47      | II |
| 3700 d    | 3863.33      | II | 470       | 4075.28      | II | 290       | 4954.78      | I  | 12                    | 7863.04      | II |
| 850       | 3869.07      | II | 470       | 4080.23      | II | 290       | 4959.13      | II | 12                    | 7917.01      | II |
| 470       | 3875.87      | II | 1400      | 4109.08      | II | 250       | 4989.94      | II | 12                    | 7958.95      | I  |
| 1100      | 3878.58      | II | 2500      | 4109.46      | II | 360       | 5076.59      | II | 12                    | 7965.73      | II |
| 1000      | 3879.55      | II | 510       | 4110.48      | II | 360       | 5092.80      | II | 15                    | 7982.09      | II |
| 780       | 3880.38      | II | 410       | 4123.88      | II | 360       | 5107.59      | II | 12                    | 7982.68      | II |
| 1200      | 3880.78      | II | 470       | 4133.36      | II | 340       | 5123.79      | II | 12                    | 8000.76      | II |
| 540       | 3887.87      | II | 510       | 4135.33      | II | 680       | 5130.60      | II | 10                    | 8120.93      | II |
| 1300      | 3889.93      | II | 3000      | 4156.08      | II | 500       | 5191.45      | II | 12                    | 8122.07      | II |
| 1300      | 3890.58      | II | 510       | 4156.26      | II | 630       | 5192.62      | II | 12                    | 8141.75      | II |
| 1300      | 3890.94      | II | 410       | 4168.00      | II | 330       | 5200.12      | II | 12                    | 8143.27      | II |
| 580       | 3891.51      | II | 810       | 4175.61      | II | 310       | 5212.37      | II | 10                    | 8231.52      | II |
| 470       | 3892.06      | II | 2400      | 4177.32      | II | 450       | 5234.20      | II | 10                    | 8307.72      | II |
| 810       | 3894.63      | II | 640       | 4179.59      | II | 250       | 5239.79      | II | 12                    | 8346.36      | II |
| 440       | 3897.63      | II | 470       | 4205.60      | II | 720       | 5249.59      | II | 17                    | 8839.10      | II |
| 2000      | 3900.21      | II | 470       | 4211.29      | II | 360       | 5255.51      | II | <i>Neon Ne Z = 10</i> |              |    |
| 1300      | 3901.84      | II | 440       | 4227.73      | II | 590       | 5273.43      | II | 66                    | 119.01       | V  |
| 1700      | 3905.89      | II | 1300      | 4232.38      | II | 680       | 5293.17      | II | 200                   | 122.52       | V  |
| 510       | 3907.84      | II | 2000      | 4247.38      | II | 220       | 5311.46      | II | 66                    | 125.12       | V  |
| 2000      | 3911.16      | II | 850       | 4252.44      | II | 500       | 5319.82      | II | 45                    | 131.99       | V  |
| 850       | 3912.23      | II | 410       | 4261.84      | II | 290       | 5361.47      | II | 50                    | 132.04       | V  |
| 440       | 3915.13      | II | 470       | 4282.44      | II | 160       | 5431.53      | II | 150                   | 140.76       | V  |
| 610       | 3915.95      | II | 710       | 4284.52      | II | 240       | 5594.43      | II | 150                   | 140.79       | V  |
| 1100      | 3920.96      | II | 5400      | 4303.58      | II | 220       | 5620.54      | I  | 100                   | 142.44       | V  |
| 510       | 3927.10      | II | 470       | 4314.52      | II | 140 d     | 5675.97      | I  | 100                   | 142.50       | V  |
| 610       | 3934.82      | II | 1100      | 4325.76      | II | 220       | 5688.53      | II | 150                   | 142.72       | V  |
| 410       | 3936.11      | II | 510       | 4327.93      | II | 130       | 5702.24      | II | 100                   | 143.27       | V  |
| 510       | 3938.86      | II | 540       | 4338.70      | II | 160       | 5708.28      | II | 150                   | 143.34       | V  |
| 2000      | 3941.51      | II | 680       | 4351.29      | II | 100       | 5729.29      | I  | 150                   | 147.13       | V  |
| 2000      | 3951.16      | II | 850       | 4358.17      | II | 160       | 5804.02      | II | 66                    | 151.23       | V  |
| 810       | 3952.20      | II | 470 d     | 4374.93      | II | 80        | 5811.57      | II | 120                   | 151.42       | V  |
| 590       | 3958.00      | II | 710       | 4385.66      | II | 70        | 5825.87      | II | 15                    | 151.82       | IV |
| 510       | 3962.21      | II | 540       | 4400.83      | II | 80        | 5842.39      | II | 15                    | 152.23       | IV |
| 1400      | 3963.12      | II | 510       | 4411.06      | II | 55        | 5858.91      | I  | 45                    | 154.50       | V  |
| 1100      | 3973.30      | II | 580       | 4446.39      | II | 45        | 6007.67      | I  | 15                    | 158.65       | IV |
| 740       | 3973.69      | II | 1400      | 4451.57      | II | 45        | 6034.24      | II | 15                    | 158.82       | IV |
| 740       | 3976.85      | II | 740       | 4462.99      | II | 55        | 6066.03      | I  | 100                   | 164.02       | V  |
| 740       | 3979.49      | II | 410       | 4501.82      | II | 45        | 6178.59      | I  | 100                   | 164.14       | V  |
| 470       | 3986.25      | II | 250       | 4516.36      | II | 45        | 6223.39      | I  | 80                    | 172.62       | IV |
| 1400      | 3990.10      | II | 340       | 4541.27      | II | 55        | 6310.49      | I  | 500                   | 173.93       | V  |
| 1000      | 3991.74      | II | 340       | 4542.61      | II | 65        | 6385.20      | II | 80                    | 177.16       | IV |
| 1100      | 3994.68      | II | 340       | 4563.22      | II | 45        | 6630.14      | I  | 150                   | 186.58       | IV |
| 410       | 4000.50      | II | 300       | 4621.94      | I  | 45        | 6650.57      | II | 100                   | 194.28       | IV |
| 540       | 4004.02      | II | 510       | 4634.24      | I  | 40        | 6740.11      | II | 100                   | 208.48       | IV |
| 410       | 4007.43      | II | 340       | 4641.10      | I  | 40        | 6900.43      | II | 100                   | 208.73       | IV |
| 3700      | 4012.25      | II | 250       | 4645.77      | II | 35        | 7037.30      | II | 80                    | 208.90       | IV |
| 540       | 4012.70      | II | 300       | 4649.67      | I  | 40        | 7066.89      | II | 150                   | 212.56       | IV |
| 1000      | 4020.87      | II | 310       | 4683.45      | I  | 29        | 7129.35      | II | 140                   | 223.24       | IV |
| 1000      | 4021.34      | II | 470       | 4706.54      | II | 24        | 7189.42      | II | 120                   | 223.60       | IV |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|
| 140       | 234.32       | IV  | 100       | 542.07       | IV  | 300       | 2216.07      | III | 150       | 2963.24      | II |
| 120       | 234.70       | IV  | 150       | 543.89       | IV  | 10        | 2220.81      | IV  | 150       | 2967.18      | II |
| 20        | 251.14       | III | 400       | 568.42       | V   | 75        | 2227.42      | V   | 100       | 2973.10      | II |
| 20        | 251.56       | III | 250       | 569.76       | V   | 110       | 2232.41      | V   | 15        | 2974.72      | I  |
| 20        | 251.73       | III | 500       | 569.83       | V   | 65        | 2245.48      | V   | 100       | 2979.46      | II |
| 40        | 267.06       | III | 250       | 572.11       | V   | 250       | 2258.02      | IV  | 12        | 2982.67      | I  |
| 40        | 267.52       | III | 800       | 572.34       | V   | 65        | 2259.57      | V   | 150       | 3001.67      | II |
| 20        | 267.71       | III | 35        | 587.213      | I   | 175       | 2262.08      | IV  | 120 p     | 3017.31      | II |
| 40        | 283.18       | III | 35        | 589.179      | I   | 240       | 2263.21      | III | 300       | 3027.02      | II |
| 160       | 283.21       | III | 35        | 589.911      | I   | 65        | 2263.39      | V   | 300       | 3028.86      | II |
| 110       | 283.69       | III | 70        | 591.830      | I   | 110       | 2264.54      | IV  | 100       | 3030.79      | II |
| 40        | 283.89       | III | 100       | 595.920      | I   | 200       | 2264.91      | III | 120       | 3034.46      | II |
| 220       | 301.12       | III | 75        | 598.706      | I   | 250       | 2265.71      | V   | 100       | 3035.92      | II |
| 220       | 313.05       | III | 35        | 598.891      | I   | 550       | 2285.79      | IV  | 100       | 3037.72      | II |
| 220       | 313.68       | III | 70        | 600.036      | I   | 30        | 2293.14      | IV  | 100       | 3039.59      | II |
| 40        | 313.95       | III | 170       | 602.726      | I   | 250       | 2293.49      | IV  | 100       | 3044.09      | II |
| 90        | 352.956      | I   | 170       | 615.628      | I   | 250       | 2350.84      | IV  | 100       | 3045.56      | II |
| 60        | 354.962      | I   | 170       | 618.672      | I   | 450       | 2352.52      | IV  | 120       | 3047.56      | II |
| 50        | 357.83       | IV  | 120       | 619.102      | I   | 700       | 2357.96      | IV  | 100       | 3054.34      | II |
| 400       | 357.96       | V   | 200       | 626.823      | I   | 250       | 2362.68      | IV  | 100       | 3054.68      | II |
| 500       | 358.47       | V   | 200       | 629.739      | I   | 250       | 2363.28      | IV  | 100       | 3059.11      | II |
| 200       | 358.72       | IV  | 1000      | 735.896      | I   | 110       | 2365.49      | IV  | 100       | 3062.49      | II |
| 500       | 359.38       | V   | 400       | 743.720      | I   | 350       | 2372.16      | IV  | 100       | 3063.30      | II |
| 90        | 361.433      | II  | 60        | 993.88       | I   | 65        | 2384.20      | IV  | 100       | 3070.89      | II |
| 60        | 362.455      | II  | 70        | 1068.65      | I   | 350       | 2384.95      | IV  | 100       | 3071.53      | II |
| 1000      | 365.59       | V   | 90        | 1131.72      | I   | 300       | 2412.73      | III | 100       | 3075.73      | II |
| 220       | 379.31       | III | 100       | 1131.85      | II  | 240       | 2412.94      | III | 120       | 3088.17      | II |
| 125       | 387.14       | IV  | 90        | 1229.83      | I   | 200       | 2413.78      | III | 100       | 3092.09      | II |
| 100       | 388.22       | IV  | 20        | 1255.03      | III | 200       | 2473.40      | III | 120       | 3092.90      | II |
| 150       | 405.854      | II  | 110       | 1255.68      | III | 80 p      | 2562.12      | II  | 100       | 3094.01      | II |
| 120       | 407.138      | II  | 160       | 1257.19      | III | 90 w      | 2567.12      | II  | 100       | 3095.10      | II |
| 800       | 416.20       | V   | 90        | 1418.38      | I   | 800       | 2590.04      | III | 100       | 3097.13      | II |
| 150       | 421.61       | IV  | 90        | 1428.58      | I   | 600       | 2593.60      | III | 100       | 3117.98      | II |
| 200       | 445.040      | II  | 90        | 1436.09      | I   | 400       | 2595.68      | III | 120       | 3118.16      | II |
| 300       | 446.256      | II  | 120       | 1681.68      | II  | 300       | 2610.03      | III | 10        | 3126.199     | I  |
| 250       | 446.590      | II  | 180       | 1688.36      | II  | 240       | 2613.41      | III | 300       | 3141.33      | II |
| 180       | 447.815      | II  | 100       | 1888.11      | II  | 200       | 2615.87      | III | 100       | 3143.72      | II |
| 150       | 454.654      | II  | 100       | 1889.71      | II  | 80        | 2623.11      | II  | 100 p     | 3148.68      | II |
| 200       | 455.274      | II  | 200       | 1907.49      | II  | 80        | 2629.89      | II  | 100       | 3164.43      | II |
| 10        | 456.275      | II  | 500       | 1916.08      | II  | 90 w      | 2636.07      | II  | 100       | 3165.65      | II |
| 120       | 456.348      | II  | 300       | 1930.03      | II  | 80        | 2638.29      | II  | 100       | 3188.74      | II |
| 90        | 456.896      | II  | 200       | 1938.83      | II  | 200       | 2638.70      | III | 120       | 3194.58      | II |
| 1000      | 460.728      | II  | 100 c     | 1945.46      | II  | 200       | 2641.07      | III | 500       | 3198.59      | II |
| 500       | 462.391      | II  | 80        | 2007.01      | II  | 80        | 2644.10      | II  | 60        | 3208.96      | II |
| 140       | 469.77       | IV  | 65        | 2018.44      | IV  | 600       | 2677.90      | III | 120       | 3209.36      | II |
| 200       | 469.82       | IV  | 110       | 2022.19      | IV  | 500       | 2678.64      | III | 120       | 3213.74      | II |
| 180       | 469.87       | IV  | 80        | 2025.56      | II  | 80        | 2762.92      | II  | 150       | 3214.33      | II |
| 140       | 469.92       | IV  | 150       | 2085.47      | II  | 90        | 2792.02      | II  | 150       | 3218.19      | II |
| 250       | 480.41       | V   | 200       | 2086.96      | III | 80        | 2794.22      | II  | 120       | 3224.82      | II |
| 150       | 481.28       | V   | 300       | 2089.43      | III | 100       | 2809.48      | II  | 120       | 3229.57      | II |
| 250       | 481.36       | V   | 240       | 2092.44      | III | 80        | 2906.59      | II  | 200       | 3230.07      | II |
| 500       | 482.99       | V   | 400       | 2095.54      | III | 80        | 2906.82      | II  | 120       | 3230.42      | II |
| 285       | 488.10       | III | 180       | 2096.11      | II  | 90        | 2910.06      | II  | 120       | 3232.02      | II |
| 220       | 488.87       | III | 120       | 2096.25      | II  | 90        | 2910.41      | II  | 150       | 3232.37      | II |
| 450       | 489.50       | III | 200       | 2161.22      | III | 80        | 2911.14      | II  | 100       | 3243.40      | II |
| 70        | 489.64       | III | 300       | 2163.77      | III | 80        | 2915.12      | II  | 100       | 3244.10      | II |
| 220       | 490.31       | III | 200       | 2180.89      | III | 80        | 2925.62      | II  | 100       | 3248.34      | II |
| 360       | 491.05       | III | 30        | 2203.88      | IV  | 80 w      | 2932.10      | II  | 100       | 3250.36      | II |
| 120       | 521.74       | IV  | 200       | 2209.35      | III | 80        | 2940.65      | II  | 150       | 3297.73      | II |
| 140       | 521.82       | IV  | 200       | 2211.85      | III | 90        | 2946.04      | II  | 150       | 3309.74      | II |
| 80        | 541.13       | IV  | 240       | 2213.76      | III | 150       | 2955.72      | II  | 300       | 3319.72      | II |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |  |
|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|-----------|--------------|--|
| 1000      | 3323.74      | II | 250       | 3727.11      | II | 100       | 6074.338     | I  | 1000      | 8571.352     | I  |           |              |  |
| 150       | 3327.15      | II | 800       | 3766.26      | II | 80        | 6096.163     | I  | 4000      | 8591.259     | I  |           |              |  |
| 100       | 3329.16      | II | 1000      | 3777.13      | II | 60        | 6128.450     | I  | 6000      | 8634.647     | I  |           |              |  |
| 200       | 3334.84      | II | 100       | 3818.43      | II | 100       | 6143.063     | I  | 3000      | 8647.041     | I  |           |              |  |
| 150       | 3344.40      | II | 120       | 3829.75      | II | 120       | 6163.594     | I  | 15000     | 8654.383     | I  |           |              |  |
| 300       | 3345.45      | II | 150       | 4219.74      | II | 250       | 6182.146     | I  | 4000      | 8655.522     | I  |           |              |  |
| 150       | 3345.83      | II | 100       | 4233.85      | II | 150       | 6217.281     | I  | 100       | 8668.26      | II |           |              |  |
| 200       | 3355.02      | II | 120       | 4250.65      | II | 150       | 6266.495     | I  | 5000      | 8679.492     | I  |           |              |  |
| 120       | 3357.82      | II | 120       | 4369.86      | II | 60        | 6304.789     | I  | 5000      | 8681.921     | I  |           |              |  |
| 200       | 3360.60      | II | 70        | 4379.40      | II | 100       | 6334.428     | I  | 2000      | 8704.112     | I  |           |              |  |
| 120       | 3362.16      | II | 150       | 4379.55      | II | 120       | 6382.992     | I  | 4000      | 8771.656     | I  |           |              |  |
| 100       | 3362.71      | II | 100       | 4385.06      | II | 200       | 6402.246     | I  | 12000     | 8780.621     | I  |           |              |  |
| 120       | 3367.22      | II | 200       | 4391.99      | II | 150       | 6506.528     | I  | 10000     | 8783.753     | I  |           |              |  |
| 12        | 3369.808     | I  | 150       | 4397.99      | II | 60        | 6532.882     | I  | 500       | 8830.907     | I  |           |              |  |
| 40        | 3369.908     | I  | 150       | 4409.30      | II | 150       | 6598.953     | I  | 7000      | 8853.867     | I  |           |              |  |
| 100       | 3371.80      | II | 100       | 4413.22      | II | 70        | 6652.093     | I  | 1000      | 8865.306     | I  |           |              |  |
| 500       | 3378.22      | II | 100       | 4421.39      | II | 90        | 6678.276     | I  | 1000      | 8865.755     | I  |           |              |  |
| 150       | 3388.42      | II | 100 p     | 4428.52      | II | 20        | 6717.043     | I  | 3000      | 8919.501     | I  |           |              |  |
| 120       | 3388.94      | II | 100 p     | 4428.63      | II | 100       | 6929.467     | I  | 2000      | 8988.57      | I  |           |              |  |
| 300       | 3392.80      | II | 150 p     | 4430.90      | II | 90        | 7024.050     | I  | 100       | 9079.46      | II |           |              |  |
| 100       | 3404.82      | II | 150 p     | 4430.94      | II | 100       | 7032.413     | I  | 6000      | 9148.67      | I  |           |              |  |
| 120       | 3406.95      | II | 120       | 4457.05      | II | 50        | 7051.292     | I  | 6000      | 9201.76      | I  |           |              |  |
| 100       | 3413.15      | II | 100       | 4522.72      | II | 80        | 7059.107     | I  | 4000      | 9220.06      | I  |           |              |  |
| 120       | 3416.91      | II | 10        | 4537.754     | I  | 100       | 7173.938     | I  | 2000      | 9221.58      | I  |           |              |  |
| 120       | 3417.69      | II | 10        | 4540.380     | I  | 150       | 7213.20      | II | 2000      | 9226.69      | I  |           |              |  |
| 50        | 3417.904     | I  | 100       | 4569.06      | II | 150       | 7235.19      | II | 1000      | 9275.52      | I  |           |              |  |
| 15        | 3418.006     | I  | 15        | 4704.395     | I  | 100       | 7245.167     | I  | 200       | 9287.56      | II |           |              |  |
| 120       | 3428.69      | II | 12        | 4708.862     | I  | 150       | 7343.94      | II | 6000      | 9300.85      | I  |           |              |  |
| 60        | 3447.703     | I  | 10        | 4710.067     | I  | 40        | 7472.439     | I  | 1500      | 9310.58      | I  |           |              |  |
| 50        | 3454.195     | I  | 10        | 4712.066     | I  | 90        | 7488.871     | I  | 3000      | 9313.97      | I  |           |              |  |
| 100       | 3456.61      | II | 15        | 4715.347     | I  | 100       | 7492.10      | II | 6000      | 9326.51      | I  |           |              |  |
| 100       | 3459.32      | II | 10        | 4752.732     | I  | 150       | 7522.82      | II | 2000      | 9373.31      | I  |           |              |  |
| 25        | 3460.524     | I  | 12        | 4788.927     | I  | 80        | 7535.774     | I  | 5000      | 9425.38      | I  |           |              |  |
| 30        | 3464.339     | I  | 10        | 4790.22      | I  | 60        | 7544.044     | I  | 3000      | 9459.21      | I  |           |              |  |
| 30        | 3466.579     | I  | 10        | 4827.344     | I  | 100       | 7724.628     | I  | 5000      | 9486.68      | I  |           |              |  |
| 60        | 3472.571     | I  | 10        | 4884.917     | I  | 120       | 7740.74      | II | 5000      | 9534.16      | I  |           |              |  |
| 150       | 3479.52      | II | 4         | 5005.159     | I  | 300       | 7839.055     | I  | 3000      | 9547.40      | I  |           |              |  |
| 200       | 3480.72      | II | 10        | 5037.751     | I  | 120       | 7926.20      | II | 120       | 9577.01      | II |           |              |  |
| 200       | 3481.93      | II | 10        | 5144.938     | I  | 400       | 7927.118     | I  | 1000      | 9665.42      | I  |           |              |  |
| 25        | 3498.064     | I  | 25        | 5330.778     | I  | 700       | 7936.996     | I  | 100       | 9808.86      | II |           |              |  |
| 30        | 3501.216     | I  | 20        | 5341.094     | I  | 2000      | 7943.181     | I  | 800       | 10295.42     | I  |           |              |  |
| 25        | 3515.191     | I  | 8         | 5343.283     | I  | 2000      | 8082.458     | I  | 2000      | 10562.41     | I  |           |              |  |
| 150       | 3520.472     | I  | 60        | 5400.562     | I  | 100       | 8084.34      | II | 1500      | 10798.07     | I  |           |              |  |
| 120       | 3542.85      | II | 5         | 5562.766     | I  | 1000      | 8118.549     | I  | 2000      | 10844.48     | I  |           |              |  |
| 120       | 3557.80      | II | 10        | 5656.659     | I  | 600       | 8128.911     | I  | 3000      | 11143.020    | I  |           |              |  |
| 100       | 3561.20      | II | 5         | 5719.225     | I  | 3000      | 8136.406     | I  | 3500      | 11177.528    | I  |           |              |  |
| 250       | 3568.50      | II | 12        | 5748.298     | I  | 2500      | 8259.379     | I  | 1600      | 11390.434    | I  |           |              |  |
| 100       | 3574.18      | II | 80        | 5764.419     | I  | 100       | 8264.81      | II | 1100      | 11409.134    | I  |           |              |  |
| 200       | 3574.61      | II | 12        | 5804.450     | I  | 2500      | 8266.077     | I  | 3000      | 11522.746    | I  |           |              |  |
| 50        | 3593.526     | I  | 40        | 5820.156     | I  | 800       | 8267.117     | I  | 1500      | 11525.020    | I  |           |              |  |
| 30        | 3593.640     | I  | 500       | 5852.488     | I  | 6000      | 8300.326     | I  | 950       | 11536.344    | I  |           |              |  |
| 15        | 3600.169     | I  | 100       | 5872.828     | I  | 100       | 8315.00      | II | 500       | 11601.537    | I  |           |              |  |
| 20        | 3633.665     | I  | 100       | 5881.895     | I  | 1500      | 8365.749     | I  | 1200      | 11614.081    | I  |           |              |  |
| 150       | 3643.93      | II | 60        | 5902.462     | I  | 100       | 8372.11      | II | 300       | 11688.002    | I  |           |              |  |
| 200       | 3664.07      | II | 60        | 5906.429     | I  | 8000      | 8377.606     | I  | 2000      | 11766.792    | I  |           |              |  |
| 20        | 3682.243     | I  | 100       | 5944.834     | I  | 1000      | 8417.159     | I  | 1500      | 11789.044    | I  |           |              |  |
| 12        | 3685.736     | I  | 100       | 5965.471     | I  | 4000      | 8418.427     | I  | 500       | 11789.889    | I  |           |              |  |
| 200       | 3694.21      | II | 100       | 5974.627     | I  | 1500      | 8463.358     | I  | 1000      | 11984.912    | I  |           |              |  |
| 10        | 3701.225     | I  | 120       | 5975.534     | I  | 800       | 8484.444     | I  | 3000      | 12066.334    | I  |           |              |  |
| 150       | 3709.62      | II | 80        | 5987.907     | I  | 5000      | 8495.360     | I  | 800       | 12459.389    | I  |           |              |  |
| 250       | 3713.08      | II | 100       | 6029.997     | I  | 600       | 8544.696     | I  | 1000      | 12689.201    | I  |           |              |  |

| Intensity                  | Wavelength/Å |   | Intensity | Wavelength/Å |   | Intensity               | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|----------------------------|--------------|---|-----------|--------------|---|-------------------------|--------------|-----|-----------|--------------|-----|
| 1100                       | 12912.014    | I | 300 l     | 3986.89      | I | 300                     | 8155.11      | I   | 300       | 863.22       | III |
| 700                        | 13219.241    | I | 300 s     | 5044.66      | I | 300 l                   | 8167.42      | I   | 300       | 867.51       | III |
| 800                        | 15230.714    | I | 300 l     | 5601.70      | I | 300 l                   | 8183.06      | I   | 300       | 973.79       | III |
| 400                        | 17161.930    | I | 300 l     | 5652.75      | I | 300 l                   | 8188.61      | I   | 400       | 979.59       | III |
| 400                        | 18035.80     | I | 300 l     | 5784.39      | I | 300 l                   | 8247.82      | I   | 500       | 1317.22      | II  |
| 1000                       | 18083.21     | I | 300 l     | 5878.04      | I | 300 l                   | 8287.11      | I   | 76        | 1398.19      | IV  |
| 350                        | 18221.11     | I | 300 s     | 6011.22      | I | 300 s                   | 8287.75      | I   | 74        | 1411.45      | IV  |
| 250                        | 18227.02     | I | 300       | 6056.09      | I | 300 l                   | 8306.22      | I   | 70        | 1438.82      | IV  |
| 2500                       | 18276.68     | I | 300 s     | 6073.90      | I | 300 s                   | 8313.66      | I   | 73        | 1449.01      | IV  |
| 2000                       | 18282.62     | I | 300 s     | 6080.05      | I | 1000 l                  | 8339.12      | I   | 76        | 1452.22      | IV  |
| 1200                       | 18303.97     | I | 300 l     | 6120.49      | I | 300                     | 8356.79      | I   | 73        | 1482.25      | IV  |
| 250                        | 18359.12     | I | 300       | 6188.59      | I | 300 l                   | 8367.11      | I   | 72        | 1489.83      | IV  |
| 1200                       | 18384.85     | I | 300 l     | 6200.00      | I | 3000                    | 8372.88      | I   | 75        | 1525.31      | IV  |
| 2000                       | 18389.95     | I | 300 s     | 6215.90      | I | 3000                    | 8529.96      | I   | 74        | 1527.68      | IV  |
| 1000                       | 18402.84     | I | 300 s     | 6317.84      | I | 1000 s                  | 8696.23      | I   | 74        | 1527.80      | IV  |
| 1200                       | 18422.39     | I | 300 l     | 6341.38      | I | 1000 s                  | 8906.02      | I   | 76        | 1534.71      | IV  |
| 300                        | 18458.65     | I | 300 l     | 6566.11      | I | 1000                    | 8942.70      | I   | 73        | 1537.25      | IV  |
| 400                        | 18475.79     | I | 300 l     | 6720.68      | I | 1000 s                  | 9004.75      | I   | 75        | 1543.41      | IV  |
| 900                        | 18591.55     | I | 300 s     | 6751.32      | I | 1000 l                  | 9006.31      | I   | 74        | 1546.23      | IV  |
| 1600                       | 18597.70     | I | 300 s     | 6795.21      | I | 10000 l                 | 9016.18      | I   | 300       | 1604.54      | III |
| 350                        | 18618.96     | I | 300 l     | 6802.62      | I | 3000 l                  | 9141.30      | I   | 300       | 1652.87      | III |
| 550                        | 18625.16     | I | 300 l     | 6805.81      | I | 3000 s                  | 9379.33      | I   | 400       | 1687.90      | III |
| 1200                       | 21041.295    | I | 300 s     | 6816.44      | I | 3000 l                  | 9468.66      | I   | 1000      | 1692.51      | III |
| 750                        | 21708.145    | I | 300 l     | 6865.45      | I | 3000 s                  | 9679.13      | I   | 800       | 1709.90      | III |
| 300                        | 22247.35     | I | 300 s     | 6907.13      | I | 3000 l                  | 9930.55      | I   | 650       | 1715.30      | III |
| 350                        | 22428.13     | I | 300 h     | 6912.91      | I | 10000 l                 | 10091.99     | I   | 500       | 1719.46      | III |
| 2250                       | 22530.40     | I | 1000 s    | 6930.31      | I | 10000 s                 | 10817.45     | I   | 400       | 1722.28      | III |
| 400                        | 22661.81     | I | 300 l     | 6963.63      | I | 10000 l                 | 11695.15     | I   | 500       | 1738.25      | III |
| 600                        | 23100.51     | I | 3000 s    | 6972.09      | I | 10000 l                 | 11776.64     | I   | 300       | 1739.78      | III |
| 1000                       | 23260.30     | I | 300       | 7014.02      | I | 10000 s                 | 12148.18     | I   | 1000      | 1741.55      | II  |
| 1050                       | 23373.00     | I | 300 l     | 7018.91      | I | 10000 s                 | 12377.42     | I   | 300       | 1741.96      | III |
| 850                        | 23565.36     | I | 300 s     | 7039.14      | I | 10000 l                 | 12407.99     | I   | 550       | 1747.01      | III |
| 3500                       | 23636.52     | I | 300 s     | 7080.01      | I | 10000 l                 | 13834.33     | I   | 300       | 1752.43      | III |
| 300                        | 23701.64     | I | 300 l     | 7174.83      | I | <i>Nickel Ni Z = 28</i> |              |     | 400       | 1753.01      | III |
| 1100                       | 23709.2      | I | 300 l     | 7184.93      | I | 55                      | 315.24       | V   | 800       | 1764.69      | III |
| 1800                       | 23951.42     | I | 300 l     | 7284.28      | I | 56                      | 315.71       | V   | 500       | 1767.94      | III |
| 600                        | 23956.46     | I | 300 l     | 7292.29      | I | 72                      | 354.18       | V   | 2000      | 1769.64      | III |
| 1000                       | 23978.12     | I | 300 l     | 7332.52      | I | 76                      | 354.42       | V   | 400       | 1776.07      | III |
| 200                        | 24098.54     | I | 300 s     | 7370.60      | I | 68                      | 354.49       | V   | 300       | 1807.24      | III |
| 500                        | 24161.42     | I | 300 l     | 7381.03      | I | 500                     | 630.71       | III | 300       | 1819.28      | III |
| 600                        | 24249.64     | I | 300 l     | 7381.65      | I | 500                     | 676.94       | III | 800       | 1823.06      | III |
| 1500                       | 24365.05     | I | 300 l     | 7402.70      | I | 300                     | 713.33       | III | 400       | 1830.01      | III |
| 800                        | 24371.60     | I | 300 s     | 7512.22      | I | 300                     | 713.38       | III | 650       | 1847.28      | III |
| 400                        | 24447.85     | I | 300 l     | 7515.15      | I | 500                     | 718.48       | III | 800       | 1854.15      | III |
| 700                        | 24459.4      | I | 300 l     | 7546.05      | I | 300                     | 722.09       | III | 300       | 1858.75      | III |
| 300                        | 24776.46     | I | 300 l     | 7624.83      | I | 500                     | 729.82       | III | 1000      | 2165.55      | II  |
| 550                        | 24928.88     | I | 300       | 7626.85      | I | 400                     | 731.70       | III | 2000      | 2169.10      | II  |
| 250                        | 25161.69     | I | 300 s     | 7681.01      | I | 300                     | 732.16       | III | 2000      | 2174.67      | II  |
| 650                        | 25524.37     | I | 300 s     | 7685.25      | I | 300                     | 747.99       | III | 1500      | 2175.15      | II  |
| 125                        | 28386.21     | I | 1000 l    | 7735.14      | I | 300                     | 750.05       | III | 2500      | 2185.50      | II  |
| 150                        | 30200.       | I | 300 l     | 7761.61      | I | 300                     | 757.80       | III | 3000      | 2192.09      | II  |
| 250                        | 33173.09     | I | 1000 l    | 7765.75      | I | 400                     | 770.22       | III | 5000      | 2205.55      | II  |
| 450                        | 33352.35     | I | 300 s     | 7776.07      | I | 500                     | 778.81       | III | 4000      | 2206.72      | II  |
| 1300                       | 33901.       | I | 300       | 7787.46      | I | 300                     | 788.04       | III | 6000      | 2216.48      | II  |
| 2200                       | 33912.10     | I | 1000 l    | 7791.38      | I | 500                     | 811.57       | III | 1000      | 2264.46      | II  |
| 600                        | 34131.31     | I | 300 l     | 7851.44      | I | 500                     | 826.14       | III | 2000      | 2270.21      | II  |
| 100                        | 34471.44     | I | 300 l     | 7887.88      | I | 500                     | 842.14       | III | 1600      | 2289.98      | I   |
| 120                        | 35834.78     | I | 300 l     | 7901.71      | I | 500                     | 845.24       | III | 630       | 2300.78      | I   |
| <i>Neptunium Np Z = 93</i> |              |   | 300 l     | 7975.98      | I | 400                     | 847.43       | III | 1000      | 2303.00      | II  |
| 300                        | 3481.93      | I | 300 h     | 8080.32      | I | 300                     | 860.64       | III | 2000      | 2310.96      | I   |
| 300 h                      | 3501.50      | I | 300 s     | 8124.59      | I | 300                     | 862.88       | III | 1700      | 2312.34      | I   |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|-----------|--------------|----|--------------------------|--------------|-----|-----------|--------------|-----|
| 1400      | 2313.66      | I  | 530       | 3612.74      | I  | 500 w                    | 9900.92      | II  | 100       | 2362.06      | III |
| 1400      | 2313.98      | I  | 6600      | 3619.39      | I  |                          |              |     | 80        | 2362.50      | III |
| 1000      | 2316.04      | II | 200       | 3664.10      | I  | <i>Niobium Nb Z = 41</i> |              |     | 80        | 2365.70      | III |
| 1400      | 2317.16      | I  | 130       | 3669.24      | I  | 80                       | 464.55       | V   | 100       | 2372.73      | III |
| 2600      | 2320.03      | I  | 180       | 3670.43      | I  | 80                       | 468.32       | V   | 170       | 2376.40      | II  |
| 1900      | 2321.38      | I  | 260       | 3674.15      | I  | 80                       | 763.77       | V   | 110       | 2387.09      | II  |
| 1400      | 2325.79      | I  | 160       | 3688.42      | I  | 80                       | 774.02       | V   | 100       | 2387.41      | III |
| 940       | 2329.96      | I  | 80        | 3693.93      | I  | 60                       | 993.54       | IV  | 140       | 2387.52      | II  |
| 1200      | 2345.54      | I  | 120       | 3722.48      | I  | 400                      | 1005.72      | IV  | 80        | 2388.23      | III |
| 400       | 2347.52      | I  | 150       | 3736.81      | I  | 500                      | 1007.05      | IV  | 45        | 2388.27      | II  |
| 1000      | 2375.42      | II | 60        | 3739.23      | I  | 500                      | 1010.19      | IV  | 160       | 2398.48      | II  |
| 240       | 2386.58      | I  | 600       | 3775.57      | I  | 100                      | 1116.08      | IV  | 80        | 2404.89      | III |
| 1000      | 2394.52      | II | 700       | 3783.53      | I  | 150                      | 1120.02      | IV  | 55        | 2405.34      | II  |
| 2000      | 2416.13      | II | 700       | 3807.14      | I  | 100                      | 1258.87      | V   | 55        | 2405.85      | II  |
| 240       | 2419.31      | I  | 110       | 3831.69      | I  | 60                       | 1314.56      | III | 140       | 2412.46      | II  |
| 160       | 2472.06      | I  | 1200      | 3858.30      | I  | 80                       | 1445.43      | III | 100       | 2413.94      | III |
| 150       | 2798.65      | I  | 110       | 3973.56      | I  | 80                       | 1445.98      | III | 160       | 2416.99      | II  |
| 250       | 2821.29      | I  | 110       | 4401.55      | I  | 80                       | 1447.09      | III | 140       | 2418.69      | II  |
| 500       | 2943.91      | I  | 85        | 4459.04      | I  | 100                      | 1456.68      | III | 100       | 2421.91      | III |
| 570       | 2981.65      | I  | 55        | 4470.48      | I  | 80                       | 1484.73      | III | 75        | 2433.80      | II  |
| 500       | 2992.60      | I  | 65        | 4605.00      | I  | 100                      | 1495.94      | III | 40        | 2435.95      | II  |
| 1000      | 2994.46      | I  | 75        | 4648.66      | I  | 80                       | 1498.02      | III | 45        | 2437.42      | II  |
| 4000      | 3002.49      | I  | 110       | 4714.42      | I  | 80                       | 1499.45      | III | 40        | 2442.14      | II  |
| 2200      | 3003.63      | I  | 45        | 4786.54      | I  | 100                      | 1501.99      | III | 28        | 2442.68      | II  |
| 3700      | 3012.00      | I  | 45        | 4855.41      | I  | 60                       | 1502.30      | IV  | 65        | 2451.87      | II  |
| 1700      | 3037.94      | I  | 40        | 4904.41      | I  | 80                       | 1513.81      | III | 65        | 2453.95      | II  |
| 3500      | 3050.82      | I  | 45        | 4980.16      | I  | 60                       | 1524.36      | IV  | 100       | 2456.99      | III |
| 1500      | 3054.32      | I  | 45        | 4984.13      | I  | 100                      | 1524.91      | III | 55        | 2458.09      | II  |
| 1900      | 3057.64      | I  | 50        | 5017.59      | I  | 100                      | 1590.21      | III | 65        | 2462.89      | I   |
| 500       | 3064.62      | I  | 100       | 5035.37      | I  | 80                       | 1598.86      | III | 80        | 2468.72      | III |
| 2600      | 3101.55      | I  | 100       | 5080.52      | I  | 80                       | 1604.72      | III | 80        | 2475.87      | III |
| 1300      | 3101.88      | I  | 65        | 5081.11      | I  | 80                       | 1639.51      | III | 110       | 2477.38      | II  |
| 2900      | 3134.11      | I  | 40 h      | 5146.48      | I  | 100                      | 1682.77      | III | 65        | 2478.29      | II  |
| 1100      | 3232.96      | I  | 40 h      | 5155.76      | I  | 100                      | 1705.44      | III | 65        | 2479.94      | II  |
| 600       | 3243.06      | I  | 180       | 5476.91      | I  | 100                      | 1707.14      | III | 35        | 2483.88      | II  |
| 660       | 3315.66      | I  | 23        | 5709.56      | I  | 100                      | 1758.33      | V   | 100       | 2499.73      | III |
| 2000      | 3331.88      | II | 16        | 5754.68      | I  | 100                      | 1877.34      | V   | 110       | 2511.00      | II  |
| 2900      | 3369.57      | I  | 10        | 5857.76      | I  | 100                      | 1892.92      | III | 110       | 2521.40      | II  |
| 3300      | 3380.57      | I  | 10        | 5892.88      | I  | 60                       | 1922.41      | IV  | 390       | 2544.80      | II  |
| 1300      | 3391.05      | I  | 10        | 6108.12      | I  | 100                      | 1938.84      | III | 100       | 2545.64      | III |
| 3300      | 3392.99      | I  | 10        | 6176.81      | I  | 60                       | 1978.22      | IV  | 110       | 2551.38      | II  |
| 8200      | 3414.76      | I  | 10        | 6191.18      | I  | 3300                     | 2029.32      | II  | 130       | 2556.94      | II  |
| 1600      | 3423.71      | I  | 13        | 6256.36      | I  | 65                       | 2032.53      | IV  | 80        | 2557.94      | III |
| 2600      | 3433.56      | I  | 16        | 6643.64      | I  | 3000                     | 2032.99      | II  | 130       | 2562.41      | II  |
| 990       | 3437.28      | I  | 22        | 6767.77      | I  | 2000                     | 2109.42      | II  | 110       | 2571.33      | II  |
| 4800      | 3446.26      | I  | 10        | 6914.56      | I  | 1700                     | 2125.21      | II  | 390       | 2583.99      | II  |
| 1300      | 3452.89      | I  | 26        | 7122.20      | I  | 1100                     | 2126.54      | II  | 390       | 2590.94      | II  |
| 5000      | 3458.47      | I  | 16        | 7393.60      | I  | 80 h                     | 2130.24      | III | 80        | 2598.86      | III |
| 5000      | 3461.65      | I  | 16        | 7409.35      | I  | 1500                     | 2131.18      | II  | 80        | 2633.17      | III |
| 1600      | 3472.54      | I  | 23        | 7422.28      | I  | 80                       | 2273.92      | III | 200       | 2642.24      | II  |
| 550       | 3483.77      | I  | 13        | 7522.76      | I  | 100                      | 2275.23      | III | 320       | 2646.26      | II  |
| 5500      | 3492.96      | I  | 19        | 7555.60      | I  | 80                       | 2279.36      | III | 330       | 2647.50      | I   |
| 660       | 3500.85      | I  | 23        | 7617.00      | I  | 100                      | 2281.51      | III | 330       | 2654.45      | I   |
| 2600      | 3510.34      | I  | 16        | 7714.32      | I  | 80                       | 2284.40      | III | 310       | 2656.08      | II  |
| 6600      | 3515.05      | I  | 19        | 7727.61      | I  | 100                      | 2290.36      | III | 80        | 2657.99      | III |
| 660       | 3519.77      | I  | 19        | 7748.89      | I  | 370                      | 2295.68      | II  | 110       | 2665.25      | II  |
| 8200      | 3524.54      | I  | 10        | 7788.94      | I  | 280                      | 2302.08      | II  | 110       | 2666.59      | II  |
| 5000      | 3566.37      | I  | 13        | 7797.59      | I  | 100                      | 2313.30      | III | 110       | 2667.30      | II  |
| 990       | 3571.87      | I  | 1000      | 8096.75      | II | 100                      | 2338.09      | III | 400       | 2671.93      | II  |
| 1300      | 3597.70      | I  | 700       | 8121.48      | II | 80                       | 2344.12      | III | 200       | 2673.57      | II  |
| 1300      | 3610.46      | I  | 9         | 8862.55      | I  | 90                       | 2349.21      | III | 200       | 2675.94      | II  |
|           |              |    |           |              |    | 80                       | 2355.54      | III |           |              |     |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |   |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|-----------|--------------|---|
| 160       | 2691.77      | II  | 80        | 3142.26      | III | 500       | 3584.97      | I  | 350       | 4143.21      | I |
| 1000      | 2697.06      | II  | 390       | 3145.40      | II  | 750       | 3589.11      | I  | 870       | 4150.12      | I |
| 320       | 2698.86      | II  | 1200      | 3163.40      | II  | 500       | 3589.36      | I  | 4400      | 4152.58      | I |
| 320       | 2702.20      | II  | 150       | 3175.78      | II  | 500       | 3593.97      | I  | 870       | 4163.47      | I |
| 150       | 2702.52      | II  | 390       | 3180.29      | II  | 500       | 3602.56      | I  | 4400      | 4163.66      | I |
| 470       | 2716.62      | II  | 300       | 3191.10      | II  | 300       | 3619.51      | II | 4000      | 4164.66      | I |
| 470       | 2721.98      | II  | 150       | 3191.43      | II  | 420       | 3649.85      | I  | 3500      | 4168.13      | I |
| 310       | 2733.26      | II  | 1000      | 3194.98      | II  | 400       | 3651.19      | II | 310       | 4184.44      | I |
| 110       | 2737.09      | II  | 120       | 3203.35      | II  | 200       | 3659.61      | II | 1200      | 4190.88      | I |
| 240       | 2768.13      | II  | 300       | 3206.34      | II  | 630       | 3660.37      | I  | 870       | 4192.07      | I |
| 310       | 2773.20      | I   | 390       | 3215.60      | II  | 900       | 3664.70      | I  | 870       | 4195.09      | I |
| 270       | 2780.24      | II  | 800       | 3225.48      | II  | 1500      | 3697.85      | I  | 1300      | 4195.66      | I |
| 110       | 2793.05      | II  | 140       | 3229.56      | II  | 330       | 3711.34      | I  | 310       | 4198.51      | I |
| 190       | 2827.08      | II  | 400       | 3236.40      | II  | 3300      | 3713.01      | I  | 350       | 4201.52      | I |
| 250       | 2841.15      | II  | 200       | 3247.47      | II  | 480       | 3716.99      | I  | 870       | 4205.31      | I |
| 280       | 2842.65      | II  | 120       | 3248.94      | II  | 2700      | 3726.24      | I  | 350       | 4214.73      | I |
| 160       | 2846.28      | II  | 320       | 3254.07      | II  | 2700      | 3739.80      | I  | 420       | 4217.94      | I |
| 240       | 2861.09      | II  | 230       | 3260.56      | II  | 670       | 3740.73      | II | 420       | 4229.15      | I |
| 100       | 2865.61      | II  | 160       | 3263.37      | II  | 1700      | 3742.39      | I  | 770       | 4262.05      | I |
| 500       | 2868.52      | II  | 200       | 3283.46      | II  | 530       | 3763.49      | I  | 420       | 4266.02      | I |
| 800       | 2875.39      | II  | 160       | 3292.02      | II  | 350       | 3765.08      | I  | 400       | 4286.99      | I |
| 270       | 2876.95      | II  | 320       | 3296.01      | I   | 530       | 3771.85      | I  | 580       | 4299.60      | I |
| 530       | 2877.03      | II  | 400       | 3312.60      | I   | 870       | 3781.01      | I  | 580       | 4300.99      | I |
| 100       | 2880.72      | II  | 120       | 3319.58      | II  | 1700      | 3787.06      | I  | 390       | 4311.27      | I |
| 570       | 2883.18      | II  | 130       | 3341.60      | II  | 1300      | 3790.15      | I  | 350       | 4326.33      | I |
| 280       | 2888.83      | II  | 1300      | 3341.97      | I   | 3500      | 3791.21      | I  | 390       | 4331.37      | I |
| 470       | 2897.81      | II  | 1300      | 3343.71      | I   | 2700      | 3798.12      | I  | 330       | 4410.21      | I |
| 400       | 2899.24      | II  | 1700      | 3349.06      | I   | 2700      | 3802.92      | I  | 150       | 4503.04      | I |
| 470       | 2908.24      | II  | 420       | 3349.52      | I   | 670       | 3803.88      | I  | 530       | 4523.41      | I |
| 670       | 2910.59      | II  | 340       | 3354.74      | I   | 530       | 3804.74      | I  | 480       | 4546.82      | I |
| 470       | 2911.74      | II  | 1700      | 3358.42      | I   | 670       | 3810.49      | I  | 370       | 4564.53      | I |
| 1100      | 2927.81      | II  | 130       | 3365.58      | II  | 530       | 3811.03      | I  | 720       | 4573.08      | I |
| 110       | 2931.47      | II  | 340       | 3366.96      | I   | 530       | 3815.51      | I  | 480       | 4581.62      | I |
| 870       | 2941.54      | II  | 130       | 3369.16      | II  | 210       | 3818.86      | II | 1200      | 4606.77      | I |
| 110 h     | 2945.88      | II  | 350       | 3374.92      | I   | 670       | 3824.88      | I  | 170       | 4616.17      | I |
| 110       | 2946.12      | II  | 170       | 3386.24      | II  | 350       | 3835.18      | I  | 450       | 4630.11      | I |
| 110       | 2946.90      | II  | 350       | 3392.34      | I   | 350       | 3863.38      | I  | 450       | 4648.95      | I |
| 1100      | 2950.88      | II  | 230       | 3408.68      | II  | 530       | 3877.56      | I  | 450       | 4663.83      | I |
| 400       | 2972.57      | II  | 180       | 3409.19      | II  | 870       | 3878.82      | I  | 340       | 4666.24      | I |
| 320       | 2974.10      | II  | 230       | 3412.94      | II  | 670       | 3883.14      | I  | 240       | 4667.22      | I |
| 210       | 2977.68      | II  | 230       | 3425.42      | II  | 1100      | 3885.44      | I  | 580       | 4672.09      | I |
| 200       | 2982.11      | II  | 230       | 3426.57      | II  | 670       | 3885.68      | I  | 530       | 4675.37      | I |
| 330       | 2990.26      | II  | 180       | 3432.70      | II  | 580       | 3891.30      | I  | 320       | 4685.14      | I |
| 470       | 2994.73      | II  | 180       | 3440.59      | II  | 670       | 3914.70      | I  | 130 c     | 4706.14      | I |
| 80        | 3001.84      | III | 200       | 3479.56      | II  | 530       | 3920.20      | I  | 260       | 4708.29      | I |
| 140       | 3024.74      | II  | 100       | 3484.05      | II  | 670       | 3937.44      | I  | 150       | 4713.50      | I |
| 350       | 3028.44      | II  | 500       | 3498.63      | I   | 520       | 3943.67      | I  | 220 c     | 4749.70      | I |
| 300       | 3032.77      | II  | 460       | 3507.96      | I   | 910 d     | 3966.09      | I  | 130 c     | 4967.78      | I |
| 100       | 3044.76      | II  | 200       | 3510.26      | II  | 1100      | 4032.52      | I  | 190       | 4988.97      | I |
| 100       | 3055.52      | II  | 200       | 3515.42      | II  | 16000 c   | 4058.94      | I  | 230       | 5017.75      | I |
| 220       | 3064.53      | II  | 200       | 3517.67      | II  | 350       | 4060.79      | I  | 150       | 5026.36      | I |
| 110       | 3069.68      | II  | 2000      | 3535.30      | I   | 12000     | 4079.73      | I  | 210       | 5039.04      | I |
| 100       | 3070.90      | II  | 1300      | 3537.48      | I   | 440       | 4100.40      | I  | 170       | 5058.01      | I |
| 110       | 3071.56      | II  | 250       | 3540.96      | II  | 6700      | 4100.92      | I  | 130       | 5065.25      | I |
| 100       | 3073.24      | II  | 500       | 3544.02      | I   | 310       | 4116.90      | I  | 750       | 5078.96      | I |
| 400       | 3076.87      | II  | 300       | 3550.45      | I   | 5300      | 4123.81      | I  | 420       | 5095.30      | I |
| 110       | 3080.35      | II  | 1000      | 3554.66      | I   | 670       | 4129.43      | I  | 170       | 5100.16      | I |
| 1800      | 3094.18      | II  | 630       | 3563.50      | I   | 770       | 4129.93      | I  | 170       | 5120.30      | I |
| 140       | 3099.19      | II  | 630       | 3563.62      | I   | 2300      | 4137.10      | I  | 210       | 5134.75      | I |
| 270       | 3127.53      | II  | 1500      | 3575.85      | I   | 440       | 4139.44      | I  | 250       | 5160.33      | I |
| 1500      | 3130.79      | II  | 5000      | 3580.27      | I   | 2700      | 4139.71      | I  | 250       | 5164.38      | I |

| Intensity               | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-------------------------|--------------|----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 230                     | 5180.31      | I  | 600 w     | 234.25       | IV  | 360       | 644.837      | II  | 115       | 1098.095     | I   |
| 190                     | 5189.20      | I  | 550       | 236.07       | IV  | 450       | 645.178      | II  | 115       | 1098.260     | I   |
| 170                     | 5193.08      | I  | 500       | 237.99       | IV  | 140       | 647.50       | I   | 105       | 1100.360     | I   |
| 150                     | 5195.84      | I  | 500 w     | 238.7        | IV  | 360       | 660.286      | II  | 40        | 1100.465     | I   |
| 150                     | 5232.81      | I  | 600       | 238.80       | IV  | 170       | 671.016      | II  | 90        | 1101.291     | I   |
| 150 d                   | 5251.62      | I  | 500 w     | 239.62       | IV  | 285       | 671.386      | II  | 360       | 1134.165     | I   |
| 270                     | 5271.53      | I  | 900       | 247.20       | IV  | 150       | 671.630      | II  | 385       | 1134.415     | I   |
| 130 c                   | 5276.20      | I  | 90        | 247.561      | V   | 160       | 671.773      | II  | 410       | 1134.980     | I   |
| 250                     | 5318.60      | I  | 120       | 247.706      | V   | 170       | 672.001      | II  | 105       | 1143.65      | I   |
| 460                     | 5344.17      | I  | 500 w     | 248.43       | IV  | 500       | 684.996      | III | 130       | 1163.884     | I   |
| 340                     | 5350.74      | I  | 500 w     | 248.46       | IV  | 570       | 685.513      | III | 60        | 1164.206     | I   |
| 110                     | 5437.27      | I  | 500 w     | 248.48       | IV  | 650       | 685.816      | III | 105       | 1164.325     | I   |
| 85                      | 5551.35      | I  | 500       | 257.95       | III | 500       | 686.335      | III | 270       | 1167.448     | I   |
| 170                     | 5642.11      | I  | 650       | 258.50       | III | 350       | 692.70       | I   | 105       | 1168.334     | I   |
| 130                     | 5664.71      | I  | 700       | 259.19       | III | 90        | 713.518      | V   | 60        | 1168.417     | I   |
| 170                     | 5665.63      | I  | 800       | 260.09       | III | 150       | 713.860      | V   | 195       | 1168.536     | I   |
| 130                     | 5729.19      | I  | 600       | 260.45       | IV  | 285       | 746.984      | II  | 230       | 1176.510     | I   |
| 110                     | 5760.34      | I  | 800       | 261.28       | III | 150       | 748.195      | V   | 105       | 1176.630     | I   |
| 110                     | 5819.43      | I  | 500       | 262.91       | III | 200       | 748.291      | V   | 195       | 1177.695     | I   |
| 130 d                   | 5838.64      | I  | 500       | 265.23       | III | 500       | 763.336      | III | 500       | 1183.031     | III |
| 190 cw                  | 5900.62      | I  | 500       | 265.27       | III | 570       | 764.359      | III | 570       | 1184.550     | III |
| 150                     | 5983.22      | I  | 150       | 266.196      | V   | 570       | 765.148      | IV  | 90        | 1188.01      | IV  |
| 75                      | 6221.96      | I  | 200       | 266.379      | V   | 250       | 771.544      | III | 410       | 1199.550     | I   |
| 85 c                    | 6430.46      | I  | 500       | 268.70       | III | 300       | 771.901      | III | 385       | 1200.223     | I   |
| 65                      | 6544.61      | I  | 650       | 270.99       | IV  | 350       | 772.385      | III | 360       | 1200.710     | I   |
| 210 cw                  | 6660.84      | I  | 250       | 283.42       | IV  | 200       | 772.891      | III | 175       | 1225.026     | I   |
| 150 cw                  | 6677.33      | I  | 300       | 283.48       | IV  | 150       | 772.975      | III | 160       | 1225.37      | I   |
| 130 c                   | 6723.62      | I  | 350       | 283.58       | IV  | 650       | 775.965      | II  | 130       | 1228.41      | I   |
| 85                      | 6828.11      | I  | 600       | 285.56       | IV  | 90        | 885.67       | I   | 160       | 1228.79      | I   |
| 85                      | 6990.32      | I  | 600 w     | 297.7        | IV  | 90        | 909.697      | I   | 1000      | 1238.821     | V   |
| 190 c                   | 7046.81      | I  | 700       | 297.82       | IV  | 80        | 910.278      | I   | 900       | 1242.804     | V   |
| 130                     | 7159.43      | I  | 650       | 300.32       | IV  | 40        | 910.645      | I   | 360       | 1243.179     | I   |
| 190 cw                  | 7372.50      | I  | 90        | 303.123      | IV  | 450       | 915.612      | II  | 315       | 1243.306     | I   |
| 65                      | 7515.93      | I  | 500       | 303.28       | IV  | 450       | 915.962      | II  | 290       | 1310.540     | I   |
| 170 c                   | 7574.58      | I  | 150       | 314.715      | III | 550       | 916.012      | II  | 250       | 1310.95      | I   |
| 75 c                    | 7726.68      | I  | 200       | 314.850      | III | 650       | 916.701      | II  | 230       | 1319.00      | I   |
| 35                      | 7885.31      | I  | 90        | 314.877      | III | 520       | 921.992      | IV  | 315       | 1319.68      | I   |
| 40                      | 8135.20      | I  | 150       | 315.053      | IV  | 500       | 922.519      | IV  | 115       | 1326.57      | I   |
| 29 cw                   | 8320.93      | I  | 120       | 322.503      | IV  | 480       | 923.057      | IV  | 115       | 1327.92      | I   |
| 29                      | 8346.08      | I  | 150       | 322.570      | IV  | 520       | 924.283      | IV  | 150       | 1387.371     | III |
| 35                      | 8905.78      | I  | 200       | 322.724      | IV  | 90        | 953.415      | I   | 360       | 1411.94      | I   |
| <i>Nitrogen N Z = 7</i> |              |    | 120       | 323.175      | IV  | 100       | 953.655      | I   | 700       | 1492.625     | I   |
| 400                     | 181.75       | IV | 600       | 323.26       | III | 130       | 953.970      | I   | 490       | 1492.820     | I   |
| 52                      | 186.069      | V  | 300       | 335.050      | IV  | 1000      | 955.335      | IV  | 640       | 1494.675     | I   |
| 62                      | 186.153      | V  | 500       | 338.35       | III | 130       | 963.990      | I   | 90        | 1549.336     | V   |
| 400                     | 191.7        | IV | 500       | 340.20       | III | 115       | 964.626      | I   | 200 l     | 1616.33      | V   |
| 400                     | 192.9        | IV | 500 w     | 351.93       | IV  | 70        | 965.041      | I   | 350 l     | 1619.69      | V   |
| 500                     | 196.87       | IV | 500       | 351.98       | III | 650       | 979.842      | III | 1000      | 1718.55      | IV  |
| 500                     | 197.23       | IV | 700       | 353.06       | IV  | 700       | 979.919      | III | 250       | 1729.945     | III |
| 500                     | 202.60       | IV | 120       | 362.833      | III | 900       | 989.790      | III | 775       | 1742.729     | I   |
| 500                     | 205.94       | IV | 150       | 362.881      | III | 700       | 991.514      | III | 700       | 1745.252     | I   |
| 500                     | 205.97       | IV | 150       | 362.946      | III | 1000      | 991.579      | III | 570       | 1747.848     | III |
| 500                     | 206.03       | IV | 90        | 362.985      | III | 150 w     | 1036.16      | IV  | 350       | 1751.218     | III |
| 90                      | 209.303      | V  | 300       | 374.204      | III | 90        | 1067.614     | I   | 650       | 1751.657     | III |
| 500                     | 217.20       | IV | 350       | 374.441      | III | 60        | 1068.612     | I   | 150       | 1804.486     | III |
| 500 d                   | 217.90       | IV | 500       | 387.48       | III | 90        | 1078.71      | IV  | 200       | 1805.669     | III |
| 500 d                   | 223.4        | IV | 500       | 420.77       | IV  | 450       | 1083.990     | II  | 150       | 1846.42      | III |
| 800 w                   | 225.12       | IV | 250       | 451.869      | III | 600       | 1084.580     | II  | 90 w      | 1860.37      | V   |
| 800                     | 225.21       | IV | 300       | 452.226      | III | 430       | 1085.546     | II  | 350       | 1885.06      | III |
| 600 w                   | 234.12       | IV | 650       | 463.74       | IV  | 650       | 1085.701     | II  | 400       | 1885.22      | III |
| 600 w                   | 234.20       | IV | 285       | 644.634      | II  | 175       | 1097.237     | I   | 200       | 1907.99      | III |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|
| 150       | 1919.55      | III | 360       | 3919.00      | II  | 185       | 5281.20      | I   | 450       | 7762.24      | II |
| 150       | 1919.77      | III | 90        | 3938.52      | III | 140       | 5292.68      | I   | 400       | 8184.87      | I  |
| 300       | 1920.65      | III | 450       | 3955.85      | II  | 90        | 5314.35      | III | 400       | 8188.02      | I  |
| 150       | 1920.84      | III | 1000      | 3995.00      | II  | 200       | 5320.82      | III | 250       | 8200.36      | I  |
| 200       | 1921.30      | III | 150       | 3998.63      | III | 150       | 5327.18      | III | 300       | 8210.72      | I  |
| 200       | 2064.01      | III | 200       | 4003.58      | III | 450       | 5495.67      | II  | 570       | 8216.34      | I  |
| 250       | 2064.42      | III | 360       | 4035.08      | II  | 285       | 5535.36      | II  | 400       | 8223.14      | I  |
| 120       | 2068.68      | III | 550       | 4041.31      | II  | 650       | 5666.63      | II  | 400       | 8242.39      | I  |
| 90        | 2071.09      | III | 360       | 4043.53      | II  | 550       | 5676.02      | II  | 550       | 8438.74      | II |
| 90        | 2080.34      | IV  | 150       | 4057.76      | IV  | 870       | 5679.56      | II  | 500       | 8567.74      | I  |
| 160       | 2095.53      | II  | 250       | 4097.33      | III | 450       | 5686.21      | II  | 570       | 8594.00      | I  |
| 70        | 2096.20      | II  | 140       | 4099.94      | I   | 450       | 5710.77      | II  | 650       | 8629.24      | I  |
| 110       | 2096.86      | II  | 200       | 4103.43      | III | 285       | 5747.30      | II  | 500       | 8655.89      | I  |
| 90        | 2117.59      | III | 185       | 4109.95      | I   | 700       | 5752.50      | I   | 220       | 8676.08      | II |
| 90        | 2121.50      | III | 285       | 4176.16      | II  | 240       | 5764.75      | I   | 700       | 8680.28      | I  |
| 110       | 2130.18      | II  | 120       | 4195.76      | III | 265       | 5829.54      | I   | 650       | 8683.40      | I  |
| 160       | 2142.78      | II  | 150       | 4200.10      | III | 235       | 5854.04      | I   | 500       | 8686.15      | I  |
| 90        | 2147.31      | III | 285       | 4227.74      | II  | 360       | 5927.81      | II  | 110       | 8687.43      | II |
| 200       | 2188.20      | III | 285       | 4236.91      | II  | 550       | 5931.78      | II  | 110 h     | 8699.00      | II |
| 150       | 2188.38      | III | 220       | 4237.05      | II  | 285       | 5940.24      | II  | 500       | 8703.25      | I  |
| 160       | 2206.09      | II  | 450       | 4241.78      | II  | 650       | 5941.65      | II  | 160 h     | 8710.54      | II |
| 160       | 2286.69      | II  | 90        | 4332.91      | III | 285       | 5952.39      | II  | 570       | 8711.70      | I  |
| 110       | 2288.44      | II  | 120       | 4345.68      | III | 160       | 5999.43      | I   | 500       | 8718.83      | I  |
| 220       | 2316.49      | II  | 300       | 4379.11      | III | 210       | 6008.47      | I   | 250       | 8728.89      | I  |
| 160       | 2316.69      | II  | 285       | 4432.74      | II  | 285       | 6167.76      | II  | 200       | 8747.36      | I  |
| 285       | 2317.05      | II  | 650       | 4447.03      | II  | 360       | 6379.62      | II  | 500       | 9386.80      | I  |
| 90 w      | 2318.09      | IV  | 90        | 4510.91      | III | 150       | 6380.77      | IV  | 570       | 9392.79      | I  |
| 160       | 2461.27      | II  | 120       | 4514.86      | III | 185       | 6411.65      | I   | 250       | 9460.68      | I  |
| 150       | 2477.69      | IV  | 360       | 4530.41      | II  | 210       | 6420.64      | I   | 200       | 9863.33      | I  |
| 110       | 2496.83      | II  | 550       | 4601.48      | II  | 210       | 6423.02      | I   | 160 h     | 9865.41      | II |
| 70        | 2496.97      | II  | 350       | 4603.73      | V   | 210       | 6428.32      | I   | 110 h     | 9868.21      | II |
| 110       | 2520.22      | II  | 90        | 4606.33      | IV  | 185       | 6437.68      | I   | 160 h     | 9887.39      | II |
| 160       | 2520.79      | II  | 450       | 4607.16      | II  | 235       | 6440.94      | I   | 220 h     | 9891.09      | II |
| 220       | 2522.23      | II  | 360       | 4613.87      | II  | 90        | 6454.11      | III | 160 h     | 9961.86      | II |
| 110       | 2590.94      | II  | 250       | 4619.98      | V   | 185       | 6457.90      | I   | 220 h     | 9969.34      | II |
| 250       | 2645.65      | IV  | 450       | 4621.39      | II  | 120       | 6467.02      | III | 285 h     | 10023.27     | II |
| 300       | 2646.18      | IV  | 870       | 4630.54      | II  | 300       | 6468.44      | I   | 220 h     | 10035.45     | II |
| 350       | 2646.96      | IV  | 90        | 4634.14      | III | 265       | 6481.71      | I   | 220 h     | 10065.15     | II |
| 250 w     | 2682.18      | III | 120       | 4640.64      | III | 750       | 6482.05      | II  | 160 h     | 10070.12     | II |
| 90        | 2689.20      | III | 550       | 4643.08      | II  | 360       | 6482.70      | I   | 250       | 10105.13     | I  |
| 160       | 2709.84      | II  | 285       | 4788.13      | II  | 300       | 6483.75      | I   | 300       | 10108.89     | I  |
| 110       | 2799.22      | II  | 450       | 4803.29      | II  | 325       | 6484.80      | I   | 350       | 10112.48     | I  |
| 110       | 2823.64      | II  | 180       | 4847.38      | I   | 160       | 6491.22      | I   | 400       | 10114.64     | I  |
| 60 l      | 2859.16      | V   | 90        | 4858.82      | III | 210       | 6499.54      | I   | 110 h     | 10126.27     | II |
| 160       | 2885.27      | II  | 150       | 4867.15      | III | 185       | 6506.31      | I   | 250       | 10539.57     | I  |
| 90 l      | 2974.52      | V   | 285       | 4895.11      | II  | 750       | 6610.56      | II  | 200       | 12074.51     | I  |
| 150 w     | 2980.78      | V   | 160       | 4914.94      | I   | 185       | 6622.54      | I   | 380       | 12186.82     | I  |
| 250 w     | 2981.31      | V   | 210       | 4935.12      | I   | 185       | 6636.94      | I   | 225       | 12288.97     | I  |
| 60 w      | 2998.43      | V   | 200 w     | 4944.56      | V   | 235       | 6644.96      | I   | 290       | 12328.76     | I  |
| 220       | 3006.83      | II  | 160       | 4950.23      | I   | 185       | 6646.50      | I   | 310       | 12381.65     | I  |
| 90        | 3078.25      | IV  | 350       | 4963.98      | I   | 235       | 6653.46      | I   | 180       | 12438.40     | I  |
| 120       | 3367.34      | III | 285       | 4987.37      | II  | 210       | 6656.51      | I   | 510       | 12461.25     | I  |
| 360       | 3437.15      | II  | 450       | 4994.36      | II  | 185       | 6722.62      | I   | 920       | 12469.62     | I  |
| 90        | 3463.37      | IV  | 650       | 5001.48      | II  | 210       | 7398.64      | I   | 500       | 13429.61     | I  |
| 570       | 3478.71      | IV  | 360       | 5002.70      | II  | 160       | 7406.12      | I   | 840       | 13581.33     | I  |
| 500       | 3482.99      | IV  | 870       | 5005.15      | II  | 265       | 7406.24      | I   | 180       | 13587.73     | I  |
| 400       | 3484.96      | IV  | 550       | 5007.32      | II  | 685       | 7423.64      | I   | 180       | 13602.27     | I  |
| 90        | 3747.54      | IV  | 450       | 5010.62      | II  | 785       | 7442.29      | I   | 290       | 13624.18     | I  |
| 90        | 3754.67      | III | 360       | 5016.39      | II  | 900       | 7468.31      | I   | 250       | 14757.07     | I  |
| 120       | 3771.05      | III | 360       | 5025.66      | II  | 185       | 7608.80      | I   | 100       | 14868.87     | I  |
| 285       | 3838.37      | II  | 550       | 5045.10      | II  | 60 w      | 7618.46      | V   | 160       | 14966.60     | I  |

| Intensity               | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity             | Wavelength/Å |    | Intensity | Wavelength/Å |     |
|-------------------------|--------------|----|-----------|--------------|----|-----------------------|--------------|----|-----------|--------------|-----|
| 180                     | 15582.27     | I  | 960       | 2770.71      | I  | 35                    | 5203.23      | I  | 150       | 202.393      | V   |
| 120 s                   | 17516.58     | I  | 2800      | 2806.91      | I  | 45                    | 5255.82      | I  | 110       | 203.78       | V   |
| 100 l                   | 17584.86     | I  | 5100      | 2838.63      | I  | 55                    | 5265.15      | I  | 150       | 203.82       | V   |
| 100                     | 17878.26     | I  | 2300      | 2844.40      | I  | 40                    | 5298.78      | I  | 100       | 203.85       | V   |
| <i>Osmium Os Z = 76</i> |              |    | 1500      | 2850.76      | I  | 110                   | 5376.79      | I  | 200       | 203.89       | V   |
| 9600                    | 2001.45      | I  | 1500      | 2860.96      | I  | 120                   | 5416.34      | I  | 100       | 203.94       | V   |
| 13000                   | 2003.73      | I  | 9600      | 2909.06      | I  | 45                    | 5416.69      | I  | 110       | 207.18       | IV  |
| 17000                   | 2010.15      | I  | 2100      | 2912.33      | I  | 28                    | 5417.51      | I  | 150       | 207.24       | IV  |
| 29000                   | 2018.14      | I  | 2100      | 2919.79      | I  | 55                    | 5443.31      | I  | 300       | 207.794      | V   |
| 14000                   | 2022.76      | I  | 1100 h    | 2948.23      | I  | 22                    | 5446.93      | I  | 150       | 215.040      | V   |
| 14000                   | 2028.23      | I  | 1400      | 2949.53      | I  | 22                    | 5457.30      | I  | 200       | 215.103      | V   |
| 18000                   | 2034.44      | I  | 4400      | 3018.04      | I  | 28                    | 5470.00      | I  | 250       | 215.245      | V   |
| 26000                   | 2045.36      | I  | 1100      | 3030.70      | I  | 22                    | 5509.33      | I  | 250       | 216.018      | V   |
| 8600                    | 2058.69      | I  | 2900      | 3040.90      | I  | 270                   | 5523.53      | I  | 520       | 220.352      | V   |
| 13000                   | 2061.69      | I  | 120       | 3042.74      | II | 22                    | 5546.82      | I  | 80        | 227.372      | V   |
| 7800                    | 2067.21      | II | 8600      | 3058.66      | I  | 80                    | 5584.44      | I  | 80        | 227.469      | V   |
| 4200                    | 2070.67      | II | 1100      | 3077.72      | I  | 35                    | 5620.08      | I  | 150       | 227.511      | V   |
| 7200                    | 2076.95      | I  | 3100      | 3156.25      | I  | 22                    | 5642.56      | I  | 80        | 227.549      | V   |
| 14000                   | 2079.97      | I  | 180       | 3173.93      | II | 28                    | 5645.25      | I  | 80        | 227.634      | V   |
| 2900                    | 2082.54      | I  | 150       | 3213.31      | II | 28                    | 5680.88      | I  | 80        | 227.689      | V   |
| 2900                    | 2089.03      | I  | 1900      | 3232.06      | I  | 170                   | 5721.93      | I  | 150       | 231.823      | V   |
| 2900                    | 2089.21      | I  | 3100      | 3262.29      | I  | 22                    | 5765.05      | I  | 140       | 233.46       | IV  |
| 6000                    | 2097.60      | I  | 3100      | 3267.94      | I  | 170                   | 5780.82      | I  | 150       | 233.50       | IV  |
| 5300                    | 2100.63      | I  | 1200      | 3290.26      | I  | 40                    | 5800.60      | I  | 110       | 233.52       | IV  |
| 2100                    | 2117.66      | I  | 7600      | 3301.56      | I  | 110                   | 5857.76      | I  | 200       | 233.56       | IV  |
| 4800                    | 2117.96      | I  | 960       | 3336.15      | I  | 28                    | 5860.64      | I  | 110       | 233.60       | IV  |
| 5300                    | 2137.11      | I  | 960       | 3370.59      | I  | 65                    | 5996.00      | I  | 90        | 238.36       | IV  |
| 2600                    | 2154.59      | I  | 620       | 3387.84      | I  | 35                    | 6227.70      | I  | 180       | 238.57       | IV  |
| 1300                    | 2157.84      | I  | 620       | 3401.86      | I  | 22                    | 6269.41      | I  | 110       | 248.459      | V   |
| 1200                    | 2158.53      | I  | 620       | 3504.66      | I  | 22                    | 6403.15      | I  | 110       | 252.56       | IV  |
| 3100                    | 2166.90      | I  | 1200      | 3528.60      | I  | 27                    | 6729.56      | I  | 110       | 252.95       | IV  |
| 1100                    | 2167.75      | I  | 1200      | 3560.86      | I  | 22                    | 7145.54      | I  | 150       | 253.08       | IV  |
| 2100                    | 2171.65      | I  | 620       | 3598.11      | I  | 26                    | 7602.95      | I  | 300       | 260.39       | IV  |
| 1100                    | 2234.61      | I  | 95        | 3604.48      | II | 7                     | 8041.29      | I  | 250       | 260.56       | IV  |
| 1300                    | 2252.15      | I  | 480       | 3670.89      | I  | <i>Oxygen O Z = 8</i> |              |    | 80 d      | 264.34       | III |
| 2000                    | 2255.85      | II | 3700      | 3752.52      | I  | 80                    | 124.616      | V  | 110       | 264.48       | III |
| 1400                    | 2264.60      | I  | 2100      | 3782.20      | I  | 110                   | 135.523      | V  | 110       | 266.97       | III |
| 1400                    | 2282.26      | II | 730       | 3876.77      | I  | 80                    | 138.109      | V  | 150       | 266.98       | III |
| 500                     | 2367.35      | II | 1000      | 3963.63      | I  | 110                   | 139.029      | V  | 150       | 267.03       | III |
| 2600                    | 2377.03      | I  | 730       | 3977.23      | I  | 80                    | 151.447      | V  | 150       | 277.38       | III |
| 1700                    | 2387.29      | I  | 960       | 4066.69      | I  | 110                   | 151.477      | V  | 300       | 279.63       | IV  |
| 1100                    | 2395.88      | I  | 1200      | 4112.02      | I  | 150                   | 151.546      | V  | 375       | 279.94       | IV  |
| 200                     | 2423.07      | II | 2500      | 4135.78      | I  | 80                    | 164.574      | V  | 110       | 285.71       | IV  |
| 1400                    | 2424.97      | I  | 1200      | 4173.23      | I  | 110                   | 164.657      | V  | 150       | 285.84       | IV  |
| 110                     | 2454.91      | II | 1200      | 4211.86      | I  | 80                    | 164.709      | V  | 110       | 286.448      | V   |
| 1800                    | 2461.42      | I  | 4900      | 4260.85      | I  | 80                    | 166.235      | V  | 80        | 295.62       | III |
| 110                     | 2468.90      | II | 560       | 4293.95      | I  | 150                   | 167.99       | V  | 110       | 295.66       | III |
| 530                     | 2486.24      | II | 560       | 4311.40      | I  | 110                   | 170.219      | V  | 120       | 295.72       | III |
| 4500                    | 2488.55      | I  | 4900      | 4420.47      | I  | 450                   | 172.169      | V  | 150       | 303.41       | III |
| 2600                    | 2498.41      | I  | 540       | 4550.41      | I  | 250                   | 185.745      | V  | 150       | 303.46       | III |
| 2400                    | 2513.25      | I  | 670       | 4793.99      | I  | 375                   | 192.751      | V  | 140       | 303.52       | III |
| 780                     | 2538.00      | II | 55        | 5031.83      | I  | 450                   | 192.799      | V  | 160       | 303.62       | III |
| 1000                    | 2542.51      | I  | 45        | 5039.12      | I  | 520                   | 192.906      | V  | 160       | 303.69       | III |
| 1000                    | 2590.76      | I  | 35        | 5072.88      | I  | 80                    | 193.003      | V  | 250       | 303.80       | III |
| 1800                    | 2613.06      | I  | 35        | 5074.77      | I  | 200                   | 194.593      | V  | 200       | 305.60       | III |
| 3800                    | 2637.13      | I  | 35        | 5079.09      | I  | 150                   | 195.86       | IV | 250       | 305.66       | III |
| 1900                    | 2644.11      | I  | 90        | 5103.50      | I  | 200                   | 196.01       | IV | 190       | 305.70       | III |
| 1900                    | 2658.60      | I  | 55        | 5110.81      | I  | 80                    | 202.161      | V  | 300       | 305.77       | III |
| 2100                    | 2689.82      | I  | 140       | 5149.74      | I  | 80                    | 202.224      | V  | 190       | 305.84       | III |
| 3000                    | 2714.64      | I  | 40        | 5193.52      | I  | 80                    | 202.283      | V  | 200       | 306.62       | IV  |
| 1300                    | 2720.04      | I  | 270       | 5202.63      | I  | 80                    | 202.334      | V  | 150       | 306.88       | IV  |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 450       | 320.979      | III | 775       | 760.445      | V   | 220       | 1763.22      | III | 775       | 2789.85      | V   |
| 300       | 328.45       | III | 640       | 761.128      | V   | 220       | 1764.48      | III | 160       | 2836.26      | IV  |
| 250       | 328.74       | III | 700       | 762.003      | V   | 750       | 1767.78      | III | 160       | 2921.45      | IV  |
| 300       | 345.31       | III | 70        | 770.793      | I   | 550       | 1768.24      | III | 200       | 2941.33      | V   |
| 110       | 355.14       | III | 90        | 771.056      | I   | 360       | 1771.67      | III | 210       | 2941.65      | V   |
| 90        | 355.33       | III | 520       | 774.518      | V   | 110       | 1773.00      | III | 80        | 2959.68      | III |
| 80        | 355.47       | III | 70        | 775.321      | I   | 110       | 1773.85      | III | 265       | 2972.29      | I   |
| 200       | 359.02       | III | 200       | 779.734      | IV  | 220       | 1779.16      | III | 250       | 2983.78      | III |
| 190       | 359.22       | III | 315       | 779.821      | IV  | 160       | 1781.03      | III | 80        | 3017.63      | III |
| 150       | 359.38       | III | 360       | 779.912      | IV  | 160       | 1784.85      | III | 80        | 3023.45      | III |
| 210       | 373.80       | III | 200       | 779.997      | IV  | 220       | 1789.66      | III | 80        | 3043.02      | III |
| 200       | 374.00       | III | 640       | 787.711      | IV  | 110       | 1848.26      | III | 200       | 3047.13      | III |
| 300       | 374.08       | III | 520       | 790.109      | IV  | 110       | 1856.62      | III | 110       | 3059.30      | III |
| 190       | 374.16       | III | 700       | 790.199      | IV  | 285       | 1872.78      | III | 460       | 3063.42      | IV  |
| 200       | 374.33       | III | 70        | 791.973      | I   | 285       | 1872.87      | III | 410       | 3071.61      | IV  |
| 210       | 374.44       | III | 300       | 796.66       | II  | 285       | 1874.94      | III | 80        | 3121.71      | III |
| 450       | 395.558      | III | 200       | 802.200      | IV  | 160       | 1920.04      | III | 160       | 3122.62      | II  |
| 300       | 434.98       | III | 160       | 802.255      | IV  | 110       | 1920.75      | III | 220       | 3129.44      | II  |
| 800       | 507.391      | III | 90        | 804.267      | I   | 110       | 1921.52      | III | 110       | 3132.86      | III |
| 900       | 507.683      | III | 70        | 804.848      | I   | 220       | 1923.49      | III | 450       | 3134.82      | II  |
| 1000      | 508.182      | III | 70        | 805.295      | I   | 110       | 1923.82      | III | 285       | 3138.44      | II  |
| 1000      | 525.795      | III | 80        | 805.810      | I   | 110       | 1926.94      | III | 160       | 3144.66      | V   |
| 250       | 537.83       | II  | 240       | 832.762      | II  | 360       | 2013.27      | III | 160       | 3209.66      | IV  |
| 300       | 538.26       | II  | 600       | 832.927      | III | 160       | 2026.96      | III | 80        | 3238.57      | III |
| 220       | 539.09       | II  | 450       | 833.332      | II  | 220       | 2045.67      | III | 200       | 3260.98      | III |
| 200       | 539.55       | II  | 780       | 833.742      | III | 160       | 2052.74      | III | 300       | 3265.46      | III |
| 150       | 539.85       | II  | 600       | 834.467      | II  | 30 d      | 2283.42      | II  | 80        | 3267.31      | III |
| 700       | 553.330      | IV  | 600       | 835.096      | III | 30 d      | 2284.89      | II  | 220       | 3270.98      | II  |
| 775       | 554.075      | IV  | 800       | 835.292      | III | 110       | 2293.32      | II  | 220       | 3273.52      | II  |
| 850       | 554.514      | IV  | 40        | 877.879      | I   | 200       | 2300.35      | II  | 220       | 3277.69      | II  |
| 700       | 555.261      | IV  | 130       | 921.296      | IV  | 30 d      | 2313.05      | II  | 360       | 3287.59      | II  |
| 700       | 597.818      | III | 160       | 921.366      | IV  | 30 d      | 2316.12      | II  | 160       | 3305.15      | II  |
| 1000      | 599.598      | III | 80        | 922.008      | I   | 30 d      | 2316.79      | II  | 160       | 3306.60      | II  |
| 580       | 608.398      | IV  | 200       | 923.367      | IV  | 50 d      | 2319.68      | II  | 80        | 3312.30      | III |
| 110       | 609.70       | III | 130       | 923.433      | IV  | 30 d      | 2322.15      | II  | 110       | 3340.74      | III |
| 640       | 609.829      | IV  | 90        | 935.193      | I   | 30 d      | 2339.31      | II  | 230       | 3348.08      | IV  |
| 160       | 610.04       | III | 40        | 948.686      | I   | 200 d     | 2390.44      | III | 270       | 3349.11      | IV  |
| 200       | 610.75       | III | 90        | 971.738      | I   | 80        | 2394.33      | III | 160       | 3354.27      | IV  |
| 100       | 610.85       | III | 40        | 976.448      | I   | 110       | 2411.60      | II  | 200       | 3375.40      | IV  |
| 270       | 616.952      | IV  | 160       | 988.773      | I   | 80        | 2422.84      | III | 220       | 3377.20      | II  |
| 150       | 617.005      | IV  | 40        | 990.204      | I   | 80        | 2425.55      | II  | 130       | 3378.06      | IV  |
| 200       | 617.036      | IV  | 250       | 1025.762     | I   | 250       | 2433.56      | II  | 360       | 3381.20      | IV  |
| 520       | 624.617      | IV  | 90        | 1027.431     | I   | 80 d      | 2436.06      | II  | 360       | 3385.52      | IV  |
| 580       | 625.130      | IV  | 160       | 1039.230     | I   | 80 d      | 2438.83      | III | 285       | 3390.25      | II  |
| 640       | 625.852      | IV  | 60        | 1040.942     | I   | 80        | 2444.26      | II  | 270       | 3396.79      | IV  |
| 1000      | 629.730      | V   | 40        | 1152.152     | I   | 300       | 2445.55      | II  | 360       | 3403.52      | IV  |
| 150       | 644.148      | II  | 900       | 1302.168     | I   | 200       | 2449.372     | IV  | 220       | 3407.38      | II  |
| 200       | 672.95       | II  | 600       | 1304.858     | I   | 200       | 2450.040     | IV  | 230       | 3409.66      | IV  |
| 150       | 673.77       | II  | 300       | 1306.029     | I   | 200       | 2454.99      | III | 160       | 3409.84      | II  |
| 230       | 681.272      | V   | 200       | 1338.612     | IV  | 200       | 2493.44      | IV  | 410       | 3411.69      | IV  |
| 70        | 685.544      | I   | 130       | 1342.992     | IV  | 200       | 2493.77      | IV  | 230       | 3413.64      | IV  |
| 800       | 702.332      | III | 230       | 1343.512     | IV  | 200       | 2507.73      | IV  | 80        | 3444.10      | III |
| 800       | 702.822      | III | 640       | 1371.292     | V   | 230       | 2509.19      | IV  | 80        | 3455.12      | III |
| 900       | 702.899      | III | 160       | 1476.89      | III | 200       | 2517.2       | IV  | 285       | 3470.81      | II  |
| 1000      | 703.850      | III | 160 w     | 1506.72      | V   | 200       | 2558.06      | III | 200       | 3489.83      | IV  |
| 900       | 718.484      | II  | 285       | 1590.01      | III | 80        | 2687.53      | III | 160       | 3492.24      | IV  |
| 600       | 718.562      | II  | 160       | 1591.33      | III | 110       | 2695.49      | III | 230       | 3560.39      | IV  |
| 70        | 744.794      | I   | 315 w     | 1643.68      | V   | 300       | 2733.34      | II  | 270       | 3563.33      | IV  |
| 700       | 758.678      | V   | 160       | 1707.996     | V   | 110       | 2747.46      | II  | 80        | 3698.70      | III |
| 640       | 759.441      | V   | 220       | 1760.12      | III | 1000      | 2781.01      | V   | 80        | 3702.75      | III |
| 580       | 760.228      | V   | 110       | 1760.42      | III | 920       | 2786.99      | V   | 80        | 3703.37      | III |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |   | Intensity                  | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|---|----------------------------|--------------|-----|
| 110       | 3707.24      | III | 50        | 4469.41      | II  | 235       | 7947.55      | I | 540                        | 11297.68     | I   |
| 220       | 3712.75      | II  | 360       | 4590.97      | II  | 210       | 7950.80      | I | 590                        | 11302.38     | I   |
| 110       | 3715.08      | III | 285       | 4596.17      | II  | 185       | 7952.16      | I | 265                        | 11358.69     | I   |
| 315 w     | 3725.93      | IV  | 80 d      | 4609.39      | II  | 110       | 7981.94      | I | 490                        | 12464.02     | I   |
| 285       | 3727.33      | II  | 160       | 4638.85      | II  | 135       | 7982.40      | I | 450                        | 12570.04     | I   |
| 360       | 3729.03      | IV  | 360       | 4641.81      | II  | 190       | 7986.98      | I | 120                        | 12990.77     | I   |
| 410       | 3736.85      | IV  | 450       | 4649.14      | II  | 135       | 7987.33      | I | 160                        | 13076.91     | I   |
| 160       | 3739.92      | II  | 160       | 4650.84      | II  | 250       | 7995.07      | I | 700                        | 13163.89     | I   |
| 110       | 3744.00      | III | 360       | 4661.64      | II  | 400       | 8221.82      | I | 750                        | 13164.85     | I   |
| 230       | 3744.89      | IV  | 285       | 4676.23      | II  | 265       | 8227.65      | I | 640                        | 13165.11     | I   |
| 360       | 3749.49      | II  | 220       | 4699.21      | II  | 265       | 8230.02      | I | 160                        | 16212.06     | I   |
| 150       | 3754.67      | III | 285       | 4705.36      | II  | 325       | 8233.00      | I | 120                        | 17966.70     | I   |
| 80        | 3757.21      | III | 160       | 4924.60      | II  | 120       | 8235.35      | I | 590                        | 18021.21     | I   |
| 250       | 3759.87      | III | 230 w     | 4930.27      | V   | 120       | 8426.16      | I | 120                        | 18041.48     | I   |
| 110       | 3791.26      | III | 220       | 4943.06      | II  | 810       | 8446.25      | I | 120                        | 18042.19     | I   |
| 160       | 3803.14      | II  | 135       | 5329.10      | I   | 1000      | 8446.36      | I | 120                        | 18046.23     | I   |
| 120       | 3823.41      | I   | 160       | 5329.68      | I   | 935       | 8446.76      | I | 140                        | 18229.23     | I   |
| 450       | 3911.96      | II  | 190       | 5330.74      | I   | 325       | 8820.43      | I | 540                        | 18243.63     | I   |
| 160       | 3919.29      | II  | 90        | 5435.18      | I   | 160 d     | 9057.01      | I | 140                        | 26173.56     | I   |
| 185       | 3947.29      | I   | 110       | 5435.78      | I   | 120       | 9118.29      | I | <i>Palladium Pd Z = 46</i> |              |     |
| 160       | 3947.48      | I   | 135       | 5436.86      | I   | 80        | 9134.71      | I | 200                        | 705.49       | III |
| 140       | 3947.59      | I   | 120       | 5577.34      | I   | 80        | 9150.14      | I | 200                        | 727.72       | III |
| 220       | 3954.37      | II  | 110       | 5592.37      | III | 80        | 9151.48      | I | 500                        | 763.06       | III |
| 100       | 3954.61      | I   | 130       | 5597.91      | V   | 235       | 9156.01      | I | 500                        | 766.42       | III |
| 200       | 3961.59      | III | 160       | 5958.39      | I   | 450       | 9260.81      | I | 2000                       | 781.02       | III |
| 450       | 3973.26      | II  | 190       | 5958.58      | I   | 490       | 9260.84      | I | 500                        | 794.08       | III |
| 220       | 3982.20      | II  | 80        | 5995.28      | I   | 450       | 9260.94      | I | 500                        | 797.52       | III |
| 160       | 4069.90      | II  | 160       | 6046.23      | I   | 400       | 9262.58      | I | 500                        | 800.03       | III |
| 285       | 4072.16      | II  | 190       | 6046.44      | I   | 540       | 9262.67      | I | 500                        | 800.10       | III |
| 450       | 4075.87      | II  | 110       | 6046.49      | I   | 590       | 9262.77      | I | 500                        | 803.67       | III |
| 80 d      | 4083.91      | II  | 100       | 6106.27      | I   | 490       | 9265.94      | I | 500                        | 825.35       | III |
| 50 d      | 4087.14      | II  | 400       | 6155.98      | I   | 640       | 9266.01      | I | 500                        | 840.58       | III |
| 150 d     | 4089.27      | II  | 450       | 6156.77      | I   | 185       | 9399.19      | I | 500                        | 856.47       | III |
| 110       | 4097.24      | II  | 490       | 6158.18      | I   | 120       | 9481.16      | I | 500                        | 864.04       | III |
| 220       | 4105.00      | II  | 80        | 6256.83      | I   | 120 d     | 9482.88      | I | 500                        | 880.59       | III |
| 285       | 4119.22      | II  | 100       | 6261.55      | I   | 235       | 9487.43      | I | 500                        | 888.84       | III |
| 100       | 4123.99      | V   | 100       | 6366.34      | I   | 140       | 9492.71      | I | 1000                       | 889.29       | III |
| 160       | 4132.81      | II  | 100       | 6374.32      | I   | 265       | 9497.97      | I | 300                        | 1596.89      | III |
| 50        | 4146.06      | II  | 320       | 6453.60      | I   | 160       | 9499.30      | I | 500                        | 1741.62      | III |
| 220       | 4153.30      | II  | 360       | 6454.44      | I   | 235       | 9505.59      | I | 4000                       | 1782.55      | III |
| 285       | 4185.46      | II  | 400       | 6455.98      | I   | 210       | 9521.96      | I | 400                        | 1843.49      | III |
| 450       | 4189.79      | II  | 130       | 6500.24      | V   | 120       | 9523.36      | I | 1500                       | 1851.59      | III |
| 80        | 4233.27      | I   | 80        | 6604.91      | I   | 120       | 9523.96      | I | 2000                       | 1852.27      | III |
| 50 d      | 4253.74      | II  | 100       | 6653.83      | I   | 100       | 9528.28      | I | 1000                       | 1859.21      | III |
| 50 d      | 4253.98      | II  | 360       | 7001.92      | I   | 100       | 9622.13      | I | 1500                       | 1874.63      | III |
| 50 d      | 4275.47      | II  | 450       | 7002.23      | I   | 120       | 9625.29      | I | 2000                       | 1885.83      | III |
| 50 d      | 4303.78      | II  | 210       | 7156.70      | I   | 160       | 9677.38      | I | 1000                       | 1887.40      | III |
| 285       | 4317.14      | II  | 400       | 7254.15      | I   | 80        | 9694.66      | I | 1500                       | 1891.34      | III |
| 160       | 4336.86      | II  | 450       | 7254.45      | I   | 65        | 9694.91      | I | 4000                       | 1914.62      | III |
| 220       | 4345.56      | II  | 320       | 7254.53      | I   | 235       | 9741.50      | I | 1000                       | 1930.33      | III |
| 285       | 4349.43      | II  | 210       | 7476.44      | I   | 235       | 9760.65      | I | 2000                       | 1941.64      | III |
| 220       | 4366.90      | II  | 100       | 7477.24      | I   | 120       | 9909.05      | I | 800                        | 2002.16      | III |
| 100       | 4368.25      | I   | 120       | 7479.08      | I   | 140       | 9936.98      | I | 1000                       | 2004.47      | III |
| 220       | 4395.95      | II  | 120       | 7480.67      | I   | 120       | 9940.41      | I | 500                        | 2055.11      | III |
| 450       | 4414.91      | II  | 100       | 7706.75      | I   | 160       | 9995.31      | I | 500                        | 2149.82      | III |
| 285       | 4416.98      | II  | 870       | 7771.94      | I   | 120 d     | 10421.18     | I | 500                        | 2177.55      | III |
| 160       | 4448.21      | II  | 810       | 7774.17      | I   | 590       | 11286.34     | I | 500                        | 2177.63      | III |
| 160       | 4452.38      | II  | 750       | 7775.39      | I   | 640       | 11286.91     | I | 100 r                      | 2231.59      | II  |
| 50        | 4465.45      | II  | 80        | 7886.27      | I   | 490       | 11287.02     | I | 200 r                      | 2296.53      | II  |
| 50 d      | 4466.28      | II  | 100       | 7943.15      | I   | 490       | 11287.32     | I | 100                        | 2426.87      | II  |
| 50        | 4467.83      | II  | 100       | 7947.17      | I   | 490       | 11295.10     | I | 100                        | 2430.94      | II  |

| Intensity | Wavelength/Å |    | Intensity                  | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|----------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 100       | 2433.11      | II | 45                         | 7915.80      | I   | 25        | 1379.429     | I   | 700       | 3175.09      | V   |
| 100       | 2435.32      | II | 55                         | 8132.82      | I   | 25        | 1381.469     | I   | 520       | 3204.04      | V   |
| 150       | 2446.17      | II | 45                         | 8300.83      | I   | 15        | 1381.637     | I   | 300       | 3219.307     | III |
| 1100      | 2447.91      | I  | 65                         | 8761.35      | I   | 500       | 1484.507     | IV  | 400       | 3233.602     | III |
| 100       | 2457.29      | II | <i>Phosphorus P Z = 15</i> |              |     | 400       | 1487.788     | IV  | 650       | 3347.736     | IV  |
| 150       | 2469.29      | II | 250                        | 328.78       | V   | 350       | 1502.228     | III | 570       | 3364.467     | IV  |
| 100       | 2471.18      | II | 150                        | 359.899      | IV  | 80        | 1532.51      | II  | 400       | 3371.122     | IV  |
| 1700      | 2476.42      | I  | 500                        | 388.318      | IV  | 120       | 1535.90      | II  | 300       | 3957.641     | III |
| 250       | 2486.52      | II | 250                        | 389.50       | V   | 450       | 1610.50      | V   | 350       | 3978.307     | III |
| 300       | 2488.92      | II | 300                        | 390.70       | V   | 150       | 1618.632     | III | 400       | 4059.312     | III |
| 200       | 2498.81      | II | 300                        | 445.158      | IV  | 200       | 1618.907     | III | 300       | 4080.084     | III |
| 150       | 2505.73      | II | 375                        | 475.60       | V   | 140       | 1671.070     | I   | 500       | 4222.195     | III |
| 150       | 2551.84      | II | 120                        | 498.180      | III | 100       | 1671.510     | I   | 350       | 4246.720     | III |
| 150       | 2565.51      | II | 520                        | 542.57       | V   | 180       | 1671.680     | I   | 400       | 4420.71      | II  |
| 100       | 2569.56      | II | 600                        | 544.92       | V   | 140       | 1672.035     | I   | 250       | 4479.776     | III |
| 150       | 2658.75      | II | 200                        | 569.853      | III | 140       | 1672.474     | I   | 250       | 4540.288     | IV  |
| 1900      | 2763.09      | I  | 200                        | 581.831      | III | 600       | 1674.591     | I   | 250       | 4541.112     | IV  |
| 150 h     | 2776.85      | II | 350                        | 629.008      | IV  | 600       | 1679.695     | I   | 500       | 4588.04      | II  |
| 100 h     | 2787.92      | II | 400                        | 629.914      | IV  | 140       | 1685.976     | I   | 500       | 4589.86      | II  |
| 200       | 2854.59      | II | 500                        | 631.779      | IV  | 100       | 1694.028     | I   | 600       | 4602.08      | II  |
| 100 h     | 2871.37      | II | 450                        | 673.90       | V   | 100       | 1694.486     | I   | 300       | 4626.70      | II  |
| 100 h     | 2878.01      | II | 10                         | 810.24       | II  | 100       | 1706.376     | I   | 300       | 4658.31      | II  |
| 520       | 2922.49      | I  | 650                        | 823.179      | IV  | 100       | 1707.553     | I   | 500       | 4943.53      | II  |
| 650       | 3002.65      | I  | 700                        | 824.730      | IV  | 600       | 1774.951     | I   | 300       | 4954.39      | II  |
| 1500      | 3027.91      | I  | 800                        | 827.932      | IV  | 500       | 1782.838     | I   | 300       | 4969.71      | II  |
| 1100      | 3065.31      | I  | 300                        | 847.669      | III | 400       | 1787.656     | I   | 100       | 5079.381     | I   |
| 2600      | 3114.04      | I  | 350                        | 855.624      | III | 140       | 1834.801     | I   | 100       | 5098.221     | I   |
| 11000     | 3242.70      | I  | 500                        | 859.652      | III | 140       | 1847.165     | I   | 100       | 5100.974     | I   |
| 2700      | 3251.64      | I  | 10                         | 865.44       | II  | 100       | 1849.820     | I   | 140       | 5109.628     | I   |
| 3500      | 3258.78      | I  | 450                        | 865.45       | V   | 140       | 1851.194     | I   | 140       | 5154.844     | I   |
| 3600      | 3302.13      | I  | 600                        | 871.39       | V   | 100       | 1852.069     | I   | 180       | 5162.290     | I   |
| 5000      | 3373.00      | I  | 700                        | 877.476      | IV  | 500       | 1858.886     | I   | 300       | 5253.52      | II  |
| 24000     | 3404.58      | I  | 300                        | 913.971      | III | 400       | 1859.393     | I   | 140       | 5293.539     | I   |
| 13000     | 3421.24      | I  | 300                        | 917.120      | III | 140       | 1864.348     | I   | 400       | 5296.13      | II  |
| 5000      | 3433.45      | I  | 350                        | 918.665      | III | 650       | 1888.523     | IV  | 250       | 5316.07      | II  |
| 6400      | 3441.40      | I  | 1000                       | 950.655      | IV  | 180       | 1905.481     | I   | 300       | 5344.75      | II  |
| 7700      | 3460.77      | I  | 250                        | 1003.598     | III | 140       | 1906.403     | I   | 180       | 5345.851     | I   |
| 10000     | 3481.15      | I  | 570                        | 1025.563     | IV  | 280       | 1907.665     | I   | 100       | 5364.631     | I   |
| 2000      | 3489.77      | I  | 500                        | 1028.096     | IV  | 280       | 2023.489     | I   | 250       | 5378.20      | II  |
| 12000     | 3516.94      | I  | 570                        | 1030.517     | IV  | 180       | 2024.516     | I   | 300       | 5386.88      | II  |
| 12000     | 3553.08      | I  | 500                        | 1033.111     | IV  | 400       | 2032.432     | I   | 400       | 5425.91      | II  |
| 4500      | 3571.16      | I  | 500                        | 1035.517     | IV  | 400       | 2033.477     | I   | 100       | 5428.094     | I   |
| 20000     | 3609.55      | I  | 900                        | 1117.98      | V   | 400       | 2135.465     | I   | 400       | 5450.74      | II  |
| 20000     | 3634.70      | I  | 570                        | 1118.551     | IV  | 400       | 2136.182     | I   | 140       | 5458.305     | I   |
| 5500      | 3690.34      | I  | 700                        | 1128.01      | V   | 400       | 2149.145     | I   | 180       | 5477.672     | I   |
| 1400      | 3718.91      | I  | 20                         | 1249.82      | II  | 280       | 2152.940     | I   | 140       | 5477.860     | I   |
| 1500      | 3799.19      | I  | 20                         | 1301.87      | II  | 500       | 2154.080     | I   | 140       | 5478.267     | I   |
| 1500      | 3832.29      | I  | 20                         | 1304.47      | II  | 180       | 2235.732     | I   | 100       | 5514.774     | I   |
| 2200      | 3894.20      | I  | 15                         | 1304.68      | II  | 450       | 2440.93      | V   | 100       | 5516.997     | I   |
| 1500      | 3958.64      | I  | 35                         | 1305.48      | II  | 250       | 2478.256     | IV  | 250       | 5588.34      | II  |
| 290       | 4087.34      | I  | 60                         | 1310.70      | II  | 750       | 2533.976     | I   | 500       | 6024.18      | II  |
| 2500      | 4212.95      | I  | 500                        | 1334.808     | III | 950       | 2535.603     | I   | 400       | 6034.04      | II  |
| 180       | 4473.59      | I  | 650                        | 1344.327     | III | 750       | 2553.262     | I   | 500       | 6043.12      | II  |
| 160       | 5163.84      | I  | 300                        | 1344.845     | III | 500       | 2554.915     | I   | 250       | 6055.50      | II  |
| 120       | 5295.63      | I  | 500                        | 1366.695     | IV  | 250       | 2605.506     | IV  | 150       | 6083.409     | III |
| 55        | 5542.80      | I  | 15                         | 1372.033     | I   | 300       | 2632.713     | III | 350       | 6087.82      | II  |
| 75        | 5670.07      | I  | 400                        | 1372.674     | IV  | 400       | 2644.295     | IV  | 180       | 6097.690     | I   |
| 55 h      | 5695.09      | I  | 15                         | 1373.500     | I   | 400       | 2728.770     | IV  | 350       | 6165.59      | II  |
| 65        | 6784.52      | I  | 10                         | 1374.732     | I   | 500       | 2739.309     | IV  | 500       | 6199.024     | I   |
| 75        | 7368.12      | I  | 15                         | 1377.080     | I   | 250       | 2739.872     | IV  | 180       | 6210.499     | I   |
| 120       | 7764.03      | I  | 15                         | 1377.937     | I   | 450       | 2978.55      | V   | 140       | 6375.681     | I   |

| Intensity | Wavelength/Å |     | Intensity                 | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|-----|---------------------------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 100       | 6388.579     | I   | 228                       | 15962.53     | I  | 240       | 2308.04      | I  | 70        | 2738.48      | I  |
| 250       | 6435.32      | II  | 296                       | 16254.77     | I  | 50        | 2310.96      | II | 70        | 2747.61      | I  |
| 600       | 6459.99      | II  | 203                       | 16292.97     | I  | 90        | 2315.50      | I  | 80        | 2753.86      | I  |
| 600       | 6503.46      | II  | 1627                      | 16482.92     | I  | 220       | 2318.29      | I  | 200       | 2754.92      | I  |
| 600       | 6507.97      | II  | 588                       | 16590.07     | I  | 100       | 2326.10      | I  | 30        | 2769.84      | I  |
| 100       | 6717.411     | I   | 225                       | 16613.05     | I  | 170       | 2340.18      | I  | 500       | 2771.67      | I  |
| 150       | 6992.690     | III | 221                       | 16738.68     | I  | 280       | 2357.10      | I  | 40        | 2773.24      | I  |
| 100       | 7102.200     | I   | 419                       | 16803.39     | I  | 180       | 2368.28      | I  | 20        | 2774.00      | I  |
| 100       | 7158.367     | I   | 471                       | 17112.48     | I  | 50        | 2377.28      | II | 50        | 2774.77      | II |
| 180       | 7165.465     | I   | 289                       | 17286.91     | I  | 130       | 2383.64      | I  | 50        | 2793.27      | I  |
| 180       | 7175.102     | I   | 299                       | 17423.67     | I  | 40        | 2386.81      | I  | 100       | 2794.21      | II |
| 180       | 7176.660     | I   | 287                       | 23844.97     | I  | 120       | 2389.53      | I  | 40 h      | 2799.98      | II |
| 200       | 7443.657     | IV  | 311                       | 29097.16     | I  | 35        | 2396.17      | I  | 140       | 2803.24      | I  |
| 250       | 7845.63      | II  | <i>Platinum Pt Z = 78</i> |              |    | 70        | 2401.87      | I  | 10        | 2808.51      | I  |
| 100       | 8046.801     | I   | 30                        | 1621.66      | II | 200       | 2403.09      | I  | 50        | 2818.25      | I  |
| 150       | 8113.528     | III | 30                        | 1723.13      | II | 100       | 2418.06      | I  | 30 h      | 2822.27      | II |
| 140       | 8278.058     | I   | 30                        | 1751.70      | II | 50        | 2424.87      | II | 1400      | 2830.30      | I  |
| 100       | 8367.856     | I   | 30                        | 1777.09      | II | 80        | 2428.04      | I  | 70        | 2834.71      | I  |
| 140       | 8531.475     | I   | 50 r                      | 1777.09      | II | 50        | 2428.20      | I  | 16        | 2853.11      | I  |
| 140       | 8613.835     | I   | 30                        | 1781.86      | II | 25        | 2429.10      | I  | 80 h      | 2860.68      | II |
| 180       | 8637.578     | I   | 30                        | 1879.09      | II | 180       | 2436.69      | I  | 40 h      | 2865.05      | II |
| 400       | 8741.529     | I   | 40                        | 1883.05      | II | 650       | 2440.06      | I  | 40 h      | 2875.85      | II |
| 100       | 8872.174     | I   | 50                        | 1889.52      | II | 60        | 2450.97      | I  | 100 h     | 2877.52      | II |
| 180       | 9175.819     | I   | 50                        | 1911.70      | II | 440       | 2467.44      | I  | 25        | 2888.20      | I  |
| 950       | 9193.85      | I   | 30                        | 1929.25      | II | 35        | 2471.01      | I  | 25        | 2893.22      | I  |
| 600       | 9278.88      | I   | 30                        | 1929.68      | II | 1000      | 2487.17      | I  | 600       | 2893.86      | I  |
| 1250      | 9304.94      | I   | 30                        | 1939.80      | II | 25        | 2488.74      | II | 300       | 2897.87      | I  |
| 500       | 9323.50      | I   | 30                        | 1949.90      | II | 200       | 2490.12      | I  | 60        | 2905.90      | I  |
| 950       | 9435.069     | I   | 30                        | 1983.74      | II | 160       | 2495.82      | I  | 120       | 2912.26      | I  |
| 950       | 9441.86      | I   | 40                        | 2014.93      | II | 240       | 2498.50      | I  | 120       | 2913.54      | I  |
| 600       | 9452.83      | I   | 3200                      | 2030.63      | I  | 50        | 2505.93      | I  | 70        | 2919.34      | I  |
| 1250      | 9493.56      | I   | 4400                      | 2032.41      | I  | 120       | 2508.50      | I  | 30        | 2921.38      | I  |
| 1700      | 9525.73      | I   | 100                       | 2036.46      | II | 50        | 2514.07      | I  | 1700      | 2929.79      | I  |
| 1500      | 9545.18      | I   | 40                        | 2041.57      | II | 60        | 2515.03      | I  | 30        | 2942.76      | I  |
| 280       | 9556.81      | I   | 5500                      | 2049.37      | I  | 240       | 2515.58      | I  | 30        | 2944.75      | I  |
| 1700      | 9563.439     | I   | 1500                      | 2067.50      | I  | 140       | 2524.30      | I  | 25        | 2959.10      | I  |
| 280       | 9593.50      | I   | 3000                      | 2084.59      | I  | 40        | 2529.41      | I  | 60        | 2960.75      | I  |
| 750       | 9609.04      | I   | 1000                      | 2103.33      | I  | 50        | 2536.49      | I  | 1800      | 2997.97      | I  |
| 400       | 9638.939     | I   | 30                        | 2115.57      | II | 160       | 2539.20      | I  | 35        | 3001.17      | II |
| 500       | 9676.24      | I   | 950                       | 2128.61      | I  | 18        | 2549.46      | I  | 220       | 3002.27      | I  |
| 180       | 9706.533     | I   | 30                        | 2130.69      | II | 50        | 2552.25      | I  | 30        | 3017.88      | I  |
| 1500      | 9734.750     | I   | 1900                      | 2144.23      | I  | 50        | 2596.00      | I  | 30 h      | 3031.22      | II |
| 280       | 9736.680     | I   | 100                       | 2144.24      | II | 70        | 2603.14      | I  | 130       | 3036.45      | I  |
| 1500      | 9750.77      | I   | 600                       | 2165.17      | I  | 30        | 2616.76      | II | 800       | 3042.64      | I  |
| 600       | 9790.21      | I   | 1500                      | 2174.67      | I  | 50        | 2619.57      | I  | 3200      | 3064.71      | I  |
| 1700      | 9796.85      | I   | 30                        | 2190.32      | II | 30        | 2625.34      | II | 30        | 3071.94      | I  |
| 280       | 9834.80      | I   | 400                       | 2202.22      | I  | 1100      | 2628.03      | I  | 130       | 3100.04      | I  |
| 400       | 9903.68      | I   | 50 h                      | 2202.58      | II | 130       | 2639.35      | I  | 320       | 3139.39      | I  |
| 280       | 9976.67      | I   | 320                       | 2222.61      | I  | 1000      | 2646.89      | I  | 140       | 3156.56      | I  |
| 229       | 10084.27     | I   | 50 h                      | 2233.11      | II | 500       | 2650.86      | I  | 120       | 3200.71      | I  |
| 458       | 10511.58     | I   | 30 h                      | 2240.99      | II | 20        | 2658.17      | I  | 320       | 3204.04      | I  |
| 962       | 10529.52     | I   | 100                       | 2245.52      | II | 2800      | 2659.45      | I  | 30        | 3230.29      | I  |
| 1235      | 10581.57     | I   | 150                       | 2249.30      | I  | 40        | 2674.57      | I  | 20        | 3233.42      | I  |
| 415       | 10596.90     | I   | 30                        | 2251.52      | II | 440       | 2677.15      | I  | 20        | 3250.36      | I  |
| 435       | 10681.40     | I   | 30 h                      | 2251.92      | II | 200       | 2698.43      | I  | 40        | 3251.98      | I  |
| 265       | 10813.13     | I   | 190                       | 2268.84      | I  | 2000      | 2702.40      | I  | 160       | 3255.92      | I  |
| 764       | 11183.23     | I   | 30 h                      | 2271.72      | II | 1600      | 2705.89      | I  | 25        | 3268.42      | I  |
| 402       | 11186.75     | I   | 280                       | 2274.38      | I  | 60        | 2713.13      | I  | 25        | 3281.97      | I  |
| 479       | 14241.64     | I   | 50 h                      | 2287.50      | II | 1300      | 2719.04      | I  | 120       | 3290.22      | I  |
| 256       | 14307.83     | I   | 30                        | 2288.20      | II | 130       | 2729.92      | I  | 500       | 3301.86      | I  |
| 714       | 15711.52     | I   | 150                       | 2289.27      | I  | 1800      | 2733.96      | I  | 60        | 3315.05      | I  |
|           |              |     | 150                       | 2292.40      | I  |           |              |    |           |              |    |

| Intensity                  | Wavelength/Å |    | Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|----------------------------|--------------|----|---------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 35                         | 3323.80      | I  | 10000                     | 7068.90      | I   | 250       | 388.92       | IV  | 10        | 514.94       | III |
| 340                        | 3408.13      | I  | 10000                     | 8691.94      | I   | 250       | 389.07       | IV  | 50        | 520.61       | III |
| 35                         | 3427.93      | I  | 3000                      | 9533.07      | I   | 250       | 389.07       | V   | 250       | 523.00       | IV  |
| 60                         | 3483.43      | I  | 3000                      | 12144.46     | I   | 250       | 390.11       | V   | 25        | 523.79       | III |
| 160                        | 3485.27      | I  | 3000                      | 16897.38     | I   | 250       | 390.42       | IV  | 200       | 526.45       | IV  |
| 120                        | 3628.11      | I  | <i>Polonium Po Z = 84</i> |              |     | 300       | 390.57       | IV  | 150       | 527.62       | IV  |
| 70                         | 3638.79      | I  | 1500 w                    | 2450.08      | I   | 200       | 391.46       | IV  | 40        | 529.80       | III |
| 70                         | 3643.17      | I  | 1500 w                    | 2558.01      | I   | 200       | 392.47       | IV  | 15        | 539.71       | III |
| 50                         | 3663.10      | I  | 2500 w                    | 3003.21      | I   | 500       | 393.14       | IV  | 15        | 546.12       | III |
| 80                         | 3671.99      | I  | 1200                      | 4170.52      | I   | 250       | 395.40       | V   | 750       | 580.32       | V   |
| 80                         | 3674.04      | I  | 800                       | 4493.21      | I   | 200       | 398.36       | V   | 250       | 585.51       | V   |
| 35                         | 3699.91      | I  | 500                       | 8618.26      | I   | 15        | 398.63       | III | 500       | 586.32       | V   |
| 18                         | 3706.53      | I  | <i>Potassium K Z = 19</i> |              |     | 200       | 398.88       | V   | 30        | 600.77       | II  |
| 80                         | 3818.69      | I  | 100                       | 214.35       | V   | 200       | 399.75       | V   | 250       | 602.27       | V   |
| 40                         | 3900.73      | I  | 150                       | 271.82       | IV  | 400       | 400.21       | IV  | 400       | 603.43       | V   |
| 110                        | 3922.96      | I  | 100                       | 273.06       | IV  | 20        | 402.10       | III | 25        | 607.93       | II  |
| 35                         | 3948.40      | I  | 150                       | 282.35       | V   | 300       | 402.91       | IV  | 30        | 612.62       | II  |
| 100                        | 3966.36      | I  | 150                       | 293.33       | V   | 250       | 403.97       | IV  | 250       | 638.67       | V   |
| 20                         | 3996.57      | I  | 300                       | 294.84       | V   | 150       | 404.41       | IV  | 750       | 646.19       | IV  |
| 110                        | 4118.69      | I  | 200                       | 296.17       | V   | 30        | 406.48       | III | 300       | 687.50       | V   |
| 80                         | 4164.56      | I  | 200                       | 297.06       | V   | 250       | 408.08       | IV  | 20        | 708.84       | III |
| 40                         | 4192.43      | I  | 200                       | 300.25       | V   | 40        | 408.96       | III | 300       | 720.43       | V   |
| 18                         | 4327.06      | I  | 200                       | 300.50       | V   | 50        | 413.79       | III | 400       | 724.42       | V   |
| 18                         | 4391.83      | I  | 200                       | 311.24       | V   | 30        | 414.87       | III | 600       | 731.86       | V   |
| 80                         | 4442.55      | I  | 250                       | 312.77       | V   | 250       | 415.05       | V   | 500       | 737.14       | IV  |
| 14                         | 4445.55      | I  | 200                       | 315.18       | V   | 200       | 415.79       | V   | 500       | 741.95       | IV  |
| 25                         | 4498.76      | I  | 250                       | 327.38       | V   | 30        | 416.00       | III | 500       | 745.26       | IV  |
| 12                         | 4520.90      | I  | 25                        | 330.68       | III | 150       | 417.28       | IV  | 400       | 746.35       | IV  |
| 35                         | 4552.42      | I  | 300                       | 340.46       | IV  | 30        | 417.54       | III | 300       | 749.99       | IV  |
| 12                         | 4879.53      | I  | 150                       | 340.74       | IV  | 30        | 418.62       | III | 150       | 754.19       | IV  |
| 14                         | 5044.04      | I  | 30                        | 341.92       | III | 400       | 422.18       | V   | 400       | 754.67       | IV  |
| 30                         | 5059.48      | I  | 15                        | 348.00       | III | 300       | 425.16       | V   | 20        | 765.31       | III |
| 35                         | 5227.66      | I  | 200                       | 349.50       | V   | 500       | 425.59       | V   | 30        | 765.64       | III |
| 40                         | 5301.02      | I  | 300                       | 354.93       | IV  | 75        | 434.72       | III | 150       | 770.29       | V   |
| 12                         | 5368.99      | I  | 150                       | 356.26       | IV  | 50        | 435.68       | III | 150       | 771.46       | V   |
| 12                         | 5390.79      | I  | 300                       | 359.73       | IV  | 250       | 438.02       | V   | 35        | 778.53       | III |
| 14                         | 5475.77      | I  | 200                       | 359.91       | IV  | 25        | 441.81       | II  | 20        | 872.31       | III |
| 14                         | 5478.50      | I  | 250                       | 362.08       | IV  | 200       | 442.30       | IV  | 10        | 873.86       | III |
| 6                          | 5763.57      | I  | 150                       | 362.15       | IV  | 300       | 443.57       | IV  | 15        | 874.04       | III |
| 20                         | 5840.12      | I  | 150                       | 363.02       | IV  | 75        | 444.34       | III | 6         | 2550.02      | III |
| 8                          | 5844.84      | I  | 500                       | 372.15       | V   | 200       | 445.61       | IV  | 5         | 2635.11      | III |
| 6                          | 6026.04      | I  | 200                       | 372.46       | V   | 250       | 446.83       | IV  | 5         | 2689.90      | III |
| 7                          | 6318.37      | I  | 200                       | 372.77       | V   | 75        | 448.60       | III | 5         | 2938.45      | III |
| 8                          | 6326.58      | I  | 300                       | 375.96       | IV  | 750       | 448.60       | IV  | 5         | 2986.20      | III |
| 9                          | 6523.45      | I  | 300                       | 375.96       | V   | 200       | 449.71       | V   | 5         | 2992.42      | III |
| 10                         | 6710.42      | I  | 250                       | 377.76       | V   | 200       | 452.90       | V   | 6         | 3052.07      | III |
| 20                         | 6760.02      | I  | 30                        | 379.12       | III | 250       | 455.67       | V   | 6         | 3056.84      | III |
| 60                         | 6842.60      | I  | 300                       | 379.12       | V   | 400       | 456.33       | IV  | 5         | 3062.18      | II  |
| 20                         | 7113.73      | I  | 300                       | 379.88       | IV  | 400       | 456.33       | V   | 5         | 3062.18      | II  |
| 10                         | 8224.74      | I  | 25                        | 380.48       | III | 75        | 466.79       | III | 4         | 3101.79      | I   |
| <i>Plutonium Pu Z = 94</i> |              |    | 250                       | 380.48       | IV  | 100       | 470.09       | III | 3         | 3102.04      | I   |
| 10000                      | 2806.11      | II | 200                       | 381.70       | IV  | 75        | 471.57       | III | 7         | 3217.16      | I   |
| 10000                      | 2950.06      | II | 30                        | 382.23       | III | 45        | 474.92       | III | 6         | 3217.62      | I   |
| 10000                      | 3000.31      | II | 300                       | 382.23       | IV  | 10        | 476.03       | II  | 11        | 3446.37      | I   |
| 10000                      | 3200.23      | II | 150                       | 382.49       | IV  | 40        | 479.18       | III | 10        | 3447.38      | I   |
| 10000                      | 3418.88      | II | 200                       | 382.65       | IV  | 10        | 482.11       | III | 3         | 3648.84      | I   |
| 10000                      | 3805.93      | I  | 300                       | 382.91       | IV  | 10        | 482.41       | III | 4         | 3648.98      | I   |
| 10000                      | 4097.12      | I  | 250                       | 384.10       | IV  | 200       | 482.71       | V   | 18        | 4044.14      | I   |
| 10000                      | 4170.95      | I  | 200                       | 386.61       | IV  | 200       | 483.75       | V   | 17        | 4047.21      | I   |
| 10000                      | 4367.41      | I  | 300                       | 387.80       | V   | 30        | 495.14       | II  | 10        | 4641.88      | I   |
| 10000                      | 5590.54      | I  |                           |              |     | 75        | 497.10       | III | 11        | 4642.37      | I   |

| Intensity | Wavelength/Å |    | Intensity                     | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|----|-------------------------------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 4         | 4740.91      | I  | 8                             | 10487.11     | I  | 680       | 3880.47      | II | 620       | 4171.82      | II |
| 6         | 4744.35      | I  | 17                            | 11019.87     | I  | 440 c     | 3885.19      | II | 730       | 4172.25      | II |
| 5         | 4753.93      | I  | 16                            | 11022.67     | I  | 440 c     | 3889.34      | II | 5200      | 4179.39      | II |
| 7         | 4757.39      | I  | 17                            | 11690.21     | I  | 770 c     | 3908.05      | II | 2500      | 4189.48      | II |
| 5         | 4786.49      | I  | 16                            | 11769.62     | I  | 630       | 3912.90      | II | 560 c     | 4191.60      | II |
| 7         | 4791.05      | I  | 17                            | 11772.83     | I  | 310       | 3913.55      | II | 2500 c    | 4206.72      | II |
| 6         | 4799.75      | I  |                               | 12522.11     | I  | 1300 c    | 3918.85      | II | 500       | 4208.32      | II |
| 8         | 4804.35      | I  |                               | 13377.86     | I  | 420       | 3919.63      | II | 320       | 4211.86      | II |
| 7         | 4849.86      | I  |                               | 13397.09     | I  | 960       | 3925.47      | II | 320       | 4217.81      | II |
| 8         | 4856.09      | I  |                               | 15163.08     | I  | 480       | 3927.46      | II | 3800      | 4222.93      | II |
| 8         | 4863.48      | I  |                               | 15168.40     | I  | 370       | 3929.29      | II | 3800      | 4225.35      | II |
| 9         | 4869.76      | I  |                               | 40158.37     | I  | 370       | 3935.82      | II | 320       | 4233.11      | II |
| 8         | 4942.02      | I  | <i>Praseodymium Pr Z = 59</i> |              |    | 730 c     | 3947.63      | II | 320 c     | 4236.15      | II |
| 9         | 4950.82      | I  | 7000                          | 865.90       | V  | 900 c     | 3949.43      | II | 960       | 4241.01      | II |
| 9         | 4956.15      | I  | 5000                          | 869.17       | V  | 900 c     | 3953.51      | II | 340       | 4243.51      | II |
| 10        | 4965.03      | I  | 2000                          | 1228.59      | IV | 380       | 3956.75      | II | 840 c     | 4247.63      | II |
| 10        | 5084.23      | I  | 5000                          | 1293.22      | IV | 470       | 3962.45      | II | 500       | 4254.40      | II |
| 11        | 5097.17      | I  | 5000                          | 1295.28      | IV | 560       | 3964.26      | II | 320       | 4269.09      | II |
| 11        | 5099.20      | I  | 5000                          | 1321.36      | IV | 1600 c    | 3964.81      | II | 790 c     | 4272.27      | II |
| 12        | 5112.25      | I  | 5000                          | 1333.57      | IV | 560 c     | 3966.57      | II | 470 c     | 4280.07      | II |
| 12        | 5323.28      | I  | 5000                          | 1354.66      | IV | 500       | 3971.16      | II | 790 c     | 4282.42      | II |
| 13        | 5339.69      | I  | 2000                          | 1360.64      | IV | 320       | 3971.67      | II | 450 c     | 4298.98      | II |
| 12        | 5342.97      | I  | 2000                          | 1365.77      | IV | 620 c     | 3972.14      | II | 1500      | 4305.76      | II |
| 14        | 5359.57      | I  | 5000                          | 1374.41      | IV | 320       | 3974.85      | II | 1300      | 4333.97      | II |
| 16        | 5782.38      | I  | 5000                          | 1435.56      | IV | 1300 c    | 3989.68      | II | 360       | 4338.70      | II |
| 17        | 5801.75      | I  | 2000                          | 1520.98      | IV | 340       | 3992.16      | II | 620 cw    | 4344.30      | II |
| 15        | 5812.15      | I  | 5000                          | 1574.55      | IV | 1600      | 3994.79      | II | 470 c     | 4347.49      | II |
| 17        | 5831.89      | I  | 5000                          | 1575.10      | IV | 560 c     | 3997.04      | II | 340       | 4350.40      | II |
| 8         | 6120.27      | II | 3000                          | 1578.38      | IV | 320       | 3999.12      | II | 450       | 4354.91      | II |
| 7         | 6307.29      | II | 2000                          | 1622.30      | IV | 620 c     | 4000.17      | II | 410 c     | 4359.79      | II |
| 19        | 6911.08      | I  | 10000                         | 1884.87      | IV | 730       | 4004.70      | II | 1200      | 4368.33      | II |
| 12        | 6936.28      | I  | 2000                          | 2083.23      | IV | 1900      | 4008.69      | II | 320       | 4371.62      | II |
| 20        | 6938.77      | I  | 3300                          | 2246.20      | V  | 620       | 4010.60      | II | 430       | 4405.83      | II |
| 7         | 6964.18      | I  | 2000 c                        | 2378.98      | IV | 730       | 4015.39      | II | 1700      | 4408.82      | II |
| 12        | 6964.67      | I  | 40 h                          | 2598.04      | II | 620       | 4020.96      | II | 410       | 4413.77      | II |
| 25        | 7664.90      | I  | 100 h                         | 2707.37      | II | 470       | 4022.71      | II | 1200 c    | 4429.13      | II |
| 24        | 7698.96      | I  | 60                            | 2760.35      | II | 360       | 4025.54      | II | 730       | 4449.83      | II |
| 5         | 7955.37      | I  | 270                           | 3168.24      | II | 360 c     | 4029.72      | II | 960       | 4468.66      | II |
| 4         | 7956.83      | I  | 200 d                         | 3195.99      | II | 730 c     | 4031.75      | II | 1100      | 4496.46      | II |
| 7         | 8078.11      | I  | 190                           | 3219.48      | II | 960       | 4033.83      | II | 790       | 4510.15      | II |
| 6         | 8079.62      | I  | 200                           | 3584.21      | II | 730       | 4038.45      | II | 340 c     | 4534.15      | II |
| 9         | 8250.18      | I  | 250                           | 3645.66      | II | 470       | 4039.34      | II | 340       | 4535.92      | II |
| 8         | 8251.74      | I  | 250                           | 3646.30      | II | 1300      | 4044.81      | II | 270 c     | 4628.74      | II |
| 3         | 8390.22      | I  | 370                           | 3668.83      | II | 340       | 4047.08      | II | 270 c     | 4672.09      | II |
| 11        | 8503.45      | I  | 290                           | 3714.05      | II | 450       | 4051.13      | II | 290       | 4695.77      | I  |
| 10        | 8505.11      | I  | 410                           | 3739.18      | II | 2200      | 4054.88      | II | 250       | 4736.69      | I  |
| 4         | 8763.96      | I  | 680                           | 3761.87      | II | 2200      | 4056.54      | II | 200       | 4924.60      | I  |
| 3         | 8767.05      | I  | 680                           | 3800.30      | II | 450       | 4058.80      | II | 320       | 4939.74      | I  |
| 13        | 8902.19      | I  | 390                           | 3811.84      | II | 3400      | 4062.81      | II | 380       | 4951.37      | I  |
| 12        | 8904.02      | I  | 1300 h                        | 3816.02      | II | 500 c     | 4079.77      | II | 270       | 5034.41      | II |
| 5         | 8923.31      | I  | 680                           | 3818.28      | II | 500 c     | 4080.98      | II | 320       | 5045.52      | I  |
| 4         | 8925.44      | I  | 310                           | 3821.80      | II | 790       | 4081.85      | II | 360       | 5110.38      | II |
| 7         | 9347.24      | I  | 960                           | 3830.72      | II | 500       | 4083.34      | II | 560       | 5110.76      | II |
| 3         | 9349.25      | I  | 480                           | 3840.99      | II | 560       | 4096.82      | II | 410       | 5129.52      | II |
| 6         | 9351.59      | I  | 580                           | 3846.59      | II | 380       | 4098.40      | II | 620       | 5173.90      | II |
| 15        | 9595.70      | I  | 1200                          | 3850.79      | II | 2900 c    | 4100.72      | II | 360       | 5206.55      | II |
| 14        | 9597.83      | I  | 720 c                         | 3851.55      | II | 1700 c    | 4118.46      | II | 360       | 5219.05      | II |
| 6         | 9949.67      | I  | 960                           | 3852.80      | II | 340       | 4130.77      | II | 560       | 5220.11      | II |
| 5         | 9954.14      | I  | 480 c                         | 3865.45      | II | 1500 c    | 4141.22      | II | 680       | 5259.73      | II |
| 9         | 10479.63     | I  | 480                           | 3876.19      | II | 2700      | 4143.11      | II | 340 c     | 5292.02      | II |
| 5         | 10482.15     | I  | 1700 c                        | 3877.18      | II | 1700 c    | 4164.16      | II | 340       | 5292.62      | II |



| Intensity                   | Wavelength/Å |     | Intensity                     | Wavelength/Å |    | Intensity                | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------------------------|--------------|-----|-------------------------------|--------------|----|--------------------------|--------------|----|-----------|--------------|----|
| 430                         | 5322.76      | II  | 1000                          | 3957.74      | II | 3000                     | 7076.27      | I  | 4900      | 2167.94      | I  |
| 65                          | 5509.15      | II  | 1000 r                        | 3998.96      | II | 3000 h                   | 7100.94      | I  | 3400      | 2176.21      | I  |
| 150                         | 5535.17      | II  | 1000                          | 4417.96      | II | 10000 s                  | 7114.89      | I  | 4200 c    | 2214.26      | II |
| 110                         | 5623.05      | II  | 900 r                         | 4728.36      | I  | 3000 h                   | 7171.55      | I  | 5200 c    | 2275.25      | II |
| 90                          | 5624.45      | II  | 900                           | 6100.21      | I  | 3000                     | 7227.13      | I  | 2900      | 2287.51      | I  |
| 90                          | 5756.17      | II  | 1000 d                        | 6520.45      | I  | 3000                     | 7318.79      | I  | 2700      | 2294.49      | I  |
| 90                          | 5779.28      | I   | <i>Protactinium Pa Z = 91</i> |              |    | 10000 l                  | 7368.25      | I  | 390       | 2298.09      | II |
| 160 d                       | 5815.17      | II  | 3000                          | 2599.16      | II | 3000 h                   | 7471.89      | I  | 610       | 2302.99      | I  |
| 90                          | 5823.72      | II  | 3000                          | 2699.22      | II | 10000 h                  | 7493.15      | I  | 680       | 2306.54      | I  |
| 90                          | 5859.68      | II  | 3000                          | 2822.79      | II | 3000 h                   | 7558.26      | I  | 800       | 2322.49      | I  |
| 160                         | 5939.90      | II  | 3000 h                        | 2871.42      | II | 10000 h                  | 7608.20      | I  | 300       | 2328.66      | I  |
| 7000 w                      | 5956.05      | III | 3000 h                        | 2891.14      | II | 10000                    | 7626.79      | I  | 860       | 2344.78      | I  |
| 90                          | 5956.60      | II  | 3000 l                        | 3011.10      | II | 10000 s                  | 7635.18      | I  | 230       | 2349.39      | I  |
| 110                         | 5967.82      | II  | 3000 s                        | 3033.59      | II | 10000                    | 7669.34      | I  | 680       | 2352.07      | I  |
| 90                          | 6006.33      | II  | 3000 l                        | 3071.24      | II | 3000                     | 7679.20      | I  | 250       | 2356.50      | I  |
| 150                         | 6017.80      | II  | 3000 l                        | 3093.23      | II | 10000 h                  | 7749.19      | I  | 1200      | 2365.90      | I  |
| 150                         | 6025.72      | II  | 3000 l                        | 3126.23      | II | 3000                     | 7872.95      | I  | 570       | 2367.68      | I  |
| 140                         | 6055.13      | I   | 3000 l                        | 3146.28      | II | 3000 l                   | 7945.56      | I  | 520       | 2369.27      | I  |
| 65                          | 6087.52      | II  | 3000 l                        | 3170.89      | II | 10000                    | 8039.34      | I  | 220       | 2370.76      | II |
| 9000 w                      | 6090.02      | III | 3000 l                        | 3171.54      | II | 10000 h                  | 8099.84      | I  | 320       | 2375.07      | I  |
| 65                          | 6114.38      | II  | 3000 l                        | 3240.58      | II | 10000                    | 8199.04      | I  | 370       | 2379.77      | I  |
| 65                          | 6148.23      | I   | 3000                          | 3274.46      | II | 10000                    | 8271.87      | I  | 340       | 2388.57      | I  |
| 5000                        | 6160.24      | III | 3000 l                        | 3332.69      | II | 3000 s                   | 8358.98      | I  | 230       | 2393.65      | I  |
| 190                         | 6161.18      | II  | 3000 s                        | 3346.66      | II | 3000 s                   | 8369.60      | I  | 320       | 2394.37      | I  |
| 270                         | 6165.94      | II  | 3000 l                        | 3452.82      | II | 3000 h                   | 8441.04      | I  | 320       | 2396.79      | I  |
| 45                          | 6244.35      | II  | 3000                          | 3504.97      | I  | 10000 h                  | 8532.66      | I  | 210 d     | 2400.72      | I  |
| 110                         | 6281.28      | II  | 3000 s                        | 3530.65      | II | 10000 s                  | 8572.96      | I  | 210       | 2401.68      | I  |
| 55 c                        | 6359.03      | I   | 3000                          | 3570.56      | I  | 3000 h                   | 8639.91      | I  | 1500      | 2405.06      | I  |
| 55                          | 6411.23      | I   | 3000                          | 3571.82      | I  | 3000 h                   | 8653.51      | I  | 740       | 2405.60      | I  |
| 45                          | 6429.63      | II  | 3000                          | 3618.07      | I  | 10000                    | 8735.27      | I  | 320       | 2406.70      | I  |
| 45                          | 6431.84      | II  | 10000                         | 3636.52      | I  | 3000                     | 10923.32     | I  | 270       | 2410.37      | I  |
| 45                          | 6486.55      | I   | 3000                          | 3702.74      | I  | 10000                    | 11791.73     | I  | 1200      | 2419.81      | I  |
| 45                          | 6566.77      | II  | 3000                          | 3752.67      | I  | 10000                    | 14344.76     | I  | 300       | 2421.73      | I  |
| 55                          | 6616.67      | I   | 3000                          | 3873.35      | I  | 3000                     | 18478.61     | I  | 300       | 2421.88      | I  |
| 75                          | 6656.83      | II  | 3000                          | 3931.83      | I  | <i>Radium Ra Z = 88</i>  |              |    | 2500      | 2428.58      | I  |
| 55                          | 6673.41      | II  | 3000 s                        | 3952.62      | II | 100                      | 3649.55      | II | 490       | 2431.54      | I  |
| 75                          | 6673.78      | II  | 10000 l                       | 3957.85      | II | 200                      | 3814.42      | II | 420       | 2432.18      | I  |
| 35 c                        | 6747.09      | I   | 3000 s                        | 3970.07      | II | 100                      | 4340.64      | II | 340 c     | 2441.47      | I  |
| 55 cw                       | 6798.60      | I   | 3000                          | 3981.82      | I  | 100                      | 4682.28      | II | 230       | 2442.51      | I  |
| 35 cw                       | 6827.60      | II  | 10000                         | 3982.23      | I  | 100                      | 4825.91      | I  | 250       | 2444.94      | I  |
| 7000                        | 6910.14      | III | 3000 l                        | 4012.96      | II | 50                       | 5660.81      | I  | 610       | 2446.98      | I  |
| 40                          | 7021.51      | II  | 3000 s                        | 4018.21      | II | 50                       | 7141.21      | I  | 610       | 2449.71      | I  |
| 5000                        | 7030.39      | III | 3000                          | 4030.16      | II | 50                       | 8019.70      | II | 390       | 2461.20      | I  |
| 4500                        | 7076.62      | III | 3000 s                        | 4046.93      | II | <i>Radon Rn Z = 86</i>   |              |    | 800 c     | 2461.84      | II |
| 20                          | 7114.55      | I   | 10000 s                       | 4056.20      | II | 100                      | 4349.60      | I  | 1200      | 2483.92      | I  |
| 24                          | 7227.70      | II  | 10000 s                       | 4070.40      | II | 200                      | 7055.42      | I  | 390       | 2485.81      | I  |
| 16                          | 7407.56      | II  | 3000 l                        | 4176.18      | II | 100                      | 7268.11      | I  | 980       | 2487.33      | I  |
| 20 c                        | 7451.74      | II  | 10000 l                       | 4217.23      | II | 100                      | 7450.00      | I  | 370       | 2496.04      | I  |
| 14                          | 7541.02      | II  | 10000 s                       | 4248.08      | II | 300                      | 7450.00      | I  | 370       | 2501.72      | I  |
| 20                          | 7645.66      | II  | 3000 s                        | 4291.34      | II | 100                      | 7809.82      | I  | 570       | 2502.35      | II |
| 16                          | 7721.84      | I   | 3000 s                        | 4601.43      | II | 100                      | 8099.51      | I  | 230       | 2504.60      | II |
| 14                          | 7871.67      | I   | 3000 l                        | 6035.78      | I  | 100                      | 8270.96      | I  | 270       | 2505.94      | I  |
| 14                          | 8067.44      | I   | 3000                          | 6162.56      | I  | 100                      | 8600.07      | I  | 1800 c    | 2508.99      | I  |
| 10 cw                       | 8122.78      | II  | 3000 l                        | 6358.61      | I  | <i>Rhenium Re Z = 75</i> |              |    | 570       | 2520.01      | I  |
| 11                          | 8141.10      | I   | 3000                          | 6379.25      | I  | 25000                    | 2003.53      | I  | 540       | 2521.50      | I  |
| 5000 w                      | 8602.74      | III | 3000 l                        | 6438.97      | I  | 16000                    | 2017.87      | I  | 370       | 2534.80      | I  |
| 10                          | 8714.59      | II  | 3000 h                        | 6792.75      | I  | 27000                    | 2049.08      | I  | 570       | 2540.51      | I  |
| <i>Promethium Pm Z = 61</i> |              |     | 10000                         | 6945.72      | I  | 10000                    | 2085.59      | I  | 740 d     | 2544.74      | I  |
| 1000                        | 3892.15      | II  | 3000                          | 6960.09      | I  | 9800                     | 2097.12      | I  | 370       | 2545.48      | I  |
| 1000                        | 3910.26      | II  | 3000 h                        | 6961.78      | I  | 3400                     | 2139.04      | II | 300       | 2552.02      | I  |
| 1000                        | 3919.10      | II  | 3000 s                        | 6992.73      | I  | 3700                     | 2156.67      | I  | 370       | 2554.63      | II |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity                | Wavelength/Å |     |
|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|--------------------------|--------------|-----|
| 1000      | 2556.51      | I  | 320       | 3069.94      | I  | 240       | 3453.50      | I  | 110 c                    | 5752.93      | I   |
| 250       | 2559.08      | I  | 260       | 3071.16      | I  | 55000 c   | 3460.46      | I  | 110 cw                   | 5776.83      | I   |
| 340       | 2564.19      | I  | 550       | 3082.43      | I  | 40000 c   | 3464.73      | I  | 550                      | 5834.31      | I   |
| 540       | 2568.64      | II | 340       | 3088.76      | I  | 400       | 3467.96      | I  | 200                      | 6307.70      | I   |
| 370       | 2571.81      | II | 700       | 3100.67      | I  | 240       | 3476.44      | I  | 200                      | 6321.90      | I   |
| 380       | 2586.79      | I  | 700       | 3108.81      | I  | 400       | 3480.38      | I  | 100 cw                   | 6605.19      | I   |
| 290       | 2599.86      | I  | 340       | 3110.86      | I  | 320       | 3480.85      | I  | 180 c                    | 6813.41      | I   |
| 290       | 2603.89      | I  | 340 c     | 3118.19      | I  | 240       | 3482.23      | I  | 260                      | 6829.90      | I   |
| 660       | 2608.50      | II | 340       | 3121.36      | I  | 560       | 3503.06      | I  | 50 cw                    | 7640.94      | I   |
| 610 d     | 2611.54      | I  | 420       | 3128.94      | I  | 320       | 3516.65      | I  | 65 cw                    | 7912.94      | I   |
| 310       | 2635.83      | II | 260       | 3134.02      | I  | 320       | 3517.33      | I  | <b>Rhodium Rh Z = 45</b> |              |     |
| 550       | 2636.64      | I  | 250       | 3141.38      | I  | 320       | 3537.46      | I  | 50                       | 813.44       | III |
| 270       | 2642.75      | I  | 440       | 3151.64      | I  | 240       | 3549.89      | I  | 80                       | 882.51       | III |
| 270       | 2649.05      | I  | 330       | 3153.79      | I  | 240       | 3570.26      | I  | 100                      | 925.75       | III |
| 660       | 2651.90      | I  | 360 c     | 3158.31      | I  | 360       | 3579.12      | I  | 150                      | 937.28       | III |
| 400       | 2654.12      | I  | 220       | 3164.52      | I  | 810 c     | 3580.15      | II | 500                      | 991.62       | III |
| 220       | 2663.63      | I  | 700       | 3168.37      | I  | 650       | 3580.97      | I  | 400                      | 992.48       | III |
| 940       | 2674.34      | I  | 220       | 3174.61      | I  | 810       | 3583.02      | I  | 500 d                    | 1009.60      | III |
| 220       | 2688.53      | I  | 440       | 3177.71      | I  | 320       | 3617.08      | I  | 200                      | 1012.22      | III |
| 1300      | 2715.47      | I  | 260       | 3178.61      | I  | 810       | 3637.84      | I  | 200                      | 1015.17      | III |
| 220       | 2732.21      | I  | 600       | 3182.87      | I  | 440       | 3651.97      | I  | 200                      | 1073.87      | III |
| 610       | 2733.04      | II | 1100      | 3184.76      | I  | 320       | 3670.53      | I  | 150                      | 1784.24      | III |
| 220       | 2758.00      | I  | 1100      | 3185.57      | I  | 860 c     | 3689.50      | I  | 200                      | 1784.94      | III |
| 210       | 2763.79      | I  | 260       | 3190.78      | I  | 1500 c    | 3691.48      | I  | 150                      | 1796.50      | III |
| 310       | 2767.74      | I  | 260       | 3192.36      | I  | 520       | 3703.24      | I  | 200                      | 1816.03      | III |
| 220       | 2768.85      | I  | 220       | 3198.58      | I  | 240       | 3709.93      | I  | 1000                     | 1832.05      | III |
| 220       | 2769.32      | I  | 1100 c    | 3204.25      | I  | 360 c     | 3717.28      | I  | 500                      | 1859.85      | III |
| 350       | 2770.42      | I  | 380       | 3235.94      | I  | 4000      | 3725.76      | I  | 800                      | 1880.66      | III |
| 550       | 2783.57      | I  | 600       | 3258.85      | I  | 240 c     | 3735.01      | I  | 500                      | 1884.91      | III |
| 220       | 2791.29      | I  | 600       | 3259.55      | I  | 810       | 3735.31      | I  | 500                      | 1887.36      | III |
| 220       | 2814.68      | I  | 300       | 3268.89      | I  | 910       | 3740.10      | I  | 700                      | 1888.62      | III |
| 880       | 2819.95      | I  | 280       | 3296.70      | I  | 300 cw    | 3745.44      | I  | 800                      | 1901.32      | III |
| 310       | 2834.08      | I  | 280       | 3296.99      | I  | 700       | 3787.52      | I  | 500                      | 1910.16      | III |
| 220       | 2843.00      | I  | 280       | 3301.60      | I  | 240       | 3869.94      | I  | 600                      | 1919.37      | III |
| 270       | 2850.98      | I  | 240       | 3302.23      | I  | 240       | 3875.26      | I  | 500                      | 1927.07      | III |
| 240       | 2867.19      | I  | 320       | 3303.21      | II | 240       | 3876.86      | I  | 700                      | 1931.79      | III |
| 2900      | 2887.68      | I  | 280       | 3303.75      | I  | 380 c     | 3917.27      | I  | 500                      | 1954.25      | III |
| 490       | 2896.01      | I  | 240       | 3313.95      | I  | 550       | 3929.85      | I  | 500                      | 1994.26      | III |
| 830 c     | 2902.48      | I  | 600       | 3322.48      | I  | 280       | 3961.04      | I  | 800                      | 2013.71      | III |
| 210       | 2905.58      | I  | 2000      | 3338.18      | I  | 350 c     | 3962.48      | I  | 500                      | 2017.47      | III |
| 550       | 2909.82      | I  | 1600      | 3342.24      | I  | 220       | 4033.31      | I  | 500                      | 2028.53      | III |
| 830 c     | 2927.42      | I  | 810       | 3344.32      | I  | 240       | 4081.43      | I  | 800                      | 2036.72      | III |
| 270       | 2930.61      | I  | 320       | 3346.20      | I  | 240 c     | 4110.89      | I  | 600                      | 2037.61      | III |
| 440       | 2943.14      | I  | 240 d     | 3356.33      | I  | 240 cw    | 4133.42      | I  | 1000                     | 2040.18      | III |
| 270       | 2962.27      | I  | 240       | 3377.74      | I  | 1800      | 4136.45      | I  | 3000                     | 2048.67      | III |
| 720       | 2965.11      | I  | 320       | 3379.06      | II | 700       | 4144.36      | I  | 2000                     | 2064.11      | III |
| 1500      | 2965.76      | I  | 320       | 3379.70      | I  | 220       | 4182.90      | I  | 800                      | 2076.84      | III |
| 310       | 2976.29      | I  | 240       | 3389.43      | I  | 220       | 4183.06      | I  | 1000                     | 2118.53      | III |
| 210       | 2978.15      | I  | 4000      | 3399.30      | I  | 650       | 4221.08      | I  | 1000                     | 2118.63      | III |
| 220       | 2980.82      | I  | 650       | 3404.72      | I  | 3600 c    | 4227.46      | I  | 1000                     | 2139.44      | III |
| 220       | 2982.19      | I  | 650       | 3405.89      | I  | 260 c     | 4257.60      | I  | 1000                     | 2152.23      | III |
| 220       | 2988.47      | I  | 240       | 3408.67      | I  | 380       | 4358.69      | I  | 3000                     | 2158.17      | III |
| 1800      | 2992.36      | I  | 320       | 3409.83      | I  | 360 cw    | 4394.38      | I  | 3000                     | 2163.19      | III |
| 5500      | 2999.60      | I  | 320       | 3417.77      | I  | 2600      | 4513.31      | I  | 3000                     | 2167.33      | III |
| 350       | 3001.14      | I  | 810       | 3419.41      | I  | 260       | 4516.64      | I  | 150                      | 2276.21      | II  |
| 220       | 3004.14      | I  | 8000      | 3424.62      | I  | 500       | 4522.73      | I  | 140                      | 2288.57      | I   |
| 500       | 3016.02      | I  | 400       | 3426.19      | I  | 2200 cw   | 4889.14      | I  | 110                      | 2309.82      | I   |
| 300       | 3016.49      | I  | 300       | 3427.61      | I  | 220       | 4923.90      | I  | 350                      | 2322.58      | I   |
| 380       | 3030.45      | I  | 320       | 3437.71      | I  | 1300      | 5270.95      | I  | 140                      | 2326.47      | I   |
| 240       | 3047.25      | I  | 400       | 3449.37      | I  | 1600 cw   | 5275.56      | I  | 190                      | 2334.77      | II  |
| 1600      | 3067.40      | I  | 16000 c   | 3451.88      | I  | 100       | 5667.88      | I  | 300                      | 2361.92      | I   |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity                 | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|---------------------------|--------------|-----|
| 110       | 2368.34      | I   | 2300      | 3280.55      | I   | 240       | 3754.12      | I  | 16                        | 6253.72      | I   |
| 270       | 2382.89      | I   | 2300      | 3283.57      | I   | 380       | 3754.27      | I  | 29                        | 6319.53      | I   |
| 230       | 2383.40      | I   | 280       | 3289.14      | I   | 490       | 3755.58      | I  | 40                        | 6752.35      | I   |
| 270       | 2386.14      | II  | 210       | 3294.28      | I   | 1000      | 3760.40      | I  | 13                        | 6827.33      | I   |
| 80        | 2415.84      | II  | 260       | 3300.46      | I   | 2300      | 3765.08      | I  | 11                        | 6857.68      | I   |
| 130       | 2427.68      | I   | 50        | 3310.69      | III | 490       | 3769.97      | I  | 20                        | 6879.94      | I   |
| 230       | 2429.52      | I   | 4200      | 3323.09      | I   | 380       | 3778.13      | I  | 65                        | 6965.67      | I   |
| 110       | 2437.90      | I   | 330       | 3338.54      | I   | 1000      | 3788.47      | I  | 16                        | 6979.15      | I   |
| 330       | 2440.34      | I   | 280       | 3360.80      | I   | 1300      | 3792.18      | I  | 16                        | 7001.58      | I   |
| 90        | 2461.04      | II  | 420       | 3368.38      | I   | 3800      | 3793.22      | I  | 18                        | 7101.64      | I   |
| 130       | 2473.09      | I   | 1100      | 3372.25      | I   | 4900      | 3799.31      | I  | 15                        | 7104.45      | I   |
| 150       | 2487.47      | I   | 110       | 3377.14      | I   | 760       | 3805.92      | I  | 18                        | 7268.18      | I   |
| 100       | 2490.77      | II  | 110       | 3385.78      | I   | 1300      | 3806.76      | I  | 35                        | 7270.82      | I   |
| 130       | 2502.46      | I   | 5600      | 3396.82      | I   | 470       | 3815.01      | I  | 18 h                      | 7442.39      | I   |
| 300       | 2504.29      | II  | 820       | 3399.70      | I   | 760       | 3816.47      | I  | 12                        | 7475.74      | I   |
| 150       | 2505.67      | I   | 160       | 3406.55      | I   | 1300      | 3818.19      | I  | 12                        | 7495.24      | I   |
| 350       | 2509.70      | I   | 820       | 3412.27      | I   | 3800      | 3822.26      | I  | 11                        | 7557.67      | I   |
| 300       | 2511.03      | II  | 330       | 3421.22      | I   | 2300      | 3828.48      | I  | 29                        | 7791.61      | I   |
| 200       | 2515.75      | I   | 120 d     | 3424.38      | I   | 2000      | 3833.89      | I  | 55                        | 7824.91      | I   |
| 130       | 2520.53      | II  | 8200      | 3434.89      | I   | 5900      | 3856.52      | I  | 21                        | 8029.91      | I   |
| 110       | 2537.04      | II  | 1400      | 3440.53      | I   | 490       | 3870.01      | I  | 29                        | 8045.36      | I   |
| 350       | 2545.70      | I   | 120       | 3447.74      | I   | 380       | 3877.34      | I  | 15                        | 8136.20      | I   |
| 550       | 2555.36      | I   | 120       | 3450.29      | I   | 120       | 3913.51      | I  | 8                         | 8425.59      | I   |
| 150       | 2622.58      | I   | 400       | 3455.22      | I   | 240       | 3922.19      | I  | <i>Rubidium Rb Z = 37</i> |              |     |
| 230       | 2625.88      | I   | 180       | 3457.07      | I   | 2000      | 3934.23      | I  | 30                        | 465.85       | III |
| 100       | 2630.42      | I   | 220       | 3457.93      | I   | 590       | 3942.72      | I  | 40                        | 481.118      | II  |
| 110       | 2647.28      | I   | 5900      | 3462.04      | I   | 3800      | 3958.86      | I  | 500                       | 482.83       | III |
| 400       | 2652.66      | I   | 180       | 3469.62      | I   | 45        | 3964.54      | II | 500                       | 489.66       | III |
| 100       | 2680.63      | I   | 4700      | 3470.66      | I   | 380       | 3975.31      | I  | 600                       | 493.48       | III |
| 400       | 2703.73      | I   | 120       | 3472.25      | I   | 240       | 3984.40      | I  | 90                        | 497.430      | II  |
| 100       | 2715.31      | II  | 4700      | 3474.78      | I   | 240       | 3995.61      | I  | 20                        | 508.434      | II  |
| 180       | 2718.54      | I   | 2100      | 3478.91      | I   | 380       | 3996.15      | I  | 150                       | 513.266      | II  |
| 160       | 2728.94      | I   | 110       | 3494.44      | I   | 120       | 4023.14      | I  | 300                       | 530.173      | II  |
| 100       | 2771.51      | I   | 1200      | 3498.73      | I   | 560       | 4082.78      | I  | 75                        | 533.801      | II  |
| 130       | 2783.03      | I   | 5900      | 3502.52      | I   | 140       | 4097.52      | I  | 1200                      | 535.86       | III |
| 150       | 2826.43      | I   | 2800      | 3507.32      | I   | 120       | 4119.68      | I  | 40                        | 542.887      | II  |
| 180       | 2826.68      | I   | 8800      | 3528.02      | I   | 1100      | 4121.68      | I  | 200                       | 555.036      | II  |
| 280       | 2862.94      | I   | 880 d     | 3538.14      | I   | 1500      | 4128.87      | I  | 1200                      | 556.19       | III |
| 110       | 2878.66      | I   | 280       | 3541.91      | I   | 2100      | 4135.27      | I  | 1500                      | 566.71       | III |
| 140       | 2882.37      | I   | 1200      | 3543.95      | I   | 240       | 4154.37      | I  | 1000                      | 572.82       | III |
| 160       | 2907.21      | I   | 1800      | 3549.54      | I   | 330       | 4196.50      | I  | 1500                      | 576.65       | III |
| 65        | 2910.17      | II  | 1200      | 3570.18      | I   | 3300      | 4211.14      | I  | 2500                      | 579.63       | III |
| 180       | 2924.02      | I   | 4700      | 3583.10      | I   | 820       | 4288.71      | I  | 1500                      | 581.26       | III |
| 130       | 2929.11      | I   | 4700      | 3596.19      | I   | 4200      | 4374.80      | I  | 2500                      | 589.419      | II  |
| 130       | 2931.94      | I   | 5900      | 3597.15      | I   | 130       | 4569.00      | I  | 1000                      | 594.94       | III |
| 230       | 2968.66      | I   | 3100      | 3612.47      | I   | 150       | 4675.03      | I  | 1300                      | 595.88       | III |
| 160       | 2977.68      | I   | 1800      | 3626.59      | I   | 70        | 4745.11      | I  | 1200                      | 598.49       | III |
| 450       | 2986.20      | I   | 8200      | 3657.99      | I   | 70        | 5090.63      | I  | 1500                      | 643.878      | II  |
| 110       | 3004.46      | I   | 1300      | 3666.22      | I   | 60        | 5155.54      | I  | 25                        | 663.76       | IV  |
| 50        | 3006.43      | III | 560       | 3681.04      | I   | 60        | 5175.97      | I  | 3000                      | 697.049      | II  |
| 130       | 3023.91      | I   | 1900      | 3690.70      | I   | 95        | 5193.14      | I  | 6000                      | 711.187      | II  |
| 50        | 3052.44      | III | 9400      | 3692.36      | I   | 130       | 5354.40      | I  | 25                        | 716.24       | IV  |
| 180       | 3083.96      | I   | 940       | 3695.52      | I   | 95        | 5390.44      | I  | 50                        | 740.85       | IV  |
| 140       | 3121.76      | I   | 280       | 3698.26      | I   | 160       | 5599.42      | I  | 10000                     | 741.456      | II  |
| 240       | 3123.70      | I   | 380       | 3698.60      | I   | 40        | 5686.38      | I  | 5000                      | 769.04       | III |
| 130       | 3155.78      | I   | 7600      | 3700.91      | I   | 29        | 5792.66      | I  | 25                        | 776.89       | IV  |
| 140       | 3189.05      | I   | 940       | 3713.02      | I   | 40        | 5806.91      | I  | 2500                      | 815.28       | III |
| 470       | 3191.19      | I   | 650       | 3735.28      | I   | 35        | 5831.58      | I  | 15                        | 850.18       | IV  |
| 190       | 3197.13      | I   | 420       | 3737.27      | I   | 130       | 5983.60      | I  | 1000                      | 1604.12      | II  |
| 520       | 3263.14      | I   | 420       | 3744.17      | I   | 35        | 6102.72      | I  | 5000                      | 1760.50      | II  |
| 520       | 3271.61      | I   | 1200      | 3748.22      | I   | 14        | 6199.99      | I  | 2000                      | 2068.92      | II  |

| Intensity | Wavelength/Å |     | Intensity                  | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |   |
|-----------|--------------|-----|----------------------------|--------------|-----|-----------|--------------|----|-----------|--------------|---|
| 10000     | 2075.95      | II  | 40 l                       | 8271.41      | I   | 110       | 2517.32      | II | 650       | 3669.49      | I |
| 30000     | 2143.83      | II  | 30                         | 8271.71      | I   | 150       | 2535.59      | II | 550       | 3726.10      | I |
| 10000     | 2217.08      | II  | 40 l                       | 8868.512     | I   | 550       | 2549.58      | I  | 8700      | 3726.93      | I |
| 5000      | 2291.71      | II  | 30                         | 8868.852     | I   | 370       | 2609.06      | I  | 11000     | 3728.03      | I |
| 50000     | 2472.20      | II  | 30 l                       | 9522.65      | I   | 830       | 2612.07      | I  | 7100      | 3730.43      | I |
| 1000      | 2631.75      | III | 20 l                       | 9540.18      | I   | 460       | 2642.96      | I  | 3500      | 3742.28      | I |
| 2000      | 2956.07      | III | 2000 c                     | 9689.05      | II  | 330       | 2651.84      | I  | 870       | 3742.78      | I |
| 500       | 3086.84      | III | 35 l                       | 10075.282    | I   | 400       | 2659.62      | I  | 2800      | 3745.59      | I |
| 500       | 3111.36      | III | 30 l                       | 10075.708    | I   | 330       | 2661.61      | II | 760       | 3753.54      | I |
| 5000 c    | 3148.90      | II  | 100                        | 13235.17     | I   | 690       | 2678.76      | II | 870       | 3755.93      | I |
| 25        | 3157.54      | I   | 20                         | 13442.81     | I   | 330       | 2692.06      | II | 1200      | 3759.84      | I |
| 50        | 3227.98      | I   | 30                         | 13443.57     | I   | 200       | 2712.41      | II | 600       | 3761.51      | I |
| 500       | 3286.41      | III | 75                         | 13665.01     | I   | 690       | 2719.52      | I  | 600       | 3767.35      | I |
| 60        | 3348.72      | I   | 1000                       | 14752.41     | I   | 140       | 2725.47      | II | 1500      | 3777.59      | I |
| 75        | 3350.82      | I   | 800                        | 15288.43     | I   | 310       | 2734.35      | II | 600       | 3782.74      | I |
| 100       | 3587.05      | I   | 150                        | 15289.48     | I   | 1800      | 2735.72      | I  | 3900      | 3786.06      | I |
| 40        | 3591.57      | I   | 20                         | 22529.65     | I   | 100       | 2778.38      | II | 6000      | 3790.51      | I |
| 5000      | 3600.60      | II  | 4                          | 27314.31     | I   | 110       | 2787.83      | II | 760       | 3798.05      | I |
| 10000     | 3600.64      | II  | <i>Ruthenium Ru Z = 44</i> |              |     | 350       | 2810.03      | I  | 7600      | 3798.90      | I |
| 25000     | 3940.51      | II  | 250                        | 850.09       | III | 1700      | 2810.55      | I  | 7600      | 3799.35      | I |
| 1000      | 4201.80      | I   | 200                        | 850.30       | III | 350       | 2818.36      | I  | 600       | 3812.72      | I |
| 500       | 4215.53      | I   | 250                        | 919.74       | III | 400       | 2829.16      | I  | 760       | 3817.27      | I |
| 90000     | 4244.40      | II  | 500                        | 940.09       | III | 640       | 2854.07      | I  | 760       | 3819.03      | I |
| 15000     | 4273.14      | II  | 500                        | 966.54       | III | 420       | 2861.41      | I  | 650       | 3822.09      | I |
| 20000     | 4571.77      | II  | 750                        | 974.14       | III | 550       | 2866.64      | I  | 550       | 3824.93      | I |
| 10000     | 4648.57      | II  | 900                        | 979.43       | III | 1800      | 2874.98      | I  | 760       | 3831.80      | I |
| 30000     | 4775.95      | II  | 500                        | 981.35       | III | 740       | 2886.54      | I  | 930       | 3839.70      | I |
| 2         | 5087.987     | I   | 900                        | 986.84       | III | 370       | 2908.88      | I  | 760       | 3850.43      | I |
| 2         | 5132.471     | I   | 900                        | 994.56       | III | 1100      | 2916.26      | I  | 1300      | 3857.55      | I |
| 10        | 5150.134     | I   | 300                        | 1001.65      | III | 180       | 2945.67      | II | 650       | 3862.69      | I |
| 10000     | 5152.08      | II  | 500                        | 1009.13      | III | 370       | 2949.50      | I  | 1300      | 3867.84      | I |
| 1         | 5165.023     | I   | 900                        | 1009.87      | III | 550       | 2965.16      | I  | 650       | 3892.21      | I |
| 2         | 5165.142     | I   | 500                        | 1014.68      | III | 170       | 2965.55      | II | 760       | 3909.08      | I |
| 15        | 5195.278     | I   | 800                        | 1190.51      | III | 140       | 2976.59      | II | 1500      | 3923.47      | I |
| 2         | 5233.968     | I   | 500                        | 1200.07      | III | 550       | 2976.92      | I  | 3300      | 3925.92      | I |
| 20        | 5260.034     | I   | 500                        | 1207.17      | III | 1400      | 2988.95      | I  | 600       | 3931.76      | I |
| 1         | 5260.228     | I   | 500                        | 1209.77      | III | 460       | 2994.96      | I  | 760       | 3945.57      | I |
| 3         | 5322.380     | I   | 300                        | 1211.31      | III | 440       | 3006.59      | I  | 600       | 3978.44      | I |
| 40        | 5362.601     | I   | 500                        | 1941.35      | III | 330       | 3017.24      | I  | 600       | 3979.42      | I |
| 4         | 5390.568     | I   | 500                        | 2009.28      | III | 310       | 3020.88      | I  | 870       | 3984.86      | I |
| 75        | 5431.532     | I   | 2400                       | 2076.43      | I   | 390       | 3064.84      | I  | 1500      | 4022.16      | I |
| 3         | 5431.830     | I   | 2600                       | 2083.77      | I   | 330       | 3096.57      | I  | 600       | 4023.83      | I |
| 6         | 5578.788     | I   | 2400                       | 2090.89      | I   | 830       | 3099.28      | I  | 1400      | 4051.40      | I |
| 40        | 5647.774     | I   | 690                        | 2255.52      | I   | 740       | 3100.84      | I  | 710       | 4054.05      | I |
| 20        | 5653.750     | I   | 780                        | 2272.09      | I   | 490       | 3294.11      | I  | 760       | 4068.37      | I |
| 60        | 5724.121     | I   | 780                        | 2279.57      | I   | 370       | 3301.59      | I  | 980       | 4076.73      | I |
| 3         | 5724.614     | I   | 480                        | 2317.80      | I   | 930       | 3339.55      | I  | 6000      | 4080.60      | I |
| 75        | 6070.755     | I   | 120                        | 2334.96      | II  | 3100      | 3417.35      | I  | 930       | 4097.79      | I |
| 30 c      | 6159.626     | I   | 190 h                      | 2342.85      | II  | 4900      | 3428.31      | I  | 1900      | 4112.74      | I |
| 75 c      | 6206.309     | I   | 310                        | 2351.33      | I   | 6400      | 3436.74      | I  | 2000      | 4144.16      | I |
| 120 c     | 6298.325     | I   | 170                        | 2357.91      | II  | 8300      | 3498.94      | I  | 650       | 4145.74      | I |
| 5         | 6299.224     | I   | 780                        | 2402.72      | II  | 640       | 3514.49      | I  | 870       | 4167.51      | I |
| 10000     | 6458.33      | II  | 150                        | 2407.92      | II  | 790       | 3539.37      | I  | 550       | 4197.58      | I |
| 5000      | 6560.81      | II  | 180                        | 2455.53      | II  | 690       | 3570.59      | I  | 550       | 4198.88      | I |
| 100 l     | 7279.997     | I   | 150                        | 2456.44      | II  | 6400      | 3589.22      | I  | 7600      | 4199.90      | I |
| 150       | 7408.173     | I   | 370                        | 2456.57      | II  | 6900      | 3593.02      | I  | 1500      | 4206.02      | I |
| 200 l     | 7618.933     | I   | 280                        | 2478.93      | II  | 6400      | 3596.18      | I  | 5400      | 4212.06      | I |
| 300       | 7757.651     | I   | 140                        | 2498.42      | II  | 1300      | 3599.76      | I  | 760       | 4214.44      | I |
| 60        | 7759.436     | I   | 140                        | 2498.57      | II  | 3100      | 3634.93      | I  | 930       | 4217.27      | I |
| 90000 c   | 7800.27      | I   | 260                        | 2507.01      | II  | 6200      | 3661.35      | I  | 550       | 4230.31      | I |
| 45000 c   | 7947.60      | I   | 110                        | 2513.32      | II  | 830       | 3663.37      | I  | 760       | 4241.05      | I |

| Intensity | Wavelength/Å |   | Intensity                 | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|---|---------------------------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 760       | 4243.06      | I | 26                        | 6982.01      | I  | 480       | 3854.56      | I  | 730       | 4716.10      | I  |
| 760       | 4284.33      | I | 26                        | 7027.98      | I  | 400       | 3858.74      | I  | 770       | 4728.42      | I  |
| 550       | 4295.93      | I | 35                        | 7238.92      | I  | 3700      | 3885.29      | II | 470       | 4745.68      | II |
| 3700      | 4297.71      | I | 16                        | 7393.93      | I  | 1600      | 3896.98      | II | 730       | 4760.27      | I  |
| 930       | 4307.60      | I | 18                        | 7468.91      | I  | 1300      | 3903.42      | II | 580       | 4783.10      | I  |
| 550       | 4319.87      | I | 26                        | 7485.79      | I  | 2500      | 3922.40      | II | 350       | 4785.86      | I  |
| 550       | 4342.07      | I | 70                        | 7499.75      | I  | 1900      | 3928.28      | II | 970       | 4841.70      | I  |
| 710       | 4354.13      | I | 26                        | 7559.61      | I  | 1300      | 3941.87      | II | 730       | 4883.97      | I  |
| 870       | 4361.21      | I | 18                        | 7621.50      | I  | 470       | 3951.89      | I  | 630       | 4910.40      | I  |
| 2400      | 4372.21      | I | 18                        | 7722.87      | I  | 1500      | 3963.00      | II | 350       | 4913.25      | II |
| 870       | 4385.39      | I | 22                        | 7791.86      | I  | 1500      | 3971.40      | II | 430       | 4918.99      | I  |
| 1300      | 4385.65      | I | 30                        | 7847.80      | I  | 620       | 3974.66      | I  | 400       | 5044.28      | I  |
| 1700      | 4390.44      | I | 80                        | 7881.49      | I  | 1000      | 3976.43      | II | 540       | 5071.20      | I  |
| 1600      | 4410.03      | I | 18                        | 8264.96      | I  | 1500      | 3990.00      | II | 510       | 5117.16      | I  |
| 1100      | 4460.04      | I | 22                        | 8710.84      | I  | 1400      | 4064.58      | II | 350       | 5122.14      | I  |
| 5400      | 4554.51      | I | <i>Samarium Sm Z = 62</i> |              |    | 1000      | 4092.27      | II | 360       | 5155.03      | II |
| 1700      | 4584.44      | I | 150                       | 2789.38      | II | 1900      | 4118.55      | II | 470       | 5175.42      | I  |
| 720       | 4647.61      | I | 410                       | 3152.52      | II | 1200      | 4152.21      | II | 250       | 5200.59      | I  |
| 1400      | 4709.48      | I | 720                       | 3183.92      | II | 1000      | 4188.13      | II | 260       | 5251.92      | I  |
| 500       | 4757.84      | I | 600                       | 3211.73      | II | 1100      | 4203.05      | II | 400       | 5271.40      | I  |
| 550       | 4869.15      | I | 530                       | 3216.85      | II | 1000      | 4225.33      | II | 250       | 5282.91      | I  |
| 160       | 5011.23      | I | 600                       | 3218.61      | II | 1200      | 4236.74      | II | 220       | 5453.00      | I  |
| 450       | 5057.33      | I | 720                       | 3230.56      | II | 2100      | 4256.39      | II | 230       | 5493.72      | I  |
| 120       | 5076.32      | I | 720                       | 3236.64      | II | 1300      | 4262.68      | II | 230       | 5516.09      | I  |
| 200       | 5093.83      | I | 720                       | 3239.66      | II | 1200      | 4279.68      | II | 140       | 5550.40      | I  |
| 530       | 5136.55      | I | 720                       | 3250.37      | II | 2200      | 4280.79      | II | 140       | 5659.86      | I  |
| 170       | 5142.76      | I | 850                       | 3254.38      | II | 710       | 4282.21      | I  | 120       | 5696.73      | I  |
| 250       | 5147.24      | I | 1700                      | 3306.39      | II | 470       | 4282.83      | I  | 85        | 5706.20      | I  |
| 110       | 5151.07      | I | 1200                      | 3321.18      | II | 1600      | 4296.74      | I  | 70        | 5773.77      | I  |
| 500       | 5155.14      | I | 1200                      | 3365.86      | II | 1900      | 4318.94      | II | 60        | 5778.33      | I  |
| 920       | 5171.03      | I | 1200                      | 3382.40      | II | 470       | 4319.53      | I  | 70 d      | 5786.98      | II |
| 180       | 5195.02      | I | 4200                      | 3568.27      | II | 1800      | 4329.02      | II | 60        | 5788.38      | I  |
| 130       | 5284.08      | I | 4200                      | 3592.60      | II | 440       | 4330.02      | I  | 60        | 5800.52      | I  |
| 260       | 5309.27      | I | 1700                      | 3604.28      | II | 1300      | 4334.15      | II | 65        | 5802.84      | I  |
| 110       | 5335.93      | I | 3400                      | 3609.49      | II | 880       | 4336.14      | I  | 65        | 5867.79      | I  |
| 130       | 5361.77      | I | 1700                      | 3621.23      | II | 1100      | 4347.80      | II | 50        | 5874.21      | I  |
| 110 h     | 5401.04      | I | 3400                      | 3634.29      | II | 440       | 4362.91      | I  | 50        | 5898.96      | I  |
| 80        | 5484.32      | I | 2200                      | 3661.36      | II | 530       | 4380.42      | I  | 65        | 5965.71      | II |
| 130       | 5510.71      | I | 2200                      | 3670.84      | II | 1600      | 4390.86      | II | 50        | 6045.00      | I  |
| 90        | 5559.75      | I | 1100                      | 3693.99      | II | 410       | 4401.17      | I  | 50        | 6070.06      | I  |
| 290       | 5636.24      | I | 1600                      | 3728.47      | II | 470       | 4419.33      | I  | 45        | 6084.12      | I  |
| 180       | 5699.05      | I | 2100                      | 3731.26      | II | 1500      | 4420.53      | II | 45 h      | 6159.56      | I  |
| 65        | 5814.98      | I | 1600                      | 3735.98      | II | 2900      | 4424.34      | II | 45        | 6256.54      | I  |
| 55        | 5919.34      | I | 2900                      | 3739.12      | II | 470       | 4429.66      | I  | 100       | 6267.28      | II |
| 80        | 5921.45      | I | 1200                      | 3743.87      | II | 1600      | 4433.88      | II | 140       | 6569.31      | II |
| 21 h      | 5973.38      | I | 930                       | 3745.46      | I  | 1800      | 4434.32      | II | 110       | 6589.72      | II |
| 16        | 5988.67      | I | 800                       | 3756.41      | I  | 530       | 4441.81      | I  | 50        | 6671.51      | I  |
| 35        | 5993.65      | I | 1200                      | 3757.53      | II | 440       | 4442.28      | I  | 120 d     | 6731.84      | II |
| 18        | 6116.77      | I | 1900                      | 3760.69      | II | 710       | 4445.15      | I  | 95        | 6794.20      | II |
| 26        | 6199.42      | I | 1100                      | 3764.37      | II | 1300      | 4452.73      | II | 120       | 6860.93      | I  |
| 26        | 6225.20      | I | 370 d                     | 3773.33      | I  | 1200      | 4454.63      | II | 120       | 6955.29      | II |
| 18        | 6295.22      | I | 1100                      | 3778.14      | II | 1000      | 4458.52      | II | 90        | 7020.44      | II |
| 16        | 6390.23      | I | 1500                      | 3788.12      | II | 2200      | 4467.34      | II | 90        | 7039.22      | II |
| 26 h      | 6444.84      | I | 1600                      | 3793.97      | II | 810       | 4470.89      | I  | 90        | 7042.24      | II |
| 21        | 6663.14      | I | 1600                      | 3797.73      | II | 370       | 4499.11      | I  | 90        | 7051.52      | II |
| 55        | 6690.00      | I | 1600                      | 3826.20      | II | 440       | 4581.73      | I  | 90        | 7082.37      | II |
| 21        | 6766.95      | I | 1100                      | 3831.50      | II | 380       | 4649.49      | I  | 26        | 7088.30      | I  |
| 30        | 6775.02      | I | 560                       | 3834.48      | I  | 470 d     | 4670.75      | I  | 30        | 7095.50      | I  |
| 21        | 6824.17      | I | 1600                      | 3843.50      | II | 1100      | 4674.60      | II | 30        | 7104.54      | I  |
| 26        | 6911.48      | I | 530                       | 3853.30      | I  | 370       | 4688.73      | I  | 26        | 7115.96      | I  |
| 110       | 6923.23      | I | 2700                      | 3854.21      | II | 530       | 4704.40      | II | 85 d      | 7149.60      | II |

| Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|---------------------------|--------------|-----|-----------|--------------|----|-----------|--------------|-----|-----------|--------------|-----|
| 23                        | 7213.82      | I   | 1200      | 2974.01      | I  | 2700      | 4047.79      | I   | 270       | 5089.89      | I   |
| 60                        | 7240.90      | II  | 1400      | 2980.75      | I  | 120       | 4049.95      | I   | 390       | 5096.73      | I   |
| 26                        | 7347.30      | I   | 340       | 2988.95      | I  | 5500      | 4054.55      | I   | 620       | 5099.23      | I   |
| 30                        | 7444.56      | I   | 2200      | 3015.36      | I  | 220       | 4056.59      | I   | 370       | 5101.12      | I   |
| 26                        | 7445.41      | I   | 2700      | 3019.34      | I  | 100       | 4068.66      | III | 180       | 5109.06      | I   |
| 13                        | 7470.76      | I   | 360       | 3030.76      | I  | 160 h     | 4074.97      | I   | 150       | 5112.86      | I   |
| 45                        | 7645.09      | II  | 120 h     | 3056.31      | I  | 160       | 4078.57      | I   | 320       | 5116.69      | I   |
| 12                        | 7645.82      | I   | 130       | 3065.11      | II | 6100      | 4082.40      | I   | 390       | 5210.52      | I   |
| 40 w                      | 7835.08      | II  | 990       | 3251.32      | II | 200       | 4086.67      | I   | 280       | 5219.67      | I   |
| 16                        | 7895.96      | I   | 1500      | 3255.69      | I  | 400       | 4087.16      | I   | 350       | 5239.82      | II  |
| 90                        | 7928.14      | II  | 4400      | 3269.91      | I  | 440 h     | 4133.00      | I   | 280       | 5258.33      | I   |
| 40                        | 8048.70      | II  | 5500      | 3273.63      | I  | 530 h     | 4140.30      | I   | 210       | 5285.76      | I   |
| 16                        | 8065.16      | I   | 110 d     | 3343.28      | II | 720       | 4152.36      | I   | 120       | 5341.05      | I   |
| 45                        | 8068.46      | II  | 270       | 3352.05      | II | 1100 h    | 4165.19      | I   | 350       | 5349.30      | I   |
| 40 w                      | 8305.79      | II  | 9900      | 3353.73      | II | 110 h     | 4218.26      | I   | 120       | 5349.71      | I   |
| 19                        | 8383.71      | I   | 2000      | 3359.68      | II | 110 h     | 4219.73      | I   | 210       | 5355.75      | I   |
| 45 w                      | 8485.99      | II  | 1700      | 3361.27      | II | 180       | 4231.93      | I   | 530       | 5356.10      | I   |
| 45 w                      | 8708.43      | II  | 1700      | 3361.94      | II | 200       | 4233.61      | I   | 270       | 5375.35      | I   |
| 95                        | 8913.66      | II  | 4000      | 3368.95      | II | 400       | 4238.05      | I   | 370       | 5392.08      | I   |
| <i>Scandium Sc Z = 21</i> |              |     | 6600      | 3372.15      | II | 15000     | 4246.83      | II  | 270       | 5446.20      | I   |
| 350                       | 180.14       | V   | 130       | 3418.51      | I  | 290       | 4294.77      | II  | 120       | 5451.34      | I   |
| 500                       | 243.87       | V   | 200       | 3429.21      | I  | 350       | 4305.71      | II  | 750       | 5481.99      | I   |
| 500                       | 252.85       | V   | 200       | 3429.48      | I  | 4200      | 4314.09      | II  | 530       | 5484.62      | I   |
| 500                       | 253.73       | V   | 270       | 3431.36      | I  | 3300      | 4320.74      | II  | 570       | 5514.22      | I   |
| 900                       | 283.91       | V   | 530       | 3435.56      | I  | 2400      | 4325.01      | II  | 660       | 5520.50      | I   |
| 800                       | 284.45       | V   | 270       | 3457.45      | I  | 180       | 4354.61      | II  | 660       | 5526.82      | II  |
| 600                       | 288.29       | V   | 180       | 3462.19      | I  | 110       | 4358.64      | I   | 70        | 5564.86      | I   |
| 900                       | 289.59       | V   | 130 d     | 3469.65      | I  | 2000      | 4374.46      | II  | 110       | 5591.33      | I   |
| 15                        | 289.85       | IV  | 110       | 3471.13      | I  | 130       | 4384.81      | II  | 80        | 5640.98      | II  |
| 1000 d                    | 291.93       | V   | 200       | 3498.91      | I  | 1100      | 4400.37      | II  | 250       | 5657.88      | II  |
| 800                       | 293.25       | V   | 2700      | 3535.73      | II | 880       | 4415.56      | II  | 1500      | 5671.81      | I   |
| 15                        | 296.31       | IV  | 6600      | 3558.55      | II | 120 h     | 4557.24      | I   | 1200      | 5686.84      | I   |
| 15                        | 299.04       | IV  | 6100      | 3567.70      | II | 160 h     | 4573.99      | I   | 1100      | 5700.21      | I   |
| 700                       | 300.00       | V   | 13000     | 3572.53      | II | 350       | 4670.40      | II  | 10        | 5706.82      | IV  |
| 1000                      | 573.36       | V   | 9900      | 3576.35      | II | 120       | 4706.97      | I   | 190       | 5708.61      | I   |
| 600                       | 587.94       | V   | 7700      | 3580.94      | II | 120       | 4709.34      | I   | 880       | 5711.75      | I   |
| 10                        | 785.12       | IV  | 4000      | 3589.64      | II | 200       | 4728.77      | I   | 230       | 5717.28      | I   |
| 25                        | 1168.61      | III | 4000      | 3590.48      | II | 490       | 4729.23      | I   | 180       | 5724.08      | I   |
| 15                        | 1550.80      | IV  | 28000     | 3613.84      | II | 590       | 4734.10      | I   | 14        | 5771.63      | IV  |
| 180                       | 1603.06      | III | 110       | 3617.43      | I  | 690       | 4737.65      | I   | 620       | 6210.68      | I   |
| 150                       | 1610.19      | III | 20000     | 3630.75      | II | 790       | 4741.02      | I   | 320       | 6239.78      | I   |
| 160                       | 2010.42      | III | 13000     | 3642.79      | II | 1200      | 4743.81      | I   | 120       | 6245.63      | II  |
| 12                        | 2118.97      | IV  | 6600      | 3645.31      | II | 200       | 4753.16      | I   | 110       | 6249.96      | I   |
| 11                        | 2185.43      | IV  | 110       | 3646.90      | I  | 220       | 4779.35      | I   | 80        | 6256.01      | III |
| 11                        | 2205.46      | IV  | 5300      | 3651.80      | II | 170       | 4839.44      | I   | 250       | 6258.96      | I   |
| 14                        | 2222.22      | IV  | 110       | 3664.25      | II | 90        | 4909.76      | I   | 750       | 6305.67      | I   |
| 11                        | 2271.33      | IV  | 290       | 3666.54      | II | 90        | 4922.84      | I   | 60        | 6378.82      | I   |
| 110                       | 2438.62      | I   | 75 h      | 3717.10      | I  | 90        | 4934.25      | I   | 90        | 6413.35      | I   |
| 560                       | 2545.22      | II  | 270       | 3833.07      | II | 170       | 4954.06      | I   | 60        | 6604.60      | II  |
| 2900                      | 2552.37      | II  | 610       | 3843.03      | II | 120       | 4973.66      | I   | 65        | 6737.87      | I   |
| 560                       | 2555.82      | II  | 20000     | 3907.49      | I  | 150       | 4980.37      | I   | 50        | 6819.52      | I   |
| 2300                      | 2560.25      | II  | 23000     | 3911.81      | I  | 140       | 4991.92      | I   | 50        | 6835.03      | I   |
| 1100                      | 2563.21      | II  | 4400      | 3933.38      | I  | 530       | 5031.02      | II  | 90        | 7449.16      | III |
| 11                        | 2586.93      | IV  | 5500      | 3996.61      | I  | 250       | 5064.32      | I   | 55 h      | 7741.17      | I   |
| 120                       | 2692.78      | I   | 530       | 4014.49      | II | 530       | 5070.23      | I   | 30        | 7800.44      | I   |
| 350                       | 2699.07      | III | 20000     | 4020.40      | I  | 250       | 5075.81      | I   | 19 h      | 8761.40      | I   |
| 360                       | 2706.77      | I   | 20000     | 4023.69      | I  | 2100      | 5081.56      | I   | 50        | 8829.78      | III |
| 210                       | 2707.95      | I   | 220       | 4030.67      | I  | 1200      | 5083.72      | I   | 30 h      | 8834.35      | I   |
| 580                       | 2711.35      | I   | 140       | 4031.39      | I  | 1100      | 5085.55      | I   | 400       | 22051.86     | I   |
| 230                       | 2734.05      | III | 220       | 4043.80      | I  | 750       | 5086.95      | I   | 150       | 22065.05     | I   |
| 340                       | 2965.86      | I   | 200       | 4046.48      | I  | 390       | 5087.14      | I   |           |              |     |

| Intensity                 | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|---------------------------|--------------|-----|-----------|--------------|-----|--------------------------|--------------|-----|-----------|--------------|-----|
| <i>Selenium Se Z = 34</i> |              |     | 285       | 2057.5       | III | 150                      | 8440.47      | I   | 100       | 1190.42      | II  |
| 360                       | 613.0        | V   | 500       | 2074.8       | I   | 150                      | 8450.38      | I   | 200       | 1193.28      | II  |
| 360                       | 652.7        | IV  | 285       | 2136.6       | IV  | 150                      | 8742.33      | I   | 250       | 1194.50      | II  |
| 450                       | 670.1        | IV  | 500       | 2164.2       | I   | 300                      | 8918.86      | I   | 100       | 1197.39      | II  |
| 360                       | 724.3        | III | 600       | 2413.5       | I   | 200                      | 9001.97      | I   | 30        | 1206.51      | III |
| 450                       | 746.4        | IV  | 300       | 2548.0       | I   | 200                      | 9038.61      | I   | 30        | 1206.53      | III |
| 450                       | 759.1        | V   | 360       | 2665.5       | IV  | 100                      | 9432.50      | I   | 9         | 1207.52      | III |
| 360                       | 808.7        | V   | 285       | 2724.3       | IV  | 200                      | 10217.25     | I   | 10        | 1210.46      | III |
| 360                       | 830.3        | V   | 285       | 2767.2       | III | 377                      | 10307.45     | I   | 50        | 1226.81      | II  |
| 360                       | 832.7        | II  | 220       | 2773.8       | III | 900                      | 10327.26     | I   | 100       | 1227.60      | II  |
| 450                       | 839.5        | V   | 160       | 2951.6       | IV  | 640                      | 10386.36     | I   | 150       | 1228.75      | II  |
| 360                       | 843.0        | III | 450       | 3387.2       | III | 275                      | 11946.87     | I   | 200       | 1229.39      | II  |
| 360                       | 845.8        | V   | 450       | 3413.9       | III | 170                      | 11952.64     | I   | 100       | 1246.74      | II  |
| 360                       | 912.9        | II  | 450       | 3457.8       | III | 205                      | 11972.93     | I   | 150       | 1248.43      | II  |
| 360                       | 959.6        | IV  | 450       | 3637.6       | III | 315                      | 14817.93     | I   | 100       | 1250.09      | II  |
| 360                       | 974.8        | III | 450       | 3738.7       | III | 410                      | 14917.47     | I   | 150       | 1250.43      | II  |
| 450                       | 996.7        | IV  | 450       | 3800.9       | III | 500                      | 15151.44     | I   | 200       | 1251.16      | II  |
| 360                       | 1013.4       | II  | 450       | 4169.1       | III | 320                      | 15471.00     | I   | 40        | 1256.49      | I   |
| 360                       | 1014.0       | II  | 360       | 4175.3       | II  | 265                      | 15520.97     | I   | 50        | 1258.80      | I   |
| 450                       | 1033.6       | II  | 450       | 4180.9       | II  | 395                      | 15618.40     | I   | 1000      | 1260.42      | II  |
| 450                       | 1049.6       | II  | 285       | 4382.9       | II  | 360                      | 16659.44     | I   | 2000      | 1264.73      | II  |
| 360                       | 1057.4       | II  | 285       | 4446.0       | II  | 505                      | 16813.78     | I   | 200       | 1265.02      | II  |
| 360                       | 1094.7       | V   | 220       | 4449.2       | II  | 205                      | 16866.54     | I   | 17        | 1294.54      | III |
| 360                       | 1099.1       | III | 285       | 4467.6       | II  | 235                      | 21374.24     | I   | 14        | 1296.73      | III |
| 450                       | 1119.2       | III | 500       | 4730.8       | I   | 680                      | 21442.56     | I   | 15        | 1298.89      | III |
| 360                       | 1141.9       | II  | 400       | 4739.0       | I   | 415                      | 21473.48     | I   | 18        | 1298.96      | III |
| 450                       | 1192.3       | II  | 300       | 4742.2       | I   | 270                      | 21716.36     | I   | 14        | 1301.15      | III |
| 450                       | 1227.6       | V   | 285       | 4840.6       | II  | 240                      | 21730.60     | I   | 16        | 1303.32      | III |
| 285                       | 1291.0       | II  | 360       | 4845.0       | II  | 150                      | 23388.85     | I   | 100       | 1304.37      | II  |
| 285                       | 1308.9       | II  | 450       | 5227.5       | II  | 265                      | 24148.18     | I   | 50 h      | 1305.59      | II  |
| 285                       | 1314.4       | IV  | 360       | 5305.4       | II  | 375                      | 24385.99     | I   | 200       | 1309.27      | II  |
| 120                       | 1435.3       | I   | 100       | 5365.5       | I   | 255                      | 25017.51     | I   | 13        | 1312.59      | III |
| 120                       | 1435.8       | I   | 120       | 5369.9       | I   | 510                      | 25127.43     | I   | 100       | 1346.87      | II  |
| 150                       | 1449.2       | I   | 110       | 5374.1       | I   | <i>Silicon Si Z = 14</i> |              |     | 100       | 1348.54      | II  |
| 150                       | 1500.9       | I   | 285       | 5522.4       | II  | 10                       | 85.18        | V   | 150       | 1350.06      | II  |
| 250                       | 1530.4       | I   | 285       | 5566.9       | II  | 15                       | 96.44        | V   | 100       | 1352.64      | II  |
| 150                       | 1531.3       | I   | 285       | 5866.3       | II  | 10                       | 97.14        | V   | 100       | 1353.72      | II  |
| 200                       | 1531.8       | I   | 450       | 6056.0       | II  | 20                       | 117.86       | V   | 15        | 1393.76      | IV  |
| 150                       | 1575.3       | I   | 285       | 6303.8       | III | 20                       | 118.97       | V   | 12        | 1402.77      | IV  |
| 150                       | 1577.6       | I   | 200       | 6325.6       | I   | 4                        | 457.82       | IV  | 13        | 1417.24      | III |
| 150                       | 1577.9       | I   | 360       | 6444.2       | II  | 8                        | 566.61       | III | 90 h      | 1485.02      | II  |
| 150                       | 1579.5       | I   | 285       | 6490.5       | II  | 8                        | 653.33       | III | 100 h     | 1485.51      | II  |
| 200                       | 1580.0       | I   | 285       | 6535.0       | II  | 7                        | 815.05       | IV  | 12        | 1500.24      | III |
| 150                       | 1587.5       | I   | 150       | 6831.3       | I   | 8                        | 818.13       | IV  | 10        | 1501.19      | III |
| 150                       | 1593.2       | I   | 120       | 6990.690     | I   | 9                        | 823.41       | III | 9         | 1501.87      | III |
| 250                       | 1606.5       | I   | 100       | 6991.792     | I   | 40 h                     | 845.77       | II  | 100 h     | 1509.10      | II  |
| 200                       | 1617.4       | I   | 200       | 7010.809     | I   | 100                      | 889.72       | II  | 50 h      | 1512.07      | II  |
| 150                       | 1621.2       | I   | 150       | 7013.875     | I   | 200                      | 892.00       | II  | 60 p      | 1516.91      | II  |
| 150                       | 1643.4       | I   | 300       | 7062.065     | I   | 9                        | 967.95       | III | 500       | 1526.72      | II  |
| 250                       | 1671.2       | I   | 200       | 7575.1       | I   | 100                      | 989.87       | II  | 1000      | 1533.45      | II  |
| 250                       | 1675.3       | I   | 250       | 7583.4       | I   | 200                      | 992.68       | II  | 150       | 1594.55      | I   |
| 250                       | 1690.7       | I   | 150       | 7592.2       | I   | 10                       | 993.52       | III | 100       | 1622.87      | I   |
| 250                       | 1793.3       | I   | 300       | 8001.0       | I   | 13                       | 994.79       | III | 300       | 1629.43      | I   |
| 300                       | 1795.3       | I   | 200       | 8036.4       | I   | 16                       | 997.39       | III | 200       | 1629.92      | I   |
| 300                       | 1855.2       | I   | 150       | 8093.2       | I   | 50                       | 1023.69      | II  | 100       | 1667.62      | I   |
| 250                       | 1858.8       | I   | 150       | 8094.7       | I   | 8                        | 1066.63      | IV  | 100       | 1668.52      | I   |
| 400                       | 1898.6       | I   | 180       | 8149.3       | I   | 14                       | 1108.37      | III | 100       | 1672.59      | I   |
| 350                       | 1913.8       | I   | 150       | 8152.0       | I   | 16                       | 1109.97      | III | 200       | 1675.20      | I   |
| 300                       | 1919.2       | I   | 200       | 8157.7       | I   | 18                       | 1113.23      | III | 200       | 1696.20      | I   |
| 500                       | 1960.9       | I   | 180       | 8163.1       | I   | 8                        | 1122.49      | IV  | 200       | 1697.94      | I   |
| 500                       | 2039.8       | I   | 150       | 8182.9       | I   | 10                       | 1128.34      | IV  | 100 h     | 1770.92      | I   |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 100 h     | 1776.83      | I   | 300       | 2904.28      | II  | 16        | 4716.65      | III | 90        | 6131.850     | I   |
| 100 h     | 1799.12      | I   | 500       | 2905.69      | II  | 50        | 4782.991     | I   | 100       | 6142.487     | I   |
| 150       | 1808.00      | II  | 55        | 2970.355     | I   | 35        | 4792.212     | I   | 100       | 6145.015     | I   |
| 500 h     | 1814.07      | I   | 150       | 2987.645     | I   | 80        | 4792.324     | I   | 160       | 6155.134     | I   |
| 200       | 1816.92      | II  | 50        | 3006.739     | I   | 15        | 4813.33      | III | 160       | 6237.320     | I   |
| 200       | 1836.51      | I   | 75        | 3020.004     | I   | 16        | 4819.72      | III | 40        | 6238.287     | I   |
| 200       | 1841.44      | I   | 100 h     | 3030.00      | II  | 18        | 4828.97      | III | 125       | 6243.813     | I   |
| 9         | 1842.55      | III | 9         | 3040.93      | III | 30        | 4947.607     | I   | 125       | 6244.468     | I   |
| 200       | 1843.77      | I   | 100 h     | 3043.69      | II  | 40        | 5006.061     | I   | 180       | 6254.188     | I   |
| 300       | 1845.51      | I   | 50 h      | 3048.30      | II  | 1000      | 5041.03      | II  | 45        | 6331.954     | I   |
| 400       | 1847.47      | I   | 150 h     | 3053.18      | II  | 1000      | 5055.98      | II  | 1000      | 6347.10      | II  |
| 200       | 1848.14      | I   | 25        | 3086.24      | III | 10 h      | 5091.42      | III | 1000      | 6371.36      | II  |
| 500       | 1850.67      | I   | 20        | 3093.42      | III | 100       | 5181.90      | II  | 45        | 6526.609     | I   |
| 200       | 1852.46      | I   | 16        | 3096.83      | III | 100 h     | 5185.25      | II  | 45        | 6527.199     | I   |
| 500 h     | 1874.84      | I   | 9         | 3165.71      | IV  | 200 h     | 5192.86      | II  | 45        | 6555.462     | I   |
| 200       | 1881.85      | I   | 16        | 3185.13      | III | 500 h     | 5202.41      | II  | 50 h      | 6660.52      | II  |
| 200       | 1887.70      | I   | 13        | 3186.02      | III | 100 h     | 5405.34      | II  | 100       | 6671.88      | II  |
| 200 h     | 1893.25      | I   | 150       | 3188.97      | II  | 100 h     | 5438.62      | II  | 7         | 6701.21      | IV  |
| 1000 h    | 1901.33      | I   | 150       | 3193.09      | II  | 100 h     | 5456.45      | II  | 50 h      | 6717.04      | II  |
| 100 h     | 1902.46      | II  | 100       | 3195.41      | II  | 500 h     | 5466.43      | II  | 100       | 6721.853     | I   |
| 50 h      | 1910.62      | II  | 14        | 3196.50      | III | 500 h     | 5466.87      | II  | 50        | 6829.82      | II  |
| 50        | 1941.67      | II  | 200       | 3199.51      | II  | 100 h     | 5469.21      | II  | 30        | 6848.568     | I   |
| 100       | 1949.56      | II  | 100 h     | 3203.87      | II  | 200 h     | 5496.45      | II  | 80        | 6976.523     | I   |
| 100       | 1954.97      | I   | 200 h     | 3210.03      | II  | 35        | 5517.535     | I   | 180       | 7003.567     | I   |
| 50        | 2058.65      | II  | 15        | 3210.55      | III | 100 h     | 5540.74      | II  | 180       | 7005.883     | I   |
| 50        | 2059.01      | II  | 75        | 3214.66      | II  | 150 h     | 5576.66      | II  | 90        | 7017.646     | I   |
| 200       | 2072.02      | II  | 12        | 3230.50      | III | 30        | 5622.221     | I   | 250       | 7034.903     | I   |
| 200       | 2072.70      | II  | 14        | 3233.95      | III | 100 h     | 5632.97      | II  | 6 h       | 7047.94      | IV  |
| 100       | 2124.12      | I   | 15        | 3241.62      | III | 200 h     | 5639.48      | II  | 200       | 7165.545     | I   |
| 50 h      | 2136.56      | II  | 12        | 3258.66      | III | 90        | 5645.611     | I   | 100       | 7226.206     | I   |
| 110       | 2207.98      | I   | 10        | 3276.26      | III | 150 h     | 5660.66      | II  | 100       | 7235.326     | I   |
| 115       | 2210.89      | I   | 300       | 3333.14      | II  | 80        | 5665.554     | I   | 180       | 7250.625     | I   |
| 110       | 2211.74      | I   | 500       | 3339.82      | II  | 1000 h    | 5669.56      | II  | 160       | 7275.294     | I   |
| 120       | 2216.67      | I   | 15        | 3486.91      | III | 120       | 5684.484     | I   | 400       | 7289.173     | I   |
| 120       | 2218.06      | I   | 9         | 3525.94      | III | 300 h     | 5688.81      | II  | 375       | 7405.774     | I   |
| 10        | 2296.87      | III | 20        | 3590.47      | III | 100       | 5690.425     | I   | 200       | 7409.082     | I   |
| 10        | 2308.19      | III | 8         | 3762.44      | IV  | 90        | 5701.105     | I   | 275       | 7415.946     | I   |
| 100 h     | 2356.30      | II  | 20 c      | 3791.41      | III | 200 h     | 5701.37      | II  | 425       | 7423.497     | I   |
| 30 h      | 2357.18      | II  | 25        | 3796.11      | III | 100 h     | 5706.37      | II  | 9 h       | 7466.32      | III |
| 50 h      | 2357.97      | II  | 30        | 3806.54      | III | 160       | 5708.397     | I   | 12 h      | 7612.36      | III |
| 300       | 2435.15      | I   | 100 h     | 3853.66      | II  | 20        | 5739.73      | III | 100       | 7680.267     | I   |
| 11        | 2449.48      | III | 500 h     | 3856.02      | II  | 45        | 5747.667     | I   | 6 h       | 7723.82      | IV  |
| 425       | 2506.90      | I   | 200 h     | 3862.60      | II  | 45        | 5753.625     | I   | 30        | 7800.008     | I   |
| 375       | 2514.32      | I   | 300       | 3905.523     | I   | 45        | 5754.220     | I   | 400       | 7848.80      | II  |
| 500       | 2516.113     | I   | 20        | 3924.47      | III | 45        | 5762.977     | I   | 500       | 7849.72      | II  |
| 7         | 2517.51      | IV  | 10        | 4088.85      | IV  | 70        | 5772.145     | I   | 30        | 7849.967     | I   |
| 350       | 2519.202     | I   | 70        | 4102.936     | I   | 70        | 5780.384     | I   | 90        | 7918.386     | I   |
| 425       | 2524.108     | I   | 9         | 4116.10      | IV  | 90        | 5793.071     | I   | 120       | 7932.349     | I   |
| 450       | 2528.509     | I   | 300 h     | 4128.07      | II  | 100       | 5797.859     | I   | 140       | 7944.001     | I   |
| 110       | 2532.381     | I   | 500 h     | 4130.89      | II  | 150 h     | 5800.47      | II  | 35        | 7970.306     | I   |
| 25        | 2541.82      | III | 100 h     | 4190.72      | II  | 200       | 5806.74      | II  | 35        | 8035.619     | I   |
| 10        | 2546.09      | III | 50        | 4198.13      | II  | 50        | 5846.13      | II  | 70        | 8093.241     | I   |
| 14        | 2559.21      | III | 9         | 4338.50      | III | 300 h     | 5868.40      | II  | 9 h       | 8102.86      | III |
| 30        | 2563.679     | I   | 30        | 4552.62      | III | 40        | 5873.764     | I   | 11 h      | 8103.45      | III |
| 85        | 2568.641     | I   | 25        | 4567.82      | III | 10 h      | 5898.79      | III | 35        | 8230.642     | I   |
| 45        | 2577.151     | I   | 20        | 4574.76      | III | 150       | 5915.22      | II  | 9 h       | 8262.57      | III |
| 190       | 2631.282     | I   | 100       | 4621.42      | II  | 200       | 5948.545     | I   | 40        | 8443.982     | I   |
| 11        | 2640.79      | III | 150       | 4621.72      | II  | 500       | 5957.56      | II  | 40        | 8501.547     | I   |
| 14        | 2655.51      | III | 9 h       | 4631.24      | IV  | 500       | 5978.93      | II  | 60        | 8502.221     | I   |
| 9         | 2817.11      | III | 10 h      | 4654.32      | IV  | 90        | 6125.021     | I   | 40        | 8536.165     | I   |
| 1000      | 2881.579     | I   | 9         | 4683.02      | III | 85        | 6131.574     | I   | 120       | 8556.780     | I   |



| Intensity               | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity               | Wavelength/Å |    | Intensity | Wavelength/Å |     |
|-------------------------|--------------|-----|-----------|--------------|-----|-------------------------|--------------|----|-----------|--------------|-----|
| 50                      | 8648.462     | I   | 95        | 1432.60      | II  | 28000 r                 | 3382.89      | I  | 12        | 162.448      | IV  |
| 40                      | 8728.011     | I   | 100       | 1464.72      | II  | 30                      | 3469.16      | I  | 10        | 163.190      | IV  |
| 75                      | 8742.451     | I   | 50        | 1466.23      | II  | 70                      | 3475.82      | II | 12        | 168.411      | IV  |
| 100                     | 8752.009     | I   | 50 r      | 1507.37      | I   | 80                      | 3495.28      | II | 10        | 168.546      | IV  |
| 35                      | 8790.389     | I   | 100 r     | 1515.63      | I   | 50                      | 3542.61      | I  | 5         | 183.95       | III |
| 100                     | 9412.72      | II  | 50 r      | 1548.58      | I   | 50 h                    | 3624.68      | I  | 10        | 190.445      | IV  |
| 100                     | 9413.506     | I   | 100       | 1555.16      | II  | 75                      | 3682.46      | II | 10        | 199.772      | IV  |
| 30                      | 10371.269    | I   | 100       | 1644.50      | II  | 30                      | 3682.50      | I  | 8         | 202.49       | III |
| 120                     | 10585.141    | I   | 60        | 1651.52      | I   | 80                      | 3683.34      | II | 8         | 202.76       | III |
| 120                     | 10603.431    | I   | 50        | 1652.10      | I   | 50 h                    | 3709.20      | I  | 8 p       | 203.06       | III |
| 120                     | 10660.975    | I   | 700       | 1656.18      | III | 200                     | 3810.94      | I  | 8         | 203.28       | III |
| 30                      | 10694.251    | I   | 120       | 1682.82      | II  | 50                      | 3811.78      | I  | 8         | 203.33       | III |
| 30                      | 10727.408    | I   | 500       | 1693.51      | III | 100 h                   | 3840.74      | I  | 15        | 229.87       | III |
| 60                      | 10749.384    | I   | 10        | 1708.11      | I   | 50 h                    | 3907.41      | I  | 50 c      | 250.52       | III |
| 30                      | 10784.550    | I   | 50        | 1709.27      | I   | 50                      | 3909.31      | II | 30        | 251.37       | III |
| 80                      | 10786.856    | I   | 125       | 1736.44      | II  | 50 h                    | 3914.40      | I  | 25        | 266.90       | III |
| 140                     | 10827.091    | I   | 750       | 1751.03      | III | 70                      | 3920.10      | II | 70        | 267.65       | III |
| 60                      | 10843.854    | I   | 10 h      | 1766.14      | I   | 60                      | 3949.43      | II | 50        | 267.87       | III |
| 130                     | 10869.541    | I   | 75        | 1790.37      | II  | 100 h                   | 3981.58      | I  | 50        | 268.63       | III |
| 30                      | 10882.802    | I   | 600       | 1917.08      | III | 70                      | 3985.19      | II | 20 p      | 272.08       | III |
| 30                      | 10885.336    | I   | 700       | 1957.62      | III | 100 h                   | 4055.48      | I  | 20        | 272.45       | III |
| 80                      | 10979.308    | I   | 100       | 1967.38      | II  | 80                      | 4085.91      | II | 10        | 319.644      | IV  |
| 30                      | 10982.061    | I   | 600       | 1975.92      | III | 100                     | 4185.48      | II | 300       | 372.08       | II  |
| 80                      | 11017.965    | I   | 500       | 1977.03      | III | 90 h                    | 4210.96      | I  | 350       | 376.38       | II  |
| 370                     | 11984.19     | I   | 600       | 2000.24      | III | 100                     | 4212.82      | I  | 100       | 378.14       | III |
| 220                     | 11991.57     | I   | 150       | 2015.96      | II  | 50                      | 4311.07      | I  | 70        | 380.10       | III |
| 440                     | 12031.51     | I   | 150       | 2033.98      | II  | 50 h                    | 4476.04      | I  | 12        | 408.684      | IV  |
| 190                     | 15888.39     | I   | 200       | 2061.17      | I   | 30 h                    | 4615.69      | I  | 10        | 409.614      | IV  |
| 95                      | 16060.03     | I   | 100       | 2069.85      | I   | 80                      | 4620.04      | II | 15        | 410.372      | IV  |
| 110                     | 19722.50     | I   | 80 r      | 2113.82      | II  | 50                      | 4620.46      | II | 10        | 411.334      | IV  |
| <i>Silver Ag Z = 47</i> |              |     | 60        | 2145.60      | II  | 60 h                    | 4668.48      | I  | 13        | 412.242      | IV  |
| 25                      | 730.83       | II  | 600       | 2161.89      | III | 30 h                    | 4677.60      | I  | 11        | 1582.18      | IV  |
| 30                      | 752.80       | II  | 50        | 2186.76      | II  | 100                     | 4788.40      | II | 11 d      | 1583.98      | IV  |
| 400                     | 799.41       | III | 60        | 2229.53      | II  | 30 h                    | 4847.82      | I  | 12        | 1584.14      | IV  |
| 15                      | 1005.32      | II  | 100 r     | 2246.43      | II  | 100                     | 4874.10      | I  | 12 d      | 1587.05      | IV  |
| 10                      | 1065.49      | II  | 500       | 2246.51      | III | 80                      | 5027.35      | II | 11        | 1615.92      | IV  |
| 12                      | 1072.23      | II  | 75 r      | 2248.74      | II  | 1000                    | 5209.08      | I  | 12        | 1618.57      | IV  |
| 250                     | 1074.22      | II  | 75        | 2280.03      | II  | 1000                    | 5465.50      | I  | 11        | 1655.47      | IV  |
| 150                     | 1107.03      | II  | 30 h      | 2309.56      | I   | 100                     | 5471.55      | I  | 15 c      | 1701.97      | IV  |
| 150                     | 1112.46      | II  | 700       | 2310.04      | III | 100                     | 5667.34      | I  | 20 d      | 1887.47      | III |
| 60                      | 1195.83      | II  | 70 r      | 2317.05      | II  | 10 h                    | 6268.50      | I  | 12        | 1960.76      | IV  |
| 50                      | 1223.33      | II  | 80 r      | 2320.29      | II  | 320                     | 7687.78      | I  | 11        | 1965.08      | IV  |
| 50                      | 1240.80      | II  | 70 r      | 2324.68      | II  | 25                      | 8005.4       | II | 12 d      | 2106.33      | IV  |
| 50                      | 1246.87      | II  | 80 r      | 2331.40      | II  | 500                     | 8273.52      | I  | 30        | 2230.33      | III |
| 55                      | 1256.81      | II  | 70        | 2357.92      | II  | 25                      | 8403.8       | II | 16        | 2232.19      | III |
| 55                      | 1257.55      | II  | 50 h      | 2375.02      | I   | 30 h                    | 8645.70      | I  | 20 h      | 2246.70      | III |
| 50                      | 1266.63      | II  | 75        | 2411.41      | II  | 10 h                    | 8704.85      | I  | 300       | 2315.65      | II  |
| 70                      | 1273.67      | II  | 90 r      | 2413.23      | II  | 12                      | 8747.6       | II | 18        | 2386.99      | III |
| 65                      | 1297.51      | II  | 100 r     | 2437.81      | II  | 15                      | 9000.9       | II | 17        | 2394.03      | III |
| 85                      | 1311.20      | II  | 80        | 2447.93      | II  | 10                      | 12551.0      | I  | 300       | 2420.99      | II  |
| 55                      | 1313.81      | II  | 80        | 2473.84      | II  | 60                      | 16819.5      | I  | 300       | 2424.73      | II  |
| 50                      | 1314.61      | II  | 60        | 2506.63      | II  | 20                      | 17416.7      | I  | 25        | 2459.31      | III |
| 60                      | 1323.84      | II  | 50 h      | 2575.63      | I   | 15                      | 18307.9      | I  | 18        | 2468.85      | III |
| 60                      | 1342.09      | II  | 60        | 2660.49      | II  | 15                      | 18382.3      | I  | 20        | 2474.73      | III |
| 50                      | 1342.57      | II  | 60        | 2721.77      | I   | <i>Sodium Na Z = 11</i> |              |    | 1000      | 2493.15      | II  |
| 70                      | 1346.62      | II  | 75        | 2767.54      | II  | 7                       | 142.232      | IV | 25        | 2497.03      | III |
| 50                      | 1353.54      | II  | 100 h     | 2824.39      | I   | 8                       | 146.064      | IV | 17        | 2510.26      | III |
| 150                     | 1364.50      | II  | 30 h      | 3130.02      | I   | 9                       | 150.298      | IV | 20        | 2543.84      | I   |
| 100                     | 1396.00      | II  | 90        | 3180.70      | II  | 8                       | 150.687      | IV | 10        | 2543.87      | I   |
| 100                     | 1410.93      | II  | 100       | 3267.35      | II  | 8                       | 155.510      | IV | 70        | 2593.87      | I   |
| 90                      | 1419.72      | II  | 55000 r   | 3280.68      | I   | 8                       | 156.537      | IV | 35        | 2593.92      | I   |

| Intensity | Wavelength/Å |    | Intensity                  | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity              | Wavelength/Å |     |
|-----------|--------------|----|----------------------------|--------------|-----|-----------|--------------|-----|------------------------|--------------|-----|
| 850       | 2611.81      | II | 20                         | 4747.941     | I   | 1875      | 491.79       | III | 40                     | 5257.71      | III |
| 850       | 2661.00      | II | 30                         | 4751.822     | I   | 1250      | 507.04       | III | 40                     | 5443.48      | III |
| 1000      | 2671.83      | II | 200                        | 4978.541     | I   | 3750      | 514.38       | III | 1500                   | 5450.84      | I   |
| 200       | 2680.34      | I  | 400                        | 4982.813     | I   | 10        | 517.28       | V   | 7000                   | 5480.84      | I   |
| 100       | 2680.43      | I  | 40                         | 5148.838     | I   | 2500      | 562.75       | III | 3500                   | 5504.17      | I   |
| 1000      | 2841.72      | II | 80                         | 5153.402     | I   | 25        | 578.01       | V   | 2600                   | 5521.83      | I   |
| 400       | 2852.81      | I  | 280                        | 5682.633     | I   | 30        | 624.93       | V   | 2000                   | 5534.81      | I   |
| 200       | 2853.01      | I  | 70                         | 5688.193     | I   | 25        | 642.23       | V   | 2000                   | 5540.05      | I   |
| 2         | 2893.62      | I  | 560                        | 5688.205     | I   | 50        | 649.21       | V   | 1000                   | 6380.75      | I   |
| 1100      | 2904.92      | II | 80000                      | 5889.950     | I   | 25        | 660.94       | V   | 900 h                  | 6386.50      | I   |
| 1100      | 2917.52      | II | 40000                      | 5895.924     | I   | 200       | 664.43       | IV  | 600 h                  | 6388.24      | I   |
| 1100      | 2919.05      | II | 120                        | 6154.225     | I   | 35        | 686.23       | V   | 9000                   | 6408.47      | I   |
| 1200      | 2919.85      | II | 240                        | 6160.747     | I   | 100       | 710.35       | IV  | 5500                   | 6504.00      | I   |
| 1300      | 2920.95      | II | 130                        | 6530.70      | II  | 12        | 747.82       | V   | 1000                   | 6546.79      | I   |
| 1000      | 2923.49      | II | 130                        | 6544.04      | II  | 50        | 1025.23      | III | 1700                   | 6550.26      | I   |
| 1200      | 2951.24      | II | 130                        | 6545.75      | II  | 35        | 1125.49      | III | 3000                   | 6617.26      | I   |
| 1100      | 2952.40      | II | 20                         | 7373.23      | I   | 50        | 1236.23      | III | 1800                   | 6791.05      | I   |
| 1000      | 2977.13      | II | 10                         | 7373.49      | I   | 1400      | 2152.84      | II  | 4800                   | 6878.38      | I   |
| 1100      | 2979.66      | II | 50                         | 7809.78      | I   | 1400      | 2165.96      | II  | 1200                   | 6892.59      | I   |
| 1100      | 2980.63      | II | 25                         | 7810.24      | I   | 100       | 2273.71      | III | 5500                   | 7070.10      | I   |
| 1300      | 2984.19      | II | 4400                       | 8183.256     | I   | 100       | 2340.13      | III | 2500                   | 7309.41      | I   |
| 1700      | 3124.42      | II | 800                        | 8194.790     | I   | 50        | 2346.97      | IV  | 500                    | 7621.50      | I   |
| 2500      | 3135.48      | II | 8800                       | 8194.824     | I   | 160       | 2428.10      | I   | 400 h                  | 7673.06      | I   |
| 1700      | 3137.86      | II | 100                        | 8649.92      | I   | 100       | 2486.52      | III | 200 h                  | 8422.80      | I   |
| 2000      | 3149.28      | II | 60                         | 8650.89      | I   | 40        | 2555.60      | IV  | 120                    | 8505.69      | II  |
| 2000      | 3163.74      | II | 25                         | 8942.96      | I   | 40        | 2571.04      | IV  | 200                    | 8688.91      | II  |
| 1000      | 3179.06      | II | 40                         | 9153.88      | I   | 100       | 3002.61      | III | 100                    | 9294.10      | I   |
| 1700      | 3189.79      | II | 60                         | 9465.94      | I   | 200       | 3012.32      | III | 400 h                  | 9448.95      | I   |
| 1600      | 3212.19      | II | 80                         | 9961.28      | I   | 10        | 3019.29      | IV  | 600                    | 9596.00      | I   |
| 1500      | 3257.96      | II | 20                         | 10566.00     | I   | 100       | 3021.73      | III | 300                    | 9624.70      | I   |
| 1700      | 3285.60      | II | 60                         | 10572.28     | I   | 50        | 3061.43      | III | 100                    | 9638.10      | I   |
| 1700      | 3301.35      | II | 200                        | 10746.44     | I   | 50        | 3182.61      | III | 100 h                  | 9647.70      | II  |
| 1200      | 3302.37      | I  | 80                         | 10749.29     | I   | 100       | 3235.39      | III | 300                    | 10036.66     | II  |
| 600       | 3302.98      | I  | 120                        | 10834.87     | I   | 400       | 3351.25      | I   | 1000                   | 10327.31     | II  |
| 1500      | 3304.96      | II | 35                         | 11190.19     | I   | 650       | 3380.71      | II  | 200                    | 10914.88     | II  |
| 1000      | 3318.04      | II | 50                         | 11197.21     | I   | 50        | 3430.76      | III | 700                    | 11241.25     | I   |
| 50        | 3426.86      | I  | 400                        | 11381.45     | I   | 950       | 3464.46      | II  | 100                    | 12014.76     | II  |
| 1500      | 3533.05      | II | 1000                       | 11403.78     | I   | 600       | 3969.26      | I   | 60                     | 12445.90     | II  |
| 1200      | 3631.27      | II | 400                        | 12679.17     | I   | 1300      | 4030.38      | I   | 40                     | 12495.00     | I   |
| 6         | 4238.99      | I  | 60                         | 14767.48     | I   | 46000     | 4077.71      | II  | 75                     | 12974.70     | II  |
| 10        | 4242.08      | I  | 100                        | 14779.73     | I   | 32000     | 4215.52      | II  | 100                    | 13123.80     | II  |
| 1         | 4249.41      | I  | 60                         | 16373.85     | I   | 9         | 4298.57      | IV  | 50                     | 17447.40     | I   |
| 2         | 4252.52      | I  | 100                        | 16388.85     | I   | 340       | 4305.45      | II  | 230                    | 20261.40     | I   |
| 15        | 4273.64      | I  | 400                        | 18465.25     | I   | 65000     | 4607.33      | I   | 120                    | 20700.70     | I   |
| 20        | 4276.79      | I  | 50                         | 22056.44     | I   | 9         | 4685.08      | IV  | 30                     | 26023.60     | I   |
| 2         | 4287.84      | I  | 25                         | 22083.67     | I   | 3200      | 4722.28      | I   | <i>Sulfur S Z = 16</i> |              |     |
| 3         | 4291.01      | I  | 60                         | 23348.41     | I   | 2200      | 4741.92      | I   | 5                      | 437.4        | V   |
| 30        | 4321.40      | I  | 100                        | 23379.13     | I   | 1400      | 4784.32      | I   | 5                      | 438.2        | V   |
| 40        | 4324.62      | I  | <i>Strontium Sr Z = 38</i> |              |     | 4800      | 4811.88      | I   | 5                      | 439.6        | V   |
| 3         | 4341.49      | I  | 15                         | 298.12       | IV  | 3600      | 4832.08      | I   | 20                     | 519.3        | IV  |
| 5         | 4344.74      | I  | 15                         | 300.12       | IV  | 3000      | 4872.49      | I   | 20                     | 520.1        | IV  |
| 40        | 4390.03      | I  | 125                        | 330.67       | III | 2000      | 4876.32      | I   | 40                     | 520.8        | IV  |
| 60        | 4393.34      | I  | 500                        | 351.62       | III | 1000      | 4891.98      | I   | 20                     | 522.0        | IV  |
| 5         | 4419.88      | I  | 75                         | 358.80       | III | 8000      | 4962.26      | I   | 20                     | 522.5        | IV  |
| 8         | 4423.25      | I  | 250                        | 363.49       | III | 1300      | 4967.94      | I   | 20                     | 551.2        | IV  |
| 60        | 4494.18      | I  | 150                        | 371.21       | III | 800 h     | 5156.07      | I   | 40                     | 652.5        | IV  |
| 100       | 4497.66      | I  | 20                         | 378.53       | IV  | 1400      | 5222.20      | I   | 40                     | 653.0        | IV  |
| 10        | 4541.63      | I  | 75                         | 392.44       | IV  | 2000      | 5225.11      | I   | 70                     | 653.6        | IV  |
| 15        | 4545.19      | I  | 50                         | 393.00       | IV  | 2000      | 5229.27      | I   | 40                     | 654.0        | IV  |
| 120       | 4664.811     | I  | 50                         | 396.22       | IV  | 2800      | 5238.55      | I   | 70                     | 655.6        | IV  |
| 200       | 4668.560     | I  | 1000                       | 437.24       | III | 4800      | 5256.90      | I   | 20                     | 655.9        | IV  |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                 | Wavelength/Å |    |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|---------------------------|--------------|----|
| 110       | 657.3        | IV  | 355       | 1316.542     | I   | 285       | 3902.0       | I   | 160                       | 9035.9       | I  |
| 40        | 658.3        | V   | 290       | 1316.618     | I   | 160       | 3928.6       | III | 450                       | 9212.9       | I  |
| 70        | 659.8        | V   | 375       | 1323.515     | I   | 360       | 3933.3       | II  | 450                       | 9228.1       | I  |
| 40        | 660.9        | IV  | 355       | 1326.643     | I   | 450       | 4120.8       | I   | 450                       | 9237.5       | I  |
| 160       | 661.4        | IV  | 775       | 1381.552     | I   | 280       | 4142.3       | II  | 285                       | 9413.5       | I  |
| 110       | 663.2        | V   | 710       | 1385.510     | I   | 360       | 4145.1       | II  | 285                       | 9421.9       | I  |
| 40        | 663.7        | IV  | 960       | 1388.435     | I   | 450       | 4153.1       | II  | 285                       | 9437.1       | I  |
| 40        | 664.8        | IV  | 640       | 1389.154     | I   | 450       | 4162.7       | II  | 650                       | 9649.9       | I  |
| 70        | 666.1        | IV  | 775       | 1392.588     | I   | 360       | 4253.6       | III | 450                       | 9672.3       | I  |
| 20        | 678.1        | V   | 1000      | 1396.112     | I   | 450       | 4694.1       | I   | 450                       | 9680.8       | I  |
| 40        | 680.3        | V   | 300       | 1409.337     | I   | 285       | 4695.4       | I   | 450                       | 9693.7       | I  |
| 110       | 680.9        | V   | 510       | 1425.030     | I   | 160       | 4696.2       | I   | 285                       | 9697.3       | I  |
| 40        | 681.6        | V   | 425       | 1433.280     | I   | 280       | 4716.2       | II  | 285                       | 9739.7       | I  |
| 20        | 693.5        | V   | 300       | 1436.968     | I   | 450       | 4815.5       | II  | 285                       | 9932.3       | I  |
| 70        | 729.5        | III | 300       | 1448.229     | I   | 360       | 4924.1       | II  | 285                       | 9949.8       | I  |
| 110       | 732.42       | III | 425       | 1472.972     | I   | 450       | 4925.3       | II  | 285                       | 9958.9       | I  |
| 70        | 735.2        | III | 550       | 1473.995     | I   | 285       | 4993.5       | I   | 285                       | 10455.5      | I  |
| 70        | 738.5        | III | 300       | 1474.380     | I   | 360       | 5428.6       | II  | 285                       | 10459.5      | I  |
| 110       | 744.9        | IV  | 355       | 1481.665     | I   | 650       | 5432.8       | II  | <i>Tantalum Ta Z = 73</i> |              |    |
| 110       | 748.4        | IV  | 485       | 1483.039     | I   | 1000      | 5453.8       | II  | 60                        | 493.07       | V  |
| 110       | 750.2        | IV  | 300       | 1483.233     | I   | 1000      | 5473.6       | II  | 1000                      | 890.87       | V  |
| 110       | 753.8        | IV  | 330       | 1485.622     | I   | 1000      | 5509.7       | II  | 500                       | 947.30       | V  |
| 285       | 786.5        | V   | 390       | 1487.150     | I   | 280       | 5564.9       | II  | 67                        | 999.34       | IV |
| 70        | 789.0        | III | 20        | 1624.0       | IV  | 1000      | 5606.1       | II  | 79                        | 1116.10      | IV |
| 70        | 796.7        | III | 20        | 1629.2       | IV  | 450       | 5640.0       | II  | 78                        | 1136.17      | IV |
| 70        | 800.5        | IV  | 680       | 1666.688     | I   | 450       | 5640.3       | II  | 85                        | 1175.51      | IV |
| 70        | 804.0        | IV  | 640       | 1687.530     | I   | 280       | 5647.0       | II  | 80                        | 1189.28      | IV |
| 70        | 809.7        | IV  | 710       | 1807.311     | I   | 650       | 5659.9       | II  | 80                        | 1192.67      | IV |
| 110       | 816.0        | IV  | 680       | 1820.343     | I   | 450       | 5664.7       | II  | 85                        | 1213.09      | IV |
| 70        | 824.9        | III | 640       | 1826.245     | I   | 160       | 5706.1       | I   | 500                       | 1213.42      | V  |
| 70        | 836.3        | III | 710       | 1900.286     | I   | 450       | 5819.2       | II  | 85                        | 1215.53      | IV |
| 160       | 849.2        | V   | 550       | 1914.698     | I   | 450       | 6052.7       | I   | 90                        | 1223.73      | IV |
| 110       | 852.2        | V   | 20        | 2387.0       | IV  | 280       | 6286.4       | II  | 88                        | 1238.12      | IV |
| 220       | 854.8        | V   | 40        | 2398.9       | IV  | 450       | 6287.1       | II  | 95                        | 1240.06      | IV |
| 110       | 857.9        | V   | 110       | 2460.5       | III | 450       | 6305.5       | II  | 87                        | 1258.34      | IV |
| 110       | 860.5        | V   | 110       | 2489.6       | III | 450       | 6312.7       | II  | 94                        | 1264.91      | IV |
| 40        | 906.9        | II  | 160       | 2496.2       | III | 280       | 6384.9       | II  | 98                        | 1272.42      | IV |
| 40        | 910.5        | II  | 160       | 2499.1       | III | 280       | 6397.3       | II  | 94                        | 1275.48      | IV |
| 40        | 912.7        | II  | 220       | 2508.2       | III | 280       | 6398.0       | II  | 86                        | 1275.94      | IV |
| 40        | 937.4        | II  | 70        | 2636.9       | III | 360       | 6413.7       | II  | 92                        | 1308.51      | IV |
| 40        | 937.7        | II  | 220       | 2665.4       | III | 160       | 6743.6       | I   | 87                        | 1315.58      | IV |
| 160       | 1062.7       | IV  | 110       | 2691.8       | III | 285       | 6748.8       | I   | 92                        | 1332.38      | IV |
| 160       | 1073.0       | IV  | 110       | 2702.8       | III | 450       | 6757.2       | I   | 86                        | 1343.30      | IV |
| 70        | 1073.5       | IV  | 220       | 2718.9       | III | 450       | 7579.0       | I   | 92                        | 1365.88      | IV |
| 285       | 1077.1       | III | 110       | 2721.4       | III | 450       | 7629.8       | I   | 5000                      | 1392.56      | V  |
| 40        | 1102.3       | II  | 220       | 2726.8       | III | 285       | 7686.1       | I   | 91                        | 1398.78      | IV |
| 70        | 1194.0       | III | 220       | 2731.1       | III | 450       | 7696.7       | I   | 93                        | 1413.40      | IV |
| 70        | 1201.0       | III | 110       | 2741.0       | III | 1000      | 7924.0       | I   | 91                        | 1454.32      | IV |
| 40        | 1234.1       | II  | 285       | 2756.9       | III | 160       | 7928.8       | I   | 92                        | 1464.41      | IV |
| 40        | 1250.5       | II  | 110       | 2775.2       | III | 285       | 7930.3       | I   | 93                        | 1469.82      | IV |
| 110       | 1253.8       | II  | 160       | 2785.5       | III | 450       | 7931.7       | I   | 90                        | 1495.25      | IV |
| 110       | 1259.5       | II  | 110       | 2863.5       | III | 450       | 7967.4       | I   | 95                        | 1514.19      | IV |
| 275       | 1270.782     | I   | 160       | 2904.3       | III | 450       | 7967.4       | II  | 85                        | 1607.70      | IV |
| 250       | 1277.216     | I   | 160       | 2986.0       | III | 450       | 8314.7       | I   | 7000                      | 1709.10      | V  |
| 280       | 1295.653     | I   | 110       | 3097.5       | IV  | 450       | 8314.7       | II  | 85                        | 1712.16      | IV |
| 275       | 1302.337     | I   | 110       | 3497.3       | III | 450       | 8585.6       | I   | 85                        | 1716.13      | IV |
| 235       | 1302.863     | I   | 160       | 3632.0       | III | 285       | 8680.5       | I   | 85                        | 2055.75      | IV |
| 235       | 1303.110     | I   | 110       | 3709.4       | III | 450       | 8694.7       | I   | 1100                      | 2140.13      | II |
| 245       | 1303.430     | I   | 160       | 3717.8       | III | 360       | 8874.5       | I   | 1500                      | 2146.87      | II |
| 260       | 1305.883     | I   | 160       | 3838.3       | III | 110       | 8882.5       | I   | 1200                      | 2182.71      | II |
| 265       | 1310.194     | I   | 285       | 3867.6       | I   | 220       | 8884.2       | I   | 1100                      | 2193.88      | II |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |   | Intensity                   | Wavelength/Å |    |
|-----------|--------------|----|-----------|--------------|----|-----------|--------------|---|-----------------------------|--------------|----|
| 1500      | 2196.03      | II | 770       | 2775.88      | I  | 200       | 5037.37      | I | 75                          | 7006.96      | I  |
| 90        | 2199.58      | IV | 680       | 2796.34      | I  | 100       | 5067.87      | I | 150                         | 7148.63      | I  |
| 1500      | 2199.67      | II | 680       | 2797.76      | II | 110       | 5115.84      | I | 110                         | 7172.90      | I  |
| 90        | 2207.64      | IV | 510       | 2806.58      | I  | 100       | 5141.62      | I | 140                         | 7301.74      | I  |
| 1400 d    | 2210.03      | II | 640       | 2844.25      | I  | 100       | 5143.69      | I | 160                         | 7346.41      | I  |
| 1400      | 2239.48      | II | 560       | 2848.52      | I  | 330       | 5156.56      | I | 140 c                       | 7352.86      | I  |
| 1200      | 2250.76      | II | 1500      | 2850.49      | I  | 110       | 5212.74      | I | 100                         | 7356.96      | I  |
| 840       | 2261.42      | II | 1900      | 2850.98      | I  | 110 d     | 5218.45      | I | 90 cw                       | 7369.09      | I  |
| 990       | 2262.30      | II | 360       | 2861.98      | I  | 140       | 5341.05      | I | 160                         | 7407.89      | I  |
| 990       | 2272.59      | II | 470       | 2871.42      | I  | 200       | 5402.51      | I | 100                         | 7882.37      | I  |
| 790       | 2285.25      | II | 380       | 2880.02      | I  | 130       | 5419.19      | I | 75                          | 8026.50      | I  |
| 600       | 2286.59      | II | 770       | 2891.84      | I  | 90        | 5518.91      | I | 75                          | 8281.62      | I  |
| 990       | 2289.16      | II | 560       | 2902.05      | I  | 150       | 5645.91      | I | <i>Technetium Tc Z = 43</i> |              |    |
| 440       | 2302.24      | II | 310       | 2915.49      | I  | 130       | 5664.90      | I | 10000 c                     | 3636.07      | I  |
| 440       | 2302.93      | II | 410       | 2925.19      | I  | 130       | 5776.77      | I | 20000 c                     | 4031.63      | I  |
| 440       | 2312.60      | II | 310       | 2932.70      | I  | 90        | 5780.71      | I | 15000                       | 4095.67      | I  |
| 420       | 2315.46      | II | 1700      | 2933.55      | I  | 130       | 5811.10      | I | 20000                       | 4262.27      | I  |
| 690       | 2331.98      | II | 470       | 2940.06      | I  | 240       | 5877.36      | I | 30000                       | 4297.06      | I  |
| 550       | 2332.19      | II | 1200      | 2940.22      | I  | 130       | 5882.30      | I | 20000                       | 4853.59      | I  |
| 250       | 2357.30      | I  | 510       | 2951.92      | I  | 90        | 5901.91      | I | <i>Tellurium Te Z = 52</i>  |              |    |
| 260       | 2361.09      | I  | 340       | 2953.56      | I  | 90        | 5918.95      | I | 8                           | 802.28       | II |
| 600       | 2364.24      | II | 1500      | 2963.32      | I  | 130       | 5939.76      | I | 8                           | 1059.51      | II |
| 320       | 2371.58      | I  | 770       | 2965.13      | II | 240       | 5944.02      | I | 8                           | 1077.66      | II |
| 1400      | 2387.06      | II | 770       | 2965.54      | I  | 190 c     | 5997.23      | I | 10                          | 1161.42      | II |
| 2400      | 2400.63      | II | 340       | 2969.47      | I  | 100       | 6020.72      | I | 10                          | 1174.34      | II |
| 320       | 2416.89      | II | 430       | 2975.56      | I  | 250       | 6045.39      | I | 12                          | 1175.79      | II |
| 360       | 2427.64      | I  | 1800      | 3012.54      | II | 100       | 6047.25      | I | 9                           | 1208.54      | II |
| 360       | 2429.71      | II | 290 d     | 3027.48      | I  | 100       | 6101.58      | I | 9                           | 1220.98      | II |
| 480       | 2432.70      | II | 530       | 3049.56      | I  | 65        | 6144.56      | I | 9                           | 1253.62      | II |
| 380       | 2470.90      | II | 530       | 3069.24      | I  | 130       | 6154.50      | I | 9                           | 1270.52      | II |
| 600       | 2474.62      | I  | 360       | 3077.24      | I  | 150       | 6256.68      | I | 10                          | 1324.92      | II |
| 500       | 2484.95      | I  | 560       | 3103.25      | I  | 150       | 6268.70      | I | 9                           | 1363.24      | II |
| 600       | 2488.70      | II | 380       | 3124.97      | I  | 150       | 6309.58      | I | 8                           | 1366.73      | II |
| 500       | 2490.46      | I  | 380       | 3130.58      | I  | 75        | 6325.08      | I | 10                          | 1374.80      | II |
| 600       | 2504.45      | I  | 270       | 3132.64      | I  | 65        | 6341.17      | I | 10                          | 1608.41      | II |
| 600       | 2507.45      | I  | 320       | 3170.29      | I  | 75        | 6356.16      | I | 10                          | 1613.15      | II |
| 1200 d    | 2526.35      | I  | 270       | 3173.59      | I  | 65        | 6360.84      | I | 5                           | 1655.4       | I  |
| 600       | 2532.12      | II | 600       | 3180.95      | I  | 90        | 6389.45      | I | 5                           | 1688.5       | I  |
| 1200      | 2559.43      | I  | 300       | 3223.83      | I  | 65        | 6428.60      | I | 6                           | 1700.0       | I  |
| 460       | 2562.10      | I  | 1100      | 3311.16      | I  | 250       | 6430.79      | I | 5                           | 1708.0       | I  |
| 600       | 2577.37      | II | 680       | 3318.84      | I  | 200       | 6450.36      | I | 10                          | 1822.4       | I  |
| 600       | 2603.49      | II | 330 d     | 3330.99      | II | 380       | 6485.37      | I | 26000                       | 2002.02      | I  |
| 1400      | 2608.63      | I  | 640       | 3371.54      | I  | 65        | 6505.52      | I | 6500                        | 2081.16      | I  |
| 1200      | 2635.58      | II | 360       | 3385.05      | I  | 100       | 6514.39      | I | 18000                       | 2142.81      | I  |
| 860       | 2636.90      | I  | 450       | 3406.94      | I  | 100       | 6516.10      | I | 3200                        | 2147.25      | I  |
| 2400      | 2647.47      | I  | 490       | 3480.52      | I  | 100       | 6574.84      | I | 500                         | 2259.02      | I  |
| 2600      | 2653.27      | I  | 380       | 3497.85      | I  | 110       | 6611.95      | I | 1200                        | 2383.26      | I  |
| 1900      | 2656.61      | I  | 490       | 3511.04      | I  | 75        | 6621.30      | I | 1500                        | 2385.78      | I  |
| 1500      | 2661.34      | I  | 750       | 3607.41      | I  | 100       | 6673.73      | I | 50                          | 2438.69      | II |
| 770       | 2675.90      | II | 980       | 3626.62      | I  | 180       | 6675.53      | I | 120                         | 2530.72      | I  |
| 1500      | 2685.17      | II | 500       | 3642.06      | I  | 75 c      | 6740.73      | I | 100                         | 2649.66      | II |
| 470       | 2694.52      | II | 210       | 3918.51      | I  | 75        | 6771.74      | I | 80                          | 2661.10      | II |
| 1000      | 2698.30      | I  | 210       | 3970.10      | I  | 160 c     | 6813.25      | I | 110                         | 2677.13      | I  |
| 1200      | 2710.13      | I  | 210       | 3996.17      | I  | 210       | 6866.23      | I | 100                         | 2858.29      | II |
| 2600      | 2714.67      | I  | 410       | 4061.40      | I  | 180       | 6875.27      | I | 150                         | 2895.41      | II |
| 470       | 2727.44      | II | 310       | 4067.91      | I  | 150       | 6902.10      | I | 70                          | 2967.29      | II |
| 1200      | 2748.78      | I  | 300       | 4205.88      | I  | 140       | 6927.38      | I | 70                          | 3047.00      | II |
| 860       | 2749.83      | I  | 360 c     | 4510.98      | I  | 140       | 6928.54      | I | 100                         | 3175.14      | I  |
| 410       | 2752.49      | II | 340       | 4574.31      | I  | 65        | 6951.26      | I | 60                          | 3256.80      | II |
| 1000      | 2758.31      | I  | 260       | 4619.51      | I  | 180       | 6966.13      | I | 60                          | 3329.22      | II |
| 430       | 2761.68      | II | 450       | 4681.88      | I  | 110 d     | 6995.22      | I |                             |              |    |

| Intensity | Wavelength/Å |    | Intensity                | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|----|--------------------------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 150       | 3406.79      | II | 689                      | 9956.30      | I  | 810 d     | 3472.79      | II | 390       | 4196.74      | I  |
| 50        | 3442.25      | II | 325                      | 9977.13      | I  | 810       | 3500.84      | II | 650       | 4203.74      | I  |
| 50        | 3521.11      | II | 5950                     | 10051.41     | I  | 5700      | 3509.17      | II | 600       | 4206.49      | I  |
| 50        | 3552.19      | II | 4097                     | 10091.01     | I  | 1300      | 3523.66      | II | 480       | 4215.09      | I  |
| 100       | 3611.78      | II | 381                      | 10118.08     | I  | 1100      | 3540.24      | II | 480       | 4232.82      | I  |
| 50        | 3617.57      | II | 397                      | 10300.56     | I  | 810       | 3543.89      | II | 650       | 4266.34      | I  |
| 50        | 4006.52      | II | 745                      | 10493.57     | I  | 3200      | 3561.74      | II | 760 cw    | 4278.52      | II |
| 70        | 4127.32      | II | 1880                     | 10918.34     | I  | 810       | 3567.35      | II | 450       | 4310.42      | I  |
| 100       | 4169.77      | II | 10200                    | 11089.56     | I  | 4200      | 3568.52      | II | 2200      | 4318.83      | I  |
| 80        | 4225.73      | II | 508                      | 11163.74     | I  | 1600      | 3568.98      | II | 600       | 4322.23      | I  |
| 100       | 4261.11      | II | 6620                     | 11487.23     | I  | 1100      | 3579.20      | II | 600       | 4325.83      | II |
| 60        | 4273.43      | II | 1580                     | 13247.75     | I  | 710       | 3585.03      | II | 3000      | 4326.43      | I  |
| 80        | 4285.85      | II | 1050                     | 14513.51     | I  | 810       | 3596.38      | II | 600       | 4332.12      | I  |
| 150       | 4364.00      | II | 1480                     | 15452.45     | I  | 1600      | 3600.44      | II | 870       | 4336.43      | I  |
| 75        | 4385.10      | II | 2430                     | 15546.23     | I  | 810       | 3625.54      | II | 600       | 4337.64      | I  |
| 170       | 4478.63      | II | 3760                     | 16403.90     | I  | 2300      | 3650.40      | II | 1700      | 4338.41      | I  |
| 80        | 4537.07      | II | 1960                     | 17303.54     | I  | 810       | 3654.88      | II | 700       | 4340.62      | I  |
| 100       | 4557.78      | II | 2780                     | 18291.59     | I  | 2000      | 3658.88      | II | 870       | 4356.81      | I  |
| 70        | 4630.62      | II | 1020                     | 21043.73     | I  | 3800      | 3676.35      | II | 330       | 4382.45      | I  |
| 100       | 4641.12      | II | 464                      | 21602.50     | I  | 810       | 3682.26      | II | 300       | 4388.23      | I  |
| 180       | 4654.37      | II | 74                       | 22555.29     | I  | 450       | 3693.58      | I  | 260       | 4390.91      | I  |
| 200       | 4686.91      | II | 38                       | 26539.17     | I  | 450       | 3700.12      | I  | 350       | 4423.10      | I  |
| 100       | 4696.38      | II | <i>Terbium Tb Z = 65</i> |              |    | 4700      | 3702.86      | II | 240       | 4436.12      | I  |
| 100       | 4706.53      | II | 1000                     | 1259.40      | IV | 2400      | 3703.92      | II | 240       | 4448.04      | I  |
| 100       | 4766.05      | II | 1000                     | 1327.67      | IV | 1000 d    | 3711.76      | II | 430       | 4493.07      | I  |
| 100       | 4784.87      | II | 1000                     | 1373.86      | IV | 650       | 3745.04      | I  | 75        | 4514.31      | II |
| 100       | 4827.14      | II | 1000                     | 1595.39      | IV | 870       | 3747.17      | II | 110       | 4549.07      | I  |
| 150       | 4831.28      | II | 5000                     | 1633.19      | IV | 870       | 3747.34      | II | 110       | 4550.45      | I  |
| 150       | 4842.90      | II | 2000                     | 2027.79      | IV | 1100      | 3755.24      | II | 110       | 4556.46      | I  |
| 130       | 4865.12      | II | 2000                     | 2089.98      | IV | 650       | 3759.35      | I  | 110       | 4563.69      | II |
| 200       | 4866.24      | II | 1000                     | 2332.54      | IV | 1700      | 3765.14      | I  | 210       | 4578.69      | II |
| 8         | 5083.0       | I  | 110                      | 2584.61      | II | 2100      | 3776.49      | II | 65        | 4584.84      | II |
| 50        | 5449.84      | II | 110                      | 2608.57      | II | 600       | 3783.53      | I  | 65        | 4591.56      | II |
| 50        | 5487.95      | II | 130                      | 2628.69      | II | 410       | 3789.92      | I  | 75 d      | 4626.32      | II |
| 150       | 5576.35      | II | 140                      | 2669.29      | II | 760 d     | 3806.85      | II | 95        | 4626.94      | II |
| 150       | 5649.26      | II | 190                      | 2704.07      | II | 1500      | 3830.26      | I  | 65        | 4632.07      | I  |
| 100       | 5666.20      | II | 270                      | 2769.53      | II | 540       | 3833.42      | I  | 65 h      | 4636.59      | I  |
| 200       | 5708.12      | II | 320                      | 2897.44      | II | 920 d     | 3842.50      | II | 85        | 4641.00      | II |
| 150       | 5755.85      | II | 250                      | 2956.21      | II | 3700      | 3848.73      | II | 210       | 4641.98      | II |
| 100       | 5974.68      | II | 230                      | 3010.59      | II | 3500 w    | 3874.17      | II | 260 cw    | 4645.31      | II |
| 50        | 6367.13      | II | 230                      | 3016.18      | II | 480       | 3888.22      | I  | 80        | 4647.23      | I  |
| 10 h      | 6790.0       | I  | 460                      | 3053.55      | II | 490       | 3894.64      | I  | 80        | 4662.79      | I  |
| 20 h      | 6837.6       | I  | 460                      | 3070.05      | II | 2400      | 3899.20      | II | 80        | 4676.90      | I  |
| 20 h      | 6854.7       | I  | 670                      | 3078.86      | II | 1600      | 3901.33      | I  | 70 c      | 4681.87      | I  |
| 15 h      | 7191.1       | I  | 480                      | 3082.36      | II | 480       | 3908.06      | I  | 80        | 4688.63      | II |
| 20 h      | 7263.5       | I  | 480                      | 3089.58      | II | 650       | 3915.43      | I  | 80        | 4693.11      | II |
| 12        | 7460.98      | II | 480                      | 3102.96      | II | 760       | 3925.45      | II | 200       | 4702.41      | II |
| 15        | 7468.75      | II | 440                      | 3139.64      | II | 810 d     | 3939.52      | II | 110       | 4707.94      | II |
| 15        | 7921.69      | II | 480                      | 3187.26      | II | 2200 d    | 3976.84      | II | 80        | 4739.93      | I  |
| 15        | 7943.14      | II | 480                      | 3199.56      | II | 1800      | 3981.87      | II | 70        | 4747.80      | I  |
| 10        | 7950.34      | II | 1100                     | 3218.93      | II | 970       | 4002.59      | II | 410 cw    | 4752.53      | II |
| 30 h      | 8061.4       | I  | 1200                     | 3219.98      | II | 1900      | 4005.47      | II | 180       | 4786.78      | I  |
| 10        | 8122.44      | II | 480                      | 3252.32      | II | 760       | 4012.75      | II | 100       | 4813.77      | I  |
| 20        | 8186.44      | II | 760                      | 3280.31      | II | 870       | 4032.28      | I  | 80        | 4875.57      | II |
| 15        | 8273.53      | II | 760                      | 3281.40      | II | 2100      | 4033.03      | II | 80        | 4881.15      | II |
| 15        | 8672.95      | II | 1000                     | 3285.04      | II | 430       | 4054.12      | I  | 95        | 4915.90      | I  |
| 10        | 8733.81      | II | 1500                     | 3293.07      | II | 410       | 4060.37      | I  | 65        | 4931.79      | I  |
| 205       | 8758.18      | I  | 3800                     | 3324.40      | II | 1300      | 4061.58      | I  | 85        | 4993.82      | II |
| 81        | 9004.37      | I  | 760                      | 3349.42      | II | 650       | 4105.37      | I  | 110       | 5078.25      | I  |
| 5660      | 9722.74      | I  | 760                      | 3364.93      | II | 1100      | 4144.41      | II | 75        | 5089.12      | II |
| 532       | 9868.92      | I  | 810                      | 3454.06      | II | 350       | 4158.53      | I  | 85        | 5186.13      | I  |

| Intensity                 | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |    |
|---------------------------|--------------|----|-----------|--------------|-----|--------------------------|--------------|-----|-----------|--------------|----|
| 120                       | 5228.12      | I  | 20        | 1034.73      | IV  | 15                       | 4981.35      | II  | 910       | 3256.274     | II |
| 75                        | 5248.71      | I  | 20        | 1036.61      | IV  | 25                       | 5078.54      | II  | 180       | 3257.366     | I  |
| 75 w                      | 5262.11      | II | 10 r      | 1049.73      | II  | 25                       | 5152.14      | II  | 910       | 3262.668     | II |
| 75                        | 5281.05      | I  | 8 r       | 1050.30      | II  | 18000                    | 5350.46      | I   | 620       | 3287.789     | II |
| 65                        | 5304.72      | I  | 5 r       | 1074.97      | II  | 15 d                     | 5384.85      | II  | 910       | 3291.739     | II |
| 110                       | 5319.23      | I  | 30        | 1079.68      | IV  | 10                       | 5410.97      | II  | 620       | 3292.520     | II |
| 65 w                      | 5337.90      | I  | 10 r      | 1130.17      | II  | 25                       | 5949.48      | II  | 240       | 3301.650     | I  |
| 160                       | 5354.88      | I  | 15 r      | 1162.55      | II  | 10                       | 6179.98      | II  | 480       | 3304.238     | I  |
| 75                        | 5369.72      | I  | 10 r      | 1167.43      | II  | 10                       | 6378.32      | II  | 510       | 3321.450     | II |
| 75                        | 5375.98      | I  | 10 r      | 1183.41      | II  | 16 h                     | 6549.84      | I   | 840       | 3325.120     | II |
| 50                        | 5424.10      | II | 12 r      | 1194.84      | II  | 10                       | 6966.5       | II  | 250       | 3330.476     | I  |
| 55                        | 5459.81      | I  | 5 r       | 1246.00      | II  | 10                       | 7815.80      | I   | 620       | 3334.604     | II |
| 55                        | 5509.61      | I  | 10        | 1266.33      | III | 20                       | 8373.6       | I   | 620       | 3337.870     | II |
| 50                        | 5514.54      | I  | 15 r      | 1307.50      | II  | 10                       | 8474.27      | I   | 310       | 3348.768     | I  |
| 65                        | 5524.12      | I  | 8 r       | 1310.20      | II  | 10                       | 8664.1       | II  | 980       | 3351.228     | II |
| 85 c                      | 5747.58      | I  | 25 r      | 1321.71      | II  | 20                       | 9130.        | II  | 620       | 3358.602     | II |
| 75                        | 5795.64      | I  | 8 r       | 1330.40      | II  | 20                       | 9130.5       | I   | 250       | 3374.974     | I  |
| 75                        | 5803.13      | II | 10 r      | 1373.52      | II  | 40                       | 9509.4       | I   | 1300      | 3392.035     | II |
| 65                        | 5815.36      | I  | 10        | 1477.14      | III | 20                       | 9930.4       | I   | 200       | 3396.727     | I  |
| 65                        | 5851.07      | I  | 8 r       | 1489.65      | I   | 30                       | 10011.9      | I   | 250       | 3398.544     | I  |
| 65                        | 5870.62      | I  | 10 r      | 1499.30      | II  | 40                       | 10488.80     | I   | 200       | 3405.558     | I  |
| 65 c                      | 5920.78      | I  | 10 r      | 1507.82      | II  | 1000                     | 11512.82     | I   | 250       | 3413.012     | I  |
| 75                        | 5967.34      | II | 15 r      | 1561.58      | II  | 150                      | 12736.4      | I   | 390       | 3421.210     | I  |
| 35                        | 6331.68      | II | 10 r      | 1568.57      | II  | 700                      | 13013.2      | I   | 270       | 3423.989     | I  |
| 35 cw                     | 6518.68      | I  | 7 r       | 1593.26      | II  | <i>Thorium Th Z = 90</i> |              |     | 980       | 3433.998     | II |
| 35                        | 6581.82      | I  | 5 h       | 1616.        | I   | 150                      | 1707.37      | IV  | 770       | 3435.976     | II |
| 90                        | 6677.94      | II | 5         | 1685.40      | I   | 200                      | 1959.02      | IV  | 1300      | 3469.920     | II |
| 40 cw                     | 6702.61      | I  | 10 r      | 1792.76      | II  | 200                      | 2002.34      | IV  | 170       | 3471.218     | I  |
| 130                       | 6794.58      | II | 12 r      | 1814.85      | II  | 200                      | 2413.50      | III | 200       | 3486.552     | I  |
| 55                        | 6896.37      | II | 25 r      | 1908.64      | II  | 200                      | 2427.94      | III | 670       | 3539.587     | II |
| 45 h                      | 6899.95      | I  | 100 r     | 2007.56      | I   | 200                      | 2431.68      | III | 180       | 3544.018     | I  |
| 40                        | 6901.98      | I  | 100 r     | 2210.71      | I   | 200                      | 2441.24      | III | 170       | 3549.595     | I  |
| 65                        | 7204.28      | I  | 30        | 2298.04      | II  | 200                      | 2441.24      | III | 200       | 3555.013     | I  |
| 40                        | 7257.73      | I  | 140       | 2315.98      | I   | 500                      | 2565.593     | II  | 530       | 3559.451     | II |
| 45                        | 7348.88      | II | 900 h     | 2379.69      | I   | 480                      | 2692.415     | II  | 200       | 3576.557     | I  |
| 45                        | 7496.12      | I  | 20        | 2530.86      | II  | 520                      | 2747.156     | II  | 270       | 3592.780     | I  |
| 27 h                      | 7582.03      | II | 700       | 2580.14      | I   | 410                      | 2752.166     | II  | 270       | 3598.120     | I  |
| 45                        | 7590.24      | I  | 420       | 2709.23      | I   | 800                      | 2832.315     | II  | 980       | 3609.445     | II |
| 65                        | 7596.44      | I  | 4400 d    | 2767.87      | I   | 1200                     | 2837.295     | II  | 200       | 3612.427     | I  |
| 30                        | 7627.81      | I  | 10        | 2849.80      | II  | 100                      | 2848.084     | I   | 480       | 3615.133     | II |
| 30                        | 7737.63      | I  | 2800      | 2918.32      | I   | 550                      | 2870.406     | II  | 270       | 3635.943     | I  |
| 30                        | 7855.79      | II | 20        | 3091.56      | II  | 100                      | 2936.086     | I   | 210       | 3642.248     | I  |
| 27                        | 7927.90      | II | 15        | 3185.51      | II  | 100                      | 2943.729     | I   | 170       | 3649.735     | I  |
| 30                        | 8025.42      | II | 15        | 3186.56      | II  | 420                      | 3049.092     | II  | 220       | 3663.202     | I  |
| 30                        | 8085.06      | II | 15        | 3187.74      | II  | 450                      | 3067.729     | II  | 280       | 3669.968     | I  |
| 65                        | 8194.82      | II | 1200      | 3229.75      | I   | 670                      | 3078.828     | II  | 700       | 3675.567     | II |
| 95                        | 8212.57      | I  | 15        | 3291.01      | II  | 480                      | 3080.217     | II  | 150       | 3682.486     | I  |
| 40                        | 8450.06      | II | 15        | 3369.15      | II  | 510                      | 3108.296     | II  | 170       | 3692.566     | I  |
| 30 h                      | 8511.80      | I  | 9         | 3456.34      | III | 100                      | 3116.263     | I   | 180       | 3698.105     | I  |
| 45                        | 8583.45      | II | 20000     | 3519.24      | I   | 510                      | 3119.526     | II  | 340       | 3706.767     | I  |
| 30                        | 8603.40      | I  | 5000      | 3529.43      | I   | 510                      | 3122.963     | II  | 590       | 3719.435     | I  |
| 65                        | 8765.74      | II | 8         | 3540.08      | II  | 480                      | 3125.507     | II  | 770       | 3721.825     | II |
| <i>Thallium Tl Z = 81</i> |              |    | 9         | 3560.68      | II  | 100                      | 3136.216     | I   | 1300      | 3741.183     | II |
| 10                        | 570.49       | IV | 12000 w   | 3775.72      | I   | 420                      | 3139.306     | II  | 310       | 3747.539     | I  |
| 5 r                       | 670.87       | II | 10        | 3832.30      | II  | 420                      | 3142.835     | II  | 650       | 3752.569     | II |
| 15 r                      | 696.30       | II | 10        | 3887.15      | II  | 420                      | 3175.726     | II  | 180       | 3770.056     | I  |
| 5 r                       | 709.23       | II | 7         | 4109.85      | III | 1100                     | 3180.193     | II  | 590       | 3803.075     | I  |
| 10 r                      | 817.18       | II | 6         | 4269.81      | III | 770                      | 3188.233     | II  | 450       | 3828.384     | I  |
| 5 r                       | 836.34       | II | 20        | 4274.98      | II  | 560                      | 3221.292     | II  | 840       | 3839.746     | II |
| 8 r                       | 1018.85      | II | 40        | 4306.80      | II  | 560                      | 3229.009     | II  | 450       | 3863.405     | II |
| 30                        | 1028.69      | IV | 20        | 4737.05      | II  | 480                      | 3235.84      | II  | 210       | 3875.374     | I  |
|                           |              |    |           |              |     | 590                      | 3238.116     | II  |           |              |    |

| Intensity | Wavelength/Å |    | Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    |
|-----------|--------------|----|--------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|----|
| 340       | 3895.419     | I  | 40                       | 7191.132     | II  | 1900      | 3151.04      | II  | 6800      | 3883.13      | I  |
| 590       | 3929.669     | II | 35                       | 7208.006     | I   | 1500      | 3157.34      | II  | 1800      | 3883.44      | II |
| 200       | 3932.911     | I  | 50                       | 7525.508     | II  | 450       | 3172.65      | I   | 5400      | 3887.35      | I  |
| 390       | 3967.392     | I  | 30                       | 7647.380     | I   | 2300      | 3172.83      | II  | 440       | 3896.62      | I  |
| 200       | 3972.155     | I  | 30                       | 8330.451     | I   | 1200      | 3236.81      | II  | 3500      | 3916.48      | I  |
| 150       | 3980.089     | I  | 40                       | 8967.641     | I   | 1600      | 3240.23      | II  | 1500      | 3949.27      | I  |
| 530       | 3994.549     | II | 20                       | 9833.42      | I   | 2300      | 3241.54      | II  | 1500      | 3958.10      | II |
| 220       | 4008.210     | I  | 20                       | 10726.93     | I   | 320       | 3246.96      | I   | 1800      | 3996.52      | II |
| 220       | 4009.056     | I  | 20                       | 10942.24     | II  | 1900      | 3258.05      | II  | 220       | 4024.23      | I  |
| 280       | 4012.495     | I  | 30                       | 11230.259    | I   | 1600      | 3266.64      | II  | 380       | 4044.47      | I  |
| 4200      | 4019.129     | II | 20                       | 11984.67     | II  | 1200      | 3267.40      | II  | 10000     | 4094.19      | I  |
| 250       | 4030.842     | I  | 20                       | 17208.22     | II  | 1100      | 3276.81      | II  | 9500      | 4105.84      | I  |
| 250       | 4036.047     | I  | 15                       | 18811.88     | I   | 1200      | 3283.40      | II  | 1100      | 4138.33      | I  |
| 250       | 4063.407     | I  | 10                       | 22264.35     | II  | 1200      | 3285.61      | II  | 8800      | 4187.62      | I  |
| 700       | 4086.520     | II | <i>Thulium Tm Z = 69</i> |              |     | 2300      | 3291.00      | II  | 6000      | 4203.73      | I  |
| 700       | 4094.747     | II | 5000                     | 2185.94      | III | 2000      | 3302.46      | II  | 380       | 4222.67      | I  |
| 150       | 4100.341     | I  | 360                      | 2284.79      | II  | 1200      | 3309.80      | II  | 3000      | 4242.15      | II |
| 840       | 4108.421     | II | 20000                    | 2296.21      | III | 230       | 3349.99      | I   | 270       | 4271.71      | I  |
| 240       | 4112.754     | I  | 5000                     | 2305.03      | III | 4000      | 3362.61      | II  | 150       | 4298.36      | I  |
| 280       | 4115.758     | I  | 20000                    | 2311.16      | III | 1700      | 3397.50      | II  | 2700      | 4359.93      | I  |
| 1100      | 4116.713     | II | 5000                     | 2312.72      | III | 850       | 3410.05      | I   | 1400      | 4386.43      | I  |
| 200       | 4127.411     | I  | 5000                     | 2326.19      | III | 340       | 3412.59      | I   | 200       | 4394.42      | I  |
| 200       | 4134.067     | I  | 6000                     | 2328.50      | III | 340       | 3416.59      | I   | 140       | 4396.50      | I  |
| 450       | 4149.986     | II | 6000                     | 2329.29      | III | 6400      | 3425.08      | II  | 120       | 4454.03      | I  |
| 620       | 4178.060     | II | 3000                     | 2331.80      | III | 340       | 3429.33      | I   | 540       | 4481.26      | II |
| 620       | 4208.890     | II | 3000                     | 2357.05      | III | 4900      | 3441.50      | II  | 150       | 4519.60      | I  |
| 110       | 4253.538     | I  | 4000                     | 2406.63      | III | 4900      | 3453.66      | II  | 260       | 4522.57      | II |
| 110       | 4260.333     | I  | 450                      | 2409.02      | II  | 8500      | 3462.20      | II  | 110       | 4548.60      | I  |
| 480       | 4277.313     | II | 450                      | 2426.17      | II  | 210       | 3467.51      | I   | 270       | 4599.02      | I  |
| 700       | 4282.042     | II | 770                      | 2480.13      | II  | 340       | 3476.69      | I   | 300       | 4615.94      | II |
| 130       | 4337.277     | I  | 30000                    | 2489.44      | III | 340       | 3480.98      | I   | 80        | 4626.33      | II |
| 1300      | 4381.860     | II | 2000                     | 2504.71      | III | 420       | 3487.38      | I   | 95        | 4626.56      | II |
| 1100      | 4391.110     | II | 1300                     | 2509.08      | II  | 340       | 3499.95      | I   | 110       | 4634.26      | II |
| 110       | 4498.940     | I  | 3000                     | 2519.78      | III | 250       | 3517.60      | I   | 120       | 4655.09      | I  |
| 280       | 4510.527     | II | 130                      | 2527.02      | I   | 1700      | 3535.52      | II  | 160       | 4681.92      | I  |
| 90        | 4723.438     | I  | 10000                    | 2552.46      | III | 420       | 3537.91      | I   | 120       | 4691.11      | I  |
| 50        | 4840.843     | I  | 360                      | 2552.76      | I   | 210       | 3555.82      | I   | 110       | 4724.26      | I  |
| 280       | 4863.163     | II | 540                      | 2561.65      | II  | 340       | 3560.92      | I   | 680       | 4733.34      | I  |
| 260       | 5017.255     | II | 430                      | 2588.27      | II  | 420       | 3563.88      | I   | 70        | 4759.90      | I  |
| 110       | 5067.974     | I  | 170 h                    | 2596.49      | I   | 1300      | 3566.47      | II  | 80        | 4831.20      | II |
| 120       | 5148.211     | II | 810                      | 2607.06      | II  | 420       | 3567.36      | I   | 140       | 4957.18      | I  |
| 95        | 5216.596     | II | 730                      | 2624.33      | II  | 280       | 3586.07      | I   | 160       | 5009.77      | II |
| 110       | 5231.160     | I  | 5000                     | 2682.32      | III | 2100      | 3608.77      | II  | 160       | 5034.22      | II |
| 95        | 5247.654     | II | 2000                     | 2707.03      | III | 1000      | 3629.09      | III | 150       | 5060.90      | I  |
| 60        | 5343.581     | I  | 3000                     | 2719.47      | III | 380       | 3638.41      | I   | 95        | 5113.97      | I  |
| 60        | 5587.026     | I  | 540                      | 2721.19      | II  | 1100      | 3668.09      | II  | 80        | 5213.38      | I  |
| 95        | 5707.103     | II | 3000                     | 2724.44      | III | 4800      | 3700.26      | II  | 650       | 5307.12      | I  |
| 70        | 5760.551     | I  | 4000                     | 2727.56      | III | 3800      | 3701.36      | II  | 80        | 5346.49      | II |
| 85        | 5989.044     | II | 680                      | 2794.60      | II  | 7700      | 3717.91      | I   | 270       | 5631.41      | I  |
| 60        | 6169.822     | I  | 730                      | 2797.27      | II  | 2400      | 3734.12      | II  | 520       | 5675.84      | I  |
| 50        | 6182.622     | I  | 2000                     | 2806.77      | III | 5000      | 3744.06      | I   | 40        | 5684.76      | II |
| 50        | 6274.116     | II | 580                      | 2827.92      | II  | 1700      | 3751.81      | I   | 35        | 5709.97      | II |
| 50        | 6274.117     | II | 200                      | 2854.17      | I   | 6000      | 3761.33      | II  | 190       | 5764.29      | I  |
| 50        | 6355.911     | II | 1600                     | 2869.23      | II  | 4800      | 3761.91      | II  | 35        | 5838.76      | II |
| 60        | 6457.283     | I  | 1000                     | 2947.72      | III | 7100      | 3795.75      | II  | 240       | 5895.63      | I  |
| 50        | 6462.614     | I  | 490                      | 2973.22      | I   | 770       | 3798.54      | I   | 140       | 5971.26      | I  |
| 50 h      | 6531.342     | I  | 1000                     | 2998.28      | III | 600       | 3807.72      | I   | 200       | 6460.26      | I  |
| 55        | 6989.656     | I  | 1500                     | 3015.30      | II  | 290       | 3826.39      | I   | 95        | 6604.96      | I  |
| 30        | 7045.795     | II | 360                      | 3081.12      | I   | 1300      | 3838.20      | II  | 110       | 6779.77      | I  |
| 30        | 7084.171     | I  | 7400                     | 3131.26      | II  | 290       | 3840.87      | I   | 120       | 6844.26      | I  |
| 30        | 7168.896     | I  | 2300                     | 3133.89      | II  | 8900      | 3848.02      | II  | 80        | 6845.76      | I  |

| Intensity            | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                 | Wavelength/Å |    | Intensity | Wavelength/Å |     |
|----------------------|--------------|-----|-----------|--------------|-----|---------------------------|--------------|----|-----------|--------------|-----|
| 10                   | 6937.37      | I   | 120 r     | 1823.00      | I   | 110                       | 3330.62      | I  | 15        | 498.26       | V   |
| 10                   | 7017.90      | I   | 9         | 1831.89      | II  | 60                        | 3351.97      | II | 14        | 502.08       | V   |
| 12                   | 7034.34      | I   | 50 r      | 1848.75      | I   | 10                        | 3472.46      | II | 13        | 526.57       | V   |
| 10                   | 7106.14      | I   | 200 r     | 1860.32      | I   | 11                        | 3575.45      | II | 18        | 779.07       | IV  |
| 17                   | 7272.62      | I   | 80        | 1886.05      | I   | 280 r                     | 3801.02      | I  | 20        | 1298.66      | III |
| 14                   | 7310.51      | I   | 100       | 1891.40      | I   | 10                        | 5332.36      | II | 20        | 1298.97      | III |
| 14                   | 7432.18      | I   | 12        | 1899.91      | II  | 20                        | 5561.95      | II | 23        | 1455.19      | III |
| 75                   | 7481.08      | I   | 50        | 1909.30      | I   | 25                        | 5588.92      | II | 20        | 1467.34      | IV  |
| 75                   | 7490.20      | I   | 80        | 1925.31      | I   | 500                       | 5631.71      | I  | 11        | 1717.40      | V   |
| 140                  | 7558.33      | I   | 500       | 1941.86      | III | 15                        | 5799.18      | II | 10        | 1841.49      | V   |
| 80                   | 7731.53      | I   | 150       | 1952.15      | I   | 50                        | 5925.44      | I  | 20        | 2067.56      | IV  |
| 40                   | 7856.08      | I   | 50 h      | 1977.6       | I   | 100                       | 5970.30      | I  | 18        | 2103.16      | IV  |
| 55                   | 7927.51      | I   | 80        | 1984.20      | I   | 150                       | 6037.70      | I  | 180       | 2273.28      | I   |
| 110                  | 7930.84      | I   | 50        | 2040.66      | I   | 250                       | 6069.00      | I  | 190       | 2279.96      | I   |
| 95                   | 8017.90      | I   | 50        | 2054.03      | I   | 100                       | 6073.46      | I  | 190       | 2305.67      | I   |
| 27                   | 8472.01      | II  | 70        | 2058.31      | I   | 400                       | 6149.71      | I  | 22        | 2413.99      | III |
| <b>Tin Sn Z = 50</b> |              |     | 80        | 2068.58      | I   | 200                       | 6154.60      | I  | 25        | 2516.05      | III |
| 7                    | 169.47       | II  | 100       | 2072.89      | I   | 150                       | 6171.50      | I  | 360       | 2525.60      | II  |
| 150                  | 361.01       | V   | 100       | 2073.08      | I   | 100                       | 6310.78      | I  | 24        | 2527.84      | III |
| 100                  | 753.01       | III | 200       | 2096.39      | I   | 70                        | 6453.50      | II | 210       | 2529.85      | I   |
| 200                  | 910.92       | III | 100       | 2100.93      | I   | 25                        | 6844.05      | II | 190       | 2531.25      | II  |
| 500                  | 956.25       | IV  | 100 r     | 2113.93      | I   | 20                        | 7191.40      | II | 190       | 2534.62      | II  |
| 7                    | 985.13       | II  | 50        | 2121.26      | I   | 10                        | 7387.79      | II | 130       | 2535.87      | II  |
| 500                  | 1019.72      | IV  | 40 r      | 2148.73      | I   | 13                        | 7741.80      | II | 23        | 2540.06      | III |
| 1000                 | 1044.49      | IV  | 20 r      | 2151.43      | I   | 100                       | 7754.97      | I  | 24        | 2563.44      | III |
| 1000                 | 1073.41      | IV  | 30        | 2151.54      | II  | 100 h                     | 8030.5       | I  | 23        | 2565.42      | III |
| 200                  | 1089.35      | V   | 80        | 2171.32      | I   | 200                       | 8114.09      | I  | 22        | 2567.56      | III |
| 8                    | 1108.19      | II  | 150 r     | 2194.49      | I   | 80                        | 8357.04      | I  | 270       | 2599.92      | I   |
| 1000                 | 1119.34      | IV  | 300 r     | 2199.34      | I   | 300                       | 8422.72      | I  | 340       | 2605.15      | I   |
| 1000                 | 1139.29      | III | 400 r     | 2209.65      | I   | 400                       | 8552.60      | I  | 510       | 2611.28      | I   |
| 1000                 | 1158.33      | III | 80 r      | 2231.72      | I   | 50 h                      | 8681.7       | I  | 300       | 2619.94      | I   |
| 200                  | 1160.74      | V   | 400 r     | 2246.05      | I   | 50 h                      | 9410.86      | I  | 640       | 2641.10      | I   |
| 10                   | 1161.43      | II  | 60        | 2251.17      | I   | 80 h                      | 9415.37      | I  | 800       | 2644.26      | I   |
| 1000                 | 1184.25      | III | 400 r     | 2268.91      | I   | 150                       | 9616.40      | I  | 950       | 2646.64      | I   |
| 2000                 | 1210.52      | III | 200 r     | 2286.68      | I   | 50                        | 9741.1       | I  | 250       | 2742.32      | I   |
| 9                    | 1219.07      | II  | 600 r     | 2317.23      | I   | 100 h                     | 9742.8       | I  | 250       | 2802.50      | I   |
| 13                   | 1223.70      | II  | 300 r     | 2334.80      | I   | 300 h                     | 9805.38      | I  | 190       | 2841.94      | II  |
| 11                   | 1243.00      | II  | 1000 r    | 2354.84      | I   | 500                       | 9850.52      | I  | 180       | 2877.44      | II  |
| 2000                 | 1251.38      | V   | 22        | 2368.33      | II  | 54                        | 10894.00     | I  | 280       | 2884.11      | II  |
| 1000                 | 1259.92      | III | 100       | 2408.15      | I   | 70                        | 11191.85     | I  | 450       | 2912.08      | I   |
| 20                   | 1290.86      | II  | 800 r     | 2421.70      | I   | 56                        | 11277.66     | I  | 340       | 2928.34      | I   |
| 200                  | 1294.36      | V   | 1000 r    | 2429.49      | I   | 200                       | 11454.59     | I  | 1100      | 2942.00      | I   |
| 1000                 | 1305.97      | III | 15        | 2448.98      | II  | 200                       | 11616.26     | I  | 1300      | 2948.26      | I   |
| 1000                 | 1314.55      | IV  | 300       | 2483.39      | I   | 258                       | 11739.78     | I  | 1600      | 2956.13      | I   |
| 20                   | 1316.59      | II  | 13        | 2483.48      | II  | 96                        | 11825.18     | I  | 22        | 2984.75      | III |
| 1000                 | 1327.34      | III | 10        | 2486.99      | II  | 106                       | 11835.82     | I  | 1300 d    | 3066.22      | II  |
| 1000                 | 1347.65      | III | 200       | 2495.70      | I   | 254                       | 11932.99     | I  | 1100      | 3072.97      | II  |
| 1000                 | 1386.74      | III | 400       | 2546.55      | I   | 48                        | 12009.50     | I  | 1600      | 3075.22      | II  |
| 25                   | 1400.52      | II  | 500 r     | 2571.58      | I   | 111                       | 12313.24     | I  | 2300      | 3078.64      | II  |
| 1000                 | 1437.52      | IV  | 200       | 2594.42      | I   | 42                        | 12530.87     | I  | 3600      | 3088.02      | II  |
| 20                   | 1475.15      | II  | 200 r     | 2661.24      | I   | 42                        | 12536.5      | I  | 720       | 3119.72      | I   |
| 9                    | 1489.22      | II  | 700 r     | 2706.51      | I   | 89                        | 12888.5      | I  | 500       | 3161.20      | II  |
| 1000                 | 1570.36      | III | 150       | 2779.81      | I   | 187                       | 12981.7      | I  | 780       | 3161.77      | II  |
| 10 r                 | 1737.21      | I   | 1400 r    | 2839.99      | I   | 187                       | 13018.5      | I  | 1000      | 3162.57      | II  |
| 15 r                 | 1751.46      | I   | 1000 r    | 2863.32      | I   | 68                        | 13081.5      | I  | 1600      | 3168.52      | II  |
| 20 r                 | 1764.98      | I   | 700 r     | 3009.14      | I   | 378                       | 13460.2      | I  | 2400      | 3186.45      | I   |
| 30 r                 | 1790.75      | I   | 850 r     | 3034.12      | I   | 144                       | 13608.2      | I  | 1000      | 3190.87      | II  |
| 80 r                 | 1804.60      | I   | 12        | 3047.50      | II  | 40                        | 20861.7      | I  | 3100      | 3191.99      | I   |
| 15                   | 1811.34      | II  | 550 r     | 3175.05      | I   | 4                         | 24738.2      | I  | 3800      | 3199.92      | I   |
| 500                  | 1811.71      | III | 550 r     | 3262.34      | I   | <b>Titanium Ti Z = 22</b> |              |    | 780       | 3202.54      | II  |
| 40 r                 | 1815.74      | I   | 50        | 3283.21      | II  | 17                        | 252.96       | V  | 1100      | 3217.06      | II  |



| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity                | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|--------------------------|--------------|-----|
| 1300      | 3222.84      | II  | 950       | 3962.85      | I   | 840       | 5020.03      | I   | 20                       | 8466.87      | III |
| 6600      | 3234.52      | II  | 950       | 3964.27      | I   | 840       | 5022.87      | I   | 90                       | 8675.39      | I   |
| 5200      | 3236.57      | II  | 4800      | 3981.76      | I   | 1200      | 5035.91      | I   | <i>Tungsten W Z = 74</i> |              |     |
| 4100      | 3239.04      | II  | 570       | 3982.48      | I   | 840       | 5036.47      | I   | 5800                     | 2001.71      | II  |
| 2600      | 3241.99      | II  | 5700      | 3989.76      | I   | 740       | 5038.40      | I   | 13000                    | 2008.07      | II  |
| 1200      | 3248.60      | II  | 7800      | 3998.64      | I   | 1200      | 5039.95      | I   | 5100                     | 2009.98      | II  |
| 1200      | 3252.91      | II  | 950       | 4008.93      | I   | 1400      | 5064.66      | I   | 4100                     | 2010.23      | II  |
| 1200      | 3254.25      | II  | 1200      | 4024.57      | I   | 1100      | 5173.75      | I   | 4100                     | 2014.23      | II  |
| 1200      | 3261.60      | II  | 840       | 4078.47      | I   | 1300      | 5192.98      | I   | 7300                     | 2026.08      | II  |
| 840       | 3314.42      | I   | 890       | 4286.01      | I   | 1400      | 5210.39      | I   | 15000                    | 2029.98      | II  |
| 2900      | 3322.94      | II  | 840       | 4287.40      | I   | 17        | 5278.12      | III | 5300                     | 2049.63      | II  |
| 2100      | 3329.46      | II  | 950       | 4289.07      | I   | 20        | 5398.93      | IV  | 9700                     | 2079.11      | II  |
| 1800      | 3335.20      | II  | 840       | 4290.94      | I   | 340       | 5512.53      | I   | 6100                     | 2094.75      | II  |
| 1100      | 3340.34      | II  | 840       | 4295.76      | I   | 270       | 5514.35      | I   | 2100                     | 2118.87      | II  |
| 5700      | 3341.88      | I   | 2000      | 4298.66      | I   | 320       | 5514.54      | I   | 2400                     | 2121.59      | II  |
| 4300      | 3349.04      | II  | 200       | 4300.05      | II  | 250       | 5644.14      | I   | 1500                     | 2166.32      | II  |
| 12000     | 3349.41      | II  | 2900      | 4300.56      | I   | 130       | 5675.44      | I   | 1300                     | 2204.48      | II  |
| 4100      | 3354.64      | I   | 4100      | 4301.09      | I   | 95        | 5689.47      | I   | 460                      | 2249.80      | I   |
| 7200      | 3361.21      | II  | 6000      | 4305.92      | I   | 95        | 5715.13      | I   | 510                      | 2277.58      | I   |
| 1100      | 3370.44      | I   | 1200      | 4314.80      | I   | 85        | 5739.51      | I   | 530 d                    | 2294.49      | I   |
| 4300      | 3371.45      | I   | 330       | 4395.04      | II  | 400       | 5866.46      | I   | 340                      | 2309.02      | I   |
| 5700      | 3372.80      | II  | 890       | 4427.10      | I   | 230       | 5899.32      | I   | 440                      | 2313.17      | I   |
| 2900 d    | 3377.48      | I   | 230       | 4443.80      | II  | 120       | 5918.55      | I   | 460                      | 2321.63      | I   |
| 1400      | 3380.28      | II  | 840       | 4449.15      | I   | 150       | 5922.12      | I   | 390 d                    | 2326.56      | I   |
| 5700      | 3383.76      | II  | 550       | 4450.90      | I   | 120       | 5941.76      | I   | 320                      | 2354.61      | I   |
| 1400      | 3385.95      | I   | 840       | 4453.32      | I   | 300       | 5953.17      | I   | 580                      | 2360.44      | I   |
| 1400      | 3387.84      | II  | 950       | 4455.33      | I   | 200       | 5965.84      | I   | 850                      | 2363.07      | I   |
| 1100      | 3394.58      | II  | 1100      | 4457.43      | I   | 270       | 5978.56      | I   | 510                      | 2374.47      | I   |
| 890       | 3444.31      | II  | 240       | 4468.50      | II  | 340       | 5999.04      | I   | 670                      | 2384.82      | I   |
| 600       | 3461.50      | II  | 530       | 4481.26      | I   | 110       | 6064.63      | I   | 730                      | 2397.09      | II  |
| 600       | 3477.18      | II  | 780       | 4512.74      | I   | 120       | 6085.23      | I   | 560                      | 2397.73      | I   |
| 480       | 3491.05      | II  | 1000      | 4518.03      | I   | 120       | 6091.17      | I   | 560                      | 2397.98      | I   |
| 890       | 3504.89      | II  | 1000      | 4522.80      | I   | 120       | 6126.22      | I   | 1700 d                   | 2405.58      | I   |
| 600       | 3510.84      | II  | 780       | 4527.31      | I   | 17        | 6246.65      | IV  | 610                      | 2415.68      | I   |
| 17        | 3576.44      | IV  | 6000      | 4533.24      | I   | 380       | 6258.10      | I   | 870                      | 2424.21      | I   |
| 600       | 3610.16      | I   | 240       | 4533.97      | II  | 380       | 6258.70      | I   | 1800                     | 2435.96      | I   |
| 4800      | 3635.46      | I   | 3600      | 4534.78      | I   | 300       | 6261.10      | I   | 580                      | 2444.06      | I   |
| 6600      | 3642.68      | I   | 2400      | 4535.58      | I   | 55        | 6546.28      | I   | 780                      | 2451.48      | II  |
| 7200      | 3653.50      | I   | 1200      | 4535.92      | I   | 65        | 6554.23      | I   | 870                      | 2452.00      | I   |
| 600       | 3671.67      | I   | 1200      | 4536.05      | I   | 75        | 6556.07      | I   | 630                      | 2454.98      | I   |
| 3100      | 3685.20      | II  | 720       | 4544.69      | I   | 18        | 6621.58      | III | 780                      | 2455.51      | I   |
| 600       | 3689.91      | I   | 950       | 4548.77      | I   | 18        | 6667.99      | III | 780                      | 2456.53      | I   |
| 2900      | 3729.82      | I   | 240       | 4549.63      | II  | 80        | 6743.12      | I   | 1100                     | 2459.30      | I   |
| 3300      | 3741.06      | I   | 15        | 4549.84      | III | 20        | 7072.64      | III | 1400                     | 2466.85      | I   |
| 330       | 3741.64      | II  | 950       | 4552.46      | I   | 18        | 7084.57      | III | 480                      | 2472.51      | I   |
| 5200      | 3752.86      | I   | 720       | 4555.49      | I   | 260       | 7209.44      | I   | 1200                     | 2474.15      | I   |
| 3300      | 3759.30      | II  | 240       | 4571.98      | II  | 130       | 7244.86      | I   | 870                      | 2480.13      | I   |
| 2900      | 3761.32      | II  | 15 d      | 4572.20      | III | 130       | 7251.72      | I   | 1500                     | 2481.44      | I   |
| 840       | 3786.04      | I   | 950       | 4617.27      | I   | 120       | 7344.72      | I   | 480 d                    | 2482.10      | I   |
| 500       | 3882.89      | I   | 480       | 4623.09      | I   | 90        | 7357.74      | I   | 580                      | 2484.74      | I   |
| 530       | 3900.54      | II  | 720       | 4656.47      | I   | 60        | 7364.11      | I   | 390                      | 2487.50      | I   |
| 2600      | 3904.78      | I   | 840       | 4667.59      | I   | 60        | 7978.88      | I   | 390                      | 2489.23      | II  |
| 500       | 3913.46      | II  | 950       | 4681.92      | I   | 55        | 8024.84      | I   | 630                      | 2495.26      | I   |
| 500       | 3914.34      | I   | 470       | 4840.87      | I   | 75        | 8364.24      | I   | 680                      | 2504.70      | I   |
| 15        | 3915.47      | III | 400       | 4885.08      | I   | 100       | 8377.85      | I   | 75                       | 2510.47      | II  |
| 1100      | 3924.53      | I   | 380       | 4899.91      | I   | 100       | 8382.54      | I   | 310                      | 2520.46      | I   |
| 890       | 3929.88      | I   | 5800      | 4981.73      | I   | 75        | 8396.87      | I   | 780                      | 2521.32      | I   |
| 1100      | 3947.78      | I   | 4600      | 4991.07      | I   | 120       | 8412.36      | I   | 270                      | 2522.04      | II  |
| 4500      | 3948.67      | I   | 4000      | 4999.51      | I   | 170       | 8426.52      | I   | 780                      | 2523.41      | I   |
| 4500      | 3956.34      | I   | 3600      | 5007.21      | I   | 490       | 8434.94      | I   | 430                      | 2527.76      | I   |
| 5200      | 3958.21      | I   | 3200 d    | 5014.19      | I   | 240       | 8435.70      | I   | 780                      | 2533.64      | I   |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |   | Intensity               | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|-----------|--------------|----|-----------|--------------|---|-------------------------|--------------|----|-----------|--------------|----|
| 1200      | 2547.14      | I  | 440       | 3046.44      | I | 2200                    | 4302.11      | I  | 580       | 2931.41      | II |
| 780       | 2550.38      | I  | 810       | 3049.69      | I | 200                     | 4378.48      | I  | 530 p     | 2940.37      | II |
| 2700      | 2551.35      | I  | 180       | 3073.28      | I | 180                     | 4384.85      | I  | 1300      | 2941.92      | II |
| 730       | 2561.97      | I  | 180 d     | 3084.83      | I | 200                     | 4408.28      | I  | 830       | 2943.90      | II |
| 870       | 2580.49      | I  | 370       | 3093.50      | I | 640                     | 4484.19      | I  | 580       | 2956.06      | II |
| 390       | 2584.39      | I  | 240       | 3107.23      | I | 170                     | 4588.73      | I  | 580       | 2967.94      | II |
| 390       | 2589.17      | II | 240       | 3108.02      | I | 640                     | 4659.87      | I  | 580       | 2971.06      | II |
| 370       | 2601.96      | I  | 230       | 3117.57      | I | 640                     | 4680.51      | I  | 530       | 2984.61      | II |
| 680       | 2606.39      | I  | 260       | 3120.18      | I | 790                     | 4843.81      | I  | 630       | 3022.21      | II |
| 370       | 2608.32      | I  | 290       | 3163.42      | I | 380                     | 4886.90      | I  | 630       | 3031.99      | II |
| 970       | 2613.08      | I  | 320       | 3176.60      | I | 220                     | 4982.59      | I  | 580       | 3050.20      | II |
| 480       | 2613.82      | I  | 190       | 3181.82      | I | 820                     | 5053.28      | I  | 630       | 3057.91      | II |
| 400       | 2620.25      | I  | 390       | 3191.57      | I | 770                     | 5224.66      | I  | 630       | 3062.54      | II |
| 400       | 2622.21      | I  | 390       | 3198.84      | I | 220                     | 5514.68      | I  | 580       | 3072.78      | II |
| 400       | 2625.22      | I  | 520       | 3207.25      | I | 65                      | 5648.37      | I  | 580       | 3093.01      | II |
| 400       | 2632.48      | I  | 1000      | 3215.56      | I | 55                      | 5735.09      | I  | 580       | 3102.39      | II |
| 400       | 2632.70      | I  | 190       | 3232.49      | I | 45                      | 5804.85      | I  | 970       | 3111.62      | II |
| 810       | 2633.13      | I  | 210       | 3254.36      | I | 40                      | 5902.64      | I  | 530       | 3119.35      | II |
| 400 d     | 2638.62      | I  | 210       | 3259.66      | I | 55                      | 5947.57      | I  | 680       | 3124.95      | II |
| 650       | 2646.18      | I  | 210 d     | 3266.62      | I | 55                      | 5965.86      | I  | 530       | 3139.61      | II |
| 400       | 2646.73      | I  | 730       | 3300.82      | I | 55                      | 6012.78      | I  | 680       | 3149.24      | II |
| 1600      | 2656.54      | I  | 440       | 3311.38      | I | 40                      | 6021.52      | I  | 530       | 3153.11      | II |
| 810       | 2662.84      | I  | 440       | 3326.20      | I | 45                      | 6292.02      | I  | 730       | 3229.50      | II |
| 810       | 2671.47      | I  | 440       | 3331.69      | I | 35                      | 6404.21      | I  | 680       | 3232.16      | II |
| 650       | 2677.28      | I  | 390       | 3373.75      | I | 40                      | 6445.12      | I  | 730       | 3291.33      | II |
| 2100      | 2681.42      | I  | 230       | 3429.59      | I | 17                      | 6611.62      | I  | 1100      | 3305.89      | II |
| 650       | 2695.67      | I  | 240       | 3443.00      | I | 13                      | 6678.42      | I  | 730       | 3390.38      | I  |
| 650       | 2699.59      | I  | 400       | 3495.24      | I | 15                      | 6693.08      | I  | 580       | 3424.56      | II |
| 400       | 2700.01      | I  | 650       | 3545.22      | I | 13                      | 6984.27      | I  | 580       | 3435.49      | I  |
| 400       | 2706.58      | I  | 240       | 3570.65      | I | 15                      | 7140.52      | I  | 630       | 3466.30      | I  |
| 400       | 2708.59      | I  | 1900      | 3617.52      | I | 9                       | 7162.64      | I  | 680       | 3482.49      | II |
| 400 d     | 2708.80      | I  | 650       | 3682.08      | I | 11                      | 7200.16      | I  | 1600      | 3489.37      | I  |
| 400       | 2715.50      | I  | 400       | 3683.30      | I | 10                      | 7278.24      | I  | 530       | 3496.41      | II |
| 2100      | 2718.91      | I  | 570       | 3688.06      | I | 15                      | 7285.81      | I  | 630       | 3500.08      | I  |
| 2600      | 2724.35      | I  | 810       | 3707.92      | I | 15                      | 7296.55      | I  | 780       | 3507.34      | I  |
| 400       | 2725.03      | I  | 510       | 3757.92      | I | 10                      | 7509.00      | I  | 1600      | 3514.61      | I  |
| 650       | 2748.84      | I  | 680       | 3760.13      | I | 17                      | 7569.92      | I  | 630       | 3533.57      | II |
| 400       | 2762.34      | I  | 1000      | 3768.45      | I | 17                      | 7614.15      | I  | 530       | 3540.47      | II |
| 400       | 2764.27      | II | 340       | 3773.71      | I | 13                      | 7688.97      | I  | 1200      | 3550.82      | II |
| 400       | 2769.74      | I  | 1000      | 3780.77      | I | 11                      | 7784.15      | I  | 680       | 3555.32      | I  |
| 810       | 2770.88      | I  | 290       | 3809.22      | I | 22                      | 8017.19      | I  | 1200      | 3561.80      | I  |
| 810       | 2774.00      | I  | 190       | 3810.38      | I | 22                      | 8055.64      | I  | 2300      | 3566.59      | I  |
| 810       | 2774.48      | I  | 260       | 3810.79      | I | 13                      | 8123.82      | I  | 530       | 3569.08      | I  |
| 810       | 2792.70      | I  | 1400      | 3817.48      | I | 10                      | 8338.08      | I  | 630       | 3578.72      | II |
| 400       | 2799.93      | I  | 1100      | 3835.06      | I | 27                      | 8585.11      | I  | 3200      | 3584.88      | I  |
| 810       | 2818.06      | I  | 730       | 3846.22      | I | 10                      | 8594.42      | I  | 840       | 3638.20      | I  |
| 1600      | 2831.38      | I  | 1800      | 3867.99      | I | 13                      | 8865.53      | I  | 2800      | 3670.07      | II |
| 810       | 2833.63      | I  | 730       | 3881.41      | I | <i>Uranium U Z = 92</i> |              |    | 1100      | 3701.52      | II |
| 810       | 2848.02      | I  | 8600      | 4008.75      | I | 440                     | 2565.41      | II | 600       | 3738.04      | II |
| 1500      | 2896.44      | I  | 540       | 4015.22      | I | 610                     | 2635.53      | II | 680       | 3746.42      | II |
| 690       | 2935.00      | I  | 910       | 4045.59      | I | 830                     | 2793.94      | II | 950       | 3748.68      | II |
| 2400      | 2944.40      | I  | 730       | 4069.95      | I | 870                     | 2802.56      | II | 600       | 3751.17      | I  |
| 2400      | 2946.99      | I  | 5000      | 4074.36      | I | 630                     | 2807.05      | II | 1900      | 3782.84      | II |
| 730 d     | 2979.71      | I  | 1000      | 4102.70      | I | 630                     | 2817.96      | II | 570       | 3793.10      | II |
| 360       | 3013.79      | I  | 540       | 4137.46      | I | 870                     | 2821.12      | II | 1900      | 3811.99      | I  |
| 520       | 3016.47      | I  | 450       | 4171.17      | I | 680                     | 2828.90      | II | 750       | 3826.51      | II |
| 770       | 3017.44      | I  | 220       | 4207.05      | I | 920                     | 2832.06      | II | 2000      | 3831.46      | II |
| 210       | 3024.93      | I  | 250       | 4219.37      | I | 970                     | 2865.68      | II | 1200      | 3839.63      | I  |
| 310 d     | 3026.67      | I  | 540       | 4244.36      | I | 1200                    | 2889.62      | II | 2400      | 3854.64      | II |
| 440 d     | 3041.73      | I  | 1400      | 4269.38      | I | 780                     | 2906.80      | II | 4900      | 3859.57      | II |
| 270       | 3043.80      | I  | 4100      | 4294.61      | I | 780                     | 2908.28      | II | 1900      | 3865.92      | II |



| Intensity                | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |   |
|--------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|---|
| 1500                     | 3871.03      | I   | 500       | 1006.46      | III | 750       | 3190.68      | II  | 510       | 4332.82      | I |
| 1000                     | 3881.45      | II  | 500       | 1149.94      | III | 1100      | 3267.70      | II  | 760       | 4341.01      | I |
| 2200                     | 3890.36      | II  | 100       | 1426.65      | IV  | 900       | 3271.12      | II  | 1000      | 4352.87      | I |
| 2000                     | 3932.02      | II  | 1000      | 1643.03      | III | 750       | 3276.12      | II  | 12000     | 4379.24      | I |
| 1200                     | 3943.82      | I   | 1000      | 1650.14      | III | 80 h      | 3514.25      | IV  | 7000      | 4384.72      | I |
| 1200                     | 3985.79      | II  | 100       | 1680.20      | V   | 560       | 3517.30      | II  | 4800      | 4389.97      | I |
| 1000                     | 4042.75      | I   | 1000      | 1694.78      | III | 560       | 3533.68      | I   | 3600      | 4395.23      | I |
| 1600                     | 4050.04      | II  | 1000      | 1760.07      | III | 560       | 3545.20      | II  | 1400      | 4400.58      | I |
| 880                      | 4062.54      | II  | 1000      | 1788.26      | III | 560       | 3556.80      | II  | 2300      | 4406.64      | I |
| 2200                     | 4090.13      | II  | 1000      | 1794.60      | III | 560       | 3589.76      | II  | 2800      | 4407.64      | I |
| 810                      | 4116.10      | II  | 1000      | 1812.19      | III | 490       | 3592.02      | II  | 3600      | 4408.20      | I |
| 880                      | 4153.97      | I   | 300       | 1861.56      | IV  | 560       | 3592.53      | I   | 4600      | 4408.51      | I |
| 1400                     | 4171.59      | II  | 500       | 1939.06      | IV  | 100       | 3679.86      | III | 640       | 4416.47      | I |
| 1000                     | 4241.67      | II  | 400       | 1951.43      | IV  | 1300      | 3688.07      | I   | 640       | 4421.57      | I |
| 600                      | 4472.33      | II  | 500       | 1997.72      | IV  | 1000      | 3690.28      | I   | 640       | 4437.84      | I |
| 620                      | 4543.63      | II  | 2100      | 2092.44      | I   | 1500      | 3692.22      | I   | 830       | 4441.68      | I |
| 170                      | 4689.07      | II  | 500       | 2268.30      | IV  | 1000      | 3695.86      | I   | 640       | 4444.21      | I |
| 150                      | 4756.81      | I   | 1000      | 2292.86      | III | 3800      | 3703.58      | I   | 610       | 4452.01      | I |
| 110                      | 5008.21      | II  | 2500      | 2330.42      | III | 1800      | 3704.70      | I   | 1000      | 4459.76      | I |
| 170                      | 5027.38      | I   | 2500      | 2371.06      | III | 320       | 3715.47      | II  | 2000      | 4460.29      | I |
| 80                       | 5160.32      | II  | 1000      | 2382.46      | III | 250       | 3727.34      | II  | 610       | 4462.36      | I |
| 70                       | 5280.38      | I   | 240       | 2507.78      | I   | 280       | 3732.76      | II  | 510       | 4577.17      | I |
| 80                       | 5475.70      | II  | 410       | 2526.22      | I   | 520       | 3790.32      | I   | 640       | 4580.40      | I |
| 70                       | 5480.26      | II  | 210       | 2527.90      | II  | 1100      | 3794.96      | I   | 830       | 4586.36      | I |
| 70                       | 5481.20      | II  | 80 h      | 2570.72      | IV  | 570       | 3799.91      | I   | 1300      | 4594.11      | I |
| 160                      | 5492.95      | II  | 230       | 2574.02      | I   | 570       | 3803.47      | I   | 230       | 4619.77      | I |
| 70                       | 5780.59      | I   | 250       | 2593.05      | III | 1000      | 3813.49      | I   | 100       | 4635.18      | I |
| 70                       | 5798.53      | II  | 250       | 2595.10      | III | 1300      | 3818.24      | I   | 130       | 4646.40      | I |
| 230                      | 5915.39      | I   | 80 h      | 2645.54      | IV  | 1700      | 3828.56      | I   | 160       | 4670.49      | I |
| 100                      | 5976.32      | I   | 180       | 2661.42      | I   | 2600      | 3840.75      | I   | 130       | 4776.36      | I |
| 90                       | 6077.29      | I   | 1100      | 2687.96      | II  | 1200      | 3855.37      | I   | 110       | 4786.51      | I |
| 55                       | 6372.46      | I   | 680       | 2700.94      | II  | 3000      | 3855.84      | I   | 130       | 4796.92      | I |
| 90                       | 6395.42      | I   | 530       | 2706.17      | II  | 1300      | 3864.86      | I   | 130       | 4807.53      | I |
| 110                      | 6449.16      | I   | 640       | 2715.69      | II  | 1500      | 3875.08      | I   | 130       | 4827.45      | I |
| 90                       | 6826.92      | I   | 180       | 2731.35      | I   | 700       | 3890.18      | I   | 150       | 4831.64      | I |
| 45                       | 7533.93      | I   | 240       | 2864.36      | I   | 2400      | 3902.25      | I   | 120       | 4832.43      | I |
| 50                       | 7881.94      | I   | 900       | 2891.64      | II  | 700       | 3909.89      | I   | 320       | 4851.48      | I |
| 35                       | 8445.39      | I   | 900       | 2892.66      | II  | 540       | 3990.57      | I   | 480       | 4864.74      | I |
| 75                       | 8607.95      | I   | 1400      | 2893.32      | II  | 430       | 3998.73      | I   | 620       | 4875.48      | I |
| 30                       | 8757.76      | I   | 900       | 2906.46      | II  | 170       | 4005.71      | II  | 740       | 4881.56      | I |
| 100                      | 10554.93     | I   | 2400      | 2908.82      | II  | 1100      | 4090.58      | I   | 110       | 5128.53      | I |
| 75                       | 11167.84     | I   | 710       | 2923.62      | I   | 1800      | 4092.69      | I   | 110       | 5138.42      | I |
| 100                      | 11384.13     | I   | 2400      | 2924.02      | II  | 890       | 4095.49      | I   | 110       | 5192.99      | I |
| 100                      | 11859.42     | I   | 1700      | 2924.64      | II  | 2800      | 4099.80      | I   | 110       | 5194.83      | I |
| 100                      | 11908.83     | I   | 900       | 2941.37      | II  | 590       | 4102.16      | I   | 110       | 5234.07      | I |
| 100                      | 12250.46     | I   | 1100      | 2944.57      | II  | 2800      | 4105.17      | I   | 110       | 5240.87      | I |
| 100                      | 13185.16     | I   | 410       | 2962.77      | I   | 2300      | 4109.79      | I   | 100       | 5401.93      | I |
| 75                       | 13306.23     | I   | 600       | 2968.38      | II  | 8900      | 4111.78      | I   | 140       | 5415.26      | I |
| 100                      | 13961.58     | I   | 1200      | 3056.33      | I   | 4300      | 4115.18      | I   | 140       | 5584.50      | I |
| 75                       | 18634.43     | I   | 1400      | 3060.46      | I   | 1800      | 4116.47      | I   | 100       | 5592.42      | I |
| 75                       | 21910.22     | I   | 2400      | 3066.38      | I   | 2000      | 4123.57      | I   | 200       | 5624.60      | I |
| <b>Vanadium V Z = 23</b> |              |     | 3800      | 3093.11      | II  | 3100      | 4128.07      | I   | 400       | 5627.64      | I |
| 20                       | 225.46       | V   | 3000      | 3102.30      | II  | 3100      | 4132.02      | I   | 110       | 5657.44      | I |
| 20                       | 251.66       | V   | 2600      | 3110.71      | II  | 2300      | 4134.49      | I   | 110       | 5668.36      | I |
| 20                       | 286.84       | V   | 2000      | 3118.38      | II  | 20        | 4200.32      | V   | 310       | 5670.85      | I |
| 35                       | 483.01       | V   | 1500      | 3125.28      | II  | 360       | 4232.46      | I   | 1200      | 5698.52      | I |
| 50                       | 633.94       | III | 3200      | 3183.41      | I   | 560       | 4268.64      | I   | 920       | 5703.56      | I |
| 200                      | 677.34       | IV  | 5300      | 3183.98      | I   | 460       | 4271.55      | I   | 570       | 5706.98      | I |
| 500                      | 684.37       | IV  | 3800      | 3185.40      | I   | 460       | 4276.96      | I   | 850       | 5727.03      | I |
| 400                      | 737.85       | IV  | 410       | 3187.71      | II  | 430       | 4284.06      | I   | 230       | 5731.25      | I |
| 100                      | 864.27       | III | 530       | 3188.51      | II  | 460       | 4330.02      | I   | 230       | 5737.06      | I |

| Intensity              | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|------------------------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|-----------|--------------|-----|
| 450                    | 6039.73      | I   | 500       | 1032.44      | II  | 2         | 3400.07      | I   | 500 h     | 4310.51      | II  |
| 480                    | 6081.44      | I   | 700       | 1037.68      | II  | 2         | 3418.37      | I   | 1000 l    | 4330.52      | II  |
| 1300                   | 6090.22      | I   | 1100      | 1041.31      | II  | 2         | 3420.00      | I   | 200 h     | 4369.20      | II  |
| 600                    | 6119.52      | I   | 10        | 1047.8       | III | 3         | 3442.66      | I   | 100 l     | 4373.78      | II  |
| 450                    | 6199.19      | I   | 1000      | 1048.27      | II  | 60        | 3444.2       | III | 500 h     | 4393.20      | II  |
| 450                    | 6216.37      | I   | 1200      | 1051.92      | II  | 70        | 3454.2       | III | 500 l     | 4395.77      | II  |
| 430                    | 6230.74      | I   | 12        | 1066.4       | III | 100 w     | 3458.7       | III | 200 l     | 4406.88      | II  |
| 710                    | 6243.10      | I   | 2000      | 1074.48      | II  | 100 h     | 3461.26      | II  | 150 l     | 4416.07      | II  |
| 280                    | 6251.82      | I   | 600       | 1083.86      | II  | 40        | 3468.22      | III | 50        | 4434.2       | III |
| 130                    | 6268.82      | I   | 1200      | 1100.43      | II  | 4         | 3469.81      | I   | 500 h     | 4448.13      | II  |
| 170                    | 6274.65      | I   | 30        | 1130.3       | III | 4         | 3472.36      | I   | 100 w     | 4462.1       | III |
| 200                    | 6285.16      | I   | 600       | 1158.47      | II  | 5         | 3506.74      | I   | 1000 h    | 4462.19      | II  |
| 200                    | 6292.83      | I   | 250       | 1169.63      | II  | 80        | 3522.83      | III | 500 l     | 4480.86      | II  |
| 170                    | 6296.49      | I   | 800 p     | 1183.05      | II  | 50        | 3542.3       | III | 100 l     | 4521.86      | II  |
| 110                    | 6531.43      | I   | 250       | 1192.04      | I   | 10        | 3549.86      | I   | 100 w     | 4569.1       | III |
| 65 c                   | 6753.00      | I   | 25        | 1232.1       | III | 50        | 3552.1       | III | 100 w     | 4570.1       | III |
| 50 c                   | 6766.49      | I   | 600       | 1244.76      | II  | 10        | 3554.04      | I   | 100 w     | 4641.4       | III |
| 40                     | 6784.98      | I   | 250       | 1250.20      | I   | 40        | 3561.4       | III | 30        | 4673.7       | III |
| 40                     | 7338.92      | I   | 1000      | 1295.59      | I   | 100       | 3579.7       | III | 60        | 4683.57      | III |
| 35                     | 7356.54      | I   | 600       | 1469.61      | I   | 80        | 3583.6       | III | 30        | 4723.60      | III |
| 29 c                   | 8027.39      | I   | 80        | 2668.98      | III | 100 w     | 3595.4       | III | 600       | 4734.152     | I   |
| 120 w                  | 8116.80      | I   | 100       | 2717.33      | III | 100       | 3606.06      | III | 100 w     | 4757.3       | III |
| 70 c                   | 8161.07      | I   | 30        | 2814.45      | III | 40        | 3607.0       | III | 150       | 4792.619     | I   |
| 60 c                   | 8919.85      | I   | 40        | 2815.91      | III | 15        | 3610.32      | I   | 500       | 4807.02      | I   |
| <i>Xenon Xe Z = 54</i> |              |     | 30        | 2827.45      | III | 8         | 3613.06      | I   | 400       | 4829.71      | I   |
| 8                      | 657.8        | III | 40        | 2847.65      | III | 100 w     | 3615.9       | III | 300       | 4843.29      | I   |
| 8                      | 660.1        | III | 30        | 2862.40      | III | 40        | 3623.1       | III | 40        | 4869.5       | III |
| 9                      | 673.8        | III | 200       | 2864.73      | II  | 600       | 3624.08      | III | 500       | 4916.51      | I   |
| 9                      | 674.0        | III | 80 w      | 2871.10      | III | 6         | 3633.06      | I   | 500       | 4923.152     | I   |
| 9                      | 676.6        | III | 60 w      | 2871.24      | III | 10        | 3669.91      | I   | 200 l     | 4971.71      | II  |
| 10                     | 694.0        | III | 30        | 2871.7       | III | 50        | 3676.67      | III | 400       | 4972.71      | II  |
| 20                     | 698.5        | III | 150 h     | 2895.22      | II  | 40        | 3685.90      | I   | 300       | 4988.77      | II  |
| 12                     | 705.1        | III | 30        | 2896.62      | III | 40        | 3693.49      | I   | 100 l     | 4991.17      | II  |
| 10                     | 721.2        | III | 50        | 2906.6       | III | 40        | 3776.3       | III | 200       | 5028.280     | I   |
| 15                     | 731.0        | III | 40        | 2911.89      | III | 300       | 3781.02      | III | 200       | 5044.92      | II  |
| 10                     | 733.3        | III | 80 w      | 2912.36      | III | 100       | 3841.5       | III | 1000      | 5080.62      | II  |
| 350                    | 740.41       | II  | 40        | 2940.2       | III | 200       | 3877.8       | III | 300       | 5122.42      | II  |
| 15                     | 742.6        | III | 60        | 2945.2       | III | 60        | 3880.5       | III | 100       | 5125.70      | II  |
| 10                     | 756.0        | III | 40        | 2947.5       | III | 100 l     | 3907.91      | II  | 100       | 5178.82      | II  |
| 10                     | 761.5        | III | 40        | 2948.1       | III | 500       | 3922.55      | III | 300       | 5188.04      | II  |
| 10                     | 769.1        | III | 80 w      | 2970.47      | III | 300       | 3950.59      | III | 400       | 5191.37      | II  |
| 25                     | 779.1        | III | 400       | 2979.32      | II  | 100       | 4037.59      | II  | 100       | 5192.10      | II  |
| 15                     | 792.9        | III | 40        | 2992.87      | III | 200       | 4050.07      | III | 60        | 5239.0       | III |
| 12                     | 796.1        | III | 30        | 3004.25      | III | 200 l     | 4057.46      | II  | 500       | 5260.44      | II  |
| 15                     | 802.0        | III | 100 h     | 3017.43      | II  | 60        | 4060.4       | III | 500       | 5261.95      | II  |
| 350                    | 803.07       | II  | 100       | 3023.81      | III | 100 h     | 4098.89      | II  | 2000      | 5292.22      | II  |
| 25                     | 823.2        | III | 40        | 3083.5       | III | 100       | 4109.1       | III | 300       | 5309.27      | II  |
| 30                     | 824.9        | III | 50        | 3091.1       | III | 100       | 4145.7       | III | 1000      | 5313.87      | II  |
| 25                     | 853.0        | III | 30        | 3106.46      | III | 200 l     | 4158.04      | II  | 2000      | 5339.33      | II  |
| 600                    | 880.80       | II  | 300       | 3128.87      | II  | 1000 h    | 4180.10      | II  | 200       | 5363.20      | II  |
| 350                    | 885.54       | II  | 100 w     | 3138.3       | III | 500 h     | 4193.15      | II  | 30        | 5367.1       | III |
| 15                     | 889.3        | III | 80 c      | 3150.82      | III | 300 h     | 4208.48      | II  | 200       | 5368.07      | II  |
| 20                     | 894.0        | III | 40        | 3185.2       | III | 100 h     | 4209.47      | II  | 500       | 5372.39      | II  |
| 20                     | 896.0        | III | 100       | 3242.86      | III | 300 h     | 4213.72      | II  | 100       | 5392.80      | I   |
| 600                    | 925.87       | II  | 80        | 3268.98      | III | 100       | 4215.60      | II  | 50        | 5401.0       | III |
| 250                    | 935.40       | II  | 30        | 3287.82      | III | 300 h     | 4223.00      | II  | 3000      | 5419.15      | II  |
| 10                     | 965.5        | III | 80 w      | 3301.55      | III | 400 h     | 4238.25      | II  | 800       | 5438.96      | II  |
| 800                    | 972.77       | II  | 40        | 3331.6       | III | 500 h     | 4245.38      | II  | 300       | 5445.45      | II  |
| 700                    | 976.68       | II  | 30        | 3358.0       | III | 100 l     | 4251.57      | II  | 200       | 5450.45      | II  |
| 35                     | 1003.4       | III | 200 h     | 3366.72      | II  | 30        | 4285.9       | III | 400       | 5460.39      | II  |
| 35                     | 1017.7       | III | 80        | 3384.12      | III | 500 h     | 4296.40      | II  | 1000      | 5472.61      | II  |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity                  | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|----|-----------|--------------|----|----------------------------|--------------|-----|
| 100 I     | 5494.86      | II  | 200       | 6528.65      | II | 300       | 8739.39      | I  | 500                        | 30794.18     | I   |
| 40        | 5524.4       | III | 100       | 6533.16      | I  | 100       | 8758.20      | I  | 6000                       | 31069.23     | I   |
| 200       | 5525.53      | II  | 1000      | 6595.01      | II | 5000      | 8819.41      | I  | 125                        | 31336.01     | I   |
| 600       | 5531.07      | II  | 100       | 6595.56      | I  | 300       | 8862.32      | I  | 550                        | 31607.91     | I   |
| 100       | 5566.62      | I   | 400       | 6597.25      | II | 200       | 8908.73      | I  | 100                        | 32293.08     | I   |
| 300       | 5616.67      | II  | 100       | 6598.84      | II | 200       | 8930.83      | I  | 1800                       | 32739.26     | I   |
| 300       | 5659.38      | II  | 150       | 6668.92      | I  | 1000      | 8952.25      | I  | 3500                       | 33666.69     | I   |
| 600       | 5667.56      | II  | 300       | 6694.32      | II | 100       | 8981.05      | I  | 150                        | 34014.67     | I   |
| 150       | 5670.91      | II  | 200       | 6728.01      | I  | 200       | 8987.57      | I  | 450                        | 34335.27     | I   |
| 100       | 5695.75      | I   | 150       | 6788.71      | II | 400       | 9045.45      | I  | 170                        | 34744.00     | I   |
| 200       | 5699.61      | II  | 100       | 6790.37      | II | 500       | 9162.65      | I  | 5000                       | 35070.25     | I   |
| 200       | 5716.10      | II  | 1000      | 6805.74      | II | 100       | 9167.52      | I  | 110                        | 35246.92     | I   |
| 500       | 5726.91      | II  | 200       | 6827.32      | I  | 100       | 9374.76      | I  | 250                        | 36209.21     | I   |
| 500       | 5751.03      | II  | 100       | 6872.11      | I  | 200       | 9513.38      | I  | 150                        | 36231.74     | I   |
| 300       | 5758.65      | II  | 300       | 6882.16      | I  | 50 h      | 9591.35      | II | 450                        | 36508.36     | I   |
| 300       | 5776.39      | II  | 80        | 6910.22      | II | 150       | 9685.32      | I  | 850                        | 36788.83     | I   |
| 100       | 5815.96      | II  | 100       | 6925.53      | I  | 50 I      | 9698.68      | II | 140                        | 38685.98     | I   |
| 300       | 5823.89      | I   | 800 h     | 6942.11      | II | 100       | 9718.16      | I  | 175                        | 38737.82     | I   |
| 150       | 5824.80      | I   | 100       | 6976.18      | I  | 2000      | 9799.70      | I  | 270                        | 38939.60     | I   |
| 100       | 5875.02      | I   | 2000      | 6990.88      | II | 3000      | 9923.19      | I  | 120                        | 39955.14     | I   |
| 300       | 5893.29      | II  | 150       | 7082.15      | II | 100       | 10838.37     | I  | <i>Ytterbium Yb Z = 70</i> |              |     |
| 100       | 5894.99      | I   | 500       | 7119.60      | I  | 90        | 11742.01     | I  | 1000                       | 1050.24      | IV  |
| 200       | 5905.13      | II  | 50 s      | 7147.50      | II | 375       | 12235.24     | I  | 1000                       | 1054.46      | IV  |
| 100       | 5934.17      | I   | 200       | 7149.03      | II | 100       | 12257.76     | I  | 5000                       | 1134.43      | IV  |
| 500       | 5945.53      | II  | 500       | 7164.83      | II | 300       | 12590.20     | I  | 900                        | 1316.04      | IV  |
| 300       | 5971.13      | II  | 100       | 7284.34      | II | 2500      | 12623.391    | I  | 800                        | 1326.36      | IV  |
| 2000      | 5976.46      | II  | 200       | 7301.80      | II | 250       | 13544.15     | I  | 900                        | 1350.26      | IV  |
| 200       | 6008.92      | II  | 200       | 7339.30      | II | 2000      | 13657.055    | I  | 80                         | 1561.42      | III |
| 1000      | 6036.20      | II  | 100       | 7386.00      | I  | 1250      | 14142.444    | I  | 80 h                       | 1765.21      | III |
| 2000      | 6051.15      | II  | 150       | 7393.79      | I  | 800       | 14240.96     | I  | 800                        | 1791.06      | IV  |
| 600       | 6093.50      | II  | 300       | 7548.45      | II | 375       | 14364.99     | I  | 100                        | 1863.32      | III |
| 1500      | 6097.59      | II  | 200       | 7584.68      | I  | 140       | 14660.81     | I  | 800                        | 1873.91      | III |
| 400       | 6101.43      | II  | 80        | 7618.57      | II | 3000      | 14732.806    | I  | 500                        | 1898.25      | III |
| 100       | 6115.08      | II  | 500       | 7642.02      | I  | 100       | 15099.72     | I  | 500                        | 1998.82      | III |
| 100       | 6146.45      | II  | 100       | 7643.91      | I  | 2500      | 15418.394    | I  | 900                        | 2116.65      | IV  |
| 150       | 6178.30      | I   | 200       | 7670.66      | II | 150       | 15557.13     | I  | 2500                       | 2116.67      | II  |
| 120       | 6179.66      | I   | 60        | 7787.04      | II | 250       | 15979.54     | I  | 800                        | 2123.32      | IV  |
| 300       | 6182.42      | I   | 100       | 7802.65      | I  | 100       | 16039.90     | I  | 3000                       | 2126.74      | II  |
| 500       | 6194.07      | II  | 100       | 7881.32      | I  | 1000      | 16053.28     | I  | 800                        | 2139.99      | IV  |
| 100       | 6198.26      | I   | 300       | 7887.40      | I  | 125       | 16554.49     | I  | 20000                      | 2144.77      | IV  |
| 60        | 6205.97      | III | 500       | 7967.34      | I  | 1500      | 16728.15     | I  | 15000                      | 2154.18      | IV  |
| 100       | 6220.02      | II  | 100       | 8029.67      | I  | 1500      | 17325.77     | I  | 370                        | 2161.60      | II  |
| 25        | 6221.7       | III | 200       | 8057.26      | I  | 350       | 18788.13     | I  | 850                        | 2185.71      | II  |
| 60        | 6238.2       | III | 150       | 8061.34      | I  | 150       | 20187.19     | I  | 640                        | 2224.46      | II  |
| 60        | 6259.05      | III | 100       | 8101.98      | I  | 3000      | 20262.242    | I  | 300                        | 2240.11      | III |
| 500       | 6270.82      | II  | 150 h     | 8151.80      | II | 250       | 21470.09     | I  | 300                        | 2305.32      | III |
| 400       | 6277.54      | II  | 100       | 8171.02      | I  | 1250      | 23193.33     | I  | 140                        | 2320.81      | II  |
| 100       | 6284.41      | II  | 700       | 8206.34      | I  | 110       | 23279.54     | I  | 170                        | 2390.74      | II  |
| 100       | 6286.01      | I   | 10000     | 8231.635     | I  | 1800      | 24824.71     | I  | 460                        | 2464.50      | I   |
| 250       | 6300.86      | II  | 500       | 8266.52      | I  | 175       | 25145.84     | I  | 140                        | 2512.06      | II  |
| 500       | 6318.06      | I   | 7000      | 8280.116     | I  | 2000      | 26269.08     | I  | 270                        | 2538.67      | II  |
| 400       | 6343.96      | II  | 2000      | 8346.82      | I  | 2500      | 26510.86     | I  | 2000                       | 2567.61      | III |
| 600       | 6356.35      | II  | 100       | 8347.24      | II | 250       | 28381.54     | I  | 1000                       | 2579.57      | III |
| 200       | 6375.28      | II  | 2000      | 8409.19      | I  | 750       | 28582.25     | I  | 800                        | 2599.14      | III |
| 100       | 6397.99      | II  | 50 h      | 8515.19      | II | 300       | 29384.41     | I  | 600                        | 2621.11      | III |
| 300       | 6469.70      | I   | 200       | 8576.01      | I  | 150       | 29448.06     | I  | 1000                       | 2642.56      | III |
| 150       | 6472.84      | I   | 50 h      | 8604.23      | II | 100       | 29649.58     | I  | 1000                       | 2651.74      | III |
| 120       | 6487.76      | I   | 250       | 8648.54      | I  | 100       | 29813.62     | I  | 700                        | 2652.25      | III |
| 100       | 6498.72      | I   | 100       | 8692.20      | I  | 600       | 30253.14     | I  | 990                        | 2653.75      | II  |
| 200 h     | 6504.18      | I   | 200       | 8696.86      | I  | 1500      | 30475.46     | I  | 200                        | 2665.04      | II  |
| 300       | 6512.83      | II  | 50 h      | 8716.19      | II | 100       | 30504.12     | I  | 2000                       | 2666.13      | III |

| Intensity | Wavelength/Å |     | Intensity | Wavelength/Å |     | Intensity               | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|-----|-----------|--------------|-----|-------------------------|--------------|-----|-----------|--------------|-----|
| 2000      | 2666.99      | III | 140       | 3418.39      | I   | 170                     | 4786.61      | II  | 500       | 344.59       | V   |
| 390       | 2671.96      | I   | 360       | 3426.04      | I   | 35                      | 4816.43      | I   | 900       | 355.86       | IV  |
| 390       | 2672.66      | II  | 240       | 3431.11      | I   | 40                      | 4837.46      | I   | 300       | 370.42       | IV  |
| 170       | 2718.35      | II  | 85        | 3452.40      | I   | 40 h                    | 4894.60      | I   | 300       | 372.05       | V   |
| 230       | 2748.66      | II  | 500       | 3454.08      | II  | 27                      | 4912.36      | I   | 400       | 379.96       | V   |
| 1300      | 2750.48      | II  | 190 d     | 3458.29      | II  | 710                     | 4935.50      | I   | 500       | 386.82       | IV  |
| 170       | 2776.28      | II  | 360       | 3460.27      | I   | 140                     | 4966.90      | I   | 300       | 403.45       | V   |
| 600       | 2795.60      | III | 2400      | 3464.37      | I   | 30                      | 5067.80      | I   | 300       | 420.74       | V   |
| 1000      | 2803.43      | III | 500       | 3476.30      | II  | 70                      | 5069.14      | I   | 600       | 425.03       | IV  |
| 600       | 2816.92      | III | 500       | 3478.84      | II  | 220                     | 5074.34      | I   | 300       | 473.10       | IV  |
| 1000      | 2818.72      | III | 50        | 3517.00      | I   | 50                      | 5076.74      | I   | 4000      | 584.98       | V   |
| 140       | 2821.15      | II  | 230       | 3520.29      | II  | 60                      | 5196.08      | I   | 2000      | 630.97       | V   |
| 190       | 2830.99      | II  | 35        | 3559.03      | I   | 85                      | 5211.60      | I   | 5000      | 805.20       | III |
| 230 h     | 2847.18      | II  | 200       | 3560.33      | II  | 100                     | 5244.11      | I   | 7000      | 809.92       | III |
| 360       | 2851.13      | II  | 170       | 3560.70      | II  | 150 h                   | 5277.04      | I   | 15000     | 989.21       | III |
| 430       | 2859.80      | II  | 360       | 3585.47      | II  | 170                     | 5335.15      | II  | 25000     | 996.37       | III |
| 140       | 2861.21      | II  | 200       | 3619.80      | II  | 30 h                    | 5351.29      | I   | 5000      | 1314.51      | III |
| 200       | 2867.06      | II  | 240       | 3637.76      | II  | 150                     | 5352.95      | II  | 4000      | 1334.04      | III |
| 45        | 2873.49      | I   | 70        | 3648.15      | I   | 30                      | 5363.66      | I   | 4000      | 2068.98      | III |
| 200       | 2888.04      | II  | 90        | 3655.73      | I   | 40                      | 5449.27      | II  | 10000     | 2127.98      | III |
| 3600      | 2891.38      | II  | 240       | 3669.69      | II  | 60                      | 5481.92      | I   | 16000     | 2191.16      | III |
| 600       | 2898.30      | III | 140       | 3675.08      | II  | 40                      | 5505.49      | I   | 350       | 2243.06      | II  |
| 1000      | 2906.31      | III | 32000     | 3694.19      | II  | 17                      | 5524.54      | I   | 10000     | 2284.34      | III |
| 170       | 2914.21      | II  | 70        | 3700.58      | I   | 85 h                    | 5539.05      | I   | 10000     | 2327.31      | III |
| 140       | 2915.28      | II  | 400       | 3711.91      | III | 2400                    | 5556.47      | I   | 50        | 2354.20      | I   |
| 280       | 2919.35      | II  | 180       | 3734.69      | I   | 60                      | 5651.98      | II  | 50000     | 2367.23      | III |
| 35        | 2934.36      | I   | 550       | 3770.10      | I   | 220                     | 5719.99      | I   | 40000     | 2414.64      | III |
| 140       | 2945.91      | II  | 80        | 3774.32      | I   | 27                      | 5771.66      | II  | 560       | 2422.20      | II  |
| 2000      | 2970.56      | II  | 60 h      | 3791.74      | I   | 35                      | 5833.99      | II  | 60        | 2694.21      | I   |
| 200       | 2983.99      | II  | 170       | 3839.91      | I   | 35                      | 5837.14      | II  | 95        | 2723.00      | I   |
| 170       | 2994.80      | II  | 340       | 3872.85      | I   | 27                      | 5854.51      | I   | 70        | 2742.53      | I   |
| 800       | 2998.00      | III | 340       | 3900.85      | I   | 17                      | 5989.33      | I   | 140       | 2760.10      | I   |
| 310       | 3005.77      | II  | 140       | 3911.27      | I   | 40                      | 5991.51      | II  | 90000     | 2817.04      | III |
| 160       | 3017.56      | II  | 500       | 3931.23      | III | 60                      | 6152.57      | II  | 45        | 2822.56      | I   |
| 160       | 3026.67      | II  | 32000     | 3987.99      | I   | 60                      | 6274.78      | II  | 70        | 2854.43      | II  |
| 2000      | 3029.49      | III | 930       | 3990.88      | I   | 200                     | 6328.52      | III | 95        | 2886.48      | I   |
| 920       | 3031.11      | II  | 50        | 4007.36      | I   | 35 h                    | 6400.35      | I   | 160       | 2919.05      | I   |
| 3000      | 3092.50      | III | 2000      | 4028.14      | III | 35 h                    | 6417.91      | I   | 99000     | 2946.01      | III |
| 28        | 3100.74      | I   | 70        | 4052.28      | I   | 340                     | 6489.06      | I   | 390       | 2948.40      | I   |
| 170       | 3107.90      | II  | 440       | 4089.68      | I   | 180                     | 6667.82      | I   | 350       | 2964.96      | I   |
| 190       | 3117.81      | II  | 470       | 4149.07      | I   | 25                      | 6727.61      | II  | 480       | 2974.59      | I   |
| 4000      | 3126.01      | III | 120       | 4174.56      | I   | 690                     | 6799.60      | I   | 750       | 2984.26      | I   |
| 1000      | 3138.58      | III | 340       | 4180.81      | II  | 9 h                     | 7244.41      | I   | 140       | 2996.94      | I   |
| 230       | 3140.94      | II  | 300       | 4213.64      | III | 8 h                     | 7305.22      | I   | 130       | 3021.73      | I   |
| 28        | 3162.29      | I   | 150 d     | 4218.56      | II  | 10 h                    | 7313.05      | I   | 190       | 3045.37      | I   |
| 800       | 3191.35      | III | 120       | 4231.97      | I   | 16 h                    | 7350.04      | I   | 95        | 3095.88      | II  |
| 390       | 3192.88      | II  | 70        | 4277.74      | I   | 25                      | 7448.28      | I   | 110       | 3173.06      | II  |
| 240       | 3201.16      | II  | 120       | 4305.97      | I   | 30 h                    | 7527.46      | I   | 220       | 3179.41      | II  |
| 2000      | 3228.58      | III | 60 h      | 4393.69      | I   | 750                     | 7699.48      | I   | 70        | 3191.31      | I   |
| 35        | 3239.58      | I   | 60 h      | 4430.21      | I   | 100                     | 7971.46      | III | 2300      | 3195.62      | II  |
| 18000     | 3289.37      | II  | 440       | 4439.19      | I   | 70 h                    | 8922.56      | II  | 2200      | 3200.27      | II  |
| 130       | 3305.25      | I   | 85 h      | 4482.42      | I   | 200                     | 10110.60     | III | 2200      | 3203.32      | II  |
| 140       | 3305.73      | II  | 100       | 4517.58      | III | 100                     | 10830.36     | III | 3900      | 3216.69      | II  |
| 80        | 3319.41      | I   | 85 h      | 4563.95      | I   | <i>Yttrium Y Z = 39</i> |              |     | 6200      | 3242.28      | II  |
| 2000      | 3325.51      | III | 640       | 4576.21      | I   | 150                     | 264.64       | IV  | 4700      | 3327.89      | II  |
| 240       | 3337.17      | II  | 200       | 4582.36      | I   | 150                     | 273.03       | IV  | 85        | 3388.59      | I   |
| 280 d     | 3342.93      | II  | 70        | 4589.21      | I   | 900                     | 333.09       | V   | 85        | 3412.47      | I   |
| 240       | 3375.48      | II  | 140       | 4590.83      | I   | 500                     | 333.80       | V   | 170       | 3485.73      | I   |
| 2000      | 3384.01      | III | 40        | 4684.27      | I   | 400                     | 335.14       | V   | 1700      | 3496.09      | II  |
| 140       | 3387.50      | I   | 190       | 4726.08      | II  | 500                     | 336.62       | V   | 3900      | 3549.01      | II  |
| 50        | 3412.45      | I   | 170 h     | 4781.87      | I   | 500                     | 339.02       | V   | 130       | 3551.80      | I   |

| Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |     | Intensity             | Wavelength/Å |     | Intensity | Wavelength/Å |     |
|-----------|--------------|----|-----------|--------------|-----|-----------------------|--------------|-----|-----------|--------------|-----|
| 540       | 3552.69      | I  | 300       | 4487.47      | I   | 160                   | 5706.73      | I   | 100       | 1767.69      | III |
| 170       | 3558.76      | I  | 500       | 4505.95      | I   | 90                    | 5743.85      | I   | 100       | 1797.64      | II  |
| 190       | 3571.43      | I  | 890       | 4527.25      | I   | 75                    | 5765.64      | I   | 100 d     | 1811.05      | II  |
| 260       | 3576.05      | I  | 440       | 4527.80      | I   | 100                   | 5781.69      | II  | 100 d     | 1833.57      | II  |
| 3300      | 3584.52      | II | 100       | 4544.32      | I   | 120                   | 6009.19      | I   | 100       | 1864.12      | II  |
| 300       | 3587.75      | I  | 100       | 4559.37      | I   | 120                   | 6023.41      | I   | 100       | 1866.08      | II  |
| 100       | 3589.69      | I  | 130       | 4596.55      | I   | 120                   | 6135.04      | I   | 100       | 1872.13      | II  |
| 2800      | 3592.92      | I  | 95        | 4604.80      | I   | 150                   | 6138.43      | I   | 100 d     | 1918.96      | II  |
| 10000     | 3600.73      | II | 2000      | 4643.70      | I   | 1200                  | 6191.73      | I   | 100 d     | 1929.67      | II  |
| 6200      | 3601.92      | II | 200 h     | 4658.32      | I   | 300                   | 6222.59      | I   | 100       | 1969.40      | II  |
| 7800      | 3611.05      | II | 2000      | 4674.84      | I   | 1000                  | 6435.00      | I   | 100       | 1982.11      | II  |
| 4300      | 3620.94      | I  | 180       | 4696.81      | I   | 90                    | 6538.60      | I   | 100       | 1986.99      | II  |
| 1900      | 3628.71      | II | 170       | 4728.53      | I   | 70                    | 6557.39      | I   | 500       | 2025.48      | II  |
| 7800      | 3633.12      | II | 160       | 4752.79      | I   | 95                    | 6613.75      | II  | 500       | 2062.00      | II  |
| 3000      | 3664.61      | II | 410       | 4760.98      | I   | 40                    | 6650.61      | I   | 200       | 2064.23      | II  |
| 170       | 3692.53      | I  | 120       | 4781.04      | I   | 150                   | 6687.58      | I   | 120       | 2079.08      | I   |
| 13000     | 3710.30      | II | 170       | 4786.89      | I   | 70                    | 6700.71      | I   | 300       | 2099.94      | II  |
| 1200      | 3747.55      | II | 180       | 4799.30      | I   | 190                   | 6793.71      | I   | 200       | 2102.18      | II  |
| 10000     | 3774.33      | II | 140       | 4819.64      | I   | 21                    | 6815.16      | I   | 800 r     | 2138.56      | I   |
| 1400      | 3776.56      | II | 120       | 4822.13      | I   | 45                    | 6845.24      | I   | 1000      | 2501.99      | II  |
| 7400      | 3788.70      | II | 770       | 4839.87      | I   | 29                    | 6887.22      | I   | 150       | 2515.81      | I   |
| 1300      | 3818.35      | II | 550       | 4845.68      | I   | 24 h                  | 6950.31      | I   | 1000      | 2557.95      | II  |
| 4000      | 3832.88      | II | 410       | 4852.69      | I   | 24                    | 6979.88      | I   | 300       | 2582.49      | I   |
| 80        | 3876.82      | I  | 120       | 4854.25      | I   | 29                    | 7052.94      | I   | 200       | 2608.56      | I   |
| 480       | 3878.28      | II | 890       | 4854.87      | II  | 35                    | 7191.66      | I   | 300       | 2608.64      | I   |
| 4400      | 3950.36      | II | 330       | 4859.84      | I   | 35                    | 7264.17      | II  | 200       | 2670.53      | I   |
| 3600      | 3982.60      | II | 1900      | 4883.69      | II  | 50                    | 7346.46      | I   | 300       | 2684.16      | I   |
| 940       | 4039.83      | I  | 95        | 4893.44      | I   | 29                    | 7450.30      | II  | 300       | 2712.49      | I   |
| 2400      | 4047.64      | I  | 1100      | 4900.12      | II  | 9000                  | 7558.71      | III | 200       | 2756.45      | I   |
| 9400      | 4077.38      | I  | 100       | 4906.11      | I   | 35                    | 7563.13      | I   | 300       | 2770.86      | I   |
| 2000      | 4083.71      | I  | 150       | 4921.87      | I   | 29                    | 7855.52      | I   | 300       | 2770.98      | I   |
| 9900      | 4102.38      | I  | 120       | 4974.30      | I   | 110                   | 7881.90      | II  | 400       | 2800.87      | I   |
| 8900      | 4128.31      | I  | 100       | 5006.97      | I   | 10000                 | 7991.43      | III | 100       | 2801.06      | I   |
| 7500      | 4142.85      | I  | 75        | 5070.21      | I   | 24                    | 8344.43      | I   | 200       | 3035.78      | I   |
| 100 h     | 4157.63      | I  | 75        | 5072.19      | I   | 10000                 | 8796.21      | III | 200       | 3072.06      | I   |
| 2400      | 4167.52      | I  | 1100      | 5087.42      | II  | 95                    | 8800.62      | I   | 300       | 3196.31      | II  |
| 2000      | 4174.14      | I  | 180       | 5135.20      | I   | 19 h                  | 8835.85      | II  | 500 r     | 3282.33      | I   |
| 8000      | 4177.54      | II | 960       | 5200.41      | II  | <i>Zinc Zn Z = 30</i> |              |     | 800       | 3302.58      | I   |
| 160       | 4217.80      | I  | 1500      | 5205.72      | II  | 200                   | 425.90       | IV  | 700 r     | 3302.94      | I   |
| 280 h     | 4220.63      | I  | 10000     | 5238.10      | III | 200                   | 428.54       | IV  | 800       | 3345.02      | I   |
| 600       | 4235.73      | II | 180       | 5240.81      | I   | 200                   | 430.59       | IV  | 500       | 3345.57      | I   |
| 2200      | 4235.94      | I  | 75        | 5380.62      | I   | 1000                  | 677.63       | III | 50        | 3883.34      | I   |
| 300       | 4251.20      | I  | 220       | 5402.78      | II  | 750                   | 677.96       | III | 300       | 4680.14      | I   |
| 360 h     | 4302.30      | I  | 90        | 5424.37      | I   | 200                   | 713.90       | III | 400       | 4722.15      | I   |
| 2800      | 4309.63      | II | 190       | 5438.24      | I   | 60                    | 1193.23      | II  | 400       | 4810.53      | I   |
| 110       | 4330.78      | I  | 710       | 5466.46      | I   | 50                    | 1239.12      | IV  | 800       | 4911.62      | II  |
| 440 h     | 4348.79      | I  | 100       | 5468.47      | I   | 50                    | 1249.69      | IV  | 500       | 4924.03      | II  |
| 120       | 4357.73      | I  | 240       | 5497.41      | II  | 500                   | 1265.74      | IV  | 200       | 5181.98      | I   |
| 800       | 4358.73      | II | 300       | 5503.45      | I   | 500                   | 1306.66      | IV  | 500       | 5894.33      | II  |
| 120       | 4366.03      | I  | 250       | 5509.90      | II  | 200                   | 1456.72      | III | 500       | 6021.18      | II  |
| 12000     | 4374.94      | II | 120       | 5521.63      | I   | 200                   | 1459.98      | IV  | 500       | 6102.49      | II  |
| 150 h     | 4375.61      | I  | 740       | 5527.54      | I   | 300                   | 1499.42      | III | 500       | 6214.61      | II  |
| 100       | 4387.74      | I  | 120       | 5544.50      | I   | 300                   | 1500.42      | III | 1000 h    | 6362.34      | I   |
| 1800      | 4398.02      | II | 180       | 5577.42      | I   | 300                   | 1505.92      | III | 300       | 7588.5       | II  |
| 890       | 4422.59      | II | 620       | 5581.87      | I   | 300                   | 1515.85      | III | 300       | 7732.5       | II  |
| 100       | 4443.66      | I  | 120       | 5606.33      | I   | 300                   | 1552.30      | III | 100       | 11054.25     | I   |
| 130       | 4446.63      | I  | 560       | 5630.13      | I   | 90                    | 1572.99      | II  | 100       | 13053.63     | I   |
| 170       | 4475.72      | I  | 120       | 5644.69      | I   | 200                   | 1629.19      | III | 100       | 13150.59     | I   |
| 180       | 4476.96      | I  | 120       | 5648.47      | I   | 200                   | 1639.33      | III | 100       | 14038.70     | I   |
| 160       | 4477.45      | I  | 740       | 5662.94      | II  | 200                   | 1673.05      | III | 20        | 16483.45     | I   |
| 110       | 4487.28      | I  | 90        | 5675.27      | I   | 80 d                  | 1735.61      | II  | 20        | 16491.98     | I   |

| Intensity                  | Wavelength/Å |     | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    | Intensity | Wavelength/Å |    |
|----------------------------|--------------|-----|-----------|--------------|----|-----------|--------------|----|-----------|--------------|----|
| 20                         | 16505.23     | I   | 620       | 2814.90      | I  | 1000      | 3430.53      | II | 770       | 3998.97      | II |
| 10                         | 24375.02     | I   | 390       | 2818.74      | II | 4700      | 3438.23      | II | 400       | 4023.98      | I  |
| <i>Zirconium Zr Z = 40</i> |              |     | 530       | 2825.56      | II | 600       | 3447.36      | I  | 770       | 4024.92      | I  |
| 500                        | 304.01       | V   | 710       | 2837.23      | I  | 410       | 3457.56      | II | 990       | 4027.20      | I  |
| 60                         | 480.66       | IV  | 660       | 2844.58      | II | 820       | 3463.02      | II | 400       | 4029.68      | II |
| 60                         | 497.23       | IV  | 350       | 2848.52      | I  | 600       | 3471.19      | I  | 490       | 4030.04      | I  |
| 60                         | 500.22       | IV  | 350       | 2851.97      | II | 1200      | 3479.39      | II | 400       | 4035.89      | I  |
| 600                        | 628.66       | IV  | 340       | 2869.81      | II | 1300      | 3481.15      | II | 610       | 4043.58      | I  |
| 500                        | 633.56       | IV  | 490       | 2875.98      | I  | 4100      | 3496.21      | II | 490       | 4044.56      | I  |
| 50                         | 690.39       | III | 300       | 2915.99      | II | 820       | 3505.67      | II | 400       | 4045.61      | II |
| 2000                       | 740.61       | V   | 270       | 2918.24      | II | 1000      | 3509.32      | I  | 610       | 4048.67      | II |
| 10000                      | 800.00       | V   | 320       | 2926.99      | II | 2000      | 3519.60      | I  | 770       | 4055.03      | I  |
| 10000                      | 806.89       | V   | 320       | 2948.94      | II | 440       | 3525.81      | II | 600       | 4055.71      | I  |
| 10000                      | 812.05       | V   | 320       | 2955.78      | II | 440       | 3533.22      | I  | 1500      | 4064.16      | I  |
| 3000                       | 841.40       | V   | 320       | 2960.87      | I  | 630       | 3542.62      | II | 2000      | 4072.70      | I  |
| 300                        | 863.65       | IV  | 320       | 2962.68      | II | 1800      | 3547.68      | I  | 240       | 4078.31      | I  |
| 500                        | 864.59       | IV  | 320       | 2968.96      | II | 630       | 3550.46      | I  | 2000      | 4081.22      | I  |
| 9000                       | 1183.97      | IV  | 320       | 2978.05      | II | 1800      | 3551.95      | II | 400       | 4121.46      | I  |
| 9000                       | 1201.77      | IV  | 820       | 2985.39      | I  | 2100      | 3556.60      | II | 1200      | 4149.20      | II |
| 10000                      | 1219.86      | IV  | 320       | 3003.74      | II | 1100      | 3566.10      | I  | 400       | 4161.21      | II |
| 500                        | 1303.93      | V   | 820       | 3011.75      | I  | 2100      | 3572.47      | II | 400       | 4166.36      | I  |
| 500 p                      | 1323.81      | V   | 350       | 3020.47      | II | 1100      | 3575.79      | I  | 660       | 4187.56      | I  |
| 1000                       | 1469.47      | IV  | 500       | 3028.04      | II | 1300      | 3576.85      | II | 400       | 4194.76      | I  |
| 10000                      | 1546.17      | IV  | 880       | 3029.52      | I  | 880       | 3586.29      | I  | 610       | 4199.09      | I  |
| 10000                      | 1598.95      | IV  | 350 d     | 3036.39      | II | 3500      | 3601.19      | I  | 610       | 4201.46      | I  |
| 5000                       | 1607.95      | IV  | 690       | 3054.84      | II | 690       | 3611.89      | II | 610       | 4208.98      | II |
| 100                        | 1612.38      | III | 690       | 3106.58      | II | 1100      | 3613.10      | II | 400       | 4213.86      | I  |
| 700                        | 1725.02      | V   | 350       | 3120.74      | I  | 1100      | 3614.77      | II | 2000      | 4227.76      | I  |
| 200                        | 1790.19      | III | 500       | 3129.18      | II | 1100      | 3623.86      | I  | 2000      | 4239.31      | I  |
| 150                        | 1793.56      | III | 500       | 3129.76      | II | 1100      | 3663.65      | I  | 770       | 4240.34      | I  |
| 125                        | 1798.13      | III | 350       | 3132.07      | I  | 390       | 3671.27      | II | 770       | 4241.20      | I  |
| 600                        | 1860.86      | V   | 690       | 3138.68      | II | 800       | 3674.72      | II | 1200      | 4241.69      | I  |
| 200                        | 1940.25      | III | 540       | 3164.31      | II | 390       | 3697.46      | II | 550       | 4282.20      | I  |
| 600                        | 2028.54      | V   | 880       | 3165.97      | II | 960       | 3698.17      | II | 550       | 4294.79      | I  |
| 125                        | 2070.43      | III | 880       | 3182.86      | II | 720       | 3709.26      | II | 550       | 4341.13      | I  |
| 200                        | 2086.78      | III | 540       | 3191.21      | I  | 560       | 3745.98      | II | 1000      | 4347.89      | I  |
| 10000                      | 2091.49      | IV  | 540       | 3212.01      | I  | 880       | 3751.60      | II | 290       | 4359.74      | II |
| 10000                      | 2092.36      | IV  | 760       | 3214.19      | II | 480       | 3764.39      | I  | 310       | 4360.81      | I  |
| 600                        | 2132.42      | V   | 630       | 3231.69      | II | 480       | 3766.72      | I  | 350       | 4366.45      | I  |
| 10000                      | 2163.68      | IV  | 630       | 3234.12      | I  | 340       | 3766.82      | II | 550       | 4507.12      | I  |
| 100                        | 2175.80      | III | 760       | 3241.05      | II | 720       | 3780.54      | I  | 610       | 4535.75      | I  |
| 100                        | 2191.15      | III | 1000      | 3273.05      | II | 560       | 3791.40      | I  | 490       | 4542.22      | I  |
| 10000                      | 2286.67      | IV  | 1300      | 3279.26      | II | 560       | 3822.41      | I  | 490       | 4575.52      | I  |
| 100                        | 2301.60      | III | 880       | 3284.71      | II | 2200      | 3835.96      | I  | 350       | 4602.57      | I  |
| 90                         | 2539.65      | I   | 540       | 3305.15      | II | 1300      | 3836.76      | II | 700       | 4633.98      | I  |
| 570                        | 2567.64      | II  | 880       | 3306.28      | II | 550       | 3843.02      | II | 2300      | 4687.80      | I  |
| 1600                       | 2568.87      | II  | 380       | 3322.99      | II | 550       | 3847.01      | I  | 510       | 4688.45      | I  |
| 2100                       | 2571.39      | II  | 380       | 3326.80      | II | 550       | 3849.25      | I  | 1900      | 4710.08      | I  |
| 250                        | 2620.56      | III | 380       | 3334.25      | II | 2900      | 3863.87      | I  | 1400      | 4739.48      | I  |
| 200                        | 2643.79      | III | 760       | 3340.56      | II | 770       | 3864.34      | I  | 870       | 4772.31      | I  |
| 150                        | 2664.26      | III | 380       | 3344.79      | II | 990       | 3877.60      | I  | 700       | 4815.63      | I  |
| 1800                       | 2678.63      | II  | 760       | 3356.09      | II | 1500      | 3885.42      | I  | 250       | 5046.58      | I  |
| 90                         | 2687.75      | I   | 540       | 3357.26      | II | 2900      | 3890.32      | I  | 360       | 5064.91      | I  |
| 750                        | 2700.13      | II  | 380       | 3374.73      | II | 2000      | 3891.38      | I  | 470       | 5078.25      | I  |
| 1300                       | 2722.61      | II  | 570       | 3387.87      | II | 610       | 3921.79      | I  | 300       | 5155.45      | I  |
| 800                        | 2726.49      | II  | 760       | 3388.30      | II | 1200      | 3929.53      | I  | 200       | 5158.00      | I  |
| 1400                       | 2734.86      | II  | 5700      | 3391.98      | II | 940       | 3958.22      | II | 100       | 5191.60      | II |
| 1100                       | 2742.56      | II  | 570       | 3393.12      | II | 490       | 3966.66      | I  | 270       | 5385.14      | I  |
| 660                        | 2745.86      | II  | 570       | 3404.83      | II | 990       | 3968.26      | I  | 160       | 5664.51      | I  |
| 660                        | 2752.21      | II  | 760       | 3410.25      | II | 660       | 3973.50      | I  | 160       | 5797.74      | I  |
| 530                        | 2758.81      | II  | 380       | 3414.66      | I  | 770       | 3991.13      | II | 340       | 5879.80      | I  |



| Intensity | Wavelength/Å |   | Intensity | Wavelength/Å |   | Intensity | Wavelength/Å |   | Intensity | Wavelength/Å |   |
|-----------|--------------|---|-----------|--------------|---|-----------|--------------|---|-----------|--------------|---|
| 170       | 6045.85      | I | 300       | 6313.02      | I | 170       | 7103.72      | I | 790       | 8070.08      | I |
| 170       | 6121.91      | I | 150       | 6953.84      | I | 590       | 7169.09      | I | 390       | 8132.99      | I |
| 680       | 6127.44      | I | 150       | 6990.84      | I | 160       | 7944.61      | I | 280       | 8212.53      | I |
| 340       | 6134.55      | I | 540       | 7097.70      | I | 160       | 8005.27      | I |           |              |   |
| 440       | 6143.20      | I | 280       | 7102.91      | I | 150       | 8063.09      | I |           |              |   |

### Sources of Data for Each Element

Numbers following the element name refer to the references on the following pages.

Actinium: 193

Aluminum: 6,8,81,89,127,144,146,227,228,282

Americium: 92

Antimony: 164,167,194,386,406

Argon: 190,203,204,219,367,368,372,373,374,375,414,421

Arsenic: 163,168,197,244,280

Astatine: 188

Barium: 1,78,111,252,259,277,279

Berkelium: 53,339

Beryllium: 15,44,73,102,115,134,135,171,175,198,335

Bismuth: 1,357,358,359,360,361

Boron: 66,69,74,94,104,171,221,222

Bromine: 42,122,124,139,142,240,243,246,248,249,250,316

Cadmium: 44,285,296,353,399

Calcium: 16,25,70,150,270

Californium: 52,331

Carbon: 22,66,211

Cerium: 1,136,166,261,305

Cesium: 78,82,154,155,200,201,259,263,325

Chlorine: 11,28,30,31,85,233,238,239

Chromium: 1,379,380,412

Cobalt: 1,100,125,159,236,276,291

Copper: 199,273,290,295,324

Curium: 51,332

Dysprosium: 1

Einsteinium: 333

Erbium: 1,301

Europium: 1,312

Fluorine: 68,169,224,225,226

Francium: 408

Gadolinium: 1,46,137,151,152

Gallium: 2,19,62,132,140,141,143,195,281

Germanium: 5,119,293,340,341,342

Gold: 38,72,234,393,395

Hafnium: 1,369,404,410,425

Helium: 16,94,173,183,317

Holmium: 1

Hydrogen: 214

Indium: 1,132,348,349,350,351,352,353,435,436

Iodine: 20,21,58,84,124,153,161,176,184

Iridium: 1

Iron: 56,63,71,101,105,138,174,278,381,382

Krypton: 61,121,123,147,208,232,366,390,409,417,421

Lanthanum: 1,78,79,220,309

Lead: 54,64,106,256,274,297,283,329,330

Lithium: 3,15,17,18,37,44,112,284,321,335

Lutetium: 1,148,310,401

Magnesium: 4,7,49,83,103,128,129,177,217,269,315,335

Manganese: 1,126,385,405,433

Mercury (198): 43,50,69,145,229,242

Mercury (Natural): 34,45,90,117,133,189,235,304,327,328,343

Molybdenum: 1,383,420

Neodymium: 1

Neon: 56,58,69,118,150,230,364,365,371,388,389,400,402,413,430

Neptunium: 93

Nickel: 1,294,415,416,422

Niobium: 1,392,407,431

Nitrogen: 66,107,108,212,213,318

Osmium: 1

Oxygen: 23,24,36,66,69,209,210,215

Palladium: 1,287,424

Phosphorus: 179,180,182,336

Platinum: 1,288

Plutonium: 91

Polonium: 47,48

Potassium: 32,59,60,75,76,86,150,160,172,268,314,322

Praseodymium: 1,149,306,308,337,338

Promethium: 196,260

Protactinium: 96

Radium: 253,254

Radon: 251

Rhenium: 1

Rhodium: 1,396

Rubidium: 12,109,130,241,257,258,262,264

Ruthenium: 1,423

Samarium: 1

Scandium: 1,88,150,298,323

Selenium: 9,80,181,216,245,247,275

Silicon: 87,170,237,292,319,320

Silver: 13,99,255,286,289,363,387,398

Sodium: 178,205,206,207,268,299,334

Strontium: 1,109,110,218,231,265,279,313

Sulfur: 29,144,202,209,210,266

Tantalum: 1,411,426

Technetium: 35

Tellurium: 1,344,345,346,347

Terbium: 1,302

Thallium: 1,195,348,354,355,356

Thorium: 1,97,98,156,157,165,434

Thulium: 1,307

Tin: 187,191,399,423

Titanium: 1,378,427,428

Tungsten: 1

Uranium: 1,303

Vanadium: 1,394,397,432

Xenon: 33,116,118,120,232,384,391,429

Ytterbium: 1,40,192,311

Yttrium: 1,77,265,419

Zinc: 39,55,113,131,185,186,370,376,377

Zirconium: 1,362,403,418

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# NIST ATOMIC TRANSITION PROBABILITIES

J. R. Fuhr and W. L. Wiese

For the 2005 edition of this *Handbook*, we include new, more accurate data for Fe I and Fe II,<sup>1</sup> and Ba I and Ba II.<sup>2</sup> The new tables contain critically evaluated atomic transition probabilities for over 10500 selected lines of all elements for which reliable data are available on an absolute scale. The material is largely for neutral and singly ionized spectra, but also includes a number of prominent lines of more highly charged ions of important elements.

Many of the data are obtained from comprehensive compilations of the Data Center on Atomic Transition Probabilities at the National Institute of Standards and Technology. Specifically, data have been taken from three recent comprehensive critical compilations on C, N and O,<sup>3</sup> on Sc through Mn<sup>4</sup> and Fe through Ni,<sup>5</sup> and special compilations on neutral and singly ionized iron and barium. Material from earlier compilations for the elements H through Ne<sup>6</sup> and Na through Ca<sup>7</sup> was supplemented by more recent material taken directly from the original literature. For the highly charged ions, some of the data were derived from studies of the systematic behavior of transition probabilities.<sup>8-10</sup> Most of the original literature is cited in the above tables and in recent bibliographies;<sup>11,12</sup> for lack of space, individual literature references are not cited here.

The wavelength range for the neutral species is normally the visible spectrum or shorter wavelengths; only the very prominent near infrared lines are included. For the higher ions, most of the strong lines are located in the far UV. The tabulation is limited to electric dipole — including intercombination — lines and comprises essentially the fairly strong transitions with estimated uncertainties in the 10% to 50% range. With the exception of hydrogen, helium, and the alkali metals, most transitions are between states with low principal quantum numbers.

The transition probability,  $A$ , is given in units of  $10^8 \text{ s}^{-1}$  and is listed to as many digits as is consistent with the indicated accuracy. The power of 10 is indicated by the E notation (i.e., E-02 means  $10^{-2}$ ). Generally, the estimated uncertainties of the  $A$ -values are  $\pm 25$  to 50% for two-digit numbers,  $\pm 10$  to 25% for three-digit numbers and  $\pm 1\%$  or better for four- and five-digit numbers.

Each transition is identified by the wavelength  $\lambda$  in ångströms ( $1 \text{ Å} = 10^{-10} \text{ m}$ ); and the statistical weights,  $g_i$  and  $g_k$ , of the lower ( $i$ ) and upper ( $k$ ) states [the product  $g_i A$  (or  $g_k f$ ) is needed for many applications]. Whenever the wavelengths of individual lines within a multiplet are extremely close, only an average wavelength for the multiplet as well as the multiplet  $A$ -value are given, and this is indicated by an asterisk (\*) to the left of the wavelength. This also has been done when the transition probability for an entire multiplet has been taken from the literature and values for individual lines cannot be determined because of insufficient knowledge of the coupling of electrons. The wavelength data have been taken either from recent compilations or from the original literature cited in bibliographies published by the Atomic Energy Levels Data Center<sup>13,14</sup> at the National Institute of Standards and Technology. Wavelength values are consistent with those given in the table “Line Spectra of the Elements,” which appears elsewhere in this *Handbook*.

In addition to the transition probability  $A$ , the atomic oscillator strength  $f$  and the line strength  $S$  are often used in the literature. The conversion factors between these quantities are (for electric-dipole transitions):

$$g_i f = 1.499 \cdot 10^{-8} \lambda^2 g_k A = 303.8 \lambda^{-1} S$$

where  $\lambda$  is in ångströms,  $A$  is in  $10^8 \text{ s}^{-1}$ , and  $S$  is in atomic units, which are

$$a_0^2 e^2 = 7.188 \cdot 10^{-59} \text{ m}^2 \text{ C}^2.$$

The table for hydrogen is presented first, followed by the tables for other elements in alphabetical sequence by element name (not symbol). Within each element, the tables are ordered by increasing ionization stage (e.g., Al I, Al II, etc.).

The transition probabilities for hydrogen and hydrogen-like ions are known precisely. Because of the hydrogen degeneracy, a “transition” is actually the sum of all fine-structure transitions between the principal quantum numbers; therefore, the hydrogen table gives weighted average  $A$ -values. For hydrogen-like ions of nuclear charge  $Z$ , the following scaling laws hold:

$$A_Z = Z^4 A_{\text{Hydrogen}}$$

$$f_Z = f_{\text{Hydrogen}}$$

$$S_Z = Z^{-2} S_{\text{Hydrogen}}$$

$$\lambda_Z = Z^{-2} \lambda_{\text{Hydrogen}}$$

For very highly charged hydrogen-like ions, starting at about  $Z > 25$ , relativistic corrections<sup>15</sup> must be applied.

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| $\lambda$       | Weights |       | $A$                   | $\lambda$    | Weights |       | $A$                   | $\lambda$       | Weights |       | $A$                   |
|-----------------|---------|-------|-----------------------|--------------|---------|-------|-----------------------|-----------------|---------|-------|-----------------------|
| $\text{\AA}$    | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ | $\text{\AA}$ | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ | $\text{\AA}$    | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ |
| <i>Hydrogen</i> |         |       |                       | 3721.94      | 8       | 392   | 1.303E-04             | 75004           | 72      | 128   | 1.561E-03             |
| <i>HI</i>       |         |       |                       | 3734.37      | 8       | 338   | 1.893E-04             | 123680          | 72      | 98    | 4.561E-03             |
| 912.768         | 2       | 1800  | 5.167E-06             | 3750.15      | 8       | 288   | 2.834E-04             | <i>Aluminum</i> |         |       |                       |
| 912.839         | 2       | 1682  | 6.122E-06             | 3770.63      | 8       | 242   | 4.397E-04             | <i>AlI</i>      |         |       |                       |
| 912.918         | 2       | 1568  | 7.297E-06             | 3797.90      | 8       | 200   | 7.122E-04             | 2263.5          | 2       | 4     | 6.6E-01               |
| 913.006         | 2       | 1458  | 8.753E-06             | 3835.38      | 8       | 162   | 1.216E-03             | 2269.1          | 4       | 6     | 7.9E-01               |
| 913.104         | 2       | 1352  | 1.057E-05             | 3889.05      | 8       | 128   | 2.215E-03             | 2269.2          | 4       | 4     | 1.3E-01               |
| 913.215         | 2       | 1250  | 1.286E-05             | 3970.07      | 8       | 98    | 4.389E-03             | 2269.2          | 4       | 4     | 1.3E-01               |
| 913.339         | 2       | 1152  | 1.578E-05             | 4101.73      | 8       | 72    | 9.732E-03             | 2367.1          | 2       | 4     | 7.2E-01               |
| 913.480         | 2       | 1058  | 1.952E-05             | 4340.46      | 8       | 50    | 2.530E-02             | 2373.1          | 4       | 6     | 8.6E-01               |
| 913.641         | 2       | 968   | 2.438E-05             | 4861.32      | 8       | 32    | 8.419E-02             | 2373.4          | 4       | 4     | 1.4E-01               |
| 913.826         | 2       | 882   | 3.077E-05             | 6562.80      | 8       | 18    | 4.410E-01             | 2568.0          | 2       | 4     | 2.3E-01               |
| 914.039         | 2       | 800   | 3.928E-05             | 8392.40      | 18      | 800   | 1.517E-05             | 2575.1          | 4       | 6     | 2.8E-01               |
| 914.286         | 2       | 722   | 5.077E-05             | 8413.32      | 18      | 722   | 1.964E-05             | 2575.4          | 4       | 4     | 4.4E-02               |
| 914.576         | 2       | 648   | 6.654E-05             | 8437.96      | 18      | 648   | 2.580E-05             | 2652.5          | 2       | 2     | 1.33E-01              |
| 914.919         | 2       | 578   | 8.858E-05             | 8467.26      | 18      | 578   | 3.444E-05             | 2660.4          | 4       | 2     | 2.64E-01              |
| 915.329         | 2       | 512   | 1.200E-04             | 8502.49      | 18      | 512   | 4.680E-05             | 3082.2          | 2       | 4     | 6.3E-01               |
| 915.824         | 2       | 450   | 1.657E-04             | 8545.39      | 18      | 450   | 6.490E-05             | 3092.7          | 4       | 6     | 7.4E-01               |
| 916.429         | 2       | 392   | 2.341E-04             | 8598.40      | 18      | 392   | 9.211E-05             | 3092.8          | 4       | 4     | 1.2E-01               |
| 917.181         | 2       | 338   | 3.393E-04             | 8665.02      | 18      | 338   | 1.343E-04             | 3944.0          | 2       | 2     | 4.93E-01              |
| 918.129         | 2       | 288   | 5.066E-04             | 8750.48      | 18      | 288   | 2.021E-04             | 3961.5          | 4       | 2     | 9.8E-01               |
| 919.351         | 2       | 242   | 7.834E-04             | 8862.79      | 18      | 242   | 3.156E-04             | 6696.0          | 2       | 4     | 1.69E-02              |
| 920.963         | 2       | 200   | 1.263E-03             | 9014.91      | 18      | 200   | 5.156E-04             | 6698.7          | 2       | 2     | 1.69E-02              |
| 923.150         | 2       | 162   | 2.143E-03             | 9229.02      | 18      | 162   | 8.905E-04             | 7835.3          | 4       | 6     | 5.7E-02               |
| 926.226         | 2       | 128   | 3.869E-03             | 9545.97      | 18      | 128   | 1.651E-03             | 7836.1          | 6       | 8     | 6.2E-02               |
| 930.748         | 2       | 98    | 7.568E-03             | 10049.4      | 18      | 98    | 3.358E-03             | <i>AlII</i>     |         |       |                       |
| 937.803         | 2       | 72    | 1.644E-02             | 10938.1      | 18      | 72    | 7.783E-03             | 1047.9          | 1       | 3     | 3.6E-01               |
| 949.743         | 2       | 50    | 4.125E-02             | 12818.1      | 18      | 50    | 2.201E-02             | 1048.6          | 3       | 5     | 4.8E-01               |
| 972.537         | 2       | 32    | 1.278E-01             | 16407.2      | 32      | 288   | 1.620E-04             | 1539.8          | 3       | 5     | 8.8E+00               |
| 1025.72         | 2       | 18    | 5.575E-01             | 16806.5      | 32      | 242   | 2.556E-04             | 1670.8          | 1       | 3     | 1.46E+01              |
| 1215.67         | 2       | 8     | 4.699E+00             | 17362.1      | 32      | 200   | 4.235E-04             | 1719.4          | 1       | 3     | 6.79E+00              |
| 3662.26         | 8       | 1800  | 2.847E-06             | 18174.1      | 32      | 162   | 7.459E-04             | 1764.0          | 5       | 5     | 9.8E+00               |
| 3663.40         | 8       | 1682  | 3.374E-06             | 18751.0      | 18      | 32    | 8.986E-02             | 1772.8          | 1       | 3     | 9.5E+00               |
| 3664.68         | 8       | 1568  | 4.022E-06             | 19445.6      | 32      | 128   | 1.424E-03             | 1777.0          | 5       | 7     | 1.7E+01               |
| 3666.10         | 8       | 1458  | 4.826E-06             | 21655.3      | 32      | 98    | 3.041E-03             | *1819.0         | 15      | 15    | 5.6E+00               |
| 3667.68         | 8       | 1352  | 5.830E-06             | 26251.5      | 32      | 72    | 7.711E-03             | 1855.9          | 1       | 3     | 8.32E-01              |
| 3669.46         | 8       | 1250  | 7.096E-06             | 27575        | 50      | 288   | 1.402E-04             | 1858.0          | 3       | 3     | 2.48E+00              |
| 3671.48         | 8       | 1152  | 8.707E-06             | 28722        | 50      | 242   | 2.246E-04             | 1862.3          | 5       | 3     | 4.12E+00              |
| 3673.76         | 8       | 1058  | 1.078E-05             | 30384        | 50      | 200   | 3.800E-04             | 1931.0          | 3       | 1     | 1.08E+01              |
| 3676.36         | 8       | 968   | 1.347E-05             | 32961        | 50      | 162   | 6.908E-04             | 1990.5          | 3       | 5     | 1.47E+01              |
| 3679.35         | 8       | 882   | 1.700E-05             | 37395        | 50      | 128   | 1.388E-03             | 2816.2          | 3       | 1     | 3.83E+00              |
| 3682.81         | 8       | 800   | 2.172E-05             | 40511.5      | 32      | 50    | 2.699E-02             | 4663.1          | 5       | 3     | 5.3E-01               |
| 3686.83         | 8       | 722   | 2.809E-05             | 43753        | 72      | 288   | 1.288E-04             | 6226.2          | 1       | 3     | 6.2E-01               |
| 3691.55         | 8       | 648   | 3.685E-05             | 46525        | 50      | 98    | 3.253E-03             | 6231.8          | 3       | 5     | 8.4E-01               |
| 3697.15         | 8       | 578   | 4.910E-05             | 46712        | 72      | 242   | 2.110E-04             | 6243.4          | 5       | 7     | 1.1E+00               |
| 3703.85         | 8       | 512   | 6.658E-05             | 51273        | 72      | 200   | 3.688E-04             | 6335.7          | 5       | 3     | 1.4E-01               |
| 3711.97         | 8       | 450   | 9.210E-05             | 59066        | 72      | 162   | 7.065E-04             | 6823.4          | 3       | 3     | 3.4E-01               |
|                 |         |       |                       | 74578        | 50      | 72    | 1.025E-02             | 6837.1          | 5       | 3     | 5.7E-01               |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 6920.3         | 3       | 1     | 9.6E-01                      |
| 7042.1         | 3       | 5     | 5.9E-01                      |
| 7056.7         | 3       | 3     | 5.8E-01                      |
| 7471.4         | 5       | 7     | 9.4E-01                      |
| <i>Al III</i>  |         |       |                              |
| *560.36        | 2       | 6     | 4.0E-01                      |
| 695.83         | 2       | 4     | 7.4E-01                      |
| 696.22         | 2       | 2     | 7.2E-01                      |
| *1352.8        | 10      | 14    | 4.40E+00                     |
| 1379.7         | 2       | 2     | 4.59E+00                     |
| 1384.1         | 4       | 2     | 9.1E+00                      |
| 1605.8         | 2       | 4     | 1.22E+01                     |
| 1611.8         | 4       | 4     | 2.42E+00                     |
| 1611.9         | 4       | 6     | 1.45E+01                     |
| 1854.7         | 2       | 4     | 5.40E+00                     |
| 1862.8         | 2       | 2     | 5.33E+00                     |
| *1935.9        | 10      | 14    | 1.22E+01                     |
| 3601.6         | 6       | 4     | 1.34E+00                     |
| 3601.9         | 4       | 4     | 1.49E-01                     |
| 3612.4         | 4       | 2     | 1.5E+00                      |
| <i>Al X</i>    |         |       |                              |
| 39.925         | 1       | 3     | 2.22E+03                     |
| 51.979         | 1       | 3     | 4.8E+03                      |
| 55.227         | 1       | 3     | 5.2E+03                      |
| 55.272         | 3       | 5     | 7.2E+03                      |
| 55.376         | 5       | 7     | 9.5E+03                      |
| 59.107         | 3       | 5     | 4.6E+03                      |
| 332.78         | 1       | 3     | 5.6E+01                      |
| 394.83         | 3       | 1     | 8.3E+01                      |
| 395.36         | 3       | 5     | 1.2E+01                      |
| 397.76         | 1       | 3     | 1.7E+01                      |
| 400.43         | 3       | 3     | 1.3E+01                      |
| 401.12         | 5       | 5     | 3.6E+01                      |
| 403.55         | 3       | 1     | 4.9E+01                      |
| 406.31         | 5       | 3     | 1.9E+01                      |
| 670.06         | 3       | 5     | 9.8E+00                      |
| 2535           | 1       | 3     | 3.8E-01                      |
| <i>Al XI</i>   |         |       |                              |
| *36.675        | 2       | 6     | 1.5E+03                      |
| 39.091         | 2       | 4     | 2.6E+03                      |
| 39.180         | 4       | 6     | 3.1E+03                      |
| 39.530         | 2       | 2     | 1.8E+02                      |
| 39.623         | 4       | 2     | 3.7E+02                      |
| 48.298         | 2       | 4     | 3.09E+03                     |
| 48.338         | 2       | 2     | 3.08E+03                     |
| 52.299         | 2       | 4     | 8.1E+03                      |
| 52.446         | 4       | 6     | 9.6E+03                      |
| 52.458         | 4       | 4     | 1.6E+03                      |
| 54.217         | 2       | 2     | 4.8E+02                      |
| 54.388         | 4       | 2     | 9.6E+02                      |
| *99.083        | 2       | 6     | 2.2E+02                      |
| 103.6          | 2       | 4     | 4.2E+02                      |
| 103.8          | 4       | 6     | 5.0E+02                      |
| *141.6         | 2       | 6     | 4.07E+02                     |
| 150.31         | 2       | 4     | 8.5E+02                      |
| 150.61         | 4       | 6     | 9.9E+02                      |
| 157.0          | 2       | 2     | 1.3E+02                      |
| 157.4          | 4       | 2     | 2.6E+02                      |
| *205.0         | 2       | 6     | 6.3E+01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| *308.6         | 2       | 6     | 9.9E+01                      |
| *341.3         | 6       | 2     | 1.3E+02                      |
| 550.05         | 2       | 4     | 8.55E+00                     |
| 568.12         | 2       | 2     | 7.73E+00                     |
| 1997           | 2       | 4     | 1.07E+00                     |
| 2069           | 2       | 2     | 9.7E-01                      |
| *4761          | 2       | 6     | 2.55E-01                     |
| 5172           | 2       | 4     | 3.95E-02                     |
| 5551           | 4       | 6     | 3.85E-02                     |
| 5687           | 4       | 4     | 6.0E-03                      |
| <i>Argon</i>   |         |       |                              |
| <i>Ar I</i>    |         |       |                              |
| 1048.22        | 1       | 3     | 5.36E+00                     |
| 1066.66        | 1       | 3     | 1.29E+00                     |
| 3406.18        | 3       | 1     | 3.9E-03                      |
| 3461.08        | 3       | 5     | 6.7E-04                      |
| 3554.30        | 5       | 5     | 2.7E-03                      |
| 3563.29        | 1       | 3     | 1.2E-03                      |
| 3567.66        | 5       | 7     | 1.1E-03                      |
| 3572.30        | 3       | 1     | 5.1E-03                      |
| 3606.52        | 3       | 1     | 7.6E-03                      |
| 3632.68        | 3       | 5     | 6.6E-04                      |
| 3634.46        | 3       | 3     | 1.3E-03                      |
| 3643.12        | 3       | 5     | 2.4E-04                      |
| 3649.83        | 3       | 1     | 8.0E-03                      |
| 3659.53        | 3       | 3     | 4.4E-04                      |
| 3670.67        | 3       | 5     | 3.1E-04                      |
| 3675.23        | 3       | 3     | 4.9E-04                      |
| 3770.37        | 1       | 3     | 7.0E-04                      |
| 3834.68        | 3       | 1     | 7.5E-03                      |
| 3894.66        | 3       | 3     | 5.7E-04                      |
| 3947.50        | 5       | 5     | 5.6E-04                      |
| 3948.98        | 5       | 3     | 4.55E-03                     |
| 4044.42        | 3       | 5     | 3.33E-03                     |
| 4045.96        | 3       | 3     | 4.1E-04                      |
| 4054.53        | 3       | 3     | 2.7E-04                      |
| 4158.59        | 5       | 5     | 1.40E-02                     |
| 4164.18        | 5       | 3     | 2.88E-03                     |
| 4181.88        | 1       | 3     | 5.61E-03                     |
| 4190.71        | 5       | 5     | 2.80E-03                     |
| 4191.03        | 1       | 3     | 5.39E-03                     |
| 4198.32        | 3       | 1     | 2.57E-02                     |
| 4200.67        | 5       | 7     | 9.67E-03                     |
| 4251.18        | 5       | 3     | 1.11E-03                     |
| 4259.36        | 3       | 1     | 3.98E-02                     |
| 4266.29        | 3       | 5     | 3.12E-03                     |
| 4272.17        | 3       | 3     | 7.97E-03                     |
| 4300.10        | 3       | 5     | 3.77E-03                     |
| 4333.56        | 3       | 5     | 5.68E-03                     |
| 4335.34        | 3       | 3     | 3.87E-03                     |
| 4345.17        | 3       | 3     | 2.97E-03                     |
| 4363.79        | 3       | 3     | 1.2E-04                      |
| 4424.00        | 1       | 3     | 7.3E-05                      |
| 4510.73        | 3       | 1     | 1.18E-02                     |
| 4522.32        | 1       | 3     | 8.98E-04                     |
| 4544.75        | 3       | 3     | 8.3E-04                      |
| 4554.32        | 3       | 5     | 3.8E-04                      |
| 4584.96        | 3       | 5     | 1.6E-03                      |
| 4586.61        | 3       | 3     | 2.3E-03                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 4587.21        | 3       | 1     | 4.9E-03                      |
| 4589.29        | 3       | 5     | 6.2E-05                      |
| 4596.10        | 3       | 3     | 9.47E-04                     |
| 4628.44        | 3       | 5     | 3.83E-04                     |
| 4642.15        | 3       | 5     | 9.6E-04                      |
| 4647.49        | 3       | 3     | 1.2E-03                      |
| 4702.32        | 3       | 3     | 1.09E-03                     |
| 4746.82        | 3       | 1     | 3.6E-03                      |
| 4752.94        | 3       | 3     | 4.5E-03                      |
| 4768.68        | 3       | 5     | 8.6E-03                      |
| 4798.74        | 7       | 9     | 8.8E-04                      |
| 4835.97        | 7       | 9     | 9.3E-04                      |
| 4836.70        | 3       | 5     | 1.02E-03                     |
| 4876.26        | 3       | 5     | 7.8E-03                      |
| 4886.29        | 7       | 9     | 1.2E-03                      |
| 4887.95        | 3       | 3     | 1.3E-02                      |
| 4894.69        | 3       | 1     | 1.8E-02                      |
| 4921.04        | 5       | 7     | 5.9E-04                      |
| 4937.72        | 7       | 5     | 3.6E-04                      |
| 4956.75        | 7       | 9     | 1.8E-03                      |
| 4989.95        | 5       | 7     | 1.1E-03                      |
| 5032.03        | 7       | 5     | 8.2E-04                      |
| 5048.81        | 3       | 5     | 4.6E-03                      |
| 5054.18        | 3       | 3     | 4.5E-03                      |
| 5056.53        | 3       | 1     | 5.7E-03                      |
| 5060.08        | 7       | 9     | 3.7E-03                      |
| 5070.99        | 5       | 3     | 2.6E-03                      |
| 5073.08        | 3       | 5     | 5.9E-04                      |
| 5078.03        | 7       | 7     | 4.7E-04                      |
| 5087.09        | 5       | 7     | 1.6E-03                      |
| 5104.74        | 3       | 5     | 8.7E-04                      |
| 5118.21        | 5       | 7     | 2.7E-03                      |
| 5127.80        | 5       | 5     | 3.3E-04                      |
| 5151.39        | 3       | 1     | 2.39E-02                     |
| 5152.30        | 3       | 5     | 1.1E-03                      |
| 5162.29        | 3       | 3     | 1.90E-02                     |
| 5177.54        | 7       | 5     | 2.4E-03                      |
| 5192.72        | 7       | 7     | 1.2E-04                      |
| 5194.02        | 3       | 1     | 7.8E-03                      |
| 5210.49        | 7       | 7     | 1.1E-03                      |
| 5214.77        | 5       | 3     | 2.1E-03                      |
| 5216.28        | 5       | 3     | 1.3E-03                      |
| 5221.27        | 7       | 9     | 8.8E-03                      |
| 5241.09        | 5       | 5     | 1.3E-03                      |
| 5246.24        | 5       | 7     | 1.2E-03                      |
| 5249.20        | 5       | 5     | 7.9E-04                      |
| 5252.79        | 5       | 7     | 5.4E-03                      |
| 5254.47        | 3       | 5     | 3.6E-03                      |
| 5286.07        | 5       | 7     | 9.6E-04                      |
| 5290.00        | 5       | 3     | 9.0E-04                      |
| 5309.52        | 5       | 5     | 1.2E-03                      |
| 5317.73        | 5       | 7     | 2.6E-03                      |
| 5373.50        | 3       | 5     | 2.7E-03                      |
| 5393.27        | 5       | 5     | 9.6E-04                      |
| 5410.48        | 5       | 7     | 2.0E-03                      |
| 5421.35        | 7       | 5     | 6.0E-03                      |
| 5439.99        | 3       | 3     | 1.9E-03                      |
| 5442.24        | 7       | 7     | 9.3E-04                      |
| 5451.65        | 3       | 5     | 4.7E-03                      |
| 5457.42        | 5       | 3     | 3.6E-03                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 5459.65        | 7       | 7     | 3.8E-04                      |
| 5467.16        | 5       | 5     | 7.6E-04                      |
| 5473.46        | 5       | 3     | 2.0E-03                      |
| 5490.12        | 5       | 5     | 8.5E-04                      |
| 5492.09        | 3       | 1     | 5.6E-03                      |
| 5495.87        | 7       | 9     | 1.69E-02                     |
| 5506.11        | 5       | 7     | 3.6E-03                      |
| 5524.96        | 7       | 7     | 1.7E-03                      |
| 5528.97        | 1       | 3     | 1.2E-03                      |
| 5534.49        | 5       | 3     | 2.7E-03                      |
| 5540.87        | 7       | 5     | 4.1E-04                      |
| 5552.77        | 3       | 3     | 7.9E-04                      |
| 5558.70        | 3       | 5     | 1.42E-02                     |
| 5559.66        | 3       | 5     | 2.2E-03                      |
| 5572.54        | 5       | 7     | 6.6E-03                      |
| 5574.22        | 3       | 5     | 4.6E-04                      |
| 5581.87        | 7       | 5     | 5.6E-04                      |
| 5588.72        | 5       | 5     | 1.5E-03                      |
| 5597.48        | 5       | 7     | 4.2E-03                      |
| 5606.73        | 3       | 3     | 2.20E-02                     |
| 5618.01        | 3       | 3     | 2.1E-03                      |
| 5620.92        | 3       | 1     | 3.6E-03                      |
| 5623.78        | 5       | 5     | 1.4E-03                      |
| 5635.58        | 3       | 5     | 9.6E-04                      |
| 5637.33        | 1       | 3     | 9.1E-04                      |
| 5639.12        | 1       | 3     | 2.1E-03                      |
| 5641.39        | 3       | 5     | 8.7E-04                      |
| 5648.69        | 5       | 3     | 1.2E-03                      |
| 5650.70        | 3       | 1     | 3.20E-02                     |
| 5659.13        | 5       | 5     | 2.6E-03                      |
| 5681.90        | 5       | 7     | 2.0E-03                      |
| 5683.73        | 5       | 5     | 2.0E-03                      |
| 5700.87        | 5       | 7     | 5.9E-03                      |
| 5712.51        | 1       | 3     | 8.7E-04                      |
| 5739.52        | 3       | 5     | 8.7E-03                      |
| 5772.11        | 5       | 7     | 2.0E-03                      |
| 5773.99        | 5       | 5     | 1.1E-03                      |
| 5783.54        | 3       | 5     | 8.1E-04                      |
| 5789.48        | 5       | 5     | 4.6E-04                      |
| 5790.40        | 5       | 3     | 3.4E-04                      |
| 5802.08        | 5       | 3     | 4.2E-03                      |
| 5843.77        | 3       | 5     | 3.3E-04                      |
| 5882.62        | 3       | 1     | 1.23E-02                     |
| 5888.58        | 7       | 5     | 1.29E-02                     |
| 5916.58        | 5       | 3     | 5.9E-04                      |
| 5927.11        | 7       | 7     | 3.7E-04                      |
| 5928.81        | 5       | 3     | 1.1E-02                      |
| 5940.86        | 1       | 3     | 1.2E-03                      |
| 5942.67        | 5       | 5     | 1.8E-03                      |
| 5943.89        | 7       | 5     | 3.6E-04                      |
| 5949.26        | 3       | 3     | 1.5E-03                      |
| 5964.48        | 1       | 3     | 7.7E-04                      |
| 5968.32        | 3       | 3     | 1.8E-03                      |
| 5971.60        | 3       | 1     | 1.1E-02                      |
| 5981.90        | 5       | 7     | 1.2E-04                      |
| 5987.30        | 7       | 7     | 1.2E-03                      |
| 5988.13        | 3       | 5     | 6.1E-04                      |
| 5994.66        | 3       | 5     | 2.6E-04                      |
| 5999.00        | 5       | 5     | 1.4E-03                      |
| 6005.73        | 5       | 3     | 1.4E-03                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 6013.68        | 7       | 5     | 1.4E-03                      |
| 6025.15        | 5       | 3     | 9.0E-03                      |
| 6043.22        | 5       | 7     | 1.47E-02                     |
| 6052.73        | 3       | 5     | 1.9E-03                      |
| 6064.76        | 5       | 7     | 5.8E-04                      |
| 6081.25        | 3       | 3     | 7.5E-04                      |
| 6085.86        | 3       | 3     | 9.0E-05                      |
| 6090.79        | 1       | 3     | 3.0E-03                      |
| 6098.81        | 3       | 3     | 5.2E-03                      |
| 6101.16        | 3       | 3     | 3.3E-03                      |
| 6104.58        | 3       | 1     | 3.4E-03                      |
| 6105.64        | 3       | 5     | 1.21E-02                     |
| 6113.46        | 3       | 5     | 4.7E-04                      |
| 6119.66        | 3       | 3     | 5.1E-04                      |
| 6121.86        | 3       | 5     | 1.3E-04                      |
| 6127.42        | 5       | 3     | 1.1E-03                      |
| 6128.73        | 3       | 5     | 8.6E-04                      |
| 6145.44        | 5       | 7     | 7.6E-03                      |
| 6155.24        | 5       | 3     | 5.1E-03                      |
| 6165.12        | 5       | 5     | 9.89E-04                     |
| 6170.17        | 5       | 5     | 5.0E-03                      |
| 6173.10        | 3       | 5     | 6.7E-03                      |
| 6179.41        | 5       | 3     | 6.6E-04                      |
| 6212.50        | 5       | 7     | 3.9E-03                      |
| 6215.94        | 5       | 5     | 5.7E-03                      |
| 6230.93        | 5       | 5     | 1.2E-04                      |
| 6243.40        | 3       | 1     | 1.3E-03                      |
| 6244.73        | 3       | 5     | 2.0E-04                      |
| 6248.41        | 3       | 5     | 6.8E-04                      |
| 6278.65        | 5       | 7     | 2.0E-04                      |
| 6296.87        | 3       | 5     | 9.0E-03                      |
| 6307.66        | 5       | 5     | 6.0E-03                      |
| 6309.14        | 3       | 3     | 7.6E-04                      |
| 6364.89        | 3       | 1     | 5.6E-03                      |
| 6369.58        | 5       | 3     | 4.2E-03                      |
| 6384.72        | 3       | 3     | 4.21E-03                     |
| 6416.31        | 3       | 5     | 1.16E-02                     |
| 6431.56        | 5       | 3     | 5.1E-04                      |
| 6466.55        | 1       | 3     | 1.5E-03                      |
| 6481.14        | 1       | 3     | 9.4E-04                      |
| 6513.85        | 3       | 3     | 5.4E-04                      |
| 6538.11        | 7       | 7     | 1.1E-03                      |
| 6596.12        | 7       | 5     | 2.3E-04                      |
| 6598.68        | 5       | 5     | 3.6E-04                      |
| 6604.02        | 7       | 5     | 2.8E-03                      |
| 6604.85        | 5       | 7     | 1.3E-04                      |
| 6632.09        | 3       | 3     | 5.3E-04                      |
| 6656.88        | 3       | 3     | 3.1E-04                      |
| 6660.68        | 3       | 1     | 7.8E-03                      |
| 6664.05        | 5       | 5     | 1.5E-03                      |
| 6677.28        | 3       | 1     | 2.36E-03                     |
| 6684.73        | 3       | 5     | 3.9E-04                      |
| 6698.47        | 3       | 3     | 2.5E-04                      |
| 6698.88        | 5       | 3     | 1.6E-03                      |
| 6719.22        | 1       | 3     | 2.4E-03                      |
| 6722.88        | 5       | 7     | 3.2E-04                      |
| 6752.84        | 3       | 5     | 1.93E-02                     |
| 6754.37        | 3       | 3     | 2.1E-03                      |
| 6756.10        | 5       | 5     | 3.6E-03                      |
| 6766.61        | 5       | 3     | 4.0E-03                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 6779.93        | 1       | 3     | 1.21E-03                     |
| 6818.29        | 3       | 1     | 2.0E-03                      |
| 6827.25        | 5       | 3     | 2.4E-03                      |
| 6851.88        | 3       | 5     | 6.7E-04                      |
| 6871.29        | 3       | 3     | 2.78E-02                     |
| 6879.59        | 3       | 5     | 1.8E-03                      |
| 6887.10        | 5       | 7     | 1.3E-03                      |
| 6888.17        | 3       | 5     | 2.5E-03                      |
| 6925.01        | 3       | 3     | 1.2E-03                      |
| 6937.67        | 3       | 1     | 3.08E-02                     |
| 6951.46        | 5       | 5     | 2.2E-03                      |
| 6960.23        | 5       | 5     | 2.4E-03                      |
| 6965.43        | 5       | 3     | 6.39E-02                     |
| 6992.17        | 3       | 1     | 7.5E-03                      |
| 7030.25        | 7       | 5     | 2.67E-02                     |
| 7067.22        | 5       | 5     | 3.80E-02                     |
| 7068.73        | 5       | 3     | 2.0E-02                      |
| 7086.70        | 1       | 3     | 1.5E-03                      |
| 7107.48        | 5       | 5     | 4.5E-03                      |
| 7125.83        | 3       | 3     | 6.0E-03                      |
| 7147.04        | 5       | 3     | 6.25E-03                     |
| 7158.83        | 3       | 1     | 2.1E-02                      |
| 7162.57        | 1       | 3     | 5.8E-04                      |
| 7206.98        | 5       | 3     | 2.48E-02                     |
| 7229.93        | 5       | 5     | 6.6E-04                      |
| 7265.17        | 3       | 3     | 1.7E-03                      |
| 7270.66        | 7       | 7     | 1.1E-03                      |
| 7272.93        | 3       | 3     | 1.83E-02                     |
| 7285.44        | 5       | 3     | 1.2E-03                      |
| 7311.72        | 3       | 3     | 1.7E-02                      |
| 7316.01        | 3       | 3     | 9.6E-03                      |
| 7350.78        | 3       | 1     | 1.2E-02                      |
| 7353.32        | 5       | 7     | 9.6E-03                      |
| 7372.12        | 7       | 9     | 1.9E-02                      |
| 7383.98        | 3       | 5     | 8.47E-02                     |
| 7392.97        | 5       | 3     | 7.2E-03                      |
| 7412.33        | 3       | 5     | 3.9E-03                      |
| 7422.26        | 3       | 5     | 6.6E-04                      |
| 7425.29        | 5       | 7     | 3.1E-03                      |
| 7435.33        | 5       | 5     | 9.0E-03                      |
| 7436.25        | 7       | 5     | 2.7E-03                      |
| 7471.17        | 3       | 3     | 2.2E-04                      |
| 7484.24        | 3       | 5     | 3.4E-03                      |
| 7503.84        | 3       | 1     | 4.45E-01                     |
| 7510.42        | 5       | 5     | 4.5E-03                      |
| 7514.65        | 3       | 1     | 4.02E-01                     |
| 7618.33        | 3       | 5     | 2.9E-03                      |
| 7628.86        | 3       | 5     | 2.9E-03                      |
| 7635.11        | 5       | 5     | 2.45E-01                     |
| 7670.04        | 5       | 3     | 2.8E-03                      |
| 7704.81        | 5       | 7     | 6.3E-04                      |
| 7723.76        | 5       | 3     | 5.18E-02                     |
| 7724.21        | 1       | 3     | 1.17E-01                     |
| 7798.55        | 3       | 5     | 8.7E-04                      |
| 7868.20        | 1       | 3     | 3.50E-03                     |
| 7891.08        | 5       | 5     | 9.5E-03                      |
| 7916.45        | 3       | 3     | 1.2E-03                      |
| 7948.18        | 1       | 3     | 1.86E-01                     |
| 8006.16        | 3       | 5     | 4.90E-02                     |
| 8014.79        | 5       | 5     | 9.28E-02                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 8037.23        | 1       | 3     | 3.59E-03                     | 14093.6        | 1       | 3     | 4.3E-02                      | 3582.4         | 4       | 6     | 2.53E+00                     |
| 8046.13        | 3       | 1     | 1.12E-02                     | 14739.1        | 5       | 7     | 8.8E-04                      | 3588.4         | 8       | 10    | 3.03E+00                     |
| 8053.31        | 5       | 3     | 8.6E-03                      | 15046.4        | 1       | 3     | 5.2E-02                      | 3605.9         | 4       | 6     | 4.4E-02                      |
| 8066.60        | 5       | 5     | 1.4E-03                      | 15172.3        | 1       | 3     | 1.3E-02                      | 3656.0         | 6       | 6     | 7.6E-02                      |
| 8103.69        | 3       | 3     | 2.5E-01                      | 15329.6        | 5       | 5     | 1.2E-03                      | 3682.5         | 4       | 2     | 1.7E-02                      |
| 8115.31        | 5       | 7     | 3.31E-01                     | 15555.5        | 5       | 7     | 9.8E-05                      | 3709.9         | 4       | 4     | 4.7E-02                      |
| 8264.52        | 3       | 3     | 1.53E-01                     | 15734.9        | 5       | 3     | 2.9E-04                      | 3717.2         | 6       | 8     | 5.2E-02                      |
| 8384.73        | 5       | 7     | 2.4E-03                      | 15816.8        | 5       | 3     | 8.7E-04                      | 3729.3         | 6       | 4     | 4.80E-01                     |
| 8408.21        | 3       | 5     | 2.23E-01                     | 15989.3        | 1       | 3     | 1.9E-02                      | 3746.9         | 4       | 6     | 2.1E-02                      |
| 8424.65        | 3       | 5     | 2.15E-01                     | 16122.7        | 5       | 3     | 3.9E-04                      | 3763.5         | 8       | 6     | 1.78E-01                     |
| 8490.30        | 3       | 5     | 9.6E-04                      | 16180.0        | 5       | 5     | 1.2E-03                      | 3766.1         | 4       | 4     | 7.4E-02                      |
| 8521.44        | 3       | 3     | 1.39E-01                     | 16264.1        | 3       | 3     | 3.0E-04                      | 3777.5         | 2       | 2     | 1.1E-02                      |
| 8605.78        | 5       | 5     | 1.04E-02                     | 16520.1        | 3       | 5     | 2.6E-03                      | 3780.8         | 8       | 8     | 7.7E-01                      |
| 8620.46        | 1       | 3     | 9.2E-03                      | 16739.8        | 3       | 5     | 3.1E-03                      | 3786.4         | 8       | 6     | 1.5E-02                      |
| 8667.94        | 1       | 3     | 2.43E-02                     | 16940.4        | 5       | 5     | 2.5E-02                      | 3799.4         | 6       | 4     | 1.7E-01                      |
| 8761.69        | 3       | 5     | 9.5E-03                      | 20317.0        | 1       | 3     | 1.6E-03                      | 3808.6         | 6       | 6     | 1.0E-02                      |
| 8784.61        | 3       | 1     | 2.4E-03                      | 20616.5        | 5       | 5     | 3.9E-03                      | 3826.8         | 6       | 6     | 2.81E-01                     |
| 8799.08        | 5       | 3     | 4.6E-03                      | 20812.0        | 5       | 7     | 7.6E-04                      | 3841.5         | 4       | 2     | 2.69E-01                     |
| 8962.19        | 3       | 3     | 1.6E-03                      | 21332.2        | 3       | 3     | 3.2E-04                      | 3844.7         | 6       | 8     | 4.8E-02                      |
| 9075.42        | 3       | 1     | 1.2E-02                      | 21534.9        | 3       | 5     | 1.1E-03                      | 3845.4         | 6       | 4     | 1.6E-02                      |
| 9122.97        | 5       | 3     | 1.89E-01                     | 22039.2        | 3       | 1     | 1.2E-03                      | 3850.6         | 4       | 4     | 3.87E-01                     |
| 9194.64        | 3       | 3     | 1.76E-02                     | 22077.4        | 5       | 3     | 1.4E-03                      | 3868.5         | 4       | 6     | 1.4E+00                      |
| 9224.50        | 3       | 5     | 5.03E-02                     | 23133.4        | 3       | 3     | 1.7E-03                      | 3872.1         | 4       | 4     | 1.5E-01                      |
| 9291.53        | 3       | 1     | 3.26E-02                     | 23844.8        | 9       | 7     | 1.1E-02                      | 3875.3         | 4       | 2     | 8.2E-02                      |
| 9354.22        | 3       | 3     | 1.06E-02                     | 23967.5        | 3       | 1     | 3.6E-03                      | 3880.3         | 2       | 2     | 2.32E-01                     |
| 9657.78        | 3       | 3     | 5.43E-02                     | <i>Ar II</i>   |         |       |                              | 3891.4         | 2       | 2     | 4.3E-02                      |
| 9784.50        | 3       | 5     | 1.47E-02                     | 2317.7         | 6       | 4     | 1.4E-01                      | 3892.0         | 6       | 4     | 6.3E-02                      |
| 10470.05       | 1       | 3     | 9.8E-03                      | 2891.6         | 4       | 2     | 1.82E-01                     | 3900.6         | 4       | 6     | 7.2E-02                      |
| 10478.0        | 3       | 3     | 2.44E-02                     | 2942.9         | 4       | 4     | 5.3E-01                      | 3911.6         | 2       | 4     | 7.7E-02                      |
| 10950.7        | 5       | 3     | 3.96E-03                     | 2979.1         | 2       | 2     | 4.16E-01                     | 3914.8         | 4       | 4     | 3.7E-02                      |
| 11078.9        | 5       | 5     | 8.3E-03                      | 3033.5         | 2       | 4     | 9.9E-02                      | 3928.6         | 2       | 4     | 2.44E-01                     |
| 11393.7        | 3       | 1     | 2.22E-02                     | 3139.0         | 6       | 6     | 5.2E-01                      | 3931.2         | 2       | 4     | 2.0E-02                      |
| 11441.8        | 5       | 3     | 1.39E-02                     | 3169.7         | 4       | 6     | 4.9E-01                      | 3932.5         | 4       | 4     | 9.3E-01                      |
| 11467.5        | 3       | 5     | 3.69E-03                     | 3181.0         | 6       | 4     | 3.7E-01                      | 3944.3         | 8       | 6     | 4.1E-02                      |
| 11488.11       | 3       | 3     | 1.9E-03                      | 3212.5         | 4       | 4     | 5.2E-02                      | 3952.7         | 4       | 4     | 2.08E-01                     |
| 11668.7        | 5       | 5     | 3.76E-02                     | 3221.6         | 6       | 6     | 1.8E-02                      | 3958.4         | 6       | 4     | 3.8E-02                      |
| 11719.5        | 5       | 3     | 9.52E-03                     | 3226.0         | 4       | 4     | 2.1E-02                      | 3968.4         | 6       | 6     | 4.8E-02                      |
| 12026.6        | 1       | 3     | 4.2E-03                      | 3243.7         | 4       | 2     | 1.06E+00                     | 3979.4         | 4       | 2     | 9.8E-01                      |
| 12112.2        | 7       | 7     | 3.1E-02                      | 3249.8         | 2       | 4     | 6.3E-01                      | 3988.2         | 6       | 6     | 4.1E-02                      |
| 12139.8        | 3       | 3     | 4.5E-02                      | 3263.6         | 2       | 4     | 1.55E-01                     | 3992.1         | 4       | 6     | 1.6E-02                      |
| 12343.7        | 5       | 7     | 2.0E-02                      | 3281.7         | 2       | 2     | 4.2E-01                      | 4013.9         | 8       | 8     | 1.05E-01                     |
| 12402.9        | 3       | 3     | 1.1E-01                      | 3430.4         | 6       | 8     | 6.2E-02                      | 4031.4         | 4       | 2     | 7.5E-02                      |
| 12439.2        | 3       | 5     | 4.9E-02                      | 3454.1         | 6       | 4     | 3.14E-01                     | 4035.5         | 4       | 6     | 4.4E-02                      |
| 12456.1        | 5       | 3     | 8.9E-02                      | 3466.3         | 8       | 6     | 3.0E-02                      | 4038.8         | 6       | 8     | 1.2E-02                      |
| 12487.6        | 7       | 5     | 1.1E-01                      | 3476.7         | 6       | 6     | 1.25E+00                     | 4042.9         | 4       | 4     | 4.06E-01                     |
| 12554.4        | 7       | 5     | 1.2E-03                      | 3491.2         | 4       | 4     | 1.79E+00                     | 4045.7         | 4       | 4     | 1.6E-02                      |
| 12702.4        | 3       | 3     | 7.1E-02                      | 3491.5         | 6       | 8     | 2.31E+00                     | 4052.9         | 2       | 4     | 6.7E-01                      |
| 12733.6        | 5       | 5     | 1.1E-02                      | 3509.8         | 2       | 2     | 2.55E+00                     | 4065.1         | 4       | 4     | 1.1E-02                      |
| 12746.3        | 3       | 3     | 2.0E-02                      | 3514.4         | 4       | 6     | 1.36E+00                     | 4072.0         | 6       | 6     | 5.8E-01                      |
| 12802.7        | 5       | 5     | 5.7E-02                      | 3520.0         | 6       | 6     | 5.2E-01                      | 4079.6         | 6       | 4     | 1.19E-01                     |
| 12933.3        | 3       | 1     | 1.0E-01                      | 3521.3         | 8       | 8     | 2.27E-01                     | 4082.4         | 6       | 6     | 2.9E-02                      |
| 12956.6        | 3       | 3     | 7.4E-02                      | 3535.3         | 2       | 4     | 5.7E-01                      | 4112.8         | 4       | 4     | 1.1E-02                      |
| 13008.5        | 5       | 3     | 8.9E-02                      | 3548.5         | 4       | 4     | 8.7E-01                      | 4128.6         | 8       | 6     | 1.4E-02                      |
| 13214.7        | 3       | 1     | 8.1E-02                      | 3550.0         | 6       | 6     | 2.6E-02                      | 4131.7         | 4       | 2     | 8.5E-01                      |
| 13273.1        | 5       | 7     | 1.5E-01                      | 3556.9         | 2       | 2     | 5.0E-02                      | 4178.4         | 6       | 4     | 1.2E-02                      |
| 13313.4        | 3       | 5     | 1.3E-01                      | 3559.5         | 6       | 8     | 2.88E+00                     | 4202.0         | 2       | 4     | 2.1E-02                      |
| 13504.0        | 5       | 7     | 1.1E-01                      | 3565.0         | 2       | 4     | 5.5E-01                      | 4228.2         | 4       | 6     | 1.31E-01                     |
| 13599.2        | 5       | 5     | 2.2E-02                      | 3576.6         | 6       | 8     | 2.75E+00                     | 4237.2         | 4       | 4     | 1.12E-01                     |
| 13622.4        | 3       | 5     | 7.3E-02                      | 3581.6         | 2       | 4     | 1.76E+00                     | 4266.5         | 6       | 6     | 1.64E-01                     |
| 13678.5        | 3       | 5     | 6.2E-02                      |                |         |       |                              | 4277.5         | 6       | 4     | 8.0E-01                      |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 4282.9         | 4       | 2     | 1.32E-01                     | 6684.3         | 8       | 6     | 1.07E-01                     | 713.81         | 2       | 2     | 2.4E+01                      |
| 4300.6         | 6       | 6     | 5.7E-02                      | 6756.6         | 4       | 4     | 2.0E-02                      | <i>Ar IX</i>   |         |       |                              |
| 4331.2         | 4       | 4     | 5.74E-01                     | 6863.5         | 6       | 6     | 2.5E-02                      | 48.739         | 1       | 3     | 1.69E+03                     |
| 4332.0         | 4       | 2     | 1.92E-01                     | 7233.5         | 2       | 4     | 3.7E-02                      | <i>Ar XIII</i> |         |       |                              |
| 4348.1         | 6       | 8     | 1.17E+00                     | 7380.4         | 4       | 4     | 5.6E-02                      | 162.96         | 5       | 3     | 3.4E+02                      |
| 4352.2         | 2       | 2     | 2.12E-01                     | 7589.3         | 6       | 4     | 1.07E-01                     | *163.08        | 9       | 3     | 5.3E+02                      |
| 4362.1         | 4       | 6     | 5.5E-02                      | <i>Ar III</i>  |         |       |                              | 184.90         | 5       | 5     | 1.66E+02                     |
| 4370.8         | 4       | 4     | 6.6E-01                      | 769.15         | 5       | 3     | 6.0E+00                      | 186.38         | 1       | 3     | 8.8E+01                      |
| 4371.3         | 6       | 4     | 2.21E-01                     | 871.10         | 5       | 3     | 1.59E+00                     | *207.89        | 9       | 9     | 9.5E+01                      |
| 4376.0         | 4       | 2     | 2.05E-01                     | 875.53         | 3       | 1     | 3.74E+00                     | *245.10        | 9       | 15    | 3.7E+01                      |
| 4379.7         | 2       | 2     | 1.00E+00                     | 878.73         | 5       | 5     | 2.79E+00                     | <i>Ar XIV</i>  |         |       |                              |
| 4383.8         | 4       | 4     | 1.1E-02                      | 879.62         | 3       | 3     | 9.2E-01                      | 180.29         | 2       | 4     | 4.5E+01                      |
| 4400.1         | 4       | 4     | 1.60E-01                     | 883.18         | 1       | 3     | 1.22E+00                     | 183.41         | 2       | 2     | 1.69E+02                     |
| 4401.0         | 8       | 6     | 3.04E-01                     | 887.40         | 3       | 5     | 9.0E-01                      | 187.95         | 4       | 4     | 1.97E+02                     |
| 4412.9         | 6       | 8     | 6.1E-02                      | 3024.1         | 5       | 7     | 2.6E+00                      | 191.35         | 4       | 2     | 7.5E+01                      |
| 4420.9         | 2       | 4     | 3.1E-02                      | 3027.2         | 5       | 5     | 6.4E-01                      | 194.39         | 2       | 2     | 4.6E+01                      |
| 4426.0         | 4       | 6     | 8.17E-01                     | 3054.8         | 3       | 5     | 1.9E+00                      | 203.35         | 4       | 2     | 7.8E+01                      |
| 4430.2         | 2       | 4     | 5.69E-01                     | 3064.8         | 3       | 3     | 1.0E+00                      | <i>Ar XV</i>   |         |       |                              |
| 4431.0         | 6       | 6     | 1.09E-01                     | 3078.2         | 1       | 3     | 1.4E+00                      | 25.05          | 1       | 3     | 1.7E+04                      |
| 4460.6         | 4       | 6     | 1.5E-02                      | 3285.9         | 5       | 7     | 2.0E+00                      | 221.10         | 1       | 3     | 9.55E+01                     |
| 4474.8         | 4       | 2     | 2.90E-01                     | 3301.9         | 5       | 5     | 2.0E+00                      | *265.3         | 9       | 9     | 8.1E+01                      |
| 4481.8         | 6       | 6     | 4.55E-01                     | 3311.3         | 5       | 3     | 2.0E+00                      | <i>Ar XVI</i>  |         |       |                              |
| 4491.0         | 6       | 4     | 4.6E-02                      | 3336.1         | 7       | 9     | 2.0E+00                      | *23.52         | 2       | 6     | 1.43E+04                     |
| 4530.5         | 6       | 4     | 2.1E-02                      | 3344.7         | 5       | 7     | 1.8E+00                      | *24.96         | 6       | 10    | 4.4E+04                      |
| 4545.1         | 4       | 4     | 4.71E-01                     | 3352.1         | 7       | 7     | 2.2E-01                      | 353.88         | 2       | 4     | 1.5E+01                      |
| 4579.4         | 2       | 2     | 8.0E-01                      | 3358.5         | 3       | 5     | 1.6E+00                      | 389.11         | 2       | 2     | 1.1E+01                      |
| 4589.9         | 4       | 6     | 6.64E-01                     | 3361.3         | 5       | 5     | 3.0E-01                      | 1268           | 2       | 4     | 1.9E+00                      |
| 4598.8         | 4       | 4     | 6.7E-02                      | 3472.6         | 5       | 7     | 2.0E-01                      | 1401           | 2       | 2     | 1.4E+00                      |
| 4609.6         | 6       | 8     | 7.89E-01                     | 3480.6         | 7       | 7     | 1.6E+00                      | 2975           | 2       | 4     | 9.0E-02                      |
| 4637.2         | 6       | 6     | 7.1E-02                      | 3499.7         | 3       | 3     | 1.3E+00                      | 3514           | 4       | 6     | 6.5E-02                      |
| 4657.9         | 4       | 2     | 8.92E-01                     | 3500.6         | 3       | 5     | 2.6E-01                      | <i>Arsenic</i> |         |       |                              |
| 4726.9         | 4       | 4     | 5.88E-01                     | 3502.7         | 5       | 3     | 4.3E-01                      | <i>As I</i>    |         |       |                              |
| 4732.1         | 6       | 4     | 6.7E-02                      | 3503.6         | 5       | 5     | 1.2E+00                      | 1890.4         | 4       | 6     | 2.0E+00                      |
| 4735.9         | 6       | 4     | 5.80E-01                     | 3511.7         | 7       | 5     | 2.6E-01                      | 1937.6         | 4       | 4     | 2.0E+00                      |
| 4764.9         | 2       | 4     | 6.4E-01                      | <i>Ar IV</i>   |         |       |                              | 1972.6         | 4       | 2     | 2.0E+00                      |
| 4806.0         | 6       | 6     | 7.80E-01                     | 840.03         | 4       | 2     | 2.73E+00                     | 2288.1         | 6       | 4     | 2.8E+00                      |
| 4847.8         | 4       | 2     | 8.49E-01                     | 843.77         | 4       | 4     | 2.70E+00                     | 2344.0         | 2       | 4     | 3.5E-01                      |
| 4879.9         | 4       | 6     | 8.23E-01                     | 850.60         | 4       | 6     | 2.63E+00                     | 2349.8         | 4       | 2     | 3.1E+00                      |
| 4889.0         | 2       | 2     | 1.9E-01                      | <i>Ar VI</i>   |         |       |                              | 2369.7         | 4       | 4     | 6.0E-01                      |
| 4904.8         | 6       | 8     | 3.7E-02                      | 292.15         | 2       | 2     | 6.9E+01                      | 2370.8         | 4       | 6     | 4.2E-01                      |
| 4933.2         | 4       | 4     | 1.44E-01                     | 294.05         | 4       | 2     | 1.36E+02                     | 2456.5         | 6       | 4     | 7.2E-02                      |
| 4965.1         | 2       | 4     | 3.94E-01                     | <i>Ar VII</i>  |         |       |                              | 2492.9         | 4       | 2     | 1.2E-01                      |
| 4972.2         | 2       | 2     | 9.7E-02                      | *250.41        | 9       | 3     | 2.78E+02                     | 2745.0         | 2       | 4     | 2.6E-01                      |
| 5009.3         | 4       | 6     | 1.51E-01                     | *477.54        | 9       | 15    | 9.92E+01                     | 2780.2         | 4       | 4     | 7.8E-01                      |
| 5017.2         | 4       | 6     | 2.07E-01                     | 585.75         | 1       | 3     | 7.83E+01                     | 2860.4         | 2       | 2     | 5.5E-01                      |
| 5017.6         | 4       | 4     | 1.1E-02                      | *637.30        | 9       | 9     | 6.7E+01                      | 2898.7         | 4       | 2     | 9.9E-02                      |
| 5062.0         | 2       | 4     | 2.23E-01                     | <i>Ar VIII</i> |         |       |                              | <i>Barium</i>  |         |       |                              |
| 5141.8         | 6       | 8     | 8.1E-02                      | 158.92         | 2       | 4     | 1.1E+02                      | <i>Ba I</i>    |         |       |                              |
| 5145.3         | 4       | 6     | 1.06E-01                     | 159.18         | 2       | 2     | 1.11E+02                     | 2380.66        | 1       | 3     | 2.62E-04                     |
| 5176.2         | 6       | 6     | 1.7E-02                      | 229.44         | 2       | 2     | 1.12E+02                     | 2380.75        | 1       | 3     | 2.44E-04                     |
| 6103.5         | 2       | 2     | 1.7E-02                      | 230.88         | 4       | 2     | 2.21E+02                     | 2380.86        | 1       | 3     | 2.55E-04                     |
| 6114.9         | 10      | 8     | 2.00E-01                     | 337.09         | 4       | 4     | 1.2E+01                      | 2380.97        | 1       | 3     | 2.57E-04                     |
| 6138.7         | 6       | 4     | 1.2E-02                      | 337.26         | 6       | 4     | 1.0E+02                      | 2381.08        | 1       | 3     | 2.50E-04                     |
| 6172.3         | 8       | 6     | 2.00E-01                     | 338.22         | 4       | 2     | 1.1E+02                      | 2381.21        | 1       | 3     | 2.91E-04                     |
| 6243.1         | 8       | 6     | 3.0E-02                      | 519.43         | 2       | 4     | 6.3E+01                      | 2381.34        | 1       | 3     | 3.15E-04                     |
| 6483.1         | 4       | 2     | 1.06E-01                     | 526.46         | 4       | 6     | 7.2E+01                      | 2381.48        | 1       | 3     | 3.41E-04                     |
| 6638.2         | 6       | 4     | 1.37E-01                     | 526.87         | 4       | 4     | 1.2E+01                      |                |         |       |                              |
| 6639.7         | 4       | 2     | 1.69E-01                     | 700.24         | 2       | 4     | 2.55E+01                     |                |         |       |                              |
| 6643.7         | 10      | 8     | 1.47E-01                     |                |         |       |                              |                |         |       |                              |
| 6666.4         | 2       | 2     | 8.8E-02                      |                |         |       |                              |                |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 2381.63        | 1       | 3     | 3.22E-04                     | 4189.44        | 3       | 5     | 1.13E-03                     | 9704.31        | 3       | 1     | 1.60E-01                     |
| 2381.79        | 1       | 3     | 3.44E-04                     | 4190.76        | 3       | 5     | 1.28E-03                     | 9821.48        | 3       | 1     | 5.50E-02                     |
| 2381.97        | 1       | 3     | 3.39E-04                     | 4192.20        | 3       | 5     | 1.36E-03                     | 10370.30       | 3       | 5     | 1.30E-02                     |
| 2382.15        | 1       | 3     | 3.63E-04                     | 4193.81        | 3       | 5     | 1.58E-03                     | 10540.10       | 5       | 3     | 1.80E-02                     |
| 2382.36        | 1       | 3     | 3.64E-04                     | 4195.59        | 3       | 5     | 1.78E-03                     | 10649.10       | 5       | 5     | 2.70E-02                     |
| 2382.57        | 1       | 3     | 3.14E-04                     | 4323.00        | 3       | 5     | 8.80E-02                     | 11075.70       | 3       | 3     | 3.10E-05                     |
| 2382.80        | 1       | 3     | 3.69E-04                     | 4402.54        | 3       | 5     | 2.70E-01                     | 11303.00       | 5       | 3     | 1.10E-03                     |
| 2383.06        | 1       | 3     | 3.57E-04                     | 4488.98        | 5       | 7     | 2.80E-01                     | 11373.70       | 3       | 1     | 1.30E-01                     |
| 2383.34        | 1       | 3     | 3.37E-04                     | 4493.64        | 5       | 5     | 1.95E-01                     | 12342.30       | 3       | 3     | 9.00E-04                     |
| 2383.63        | 1       | 3     | 3.70E-04                     | 4573.85        | 3       | 1     | 1.21E+00                     | 14723.10       | 3       | 5     | 8.60E-03                     |
| 2383.96        | 1       | 3     | 3.20E-04                     | 4579.64        | 5       | 5     | 7.00E-01                     | 14999.90       | 5       | 3     | 2.50E-03                     |
| 2384.32        | 1       | 3     | 2.97E-04                     | 4599.72        | 3       | 1     | 4.07E-01                     | 17186.90       | 3       | 1     | 2.70E-02                     |
| 2384.71        | 1       | 3     | 3.00E-04                     | 4619.92        | 1       | 3     | 2.70E-02                     | 18202.80       | 5       | 3     | 1.20E-02                     |
| 2385.15        | 1       | 3     | 2.50E-04                     | 4700.42        | 3       | 3     | 6.10E-02                     | 21567.70       | 5       | 3     | 2.60E-03                     |
| 2385.62        | 1       | 3     | 2.30E-04                     | 4726.43        | 5       | 3     | 3.30E-01                     | 30685.30       | 5       | 3     | 6.50E-03                     |
| 2386.15        | 1       | 3     | 2.03E-04                     | 4801.30        | 9       | 3     | 1.39E-01                     | <i>Ba II</i>   |         |       |                              |
| 2386.74        | 1       | 3     | 1.87E-04                     | 4902.85        | 5       | 3     | 5.40E-02                     | 1622.43        | 2       | 4     | 2.46E-02                     |
| 2387.40        | 1       | 3     | 1.37E-04                     | 5169.53        | 5       | 3     | 9.00E-04                     | 1630.36        | 2       | 2     | 2.42E-02                     |
| 2388.13        | 1       | 3     | 9.66E-05                     | 5519.04        | 3       | 5     | 5.70E-01                     | 1761.74        | 4       | 4     | 1.00E-02                     |
| 2388.96        | 1       | 3     | 8.37E-05                     | 5535.48        | 1       | 3     | 1.19E+00                     | 1771.10        | 4       | 2     | 1.00E-01                     |
| 2399.39        | 1       | 3     | 1.10E-04                     | 5777.62        | 5       | 7     | 8.00E-01                     | 1786.95        | 6       | 4     | 9.00E-02                     |
| 2402.07        | 1       | 3     | 4.60E-04                     | 5784.04        | 3       | 5     | 2.10E-01                     | 1892.49        | 2       | 4     | 1.30E-01                     |
| 2405.30        | 1       | 3     | 4.90E-04                     | 5800.23        | 5       | 5     | 2.39E-01                     | 1954.28        | 4       | 6     | 1.40E-01                     |
| 2409.23        | 1       | 3     | 8.60E-04                     | 5826.27        | 5       | 3     | 4.50E-01                     | 1955.05        | 4       | 4     | 2.40E-02                     |
| 2414.08        | 1       | 3     | 1.50E-03                     | 5971.70        | 5       | 5     | 1.62E-01                     | 1985.75        | 2       | 4     | 2.00E-01                     |
| 2420.11        | 1       | 3     | 2.30E-03                     | 5997.09        | 3       | 3     | 2.80E-01                     | 1999.55        | 2       | 4     | 7.12E-02                     |
| 2427.41        | 1       | 3     | 5.60E-03                     | 6019.47        | 3       | 1     | 8.10E-01                     | 2009.28        | 2       | 2     | 6.51E-02                     |
| 2438.81        | 1       | 3     | 1.40E-03                     | 6063.11        | 5       | 3     | 5.60E-01                     | 2024.06        | 2       | 2     | 6.86E-02                     |
| 2452.33        | 1       | 3     | 8.10E-04                     | 6083.39        | 3       | 1     | 1.10E-01                     | 2052.75        | 4       | 6     | 2.20E-01                     |
| 2472.74        | 1       | 3     | 4.60E-03                     | 6129.23        | 3       | 1     | 6.00E-02                     | 2054.09        | 4       | 4     | 3.70E-02                     |
| 3071.58        | 1       | 3     | 4.20E-01                     | 6309.36        | 3       | 3     | 2.00E-04                     | 2079.98        | 4       | 2     | 1.17E-01                     |
| 3501.11        | 1       | 3     | 3.50E-01                     | 6341.68        | 5       | 7     | 1.16E-01                     | 2153.93        | 2       | 4     | 3.43E-01                     |
| 3889.33        | 1       | 3     | 1.10E-02                     | 6450.85        | 3       | 5     | 1.10E-01                     | 2200.89        | 2       | 2     | 1.13E-01                     |
| 4132.43        | 1       | 3     | 1.50E-02                     | 6498.76        | 7       | 7     | 5.40E-01                     | 2214.76        | 4       | 4     | 1.60E-02                     |
| 4175.69        | 3       | 5     | 1.97E-04                     | 6527.31        | 5       | 5     | 3.30E-01                     | 2232.79        | 4       | 6     | 3.69E-01                     |
| 4175.91        | 3       | 5     | 1.98E-04                     | 6527.40        | 15      | 15    | 6.15E-01                     | 2235.38        | 4       | 4     | 6.13E-02                     |
| 4176.12        | 3       | 5     | 2.08E-04                     | 6595.33        | 3       | 3     | 3.80E-01                     | 2245.69        | 4       | 2     | 1.60E-01                     |
| 4176.36        | 3       | 5     | 2.19E-04                     | 6675.27        | 5       | 3     | 1.89E-01                     | 2254.78        | 6       | 4     | 1.40E-01                     |
| 4176.60        | 3       | 5     | 2.26E-04                     | 6693.84        | 7       | 5     | 1.46E-01                     | 2285.99        | 4       | 2     | 2.03E-01                     |
| 4176.86        | 3       | 5     | 2.48E-04                     | 6986.80        | 5       | 3     | 5.20E-03                     | 2528.41        | 2       | 4     | 6.91E-01                     |
| 4177.15        | 3       | 5     | 2.77E-04                     | 7059.94        | 7       | 9     | 5.00E-01                     | 2634.78        | 4       | 6     | 7.33E-01                     |
| 4177.44        | 3       | 5     | 3.03E-04                     | 7120.33        | 3       | 5     | 1.10E-01                     | 2641.37        | 4       | 4     | 1.21E-01                     |
| 4177.74        | 3       | 5     | 3.14E-04                     | 7195.23        | 1       | 3     | 5.60E-02                     | 2647.26        | 2       | 2     | 2.26E-01                     |
| 4178.07        | 3       | 5     | 3.07E-04                     | 7213.60        | 5       | 5     | 6.50E-04                     | 2771.35        | 4       | 2     | 3.95E-01                     |
| 4178.43        | 3       | 5     | 3.64E-04                     | 7280.30        | 5       | 7     | 3.20E-01                     | 3390.18        | 4       | 6     | 4.54E-03                     |
| 4178.80        | 3       | 5     | 4.01E-04                     | 7392.41        | 3       | 3     | 1.81E-01                     | 3412.44        | 6       | 8     | 4.77E-03                     |
| 4179.20        | 3       | 5     | 4.31E-04                     | 7417.54        | 7       | 5     | 7.70E-03                     | 3413.95        | 6       | 6     | 3.18E-04                     |
| 4179.64        | 3       | 5     | 4.46E-04                     | 7488.08        | 7       | 7     | 7.30E-02                     | 3552.45        | 4       | 6     | 3.87E-03                     |
| 4180.09        | 3       | 5     | 4.53E-04                     | 7528.18        | 5       | 5     | 2.70E-02                     | 3576.28        | 6       | 8     | 4.07E-03                     |
| 4180.57        | 3       | 5     | 4.55E-04                     | 7610.48        | 5       | 5     | 1.10E-02                     | 3578.57        | 6       | 6     | 2.71E-04                     |
| 4181.09        | 3       | 5     | 4.99E-04                     | 7644.90        | 9       | 3     | 5.03E-01                     | 3891.78        | 2       | 4     | 2.17E+00                     |
| 4181.66        | 3       | 5     | 5.42E-04                     | 7672.09        | 3       | 5     | 1.52E-01                     | 4130.65        | 4       | 6     | 2.18E+00                     |
| 4182.27        | 3       | 5     | 6.11E-04                     | 7780.48        | 5       | 5     | 7.60E-02                     | 4166.00        | 4       | 4     | 3.54E-01                     |
| 4182.94        | 3       | 5     | 6.65E-04                     | 7877.80        | 3       | 5     | 1.60E-02                     | 4216.07        | 2       | 4     | 5.09E-02                     |
| 4183.64        | 3       | 5     | 6.70E-04                     | 7905.75        | 5       | 3     | 2.65E-01                     | 4267.92        | 6       | 8     | 3.10E-01                     |
| 4184.40        | 3       | 5     | 7.93E-04                     | 8147.70        | 5       | 5     | 6.30E-02                     | 4309.26        | 8       | 10    | 3.10E-01                     |
| 4185.25        | 3       | 5     | 8.43E-04                     | 8560.00        | 5       | 5     | 2.00E-01                     | 4325.75        | 4       | 6     | 5.65E-02                     |
| 4186.16        | 3       | 5     | 9.24E-04                     | 8654.08        | 5       | 7     | 3.10E-03                     | 4329.56        | 4       | 4     | 9.39E-03                     |
| 4187.15        | 3       | 5     | 9.90E-04                     | 9370.12        | 5       | 5     | 7.60E-02                     | 4524.93        | 2       | 2     | 6.63E-01                     |
| 4188.25        | 3       | 5     | 1.03E-03                     | 9645.60        | 7       | 5     | 1.10E-01                     |                |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 4554.03        | 2       | 4     | 1.11E+00                     |
| 4708.90        | 2       | 4     | 8.47E-02                     |
| 4843.48        | 4       | 6     | 9.34E-02                     |
| 4847.19        | 2       | 2     | 3.49E-02                     |
| 4850.92        | 4       | 4     | 1.55E-02                     |
| 4899.93        | 4       | 2     | 1.04E+00                     |
| 4934.08        | 2       | 2     | 9.53E-01                     |
| 4957.09        | 6       | 8     | 5.13E-01                     |
| 4997.79        | 4       | 2     | 6.37E-02                     |
| 5012.95        | 8       | 10    | 5.15E-01                     |
| 5185.06        | 2       | 4     | 1.10E-02                     |
| 5267.01        | 2       | 2     | 1.00E-02                     |
| 5361.35        | 4       | 6     | 4.01E-02                     |
| 5391.59        | 6       | 8     | 4.22E-02                     |
| 5413.57        | 6       | 6     | 9.21E-05                     |
| 5421.06        | 6       | 6     | 2.77E-03                     |
| 5428.84        | 6       | 4     | 1.92E-03                     |
| 5480.25        | 8       | 6     | 1.78E-03                     |
| 5784.15        | 2       | 4     | 1.59E-01                     |
| 5853.67        | 4       | 4     | 6.00E-02                     |
| 5981.26        | 4       | 6     | 1.73E-01                     |
| 5999.91        | 4       | 4     | 2.86E-02                     |
| 6135.60        | 2       | 2     | 6.64E-02                     |
| 6141.71        | 6       | 4     | 4.12E-01                     |
| 6378.92        | 4       | 2     | 1.18E-01                     |
| 6496.90        | 4       | 2     | 3.10E-01                     |
| 6769.48        | 6       | 8     | 9.35E-01                     |
| 6874.08        | 8       | 10    | 9.26E-01                     |
| 6995.14        | 6       | 8     | 8.90E-03                     |
| 7115.03        | 8       | 10    | 8.80E-03                     |
| 8496.80        | 2       | 4     | 3.31E-02                     |
| 8591.43        | 6       | 6     | 6.19E-04                     |
| 8661.90        | 6       | 4     | 1.27E-02                     |
| 8703.69        | 4       | 6     | 3.69E-02                     |
| 8710.77        | 6       | 8     | 7.88E-01                     |
| 8719.12        | 4       | 4     | 6.12E-03                     |
| 8737.75        | 4       | 6     | 7.29E-01                     |
| 8760.61        | 8       | 6     | 1.17E-02                     |
| 8897.46        | 6       | 6     | 4.93E-02                     |
| 9603.12        | 2       | 4     | 4.16E-01                     |
| 10115.00       | 4       | 6     | 4.27E-01                     |
| 10212.80       | 4       | 4     | 6.92E-02                     |
| 10709.80       | 6       | 6     | 9.90E-05                     |
| 10768.00       | 2       | 4     | 5.56E-02                     |
| 10769.70       | 6       | 4     | 2.04E-03                     |
| 10993.40       | 8       | 6     | 1.83E-03                     |
| 11088.50       | 4       | 6     | 6.11E-02                     |
| 11127.50       | 4       | 4     | 1.01E-02                     |
| 11519.50       | 2       | 2     | 2.47E-02                     |
| 11577.10       | 2       | 2     | 1.75E-01                     |
| 11931.90       | 4       | 2     | 4.44E-02                     |
| 12475.00       | 4       | 2     | 2.80E-01                     |
| 13057.80       | 2       | 4     | 2.14E-01                     |
| 14211.50       | 2       | 2     | 1.66E-01                     |
| 17738.90       | 6       | 8     | 2.16E-01                     |
| 18530.70       | 8       | 10    | 1.96E-01                     |
| 18729.70       | 2       | 4     | 1.23E-01                     |
| 19642.60       | 4       | 6     | 1.28E-01                     |
| 19845.10       | 4       | 4     | 2.07E-02                     |
| 22994.70       | 2       | 2     | 6.18E-02                     |

| $\lambda$<br>Å   | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|------------------|---------|-------|------------------------------|
|                  | $g_i$   | $g_k$ |                              |
| 24612.50         | 4       | 4     | 4.75E-03                     |
| 24699.00         | 4       | 2     | 9.98E-02                     |
| 25923.20         | 6       | 4     | 3.66E-02                     |
| 27687.20         | 2       | 4     | 6.10E-02                     |
| 29058.90         | 4       | 2     | 2.89E-02                     |
| 30196.00         | 2       | 2     | 4.70E-02                     |
| 42934.70         | 6       | 8     | 4.82E-03                     |
| 43294.30         | 4       | 6     | 4.39E-03                     |
| 47520.80         | 6       | 6     | 2.37E-04                     |
| <i>Beryllium</i> |         |       |                              |
| <i>Be I</i>      |         |       |                              |
| 1491.8           | 1       | 3     | 1.3E-02                      |
| 1661.5           | 1       | 3     | 2.0E-01                      |
| 2348.6           | 1       | 3     | 5.55E+00                     |
| *2494.7          | 9       | 15    | 1.6E+00                      |
| *2650.6          | 9       | 9     | 4.24E+00                     |
| 4572.7           | 3       | 5     | 7.9E-01                      |
| <i>Be II</i>     |         |       |                              |
| 1197.1           | 2       | 2     | 4.7E-01                      |
| 1197.2           | 4       | 2     | 9.4E-01                      |
| 1512.3           | 2       | 4     | 9.2E+00                      |
| 1512.4           | 4       | 6     | 1.1E+01                      |
| 1776.1           | 2       | 2     | 1.4E+00                      |
| 1776.3           | 4       | 2     | 2.9E+00                      |
| *2453.8          | 2       | 6     | 1.42E-01                     |
| 3046.5           | 2       | 4     | 4.8E-01                      |
| 3046.7           | 4       | 6     | 5.9E-01                      |
| 3130.4           | 2       | 4     | 1.14E+00                     |
| 3131.1           | 2       | 2     | 1.15E+00                     |
| 3241.6           | 2       | 2     | 1.41E-01                     |
| 3241.8           | 4       | 2     | 2.8E-01                      |
| 3274.6           | 2       | 4     | 1.9E-01                      |
| 3274.7           | 2       | 2     | 1.9E-01                      |
| 4360.7           | 2       | 4     | 9.2E-01                      |
| 4361.0           | 4       | 6     | 1.1E+00                      |
| *5255.9          | 2       | 6     | 2.56E-02                     |
| 5270.3           | 2       | 2     | 3.30E-01                     |
| 5270.8           | 4       | 2     | 6.6E-01                      |
| 6279.4           | 2       | 4     | 1.2E-01                      |
| 6279.7           | 4       | 6     | 1.43E-01                     |
| 6756.7           | 2       | 2     | 5.1E-02                      |
| 6757.1           | 4       | 2     | 1.02E-01                     |
| 7401.2           | 2       | 4     | 3.0E-02                      |
| 7401.4           | 2       | 2     | 3.0E-02                      |
| <i>Bismuth</i>   |         |       |                              |
| <i>Bi I</i>      |         |       |                              |
| 1954.5           | 4       | 6     | 1.2E+00                      |
| 2021.2           | 4       | 4     | 6.0E-02                      |
| 2061.7           | 4       | 6     | 9.9E-01                      |
| 2110.3           | 4       | 2     | 9.1E-01                      |
| 2177.3           | 4       | 2     | 2.6E-02                      |
| 2228.3           | 4       | 4     | 8.9E-01                      |
| 2230.6           | 4       | 6     | 2.6E+00                      |
| 2276.6           | 4       | 4     | 2.5E-01                      |
| 2515.7           | 4       | 6     | 4.3E-02                      |
| 2627.9           | 4       | 4     | 4.7E-01                      |
| 2696.8           | 4       | 6     | 6.4E-02                      |
| 2780.5           | 4       | 2     | 3.09E-01                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 2798.7         | 6       | 6     | 3.6E-02                      |
| 2898.0         | 4       | 2     | 1.53E+00                     |
| 2938.3         | 6       | 4     | 1.23E+00                     |
| 2989.0         | 4       | 4     | 5.5E-01                      |
| 2993.3         | 4       | 6     | 1.6E-01                      |
| 3024.6         | 6       | 6     | 8.8E-01                      |
| 3067.7         | 4       | 2     | 2.07E+00                     |
| 3076.7         | 4       | 4     | 3.5E-02                      |
| 3397.2         | 6       | 4     | 1.81E-01                     |
| 3402.9         | 6       | 6     | 1.6E-02                      |
| 3510.9         | 6       | 4     | 6.8E-02                      |
| 3596.1         | 2       | 4     | 1.98E-01                     |
| 3888.2         | 2       | 2     | 6.9E-02                      |
| 4121.5         | 2       | 2     | 1.64E-01                     |
| 4308.5         | 2       | 4     | 1.6E-02                      |
| 4493.0         | 2       | 4     | 1.5E-02                      |
| 4722.5         | 4       | 2     | 1.17E-01                     |
| 6134.8         | 4       | 4     | 1.8E-02                      |
| <i>Boron</i>   |         |       |                              |
| <i>BI</i>      |         |       |                              |
| 1378.6         | 2       | 4     | 3.50E+00                     |
| 1378.9         | 2       | 2     | 1.40E+01                     |
| 1378.9         | 4       | 4     | 1.75E+01                     |
| 1379.2         | 4       | 2     | 7.0E+00                      |
| 1465.5         | 2       | 4     | 3.34E+00                     |
| 1465.7         | 4       | 4     | 6.7E+00                      |
| 1465.8         | 6       | 4     | 1.00E+01                     |
| 1825.9         | 2       | 4     | 1.76E+00                     |
| 1826.4         | 4       | 6     | 2.11E+00                     |
| 2088.9         | 2       | 4     | 2.8E-01                      |
| 2089.6         | 4       | 6     | 3.3E-01                      |
| 2496.8         | 2       | 2     | 8.64E-01                     |
| 2497.7         | 4       | 2     | 1.73E+00                     |
| <i>Bromine</i> |         |       |                              |
| <i>Br I</i>    |         |       |                              |
| 1488.5         | 4       | 4     | 1.2E+00                      |
| 1540.7         | 4       | 4     | 1.4E+00                      |
| 1574.8         | 2       | 4     | 2.0E-01                      |
| 1576.4         | 4       | 6     | 2.1E-02                      |
| 1633.4         | 2       | 4     | 8.1E-02                      |
| 4365.1         | 2       | 4     | 7.5E-03                      |
| 4425.1         | 4       | 2     | 4.2E-03                      |
| 4441.7         | 6       | 4     | 7.5E-03                      |
| 4472.6         | 4       | 4     | 9.3E-03                      |
| 4477.7         | 6       | 8     | 1.3E-02                      |
| 4513.4         | 6       | 4     | 2.8E-03                      |
| 4525.6         | 6       | 6     | 7.2E-03                      |
| 4575.7         | 4       | 4     | 1.6E-02                      |
| 4614.6         | 4       | 6     | 5.4E-03                      |
| 4979.8         | 4       | 4     | 2.6E-03                      |
| 5245.1         | 2       | 4     | 3.1E-03                      |
| 5345.4         | 2       | 4     | 7.6E-03                      |
| 7348.5         | 4       | 6     | 1.2E-01                      |
| 7513.0         | 6       | 4     | 1.2E-01                      |
| 7803.0         | 2       | 4     | 5.3E-02                      |
| 7938.7         | 6       | 6     | 1.9E-01                      |
| 8131.5         | 2       | 4     | 3.8E-02                      |
| 8343.7         | 2       | 2     | 2.2E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 8446.6         | 4       | 4     | 1.2E-01                      | 4289.4         | 1       | 3     | 6.0E-01                      | 2103.2         | 2       | 4     | 8.2E-01                      |
| 8638.7         | 6       | 4     | 9.7E-02                      | 4299.0         | 3       | 3     | 4.66E-01                     | 2112.8         | 4       | 6     | 9.7E-01                      |
| Br II          |         |       |                              | 4302.5         | 5       | 5     | 1.36E+00                     | 2113.2         | 4       | 4     | 1.6E-01                      |
| 4704.9         | 5       | 7     | 1.1E+00                      | 4307.7         | 3       | 1     | 1.99E+00                     | 2197.8         | 2       | 2     | 3.1E-01                      |
| 4785.5         | 5       | 5     | 9.4E-01                      | 4318.7         | 5       | 3     | 7.4E-01                      | 2208.6         | 4       | 2     | 6.2E-01                      |
| 4816.7         | 5       | 3     | 1.1E+00                      | 4355.1         | 5       | 7     | 1.9E-01                      | 3158.9         | 2       | 4     | 3.1E+00                      |
| <i>Cadmium</i> |         |       |                              | 4425.4         | 1       | 3     | 4.98E-01                     | 3179.3         | 4       | 6     | 3.6E+00                      |
| <i>Cd I</i>    |         |       |                              | 4435.0         | 3       | 5     | 6.7E-01                      | 3181.3         | 4       | 4     | 5.8E-01                      |
| 2288.0         | 1       | 3     | 5.3E+00                      | 4435.7         | 3       | 3     | 3.42E-01                     | 3706.0         | 2       | 2     | 8.8E-01                      |
| 2836.9         | 1       | 3     | 2.8E-01                      | 4454.8         | 5       | 7     | 8.7E-01                      | 3736.9         | 4       | 2     | 1.7E+00                      |
| 2880.8         | 3       | 5     | 4.2E-01                      | 4455.9         | 5       | 5     | 2.0E-01                      | 3933.7         | 2       | 4     | 1.47E+00                     |
| 2881.2         | 3       | 3     | 2.4E-01                      | 4526.9         | 5       | 3     | 4.1E-01                      | 3968.5         | 2       | 2     | 1.4E+00                      |
| 2980.6         | 5       | 7     | 5.9E-01                      | 4578.6         | 3       | 5     | 1.76E-01                     | <i>Ca III</i>  |         |       |                              |
| 2981.4         | 5       | 5     | 1.5E-01                      | 4581.4         | 5       | 7     | 2.09E-01                     | 357.97         | 1       | 3     | 8.8E+02                      |
| 3261.1         | 1       | 3     | 4.06E-03                     | 4585.9         | 7       | 9     | 2.29E-01                     | 439.69         | 1       | 3     | 1.9E-01                      |
| 3403.7         | 1       | 3     | 7.7E-01                      | 4685.3         | 3       | 5     | 8.0E-02                      | 490.55         | 1       | 3     | 1.6E-02                      |
| 3466.2         | 3       | 5     | 1.2E+00                      | 4878.1         | 5       | 7     | 1.88E-01                     | <i>Ca V</i>    |         |       |                              |
| 3467.7         | 3       | 3     | 6.7E-01                      | 5041.6         | 5       | 3     | 3.3E-01                      | 558.60         | 5       | 3     | 2.2E+01                      |
| 3610.5         | 5       | 7     | 1.3E+00                      | 5188.9         | 3       | 5     | 4.0E-01                      | 637.93         | 5       | 3     | 3.9E+00                      |
| 3612.9         | 5       | 5     | 3.5E-01                      | 5261.7         | 3       | 3     | 1.5E-01                      | 643.12         | 3       | 1     | 9.1E+00                      |
| 4140.5         | 3       | 5     | 4.7E-02                      | 5262.2         | 3       | 1     | 6.0E-01                      | 646.57         | 5       | 5     | 6.9E+00                      |
| 4662.4         | 3       | 5     | 5.5E-02                      | 5264.2         | 5       | 5     | 9.1E-02                      | 647.88         | 3       | 3     | 2.3E+00                      |
| 4678.1         | 1       | 3     | 1.3E-01                      | 5265.6         | 5       | 3     | 4.4E-01                      | 651.55         | 1       | 3     | 2.9E+00                      |
| 4799.9         | 3       | 3     | 4.1E-01                      | 5270.3         | 7       | 5     | 5.0E-01                      | 656.76         | 3       | 5     | 2.1E+00                      |
| 5085.8         | 5       | 3     | 5.6E-01                      | 5582.0         | 5       | 7     | 6.0E-02                      | <i>Ca VII</i>  |         |       |                              |
| 6438.5         | 3       | 5     | 5.9E-01                      | 5588.8         | 7       | 7     | 4.9E-01                      | 550.20         | 5       | 5     | 1.8E+01                      |
| <i>Cd II</i>   |         |       |                              | 5590.1         | 3       | 5     | 8.3E-02                      | 624.39         | 1       | 3     | 3.3E+00                      |
| 2144.4         | 2       | 4     | 2.8E+00                      | 5594.5         | 5       | 5     | 3.8E-01                      | 630.54         | 3       | 5     | 4.5E+00                      |
| 2265.0         | 2       | 2     | 3.0E+00                      | 5598.5         | 3       | 3     | 4.3E-01                      | 630.79         | 3       | 3     | 2.2E+00                      |
| 2572.9         | 2       | 2     | 1.7E+00                      | 5601.3         | 7       | 5     | 8.6E-02                      | 639.15         | 5       | 7     | 5.7E+00                      |
| 2748.5         | 4       | 2     | 2.8E+00                      | 5602.9         | 5       | 3     | 1.4E-01                      | 640.41         | 5       | 5     | 1.3E+00                      |
| 4415.6         | 4       | 6     | 1.4E-02                      | 5857.5         | 3       | 5     | 6.6E-01                      | <i>Ca VIII</i> |         |       |                              |
| <i>Calcium</i> |         |       |                              | 6102.7         | 1       | 3     | 9.6E-02                      | 182.71         | 2       | 2     | 1.6E+02                      |
| <i>Ca I</i>    |         |       |                              | 6122.2         | 3       | 3     | 2.87E-01                     | 184.16         | 4       | 2     | 3.2E+02                      |
| 2275.5         | 1       | 3     | 3.01E-01                     | 6161.3         | 5       | 5     | 3.3E-02                      | <i>Ca IX</i>   |         |       |                              |
| 2995.0         | 1       | 3     | 3.67E-01                     | 6162.2         | 5       | 3     | 3.54E-01                     | 163.23         | 5       | 3     | 3.76E+02                     |
| 2997.3         | 3       | 5     | 2.41E-01                     | 6163.8         | 3       | 3     | 5.6E-02                      | 371.89         | 1       | 3     | 8.8E+01                      |
| 2999.6         | 3       | 3     | 2.79E-01                     | 6166.4         | 3       | 1     | 2.2E-01                      | 373.81         | 3       | 5     | 1.16E+02                     |
| 3000.9         | 3       | 1     | 1.58E+00                     | 6169.1         | 5       | 3     | 1.7E-01                      | 378.08         | 5       | 7     | 1.5E+02                      |
| 3006.9         | 5       | 5     | 7.5E-01                      | 6169.6         | 7       | 5     | 1.9E-01                      | 395.03         | 3       | 5     | 2.2E+02                      |
| 3009.2         | 5       | 3     | 4.30E-01                     | 6439.1         | 7       | 9     | 5.3E-01                      | 466.24         | 1       | 3     | 1.12E+02                     |
| 3344.5         | 1       | 3     | 1.51E-01                     | 6449.8         | 3       | 5     | 9.0E-02                      | 498.01         | 3       | 5     | 2.49E+01                     |
| 3350.2         | 3       | 5     | 1.78E-01                     | 6462.6         | 5       | 7     | 4.7E-01                      | 506.18         | 5       | 5     | 7.2E+01                      |
| 3361.9         | 5       | 7     | 2.23E-01                     | 6471.7         | 7       | 7     | 5.9E-02                      | 515.57         | 5       | 3     | 3.75E+01                     |
| 3624.1         | 1       | 3     | 2.12E-01                     | 6493.8         | 3       | 5     | 4.4E-01                      | <i>Ca X</i>    |         |       |                              |
| 3630.8         | 3       | 5     | 2.97E-01                     | 6499.7         | 5       | 5     | 8.1E-02                      | 110.96         | 2       | 4     | 2.9E+02                      |
| 3631.0         | 3       | 3     | 1.53E-01                     | <i>Ca II</i>   |         |       |                              | 111.20         | 2       | 2     | 2.92E+02                     |
| 3644.4         | 5       | 7     | 3.55E-01                     | 1341.9         | 2       | 4     | 1.5E-02                      | 151.84         | 2       | 2     | 2.3E+02                      |
| 3644.8         | 5       | 5     | 9.4E-02                      | 1342.5         | 2       | 2     | 1.5E-02                      | 153.02         | 4       | 2     | 4.5E+02                      |
| 3870.5         | 3       | 5     | 7.2E-02                      | 1649.9         | 2       | 4     | 3.2E-03                      | 206.57         | 4       | 4     | 2.9E+01                      |
| 3957.1         | 3       | 3     | 9.8E-02                      | 1652.0         | 2       | 2     | 3.1E-03                      | 206.75         | 6       | 4     | 2.6E+02                      |
| 3973.7         | 5       | 3     | 1.75E-01                     | 1673.9         | 2       | 4     | 2.24E-01                     | 207.39         | 4       | 2     | 2.8E+02                      |
| 4092.6         | 3       | 5     | 1.1E-01                      | 1680.1         | 4       | 6     | 2.65E-01                     | 411.70         | 2       | 4     | 8.3E+01                      |
| 4094.9         | 5       | 7     | 1.2E-01                      | 1680.1         | 4       | 4     | 4.41E-02                     | 419.75         | 4       | 6     | 9.5E+01                      |
| 4098.5         | 7       | 9     | 1.3E-01                      | 1807.3         | 2       | 4     | 3.54E-01                     | 420.47         | 4       | 4     | 1.6E+01                      |
| 4108.5         | 5       | 7     | 9.0E-01                      | 1814.5         | 4       | 6     | 4.2E-01                      | 557.76         | 2       | 4     | 3.50E+01                     |
| 4226.7         | 1       | 3     | 2.18E+00                     | 1814.7         | 4       | 4     | 7.0E-02                      | 574.01         | 2       | 2     | 3.2E+01                      |
| 4283.0         | 3       | 5     | 4.34E-01                     | 1843.1         | 2       | 2     | 1.6E-01                      |                |         |       |                              |
|                |         |       |                              | 1850.7         | 4       | 2     | 3.08E-01                     |                |         |       |                              |

| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| <b>Ca XI</b>    |         |       |                              | 1431.60        | 5       | 7     | 2.11E+00                     | 6655.52        | 3       | 3     | 5.03E-03                     |
| 30.448          | 1       | 3     | 6.2E+03                      | 1432.10        | 5       | 5     | 2.01E+00                     | 6828.12        | 3       | 5     | 9.89E-03                     |
| 30.867          | 1       | 3     | 4.9E+04                      | 1432.53        | 5       | 3     | 2.11E+00                     | 7111.47        | 3       | 5     | 2.17E-02                     |
| 35.212          | 1       | 3     | 2.0E+03                      | 1459.03        | 5       | 3     | 4.76E-01                     | 7113.18        | 7       | 9     | 2.47E-02                     |
| <b>Ca XII</b>   |         |       |                              | 1463.34        | 5       | 7     | 1.88E+00                     | 7115.17        | 5       | 7     | 2.19E-02                     |
| 140.05          | 4       | 2     | 3.7E+02                      | 1467.40        | 5       | 3     | 5.49E-01                     | 7115.18        | 3       | 1     | 4.43E-02                     |
| 147.27          | 2       | 2     | 1.6E+02                      | 1468.41        | 5       | 3     | 3.90E-02                     | 7116.99        | 7       | 5     | 3.26E-02                     |
| <b>Ca XV</b>    |         |       |                              | 1470.09        | 5       | 7     | 1.37E-02                     | 7119.66        | 5       | 3     | 3.12E-02                     |
| 141.69          | 5       | 3     | 4.08E+02                     | 1472.23        | 5       | 3     | 8.01E-03                     | 7860.88        | 5       | 5     | 1.53E-02                     |
| *142.23         | 9       | 3     | 6.3E+02                      | 1481.76        | 5       | 5     | 3.92E-01                     | 8058.62        | 5       | 5     | 1.09E-02                     |
| 161.00          | 5       | 5     | 1.9E+02                      | 1560.31        | 1       | 3     | 6.57E-01                     | 8335.15        | 3       | 1     | 3.51E-01                     |
| <b>Ca XVII</b>  |         |       |                              | 1561.34        | 5       | 5     | 2.94E-01                     | 9061.44        | 3       | 5     | 7.31E-02                     |
| 19.558          | 1       | 3     | 3.8E+04                      | 1561.44        | 5       | 7     | 1.18E+00                     | 9062.49        | 1       | 3     | 9.48E-02                     |
| 21.198          | 3       | 5     | 4.9E+04                      | 1656.27        | 3       | 5     | 8.58E-01                     | 9078.29        | 3       | 3     | 7.07E-02                     |
| 192.82          | 1       | 3     | 1.21E+02                     | 1656.93        | 1       | 3     | 1.13E+00                     | 9088.51        | 3       | 1     | 3.00E-01                     |
| 218.82          | 3       | 5     | 2.76E+01                     | 1657.01        | 5       | 5     | 2.52E+00                     | 9094.83        | 5       | 5     | 2.28E-01                     |
| 223.02          | 1       | 3     | 3.44E+01                     | 1657.38        | 3       | 3     | 8.64E-01                     | 9111.81        | 5       | 3     | 1.35E-01                     |
| 228.72          | 3       | 3     | 2.37E+01                     | 1657.91        | 3       | 1     | 3.43E+00                     | 9405.73        | 3       | 5     | 2.91E-01                     |
| 232.83          | 5       | 5     | 6.5E+01                      | 1657.91        | 3       | 1     | 3.43E+00                     | 9405.73        | 3       | 5     | 2.91E-01                     |
| 244.06          | 5       | 3     | 3.28E+01                     | 1658.12        | 5       | 3     | 1.44E+00                     | 9603.03        | 1       | 3     | 3.06E-02                     |
| <b>Ca XVIII</b> |         |       |                              | 1751.83        | 1       | 3     | 9.07E-01                     | 9620.78        | 3       | 3     | 8.62E-02                     |
| *18.71          | 2       | 6     | 2.31E+04                     | 1763.91        | 1       | 3     | 3.59E-02                     | 9658.43        | 5       | 3     | 1.25E-01                     |
| *19.74          | 6       | 10    | 7.0E+04                      | 1765.37        | 1       | 3     | 1.04E-02                     | <b>C II</b>    |         |       |                              |
| 302.19          | 2       | 4     | 2.0E+01                      | 1930.90        | 5       | 3     | 3.51E+00                     | 687.345        | 4       | 6     | 2.84E+01                     |
| 344.76          | 2       | 2     | 1.3E+01                      | 2478.56        | 1       | 3     | 3.40E-01                     | 858.092        | 2       | 2     | 1.18E+00                     |
| <b>Carbon</b>   |         |       |                              | 2902.23        | 1       | 3     | 4.32E-03                     | 858.559        | 4       | 2     | 2.35E+00                     |
| <b>CI</b>       |         |       |                              | 2903.27        | 3       | 3     | 1.29E-02                     | 903.623        | 2       | 4     | 6.85E+00                     |
| 945.191         | 1       | 3     | 3.79E+00                     | 2905.00        | 5       | 3     | 2.15E-02                     | 903.962        | 2       | 2     | 2.74E+01                     |
| 945.338         | 3       | 3     | 1.14E+01                     | 4371.37        | 3       | 3     | 1.27E-02                     | 904.142        | 4       | 4     | 3.42E+01                     |
| 945.579         | 5       | 3     | 1.89E+01                     | 4762.31        | 1       | 3     | 3.37E-03                     | 904.480        | 4       | 2     | 1.37E+01                     |
| 1193.24         | 5       | 7     | 1.22E+00                     | 4762.53        | 3       | 5     | 2.72E-03                     | 1009.86        | 2       | 4     | 5.71E+00                     |
| 1260.74         | 1       | 3     | 5.32E-01                     | 4766.67        | 3       | 3     | 2.36E-03                     | 1010.08        | 4       | 4     | 1.14E+01                     |
| 1260.93         | 3       | 1     | 1.70E+00                     | 4770.03        | 3       | 1     | 1.07E-02                     | 1010.37        | 6       | 4     | 1.71E+01                     |
| 1261.00         | 3       | 3     | 4.42E-01                     | 4771.74        | 5       | 5     | 7.97E-03                     | 1036.34        | 2       | 2     | 7.61E+00                     |
| 1261.12         | 3       | 5     | 3.71E-01                     | 4775.90        | 5       | 3     | 4.84E-03                     | 1037.02        | 4       | 2     | 1.52E+01                     |
| 1261.43         | 5       | 3     | 7.06E-01                     | 4812.92        | 1       | 3     | 4.03E-04                     | 1323.91        | 4       | 4     | 4.33E+00                     |
| 1261.55         | 5       | 5     | 1.27E+00                     | 4817.37        | 3       | 3     | 8.76E-04                     | 1323.95        | 6       | 6     | 4.49E+00                     |
| 1274.11         | 5       | 7     | 1.03E-02                     | 4826.80        | 5       | 3     | 6.28E-04                     | 1334.53        | 2       | 4     | 2.37E+00                     |
| 1277.25         | 1       | 3     | 1.27E+00                     | 4932.05        | 3       | 1     | 6.02E-02                     | 1335.71        | 4       | 6     | 2.84E+00                     |
| 1277.28         | 3       | 5     | 1.73E+00                     | 5023.84        | 7       | 9     | 1.81E-03                     | 2091.14        | 2       | 4     | 1.00E-01                     |
| 1277.51         | 3       | 3     | 9.12E-01                     | 5039.06        | 7       | 9     | 4.73E-03                     | 2091.19        | 4       | 6     | 1.69E-01                     |
| 1277.55         | 5       | 7     | 2.31E+00                     | 5041.48        | 3       | 5     | 5.25E-03                     | 2091.65        | 6       | 8     | 2.41E-01                     |
| 1277.72         | 5       | 5     | 6.35E-01                     | 5041.79        | 5       | 7     | 3.28E-03                     | 2093.16        | 6       | 6     | 7.20E-02                     |
| 1277.95         | 5       | 3     | 5.56E-02                     | 5052.17        | 3       | 5     | 2.60E-02                     | 2173.85        | 2       | 4     | 2.31E-01                     |
| 1279.23         | 5       | 7     | 1.10E-01                     | 5380.34        | 3       | 3     | 1.86E-02                     | 2174.17        | 2       | 2     | 2.31E-01                     |
| 1279.89         | 3       | 5     | 3.08E-01                     | 5545.05        | 3       | 3     | 3.04E-03                     | 2509.13        | 2       | 4     | 4.53E-01                     |
| 1280.14         | 1       | 3     | 3.11E-01                     | 5668.94        | 3       | 3     | 2.35E-02                     | 2511.74        | 4       | 4     | 9.04E-02                     |
| 1280.33         | 5       | 5     | 5.77E-01                     | 5793.12        | 7       | 5     | 3.44E-03                     | 2512.06        | 4       | 6     | 5.42E-01                     |
| 1280.40         | 3       | 3     | 1.73E-01                     | 5794.47        | 5       | 5     | 6.44E-04                     | 2727.31        | 2       | 4     | 6.63E-02                     |
| 1280.60         | 3       | 1     | 8.22E-01                     | 5800.23        | 3       | 3     | 1.04E-03                     | 2728.72        | 4       | 4     | 3.31E-01                     |
| 1280.85         | 5       | 3     | 3.33E-01                     | 5800.60        | 5       | 3     | 3.04E-03                     | 2729.21        | 2       | 2     | 2.65E-01                     |
| 1328.83         | 1       | 3     | 7.95E-01                     | 5805.20        | 3       | 1     | 4.12E-03                     | 2730.63        | 4       | 2     | 1.32E-01                     |
| 1329.09         | 3       | 1     | 2.41E+00                     | 6001.12        | 5       | 5     | 3.22E-03                     | 5132.95        | 2       | 4     | 3.89E-01                     |
| 1329.58         | 5       | 5     | 1.79E+00                     | 6006.02        | 7       | 5     | 1.79E-02                     | 5133.28        | 4       | 6     | 2.80E-01                     |
| 1329.60         | 5       | 3     | 1.00E+00                     | 6007.18        | 3       | 3     | 5.34E-03                     | 5137.26        | 2       | 2     | 1.55E-01                     |
| 1355.84         | 5       | 7     | 1.04E+00                     | 6010.68        | 3       | 1     | 2.13E-02                     | 5139.17        | 4       | 4     | 1.24E-01                     |
| 1364.16         | 5       | 5     | 1.57E-01                     | 6013.17        | 7       | 5     | 1.79E-02                     | 5143.49        | 4       | 2     | 7.73E-01                     |
|                 |         |       |                              | 6013.21        | 7       | 9     | 4.35E-03                     | 5145.16        | 6       | 6     | 6.49E-01                     |
|                 |         |       |                              | 6014.83        | 5       | 3     | 1.60E-02                     | 5151.08        | 6       | 4     | 4.16E-01                     |
|                 |         |       |                              | 6016.45        | 5       | 7     | 3.86E-03                     | 5640.55        | 2       | 4     | 9.89E-02                     |
|                 |         |       |                              | 6587.61        | 3       | 3     | 5.09E-02                     |                |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 5648.07        | 4       | 4     | 1.97E-01                     | 386.203        | 1       | 3     | 3.46E+01                     | 9705.41        | 3       | 5     | 5.93E-02                     |
| 5662.46        | 6       | 4     | 2.93E-01                     | 459.466        | 1       | 3     | 5.91E+01                     | 9706.44        | 3       | 3     | 3.29E-02                     |
| 5818.31        | 2       | 2     | 3.38E-02                     | 459.514        | 3       | 5     | 7.97E+01                     | 9715.09        | 5       | 7     | 7.88E-02                     |
| 5822.98        | 2       | 4     | 3.38E-03                     | 459.627        | 5       | 7     | 1.06E+02                     | 9717.75        | 5       | 5     | 1.97E-02                     |
| 5823.18        | 4       | 2     | 3.38E-02                     | 574.281        | 3       | 5     | 6.24E+01                     | 9718.79        | 5       | 3     | 2.19E-03                     |
| 5827.85        | 4       | 4     | 2.16E-02                     | 977.020        | 1       | 3     | 1.767E+01                    | <i>C IV</i>    |         |       |                              |
| 5836.37        | 6       | 4     | 4.22E-02                     | 1174.93        | 3       | 5     | 3.293E+00                    | *312.43        | 2       | 6     | 4.63E+01                     |
| 5843.62        | 6       | 6     | 1.20E-02                     | 1175.26        | 1       | 3     | 4.385E+00                    | *384.13        | 6       | 10    | 1.76E+02                     |
| 5856.06        | 8       | 6     | 5.31E-02                     | 1175.59        | 3       | 3     | 3.287E+00                    | 1548.19        | 2       | 4     | 2.65E+00                     |
| 6095.29        | 2       | 4     | 4.20E-01                     | 1175.71        | 5       | 5     | 9.856E+00                    | 1550.77        | 2       | 2     | 2.64E+00                     |
| 6098.51        | 4       | 6     | 5.03E-01                     | 1175.99        | 3       | 1     | 1.313E+01                    | 5801.31        | 2       | 4     | 3.17E-01                     |
| 6102.56        | 4       | 4     | 8.37E-02                     | 1176.37        | 5       | 3     | 5.468E+00                    | 5811.97        | 2       | 2     | 3.16E-01                     |
| 6578.05        | 2       | 4     | 3.63E-01                     | 1247.38        | 3       | 1     | 2.082E+01                    | <i>C V</i>     |         |       |                              |
| 6582.88        | 2       | 2     | 3.62E-01                     | 2296.87        | 3       | 5     | 1.376E+00                    | 34.9728        | 1       | 3     | 2.554E+03                    |
| 6724.56        | 2       | 4     | 3.17E-02                     | 2849.05        | 3       | 1     | 1.95E-01                     | 40.2678        | 1       | 3     | 8.873E+03                    |
| 6727.07        | 2       | 2     | 6.34E-02                     | 3703.70        | 3       | 3     | 5.90E-01                     | *227.19        | 3       | 9     | 1.363E+02                    |
| 6727.26        | 4       | 6     | 2.96E-02                     | 4325.56        | 3       | 5     | 1.24E-01                     | 247.315        | 1       | 3     | 1.278E+02                    |
| 6731.07        | 4       | 4     | 5.06E-02                     | 4647.42        | 3       | 5     | 7.26E-01                     | *248.71        | 9       | 15    | 4.247E+02                    |
| 6733.58        | 4       | 2     | 6.32E-02                     | 4650.25        | 3       | 3     | 7.25E-01                     | *260.19        | 9       | 3     | 6.680E+01                    |
| 6734.00        | 6       | 8     | 1.80E-02                     | 4651.02        | 3       | 5     | 2.28E-01                     | 267.267        | 3       | 5     | 3.947E+02                    |
| 6738.61        | 6       | 6     | 7.23E-02                     | 4651.47        | 3       | 1     | 7.24E-01                     | *2273.9        | 3       | 9     | 5.646E-01                    |
| 6742.43        | 6       | 4     | 4.41E-02                     | 4652.05        | 1       | 3     | 3.04E-01                     | 3526.66        | 1       | 3     | 1.663E-01                    |
| 6750.54        | 8       | 8     | 1.08E-01                     | 4659.06        | 3       | 3     | 2.27E-01                     | 8420.72        | 3       | 5     | 6.898E-02                    |
| 6755.16        | 8       | 6     | 2.38E-02                     | 4663.64        | 3       | 1     | 9.05E-01                     | *8433.2        | 3       | 9     | 6.868E-02                    |
| 6779.94        | 4       | 6     | 2.56E-01                     | 4665.86        | 5       | 5     | 6.78E-01                     | 8448.12        | 3       | 1     | 6.832E-02                    |
| 6780.59        | 2       | 4     | 1.52E-01                     | 4673.95        | 5       | 3     | 3.75E-01                     | 8449.19        | 3       | 3     | 6.829E-02                    |
| 6783.91        | 6       | 8     | 3.65E-01                     | 5244.66        | 1       | 3     | 5.30E-02                     | <i>Cesium</i>  |         |       |                              |
| 6787.21        | 2       | 2     | 3.04E-01                     | 5253.58        | 3       | 3     | 1.58E-01                     | <i>Cs I</i>    |         |       |                              |
| 6791.47        | 4       | 4     | 1.94E-01                     | 5272.52        | 5       | 3     | 2.61E-01                     | 3203.5         | 2       | 4     | 7.6E-06                      |
| 6798.10        | 4       | 2     | 6.04E-02                     | 5695.92        | 3       | 5     | 4.27E-01                     | 3205.3         | 2       | 4     | 7.9E-06                      |
| 6800.69        | 6       | 6     | 1.09E-01                     | 5858.34        | 3       | 1     | 1.34E-01                     | 3207.5         | 2       | 4     | 8.5E-06                      |
| 6812.28        | 6       | 4     | 1.80E-02                     | 5863.25        | 3       | 3     | 3.35E-02                     | 3210.0         | 2       | 4     | 9.4E-06                      |
| 7046.25        | 4       | 2     | 3.20E-01                     | 5871.68        | 5       | 3     | 1.00E-01                     | 3212.8         | 2       | 4     | 1.19E-05                     |
| 7053.09        | 4       | 4     | 3.19E-01                     | 5880.56        | 5       | 5     | 1.99E-02                     | 3216.2         | 2       | 4     | 1.49E-05                     |
| 7063.68        | 4       | 6     | 3.17E-01                     | 5894.07        | 7       | 5     | 1.11E-01                     | 3220.1         | 2       | 4     | 1.7E-05                      |
| 7112.48        | 2       | 4     | 2.94E-01                     | 6727.48        | 1       | 3     | 1.12E-01                     | 3220.2         | 2       | 2     | 1.07E-07                     |
| 7113.04        | 4       | 6     | 3.15E-01                     | 6731.04        | 3       | 5     | 1.50E-01                     | 3224.8         | 2       | 4     | 2.0E-05                      |
| 7115.63        | 6       | 8     | 3.60E-01                     | 6742.15        | 3       | 3     | 8.32E-02                     | 3225.0         | 2       | 2     | 1.43E-07                     |
| 7119.76        | 4       | 4     | 1.17E-01                     | 6744.39        | 5       | 7     | 1.99E-01                     | 3230.5         | 2       | 4     | 2.5E-05                      |
| 7119.91        | 8       | 10    | 4.19E-01                     | 6762.17        | 5       | 5     | 4.95E-02                     | 3230.7         | 2       | 2     | 1.97E-07                     |
| 7125.72        | 6       | 6     | 1.02E-01                     | 6773.39        | 5       | 3     | 5.47E-03                     | 3237.4         | 2       | 4     | 2.8E-05                      |
| 7132.47        | 6       | 4     | 8.33E-03                     | 6851.18        | 3       | 5     | 7.60E-03                     | 3237.6         | 2       | 2     | 2.63E-07                     |
| 7134.10        | 8       | 8     | 5.93E-02                     | 6853.68        | 5       | 7     | 5.64E-03                     | 3245.9         | 2       | 4     | 3.45E-05                     |
| 7231.33        | 2       | 4     | 3.52E-01                     | 6857.24        | 3       | 3     | 3.79E-02                     | 3246.2         | 2       | 2     | 3.7E-07                      |
| 7236.42        | 4       | 6     | 4.22E-01                     | 6862.69        | 5       | 5     | 3.51E-02                     | 3256.7         | 2       | 4     | 4.25E-05                     |
| 7237.17        | 4       | 4     | 7.03E-02                     | 6868.78        | 5       | 3     | 1.26E-02                     | 3257.1         | 2       | 2     | 7.0E-07                      |
| 8028.85        | 2       | 2     | 1.71E-02                     | 6872.04        | 7       | 7     | 4.46E-02                     | 3270.5         | 2       | 4     | 5.6E-05                      |
| 8037.73        | 2       | 4     | 4.26E-02                     | 6881.10        | 7       | 5     | 7.80E-03                     | 3271.0         | 2       | 2     | 9.8E-07                      |
| 8039.40        | 4       | 2     | 8.51E-02                     | 7353.88        | 5       | 3     | 3.09E-02                     | 3288.6         | 2       | 4     | 1.0E-04                      |
| 8048.31        | 4       | 4     | 1.36E-02                     | 7707.43        | 3       | 5     | 1.30E-01                     | 3289.3         | 2       | 2     | 2.7E-06                      |
| 8062.10        | 4       | 6     | 3.04E-02                     | 7771.76        | 3       | 1     | 1.77E-01                     | 3313.1         | 2       | 4     | 1.6E-04                      |
| 8062.80        | 6       | 4     | 4.56E-02                     | 7780.41        | 3       | 3     | 1.76E-01                     | 3314.0         | 2       | 2     | 5.2E-06                      |
| 8076.64        | 6       | 6     | 7.05E-02                     | 7796.00        | 3       | 5     | 1.75E-01                     | 3347.5         | 2       | 4     | 2.2E-04                      |
| 9238.30        | 4       | 6     | 3.34E-02                     | 8500.32        | 1       | 3     | 1.01E-01                     | 3348.8         | 2       | 2     | 1.1E-05                      |
| 9251.01        | 2       | 4     | 2.77E-02                     | 9593.32        | 3       | 3     | 5.32E-03                     | 3397.9         | 2       | 4     | 4.0E-04                      |
| 9863.06        | 2       | 4     | 5.56E-02                     | 9651.47        | 5       | 5     | 1.57E-02                     | 3400.0         | 2       | 2     | 2.4E-05                      |
| 9870.78        | 4       | 6     | 9.31E-02                     | 9696.48        | 5       | 7     | 7.53E-03                     | 3476.8         | 2       | 4     | 6.6E-04                      |
| 9882.68        | 6       | 8     | 1.33E-01                     | 9696.54        | 3       | 5     | 7.12E-03                     | 3480.0         | 2       | 2     | 6.6E-05                      |
| <i>C III</i>   |         |       |                              | 9699.57        | 7       | 9     | 8.47E-03                     |                |         |       |                              |
| 310.170        | 1       | 3     | 6.56E+00                     | 9701.10        | 1       | 3     | 4.40E-02                     |                |         |       |                              |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 3611.4         | 2       | 4     | 1.5E-03                      |
| 3617.3         | 2       | 2     | 2.5E-04                      |
| 3876.1         | 2       | 4     | 3.8E-03                      |
| 3888.6         | 2       | 2     | 9.7E-04                      |
| 4555.3         | 2       | 4     | 1.88E-02                     |
| 4593.2         | 2       | 2     | 8.0E-03                      |
| 8521.1         | 2       | 4     | 3.27E-01                     |
| 8943.5         | 2       | 2     | 2.87E-01                     |

*Chlorine**Cl I*

|        |   |   |          |
|--------|---|---|----------|
| 1188.8 | 4 | 6 | 2.33E+00 |
| 1188.8 | 4 | 4 | 2.71E-01 |
| 1201.4 | 2 | 4 | 2.39E+00 |
| 1335.7 | 4 | 2 | 1.74E+00 |
| 1347.2 | 4 | 4 | 4.19E+00 |
| 1351.7 | 2 | 2 | 3.23E+00 |
| 1363.4 | 2 | 4 | 7.5E-01  |
| 4323.3 | 4 | 4 | 1.1E-02  |
| 4363.3 | 4 | 6 | 6.8E-03  |
| 4379.9 | 4 | 4 | 1.4E-02  |
| 4389.8 | 6 | 8 | 1.4E-02  |
| 4526.2 | 4 | 4 | 5.1E-02  |
| 4601.0 | 2 | 2 | 4.2E-02  |
| 4661.2 | 2 | 4 | 1.2E-02  |
| 7256.6 | 6 | 4 | 1.5E-01  |
| 7414.1 | 6 | 4 | 4.7E-02  |
| 7547.1 | 4 | 4 | 1.2E-01  |
| 7717.6 | 4 | 4 | 3.0E-02  |
| 7745.0 | 2 | 4 | 6.3E-02  |
| 7769.2 | 6 | 6 | 6.0E-02  |
| 7821.4 | 6 | 8 | 9.8E-02  |
| 7830.8 | 4 | 4 | 9.7E-02  |
| 7878.2 | 6 | 6 | 1.8E-02  |
| 7899.3 | 4 | 6 | 5.1E-02  |
| 7924.6 | 2 | 4 | 2.1E-02  |
| 7935.0 | 6 | 8 | 3.9E-02  |
| 7997.9 | 4 | 4 | 2.1E-02  |

*Cl II*

|        |   |   |          |
|--------|---|---|----------|
| 3329.1 | 5 | 7 | 1.5E+00  |
| 3522.1 | 7 | 7 | 1.4E+00  |
| 3798.8 | 5 | 7 | 1.6E+00  |
| 3805.2 | 7 | 9 | 1.8E+00  |
| 3809.5 | 3 | 5 | 1.5E+00  |
| 3851.0 | 5 | 7 | 1.8E+00  |
| 3851.4 | 5 | 5 | 1.6E+00  |
| 3854.7 | 3 | 5 | 2.2E+00  |
| 3861.9 | 5 | 7 | 2.4E+00  |
| 3868.6 | 7 | 9 | 2.7E+00  |
| 3913.9 | 9 | 9 | 8.2E-01  |
| 3990.2 | 5 | 7 | 8.4E-01  |
| 4132.5 | 5 | 5 | 1.6E+00  |
| 4276.5 | 9 | 7 | 7.6E-01  |
| 4768.7 | 3 | 5 | 7.7E-01  |
| 4781.3 | 5 | 7 | 1.0E+00  |
| 4794.6 | 5 | 7 | 1.04E+00 |
| 4810.1 | 5 | 5 | 9.9E-01  |
| 4819.5 | 5 | 3 | 1.00E+00 |
| 4904.8 | 5 | 7 | 8.1E-01  |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 4917.7         | 3       | 5     | 7.5E-01                      |
| 5078.3         | 7       | 7     | 7.7E-01                      |
| 5219.1         | 3       | 9     | 8.6E-01                      |
| 5392.1         | 5       | 7     | 1.0E+00                      |

*Cl III*

|        |   |    |         |
|--------|---|----|---------|
| 2298.5 | 4 | 4  | 4.2E+00 |
| 2340.6 | 6 | 6  | 4.2E+00 |
| 2370.4 | 8 | 6  | 2.8E+00 |
| 2531.8 | 2 | 4  | 4.4E+00 |
| 2532.5 | 4 | 6  | 5.3E+00 |
| 2577.1 | 4 | 6  | 4.3E+00 |
| 2580.7 | 6 | 8  | 4.7E+00 |
| 2601.2 | 2 | 4  | 4.6E+00 |
| 2603.6 | 4 | 6  | 5.0E+00 |
| 2609.5 | 6 | 8  | 5.7E+00 |
| 2617.0 | 8 | 10 | 6.6E+00 |
| 2661.6 | 4 | 6  | 3.4E+00 |
| 2665.5 | 6 | 8  | 4.8E+00 |
| 2691.5 | 4 | 4  | 3.5E+00 |
| 2710.4 | 4 | 6  | 3.5E+00 |
| 3340.4 | 6 | 6  | 1.5E+00 |
| 3392.9 | 4 | 4  | 1.9E+00 |
| 3393.5 | 6 | 6  | 1.9E+00 |
| 3530.0 | 6 | 8  | 1.8E+00 |
| 3560.7 | 4 | 6  | 1.7E+00 |
| 3602.1 | 6 | 8  | 1.7E+00 |
| 3612.9 | 4 | 6  | 1.2E+00 |
| 3720.5 | 4 | 6  | 1.7E+00 |

*Chromium**Cr I*

|         |   |    |         |
|---------|---|----|---------|
| 1999.95 | 9 | 9  | 1.4E+00 |
| 2383.30 | 9 | 11 | 4.1E-01 |
| 2389.21 | 3 | 5  | 2.3E-01 |
| 2408.60 | 9 | 7  | 6.7E-01 |
| 2408.72 | 7 | 5  | 2.9E-01 |
| 2492.57 | 3 | 5  | 4.5E-01 |
| 2495.08 | 3 | 3  | 2.7E-01 |
| 2496.30 | 5 | 7  | 5.6E-01 |
| 2502.55 | 7 | 9  | 2.2E-01 |
| 2504.31 | 7 | 9  | 4.5E-01 |
| 2508.11 | 5 | 5  | 2.1E-01 |
| 2508.97 | 5 | 3  | 3.8E-01 |
| 2527.11 | 9 | 9  | 5.3E-01 |
| 2549.55 | 3 | 3  | 4.8E-01 |
| 2560.70 | 5 | 5  | 4.3E-01 |
| 2571.74 | 7 | 5  | 6.4E-01 |
| 2577.66 | 7 | 7  | 2.6E-01 |
| 2591.84 | 9 | 7  | 6.5E-01 |
| 2620.48 | 5 | 3  | 1.9E-01 |
| 2673.64 | 3 | 3  | 1.8E-01 |
| 2701.99 | 9 | 11 | 2.1E-01 |
| 2726.50 | 5 | 7  | 7.5E-01 |
| 2731.90 | 5 | 5  | 7.8E-01 |
| 2736.46 | 5 | 3  | 7.5E-01 |
| 2752.85 | 3 | 3  | 8.7E-01 |
| 2757.09 | 5 | 5  | 6.8E-01 |
| 2761.74 | 5 | 3  | 6.8E-01 |
| 2764.36 | 7 | 7  | 3.7E-01 |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 2769.90        | 7       | 5     | 1.1E+00                      |
| 2780.70        | 9       | 7     | 1.4E+00                      |
| 2879.27        | 5       | 7     | 2.1E-01                      |
| 2887.00        | 3       | 5     | 2.7E-01                      |
| 2889.22        | 9       | 9     | 6.6E-01                      |
| 2893.25        | 7       | 7     | 5.2E-01                      |
| 2894.17        | 1       | 3     | 3.3E-01                      |
| 2896.76        | 5       | 5     | 3.0E-01                      |
| 2905.48        | 3       | 1     | 1.3E+00                      |
| 2909.05        | 5       | 3     | 6.8E-01                      |
| 2910.89        | 7       | 5     | 3.4E-01                      |
| 2911.15        | 9       | 7     | 2.6E-01                      |
| 2967.64        | 7       | 9     | 3.9E-01                      |
| 2971.10        | 5       | 7     | 7.1E-01                      |
| 2975.48        | 3       | 5     | 8.9E-01                      |
| 2980.78        | 1       | 3     | 5.10E-01                     |
| 2988.64        | 5       | 7     | 5.2E-01                      |
| 2991.88        | 3       | 1     | 3.0E+00                      |
| 2994.06        | 5       | 5     | 2.5E-01                      |
| 2995.09        | 5       | 5     | 4.3E-01                      |
| 2996.57        | 5       | 3     | 2.0E+00                      |
| 2998.78        | 5       | 3     | 4.07E-01                     |
| 3000.88        | 7       | 5     | 1.6E+00                      |
| 3005.06        | 9       | 7     | 9.2E-01                      |
| 3013.72        | 3       | 5     | 8.3E-01                      |
| 3015.20        | 1       | 3     | 1.63E+00                     |
| 3020.67        | 3       | 3     | 1.5E+00                      |
| 3021.58        | 9       | 11    | 2.91E+00                     |
| 3024.36        | 5       | 5     | 1.27E+00                     |
| 3029.17        | 5       | 3     | 3.8E-01                      |
| 3030.25        | 7       | 7     | 1.1E+00                      |
| 3031.35        | 5       | 3     | 3.1E-01                      |
| 3034.19        | 7       | 7     | 3.5E-01                      |
| 3037.05        | 9       | 9     | 5.4E-01                      |
| 3040.84        | 7       | 5     | 7.4E-01                      |
| 3053.87        | 9       | 7     | 7.97E-01                     |
| 3148.44        | 9       | 11    | 5.6E-01                      |
| 3155.16        | 11      | 13    | 5.7E-01                      |
| 3163.76        | 13      | 15    | 6.0E-01                      |
| 3237.73        | 9       | 9     | 1.3E+00                      |
| 3238.09        | 11      | 11    | 2.0E-01                      |
| 3578.68        | 7       | 9     | 1.48E+00                     |
| 3593.48        | 7       | 7     | 1.50E+00                     |
| 3605.32        | 7       | 5     | 1.62E+00                     |
| 3639.80        | 13      | 11    | 1.8E+00                      |
| 3743.89        | 13      | 13    | 7.61E-01                     |
| 3757.66        | 7       | 7     | 4.13E-01                     |
| 3768.24        | 5       | 5     | 5.10E-01                     |
| 3804.80        | 9       | 9     | 6.9E-01                      |
| 3963.69        | 13      | 15    | 1.3E+00                      |
| 3969.75        | 11      | 13    | 1.2E+00                      |
| 3983.90        | 7       | 9     | 1.05E+00                     |
| 3991.12        | 5       | 7     | 1.07E+00                     |
| 4001.44        | 9       | 11    | 6.8E-01                      |
| 4039.10        | 15      | 15    | 6.7E-01                      |
| 4048.78        | 13      | 13    | 6.4E-01                      |
| 4058.78        | 11      | 11    | 6.7E-01                      |
| 4065.71        | 9       | 11    | 3.5E-01                      |
| 4165.52        | 11      | 13    | 7.5E-01                      |
| 4204.48        | 13      | 11    | 3.1E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 4254.33        | 7       | 9     | 3.15E-01                     | 5783.89        | 5       | 5     | 2.02E-01                     | 1127.63        | 9       | 11    | 3.5E+01                      |
| 4263.15        | 15      | 17    | 6.4E-01                      | 5787.97        | 5       | 7     | 2.35E-01                     | 1465.86        | 5       | 3     | 1.1E+01                      |
| 4274.81        | 7       | 7     | 3.07E-01                     | <i>Cr II</i>   |         |       |                              | 1481.65        | 3       | 1     | 1.0E+01                      |
| 4275.98        | 11      | 11    | 2.2E-01                      | 2653.57        | 4       | 6     | 3.5E-01                      | 1519.03        | 5       | 7     | 9.5E+00                      |
| 4280.42        | 13      | 15    | 4.7E-01                      | 2658.59        | 2       | 4     | 5.8E-01                      | 1579.70        | 7       | 9     | 8.6E+00                      |
| 4289.73        | 7       | 5     | 3.16E-01                     | 2666.02        | 6       | 8     | 5.9E-01                      | <i>Cr VI</i>   |         |       |                              |
| 4291.97        | 7       | 5     | 2.4E-01                      | 2668.71        | 4       | 2     | 1.4E+00                      | 161.687        | 6       | 6     | 1.7E+02                      |
| 4297.75        | 11      | 13    | 4.9E-01                      | 2671.80        | 6       | 4     | 1.0E+00                      | 168.088        | 4       | 6     | 2.0E+02                      |
| 4298.05        | 9       | 9     | 2.6E-01                      | 2672.83        | 8       | 6     | 5.5E-01                      | 201.007        | 4       | 4     | 2.5E+03                      |
| 4300.52        | 9       | 7     | 1.9E-01                      | 2744.97        | 4       | 6     | 8.5E-01                      | 201.224        | 4       | 6     | 1.8E+02                      |
| 4301.19        | 11      | 9     | 2.6E-01                      | 2787.61        | 6       | 6     | 1.5E+00                      | 201.388        | 6       | 4     | 2.7E+02                      |
| 4302.78        | 11      | 11    | 2.5E-01                      | 2822.38        | 14      | 16    | 2.3E+00                      | 201.606        | 6       | 6     | 2.6E+03                      |
| 4319.66        | 5       | 3     | 1.8E-01                      | 2835.63        | 10      | 12    | 2.0E+00                      | 202.442        | 6       | 4     | 1.0E+03                      |
| 4337.25        | 5       | 7     | 2.0E-01                      | 2840.01        | 10      | 12    | 2.7E+00                      | 202.739        | 4       | 2     | 1.2E+03                      |
| 4373.65        | 9       | 9     | 2.8E-01                      | 2843.24        | 8       | 10    | 6.4E-01                      | 226.241        | 6       | 8     | 7.2E+02                      |
| 4376.80        | 13      | 13    | 3.2E-01                      | 2849.83        | 6       | 8     | 9.2E-01                      | 227.202        | 4       | 6     | 6.6E+02                      |
| 4413.86        | 7       | 5     | 2.7E-01                      | 2851.35        | 8       | 10    | 2.2E+00                      | <i>Cr X</i>    |         |       |                              |
| 4422.70        | 5       | 5     | 2.7E-01                      | 2856.77        | 4       | 6     | 4.3E-01                      | 216.72         | 6       | 8     | 9.0E+02                      |
| 4424.29        | 9       | 7     | 2.1E-01                      | 2857.40        | 6       | 8     | 2.8E-01                      | 223.86         | 4       | 2     | 7.7E+02                      |
| 4429.93        | 3       | 3     | 2.4E-01                      | 2860.92        | 2       | 4     | 6.9E-01                      | 224.74         | 4       | 4     | 7.6E+02                      |
| 4432.16        | 1       | 3     | 1.8E-01                      | 2862.57        | 8       | 8     | 6.3E-01                      | 226.24         | 4       | 6     | 7.3E+02                      |
| 4432.77        | 15      | 15    | 4.9E-01                      | 2866.72        | 4       | 4     | 1.2E+00                      | 227.42         | 4       | 4     | 5.2E+02                      |
| 4443.72        | 3       | 1     | 4.5E-01                      | 2867.09        | 4       | 4     | 1.1E+00                      | 227.50         | 4       | 6     | 1.8E+01                      |
| 4482.88        | 3       | 3     | 3.0E-01                      | 2867.65        | 2       | 2     | 1.1E+00                      | 228.63         | 6       | 4     | 8.1E+01                      |
| 4490.55        | 9       | 7     | 3.9E-01                      | 2870.43        | 6       | 6     | 1.3E+00                      | 228.71         | 6       | 6     | 4.5E+02                      |
| 4492.31        | 5       | 3     | 4.47E-01                     | 2873.81        | 4       | 2     | 8.8E-01                      | 231.21         | 2       | 4     | 1.2E+02                      |
| 4495.28        | 9       | 7     | 2.0E-01                      | 2880.86        | 6       | 4     | 7.9E-01                      | 232.96         | 4       | 4     | 4.4E+02                      |
| 4500.29        | 7       | 7     | 2.1E-01                      | 2898.53        | 10      | 12    | 1.2E+00                      | 242.20         | 2       | 4     | 5.0E+01                      |
| 4506.84        | 13      | 11    | 2.7E-01                      | 2921.81        | 8       | 10    | 9.0E-01                      | 244.19         | 4       | 6     | 5.8E+01                      |
| 4540.72        | 11      | 11    | 3.14E-01                     | 2930.83        | 2       | 4     | 1.1E+00                      | 395.984        | 4       | 4     | 2.4E+01                      |
| 4564.17        | 11      | 13    | 5.1E-01                      | 2935.12        | 6       | 8     | 1.8E+00                      | 398.150        | 6       | 6     | 2.1E+01                      |
| 4595.60        | 13      | 13    | 4.7E-01                      | 2953.34        | 2       | 2     | 1.8E+00                      | <i>Cr XI</i>   |         |       |                              |
| 4622.47        | 7       | 7     | 4.1E-01                      | 2966.03        | 10      | 8     | 5.4E-01                      | 214.31         | 5       | 7     | 1.4E+01                      |
| 4663.33        | 3       | 3     | 2.0E-01                      | 2971.90        | 14      | 14    | 2.0E+00                      | 226.45         | 5       | 7     | 6.0E+02                      |
| 4665.90        | 3       | 3     | 3.0E-01                      | 2979.73        | 12      | 12    | 1.8E+00                      | 232            | 3       | 1     | 4.1E+02                      |
| 4689.38        | 7       | 5     | 2.3E-01                      | 2985.32        | 10      | 10    | 2.2E+00                      | 235.53         | 5       | 7     | 5.5E+02                      |
| 4698.46        | 9       | 7     | 2.2E-01                      | 2989.18        | 8       | 8     | 2.2E+00                      | 240.76         | 1       | 3     | 4.8E+02                      |
| 4708.02        | 11      | 9     | 4.31E-01                     | 3118.64        | 2       | 4     | 1.7E+00                      | 250.28         | 5       | 7     | 1.0E+01                      |
| 4718.43        | 13      | 11    | 3.4E-01                      | 3120.36        | 4       | 6     | 1.5E+00                      | 366.491        | 3       | 3     | 1.2E+01                      |
| 4730.69        | 7       | 5     | 3.83E-01                     | 3122.59        | 12      | 12    | 4.4E-01                      | 366.942        | 3       | 1     | 3.0E+01                      |
| 4737.33        | 9       | 7     | 3.38E-01                     | 3128.69        | 4       | 4     | 8.1E-01                      | 374.927        | 5       | 5     | 2.3E+01                      |
| 4741.09        | 3       | 5     | 2.2E-01                      | 3136.68        | 6       | 6     | 6.4E-01                      | 422.083        | 3       | 5     | 1.0E+01                      |
| 4752.07        | 13      | 13    | 6.2E-01                      | 4588.22        | 8       | 6     | 1.2E-01                      | <i>Cr XII</i>  |         |       |                              |
| 4756.09        | 11      | 9     | 4.0E-01                      | <i>Cr V</i>    |         |       |                              | 216            | 4       | 6     | 2.4E+02                      |
| 4792.49        | 7       | 5     | 2.6E-01                      | 434.306        | 9       | 9     | 1.5E+01                      | 218            | 6       | 8     | 2.4E+02                      |
| 4801.02        | 9       | 7     | 3.06E-01                     | 436.351        | 9       | 7     | 2.4E+01                      | 239            | 2       | 2     | 1.6E+02                      |
| 4816.13        | 9       | 9     | 1.8E-01                      | 436.601        | 7       | 5     | 2.1E+01                      | 244.70         | 2       | 4     | 3.0E+02                      |
| 4870.79        | 7       | 9     | 3.5E-01                      | 437.420        | 7       | 7     | 1.4E+01                      | 247            | 4       | 2     | 2.4E+02                      |
| 4887.01        | 9       | 11    | 3.2E-01                      | 437.655        | 5       | 5     | 1.3E+01                      | 247            | 2       | 2     | 3.3E+02                      |
| 4922.28        | 11      | 13    | 4.0E-01                      | 441.056        | 5       | 3     | 2.3E+01                      | 248            | 6       | 8     | 1.4E+02                      |
| 4966.80        | 3       | 1     | 3.0E-01                      | 456.357        | 1       | 3     | 9.5E+00                      | 250            | 6       | 8     | 3.5E+02                      |
| 5204.51        | 5       | 3     | 5.09E-01                     | 456.637        | 3       | 1     | 3.3E+01                      | 250            | 6       | 6     | 2.2E+02                      |
| 5206.02        | 5       | 5     | 5.14E-01                     | 456.743        | 3       | 3     | 9.1E+00                      | 251.52         | 4       | 6     | 3.4E+02                      |
| 5208.42        | 5       | 7     | 5.06E-01                     | 457.028        | 5       | 5     | 2.7E+01                      | 252            | 4       | 6     | 2.0E+02                      |
| 5243.38        | 5       | 3     | 2.19E-01                     | 457.504        | 5       | 3     | 1.2E+01                      | 256            | 2       | 2     | 1.5E+02                      |
| 5297.37        | 7       | 9     | 3.88E-01                     | 464.015        | 9       | 7     | 3.6E+01                      | 259            | 2       | 4     | 3.2E+02                      |
| 5297.99        | 7       | 7     | 3.0E-01                      | 469.634        | 5       | 5     | 2.3E+01                      | 269            | 2       | 2     | 2.1E+02                      |
| 5328.36        | 9       | 11    | 6.2E-01                      | 1106.25        | 7       | 9     | 1.2E+01                      | 300.32         | 2       | 2     | 1.4E+02                      |
| 5329.17        | 9       | 9     | 2.25E-01                     | 1121.07        | 7       | 9     | 2.1E+01                      |                |         |       |                              |
| 5783.11        | 3       | 3     | 2.1E-01                      |                |         |       |                              |                |         |       |                              |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 305.81         | 4       | 4     | 2.76E+02                     | 125.3           | 6       | 8     | 5.4E+02                      | 123.87         | 6       | 4     | 3.9E+02                      |
| 309            | 4       | 2     | 2.7E+02                      | 148.5           | 2       | 4     | 2.18E+02                     | 125.51         | 4       | 4     | 3.4E+02                      |
| 309            | 6       | 6     | 1.6E+02                      | 149.1           | 2       | 2     | 2.1E+02                      | 128.10         | 6       | 6     | 2.8E+02                      |
| 311.55         | 4       | 2     | 1.6E+02                      | 157.1           | 2       | 4     | 3.3E+02                      | 136.52         | 4       | 2     | 1.66E+02                     |
| 324            | 4       | 6     | 2.2E+02                      | 158.4           | 4       | 6     | 3.7E+02                      | 139.87         | 4       | 4     | 1.49E+02                     |
| 327            | 6       | 8     | 2.2E+02                      | 187.02          | 4       | 6     | 9.3E+02                      | 140.82         | 4       | 2     | 2.66E+02                     |
| 332.06         | 6       | 4     | 1.4E+02                      | 187.30          | 6       | 8     | 9.6E+02                      | 155.46         | 2       | 2     | 2.84E+02                     |
| <i>Cr XIII</i> |         |       |                              | 189.1           | 2       | 2     | 2.13E+02                     | 157.40         | 4       | 4     | 2.83E+02                     |
| 49.59          | 1       | 3     | 9.9E+02                      | 191.0           | 4       | 2     | 4.11E+02                     | <i>Cr XIX</i>  |         |       |                              |
| 67.01          | 1       | 3     | 1.67E+03                     | 222.9           | 4       | 2     | 2.2E+02                      | 14.73          | 3       | 3     | 7.1E+04                      |
| 228            | 5       | 7     | 1.8E+02                      | 346.3           | 4       | 6     | 2.4E+02                      | 14.80          | 1       | 3     | 1.3E+05                      |
| 267.73         | 5       | 7     | 1.9E+02                      | 346.5           | 6       | 8     | 2.5E+02                      | 14.81          | 5       | 3     | 3.4E+04                      |
| 270            | 3       | 1     | 1.7E+02                      | <i>Cr XV</i>    |         |       |                              | 14.84          | 5       | 7     | 1.3E+05                      |
| 276.4          | 5       | 7     | 2.2E+02                      | 18.497          | 1       | 3     | 1.62E+05                     | 109.64         | 3       | 3     | 2.46E+02                     |
| 277            | 1       | 3     | 2.1E+02                      | 18.782          | 1       | 3     | 2.8E+04                      | 110.37         | 5       | 3     | 6.0E+02                      |
| 279.32         | 3       | 5     | 3.5E+02                      | 19.015          | 1       | 3     | 6.3E+02                      | 113.97         | 5       | 3     | 5.5E+02                      |
| 286            | 3       | 1     | 4.6E+02                      | 20.863          | 1       | 3     | 6.0E+03                      | 118.31         | 3       | 1     | 3.29E+02                     |
| 328.29         | 1       | 3     | 1.86E+02                     | 21.153          | 1       | 3     | 5.6E+03                      | 118.67         | 5       | 3     | 2.1E+02                      |
| 345            | 7       | 9     | 1.74E+02                     | 102             | 3       | 3     | 1.6E+02                      | 118.83         | 3       | 3     | 1.35E+02                     |
| <i>Cr XIV</i>  |         |       |                              | 102.18          | 5       | 3     | 7.0E+02                      | 126.30         | 1       | 3     | 1.56E+02                     |
| *38.036        | 2       | 6     | 2.47E+02                     | 103             | 3       | 1     | 3.8E+02                      | 126.33         | 5       | 5     | 4.35E+02                     |
| 39.796         | 2       | 4     | 3.05E+02                     | 105             | 7       | 5     | 5.3E+02                      | 130.99         | 7       | 5     | 2.9E+02                      |
| 40.018         | 4       | 6     | 3.6E+02                      | 111.27          | 3       | 3     | 1.7E+02                      | 134.89         | 3       | 1     | 1.98E+02                     |
| 40.782         | 2       | 4     | 3.9E+02                      | <i>Cr XVI</i>   |         |       |                              | 138.15         | 3       | 1     | 1.75E+02                     |
| 40.800         | 2       | 2     | 3.9E+02                      | 17.073          | 4       | 6     | 1.2E+04                      | 138.45         | 5       | 5     | 1.71E+02                     |
| 41.556         | 2       | 4     | 4.5E+02                      | 17.242          | 2       | 4     | 8.6E+04                      | 140.92         | 5       | 3     | 1.38E+02                     |
| 41.788         | 4       | 6     | 5.3E+02                      | 17.299          | 4       | 4     | 2.5E+04                      | 143.57         | 3       | 1     | 7.2E+02                      |
| 44.597         | 2       | 4     | 7.1E+02                      | 17.372          | 4       | 4     | 1.4E+05                      | 163.94         | 5       | 5     | 3.1E+02                      |
| 44.869         | 4       | 6     | 8.3E+02                      | 17.438          | 4       | 2     | 1.1E+05                      | 179.18         | 3       | 1     | 1.45E+02                     |
| 46.125         | 4       | 2     | 3.1E+02                      | 17.514          | 2       | 4     | 1.1E+05                      | <i>Cr XX</i>   |         |       |                              |
| 46.468         | 2       | 4     | 6.6E+02                      | 17.587          | 2       | 4     | 2.0E+04                      | 14.13          | 2       | 4     | 1.1E+05                      |
| 46.527         | 2       | 2     | 6.7E+02                      | 17.656          | 2       | 2     | 2.0E+04                      | 14.26          | 4       | 6     | 1.3E+05                      |
| 48.300         | 4       | 6     | 5.9E+02                      | 19.442          | 4       | 2     | 9.9E+03                      | 128.42         | 4       | 4     | 3.8E+02                      |
| 48.338         | 6       | 8     | 6.3E+02                      | 19.714          | 2       | 2     | 1.1E+04                      | 131.31         | 6       | 4     | 1.27E+02                     |
| 50.821         | 2       | 4     | 1.2E+03                      | <i>Cr XVII</i>  |         |       |                              | 133.82         | 2       | 4     | 8.3E+01                      |
| 51.172         | 4       | 6     | 1.4E+03                      | 16.31           | 5       | 3     | 9.6E+03                      | 135.26         | 4       | 2     | 2.41E+02                     |
| 51.180         | 4       | 4     | 2.3E+02                      | 16.32           | 5       | 7     | 3.2E+04                      | 140.75         | 4       | 4     | 1.35E+02                     |
| 52.321         | 4       | 6     | 1.0E+03                      | 16.37           | 3       | 1     | 9.7E+04                      | 148.99         | 6       | 4     | 1.75E+02                     |
| 52.363         | 6       | 8     | 1.1E+03                      | 16.44           | 5       | 7     | 1.3E+05                      | 156.00         | 2       | 4     | 8.4E+01                      |
| 53.760         | 2       | 2     | 3.0E+02                      | 16.59           | 3       | 1     | 5.7E+04                      | 167.97         | 6       | 6     | 1.12E+02                     |
| 54.164         | 4       | 2     | 5.9E+02                      | 16.65           | 5       | 5     | 1.1E+04                      | 180.85         | 4       | 4     | 1.6E+02                      |
| 60.699         | 4       | 6     | 2.05E+03                     | 16.66           | 1       | 3     | 1.8E+05                      | <i>Cr XXI</i>  |         |       |                              |
| 60.756         | 6       | 8     | 2.19E+03                     | 16.68           | 5       | 7     | 6.8E+04                      | 12.97          | 3       | 1     | 4.8E+04                      |
| 63.324         | 2       | 4     | 1.07E+03                     | 16.80           | 5       | 7     | 4.4E+04                      | 12.98          | 5       | 5     | 3.9E+04                      |
| 63.539         | 2       | 2     | 1.13E+03                     | 16.97           | 1       | 3     | 2.63E+04                     | 13.02          | 3       | 5     | 3.8E+04                      |
| 68.594         | 2       | 4     | 1.98E+03                     | 16.97           | 3       | 3     | 1.5E+04                      | 13.02          | 5       | 7     | 3.9E+04                      |
| 69.213         | 4       | 6     | 2.31E+03                     | 17.968          | 5       | 3     | 8.6E+03                      | 13.08          | 1       | 3     | 5.2E+04                      |
| 69.247         | 4       | 4     | 3.8E+02                      | 18.336          | 5       | 3     | 1.7E+04                      | 13.22          | 3       | 1     | 4.6E+04                      |
| 86.060         | 4       | 6     | 5.3E+03                      | 18.336          | 5       | 5     | 1.6E+04                      | 13.34          | 3       | 5     | 5.2E+04                      |
| 86.169         | 6       | 8     | 5.9E+03                      | 18.389          | 1       | 3     | 9.2E+03                      | 13.49          | 1       | 3     | 9.0E+04                      |
| 86.185         | 6       | 6     | 3.9E+02                      | <i>Cr XVIII</i> |         |       |                              | 13.53          | 3       | 3     | 6.6E+04                      |
| 101.05         | 6       | 4     | 4.4E+02                      | 95.77           | 4       | 2     | 3.08E+02                     | 13.55          | 3       | 5     | 1.2E+05                      |
| 101.42         | 4       | 2     | 4.83E+02                     | 102.32          | 4       | 4     | 1.54E+02                     | 13.65          | 5       | 7     | 1.5E+05                      |
| 104.4          | 4       | 6     | 3.0E+02                      | 104.98          | 6       | 4     | 8.7E+02                      | 13.66          | 3       | 1     | 1.2E+05                      |
| 104.5          | 6       | 8     | 3.1E+02                      | 106.84          | 4       | 2     | 3.4E+02                      | 13.67          | 5       | 5     | 3.9E+04                      |
| 109.8          | 2       | 4     | 2.3E+02                      | 110.41          | 4       | 2     | 7.9E+02                      | 13.68          | 3       | 3     | 8.2E+04                      |
| 110.4          | 4       | 6     | 2.8E+02                      | 112.27          | 4       | 2     | 4.24E+02                     | 13.75          | 5       | 3     | 4.5E+04                      |
| 118.3          | 4       | 2     | 2.1E+02                      | 119.62          | 2       | 2     | 3.2E+02                      | 13.75          | 5       | 5     | 9.5E+04                      |
| 125.2          | 4       | 6     | 5.0E+02                      |                 |         |       |                              |                |         |       |                              |

| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 13.76           | 1       | 3     | 1.51E+05                     | 2424.93        | 10      | 10    | 3.2E+00                      | 3523.42        | 4       | 2     | 9.8E-01                      |
| 13.78           | 5       | 7     | 1.7E+05                      | 2432.21        | 8       | 8     | 2.6E+00                      | 3526.85        | 10      | 10    | 1.3E-01                      |
| 13.84           | 5       | 7     | 2.59E+05                     | 2436.66        | 6       | 6     | 2.6E+00                      | 3529.03        | 6       | 8     | 8.8E-02                      |
| 13.87           | 3       | 5     | 8.5E+04                      | 2439.04        | 4       | 4     | 2.7E+00                      | 3529.82        | 8       | 10    | 4.6E-01                      |
| 13.92           | 3       | 5     | 8.5E+04                      | 2460.80        | 4       | 6     | 1.2E-01                      | 3533.36        | 4       | 6     | 9.1E-02                      |
| 13.93           | 5       | 7     | 4.2E+04                      | 2467.69        | 6       | 8     | 7.0E-02                      | 3560.89        | 4       | 4     | 2.3E-01                      |
| 13.95           | 5       | 5     | 3.8E+04                      | 2470.27        | 10      | 12    | 1.5E-01                      | 3564.95        | 6       | 8     | 7.0E-02                      |
| 14.04           | 3       | 5     | 1.2E+05                      | 2476.64        | 10      | 8     | 2.2E-01                      | 3569.37        | 8       | 8     | 1.6E+00                      |
| 14.24           | 1       | 3     | 1.41E+05                     | 2504.52        | 10      | 8     | 1.8E-01                      | 3574.97        | 6       | 6     | 1.5E-01                      |
| <i>Cr XXII</i>  |         |       |                              | 2511.02        | 10      | 10    | 9.2E-01                      | 3575.36        | 8       | 8     | 9.6E-02                      |
| 2.190           | 4       | 2     | 1.7E+06                      | 2521.36        | 10      | 8     | 3.0E+00                      | 3585.15        | 8       | 8     | 7.1E-02                      |
| 2.191           | 2       | 2     | 2.5E+06                      | 2528.97        | 8       | 6     | 2.8E+00                      | 3587.19        | 6       | 6     | 1.4E+00                      |
| 2.198           | 4       | 4     | 4.5E+06                      | 2530.13        | 6       | 6     | 7.1E-02                      | 3594.87        | 6       | 6     | 9.2E-02                      |
| 2.199           | 2       | 4     | 2.3E+06                      | 2535.96        | 6       | 4     | 1.9E+00                      | 3602.08        | 4       | 4     | 1.0E-01                      |
| 2.202           | 4       | 6     | 1.6E+06                      | 2536.50        | 8       | 8     | 3.0E-01                      | 3704.06        | 6       | 8     | 1.2E-01                      |
| 2.203           | 4       | 2     | 1.3E+06                      | 2544.25        | 4       | 2     | 3.0E+00                      | 3745.49        | 8       | 8     | 7.5E-02                      |
| 13.149          | 2       | 4     | 1.29E+05                     | 2562.12        | 4       | 4     | 3.9E-01                      | 3842.05        | 8       | 6     | 1.3E-01                      |
| 13.292          | 4       | 6     | 1.54E+05                     | 2567.34        | 6       | 6     | 3.0E-01                      | 3845.47        | 8       | 10    | 4.6E-01                      |
| <i>Cr XXIII</i> |         |       |                              | 2574.35        | 8       | 8     | 1.7E-01                      | 3861.16        | 6       | 4     | 1.4E-01                      |
| 1.7632          | 1       | 3     | 3.68E+05                     | 2685.34        | 6       | 8     | 5.5E-02                      | 3873.12        | 10      | 8     | 1.2E-01                      |
| 1.8557          | 1       | 3     | 8.97E+05                     | 3017.55        | 8       | 6     | 6.9E-02                      | 3873.95        | 8       | 6     | 1.0E-01                      |
| 2.095           | 3       | 1     | 3.5E+06                      | 3044.00        | 10      | 10    | 1.9E-01                      | 3881.87        | 6       | 4     | 8.2E-02                      |
| 2.101           | 1       | 3     | 2.0E+06                      | 3048.89        | 6       | 4     | 7.5E-02                      | 3894.07        | 6       | 8     | 6.9E-01                      |
| 2.101           | 5       | 5     | 7.9E+05                      | 3061.82        | 8       | 8     | 1.6E-01                      | 3894.98        | 4       | 2     | 8.8E-02                      |
| 2.102           | 3       | 5     | 2.1E+06                      | 3072.34        | 6       | 6     | 1.5E-01                      | 3935.96        | 8       | 10    | 6.2E-02                      |
| 2.103           | 3       | 5     | 1.2E+06                      | 3086.78        | 4       | 4     | 1.9E-01                      | 3995.31        | 8       | 10    | 2.5E-01                      |
| 2.104           | 1       | 3     | 1.4E+06                      | 3354.37        | 8       | 6     | 1.1E-01                      | 3997.90        | 6       | 8     | 7.0E-02                      |
| 2.105           | 3       | 3     | 9.6E+05                      | 3367.11        | 10      | 8     | 6.0E-02                      | 4092.39        | 8       | 8     | 5.7E-02                      |
| 2.106           | 3       | 3     | 2.0E+06                      | 3385.22        | 8       | 6     | 1.1E-01                      | 4110.53        | 6       | 6     | 5.5E-02                      |
| 2.107           | 5       | 5     | 2.3E+06                      | 3388.16        | 6       | 4     | 2.4E-01                      | 4118.77        | 6       | 8     | 1.6E-01                      |
| 2.107           | 3       | 5     | 3.3E+06                      | 3395.37        | 6       | 8     | 2.9E-01                      | 4121.32        | 8       | 10    | 1.9E-01                      |
| 2.109           | 5       | 3     | 1.7E+06                      | 3405.12        | 10      | 10    | 1.0E+00                      | 5146.75        | 8       | 8     | 1.5E-01                      |
| 2.113           | 3       | 5     | 5.9E+05                      | 3409.17        | 8       | 8     | 4.2E-01                      | 5212.70        | 10      | 10    | 1.9E-01                      |
| 2.119           | 3       | 1     | 2.7E+05                      | 3412.34        | 8       | 10    | 6.1E-01                      | 5265.79        | 6       | 8     | 5.0E-02                      |
| 2.129           | 3       | 1     | 5.1E+05                      | 3412.63        | 10      | 8     | 1.2E-01                      | 5280.63        | 10      | 8     | 2.8E-01                      |
| 2.1818          | 1       | 3     | 3.37E+06                     | 3414.74        | 4       | 4     | 8.8E-02                      | 5352.05        | 12      | 10    | 2.7E-01                      |
| 2.1923          | 1       | 3     | 2.34E+05                     | 3417.15        | 6       | 6     | 3.2E-01                      | 5477.09        | 6       | 8     | 6.8E-02                      |
| <i>Cobalt</i>   |         |       |                              | 3431.58        | 8       | 6     | 1.1E-01                      | 5483.96        | 8       | 10    | 7.3E-02                      |
| <i>Co I</i>     |         |       |                              | 3433.05        | 4       | 4     | 1.0E+00                      | 6082.43        | 10      | 10    | 5.4E-02                      |
| 2287.80         | 8       | 8     | 8.6E-01                      | 3442.92        | 6       | 4     | 1.2E-01                      | 6455.00        | 8       | 10    | 9.0E-02                      |
| 2295.22         | 10      | 8     | 2.2E-01                      | 3443.64        | 8       | 8     | 6.9E-01                      | 7838.12        | 8       | 10    | 5.4E-02                      |
| 2309.03         | 10      | 10    | 5.6E-01                      | 3449.17        | 6       | 6     | 7.6E-01                      | 8093.93        | 12      | 10    | 2.0E-01                      |
| 2323.13         | 8       | 8     | 5.0E-01                      | 3449.44        | 10      | 10    | 1.8E-01                      | 8372.79        | 10      | 10    | 8.7E-02                      |
| 2325.53         | 6       | 8     | 1.1E-01                      | 3453.51        | 10      | 12    | 1.1E+00                      | <i>Co II</i>   |         |       |                              |
| 2335.98         | 6       | 6     | 5.1E-01                      | 3455.24        | 4       | 2     | 1.9E-01                      | 2286.15        | 11      | 13    | 3.3E+00                      |
| 2338.66         | 4       | 4     | 7.7E-01                      | 3462.80        | 4       | 6     | 7.9E-01                      | 2307.85        | 9       | 11    | 2.6E+00                      |
| 2353.36         | 8       | 10    | 1.5E-01                      | 3465.79        | 10      | 12    | 9.2E-02                      | 2311.61        | 7       | 9     | 2.8E+00                      |
| 2355.48         | 6       | 8     | 1.3E-01                      | 3474.02        | 6       | 8     | 5.6E-01                      | 2314.05        | 5       | 7     | 2.8E+00                      |
| 2358.18         | 4       | 6     | 1.4E-01                      | 3483.41        | 8       | 10    | 5.5E-02                      | 2314.97        | 3       | 5     | 2.7E+00                      |
| 2365.06         | 10      | 10    | 1.3E-01                      | 3489.40        | 8       | 6     | 1.3E+00                      | 2330.36        | 5       | 3     | 1.32E+00                     |
| 2371.85         | 6       | 8     | 7.3E-02                      | 3491.32        | 4       | 4     | 5.0E-02                      | 2344.28        | 3       | 3     | 1.5E+00                      |
| 2384.86         | 10      | 8     | 2.4E-01                      | 3495.68        | 4       | 6     | 4.9E-01                      | 2353.41        | 7       | 7     | 1.9E+00                      |
| 2392.03         | 6       | 6     | 4.0E-01                      | 3502.28        | 10      | 8     | 8.0E-01                      | 2363.80        | 9       | 9     | 2.1E+00                      |
| 2402.06         | 8       | 6     | 5.1E-01                      | 3502.63        | 6       | 6     | 5.2E-02                      | 2378.62        | 11      | 9     | 1.9E+00                      |
| 2407.25         | 10      | 12    | 3.6E+00                      | 3506.32        | 8       | 6     | 8.2E-01                      | 2383.45        | 9       | 7     | 1.8E+00                      |
| 2412.76         | 4       | 6     | 6.5E-01                      | 3509.84        | 6       | 8     | 3.2E-01                      | 2388.92        | 11      | 11    | 2.8E+00                      |
| 2414.46         | 6       | 8     | 3.4E+00                      | 3512.64        | 6       | 4     | 1.0E+00                      | 2389.54        | 5       | 3     | 1.5E+00                      |
| 2415.29         | 4       | 6     | 3.6E+00                      | 3513.48        | 8       | 10    | 7.8E-02                      | 2404.17        | 3       | 3     | 1.5E+00                      |
|                 |         |       |                              | 3518.34        | 6       | 4     | 1.6E+00                      | 2417.66        | 9       | 9     | 8.5E-01                      |
|                 |         |       |                              | 3521.58        | 10      | 8     | 1.8E-01                      |                |         |       |                              |

| $\lambda$         | Weights |       | $A$                   |
|-------------------|---------|-------|-----------------------|
| $\text{\AA}$      | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ |
| <i>Copper</i>     |         |       |                       |
| <i>Cu I</i>       |         |       |                       |
| *2024.3           | 2       | 6     | 9.8E-02               |
| 2165.1            | 2       | 4     | 5.1E-01               |
| 2178.9            | 2       | 4     | 9.13E-01              |
| 2181.7            | 2       | 2     | 1.0E+00               |
| 2225.7            | 2       | 2     | 4.6E-01               |
| 2244.3            | 2       | 4     | 1.19E-02              |
| 2441.6            | 2       | 2     | 2.0E-02               |
| 2492.2            | 2       | 4     | 3.11E-02              |
| 2618.4            | 6       | 4     | 3.07E-01              |
| 2766.4            | 4       | 4     | 9.6E-02               |
| 2824.4            | 6       | 6     | 7.8E-02               |
| 2961.2            | 6       | 8     | 3.76E-02              |
| 3063.4            | 4       | 4     | 1.55E-02              |
| 3194.1            | 4       | 4     | 1.55E-02              |
| 3247.5            | 2       | 4     | 1.39E+00              |
| 3274.0            | 2       | 2     | 1.37E+00              |
| 3337.8            | 6       | 8     | 3.8E-03               |
| 4022.6            | 2       | 4     | 1.90E-01              |
| 4062.6            | 4       | 6     | 2.10E-01              |
| 4249.0            | 2       | 2     | 1.95E-01              |
| 4275.1            | 6       | 8     | 3.45E-01              |
| 4480.4            | 2       | 2     | 3.0E-02               |
| 4509.4            | 4       | 2     | 2.75E-01              |
| 4530.8            | 4       | 2     | 8.4E-02               |
| 4539.7            | 6       | 4     | 2.12E-01              |
| 4587.0            | 8       | 6     | 3.20E-01              |
| 4651.1            | 10      | 8     | 3.80E-01              |
| 4704.6            | 8       | 8     | 5.5E-02               |
| 5105.5            | 6       | 4     | 2.0E-02               |
| 5153.2            | 2       | 4     | 6.0E-01               |
| 5218.2            | 4       | 6     | 7.5E-01               |
| 5220.1            | 4       | 4     | 1.50E-01              |
| 5292.5            | 8       | 8     | 1.09E-01              |
| 5700.2            | 4       | 4     | 2.4E-03               |
| 5782.1            | 4       | 2     | 1.65E-02              |
| <i>Cu II</i>      |         |       |                       |
| 2489.7            | 5       | 5     | 1.5E-02               |
| 2544.8            | 9       | 7     | 1.1E+00               |
| 2689.3            | 7       | 7     | 4.1E-01               |
| 2701.0            | 5       | 5     | 6.7E-01               |
| 2703.2            | 3       | 3     | 1.2E+00               |
| 2713.5            | 5       | 5     | 6.8E-01               |
| <i>Dysprosium</i> |         |       |                       |
| <i>Dy I</i>       |         |       |                       |
| 2862.7            | 17      | 15    | 6.5E-02               |
| 2964.6            | 17      | 17    | 6.5E-02               |
| 3147.7            | 15      | 17    | 1.1E-01               |
| 3263.2            | 15      | 13    | 1.4E-01               |
| 3511.0            | 15      | 13    | 3.1E-01               |
| 3571.4            | 15      | 13    | 2.0E-01               |
| 3757.1            | 17      | 19    | 3.0E+00               |
| 3868.8            | 17      | 17    | 3.1E+00               |
| 3967.5            | 17      | 19    | 8.7E-01               |
| 4046.0            | 17      | 15    | 1.5E+00               |
| 4103.9            | 13      | 11    | 1.7E+00               |
| 4186.8            | 17      | 17    | 1.32E+00              |

| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |
| 4194.8          | 17      | 17    | 7.2E-01                      |
| 4211.7          | 17      | 19    | 2.08E+00                     |
| 4218.1          | 15      | 15    | 1.85E+00                     |
| 4221.1          | 15      | 17    | 1.52E+00                     |
| 4225.2          | 13      | 15    | 4.5E+00                      |
| 4268.3          | 15      | 15    | 3.6E-02                      |
| 4276.7          | 13      | 13    | 7.3E-01                      |
| 4292.0          | 15      | 15    | 5.8E-02                      |
| 4577.8          | 17      | 19    | 2.2E-02                      |
| 4589.4          | 17      | 15    | 1.3E-01                      |
| 4612.3          | 17      | 15    | 8.2E-02                      |
| 5077.7          | 17      | 17    | 5.7E-03                      |
| 5301.6          | 17      | 15    | 1.1E-02                      |
| 5547.3          | 17      | 17    | 2.7E-03                      |
| 5639.5          | 17      | 19    | 4.7E-03                      |
| 5974.5          | 17      | 17    | 4.0E-03                      |
| 5988.6          | 17      | 15    | 5.3E-03                      |
| 6010.8          | 15      | 15    | 2.6E-02                      |
| 6088.3          | 15      | 13    | 3.5E-02                      |
| 6168.4          | 15      | 17    | 2.5E-02                      |
| 6259.1          | 17      | 19    | 8.5E-03                      |
| 6579.4          | 17      | 15    | 7.5E-03                      |
| <b>Erbium</b>   |         |       |                              |
| <b>Er I</b>     |         |       |                              |
| 3862.9          | 13      | 13    | 2.5E+00                      |
| 4008.0          | 13      | 15    | 2.6E+00                      |
| 4151.1          | 13      | 11    | 1.8E+00                      |
| <b>Europium</b> |         |       |                              |
| <b>Eu I</b>     |         |       |                              |
| 2372.9          | 8       | 6     | 1.9E-01                      |
| 2375.3          | 8       | 8     | 2.0E-01                      |
| 2379.7          | 8       | 10    | 2.0E-01                      |
| 2619.3          | 8       | 10    | 7.0E-03                      |
| 2643.8          | 8       | 8     | 6.6E-03                      |
| 2659.4          | 8       | 10    | 1.2E-02                      |
| 2682.6          | 8       | 6     | 1.2E-02                      |
| 2710.0          | 8       | 10    | 1.4E-01                      |
| 2724.0          | 8       | 8     | 1.2E-01                      |
| 2731.4          | 8       | 8     | 3.1E-02                      |
| 2732.6          | 8       | 6     | 3.7E-02                      |
| 2735.3          | 8       | 10    | 4.7E-02                      |
| 2738.6          | 8       | 10    | 1.3E-02                      |
| 2743.3          | 8       | 6     | 1.1E-01                      |
| 2745.6          | 8       | 6     | 5.0E-02                      |
| 2747.8          | 8       | 8     | 5.2E-02                      |
| 2772.9          | 8       | 6     | 1.0E-02                      |
| 2878.9          | 8       | 10    | 2.8E-02                      |
| 2892.5          | 8       | 8     | 1.0E-01                      |
| 2893.0          | 8       | 6     | 1.0E-01                      |
| 2909.0          | 8       | 10    | 6.9E-02                      |
| 2958.9          | 8       | 6     | 1.6E-02                      |
| 3059.0          | 8       | 8     | 3.8E-02                      |
| 3067.0          | 8       | 10    | 9.1E-03                      |
| 3106.2          | 8       | 10    | 5.5E-02                      |
| 3111.4          | 8       | 10    | 3.0E-01                      |
| 3168.3          | 8       | 10    | 6.9E-02                      |
| 3185.5          | 8       | 10    | 5.8E-03                      |
| 3210.6          | 8       | 8     | 1.1E-01                      |

| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |
| 3212.8          | 8       | 8     | 2.9E-01                      |
| 3213.8          | 8       | 6     | 1.8E-01                      |
| 3235.1          | 8       | 10    | 1.0E-02                      |
| 3241.4          | 8       | 8     | 2.3E-02                      |
| 3246.0          | 8       | 6     | 1.4E-02                      |
| 3247.6          | 8       | 8     | 2.3E-02                      |
| 3322.3          | 8       | 6     | 3.5E-02                      |
| 3334.3          | 8       | 6     | 3.4E-01                      |
| 3350.4          | 8       | 10    | 1.5E-02                      |
| 3353.7          | 8       | 8     | 5.8E-03                      |
| 3457.1          | 8       | 8     | 8.4E-03                      |
| 3467.9          | 8       | 8     | 1.0E-02                      |
| 3589.3          | 8       | 6     | 6.9E-03                      |
| 4594.0          | 8       | 10    | 1.4E+00                      |
| 4627.2          | 8       | 8     | 1.3E+00                      |
| 4661.9          | 8       | 6     | 1.3E+00                      |
| 5645.8          | 8       | 6     | 5.4E-03                      |
| 5765.2          | 8       | 8     | 1.1E-02                      |
| 6018.2          | 8       | 10    | 8.5E-03                      |
| 6291.3          | 8       | 6     | 1.8E-03                      |
| 6864.5          | 8       | 10    | 5.8E-03                      |
| 7106.5          | 8       | 8     | 2.6E-03                      |
| <b>Fluorine</b> |         |       |                              |
| <b>FI</b>       |         |       |                              |
| 806.96          | 4       | 6     | 3.3E+00                      |
| 809.60          | 2       | 4     | 2.8E+00                      |
| 951.87          | 4       | 2     | 2.6E+00                      |
| 954.83          | 4       | 4     | 5.77E+00                     |
| 955.55          | 2       | 2     | 5.1E+00                      |
| 958.52          | 2       | 4     | 1.3E+00                      |
| 6239.7          | 6       | 4     | 2.5E-01                      |
| 6348.5          | 4       | 4     | 1.8E-01                      |
| 6413.7          | 2       | 4     | 1.1E-01                      |
| 6708.3          | 6       | 4     | 1.4E-02                      |
| 6774.0          | 6       | 6     | 1.0E-01                      |
| 6795.5          | 4       | 2     | 5.2E-02                      |
| 6834.3          | 4       | 4     | 2.1E-01                      |
| 6856.0          | 6       | 8     | 4.94E-01                     |
| 6870.2          | 2       | 2     | 3.8E-01                      |
| 6902.5          | 4       | 6     | 3.2E-01                      |
| 6909.8          | 2       | 4     | 2.2E-01                      |
| 6966.4          | 4       | 2     | 1.1E-01                      |
| 7037.5          | 4       | 4     | 3.0E-01                      |
| 7127.9          | 2       | 2     | 3.8E-01                      |
| 7309.0          | 6       | 8     | 4.7E-01                      |
| 7311.0          | 4       | 2     | 3.9E-01                      |
| 7314.3          | 4       | 6     | 4.8E-01                      |
| 7332.0          | 6       | 4     | 3.1E-01                      |
| 7398.7          | 6       | 6     | 2.85E-01                     |
| 7425.7          | 4       | 2     | 3.4E-01                      |
| 7482.7          | 4       | 4     | 5.6E-02                      |
| 7489.2          | 2       | 2     | 1.1E-01                      |
| 7514.9          | 2       | 2     | 5.2E-02                      |
| 7552.2          | 4       | 6     | 7.8E-02                      |
| 7573.4          | 2       | 4     | 1.0E-01                      |
| 7607.2          | 4       | 4     | 7.0E-02                      |
| 7754.7          | 4       | 6     | 3.82E-01                     |
| 7800.2          | 2       | 4     | 2.1E-01                      |

| $\lambda$        | Weights |       | $A$                   | $\lambda$     | Weights |       | $A$                   | $\lambda$      | Weights |       | $A$                   |
|------------------|---------|-------|-----------------------|---------------|---------|-------|-----------------------|----------------|---------|-------|-----------------------|
| $\text{\AA}$     | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ | $\text{\AA}$  | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ | $\text{\AA}$   | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ |
| <i>Gallium</i>   |         |       |                       | 1075.1        | 4       | 2     | 1.3E+00               | 4024.0         | 3       | 1     | 1.128E-02             |
| <i>Ga I</i>      |         |       |                       | 1237.1        | 2       | 4     | 1.9E+01               | *4026.2        | 9       | 15    | 1.160E-01             |
| 2195.4           | 2       | 2     | 1.9E-02               | 1261.9        | 4       | 6     | 2.2E+01               | *4120.8        | 9       | 3     | 4.453E-02             |
| 2199.7           | 4       | 2     | 3.3E-02               | 1264.7        | 4       | 4     | 3.5E+00               | 4143.8         | 3       | 5     | 4.881E-02             |
| 2214.4           | 4       | 6     | 1.2E-02               | 1602.5        | 2       | 2     | 3.4E+00               | 4169.0         | 3       | 1     | 1.830E-02             |
| 2235.9           | 4       | 2     | 4.3E-02               | 1649.2        | 4       | 2     | 6.5E+00               | 4387.9         | 3       | 5     | 8.989E-02             |
| 2255.0           | 2       | 2     | 3.1E-02               | 4741.8        | 2       | 4     | 4.6E-01               | 4437.6         | 3       | 1     | 3.269E-02             |
| 2259.2           | 4       | 6     | 3.1E-02               | 4814.6        | 4       | 6     | 5.1E-01               | *4471.5        | 9       | 15    | 2.458E-01             |
| 2294.2           | 2       | 4     | 7.0E-02               | 4824.1        | 4       | 4     | 8.6E-02               | *4713.2        | 9       | 3     | 9.521E-02             |
| 2297.9           | 4       | 2     | 5.8E-02               | 5131.8        | 4       | 6     | 1.9E+00               | 4921.9         | 3       | 5     | 1.986E-01             |
| 2338.2           | 4       | 6     | 9.8E-02               | 5178.5        | 6       | 6     | 1.3E-01               | 5015.7         | 1       | 3     | 1.337E-01             |
| 2371.3           | 2       | 2     | 5.7E-02               | 5178.6        | 6       | 8     | 2.0E+00               | 5047.7         | 3       | 1     | 6.771E-02             |
| 2418.7           | 4       | 2     | 1.0E-01               | 5893.4        | 2       | 4     | 9.2E-01               | *5875.7        | 9       | 15    | 7.070E-01             |
| 2450.1           | 2       | 4     | 2.8E-01               | 6021.0        | 2       | 2     | 8.4E-01               | 6678.2         | 3       | 5     | 6.371E-01             |
| 2500.2           | 4       | 6     | 3.4E-01               | 6336.4        | 2       | 2     | 4.4E-01               | *7065.2        | 9       | 3     | 2.785E-01             |
| 2659.9           | 2       | 2     | 1.2E-01               | 6484.2        | 4       | 2     | 8.5E-01               | 7281.4         | 3       | 1     | 1.830E-01             |
| 2719.7           | 4       | 2     | 2.3E-01               | <i>Gold</i>   |         |       |                       | *8361.7        | 3       | 9     | 3.813E-03             |
| 2874.2           | 2       | 4     | 1.2E+00               | <i>Au I</i>   |         |       |                       | *9463.6        | 3       | 9     | 5.687E-03             |
| 2943.6           | 4       | 6     | 1.4E+00               | 2427.95       | 2       | 4     | 1.99E+00              | 9603.4         | 1       | 3     | 5.829E-03             |
| 2944.2           | 4       | 4     | 2.7E-01               | 2675.95       | 2       | 2     | 1.64E+00              | *9702.6        | 9       | 3     | 8.651E-03             |
| 4033.0           | 2       | 2     | 4.9E-01               | 3122.78       | 6       | 4     | 1.90E-01              | *10311         | 9       | 15    | 1.995E-02             |
| 4172.0           | 4       | 2     | 9.2E-01               | 6278.30       | 4       | 2     | 3.4E-02               | *10668         | 9       | 3     | 1.447E-02             |
| <i>Ga II</i>     |         |       |                       |               |         |       |                       | *10830         | 3       | 9     | 1.022E-01             |
| 829.60           | 1       | 3     | 2.2E-01               | <i>Helium</i> |         |       |                       | *10913         | 15      | 21    | 1.980E-02             |
| 1414.4           | 1       | 3     | 1.88E+01              | <i>He I</i>   |         |       |                       | 10917          | 5       | 7     | 1.608E-02             |
| <i>Germanium</i> |         |       |                       | 510.00        | 1       | 3     | 4.622E-01             | *10997         | 15      | 9     | 1.425E-03             |
| <i>Ge I</i>      |         |       |                       | 512.10        | 1       | 3     | 7.317E-01             | 11013          | 1       | 3     | 9.250E-03             |
| 1944.7           | 3       | 1     | 7.0E-01               | 515.62        | 1       | 3     | 1.258E+00             | 11045          | 3       | 5     | 1.846E-02             |
| 1955.1           | 3       | 3     | 2.8E-01               | 522.21        | 1       | 3     | 2.436E+00             | 11226          | 3       | 1     | 1.117E-02             |
| 1988.3           | 5       | 3     | 2.5E-01               | 537.03        | 1       | 3     | 5.663E+00             | *11969         | 9       | 15    | 3.478E-02             |
| 1998.9           | 5       | 5     | 5.5E-01               | 584.33        | 1       | 3     | 1.799E+01             | *12528         | 3       | 9     | 7.093E-03             |
| 2041.7           | 1       | 3     | 1.1E+00               | *2677.1       | 3       | 9     | 4.417E-03             | 12756          | 5       | 3     | 1.275E-03             |
| 2065.2           | 3       | 3     | 8.5E-01               | *2696.1       | 3       | 9     | 6.023E-03             | *12785         | 15      | 21    | 4.134E-02             |
| 2068.7           | 3       | 5     | 1.2E+00               | *2723.2       | 3       | 9     | 8.500E-03             | 12791          | 5       | 7     | 3.248E-02             |
| 2086.0           | 3       | 5     | 4.0E-01               | *2763.8       | 3       | 9     | 1.251E-02             | *12846         | 9       | 3     | 2.732E-02             |
| 2094.3           | 5       | 7     | 9.7E-01               | *2829.1       | 3       | 9     | 1.939E-02             | 12968          | 3       | 5     | 3.362E-02             |
| 2105.8           | 5       | 5     | 1.7E-01               | *2829.1       | 3       | 9     | 1.939E-02             | *12985         | 15      | 9     | 2.729E-03             |
| 2256.0           | 5       | 5     | 3.2E-02               | *2945.1       | 3       | 9     | 3.201E-02             | <i>Indium</i>  |         |       |                       |
| 2417.4           | 5       | 5     | 9.6E-01               | *3187.7       | 3       | 9     | 5.636E-02             | <i>In I</i>    |         |       |                       |
| 2498.0           | 1       | 3     | 1.3E-01               | 3231.3        | 1       | 3     | 5.102E-03             | 2560.2         | 2       | 4     | 4.0E-01               |
| 2533.2           | 3       | 3     | 1.0E-01               | 3258.3        | 1       | 3     | 6.963E-03             | 2710.3         | 4       | 6     | 4.0E-01               |
| 2589.2           | 5       | 3     | 5.1E-02               | 3296.8        | 1       | 3     | 9.843E-03             | 3039.4         | 2       | 4     | 1.3E+00               |
| 2592.5           | 3       | 5     | 7.1E-01               | 3354.6        | 1       | 3     | 1.454E-02             | 3256.1         | 4       | 6     | 1.3E+00               |
| 2651.2           | 5       | 5     | 2.0E+00               | 3447.6        | 1       | 3     | 2.269E-02             | 4101.8         | 2       | 2     | 5.6E-01               |
| 2651.6           | 1       | 3     | 8.5E-01               | *3554.4       | 9       | 15    | 7.597E-03             | 4511.3         | 4       | 2     | 1.02E+00              |
| 2691.3           | 3       | 3     | 6.1E-01               | *3563.0       | 9       | 3     | 4.836E-03             | <i>In II</i>   |         |       |                       |
| 2709.6           | 3       | 1     | 2.8E+00               | *3587.3       | 9       | 15    | 1.811E-02             | 2941.1         | 3       | 1     | 1.4E+00               |
| 2754.6           | 5       | 3     | 1.1E+00               | 3613.6        | 1       | 3     | 3.802E-02             | <i>Iodine</i>  |         |       |                       |
| 3039.1           | 5       | 3     | 2.8E+00               | *3634.2       | 9       | 15    | 2.606E-02             | <i>I I</i>     |         |       |                       |
| 3124.8           | 5       | 5     | 3.1E-02               | *3652.0       | 9       | 3     | 9.744E-03             | 1782.8         | 4       | 4     | 2.71E+00              |
| 3269.5           | 5       | 3     | 2.9E-01               | *3705.0       | 9       | 15    | 3.953E-02             | 1830.4         | 4       | 6     | 1.6E-01               |
| 4226.6           | 1       | 3     | 2.1E-01               | *3819.6       | 9       | 15    | 6.435E-02             | <i>Iridium</i> |         |       |                       |
| 4685.8           | 1       | 3     | 9.5E-02               | 3833.6        | 3       | 5     | 9.647E-03             | <i>Ir I</i>    |         |       |                       |
| <i>Ge II</i>     |         |       |                       | *3867.5       | 9       | 3     | 2.447E-02             | 2475.12        | 10      | 10    | 2.1E-01               |
| 999.10           | 2       | 4     | 1.9E+00               | 3871.8        | 3       | 5     | 1.339E-02             | 2502.98        | 10      | 12    | 3.2E-01               |
| 1016.6           | 4       | 6     | 2.1E+00               | *3888.7       | 3       | 9     | 9.475E-02             | 2639.71        | 10      | 10    | 4.7E-01               |
| 1017.1           | 4       | 4     | 3.5E-01               | 3926.5        | 3       | 5     | 1.937E-02             | 2661.98        | 10      | 10    | 2.5E-01               |
| 1055.0           | 2       | 2     | 6.9E-01               | 3935.9        | 3       | 1     | 7.448E-03             |                |         |       |                       |
|                  |         |       |                       | 3964.7        | 1       | 3     | 6.951E-02             |                |         |       |                       |
|                  |         |       |                       | 4009.3        | 3       | 5     | 2.961E-02             |                |         |       |                       |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 2664.79        | 10      | 8     | 4.0E-01                      | 2443.87        | 11      | 11    | 5.89E-02                     | 2606.83        | 9       | 11    | 2.43E-01                     |
| 2694.23        | 10      | 12    | 4.8E-01                      | 2453.48        | 9       | 7     | 1.89E-01                     | 2609.22        | 7       | 7     | 4.60E-01                     |
| 2849.72        | 10      | 10    | 2.2E-01                      | 2453.57        | 11      | 13    | 1.23E-01                     | 2618.02        | 7       | 7     | 1.50E-01                     |
| 2853.31        | 10      | 10    | 2.0E-03                      | 2457.60        | 11      | 11    | 4.81E-01                     | 2623.53        | 7       | 9     | 2.13E-01                     |
| 2882.64        | 10      | 8     | 7.2E-02                      | 2462.18        | 7       | 5     | 1.10E-01                     | 2632.24        | 5       | 5     | 1.21E-01                     |
| 2924.79        | 10      | 12    | 1.42E-01                     | 2462.65        | 9       | 9     | 5.85E-01                     | 2635.72        | 11      | 9     | 4.29E-02                     |
| 2934.64        | 8       | 10    | 2.0E-01                      | 2463.73        | 7       | 5     | 1.64E-01                     | 2635.81        | 5       | 7     | 2.11E-01                     |
| 2951.22        | 10      | 8     | 2.8E-02                      | 2465.15        | 9       | 9     | 4.35E-01                     | 2641.03        | 9       | 7     | 7.71E-02                     |
| 3003.63        | 8       | 10    | 5.9E-02                      | 2468.88        | 11      | 11    | 2.40E-01                     | 2641.64        | 9       | 7     | 6.47E-02                     |
| 3168.88        | 8       | 10    | 5.47E-02                     | 2470.97        | 9       | 11    | 2.36E-02                     | 2644.00        | 3       | 5     | 2.34E-01                     |
| 3220.78        | 10      | 8     | 2.4E-01                      | 2472.34        | 11      | 13    | 7.21E-02                     | 2656.15        | 13      | 15    | 1.63E-01                     |
| 3558.99        | 6       | 8     | 1.5E-02                      | 2472.87        | 5       | 3     | 2.10E-01                     | 2662.06        | 7       | 5     | 4.64E-02                     |
| 3573.72        | 8       | 10    | 5.4E-02                      | 2472.89        | 7       | 7     | 1.30E+00                     | 2666.81        | 11      | 9     | 8.91E-02                     |
| 3617.21        | 6       | 8     | 2.0E-02                      | 2473.16        | 9       | 9     | 2.75E-02                     | 2666.97        | 9       | 11    | 5.16E-02                     |
| 3628.67        | 8       | 8     | 2.8E-02                      | 2474.81        | 7       | 7     | 6.13E-01                     | 2669.49        | 11      | 13    | 1.34E-01                     |
| 3661.71        | 8       | 10    | 4.0E-02                      | 2476.66        | 5       | 3     | 3.05E-01                     | 2679.02        | 9       | 11    | 1.10E-01                     |
| 3734.77        | 8       | 8     | 2.7E-02                      | 2479.48        | 5       | 5     | 2.10E-01                     | 2679.06        | 11      | 11    | 1.50E-01                     |
| 4033.76        | 8       | 10    | 2.7E-02                      | 2479.78        | 5       | 5     | 1.74E+00                     | 2689.21        | 9       | 7     | 1.68E-01                     |
| 4069.92        | 6       | 8     | 3.6E-02                      | 2483.27        | 9       | 11    | 4.80E+00                     | 2689.83        | 7       | 9     | 3.04E-02                     |
| 4913.35        | 12      | 12    | 3.3E-02                      | 2483.53        | 5       | 5     | 2.09E-01                     | 2697.02        | 7       | 9     | 3.51E-02                     |
| 4939.24        | 10      | 12    | 2.5E-03                      | 2484.19        | 3       | 3     | 2.26E+00                     | 2699.11        | 9       | 9     | 5.59E-02                     |
| <i>Iron</i>    |         |       |                              | 2485.99        | 9       | 9     | 2.94E-02                     | 2701.91        | 9       | 7     | 1.05E-01                     |
| <i>Fe I</i>    |         |       |                              | 2486.69        | 7       | 9     | 1.47E-01                     | 2702.45        | 13      | 11    | 4.23E-02                     |
| 1934.54        | 9       | 7     | 2.5E-01                      | 2487.07        | 3       | 3     | 6.40E-01                     | 2706.01        | 13      | 13    | 2.28E-01                     |
| 1937.27        | 9       | 7     | 2.2E-01                      | 2488.14        | 7       | 9     | 4.20E+00                     | 2706.58        | 7       | 5     | 2.69E-01                     |
| 1940.66        | 7       | 5     | 2.6E-01                      | 2489.75        | 1       | 3     | 2.31E+00                     | 2708.57        | 9       | 9     | 6.49E-01                     |
| 2132.02        | 9       | 9     | 7.6E-02                      | 2489.91        | 3       | 5     | 8.72E-02                     | 2710.54        | 5       | 7     | 5.99E-02                     |
| 2145.19        | 7       | 7     | 5.7E-02                      | 2490.64        | 5       | 7     | 3.44E+00                     | 2711.66        | 9       | 11    | 4.99E-02                     |
| 2153.01        | 5       | 5     | 6.9E-02                      | 2491.16        | 3       | 5     | 2.91E+00                     | 2716.26        | 9       | 9     | 3.70E-02                     |
| 2161.58        | 3       | 5     | 5.0E-02                      | 2491.99        | 9       | 9     | 3.25E-01                     | 2716.42        | 11      | 9     | 4.96E-02                     |
| 2166.77        | 9       | 7     | 2.7E+00                      | 2494.00        | 3       | 5     | 8.89E-02                     | 2718.44        | 5       | 3     | 3.79E-01                     |
| 2171.30        | 5       | 7     | 5.1E-02                      | 2496.53        | 9       | 11    | 2.15E-01                     | 2719.03        | 9       | 7     | 1.42E+00                     |
| 2173.21        | 3       | 5     | 8.3E-02                      | 2501.13        | 9       | 7     | 6.75E-01                     | 2719.06        | 7       | 7     | 7.40E-01                     |
| 2176.84        | 1       | 3     | 1.0E-01                      | 2501.69        | 11      | 9     | 3.69E-02                     | 2719.42        | 11      | 11    | 3.20E-01                     |
| 2191.84        | 5       | 5     | 1.2E+00                      | 2505.01        | 9       | 11    | 2.56E-01                     | 2720.90        | 7       | 5     | 1.04E+00                     |
| 2196.04        | 3       | 3     | 1.2E+00                      | 2506.57        | 7       | 9     | 2.04E-01                     | 2723.58        | 5       | 3     | 5.69E-01                     |
| 2200.39        | 1       | 3     | 8.9E-01                      | 2507.90        | 7       | 9     | 1.93E-01                     | 2724.95        | 7       | 9     | 4.76E-02                     |
| 2200.72        | 3       | 5     | 2.8E-01                      | 2510.83        | 7       | 5     | 1.29E+00                     | 2726.06        | 3       | 1     | 5.52E-01                     |
| 2259.51        | 9       | 11    | 5.66E-02                     | 2517.66        | 5       | 7     | 1.58E-01                     | 2728.02        | 9       | 9     | 3.45E-02                     |
| 2272.07        | 7       | 9     | 2.92E-02                     | 2518.10        | 5       | 3     | 1.93E+00                     | 2728.82        | 9       | 9     | 2.98E-01                     |
| 2276.03        | 9       | 7     | 1.25E-01                     | 2519.63        | 3       | 5     | 1.34E-01                     | 2731.28        | 5       | 7     | 6.84E-02                     |
| 2284.09        | 7       | 5     | 1.29E-01                     | 2522.85        | 9       | 9     | 2.13E+00                     | 2733.58        | 11      | 9     | 7.10E-01                     |
| 2287.25        | 5       | 3     | 2.23E-01                     | 2524.29        | 3       | 1     | 3.23E+00                     | 2735.48        | 9       | 7     | 5.03E-01                     |
| 2292.52        | 7       | 9     | 2.96E-02                     | 2527.27        | 13      | 13    | 3.46E-01                     | 2737.31        | 3       | 3     | 7.25E-01                     |
| 2294.41        | 3       | 1     | 3.61E-01                     | 2527.44        | 7       | 7     | 1.93E+00                     | 2737.64        | 13      | 11    | 1.14E-01                     |
| 2297.79        | 7       | 7     | 1.44E-01                     | 2529.14        | 5       | 5     | 9.91E-01                     | 2742.25        | 7       | 5     | 3.41E-01                     |
| 2298.17        | 9       | 9     | 3.09E-01                     | 2529.31        | 5       | 7     | 4.86E+00                     | 2742.41        | 5       | 5     | 4.70E-01                     |
| 2299.22        | 5       | 5     | 7.03E-02                     | 2529.84        | 3       | 3     | 3.83E-01                     | 2743.57        | 7       | 7     | 4.84E-02                     |
| 2300.14        | 5       | 7     | 4.99E-02                     | 2533.14        | 11      | 11    | 2.07E-01                     | 2744.07        | 1       | 3     | 3.09E-01                     |
| 2301.68        | 1       | 3     | 8.68E-02                     | 2535.61        | 1       | 3     | 9.59E-01                     | 2744.53        | 5       | 3     | 2.53E-01                     |
| 2303.58        | 3       | 5     | 4.83E-02                     | 2537.17        | 13      | 15    | 3.70E+00                     | 2750.14        | 7       | 7     | 2.74E-01                     |
| 2309.00        | 3       | 5     | 1.02E-01                     | 2537.46        | 9       | 11    | 3.19E-02                     | 2753.69        | 3       | 1     | 4.00E-01                     |
| 2313.10        | 5       | 7     | 1.18E-01                     | 2540.97        | 3       | 5     | 9.59E-01                     | 2754.03        | 5       | 5     | 7.29E-02                     |
| 2320.36        | 7       | 9     | 1.41E-01                     | 2542.10        | 11      | 13    | 4.47E+00                     | 2755.18        | 11      | 9     | 5.13E-02                     |
| 2373.62        | 7       | 7     | 6.53E-02                     | 2543.92        | 9       | 11    | 4.70E+00                     | 2756.33        | 3       | 5     | 1.41E-01                     |
| 2389.97        | 5       | 7     | 4.47E-02                     | 2545.98        | 5       | 7     | 7.16E-01                     | 2757.32        | 3       | 3     | 2.85E-01                     |
| 2438.18        | 11      | 9     | 7.09E-02                     | 2549.61        | 7       | 9     | 2.31E-01                     | 2761.78        | 5       | 5     | 1.94E-01                     |
| 2439.74        | 13      | 13    | 3.46E+00                     | 2576.69        | 11      | 11    | 1.13E-01                     | 2762.03        | 7       | 7     | 1.76E-01                     |
| 2442.57        | 11      | 11    | 3.12E+00                     | 2584.54        | 11      | 13    | 3.15E-01                     | 2767.52        | 9       | 9     | 1.48E-01                     |
|                |         |       |                              | 2599.57        | 9       | 9     | 1.47E-01                     | 2769.30        | 13      | 13    | 1.80E-01                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 2772.07        | 11      | 11    | 2.34E-02                     | 2973.13        | 5       | 7     | 1.35E-01                     | 3099.89        | 3       | 3     | 1.93E-01                     |
| 2772.11        | 5       | 7     | 4.12E-02                     | 2973.24        | 7       | 9     | 1.83E-01                     | 3099.97        | 9       | 9     | 8.23E-02                     |
| 2778.22        | 11      | 11    | 9.08E-02                     | 2976.13        | 5       | 7     | 9.70E-02                     | 3100.30        | 5       | 5     | 1.87E-01                     |
| 2780.70        | 9       | 9     | 9.01E-02                     | 2980.53        | 7       | 7     | 1.66E-01                     | 3100.67        | 7       | 7     | 1.35E-01                     |
| 2784.34        | 11      | 11    | 2.30E-02                     | 2981.45        | 7       | 5     | 6.53E-02                     | 3100.84        | 13      | 11    | 2.73E-02                     |
| 2787.93        | 9       | 11    | 2.27E-02                     | 2981.85        | 7       | 9     | 1.86E-01                     | 3101.00        | 9       | 9     | 5.53E-02                     |
| 2788.10        | 11      | 13    | 5.92E-01                     | 2982.23        | 9       | 7     | 3.47E-02                     | 3112.08        | 11      | 11    | 5.24E-02                     |
| 2789.80        | 11      | 9     | 2.36E-01                     | 2983.57        | 9       | 7     | 2.79E-01                     | 3119.49        | 11      | 9     | 8.28E-02                     |
| 2797.78        | 9       | 9     | 4.52E-02                     | 2987.29        | 9       | 7     | 5.25E-02                     | 3120.44        | 9       | 7     | 7.26E-02                     |
| 2803.61        | 9       | 9     | 1.04E-01                     | 2990.39        | 9       | 11    | 3.5E-01                      | 3125.68        | 13      | 11    | 8.46E-02                     |
| 2804.52        | 9       | 9     | 1.05E-01                     | 2994.43        | 7       | 5     | 4.39E-01                     | 3132.52        | 9       | 7     | 3.39E-01                     |
| 2804.86        | 9       | 7     | 2.40E-01                     | 2996.39        | 3       | 5     | 1.70E-01                     | 3142.45        | 7       | 7     | 3.93E-02                     |
| 2806.98        | 9       | 11    | 1.15E-01                     | 2999.51        | 11      | 11    | 1.70E-01                     | 3142.89        | 5       | 5     | 5.65E-02                     |
| 2812.04        | 9       | 9     | 5.00E-02                     | 3000.45        | 9       | 11    | 5.41E-02                     | 3143.99        | 9       | 9     | 6.10E-01                     |
| 2813.29        | 9       | 11    | 3.42E-01                     | 3000.95        | 5       | 3     | 6.42E-01                     | 3145.06        | 9       | 9     | 4.65E-02                     |
| 2823.28        | 7       | 7     | 1.51E-01                     | 3003.03        | 7       | 5     | 7.50E-02                     | 3147.79        | 7       | 7     | 7.59E-02                     |
| 2825.56        | 7       | 9     | 1.32E-01                     | 3004.11        | 11      | 11    | 2.79E-02                     | 3153.20        | 7       | 9     | 7.91E-02                     |
| 2832.44        | 7       | 9     | 2.38E-01                     | 3005.30        | 13      | 15    | 2.94E-02                     | 3154.50        | 5       | 7     | 4.64E-02                     |
| 2834.75        | 9       | 11    | 5.41E-02                     | 3007.15        | 9       | 7     | 7.34E-02                     | 3156.27        | 7       | 7     | 6.36E-01                     |
| 2838.12        | 5       | 5     | 1.28E-01                     | 3008.14        | 3       | 1     | 1.07E+00                     | 3157.04        | 9       | 11    | 1.26E-01                     |
| 2843.63        | 9       | 7     | 6.96E-02                     | 3009.09        | 13      | 11    | 7.77E-02                     | 3157.89        | 5       | 7     | 1.61E-01                     |
| 2843.98        | 5       | 7     | 3.17E-01                     | 3009.57        | 9       | 9     | 1.43E-01                     | 3160.66        | 9       | 9     | 1.93E-01                     |
| 2845.59        | 7       | 5     | 7.86E-02                     | 3011.48        | 7       | 9     | 3.79E-01                     | 3161.95        | 11      | 13    | 4.65E-02                     |
| 2851.80        | 3       | 5     | 3.37E-01                     | 3015.92        | 11      | 9     | 6.3E-02                      | 3165.86        | 7       | 9     | 5.35E-02                     |
| 2853.77        | 7       | 9     | 5.91E-02                     | 3016.18        | 5       | 3     | 8.85E-02                     | 3166.44        | 9       | 7     | 1.14E-01                     |
| 2863.43        | 9       | 9     | 4.13E-02                     | 3018.98        | 7       | 7     | 1.03E-01                     | 3171.35        | 9       | 7     | 1.85E-01                     |
| 2868.45        | 5       | 3     | 1.45E-01                     | 3019.29        | 9       | 11    | 2.33E-02                     | 3175.44        | 11      | 11    | 1.44E-01                     |
| 2877.30        | 9       | 9     | 4.61E-02                     | 3020.49        | 5       | 5     | 1.94E-01                     | 3178.01        | 11      | 9     | 1.28E-01                     |
| 2883.75        | 11      | 11    | 2.91E-02                     | 3020.64        | 9       | 9     | 7.59E-01                     | 3180.22        | 7       | 9     | 4.42E-01                     |
| 2887.81        | 11      | 13    | 7.98E-02                     | 3021.07        | 7       | 7     | 4.55E-01                     | 3181.52        | 7       | 5     | 1.84E-01                     |
| 2892.48        | 9       | 9     | 8.78E-02                     | 3024.03        | 3       | 5     | 4.87E-02                     | 3182.06        | 9       | 9     | 3.23E-02                     |
| 2894.50        | 5       | 5     | 4.83E-01                     | 3025.64        | 13      | 13    | 5.86E-01                     | 3182.97        | 5       | 7     | 1.42E-01                     |
| 2895.03        | 7       | 7     | 4.24E-02                     | 3025.84        | 1       | 3     | 3.48E-01                     | 3188.57        | 11      | 11    | 5.00E-02                     |
| 2899.41        | 5       | 3     | 4.68E-01                     | 3026.46        | 5       | 5     | 1.10E-01                     | 3188.82        | 3       | 5     | 2.53E-01                     |
| 2901.91        | 11      | 11    | 1.78E-01                     | 3030.15        | 11      | 11    | 5.04E-01                     | 3190.65        | 9       | 11    | 5.75E-02                     |
| 2907.52        | 9       | 11    | 1.61E-01                     | 3031.64        | 3       | 3     | 1.38E-01                     | 3190.82        | 9       | 9     | 5.55E-02                     |
| 2908.86        | 7       | 9     | 8.98E-02                     | 3037.39        | 3       | 5     | 2.91E-01                     | 3192.80        | 3       | 5     | 5.01E-01                     |
| 2918.02        | 13      | 13    | 1.18E+00                     | 3040.43        | 9       | 11    | 2.45E-02                     | 3193.30        | 5       | 7     | 3.07E-01                     |
| 2919.84        | 9       | 11    | 7.44E-02                     | 3041.64        | 7       | 9     | 4.24E-02                     | 3194.42        | 5       | 3     | 1.08E-01                     |
| 2920.69        | 5       | 5     | 6.38E-02                     | 3041.74        | 7       | 9     | 5.20E-02                     | 3196.12        | 11      | 9     | 1.40E-01                     |
| 2923.29        | 11      | 11    | 1.39E+00                     | 3042.02        | 3       | 5     | 4.70E-02                     | 3196.93        | 9       | 11    | 5.97E-01                     |
| 2923.85        | 11      | 11    | 2.97E-01                     | 3042.66        | 5       | 7     | 5.20E-02                     | 3199.53        | 9       | 9     | 2.23E-01                     |
| 2925.36        | 7       | 9     | 1.69E-01                     | 3047.60        | 5       | 7     | 2.84E-01                     | 3202.56        | 9       | 7     | 6.18E-02                     |
| 2929.01        | 7       | 5     | 5.10E-02                     | 3053.07        | 3       | 5     | 1.53E-01                     | 3205.40        | 3       | 3     | 9.77E-01                     |
| 2929.12        | 9       | 9     | 1.53E+00                     | 3055.26        | 7       | 5     | 9.48E-02                     | 3210.23        | 9       | 11    | 1.15E-01                     |
| 2936.90        | 9       | 9     | 1.40E-01                     | 3057.45        | 11      | 9     | 3.13E-01                     | 3210.83        | 5       | 3     | 9.24E-01                     |
| 2947.36        | 5       | 5     | 9.30E-02                     | 3059.09        | 7       | 9     | 1.63E-01                     | 3211.61        | 9       | 9     | 3.07E-02                     |
| 2947.88        | 7       | 7     | 1.83E-01                     | 3060.54        | 9       | 7     | 6.75E-02                     | 3211.99        | 11      | 9     | 4.64E-01                     |
| 2948.43        | 9       | 9     | 3.32E-01                     | 3066.48        | 9       | 7     | 9.11E-02                     | 3214.01        | 7       | 7     | 8.38E-01                     |
| 2953.49        | 7       | 7     | 3.64E-01                     | 3067.00        | 11      | 13    | 1.71E-01                     | 3214.06        | 7       | 5     | 1.18E+00                     |
| 2953.94        | 5       | 5     | 1.89E-01                     | 3067.12        | 5       | 7     | 3.89E-02                     | 3215.94        | 5       | 5     | 6.19E-01                     |
| 2954.65        | 5       | 7     | 1.06E-01                     | 3067.24        | 9       | 7     | 3.12E-01                     | 3217.38        | 11      | 9     | 1.50E-01                     |
| 2957.36        | 3       | 3     | 1.77E-01                     | 3068.17        | 5       | 3     | 1.11E-01                     | 3219.58        | 7       | 9     | 4.64E-01                     |
| 2957.48        | 5       | 3     | 1.31E-01                     | 3073.98        | 11      | 9     | 3.83E-02                     | 3219.80        | 9       | 7     | 3.61E-01                     |
| 2959.99        | 11      | 13    | 5.02E-01                     | 3075.72        | 7       | 5     | 3.14E-01                     | 3221.92        | 3       | 3     | 1.22E-01                     |
| 2960.66        | 11      | 9     | 8.48E-02                     | 3078.43        | 1       | 3     | 1.52E-01                     | 3222.07        | 11      | 11    | 8.65E-01                     |
| 2965.25        | 1       | 3     | 1.16E-01                     | 3079.99        | 9       | 11    | 8.35E-02                     | 3225.79        | 11      | 13    | 1.18E+00                     |
| 2966.90        | 9       | 11    | 2.72E-01                     | 3083.74        | 5       | 3     | 3.08E-01                     | 3227.80        | 9       | 7     | 4.96E-01                     |
| 2968.48        | 3       | 3     | 8.26E-02                     | 3091.58        | 3       | 1     | 5.53E-01                     | 3228.25        | 5       | 3     | 3.72E-01                     |
| 2970.10        | 3       | 5     | 1.08E-01                     | 3098.19        | 11      | 11    | 7.52E-02                     | 3229.99        | 9       | 11    | 1.06E-01                     |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3230.21        | 5       | 5     | 2.06E-01                     | 3406.80        | 3       | 3     | 2.08E-01                     | 3534.53        | 11      | 11    | 2.20E-02                     |
| 3230.96        | 7       | 5     | 3.7E-01                      | 3407.46        | 7       | 9     | 6.09E-01                     | 3536.56        | 5       | 7     | 9.95E-01                     |
| 3233.05        | 13      | 15    | 4.19E-01                     | 3410.17        | 3       | 5     | 5.07E-01                     | 3537.73        | 5       | 3     | 1.33E-01                     |
| 3233.97        | 9       | 9     | 2.08E-01                     | 3411.35        | 9       | 9     | 6.0E-02                      | 3537.89        | 11      | 11    | 8.0E-02                      |
| 3239.43        | 9       | 9     | 2.95E-01                     | 3413.13        | 5       | 7     | 3.23E-01                     | 3540.12        | 7       | 9     | 9.48E-02                     |
| 3244.19        | 9       | 11    | 3.06E-01                     | 3415.53        | 3       | 5     | 4.64E-02                     | 3541.08        | 9       | 11    | 8.65E-01                     |
| 3246.96        | 5       | 3     | 1.09E-01                     | 3417.84        | 3       | 3     | 4.01E-01                     | 3542.08        | 7       | 9     | 9.51E-01                     |
| 3248.20        | 7       | 7     | 1.92E-01                     | 3418.51        | 3       | 1     | 9.88E-01                     | 3543.67        | 3       | 5     | 1.6E-01                      |
| 3250.76        | 11      | 11    | 2.85E-02                     | 3422.66        | 3       | 5     | 1.38E-01                     | 3545.64        | 9       | 9     | 2.05E-01                     |
| 3252.91        | 9       | 11    | 2.20E-02                     | 3424.28        | 7       | 7     | 1.61E-01                     | 3547.19        | 9       | 9     | 7.13E-02                     |
| 3253.60        | 7       | 9     | 1.62E-01                     | 3425.01        | 9       | 7     | 2.57E-01                     | 3552.11        | 3       | 5     | 4.8E-02                      |
| 3254.36        | 11      | 13    | 4.24E-01                     | 3426.63        | 5       | 3     | 1.94E-01                     | 3552.83        | 5       | 5     | 1.74E-01                     |
| 3257.23        | 9       | 9     | 4.76E-02                     | 3426.67        | 11      | 11    | 1.07E-01                     | 3553.74        | 11      | 9     | 1.09E+00                     |
| 3257.59        | 7       | 5     | 8.94E-02                     | 3427.12        | 7       | 9     | 5.04E-01                     | 3554.50        | 3       | 5     | 9.87E-02                     |
| 3259.99        | 7       | 9     | 2.99E-02                     | 3428.19        | 5       | 5     | 1.71E-01                     | 3554.92        | 11      | 13    | 1.40E+00                     |
| 3264.51        | 5       | 3     | 1.01E-01                     | 3431.81        | 5       | 7     | 5.53E-02                     | 3556.88        | 9       | 11    | 4.1E-01                      |
| 3265.62        | 7       | 5     | 3.06E-01                     | 3440.61        | 9       | 7     | 1.71E-01                     | 3558.52        | 5       | 7     | 1.77E-01                     |
| 3271.00        | 5       | 3     | 6.4E-01                      | 3440.99        | 7       | 5     | 1.24E-01                     | 3559.50        | 3       | 3     | 2.2E-01                      |
| 3271.48        | 7       | 7     | 8.47E-02                     | 3443.88        | 5       | 3     | 7.92E-02                     | 3560.70        | 7       | 9     | 7.4E-02                      |
| 3280.26        | 9       | 11    | 4.21E-01                     | 3445.15        | 5       | 7     | 2.34E-01                     | 3565.38        | 7       | 9     | 4.29E-01                     |
| 3282.89        | 3       | 5     | 3.42E-01                     | 3447.28        | 5       | 5     | 1.07E-01                     | 3567.03        | 5       | 7     | 8.34E-02                     |
| 3284.59        | 5       | 5     | 5.64E-02                     | 3450.33        | 3       | 3     | 2.34E-01                     | 3568.82        | 7       | 9     | 6.72E-02                     |
| 3286.75        | 7       | 7     | 5.99E-01                     | 3451.91        | 3       | 5     | 1.13E-01                     | 3568.97        | 11      | 9     | 4.64E-02                     |
| 3290.99        | 3       | 5     | 7.58E-02                     | 3458.30        | 3       | 1     | 2.92E-01                     | 3570.10        | 9       | 11    | 6.76E-01                     |
| 3292.02        | 7       | 9     | 5.77E-01                     | 3459.91        | 5       | 3     | 2.17E-01                     | 3572.00        | 11      | 11    | 2.89E-01                     |
| 3292.59        | 3       | 3     | 3.0E-01                      | 3465.86        | 3       | 3     | 1.19E-01                     | 3572.59        | 9       | 9     | 3.31E-02                     |
| 3298.13        | 3       | 5     | 9.01E-02                     | 3468.84        | 9       | 11    | 2.61E-02                     | 3573.39        | 5       | 7     | 1.05E-01                     |
| 3305.97        | 5       | 7     | 4.05E-01                     | 3469.01        | 9       | 9     | 8.58E-02                     | 3573.83        | 13      | 13    | 2.41E-02                     |
| 3306.34        | 9       | 9     | 5.74E-01                     | 3475.45        | 5       | 5     | 9.75E-02                     | 3573.89        | 9       | 7     | 5.73E-01                     |
| 3306.35        | 3       | 5     | 4.84E-01                     | 3475.65        | 7       | 5     | 8.61E-02                     | 3575.11        | 3       | 3     | 1.60E-01                     |
| 3307.23        | 13      | 13    | 1.97E-01                     | 3476.34        | 7       | 7     | 2.70E-01                     | 3575.25        | 11      | 9     | 7.43E-02                     |
| 3310.34        | 11      | 11    | 3.78E-02                     | 3476.85        | 7       | 9     | 3.21E-02                     | 3575.37        | 5       | 5     | 3.06E-01                     |
| 3310.49        | 7       | 9     | 6.17E-02                     | 3485.34        | 5       | 3     | 1.30E-01                     | 3576.76        | 11      | 9     | 8.8E-02                      |
| 3314.74        | 5       | 7     | 7.25E-01                     | 3489.67        | 11      | 13    | 7.47E-02                     | 3578.38        | 1       | 3     | 7.82E-02                     |
| 3319.25        | 9       | 9     | 3.73E-02                     | 3490.57        | 7       | 7     | 6.14E-02                     | 3581.19        | 11      | 13    | 1.02E+00                     |
| 3322.47        | 9       | 11    | 8.21E-02                     | 3495.29        | 9       | 7     | 9.46E-02                     | 3581.65        | 11      | 9     | 3.21E-02                     |
| 3323.74        | 5       | 5     | 2.8E-01                      | 3497.10        | 7       | 7     | 9.02E-02                     | 3581.81        | 3       | 5     | 8.68E-02                     |
| 3328.87        | 11      | 11    | 2.21E-01                     | 3500.56        | 7       | 5     | 5.28E-02                     | 3582.20        | 13      | 11    | 2.35E-01                     |
| 3335.77        | 3       | 5     | 7.48E-02                     | 3505.06        | 5       | 3     | 1.77E-01                     | 3584.66        | 11      | 11    | 3.29E-01                     |
| 3336.26        | 9       | 9     | 4.91E-02                     | 3506.50        | 5       | 5     | 7.35E-02                     | 3584.79        | 7       | 5     | 1.56E-01                     |
| 3337.67        | 11      | 9     | 6.06E-02                     | 3508.47        | 9       | 11    | 6.46E-02                     | 3584.96        | 11      | 9     | 6.74E-01                     |
| 3340.56        | 5       | 5     | 4.95E-02                     | 3513.82        | 11      | 11    | 3.40E-02                     | 3585.19        | 11      | 9     | 3.19E-02                     |
| 3341.91        | 11      | 11    | 3.02E-02                     | 3516.41        | 7       | 9     | 3.6E-02                      | 3585.32        | 7       | 7     | 1.17E-01                     |
| 3342.29        | 3       | 3     | 9.42E-02                     | 3516.56        | 7       | 5     | 6.82E-02                     | 3585.71        | 9       | 9     | 3.75E-02                     |
| 3347.93        | 5       | 5     | 4.91E-02                     | 3521.26        | 9       | 9     | 6.14E-02                     | 3586.11        | 13      | 11    | 7.02E-01                     |
| 3354.06        | 1       | 3     | 1.34E-01                     | 3522.27        | 11      | 11    | 5.03E-02                     | 3586.74        | 13      | 13    | 3.62E-02                     |
| 3355.23        | 9       | 9     | 2.59E-01                     | 3522.90        | 5       | 7     | 3.51E-02                     | 3586.98        | 5       | 5     | 1.66E-01                     |
| 3369.55        | 9       | 9     | 2.15E-01                     | 3523.31        | 5       | 3     | 1.06E-01                     | 3587.24        | 7       | 9     | 7.73E-02                     |
| 3370.78        | 11      | 11    | 2.89E-01                     | 3524.07        | 7       | 5     | 9.9E-02                      | 3588.53        | 9       | 7     | 7.21E-02                     |
| 3380.11        | 7       | 7     | 1.66E-01                     | 3524.24        | 5       | 7     | 5.04E-02                     | 3588.61        | 11      | 11    | 1.19E-01                     |
| 3383.69        | 5       | 3     | 8.33E-02                     | 3526.17        | 7       | 7     | 4.14E-02                     | 3588.92        | 5       | 3     | 2.15E-01                     |
| 3383.98        | 7       | 7     | 6.52E-02                     | 3526.24        | 7       | 9     | 1.70E-01                     | 3589.45        | 9       | 7     | 1.05E-01                     |
| 3392.30        | 5       | 5     | 9.93E-02                     | 3526.38        | 7       | 7     | 4.13E-01                     | 3594.63        | 9       | 9     | 3.14E-01                     |
| 3392.65        | 7       | 7     | 1.88E-01                     | 3526.47        | 5       | 5     | 1.29E-01                     | 3595.30        | 5       | 5     | 8.21E-02                     |
| 3394.58        | 5       | 3     | 8.70E-02                     | 3526.67        | 5       | 5     | 5.26E-01                     | 3597.02        | 5       | 3     | 1.8E-01                      |
| 3399.33        | 5       | 5     | 2.76E-01                     | 3527.79        | 9       | 9     | 2.17E-01                     | 3599.63        | 11      | 9     | 2.33E-01                     |
| 3402.26        | 13      | 13    | 2.19E-01                     | 3529.82        | 3       | 3     | 7.75E-01                     | 3602.46        | 7       | 7     | 1.02E-01                     |
| 3403.29        | 5       | 7     | 3.98E-02                     | 3530.39        | 13      | 13    | 4.65E-02                     | 3602.53        | 7       | 5     | 2.12E-01                     |
| 3404.35        | 5       | 7     | 1.09E-01                     | 3533.01        | 1       | 3     | 8.52E-01                     | 3603.20        | 11      | 11    | 2.59E-01                     |
| 3406.44        | 3       | 5     | 2.7E-01                      | 3533.20        | 3       | 5     | 8.25E-01                     | 3603.82        | 3       | 3     | 1.70E-01                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3605.45        | 9       | 9     | 4.66E-01                     | 3689.46        | 9       | 9     | 3.70E-01                     | 3781.94        | 5       | 7     | 3.8E-02                      |
| 3605.50        | 13      | 11    | 2.12E-01                     | 3690.45        | 1       | 3     | 1.22E-01                     | 3785.95        | 11      | 13    | 4.14E-02                     |
| 3606.68        | 11      | 13    | 8.29E-01                     | 3690.73        | 11      | 11    | 2.99E-01                     | 3786.19        | 5       | 5     | 1.3E-01                      |
| 3608.14        | 9       | 11    | 6.22E-02                     | 3694.01        | 5       | 7     | 8.35E-01                     | 3787.16        | 5       | 5     | 9.9E-02                      |
| 3608.86        | 3       | 5     | 8.13E-01                     | 3695.05        | 7       | 9     | 2.01E-01                     | 3787.88        | 3       | 5     | 1.29E-01                     |
| 3610.16        | 13      | 13    | 5.90E-01                     | 3697.43        | 7       | 7     | 1.94E-01                     | 3789.18        | 9       | 11    | 2.16E-02                     |
| 3610.69        | 5       | 3     | 1.05E-01                     | 3698.60        | 5       | 7     | 3.6E-02                      | 3789.82        | 9       | 7     | 4.1E-02                      |
| 3612.07        | 11      | 13    | 1.11E-01                     | 3699.14        | 5       | 7     | 4.9E-02                      | 3793.48        | 7       | 7     | 7.92E-02                     |
| 3613.44        | 7       | 7     | 7.0E-02                      | 3701.09        | 7       | 9     | 6.35E-01                     | 3794.34        | 9       | 11    | 4.15E-02                     |
| 3617.79        | 5       | 7     | 7.09E-01                     | 3702.03        | 3       | 1     | 3.7E-01                      | 3795.00        | 5       | 7     | 1.15E-01                     |
| 3618.30        | 11      | 9     | 4.89E-02                     | 3703.55        | 7       | 7     | 3.84E-02                     | 3797.51        | 13      | 13    | 4.57E-01                     |
| 3618.39        | 9       | 9     | 8.88E-02                     | 3703.69        | 9       | 11    | 6.31E-02                     | 3798.51        | 9       | 11    | 3.23E-02                     |
| 3618.77        | 5       | 7     | 7.22E-01                     | 3703.82        | 1       | 3     | 1.02E-01                     | 3799.55        | 7       | 9     | 7.31E-02                     |
| 3621.46        | 9       | 11    | 4.45E-01                     | 3704.46        | 11      | 9     | 1.42E-01                     | 3801.68        | 5       | 7     | 6.26E-02                     |
| 3621.72        | 11      | 9     | 1.07E-01                     | 3707.92        | 7       | 5     | 3.32E-01                     | 3801.98        | 11      | 13    | 3.7E-02                      |
| 3622.00        | 7       | 7     | 5.14E-01                     | 3709.25        | 9       | 7     | 1.56E-01                     | 3802.28        | 5       | 5     | 5.63E-02                     |
| 3623.19        | 13      | 13    | 6.68E-02                     | 3711.22        | 7       | 9     | 3.62E-02                     | 3804.01        | 11      | 9     | 4.6E-02                      |
| 3625.14        | 11      | 9     | 8.15E-02                     | 3711.41        | 3       | 5     | 1.28E-01                     | 3805.34        | 9       | 11    | 8.60E-01                     |
| 3630.35        | 9       | 7     | 1.04E-01                     | 3716.44        | 9       | 7     | 3.49E-01                     | 3806.22        | 3       | 3     | 2.5E-01                      |
| 3631.10        | 11      | 11    | 2.15E-01                     | 3718.41        | 7       | 7     | 5.17E-02                     | 3806.70        | 11      | 11    | 4.35E-01                     |
| 3631.46        | 7       | 9     | 5.17E-01                     | 3719.93        | 9       | 11    | 1.62E-01                     | 3807.54        | 3       | 5     | 9.37E-02                     |
| 3632.04        | 3       | 5     | 6.74E-01                     | 3721.50        | 5       | 5     | 1.94E-01                     | 3808.73        | 9       | 9     | 3.54E-02                     |
| 3632.56        | 11      | 9     | 5.69E-02                     | 3722.56        | 5       | 5     | 4.97E-02                     | 3810.76        | 5       | 3     | 1.94E-01                     |
| 3633.07        | 9       | 11    | 3.54E-02                     | 3724.38        | 5       | 7     | 1.04E-01                     | 3812.96        | 7       | 5     | 7.91E-02                     |
| 3634.33        | 9       | 7     | 1.05E-01                     | 3726.93        | 5       | 5     | 4.57E-01                     | 3813.06        | 7       | 7     | 5.52E-02                     |
| 3636.22        | 5       | 7     | 2.20E-01                     | 3727.09        | 9       | 7     | 1.71E-01                     | 3813.88        | 13      | 11    | 6.62E-02                     |
| 3637.87        | 9       | 9     | 5.9E-02                      | 3727.62        | 7       | 5     | 2.24E-01                     | 3815.84        | 9       | 7     | 1.12E+00                     |
| 3638.30        | 7       | 9     | 2.36E-01                     | 3727.81        | 7       | 5     | 1.91E-01                     | 3816.34        | 5       | 7     | 4.16E-02                     |
| 3640.39        | 9       | 11    | 3.57E-01                     | 3730.39        | 9       | 11    | 9.73E-02                     | 3817.64        | 11      | 11    | 7.7E-02                      |
| 3644.80        | 7       | 5     | 8.3E-02                      | 3730.46        | 7       | 9     | 3.09E-02                     | 3819.49        | 7       | 5     | 4.9E-02                      |
| 3645.07        | 9       | 9     | 2.91E-02                     | 3730.95        | 5       | 7     | 3.50E-02                     | 3820.43        | 11      | 9     | 6.67E-01                     |
| 3645.82        | 1       | 3     | 4.87E-01                     | 3732.40        | 5       | 5     | 2.69E-01                     | 3821.18        | 11      | 13    | 5.54E-01                     |
| 3647.42        | 3       | 3     | 3.38E-01                     | 3734.86        | 11      | 11    | 9.01E-01                     | 3821.83        | 5       | 5     | 7.30E-02                     |
| 3647.84        | 9       | 11    | 2.91E-01                     | 3735.32        | 9       | 9     | 2.70E-01                     | 3825.88        | 9       | 7     | 5.97E-01                     |
| 3649.51        | 11      | 9     | 3.94E-01                     | 3737.13        | 7       | 9     | 1.41E-01                     | 3827.82        | 7       | 5     | 1.05E+00                     |
| 3650.03        | 7       | 7     | 2.26E-01                     | 3738.31        | 11      | 13    | 3.44E-01                     | 3829.45        | 3       | 3     | 1.32E-01                     |
| 3650.28        | 11      | 11    | 6.15E-02                     | 3740.24        | 7       | 9     | 1.3E-01                      | 3833.31        | 9       | 9     | 4.68E-02                     |
| 3651.47        | 7       | 9     | 5.83E-01                     | 3742.62        | 9       | 9     | 6.75E-02                     | 3834.22        | 7       | 5     | 4.52E-01                     |
| 3655.46        | 5       | 5     | 1.18E-01                     | 3743.36        | 5       | 3     | 2.60E-01                     | 3836.33        | 5       | 5     | 3.29E-01                     |
| 3659.52        | 9       | 9     | 6.31E-02                     | 3743.47        | 11      | 11    | 6.05E-01                     | 3839.26        | 9       | 9     | 2.35E-01                     |
| 3664.54        | 7       | 9     | 4.68E-02                     | 3744.10        | 5       | 3     | 3.17E-01                     | 3840.44        | 5       | 3     | 4.70E-01                     |
| 3666.24        | 11      | 9     | 3.87E-02                     | 3745.56        | 5       | 7     | 1.15E-01                     | 3841.05        | 5       | 3     | 1.36E+00                     |
| 3667.25        | 9       | 7     | 1.3E-01                      | 3746.93        | 7       | 7     | 2.33E-01                     | 3843.26        | 9       | 7     | 3.70E-01                     |
| 3668.21        | 7       | 9     | 3.2E-02                      | 3748.26        | 3       | 5     | 9.15E-02                     | 3845.70        | 5       | 7     | 5.89E-02                     |
| 3669.15        | 9       | 7     | 8.03E-02                     | 3748.96        | 9       | 11    | 1.48E-01                     | 3845.99        | 9       | 7     | 4.5E-02                      |
| 3669.52        | 9       | 7     | 2.34E-01                     | 3749.49        | 9       | 9     | 7.63E-01                     | 3846.41        | 11      | 9     | 1.68E-01                     |
| 3670.02        | 3       | 5     | 8.60E-02                     | 3753.61        | 7       | 5     | 1.22E-01                     | 3846.80        | 7       | 7     | 6.20E-01                     |
| 3670.09        | 11      | 13    | 7.20E-02                     | 3756.94        | 11      | 11    | 2.2E-01                      | 3849.97        | 3       | 1     | 6.05E-01                     |
| 3674.76        | 5       | 3     | 7.91E-02                     | 3757.45        | 5       | 3     | 8.26E-02                     | 3852.57        | 7       | 9     | 3.26E-02                     |
| 3676.31        | 9       | 11    | 4.63E-02                     | 3758.23        | 7       | 7     | 6.34E-01                     | 3854.37        | 9       | 7     | 5.07E-02                     |
| 3677.31        | 5       | 7     | 2.28E-01                     | 3759.15        | 13      | 11    | 4.55E-02                     | 3856.37        | 7       | 5     | 4.64E-02                     |
| 3677.63        | 7       | 5     | 6.08E-01                     | 3760.05        | 13      | 15    | 4.47E-02                     | 3859.21        | 13      | 11    | 7.25E-02                     |
| 3682.17        | 7       | 5     | 1.04E-01                     | 3760.53        | 3       | 5     | 5.50E-02                     | 3859.91        | 9       | 9     | 9.69E-02                     |
| 3682.24        | 5       | 5     | 1.5E+00                      | 3762.20        | 9       | 11    | 2.4E-02                      | 3865.52        | 3       | 3     | 1.55E-01                     |
| 3684.11        | 9       | 7     | 2.97E-01                     | 3763.79        | 5       | 5     | 5.44E-01                     | 3867.22        | 5       | 5     | 3.16E-01                     |
| 3684.14        | 9       | 7     | 9.29E-02                     | 3765.54        | 13      | 15    | 9.51E-01                     | 3871.75        | 11      | 11    | 5.83E-02                     |
| 3686.00        | 9       | 11    | 3.34E-01                     | 3765.70        | 11      | 11    | 2.36E-02                     | 3872.50        | 5       | 5     | 1.05E-01                     |
| 3687.46        | 11      | 9     | 8.00E-02                     | 3767.19        | 3       | 3     | 6.39E-01                     | 3873.76        | 11      | 9     | 6.57E-02                     |
| 3687.66        | 9       | 9     | 7.38E-02                     | 3778.51        | 7       | 5     | 1.17E-01                     | 3878.02        | 7       | 7     | 7.72E-02                     |
| 3688.46        | 7       | 9     | 7.3E-02                      | 3779.45        | 3       | 3     | 1.05E-01                     | 3878.67        | 9       | 7     | 7.02E-02                     |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3878.73        | 3       | 3     | 5.34E-01                     | 3997.39        | 9       | 11    | 1.26E-01                     | 4175.64        | 3       | 5     | 1.14E-01                     |
| 3883.28        | 7       | 7     | 1.28E-01                     | 3998.05        | 11      | 9     | 5.70E-02                     | 4181.75        | 5       | 7     | 2.32E-01                     |
| 3884.36        | 11      | 9     | 3.99E-02                     | 4005.24        | 7       | 5     | 2.04E-01                     | 4182.38        | 5       | 5     | 5.04E-02                     |
| 3885.51        | 3       | 5     | 7.26E-02                     | 4006.31        | 11      | 9     | 5.1E-02                      | 4184.89        | 5       | 5     | 1.03E-01                     |
| 3886.28        | 7       | 7     | 5.29E-02                     | 4009.71        | 3       | 5     | 4.64E-02                     | 4187.04        | 7       | 5     | 2.15E-01                     |
| 3887.05        | 9       | 9     | 3.52E-02                     | 4014.53        | 9       | 7     | 1.53E-01                     | 4187.80        | 9       | 7     | 1.52E-01                     |
| 3888.51        | 5       | 5     | 2.50E-01                     | 4017.15        | 9       | 11    | 3.25E-02                     | 4191.43        | 5       | 3     | 2.73E-01                     |
| 3888.82        | 5       | 3     | 1.95E-01                     | 4018.27        | 5       | 7     | 3.44E-02                     | 4195.33        | 11      | 11    | 1.11E-01                     |
| 3891.93        | 3       | 3     | 2.71E-01                     | 4021.87        | 7       | 9     | 8.55E-02                     | 4196.21        | 7       | 7     | 1.09E-01                     |
| 3893.39        | 11      | 11    | 1.00E-01                     | 4024.73        | 7       | 9     | 8.09E-02                     | 4198.25        | 9       | 9     | 1.47E-01                     |
| 3894.01        | 5       | 5     | 1.03E-01                     | 4030.49        | 9       | 11    | 1.04E-01                     | 4198.30        | 11      | 9     | 8.03E-02                     |
| 3897.89        | 11      | 13    | 6.20E-02                     | 4030.89        | 9       | 7     | 5.02E-02                     | 4198.63        | 5       | 5     | 1.25E-01                     |
| 3900.52        | 7       | 7     | 7.9E-02                      | 4031.96        | 3       | 5     | 7.6E-02                      | 4199.10        | 9       | 11    | 4.92E-01                     |
| 3902.95        | 7       | 7     | 2.14E-01                     | 4040.64        | 5       | 7     | 4.8E-02                      | 4200.92        | 7       | 9     | 6.25E-02                     |
| 3903.90        | 9       | 9     | 7.61E-02                     | 4043.90        | 7       | 7     | 8.69E-02                     | 4202.03        | 9       | 9     | 8.22E-02                     |
| 3906.75        | 5       | 7     | 7.05E-02                     | 4044.61        | 5       | 3     | 8.17E-02                     | 4203.94        | 13      | 13    | 2.97E-02                     |
| 3907.93        | 7       | 5     | 6.67E-02                     | 4045.59        | 9       | 7     | 7.39E-02                     | 4203.98        | 3       | 5     | 7.37E-02                     |
| 3909.66        | 3       | 5     | 5.7E-02                      | 4045.81        | 9       | 9     | 8.62E-01                     | 4210.34        | 3       | 3     | 1.48E-01                     |
| 3911.00        | 9       | 9     | 2.68E-02                     | 4054.87        | 5       | 3     | 9.61E-02                     | 4217.55        | 3       | 5     | 2.46E-01                     |
| 3916.73        | 13      | 11    | 9.83E-02                     | 4058.22        | 9       | 7     | 4.47E-02                     | 4219.36        | 11      | 13    | 2.88E-01                     |
| 3918.42        | 3       | 1     | 4.22E-01                     | 4062.44        | 3       | 3     | 1.85E-01                     | 4222.21        | 7       | 7     | 5.76E-02                     |
| 3918.64        | 7       | 7     | 1.17E-01                     | 4063.59        | 7       | 7     | 6.65E-01                     | 4224.17        | 9       | 11    | 1.06E-01                     |
| 3919.07        | 9       | 9     | 3.72E-02                     | 4067.98        | 9       | 9     | 1.51E-01                     | 4224.51        | 3       | 5     | 6.81E-02                     |
| 3925.64        | 5       | 5     | 8.04E-02                     | 4070.77        | 7       | 5     | 1.1E-01                      | 4225.45        | 5       | 7     | 1.65E-01                     |
| 3925.94        | 1       | 3     | 1.67E-01                     | 4071.74        | 5       | 5     | 7.64E-01                     | 4227.43        | 11      | 13    | 5.29E-01                     |
| 3926.01        | 7       | 7     | 7.26E-02                     | 4073.76        | 5       | 3     | 1.68E-01                     | 4233.60        | 3       | 5     | 1.85E-01                     |
| 3928.08        | 9       | 9     | 5.64E-02                     | 4074.79        | 9       | 9     | 3.43E-02                     | 4235.94        | 9       | 9     | 1.88E-01                     |
| 3931.12        | 5       | 7     | 4.8E-02                      | 4076.63        | 9       | 9     | 1.32E-01                     | 4238.81        | 7       | 9     | 2.41E-01                     |
| 3932.63        | 9       | 11    | 2.70E-02                     | 4076.80        | 5       | 7     | 3.81E-02                     | 4245.26        | 1       | 3     | 9.0E-02                      |
| 3933.60        | 3       | 5     | 5.92E-02                     | 4079.17        | 5       | 5     | 5.4E-02                      | 4246.09        | 7       | 5     | 5.85E-02                     |
| 3935.81        | 5       | 5     | 1.14E-01                     | 4080.21        | 3       | 1     | 2.3E-01                      | 4247.43        | 9       | 11    | 1.94E-01                     |
| 3941.28        | 5       | 5     | 9.1E-02                      | 4084.49        | 11      | 9     | 8.66E-02                     | 4250.12        | 5       | 7     | 2.07E-01                     |
| 3942.44        | 3       | 5     | 9.62E-02                     | 4085.00        | 3       | 5     | 4.7E-02                      | 4250.79        | 7       | 7     | 1.02E-01                     |
| 3946.99        | 9       | 11    | 3.91E-02                     | 4085.30        | 7       | 7     | 8.92E-02                     | 4260.47        | 11      | 11    | 3.99E-01                     |
| 3947.53        | 5       | 5     | 5.12E-02                     | 4085.98        | 7       | 5     | 5.1E-02                      | 4267.83        | 1       | 3     | 8.17E-02                     |
| 3948.10        | 7       | 9     | 1.31E-01                     | 4098.18        | 7       | 7     | 7.49E-02                     | 4271.15        | 7       | 9     | 1.82E-01                     |
| 3948.77        | 11      | 9     | 2.08E-01                     | 4107.49        | 5       | 3     | 1.74E-01                     | 4271.76        | 9       | 11    | 2.28E-01                     |
| 3949.95        | 7       | 5     | 4.79E-02                     | 4109.80        | 3       | 3     | 1.51E-01                     | 4276.68        | 9       | 9     | 2.6E-02                      |
| 3951.16        | 3       | 5     | 4.29E-01                     | 4112.96        | 11      | 13    | 1.1E-01                      | 4282.40        | 7       | 5     | 1.21E-01                     |
| 3952.60        | 11      | 11    | 2.97E-02                     | 4118.55        | 11      | 13    | 4.96E-01                     | 4294.12        | 9       | 9     | 3.12E-02                     |
| 3953.15        | 7       | 9     | 2.97E-02                     | 4125.62        | 9       | 11    | 9.9E-02                      | 4299.23        | 9       | 11    | 1.29E-01                     |
| 3955.34        | 3       | 3     | 1.5E-01                      | 4126.18        | 11      | 11    | 4.2E-02                      | 4307.90        | 7       | 9     | 3.38E-01                     |
| 3956.46        | 13      | 11    | 1.76E-01                     | 4127.61        | 1       | 3     | 1.43E-01                     | 4309.03        | 13      | 13    | 1.96E-02                     |
| 3956.68        | 11      | 13    | 1.22E-01                     | 4132.06        | 5       | 7     | 1.18E-01                     | 4315.08        | 5       | 5     | 7.76E-02                     |
| 3957.02        | 5       | 7     | 1.67E-01                     | 4132.90        | 3       | 5     | 7.70E-02                     | 4325.76        | 5       | 7     | 5.16E-01                     |
| 3960.28        | 5       | 7     | 4.10E-02                     | 4134.68        | 5       | 7     | 1.25E-01                     | 4327.10        | 5       | 5     | 1.12E-01                     |
| 3963.10        | 3       | 5     | 1.5E-01                      | 4137.00        | 3       | 5     | 2.75E-01                     | 4369.77        | 9       | 9     | 6.09E-02                     |
| 3967.42        | 9       | 7     | 1.52E-01                     | 4142.59        | 3       | 5     | 7.5E-02                      | 4383.55        | 9       | 11    | 5.00E-01                     |
| 3967.96        | 7       | 9     | 6.09E-02                     | 4143.41        | 9       | 9     | 2.70E-01                     | 4388.41        | 7       | 7     | 1.03E-01                     |
| 3969.26        | 9       | 7     | 2.26E-01                     | 4143.87        | 7       | 9     | 1.33E-01                     | 4401.29        | 7       | 7     | 6.4E-02                      |
| 3970.39        | 3       | 1     | 3.9E-01                      | 4149.37        | 11      | 13    | 4.23E-02                     | 4404.75        | 7       | 9     | 2.75E-01                     |
| 3971.32        | 11      | 9     | 4.97E-02                     | 4153.90        | 7       | 9     | 2.05E-01                     | 4415.12        | 5       | 7     | 1.19E-01                     |
| 3973.65        | 5       | 7     | 5.81E-02                     | 4154.50        | 5       | 3     | 2.64E-01                     | 4422.57        | 3       | 3     | 8.72E-02                     |
| 3976.61        | 3       | 5     | 1.20E-01                     | 4154.81        | 9       | 11    | 1.40E-01                     | 4433.22        | 5       | 3     | 2.1E-01                      |
| 3977.74        | 5       | 5     | 6.41E-02                     | 4156.80        | 5       | 5     | 1.20E-01                     | 4443.19        | 1       | 3     | 1.02E-01                     |
| 3981.77        | 9       | 9     | 3.57E-02                     | 4157.78        | 5       | 7     | 2.18E-01                     | 4455.03        | 9       | 7     | 4.1E-02                      |
| 3983.96        | 9       | 7     | 5.72E-02                     | 4158.79        | 3       | 5     | 1.6E-01                      | 4466.55        | 5       | 7     | 1.20E-01                     |
| 3985.39        | 5       | 5     | 8.53E-02                     | 4170.90        | 5       | 5     | 6.29E-02                     | 4469.38        | 5       | 7     | 1.59E-01                     |
| 3989.86        | 5       | 7     | 5.3E-02                      | 4172.12        | 7       | 5     | 9.80E-02                     | 4476.02        | 3       | 5     | 1.01E-01                     |
| 3996.96        | 9       | 9     | 7.95E-02                     | 4172.64        | 11      | 11    | 2.24E-02                     | 4484.22        | 7       | 9     | 5.04E-02                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 4485.68        | 3       | 3     | 1.1E-01                      | 5364.87        | 5       | 7     | 5.59E-01                     | 22473.28       | 11      | 11    | 3.32E-02                     |
| 4494.56        | 5       | 7     | 3.45E-02                     | 5367.47        | 7       | 9     | 7.13E-01                     | 23566.67       | 9       | 11    | 2.21E-02                     |
| 4528.61        | 7       | 9     | 5.44E-02                     | 5369.96        | 9       | 11    | 7.22E-01                     | 24547.95       | 11      | 9     | 3.72E-02                     |
| 4547.85        | 5       | 7     | 4.48E-02                     | 5373.71        | 7       | 9     | 3.7E-02                      | 24729.10       | 13      | 11    | 5.08E-02                     |
| 4556.13        | 7       | 5     | 1.05E-01                     | 5383.37        | 11      | 13    | 7.81E-01                     | <i>Fe II</i>   |         |       |                              |
| 4619.29        | 7       | 5     | 5.2E-02                      | 5393.17        | 7       | 9     | 4.91E-02                     | 1055.26        | 10      | 8     | 4.6E-01                      |
| 4638.01        | 7       | 7     | 3.37E-02                     | 5398.28        | 5       | 5     | 9.0E-02                      | 1063.97        | 10      | 8     | 3.5E-01                      |
| 4654.61        | 7       | 7     | 3.68E-02                     | 5404.15        | 9       | 11    | 6.92E-01                     | 1068.35        | 8       | 8     | 1.59E+00                     |
| 4667.45        | 7       | 9     | 6.03E-02                     | 5410.91        | 7       | 9     | 6.33E-01                     | 1071.58        | 6       | 8     | 1.14E+00                     |
| 4673.16        | 5       | 7     | 3.81E-02                     | 5415.20        | 11      | 13    | 7.67E-01                     | 1096.88        | 10      | 8     | 2.26E+00                     |
| 4678.85        | 7       | 9     | 4.97E-02                     | 5463.28        | 9       | 9     | 2.9E-01                      | 1112.05        | 10      | 12    | 2.0E-01                      |
| 4736.77        | 9       | 11    | 4.78E-02                     | 5473.90        | 7       | 7     | 5.2E-02                      | 1121.97        | 10      | 8     | 1.92E+00                     |
| 4789.65        | 5       | 7     | 4.57E-02                     | 5476.29        | 7       | 9     | 2.87E-02                     | 1122.84        | 8       | 6     | 1.81E+00                     |
| 4800.65        | 7       | 9     | 3.01E-02                     | 5476.56        | 9       | 9     | 8.70E-02                     | 1125.45        | 10      | 8     | 1.03E+00                     |
| 4859.74        | 5       | 3     | 1.62E-01                     | 5563.60        | 5       | 7     | 3.4E-02                      | 1127.10        | 10      | 10    | 5.9E-02                      |
| 4871.32        | 7       | 5     | 2.44E-01                     | 5569.62        | 5       | 3     | 2.34E-01                     | 1128.05        | 2       | 4     | 1.40E+00                     |
| 4872.14        | 3       | 3     | 2.54E-01                     | 5572.84        | 7       | 5     | 2.28E-01                     | 1130.44        | 6       | 8     | 3.1E-01                      |
| 4878.21        | 1       | 3     | 1.21E-01                     | 5576.09        | 3       | 1     | 2.5E-01                      | 1133.40        | 8       | 10    | 2.6E-01                      |
| 4890.76        | 5       | 5     | 2.25E-01                     | 5586.76        | 9       | 7     | 2.19E-01                     | 1133.67        | 10      | 8     | 3.1E-01                      |
| 4891.49        | 9       | 7     | 3.08E-01                     | 5594.66        | 9       | 9     | 5.20E-02                     | 1138.63        | 8       | 8     | 5.5E-01                      |
| 4903.31        | 3       | 5     | 6.58E-02                     | 5602.95        | 3       | 3     | 1.00E-01                     | 1142.37        | 10      | 8     | 2.6E-01                      |
| 4918.99        | 7       | 7     | 1.79E-01                     | 5615.64        | 11      | 9     | 2.64E-01                     | 1143.23        | 10      | 10    | 9.8E-01                      |
| 4920.50        | 11      | 9     | 3.58E-01                     | 5624.54        | 5       | 5     | 7.41E-02                     | 1144.94        | 10      | 12    | 3.52E+00                     |
| 4957.30        | 9       | 9     | 1.18E-01                     | 5633.95        | 11      | 13    | 7.7E-02                      | 1147.41        | 8       | 8     | 1.24E+00                     |
| 4957.60        | 13      | 11    | 4.22E-01                     | 5638.26        | 9       | 7     | 4.4E-02                      | 1148.28        | 8       | 10    | 3.35E+00                     |
| 4966.09        | 11      | 11    | 3.31E-02                     | 5649.99        | 3       | 5     | 5.1E-02                      | 1151.15        | 6       | 8     | 2.23E+00                     |
| 4973.10        | 3       | 3     | 1.1E-01                      | 5655.18        | 7       | 9     | 4.7E-02                      | 1267.42        | 8       | 6     | 9.3E-01                      |
| 4978.60        | 5       | 3     | 1.19E-01                     | 5658.82        | 7       | 7     | 4.34E-02                     | 1272.61        | 6       | 4     | 3.3E-01                      |
| 4985.25        | 5       | 5     | 1.48E-01                     | 5662.52        | 11      | 9     | 6.18E-02                     | 1272.65        | 6       | 4     | 2.2E-01                      |
| 4988.95        | 7       | 7     | 5.2E-02                      | 5679.02        | 5       | 7     | 3.7E-02                      | 1371.02        | 14      | 12    | 1.74E+00                     |
| 5001.86        | 9       | 7     | 3.7E-01                      | 5686.53        | 9       | 11    | 6.71E-02                     | 1563.79        | 8       | 8     | 1.33E+00                     |
| 5006.12        | 11      | 11    | 5.87E-02                     | 5705.99        | 7       | 9     | 6.1E-02                      | 1580.63        | 8       | 10    | 5.8E-01                      |
| 5014.94        | 7       | 5     | 2.64E-01                     | 5753.12        | 3       | 5     | 8.26E-02                     | 1588.69        | 10      | 8     | 4.9E-03                      |
| 5021.59        | 7       | 9     | 6.18E-02                     | 5762.99        | 5       | 7     | 9.6E-02                      | 1608.45        | 10      | 8     | 1.91E+00                     |
| 5022.24        | 5       | 3     | 2.4E-01                      | 5816.37        | 9       | 11    | 4.49E-02                     | 1608.54        | 10      | 8     | 2.1E-02                      |
| 5048.44        | 3       | 5     | 4.88E-02                     | 5905.67        | 5       | 3     | 1.1E-01                      | 1610.92        | 10      | 10    | 1.94E-01                     |
| 5068.77        | 9       | 7     | 3.37E-02                     | 6301.50        | 5       | 5     | 6.43E-02                     | 1611.20        | 10      | 8     | 4.40E-02                     |
| 5074.75        | 9       | 11    | 1.4E-01                      | 6400.00        | 7       | 9     | 9.27E-02                     | 1618.47        | 8       | 8     | 5.53E-01                     |
| 5090.77        | 7       | 5     | 1.9E-01                      | 6411.65        | 5       | 7     | 4.43E-02                     | 1621.25        | 8       | 8     | 1.3E-02                      |
| 5121.64        | 5       | 5     | 7.9E-02                      | 6419.95        | 7       | 7     | 1.2E-01                      | 1621.69        | 8       | 6     | 1.32E+00                     |
| 5137.38        | 11      | 9     | 1.0E-01                      | 6469.19        | 3       | 3     | 8.3E-02                      | 1623.09        | 8       | 8     | 1.99E-01                     |
| 5139.25        | 7       | 5     | 9.16E-02                     | 6496.47        | 5       | 5     | 7.8E-02                      | 1625.52        | 8       | 10    | 4.04E-01                     |
| 5139.46        | 9       | 9     | 8.69E-02                     | 6569.22        | 7       | 9     | 6.0E-02                      | 1625.91        | 6       | 8     | 1.02E-01                     |
| 5184.27        | 5       | 7     | 3.8E-02                      | 6633.75        | 7       | 7     | 3.44E-02                     | 1629.16        | 6       | 6     | 8.66E-01                     |
| 5191.46        | 5       | 3     | 2.32E-01                     | 6841.34        | 5       | 7     | 3.4E-02                      | 1631.13        | 6       | 4     | 6.93E-01                     |
| 5192.34        | 7       | 7     | 1.34E-01                     | 6855.16        | 7       | 9     | 2.86E-02                     | 1633.91        | 6       | 8     | 3.85E-01                     |
| 5208.59        | 7       | 5     | 6.23E-02                     | 7187.32        | 9       | 11    | 8.36E-02                     | 1634.35        | 4       | 6     | 3.21E-01                     |
| 5215.18        | 5       | 3     | 1.10E-01                     | 7511.02        | 11      | 11    | 1.35E-01                     | 1635.40        | 8       | 6     | 2.28E+00                     |
| 5226.86        | 5       | 5     | 1.36E-01                     | 8220.38        | 13      | 11    | 1.69E-01                     | 1636.33        | 4       | 4     | 9.63E-01                     |
| 5232.94        | 9       | 11    | 1.94E-01                     | 8699.45        | 7       | 9     | 4.08E-02                     | 1637.40        | 10      | 8     | 3.57E-01                     |
| 5235.39        | 9       | 7     | 3.75E-02                     | 9012.07        | 11      | 9     | 4.46E-02                     | 1639.40        | 2       | 4     | 6.85E-01                     |
| 5242.49        | 13      | 11    | 2.38E-02                     | 9401.11        | 9       | 11    | 2.64E-02                     | 1641.76        | 6       | 4     | 1.76E+00                     |
| 5263.31        | 5       | 5     | 6.36E-02                     | 9414.04        | 7       | 9     | 3.98E-02                     | 1647.16        | 6       | 6     | 4.98E-01                     |
| 5266.56        | 7       | 9     | 1.10E-01                     | 9443.80        | 5       | 7     | 6.39E-02                     | 1661.32        | 10      | 8     | 1.2E-02                      |
| 5273.16        | 1       | 3     | 8.12E-02                     | 9569.91        | 11      | 11    | 2.50E-02                     | 1663.70        | 6       | 8     | 9.9E-03                      |
| 5281.79        | 5       | 7     | 5.00E-02                     | 9626.50        | 9       | 9     | 4.51E-02                     | 1670.75        | 10      | 8     | 1.06E+00                     |
| 5283.62        | 7       | 7     | 1.02E-01                     | 9738.57        | 11      | 13    | 7.64E-02                     | 1676.86        | 8       | 8     | 6.75E-02                     |
| 5302.30        | 3       | 5     | 9.04E-02                     | 9763.38        | 3       | 5     | 5.42E-02                     | 1688.40        | 6       | 8     | 2.53E-02                     |
| 5324.18        | 9       | 9     | 2.06E-01                     | 9861.74        | 7       | 9     | 5.49E-02                     | 1702.04        | 10      | 12    | 1.02E+00                     |
| 5339.93        | 5       | 7     | 6.36E-02                     | 9889.04        | 9       | 11    | 2.22E-02                     |                |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 1761.37        | 8       | 8     | 1.42E+00                     | 2352.31        | 2       | 4     | 4.38E+00                     | 2412.01        | 6       | 8     | 1.66E-01                     |
| 1785.27        | 6       | 8     | 1.2E+01                      | 2353.47        | 12      | 14    | 4.98E+00                     | 2413.31        | 2       | 4     | 1.02E+00                     |
| 1786.75        | 6       | 6     | 1.2E+01                      | 2353.68        | 8       | 8     | 1.30E+00                     | 2414.10        | 14      | 12    | 1.05E-02                     |
| 1788.08        | 6       | 4     | 4.6E+00                      | 2354.48        | 10      | 8     | 8.13E-01                     | 2414.51        | 10      | 8     | 4.2E-03                      |
| 1796.98        | 6       | 8     | 3.0E-03                      | 2354.89        | 6       | 4     | 2.67E-01                     | 2416.45        | 8       | 10    | 2.38E+00                     |
| 1818.52        | 8       | 8     | 5.70E-02                     | 2356.21        | 6       | 8     | 7.1E-03                      | 2417.87        | 12      | 12    | 9.5E-01                      |
| 1833.08        | 6       | 8     | 2.2E-02                      | 2359.11        | 4       | 6     | 5.0E-01                      | 2418.17        | 6       | 8     | 2.0E-02                      |
| 1863.11        | 6       | 8     | 2.4E-03                      | 2359.60        | 10      | 10    | 2.25E-01                     | 2418.44        | 6       | 8     | 2.28E+00                     |
| 2020.75        | 6       | 8     | 1.83E-01                     | 2360.00        | 10      | 10    | 3.59E-01                     | 2419.89        | 10      | 10    | 2.2E-02                      |
| 2057.33        | 6       | 8     | 2.80E-02                     | 2360.29        | 8       | 6     | 6.23E-01                     | 2422.69        | 6       | 8     | 1.46E+00                     |
| 2074.19        | 10      | 8     | 2.30E-02                     | 2360.53        | 6       | 8     | 2.22E-01                     | 2422.93        | 10      | 8     | 2.94E-02                     |
| 2078.16        | 10      | 10    | 2.84E-02                     | 2361.73        | 8       | 8     | 2.40E-01                     | 2423.21        | 4       | 6     | 1.40E+00                     |
| 2097.02        | 8       | 8     | 1.07E-02                     | 2362.02        | 8       | 8     | 1.41E-01                     | 2424.15        | 10      | 12    | 2.21E+00                     |
| 2122.45        | 10      | 8     | 4.8E-03                      | 2363.86        | 8       | 10    | 5.3E+00                      | 2424.39        | 6       | 8     | 1.61E-01                     |
| 2146.37        | 8       | 8     | 7.1E-03                      | 2364.83        | 8       | 8     | 5.90E-01                     | 2424.50        | 8       | 8     | 2.9E-03                      |
| 2162.02        | 10      | 10    | 2.54E-01                     | 2365.76        | 6       | 6     | 2.16E+00                     | 2424.59        | 6       | 6     | 1.24E+00                     |
| 2182.36        | 10      | 8     | 8.6E-02                      | 2366.59        | 6       | 6     | 1.01E-01                     | 2424.65        | 8       | 8     | 6.55E-02                     |
| 2187.68        | 8       | 8     | 2.87E-02                     | 2366.88        | 8       | 10    | 3.51E-02                     | 2428.08        | 12      | 10    | 7.0E-03                      |
| 2189.03        | 10      | 10    | 1.97E-02                     | 2368.60        | 6       | 4     | 6.06E-01                     | 2428.36        | 8       | 10    | 2.68E+00                     |
| 2191.98        | 8       | 8     | 7.54E-01                     | 2369.95        | 10      | 12    | 5.9E+00                      | 2428.80        | 4       | 4     | 1.38E+00                     |
| 2201.59        | 6       | 8     | 7.77E-01                     | 2370.50        | 4       | 4     | 1.73E-01                     | 2429.04        | 2       | 4     | 1.23E+00                     |
| 2208.41        | 10      | 10    | 1.59E+00                     | 2372.36        | 10      | 8     | 6.6E-03                      | 2429.39        | 4       | 4     | 6.9E-01                      |
| 2209.03        | 10      | 8     | 1.27E+00                     | 2373.74        | 10      | 10    | 4.25E-01                     | 2429.86        | 8       | 8     | 1.51E+00                     |
| 2213.66        | 14      | 14    | 3.26E-01                     | 2375.19        | 4       | 2     | 9.81E-01                     | 2430.08        | 8       | 10    | 1.91E+00                     |
| 2218.26        | 8       | 10    | 1.57E+00                     | 2376.43        | 12      | 14    | 6.4E+00                      | 2432.26        | 6       | 8     | 1.57E+00                     |
| 2220.38        | 12      | 12    | 4.19E-01                     | 2378.55        | 8       | 8     | 1.70E-01                     | 2432.87        | 14      | 14    | 2.86E+00                     |
| 2228.73        | 6       | 8     | 1.59E+00                     | 2378.70        | 8       | 8     | 1.49E-01                     | 2433.50        | 10      | 12    | 1.30E-01                     |
| 2249.18        | 10      | 8     | 3.00E-02                     | 2379.28        | 8       | 8     | 2.73E-01                     | 2434.06        | 8       | 6     | 7.2E-01                      |
| 2250.18        | 4       | 4     | 1.67E-02                     | 2379.42        | 10      | 10    | 3.68E-01                     | 2434.24        | 8       | 10    | 2.01E+00                     |
| 2250.94        | 6       | 6     | 3.19E-02                     | 2380.76        | 6       | 8     | 3.10E-01                     | 2434.73        | 12      | 12    | 2.79E+00                     |
| 2251.56        | 8       | 6     | 9.8E-03                      | 2382.04        | 10      | 12    | 3.13E+00                     | 2434.95        | 4       | 6     | 1.39E+00                     |
| 2253.13        | 8       | 8     | 4.41E-02                     | 2382.36        | 4       | 6     | 3.19E-02                     | 2435.00        | 8       | 8     | 2.02E+00                     |
| 2254.41        | 4       | 2     | 5.5E-03                      | 2382.90        | 12      | 14    | 1.62E-01                     | 2436.62        | 6       | 8     | 2.70E+00                     |
| 2255.77        | 6       | 4     | 4.75E-01                     | 2383.06        | 8       | 6     | 1.0E-01                      | 2439.30        | 12      | 14    | 2.25E+00                     |
| 2260.08        | 10      | 10    | 3.18E-02                     | 2383.24        | 6       | 6     | 3.59E-01                     | 2440.42        | 6       | 8     | 1.18E+00                     |
| 2260.24        | 2       | 2     | 3.4E-02                      | 2384.39        | 4       | 4     | 3.22E-01                     | 2441.13        | 10      | 10    | 8.95E-01                     |
| 2260.86        | 4       | 6     | 2.16E-02                     | 2385.01        | 6       | 8     | 3.60E-02                     | 2442.38        | 10      | 12    | 2.75E+00                     |
| 2262.69        | 4       | 4     | 1.98E-02                     | 2388.39        | 10      | 12    | 2.02E-01                     | 2443.71        | 8       | 10    | 1.44E+00                     |
| 2266.00        | 6       | 6     | 1.0E-02                      | 2388.63        | 8       | 8     | 1.05E+00                     | 2444.52        | 6       | 8     | 2.78E+00                     |
| 2267.59        | 6       | 8     | 3.69E-02                     | 2390.10        | 14      | 16    | 5.5E+00                      | 2445.11        | 12      | 12    | 2.03E+00                     |
| 2268.56        | 2       | 4     | 6.0E-03                      | 2390.76        | 6       | 6     | 1.17E+00                     | 2445.57        | 4       | 6     | 2.07E+00                     |
| 2268.82        | 8       | 8     | 3.97E-03                     | 2391.48        | 8       | 10    | 3.77E-02                     | 2445.80        | 4       | 6     | 1.23E+00                     |
| 2279.92        | 8       | 10    | 4.49E-02                     | 2394.00        | 12      | 10    | 9.4E-02                      | 2446.11        | 8       | 8     | 1.06E+00                     |
| 2292.42        | 12      | 10    | 8.42E-03                     | 2395.42        | 6       | 4     | 2.67E-01                     | 2446.47        | 12      | 14    | 2.99E-01                     |
| 2296.88        | 6       | 8     | 1.82E-02                     | 2395.63        | 8       | 10    | 2.59E+00                     | 2447.21        | 6       | 6     | 1.15E+00                     |
| 2312.22        | 10      | 8     | 9.3E-03                      | 2396.72        | 10      | 12    | 2.15E-01                     | 2447.33        | 4       | 2     | 2.56E+00                     |
| 2327.40        | 6       | 4     | 6.55E-01                     | 2399.24        | 6       | 6     | 1.39E+00                     | 2447.76        | 12      | 10    | 1.97E+00                     |
| 2327.88        | 10      | 12    | 1.08E+00                     | 2400.05        | 12      | 14    | 4.57E+00                     | 2449.96        | 4       | 4     | 1.24E+00                     |
| 2331.31        | 10      | 8     | 3.17E-01                     | 2401.29        | 6       | 8     | 1.89E+00                     | 2450.21        | 2       | 4     | 1.26E+00                     |
| 2332.80        | 8       | 6     | 1.31E+00                     | 2402.45        | 10      | 10    | 5.8E-01                      | 2453.98        | 8       | 10    | 1.31E+00                     |
| 2338.01        | 4       | 4     | 1.13E+00                     | 2402.60        | 6       | 8     | 2.17E-02                     | 2454.58        | 14      | 12    | 1.16E+00                     |
| 2338.54        | 10      | 12    | 5.6E-02                      | 2402.63        | 8       | 8     | 8.19E-01                     | 2455.71        | 8       | 8     | 1.01E+00                     |
| 2343.50        | 10      | 8     | 1.73E+00                     | 2404.43        | 4       | 2     | 6.44E-01                     | 2455.90        | 4       | 6     | 1.73E+00                     |
| 2343.96        | 8       | 6     | 3.13E-01                     | 2404.89        | 6       | 8     | 1.96E+00                     | 2457.10        | 6       | 4     | 4.71E-01                     |
| 2344.28        | 2       | 4     | 9.27E-01                     | 2406.09        | 6       | 8     | 2.05E-02                     | 2458.78        | 10      | 12    | 2.31E+00                     |
| 2345.34        | 14      | 12    | 7.3E-01                      | 2406.66        | 4       | 4     | 1.61E+00                     | 2458.97        | 6       | 4     | 2.51E+00                     |
| 2348.12        | 10      | 8     | 6.50E-01                     | 2410.27        | 8       | 8     | 7.65E-01                     | 2460.44        | 10      | 12    | 5.39E+00                     |
| 2348.30        | 6       | 6     | 1.15E+00                     | 2410.52        | 4       | 6     | 1.55E+00                     | 2461.28        | 6       | 8     | 2.34E+00                     |
| 2351.20        | 12      | 10    | 7.19E-01                     | 2411.07        | 2       | 2     | 2.37E+00                     | 2461.86        | 8       | 10    | 2.43E+00                     |
| 2351.67        | 6       | 6     | 1.80E+00                     | 2411.81        | 10      | 12    | 4.33E+00                     | 2463.28        | 12      | 10    | 7.1E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 2464.01        | 10      | 8     | 1.32E+00                     | 2525.92        | 8       | 8     | 7.4E-01                      | 2559.93        | 6       | 8     | 2.47E-01                     |
| 2464.91        | 6       | 4     | 2.22E+00                     | 2526.08        | 10      | 8     | 3.52E-01                     | 2560.28        | 4       | 4     | 1.77E+00                     |
| 2465.91        | 8       | 6     | 1.62E+00                     | 2526.29        | 6       | 6     | 2.47E+00                     | 2561.59        | 10      | 10    | 1.1E-02                      |
| 2466.50        | 2       | 4     | 2.40E+00                     | 2527.10        | 12      | 10    | 3.67E-01                     | 2562.09        | 4       | 2     | 1.62E+00                     |
| 2466.67        | 4       | 2     | 2.64E+00                     | 2527.71        | 10      | 8     | 9.1E-01                      | 2562.54        | 8       | 6     | 1.79E+00                     |
| 2466.82        | 6       | 4     | 1.77E+00                     | 2528.68        | 10      | 8     | 2.3E-02                      | 2563.48        | 6       | 4     | 1.51E+00                     |
| 2468.30        | 10      | 10    | 9.8E-02                      | 2529.08        | 4       | 6     | 1.80E+00                     | 2566.22        | 8       | 10    | 2.61E+00                     |
| 2469.37        | 10      | 8     | 2.23E-02                     | 2529.23        | 12      | 10    | 3.27E-01                     | 2566.40        | 8       | 6     | 2.29E+00                     |
| 2469.52        | 8       | 6     | 2.58E+00                     | 2529.55        | 10      | 10    | 2.20E+00                     | 2566.62        | 10      | 12    | 7.1E-02                      |
| 2470.41        | 6       | 6     | 6.0E-01                      | 2530.10        | 4       | 6     | 6.6E-01                      | 2566.91        | 4       | 2     | 1.15E+00                     |
| 2470.67        | 8       | 6     | 1.54E+00                     | 2533.63        | 12      | 12    | 1.92E+00                     | 2568.41        | 2       | 4     | 4.77E-01                     |
| 2470.85        | 8       | 8     | 5.4E-03                      | 2534.42        | 8       | 8     | 1.83E+00                     | 2568.89        | 8       | 8     | 2.8E-02                      |
| 2471.28        | 10      | 8     | 4.15E-01                     | 2535.36        | 6       | 4     | 2.46E+00                     | 2569.78        | 2       | 4     | 1.11E+00                     |
| 2472.61        | 8       | 10    | 3.22E+00                     | 2535.49        | 10      | 8     | 7.47E-01                     | 2570.55        | 6       | 8     | 1.1E-03                      |
| 2473.32        | 2       | 2     | 2.74E+00                     | 2536.67        | 12      | 12    | 5.7E-01                      | 2570.85        | 8       | 6     | 1.84E+00                     |
| 2475.12        | 4       | 6     | 3.72E+00                     | 2536.81        | 10      | 10    | 1.69E+00                     | 2571.55        | 10      | 10    | 2.89E-02                     |
| 2475.54        | 6       | 8     | 3.18E+00                     | 2536.84        | 12      | 14    | 6.8E-01                      | 2572.97        | 6       | 8     | 7.89E-02                     |
| 2476.27        | 8       | 10    | 9.7E-02                      | 2537.14        | 10      | 10    | 1.44E+00                     | 2573.21        | 8       | 10    | 1.42E-01                     |
| 2477.35        | 8       | 8     | 1.70E-01                     | 2538.21        | 14      | 12    | 1.26E+00                     | 2573.76        | 8       | 8     | 2.3E-02                      |
| 2478.57        | 6       | 6     | 9.1E-01                      | 2538.40        | 6       | 8     | 3.7E-02                      | 2574.37        | 6       | 4     | 2.43E+00                     |
| 2480.16        | 10      | 8     | 1.55E+00                     | 2538.50        | 8       | 6     | 5.9E-01                      | 2576.86        | 10      | 12    | 1.32E+00                     |
| 2481.05        | 12      | 12    | 1.46E-01                     | 2538.68        | 6       | 8     | 7.4E-01                      | 2577.43        | 6       | 8     | 7.8E-03                      |
| 2482.12        | 14      | 14    | 6.5E-01                      | 2538.91        | 10      | 8     | 1.28E+00                     | 2577.92        | 2       | 2     | 1.24E+00                     |
| 2482.33        | 4       | 4     | 2.23E+00                     | 2538.99        | 14      | 12    | 1.93E+00                     | 2580.72        | 8       | 6     | 2.2E-02                      |
| 2482.66        | 12      | 10    | 1.25E+00                     | 2539.81        | 8       | 8     | 5.6E-02                      | 2581.11        | 6       | 6     | 7.61E-02                     |
| 2482.87        | 6       | 4     | 1.69E+00                     | 2540.52        | 2       | 2     | 1.26E+00                     | 2582.41        | 6       | 8     | 2.22E-01                     |
| 2483.72        | 8       | 10    | 5.4E-01                      | 2540.66        | 6       | 8     | 1.70E+00                     | 2582.58        | 4       | 4     | 8.80E-01                     |
| 2484.24        | 4       | 6     | 8.3E-02                      | 2541.10        | 8       | 6     | 9.6E-01                      | 2583.05        | 8       | 10    | 2.16E-02                     |
| 2484.44        | 8       | 8     | 2.16E+00                     | 2541.84        | 8       | 6     | 8.2E-01                      | 2583.35        | 8       | 10    | 9.0E-03                      |
| 2489.11        | 4       | 4     | 2.6E-02                      | 2542.32        | 4       | 2     | 3.9E-03                      | 2585.62        | 10      | 10    | 3.09E-01                     |
| 2489.48        | 12      | 12    | 5.1E-01                      | 2542.74        | 2       | 2     | 1.61E+00                     | 2585.88        | 10      | 8     | 8.94E-01                     |
| 2489.83        | 12      | 12    | 1.94E+00                     | 2543.38        | 10      | 12    | 6.7E-01                      | 2586.06        | 6       | 4     | 5.8E-02                      |
| 2490.71        | 10      | 12    | 1.44E+00                     | 2543.43        | 6       | 4     | 8.3E-01                      | 2587.95        | 8       | 10    | 1.69E+00                     |
| 2490.86        | 8       | 8     | 8.8E-01                      | 2544.97        | 4       | 6     | 3.93E-01                     | 2588.19        | 2       | 2     | 1.5E-01                      |
| 2491.40        | 10      | 8     | 1.01E+00                     | 2545.22        | 8       | 10    | 5.3E-01                      | 2588.80        | 8       | 8     | 8.4E-02                      |
| 2492.34        | 10      | 12    | 2.30E-01                     | 2545.44        | 8       | 10    | 1.52E-01                     | 2590.55        | 4       | 6     | 7.9E-02                      |
| 2493.26        | 14      | 16    | 3.04E+00                     | 2545.53        | 8       | 10    | 1.2E-02                      | 2591.54        | 6       | 6     | 5.72E-01                     |
| 2493.88        | 6       | 6     | 1.74E+00                     | 2546.67        | 8       | 8     | 7.98E-01                     | 2592.79        | 14      | 16    | 2.74E+00                     |
| 2494.12        | 12      | 10    | 2.97E-02                     | 2547.34        | 8       | 8     | 2.28E-01                     | 2593.73        | 2       | 4     | 1.63E-01                     |
| 2497.68        | 10      | 12    | 8.4E-03                      | 2548.16        | 6       | 8     | 8.0E-03                      | 2594.96        | 8       | 8     | 1.0E-01                      |
| 2497.82        | 6       | 6     | 1.68E+00                     | 2548.32        | 4       | 6     | 2.69E-01                     | 2595.28        | 12      | 10    | 1.67E-03                     |
| 2500.92        | 6       | 8     | 2.41E+00                     | 2548.59        | 10      | 10    | 2.67E-01                     | 2595.30        | 10      | 8     | 1.2E-02                      |
| 2501.35        | 2       | 2     | 1.48E+00                     | 2548.74        | 4       | 2     | 2.43E+00                     | 2598.37        | 8       | 6     | 1.43E+00                     |
| 2502.39        | 8       | 8     | 1.43E+00                     | 2548.92        | 12      | 10    | 6.0E-01                      | 2599.40        | 10      | 10    | 2.35E+00                     |
| 2503.33        | 12      | 12    | 7.3E-01                      | 2549.08        | 10      | 8     | 1.89E+00                     | 2604.05        | 8       | 8     | 1.49E-01                     |
| 2503.54        | 8       | 8     | 3.32E-01                     | 2549.40        | 4       | 4     | 1.65E+00                     | 2604.67        | 8       | 10    | 1.2E-02                      |
| 2503.57        | 10      | 10    | 2.53E-01                     | 2549.46        | 6       | 6     | 1.12E+00                     | 2605.04        | 6       | 8     | 2.34E+00                     |
| 2503.88        | 10      | 10    | 2.23E+00                     | 2549.77        | 8       | 6     | 2.35E-01                     | 2605.31        | 4       | 4     | 1.99E+00                     |
| 2506.09        | 10      | 10    | 9.9E-01                      | 2550.03        | 10      | 10    | 1.74E+00                     | 2605.43        | 6       | 6     | 3.40E-01                     |
| 2506.80        | 8       | 10    | 1.98E+00                     | 2550.15        | 8       | 10    | 3.91E-01                     | 2605.90        | 4       | 2     | 1.27E+00                     |
| 2508.34        | 8       | 10    | 3.79E-01                     | 2550.57        | 12      | 12    | 1.6E-02                      | 2606.52        | 6       | 6     | 2.31E+00                     |
| 2510.57        | 8       | 8     | 1.54E-01                     | 2550.68        | 12      | 12    | 1.07E+00                     | 2607.09        | 6       | 4     | 1.73E+00                     |
| 2511.76        | 8       | 10    | 2.30E+00                     | 2551.20        | 10      | 8     | 2.48E-01                     | 2608.85        | 10      | 8     | 5.0E-02                      |
| 2513.15        | 10      | 8     | 2.49E-01                     | 2554.94        | 8       | 8     | 2.6E-02                      | 2609.13        | 8       | 10    | 2.77E-01                     |
| 2514.38        | 8       | 8     | 2.11E+00                     | 2555.07        | 6       | 8     | 1.96E-01                     | 2609.44        | 6       | 8     | 6.0E-02                      |
| 2517.14        | 2       | 4     | 9.2E-01                      | 2555.45        | 4       | 6     | 2.49E-01                     | 2609.87        | 8       | 8     | 1.34E-01                     |
| 2519.05        | 8       | 6     | 2.10E+00                     | 2557.08        | 8       | 10    | 2.8E-02                      | 2611.07        | 4       | 6     | 7.28E-02                     |
| 2521.09        | 6       | 4     | 2.05E+00                     | 2557.51        | 10      | 8     | 1.53E-01                     | 2611.34        | 8       | 6     | 1.4E-02                      |
| 2521.82        | 8       | 8     | 2.36E+00                     | 2559.24        | 8       | 8     | 6.4E-02                      | 2611.87        | 8       | 8     | 1.20E+00                     |
| 2525.39        | 14      | 14    | 1.91E+00                     | 2559.77        | 6       | 8     | 2.42E-01                     | 2613.57        | 10      | 12    | 2.0E-02                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 2613.82        | 4       | 2     | 2.12E+00                     | 2699.20        | 4       | 4     | 6.2E-01                      | 2770.50        | 12      | 10    | 4.08E-02                     |
| 2614.19        | 8       | 10    | 3.3E-02                      | 2703.99        | 8       | 8     | 1.38E+00                     | 2771.19        | 10      | 12    | 4.3E-02                      |
| 2614.59        | 10      | 8     | 3.37E-02                     | 2704.58        | 8       | 8     | 1.66E-02                     | 2771.56        | 6       | 4     | 1.9E-02                      |
| 2614.87        | 8       | 6     | 3.5E-02                      | 2707.13        | 4       | 6     | 8.3E-01                      | 2772.73        | 6       | 8     | 1.1E-03                      |
| 2617.62        | 6       | 6     | 4.88E-01                     | 2709.06        | 4       | 6     | 3.88E-01                     | 2774.69        | 2       | 4     | 2.73E-01                     |
| 2619.08        | 10      | 10    | 2.48E-01                     | 2709.38        | 6       | 4     | 2.78E-03                     | 2775.34        | 6       | 6     | 1.5E-04                      |
| 2620.17        | 6       | 6     | 1.1E-01                      | 2709.99        | 6       | 8     | 8.7E-03                      | 2776.18        | 6       | 8     | 2.66E-02                     |
| 2620.41        | 4       | 4     | 4.30E-02                     | 2711.84        | 12      | 14    | 4.36E-01                     | 2776.91        | 8       | 8     | 4.08E-01                     |
| 2620.70        | 8       | 8     | 3.43E-01                     | 2712.39        | 10      | 12    | 1.29E-01                     | 2779.30        | 10      | 8     | 1.00E+00                     |
| 2621.67        | 2       | 2     | 5.60E-01                     | 2714.41        | 8       | 6     | 5.70E-01                     | 2779.91        | 2       | 4     | 2.56E-01                     |
| 2623.13        | 14      | 14    | 8.8E-02                      | 2716.22        | 6       | 6     | 1.15E+00                     | 2780.05        | 2       | 2     | 3.3E-01                      |
| 2623.72        | 6       | 6     | 1.92E-01                     | 2716.44        | 6       | 6     | 2.8E-02                      | 2783.69        | 12      | 10    | 1.06E+00                     |
| 2625.49        | 12      | 14    | 2.55E+00                     | 2716.57        | 14      | 12    | 1.35E+00                     | 2784.28        | 2       | 4     | 3.4E-02                      |
| 2625.67        | 8       | 10    | 3.52E-01                     | 2716.70        | 8       | 8     | 1.02E-03                     | 2785.19        | 12      | 10    | 1.53E+00                     |
| 2626.50        | 4       | 6     | 3.48E-01                     | 2717.88        | 16      | 14    | 1.51E+00                     | 2787.24        | 8       | 6     | 1.83E-01                     |
| 2626.70        | 8       | 8     | 1.94E-02                     | 2718.64        | 10      | 8     | 1.18E+00                     | 2790.56        | 8       | 10    | 2.1E-02                      |
| 2628.29        | 2       | 4     | 8.74E-01                     | 2719.30        | 6       | 8     | 4.44E-01                     | 2793.89        | 10      | 12    | 1.26E-01                     |
| 2628.58        | 6       | 6     | 3.4E-02                      | 2721.81        | 12      | 10    | 5.1E-02                      | 2796.63        | 10      | 10    | 2.0E-01                      |
| 2629.59        | 6       | 8     | 7.2E-01                      | 2722.06        | 8       | 8     | 1.42E-01                     | 2797.92        | 10      | 10    | 3.2E-02                      |
| 2630.07        | 4       | 6     | 5.1E-01                      | 2722.74        | 6       | 8     | 8.2E-01                      | 2799.29        | 10      | 8     | 1.55E-01                     |
| 2631.05        | 4       | 6     | 8.16E-01                     | 2724.88        | 6       | 6     | 9.58E-02                     | 2799.72        | 10      | 10    | 5.0E-03                      |
| 2631.32        | 6       | 8     | 6.29E-01                     | 2726.52        | 6       | 8     | 5.0E-02                      | 2804.02        | 6       | 6     | 1.6E-02                      |
| 2631.61        | 10      | 12    | 6.6E-01                      | 2727.38        | 12      | 10    | 3.12E-01                     | 2805.32        | 4       | 6     | 2.5E-02                      |
| 2633.20        | 6       | 4     | 1.21E+00                     | 2727.54        | 6       | 4     | 9.38E-01                     | 2805.79        | 8       | 8     | 3.22E-02                     |
| 2636.70        | 4       | 4     | 8.8E-02                      | 2728.91        | 8       | 10    | 1.25E-01                     | 2809.78        | 8       | 8     | 3.10E-01                     |
| 2637.50        | 6       | 6     | 6.2E-01                      | 2730.73        | 4       | 4     | 2.79E-01                     | 2811.27        | 12      | 10    | 1.2E-02                      |
| 2637.64        | 2       | 4     | 6.6E-01                      | 2732.01        | 10      | 8     | 7.05E-02                     | 2812.49        | 4       | 4     | 2.9E-02                      |
| 2639.57        | 2       | 2     | 8.0E-01                      | 2732.45        | 10      | 10    | 9.8E-04                      | 2813.61        | 8       | 10    | 3.40E-02                     |
| 2641.12        | 4       | 4     | 3.7E-02                      | 2732.94        | 8       | 6     | 9.5E-01                      | 2817.09        | 6       | 4     | 3.37E-01                     |
| 2642.01        | 6       | 6     | 2.29E-01                     | 2736.49        | 2       | 4     | 1.5E-02                      | 2819.34        | 12      | 12    | 9.7E-03                      |
| 2646.21        | 12      | 10    | 1.44E-02                     | 2736.97        | 4       | 2     | 1.22E+00                     | 2826.03        | 8       | 6     | 4.5E-02                      |
| 2649.47        | 6       | 8     | 1.98E+00                     | 2739.55        | 8       | 8     | 2.21E+00                     | 2827.43        | 12      | 14    | 2.4E-02                      |
| 2650.48        | 6       | 8     | 1.60E+00                     | 2741.39        | 6       | 6     | 2.03E-01                     | 2828.63        | 12      | 10    | 6.9E-02                      |
| 2651.30        | 12      | 12    | 4.0E-03                      | 2743.20        | 2       | 4     | 1.97E+00                     | 2831.56        | 4       | 6     | 7.6E-01                      |
| 2652.57        | 10      | 8     | 4.45E-02                     | 2744.90        | 6       | 8     | 3.62E-02                     | 2833.09        | 6       | 6     | 4.55E-01                     |
| 2654.63        | 4       | 4     | 8.1E-01                      | 2746.48        | 4       | 6     | 2.05E+00                     | 2835.71        | 4       | 6     | 5.1E-01                      |
| 2657.92        | 10      | 10    | 3.2E-02                      | 2746.98        | 6       | 6     | 1.69E+00                     | 2836.19        | 4       | 4     | 5.4E-02                      |
| 2658.25        | 8       | 8     | 2.12E-01                     | 2749.18        | 4       | 4     | 1.21E+00                     | 2836.51        | 2       | 4     | 9.8E-02                      |
| 2659.06        | 10      | 10    | 2.5E-03                      | 2749.32        | 6       | 8     | 2.16E+00                     | 2837.30        | 10      | 12    | 1.9E-02                      |
| 2662.56        | 2       | 2     | 1.33E+00                     | 2749.49        | 2       | 2     | 1.16E+00                     | 2838.22        | 4       | 2     | 8.6E-01                      |
| 2664.66        | 8       | 10    | 1.91E+00                     | 2750.01        | 10      | 10    | 1.8E-02                      | 2839.51        | 10      | 8     | 1.47E+00                     |
| 2666.64        | 6       | 8     | 1.87E+00                     | 2751.13        | 4       | 4     | 2.92E-01                     | 2839.80        | 8       | 10    | 5.8E-01                      |
| 2667.22        | 4       | 6     | 1.02E+00                     | 2752.15        | 4       | 4     | 7.7E-01                      | 2840.34        | 12      | 12    | 7.7E-02                      |
| 2669.93        | 2       | 4     | 5.2E-01                      | 2753.29        | 10      | 12    | 1.89E+00                     | 2840.65        | 2       | 4     | 7.6E-01                      |
| 2670.38        | 6       | 8     | 6.0E-02                      | 2754.89        | 8       | 6     | 1.21E+00                     | 2840.76        | 10      | 12    | 1.49E-01                     |
| 2671.39        | 2       | 4     | 6.5E-01                      | 2755.74        | 8       | 10    | 2.15E+00                     | 2841.36        | 10      | 10    | 4.3E-03                      |
| 2680.23        | 6       | 8     | 1.10E-01                     | 2756.51        | 6       | 8     | 7.3E-02                      | 2842.08        | 8       | 8     | 1.5E-02                      |
| 2682.51        | 8       | 10    | 9.2E-01                      | 2757.03        | 10      | 8     | 8.07E-02                     | 2843.32        | 10      | 10    | 1.40E-02                     |
| 2683.00        | 4       | 6     | 7.3E-01                      | 2759.33        | 8       | 8     | 2.7E-04                      | 2843.48        | 4       | 6     | 9.6E-02                      |
| 2684.75        | 8       | 10    | 1.57E+00                     | 2761.81        | 2       | 4     | 1.38E-01                     | 2844.96        | 2       | 2     | 5.5E-01                      |
| 2684.96        | 12      | 12    | 6.4E-03                      | 2762.33        | 6       | 6     | 6.0E-01                      | 2845.60        | 8       | 6     | 1.57E+00                     |
| 2686.11        | 6       | 6     | 9.4E-03                      | 2762.45        | 6       | 4     | 3.3E-02                      | 2847.21        | 8       | 6     | 1.7E-04                      |
| 2686.39        | 6       | 4     | 1.6E-02                      | 2763.66        | 14      | 12    | 1.34E+00                     | 2847.77        | 4       | 4     | 5.1E-01                      |
| 2691.74        | 10      | 8     | 5.04E-02                     | 2763.91        | 8       | 6     | 2.9E-02                      | 2848.11        | 6       | 6     | 9.9E-01                      |
| 2692.60        | 10      | 12    | 1.40E+00                     | 2764.79        | 12      | 12    | 1.1E-02                      | 2848.32        | 6       | 4     | 1.59E+00                     |
| 2692.83        | 8       | 6     | 1.64E-02                     | 2765.13        | 10      | 8     | 1.47E+00                     | 2848.91        | 12      | 10    | 5.3E-02                      |
| 2693.86        | 8       | 6     | 4.2E-02                      | 2767.50        | 12      | 14    | 1.58E+00                     | 2849.61        | 10      | 12    | 4.6E-02                      |
| 2697.33        | 4       | 4     | 2.48E-01                     | 2768.93        | 4       | 6     | 4.75E-02                     | 2852.87        | 2       | 4     | 1.65E-02                     |
| 2697.46        | 4       | 2     | 1.65E+00                     | 2769.15        | 8       | 10    | 6.6E-02                      | 2853.21        | 6       | 6     | 2.3E-02                      |
| 2697.73        | 10      | 8     | 2.6E-02                      | 2769.35        | 12      | 14    | 2.07E-01                     | 2855.67        | 8       | 10    | 9.2E-02                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 2856.15        | 10      | 10    | 5.0E-02                      | 2975.94        | 2       | 2     | 9.1E-03                      | 3210.44        | 2       | 4     | 3.63E-02                     |
| 2856.38        | 6       | 8     | 4.42E-01                     | 2978.85        | 10      | 10    | 7.2E-03                      | 3211.08        | 6       | 8     | 2.1E-03                      |
| 2856.91        | 8       | 8     | 1.32E+00                     | 2979.35        | 2       | 4     | 1.61E-02                     | 3213.31        | 4       | 6     | 6.12E-02                     |
| 2857.17        | 6       | 8     | 1.22E-01                     | 2980.96        | 6       | 8     | 1.1E-02                      | 3227.74        | 6       | 8     | 8.9E-02                      |
| 2857.42        | 6       | 6     | 2.0E-02                      | 2982.06        | 4       | 6     | 2.41E-01                     | 3231.71        | 6       | 8     | 1.4E-02                      |
| 2858.34        | 10      | 12    | 4.85E-01                     | 2984.82        | 6       | 6     | 4.29E-01                     | 3232.78        | 8       | 6     | 5.0E-02                      |
| 2861.17        | 4       | 4     | 1.7E-03                      | 2985.54        | 2       | 4     | 2.39E-01                     | 3237.40        | 4       | 4     | 1.8E-02                      |
| 2864.97        | 8       | 8     | 4.3E-02                      | 2997.30        | 6       | 8     | 8.6E-02                      | 3237.82        | 2       | 4     | 6.8E-02                      |
| 2868.87        | 6       | 6     | 7.3E-03                      | 2998.85        | 6       | 8     | 4.2E-03                      | 3241.69        | 8       | 8     | 1.9E-03                      |
| 2869.16        | 8       | 10    | 1.4E-02                      | 3000.06        | 8       | 6     | 3.0E-02                      | 3243.72        | 10      | 8     | 5.1E-02                      |
| 2869.31        | 4       | 6     | 4.04E-01                     | 3002.32        | 6       | 8     | 2.0E-02                      | 3247.17        | 4       | 6     | 7.1E-02                      |
| 2869.70        | 8       | 6     | 1.1E-02                      | 3002.65        | 4       | 6     | 1.79E-01                     | 3247.39        | 8       | 8     | 6.0E-03                      |
| 2870.61        | 8       | 10    | 7.5E-03                      | 3004.26        | 8       | 8     | 8.6E-03                      | 3255.89        | 8       | 8     | 2.78E-03                     |
| 2871.06        | 10      | 12    | 2.2E-02                      | 3020.01        | 12      | 10    | 6.4E-04                      | 3257.36        | 8       | 6     | 1.5E-03                      |
| 2871.13        | 12      | 10    | 3.0E-02                      | 3021.42        | 8       | 6     | 3.8E-03                      | 3258.77        | 6       | 8     | 9.39E-02                     |
| 2872.38        | 10      | 8     | 1.70E-01                     | 3036.96        | 6       | 6     | 2.22E-01                     | 3259.05        | 8       | 10    | 6.7E-02                      |
| 2873.40        | 8       | 10    | 4.56E-01                     | 3044.84        | 8       | 10    | 1.2E-02                      | 3266.94        | 10      | 10    | 4.5E-03                      |
| 2875.35        | 8       | 10    | 1.35E-01                     | 3048.99        | 4       | 4     | 3.84E-01                     | 3267.04        | 8       | 10    | 2.0E-04                      |
| 2876.80        | 8       | 8     | 9.56E-02                     | 3056.80        | 14      | 12    | 1.7E-02                      | 3268.51        | 8       | 6     | 6.8E-03                      |
| 2879.25        | 10      | 8     | 3.6E-02                      | 3062.24        | 12      | 10    | 1.36E-01                     | 3269.77        | 10      | 8     | 5.2E-03                      |
| 2880.76        | 8       | 8     | 2.21E-02                     | 3065.32        | 6       | 6     | 2.9E-02                      | 3273.49        | 8       | 8     | 8.5E-03                      |
| 2883.71        | 12      | 14    | 1.48E-01                     | 3070.69        | 10      | 8     | 1.28E-02                     | 3276.60        | 6       | 8     | 1.0E-02                      |
| 2884.76        | 6       | 8     | 2.46E-01                     | 3071.12        | 2       | 4     | 2.59E-01                     | 3277.35        | 8       | 10    | 3.31E-03                     |
| 2885.93        | 14      | 12    | 3.8E-02                      | 3076.44        | 4       | 6     | 3.75E-01                     | 3279.64        | 10      | 10    | 5.8E-03                      |
| 2886.24        | 12      | 10    | 6.9E-03                      | 3077.17        | 14      | 12    | 1.35E-01                     | 3281.29        | 6       | 6     | 2.31E-03                     |
| 2887.31        | 6       | 4     | 1.9E-02                      | 3078.68        | 6       | 8     | 5.5E-01                      | 3285.41        | 4       | 2     | 4.5E-04                      |
| 2888.10        | 4       | 6     | 6.1E-02                      | 3089.38        | 6       | 8     | 2.2E-02                      | 3289.35        | 8       | 8     | 2.1E-02                      |
| 2892.83        | 4       | 6     | 1.8E-03                      | 3096.29        | 8       | 8     | 1.9E-02                      | 3295.23        | 6       | 8     | 3.6E-03                      |
| 2894.78        | 10      | 12    | 5.7E-02                      | 3101.89        | 6       | 8     | 9.1E-03                      | 3295.82        | 4       | 4     | 2.04E-03                     |
| 2895.22        | 8       | 10    | 1.09E-01                     | 3105.17        | 4       | 2     | 7.5E-02                      | 3297.88        | 6       | 4     | 1.0E-02                      |
| 2897.27        | 6       | 4     | 1.8E-01                      | 3105.55        | 2       | 2     | 7.0E-02                      | 3302.86        | 6       | 8     | 2.78E-04                     |
| 2902.32        | 6       | 8     | 8.81E-03                     | 3106.57        | 8       | 8     | 1.88E-02                     | 3303.46        | 2       | 2     | 6.5E-04                      |
| 2902.46        | 10      | 10    | 3.2E-02                      | 3114.30        | 4       | 4     | 6.4E-02                      | 3304.43        | 6       | 8     | 2.0E-03                      |
| 2906.12        | 2       | 4     | 4.4E-02                      | 3114.69        | 2       | 4     | 2.5E-02                      | 3313.99        | 2       | 4     | 1.4E-04                      |
| 2907.86        | 8       | 6     | 1.3E-03                      | 3116.58        | 6       | 4     | 5.5E-02                      | 3323.06        | 8       | 10    | 1.4E-02                      |
| 2910.76        | 8       | 8     | 1.5E-02                      | 3129.01        | 8       | 10    | 2.3E-03                      | 3325.01        | 8       | 8     | 3.35E-03                     |
| 2916.15        | 8       | 8     | 4.8E-04                      | 3131.72        | 12      | 10    | 6.6E-03                      | 3360.11        | 12      | 12    | 2.1E-03                      |
| 2917.08        | 6       | 8     | 2.7E-02                      | 3133.05        | 4       | 6     | 1.5E-02                      | 3366.97        | 8       | 6     | 2.2E-02                      |
| 2917.47        | 6       | 8     | 1.4E-03                      | 3135.36        | 6       | 6     | 8.8E-02                      | 3381.01        | 6       | 4     | 3.0E-02                      |
| 2922.02        | 8       | 10    | 3.8E-02                      | 3144.75        | 8       | 6     | 2.7E-02                      | 3388.14        | 8       | 10    | 3.8E-04                      |
| 2926.59        | 8       | 10    | 5.1E-02                      | 3146.75        | 10      | 10    | 4.9E-06                      | 3395.33        | 8       | 8     | 3.66E-03                     |
| 2934.49        | 8       | 10    | 5.6E-03                      | 3154.20        | 10      | 10    | 2.06E-01                     | 3398.36        | 14      | 14    | 2.5E-03                      |
| 2939.51        | 6       | 4     | 4.0E-03                      | 3155.95        | 10      | 8     | 4.17E-03                     | 3416.02        | 4       | 2     | 2.6E-03                      |
| 2944.40        | 4       | 2     | 3.5E-01                      | 3162.80        | 8       | 8     | 5.5E-02                      | 3425.57        | 6       | 8     | 2.1E-04                      |
| 2945.26        | 6       | 6     | 5.6E-04                      | 3163.09        | 6       | 6     | 1.92E-03                     | 3436.11        | 8       | 6     | 5.7E-03                      |
| 2947.65        | 6       | 4     | 2.01E-01                     | 3166.67        | 6       | 4     | 1.4E-03                      | 3442.22        | 8       | 6     | 3.2E-03                      |
| 2949.18        | 10      | 8     | 2.45E-01                     | 3167.86        | 8       | 8     | 1.59E-01                     | 3453.62        | 8       | 10    | 8.5E-03                      |
| 2953.77        | 6       | 8     | 5.2E-02                      | 3170.34        | 4       | 2     | 8.2E-03                      | 3456.92        | 8       | 6     | 7.1E-03                      |
| 2954.05        | 8       | 8     | 1.2E-02                      | 3177.53        | 8       | 8     | 1.74E-01                     | 3463.96        | 6       | 6     | 7.6E-05                      |
| 2959.60        | 8       | 6     | 9.7E-02                      | 3179.50        | 6       | 8     | 1.11E-01                     | 3464.50        | 10      | 8     | 2.2E-03                      |
| 2959.84        | 8       | 6     | 1.36E-01                     | 3180.15        | 4       | 6     | 7.7E-02                      | 3468.68        | 8       | 8     | 2.0E-02                      |
| 2961.28        | 4       | 2     | 8.9E-03                      | 3183.11        | 4       | 6     | 9.80E-03                     | 3475.74        | 6       | 8     | 1.7E-04                      |
| 2964.13        | 8       | 6     | 4.6E-02                      | 3185.32        | 2       | 4     | 3.00E-03                     | 3487.99        | 4       | 6     | 1.7E-04                      |
| 2964.62        | 2       | 2     | 6.5E-02                      | 3186.74        | 4       | 4     | 3.85E-02                     | 3493.47        | 10      | 10    | 3.2E-02                      |
| 2965.03        | 4       | 4     | 9.43E-02                     | 3187.30        | 10      | 10    | 5.0E-02                      | 3494.67        | 4       | 6     | 7.1E-04                      |
| 2965.41        | 6       | 4     | 1.1E-02                      | 3192.07        | 8       | 10    | 5.2E-03                      | 3495.62        | 10      | 8     | 2.62E-03                     |
| 2968.74        | 8       | 10    | 2.4E-03                      | 3192.91        | 6       | 6     | 1.27E-02                     | 3499.88        | 8       | 8     | 4.29E-03                     |
| 2969.94        | 8       | 6     | 2.28E-01                     | 3193.80        | 2       | 2     | 5.4E-02                      | 3503.47        | 2       | 2     | 2.6E-04                      |
| 2970.52        | 4       | 6     | 2.70E-02                     | 3193.86        | 8       | 8     | 3.86E-02                     | 3507.40        | 2       | 4     | 4.1E-04                      |
| 2970.69        | 10      | 8     | 4.15E-02                     | 3196.07        | 6       | 8     | 1.61E-02                     | 3508.20        | 2       | 4     | 1.2E-04                      |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3614.88        | 8       | 8     | 4.2E-03                      | 4833.20        | 12      | 10    | 4.6E-06                      | 5965.62        | 10      | 10    | 2.19E-01                     |
| 3621.27        | 2       | 4     | 2.2E-02                      | 4840.00        | 10      | 8     | 4.0E-06                      | 5991.38        | 12      | 10    | 4.2E-05                      |
| 3624.89        | 2       | 2     | 2.4E-02                      | 4893.82        | 8       | 6     | 2.5E-05                      | 6084.11        | 10      | 8     | 3.0E-05                      |
| 3632.29        | 10      | 10    | 1.2E-03                      | 4923.93        | 6       | 4     | 4.28E-02                     | 6113.32        | 8       | 6     | 1.7E-05                      |
| 3711.98        | 4       | 6     | 1.5E-03                      | 4990.51        | 6       | 8     | 5.2E-01                      | 6129.70        | 10      | 10    | 3.2E-06                      |
| 3748.48        | 6       | 4     | 3.4E-02                      | 4993.36        | 10      | 8     | 6.9E-05                      | 6147.74        | 4       | 2     | 1.3E-03                      |
| 3759.46        | 4       | 2     | 3.2E-02                      | 5000.74        | 2       | 4     | 1.8E-05                      | 6149.26        | 2       | 2     | 1.3E-03                      |
| 3814.12        | 4       | 6     | 4.9E-03                      | 5001.96        | 12      | 14    | 1.57E+00                     | 6175.15        | 8       | 8     | 1.8E-03                      |
| 3824.93        | 6       | 6     | 3.2E-05                      | 5018.44        | 6       | 6     | 2.0E-02                      | 6179.38        | 8       | 6     | 4.6E-04                      |
| 3827.08        | 6       | 8     | 2.5E-03                      | 5030.63        | 10      | 10    | 7.1E-01                      | 6238.39        | 4       | 4     | 7.5E-04                      |
| 3906.04        | 6       | 8     | 1.1E-02                      | 5035.71        | 10      | 12    | 9.4E-01                      | 6239.95        | 2       | 4     | 1.1E-04                      |
| 3914.50        | 6       | 4     | 4.6E-05                      | 5100.66        | 10      | 8     | 2.0E-05                      | 6247.56        | 6       | 4     | 1.6E-03                      |
| 3935.96        | 8       | 10    | 8.3E-03                      | 5132.67        | 10      | 10    | 2.0E-05                      | 6305.30        | 10      | 10    | 1.4E-03                      |
| 3938.29        | 6       | 6     | 6.1E-05                      | 5136.80        | 6       | 4     | 2.8E-05                      | 6331.95        | 6       | 8     | 1.8E-03                      |
| 3938.97        | 4       | 6     | 8.4E-03                      | 5144.35        | 4       | 6     | 8.5E-01                      | 6369.46        | 6       | 4     | 1.40E-04                     |
| 3945.21        | 4       | 4     | 3.9E-05                      | 5149.47        | 8       | 10    | 9.0E-01                      | 6383.72        | 6       | 6     | 1.1E-03                      |
| 3974.17        | 4       | 6     | 6.3E-05                      | 5169.03        | 6       | 8     | 4.22E-02                     | 6416.92        | 6       | 6     | 3.6E-04                      |
| 4024.55        | 6       | 6     | 2.5E-03                      | 5197.58        | 6       | 4     | 5.4E-03                      | 6432.68        | 6       | 6     | 8.5E-05                      |
| 4075.95        | 6       | 4     | 1.6E-05                      | 5227.48        | 12      | 14    | 1.22E+00                     | 6446.41        | 8       | 10    | 1.3E-03                      |
| 4087.28        | 6       | 4     | 3.0E-05                      | 5234.62        | 8       | 6     | 2.5E-03                      | 6456.38        | 8       | 6     | 1.7E-03                      |
| 4122.67        | 6       | 6     | 3.3E-04                      | 5247.95        | 4       | 6     | 1.43E+00                     | 6516.08        | 6       | 8     | 8.3E-05                      |
| 4124.79        | 6       | 8     | 3.4E-05                      | 5251.23        | 6       | 8     | 8.0E-01                      | 7222.39        | 4       | 2     | 2.5E-04                      |
| 4128.75        | 6       | 4     | 2.6E-04                      | 5262.48        | 4       | 6     | 8.0E-07                      | 7224.49        | 2       | 2     | 2.8E-04                      |
| 4173.46        | 6       | 6     | 4.43E-03                     | 5264.18        | 8       | 10    | 4.76E-01                     | 7301.56        | 6       | 6     | 2.1E-05                      |
| 4178.86        | 6       | 8     | 1.72E-03                     | 5264.81        | 6       | 4     | 3.52E-04                     | 7320.65        | 6       | 4     | 1.4E-04                      |
| 4180.98        | 4       | 4     | 2.2E-04                      | 5272.40        | 6       | 6     | 3.9E-03                      | 7449.33        | 4       | 6     | 1.68E-04                     |
| 4233.17        | 6       | 8     | 7.22E-03                     | 5276.00        | 10      | 8     | 3.76E-03                     | 7462.41        | 6       | 6     | 2.7E-04                      |
| 4258.15        | 4       | 4     | 3.1E-04                      | 5284.11        | 6       | 8     | 1.9E-04                      | 7479.69        | 6       | 8     | 3.5E-05                      |
| 4273.33        | 4       | 2     | 9.1E-04                      | 5306.18        | 6       | 8     | 3.28E-01                     | 7515.83        | 8       | 6     | 8.1E-05                      |
| 4296.57        | 4       | 6     | 7.0E-04                      | 5316.22        | 14      | 14    | 3.69E-01                     | 7711.72        | 8       | 8     | 4.94E-04                     |
| 4303.18        | 4       | 4     | 2.20E-03                     | 5316.62        | 12      | 10    | 3.89E-03                     | <i>Fe III</i>  |         |       |                              |
| 4351.77        | 4       | 6     | 4.86E-03                     | 5316.78        | 8       | 6     | 6.5E-04                      | 1843.4         | 9       | 7     | 4.8E+00                      |
| 4369.41        | 2       | 4     | 2.3E-04                      | 5325.55        | 8       | 8     | 8.0E-04                      | 1844.3         | 7       | 5     | 4.9E+00                      |
| 4384.32        | 12      | 10    | 7.2E-05                      | 5387.06        | 12      | 14    | 5.2E-01                      | 1846.9         | 5       | 3     | 5.5E+00                      |
| 4385.39        | 2       | 2     | 4.5E-03                      | 5395.86        | 6       | 8     | 5.5E-01                      | 1854.38        | 3       | 1     | 5.7E+00                      |
| 4413.60        | 10      | 10    | 2.2E-05                      | 5402.06        | 10      | 12    | 5.6E-01                      | 1865.20        | 7       | 7     | 6.1E+00                      |
| 4416.83        | 2       | 4     | 2.1E-03                      | 5414.07        | 8       | 8     | 9.4E-05                      | 1893.98        | 11      | 9     | 5.5E+00                      |
| 4472.93        | 6       | 4     | 2.5E-04                      | 5425.26        | 10      | 10    | 9.2E-05                      | 1896.80        | 13      | 11    | 5.0E+00                      |
| 4489.18        | 8       | 6     | 5.9E-04                      | 5427.83        | 12      | 10    | 5.9E-03                      | 1904.3         | 5       | 5     | 5.7E+00                      |
| 4491.41        | 4       | 4     | 1.89E-03                     | 5429.99        | 8       | 10    | 6.0E-01                      | 1907.58        | 15      | 13    | 5.3E+00                      |
| 4508.29        | 4       | 2     | 7.3E-03                      | 5465.93        | 6       | 8     | 6.2E-01                      | 1915.08        | 13      | 15    | 6.0E+00                      |
| 4515.34        | 6       | 6     | 2.37E-03                     | 5482.31        | 10      | 12    | 4.78E-01                     | 1922.79        | 11      | 13    | 5.5E+00                      |
| 4520.22        | 10      | 8     | 9.8E-04                      | 5493.83        | 8       | 10    | 4.01E-01                     | 1930.39        | 9       | 11    | 5.1E+00                      |
| 4522.63        | 6       | 4     | 8.4E-03                      | 5506.19        | 12      | 14    | 1.14E+00                     | 1931.51        | 9       | 11    | 5.3E+00                      |
| 4534.17        | 4       | 6     | 2.3E-04                      | 5510.78        | 10      | 12    | 2.28E-01                     | 1937.35        | 7       | 9     | 5.1E+00                      |
| 4541.52        | 4       | 4     | 8.6E-04                      | 5525.12        | 10      | 8     | 3.17E-05                     | 1943.48        | 5       | 7     | 5.0E+00                      |
| 4549.19        | 4       | 6     | 9.2E-03                      | 5529.05        | 6       | 6     | 2.01E-01                     | 1950.33        | 13      | 15    | 5.5E+00                      |
| 4549.47        | 8       | 6     | 1.00E-02                     | 5534.85        | 12      | 10    | 3.0E-04                      | 1951.01        | 11      | 11    | 5.3E+00                      |
| 4555.89        | 8       | 8     | 2.26E-03                     | 5544.76        | 12      | 12    | 2.49E-01                     | 1952.65        | 9       | 9     | 4.9E+00                      |
| 4576.34        | 6       | 6     | 6.4E-04                      | 5607.14        | 6       | 8     | 4.63E-05                     | 1953.32        | 7       | 7     | 5.1E+00                      |
| 4582.84        | 6       | 8     | 3.44E-04                     | 5627.50        | 8       | 6     | 2.93E-05                     | 1987.50        | 13      | 13    | 4.9E+00                      |
| 4583.84        | 10      | 8     | 7.22E-03                     | 5725.96        | 6       | 6     | 5.1E-06                      | <i>Fe VII</i>  |         |       |                              |
| 4620.52        | 8       | 8     | 2.53E-04                     | 5783.63        | 8       | 10    | 4.62E-01                     | 150.807        | 5       | 7     | 1.3E+03                      |
| 4629.34        | 10      | 10    | 1.72E-03                     | 5813.68        | 6       | 4     | 8.8E-04                      | 150.852        | 7       | 9     | 1.3E+03                      |
| 4635.32        | 6       | 8     | 1.0E-02                      | 5823.15        | 8       | 10    | 2.0E-04                      | 151.023        | 9       | 11    | 1.6E+03                      |
| 4656.98        | 6       | 6     | 1.37E-04                     | 5824.41        | 6       | 6     | 8.3E-07                      | 151.046        | 7       | 7     | 2.2E+02                      |
| 4666.76        | 8       | 10    | 1.3E-04                      | 5885.01        | 4       | 6     | 6.4E-01                      | 151.145        | 9       | 9     | 2.1E+02                      |
| 4670.18        | 6       | 8     | 3.2E-05                      | 5902.83        | 8       | 10    | 4.98E-01                     | 151.432        | 5       | 7     | 2.2E+02                      |
| 4720.15        | 4       | 6     | 7.5E-06                      | 5955.70        | 6       | 8     | 4.19E-01                     | 151.512        | 5       | 5     | 5.3E+02                      |
| 4731.45        | 6       | 8     | 2.8E-04                      | 5961.71        | 10      | 12    | 7.4E-01                      |                |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 151.675        | 7       | 7     | 3.9E+02                      | 92.81          | 9       | 11    | 3.7E+03                      | 217            | 6       | 8     | 4.0E+02                      |
| 151.782        | 9       | 9     | 2.4E+02                      | 92.87          | 11      | 13    | 3.9E+03                      | 217            | 6       | 6     | 2.6E+02                      |
| 154.307        | 3       | 1     | 8.9E+02                      | 93.433         | 9       | 11    | 3.2E+03                      | 219            | 2       | 4     | 4.8E+02                      |
| 154.335        | 5       | 7     | 1.2E+03                      | 179.762        | 5       | 7     | 1.67E+03                     | 219            | 4       | 6     | 2.4E+02                      |
| 154.363        | 3       | 3     | 4.2E+02                      | <i>Fe XII</i>  |         |       |                              | 219.123        | 4       | 6     | 3.9E+02                      |
| 154.565        | 5       | 3     | 3.5E+02                      | 65.905         | 4       | 4     | 2.0E+03                      | 220            | 4       | 4     | 3.2E+02                      |
| 154.650        | 5       | 5     | 8.8E+02                      | 66.526         | 6       | 8     | 1.7E+03                      | 221            | 4       | 6     | 5.9E+02                      |
| 154.848        | 1       | 3     | 7.7E+02                      | 66.960         | 4       | 6     | 1.6E+03                      | 226            | 2       | 4     | 3.9E+02                      |
| 154.921        | 3       | 5     | 9.7E+02                      | 67.164         | 4       | 2     | 1.1E+03                      | 234            | 2       | 2     | 2.8E+02                      |
| 154.941        | 3       | 3     | 2.4E+02                      | 67.821         | 4       | 6     | 1.4E+03                      | 264.787        | 4       | 4     | 3.38E+02                     |
| 154.949        | 5       | 7     | 1.0E+03                      | 68.382         | 2       | 4     | 1.7E+03                      | 265            | 4       | 4     | 1.5E+02                      |
| 155.994        | 9       | 11    | 1.8E+03                      | 80.541         | 6       | 6     | 8.7E+02                      | 266            | 6       | 4     | 1.7E+02                      |
| 158.481        | 9       | 9     | 2.3E+02                      | 81.943         | 6       | 4     | 1.4E+03                      | 268            | 6       | 6     | 2.1E+02                      |
| 165.087        | 1       | 3     | 6.9E+02                      | 82.226         | 4       | 2     | 1.9E+03                      | 268            | 4       | 2     | 3.3E+02                      |
| 165.919        | 7       | 5     | 2.8E+03                      | 84.48          | 4       | 6     | 4.5E+03                      | 270.524        | 4       | 2     | 2.1E+02                      |
| 166.365        | 9       | 7     | 2.9E+03                      | 84.48          | 8       | 10    | 4.9E+03                      | 274.203        | 2       | 2     | 1.8E+02                      |
| 173.441        | 9       | 9     | 3.6E+03                      | 84.52          | 10      | 12    | 5.2E+03                      | 280            | 4       | 6     | 2.8E+02                      |
| 176.744        | 9       | 9     | 2.7E+03                      | 84.52          | 6       | 8     | 4.0E+03                      | 283            | 6       | 8     | 2.7E+02                      |
| 176.928        | 7       | 7     | 2.4E+03                      | 84.85          | 6       | 8     | 2.3E+03                      | 288.45         | 6       | 4     | 1.6E+02                      |
| 177.172        | 5       | 5     | 1.5E+03                      | 85.14          | 8       | 10    | 3.4E+03                      | <i>Fe XV</i>   |         |       |                              |
| 235.221        | 5       | 3     | 1.7E+02                      | 85.477         | 10      | 12    | 4.6E+03                      | 38.95          | 1       | 3     | 1.69E+03                     |
| 240.053        | 3       | 1     | 1.3E+02                      | 186.880        | 6       | 8     | 1.0E+03                      | 52.911         | 1       | 3     | 2.94E+03                     |
| 243.379        | 9       | 7     | 2.1E+02                      | 192.394        | 4       | 2     | 9.0E+02                      | 59.404         | 3       | 5     | 3.4E+03                      |
| <i>Fe VIII</i> |         |       |                              | 193.509        | 4       | 4     | 9.1E+02                      | 63.959         | 5       | 7     | 1.6E+03                      |
| 112.472        | 4       | 4     | 3.6E+02                      | 195.119        | 4       | 6     | 8.6E+02                      | 65.370         | 1       | 3     | 3.2E+02                      |
| 112.486        | 6       | 6     | 4.3E+02                      | <i>Fe XIII</i> |         |       |                              | 65.612         | 3       | 3     | 9.8E+02                      |
| 116.196        | 4       | 6     | 4.5E+02                      | 62.353         | 1       | 3     | 2.0E+03                      | 66.238         | 5       | 3     | 1.6E+03                      |
| 117.197        | 6       | 8     | 3.8E+02                      | 62.46          | 5       | 7     | 1.2E+03                      | 68.860         | 9       | 11    | 9.2E+03                      |
| 167.486        | 4       | 4     | 3.0E+03                      | 62.699         | 3       | 5     | 2.3E+03                      | 69.7           | 3       | 1     | 1.9E+03                      |
| 168.172        | 6       | 6     | 3.1E+03                      | 63.188         | 5       | 7     | 3.9E+03                      | 69.942         | 3       | 5     | 7.4E+03                      |
| 168.545        | 6       | 4     | 2.0E+03                      | 64.139         | 1       | 3     | 2.1E+03                      | 69.989         | 5       | 7     | 7.9E+03                      |
| 168.929        | 4       | 2     | 2.1E+03                      | 74.845         | 5       | 5     | 1.0E+03                      | 70.052         | 7       | 9     | 8.8E+03                      |
| 185.213        | 6       | 8     | 1.0E+03                      | 75.892         | 5       | 3     | 7.7E+02                      | 70.224         | 1       | 3     | 4.13E+03                     |
| 186.601        | 4       | 6     | 9.4E+02                      | 76.117         | 5       | 3     | 2.1E+03                      | 70.53          | 7       | 5     | 2.6E+02                      |
| <i>Fe X</i>    |         |       |                              | 78.452         | 9       | 11    | 6.3E+03                      | 70.59          | 7       | 7     | 1.7E+03                      |
| 76.822         | 2       | 2     | 1.8E+03                      | 84.270         | 7       | 9     | 5.5E+03                      | 73.199         | 7       | 9     | 8.8E+03                      |
| 77.865         | 4       | 6     | 1.6E+03                      | 107.384        | 7       | 5     | 1.8E+03                      | 73.473         | 5       | 7     | 6.2E+03                      |
| 100.026        | 8       | 10    | 2.6E+03                      | <i>Fe XIV</i>  |         |       |                              | 233.857        | 5       | 7     | 2.2E+02                      |
| 101.733        | 6       | 8     | 1.8E+03                      | 58.963         | 2       | 4     | 2.7E+03                      | 235            | 1       | 3     | 2.5E+02                      |
| 101.846        | 4       | 6     | 1.7E+03                      | 59.579         | 4       | 6     | 3.1E+03                      | 243            | 1       | 3     | 2.4E+02                      |
| 102.095        | 10      | 12    | 2.9E+03                      | 69.176         | 4       | 6     | 5.6E+02                      | 243            | 5       | 7     | 2.3E+02                      |
| 102.192        | 10      | 12    | 2.9E+03                      | 69.386         | 2       | 4     | 7.6E+02                      | 243.790        | 3       | 5     | 4.2E+02                      |
| 102.829        | 4       | 6     | 2.1E+03                      | 69.66          | 2       | 2     | 8.9E+02                      | 248            | 3       | 1     | 5.4E+02                      |
| 103.319        | 6       | 8     | 2.6E+03                      | 69.66          | 6       | 6     | 1.3E+03                      | 284.160        | 1       | 3     | 2.28E+02                     |
| 103.724        | 6       | 8     | 1.7E+03                      | 70.251         | 6       | 4     | 8.1E+02                      | <i>Fe XVI</i>  |         |       |                              |
| 104.638        | 8       | 10    | 2.1E+03                      | 70.613         | 4       | 2     | 1.7E+03                      | 31.041         | 2       | 4     | 5.2E+02                      |
| 174.534        | 4       | 6     | 1.8E+03                      | 72.80          | 10      | 12    | 7.9E+03                      | 31.242         | 4       | 6     | 6.1E+02                      |
| 175.266        | 2       | 4     | 1.72E+03                     | 76.022         | 4       | 6     | 6.6E+03                      | 32.166         | 2       | 4     | 6.8E+02                      |
| <i>Fe XI</i>   |         |       |                              | 76.152         | 6       | 8     | 7.0E+03                      | 32.192         | 2       | 2     | 6.7E+02                      |
| 72.166         | 5       | 7     | 2.9E+03                      | 91.009         | 6       | 4     | 5.1E+02                      | 32.433         | 2       | 4     | 7.7E+02                      |
| 72.310         | 5       | 5     | 1.5E+03                      | 91.273         | 4       | 2     | 5.6E+02                      | 32.652         | 4       | 6     | 9.1E+02                      |
| 72.635         | 5       | 7     | 1.6E+03                      | 188            | 4       | 6     | 2.7E+02                      | 34.857         | 2       | 4     | 1.23E+03                     |
| 91.394         | 5       | 7     | 2.6E+03                      | 190            | 6       | 8     | 2.8E+02                      | 35.106         | 4       | 6     | 1.44E+03                     |
| 91.472         | 7       | 9     | 2.5E+03                      | 207            | 2       | 2     | 2.1E+02                      | 35.333         | 4       | 6     | 6.4E+02                      |
| 91.63          | 3       | 5     | 2.3E+03                      | 211.316        | 2       | 4     | 3.6E+02                      | 35.368         | 6       | 8     | 6.8E+02                      |
| 91.63          | 7       | 9     | 3.4E+03                      | 213            | 4       | 2     | 2.8E+02                      | 36.01          | 4       | 2     | 5.0E+02                      |
| 91.63          | 5       | 7     | 2.8E+03                      | 214            | 2       | 2     | 4.0E+02                      | 36.749         | 2       | 4     | 1.1E+03                      |
| 91.733         | 9       | 11    | 4.1E+03                      | 216            | 6       | 8     | 1.7E+02                      | 36.803         | 2       | 2     | 1.2E+03                      |
|                |         |       |                              |                |         |       |                              | 37.096         | 4       | 6     | 1.0E+03                      |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 37.138         | 6       | 8     | 1.07E+03                     | 13.68          | 3       | 1     | 8.0E+04                      | 8.65           | 5       | 7     | 3.9E+04                      |
| 39.827         | 2       | 4     | 2.1E+03                      | 13.69          | 5       | 7     | 2.3E+04                      | 8.66           | 5       | 5     | 4.4E+03                      |
| 40.153         | 4       | 6     | 2.5E+03                      | 13.700         | 1       | 3     | 2.7E+05                      | 8.74           | 1       | 3     | 2.5E+04                      |
| 40.161         | 4       | 4     | 4.1E+02                      | 13.71          | 5       | 5     | 2.2E+04                      | 9.42           | 3       | 1     | 4.3E+04                      |
| 40.199         | 4       | 6     | 1.7E+03                      | 13.738         | 5       | 7     | 1.0E+04                      | 9.42           | 3       | 3     | 3.3E+04                      |
| 40.245         | 6       | 8     | 1.8E+03                      | 13.796         | 5       | 7     | 7.0E+04                      | 9.44           | 3       | 5     | 1.7E+04                      |
| 41.91          | 2       | 2     | 4.72E+02                     | 13.83          | 5       | 5     | 1.4E+04                      | 9.45           | 1       | 3     | 5.2E+04                      |
| 42.30          | 4       | 2     | 9.2E+02                      | 13.934         | 1       | 3     | 4.51E+04                     | 9.46           | 5       | 3     | 1.5E+04                      |
| 46.661         | 4       | 6     | 3.46E+03                     | 13.961         | 3       | 3     | 2.0E+04                      | 9.47           | 5       | 7     | 4.9E+04                      |
| 46.718         | 6       | 8     | 3.7E+03                      | 14.668         | 5       | 7     | 1.1E+04                      | 9.47           | 5       | 5     | 6.1E+03                      |
| 50.350         | 2       | 4     | 1.86E+03                     | 14.671         | 5       | 3     | 1.1E+04                      | 9.52           | 3       | 3     | 8.1E+03                      |
| 50.555         | 2       | 2     | 1.98E+03                     | 14.929         | 3       | 3     | 1.2E+04                      | 9.58           | 5       | 5     | 5.2E+03                      |
| 54.142         | 2       | 4     | 3.41E+03                     | 14.966         | 5       | 3     | 2.5E+04                      | 9.59           | 5       | 5     | 1.0E+04                      |
| 54.728         | 4       | 6     | 4.16E+03                     | 14.995         | 5       | 5     | 2.2E+04                      | 9.67           | 1       | 3     | 5.7E+04                      |
| 54.769         | 4       | 4     | 6.97E+02                     | 15.015         | 1       | 3     | 1.4E+04                      | 9.68           | 5       | 7     | 4.0E+03                      |
| 62.879         | 2       | 2     | 1.05E+03                     | 16.668         | 3       | 1     | 1.1E+04                      | 9.74           | 5       | 3     | 5.3E+03                      |
| 63.719         | 4       | 2     | 2.18E+03                     | <i>Fe XX</i>   |         |       |                              | 12.02          | 1       | 3     | 1.3E+04                      |
| 66.263         | 4       | 6     | 9.39E+03                     | 12.67          | 6       | 6     | 1.0E+04                      | 12.13          | 3       | 3     | 1.8E+04                      |
| 66.368         | 6       | 8     | 1.00E+04                     | 12.69          | 4       | 6     | 1.2E+04                      | 12.18          | 5       | 7     | 2.2E+04                      |
| 66.392         | 6       | 6     | 6.69E+02                     | 12.73          | 4       | 2     | 4.0E+04                      | 12.19          | 5       | 3     | 6.4E+03                      |
| 76.502         | 6       | 4     | 6.7E+02                      | 12.77          | 4       | 4     | 2.1E+05                      | 12.21          | 3       | 1     | 1.5E+05                      |
| 76.796         | 4       | 2     | 7.72E+02                     | 12.78          | 4       | 2     | 6.9E+04                      | 12.21          | 3       | 3     | 1.2E+05                      |
| 80.192         | 4       | 6     | 5.2E+02                      | 12.78          | 2       | 4     | 1.4E+05                      | 12.25          | 1       | 3     | 2.1E+05                      |
| 80.270         | 6       | 8     | 5.4E+02                      | 12.79          | 6       | 4     | 1.7E+04                      | 12.28          | 5       | 3     | 5.2E+04                      |
| 85.587         | 2       | 4     | 4.0E+02                      | 12.82          | 4       | 4     | 1.1E+05                      | 12.30          | 5       | 7     | 2.1E+05                      |
| 86.133         | 4       | 6     | 4.8E+02                      | 12.88          | 6       | 4     | 2.7E+04                      | 12.36          | 3       | 3     | 3.6E+04                      |
| 96.256         | 4       | 6     | 8.7E+02                      | 12.89          | 4       | 4     | 4.4E+04                      | 12.37          | 5       | 7     | 3.1E+05                      |
| 96.348         | 6       | 8     | 9.3E+02                      | 12.90          | 4       | 2     | 6.2E+03                      | 12.38          | 5       | 3     | 6.9E+03                      |
| 117.2          | 2       | 4     | 3.93E+02                     | 12.90          | 4       | 6     | 1.4E+05                      | 12.47          | 5       | 7     | 5.8E+04                      |
| 117.7          | 2       | 2     | 3.9E+02                      | 12.92          | 2       | 4     | 1.7E+04                      | 12.47          | 5       | 3     | 1.3E+04                      |
| 123.4          | 2       | 4     | 5.9E+02                      | 12.93          | 4       | 6     | 1.6E+05                      | 12.49          | 5       | 7     | 1.3E+04                      |
| 124.5          | 4       | 6     | 7.0E+02                      | 12.93          | 2       | 2     | 1.2E+04                      | 12.53          | 5       | 5     | 1.5E+04                      |
| 144.06         | 4       | 6     | 1.6E+03                      | 12.98          | 2       | 2     | 6.7E+04                      | 12.57          | 1       | 3     | 7.2E+04                      |
| 144.25         | 6       | 8     | 1.6E+03                      | 12.99          | 6       | 6     | 5.1E+04                      | 12.73          | 5       | 5     | 8.2E+03                      |
| 148            | 4       | 2     | 6.5E+02                      | 13.00          | 6       | 4     | 1.1E+04                      | 12.95          | 3       | 5     | 6.2E+03                      |
| 266.7          | 4       | 6     | 3.9E+02                      | 13.01          | 2       | 4     | 3.0E+04                      | 13.00          | 1       | 3     | 7.2E+03                      |
| 267.0          | 6       | 8     | 4.3E+02                      | 13.03          | 4       | 2     | 8.6E+04                      | 13.03          | 5       | 5     | 1.3E+04                      |
| <i>Fe XVII</i> |         |       |                              | 13.07          | 6       | 4     | 8.2E+03                      | 13.14          | 3       | 1     | 2.0E+04                      |
| 11.023         | 1       | 3     | 2.1E+04                      | 13.13          | 2       | 4     | 8.9E+04                      | 13.41          | 1       | 3     | 7.3E+03                      |
| 12.123         | 1       | 3     | 8.0E+04                      | 13.24          | 4       | 4     | 1.2E+04                      | <i>Fe XXII</i> |         |       |                              |
| 12.264         | 1       | 3     | 5.9E+04                      | 13.28          | 4       | 4     | 6.1E+03                      | 9.002          | 4       | 6     | 5.5E+04                      |
| 12.526         | 1       | 3     | 3.0E+03                      | 13.70          | 4       | 6     | 1.1E+04                      | 9.006          | 6       | 8     | 5.7E+04                      |
| 12.681         | 1       | 3     | 3.5E+03                      | 13.71          | 2       | 2     | 9.9E+03                      | 9.006          | 6       | 6     | 5.3E+04                      |
| 13.823         | 1       | 3     | 3.3E+04                      | 13.78          | 4       | 4     | 1.0E+04                      | 9.163          | 4       | 6     | 6.9E+04                      |
| 13.891         | 1       | 3     | 3.4E+03                      | 13.79          | 6       | 6     | 1.2E+04                      | 9.183          | 6       | 8     | 8.3E+04                      |
| 15.015         | 1       | 3     | 2.28E+05                     | 13.83          | 4       | 2     | 9.8E+03                      | 9.241          | 4       | 6     | 5.1E+04                      |
| 15.262         | 1       | 3     | 6.0E+04                      | 13.90          | 4       | 2     | 1.2E+04                      | 11.748         | 4       | 4     | 1.2E+05                      |
| 16.777         | 1       | 3     | 8.29E+03                     | 13.98          | 6       | 4     | 1.6E+04                      | 11.748         | 4       | 6     | 1.6E+05                      |
| 17.054         | 1       | 3     | 9.33E+03                     | 13.99          | 4       | 2     | 2.2E+04                      | 11.748         | 4       | 2     | 1.8E+05                      |
| 41.37          | 9       | 11    | 4.8E+03                      | 14.05          | 4       | 4     | 1.7E+04                      | 11.763         | 2       | 4     | 1.6E+05                      |
| 49.427         | 3       | 3     | 4.0E+03                      | 14.23          | 2       | 2     | 6.3E+03                      | 11.789         | 2       | 2     | 2.6E+05                      |
| 50.26          | 7       | 9     | 6.0E+03                      | <i>Fe XXI</i>  |         |       |                              | 11.789         | 6       | 8     | 1.2E+05                      |
| 58.76          | 9       | 11    | 1.2E+04                      | 8.53           | 3       | 1     | 1.8E+04                      | 11.797         | 2       | 4     | 1.7E+05                      |
| <i>Fe XIX</i>  |         |       |                              | 8.53           | 3       | 5     | 6.1E+03                      | 11.823         | 6       | 4     | 7.9E+04                      |
| 13.413         | 5       | 3     | 1.3E+04                      | 8.53           | 3       | 3     | 1.5E+04                      | 11.837         | 6       | 8     | 2.3E+05                      |
| 13.426         | 5       | 7     | 4.8E+04                      | 8.56           | 5       | 7     | 2.0E+04                      | 11.837         | 6       | 6     | 1.7E+05                      |
| 13.47          | 3       | 1     | 1.5E+05                      | 8.56           | 1       | 3     | 2.1E+04                      | 11.886         | 4       | 6     | 1.3E+05                      |
| 13.520         | 5       | 7     | 2.0E+05                      | 8.56           | 5       | 3     | 6.5E+03                      | 11.898         | 2       | 4     | 8.2E+04                      |
| 13.56          | 3       | 5     | 1.0E+04                      | 8.64           | 5       | 7     | 1.5E+04                      | 11.922         | 4       | 6     | 1.8E+05                      |

| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 11.976          | 6       | 8     | 5.9E+04                      | 1.8614         | 4       | 4     | 6.24E+06                     | 4463.7         | 3       | 3     | 2.3E-02                      |
| 12.027          | 2       | 4     | 6.9E+04                      | 1.8626         | 2       | 4     | 3.16E+06                     | 4502.4         | 3       | 5     | 9.2E-03                      |
| 12.045          | 6       | 8     | 2.4E+05                      | 1.8627         | 2       | 2     | 5.47E+06                     | 5562.2         | 5       | 5     | 2.8E-03                      |
| 12.045          | 4       | 4     | 9.7E+04                      | 1.8637         | 2       | 2     | 1.91E+06                     | 5570.3         | 5       | 3     | 2.1E-02                      |
| 12.053          | 4       | 6     | 6.1E+04                      | 1.8655         | 4       | 6     | 2.14E+06                     | 5649.6         | 1       | 3     | 3.7E-03                      |
| 12.077          | 2       | 4     | 1.0E+05                      | 1.8672         | 4       | 2     | 1.63E+06                     | 5870.9         | 3       | 5     | 1.8E-02                      |
| 12.077          | 4       | 6     | 2.4E+05                      | 1.8678         | 4       | 4     | 3.5E+05                      | 6904.7         | 3       | 5     | 1.3E-02                      |
| 12.095          | 6       | 6     | 7.8E+04                      | 1.8721         | 4       | 6     | 3.2E+05                      | 7224.1         | 3       | 5     | 1.4E-02                      |
| 12.193          | 2       | 4     | 7.2E+04                      | 1.8721         | 2       | 2     | 2.0E+05                      | 7587.4         | 3       | 1     | 5.1E-01                      |
| 12.193          | 4       | 6     | 9.9E+04                      | 1.8730         | 2       | 4     | 1.5E+05                      | 7601.5         | 5       | 5     | 3.1E-01                      |
| 12.325          | 2       | 2     | 1.5E+05                      | 1.8739         | 4       | 4     | 8.3E+04                      | 7685.2         | 3       | 1     | 4.9E-01                      |
| <i>Fe XXIII</i> |         |       |                              | 1.891          | 2       | 2     | 9.7E+04                      | 7694.5         | 5       | 3     | 5.6E-02                      |
| 7.733           | 5       | 7     | 3.0E+04                      | 1.897          | 4       | 2     | 9.8E+04                      | 7854.8         | 1       | 3     | 2.3E-01                      |
| 7.849           | 5       | 7     | 4.9E+04                      | 8.231          | 2       | 4     | 6.10E+04                     | 8059.5         | 1       | 3     | 1.9E-01                      |
| 8.307           | 1       | 3     | 4.8E+04                      | 8.316          | 4       | 6     | 7.07E+04                     | 8104.4         | 5       | 5     | 1.3E-01                      |
| 8.529           | 1       | 3     | 4.3E+04                      | 10.619         | 2       | 4     | 7.28E+04                     | 8112.9         | 5       | 7     | 3.6E-01                      |
| 8.550           | 3       | 5     | 6.0E+04                      | 10.663         | 2       | 2     | 7.51E+04                     | 8190.1         | 3       | 5     | 1.1E-01                      |
| 8.552           | 3       | 3     | 3.2E+04                      | 11.030         | 2       | 4     | 1.84E+05                     | 8263.2         | 3       | 5     | 3.5E-01                      |
| 8.614           | 5       | 7     | 7.7E+04                      | 11.171         | 4       | 6     | 2.18E+05                     | 8281.1         | 3       | 3     | 1.9E-01                      |
| 8.664           | 3       | 3     | 4.4E+04                      | <i>Fe XXV</i>  |         |       |                              | 8298.1         | 3       | 3     | 3.2E-01                      |
| 8.669           | 5       | 7     | 6.1E+04                      | 1.4607         | 1       | 3     | 2.54E+05                     | 8508.9         | 3       | 3     | 2.4E-01                      |
| 8.672           | 1       | 3     | 6.8E+04                      | 1.4945         | 1       | 3     | 5.05E+05                     | 8776.7         | 3       | 5     | 2.7E-01                      |
| 8.752           | 5       | 7     | 1.2E+05                      | 1.5730         | 1       | 3     | 1.24E+06                     | 8928.7         | 5       | 3     | 3.7E-01                      |
| 8.764           | 5       | 7     | 4.6E+04                      | 1.5749         | 1       | 3     | 1.5E+05                      | <i>Kr II</i>   |         |       |                              |
| 8.814           | 3       | 5     | 6.2E+04                      | 1.778          | 3       | 3     | 8.7E+04                      | 4250.6         | 4       | 4     | 1.2E-01                      |
| 10.902          | 5       | 5     | 5.3E+04                      | 1.782          | 3       | 1     | 4.69E+06                     | 4292.9         | 4       | 4     | 9.6E-01                      |
| 10.910          | 3       | 1     | 6.7E+04                      | 1.787          | 1       | 3     | 2.57E+06                     | 4355.5         | 6       | 8     | 1.0E+00                      |
| 10.927          | 5       | 7     | 6.0E+04                      | 1.787          | 5       | 5     | 1.19E+06                     | 4431.7         | 2       | 2     | 1.8E+00                      |
| 10.934          | 3       | 5     | 5.4E+04                      | 1.788          | 3       | 5     | 2.68E+06                     | 4436.8         | 2       | 4     | 6.6E-01                      |
| 10.979          | 1       | 3     | 7.9E+04                      | 1.788          | 3       | 5     | 1.63E+06                     | 4577.2         | 6       | 8     | 9.6E-01                      |
| 11.018          | 1       | 3     | 4.9E+04                      | 1.789          | 1       | 3     | 1.78E+06                     | 4583.0         | 6       | 4     | 7.6E-01                      |
| 11.086          | 3       | 1     | 6.5E+04                      | 1.790          | 3       | 3     | 1.23E+06                     | 4615.3         | 4       | 4     | 5.4E-01                      |
| 11.165          | 3       | 5     | 6.7E+04                      | 1.791          | 3       | 5     | 4.10E+06                     | 4619.2         | 4       | 6     | 8.1E-01                      |
| 11.255          | 3       | 3     | 3.7E+04                      | 1.791          | 3       | 3     | 2.59E+06                     | 4633.9         | 4       | 6     | 7.1E-01                      |
| 11.298          | 1       | 3     | 1.3E+05                      | 1.792          | 3       | 1     | 4.92E+06                     | 4658.9         | 6       | 4     | 6.5E-01                      |
| 11.325          | 3       | 5     | 1.7E+05                      | 1.792          | 5       | 5     | 2.81E+06                     | 4739.0         | 6       | 6     | 7.6E-01                      |
| 11.338          | 3       | 3     | 9.3E+04                      | 1.793          | 3       | 1     | 2.67E+06                     | 4762.4         | 2       | 4     | 4.2E-01                      |
| 11.429          | 3       | 1     | 1.7E+05                      | 1.794          | 5       | 3     | 2.22E+06                     | 4765.7         | 4       | 6     | 6.7E-01                      |
| 11.433          | 3       | 3     | 1.2E+05                      | 1.797          | 3       | 5     | 8.8E+05                      | 4811.8         | 2       | 4     | 1.7E-01                      |
| 11.441          | 5       | 7     | 2.2E+05                      | 1.798          | 3       | 3     | 1.0E+05                      | 4825.2         | 2       | 4     | 1.9E-01                      |
| 11.445          | 5       | 5     | 5.6E+04                      | 1.800          | 1       | 3     | 8.6E+04                      | 4832.1         | 4       | 2     | 7.3E-01                      |
| 11.485          | 3       | 5     | 1.40E+05                     | 1.802          | 3       | 1     | 4.1E+05                      | 5208.3         | 4       | 4     | 1.4E-01                      |
| 11.491          | 5       | 3     | 5.9E+04                      | 1.810          | 3       | 1     | 5.9E+05                      | 5308.7         | 4       | 6     | 2.4E-02                      |
| 11.519          | 5       | 5     | 1.16E+05                     | 1.8502         | 1       | 3     | 4.57E+06                     | 7407.0         | 6       | 6     | 7.0E-02                      |
| 11.520          | 1       | 3     | 2.16E+05                     | 1.8593         | 1       | 3     | 4.42E+05                     | <i>Lead</i>    |         |       |                              |
| 11.524          | 5       | 7     | 2.3E+05                      | 10.038         | 3       | 3     | 8.08E+04                     | <i>Pb I</i>    |         |       |                              |
| 11.593          | 5       | 7     | 3.58E+05                     | <i>Krypton</i> |         |       |                              | 2022.0         | 1       | 3     | 5.2E-02                      |
| 11.613          | 3       | 5     | 1.0E+05                      | <i>Kr I</i>    |         |       |                              | 2053.3         | 1       | 3     | 1.2E-01                      |
| 11.615          | 3       | 3     | 4.4E+04                      | 1164.9         | 1       | 3     | 3.16E+00                     | 2170.0         | 1       | 3     | 1.5E+00                      |
| 11.691          | 5       | 7     | 7.7E+04                      | 1235.8         | 1       | 3     | 3.12E+00                     | 2401.9         | 3       | 3     | 1.9E-01                      |
| 11.698          | 5       | 5     | 7.3E+04                      | 4274.0         | 5       | 5     | 2.6E-02                      | 2446.2         | 3       | 3     | 2.5E-01                      |
| 11.737          | 3       | 5     | 1.8E+05                      | 4351.4         | 3       | 1     | 3.2E-02                      | 2476.4         | 3       | 5     | 2.8E-01                      |
| 11.898          | 1       | 3     | 2.03E+05                     | 4362.6         | 5       | 3     | 8.4E-03                      | 2577.3         | 5       | 3     | 5.0E-01                      |
| <i>Fe XXIV</i>  |         |       |                              | 4376.1         | 3       | 1     | 5.6E-02                      | 2613.7         | 3       | 3     | 2.7E-01                      |
| 1.8523          | 2       | 2     | 1.0E+05                      | 4400.0         | 3       | 5     | 2.0E-02                      | 2614.2         | 3       | 5     | 1.9E+00                      |
| 1.8552          | 2       | 4     | 4.82E+06                     | 4410.4         | 3       | 3     | 4.4E-03                      | 2628.3         | 5       | 3     | 3.1E-02                      |
| 1.8563          | 4       | 2     | 2.43E+06                     | 4425.2         | 3       | 3     | 9.7E-03                      | 2657.1         | 3       | 5     | 9.8E-04                      |
| 1.8572          | 2       | 2     | 3.06E+06                     | 4453.9         | 3       | 5     | 7.8E-03                      | 2663.2         | 5       | 5     | 7.1E-01                      |
| 1.858           | 2       | 4     | 1.2E+05                      |                |         |       |                              |                |         |       |                              |

| $\lambda$<br>Å   | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|------------------|---------|-------|------------------------------|
|                  | $g_i$   | $g_k$ |                              |
| 2802.0           | 5       | 7     | 1.6E+00                      |
| 2823.2           | 5       | 5     | 2.6E-01                      |
| 2833.1           | 1       | 3     | 5.8E-01                      |
| 2873.3           | 5       | 5     | 3.7E-01                      |
| 3572.7           | 5       | 3     | 9.9E-01                      |
| 3639.6           | 3       | 3     | 3.4E-01                      |
| 3671.5           | 5       | 3     | 4.4E-01                      |
| 3683.5           | 3       | 1     | 1.5E+00                      |
| 3739.9           | 5       | 5     | 7.3E-01                      |
| 4019.6           | 5       | 7     | 3.5E-02                      |
| 4057.8           | 5       | 3     | 8.9E-01                      |
| 4062.1           | 5       | 3     | 9.2E-01                      |
| 4168.0           | 5       | 5     | 1.2E-02                      |
| 5005.4           | 1       | 3     | 2.7E-01                      |
| 5201.4           | 1       | 3     | 1.9E-01                      |
| 7229.0           | 5       | 3     | 8.9E-03                      |
| <b>Lithium</b>   |         |       |                              |
| <b>Li I</b>      |         |       |                              |
| *2741.2          | 2       | 6     | 1.3E-02                      |
| *3232.7          | 2       | 6     | 1.17E-02                     |
| *4602.9          | 6       | 10    | 2.23E-01                     |
| *6103.6          | 6       | 10    | 6.860E-01                    |
| *6707.8          | 2       | 6     | 3.691E-01                    |
| <b>Lutetium</b>  |         |       |                              |
| <b>Lu I</b>      |         |       |                              |
| 3376.5           | 4       | 4     | 2.23E+00                     |
| 3567.8           | 4       | 6     | 5.9E-01                      |
| 3620.3           | 6       | 4     | 1.1E-02                      |
| 3841.2           | 6       | 6     | 2.5E-01                      |
| 4518.6           | 4       | 4     | 2.1E-01                      |
| <b>Magnesium</b> |         |       |                              |
| <b>Mg I</b>      |         |       |                              |
| 2025.8           | 1       | 3     | 8.4E-01                      |
| *2779.8          | 9       | 9     | 5.2E+00                      |
| *2850.0          | 9       | 15    | 2.3E-01                      |
| 2852.1           | 1       | 3     | 4.95E+00                     |
| *3094.9          | 9       | 15    | 5.2E-01                      |
| 3329.9           | 1       | 3     | 3.3E-02                      |
| 3332.2           | 3       | 3     | 9.7E-02                      |
| 3336.7           | 5       | 3     | 1.6E-01                      |
| *3835.3          | 9       | 15    | 1.68E+00                     |
| 4703.0           | 3       | 5     | 2.55E-01                     |
| 5167.3           | 1       | 3     | 1.16E-01                     |
| 5172.7           | 3       | 3     | 3.46E-01                     |
| 5183.6           | 5       | 3     | 5.75E-01                     |
| 5528.4           | 3       | 5     | 1.99E-01                     |
| <b>Mg II</b>     |         |       |                              |
| 1239.9           | 2       | 4     | 1.4E-02                      |
| 1240.4           | 2       | 2     | 1.4E-02                      |
| *2660.8          | 10      | 14    | 3.8E-01                      |
| 2790.8           | 2       | 4     | 4.0E+00                      |
| 2795.5           | 2       | 4     | 2.6E+00                      |
| 2797.9           | 4       | 4     | 7.9E-01                      |
| 2798.1           | 4       | 6     | 4.8E+00                      |
| 2802.7           | 2       | 2     | 2.6E+00                      |
| 2928.8           | 2       | 2     | 1.2E+00                      |
| 2936.5           | 4       | 2     | 2.3E+00                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| *3104.8        | 10      | 14    | 8.1E-01                      |
| 3848.2         | 6       | 4     | 2.8E-02                      |
| 3848.3         | 4       | 4     | 3.0E-03                      |
| 3850.4         | 4       | 2     | 3.0E-02                      |
| *4481.2        | 10      | 14    | 2.23E+00                     |
| 9218.3         | 2       | 4     | 3.6E-01                      |
| 9244.3         | 2       | 2     | 3.6E-01                      |
| <b>Mg IV</b>   |         |       |                              |
| 320.99         | 4       | 2     | 1.2E+02                      |
| 323.31         | 2       | 2     | 5.9E+01                      |
| 1219.0         | 6       | 6     | 5.9E+00                      |
| 1375.5         | 4       | 4     | 4.5E+00                      |
| 1459.6         | 6       | 4     | 4.6E+00                      |
| 1495.5         | 4       | 6     | 6.4E+00                      |
| 1510.7         | 4       | 4     | 6.7E+00                      |
| 1683.0         | 6       | 8     | 5.8E+00                      |
| 1698.8         | 4       | 6     | 3.9E+00                      |
| 1893.9         | 6       | 6     | 2.8E+00                      |
| <b>Mg VI</b>   |         |       |                              |
| *269.92        | 10      | 6     | 3.1E+02                      |
| *292.53        | 6       | 6     | 9.0E+01                      |
| *314.64        | 6       | 2     | 1.8E+02                      |
| *349.15        | 10      | 10    | 6.1E+01                      |
| *387.94        | 6       | 10    | 1.3E+01                      |
| 399.29         | 4       | 2     | 2.8E+01                      |
| 400.68         | 4       | 4     | 2.8E+01                      |
| 403.32         | 4       | 6     | 2.7E+01                      |
| <b>Mg VII</b>  |         |       |                              |
| 277.01         | 3       | 3     | 9.5E+01                      |
| 278.41         | 5       | 3     | 1.5E+02                      |
| 280.74         | 5       | 3     | 2.0E+02                      |
| 319.02         | 5       | 5     | 8.9E+01                      |
| *366.42        | 9       | 9     | 4.4E+01                      |
| *433.04        | 9       | 15    | 1.6E+01                      |
| 1334.3         | 5       | 5     | 5.3E+00                      |
| 1410.0         | 5       | 5     | 2.57E+00                     |
| 1487.0         | 3       | 5     | 3.02E+00                     |
| 1487.9         | 5       | 7     | 3.66E+00                     |
| <b>Mg VIII</b> |         |       |                              |
| *74.976        | 6       | 10    | 4.3E+03                      |
| 315.02         | 4       | 4     | 1.2E+02                      |
| *342.29        | 10      | 6     | 6.3E+01                      |
| 353.86         | 4       | 4     | 3.89E+01                     |
| 356.00         | 6       | 4     | 5.7E+01                      |
| *428.52        | 10      | 10    | 3.24E+01                     |
| *434.62        | 6       | 10    | 1.6E+01                      |
| *489.33        | 6       | 6     | 3.9E+01                      |
| *686.92        | 6       | 10    | 9.4E+00                      |
| <b>Mg IX</b>   |         |       |                              |
| 62.751         | 1       | 3     | 2.87E+03                     |
| *67.189        | 9       | 15    | 6.20E+03                     |
| *71.965        | 9       | 3     | 1.22E+03                     |
| 72.312         | 3       | 5     | 4.43E+03                     |
| 77.737         | 3       | 1     | 3.92E+02                     |
| 368.07         | 1       | 3     | 5.27E+01                     |
| 438.69         | 3       | 1     | 7.9E+01                      |
| *443.74        | 9       | 9     | 4.19E+01                     |
| 749.55         | 3       | 5     | 8.2E+00                      |

| $\lambda$<br>Å   | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|------------------|---------|-------|------------------------------|
|                  | $g_i$   | $g_k$ |                              |
| 1639.8           | 3       | 5     | 2.1E+00                      |
| 2814.2           | 1       | 3     | 3.35E-01                     |
| <b>Mg X</b>      |         |       |                              |
| 57.876           | 2       | 4     | 2.09E+03                     |
| 57.920           | 2       | 2     | 2.09E+03                     |
| 63.152           | 2       | 4     | 5.6E+03                      |
| 63.295           | 4       | 6     | 6.7E+03                      |
| 609.79           | 2       | 4     | 7.53E+00                     |
| 624.94           | 2       | 2     | 7.01E+00                     |
| 2212.5           | 2       | 4     | 9.64E-01                     |
| 2278.7           | 2       | 2     | 8.82E-01                     |
| 5918.7           | 2       | 4     | 3.20E-02                     |
| 6229.6           | 4       | 6     | 3.30E-02                     |
| <b>Mg XI</b>     |         |       |                              |
| 7.310            | 1       | 3     | 1.15E+04                     |
| 7.473            | 1       | 3     | 2.27E+04                     |
| 7.850            | 1       | 3     | 5.50E+04                     |
| 9.169            | 1       | 3     | 1.97E+05                     |
| <b>Manganese</b> |         |       |                              |
| <b>Mn I</b>      |         |       |                              |
| 2794.82          | 6       | 8     | 3.7E+00                      |
| 2798.27          | 6       | 6     | 3.6E+00                      |
| 2801.08          | 6       | 4     | 3.7E+00                      |
| 3007.65          | 6       | 8     | 1.8E-01                      |
| 3011.38          | 8       | 10    | 3.1E-01                      |
| 3016.45          | 10      | 12    | 2.9E-01                      |
| 3043.36          | 8       | 8     | 5.9E-01                      |
| 3044.57          | 10      | 8     | 5.7E-01                      |
| 3045.59          | 10      | 10    | 6.7E-01                      |
| 3045.80          | 8       | 10    | 1.7E-01                      |
| 3047.03          | 12      | 12    | 6.1E-01                      |
| 3054.36          | 8       | 6     | 4.6E-01                      |
| 3070.27          | 6       | 6     | 1.9E-01                      |
| 3073.18          | 4       | 4     | 3.7E-01                      |
| 3082.71          | 14      | 14    | 2.9E-01                      |
| 3110.68          | 6       | 8     | 2.7E-01                      |
| 3113.80          | 12      | 10    | 2.6E-01                      |
| 3118.10          | 4       | 6     | 1.7E-01                      |
| 3122.88          | 10      | 10    | 1.9E-01                      |
| 3126.85          | 8       | 6     | 2.3E-01                      |
| 3132.28          | 10      | 10    | 2.1E-01                      |
| 3132.79          | 8       | 8     | 2.7E-01                      |
| 3175.58          | 8       | 10    | 1.8E-01                      |
| 3201.11          | 4       | 6     | 2.2E-01                      |
| 3228.09          | 10      | 12    | 6.4E-01                      |
| 3230.23          | 10      | 12    | 1.9E-01                      |
| 3230.72          | 8       | 8     | 3.5E-01                      |
| 3240.88          | 6       | 4     | 2.2E-01                      |
| 3243.78          | 6       | 6     | 5.3E-01                      |
| 3251.13          | 4       | 2     | 2.3E-01                      |
| 3252.95          | 4       | 4     | 1.8E-01                      |
| 3256.14          | 4       | 6     | 5.0E-01                      |
| 3258.41          | 2       | 2     | 9.7E-01                      |
| 3260.24          | 2       | 4     | 3.8E-01                      |
| 3267.79          | 14      | 14    | 3.5E-01                      |
| 3268.72          | 6       | 8     | 3.3E-01                      |
| 3270.35          | 12      | 12    | 2.6E-01                      |
| 3273.02          | 10      | 10    | 2.7E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å    | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|-------------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                   | $g_i$   | $g_k$ |                              |
| 3298.23        | 6       | 4     | 2.8E-01                      | 4070.28        | 2       | 2     | 2.3E-01                      | 3482.90           | 5       | 5     | 2.0E-01                      |
| 3303.28        | 4       | 4     | 1.9E-01                      | 4079.42        | 2       | 4     | 3.8E-01                      | 3488.68           | 3       | 3     | 2.5E-01                      |
| 3463.66        | 8       | 8     | 3.2E-01                      | 4082.95        | 4       | 6     | 2.95E-01                     | <i>Mn VI</i>      |         |       |                              |
| 3470.01        | 6       | 8     | 2.4E-01                      | 4083.63        | 6       | 8     | 2.8E-01                      | 307.999           | 9       | 9     | 3.7E+01                      |
| 3511.83        | 12      | 12    | 2.7E-01                      | 4089.94        | 8       | 10    | 1.7E-01                      | 309.440           | 9       | 7     | 5.7E+01                      |
| 3535.30        | 10      | 10    | 1.7E-01                      | 4105.37        | 10      | 8     | 1.7E-01                      | 309.579           | 7       | 5     | 4.4E+01                      |
| 3559.81        | 6       | 6     | 2.1E-01                      | 4135.03        | 12      | 12    | 3.0E-01                      | 310.058           | 7       | 7     | 3.4E+01                      |
| 3577.87        | 10      | 8     | 9.4E-01                      | 4141.06        | 10      | 10    | 2.6E-01                      | 310.182           | 5       | 5     | 2.8E+01                      |
| 3595.11        | 6       | 4     | 1.8E-01                      | 4148.80        | 8       | 8     | 2.3E-01                      | 311.748           | 5       | 3     | 5.7E+01                      |
| 3601.27        | 12      | 10    | 2.3E-01                      | 4176.61        | 14      | 12    | 2.4E-01                      | 320.598           | 3       | 5     | 1.5E+01                      |
| 3607.53        | 8       | 8     | 2.3E-01                      | 4189.99        | 12      | 10    | 2.0E-01                      | 320.681           | 1       | 3     | 2.2E+01                      |
| 3608.49        | 6       | 6     | 3.6E-01                      | 4201.78        | 10      | 8     | 2.3E-01                      | 320.874           | 3       | 1     | 7.8E+01                      |
| 3610.30        | 4       | 4     | 4.2E-01                      | 4235.30        | 8       | 6     | 9.17E-01                     | 320.979           | 3       | 3     | 2.2E+01                      |
| 3635.70        | 10      | 8     | 2.1E-01                      | 4239.74        | 4       | 2     | 3.9E-01                      | 321.176           | 5       | 5     | 6.0E+01                      |
| 3660.40        | 12      | 14    | 9.1E-01                      | 4257.67        | 2       | 2     | 3.7E-01                      | 321.541           | 5       | 3     | 2.7E+01                      |
| 3675.67        | 6       | 8     | 2.2E-01                      | 4265.93        | 4       | 4     | 4.92E-01                     | 325.146           | 9       | 7     | 1.3E+02                      |
| 3676.96        | 10      | 12    | 7.3E-01                      | 4281.10        | 6       | 6     | 2.3E-01                      | 328.431           | 5       | 5     | 4.4E+01                      |
| 3680.15        | 12      | 10    | 1.9E-01                      | 4411.87        | 12      | 10    | 2.6E-01                      | 328.558           | 3       | 5     | 1.2E+01                      |
| 3682.09        | 8       | 10    | 7.6E-01                      | 4414.89        | 8       | 6     | 2.93E-01                     | 329.043           | 1       | 3     | 1.1E+01                      |
| 3684.87        | 6       | 8     | 2.6E-01                      | 4419.77        | 10      | 8     | 2.1E-01                      | 1236.23           | 5       | 3     | 1.3E+01                      |
| 3706.08        | 12      | 14    | 1.4E+00                      | 4436.36        | 6       | 4     | 4.37E-01                     | 1255.77           | 3       | 1     | 1.2E+01                      |
| 3718.92        | 10      | 12    | 9.6E-01                      | 4451.58        | 8       | 8     | 7.98E-01                     | 1285.10           | 5       | 7     | 1.1E+01                      |
| 3731.94        | 8       | 10    | 1.0E+00                      | 4453.01        | 4       | 2     | 5.44E-01                     | 1333.87           | 7       | 9     | 1.0E+01                      |
| 3771.44        | 14      | 14    | 1.9E-01                      | 4455.82        | 4       | 6     | 1.7E-01                      | <i>Mercury</i>    |         |       |                              |
| 3773.86        | 12      | 12    | 2.5E-01                      | 4457.04        | 6       | 4     | 2.34E-01                     | <i>Hg I</i>       |         |       |                              |
| 3800.55        | 6       | 8     | 2.7E-01                      | 4457.55        | 6       | 6     | 4.27E-01                     | 2536.52           | 1       | 3     | 8.00E-02                     |
| 3806.72        | 10      | 12    | 5.9E-01                      | 4458.26        | 6       | 8     | 4.62E-01                     | 2652.04           | 3       | 5     | 3.88E-01                     |
| 3823.51        | 8       | 10    | 5.21E-01                     | 4461.09        | 8       | 8     | 1.7E-01                      | 2655.13           | 3       | 5     | 1.1E-01                      |
| 3823.89        | 6       | 6     | 2.31E-01                     | 4462.03        | 8       | 10    | 7.00E-01                     | 2752.78           | 1       | 3     | 6.10E-02                     |
| 3833.87        | 4       | 4     | 3.14E-01                     | 4464.68        | 6       | 6     | 4.39E-01                     | 2856.94           | 3       | 1     | 1.1E-02                      |
| 3834.37        | 6       | 8     | 4.29E-01                     | 4470.14        | 4       | 4     | 3.00E-01                     | 2893.60           | 3       | 3     | 1.6E-01                      |
| 3839.78        | 2       | 2     | 4.64E-01                     | 4472.79        | 2       | 2     | 4.35E-01                     | 2925.4            | 5       | 3     | 7.7E-02                      |
| 3841.07        | 4       | 6     | 3.3E-01                      | 4479.40        | 8       | 10    | 3.4E-01                      | 2967.3            | 1       | 3     | 4.5E-01                      |
| 3843.99        | 2       | 4     | 2.11E-01                     | 4490.08        | 2       | 4     | 2.49E-01                     | 3021.50           | 5       | 7     | 5.09E-01                     |
| 3889.46        | 12      | 14    | 3.1E-01                      | 4498.90        | 4       | 6     | 2.49E-01                     | 3023.48           | 5       | 5     | 9.4E-02                      |
| 3898.37        | 6       | 8     | 1.7E-01                      | 4502.22        | 6       | 8     | 1.86E-01                     | 3027.49           | 5       | 5     | 2.0E-02                      |
| 3899.34        | 4       | 6     | 2.4E-01                      | 4605.37        | 10      | 12    | 3.6E-01                      | 3125.66           | 3       | 5     | 6.56E-01                     |
| 3924.08        | 2       | 4     | 9.4E-01                      | 4626.54        | 12      | 14    | 3.6E-01                      | 3341.48           | 5       | 3     | 1.68E-01                     |
| 3926.48        | 6       | 8     | 5.4E-01                      | 4709.71        | 8       | 8     | 1.72E-01                     | 3650.15           | 5       | 7     | 1.3E+00                      |
| 3951.98        | 2       | 2     | 3.1E-01                      | 4727.46        | 6       | 6     | 1.7E-01                      | 3654.83           | 5       | 5     | 1.8E-01                      |
| 3952.84        | 6       | 6     | 4.1E-01                      | 4739.11        | 4       | 4     | 2.40E-01                     | 4046.56           | 1       | 3     | 2.1E-01                      |
| 3975.88        | 2       | 4     | 1.8E-01                      | 4754.05        | 6       | 8     | 3.03E-01                     | 4077.81           | 3       | 1     | 4.0E-02                      |
| 3982.16        | 4       | 2     | 3.5E-01                      | 4761.53        | 2       | 4     | 5.35E-01                     | 4108.1            | 3       | 1     | 3.0E-02                      |
| 3982.58        | 6       | 4     | 2.3E-01                      | 4762.38        | 8       | 10    | 7.83E-01                     | 4339.22           | 3       | 5     | 2.88E-02                     |
| 3982.90        | 6       | 4     | 5.5E-01                      | 4765.86        | 4       | 6     | 4.1E-01                      | 4347.50           | 3       | 5     | 8.4E-02                      |
| 3991.60        | 2       | 2     | 2.1E-01                      | 4766.43        | 6       | 8     | 4.6E-01                      | 4358.34           | 3       | 3     | 5.57E-01                     |
| 4011.91        | 8       | 8     | 2.3E-01                      | 4783.43        | 8       | 8     | 4.01E-01                     | 4916.07           | 3       | 1     | 5.8E-02                      |
| 4018.11        | 10      | 8     | 2.54E-01                     | 4823.53        | 10      | 8     | 4.99E-01                     | 5025.64           | 3       | 3     | 2.7E-04                      |
| 4030.76        | 6       | 8     | 1.7E-01                      | 6013.48        | 4       | 6     | 1.72E-01                     | 5460.75           | 5       | 3     | 4.87E-01                     |
| 4033.07        | 6       | 6     | 1.65E-01                     | 6021.79        | 8       | 6     | 3.32E-01                     | 5769.59           | 3       | 5     | 2.36E-01                     |
| 4034.49        | 6       | 4     | 1.58E-01                     | <i>Mn II</i>   |         |       |                              | 6234.4            | 1       | 3     | 5.3E-03                      |
| 4041.36        | 10      | 10    | 7.87E-01                     | 2593.72        | 7       | 7     | 2.6E+00                      | 6716.4            | 1       | 3     | 4.3E-03                      |
| 4048.75        | 6       | 4     | 7.5E-01                      | 2605.68        | 7       | 5     | 2.7E+00                      | 6907.5            | 3       | 5     | 2.8E-02                      |
| 4052.48        | 6       | 8     | 3.8E-01                      | 2933.05        | 5       | 3     | 2.0E+00                      | 7728.8            | 1       | 3     | 9.7E-03                      |
| 4055.55        | 8       | 8     | 4.31E-01                     | 2939.31        | 5       | 5     | 1.9E+00                      | 10139.79          | 3       | 1     | 2.71E-01                     |
| 4058.94        | 4       | 2     | 7.25E-01                     | 2949.20        | 5       | 7     | 1.9E+00                      | <i>Molybdenum</i> |         |       |                              |
| 4061.74        | 8       | 6     | 1.9E-01                      | 3441.99        | 9       | 7     | 4.3E-01                      | <i>Mo I</i>       |         |       |                              |
| 4063.53        | 6       | 6     | 1.69E-01                     | 3460.32        | 7       | 5     | 3.2E-01                      | 2616.79           | 3       | 5     | 7.34E-01                     |
| 4065.08        | 12      | 14    | 2.5E-01                      | 3474.13        | 5       | 3     | 1.5E-01                      |                   |         |       |                              |
| 4066.24        | 10      | 8     | 2.2E-01                      |                |         |       |                              |                   |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 2621.06        | 7       | 7     | 1.16E-01                     | 3036.31        | 3       | 5     | 5.81E-01                     | 3228.21        | 5       | 7     | 3.85E-01                     |
| 2628.96        | 3       | 3     | 2.81E-01                     | 3041.70        | 13      | 11    | 5.94E-01                     | 3229.79        | 9       | 11    | 1.44E-01                     |
| 2629.85        | 5       | 7     | 7.75E-01                     | 3046.80        | 13      | 11    | 1.63E-01                     | 3233.14        | 13      | 13    | 6.33E-01                     |
| 2631.50        | 1       | 3     | 2.54E-01                     | 3047.31        | 11      | 9     | 5.01E-01                     | 3237.06        | 7       | 9     | 2.95E-01                     |
| 2638.30        | 5       | 5     | 7.57E-01                     | 3055.32        | 9       | 7     | 4.29E-01                     | 3244.47        | 5       | 3     | 2.80E-01                     |
| 2640.98        | 7       | 5     | 1.20E+00                     | 3057.56        | 7       | 5     | 2.64E-01                     | 3247.61        | 5       | 5     | 1.71E-01                     |
| 2644.36        | 5       | 7     | 1.96E-01                     | 3061.59        | 7       | 5     | 4.41E-01                     | 3249.93        | 5       | 3     | 1.87E-01                     |
| 2649.46        | 7       | 9     | 9.84E-01                     | 3064.27        | 13      | 13    | 8.46E-01                     | 3251.65        | 3       | 5     | 3.05E-01                     |
| 2655.02        | 9       | 7     | 4.08E-01                     | 3065.04        | 13      | 13    | 3.08E-01                     | 3256.21        | 5       | 3     | 6.89E-01                     |
| 2658.11        | 7       | 7     | 6.43E-01                     | 3069.51        | 5       | 5     | 1.52E-01                     | 3256.72        | 3       | 3     | 1.31E-01                     |
| 2665.09        | 7       | 9     | 1.32E-01                     | 3069.96        | 11      | 11    | 2.72E-01                     | 3259.16        | 11      | 13    | 1.62E-01                     |
| 2679.85        | 9       | 11    | 1.31E+00                     | 3070.89        | 9       | 11    | 1.87E-01                     | 3262.63        | 7       | 9     | 3.62E-01                     |
| 2684.16        | 9       | 9     | 4.18E-01                     | 3074.37        | 11      | 11    | 1.42E+00                     | 3264.40        | 11      | 9     | 5.42E-01                     |
| 2706.11        | 3       | 5     | 2.03E-01                     | 3079.88        | 9       | 11    | 9.55E-01                     | 3265.14        | 5       | 7     | 2.60E-01                     |
| 2710.74        | 3       | 3     | 1.57E-01                     | 3080.40        | 7       | 9     | 3.61E-01                     | 3266.16        | 9       | 11    | 1.95E-01                     |
| 2725.15        | 3       | 5     | 2.79E-01                     | 3081.16        | 3       | 5     | 2.35E-01                     | 3270.90        | 7       | 7     | 3.59E-01                     |
| 2728.71        | 3       | 3     | 1.26E-01                     | 3085.62        | 9       | 9     | 1.63E+00                     | 3276.07        | 11      | 9     | 1.18E-01                     |
| 2733.39        | 5       | 7     | 2.95E-01                     | 3089.13        | 11      | 9     | 1.53E-01                     | 3285.03        | 1       | 3     | 1.41E-01                     |
| 2743.71        | 1       | 3     | 2.47E-01                     | 3089.71        | 5       | 7     | 2.34E-01                     | 3285.35        | 9       | 7     | 4.49E-01                     |
| 2745.38        | 13      | 11    | 1.29E-01                     | 3094.66        | 7       | 7     | 1.63E+00                     | 3287.38        | 5       | 5     | 1.38E-01                     |
| 2751.47        | 7       | 9     | 2.54E-01                     | 3099.92        | 9       | 7     | 1.45E-01                     | 3289.01        | 9       | 9     | 5.08E-01                     |
| 2756.26        | 5       | 3     | 1.18E-01                     | 3100.88        | 7       | 9     | 1.20E+00                     | 3290.82        | 7       | 5     | 5.44E-01                     |
| 2761.53        | 9       | 11    | 2.06E-01                     | 3101.34        | 5       | 5     | 1.92E+00                     | 3305.56        | 5       | 3     | 1.74E-01                     |
| 2763.02        | 3       | 1     | 4.44E-01                     | 3106.34        | 7       | 5     | 2.21E-01                     | 3305.91        | 7       | 9     | 3.06E-01                     |
| 2766.25        | 3       | 5     | 1.17E-01                     | 3117.54        | 13      | 13    | 1.89E-01                     | 3307.13        | 7       | 9     | 1.25E-01                     |
| 2787.83        | 9       | 7     | 2.85E-01                     | 3123.03        | 3       | 3     | 2.81E-01                     | 3312.33        | 7       | 5     | 1.62E-01                     |
| 2792.96        | 5       | 3     | 1.53E-01                     | 3125.03        | 5       | 3     | 1.98E-01                     | 3323.95        | 9       | 7     | 2.82E-01                     |
| 2798.02        | 7       | 5     | 1.22E-01                     | 3132.59        | 7       | 9     | 1.79E+00                     | 3325.13        | 5       | 3     | 2.26E-01                     |
| 2801.47        | 5       | 7     | 1.24E-01                     | 3135.90        | 9       | 11    | 3.68E-01                     | 3325.67        | 5       | 5     | 1.72E-01                     |
| 2825.68        | 5       | 7     | 2.53E-01                     | 3136.75        | 9       | 11    | 1.57E-01                     | 3327.30        | 1       | 3     | 2.88E-01                     |
| 2826.75        | 7       | 7     | 4.23E-01                     | 3142.75        | 3       | 5     | 4.10E-01                     | 3336.56        | 9       | 9     | 1.64E-01                     |
| 2876.54        | 9       | 9     | 2.84E-01                     | 3147.35        | 13      | 11    | 2.41E-01                     | 3340.16        | 5       | 3     | 1.20E-01                     |
| 2886.60        | 11      | 11    | 4.74E-01                     | 3155.19        | 7       | 7     | 2.75E-01                     | 3344.73        | 3       | 5     | 6.04E-01                     |
| 2906.06        | 3       | 3     | 8.04E-01                     | 3158.17        | 7       | 7     | 4.63E-01                     | 3346.83        | 11      | 11    | 1.13E-01                     |
| 2913.52        | 5       | 3     | 1.38E-01                     | 3170.34        | 7       | 7     | 1.37E+00                     | 3347.00        | 3       | 3     | 2.72E-01                     |
| 2915.38        | 5       | 3     | 7.31E-01                     | 3171.38        | 5       | 7     | 2.03E-01                     | 3358.12        | 5       | 7     | 7.59E-01                     |
| 2918.84        | 5       | 3     | 3.79E-01                     | 3175.59        | 13      | 11    | 8.40E-01                     | 3361.37        | 9       | 9     | 1.38E-01                     |
| 2930.39        | 1       | 3     | 1.91E-01                     | 3179.78        | 11      | 13    | 2.33E-01                     | 3363.78        | 5       | 7     | 2.74E-01                     |
| 2936.50        | 11      | 11    | 2.33E-01                     | 3183.03        | 11      | 9     | 3.98E-01                     | 3363.87        | 5       | 7     | 1.39E-01                     |
| 2945.43        | 7       | 7     | 3.66E-01                     | 3184.58        | 7       | 5     | 2.77E-01                     | 3373.81        | 3       | 3     | 2.03E-01                     |
| 2945.66        | 3       | 3     | 4.08E-01                     | 3185.10        | 7       | 7     | 2.54E-01                     | 3375.22        | 7       | 7     | 1.38E-01                     |
| 2946.01        | 5       | 5     | 1.68E-01                     | 3185.71        | 5       | 3     | 6.10E-01                     | 3375.65        | 7       | 9     | 1.56E-01                     |
| 2951.45        | 9       | 9     | 1.43E-01                     | 3188.10        | 7       | 9     | 3.45E-01                     | 3378.19        | 3       | 1     | 1.88E-01                     |
| 2959.48        | 9       | 11    | 1.75E-01                     | 3188.41        | 5       | 7     | 4.40E-01                     | 3378.46        | 13      | 13    | 3.75E-01                     |
| 2972.96        | 5       | 3     | 2.69E-01                     | 3192.79        | 9       | 11    | 1.88E-01                     | 3379.96        | 5       | 5     | 4.11E-01                     |
| 2977.27        | 9       | 7     | 3.28E-01                     | 3193.98        | 7       | 5     | 1.53E+00                     | 3382.48        | 3       | 3     | 2.66E-01                     |
| 2978.28        | 7       | 5     | 1.50E-01                     | 3194.88        | 9       | 11    | 1.75E-01                     | 3384.61        | 7       | 9     | 7.32E-01                     |
| 2983.04        | 1       | 3     | 2.82E-01                     | 3195.96        | 9       | 7     | 4.10E-01                     | 3385.87        | 9       | 11    | 3.30E-01                     |
| 2987.92        | 3       | 5     | 8.43E-01                     | 3197.18        | 1       | 3     | 1.47E-01                     | 3389.79        | 5       | 7     | 1.85E-01                     |
| 2988.23        | 5       | 7     | 4.28E-01                     | 3198.85        | 15      | 13    | 7.22E-01                     | 3392.17        | 9       | 9     | 1.97E-01                     |
| 2988.68        | 7       | 9     | 1.61E-01                     | 3200.89        | 3       | 5     | 1.82E-01                     | 3393.65        | 11      | 11    | 2.08E-01                     |
| 2989.80        | 9       | 7     | 9.27E-01                     | 3205.22        | 1       | 3     | 4.27E-01                     | 3404.33        | 7       | 7     | 2.10E-01                     |
| 3000.24        | 9       | 9     | 1.40E-01                     | 3205.43        | 9       | 11    | 2.55E-01                     | 3413.37        | 11      | 11    | 1.25E-01                     |
| 3000.44        | 5       | 5     | 1.25E-01                     | 3205.89        | 9       | 9     | 5.35E-01                     | 3415.27        | 9       | 9     | 1.83E-01                     |
| 3000.85        | 5       | 7     | 2.58E-01                     | 3208.84        | 7       | 5     | 2.77E-01                     | 3415.61        | 7       | 9     | 1.29E-01                     |
| 3001.43        | 5       | 5     | 2.31E-01                     | 3210.97        | 7       | 5     | 6.94E-01                     | 3416.14        | 9       | 11    | 2.45E-01                     |
| 3007.71        | 7       | 5     | 1.90E-01                     | 3214.44        | 9       | 7     | 2.01E-01                     | 3418.52        | 5       | 3     | 1.41E-01                     |
| 3013.39        | 7       | 5     | 6.06E-01                     | 3215.07        | 3       | 5     | 4.20E-01                     | 3419.69        | 7       | 7     | 1.15E-01                     |
| 3016.78        | 9       | 9     | 2.75E-01                     | 3216.78        | 15      | 13    | 2.10E-01                     | 3420.04        | 5       | 5     | 3.28E-01                     |
| 3025.00        | 5       | 5     | 8.49E-01                     | 3221.73        | 3       | 1     | 1.41E+00                     | 3422.31        | 9       | 9     | 2.52E-01                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3425.13        | 11      | 11    | 2.29E-01                     | 3598.88        | 13      | 11    | 5.67E-01                     | 3777.72        | 13      | 11    | 1.66E-01                     |
| 3427.90        | 11      | 13    | 4.09E-01                     | 3600.73        | 9       | 9     | 2.07E-01                     | 3788.25        | 7       | 9     | 2.87E-01                     |
| 3434.79        | 7       | 7     | 1.75E-01                     | 3601.88        | 7       | 9     | 1.15E-01                     | 3794.43        | 9       | 9     | 1.22E-01                     |
| 3435.45        | 15      | 15    | 1.50E+00                     | 3602.94        | 5       | 7     | 2.96E-01                     | 3797.47        | 7       | 5     | 1.48E-01                     |
| 3437.21        | 11      | 9     | 8.06E-01                     | 3604.07        | 9       | 7     | 3.25E-01                     | 3798.25        | 7       | 9     | 6.90E-01                     |
| 3438.87        | 1       | 3     | 2.34E-01                     | 3610.61        | 5       | 3     | 1.78E-01                     | 3801.84        | 9       | 7     | 3.16E-01                     |
| 3441.87        | 5       | 3     | 1.34E-01                     | 3611.99        | 7       | 7     | 1.16E-01                     | 3805.99        | 5       | 5     | 2.44E-01                     |
| 3442.66        | 3       | 3     | 2.94E-01                     | 3615.16        | 7       | 9     | 1.96E-01                     | 3819.78        | 9       | 11    | 1.47E-01                     |
| 3445.03        | 7       | 9     | 1.53E-01                     | 3623.22        | 11      | 9     | 5.58E-01                     | 3824.78        | 5       | 7     | 1.40E-01                     |
| 3445.26        | 7       | 5     | 2.96E-01                     | 3624.46        | 9       | 11    | 5.27E-01                     | 3827.15        | 7       | 7     | 1.94E-01                     |
| 3445.80        | 9       | 9     | 1.14E-01                     | 3624.62        | 5       | 7     | 1.37E-01                     | 3828.88        | 7       | 7     | 1.35E-01                     |
| 3447.12        | 9       | 11    | 8.75E-01                     | 3638.20        | 5       | 3     | 3.51E-01                     | 3830.81        | 5       | 5     | 1.83E-01                     |
| 3447.29        | 5       | 3     | 1.79E-01                     | 3638.21        | 5       | 3     | 3.33E-01                     | 3831.07        | 7       | 9     | 1.20E-01                     |
| 3449.07        | 7       | 9     | 1.52E-01                     | 3640.62        | 7       | 5     | 1.94E-01                     | 3832.11        | 9       | 9     | 3.05E-01                     |
| 3449.85        | 5       | 7     | 1.65E-01                     | 3647.84        | 7       | 7     | 2.11E-01                     | 3833.75        | 9       | 9     | 1.70E-01                     |
| 3452.60        | 7       | 7     | 2.48E-01                     | 3648.70        | 7       | 5     | 1.15E-01                     | 3834.64        | 3       | 5     | 1.20E-01                     |
| 3456.15        | 5       | 5     | 3.60E-01                     | 3654.58        | 3       | 3     | 1.80E-01                     | 3846.18        | 7       | 7     | 1.26E-01                     |
| 3456.52        | 3       | 3     | 2.96E-01                     | 3657.36        | 5       | 7     | 2.03E-01                     | 3847.25        | 3       | 1     | 2.41E-01                     |
| 3460.22        | 5       | 3     | 2.77E-01                     | 3658.13        | 9       | 9     | 1.86E-01                     | 3848.30        | 9       | 9     | 1.26E-01                     |
| 3460.78        | 9       | 7     | 6.03E-01                     | 3659.36        | 7       | 9     | 6.70E-01                     | 3851.99        | 11      | 9     | 1.78E-01                     |
| 3465.84        | 3       | 1     | 9.99E-01                     | 3660.92        | 3       | 5     | 1.34E-01                     | 3864.10        | 7       | 7     | 6.24E-01                     |
| 3466.19        | 9       | 7     | 2.11E-01                     | 3662.15        | 7       | 9     | 1.45E-01                     | 3866.69        | 3       | 5     | 1.74E-01                     |
| 3466.96        | 7       | 7     | 1.52E-01                     | 3662.99        | 11      | 11    | 3.48E-01                     | 3867.67        | 5       | 3     | 2.22E-01                     |
| 3467.85        | 5       | 7     | 2.63E-01                     | 3663.27        | 7       | 5     | 2.30E-01                     | 3869.08        | 5       | 3     | 1.35E-01                     |
| 3469.22        | 5       | 3     | 6.96E-01                     | 3664.81        | 11      | 13    | 9.54E-01                     | 3874.15        | 7       | 5     | 1.67E-01                     |
| 3469.63        | 13      | 15    | 1.51E-01                     | 3664.88        | 1       | 3     | 1.92E-01                     | 3902.95        | 7       | 5     | 6.17E-01                     |
| 3470.92        | 3       | 5     | 2.91E-01                     | 3669.34        | 9       | 7     | 2.16E-01                     | 3909.54        | 9       | 7     | 1.13E-01                     |
| 3475.03        | 3       | 3     | 4.68E-01                     | 3672.81        | 9       | 11    | 1.95E-01                     | 3911.94        | 5       | 5     | 1.15E-01                     |
| 3479.42        | 7       | 5     | 2.26E-01                     | 3672.82        | 9       | 9     | 1.13E-01                     | 3915.43        | 5       | 5     | 1.40E-01                     |
| 3483.67        | 7       | 7     | 1.13E-01                     | 3676.23        | 3       | 1     | 5.22E-01                     | 3916.43        | 5       | 3     | 1.78E-01                     |
| 3483.83        | 7       | 5     | 1.41E-01                     | 3680.68        | 11      | 11    | 2.96E-01                     | 3919.55        | 11      | 13    | 2.24E-01                     |
| 3489.43        | 7       | 7     | 3.27E-01                     | 3681.72        | 9       | 7     | 1.68E-01                     | 3955.48        | 13      | 11    | 1.71E-01                     |
| 3504.41        | 7       | 9     | 8.06E-01                     | 3683.01        | 3       | 5     | 1.20E-01                     | 3973.76        | 11      | 13    | 4.39E-01                     |
| 3505.31        | 7       | 9     | 2.25E-01                     | 3687.96        | 5       | 7     | 2.12E-01                     | 3977.90        | 9       | 7     | 1.35E-01                     |
| 3508.11        | 9       | 9     | 1.59E-01                     | 3688.97        | 11      | 9     | 3.26E-01                     | 3980.20        | 5       | 3     | 2.70E-01                     |
| 3510.77        | 13      | 13    | 4.75E-01                     | 3690.59        | 11      | 9     | 2.07E-01                     | 3991.85        | 11      | 9     | 1.29E-01                     |
| 3517.55        | 11      | 11    | 5.41E-01                     | 3694.94        | 5       | 7     | 6.36E-01                     | 4010.13        | 5       | 3     | 4.38E-01                     |
| 3518.21        | 3       | 3     | 3.64E-01                     | 3696.04        | 11      | 11    | 3.59E-01                     | 4021.01        | 9       | 11    | 2.65E-01                     |
| 3521.38        | 9       | 9     | 1.39E-01                     | 3698.07        | 7       | 5     | 1.48E-01                     | 4051.18        | 13      | 11    | 1.36E-01                     |
| 3521.41        | 9       | 11    | 6.06E-01                     | 3708.55        | 7       | 9     | 1.28E-01                     | 4062.08        | 11      | 9     | 1.96E-01                     |
| 3524.65        | 5       | 3     | 3.10E-01                     | 3715.75        | 9       | 7     | 2.38E-01                     | 4069.88        | 13      | 11    | 3.25E-01                     |
| 3524.98        | 7       | 9     | 2.25E-01                     | 3718.48        | 5       | 7     | 1.34E-01                     | 4076.19        | 9       | 9     | 1.16E-01                     |
| 3538.92        | 11      | 11    | 2.24E-01                     | 3720.25        | 7       | 9     | 2.86E-01                     | 4084.37        | 9       | 7     | 1.94E-01                     |
| 3540.57        | 5       | 3     | 4.46E-01                     | 3725.55        | 7       | 7     | 1.60E-01                     | 4102.15        | 5       | 3     | 1.22E-01                     |
| 3542.17        | 7       | 5     | 4.93E-01                     | 3727.68        | 9       | 11    | 1.51E-01                     | 4107.46        | 7       | 5     | 2.02E-01                     |
| 3552.71        | 9       | 7     | 3.64E-01                     | 3728.30        | 7       | 5     | 1.55E-01                     | 4120.09        | 13      | 15    | 6.05E-01                     |
| 3555.64        | 3       | 3     | 3.46E-01                     | 3728.50        | 7       | 9     | 2.20E-01                     | 4131.92        | 9       | 11    | 1.56E-01                     |
| 3558.09        | 5       | 7     | 5.43E-01                     | 3733.02        | 7       | 7     | 1.45E-01                     | 4148.98        | 9       | 11    | 1.56E-01                     |
| 3563.75        | 1       | 3     | 1.53E-01                     | 3733.41        | 13      | 13    | 2.80E-01                     | 4157.40        | 13      | 11    | 2.17E-01                     |
| 3566.05        | 9       | 9     | 2.67E-01                     | 3735.62        | 11      | 11    | 1.66E-01                     | 4157.90        | 9       | 11    | 1.60E-01                     |
| 3566.74        | 7       | 7     | 1.43E-01                     | 3742.28        | 7       | 7     | 1.56E-01                     | 4185.82        | 11      | 13    | 3.82E-01                     |
| 3570.64        | 15      | 15    | 7.18E-01                     | 3747.19        | 5       | 7     | 3.07E-01                     | 4188.32        | 11      | 13    | 3.32E-01                     |
| 3573.88        | 3       | 5     | 3.58E-01                     | 3748.48        | 9       | 11    | 3.95E-01                     | 4194.56        | 11      | 11    | 2.70E-01                     |
| 3580.54        | 13      | 11    | 5.49E-01                     | 3755.10        | 3       | 5     | 1.41E-01                     | 4232.59        | 9       | 11    | 3.17E-01                     |
| 3581.88        | 11      | 13    | 3.81E-01                     | 3755.16        | 9       | 9     | 2.48E-01                     | 4240.83        | 5       | 5     | 1.68E-01                     |
| 3584.25        | 3       | 3     | 1.73E-01                     | 3758.52        | 9       | 9     | 1.22E-01                     | 4246.02        | 11      | 13    | 2.00E-01                     |
| 3585.57        | 7       | 5     | 3.95E-01                     | 3759.60        | 9       | 7     | 1.82E-01                     | 4251.88        | 13      | 11    | 1.76E-01                     |
| 3588.95        | 7       | 7     | 1.18E-01                     | 3760.88        | 9       | 9     | 2.16E-01                     | 4254.95        | 7       | 9     | 2.01E-01                     |
| 3590.74        | 7       | 9     | 2.23E-01                     | 3768.73        | 9       | 9     | 2.88E-01                     | 4269.28        | 11      | 11    | 1.36E-01                     |
| 3595.55        | 5       | 5     | 2.32E-01                     | 3769.99        | 7       | 9     | 2.46E-01                     | 4276.91        | 7       | 9     | 2.85E-01                     |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å   | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|------------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                  | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 4277.24        | 9       | 11    | 1.35E-01                     | 5926.37          | 7       | 7     | 1.63E-01                     | 735.90         | 1       | 3     | 6.11E+00                     |
| 4317.92        | 15      | 15    | 1.28E-01                     | 5928.88          | 7       | 9     | 5.32E-01                     | 743.72         | 1       | 3     | 4.86E-01                     |
| 4325.80        | 3       | 3     | 1.84E-01                     | 7154.11          | 9       | 9     | 3.45E-01                     | 3369.8         | 5       | 5     | 1.0E-03                      |
| 4326.14        | 5       | 7     | 2.56E-01                     | <i>Neodymium</i> |         |       |                              | 3369.9         | 5       | 3     | 7.6E-03                      |
| 4340.74        | 5       | 7     | 1.23E-01                     | <i>Nd II</i>     |         |       |                              | 3375.6         | 5       | 3     | 2.2E-03                      |
| 4381.63        | 13      | 13    | 2.93E-01                     | 3780.4           | 16      | 18    | 1.4E-01                      | 3417.9         | 3       | 5     | 9.2E-03                      |
| 4382.41        | 11      | 13    | 3.83E-01                     | 3805.4           | 14      | 16    | 6.9E-01                      | 3418.0         | 3       | 3     | 2.2E-03                      |
| 4409.94        | 13      | 13    | 1.38E-01                     | 3807.2           | 10      | 12    | 4.9E-02                      | 3423.9         | 3       | 3     | 1.0E-03                      |
| 4411.69        | 11      | 11    | 2.63E-01                     | 3863.3           | 8       | 10    | 1.5E-01                      | 3447.7         | 5       | 5     | 2.1E-02                      |
| 4434.95        | 9       | 9     | 2.51E-01                     | 3941.5           | 10      | 10    | 6.1E-01                      | 3450.8         | 5       | 3     | 4.9E-03                      |
| 4446.42        | 11      | 11    | 1.90E-01                     | 3951.2           | 12      | 12    | 6.0E-01                      | 3454.2         | 3       | 1     | 3.7E-02                      |
| 4457.35        | 7       | 7     | 1.28E-01                     | 3973.3           | 18      | 18    | 6.3E-01                      | 3460.5         | 1       | 3     | 7.0E-03                      |
| 4474.57        | 5       | 5     | 2.10E-01                     | 3979.5           | 10      | 12    | 2.7E-01                      | 3464.3         | 5       | 5     | 6.7E-03                      |
| 4491.65        | 11      | 11    | 2.09E-01                     | 3990.1           | 16      | 16    | 5.2E-01                      | 3466.6         | 1       | 3     | 1.3E-02                      |
| 4536.80        | 13      | 15    | 5.03E-01                     | 4012.3           | 18      | 20    | 5.5E-01                      | 3472.6         | 5       | 7     | 1.7E-02                      |
| 4598.23        | 1       | 3     | 1.47E-01                     | 4061.1           | 16      | 18    | 4.4E-01                      | 3498.1         | 3       | 5     | 5.1E-03                      |
| 4624.23        | 9       | 9     | 1.32E-01                     | 4106.6           | 14      | 16    | 6.8E-02                      | 3501.2         | 3       | 3     | 1.2E-02                      |
| 4633.08        | 3       | 5     | 2.35E-01                     | 4109.5           | 14      | 16    | 3.7E-01                      | 3510.7         | 5       | 3     | 2.2E-03                      |
| 4649.06        | 3       | 1     | 1.25E-01                     | 4133.4           | 14      | 12    | 1.5E-01                      | 3515.2         | 3       | 5     | 6.9E-03                      |
| 4652.24        | 5       | 7     | 1.55E-01                     | 4156.1           | 12      | 14    | 3.4E-01                      | 3520.5         | 3       | 1     | 9.3E-02                      |
| 4686.08        | 3       | 3     | 1.72E-01                     | 4205.6           | 18      | 16    | 1.8E-01                      | 3593.5         | 3       | 5     | 9.9E-03                      |
| 4688.21        | 13      | 15    | 1.54E-01                     | 4284.5           | 18      | 18    | 8.5E-02                      | 3593.6         | 3       | 3     | 6.6E-03                      |
| 4707.25        | 7       | 9     | 3.63E-01                     | 4303.6           | 8       | 10    | 4.7E-01                      | 3600.2         | 3       | 3     | 4.3E-03                      |
| 4718.86        | 5       | 5     | 2.17E-01                     | 4325.8           | 16      | 16    | 1.6E-01                      | 3633.7         | 3       | 1     | 1.1E-02                      |
| 4723.05        | 9       | 9     | 1.23E-01                     | 4358.2           | 14      | 14    | 1.5E-01                      | 3682.2         | 3       | 5     | 1.6E-03                      |
| 4731.44        | 9       | 11    | 4.49E-01                     | 4382.7           | 12      | 10    | 4.0E-02                      | 3685.7         | 3       | 3     | 3.9E-03                      |
| 4758.50        | 11      | 9     | 3.01E-01                     | 4400.8           | 10      | 10    | 6.8E-02                      | 3701.2         | 3       | 5     | 2.2E-03                      |
| 4760.18        | 11      | 13    | 4.67E-01                     | 4451.6           | 12      | 14    | 2.5E-01                      | 4536.3         | 3       | 3     | 5.0E-03                      |
| 4764.11        | 9       | 7     | 2.16E-01                     | 4456.4           | 16      | 18    | 6.4E-02                      | 4702.5         | 3       | 3     | 2.1E-03                      |
| 4811.05        | 13      | 11    | 4.36E-01                     | 4463.0           | 14      | 16    | 1.8E-01                      | 4708.9         | 3       | 3     | 4.2E-02                      |
| 4819.25        | 11      | 9     | 2.71E-01                     | 4958.1           | 12      | 10    | 1.2E-02                      | 4955.4         | 3       | 3     | 3.3E-03                      |
| 4830.51        | 9       | 7     | 4.07E-01                     | 5130.6           | 22      | 20    | 1.6E-01                      | 5113.7         | 3       | 3     | 1.0E-02                      |
| 4858.39        | 13      | 11    | 1.24E-01                     | 5192.6           | 20      | 18    | 1.7E-01                      | 5120.5         | 3       | 3     | 5.6E-03                      |
| 4868.02        | 7       | 5     | 3.11E-01                     | 5249.6           | 18      | 16    | 1.8E-01                      | 5154.4         | 3       | 3     | 1.9E-02                      |
| 5037.18        | 9       | 7     | 1.14E-01                     | 5276.9           | 12      | 10    | 1.2E-01                      | 5191.3         | 3       | 3     | 1.3E-02                      |
| 5044.36        | 7       | 5     | 1.31E-01                     | 5293.2           | 16      | 14    | 1.2E-01                      | 5326.4         | 3       | 3     | 6.8E-03                      |
| 5047.70        | 3       | 1     | 2.61E-01                     | 5302.3           | 20      | 18    | 1.1E-01                      | 5333.3         | 3       | 3     | 5.3E-03                      |
| 5163.18        | 9       | 11    | 2.03E-01                     | 5311.5           | 14      | 12    | 1.1E-01                      | 5341.1         | 3       | 3     | 1.1E-01                      |
| 5171.06        | 5       | 7     | 1.84E-01                     | 5319.8           | 12      | 10    | 1.6E-01                      | 5400.6         | 3       | 1     | 9.0E-03                      |
| 5172.94        | 5       | 5     | 4.11E-01                     | 5357.0           | 18      | 16    | 1.8E-01                      | 5418.6         | 3       | 3     | 5.2E-03                      |
| 5174.18        | 5       | 3     | 5.83E-01                     | 5371.9           | 20      | 20    | 5.1E-02                      | 5433.7         | 3       | 3     | 2.83E-03                     |
| 5191.45        | 7       | 9     | 1.62E-01                     | 5485.7           | 18      | 18    | 5.7E-02                      | 5652.6         | 3       | 3     | 8.9E-03                      |
| 5238.21        | 7       | 9     | 3.74E-01                     | 5594.4           | 16      | 16    | 7.0E-02                      | 5662.5         | 3       | 3     | 6.9E-03                      |
| 5240.87        | 7       | 7     | 3.89E-01                     | 5620.6           | 18      | 18    | 1.3E-01                      | 5852.5         | 3       | 1     | 6.82E-01                     |
| 5242.80        | 7       | 5     | 2.01E-01                     | 5688.5           | 14      | 14    | 5.9E-02                      | 5868.4         | 3       | 3     | 1.4E-02                      |
| 5261.53        | 5       | 7     | 1.13E-01                     | 5718.1           | 16      | 16    | 8.7E-02                      | 5881.9         | 5       | 3     | 1.15E-01                     |
| 5280.85        | 5       | 5     | 1.28E-01                     | 5726.8           | 10      | 10    | 5.6E-02                      | 5913.6         | 3       | 3     | 4.8E-02                      |
| 5355.52        | 9       | 9     | 1.21E-01                     | 5740.9           | 12      | 12    | 7.2E-02                      | 5939.3         | 5       | 3     | 2.00E-03                     |
| 5356.46        | 11      | 11    | 2.11E-01                     | 5804.0           | 10      | 10    | 4.6E-02                      | 5944.8         | 5       | 5     | 1.13E-01                     |
| 5360.51        | 9       | 11    | 6.19E-01                     | 5865.1           | 16      | 18    | 1.3E-02                      | 5961.6         | 3       | 3     | 3.3E-02                      |
| 5364.28        | 9       | 9     | 2.26E-01                     | 6051.9           | 12      | 10    | 1.1E-02                      | 5975.5         | 5       | 3     | 3.51E-02                     |
| 5460.50        | 5       | 3     | 3.46E-01                     | <i>Neon</i>      |         |       |                              | 6030.0         | 3       | 3     | 5.61E-02                     |
| 5493.76        | 7       | 5     | 2.13E-01                     | <i>Ne I</i>      |         |       |                              | 6046.1         | 3       | 3     | 2.26E-03                     |
| 5506.49        | 5       | 7     | 3.61E-01                     | 615.63           | 1       | 3     | 3.8E-01                      | 6074.3         | 3       | 1     | 6.03E-01                     |
| 5533.03        | 5       | 5     | 3.72E-01                     | 618.67           | 1       | 3     | 9.3E-01                      | 6096.2         | 3       | 5     | 1.81E-01                     |
| 5570.44        | 5       | 3     | 3.30E-01                     | 619.10           | 1       | 3     | 3.3E-01                      | 6118.0         | 5       | 3     | 6.09E-03                     |
| 5849.71        | 3       | 3     | 3.02E-01                     | 626.82           | 1       | 3     | 7.4E-01                      | 6128.5         | 3       | 3     | 6.7E-03                      |
| 5851.50        | 3       | 5     | 1.55E-01                     | 629.74           | 1       | 3     | 4.8E-01                      | 6143.1         | 5       | 5     | 2.82E-01                     |
| 5893.36        | 5       | 5     | 2.60E-01                     |                  |         |       |                              | 6150.3         | 3       | 3     | 1.5E-02                      |
| 5895.93        | 5       | 7     | 3.12E-01                     |                  |         |       |                              | 6163.6         | 1       | 3     | 1.46E-01                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 6217.3         | 5       | 3     | 6.37E-02                     | 462.39         | 2       | 2     | 2.3E+01                      | 3243.4         | 6       | 6     | 2.3E-01                      |
| 6266.5         | 1       | 3     | 2.49E-01                     | 1907.5         | 4       | 2     | 2.8E-01                      | 3244.1         | 6       | 8     | 1.5E+00                      |
| 6273.0         | 3       | 3     | 9.7E-03                      | 1916.1         | 4       | 4     | 6.9E-01                      | 3248.1         | 4       | 4     | 2.4E-01                      |
| 6293.7         | 3       | 3     | 6.39E-03                     | 1930.0         | 2       | 2     | 5.7E-01                      | 3255.4         | 6       | 4     | 3.8E-02                      |
| 6304.8         | 3       | 5     | 4.16E-02                     | 1938.8         | 2       | 4     | 1.3E-01                      | 3263.4         | 2       | 4     | 3.9E-01                      |
| 6328.2         | 5       | 3     | 3.39E-02                     | 2858.0         | 6       | 6     | 7.9E-01                      | 3269.9         | 4       | 6     | 5.1E-01                      |
| 6330.9         | 3       | 3     | 2.3E-02                      | 2870.0         | 6       | 6     | 1.7E-01                      | 3270.8         | 6       | 4     | 5.7E-02                      |
| 6334.4         | 5       | 5     | 1.61E-01                     | 2873.0         | 6       | 4     | 3.8E-01                      | 3297.7         | 6       | 6     | 4.3E-01                      |
| 6351.9         | 1       | 3     | 3.45E-03                     | 2876.3         | 4       | 6     | 7.8E-01                      | 3309.7         | 4       | 2     | 3.1E-01                      |
| 6383.0         | 3       | 3     | 3.21E-01                     | 2876.5         | 6       | 4     | 3.3E-01                      | 3310.5         | 4       | 4     | 6.9E-02                      |
| 6401.1         | 3       | 3     | 1.39E-02                     | 2878.1         | 2       | 2     | 6.9E-02                      | 3311.3         | 4       | 2     | 2.6E-01                      |
| 6402.2         | 5       | 7     | 5.14E-01                     | 2888.4         | 4       | 6     | 7.0E-02                      | 3314.7         | 6       | 6     | 4.4E-02                      |
| 6506.5         | 3       | 5     | 3.00E-01                     | 2891.5         | 4       | 4     | 6.1E-02                      | 3319.7         | 4       | 2     | 1.6E+00                      |
| 6532.9         | 1       | 3     | 1.08E-01                     | 2897.0         | 6       | 8     | 5.2E-02                      | 3320.2         | 8       | 6     | 2.1E-01                      |
| 6599.0         | 3       | 3     | 2.32E-01                     | 2906.8         | 2       | 4     | 5.5E-01                      | 3323.7         | 4       | 4     | 1.6E+00                      |
| 6602.9         | 3       | 3     | 5.9E-03                      | 2910.1         | 4       | 2     | 1.7E+00                      | 3327.2         | 4       | 4     | 9.1E-01                      |
| 6652.1         | 3       | 1     | 2.9E-03                      | 2910.4         | 2       | 4     | 5.9E-01                      | 3329.2         | 8       | 8     | 8.8E-01                      |
| 6678.3         | 3       | 5     | 2.33E-01                     | 2916.2         | 6       | 4     | 9.6E-02                      | 3330.7         | 6       | 6     | 3.9E-02                      |
| 6717.0         | 3       | 3     | 2.17E-01                     | 2925.6         | 2       | 2     | 5.6E-01                      | 3334.8         | 6       | 8     | 1.8E+00                      |
| 6721.1         | 3       | 3     | 4.9E-04                      | 2933.7         | 6       | 6     | 6.9E-02                      | 3336.1         | 4       | 6     | 1.1E+00                      |
| 6929.5         | 3       | 5     | 1.74E-01                     | 2955.7         | 6       | 4     | 1.2E+00                      | 3344.4         | 2       | 2     | 1.5E+00                      |
| 7024.1         | 3       | 3     | 1.89E-02                     | 3001.7         | 4       | 4     | 8.7E-01                      | 3345.5         | 6       | 4     | 1.4E+00                      |
| 7032.4         | 5       | 3     | 2.53E-01                     | 3017.3         | 6       | 4     | 3.5E-01                      | 3345.8         | 4       | 4     | 2.2E-01                      |
| 7051.3         | 3       | 3     | 3.0E-02                      | 3027.0         | 6       | 6     | 1.4E+00                      | 3353.6         | 4       | 2     | 1.2E-01                      |
| 7059.1         | 3       | 5     | 6.8E-02                      | 3028.7         | 4       | 2     | 8.5E-01                      | 3355.0         | 4       | 6     | 1.3E+00                      |
| 7173.9         | 3       | 5     | 2.87E-02                     | 3028.9         | 2       | 4     | 4.7E-01                      | 3356.3         | 6       | 6     | 2.0E-01                      |
| 7245.2         | 3       | 3     | 9.35E-02                     | 3034.5         | 6       | 8     | 3.1E+00                      | 3357.8         | 6       | 6     | 5.0E-01                      |
| 7304.8         | 1       | 3     | 2.55E-03                     | 3037.7         | 4       | 4     | 2.1E+00                      | 3360.3         | 2       | 4     | 8.6E-01                      |
| 7438.9         | 1       | 3     | 2.31E-02                     | 3045.6         | 2       | 2     | 2.5E+00                      | 3360.6         | 2       | 4     | 8.2E-01                      |
| 7472.4         | 3       | 3     | 4.0E-02                      | 3047.6         | 4       | 6     | 1.8E+00                      | 3362.9         | 4       | 2     | 3.5E-01                      |
| 7535.8         | 3       | 3     | 4.3E-01                      | 3054.7         | 2       | 4     | 9.4E-01                      | 3371.8         | 4       | 6     | 2.2E-01                      |
| 7937.0         | 5       | 5     | 7.8E-03                      | 3092.9         | 6       | 6     | 1.3E+00                      | 3374.1         | 4       | 4     | 3.0E-01                      |
| 8082.5         | 3       | 3     | 1.2E-03                      | 3097.1         | 8       | 8     | 1.3E+00                      | 3378.2         | 2       | 2     | 1.7E+00                      |
| 8118.5         | 3       | 3     | 4.9E-02                      | 3118.0         | 8       | 6     | 4.2E-02                      | 3379.3         | 2       | 2     | 3.0E-01                      |
| 8128.9         | 3       | 5     | 7.2E-03                      | 3134.1         | 6       | 4     | 2.6E-01                      | 3386.2         | 4       | 6     | 5.5E-02                      |
| 8259.4         | 5       | 5     | 2.03E-02                     | 3140.4         | 8       | 6     | 2.4E-01                      | 3388.4         | 4       | 6     | 2.2E+00                      |
| 8571.4         | 3       | 3     | 5.5E-02                      | 3151.1         | 6       | 6     | 4.8E-02                      | 3390.6         | 2       | 4     | 7.7E-02                      |
| 8582.9         | 3       | 5     | 1.00E-02                     | 3154.8         | 8       | 6     | 1.8E-02                      | 3392.8         | 2       | 4     | 4.4E-01                      |
| 8647.0         | 5       | 5     | 3.91E-02                     | 3164.4         | 8       | 8     | 1.6E-01                      | 3404.8         | 4       | 6     | 1.9E+00                      |
| 8681.9         | 3       | 3     | 2.1E-01                      | 3165.7         | 6       | 6     | 1.2E-01                      | 3407.0         | 6       | 8     | 2.3E+00                      |
| 8767.5         | 3       | 3     | 1.1E-03                      | 3173.6         | 6       | 4     | 4.5E-02                      | 3411.4         | 4       | 2     | 6.1E-01                      |
| 8771.7         | 3       | 3     | 1.6E-01                      | 3176.1         | 4       | 6     | 6.0E-02                      | 3413.2         | 4       | 4     | 1.8E+00                      |
| 8783.8         | 3       | 5     | 3.13E-01                     | 3187.6         | 4       | 6     | 1.4E-02                      | 3414.9         | 4       | 6     | 1.8E-02                      |
| 8865.3         | 3       | 3     | 9.4E-03                      | 3188.7         | 6       | 6     | 3.9E-01                      | 3416.9         | 6       | 6     | 6.4E-01                      |
| 9201.8         | 3       | 3     | 9.1E-02                      | 3190.9         | 4       | 6     | 1.5E-01                      | 3417.7         | 6       | 8     | 1.6E+00                      |
| 9433.0         | 3       | 3     | 1.1E-03                      | 3194.6         | 4       | 4     | 5.2E-01                      | 3438.9         | 2       | 2     | 1.4E+00                      |
| 9486.7         | 3       | 3     | 2.5E-02                      | 3198.6         | 6       | 8     | 1.7E+00                      | 3440.7         | 2       | 4     | 3.5E-01                      |
| 9534.2         | 3       | 3     | 6.3E-02                      | 3198.9         | 4       | 4     | 2.3E-01                      | 3453.1         | 4       | 4     | 4.6E-01                      |
| 10621          | 3       | 3     | 2.4E-03                      | 3209.0         | 8       | 8     | 1.6E-01                      | 3454.8         | 4       | 4     | 1.6E+00                      |
| 11409          | 3       | 3     | 4.2E-02                      | 3209.4         | 2       | 4     | 6.0E-01                      | 3456.6         | 2       | 4     | 9.6E-01                      |
| 11525          | 3       | 3     | 8.4E-02                      | 3213.7         | 2       | 4     | 1.7E+00                      | 3457.1         | 4       | 6     | 9.9E-02                      |
| 11767          | 3       | 3     | 6.9E-02                      | 3214.3         | 4       | 6     | 2.2E+00                      | 3459.3         | 6       | 6     | 1.6E+00                      |
| 12459          | 3       | 3     | 1.5E-02                      | 3218.2         | 8       | 10    | 3.6E+00                      | 3475.2         | 4       | 4     | 1.2E-02                      |
| <i>Ne II</i>   |         |       |                              | 3224.8         | 6       | 8     | 3.5E+00                      | 3477.6         | 4       | 6     | 4.3E-01                      |
| *357.03        | 6       | 10    | 3.8E+01                      | 3229.5         | 8       | 8     | 1.3E-01                      | 3481.9         | 4       | 2     | 1.4E+00                      |
| *361.77        | 6       | 2     | 1.6E+01                      | 3229.6         | 8       | 10    | 3.6E+00                      | 3503.6         | 2       | 2     | 2.0E+00                      |
| *406.28        | 6       | 10    | 1.8E+01                      | 3230.1         | 6       | 6     | 1.8E+00                      | 3522.7         | 4       | 2     | 2.3E-02                      |
| *446.37        | 6       | 6     | 4.07E+01                     | 3230.4         | 4       | 6     | 1.4E-01                      | 3538.0         | 4       | 2     | 7.6E-01                      |
| 460.73         | 4       | 2     | 4.7E+01                      | 3232.0         | 6       | 4     | 2.7E-01                      | 3539.9         | 4       | 4     | 3.6E-02                      |
|                |         |       |                              | 3232.4         | 4       | 4     | 1.6E+00                      | 3542.2         | 6       | 4     | 6.0E-01                      |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 3542.9         | 4       | 6     | 1.2E+00                      |
| 3546.2         | 2       | 4     | 6.3E-02                      |
| 3551.6         | 2       | 4     | 3.7E-02                      |
| 3557.8         | 2       | 2     | 1.9E-01                      |
| 3561.2         | 4       | 6     | 2.1E-01                      |
| 3565.8         | 4       | 4     | 6.2E-01                      |
| 3568.5         | 6       | 8     | 1.4E+00                      |
| 3571.2         | 4       | 4     | 6.3E-01                      |
| 3574.2         | 6       | 6     | 1.0E-01                      |
| 3574.6         | 4       | 6     | 1.3E+00                      |
| 3590.4         | 4       | 6     | 3.6E-02                      |
| 3594.2         | 4       | 2     | 1.3E+00                      |
| 3612.3         | 2       | 4     | 2.6E-01                      |
| 3628.0         | 4       | 4     | 6.0E-01                      |
| 3632.7         | 4       | 4     | 1.3E-01                      |
| 3643.9         | 4       | 4     | 3.2E-01                      |
| 3644.9         | 2       | 4     | 9.9E-01                      |
| 3659.9         | 4       | 6     | 6.7E-02                      |
| 3664.1         | 6       | 4     | 7.0E-01                      |
| 3679.8         | 4       | 2     | 3.2E-01                      |
| 3694.2         | 6       | 6     | 1.0E+00                      |
| 3697.1         | 2       | 2     | 2.8E-01                      |
| 3701.8         | 4       | 6     | 2.7E-01                      |
| 3709.6         | 4       | 2     | 1.1E+00                      |
| 3713.1         | 4       | 6     | 1.3E+00                      |
| 3721.8         | 4       | 6     | 2.0E-01                      |
| 3726.9         | 4       | 4     | 1.2E-01                      |
| 3727.1         | 2       | 4     | 9.8E-01                      |
| 3734.9         | 4       | 4     | 1.9E-01                      |
| 3744.6         | 2       | 4     | 2.6E-01                      |
| 3751.2         | 2       | 2     | 1.8E-01                      |
| 3753.8         | 4       | 6     | 4.5E-01                      |
| 3766.3         | 4       | 6     | 2.9E-01                      |
| 3777.1         | 2       | 4     | 4.2E-01                      |
| 3800.0         | 4       | 4     | 3.7E-01                      |
| 3818.4         | 2       | 4     | 6.1E-01                      |
| 3829.8         | 4       | 6     | 8.4E-01                      |
| 3942.3         | 4       | 6     | 1.0E-02                      |
| <i>Ne V</i>    |         |       |                              |
| *142.61        | 9       | 9     | 6.7E+02                      |
| *143.32        | 9       | 15    | 1.2E+03                      |
| 147.13         | 5       | 7     | 1.5E+03                      |
| 151.23         | 5       | 5     | 3.38E+02                     |
| 154.50         | 1       | 3     | 7.0E+02                      |
| *167.69        | 9       | 9     | 1.5E+02                      |
| *358.93        | 9       | 3     | 2.1E+02                      |
| 365.59         | 5       | 3     | 1.35E+02                     |
| *482.15        | 9       | 9     | 3.01E+01                     |
| *571.04        | 9       | 15    | 1.0E+01                      |
| 2259.6         | 3       | 5     | 1.9E+00                      |
| 2265.7         | 5       | 7     | 2.4E+00                      |
| <i>Ne VII</i>  |         |       |                              |
| 97.502         | 1       | 3     | 1.07E+03                     |
| *115.46        | 9       | 3     | 4.8E+02                      |
| 116.69         | 3       | 5     | 1.6E+03                      |
| 127.66         | 3       | 1     | 1.9E+02                      |
| 465.22         | 1       | 3     | 4.09E+01                     |
| 558.61         | 3       | 5     | 8.11E+00                     |
| 559.95         | 1       | 3     | 1.07E+01                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 561.38         | 3       | 3     | 7.99E+00                     |
| 561.73         | 5       | 5     | 2.39E+01                     |
| 562.99         | 3       | 1     | 3.17E+01                     |
| 564.53         | 5       | 3     | 1.31E+01                     |
| <i>Ne VIII</i> |         |       |                              |
| *88.09         | 2       | 6     | 8.4E+02                      |
| *98.208        | 6       | 10    | 2.77E+03                     |
| 770.41         | 2       | 4     | 5.90E+00                     |
| 780.32         | 2       | 2     | 5.69E+00                     |
| 2820.7         | 2       | 4     | 7.20E-01                     |
| 2860.1         | 2       | 2     | 6.88E-01                     |
| <i>Nickel</i>  |         |       |                              |
| <i>Ni I</i>    |         |       |                              |
| 1963.85        | 7       | 7     | 1.1E-01                      |
| 1976.87        | 7       | 9     | 1.1E+00                      |
| 1981.61        | 5       | 5     | 1.3E-01                      |
| 1990.25        | 5       | 7     | 8.3E-01                      |
| 2007.01        | 5       | 5     | 1.7E-01                      |
| 2007.69        | 7       | 7     | 9.0E-02                      |
| 2014.25        | 3       | 5     | 9.3E-01                      |
| 2025.40        | 7       | 5     | 2.3E-01                      |
| 2026.62        | 9       | 7     | 2.4E-01                      |
| 2047.35        | 7       | 5     | 1.8E-01                      |
| 2052.04        | 9       | 9     | 9.7E-02                      |
| 2055.50        | 5       | 3     | 3.3E-01                      |
| 2059.92        | 7       | 5     | 2.1E-01                      |
| 2060.20        | 5       | 3     | 2.3E-01                      |
| 2064.39        | 3       | 1     | 4.0E-01                      |
| 2069.52        | 5       | 5     | 1.1E-01                      |
| 2085.57        | 5       | 5     | 2.6E+00                      |
| 2089.09        | 7       | 5     | 9.7E-02                      |
| 2095.13        | 5       | 7     | 1.1E-01                      |
| 2114.43        | 5       | 5     | 9.7E-02                      |
| 2121.40        | 7       | 5     | 2.8E-01                      |
| 2124.80        | 5       | 3     | 3.8E-01                      |
| 2147.80        | 5       | 3     | 4.7E-01                      |
| 2157.83        | 5       | 3     | 4.1E-01                      |
| 2158.31        | 7       | 5     | 6.9E-01                      |
| 2161.04        | 5       | 5     | 1.3E-01                      |
| 2173.54        | 5       | 3     | 1.5E-01                      |
| 2174.48        | 3       | 1     | 8.9E-01                      |
| 2182.38        | 7       | 5     | 1.3E-01                      |
| 2183.91        | 5       | 5     | 1.2E-01                      |
| 2190.22        | 5       | 5     | 3.0E-01                      |
| 2197.35        | 3       | 3     | 7.8E-01                      |
| 2201.59        | 5       | 3     | 7.3E-01                      |
| 2221.94        | 5       | 3     | 2.2E-01                      |
| 2244.46        | 5       | 5     | 3.8E-01                      |
| 2253.57        | 7       | 7     | 1.9E-01                      |
| 2254.81        | 9       | 9     | 9.6E-02                      |
| 2258.15        | 7       | 5     | 1.7E-01                      |
| 2259.56        | 5       | 3     | 2.0E-01                      |
| 2261.42        | 9       | 7     | 9.1E-02                      |
| 2287.32        | 3       | 5     | 1.8E-01                      |
| 2289.98        | 9       | 7     | 2.1E+00                      |
| 2293.11        | 5       | 5     | 3.8E-01                      |
| 2300.77        | 7       | 7     | 7.5E-01                      |
| 2302.97        | 3       | 3     | 4.5E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 2307.35        | 5       | 7     | 1.6E-01                      |
| 2312.34        | 7       | 7     | 5.5E+00                      |
| 2313.98        | 5       | 5     | 5.0E+00                      |
| 2317.16        | 7       | 5     | 3.8E+00                      |
| 2320.03        | 9       | 11    | 6.9E+00                      |
| 2321.38        | 5       | 7     | 5.6E+00                      |
| 2324.65        | 7       | 9     | 1.8E-01                      |
| 2325.79        | 7       | 9     | 3.5E+00                      |
| 2329.96        | 5       | 3     | 5.3E+00                      |
| 2345.54        | 9       | 7     | 2.2E+00                      |
| 2346.63        | 7       | 5     | 5.5E-01                      |
| 2347.51        | 9       | 9     | 2.2E-01                      |
| 2348.73        | 7       | 7     | 2.2E-01                      |
| 2419.31        | 7       | 5     | 2.0E-01                      |
| 2943.91        | 7       | 5     | 1.1E-01                      |
| 2981.65        | 5       | 3     | 2.8E-01                      |
| 3002.48        | 7       | 7     | 8.0E-01                      |
| 3003.62        | 5       | 5     | 6.9E-01                      |
| 3012.00        | 5       | 5     | 1.3E+00                      |
| 3037.93        | 7       | 7     | 2.8E-01                      |
| 3050.82        | 7       | 9     | 6.0E-01                      |
| 3054.31        | 5       | 5     | 4.0E-01                      |
| 3057.64        | 3       | 3     | 1.0E+00                      |
| 3064.62        | 5       | 7     | 1.1E-01                      |
| 3101.56        | 5       | 7     | 6.3E-01                      |
| 3101.88        | 5       | 7     | 4.9E-01                      |
| 3134.11        | 3       | 5     | 7.3E-01                      |
| 3225.02        | 5       | 3     | 9.3E-02                      |
| 3369.56        | 9       | 7     | 1.8E-01                      |
| 3380.57        | 5       | 3     | 1.3E+00                      |
| 3392.98        | 7       | 7     | 2.4E-01                      |
| 3414.76        | 7       | 9     | 5.5E-01                      |
| 3423.71        | 3       | 3     | 3.3E-01                      |
| 3433.56        | 7       | 7     | 1.7E-01                      |
| 3446.26        | 5       | 5     | 4.4E-01                      |
| 3452.88        | 5       | 7     | 9.8E-02                      |
| 3458.46        | 3       | 5     | 6.1E-01                      |
| 3461.66        | 7       | 9     | 2.7E-01                      |
| 3472.55        | 5       | 7     | 1.2E-01                      |
| 3483.77        | 5       | 3     | 1.4E-01                      |
| 3492.96        | 5       | 3     | 9.8E-01                      |
| 3510.33        | 3       | 1     | 1.2E+00                      |
| 3515.05        | 5       | 7     | 4.2E-01                      |
| 3524.54        | 7       | 5     | 1.0E+00                      |
| 3566.37        | 5       | 5     | 5.6E-01                      |
| 3597.70        | 3       | 3     | 1.4E-01                      |
| 3619.39        | 5       | 7     | 6.6E-01                      |
| 4027.67        | 5       | 7     | 1.3E-01                      |
| 4295.88        | 9       | 7     | 1.7E-01                      |
| 4401.54        | 9       | 11    | 3.8E-01                      |
| 4462.46        | 3       | 5     | 1.7E-01                      |
| 4470.48        | 5       | 7     | 1.9E-01                      |
| 4600.37        | 5       | 3     | 2.6E-01                      |
| 4604.99        | 9       | 7     | 2.3E-01                      |
| 4606.23        | 5       | 3     | 1.0E-01                      |
| 4648.66        | 11      | 9     | 2.4E-01                      |
| 4686.22        | 5       | 5     | 1.4E-01                      |
| 4701.54        | 9       | 9     | 1.4E-01                      |
| 4714.42        | 13      | 11    | 4.6E-01                      |
| 4715.78        | 7       | 7     | 2.0E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|-----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                 | $g_i$   | $g_k$ |                              |
| 4732.47        | 7       | 9     | 9.3E-02                      | 2270.21        | 8       | 10    | 1.56E+00                     | 187             | 4       | 6     | 1.2E+02                      |
| 4752.43        | 3       | 3     | 2.0E-01                      | 2278.77        | 8       | 6     | 2.8E+00                      | 187             | 4       | 2     | 3.3E+02                      |
| 4756.52        | 9       | 9     | 1.5E-01                      | 2287.09        | 6       | 4     | 2.8E+00                      | 188             | 2       | 2     | 4.7E+02                      |
| 4786.54        | 11      | 11    | 1.8E-01                      | 2296.55        | 8       | 8     | 1.98E+00                     | 190             | 6       | 8     | 2.0E+02                      |
| 4812.00        | 3       | 1     | 9.5E-02                      | 2297.14        | 6       | 4     | 2.70E+00                     | 192             | 6       | 8     | 4.54E+02                     |
| 4829.03        | 5       | 7     | 1.9E-01                      | 2297.49        | 4       | 2     | 3.0E+00                      | 192             | 6       | 6     | 3.1E+02                      |
| 4831.18        | 9       | 7     | 1.6E-01                      | 2298.27        | 6       | 6     | 2.8E+00                      | 194             | 4       | 6     | 2.8E+02                      |
| 4838.64        | 9       | 7     | 2.2E-01                      | 2303.00        | 8       | 6     | 2.9E+00                      | 194             | 2       | 4     | 5.5E+02                      |
| 4855.41        | 5       | 5     | 5.7E-01                      | 2316.04        | 10      | 8     | 2.88E+00                     | 194             | 2       | 2     | 1.1E+02                      |
| 4904.41        | 5       | 3     | 6.2E-01                      | 2334.58        | 8       | 8     | 8.0E-01                      | 194             | 4       | 4     | 3.5E+02                      |
| 4912.03        | 3       | 3     | 1.5E-01                      | 2375.42        | 6       | 8     | 6.6E-01                      | 194.04          | 4       | 6     | 4.6E+02                      |
| 4913.97        | 1       | 3     | 2.2E-01                      | 2394.52        | 8       | 10    | 1.70E+00                     | 195.27          | 4       | 4     | 9.5E+01                      |
| 4918.36        | 9       | 7     | 2.3E-01                      | 2416.13        | 6       | 8     | 2.1E+00                      | 196             | 4       | 6     | 6.7E+02                      |
| 4935.83        | 7       | 5     | 2.4E-01                      | 2437.89        | 8       | 10    | 5.4E-01                      | 197             | 4       | 6     | 1.5E+02                      |
| 4937.34        | 9       | 9     | 1.2E-01                      | 2510.87        | 8       | 10    | 5.8E-01                      | 197             | 4       | 2     | 1.2E+02                      |
| 4953.20        | 5       | 5     | 1.2E-01                      | <i>Ni III</i>  |         |       |                              | 199             | 2       | 4     | 4.9E+02                      |
| 4980.17        | 9       | 11    | 1.9E-01                      | 1692.51        | 11      | 13    | 7.9E+00                      | 206             | 2       | 2     | 3.7E+02                      |
| 5000.34        | 7       | 7     | 1.4E-01                      | 1709.90        | 9       | 11    | 6.3E+00                      | 217             | 4       | 4     | 1.1E+02                      |
| 5012.46        | 7       | 7     | 1.1E-01                      | 1719.46        | 5       | 7     | 6.0E+00                      | 218.391         | 2       | 4     | 9.5E+01                      |
| 5017.58        | 11      | 11    | 2.0E-01                      | 1722.28        | 3       | 5     | 5.9E+00                      | 223.119         | 2       | 2     | 1.3E+02                      |
| 5035.37        | 7       | 9     | 5.7E-01                      | 1724.52        | 3       | 1     | 6.7E+00                      | 231             | 4       | 4     | 1.6E+02                      |
| 5042.20        | 3       | 5     | 1.4E-01                      | 1741.96        | 9       | 7     | 5.7E+00                      | 232.475         | 4       | 4     | 4.07E+02                     |
| 5048.85        | 7       | 7     | 1.6E-01                      | 1752.43        | 7       | 5     | 5.5E+00                      | 233             | 6       | 4     | 2.4E+02                      |
| 5080.53        | 9       | 11    | 3.2E-01                      | 1760.56        | 5       | 3     | 6.5E+00                      | 235             | 4       | 2     | 3.8E+02                      |
| 5081.11        | 7       | 9     | 5.7E-01                      | 1769.64        | 11      | 11    | 6.2E+00                      | 235             | 6       | 6     | 2.5E+02                      |
| 5082.35        | 3       | 3     | 2.5E-01                      | 1823.06        | 9       | 9     | 5.6E+00                      | 236             | 4       | 4     | 1.2E+02                      |
| 5084.08        | 7       | 9     | 3.1E-01                      | <i>Ni XIV</i>  |         |       |                              | 237.875         | 4       | 2     | 2.6E+02                      |
| 5099.95        | 7       | 7     | 2.9E-01                      | 164.13         | 6       | 8     | 1.2E+03                      | 238             | 6       | 4     | 1.3E+02                      |
| 5115.40        | 11      | 9     | 2.2E-01                      | 168            | 2       | 4     | 2.4E+02                      | 239.550         | 2       | 2     | 2.6E+02                      |
| 5129.37        | 7       | 5     | 1.2E-01                      | 168.12         | 4       | 2     | 8.5E+02                      | 245             | 4       | 4     | 1.4E+02                      |
| 5155.14        | 5       | 5     | 1.1E-01                      | 169.69         | 4       | 4     | 9.8E+02                      | 245             | 4       | 6     | 3.2E+02                      |
| 5155.76        | 5       | 7     | 2.9E-01                      | 170.50         | 4       | 4     | 7.1E+02                      | 249             | 6       | 8     | 3.3E+02                      |
| 5176.57        | 5       | 5     | 1.8E-01                      | 171.37         | 4       | 6     | 9.4E+02                      | 249             | 6       | 4     | 1.2E+02                      |
| 5371.33        | 7       | 7     | 1.6E-01                      | 172.16         | 6       | 6     | 4.7E+02                      | 250             | 4       | 2     | 1.6E+02                      |
| 5476.91        | 1       | 3     | 9.5E-02                      | 172.80         | 6       | 4     | 1.4E+02                      | 254             | 6       | 4     | 1.8E+02                      |
| 5637.12        | 3       | 3     | 1.1E-01                      | 177.28         | 4       | 4     | 5.6E+02                      | <i>Ni XVII</i>  |         |       |                              |
| 5664.02        | 5       | 7     | 1.1E-01                      | 178            | 2       | 4     | 8.9E+01                      | 30.919          | 1       | 3     | 2.77E+03                     |
| 5695.00        | 3       | 3     | 1.7E-01                      | 181            | 4       | 6     | 7.4E+01                      | 42.855          | 1       | 3     | 4.75E+03                     |
| 6086.29        | 3       | 5     | 1.1E-01                      | 182.14         | 4       | 2     | 1.5E+02                      | 54.451          | 9       | 11    | 1.5E+04                      |
| 6175.42        | 3       | 3     | 1.7E-01                      | 196            | 4       | 2     | 3.8E+01                      | 55.361          | 1       | 3     | 6.7E+03                      |
| 7122.24        | 5       | 7     | 2.1E-01                      | 288.894        | 4       | 4     | 4.6E+01                      | 57.348          | 7       | 9     | 1.4E+04                      |
| 7381.94        | 9       | 11    | 9.7E-02                      | 292.399        | 6       | 6     | 3.6E+01                      | 197.39          | 1       | 3     | 1.6E+02                      |
| 7422.30        | 7       | 5     | 1.8E-01                      | <i>Ni XV</i>   |         |       |                              | 199.87          | 3       | 5     | 2.1E+02                      |
| 7727.66        | 7       | 7     | 1.1E-01                      | 50.249         | 5       | 7     | 6.8E+03                      | 204             | 3       | 3     | 1.8E+02                      |
| <i>Ni II</i>   |         |       |                              | 60.890         | 9       | 11    | 1.0E+04                      | 205             | 3       | 1     | 2.4E+02                      |
| 2165.55        | 10      | 10    | 2.4E+00                      | 64.635         | 7       | 9     | 9.6E+03                      | 206             | 1       | 3     | 3.0E+02                      |
| 2169.10        | 8       | 8     | 1.58E+00                     | 163.64         | 5       | 7     | 5.6E+01                      | 207.50          | 5       | 7     | 2.5E+02                      |
| 2174.67        | 8       | 10    | 1.43E+00                     | 173.73         | 5       | 7     | 7.6E+02                      | 215.89          | 3       | 5     | 4.8E+02                      |
| 2175.15        | 6       | 6     | 1.77E+00                     | 175            | 3       | 1     | 5.7E+02                      | 216             | 1       | 3     | 2.7E+02                      |
| 2184.61        | 4       | 4     | 2.90E+00                     | 179.28         | 5       | 7     | 7.5E+02                      | 217             | 5       | 7     | 2.4E+02                      |
| 2201.41        | 4       | 6     | 1.3E+00                      | 181            | 1       | 3     | 6.8E+02                      | 227             | 5       | 5     | 1.6E+02                      |
| 2206.72        | 6       | 8     | 1.66E+00                     | 269            | 3       | 1     | 5.3E+01                      | 249.180         | 1       | 3     | 2.75E+02                     |
| 2216.48        | 10      | 12    | 3.4E+00                      | 278.386        | 5       | 5     | 4.3E+01                      | 281.50          | 3       | 1     | 2.1E+02                      |
| 2220.40        | 6       | 8     | 2.3E+00                      | <i>Ni XVI</i>  |         |       |                              | 282             | 3       | 1     | 2.4E+02                      |
| 2222.96        | 10      | 10    | 9.8E-01                      | 166            | 4       | 6     | 3.1E+02                      | 284             | 5       | 3     | 1.5E+02                      |
| 2224.86        | 8       | 8     | 1.55E+00                     | 168            | 6       | 8     | 3.2E+02                      | 292             | 5       | 7     | 2.2E+02                      |
| 2226.33        | 6       | 6     | 1.3E+00                      | 182            | 2       | 2     | 2.5E+02                      | <i>Ni XVIII</i> |         |       |                              |
| 2253.85        | 4       | 6     | 1.98E+00                     | 185.23         | 2       | 4     | 4.2E+02                      | 24.881          | 2       | 4     | 8.6E+02                      |
| 2264.46        | 6       | 8     | 1.43E+00                     |                |         |       |                              | 25.070          | 4       | 6     | 9.9E+02                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|-----------------|---------|-------|------------------------------|-----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                 | $g_i$   | $g_k$ |                              |                 | $g_i$   | $g_k$ |                              |
| 26.02          | 2       | 4     | 1.26E+03                     | 11.48           | 3       | 1     | 1.1E+05                      | 137.01          | 4       | 4     | 2.6E+02                      |
| 26.020         | 2       | 4     | 1.1E+03                      | 11.48           | 1       | 3     | 4.0E+05                      | 138.80          | 4       | 6     | 7.2E+01                      |
| 26.046         | 2       | 2     | 1.1E+03                      | 11.517          | 5       | 7     | 1.4E+05                      | 153.47          | 2       | 2     | 1.27E+02                     |
| 26.218         | 4       | 6     | 1.5E+03                      | 11.539          | 5       | 7     | 1.2E+05                      | 159.69          | 2       | 4     | 8.9E+01                      |
| 27.98          | 4       | 6     | 1.0E+03                      | 11.67           | 1       | 3     | 8.0E+04                      | <i>Ni XXV</i>   |         |       |                              |
| 27.982         | 2       | 4     | 2.0E+03                      | 11.72           | 3       | 3     | 2.3E+04                      | 9.30            | 3       | 1     | 9.3E+04                      |
| 28.018         | 6       | 8     | 1.1E+03                      | 12.454          | 5       | 3     | 3.3E+04                      | 9.31            | 5       | 7     | 8.2E+04                      |
| 28.220         | 4       | 6     | 2.33E+03                     | 12.472          | 3       | 3     | 1.8E+04                      | 9.32            | 3       | 5     | 7.8E+04                      |
| 29.383         | 4       | 6     | 1.58E+03                     | 12.502          | 5       | 5     | 2.8E+04                      | 9.34            | 1       | 3     | 1.1E+05                      |
| 29.422         | 6       | 8     | 1.69E+03                     | <i>Ni XXII</i>  |         |       |                              | 9.42            | 3       | 1     | 9.0E+04                      |
| 29.779         | 2       | 4     | 1.9E+03                      | 72.52           | 4       | 2     | 2.84E+02                     | 9.49            | 3       | 5     | 8.9E+04                      |
| 29.829         | 2       | 2     | 1.9E+03                      | 84.06           | 6       | 4     | 1.2E+03                      | 9.60            | 1       | 3     | 1.8E+05                      |
| 31.845         | 4       | 6     | 2.7E+03                      | 84.24           | 4       | 2     | 5.6E+02                      | 9.63            | 3       | 5     | 2.4E+05                      |
| 31.890         | 6       | 8     | 3.0E+03                      | 85.86           | 4       | 2     | 4.9E+02                      | 9.64            | 3       | 3     | 1.3E+05                      |
| 32.034         | 2       | 4     | 3.4E+03                      | 88.00           | 4       | 2     | 1.2E+03                      | 9.71            | 3       | 1     | 2.3E+05                      |
| 32.340         | 4       | 6     | 4.0E+03                      | 95.95           | 2       | 2     | 4.4E+02                      | 9.71            | 3       | 3     | 1.8E+05                      |
| 36.990         | 4       | 6     | 5.5E+03                      | 98.16           | 4       | 4     | 5.2E+02                      | 9.74            | 5       | 7     | 3.0E+05                      |
| 37.049         | 6       | 8     | 5.9E+03                      | 98.58           | 4       | 4     | 2.45E+02                     | 9.75            | 3       | 5     | 1.3E+05                      |
| 41.015         | 2       | 4     | 2.97E+03                     | 100.60          | 6       | 6     | 3.9E+02                      | 9.76            | 1       | 3     | 3.03E+05                     |
| 41.218         | 2       | 2     | 3.2E+03                      | 101.31          | 6       | 4     | 4.83E+02                     | 9.76            | 5       | 3     | 7.5E+04                      |
| 43.814         | 2       | 4     | 5.5E+03                      | 103.31          | 4       | 2     | 2.66E+02                     | 9.78            | 5       | 7     | 2.9E+05                      |
| 44.365         | 4       | 6     | 6.8E+03                      | 106.04          | 4       | 4     | 2.36E+02                     | 9.86            | 5       | 7     | 4.8E+05                      |
| 44.405         | 4       | 4     | 1.14E+03                     | 106.16          | 4       | 2     | 5.1E+02                      | 9.87            | 3       | 5     | 2.03E+05                     |
| 52.615         | 4       | 6     | 1.5E+04                      | 124.31          | 2       | 2     | 3.7E+02                      | 9.92            | 5       | 5     | 1.3E+05                      |
| 52.720         | 6       | 8     | 1.6E+04                      | 126.32          | 4       | 4     | 3.3E+02                      | 9.94            | 5       | 7     | 1.29E+05                     |
| 52.745         | 6       | 6     | 1.06E+03                     | <i>Ni XXIII</i> |         |       |                              | 9.97            | 3       | 5     | 2.5E+05                      |
| 59.950         | 6       | 4     | 9.6E+02                      | 87.66           | 3       | 3     | 2.8E+02                      | 10.08           | 1       | 3     | 2.80E+05                     |
| 60.212         | 4       | 2     | 1.1E+03                      | 88.11           | 5       | 3     | 8.3E+02                      | <i>Ni XXVI</i>  |         |       |                              |
| 63.512         | 4       | 6     | 7.9E+02                      | 90.49           | 3       | 3     | 1.77E+02                     | 1.5930          | 4       | 2     | 3.4E+06                      |
| 63.589         | 6       | 8     | 8.5E+02                      | 90.96           | 5       | 3     | 2.5E+02                      | 1.5935          | 2       | 2     | 4.0E+06                      |
| 69.075         | 4       | 6     | 8.0E+02                      | 91.83           | 5       | 3     | 7.5E+02                      | 1.5973          | 4       | 4     | 8.1E+06                      |
| 76.254         | 4       | 6     | 1.38E+03                     | 92.32           | 3       | 1     | 4.39E+02                     | 1.5977          | 2       | 4     | 4.4E+06                      |
| 76.359         | 6       | 8     | 1.47E+03                     | 100.42          | 1       | 3     | 2.1E+02                      | 1.5982          | 2       | 2     | 7.3E+06                      |
| 99.275         | 2       | 4     | 1.0E+03                      | 102.08          | 5       | 5     | 5.3E+02                      | 1.5996          | 2       | 2     | 2.7E+06                      |
| 100.4          | 4       | 6     | 1.2E+03                      | 103.23          | 3       | 3     | 2.4E+02                      | 1.6005          | 4       | 6     | 2.7E+06                      |
| 114.46         | 4       | 6     | 2.5E+03                      | 103.67          | 5       | 5     | 1.78E+02                     | 1.6036          | 4       | 2     | 2.1E+06                      |
| 114.74         | 6       | 8     | 2.7E+03                      | 104.70          | 3       | 1     | 2.94E+02                     | 9.390           | 2       | 4     | 2.59E+05                     |
| <i>Ni XIX</i>  |         |       |                              | 106.02          | 5       | 5     | 2.87E+02                     | 9.535           | 4       | 6     | 2.96E+05                     |
| 9.140          | 1       | 3     | 3.1E+04                      | 108.27          | 7       | 5     | 3.32E+02                     | <i>Ni XXVII</i> |         |       |                              |
| 9.153          | 1       | 3     | 5.2E+03                      | 111.23          | 3       | 1     | 2.26E+02                     | 1.2534          | 1       | 3     | 3.35E+05                     |
| 9.977          | 1       | 3     | 1.1E+05                      | 111.78          | 5       | 3     | 2.19E+02                     | 1.2824          | 1       | 3     | 6.38E+05                     |
| 10.110         | 1       | 3     | 9.4E+04                      | 111.86          | 1       | 3     | 1.7E+02                      | 1.3500          | 1       | 3     | 1.63E+06                     |
| 10.283         | 1       | 3     | 4.7E+03                      | 112.55          | 3       | 1     | 1.0E+03                      | 1.3516          | 1       | 3     | 2.4E+05                      |
| 10.433         | 1       | 3     | 5.1E+03                      | 128.87          | 5       | 5     | 4.02E+02                     | 1.531           | 3       | 3     | 2.0E+05                      |
| 11.539         | 1       | 3     | 4.8E+04                      | 133.54          | 3       | 3     | 1.86E+02                     | 1.534           | 3       | 1     | 6.9E+06                      |
| 11.599         | 1       | 3     | 6.3E+03                      | 137.55          | 3       | 1     | 2.53E+02                     | 1.537           | 5       | 5     | 2.3E+06                      |
| 12.435         | 1       | 3     | 3.66E+05                     | <i>Ni XXIV</i>  |         |       |                              | 1.537           | 1       | 3     | 3.7E+06                      |
| 12.656         | 1       | 3     | 1.0E+05                      | 101.13          | 6       | 4     | 1.63E+02                     | 1.538           | 3       | 5     | 3.9E+06                      |
| 13.779         | 1       | 3     | 1.23E+04                     | 102.11          | 4       | 4     | 5.4E+02                      | 1.539           | 1       | 3     | 2.6E+06                      |
| 14.043         | 1       | 3     | 1.31E+04                     | 103.43          | 2       | 4     | 1.3E+02                      | 1.539           | 3       | 5     | 2.6E+06                      |
| 40.7           | 3       | 3     | 6.4E+03                      | 103.53          | 4       | 2     | 4.17E+02                     | 1.540           | 3       | 3     | 1.7E+06                      |
| 40.7           | 3       | 1     | 8.4E+03                      | 104.64          | 2       | 2     | 4.7E+02                      | 1.541           | 3       | 5     | 5.5E+06                      |
| 41.132         | 7       | 9     | 9.4E+03                      | 106.68          | 4       | 2     | 3.67E+02                     | 1.542           | 3       | 3     | 3.6E+06                      |
| <i>Ni XXI</i>  |         |       |                              | 113.14          | 4       | 4     | 1.65E+02                     | 1.542           | 5       | 5     | 3.5E+06                      |
| 11.13          | 3       | 3     | 1.7E+04                      | 118.52          | 2       | 4     | 1.5E+02                      | 1.544           | 5       | 3     | 3.2E+06                      |
| 11.23          | 5       | 3     | 1.7E+04                      | 122.72          | 6       | 4     | 2.17E+02                     | 1.546           | 3       | 5     | 1.6E+06                      |
| 11.239         | 5       | 7     | 5.7E+04                      | 134.73          | 6       | 6     | 1.44E+02                     | 1.547           | 3       | 3     | 2.1E+05                      |
| 11.28          | 3       | 1     | 2.2E+05                      | 135.47          | 4       | 4     | 8.0E+01                      | 1.549           | 1       | 3     | 2.0E+05                      |
| 11.318         | 5       | 7     | 2.8E+05                      |                 |         |       |                              |                 |         |       |                              |

| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 1.551           | 3       | 1     | 8.2E+05                      | 6926.67        | 4       | 6     | 7.75E-03                     | 9968.51        | 6       | 4     | 4.50E-03                     |
| 1.558           | 3       | 1     | 6.5E+05                      | 6945.18        | 6       | 6     | 1.83E-02                     | 9980.42        | 4       | 6     | 8.10E-03                     |
| 1.5883          | 1       | 3     | 6.02E+06                     | 6951.60        | 2       | 4     | 1.03E-02                     | 9997.73        | 8       | 8     | 9.20E-03                     |
| 1.5963          | 1       | 3     | 7.70E+05                     | 6960.50        | 4       | 4     | 4.67E-03                     | <i>N II</i>    |         |       |                              |
| <i>Nitrogen</i> |         |       |                              | 6973.07        | 2       | 2     | 3.83E-03                     | 474.891        | 5       | 5     | 9.66E+00                     |
| <i>NI</i>       |         |       |                              | 6979.18        | 6       | 4     | 9.83E-03                     | 475.647        | 1       | 3     | 1.17E+01                     |
| 1163.88         | 6       | 6     | 7.52E-01                     | 6982.03        | 4       | 2     | 2.04E-02                     | 475.698        | 3       | 5     | 1.58E+01                     |
| 1164.00         | 4       | 6     | 1.27E-02                     | 7423.64        | 2       | 4     | 5.95E-02                     | 475.757        | 3       | 3     | 8.75E+00                     |
| 1164.21         | 6       | 4     | 5.17E-02                     | 7442.30        | 4       | 4     | 1.24E-01                     | 475.803        | 5       | 7     | 2.10E+01                     |
| 1164.32         | 4       | 4     | 6.94E-01                     | 7468.31        | 6       | 4     | 1.93E-01                     | 475.884        | 5       | 5     | 5.25E+00                     |
| 1167.45         | 6       | 8     | 1.29E+00                     | 7898.98        | 6       | 4     | 2.82E-01                     | 508.697        | 5       | 5     | 1.91E+00                     |
| 1168.42         | 6       | 6     | 4.24E-02                     | 7899.28        | 4       | 4     | 3.28E-02                     | 510.758        | 5       | 7     | 1.87E+01                     |
| 1168.54         | 4       | 6     | 1.24E+00                     | 7915.42        | 4       | 2     | 3.13E-01                     | 513.849        | 5       | 5     | 1.24E+01                     |
| 1176.51         | 6       | 4     | 9.22E-01                     | 8184.86        | 4       | 6     | 8.58E-02                     | 529.355        | 1       | 3     | 7.23E+00                     |
| 1176.63         | 4       | 4     | 1.02E-01                     | 8188.01        | 2       | 4     | 1.27E-01                     | 529.413        | 3       | 1     | 2.43E+01                     |
| 1177.69         | 4       | 2     | 1.02E+00                     | 8200.36        | 2       | 2     | 4.95E-02                     | 529.491        | 3       | 3     | 6.75E+00                     |
| 1199.55         | 4       | 6     | 4.01E+00                     | 8210.72        | 4       | 4     | 4.84E-02                     | 529.637        | 3       | 5     | 4.92E+00                     |
| 1200.22         | 4       | 4     | 3.99E+00                     | 8216.34        | 6       | 6     | 2.23E-01                     | 529.722        | 5       | 3     | 1.03E+01                     |
| 1200.71         | 4       | 2     | 3.98E+00                     | 8223.13        | 4       | 2     | 2.64E-01                     | 529.867        | 5       | 5     | 1.94E+01                     |
| 1310.54         | 4       | 6     | 8.42E-01                     | 8242.39        | 6       | 4     | 1.36E-01                     | 533.511        | 1       | 3     | 2.39E+01                     |
| 1316.29         | 4       | 6     | 1.42E-02                     | 8567.74        | 2       | 4     | 4.92E-02                     | 533.581        | 3       | 5     | 3.20E+01                     |
| 1492.63         | 6       | 4     | 3.13E+00                     | 8594.00        | 2       | 2     | 2.09E-01                     | 533.650        | 3       | 3     | 1.66E+01                     |
| 1492.82         | 4       | 4     | 3.51E-01                     | 8629.24        | 4       | 4     | 2.66E-01                     | 533.729        | 5       | 7     | 4.13E+01                     |
| 1494.68         | 4       | 2     | 3.72E+00                     | 8655.88        | 4       | 2     | 1.05E-01                     | 533.815        | 5       | 5     | 9.19E+00                     |
| 3822.03         | 2       | 2     | 3.70E-02                     | 8680.28        | 6       | 8     | 2.46E-01                     | 547.818        | 5       | 3     | 2.16E+00                     |
| 3830.43         | 4       | 4     | 4.67E-02                     | 8683.40        | 4       | 6     | 1.80E-01                     | 559.762        | 1       | 3     | 1.14E+01                     |
| 3834.22         | 4       | 2     | 1.89E-02                     | 8686.15        | 2       | 4     | 1.09E-01                     | 574.650        | 5       | 7     | 3.60E+01                     |
| 4099.94         | 2       | 4     | 3.48E-02                     | 8703.25        | 2       | 2     | 2.10E-01                     | 582.156        | 5       | 5     | 2.85E+01                     |
| 4109.95         | 4       | 6     | 3.90E-02                     | 8711.70        | 4       | 4     | 1.28E-01                     | 635.197        | 1       | 3     | 2.33E+01                     |
| 4113.97         | 4       | 4     | 6.62E-03                     | 8718.84        | 6       | 6     | 6.75E-02                     | 644.634        | 1       | 3     | 1.21E+01                     |
| 4137.64         | 2       | 4     | 2.80E-03                     | 8728.90        | 4       | 2     | 3.76E-02                     | 644.837        | 3       | 3     | 3.64E+01                     |
| 4143.43         | 4       | 4     | 6.09E-03                     | 8747.37        | 6       | 4     | 1.04E-02                     | 645.178        | 5       | 3     | 6.07E+01                     |
| 4151.48         | 6       | 4     | 1.01E-02                     | 9028.92        | 2       | 2     | 3.02E-01                     | 660.286        | 5       | 3     | 3.69E+01                     |
| 4249.87         | 4       | 2     | 2.59E-02                     | 9045.88        | 6       | 8     | 2.80E-01                     | 671.016        | 3       | 5     | 2.47E+00                     |
| 4264.00         | 6       | 4     | 2.26E-02                     | 9049.49        | 6       | 6     | 1.88E-02                     | 671.386        | 5       | 5     | 7.40E+00                     |
| 4356.29         | 6       | 8     | 5.10E-02                     | 9049.89        | 4       | 6     | 2.60E-01                     | 671.411        | 1       | 3     | 3.04E+00                     |
| 4385.54         | 2       | 2     | 8.84E-03                     | 9060.48        | 2       | 4     | 2.95E-01                     | 671.630        | 3       | 3     | 2.27E+00                     |
| 4392.41         | 4       | 2     | 1.76E-02                     | 9187.45        | 6       | 6     | 2.44E-01                     | 671.773        | 3       | 1     | 9.85E+00                     |
| 4435.43         | 2       | 4     | 7.51E-03                     | 9187.86        | 4       | 6     | 1.76E-02                     | 672.001        | 5       | 3     | 3.87E+00                     |
| 4442.45         | 4       | 4     | 3.81E-02                     | 9207.59        | 6       | 4     | 2.70E-02                     | 745.841        | 1       | 3     | 1.25E+01                     |
| 4669.89         | 4       | 4     | 7.49E-03                     | 9208.00        | 4       | 4     | 2.33E-01                     | 746.984        | 5       | 3     | 3.85E+01                     |
| 4914.94         | 2       | 2     | 8.08E-03                     | 9386.81        | 2       | 4     | 2.24E-01                     | 748.369        | 5       | 3     | 3.83E+00                     |
| 4935.12         | 4       | 2     | 1.76E-02                     | 9392.79        | 4       | 6     | 2.63E-01                     | 775.965        | 5       | 5     | 3.08E+01                     |
| 5199.84         | 2       | 2     | 1.87E-02                     | 9460.68        | 4       | 4     | 3.98E-02                     | 915.612        | 1       | 3     | 4.38E+00                     |
| 5201.61         | 2       | 4     | 1.87E-02                     | 9776.90        | 2       | 4     | 1.18E-02                     | 915.962        | 3       | 1     | 1.32E+01                     |
| 5281.20         | 6       | 6     | 2.45E-03                     | 9786.78        | 4       | 6     | 1.13E-02                     | 1083.99        | 1       | 3     | 2.18E+00                     |
| 5344.05         | 6       | 6     | 6.10E-04                     | 9788.29        | 2       | 2     | 2.99E-02                     | 1085.55        | 5       | 5     | 9.47E-01                     |
| 5356.62         | 4       | 6     | 1.41E-03                     | 9798.56        | 4       | 4     | 2.75E-02                     | 1085.70        | 5       | 7     | 3.87E+00                     |
| 5367.01         | 4       | 4     | 1.07E-03                     | 9810.01        | 4       | 2     | 5.30E-02                     | 3408.13        | 3       | 1     | 2.19E-01                     |
| 5372.61         | 2       | 4     | 8.34E-04                     | 9814.02        | 6       | 8     | 6.56E-03                     | 3437.14        | 3       | 1     | 2.07E+00                     |
| 5378.27         | 2       | 2     | 1.66E-03                     | 9822.75        | 6       | 6     | 4.95E-02                     | 3593.60        | 3       | 5     | 1.21E-01                     |
| 6606.18         | 4       | 6     | 8.87E-04                     | 9834.61        | 6       | 4     | 4.50E-02                     | 3609.10        | 3       | 3     | 1.41E-01                     |
| 6622.54         | 6       | 6     | 7.93E-03                     | 9863.33        | 8       | 8     | 9.62E-02                     | 3615.86        | 3       | 1     | 1.53E-01                     |
| 6626.99         | 2       | 4     | 2.20E-03                     | 9872.15        | 8       | 6     | 2.97E-02                     | 3829.80        | 3       | 5     | 2.42E-01                     |
| 6636.94         | 4       | 4     | 1.40E-02                     | 9883.38        | 2       | 2     | 2.93E-02                     | 3838.37        | 5       | 5     | 6.98E-01                     |
| 6644.96         | 8       | 6     | 3.49E-02                     | 9905.52        | 4       | 2     | 3.11E-03                     | 3842.19        | 1       | 3     | 3.06E-01                     |
| 6646.50         | 2       | 2     | 2.18E-02                     | 9909.22        | 2       | 4     | 7.58E-03                     | 3847.40        | 3       | 3     | 2.22E-01                     |
| 6653.46         | 6       | 4     | 2.74E-02                     | 9931.47        | 4       | 4     | 3.64E-02                     | 3855.10        | 3       | 1     | 8.82E-01                     |
| 6656.51         | 4       | 2     | 2.17E-02                     | 9947.07        | 6       | 8     | 1.08E-02                     | 3856.06        | 5       | 3     | 3.71E-01                     |
|                 |         |       |                              | 9965.75        | 4       | 6     | 7.60E-03                     |                |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3919.00        | 3       | 3     | 6.76E-01                     | 5025.66        | 7       | 7     | 1.07E-01                     | 5931.78        | 3       | 5     | 4.27E-01                     |
| 3955.85        | 3       | 5     | 1.31E-01                     | 5040.71        | 7       | 5     | 3.78E-03                     | 5940.24        | 3       | 3     | 2.26E-01                     |
| 3995.00        | 3       | 5     | 1.35E+00                     | 5045.10        | 5       | 3     | 3.42E-01                     | 5941.65        | 5       | 7     | 5.54E-01                     |
| 4114.33        | 3       | 3     | 1.42E-03                     | 5073.59        | 3       | 3     | 2.59E-02                     | 5952.39        | 5       | 5     | 1.27E-01                     |
| 4124.08        | 3       | 5     | 3.20E-01                     | 5168.05        | 3       | 5     | 3.06E-01                     | 5960.91        | 5       | 3     | 1.34E-02                     |
| 4133.67        | 5       | 5     | 5.30E-01                     | 5170.16        | 3       | 3     | 6.54E-01                     | 6065.00        | 3       | 5     | 2.21E-03                     |
| 4145.77        | 7       | 5     | 7.36E-01                     | 5171.27        | 3       | 1     | 8.71E-01                     | 6284.32        | 5       | 3     | 7.74E-02                     |
| 4374.99        | 3       | 5     | 5.55E-03                     | 5171.47        | 5       | 7     | 5.81E-01                     | 6379.62        | 3       | 3     | 6.11E-02                     |
| 4447.03        | 3       | 5     | 1.14E+00                     | 5172.34        | 3       | 5     | 6.01E-01                     | 6482.05        | 3       | 3     | 3.01E-01                     |
| 4459.94        | 3       | 1     | 1.12E-01                     | 5172.97        | 1       | 3     | 5.01E-01                     | 6610.56        | 5       | 7     | 6.34E-01                     |
| 4465.53        | 3       | 3     | 2.36E-02                     | 5173.39        | 5       | 7     | 7.36E-01                     | 6857.03        | 5       | 3     | 2.53E-01                     |
| 4477.68        | 5       | 3     | 8.85E-02                     | 5174.46        | 5       | 5     | 5.07E-01                     | 6869.58        | 5       | 5     | 2.51E-01                     |
| 4488.09        | 5       | 5     | 1.30E-02                     | 5175.89        | 7       | 9     | 8.93E-01                     | 6887.83        | 5       | 7     | 2.49E-01                     |
| 4507.56        | 7       | 5     | 1.00E-01                     | 5176.57        | 5       | 3     | 2.17E-01                     | 7762.24        | 5       | 5     | 8.74E-02                     |
| 4564.76        | 3       | 5     | 1.41E-02                     | 5177.06        | 3       | 3     | 5.00E-01                     | 8438.74        | 1       | 3     | 2.24E-01                     |
| 4601.48        | 3       | 5     | 2.35E-01                     | 5179.34        | 7       | 9     | 8.67E-01                     | 8831.75        | 1       | 3     | 8.42E-03                     |
| 4607.15        | 1       | 3     | 3.26E-01                     | 5179.52        | 9       | 11    | 1.07E+00                     | 8855.30        | 3       | 3     | 2.51E-02                     |
| 4613.87        | 3       | 3     | 2.26E-01                     | 5180.36        | 5       | 5     | 4.28E-01                     | 8893.29        | 5       | 3     | 4.12E-02                     |
| 4621.39        | 3       | 1     | 9.55E-01                     | 5183.20        | 7       | 7     | 2.88E-01                     | <i>N III</i>   |         |       |                              |
| 4630.54        | 5       | 5     | 7.72E-01                     | 5184.96        | 7       | 7     | 3.20E-01                     | 374.198        | 2       | 4     | 9.89E+01                     |
| 4643.09        | 5       | 3     | 4.51E-01                     | 5185.09        | 5       | 3     | 7.11E-02                     | 451.871        | 2       | 2     | 1.03E+01                     |
| 4654.53        | 3       | 5     | 2.43E-02                     | 5186.21        | 7       | 5     | 5.76E-02                     | 452.227        | 4       | 2     | 2.05E+01                     |
| 4667.21        | 3       | 3     | 2.99E-02                     | 5190.38        | 9       | 9     | 1.77E-01                     | 684.998        | 2       | 4     | 9.63E+00                     |
| 4674.91        | 3       | 1     | 1.05E-01                     | 5191.96        | 7       | 5     | 4.25E-02                     | 685.515        | 2       | 2     | 3.83E+01                     |
| 4694.27        | 1       | 3     | 1.23E-01                     | 5199.50        | 9       | 7     | 1.51E-02                     | 685.817        | 4       | 4     | 4.54E+01                     |
| 4695.90        | 3       | 5     | 1.29E-01                     | 5313.42        | 3       | 3     | 1.41E-01                     | 686.336        | 4       | 2     | 1.95E+01                     |
| 4697.64        | 3       | 3     | 3.06E-02                     | 5320.20        | 5       | 3     | 4.20E-01                     | 763.334        | 2       | 2     | 9.58E+00                     |
| 4698.55        | 3       | 1     | 3.67E-01                     | 5320.96        | 3       | 5     | 2.52E-01                     | 764.351        | 4       | 2     | 1.85E+01                     |
| 4700.03        | 5       | 7     | 1.05E-01                     | 5327.76        | 5       | 5     | 4.65E-02                     | 771.545        | 2       | 4     | 8.19E+00                     |
| 4702.50        | 5       | 5     | 9.15E-02                     | 5338.73        | 5       | 7     | 1.85E-01                     | 771.901        | 4       | 4     | 1.64E+01                     |
| 4704.25        | 5       | 3     | 2.13E-01                     | 5340.21        | 7       | 5     | 2.59E-01                     | 772.384        | 6       | 4     | 2.45E+01                     |
| 4706.40        | 7       | 9     | 6.09E-02                     | 5351.23        | 7       | 7     | 3.67E-01                     | 772.889        | 6       | 4     | 2.09E+01                     |
| 4709.58        | 7       | 7     | 1.82E-01                     | 5383.72        | 3       | 5     | 3.31E-03                     | 772.955        | 4       | 2     | 2.34E+01                     |
| 4712.07        | 7       | 5     | 1.46E-01                     | 5452.07        | 1       | 3     | 8.89E-02                     | 979.832        | 4       | 4     | 8.84E+00                     |
| 4718.38        | 9       | 9     | 3.02E-01                     | 5454.22        | 3       | 1     | 3.34E-01                     | 979.905        | 6       | 6     | 9.21E+00                     |
| 4721.58        | 9       | 7     | 7.75E-02                     | 5462.58        | 3       | 3     | 1.00E-01                     | 989.799        | 2       | 4     | 4.18E+00                     |
| 4774.24        | 3       | 5     | 3.24E-02                     | 5478.09        | 3       | 5     | 4.75E-02                     | 991.511        | 4       | 4     | 8.17E-01                     |
| 4779.72        | 3       | 3     | 2.52E-01                     | 5480.05        | 5       | 3     | 1.30E-01                     | 991.577        | 4       | 6     | 4.97E+00                     |
| 4781.19        | 5       | 7     | 2.05E-02                     | 5495.65        | 5       | 5     | 2.40E-01                     | 1747.85        | 2       | 4     | 1.28E+00                     |
| 4788.14        | 5       | 5     | 2.52E-01                     | 5526.23        | 3       | 5     | 2.13E-01                     | 1751.22        | 4       | 4     | 2.48E-01                     |
| 4793.65        | 5       | 3     | 7.77E-02                     | 5530.24        | 5       | 7     | 4.04E-01                     | 1751.66        | 4       | 6     | 1.51E+00                     |
| 4803.29        | 7       | 7     | 3.18E-01                     | 5535.35        | 7       | 9     | 6.04E-01                     | 2972.55        | 2       | 2     | 6.67E-01                     |
| 4810.30        | 7       | 5     | 4.75E-02                     | 5535.38        | 3       | 3     | 4.53E-01                     | 2977.33        | 4       | 2     | 3.32E-01                     |
| 4860.17        | 3       | 5     | 1.61E-02                     | 5540.06        | 3       | 1     | 6.03E-01                     | 2978.84        | 2       | 4     | 1.66E-01                     |
| 4987.38        | 3       | 1     | 7.48E-01                     | 5543.47        | 5       | 5     | 3.51E-01                     | 2983.64        | 4       | 4     | 8.24E-01                     |
| 4991.24        | 3       | 5     | 3.54E-01                     | 5551.92        | 7       | 7     | 2.00E-01                     | 3342.76        | 2       | 2     | 3.80E-01                     |
| 4994.36        | 5       | 7     | 2.62E-01                     | 5552.68        | 5       | 3     | 1.50E-01                     | 3353.98        | 2       | 4     | 7.66E-01                     |
| 4994.37        | 3       | 3     | 7.60E-01                     | 5565.26        | 7       | 5     | 3.97E-02                     | 3354.32        | 4       | 6     | 5.51E-01                     |
| 4997.22        | 3       | 3     | 1.96E-01                     | 5666.63        | 3       | 5     | 3.74E-01                     | 3355.46        | 4       | 2     | 7.51E-01                     |
| 5001.13        | 3       | 5     | 9.76E-01                     | 5676.02        | 1       | 3     | 2.96E-01                     | 3358.78        | 2       | 2     | 3.05E-01                     |
| 5001.47        | 5       | 7     | 1.05E+00                     | 5679.56        | 5       | 7     | 5.25E-01                     | 3360.98        | 4       | 4     | 2.44E-01                     |
| 5002.70        | 1       | 3     | 8.45E-02                     | 5686.21        | 3       | 3     | 1.94E-01                     | 3365.80        | 4       | 2     | 1.52E+00                     |
| 5005.15        | 7       | 9     | 1.16E+00                     | 5710.77        | 5       | 5     | 1.24E-01                     | 3367.36        | 6       | 6     | 1.27E+00                     |
| 5005.30        | 5       | 5     | 6.51E-02                     | 5730.66        | 5       | 3     | 1.34E-02                     | 3374.07        | 6       | 4     | 8.13E-01                     |
| 5007.33        | 3       | 5     | 7.89E-01                     | 5747.30        | 3       | 5     | 3.40E-02                     | 3745.95        | 2       | 4     | 1.90E-01                     |
| 5010.62        | 3       | 3     | 2.19E-01                     | 5767.45        | 3       | 3     | 2.44E-02                     | 3752.63        | 2       | 2     | 6.67E-02                     |
| 5011.31        | 5       | 3     | 5.84E-01                     | 5893.15        | 5       | 7     | 2.88E-01                     | 3754.69        | 4       | 4     | 3.78E-01                     |
| 5012.04        | 7       | 7     | 5.19E-01                     | 5897.25        | 3       | 5     | 2.16E-01                     | 3762.60        | 4       | 4     | 4.24E-02                     |
| 5016.38        | 5       | 5     | 1.62E-01                     | 5899.83        | 1       | 3     | 1.60E-01                     | 3771.03        | 6       | 4     | 5.59E-01                     |
| 5023.05        | 7       | 5     | 3.61E-01                     | 5927.81        | 1       | 3     | 3.22E-01                     |                |         |       |                              |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3771.36        | 6       | 4     | 8.28E-02                     | 7371.51        | 4       | 4     | 3.53E-02                     | 7103.24        | 1       | 3     | 6.28E-02                     |
| 3792.97        | 8       | 6     | 1.03E-01                     | 7404.54        | 6       | 6     | 3.61E-02                     | 7109.35        | 3       | 5     | 8.46E-02                     |
| 3934.50        | 2       | 4     | 7.49E-01                     | 8307.51        | 2       | 4     | 1.65E-02                     | 7111.28        | 3       | 3     | 4.70E-02                     |
| 3938.51        | 4       | 6     | 8.96E-01                     | 8344.95        | 2       | 2     | 6.52E-02                     | *7116.8        | 9       | 15    | 1.12E-01                     |
| 3942.88        | 4       | 4     | 1.49E-01                     | 8386.39        | 4       | 4     | 8.03E-02                     | 7122.98        | 5       | 7     | 1.12E-01                     |
| 4097.36        | 2       | 4     | 8.70E-01                     | 8424.56        | 4       | 2     | 3.17E-02                     | 7127.25        | 5       | 5     | 2.80E-02                     |
| 4103.39        | 2       | 2     | 8.67E-01                     | <i>NIV</i>     |         |       |                              | 7127.25        | 5       | 3     | 3.11E-03                     |
| 4195.74        | 2       | 4     | 9.37E-01                     | 247.205        | 1       | 3     | 1.19E+02                     | 9165.07        | 3       | 5     | 4.23E-02                     |
| 4200.07        | 4       | 6     | 1.12E+00                     | *283.52        | 9       | 15    | 3.05E+02                     | 9182.16        | 5       | 7     | 4.45E-02                     |
| 4215.77        | 4       | 4     | 1.85E-01                     | *322.64        | 9       | 3     | 8.99E+01                     | 9222.99        | 7       | 9     | 4.95E-02                     |
| 4318.78        | 2       | 4     | 5.40E-02                     | 335.047        | 3       | 5     | 1.845E+02                    | 9247.04        | 5       | 5     | 7.66E-03                     |
| 4321.22        | 2       | 2     | 1.08E-01                     | 387.356        | 3       | 1     | 2.55E+01                     | 9311.55        | 7       | 7     | 5.36E-03                     |
| 4321.39        | 4       | 6     | 5.03E-02                     | 765.147        | 1       | 3     | 2.320E+01                    | <i>NV</i>      |         |       |                              |
| 4325.43        | 4       | 4     | 8.60E-02                     | *923.16        | 9       | 9     | 1.759E+01                    | *209.29        | 2       | 6     | 1.21E+02                     |
| 4327.69        | 6       | 8     | 3.06E-02                     | 955.334        | 3       | 1     | 2.919E+01                    | *247.66        | 6       | 10    | 4.26E+02                     |
| 4327.88        | 4       | 2     | 1.07E-01                     | 1718.55        | 3       | 5     | 2.321E+00                    | 1238.82        | 2       | 4     | 3.40E+00                     |
| 4332.95        | 6       | 6     | 1.23E-01                     | 2649.88        | 3       | 3     | 1.07E+00                     | 1242.80        | 2       | 2     | 3.37E+00                     |
| 4337.01        | 6       | 4     | 7.47E-02                     | 3052.20        | 1       | 3     | 1.33E-01                     | 4603.74        | 2       | 4     | 4.14E-01                     |
| 4345.81        | 8       | 8     | 1.82E-01                     | 3059.60        | 3       | 3     | 3.95E-01                     | 4619.97        | 2       | 2     | 4.10E-01                     |
| 4351.11        | 8       | 6     | 4.01E-02                     | 3075.19        | 5       | 3     | 6.48E-01                     | <i>NVI</i>     |         |       |                              |
| 4510.88        | 2       | 4     | 2.84E-01                     | 3443.61        | 3       | 5     | 3.46E-01                     | 24.8980        | 1       | 3     | 5.158E+03                    |
| 4510.96        | 4       | 6     | 4.77E-01                     | 3445.22        | 1       | 3     | 4.60E-01                     | 28.7870        | 1       | 3     | 1.809E+04                    |
| 4514.85        | 6       | 8     | 6.80E-01                     | 3454.65        | 3       | 3     | 3.42E-01                     | *161.220       | 3       | 9     | 2.859E+02                    |
| 4518.14        | 2       | 2     | 5.65E-01                     | 3461.36        | 3       | 1     | 1.36E+00                     | 173.275        | 1       | 3     | 2.697E+02                    |
| 4523.56        | 4       | 4     | 3.61E-01                     | 3463.36        | 5       | 5     | 1.02E+00                     | *173.93        | 9       | 15    | 8.756E+02                    |
| 4530.86        | 4       | 2     | 1.12E-01                     | 3474.53        | 5       | 3     | 5.61E-01                     | 185.192        | 3       | 5     | 8.205E+02                    |
| 4534.58        | 6       | 6     | 2.01E-01                     | 3478.72        | 3       | 5     | 1.06E+00                     | *1901          | 3       | 9     | 6.780E-01                    |
| 4547.30        | 6       | 4     | 3.33E-02                     | *3480.8        | 3       | 9     | 1.06E+00                     | 2896.4         | 1       | 3     | 2.079E-01                    |
| 4634.13        | 2       | 4     | 6.36E-01                     | 3483.00        | 3       | 3     | 1.06E+00                     | *6991.1        | 3       | 9     | 8.384E-02                    |
| 4640.64        | 4       | 6     | 7.60E-01                     | 3484.93        | 3       | 1     | 1.06E+00                     | 9622.0         | 1       | 3     | 3.276E-02                    |
| 4641.85        | 4       | 4     | 1.26E-01                     | 3689.94        | 3       | 1     | 9.10E-02                     | <i>Oxygen</i>  |         |       |                              |
| 4858.70        | 2       | 4     | 4.35E-01                     | 3694.14        | 3       | 3     | 2.27E-02                     | <i>OI</i>      |         |       |                              |
| 4858.98        | 4       | 6     | 4.66E-01                     | 3707.39        | 5       | 3     | 6.73E-02                     | 791.973        | 5       | 5     | 4.94E+00                     |
| 4861.27        | 6       | 8     | 5.32E-01                     | 3714.43        | 5       | 5     | 1.34E-02                     | 792.938        | 1       | 3     | 2.19E+00                     |
| 4867.12        | 4       | 4     | 1.73E-01                     | 3735.43        | 7       | 5     | 7.37E-02                     | 792.967        | 3       | 5     | 1.64E+00                     |
| 4867.17        | 8       | 10    | 6.18E-01                     | 3747.54        | 3       | 5     | 9.92E-01                     | 877.798        | 5       | 3     | 2.85E+00                     |
| 4873.60        | 6       | 6     | 1.50E-01                     | 4057.76        | 3       | 5     | 6.62E-01                     | 877.879        | 5       | 5     | 5.12E+00                     |
| 4881.78        | 6       | 4     | 1.22E-02                     | 4740.26        | 3       | 5     | 1.53E-02                     | 922.008        | 5       | 7     | 1.23E+00                     |
| 4884.14        | 8       | 8     | 8.71E-02                     | 4747.96        | 3       | 3     | 7.60E-02                     | 935.193        | 5       | 5     | 1.33E+00                     |
| 4896.58        | 8       | 6     | 5.86E-03                     | 4752.49        | 5       | 7     | 1.13E-02                     | 1028.16        | 1       | 3     | 4.22E-01                     |
| 5260.86        | 2       | 2     | 2.80E-02                     | 4762.09        | 5       | 5     | 6.99E-02                     | 1152.15        | 5       | 5     | 5.28E+00                     |
| 5270.57        | 2       | 4     | 6.95E-02                     | 4769.86        | 5       | 3     | 2.50E-02                     | 1217.65        | 1       | 3     | 2.06E+00                     |
| 5272.68        | 4       | 2     | 1.39E-01                     | 4786.92        | 7       | 7     | 8.79E-02                     | 1302.17        | 5       | 3     | 3.41E+00                     |
| 5282.43        | 4       | 4     | 2.21E-02                     | 4796.66        | 7       | 5     | 1.53E-02                     | 1304.86        | 3       | 3     | 2.03E+00                     |
| 5297.75        | 4       | 6     | 4.93E-02                     | 5200.41        | 3       | 5     | 2.67E-01                     | 1306.03        | 1       | 3     | 6.76E-01                     |
| 5298.95        | 6       | 4     | 7.38E-02                     | 5204.28        | 5       | 7     | 3.55E-01                     | 3823.41        | 7       | 7     | 6.63E-03                     |
| 5314.36        | 6       | 6     | 1.14E-01                     | 5205.15        | 1       | 3     | 1.97E-01                     | 3823.87        | 5       | 3     | 1.87E-03                     |
| 5320.87        | 6       | 8     | 5.68E-01                     | 5226.70        | 3       | 3     | 1.46E-01                     | 3824.35        | 5       | 5     | 5.19E-03                     |
| 5327.19        | 4       | 6     | 5.29E-01                     | 5245.60        | 5       | 5     | 8.66E-02                     | 3825.02        | 3       | 3     | 5.59E-03                     |
| 5352.46        | 6       | 6     | 3.72E-02                     | 5272.35        | 5       | 3     | 9.48E-03                     | 3825.19        | 5       | 7     | 8.31E-04                     |
| 6365.84        | 2       | 2     | 2.18E-01                     | 5288.25        | 5       | 3     | 3.22E-02                     | 3855.01        | 5       | 5     | 1.63E-02                     |
| 6394.75        | 2       | 4     | 2.15E-01                     | 5736.93        | 3       | 5     | 1.84E-01                     | 3947.29        | 5       | 7     | 4.91E-03                     |
| 6445.34        | 2       | 4     | 8.89E-02                     | 5776.31        | 1       | 3     | 1.85E-02                     | 3947.48        | 5       | 5     | 4.88E-03                     |
| 6450.79        | 2       | 2     | 1.77E-01                     | 5784.76        | 3       | 1     | 5.51E-02                     | 3947.59        | 5       | 3     | 4.87E-03                     |
| 6454.08        | 4       | 6     | 1.49E-01                     | 5795.09        | 3       | 3     | 1.37E-02                     | 3951.93        | 3       | 1     | 3.10E-03                     |
| 6463.09        | 4       | 4     | 1.13E-01                     | 5812.31        | 3       | 5     | 1.36E-02                     | 3952.98        | 5       | 3     | 1.29E-03                     |
| 6467.02        | 6       | 8     | 2.11E-01                     | 5826.43        | 5       | 3     | 2.25E-02                     | 3953.00        | 1       | 3     | 1.03E-03                     |
| 6468.57        | 4       | 2     | 3.52E-02                     | 5843.84        | 5       | 5     | 4.01E-02                     | 3954.52        | 3       | 5     | 7.73E-04                     |
| 6478.76        | 6       | 6     | 6.31E-02                     | 6380.75        | 1       | 3     | 1.42E-01                     |                |         |       |                              |
| 6487.84        | 6       | 4     | 1.05E-02                     |                |         |       |                              |                |         |       |                              |

| $\lambda$    | Weights |       | $A$                   | $\lambda$    | Weights |       | $A$                   | $\lambda$    | Weights |       | $A$                   |
|--------------|---------|-------|-----------------------|--------------|---------|-------|-----------------------|--------------|---------|-------|-----------------------|
| $\text{\AA}$ | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ | $\text{\AA}$ | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ | $\text{\AA}$ | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ |
| 3954.61      | 5       | 5     | 2.32E-03              | 9260.85      | 3       | 3     | 3.34E-01              | 3843.58      | 4       | 6     | 3.55E-02              |
| 3997.95      | 5       | 3     | 2.41E-02              | 9260.94      | 3       | 5     | 1.56E-01              | 3847.89      | 2       | 2     | 1.95E-01              |
| 4217.09      | 3       | 1     | 5.44E-03              | 9262.58      | 5       | 3     | 1.11E-01              | 3850.80      | 4       | 6     | 6.00E-03              |
| 4222.77      | 5       | 3     | 2.26E-03              | 9262.67      | 5       | 5     | 2.60E-01              | 3851.03      | 4       | 4     | 1.59E-01              |
| 4222.82      | 1       | 3     | 1.81E-03              | 9262.78      | 5       | 7     | 2.97E-01              | 3851.47      | 8       | 8     | 2.72E-02              |
| 4233.27      | 5       | 5     | 4.04E-03              | 9265.83      | 7       | 5     | 2.97E-02              | 3856.13      | 4       | 2     | 2.28E-01              |
| 4368.19      | 3       | 1     | 7.56E-03              | 9265.93      | 7       | 7     | 1.48E-01              | 3857.16      | 6       | 6     | 6.59E-02              |
| 4368.24      | 3       | 5     | 7.59E-03              | 9266.01      | 7       | 9     | 4.45E-01              | 3863.50      | 6       | 8     | 6.49E-02              |
| 4967.38      | 3       | 5     | 4.43E-03              | 9482.89      | 5       | 3     | 2.34E-01              | 3864.13      | 2       | 2     | 9.12E-02              |
| 4967.88      | 5       | 7     | 8.44E-03              | 9622.11      | 5       | 3     | 5.22E-04              | 3864.43      | 6       | 6     | 2.15E-01              |
| 4968.79      | 7       | 9     | 1.27E-02              | 9622.16      | 3       | 3     | 1.57E-03              | 3864.67      | 6       | 4     | 1.80E-01              |
| 5019.29      | 5       | 5     | 7.13E-03              | 9625.26      | 7       | 5     | 3.25E-04              | 3874.09      | 2       | 4     | 3.26E-02              |
| 5020.22      | 7       | 5     | 9.98E-03              | 9625.30      | 7       | 7     | 1.85E-03              | 3875.80      | 8       | 6     | 3.38E-02              |
| 5329.11      | 3       | 5     | 9.48E-03              | 9694.66      | 5       | 7     | 4.54E-04              | 3882.19      | 8       | 8     | 5.50E-01              |
| 5329.69      | 5       | 7     | 1.81E-02              | 9694.91      | 5       | 5     | 4.54E-04              | 3882.45      | 4       | 4     | 8.94E-02              |
| 5330.74      | 7       | 9     | 2.71E-02              | 9695.06      | 5       | 3     | 4.54E-04              | 3883.14      | 8       | 6     | 1.13E-01              |
| 5435.18      | 3       | 5     | 7.74E-03              | <i>O II</i>  |         |       |                       | 3893.52      | 4       | 6     | 1.89E-02              |
| 5435.77      | 5       | 5     | 1.29E-02              | 429.918      | 4       | 2     | 4.25E+01              | 3907.45      | 6       | 6     | 8.64E-02              |
| 5436.86      | 7       | 5     | 1.80E-02              | 430.041      | 4       | 4     | 4.13E+01              | 3911.96      | 6       | 4     | 1.09E+00              |
| 5512.60      | 3       | 5     | 2.69E-03              | 430.176      | 4       | 6     | 4.36E+01              | 3912.12      | 4       | 4     | 1.41E-01              |
| 5512.77      | 5       | 7     | 3.58E-03              | 483.760      | 4       | 2     | 2.05E+01              | 3919.27      | 4       | 2     | 1.22E+00              |
| 5554.83      | 3       | 3     | 5.83E-03              | 483.980      | 6       | 4     | 1.80E+01              | 3945.04      | 2       | 4     | 2.05E-01              |
| 5555.00      | 5       | 3     | 9.71E-03              | 484.027      | 4       | 4     | 3.22E+00              | 3954.36      | 2       | 2     | 8.57E-01              |
| 5958.39      | 3       | 5     | 6.80E-03              | 485.087      | 6       | 8     | 2.60E+01              | 3973.26      | 4       | 4     | 1.04E+00              |
| 5958.58      | 5       | 7     | 9.06E-03              | 485.470      | 6       | 6     | 1.20E+00              | 3982.71      | 4       | 2     | 4.27E-01              |
| 6046.23      | 3       | 3     | 1.05E-02              | 485.518      | 4       | 6     | 1.93E+01              | 4069.62      | 2       | 4     | 1.52E+00              |
| 6046.44      | 5       | 3     | 1.75E-02              | 2290.85      | 2       | 4     | 7.41E-02              | 4069.88      | 4       | 6     | 1.53E+00              |
| 6046.49      | 1       | 3     | 3.50E-03              | 2293.30      | 2       | 2     | 3.25E-01              | 4072.15      | 6       | 8     | 1.98E+00              |
| 6155.99      | 3       | 5     | 2.67E-02              | 2300.33      | 4       | 4     | 4.17E-01              | 4075.86      | 8       | 10    | 2.11E+00              |
| 6156.78      | 5       | 7     | 5.08E-02              | 2302.81      | 4       | 2     | 1.67E-01              | 4078.84      | 4       | 4     | 5.52E-01              |
| 6158.19      | 7       | 9     | 7.62E-02              | 2365.14      | 4       | 2     | 1.52E-01              | 4084.65      | 6       | 8     | 7.28E-02              |
| 6324.84      | 7       | 5     | 3.76E-05              | 2375.72      | 6       | 4     | 1.35E-01              | 4085.11      | 6       | 6     | 4.55E-01              |
| 6453.60      | 3       | 5     | 1.65E-02              | 2406.38      | 6       | 4     | 1.85E-01              | 4092.93      | 8       | 8     | 2.65E-01              |
| 6454.44      | 5       | 5     | 2.75E-02              | 2407.48      | 4       | 4     | 2.25E-01              | 4094.14      | 6       | 4     | 4.70E-02              |
| 6455.98      | 7       | 5     | 3.85E-02              | 2411.60      | 4       | 2     | 2.05E-01              | 4096.53      | 4       | 6     | 1.73E-01              |
| 6726.28      | 5       | 5     | 1.18E-05              | 2411.64      | 2       | 2     | 1.10E-01              | 4097.22      | 2       | 4     | 3.62E-01              |
| 6726.54      | 5       | 3     | 6.44E-06              | 2415.13      | 4       | 2     | 2.20E-01              | 4103.00      | 2       | 2     | 5.09E-01              |
| 7001.92      | 3       | 5     | 2.65E-02              | 2418.46      | 6       | 6     | 2.30E-01              | 4104.72      | 4       | 6     | 3.14E-01              |
| 7002.23      | 5       | 7     | 3.53E-02              | 2425.57      | 6       | 6     | 1.77E-01              | 4104.99      | 4       | 4     | 9.14E-01              |
| 7254.15      | 3       | 3     | 2.24E-02              | 2433.54      | 2       | 4     | 4.21E-01              | 4106.02      | 8       | 6     | 1.70E-02              |
| 7254.45      | 5       | 3     | 3.73E-02              | 2436.06      | 4       | 4     | 1.69E-01              | 4109.84      | 6       | 6     | 1.21E-02              |
| 7254.53      | 1       | 3     | 7.45E-03              | 2444.25      | 4       | 4     | 7.56E-02              | 4110.19      | 6       | 4     | 2.54E-01              |
| 7771.94      | 5       | 7     | 3.69E-01              | 2445.53      | 4       | 6     | 4.98E-01              | 4110.79      | 4       | 2     | 7.70E-01              |
| 7774.17      | 5       | 5     | 3.69E-01              | 2517.96      | 4       | 6     | 7.72E-02              | 4112.02      | 6       | 6     | 1.81E-01              |
| 7775.39      | 5       | 3     | 3.69E-01              | 2523.21      | 2       | 2     | 9.63E-02              | 4113.83      | 8       | 6     | 2.41E-01              |
| 7981.94      | 3       | 3     | 2.33E-04              | 2526.87      | 4       | 4     | 1.20E-01              | 4119.22      | 6       | 8     | 1.33E+00              |
| 7982.40      | 1       | 3     | 3.09E-04              | 2530.28      | 6       | 8     | 8.16E-02              | 4120.28      | 6       | 6     | 2.15E-01              |
| 7986.98      | 3       | 5     | 4.19E-04              | 2571.46      | 2       | 4     | 1.15E-01              | 4120.55      | 6       | 4     | 2.60E-01              |
| 7987.33      | 5       | 5     | 1.41E-04              | 2575.28      | 4       | 6     | 1.37E-01              | 4121.46      | 2       | 2     | 5.60E-01              |
| 7995.07      | 5       | 7     | 5.63E-04              | 3134.73      | 8       | 6     | 1.23E+00              | 4129.32      | 4       | 2     | 1.79E-01              |
| 8221.82      | 7       | 7     | 2.89E-01              | 3273.43      | 8       | 6     | 9.99E-01              | 4132.80      | 2       | 4     | 9.13E-01              |
| 8227.65      | 5       | 3     | 8.13E-02              | 3377.15      | 2       | 2     | 1.27E+00              | 4140.70      | 4       | 4     | 4.09E-02              |
| 8230.00      | 5       | 5     | 2.26E-01              | 3390.21      | 2       | 4     | 1.22E+00              | 4153.30      | 4       | 6     | 7.91E-01              |
| 8233.00      | 3       | 3     | 2.43E-01              | 3407.28      | 6       | 6     | 1.02E+00              | 4156.53      | 6       | 4     | 2.11E-01              |
| 8235.35      | 3       | 5     | 4.86E-02              | 3712.74      | 2       | 4     | 2.84E-01              | 4169.22      | 6       | 6     | 2.71E-01              |
| 8446.25      | 3       | 1     | 3.22E-01              | 3727.32      | 4       | 4     | 5.81E-01              | 4185.44      | 6       | 8     | 1.91E+00              |
| 8446.36      | 3       | 5     | 3.22E-01              | 3749.48      | 6       | 4     | 9.31E-01              | 4189.58      | 8       | 8     | 7.06E-02              |
| 8446.76      | 3       | 3     | 3.22E-01              | 3833.07      | 6       | 8     | 1.02E-02              | 4189.79      | 8       | 10    | 1.98E+00              |
| 8820.42      | 5       | 7     | 2.93E-01              | 3842.81      | 2       | 4     | 7.45E-02              | 4192.51      | 6       | 4     | 3.21E-01              |
| 9260.81      | 3       | 1     | 4.46E-01              |              |         |       |                       | 4196.27      | 4       | 4     | 3.56E-02              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 4196.70        | 4       | 2     | 3.56E-01                     | 4864.88        | 4       | 2     | 8.07E-02                     | 597.814        | 1       | 3     | 1.49E+01                     |
| 4317.14        | 2       | 4     | 3.70E-01                     | 4871.52        | 4       | 6     | 5.60E-01                     | 599.590        | 5       | 5     | 5.41E+01                     |
| 4319.63        | 4       | 6     | 2.55E-01                     | 4872.02        | 4       | 4     | 9.34E-02                     | 702.337        | 1       | 3     | 6.06E+00                     |
| 4319.87        | 2       | 2     | 5.62E-01                     | 4890.86        | 4       | 2     | 4.80E-01                     | 702.838        | 3       | 1     | 1.83E+01                     |
| 4325.76        | 2       | 2     | 1.47E-01                     | 4906.83        | 4       | 4     | 4.54E-01                     | 832.929        | 1       | 3     | 3.41E+00                     |
| 4327.46        | 6       | 6     | 6.76E-01                     | 4924.53        | 4       | 6     | 5.43E-01                     | 835.092        | 5       | 5     | 1.44E+00                     |
| 4327.85        | 6       | 4     | 7.24E-02                     | 4941.07        | 2       | 4     | 5.87E-01                     | 835.289        | 5       | 7     | 5.99E+00                     |
| 4328.59        | 4       | 2     | 1.12E+00                     | 4943.01        | 4       | 6     | 7.78E-01                     | 1679.03        | 3       | 5     | 6.57E-01                     |
| 4331.47        | 4       | 6     | 4.82E-02                     | 4955.71        | 4       | 4     | 1.82E-01                     | 1686.73        | 3       | 3     | 6.48E-01                     |
| 4331.86        | 4       | 4     | 6.50E-01                     | 5159.94        | 2       | 2     | 3.29E-01                     | 1760.41        | 3       | 5     | 8.38E-01                     |
| 4336.86        | 4       | 4     | 1.57E-01                     | 5175.90        | 4       | 2     | 1.49E-01                     | 1764.46        | 5       | 5     | 2.50E+00                     |
| 4345.56        | 4       | 2     | 8.31E-01                     | 5190.50        | 2       | 4     | 1.26E-01                     | 1766.63        | 1       | 3     | 1.11E+00                     |
| 4347.22        | 6       | 4     | 1.19E-01                     | 5206.65        | 4       | 4     | 3.58E-01                     | 1772.28        | 3       | 1     | 3.29E+00                     |
| 4347.41        | 4       | 4     | 9.32E-01                     | 5583.22        | 2       | 4     | 2.17E-02                     | 1772.97        | 5       | 3     | 1.37E+00                     |
| 4349.43        | 6       | 6     | 6.91E-01                     | 5611.07        | 2       | 2     | 2.14E-02                     | 2390.43        | 3       | 3     | 1.62E+00                     |
| 4351.26        | 6       | 6     | 9.89E-01                     | 6627.37        | 4       | 4     | 1.73E-01                     | 2454.97        | 3       | 1     | 3.43E+00                     |
| 4351.46        | 4       | 6     | 5.82E-02                     | 6641.03        | 2       | 2     | 9.88E-02                     | 2665.68        | 3       | 5     | 6.75E-01                     |
| 4359.40        | 4       | 6     | 1.44E-02                     | 6666.66        | 4       | 2     | 6.78E-02                     | 2674.58        | 5       | 5     | 1.11E+00                     |
| 4366.89        | 6       | 4     | 3.98E-01                     | 6677.87        | 2       | 4     | 3.37E-02                     | 2683.66        | 3       | 1     | 1.85E+00                     |
| 4369.27        | 4       | 4     | 3.57E-01                     | 6717.75        | 2       | 2     | 1.33E-01                     | 2686.15        | 7       | 5     | 1.54E+00                     |
| 4395.93        | 6       | 6     | 3.91E-01                     | 6721.39        | 4       | 2     | 1.81E-01                     | 2687.55        | 3       | 3     | 1.84E+00                     |
| 4405.98        | 6       | 4     | 4.30E-02                     | 6810.48        | 6       | 8     | 1.64E-03                     | 2695.48        | 3       | 5     | 1.82E+00                     |
| 4414.90        | 4       | 6     | 8.34E-01                     | 6844.10        | 4       | 6     | 2.97E-03                     | 2794.14        | 3       | 1     | 1.82E-01                     |
| 4416.97        | 2       | 4     | 7.13E-01                     | 6846.80        | 8       | 8     | 3.17E-02                     | 2798.93        | 3       | 3     | 4.52E-02                     |
| 4443.01        | 6       | 6     | 5.05E-01                     | 6869.48        | 6       | 6     | 5.35E-02                     | 2809.66        | 5       | 3     | 1.34E-01                     |
| 4443.52        | 6       | 8     | 1.89E-02                     | 6884.88        | 4       | 4     | 6.12E-02                     | 2818.70        | 5       | 5     | 2.66E-02                     |
| 4447.68        | 8       | 6     | 2.52E-02                     | 6895.10        | 10      | 8     | 2.72E-01                     | 2836.31        | 7       | 5     | 1.46E-01                     |
| 4448.19        | 8       | 8     | 5.10E-01                     | 6906.44        | 8       | 6     | 2.48E-01                     | 2959.69        | 3       | 5     | 1.83E+00                     |
| 4452.38        | 4       | 4     | 1.37E-01                     | 6907.87        | 4       | 2     | 3.03E-01                     | 2983.78        | 3       | 5     | 2.15E+00                     |
| 4466.24        | 2       | 4     | 9.00E-01                     | 6910.56        | 6       | 4     | 2.43E-01                     | 2992.08        | 3       | 5     | 9.32E-02                     |
| 4467.46        | 2       | 2     | 9.00E-01                     | <i>O III</i>   |         |       |                              | 2996.48        | 3       | 3     | 4.64E-01                     |
| 4563.18        | 4       | 4     | 7.18E-03                     | 263.694        | 1       | 3     | 3.32E+01                     | 2997.69        | 5       | 7     | 6.88E-02                     |
| 4590.97        | 6       | 8     | 8.85E-01                     | 263.727        | 3       | 5     | 4.48E+01                     | 3004.34        | 5       | 5     | 4.27E-01                     |
| 4595.96        | 6       | 6     | 4.87E-02                     | 263.773        | 3       | 3     | 2.49E+01                     | 3008.78        | 5       | 3     | 1.53E-01                     |
| 4596.18        | 4       | 6     | 8.34E-01                     | 263.817        | 5       | 7     | 5.97E+01                     | 3017.62        | 7       | 7     | 5.38E-01                     |
| 4638.86        | 2       | 4     | 3.71E-01                     | 263.861        | 5       | 5     | 1.49E+01                     | 3023.43        | 3       | 5     | 4.79E-01                     |
| 4641.81        | 4       | 6     | 5.96E-01                     | 277.386        | 5       | 7     | 9.43E+01                     | 3024.36        | 7       | 5     | 9.39E-02                     |
| 4649.13        | 6       | 8     | 7.81E-01                     | 279.788        | 5       | 5     | 4.25E+01                     | 3024.54        | 1       | 3     | 6.16E-01                     |
| 4650.84        | 2       | 2     | 6.86E-01                     | 295.942        | 1       | 3     | 5.56E+01                     | 3035.41        | 3       | 3     | 4.59E-01                     |
| 4661.63        | 4       | 4     | 4.10E-01                     | 303.413        | 1       | 3     | 4.29E+01                     | 3042.07        | 3       | 1     | 1.94E+00                     |
| 4673.73        | 4       | 2     | 1.35E-01                     | 303.461        | 3       | 1     | 1.29E+02                     | 3047.10        | 5       | 5     | 1.49E+00                     |
| 4676.23        | 6       | 6     | 2.05E-01                     | 303.517        | 3       | 3     | 3.21E+01                     | 3059.28        | 5       | 3     | 8.72E-01                     |
| 4690.89        | 2       | 4     | 1.86E-01                     | 303.622        | 3       | 5     | 3.21E+01                     | 3064.98        | 1       | 3     | 2.17E-01                     |
| 4691.42        | 2       | 2     | 7.43E-01                     | 303.695        | 5       | 3     | 5.34E+01                     | 3068.13        | 3       | 1     | 6.49E-01                     |
| 4696.35        | 6       | 4     | 3.25E-02                     | 303.800        | 5       | 5     | 9.61E+01                     | 3068.26        | 3       | 3     | 5.41E-02                     |
| 4698.44        | 6       | 6     | 6.59E-02                     | 305.596        | 1       | 3     | 1.20E+02                     | 3068.67        | 3       | 5     | 2.27E-01                     |
| 4699.01        | 6       | 8     | 9.88E-01                     | 305.656        | 3       | 5     | 1.62E+02                     | 3074.14        | 5       | 7     | 1.84E-01                     |
| 4699.22        | 4       | 6     | 9.36E-01                     | 305.702        | 3       | 3     | 9.01E+01                     | 3074.72        | 5       | 3     | 3.76E-01                     |
| 4701.18        | 4       | 4     | 9.23E-01                     | 305.767        | 5       | 7     | 2.16E+02                     | 3075.13        | 5       | 5     | 1.61E-01                     |
| 4701.71        | 4       | 2     | 3.69E-01                     | 305.836        | 5       | 5     | 5.40E+01                     | 3075.95        | 7       | 9     | 1.07E-01                     |
| 4703.16        | 4       | 6     | 9.20E-01                     | 320.978        | 5       | 7     | 2.17E+02                     | 3083.65        | 7       | 7     | 3.20E-01                     |
| 4705.35        | 6       | 8     | 1.10E+00                     | 328.448        | 5       | 5     | 1.04E+02                     | 3084.64        | 7       | 5     | 2.55E-01                     |
| 4710.01        | 4       | 6     | 2.98E-01                     | 345.312        | 1       | 3     | 1.35E+02                     | 3088.04        | 9       | 9     | 5.30E-01                     |
| 4741.70        | 6       | 6     | 4.71E-02                     | 374.073        | 5       | 5     | 2.85E+01                     | 3095.79        | 9       | 7     | 1.35E-01                     |
| 4751.28        | 6       | 8     | 6.39E-02                     | 395.557        | 5       | 3     | 2.80E+01                     | 3115.67        | 3       | 1     | 1.39E+00                     |
| 4752.69        | 6       | 6     | 1.45E-02                     | 507.388        | 1       | 3     | 1.61E+01                     | 3121.63        | 3       | 3     | 1.38E+00                     |
| 4844.92        | 4       | 6     | 1.02E-02                     | 507.680        | 3       | 3     | 4.82E+01                     | 3132.79        | 3       | 5     | 1.37E+00                     |
| 4856.39        | 4       | 6     | 5.58E-02                     | 508.178        | 5       | 3     | 8.04E+01                     | 3198.18        | 3       | 5     | 9.57E-02                     |
| 4856.76        | 4       | 4     | 1.00E-01                     | 525.794        | 5       | 3     | 9.60E+01                     | 3201.14        | 3       | 3     | 4.77E-01                     |
| 4860.97        | 2       | 4     | 4.70E-01                     |                |         |       |                              | 3202.51        | 5       | 7     | 7.08E-02                     |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3207.61        | 5       | 5     | 4.40E-01                     | 3698.72        | 5       | 7     | 7.62E-01                     | 625.127        | 4       | 4     | 2.13E+01                     |
| 3210.58        | 5       | 3     | 1.58E-01                     | 3703.36        | 7       | 9     | 1.14E+00                     | 625.853        | 6       | 4     | 3.19E+01                     |
| 3216.07        | 7       | 7     | 5.58E-01                     | 3704.75        | 3       | 3     | 8.53E-01                     | 779.736        | 6       | 4     | 1.46E+00                     |
| 3221.21        | 7       | 5     | 9.75E-02                     | 3707.27        | 3       | 5     | 7.34E-01                     | 779.820        | 4       | 4     | 1.31E+01                     |
| 3260.86        | 5       | 7     | 1.68E+00                     | 3709.54        | 3       | 1     | 1.13E+00                     | 779.912        | 6       | 6     | 1.36E+01                     |
| 3265.33        | 7       | 9     | 1.88E+00                     | 3712.49        | 5       | 5     | 6.59E-01                     | 779.997        | 4       | 6     | 9.70E-01                     |
| 3267.20        | 3       | 5     | 1.58E+00                     | 3714.03        | 3       | 3     | 4.06E-01                     | 787.710        | 2       | 4     | 5.95E+00                     |
| 3281.83        | 5       | 5     | 2.89E-01                     | 3715.09        | 5       | 7     | 9.73E-01                     | 790.112        | 4       | 4     | 1.18E+00                     |
| 3284.45        | 7       | 7     | 2.06E-01                     | 3720.89        | 7       | 7     | 3.74E-01                     | 790.199        | 4       | 6     | 7.08E+00                     |
| 3299.39        | 1       | 3     | 1.64E-01                     | 3721.95        | 5       | 3     | 2.80E-01                     | 921.296        | 2       | 4     | 2.21E+00                     |
| 3312.33        | 3       | 3     | 4.60E-01                     | 3725.31        | 5       | 5     | 2.41E-01                     | 921.365        | 2       | 2     | 8.83E+00                     |
| 3326.06        | 3       | 3     | 2.65E-01                     | 3728.51        | 5       | 7     | 1.29E+00                     | 923.367        | 4       | 4     | 1.10E+01                     |
| 3330.30        | 3       | 5     | 6.81E-01                     | 3728.84        | 7       | 9     | 1.45E+00                     | 923.436        | 4       | 2     | 4.39E+00                     |
| 3330.32        | 3       | 5     | 4.76E-01                     | 3729.80        | 3       | 5     | 1.22E+00                     | 1338.61        | 2       | 4     | 2.17E+00                     |
| 3332.41        | 5       | 3     | 7.92E-01                     | 3732.13        | 5       | 3     | 2.67E-02                     | 1342.99        | 4       | 4     | 4.29E-01                     |
| 3332.93        | 5       | 7     | 5.04E-01                     | 3734.83        | 7       | 5     | 7.40E-02                     | 1343.51        | 4       | 6     | 2.57E+00                     |
| 3336.67        | 3       | 3     | 3.76E-01                     | 3742.63        | 5       | 5     | 2.24E-01                     | 2120.58        | 2       | 2     | 1.05E+00                     |
| 3336.69        | 5       | 5     | 8.77E-02                     | 3746.90        | 7       | 7     | 1.59E-01                     | 2132.64        | 4       | 4     | 1.29E+00                     |
| 3340.76        | 5       | 3     | 6.57E-01                     | 3754.70        | 3       | 5     | 7.53E-01                     | 2493.39        | 2       | 4     | 1.18E+00                     |
| 3344.20        | 5       | 5     | 1.25E-01                     | 3757.23        | 1       | 3     | 5.56E-01                     | 2493.75        | 4       | 6     | 8.48E-01                     |
| 3344.51        | 5       | 7     | 3.48E-01                     | 3759.88        | 5       | 7     | 9.79E-01                     | 2493.99        | 2       | 2     | 6.09E-01                     |
| 3347.98        | 7       | 5     | 4.86E-01                     | 3774.03        | 3       | 3     | 3.91E-01                     | 2499.27        | 2       | 2     | 4.68E-01                     |
| 3350.62        | 5       | 3     | 1.12E+00                     | 3791.28        | 5       | 5     | 2.24E-01                     | 2501.81        | 4       | 4     | 3.73E-01                     |
| 3350.92        | 7       | 7     | 9.91E-01                     | 3810.98        | 5       | 3     | 2.37E-02                     | 2507.73        | 4       | 2     | 2.32E+00                     |
| 3355.86        | 7       | 7     | 6.89E-01                     | 3816.75        | 5       | 3     | 9.63E-02                     | 2509.22        | 6       | 6     | 1.94E+00                     |
| 3362.31        | 7       | 5     | 6.87E-01                     | 3961.57        | 5       | 7     | 1.25E+00                     | 2510.58        | 4       | 2     | 1.19E+00                     |
| 3376.61        | 3       | 1     | 1.49E+00                     | 4072.64        | 1       | 3     | 3.37E-01                     | 2517.37        | 6       | 4     | 1.24E+00                     |
| 3376.76        | 3       | 3     | 1.12E+00                     | 4073.98        | 3       | 5     | 4.54E-01                     | 2781.22        | 2       | 2     | 1.03E-01                     |
| 3377.26        | 3       | 5     | 5.20E-01                     | 4081.02        | 5       | 7     | 6.02E-01                     | 2803.57        | 6       | 4     | 1.26E-01                     |
| 3382.61        | 5       | 7     | 9.86E-01                     | 4089.30        | 3       | 3     | 2.49E-01                     | 2805.87        | 2       | 4     | 2.90E-01                     |
| 3383.31        | 5       | 3     | 3.70E-01                     | 4103.07        | 5       | 5     | 1.48E-01                     | 2812.50        | 6       | 6     | 3.58E-02                     |
| 3383.81        | 5       | 5     | 8.62E-01                     | 4118.60        | 5       | 3     | 1.63E-02                     | 2816.53        | 4       | 4     | 5.74E-01                     |
| 3384.90        | 7       | 9     | 1.48E+00                     | 4440.09        | 5       | 3     | 4.42E-01                     | 2829.17        | 8       | 6     | 1.56E-01                     |
| 3394.22        | 7       | 7     | 4.88E-01                     | 4447.69        | 5       | 5     | 4.40E-01                     | 2836.27        | 6       | 4     | 8.43E-01                     |
| 3395.43        | 7       | 5     | 9.75E-02                     | 4461.61        | 5       | 7     | 4.36E-01                     | 2916.31        | 2       | 4     | 1.06E+00                     |
| 3406.88        | 1       | 3     | 1.93E-01                     | 4524.22        | 3       | 1     | 3.38E-01                     | 2921.46        | 4       | 6     | 1.27E+00                     |
| 3408.13        | 3       | 1     | 5.79E-01                     | 4532.78        | 5       | 3     | 1.40E-01                     | 2926.18        | 4       | 4     | 2.11E-01                     |
| 3415.26        | 3       | 3     | 1.44E-01                     | 4535.29        | 3       | 3     | 8.40E-02                     | 3063.43        | 2       | 4     | 1.30E+00                     |
| 3428.63        | 3       | 5     | 1.42E-01                     | 4555.39        | 5       | 5     | 2.49E-01                     | 3071.60        | 2       | 2     | 1.29E+00                     |
| 3430.57        | 5       | 3     | 2.37E-01                     | 4557.91        | 3       | 5     | 8.27E-02                     | 3177.89        | 2       | 4     | 7.59E-02                     |
| 3444.05        | 5       | 5     | 4.21E-01                     | 5268.30        | 1       | 3     | 3.50E-01                     | 3180.77        | 2       | 2     | 1.51E-01                     |
| 3446.68        | 3       | 5     | 9.71E-01                     | 5508.24        | 5       | 5     | 1.06E-01                     | 3180.99        | 4       | 6     | 7.06E-02                     |
| 3447.15        | 1       | 3     | 8.09E-01                     | 5592.25        | 3       | 3     | 3.27E-01                     | 3185.74        | 4       | 4     | 1.21E-01                     |
| 3447.97        | 5       | 7     | 1.19E+00                     | <i>OIV</i>     |         |       |                              | 3188.22        | 6       | 8     | 4.28E-02                     |
| 3450.91        | 7       | 9     | 1.44E+00                     | 238.360        | 2       | 4     | 2.96E+02                     | 3188.64        | 4       | 2     | 1.50E-01                     |
| 3451.30        | 3       | 3     | 8.06E-01                     | 238.570        | 4       | 6     | 3.54E+02                     | 3194.78        | 6       | 6     | 1.71E-01                     |
| 3454.84        | 5       | 5     | 6.89E-01                     | 238.579        | 4       | 4     | 5.90E+01                     | 3199.58        | 6       | 4     | 1.04E-01                     |
| 3454.99        | 9       | 11    | 1.72E+00                     | 279.631        | 2       | 2     | 2.68E+01                     | 3209.65        | 8       | 8     | 2.53E-01                     |
| 3459.48        | 5       | 3     | 1.14E-01                     | 279.933        | 4       | 2     | 5.34E+01                     | 3216.31        | 8       | 6     | 5.56E-02                     |
| 3459.94        | 7       | 7     | 5.14E-01                     | 553.329        | 2       | 4     | 1.22E+01                     | 3348.06        | 2       | 4     | 8.51E-01                     |
| 3466.13        | 9       | 9     | 2.84E-01                     | 554.076        | 2       | 2     | 4.86E+01                     | 3349.11        | 4       | 6     | 1.02E+00                     |
| 3466.85        | 7       | 5     | 6.82E-02                     | 554.513        | 4       | 4     | 6.06E+01                     | 3354.27        | 4       | 2     | 7.71E-01                     |
| 3475.24        | 9       | 7     | 2.42E-02                     | 555.263        | 4       | 2     | 2.41E+01                     | 3362.55        | 4       | 4     | 7.65E-01                     |
| 3520.94        | 1       | 3     | 1.50E-01                     | 608.397        | 2       | 2     | 1.21E+01                     | 3375.40        | 4       | 6     | 7.56E-01                     |
| 3531.22        | 3       | 1     | 4.45E-01                     | 609.829        | 4       | 2     | 2.40E+01                     | 3378.02        | 4       | 4     | 1.66E-01                     |
| 3533.38        | 3       | 3     | 1.11E-01                     | 616.952        | 6       | 4     | 2.60E+01                     | 3381.21        | 4       | 6     | 7.19E-01                     |
| 3534.90        | 3       | 5     | 1.11E-01                     | 617.005        | 4       | 4     | 2.89E+00                     | 3381.30        | 2       | 4     | 4.28E-01                     |
| 3555.24        | 5       | 3     | 1.82E-01                     | 617.036        | 4       | 2     | 2.89E+01                     | 3385.52        | 6       | 8     | 1.02E+00                     |
| 3556.78        | 5       | 5     | 3.26E-01                     | 624.619        | 2       | 4     | 1.07E+01                     | 3390.19        | 2       | 2     | 8.49E-01                     |
| 3695.38        | 3       | 5     | 4.01E-01                     |                |         |       |                              | 3396.80        | 4       | 4     | 5.40E-01                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å    | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|-------------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                   | $g_i$   | $g_k$ |                              |
| 3405.77        | 4       | 2     | 1.67E-01                     | 2781.01        | 3       | 5     | 1.40E+00                     | *173.03           | 6       | 10    | 8.78E+02                     |
| 3409.70        | 6       | 6     | 3.00E-01                     | *2784.0        | 3       | 9     | 1.40E+00                     | 1031.91           | 2       | 4     | 4.16E+00                     |
| 3411.30        | 4       | 4     | 1.69E-01                     | 2786.99        | 3       | 3     | 1.39E+00                     | 1037.61           | 2       | 2     | 4.09E+00                     |
| 3411.69        | 4       | 6     | 1.02E+00                     | 2789.85        | 3       | 1     | 1.38E+00                     | 3811.35           | 2       | 4     | 5.14E-01                     |
| 3425.55        | 6       | 4     | 4.94E-02                     | 3058.68        | 3       | 5     | 1.39E+00                     | 3834.24           | 2       | 2     | 5.05E-01                     |
| 3489.89        | 4       | 6     | 7.29E-01                     | 3144.66        | 3       | 5     | 8.86E-01                     | <i>O VII</i>      |         |       |                              |
| 3492.21        | 2       | 4     | 6.06E-01                     | 3219.24        | 3       | 1     | 1.54E-01                     | 18.6270           | 1       | 3     | 9.365E+03                    |
| 3493.43        | 4       | 4     | 1.21E-01                     | 3222.29        | 1       | 3     | 1.16E-01                     | 21.6020           | 1       | 3     | 3.309E+04                    |
| 3560.39        | 4       | 6     | 1.03E+00                     | 3227.54        | 3       | 3     | 3.38E-02                     | *120.33           | 3       | 9     | 5.334E+02                    |
| 3563.33        | 6       | 8     | 1.10E+00                     | 3239.21        | 3       | 3     | 3.28E-01                     | 128.411           | 1       | 3     | 8.982E+02                    |
| 3593.08        | 6       | 6     | 7.15E-02                     | 3248.28        | 5       | 3     | 1.18E-01                     | *128.46           | 9       | 15    | 1.615E+03                    |
| 3725.89        | 2       | 4     | 5.61E-01                     | 3263.54        | 5       | 5     | 1.86E-02                     | 135.820           | 3       | 5     | 1.523E+03                    |
| 3725.94        | 4       | 6     | 6.01E-01                     | 3275.64        | 5       | 3     | 4.76E-01                     | *1630.3           | 3       | 9     | 7.935E-01                    |
| 3729.03        | 6       | 8     | 6.86E-01                     | 3297.62        | 7       | 5     | 1.30E-01                     | 2448.98           | 1       | 3     | 2.514E-01                    |
| 3736.68        | 4       | 4     | 2.23E-01                     | 3690.17        | 3       | 5     | 1.97E-02                     | *5933.1           | 3       | 9     | 1.002E-01                    |
| 3736.85        | 8       | 10    | 7.95E-01                     | 3698.36        | 3       | 3     | 1.03E-01                     | 8241.76           | 1       | 3     | 3.864E-02                    |
| 3744.89        | 6       | 6     | 1.92E-01                     | 3702.72        | 5       | 7     | 1.41E-02                     | <i>Phosphorus</i> |         |       |                              |
| 3758.39        | 8       | 8     | 1.11E-01                     | 3717.31        | 5       | 5     | 9.63E-02                     | <i>P I</i>        |         |       |                              |
| 3930.68        | 2       | 2     | 3.80E-02                     | 3725.63        | 5       | 3     | 2.91E-02                     | 1671.7            | 4       | 2     | 3.9E-01                      |
| 3942.06        | 2       | 4     | 9.42E-02                     | 3746.64        | 7       | 7     | 1.18E-01                     | 1674.6            | 4       | 4     | 4.0E-01                      |
| 3945.31        | 4       | 2     | 1.88E-01                     | 3761.58        | 7       | 5     | 1.61E-02                     | 1679.7            | 4       | 6     | 3.9E-01                      |
| 3956.77        | 4       | 4     | 2.98E-02                     | 4119.37        | 3       | 5     | 3.66E-01                     | 1775.0            | 4       | 6     | 2.17E+00                     |
| 3974.58        | 4       | 6     | 6.62E-02                     | 4120.49        | 3       | 1     | 3.33E-01                     | 1782.9            | 4       | 4     | 2.14E+00                     |
| 3977.09        | 6       | 4     | 9.91E-02                     | 4123.96        | 5       | 7     | 4.81E-01                     | 1787.7            | 4       | 2     | 2.13E+00                     |
| 3995.08        | 6       | 6     | 1.52E-01                     | 4125.49        | 1       | 3     | 2.70E-01                     | 2135.5            | 4       | 4     | 2.11E-01                     |
| 4687.03        | 2       | 4     | 2.79E-01                     | 4134.11        | 3       | 3     | 3.34E-01                     | 2136.2            | 6       | 4     | 2.83E+00                     |
| 4772.60        | 2       | 4     | 1.23E-01                     | 4153.27        | 3       | 3     | 1.92E-01                     | 2149.1            | 4       | 2     | 3.18E+00                     |
| 4779.10        | 2       | 2     | 2.45E-01                     | 4158.86        | 3       | 5     | 3.39E-01                     | 2152.9            | 2       | 4     | 4.85E-01                     |
| 4783.42        | 4       | 6     | 2.06E-01                     | 4178.46        | 5       | 5     | 1.12E-01                     | 2154.1            | 4       | 4     | 1.73E-01                     |
| 4794.18        | 4       | 4     | 1.56E-01                     | 4213.35        | 5       | 3     | 1.19E-02                     | 2154.1            | 4       | 6     | 5.8E-01                      |
| 4798.27        | 6       | 8     | 2.91E-01                     | 4522.66        | 5       | 3     | 1.02E-02                     | 2534.0            | 2       | 4     | 2.00E-01                     |
| 4813.15        | 6       | 6     | 8.65E-02                     | 4554.53        | 3       | 5     | 2.41E-01                     | 2535.6            | 4       | 4     | 9.5E-01                      |
| 5305.51        | 4       | 4     | 6.10E-02                     | 5114.06        | 1       | 3     | 1.80E-01                     | 2553.3            | 2       | 2     | 7.1E-01                      |
| 5362.51        | 6       | 6     | 6.12E-02                     | 5339.94        | 1       | 3     | 1.85E-02                     | 2554.9            | 4       | 2     | 3.00E-01                     |
| 6876.49        | 2       | 4     | 1.88E-02                     | 5349.74        | 3       | 1     | 7.04E-02                     | <i>P II</i>       |         |       |                              |
| 6931.60        | 2       | 2     | 7.35E-02                     | 5372.71        | 3       | 3     | 1.42E-02                     | 1301.9            | 1       | 3     | 5.0E-01                      |
| 7004.11        | 4       | 4     | 8.90E-02                     | 5414.59        | 3       | 5     | 9.29E-03                     | 1304.5            | 3       | 1     | 1.5E+00                      |
| 7061.30        | 4       | 2     | 3.48E-02                     | 5428.38        | 5       | 3     | 2.68E-02                     | 1304.7            | 3       | 3     | 3.7E-01                      |
| <i>O V</i>     |         |       |                              | 5471.12        | 5       | 5     | 4.86E-02                     | 1305.5            | 3       | 5     | 3.8E-01                      |
| 172.169        | 1       | 3     | 2.94E+02                     | 5571.81        | 1       | 3     | 8.33E-02                     | 1309.9            | 5       | 3     | 6.2E-01                      |
| *192.85        | 9       | 15    | 6.90E+02                     | 5580.12        | 3       | 5     | 1.11E-01                     | 1310.7            | 5       | 5     | 1.1E+00                      |
| *215.17        | 9       | 3     | 1.83E+02                     | 5583.23        | 3       | 3     | 6.20E-02                     | 4475.3            | 5       | 7     | 1.3E+00                      |
| 220.353        | 3       | 5     | 4.292E+02                    | *5589.9        | 9       | 15    | 1.49E-01                     | 4499.2            | 5       | 7     | 1.4E+00                      |
| 248.460        | 3       | 1     | 5.59E+01                     | 5597.89        | 5       | 7     | 1.48E-01                     | 4530.8            | 3       | 5     | 1.0E+00                      |
| 629.732        | 1       | 3     | 2.872E+01                    | 5604.27        | 5       | 5     | 3.68E-02                     | 4554.8            | 3       | 5     | 9.6E-01                      |
| 758.677        | 3       | 5     | 5.547E+00                    | 5607.41        | 5       | 3     | 4.08E-03                     | 4588.0            | 5       | 7     | 1.7E+00                      |
| 759.442        | 1       | 3     | 7.373E+00                    | 6330.05        | 5       | 7     | 1.21E-01                     | 4589.9            | 3       | 5     | 1.6E+00                      |
| 760.227        | 3       | 3     | 5.514E+00                    | 6460.12        | 3       | 5     | 9.37E-02                     | 4602.1            | 7       | 9     | 1.9E+00                      |
| 760.446        | 5       | 5     | 1.652E+01                    | 6466.14        | 5       | 7     | 1.01E-01                     | 4943.5            | 7       | 5     | 6.3E-01                      |
| 761.128        | 3       | 1     | 2.197E+01                    | 6500.24        | 7       | 9     | 1.11E-01                     | 5253.5            | 3       | 5     | 1.0E+00                      |
| 762.004        | 5       | 3     | 9.125E+00                    | 6543.77        | 5       | 5     | 1.64E-02                     | 5425.9            | 5       | 5     | 6.9E-01                      |
| 774.518        | 3       | 1     | 3.804E+01                    | 6601.28        | 7       | 7     | 1.14E-02                     | 6024.2            | 3       | 5     | 5.1E-01                      |
| 1371.30        | 3       | 5     | 3.336E+00                    | 6764.72        | 1       | 3     | 4.37E-02                     | 6043.1            | 5       | 7     | 6.8E-01                      |
| 2729.31        | 3       | 5     | 4.52E-01                     | 6789.62        | 3       | 5     | 5.79E-02                     | <i>P III</i>      |         |       |                              |
| 2731.45        | 1       | 3     | 5.90E-01                     | 6817.40        | 3       | 3     | 3.00E-02                     | 1334.8            | 2       | 4     | 5.5E-01                      |
| 2743.61        | 3       | 3     | 4.38E-01                     | 6828.95        | 5       | 7     | 7.35E-02                     | 1344.3            | 4       | 6     | 6.4E-01                      |
| 2752.23        | 3       | 1     | 1.82E+00                     | 6878.76        | 5       | 5     | 1.65E-02                     | 1344.8            | 4       | 4     | 1.1E-01                      |
| 2755.13        | 5       | 5     | 1.37E+00                     | <i>O VI</i>    |         |       |                              |                   |         |       |                              |
| 2769.69        | 5       | 3     | 7.88E-01                     | *150.10        | 2       | 6     | 2.62E+02                     |                   |         |       |                              |

| $\lambda$<br>Å      | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|---------------------|---------|-------|------------------------------|
|                     | $g_i$   | $g_k$ |                              |
| 4057.4              | 4       | 4     | 1.0E-01                      |
| 4059.3              | 6       | 4     | 9.0E-01                      |
| 4080.1              | 4       | 2     | 9.9E-01                      |
| <i>Potassium</i>    |         |       |                              |
| <i>K I</i>          |         |       |                              |
| 4044.1              | 2       | 4     | 1.24E-02                     |
| 4047.2              | 2       | 2     | 1.24E-02                     |
| 5084.2              | 2       | 2     | 3.50E-03                     |
| 5099.2              | 4       | 2     | 7.0E-03                      |
| 5323.3              | 2       | 2     | 6.3E-03                      |
| 5339.7              | 4       | 2     | 1.26E-02                     |
| 5343.0              | 2       | 4     | 4.0E-03                      |
| 5359.6              | 4       | 6     | 4.6E-03                      |
| 5782.4              | 2       | 2     | 1.23E-02                     |
| 5801.8              | 4       | 2     | 2.46E-02                     |
| 5812.2              | 2       | 4     | 2.8E-03                      |
| 5831.9              | 4       | 6     | 3.2E-03                      |
| 6911.1              | 2       | 2     | 2.72E-02                     |
| 6938.8              | 4       | 2     | 5.4E-02                      |
| 7664.9              | 2       | 4     | 3.87E-01                     |
| 7699.0              | 2       | 2     | 3.82E-01                     |
| <i>K II</i>         |         |       |                              |
| 607.93              | 1       | 3     | 1.3E-02                      |
| <i>K III</i>        |         |       |                              |
| 2550.0              | 6       | 4     | 2.0E+00                      |
| 2635.1              | 4       | 4     | 1.2E+00                      |
| 2992.4              | 6       | 8     | 2.5E+00                      |
| 3052.1              | 4       | 6     | 1.7E+00                      |
| 3202.0              | 4       | 4     | 1.8E+00                      |
| 3289.1              | 4       | 6     | 2.0E+00                      |
| 3322.4              | 6       | 6     | 1.3E+00                      |
| 3421.8              | 2       | 4     | 1.5E+00                      |
| <i>K XVI</i>        |         |       |                              |
| 206.27              | 1       | 3     | 9.4E+01                      |
| <i>K XVII</i>       |         |       |                              |
| 22.020              | 2       | 4     | 4.7E+04                      |
| 22.163              | 4       | 6     | 5.6E+04                      |
| 22.18               | 4       | 4     | 9.3E+03                      |
| 22.60               | 2       | 2     | 2.5E+03                      |
| 22.76               | 4       | 2     | 4.7E+03                      |
| <i>Praseodymium</i> |         |       |                              |
| <i>Pr II</i>        |         |       |                              |
| 3997.0              | 15      | 15    | 1.87E-01                     |
| 4062.8              | 13      | 15    | 1.00E+00                     |
| 4100.7              | 17      | 19    | 8.4E-01                      |
| 4143.1              | 15      | 17    | 5.8E-01                      |
| 4179.4              | 13      | 15    | 5.2E-01                      |
| 4222.9              | 11      | 13    | 3.91E-01                     |
| 4241.0              | 17      | 15    | 2.30E-01                     |
| 4359.8              | 15      | 15    | 1.1E-01                      |
| 4405.8              | 17      | 17    | 9.0E-02                      |
| 4429.3              | 15      | 15    | 2.28E-01                     |
| 4449.8              | 13      | 13    | 1.24E-01                     |
| 4468.7              | 11      | 13    | 1.54E-01                     |
| 4510.2              | 13      | 15    | 1.16E-01                     |
| 4534.2              | 15      | 17    | 4.9E-02                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 4734.2         | 15      | 13    | 2.5E-02                      |
| 4879.1         | 15      | 15    | 1.8E-02                      |
| 4886.0         | 15      | 15    | 1.3E-02                      |
| 4912.6         | 17      | 15    | 5.7E-02                      |
| 5034.4         | 19      | 19    | 1.1E-01                      |
| 5110.8         | 21      | 19    | 2.78E-01                     |
| 5135.1         | 17      | 17    | 1.25E-01                     |
| 5173.9         | 19      | 17    | 3.18E-01                     |
| 5219.1         | 15      | 15    | 9.5E-02                      |
| 5220.1         | 17      | 15    | 2.35E-01                     |
| 5251.7         | 15      | 13    | 1.1E-02                      |
| 5259.7         | 15      | 13    | 2.24E-01                     |
| 5292.6         | 13      | 13    | 9.3E-02                      |
| 5810.6         | 17      | 19    | 2.3E-02                      |
| 5879.3         | 15      | 15    | 7.6E-02                      |
| 6200.8         | 15      | 17    | 1.8E-02                      |
| 6278.7         | 13      | 15    | 2.6E-02                      |
| 6398.0         | 11      | 13    | 1.9E-02                      |
| <i>Rhodium</i> |         |       |                              |
| <i>Rh I</i>    |         |       |                              |
| 3083.96        | 8       | 6     | 4.8E-02                      |
| 3114.91        | 6       | 4     | 4.45E-02                     |
| 3121.76        | 6       | 6     | 1.1E-01                      |
| 3123.70        | 10      | 8     | 4.6E-02                      |
| 3137.71        | 4       | 6     | 3.3E-02                      |
| 3189.05        | 6       | 6     | 3.03E-01                     |
| 3197.13        | 6       | 4     | 4.35E-02                     |
| 3263.14        | 6       | 6     | 1.3E-01                      |
| 3271.61        | 6       | 4     | 2.0E-01                      |
| 3280.55        | 8       | 8     | 2.36E-01                     |
| 3283.57        | 6       | 8     | 4.4E-01                      |
| 3289.14        | 4       | 4     | 1.0E-01                      |
| 3323.09        | 8       | 10    | 6.3E-01                      |
| 3331.09        | 4       | 2     | 5.40E-02                     |
| 3338.54        | 8       | 6     | 3.5E-02                      |
| 3360.80        | 4       | 4     | 1.2E-01                      |
| 3368.38        | 6       | 4     | 1.1E-01                      |
| 3396.82        | 10      | 10    | 6.5E-01                      |
| 3399.70        | 6       | 8     | 1.2E-01                      |
| 3462.04        | 6       | 6     | 6.2E-01                      |
| 3470.66        | 4       | 4     | 8.5E-01                      |
| 3478.91        | 6       | 6     | 3.32E-01                     |
| 3484.04        | 6       | 8     | 9.3E-03                      |
| 3498.73        | 4       | 6     | 2.12E-01                     |
| 3502.52        | 10      | 10    | 4.3E-01                      |
| 3507.32        | 6       | 8     | 3.4E-01                      |
| 3528.02        | 8       | 8     | 8.5E-01                      |
| 3543.95        | 4       | 4     | 4.65E-01                     |
| 3549.54        | 6       | 6     | 2.22E-01                     |
| 3570.18        | 4       | 6     | 1.82E-01                     |
| 3583.10        | 8       | 10    | 2.6E-01                      |
| 3596.19        | 6       | 4     | 5.5E-01                      |
| 3597.15        | 6       | 8     | 5.9E-01                      |
| 3612.47        | 4       | 2     | 8.90E-01                     |
| 3620.46        | 6       | 4     | 8.5E-02                      |
| 3654.87        | 8       | 8     | 6.0E-02                      |
| 3657.99        | 8       | 6     | 8.8E-01                      |
| 3666.22        | 6       | 8     | 8.4E-02                      |
| 3690.70        | 6       | 4     | 3.23E-01                     |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 3692.36        | 10      | 8     | 9.1E-01                      |
| 3700.91        | 8       | 10    | 3.9E-01                      |
| 3713.02        | 4       | 4     | 8.3E-02                      |
| 3788.47        | 4       | 6     | 1.4E-01                      |
| 3793.22        | 8       | 6     | 4.2E-01                      |
| 3799.31        | 8       | 8     | 5.5E-01                      |
| 3806.76        | 6       | 6     | 6.2E-02                      |
| 3818.19        | 6       | 4     | 5.8E-01                      |
| 3822.26        | 6       | 6     | 8.5E-01                      |
| 3828.48        | 6       | 6     | 6.2E-01                      |
| 3833.89        | 6       | 4     | 5.8E-01                      |
| 3856.52        | 8       | 10    | 5.9E-01                      |
| 3872.39        | 4       | 6     | 6.7E-03                      |
| 3877.34        | 8       | 6     | 3.7E-02                      |
| 3913.51        | 8       | 8     | 2.5E-03                      |
| 3922.19        | 4       | 2     | 6.25E-02                     |
| 3934.23        | 8       | 8     | 1.58E-01                     |
| 3942.72        | 4       | 2     | 7.15E-01                     |
| 3958.86        | 6       | 8     | 5.5E-01                      |
| 3984.40        | 4       | 4     | 1.1E-01                      |
| 3995.61        | 4       | 6     | 4.7E-02                      |
| 4053.44        | 2       | 2     | 2.8E-02                      |
| 4056.34        | 6       | 4     | 9.5E-03                      |
| 4082.78        | 6       | 4     | 1.4E-01                      |
| 4097.52        | 2       | 4     | 7.0E-02                      |
| 4121.68        | 6       | 6     | 9.8E-02                      |
| 4128.87        | 6       | 8     | 1.73E-01                     |
| 4135.27        | 8       | 8     | 1.0E-01                      |
| 4196.50        | 6       | 8     | 3.9E-02                      |
| 4211.14        | 8       | 10    | 1.62E-01                     |
| 4244.44        | 4       | 4     | 6.5E-03                      |
| 4278.60        | 4       | 6     | 9.2E-03                      |
| 4288.71        | 6       | 8     | 6.1E-02                      |
| 4373.04        | 2       | 4     | 1.8E-02                      |
| 4374.80        | 8       | 10    | 1.64E-01                     |
| 4379.92        | 6       | 6     | 2.48E-02                     |
| 4492.47        | 6       | 6     | 4.5E-03                      |
| 4528.72        | 6       | 8     | 1.35E-02                     |
| 4548.73        | 4       | 6     | 5.5E-03                      |
| 4551.64        | 4       | 4     | 4.00E-02                     |
| 4565.19        | 4       | 4     | 1.1E-02                      |
| 4569.00        | 6       | 8     | 1.0E-02                      |
| 4608.12        | 2       | 2     | 2.1E-02                      |
| 4675.03        | 8       | 8     | 6.4E-03                      |
| 4721.00        | 6       | 4     | 3.43E-03                     |
| 4745.11        | 6       | 6     | 5.2E-03                      |
| 4755.58        | 4       | 4     | 6.0E-03                      |
| 4842.43        | 6       | 8     | 1.6E-03                      |
| 4963.71        | 2       | 2     | 3.0E-02                      |
| 4977.75        | 4       | 4     | 9.8E-03                      |
| 4979.18        | 4       | 6     | 1.0E-02                      |
| 5090.63        | 6       | 6     | 5.0E-03                      |
| 5120.69        | 6       | 8     | 3.1E-03                      |
| 5130.76        | 4       | 4     | 4.35E-03                     |
| 5155.54        | 2       | 4     | 9.8E-03                      |
| 5184.19        | 6       | 8     | 1.6E-03                      |
| 5212.73        | 4       | 2     | 5.95E-03                     |
| 5292.14        | 10      | 10    | 3.7E-03                      |
| 5390.44        | 4       | 6     | 9.5E-03                      |
| 5424.72        | 4       | 4     | 5.0E-03                      |

| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 5599.42         | 6       | 8     | 1.3E-02                      | 3911.81        | 6       | 8     | 1.79E+00                     | 4983.43        | 4       | 4     | 2.58E-01                     |
| 5983.60         | 10      | 10    | 2.1E-02                      | 3933.38        | 6       | 6     | 1.62E-01                     | 4991.91        | 6       | 6     | 3.8E-01                      |
| <i>Rubidium</i> |         |       |                              | 3996.60        | 4       | 6     | 1.65E-01                     | 4995.00        | 4       | 6     | 5.9E-02                      |
| <i>Rb I</i>     |         |       |                              | 4020.39        | 4       | 4     | 1.63E+00                     | 5018.41        | 6       | 4     | 2.09E-01                     |
| 3022.5          | 2       | 4     | 4.13E-05                     | 4023.22        | 4       | 4     | 3.0E-01                      | 5021.52        | 4       | 4     | 2.30E-01                     |
| 3032.0          | 2       | 4     | 4.93E-05                     | 4023.68        | 6       | 6     | 1.65E+00                     | 5064.31        | 8       | 10    | 7.3E-02                      |
| 3044.2          | 2       | 4     | 8.2E-05                      | 4031.38        | 6       | 6     | 2.9E-01                      | 5066.38        | 6       | 6     | 3.6E-02                      |
| 3060.2          | 2       | 4     | 1.05E-04                     | 4036.86        | 6       | 4     | 7.9E-02                      | 5070.17        | 6       | 8     | 1.16E-01                     |
| 3082.0          | 2       | 4     | 1.49E-04                     | 4043.80        | 8       | 8     | 3.11E-01                     | 5072.71        | 2       | 4     | 2.0E-02                      |
| 3112.6          | 2       | 4     | 2.5E-04                      | 4047.80        | 6       | 4     | 1.54E-01                     | 5075.82        | 4       | 6     | 1.15E-01                     |
| 3113.1          | 2       | 2     | 1.3E-04                      | 4051.83        | 8       | 6     | 7.7E-02                      | 5080.22        | 4       | 4     | 4.1E-02                      |
| 3157.5          | 2       | 4     | 3.38E-04                     | 4054.54        | 4       | 2     | 1.67E-01                     | 5081.56        | 10      | 10    | 7.6E-01                      |
| 3158.3          | 2       | 2     | 2.0E-04                      | 4067.00        | 6       | 8     | 1.91E-01                     | 5083.72        | 8       | 8     | 6.2E-01                      |
| 3228.0          | 2       | 4     | 6.4E-04                      | 4067.63        | 10      | 8     | 4.1E-02                      | 5085.55        | 6       | 6     | 5.7E-01                      |
| 3229.2          | 2       | 2     | 3.8E-04                      | 4074.96        | 4       | 6     | 3.7E-01                      | 5086.94        | 4       | 4     | 6.6E-01                      |
| 3348.7          | 2       | 4     | 1.37E-03                     | 4078.56        | 2       | 4     | 4.3E-01                      | 5096.72        | 6       | 4     | 1.69E-01                     |
| 3350.8          | 2       | 2     | 8.9E-04                      | 4080.57        | 4       | 4     | 6.6E-02                      | 5099.27        | 4       | 6     | 1.50E-01                     |
| 3587.1          | 2       | 4     | 3.97E-03                     | 4082.39        | 6       | 4     | 2.73E-01                     | 5101.12        | 10      | 8     | 8.8E-02                      |
| 3591.6          | 2       | 2     | 2.9E-03                      | 4086.66        | 6       | 8     | 3.7E-01                      | 5331.79        | 4       | 4     | 1.11E-01                     |
| 4201.8          | 2       | 4     | 1.8E-02                      | 4087.47        | 4       | 6     | 1.12E-01                     | 5339.43        | 6       | 6     | 1.06E-01                     |
| 4215.5          | 2       | 2     | 1.5E-02                      | 4093.12        | 4       | 4     | 1.23E-01                     | 5341.07        | 4       | 2     | 3.8E-01                      |
| 7800.3          | 2       | 4     | 3.70E-01                     | 4094.86        | 6       | 6     | 1.44E-01                     | 5349.34        | 6       | 4     | 5.9E-01                      |
| 7947.6          | 2       | 2     | 3.40E-01                     | 4098.36        | 8       | 8     | 8.7E-02                      | 5350.28        | 8       | 8     | 6.8E-02                      |
| <i>Scandium</i> |         |       |                              | 4132.98        | 4       | 6     | 1.19E+00                     | 5355.79        | 6       | 4     | 3.0E-01                      |
| <i>Sc I</i>     |         |       |                              | 4140.27        | 6       | 8     | 1.17E+00                     | 5356.10        | 8       | 6     | 5.7E-01                      |
| 2116.7          | 4       | 4     | 2.0E-01                      | 4147.38        | 6       | 6     | 1.74E-01                     | 5375.37        | 8       | 6     | 3.4E-01                      |
| 2120.4          | 6       | 6     | 2.0E-01                      | 4161.85        | 8       | 8     | 1.77E-01                     | 5392.06        | 10      | 8     | 4.2E-01                      |
| 2262.3          | 4       | 4     | 5.8E-02                      | 4171.53        | 6       | 4     | 1.36E-01                     | 5416.16        | 4       | 6     | 4.4E-02                      |
| 2266.6          | 4       | 2     | 4.8E-01                      | 4186.42        | 6       | 8     | 8.4E-02                      | 5416.41        | 6       | 6     | 2.0E-02                      |
| 2270.9          | 6       | 4     | 4.6E-01                      | 4187.61        | 8       | 6     | 1.28E-01                     | 5425.55        | 6       | 8     | 4.5E-02                      |
| 2280.8          | 4       | 6     | 2.8E-01                      | 4193.53        | 4       | 6     | 6.1E-02                      | 5429.42        | 2       | 4     | 9.0E-02                      |
| 2289.6          | 6       | 6     | 4.1E-02                      | 4204.52        | 6       | 8     | 3.5E-02                      | 5432.98        | 4       | 4     | 5.4E-02                      |
| 2311.29         | 4       | 6     | 4.1E-02                      | 4205.20        | 10      | 8     | 1.12E-01                     | 5433.25        | 6       | 4     | 9.7E-02                      |
| 2315.69         | 4       | 4     | 2.5E-01                      | 4212.32        | 4       | 6     | 1.58E-01                     | 5438.28        | 4       | 6     | 3.4E-02                      |
| 2320.32         | 6       | 6     | 2.4E-01                      | 4212.48        | 6       | 6     | 8.6E-02                      | 5439.04        | 2       | 2     | 1.74E-01                     |
| 2324.75         | 6       | 4     | 4.1E-02                      | 4216.08        | 2       | 4     | 2.36E-01                     | 5442.62        | 4       | 2     | 2.15E-01                     |
| 2328.19         | 4       | 6     | 4.6E-02                      | 4218.23        | 4       | 4     | 2.26E-01                     | 5446.20        | 8       | 8     | 2.8E-01                      |
| 2334.67         | 4       | 2     | 1.7E-01                      | 4225.54        | 6       | 8     | 9.5E-02                      | 5451.37        | 6       | 6     | 1.50E-01                     |
| 2346.03         | 6       | 4     | 1.3E-01                      | 4225.69        | 4       | 6     | 7.6E-02                      | 5455.24        | 4       | 4     | 6.6E-02                      |
| 2429.19         | 4       | 4     | 2.8E-01                      | 4231.64        | 4       | 4     | 1.31E-01                     | 5464.95        | 4       | 2     | 3.2E-02                      |
| 2438.63         | 6       | 6     | 2.1E-01                      | 4233.59        | 6       | 6     | 4.0E-01                      | 5468.40        | 6       | 4     | 9.7E-02                      |
| 2468.40         | 4       | 2     | 4.9E-02                      | 4238.05        | 8       | 8     | 7.1E-01                      | 5472.19        | 8       | 6     | 9.7E-02                      |
| 2692.78         | 4       | 2     | 1.61E-01                     | 4239.55        | 6       | 4     | 2.27E-01                     | 5482.01        | 8       | 8     | 5.2E-01                      |
| 2699.02         | 4       | 6     | 2.4E-02                      | 4246.14        | 8       | 6     | 1.15E-01                     | 5484.63        | 6       | 6     | 5.2E-01                      |
| 2706.74         | 4       | 4     | 3.1E-01                      | 4542.55        | 6       | 4     | 1.28E-01                     | 5514.23        | 6       | 8     | 4.1E-01                      |
| 2707.93         | 6       | 4     | 1.49E-01                     | 4544.67        | 8       | 6     | 1.33E-01                     | 5520.52        | 8       | 10    | 4.3E-01                      |
| 2711.34         | 6       | 6     | 3.2E-01                      | 4706.94        | 4       | 6     | 2.81E-01                     | 5526.10        | 4       | 4     | 7.1E-02                      |
| 2965.88         | 4       | 6     | 7.5E-02                      | 4709.31        | 6       | 8     | 4.0E-01                      | 5541.07        | 6       | 6     | 5.5E-02                      |
| 2974.01         | 4       | 4     | 5.5E-01                      | 4711.72        | 2       | 4     | 1.81E-01                     | 5631.04        | 2       | 4     | 3.0E-02                      |
| 2980.76         | 6       | 6     | 5.4E-01                      | 4714.30        | 4       | 4     | 2.14E-01                     | 5671.83        | 10      | 12    | 5.4E-01                      |
| 2988.97         | 6       | 4     | 6.9E-02                      | 4719.31        | 6       | 6     | 1.04E-01                     | 5686.86        | 8       | 10    | 4.9E-01                      |
| 3015.37         | 4       | 6     | 7.8E-01                      | 4728.77        | 8       | 8     | 1.16E-01                     | 5700.19        | 6       | 8     | 4.6E-01                      |
| 3019.35         | 6       | 8     | 8.7E-01                      | 4729.20        | 4       | 4     | 2.20E-01                     | 5708.64        | 10      | 10    | 4.7E-02                      |
| 3030.76         | 6       | 6     | 1.00E-01                     | 4729.24        | 6       | 6     | 1.93E-01                     | 5711.79        | 4       | 6     | 4.5E-01                      |
| 3255.68         | 4       | 4     | 3.2E-01                      | 4734.11        | 4       | 2     | 1.10E+00                     | 5717.31        | 8       | 8     | 7.5E-02                      |
| 3269.90         | 4       | 2     | 3.13E+00                     | 4737.65        | 6       | 4     | 8.8E-01                      | 5724.13        | 6       | 6     | 7.4E-02                      |
| 3273.63         | 6       | 4     | 2.81E+00                     | 4741.02        | 8       | 6     | 9.1E-01                      | 5988.43        | 6       | 6     | 6.6E-02                      |
| 3907.48         | 4       | 6     | 1.66E+00                     | 4743.82        | 10      | 8     | 9.8E-01                      | 6026.16        | 4       | 4     | 7.2E-02                      |
|                 |         |       |                              | 4973.67        | 4       | 2     | 8.4E-01                      | 6146.20        | 6       | 8     | 4.2E-02                      |
|                 |         |       |                              | 4980.36        | 6       | 4     | 5.6E-01                      | 6198.43        | 4       | 6     | 3.5E-02                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 6249.96        | 6       | 8     | 3.2E-02                      |
| 6262.22        | 4       | 6     | 8.4E-02                      |
| 6280.16        | 2       | 4     | 4.0E-02                      |
| 6284.16        | 6       | 6     | 3.9E-02                      |
| 6284.73        | 4       | 4     | 7.1E-02                      |
| 6293.02        | 2       | 2     | 1.04E-01                     |
| 7741.16        | 10      | 10    | 3.8E-02                      |
| 7800.42        | 8       | 8     | 5.1E-02                      |
| <i>Sc II</i>   |         |       |                              |
| 1880.6         | 5       | 3     | 5.0E+00                      |
| 2064.3         | 7       | 5     | 2.2E+00                      |
| 2068.0         | 5       | 3     | 2.0E+00                      |
| 2273.1         | 1       | 3     | 7.7E+00                      |
| 2545.20        | 5       | 5     | 4.0E-01                      |
| 2552.35        | 7       | 5     | 2.21E+00                     |
| 2555.79        | 3       | 3     | 6.9E-01                      |
| 2560.23        | 5       | 3     | 2.01E+00                     |
| 2563.19        | 3       | 1     | 2.70E+00                     |
| 2611.19        | 5       | 5     | 2.2E+00                      |
| 2667.70        | 3       | 5     | 1.5E+00                      |
| 2746.36        | 3       | 1     | 3.9E+00                      |
| 2782.31        | 5       | 5     | 1.3E+00                      |
| 2789.15        | 7       | 7     | 1.3E+00                      |
| 2801.31        | 9       | 9     | 1.3E+00                      |
| 2819.49        | 3       | 5     | 2.3E+00                      |
| 2822.12        | 5       | 7     | 2.5E+00                      |
| 2826.64        | 7       | 9     | 2.8E+00                      |
| 2870.85        | 5       | 3     | 1.1E+00                      |
| 2912.98        | 5       | 3     | 1.1E+00                      |
| 2979.68        | 3       | 5     | 1.2E+00                      |
| 2988.92        | 5       | 7     | 2.9E+00                      |
| 3039.92        | 7       | 9     | 3.5E+00                      |
| 3045.73        | 5       | 7     | 3.68E+00                     |
| 3052.92        | 7       | 9     | 3.92E+00                     |
| 3060.54        | 7       | 7     | 3.0E-01                      |
| 3065.12        | 9       | 11    | 4.00E+00                     |
| 3075.36        | 9       | 9     | 2.5E-01                      |
| 3128.27        | 3       | 3     | 1.9E+00                      |
| 3133.07        | 5       | 5     | 1.8E+00                      |
| 3139.72        | 7       | 7     | 2.1E+00                      |
| 3190.98        | 3       | 3     | 1.1E+00                      |
| 3199.33        | 5       | 3     | 1.9E+00                      |
| 3312.72        | 5       | 7     | 1.2E+00                      |
| 3320.40        | 5       | 3     | 1.2E+00                      |
| 3343.23        | 9       | 7     | 1.1E+00                      |
| 3353.72        | 5       | 7     | 1.51E+00                     |
| 3359.67        | 5       | 5     | 2.16E-01                     |
| 3361.26        | 3       | 3     | 3.4E-01                      |
| 3361.93        | 3       | 1     | 1.17E+00                     |
| 3368.94        | 5       | 3     | 8.3E-01                      |
| 3372.15        | 7       | 5     | 9.9E-01                      |
| 3379.16        | 3       | 3     | 2.5E+00                      |
| 3535.71        | 5       | 3     | 6.1E-01                      |
| 3558.53        | 5       | 7     | 3.0E-01                      |
| 3567.70        | 3       | 5     | 3.5E-01                      |
| 3572.53        | 7       | 7     | 1.38E+00                     |
| 3576.34        | 5       | 5     | 1.06E+00                     |
| 3580.93        | 3       | 3     | 1.23E+00                     |
| 3589.63        | 5       | 3     | 4.6E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 3590.47        | 7       | 5     | 2.9E-01                      |
| 3613.83        | 7       | 9     | 1.48E+00                     |
| 3630.74        | 5       | 7     | 1.20E+00                     |
| 3642.78        | 3       | 5     | 1.13E+00                     |
| 3645.31        | 7       | 7     | 2.74E-01                     |
| 3651.80        | 5       | 5     | 3.0E-01                      |
| 3859.59        | 7       | 5     | 1.1E+00                      |
| 4246.82        | 5       | 5     | 1.29E+00                     |
| 4314.08        | 9       | 7     | 4.1E-01                      |
| 4320.75        | 7       | 5     | 4.0E-01                      |
| 4325.00        | 5       | 3     | 4.3E-01                      |
| 4374.46        | 9       | 9     | 1.48E-01                     |
| 4400.39        | 7       | 7     | 1.43E-01                     |
| 4415.54        | 5       | 5     | 1.47E-01                     |
| 4670.41        | 5       | 7     | 1.16E-01                     |
| 5031.01        | 5       | 3     | 3.5E-01                      |
| 5239.81        | 1       | 3     | 1.39E-01                     |
| 5526.79        | 9       | 7     | 3.3E-01                      |
| 5657.91        | 5       | 5     | 1.04E-01                     |
| 5669.06        | 3       | 1     | 1.31E-01                     |
| <i>Silicon</i> |         |       |                              |
| <i>Si I</i>    |         |       |                              |
| 1977.6         | 1       | 3     | 1.8E-01                      |
| 1979.2         | 3       | 1     | 5.1E-01                      |
| 1980.6         | 3       | 3     | 1.3E-01                      |
| 1983.2         | 3       | 5     | 1.4E-01                      |
| 1986.4         | 5       | 3     | 2.1E-01                      |
| 1989.0         | 5       | 5     | 4.1E-01                      |
| 2208.0         | 1       | 3     | 3.11E-01                     |
| 2210.9         | 3       | 5     | 4.16E-01                     |
| 2211.7         | 3       | 3     | 2.32E-01                     |
| 2216.7         | 5       | 7     | 5.5E-01                      |
| 2218.1         | 5       | 5     | 1.38E-01                     |
| 2506.9         | 3       | 5     | 4.66E-01                     |
| 2514.3         | 1       | 3     | 6.1E-01                      |
| 2516.1         | 5       | 5     | 1.21E+00                     |
| 2519.2         | 3       | 3     | 4.56E-01                     |
| 2524.1         | 3       | 1     | 1.81E+00                     |
| 2528.5         | 5       | 3     | 7.7E-01                      |
| 2532.4         | 1       | 3     | 2.6E-01                      |
| 2631.3         | 1       | 3     | 9.7E-01                      |
| 2881.6         | 5       | 3     | 1.89E+00                     |
| 3905.5         | 1       | 3     | 1.18E-01                     |
| 4738.8         | 3       | 3     | 1.0E-02                      |
| 4783.0         | 5       | 3     | 1.7E-02                      |
| 4792.3         | 5       | 5     | 1.7E-02                      |
| 4818.1         | 5       | 7     | 1.1E-02                      |
| 4821.2         | 3       | 5     | 8.0E-03                      |
| 4947.6         | 3       | 1     | 4.2E-02                      |
| 5006.1         | 3       | 5     | 2.8E-02                      |
| 5622.2         | 3       | 3     | 1.6E-02                      |
| 5690.4         | 3       | 3     | 1.2E-02                      |
| 5708.4         | 5       | 5     | 1.4E-02                      |
| 5754.2         | 5       | 3     | 1.5E-02                      |
| 5772.1         | 3       | 1     | 3.6E-02                      |
| 5948.5         | 3       | 5     | 2.2E-02                      |
| 7226.2         | 3       | 5     | 7.9E-03                      |
| 7405.8         | 3       | 5     | 3.7E-02                      |
| 7409.1         | 5       | 7     | 2.3E-02                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 7680.3         | 3       | 5     | 4.6E-02                      |
| 7918.4         | 3       | 5     | 5.2E-02                      |
| 7932.3         | 5       | 7     | 5.1E-02                      |
| 7944.0         | 7       | 9     | 5.8E-02                      |
| 7970.3         | 5       | 5     | 7.1E-03                      |
| <i>Si II</i>   |         |       |                              |
| 989.87         | 2       | 4     | 6.7E+00                      |
| 992.68         | 4       | 6     | 8.0E+00                      |
| 1020.7         | 2       | 2     | 1.3E+00                      |
| 1190.4         | 2       | 4     | 6.9E+00                      |
| 1193.3         | 2       | 2     | 2.8E+01                      |
| 1194.5         | 4       | 4     | 3.6E+01                      |
| 1197.4         | 4       | 2     | 1.4E+01                      |
| 1248.4         | 4       | 4     | 1.3E+01                      |
| 1251.2         | 6       | 4     | 1.9E+01                      |
| 1260.4         | 2       | 4     | 2.0E+01                      |
| 1264.7         | 4       | 6     | 2.3E+01                      |
| 1304.4         | 2       | 2     | 3.6E+00                      |
| 1309.3         | 4       | 2     | 7.0E+00                      |
| 1526.7         | 2       | 2     | 3.73E+00                     |
| 1533.5         | 4       | 2     | 7.4E+00                      |
| 1808.0         | 2       | 4     | 3.7E-02                      |
| 2904.3         | 4       | 6     | 6.7E-01                      |
| 2905.7         | 6       | 8     | 7.1E-01                      |
| 3210.0         | 4       | 6     | 4.6E-01                      |
| 4128.1         | 4       | 6     | 1.32E+00                     |
| 4130.9         | 6       | 8     | 1.42E+00                     |
| 5041.0         | 2       | 4     | 9.8E-01                      |
| 5056.0         | 4       | 6     | 1.2E+00                      |
| 5957.6         | 2       | 2     | 4.2E-01                      |
| 5978.9         | 4       | 2     | 8.1E-01                      |
| 6347.1         | 2       | 4     | 7.0E-01                      |
| 6371.4         | 2       | 2     | 6.9E-01                      |
| 7848.8         | 4       | 6     | 3.9E-01                      |
| 7849.7         | 6       | 8     | 4.2E-01                      |
| <i>Si III</i>  |         |       |                              |
| 883.40         | 5       | 7     | 6.3E+01                      |
| 994.79         | 3       | 3     | 7.89E+00                     |
| 997.39         | 5       | 3     | 1.31E+01                     |
| 1141.6         | 3       | 5     | 3.0E+01                      |
| 1144.3         | 5       | 7     | 3.9E+01                      |
| 1161.6         | 5       | 5     | 1.6E+01                      |
| 1206.5         | 1       | 3     | 2.59E+01                     |
| 1206.5         | 3       | 5     | 4.89E+01                     |
| 1207.5         | 5       | 5     | 1.9E+01                      |
| 1294.5         | 3       | 5     | 5.42E+00                     |
| 1296.7         | 1       | 3     | 7.19E+00                     |
| 1298.9         | 3       | 3     | 5.36E+00                     |
| 1299.0         | 5       | 5     | 1.61E+01                     |
| 1301.2         | 3       | 1     | 2.13E+01                     |
| 1303.3         | 5       | 3     | 8.85E+00                     |
| 1328.8         | 1       | 3     | 2.7E+01                      |
| 1417.2         | 3       | 1     | 2.60E+01                     |
| 1435.8         | 5       | 7     | 2.1E+01                      |
| 1589.0         | 5       | 3     | 1.1E+01                      |
| 1778.7         | 7       | 9     | 4.4E+00                      |
| 1783.1         | 5       | 7     | 3.8E+00                      |
| 3241.6         | 5       | 3     | 2.3E+00                      |
| *3486.9        | 15      | 21    | 1.8E+00                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3590.5         | 3       | 5     | 3.9E+00                      | 225.03         | 3       | 3     | 1.2E+02                      | 4393.3         | 4       | 4     | 1.6E-03                      |
| 4552.6         | 3       | 5     | 1.26E+00                     | 227.01         | 5       | 3     | 2.0E+02                      | 4393.3         | 4       | 6     | 9.2E-03                      |
| 4554.0         | 5       | 3     | 7.6E-01                      | 227.30         | 5       | 3     | 2.3E+02                      | 4494.2         | 2       | 4     | 1.2E-02                      |
| 4567.8         | 3       | 3     | 1.25E+00                     | 258.10         | 5       | 5     | 1.04E+02                     | 4497.7         | 4       | 6     | 1.4E-02                      |
| 4683.0         | 5       | 5     | 9.5E-01                      | *294.37        | 9       | 9     | 5.9E+01                      | 4497.7         | 4       | 4     | 2.4E-03                      |
| 4716.7         | 5       | 7     | 2.8E+00                      | *347.36        | 9       | 15    | 2.2E+01                      | 4664.8         | 2       | 4     | 2.33E-02                     |
| 5451.5         | 3       | 5     | 6.0E-01                      | <i>Si X</i>    |         |       |                              | 4668.6         | 4       | 4     | 4.1E-03                      |
| 5473.1         | 5       | 7     | 7.9E-01                      | 253.77         | 2       | 4     | 2.9E+01                      | 4668.6         | 4       | 6     | 2.5E-02                      |
| 5716.3         | 9       | 7     | 1.9E-01                      | 256.57         | 2       | 2     | 1.1E+02                      | 4747.9         | 2       | 2     | 6.3E-03                      |
| 5739.7         | 1       | 3     | 4.7E-01                      | 258.35         | 4       | 4     | 1.4E+02                      | 4751.8         | 4       | 2     | 1.27E-02                     |
| 7462.6         | 5       | 3     | 4.9E-01                      | 261.05         | 4       | 2     | 5.4E+01                      | 4978.5         | 2       | 4     | 4.1E-02                      |
| 7466.3         | 7       | 5     | 5.4E-01                      | 272.00         | 2       | 2     | 3.0E+01                      | 4982.8         | 4       | 4     | 8.2E-03                      |
| 7612.4         | 3       | 5     | 1.1E+00                      | 277.26         | 4       | 2     | 5.7E+01                      | 4982.8         | 4       | 6     | 4.89E-02                     |
| <i>Si IV</i>   |         |       |                              | 287.08         | 2       | 4     | 2.6E+01                      | 5148.8         | 2       | 2     | 1.17E-02                     |
| 457.82         | 2       | 4     | 3.6E+00                      | 289.19         | 4       | 4     | 5.0E+01                      | 5153.4         | 4       | 2     | 2.33E-02                     |
| 458.16         | 2       | 2     | 3.6E+00                      | 292.22         | 6       | 4     | 7.3E+01                      | 5682.6         | 2       | 4     | 1.03E-01                     |
| 515.12         | 2       | 2     | 4.1E+00                      | *347.73        | 10      | 10    | 4.3E+01                      | 5688.2         | 4       | 6     | 1.2E-01                      |
| 516.35         | 4       | 2     | 8.2E+00                      | *353.09        | 6       | 10    | 2.1E+01                      | 5688.2         | 4       | 4     | 2.1E-02                      |
| *560.50        | 6       | 10    | 1.0E+00                      | <i>Si XI</i>   |         |       |                              | 5890.0         | 2       | 4     | 6.11E-01                     |
| *749.94        | 10      | 14    | 1.45E+01                     | 43.763         | 1       | 3     | 6.11E+03                     | 5895.9         | 2       | 2     | 6.10E-01                     |
| 815.05         | 2       | 2     | 1.23E+01                     | *49.116        | 9       | 3     | 2.45E+03                     | 6154.2         | 2       | 2     | 2.6E-02                      |
| 818.13         | 4       | 2     | 2.44E+01                     | 49.222         | 3       | 5     | 8.9E+03                      | 6160.8         | 4       | 2     | 5.2E-02                      |
| *860.74        | 10      | 6     | 1.8E+00                      | 52.296         | 3       | 1     | 7.6E+02                      | 8183.3         | 2       | 4     | 4.53E-01                     |
| *1066.6        | 10      | 14    | 3.91E+01                     | 303.30         | 1       | 3     | 6.42E+01                     | 8194.8         | 4       | 6     | 5.4E-01                      |
| 1122.5         | 2       | 4     | 2.05E+01                     | 358.29         | 3       | 1     | 1.03E+02                     | 8194.8         | 4       | 4     | 9.0E-02                      |
| 1128.3         | 4       | 4     | 4.03E+00                     | 358.63         | 3       | 5     | 1.38E+01                     | 11381          | 2       | 2     | 8.9E-02                      |
| 1128.3         | 4       | 6     | 2.42E+01                     | 361.41         | 1       | 3     | 1.80E+01                     | 11404          | 4       | 2     | 1.76E-01                     |
| 1393.8         | 2       | 4     | 7.73E+00                     | 364.50         | 3       | 3     | 1.32E+01                     | <i>Na II</i>   |         |       |                              |
| 1402.8         | 2       | 2     | 7.58E+00                     | 365.42         | 5       | 5     | 3.90E+01                     | 300.15         | 1       | 3     | 3.0E+01                      |
| *1724.1        | 10      | 6     | 5.5E+00                      | 368.28         | 3       | 1     | 5.1E+01                      | 301.44         | 1       | 3     | 4.9E+01                      |
| <i>Si V</i>    |         |       |                              | 371.48         | 5       | 3     | 2.07E+01                     | 372.08         | 1       | 3     | 3.4E+01                      |
| 96.439         | 1       | 3     | 4.8E+02                      | 604.14         | 3       | 5     | 1.12E+01                     | <i>Na III</i>  |         |       |                              |
| 97.143         | 1       | 3     | 2.0E+03                      | 2300.8         | 1       | 3     | 4.34E-01                     | 378.14         | 4       | 2     | 7.7E+01                      |
| 117.86         | 1       | 3     | 3.0E+02                      | <i>Si XII</i>  |         |       |                              | 380.10         | 2       | 2     | 3.7E+01                      |
| <i>Si VI</i>   |         |       |                              | *40.924        | 2       | 6     | 4.42E+03                     | 1991.0         | 4       | 6     | 8.3E+00                      |
| 246.00         | 4       | 2     | 1.7E+02                      | *44.118        | 6       | 10    | 1.4E+04                      | 2004.2         | 2       | 4     | 4.6E+00                      |
| 249.12         | 2       | 2     | 8.5E+01                      | 499.43         | 2       | 4     | 9.56E+00                     | 2011.9         | 6       | 8     | 8.4E+00                      |
| <i>Si VII</i>  |         |       |                              | 520.72         | 2       | 2     | 8.47E+00                     | 2151.5         | 2       | 4     | 4.4E+00                      |
| 217.83         | 5       | 3     | 4.3E+02                      | 1862           | 2       | 4     | 1.15E+00                     | 2174.5         | 4       | 6     | 5.3E+00                      |
| 272.64         | 5       | 3     | 5.1E+01                      | 1949           | 2       | 2     | 1.0E+00                      | 2230.3         | 6       | 8     | 3.7E+00                      |
| 274.18         | 3       | 1     | 1.2E+02                      | 4620           | 2       | 4     | 4.6E-02                      | 2232.2         | 4       | 4     | 3.3E+00                      |
| 275.35         | 5       | 5     | 8.9E+01                      | 4942           | 4       | 6     | 4.5E-02                      | 2246.7         | 4       | 6     | 2.4E+00                      |
| 275.67         | 3       | 3     | 3.0E+01                      | <i>Silver</i>  |         |       |                              | 2459.3         | 4       | 6     | 3.0E+00                      |
| 276.84         | 1       | 3     | 3.9E+01                      | <i>Ag I</i>    |         |       |                              | 2468.9         | 2       | 4     | 2.4E+00                      |
| 278.45         | 3       | 5     | 2.9E+01                      | 2061.2         | 2       | 4     | 3.1E-02                      | 2497.0         | 6       | 6     | 1.7E+00                      |
| <i>Si VIII</i> |         |       |                              | 2069.9         | 2       | 2     | 1.5E-02                      | <i>Na V</i>    |         |       |                              |
| 214.76         | 4       | 2     | 4.1E+02                      | 3280.7         | 2       | 4     | 1.4E+00                      | *307.89        | 10      | 6     | 2.0E+02                      |
| 216.92         | 6       | 4     | 3.6E+02                      | 3382.9         | 2       | 2     | 1.3E+00                      | *333.46        | 6       | 6     | 5.6E+01                      |
| 232.86         | 2       | 2     | 8.0E+01                      | 5209.1         | 2       | 4     | 7.5E-01                      | *369.01        | 10      | 6     | 1.2E+02                      |
| 235.56         | 4       | 4     | 9.7E+01                      | 5465.5         | 4       | 6     | 8.6E-01                      | *400.72        | 10      | 10    | 5.0E+01                      |
| 250.45         | 2       | 2     | 7.7E+01                      | 5471.6         | 4       | 4     | 1.4E-01                      | *445.14        | 6       | 10    | 7.1E+00                      |
| 250.79         | 4       | 2     | 1.6E+02                      | <i>Sodium</i>  |         |       |                              | 459.90         | 4       | 2     | 2.3E+01                      |
| 314.31         | 4       | 2     | 5.2E+01                      | <i>Na I</i>    |         |       |                              | 461.05         | 4       | 4     | 2.3E+01                      |
| 316.20         | 4       | 4     | 5.0E+01                      | 3302.4         | 2       | 4     | 2.81E-02                     | 463.26         | 4       | 6     | 2.2E+01                      |
| 319.83         | 4       | 6     | 4.9E+01                      | 3303.0         | 2       | 2     | 2.81E-02                     | 510.10         | 2       | 2     | 5.6E+01                      |
| <i>Si IX</i>   |         |       |                              | 4390.0         | 2       | 4     | 7.7E-03                      | 511.19         | 4       | 4     | 6.8E+01                      |
| 223.73         | 1       | 3     | 4.2E+01                      |                |         |       |                              | <i>Na VI</i>   |         |       |                              |
|                |         |       |                              |                |         |       |                              | 313.75         | 5       | 3     | 1.3E+02                      |



| $\lambda$<br>Å   | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|------------------|---------|-------|------------------------------|
|                  | $g_i$   | $g_k$ |                              |
| 361.25           | 5       | 5     | 7.7E+01                      |
| *416.53          | 9       | 9     | 3.7E+01                      |
| *492.80          | 9       | 15    | 1.3E+01                      |
| 1550.6           | 5       | 5     | 4.35E+00                     |
| 1567.8           | 5       | 3     | 2.68E+00                     |
| 1608.5           | 3       | 1     | 2.6E+00                      |
| 1649.4           | 5       | 5     | 2.05E+00                     |
| 1741.5           | 3       | 5     | 2.59E+00                     |
| 1747.5           | 5       | 7     | 3.1E+00                      |
| <i>Na VII</i>    |         |       |                              |
| *94.409          | 6       | 10    | 2.7E+03                      |
| *105.27          | 6       | 2     | 4.5E+02                      |
| 353.29           | 4       | 4     | 1.0E+02                      |
| 381.30           | 4       | 2     | 4.0E+01                      |
| 397.49           | 4       | 4     | 3.5E+01                      |
| 399.18           | 6       | 4     | 5.2E+01                      |
| *483.28          | 10      | 10    | 2.9E+01                      |
| 486.74           | 2       | 4     | 1.1E+01                      |
| 491.95           | 4       | 6     | 1.3E+01                      |
| 555.80           | 4       | 4     | 2.3E+01                      |
| 777.83           | 4       | 6     | 6.8E+00                      |
| <i>Na VIII</i>   |         |       |                              |
| *83.34           | 9       | 15    | 3.94E+03                     |
| *89.88           | 9       | 3     | 8.09E+02                     |
| 90.536           | 3       | 5     | 2.86E+03                     |
| 411.15           | 1       | 3     | 4.42E+01                     |
| 1239.4           | 3       | 3     | 3.02E+00                     |
| 1802.7           | 3       | 1     | 2.70E+00                     |
| 1867.7           | 3       | 5     | 2.01E+00                     |
| 2059.1           | 3       | 5     | 1.80E+00                     |
| 2558.2           | 5       | 3     | 2.26E-02                     |
| 2772.0           | 3       | 5     | 4.19E-01                     |
| 3021.0           | 5       | 7     | 4.90E-01                     |
| 3108.9           | 1       | 3     | 2.58E-01                     |
| 3182.3           | 1       | 3     | 2.92E-01                     |
| <i>Na IX</i>     |         |       |                              |
| 70.615           | 2       | 4     | 1.35E+03                     |
| 70.653           | 2       | 2     | 1.35E+03                     |
| 77.764           | 2       | 4     | 3.6E+03                      |
| 77.911           | 4       | 6     | 4.3E+03                      |
| 681.72           | 2       | 4     | 6.63E+00                     |
| 694.17           | 2       | 2     | 6.30E+00                     |
| 2487.7           | 2       | 4     | 8.32E-01                     |
| 2535.8           | 2       | 2     | 7.89E-01                     |
| 6841.8           | 2       | 4     | 2.59E-02                     |
| 7103.4           | 4       | 6     | 2.78E-02                     |
| <i>Strontium</i> |         |       |                              |
| <i>Sr I</i>      |         |       |                              |
| 2206.2           | 1       | 3     | 6.6E-03                      |
| 2211.3           | 1       | 3     | 8.5E-03                      |
| 2217.8           | 1       | 3     | 1.2E-02                      |
| 2226.3           | 1       | 3     | 1.6E-02                      |
| 2237.7           | 1       | 3     | 2.3E-02                      |
| 2253.3           | 1       | 3     | 3.7E-02                      |
| 2275.3           | 1       | 3     | 6.7E-02                      |
| 2307.3           | 1       | 3     | 1.2E-01                      |
| 2354.3           | 1       | 3     | 1.8E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 2428.1         | 1       | 3     | 1.7E-01                      |
| 2569.5         | 1       | 3     | 5.3E-02                      |
| 2931.8         | 1       | 3     | 1.9E-02                      |
| 4607.3         | 1       | 3     | 2.01E+00                     |
| <i>Sr II</i>   |         |       |                              |
| 2018.7         | 2       | 2     | 1.2E-01                      |
| 2051.9         | 4       | 2     | 2.4E-01                      |
| 2282.0         | 2       | 4     | 8.3E-01                      |
| 2322.4         | 4       | 6     | 9.1E-01                      |
| 2324.5         | 4       | 4     | 1.5E-01                      |
| 2423.5         | 2       | 2     | 2.4E-01                      |
| 2471.6         | 4       | 2     | 4.8E-01                      |
| 3464.5         | 4       | 6     | 3.1E+00                      |
| 3474.9         | 4       | 4     | 5.1E-01                      |
| 4077.7         | 2       | 4     | 1.42E+00                     |
| 4161.8         | 2       | 2     | 6.5E-01                      |
| 4215.5         | 2       | 2     | 1.27E+00                     |
| 4305.5         | 4       | 2     | 1.4E+00                      |
| 4414.8         | 4       | 6     | 1.1E-01                      |
| 4417.5         | 4       | 4     | 1.8E-02                      |
| 4585.9         | 4       | 2     | 7.0E-02                      |
| 5303.1         | 2       | 4     | 1.9E-01                      |
| 5379.1         | 4       | 6     | 2.2E-01                      |
| 5385.5         | 4       | 4     | 3.7E-02                      |
| 5723.7         | 2       | 2     | 7.1E-02                      |
| 5819.0         | 4       | 2     | 1.4E-01                      |
| 8688.9         | 4       | 6     | 5.5E-01                      |
| 8719.6         | 4       | 4     | 9.7E-02                      |
| <i>Sulfur</i>  |         |       |                              |
| <i>SI</i>      |         |       |                              |
| 1295.7         | 5       | 5     | 4.9E+00                      |
| 1296.2         | 5       | 3     | 2.7E+00                      |
| 1302.3         | 3       | 5     | 1.8E+00                      |
| 1302.9         | 3       | 3     | 1.6E+00                      |
| 1303.1         | 3       | 1     | 6.6E+00                      |
| 1303.4         | 5       | 3     | 1.9E+00                      |
| 1305.9         | 1       | 3     | 2.4E+00                      |
| 1401.5         | 5       | 3     | 9.1E-01                      |
| 1409.3         | 3       | 3     | 5.0E-01                      |
| 1412.9         | 1       | 3     | 1.6E-01                      |
| 1425.0         | 5       | 7     | 4.5E+00                      |
| 1425.2         | 5       | 5     | 1.2E+00                      |
| 1433.3         | 3       | 5     | 3.3E+00                      |
| 1433.3         | 3       | 3     | 1.9E+00                      |
| 1437.0         | 1       | 3     | 2.4E+00                      |
| 1448.2         | 5       | 3     | 7.3E+00                      |
| 1473.0         | 5       | 7     | 4.2E-01                      |
| 1474.0         | 5       | 7     | 1.6E+00                      |
| 1474.4         | 5       | 5     | 5.0E-01                      |
| 1474.6         | 5       | 3     | 6.2E-02                      |
| 1481.7         | 3       | 5     | 1.7E-01                      |
| 1483.0         | 3       | 5     | 1.2E+00                      |
| 1483.2         | 3       | 3     | 7.5E-01                      |
| 1487.2         | 1       | 3     | 8.7E-01                      |
| 1666.7         | 5       | 5     | 6.3E+00                      |
| 1687.5         | 1       | 3     | 9.4E-01                      |
| 1782.3         | 1       | 3     | 1.9E+00                      |
| 1807.3         | 5       | 3     | 3.8E+00                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 1820.3         | 3       | 3     | 2.2E+00                      |
| 1826.2         | 1       | 3     | 7.2E-01                      |
| 4694.1         | 5       | 7     | 6.7E-03                      |
| 4695.4         | 5       | 5     | 6.7E-03                      |
| 4696.2         | 5       | 3     | 6.5E-03                      |
| 6403.6         | 3       | 5     | 5.7E-03                      |
| 6408.1         | 5       | 5     | 9.5E-03                      |
| 6415.5         | 7       | 5     | 1.3E-02                      |
| *6751.2        | 15      | 25    | 7.9E-02                      |
| 7679.6         | 3       | 5     | 1.2E-02                      |
| 7686.1         | 5       | 5     | 2.0E-02                      |
| 7696.7         | 7       | 5     | 2.8E-02                      |
| <i>S II</i>    |         |       |                              |
| 1124.4         | 2       | 4     | 1.0E+00                      |
| 1125.0         | 4       | 4     | 4.6E+00                      |
| 1131.0         | 2       | 2     | 3.5E+00                      |
| 1131.6         | 4       | 2     | 1.4E+00                      |
| 1250.5         | 4       | 2     | 4.6E-01                      |
| 1253.8         | 4       | 4     | 4.2E-01                      |
| 1259.5         | 4       | 6     | 3.4E-01                      |
| 4463.6         | 8       | 6     | 5.3E-01                      |
| 4483.4         | 6       | 4     | 3.1E-01                      |
| 4486.7         | 4       | 2     | 6.6E-01                      |
| 4524.7         | 4       | 4     | 9.3E-02                      |
| 4525.0         | 6       | 4     | 1.2E+00                      |
| 4552.4         | 4       | 2     | 1.2E+00                      |
| 4656.7         | 2       | 4     | 9.0E-02                      |
| 4716.2         | 4       | 4     | 2.9E-01                      |
| 4815.5         | 6       | 4     | 8.8E-01                      |
| 4885.6         | 2       | 4     | 1.7E-01                      |
| 4917.2         | 2       | 2     | 6.6E-01                      |
| 4924.1         | 4       | 6     | 2.2E-01                      |
| 4925.3         | 2       | 4     | 2.4E-01                      |
| 4942.5         | 2       | 2     | 1.5E-01                      |
| 4991.9         | 4       | 4     | 1.5E-01                      |
| 5009.5         | 4       | 2     | 7.0E-01                      |
| 5014.0         | 4       | 4     | 8.4E-01                      |
| 5027.2         | 4       | 2     | 2.6E-01                      |
| 5032.4         | 6       | 6     | 8.1E-01                      |
| 5047.3         | 4       | 2     | 3.6E-01                      |
| 5103.3         | 6       | 4     | 5.0E-01                      |
| 5142.3         | 2       | 2     | 1.9E-01                      |
| 5201.0         | 4       | 4     | 7.5E-01                      |
| 5201.3         | 6       | 4     | 6.5E-02                      |
| 5212.6         | 4       | 6     | 9.8E-02                      |
| 5212.6         | 6       | 6     | 8.5E-01                      |
| 5320.7         | 6       | 8     | 9.2E-01                      |
| 5345.7         | 4       | 6     | 8.8E-01                      |
| 5345.7         | 6       | 6     | 1.1E-01                      |
| 5428.6         | 2       | 4     | 4.2E-01                      |
| 5432.8         | 4       | 6     | 6.8E-01                      |
| 5453.8         | 6       | 8     | 8.5E-01                      |
| 5473.6         | 2       | 2     | 7.3E-01                      |
| 5509.7         | 4       | 4     | 4.0E-01                      |
| 5526.2         | 8       | 8     | 8.1E-02                      |
| 5536.8         | 4       | 6     | 6.6E-02                      |
| 5556.0         | 4       | 2     | 1.1E-01                      |
| 5564.9         | 6       | 6     | 1.7E-01                      |
| 5578.8         | 6       | 6     | 1.1E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 5606.1         | 10      | 8     | 5.4E-01                      |
| 5616.6         | 4       | 4     | 1.2E-01                      |
| 5640.0         | 4       | 6     | 6.6E-01                      |
| 5645.6         | 6       | 4     | 1.8E-02                      |
| 5647.0         | 2       | 4     | 5.7E-01                      |
| 5659.9         | 6       | 4     | 4.6E-01                      |
| 5664.7         | 4       | 2     | 5.8E-01                      |
| 5819.2         | 4       | 4     | 8.5E-02                      |
| 6305.5         | 8       | 6     | 1.8E-01                      |
| 6312.7         | 6       | 4     | 3.0E-01                      |
| <i>S III</i>   |         |       |                              |
| 2496.2         | 7       | 5     | 2.5E+00                      |
| 2508.2         | 5       | 3     | 2.3E+00                      |
| 2636.9         | 3       | 5     | 4.5E-01                      |
| 2665.4         | 5       | 5     | 1.4E+00                      |
| 2680.5         | 1       | 3     | 6.2E-01                      |
| 2691.8         | 3       | 3     | 4.6E-01                      |
| 2702.8         | 3       | 1     | 1.9E+00                      |
| 2718.9         | 3       | 3     | 1.2E+00                      |
| 2721.4         | 5       | 3     | 7.7E-01                      |
| 2726.8         | 3       | 5     | 6.0E-01                      |
| 2731.1         | 5       | 5     | 1.1E+00                      |
| 2756.9         | 7       | 7     | 1.4E+00                      |
| 2785.5         | 3       | 3     | 6.1E-01                      |
| 2856.0         | 5       | 7     | 5.1E+00                      |
| 2863.5         | 7       | 9     | 5.7E+00                      |
| 2872.0         | 3       | 5     | 4.7E+00                      |
| 2950.2         | 3       | 5     | 3.0E+00                      |
| 2964.8         | 5       | 7     | 4.0E+00                      |
| 3662.0         | 3       | 3     | 6.4E-01                      |
| 3717.8         | 5       | 3     | 1.0E+00                      |
| 3778.9         | 3       | 5     | 4.4E-01                      |
| 3831.8         | 1       | 3     | 5.6E-01                      |
| 3837.8         | 3       | 3     | 4.2E-01                      |
| 3838.3         | 5       | 5     | 1.3E+00                      |
| 3860.6         | 3       | 1     | 1.6E+00                      |
| 3899.1         | 5       | 3     | 6.7E-01                      |
| 4253.6         | 5       | 7     | 1.2E+00                      |
| 4285.0         | 3       | 5     | 9.0E-01                      |
| <i>S IV</i>    |         |       |                              |
| 551.17         | 2       | 2     | 2.06E+01                     |
| 554.07         | 4       | 2     | 4.08E+01                     |
| 3097.5         | 2       | 4     | 2.6E+00                      |
| 3117.7         | 2       | 2     | 2.5E+00                      |
| <i>S V</i>     |         |       |                              |
| 437.37         | 1       | 3     | 1.12E+01                     |
| 438.19         | 3       | 3     | 3.33E+01                     |
| 439.65         | 5       | 3     | 5.5E+01                      |
| *661.52        | 9       | 15    | 6.44E+01                     |
| *679.01        | 9       | 15    | 8.6E+01                      |
| *690.75        | 9       | 9     | 5.0E+01                      |
| 786.48         | 1       | 3     | 5.25E+01                     |
| *854.85        | 9       | 9     | 4.18E+01                     |
| <i>S VI</i>    |         |       |                              |
| 248.99         | 2       | 4     | 3.1E+01                      |
| 249.27         | 2       | 2     | 3.1E+01                      |
| 388.94         | 2       | 2     | 4.5E+01                      |
| 390.86         | 4       | 2     | 8.8E+01                      |

| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |
| 706.48          | 2       | 4     | 4.17E+01                     |
| 712.68          | 4       | 6     | 4.85E+01                     |
| 712.84          | 4       | 4     | 8.1E+00                      |
| 933.38          | 2       | 4     | 1.7E+01                      |
| 944.52          | 2       | 2     | 1.6E+01                      |
| <i>S VII</i>    |         |       |                              |
| 60.161          | 1       | 3     | 9.46E+03                     |
| 60.804          | 1       | 3     | 5.1E+02                      |
| 72.029          | 1       | 3     | 8.61E+02                     |
| <i>S VIII</i>   |         |       |                              |
| 198.55          | 4       | 2     | 2.5E+02                      |
| 202.61          | 2       | 2     | 1.2E+02                      |
| <i>S XI</i>     |         |       |                              |
| *189.90         | 9       | 3     | 4.3E+02                      |
| 190.37          | 5       | 3     | 2.8E+02                      |
| 215.95          | 5       | 5     | 1.4E+02                      |
| 217.63          | 1       | 3     | 7.2E+01                      |
| 239.81          | 1       | 3     | 2.6E+01                      |
| 242.57          | 3       | 5     | 1.9E+01                      |
| 242.82          | 3       | 3     | 1.9E+01                      |
| 246.90          | 5       | 5     | 5.4E+01                      |
| 247.12          | 5       | 3     | 3.0E+01                      |
| *288.49         | 9       | 15    | 2.9E+01                      |
| <i>S XII</i>    |         |       |                              |
| 212.14          | 2       | 4     | 3.7E+01                      |
| 215.18          | 2       | 2     | 1.4E+02                      |
| 218.20          | 4       | 4     | 1.7E+02                      |
| 221.44          | 4       | 2     | 6.4E+01                      |
| 227.50          | 2       | 2     | 3.7E+01                      |
| 234.48          | 4       | 2     | 6.8E+01                      |
| <i>S XIII</i>   |         |       |                              |
| 32.236          | 1       | 3     | 1.09E+04                     |
| 37.600          | 3       | 1     | 1.3E+03                      |
| 256.66          | 1       | 3     | 8.7E+01                      |
| 299.89          | 3       | 5     | 1.78E+01                     |
| 303.37          | 1       | 3     | 2.28E+01                     |
| 307.36          | 3       | 3     | 1.64E+01                     |
| 308.91          | 5       | 5     | 4.82E+01                     |
| 312.68          | 3       | 1     | 6.3E+01                      |
| 316.84          | 5       | 3     | 2.50E+01                     |
| 500.42          | 3       | 5     | 1.43E+01                     |
| <i>S XIV</i>    |         |       |                              |
| *30.434         | 2       | 6     | 8.28E+03                     |
| *32.517         | 6       | 10    | 2.6E+04                      |
| 417.67          | 2       | 4     | 1.2E+01                      |
| 445.71          | 2       | 2     | 1.0E+01                      |
| 1550            | 2       | 4     | 1.4E+00                      |
| 1663            | 2       | 2     | 1.2E+00                      |
| 3967            | 2       | 4     | 5.4E-02                      |
| 4153            | 4       | 6     | 5.7E-02                      |
| <i>Tantalum</i> |         |       |                              |
| <i>Ta I</i>     |         |       |                              |
| 3127.9          | 4       | 6     | 5.7E-03                      |
| 3168.3          | 4       | 4     | 6.0E-03                      |
| 3170.3          | 8       | 10    | 8.5E-02                      |
| 3205.5          | 6       | 8     | 5.6E-03                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 3260.2         | 4       | 4     | 5.8E-03                      |
| 3337.8         | 6       | 6     | 1.3E-02                      |
| 3383.9         | 6       | 4     | 5.3E-03                      |
| 3406.9         | 4       | 6     | 6.8E-02                      |
| 3419.7         | 8       | 8     | 1.91E-02                     |
| 3463.8         | 4       | 6     | 2.62E-02                     |
| 3484.6         | 4       | 4     | 8.5E-03                      |
| 3488.8         | 6       | 4     | 7.3E-03                      |
| 3497.9         | 6       | 8     | 4.9E-02                      |
| 3505.0         | 8       | 6     | 2.72E-02                     |
| 3553.4         | 4       | 6     | 3.3E-03                      |
| 3607.4         | 6       | 8     | 4.6E-02                      |
| 3625.2         | 10      | 8     | 1.0E-02                      |
| 3626.6         | 8       | 10    | 7.1E-02                      |
| 3642.1         | 10      | 12    | 5.5E-02                      |
| 3657.5         | 6       | 6     | 4.3E-03                      |
| 3731.0         | 4       | 6     | 5.3E-03                      |
| 3754.5         | 8       | 8     | 6.5E-03                      |
| 3784.3         | 4       | 6     | 4.3E-02                      |
| 3792.1         | 4       | 4     | 9.0E-03                      |
| 3826.9         | 6       | 6     | 5.2E-03                      |
| 3836.6         | 8       | 10    | 4.0E-03                      |
| 3848.1         | 10      | 8     | 1.30E-02                     |
| 3858.6         | 10      | 10    | 2.5E-03                      |
| 3918.5         | 4       | 2     | 2.5E-02                      |
| 3922.8         | 4       | 4     | 3.98E-02                     |
| 3996.2         | 2       | 4     | 3.35E-02                     |
| 3999.3         | 4       | 4     | 1.8E-02                      |
| 4003.7         | 10      | 8     | 3.1E-03                      |
| 4006.8         | 6       | 8     | 7.6E-03                      |
| 4026.9         | 4       | 4     | 3.60E-02                     |
| 4029.9         | 10      | 10    | 2.8E-02                      |
| 4030.7         | 8       | 10    | 2.3E-03                      |
| 4040.9         | 10      | 12    | 7.3E-03                      |
| 4061.4         | 2       | 4     | 6.5E-02                      |
| 4064.6         | 4       | 4     | 3.83E-02                     |
| 4067.2         | 6       | 4     | 6.8E-03                      |
| 4067.9         | 6       | 8     | 8.4E-03                      |
| 4097.2         | 10      | 10    | 2.1E-03                      |
| 4105.0         | 6       | 4     | 1.1E-02                      |
| 4136.2         | 8       | 6     | 1.82E-02                     |
| 4147.9         | 10      | 8     | 1.79E-02                     |
| 4175.2         | 6       | 8     | 2.8E-02                      |
| 4205.9         | 8       | 10    | 8.9E-03                      |
| 4303.0         | 6       | 6     | 2.08E-02                     |
| 4378.8         | 8       | 6     | 4.8E-03                      |
| 4386.1         | 4       | 6     | 1.0E-02                      |
| 4402.5         | 6       | 6     | 2.28E-02                     |
| 4415.7         | 2       | 4     | 2.53E-02                     |
| 4441.0         | 4       | 6     | 7.5E-03                      |
| 4441.7         | 10      | 8     | 9.0E-03                      |
| 4473.5         | 6       | 8     | 1.36E-02                     |
| 4511.0         | 10      | 12    | 1.56E-02                     |
| 4511.5         | 10      | 8     | 3.6E-03                      |
| 4514.2         | 10      | 10    | 3.1E-03                      |
| 4521.1         | 10      | 10    | 2.3E-03                      |
| 4530.9         | 4       | 6     | 2.42E-02                     |
| 4547.2         | 4       | 6     | 5.3E-03                      |
| 4553.7         | 6       | 8     | 9.5E-03                      |
| 4565.9         | 8       | 8     | 2.5E-02                      |



| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 4574.3         | 4       | 4     | 1.2E-02                      | 5944.0          | 4       | 6     | 2.13E-02                     | 2601.1         | 8       | 6     | 1.7E-01                      |
| 4580.7         | 8       | 10    | 2.1E-03                      | 5997.2          | 10      | 10    | 2.4E-02                      | 2622.5         | 8       | 10    | 6.1E-02                      |
| 4619.5         | 6       | 4     | 5.3E-02                      | 6020.7          | 2       | 4     | 1.0E-02                      | 2841.1         | 6       | 6     | 2.0E-01                      |
| 4633.1         | 4       | 4     | 1.2E-02                      | 6045.4          | 6       | 8     | 2.6E-02                      | 2854.2         | 8       | 6     | 2.7E-01                      |
| 4669.1         | 6       | 4     | 2.85E-02                     | 6047.3          | 8       | 10    | 9.0E-03                      | 2914.8         | 8       | 8     | 7.7E-02                      |
| 4681.9         | 6       | 6     | 1.5E-02                      | 6249.8          | 6       | 6     | 3.5E-03                      | 2933.0         | 8       | 6     | 1.0E-01                      |
| 4684.9         | 10      | 8     | 2.8E-03                      | 6258.7          | 6       | 8     | 3.3E-03                      | 2973.2         | 8       | 8     | 2.3E-01                      |
| 4685.3         | 6       | 8     | 3.4E-03                      | 6309.6          | 4       | 6     | 1.83E-02                     | 3046.9         | 8       | 8     | 1.8E-01                      |
| 4691.9         | 2       | 4     | 4.08E-02                     | 6360.8          | 6       | 8     | 4.6E-03                      | 3081.1         | 8       | 8     | 1.9E-01                      |
| 4706.1         | 6       | 6     | 1.4E-02                      | 6428.6          | 6       | 6     | 6.0E-03                      | 3122.5         | 6       | 6     | 5.2E-01                      |
| 4740.2         | 4       | 4     | 5.0E-02                      | 6430.8          | 8       | 8     | 2.9E-02                      | 3142.4         | 6       | 6     | 8.8E-02                      |
| 4758.0         | 4       | 6     | 7.5E-03                      | 6450.4          | 8       | 10    | 2.2E-02                      | 3172.7         | 8       | 8     | 1.8E-01                      |
| 4769.0         | 8       | 8     | 2.8E-02                      | 6485.4          | 10      | 10    | 5.8E-02                      | 3233.7         | 8       | 10    | 5.1E-02                      |
| 4780.9         | 10      | 8     | 2.16E-02                     | 6514.4          | 6       | 4     | 2.2E-02                      | 3247.0         | 6       | 8     | 3.0E-01                      |
| 4812.8         | 4       | 4     | 1.2E-02                      | 6516.1          | 6       | 8     | 1.25E-02                     | 3251.8         | 6       | 4     | 5.2E-01                      |
| 4825.4         | 6       | 6     | 2.63E-02                     | 6612.0          | 6       | 4     | 1.9E-02                      | 3380.7         | 6       | 8     | 2.0E-01                      |
| 4832.2         | 4       | 4     | 1.7E-02                      | 6673.7          | 2       | 4     | 9.0E-03                      | 3406.0         | 6       | 8     | 1.5E-01                      |
| 4852.2         | 4       | 4     | 1.7E-02                      | 6771.7          | 4       | 4     | 5.8E-03                      | 3410.1         | 8       | 10    | 1.0E-01                      |
| 4884.0         | 6       | 8     | 1.1E-02                      | 6866.2          | 8       | 6     | 2.58E-02                     | 3416.6         | 8       | 8     | 5.7E-02                      |
| 4904.6         | 12      | 10    | 1.95E-02                     | 6927.4          | 10      | 12    | 1.01E-02                     | 3418.6         | 6       | 6     | 1.1E-01                      |
| 4920.9         | 8       | 10    | 2.1E-03                      | 6928.5          | 10      | 8     | 1.69E-02                     | 3563.9         | 8       | 6     | 9.8E-02                      |
| 4921.3         | 2       | 4     | 1.2E-02                      | 6951.3          | 10      | 10    | 3.7E-03                      | 3567.4         | 8       | 10    | 4.2E-02                      |
| 4926.0         | 4       | 4     | 1.5E-02                      | 6953.9          | 6       | 8     | 8.3E-03                      | 3744.1         | 8       | 8     | 9.5E-01                      |
| 4936.4         | 8       | 6     | 4.5E-02                      | 6966.1          | 8       | 8     | 1.2E-02                      | 3751.8         | 8       | 10    | 1.9E-01                      |
| 4969.7         | 4       | 4     | 1.0E-02                      | 6969.5          | 10      | 10    | 2.9E-03                      | 3798.5         | 6       | 4     | 1.2E+00                      |
| 5012.5         | 4       | 4     | 1.9E-02                      | 7407.9          | 6       | 4     | 2.0E-02                      | 3807.7         | 6       | 6     | 3.9E-01                      |
| 5037.4         | 10      | 8     | 4.4E-02                      | <i>Thallium</i> |         |       |                              | 3883.1         | 8       | 6     | 1.0E+00                      |
| 5043.3         | 6       | 4     | 2.73E-02                     | <i>Tl I</i>     |         |       |                              | 3887.4         | 8       | 8     | 3.8E-01                      |
| 5067.9         | 8       | 6     | 2.92E-02                     | 2104.6          | 2       | 4     | 4.0E-02                      | 3916.5         | 6       | 8     | 1.5E+00                      |
| 5069.9         | 10      | 12    | 1.7E-03                      | 2118.9          | 2       | 2     | 2.0E-02                      | 3949.3         | 6       | 6     | 1.0E+00                      |
| 5082.3         | 10      | 12    | 1.9E-03                      | 2129.3          | 2       | 4     | 5.8E-02                      | 4022.6         | 6       | 8     | 4.0E-02                      |
| 5087.4         | 6       | 4     | 1.5E-02                      | 2151.9          | 2       | 2     | 3.1E-02                      | 4044.5         | 6       | 4     | 2.9E-01                      |
| 5090.7         | 8       | 6     | 9.5E-03                      | 2168.6          | 2       | 4     | 9.8E-02                      | 4094.2         | 8       | 6     | 9.0E-01                      |
| 5095.3         | 6       | 6     | 5.0E-03                      | 2237.8          | 2       | 4     | 1.9E-01                      | 4105.8         | 8       | 10    | 6.0E-01                      |
| 5136.5         | 2       | 2     | 4.5E-02                      | 2316.0          | 2       | 2     | 7.8E-02                      | 4138.3         | 6       | 4     | 7.0E-01                      |
| 5141.6         | 4       | 2     | 1.2E-02                      | 2379.7          | 2       | 4     | 4.4E-01                      | 4158.6         | 6       | 8     | 5.5E-02                      |
| 5143.7         | 6       | 4     | 1.7E-02                      | 2507.9          | 4       | 2     | 1.1E-02                      | 4187.6         | 8       | 8     | 6.1E-01                      |
| 5147.6         | 6       | 4     | 9.0E-03                      | 2538.2          | 4       | 2     | 1.6E-02                      | 4203.7         | 8       | 10    | 2.5E-01                      |
| 5161.8         | 4       | 6     | 6.3E-03                      | 2580.1          | 2       | 2     | 1.8E-01                      | 4222.7         | 6       | 8     | 1.5E-01                      |
| 5218.7         | 8       | 6     | 8.2E-03                      | 2609.0          | 4       | 6     | 1.0E-01                      | 4271.7         | 6       | 6     | 1.1E-01                      |
| 5235.4         | 6       | 6     | 4.7E-03                      | 2609.8          | 4       | 4     | 1.9E-02                      | 4359.9         | 8       | 6     | 1.3E-01                      |
| 5295.0         | 6       | 6     | 7.5E-03                      | 2665.6          | 4       | 2     | 5.7E-02                      | 4386.4         | 8       | 8     | 4.2E-02                      |
| 5336.1         | 6       | 8     | 5.5E-03                      | 2709.2          | 4       | 6     | 1.7E-01                      | 4394.4         | 6       | 4     | 1.1E-01                      |
| 5349.6         | 6       | 4     | 2.2E-02                      | 2710.7          | 4       | 4     | 3.7E-02                      | 4643.1         | 6       | 6     | 3.4E-02                      |
| 5354.7         | 4       | 4     | 6.5E-03                      | 2767.9          | 2       | 4     | 1.26E+00                     | 4681.9         | 6       | 8     | 3.9E-02                      |
| 5396.0         | 6       | 8     | 2.5E-03                      | 2826.2          | 4       | 2     | 8.0E-02                      | 4691.1         | 6       | 6     | 3.9E-02                      |
| 5402.5         | 4       | 2     | 1.4E-02                      | 2918.3          | 4       | 6     | 4.2E-01                      | 5307.1         | 8       | 10    | 2.3E-02                      |
| 5435.3         | 4       | 6     | 1.1E-02                      | 2921.5          | 4       | 4     | 7.6E-02                      | 5658.3         | 6       | 8     | 1.0E-02                      |
| 5499.4         | 10      | 10    | 6.1E-03                      | 3229.8          | 4       | 2     | 1.73E-01                     | 5675.8         | 8       | 10    | 1.3E-02                      |
| 5518.9         | 8       | 10    | 3.8E-02                      | 3519.2          | 4       | 6     | 1.24E+00                     | 5760.2         | 6       | 6     | 1.3E-02                      |
| 5620.7         | 8       | 10    | 6.0E-03                      | 3529.4          | 4       | 4     | 2.20E-01                     | <i>Tin</i>     |         |       |                              |
| 5640.2         | 6       | 8     | 4.9E-03                      | 3775.7          | 2       | 2     | 6.25E-01                     | <i>Sn I</i>    |         |       |                              |
| 5645.9         | 6       | 8     | 1.43E-02                     | 5350.5          | 4       | 2     | 7.05E-01                     | 2073.1         | 1       | 3     | 3.6E-02                      |
| 5699.2         | 6       | 6     | 4.2E-03                      | <i>Thulium</i>  |         |       |                              | 2199.3         | 3       | 5     | 2.9E-01                      |
| 5767.9         | 6       | 8     | 2.6E-03                      | <i>Tm I</i>     |         |       |                              | 2209.7         | 5       | 5     | 5.6E-01                      |
| 5780.7         | 4       | 6     | 3.3E-03                      | 2513.8          | 8       | 10    | 6.9E-02                      | 2246.1         | 1       | 3     | 1.6E+00                      |
| 5811.1         | 8       | 6     | 5.7E-03                      | 2527.0          | 8       | 8     | 1.7E-01                      | 2268.9         | 5       | 7     | 1.2E+00                      |
| 5849.7         | 10      | 8     | 2.8E-03                      | 2596.5          | 8       | 10    | 1.6E-01                      | 2286.7         | 5       | 5     | 3.1E-01                      |
| 5877.4         | 10      | 12    | 2.3E-02                      |                 |         |       |                              | 2317.2         | 5       | 7     | 2.0E+00                      |
| 5939.8         | 2       | 4     | 1.6E-02                      |                 |         |       |                              |                |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 2334.8         | 3       | 3     | 6.6E-01                      | 5596.2          | 4       | 4     | 1.5E-01                      | 4055.01        | 1       | 3     | 2.8E-01                      |
| 2354.8         | 3       | 5     | 1.7E+00                      | 5797.2          | 6       | 6     | 2.8E-01                      | 4060.26        | 3       | 5     | 2.4E-01                      |
| 2380.7         | 3       | 5     | 3.1E-02                      | 5799.2          | 6       | 8     | 8.1E-01                      | 4064.20        | 3       | 3     | 2.4E-01                      |
| 2408.2         | 5       | 3     | 1.8E-01                      | 6453.5          | 2       | 4     | 1.2E+00                      | 4065.09        | 3       | 1     | 7.0E-01                      |
| 2421.7         | 5       | 7     | 2.5E+00                      | 6761.5          | 2       | 2     | 3.2E-01                      | 4186.12        | 9       | 9     | 2.10E-01                     |
| 2429.5         | 5       | 7     | 1.5E+00                      | 6844.1          | 2       | 2     | 6.6E-01                      | 4266.23        | 5       | 5     | 3.1E-01                      |
| 2433.5         | 5       | 3     | 8.0E-03                      | <i>Titanium</i> |         |       |                              | 4284.99        | 5       | 5     | 3.2E-01                      |
| 2455.2         | 5       | 5     | 1.1E-02                      | <i>Ti I</i>     |         |       |                              | 4289.07        | 5       | 5     | 3.0E-01                      |
| 2476.4         | 5       | 3     | 1.1E-02                      | 2276.75         | 7       | 5     | 1.3E+00                      | 4290.93        | 3       | 3     | 4.5E-01                      |
| 2483.4         | 5       | 5     | 2.1E-01                      | 2280.00         | 9       | 7     | 9.4E-01                      | 4295.75        | 3       | 1     | 1.3E+00                      |
| 2491.8         | 1       | 3     | 1.7E-01                      | 2299.86         | 5       | 5     | 6.9E-01                      | 4393.93        | 9       | 11    | 3.3E-01                      |
| 2495.7         | 5       | 5     | 6.2E-01                      | 2302.75         | 7       | 7     | 5.7E-01                      | 4417.27        | 11      | 9     | 3.6E-01                      |
| 2523.9         | 5       | 3     | 7.4E-02                      | 2305.69         | 9       | 9     | 5.2E-01                      | 4449.14        | 11      | 11    | 9.7E-01                      |
| 2546.6         | 1       | 3     | 2.1E-01                      | 2424.26         | 9       | 9     | 1.7E-01                      | 4450.90        | 9       | 9     | 9.6E-01                      |
| 2558.0         | 1       | 3     | 3.4E-01                      | 2520.54         | 5       | 3     | 3.8E-01                      | 4453.31        | 5       | 5     | 5.98E-01                     |
| 2571.6         | 5       | 7     | 4.5E-01                      | 2529.87         | 7       | 5     | 3.8E-01                      | 4453.71        | 7       | 7     | 4.7E-01                      |
| 2594.4         | 5       | 5     | 3.0E-01                      | 2541.92         | 9       | 7     | 4.3E-01                      | 4455.32        | 7       | 7     | 4.8E-01                      |
| 2636.9         | 1       | 3     | 1.1E-01                      | 2599.91         | 5       | 5     | 6.7E-01                      | 4457.43        | 9       | 9     | 5.6E-01                      |
| 2661.2         | 3       | 3     | 1.1E-01                      | 2605.16         | 7       | 7     | 6.4E-01                      | 4465.81        | 5       | 7     | 3.28E-01                     |
| 2706.5         | 3       | 5     | 6.6E-01                      | 2611.29         | 9       | 9     | 6.4E-01                      | 4481.26        | 7       | 7     | 5.7E-01                      |
| 2761.8         | 5       | 5     | 3.7E-03                      | 2611.47         | 7       | 5     | 3.3E-01                      | 4496.15        | 7       | 5     | 4.4E-01                      |
| 2779.8         | 5       | 7     | 1.8E-01                      | 2619.94         | 9       | 7     | 2.1E-01                      | 4518.02        | 7       | 9     | 1.72E-01                     |
| 2785.0         | 5       | 3     | 1.4E-01                      | 2631.55         | 7       | 7     | 1.7E-01                      | 4522.80        | 5       | 7     | 1.9E-01                      |
| 2788.0         | 1       | 3     | 1.4E-01                      | 2632.42         | 5       | 5     | 2.7E-01                      | 4527.31        | 3       | 5     | 2.2E-01                      |
| 2812.6         | 1       | 3     | 2.3E-01                      | 2641.12         | 5       | 3     | 1.8E+00                      | 4533.24        | 11      | 11    | 8.83E-01                     |
| 2813.6         | 5       | 5     | 1.2E-01                      | 2644.28         | 7       | 5     | 1.4E+00                      | 4534.78        | 9       | 9     | 6.87E-01                     |
| 2840.0         | 5       | 5     | 1.7E+00                      | 2646.65         | 9       | 7     | 1.5E+00                      | 4544.69        | 5       | 3     | 3.3E-01                      |
| 2850.6         | 5       | 5     | 3.3E-01                      | 2733.27         | 5       | 5     | 1.9E+00                      | 4548.76        | 7       | 5     | 2.85E-01                     |
| 2863.3         | 1       | 3     | 5.4E-01                      | 2735.30         | 3       | 1     | 4.1E+00                      | 4552.45        | 9       | 7     | 2.1E-01                      |
| 2913.5         | 1       | 3     | 8.3E-01                      | 2912.07         | 5       | 7     | 1.3E+00                      | 4563.43        | 9       | 11    | 2.1E-01                      |
| 3009.1         | 3       | 3     | 3.8E-01                      | 2942.00         | 5       | 5     | 1.0E+00                      | 4617.27        | 7       | 9     | 8.51E-01                     |
| 3032.8         | 1       | 3     | 6.2E-01                      | 2948.26         | 7       | 7     | 9.3E-01                      | 4623.10        | 5       | 7     | 5.74E-01                     |
| 3034.1         | 3       | 1     | 2.0E+00                      | 2956.13         | 9       | 9     | 9.7E-01                      | 4639.94        | 3       | 3     | 6.64E-01                     |
| 3141.8         | 1       | 3     | 1.9E-01                      | 2956.80         | 7       | 5     | 1.8E-01                      | 4640.43        | 3       | 1     | 5.0E-01                      |
| 3175.1         | 5       | 3     | 1.0E+00                      | 3186.45         | 5       | 7     | 8.0E-01                      | 4645.19        | 3       | 1     | 8.57E-01                     |
| 3218.7         | 1       | 3     | 4.7E-02                      | 3191.99         | 7       | 9     | 8.5E-01                      | 4650.02        | 5       | 3     | 2.6E-01                      |
| 3223.6         | 5       | 5     | 1.2E-03                      | 3199.92         | 9       | 11    | 9.4E-01                      | 4742.79        | 9       | 9     | 5.3E-01                      |
| 3262.3         | 5       | 3     | 2.7E+00                      | 3341.88         | 5       | 7     | 6.5E-01                      | 4758.12        | 11      | 11    | 7.13E-01                     |
| 3330.6         | 5       | 5     | 2.0E-01                      | 3354.63         | 7       | 9     | 6.9E-01                      | 4759.27        | 13      | 13    | 7.40E-01                     |
| 3655.8         | 1       | 3     | 4.1E-02                      | 3370.44         | 5       | 3     | 7.6E-01                      | 4778.26        | 9       | 9     | 2.0E-01                      |
| 3801.0         | 5       | 3     | 2.8E-01                      | 3371.45         | 9       | 11    | 7.2E-01                      | 4805.42        | 5       | 7     | 5.8E-01                      |
| 4524.7         | 1       | 3     | 2.6E-01                      | 3377.58         | 7       | 5     | 6.9E-01                      | 4840.87        | 5       | 5     | 1.76E-01                     |
| 5631.7         | 1       | 3     | 2.4E-02                      | 3385.94         | 9       | 7     | 5.0E-01                      | 4856.01        | 13      | 15    | 5.2E-01                      |
| 5970.3         | 5       | 3     | 9.6E-02                      | 3635.46         | 5       | 7     | 8.04E-01                     | 4885.08        | 11      | 13    | 4.90E-01                     |
| 6037.7         | 5       | 5     | 5.0E-02                      | 3642.68         | 7       | 9     | 7.74E-01                     | 4913.62        | 7       | 9     | 4.44E-01                     |
| 6069.0         | 1       | 3     | 4.6E-02                      | 3653.50         | 9       | 11    | 7.54E-01                     | 4928.34        | 3       | 5     | 6.2E-01                      |
| 6073.5         | 3       | 1     | 6.3E-02                      | 3724.57         | 9       | 9     | 9.1E-01                      | 4981.73        | 11      | 13    | 6.60E-01                     |
| 6171.5         | 3       | 3     | 4.9E-02                      | 3725.16         | 5       | 3     | 7.3E-01                      | 4989.14        | 7       | 5     | 3.25E-01                     |
| <i>Sn II</i>   |         |       |                              | 3729.81         | 5       | 5     | 4.27E-01                     | 4991.07        | 9       | 11    | 5.84E-01                     |
| 2368.3         | 4       | 2     | 4.4E-03                      | 3741.06         | 7       | 7     | 4.17E-01                     | 4999.50        | 7       | 9     | 5.27E-01                     |
| 2449.0         | 4       | 6     | 3.7E-01                      | 3752.86         | 9       | 9     | 5.04E-01                     | 5000.99        | 9       | 7     | 3.52E-01                     |
| 2487.0         | 6       | 8     | 5.5E-01                      | 3786.04         | 5       | 3     | 1.4E+00                      | 5007.21        | 5       | 7     | 4.92E-01                     |
| 3283.2         | 4       | 6     | 1.0E+00                      | 3948.67         | 5       | 3     | 4.85E-01                     | 5014.28        | 3       | 5     | 6.8E-01                      |
| 3352.0         | 6       | 8     | 1.0E+00                      | 3956.34         | 7       | 5     | 3.00E-01                     | 5036.47        | 7       | 9     | 3.94E-01                     |
| 3472.5         | 2       | 4     | 1.6E-01                      | 3958.21         | 9       | 7     | 4.05E-01                     | 5038.40        | 5       | 7     | 3.87E-01                     |
| 3575.5         | 4       | 6     | 1.3E-01                      | 3981.76         | 5       | 5     | 3.76E-01                     | 5062.11        | 5       | 3     | 2.98E-01                     |
| 5332.4         | 2       | 4     | 8.6E-01                      | 3989.76         | 7       | 7     | 3.79E-01                     | 5210.39        | 9       | 9     | 3.57E-02                     |
| 5562.0         | 4       | 6     | 1.2E+00                      | 3998.64         | 9       | 9     | 4.08E-01                     | 5222.69        | 3       | 3     | 1.95E-01                     |
| 5588.9         | 4       | 6     | 8.5E-01                      | 4013.24         | 7       | 5     | 2.0E-01                      | 5224.30        | 11      | 11    | 3.6E-01                      |
|                |         |       |                              |                 |         |       |                              | 5259.98        | 5       | 7     | 2.3E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 5351.07        | 7       | 7     | 3.4E-01                      |
| 5503.90        | 11      | 9     | 2.6E-01                      |
| 5774.04        | 9       | 11    | 5.5E-01                      |
| 5785.98        | 11      | 13    | 6.1E-01                      |
| 5804.27        | 13      | 15    | 6.8E-01                      |
| 6098.66        | 9       | 7     | 2.5E-01                      |
| 6220.46        | 9       | 7     | 1.8E-01                      |
| <i>Ti II</i>   |         |       |                              |
| 2440.91        | 4       | 4     | 5.1E-01                      |
| 2451.18        | 6       | 6     | 4.5E-01                      |
| 2525.59        | 10      | 8     | 5.6E-01                      |
| 2531.28        | 8       | 6     | 4.9E-01                      |
| 2534.63        | 6       | 4     | 5.4E-01                      |
| 2535.89        | 4       | 2     | 6.8E-01                      |
| 2555.99        | 6       | 8     | 3.2E-01                      |
| 2635.44        | 4       | 4     | 1.9E+00                      |
| 2638.56        | 6       | 6     | 1.7E+00                      |
| 2642.02        | 8       | 8     | 1.9E+00                      |
| 2645.86        | 10      | 10    | 2.7E+00                      |
| 2746.54        | 6       | 8     | 2.6E+00                      |
| 2751.59        | 8       | 10    | 3.7E+00                      |
| 2752.68        | 8       | 10    | 1.1E+00                      |
| 2757.62        | 6       | 8     | 7.2E-01                      |
| 2758.35        | 4       | 6     | 9.9E-01                      |
| 2758.79        | 2       | 4     | 4.4E-01                      |
| 2764.28        | 4       | 4     | 7.4E-01                      |
| 2804.82        | 6       | 8     | 4.6E+00                      |
| 2810.30        | 8       | 10    | 5.1E+00                      |
| 2817.83        | 10      | 12    | 3.8E+00                      |
| 2819.87        | 8       | 8     | 6.5E-01                      |
| 2821.26        | 6       | 8     | 7.9E-01                      |
| 2827.12        | 8       | 10    | 1.0E+00                      |
| 2828.06        | 12      | 14    | 4.4E+00                      |
| 2828.64        | 6       | 6     | 1.2E+00                      |
| 2828.83        | 10      | 10    | 9.1E-01                      |
| 2834.02        | 10      | 12    | 7.9E-01                      |
| 2836.47        | 8       | 8     | 1.2E+00                      |
| 2839.64        | 12      | 12    | 8.3E-01                      |
| 2845.93        | 10      | 10    | 1.2E+00                      |
| 2851.11        | 2       | 4     | 4.1E-01                      |
| 2856.10        | 12      | 12    | 1.5E+00                      |
| 2862.33        | 4       | 6     | 4.0E-01                      |
| 2877.47        | 8       | 8     | 5.7E-01                      |
| 2884.13        | 10      | 10    | 5.2E-01                      |
| 2910.65        | 8       | 8     | 4.6E-01                      |
| 2926.64        | 10      | 8     | 8.9E-01                      |
| 2931.10        | 6       | 6     | 3.2E+00                      |
| 2936.02        | 4       | 6     | 2.7E+00                      |
| 2938.57        | 6       | 8     | 2.4E+00                      |
| 2941.90        | 8       | 10    | 1.8E+00                      |
| 2942.97        | 8       | 8     | 1.1E+00                      |
| 2945.30        | 10      | 12    | 2.7E+00                      |
| 2952.00        | 8       | 8     | 3.0E-01                      |
| 2954.59        | 10      | 12    | 4.0E+00                      |
| 2958.80        | 8       | 10    | 4.0E+00                      |
| 2979.06        | 4       | 6     | 1.2E+00                      |
| 2990.06        | 6       | 8     | 5.6E-01                      |
| 3017.17        | 12      | 12    | 3.6E-01                      |
| 3022.64        | 10      | 10    | 1.2E+00                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 3023.67        | 8       | 8     | 1.0E+00                      |
| 3029.76        | 10      | 10    | 3.5E-01                      |
| 3056.75        | 2       | 4     | 3.2E-01                      |
| 3058.08        | 6       | 6     | 5.0E-01                      |
| 3066.34        | 4       | 4     | 3.3E-01                      |
| 3071.25        | 6       | 4     | 3.6E-01                      |
| 3072.99        | 4       | 2     | 1.6E+00                      |
| 3075.23        | 6       | 4     | 1.13E+00                     |
| 3078.65        | 8       | 6     | 1.09E+00                     |
| 3081.52        | 10      | 8     | 1.1E+00                      |
| 3088.04        | 10      | 8     | 1.25E+00                     |
| 3089.44        | 8       | 6     | 1.3E+00                      |
| 3097.20        | 4       | 6     | 4.4E-01                      |
| 3103.81        | 10      | 8     | 1.1E+00                      |
| 3105.10        | 2       | 4     | 6.3E-01                      |
| 3106.26        | 6       | 6     | 7.8E-01                      |
| 3117.67        | 4       | 2     | 1.1E+00                      |
| 3119.83        | 6       | 4     | 5.9E-01                      |
| 3127.86        | 6       | 6     | 1.6E+00                      |
| 3128.50        | 8       | 8     | 1.1E+00                      |
| 3161.23        | 4       | 2     | 5.9E-01                      |
| 3161.80        | 6       | 4     | 4.6E-01                      |
| 3162.59        | 8       | 6     | 3.9E-01                      |
| 3168.55        | 10      | 8     | 4.1E-01                      |
| 3181.73        | 6       | 8     | 4.6E-01                      |
| 3182.54        | 4       | 6     | 4.3E-01                      |
| 3189.49        | 4       | 4     | 9.2E-01                      |
| 3190.91        | 6       | 8     | 1.3E+00                      |
| 3202.56        | 4       | 6     | 1.1E+00                      |
| 3224.25        | 12      | 10    | 7.0E-01                      |
| 3228.62        | 4       | 2     | 2.0E+00                      |
| 3232.29        | 8       | 6     | 6.0E-01                      |
| 3234.51        | 10      | 10    | 1.38E+00                     |
| 3236.13        | 4       | 4     | 7.0E-01                      |
| 3236.58        | 8       | 8     | 1.11E+00                     |
| 3239.04        | 6       | 6     | 9.87E-01                     |
| 3239.66        | 6       | 4     | 9.4E-01                      |
| 3241.99        | 4       | 4     | 1.16E+00                     |
| 3251.91        | 6       | 4     | 3.38E-01                     |
| 3252.92        | 8       | 6     | 3.9E-01                      |
| 3272.07        | 2       | 4     | 3.2E-01                      |
| 3278.28        | 4       | 4     | 9.6E-01                      |
| 3278.91        | 6       | 4     | 1.0E+00                      |
| 3282.32        | 2       | 2     | 1.6E+00                      |
| 3287.66        | 8       | 10    | 1.4E+00                      |
| 3315.32        | 2       | 4     | 3.8E-01                      |
| 3321.70        | 4       | 4     | 7.2E-01                      |
| 3322.94        | 10      | 10    | 3.96E-01                     |
| 3329.46        | 8       | 8     | 3.25E-01                     |
| 3332.11        | 6       | 4     | 1.1E+00                      |
| 3340.34        | 4       | 4     | 3.6E-01                      |
| 3361.23        | 8       | 10    | 1.1E+00                      |
| 3372.80        | 6       | 8     | 1.11E+00                     |
| 3383.77        | 4       | 6     | 1.09E+00                     |
| 3452.49        | 2       | 2     | 7.7E-01                      |
| 3456.40        | 4       | 4     | 8.2E-01                      |
| 3465.56        | 4       | 2     | 4.1E-01                      |
| 3483.63        | 10      | 8     | 9.7E-01                      |
| 3492.37        | 8       | 6     | 9.8E-01                      |
| 3504.90        | 10      | 10    | 8.2E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |
| 3510.86        | 8       | 8     | 9.3E-01                      |
| 3520.27        | 2       | 4     | 4.8E-01                      |
| 3535.41        | 4       | 6     | 5.5E-01                      |
| 3641.33        | 4       | 2     | 4.9E-01                      |
| 3706.23        | 4       | 4     | 3.1E-01                      |
| 3741.64        | 6       | 6     | 6.2E-01                      |
| 3757.70        | 4       | 4     | 4.1E-01                      |
| 3759.30        | 8       | 8     | 9.4E-01                      |
| 3761.33        | 6       | 6     | 9.9E-01                      |
| 4911.18        | 6       | 4     | 3.2E-01                      |
| <i>Ti III</i>  |         |       |                              |
| 865.79         | 5       | 3     | 6.6E+01                      |
| 1002.37        | 5       | 5     | 7.6E+00                      |
| 1004.67        | 7       | 5     | 4.3E+01                      |
| 1005.80        | 3       | 3     | 1.3E+01                      |
| 1007.16        | 5       | 3     | 3.8E+01                      |
| 1008.12        | 3       | 1     | 5.1E+01                      |
| 1286.37        | 9       | 9     | 2.0E+00                      |
| 1289.30        | 7       | 7     | 2.2E+00                      |
| 1291.62        | 5       | 5     | 2.4E+00                      |
| 1293.23        | 9       | 7     | 1.0E+00                      |
| 1298.97        | 7       | 5     | 4.9E+00                      |
| 1327.59        | 5       | 3     | 3.2E+00                      |
| 1420.44        | 1       | 3     | 1.2E+00                      |
| 1421.63        | 3       | 1     | 4.0E+00                      |
| 1422.41        | 5       | 5     | 3.0E+00                      |
| 1424.14        | 5       | 3     | 1.6E+00                      |
| 1455.19        | 9       | 7     | 6.4E+00                      |
| 1498.70        | 5       | 5     | 2.8E+00                      |
| 2007.36        | 3       | 3     | 3.4E+00                      |
| 2007.60        | 1       | 3     | 1.2E+00                      |
| 2010.80        | 5       | 3     | 5.4E+00                      |
| 2097.30        | 5       | 7     | 3.3E+00                      |
| 2099.86        | 3       | 5     | 2.5E+00                      |
| 2104.86        | 3       | 3     | 1.1E+00                      |
| 2105.09        | 1       | 3     | 1.7E+00                      |
| 2199.22        | 3       | 3     | 5.7E+00                      |
| 2237.77        | 7       | 7     | 2.4E+00                      |
| 2331.35        | 3       | 1     | 4.3E+00                      |
| 2331.66        | 3       | 3     | 1.2E+00                      |
| 2339.00        | 5       | 3     | 3.0E+00                      |
| 2346.79        | 7       | 5     | 3.3E+00                      |
| 2374.99        | 5       | 3     | 4.0E+00                      |
| 2413.99        | 5       | 7     | 3.8E+00                      |
| 2516.05        | 7       | 9     | 3.4E+00                      |
| 2567.56        | 3       | 3     | 2.3E+00                      |
| 2984.75        | 5       | 5     | 1.9E+00                      |
| 3066.51        | 3       | 3     | 2.5E+00                      |
| 3228.89        | 3       | 3     | 1.5E+00                      |
| 3278.31        | 7       | 9     | 3.4E+00                      |
| 3320.94        | 3       | 5     | 2.8E+00                      |
| 3340.20        | 7       | 9     | 3.7E+00                      |
| 3346.18        | 9       | 11    | 3.7E+00                      |
| 3354.71        | 11      | 13    | 4.4E+00                      |
| 3397.24        | 3       | 1     | 1.8E+00                      |
| 3404.46        | 3       | 3     | 1.8E+00                      |
| 3417.62        | 3       | 5     | 1.9E+00                      |
| 3915.47        | 9       | 11    | 2.1E+00                      |
| 4119.14        | 5       | 5     | 9.9E-01                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 4213.26        | 9       | 11    | 2.2E+00                      | 439.513        | 3       | 3     | 7.5E+00                      | 60.762         | 2       | 2     | 3.5E+02                      |
| 4215.53        | 9       | 11    | 2.2E+00                      | 439.745        | 3       | 1     | 2.1E+01                      | 61.286         | 4       | 2     | 1.8E+02                      |
| 4247.62        | 11      | 13    | 1.1E+00                      | 447.484        | 5       | 5     | 1.6E+01                      | 62.433         | 4       | 6     | 2.08E+02                     |
| 4248.54        | 5       | 7     | 2.3E+00                      | 447.701        | 5       | 3     | 6.5E+00                      | 62.470         | 6       | 8     | 2.22E+02                     |
| 4250.09        | 3       | 5     | 9.5E-01                      | 507.174        | 3       | 5     | 6.5E+00                      | 65.540         | 4       | 6     | 3.2E+02                      |
| 4259.01        | 11      | 13    | 9.4E-01                      | 516.215        | 5       | 7     | 6.9E+00                      | 65.577         | 6       | 8     | 3.5E+02                      |
| 4269.84        | 9       | 11    | 1.7E+00                      | <i>Ti X</i>    |         |       |                              | 67.171         | 2       | 4     | 6.2E+02                      |
| 4285.61        | 13      | 15    | 3.0E+00                      | 253            | 4       | 6     | 2.1E+02                      | 67.555         | 4       | 6     | 7.2E+02                      |
| 4288.66        | 11      | 13    | 1.1E+00                      | 254            | 6       | 8     | 2.3E+02                      | 70.986         | 4       | 6     | 5.7E+02                      |
| 4296.70        | 11      | 13    | 1.6E+00                      | 281            | 2       | 2     | 1.1E+02                      | 71.031         | 6       | 8     | 6.1E+02                      |
| 4319.56        | 9       | 11    | 1.1E+00                      | 289.579        | 2       | 4     | 2.5E+02                      | 71.545         | 2       | 2     | 1.8E+02                      |
| 4343.25        | 3       | 1     | 1.0E+00                      | 290.294        | 4       | 6     | 1.1E+02                      | 71.987         | 4       | 2     | 3.48E+02                     |
| 4378.94        | 3       | 5     | 1.6E+00                      | 291            | 4       | 2     | 1.8E+02                      | 82.121         | 2       | 4     | 5.9E+02                      |
| 4433.91        | 11      | 13    | 1.8E+00                      | 291            | 2       | 2     | 2.3E+02                      | 82.307         | 4       | 6     | 1.13E+03                     |
| 4440.66        | 1       | 3     | 1.2E+00                      | 292            | 6       | 8     | 1.1E+02                      | 82.344         | 2       | 2     | 5.8E+02                      |
| 4533.26        | 3       | 5     | 1.5E+00                      | 293.684        | 6       | 8     | 2.97E+02                     | 82.368         | 6       | 8     | 1.2E+03                      |
| 4576.53        | 9       | 7     | 1.3E+00                      | 293.798        | 6       | 6     | 1.7E+02                      | 89.844         | 2       | 4     | 9.9E+02                      |
| 4628.07        | 3       | 1     | 1.5E+00                      | 295.584        | 4       | 6     | 2.9E+02                      | 90.512         | 4       | 6     | 1.16E+03                     |
| 4652.86        | 7       | 9     | 2.6E+00                      | 296            | 4       | 6     | 1.4E+02                      | 90.547         | 4       | 4     | 1.9E+02                      |
| 4874.00        | 5       | 7     | 1.5E+00                      | 297            | 4       | 6     | 9.9E+01                      | 116.497        | 4       | 6     | 3.0E+03                      |
| 4914.32        | 3       | 3     | 1.1E+00                      | 298            | 4       | 6     | 4.3E+02                      | 116.597        | 6       | 8     | 3.2E+03                      |
| 4971.19        | 9       | 11    | 2.1E+00                      | 302            | 2       | 2     | 1.6E+02                      | 116.62         | 6       | 6     | 2.1E+02                      |
| 5083.80        | 5       | 3     | 9.7E-01                      | 305            | 2       | 4     | 2.5E+02                      | 139.884        | 6       | 4     | 2.6E+02                      |
| 5278.33        | 3       | 3     | 9.4E-01                      | 317            | 2       | 2     | 1.5E+02                      | 140.361        | 4       | 2     | 2.9E+02                      |
| 7506.87        | 11      | 13    | 1.1E+00                      | 355.815        | 2       | 2     | 1.3E+02                      | 141.6          | 4       | 6     | 1.7E+02                      |
| <i>Ti IV</i>   |         |       |                              | 360.133        | 4       | 4     | 2.19E+02                     | 141.7          | 6       | 8     | 1.7E+02                      |
| 423.49         | 4       | 6     | 4.9E+01                      | 363            | 4       | 2     | 2.1E+02                      | 169.7          | 4       | 6     | 2.8E+02                      |
| 424.16         | 6       | 8     | 5.3E+01                      | 363            | 6       | 6     | 1.3E+02                      | 169.8          | 6       | 8     | 2.9E+02                      |
| 433.63         | 4       | 2     | 5.5E+00                      | 365.628        | 4       | 2     | 1.2E+02                      | 207.2          | 2       | 4     | 1.5E+02                      |
| 433.76         | 6       | 4     | 5.0E+00                      | 382            | 4       | 6     | 1.8E+02                      | 208.5          | 4       | 6     | 1.8E+02                      |
| 729.36         | 4       | 2     | 5.7E+00                      | 385            | 6       | 8     | 1.8E+02                      | 252.8          | 4       | 6     | 4.8E+02                      |
| 1183.64        | 2       | 2     | 6.9E+00                      | 389.99         | 6       | 4     | 1.1E+02                      | 253.1          | 6       | 8     | 5.2E+02                      |
| 1195.21        | 4       | 2     | 1.4E+01                      | <i>Ti XI</i>   |         |       |                              | 257.5          | 4       | 2     | 2.4E+02                      |
| 1451.74        | 2       | 4     | 1.8E+01                      | 65.403         | 1       | 3     | 5.1E+02                      | <i>Ti XIII</i> |         |       |                              |
| 1467.34        | 4       | 6     | 2.1E+01                      | 87.725         | 1       | 3     | 8.5E+02                      | 23.356         | 1       | 3     | 1.02E+05                     |
| 2067.56        | 2       | 4     | 5.1E+00                      | 266            | 5       | 7     | 1.8E+02                      | 23.698         | 1       | 3     | 1.2E+04                      |
| 2103.16        | 2       | 2     | 5.0E+00                      | 308.250        | 3       | 5     | 1.3E+02                      | 23.991         | 1       | 3     | 3.4E+02                      |
| 2541.79        | 4       | 6     | 6.9E+00                      | 313.229        | 5       | 7     | 1.6E+02                      | 26.641         | 1       | 3     | 4.06E+03                     |
| 2546.88        | 6       | 8     | 7.4E+00                      | 318            | 3       | 1     | 1.4E+02                      | 26.960         | 1       | 3     | 3.06E+03                     |
| 2862.60        | 4       | 2     | 4.1E+00                      | 322.75         | 5       | 7     | 1.99E+02                     | 117.1          | 3       | 3     | 1.3E+02                      |
| 3576.44        | 4       | 6     | 4.6E+00                      | 323            | 1       | 3     | 1.8E+02                      | 117.3          | 3       | 1     | 2.8E+02                      |
| <i>Ti VIII</i> |         |       |                              | 327.192        | 3       | 5     | 2.9E+02                      | 120.2          | 5       | 3     | 5.4E+02                      |
| 249            | 6       | 4     | 1.0E+01                      | 332            | 3       | 1     | 3.25E+02                     | 120.2          | 7       | 5     | 4.4E+02                      |
| 258.610        | 6       | 8     | 7.5E+02                      | 386.140        | 1       | 3     | 1.48E+02                     | 128.7          | 3       | 3     | 1.2E+02                      |
| 269.533        | 4       | 6     | 6.0E+02                      | 408            | 7       | 9     | 1.37E+02                     | <i>Ti XIV</i>  |         |       |                              |
| 272.037        | 4       | 4     | 4.3E+02                      | 425.74         | 3       | 1     | 1.2E+02                      | 21.341         | 4       | 6     | 9.8E+03                      |
| 272.843        | 6       | 4     | 6.2E+01                      | 446.69         | 3       | 1     | 1.2E+02                      | 21.522         | 2       | 4     | 4.5E+04                      |
| 276.701        | 2       | 4     | 9.3E+01                      | 453            | 5       | 7     | 1.3E+02                      | 21.657         | 4       | 4     | 1.3E+04                      |
| 277.813        | 4       | 4     | 3.8E+02                      | <i>Ti XII</i>  |         |       |                              | 21.733         | 4       | 4     | 8.8E+04                      |
| 289.375        | 2       | 4     | 3.6E+01                      | 52.896         | 2       | 4     | 1.61E+02                     | 21.82          | 4       | 2     | 6.4E+04                      |
| 478.971        | 4       | 4     | 1.7E+01                      | 53.140         | 4       | 6     | 1.9E+02                      | 21.883         | 2       | 4     | 7.0E+04                      |
| 480.376        | 6       | 6     | 1.5E+01                      | 53.433         | 2       | 4     | 2.1E+02                      | 21.958         | 2       | 4     | 1.2E+04                      |
| <i>Ti IX</i>   |         |       |                              | 53.457         | 2       | 2     | 2.1E+02                      | 22.05          | 2       | 2     | 1.4E+04                      |
| 267.941        | 5       | 7     | 5.1E+02                      | 55.181         | 2       | 4     | 2.4E+02                      | 24.592         | 4       | 2     | 6.1E+03                      |
| 278.713        | 5       | 7     | 4.7E+02                      | 55.443         | 4       | 6     | 2.81E+02                     | 24.891         | 2       | 2     | 7.5E+03                      |
| 281.446        | 3       | 1     | 3.2E+02                      | 59.133         | 2       | 4     | 3.72E+02                     | <i>Ti XV</i>   |         |       |                              |
| 285.128        | 1       | 3     | 4.1E+02                      | 59.435         | 4       | 6     | 4.41E+02                     | 20.19          | 5       | 7     | 6.9E+03                      |
| 433.567        | 1       | 3     | 6.9E+00                      | 60.701         | 2       | 4     | 3.4E+02                      | 20.234         | 5       | 7     | 1.9E+04                      |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|-----------------|---------|-------|------------------------------|-----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                 | $g_i$   | $g_k$ |                              |                 | $g_i$   | $g_k$ |                              |
| 20.234         | 3       | 3     | 4.9E+04                      | 163.049         | 3       | 1     | 6.2E+02                      | 10.690          | 4       | 6     | 1.58E+04                     |
| 20.246         | 1       | 3     | 4.2E+04                      | 186.863         | 5       | 5     | 2.66E+02                     | *11.452         | 2       | 6     | 1.7E+04                      |
| 20.250         | 5       | 3     | 6.5E+03                      | 207.73          | 3       | 1     | 1.07E+02                     | 11.872          | 2       | 4     | 2.8E+04                      |
| 20.29          | 3       | 3     | 1.1E+04                      | <i>Ti XVIII</i> |         |       |                              | 11.958          | 4       | 6     | 3.4E+04                      |
| 20.30          | 1       | 3     | 3.4E+04                      | 17.22           | 2       | 4     | 7.3E+04                      | 11.958          | 4       | 4     | 5.6E+03                      |
| 20.30          | 1       | 1     | 5.8E+04                      | 17.365          | 4       | 6     | 8.6E+04                      | 15.211          | 2       | 4     | 3.50E+04                     |
| 20.313         | 5       | 3     | 7.5E+04                      | 17.39           | 4       | 4     | 1.4E+04                      | 15.253          | 2       | 2     | 3.58E+04                     |
| 20.418         | 5       | 7     | 8.0E+04                      | 133.852         | 2       | 4     | 5.2E+01                      | 15.907          | 2       | 4     | 8.84E+04                     |
| 20.538         | 3       | 3     | 3.8E+04                      | 144.759         | 4       | 4     | 3.2E+02                      | 16.049          | 4       | 6     | 1.05E+05                     |
| 20.54          | 3       | 1     | 4.1E+04                      | 150.15          | 6       | 4     | 1.15E+02                     | 16.067          | 4       | 4     | 1.8E+04                      |
| 20.551         | 1       | 3     | 1.3E+04                      | 153.15          | 4       | 2     | 1.97E+02                     | 31.586          | 4       | 6     | 5.49E+03                     |
| 20.689         | 5       | 7     | 4.3E+04                      | 153.23          | 2       | 4     | 6.7E+01                      | 45.650          | 2       | 4     | 9.6E+03                      |
| 20.698         | 1       | 3     | 1.1E+05                      | 159.00          | 4       | 4     | 1.16E+02                     | 45.996          | 4       | 6     | 1.1E+04                      |
| 20.771         | 5       | 3     | 1.1E+04                      | 166.225         | 6       | 4     | 1.54E+02                     | <i>Ti XXI</i>   |         |       |                              |
| 20.897         | 5       | 7     | 2.85E+04                     | 179.902         | 2       | 4     | 6.3E+01                      | 2.0633          | 1       | 3     | 1.32E+05                     |
| 20.928         | 5       | 5     | 8.4E+03                      | 189.663         | 6       | 6     | 9.6E+01                      | 2.1108          | 1       | 3     | 2.60E+05                     |
| 21.065         | 3       | 3     | 1.1E+04                      | 191.23          | 4       | 4     | 6.6E+01                      | 2.2211          | 1       | 3     | 6.35E+05                     |
| 21.079         | 1       | 3     | 1.58E+04                     | 197.838         | 4       | 6     | 4.56E+01                     | 2.497           | 3       | 1     | 2.4E+06                      |
| 21.102         | 3       | 5     | 1.3E+04                      | 208.07          | 4       | 4     | 1.2E+02                      | 2.505           | 5       | 5     | 3.5E+05                      |
| 22.482         | 5       | 3     | 6.4E+03                      | <i>Ti XIX</i>   |         |       |                              | 2.505           | 1       | 3     | 1.4E+06                      |
| 22.936         | 5       | 5     | 1.1E+04                      | 15.67           | 3       | 1     | 3.3E+04                      | 2.507           | 3       | 5     | 1.4E+06                      |
| 22.966         | 5       | 3     | 1.1E+04                      | 15.68           | 5       | 5     | 2.7E+04                      | 2.508           | 3       | 5     | 7.9E+05                      |
| 23.034         | 1       | 3     | 6.3E+03                      | 15.74           | 5       | 7     | 2.7E+04                      | 2.510           | 3       | 3     | 6.9E+05                      |
| <i>Ti XVI</i>  |         |       |                              | 15.75           | 3       | 5     | 2.4E+04                      | 2.510           | 1       | 3     | 9.6E+05                      |
| 110.561        | 4       | 2     | 3.36E+02                     | 15.83           | 1       | 3     | 3.2E+04                      | 2.511           | 3       | 3     | 1.4E+06                      |
| 116.198        | 4       | 4     | 1.45E+02                     | 15.86           | 1       | 3     | 2.9E+04                      | 2.512           | 5       | 5     | 1.8E+06                      |
| 118.215        | 6       | 4     | 7.4E+02                      | 16.02           | 3       | 1     | 3.1E+04                      | 2.512           | 3       | 1     | 1.4E+06                      |
| 121.382        | 4       | 2     | 2.4E+02                      | 16.18           | 3       | 5     | 3.8E+04                      | 2.513           | 3       | 1     | 2.7E+06                      |
| 124.805        | 4       | 2     | 6.1E+02                      | 16.41           | 1       | 3     | 6.1E+04                      | 2.513           | 3       | 5     | 2.4E+06                      |
| 129.075        | 4       | 2     | 3.81E+02                     | 16.43           | 3       | 5     | 8.2E+04                      | 2.514           | 5       | 3     | 1.2E+06                      |
| 134.724        | 2       | 2     | 2.6E+02                      | 16.46           | 3       | 3     | 4.4E+04                      | 2.520           | 3       | 5     | 2.6E+05                      |
| 138.800        | 6       | 4     | 3.5E+02                      | 16.51           | 5       | 7     | 1.0E+05                      | 2.527           | 3       | 1     | 1.2E+05                      |
| 143.459        | 4       | 4     | 2.8E+02                      | 16.55           | 5       | 5     | 2.7E+04                      | 2.539           | 3       | 1     | 4.1E+05                      |
| 145.665        | 6       | 6     | 2.3E+02                      | 16.61           | 3       | 1     | 8.0E+04                      | 2.6102          | 1       | 3     | 2.40E+06                     |
| 157.812        | 4       | 2     | 1.32E+02                     | 16.64           | 3       | 3     | 5.3E+04                      | 2.6227          | 1       | 3     | 1.12E+05                     |
| 161.168        | 4       | 4     | 1.2E+02                      | 16.69           | 1       | 3     | 1.02E+05                     | <i>Tungsten</i> |         |       |                              |
| 163.610        | 4       | 2     | 1.92E+02                     | 16.71           | 3       | 5     | 7.3E+04                      | <i>WI</i>       |         |       |                              |
| 169.740        | 4       | 6     | 1.0E+02                      | 16.72           | 5       | 3     | 3.3E+04                      | 2879.4          | 1       | 3     | 2.4E-01                      |
| 176.267        | 2       | 2     | 2.45E+02                     | 16.72           | 5       | 5     | 7.3E+04                      | 2911.0          | 1       | 3     | 7.7E-02                      |
| 178.240        | 4       | 4     | 2.52E+02                     | 16.74           | 5       | 7     | 1.2E+05                      | 2923.5          | 7       | 9     | 1.54E-02                     |
| <i>Ti XVII</i> |         |       |                              | 16.77           | 3       | 3     | 2.6E+04                      | 2935.0          | 3       | 5     | 1.5E-01                      |
| 18.05          | 3       | 3     | 4.5E+04                      | 16.80           | 5       | 7     | 1.81E+05                     | 3013.8          | 7       | 9     | 6.4E-02                      |
| 18.13          | 5       | 3     | 2.4E+04                      | 16.85           | 3       | 5     | 4.4E+04                      | 3016.5          | 9       | 11    | 9.27E-02                     |
| 18.13          | 1       | 3     | 8.1E+04                      | 17.08           | 3       | 5     | 8.3E+04                      | 3017.4          | 7       | 9     | 1.21E-01                     |
| 18.176         | 5       | 7     | 9.2E+04                      | 17.36           | 1       | 3     | 9.5E+04                      | 3024.9          | 3       | 3     | 1.4E-01                      |
| 123.654        | 3       | 3     | 2.3E+02                      | <i>Ti XX</i>    |         |       |                              | 3046.4          | 3       | 5     | 5.8E-02                      |
| 124.553        | 5       | 3     | 5.2E+02                      | 2.629           | 2       | 4     | 4.9E+04                      | 3049.7          | 7       | 5     | 1.7E-01                      |
| 127.782        | 5       | 3     | 4.6E+02                      | 2.6295          | 4       | 4     | 3.2E+06                      | 3064.9          | 5       | 7     | 1.1E-02                      |
| 135.202        | 3       | 1     | 2.93E+02                     | 2.631           | 2       | 2     | 6.1E+05                      | 3084.9          | 5       | 5     | 1.3E-02                      |
| 136.160        | 5       | 3     | 1.95E+02                     | 2.6319          | 2       | 4     | 1.5E+06                      | 3093.5          | 7       | 9     | 4.4E-02                      |
| 136.393        | 3       | 3     | 1.14E+02                     | 2.632           | 2       | 2     | 2.7E+06                      | 3107.2          | 5       | 7     | 2.33E-02                     |
| 141.948        | 5       | 5     | 3.87E+02                     | 2.6355          | 4       | 6     | 1.2E+06                      | 3108.0          | 7       | 9     | 1.58E-02                     |
| 142.589        | 1       | 3     | 1.35E+02                     | 8.621           | 4       | 2     | 1.1E+06                      | 3145.5          | 9       | 9     | 4.8E-03                      |
| 144.405        | 5       | 5     | 9.4E+01                      | 9.788           | 4       | 6     | 5.26E+03                     | 3170.2          | 7       | 5     | 6.0E-03                      |
| 146.067        | 7       | 5     | 2.6E+02                      | 10.046          | 2       | 4     | 7.29E+03                     | 3176.6          | 3       | 5     | 2.12E-02                     |
| 154.133        | 3       | 1     | 1.63E+02                     | 10.109          | 4       | 6     | 8.6E+03                      | 3183.5          | 7       | 7     | 2.64E-03                     |
| 156.54         | 3       | 1     | 1.44E+02                     | *10.278         | 2       | 6     | 8.4E+03                      | 3184.4          | 5       | 3     | 2.3E-02                      |
| 158.469        | 5       | 5     | 1.4E+02                      | 10.620          | 2       | 4     | 1.34E+04                     | 3191.6          | 1       | 3     | 3.2E-02                      |
| 159.62         | 5       | 3     | 1.03E+02                     |                 |         |       |                              |                 |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3198.8         | 7       | 9     | 4.6E-02                      | 4294.6         | 7       | 5     | 1.2E-01                      | 6285.9         | 7       | 5     | 6.6E-03                      |
| 3207.3         | 7       | 9     | 3.0E-02                      | 4302.1         | 7       | 7     | 3.6E-02                      | 6292.0         | 3       | 5     | 2.26E-03                     |
| 3208.3         | 5       | 5     | 4.4E-02                      | 4355.2         | 9       | 9     | 5.1E-03                      | 6303.2         | 9       | 9     | 1.84E-03                     |
| 3215.6         | 9       | 11    | 2.1E-01                      | 4361.8         | 9       | 7     | 1.64E-03                     | 6404.2         | 5       | 7     | 1.50E-03                     |
| 3221.9         | 5       | 7     | 1.61E-02                     | 4378.5         | 7       | 5     | 3.48E-03                     | 6439.7         | 9       | 9     | 1.29E-03                     |
| 3223.1         | 5       | 3     | 3.53E-03                     | 4458.1         | 3       | 5     | 4.2E-03                      | 6445.1         | 7       | 5     | 6.4E-03                      |
| 3232.5         | 9       | 9     | 2.4E-02                      | 4466.3         | 7       | 5     | 1.5E-02                      | 6532.4         | 3       | 5     | 4.6E-03                      |
| 3235.1         | 7       | 5     | 2.68E-03                     | 4472.5         | 13      | 11    | 1.55E-03                     | 6538.1         | 11      | 9     | 2.7E-03                      |
| 3259.7         | 7       | 7     | 1.3E-02                      | 4484.2         | 3       | 5     | 5.6E-03                      | 6563.2         | 5       | 5     | 2.04E-03                     |
| 3300.8         | 7       | 9     | 8.1E-02                      | 4492.3         | 9       | 11    | 3.6E-03                      | 6814.9         | 9       | 9     | 1.46E-03                     |
| 3311.4         | 7       | 5     | 5.6E-02                      | 4495.3         | 11      | 11    | 3.3E-03                      | 7285.8         | 13      | 11    | 1.47E-03                     |
| 3363.3         | 9       | 7     | 6.6E-03                      | 4504.8         | 9       | 7     | 7.0E-03                      | 7569.9         | 5       | 3     | 3.73E-03                     |
| 3371.0         | 7       | 5     | 1.0E-02                      | 4552.5         | 9       | 9     | 1.42E-03                     | 7664.9         | 5       | 3     | 3.80E-03                     |
| 3371.4         | 3       | 3     | 6.7E-03                      | 4586.8         | 1       | 3     | 4.20E-03                     | 8017.2         | 5       | 7     | 1.6E-03                      |
| 3386.1         | 7       | 7     | 2.64E-03                     | 4592.6         | 7       | 9     | 3.4E-03                      | 8358.7         | 5       | 7     | 1.89E-03                     |
| 3413.0         | 7       | 9     | 9.7E-03                      | 4609.9         | 7       | 9     | 1.42E-02                     | 9381.4         | 9       | 7     | 1.53E-03                     |
| 3459.5         | 9       | 9     | 2.04E-03                     | 4613.3         | 9       | 9     | 2.9E-03                      | <i>Uranium</i> |         |       |                              |
| 3510.0         | 7       | 9     | 5.2E-03                      | 4634.8         | 9       | 9     | 8.8E-03                      | <i>UI</i>      |         |       |                              |
| 3545.2         | 1       | 3     | 3.2E-02                      | 4659.9         | 1       | 3     | 1.0E-02                      | 3553.0         | 13      | 13    | 2.0E-02                      |
| 3570.6         | 5       | 3     | 6.7E-03                      | 4680.5         | 7       | 7     | 1.4E-02                      | 3553.0         | 9       | 7     | 1.4E-02                      |
| 3606.1         | 3       | 5     | 9.6E-03                      | 4720.4         | 3       | 5     | 3.22E-03                     | 3553.4         | 15      | 13    | 2.2E-02                      |
| 3617.5         | 7       | 7     | 1.1E-01                      | 4729.6         | 7       | 5     | 7.8E-03                      | 3554.5         | 11      | 9     | 8.4E-03                      |
| 3631.9         | 3       | 5     | 1.3E-02                      | 4752.6         | 3       | 3     | 5.20E-03                     | 3554.9         | 15      | 17    | 7.9E-03                      |
| 3675.6         | 9       | 11    | 1.20E-02                     | 4757.5         | 7       | 5     | 2.72E-03                     | 3555.3         | 13      | 15    | 2.7E-02                      |
| 3682.1         | 9       | 11    | 2.0E-02                      | 4757.8         | 11      | 9     | 4.1E-03                      | 3555.8         | 13      | 11    | 4.1E-03                      |
| 3707.9         | 7       | 7     | 2.9E-02                      | 4788.4         | 9       | 11    | 2.6E-03                      | 3556.9         | 13      | 11    | 7.5E-03                      |
| 3757.9         | 7       | 9     | 1.38E-02                     | 4843.8         | 5       | 5     | 1.9E-02                      | 3557.8         | 13      | 13    | 2.9E-02                      |
| 3760.1         | 5       | 7     | 1.99E-02                     | 4886.9         | 9       | 11    | 8.1E-03                      | 3558.0         | 11      | 13    | 1.6E-02                      |
| 3768.5         | 3       | 3     | 3.47E-02                     | 4924.6         | 13      | 11    | 1.75E-03                     | 3558.6         | 9       | 7     | 3.9E-02                      |
| 3780.8         | 7       | 5     | 4.2E-02                      | 4931.6         | 7       | 5     | 1.0E-02                      | 3559.4         | 7       | 9     | 1.5E-02                      |
| 3809.2         | 7       | 5     | 9.0E-03                      | 4948.6         | 9       | 11    | 1.36E-03                     | 3560.3         | 9       | 7     | 6.4E-02                      |
| 3817.5         | 7       | 7     | 3.1E-02                      | 4972.6         | 9       | 11    | 3.9E-03                      | 3561.4         | 15      | 13    | 5.5E-02                      |
| 3829.1         | 3       | 3     | 3.83E-03                     | 4982.6         | 1       | 3     | 4.17E-03                     | 3561.5         | 9       | 9     | 2.5E-02                      |
| 3835.1         | 5       | 5     | 5.2E-02                      | 4986.9         | 11      | 9     | 6.3E-03                      | 3561.8         | 13      | 11    | 5.7E-02                      |
| 3846.3         | 3       | 5     | 2.14E-02                     | 5006.2         | 9       | 7     | 1.2E-02                      | 3563.7         | 13      | 13    | 2.9E-02                      |
| 3847.5         | 1       | 3     | 8.3E-03                      | 5015.3         | 7       | 9     | 5.4E-03                      | 3563.8         | 7       | 7     | 1.1E-02                      |
| 3864.3         | 5       | 5     | 5.6E-03                      | 5040.4         | 3       | 5     | 5.2E-03                      | 3565.0         | 13      | 11    | 2.9E-02                      |
| 3868.0         | 7       | 9     | 4.6E-02                      | 5053.3         | 3       | 3     | 1.9E-02                      | 3566.0         | 13      | 15    | 1.7E-02                      |
| 3881.4         | 7       | 7     | 3.6E-02                      | 5071.5         | 13      | 11    | 3.4E-03                      | 3566.6         | 11      | 11    | 2.4E-01                      |
| 3968.5         | 1       | 3     | 5.07E-03                     | 5117.6         | 11      | 11    | 1.61E-03                     | 3568.8         | 13      | 13    | 3.8E-02                      |
| 3975.5         | 9       | 11    | 4.1E-03                      | 5124.2         | 5       | 5     | 4.0E-03                      | 3569.1         | 17      | 15    | 1.1E-01                      |
| 4001.4         | 9       | 9     | 5.6E-03                      | 5141.2         | 7       | 9     | 1.12E-03                     | 3569.4         | 9       | 9     | 1.5E-02                      |
| 4008.8         | 7       | 9     | 1.63E-01                     | 5224.7         | 7       | 5     | 1.2E-02                      | 3570.1         | 13      | 11    | 1.3E-02                      |
| 4019.3         | 5       | 3     | 6.7E-03                      | 5243.0         | 9       | 7     | 1.1E-02                      | 3570.2         | 11      | 9     | 5.3E-03                      |
| 4028.8         | 1       | 3     | 2.0E-02                      | 5254.5         | 7       | 5     | 3.86E-03                     | 3570.6         | 13      | 15    | 2.7E-02                      |
| 4045.6         | 7       | 5     | 2.88E-02                     | 5268.6         | 9       | 9     | 1.4E-03                      | 3570.7         | 15      | 15    | 1.2E-02                      |
| 4055.2         | 7       | 9     | 1.79E-03                     | 5500.5         | 11      | 9     | 6.9E-03                      | 3571.2         | 11      | 11    | 6.3E-03                      |
| 4070.0         | 7       | 5     | 3.60E-02                     | 5514.7         | 5       | 3     | 7.3E-03                      | 3571.6         | 17      | 15    | 1.3E-01                      |
| 4070.6         | 3       | 5     | 5.6E-03                      | 5537.7         | 9       | 11    | 2.2E-03                      | 3572.9         | 13      | 15    | 1.5E-02                      |
| 4074.4         | 7       | 7     | 1.0E-01                      | 5617.1         | 7       | 7     | 1.47E-03                     | 3573.9         | 13      | 11    | 4.0E-02                      |
| 4088.3         | 5       | 3     | 4.13E-03                     | 5631.9         | 9       | 7     | 1.43E-03                     | 3574.1         | 13      | 15    | 3.5E-02                      |
| 4102.7         | 9       | 7     | 4.9E-02                      | 5660.7         | 13      | 11    | 6.8E-03                      | 3574.8         | 13      | 15    | 1.9E-02                      |
| 4115.6         | 11      | 11    | 4.8E-03                      | 5675.4         | 5       | 5     | 2.20E-03                     | 3577.1         | 17      | 15    | 4.3E-02                      |
| 4137.5         | 5       | 7     | 8.4E-03                      | 5796.5         | 9       | 7     | 2.21E-03                     | 3577.5         | 15      | 13    | 7.8E-03                      |
| 4171.2         | 7       | 9     | 8.6E-03                      | 5891.6         | 7       | 7     | 1.47E-03                     | 3577.8         | 11      | 11    | 8.3E-03                      |
| 4203.8         | 9       | 7     | 4.9E-03                      | 5947.6         | 5       | 7     | 2.40E-03                     | 3577.9         | 13      | 13    | 2.3E-02                      |
| 4219.4         | 9       | 7     | 6.1E-03                      | 5965.9         | 7       | 5     | 1.0E-02                      | 3578.3         | 13      | 11    | 2.0E-02                      |
| 4244.4         | 9       | 11    | 1.38E-02                     | 6021.5         | 5       | 3     | 8.7E-03                      | 3580.0         | 9       | 9     | 1.2E-02                      |
| 4269.4         | 7       | 5     | 3.04E-02                     | 6081.4         | 5       | 3     | 4.7E-03                      | 3580.2         | 11      | 9     | 2.9E-02                      |
| 4283.8         | 9       | 7     | 1.69E-03                     | 6203.5         | 7       | 7     | 3.0E-03                      |                |         |       |                              |



| $\lambda$<br>Å  | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|-----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                 | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 3580.4          | 11      | 13    | 7.5E-03                      | 3543.49        | 2       | 2     | 6.7E-01                      | 4232.95        | 8       | 8     | 7.7E-01                      |
| 3580.9          | 13      | 13    | 2.1E-02                      | 3545.33        | 4       | 4     | 3.7E-01                      | 4268.64        | 14      | 14    | 1.2E+00                      |
| 3582.6          | 13      | 13    | 2.9E-02                      | 3553.27        | 6       | 6     | 2.2E-01                      | 4271.55        | 12      | 12    | 9.6E-01                      |
| 3584.6          | 7       | 5     | 2.4E-02                      | 3555.14        | 4       | 2     | 2.6E-01                      | 4276.95        | 10      | 10    | 9.4E-01                      |
| 3584.9          | 13      | 15    | 1.8E-01                      | 3663.60        | 4       | 6     | 3.1E+00                      | 4284.05        | 8       | 8     | 1.2E+00                      |
| 3585.4          | 11      | 11    | 1.9E-02                      | 3667.74        | 6       | 8     | 2.7E+00                      | 4291.82        | 12      | 14    | 8.8E-01                      |
| 3585.8          | 11      | 9     | 2.8E-02                      | 3672.41        | 12      | 12    | 9.2E-01                      | 4296.10        | 10      | 12    | 7.7E-01                      |
| 3587.8          | 9       | 11    | 1.3E-02                      | 3673.41        | 8       | 10    | 2.7E+00                      | 4297.67        | 8       | 10    | 7.0E-01                      |
| 3588.3          | 7       | 9     | 1.8E-02                      | 3676.70        | 14      | 14    | 1.3E+00                      | 4298.03        | 6       | 8     | 7.8E-01                      |
| 3589.7          | 11      | 13    | 2.1E-02                      | 3680.12        | 10      | 12    | 2.2E+00                      | 4379.23        | 10      | 12    | 1.1E+00                      |
| 3589.8          | 15      | 13    | 5.9E-02                      | 3686.26        | 10      | 12    | 2.3E-01                      | 4384.71        | 8       | 10    | 1.1E+00                      |
| 3590.7          | 9       | 7     | 2.2E-02                      | 3687.50        | 12      | 14    | 2.9E+00                      | 4389.98        | 6       | 8     | 6.9E-01                      |
| 3591.7          | 11      | 9     | 5.3E-02                      | 3688.07        | 8       | 8     | 3.5E-01                      | 4395.22        | 4       | 6     | 5.5E-01                      |
| 3593.0          | 11      | 11    | 1.4E-02                      | 3690.28        | 2       | 4     | 4.5E-01                      | 4400.57        | 2       | 4     | 3.4E-01                      |
| 3593.2          | 13      | 15    | 4.2E-02                      | 3692.22        | 6       | 6     | 5.4E-01                      | 4406.64        | 10      | 10    | 2.2E-01                      |
| 3593.7          | 11      | 11    | 7.2E-02                      | 3695.34        | 14      | 16    | 2.8E+00                      | 4407.63        | 8       | 8     | 4.4E-01                      |
| <i>Vanadium</i> |         |       |                              | 3695.86        | 4       | 4     | 6.6E-01                      | 4408.20        | 6       | 6     | 6.0E-01                      |
| <i>VI</i>       |         |       |                              | 3703.57        | 10      | 8     | 9.2E-01                      | 4416.47        | 4       | 2     | 2.6E-01                      |
| 3043.12         | 6       | 8     | 2.3E-01                      | 3704.70        | 8       | 6     | 6.6E-01                      | 4452.01        | 14      | 16    | 9.2E-01                      |
| 3050.39         | 10      | 8     | 5.3E-01                      | 3705.04        | 6       | 4     | 3.6E-01                      | 4457.75        | 10      | 12    | 2.7E-01                      |
| 3053.65         | 4       | 4     | 1.3E+00                      | 3706.03        | 10      | 10    | 5.2E-01                      | 4460.33        | 10      | 8     | 3.0E-01                      |
| 3056.33         | 6       | 6     | 1.3E+00                      | 3708.71        | 12      | 12    | 4.4E-01                      | 4462.36        | 12      | 14    | 7.6E-01                      |
| 3060.46         | 8       | 8     | 1.4E+00                      | 3790.46        | 10      | 8     | 2.3E-01                      | 4468.00        | 8       | 10    | 2.3E-01                      |
| 3066.37         | 10      | 10    | 2.1E+00                      | 3794.96        | 10      | 10    | 2.3E-01                      | 4469.71        | 10      | 12    | 6.2E-01                      |
| 3066.53         | 6       | 4     | 3.2E-01                      | 3806.79        | 10      | 10    | 2.5E-01                      | 4474.04        | 10      | 8     | 4.7E-01                      |
| 3075.93         | 4       | 6     | 2.8E-01                      | 3818.24        | 4       | 2     | 6.73E-01                     | 4496.06        | 8       | 6     | 4.0E-01                      |
| 3080.33         | 2       | 4     | 2.7E-01                      | 3828.56        | 6       | 4     | 5.33E-01                     | 4514.18        | 6       | 4     | 3.3E-01                      |
| 3083.54         | 6       | 8     | 2.5E-01                      | 3840.75        | 8       | 6     | 5.48E-01                     | 4524.21        | 12      | 10    | 3.0E-01                      |
| 3087.06         | 2       | 2     | 9.2E-01                      | 3855.36        | 4       | 4     | 3.30E-01                     | 4525.17        | 4       | 2     | 4.1E-01                      |
| 3088.11         | 4       | 6     | 4.9E-01                      | 3855.85        | 10      | 8     | 5.78E-01                     | 4529.58        | 10      | 8     | 2.4E-01                      |
| 3089.13         | 4       | 4     | 5.3E-01                      | 3863.86        | 8       | 6     | 3.1E-01                      | 4545.40        | 10      | 12    | 7.6E-01                      |
| 3093.79         | 6       | 6     | 4.1E-01                      | 3864.86        | 6       | 6     | 2.70E-01                     | 4560.72        | 8       | 10    | 7.0E-01                      |
| 3094.69         | 2       | 4     | 4.3E-01                      | 3871.07        | 10      | 8     | 2.8E-01                      | 4571.79        | 6       | 8     | 6.0E-01                      |
| 3112.92         | 4       | 2     | 5.0E-01                      | 3875.07        | 8       | 8     | 2.36E-01                     | 4578.73        | 4       | 6     | 6.8E-01                      |
| 3183.41         | 6       | 8     | 2.4E+00                      | 3902.26        | 10      | 10    | 2.68E-01                     | 4706.16        | 6       | 4     | 2.4E-01                      |
| 3183.96         | 8       | 10    | 2.5E+00                      | 3921.86        | 4       | 2     | 2.7E-01                      | 4757.47        | 4       | 2     | 7.6E-01                      |
| 3183.98         | 4       | 6     | 2.4E+00                      | 3922.43        | 6       | 6     | 2.6E-01                      | 4766.62        | 6       | 4     | 5.6E-01                      |
| 3185.38         | 10      | 12    | 2.7E+00                      | 3930.02        | 10      | 10    | 3.3E-01                      | 4776.36        | 8       | 6     | 5.1E-01                      |
| 3198.01         | 6       | 6     | 3.9E-01                      | 3934.01        | 8       | 8     | 6.2E-01                      | 4786.50        | 10      | 8     | 4.7E-01                      |
| 3202.39         | 8       | 8     | 4.0E-01                      | 3992.80        | 12      | 10    | 1.2E+00                      | 4796.92        | 12      | 10    | 4.8E-01                      |
| 3205.58         | 8       | 10    | 1.3E+00                      | 3998.73        | 14      | 12    | 1.0E+00                      | 4807.52        | 14      | 12    | 5.8E-01                      |
| 3207.41         | 10      | 10    | 2.6E-01                      | 4050.96        | 10      | 10    | 1.4E+00                      | 5193.00        | 12      | 12    | 4.0E-01                      |
| 3212.43         | 10      | 12    | 1.4E+00                      | 4051.35        | 12      | 12    | 1.3E+00                      | 5195.39        | 8       | 8     | 2.3E-01                      |
| 3218.87         | 8       | 6     | 3.5E-01                      | 4090.57        | 8       | 10    | 8.5E-01                      | 5234.08        | 10      | 10    | 4.9E-01                      |
| 3233.19         | 10      | 8     | 3.2E-01                      | 4092.68        | 8       | 10    | 2.30E-01                     | 5240.87        | 12      | 12    | 4.3E-01                      |
| 3273.03         | 8       | 8     | 2.7E-01                      | 4095.48        | 6       | 8     | 7.2E-01                      | 5415.25        | 12      | 14    | 3.1E-01                      |
| 3284.36         | 10      | 10    | 2.8E-01                      | 4099.78        | 6       | 8     | 4.10E-01                     | 5487.91        | 12      | 10    | 2.9E-01                      |
| 3309.18         | 4       | 4     | 3.2E-01                      | 4102.15        | 4       | 6     | 7.1E-01                      | 5507.75        | 10      | 8     | 3.5E-01                      |
| 3329.85         | 6       | 4     | 7.7E-01                      | 4104.77        | 10      | 8     | 2.1E+00                      | 6090.21        | 8       | 6     | 2.60E-01                     |
| 3356.35         | 4       | 6     | 3.1E-01                      | 4105.16        | 4       | 6     | 4.9E-01                      | <i>VII</i>     |         |       |                              |
| 3365.55         | 2       | 4     | 4.8E-01                      | 4109.78        | 2       | 4     | 5.00E-01                     | 2527.90        | 13      | 13    | 6.1E-01                      |
| 3376.05         | 4       | 4     | 3.2E-01                      | 4111.78        | 10      | 10    | 1.01E+00                     | 2528.47        | 9       | 9     | 5.2E-01                      |
| 3377.39         | 4       | 2     | 9.0E-01                      | 4115.18        | 8       | 8     | 5.80E-01                     | 2528.83        | 11      | 11    | 5.3E-01                      |
| 3377.62         | 6       | 6     | 6.0E-01                      | 4116.47        | 6       | 6     | 3.2E-01                      | 2554.04        | 9       | 9     | 5.4E-01                      |
| 3397.58         | 6       | 4     | 2.3E-01                      | 4116.59        | 2       | 2     | 2.90E-01                     | 2589.10        | 9       | 9     | 7.7E-01                      |
| 3400.39         | 8       | 8     | 2.5E-01                      | 4123.50        | 4       | 2     | 1.00E+00                     | 2640.86        | 5       | 7     | 1.2E+00                      |
| 3529.73         | 4       | 6     | 4.1E-01                      | 4128.06        | 6       | 4     | 7.70E-01                     | 2677.80        | 3       | 5     | 3.4E-01                      |
| 3533.68         | 6       | 8     | 5.2E-01                      | 4131.99        | 8       | 6     | 5.5E-01                      | 2679.33        | 7       | 7     | 3.4E-01                      |
| 3533.76         | 2       | 4     | 3.7E-01                      | 4134.49        | 10      | 8     | 2.90E-01                     | 2683.09        | 1       | 3     | 3.4E-01                      |
|                 |         |       |                              | 4232.46        | 10      | 10    | 9.8E-01                      |                |         |       |                              |

| $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights     |       | $A$<br>$10^8 \text{ s}^{-1}$ |         |
|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|-------------|-------|------------------------------|---------|
|                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$       | $g_k$ |                              |         |
| 2687.96        | 9       | 9     | 7.6E-01                      | 3271.12        | 7       | 9     | 6.9E-01                      | 1308.06        | 7           | 9     | 7.9E+00                      |         |
| 2689.88        | 3       | 1     | 9.2E-01                      | 3276.12        | 9       | 11    | 5.2E-01                      | 1309.50        | 5           | 5     | 8.7E+00                      |         |
| 2690.25        | 7       | 5     | 3.4E-01                      | 3279.84        | 9       | 11    | 5.8E-01                      | 1312.72        | 7           | 7     | 8.6E+00                      |         |
| 2690.79        | 5       | 3     | 5.2E-01                      | 3287.71        | 5       | 7     | 7.5E-01                      | 1317.57        | 5           | 7     | 8.7E+00                      |         |
| 2700.94        | 9       | 11    | 3.5E-01                      | 3337.85        | 5       | 7     | 5.3E-01                      | 1321.92        | 7           | 9     | 9.9E+00                      |         |
| 2706.17        | 7       | 9     | 3.4E-01                      | 3517.30        | 9       | 7     | 3.8E-01                      | 1326.81        | 3           | 5     | 4.0E+00                      |         |
| 2734.22        | 9       | 7     | 6.2E-01                      | 3530.77        | 5       | 3     | 4.5E-01                      | 1329.29        | 5           | 5     | 1.5E+01                      |         |
| 2753.41        | 13      | 11    | 4.2E-01                      | 3545.19        | 7       | 5     | 4.3E-01                      | 1329.97        | 3           | 3     | 4.8E+00                      |         |
| 2784.20        | 9       | 9     | 1.3E+00                      | 3556.80        | 9       | 7     | 5.1E-01                      | 1330.36        | 1           | 3     | 6.0E+00                      |         |
| 2787.91        | 7       | 9     | 5.0E-01                      | 3592.01        | 7       | 5     | 4.4E-01                      | 1331.67        | 3           | 1     | 1.7E+01                      |         |
| 2825.86        | 9       | 7     | 1.2E+00                      | 3618.92        | 3       | 5     | 3.3E-01                      | 1332.46        | 5           | 3     | 7.5E+00                      |         |
| 2843.82        | 7       | 5     | 9.9E-01                      | <i>VIII</i>    |         |       |                              | 1334.49        | 9           | 9     | 8.3E+00                      |         |
| 2847.57        | 9       | 7     | 4.6E-01                      |                | 2318.06 | 8     | 10                           | 4.6E+00        | 1355.13     | 7     | 9                            | 2.5E+01 |
| 2854.34        | 11      | 9     | 5.0E-01                      |                | 2323.82 | 6     | 8                            | 3.8E+00        | 1356.53     | 5     | 3                            | 4.9E+00 |
| 2862.31        | 11      | 11    | 3.6E-01                      |                | 2330.42 | 10    | 10                           | 3.2E+00        | 1395.00     | 5     | 7                            | 1.4E+01 |
| 2868.11        | 5       | 3     | 2.1E+00                      |                | 2331.75 | 8     | 8                            | 2.5E+00        | 1400.42     | 5     | 7                            | 7.5E+00 |
| 2869.13        | 13      | 11    | 4.8E-01                      |                | 2334.21 | 6     | 6                            | 2.2E+00        | 1403.62     | 7     | 9                            | 8.4E+00 |
| 2882.49        | 5       | 5     | 4.2E-01                      |                | 2337.13 | 4     | 4                            | 2.7E+00        | 1412.69     | 3     | 3                            | 1.1E+01 |
| 2884.78        | 3       | 3     | 5.6E-01                      |                | 2343.10 | 6     | 8                            | 3.6E+00        | 1414.41     | 5     | 7                            | 1.2E+01 |
| 2889.61        | 3       | 1     | 1.9E+00                      |                | 2358.73 | 6     | 8                            | 4.2E+00        | 1414.84     | 5     | 5                            | 4.6E+00 |
| 2891.64        | 5       | 3     | 1.4E+00                      |                | 2366.31 | 8     | 10                           | 4.2E+00        | 1418.53     | 7     | 7                            | 5.2E+00 |
| 2892.43        | 9       | 9     | 3.6E-01                      | 2371.06        | 10      | 12    | 5.2E+00                      | 1419.58        | 7           | 9     | 1.3E+01                      |         |
| 2892.65        | 7       | 5     | 1.3E+00                      | 2373.06        | 4       | 6     | 2.9E+00                      | 1423.72        | 3           | 5     | 7.1E+00                      |         |
| 2893.31        | 9       | 7     | 1.2E+00                      | 2382.46        | 8       | 10    | 5.0E+00                      | 1426.65        | 9           | 11    | 2.2E+01                      |         |
| 2903.07        | 3       | 5     | 3.4E-01                      | 2393.58        | 6       | 8     | 4.3E+00                      | 1429.11        | 5           | 5     | 5.0E+00                      |         |
| 2906.45        | 7       | 7     | 7.8E-01                      | 2404.18        | 4       | 6     | 2.5E+00                      | 1434.84        | 7           | 7     | 5.4E+00                      |         |
| 2908.81        | 11      | 9     | 1.6E+00                      | 2516.14        | 10      | 10    | 3.7E+00                      | 1451.04        | 3           | 3     | 7.0E+00                      |         |
| 2910.01        | 5       | 5     | 1.1E+00                      | 2521.55        | 8       | 8     | 3.5E+00                      | 1454.00        | 5           | 3     | 1.1E+01                      |         |
| 2910.38        | 3       | 3     | 1.2E+00                      | 2548.21        | 6       | 4     | 2.0E+00                      | 1520.14        | 5           | 7     | 7.2E+00                      |         |
| 2911.05        | 7       | 9     | 3.7E-01                      | 2554.22        | 8       | 6     | 1.2E+00                      | 1522.49        | 3           | 5     | 5.5E+00                      |         |
| 2912.46        | 11      | 9     | 5.0E-01                      | 2593.05        | 6       | 6     | 2.8E+00                      | 1601.92        | 3           | 3     | 1.2E+01                      |         |
| 2915.88        | 9       | 7     | 4.9E-01                      | 2595.10        | 8       | 8     | 2.8E+00                      | 1611.88        | 7           | 7     | 5.2E+00                      |         |
| 2924.02        | 11      | 11    | 1.7E+00                      | <i>VIV</i>     |         |       |                              | 1806.18        | 5           | 3     | 7.3E+00                      |         |
| 2924.63        | 9       | 9     | 1.2E+00                      |                | 677.345 | 9     | 9                            | 6.7E+00        | 1809.85     | 3     | 1                            | 7.2E+00 |
| 2930.80        | 7       | 7     | 5.8E-01                      |                | 680.632 | 9     | 7                            | 1.2E+01        | 1817.68     | 5     | 3                            | 4.8E+00 |
| 2941.37        | 11      | 9     | 3.5E-01                      |                | 681.145 | 7     | 5                            | 1.1E+01        | 1825.84     | 7     | 5                            | 5.3E+00 |
| 2944.57        | 9       | 7     | 7.6E-01                      |                | 682.455 | 7     | 7                            | 6.5E+00        | 1861.56     | 5     | 7                            | 6.6E+00 |
| 2948.08        | 9       | 11    | 4.0E-01                      |                | 682.923 | 5     | 5                            | 6.9E+00        | 1939.07     | 7     | 9                            | 5.8E+00 |
| 2952.07        | 7       | 5     | 7.2E-01                      |                | 684.450 | 7     | 5                            | 7.7E+00        | 1951.43     | 5     | 7                            | 5.0E+00 |
| 2955.58        | 7       | 9     | 3.3E-01                      |                | 691.530 | 5     | 3                            | 1.1E+01        | 1963.10     | 3     | 5                            | 4.8E+00 |
| 2968.37        | 7       | 9     | 7.0E-01                      |                | 723.537 | 3     | 1                            | 1.5E+01        | 1997.72     | 7     | 7                            | 4.7E+00 |
| 2972.26        | 5       | 7     | 5.2E-01                      |                | 724.068 | 5     | 5                            | 1.1E+01        | 2084.43     | 5     | 5                            | 4.0E+00 |
| 2973.98        | 9       | 11    | 3.5E-01                      | 724.809        | 5       | 3     | 5.6E+00                      | 2120.05        | 7           | 9     | 8.1E+00                      |         |
| 2985.18        | 7       | 9     | 4.4E-01                      | 737.854        | 9       | 7     | 2.4E+01                      | 2141.20        | 3           | 5     | 7.0E+00                      |         |
| 3001.20        | 7       | 7     | 7.5E-01                      | 750.110        | 5       | 5     | 1.0E+01                      | 2146.83        | 7           | 9     | 6.6E+00                      |         |
| 3014.82        | 5       | 3     | 8.9E-01                      | 884.146        | 1       | 3     | 4.7E+00                      | 2149.85        | 5           | 7     | 5.1E+00                      |         |
| 3016.78        | 7       | 5     | 5.0E-01                      | 1071.05        | 5       | 5     | 6.1E+00                      | 2151.09        | 7           | 9     | 4.3E+00                      |         |
| 3020.21        | 9       | 7     | 5.0E-01                      | 1110.72        | 3       | 3     | 5.0E+00                      | 2155.34        | 11          | 13    | 1.2E+01                      |         |
| 3048.21        | 11      | 13    | 7.0E-01                      | 1112.20        | 7       | 7     | 6.3E+00                      | 2446.80        | 9           | 11    | 5.3E+00                      |         |
| 3063.25        | 9       | 11    | 1.0E+00                      | 1112.44        | 5       | 5     | 5.0E+00                      | 2570.72        | 9           | 11    | 7.6E+00                      |         |
| 3100.94        | 7       | 7     | 5.8E-01                      | 1127.84        | 7       | 5     | 8.9E+00                      | 3284.56        | 7           | 9     | 5.3E+00                      |         |
| 3113.56        | 11      | 11    | 5.0E-01                      | 1131.26        | 9       | 7     | 9.4E+00                      | 3496.42        | 7           | 9     | 4.4E+00                      |         |
| 3122.89        | 11      | 13    | 7.6E-01                      | 1194.46        | 7       | 5     | 1.0E+01                      | 3514.25        | 9           | 11    | 4.7E+00                      |         |
| 3134.93        | 13      | 13    | 5.9E-01                      | 1226.52        | 5       | 5     | 1.5E+01                      | <i>Xenon</i>   |             |       |                              |         |
| 3136.50        | 11      | 11    | 5.3E-01                      | 1243.72        | 3       | 1     | 9.4E+00                      |                | <i>Xe I</i> |       |                              |         |
| 3139.73        | 9       | 9     | 5.2E-01                      | 1247.07        | 5       | 3     | 4.7E+00                      | 1043.8         |             | 1     | 3                            | 5.9E-01 |
| 3151.32        | 3       | 5     | 4.4E-01                      | 1272.97        | 3       | 1     | 2.7E+01                      | 1047.1         | 1           | 3     | 1.3E+00                      |         |
| 3190.69        | 9       | 9     | 3.3E-01                      | 1304.17        | 3       | 5     | 1.5E+01                      | 1050.1         | 1           | 3     | 8.5E-02                      |         |
| 3250.78        | 11      | 9     | 5.2E-01                      | 1305.42        | 5       | 7     | 7.0E+00                      | 1056.1         | 1           | 3     | 2.45E+00                     |         |
| 3251.87        | 5       | 7     | 3.5E-01                      |                |         |       |                              |                |             |       |                              |         |



| $\lambda$<br>Å   | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ | $\lambda$<br>Å | Weights |       | $A$<br>$10^8 \text{ s}^{-1}$ |
|------------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|----------------|---------|-------|------------------------------|
|                  | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |                | $g_i$   | $g_k$ |                              |
| 1061.2           | 1       | 3     | 1.9E-01                      | 2984.25        | 6       | 8     | 4.8E-01                      | 4981.97        | 4       | 6     | 4.7E-03                      |
| 1068.2           | 1       | 3     | 3.99E+00                     | 2995.26        | 6       | 4     | 5.1E-02                      | 5004.44        | 6       | 4     | 1.2E-02                      |
| 1085.4           | 1       | 3     | 4.10E-01                     | 2996.94        | 4       | 6     | 8.4E-02                      | 5205.01        | 4       | 4     | 8.4E-03                      |
| 1099.7           | 1       | 3     | 4.34E-01                     | 3005.26        | 4       | 4     | 4.8E-02                      | 5258.47        | 6       | 6     | 2.9E-03                      |
| 1110.7           | 1       | 3     | 1.5E+00                      | 3022.28        | 6       | 6     | 6.6E-02                      | 5271.82        | 8       | 6     | 1.1E-02                      |
| 1129.3           | 1       | 3     | 4.4E-02                      | 3045.36        | 6       | 6     | 1.07E-01                     | 5380.63        | 6       | 4     | 3.2E-01                      |
| 1170.4           | 1       | 3     | 1.6E+00                      | 3053.95        | 6       | 4     | 1.9E-03                      | 5381.24        | 4       | 4     | 9.9E-03                      |
| 1192.0           | 1       | 3     | 6.2E+00                      | 3155.65        | 4       | 6     | 2.7E-03                      | 5388.39        | 6       | 8     | 1.1E-02                      |
| 1250.2           | 1       | 3     | 1.4E-01                      | 3172.84        | 4       | 4     | 9.9E-03                      | 5390.81        | 8       | 6     | 2.9E-02                      |
| 1295.6           | 1       | 3     | 2.46E+00                     | 3185.96        | 6       | 8     | 1.2E-03                      | 5401.88        | 6       | 8     | 6.0E-03                      |
| 1469.6           | 1       | 3     | 2.81E+00                     | 3209.38        | 6       | 6     | 3.0E-03                      | 5424.36        | 6       | 4     | 3.47E-01                     |
| 4501.0           | 5       | 3     | 6.2E-03                      | 3227.16        | 6       | 4     | 1.10E-03                     | 5466.24        | 4       | 4     | 1.0E-01                      |
| 4524.7           | 5       | 5     | 2.1E-03                      | 3484.05        | 4       | 6     | 1.2E-02                      | 5466.47        | 10      | 12    | 6.3E-01                      |
| 4624.3           | 5       | 5     | 7.2E-03                      | 3549.66        | 6       | 6     | 1.0E-03                      | 5469.10        | 4       | 6     | 3.6E-03                      |
| 4671.2           | 5       | 7     | 1.0E-02                      | 3552.69        | 4       | 4     | 2.3E-01                      | 5513.65        | 6       | 6     | 2.39E-01                     |
| 4807.0           | 3       | 1     | 2.4E-02                      | 4077.36        | 4       | 6     | 1.1E+00                      | 5519.88        | 4       | 6     | 1.2E-02                      |
| 7119.6           | 7       | 9     | 6.6E-02                      | 4083.71        | 4       | 4     | 2.5E-01                      | 5526.43        | 6       | 4     | 3.9E-03                      |
| 7967.3           | 1       | 3     | 3.0E-03                      | 4102.36        | 6       | 8     | 1.3E+00                      | 5527.56        | 8       | 10    | 5.4E-01                      |
| 8409.2           | 5       | 3     | 1.0E-02                      | 4128.30        | 6       | 6     | 1.6E+00                      | 5541.63        | 8       | 8     | 5.2E-02                      |
| <i>Xe II</i>     |         |       |                              | 4142.84        | 4       | 4     | 1.6E+00                      | 5551.00        | 4       | 4     | 6.9E-02                      |
| 4180.1           | 4       | 4     | 2.2E+00                      | 4167.51        | 6       | 6     | 2.38E-01                     | 5573.03        | 6       | 4     | 1.8E-02                      |
| 4330.5           | 6       | 8     | 1.4E+00                      | 4235.93        | 6       | 4     | 3.0E-01                      | 5594.12        | 6       | 8     | 5.0E-02                      |
| 4414.8           | 6       | 6     | 1.0E+00                      | 4352.40        | 4       | 4     | 6.7E-03                      | 5606.34        | 10      | 10    | 5.84E-02                     |
| 4603.0           | 4       | 4     | 8.2E-01                      | 4379.33        | 6       | 4     | 7.83E-01                     | 5619.96        | 6       | 4     | 2.0E-02                      |
| 4844.3           | 6       | 8     | 1.1E+00                      | 4385.47        | 4       | 4     | 6.9E-02                      | 5630.14        | 4       | 6     | 4.9E-01                      |
| 4876.5           | 6       | 8     | 6.3E-01                      | 4394.01        | 8       | 8     | 1.9E-02                      | 5641.78        | 2       | 4     | 1.9E-02                      |
| 5260.4           | 2       | 4     | 2.2E-01                      | 4409.70        | 4       | 6     | 2.7E-03                      | 5675.27        | 6       | 6     | 9.3E-02                      |
| 5262.0           | 4       | 4     | 8.5E-01                      | 4417.43        | 10      | 8     | 3.2E-02                      | 5675.64        | 4       | 6     | 4.3E-02                      |
| 5292.2           | 6       | 6     | 8.9E-01                      | 4437.34        | 6       | 6     | 8.64E-02                     | 5693.63        | 4       | 4     | 1.1E-01                      |
| 5372.4           | 4       | 2     | 7.1E-01                      | 4443.65        | 10      | 8     | 1.1E-01                      | 5714.94        | 8       | 6     | 2.0E-02                      |
| 5419.2           | 4       | 6     | 6.2E-01                      | 4459.01        | 4       | 6     | 1.8E-02                      | 5729.25        | 6       | 6     | 2.2E-03                      |
| 5439.0           | 4       | 2     | 7.4E-01                      | 4476.95        | 8       | 6     | 2.8E-01                      | 5732.09        | 6       | 6     | 7.5E-02                      |
| 5472.6           | 8       | 8     | 9.9E-02                      | 4491.74        | 10      | 10    | 2.3E-02                      | 5740.22        | 8       | 6     | 4.0E-02                      |
| 5531.1           | 8       | 6     | 8.8E-02                      | 4514.01        | 4       | 6     | 3.34E-01                     | 5757.59        | 4       | 6     | 7.6E-03                      |
| 5719.6           | 4       | 6     | 6.1E-02                      | 4527.78        | 8       | 6     | 8.33E-01                     | 5788.36        | 4       | 4     | 9.4E-03                      |
| 5976.5           | 4       | 4     | 2.8E-01                      | 4534.09        | 6       | 8     | 4.4E-02                      | 5844.13        | 6       | 4     | 5.6E-03                      |
| 6036.2           | 6       | 6     | 7.5E-02                      | 4544.31        | 6       | 6     | 4.10E-01                     | 5879.93        | 4       | 2     | 8.5E-02                      |
| 6051.2           | 8       | 6     | 1.7E-01                      | 4559.36        | 2       | 4     | 4.0E-01                      | 5902.91        | 6       | 8     | 4.0E-02                      |
| 6097.6           | 6       | 4     | 2.6E-01                      | 4581.33        | 6       | 4     | 1.5E-01                      | 6087.94        | 6       | 4     | 1.1E-01                      |
| 6270.8           | 4       | 6     | 1.8E-01                      | 4613.00        | 6       | 4     | 1.8E-01                      | 6191.72        | 4       | 4     | 4.7E-02                      |
| 6277.5           | 4       | 6     | 3.6E-02                      | 4643.70        | 4       | 6     | 1.8E-01                      | 6222.58        | 4       | 6     | 5.9E-03                      |
| 6805.7           | 8       | 6     | 6.1E-02                      | 4653.78        | 4       | 6     | 1.6E-01                      | 6402.01        | 6       | 4     | 2.7E-03                      |
| 6990.9           | 10      | 8     | 2.7E-01                      | 4674.85        | 6       | 8     | 1.3E-01                      | 6435.02        | 6       | 6     | 4.0E-02                      |
| <i>Ytterbium</i> |         |       |                              | 4725.84        | 4       | 4     | 1.5E-01                      | 6437.17        | 10      | 8     | 4.8E-02                      |
| <i>Yb I</i>      |         |       |                              | 4762.96        | 6       | 4     | 4.2E-02                      | 6538.57        | 10      | 10    | 1.5E-01                      |
| 2464.5           | 1       | 3     | 9.1E-01                      | 4780.16        | 2       | 4     | 8.9E-02                      | 6622.48        | 8       | 6     | 4.5E-03                      |
| 2672.0           | 1       | 3     | 1.18E-01                     | 4781.03        | 8       | 10    | 1.0E-01                      | 6815.15        | 2       | 4     | 7.18E-02                     |
| 3464.4           | 1       | 3     | 6.2E-01                      | 4799.30        | 6       | 8     | 1.6E-01                      | 7009.89        | 2       | 4     | 4.4E-02                      |
| 3988.0           | 1       | 3     | 1.76E+00                     | 4804.31        | 6       | 4     | 2.6E-01                      | 7035.15        | 4       | 4     | 6.3E-02                      |
| 5556.5           | 1       | 3     | 1.14E-02                     | 4804.80        | 4       | 4     | 3.84E-01                     | <i>Y II</i>    |         |       |                              |
| <i>Yb II</i>     |         |       |                              | 4821.63        | 6       | 6     | 1.0E-01                      | 3112.03        | 1       | 3     | 1.3E-02                      |
| 3289.4           | 2       | 4     | 1.8E+00                      | 4845.67        | 8       | 8     | 6.8E-01                      | 3179.42        | 3       | 5     | 3.8E-02                      |
| 3694.2           | 2       | 2     | 1.4E+00                      | 4852.68        | 6       | 6     | 6.2E-01                      | 3195.62        | 3       | 3     | 8.23E-01                     |
| <i>Yttrium</i>   |         |       |                              | 4856.71        | 6       | 6     | 2.0E-01                      | 3200.27        | 5       | 5     | 4.8E-01                      |
| <i>Y I</i>       |         |       |                              | 4859.84        | 4       | 4     | 7.26E-01                     | 3203.32        | 3       | 1     | 2.77E+00                     |
| 2948.41          | 4       | 4     | 3.5E-01                      | 4893.44        | 6       | 4     | 2.2E-01                      | 3216.69        | 5       | 3     | 2.0E+00                      |
| 2974.59          | 4       | 6     | 3.5E-01                      | 4900.08        | 8       | 6     | 2.0E-01                      | 3242.28        | 7       | 5     | 2.0E+00                      |
|                  |         |       |                              | 4906.11        | 10      | 8     | 1.2E-01                      | 3448.81        | 5       | 5     | 4.1E-02                      |
|                  |         |       |                              | 4950.01        | 8       | 6     | 2.0E-02                      | 3467.88        | 5       | 3     | 2.7E-02                      |
|                  |         |       |                              | 4963.49        | 4       | 4     | 1.4E-02                      |                |         |       |                              |

| $\lambda$    | Weights |       | $A$                   | $\lambda$    | Weights |       | $A$                   | $\lambda$    | Weights     |        | $A$                   |          |
|--------------|---------|-------|-----------------------|--------------|---------|-------|-----------------------|--------------|-------------|--------|-----------------------|----------|
| $\text{\AA}$ | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ | $\text{\AA}$ | $g_i$   | $g_k$ | $10^8 \text{ s}^{-1}$ | $\text{\AA}$ | $g_i$       | $g_k$  | $10^8 \text{ s}^{-1}$ |          |
| 3496.08      | 1       | 3     | 3.49E-01              | 4374.95      | 5       | 5     | 9.97E-01              | <i>Zinc</i>  |             |        |                       |          |
| 3549.01      | 5       | 7     | 3.97E-01              | 4398.01      | 5       | 3     | 1.16E-01              |              |             |        |                       |          |
| 3584.51      | 3       | 5     | 4.02E-01              | 4422.59      | 3       | 1     | 1.83E-01              |              | <i>Zn I</i> |        |                       |          |
| 3600.74      | 7       | 7     | 1.4E+00               | 4682.33      | 5       | 5     | 1.9E-02               |              |             | 748.29 | 1                     | 3        |
| 3601.91      | 3       | 3     | 1.13E+00              | 4786.58      | 7       | 7     | 2.1E-02               | 765.60       |             | 1      | 3                     | 7.6E-02  |
| 3611.04      | 5       | 5     | 1.04E+00              | 4823.31      | 5       | 5     | 4.3E-02               | 792.05       |             | 1      | 3                     | 5.7E-02  |
| 3628.70      | 5       | 3     | 3.3E-01               | 4854.87      | 5       | 3     | 3.9E-01               | 793.85       |             | 1      | 3                     | 1.8E-01  |
| 3664.62      | 7       | 5     | 3.7E-01               | 4881.44      | 5       | 3     | 1.5E-03               | 809.92       |             | 1      | 3                     | 2.6E-01  |
| 3710.29      | 7       | 9     | 1.5E+00               | 4883.69      | 9       | 7     | 4.7E-01               | 1109.1       |             | 1      | 3                     | 3.05E-01 |
| 3747.55      | 3       | 3     | 1.9E-01               | 4900.11      | 7       | 5     | 4.51E-01              | 2138.6       |             | 1      | 3                     | 7.09E+00 |
| 3774.34      | 5       | 7     | 1.1E+00               | 4982.13      | 7       | 9     | 1.5E-02               | 3075.9       |             | 1      | 3                     | 3.29E-04 |
| 3776.56      | 5       | 3     | 2.42E-01              | 5087.42      | 9       | 9     | 2.0E-01               | 3282.3       |             | 1      | 3                     | 9.0E-01  |
| 3788.70      | 3       | 5     | 8.1E-01               | 5119.11      | 5       | 7     | 1.6E-02               | 3302.6       |             | 3      | 5                     | 1.2E+00  |
| 3818.34      | 5       | 5     | 9.70E-02              | 5200.41      | 5       | 5     | 1.3E-01               | 3302.9       |             | 3      | 3                     | 6.7E-01  |
| 3832.90      | 7       | 7     | 3.0E-01               | 5205.73      | 7       | 7     | 1.6E-01               | 3345.0       |             | 5      | 7                     | 1.7E+00  |
| 3878.29      | 7       | 5     | 2.9E-02               | 5289.82      | 7       | 5     | 6.7E-03               | 3345.6       |             | 5      | 5                     | 4.0E-01  |
| 3930.66      | 5       | 5     | 2.1E-02               | 5320.78      | 9       | 7     | 3.9E-03               | 3345.9       |             | 5      | 3                     | 4.5E-02  |
| 3950.36      | 3       | 5     | 2.80E-01              | 5473.39      | 3       | 5     | 4.3E-02               | 6362.3       |             | 3      | 5                     | 4.74E-01 |
| 3951.59      | 5       | 3     | 1.5E-02               | 5480.73      | 1       | 3     | 7.62E-02              | 11054        | 3           | 1      | 2.43E-01              |          |
| 3982.60      | 5       | 5     | 2.7E-01               | 5497.41      | 5       | 5     | 1.2E-01               | <i>Zn II</i> |             |        |                       |          |
| 4124.91      | 5       | 7     | 1.8E-02               | 5509.90      | 5       | 5     | 4.24E-02              |              | 2025.5      | 2      | 4                     | 3.3E+00  |
| 4177.54      | 5       | 5     | 5.27E-01              | 5544.61      | 3       | 1     | 1.8E-01               |              | 2064.2      | 2      | 4                     | 4.6E+00  |
| 4199.27      | 3       | 5     | 5.36E-03              | 5546.01      | 5       | 3     | 5.8E-02               |              | 2099.9      | 4      | 6                     | 5.6E+00  |
| 4204.69      | 1       | 3     | 2.20E-02              | 5728.89      | 5       | 5     | 3.0E-02               |              | 2102.2      | 4      | 4                     | 9.3E-01  |
| 4235.73      | 5       | 5     | 2.3E-02               | 6613.74      | 5       | 7     | 1.7E-02               |              | 4911.6      | 4      | 6                     | 1.6E+00  |
| 4309.62      | 7       | 5     | 1.29E-01              | 6832.48      | 5       | 5     | 3.3E-03               |              |             |        |                       |          |
| 4358.73      | 3       | 3     | 5.55E-02              | 7264.16      | 5       | 3     | 1.3E-02               |              |             |        |                       |          |

# ELECTRON AFFINITIES

Thomas M. Miller

Electron affinity is defined as the energy difference between the lowest (ground) state of the neutral and the lowest state of the corresponding negative ion. The accuracy of electron affinity measurements has been greatly improved since the advent of laser photodetachment experiments with negative ions. Electron affinities can be determined with optical precision, though a detailed understanding of atomic and molecular states and splittings is required to specify the photodetachment threshold corresponding to the electron affinity.

Atomic and molecular electron affinities are discussed in two excellent articles reviewing photodetachment studies which appear in *Gas Phase Ion Chemistry*, Vol. 3, Bowers, M. T., Ed., Academic Press, Orlando, 1984: Chapter 21 by Drzaic, P. S., Marks, J., and Brauman, J. I., "Electron Photodetachment from Gas Phase Negative Ions," p. 167, and Chapter 22 by Mead, R. D., Stevens, A. E., and Lineberger, W. C., "Photodetachment in Negative Ion Beams," p. 213. Persons interested in photodetachment details should consult these articles and the critical reviews of Andersen, T., Haugen, H. K., and Hotop, H., *J. Phys. Chem. Ref. Data*, 28, 1511, 1999; Hotop, H. and Lineberger, W. C., *J. Phys. Chem. Ref. Data*, 14, 731, 1985; and Andersen, T., Haugen, H. K., and Hotop, H., *J. Phys. Chem. Ref. Data* 28, 1511, 1999. For simplicity in the tables below, any electron affinity that was discussed in the articles by Drzaic et al. or Hotop and Lineberger is referenced to these sources, where original references are given. The development of cluster-ion pho-

todetachment apparatuses has brought an explosion of electron affinity estimates for atomic and molecular clusters. The policy in this tabulation is to list the electron affinities for the atoms, diatoms, and triatoms, if adiabatic electron affinities have been determined, but to refer the reader to original sources for higher-order clusters. Additional data on molecular electron affinities may be found in Lias, S. G., Bartmess, J. E., Liebman, J. F., Holmes, J. L., Levin, R. D., and Mallard, W. G., *Gas Phase Ion and Neutral Thermochemistry, J. Phys. Chem. Ref. Data*, 17, (Supplement No. 1), 1988 and on the NIST WebBook at the Internet address <http://webbook.nist.gov/>.

For the present tabulation the 2002 CODATA value  $e/hc = 8065.54445 \pm 0.00069 \text{ cm}^{-1} \text{ eV}^{-1}$  (<http://physics.nist.gov>) has been used to convert electron affinities from the units used in spectroscopic work,  $\text{cm}^{-1}$ , into eV for these tables. The 86 ppb uncertainty in  $e/hc$  is insignificant compared to uncertainties in the electron affinity measurements.

Abbreviations used in the tables: calc = calculated value; PT = photodetachment threshold using a lamp as a light source; LPT = laser photodetachment threshold; LPES = laser photoelectron spectroscopy; DA = dissociative attachment; attach = electron attachment/detachment equilibrium; e-scat = electron scattering; kinetic = dissociation kinetics; Knud=Knudsen cell; CT = charge transfer; CD = collisional detachment; and ZEKE = zero electron kinetic energy spectroscopy.

TABLE 1. Atomic Electron Affinities

| Atomic number | Atom | Electron affinity in eV | Uncertainty in eV | Method | Ref. |           |
|---------------|------|-------------------------|-------------------|--------|------|-----------|
| 1             | H    | 0.754195                | 0.000019          | LPT    | 89   |           |
|               |      | 0.75420812              | —                 | calc   | 205  |           |
|               | D    | 0.754593                | 0.000074          | LPT    | 89   | deuterium |
|               | D    | 0.75465624              | —                 | calc   | 205  | deuterium |
|               | T    | 0.75480540              | —                 | calc   | 205  | tritium   |
| 2             | He   | not stable              | —                 | calc   | 1    |           |
| 3             | Li   | 0.618049                | 0.000020          | LPT    | 185  |           |
| 4             | Be   | not stable              | —                 | calc   | 1    |           |
| 5             | B    | 0.279723                | 0.000025          | LPES   | 191  |           |
| 6             | C    | 1.262119                | 0.000020          | LPT    | 28   |           |
| 7             | N    | not stable              | —                 | DA     | 1    |           |
| 8             | O    | 1.4611096               | 0.0000007         | LPT    | 4    |           |
| 9             | F    | 3.4011895               | 0.0000025         | LPT    | 227  |           |
| 10            | Ne   | not stable              | —                 | calc   | 1    |           |
| 11            | Na   | 0.547926                | 0.000025          | LPT    | 1    |           |
| 12            | Mg   | not stable              | —                 | e-scat | 1    |           |
| 13            | Al   | 0.43283                 | 0.00005           | LPES   | 208  |           |
| 14            | Si   | 1.3895220               | 0.0000024         | LPES   | 227  |           |
| 15            | P    | 0.7465                  | 0.0003            | LPT    | 1    |           |
| 16            | S    | 2.077103                | 0.000001          | LPT    | 1    |           |
| 17            | Cl   | 3.612724                | 0.000027          | LPT    | 52   |           |
| 18            | Ar   | not stable              | —                 | calc   | 1    |           |
| 19            | K    | 0.50147                 | 0.00010           | LPT    | 1    |           |
| 20            | Ca   | 0.02455                 | 0.00010           | LPT    | 44   |           |
| 21            | Sc   | 0.188                   | 0.020             | LPES   | 1    |           |
| 22            | Ti   | 0.079                   | 0.014             | LPES   | 1    |           |
| 23            | V    | 0.525                   | 0.012             | LPES   | 1    |           |
| 24            | Cr   | 0.666                   | 0.012             | LPES   | 1    |           |
| 25            | Mn   | not stable              | —                 | calc   | 1    |           |

| Atomic<br>number | Atom        | Electron affinity<br>in eV | Uncertainty<br>in eV | Method | Ref. |
|------------------|-------------|----------------------------|----------------------|--------|------|
| 26               | Fe          | 0.151                      | 0.003                | LPES   | 27   |
| 27               | Co          | 0.662                      | 0.003                | LPES   | 27   |
| 28               | Ni          | 1.156                      | 0.010                | LPES   | 1    |
| 29               | Cu          | 1.235                      | 0.005                | LPES   | 37   |
| 30               | Zn          | not stable                 | —                    | e-scat | 1    |
| 31               | Ga          | 0.43                       | 0.03                 | LPES   | 183  |
| 32               | Ge          | 1.232712                   | 0.000015             | LPES   | 28   |
| 33               | As          | 0.814                      | 0.008                | LPES   | 200  |
| 34               | Se          | 2.020670                   | 0.000025             | LPT    | 1    |
| 35               | Br          | 3.363588                   | 0.000002             | LPT    | 74   |
| 36               | Kr          | not stable                 | —                    | calc   | 1    |
| 37               | Rb          | 0.48592                    | 0.00002              | LPT    | 1    |
| 38               | Sr          | 0.048                      | 0.006                | LPT    | 122  |
| 39               | Y           | 0.307                      | 0.012                | LPES   | 1    |
| 40               | Zr          | 0.426                      | 0.014                | LPES   | 1    |
| 41               | Nb          | 0.893                      | 0.025                | LPES   | 1    |
| 42               | Mo          | 0.748                      | 0.002                | LPES   | 127  |
| 43               | Tc          | 0.55                       | 0.20                 | calc   | 1    |
| 44               | Ru          | 1.05                       | 0.15                 | calc   | 1    |
| 45               | Rh          | 1.137                      | 0.008                | LPES   | 1    |
| 46               | Pd          | 0.562                      | 0.005                | LPES   | 116  |
| 47               | Ag          | 1.302                      | 0.007                | LPES   | 1    |
| 48               | Cd          | not stable                 | —                    | e-scat | 1    |
| 49               | In          | 0.3                        | 0.2                  | PT     | 1    |
| 50               | Sn          | 1.112067                   | 0.000015             | LPES   | 28   |
| 51               | Sb          | 1.046                      | 0.005                | LPES   | 108  |
| 52               | Te          | 1.970876                   | 0.000007             | LPT    | 261  |
| 53               | I           | 3.059037                   | 0.000010             | LPT    | 92   |
| 54               | Xe          | not stable                 | —                    | calc   | 1    |
| 55               | Cs          | 0.471626                   | 0.000025             | LPT    | 1    |
| 56               | Ba          | 0.14462                    | 0.00006              | LPT    | 195  |
| 57               | La          | 0.47                       | 0.02                 | LPT    | 184  |
| 58               | Ce          | 0.955                      | 0.026                | LPES   | 269  |
| 59               | Pr          | 0.962                      | 0.024                | LPES   | 225  |
| 63               | Eu          | 0.864                      | 0.024                | LPES   | 268  |
| 69               | Tm          | 1.029                      | 0.022                | LPES   | 264  |
| 70               | Yb          | -0.020                     | —                    | calc   | 196  |
| 71               | Lu          | 0.34                       | 0.01                 | LPT    | 223  |
| 72               | Hf          | »0                         | —                    | calc   | 1    |
| 73               | Ta          | 0.322                      | 0.012                | LPES   | 1    |
| 74               | W           | 0.815                      | 0.002                | LPES   | 37   |
| 75               | Re          | 0.15                       | 0.15                 | calc   | 1    |
| 76               | Os          | 1.1                        | 0.2                  | calc   | 1    |
| 77               | Ir          | 1.5638                     | 0.0005               | LPT    | 141  |
| 78               | Pt          | 2.128                      | 0.002                | LPT    | 1    |
| 79               | Au          | 2.30863                    | 0.00003              | LPT    | 1    |
| 80               | Hg          | not stable                 | —                    | e-scat | 1    |
| 81               | Tl          | 0.2                        | 0.2                  | PT     | 1    |
| 82               | Pb          | 0.364                      | 0.008                | LPES   | 1    |
| 83               | Bi          | 0.942362                   | 0.000013             | LPT    | 262  |
| 84               | Po          | 1.9                        | 0.3                  | calc   | 1    |
| 85               | At          | 2.8                        | 0.2                  | calc   | 1    |
| 86               | Rn          | not stable                 | —                    | calc   | 1    |
| 87               | Fr          | 0.46                       | —                    | calc   | 82   |
| 88               | Ra          | 0.10                       | —                    | calc   | 273  |
| 89               | Ac          | 0.35                       | —                    | calc   | 207  |
| 118              | ekaradon    | 0.056                      | 0.01                 | calc   | 140  |
| 121              | ekaactinium | 0.57                       | —                    | calc   | 207  |

TABLE 2. Electron Affinities for Diatomic Molecules

| Molecule        | Electron<br>affinity in eV | Uncertainty<br>in eV | Method | Ref. | Molecule        | Electron<br>affinity in eV | Uncertainty<br>in eV | Method | Ref. |
|-----------------|----------------------------|----------------------|--------|------|-----------------|----------------------------|----------------------|--------|------|
| Ag <sub>2</sub> | 1.023                      | 0.007                | LPES   | 37   | MnH             | 0.869                      | 0.010                | LPES   | 9    |
| AgO             | 1.654                      | 0.002                | LPES   | 233  | MnO             | 1.375                      | 0.010                | LPES   | 158  |
| Al <sub>2</sub> | 1.10                       | 0.15                 | LPES   | 68   | MoO             | 1.290                      | 0.006                | LPES   | 127  |
| AlO             | 2.60                       | 0.02                 | LPES   | 143  | NH              | 0.370                      | 0.004                | LPT    | 32   |
| AlP             | 2.043                      | 0.020                | LPES   | 218  | NO              | 0.026                      | 0.005                | LPES   | 73   |
| AlS             | 2.60                       | 0.03                 | LPES   | 129  | NRh             | 1.51                       | 0.02                 | LPES   | 206  |
| As <sub>2</sub> | 0.739                      | 0.008                | LPES   | 200  | NS              | 1.194                      | 0.011                | LPES   | 2    |
| AsH             | 1.0                        | 0.1                  | PT     | 2    | Na <sub>2</sub> | 0.430                      | 0.015                | LPES   | 104  |
| AsO             | 1.286                      | 0.008                | LPES   | 198  | NaBr            | 0.788                      | 0.010                | LPES   | 30   |
| Au <sub>2</sub> | 1.938                      | 0.007                | LPES   | 37   | NaCl            | 0.727                      | 0.010                | LPES   | 30   |
| AuO             | 2.374                      | 0.007                | LPES   | 282  | NaF             | 0.520                      | 0.010                | LPES   | 30   |
| AuPd            | 1.88                       | —                    | LPES   | 220  | NaI             | 0.865                      | 0.010                | LPES   | 30   |
| AuS             | 2.469                      | 0.006                | LPES   | 282  | NaK             | 0.465                      | 0.030                | LPES   | 104  |
| BN              | 3.160                      | 0.005                | LPES   | 189  | NbO             | 1.29                       | 0.02                 | LPES   | 174  |
| BO              | 2.508                      | 0.008                | LPES   | 6    | Ni <sub>2</sub> | 0.926                      | 0.010                | LPES   | 112  |
| BeH             | 0.7                        | 0.1                  | PT     | 2    | NiCu            | 0.889                      | 0.010                | LPES   | 128  |
| Bi <sub>2</sub> | 1.271                      | 0.008                | LPES   | 119  | NiAg            | 0.979                      | 0.010                | LPES   | 128  |
| Br <sub>2</sub> | 2.55                       | 0.10                 | CT     | 2    | NiD             | 0.477                      | 0.007                | LPES   | 29   |
| BrO             | 2.353                      | 0.006                | LPES   | 88   | NiH             | 0.481                      | 0.007                | LPES   | 29   |
| C <sub>2</sub>  | 3.269                      | 0.006                | LPES   | 87   | NiO             | 1.470                      | 0.003                | LPES   | 146  |
| CH              | 1.238                      | 0.008                | LPES   | 2    | O <sub>2</sub>  | 0.450                      | 0.002                | LPES   | 222  |
| CN              | 3.862                      | 0.004                | LPES   | 111  | OD              | 1.825533                   | 0.000037             | LPT    | 142  |
| CRh             | 1.46                       | 0.02                 | LPES   | 206  | OH              | 1.8276487                  | 0.000011             | LPT    | 226  |
| CS              | 0.205                      | 0.021                | LPES   | 2    | ORh             | 1.58                       | 0.02                 | LPES   | 206  |
| CaH             | 0.93                       | 0.05                 | PT     | 2    | P <sub>2</sub>  | 0.589                      | 0.025                | LPES   | 42   |
| Cl <sub>2</sub> | 2.38                       | 0.10                 | CT     | 2    | PH              | 1.027                      | 0.006                | LPES   | 281  |
| ClO             | 2.275                      | 0.006                | LPES   | 88   | PO              | 1.092                      | 0.010                | LPES   | 2    |
| Co <sub>2</sub> | 1.110                      | 0.008                | LPES   | 27   | Pb <sub>2</sub> | 1.366                      | 0.010                | LPES   | 117  |
| CoD             | 0.680                      | 0.010                | LPES   | 29   | PbO             | 0.722                      | 0.006                | LPES   | 105  |
| CoH             | 0.671                      | 0.010                | LPES   | 29   | PbS             | 1.049                      | 0.010                | LPES   | 228  |
| Cr <sub>2</sub> | 0.505                      | 0.005                | LPES   | 114  | Pd <sub>2</sub> | 1.685                      | 0.008                | LPES   | 112  |
| CrD             | 0.568                      | 0.010                | LPES   | 29   | PdCO            | 0.604                      | 0.010                | LPES   | 160  |
| CrH             | 0.563                      | 0.010                | LPES   | 29   | PdO             | 1.570                      | 0.006                | LPES   | 290  |
| CrO             | 1.221                      | 0.006                | LPES   | 5    | Pt <sub>2</sub> | 1.898                      | 0.008                | LPES   | 112  |
| Cs <sub>2</sub> | 0.469                      | 0.015                | LPES   | 104  | PtN             | 1.240                      | 0.010                | LPES   | 46   |
| CsCl            | 0.455                      | 0.010                | LPES   | 30   | Rb <sub>2</sub> | 0.498                      | 0.015                | LPES   | 104  |
| CsO             | 0.273                      | 0.012                | LPES   | 133  | RbCl            | 0.544                      | 0.010                | LPES   | 30   |
| Cu <sub>2</sub> | 0.836                      | 0.006                | LPES   | 37   | RbCs            | 0.478                      | 0.020                | LPES   | 104  |
| CuO             | 1.777                      | 0.006                | LPES   | 118  | Re <sub>2</sub> | 1.571                      | 0.008                | LPES   | 33   |
| F <sub>2</sub>  | 3.08                       | 0.10                 | CT     | 2    | S <sub>2</sub>  | 1.670                      | 0.015                | LPES   | 53   |
| FO              | 2.272                      | 0.006                | LPES   | 88   | SD              | 2.315                      | 0.002                | LPES   | 10   |
| Fe <sub>2</sub> | 0.902                      | 0.008                | LPES   | 27   | SF              | 2.285                      | 0.006                | LPES   | 93   |
| FeD             | 0.932                      | 0.015                | LPES   | 9    | SH              | 2.314343                   | 0.000004             | LPT    | 47   |
| FeH             | 0.934                      | 0.011                | LPES   | 9    | SO              | 1.125                      | 0.005                | LPES   | 84   |
| FeO             | 1.493                      | 0.005                | LPES   | 45   | Sb <sub>2</sub> | 1.282                      | 0.008                | LPES   | 108  |
| GaAs            | 1.949                      | 0.020                | LPES   | 218  | ScO             | 1.35                       | 0.02                 | LPES   | 171  |
| GaO             | 2.612                      | 0.008                | LPES   | 279  | Se <sub>2</sub> | 1.94                       | 0.07                 | LPES   | 38   |
| GaP             | 1.988                      | 0.020                | LPES   | 218  | SeH             | 2.212519                   | 0.000025             | LPT    | 48   |
| Ge <sub>2</sub> | 2.035                      | 0.001                | LPES   | 123  | SeO             | 1.456                      | 0.020                | LPES   | 41   |
| I <sub>2</sub>  | 2.524                      | 0.015                | LPES   | 305  | Si <sub>2</sub> | 2.201                      | 0.010                | LPES   | 100  |
| IBr             | 2.55                       | 0.10                 | CT     | 2    | SiF             | 0.81                       | 0.02                 | LPES   | 278  |
| IO              | 2.378                      | 0.006                | LPES   | 88   | SiH             | 1.277                      | 0.009                | LPES   | 2    |
| InP             | 1.845                      | 0.020                | LPES   | 218  | SiN             | 2.949                      | 0.008                | LPES   | 274  |
| K <sub>2</sub>  | 0.497                      | 0.012                | LPES   | 104  | Sn <sub>2</sub> | 1.962                      | 0.010                | LPES   | 117  |
| KBr             | 0.642                      | 0.010                | LPES   | 30   | SnO             | 0.598                      | 0.006                | LPES   | 168  |
| KCl             | 0.582                      | 0.010                | LPES   | 30   | SnPb            | 1.569                      | 0.008                | LPES   | 117  |
| KCs             | 0.471                      | 0.020                | LPES   | 104  | Te <sub>2</sub> | 1.92                       | 0.07                 | LPES   | 38   |
| KI              | 0.728                      | 0.010                | LPES   | 30   | TeH             | 2.102                      | 0.015                | LPES   | 39   |
| KRb             | 0.486                      | 0.020                | LPES   | 104  | TeO             | 1.697                      | 0.022                | LPES   | 40   |
| LiCl            | 0.593                      | 0.010                | LPES   | 30   | TiO             | 1.30                       | 0.03                 | LPES   | 172  |
| LiD             | 0.337                      | 0.012                | LPES   | 102  | VO              | 1.229                      | 0.008                | LPES   | 170  |
| LiH             | 0.342                      | 0.012                | LPES   | 102  | YO              | 1.35                       | 0.02                 | LPES   | 171  |
| MgCl            | 1.589                      | 0.011                | LPES   | 31   | ZnF             | 1.974                      | 0.008                | LPES   | 179  |
| MgH             | 1.05                       | 0.06                 | PT     | 2    | ZnH             | <0.95                      | —                    | PT     | 2    |
| MgI             | 1.899                      | 0.018                | LPES   | 31   | ZnO             | 2.087                      | 0.008                | LPES   | 179  |
| MgO             | 1.630                      | 0.025                | LPES   | 178  | ZrO             | 1.3                        | 0.3                  | LPES   | 173  |
| MnD             | 0.866                      | 0.010                | LPES   | 9    |                 |                            |                      |        |      |

TABLE 3. Electron Affinities for Triatomic Molecules

| Molecule           | Electron<br>affinity in eV | Uncertainty<br>in eV | Method | Ref.                    | Molecule                        | Electron<br>affinity in eV | Uncertainty<br>in eV | Method | Ref.                    |
|--------------------|----------------------------|----------------------|--------|-------------------------|---------------------------------|----------------------------|----------------------|--------|-------------------------|
| Ag <sub>3</sub>    | 2.32                       | 0.05                 | LPES   | 37                      | Ga <sub>2</sub> P               | 2.481                      | 0.015                | LPES   | 192                     |
| AgCN               | 1.588                      | 0.010                | LPES   | 163                     | Ge <sub>3</sub>                 | 2.23                       | 0.01                 | LPES   | 123                     |
| Al <sub>3</sub>    | 1.4                        | 0.15                 | LPES   | 68                      | GeH <sub>2</sub>                | 1.097                      | 0.015                | LPES   | 28                      |
| AlO <sub>2</sub>   | 4.23                       | 0.02                 | LPES   | 143                     | HCO                             | 0.313                      | 0.005                | LPES   | 35                      |
| AlP <sub>2</sub>   | 1.933                      | 0.007                | LPES   | 217                     | HCl <sub>2</sub>                | 4.896                      | 0.005                | LPES   | 69                      |
| Al <sub>2</sub> N  | 2.571                      | 0.008                | LPES   | 297                     | HNO                             | 0.338                      | 0.015                | LPES   | 14                      |
| Al <sub>2</sub> P  | 2.513                      | 0.020                | LPES   | 217                     | HO <sub>2</sub>                 | 1.078                      | 0.006                | LPES   | 15                      |
| Al <sub>2</sub> S  | 0.80                       | 0.12                 | LPES   | 129                     | HS <sub>2</sub>                 | 1.907                      | 0.015                | LPES   | 53                      |
| As <sub>3</sub>    | 1.45                       | 0.03                 | LPES   | 200                     | I <sub>3</sub>                  | 4.226                      | 0.013                | LPES   | 162                     |
| AsH <sub>2</sub>   | 1.27                       | 0.03                 | PT     | 2                       | InP <sub>2</sub>                | 1.61                       | 0.05                 | LPES   | 137                     |
| Au <sub>3</sub>    | 3.7                        | 0.3                  | LPES   | 37                      | In <sub>2</sub> P               | 2.36                       | 0.05                 | LPES   | 137                     |
| AuBr <sub>2</sub>  | 4.46                       | 0.07                 | LPES   | 294                     | K <sub>3</sub>                  | 0.956                      | 0.050                | LPES   | 18                      |
| AuCl <sub>2</sub>  | 4.60                       | 0.07                 | LPES   | 294                     | MnD <sub>2</sub>                | 0.465                      | 0.014                | LPES   | 34                      |
| AuI <sub>2</sub>   | 4.18                       | 0.07                 | LPES   | 294                     | MnH <sub>2</sub>                | 0.444                      | 0.016                | LPES   | 34                      |
| Au <sub>2</sub> H  | 3.55                       | 0.03                 | LPES   | 276                     | MnO <sub>2</sub>                | 2.06                       | 0.03                 | LPES   | 158                     |
| Au <sub>2</sub> Pd | 3.80                       | —                    | LPES   | 220                     | N <sub>3</sub>                  | 2.70                       | 0.12                 | PT     | 2                       |
| BO <sub>2</sub>    | 4.3                        | 0.2                  | CT     | 98                      | N <sub>3</sub>                  | 2.68                       | 0.01                 | LPT    | 255                     |
| B <sub>2</sub> N   | 3.098                      | 0.005                | LPES   | 193                     | NCN                             | 2.484                      | 0.006                | LPES   | 154                     |
| B <sub>3</sub>     | 2.82                       | 0.02                 | LPES   | 221                     | NCO                             | 3.609                      | 0.005                | LPES   | 111                     |
| Bi <sub>3</sub>    | 1.60                       | 0.03                 | LPES   | 119                     | NCS                             | 3.537                      | 0.005                | LPES   | 111                     |
| C <sub>3</sub>     | 1.981                      | 0.020                | LPES   | 11                      | NH <sub>2</sub>                 | 0.771                      | 0.005                | LPES   | 58                      |
| CBr <sub>2</sub>   | 1.88                       | 0.07                 | LPES   | 235                     | N <sub>2</sub> O                | -0.03                      | 0.10                 | calc   | 59                      |
| CCl <sub>2</sub>   | 1.59                       | 0.07                 | LPES   | 235                     | NO <sub>2</sub>                 | 2.273                      | 0.005                | LPES   | 63                      |
| CD <sub>2</sub>    | 0.645                      | 0.006                | LPES   | 12                      | (NO)R                           | R=Ar,Kr,Xe                 | —                    | LPES   | 90                      |
| CDF                | 0.535                      | 0.005                | LPES   | 95                      | Na <sub>3</sub>                 | 1.019                      | 0.060                | LPES   | 18                      |
| CF <sub>2</sub>    | 0.180                      | 0.020                | LPES   | 235                     | NaCS <sub>2</sub>               | 0.80                       | 0.05                 | LPES   | 278                     |
| CH <sub>2</sub>    | 0.652                      | 0.006                | LPES   | 12                      | Na <sub>2</sub> CS <sub>2</sub> | 0.25                       | 0.05                 | LPES   | 278                     |
| CHBr               | 1.454                      | 0.005                | LPES   | 95                      | Nb <sub>3</sub>                 | 1.032                      | 0.010                | LPES   | 175                     |
| CHCl               | 1.210                      | 0.005                | LPES   | 95                      | Ni <sub>3</sub>                 | 1.41                       | 0.05                 | LPES   | 55                      |
| CHF                | 0.542                      | 0.005                | LPES   | 95                      | NiCN                            | 1.771                      | 0.010                | LPES   | 287                     |
| CHI                | 1.42                       | 0.17                 | LPES   | 95                      | NiCO                            | 0.804                      | 0.012                | LPES   | 2                       |
| Cl <sub>2</sub>    | 2.09                       | 0.07                 | LPES   | 235                     | NiD <sub>2</sub>                | 1.926                      | 0.007                | LPES   | 34                      |
| C <sub>2</sub> Cr  | 2.30                       | 1.617                | 0.015  | 271                     | NiH <sub>2</sub>                | 1.934                      | 0.008                | LPES   | 34                      |
| C <sub>2</sub> H   | 2.969                      | 0.006                | LPES   | 87                      | NiO <sub>2</sub>                | 3.05                       | 0.01                 | LPES   | 214 ONiO                |
| C <sub>2</sub> Nb  | 1.380                      | 0.025                | LPES   | 243                     | NiO <sub>2</sub>                | 0.82                       | 0.03                 | LPES   | 214 Ni(O <sub>2</sub> ) |
| C <sub>2</sub> O   | 2.289                      | 0.018                | LPES   | 180                     | O <sub>3</sub>                  | 2.1028                     | 0.0025               | LPT    | 2                       |
| COS                | -0.04                      | —                    | LPES   | 272                     | O <sub>2</sub> Ar               | 0.52                       | 0.02                 | LPES   | 75                      |
| CS <sub>2</sub>    | 0.58                       | 0.05                 | LPES   | 278                     | OCIO                            | 2.140                      | 0.008                | LPES   | 88                      |
| C <sub>2</sub> Ti  | 1.542                      | 0.020                | LPES   | 147                     | OIO                             | 2.577                      | 0.008                | LPES   | 88                      |
| CoD <sub>2</sub>   | 1.465                      | 0.013                | LPES   | 34                      | PH <sub>2</sub>                 | 1.263                      | 0.006                | LPES   | 281                     |
| CoH <sub>2</sub>   | 1.450                      | 0.014                | LPES   | 34                      | P <sub>2</sub> H                | 1.514                      | 0.010                | LPES   | 281                     |
| CrH <sub>2</sub>   | >2.5                       | —                    | LPES   | 34                      | PO <sub>2</sub>                 | 3.42                       | 0.01                 | LPES   | 124                     |
| Cr <sub>2</sub> D  | 1.464                      | 0.005                | LPES   | 107                     | Pd <sub>3</sub>                 | <1.5                       | 0.1                  | LPES   | 55                      |
| Cr <sub>2</sub> H  | 1.474                      | 0.005                | LPES   | 107                     | PdCN                            | 2.543                      | 0.007                | LPES   | 287                     |
| Cr <sub>2</sub> O  | 0.9                        | 0.1                  | LPES   | 306                     | PdCO                            | 0.606                      | 0.010                | LPES   | 293                     |
| CrO <sub>2</sub>   | 2.413                      | 0.008                | LPES   | 144 OCrO                | Pt <sub>3</sub>                 | 1.87                       | 0.02                 | LPES   | 55                      |
| CrO <sub>2</sub>   | 1.5                        | 0.06                 | LPES   | 241 Cr(O <sub>2</sub> ) | PtCN                            | 3.191                      | 0.003                | LPES   | 287                     |
| Cs <sub>3</sub>    | 0.864                      | 0.030                | LPES   | 18                      | PtCO                            | 1.212                      | 0.010                | LPES   | 293                     |
| Cu <sub>3</sub>    | 2.11                       | 0.05                 | LPES   | 37                      | Rb <sub>3</sub>                 | 0.920                      | 0.030                | LPES   | 18                      |
| CuCN               | 1.466                      | 0.010                | LPES   | 163                     | ReO <sub>2</sub>                | 2.5                        | 0.1                  | LPES   | 216                     |
| CuCl <sub>2</sub>  | 4.35                       | 0.05                 | LPES   | 177                     | S <sub>3</sub>                  | 2.093                      | 0.025                | LPES   | 16                      |
| CuBr <sub>2</sub>  | 4.35                       | 0.05                 | LPES   | 177                     | SO <sub>2</sub>                 | 1.107                      | 0.008                | LPES   | 16                      |
| DCO                | 0.301                      | 0.005                | LPES   | 35                      | S <sub>2</sub> O                | 1.877                      | 0.008                | LPES   | 16                      |
| DNO                | 0.330                      | 0.015                | LPES   | 14                      | Sb <sub>3</sub>                 | 1.85                       | 0.03                 | LPES   | 108                     |
| DO <sub>2</sub>    | 1.077                      | 0.005                | LPES   | 15                      | SeO <sub>2</sub>                | 1.823                      | 0.050                | LPES   | 38                      |
| DS <sub>2</sub>    | 1.912                      | 0.015                | LPES   | 53                      | SiF <sub>2</sub>                | 0.10                       | 0.10                 | LPES   | 278                     |
| Fe <sub>3</sub>    | 1.43                       | 0.06                 | LPES   | 149                     | Si <sub>2</sub> F               | 1.99                       | 0.28                 | LPES   | 17                      |
| FeC <sub>2</sub>   | 1.9782                     | 0.0006               | LPES   | 254                     | SiH <sub>2</sub>                | 1.124                      | 0.020                | LPES   | 2                       |
| FeCO               | 1.157                      | 0.005                | LPES   | 103                     | Si <sub>2</sub> H               | 2.31                       | 0.01                 | LPES   | 182                     |
| FeD <sub>2</sub>   | 1.038                      | 0.013                | LPES   | 34                      | Si <sub>3</sub>                 | 2.29                       | 0.02                 | LPES   | 110                     |
| FeH <sub>2</sub>   | 1.049                      | 0.014                | LPES   | 34                      | Sn <sub>3</sub>                 | 2.24                       | 0.01                 | LPES   | 289                     |
| FeO <sub>2</sub>   | 2.358                      | 0.030                | LPES   | 130                     | SnCN                            | 1.922                      | 0.006                | LPES   | 292                     |
| Fe <sub>2</sub> H  | 0.564                      | 0.019                | LPES   | 254                     | Ta <sub>3</sub>                 | 1.36                       | 0.03                 | LPES   | 169                     |
| Fe <sub>2</sub> O  | 1.60                       | 0.02                 | LPES   | 152                     | TiO <sub>2</sub>                | 1.59                       | 0.03                 | LPES   | 172                     |
| GaAs <sub>2</sub>  | 1.894                      | 0.033                | LPES   | 192                     | V <sub>3</sub>                  | 1.107                      | 0.010                | LPES   | 176                     |
| GaP <sub>2</sub>   | 1.666                      | 0.041                | LPES   | 192                     | VO <sub>2</sub>                 | 2.3                        | 0.2                  | CT     | 101                     |
| Ga <sub>2</sub> As | 2.428                      | 0.020                | LPES   | 192                     | WO <sub>2</sub>                 | 1.958                      | 0.050                | LPES   | 233                     |
| Ga <sub>2</sub> N  | 2.506                      | 0.008                | LPES   | 302                     |                                 |                            |                      |        |                         |

TABLE 4. Electron Affinities for Larger Polyatomic Molecules

| Molecule                                      | Electron affinity<br>in eV | Uncertainty<br>in eV | Method | Ref.                       |
|-----------------------------------------------|----------------------------|----------------------|--------|----------------------------|
| Ag <sub>n</sub>                               | <i>n</i> =1-60             | —                    | LPES   | 37                         |
| Al <sub>n</sub>                               | <i>n</i> =3-32             | —                    | LPES   | 68                         |
| Al <sub>5</sub>                               | 2.23                       | 0.05                 | LPES   | 238                        |
| Al <sub>2</sub> C <sub>2</sub>                | 0.64                       | 0.05                 | LPES   | 239 acetylide              |
| Al <sub>3</sub> C                             | 2.56                       | 0.06                 | LPES   | 161                        |
| Al <sub>3</sub> C <sub>2</sub>                | 2.19                       | 0.03                 | LPES   | 244                        |
| Al <sub>3</sub> Ge <sub>2</sub>               | 2.43                       | 0.03                 | LPES   | 244                        |
| Al <sub>3</sub> Si <sub>2</sub>               | 2.36                       | 0.03                 | LPES   | 244                        |
| Al <sub>3</sub> O                             | 1.00                       | 0.15                 | LPES   | 68                         |
| Al <sub>5</sub> H <sub>2</sub> O <sub>5</sub> | 3.10                       | 0.10                 | LPES   | 283                        |
| Al <sub>5</sub> O <sub>4</sub>                | 3.50                       | 0.05                 | LPES   | 283                        |
| Al <sub>n</sub> O <sub>m</sub>                | <i>n</i> =1,2              | <i>m</i> =1-5        | LPES   | 143                        |
| Al <sub>n</sub> O <sub>m</sub>                | <i>n</i> =3-7              | <i>m</i> =2-5        | LPES   | 267                        |
| Al <sub>n</sub> P <sub>m</sub>                | <i>n</i> =1-4              | <i>m</i> =1-4        | LPES   | 217                        |
| Al <sub>n</sub> S <sub>m</sub>                | <i>n</i> =1-5              | <i>m</i> =1-3        | LPES   | 129                        |
| Ar(H <sub>2</sub> O) <sub>n</sub>             | <i>n</i> =2,6,7            | —                    | LPES   | 77                         |
| Ar <sub>n</sub> Br                            | <i>n</i> =2-9              | —                    | ZEKE   | 212                        |
| Ar <sub>n</sub> I                             | <i>n</i> =2-19             | —                    | ZEKE   | 212                        |
| As <sub>4</sub>                               | <0.8                       | —                    | LPES   | 200                        |
| As <sub>5</sub>                               | ≈1.7                       | —                    | LPES   | 200                        |
| As <sub>5</sub>                               | ≈3.5                       | —                    | LPES   | 253                        |
| Au <sub>n</sub>                               | <i>n</i> =1-233            | —                    | LPES   | 37                         |
| AuF <sub>6</sub>                              | 7.5                        | estimate             | CT     | 98                         |
| Au <sub>3</sub> Pd                            | 2.51                       | —                    | LPES   | 220                        |
| Au <sub>4</sub> Pd                            | 2.69                       | —                    | LPES   | 220                        |
| Au <sub>6</sub>                               | 2.06                       | 0.02                 | LPES   | 288                        |
| Au <sub>6</sub> (CO)                          | 2.04                       | 0.05                 | LPES   | 288                        |
| Au <sub>6</sub> (CO) <sub>2</sub>             | 2.03                       | 0.05                 | LPES   | 288                        |
| Au <sub>6</sub> (CO) <sub>3</sub>             | 1.95                       | 0.05                 | LPES   | 288                        |
| Au <sub>12</sub> Nb                           | 3.70                       | 0.03                 | LPES   | 275                        |
| Au <sub>12</sub> Ta                           | 3.77                       | 0.03                 | LPES   | 275                        |
| Au <sub>12</sub> V                            | 3.76                       | 0.03                 | LPES   | 275                        |
| B <sub>5</sub>                                | 2.33                       | 0.02                 | LPES   | 245                        |
| BD <sub>3</sub>                               | 0.027                      | 0.014                | LPES   | 62                         |
| BH <sub>3</sub>                               | 0.038                      | 0.015                | LPES   | 62                         |
| B <sub>6</sub> Li                             | 2.3                        | 0.1                  | LPES   | 298                        |
| B <sub>3</sub> N                              | 2.098                      | 0.035                | LPES   | 193                        |
| Bi <sub>n</sub>                               | <i>n</i> =2-9              | —                    | LPES   | 213                        |
| Bi <sub>4</sub>                               | 1.05                       | 0.010                | LPES   | 119                        |
| Bi <sub>5</sub>                               | 2.87                       | 0.02                 | LPES   | 253                        |
| Br(CO <sub>2</sub> )                          | 3.582                      | 0.017                | LPES   | 131                        |
| Br(H <sub>2</sub> O) <sub>n</sub>             | <i>n</i> =1-4              | —                    | LPES   | 250                        |
| Br <sub>7</sub> Au <sub>2</sub>               | 3.52                       | 0.02                 | LPES   | 301                        |
| C <sub>n</sub>                                | <i>n</i> =2-84             | —                    | LPES   | 70                         |
| C <sub>n</sub> Cr                             | <i>n</i> =2-8              | —                    | LPES   | 271                        |
| C <sub>n</sub> Nb                             | <i>n</i> =2-7              | —                    | LPES   | 243                        |
| (CO <sub>2</sub> ) <sub>n</sub>               | <i>n</i> =1,2              | —                    | LPES   | 75                         |
| (CS) <sub>n</sub>                             | <i>n</i> =2                | —                    | LPES   | 75                         |
| (CS <sub>2</sub> ) <sub>n</sub>               | <i>n</i> =1,2              | —                    | LPES   | 75                         |
| CAI <sub>3</sub> Ge                           | 2.70                       | 0.06                 | LPES   | 224                        |
| CAI <sub>3</sub> Si                           | 2.77                       | 0.06                 | LPES   | 224                        |
| CCl <sub>4</sub>                              | ≤1.14                      | —                    | CT     | 266                        |
| CCoNO <sub>3</sub>                            | 1.73                       | 0.03                 | LPES   | 199 Co(CO <sub>2</sub> )NO |
| CDO <sub>2</sub>                              | 3.510                      | 0.015                | LPES   | 109                        |
| CF <sub>3</sub>                               | 1.82                       | 0.05                 | LPES   | 187                        |
| CF <sub>3</sub> Br                            | 0.91                       | 0.2                  | CD     | 2                          |
| CF <sub>3</sub> I                             | 1.57                       | 0.2                  | CD     | 2                          |
| CFO <sub>2</sub>                              | 4.277                      | 0.030                | LPES   | 131                        |
| CHCl <sub>3</sub>                             | ≤0.78                      | —                    | CT     | 266                        |



| Molecule                                       | Electron affinity<br>in eV | Uncertainty<br>in eV | Method | Ref.                                      |
|------------------------------------------------|----------------------------|----------------------|--------|-------------------------------------------|
| CHO <sub>2</sub>                               | 3.498                      | 0.015                | LPES   | 109                                       |
| CH <sub>2</sub> O <sub>4</sub>                 | 2.1                        | 0.2                  | PT     | 2 CO <sub>3</sub> (H <sub>2</sub> O)      |
| CH <sub>2</sub> S                              | 0.465                      | 0.023                | LPES   | 53                                        |
| CD <sub>3</sub> NO <sub>2</sub>                | 0.24                       | 0.08                 | LPES   | 211                                       |
| CD <sub>3</sub> O                              | 1.559                      | 0.004                | LPES   | 194                                       |
| CD <sub>3</sub> O <sub>2</sub>                 | 1.154                      | 0.004                | LPES   | 188 d <sub>3</sub> -methyl peroxy radical |
| CD <sub>3</sub> S                              | 1.856                      | 0.006                | LPT    | 2                                         |
| CD <sub>3</sub> S <sub>2</sub>                 | 1.748                      | 0.022                | LPES   | 53                                        |
| CH <sub>3</sub>                                | 0.08                       | 0.03                 | LPES   | 2                                         |
| CH <sub>3</sub> I                              | 0.11                       | 0.02                 | LPES   | 277                                       |
| CH <sub>3</sub> NO <sub>2</sub>                | 0.26                       | 0.08                 | LPES   | 211                                       |
| CH <sub>3</sub> O                              | 1.572                      | 0.004                | LPES   | 194                                       |
| CH <sub>3</sub> O <sub>2</sub>                 | 1.161                      | 0.005                | LPES   | 188 methyl peroxy radical                 |
| CH <sub>3</sub> S                              | 1.867                      | 0.004                | LPES   | 166                                       |
| CH <sub>3</sub> S <sub>2</sub>                 | 1.757                      | 0.022                | LPES   | 53                                        |
| CH <sub>3</sub> Si                             | 0.852                      | 0.010                | LPES   | 97 CH <sub>3</sub> -Si                    |
| CH <sub>3</sub> Si                             | 2.010                      | 0.010                | LPES   | 97 CH <sub>2</sub> =SiH                   |
| CH <sub>4</sub> N                              | 0.432                      | 0.015                | LPES   | 215                                       |
| CH <sub>5</sub> Si                             | 1.19                       | 0.04                 | LPT    | 65 CH <sub>3</sub> SiH <sub>2</sub>       |
| CO <sub>3</sub>                                | 2.69                       | 0.14                 | LPES   | 2                                         |
| C <sub>2</sub> F <sub>2</sub>                  | 2.255                      | 0.006                | LPES   | 106 difluorovinylidene                    |
| C <sub>2</sub> DN                              | 2.009                      | 0.020                | LPES   | 219 DCCN                                  |
| C <sub>2</sub> DN                              | 1.877                      | 0.010                | LPES   | 219 DCNC                                  |
| C <sub>2</sub> DO                              | 2.350                      | 0.020                | LPES   | 13                                        |
| C <sub>2</sub> HF                              | 1.718                      | 0.006                | LPES   | 106 monofluorovinylidene                  |
| C <sub>2</sub> HN                              | 2.003                      | 0.014                | LPES   | 219 HCCN                                  |
| C <sub>2</sub> HN                              | 1.883                      | 0.013                | LPES   | 219 HCNC                                  |
| C <sub>2</sub> HO                              | 2.338                      | 0.008                | LPES   | 190                                       |
| C <sub>2</sub> HNPd                            | 2.17                       | 0.03                 | LPES   | 291                                       |
| C <sub>2</sub> HPd                             | 1.98                       | 0.03                 | LPES   | 287                                       |
| C <sub>2</sub> HPt                             | 2.650                      | 0.010                | LPES   | 287                                       |
| C <sub>2</sub> D <sub>2</sub>                  | 0.492                      | 0.006                | LPES   | 83 vinylidene-d <sub>2</sub>              |
| C <sub>2</sub> HD                              | 0.489                      | 0.006                | LPES   | 83 vinylidene-d <sub>1</sub>              |
| C <sub>2</sub> HFe                             | 1.4512                     | 0.0025               | LPES   | 254                                       |
| C <sub>2</sub> HNi                             | 1.063                      | 0.019                | LPES   | 254                                       |
| C <sub>2</sub> H <sub>2</sub>                  | 0.490                      | 0.006                | LPES   | 83 vinylidene                             |
| C <sub>2</sub> H <sub>2</sub> FO               | 2.22                       | 0.09                 | PT     | 2 acetyl fluoride enolate                 |
| C <sub>2</sub> D <sub>2</sub> N                | 1.538                      | 0.012                | LPES   | 21 cyanomethyl-d <sub>2</sub> radical     |
| C <sub>2</sub> D <sub>2</sub> N                | 1.070                      | 0.024                | LPES   | 21 isocyanomethyl-d <sub>2</sub> radical  |
| C <sub>2</sub> H <sub>2</sub> Fe               | 1.328                      | 0.019                | LPES   | 254                                       |
| C <sub>2</sub> H <sub>2</sub> N                | 1.543                      | 0.014                | LPES   | 21 cyanomethyl radical                    |
| C <sub>2</sub> H <sub>2</sub> N                | 1.059                      | 0.024                | LPES   | 21 isocyanomethyl radical                 |
| C <sub>2</sub> H <sub>2</sub> Ni               | 2.531                      | 0.005                | LPES   | 287 HNiC <sub>2</sub> H                   |
| C <sub>2</sub> H <sub>3</sub>                  | 0.667                      | 0.024                | LPES   | 90 vinyl                                  |
| C <sub>2</sub> H <sub>3</sub> Fe               | 1.587                      | 0.019                | LPES   | 254                                       |
| C <sub>2</sub> H <sub>3</sub> Ni               | 1.103                      | 0.019                | LPES   | 254                                       |
| C <sub>2</sub> D <sub>3</sub> O                | 1.81897                    | 0.00012              | LPT    | 22 acetaldehyde-d <sub>3</sub> enolate    |
| C <sub>2</sub> H <sub>3</sub> O                | 1.82476                    | 0.00012              | LPT    | 22 acetaldehyde enolate                   |
| C <sub>2</sub> D <sub>5</sub> O                | 1.699                      | 0.004                | LPES   | 194 ethoxide-d <sub>3</sub>               |
| C <sub>2</sub> H <sub>5</sub> N                | 0.56                       | 0.01                 | PT     | 2 ethyl nitrine                           |
| C <sub>2</sub> H <sub>5</sub> O                | 1.712                      | 0.004                | LPES   | 194 ethoxide                              |
| C <sub>2</sub> H <sub>5</sub> O <sub>2</sub>   | 1.186                      | 0.004                | LPES   | 188 ethyl peroxy radical                  |
| C <sub>2</sub> H <sub>5</sub> S                | 1.953                      | 0.006                | LPT    | 2 ethyl sulfide                           |
| C <sub>2</sub> H <sub>5</sub> S                | 0.868                      | 0.051                | LPES   | 53 CH <sub>3</sub> SCH <sub>2</sub>       |
| C <sub>2</sub> H <sub>7</sub> O <sub>2</sub>   | 2.26                       | 0.08                 | PT     | 50 MeOHOMe                                |
| C <sub>3</sub> Fe                              | 1.69                       | 0.08                 | LPES   | 132                                       |
| C <sub>3</sub> H                               | 1.858                      | 0.023                | LPES   | 11                                        |
| C <sub>3</sub> HFe                             | 1.58                       | 0.06                 | LPES   | 132                                       |
| C <sub>3</sub> H <sub>2</sub>                  | 1.794                      | 0.008                | LPES   | 153                                       |
| C <sub>3</sub> H <sub>2</sub> F <sub>3</sub> O | 2.625                      | 0.010                | LPT    | 113 1,1,1-trifluoroacetone enolate        |



| Molecule                                       | Electron affinity<br>in eV | Uncertainty<br>in eV | Method  | Ref.                                             |
|------------------------------------------------|----------------------------|----------------------|---------|--------------------------------------------------|
| C <sub>3</sub> H <sub>3</sub>                  | 0.893                      | 0.025                | LPES    | 24 propargyl radical                             |
| C <sub>3</sub> H <sub>2</sub> D                | 0.88                       | 0.15                 | LPES    | 24 propargyl- <i>d</i> <sub>1</sub> radical      |
| C <sub>3</sub> D <sub>2</sub> H                | 0.907                      | 0.023                | LPES    | 24 propargyl- <i>d</i> <sub>2</sub> radical      |
| C <sub>3</sub> H <sub>3</sub> N                | 1.247                      | 0.012                | LPES    | 21 CH <sub>3</sub> CH-CN                         |
| C <sub>3</sub> D <sub>5</sub>                  | 0.464                      | 0.006                | LPES    | 138 allyl- <i>d</i> <sub>5</sub>                 |
| C <sub>3</sub> H <sub>5</sub>                  | 0.481                      | 0.008                | LPES    | 138 allyl                                        |
| C <sub>3</sub> H <sub>5</sub>                  | 0.397                      | 0.069                | kinetic | 155 cyclopropyl                                  |
| C <sub>3</sub> H <sub>4</sub> D                | 0.373                      | 0.019                | LPES    | 25 allyl- <i>d</i> <sub>1</sub>                  |
| C <sub>3</sub> H <sub>5</sub> O                | 1.758                      | 0.019                | LPT     | 113 acetone enolate                              |
| C <sub>3</sub> H <sub>5</sub> O                | 1.621                      | 0.006                | LPT     | 113 propionaldehyde enolate                      |
| C <sub>3</sub> H <sub>5</sub> O <sub>2</sub>   | 1.80                       | 0.06                 | PT      | 2 methyl acetate enolate                         |
| C <sub>3</sub> H <sub>7</sub> O                | 1.789                      | 0.033                | LPES    | 23 propyl oxide                                  |
| C <sub>3</sub> H <sub>7</sub> O                | 1.847                      | 0.004                | LPES    | 194 isopropyl oxide                              |
| C <sub>3</sub> H <sub>7</sub> S                | 2.00                       | 0.02                 | PT      | 2 propyl sulfide                                 |
| C <sub>3</sub> H <sub>7</sub> S                | 2.02                       | 0.02                 | PT      | 2 isopropyl sulfide                              |
| C <sub>3</sub> O                               | 1.34                       | 0.15                 | LPES    | 11                                               |
| C <sub>3</sub> O <sub>2</sub>                  | 0.85                       | 0.15                 | LPES    | 11                                               |
| C <sub>3</sub> Ti                              | 1.561                      | 0.015                | LPES    | 147                                              |
| C <sub>4</sub> F <sub>4</sub> Cl <sub>2</sub>  | 0.87                       | 0.08                 | attach  | 258 1,2-dichlorotetrafluoro-cyclobutene          |
| C <sub>4</sub> F <sub>4</sub> O <sub>3</sub>   | 0.5                        | 0.2                  | CD      | 2 tetrafluorosuccinic anhydride                  |
| C <sub>4</sub> F <sub>8</sub>                  | 0.63                       | 0.05                 | attach  | 256 octafluorocyclobutane                        |
| C <sub>4</sub> Fe                              | <2.2                       | 0.2                  | LPES    | 132                                              |
| C <sub>4</sub> HFe                             | 1.67                       | 0.06                 | LPES    | 132                                              |
| C <sub>4</sub> H <sub>2</sub> Fe               | 1.633                      | 0.019                | LPES    | 254                                              |
| C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>   | 1.44                       | 0.10                 | CT      | 61 maleic anhydride                              |
| C <sub>4</sub> H <sub>3</sub> Fe               | 1.182                      | 0.019                | LPES    | 254                                              |
| C <sub>4</sub> H <sub>3</sub> Ni               | 0.824                      | 0.019                | LPES    | 254                                              |
| C <sub>4</sub> D <sub>4</sub>                  | 0.909                      | 0.015                | LPES    | 125 vinylvinylidene- <i>d</i> <sub>4</sub>       |
| C <sub>4</sub> H <sub>4</sub>                  | 0.914                      | 0.015                | LPES    | 125 vinylvinylidene                              |
| C <sub>4</sub> H <sub>4</sub> N                | 2.145                      | 0.010                | LPES    | 265 pyrrolyl                                     |
| C <sub>4</sub> H <sub>4</sub> N <sub>3</sub> O | 0.75                       | —                    | LPES    | 285 NO (pyrimidine)                              |
| C <sub>4</sub> H <sub>5</sub> O                | 1.801                      | 0.008                | LPT     | 113 cyclobutanone enolate                        |
| C <sub>4</sub> H <sub>6</sub>                  | 0.431                      | 0.006                | LPES    | 135 trimethylenemethane                          |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | 0.69                       | 0.10                 | CT      | 61 2,3-butanedione                               |
| C <sub>4</sub> H <sub>6</sub> D                | 0.493                      | 0.008                | LPES    | 138 2-methylallyl- <i>d</i> <sub>7</sub>         |
| C <sub>4</sub> H <sub>7</sub>                  | 0.505                      | 0.006                | LPES    | 138 2-methylallyl                                |
| C <sub>4</sub> H <sub>7</sub> O                | 1.67                       | 0.05                 | PT      | 2 butyraldehyde enolate                          |
| C <sub>4</sub> H <sub>5</sub> DO               | 1.67                       | 0.05                 | PT      | 2 2-butanone-3- <i>d</i> <sub>1</sub> enolate    |
| C <sub>4</sub> H <sub>4</sub> D <sub>2</sub> O | 1.75                       | 0.06                 | PT      | 2 2-butanone-3,3- <i>d</i> <sub>2</sub> enolate  |
| C <sub>4</sub> H <sub>9</sub> O                | 1.909                      | 0.004                | LPES    | 194 <i>t</i> -butoxyl                            |
| C <sub>4</sub> H <sub>9</sub> S                | 2.03                       | 0.02                 | PT      | 2 <i>n</i> -butyl sulfide                        |
| C <sub>4</sub> H <sub>9</sub> S                | 2.07                       | 0.02                 | PT      | 2 <i>t</i> -butyl sulfide                        |
| C <sub>4</sub> O                               | 2.05                       | 0.15                 | LPES    | 11                                               |
| C <sub>4</sub> O <sub>2</sub>                  | 2.0                        | 0.2                  | LPES    | 11                                               |
| C <sub>4</sub> Ti                              | 1.494                      | 0.020                | LPES    | 147                                              |
| C <sub>5</sub>                                 | 2.853                      | 0.001                | LPT     | 99                                               |
| C <sub>5</sub> F <sub>5</sub> N                | 0.70                       | 0.05                 | attach  | 259 pentafluoropyridine                          |
| C <sub>5</sub> F <sub>6</sub> O <sub>3</sub>   | 1.5                        | 0.2                  | CD      | 2 hexafluoroglutaric anhydride                   |
| C <sub>5</sub> HF <sub>4</sub> N               | 0.40                       | 0.08                 | attach  | 259 tetrafluoropyridine                          |
| C <sub>5</sub> D <sub>5</sub>                  | 1.790                      | 0.008                | LPES    | 11 cyclopentadienyl- <i>d</i> <sub>5</sub>       |
| C <sub>5</sub> H <sub>5</sub>                  | 1.804                      | 0.007                | LPES    | 11 cyclopentadienyl                              |
| C <sub>5</sub> H <sub>5</sub> NO <sub>2</sub>  | 1.39                       | —                    | LPES    | 285 O <sub>2</sub> (pyridine)                    |
| C <sub>5</sub> H <sub>5</sub> N <sub>2</sub> O | 0.62                       | —                    | LPES    | 285 NO (pyridine)                                |
| C <sub>5</sub> H <sub>7</sub>                  | 0.91                       | 0.03                 | PT      | 2 pentadienyl                                    |
| C <sub>5</sub> H <sub>7</sub> NO <sub>3</sub>  | 1.87                       | —                    | LPES    | 285 O <sub>2</sub> (pyridine · H <sub>2</sub> O) |
| C <sub>5</sub> H <sub>7</sub> O                | 1.598                      | 0.007                | LPT     | 113 cyclopentanone enolate                       |
| C <sub>5</sub> H <sub>9</sub> O                | 1.69                       | 0.05                 | PT      | 2 3-pentanone enolate                            |
| C <sub>5</sub> H <sub>11</sub> O               | 1.93                       | 0.05                 | LPT     | 2 neopentoxyl                                    |
| C <sub>5</sub> H <sub>11</sub> S               | 2.09                       | 0.02                 | PT      | 2 pentyl sulfide                                 |
| C <sub>5</sub> O <sub>2</sub>                  | 1.2                        | 0.2                  | LPES    | 11                                               |

| Molecule                                                     | Electron affinity<br>in eV | Uncertainty<br>in eV | Method | Ref.                                                                      |
|--------------------------------------------------------------|----------------------------|----------------------|--------|---------------------------------------------------------------------------|
| C <sub>5</sub> Ti                                            | 1.748                      | 0.050                | LPES   | 147                                                                       |
| C <sub>6</sub>                                               | 4.180                      | 0.001                | LPT    | 8                                                                         |
| C <sub>6</sub> Br <sub>4</sub> O <sub>2</sub>                | 2.44                       | 0.20                 | CT     | 2 tetrabromo-BQ                                                           |
| C <sub>6</sub> Cl <sub>4</sub> O <sub>2</sub>                | 2.78                       | 0.10                 | CT     | 61 tetrachloro-BQ                                                         |
| C <sub>6</sub> F <sub>4</sub> O <sub>2</sub>                 | 2.70                       | 0.10                 | CT     | 61 tetrafluoro-BQ                                                         |
| C <sub>6</sub> F <sub>5</sub> Br                             | 1.15                       | 0.11                 | CT     | 67 pentafluorobromobenzene                                                |
| C <sub>6</sub> F <sub>5</sub> Cl                             | 0.75                       | 0.05                 | attach | 260 pentafluorochlorobenzene                                              |
| C <sub>6</sub> F <sub>5</sub> I                              | 1.41                       | 0.11                 | CT     | 67 pentafluoroiodobenzene                                                 |
| C <sub>6</sub> F <sub>5</sub> NO <sub>2</sub>                | 1.52                       | 0.11                 | CT     | 67 pentafluoro-NB                                                         |
| C <sub>6</sub> F <sub>6</sub>                                | 0.53                       | 0.05                 | attach | 257 hexafluorobenzene                                                     |
| C <sub>6</sub> F <sub>10</sub>                               | >1.4                       | 0.3                  | CT     | 2 perfluorocyclohexane                                                    |
| C <sub>6</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub> | 2.48                       | 0.10                 | CT     | 61 2,6-dichloro-BQ                                                        |
| C <sub>6</sub> H <sub>3</sub> F <sub>2</sub> NO <sub>2</sub> | 1.17                       | 0.10                 | CT     | 61 2,4-difluoro-NB                                                        |
| C <sub>6</sub> D <sub>4</sub>                                | 0.551                      | 0.010                | LPES   | 36 <i>o</i> -benzyne-d <sub>4</sub>                                       |
| C <sub>6</sub> H <sub>4</sub>                                | 0.560                      | 0.010                | LPES   | 36 <i>o</i> -benzyne                                                      |
| C <sub>6</sub> H <sub>4</sub> BrNO <sub>2</sub>              | 1.16                       | 0.10                 | CT     | 61 <i>o</i> -bromo-NB                                                     |
| C <sub>6</sub> H <sub>4</sub> BrNO <sub>2</sub>              | 1.32                       | 0.10                 | CT     | 61 <i>m</i> -bromo-NB                                                     |
| C <sub>6</sub> H <sub>4</sub> BrNO <sub>2</sub>              | 1.29                       | 0.10                 | CT     | 61 <i>p</i> -bromo-NB                                                     |
| C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>              | 1.14                       | 0.10                 | CT     | 61 <i>o</i> -chloro-NB                                                    |
| C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>              | 1.28                       | 0.10                 | CT     | 61 <i>m</i> -chloro-NB                                                    |
| C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>              | 1.26                       | 0.10                 | CT     | 61 <i>p</i> -chloro-NB                                                    |
| C <sub>6</sub> H <sub>4</sub> ClO                            | ≤2.58                      | 0.08                 | PT     | 2 <i>o</i> -chlorophenoxide                                               |
| C <sub>6</sub> H <sub>4</sub> FNO <sub>2</sub>               | 1.07                       | 0.10                 | CT     | 61 <i>o</i> -fluoro-NB                                                    |
| C <sub>6</sub> H <sub>4</sub> FNO <sub>2</sub>               | 1.23                       | 0.10                 | CT     | 61 <i>m</i> -fluoro-NB                                                    |
| C <sub>6</sub> H <sub>4</sub> FNO <sub>2</sub>               | 1.12                       | 0.10                 | CT     | 61 <i>p</i> -fluoro-NB                                                    |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>  | 1.65                       | 0.10                 | CT     | 61 <i>o</i> -diNB                                                         |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>  | 1.65                       | 0.10                 | CT     | 61 <i>m</i> -diNB                                                         |
| C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>  | 2.00                       | 0.10                 | CT     | 61 <i>p</i> -diNB                                                         |
| C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>                 | 1.860                      | 0.005                | LPES   | 284 1,4-benzoquinone (BQ)                                                 |
| C <sub>6</sub> D <sub>5</sub>                                | 1.092                      | 0.020                | LPES   | 26 phenyl- <i>d</i> <sub>5</sub>                                          |
| C <sub>6</sub> D <sub>5</sub> N                              | 1.44                       | 0.02                 | LPES   | 96 phenylnitrene- <i>d</i> <sub>5</sub>                                   |
| C <sub>6</sub> H <sub>2</sub> O <sub>2</sub>                 | 1.859                      | 0.005                | LPES   | 232 dehydrobenzoquinone                                                   |
| C <sub>6</sub> H <sub>3</sub> O <sub>2</sub>                 | <2.18                      | —                    | LPES   | 232 benzoquinonide                                                        |
| C <sub>6</sub> H <sub>5</sub>                                | 1.096                      | 0.006                | LPES   | 26 phenyl                                                                 |
| C <sub>6</sub> H <sub>5</sub> N                              | 1.429                      | 0.011                | LPT    | 115 phenylnitrene                                                         |
| C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>                | 1.00                       | 0.01                 | LPES   | 164 nitrobenzene (NB)                                                     |
| C <sub>6</sub> H <sub>5</sub> O                              | 2.253                      | 0.006                | LPES   | 26 phenoxyl                                                               |
| C <sub>6</sub> H <sub>5</sub> S                              | <2.47                      | 0.06                 | PT     | 2 thiophenoxide                                                           |
| C <sub>6</sub> H <sub>5</sub> NH                             | 1.70                       | 0.03                 | PT     | 2 anilide                                                                 |
| C <sub>6</sub> H <sub>6</sub> NO                             | 0.44                       | —                    | LPES   | 285 NO (benzene)                                                          |
| C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                 | 1.06                       | —                    | LPES   | 285 O <sub>2</sub> (benzene)                                              |
| C <sub>6</sub> H <sub>7</sub>                                | <1.67                      | 0.04                 | PT     | 2 methylchylpentadienyl                                                   |
| C <sub>6</sub> H <sub>8</sub>                                | 0.855                      | 0.010                | LPES   | 203 (CH <sub>2</sub> ) <sub>2</sub> C-C(CH <sub>2</sub> ) <sub>2</sub>    |
| C <sub>6</sub> H <sub>8</sub> Si                             | 1.435                      | 0.004                | LPT    | 65 C <sub>6</sub> H <sub>5</sub> SiH <sub>3</sub>                         |
| C <sub>6</sub> H <sub>9</sub>                                | 0.654                      | 0.010                | LPES   | 203 CH <sub>2</sub> =C(CH <sub>3</sub> )-C(CH <sub>2</sub> ) <sub>2</sub> |
| C <sub>6</sub> H <sub>9</sub> O                              | 1.526                      | 0.010                | LPT    | 113 cyclohexanone enolate                                                 |
| C <sub>6</sub> H <sub>10</sub>                               | 0.645                      | 0.015                | LPES   | 126 <i>t</i> -butyl vinylidene                                            |
| C <sub>6</sub> H <sub>11</sub> O                             | 1.755                      | +0.05/-0.005         | LPT    | 113 pinacolone enolate                                                    |
| C <sub>6</sub> H <sub>11</sub> O                             | 1.82                       | 0.06                 | PT     | 2 3,3-dimethylbutan-2-yl enolate                                          |
| C <sub>6</sub> N <sub>4</sub>                                | 2.3                        | 0.3                  | PT     | 2 TCNE                                                                    |
| C <sub>6</sub> F <sub>5</sub> N                              | 1.11                       | 0.11                 | CT     | 67 pentafluorobenzonitrile                                                |
| C <sub>7</sub> F <sub>8</sub>                                | 0.86                       | 0.11                 | CT     | 67 octafluorotoluene                                                      |
| C <sub>7</sub> F <sub>14</sub>                               | 1.08                       | 0.10                 | CT     | 61 perfluoromethylcyclohexane                                             |
| C <sub>7</sub> HF <sub>5</sub> O                             | 1.10                       | 0.11                 | CT     | 67 pentafluorobenzaldehyde                                                |
| C <sub>7</sub> H <sub>3</sub> N <sub>3</sub> O <sub>4</sub>  | 2.16                       | 0.10                 | CT     | 61 3,5-(NO <sub>2</sub> ) <sub>2</sub> -benzonitrile                      |
| C <sub>7</sub> H <sub>4</sub> F <sub>3</sub> NO <sub>2</sub> | 1.41                       | 0.10                 | CT     | 61 <i>m</i> -trifluoromethyl-NB                                           |
| C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>  | 1.61                       | 0.10                 | CT     | 61 <i>o</i> -cyano-NB                                                     |
| C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>  | 1.56                       | 0.10                 | CT     | 61 <i>m</i> -cyano-NB                                                     |
| C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub>  | 1.72                       | 0.10                 | CT     | 61 <i>p</i> -cyano-NB                                                     |
| C <sub>7</sub> H <sub>6</sub> Br                             | 1.308                      | 0.008                | LPES   | 167 <i>o</i> -bromobenzyl                                                 |

| Molecule                                                     | Electron affinity<br>in eV | Uncertainty<br>in eV | Method | Ref.                                                   |
|--------------------------------------------------------------|----------------------------|----------------------|--------|--------------------------------------------------------|
| C <sub>7</sub> H <sub>6</sub> Br                             | 1.307                      | 0.008                | LPES   | 167 <i>m</i> -bromobenzyl                              |
| C <sub>7</sub> H <sub>6</sub> Br                             | 1.229                      | 0.008                | LPES   | 167 <i>p</i> -bromobenzyl                              |
| C <sub>7</sub> H <sub>6</sub> Cl                             | 1.257                      | 0.008                | LPES   | 167 <i>o</i> -chlorobenzyl                             |
| C <sub>7</sub> H <sub>6</sub> Cl                             | 1.272                      | 0.008                | LPES   | 167 <i>m</i> -chlorobenzyl                             |
| C <sub>7</sub> H <sub>6</sub> Cl                             | 1.174                      | 0.008                | LPES   | 167 <i>p</i> -chlorobenzyl                             |
| C <sub>7</sub> H <sub>6</sub> F                              | 1.091                      | 0.008                | LPES   | 167 <i>o</i> -fluorobenzyl                             |
| C <sub>7</sub> H <sub>6</sub> F                              | 1.173                      | 0.008                | LPES   | 167 <i>m</i> -fluorobenzyl                             |
| C <sub>7</sub> H <sub>6</sub> F                              | 0.937                      | 0.008                | LPES   | 167 <i>p</i> -fluorobenzyl                             |
| C <sub>7</sub> H <sub>6</sub> FO                             | 2.218                      | 0.010                | LPT    | 2 <i>m</i> -fluoroacetophenone enolate                 |
| C <sub>7</sub> H <sub>6</sub> FO                             | 2.176                      | 0.010                | LPT    | 2 <i>p</i> -fluoroacetophenone enolate                 |
| C <sub>7</sub> H <sub>6</sub> FeO <sub>3</sub>               | 0.990                      | 0.10                 | CT     | 120 $\eta_4$ -1,3-butadiene-Fe(CO) <sub>3</sub>        |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>  | 1.77                       | 0.05                 | PT     | 60 3,4-dinitrotoluene                                  |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>  | 1.77                       | 0.05                 | PT     | 60 2,3-dinitrotoluene                                  |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>  | 1.60                       | 0.05                 | PT     | 60 2,4-dinitrotoluene                                  |
| C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>  | 1.55                       | 0.05                 | PT     | 60 2,6-dinitrotoluene                                  |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>                 | 1.85                       | 0.10                 | CT     | 61 <i>o</i> -CH <sub>3</sub> -BQ                       |
| C <sub>7</sub> H <sub>7</sub>                                | 0.912                      | 0.006                | LPES   | 26 benzyl                                              |
| C <sub>7</sub> H <sub>7</sub>                                | 0.868                      | 0.006                | LPES   | 136 1-quadricyclanide                                  |
| C <sub>7</sub> H <sub>7</sub>                                | 0.962                      | 0.006                | LPES   | 136 2-quadricyclanide                                  |
| C <sub>7</sub> H <sub>7</sub>                                | 1.286                      | 0.006                | LPES   | 136 norbornadienide                                    |
| C <sub>7</sub> H <sub>7</sub>                                | 0.39                       | 0.04                 | LPES   | 136 cycloheptatrienide                                 |
| C <sub>7</sub> H <sub>7</sub>                                | 3.046                      | 0.006                | LPES   | 136 1-(1,6-heptadiynide)                               |
| C <sub>7</sub> H <sub>7</sub>                                | >1.140                     | 0.006                | LPES   | 136 3-(1,6-heptadiynide)                               |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                | 0.92                       | 0.10                 | CT     | 61 <i>o</i> -methyl-NB                                 |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                | 0.99                       | 0.10                 | CT     | 61 <i>m</i> -methyl-NB                                 |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>                | 0.95                       | 0.10                 | CT     | 61 <i>p</i> -methyl-NB                                 |
| C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                | 1.04                       | 0.10                 | CT     | 61 <i>m</i> -OCH <sub>3</sub> -NB                      |
| C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>                | 0.91                       | 0.10                 | CT     | 61 <i>p</i> -OCH <sub>3</sub> -NB                      |
| C <sub>7</sub> H <sub>7</sub> O                              | <2.36                      | 0.06                 | PT     | 2 <i>o</i> -methyl phenoxide                           |
| C <sub>7</sub> H <sub>7</sub> O                              | 2.14                       | 0.02                 | PT     | 50 benzyloxide                                         |
| C <sub>7</sub> H <sub>8</sub> FO                             | <3.05                      | 0.06                 | PT     | 50 PhCH <sub>2</sub> OHF                               |
| C <sub>7</sub> H <sub>9</sub>                                | 1.27                       | 0.03                 | PT     | 2 heptatrienyl                                         |
| C <sub>7</sub> H <sub>9</sub> O                              | 1.61                       | 0.05                 | PT     | 2 2-norbornanone enolate                               |
| C <sub>7</sub> H <sub>9</sub> Si                             | 1.33                       | 0.04                 | LPT    | 65 C <sub>6</sub> H <sub>5</sub> (CH <sub>3</sub> )SiH |
| C <sub>7</sub> H <sub>11</sub> O                             | 1.598                      | 0.007                | LPT    | 113 cycloheptanone enolate                             |
| C <sub>7</sub> H <sub>11</sub> O                             | 1.49                       | 0.04                 | PT     | 2 2,5-dimethyl-<br>cyclopentanone enolate              |
| C <sub>7</sub> H <sub>13</sub> O                             | 1.72                       | 0.06                 | PT     | 2 4-heptanone enolate                                  |
| C <sub>7</sub> H <sub>13</sub> O                             | 1.46                       | 0.04                 | PT     | 2 diisopropyl ketone enolate                           |
| C <sub>8</sub> F <sub>14</sub> N <sub>2</sub>                | 1.89                       | 0.10                 | CT     | 51 1,4-(CN) <sub>2</sub> C <sub>6</sub> F <sub>4</sub> |
| C <sub>8</sub> H <sub>3</sub> F <sub>5</sub> O               | 0.88                       | 0.11                 | CT     | 67 pentafluoroacetophenone                             |
| C <sub>8</sub> H <sub>3</sub> F <sub>6</sub> NO <sub>2</sub> | 1.79                       | 0.10                 | CT     | 61 3,5-(CF <sub>3</sub> ) <sub>2</sub> -NB             |
| C <sub>8</sub> H <sub>4</sub> F <sub>3</sub> N               | 0.70                       | 0.05                 | attach | 263 <i>o</i> -trifluoromethylbenzonitrile              |
| C <sub>8</sub> H <sub>4</sub> F <sub>3</sub> N               | 0.67                       | 0.05                 | attach | 263 <i>m</i> -trifluoromethylbenzonitrile              |
| C <sub>8</sub> H <sub>4</sub> F <sub>3</sub> N               | 0.83                       | 0.05                 | attach | 263 <i>p</i> -trifluoromethylbenzonitrile              |
| C <sub>8</sub> H <sub>4</sub> O <sub>3</sub>                 | 1.21                       | 0.10                 | CT     | 61 phthalic anhydride                                  |
| C <sub>8</sub> H <sub>6</sub>                                | 1.044                      | 0.008                | LPES   | 148                                                    |
| C <sub>8</sub> H <sub>7</sub>                                | 1.091                      | 0.008                | LPES   | 134                                                    |
| C <sub>8</sub> H <sub>7</sub> O                              | 2.057                      | 0.010                | PT     | 2 acetophenone enolate                                 |
| C <sub>8</sub> H <sub>7</sub> O                              | 2.10                       | 0.08                 | LPT    | 2 phenylacetaldehyde enolate                           |
| C <sub>8</sub> H <sub>8</sub>                                | 0.55                       | 0.02                 | CT     | 134 cyclooctatetraene                                  |
| C <sub>8</sub> H <sub>8</sub>                                | 0.919                      | 0.008                | LPES   | 139 <i>m</i> -xylene                                   |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                | 1.21                       | 0.05                 | PT     | 60 3,5-dimethyl-NB                                     |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                | 2.61                       | 0.05                 | PT     | 60 2,6-dimethyl-NB                                     |
| C <sub>8</sub> H <sub>9</sub> NO <sub>2</sub>                | 0.86                       | 0.10                 | CT     | 61 2,3-dimethyl-NB                                     |
| C <sub>8</sub> H <sub>13</sub> O                             | 1.63                       | 0.06                 | PT     | 2 cyclooctanone enolate                                |
| C <sub>8</sub> N <sub>4</sub> NiS <sub>4</sub>               | 4.56                       | 0.04                 | LPES   | 307 Ni-bis(dithiolene)                                 |
| C <sub>8</sub> N <sub>4</sub> PdS <sub>4</sub>               | 4.55                       | 0.04                 | LPES   | 307 Pd-bis(dithiolene)                                 |
| C <sub>8</sub> N <sub>4</sub> PtS <sub>4</sub>               | 4.45                       | 0.04                 | LPES   | 307 Pt-bis(dithiolene)                                 |
| C <sub>8</sub> S <sub>2</sub>                                | 0.049                      | 0.005                | LPES   | 230 bithiophene                                        |

| Molecule                   | Electron affinity<br>in eV | Uncertainty<br>in eV | Method | Ref.                                                               |
|----------------------------|----------------------------|----------------------|--------|--------------------------------------------------------------------|
| $C_9H_8FeO_3$              | 0.76                       | 0.10                 | CT     | 120 $\eta_4$ -1,3-cyclohexadiene-Fe(CO) <sub>3</sub>               |
| $C_9H_9O$                  | 2.030                      | 0.010                | LPT    | 2 <i>m</i> -methylacetophenone enolate                             |
| $C_9H_9SiN$                | 1.43                       | 0.10                 | PT     | 2 trimethylsilylnitrene                                            |
| $C_9H_{11}NO_2$            | 0.70                       | 0.10                 | CT     | 61 2,4,6-trimethyl-NB                                              |
| $C_9H_{15}O$               | 1.69                       | 0.06                 | PT     | 2 cyclononanone enolate                                            |
| $C_{10}H_4C_{12}O_2$       | 2.19                       | 0.10                 | CT     | 61 2,3-dichloro-1,4-naphthoquinone                                 |
| $C_{10}H_6N_2O_4$          | 1.78                       | 0.10                 | CT     | 61 1,3-dinitronaphthalene                                          |
| $C_{10}H_6N_2O_4$          | 1.77                       | 0.10                 | CT     | 61 1,5-dinitronaphthalene                                          |
| $C_{10}H_6O_2$             | 1.81                       | 0.10                 | CT     | 61 1,4-naphthoquinone                                              |
| $C_{10}H_7$                | 1.403                      | 0.015                | LPES   | 197 1-naphthyl radical                                             |
| $C_{10}H_7NO_2$            | 1.23                       | 0.10                 | CT     | 61 1-nitronaphthalene                                              |
| $C_{10}H_7NO_2$            | 1.18                       | 0.10                 | CT     | 61 2-nitronaphthalene                                              |
| $C_{10}H_8$                | 0.790                      | 0.008                | LPES   | 230 azulene                                                        |
| $C_{10}H_8CrO_3$           | 0.93                       | 0.10                 | CT     | 120 $\eta_4$ -1,3,5-cycloheptatriene Cr(CO) <sub>3</sub>           |
| $C_{10}H_8FeO_3$           | 0.98                       | 0.10                 | CT     | 120 $\eta_4$ -1,3,5-cycloheptatriene-Fe(CO) <sub>3</sub>           |
| $C_{10}H_8NO$              | 0.66                       | —                    | LPES   | 285 NO <sup>−</sup> (naphthlene)                                   |
| $C_{10}H_8O_2$             | 1.41                       | —                    | LPES   | 285 O <sub>2</sub> (naphthlene)                                    |
| $C_{10}H_{10}O_3$          | 2.09                       | —                    | LPES   | 285 O <sub>2</sub> (naphthlene · H <sub>2</sub> O)                 |
| $C_{10}H_{12}O_4$          | 2.72                       | —                    | LPES   | 285 O <sub>2</sub> (naphthlene · (H <sub>2</sub> O) <sub>2</sub> ) |
| $C_{10}H_{17}O$            | 1.83                       | 0.06                 | PT     | 2 cyclodecanone enolate                                            |
| $C_{11}H_8FeO_3$           | 1.29                       | 0.10                 | CT     | 120 $\eta_4$ -1,3-butadiene-Fe(CO) <sub>3</sub>                    |
| $C_{12}F_{10}$             | 0.82                       | 0.11                 | CT     | 67 decafluorobiphenyl                                              |
| $C_{12}H_4N_4$             | 2.8                        | 0.3                  | CD     | 2 TCNQ                                                             |
| $C_{12}H_9$                | 1.07                       | 0.10                 | PT     | 2 perinaphthenyl                                                   |
| $C_{12}H_{12}NO$           | 0.79                       | —                    | LPES   | 285 NO(benzene) <sub>2</sub>                                       |
| $C_{12}H_{15}O$            | 2.032                      | 0.010                | LPT    | 2 <i>t</i> -butylacetophenone enolate                              |
| $C_{12}H_{21}O$            | 1.90                       | 0.07                 | PT     | 2 cyclododecanone enolate                                          |
| $C_{13}F_{10}O$            | 1.52                       | 0.11                 | CT     | 67 decafluorobenzophenone                                          |
| $C_{13}H_9FO$              | 0.64                       | 0.10                 | CT     | 61 4-fluorobenzophenone                                            |
| $C_{13}H_{10}O$            | 0.62                       | 0.10                 | CT     | 61 benzophenone                                                    |
| $C_{14}H_9NO_2$            | 1.43                       | 0.10                 | CT     | 61 9-nitroanthracene                                               |
| $C_{14}H_{10}$             | 0.530                      | 0.005                | LPES   | 286 anthracene                                                     |
| $C_{14}H_{12}O$            | 0.770                      | 0.005                | LPES   | 286 anthracene · H <sub>2</sub> O                                  |
| $(C_{14}H_{10})_n$         | $n=1-16$                   | —                    | LPES   | 231 anthracene clusters                                            |
| $C_{16}H_{10}$             | 0.406                      | 0.010                | LPES   | 270 pyrene                                                         |
| $C_{18}H_{12}$             | 1.04                       | 0.10                 | CT     | 66 tetracene                                                       |
| $C_{18}H_{12}$             | 0.32                       | 0.01                 | LPES   | 303 chrysene                                                       |
| $C_{20}H_{12}$             | 0.79                       | 0.10                 | CT     | 66 benz[a]pyrene                                                   |
| $C_{20}H_{12}$             | 0.973                      | 0.005                | LPES   | 236 perylene                                                       |
| $C_{20}H_{16}NO$           | 1.06                       | —                    | LPES   | 285 NO(naphthalene) <sub>2</sub>                                   |
| $C_{22}H_{14}$             | 1.35                       | 0.10                 | CT     | 66 pentacene                                                       |
| $C_{44}Cl_{28}FeN_4$       | 2.59                       | 0.11                 | CT     | 186 FeTPPCl <sub>28</sub>                                          |
| $C_{44}Cl_8FeN_4$          | 3.21                       | 0.03                 | CT     | 186 FeTPPβCl <sub>8</sub>                                          |
| $C_{44}Cl_9FeN_4$          | 3.35                       | 0.03                 | CT     | 186 FeTPPF <sub>20</sub> βCl <sub>8</sub> Cl                       |
| $C_{44}H_8FeN_4$           | 2.15                       | 0.15                 | CT     | 186 FeTPPF <sub>20</sub>                                           |
| $C_{44}H_8ClF_{20}FeN_4$   | 3.14                       | 0.03                 | CT     | 186 FeTPPF <sub>20</sub> Cl                                        |
| $C_{44}H_8Cl_{21}FeN_4$    | 2.93                       | 0.23                 | CT     | 186 FeTPPoCl <sub>20</sub> Cl                                      |
| $C_{44}H_{12}Cl_{17}FeN_4$ | 3.14                       | 0.03                 | CT     | 186 FeTPPoCl <sub>8</sub> βCl <sub>8</sub> Cl                      |
| $C_{44}H_{20}Cl_8FeN_4$    | 1.86                       | 0.03                 | CT     | 186 FeTPPoCl <sub>8</sub>                                          |
| $C_{44}H_{20}Cl_9FeN_4$    | 2.10                       | 0.19                 | CT     | 186 FeTPPoCl <sub>8</sub> Cl                                       |
| $C_{44}H_{28}FeN_4$        | 1.87                       | 0.03                 | CT     | 186 iron tetraphenylporphyrin (FeTPP)                              |
| $C_{44}H_{28}NiN_4$        | 1.51                       | 0.01                 | CT     | 186 nickel tetraphenylporphyrin (NiTPP)                            |
| $C_{44}H_{28}ClFeN_4$      | 2.15                       | 0.15                 | CT     | 186 FeTPPCl                                                        |
| $C_{44}H_{30}N_4$          | 1.69                       | 0.01                 | CT     | 186 H <sub>2</sub> tetraphenylporphyrin                            |
| $C_{45}H_{29}NiN_4O$       | 1.74                       | 0.01                 | CT     | 186 NiTPPCHO                                                       |
| $C_{52}H_{39}FeN_7O$       | 1.97                       | 0.03                 | CT     | 186 FeTPP-val                                                      |
| $C_{60}$                   | 2.683                      | 0.008                | LPES   | 201                                                                |
| $C_{60}F_2$                | 2.74                       | 0.07                 | Knud   | 202                                                                |
| $C_{64}H_{64}FeN_8O_4$     | 2.07                       | 0.03                 | CT     | 186 FeTPP-piv                                                      |
| $C_{70}F_2$                | 2.80                       | 0.07                 | Knud   | 202                                                                |

| Molecule                         | Electron affinity<br>in eV | Uncertainty<br>in eV           | Method | Ref. |
|----------------------------------|----------------------------|--------------------------------|--------|------|
| (benzene) <sub>n</sub>           | <i>n</i> =53-124           | —                              | LPES   | 248  |
| (toluene) <sub>n</sub>           | <i>n</i> =33-139           | —                              | LPES   | 248  |
| CeF <sub>4</sub>                 | 3.8                        | 0.4                            | CT     | 98   |
| Cl(CO <sub>2</sub> )             | 3.907                      | 0.010                          | LPES   | 131  |
| Cl(H <sub>2</sub> O)             | <i>n</i> =1-4              | —                              | LPES   | 250  |
| Co <sub>n</sub>                  | <i>n</i> =1-108            | —                              | LPES   | 251  |
| CoBr <sub>3</sub>                | 4.6                        | 0.1                            | LPES   | 249  |
| CoCl <sub>3</sub>                | 4.7                        | 0.1                            | LPES   | 249  |
| CoF <sub>4</sub>                 | 6.4                        | 0.3                            | CT     | 98   |
| Cr(CO) <sub>3</sub>              | 1.349                      | 0.006                          | LPES   | 94   |
| CrO <sub>3</sub>                 | 3.66                       | 0.02                           | LPES   | 241  |
| CrO <sub>4</sub>                 | 4.98                       | 0.09                           | LPES   | 241  |
| CrO <sub>5</sub>                 | 4.4                        | 0.1                            | LPES   | 241  |
| Cr <sub>2</sub> O <sub>n</sub>   | <i>n</i> =1-7              | —                              | LPES   | 306  |
| CsO <sub>4</sub>                 | 2.5                        | 0.2                            | LPES   | 252  |
| Cu <sub>n</sub>                  | <i>n</i> =1-411            | —                              | LPES   | 37   |
| CuBr <sub>2</sub>                | 4.35                       | 0.05                           | LPES   | 237  |
| Cu(CN) <sub>m</sub>              | <i>n</i> =1-6              | <i>m</i> =1-6                  | LPES   | 159  |
| CuCl <sub>2</sub>                | 4.35                       | 0.05                           | LPES   | 237  |
| F(H <sub>2</sub> O) <sub>n</sub> | <i>n</i> =1-4              | —                              | LPES   | 242  |
| F(H <sub>2</sub> O) <sub>n</sub> | <i>n</i> =1-4              | —                              | LPES   | 250  |
| Fe <sub>n</sub>                  | <i>n</i> =3-34             | —                              | LPES   | 149  |
| Fe(CO) <sub>2</sub>              | 1.22                       | 0.02                           | LPES   | 2    |
| Fe(CO) <sub>3</sub>              | 1.8                        | 0.2                            | LPES   | 2    |
| Fe(CO) <sub>4</sub>              | 2.4                        | 0.3                            | LPES   | 2    |
| FeBr <sub>3</sub>                | 4.26                       | 0.06                           | LPES   | 249  |
| FeBr <sub>4</sub>                | 5.50                       | 0.08                           | LPES   | 249  |
| FeCl <sub>3</sub>                | 4.22                       | 0.06                           | LPES   | 249  |
| FeCl <sub>4</sub>                | 6.00                       | 0.08                           | LPES   | 249  |
| FeF <sub>3</sub>                 | 3.6                        | 0.1                            | CT     | 98   |
| FeF <sub>4</sub>                 | 6.0                        | estimate                       | CT     | 98   |
| Fe <sub>2</sub> H <sub>2</sub>   | 0.942                      | 0.019                          | LPES   | 254  |
| Fe <sub>n</sub> O <sub>m</sub>   | <i>n</i> =1-4              | <i>m</i> =1-6                  | LPES   | 152  |
| Ga <sub>2</sub> As <sub>3</sub>  | 2.783                      | 0.024                          | LPES   | 192  |
| Ga <sub>x</sub> As <sub>y</sub>  | <i>n</i> =2-50             | <i>n</i> = <i>x</i> + <i>y</i> | LPES   | 229  |
| Ga <sub>2</sub> P <sub>3</sub>   | 2.991                      | 0.026                          | LPES   | 192  |
| Ge <sub>n</sub>                  | <i>n</i> =3-15             | —                              | LPES   | 71   |
| Ge <sub>x</sub> As <sub>y</sub>  | <i>n</i> =5-30             | <i>n</i> = <i>x</i> + <i>y</i> | LPES   | 72   |
| GeH <sub>3</sub>                 | <1.74                      | 0.04                           | PT     | 2    |
| H(NH <sub>3</sub> ) <sub>n</sub> | <i>n</i> =1,2              | —                              | LPES   | 76   |
| HNO <sub>3</sub>                 | 0.57                       | 0.15                           | CD     | 2    |
| (H <sub>2</sub> O) <sub>n</sub>  | <i>n</i> =2-19             | —                              | LPES   | 77   |
| I(CO <sub>2</sub> )              | 3.225                      | 0.001                          | LPES   | 131  |
| I(H <sub>2</sub> O) <sub>n</sub> | <i>n</i> =1-4              | —                              | LPES   | 250  |
| In <sub>x</sub> P <sub>y</sub>   | <i>n</i> =2-8              | <i>n</i> = <i>x</i> + <i>y</i> | LPES   | 137  |
| IrF <sub>4</sub>                 | 4.7                        | 0.3                            | CT     | 98   |
| IrF <sub>6</sub>                 | 6.5                        | 0.4                            | CT     | 98   |
| K <sub>n</sub>                   | <i>n</i> =2-7              | —                              | LPES   | 18   |
| KO <sub>4</sub>                  | 2.8                        | 0.2                            | LPES   | 252  |
| LiO <sub>4</sub>                 | 3.3                        | 0.2                            | LPES   | 252  |
| MnBr <sub>3</sub>                | 5.03                       | 0.06                           | LPES   | 249  |
| MnCl <sub>3</sub>                | 5.07                       | 0.06                           | LPES   | 249  |
| MnF <sub>4</sub>                 | 5.5                        | 0.2                            | CT     | 98   |
| MnO <sub>3</sub>                 | 3.335                      | 0.010                          | LPES   | 158  |
| Mo(CO) <sub>3</sub>              | 1.337                      | 0.006                          | LPES   | 94   |
| MoF <sub>5</sub>                 | 3.5                        | 0.2                            | CT     | 98   |
| MoF <sub>6</sub>                 | 3.8                        | 0.2                            | CT     | 98   |
| MoO <sub>3</sub>                 | 3.17                       | 0.02                           | LPES   | 280  |
| MoO <sub>4</sub>                 | 5.20                       | 0.07                           | LPES   | 86   |
| MoO <sub>5</sub>                 | 5.10                       | 0.07                           | LPES   | 86   |

| Molecule                                        | Electron affinity<br>in eV | Uncertainty<br>in eV | Method | Ref.                                            |
|-------------------------------------------------|----------------------------|----------------------|--------|-------------------------------------------------|
| Mo <sub>2</sub> O <sub>2</sub>                  | 2.24                       | 0.02                 | LPES   | 280                                             |
| Mo <sub>2</sub> O <sub>3</sub>                  | 2.33                       | 0.07                 | LPES   | 280                                             |
| Mo <sub>2</sub> O <sub>4</sub>                  | 2.13                       | 0.04                 | LPES   | 280                                             |
| N <sub>2</sub> CD                               | 2.622                      | 0.005                | LPES   | 154 NCND                                        |
| N <sub>2</sub> CH                               | 2.622                      | 0.005                | LPES   | 154 NCNH                                        |
| (NH <sub>3</sub> ) <sub>n</sub>                 | <i>n</i> =41-1100          | —                    | LPES   | 77                                              |
| NH <sub>2</sub> (NH <sub>3</sub> ) <sub>n</sub> | <i>n</i> =1,2              | —                    | LPES   | 78                                              |
| NO(H <sub>2</sub> O) <sub>n</sub>               | <i>n</i> =1,2              | —                    | LPES   | 75                                              |
| NO <sub>3</sub>                                 | 3.937                      | 0.014                | LPES   | 85                                              |
| NO <sub>3</sub> (H <sub>2</sub> O) <sub>n</sub> | <i>n</i> =0-6              | —                    | LPES   | 240                                             |
| NO(N <sub>2</sub> O) <sub>n</sub>               | <i>n</i> =1,2              | —                    | LPES   | 79                                              |
| (NO) <sub>2</sub>                               | >2.1                       | —                    | LPES   | 75                                              |
| (N <sub>2</sub> O) <sub>n</sub>                 | <i>n</i> =1,2              | —                    | LPES   | 81                                              |
| Na <sub>n</sub>                                 | <i>n</i> =2-5              | —                    | LPES   | 18                                              |
| (NaF) <sub>n</sub>                              | <i>n</i> =1-7,12           | —                    | LPES   | 64                                              |
| Na(NaF) <sub>n</sub>                            | <i>n</i> =5,7-12           | —                    | LPES   | 64                                              |
| NaO <sub>4</sub>                                | 3.1                        | 0.2                  | LPES   | 252                                             |
| NaO <sub>5</sub>                                | 3.2                        | 0.2                  | LPES   | 252                                             |
| NaSO <sub>3</sub>                               | 2.3                        | 0.2                  | LPES   | 252                                             |
| Nb <sub>n</sub>                                 | <i>n</i> =6-17             | —                    | LPES   | 181                                             |
| Nb <sub>8</sub>                                 | 1.513                      | 0.008                | LPES   | 157                                             |
| Nb <sub>3</sub> O                               | 1.393                      | 0.006                | LPES   | 169                                             |
| Ni <sub>n</sub>                                 | <i>n</i> =1-100            | —                    | LPES   | 247                                             |
| Ni <sub>n</sub> (benzene) <sub>m</sub>          | <i>n</i> =1-3              | <i>m</i> =1,2        | LPES   | 295                                             |
| NiBr <sub>3</sub>                               | 4.94                       | 0.08                 | LPES   | 249                                             |
| NiCl <sub>3</sub>                               | 5.20                       | 0.08                 | LPES   | 249                                             |
| Ni(CO) <sub>2</sub>                             | 0.643                      | 0.014                | LPES   | 2                                               |
| Ni(CO) <sub>3</sub>                             | 1.077                      | 0.013                | LPES   | 2                                               |
| Ni(CO)H                                         | 1.126                      | 0.010                | LPES   | 293 HNiCO                                       |
| OH(H <sub>2</sub> O)                            | <2.95                      | 0.15                 | PT     | 2                                               |
| OH(NH <sub>3</sub> )                            | 2.35                       | 0.07                 | LPES   | 234                                             |
| OH(N <sub>2</sub> O)                            | 2.14                       | 0.02                 | LPES   | 209                                             |
| OH(N <sub>2</sub> O) <sub>n</sub>               | <i>n</i> =1-5              | —                    | LPES   | 209                                             |
| OsF <sub>4</sub>                                | 3.9                        | 0.3                  | CT     | 98                                              |
| OsF <sub>6</sub>                                | 6.0                        | 0.3                  | CT     | 98                                              |
| P <sub>5</sub>                                  | 3.88                       | 0.03                 | LPES   | 253                                             |
| PBr <sub>3</sub>                                | 1.59                       | 0.15                 | CD     | 2                                               |
| PBr <sub>2</sub> Cl                             | 1.63                       | 0.20                 | CD     | 2                                               |
| PCl <sub>2</sub> Br                             | 1.52                       | 0.20                 | CD     | 2                                               |
| PCl <sub>3</sub>                                | 0.82                       | 0.10                 | CD     | 2                                               |
| PF <sub>5</sub>                                 | 0.75                       | 0.15                 | CT     | 121                                             |
| PO <sub>3</sub>                                 | 4.95                       | 0.06                 | LPES   | 156                                             |
| POCl <sub>2</sub>                               | 3.83                       | 0.25                 | CD     | 2                                               |
| POCl <sub>3</sub>                               | 1.41                       | 0.20                 | CD     | 2                                               |
| P <sub>2</sub> H <sub>2</sub>                   | 1.00                       | 0.01                 | LPES   | 281 <i>trans</i> -P <sub>2</sub> H <sub>2</sub> |
| P <sub>2</sub> H <sub>2</sub>                   | 1.03                       | 0.01                 | LPES   | 281 <i>cis</i> -P <sub>2</sub> H <sub>2</sub>   |
| PtF <sub>4</sub>                                | 5.5                        | 0.3                  | CT     | 98                                              |
| PtF <sub>6</sub>                                | 7.0                        | 0.4                  | CT     | 98                                              |
| ReF <sub>6</sub>                                | 4.7                        | estimate             | CT     | 98                                              |
| ReO <sub>3</sub>                                | 3.6                        | 0.1                  | LPES   | 216                                             |
| RhF <sub>4</sub>                                | 5.4                        | 0.3                  | CT     | 98                                              |
| RuF <sub>4</sub>                                | 4.8                        | 0.3                  | CT     | 98                                              |
| RuF <sub>5</sub>                                | 5.2                        | 0.4                  | CT     | 98                                              |
| RuF <sub>6</sub>                                | 7.5                        | 0.3                  | CT     | 98                                              |
| SF <sub>4</sub>                                 | 1.5                        | 0.2                  | CT     | 91                                              |
| SF <sub>5</sub>                                 | 4.23                       | 0.12                 | e-scat | 204                                             |
| SF <sub>6</sub>                                 | 1.05                       | 0.10                 | CT     | 56                                              |
| SO <sub>3</sub>                                 | 1.97                       | 0.10                 | LPES   | 165                                             |
| (SO <sub>2</sub> ) <sub>2</sub>                 | 0.6                        | 0.2                  | LPES   | 80                                              |

| Molecule                        | Electron affinity<br>in eV | Uncertainty<br>in eV | Method | Ref. |
|---------------------------------|----------------------------|----------------------|--------|------|
| Sb <sub>n</sub>                 | <i>n</i> =2-9              | —                    | LPES   | 213  |
| Sb <sub>5</sub>                 | 3.46                       | 0.03                 | LPES   | 253  |
| ScBr <sub>4</sub>               | 6.13                       | 0.08                 | LPES   | 249  |
| ScCl <sub>4</sub>               | 6.89                       | 0.08                 | LPES   | 249  |
| SeF <sub>6</sub>                | 2.9                        | 0.2                  | CD     | 2    |
| Si <sub>4</sub>                 | 2.13                       | 0.01                 | LPES   | 110  |
| Si <sub>5</sub>                 | 2.59                       | 0.02                 | LPES   | 110  |
| Si <sub>7</sub>                 | 1.85                       | 0.02                 | LPES   | 110  |
| Si <sub>n</sub>                 | <i>n</i> =3-20             | —                    | LPES   | 71   |
| Si <sub>2</sub> C <sub>3</sub>  | 1.766                      | 0.012                | LPES   | 296  |
| SiD <sub>3</sub>                | 1.386                      | 0.022                | LPES   | 43   |
| SiF <sub>3</sub>                | 2.41                       | 0.22                 | LPES   | 17   |
| SiF <sub>4</sub>                | ≤0                         | —                    | LPES   | 17   |
| SiF <sub>5</sub>                | ≥4.66                      | —                    | LPES   | 17   |
| Si <sub>n</sub> F               | <i>n</i> =2-11             | —                    | LPES   | 17   |
| SiH <sub>3</sub>                | 1.406                      | 0.014                | LPES   | 43   |
| Si <sub>3</sub> H               | 2.53                       | 0.01                 | LPES   | 182  |
| Si <sub>4</sub> H               | 2.68                       | 0.01                 | LPES   | 182  |
| Si <sub>n</sub> Na <sub>m</sub> | <i>n</i> =4-11             | <i>m</i> =1-3        | LPES   | 210  |
| Sn <sub>n</sub>                 | <i>n</i> =1-12             | —                    | LPES   | 289  |
| SnCH <sub>2</sub> CN            | 1.57                       | 0.02                 | LPES   | 292  |
| Sn(CN) <sub>2</sub>             | 2.622                      | 0.004                | LPES   | 292  |
| Sn(CN)(CH <sub>2</sub> CN)      | 2.29                       | 0.05                 | LPES   | 292  |
| Ta <sub>3</sub> O               | 1.583                      | 0.010                | LPES   | 169  |
| TeF <sub>6</sub>                | 3.34                       | 0.17                 | CD     | 2    |
| Ti <sub>n</sub>                 | <i>n</i> =1-130            | —                    | LPES   | 151  |
| TiO <sub>3</sub>                | 4.2                        | —                    | LPES   | 172  |
| UF <sub>5</sub>                 | 3.7                        | 0.2                  | CT     | 98   |
| UF <sub>6</sub>                 | 5.1                        | 0.2                  | CT     | 98   |
| UO <sub>3</sub>                 | <2.1                       | —                    | CT     | 98   |
| V <sub>n</sub>                  | <i>n</i> =3-65             | —                    | LPES   | 150  |
| VF <sub>4</sub>                 | 3.5                        | 0.2                  | CT     | 98   |
| V <sub>2</sub> O <sub>n</sub>   | <i>n</i> =3-7              | —                    | LPES   | 246  |
| V <sub>3</sub> O                | 1.218                      | 0.008                | LPES   | 169  |
| V <sub>4</sub> O <sub>10</sub>  | 4.2                        | 0.6                  | CT     | 101  |
| W(CO) <sub>3</sub>              | 1.859                      | 0.006                | LPES   | 94   |
| WF <sub>5</sub>                 | 1.25                       | 0.3                  | CD     | 18   |
| WF <sub>6</sub>                 | 3.5                        | 0.1                  | CT     | 19   |
| WO <sub>2</sub>                 | 1.998                      | 0.010                | LPES   | 299  |
| WO <sub>3</sub>                 | 3.62                       | 0.05                 | LPES   | 86   |
| (WO <sub>3</sub> ) <sub>n</sub> | <i>n</i> =7-10             | —                    | LPES   | 300  |
| WO <sub>4</sub>                 | 5.30                       | 0.05                 | LPES   | 86   |
| WO <sub>5</sub>                 | 5.1                        | 0.1                  | LPES   | 86   |

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# ATOMIC AND MOLECULAR POLARIZABILITIES

Thomas M. Miller

The *polarizability* of an atom or molecule describes the response of the electron cloud to an external field. The atomic or molecular energy shift  $\Delta W$  due to an external electric field  $E$  is proportional to  $E^2$  for external fields that are weak compared to the internal electric fields between the nucleus and electron cloud. The *electric dipole polarizability*  $\alpha$  is the constant of proportionality defined by  $\Delta W = -\alpha E^2/2$ . The induced electric dipole moment is  $\alpha E$ . *Hyperpolarizabilities*, coefficients of higher powers of  $E$ , are less often required. Technically, the polarizability is a tensor quantity but for spherically symmetric charge distributions reduces to a single number. In any case, an *average polarizability* is usually adequate in calculations. Frequency-dependent or *dynamic polarizabilities* are needed for electric fields that vary in time, except for frequencies that are much lower than electron orbital frequencies, where *static polarizabilities* suffice.

Polarizabilities for atoms and molecules in excited states are found to be larger than for ground states and may be positive or negative. Molecular polarizabilities are very slightly temperature dependent since the size of the molecule depends on its rovibrational state. Only in the case of dihydrogen has this effect been studied enough to warrant consideration in Table 3.

Polarizabilities are normally expressed in c.g.s. units of  $\text{cm}^3$ . Ground state polarizabilities are in the range of  $10^{-24} \text{ cm}^3 = 1 \text{ \AA}^3$  and hence are often given in  $\text{\AA}^3$  units. Theorists tend to use atomic units of  $a_0^3$  where  $a_0$  is the Bohr radius. The conversion is  $\alpha(\text{cm}^3) = 0.148184 \times 10^{-24} \times \alpha(a_0^3)$ . Polarizabilities are only recently encountered in SI units,  $\text{C m}^2/\text{V} = \text{J}/(\text{V/m})^2$ . The conversion from c.g.s. units to SI units is  $\alpha(\text{C m}^2/\text{V}) = 4\pi\epsilon_0 \times 10^{-6} \alpha(\text{cm}^3)$ , where  $\epsilon_0$  is

the permittivity of free space in SI units and the factor  $10^{-6}$  simply converts  $\text{cm}^3$  into  $\text{m}^3$ . Thus,  $\alpha(\text{C m}^2/\text{V}) = 1.11265 \times 10^{-16} \times \alpha(\text{cm}^3)$ . Persons measuring excited state polarizabilities by optical methods tend to use units of  $\text{MHz}/(\text{V/cm})^2$ , where the energy shift,  $\Delta W$ , is expressed in frequency units with a factor of  $h$  understood. The polarizability is  $-2 \Delta W/E^2$ . The conversion into c.g.s. units is  $\alpha(\text{cm}^3) = 5.95531 \times 10^{-16} \times \alpha[\text{MHz}/(\text{V/cm})^2]$ .

The polarizability appears in many formulas for low-energy processes involving the valence electrons of atoms or molecules. These formulas are given below in c.g.s. units: the polarizability  $\alpha$  is in  $\text{cm}^3$ ; masses  $m$  or  $\mu$  are in grams; energies are in ergs; and electric charges are in esu, where  $e = 4.8032 \times 10^{-10}$  esu. The symbol  $\alpha(\nu)$  denotes a frequency ( $\nu$ ) dependent polarizability, where  $\alpha(\nu)$  reduces to the static polarizability  $\alpha$  for  $\nu = 0$ . For further information, see Bonin, K. D., and Kresin, V. V., *Electric Dipole Polarizabilities of Atoms, Molecules, and Clusters*, World Scientific, Singapore, 1997; Bonin, K. D., and Kadar-Kallen, *Int. J. Mod. Phys. B*, 24, 3313, 1994; and Miller, T. M., and Bederson, B., *Advances in Atomic and Molecular Physics*, 13, 1, 1977, and Gould, H., and Miller, T. M., *Advances in Atomic, Molecular, and Optical Physics*, 51, 243, 2005. Details on polarizability-related interactions, especially in regard to hyperpolarizabilities and nonlinear optical phenomena, are given by Bogaard, M. P., and Orr, B. J., in *Physical Chemistry, Series Two, Vol. 2, Molecular Structure and Properties*, Buckingham, A. D., Ed., Butterworths, London, 1975, pp. 149–194. A tabulation of tensor and hyperpolarizabilities is included. The gas number density,  $n$ , in Table 1 is usually taken to be that of 1 atm at 0 °C in reporting experimental data.

TABLE 1. Formulas Involving Polarizability

| Description                                             | Formula                                                                                                   | Remarks                                                                                                                                                                                                                                                                                           |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lorentz-Lorenz relation                                 | $\alpha(\nu) = \frac{3}{4\pi n} \left[ \frac{\eta^2(\nu) - 1}{\eta^2(\nu) + 2} \right]$                   | For a gas of atoms or nonpolar molecules; the index of refraction is $\eta(\nu)$                                                                                                                                                                                                                  |
| Refraction by polar molecules                           | $\alpha(\nu) + \frac{d^2}{3kT} = \frac{3}{4\pi n} \left[ \frac{\eta^2(\nu) - 1}{\eta^2(\nu) + 2} \right]$ | The dipole moment is $d$ , in esu cm ( $= 10^{-18}$ D)                                                                                                                                                                                                                                            |
| Dielectric constant (dimensionless)                     | $\kappa(\nu) = 1 + 4\pi n \alpha(\nu)$                                                                    | From the Lorentz-Lorenz relation for the usual case of $\kappa(\nu) \approx 1$                                                                                                                                                                                                                    |
| Index of refraction (dimensionless)                     | $\eta(\nu) = 1 + 2\pi n \alpha(\nu)$                                                                      | From $\eta^2(\nu) = \kappa(\nu)$                                                                                                                                                                                                                                                                  |
| Diamagnetic susceptibility                              | $\chi_m = e^2 (a_0 N \alpha)^{1/2} / 4m_e c^2$                                                            | From the approximation that the static polarizability is given by the variational formula $\alpha = (4/9a_0) \Sigma (N r_i^2)^2$ ; $N$ is the number of electrons, $m_e$ is the electron mass; a crude approximation is $\chi_m = (E_i / 4m_e c^2) \alpha$ , where $E_i$ is the ionization energy |
| Long-range electron- or ion-molecule interaction energy | $V(r) = -e^2 \alpha / 2r^4$                                                                               | The target molecule polarizability is $\alpha$                                                                                                                                                                                                                                                    |
| Ion mobility in a gas                                   | $\kappa = -13.87 / (\alpha \mu)^{1/2} \text{ cm}^2 / \text{V} \cdot \text{s}$                             | This one formula is not in c.g.s. units. Enter $\alpha$ in $\text{\AA}^3$ or $10^{-24} \text{ cm}^3$ units and the reduced mass $\mu$ of the ion-molecule pair in amu. Classical limit; pure polarization potential                                                                               |
| Langevin capture cross section                          | $\sigma(v_o) = (2\pi e / v_o) (\alpha / \mu)^{1/2}$                                                       | The relative velocity of approach for an ion-molecule pair is $v_o$ ; the target molecular polarizability is $\alpha$ and the reduced mass of the ion-molecule pair is $\mu$                                                                                                                      |
| Langevin reaction rate coefficient                      | $k = 2\pi e (\alpha / \mu)^{1/2}$                                                                         | Collisional rate coefficient for an ion-molecule reaction                                                                                                                                                                                                                                         |
| Rate coefficient for polar molecules                    | $k_d = 2\pi e \left[ (\alpha / \mu)^{1/2} + cd(2 / \mu \pi kT)^{1/2} \right]$                             | The dipole moment of the neutral is $d$ in esu cm; the number $c$ is a "locking factor" that depends on $\alpha$ and $d$ , and is between 0 and 1                                                                                                                                                 |

| Description                                                            | Formula                                                                                                                                                               | Remarks                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Modified effective range cross section for electron-neutral scattering | $\sigma(k) = 4\pi A^2 + 32\pi^4 \mu e^2 \alpha A k / 3h^2 + \dots$                                                                                                    | Here, $k$ is the electron momentum divided by $h/2\pi$ , where $h$ is Planck's constant; $A$ is called the "scattering length"; the reduced mass is $\mu$                                                                                             |
| van der Waals constant between two systems A, B                        | $C_6 = \frac{3}{2} \left[ \frac{\alpha^A \alpha^B E^A E^B}{E^A + E^B} \right]$                                                                                        | For the interaction potential term $V_6(r) = -C_6/r^6$ ; $E^{A,B}$ represents average dipole transition energies and $\alpha^{A,B}$ the respective polarizabilities of A, B                                                                           |
| Dipole-quadrupole constant between two systems A, B                    | $C_8 = \frac{15}{4} \left[ \frac{\alpha^A \alpha_q^B E^A E_q^B}{E^A + E_q^B} \right] + \frac{15}{4} \left[ \frac{\alpha_q^A \alpha^B E_q^A E^B}{E_q^A + E^B} \right]$ | For the interaction potential term $V_8(r) = -C_8/r^8$ ; $E_q^{A,B}$ represents average quadrupole transition energies and $\alpha_q^{A,B}$ are the respective quadrupole polarizabilities of A, B                                                    |
| van der Waals constant between an atom and a surface                   | $C_3 = \frac{\alpha g E^A E^S}{8(E^A + E^S)}$                                                                                                                         | For an interaction potential $V_3(r) = -C_3/r^3$ ; $E^{A,S}$ are characteristic energies of the atom and surface; $g = 1$ for a free-electron metal and $g = (\epsilon_\infty - 1)/(\epsilon_\infty + 1)$ for an ionic crystal                        |
| Relationship between $\alpha(\nu)$ and oscillator strengths            | $\alpha(\nu) = \frac{e^2 h^2}{4\pi^2 m_e} \sum \frac{f_k}{E_k^2 - (h\nu)^2}$                                                                                          | Here, $f_k$ is the oscillator strength from the ground state to an excited state $k$ , with excitation energy $E_k$ . This formula is often used to estimate static polarizabilities ( $\nu = 0$ )                                                    |
| Dynamic polarizability                                                 | $\alpha(\nu) = \frac{\alpha E_r^2}{E_r^2 - (h\nu)^2}$                                                                                                                 | Approximate variation of the frequency-dependent polarizability $\alpha(\nu)$ from $\nu = 0$ up to the first dipole-allowed electronic transition, of energy $E_r$ ; the static dipole polarizability is $\alpha(0)$ ; infrared contributions ignored |
| Rayleigh scattering cross section                                      | $\alpha(\nu) = \frac{8\pi}{9c^4} (2\pi\nu)^4 \times [3\alpha^2(\nu) + 2\gamma^2(\nu) / 3]$                                                                            | The photon frequency is $\nu$ ; the polarizability anisotropy (the difference between polarizabilities parallel and perpendicular to the molecular axis) is $\gamma(\nu)$                                                                             |
| Verdet constant                                                        | $V(\nu) = \frac{\nu n}{2m_e c^2} \left[ \frac{d\alpha(\nu)}{d\nu} \right]$                                                                                            | Defined from $\theta = V(\nu)B$ , where $\theta$ is the angle of rotation of linearly polarized light through a medium of number density $n$ , per unit length, for a longitudinal magnetic field strength $B$ (Faraday effect)                       |

TABLE 2. Static Average Electric Dipole Polarizabilities for Ground State Atoms (in Units of  $10^{-24} \text{ cm}^3$ )

| Atomic number | Atom | Polarizability | Estimated accuracy (%) | Method     | Ref.      | Atomic number | Atom | Polarizability | Estimated accuracy (%) | Method     | Ref.      |
|---------------|------|----------------|------------------------|------------|-----------|---------------|------|----------------|------------------------|------------|-----------|
| 1             | H    | 0.666793       | "exact"                | calc       | MB77      | 18            | Ar   | 1.6411         | 0.05                   | index/diel | NB65/OC67 |
| 2             | He   | 0.2050522      | "exact"                | calc       | LJS04     | 19            | K    | 43.4           | 2                      | beam       | MB77      |
|               |      | 0.2050         | 0.1                    | index/diel | NB65/OC67 | 20            | Ca   | 22.8           | 2                      | calc       | MB77      |
| 3             | Li   | 24.33          | 0.7                    | beam       | MJBTV06   |               |      | 29.4           | 6                      | calc       | BM02      |
| 4             | Be   | 5.60           | 2                      | calc       | MB77      |               |      | 25.0           | 8                      | beam       | MB77      |
| 5             | B    | 3.03           | 2                      | calc       | MB77      | 21            | Sc   | 17.8           | 25                     | calc       | D84       |
| 6             | C    | 1.76           | 2                      | calc       | MB77      | 22            | Ti   | 14.6           | 25                     | calc       | D84       |
| 7             | N    | 1.10           | 2                      | calc/index | MB77      | 23            | V    | 12.4           | 25                     | calc       | D84       |
| 8             | O    | 0.802          | 2                      | calc/index | MB77      | 24            | Cr   | 11.6           | 25                     | calc       | D84       |
| 9             | F    | 0.557          | 2                      | calc       | MB77      | 25            | Mn   | 9.4            | 25                     | calc       | D84       |
| 10            | Ne   | 0.3956         | 0.1                    | diel       | OC67      | 26            | Fe   | 8.4            | 25                     | calc       | D84       |
| 11            | Na   | 24.11          | 0.12                   | interferom | ESCHP94   | 27            | Co   | 7.5            | 25                     | calc       | D84       |
| 12            | Mg   | 10.6           | 2                      | calc       | MB77      | 28            | Ni   | 6.8            | 25                     | calc       | D84       |
|               |      | 11.1           | 5                      | calc       | S71       | 29            | Cu   | 6.2            | 6                      | calc       | BM02      |
|               |      | 10.6           | 5                      | calc       | BM02      |               |      | 6.1            | 25                     | calc       | D84       |
| 13            | Al   | 6.8            | 4.4                    | beam       | MMD90     | 30            | Zn   | 5.75           | 2                      | index      | GHM96     |
| 14            | Si   | 5.38           | 2                      | calc       | MB77      |               |      | 6.1            | 6                      | calc       | BM02      |
| 15            | P    | 3.63           | 2                      | calc       | MB77      |               |      | 5.6            | 25                     | calc       | D84       |
| 16            | S    | 2.90           | 2                      | calc       | MB77      | 31            | Ga   | 8.12           | 2                      | calc       | MB77      |
| 17            | Cl   | 2.18           | 2                      | calc       | MB77      | 32            | Ge   | 6.07           | 2                      | calc       | MB77      |
|               |      |                |                        |            |           | 33            | As   | 4.31           | 2                      | calc       | MB77      |
|               |      |                |                        |            |           | 34            | Se   | 3.77           | 2                      | calc       | MB77      |
|               |      |                |                        |            |           | 35            | Br   | 3.05           | 2                      | calc       | MB77      |

| Atomic number | Atom | Polarizability | Estimated accuracy |        |  | Ref.     | Atomic number | Atom        | Polarizability | Estimated accuracy |        |  | Ref.   |
|---------------|------|----------------|--------------------|--------|--|----------|---------------|-------------|----------------|--------------------|--------|--|--------|
|               |      |                | (%)                | Method |  |          |               |             |                | (%)                | Method |  |        |
| 36            | Kr   | 2.4844         | 0.05               | diel   |  | OC67     | 69            | Tm          | 21.8           | 25                 | calc   |  | D84    |
| 37            | Rb   | 47.3           | 2                  | beam   |  | MB77     | 70            | Yb          | 21.0           | 25                 | calc   |  | D84    |
| 38            | Sr   | 27.6           | 8                  | beam   |  | MB77     | 71            | Lu          | 21.9           | 25                 | calc   |  | D84    |
|               |      | 23.5           | 6                  | calc   |  | BM02     | 72            | Hf          | 16.2           | 25                 | calc   |  | D84    |
| 39            | Y    | 22.7           | 25                 | calc   |  | D84      | 73            | Ta          | 13.1           | 25                 | calc   |  | D84    |
| 40            | Zr   | 17.9           | 25                 | calc   |  | D84      | 74            | W           | 11.1           | 25                 | calc   |  | D84    |
| 41            | Nb   | 15.7           | 25                 | calc   |  | D84      | 75            | Re          | 9.7            | 25                 | calc   |  | D84    |
| 42            | Mo   | 12.8           | 25                 | calc   |  | D84      | 76            | Os          | 8.5            | 25                 | calc   |  | D84    |
| 43            | Tc   | 11.4           | 25                 | calc   |  | D84      | 77            | Ir          | 7.6            | 25                 | calc   |  | D84    |
| 44            | Ru   | 9.6            | 25                 | calc   |  | D84      | 78            | Pt          | 6.5            | 25                 | calc   |  | D84    |
| 45            | Rh   | 8.6            | 25                 | calc   |  | D84      | 79            | Au          | 5.8            | 25                 | calc   |  | D84    |
| 46            | Pd   | 4.8            | 25                 | calc   |  | D84      | 80            | Hg          | 5.02           | 1                  | index  |  | GH96   |
| 47            | Ag   | 7.2            | 25                 | calc   |  | D84      |               |             | 5.7            | 25                 | calc   |  | D84    |
| 48            | Cd   | 7.36           | 3                  | index  |  | GH95     | 81            | Tl          | 7.6            | 15                 | beam   |  | NYU84  |
|               |      | 7.4            | 6                  | calc   |  | BM02     |               |             | 7.5            | 25                 | calc   |  | D84    |
|               |      | 7.2            | 25                 | calc   |  | D84      | 82            | Pb          | 6.8            | 25                 | calc   |  | D84    |
| 49            | In   | 10.2           | 12                 | beam   |  | GMBJSJ84 | 83            | Bi          | 7.4            | 25                 | calc   |  | D84    |
|               |      | 9.1            | 25                 | calc   |  | D84      | 84            | Po          | 6.8            | 25                 | calc   |  | D84    |
| 50            | Sn   | 7.7            | 25                 | calc   |  | D84      | 85            | At          | 6.0            | 25                 | calc   |  | D84    |
| 51            | Sb   | 6.6            | 25                 | calc   |  | D84      | 86            | Rn          | 5.3            | 25                 | calc   |  | D84    |
| 52            | Te   | 5.5            | 25                 | calc   |  | D84      | 87            | Fr          | 48.60          | 2                  | calc   |  | LSMS05 |
| 53            | I    | 5.35           | 25                 | index  |  | A56      |               |             | 47.1           | 5                  | calc   |  | DJSB99 |
|               |      | 4.7            | 25                 | calc   |  | D84      | 88            | Ra          | 38.3           | 25                 | calc   |  | D84    |
| 54            | Xe   | 4.044          | 0.5                | diel   |  | MB77     | 89            | Ac          | 32.1           | 25                 | calc   |  | D84    |
| 55            | Cs   | 59.42          | 0.13               | beam   |  | AG03     | 90            | Th          | 32.1           | 25                 | calc   |  | D84    |
| 56            | Ba   | 39.7           | 8                  | beam   |  | MB77     | 91            | Pa          | 25.4           | 25                 | calc   |  | D84    |
| 57            | La   | 31.1           | 25                 | calc   |  | D84      | 92            | U           | 24.9           | 6                  | beam   |  | KB94   |
| 58            | Ce   | 29.6           | 25                 | calc   |  | D84      | 93            | Np          | 24.8           | 25                 | calc   |  | D84    |
| 59            | Pr   | 28.2           | 25                 | calc   |  | D84      | 94            | Pu          | 24.5           | 25                 | calc   |  | D84    |
| 60            | Nd   | 31.4           | 25                 | calc   |  | D84      | 95            | Am          | 23.3           | 25                 | calc   |  | D84    |
| 61            | Pm   | 30.1           | 25                 | calc   |  | D84      | 96            | Cm          | 23.0           | 25                 | calc   |  | D84    |
| 62            | Sm   | 28.8           | 25                 | calc   |  | D84      | 97            | Bk          | 22.7           | 25                 | calc   |  | D84    |
| 63            | Eu   | 27.7           | 25                 | calc   |  | D84      | 98            | Cf          | 20.5           | 25                 | calc   |  | D84    |
| 64            | Gd   | 23.5           | 25                 | calc   |  | D84      | 99            | Es          | 19.7           | 25                 | calc   |  | D84    |
| 65            | Tb   | 25.5           | 25                 | calc   |  | D84      | 100           | Fm          | 23.8           | 25                 | calc   |  | D84    |
| 66            | Dy   | 24.5           | 25                 | calc   |  | D84      | 101           | Md          | 18.2           | 25                 | calc   |  | D84    |
| 67            | Ho   | 23.6           | 25                 | calc   |  | D84      | 102           | No          | 17.5           | 25                 | calc   |  | D84    |
| 68            | Er   | 22.7           | 25                 | calc   |  | D84      | 119           | ekafrancium | 24.26          | 2                  | cal    |  | LSMS05 |

<sup>a</sup> Methods: calc = calculated value; beam = atomic beam deflection technique; interferom = atomic beam interference; index = determination based on the measured index of refraction; diel = determination based on the measured dielectric constant.

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**TABLE 3. Average Electric Dipole Polarizabilities for Ground State Diatomic Molecules (in Units of  $10^{-24} \text{ cm}^3$ )**

| Molecule                        | Polarizability | Ref. | Molecule        | Polarizability | Ref. |
|---------------------------------|----------------|------|-----------------|----------------|------|
| Al <sub>2</sub>                 | 19             | 23   |                 | 5.35           | 2    |
| BH                              | 3.32*          | 1    | HgCl            | 7.4*           | 9    |
| Br <sub>2</sub>                 | 7.02           | 2    | ICl             | 12.3           | 2    |
| CO                              | 1.95           | 3    | K <sub>2</sub>  | 77             | 22   |
| Cl <sub>2</sub>                 | 4.61           | 3    |                 | 72             | 21   |
| Cs <sub>2</sub>                 | 104            | 22   | Li <sub>2</sub> | 32.8           | 29   |
| CsK                             | 89             | 22   |                 | 34             | 22   |
| D <sub>2</sub> ( $\nu=0, J=0$ ) | 0.7921*        | 5    | LiCl            | 3.46*          | 10   |
| D <sub>2</sub> (293 K)          | 0.7954         | 6    | LiF             | 10.8*          | 11   |
| DCl                             | 2.84           | 2    | LiH             | 3.84*          | 12   |
| F <sub>2</sub>                  | 1.38*          | 7    |                 | 3.68*          | 13   |
| H <sub>2</sub> ( $\nu=0, J=0$ ) | 0.8023*        | 5    |                 | 3.88*          | 14   |
| H <sub>2</sub> (293 K)          | 0.8045*        | 5    | N <sub>2</sub>  | 1.7403         | 6,8  |
| H <sub>2</sub> (293 K)          | 0.8042         | 6    | NO              | 1.70           | 2    |
| H <sub>2</sub> (322 K)          | 0.8059         | 8    | Na <sub>2</sub> | 40             | 22   |
| HBr                             | 3.61           | 3    |                 | 38             | 21   |
| HCl                             | 2.63           | 3    | NaK             | 51             | 22   |
|                                 | 2.77           | 2    | NaLi            | 40             | 4    |
| HD ( $\nu=0, J=0$ )             | 0.7976*        | 5    | O <sub>2</sub>  | 1.5812         | 6    |
| HF                              | 0.80           | 27   | Rb <sub>2</sub> | 79             | 22   |
| HI                              | 5.44           | 3    |                 |                |      |

**TABLE 4. Average Electric Dipole Polarizabilities for Ground State Triatomic Molecules (in Units of  $10^{-24} \text{ cm}^3$ )**

| Molecule          | Polarizability | Ref. | Molecule           | Polarizability | Ref. |
|-------------------|----------------|------|--------------------|----------------|------|
| BeH <sub>2</sub>  | 4.34*          | 14   | HgI <sub>2</sub>   | 19.1           | 2    |
| CO <sub>2</sub>   | 2.911          | 8    | Li <sub>3</sub>    | 34.5           | 29   |
| CS <sub>2</sub>   | 8.74           | 3    | LiNa <sub>2</sub>  | 61.2           | 30   |
|                   | 8.86           | 2    | Li <sub>2</sub> Na | 35.4           | 30   |
| D <sub>2</sub> O  | 1.26           | 2    | N <sub>2</sub> O   | 3.03           | 8    |
| H <sub>2</sub> O  | 1.45           | 2    | NO <sub>2</sub>    | 3.02           | 2+   |
| H <sub>2</sub> S  | 3.782          | 3    | Na <sub>3</sub>    | 70             | 21   |
|                   | 3.95           | 2    | O <sub>3</sub>     | 3.21           | 2    |
| HCN               | 2.59           | 3    | OCS                | 5.71           | 2    |
|                   | 2.46           | 2    |                    | 5.2            | 15   |
| HgBr <sub>2</sub> | 14.5           | 2    | SO <sub>2</sub>    | 3.72           | 3    |
| HgCl <sub>2</sub> | 11.6           | 2    |                    | 4.28           | 2    |

**TABLE 5. Average Electric Dipole Polarizabilities for Ground State Inorganic Polyatomic Molecules (Larger than Triatomic) (in Units of  $10^{-24} \text{ cm}^3$ )**

| Molecule                         | Polarizability | Ref. | Molecule                        | Polarizability    | Ref. |
|----------------------------------|----------------|------|---------------------------------|-------------------|------|
| AsCl <sub>3</sub>                | 14.9           | 2    | (HgCl) <sub>2</sub>             | 14.7              | 9    |
| AsN <sub>3</sub>                 | 5.75           | 2    | K <sub>n</sub>                  | $n=2,5,7-9,11,20$ | 21   |
| BCl <sub>3</sub>                 | 9.38           | 20   | (KBr) <sub>2</sub>              | 42.0              | 16   |
| BF <sub>3</sub>                  | 3.31           | 2    | (KCl) <sub>2</sub>              | 32.1              | 16   |
| (BN <sub>3</sub> ) <sub>2</sub>  | 5.73           | 2    | (KF) <sub>2</sub>               | 21.0              | 16   |
| (BH <sub>2</sub> N) <sub>3</sub> | 8.0            | 2+   | (KI) <sub>2</sub>               | 36.3              | 16   |
| ClF <sub>3</sub>                 | 6.32           | 2    | Li <sub>n</sub>                 | $n=2-22$          | 29   |
| (CsBr) <sub>2</sub>              | 54.5           | 16   | (LiBr) <sub>2</sub>             | 18.9              | 16   |
| (CsCl) <sub>2</sub>              | 42.4           | 16   | (LiCl) <sub>2</sub>             | 13.1              | 16   |
| (CsF) <sub>2</sub>               | 28.4           | 16   | (LiF) <sub>2</sub>              | 6.9               | 16   |
| (CsI) <sub>2</sub>               | 51.8           | 16   | (LiI) <sub>2</sub>              | 23.4              | 16   |
| Ga <sub>n</sub> As <sub>m</sub>  | $n+m=4-30$     | 28   | LiNa <sub>3</sub>               | 75.6              | 30   |
| GeCl <sub>4</sub>                | 15.1           | 2    | Li <sub>2</sub> Na <sub>2</sub> | 60.0              | 30   |
| GeH <sub>3</sub> Cl              | 6.7            | 2+   | Li <sub>3</sub> Na              | 54.8              | 30   |



| Molecule                        | Polarizability | Ref. | Molecule                         | Polarizability | Ref. |
|---------------------------------|----------------|------|----------------------------------|----------------|------|
| ND <sub>3</sub>                 | 1.70           | 2    | (RbI) <sub>2</sub>               | 46.3           | 16   |
| NF <sub>3</sub>                 | 3.62           | 2    | SF <sub>6</sub>                  | 6.54           | 8    |
| NH <sub>3</sub>                 | 2.81           | 20   | (SF <sub>5</sub> ) <sub>2</sub>  | 13.2           | 2    |
|                                 | 2.10           | 2    | SO <sub>3</sub>                  | 4.84           | 2    |
|                                 | 2.26           | 3    | SO <sub>2</sub> Cl <sub>2</sub>  | 10.5           | 2    |
|                                 | 2.22*          | 33   | SeF <sub>6</sub>                 | 7.33           | 2    |
| (NO <sub>2</sub> ) <sub>2</sub> | 6.69           | 2    | SiF <sub>4</sub>                 | 5.45           | 2    |
| Na <sub>n</sub>                 | <i>n</i> =1-40 | 21   | SiH <sub>4</sub>                 | 5.44           | 2    |
| (NaBr) <sub>2</sub>             | 26.8           | 16   | (SiH <sub>3</sub> ) <sub>2</sub> | 11.1           | 2    |
| (NaCl) <sub>2</sub>             | 23.4           | 16   | SiHCl <sub>3</sub>               | 10.7           | 2    |
| (NaF) <sub>2</sub>              | 20.7           | 16   | SiH <sub>2</sub> Cl <sub>2</sub> | 8.92           | 2    |
| (NaI) <sub>2</sub>              | 26.9           | 16   | SiH <sub>3</sub> Cl              | 7.02           | 2    |
| OsO <sub>4</sub>                | 8.17           | 2    | SnBr <sub>4</sub>                | 22.0           | 2    |
| PCl <sub>3</sub>                | 12.8           | 2    | SnCl <sub>4</sub>                | 18.0           | 2    |
| PF <sub>5</sub>                 | 6.10           | 2    |                                  | 13.8           | 15   |
| PH <sub>3</sub>                 | 4.84           | 2    | SnI <sub>4</sub>                 | 32.3           | 2    |
| (RbBr) <sub>2</sub>             | 48.2           | 16   | TeF <sub>6</sub>                 | 9.00           | 2    |
| (RbCl) <sub>2</sub>             | 43.2           | 16   | TiCl <sub>4</sub>                | 16.4           | 2    |
| (RbF) <sub>2</sub>              | 40.7           | 16   | UF <sub>6</sub>                  | 12.5           | 2    |

TABLE 6. Average Electric Dipole Polarizabilities for Ground State Hydrocarbon Molecules (in Units of 10<sup>-24</sup> cm<sup>3</sup>)

| Molecule                       | Name                         | Polarizability | Ref. | Molecule                        | Name                          | Polarizability | Ref. |
|--------------------------------|------------------------------|----------------|------|---------------------------------|-------------------------------|----------------|------|
| CH <sub>4</sub>                | methane                      | 2.593          | 8    |                                 |                               | 10.87          | 15   |
| C <sub>2</sub> H <sub>2</sub>  | acetylene                    | 3.33           | 3    |                                 | 1-hexene                      | 11.65          | 27   |
|                                |                              | 3.93           | 2    | C <sub>6</sub> H <sub>14</sub>  | hexane                        | 11.9           | 2    |
| C <sub>2</sub> H <sub>4</sub>  | ethylene                     | 4.252          | 8    | C <sub>7</sub> H <sub>8</sub>   | toluene                       | 11.8           | 25   |
| C <sub>2</sub> H <sub>6</sub>  | ethane                       | 4.47           | 3    |                                 |                               | 12.26          | 15   |
|                                |                              | 4.43           | 2    |                                 |                               | 12.3           | 2    |
| C <sub>3</sub> H <sub>4</sub>  | propyne                      | 6.18           | 2    | C <sub>7</sub> H <sub>12</sub>  | 1-heptyne                     | 12.8           | 2†   |
| C <sub>3</sub> H <sub>6</sub>  | propene                      | 6.26           | 2    | C <sub>7</sub> H <sub>14</sub>  | methylcyclohexane             | 13.1           | 2    |
|                                | cyclopropane                 | 5.66           | 2    |                                 | 1-heptene                     | 13.51          | 27   |
| C <sub>3</sub> H <sub>8</sub>  | propane                      | 6.29           | 3    | C <sub>7</sub> H <sub>16</sub>  | heptane                       | 13.61          | 2    |
|                                |                              | 6.37           | 2    | C <sub>8</sub> H <sub>8</sub>   | styrene                       | 15.0           | 2    |
| C <sub>4</sub> H <sub>6</sub>  | 1-butyne                     | 7.41           | 2†   |                                 |                               | 14.41          | 27   |
|                                | 1,3-butadiene                | 8.64           | 2    | C <sub>8</sub> H <sub>10</sub>  | ethylbenzene                  | 14.2           | 2    |
| C <sub>4</sub> H <sub>8</sub>  | 1-butene                     | 7.97           | 2    |                                 | <i>o</i> -xylene              | 14.9           | 2    |
|                                |                              | 8.52           | 2    |                                 |                               | 14.1           | 15   |
|                                | <i>trans</i> -2-butene       | 8.49           | 2    |                                 | <i>p</i> -xylene              | 13.7           | 25   |
|                                | 2-methylpropene              | 8.29           | 2    |                                 |                               | 14.2           | 15   |
| C <sub>4</sub> H <sub>10</sub> | butane                       | 8.20           | 2    |                                 |                               | 14.9           | 2    |
|                                | isobutane                    | 8.14           | 27   |                                 | <i>m</i> -xylene              | 14.2           | 15   |
| C <sub>5</sub> H <sub>6</sub>  | 1,3-cyclopentadiene          | 8.64           | 2    | C <sub>8</sub> H <sub>16</sub>  | ethylcyclohexane              | 15.9           | 2    |
| C <sub>5</sub> H <sub>8</sub>  | 1-pentyne                    | 9.12           | 2    | C <sub>8</sub> H <sub>18</sub>  | <i>n</i> -octane              | 15.9           | 2    |
|                                | <i>trans</i> -1,3-pentadiene | 10.0           | 2    |                                 | 3-methylheptane               | 15.44          | 27   |
|                                | isoprene                     | 9.99           | 2    |                                 | 2,2,4-trimethylpentane        | 15.44          | 27   |
| C <sub>5</sub> H <sub>10</sub> | cyclopentane                 | 9.15           | 18   | C <sub>9</sub> H <sub>10</sub>  | $\alpha$ -methylstyrene       | 16.05          | 27   |
|                                | 1-pentene                    | 9.65           | 27   | C <sub>9</sub> H <sub>12</sub>  | isopropylbenzene              | 16.0           | 2†   |
|                                | 2-pentene                    | 9.84           | 27   |                                 | 1,3,5-trimethylbenzene        | 15.5           | 25   |
| C <sub>5</sub> H <sub>12</sub> | pentane                      | 9.99           | 2    |                                 |                               | 16.14          | 27   |
|                                | neopentane                   | 10.20          | 18   | C <sub>9</sub> H <sub>18</sub>  | isopropylcyclohexane          | 17.2           | 2    |
| C <sub>6</sub> H <sub>6</sub>  | benzene                      | 10.0           | 25   | C <sub>9</sub> H <sub>20</sub>  | nonane                        | 17.36          | 27   |
|                                |                              | 10.32          | 3    | C <sub>10</sub> H <sub>8</sub>  | naphthalene                   | 16.5           | 17   |
|                                |                              | 10.74          | 2    |                                 |                               | 17.48          | 27   |
| C <sub>6</sub> H <sub>10</sub> | 1-hexyne                     | 10.9           | 2†   | C <sub>10</sub> H <sub>14</sub> | durene                        | 17.3           | 25   |
|                                | 2-ethyl-1,3-butadiene        | 11.8           | 2†   |                                 | <i>tert</i> -butylbenzene     | 17.2           | 25   |
|                                | 3-methyl-1,3-pentadiene      | 11.8           | 2†   |                                 |                               | 17.8           | 2†   |
|                                | 2-methyl-1,3-pentadiene      | 12.1           | 2†   | C <sub>10</sub> H <sub>20</sub> | <i>tert</i> -butylcyclohexane | 19.8           | 2    |
|                                | 2,3-dimethyl-1,3-butadiene   | 11.8           | 2†   | C <sub>10</sub> H <sub>22</sub> | decane                        | 19.10          | 27   |
|                                | cyclohexene                  | 10.7           | 2†   | C <sub>11</sub> H <sub>10</sub> | $\alpha$ -methylnaphthalene   | 19.35          | 27   |
| C <sub>6</sub> H <sub>12</sub> | cyclohexane                  | 11.0           | 18   |                                 | $\beta$ -methylnaphthalene    | 19.52          | 27   |

| Molecule                        | Name                                   | Polarizability | Ref. | Molecule                        | Name                                    | Polarizability | Ref. |
|---------------------------------|----------------------------------------|----------------|------|---------------------------------|-----------------------------------------|----------------|------|
| C <sub>11</sub> H <sub>14</sub> | $\alpha,\beta,\beta$ -trimethylstyrene | 19.64          | 27   |                                 | phenanthrene                            | 36.8*          | 17   |
| C <sub>11</sub> H <sub>16</sub> | pentamethylbenzene                     | 19.1           | 25   |                                 |                                         | 24.70          | 27   |
| C <sub>11</sub> H <sub>24</sub> | undecane                               | 21.03          | 27   | C <sub>14</sub> H <sub>22</sub> | <i>p</i> -di- <i>tert</i> -butylbenzene | 24.5           | 25   |
| C <sub>12</sub> H <sub>10</sub> | acenaphthene                           | 20.61          | 27   | C <sub>16</sub> H <sub>10</sub> | pyrene                                  | 28.22          | 27   |
| C <sub>12</sub> H <sub>12</sub> | $\alpha$ -ethylnaphthalene             | 21.19          | 27   | C <sub>17</sub> H <sub>12</sub> | 2,3-benzfluorene                        | 30.21          | 27   |
|                                 | $\beta$ -ethylnaphthalene              | 21.36          | 27   | C <sub>18</sub> H <sub>12</sub> | naphthacene                             | 32.27          | 27   |
| C <sub>12</sub> H <sub>18</sub> | hexamethylbenzene                      | 20.9           | 25   |                                 | 1,2-benzanthracene                      | 32.86          | 27   |
| C <sub>12</sub> H <sub>26</sub> | dodecane                               | 22.75          | 27   |                                 | chrysene                                | 33.06          | 27   |
| C <sub>13</sub> H <sub>10</sub> | fluorene                               | 21.68          | 27   |                                 | triphenylene                            | 31.07          | 27   |
| C <sub>14</sub> H <sub>10</sub> | anthracene                             | 25.4           | 17   | C <sub>18</sub> H <sub>30</sub> | 1,3,5-tri- <i>tert</i> -butylbenzene    | 31.8           | 25   |
|                                 |                                        | 25.93          | 27   | C <sub>24</sub> H <sub>12</sub> | coronene                                | 42.50          | 27   |

TABLE 7. Average Electric Dipole Polarizabilities for Ground State Organic Halides (in Units of 10<sup>-24</sup> cm<sup>3</sup>)

| Molecule                                      | Name                          | Polarizability | Ref.           | Molecule                                                     | Name                              | Polarizability | Ref.           |
|-----------------------------------------------|-------------------------------|----------------|----------------|--------------------------------------------------------------|-----------------------------------|----------------|----------------|
| CBr <sub>2</sub> F <sub>2</sub>               | dibromodifluoromethane        | 9.0            | 2 <sup>†</sup> |                                                              | <i>trans</i> -dichloroethylene    | 8.15           | 27             |
| CClF <sub>3</sub>                             | chlorotrifluoromethane        | 5.72           | 20             |                                                              | <i>cis</i> -dichloroethylene      | 8.03           | 27             |
|                                               |                               | 5.59           | 2              | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub> | 1,1-dichloro-2,2-difluoroethane   | 8.4            | 2 <sup>†</sup> |
| CCl <sub>2</sub> F <sub>2</sub>               | dichlorodifluoromethane       | 7.93           | 20             |                                                              |                                   |                |                |
|                                               |                               | 7.81           | 2              | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O              | chloroacetyl chloride             | 8.92           | 2              |
| CCl <sub>2</sub> O                            | phosgene                      | 7.29           | 2              | C <sub>2</sub> H <sub>2</sub> Cl <sub>3</sub> F              | 1,2,2-trichloro-1-fluoroethane    | 10.2           | 2 <sup>†</sup> |
| CCl <sub>2</sub> S                            | thiophosgene                  | 10.2           | 2              | C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>                | 1,1,2,2-tetrachloroethane         | 12.1           | 2 <sup>†</sup> |
| CCl <sub>3</sub> F                            | trichlorofluoromethane        | 9.47           | 2              | C <sub>2</sub> H <sub>2</sub> ClN                            | chloroacetoneitrile               | 6.10           | 18             |
| CCl <sub>3</sub> NO <sub>2</sub>              | trichloronitromethane         | 10.8           | 2 <sup>†</sup> | C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>                 | 1,1-difluoroethylene              | 5.01           | 20             |
| CCl <sub>4</sub>                              | carbon tetrachloride          | 11.2           | 2              | C <sub>2</sub> H <sub>3</sub> Br                             | bromoethylene                     | 7.59           | 2              |
|                                               |                               | 10.5           | 3              | C <sub>2</sub> H <sub>3</sub> Cl                             | chloroethylene                    | 6.41           | 2              |
| CF <sub>4</sub>                               | carbon tetrafluoride          | 3.838          | 8              | C <sub>2</sub> H <sub>3</sub> ClF <sub>2</sub>               | 1-chloro-1,1-difluoroethane       | 8.05           | 2              |
| CF <sub>2</sub> O                             | carbonylfluoride              | 1.88*          | 17             | C <sub>2</sub> H <sub>3</sub> ClO                            | acetyl chloride                   | 6.62           | 2              |
| CHBr <sub>3</sub>                             | bromoform                     | 11.8           | 27             | C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>               | methyl chloroformate              | 7.1            | 2 <sup>†</sup> |
| CHBrF <sub>2</sub>                            | bromodifluoromethane          | 5.7            | 2 <sup>†</sup> | C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>                | 1,1,1-trichloroethane             | 10.7           | 2              |
| CHClF <sub>2</sub>                            | chlorodifluoromethane         | 6.38           | 20             | C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>                 | 1,1,1-trifluoroethane             | 4.4            | 2 <sup>†</sup> |
|                                               |                               | 5.91           | 2              | C <sub>2</sub> H <sub>3</sub> I                              | iodoethylene                      | 9.3            | 2 <sup>†</sup> |
| CHCl <sub>2</sub> F                           | dichlorofluoromethane         | 6.82           | 2              | C <sub>2</sub> H <sub>4</sub> BrCl                           | 1-bromo-2-chloroethane            | 9.5            | 2 <sup>†</sup> |
| CHCl <sub>3</sub>                             | chloroform                    | 9.5            | 8              | C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>                | 1,2-dibromoethane                 | 10.7           | 2 <sup>†</sup> |
|                                               |                               | 8.23           | 27             | C <sub>2</sub> H <sub>4</sub> ClF                            | 1-chloro-2-fluoroethane           | 6.5            | 2 <sup>†</sup> |
| CHF <sub>3</sub>                              | fluoroform                    | 3.52           | 20             | C <sub>2</sub> H <sub>4</sub> ClNO <sub>2</sub>              | 1-chloro-1-nitroethane            | 10.9           | 2              |
|                                               |                               | 3.57           | 8              | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                | 1,1-dichloroethane                | 8.64           | 2              |
| CHFO                                          | fluoroformaldehyde            | 1.76*          | 17             |                                                              | 1,2-dichloroethane                | 8.0            | 2 <sup>†</sup> |
| CHI <sub>3</sub>                              | iodoform                      | 18.0           | 27             | C <sub>2</sub> H <sub>5</sub> Br                             | bromoethane                       | 8.05           | 2              |
| CH <sub>2</sub> Br <sub>2</sub>               | dibromomethane                | 9.32           | 2              |                                                              |                                   | 7.28           | 27             |
|                                               |                               | 8.68           | 27             | C <sub>2</sub> H <sub>5</sub> Cl                             | chloroethane                      | 7.27           | 20             |
| CH <sub>2</sub> ClNO <sub>2</sub>             | chloronitromethane            | 6.9            | 2 <sup>†</sup> |                                                              |                                   | 8.29           | 2              |
| CH <sub>2</sub> Cl <sub>2</sub>               | dichloromethane               | 6.48           | 3              |                                                              |                                   | 6.4            | 15             |
|                                               |                               | 7.93           | 2              | C <sub>2</sub> H <sub>5</sub> ClO                            | 2-chloroethanol                   | 7.1            | 2 <sup>†</sup> |
| CH <sub>2</sub> I <sub>2</sub>                | diiodomethane                 | 12.90          | 27             |                                                              |                                   | 6.88           | 27             |
| CH <sub>3</sub> Br                            | bromomethane                  | 5.87           | 20             |                                                              | chloromethyl methyl ether         | 7.1            | 2 <sup>†</sup> |
|                                               |                               | 6.03           | 2              | C <sub>2</sub> H <sub>5</sub> F                              | fluoroethane                      | 4.96           | 2              |
|                                               |                               | 5.55           | 15             | C <sub>2</sub> H <sub>5</sub> I                              | iodoethane                        | 10.0           | 2              |
| CH <sub>3</sub> Cl                            | chloromethane                 | 5.35           | 20             | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                | dichloropropene                   | 10.1           | 2 <sup>†</sup> |
|                                               |                               | 4.72           | 8              | C <sub>3</sub> H <sub>5</sub> Cl                             | chloropropene                     | 8.3            | 2              |
| CH <sub>3</sub> F                             | fluoromethane                 | 2.97           | 8              | C <sub>3</sub> H <sub>5</sub> ClO                            | chloroacetone                     | 8.4            | 2 <sup>†</sup> |
| CH <sub>3</sub> I                             | iodomethane                   | 7.97           | 2              | C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>               | ethyl chloroformate               | 9.0            | 2 <sup>†</sup> |
| C <sub>2</sub> ClF <sub>5</sub>               | chloropentafluoroethane       | 6.3            | 2 <sup>†</sup> | C <sub>3</sub> H <sub>6</sub> ClNO <sub>2</sub>              | 1-chloro-1-nitropropane           | 10.4           | 2 <sup>†</sup> |
| C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub> | 1,2-dichlorotetrafluoroethane | 8.5            | 2 <sup>†</sup> | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                | dichloropropane                   | 10.9           | 2 <sup>†</sup> |
| C <sub>2</sub> Cl <sub>3</sub> N              | trichloroacetoneitrile        | 10.42          | 18             | C <sub>3</sub> H <sub>7</sub> Br                             | 1-bromopropane                    | 9.4            | 2 <sup>†</sup> |
| C <sub>2</sub> F <sub>6</sub>                 | hexafluoroethane              | 6.82           | 2              |                                                              |                                   | 9.07           | 27             |
| C <sub>2</sub> HBr                            | bromoacetylene                | 7.39           | 2              |                                                              | 2-bromopropane                    | 9.6            | 2 <sup>†</sup> |
| C <sub>2</sub> HCl                            | chloroacetylene               | 6.07           | 2              | C <sub>3</sub> H <sub>7</sub> Cl                             | chloropropane                     | 10.0           | 2              |
| C <sub>2</sub> HCl <sub>3</sub>               | trichloroethlyene             | 10.03          | 27             | C <sub>3</sub> H <sub>7</sub> ClO                            | $\beta$ -chloroethyl methyl ether | 8.71           | 27             |
| C <sub>2</sub> HCl <sub>5</sub>               | pentachloroethane             | 14.0           | 2              |                                                              | 2-chloro-1-propanol               | 8.89           | 27             |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> | 1,1-dichloroethylene          | 7.83           | 27             |                                                              | 3-chloro-1-propanol               | 8.84           | 27             |

| Molecule                                                     | Name                          | Polarizability | Ref.           | Molecule                                         | Name                                         | Polarizability | Ref.           |
|--------------------------------------------------------------|-------------------------------|----------------|----------------|--------------------------------------------------|----------------------------------------------|----------------|----------------|
| C <sub>3</sub> H <sub>7</sub> I                              | 1-iodopropane                 | 11.5           | 2 <sup>†</sup> | C <sub>6</sub> H <sub>5</sub> Br                 | bromobenzene                                 | 14.7           | 2              |
| C <sub>4</sub> H <sub>5</sub> Cl                             | 4-chloro-1,2-butadiene        | 10.0           | 2 <sup>†</sup> |                                                  |                                              | 13.62          | 27             |
| C <sub>4</sub> H <sub>7</sub> Cl                             | 1-chloro-2-methylpropene      | 10.8           | 2              | C <sub>6</sub> H <sub>5</sub> Cl                 | chlorobenzene                                | 14.1           | 2              |
| C <sub>4</sub> H <sub>7</sub> ClO <sub>2</sub>               | 2-chlorobutyric acid          | 10.87          | 27             |                                                  |                                              | 12.3           | 15             |
|                                                              | 3-chlorobutyric acid          | 10.80          | 27             | C <sub>6</sub> H <sub>5</sub> ClO                | chlorophenol                                 | 13.0           | 2 <sup>†</sup> |
|                                                              | 4-chlorobutyric acid          | 10.69          | 27             | C <sub>6</sub> H <sub>5</sub> F                  | fluorobenzene                                | 10.3           | 2              |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>                | 1,4-dichlorobutane            | 12.0           | 2 <sup>†</sup> | C <sub>6</sub> H <sub>5</sub> I                  | iodobenzene                                  | 15.5           | 2 <sup>†</sup> |
| C <sub>4</sub> H <sub>9</sub> Br                             | bromobutane                   | 13.9           | 2              | C <sub>6</sub> H <sub>11</sub> ClO <sub>2</sub>  | ethyl 2-chlorobutanoate                      | 14.16          | 27             |
|                                                              |                               | 10.86          | 27             |                                                  | ethyl 3-chlorobutanoate                      | 14.13          | 27             |
| C <sub>4</sub> H <sub>9</sub> Cl                             | 1-chlorobutane                | 11.3           | 2              |                                                  | ethyl 4-chlorobutanoate                      | 14.11          | 27             |
|                                                              | 1-chloro-2-methylpropane      | 11.1           | 2              | C <sub>6</sub> H <sub>13</sub> Br                | bromohexane                                  | 14.44          | 27             |
|                                                              | 2-chloro-2-methylpropane      | 12.5           | 2 <sup>†</sup> | C <sub>6</sub> H <sub>13</sub> F                 | fluorohexane                                 | 11.80          | 27             |
|                                                              | 2-chlorobutane                | 12.4           | 2              | C <sub>7</sub> H <sub>7</sub> Br                 | <i>p</i> -bromotoluene                       | 14.80          | 27             |
| C <sub>4</sub> H <sub>9</sub> ClO                            | β-chloroethyl ethyl ether     | 10.56          | 27             | C <sub>7</sub> H <sub>7</sub> Cl                 | <i>p</i> -chlorotoluene                      | 13.70          | 27             |
|                                                              | 2-chloro-1-butanol            | 10.70          | 27             | C <sub>7</sub> H <sub>7</sub> F                  | <i>p</i> -fluorotoluene                      | 11.70          | 27             |
|                                                              | 3-chloro-1-butanol            | 10.38          | 27             | C <sub>7</sub> H <sub>7</sub> I                  | <i>p</i> -iodotoluene                        | 17.10          | 27             |
| C <sub>4</sub> H <sub>9</sub> I                              | 1-iodobutane                  | 13.3           | 2 <sup>†</sup> | C <sub>7</sub> H <sub>15</sub> Br                | 1-bromoheptane                               | 16.8           | 2 <sup>†</sup> |
|                                                              |                               | 12.65          | 27             |                                                  |                                              | 16.23          | 27             |
| C <sub>5</sub> H <sub>9</sub> ClO <sub>2</sub>               | methyl 2-chlorobutanoate      | 12.33          | 27             | C <sub>7</sub> H <sub>15</sub> F                 | fluoroheptane                                | 13.66          | 27             |
|                                                              | methyl 3-chlorobutanoate      | 12.31          | 27             | C <sub>8</sub> H <sub>17</sub> Br                | bromooctane                                  | 18.02          | 27             |
|                                                              | methyl 4-chlorobutanoate      | 12.27          | 27             | C <sub>8</sub> H <sub>17</sub> F                 | fluorooctane                                 | 15.46          | 27             |
|                                                              | 2-chloropentanoic acid        | 12.69          | 27             | C <sub>9</sub> H <sub>19</sub> Br                | bromononane                                  | 19.81          | 27             |
|                                                              | 3-chloropentanoic acid        | 12.57          | 27             | C <sub>9</sub> H <sub>19</sub> F                 | fluorononane                                 | 17.34          | 27             |
|                                                              | 4-chloropentanoic acid        | 12.53          | 27             | C <sub>10</sub> F <sub>8</sub>                   | octafluoronaphthalene                        | 17.64          | 27             |
| C <sub>5</sub> H <sub>11</sub> Br                            | 1-bromopentane                | 13.1           | 2 <sup>†</sup> | C <sub>10</sub> H <sub>7</sub> Br                | α-bromonaphthalene                           | 20.34          | 27             |
| C <sub>5</sub> H <sub>11</sub> Cl                            | 1-chloropentane               | 12.0           | 2 <sup>†</sup> | C <sub>10</sub> H <sub>7</sub> Cl                | α-chloronaphthalene                          | 19.30          | 27             |
| C <sub>5</sub> H <sub>11</sub> F                             | fluoropentane                 | 9.95           | 27             |                                                  | β-chloronaphthalene                          | 19.58          | 27             |
| C <sub>6</sub> F <sub>6</sub>                                | hexafluorobenzene             | 9.58           | 27             | C <sub>10</sub> H <sub>7</sub> I                 | α-iodonaphthalene                            | 22.41          | 27             |
| C <sub>6</sub> HF <sub>5</sub>                               | pentafluorobenzene            | 9.63           | 27             |                                                  | β-iodonaphthalene                            | 22.95          | 27             |
| C <sub>6</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub> | 2,5-dichloro-1,4-benzoquinone | 18.4           | 2              | C <sub>10</sub> H <sub>21</sub> Br               | bromodecane                                  | 21.60          | 27             |
| C <sub>6</sub> H <sub>2</sub> F <sub>4</sub>                 | 1,2,3,4-tetrafluorobenzene    | 9.69           | 27             | C <sub>10</sub> H <sub>21</sub> F                | fluorodecane                                 | 19.18          | 27             |
|                                                              | 1,2,4,5-tetrafluorobenzene    | 9.69           | 27             | C <sub>11</sub> H <sub>23</sub> F                | fluoroundecane                               | 21.00          | 27             |
| C <sub>6</sub> H <sub>3</sub> F <sub>3</sub>                 | 1,3,5-trifluorobenzene        | 9.74           | 27             | C <sub>12</sub> H <sub>25</sub> Br               | bromododecane                                | 25.18          | 27             |
| C <sub>6</sub> H <sub>4</sub> BrF                            | <i>p</i> -bromofluorobenzene  | 13.4           | 2 <sup>†</sup> | C <sub>12</sub> H <sub>25</sub> F                | fluorododecane                               | 22.83          | 27             |
| C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>              | chloronitrobenzene            | 14.6           | 2 <sup>†</sup> | C <sub>12</sub> H <sub>8</sub> Br <sub>2</sub> O | 4,4'-dibromodiphenyl ether                   | 27.8           | 2 <sup>†</sup> |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                | <i>o</i> -dichlorobenzene     | 14.17          | 27             | C <sub>12</sub> H <sub>8</sub> BrO               | 4-bromodiphenyl ether                        | 24.2           | 2 <sup>†</sup> |
|                                                              | <i>m</i> -dichlorobenzene     | 14.23          | 27             | C <sub>13</sub> H <sub>11</sub> BrO              | <i>p</i> -bromophenyl- <i>p</i> -tolyl ether | 26.6           | 2 <sup>†</sup> |
|                                                              | <i>p</i> -dichlorobenzene     | 14.20          | 27             | C <sub>14</sub> H <sub>9</sub> Br                | 9-bromoanthracene                            | 28.32          | 27             |
| C <sub>6</sub> H <sub>4</sub> FI                             | <i>p</i> -fluoriodobenzene    | 15.5           | 2 <sup>†</sup> | C <sub>14</sub> H <sub>9</sub> Cl                | 9-chloroanthracene                           | 27.35          | 27             |
| C <sub>6</sub> H <sub>4</sub> FNO <sub>2</sub>               | <i>p</i> -fluoronitrobenzene  | 12.8           | 2 <sup>†</sup> | C <sub>14</sub> H <sub>9</sub> F                 | fluoranthracene                              | 28.34          | 27             |
| C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>                 | <i>o</i> -difluorobenzene     | 9.80           | 27             | C <sub>14</sub> H <sub>25</sub> F                | fluorotetradecane                            | 26.57          | 27             |
|                                                              | <i>m</i> -difluorobenzene     | 10.3           | 2 <sup>†</sup> | C <sub>16</sub> H <sub>33</sub> Br               | bromohexadecane                              | 32.34          | 27             |
|                                                              | <i>p</i> -difluorobenzene     | 9.80           | 27             | C <sub>18</sub> H <sub>37</sub> Br               | bromooctadecane                              | 35.92          | 27             |

TABLE 8. Static Average Electric Dipole Polarizabilities for Other Ground State Organic Molecules (in Units of 10<sup>-24</sup> cm<sup>3</sup>)

| Molecule                        | Name              | Polarizability | Ref.           | Molecule                                      | Name                       | Polarizability | Ref.           |
|---------------------------------|-------------------|----------------|----------------|-----------------------------------------------|----------------------------|----------------|----------------|
| CN <sub>4</sub> O <sub>8</sub>  | tetranitromethane | 15.3           | 2              | C <sub>2</sub> H <sub>3</sub> N               | acetonitrile               | 4.40           | 2 <sup>†</sup> |
| CH <sub>2</sub> O               | formaldehyde      | 2.8            | 2 <sup>†</sup> |                                               |                            | 4.48           | 18             |
|                                 |                   | 2.45           | 18             | C <sub>2</sub> H <sub>4</sub> O               | acetaldehyde               | 4.6            | 2 <sup>†</sup> |
| CH <sub>2</sub> O <sub>2</sub>  | formic acid       | 3.4            | 2 <sup>†</sup> |                                               |                            | 4.59           | 18             |
| CH <sub>3</sub> NO              | formamide         | 4.2            | 2 <sup>†</sup> |                                               | ethylene oxide             | 4.43           | 18             |
|                                 |                   | 4.08           | 18             | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>  | acetic acid                | 5.1            | 2 <sup>†</sup> |
| CH <sub>3</sub> NO <sub>2</sub> | nitromethane      | 7.37           | 2              |                                               | methyl formate             | 5.05           | 27             |
| CH <sub>4</sub> O               | methanol          | 3.29           | 2              | C <sub>2</sub> H <sub>4</sub> O <sub>4</sub>  | formic acid dimer          | 12.7           | 2              |
|                                 |                   | 3.23           | 15             | C <sub>2</sub> H <sub>5</sub> NO              | acetamide                  | 5.67           | 18             |
|                                 |                   | 3.32           | 18             |                                               | <i>N</i> -methyl formamide | 5.91           | 18             |
| CH <sub>5</sub> N               | methyl amine      | 4.7            | 2              | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub> | nitroethane                | 9.63           | 2              |
|                                 |                   | 4.01           | 19             |                                               | ethyl nitrite              | 7.0            | 15             |
|                                 |                   | 4.01*          | 33             | C <sub>2</sub> H <sub>6</sub> O               | ethanol                    | 5.41           | 2              |
| C <sub>2</sub> N <sub>2</sub>   | cyanogen          | 7.99           | 2              |                                               |                            | 5.11           | 18             |
| C <sub>2</sub> H <sub>2</sub> O | ketene            | 4.4            | 2 <sup>†</sup> |                                               | methyl ether               | 5.29           | 20             |

| Molecule                                       | Name                             | Polarizability | Ref.           | Molecule                                                    | Name                            | Polarizability | Ref.           |
|------------------------------------------------|----------------------------------|----------------|----------------|-------------------------------------------------------------|---------------------------------|----------------|----------------|
|                                                |                                  | 5.84           | 2              |                                                             | 1,4-dioxane                     | 10.0           | 2              |
|                                                |                                  | 5.16           | 15             |                                                             | <i>p</i> -dioxane               | 8.60           | 18             |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>   | ethylene glycol                  | 5.7            | 2 <sup>†</sup> |                                                             | 2-methyl-1,3-dioxolane          | 9.44           | 15             |
|                                                |                                  | 5.61           | 27             |                                                             | butyric acid                    | 8.58           | 27             |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub> S | dimethyl sulfone                 | 7.3            | 2 <sup>†</sup> |                                                             | methyl propionate               | 8.97           | 27             |
| C <sub>2</sub> H <sub>6</sub> S                | ethanethiol                      | 7.41           | 2              | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>               | 1-nitrobutane                   | 10.4           | 2 <sup>†</sup> |
| C <sub>2</sub> H <sub>7</sub> N                | ethyl amine                      | 7.10           | 2              |                                                             | 2-methyl-2-nitropropane         | 10.3           | 2 <sup>†</sup> |
|                                                | dimethyl amine                   | 6.37           | 2              | C <sub>4</sub> H <sub>10</sub> O                            | ethyl ether                     | 10.2           | 2              |
|                                                |                                  | 5.90*          | 33             |                                                             |                                 | 8.73           | 15             |
| C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>   | ethylene diamine                 | 7.2            | 2 <sup>†</sup> |                                                             | 1-butanol                       | 8.88           | 2              |
| C <sub>3</sub> H <sub>2</sub> N <sub>2</sub>   | malononitrile                    | 5.79           | 18             |                                                             | 2-methylpropanol                | 8.92           | 2              |
| C <sub>3</sub> H <sub>3</sub> N                | acrylonitrile                    | 8.05           | 2              |                                                             | methyl propyl ether             | 8.86           | 27             |
| C <sub>3</sub> H <sub>4</sub> N <sub>2</sub>   | pyrazole                         | 7.23           | 27             |                                                             | ethylene glycol monoethyl ether | 9.28           | 27             |
| C <sub>3</sub> H <sub>4</sub> O                | propenal                         | 6.38           | 2 <sup>†</sup> | C <sub>4</sub> H <sub>10</sub> S                            | ethyl sulfide                   | 10.8           | 2              |
| C <sub>3</sub> H <sub>5</sub> N                | propionitrile                    | 6.70           | 2              | C <sub>4</sub> H <sub>11</sub> N                            | butylamine                      | 13.5           | 2              |
|                                                |                                  | 6.24           | 18             |                                                             | diethylamine                    | 10.2           | 2              |
|                                                |                                  | 6.27*          | 32             |                                                             |                                 | 9.61           | 27             |
| C <sub>3</sub> H <sub>6</sub> O                | acetone                          | 6.33           | 15             | C <sub>5</sub> H <sub>5</sub> N                             | pyridine                        | 9.5            | 15             |
|                                                |                                  | 6.4            | 2 <sup>†</sup> |                                                             |                                 | 9.18           | 27             |
|                                                |                                  | 6.39           | 18             |                                                             | 4-cyano-1,3-butadiene           | 10.5           | 2 <sup>†</sup> |
|                                                | allyl alcohol                    | 7.65           | 2              | C <sub>5</sub> H <sub>8</sub> N <sub>2</sub>                | 1,5-dimethylpyrazole            | 10.72          | 27             |
|                                                | propionaldehyde                  | 6.50           | 2              | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                | acetyl acetone                  | 10.5           | 2 <sup>†</sup> |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | propionic acid                   | 6.9            | 2 <sup>†</sup> | C <sub>5</sub> H <sub>9</sub> N                             | valeronitrile                   | 10.4           | 2              |
|                                                | ethyl formate                    | 8.01           | 2              |                                                             | 22-DMPN                         | 9.59           | 18             |
|                                                |                                  | 6.88           | 27             | C <sub>5</sub> H <sub>10</sub> O                            | diethyl ketone                  | 9.93           | 15             |
|                                                | methyl acetate                   | 6.94           | 2              |                                                             | methyl propyl ketone            | 9.93           | 15             |
|                                                |                                  | 6.81           | 27             | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>               | ethyl propionate                | 10.41          | 27             |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>   | dimethyl carbonate               | 7.7            | 2 <sup>†</sup> |                                                             | methyl butanoate                | 10.41          | 27             |
| C <sub>3</sub> H <sub>7</sub> NO               | <i>N</i> -methyl acetamide       | 7.82           | 18             | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>               | diethyl carbonate               | 11.3           | 2              |
|                                                | <i>N,N</i> -dimethyl formamide   | 7.81           | 18             | C <sub>5</sub> H <sub>12</sub> O                            | ethyl propyl ether              | 10.68          | 27             |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>  | nitropropane                     | 8.5            | 2 <sup>†</sup> | C <sub>5</sub> H <sub>12</sub> O <sub>4</sub>               | tetramethyl orthocarbonate      | 13.0           | 2 <sup>†</sup> |
| C <sub>3</sub> H <sub>8</sub> O                | 2-propanol                       | 7.61           | 2              | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub> | <i>p</i> -dinitrobenzene        | 18.4           | 2              |
|                                                |                                  | 6.97           | 18             | C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>                | <i>p</i> -benzoquinone          | 14.5           | 2              |
|                                                | 1-propanol                       | 6.74           | 2              | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>               | nitrobenzene                    | 14.7           | 2              |
|                                                | ethyl methyl ether               | 7.93           | 2              |                                                             |                                 | 12.92          | 15             |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>   | dimethoxymethane                 | 7.7            | 2 <sup>†</sup> | C <sub>6</sub> H <sub>6</sub> O                             | phenol                          | 11.1           | 2 <sup>†</sup> |
|                                                | ethylene glycol monomethyl ether | 7.44           | 27             |                                                             |                                 | 9.94*          | 17             |
| C <sub>3</sub> H <sub>9</sub> N                | propylamine                      | 7.70           | 27             | C <sub>6</sub> H <sub>7</sub> N                             | aniline                         | 12.1           | 2 <sup>†</sup> |
|                                                |                                  | 9.20           | 2              | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                | phenylenediamine                | 13.8           | 2 <sup>†</sup> |
|                                                | isopropylamine                   | 7.77           | 27             |                                                             | phenylhydrazine                 | 12.91          | 27             |
|                                                | trimethylamine                   | 8.15           | 2              | C <sub>6</sub> H <sub>10</sub> N <sub>2</sub>               | 1-ethyl-5-methylpyrazole        | 12.50          | 27             |
|                                                |                                  | 7.78*          | 33             | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>               | ethyl acetoacetate              | 12.9           | 2 <sup>†</sup> |
| C <sub>4</sub> H <sub>2</sub> N <sub>2</sub>   | fumaronitrile                    | 11.8           | 2              | C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>               | dimethylketazine                | 15.6           | 2              |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>   | succinonitrile                   | 8.1            | 2 <sup>†</sup> | C <sub>6</sub> H <sub>12</sub> O                            | cyclohexanol                    | 11.56          | 18             |
|                                                | pyrimidine                       | 8.53*          | 17             | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>               | amyl formate                    | 14.2           | 2              |
|                                                | pyridazine                       | 9.27*          | 17             | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>               | paraldehyde                     | 17.9           | 2              |
| C <sub>4</sub> H <sub>4</sub> O <sub>2</sub>   | diketene                         | 8.0            | 2 <sup>†</sup> | C <sub>6</sub> H <sub>14</sub> O                            | propyl ether                    | 12.8           | 2              |
| C <sub>4</sub> H <sub>4</sub> S                | thiophene                        | 9.67           | 2              |                                                             |                                 | 12.5           | 15             |
| C <sub>4</sub> H <sub>5</sub> N                | methacrylonitrile                | 8.0            | 2 <sup>†</sup> | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>               | 1,1-diethoxyethane              | 13.2           | 2 <sup>†</sup> |
|                                                | <i>trans</i> -crotononitrile     | 8.2            | 2 <sup>†</sup> |                                                             | 1,2-diethoxyethane              | 11.3           | 2 <sup>†</sup> |
| C <sub>4</sub> H <sub>6</sub> N <sub>2</sub>   | <i>N</i> -methylpyrazole         | 8.99           | 27             | C <sub>6</sub> H <sub>15</sub> N                            | triethylamine                   | 13.1           | 2              |
| C <sub>4</sub> H <sub>6</sub> O                | crotonaldehyde                   | 8.5            | 2 <sup>†</sup> |                                                             |                                 | 13.38          | 27             |
|                                                | methacrylaldehyde                | 8.3            | 2 <sup>†</sup> |                                                             | dipropylamine                   | 13.29          | 27             |
|                                                |                                  | 8.2            | 2 <sup>†</sup> | C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> | <i>p</i> -cyanonitrobenzene     | 19.0           | 2              |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | biacetyl                         | 8.2            | 2 <sup>†</sup> | C <sub>7</sub> H <sub>5</sub> N                             | benzonitrile                    | 12.5           | 2 <sup>†</sup> |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>   | acetic anhydride                 | 8.9            | 2 <sup>†</sup> | C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub>               | nitroanisole                    | 15.7           | 2 <sup>†</sup> |
| C <sub>4</sub> H <sub>6</sub> S                | divinyl sulfide                  | 10.9           | 2 <sup>†</sup> | C <sub>7</sub> H <sub>8</sub> O                             | anisole                         | 13.1           | 2 <sup>†</sup> |
| C <sub>4</sub> H <sub>7</sub> N                | butyronitrile                    | 8.4            | 2 <sup>†</sup> | C <sub>7</sub> H <sub>9</sub> NO                            | <i>o</i> -anisidine             | 14.2           | 2 <sup>†</sup> |
|                                                | isobutyronitrile                 | 8.05           | 18             | C <sub>7</sub> H <sub>10</sub> N <sub>2</sub>               | 1,1-methylphenylhydrazine       | 14.81          | 27             |
|                                                |                                  | 8.05*          | 32             | C <sub>7</sub> H <sub>14</sub> O                            | cyclohexyl methyl ether         | 13.4           | 2 <sup>†</sup> |
| C <sub>4</sub> H <sub>8</sub> O                | butanal                          | 8.2            | 2 <sup>†</sup> |                                                             | 2,4-dimethyl-3-pentanone        | 13.5           | 15             |
|                                                | methyl ethyl ketone              | 8.13           | 15             | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>               | pentyl acetate                  | 14.9           | 2              |
|                                                | <i>trans</i> -2,3-epoxy butane   | 8.22*          | 17             | C <sub>8</sub> H <sub>4</sub> N <sub>2</sub>                | <i>p</i> -dicyanobenzene        | 19.2           | 2              |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | ethyl acetate                    | 9.7            | 2              |                                                             |                                 |                |                |
|                                                |                                  | 8.62           | 27             |                                                             |                                 |                |                |

| Molecule                                      | Name                             | Polarizability | Ref.           | Molecule                                          | Name                      | Polarizability | Ref.           |
|-----------------------------------------------|----------------------------------|----------------|----------------|---------------------------------------------------|---------------------------|----------------|----------------|
| C <sub>8</sub> H <sub>6</sub> N <sub>2</sub>  | quinoxaline                      | 15.13          | 27             |                                                   | 2-methylquinoline         | 18.65          | 27             |
| C <sub>6</sub> H <sub>8</sub> O               | acetophenone                     | 15.0           | 2              |                                                   | 1-methylisoquinoline      | 18.28          | 27             |
| C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | 2,5-dimethyl-1,4-benzoquinone    | 18.8           | 2              | C <sub>10</sub> H <sub>10</sub> Fe                | ferrocene                 | 17.1           | 26             |
| C <sub>8</sub> H <sub>10</sub> O              | phenetole                        | 14.9           | 2              | C <sub>10</sub> H <sub>10</sub> N <sub>2</sub>    | 2,3-dimethylquinoxaline   | 18.70          | 27             |
| C <sub>8</sub> H <sub>11</sub> N              | N-dimethylaniline                | 16.2           | 2 <sup>†</sup> | C <sub>10</sub> H <sub>14</sub> BeO <sub>4</sub>  | beryllium acetylacetonate | 34.1           | 2              |
| C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> | 1,1-ethylphenylhydrazine         | 16.62          | 27             | C <sub>11</sub> H <sub>8</sub> O                  | 1-naphthaldehyde          | 19.75          | 27             |
| C <sub>8</sub> H <sub>12</sub> O <sub>2</sub> | ethyl sorbate                    | 17.2           | 2 <sup>†</sup> |                                                   | 2-naphthaldehyde          | 20.06          | 27             |
|                                               | tetramethylcyclobutane-1,3-dione | 18.6           | 2              | C <sub>12</sub> H <sub>8</sub> N <sub>2</sub>     | phenazine                 | 23.43          | 27             |
| C <sub>8</sub> H <sub>14</sub> O <sub>4</sub> | diethyl succinate                | 16.8           | 2 <sup>†</sup> | C <sub>12</sub> H <sub>9</sub> NO <sub>3</sub>    | 4-nitrodiphenyl ether     | 24.7           | 2 <sup>†</sup> |
| C <sub>8</sub> H <sub>18</sub> O              | butyl ether                      | 17.2           | 2              | C <sub>14</sub> H <sub>8</sub> O <sub>2</sub>     | anthraquinone             | 24.46          | 27             |
| C <sub>9</sub> H <sub>7</sub> N               | quinoline                        | 15.70          | 27             | C <sub>14</sub> H <sub>14</sub> O                 | di- <i>p</i> -tolyl ether | 24.9           | 2 <sup>†</sup> |
|                                               | isoquinoline                     | 16.43          | 27             | C <sub>15</sub> H <sub>21</sub> AlO <sub>6</sub>  | aluminum acetylacetonate  | 51.9           | 2              |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub> | ethyl benzoate                   | 16.9           | 2 <sup>†</sup> | C <sub>15</sub> H <sub>21</sub> CrO <sub>6</sub>  | chromium acetylacetonate  | 53.7           | 2              |
| C <sub>9</sub> H <sub>21</sub> N              | tripropylamine                   | 18.87          | 27             | C <sub>15</sub> H <sub>21</sub> FeO <sub>6</sub>  | ferric acetylacetonate    | 58.1           | 2              |
| C <sub>10</sub> H <sub>9</sub> N              | α-naphthylamine                  | 19.50          | 27             | C <sub>20</sub> H <sub>26</sub> O <sub>8</sub> Th | thorium acetylacetonate   | 79.0           | 2              |
|                                               | β-naphthylamine                  | 19.73          | 27             | C <sub>60</sub>                                   | buckminsterfullerene      | 76.5           | 24             |
|                                               |                                  |                |                |                                                   |                           | 79             | 31             |

*Note:* All polarizabilities in the tables are experimental values except those values marked by an asterisk (\*), which indicates a calculated result. The experimental polarizabilities are mostly determined by measurements of a dielectric constant or refractive index that are quite accurate (0.5% or better). However, one should treat many of the results with several percent of caution because of the age of the data and because some of the results refer to optical frequencies rather than static. Comments given with the references are intended to allow one to judge the degree of caution required. Interested persons should consult these references. In many cases, the reference given is to a theoretical paper in which the experimental results are quoted. These papers, noted in the References, contain valuable information on polarizability calculations and experimental data which often includes the tensor components of the polarizability.

An empirical additive formula for molecular polarizabilities at 589 nm frequency has been given in Bosque, R., and Sales, J., *J. Chem. Inf. Comput. Sci.* 42, 1154, 2002:  $\alpha = 0.32 + 1.51\#C + 0.17\#H + 0.57\#O + 1.05\#N + 2.99\#S + 2.48\#P + 2.16\#Cl + 3.29\#Br + 5.45\#I$ , where "#C" denotes the number of carbon atoms in the molecule, etc.

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# IONIZATION ENERGIES OF ATOMS AND ATOMIC IONS

The ionization energies (often called ionization potentials) of neutral and partially ionized atoms are listed in this table. Data were obtained from the compilations cited below, supplemented by results from the recent research literature. Values for the first and second ionization energies come from Reference 6. All values are given in electron volts (eV).

Following the traditional spectroscopic notation, columns are headed I, II, III, etc. up to XXX, where I indicates the neutral atom, II the singly ionized atom, III the doubly ionized atom, etc. The first section of the table includes spectra I to VIII of all the elements through rutherfordium; subsequent sections cover higher spectra (ionization stages) for those elements for which data are available.

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## Neutral Atoms to +7 Ions

| Z  | Element | I         | II        | III       | IV        | V         | VI        | VII      | VIII     |
|----|---------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|
| 1  | H       | 13.598443 |           |           |           |           |           |          |          |
| 2  | He      | 24.587387 | 54.417760 |           |           |           |           |          |          |
| 3  | Li      | 5.391719  | 75.6400   | 122.45429 |           |           |           |          |          |
| 4  | Be      | 9.32270   | 18.21114  | 153.89661 | 217.71865 |           |           |          |          |
| 5  | B       | 8.29802   | 25.1548   | 37.93064  | 259.37521 | 340.22580 |           |          |          |
| 6  | C       | 11.26030  | 24.3833   | 47.8878   | 64.4939   | 392.087   | 489.99334 |          |          |
| 7  | N       | 14.5341   | 29.6013   | 47.44924  | 77.4735   | 97.8902   | 552.0718  | 667.046  |          |
| 8  | O       | 13.61805  | 35.1211   | 54.9355   | 77.41353  | 113.8990  | 138.1197  | 739.29   | 871.4101 |
| 9  | F       | 17.4228   | 34.9708   | 62.7084   | 87.1398   | 114.2428  | 157.1651  | 185.186  | 953.9112 |
| 10 | Ne      | 21.56454  | 40.96296  | 63.45     | 97.12     | 126.21    | 157.93    | 207.2759 | 239.0989 |
| 11 | Na      | 5.139076  | 47.2864   | 71.6200   | 98.91     | 138.40    | 172.18    | 208.50   | 264.25   |
| 12 | Mg      | 7.646235  | 15.03527  | 80.1437   | 109.2655  | 141.27    | 186.76    | 225.02   | 265.96   |
| 13 | Al      | 5.985768  | 18.82855  | 28.44765  | 119.992   | 153.825   | 190.49    | 241.76   | 284.66   |
| 14 | Si      | 8.15168   | 16.34584  | 33.49302  | 45.14181  | 166.767   | 205.27    | 246.5    | 303.54   |
| 15 | P       | 10.48669  | 19.7695   | 30.2027   | 51.4439   | 65.0251   | 220.421   | 263.57   | 309.60   |
| 16 | S       | 10.36001  | 23.33788  | 34.79     | 47.222    | 72.5945   | 88.0530   | 280.948  | 328.75   |
| 17 | Cl      | 12.96763  | 23.8136   | 39.61     | 53.4652   | 67.8      | 97.03     | 114.1958 | 348.28   |
| 18 | Ar      | 15.759610 | 27.62966  | 40.74     | 59.81     | 75.02     | 91.009    | 124.323  | 143.460  |
| 19 | K       | 4.3406633 | 31.63     | 45.806    | 60.91     | 82.66     | 99.4      | 117.56   | 154.88   |
| 20 | Ca      | 6.11316   | 11.87172  | 50.9131   | 67.27     | 84.50     | 108.78    | 127.2    | 147.24   |
| 21 | Sc      | 6.56149   | 12.79977  | 24.75666  | 73.4894   | 91.65     | 110.68    | 138.0    | 158.1    |
| 22 | Ti      | 6.82812   | 13.5755   | 27.4917   | 43.2672   | 99.30     | 119.53    | 140.8    | 170.4    |
| 23 | V       | 6.74619   | 14.618    | 29.311    | 46.709    | 65.2817   | 128.13    | 150.6    | 173.4    |
| 24 | Cr      | 6.76651   | 16.4857   | 30.96     | 49.16     | 69.46     | 90.6349   | 160.18   | 184.7    |
| 25 | Mn      | 7.43402   | 15.6400   | 33.668    | 51.2      | 72.4      | 95.6      | 119.203  | 194.5    |
| 26 | Fe      | 7.9024    | 16.1877   | 30.652    | 54.8      | 75.0      | 99.1      | 124.98   | 151.06   |
| 27 | Co      | 7.88101   | 17.084    | 33.50     | 51.3      | 79.5      | 102.0     | 128.9    | 157.8    |
| 28 | Ni      | 7.6398    | 18.16884  | 35.19     | 54.9      | 76.06     | 108       | 133      | 162      |
| 29 | Cu      | 7.72638   | 20.2924   | 36.841    | 57.38     | 79.8      | 103       | 139      | 166      |
| 30 | Zn      | 9.394199  | 17.96439  | 39.723    | 59.4      | 82.6      | 108       | 134      | 174      |
| 31 | Ga      | 5.999301  | 20.51515  | 30.7258   | 63.241    | 86.01     | 112.7     | 140.9    | 169.9    |
| 32 | Ge      | 7.89943   | 15.93461  | 34.2241   | 45.7131   | 93.5      |           |          |          |
| 33 | As      | 9.7886    | 18.5892   | 28.351    | 50.13     | 62.63     | 127.6     |          |          |
| 34 | Se      | 9.75239   | 21.19     | 30.8204   | 42.9450   | 68.3      | 81.7      | 155.4    |          |
| 35 | Br      | 11.8138   | 21.591    | 36        | 47.3      | 59.7      | 88.6      | 103.0    | 192.8    |
| 36 | Kr      | 13.99961  | 24.35984  | 36.950    | 52.5      | 64.7      | 78.5      | 111.0    | 125.802  |
| 37 | Rb      | 4.177128  | 27.2895   | 40        | 52.6      | 71.0      | 84.4      | 99.2     | 136      |
| 38 | Sr      | 5.69485   | 11.0301   | 42.89     | 57        | 71.6      | 90.8      | 106      | 122.3    |
| 39 | Y       | 6.2173    | 12.224    | 20.52     | 60.597    | 77.0      | 93.0      | 116      | 129      |
| 40 | Zr      | 6.63390   | 13.1      | 22.99     | 34.34     | 80.348    |           |          |          |
| 41 | Nb      | 6.75885   | 14.0      | 25.04     | 38.3      | 50.55     | 102.057   | 125      |          |

| Neutral Atoms to +7 Ions |         |          |          |          |          |       |         |         |       |
|--------------------------|---------|----------|----------|----------|----------|-------|---------|---------|-------|
| Z                        | Element | I        | II       | III      | IV       | V     | VI      | VII     | VIII  |
| 42                       | Mo      | 7.09243  | 16.16    | 27.13    | 46.4     | 54.49 | 68.8276 | 125.664 | 143.6 |
| 43                       | Tc      | 7.28     | 15.26    | 29.54    |          |       |         |         |       |
| 44                       | Ru      | 7.36050  | 16.76    | 28.47    |          |       |         |         |       |
| 45                       | Rh      | 7.45890  | 18.08    | 31.06    |          |       |         |         |       |
| 46                       | Pd      | 8.3369   | 19.43    | 32.93    |          |       |         |         |       |
| 47                       | Ag      | 7.57623  | 21.47746 | 34.83    |          |       |         |         |       |
| 48                       | Cd      | 8.99382  | 16.90831 | 37.48    |          |       |         |         |       |
| 49                       | In      | 5.78636  | 18.8703  | 28.03    | 54       |       |         |         |       |
| 50                       | Sn      | 7.34392  | 14.6322  | 30.50260 | 40.73502 | 72.28 |         |         |       |
| 51                       | Sb      | 8.60839  | 16.63    | 25.3     | 44.2     | 56    | 108     |         |       |
| 52                       | Te      | 9.0096   | 18.6     | 27.96    | 37.41    | 58.75 | 70.7    | 137     |       |
| 53                       | I       | 10.45126 | 19.1313  | 33       |          |       |         |         |       |
| 54                       | Xe      | 12.12984 | 20.9750  | 32.1230  |          |       |         |         |       |
| 55                       | Cs      | 3.893905 | 23.15744 |          |          |       |         |         |       |
| 56                       | Ba      | 5.211664 | 10.00383 |          |          |       |         |         |       |
| 57                       | La      | 5.5769   | 11.059   | 19.1773  | 49.95    | 61.6  |         |         |       |
| 58                       | Ce      | 5.5387   | 10.85    | 20.198   | 36.758   | 65.55 | 77.6    |         |       |
| 59                       | Pr      | 5.473    | 10.55    | 21.624   | 38.98    | 57.53 |         |         |       |
| 60                       | Nd      | 5.5250   | 10.72    | 22.1     | 40.4     |       |         |         |       |
| 61                       | Pm      | 5.582    | 10.90    | 22.3     | 41.1     |       |         |         |       |
| 62                       | Sm      | 5.6437   | 11.07    | 23.4     | 41.4     |       |         |         |       |
| 63                       | Eu      | 5.67038  | 11.25    | 24.92    | 42.7     |       |         |         |       |
| 64                       | Gd      | 6.14980  | 12.09    | 20.63    | 44.0     |       |         |         |       |
| 65                       | Tb      | 5.8638   | 11.52    | 21.91    | 39.79    |       |         |         |       |
| 66                       | Dy      | 5.9389   | 11.67    | 22.8     | 41.47    |       |         |         |       |
| 67                       | Ho      | 6.0215   | 11.80    | 22.84    | 42.5     |       |         |         |       |
| 68                       | Er      | 6.1077   | 11.93    | 22.74    | 42.7     |       |         |         |       |
| 69                       | Tm      | 6.18431  | 12.05    | 23.68    | 42.7     |       |         |         |       |
| 70                       | Yb      | 6.25416  | 12.176   | 25.05    | 43.56    |       |         |         |       |
| 71                       | Lu      | 5.42586  | 13.9     | 20.9594  | 45.25    | 66.8  |         |         |       |
| 72                       | Hf      | 6.82507  | 15       | 23.3     | 33.33    |       |         |         |       |
| 73                       | Ta      | 7.54957  |          |          |          |       |         |         |       |
| 74                       | W       | 7.86403  | 16.1     |          |          |       |         |         |       |
| 75                       | Re      | 7.83352  |          |          |          |       |         |         |       |
| 76                       | Os      | 8.43823  |          |          |          |       |         |         |       |
| 77                       | Ir      | 8.96702  |          |          |          |       |         |         |       |
| 78                       | Pt      | 8.9588   | 18.563   |          |          |       |         |         |       |
| 79                       | Au      | 9.22553  | 20.20    |          |          |       |         |         |       |
| 80                       | Hg      | 10.4375  | 18.7568  | 34.2     |          |       |         |         |       |
| 81                       | Tl      | 6.108194 | 20.4283  | 29.83    |          |       |         |         |       |
| 82                       | Pb      | 7.41663  | 15.03248 | 31.9373  | 42.32    | 68.8  |         |         |       |
| 83                       | Bi      | 7.2855   | 16.703   | 25.56    | 45.3     | 56.0  | 88.3    |         |       |
| 84                       | Po      | 8.414    |          |          |          |       |         |         |       |
| 85                       | At      |          |          |          |          |       |         |         |       |
| 86                       | Rn      | 10.7485  |          |          |          |       |         |         |       |
| 87                       | Fr      | 4.072741 |          |          |          |       |         |         |       |
| 88                       | Ra      | 5.278423 | 10.14715 |          |          |       |         |         |       |
| 89                       | Ac      | 5.17     | 11.75    |          |          |       |         |         |       |
| 90                       | Th      | 6.3067   | 11.9     | 20.0     | 28.8     |       |         |         |       |
| 91                       | Pa      | 5.89     |          |          |          |       |         |         |       |
| 92                       | U       | 6.1941   | 10.6     |          |          |       |         |         |       |
| 93                       | Np      | 6.2657   |          |          |          |       |         |         |       |
| 94                       | Pu      | 6.0260   | 11.2     |          |          |       |         |         |       |
| 95                       | Am      | 5.9738   |          |          |          |       |         |         |       |
| 96                       | Cm      | 5.9914   |          |          |          |       |         |         |       |
| 97                       | Bk      | 6.1979   |          |          |          |       |         |         |       |
| 98                       | Cf      | 6.2817   | 11.8     |          |          |       |         |         |       |
| 99                       | Es      | 6.42     | 12.0     |          |          |       |         |         |       |
| 100                      | Fm      | 6.50     |          |          |          |       |         |         |       |
| 101                      | Md      | 6.58     |          |          |          |       |         |         |       |
| 102                      | No      | 6.65     |          |          |          |       |         |         |       |
| 103                      | Lr      | 4.9      |          |          |          |       |         |         |       |
| 104                      | Rf      | 6.0      |          |          |          |       |         |         |       |



| <b>+8 Ions to +15 Ions</b> |         |           |           |          |           |           |          |          |           |
|----------------------------|---------|-----------|-----------|----------|-----------|-----------|----------|----------|-----------|
| Z                          | Element | IX        | X         | XI       | XII       | XIII      | XIV      | XV       | XVI       |
| 9                          | F       | 1103.1176 |           |          |           |           |          |          |           |
| 10                         | Ne      | 1195.8286 | 1362.1995 |          |           |           |          |          |           |
| 11                         | Na      | 299.864   | 1465.121  | 1648.702 |           |           |          |          |           |
| 12                         | Mg      | 328.06    | 367.50    | 1761.805 | 1962.6650 |           |          |          |           |
| 13                         | Al      | 330.13    | 398.75    | 442.00   | 2085.98   | 2304.1410 |          |          |           |
| 14                         | Si      | 351.12    | 401.37    | 476.36   | 523.42    | 2437.63   | 2673.182 |          |           |
| 15                         | P       | 372.13    | 424.4     | 479.46   | 560.8     | 611.74    | 2816.91  | 3069.842 |           |
| 16                         | S       | 379.55    | 447.5     | 504.8    | 564.44    | 652.2     | 707.01   | 3223.78  | 3494.1892 |
| 17                         | Cl      | 400.06    | 455.63    | 529.28   | 591.99    | 656.71    | 749.76   | 809.40   | 3658.521  |
| 18                         | Ar      | 422.45    | 478.69    | 538.96   | 618.26    | 686.10    | 755.74   | 854.77   | 918.03    |
| 19                         | K       | 175.8174  | 503.8     | 564.7    | 629.4     | 714.6     | 786.6    | 861.1    | 968       |
| 20                         | Ca      | 188.54    | 211.275   | 591.9    | 657.2     | 726.6     | 817.6    | 894.5    | 974       |
| 21                         | Sc      | 180.03    | 225.18    | 249.798  | 687.36    | 756.7     | 830.8    | 927.5    | 1009      |
| 22                         | Ti      | 192.1     | 215.92    | 265.07   | 291.500   | 787.84    | 863.1    | 941.9    | 1044      |
| 23                         | V       | 205.8     | 230.5     | 255.7    | 308.1     | 336.277   | 896.0    | 976      | 1060      |
| 24                         | Cr      | 209.3     | 244.4     | 270.8    | 298.0     | 354.8     | 384.168  | 1010.6   | 1097      |
| 25                         | Mn      | 221.8     | 248.3     | 286.0    | 314.4     | 343.6     | 403.0    | 435.163  | 1134.7    |
| 26                         | Fe      | 233.6     | 262.1     | 290.2    | 330.8     | 361.0     | 392.2    | 457      | 489.256   |
| 27                         | Co      | 186.13    | 275.4     | 305      | 336       | 379       | 411      | 444      | 511.96    |
| 28                         | Ni      | 193       | 224.6     | 321.0    | 352       | 384       | 430      | 464      | 499       |
| 29                         | Cu      | 199       | 232       | 265.3    | 369       | 401       | 435      | 484      | 520       |
| 30                         | Zn      | 203       | 238       | 274      | 310.8     | 419.7     | 454      | 490      | 542       |
| 31                         | Ga      | 210.8     | 244.0     | 280.7    | 319.2     | 357.2     | 471.2    | 508.8    | 548.3     |
| 36                         | Kr      | 230.85    | 268.2     | 308      | 350       | 391       | 447      | 492      | 541       |
| 37                         | Rb      | 150       | 277.1     |          |           |           |          |          |           |
| 38                         | Sr      | 162       | 177       | 324.1    |           |           |          |          |           |
| 39                         | Y       | 146.2     | 191       | 206      | 374.0     |           |          |          |           |
| 42                         | Mo      | 164.12    | 186.4     | 209.3    | 230.28    | 279.1     | 302.60   | 544.0    | 570       |

| <b>+16 Ions to +23 Ions</b> |         |           |           |          |          |          |         |         |         |
|-----------------------------|---------|-----------|-----------|----------|----------|----------|---------|---------|---------|
| Z                           | Element | XVII      | XVIII     | XIX      | XX       | XXI      | XXII    | XXIII   | XXIV    |
| 17                          | Cl      | 3946.2960 |           |          |          |          |         |         |         |
| 18                          | Ar      | 4120.8857 | 4426.2296 |          |          |          |         |         |         |
| 19                          | K       | 1033.4    | 4610.8    | 4934.046 |          |          |         |         |         |
| 20                          | Ca      | 1087      | 1157.8    | 5128.8   | 5469.864 |          |         |         |         |
| 21                          | Sc      | 1094      | 1213      | 1287.97  | 5674.8   | 6033.712 |         |         |         |
| 22                          | Ti      | 1131      | 1221      | 1346     | 1425.4   | 6249.0   | 6625.82 |         |         |
| 23                          | V       | 1168      | 1260      | 1355     | 1486     | 1569.6   | 6851.3  | 7246.12 |         |
| 24                          | Cr      | 1185      | 1299      | 1396     | 1496     | 1634     | 1721.4  | 7481.7  | 7894.81 |
| 25                          | Mn      | 1224      | 1317      | 1437     | 1539     | 1644     | 1788    | 1879.9  | 8140.6  |
| 26                          | Fe      | 1266      | 1358      | 1456     | 1582     | 1689     | 1799    | 1950    | 2023    |
| 27                          | Co      | 546.58    | 1397.2    | 1504.6   | 1603     | 1735     | 1846    | 1962    | 2119    |
| 28                          | Ni      | 571.08    | 607.06    | 1541     | 1648     | 1756     | 1894    | 2011    | 2131    |
| 29                          | Cu      | 557       | 633       | 670.588  | 1697     | 1804     | 1916    | 2060    | 2182    |
| 30                          | Zn      | 579       | 619       | 698      | 738      | 1856     |         |         |         |
| 36                          | Kr      | 592       | 641       | 786      | 833      | 884      | 937     | 998     | 1051    |
| 42                          | Mo      | 636       | 702       | 767      | 833      | 902      | 968     | 1020    | 1082    |

| <b>+24 Ions to +29 Ions</b> |         |         |         |          |          |           |      |
|-----------------------------|---------|---------|---------|----------|----------|-----------|------|
| Z                           | Element | XXV     | XXVI    | XXVII    | XXVIII   | XXIX      | XXX  |
| 25                          | Mn      | 8571.94 |         |          |          |           |      |
| 26                          | Fe      | 8828    | 9277.69 |          |          |           |      |
| 27                          | Co      | 2219.0  | 9544.1  | 10012.12 |          |           |      |
| 28                          | Ni      | 2295    | 2399.2  | 10288.8  | 10775.40 |           |      |
| 29                          | Cu      | 2308    | 2478    | 2587.5   | 11062.38 | 11567.617 |      |
| 36                          | Kr      | 1151    | 1205.3  | 2928     | 3070     | 3227      | 3381 |
| 42                          | Mo      | 1263    | 1323    | 1387     | 1449     | 1535      | 1601 |

# IONIZATION ENERGIES OF GAS-PHASE MOLECULES

Sharon G. Lias

This table presents values for the first ionization energies (IP) of approximately 1000 molecules and atoms. Substances are listed by molecular formula in the modified Hill order (see Preface). Values enclosed in parentheses are considered not to be well established. Data appearing in the 1988 reference were updated in 1996 for inclusion in the database of ionization energies available at the Internet site of the Standard Reference Data program of the National Institute of Standards and Technology (<http://webbook.nist.gov>). The list appearing here includes these updates.

The list also includes values for enthalpies of formation of the ions at 298 K,  $\Delta_f H_{\text{ion}}$ , given according to the ion convention used by

mass spectrometrists; to convert these values to the electron convention used by thermodynamicists, add 6 kJ/mol. Details on the calculation of  $\Delta_f H_{\text{ion}}$ , as well as data for a much larger number of molecules, may be found in the reference and on the Internet site.

## Reference

Lias, S. G., Bartmess, J. E., Liebman, J. F., Holmes, J. L., Levin, R. D., and Mallard, W.G., *Gas-Phase Ion and Neutral Thermochemistry*, *J. Phys. Chem. Ref. Data*, Vol. 17, Suppl. No. 1, 1988.

| Mol.<br>form.                           | Name                  | IP/eV                 | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|-----------------------------------------|-----------------------|-----------------------|-------------------------------------|
| <i>Substances not containing carbon</i> |                       |                       |                                     |
| Ac                                      | Actinium              | 5.17                  | 905                                 |
| Ag                                      | Silver                | 7.57624               | 1016                                |
| AgCl                                    | Silver(I) chloride    | ( $\leq 10.08$ )      | $\leq 1065$                         |
| AgF                                     | Silver(I) fluoride    | ( $11.0 \pm 0.3$ )    | 1071                                |
| Al                                      | Aluminum              | 5.98577               | 905                                 |
| AlBr                                    | Aluminum monobromide  | (9.3)                 | 913                                 |
| AlBr <sub>3</sub>                       | Aluminum tribromide   | (10.4)                | 593                                 |
| AlCl                                    | Aluminum monochloride | 9.4                   | 855                                 |
| AlCl <sub>3</sub>                       | Aluminum trichloride  | (12.01)               | 573                                 |
| AlF                                     | Aluminum monofluoride | $9.73 \pm 0.01$       | 673                                 |
| AlF <sub>3</sub>                        | Aluminum trifluoride  | $\leq 15.45$          | $\leq 282$                          |
| AlI                                     | Aluminum monoiodide   | $9.3 \pm 0.3$         | 965                                 |
| AlI <sub>3</sub>                        | Aluminum triiodide    | (9.1)                 | 673                                 |
| Am                                      | Americium             | $5.9738 \pm 0.0002$   | 860                                 |
| Ar                                      | Argon                 | 15.75962              | 1521                                |
| As                                      | Arsenic               | 9.8152                | 1250                                |
| AsCl <sub>3</sub>                       | Arsenic(III) chloride | ( $10.55 \pm 0.025$ ) | 754                                 |
| AsF <sub>3</sub>                        | Arsenic(III) fluoride | ( $12.84 \pm 0.05$ )  | 452                                 |
| AsH <sub>3</sub>                        | Arsine                | (9.89)                | 1021                                |
| Au                                      | Gold                  | 9.22567               | 1254                                |
| B                                       | Boron                 | 8.29803               | 1363                                |
| BBr <sub>3</sub>                        | Boron tribromide      | (10.51)               | 809                                 |
| BCl <sub>3</sub>                        | Boron trichloride     | $11.60 \pm 0.02$      | 718                                 |
| BF                                      | Fluoroborane          | $11.12 \pm 0.01$      | 957                                 |
|                                         | Difluoroborane        | (9.4)                 | 317                                 |
| BF <sub>3</sub>                         | Boron trifluoride     | $15.7 \pm 0.3$        | 365                                 |
| BH                                      | Boron monohydride     | (9.77)                | 1385                                |
| BH <sub>3</sub>                         | Borane                | $12.026 \pm 0.024$    | 1261                                |
| BI <sub>3</sub>                         | Boron triiodide       | ( $9.25 \pm 0.03$ )   | 964                                 |
| BO <sub>2</sub>                         | Boron dioxide         | ( $13.5 \pm 0.3$ )    | 1001                                |
| B <sub>2</sub> H <sub>6</sub>           | Diborane              | $11.38 \pm 0.05$      | 1134                                |
| B <sub>2</sub> O <sub>3</sub>           | Boron oxide           | $13.5 \pm 0.15$       | 460                                 |
| B <sub>4</sub> H <sub>10</sub>          | Tetraborane           | $10.76 \pm 0.04$      | 1105                                |
| B <sub>5</sub> H <sub>9</sub>           | Pentaborane(9)        | $9.90 \pm 0.04$       | 1028                                |
| B <sub>6</sub> H <sub>10</sub>          | Hexaborane            | (9.0)                 | 965                                 |
| Ba                                      | Barium                | 5.21170               | 683                                 |
| BaO                                     | Barium oxide          | $6.91 \pm 0.06$       | 543                                 |
| Be                                      | Beryllium             | 9.32263               | 1224                                |
| BeO                                     | Beryllium oxide       | ( $10.1 \pm 0.4$ )    | 1111                                |
| Bi                                      | Bismuth               | 7.2855                | 908                                 |
| BiCl <sub>3</sub>                       | Bismuth trichloride   | (10.4)                | 736                                 |

| Mol.<br>form.                     | Name                          | IP/eV            | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|-----------------------------------|-------------------------------|------------------|-------------------------------------|
| Bk                                | Berkelium                     | 6.23             | 911                                 |
| Br                                | Bromine (atomic)              | 11.81381         | 1252                                |
| BrCl                              | Bromine chloride              | 11.01            | 1079                                |
| BrF                               | Bromine fluoride              | 11.86            | 1086                                |
| BrF <sub>5</sub>                  | Bromine pentafluoride         | 13.172 ± 0.002   | 840                                 |
| BrH                               | Hydrogen bromide              | 11.66 ± 0.03     | 1087                                |
| BrH <sub>3</sub> Si               | Bromosilane                   | 10.6             | 943                                 |
| BrI                               | Iodine bromide                | 9.790 ± 0.004    | 986                                 |
| BrK                               | Potassium bromide             | 7.85 ± 0.1       | 578                                 |
| BrLi                              | Lithium bromide               | (8.7)            | 685                                 |
| BrNO                              | Nitrosyl bromide              | 10.17 ± 0.03     | 1065                                |
| BrNa                              | Sodium bromide                | 8.31 ± 0.1       | 660                                 |
| BrO                               | Bromine monoxide              | 10.46 ± 0.02     | 1135                                |
| BrRb                              | Rubidium bromide              | 7.94 ± 0.03      | 583                                 |
| BrTl                              | Thallium(I) bromide           | 9.14 ± 0.02      | 844                                 |
| Br <sub>2</sub>                   | Bromine                       | 10.516 ± 0.005   | 1046                                |
| Br <sub>2</sub> Hg                | Mercury(II) bromide           | 10.560 ± 0.003   | 935                                 |
| Br <sub>2</sub> Sn                | Tin(II) bromide               | 9.0              | 839                                 |
| Br <sub>3</sub> Ga                | Gallium(III) bromide          | 10.40            | 711                                 |
| Br <sub>3</sub> P                 | Phosphorus(III) bromide       | 9.7              | 798                                 |
| Br <sub>4</sub> Hf                | Hafnium(IV) bromide           | (10.9)           | 366                                 |
| Br <sub>4</sub> Sn                | Tin(IV) bromide               | 10.6             | 709                                 |
| Br <sub>4</sub> Ti                | Titanium(IV) bromide          | 10.3             | 375                                 |
| Br <sub>4</sub> Zr                | Zirconium(IV) bromide         | (10.7)           | 388                                 |
| Ca                                | Calcium                       | 6.11316          | 768                                 |
| CaCl                              | Calcium monochloride          | 5.86 ± 0.07      | 462                                 |
| CaO                               | Calcium oxide                 | 6.66 ± 0.18      | 668                                 |
| Cd                                | Cadmium                       | 8.99367          | 980                                 |
| Ce                                | Cerium                        | 5.5387           | 957                                 |
| Cf                                | Californium                   | 6.30             | 805                                 |
| Cl                                | Chlorine (atomic)             | 12.96764         | 1373                                |
| ClCs                              | Cesium chloride               | (7.84 ± 0.05)    | 510                                 |
| ClF                               | Chlorine fluoride             | 12.66 ± 0.01     | 1171                                |
| ClFO <sub>3</sub>                 | Perchloryl fluoride           | (12.945 ± 0.005) | 1224                                |
| ClF <sub>2</sub>                  | Chlorine difluoride           | (12.77 ± 0.05)   | 1128                                |
| ClF <sub>3</sub>                  | Chlorine trifluoride          | (12.65 ± 0.05)   | 1057                                |
| ClF <sub>5</sub> S                | Sulfur chloride pentafluoride | (12.335 ± 0.005) | 144                                 |
| ClH                               | Hydrogen chloride             | 12.749 ± 0.009   | 1137                                |
| ClHO                              | Hypochlorous acid             | (11.12 ± 0.01)   | 993                                 |
| ClH <sub>3</sub> Si               | Chlorosilane                  | 11.4             | 899                                 |
| ClI                               | Iodine chloride               | 10.088 ± 0.01    | 991                                 |
| ClIn                              | Indium(I) chloride            | (9.51)           | 842                                 |
| ClK                               | Potassium chloride            | (8.0 ± 0.4)      | 557                                 |
| CLi                               | Lithium chloride              | 9.57             | 727                                 |
| ClNO                              | Nitrosyl chloride             | 10.87 ± 0.01     | 1099                                |
| ClNO <sub>2</sub>                 | Nitryl chloride               | (11.84)          | 1155                                |
| ClNa                              | Sodium chloride               | 8.92 ± 0.06      | 681                                 |
| ClO                               | Chlorine monoxide             | 10.95            | 1159                                |
| ClO <sub>2</sub>                  | Chlorine dioxide              | 10.33 ± 0.02     | 1093                                |
| ClRb                              | Rubidium chloride             | (8.50 ± 0.03)    | 590                                 |
| ClTl                              | Thallium(I) chloride          | 9.70 ± 0.03      | 869                                 |
| Cl <sub>2</sub>                   | Chlorine                      | 11.480 ± 0.005   | 1108                                |
| Cl <sub>2</sub> CrO <sub>2</sub>  | Chromyl chloride              | 11.6             | 580                                 |
| Cl <sub>2</sub> Ge                | Germanium(II) chloride        | (10.20 ± 0.05)   | 813                                 |
| Cl <sub>2</sub> H <sub>2</sub> Si | Dichlorosilane                | 11.4             | 765                                 |
| Cl <sub>2</sub> Hg                | Mercury(II) chloride          | 11.380 ± 0.003   | 952                                 |
| Cl <sub>2</sub> O                 | Chlorine oxide                | 10.94            | 1135                                |
| Cl <sub>2</sub> OS                | Thionyl chloride              | 10.96            | 844                                 |
| Cl <sub>2</sub> O <sub>2</sub> S  | Sulfuryl chloride             | 12.05            | 807                                 |
| Cl <sub>2</sub> Pb                | Lead(II) chloride             | (10.2)           | 791                                 |

| Mol.<br>form.                    | Name                              | IP/eV          | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|----------------------------------|-----------------------------------|----------------|-------------------------------------|
| Cl <sub>2</sub> S                | Sulfur dichloride                 | 9.45 ± 0.03    | 895                                 |
| Cl <sub>2</sub> Si               | Dichlorosilylene                  | (10.93 ± 0.10) | 887                                 |
| Cl <sub>2</sub> Sn               | Tin(II) chloride                  | (10.0)         | 760                                 |
| Cl <sub>3</sub> Ga               | Gallium(III) chloride             | 11.52          | 664                                 |
| Cl <sub>3</sub> HSi              | Trichlorosilane                   | (11.7)         | 648                                 |
| Cl <sub>3</sub> N                | Nitrogen trichloride              | (10.12 ± 0.1)  | 1244                                |
| Cl <sub>3</sub> OP               | Phosphorus(V) oxychloride         | 11.36 ± 0.02   | 540                                 |
| Cl <sub>3</sub> OV               | Vanadyl trichloride               | (11.6)         | 425                                 |
| Cl <sub>3</sub> P                | Phosphorus(III) chloride          | 9.91           | 668                                 |
| Cl <sub>3</sub> PS               | Phosphorus(V) sulfide trichloride | 9.71 ± 0.03    | 573                                 |
| Cl <sub>3</sub> Sb               | Antimony(III) chloride            | (≤ 10.7)       | s719                                |
| Cl <sub>4</sub> Ge               | Germanium(IV) chloride            | 11.68 ± 0.05   | 629                                 |
| Cl <sub>4</sub> Hf               | Hafnium(IV) chloride              | (11.7)         | 246                                 |
| Cl <sub>4</sub> Si               | Tetrachlorosilane                 | 11.79 ± 0.01   | 527                                 |
| Cl <sub>4</sub> Sn               | Tin(IV) chloride                  | 11.7 ± 0.2     | 656                                 |
| Cl <sub>4</sub> Ti               | Titanium(IV) chloride             | (11.5)         | 349                                 |
| Cl <sub>4</sub> V                | Vanadium(IV) chloride             | (9.2)          | 361                                 |
| Cl <sub>4</sub> Zr               | Zirconium(IV) chloride            | (11.2)         | 210                                 |
| Cl <sub>5</sub> Mo               | Molybdenum(V) chloride            | (8.7)          | 392                                 |
| Cl <sub>5</sub> Nb               | Niobium(V) chloride               | (10.97)        | 356                                 |
| Cl <sub>5</sub> P                | Phosphorus(V) chloride            | (10.2)         | 608                                 |
| Cl <sub>5</sub> Ta               | Tantalum(V) chloride              | (11.08)        | 303                                 |
| Cl <sub>6</sub> W                | Tungsten(VI) chloride             | (9.5)          | 348                                 |
| Cm                               | Curium                            | 6.02           | 966                                 |
| Co                               | Cobalt                            | 7.8810         | 1187                                |
| Cr                               | Chromium                          | 6.76664        | 1050                                |
| Cs                               | Cesium                            | 3.89390        | 452                                 |
| CsF                              | Cesium fluoride                   | (8.80 ± 0.10)  | 489                                 |
| CsNa                             | Cesium sodium                     | (4.05 ± 0.04)  | 535                                 |
| Cu                               | Copper                            | 7.72638        | 1084                                |
| CuF                              | Copper(I) fluoride                | 10.15 ± 0.02   | 984                                 |
| Dy                               | Dysprosium                        | 5.9389         | 862                                 |
| Er                               | Erbium                            | 6.1078         | 907                                 |
| Es                               | Einsteinium                       | 6.42           | 753                                 |
| Eu                               | Europium                          | 5.6704         | 723                                 |
| F                                | Fluorine (atomic)                 | 17.42282       | 1761                                |
| FGa                              | Gallium monofluoride              | (9.6 ± 0.5)    | 700                                 |
| FH                               | Hydrogen fluoride                 | 16.044 ± 0.003 | 1276                                |
| FHO                              | Hypofluorous acid                 | 12.71 ± 0.01   | 1130                                |
| FH <sub>3</sub> Si               | Fluorosilane                      | 11.7           | 752                                 |
| FI                               | Iodine fluoride                   | 10.54 ± 0.01   | 922                                 |
| FIIn                             | Indium monofluoride               | (9.6 ± 0.5)    | 740                                 |
| FNO                              | Nitrosyl fluoride                 | 12.63 ± 0.03   | 1152                                |
| FNO <sub>2</sub>                 | Nitryl fluoride                   | (13.09)        | 1154                                |
| FNS                              | Thionitrosyl fluoride (NSF)       | 11.51 ± 0.04   | 1090                                |
| FO                               | Fluorine monoxide                 | 12.78 ± 0.03   | 1342                                |
| FO <sub>2</sub>                  | Fluorine superoxide (FOO)         | (12.6 ± 0.2)   | 1228                                |
| FS                               | Sulfur fluoride                   | 10.09          | 986                                 |
| FTl                              | Thallium(I) fluoride              | 10.52          | 835                                 |
| F <sub>2</sub>                   | Fluorine                          | 15.697 ± 0.003 | 1515                                |
| F <sub>2</sub> Ge                | Germanium(II) fluoride            | (≤ 11.65)      | 551                                 |
| F <sub>2</sub> HN                | Difluoramine                      | (11.53 ± 0.08) | 1046                                |
| F <sub>2</sub> H <sub>2</sub> Si | Difluorosilane                    | (12.2)         | 386                                 |
| F <sub>2</sub> Mg                | Magnesium fluoride                | (13.6 ± 0.3)   | 588                                 |
| F <sub>2</sub> N                 | Difluoroamidogen                  | 11.628 ± 0.01  | 1155                                |
| F <sub>2</sub> N <sub>2</sub>    | <i>trans</i> -Difluorodiazine     | (12.8)         | 1315                                |
| F <sub>2</sub> O                 | Fluorine monoxide                 | 13.11 ± 0.01   | 1290                                |
| F <sub>2</sub> OS                | Thionyl fluoride                  | 12.25          | 688                                 |
| F <sub>2</sub> O <sub>2</sub> S  | Sulfuryl fluoride                 | 13.04 ± 0.01   | 501                                 |
| F <sub>2</sub> Pb                | Lead(II) fluoride                 | (11.5)         | 679                                 |

| Mol.<br>form.                  | Name                              | IP/eV              | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|--------------------------------|-----------------------------------|--------------------|-------------------------------------|
| F <sub>2</sub> S               | Sulfur difluoride                 | (10.08)            | 676                                 |
| F <sub>2</sub> Si              | Difluorosilylene                  | 10.78 ± 0.05       | 450                                 |
| F <sub>2</sub> Sn              | Tin(II) fluoride                  | (11.1)             | 586                                 |
| F <sub>2</sub> Xe              | Xenon difluoride                  | 12.35 ± 0.01       | 1083                                |
| F <sub>3</sub> HSi             | Trifluorosilane                   | (14.0)             | 150                                 |
| F <sub>3</sub> N               | Nitrogen trifluoride              | 13.00 ± 0.02       | 1125                                |
| F <sub>3</sub> NO              | Trifluoramine oxide               | 13.31 ± 0.06       | 1121                                |
| F <sub>3</sub> OP              | Phosphorus(V) oxyfluoride         | 12.76 ± 0.01       | -24                                 |
| F <sub>3</sub> P               | Phosphorus(III) fluoride          | 11.60 ± 0.05       | 161                                 |
| F <sub>3</sub> PS              | Phosphorus(V) sulfide trifluoride | ≤ 11.05 ± 0.035    | ≤ 58                                |
| F <sub>3</sub> Si              | Trifluorosilyl                    | (9.99)             | - 32                                |
| F <sub>4</sub> Ge              | Germanium(IV) fluoride            | (15.5)             | 307                                 |
| F <sub>4</sub> N <sub>2</sub>  | Tetrafluorohydrazine              | 11.94 ± 0.03       | 1119                                |
| F <sub>4</sub> S               | Sulfur tetrafluoride              | 12.0 ± 0.3         | 399                                 |
| F <sub>4</sub> Si              | Tetrafluorosilane                 | 15.24 ± 0.14       | -144                                |
| F <sub>4</sub> Xe              | Xenon tetrafluoride               | 12.65 ± 0.1        | 1016                                |
| F <sub>5</sub> I               | Iodine pentafluoride              | 12.943 ± 0.005     | 408                                 |
| F <sub>5</sub> P               | Phosphorus(V) fluoride            | (15.1)             | -137                                |
| F <sub>5</sub> S               | Sulfur pentafluoride              | 9.60 ± 0.05        | 10                                  |
| F <sub>6</sub> Mo              | Molybdenum(VI) fluoride           | (14.5 ± 0.1)       | -159                                |
| F <sub>6</sub> S               | Sulfur hexafluoride               | 15.32 ± 0.02       | 258                                 |
| F <sub>6</sub> U               | Uranium(VI) fluoride              | 14.00 ± 0.10       | -796                                |
| Fe                             | Iron                              | 7.9024             | 1177                                |
| Fm                             | Fermium                           | 6.50               | 627                                 |
| Ga                             | Gallium                           | 5.99930            | 851                                 |
| GaI <sub>3</sub>               | Gallium(III) iodide               | 9.40               | 765                                 |
| Gd                             | Gadolinium                        | 6.1500             | 991                                 |
| Ge                             | Germanium                         | 7.900              | 1139                                |
| GeH <sub>4</sub>               | Germane                           | ≤ 10.53            | ≤ 1108                              |
| GeI <sub>4</sub>               | Germanium(IV) iodide              | (9.42)             | 850                                 |
| GeO                            | Germanium(II) oxide               | 11.25 ± 0.01       | 1044                                |
| GeS                            | Germanium(II) sulfide             | (9.98)             | 1055                                |
| H                              | Hydrogen (atomic)                 | 13.59844           | 1530                                |
| HI                             | Hydrogen iodide                   | 10.386 ± 0.001     | 1028                                |
| HLi                            | Lithium hydride                   | 7.7                | 882                                 |
| HN                             | Imidogen                          | ≤ 13.49 ± 0.01     | 1678                                |
| HNO                            | Nitrosyl hydride                  | (10.1)             | 1075                                |
| HNO <sub>2</sub>               | Nitrous acid                      | ≤ 11.3             | ≤ 1011                              |
| HNO <sub>3</sub>               | Nitric acid                       | 11.95 ± 0.01       | 1019                                |
| HN <sub>3</sub>                | Hydrazoic acid                    | 10.72 ± 0.025      | 1328                                |
| HO                             | Hydroxyl                          | 13.0170 ± 0.0002   | 1294                                |
| HO <sub>2</sub>                | Hydroperoxy                       | 11.35 ± 0.01       | 1106                                |
| HS                             | Mercapto                          | 10.4219 ± 0.0004   | 1145                                |
| H <sub>2</sub>                 | Hydrogen                          | 15.42593 ± 0.00005 | 1488                                |
| H <sub>2</sub> N               | Amidogen                          | 11.14 ± 0.01       | 1264                                |
| H <sub>2</sub> O               | Water                             | 12.6206 ± 0.0020   | 976                                 |
| H <sub>2</sub> O <sub>2</sub>  | Hydrogen peroxide                 | 10.58 ± 0.04       | 885                                 |
| H <sub>2</sub> S               | Hydrogen sulfide                  | 10.457 ± 0.012     | 989                                 |
| H <sub>2</sub> Se              | Hydrogen selenide                 | 9.892 ± 0.005      | 984                                 |
| H <sub>2</sub> Si              | Silylene                          | 8.244 ± 0.025      | 1084                                |
| H <sub>3</sub> N               | Ammonia                           | 10.070 ± 0.020     | 925                                 |
| H <sub>3</sub> NO              | Hydroxylamine                     | (10.00)            | 923                                 |
| H <sub>3</sub> P               | Phosphine                         | 9.869 ± 0.002      | 958                                 |
| H <sub>3</sub> Sb              | Stibine                           | 9.54 ± 0.03        | 1067                                |
| H <sub>4</sub> N <sub>2</sub>  | Hydrazine                         | 8.1 ± 0.15         | 877                                 |
| H <sub>4</sub> Si              | Silane                            | 11.00 ± 0.02       | 1095                                |
| H <sub>4</sub> Sn              | Stannane                          | (10.75)            | 1200                                |
| H <sub>6</sub> Si <sub>2</sub> | Disilane                          | 9.74 ± 0.02        | 1019                                |
| H <sub>8</sub> Si <sub>3</sub> | Trisilane                         | (9.2)              | 1009                                |
| He                             | Helium                            | 24.58741           | 2372                                |

| Mol.<br>form.                 | Name                 | IP/eV             | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|-------------------------------|----------------------|-------------------|-------------------------------------|
| Hf                            | Hafnium              | 6.82507 ± 0.00004 | 1278                                |
| Hg                            | Mercury              | 10.43750          | 1069                                |
| HgI <sub>2</sub>              | Mercury(II) iodide   | 9.5088 ± 0.0022   | 900                                 |
| Ho                            | Holmium              | 6.0216            | 882                                 |
| I                             | Iodine (atomic)      | 10.45126          | 1115                                |
| IK                            | Potassium iodide     | (7.21 ± 0.3)      | 570                                 |
| ILi                           | Lithium iodide       | (7.5)             | 633                                 |
| INa                           | Sodium iodide        | 7.64 ± 0.02       | 659                                 |
| ITl                           | Thallium(I) iodide   | 8.47 ± 0.02       | 826                                 |
| I <sub>2</sub>                | Iodine               | 9.3074 ± 0.0002   | 960                                 |
| I <sub>4</sub> Ti             | Titanium(IV) iodide  | (9.1)             | 602                                 |
| I <sub>4</sub> Zr             | Zirconium(IV) iodide | (9.3)             | 500                                 |
| In                            | Indium               | 5.78636           | 802                                 |
| Ir                            | Iridium              | 9.1               | 1543                                |
| K                             | Potassium            | 4.34066           | 508                                 |
| KLi                           | Lithium potassium    | 4.57 ± 0.04       | 512                                 |
| KNa                           | Potassium sodium     | 4.41636 ± 0.00017 | 561                                 |
| K <sub>2</sub>                | Dipotassium          | 4.0637 ± 0.0002   | 519                                 |
| Kr                            | Krypton              | 13.99961          | 1351                                |
| La                            | Lanthanum            | 5.5770            | 969                                 |
| Li                            | Lithium              | 5.39172           | 680                                 |
| LiNa                          | Lithium sodium       | 5.05 ± 0.04       | 571                                 |
| LiO                           | Lithium monoxide     | (8.44)            | 894                                 |
| LiRb                          | Lithium rubidium     | 4.3 ± 0.1         | 486                                 |
| Li <sub>2</sub>               | Dilithium            | 5.1127 ± 0.0003   | 709                                 |
| Lu                            | Lutetium             | 5.42585           | 950                                 |
| Md                            | Mendelevium          | 6.58              | 635                                 |
| Mg                            | Magnesium            | 7.64624           | 885                                 |
| MgO                           | Magnesium oxide      | (8.76 ± 0.22)     | 901                                 |
| Mn                            | Manganese            | 7.43402           | 998                                 |
| Mo                            | Molybdenum           | 7.09243           | 1343                                |
| N                             | Nitrogen (atomic)    | 14.53414          | 1875                                |
| NO                            | Nitric oxide         | 9.26438 ± 0.00005 | 985                                 |
| NO <sub>2</sub>               | Nitrogen dioxide     | 9.586 ± 0.002     | 958                                 |
| NP                            | Phosphorus nitride   | 11.84 ± 0.04      | 1247                                |
| NS                            | Nitrogen sulfide     | 8.87 ± 0.01       | 1119                                |
| N <sub>2</sub>                | Nitrogen             | 15.5808           | 1503                                |
| N <sub>2</sub> O              | Nitrous oxide        | 12.886            | 1325                                |
| N <sub>2</sub> O <sub>4</sub> | Nitrogen tetroxide   | (10.8)            | 1050                                |
| N <sub>2</sub> O <sub>5</sub> | Nitrogen pentoxide   | (11.9)            | 1161                                |
| Na                            | Sodium               | 5.13908           | 603                                 |
| NaRb                          | Rubidium sodium      | 4.32 ± 0.04       | 480                                 |
| Na <sub>2</sub>               | Disodium             | 4.894 ± 0.003     | 614                                 |
| Nb                            | Niobium              | 6.75885           | 1384                                |
| Nd                            | Neodymium            | 5.5250            | 859                                 |
| Ne                            | Neon                 | 21.56454          | 2081                                |
| Ni                            | Nickel               | 7.6398            | 1167                                |
| No                            | Nobelium             | 6.65              | 642                                 |
| Np                            | Neptunium            | 6.2657 ± 0.0003   | 1069                                |
| O                             | Oxygen (atomic)      | 13.61806          | 1563                                |
| OPb                           | Lead(II) oxide       | 9.08 ± 0.10       | 939                                 |
| OS                            | Sulfur monoxide      | 10.294 ± 0.004    | 998                                 |
| OS <sub>2</sub>               | Sulfur oxide (SSO)   | 10.584 ± 0.005    | 971                                 |
| OSi                           | Silicon monoxide     | 11.49 ± 0.20      | 1008                                |
| OSn                           | Tin(II) oxide        | 9.60 ± 0.02       | 944                                 |
| OSr                           | Strontium oxide      | 6.6 ± 0.2         | 623                                 |
| O <sub>2</sub>                | Oxygen               | 12.0697 ± 0.0002  | 1165                                |
| O <sub>2</sub> S              | Sulfur dioxide       | 12.349 ± 0.001    | 894                                 |
| O <sub>2</sub> Th             | Thorium(IV) oxide    | (8.7 ± 0.15)      | 342                                 |
| O <sub>2</sub> Ti             | Titanium(IV) oxide   | (9.54 ± 0.1)      | 623                                 |

| Mol.<br>form.                       | Name                       | IP/eV          | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|-------------------------------------|----------------------------|----------------|-------------------------------------|
| O <sub>2</sub> U                    | Uranium(IV) oxide          | (5.4 ± 0.1)    | 57                                  |
| O <sub>3</sub>                      | Ozone                      | 12.43          | 1342                                |
| O <sub>3</sub> S                    | Sulfur trioxide            | 12.82 ± 0.03   | 841                                 |
| O <sub>3</sub> U                    | Uranium(VI) oxide          | (10.5 ± 0.5)   | 214                                 |
| O <sub>4</sub> Os                   | Osmium(VIII) oxide         | (12.32)        | 850                                 |
| O <sub>4</sub> Ru                   | Ruthenium(VIII) oxide      | 12.15 ± 0.03   | 988                                 |
| O <sub>7</sub> Re <sub>2</sub>      | Rhenium(VII) oxide         | (12.7 ± 0.2)   | 125                                 |
| Os                                  | Osmium                     | 8.7            | 1630                                |
| P                                   | Phosphorus                 | 10.48669       | 1328                                |
| P <sub>2</sub>                      | Diphosphorus               | 10.53          | 1160                                |
| Pa                                  | Protactinium               | 5.89           | 1133                                |
| Pb                                  | Lead                       | 7.41666        | 911                                 |
| PbS                                 | Lead(II) sulfide           | (8.5 ± 0.5)    | 954                                 |
| Pd                                  | Palladium                  | 8.3367         | 1181                                |
| Pm                                  | Promethium                 | 5.55           | 536                                 |
| Pr                                  | Praseodymium               | 5.464          | 883                                 |
| Pt                                  | Platinum                   | 9.0            | 1433                                |
| Pu                                  | Plutonium                  | 6.025          | 926                                 |
| Ra                                  | Radium                     | 5.27892        | 668                                 |
| Rb                                  | Rubidium                   | 4.17713        | 484                                 |
| Re                                  | Rhenium                    | 7.88           | 1530                                |
| Rh                                  | Rhodium                    | 7.45890        | 1276                                |
| Rn                                  | Radon                      | 10.74850       | 1037                                |
| Ru                                  | Ruthenium                  | 7.36050        | 1355                                |
| S                                   | Sulfur                     | 10.36001       | 1277                                |
| SSn                                 | Tin(II) sulfide            | (8.8)          | 966                                 |
| S <sub>2</sub>                      | Disulfur                   | 9.356 ± 0.002  | 1031                                |
| Sb                                  | Antimony                   | 8.64           | 1096                                |
| Sc                                  | Scandium                   | 6.56144        | 1010                                |
| Se                                  | Selenium                   | 9.75238        | 1168                                |
| Si                                  | Silicon                    | 8.15169        | 1238                                |
| Sm                                  | Samarium                   | 5.6437         | 751                                 |
| Sn                                  | Tin                        | 7.34381        | 1011                                |
| Sr                                  | Strontium                  | 5.69484        | 713                                 |
| Ta                                  | Tantalum                   | 7.89           | 1544                                |
| Tb                                  | Terbium                    | 5.8639         | 955                                 |
| Tc                                  | Technetium                 | 7.28           | 1380                                |
| Te                                  | Tellurium                  | 9.0096         | 1066                                |
| Th                                  | Thorium                    | 6.308 ± 0.003  | 1207                                |
| Ti                                  | Titanium                   | 6.8282         | 1127                                |
| Tl                                  | Thallium                   | 6.10829        | 771                                 |
| Tm                                  | Thulium                    | 6.18431        | 827                                 |
| U                                   | Uranium                    | 6.19405        | 1129                                |
| V                                   | Vanadium                   | 6.746 ± 0.002  | 1166                                |
| W                                   | Tungsten                   | 7.98           | 1621                                |
| Xe                                  | Xenon                      | 12.12987       | 1170                                |
| Y                                   | Yttrium                    | 6.217          | 1022                                |
| Yb                                  | Ytterbium                  | 6.25416        | 754                                 |
| Zn                                  | Zinc                       | 9.39405        | 1037                                |
| Zr                                  | Zirconium                  | 6.63390        | 1251                                |
| <i>Substances containing carbon</i> |                            |                |                                     |
| C                                   | Carbon                     | 11.26030       | 1803                                |
| CBrClF <sub>2</sub>                 | Bromochlorodifluoromethane | (11.21)        | 642                                 |
| CBrCl <sub>3</sub>                  | Bromotrichloromethane      | (10.6)         | 980                                 |
| CBrF <sub>3</sub>                   | Bromotrifluoromethane      | (11.40)        | 451                                 |
| CBr <sub>2</sub> F <sub>2</sub>     | Dibromodifluoromethane     | 11.03 ± 0.04   | 683                                 |
| CBr <sub>4</sub>                    | Tetrabromomethane          | (10.31 ± 0.02) | 1079                                |
| CCl                                 | Chloromethylidyne          | (8.9 ± 0.2)    | 1244                                |
| CClF <sub>3</sub>                   | Chlorotrifluoromethane     | 12.6 ± 0.2     | 505                                 |

| Mol.<br>form.                      | Name                    | IP/eV               | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|------------------------------------|-------------------------|---------------------|-------------------------------------|
| CClN                               | Cyanogen chloride       | $12.34 \pm 0.01$    | 1329                                |
| CCl <sub>2</sub>                   | Dichloromethylene       | (9.27)              | 1058                                |
| CCl <sub>2</sub> F <sub>2</sub>    | Dichlorodifluoromethane | $12.05 \pm 0.24$    | 685                                 |
| CCl <sub>2</sub> O                 | Carbonyl chloride       | (11.5)              | 888                                 |
| CCl <sub>3</sub> F                 | Trichlorofluoromethane  | $11.77 \pm 0.02$    | 868                                 |
| CCl <sub>4</sub>                   | Tetrachloromethane      | $11.47 \pm 0.01$    | 1010                                |
| CF                                 | Fluoromethylidyne       | $9.11 \pm 0.01$     | 1134                                |
| CFN                                | Cyanogen fluoride       | $13.34 \pm 0.02$    | 1325                                |
| CF <sub>2</sub>                    | Difluoromethylene       | $11.44 \pm 0.03$    | 899                                 |
| CF <sub>2</sub> O                  | Carbonyl fluoride       | $13.035 \pm 0.030$  | 617                                 |
| CF <sub>3</sub>                    | Trifluoromethyl         | $8.7 \pm 0.2$       | 379                                 |
| CF <sub>3</sub> I                  | Trifluoroiodomethane    | 10.23               | 397                                 |
| CH                                 | Methylidyne             | $10.64 \pm 0.01$    | 1622                                |
| CHBrCl <sub>2</sub>                | Bromodichloromethane    | 10.6                | 973                                 |
| CHBr <sub>2</sub> Cl               | Chlorodibromomethane    | $10.59 \pm 0.01$    | 1030                                |
| CHBr <sub>3</sub>                  | Tribromomethane         | $10.48 \pm 0.02$    | 1035                                |
| CHCl                               | Chloromethylene         | 9.84                | 1247                                |
| CHClF <sub>2</sub>                 | Chlorodifluoromethane   | (12.2)              | 693                                 |
| CHCl <sub>2</sub> F                | Dichlorofluoromethane   | (11.5)              | 829                                 |
| CHCl <sub>3</sub>                  | Trichloromethane        | $11.37 \pm 0.02$    | 992                                 |
| CHF                                | Fluoromethylene         | $10.06 \pm 0.05$    | 1121                                |
| CHF <sub>3</sub>                   | Trifluoromethane        | (13.86)             | 643                                 |
| CHI <sub>3</sub>                   | Triiodomethane          | $9.25 \pm 0.02$     | 1010                                |
| CHN                                | Hydrogen cyanide        | $13.60 \pm 0.01$    | 1447                                |
| CHN                                | Hydrogen isocyanide     | (12.5 $\pm$ 0.1)    | 1407                                |
| CHNO                               | Isocyanic acid          | $11.595 \pm 0.005$  | 1016                                |
| CHNO                               | Fulminic acid           | (10.83)             | 1263                                |
| CHO                                | Oxomethyl (HCO)         | (8.55)              | 826                                 |
| CH <sub>2</sub>                    | Methylene               | $10.396 \pm 0.003$  | 1392                                |
| CH <sub>2</sub> BrCl               | Bromochloromethane      | $10.77 \pm 0.01$    | 1085                                |
| CH <sub>2</sub> Br <sub>2</sub>    | Dibromomethane          | (10.50 $\pm$ 0.02)  | 1013                                |
| CH <sub>2</sub> ClF                | Chlorofluoromethane     | $11.71 \pm 0.01$    | 870                                 |
| CH <sub>2</sub> Cl <sub>2</sub>    | Dichloromethane         | $11.32 \pm .01$     | 996                                 |
| CH <sub>2</sub> F <sub>2</sub>     | Difluoromethane         | 12.71               | 774                                 |
| CH <sub>2</sub> I <sub>2</sub>     | Diiodomethane           | $9.46 \pm 0.02$     | 1030                                |
| CH <sub>2</sub> N <sub>2</sub>     | Diazomethane            | $8.999 \pm 0.001$   | 1098                                |
| CH <sub>2</sub> N <sub>2</sub>     | Cyanamide               | (10.4)              | 1137                                |
| CH <sub>2</sub> O                  | Formaldehyde            | $10.88 \pm 0.01$    | 941                                 |
| CH <sub>2</sub> O <sub>2</sub>     | Formic acid             | $11.33 \pm 0.01$    | 715                                 |
| CH <sub>3</sub>                    | Methyl                  | $9.843 \pm 0.002$   | 1095                                |
| CH <sub>3</sub> BO                 | Borane carbonyl         | $11.14 \pm 0.02$    | 962                                 |
| CH <sub>3</sub> Br                 | Bromomethane            | $10.541 \pm 0.003$  | 979                                 |
| CH <sub>3</sub> Cl                 | Chloromethane           | $11.22 \pm 0.01$    | 1001                                |
| CH <sub>3</sub> Cl <sub>3</sub> Si | Methyltrichlorosilane   | (11.36 $\pm$ 0.03)  | 548                                 |
| CH <sub>3</sub> F                  | Fluoromethane           | $12.47 \pm 0.02$    | 956                                 |
| CH <sub>3</sub> I                  | Iodomethane             | 9.538               | 936                                 |
| CH <sub>3</sub> NO                 | Formamide               | $10.16 \pm 0.06$    | 796                                 |
| CH <sub>3</sub> NO <sub>2</sub>    | Nitromethane            | $11.08 \pm 0.07$    | 994                                 |
| CH <sub>3</sub> N <sub>3</sub>     | Methyl azide            | $9.81 \pm 0.02$     | 1227                                |
| CH <sub>3</sub> O                  | Methoxy                 | (10.72)             | 1050                                |
| CH <sub>4</sub>                    | Methane                 | $12.61 \pm 0.01$    | 1143                                |
| CH <sub>4</sub> N <sub>2</sub> O   | Urea                    | 9.7                 | 690                                 |
| CH <sub>4</sub> O                  | Methanol                | $10.85 \pm 0.01$    | 845                                 |
| CH <sub>4</sub> S                  | Methanethiol            | $9.44 \pm 0.005$    | 888                                 |
| CH <sub>5</sub> N                  | Methylamine             | (8.80)              | 826                                 |
| CH <sub>6</sub> N <sub>2</sub>     | Methylhydrazine         | $7.7 \pm 0.15$      | 835                                 |
| CH <sub>6</sub> Si                 | Methylsilane            | (10.7)              | 1003                                |
| CN                                 | Cyanide                 | 13.5984             | 1748                                |
| CNO                                | Cyanate                 | $11.76 \pm 0.01$    | 1290                                |
| CO                                 | Carbon monoxide         | $14.014 \pm 0.0003$ | 1242                                |



| Mol.<br>form.                                   | Name                                   | IP/eV            | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|-------------------------------------------------|----------------------------------------|------------------|-------------------------------------|
| COS                                             | Carbon oxysulfide                      | 11.18 ± 0.01     | 936                                 |
| COSe                                            | Carbon oxyselenide                     | 10.36 ± 0.01     | 929                                 |
| CO <sub>2</sub>                                 | Carbon dioxide                         | 13.773 ± 0.002   | 935                                 |
| CS                                              | Carbon sulfide                         | 11.33 ± 0.01     | 1361                                |
| CS <sub>2</sub>                                 | Carbon disulfide                       | 10.0685 ± 0.0020 | 1089                                |
| C <sub>2</sub>                                  | Dicarbon                               | (11.4 ± 0.3)     | 2000                                |
| C <sub>2</sub> Br <sub>2</sub> F <sub>4</sub>   | 1,2-Dibromotetrafluoroethane           | (11.1)           | 280                                 |
| C <sub>2</sub> ClF <sub>3</sub>                 | Chlorotrifluoroethylene                | 9.81 ± 0.03      | 373                                 |
| C <sub>2</sub> ClF <sub>5</sub>                 | Chloropentafluoroethane                | (12.6)           | 99                                  |
| C <sub>2</sub> Cl <sub>2</sub>                  | Dichloroacetylene                      | 9.9              | 1165                                |
| C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>   | 1,2-Dichlorotetrafluoroethane          | 12.2             | 252                                 |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>   | 1,1,1-Trichlorotrifluoroethane         | 11.5             | 386                                 |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>   | 1,1,2-Trichlorotrifluoroethane         | 11.99 ± 0.02     | 429                                 |
| C <sub>2</sub> Cl <sub>4</sub>                  | Tetrachloroethylene                    | 9.326 ± 0.001    | 887                                 |
| C <sub>2</sub> Cl <sub>4</sub> F <sub>2</sub>   | 1,1,2,2-Tetrachloro-1,2-difluoroethane | (11.3)           | 563                                 |
| C <sub>2</sub> Cl <sub>4</sub> O                | Trichloroacetyl chloride               | (11.0)           | 827                                 |
| C <sub>2</sub> Cl <sub>6</sub>                  | Hexachloroethane                       | (11.1)           | 920                                 |
| C <sub>2</sub> F <sub>3</sub> N                 | Trifluoroacetoneitrile                 | 13.93 ± 0.07     | 845                                 |
| C <sub>2</sub> F <sub>4</sub>                   | Tetrafluoroethylene                    | 10.12 ± 0.02     | 315                                 |
| C <sub>2</sub> F <sub>6</sub>                   | Hexafluoroethane                       | (13.6)           | -30                                 |
| C <sub>2</sub> H                                | Ethynyl                                | (11.61 ± 0.07)   | 1685                                |
| C <sub>2</sub> HBr                              | Bromoacetylene                         | 10.31 ± 0.02     | 1242                                |
| C <sub>2</sub> HBrClF <sub>3</sub>              | 2-Bromo-2-chloro-1,1,1-trifluoroethane | (11.0)           | 363                                 |
| C <sub>2</sub> HCl                              | Chloroacetylene                        | 10.58 ± 0.02     | 1276                                |
| C <sub>2</sub> HClF <sub>2</sub>                | 1-Chloro-2,2-difluoroethylene          | 9.80 ± 0.04      | 628                                 |
| C <sub>2</sub> HCl <sub>3</sub>                 | Trichloroethylene                      | 9.46 ± 0.02      | 894                                 |
| C <sub>2</sub> HCl <sub>3</sub> O               | Dichloroacetyl chloride                | (10.9)           | 809                                 |
| C <sub>2</sub> HCl <sub>5</sub>                 | Pentachloroethane                      | (11.0)           | 919                                 |
| C <sub>2</sub> HF                               | Fluoroacetylene                        | 11.26            | 1195                                |
| C <sub>2</sub> HF <sub>3</sub>                  | Trifluoroethylene                      | 10.14            | 489                                 |
| C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>   | Trifluoroacetic acid                   | 11.46            | 75                                  |
| C <sub>2</sub> H <sub>2</sub>                   | Acetylene                              | 11.400 ± 0.002   | 1328                                |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>   | 1,1-Dichloroethylene                   | 9.81 ± 0.04      | 949                                 |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>   | <i>cis</i> -1,2-Dichloroethylene       | 9.66 ± 0.01      | 936                                 |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>   | <i>trans</i> -1,2-Dichloroethylene     | 9.64 ± 0.02      | 934                                 |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O | Chloroacetyl chloride                  | (≤ 10.3)         | 815                                 |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>   | 1,1,1,2-Tetrachloroethane              | (11.1)           | 920                                 |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>   | 1,1,2,2-Tetrachloroethane              | (≤ 11.62)        | ≤ 971                               |
| C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>    | 1,1-Difluoroethylene                   | 10.29 ± 0.01     | 650                                 |
| C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>    | <i>cis</i> -1,2-Difluoroethylene       | 10.23 ± 0.02     | 690                                 |
| C <sub>2</sub> H <sub>2</sub> O                 | Ketene                                 | 9.617 ± 0.003    | 880                                 |
| C <sub>2</sub> H <sub>2</sub> O <sub>2</sub>    | Glyoxal                                | 10.2             | 773                                 |
| C <sub>2</sub> H <sub>2</sub> S <sub>2</sub>    | Thiirene                               | 8.61             | 892                                 |
| C <sub>2</sub> H <sub>3</sub> Br                | Bromoethylene                          | 9.83 ± 0.02      | 1028                                |
| C <sub>2</sub> H <sub>3</sub> Cl                | Chloroethylene                         | 9.99 ± 0.02      | 985                                 |
| C <sub>2</sub> H <sub>3</sub> ClF <sub>2</sub>  | 1-Chloro-1,1-difluoroethane            | (11.98)          | 626                                 |
| C <sub>2</sub> H <sub>3</sub> ClO               | Acetyl chloride                        | 10.82 ± 0.04     | 801                                 |
| C <sub>2</sub> H <sub>3</sub> ClO               | Chloroacetaldehyde                     | (10.48)          | 815                                 |
| C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>  | Chloroacetic acid                      | (10.7)           | 597                                 |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>   | 1,1,1-Trichloroethane                  | (11.0)           | 917                                 |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>   | 1,1,2-Trichloroethane                  | (11.0)           | 911                                 |
| C <sub>2</sub> H <sub>3</sub> F                 | Fluoroethylene                         | 10.36 ± 0.01     | 861                                 |
| C <sub>2</sub> H <sub>3</sub> FO                | Acetyl fluoride                        | (11.5)           | 667                                 |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>    | 1,1,1-Trifluoroethane                  | 13.3 ± 0.5       | 536                                 |
| C <sub>2</sub> H <sub>3</sub> N                 | Acetonitrile                           | 12.20 ± 0.01     | 1253                                |
| C <sub>2</sub> H <sub>3</sub> NO                | Methylisocyanate                       | (10.67)          | 900                                 |
| C <sub>2</sub> H <sub>4</sub>                   | Ethylene                               | 10.5138 ± 0.0006 | 1067                                |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>   | 1,2-Dibromoethane                      | 10.35 ± 0.04     | 961                                 |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>   | 1,1-Dichloroethane                     | 11.04 ± 0.02     | 935                                 |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>   | 1,2-Dichloroethane                     | 11.04 ± 0.02     | 931                                 |

| Mol.<br>form.                              | Name                      | IP/eV               | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|--------------------------------------------|---------------------------|---------------------|-------------------------------------|
| $\text{C}_2\text{H}_4\text{F}_2$           | 1,1-Difluoroethane        | (11.87)             | 643                                 |
| $\text{C}_2\text{H}_4\text{O}$             | Acetaldehyde              | $10.229 \pm 0.0007$ | 821                                 |
| $\text{C}_2\text{H}_4\text{O}$             | Ethylene oxide            | $10.56 \pm 0.01$    | 966                                 |
| $\text{C}_2\text{H}_4\text{O}_2$           | Acetic acid               | $10.65 \pm 0.02$    | 595                                 |
| $\text{C}_2\text{H}_4\text{O}_2$           | Methyl formate            | $10.835 \pm 0.005$  | 690                                 |
| $\text{C}_2\text{H}_5\text{Br}$            | Bromoethane               | $10.29 \pm 0.01$    | 931                                 |
| $\text{C}_2\text{H}_5\text{Cl}$            | Chloroethane              | $10.98 \pm 0.02$    | 947                                 |
| $\text{C}_2\text{H}_5\text{ClO}$           | 2-Chloroethanol           | (10.5)              | 756                                 |
| $\text{C}_2\text{H}_5\text{F}$             | Fluoroethane              | (11.78)             | 873                                 |
| $\text{C}_2\text{H}_5\text{I}$             | Iodoethane                | $9.3492 \pm 0.0006$ | 893                                 |
| $\text{C}_2\text{H}_5\text{N}$             | Ethyleneimine             | $(9.5 \pm 0.3)$     | 1044                                |
| $\text{C}_2\text{H}_5\text{NO}$            | Acetamide                 | $9.65 \pm 0.03$     | 693                                 |
| $\text{C}_2\text{H}_5\text{NO}$            | <i>N</i> -Methylformamide | $9.83 \pm 0.04$     | 760                                 |
| $\text{C}_2\text{H}_5\text{NO}_2$          | Nitroethane               | $10.88 \pm 0.05$    | 948                                 |
| $\text{C}_2\text{H}_6$                     | Ethane                    | $11.56 \pm 0.02$    | 1031                                |
| $\text{C}_2\text{H}_6\text{Cl}_2\text{Si}$ | Dichlorodimethylsilane    | (10.7)              | 576                                 |
| $\text{C}_2\text{H}_6\text{O}$             | Ethanol                   | $10.43 \pm 0.05$    | 772                                 |
| $\text{C}_2\text{H}_6\text{O}$             | Dimethyl ether            | $10.025 \pm 0.025$  | 783                                 |
| $\text{C}_2\text{H}_6\text{OS}$            | Dimethyl sulfoxide        | $9.10 \pm 0.03$     | 727                                 |
| $\text{C}_2\text{H}_6\text{O}_2$           | Ethylene glycol           | 10.16               | 593                                 |
| $\text{C}_2\text{H}_6\text{S}$             | Ethanethiol               | $9.31 \pm 0.03$     | 851                                 |
| $\text{C}_2\text{H}_6\text{S}$             | Dimethyl sulfide          | $8.69 \pm 0.02$     | 801                                 |
| $\text{C}_2\text{H}_6\text{S}_2$           | Dimethyl disulfide        | $(7.4 \pm 0.3)$     | 690                                 |
| $\text{C}_2\text{H}_7\text{N}$             | Ethylamine                | $8.86 \pm 0.02$     | 808                                 |
| $\text{C}_2\text{H}_7\text{N}$             | Dimethylamine             | $8.24 \pm 0.08$     | 777                                 |
| $\text{C}_2\text{H}_7\text{NO}$            | Ethanolamine              | 8.96                | 664                                 |
| $\text{C}_2\text{H}_8\text{N}_2$           | 1,2-Ethanediamine         | (8.6)               | 812                                 |
| $\text{C}_2\text{H}_8\text{N}_2$           | 1,1-Dimethylhydrazine     | $7.29 \pm 0.05$     | 787                                 |
| $\text{C}_2\text{N}_2$                     | Cyanogen                  | $13.37 \pm 0.01$    | 1597                                |
| $\text{C}_3\text{F}_6$                     | Perfluoropropene          | $10.60 \pm 0.03$    | -103                                |
| $\text{C}_3\text{F}_6\text{O}$             | Perfluoroacetone          | $(11.57 \pm 0.13)$  | -282                                |
| $\text{C}_3\text{F}_8$                     | Perfluoropropane          | (13.38)             | -491                                |
| $\text{C}_3\text{HN}$                      | Cyanoacetylene            | $11.64 \pm 0.01$    | 1475                                |
| $\text{C}_3\text{H}_2\text{O}$             | 2-Propynal                | $(10.7 \pm 0.1)$    | 1145                                |
| $\text{C}_3\text{H}_3\text{F}_3$           | 3,3,3-Trifluoropropene    | (10.9)              | 437                                 |
| $\text{C}_3\text{H}_3\text{N}$             | 2-Propenenitrile          | $10.91 \pm 0.01$    | 1237                                |
| $\text{C}_3\text{H}_3\text{NO}$            | Oxazole                   | (9.9)               | 940                                 |
| $\text{C}_3\text{H}_3\text{NO}$            | Isoxazole                 | (9.93)              | 1038                                |
| $\text{C}_3\text{H}_4$                     | Allene                    | $9.692 \pm 0.004$   | 1126                                |
| $\text{C}_3\text{H}_4$                     | Propyne                   | $10.37 \pm 0.01$    | 1187                                |
| $\text{C}_3\text{H}_4$                     | Cyclopropene              | $9.67 \pm 0.01$     | 1209                                |
| $\text{C}_3\text{H}_4\text{N}_2$           | Imidazole                 | (8.81)              | 997                                 |
| $\text{C}_3\text{H}_4\text{O}$             | Propargyl alcohol         | $10.49 \pm 0.02$    | 1060                                |
| $\text{C}_3\text{H}_4\text{O}$             | Acrolein                  | $10.103 \pm 0.006$  | 900                                 |
| $\text{C}_3\text{H}_4\text{O}$             | Cyclopropanone            | $(9.1 \pm 0.1)$     | 895                                 |
| $\text{C}_3\text{H}_4\text{O}_2$           | Propenoic acid            | 10.60               | 701                                 |
| $\text{C}_3\text{H}_4\text{O}_2$           | 2-Oxetanone               | $(9.70 \pm 0.01)$   | 653                                 |
| $\text{C}_3\text{H}_5\text{Br}$            | 3-Bromopropene            | (9.96)              | 1008                                |
| $\text{C}_3\text{H}_5\text{Cl}$            | 3-Chloropropene           | $10.04 \pm 0.01$    | 965                                 |
| $\text{C}_3\text{H}_5\text{ClO}$           | Epichlorohydrin           | (10.64)             | 919                                 |
| $\text{C}_3\text{H}_5\text{ClO}_2$         | Methyl chloroacetate      | (10.3)              | 575                                 |
| $\text{C}_3\text{H}_5\text{F}$             | 3-Fluoropropene           | (10.11)             | 821                                 |
| $\text{C}_3\text{H}_5\text{N}$             | Propanenitrile            | $11.84 \pm 0.02$    | 1194                                |
| $\text{C}_3\text{H}_5\text{NO}$            | Acrylamide                | (9.5)               | 720                                 |
| $\text{C}_3\text{H}_6$                     | Propene                   | $9.73 \pm 0.02$     | 959                                 |
| $\text{C}_3\text{H}_6$                     | Cyclopropane              | 9.86                | 1005                                |
| $\text{C}_3\text{H}_6\text{Br}_2$          | 1,2-Dibromopropane        | (10.1)              | 903                                 |
| $\text{C}_3\text{H}_6\text{Br}_2$          | 1,3-Dibromopropane        | $(\leq 10.2)$       | $\leq 919$                          |
| $\text{C}_3\text{H}_6\text{Cl}_2$          | 1,2-Dichloropropane       | $10.8 \pm 0.1$      | 886                                 |
| $\text{C}_3\text{H}_6\text{Cl}_2$          | 1,3-Dichloropropane       | $10.89 \pm 0.04$    | 892                                 |

| Mol.<br>form.                                 | Name                     | IP/eV          | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|-----------------------------------------------|--------------------------|----------------|-------------------------------------|
| C <sub>3</sub> H <sub>6</sub> O               | Allyl alcohol            | 9.67 ± 0.05    | 808                                 |
| C <sub>3</sub> H <sub>6</sub> O               | Methyl vinyl ether       | 8.95 ± 0.01    | 763                                 |
| C <sub>3</sub> H <sub>6</sub> O               | Propanal                 | 9.96 ± 0.01    | 772                                 |
| C <sub>3</sub> H <sub>6</sub> O               | Acetone                  | 9.703 ± 0.006  | 719                                 |
| C <sub>3</sub> H <sub>6</sub> O               | Methyloxirane            | (10.22)        | 892                                 |
| C <sub>3</sub> H <sub>6</sub> O               | Oxetane                  | 9.65 ± 0.01    | 851                                 |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Propanoic acid           | 10.525 ± 0.003 | 568                                 |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Ethyl formate            | 10.61 ± 0.01   | 639                                 |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | Methyl acetate           | 10.25 ± 0.02   | 579                                 |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>  | 1,3-Dioxolane            | (9.9)          | 658                                 |
| C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>  | 1,3,5-Trioxane           | (10.3)         | 528                                 |
| C <sub>3</sub> H <sub>7</sub> Br              | 1-Bromopropane           | 10.18 ± 0.01   | 898                                 |
| C <sub>3</sub> H <sub>7</sub> Br              | 2-Bromopropane           | 10.10 ± 0.03   | 877                                 |
| C <sub>3</sub> H <sub>7</sub> Cl              | 1-Chloropropane          | 10.81 ± 0.01   | 911                                 |
| C <sub>3</sub> H <sub>7</sub> Cl              | 2-Chloropropane          | 10.79 ± 0.02   | 896                                 |
| C <sub>3</sub> H <sub>7</sub> F               | 1-Fluoropropane          | (11.3)         | 806                                 |
| C <sub>3</sub> H <sub>7</sub> F               | 2-Fluoropropane          | (11.08)        | 776                                 |
| C <sub>3</sub> H <sub>7</sub> I               | 1-Iodopropane            | 9.25 ± 0.01    | 860                                 |
| C <sub>3</sub> H <sub>7</sub> I               | 2-Iodopropane            | 9.19 ± 0.02    | 845                                 |
| C <sub>3</sub> H <sub>7</sub> N               | Allylamine               | (8.76)         | 891                                 |
| C <sub>3</sub> H <sub>7</sub> N               | Cyclopropylamine         | (8.8)          | 926                                 |
| C <sub>3</sub> H <sub>7</sub> N               | Propyleneimine           | (9.0)          | 960                                 |
| C <sub>3</sub> H <sub>7</sub> NO              | N,N-Dimethylformamide    | (9.12)         | 688                                 |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub> | 1-Nitropropane           | (10.81)        | 919                                 |
| C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub> | 2-Nitropropane           | (10.71)        | 894                                 |
| C <sub>3</sub> H <sub>8</sub>                 | Propane                  | 10.95 ± 0.05   | 952                                 |
| C <sub>3</sub> H <sub>8</sub> O               | 1-Propanol               | 10.18 ± 0.06   | 727                                 |
| C <sub>3</sub> H <sub>8</sub> O               | 2-Propanol               | 10.17 ± 0.02   | 709                                 |
| C <sub>3</sub> H <sub>8</sub> O               | Ethyl methyl ether       | 9.72 ± 0.07    | 722                                 |
| C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>  | Dimethoxymethane         | 9.7            | 588                                 |
| C <sub>3</sub> H <sub>8</sub> S               | 1-Propanethiol           | 9.20 ± 0.01    | 819                                 |
| C <sub>3</sub> H <sub>8</sub> S               | 2-Propanethiol           | 9.145 ± 0.005  | 806                                 |
| C <sub>3</sub> H <sub>8</sub> S               | Ethyl methyl sulfide     | (8.55)         | 765                                 |
| C <sub>3</sub> H <sub>9</sub> BO <sub>3</sub> | Trimethyl borate         | (10.0)         | 65                                  |
| C <sub>3</sub> H <sub>9</sub> ClSi            | Trimethylchlorosilane    | (10.15)        | 624                                 |
| C <sub>3</sub> H <sub>9</sub> N               | Propylamine              | (8.78)         | 777                                 |
| C <sub>3</sub> H <sub>9</sub> N               | Isopropylamine           | (8.72)         | 758                                 |
| C <sub>3</sub> H <sub>9</sub> N               | Trimethylamine           | 7.82 ± 0.06    | 731                                 |
| C <sub>3</sub> H <sub>9</sub> NO              | 3-Amino-1-propanol       | (9.0)          | 651                                 |
| C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>  | Maleic anhydride         | (10.8)         | 645                                 |
| C <sub>4</sub> H <sub>4</sub>                 | 1-Buten-3-yne            | 9.58 ± 0.02    | 1230                                |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>  | Succinonitrile           | (12.1 ± 0.25)  | 1377                                |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>  | Pyrimidine               | 9.23           | 1087                                |
| C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>  | Pyridazine               | 8.67 ± 0.03    | 1112                                |
| C <sub>4</sub> H <sub>4</sub> O               | Furan                    | 8.883 ± 0.003  | 822                                 |
| C <sub>4</sub> H <sub>4</sub> O <sub>2</sub>  | Diketene                 | (9.6 ± 0.02)   | 736                                 |
| C <sub>4</sub> H <sub>4</sub> O <sub>3</sub>  | Succinic anhydride       | (10.6)         | 500                                 |
| C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>  | Fumaric acid             | (10.7)         | 355                                 |
| C <sub>4</sub> H <sub>4</sub> S               | Thiophene                | 8.86 ± 0.02    | 970                                 |
| C <sub>4</sub> H <sub>5</sub> N               | Methylacrylonitrile      | 10.34          | 1127                                |
| C <sub>4</sub> H <sub>5</sub> N               | Pyrrole                  | 8.207 ± 0.005  | 900                                 |
| C <sub>4</sub> H <sub>5</sub> N               | Cyclopropanecarbonitrile | (10.25)        | 1173                                |
| C <sub>4</sub> H <sub>6</sub>                 | 1,2-Butadiene            | (9.03)         | 1034                                |
| C <sub>4</sub> H <sub>6</sub>                 | 1,3-Butadiene            | 9.082 ± 0.004  | 986                                 |
| C <sub>4</sub> H <sub>6</sub>                 | 1-Butyne                 | 10.19 ± 0.02   | 1148                                |
| C <sub>4</sub> H <sub>6</sub>                 | 2-Butyne                 | 9.59 ± 0.03    | 1071                                |
| C <sub>4</sub> H <sub>6</sub>                 | Cyclobutene              | 9.43 ± 0.02    | 1067                                |
| C <sub>4</sub> H <sub>6</sub> O               | Divinyl ether            | (8.7)          | 827                                 |
| C <sub>4</sub> H <sub>6</sub> O               | <i>trans</i> -2-Butenal  | 9.73 ± 0.01    | 835                                 |
| C <sub>4</sub> H <sub>6</sub> O               | 2-Methylpropenal         | (9.92)         | 834                                 |

| Mol.<br>form.                                  | Name                            | IP/eV         | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|------------------------------------------------|---------------------------------|---------------|-------------------------------------|
| C <sub>4</sub> H <sub>6</sub> O                | Cyclobutanone                   | (9.35)        | 815                                 |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | <i>cis</i> -Crotonic acid       | (10.08)       | 625                                 |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | <i>trans</i> -Crotonic acid     | (9.9)         | 604                                 |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | Methacrylic acid                | (10.15)       | 611                                 |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | Vinyl acetate                   | 9.19 ± 0.05   | 572                                 |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>   | Methyl acrylate                 | (9.9)         | 641                                 |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>   | Acetic anhydride                | (10.0)        | 398                                 |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>   | Dimethyl oxalate                | (10.0)        | 287                                 |
| C <sub>4</sub> H <sub>6</sub> S                | 2,5-Dihydrothiophene            | (8.4)         | 898                                 |
| C <sub>4</sub> H <sub>7</sub> N                | Butanenitrile                   | (11.2)        | 1110                                |
| C <sub>4</sub> H <sub>7</sub> N                | 2-Methylpropanenitrile          | (11.3)        | 1115                                |
| C <sub>4</sub> H <sub>7</sub> NO               | 2-Pyrrolidone                   | (9.2)         | 674                                 |
| C <sub>4</sub> H <sub>8</sub>                  | 1-Butene                        | 9.55 ± 0.06   | 921                                 |
| C <sub>4</sub> H <sub>8</sub>                  | <i>cis</i> -2-Butene            | 9.11 ± 0.01   | 871                                 |
| C <sub>4</sub> H <sub>8</sub>                  | <i>trans</i> -2-Butene          | 9.10 ± 0.01   | 866                                 |
| C <sub>4</sub> H <sub>8</sub>                  | Isobutene                       | 9.239 ± 0.003 | 875                                 |
| C <sub>4</sub> H <sub>8</sub>                  | Cyclobutane                     | (9.82 ± 0.05) | 976                                 |
| C <sub>4</sub> H <sub>8</sub>                  | Methylcyclopropane              | (9.46)        | 936                                 |
| C <sub>4</sub> H <sub>8</sub> Br <sub>2</sub>  | 1,4-Dibromobutane               | (10.15)       | 879                                 |
| C <sub>4</sub> H <sub>8</sub> O                | Ethyl vinyl ether               | (8.98)        | 709                                 |
| C <sub>4</sub> H <sub>8</sub> O                | 1,2-Epoxybutane                 | (≤ 10.15)     | 862                                 |
| C <sub>4</sub> H <sub>8</sub> O                | Butanal                         | 9.84 ± 0.02   | 742                                 |
| C <sub>4</sub> H <sub>8</sub> O                | Isobutanal                      | 9.71 ± 0.01   | 721                                 |
| C <sub>4</sub> H <sub>8</sub> O                | 2-Butanone                      | 9.52 ± 0.04   | 678                                 |
| C <sub>4</sub> H <sub>8</sub> O                | Tetrahydrofuran                 | 9.38 ± 0.05   | 721                                 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Butanoic acid                   | 10.17 ± 0.05  | 509                                 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 2-Methylpropanoic acid          | 10.33 ± 0.03  | 516                                 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Propyl formate                  | 10.52 ± 0.02  | 555                                 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Ethyl acetate                   | 10.01 ± 0.05  | 522                                 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | Methyl propanoate               | 10.15 ± 0.03  | 548                                 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 1,3-Dioxane                     | 9.8           | 607                                 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>   | 1,4-Dioxane                     | 9.19 ± 0.01   | 571                                 |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> S | Sulfolane                       | (9.8)         | 577                                 |
| C <sub>4</sub> H <sub>8</sub> S                | Tetrahydrothiophene             | 8.38          | 774                                 |
| C <sub>4</sub> H <sub>9</sub> Br               | 1-Bromobutane                   | (10.12)       | 869                                 |
| C <sub>4</sub> H <sub>9</sub> Br               | 2-Bromobutane                   | 10.01 ± 0.02  | 845                                 |
| C <sub>4</sub> H <sub>9</sub> Br               | 1-Bromo-2-methylpropane         | 10.09 ± 0.02  | 861                                 |
| C <sub>4</sub> H <sub>9</sub> Br               | 2-Bromo-2-methylpropane         | 9.92 ± 0.03   | 823                                 |
| C <sub>4</sub> H <sub>9</sub> Cl               | 1-Chlorobutane                  | 10.67 ± 0.03  | 875                                 |
| C <sub>4</sub> H <sub>9</sub> Cl               | 2-Chlorobutane                  | 10.53         | 857                                 |
| C <sub>4</sub> H <sub>9</sub> Cl               | 1-Chloro-2-methylpropane        | 10.73 ± 0.07  | 877                                 |
| C <sub>4</sub> H <sub>9</sub> Cl               | 2-Chloro-2-methylpropane        | (10.61)       | 842                                 |
| C <sub>4</sub> H <sub>9</sub> I                | 1-Iodobutane                    | 9.23 ± 0.01   | 840                                 |
| C <sub>4</sub> H <sub>9</sub> I                | 2-Iodobutane                    | 9.10 ± 0.02   | 815                                 |
| C <sub>4</sub> H <sub>9</sub> I                | 1-Iodo-2-methylpropane          | 9.19 ± 0.01   | 824                                 |
| C <sub>4</sub> H <sub>9</sub> I                | 2-Iodo-2-methylpropane          | (9.02)        | 798                                 |
| C <sub>4</sub> H <sub>9</sub> N                | Pyrrolidine                     | (8.0)         | 769                                 |
| C <sub>4</sub> H <sub>9</sub> NO               | <i>N,N</i> -Dimethylacetamide   | 8.81 ± 0.03   | 616                                 |
| C <sub>4</sub> H <sub>9</sub> NO               | Morpholine                      | (8.2)         | 841                                 |
| C <sub>4</sub> H <sub>10</sub>                 | Butane                          | 10.53 ± 0.10  | 890                                 |
| C <sub>4</sub> H <sub>10</sub>                 | Isobutane                       | (10.57)       | 886                                 |
| C <sub>4</sub> H <sub>10</sub> O               | 1-Butanol                       | 9.99 ± 0.05   | 689                                 |
| C <sub>4</sub> H <sub>10</sub> O               | 2-Butanol                       | 9.88 ± 0.03   | 658                                 |
| C <sub>4</sub> H <sub>10</sub> O               | 2-Methyl-1-propanol             | 10.02 ± 0.04  | 683                                 |
| C <sub>4</sub> H <sub>10</sub> O               | 2-Methyl-2-propanol             | 9.90 ± 0.02   | 642                                 |
| C <sub>4</sub> H <sub>10</sub> O               | Diethyl ether                   | 9.51 ± 0.03   | 666                                 |
| C <sub>4</sub> H <sub>10</sub> O               | Methyl propyl ether             | 9.41 ± 0.07   | 670                                 |
| C <sub>4</sub> H <sub>10</sub> O               | Isopropyl methyl ether          | 9.45 ± 0.04   | 661                                 |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>  | Ethylene glycol monoethyl ether | (9.6)         | 529                                 |
| C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>  | Ethylene glycol dimethyl ether  | (9.3)         | 558                                 |

| Mol.<br>form.                                 | Name                           | IP/eV          | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|-----------------------------------------------|--------------------------------|----------------|-------------------------------------|
| C <sub>4</sub> H <sub>10</sub> S              | 1-Butanethiol                  | 9.14 ± 0.01    | 794                                 |
| C <sub>4</sub> H <sub>10</sub> S              | 2-Butanethiol                  | (9.10)         | 781                                 |
| C <sub>4</sub> H <sub>10</sub> S              | 2-Methyl-1-propanethiol        | (9.12)         | 783                                 |
| C <sub>4</sub> H <sub>10</sub> S              | 2-Methyl-2-propanethiol        | (9.03)         | 762                                 |
| C <sub>4</sub> H <sub>10</sub> S              | Diethyl sulfide                | (8.43)         | 730                                 |
| C <sub>4</sub> H <sub>10</sub> S              | Methyl propyl sulfide          | (8.8)          | 767                                 |
| C <sub>4</sub> H <sub>10</sub> S              | Isopropyl methyl sulfide       | (8.7)          | 749                                 |
| C <sub>4</sub> H <sub>10</sub> S <sub>2</sub> | Diethyl disulfide              | (8.27)         | 724                                 |
| C <sub>4</sub> H <sub>11</sub> N              | Butylamine                     | 8.7 ± 0.1      | 748                                 |
| C <sub>4</sub> H <sub>11</sub> N              | <i>sec</i> -Butylamine         | 8.46 ± 0.1     | 711                                 |
| C <sub>4</sub> H <sub>11</sub> N              | <i>tert</i> -Butylamine        | 8.46 ± 0.1     | 695                                 |
| C <sub>4</sub> H <sub>11</sub> N              | Isobutylamine                  | 8.50 ± 0.1     | 721                                 |
| C <sub>4</sub> H <sub>11</sub> N              | Diethylamine                   | 7.85 ± 0.1     | 684                                 |
| C <sub>4</sub> H <sub>12</sub> Si             | Tetramethylsilane              | 9.80 ± 0.04    | 713                                 |
| C <sub>4</sub> H <sub>12</sub> Sn             | Tetramethylstannane            | 8.89 ± 0.05    | 837                                 |
| C <sub>4</sub> NiO <sub>4</sub>               | Nickel carbonyl                | 8.27 ± 0.04    | 200                                 |
| C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>  | Furfural                       | 9.22 ± 0.01    | 739                                 |
| C <sub>5</sub> H <sub>5</sub> N               | Pyridine                       | 9.25           | 1031                                |
| C <sub>5</sub> H <sub>6</sub>                 | 1-Penten-3-yne                 | 9.00 ± 0.01    | 1119                                |
| C <sub>5</sub> H <sub>6</sub>                 | <i>cis</i> -3-Penten-1-yne     | 9.14 ± 0.04    | 1137                                |
| C <sub>5</sub> H <sub>6</sub>                 | <i>trans</i> -3-Penten-1-yne   | 9.05 ± 0.01    | 1128                                |
| C <sub>5</sub> H <sub>6</sub>                 | 2-Methyl-1-buten-3-yne         | 9.25 ± 0.02    | 1152                                |
| C <sub>5</sub> H <sub>6</sub>                 | 1,3-Cyclopentadiene            | 8.55 ± 0.02    | 955                                 |
| C <sub>5</sub> H <sub>6</sub> O               | 2-Methylfuran                  | 8.38 ± 0.02    | 729                                 |
| C <sub>5</sub> H <sub>6</sub> O               | 3-Methylfuran                  | (8.64)         | 763                                 |
| C <sub>5</sub> H <sub>6</sub> S               | 2-Methylthiophene              | (8.14)         | 867                                 |
| C <sub>5</sub> H <sub>6</sub> S               | 3-Methylthiophene              | (8.40)         | 893                                 |
| C <sub>5</sub> H <sub>8</sub>                 | <i>cis</i> -1,3-Pentadiene     | 8.63 ± 0.03    | 914                                 |
| C <sub>5</sub> H <sub>8</sub>                 | <i>trans</i> -1,3-Pentadiene   | 8.59 ± 0.02    | 905                                 |
| C <sub>5</sub> H <sub>8</sub>                 | 1,4-Pentadiene                 | 9.60 ± 0.02    | 1032                                |
| C <sub>5</sub> H <sub>8</sub>                 | 2-Methyl-1,3-butadiene         | 8.84 ± 0.01    | 928                                 |
| C <sub>5</sub> H <sub>8</sub>                 | 1-Pentyne                      | 10.10 ± 0.01   | 1119                                |
| C <sub>5</sub> H <sub>8</sub>                 | Cyclopentene                   | 9.01 ± 0.01    | 905                                 |
| C <sub>5</sub> H <sub>8</sub>                 | Spiropentane                   | (9.26)         | 1078                                |
| C <sub>5</sub> H <sub>8</sub> O               | Cyclopropyl methyl ketone      | (≤ 9.46)       | 796                                 |
| C <sub>5</sub> H <sub>8</sub> O               | Cyclopentanone                 | 9.26 ± 0.01    | 701                                 |
| C <sub>5</sub> H <sub>8</sub> O               | 3,4-Dihydro-2H-pyran           | 8.35 ± 0.01    | 681                                 |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>  | Ethyl acrylate                 | (≤ 10.3)       | 617                                 |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>  | Methyl methacrylate            | (9.7)          | 589                                 |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>  | 2,4-Pentanedione               | 8.85 ± 0.01    | 469                                 |
| C <sub>5</sub> H <sub>9</sub> NO              | <i>N</i> -Methyl-2-pyrrolidone | (≤ 9.17)       | ≤ 676                               |
| C <sub>5</sub> H <sub>10</sub>                | 1-Pentene                      | 9.51 ± 0.01    | 896                                 |
| C <sub>5</sub> H <sub>10</sub>                | <i>cis</i> -2-Pentene          | 9.01 ± 0.03    | 843                                 |
| C <sub>5</sub> H <sub>10</sub>                | <i>trans</i> -2-Pentene        | 9.04 ± 0.01    | 841                                 |
| C <sub>5</sub> H <sub>10</sub>                | 2-Methyl-1-butene              | 9.12 ± 0.01    | 844                                 |
| C <sub>5</sub> H <sub>10</sub>                | 3-Methyl-1-butene              | 9.52 ± 0.01    | 891                                 |
| C <sub>5</sub> H <sub>10</sub>                | 2-Methyl-2-butene              | 8.69 ± 0.01    | 796                                 |
| C <sub>5</sub> H <sub>10</sub>                | Cyclopentane                   | (10.33 ± 0.15) | 918                                 |
| C <sub>5</sub> H <sub>10</sub> O              | 2,2-Dimethylpropanal           | 9.51 ± 0.01    | 675                                 |
| C <sub>5</sub> H <sub>10</sub> O              | Cyclopentanol                  | (9.72)         | 695                                 |
| C <sub>5</sub> H <sub>10</sub> O              | Pentanal                       | 9.74 ± 0.04    | 709                                 |
| C <sub>5</sub> H <sub>10</sub> O              | 2-Pentanone                    | 9.38 ± 0.01    | 646                                 |
| C <sub>5</sub> H <sub>10</sub> O              | 3-Pentanone                    | 9.31 ± 0.01    | 640                                 |
| C <sub>5</sub> H <sub>10</sub> O              | 3-Methyl-2-butanone            | 9.30 ± 0.01    | 635                                 |
| C <sub>5</sub> H <sub>10</sub> O              | Tetrahydropyran                | 9.25 ± 0.01    | 670                                 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Pentanoic acid                 | (≤ 10.53)      | ≤ 527                               |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | 3-Methylbutanoic acid          | (≤ 10.51)      | ≤ 499                               |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Butyl formate                  | 10.52 ± 0.02   | 584                                 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Propyl acetate                 | (≤ 9.92)       | 501                                 |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> | Isopropyl acetate              | 9.99 ± 0.03    | 482                                 |

| Mol.<br>form.                              | Name                              | IP/eV                 | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|--------------------------------------------|-----------------------------------|-----------------------|-------------------------------------|
| $\text{C}_5\text{H}_{10}\text{O}_2$        | Ethyl propanoate                  | (10.00)               | 500                                 |
| $\text{C}_5\text{H}_{10}\text{O}_2$        | Methyl butanoate                  | (10.07)               | 520                                 |
| $\text{C}_5\text{H}_{10}\text{S}$          | Thiacyclohexane                   | (8.2)                 | 728                                 |
| $\text{C}_5\text{H}_{11}\text{Br}$         | 1-Bromopentane                    | $10.10 \pm 0.01$      | 846                                 |
| $\text{C}_5\text{H}_{11}\text{I}$          | 1-Iodopentane                     | $9.20 \pm 0.01$       | 817                                 |
| $\text{C}_5\text{H}_{11}\text{N}$          | Piperidine                        | $8.03 \pm 0.11$       | 726                                 |
| $\text{C}_5\text{H}_{11}\text{N}$          | <i>N</i> -Methylpyrrolidine       | $\leq 8.41 \pm 0.02$  | $\leq 809$                          |
| $\text{C}_5\text{H}_{12}$                  | Pentane                           | $10.28 \pm 0.10$      | 845                                 |
| $\text{C}_5\text{H}_{12}$                  | Isopentane                        | $10.32 \pm 0.05$      | 843                                 |
| $\text{C}_5\text{H}_{12}$                  | Neopentane                        | $(\leq 10.2)$         | $\leq 818$                          |
| $\text{C}_5\text{H}_{12}\text{O}$          | 1-Pentanol                        | (10.00)               | 668                                 |
| $\text{C}_5\text{H}_{12}\text{O}$          | 2-Pentanol                        | (9.78)                | 630                                 |
| $\text{C}_5\text{H}_{12}\text{O}$          | 3-Pentanol                        | 9.78                  | 628                                 |
| $\text{C}_5\text{H}_{12}\text{O}$          | 2-Methyl-1-butanol                | (9.86)                | 649                                 |
| $\text{C}_5\text{H}_{12}\text{O}$          | 2-Methyl-2-butanol                | (9.8)                 | 615                                 |
| $\text{C}_5\text{H}_{12}\text{O}$          | 3-Methyl-2-butanol                | $(9.88 \pm 0.13)$     | 637                                 |
| $\text{C}_5\text{H}_{12}\text{O}$          | Butyl methyl ether                | $(9.4 \pm 0.1)$       | 648                                 |
| $\text{C}_5\text{H}_{12}\text{O}$          | Methyl <i>tert</i> -butyl ether   | (9.24)                | 608                                 |
| $\text{C}_5\text{H}_{12}\text{O}$          | Ethyl propyl ether                | (9.45)                | 640                                 |
| $\text{C}_5\text{H}_{12}\text{S}$          | <i>tert</i> -Butyl methyl sulfide | (8.38)                | 687                                 |
| $\text{C}_5\text{H}_{12}\text{S}$          | Ethyl propyl sulfide              | (8.50)                | 716                                 |
| $\text{C}_5\text{H}_{12}\text{S}$          | Ethyl isopropyl sulfide           | (8.35)                | 689                                 |
| $\text{C}_6\text{BrF}_5$                   | Bromopentafluorobenzene           | (9.67)                | 222                                 |
| $\text{C}_6\text{ClF}_5$                   | Chloropentafluorobenzene          | (9.72)                | 126                                 |
| $\text{C}_6\text{Cl}_6$                    | Hexachlorobenzene                 | (8.98)                | 822                                 |
| $\text{C}_6\text{F}_6$                     | Hexafluorobenzene                 | $9.89 \pm 0.04$       | 8                                   |
| $\text{C}_6\text{F}_{12}$                  | Perfluorocyclohexane              | (13.2)                | -1095                               |
| $\text{C}_6\text{HF}_5$                    | Pentafluorobenzene                | (9.63)                | 122                                 |
| $\text{C}_6\text{HF}_5\text{O}$            | Pentafluorophenol                 | (9.20)                | -71                                 |
| $\text{C}_6\text{H}_2\text{F}_4$           | 1,2,3,4-Tetrafluorobenzene        | (9.53)                | 284                                 |
| $\text{C}_6\text{H}_2\text{F}_4$           | 1,2,3,5-Tetrafluorobenzene        | (9.53)                | 263                                 |
| $\text{C}_6\text{H}_2\text{F}_4$           | 1,2,4,5-Tetrafluorobenzene        | (9.35)                | 254                                 |
| $\text{C}_6\text{H}_3\text{Cl}_3$          | 1,2,4-Trichlorobenzene            | (9.04)                | 880                                 |
| $\text{C}_6\text{H}_3\text{Cl}_3$          | 1,3,5-Trichlorobenzene            | $9.32 \pm 0.02$       | 899                                 |
| $\text{C}_6\text{H}_4\text{ClNO}_2$        | 1-Chloro-3-nitrobenzene           | $(9.92 \pm 0.1)$      | 995                                 |
| $\text{C}_6\text{H}_4\text{ClNO}_2$        | 1-Chloro-4-nitrobenzene           | $(9.96 \pm 0.1)$      | 999                                 |
| $\text{C}_6\text{H}_4\text{Cl}_2$          | <i>o</i> -Dichlorobenzene         | $9.06 \pm 0.02$       | 907                                 |
| $\text{C}_6\text{H}_4\text{Cl}_2$          | <i>m</i> -Dichlorobenzene         | $9.10 \pm 0.02$       | 906                                 |
| $\text{C}_6\text{H}_4\text{Cl}_2$          | <i>p</i> -Dichlorobenzene         | $8.92 \pm 0.02$       | 885                                 |
| $\text{C}_6\text{H}_4\text{FNO}_2$         | 1-Fluoro-4-nitrobenzene           | (9.90)                | 826                                 |
| $\text{C}_6\text{H}_4\text{F}_2$           | <i>o</i> -Difluorobenzene         | $9.29 \pm 0.01$       | 602                                 |
| $\text{C}_6\text{H}_4\text{F}_2$           | <i>m</i> -Difluorobenzene         | $9.33 \pm 0.01$       | 591                                 |
| $\text{C}_6\text{H}_4\text{F}_2$           | <i>p</i> -Difluorobenzene         | $9.1589 \pm 0.0003$   | 577                                 |
| $\text{C}_6\text{H}_4\text{O}_2$           | <i>p</i> -Benzoquinone            | $10.01 \pm 0.06$      | 844                                 |
| $\text{C}_6\text{H}_5\text{Br}$            | Bromobenzene                      | $9.00 \pm 0.02$       | 971                                 |
| $\text{C}_6\text{H}_5\text{Cl}$            | Chlorobenzene                     | $9.07 \pm 0.02$       | 930                                 |
| $\text{C}_6\text{H}_5\text{ClO}$           | <i>m</i> -Chlorophenol            | $8.655 \pm 0.001$     | 680                                 |
| $\text{C}_6\text{H}_5\text{ClO}$           | <i>p</i> -Chlorophenol            | $(\leq 8.69)$         | $\leq 692$                          |
| $\text{C}_6\text{H}_5\text{F}$             | Fluorobenzene                     | $9.20 \pm 0.01$       | 772                                 |
| $\text{C}_6\text{H}_5\text{I}$             | Iodobenzene                       | 8.685                 | 1003                                |
| $\text{C}_6\text{H}_5\text{NO}_2$          | Nitrobenzene                      | $9.86 \pm 0.02$       | 1019                                |
| $\text{C}_6\text{H}_5\text{NO}_3$          | <i>o</i> -Nitrophenol             | (9.1)                 | 782                                 |
| $\text{C}_6\text{H}_5\text{NO}_3$          | <i>m</i> -Nitrophenol             | (9.0)                 | 755                                 |
| $\text{C}_6\text{H}_5\text{NO}_3$          | <i>p</i> -Nitrophenol             | (9.1)                 | 761                                 |
| $\text{C}_6\text{H}_6$                     | Benzene                           | $9.24378 \pm 0.00007$ | 975                                 |
| $\text{C}_6\text{H}_6$                     | Fulvene                           | (8.36)                | 1031                                |
| $\text{C}_6\text{H}_6\text{ClN}$           | <i>o</i> -Chloroaniline           | (8.50)                | 883                                 |
| $\text{C}_6\text{H}_6\text{ClN}$           | <i>m</i> -Chloroaniline           | (8.09)                | 835                                 |
| $\text{C}_6\text{H}_6\text{ClN}$           | <i>p</i> -Chloroaniline           | $(\leq 8.18)$         | $\leq 844$                          |
| $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | <i>o</i> -Nitroaniline            | (8.27)                | 861                                 |

| Mol.<br>form.                              | Name                              | IP/eV             | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|--------------------------------------------|-----------------------------------|-------------------|-------------------------------------|
| $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | <i>m</i> -Nitroaniline            | (8.31)            | 865                                 |
| $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | <i>p</i> -Nitroaniline            | (8.34)            | 859                                 |
| $\text{C}_6\text{H}_6\text{O}$             | Phenol                            | $8.49 \pm 0.02$   | 723                                 |
| $\text{C}_6\text{H}_6\text{O}_2$           | <i>p</i> -Hydroquinone            | $7.94 \pm 0.01$   | 503                                 |
| $\text{C}_6\text{H}_6\text{S}$             | Benzenethiol                      | (8.32)            | 915                                 |
| $\text{C}_6\text{H}_7\text{N}$             | Aniline                           | $7.720 \pm 0.002$ | 832                                 |
| $\text{C}_6\text{H}_7\text{N}$             | 2-Methylpyridine                  | (9.02)            | 970                                 |
| $\text{C}_6\text{H}_7\text{N}$             | 3-Methylpyridine                  | (9.04)            | 979                                 |
| $\text{C}_6\text{H}_7\text{N}$             | 4-Methylpyridine                  | (9.04)            | 976                                 |
| $\text{C}_6\text{H}_8\text{N}_2$           | <i>o</i> -Phenylenediamine        | (7.2)             | 787                                 |
| $\text{C}_6\text{H}_8\text{N}_2$           | <i>m</i> -Phenylenediamine        | (7.14)            | 777                                 |
| $\text{C}_6\text{H}_8\text{N}_2$           | <i>p</i> -Phenylenediamine        | $(6.87 \pm 0.05)$ | 759                                 |
| $\text{C}_6\text{H}_{10}$                  | 1,5-Hexadiene                     | $9.27 \pm 0.05$   | 978                                 |
| $\text{C}_6\text{H}_{10}$                  | 1-Hexyne                          | $10.03 \pm 0.05$  | 1089                                |
| $\text{C}_6\text{H}_{10}$                  | 3,3-Dimethyl-1-butyne             | $9.90 \pm 0.04$   | 1060                                |
| $\text{C}_6\text{H}_{10}$                  | Cyclohexene                       | $8.945 \pm 0.01$  | 859                                 |
| $\text{C}_6\text{H}_{10}\text{O}$          | Cyclohexanone                     | $9.14 \pm 0.01$   | 656                                 |
| $\text{C}_6\text{H}_{10}\text{O}$          | Mesityl oxide                     | $9.10 \pm 0.01$   | 694                                 |
| $\text{C}_6\text{H}_{10}\text{O}_4$        | Diethyl oxalate                   | (9.8)             | 205                                 |
| $\text{C}_6\text{H}_{11}\text{NO}$         | Caprolactam                       | $(9.07 \pm 0.02)$ | 629                                 |
| $\text{C}_6\text{H}_{12}$                  | 1-Hexene                          | $9.44 \pm 0.04$   | 869                                 |
| $\text{C}_6\text{H}_{12}$                  | <i>cis</i> -2-Hexene              | $(8.97 \pm 0.01)$ | 818                                 |
| $\text{C}_6\text{H}_{12}$                  | <i>trans</i> -2-Hexene            | $(8.97 \pm 0.01)$ | 814                                 |
| $\text{C}_6\text{H}_{12}$                  | 2-Methyl-1-pentene                | $(9.08 \pm 0.01)$ | 817                                 |
| $\text{C}_6\text{H}_{12}$                  | 4-Methyl-1-pentene                | $9.45 \pm 0.01$   | 862                                 |
| $\text{C}_6\text{H}_{12}$                  | 2-Methyl-2-pentene                | (8.58)            | 761                                 |
| $\text{C}_6\text{H}_{12}$                  | 4-Methyl- <i>cis</i> -2-pentene   | $8.98 \pm 0.01$   | 809                                 |
| $\text{C}_6\text{H}_{12}$                  | 4-Methyl- <i>trans</i> -2-pentene | $(8.97 \pm 0.01)$ | 804                                 |
| $\text{C}_6\text{H}_{12}$                  | 2-Ethyl-1-butene                  | $(9.06 \pm 0.02)$ | 818                                 |
| $\text{C}_6\text{H}_{12}$                  | 2,3-Dimethyl-1-butene             | $(9.07 \pm 0.01)$ | 812                                 |
| $\text{C}_6\text{H}_{12}$                  | 2,3-Dimethyl-2-butene             | $8.27 \pm 0.01$   | 729                                 |
| $\text{C}_6\text{H}_{12}$                  | Cyclohexane                       | $9.86 \pm 0.03$   | 828                                 |
| $\text{C}_6\text{H}_{12}$                  | Methylcyclopentane                | (9.85)            | 845                                 |
| $\text{C}_6\text{H}_{12}\text{O}$          | Hexanal                           | $9.72 \pm 0.05$   | 691                                 |
| $\text{C}_6\text{H}_{12}\text{O}$          | 2-Hexanone                        | $9.3 \pm 0.1$     | 626                                 |
| $\text{C}_6\text{H}_{12}\text{O}$          | 3-Hexanone                        | $9.12 \pm 0.02$   | 600                                 |
| $\text{C}_6\text{H}_{12}\text{O}$          | 3-Methyl-2-pentanone              | $9.21 \pm 0.01$   | 600                                 |
| $\text{C}_6\text{H}_{12}\text{O}$          | 4-Methyl-2-pentanone              | $9.30 \pm 0.01$   | 609                                 |
| $\text{C}_6\text{H}_{12}\text{O}$          | 2-Methyl-3-pentanone              | $9.10 \pm 0.01$   | 592                                 |
| $\text{C}_6\text{H}_{12}\text{O}$          | 3,3-Dimethyl-2-butanone           | $9.12 \pm 0.02$   | 589                                 |
| $\text{C}_6\text{H}_{12}\text{O}$          | Cyclohexanol                      | (9.75)            | 651                                 |
| $\text{C}_6\text{H}_{12}\text{O}_2$        | Hexanoic acid                     | $\leq 10.12$      | $\leq 463$                          |
| $\text{C}_6\text{H}_{12}\text{O}_2$        | Butyl acetate                     | $(9.92 \pm .05)$  | 471                                 |
| $\text{C}_6\text{H}_{12}\text{O}_2$        | <i>sec</i> -Butyl acetate         | 9.90              | 453                                 |
| $\text{C}_6\text{H}_{12}\text{O}_2$        | Methyl 2,2-dimethylpropanoate     | $(9.90 \pm 0.04)$ | 466                                 |
| $\text{C}_6\text{H}_{13}\text{I}$          | 1-Iodohexane                      | 9.179             | 794                                 |
| $\text{C}_6\text{H}_{13}\text{N}$          | Cyclohexylamine                   | (8.86)            | 750                                 |
| $\text{C}_6\text{H}_{14}$                  | Hexane                            | 10.13             | 810                                 |
| $\text{C}_6\text{H}_{14}$                  | 2-Methylpentane                   | (10.12)           | 802                                 |
| $\text{C}_6\text{H}_{14}$                  | 3-Methylpentane                   | (10.08)           | 801                                 |
| $\text{C}_6\text{H}_{14}$                  | 2,2-Dimethylbutane                | (10.06)           | 787                                 |
| $\text{C}_6\text{H}_{14}$                  | 2,3-Dimethylbutane                | (10.02)           | 791                                 |
| $\text{C}_6\text{H}_{14}\text{O}$          | 1-Hexanol                         | (9.89)            | 639                                 |
| $\text{C}_6\text{H}_{14}\text{O}$          | 2-Hexanol                         | $(9.80 \pm 0.03)$ | 611                                 |
| $\text{C}_6\text{H}_{14}\text{O}$          | 3-Hexanol                         | $(9.63 \pm 0.03)$ | 599                                 |
| $\text{C}_6\text{H}_{14}\text{O}$          | Dipropyl ether                    | (9.27)            | 602                                 |
| $\text{C}_6\text{H}_{14}\text{O}$          | Diisopropyl ether                 | $9.20 \pm 0.05$   | 569                                 |
| $\text{C}_6\text{H}_{14}\text{O}$          | Butyl ethyl ether                 | (9.36)            | 610                                 |
| $\text{C}_6\text{H}_{14}\text{O}$          | Methyl pentyl ether               | $(\leq 9.67)$     | $\leq 657$                          |
| $\text{C}_6\text{H}_{14}\text{O}_2$        | 1,1-Diethoxyethane                | (9.2)             | 434                                 |



| Mol.<br>form.                        | Name                                   | IP/eV                  | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|--------------------------------------|----------------------------------------|------------------------|-------------------------------------|
| $\text{C}_6\text{H}_{14}\text{O}_3$  | Diethylene glycol dimethyl ether       | $\leq 9.8$             | $\leq 448$                          |
| $\text{C}_6\text{H}_{14}\text{S}$    | Dipropyl sulfide                       | $8.30 \pm 0.02$        | 676                                 |
| $\text{C}_6\text{H}_{14}\text{S}$    | Diisopropyl sulfide                    | $(8.2 \pm 0.2)$        | 649                                 |
| $\text{C}_6\text{H}_{15}\text{N}$    | Hexylamine                             | $(8.63 \pm 0.05)$      | 699                                 |
| $\text{C}_6\text{H}_{15}\text{N}$    | Dipropylamine                          | $(7.84 \pm 0.02)$      | 641                                 |
| $\text{C}_6\text{H}_{15}\text{N}$    | Diisopropylamine                       | $(7.73 \pm 0.03)$      | 602                                 |
| $\text{C}_6\text{H}_{15}\text{N}$    | Triethylamine                          | $(7.50 \pm 0.02)$      | 631                                 |
| $\text{C}_6\text{H}_{15}\text{NO}_3$ | Triethanolamine                        | $(7.9)$                | 206                                 |
| $\text{C}_7\text{H}_3\text{F}_5$     | 2,3,4,5,6-Pentafluorotoluene           | $(9.4)$                | 64                                  |
| $\text{C}_7\text{H}_5\text{ClO}$     | Benzoyl chloride                       | $(9.53)$               | 815                                 |
| $\text{C}_7\text{H}_5\text{Cl}_3$    | (Trichloromethyl)benzene               | $(\leq 9.60)$          | $\leq 914$                          |
| $\text{C}_7\text{H}_5\text{F}_3$     | (Trifluoromethyl)benzene               | $9.685 \pm 0.005$      | 335                                 |
| $\text{C}_7\text{H}_5\text{N}$       | Benzonitrile                           | $9.70 \pm 0.01$        | 1154                                |
| $\text{C}_7\text{H}_6\text{O}$       | Benzaldehyde                           | $9.49 \pm 0.02$        | 878                                 |
| $\text{C}_7\text{H}_6\text{O}_2$     | Benzoic acid                           | $(9.3)$                | 604                                 |
| $\text{C}_7\text{H}_7\text{Br}$      | <i>p</i> -Bromotoluene                 | $8.67 \pm 0.02$        | 908                                 |
| $\text{C}_7\text{H}_7\text{Cl}$      | <i>o</i> -Chlorotoluene                | $(8.7 \pm 0.1)$        | 856                                 |
| $\text{C}_7\text{H}_7\text{Cl}$      | <i>m</i> -Chlorotoluene                | $(8.83)$               | 869                                 |
| $\text{C}_7\text{H}_7\text{Cl}$      | <i>p</i> -Chlorotoluene                | $(8.69)$               | 855                                 |
| $\text{C}_7\text{H}_7\text{Cl}$      | (Chloromethyl)benzene                  | $9.10 \pm 0.02$        | 897                                 |
| $\text{C}_7\text{H}_7\text{F}$       | <i>o</i> -Fluorotoluene                | $8.91 \pm 0.01$        | 709                                 |
| $\text{C}_7\text{H}_7\text{F}$       | <i>m</i> -Fluorotoluene                | $8.91 \pm 0.01$        | 709                                 |
| $\text{C}_7\text{H}_7\text{F}$       | <i>p</i> -Fluorotoluene                | $8.79 \pm 0.01$        | 701                                 |
| $\text{C}_7\text{H}_7\text{NO}$      | Benzamide                              | $(9.25)$               | 792                                 |
| $\text{C}_7\text{H}_7\text{NO}_2$    | <i>o</i> -Nitrotoluene                 | 9.24                   | 946                                 |
| $\text{C}_7\text{H}_7\text{NO}_2$    | <i>m</i> -Nitrotoluene                 | $9.45 \pm 0.1$         | 941                                 |
| $\text{C}_7\text{H}_7\text{NO}_2$    | <i>p</i> -Nitrotoluene                 | $9.46 \pm 0.05$        | 942                                 |
| $\text{C}_7\text{H}_8$               | Toluene                                | $8.8276 \pm 0.0006$    | 901                                 |
| $\text{C}_7\text{H}_8\text{O}$       | <i>o</i> -Cresol                       | $(8.24)$               | 670                                 |
| $\text{C}_7\text{H}_8\text{O}$       | <i>m</i> -Cresol                       | $8.29 \pm 0.07$        | 668                                 |
| $\text{C}_7\text{H}_8\text{O}$       | <i>p</i> -Cresol                       | $(8.3)$                | 675                                 |
| $\text{C}_7\text{H}_8\text{O}$       | Benzyl alcohol                         | $(8.3)$                | 701                                 |
| $\text{C}_7\text{H}_8\text{O}$       | Anisole                                | $8.22 \pm 0.03$        | 725                                 |
| $\text{C}_7\text{H}_9\text{N}$       | Benzylamine                            | $(8.64)$               | 917                                 |
| $\text{C}_7\text{H}_9\text{N}$       | <i>o</i> -Methylaniline                | $(7.44 \pm 0.02)$      | 772                                 |
| $\text{C}_7\text{H}_9\text{N}$       | <i>m</i> -Methylaniline                | $(7.50 \pm 0.02)$      | 778                                 |
| $\text{C}_7\text{H}_9\text{N}$       | <i>p</i> -Methylaniline                | $(7.24 \pm 0.02)$      | 753                                 |
| $\text{C}_7\text{H}_9\text{N}$       | <i>N</i> -Methylaniline                | $7.34 \pm 0.04$        | 792                                 |
| $\text{C}_7\text{H}_9\text{N}$       | 2,3-Dimethylpyridine                   | $(8.85 \pm 0.02)$      | 922                                 |
| $\text{C}_7\text{H}_9\text{N}$       | 2,4-Dimethylpyridine                   | $(8.85 \pm 0.03)$      | 918                                 |
| $\text{C}_7\text{H}_9\text{N}$       | 2,5-Dimethylpyridine                   | $(\leq 8.80 \pm 0.05)$ | $\leq 916$                          |
| $\text{C}_7\text{H}_9\text{N}$       | 2,6-Dimethylpyridine                   | $8.86 \pm 0.03$        | 913                                 |
| $\text{C}_7\text{H}_9\text{N}$       | 3,4-Dimethylpyridine                   | $(\leq 9.15)$          | $\leq 953$                          |
| $\text{C}_7\text{H}_9\text{N}$       | 3,5-Dimethylpyridine                   | $(\leq 9.25)$          | $\leq 965$                          |
| $\text{C}_7\text{H}_{10}\text{O}$    | Dicyclopropyl ketone                   | $(9.1)$                | 1041                                |
| $\text{C}_7\text{H}_{14}$            | 1-Heptene                              | $9.34 \pm 0.10$        | 839                                 |
| $\text{C}_7\text{H}_{14}$            | <i>trans</i> -3-Heptene                | $(8.92)$               | 790                                 |
| $\text{C}_7\text{H}_{14}$            | Cycloheptane                           | 9.97                   | 844                                 |
| $\text{C}_7\text{H}_{14}$            | Methylcyclohexane                      | 9.64                   | 775                                 |
| $\text{C}_7\text{H}_{14}$            | <i>cis</i> -1,2-Dimethylcyclopentane   | $(9.92 \pm 0.05)$      | 828                                 |
| $\text{C}_7\text{H}_{14}$            | <i>trans</i> -1,2-Dimethylcyclopentane | $9.7 \pm 0.2$          | 799                                 |
| $\text{C}_7\text{H}_{14}\text{O}$    | 1-Heptanal                             | $(9.65)$               | 668                                 |
| $\text{C}_7\text{H}_{14}\text{O}$    | 2-Heptanone                            | $9.28 \pm 0.10$        | 594                                 |
| $\text{C}_7\text{H}_{14}\text{O}$    | 3-Heptanone                            | $9.18 \pm 0.08$        | 589                                 |
| $\text{C}_7\text{H}_{14}\text{O}$    | 4-Heptanone                            | $9.10 \pm 0.06$        | 577                                 |
| $\text{C}_7\text{H}_{14}\text{O}$    | 5-Methyl-2-hexanone                    | $(9.28)$               | 586                                 |
| $\text{C}_7\text{H}_{14}\text{O}$    | 2,4-Dimethyl-3-pentanone               | $8.95 \pm 0.01$        | 552                                 |
| $\text{C}_7\text{H}_{14}\text{O}$    | 1-Methylcyclohexanol                   | $(9.8 \pm 0.2)$        | 586                                 |
| $\text{C}_7\text{H}_{16}$            | Heptane                                | $9.93 \pm 0.10$        | 771                                 |
| $\text{C}_7\text{H}_{16}\text{O}$    | 1-Heptanol                             | $(9.84)$               | 614                                 |



| Mol.<br>form.                     | Name                                  | IP/eV               | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|-----------------------------------|---------------------------------------|---------------------|-------------------------------------|
| $\text{C}_7\text{H}_{16}\text{O}$ | 2-Heptanol                            | (9.70)              | 580                                 |
| $\text{C}_7\text{H}_{16}\text{O}$ | 3-Heptanol                            | (9.68)              | 578                                 |
| $\text{C}_7\text{H}_{16}\text{O}$ | 4-Heptanol                            | (9.61)              | 572                                 |
| $\text{C}_7\text{H}_{16}\text{O}$ | Ethyl pentyl ether                    | ( $\leq 9.49$ )     | $\leq 602$                          |
| $\text{C}_8\text{H}_4\text{O}_3$  | Phthalic anhydride                    | (10.1)              | 603                                 |
| $\text{C}_8\text{H}_6\text{O}_4$  | Isophthalic acid                      | (9.98)              | 268                                 |
| $\text{C}_8\text{H}_6\text{O}_4$  | Terephthalic acid                     | (9.86)              | 232                                 |
| $\text{C}_8\text{H}_7\text{N}$    | 2-Methylbenzonitrile                  | ( $\leq 9.38$ )     | 1085                                |
| $\text{C}_8\text{H}_7\text{N}$    | 3-Methylbenzonitrile                  | ( $\leq 9.34$ )     | 1085                                |
| $\text{C}_8\text{H}_7\text{N}$    | 4-Methylbenzonitrile                  | $9.32 \pm 0.02$     | 1083                                |
| $\text{C}_8\text{H}_7\text{N}$    | Indole                                | $7.7602 \pm 0.0006$ | 908                                 |
| $\text{C}_8\text{H}_8$            | Styrene                               | $8.464 \pm 0.001$   | 964                                 |
| $\text{C}_8\text{H}_8\text{O}$    | <i>p</i> -Tolualdehyde                | (9.33)              | 825                                 |
| $\text{C}_8\text{H}_8\text{O}$    | Acetophenone                          | $9.29 \pm 0.03$     | 810                                 |
| $\text{C}_8\text{H}_8\text{O}_2$  | <i>o</i> -Toluic acid                 | (9.1)               | 558                                 |
| $\text{C}_8\text{H}_8\text{O}_2$  | <i>m</i> -Toluic acid                 | (9.43)              | 579                                 |
| $\text{C}_8\text{H}_8\text{O}_2$  | <i>p</i> -Toluic acid                 | (9.23)              | 560                                 |
| $\text{C}_8\text{H}_8\text{O}_2$  | Benzeneacetic acid                    | (8.26)              | 479                                 |
| $\text{C}_8\text{H}_8\text{O}_2$  | Methyl benzoate                       | $9.32 \pm 0.03$     | 611                                 |
| $\text{C}_8\text{H}_{10}$         | Ethylbenzene                          | $8.77 \pm 0.01$     | 876                                 |
| $\text{C}_8\text{H}_{10}$         | <i>o</i> -Xylene                      | $8.56 \pm 0.01$     | 844                                 |
| $\text{C}_8\text{H}_{10}$         | <i>m</i> -Xylene                      | $8.56 \pm 0.01$     | 843                                 |
| $\text{C}_8\text{H}_{10}$         | <i>p</i> -Xylene                      | $8.44 \pm 0.01$     | 832                                 |
| $\text{C}_8\text{H}_{10}\text{O}$ | <i>p</i> -Ethylphenol                 | (7.84)              | 613                                 |
| $\text{C}_8\text{H}_{10}\text{O}$ | 2,3-Xylenol                           | (8.26)              | 640                                 |
| $\text{C}_8\text{H}_{10}\text{O}$ | 2,4-Xylenol                           | (8.0)               | 609                                 |
| $\text{C}_8\text{H}_{10}\text{O}$ | 2,6-Xylenol                           | (8.05)              | 615                                 |
| $\text{C}_8\text{H}_{10}\text{O}$ | 3,4-Xylenol                           | (8.09)              | 624                                 |
| $\text{C}_8\text{H}_{10}\text{O}$ | Phenetole                             | (8.13)              | 683                                 |
| $\text{C}_8\text{H}_{11}\text{N}$ | 2,4,6-Trimethylpyridine               | ( $\leq 8.9$ )      | $\leq 880$                          |
| $\text{C}_8\text{H}_{11}\text{N}$ | <i>N</i> -Ethylaniline                | ( $\leq 7.67$ )     | $\leq 794$                          |
| $\text{C}_8\text{H}_{11}\text{N}$ | <i>N,N</i> -Dimethylaniline           | $7.12 \pm 0.02$     | 787                                 |
| $\text{C}_8\text{H}_{14}$         | 1-Octyne                              | ( $9.95 \pm 0.02$ ) | 1040                                |
| $\text{C}_8\text{H}_{14}$         | 2-Octyne                              | $9.31 \pm 0.01$     | 961                                 |
| $\text{C}_8\text{H}_{14}$         | 3-Octyne                              | $9.22 \pm 0.01$     | 952                                 |
| $\text{C}_8\text{H}_{14}$         | 4-Octyne                              | $9.20 \pm 0.01$     | 946                                 |
| $\text{C}_8\text{H}_{16}$         | 1-Octene                              | $9.43 \pm 0.01$     | 829                                 |
| $\text{C}_8\text{H}_{16}$         | Cyclooctane                           | $9.75 \pm 0.05$     | 816                                 |
| $\text{C}_8\text{H}_{16}$         | Ethylcyclohexane                      | (9.54)              | 748                                 |
| $\text{C}_8\text{H}_{16}$         | 1,1-Dimethylcyclohexane               | (9.42)              | 728                                 |
| $\text{C}_8\text{H}_{16}$         | <i>cis</i> -1,2-Dimethylcyclohexane   | ( $< 9.78$ )        | 772                                 |
| $\text{C}_8\text{H}_{16}$         | <i>trans</i> -1,2-Dimethylcyclohexane | 9.41                | 728                                 |
| $\text{C}_8\text{H}_{16}$         | <i>cis</i> -1,3-Dimethylcyclohexane   | ( $< 9.98$ )        | 778                                 |
| $\text{C}_8\text{H}_{16}$         | <i>trans</i> -1,3-Dimethylcyclohexane | 9.53                | 743                                 |
| $\text{C}_8\text{H}_{16}$         | <i>cis</i> -1,4-Dimethylcyclohexane   | ( $< 9.93$ )        | 782                                 |
| $\text{C}_8\text{H}_{16}$         | <i>trans</i> -1,4-Dimethylcyclohexane | (9.56)              | 738                                 |
| $\text{C}_8\text{H}_{16}$         | Propylcyclopentane                    | (9.34)              | 753                                 |
| $\text{C}_8\text{H}_{16}\text{O}$ | 2,2,4-Trimethyl-3-pentanone           | (8.80)              | 511                                 |
| $\text{C}_8\text{H}_{18}$         | Octane                                | $9.80 \pm 0.10$     | 737                                 |
| $\text{C}_8\text{H}_{18}$         | 2-Methylheptane                       | (9.84)              | 734                                 |
| $\text{C}_8\text{H}_{18}$         | 2,2,4-Trimethylpentane                | (9.86)              | 713                                 |
| $\text{C}_8\text{H}_{18}$         | 2,2,3,3-Tetramethylbutane             | 9.8                 | 720                                 |
| $\text{C}_8\text{H}_{18}\text{O}$ | Dibutyl ether                         | (9.28)              | $\leq 560$                          |
| $\text{C}_8\text{H}_{18}\text{O}$ | Di- <i>sec</i> -butyl ether           | (9.11)              | 511                                 |
| $\text{C}_8\text{H}_{18}\text{O}$ | Di- <i>tert</i> -butyl ether          | $8.88 \pm 0.07$     | 493                                 |
| $\text{C}_8\text{H}_{18}\text{S}$ | Dibutyl sulfide                       | (8.2)               | 624                                 |
| $\text{C}_8\text{H}_{18}\text{S}$ | Di- <i>tert</i> -butyl sulfide        | (8.0)               | 583                                 |
| $\text{C}_8\text{H}_{18}\text{S}$ | Diisobutyl sulfide                    | (8.34)              | 625                                 |
| $\text{C}_8\text{H}_{19}\text{N}$ | Dibutylamine                          | (7.69)              | 586                                 |
| $\text{C}_8\text{H}_{19}\text{N}$ | Diisobutylamine                       | (7.8)               | 574                                 |

| Mol.<br>form.                                  | Name                                      | IP/eV               | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|------------------------------------------------|-------------------------------------------|---------------------|-------------------------------------|
| $\text{C}_8\text{H}_{20}\text{Si}$             | Tetraethylsilane                          | (8.9)               | 595                                 |
| $\text{C}_9\text{H}_7\text{N}$                 | Quinoline                                 | $8.62 \pm 0.01$     | 1041                                |
| $\text{C}_9\text{H}_7\text{N}$                 | Isoquinoline                              | $8.53 \pm 0.03$     | 1032                                |
| $\text{C}_9\text{H}_8$                         | Indene                                    | $8.14 \pm 0.01$     | 949                                 |
| $\text{C}_9\text{H}_{10}$                      | <i>o</i> -Methylstyrene                   | (8.20)              | 908                                 |
| $\text{C}_9\text{H}_{10}$                      | <i>m</i> -Methylstyrene                   | (8.15)              | 899                                 |
| $\text{C}_9\text{H}_{10}$                      | <i>p</i> -Methylstyrene                   | (8.1)               | 895                                 |
| $\text{C}_9\text{H}_{10}$                      | Cyclopropylbenzene                        | (8.35)              | 956                                 |
| $\text{C}_9\text{H}_{10}$                      | Indan                                     | (8.3)               | 864                                 |
| $\text{C}_9\text{H}_{10}\text{O}_2$            | Ethyl benzoate                            | (8.9)               | 537                                 |
| $\text{C}_9\text{H}_{12}$                      | Propylbenzene                             | $8.713 \pm 0.010$   | 848                                 |
| $\text{C}_9\text{H}_{12}$                      | Isopropylbenzene                          | $8.73 \pm 0.01$     | 847                                 |
| $\text{C}_9\text{H}_{12}$                      | 1,2,3-Trimethylbenzene                    | $8.42 \pm 0.02$     | 803                                 |
| $\text{C}_9\text{H}_{12}$                      | 1,2,4-Trimethylbenzene                    | $8.27 \pm 0.01$     | 784                                 |
| $\text{C}_9\text{H}_{12}$                      | 1,3,5-Trimethylbenzene                    | $8.41 \pm 0.01$     | 796                                 |
| $\text{C}_9\text{H}_{13}\text{N}$              | <i>N,N</i> -Dimethyl- <i>o</i> -toluidine | $7.40 \pm 0.02$     | 814                                 |
| $\text{C}_9\text{H}_{14}\text{O}$              | Isophorone                                | ( $\leq 9.07$ )     | $\leq 670$                          |
| $\text{C}_9\text{H}_{18}$                      | Butylcyclopentane                         | (9.95)              | 793                                 |
| $\text{C}_9\text{H}_{18}$                      | Propylcyclohexane                         | (9.46)              | 720                                 |
| $\text{C}_9\text{H}_{18}$                      | Isopropylcyclohexane                      | (9.33)              | 704                                 |
| $\text{C}_9\text{H}_{18}\text{O}$              | 2-Nonanone                                | (9.16)              | 545                                 |
| $\text{C}_9\text{H}_{18}\text{O}$              | 5-Nonanone                                | (9.07)              | 530                                 |
| $\text{C}_9\text{H}_{18}\text{O}$              | 2,6-Dimethyl-4-heptanone                  | $9.01 \pm 0.06$     | 512                                 |
| $\text{C}_9\text{H}_{20}$                      | Nonane                                    | $9.71 \pm 0.10$     | 709                                 |
| $\text{C}_{10}\text{F}_8$                      | Perfluoronaphthalene                      | 8.85                | -368                                |
| $\text{C}_{10}\text{H}_7\text{Br}$             | 1-Bromonaphthalene                        | $8.08 \pm 0.03$     | 955                                 |
| $\text{C}_{10}\text{H}_7\text{Cl}$             | 1-Chloronaphthalene                       | (8.13)              | 906                                 |
| $\text{C}_{10}\text{H}_8$                      | Naphthalene                               | $8.1442 \pm 0.0009$ | 936                                 |
| $\text{C}_{10}\text{H}_8$                      | Azulene                                   | $7.38 \pm 0.05$     | 1001                                |
| $\text{C}_{10}\text{H}_8\text{O}$              | 1-Naphthol                                | $7.76 \pm 0.03$     | 719                                 |
| $\text{C}_{10}\text{H}_8\text{O}$              | 2-Naphthol                                | $7.87 \pm 0.06$     | 729                                 |
| $\text{C}_{10}\text{H}_{10}\text{O}_4$         | Dimethyl phthalate                        | ( $9.64 \pm 0.07$ ) | 277                                 |
| $\text{C}_{10}\text{H}_{12}$                   | 1,2,3,4-Tetrahydronaphthalene             | $8.46 \pm 0.02$     | 841                                 |
| $\text{C}_{10}\text{H}_{14}$                   | Butylbenzene                              | $8.69 \pm 0.02$     | 826                                 |
| $\text{C}_{10}\text{H}_{14}$                   | <i>sec</i> -Butylbenzene                  | $8.68 \pm 0.02$     | 820                                 |
| $\text{C}_{10}\text{H}_{14}$                   | <i>tert</i> -Butylbenzene                 | $8.68 \pm 0.05$     | 816                                 |
| $\text{C}_{10}\text{H}_{14}$                   | Isobutylbenzene                           | $8.69 \pm 0.02$     | 817                                 |
| $\text{C}_{10}\text{H}_{14}$                   | <i>p</i> -Cymene                          | (8.29)              | 771                                 |
| $\text{C}_{10}\text{H}_{14}$                   | <i>o</i> -Diethylbenzene                  | ( $\leq 8.51$ )     | $\leq 804$                          |
| $\text{C}_{10}\text{H}_{14}$                   | <i>m</i> -Diethylbenzene                  | (8.49)              | 798                                 |
| $\text{C}_{10}\text{H}_{14}$                   | <i>p</i> -Diethylbenzene                  | (8.40)              | 790                                 |
| $\text{C}_{10}\text{H}_{14}$                   | 1,2,4,5-Tetramethylbenzene                | $8.04 \pm 0.02$     | 730                                 |
| $\text{C}_{10}\text{H}_{14}\text{O}$           | <i>p</i> - <i>tert</i> -Butylphenol       | (7.8)               | 552                                 |
| $\text{C}_{10}\text{H}_{16}$                   | $\alpha$ -Pinene                          | (8.07)              | 808                                 |
| $\text{C}_{10}\text{H}_{16}\text{O}$           | Camphor                                   | (8.76)              | 577                                 |
| $\text{C}_{10}\text{H}_{18}$                   | <i>cis</i> -Decahydronaphthalene          | $9.36 \pm 0.04$     | 734                                 |
| $\text{C}_{10}\text{H}_{18}$                   | <i>trans</i> -Decahydronaphthalene        | $9.34 \pm 0.04$     | 720                                 |
| $\text{C}_{10}\text{H}_{20}$                   | 1-Decene                                  | $9.42 \pm 0.05$     | 786                                 |
| $\text{C}_{10}\text{H}_{20}$                   | Butylcyclohexane                          | (9.41)              | 695                                 |
| $\text{C}_{10}\text{H}_{22}$                   | Decane                                    | (9.65)              | 682                                 |
| $\text{C}_{11}\text{H}_{10}$                   | 1-Methylnaphthalene                       | $7.97 \pm 0.03$     | 882                                 |
| $\text{C}_{11}\text{H}_{10}$                   | 2-Methylnaphthalene                       | $7.91 \pm 0.08$     | 877                                 |
| $\text{C}_{11}\text{H}_{16}$                   | <i>p</i> - <i>tert</i> -Butyltoluene      | (8.12)              | 730                                 |
| $\text{C}_{11}\text{H}_{24}$                   | Undecane                                  | (9.56)              | 650                                 |
| $\text{C}_{11}\text{H}_{24}$                   | 2-Methyldecane                            | (9.7)               | 658                                 |
| $\text{C}_{12}\text{H}_8$                      | Acenaphthylene                            | (8.22)              | 1053                                |
| $\text{C}_{12}\text{H}_9\text{N}$              | Carbazole                                 | (7.57)              | 961                                 |
| $\text{C}_{12}\text{H}_{10}$                   | Acenaphthene                              | $7.75 \pm 0.07$     | 903                                 |
| $\text{C}_{12}\text{H}_{10}$                   | Biphenyl                                  | $8.23 \pm 0.10$     | 977                                 |
| $\text{C}_{12}\text{H}_{10}\text{N}_2\text{O}$ | <i>trans</i> -Azoxybenzene                | (8.1)               | 1123                                |

| Mol.<br>form.                        | Name                   | IP/eV               | $\Delta_f H_{\text{ion}}$<br>kJ/mol |
|--------------------------------------|------------------------|---------------------|-------------------------------------|
| $\text{C}_{12}\text{H}_{10}\text{O}$ | Diphenyl ether         | (8.09)              | 766                                 |
| $\text{C}_{12}\text{H}_{11}\text{N}$ | Diphenylamine          | $7.16 \pm 0.04$     | 908                                 |
| $\text{C}_{12}\text{H}_{18}$         | 5,7-Dodecadiyne        | (8.67)              | 1079                                |
| $\text{C}_{12}\text{H}_{18}$         | Hexamethylbenzene      | $7.85 \pm 0.01$     | 670                                 |
| $\text{C}_{12}\text{H}_{22}$         | Cyclohexylcyclohexane  | (9.41)              | 690                                 |
| $\text{C}_{12}\text{H}_{27}\text{N}$ | Tributylamine          | (7.4)               | 492                                 |
| $\text{C}_{13}\text{H}_{10}$         | 9H-Fluorene            | $7.91 \pm 0.02$     | 952                                 |
| $\text{C}_{13}\text{H}_{10}\text{O}$ | Benzophenone           | $9.08 \pm 0.05$     | 926                                 |
| $\text{C}_{13}\text{H}_{12}$         | Diphenylmethane        | (8.55)              | 963                                 |
| $\text{C}_{14}\text{H}_{10}$         | Anthracene             | $7.439 \pm 0.006$   | 948                                 |
| $\text{C}_{14}\text{H}_{10}$         | Phenanthrene           | $7.8914 \pm 0.0006$ | 966                                 |
| $\text{C}_{14}\text{H}_{10}$         | Diphenylacetylene      | $7.94 \pm 0.03$     | 1168                                |
| $\text{C}_{14}\text{H}_{12}$         | <i>cis</i> -Stilbene   | (7.80)              | 1005                                |
| $\text{C}_{14}\text{H}_{12}$         | <i>trans</i> -Stilbene | $7.656 \pm 0.001$   | 973                                 |
| $\text{C}_{14}\text{H}_{14}$         | 1,2-Diphenylethane     | $8.9 \pm 0.1$       | 1002                                |
| $\text{C}_{16}\text{H}_{10}$         | Fluoranthene           | $7.9 \pm 0.1$       | 1052                                |
| $\text{C}_{16}\text{H}_{10}$         | Pyrene                 | $7.4256 \pm 0.0006$ | 935                                 |
| $\text{C}_{18}\text{H}_{12}$         | Chrysene               | $7.60 \pm 0.01$     | 1017                                |
| $\text{C}_{18}\text{H}_{14}$         | <i>o</i> -Terphenyl    | (7.99)              | 1056                                |
| $\text{C}_{18}\text{H}_{14}$         | <i>m</i> -Terphenyl    | (8.01)              | 1057                                |
| $\text{C}_{18}\text{H}_{14}$         | <i>p</i> -Terphenyl    | $7.80 \pm 0.03$     | 1037                                |
| $\text{C}_{20}\text{H}_{12}$         | Perylene               | $6.960 \pm 0.001$   | 981                                 |
| $\text{C}_{24}\text{H}_{12}$         | Coronene               | $7.29 \pm 0.01$     | 1026                                |

## X-RAY ATOMIC ENERGY LEVELS

The energy levels in this tables are the values recommended by Bearden and Burr on the basis of a thorough review of the literature on x-ray wavelengths and related data. All values are in electron volts (eV). Values in parentheses are interpolated, and an asterisk \* indicates a level which is not resolved from the level above it. See Reference 1 for uncertainties in the levels and a complete description of how the recommended values were obtained.

### References

1. Bearden, J. A., and Burr, A. F., *Rev. Mod. Phys.*, 39, 125, 1967; also published as *X-Ray Wavelengths and X-Ray Atomic Energy Levels*, Natl. Stand. Ref. Data Sys. — Natl. Bur. Standards (U.S.), No. 14, 1967.
2. Gray, D. E., Ed., *American Institute of Physics Handbook, Third Edition*, pp. 7-158 to 7-167, McGraw-Hill, New York, 1972.

| Level               | <sup>1</sup> H   | <sup>2</sup> He  | <sup>3</sup> Li  | <sup>4</sup> Be  | <sup>5</sup> B   | <sup>6</sup> C   | <sup>7</sup> N   | <sup>8</sup> O   |
|---------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| K                   | 13.59811         | 24.58678         | 54.75            | 111.0            | 188.0            | 283.8            | 401.6            | 532.0            |
| L <sub>I</sub>      |                  |                  |                  |                  |                  |                  |                  | 23.7             |
| L <sub>II,III</sub> |                  |                  |                  |                  | 4.7              | 6.4              | 9.2              | 7.1              |
| Level               | <sup>9</sup> F   | <sup>10</sup> Ne | <sup>11</sup> Na | <sup>12</sup> Mg | <sup>13</sup> Al | <sup>14</sup> Si | <sup>15</sup> P  | <sup>16</sup> S  |
| K                   | 685.4            | 866.9            | 1072.1           | 1305.0           | 1559.6           | 1838.9           | 2145.5           | 2472.0           |
| L <sub>I</sub>      | (31)             | (45)             | 63.3             | 89.4             | 117.7            | 148.7            | 189.3            | 229.2            |
| L <sub>II,III</sub> | 8.6              | 18.3             | 31.1             | 51.4             | 73.1             | 99.2             | 132.2            | 164.8            |
| Level               | <sup>17</sup> Cl | <sup>18</sup> Ar | <sup>19</sup> K  | <sup>20</sup> Ca | <sup>21</sup> Sc | <sup>22</sup> Ti | <sup>23</sup> V  | <sup>24</sup> Cr |
| K                   | 2822.4           | 3202.9           | 3607.4           | 4038.1           | 4492.8           | 4966.4           | 5465.1           | 5989.2           |
| L <sub>I</sub>      | 270.2            | 320              | 377.1            | 437.8            | 500.4            | 563.7            | 628.2            | 694.6            |
| L <sub>II</sub>     | 201.6            | 247.3            | 296.3            | 350.0            | 406.7            | 461.5            | 520.5            | 583.7            |
| L <sub>III</sub>    | 200.0            | 245.2            | 293.6            | 346.4            | 402.2            | 455.5            | 512.9            | 574.5            |
| M <sub>I</sub>      | 17.5             | 25.3             | 33.9             | 43.7             | 53.8             | 60.3             | 66.5             | 74.1             |
| M <sub>II,III</sub> | 6.8              | 12.4             | 17.8             | 25.4             | 32.3             | 34.6             | 37.8             | 42.5             |
| M <sub>IV</sub>     |                  |                  |                  |                  | 6.6              | 3.7              | 2.2              | 2.3              |
| Level               | <sup>25</sup> Mn | <sup>26</sup> Fe | <sup>27</sup> Co | <sup>28</sup> Ni | <sup>29</sup> Cu | <sup>30</sup> Zn | <sup>31</sup> Ga | <sup>32</sup> Ge |
| K                   | 6539.0           | 7112.0           | 7708.9           | 8332.8           | 8978.9           | 9658.6           | 10367.1          | 11103.1          |
| L <sub>I</sub>      | 769.0            | 846.1            | 925.6            | 1008.1           | 1096.1           | 1193.6           | 1297.7           | 1414.3           |
| L <sub>II</sub>     | 651.4            | 721.1            | 793.6            | 871.9            | 951.0            | 1042.8           | 1142.3           | 1247.8           |
| L <sub>III</sub>    | 640.3            | 708.1            | 778.6            | 854.7            | 931.1            | 1019.7           | 1115.4           | 1216.7           |
| M <sub>I</sub>      | 83.9             | 92.9             | 100.7            | 111.8            | 119.8            | 135.9            | 158.1            | 180.0            |
| M <sub>II</sub>     | 48.6             | 54.0             | 59.5             | 68.1             | 73.6             | 86.6             | 106.8            | 127.9            |
| M <sub>III</sub>    | 48.6*            | 54.0*            | 59.5*            | 68.1*            | 73.6*            | 86.6*            | 102.9            | 120.8            |
| M <sub>IV</sub>     | 3.3              | 3.6              | 2.9              | 3.6              | 1.6              | 8.1              | 17.4             | 28.7             |
| Level               | <sup>33</sup> As | <sup>34</sup> Se | <sup>35</sup> Br | <sup>36</sup> Kr | <sup>37</sup> Rb | <sup>38</sup> Sr | <sup>39</sup> Y  | <sup>40</sup> Zr |
| K                   | 11866.7          | 12657.8          | 13473.7          | 14325.6          | 15199.7          | 16104.6          | 17038.4          | 17997.6          |
| L <sub>I</sub>      | 1526.5           | 1653.9           | 1782.0           | 1921.0           | 2065.1           | 2216.3           | 2372.5           | 2531.6           |
| L <sub>II</sub>     | 1358.6           | 1476.2           | 1596.0           | 1727.2           | 1863.9           | 2006.8           | 2155.5           | 2306.7           |
| L <sub>III</sub>    | 1323.1           | 1435.8           | 1549.9           | 1674.9           | 1804.4           | 1939.6           | 2080.0           | 2222.3           |
| M <sub>I</sub>      | 203.5            | 231.5            | 256.5            |                  | 322.1            | 357.5            | 393.6            | 430.3            |
| M <sub>II</sub>     | 146.4            | 168.2            | 189.3            | 222.7            | 247.4            | 279.8            | 312.4            | 344.2            |
| M <sub>III</sub>    | 140.5            | 161.9            | 181.5            | 213.8            | 238.5            | 269.1            | 300.3            | 330.5            |
| M <sub>IV</sub>     | 41.2             | 56.7             | 70.1             | 88.9             | 111.8            | 135.0            | 159.6            | 182.4            |
| M <sub>V</sub>      | 41.2*            | 56.7*            | 69.0             | 88.9*            | 110.3            | 133.1            | 157.4            | 180.0            |
| N <sub>I</sub>      |                  |                  | 27.3             | 24.0             | 29.3             | 37.7             | 45.4             | 51.3             |
| N <sub>II</sub>     | 2.5              | 5.6              | 5.2              | 10.6             | 14.8             | 19.9             | 25.6             | 28.7             |
| N <sub>III</sub>    | 2.5*             | 5.6*             | 4.6              | 10.6*            | 14.0             | 19.9*            | 25.6*            | 28.7*            |
| Level               | <sup>41</sup> Nb | <sup>42</sup> Mo | <sup>43</sup> Tc | <sup>44</sup> Ru | <sup>45</sup> Rh | <sup>46</sup> Pd | <sup>47</sup> Ag | <sup>48</sup> Cd |
| K                   | 18985.6          | 19999.5          | 21044.0          | 22117.2          | 23219.9          | 24350.3          | 25514.0          | 26711.2          |
| L <sub>I</sub>      | 2697.7           | 2865.5           | 3042.5           | 3224.0           | 3411.9           | 3604.3           | 3805.8           | 4018.0           |
| L <sub>II</sub>     | 2464.7           | 2625.1           | 2793.2           | 2966.9           | 3146.1           | 3330.3           | 3523.7           | 3727.0           |
| L <sub>III</sub>    | 2370.5           | 2520.2           | 2676.9           | 2837.9           | 3003.8           | 3173.3           | 3351.1           | 3537.5           |
| M <sub>I</sub>      | 468.4            | 504.6            |                  | 585.0            | 627.1            | 669.9            | 717.5            | 770.2            |
| M <sub>II</sub>     | 378.4            | 409.7            | 444.9            | 482.8            | 521.0            | 559.1            | 602.4            | 650.7            |
| M <sub>III</sub>    | 363.0            | 392.3            | 425.0            | 460.6            | 496.2            | 531.5            | 571.4            | 616.5            |
| M <sub>IV</sub>     | 207.4            | 230.3            | 256.4            | 283.6            | 311.7            | 340.0            | 372.8            | 410.5            |

| Level               | <sup>41</sup> Nb | <sup>42</sup> Mo | <sup>43</sup> Tc | <sup>44</sup> Ru | <sup>45</sup> Rh | <sup>46</sup> Pd | <sup>47</sup> Ag | <sup>48</sup> Cd |
|---------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| M <sub>V</sub>      | 204.6            | 227.0            | 252.9            | 279.4            | 307.0            | 334.7            | 366.7            | 403.7            |
| N <sub>I</sub>      | 58.1             | 61.8             |                  | 74.9             | 81.0             | 86.4             | 95.2             | 107.6            |
| N <sub>II</sub>     | 33.9             | 34.8             | 38.9             | 43.1             | 47.9             | 51.1             | 62.6             | 66.9             |
| N <sub>III</sub>    | 33.9*            | 34.8*            | 38.9*            | 43.1*            | 47.9*            | 51.1*            | 55.9             | 66.9*            |
| N <sub>IVV</sub>    | 3.2              | 1.8              |                  | 2.0              | 2.5              | 1.5              | 3.3              | 9.3              |
| Level               | <sup>49</sup> In | <sup>50</sup> Sn | <sup>51</sup> Sb | <sup>52</sup> Te | <sup>53</sup> I  | <sup>54</sup> Xe | <sup>55</sup> Cs | <sup>56</sup> Ba |
| K                   | 27939.9          | 29200.1          | 30491.2          | 31813.8          | 33169.4          | 34561.4          | 35984.6          | 37440.6          |
| L <sub>I</sub>      | 4237.5           | 4464.7           | 4698.3           | 4939.2           | 5188.1           | 5452.8           | 5714.3           | 5988.8           |
| L <sub>II</sub>     | 3938.0           | 4156.1           | 4380.4           | 4612.0           | 4852.1           | 5103.7           | 5359.4           | 5623.6           |
| L <sub>III</sub>    | 3730.1           | 3928.8           | 4132.2           | 4341.4           | 4557.1           | 4782.2           | 5011.9           | 5247.0           |
| M <sub>I</sub>      | 825.6            | 883.8            | 943.7            | 1006.0           | 1072.1           |                  | 1217.1           | 1292.8           |
| M <sub>II</sub>     | 702.2            | 756.4            | 811.9            | 869.7            | 930.5            | 999.0            | 1065.0           | 1136.7           |
| M <sub>III</sub>    | 664.3            | 714.4            | 765.6            | 818.7            | 874.6            | 937.0            | 997.6            | 1062.2           |
| M <sub>IV</sub>     | 450.8            | 493.3            | 536.9            | 582.5            | 631.3            |                  | 739.5            | 796.1            |
| M <sub>V</sub>      | 443.1            | 484.8            | 527.5            | 572.1            | 619.4            | 672.3            | 725.5            | 780.7            |
| N <sub>I</sub>      | 121.9            | 136.5            | 152.0            | 168.3            | 186.4            |                  | 230.8            | 253.0            |
| N <sub>II</sub>     | 77.4             | 88.6             | 98.4             | 110.2            | 122.7            | 146.7            | 172.3            | 191.8            |
| N <sub>III</sub>    | 77.4*            | 88.6*            | 98.4*            | 110.2*           | 122.7*           | 146.7*           | 161.6            | 179.7            |
| N <sub>IV</sub>     | 16.2             | 23.9             | 31.4             | 39.8             | 49.6             |                  | 78.8             | 92.5             |
| N <sub>V</sub>      | 16.2*            | 23.9*            | 31.4*            | 39.8*            | 49.6*            |                  | 76.5             | 89.9             |
| O <sub>I</sub>      | 0.1              | 0.9              | 6.7              | 11.6             | 13.6             |                  | 22.7             | 39.1             |
| O <sub>II</sub>     | 0.8              | 1.1              | 2.1              | 2.3              | 3.3              |                  | 13.1             | 16.6             |
| O <sub>III</sub>    | 0.8*             | 1.1*             | 2.1*             | 2.3*             | 3.3*             |                  | 11.4             | 14.6             |
| Level               | <sup>57</sup> La | <sup>58</sup> Ce | <sup>59</sup> Pr | <sup>60</sup> Nd | <sup>61</sup> Pm | <sup>62</sup> Sm | <sup>63</sup> Eu | <sup>64</sup> Gd |
| K                   | 38924.6          | 40443.0          | 41990.6          | 43568.9          | 45184.0          | 46834.2          | 48519.0          | 50239.1          |
| L <sub>I</sub>      | 6266.3           | 6548.8           | 6834.8           | 7126.0           | 7427.9           | 7736.8           | 8052.0           | 8375.6           |
| L <sub>II</sub>     | 5890.6           | 6164.2           | 6440.4           | 6721.5           | 7012.8           | 7311.8           | 7617.1           | 7930.3           |
| L <sub>III</sub>    | 5482.7           | 5723.4           | 5964.3           | 6207.9           | 6459.3           | 6716.2           | 6976.9           | 7242.8           |
| M <sub>I</sub>      | 1361.3           | 1434.6           | 1511.0           | 1575.3           |                  | 1722.8           | 1800.0           | 1880.8           |
| M <sub>II</sub>     | 1204.4           | 1272.8           | 1337.4           | 1402.8           | 1471.4           | 1540.7           | 1613.9           | 1688.3           |
| M <sub>III</sub>    | 1123.4           | 1185.4           | 1242.2           | 1297.4           | 1356.9           | 1419.8           | 1480.6           | 1544.0           |
| M <sub>IV</sub>     | 848.5            | 901.3            | 951.1            | 999.9            | 1051.5           | 1106.0           | 1160.6           | 1217.2           |
| M <sub>V</sub>      | 831.7            | 883.3            | 931.0            | 977.7            | 1026.9           | 1080.2           | 1130.9           | 1185.2           |
| N <sub>I</sub>      | 270.4            | 289.6            | 304.5            | 315.2            |                  | 345.7            | 360.2            | 375.8            |
| N <sub>II</sub>     | 205.8            | 223.3            | 236.3            | 243.3            | 242              | 265.6            | 283.9            | 288.5            |
| N <sub>III</sub>    | 191.4            | 207.2            | 217.6            | 224.6            | 242*             | 247.4            | 256.6            | 270.9            |
| N <sub>IVV</sub>    | 98.9             | 110.0            | 113.2            | 117.5            | 120.4            | 129.0            | 133.2            | 140.5            |
| N <sub>VI,VII</sub> |                  | 0.1              | 2.0              | 1.5              |                  | 5.5              | 0.0              | 0.1              |
| O <sub>I</sub>      | 32.3             | 37.8             | 37.4             | 37.5             |                  | 37.4             | 31.8             | 36.1             |
| O <sub>II,III</sub> | 14.4             | 19.8             | 22.3             | 21.1             |                  | 21.3             | 22.0             | 20.3             |
| Level               | <sup>65</sup> Tb | <sup>66</sup> Dy | <sup>67</sup> Ho | <sup>68</sup> Er | <sup>69</sup> Tm | <sup>70</sup> Yb | <sup>71</sup> Lu | <sup>72</sup> Hf |
| K                   | 51995.7          | 53788.5          | 55617.7          | 57485.5          | 59389.6          | 61332.3          | 63313.8          | 65350.8          |
| L <sub>I</sub>      | 8708.0           | 9045.8           | 9394.2           | 9751.3           | 10115.7          | 10486.4          | 10870.4          | 11270.7          |
| L <sub>II</sub>     | 8251.6           | 8580.6           | 8917.8           | 9264.3           | 9616.9           | 9978.2           | 10348.6          | 10739.4          |
| L <sub>III</sub>    | 7514.0           | 7790.1           | 8071.1           | 8357.9           | 8648.0           | 8943.6           | 9244.1           | 9560.7           |
| M <sub>I</sub>      | 1967.5           | 2046.8           | 2128.3           | 2206.5           | 2306.8           | 2398.1           | 2491.2           | 2600.9           |
| M <sub>II</sub>     | 1767.7           | 1841.8           | 1922.8           | 2005.8           | 2089.8           | 2173.0           | 2263.5           | 2365.4           |
| M <sub>III</sub>    | 1611.3           | 1675.6           | 1741.2           | 1811.8           | 1884.5           | 1949.8           | 2023.6           | 2107.6           |
| M <sub>IV</sub>     | 1275.0           | 1332.5           | 1391.5           | 1453.3           | 1514.6           | 1576.3           | 1639.4           | 1716.4           |
| M <sub>V</sub>      | 1241.2           | 1294.9           | 1351.4           | 1409.3           | 1467.7           | 1527.8           | 1588.5           | 1661.7           |
| N <sub>I</sub>      | 397.9            | 416.3            | 435.7            | 449.1            | 471.7            | 487.2            | 506.2            | 538.1            |
| N <sub>II</sub>     | 310.2            | 331.8            | 343.5            | 366.2            | 385.9            | 396.7            | 410.1            | 437.0            |
| N <sub>III</sub>    | 385.0            | 292.9            | 306.6            | 320.0            | 336.6            | 343.5            | 359.3            | 380.4            |
| N <sub>IV</sub>     | 147.0            | 154.2            | 161.0            | 176.7            | 179.6            | 198.1            | 204.8            | 223.8            |
| N <sub>V</sub>      | 147.0*           | 154.2*           | 161.0*           | 167.6            | 179.6*           | 184.9            | 195.0            | 213.7            |
| N <sub>VI,VII</sub> | 2.6              | 4.2              | 3.7              | 4.3              | 5.3              | 6.3              | 6.9              | 17.1             |
| O <sub>I</sub>      | 39.0             | 62.9             | 51.2             | 59.8             | 53.2             | 54.1             | 56.8             | 64.9             |
| O <sub>II</sub>     | 25.4             | 26.3             | 20.3             | 29.4             | 32.3             | 23.4             | 28.0             | 38.1             |
| O <sub>III</sub>    | 25.4*            | 26.3*            | 20.3*            | 29.4*            | 32.3*            | 23.4*            | 28.0*            | 30.6             |

| Level               | <sup>73</sup> Ta | <sup>74</sup> W  | <sup>75</sup> Re | <sup>76</sup> Os | <sup>77</sup> Ir | <sup>78</sup> Pt | <sup>79</sup> Au | <sup>80</sup> Hg |
|---------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| K                   | 67416.4          | 69525.0          | 71676.4          | 73870.8          | 76111.0          | 78394.8          | 80724.9          | 83102.3          |
| L <sub>I</sub>      | 11681.5          | 12099.8          | 12526.7          | 12968.0          | 13418.5          | 13879.9          | 14352.8          | 14839.3          |
| L <sub>II</sub>     | 11136.1          | 11544.0          | 11958.7          | 12385.0          | 12824.1          | 13272.6          | 13733.6          | 14208.7          |
| L <sub>III</sub>    | 9881.1           | 10206.8          | 10535.3          | 10870.9          | 11215.2          | 11563.7          | 11918.7          | 12283.9          |
| M <sub>I</sub>      | 2708.0           | 2819.6           | 2931.7           | 3048.5           | 3173.7           | 3296.0           | 3424.9           | 3561.6           |
| M <sub>II</sub>     | 2468.7           | 2574.9           | 2681.6           | 2792.2           | 2908.7           | 3026.5           | 3147.8           | 3278.5           |
| M <sub>III</sub>    | 2194.0           | 2281.0           | 2367.3           | 2457.2           | 2550.7           | 2645.4           | 2743.0           | 2847.1           |
| M <sub>IV</sub>     | 1793.2           | 1871.6           | 1948.9           | 2030.8           | 2116.1           | 2201.9           | 2291.1           | 2384.9           |
| M <sub>V</sub>      | 1735.1           | 1809.2           | 1882.9           | 1960.1           | 2040.4           | 2121.6           | 2205.7           | 2294.9           |
| N <sub>I</sub>      | 565.5            | 595.0            | 625.0            | 654.3            | 690.1            | 722.0            | 758.8            | 800.3            |
| N <sub>II</sub>     | 464.8            | 491.6            | 517.9            | 546.5            | 577.1            | 609.2            | 643.7            | 676.9            |
| N <sub>III</sub>    | 404.5            | 425.3            | 444.4            | 468.2            | 494.3            | 519.0            | 545.4            | 571.0            |
| N <sub>IV</sub>     | 241.3            | 258.8            | 273.7            | 289.4            | 311.4            | 330.8            | 352.0            | 378.3            |
| N <sub>V</sub>      | 229.3            | 245.4            | 260.2            | 272.8            | 294.9            | 313.3            | 333.9            | 359.8            |
| N <sub>VI</sub>     | 25.0             | 36.5             | 40.6             | 46.3             | 63.4             | 74.3             | 86.4             | 102.2            |
| N <sub>VII</sub>    | 25.0*            | 33.6             | 40.6*            | 46.3*            | 60.5             | 71.1             | 82.8             | 98.5             |
| O <sub>I</sub>      | 71.1             | 77.1             | 82.8             | 83.7             | 95.2             | 101.7            | 107.8            | 120.3            |
| O <sub>II</sub>     | 44.9             | 46.8             | 45.6             | 58.0             | 63.0             | 65.3             | 71.7             | 80.5             |
| O <sub>III</sub>    | 36.4             | 35.6             | 34.6             | 45.4             | 50.5             | 51.7             | 53.7             | 57.6             |
| O <sub>IV,V</sub>   | 5.7              | 6.1              | 3.5              |                  | 3.8              | 2.2              | 2.5              | 6.4              |
| Level               | <sup>81</sup> Tl | <sup>82</sup> Pb | <sup>83</sup> Bi | <sup>84</sup> Po | <sup>85</sup> At | <sup>86</sup> Rn | <sup>87</sup> Fr | <sup>88</sup> Ra |
| K                   | 85530.4          | 88004.5          | 90525.9          | 93105.0          | 95729.9          | 98404            | 101137           | 103921.9         |
| L <sub>I</sub>      | 15346.7          | 15860.8          | 16387.5          | 16939.3          | 17493            | 18049            | 18639            | 19236.7          |
| L <sub>II</sub>     | 14697.9          | 15200.0          | 15711.1          | 16244.3          | 16784.7          | 17337.1          | 17906.5          | 18484.3          |
| L <sub>III</sub>    | 12657.5          | 13035.2          | 13418.6          | 13813.8          | 14213.5          | 14619.4          | 15031.2          | 15444.4          |
| M <sub>I</sub>      | 3704.1           | 3850.7           | 3999.1           | 4149.4           | (4317)           | (4482)           | (4652)           | 4822.0           |
| M <sub>II</sub>     | 3415.7           | 3554.2           | 3696.3           | 3854.1           | 4008             | 4159             | 4327             | 4489.5           |
| M <sub>III</sub>    | 2956.6           | 3066.4           | 3176.9           | 3301.9           | 3426             | 3538             | 3663             | 3791.8           |
| M <sub>IV</sub>     | 2485.1           | 2585.6           | 2687.6           | 2798.0           | 2908.7           | 3021.5           | 3136.2           | 3248.4           |
| M <sub>V</sub>      | 2389.3           | 2484.0           | 2579.6           | 2683.0           | 2786.7           | 2892.4           | 2999.9           | 3104.9           |
| N <sub>I</sub>      | 845.5            | 893.6            | 938.2            | 995.3            | (1042)           | (1097)           | (1153)           | 1208.4           |
| N <sub>II</sub>     | 721.3            | 763.9            | 805.3            | 851              | 886              | 929              | 980              | 1057.6           |
| N <sub>III</sub>    | 609.0            | 644.5            | 678.9            | 705              | 740              | 768              | 810              | 879.1            |
| N <sub>IV</sub>     | 406.6            | 435.2            | 463.6            | 500.2            | 533.2            | 566.6            | 603.3            | 635.9            |
| N <sub>V</sub>      | 386.2            | 412.9            | 440.0            | 473.4            |                  |                  | 577              | 602.7            |
| N <sub>VI</sub>     | 122.8            | 142.9            | 161.9            |                  |                  |                  |                  | 298.9            |
| N <sub>VII</sub>    | 118.5            | 138.1            | 157.4            |                  |                  |                  |                  | 298.9*           |
| O <sub>I</sub>      | 136.3            | 147.3            | 159.3            |                  |                  |                  |                  | 254.4            |
| O <sub>II</sub>     | 99.6             | 104.8            | 116.8            |                  |                  |                  |                  | 200.4            |
| O <sub>III</sub>    | 75.4             | 86.0             | 92.8             |                  |                  |                  |                  | 152.8            |
| O <sub>IV</sub>     | 15.3             | 21.8             | 26.5             | 31.4             |                  |                  |                  | 67.2             |
| O <sub>V</sub>      | 13.1             | 19.2             | 24.4             | 31.4*            |                  |                  |                  | 67.2*            |
| P <sub>I</sub>      |                  | 3.1              |                  |                  |                  |                  |                  | 43.5             |
| P <sub>II,III</sub> |                  | 0.7              | 2.7              |                  |                  |                  |                  | 18.8             |
| Level               | <sup>89</sup> Ac | <sup>90</sup> Th | <sup>91</sup> Pa | <sup>92</sup> U  | <sup>93</sup> Np | <sup>94</sup> Pu | <sup>95</sup> Am | <sup>96</sup> Cm |
| K                   | 106755.3         | 109650.9         | 112601.4         | 115606.1         | 118678           | 121818           | 125027           | 128220           |
| L <sub>I</sub>      | 19840            | 20472.1          | 21104.6          | 21757.4          | 22426.8          | 23097.2          | 23772.9          | 24460            |
| L <sub>II</sub>     | 19083.2          | 19693.2          | 20313.7          | 20947.6          | 21600.5          | 22266.2          | 22944.0          | 23779            |
| L <sub>III</sub>    | 15871.0          | 16300.3          | 16733.1          | 17166.3          | 17610.0          | 18056.8          | 18504.1          | 18930            |
| M <sub>I</sub>      | (5002)           | 5182.3           | 5366.9           | 5548.0           | 5723.2           | 5932.9           | 6120.5           | 6288             |
| M <sub>II</sub>     | 4656             | 4830.4           | 5000.9           | 5182.2           | 5366.2           | 5541.2           | 5710.2           | 5895             |
| M <sub>III</sub>    | 3909             | 4046.1           | 4173.8           | 4303.4           | 4434.7           | 4556.6           | 4667.0           | 4797             |
| M <sub>IV</sub>     | 3370.2           | 3490.8           | 3611.2           | 3727.6           | 3850.3           | 3972.6           | 4092.1           | 4227             |
| M <sub>V</sub>      | 3219.0           | 3332.0           | 3441.8           | 3551.7           | 3665.8           | 3778.1           | 3886.9           | 3971             |
| N <sub>I</sub>      | (1269)           | 1329.5           | 1387.1           | 1440.8           | 1500.7           | 1558.6           | 1617.1           | 1643             |
| N <sub>II</sub>     | 1080             | 1168.2           | 1224.3           | 1272.6           | 1327.7           | 1372.1           | 1411.8           | 1440             |
| N <sub>III</sub>    | 890              | 967.3            | 1006.7           | 1044.9           | 1086.8           | 1114.8           | (1135.7)         | 1154             |
| N <sub>IV</sub>     | 674.9            | 714.1            | 743.4            | 780.4            | 815.9            | 848.9            | 878.7            |                  |

| Level            | <sup>89</sup> Ac | <sup>90</sup> Th | <sup>91</sup> Pa | <sup>92</sup> U   | <sup>93</sup> Np  | <sup>94</sup> Pu  | <sup>95</sup> Am  | <sup>96</sup> Cm |
|------------------|------------------|------------------|------------------|-------------------|-------------------|-------------------|-------------------|------------------|
| N <sub>v</sub>   |                  | 676.4            | 708.2            | 737.7             | 770.3             | 801.4             | 827.6             |                  |
| N <sub>vi</sub>  |                  | 344.4            | 371.2            | 391.3             | 415.0             | 445.8             |                   |                  |
| N <sub>vii</sub> |                  | 335.2            | 359.5            | 380.9             | 404.4             | 432.4             |                   |                  |
| O <sub>i</sub>   |                  | 290.2            | 309.6            | 323.7             |                   | 351.9             |                   | 385              |
| O <sub>ii</sub>  |                  | 229.4            | 222.9            | 259.3             | 283.4             | 274.1             |                   |                  |
| O <sub>iii</sub> |                  | 181.8            | 222.9*           | 195.1             | 206.1             | 206.5             |                   |                  |
| O <sub>iv</sub>  |                  | 94.3             | 94.1             | 105.0             | 109.3             | 116.0             | 115.8             |                  |
| O <sub>v</sub>   |                  | 87.9             | 94.1*            | 96.3              | 101.3             | 105.4             | 103.3             |                  |
| P <sub>i</sub>   |                  | 59.5             |                  | 70.7              |                   |                   |                   |                  |
| P <sub>ii</sub>  |                  | 49.0             |                  | 42.3              |                   |                   |                   |                  |
| P <sub>iii</sub> |                  | 43.0             |                  | 32.3              |                   |                   |                   |                  |
| Level            | <sup>97</sup> Bk | <sup>98</sup> Cf | <sup>99</sup> Es | <sup>100</sup> Fm | <sup>101</sup> Md | <sup>102</sup> No | <sup>103</sup> Lr |                  |
| K                | 131590           | 135960           | 139490           | 143090            | 146780            | 150540            | 154380            |                  |
| L <sub>i</sub>   | 25275            | 26110            | 26900            | 27700             | 28530             | 29380             | 30240             |                  |
| L <sub>ii</sub>  | 24385            | 25250            | 26020            | 26810             | 27610             | 28440             | 29280             |                  |
| L <sub>iii</sub> | 19452            | 19930            | 20410            | 20900             | 21390             | 21880             | 22360             |                  |
| M <sub>i</sub>   | 6556             | 6754             | 6977             | 7205              | 7441              | 7675              | 7900              |                  |
| M <sub>ii</sub>  | 6147             | 6359             | 6574             | 6793              | 7019              | 7245              | 7460              |                  |
| M <sub>iii</sub> | 4977             | 5109             | 5252             | 5397              | 5546              | 5688              | 5710              |                  |
| M <sub>iv</sub>  | 4366             | 4497             | 4630             | 4766              | 4903              | 5037              | 5150              |                  |
| M <sub>v</sub>   | 4132             | 4253             | 4374             | 4498              | 4622              | 4741              | 4860              |                  |
| N <sub>i</sub>   | 1755             | 1799             | 1868             | 1937              | 2010              | 2078              | 2140              |                  |
| N <sub>ii</sub>  | 1554             | 1616             | 1680             | 1747              | 1814              | 1876              | 1930              |                  |
| N <sub>iii</sub> | 1235             | 1279             | 1321             | 1366              | 1410              | 1448              | 1480              |                  |
| O <sub>i</sub>   | 398              | 419              | 435              | 454               | 472               | 484               | 490               |                  |

# ELECTRON BINDING ENERGIES OF THE ELEMENTS

Gwyn P. Williams

This table gives the binding energies in electron volts (eV) for selected electronic levels of the elements. For metallic elements the binding energy is referred to the Fermi level; for semiconductors, to the valence band maximum; and for gases and insulators, to the vacuum level. The atomic number is listed after the element name.

## References

1. Fluggle, J. C., and Martensson, N., *J. Elect. Spect.*, 21, 275, 1980.
2. Cardona, M. and Ley, L., *Photoemission from Solids*, Springer-Verlag, Heidelberg, 1978.
3. Bearden, J. A. and Burr, A. F., *Rev. Mod. Phys.*, 39, 125, 1967.

### Actinium (89)

|       |                   |                   |
|-------|-------------------|-------------------|
| K     | 1s                | 106755            |
| L I   | 2s                | 19840             |
| L II  | 2p <sub>1/2</sub> | 19083             |
| L III | 2p <sub>3/2</sub> | 15871             |
| M I   | 3s                | 5002              |
| M II  | 3p <sub>1/2</sub> | 4656              |
| M III | 3p <sub>3/2</sub> | 3909              |
| M IV  | 3d <sub>3/2</sub> | 3370              |
| M V   | 3d <sub>5/2</sub> | 3219              |
| N I   | 4s                | 1269 <sup>a</sup> |
| N II  | 4p <sub>1/2</sub> | 1080 <sup>a</sup> |
| N III | 4p <sub>3/2</sub> | 890 <sup>a</sup>  |
| N IV  | 4d <sub>3/2</sub> | 675 <sup>a</sup>  |
| N V   | 4d <sub>5/2</sub> | 639 <sup>a</sup>  |
| N VI  | 4f <sub>5/2</sub> | 319 <sup>a</sup>  |
| N VII | 4f <sub>7/2</sub> | 319 <sup>a</sup>  |
| O I   | 5s                | 272 <sup>a</sup>  |
| O II  | 5p <sub>1/2</sub> | 215 <sup>a</sup>  |
| O III | 5p <sub>3/2</sub> | 167 <sup>a</sup>  |
| O IV  | 5d <sub>3/2</sub> | 80 <sup>a</sup>   |
| O V   | 5d <sub>5/2</sub> | 80 <sup>a</sup>   |
| P I   | 6s                | —                 |
| P II  | 6p <sub>1/2</sub> | —                 |
| P III | 6p <sub>3/2</sub> | —                 |

### Aluminum (13)

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 1559.0             |
| L I   | 2s                | 117.8 <sup>a</sup> |
| L II  | 2p <sub>1/2</sub> | 72.9 <sup>a</sup>  |
| L III | 2p <sub>3/2</sub> | 72.5 <sup>a</sup>  |

### Antimony (51)

|       |                   |                     |
|-------|-------------------|---------------------|
| K     | 1s                | 30419               |
| L I   | 2s                | 4698                |
| L II  | 2p <sub>1/2</sub> | 4380                |
| L III | 2p <sub>3/2</sub> | 4132                |
| M I   | 3s                | 946 <sup>b</sup>    |
| M II  | 3p <sub>1/2</sub> | 812.7 <sup>b</sup>  |
| M III | 3p <sub>3/2</sub> | 766.4 <sup>b</sup>  |
| M IV  | 3d <sub>3/2</sub> | 537.5 <sup>b</sup>  |
| M V   | 3d <sub>5/2</sub> | 528.2 <sup>b</sup>  |
| N I   | 4s                | 153.2 <sup>b</sup>  |
| N II  | 4p <sub>1/2</sub> | 95.6 <sup>b,c</sup> |
| N III | 4p <sub>3/2</sub> | 95.6 <sup>b</sup>   |
| N IV  | 4d <sub>3/2</sub> | 33.3 <sup>b</sup>   |
| N V   | 4d <sub>5/2</sub> | 32.1 <sup>b</sup>   |

### Argon (18)

|     |    |                     |
|-----|----|---------------------|
| K   | 1s | 3205.9 <sup>a</sup> |
| L I | 2s | 326.3 <sup>a</sup>  |

|       |                   |                    |
|-------|-------------------|--------------------|
| L II  | 2p <sub>1/2</sub> | 250.6 <sup>a</sup> |
| L III | 2p <sub>3/2</sub> | 248.4 <sup>a</sup> |
| M I   | 3s                | 29.3 <sup>a</sup>  |
| M II  | 3p <sub>1/2</sub> | 15.9 <sup>a</sup>  |
| M III | 3p <sub>3/2</sub> | 15.7 <sup>a</sup>  |

### Arsenic (33)

|       |                   |                       |
|-------|-------------------|-----------------------|
| K     | 1s                | 11867                 |
| L I   | 2s                | 1527.0 <sup>a,d</sup> |
| L II  | 2p <sub>1/2</sub> | 1359.1 <sup>a,d</sup> |
| L III | 2p <sub>3/2</sub> | 1323.6 <sup>a,d</sup> |
| M I   | 3s                | 204.7 <sup>a</sup>    |
| M II  | 3p <sub>1/2</sub> | 146.2 <sup>a</sup>    |
| M III | 3p <sub>3/2</sub> | 141.2 <sup>a</sup>    |
| M IV  | 3d <sub>3/2</sub> | 41.7 <sup>a</sup>     |
| M V   | 3d <sub>5/2</sub> | 41.7 <sup>a</sup>     |

### Astatine (85)

|       |                   |                   |
|-------|-------------------|-------------------|
| K     | 1s                | 95730             |
| L I   | 2s                | 17493             |
| L II  | 2p <sub>1/2</sub> | 16785             |
| L III | 2p <sub>3/2</sub> | 14214             |
| M I   | 3s                | 4317              |
| M II  | 3p <sub>1/2</sub> | 4008              |
| M III | 3p <sub>3/2</sub> | 3426              |
| M IV  | 3d <sub>3/2</sub> | 2909              |
| M V   | 3d <sub>5/2</sub> | 2787              |
| N I   | 4s                | 1042 <sup>a</sup> |
| N II  | 4p <sub>1/2</sub> | 886 <sup>a</sup>  |
| N III | 4p <sub>3/2</sub> | 740 <sup>a</sup>  |
| N IV  | 4d <sub>3/2</sub> | 533 <sup>a</sup>  |
| N V   | 4d <sub>5/2</sub> | 507 <sup>a</sup>  |
| N VI  | 4f <sub>5/2</sub> | 210 <sup>a</sup>  |
| N VII | 4f <sub>7/2</sub> | 210 <sup>a</sup>  |
| O I   | 5s                | 195 <sup>a</sup>  |
| O II  | 5p <sub>1/2</sub> | 148 <sup>a</sup>  |
| O III | 5p <sub>3/2</sub> | 115 <sup>a</sup>  |
| O IV  | 5d <sub>3/2</sub> | 40 <sup>a</sup>   |
| O V   | 5d <sub>5/2</sub> | 40 <sup>a</sup>   |

### Barium (56)

|       |                   |                     |
|-------|-------------------|---------------------|
| K     | 1s                | 37441               |
| L I   | 2s                | 5989                |
| L II  | 2p <sub>1/2</sub> | 5624                |
| L III | 2p <sub>3/2</sub> | 5247                |
| M I   | 3s                | 1293 <sup>a,d</sup> |
| M II  | 3p <sub>1/2</sub> | 1137 <sup>a,d</sup> |
| M III | 3p <sub>3/2</sub> | 1063 <sup>a,d</sup> |
| M IV  | 3d <sub>3/2</sub> | 795.7 <sup>a</sup>  |
| M V   | 3d <sub>5/2</sub> | 780.5 <sup>a</sup>  |
| N I   | 4s                | 253.5 <sup>b</sup>  |
| N II  | 4p <sub>1/2</sub> | 192                 |

|       |                   |                    |
|-------|-------------------|--------------------|
| N III | 4p <sub>3/2</sub> | 178.6 <sup>b</sup> |
| N IV  | 4d <sub>3/2</sub> | 92.6 <sup>b</sup>  |
| N V   | 4d <sub>5/2</sub> | 89.9 <sup>b</sup>  |
| N VI  | 4f <sub>5/2</sub> | —                  |
| N VII | 4f <sub>7/2</sub> | —                  |
| O I   | 5s                | 30.3 <sup>b</sup>  |
| O II  | 5p <sub>1/2</sub> | 17.0 <sup>b</sup>  |
| O III | 5p <sub>3/2</sub> | 14.8 <sup>b</sup>  |

### Beryllium (4)

|   |    |                    |
|---|----|--------------------|
| K | 1s | 111.5 <sup>a</sup> |
|---|----|--------------------|

### Bismuth (83)

|       |                   |                      |
|-------|-------------------|----------------------|
| K     | 1s                | 90526                |
| L I   | 2s                | 16388                |
| L II  | 2p <sub>1/2</sub> | 15711                |
| L III | 2p <sub>3/2</sub> | 13419                |
| M I   | 3s                | 3999                 |
| M II  | 3p <sub>1/2</sub> | 3696                 |
| M III | 3p <sub>3/2</sub> | 3177                 |
| M IV  | 3d <sub>3/2</sub> | 2688                 |
| M V   | 3d <sub>5/2</sub> | 2580                 |
| N I   | 4s                | 939 <sup>b</sup>     |
| N II  | 4p <sub>1/2</sub> | 805.2 <sup>b</sup>   |
| N III | 4p <sub>3/2</sub> | 678.8 <sup>b</sup>   |
| N IV  | 4d <sub>3/2</sub> | 464.0 <sup>b</sup>   |
| N V   | 4d <sub>5/2</sub> | 440.1 <sup>b</sup>   |
| N VI  | 4f <sub>5/2</sub> | 162.3 <sup>b</sup>   |
| N VII | 4f <sub>7/2</sub> | 157.0 <sup>b</sup>   |
| O I   | 5s                | 159.3 <sup>a,d</sup> |
| O II  | 5p <sub>1/2</sub> | 119.0 <sup>b</sup>   |
| O III | 5p <sub>3/2</sub> | 92.6 <sup>b</sup>    |
| O IV  | 5d <sub>3/2</sub> | 26.9 <sup>b</sup>    |
| O V   | 5d <sub>5/2</sub> | 23.8 <sup>b</sup>    |

### Boron (5)

|   |    |                  |
|---|----|------------------|
| K | 1s | 188 <sup>a</sup> |
|---|----|------------------|

### Bromine (35)

|       |                   |                   |
|-------|-------------------|-------------------|
| K     | 1s                | 13474             |
| L I   | 2s                | 1782 <sup>a</sup> |
| L II  | 2p <sub>1/2</sub> | 1596 <sup>a</sup> |
| L III | 2p <sub>3/2</sub> | 1550 <sup>a</sup> |
| M I   | 3s                | 257 <sup>a</sup>  |
| M II  | 3p <sub>1/2</sub> | 189 <sup>a</sup>  |
| M III | 3p <sub>3/2</sub> | 182 <sup>a</sup>  |
| M IV  | 3d <sub>3/2</sub> | 70 <sup>a</sup>   |
| M V   | 3d <sub>5/2</sub> | 69 <sup>a</sup>   |

### Cadmium (48)

|      |                   |       |
|------|-------------------|-------|
| K    | 1s                | 26711 |
| L I  | 2s                | 4018  |
| L II | 2p <sub>1/2</sub> | 3727  |

|       |                   |                     |
|-------|-------------------|---------------------|
| L III | 2p <sub>3/2</sub> | 3538                |
| M I   | 3s                | 772.0 <sup>b</sup>  |
| M II  | 3p <sub>1/2</sub> | 652.6 <sup>b</sup>  |
| M III | 3p <sub>3/2</sub> | 618.4 <sup>b</sup>  |
| M IV  | 3d <sub>3/2</sub> | 411.9 <sup>b</sup>  |
| M V   | 3d <sub>5/2</sub> | 405.2 <sup>b</sup>  |
| N I   | 4s                | 109.8 <sup>b</sup>  |
| N II  | 4p <sub>1/2</sub> | 63.9 <sup>b,c</sup> |
| N III | 4p <sub>3/2</sub> | 63.9 <sup>b,c</sup> |
| N IV  | 4d <sub>3/2</sub> | 11.7 <sup>b</sup>   |
| N V   | 4d <sub>5/2</sub> | 10.7 <sup>b</sup>   |

### Calcium (20)

|       |                   |                     |
|-------|-------------------|---------------------|
| K     | 1s                | 4038.5 <sup>a</sup> |
| L I   | 2s                | 438.4 <sup>b</sup>  |
| L II  | 2p <sub>1/2</sub> | 349.7 <sup>b</sup>  |
| L III | 2p <sub>3/2</sub> | 346.2 <sup>b</sup>  |
| M I   | 3s                | 44.3 <sup>b</sup>   |
| M II  | 3p <sub>1/2</sub> | 25.4 <sup>b</sup>   |
| M III | 3p <sub>3/2</sub> | 25.4 <sup>b</sup>   |

### Carbon (6)

|   |    |                    |
|---|----|--------------------|
| K | 1s | 284.2 <sup>a</sup> |
|---|----|--------------------|

### Cerium (58)

|       |                   |                     |
|-------|-------------------|---------------------|
| K     | 1s                | 40443               |
| L I   | 2s                | 6548                |
| L II  | 2p <sub>1/2</sub> | 6164                |
| L III | 2p <sub>3/2</sub> | 5723                |
| M I   | 3s                | 1436 <sup>a,d</sup> |
| M II  | 3p <sub>1/2</sub> | 1274 <sup>a,d</sup> |
| M III | 3p <sub>3/2</sub> | 1187 <sup>a,d</sup> |
| M IV  | 3d <sub>3/2</sub> | 902.4 <sup>a</sup>  |
| M V   | 3d <sub>5/2</sub> | 883.8 <sup>a</sup>  |
| N I   | 4s                | 291.0 <sup>a</sup>  |
| N II  | 4p <sub>1/2</sub> | 223.3               |
| N III | 4p <sub>3/2</sub> | 206.5 <sup>a</sup>  |
| N IV  | 4d <sub>3/2</sub> | 109 <sup>a</sup>    |
| N V   | 4d <sub>5/2</sub> | —                   |
| N VI  | 4f <sub>5/2</sub> | 0.1                 |
| N VII | 4f <sub>7/2</sub> | 0.1                 |
| O I   | 5s                | 37.8                |
| O II  | 5p <sub>1/2</sub> | 19.8 <sup>a</sup>   |
| O III | 5p <sub>3/2</sub> | 17.0 <sup>a</sup>   |

### Cesium (55)

|       |                   |                     |
|-------|-------------------|---------------------|
| K     | 1s                | 35985               |
| L I   | 2s                | 5714                |
| L II  | 2p <sub>1/2</sub> | 5359                |
| L III | 2p <sub>3/2</sub> | 5012                |
| M I   | 3s                | 1211 <sup>a,d</sup> |
| M II  | 3p <sub>1/2</sub> | 1071 <sup>a</sup>   |



|       |                   |                    |
|-------|-------------------|--------------------|
| M III | 3p <sub>3/2</sub> | 1003 <sup>a</sup>  |
| M IV  | 3d <sub>3/2</sub> | 740.5 <sup>a</sup> |
| M V   | 3d <sub>5/2</sub> | 726.6 <sup>a</sup> |
| N I   | 4s                | 232.3 <sup>a</sup> |
| N II  | 4p <sub>1/2</sub> | 172.4 <sup>a</sup> |
| N III | 4p <sub>3/2</sub> | 161.3 <sup>a</sup> |
| N IV  | 4d <sub>3/2</sub> | 79.8 <sup>a</sup>  |
| N V   | 4d <sub>5/2</sub> | 77.5 <sup>a</sup>  |
| N VI  | 4f <sub>5/2</sub> | —                  |
| N VII | 4f <sub>7/2</sub> | —                  |
| O I   | 5s                | 22.7               |
| O II  | 5p <sub>1/2</sub> | 14.2 <sup>a</sup>  |
| O III | 5p <sub>3/2</sub> | 12.1 <sup>a</sup>  |

**Chlorine (17)**

|       |                   |                  |
|-------|-------------------|------------------|
| K     | 1s                | 2822.0           |
| L I   | 2s                | 270 <sup>a</sup> |
| L II  | 2p <sub>1/2</sub> | 202 <sup>a</sup> |
| L III | 2p <sub>3/2</sub> | 200 <sup>a</sup> |

**Chromium(24)**

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 5989               |
| L I   | 2s                | 696.0 <sup>b</sup> |
| L II  | 2p <sub>1/2</sub> | 583.8 <sup>b</sup> |
| L III | 2p <sub>3/2</sub> | 574.1 <sup>b</sup> |
| M I   | 3s                | 74.1 <sup>b</sup>  |
| M II  | 3p <sub>1/2</sub> | 42.2 <sup>b</sup>  |
| M III | 3p <sub>3/2</sub> | 42.2 <sup>b</sup>  |

**Cobalt (27)**

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 7709               |
| L I   | 2s                | 925.1 <sup>b</sup> |
| L II  | 2p <sub>1/2</sub> | 793.2 <sup>b</sup> |
| L III | 2p <sub>3/2</sub> | 778.1 <sup>b</sup> |
| M I   | 3s                | 101.0 <sup>b</sup> |
| M II  | 3p <sub>1/2</sub> | 58.9 <sup>b</sup>  |
| M III | 3p <sub>3/2</sub> | 58.9 <sup>b</sup>  |

**Copper (29)**

|       |                   |                     |
|-------|-------------------|---------------------|
| K     | 1s                | 8979                |
| L I   | 2s                | 1096.7 <sup>b</sup> |
| L II  | 2p <sub>1/2</sub> | 952.3 <sup>b</sup>  |
| L III | 2p <sub>3/2</sub> | 932.5 <sup>b</sup>  |
| M I   | 3s                | 122.5 <sup>b</sup>  |
| M II  | 3p <sub>1/2</sub> | 77.3 <sup>b</sup>   |
| M III | 3p <sub>3/2</sub> | 75.1 <sup>b</sup>   |

**Dysprosium (66)**

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 53789              |
| L I   | 2s                | 9046               |
| L II  | 2p <sub>1/2</sub> | 8581               |
| L III | 2p <sub>3/2</sub> | 7790               |
| M I   | 3s                | 2047               |
| M II  | 3p <sub>1/2</sub> | 1842               |
| M III | 3p <sub>3/2</sub> | 1676               |
| M IV  | 3d <sub>3/2</sub> | 1333               |
| M V   | 3d <sub>5/2</sub> | 1292 <sup>a</sup>  |
| N I   | 4s                | 414.2 <sup>a</sup> |
| N II  | 4p <sub>1/2</sub> | 333.5 <sup>a</sup> |
| N III | 4p <sub>3/2</sub> | 293.2 <sup>a</sup> |
| N IV  | 4d <sub>3/2</sub> | 153.6 <sup>a</sup> |
| N V   | 4d <sub>5/2</sub> | 153.6 <sup>a</sup> |
| N VI  | 4f <sub>5/2</sub> | 8.0 <sup>a</sup>   |
| N VII | 4f <sub>7/2</sub> | 4.3 <sup>a</sup>   |
| O I   | 5s                | 49.9 <sup>a</sup>  |

|       |                   |      |
|-------|-------------------|------|
| O II  | 5p <sub>1/2</sub> | 26.3 |
| O III | 5p <sub>3/2</sub> | 26.3 |

**Erbium (68)**

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 57486              |
| L I   | 2s                | 9751               |
| L II  | 2p <sub>1/2</sub> | 9264               |
| L III | 2p <sub>3/2</sub> | 8358               |
| M I   | 3s                | 2206               |
| M II  | 3p <sub>1/2</sub> | 2006               |
| M III | 3p <sub>3/2</sub> | 1812               |
| M IV  | 3d <sub>3/2</sub> | 1453               |
| M V   | 3d <sub>5/2</sub> | 1409               |
| N I   | 4s                | 449.8 <sup>a</sup> |
| N II  | 4p <sub>1/2</sub> | 366.2              |
| N III | 4p <sub>3/2</sub> | 320.2 <sup>a</sup> |
| N IV  | 4d <sub>3/2</sub> | 167.6 <sup>a</sup> |
| N V   | 4d <sub>5/2</sub> | 167.6 <sup>a</sup> |
| N VI  | 4f <sub>5/2</sub> | —                  |
| N VII | 4f <sub>7/2</sub> | 4.7 <sup>a</sup>   |
| O I   | 5s                | 50.6 <sup>a</sup>  |
| O II  | 5p <sub>1/2</sub> | 31.4 <sup>a</sup>  |
| O III | 5p <sub>3/2</sub> | 24.7 <sup>a</sup>  |

**Europium (63)**

|       |                   |                     |
|-------|-------------------|---------------------|
| K     | 1s                | 48519               |
| L I   | 2s                | 8052                |
| L II  | 2p <sub>1/2</sub> | 7617                |
| L III | 2p <sub>3/2</sub> | 6977                |
| M I   | 3s                | 1800                |
| M II  | 3p <sub>1/2</sub> | 1614                |
| M III | 3p <sub>3/2</sub> | 1481                |
| M IV  | 3d <sub>3/2</sub> | 1158.6 <sup>a</sup> |
| M V   | 3d <sub>5/2</sub> | 1127.5 <sup>a</sup> |
| N I   | 4s                | 360                 |
| N II  | 4p <sub>1/2</sub> | 284                 |
| N III | 4p <sub>3/2</sub> | 257                 |
| N IV  | 4d <sub>3/2</sub> | 133                 |
| N V   | 4d <sub>5/2</sub> | 1227 <sup>a</sup>   |
| N VI  | 4f <sub>5/2</sub> | 0                   |
| N VII | 4f <sub>7/2</sub> | 0                   |
| O I   | 5s                | 32                  |
| O II  | 5p <sub>1/2</sub> | 22                  |
| O III | 5p <sub>3/2</sub> | 22                  |

**Fluorine (9)**

|   |    |                    |
|---|----|--------------------|
| K | 1s | 696.7 <sup>a</sup> |
|---|----|--------------------|

**Francium (87)**

|       |                   |                   |
|-------|-------------------|-------------------|
| K     | 1s                | 101137            |
| L I   | 2s                | 18639             |
| L II  | 2p <sub>1/2</sub> | 17907             |
| L III | 2p <sub>3/2</sub> | 15031             |
| M I   | 3s                | 4652              |
| M II  | 3p <sub>1/2</sub> | 4327              |
| M III | 3p <sub>3/2</sub> | 3663              |
| M IV  | 3d <sub>3/2</sub> | 3136              |
| M V   | 3d <sub>5/2</sub> | 3000              |
| N I   | 4s                | 1153 <sup>a</sup> |
| N II  | 4p <sub>1/2</sub> | 980 <sup>a</sup>  |
| N III | 4p <sub>3/2</sub> | 810 <sup>a</sup>  |
| N IV  | 4d <sub>3/2</sub> | 603 <sup>a</sup>  |
| N V   | 4d <sub>5/2</sub> | 577 <sup>a</sup>  |
| N VI  | 4f <sub>5/2</sub> | 268 <sup>a</sup>  |
| N VII | 4f <sub>7/2</sub> | 268 <sup>a</sup>  |

|       |                   |                  |
|-------|-------------------|------------------|
| O I   | 5s                | 234 <sup>a</sup> |
| O II  | 5p <sub>1/2</sub> | 182 <sup>a</sup> |
| O III | 5p <sub>3/2</sub> | 140 <sup>a</sup> |
| O IV  | 5d <sub>3/2</sub> | 58 <sup>a</sup>  |
| O V   | 5d <sub>5/2</sub> | 58 <sup>a</sup>  |
| P I   | 6s                | 34               |
| P II  | 6p <sub>1/2</sub> | 15               |
| P III | 6p <sub>3/2</sub> | 15               |

**Gadolinium (64)**

|       |                   |                     |
|-------|-------------------|---------------------|
| K     | 1s                | 50239               |
| L I   | 2s                | 8376                |
| L II  | 2p <sub>1/2</sub> | 7930                |
| L III | 2p <sub>3/2</sub> | 7243                |
| M I   | 3s                | 1881                |
| M II  | 3p <sub>1/2</sub> | 1688                |
| M III | 3p <sub>3/2</sub> | 1544                |
| M IV  | 3d <sub>3/2</sub> | 1221.9 <sup>a</sup> |
| M V   | 3d <sub>5/2</sub> | 1189.6 <sup>a</sup> |
| N I   | 4s                | 378.6 <sup>a</sup>  |
| N II  | 4p <sub>1/2</sub> | 286                 |
| N III | 4p <sub>3/2</sub> | 271                 |
| N IV  | 4d <sub>3/2</sub> | —                   |
| N V   | 4d <sub>5/2</sub> | 142.6 <sup>a</sup>  |
| N VI  | 4f <sub>5/2</sub> | 8.6 <sup>a</sup>    |
| N VII | 4f <sub>7/2</sub> | 8.6 <sup>a</sup>    |
| O I   | 5s                | 36                  |
| O II  | 5p <sub>1/2</sub> | 20                  |
| O III | 5p <sub>3/2</sub> | 20                  |

**Gallium (31)**

|       |                   |                       |
|-------|-------------------|-----------------------|
| K     | 1s                | 10367                 |
| L I   | 2s                | 1299.0 <sup>a,d</sup> |
| L II  | 2p <sub>1/2</sub> | 1143.2 <sup>b</sup>   |
| L III | 2p <sub>3/2</sub> | 1116.4 <sup>b</sup>   |
| M I   | 3s                | 159.5 <sup>b</sup>    |
| M II  | 3p <sub>1/2</sub> | 103.5 <sup>b</sup>    |
| M III | 3p <sub>3/2</sub> | 100.0 <sup>b</sup>    |
| M IV  | 3d <sub>3/2</sub> | 18.7 <sup>b</sup>     |
| M V   | 3d <sub>5/2</sub> | 18.7 <sup>b</sup>     |

**Germanium (32)**

|       |                   |                       |
|-------|-------------------|-----------------------|
| K     | 1s                | 11103                 |
| L I   | 2s                | 1414.6 <sup>a,d</sup> |
| L II  | 2p <sub>1/2</sub> | 1248.1 <sup>a,d</sup> |
| L III | 2p <sub>3/2</sub> | 1217.0 <sup>a,d</sup> |
| M I   | 3s                | 180.1 <sup>a</sup>    |
| M II  | 3p <sub>1/2</sub> | 124.9 <sup>a</sup>    |
| M III | 3p <sub>3/2</sub> | 120.8 <sup>a</sup>    |
| M IV  | 3d <sub>3/2</sub> | 29.8 <sup>a</sup>     |
| M V   | 3d <sub>5/2</sub> | 29.2 <sup>a</sup>     |

**Gold (79)**

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 80725              |
| L I   | 2s                | 14353              |
| L II  | 2p <sub>1/2</sub> | 13734              |
| L III | 2p <sub>3/2</sub> | 11919              |
| M I   | 3s                | 3425               |
| M II  | 3p <sub>1/2</sub> | 3148               |
| M III | 3p <sub>3/2</sub> | 2743               |
| M IV  | 3d <sub>3/2</sub> | 2291               |
| M V   | 3d <sub>5/2</sub> | 2206               |
| N I   | 4s                | 762.1 <sup>b</sup> |
| N II  | 4p <sub>1/2</sub> | 642.7 <sup>b</sup> |
| N III | 4p <sub>3/2</sub> | 546.3 <sup>b</sup> |

|       |                   |                      |
|-------|-------------------|----------------------|
| N IV  | 4d <sub>3/2</sub> | 353.2 <sup>b</sup>   |
| N V   | 4d <sub>5/2</sub> | 335.1 <sup>b</sup>   |
| N VI  | 4f <sub>5/2</sub> | 87.6 <sup>b</sup>    |
| N VII | 4f <sub>7/2</sub> | 83.9 <sup>b</sup>    |
| O I   | 5s                | 107.2 <sup>a,d</sup> |
| O II  | 5p <sub>1/2</sub> | 74.2 <sup>b</sup>    |
| O III | 5p <sub>3/2</sub> | 57.2 <sup>b</sup>    |

**Hafnium (72)**

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 65351              |
| L I   | 2s                | 11271              |
| L II  | 2p <sub>1/2</sub> | 10739              |
| L III | 2p <sub>3/2</sub> | 9561               |
| M I   | 3s                | 2601               |
| M II  | 3p <sub>1/2</sub> | 2365               |
| M III | 3p <sub>3/2</sub> | 2107               |
| M IV  | 3d <sub>3/2</sub> | 1176               |
| M V   | 3d <sub>5/2</sub> | 1662               |
| N I   | 4s                | 538 <sup>a</sup>   |
| N II  | 4p <sub>1/2</sub> | 438.2 <sup>b</sup> |
| N III | 4p <sub>3/2</sub> | 380.7 <sup>b</sup> |
| N IV  | 4d <sub>3/2</sub> | 220.0 <sup>b</sup> |
| N V   | 4d <sub>5/2</sub> | 211.5 <sup>b</sup> |
| N VI  | 4f <sub>5/2</sub> | 15.9 <sup>b</sup>  |
| N VII | 4f <sub>7/2</sub> | 14.2 <sup>b</sup>  |
| O I   | 5s                | 64.2 <sup>b</sup>  |
| O II  | 5p <sub>1/2</sub> | 38 <sup>a</sup>    |
| O III | 5p <sub>3/2</sub> | 29.9 <sup>b</sup>  |

**Helium (2)**

|   |    |                   |
|---|----|-------------------|
| K | 1s | 24.6 <sup>a</sup> |
|---|----|-------------------|

**Holmium (67)**

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 55618              |
| L I   | 2s                | 9394               |
| L II  | 2p <sub>1/2</sub> | 8918               |
| L III | 2p <sub>3/2</sub> | 8071               |
| M I   | 3s                | 2128               |
| M II  | 3p <sub>1/2</sub> | 1923               |
| M III | 3p <sub>3/2</sub> | 1741               |
| M IV  | 3d <sub>3/2</sub> | 1392               |
| M V   | 3d <sub>5/2</sub> | 1351               |
| N I   | 4s                | 432.4 <sup>a</sup> |
| N II  | 4p <sub>1/2</sub> | 343.5              |
| N III | 4p <sub>3/2</sub> | 308.2 <sup>a</sup> |
| N IV  | 4d <sub>3/2</sub> | 160 <sup>a</sup>   |
| N V   | 4d <sub>5/2</sub> | 160 <sup>a</sup>   |
| N VI  | 4f <sub>5/2</sub> | 8.6 <sup>a</sup>   |
| N VII | 4f <sub>7/2</sub> | 5.2 <sup>a</sup>   |
| O I   | 5s                | 49.3 <sup>a</sup>  |
| O II  | 5p <sub>1/2</sub> | 30.8 <sup>a</sup>  |
| O III | 5p <sub>3/2</sub> | 24.1 <sup>a</sup>  |

**Hydrogen (1)**

|   |    |      |
|---|----|------|
| K | 1s | 13.6 |
|---|----|------|

**Indium (49)**

|       |                   |                    |
|-------|-------------------|--------------------|
| K     | 1s                | 27940              |
| L I   | 2s                | 4238               |
| L II  | 2p <sub>1/2</sub> | 3938               |
| L III | 2p <sub>3/2</sub> | 3730               |
| M I   | 3s                | 827.2 <sup>b</sup> |
| M II  | 3p <sub>1/2</sub> | 703.2 <sup>b</sup> |
| M III | 3p <sub>3/2</sub> | 665.3 <sup>b</sup> |
| M IV  | 3d <sub>3/2</sub> | 451.4 <sup>b</sup> |

|                     |                   |                     |                       |                   |                     |                        |                   |                     |                     |                   |                     |
|---------------------|-------------------|---------------------|-----------------------|-------------------|---------------------|------------------------|-------------------|---------------------|---------------------|-------------------|---------------------|
| M V                 | 3d <sub>5/2</sub> | 443.9 <sup>b</sup>  | N III                 | 4p <sub>3/2</sub> | 14.1 <sup>a</sup>   | N VII                  | 4f <sub>7/2</sub> | 7.5 <sup>a</sup>    | M IV                | 3d <sub>3/2</sub> | 1003.3 <sup>a</sup> |
| N I                 | 4s                | 122.9 <sup>b</sup>  | <i>Lanthanum (57)</i> |                   |                     | O I                    | 5s                | 57.3 <sup>a</sup>   | M V                 | 3d <sub>5/2</sub> | 980.4 <sup>a</sup>  |
| N II                | 4p <sub>1/2</sub> | 73.5 <sup>b,c</sup> | K                     | 1s                | 38925               | O II                   | 5p <sub>1/2</sub> | 33.6 <sup>a</sup>   | N I                 | 4s                | 319.2 <sup>a</sup>  |
| N III               | 4p <sub>3/2</sub> | 73.5 <sup>b,c</sup> | L I                   | 2s                | 6266                | O III                  | 5p <sub>3/2</sub> | 26.7 <sup>a</sup>   | N II                | 4p <sub>1/2</sub> | 243.3               |
| N IV                | 4d <sub>3/2</sub> | 17.7 <sup>b</sup>   | L II                  | 2p <sub>1/2</sub> | 5891                | <i>Magnesium (12)</i>  |                   |                     | N III               | 4p <sub>3/2</sub> | 224.6               |
| N V                 | 4d <sub>5/2</sub> | 16.9 <sup>b</sup>   | L III                 | 2p <sub>3/2</sub> | 5483                | K                      | 1s                | 1303.0 <sup>b</sup> | N IV                | 4d <sub>3/2</sub> | 120.5 <sup>a</sup>  |
| <i>Iodine (53)</i>  |                   |                     | M I                   | 3s                | 1362 <sup>a,d</sup> | L I                    | 2s                | 88.6 <sup>a</sup>   | N V                 | 4d <sub>5/2</sub> | 120.5 <sup>a</sup>  |
| K                   | 1s                | 33169               | M II                  | 3p <sub>1/2</sub> | 1209 <sup>a,d</sup> | L II                   | 2p <sub>1/2</sub> | 49.6 <sup>b</sup>   | N VI                | 4f <sub>5/2</sub> | 1.5                 |
| L I                 | 2s                | 5188                | M III                 | 3p <sub>3/2</sub> | 1128 <sup>a,d</sup> | L III                  | 2p <sub>3/2</sub> | 49.2 <sup>a</sup>   | N VII               | 4f <sub>7/2</sub> | 1.5                 |
| L II                | 2p <sub>1/2</sub> | 4852                | M IV                  | 3d <sub>3/2</sub> | 853 <sup>a</sup>    | <i>Manganese (25)</i>  |                   |                     | O I                 | 5s                | 37.5                |
| L III               | 2p <sub>3/2</sub> | 4557                | M V                   | 3d <sub>5/2</sub> | 836 <sup>a</sup>    | K                      | 1s                | 6539                | O II                | 5p <sub>1/2</sub> | 21.1                |
| M I                 | 3s                | 1072 <sup>a</sup>   | N I                   | 4s                | 247.7 <sup>a</sup>  | L I                    | 2s                | 769.1 <sup>b</sup>  | O III               | 5p <sub>3/2</sub> | 21.1                |
| M II                | 3p <sub>1/2</sub> | 931 <sup>a</sup>    | N II                  | 4p <sub>1/2</sub> | 205.8               | L II                   | 2p <sub>1/2</sub> | 649.9 <sup>b</sup>  | <i>Neon (10)</i>    |                   |                     |
| M III               | 3p <sub>3/2</sub> | 875 <sup>a</sup>    | N III                 | 4p <sub>3/2</sub> | 196.0 <sup>a</sup>  | L III                  | 2p <sub>3/2</sub> | 638.7 <sup>b</sup>  | K                   | 1s                | 870.2 <sup>a</sup>  |
| M IV                | 3d <sub>3/2</sub> | 631 <sup>a</sup>    | N IV                  | 4d <sub>3/2</sub> | 105.3 <sup>a</sup>  | M I                    | 3s                | 82.3 <sup>b</sup>   | L I                 | 2s                | 48.5 <sup>a</sup>   |
| M V                 | 3d <sub>5/2</sub> | 620 <sup>a</sup>    | N V                   | 4d <sub>5/2</sub> | 102.5 <sup>a</sup>  | M II                   | 3p <sub>1/2</sub> | 47.2 <sup>b</sup>   | L II                | 2p <sub>1/2</sub> | 21.7 <sup>a</sup>   |
| N I                 | 4s                | 186 <sup>a</sup>    | N VI                  | 4f <sub>5/2</sub> | —                   | M III                  | 3p <sub>3/2</sub> | 47.2 <sup>b</sup>   | L III               | 2p <sub>3/2</sub> | 21.6 <sup>a</sup>   |
| N II                | 4p <sub>1/2</sub> | 123 <sup>a</sup>    | N VII                 | 4f <sub>7/2</sub> | —                   | <i>Mercury (80)</i>    |                   |                     | <i>Nickel (28)</i>  |                   |                     |
| N III               | 4p <sub>3/2</sub> | 123 <sup>a</sup>    | O I                   | 5s                | 34.3 <sup>a</sup>   | K                      | 1s                | 83102               | K                   | 1s                | 8333                |
| N IV                | 4d <sub>3/2</sub> | 50 <sup>a</sup>     | O II                  | 5p <sub>1/2</sub> | 19.3 <sup>a</sup>   | L I                    | 2s                | 14839               | L I                 | 2s                | 1008.6 <sup>b</sup> |
| N V                 | 4d <sub>5/2</sub> | 50 <sup>a</sup>     | O III                 | 5p <sub>3/2</sub> | 16.8 <sup>a</sup>   | L II                   | 2p <sub>1/2</sub> | 14209               | L II                | 2p <sub>1/2</sub> | 870.0 <sup>b</sup>  |
| <i>Iridium (77)</i> |                   |                     | <i>Lead (82)</i>      |                   |                     | L III                  | 2p <sub>3/2</sub> | 12284               | L III               | 2p <sub>3/2</sub> | 852.7 <sup>b</sup>  |
| K                   | 1s                | 76111               | K                     | 1s                | 88005               | M I                    | 3s                | 3562                | M I                 | 3s                | 110.8 <sup>b</sup>  |
| L I                 | 2s                | 13419               | L I                   | 2s                | 15861               | M II                   | 3p <sub>1/2</sub> | 3279                | M II                | 3p <sub>1/2</sub> | 68.0 <sup>b</sup>   |
| L II                | 2p <sub>1/2</sub> | 12824               | L II                  | 2p <sub>1/2</sub> | 15200               | M III                  | 3p <sub>3/2</sub> | 2847                | M III               | 3p <sub>3/2</sub> | 66.2 <sup>b</sup>   |
| L III               | 2p <sub>3/2</sub> | 11215               | L III                 | 2p <sub>3/2</sub> | 13055               | M IV                   | 3d <sub>3/2</sub> | 2385                | <i>Niobium (41)</i> |                   |                     |
| M I                 | 3s                | 3174                | M I                   | 3s                | 3851                | M V                    | 3d <sub>5/2</sub> | 2295                | K                   | 1s                | 18986               |
| M II                | 3p <sub>1/2</sub> | 2909                | M II                  | 3p <sub>1/2</sub> | 3554                | N I                    | 4s                | 802.2 <sup>b</sup>  | L I                 | 2s                | 2698                |
| M III               | 3p <sub>3/2</sub> | 2551                | M III                 | 3p <sub>3/2</sub> | 3066                | N II                   | 4p <sub>1/2</sub> | 680.2 <sup>b</sup>  | L II                | 2p <sub>1/2</sub> | 2465                |
| M IV                | 3d <sub>3/2</sub> | 2116                | M IV                  | 3d <sub>3/2</sub> | 2586                | N III                  | 4p <sub>3/2</sub> | 576.6 <sup>b</sup>  | L III               | 2p <sub>3/2</sub> | 2371                |
| M V                 | 3d <sub>5/2</sub> | 2040                | M V                   | 3d <sub>5/2</sub> | 2484                | N IV                   | 4d <sub>3/2</sub> | 378.2 <sup>b</sup>  | M I                 | 3s                | 466.6 <sup>b</sup>  |
| N I                 | 4s                | 691.1 <sup>b</sup>  | N I                   | 4s                | 891.8 <sup>b</sup>  | N V                    | 4d <sub>5/2</sub> | 358.8 <sup>b</sup>  | M II                | 3p <sub>1/2</sub> | 376.1 <sup>b</sup>  |
| N II                | 4p <sub>1/2</sub> | 577.8 <sup>b</sup>  | N II                  | 4p <sub>1/2</sub> | 761.9 <sup>b</sup>  | N VI                   | 4f <sub>5/2</sub> | 104.0 <sup>b</sup>  | M III               | 3p <sub>3/2</sub> | 360.6 <sup>b</sup>  |
| N III               | 4p <sub>3/2</sub> | 495.8 <sup>b</sup>  | N III                 | 4p <sub>3/2</sub> | 643.5 <sup>b</sup>  | N VII                  | 4f <sub>7/2</sub> | 99.9 <sup>b</sup>   | M IV                | 3d <sub>3/2</sub> | 205.0 <sup>b</sup>  |
| N IV                | 4d <sub>3/2</sub> | 311.9 <sup>b</sup>  | N IV                  | 4d <sub>3/2</sub> | 434.3 <sup>b</sup>  | O I                    | 5s                | 127 <sup>b</sup>    | M V                 | 3d <sub>5/2</sub> | 202.3 <sup>b</sup>  |
| N V                 | 4d <sub>5/2</sub> | 296.3 <sup>b</sup>  | N V                   | 4d <sub>5/2</sub> | 412.2 <sup>b</sup>  | O II                   | 5p <sub>3/2</sub> | 83.1 <sup>b</sup>   | N I                 | 4s                | 56.4 <sup>b</sup>   |
| N VI                | 4f <sub>5/2</sub> | 63.8 <sup>b</sup>   | N VI                  | 4f <sub>5/2</sub> | 141.7 <sup>b</sup>  | O III                  | 5p <sub>3/2</sub> | 64.5 <sup>b</sup>   | N II                | 4p <sub>1/2</sub> | 32.6 <sup>b</sup>   |
| N VII               | 4f <sub>7/2</sub> | 60.8 <sup>b</sup>   | N VII                 | 4f <sub>7/2</sub> | 136.9 <sup>b</sup>  | O IV                   | 5d <sub>3/2</sub> | 9.6 <sup>b</sup>    | N III               | 4p <sub>3/2</sub> | 30.8 <sup>b</sup>   |
| O I                 | 5s                | 95.2 <sup>a,d</sup> | O I                   | 5s                | 147 <sup>a,d</sup>  | O V                    | 5d <sub>5/2</sub> | 7.8 <sup>b</sup>    | <i>Nitrogen (7)</i> |                   |                     |
| O II                | 5p <sub>1/2</sub> | 63.0 <sup>a,d</sup> | O II                  | 5p <sub>1/2</sub> | 106.4 <sup>b</sup>  | <i>Molybdenum (42)</i> |                   |                     | K                   | 1s                | 409.9 <sup>a</sup>  |
| O III               | 5p <sub>3/2</sub> | 48.0 <sup>b</sup>   | O III                 | 5p <sub>3/2</sub> | 83.3 <sup>b</sup>   | K                      | 1s                | 20000               | L I                 | 2s                | 37.3 <sup>a</sup>   |
| <i>Iron (26)</i>    |                   |                     | O IV                  | 5d <sub>3/2</sub> | 20.7 <sup>b</sup>   | L I                    | 2s                | 2866                | <i>Osmium (76)</i>  |                   |                     |
| K                   | 1s                | 7112                | O V                   | 5d <sub>5/2</sub> | 18.1 <sup>b</sup>   | L II                   | 2p <sub>1/2</sub> | 2625                | K                   | 1s                | 73871               |
| L I                 | 2s                | 844.6 <sup>b</sup>  | <i>Lithium (3)</i>    |                   |                     | L III                  | 2p <sub>3/2</sub> | 2520                | L I                 | 2s                | 12968               |
| L II                | 2p <sub>1/2</sub> | 719.9 <sup>b</sup>  | K                     | 1s                | 54.7 <sup>a</sup>   | M I                    | 3s                | 506.3 <sup>b</sup>  | L II                | 2p <sub>1/2</sub> | 12385               |
| L III               | 2p <sub>3/2</sub> | 706.8 <sup>b</sup>  | <i>Lutetium</i>       |                   |                     | M II                   | 3p <sub>1/2</sub> | 411.6 <sup>b</sup>  | L III               | 2p <sub>3/2</sub> | 10871               |
| M I                 | 3s                | 91.3 <sup>b</sup>   | K                     | 1s                | 63314               | M III                  | 3p <sub>3/2</sub> | 394.0 <sup>b</sup>  | M I                 | 3s                | 3049                |
| M II                | 3p <sub>1/2</sub> | 52.7 <sup>b</sup>   | L I                   | 2s                | 10870               | M IV                   | 3d <sub>3/2</sub> | 231.1 <sup>b</sup>  | M II                | 3p <sub>1/2</sub> | 2792                |
| M III               | 3p <sub>3/2</sub> | 52.7 <sup>b</sup>   | L II                  | 2p <sub>1/2</sub> | 10349               | M V                    | 3d <sub>5/2</sub> | 227.9 <sup>b</sup>  | M III               | 3p <sub>3/2</sub> | 2457                |
| <i>Krypton (36)</i> |                   |                     | L III                 | 2p <sub>3/2</sub> | 9244                | N I                    | 4s                | 63.2 <sup>b</sup>   | M IV                | 3d <sub>3/2</sub> | 2031                |
| K                   | 1s                | 14326               | M I                   | 3s                | 2491                | N II                   | 4p <sub>1/2</sub> | 37.6 <sup>b</sup>   | M V                 | 3d <sub>5/2</sub> | 1960                |
| L I                 | 2s                | 1921                | M II                  | 3p <sub>1/2</sub> | 2264                | N III                  | 4p <sub>3/2</sub> | 35.5 <sup>b</sup>   | N I                 | 4s                | 658.2 <sup>b</sup>  |
| L II                | 2p <sub>1/2</sub> | 1730.9 <sup>a</sup> | M III                 | 3p <sub>3/2</sub> | 2024                | <i>Neodymium (60)</i>  |                   |                     | N II                | 4p <sub>1/2</sub> | 549.1 <sup>b</sup>  |
| L III               | 2p <sub>3/2</sub> | 1678.4 <sup>a</sup> | M IV                  | 3d <sub>3/2</sub> | 1639                | K                      | 1s                | 43569               | N III               | 4p <sub>3/2</sub> | 470.7 <sup>b</sup>  |
| M I                 | 3s                | 292.8 <sup>a</sup>  | M V                   | 3d <sub>5/2</sub> | 1589                | L I                    | 2s                | 7126                | N IV                | 4d <sub>3/2</sub> | 293.1 <sup>b</sup>  |
| M II                | 3p <sub>1/2</sub> | 222.2 <sup>a</sup>  | N I                   | 4s                | 506.8 <sup>a</sup>  | L II                   | 2p <sub>1/2</sub> | 6722                | N V                 | 4d <sub>5/2</sub> | 278.5 <sup>b</sup>  |
| M III               | 3p <sub>3/2</sub> | 214.4 <sup>a</sup>  | N II                  | 4p <sub>1/2</sub> | 412.4 <sup>a</sup>  | L III                  | 2p <sub>3/2</sub> | 6208                | N VI                | 4f <sub>5/2</sub> | 53.4 <sup>b</sup>   |
| M IV                | 3d <sub>3/2</sub> | 95.0 <sup>a</sup>   | N III                 | 4p <sub>3/2</sub> | 359.2 <sup>a</sup>  | M I                    | 3s                | 1575                | N VII               | 4f <sub>7/2</sub> | 50.7 <sup>b</sup>   |
| M V                 | 3d <sub>5/2</sub> | 93.8 <sup>a</sup>   | N IV                  | 4d <sub>3/2</sub> | 206.1 <sup>a</sup>  | M II                   | 3p <sub>1/2</sub> | 1403                | O I                 | 5s                | 84 <sup>a</sup>     |
| N I                 | 4s                | 27.5 <sup>a</sup>   | N V                   | 4d <sub>5/2</sub> | 196.3 <sup>a</sup>  | M III                  | 3p <sub>3/2</sub> | 1297                | O II                | 5p <sub>1/2</sub> | 58 <sup>a</sup>     |
| N II                | 4p <sub>1/2</sub> | 14.1 <sup>a</sup>   | N VI                  | 4f <sub>5/2</sub> | 8.9 <sup>a</sup>    |                        |                   |                     |                     |                   |                     |

|                        |                   |                      |
|------------------------|-------------------|----------------------|
| O III                  | 5p <sub>3/2</sub> | 44.5 <sup>b</sup>    |
| <b>Oxygen (8)</b>      |                   |                      |
| K                      | 1s                | 543.1 <sup>a</sup>   |
| L I                    | 2s                | 41.6 <sup>a</sup>    |
| <b>Palladium (46)</b>  |                   |                      |
| K                      | 1s                | 24350                |
| L I                    | 2s                | 3604                 |
| L II                   | 2p <sub>1/2</sub> | 3330                 |
| L III                  | 2p <sub>3/2</sub> | 3173                 |
| M I                    | 3s                | 671.6 <sup>b</sup>   |
| M II                   | 3p <sub>1/2</sub> | 559.9 <sup>b</sup>   |
| M III                  | 3p <sub>3/2</sub> | 532.3 <sup>b</sup>   |
| M IV                   | 3d <sub>3/2</sub> | 340.5 <sup>b</sup>   |
| M V                    | 3d <sub>5/2</sub> | 335.2 <sup>b</sup>   |
| N I                    | 4s                | 87.1 <sup>a,d</sup>  |
| N II                   | 4p <sub>1/2</sub> | 55.7 <sup>b,c</sup>  |
| N III                  | 4p <sub>3/2</sub> | 50.9 <sup>b,c</sup>  |
| <b>Phosphorus (15)</b> |                   |                      |
| K                      | 1s                | 2145.5               |
| L I                    | 2s                | 189 <sup>a</sup>     |
| L II                   | 2p <sub>1/2</sub> | 136 <sup>a</sup>     |
| L III                  | 2p <sub>3/2</sub> | 135 <sup>a</sup>     |
| <b>Platinum (78)</b>   |                   |                      |
| K                      | 1s                | 78395                |
| L I                    | 2s                | 13880                |
| L II                   | 2p <sub>1/2</sub> | 13273                |
| L III                  | 2p <sub>3/2</sub> | 11564                |
| M I                    | 3s                | 3296                 |
| M II                   | 3p <sub>1/2</sub> | 3027                 |
| M III                  | 3p <sub>3/2</sub> | 2645                 |
| M IV                   | 3d <sub>3/2</sub> | 2202                 |
| M V                    | 3d <sub>5/2</sub> | 2122                 |
| N I                    | 4s                | 725.4 <sup>b</sup>   |
| N II                   | 4p <sub>1/2</sub> | 609.1 <sup>b</sup>   |
| N III                  | 4p <sub>3/2</sub> | 519.4 <sup>b</sup>   |
| N IV                   | 4d <sub>3/2</sub> | 331.6 <sup>b</sup>   |
| N V                    | 4d <sub>5/2</sub> | 314.6 <sup>b</sup>   |
| N VI                   | 4f <sub>5/2</sub> | 74.5 <sup>b</sup>    |
| N VII                  | 4f <sub>7/2</sub> | 71.2 <sup>b</sup>    |
| O I                    | 5s                | 101.7 <sup>a,d</sup> |
| O II                   | 5p <sub>1/2</sub> | 65.3 <sup>a,b</sup>  |
| O III                  | 5p <sub>3/2</sub> | 51.7 <sup>b</sup>    |
| <b>Polonium (84)</b>   |                   |                      |
| K                      | 1s                | 93105                |
| L I                    | 2s                | 16939                |
| L II                   | 2p <sub>1/2</sub> | 16244                |
| L III                  | 2p <sub>3/2</sub> | 13814                |
| M I                    | 3s                | 4149                 |
| M II                   | 3p <sub>1/2</sub> | 3854                 |
| M III                  | 3p <sub>3/2</sub> | 3302                 |
| M IV                   | 3d <sub>3/2</sub> | 2798                 |
| M V                    | 3d <sub>5/2</sub> | 2683                 |
| N I                    | 4s                | 995 <sup>a</sup>     |
| N II                   | 4p <sub>1/2</sub> | 851 <sup>a</sup>     |
| N III                  | 4p <sub>3/2</sub> | 705 <sup>a</sup>     |
| N IV                   | 4d <sub>3/2</sub> | 500 <sup>a</sup>     |
| N V                    | 4d <sub>5/2</sub> | 473 <sup>a</sup>     |
| N VI                   | 4f <sub>5/2</sub> | 184 <sup>a</sup>     |
| N VII                  | 4f <sub>7/2</sub> | 184 <sup>a</sup>     |
| O I                    | 5s                | 177 <sup>a</sup>     |

|                          |                   |                     |
|--------------------------|-------------------|---------------------|
| O II                     | 5p <sub>1/2</sub> | 132 <sup>a</sup>    |
| O III                    | 5p <sub>3/2</sub> | 104 <sup>a</sup>    |
| O IV                     | 5d <sub>3/2</sub> | 31 <sup>a</sup>     |
| O V                      | 5d <sub>5/2</sub> | 31 <sup>a</sup>     |
| <b>Potassium (19)</b>    |                   |                     |
| K                        | 1s                | 3608.4 <sup>a</sup> |
| L I                      | 2s                | 378.6 <sup>a</sup>  |
| L II                     | 2p <sub>1/2</sub> | 297.3 <sup>a</sup>  |
| L III                    | 2p <sub>3/2</sub> | 294.6 <sup>a</sup>  |
| M I                      | 3s                | 34.8 <sup>a</sup>   |
| M II                     | 3p <sub>1/2</sub> | 18.3 <sup>a</sup>   |
| M III                    | 3p <sub>3/2</sub> | 18.3 <sup>a</sup>   |
| <b>Praseodymium (59)</b> |                   |                     |
| K                        | 1s                | 41991               |
| L I                      | 2s                | 6835                |
| L II                     | 2p <sub>1/2</sub> | 6440                |
| L III                    | 2p <sub>3/2</sub> | 5964                |
| M I                      | 3s                | 1511                |
| M II                     | 3p <sub>1/2</sub> | 1337                |
| M III                    | 3p <sub>3/2</sub> | 1242                |
| M IV                     | 3d <sub>3/2</sub> | 948.3 <sup>a</sup>  |
| M V                      | 3d <sub>5/2</sub> | 928.8 <sup>a</sup>  |
| N I                      | 4s                | 304.5               |
| N II                     | 4p <sub>1/2</sub> | 236.3               |
| N III                    | 4p <sub>3/2</sub> | 217.6               |
| N IV                     | 4d <sub>3/2</sub> | 115.1 <sup>a</sup>  |
| N V                      | 4d <sub>5/2</sub> | 115.1 <sup>a</sup>  |
| N VI                     | 4f <sub>5/2</sub> | 2.0                 |
| N VII                    | 4f <sub>7/2</sub> | 2.0                 |
| O I                      | 5s                | 37.4                |
| O II                     | 5p <sub>1/2</sub> | 22.3                |
| O III                    | 5p <sub>3/2</sub> | 22.3                |
| <b>Promethium (61)</b>   |                   |                     |
| K                        | 1s                | 45184               |
| L I                      | 2s                | 7428                |
| L II                     | 2p <sub>1/2</sub> | 7013                |
| L III                    | 2p <sub>3/2</sub> | 6459                |
| M I                      | 3s                | —                   |
| M II                     | 3p <sub>1/2</sub> | 1471.4              |
| M III                    | 3p <sub>3/2</sub> | 1357                |
| M IV                     | 3d <sub>3/2</sub> | 1052                |
| M V                      | 3d <sub>5/2</sub> | 1027                |
| N I                      | 4s                | —                   |
| N II                     | 4p <sub>1/2</sub> | 242                 |
| N III                    | 4p <sub>3/2</sub> | 242                 |
| N IV                     | 4d <sub>3/2</sub> | 120                 |
| N V                      | 4d <sub>5/2</sub> | 120                 |
| <b>Protactinium (91)</b> |                   |                     |
| K                        | 1s                | 112601              |
| L I                      | 2s                | 21105               |
| L II                     | 2p <sub>1/2</sub> | 20314               |
| L III                    | 2p <sub>3/2</sub> | 16733               |
| M I                      | 3s                | 5367                |
| M II                     | 3p <sub>1/2</sub> | 5001                |
| M III                    | 3p <sub>3/2</sub> | 4174                |
| M IV                     | 3d <sub>3/2</sub> | 3611                |
| M V                      | 3d <sub>5/2</sub> | 3442                |
| N I                      | 4s                | 1387 <sup>a</sup>   |
| N II                     | 4p <sub>1/2</sub> | 1224 <sup>a</sup>   |
| N III                    | 4p <sub>3/2</sub> | 1007 <sup>a</sup>   |
| N IV                     | 4d <sub>3/2</sub> | 743 <sup>a</sup>    |

|                     |                   |                   |
|---------------------|-------------------|-------------------|
| N V                 | 4d <sub>5/2</sub> | 708 <sup>a</sup>  |
| N VI                | 4f <sub>5/2</sub> | 371 <sup>a</sup>  |
| N VII               | 4f <sub>7/2</sub> | 360 <sup>a</sup>  |
| O I                 | 5s                | 310 <sup>a</sup>  |
| O II                | 5p <sub>1/2</sub> | 232 <sup>a</sup>  |
| O III               | 5p <sub>3/2</sub> | 232 <sup>a</sup>  |
| O IV                | 5d <sub>3/2</sub> | 94 <sup>a</sup>   |
| O V                 | 5d <sub>5/2</sub> | 94 <sup>a</sup>   |
| P I                 | 6s                | —                 |
| P II                | 6p <sub>1/2</sub> | —                 |
| P III               | 6p <sub>3/2</sub> | —                 |
| <b>Radium (88)</b>  |                   |                   |
| K                   | 1s                | 103922            |
| L I                 | 2s                | 19237             |
| L II                | 2p <sub>1/2</sub> | 18484             |
| L III               | 2p <sub>3/2</sub> | 15444             |
| M I                 | 3s                | 4822              |
| M II                | 3p <sub>1/2</sub> | 4490              |
| M III               | 3p <sub>3/2</sub> | 3792              |
| M IV                | 3d <sub>3/2</sub> | 3248              |
| M V                 | 3d <sub>5/2</sub> | 3105              |
| N I                 | 4s                | 1208 <sup>a</sup> |
| N II                | 4p <sub>1/2</sub> | 1058              |
| N III               | 4p <sub>3/2</sub> | 879 <sup>a</sup>  |
| N IV                | 4d <sub>3/2</sub> | 636 <sup>a</sup>  |
| N V                 | 4d <sub>5/2</sub> | 603 <sup>a</sup>  |
| N VI                | 4f <sub>5/2</sub> | 299 <sup>a</sup>  |
| N VII               | 4f <sub>7/2</sub> | 299 <sup>a</sup>  |
| O I                 | 5s                | 254 <sup>a</sup>  |
| O II                | 5p <sub>1/2</sub> | 200 <sup>a</sup>  |
| O III               | 5p <sub>3/2</sub> | 153 <sup>a</sup>  |
| O IV                | 5d <sub>3/2</sub> | 68 <sup>a</sup>   |
| O V                 | 5d <sub>5/2</sub> | 68 <sup>a</sup>   |
| P I                 | 6s                | 44                |
| P II                | 6p <sub>1/2</sub> | 19                |
| P III               | 6p <sub>3/2</sub> | 19                |
| <b>Radon (86)</b>   |                   |                   |
| K                   | 1s                | 98404             |
| L I                 | 2s                | 18049             |
| L II                | 2p <sub>1/2</sub> | 17337             |
| L III               | 2p <sub>3/2</sub> | 14619             |
| M I                 | 3s                | 4482              |
| M II                | 3p <sub>1/2</sub> | 4159              |
| M III               | 3p <sub>3/2</sub> | 3538              |
| M IV                | 3d <sub>3/2</sub> | 3022              |
| M V                 | 3d <sub>5/2</sub> | 2892              |
| N I                 | 4s                | 1097 <sup>a</sup> |
| N II                | 4p <sub>1/2</sub> | 929 <sup>a</sup>  |
| N III               | 4p <sub>3/2</sub> | 768 <sup>a</sup>  |
| N IV                | 4d <sub>3/2</sub> | 567 <sup>a</sup>  |
| N V                 | 4d <sub>5/2</sub> | 541 <sup>a</sup>  |
| N VI                | 4f <sub>5/2</sub> | 238 <sup>a</sup>  |
| N VII               | 4f <sub>7/2</sub> | 238 <sup>a</sup>  |
| O I                 | 5s                | 214 <sup>a</sup>  |
| O II                | 5p <sub>1/2</sub> | 164 <sup>a</sup>  |
| O III               | 5p <sub>3/2</sub> | 127 <sup>a</sup>  |
| O IV                | 5d <sub>3/2</sub> | 48 <sup>a</sup>   |
| O V                 | 5d <sub>5/2</sub> | 48 <sup>a</sup>   |
| P I                 | 6s                | 26                |
| <b>Rhenium (75)</b> |                   |                   |
| K                   | 1s                | 71676             |

|                       |                   |                     |
|-----------------------|-------------------|---------------------|
| L I                   | 2s                | 12527               |
| L II                  | 2p <sub>1/2</sub> | 11959               |
| L III                 | 2p <sub>3/2</sub> | 10535               |
| M I                   | 3s                | 2932                |
| M II                  | 3p <sub>1/2</sub> | 2682                |
| M III                 | 3p <sub>3/2</sub> | 2367                |
| M IV                  | 3d <sub>3/2</sub> | 1949                |
| M V                   | 3d <sub>5/2</sub> | 1883                |
| N I                   | 4s                | 625.4 <sup>b</sup>  |
| N II                  | 4p <sub>1/2</sub> | 518.7 <sup>b</sup>  |
| N III                 | 4p <sub>3/2</sub> | 446.8 <sup>b</sup>  |
| N IV                  | 4d <sub>3/2</sub> | 273.9 <sup>b</sup>  |
| N V                   | 4d <sub>5/2</sub> | 260.5 <sup>b</sup>  |
| N VI                  | 4f <sub>5/2</sub> | 42.9 <sup>a</sup>   |
| N VII                 | 4f <sub>7/2</sub> | 40.5 <sup>a</sup>   |
| O I                   | 5s                | 83 <sup>b</sup>     |
| O II                  | 5p <sub>1/2</sub> | 45.6 <sup>b</sup>   |
| O III                 | 5p <sub>3/2</sub> | 34.6 <sup>a,d</sup> |
| <b>Rhodium (45)</b>   |                   |                     |
| K                     | 1s                | 23220               |
| L I                   | 2s                | 3412                |
| L II                  | 2p <sub>1/2</sub> | 3146                |
| L III                 | 2p <sub>3/2</sub> | 3004                |
| M I                   | 3s                | 628.1 <sup>b</sup>  |
| M II                  | 3p <sub>1/2</sub> | 521.3 <sup>b</sup>  |
| M III                 | 3p <sub>3/2</sub> | 496.5 <sup>b</sup>  |
| M IV                  | 3d <sub>3/2</sub> | 311.9 <sup>b</sup>  |
| M V                   | 3d <sub>5/2</sub> | 307.2 <sup>b</sup>  |
| N I                   | 4s                | 81.4 <sup>a,d</sup> |
| N II                  | 4p <sub>1/2</sub> | 50.5 <sup>b</sup>   |
| N III                 | 4p <sub>3/2</sub> | 47.3 <sup>b</sup>   |
| <b>Rubidium (37)</b>  |                   |                     |
| K                     | 1s                | 15200               |
| L I                   | 2s                | 2065                |
| L II                  | 2p <sub>1/2</sub> | 1864                |
| L III                 | 2p <sub>3/2</sub> | 1804                |
| M I                   | 3s                | 326.7 <sup>a</sup>  |
| M II                  | 3p <sub>1/2</sub> | 248.7 <sup>a</sup>  |
| M III                 | 3p <sub>3/2</sub> | 239.1 <sup>a</sup>  |
| M IV                  | 3d <sub>3/2</sub> | 113.0 <sup>a</sup>  |
| M V                   | 3d <sub>5/2</sub> | 112 <sup>a</sup>    |
| N I                   | 4s                | 30.5 <sup>a</sup>   |
| N II                  | 4p <sub>1/2</sub> | 16.3 <sup>a</sup>   |
| N III                 | 4p <sub>3/2</sub> | 15.3 <sup>a</sup>   |
| <b>Ruthenium (44)</b> |                   |                     |
| K                     | 1s                | 22117               |
| L I                   | 2s                | 3224                |
| L II                  | 2p <sub>1/2</sub> | 2967                |
| L III                 | 2p <sub>3/2</sub> | 2838                |
| M I                   | 3s                | 586.2 <sup>b</sup>  |
| M II                  | 3p <sub>1/2</sub> | 483.3 <sup>b</sup>  |
| M III                 | 3p <sub>3/2</sub> | 461.5 <sup>b</sup>  |
| M IV                  | 3d <sub>3/2</sub> | 284.2 <sup>b</sup>  |
| M V                   | 3d <sub>5/2</sub> | 280.0 <sup>b</sup>  |
| N I                   | 4s                | 75.0 <sup>b</sup>   |
| N II                  | 4p <sub>1/2</sub> | 46.5 <sup>b</sup>   |
| N III                 | 4p <sub>3/2</sub> | 43.2 <sup>b</sup>   |
| <b>Samarium (62)</b>  |                   |                     |
| K                     | 1s                | 46834               |
| L I                   | 2s                | 7737                |
| L II                  | 2p <sub>1/2</sub> | 7312                |

|                       |                   |                       |                        |                   |                      |                      |                   |                     |                      |                   |                     |
|-----------------------|-------------------|-----------------------|------------------------|-------------------|----------------------|----------------------|-------------------|---------------------|----------------------|-------------------|---------------------|
| L III                 | 2p <sub>3/2</sub> | 6716                  | L II                   | 2p <sub>1/2</sub> | 2007                 | N IV                 | 4d <sub>3/2</sub> | 41.9 <sup>b</sup>   | O I                  | 5s                | 290 <sup>a,c</sup>  |
| M I                   | 3s                | 1723                  | L III                  | 2p <sub>3/2</sub> | 1940                 | N V                  | 4d <sub>5/2</sub> | 40.4 <sup>b</sup>   | O II                 | 5p <sub>1/2</sub> | 229 <sup>a,c</sup>  |
| M II                  | 3p <sub>1/2</sub> | 1541                  | M I                    | 3s                | 358.7 <sup>b</sup>   | <i>Terbium (65)</i>  |                   |                     | O III                | 5p <sub>3/2</sub> | 182 <sup>a,c</sup>  |
| M III                 | 3p <sub>3/2</sub> | 1419.8                | M II                   | 3p <sub>1/2</sub> | 280.3 <sup>b</sup>   | K                    | 1s                | 51996               | O IV                 | 5d <sub>3/2</sub> | 92.5 <sup>b</sup>   |
| M IV                  | 3d <sub>3/2</sub> | 1110.9 <sup>a</sup>   | M III                  | 3p <sub>3/2</sub> | 270.0 <sup>b</sup>   | L I                  | 2s                | 8708                | O V                  | 5d <sub>5/2</sub> | 85.4 <sup>b</sup>   |
| M V                   | 3d <sub>5/2</sub> | 1083.4 <sup>a</sup>   | M IV                   | 3d <sub>3/2</sub> | 136.0 <sup>b</sup>   | L II                 | 2p <sub>1/2</sub> | 8252                | P I                  | 6s                | 41.4 <sup>b</sup>   |
| N I                   | 4s                | 347.2 <sup>a</sup>    | M V                    | 3d <sub>5/2</sub> | 134.2 <sup>b</sup>   | L III                | 2p <sub>3/2</sub> | 7514                | P II                 | 6p <sub>1/2</sub> | 24.5 <sup>b</sup>   |
| N II                  | 4p <sub>1/2</sub> | 265.6                 | N I                    | 4s                | 38.9 <sup>b</sup>    | M I                  | 3s                | 1968                | P III                | 6p <sub>3/2</sub> | 16.6 <sup>b</sup>   |
| N III                 | 4p <sub>3/2</sub> | 247.4                 | N II                   | 4p <sub>1/2</sub> | 21.6 <sup>b</sup>    | M II                 | 3p <sub>1/2</sub> | 1768                | <i>Thulium (69)</i>  |                   |                     |
| N IV                  | 4d <sub>3/2</sub> | 129.0                 | N III                  | 4p <sub>3/2</sub> | 20.1 <sup>b</sup>    | M III                | 3p <sub>3/2</sub> | 1611                | K                    | 1s                | 59390               |
| N V                   | 4d <sub>5/2</sub> | 129.0                 | <i>Sulfur (16)</i>     |                   |                      | M IV                 | 3d <sub>3/2</sub> | 1267.9 <sup>a</sup> | L I                  | 2s                | 10116               |
| N VI                  | 4f <sub>5/2</sub> | 5.2                   | K                      | 1s                | 2472                 | M V                  | 3d <sub>5/2</sub> | 1241.1 <sup>a</sup> | L II                 | 2p <sub>1/2</sub> | 9617                |
| N VII                 | 4f <sub>7/2</sub> | 5.2                   | L I                    | 2s                | 230.9 <sup>a,d</sup> | N I                  | 4s                | 396.0 <sup>a</sup>  | L III                | 2p <sub>3/2</sub> | 8648                |
| O I                   | 5s                | 37.4                  | L II                   | 2p <sub>1/2</sub> | 163.6 <sup>a</sup>   | N II                 | 4p <sub>1/2</sub> | 322.4 <sup>a</sup>  | M I                  | 3s                | 2307                |
| O II                  | 5p <sub>1/2</sub> | 21.3                  | L III                  | 2p <sub>3/2</sub> | 162.5 <sup>a</sup>   | N III                | 4p <sub>3/2</sub> | 284.1 <sup>a</sup>  | M II                 | 3p <sub>1/2</sub> | 2090                |
| O III                 | 5p <sub>3/2</sub> | 21.3                  | <i>Tantalum (73)</i>   |                   |                      | N IV                 | 4d <sub>3/2</sub> | 150.5 <sup>a</sup>  | M III                | 3p <sub>3/2</sub> | 1885                |
| <i>Scandium (21)</i>  |                   |                       | K                      | 1s                | 67416                | N V                  | 4d <sub>5/2</sub> | 150.5 <sup>a</sup>  | M IV                 | 3d <sub>3/2</sub> | 1515                |
| K                     | 1s                | 4492                  | L I                    | 2s                | 11682                | N VI                 | 4f <sub>5/2</sub> | 7.7 <sup>a</sup>    | M V                  | 3d <sub>5/2</sub> | 1468                |
| L I                   | 2s                | 498.0 <sup>a</sup>    | L II                   | 2p <sub>1/2</sub> | 11136                | N VII                | 4f <sub>7/2</sub> | 2.4 <sup>a</sup>    | N I                  | 4s                | 470.9 <sup>a</sup>  |
| L II                  | 2p <sub>1/2</sub> | 403.6 <sup>a</sup>    | L III                  | 2p <sub>3/2</sub> | 9881                 | O I                  | 5s                | 45.6 <sup>a</sup>   | N II                 | 4p <sub>1/2</sub> | 385.9 <sup>a</sup>  |
| L III                 | 2p <sub>3/2</sub> | 389.7 <sup>a</sup>    | M I                    | 3s                | 2708                 | O II                 | 5p <sub>1/2</sub> | 28.7 <sup>a</sup>   | N III                | 4p <sub>3/2</sub> | 332.6 <sup>a</sup>  |
| M I                   | 3s                | 51.1 <sup>a</sup>     | M II                   | 3p <sub>1/2</sub> | 2469                 | O III                | 5p <sub>3/2</sub> | 22.6 <sup>a</sup>   | N IV                 | 4d <sub>3/2</sub> | 175.5 <sup>a</sup>  |
| M II                  | 3p <sub>1/2</sub> | 28.3 <sup>a</sup>     | M III                  | 3p <sub>3/2</sub> | 2194                 | <i>Thallium (81)</i> |                   |                     | N V                  | 4d <sub>5/2</sub> | 175.5 <sup>a</sup>  |
| M III                 | 3p <sub>3/2</sub> | 28.3 <sup>a</sup>     | M IV                   | 3d <sub>3/2</sub> | 1793                 | K                    | 1s                | 85530               | N VI                 | 4f <sub>5/2</sub> | —                   |
| <i>Selenium (34)</i>  |                   |                       | M V                    | 3d <sub>5/2</sub> | 1735                 | L I                  | 2s                | 15347               | N VII                | 4f <sub>7/2</sub> | 4.6                 |
| K                     | 1s                | 12658                 | N I                    | 4s                | 563.4 <sup>b</sup>   | L II                 | 2p <sub>1/2</sub> | 14698               | O I                  | 5s                | 54.7 <sup>a</sup>   |
| L I                   | 2s                | 1652.0 <sup>a,d</sup> | N II                   | 4p <sub>1/2</sub> | 463.4 <sup>b</sup>   | L III                | 2p <sub>3/2</sub> | 12658               | O II                 | 5p <sub>1/2</sub> | 31.8 <sup>a</sup>   |
| L II                  | 2p <sub>1/2</sub> | 1474.3 <sup>a,d</sup> | N III                  | 4p <sub>3/2</sub> | 400.9 <sup>b</sup>   | M I                  | 3s                | 3704                | O III                | 5p <sub>3/2</sub> | 25.0 <sup>a</sup>   |
| L III                 | 2p <sub>3/2</sub> | 1433.9 <sup>a,d</sup> | N IV                   | 4d <sub>3/2</sub> | 237.9 <sup>b</sup>   | M II                 | 3p <sub>1/2</sub> | 3416                | <i>Tin (50)</i>      |                   |                     |
| M I                   | 3s                | 229.6 <sup>a</sup>    | N V                    | 4d <sub>5/2</sub> | 226.4 <sup>b</sup>   | M III                | 3p <sub>3/2</sub> | 2957                | K                    | 1s                | 29200               |
| M II                  | 3p <sub>1/2</sub> | 166.5 <sup>a</sup>    | N VI                   | 4f <sub>5/2</sub> | 23.5 <sup>b</sup>    | M IV                 | 3d <sub>3/2</sub> | 2485                | L I                  | 2s                | 4465                |
| M III                 | 3p <sub>3/2</sub> | 160.7 <sup>a</sup>    | N VII                  | 4f <sub>7/2</sub> | 21.6 <sup>b</sup>    | M V                  | 3d <sub>5/2</sub> | 2389                | L II                 | 2p <sub>1/2</sub> | 4156                |
| M IV                  | 3d <sub>3/2</sub> | 55.5 <sup>a</sup>     | O I                    | 5s                | 69.7 <sup>b</sup>    | N I                  | 4s                | 846.2 <sup>b</sup>  | L III                | 2p <sub>3/2</sub> | 3929                |
| M V                   | 3d <sub>5/2</sub> | 54.6 <sup>a</sup>     | O II                   | 5p <sub>1/2</sub> | 42.2 <sup>a</sup>    | N II                 | 4p <sub>1/2</sub> | 720.5 <sup>b</sup>  | M I                  | 3s                | 884.7 <sup>b</sup>  |
| <i>Silicon (14)</i>   |                   |                       | O III                  | 5p <sub>3/2</sub> | 32.7 <sup>b</sup>    | N III                | 4p <sub>3/2</sub> | 609.5 <sup>b</sup>  | M II                 | 3p <sub>1/2</sub> | 756.5 <sup>b</sup>  |
| K                     | 1s                | 1839                  | <i>Technetium (43)</i> |                   |                      | N IV                 | 4d <sub>3/2</sub> | 405.7 <sup>b</sup>  | M III                | 3p <sub>3/2</sub> | 714.6 <sup>b</sup>  |
| L I                   | 2s                | 149.7 <sup>a,d</sup>  | K                      | 1s                | 21044                | N V                  | 4d <sub>5/2</sub> | 385.0 <sup>b</sup>  | M IV                 | 3d <sub>3/2</sub> | 493.2 <sup>b</sup>  |
| L II                  | 2p <sub>1/2</sub> | 99.8 <sup>a</sup>     | L I                    | 2s                | 3043                 | N VI                 | 4f <sub>5/2</sub> | 122.2 <sup>b</sup>  | M V                  | 3d <sub>5/2</sub> | 484.9 <sup>b</sup>  |
| L III                 | 2p <sub>3/2</sub> | 99.2 <sup>a</sup>     | L II                   | 2p <sub>1/2</sub> | 2793                 | N VII                | 4f <sub>7/2</sub> | 117.8 <sup>b</sup>  | N I                  | 4s                | 137.1 <sup>b</sup>  |
| <i>Silver (47)</i>    |                   |                       | L III                  | 2p <sub>3/2</sub> | 2677                 | O I                  | 5s                | 136 <sup>a,d</sup>  | N II                 | 4p <sub>1/2</sub> | 83.6 <sup>b,c</sup> |
| K                     | 1s                | 25514                 | M I                    | 3s                | 586.1 <sup>a</sup>   | O II                 | 5p <sub>1/2</sub> | 94.6 <sup>b</sup>   | N III                | 4p <sub>3/2</sub> | 83.6 <sup>b,c</sup> |
| L I                   | 2s                | 3806                  | M II                   | 3p <sub>1/2</sub> | 447.6 <sup>a</sup>   | O III                | 5p <sub>3/2</sub> | 73.5 <sup>b</sup>   | N IV                 | 4d <sub>3/2</sub> | 24.9 <sup>b</sup>   |
| L II                  | 2p <sub>1/2</sub> | 3524                  | M III                  | 3p <sub>3/2</sub> | 417.7 <sup>a</sup>   | O IV                 | 5d <sub>3/2</sub> | 14.7 <sup>b</sup>   | N V                  | 4d <sub>5/2</sub> | 23.9 <sup>b</sup>   |
| L III                 | 2p <sub>3/2</sub> | 3351                  | M IV                   | 3d <sub>3/2</sub> | 257.6 <sup>a</sup>   | O V                  | 5d <sub>5/2</sub> | 12.5 <sup>b</sup>   | <i>Titanium (22)</i> |                   |                     |
| M I                   | 3s                | 719.0 <sup>b</sup>    | M V                    | 3d <sub>5/2</sub> | 253.9 <sup>a</sup>   | <i>Thorium (90)</i>  |                   |                     | K                    | 1s                | 4966                |
| M II                  | 3p <sub>1/2</sub> | 603.8 <sup>b</sup>    | N I                    | 4s                | 69.5 <sup>a</sup>    | K                    | 1s                | 109651              | L I                  | 2s                | 560.9 <sup>b</sup>  |
| M III                 | 3p <sub>3/2</sub> | 573.0 <sup>b</sup>    | N II                   | 4p <sub>1/2</sub> | 42.3 <sup>a</sup>    | L I                  | 2s                | 20472               | L II                 | 2p <sub>1/2</sub> | 460.2 <sup>b</sup>  |
| M IV                  | 3d <sub>3/2</sub> | 374.0 <sup>b</sup>    | N III                  | 4p <sub>3/2</sub> | 39.9 <sup>a</sup>    | L II                 | 2p <sub>1/2</sub> | 19693               | L III                | 2p <sub>3/2</sub> | 453.8 <sup>b</sup>  |
| M V                   | 3d <sub>5/2</sub> | 368.0 <sup>b</sup>    | <i>Tellurium (52)</i>  |                   |                      | L III                | 2p <sub>3/2</sub> | 16300               | M I                  | 3s                | 58.7 <sup>b</sup>   |
| N I                   | 4s                | 97.0 <sup>b</sup>     | K                      | 1s                | 31814                | M I                  | 3s                | 5182                | M II                 | 3p <sub>1/2</sub> | 32.6 <sup>b</sup>   |
| N II                  | 4p <sub>1/2</sub> | 63.7 <sup>b</sup>     | L I                    | 2s                | 4939                 | M II                 | 3p <sub>1/2</sub> | 4830                | M III                | 3p <sub>3/2</sub> | 32.6 <sup>b</sup>   |
| N III                 | 4p <sub>3/2</sub> | 58.3 <sup>b</sup>     | L II                   | 2p <sub>1/2</sub> | 4612                 | M III                | 3p <sub>3/2</sub> | 4046                | <i>Tungsten (74)</i> |                   |                     |
| <i>Sodium (11)</i>    |                   |                       | L III                  | 2p <sub>3/2</sub> | 4341                 | M IV                 | 3d <sub>3/2</sub> | 3491                | K                    | 1s                | 69525               |
| K                     | 1s                | 1070.8 <sup>b</sup>   | M I                    | 3s                | 1006 <sup>b</sup>    | M V                  | 3d <sub>5/2</sub> | 3332                | L I                  | 2s                | 12100               |
| L I                   | 2s                | 63.5 <sup>b</sup>     | M II                   | 3p <sub>1/2</sub> | 870.8 <sup>b</sup>   | N I                  | 4s                | 1330 <sup>a</sup>   | L II                 | 2p <sub>1/2</sub> | 11544               |
| L II                  | 2p <sub>1/2</sub> | 30.4 <sup>b</sup>     | M III                  | 3p <sub>3/2</sub> | 820.0 <sup>b</sup>   | N II                 | 4p <sub>1/2</sub> | 1168 <sup>a</sup>   | L III                | 2p <sub>3/2</sub> | 10207               |
| L III                 | 2p <sub>3/2</sub> | 30.5 <sup>a</sup>     | M IV                   | 3d <sub>3/2</sub> | 583.4 <sup>b</sup>   | N III                | 4p <sub>3/2</sub> | 966.4 <sup>b</sup>  | M I                  | 3s                | 2820                |
| <i>Strontium (38)</i> |                   |                       | M V                    | 3d <sub>5/2</sub> | 573.0 <sup>b</sup>   | N IV                 | 4d <sub>3/2</sub> | 712.1 <sup>b</sup>  | M II                 | 3p <sub>1/2</sub> | 2575                |
| K                     | 1s                | 16105                 | N I                    | 4s                | 169.4 <sup>b</sup>   | N V                  | 4d <sub>5/2</sub> | 675.2 <sup>b</sup>  | M III                | 3p <sub>3/2</sub> | 2281                |
| L I                   | 2s                | 2216                  | N II                   | 4p <sub>1/2</sub> | 103.3 <sup>b,c</sup> | N VI                 | 4f <sub>5/2</sub> | 342.4 <sup>b</sup>  | M IV                 | 3d <sub>3/2</sub> | 1949                |
|                       |                   |                       | N III                  | 4p <sub>3/2</sub> | 103.3 <sup>b,c</sup> | N VII                | 4f <sub>7/2</sub> | 333.1 <sup>b</sup>  |                      |                   |                     |

|                     |                   |                      |                      |                   |                      |                       |                   |                      |                       |                   |                     |
|---------------------|-------------------|----------------------|----------------------|-------------------|----------------------|-----------------------|-------------------|----------------------|-----------------------|-------------------|---------------------|
| M V                 | 3d <sub>5/2</sub> | 1809                 | O II                 | 5p <sub>1/2</sub> | 257 <sup>a,c,d</sup> | N VII                 | 4f <sub>7/2</sub> | —                    | M III                 | 3p <sub>3/2</sub> | 298.8 <sup>a</sup>  |
| N I                 | 4s                | 594.1 <sup>b</sup>   | O III                | 5p <sub>3/2</sub> | 192 <sup>a,c,d</sup> | O I                   | 5s                | 23.3 <sup>a</sup>    | M IV                  | 3d <sub>3/2</sub> | 157.7 <sup>b</sup>  |
| N II                | 4p <sub>1/2</sub> | 490.4 <sup>b</sup>   | O IV                 | 5d <sub>3/2</sub> | 102.8 <sup>b</sup>   | O II                  | 5p <sub>1/2</sub> | 13.4 <sup>a</sup>    | M V                   | 3d <sub>5/2</sub> | 155.8 <sup>b</sup>  |
| N III               | 4p <sub>3/2</sub> | 423.6 <sup>b</sup>   | O V                  | 5d <sub>5/2</sub> | 94.2 <sup>b</sup>    | O III                 | 5p <sub>3/2</sub> | 12.1 <sup>a</sup>    | N I                   | 4s                | 43.8 <sup>a</sup>   |
| N IV                | 4d <sub>3/2</sub> | 255.9 <sup>b</sup>   | P I                  | 6s                | 43.9 <sup>b</sup>    | <i>Ytterbium (70)</i> |                   |                      | N II                  | 4p <sub>1/2</sub> | 24.4 <sup>a</sup>   |
| N V                 | 4d <sub>5/2</sub> | 243.5 <sup>b</sup>   | P II                 | 6p <sub>1/2</sub> | 26.8 <sup>b</sup>    | K                     | 1s                | 61332                | N III                 | 4p <sub>3/2</sub> | 23.1 <sup>a</sup>   |
| N VI                | 4f <sub>5/2</sub> | 33.6 <sup>a</sup>    | P III                | 6p <sub>3/2</sub> | 16.8 <sup>b</sup>    | L I                   | 2s                | 10486                | <i>Zinc (30)</i>      |                   |                     |
| N VII               | 4f <sub>7/2</sub> | 31.4 <sup>b</sup>    | <i>Vanadium (23)</i> |                   |                      | L II                  | 2p <sub>1/2</sub> | 9978                 | K                     | 1s                | 9659                |
| O I                 | 5s                | 75.6 <sup>b</sup>    | K                    | 1s                | 5465                 | L III                 | 2p <sub>3/2</sub> | 8944                 | L I                   | 2s                | 1196.2 <sup>a</sup> |
| O II                | 5p <sub>1/2</sub> | 453 <sup>a,d</sup>   | L I                  | 2s                | 626.7 <sup>b</sup>   | M I                   | 3s                | 2398                 | L II                  | 2p <sub>1/2</sub> | 1044.9 <sup>a</sup> |
| O III               | 5p <sub>3/2</sub> | 36.8 <sup>b</sup>    | L II                 | 2p <sub>1/2</sub> | 519.8 <sup>b</sup>   | M II                  | 3p <sub>1/2</sub> | 2173                 | L III                 | 2p <sub>3/2</sub> | 1021.8 <sup>a</sup> |
| <i>Uranium (92)</i> |                   |                      | L III                | 2p <sub>3/2</sub> | 521.1 <sup>b</sup>   | M III                 | 3p <sub>3/2</sub> | 1950                 | M I                   | 3s                | 139.8 <sup>a</sup>  |
| K                   | 1s                | 115606               | M I                  | 3s                | 66.3 <sup>b</sup>    | M IV                  | 3d <sub>3/2</sub> | 1576                 | M II                  | 3p <sub>1/2</sub> | 91.4 <sup>a</sup>   |
| L I                 | 2s                | 21757                | M II                 | 3p <sub>1/2</sub> | 37.2 <sup>b</sup>    | M V                   | 3d <sub>5/2</sub> | 1528                 | M III                 | 3p <sub>3/2</sub> | 88.6 <sup>a</sup>   |
| L II                | 2p <sub>1/2</sub> | 20948                | M III                | 3p <sub>3/2</sub> | 37.2 <sup>b</sup>    | N I                   | 4s                | 480.5 <sup>a</sup>   | M IV                  | 3d <sub>3/2</sub> | 10.2 <sup>a</sup>   |
| L III               | 2p <sub>3/2</sub> | 17166                | <i>Xenon (54)</i>    |                   |                      | N II                  | 4p <sub>1/2</sub> | 388.7 <sup>a</sup>   | M V                   | 3d <sub>5/2</sub> | 10.1 <sup>a</sup>   |
| M I                 | 3s                | 5548                 | K                    | 1s                | 34561                | N III                 | 4p <sub>3/2</sub> | 339.7 <sup>a</sup>   | <i>Zirconium (40)</i> |                   |                     |
| M II                | 3p <sub>1/2</sub> | 5182                 | L I                  | 2s                | 5453                 | N IV                  | 4d <sub>3/2</sub> | 191.2 <sup>a</sup>   | K                     | 1s                | 17998               |
| M III               | 3p <sub>3/2</sub> | 4303                 | L II                 | 2p <sub>1/2</sub> | 5107                 | N V                   | 4d <sub>5/2</sub> | 182.4 <sup>a</sup>   | L I                   | 2s                | 2532                |
| M IV                | 3d <sub>3/2</sub> | 3728                 | L III                | 2p <sub>3/2</sub> | 4786                 | N VI                  | 4f <sub>5/2</sub> | 2.5 <sup>a</sup>     | L II                  | 2p <sub>1/2</sub> | 2307                |
| M V                 | 3d <sub>5/2</sub> | 3552                 | M I                  | 3s                | 1148.7 <sup>a</sup>  | N VII                 | 4f <sub>7/2</sub> | 1.3 <sup>a</sup>     | L III                 | 2p <sub>3/2</sub> | 2223                |
| N I                 | 4s                | 1439 <sup>a,d</sup>  | M II                 | 3p <sub>1/2</sub> | 1002.1 <sup>a</sup>  | O I                   | 5s                | 52.0 <sup>a</sup>    | M I                   | 3s                | 430.3 <sup>b</sup>  |
| N II                | 4p <sub>1/2</sub> | 1271 <sup>a,d</sup>  | M III                | 3p <sub>3/2</sub> | 940.6 <sup>a</sup>   | O II                  | 5p <sub>1/2</sub> | 30.3 <sup>a</sup>    | M II                  | 3p <sub>1/2</sub> | 343.5 <sup>b</sup>  |
| N III               | 4p <sub>3/2</sub> | 1043 <sup>b</sup>    | M IV                 | 3d <sub>3/2</sub> | 689.0 <sup>a</sup>   | O III                 | 5p <sub>3/2</sub> | 24.1 <sup>a</sup>    | M III                 | 3p <sub>3/2</sub> | 329.8 <sup>b</sup>  |
| N IV                | 4d <sub>3/2</sub> | 778.3 <sup>b</sup>   | M V                  | 3d <sub>5/2</sub> | 676.4 <sup>a</sup>   | <i>Yttrium (39)</i>   |                   |                      | M IV                  | 3d <sub>3/2</sub> | 181.1 <sup>b</sup>  |
| N V                 | 4d <sub>5/2</sub> | 736.2 <sup>b</sup>   | N I                  | 4s                | 213.2 <sup>a</sup>   | K                     | 1s                | 17038                | M V                   | 3d <sub>5/2</sub> | 178.8 <sup>b</sup>  |
| N VI                | 4f <sub>5/2</sub> | 388.2 <sup>a</sup>   | N II                 | 4p <sub>1/2</sub> | 146.7                | L I                   | 2s                | 2373                 | N I                   | 4s                | 50.6 <sup>b</sup>   |
| N VII               | 4f <sub>7/2</sub> | 377.4 <sup>b</sup>   | N III                | 4p <sub>3/2</sub> | 145.5 <sup>a</sup>   | L II                  | 2p <sub>1/2</sub> | 2156                 | N II                  | 4p <sub>1/2</sub> | 28.5 <sup>b</sup>   |
| O I                 | 5s                | 321 <sup>a,c,d</sup> | N IV                 | 4d <sub>3/2</sub> | 69.5 <sup>a</sup>    | L III                 | 2p <sub>3/2</sub> | 2080                 | N III                 | 4p <sub>3/2</sub> | 27.1 <sup>b</sup>   |
|                     |                   |                      | N V                  | 4d <sub>5/2</sub> | 67.5 <sup>a</sup>    | M I                   | 3s                | 392.0 <sup>a,d</sup> |                       |                   |                     |
|                     |                   |                      | N VI                 | 4f <sub>5/2</sub> | —                    | M II                  | 3p <sub>1/2</sub> | 310.6 <sup>a</sup>   |                       |                   |                     |

<sup>a</sup> Reference 1.<sup>b</sup> Reference 2 (remaining values from Reference 3).<sup>c</sup> One-particle approximation not valid.<sup>d</sup> Derived using energy differences from Reference 3.

# NATURAL WIDTH OF X-RAY LINES

Natural widths of K X-ray lines in eV:

| Element | $K\alpha_1$ | $K\alpha_2$ | $K\beta_1$ | $K\beta_3$ | Element | $K\alpha_1$ | $K\alpha_2$ | $K\beta_1$ | $K\beta_3$ |
|---------|-------------|-------------|------------|------------|---------|-------------|-------------|------------|------------|
| Ca      | 1.00        | 0.98        |            |            | Ce      | 18.60       | 19.50       | 20.60      | 18.60      |
| Ti      | 1.45        | 2.13        |            |            | Nd      | 21.50       | 21.50       | 23.25      | 21.33      |
| Cr      | 2.05        | 2.64        |            |            | Sm      | 26.00       | 24.70       | 25.65      | 24.65      |
| Fe      | 2.45        | 3.20        |            |            | Gd      | 29.50       | 28.00       | 29.37      | 28.00      |
| Ni      | 3.00        | 3.70        |            |            | Dy      | 33.90       | 32.20       | 32.73      | 32.00      |
| Zn      | 3.40        | 3.96        |            |            | Er      | 35.00       | 35.50       | 36.20      | 35.70      |
| Ge      | 3.75        | 4.18        |            |            | Yb      | 38.80       | 40.60       | 41.43      | 41.15      |
| Se      | 4.10        | 4.43        |            |            | Hf      | 42.70       | 44.30       | 46.00      | 46.10      |
| Kr      | 4.23        | 4.62        |            |            | W       | 46.80       | 48.00       | 51.83      | 51.50      |
| Sr      | 5.17        | 4.97        |            |            | Os      | 49.00       | 49.40       | 55.90      | 55.95      |
| Zr      | 5.70        | 5.25        |            |            | Pt      | 54.10       | 54.30       | 59.98      | 62.13      |
| Mo      | 6.82        | 6.80        |            |            | Hg      | 64.75       | 68.20       | 65.75      | 68.95      |
| Ru      | 7.41        | 7.96        |            |            | Pb      | 67.10       | 72.30       | 72.20      | 73.80      |
| Pd      | 8.80        | 9.20        |            |            | Po      | 73.20       | 75.10       | 78.60      | 80.10      |
| Cd      | 9.80        | 10.40       |            |            | Rn      | 80.00       | 81.50       | 85.50      | 86.50      |
| Sn      | 11.20       | 12.40       | 11.80      | 11.00      | Ra      | 87.00       | 88.20       | 94.20      | 95.50      |
| Te      | 12.80       | 14.20       | 13.30      | 13.10      | Th      | 94.70       | 95.00       | 99.70      | 101.00     |
| Xe      | 14.20       | 15.10       | 15.30      | 14.50      | U       | 103.00      | 104.30      | 105.00     | 107.30     |
| Ba      | 16.10       | 16.80       | 18.15      | 16.70      |         |             |             |            |            |

From Salem, S. I. and Lee, P. L., *At. Data Nucl. Data Tables*, 18, 233, 1976.

Natural widths of L X-ray lines in eV:

| Element | $L\alpha_1$ | $L\alpha_2$ | $L\beta_1$ | $L\beta_2$ | $L\beta_3$ | $L\beta_4$ | $L\gamma_1$ |
|---------|-------------|-------------|------------|------------|------------|------------|-------------|
| Zr      | 1.68        | 1.52        | 1.87       | 5.13       | 5.50       | 5.60       | 3.34        |
| Mo      | 1.86        | 1.80        | 2.03       | 5.30       | 5.90       | 5.78       | 3.76        |
| Ru      | 2.03        | 1.98        | 2.18       | 5.45       | 6.35       | 5.96       | 4.15        |
| Pd      | 2.21        | 2.16        | 2.36       | 5.63       | 6.80       | 6.18       | 4.50        |
| Gd      | 2.43        | 2.40        | 2.54       | 5.82       | 7.23       | 6.28       | 4.83        |
| Sn      | 2.62        | 2.62        | 2.75       | 6.10       | 7.70       | 6.60       | 5.23        |
| Tc      | 2.88        | 2.88        | 2.96       | 6.25       | 8.22       | 6.82       | 5.60        |
| Xe      | 3.15        | 3.15        | 3.20       | 6.43       | 8.70       | 7.15       | 5.95        |
| Ba      | 3.39        | 3.45        | 3.45       | 6.70       | 9.20       | 7.42       | 6.35        |
| Ce      | 3.70        | 3.78        | 3.73       | 6.86       | 9.70       | 7.82       | 6.75        |
| Nd      | 3.93        | 4.08        | 4.00       | 7.18       | 10.30      | 8.15       | 7.16        |
| Sm      | 4.13        | 4.50        | 4.33       | 7.42       | 10.80      | 8.60       | 7.50        |
| Cd      | 4.46        | 4.90        | 4.63       | 7.70       | 11.20      | 9.08       | 7.83        |
| Dy      | 4.81        | 5.35        | 5.03       | 7.90       | 11.50      | 9.60       | 8.30        |
| Er      | 5.17        | 5.73        | 5.45       | 8.28       | 11.85      | 10.03      | 8.75        |
| Yb      | 5.40        | 6.22        | 5.90       | 8.58       | 12.20      | 11.00      | 9.20        |
| Hf      | 5.83        | 6.70        | 6.36       | 8.92       | 12.40      | 12.80      | 9.63        |
| W       | 6.50        | 7.20        | 6.90       | 9.06       | 13.10      | 14.60      | 10.20       |
| Os      | 7.04        | 7.70        | 7.42       | 9.60       | 14.60      | 16.50      | 10.65       |
| Pt      | 7.60        | 8.28        | 8.00       | 9.95       | 16.10      | 18.00      | 11.20       |
| Hg      | 8.10        | 8.80        | 8.70       | 10.40      | 17.40      | 19.70      | 11.80       |
| Pb      | 8.82        | 9.35        | 9.35       | 10.75      | 18.65      | 21.30      | 12.30       |
| Po      | 9.50        | 9.95        | 10.10      | 11.25      | 19.90      | 22.70      | 13.05       |
| Rn      | 10.03       | 10.50       | 10.65      | 11.65      | 21.00      | 24.00      | 13.55       |
| Ra      | 11.00       | 11.20       | 11.60      | 12.20      | 22.00      | 25.20      | 14.30       |
| Th      | 11.90       | 11.80       | 12.40      | 12.80      | 22.85      | 26.35      | 15.00       |
| U       | 12.40       | 12.40       | 13.50      | 13.30      | 23.70      | 27.50      | 15.70       |
| Pu      | 13.20       | 13.00       | 14.10      | 13.90      | 24.10      | 28.30      | 16.40       |
| Cm      | 14.80       | 13.60       | 15.70      | 14.60      | 25.00      | 29.40      | 17.10       |

# PHOTON ATTENUATION COEFFICIENTS

Martin J. Berger and John H. Hubbell

This table gives mass attenuation coefficients for photons for all elements at energies between 1 keV (soft x-rays) and 1 GeV (hard gamma rays). The mass attenuation coefficient  $\mu$  describes the attenuation of radiation as it passes through matter by the relation

$$I(x)/I_0 = e^{-\mu\rho x}$$

where  $I_0$  is the initial intensity,  $I(x)$  the intensity after path length  $x$ , and  $\rho$  is the mass density of the element in question. To a high approximation the mass attenuation coefficient is additive for the elements present, independent of the way in which they are bound in chemical compounds.

The power of ten is indicated beside each number in the table; i.e., 7.41 + 03 means  $7.41 \times 10^3$ . A vertical line between two columns indicates that an absorption edge lies between those energy values. The various edges are labeled at the bottom of the table.

The attenuation coefficients were calculated with the computer program XCOM (Reference 1), which uses a cross-section database compiled at the Photon and Charged Particle Data Center at the National Institute of Standards and Technology. Their accuracy has been confirmed at all energies by extensive comparisons with experimental attenuation coefficients. Such comparisons for X-ray energies up to 100 keV can be found in Reference 2.

## References

1. Berger, M. J. and Hubbell, J. H., *National Bureau of Standards Report NBSIR-87-3597*, 1987.
2. Saloman, E. B., Hubbell, J. H., and Scofield, J. H., *Atomic Data and Nuclear Data Tables*, 38, 1, 1988.



|        |     | Mass attenuation coefficient, cm <sup>2</sup> /g |           |           |           |           |           |           |         |         |
|--------|-----|--------------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|---------|---------|
|        |     | Photon energy, MeV                               |           |           |           |           |           |           |         |         |
| Atomic | no. | 0.001                                            | 0.002     | 0.005     | 0.01      | 0.02      | 0.05      | 0.1       | 0.2     | 0.5     |
| H      | 1   | 7.21 + 00                                        | 1.06 + 00 | 4.19-01   | 3.85-01   | 3.69-01   | 3.36-01   | 2.94-01   | 2.43-01 | 1.73-01 |
| He     | 2   | 6.08 + 01                                        | 6.86 + 00 | 5.77-01   | 2.48-01   | 1.96-01   | 1.70-01   | 1.49-01   | 1.22-01 | 8.71-02 |
| Li     | 3   | 2.34 + 02                                        | 2.71 + 01 | 1.62 + 00 | 3.40-01   | 1.86-01   | 1.49-01   | 1.29-01   | 1.06-01 | 7.53-02 |
| Be     | 4   | 6.04 + 02                                        | 7.47 + 01 | 4.37 + 00 | 6.47-01   | 2.25-01   | 1.55-01   | 1.33-01   | 1.09-01 | 7.74-02 |
| B      | 5   | 1.23 + 03                                        | 1.60 + 02 | 9.68 + 00 | 1.25 + 00 | 3.01-01   | 1.66-01   | 1.39-01   | 1.14-01 | 8.07-02 |
| C      | 6   | 2.21 + 03                                        | 3.03 + 02 | 1.91 + 01 | 2.37 + 00 | 4.42-01   | 1.87-01   | 1.51-01   | 1.23-01 | 8.72-02 |
| N      | 7   | 3.31 + 03                                        | 4.77 + 02 | 3.14 + 01 | 3.88 + 00 | 6.18-01   | 1.98-01   | 1.53-01   | 1.23-01 | 8.72-02 |
| O      | 8   | 4.59 + 03                                        | 6.95 + 02 | 4.79 + 01 | 5.95 + 00 | 8.65-01   | 2.13-01   | 1.55-01   | 1.24-01 | 8.73-02 |
| F      | 9   | 5.65 + 03                                        | 9.05 + 02 | 6.51 + 01 | 8.21 + 00 | 1.13 + 00 | 2.21-01   | 1.50-01   | 1.18-01 | 8.27-02 |
| Ne     | 10  | 7.41 + 03                                        | 1.24 + 03 | 9.34 + 01 | 1.20 + 01 | 1.61 + 00 | 2.58-01   | 1.60-01   | 1.24-01 | 8.66-02 |
| Na     | 11  | 6.54 + 02                                        | 1.52 + 03 | 1.19 + 02 | 1.56 + 01 | 2.06 + 00 | 2.80-01   | 1.59-01   | 1.20-01 | 8.37-02 |
| Mg     | 12  | 9.22 + 02                                        | 1.93 + 03 | 1.58 + 02 | 2.11 + 01 | 2.76 + 00 | 3.29-01   | 1.69-01   | 1.24-01 | 8.65-02 |
| Al     | 13  | 1.19 + 03                                        | 2.26 + 03 | 1.93 + 02 | 2.62 + 01 | 3.44 + 00 | 3.68-01   | 1.70-01   | 1.22-01 | 8.44-02 |
| Si     | 14  | 1.57 + 03                                        | 2.78 + 03 | 2.45 + 02 | 3.39 + 01 | 4.46 + 00 | 4.38-01   | 1.84-01   | 1.28-01 | 8.75-02 |
| P      | 15  | 1.91 + 03                                        | 3.02 + 02 | 2.86 + 02 | 4.04 + 01 | 5.35 + 00 | 4.92-01   | 1.87-01   | 1.25-01 | 8.51-02 |
| S      | 16  | 2.43 + 03                                        | 3.85 + 02 | 3.49 + 02 | 5.01 + 01 | 6.71 + 00 | 5.85-01   | 2.02-01   | 1.30-01 | 8.78-02 |
| Cl     | 17  | 2.83 + 03                                        | 4.52 + 02 | 3.90 + 02 | 5.73 + 01 | 7.74 + 00 | 6.48-01   | 2.05-01   | 1.27-01 | 8.45-02 |
| Ar     | 18  | 3.18 + 03                                        | 5.12 + 02 | 4.23 + 02 | 6.32 + 01 | 8.63 + 00 | 7.01-01   | 2.04-01   | 1.20-01 | 7.96-02 |
| K      | 19  | 4.06 + 03                                        | 6.59 + 02 | 5.19 + 02 | 7.91 + 01 | 1.09 + 01 | 8.68-01   | 2.34-01   | 1.32-01 | 8.60-02 |
| Ca     | 20  | 4.87 + 03                                        | 8.00 + 02 | 6.03 + 02 | 9.34 + 01 | 1.31 + 01 | 1.02 + 00 | 2.57-01   | 1.38-01 | 8.85-02 |
| Sc     | 21  | 5.24 + 03                                        | 8.70 + 02 | 6.31 + 02 | 9.95 + 01 | 1.41 + 01 | 1.09 + 00 | 2.58-01   | 1.31-01 | 8.31-02 |
| Ti     | 22  | 5.87 + 03                                        | 9.86 + 02 | 6.84 + 02 | 1.11 + 02 | 1.59 + 01 | 1.21 + 00 | 2.72-01   | 1.31-01 | 8.19-02 |
| V      | 23  | 6.50 + 03                                        | 1.11 + 03 | 9.29 + 01 | 1.22 + 02 | 1.77 + 01 | 1.35 + 00 | 2.88-01   | 1.32-01 | 8.07-02 |
| Cr     | 24  | 7.40 + 03                                        | 1.28 + 03 | 1.08 + 02 | 1.39 + 02 | 2.04 + 01 | 1.55 + 00 | 3.17-01   | 1.38-01 | 8.28-02 |
| Mn     | 25  | 8.09 + 03                                        | 1.42 + 03 | 1.21 + 02 | 1.51 + 02 | 2.25 + 01 | 1.71 + 00 | 3.37-01   | 1.39-01 | 8.19-02 |
| Fe     | 26  | 9.09 + 03                                        | 1.63 + 03 | 1.40 + 02 | 1.71 + 02 | 2.57 + 01 | 1.96 + 00 | 3.72-01   | 1.46-01 | 8.41-02 |
| Co     | 27  | 9.80 + 03                                        | 1.78 + 03 | 1.54 + 02 | 1.84 + 02 | 2.80 + 01 | 2.14 + 00 | 3.95-01   | 1.48-01 | 8.32-02 |
| Ni     | 28  | 9.86 + 03                                        | 2.05 + 03 | 1.79 + 02 | 2.09 + 02 | 3.22 + 01 | 2.47 + 00 | 4.44-01   | 1.58-01 | 8.70-02 |
| Cu     | 29  | 1.06 + 04                                        | 2.15 + 03 | 1.90 + 02 | 2.16 + 02 | 3.38 + 01 | 2.61 + 00 | 4.58-01   | 1.56-01 | 8.36-02 |
| Zn     | 30  | 1.55 + 03                                        | 2.37 + 03 | 2.12 + 02 | 2.33 + 02 | 3.72 + 01 | 2.89 + 00 | 4.97-01   | 1.62-01 | 8.45-02 |
| Ga     | 31  | 1.70 + 03                                        | 2.52 + 03 | 2.27 + 02 | 3.42 + 01 | 3.93 + 01 | 3.08 + 00 | 5.20-01   | 1.62-01 | 8.24-02 |
| Ge     | 32  | 1.89 + 03                                        | 2.71 + 03 | 2.47 + 02 | 3.74 + 01 | 4.22 + 01 | 3.34 + 00 | 5.55-01   | 1.66-01 | 8.21-02 |
| As     | 33  | 2.12 + 03                                        | 2.93 + 03 | 2.71 + 02 | 4.12 + 01 | 4.56 + 01 | 3.63 + 00 | 5.97-01   | 1.72-01 | 8.26-02 |
| Se     | 34  | 2.32 + 03                                        | 3.10 + 03 | 2.90 + 02 | 4.41 + 01 | 4.82 + 01 | 3.86 + 00 | 6.28-01   | 1.74-01 | 8.13-02 |
| Br     | 35  | 2.62 + 03                                        | 3.41 + 03 | 3.21 + 02 | 4.91 + 01 | 5.27 + 01 | 4.26 + 00 | 6.86-01   | 1.84-01 | 8.33-02 |
| Kr     | 36  | 2.85 + 03                                        | 3.60 + 03 | 3.43 + 02 | 5.26 + 01 | 5.55 + 01 | 4.52 + 00 | 7.22-01   | 1.87-01 | 8.23-02 |
| Rb     | 37  | 3.17 + 03                                        | 3.41 + 03 | 3.74 + 02 | 5.77 + 01 | 5.98 + 01 | 4.92 + 00 | 7.80-01   | 1.96-01 | 8.36-02 |
| Sr     | 38  | 3.49 + 03                                        | 2.59 + 03 | 4.06 + 02 | 6.27 + 01 | 6.39 + 01 | 5.31 + 00 | 8.37-01   | 2.04-01 | 8.44-02 |
| Y      | 39  | 3.86 + 03                                        | 7.42 + 02 | 4.42 + 02 | 6.87 + 01 | 6.86 + 01 | 5.76 + 00 | 9.05-01   | 2.15-01 | 8.61-02 |
| Zr     | 40  | 4.21 + 03                                        | 8.12 + 02 | 4.76 + 02 | 7.42 + 01 | 7.24 + 01 | 6.17 + 00 | 9.66-01   | 2.24-01 | 8.69-02 |
| Nb     | 41  | 4.60 + 03                                        | 8.89 + 02 | 5.13 + 02 | 8.04 + 01 | 7.71 + 01 | 6.64 + 00 | 1.04 + 00 | 2.34-01 | 8.83-02 |
| Mo     | 42  | 4.94 + 03                                        | 9.60 + 02 | 5.45 + 02 | 8.58 + 01 | 1.31 + 01 | 7.04 + 00 | 1.10 + 00 | 2.42-01 | 8.85-02 |
| Tc     | 43  | 5.36 + 03                                        | 1.04 + 03 | 5.84 + 02 | 9.23 + 01 | 1.41 + 01 | 7.52 + 00 | 1.17 + 00 | 2.53-01 | 8.97-02 |
| Ru     | 44  | 5.72 + 03                                        | 1.12 + 03 | 6.17 + 02 | 9.80 + 01 | 1.50 + 01 | 7.92 + 00 | 1.23 + 00 | 2.62-01 | 8.99-02 |
| Rh     | 45  | 6.17 + 03                                        | 1.21 + 03 | 6.59 + 02 | 1.05 + 02 | 1.61 + 01 | 8.45 + 00 | 1.31 + 00 | 2.74-01 | 9.13-02 |
| Pd     | 46  | 6.54 + 03                                        | 1.29 + 03 | 6.91 + 02 | 1.11 + 02 | 1.70 + 01 | 8.85 + 00 | 1.38 + 00 | 2.83-01 | 9.13-02 |
| Ag     | 47  | 7.04 + 03                                        | 1.40 + 03 | 7.39 + 02 | 1.19 + 02 | 1.84 + 01 | 9.45 + 00 | 1.47 + 00 | 2.97-01 | 9.32-02 |
| Cd     | 48  | 7.35 + 03                                        | 1.47 + 03 | 7.69 + 02 | 1.24 + 02 | 1.92 + 01 | 9.78 + 00 | 1.52 + 00 | 3.04-01 | 9.25-02 |
| In     | 49  | 7.81 + 03                                        | 1.58 + 03 | 8.13 + 02 | 1.32 + 02 | 2.04 + 01 | 1.03 + 01 | 1.61 + 00 | 3.17-01 | 9.37-02 |
| Sn     | 50  | 8.16 + 03                                        | 1.66 + 03 | 8.47 + 02 | 1.38 + 02 | 2.15 + 01 | 1.07 + 01 | 1.68 + 00 | 3.26-01 | 9.37-02 |

L<sub>3</sub> L<sub>1</sub>  
L<sub>2</sub>

K EDGE



|    |            | Mass attenuation coefficient, cm <sup>2</sup> /g |         |         |         |         |         |         |         |         |
|----|------------|--------------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
|    |            | Photon energy, MeV                               |         |         |         |         |         |         |         |         |
|    | Atomic no. | 1.0                                              | 2.0     | 5.0     | 10.0    | 20.0    | 50.0    | 100.0   | 500.0   | 1000.0  |
| H  | 1          | 1.26-01                                          | 8.77-02 | 5.05-02 | 3.25-02 | 2.15-02 | 1.42-02 | 1.19-02 | 1.14-02 | 1.16-02 |
| He | 2          | 6.36-02                                          | 4.42-02 | 2.58-02 | 1.70-02 | 1.18-02 | 8.61-03 | 7.78-03 | 7.79-03 | 7.95-03 |
| Li | 3          | 5.50-02                                          | 3.83-02 | 2.26-02 | 1.53-02 | 1.11-02 | 8.68-03 | 8.21-03 | 8.61-03 | 8.87-03 |
| Be | 4          | 5.65-02                                          | 3.94-02 | 2.35-02 | 1.63-02 | 1.23-02 | 1.02-02 | 9.94-03 | 1.08-02 | 1.12-02 |
| B  | 5          | 5.89-02                                          | 4.11-02 | 2.48-02 | 1.76-02 | 1.37-02 | 1.19-02 | 1.19-02 | 1.32-02 | 1.37-02 |
| C  | 6          | 6.36-02                                          | 4.44-02 | 2.71-02 | 1.96-02 | 1.58-02 | 1.43-02 | 1.46-02 | 1.64-02 | 1.70-02 |
| N  | 7          | 6.36-02                                          | 4.45-02 | 2.74-02 | 2.02-02 | 1.67-02 | 1.57-02 | 1.63-02 | 1.85-02 | 1.92-02 |
| O  | 8          | 6.37-02                                          | 4.46-02 | 2.78-02 | 2.09-02 | 1.77-02 | 1.71-02 | 1.79-02 | 2.06-02 | 2.13-02 |
| F  | 9          | 6.04-02                                          | 4.23-02 | 2.66-02 | 2.04-02 | 1.77-02 | 1.75-02 | 1.86-02 | 2.14-02 | 2.21-02 |
| Ne | 10         | 6.32-02                                          | 4.43-02 | 2.82-02 | 2.20-02 | 1.95-02 | 1.96-02 | 2.11-02 | 2.43-02 | 2.51-02 |
| Na | 11         | 6.10-02                                          | 4.28-02 | 2.75-02 | 2.18-02 | 1.97-02 | 2.03-02 | 2.19-02 | 2.53-02 | 2.62-02 |
| Mg | 12         | 6.30-02                                          | 4.43-02 | 2.87-02 | 2.31-02 | 2.13-02 | 2.23-02 | 2.42-02 | 2.81-02 | 2.90-02 |
| Al | 13         | 6.15-02                                          | 4.32-02 | 2.84-02 | 2.32-02 | 2.17-02 | 2.31-02 | 2.52-02 | 2.93-02 | 3.03-02 |
| Si | 14         | 6.36-02                                          | 4.48-02 | 2.97-02 | 2.46-02 | 2.34-02 | 2.52-02 | 2.76-02 | 3.23-02 | 3.34-02 |
| P  | 15         | 6.18-02                                          | 4.36-02 | 2.91-02 | 2.45-02 | 2.36-02 | 2.58-02 | 2.84-02 | 3.33-02 | 3.45-02 |
| S  | 16         | 6.37-02                                          | 4.50-02 | 3.04-02 | 2.59-02 | 2.53-02 | 2.79-02 | 3.08-02 | 3.62-02 | 3.75-02 |
| Cl | 17         | 6.13-02                                          | 4.33-02 | 2.95-02 | 2.55-02 | 2.52-02 | 2.81-02 | 3.11-02 | 3.67-02 | 3.80-02 |
| Ar | 18         | 5.76-02                                          | 4.07-02 | 2.80-02 | 2.45-02 | 2.45-02 | 2.76-02 | 3.07-02 | 3.62-02 | 3.75-02 |
| K  | 19         | 6.22-02                                          | 4.40-02 | 3.05-02 | 2.70-02 | 2.74-02 | 3.11-02 | 3.46-02 | 4.09-02 | 4.24-02 |
| Ca | 20         | 6.39-02                                          | 4.52-02 | 3.17-02 | 2.84-02 | 2.90-02 | 3.32-02 | 3.71-02 | 4.40-02 | 4.56-02 |
| Sc | 21         | 5.98-02                                          | 4.24-02 | 3.00-02 | 2.72-02 | 2.80-02 | 3.23-02 | 3.62-02 | 4.30-02 | 4.45-02 |
| Ti | 22         | 5.89-02                                          | 4.18-02 | 2.98-02 | 2.73-02 | 2.84-02 | 3.30-02 | 3.71-02 | 4.40-02 | 4.56-02 |
| V  | 23         | 5.79-02                                          | 4.11-02 | 2.96-02 | 2.74-02 | 2.88-02 | 3.36-02 | 3.78-02 | 4.49-02 | 4.65-02 |
| Cr | 24         | 5.93-02                                          | 4.21-02 | 3.06-02 | 2.86-02 | 3.03-02 | 3.56-02 | 4.01-02 | 4.76-02 | 4.93-02 |
| Mn | 25         | 5.85-02                                          | 4.16-02 | 3.04-02 | 2.87-02 | 3.07-02 | 3.63-02 | 4.09-02 | 4.86-02 | 5.04-02 |
| Fe | 26         | 5.99-02                                          | 4.26-02 | 3.15-02 | 2.99-02 | 3.22-02 | 3.83-02 | 4.33-02 | 5.15-02 | 5.33-02 |
| Co | 27         | 5.91-02                                          | 4.20-02 | 3.13-02 | 3.00-02 | 3.26-02 | 3.88-02 | 4.40-02 | 5.23-02 | 5.41-02 |
| Ni | 28         | 6.16-02                                          | 4.39-02 | 3.29-02 | 3.18-02 | 3.48-02 | 4.17-02 | 4.73-02 | 5.61-02 | 5.81-02 |
| Cu | 29         | 5.90-02                                          | 4.20-02 | 3.18-02 | 3.10-02 | 3.41-02 | 4.10-02 | 4.66-02 | 5.53-02 | 5.72-02 |
| Zn | 30         | 5.94-02                                          | 4.24-02 | 3.22-02 | 3.18-02 | 3.51-02 | 4.24-02 | 4.82-02 | 5.72-02 | 5.91-02 |
| Ga | 31         | 5.77-02                                          | 4.11-02 | 3.16-02 | 3.13-02 | 3.48-02 | 4.22-02 | 4.80-02 | 5.70-02 | 5.89-02 |
| Ge | 32         | 5.73-02                                          | 4.09-02 | 3.16-02 | 3.16-02 | 3.53-02 | 4.30-02 | 4.89-02 | 5.80-02 | 6.00-02 |
| As | 33         | 5.73-02                                          | 4.09-02 | 3.19-02 | 3.21-02 | 3.60-02 | 4.40-02 | 5.01-02 | 5.95-02 | 6.15-02 |
| Se | 34         | 5.62-02                                          | 4.01-02 | 3.14-02 | 3.19-02 | 3.60-02 | 4.41-02 | 5.03-02 | 5.97-02 | 6.17-02 |
| Br | 35         | 5.73-02                                          | 4.09-02 | 3.23-02 | 3.29-02 | 3.74-02 | 4.60-02 | 5.24-02 | 6.22-02 | 6.43-02 |
| Kr | 36         | 5.63-02                                          | 4.02-02 | 3.20-02 | 3.28-02 | 3.74-02 | 4.61-02 | 5.26-02 | 6.25-02 | 6.46-02 |
| Rb | 37         | 5.69-02                                          | 4.06-02 | 3.25-02 | 3.36-02 | 3.85-02 | 4.75-02 | 5.43-02 | 6.45-02 | 6.67-02 |
| Sr | 38         | 5.71-02                                          | 4.08-02 | 3.29-02 | 3.41-02 | 3.93-02 | 4.87-02 | 5.56-02 | 6.61-02 | 6.83-02 |
| Y  | 39         | 5.80-02                                          | 4.14-02 | 3.35-02 | 3.50-02 | 4.05-02 | 5.03-02 | 5.75-02 | 6.83-02 | 7.06-02 |
| Zr | 40         | 5.81-02                                          | 4.15-02 | 3.38-02 | 3.55-02 | 4.12-02 | 5.13-02 | 5.87-02 | 6.98-02 | 7.22-02 |
| Nb | 41         | 5.87-02                                          | 4.18-02 | 3.44-02 | 3.63-02 | 4.22-02 | 5.27-02 | 6.03-02 | 7.17-02 | 7.42-02 |
| Mo | 42         | 5.84-02                                          | 4.16-02 | 3.44-02 | 3.65-02 | 4.26-02 | 5.33-02 | 6.10-02 | 7.26-02 | 7.51-02 |
| Tc | 43         | 5.88-02                                          | 4.19-02 | 3.48-02 | 3.71-02 | 4.35-02 | 5.45-02 | 6.24-02 | 7.43-02 | 7.68-02 |
| Ru | 44         | 5.85-02                                          | 4.16-02 | 3.48-02 | 3.73-02 | 4.39-02 | 5.50-02 | 6.30-02 | 7.51-02 | 7.77-02 |
| Rh | 45         | 5.89-02                                          | 4.20-02 | 3.53-02 | 3.80-02 | 4.48-02 | 5.63-02 | 6.45-02 | 7.69-02 | 7.94-02 |
| Pd | 46         | 5.85-02                                          | 4.16-02 | 3.52-02 | 3.80-02 | 4.50-02 | 5.66-02 | 6.49-02 | 7.73-02 | 8.00-02 |
| Ag | 47         | 5.92-02                                          | 4.21-02 | 3.58-02 | 3.88-02 | 4.61-02 | 5.81-02 | 6.67-02 | 7.93-02 | 8.20-02 |
| Cd | 48         | 5.83-02                                          | 4.14-02 | 3.54-02 | 3.85-02 | 4.59-02 | 5.79-02 | 6.64-02 | 7.91-02 | 8.18-02 |
| In | 49         | 5.85-02                                          | 4.15-02 | 3.56-02 | 3.90-02 | 4.65-02 | 5.88-02 | 6.75-02 | 8.04-02 | 8.32-02 |
| Sn | 50         | 5.80-02                                          | 4.11-02 | 3.55-02 | 3.90-02 | 4.66-02 | 5.90-02 | 6.78-02 | 8.07-02 | 8.35-02 |

|        |     | Mass attenuation coefficient, cm <sup>2</sup> /g |                |                |           |                |           |           |           |         |
|--------|-----|--------------------------------------------------|----------------|----------------|-----------|----------------|-----------|-----------|-----------|---------|
|        |     | Photon energy, MeV                               |                |                |           |                |           |           |           |         |
| Atomic | no. | 0.001                                            | 0.002          | 0.005          | 0.01      | 0.02           | 0.05      | 0.1       | 0.2       | 0.5     |
| Sb     | 51  | 8.58 + 03                                        | 1.77 + 03      | 8.85 + 02      | 1.46 + 02 | 2.27 + 01      | 1.12 + 01 | 1.76 + 00 | 3.38-01   | 9.45-02 |
| Te     | 52  | 8.43 + 03                                        | 1.83 + 03      | 9.01 + 02      | 1.50 + 02 | 2.34 + 01      | 1.14 + 01 | 1.80 + 00 | 3.43-01   | 9.33-02 |
| I      | 53  | 9.10 + 03                                        | 2.00 + 03      | 8.43 + 02      | 1.63 + 02 | 2.54 + 01      | 1.23 + 01 | 1.94 + 00 | 3.66-01   | 9.70-02 |
| Xe     | 54  | 9.41 + 03                                        | 2.09 + 03      | 6.39 + 02      | 1.69 + 02 | 2.65 + 01      | 1.27 + 01 | 2.01 + 00 | 3.76-01   | 9.70-02 |
| Cs     | 55  | 9.37 + 03                                        | 2.23 + 03      | 2.30 + 02      | 1.79 + 02 | 2.82 + 01      | 1.34 + 01 | 2.12 + 00 | 3.94-01   | 9.91-02 |
| ZB     | 56  | 8.54 + 03                                        | 2.32 + 03      | 2.41 + 02      | 1.86 + 02 | 2.94 + 01      | 1.38 + 01 | 2.20 + 00 | 4.05-01   | 9.92-02 |
| La     | 57  | 9.09 + 03                                        | 2.46 + 03      | 2.58 + 02      | 1.97 + 02 | 3.12 + 01      | 1.45 + 01 | 2.32 + 00 | 4.24-01   | 1.01-01 |
| Ce     | 58  | 9.71 + 03                                        | 2.61 + 03      | 2.74 + 02      | 2.08 + 02 | 3.31 + 01      | 1.52 + 01 | 2.45 + 00 | 4.45-01   | 1.04-01 |
| Pr     | 59  | 1.06 + 04                                        | 2.77 + 03      | 2.92 + 02      | 2.21 + 02 | 3.53 + 01      | 1.60 + 01 | 2.59 + 00 | 4.69-01   | 1.07-01 |
| Nd     | 60  | 6.63 + 03                                        | 2.88 + 03      | 3.06 + 02      | 2.30 + 02 | 3.68 + 01      | 1.65 + 01 | 2.69 + 00 | 4.84-01   | 1.08-01 |
| Pm     | 61  | 2.06 + 03                                        | 3.05 + 03      | 3.26 + 02      | 2.44 + 02 | 3.92 + 01      | 1.73 + 01 | 2.84 + 00 | 5.10-01   | 1.12-01 |
| Sm     | 62  | 2.11 + 03                                        | 3.12 + 03      | 3.36 + 02      | 2.50 + 02 | 4.03 + 01      | 1.77 + 01 | 2.90 + 00 | 5.19-01   | 1.11-01 |
| Eu     | 63  | 2.22 + 03                                        | 3.28 + 03      | 3.54 + 02      | 2.63 + 02 | 4.24 + 01      | 1.85 + 01 | 3.04 + 00 | 5.43-01   | 1.14-01 |
| Gd     | 64  | 2.29 + 03                                        | 3.36 + 03      | 3.65 + 02      | 2.69 + 02 | 4.36 + 01      | 3.86 + 00 | 3.11 + 00 | 5.54-01   | 1.14-01 |
| Tb     | 65  | 2.40 + 03                                        | 3.51 + 03      | 3.84 + 02      | 2.82 + 02 | 4.59 + 01      | 4.06 + 00 | 3.25 + 00 | 5.77-01   | 1.17-01 |
| Dy     | 66  | 2.49 + 03                                        | 3.47 + 03      | 3.99 + 02      | 2.90 + 02 | 4.76 + 01      | 4.23 + 00 | 3.36 + 00 | 5.95-01   | 1.18-01 |
| Ho     | 67  | 2.62 + 03                                        | 3.59 + 03      | 4.17 + 02      | 3.01 + 02 | 4.98 + 01      | 4.43 + 00 | 3.49 + 00 | 6.18-01   | 1.20-01 |
| Er     | 68  | 2.75 + 03                                        | 3.52 + 03      | 4.36 + 02      | 3.13 + 02 | 5.20 + 01      | 4.63 + 00 | 3.63 + 00 | 6.41-01   | 1.23-01 |
| Tm     | 69  | 2.90 + 03                                        | 3.69 + 03      | 4.57 + 02      | 2.83 + 02 | 5.45 + 01      | 4.87 + 00 | 3.78 + 00 | 6.68-01   | 1.26-01 |
| Yb     | 70  | 3.02 + 03                                        | 3.80 + 03      | 4.72 + 02      | 2.94 + 02 | 5.63 + 01      | 5.04 + 00 | 3.88 + 00 | 6.86-01   | 1.27-01 |
| Lu     | 71  | 3.19 + 03                                        | 3.45 + 03      | 4.94 + 02      | 2.21 + 02 | 5.88 + 01      | 5.28 + 00 | 4.03 + 00 | 7.13-01   | 1.30-01 |
| Hf     | 72  | 3.34 + 03                                        | 3.60 + 03      | 5.11 + 02      | 2.30 + 02 | 6.09 + 01      | 5.48 + 00 | 4.15 + 00 | 7.34-01   | 1.32-01 |
| Ta     | 73  | 3.51 + 03                                        | 3.77 + 03      | 5.33 + 02      | 2.38 + 02 | 6.33 + 01      | 5.72 + 00 | 4.30 + 00 | 7.60-01   | 1.35-01 |
| W      | 74  | 3.68 + 03                                        | 3.92 + 03      | 5.53 + 02      | 9.69 + 01 | 6.57 + 01      | 5.95 + 00 | 4.44 + 00 | 7.84-01   | 1.38-01 |
| Re     | 75  | 3.87 + 03                                        | 3.77 + 03      | 5.76 + 02      | 1.01 + 02 | 6.84 + 01      | 6.21 + 00 | 4.59 + 00 | 8.12-01   | 1.41-01 |
| Os     | 76  | 4.03 + 03                                        | 2.22 + 03      | 5.93 + 02      | 1.04 + 02 | 7.04 + 01      | 6.41 + 00 | 4.70 + 00 | 8.33-01   | 1.43-01 |
| Ir     | 77  | 4.24 + 03                                        | 1.03 + 03      | 6.18 + 02      | 1.09 + 02 | 7.32 + 01      | 6.69 + 00 | 4.86 + 00 | 8.63-01   | 1.46-01 |
| Pt     | 78  | 4.43 + 03                                        | 1.08 + 03      | 6.40 + 02      | 1.13 + 02 | 7.57 + 01      | 6.95 + 00 | 4.99 + 00 | 8.90-01   | 1.49-01 |
| Au     | 79  | 4.65 + 03                                        | 1.14 + 03      | 6.66 + 02      | 1.18 + 02 | 7.88 + 01      | 7.26 + 00 | 5.16 + 00 | 9.22-01   | 1.53-01 |
| Hg     | 80  | 4.83 + 03                                        | 1.18 + 03      | 6.87 + 02      | 1.22 + 02 | 8.12 + 01      | 7.50 + 00 | 5.28 + 00 | 9.46-01   | 1.56-01 |
| Tl     | 81  | 5.01 + 03                                        | 1.23 + 03      | 7.07 + 02      | 1.26 + 02 | 8.36 + 01      | 7.75 + 00 | 5.40 + 00 | 9.69-01   | 1.58-01 |
| Pb     | 82  | 5.21 + 03                                        | 1.29 + 03      | 7.30 + 02      | 1.31 + 02 | 8.64 + 01      | 8.04 + 00 | 5.55 + 00 | 9.99-01   | 1.61-01 |
| Bi     | 83  | 5.44 + 03                                        | 1.35 + 03      | 7.58 + 02      | 1.36 + 02 | 8.95 + 01      | 8.38 + 00 | 5.74 + 00 | 1.03 + 00 | 1.66-01 |
| Po     | 84  | 5.72 + 03                                        | 1.42 + 03      | 7.93 + 02      | 1.43 + 02 | 9.35 + 01      | 8.80 + 00 | 5.99 + 00 | 1.08 + 00 | 1.71-01 |
| At     | 85  | 5.87 + 03                                        | 1.49 + 03      | 8.25 + 02      | 1.49 + 02 | 9.70 + 01      | 9.19 + 00 | 6.17 + 00 | 1.12 + 00 | 1.77-01 |
| Rn     | 86  | 5.83 + 03                                        | 1.49 + 03      | 8.16 + 02      | 1.48 + 02 | 9.56 + 01      | 9.12 + 00 | 6.09 + 00 | 1.10 + 00 | 1.73-01 |
| Fr     | 87  | 6.08 + 03                                        | 1.56 + 03      | 8.49 + 02      | 1.54 + 02 | 9.93 + 01      | 9.52 + 00 | 1.66 + 00 | 1.14 + 00 | 1.78-01 |
| Ra     | 88  | 6.20 + 03                                        | 1.62 + 03      | 8.74 + 02      | 1.59 + 02 | 1.02 + 02      | 9.85 + 00 | 1.71 + 00 | 1.17 + 00 | 1.82-01 |
| Ac     | 89  | 6.47 + 03                                        | 1.70 + 03      | 8.69 + 02      | 1.65 + 02 | 1.06 + 02      | 1.03 + 01 | 1.79 + 00 | 1.21 + 00 | 1.87-01 |
| Th     | 90  | 6.61 + 03                                        | 1.74 + 03      | 8.88 + 02      | 1.69 + 02 | 9.37 + 01      | 1.05 + 01 | 1.83 + 00 | 1.23 + 00 | 1.90-01 |
| Pa     | 91  | 6.53 + 03                                        | 1.83 + 03      | 8.76 + 02      | 1.77 + 02 | 7.03 + 01      | 1.10 + 01 | 1.92 + 00 | 1.29 + 00 | 1.97-01 |
| U      | 92  | 6.63 + 03                                        | 1.86 + 03      | 8.89 + 02      | 1.79 + 02 | 7.11 + 01      | 1.12 + 01 | 1.95 + 00 | 1.30 + 00 | 1.98-01 |
| Np     | 93  | 6.95 + 03                                        | 1.96 + 03      | 9.32 + 02      | 1.87 + 02 | 7.45 + 01      | 1.18 + 01 | 2.05 + 00 | 1.35 + 00 | 2.05-01 |
| Pu     | 94  | 7.19 + 03                                        | 2.04 + 03      | 9.65 + 02      | 1.94 + 02 | 7.71 + 01      | 1.22 + 01 | 2.13 + 00 | 1.39 + 00 | 2.10-01 |
| Am     | 95  | 7.37 + 03                                        | 2.10 + 03      | 9.90 + 02      | 1.98 + 02 | 7.93 + 01      | 1.25 + 01 | 2.19 + 00 | 1.42 + 00 | 2.14-01 |
| Cm     | 96  | 7.54 + 03                                        | 2.15 + 03      | 1.02 + 03      | 2.03 + 02 | 8.14 + 01      | 1.28 + 01 | 2.25 + 00 | 1.44 + 00 | 2.18-01 |
| Bk     | 97  | 7.84 + 03                                        | 2.25 + 03      | 1.06 + 03      | 2.10 + 02 | 8.39 + 01      | 1.34 + 01 | 2.35 + 00 | 1.50 + 00 | 2.25-01 |
| Cf     | 98  | 7.89 + 03                                        | 2.31 + 03      | 9.27 + 02      | 2.15 + 02 | 8.58 + 01      | 1.37 + 01 | 2.41 + 00 | 1.52 + 00 | 2.29-01 |
| Es     | 99  | 7.79 + 03                                        | 2.40 + 03      | 9.59 + 02      | 2.22 + 02 | 4.01 + 01      | 1.42 + 01 | 2.51 + 00 | 1.57 + 00 | 2.36-01 |
| Fm     | 100 | 7.13 + 03                                        | 2.46 + 03      | 9.77 + 02      | 2.26 + 02 | 4.09 + 01      | 1.45 + 01 | 2.57 + 00 | 1.59 + 00 | 2.39-01 |
|        |     | N <sub>5</sub>                                   | M <sub>5</sub> | M <sub>3</sub> |           | L <sub>3</sub> | K EDGE    |           |           |         |
|        |     | N <sub>4</sub>                                   | M <sub>4</sub> | M <sub>2</sub> |           | L <sub>2</sub> |           |           |           |         |
|        |     | N <sub>3</sub>                                   |                | M <sub>1</sub> |           | L <sub>1</sub> |           |           |           |         |
|        |     | N <sub>2</sub>                                   |                |                |           |                |           |           |           |         |
|        |     | N <sub>1</sub>                                   |                |                |           |                |           |           |           |         |

|    |            | Mass attenuation coefficient, cm <sup>2</sup> /g |         |         |         |         |         |         |         |         |
|----|------------|--------------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
|    |            | Photon energy, MeV                               |         |         |         |         |         |         |         |         |
|    | Atomic no. | 1.0                                              | 2.0     | 5.0     | 10.0    | 20.0    | 50.0    | 100.0   | 500.0   | 1000.0  |
| Sb | 51         | 5.80-02                                          | 4.10-02 | 3.56-02 | 3.92-02 | 4.70-02 | 5.96-02 | 6.85-02 | 8.16-02 | 8.44-02 |
| Te | 52         | 5.67-02                                          | 4.01-02 | 3.49-02 | 3.86-02 | 4.64-02 | 5.89-02 | 6.77-02 | 8.07-02 | 8.35-02 |
| I  | 53         | 5.84-02                                          | 4.12-02 | 3.61-02 | 4.00-02 | 4.82-02 | 6.13-02 | 7.04-02 | 8.40-02 | 8.69-02 |
| Xe | 54         | 5.78-02                                          | 4.08-02 | 3.58-02 | 3.99-02 | 4.82-02 | 6.12-02 | 7.04-02 | 8.40-02 | 8.69-02 |
| Cs | 55         | 5.85-02                                          | 4.12-02 | 3.64-02 | 4.06-02 | 4.91-02 | 6.25-02 | 7.19-02 | 8.58-02 | 8.88-02 |
| ZB | 56         | 5.80-02                                          | 4.08-02 | 3.61-02 | 4.04-02 | 4.90-02 | 6.25-02 | 7.19-02 | 8.58-02 | 8.88-02 |
| La | 57         | 5.88-02                                          | 4.12-02 | 3.66-02 | 4.11-02 | 5.00-02 | 6.37-02 | 7.34-02 | 8.76-02 | 9.06-02 |
| Ce | 58         | 5.96-02                                          | 4.18-02 | 3.73-02 | 4.19-02 | 5.10-02 | 6.52-02 | 7.50-02 | 8.96-02 | 9.27-02 |
| Pr | 59         | 6.07-02                                          | 4.24-02 | 3.80-02 | 4.29-02 | 5.23-02 | 6.68-02 | 7.69-02 | 9.19-02 | 9.50-02 |
| Nd | 60         | 6.07-02                                          | 4.24-02 | 3.81-02 | 4.30-02 | 5.26-02 | 6.72-02 | 7.74-02 | 9.25-02 | 9.56-02 |
| Pm | 61         | 6.19-02                                          | 4.31-02 | 3.88-02 | 4.40-02 | 5.38-02 | 6.89-02 | 7.94-02 | 9.48-02 | 9.81-02 |
| Sm | 62         | 6.11-02                                          | 4.24-02 | 3.83-02 | 4.35-02 | 5.34-02 | 6.84-02 | 7.88-02 | 9.41-02 | 9.73-02 |
| Eu | 63         | 6.19-02                                          | 4.28-02 | 3.88-02 | 4.42-02 | 5.42-02 | 6.96-02 | 8.02-02 | 9.57-02 | 9.90-02 |
| Gd | 64         | 6.12-02                                          | 4.23-02 | 3.84-02 | 4.38-02 | 5.38-02 | 6.91-02 | 7.97-02 | 9.51-02 | 9.83-02 |
| Tb | 65         | 6.20-02                                          | 4.27-02 | 3.89-02 | 4.45-02 | 5.47-02 | 7.03-02 | 8.11-02 | 9.67-02 | 1.00-01 |
| Dy | 66         | 6.20-02                                          | 4.26-02 | 3.90-02 | 4.46-02 | 5.49-02 | 7.06-02 | 8.15-02 | 9.72-02 | 1.00-01 |
| Ho | 67         | 6.26-02                                          | 4.29-02 | 3.93-02 | 4.50-02 | 5.55-02 | 7.14-02 | 8.24-02 | 9.83-02 | 1.02-01 |
| Er | 68         | 6.32-02                                          | 4.32-02 | 3.96-02 | 4.55-02 | 5.61-02 | 7.23-02 | 8.34-02 | 9.95-02 | 1.03-01 |
| Tm | 69         | 6.40-02                                          | 4.36-02 | 4.01-02 | 4.61-02 | 5.70-02 | 7.35-02 | 8.48-02 | 1.01-01 | 1.04-01 |
| Yb | 70         | 6.40-02                                          | 4.35-02 | 4.00-02 | 4.61-02 | 5.70-02 | 7.35-02 | 8.49-02 | 1.01-01 | 1.04-01 |
| Lu | 71         | 6.48-02                                          | 4.39-02 | 4.05-02 | 4.66-02 | 5.77-02 | 7.45-02 | 8.60-02 | 1.02-01 | 1.06-01 |
| Hf | 72         | 6.50-02                                          | 4.39-02 | 4.05-02 | 4.68-02 | 5.80-02 | 7.48-02 | 8.64-02 | 1.03-01 | 1.06-01 |
| Ta | 73         | 6.57-02                                          | 4.41-02 | 4.08-02 | 4.72-02 | 5.85-02 | 7.56-02 | 8.73-02 | 1.04-01 | 1.07-01 |
| W  | 74         | 6.62-02                                          | 4.43-02 | 4.10-02 | 4.75-02 | 5.89-02 | 7.62-02 | 8.80-02 | 1.05-01 | 1.08-01 |
| Re | 75         | 6.69-02                                          | 4.46-02 | 4.14-02 | 4.79-02 | 5.95-02 | 7.70-02 | 8.89-02 | 1.06-01 | 1.09-01 |
| Os | 76         | 6.71-02                                          | 4.46-02 | 4.13-02 | 4.79-02 | 5.96-02 | 7.71-02 | 8.90-02 | 1.06-01 | 1.10-01 |
| Ir | 77         | 6.79-02                                          | 4.50-02 | 4.17-02 | 4.84-02 | 6.02-02 | 7.80-02 | 9.01-02 | 1.07-01 | 1.11-01 |
| Pt | 78         | 6.86-02                                          | 4.52-02 | 4.20-02 | 4.87-02 | 6.06-02 | 7.86-02 | 9.08-02 | 1.08-01 | 1.12-01 |
| Au | 79         | 6.95-02                                          | 4.57-02 | 4.24-02 | 4.93-02 | 6.14-02 | 7.95-02 | 9.19-02 | 1.09-01 | 1.13-01 |
| Hg | 80         | 6.99-02                                          | 4.57-02 | 4.25-02 | 4.94-02 | 6.15-02 | 7.98-02 | 9.22-02 | 1.10-01 | 1.13-01 |
| Tl | 81         | 7.03-02                                          | 4.58-02 | 4.25-02 | 4.94-02 | 6.16-02 | 8.00-02 | 9.24-02 | 1.10-01 | 1.14-01 |
| Pb | 82         | 7.10-02                                          | 4.61-02 | 4.27-02 | 4.97-02 | 6.21-02 | 8.06-02 | 9.31-02 | 1.11-01 | 1.15-01 |
| Bi | 83         | 7.21-02                                          | 4.66-02 | 4.32-02 | 5.03-02 | 6.28-02 | 8.15-02 | 9.42-02 | 1.12-01 | 1.16-01 |
| Po | 84         | 7.39-02                                          | 4.75-02 | 4.40-02 | 5.12-02 | 6.40-02 | 8.32-02 | 9.61-02 | 1.15-01 | 1.18-01 |
| At | 85         | 7.54-02                                          | 4.82-02 | 4.46-02 | 5.20-02 | 6.49-02 | 8.44-02 | 9.76-02 | 1.16-01 | 1.20-01 |
| Rn | 86         | 7.30-02                                          | 4.65-02 | 4.30-02 | 5.01-02 | 6.26-02 | 8.14-02 | 9.42-02 | 1.12-01 | 1.16-01 |
| Fr | 87         | 7.45-02                                          | 4.72-02 | 4.36-02 | 5.08-02 | 6.35-02 | 8.26-02 | 9.56-02 | 1.14-01 | 1.18-01 |
| Ra | 88         | 7.53-02                                          | 4.75-02 | 4.38-02 | 5.10-02 | 6.38-02 | 8.31-02 | 9.61-02 | 1.15-01 | 1.19-01 |
| Ac | 89         | 7.69-02                                          | 4.82-02 | 4.44-02 | 5.17-02 | 6.47-02 | 8.43-02 | 9.75-02 | 1.16-01 | 1.20-01 |
| Th | 90         | 7.71-02                                          | 4.81-02 | 4.42-02 | 5.15-02 | 6.45-02 | 8.40-02 | 9.72-02 | 1.16-01 | 1.20-01 |
| Pa | 91         | 7.94-02                                          | 4.93-02 | 4.52-02 | 5.26-02 | 6.59-02 | 8.60-02 | 9.95-02 | 1.19-01 | 1.23-01 |
| U  | 92         | 7.90-02                                          | 4.88-02 | 4.46-02 | 5.19-02 | 6.51-02 | 8.49-02 | 9.83-02 | 1.17-01 | 1.21-01 |
| Np | 93         | 8.13-02                                          | 4.99-02 | 4.56-02 | 5.30-02 | 6.65-02 | 8.68-02 | 1.01-01 | 1.20-01 | 1.24-01 |
| Pu | 94         | 8.26-02                                          | 5.05-02 | 4.60-02 | 5.34-02 | 6.71-02 | 8.76-02 | 1.01-01 | 1.21-01 | 1.25-01 |
| Am | 95         | 8.33-02                                          | 5.06-02 | 4.60-02 | 5.34-02 | 6.70-02 | 8.77-02 | 1.02-01 | 1.21-01 | 1.25-01 |
| Cm | 96         | 8.41-02                                          | 5.08-02 | 4.60-02 | 5.34-02 | 6.70-02 | 8.77-02 | 1.02-01 | 1.21-01 | 1.26-01 |
| Bk | 97         | 8.62-02                                          | 5.18-02 | 4.68-02 | 5.42-02 | 6.81-02 | 8.92-02 | 1.03-01 | 1.24-01 | 1.28-01 |
| Cf | 98         | 8.70-02                                          | 5.20-02 | 4.68-02 | 5.42-02 | 6.81-02 | 8.92-02 | 1.04-01 | 1.24-01 | 1.28-01 |
| Es | 99         | 8.89-02                                          | 5.28-02 | 4.74-02 | 5.48-02 | 6.89-02 | 9.04-02 | 1.05-01 | 1.25-01 | 1.29-01 |
| Fm | 100        | 8.94-02                                          | 5.28-02 | 4.72-02 | 5.45-02 | 6.86-02 | 9.00-02 | 1.05-01 | 1.25-01 | 1.29-01 |

# CLASSIFICATION OF ELECTROMAGNETIC RADIATION

Hans Dolezalek

Basic Conversions:  
 $c = \lambda \nu = v/k$   
 $\nu = c/\lambda = ck$

$\lambda = c/\nu = 1/k$   
 $k = \nu/c = 1/\lambda$   
 $c = \text{speed of light} = 2.99792458 \times 10^8 \text{ m/s}$

| Frequency ( $\nu$ )                                                   | Wavelength ( $\lambda$ )                                                      | Wave number ( $k$ )                                                                                    | Names of bands                                                                      | Approximate photon energies                                     |
|-----------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| $3 \times 10^0 - 3 \times 10^1 \text{ Hz}$<br>3 – 30 Hz               | $10^8 - 10^7 \text{ m}$<br>100 – 10 Mm                                        | $10^{-8} - 10^{-7} \text{ m}^{-1}$<br>10 – 100 Gm <sup>-1</sup>                                        | ELF-(ELF 1), ITU band no. 1                                                         |                                                                 |
| $3 \times 10^1 - 3 \times 10^2 \text{ Hz}$<br>30 – 300 Hz             | $10^7 - 10^6 \text{ m}$<br>10 – 1 Mm                                          | $10^{-7} - 10^{-6} \text{ m}^{-1}$<br>100 Gm <sup>-1</sup> – 1Mm <sup>-1</sup>                         | SLF-(ELF 2), ITU band no. 2, megameter waves                                        |                                                                 |
| $3 \times 10^2 - 3 \times 10^3 \text{ Hz}$<br>300 Hz – 3 kHz          | $10^6 - 10^5 \text{ m}$<br>1 Mm – 100 km                                      | $10^{-6} - 10^{-5} \text{ m}^{-1}$<br>1 – 10 Mm <sup>-1</sup>                                          | ULF-(ELF 3), ITU band no. 3                                                         |                                                                 |
| $3 \times 10^3 - 3 \times 10^4 \text{ Hz}$<br>3 – 30 kHz              | $10^5 - 10^4 \text{ m}$<br>100 – 10 km                                        | $10^{-5} - 10^{-4} \text{ m}^{-1}$<br>10 – 100 Mm <sup>-1</sup>                                        | VLF, ITU band no. 4, myriameter waves                                               |                                                                 |
| $3 \times 10^4 - 3 \times 10^5 \text{ Hz}$<br>30 – 300 kHz            | $10^4 - 10^3 \text{ m}$<br>10 – 1 km                                          | $10^{-4} - 10^{-3} \text{ m}^{-1}$<br>100 Mm <sup>-1</sup> – 1 km <sup>-1</sup>                        | LF, ITU band no. 5, kilometer waves                                                 |                                                                 |
| $3 \times 10^5 - 3 \times 10^6 \text{ Hz}$<br>300 kHz – 3 MHz         | $10^3 - 10^2 \text{ m}$<br>1 km – 100 m                                       | $10^{-3} - 10^{-2} \text{ m}^{-1}$<br>1 – 10 km <sup>-1</sup>                                          | MF, ITU band no. 6, hectometer waves                                                |                                                                 |
| $3 \times 10^6 - 3 \times 10^7 \text{ Hz}$<br>3 – 30 MHz              | $10^2 - 10^1 \text{ m}$<br>100 – 10 m                                         | $10^{-2} - 10^{-1} \text{ m}^{-1}$<br>10 – 100 km <sup>-1</sup>                                        | HF, ITU band no. 7, decameter waves                                                 |                                                                 |
| $3 \times 10^7 - 3 \times 10^8 \text{ Hz}$<br>30 – 300 MHz            | $10^1 - 10^0 \text{ m}$<br>10 – 1 m                                           | $10^{-1} - 10^0 \text{ m}^{-1}$<br>100 km <sup>-1</sup> – 1 mm <sup>-1</sup>                           | VHF, ITU band no. 8, meter waves                                                    |                                                                 |
| $3 \times 10^8 - 3 \times 10^9 \text{ Hz}$<br>300 MHz – 3 GHz         | $10^0 - 10^{-1} \text{ m}$<br>1 m – 100 mm                                    | $10^0 - 10^1 \text{ m}^{-1}$<br>1 – 10 m <sup>-1</sup>                                                 | UHF, ITU band no. 9, decimeter waves <sup>a</sup>                                   |                                                                 |
| $3 \times 10^9 - 3 \times 10^{10} \text{ Hz}$<br>3 – 30 GHz           | $10^{-1} - 10^{-2} \text{ m}$<br>100 – 10 mm                                  | $10^1 - 10^2 \text{ m}^{-1}$<br>10 – 100 m <sup>-1</sup>                                               | SHF, ITU band no. 10, centimeter waves <sup>a</sup>                                 |                                                                 |
| $3 \times 10^{10} - 3 \times 10^{11} \text{ Hz}$<br>30 – 300 GHz      | $10^{-2} - 10^{-3} \text{ m}$<br>10 – 1 mm                                    | $10^2 - 10^3 \text{ m}^{-1}$<br>100 m <sup>-1</sup> – 1 mm <sup>-1</sup><br>(1 – 10 cm <sup>-1</sup> ) | EHF, ITU band no. 11, millimeter waves                                              |                                                                 |
| $3 \times 10^{11} - 3 \times 10^{12} \text{ Hz}$<br>300 GHz – 3 THz   | $10^{-3} - 10^{-4} \text{ m}$<br>1 mm – 100 $\mu\text{m}$                     | $10^3 - 10^4 \text{ m}^{-1}$<br>(1 – 10 mm <sup>-1</sup> )<br>(10 – 100 cm <sup>-1</sup> )             | Part of micrometer waves, includes part of far or thermal infrared; ITU band no. 12 |                                                                 |
| $3 \times 10^{12} - 3 \times 10^{13} \text{ Hz}$<br>3 – 30 THz        | $10^{-4} - 10^{-5} \text{ m}$<br>100 – 10 $\mu\text{m}$                       | $10^4 - 10^5 \text{ m}^{-1}$<br>10 – 100 mm <sup>-1</sup><br>(100 – 1000 cm <sup>-1</sup> )            | Part of micrometer waves includes part of far (thermal) infrared                    |                                                                 |
| $3 \times 10^{13} - 3 \times 10^{14} \text{ Hz}$<br>30 – 300 THz      | $10^{-5} - 10^{-6} \text{ m}$<br>10 – 1 $\mu\text{m}$<br>(100,000 – 10,000 Å) | $10^5 - 10^6 \text{ m}^{-1}$<br>100 mm <sup>-1</sup> – 1 $\mu\text{m}^{-1}$                            | Part of $\mu\text{m}$ waves, part of infrared                                       | $(1.6 - 16) \times 10^{-20} \text{ joule}$<br>{0.1 – 1 eV}      |
| $3 \times 10^{14} - 3 \times 10^{15} \text{ Hz}$<br>300 THz – 3 PHz   | $10^{-6} - 10^{-7} \text{ m}$<br>1 $\mu\text{m}$ – 100 m<br>(10,000 – 1000 Å) | $10^6 - 10^7 \text{ m}^{-1}$<br>1 – 10 $\mu\text{m}^{-1}$                                              | Near infrared, visible, near ultraviolet                                            | $(1.6 - 16) \times 10^{-19} \text{ joule}$<br>{1 – 10 eV}       |
| $3 \times 10^{15} - 3 \times 10^{16} \text{ Hz}$<br>3 – 30 PHz        | $10^{-7} - 10^{-8} \text{ m}$<br>100 – 10 nm<br>(1000 – 100 Å)                | $10^7 - 10^8 \text{ m}^{-1}$<br>10 – 100 $\mu\text{m}^{-1}$                                            | Part of vacuum ultraviolet                                                          | $(1.6 - 16) \times 10^{-18} \text{ joule}$<br>{10 – 100 eV}     |
| $3 \times 10^{16} - 3 \times 10^{17} \text{ Hz}$<br>30 – 300 PHz      | $10^{-8} - 10^{-9} \text{ m}$<br>10 – 1 nm<br>(100 – 10 Å)                    | $10^8 - 10^9 \text{ m}^{-1}$<br>100 $\mu\text{m}^{-1}$ – 1 nm <sup>-1</sup>                            | Part of soft X-rays                                                                 | $(1.6 - 16) \times 10^{-17} \text{ joule}$<br>{100 – 1000 eV}   |
| $3 \times 10^{17} - 3 \times 10^{18} \text{ Hz}$<br>300 PHz – 3 EHz   | $10^{-9} - 10^{-10} \text{ m}$<br>1 nm – 100 pm<br>(10 – 1 Å)                 | $10^9 - 10^{10} \text{ m}^{-1}$<br>1 – 10 nm <sup>-1</sup>                                             | Part of soft X-rays                                                                 | $(1.6 - 16) \times 10^{-16} \text{ joule}$<br>{1 – 10 keV}      |
| $3 \times 10^{18} - 3 \times 10^{19} \text{ Hz}$<br>3 – 30 EHz        | $10^{-10} - 10^{-11} \text{ m}$<br>100 – 10 pm<br>(1 – 0.1 Å)                 | $10^{10} - 10^{11} \text{ m}^{-1}$<br>10 – 100 nm <sup>-1</sup>                                        | Hard X-rays and part of soft $\gamma$ -rays                                         | $(1.6 - 16) \times 10^{-15} \text{ joule}$<br>{10 – 100 keV}    |
| $3 \times 10^{19} - 3 \times 10^{20} \text{ Hz}$<br>30 – 300 EHz      | $10^{-11} - 10^{-12} \text{ m}$<br>10 – 1 pm<br>(0.1 – 0.01 Å)                | $10^{11} - 10^{12} \text{ m}^{-1}$<br>100 nm <sup>-1</sup> – 1 pm <sup>-1</sup>                        | Part of soft and part of hard $\gamma$ -rays (limit at 510 keV)                     | $(1.6 - 16) \times 10^{-14} \text{ joule}$<br>{100 keV – 1 MeV} |
| $3 \times 10^{20} - 3 \times 10^{21} \text{ Hz}$<br>300 – 3000 EHz    | $10^{-12} - 10^{-13} \text{ m}$<br>1 pm – 100 fm<br>(0.01 – 0.001 Å)          | $10^{12} - 10^{13} \text{ m}^{-1}$<br>1 – 10 pm <sup>-1</sup>                                          | Part of hard $\gamma$ -rays and part of “cosmic” $\gamma$ -rays                     | $(1.6 - 16) \times 10^{-13} \text{ joule}$<br>{1 – 10 MeV}      |
| $3 \times 10^{21} - 3 \times 10^{22} \text{ Hz}$<br>3000 – 30,000 EHz | $10^{-13} - 10^{-14} \text{ m}$<br>100 – 10 fm<br>(0.001 – 0.0001 Å)          | $10^{13} - 10^{14} \text{ m}^{-1}$<br>10 – 100 pm <sup>-1</sup>                                        | $\gamma$ -rays produced by cosmic rays                                              | $(1.6 - 16) \times 10^{-12} \text{ joule}$<br>{10 – 100 MeV}    |

*Note:* Abbreviations used in this table: Å—ångstrom ( $1 \text{ Å} = 10^{-10} \text{ m}$ ); EHz—exahertz ( $10^{18}$  hertz); EHF—extremely high frequency; ELF—extremely low frequency; eV—electron volt ( $1 \text{ eV} = 1.60218 \times 10^{-19} \text{ joule}$ ); fm—femtometer ( $10^{-15} \text{ m}$ ); GHz—gigahertz ( $10^9$  hertz); Gm—gigameter ( $10^9 \text{ m}$ ); HF—high frequency; Hz—hertz ( $\text{s}^{-1}$ ); ITU—International Telecommunications Union; keV—kiloelectron volt ( $10^3 \text{ eV}$ ); km—kilometer ( $10^3 \text{ m}$ ); LF—low frequency; m—meter; MeV—megaelectron volt ( $10^6 \text{ eV}$ ); MF—medium frequency; MHz—megahertz ( $10^6$  hertz); Mm—megameter ( $10^6 \text{ meter}$ ); mm—millimeter ( $10^{-3} \text{ meter}$ );  $\mu\text{m}$ —micrometer ( $10^{-6} \text{ meter}$ ); nm—nanometer ( $10^{-9} \text{ meter}$ ); PHz—petahertz ( $10^{15}$  hertz); pm—picometer ( $10^{-12} \text{ meter}$ ); SHF—super high frequency; SLF—super low frequency; THz—terahertz; UHF—ultra high frequency; ULF—ultra low frequency; VHF—very high frequency; VLF—very low frequency.

<sup>a</sup> Also called “microwaves”; not to be confused with “micrometer waves”.

### Letter Designations of Microwave Bands

| Frequency (GHz) | Wavelength (cm) | Wavenumber ( $\text{cm}^{-1}$ ) | Band    |
|-----------------|-----------------|---------------------------------|---------|
| 1—2             | 30—15           | 0.033—0.067                     | L-Band  |
| 2—4             | 15—7.5          | 0.067—0.133                     | S-Band  |
| 4—8             | 7.5—3.7         | 0.133—0.267                     | C-Band  |
| 8—12            | 3.7—2.5         | 0.267—0.4                       | X-Band  |
| 12—18           | 2.5—1.7         | 0.4—0.6                         | Ku-Band |
| 18—27           | 1.7—1.1         | 0.6—0.9                         | K-Band  |
| 27—40           | 1.1—0.75        | 0.9—1.33                        | Ka-Band |

## BLACK BODY RADIATION

The total power radiated from an ideal black body and the wavelength corresponding to maximum power are given here as a function of absolute temperature. Constants used in the calculation are taken from the table “Fundamental Physical Constants” in

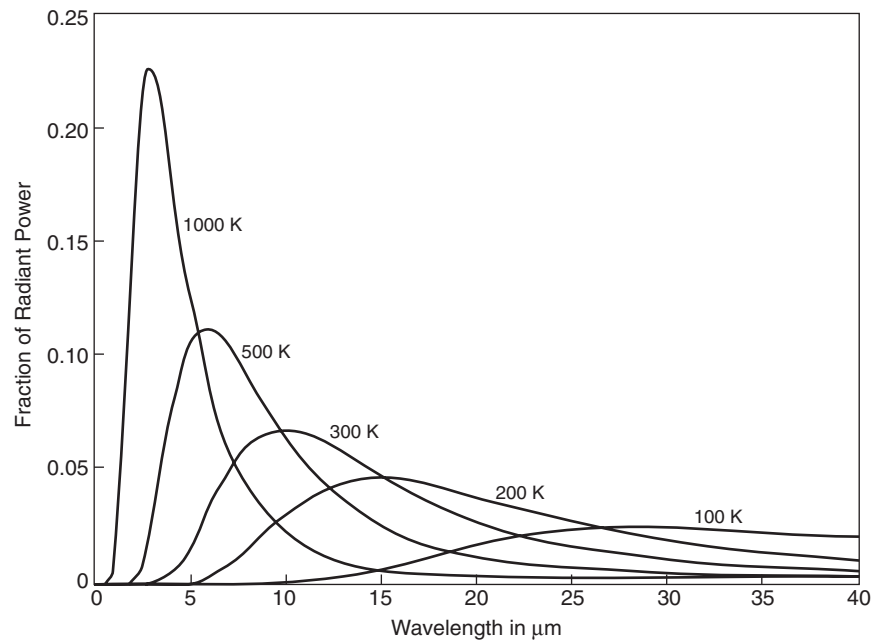
Section 1. The radiated power in a band  $\Delta\lambda$  at  $\lambda_{\max}$  may be calculated from:

$$P_{\max} = 0.657548 (\Delta\lambda/\lambda_{\max}) P_{\text{tot}}$$

| $T/\text{K}$ | $P_{\text{tot}}$        | $\lambda_{\max}/\mu\text{m}$ | $T/\text{K}$ | $P_{\text{tot}}$ | $\lambda_{\max}/\mu\text{m}$ | $T/\text{K}$ | $P_{\text{tot}}$        | $\lambda_{\max}/\mu\text{m}$ |
|--------------|-------------------------|------------------------------|--------------|------------------|------------------------------|--------------|-------------------------|------------------------------|
| 50           | 0.354 W/m <sup>2</sup>  | 57.955                       | 740          | 17.004           | 3.916                        | 1520         | 302.689                 | 1.906                        |
| 100          | 5.671                   | 28.978                       | 750          | 17.942           | 3.864                        | 1540         | 318.937                 | 1.882                        |
| 150          | 28.707                  | 19.318                       | 760          | 18.918           | 3.813                        | 1560         | 335.831                 | 1.858                        |
| 200          | 90.728                  | 14.489                       | 770          | 19.934           | 3.763                        | 1580         | 353.387                 | 1.834                        |
| 250          | 221.504                 | 11.591                       | 780          | 20.989           | 3.715                        | 1600         | 371.623                 | 1.811                        |
| 273          | 314.973                 | 10.614                       | 790          | 22.087           | 3.668                        | 1620         | 390.555                 | 1.789                        |
| 280          | 348.541                 | 10.349                       | 800          | 23.226           | 3.622                        | 1640         | 410.202                 | 1.767                        |
| 290          | 401.064                 | 9.992                        | 810          | 24.410           | 3.577                        | 1660         | 430.581                 | 1.746                        |
| 300          | 459.311                 | 9.659                        | 820          | 25.638           | 3.534                        | 1680         | 451.710                 | 1.725                        |
| 310          | 523.684                 | 9.348                        | 830          | 26.911           | 3.491                        | 1700         | 473.607                 | 1.705                        |
| 320          | 594.596                 | 9.055                        | 840          | 28.232           | 3.450                        | 1720         | 496.290                 | 1.685                        |
| 330          | 672.478                 | 8.781                        | 850          | 29.600           | 3.409                        | 1740         | 519.779                 | 1.665                        |
| 340          | 757.771                 | 8.523                        | 860          | 31.018           | 3.369                        | 1760         | 544.093                 | 1.646                        |
| 350          | 850.931                 | 8.279                        | 870          | 32.486           | 3.331                        | 1780         | 569.249                 | 1.628                        |
| 360          | 952.428                 | 8.049                        | 880          | 34.006           | 3.293                        | 1800         | 595.267                 | 1.610                        |
| 370          | 1.063 kW/m <sup>2</sup> | 7.832                        | 890          | 35.578           | 3.256                        | 1820         | 622.168                 | 1.592                        |
| 380          | 1.182                   | 7.626                        | 900          | 37.204           | 3.220                        | 1840         | 649.970                 | 1.575                        |
| 390          | 1.312                   | 7.430                        | 910          | 38.886           | 3.184                        | 1860         | 678.694                 | 1.558                        |
| 400          | 1.452                   | 7.244                        | 920          | 40.623           | 3.150                        | 1880         | 708.359                 | 1.541                        |
| 410          | 1.602                   | 7.068                        | 930          | 42.418           | 3.116                        | 1900         | 738.987                 | 1.525                        |
| 420          | 1.764                   | 6.899                        | 940          | 44.272           | 3.083                        | 1920         | 770.597                 | 1.509                        |
| 430          | 1.939                   | 6.739                        | 950          | 46.187           | 3.050                        | 1940         | 803.210                 | 1.494                        |
| 440          | 2.125                   | 6.586                        | 960          | 48.162           | 3.018                        | 1960         | 836.848                 | 1.478                        |
| 450          | 2.325                   | 6.439                        | 970          | 50.201           | 2.987                        | 1980         | 871.531                 | 1.464                        |
| 460          | 2.539                   | 6.299                        | 980          | 52.303           | 2.957                        | 2000         | 907.282                 | 1.449                        |
| 470          | 2.767                   | 6.165                        | 990          | 54.471           | 2.927                        | 2020         | 944.121                 | 1.435                        |
| 480          | 3.010                   | 6.037                        | 1000         | 56.705           | 2.898                        | 2040         | 982.071                 | 1.420                        |
| 490          | 3.269                   | 5.914                        | 1020         | 61.379           | 2.841                        | 2060         | 1.021 MW/m <sup>2</sup> | 1.407                        |
| 500          | 3.544                   | 5.796                        | 1040         | 66.337           | 2.786                        | 2080         | 1.061                   | 1.393                        |
| 510          | 3.836                   | 5.682                        | 1060         | 71.589           | 2.734                        | 2100         | 1.103                   | 1.380                        |
| 520          | 4.146                   | 5.573                        | 1080         | 77.147           | 2.683                        | 2120         | 1.145                   | 1.367                        |
| 530          | 4.474                   | 5.467                        | 1100         | 83.022           | 2.634                        | 2140         | 1.189                   | 1.354                        |
| 540          | 4.822                   | 5.366                        | 1120         | 89.227           | 2.587                        | 2160         | 1.234                   | 1.342                        |
| 550          | 5.189                   | 5.269                        | 1140         | 95.773           | 2.542                        | 2180         | 1.281                   | 1.329                        |
| 560          | 5.577                   | 5.175                        | 1160         | 102.672          | 2.498                        | 2200         | 1.328                   | 1.317                        |
| 570          | 5.986                   | 5.084                        | 1180         | 109.939          | 2.456                        | 2220         | 1.377                   | 1.305                        |
| 580          | 6.417                   | 4.996                        | 1200         | 117.584          | 2.415                        | 2240         | 1.428                   | 1.294                        |
| 590          | 6.871                   | 4.911                        | 1220         | 125.621          | 2.375                        | 2260         | 1.479                   | 1.282                        |
| 600          | 7.349                   | 4.830                        | 1240         | 134.063          | 2.337                        | 2280         | 1.532                   | 1.271                        |
| 610          | 7.851                   | 4.750                        | 1260         | 142.924          | 2.300                        | 2300         | 1.587                   | 1.260                        |
| 620          | 8.379                   | 4.674                        | 1280         | 152.217          | 2.264                        | 2320         | 1.643                   | 1.249                        |
| 630          | 8.933                   | 4.600                        | 1300         | 161.955          | 2.229                        | 2340         | 1.700                   | 1.238                        |
| 640          | 9.514                   | 4.528                        | 1320         | 172.154          | 2.195                        | 2360         | 1.759                   | 1.228                        |
| 650          | 10.122                  | 4.458                        | 1340         | 182.827          | 2.163                        | 2380         | 1.819                   | 1.218                        |
| 660          | 10.760                  | 4.391                        | 1360         | 193.989          | 2.131                        | 2400         | 1.881                   | 1.207                        |
| 670          | 11.427                  | 4.325                        | 1380         | 205.655          | 2.100                        | 2420         | 1.945                   | 1.197                        |
| 680          | 12.124                  | 4.261                        | 1400         | 217.838          | 2.070                        | 2440         | 2.010                   | 1.188                        |
| 690          | 12.853                  | 4.200                        | 1420         | 230.556          | 2.041                        | 2460         | 2.077                   | 1.178                        |
| 700          | 13.615                  | 4.140                        | 1440         | 243.822          | 2.012                        | 2480         | 2.145                   | 1.168                        |
| 710          | 14.410                  | 4.081                        | 1460         | 257.652          | 1.985                        | 2500         | 2.215                   | 1.159                        |
| 720          | 15.239                  | 4.025                        | 1480         | 272.063          | 1.958                        | 2550         | 2.398                   | 1.136                        |
| 730          | 16.103                  | 3.970                        | 1500         | 287.070          | 1.932                        | 2600         | 2.591                   | 1.115                        |

| $T/K$ | $P_{\text{tot}}$ | $\lambda_{\text{max}}/\mu\text{m}$ | $T/K$ | $P_{\text{tot}}$ | $\lambda_{\text{max}}/\mu\text{m}$ | $T/K$ | $P_{\text{tot}}$ | $\lambda_{\text{max}}/\mu\text{m}$ |
|-------|------------------|------------------------------------|-------|------------------|------------------------------------|-------|------------------|------------------------------------|
| 2650  | 2.796            | 1.093                              | 3600  | 9.524            | 0.805                              | 5100  | 38.362           | 0.568                              |
| 2700  | 3.014            | 1.073                              | 3650  | 10.065           | 0.794                              | 5200  | 41.461           | 0.557                              |
| 2750  | 3.243            | 1.054                              | 3700  | 10.627           | 0.783                              | 5300  | 44.743           | 0.547                              |
| 2800  | 3.485            | 1.035                              | 3750  | 11.214           | 0.773                              | 5400  | 48.217           | 0.537                              |
| 2850  | 3.741            | 1.017                              | 3800  | 11.824           | 0.763                              | 5500  | 51.889           | 0.527                              |
| 2900  | 4.011            | 0.999                              | 3850  | 12.458           | 0.753                              | 5600  | 55.767           | 0.517                              |
| 2950  | 4.294            | 0.982                              | 3900  | 13.118           | 0.743                              | 5700  | 59.858           | 0.508                              |
| 3000  | 4.593            | 0.966                              | 3950  | 13.804           | 0.734                              | 5800  | 64.170           | 0.500                              |
| 3050  | 4.907            | 0.950                              | 4000  | 14.517           | 0.724                              | 5900  | 68.712           | 0.491                              |
| 3100  | 5.237            | 0.935                              | 4100  | 16.024           | 0.707                              | 6000  | 73.490           | 0.483                              |
| 3150  | 5.583            | 0.920                              | 4200  | 17.645           | 0.690                              | 6500  | 101.222          | 0.446                              |
| 3200  | 5.946            | 0.906                              | 4300  | 19.386           | 0.674                              | 7000  | 136.149          | 0.414                              |
| 3250  | 6.326            | 0.892                              | 4400  | 21.254           | 0.659                              | 7500  | 179.418          | 0.386                              |
| 3300  | 6.725            | 0.878                              | 4500  | 23.253           | 0.644                              | 8000  | 232.264          | 0.362                              |
| 3350  | 7.142            | 0.865                              | 4600  | 25.389           | 0.630                              | 8500  | 296.004          | 0.341                              |
| 3400  | 7.578            | 0.852                              | 4700  | 27.670           | 0.617                              | 9000  | 372.042          | 0.322                              |
| 3450  | 8.033            | 0.840                              | 4800  | 30.101           | 0.604                              | 9500  | 461.867          | 0.305                              |
| 3500  | 8.509            | 0.828                              | 4900  | 32.689           | 0.591                              | 10000 | 567.051          | 0.290                              |
| 3550  | 9.006            | 0.816                              | 5000  | 35.441           | 0.580                              |       |                  |                                    |

The curves below show, for various temperatures, the fraction of radiant power as a function of wavelength. The function plotted is  $P_{\lambda}/\Delta\lambda P_{\text{tot}}$ , where  $P_{\lambda}$  is the power at wavelength  $\lambda$  in a small interval  $\Delta\lambda$  (in  $\mu\text{m}$ ), and  $P_{\text{tot}}$  is the total power.



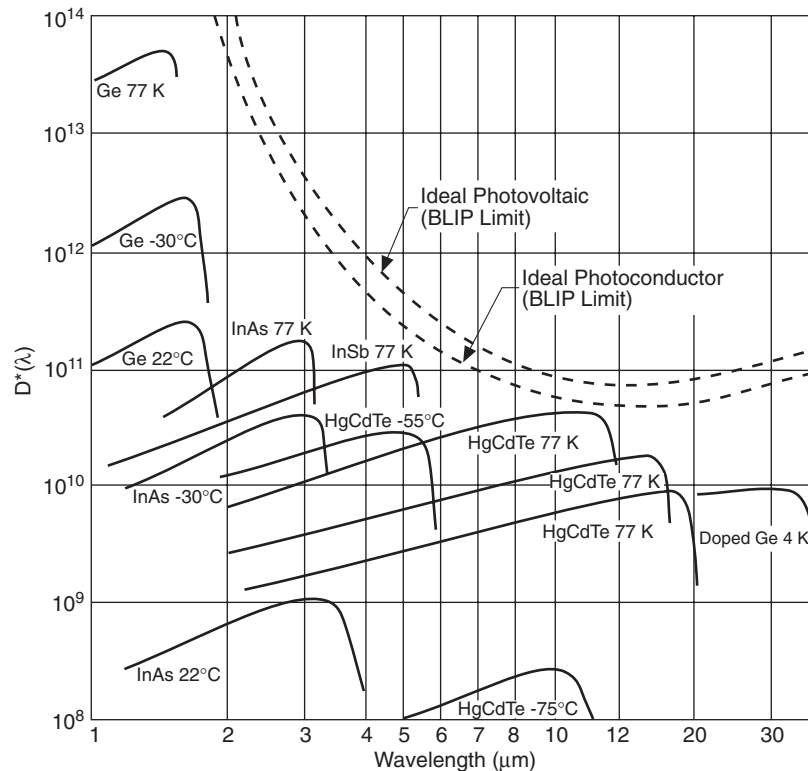
## CHARACTERISTICS OF INFRARED DETECTORS

This graph summarizes the wavelength response of some semiconductors used as detectors for infrared radiation. The quantity  $D^*(\lambda)$  is the signal to noise ratio for an incident radiant power density of  $1 \text{ W/cm}^2$  and a bandwidth of  $1 \text{ Hz}$  ( $60^\circ$  field of view). The Ge, InAs, and InSb detectors are photovoltaics, while the HgCdTe series are photoconductive devices. The cutoff wavelength of the latter can be varied by adjusting the relative amounts of Hg, Cd,

and Te (three examples are shown at  $77 \text{ K}$ ). The graph also shows the theoretical background limited sensitivity for ideal detectors which introduce no intrinsic noise.

### Reference

*Infrared Detectors 1995*, EG&G Judson, Montgomeryville, PA.





## REFRACTIVE INDEX AND TRANSMITTANCE OF REPRESENTATIVE GLASSES

Typical values of the index of refraction and internal transmittance (fraction of light transmitted through a one centimeter thickness) are tabulated here for selected types of glasses, as well as for synthetic fused (vitreous) silica. Nominal compositions are given in the first part of the table. The second part gives the index of refraction, relative to air, and the internal transmittance for representative samples of each glass at wavelengths in the infrared, visible, and near-ultraviolet regions. It should be emphasized that wide variation of these parameters may be found among subtypes of each glass. More detailed data may be found in Reference 3.

Assuming that the Lambert-Beer Law is followed, the transmittance of a glass plate of thickness  $d$  (in centimeters) can be obtained by raising the transmittance value in the table to the power  $d$ .

### References

1. Weber, M. J., *CRC Handbook of Laser Science and Technology*, Vol. IV, Part 2, CRC Press, Boca Raton, FL, 1988.
2. Gray, D. E., Ed., *American Institute of Physics Handbook, Third Edition*, McGraw Hill, New York, 1972.
3. *Schott Optical Glass*, Schott Glass Technologies, Inc., 400 York Ave., Duryea, PA 18642.
4. Kaye, G. W. C., and Laby, T. H., *Tables of Physical and Chemical Constants, 15th Edition*, Longman, London, 1986.

| Type             | Name                  | Composition in percent by mass |                               |                                |                   |                  |     |     |     |     |                               |
|------------------|-----------------------|--------------------------------|-------------------------------|--------------------------------|-------------------|------------------|-----|-----|-----|-----|-------------------------------|
|                  |                       | SiO <sub>2</sub>               | B <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | Na <sub>2</sub> O | K <sub>2</sub> O | CaO | BaO | ZnO | PbO | P <sub>2</sub> O <sub>5</sub> |
| PK               | Phosphate crown       |                                | 3                             | 10                             |                   | 12               | 5   |     |     |     | 70                            |
| PSK              | Dense phosphate crown |                                | 3                             | 5                              |                   |                  | 4   | 28  |     |     | 60                            |
| BK               | Borosilicate crown    | 70                             | 10                            |                                | 8                 | 8                | 1   | 3   |     |     |                               |
| K                | Crown                 | 74                             |                               |                                | 9                 | 11               | 6   |     |     |     |                               |
| ZK               | Zinc crown            | 71                             |                               |                                | 17                |                  |     |     | 12  |     |                               |
| BaK              | Barium crown          | 60                             | 3                             |                                | 3                 | 10               |     | 19  | 5   |     |                               |
| SK               | Dense crown           | 39                             | 15                            | 5                              |                   |                  |     | 41  |     |     |                               |
| KF               | Crown flint           | 67                             |                               | 2                              | 16                |                  |     |     | 3   | 12  |                               |
| BaLF             | Barium light flint    | 51                             |                               |                                | 6                 | 5                |     | 20  | 14  | 4   |                               |
| SSK              | Extra dense crown     | 35                             | 10                            | 5                              |                   |                  |     | 42  | 8   |     |                               |
| LLF              | Extra light flint     | 63                             |                               |                                | 5                 | 8                |     |     |     | 24  |                               |
| BaF              | Barium flint          | 46                             |                               |                                |                   | 8                |     | 16  | 8   | 22  |                               |
| LF               | Light flint           | 53                             |                               |                                | 5                 | 8                |     |     |     | 34  |                               |
| F                | Flint                 | 47                             |                               |                                | 2                 | 7                |     |     |     | 44  |                               |
| BaSF             | Dense barium flint    | 43                             |                               |                                | 1                 | 7                |     | 11  | 5   | 33  |                               |
| SF               | Dense flint           | 33                             |                               |                                |                   | 5                |     |     |     | 62  |                               |
| KzFS             | Short flint           |                                |                               |                                |                   |                  |     |     |     |     |                               |
| SiO <sub>2</sub> | Fused silica          | 100                            |                               |                                |                   |                  |     |     |     |     |                               |

| Type             | Index of refraction |          |                      |                      | Transmittance of 1 cm plate |          |          |        |
|------------------|---------------------|----------|----------------------|----------------------|-----------------------------|----------|----------|--------|
|                  | 1.060 $\mu$ m       | 546.1 nm | 365.0 nm             | 312.6 nm             | 1.060 $\mu$ m               | 546.1 nm | 365.0 nm | 310 nm |
| PK               | 1.51519             | 1.52736  | 1.54503              | 1.5574               | 0.997                       | 0.998    | 0.987    | 0.46   |
| PSK              | 1.54154             | 1.55440  | 1.57342              | 1.5868               | 0.996                       | 0.998    | 0.984    | 0.46   |
| BK               | 1.50669             | 1.51872  | 1.53627              | 1.5486               | 0.999                       | 0.998    | 0.987    | 0.35   |
| K                | 1.50091             | 1.51314  | 1.53189              | 1.5454               | 0.998                       | 0.998    | 0.988    | 0.40   |
| ZK               | 1.52220             | 1.53534  | 1.55588              | 1.5708               | 0.996                       | 0.998    | 0.976    | 0.27   |
| BaK              | 1.55695             | 1.57124  | 1.59407              | 1.6108               | 0.998                       | 0.997    | 0.986    | 0.28   |
| SK               | 1.59490             | 1.60994  | 1.63398              |                      | 0.998                       | 0.998    | 0.959    | 0.28   |
| KF               | 1.50586             | 1.51978  | 1.54251              | 1.5600               | 0.998                       | 0.996    | 0.989    | 0.49   |
| BaLF             | 1.57579             | 1.59166  | 1.61804              |                      | 0.996                       | 0.998    | 0.933    | 0.010  |
| SSK              | 1.60402             | 1.61993  | 1.64595              |                      | 0.999                       | 0.998    | 0.915    | 0.010  |
| LaK              | 1.69710             | 1.71616  | 1.74573              |                      | 0.999                       | 0.998    | 0.882    | 0.17   |
| LLF              | 1.52775             | 1.54344  | 1.57038              |                      | 0.998                       | 0.997    | 0.990    | 0.32   |
| BaF              | 1.56873             | 1.58565  | 1.61524              |                      | 0.999                       | 0.997    | 0.992    | 0.004  |
| LF               | 1.56594             | 1.58482  | 1.61926              |                      | 0.999                       | 0.998    | 0.981    | 0.008  |
| F                | 1.58636             | 1.60718  | 1.64606              |                      | 0.997                       | 0.998    | 0.959    |        |
| BaSF             | 1.60889             | 1.62987  | 1.66926              |                      | 0.999                       | 0.998    | 0.857    |        |
| SF               | 1.71350             | 1.74620  | 1.8145               |                      | 0.998                       | 0.997    | 0.650    |        |
| KzFS             | 1.59680             | 1.61639  | 1.64849              | 1.6739               |                             | 0.998    | 0.672    | 0.012  |
| SiO <sub>2</sub> | 1.44968             | 1.46008  | 1.47435 <sup>a</sup> | 1.53430 <sup>b</sup> |                             |          |          |        |

<sup>a</sup> At 366.3 nm.

<sup>b</sup> At 213.9 nm.

## INDEX OF REFRACTION OF WATER

This table gives the index of refraction of liquid water at atmospheric pressure, relative to a vacuum, at several temperatures and wavelengths. It is generated from the formulation in Reference 1, which covers a wide range of temperature, pressure, and wavelength. The wavelengths listed here correspond to prominent lines of cadmium (226.50 and 361.05 nm), potassium (404.41 nm), sodium (589.00 nm), Ne (632.80 nm, from a helium - neon laser), and mercury (1.01398  $\mu\text{m}$ ).

### References

1. Schiebener, P., Straub, J., Levelt Sengers, J. M. H., and Gallagher, J. S., *J. Phys. Chem. Ref. Data*, 19, 677, 1990; 19, 1617, 1990.
2. Marsh, K. N., Editor, *Recommended Reference Materials for the Realization of Physicochemical Properties*, Blackwell Scientific Publications, Oxford, 1987.

| $t/^{\circ}\text{C}$ | 226.50 nm | 361.05 nm | 404.41 nm | 589.00 nm | 632.80 nm | 1.01398 $\mu\text{m}$ |
|----------------------|-----------|-----------|-----------|-----------|-----------|-----------------------|
| 0                    | 1.39450   | 1.34896   | 1.34415   | 1.33432   | 1.33306   | 1.32612               |
| 10                   | 1.39422   | 1.34870   | 1.34389   | 1.33408   | 1.33282   | 1.32591               |
| 20                   | 1.39336   | 1.34795   | 1.34315   | 1.33336   | 1.33211   | 1.32524               |
| 30                   | 1.39208   | 1.34682   | 1.34205   | 1.33230   | 1.33105   | 1.32424               |
| 40                   | 1.39046   | 1.34540   | 1.34065   | 1.33095   | 1.32972   | 1.32296               |
| 50                   | 1.38854   | 1.34373   | 1.33901   | 1.32937   | 1.32814   | 1.32145               |
| 60                   | 1.38636   | 1.34184   | 1.33714   | 1.32757   | 1.32636   | 1.31974               |
| 70                   | 1.38395   | 1.33974   | 1.33508   | 1.32559   | 1.32438   | 1.31784               |
| 80                   | 1.38132   | 1.33746   | 1.33284   | 1.32342   | 1.32223   | 1.31576               |
| 90                   | 1.37849   | 1.33501   | 1.33042   | 1.32109   | 1.31991   | 1.31353               |
| 100                  | 1.37547   | 1.33239   | 1.32784   | 1.31861   | 1.31744   | 1.31114               |

# INDEX OF REFRACTION OF LIQUIDS FOR CALIBRATION PURPOSES

This table gives the index of refraction of six liquids which are available in highly pure form and whose index of refraction has been accurately measured as a function of wavelength and temperature. They are therefore useful for calibration of refractometers. The estimated uncertainty in the values is:

|                                    |          |
|------------------------------------|----------|
| 2,2,4-Trimethylpentane             | ±0.00003 |
| Hexadecane                         | ±0.00008 |
| <i>trans</i> -Bicyclo[4.0.0]decane | ±0.00008 |
| 1-Methylnaphthalene                | ±0.00008 |
| Toluene                            | ±0.00003 |
| Methylcyclohexane                  | ±0.00003 |

Full details are given in the references. This table is reprinted from Reference 1 by permission of the International Union of Pure and Applied Chemistry.

## References

1. Marsh, K. N., Editor, *Recommended Reference Materials for the Realization of Physicochemical Properties*, Blackwell Scientific Publications, Oxford, 1987.
2. Tilton, L. W., *J. Opt. Soc. Am.*, 32, 71, 1941.

| $\lambda$<br>nm | 2,2,4-Trimethylpentane |         |         | Hexadecane |         |         |
|-----------------|------------------------|---------|---------|------------|---------|---------|
|                 | 20°C                   | 25°C    | 30°C    | 20°C       | 25°C    | 30°C    |
| 667.81          | 1.38916                | 1.38670 | 1.38424 | 1.43204    | 1.43001 | 1.42798 |
| 656.28          | 1.38945                | 1.38698 | 1.38452 | 1.43235    | 1.43032 | 1.42829 |
| 589.26          | 1.39145                | 1.38898 | 1.38650 | 1.43453    | 1.43250 | 1.43047 |
| 546.07          | 1.39316                | 1.39068 | 1.38820 | 1.43640    | 1.43436 | 1.43232 |
| 501.57          | 1.39544                | 1.39294 | 1.39044 | 1.43888    | 1.43684 | 1.43480 |
| 486.13          | 1.39639                | 1.39389 | 1.39138 | 1.43993    | 1.43788 | 1.43583 |
| 435.83          | 1.40029                | 1.39776 | 1.39523 | 1.44419    | 1.44213 | 1.44007 |

| $\lambda$<br>nm | <i>trans</i> -Bicyclo[4.4.0]decane |         |         | 1-Methylnaphthalene |         |         |
|-----------------|------------------------------------|---------|---------|---------------------|---------|---------|
|                 | 20°C                               | 25°C    | 30°C    | 20°C                | 25°C    | 30°C    |
| 667.81          | 1.46654                            | 1.46438 | 1.46222 | 1.60828             | 1.60592 | 1.60360 |
| 656.28          | 1.46688                            | 1.46472 | 1.46256 | 1.60940             | 1.60703 | 1.60471 |
| 589.26          | 1.46932                            | 1.46715 | 1.46498 | 1.61755             | 1.61512 | 1.61278 |
| 546.07          | 1.47141                            | 1.46923 | 1.46705 | 1.62488             | 1.62240 | 1.62005 |
| 501.57          | 1.47420                            | 1.47200 | 1.46980 | 1.63513             | 1.63259 | 1.63022 |
| 486.13          | 1.47535                            | 1.47315 | 1.47095 | 1.63958             | 1.63701 | 1.63463 |
| 435.83          | 1.48011                            | 1.47789 | 1.47567 |                     | 1.65627 | 1.65386 |

| $\lambda$<br>nm | Toluene |         |         | Methylcyclohexane |         |         |
|-----------------|---------|---------|---------|-------------------|---------|---------|
|                 | 20°C    | 25°C    | 30°C    | 20°C              | 25°C    | 30°C    |
| 667.81          | 1.49180 | 1.48903 | 1.48619 | 1.42064           | 1.41812 | 1.41560 |
| 656.28          | 1.49243 | 1.48966 | 1.48682 | 1.42094           | 1.41842 | 1.41591 |
| 589.26          | 1.49693 | 1.49413 | 1.49126 | 1.42312           | 1.42058 | 1.41806 |
| 546.07          | 1.50086 | 1.49803 | 1.49514 | 1.42497           | 1.42243 | 1.41989 |
| 501.57          | 1.50620 | 1.50334 | 1.50041 | 1.42744           | 1.42488 | 1.42233 |
| 486.13          | 1.50847 | 1.50559 | 1.50265 | 1.42847           | 1.42590 | 1.42334 |
| 435.83          | 1.51800 | 1.51506 | 1.51206 | 1.43269           | 1.43010 | 1.42752 |

## INDEX OF REFRACTION OF AIR

This is a table of the index of refraction  $n$  of dry air at 15°C and a pressure of 101.325 kPa and containing 0.045% by volume of carbon dioxide (“standard air”). The index of refraction is defined by  $n = \lambda_{\text{vac}} / \lambda_{\text{air}}$  where  $\lambda$  is the wavelength of the radiation. The index is calculated from the expression

$$(n-1) \times 10^8 = 8342.54 + 2406147(130 - \sigma^2)^{-1} + 15998(38.9 - \sigma^2)^{-1}$$

where  $\sigma = 1/\lambda_{\text{vac}}$  and  $\lambda_{\text{vac}}$  has units of  $\mu\text{m}$ . The equation is valid for  $\lambda_{\text{vac}}$  from 200 nm to 2  $\mu\text{m}$ . The table also gives the correction  $(n-1)\lambda_{\text{air}}$  which must be added to the wavelength in air to obtain  $\lambda_{\text{vac}}$ .

If the air is at a temperature  $t$  in °C (ITS-90) and a pressure  $p$  in pascals, a value of  $(n - 1)$  from this table should be multiplied by

$$p[1 + p(60.1 - 0.972t) \times 10^{-10}]/96095.43(1 + 0.003661t)$$

## References

1. Birch, K. P., and Downs, M. J., *Metrologia*, 31, 315, 1994.
2. Edlen, B., *Metrologia* 2, 71, 1966.

| $\lambda_{\text{vac}}$ | $(n-1) \times 10^8$ | $\lambda_{\text{vac}} - \lambda_{\text{air}}$ | $\lambda_{\text{vac}}$ | $(n-1) \times 10^8$ | $\lambda_{\text{vac}} - \lambda_{\text{air}}$ | $\lambda_{\text{vac}}$ | $(n-1) \times 10^8$ | $\lambda_{\text{vac}} - \lambda_{\text{air}}$ |
|------------------------|---------------------|-----------------------------------------------|------------------------|---------------------|-----------------------------------------------|------------------------|---------------------|-----------------------------------------------|
| 200 nm                 | 32409               | 0.06480 nm                                    | 540                    | 27804               | 0.15010                                       | 880                    | 27462               | 0.24160                                       |
| 210                    | 31748               | 0.06665                                       | 550                    | 27784               | 0.15277                                       | 890                    | 27458               | 0.24431                                       |
| 220                    | 31226               | 0.06868                                       | 560                    | 27765               | 0.15544                                       | 900                    | 27454               | 0.24701                                       |
| 230                    | 30801               | 0.07082                                       | 570                    | 27747               | 0.15811                                       | 910                    | 27449               | 0.24972                                       |
| 240                    | 30447               | 0.07305                                       | 580                    | 27730               | 0.16079                                       | 920                    | 27445               | 0.25243                                       |
| 250                    | 30148               | 0.07535                                       | 590                    | 27714               | 0.16347                                       | 930                    | 27441               | 0.25513                                       |
| 260                    | 29892               | 0.07769                                       | 600                    | 27698               | 0.16614                                       | 940                    | 27437               | 0.25784                                       |
| 270                    | 29670               | 0.08009                                       | 610                    | 27684               | 0.16882                                       | 950                    | 27434               | 0.26055                                       |
| 280                    | 29477               | 0.08251                                       | 620                    | 27670               | 0.17151                                       | 960                    | 27430               | 0.26326                                       |
| 290                    | 29307               | 0.08497                                       | 630                    | 27657               | 0.17419                                       | 970                    | 27427               | 0.26597                                       |
| 300                    | 29157               | 0.08745                                       | 640                    | 27644               | 0.17688                                       | 980                    | 27423               | 0.26868                                       |
| 310                    | 29023               | 0.08995                                       | 650                    | 27632               | 0.17956                                       | 990                    | 27420               | 0.27138                                       |
| 320                    | 28904               | 0.09247                                       | 660                    | 27621               | 0.18225                                       |                        |                     |                                               |
| 330                    | 28796               | 0.09500                                       | 670                    | 27610               | 0.18494                                       | 1.00 $\mu\text{m}$     | 27417               | 0.0002741                                     |
| 340                    | 28700               | 0.09755                                       | 680                    | 27600               | 0.18763                                       | 1.05                   | 27402               | 0.0002876                                     |
| 350                    | 28612               | 0.10011                                       | 690                    | 27590               | 0.19032                                       | 1.10                   | 27390               | 0.0003012                                     |
| 360                    | 28532               | 0.10269                                       | 700                    | 27581               | 0.19301                                       | 1.15                   | 27379               | 0.0003148                                     |
| 370                    | 28460               | 0.10527                                       | 710                    | 27572               | 0.19570                                       | 1.20                   | 27370               | 0.0003283                                     |
| 380                    | 28393               | 0.10786                                       | 720                    | 27563               | 0.19840                                       | 1.25                   | 27361               | 0.0003419                                     |
| 390                    | 28332               | 0.11046                                       | 730                    | 27555               | 0.20109                                       | 1.30                   | 27354               | 0.0003555                                     |
| 400                    | 28276               | 0.11307                                       | 740                    | 27547               | 0.20379                                       | 1.35                   | 27347               | 0.0003691                                     |
| 410                    | 28224               | 0.11569                                       | 750                    | 27539               | 0.20649                                       | 1.40                   | 27341               | 0.0003827                                     |
| 420                    | 28177               | 0.11831                                       | 760                    | 27532               | 0.20918                                       | 1.45                   | 27336               | 0.0003963                                     |
| 430                    | 28132               | 0.12094                                       | 770                    | 27525               | 0.21188                                       | 1.50                   | 27331               | 0.0004099                                     |
| 440                    | 28091               | 0.12357                                       | 780                    | 27518               | 0.21458                                       | 1.55                   | 27327               | 0.0004234                                     |
| 450                    | 28053               | 0.12620                                       | 790                    | 27511               | 0.21728                                       | 1.60                   | 27323               | 0.0004370                                     |
| 460                    | 28018               | 0.12885                                       | 800                    | 27505               | 0.21998                                       | 1.65                   | 27319               | 0.0004506                                     |
| 470                    | 27985               | 0.13149                                       | 810                    | 27499               | 0.22268                                       | 1.70                   | 27316               | 0.0004642                                     |
| 480                    | 27954               | 0.13414                                       | 820                    | 27493               | 0.22538                                       | 1.75                   | 27313               | 0.0004778                                     |
| 490                    | 27925               | 0.13679                                       | 830                    | 27488               | 0.22808                                       | 1.80                   | 27310               | 0.0004914                                     |
| 500                    | 27897               | 0.13945                                       | 840                    | 27482               | 0.23079                                       | 1.85                   | 27307               | 0.0005050                                     |
| 510                    | 27872               | 0.14211                                       | 850                    | 27477               | 0.23349                                       | 1.90                   | 27305               | 0.0005187                                     |
| 520                    | 27848               | 0.14477                                       | 860                    | 27472               | 0.23619                                       | 1.95                   | 27303               | 0.0005323                                     |
| 530                    | 27825               | 0.14743                                       | 870                    | 27467               | 0.23890                                       | 2.00                   | 27301               | 0.0005459                                     |

# CHARACTERISTICS OF LASER SOURCES

William F. Krupke

Light amplification by stimulated emission of radiation was first demonstrated by Maiman in 1960, the result of a population inversion produced between energy levels of chromium ions in a ruby crystal when irradiated with a xenon flashlamp. Since then population inversions and coherent emission have been generated in literally thousands of substances (neutral and ionized gases, liquids, and solids) using a variety of incoherent excitation techniques (optical pumping, electrical discharges, gas-dynamic flow, electron-beams, chemical reactions, nuclear decay).

The extrema of laser output parameters that have been demonstrated to date and the laser media used are summarized in Table 1. Note that the extreme power and energy parameters listed in this table were attained with laser systems rather than with simple laser oscillators.

Laser sources are commonly classified in terms of the state-of-matter of the active medium: gas, liquid, and solid. Each of these classes is further subdivided into one or more types as shown in Table 2. A well-known representative example of each type of laser is also given in Table 2 together with its nominal operation wavelength and the methods by which it is pumped.

The various lasers together cover a wide spectral range from the far ultraviolet to the far infrared. The particular wavelength of emission (usually a narrow line) is presented for some six dozen lasers in Figures 1A and 1B.

By suitably designing the excitation source and/or by controlling the laser resonator structure, laser systems can provide continuous or pulsed radiation as shown in Table 3.

Besides the method of excitation and the temporal behavior of a laser, there are many other parameters that characterize its operation and efficiency, as shown in Tables 4 and 5.

Although many lasers only emit in one or more narrow spectral "lines," an increasing number of lasers can be tuned by changing the composition or the pressure of the medium, or by varying the wavelength of the pump bands. The spectral regions in which these tunable lasers operate are presented in Figure 2.

## Reference

Krupke, W. F., in *Handbook of Laser Science and Technology*, Vol. I, Weber, M. J., Ed., CRC Press, Boca Raton, FL, 1986.

TABLE 1. Extrema of Output Parameters of Laser Devices or Systems

| Parameter                    | Value                                      | Laser medium                             |
|------------------------------|--------------------------------------------|------------------------------------------|
| Peak power                   | $1 \times 10^{14}$ W(collimated)           | Nd:glass                                 |
| Peak power density           | $10^{18}$ W/cm <sup>2</sup> (focused)      | Nd:glass                                 |
| Pulse energy                 | $>10^5$ J                                  | CO <sub>2</sub> , Nd:glass               |
| Average power                | $10^5$ W                                   | CO <sub>2</sub>                          |
| Pulse duration               | $3 \times 10^{-15}$ s continuous wave (cw) | Rh6G dye; various gases, liquids, solids |
| Wavelength                   | 60 nm $\leftrightarrow$ 385 $\mu$ m        | Many required                            |
| Efficiency (nonlaser pumped) | 70%                                        | CO                                       |
| Beam quality                 | Diffraction limited                        | Various gases, liquids, solids           |
| Spectral linewidth           | 20 Hz (for $10^{-1}$ s)                    | Neon-helium                              |
| Spatial coherence            | 10 m                                       | Ruby                                     |

TABLE 2. Classes, Types, and Representative Examples of Laser Sources

| Class  | Type (characteristic)                        | Representative example                          | Nominal operating wavelength (nm) | Method(s) of excitation         |
|--------|----------------------------------------------|-------------------------------------------------|-----------------------------------|---------------------------------|
| Gas    | Atom, neutral (electronic transition)        | Neon-Helium (Ne-He)                             | 633                               | Glow discharge                  |
|        | Atom, ionic (electronic transition)          | Argon (Ar <sup>+</sup> )                        | 488                               | Arc discharge                   |
|        | Molecule, neutral (electronic transition)    | Krypton fluoride (KrF)                          | 248                               | Glow discharge; e-beam          |
|        | Molecule, neutral (vibrational transition)   | Carbon dioxide (CO <sub>2</sub> )               | 10600                             | Glow discharge; gasdynamic flow |
|        | Molecule, neutral (rotational transition)    | Methyl fluoride (CH <sub>3</sub> F)             | 496000                            | Laser pumping                   |
| Liquid | Molecule, ionic (electronic transition)      | Nitrogen ion (N <sub>2</sub> <sup>+</sup> )     | 420                               | E-beam                          |
|        | Organic solvent (dye-chromophore)            | Rhodamine dye (Rh6G)                            | 580–610                           | Flashlamp; laser pumping        |
|        | Organic solvent (rare earth chelate)         | Europium:TTF                                    | 612                               | Flashlamp                       |
|        | Inorganic solvent (trivalent rare earth ion) | Neodymium:POCl <sub>4</sub>                     | 1060                              | Flashlamp                       |
|        | Insulator, crystal (impurity)                | Neodymium:YAG                                   | 1064                              | Flashlamp, arc lamp             |
| Solid  | Insulator, crystal (stoichiometric)          | Neodymium:UP(NdP <sub>5</sub> O <sub>14</sub> ) | 1052                              | Flashlamp                       |
|        | Insulator, crystal (color center)            | F <sub>2</sub> :LiF                             | 1120                              | Laser pumping                   |
|        | Insulator, amorphous (impurity)              | Neodymium:glass                                 | 1061                              | Flashlamp                       |
|        | Semiconductor (p-n junction)                 | GaAs                                            | 820                               | Injection current               |
|        | Semiconductor (electron-hole plasma)         | GaAs                                            | 890                               | E- beam, laser pumping          |

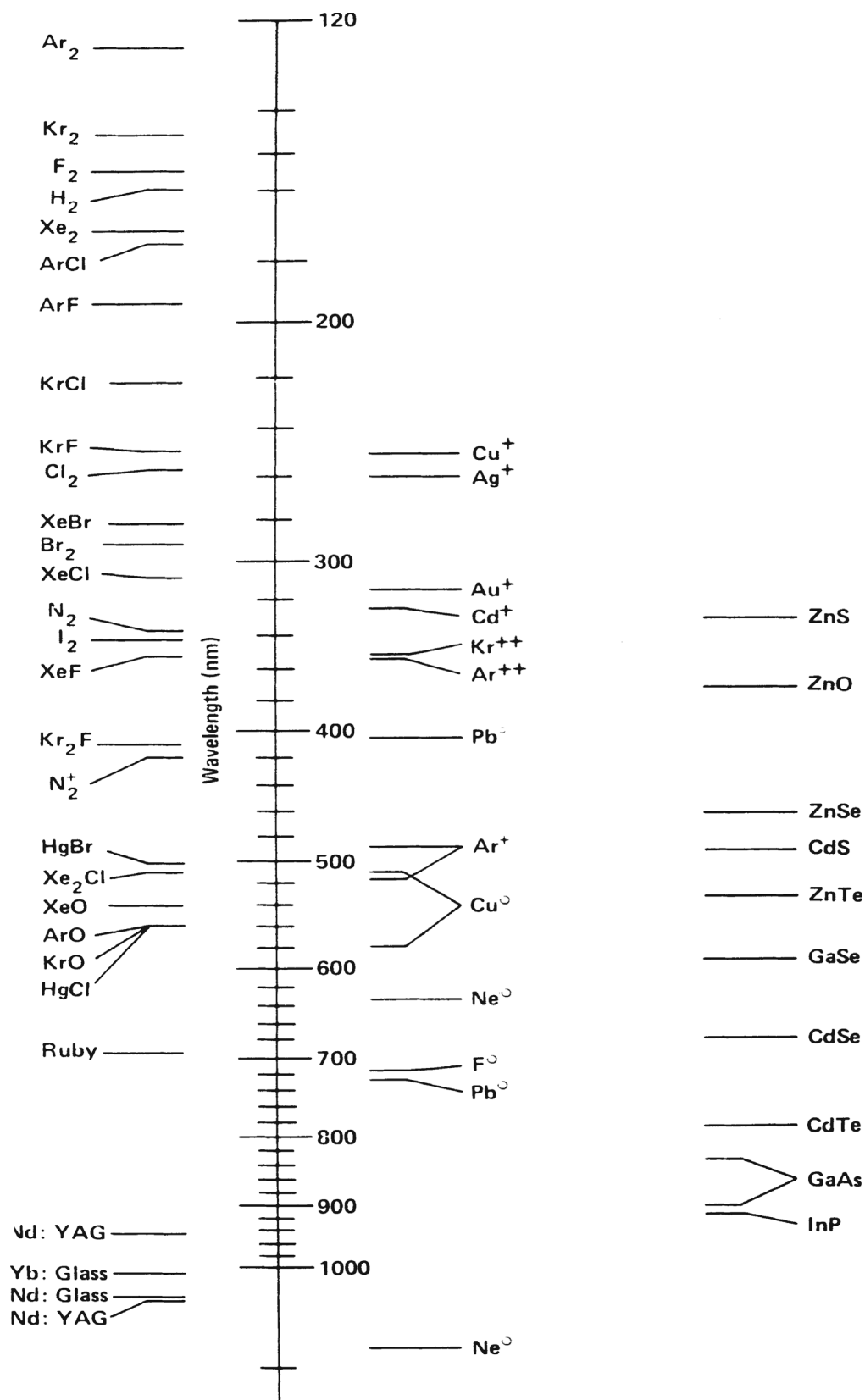


FIGURE 1A. Wavelengths of lasers operating in the 120 to 1200 nm spectral region.

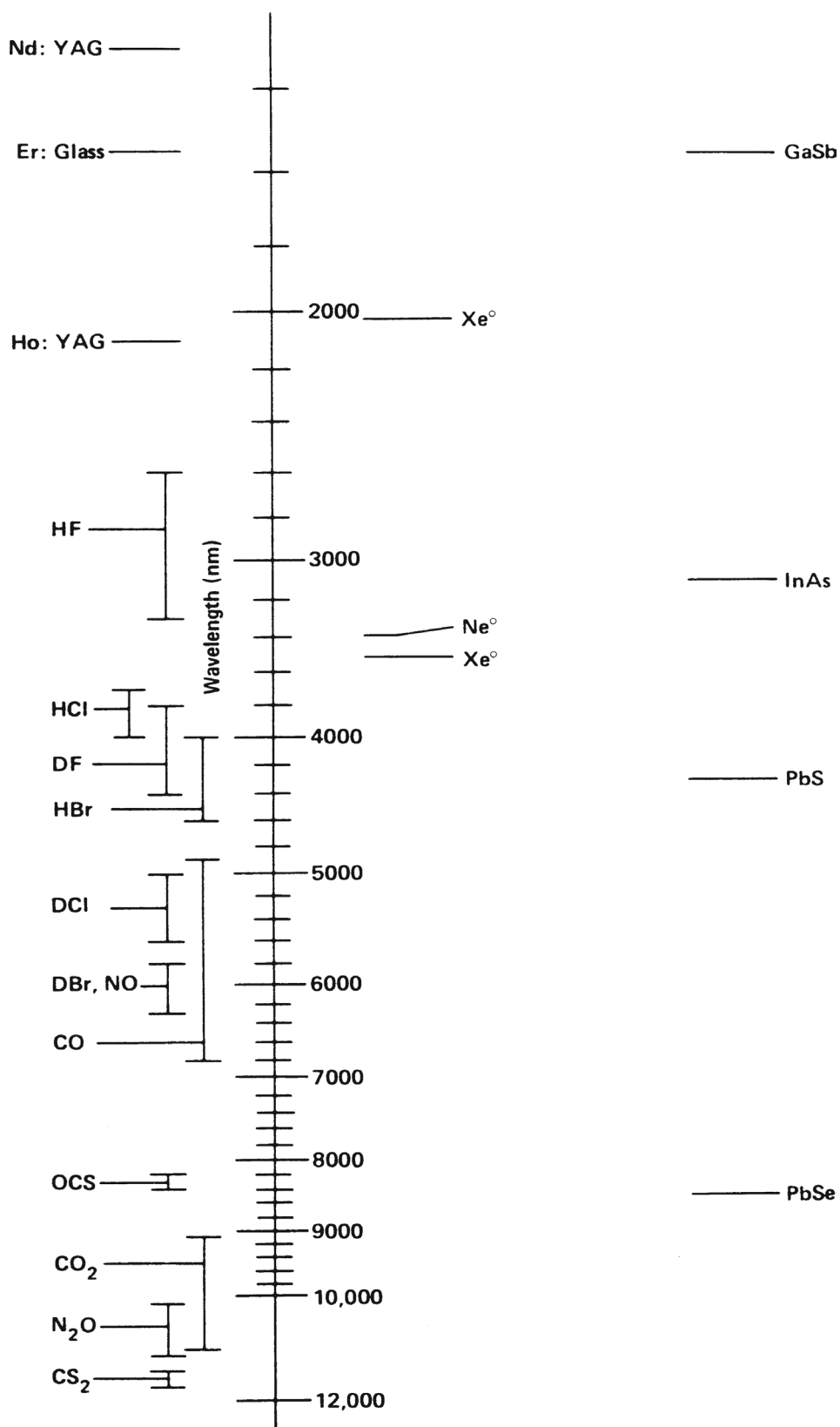


FIGURE 1B. Wavelength of lasers operating in the 1300 to 12,000 nm spectral region.

TABLE 3. Temporal Characteristics of Lasers and Laser Systems

| Form            | Technique                                                                                                                             | Pulse width range (s) |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Continuous wave | Excitation is continuous; resonator Q is held constant at some moderate value                                                         | $\infty$              |
| Pulsed          | Excitation is pulsed; resonator Q is held constant at some moderate value                                                             | $10^{-8} - 10^{-3}$   |
| Q-Switched      | Excitation is continuous or pulsed; resonator Q is switched from a very low value to a moderate value                                 | $10^{-8} - 10^{-6}$   |
| Cavity dumped   | Excitation is continuous or pulsed; resonator Q is switched from a very high value to a low value                                     | $10^{-7} - 10^{-5}$   |
| Mode locked     | Excitation is continuous or pulsed; phase or loss of the resonator modes is modulated at a rate related to the resonator transit time | $10^{-12} - 10^{-9}$  |

TABLE 4. Properties and Performance of Some Continuous Wave (CW) Lasers

| Parameter                        | Unit                      | Gas           |               |                                     | Liquid                     | Solid            |                                |
|----------------------------------|---------------------------|---------------|---------------|-------------------------------------|----------------------------|------------------|--------------------------------|
|                                  |                           | Neon helium   | Argon ion     | Carbon dioxide                      | Rhodamine 6G dye           | Nd:YAG           | GaAs                           |
| Excitation method                |                           | DC discharge  | DC discharge  | DC discharge                        | Ar <sup>+</sup> laser pump | Krypton arc lamp | DC injection                   |
| Gain medium composition          |                           | Neon:helium   | Argon         | CO <sub>2</sub> :N <sub>2</sub> :He | Rh 6G:H <sub>2</sub> O     | Nd:YAG           | p:n:GaAs                       |
| Gain medium density              | Torr ions/cm <sup>3</sup> | 0.1:1.0       | 0.4           | 0.4:0.8:5.0                         | 2(18):2(22)                | 1.5(20):2(22)    | 2(19):3(18):3(22)              |
| Wavelength                       | nm                        | 633           | 488           | 10600                               | 590                        | 1064             | 810                            |
| Laser cross-section              | cm <sup>-2</sup>          | 3(-13)        | 1.6(-12)      | 1.5(-16)                            | 1.8(-16)                   | 7(-19)           | ~6(-15)                        |
| Radiative lifetime (upper level) | s                         | ~1(-7)        | 7.5(-9)       | 4(-3)                               | 6.5(-9)                    | 2.6(-4)          | ~1(-9)                         |
| Decay lifetime (upper level)     | s                         | ~1(-7)        | ~5.0(-9)      | ~4(-3)                              | 6.0(-9)                    | 2.3(-4)          | ~1(-9)                         |
| Gain bandwidth                   | nm                        | 2(-3)         | 5(-3)         | 1.6(-2)                             | 80                         | 0.5              | 10                             |
| Type, gain saturation            |                           | Inhomogeneous | Inhomogeneous | Homogeneous                         | Homogeneous                | Homogeneous      | Homogeneous                    |
| Homogeneous saturation flux      | W cm <sup>-2</sup>        |               |               | ~20                                 | 3(5)                       | 2.3(3)           | ~2(4)                          |
| Decay lifetime (lower level)     | s                         | ~1(-8)        | ~4(-10)       | ~5(-6)                              | <1(-12)                    | <1(-7)           | <1(-12)                        |
| Inversion density                | cm <sup>-3</sup>          | ~1(9)         | 2(10)         | 2(15)                               | 2(16)                      | 6(16)            | 1(16)                          |
| Small signal gain coefficient    | cm <sup>-1</sup>          | ~1(-3)        | ~3(-2)        | 1(-2)                               | 4                          | 5(-2)            | 40                             |
| Pump power density               | W cm <sup>-3</sup>        | 3             | 900           | 0.15                                | 1(6)                       | 150              | 7(7)                           |
| Output power density             | W cm <sup>-3</sup>        | 2.6(-3)       | ~1            | 2(-2)                               | 3(5)                       | 95               | 5(6)                           |
| Laser size (diameter: length)    | cm:cm                     | 0.5:100       | 0.3:100       | 5.0:600                             | 1(-3):0.3                  | 0.6:10           | 5(-4):7(-3);2(-2) <sup>a</sup> |
| Excitation current/voltage       | A/V                       | 3(-2):2(3)    | 30:300        | 0.1:1.5(4)                          |                            | 90:125           | 1.0/1.7                        |
| Excitation current density       | A cm <sup>-2</sup>        | 0.15          | 600           | 6(-3)                               |                            | 140              | 4.5(3)                         |
| Excitation power                 | W                         | 60            | 9(3)          | 1.5(3)                              | 4                          | 1.1(4)           | 1.7                            |
| Output power                     | W                         | 0.06          | 10            | 240                                 | 0.3                        | 300              | 0.12                           |
| Efficiency <sup>b</sup>          | %                         | 0.1           | 0.1           | 13                                  | 7                          | 2.6              | 7                              |

<sup>a</sup> Junction thickness:width:length.<sup>b</sup> Pressure dependent.



TABLE 5. Properties and Performance of Some Pulsed Lasers

| Parameter                        | Unit                 | Gas                                 |                                     |                      |                      | Liquid          | Solid           |                 |
|----------------------------------|----------------------|-------------------------------------|-------------------------------------|----------------------|----------------------|-----------------|-----------------|-----------------|
|                                  |                      | Carbon dioxide                      |                                     | Krypton fluoride     |                      | Rhodamine 6G    | Nd:YAG          | Nd:glass        |
| Excitation method                |                      | TEA-discharge                       | E- beam/sust.                       | Glow discharge       | E-beam               | Xenon flashlamp | Xenon flashlamp | Xenon flashlamp |
| Gain medium composition          |                      | CO <sub>2</sub> :N <sub>2</sub> :He | CO <sub>2</sub> :N <sub>2</sub> :He | He:Kr:F <sub>2</sub> | Ar:Kr:F <sub>2</sub> | Rh6G:alcohol    | Nd:YAG          | Nd:Glass        |
| Gain medium density              | torr                 | 100:50:600                          | 240:240:320                         | 1070:70:3            | 1235:52:3            |                 |                 | —               |
|                                  | ions/cm <sup>3</sup> |                                     |                                     |                      |                      | 1(18):1.5(22)   | 1.5(20):1(22)   | 3(20):2(22)     |
| Wavelength                       | nm                   | 10600                               | 10600                               | 249                  | 249                  | 590             | 1064            | 1061            |
| Laser cross-section              | cm <sup>-2</sup>     | 2(-18)                              | 2(-18)                              | 2(-16)               | 2(-16)               | 1.8(-16)        | 7(-19)          | 2.8(-20)        |
| Radiative lifetime (upper level) | s                    | 4(-3)                               | 4(-3)                               | 7(-9)                | 7(-9)                | 6.5(-9)         | 2.6(-4)         | 4.1(-4)         |
| Decay lifetime (upper level)     | s                    | ~1(-4)                              | 5(-5)                               | 2(-9)                | 3(-9)                | 6.0(-9)         | 2.3(-4)         | 3.7(-4)         |
| Gain bandwidth                   | nm                   | 1                                   | 1                                   | 2                    | 2                    | 80              | 0.5             | 26              |
| Homogeneous saturation fluence   | J/cm <sup>2</sup>    | 0.2                                 | 0.2                                 | 4(-3)                | 4(-3)                | 2(-3)           | 0.6             | ~5              |
| Decay lifetime (lower level)     | s                    | 5(-8) <sup>a</sup>                  | 1(-8) <sup>a</sup>                  | <1(-12)              | <1(-12)              | <1(-12)         | <1(-7)          | <1(-8)          |
| Inversion density                | cm <sup>-3</sup>     | 3(17)                               | 6(17)                               | 4(14)                | 2(14)                | 2(16)           | 4(17)           | 3(18)           |
| Small signal gain coefficient    | cm <sup>-1</sup>     | 2(-2)                               | 4(-2)                               | 8–92)                | 4(-2)                | 4               | 0.3             | 8(-2)           |
| Medium excitation energy density | J/cm <sup>3</sup>    | 0.1                                 | 0.36                                | 0.15                 | 0.13                 | 2.8             | 0.15            | 0.6             |
| Output energy density            | J/cm <sup>3</sup>    | 2(-2)                               | 1.8(-2)                             | 1.5(-3)              | 1.2(-2)              | 0.85            | 5(-2)           | 2(-2)           |
| Laser dimensions                 | cm:<br>cm:<br>cm     | 4.5:4.5:87                          | 10:10:100                           | 1.5:4.5:100          | 8.5:10:100           | 1.2:25          | 0.6:7.5         | 0.6:8.3         |
| Excitation current/voltage       | A/V                  | 6(4)/3.3(3)                         | 2.4(4)/4(4)                         | 2.5(4)/1.5(5)        | 1.2(4)/2.5(5)        | 2(5)/2.5(4)     |                 |                 |
| Excitation current density       | A cm <sup>-2</sup>   | 8.5                                 | 22                                  | 170                  | 11.5                 | 2.6(3)          |                 |                 |
| Excitation peak power            | W                    | 2(8)                                | 9(8)                                | 4(9)                 | 3(9)                 | 5.4(9)          | 4(4)            | 9(4)            |
| Output pulse energy              | J                    | 35                                  | 180                                 | 1                    | 102                  | 32              | 0.1             | 1.0             |
| Output pulse length              | s                    | 1(-6)                               | 4(-6)                               | 2.5(-8)              | 6(-7)                | 3.2(-6)         | 2(-8)           | 1(-4)           |
| Output pulse power               | W                    | 3.5(7)                              | 4(7)                                | 4(7)                 | 2(8)                 | 1(7)            | 5(6)            | 1(4)            |
| Efficiency                       | %                    | 17                                  | 5                                   | 1                    | 10 <sup>b</sup>      | 0.2             | 1.5             | 3.7             |

<sup>a</sup> Pressure dependent.<sup>b</sup> Intrinsic efficiency ≡ energy output/energy deposited in gas.

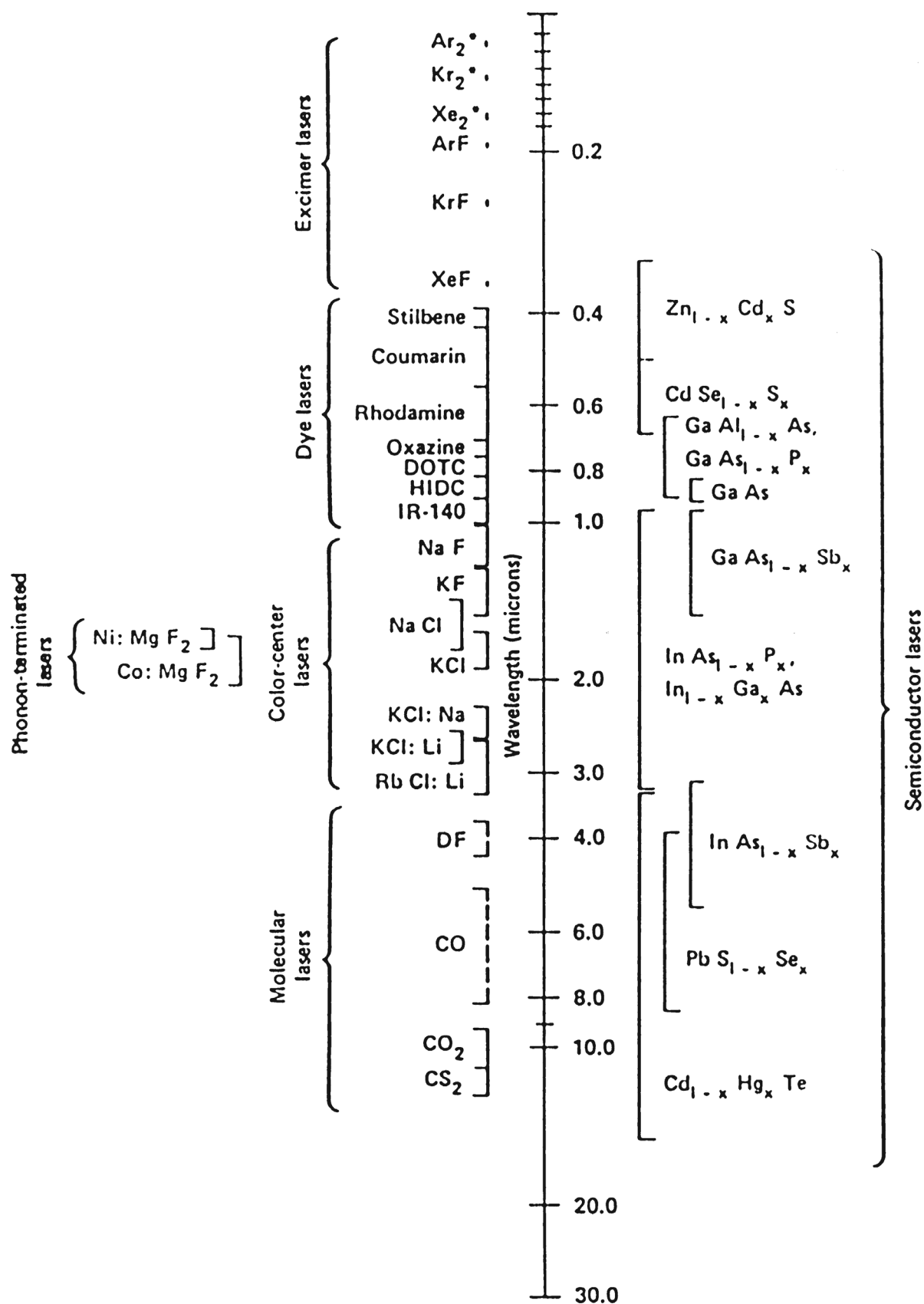


FIGURE 2. Spectral tuning ranges of various types of tunable lasers.

# INFRARED LASER FREQUENCIES

Arthur Maki

The CO<sub>2</sub> laser has been the subject of a number of very accurate frequency measurements. Most of the earlier measurements are given by Bradley et al.<sup>1</sup> That analysis was based on a single absolute frequency measurement and many laser frequency differences. New measurements of the methane frequency<sup>2-4</sup> have made it necessary to slightly revise that single absolute frequency measurement. In addition, there have been several other absolute frequency measurements<sup>5-7</sup> that have been used here to improve the accuracy of the present tables. New frequency difference measurements have also been added to the database used for the present tables.<sup>8</sup>

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## Frequencies for the 00°1-(10°0,02°0)<sub>I</sub> and 00°1-(10°0,02°0)<sub>II</sub> Bands of <sup>12</sup>C<sup>16</sup>O<sub>2</sub> with the Estimated 2σ Uncertainties

| Band I frequency |               |                   | Band II frequency |               |                   |
|------------------|---------------|-------------------|-------------------|---------------|-------------------|
| Line             | (MHz)         | Uncertainty (MHz) | Line              | (MHz)         | Uncertainty (MHz) |
| P(70)            | 26721305.4647 | 0.1680            | P(70)             | 29789856.3783 | 0.0308            |
| P(68)            | 26794232.6712 | 0.1217            | P(68)             | 29861850.7690 | 0.0192            |
| P(66)            | 26866318.8073 | 0.0867            | P(66)             | 29933216.1760 | 0.0122            |
| P(64)            | 26937571.7234 | 0.0606            | P(64)             | 30003944.2861 | 0.0086            |
| P(62)            | 27007998.9216 | 0.0415            | P(62)             | 30074026.9127 | 0.0072            |
| P(60)            | 27077607.5643 | 0.0279            | P(60)             | 30143456.0039 | 0.0066            |
| P(58)            | 27146404.4834 | 0.0185            | P(58)             | 30212223.6504 | 0.0061            |
| P(56)            | 27214396.1873 | 0.0121            | P(56)             | 30280322.0930 | 0.0055            |
| P(54)            | 27281588.8696 | 0.0081            | P(54)             | 30347743.7306 | 0.0049            |
| P(52)            | 27347988.4161 | 0.0057            | P(52)             | 30414481.1273 | 0.0044            |
| P(50)            | 27413600.4119 | 0.0043            | P(50)             | 30480527.0196 | 0.0041            |
| P(48)            | 27478430.1487 | 0.0036            | P(48)             | 30545874.3239 | 0.0039            |
| P(46)            | 27542482.6310 | 0.0032            | P(46)             | 30610516.1429 | 0.0039            |
| P(44)            | 27605762.5826 | 0.0030            | P(44)             | 30674445.7724 | 0.0039            |
| P(42)            | 27668274.4525 | 0.0028            | P(42)             | 30737656.7080 | 0.0039            |
| P(40)            | 27730022.4206 | 0.0027            | P(40)             | 30800142.6511 | 0.0039            |
| P(38)            | 27791010.4036 | 0.0026            | P(38)             | 30861897.5150 | 0.0038            |
| P(36)            | 27851242.0594 | 0.0025            | P(36)             | 30922915.4310 | 0.0037            |
| P(34)            | 27910720.7927 | 0.0024            | P(34)             | 30983190.7534 | 0.0037            |
| P(32)            | 27969449.7593 | 0.0023            | P(32)             | 31042718.0652 | 0.0037            |
| P(30)            | 28027431.8708 | 0.0022            | P(30)             | 31101492.1833 | 0.0036            |
| P(28)            | 28084669.7981 | 0.0021            | P(28)             | 31159508.1631 | 0.0037            |
| P(26)            | 28141165.9762 | 0.0020            | P(26)             | 31216761.3029 | 0.0037            |
| P(24)            | 28196922.6067 | 0.0019            | P(24)             | 31273247.1487 | 0.0037            |
| P(22)            | 28251941.6622 | 0.0017            | P(22)             | 31328961.4978 | 0.0037            |
| P(20)            | 28306224.8888 | 0.0016            | P(20)             | 31383900.4028 | 0.0037            |
| P(18)            | 28359773.8090 | 0.0014            | P(18)             | 31438060.1749 | 0.0037            |
| P(16)            | 28412589.7245 | 0.0012            | P(16)             | 31491437.3872 | 0.0036            |
| P(14)            | 28464673.7184 | 0.0011            | P(14)             | 31544028.8776 | 0.0036            |
| P(12)            | 28516026.6574 | 0.0009            | P(12)             | 31595831.7516 | 0.0036            |
| P(10)            | 28566649.1935 | 0.0008            | P(10)             | 31646843.3843 | 0.0035            |
| P(8)             | 28616541.7661 | 0.0008            | P(8)              | 31697061.4225 | 0.0035            |
| P(6)             | 28665704.6027 | 0.0008            | P(6)              | 31746483.7868 | 0.0035            |
| P(4)             | 28714137.7205 | 0.0008            | P(4)              | 31795108.6724 | 0.0035            |
| P(2)             | 28761840.9272 | 0.0008            | P(2)              | 31842934.5511 | 0.0035            |
| R(0)             | 28832026.2198 | 0.0008            | R(0)              | 31913172.5691 | 0.0035            |
| R(2)             | 28877902.4382 | 0.0007            | R(2)              | 31958996.0621 | 0.0034            |
| R(4)             | 28923046.4303 | 0.0006            | R(4)              | 32004017.3822 | 0.0034            |

| Line  | Band I frequency<br>(MHz) | Uncertainty (MHz) | Line  | Band II frequency<br>(MHz) | Uncertainty (MHz) |
|-------|---------------------------|-------------------|-------|----------------------------|-------------------|
| R(6)  | 28967457.0657             | 0.0005            | R(6)  | 32048236.2498              | 0.0034            |
| R(8)  | 29011133.0054             | 0.0003            | R(8)  | 32091652.6619              | 0.0034            |
| R(10) | 29054072.7010             | 0.0001            | R(10) | 32134266.8917              | 0.0034            |
| R(12) | 29096274.3935             | 0.0003            | R(12) | 32176079.4878              | 0.0034            |
| R(14) | 29137736.1129             | 0.0005            | R(14) | 32217091.2721              | 0.0035            |
| R(16) | 29178455.6759             | 0.0007            | R(16) | 32257303.3386              | 0.0036            |
| R(18) | 29218430.6852             | 0.0009            | R(18) | 32296717.0510              | 0.0037            |
| R(20) | 29257658.5269             | 0.0010            | R(20) | 32335334.0408              | 0.0038            |
| R(22) | 29296136.3689             | 0.0011            | R(22) | 32373156.2044              | 0.0039            |
| R(24) | 29333861.1583             | 0.0012            | R(24) | 32410185.7003              | 0.0041            |
| R(26) | 29370829.6191             | 0.0011            | R(26) | 32446424.9459              | 0.0042            |
| R(28) | 29407038.2491             | 0.0011            | R(28) | 32481876.6140              | 0.0042            |
| R(30) | 29442483.3168             | 0.0011            | R(30) | 32516543.6293              | 0.0042            |
| R(32) | 29477160.8582             | 0.0012            | R(32) | 32550429.1641              | 0.0042            |
| R(34) | 29511066.6733             | 0.0013            | R(34) | 32583536.6340              | 0.0042            |
| R(36) | 29544196.3221             | 0.0015            | R(36) | 32615869.6937              | 0.0041            |
| R(38) | 29576545.1205             | 0.0017            | R(38) | 32647432.2320              | 0.0040            |
| R(40) | 29608108.1360             | 0.0019            | R(40) | 32678228.3665              | 0.0039            |
| R(42) | 29638880.1831             | 0.0022            | R(42) | 32708262.4386              | 0.0038            |
| R(44) | 29668855.8183             | 0.0024            | R(44) | 32737539.0081              | 0.0039            |
| R(46) | 29698029.3350             | 0.0027            | R(46) | 32766062.8469              | 0.0041            |
| R(48) | 29726394.7582             | 0.0032            | R(48) | 32793838.9334              | 0.0045            |
| R(50) | 29753945.8385             | 0.0037            | R(50) | 32820872.4463              | 0.0055            |
| R(52) | 29780676.0464             | 0.0042            | R(52) | 32847168.7576              | 0.0071            |
| R(54) | 29806578.5659             | 0.0047            | R(54) | 32872733.4269              | 0.0099            |
| R(56) | 29831646.2878             | 0.0052            | R(56) | 32897572.1935              | 0.0141            |
| R(58) | 29855871.8032             | 0.0058            | R(58) | 32921690.9701              | 0.0202            |
| R(60) | 29879247.3960             | 0.0074            | R(60) | 32945095.8355              | 0.0288            |
| R(62) | 29901765.0357             | 0.0113            | R(62) | 32967793.0268              | 0.0407            |
| R(64) | 29923416.3695             | 0.0186            | R(64) | 32989788.9322              | 0.0567            |
| R(66) | 29944192.7145             | 0.0302            | R(66) | 33011090.0831              | 0.0780            |
| R(68) | 29964085.0488             | 0.0475            | R(68) | 33031703.1467              | 0.1060            |
| R(70) | 29983084.0036             | 0.0720            | R(70) | 33051634.9172              | 0.1423            |

**Frequencies for the  $00^{\circ}1-(10^{\circ}0,02^{\circ}0)_I$  and  $00^{\circ}1-(10^{\circ}0,02^{\circ}0)_{II}$  Bands of  $^{13}\text{C}^{16}\text{O}_2$  with the Estimated  $2\sigma$  Uncertainties**

|       |               |        |       |               |        |
|-------|---------------|--------|-------|---------------|--------|
| P(66) | 25523832.1808 | 0.7836 | P(66) | 28512082.5283 | 1.2894 |
| P(64) | 25590013.4703 | 0.5415 | P(64) | 28585121.9396 | 0.9194 |
| P(62) | 25655543.6502 | 0.3629 | P(62) | 28657449.4180 | 0.6420 |
| P(60) | 25720428.2487 | 0.2339 | P(60) | 28729056.6374 | 0.4375 |
| P(58) | 25784672.4840 | 0.1430 | P(58) | 28799935.4147 | 0.2897 |
| P(56) | 25848281.2771 | 0.0810 | P(56) | 28870077.7187 | 0.1853 |
| P(54) | 25911259.2627 | 0.0405 | P(54) | 28939475.6771 | 0.1135 |
| P(52) | 25973610.8005 | 0.0157 | P(52) | 29008121.5846 | 0.0659 |
| P(50) | 26035339.9857 | 0.0045 | P(50) | 29076007.9109 | 0.0357 |
| P(48) | 26096450.6582 | 0.0079 | P(48) | 29143127.3077 | 0.0180 |
| P(46) | 26156946.4123 | 0.0101 | P(46) | 29209472.6164 | 0.0090 |
| P(44) | 26216830.6053 | 0.0101 | P(44) | 29275036.8754 | 0.0058 |
| P(42) | 26276106.3655 | 0.0090 | P(42) | 29339813.3270 | 0.0050 |
| P(40) | 26334776.6003 | 0.0077 | P(40) | 29403795.4243 | 0.0044 |
| P(38) | 26392844.0030 | 0.0068 | P(38) | 29466976.8383 | 0.0037 |
| P(36) | 26450311.0599 | 0.0063 | P(36) | 29529351.4635 | 0.0032 |
| P(34) | 26507180.0565 | 0.0061 | P(34) | 29590913.4252 | 0.0029 |
| P(32) | 26563453.0836 | 0.0060 | P(32) | 29651657.0844 | 0.0028 |
| P(30) | 26619132.0428 | 0.0058 | P(30) | 29711577.0447 | 0.0028 |
| P(28) | 26674218.6515 | 0.0055 | P(28) | 29770668.1566 | 0.0031 |
| P(26) | 26728714.4479 | 0.0054 | P(26) | 29828925.5239 | 0.0035 |
| P(24) | 26782620.7952 | 0.0054 | P(24) | 29886344.5074 | 0.0041 |
| P(22) | 26835938.8858 | 0.0054 | P(22) | 29942920.7308 | 0.0046 |
| P(20) | 26888669.7451 | 0.0055 | P(20) | 29998650.0838 | 0.0051 |
| P(18) | 26940814.2347 | 0.0055 | P(18) | 30053528.7271 | 0.0054 |

| Line  | Band I frequency<br>(MHz) | Uncertainty (MHz) | Line  | Band II frequency<br>(MHz) | Uncertainty (MHz) |
|-------|---------------------------|-------------------|-------|----------------------------|-------------------|
| P(16) | 26992373.0555             | 0.0055            | P(16) | 30107553.0955              | 0.0055            |
| P(14) | 27043346.7508             | 0.0054            | P(14) | 30160719.9016              | 0.0055            |
| P(12) | 27093735.7083             | 0.0052            | P(12) | 30213026.1388              | 0.0054            |
| P(10) | 27143540.1624             | 0.0051            | P(10) | 30264469.0839              | 0.0054            |
| P(8)  | 27192760.1962             | 0.0049            | P(8)  | 30315046.2994              | 0.0054            |
| P(6)  | 27241395.7431             | 0.0048            | P(6)  | 30364755.6359              | 0.0055            |
| P(4)  | 27289446.5880             | 0.0047            | P(4)  | 30413595.2335              | 0.0056            |
| P(2)  | 27336912.3682             | 0.0046            | P(2)  | 30461563.5231              | 0.0057            |
| R(0)  | 27407012.8882             | 0.0045            | P(0)  | 30531879.5415              | 0.0057            |
| R(2)  | 27453013.4589             | 0.0043            | P(2)  | 30577664.6138              | 0.0056            |
| R(4)  | 27498426.5430             | 0.0040            | P(4)  | 30622575.1885              | 0.0054            |
| R(6)  | 27543251.1200             | 0.0037            | P(6)  | 30666611.0128              | 0.0051            |
| R(8)  | 27587486.0225             | 0.0034            | P(8)  | 30709772.1257              | 0.0047            |
| R(10) | 27631129.9356             | 0.0031            | P(10) | 30752058.8571              | 0.0045            |
| R(12) | 27674181.3963             | 0.0029            | P(12) | 30793471.8269              | 0.0044            |
| R(14) | 27716638.7917             | 0.0029            | P(14) | 30834011.9425              | 0.0043            |
| R(16) | 27758500.3577             | 0.0029            | P(16) | 30873680.3976              | 0.0044            |
| R(18) | 27799764.1770             | 0.0029            | P(18) | 30912478.6694              | 0.0044            |
| R(20) | 27840428.1773             | 0.0030            | P(20) | 30950408.5159              | 0.0044            |
| R(22) | 27880490.1283             | 0.0029            | P(22) | 30987471.9732              | 0.0043            |
| R(24) | 27919947.6395             | 0.0029            | P(24) | 31023671.3517              | 0.0042            |
| R(26) | 27958798.1567             | 0.0028            | P(26) | 31059009.2327              | 0.0042            |
| R(28) | 27997038.9591             | 0.0028            | P(28) | 31093488.4642              | 0.0042            |
| R(30) | 28034667.1551             | 0.0027            | P(30) | 31127112.1569              | 0.0043            |
| R(32) | 28071679.6785             | 0.0027            | P(32) | 31159883.6793              | 0.0045            |
| R(34) | 28108073.2842             | 0.0026            | P(34) | 31191806.6529              | 0.0046            |
| R(36) | 28143844.5432             | 0.0026            | P(36) | 31222884.9469              | 0.0048            |
| R(38) | 28178989.8377             | 0.0026            | P(38) | 31253122.6730              | 0.0053            |
| R(40) | 28213505.3554             | 0.0028            | P(40) | 31282524.1795              | 0.0061            |
| R(42) | 28247387.0838             | 0.0033            | P(42) | 31311094.0452              | 0.0077            |
| R(44) | 28280630.8035             | 0.0046            | P(44) | 31338837.0736              | 0.0108            |
| R(46) | 28313232.0818             | 0.0083            | P(46) | 31365758.2858              | 0.0173            |
| R(48) | 28345186.2652             | 0.0161            | P(48) | 31391862.9147              | 0.0295            |
| R(50) | 28376488.4720             | 0.0301            | P(50) | 31417156.3972              | 0.0505            |
| R(52) | 28407133.5839             | 0.0531            | P(52) | 31441644.3679              | 0.0845            |
| R(54) | 28437116.2372             | 0.0887            | P(54) | 31465332.6516              | 0.1366            |
| R(56) | 28466430.8141             | 0.1419            | P(56) | 31488227.2557              | 0.2138            |
| R(58) | 28495071.4324             | 0.2188            | P(58) | 31510334.3631              | 0.3247            |
| R(60) | 28523031.9357             | 0.3271            | P(60) | 31531660.3243              | 0.4800            |
| R(62) | 28550305.8819             | 0.4763            | P(62) | 31552211.6497              | 0.6932            |
| R(64) | 28576886.5323             | 0.6781            | P(64) | 31571995.0017              | 0.9805            |
| R(66) | 28602766.8393             | 0.9467            | P(66) | 31591017.1868              | 1.3619            |

**Frequencies for the  $00^{\circ}1-(10^{\circ}0,02^{\circ}0)_I$  and  $00^{\circ}1-(10^{\circ}0,02^{\circ}0)_{II}$  Bands of  $^{12}\text{C}^{18}\text{O}_2$  with the Estimated  $2\sigma$  Uncertainties**

|       |               |        |       |               |        |
|-------|---------------|--------|-------|---------------|--------|
| P(70) | 27045326.3119 | 0.4540 | P(70) | 30695237.5856 | 0.0858 |
| P(68) | 27114914.0922 | 0.3324 | P(68) | 30755520.2231 | 0.0570 |
| P(66) | 27183635.7945 | 0.2392 | P(66) | 30815311.4928 | 0.0364 |
| P(64) | 27251496.4118 | 0.1688 | P(64) | 30874607.2084 | 0.0223 |
| P(62) | 27318500.7361 | 0.1165 | P(62) | 30933403.2309 | 0.0131 |
| P(60) | 27384653.3618 | 0.0783 | P(60) | 30991695.4724 | 0.0075 |
| P(58) | 27449958.6881 | 0.0510 | P(58) | 31049479.9009 | 0.0049 |
| P(56) | 27514420.9224 | 0.0319 | P(56) | 31106752.5446 | 0.0041 |
| P(54) | 27578044.0828 | 0.0191 | P(54) | 31163509.4964 | 0.0040 |
| P(52) | 27640832.0010 | 0.0108 | P(52) | 31219746.9183 | 0.0040 |
| P(50) | 27702788.3248 | 0.0059 | P(50) | 31275461.0455 | 0.0039 |
| P(48) | 27763916.5206 | 0.0035 | P(48) | 31330648.1908 | 0.0039 |
| P(46) | 27824219.8762 | 0.0028 | P(46) | 31385304.7490 | 0.0039 |
| P(44) | 27883701.5029 | 0.0026 | P(44) | 31439427.2006 | 0.0039 |
| P(42) | 27942364.3379 | 0.0025 | P(42) | 31493012.1163 | 0.0038 |
| P(40) | 28000211.1464 | 0.0024 | P(40) | 31546056.1605 | 0.0038 |

| Line  | Band I frequency<br>(MHz) | Uncertainty (MHz) | Line  | Band II frequency<br>(MHz) | Uncertainty (MHz) |
|-------|---------------------------|-------------------|-------|----------------------------|-------------------|
| P(38) | 28057244.5242             | 0.0022            | P(38) | 31598556.0954              | 0.0037            |
| P(36) | 28113466.8992             | 0.0021            | P(36) | 31650508.7847              | 0.0037            |
| P(34) | 28168880.5335             | 0.0020            | P(34) | 31701911.1970              | 0.0037            |
| P(32) | 28223487.5256             | 0.0019            | P(32) | 31752760.4093              | 0.0037            |
| P(30) | 28277289.8118             | 0.0017            | P(30) | 31803053.6105              | 0.0037            |
| P(28) | 28330289.1679             | 0.0016            | P(28) | 31852788.1043              | 0.0038            |
| P(26) | 28382487.2111             | 0.0015            | P(26) | 31901961.3125              | 0.0038            |
| P(24) | 28433885.4012             | 0.0013            | P(24) | 31950570.7773              | 0.0038            |
| P(22) | 28484485.0420             | 0.0012            | P(22) | 31998614.1649              | 0.0038            |
| P(20) | 28534287.2828             | 0.0011            | P(20) | 32046089.2669              | 0.0037            |
| P(18) | 28583293.1193             | 0.0010            | P(18) | 32092994.0036              | 0.0037            |
| P(16) | 28631503.3952             | 0.0010            | P(16) | 32139326.4254              | 0.0036            |
| P(14) | 28678918.8025             | 0.0009            | P(14) | 32185084.7154              | 0.0036            |
| P(12) | 28725539.8830             | 0.0010            | P(12) | 32230267.1907              | 0.0036            |
| P(10) | 28771367.0288             | 0.0010            | P(10) | 32274872.3041              | 0.0037            |
| P(8)  | 28816400.4829             | 0.0010            | P(8)  | 32318898.6455              | 0.0038            |
| P(6)  | 28860640.3403             | 0.0011            | P(6)  | 32362344.9434              | 0.0039            |
| P(4)  | 28904086.5477             | 0.0011            | P(4)  | 32405210.0652              | 0.0041            |
| P(2)  | 28946738.9048             | 0.0011            | P(2)  | 32447493.0185              | 0.0041            |
| R(0)  | 29009228.1702             | 0.0010            | P(0)  | 32509824.0580              | 0.0042            |
| R(2)  | 29049894.0586             | 0.0010            | P(2)  | 32550648.1723              | 0.0042            |
| R(4)  | 29089764.2368             | 0.0009            | P(4)  | 32590887.7542              | 0.0042            |
| R(6)  | 29128837.8426             | 0.0008            | P(6)  | 32630542.4457              | 0.0041            |
| R(8)  | 29167113.8668             | 0.0008            | P(8)  | 32669612.0295              | 0.0041            |
| R(10) | 29204591.1529             | 0.0009            | P(10) | 32708096.4282              | 0.0040            |
| R(12) | 29241268.3964             | 0.0010            | P(12) | 32745995.7040              | 0.0040            |
| R(14) | 29277144.1444             | 0.0011            | P(14) | 32783310.0573              | 0.0040            |
| R(16) | 29312216.7955             | 0.0012            | P(16) | 32820039.8258              | 0.0040            |
| R(18) | 29346484.5984             | 0.0012            | P(18) | 32856185.4827              | 0.0040            |
| R(20) | 29379945.6517             | 0.0013            | P(20) | 32891747.6358              | 0.0040            |
| R(22) | 29412597.9024             | 0.0013            | P(22) | 32926727.0254              | 0.0040            |
| R(24) | 29444439.1458             | 0.0013            | P(24) | 32961124.5220              | 0.0040            |
| R(26) | 29475467.0236             | 0.0014            | P(26) | 32994941.1249              | 0.0040            |
| R(28) | 29505679.0230             | 0.0015            | P(28) | 33028177.9594              | 0.0040            |
| R(30) | 29535072.4755             | 0.0016            | P(30) | 33060836.2743              | 0.0040            |
| R(32) | 29563644.5557             | 0.0018            | P(32) | 33092917.4394              | 0.0041            |
| R(34) | 29591392.2794             | 0.0020            | P(34) | 33124422.9429              | 0.0043            |
| R(36) | 29618312.5023             | 0.0023            | P(36) | 33155354.3878              | 0.0046            |
| R(38) | 29644401.9182             | 0.0028            | P(38) | 33185713.4894              | 0.0049            |
| R(40) | 29669657.0575             | 0.0036            | P(40) | 33215502.0716              | 0.0056            |
| R(42) | 29694074.2853             | 0.0053            | P(42) | 33244722.0637              | 0.0068            |
| R(44) | 29717649.7992             | 0.0082            | P(44) | 33273375.4969              | 0.0092            |
| R(46) | 29740379.6276             | 0.0128            | P(46) | 33301464.5003              | 0.0134            |
| R(48) | 29762259.6274             | 0.0200            | P(48) | 33328991.2976              | 0.0199            |
| R(50) | 29783285.4820             | 0.0307            | P(50) | 33355958.2027              | 0.0294            |
| R(52) | 29803452.6988             | 0.0461            | P(52) | 33382367.6161              | 0.0427            |
| R(54) | 29822756.6072             | 0.0681            | P(54) | 33408222.0209              | 0.0607            |
| R(56) | 29841192.3558             | 0.0985            | P(56) | 33433523.9780              | 0.0848            |
| R(58) | 29858754.9100             | 0.1401            | P(58) | 33458276.1228              | 0.1165            |
| R(60) | 29875439.0495             | 0.1960            | P(60) | 33482481.1601              | 0.1576            |
| R(62) | 29891239.3658             | 0.2702            | P(62) | 33506141.8605              | 0.2104            |
| R(64) | 29906150.2589             | 0.3673            | P(64) | 33529261.0556              | 0.2775            |
| R(66) | 29920165.9352             | 0.4930            | P(66) | 33551841.6335              | 0.3621            |
| R(68) | 29933280.4042             | 0.6540            | P(68) | 33573886.5352              | 0.4679            |
| R(70) | 29945487.4756             | 0.8581            | P(70) | 33595398.7493              | 0.5992            |

**Frequencies for the  $00^{\circ}1-(10^{\circ}0,02^{\circ}0)_I$  and  $00^{\circ}1-(10^{\circ}0,02^{\circ}0)_{II}$  Bands of  $^{13}\text{C}^{18}\text{O}_2$  with the Estimated  $2\sigma$  Uncertainties**

|       |               |        |       |               |        |
|-------|---------------|--------|-------|---------------|--------|
| P(70) | 25967863.7652 | 1.1146 | P(70) | 28960476.2278 | 0.4069 |
| P(68) | 26033448.2798 | 0.8152 | P(68) | 29022326.9578 | 0.2861 |
| P(66) | 26098273.9159 | 0.5860 | P(66) | 29083661.3546 | 0.1961 |

| Line  | Band I frequency<br>(MHz) | Uncertainty (MHz) | Line  | Band II frequency<br>(MHz) | Uncertainty (MHz) |
|-------|---------------------------|-------------------|-------|----------------------------|-------------------|
| P(64) | 26162346.4813             | 0.4129            | P(64) | 29144473.5795              | 0.1303            |
| P(62) | 26225671.5466             | 0.2844            | P(62) | 29204757.8761              | 0.0833            |
| P(60) | 26288254.4494             | 0.1906            | P(60) | 29264508.5768              | 0.0507            |
| P(58) | 26350100.2984             | 0.1237            | P(58) | 29323720.1086              | 0.0290            |
| P(56) | 26411213.9778             | 0.0772            | P(56) | 29382386.9988              | 0.0152            |
| P(54) | 26471600.1504             | 0.0459            | P(54) | 29440503.8809              | 0.0073            |
| P(52) | 26531263.2618             | 0.0258            | P(52) | 29498065.4997              | 0.0038            |
| P(50) | 26590207.5442             | 0.0138            | P(50) | 29555066.7172              | 0.0032            |
| P(48) | 26648437.0195             | 0.0077            | P(48) | 29611502.5178              | 0.0031            |
| P(46) | 26705955.5026             | 0.0057            | P(46) | 29667368.0132              | 0.0031            |
| P(44) | 26762766.6051             | 0.0055            | P(44) | 29722658.4475              | 0.0034            |
| P(42) | 26818873.7378             | 0.0055            | P(42) | 29777369.2022              | 0.0039            |
| P(40) | 26874280.1143             | 0.0056            | P(40) | 29831495.8006              | 0.0044            |
| P(38) | 26928988.7531             | 0.0056            | P(38) | 29885033.9125              | 0.0049            |
| P(36) | 26983002.4809             | 0.0056            | P(36) | 29937979.3584              | 0.0053            |
| P(34) | 27036323.9351             | 0.0055            | P(34) | 29990328.1139              | 0.0054            |
| P(32) | 27088955.5657             | 0.0054            | P(32) | 30042076.3132              | 0.0055            |
| P(30) | 27140899.6384             | 0.0051            | P(30) | 30093220.2534              | 0.0055            |
| P(28) | 27192158.2363             | 0.0049            | P(28) | 30143756.3978              | 0.0054            |
| P(26) | 27242733.2620             | 0.0047            | P(26) | 30193681.3793              | 0.0053            |
| P(24) | 27292626.4396             | 0.0044            | P(24) | 30242992.0038              | 0.0052            |
| P(22) | 27341839.3165             | 0.0042            | P(22) | 30291685.2529              | 0.0051            |
| P(20) | 27390373.2651             | 0.0040            | P(20) | 30339758.2870              | 0.0049            |
| P(18) | 27438229.4843             | 0.0037            | P(18) | 30387208.4477              | 0.0048            |
| P(16) | 27485409.0008             | 0.0035            | P(16) | 30434033.2603              | 0.0046            |
| P(14) | 27531912.6704             | 0.0033            | P(14) | 30480230.4356              | 0.0045            |
| P(12) | 27577741.1795             | 0.0031            | P(12) | 30525797.8725              | 0.0044            |
| P(10) | 27622895.0455             | 0.0031            | P(10) | 30570733.6593              | 0.0043            |
| P(8)  | 27667374.6182             | 0.0031            | P(8)  | 30615036.0750              | 0.0043            |
| P(6)  | 27711180.0803             | 0.0033            | P(6)  | 30658703.5912              | 0.0044            |
| P(4)  | 27754311.4480             | 0.0034            | P(4)  | 30701734.8727              | 0.0045            |
| P(2)  | 27796768.5718             | 0.0036            | P(2)  | 30744128.7785              | 0.0045            |
| R(0)  | 27859189.3155             | 0.0036            | P(0)  | 30806522.5414              | 0.0045            |
| R(2)  | 27899959.0889             | 0.0035            | P(2)  | 30847319.2956              | 0.0044            |
| R(4)  | 27940052.7921             | 0.0033            | P(4)  | 30887476.2168              | 0.0043            |
| R(6)  | 27979469.5315             | 0.0031            | P(6)  | 30926993.0424              | 0.0042            |
| R(8)  | 28018208.2478             | 0.0028            | P(8)  | 30965869.7046              | 0.0041            |
| R(10) | 28056267.7161             | 0.0026            | P(10) | 31004106.3298              | 0.0040            |
| R(12) | 28093646.5448             | 0.0025            | P(12) | 31041703.2379              | 0.0040            |
| R(14) | 28130343.1757             | 0.0025            | P(14) | 31078660.9408              | 0.0040            |
| R(16) | 28166355.8825             | 0.0025            | P(16) | 31114980.1420              | 0.0040            |
| R(18) | 28201682.7706             | 0.0025            | P(18) | 31150661.7340              | 0.0041            |
| R(20) | 28236321.7757             | 0.0025            | P(20) | 31185706.7976              | 0.0042            |
| R(22) | 28270270.6628             | 0.0024            | P(22) | 31220116.5992              | 0.0043            |
| R(24) | 28303527.0249             | 0.0024            | P(24) | 31253892.5891              | 0.0043            |
| R(26) | 28336088.2817             | 0.0023            | P(26) | 31287036.3991              | 0.0044            |
| R(28) | 28367951.6781             | 0.0024            | P(28) | 31319549.8396              | 0.0043            |
| R(30) | 28399114.2823             | 0.0025            | P(30) | 31351434.8973              | 0.0043            |
| R(32) | 28429572.9843             | 0.0026            | P(32) | 31382693.7318              | 0.0042            |
| R(34) | 28459324.4940             | 0.0028            | P(34) | 31413328.6728              | 0.0042            |
| R(36) | 28488365.3390             | 0.0029            | P(36) | 31443342.2165              | 0.0041            |
| R(38) | 28516691.8625             | 0.0029            | P(38) | 31472737.0219              | 0.0040            |
| R(40) | 28544300.2211             | 0.0031            | P(40) | 31501515.9074              | 0.0039            |
| R(42) | 28571186.3823             | 0.0032            | P(42) | 31529681.8467              | 0.0040            |
| R(44) | 28597346.1222             | 0.0032            | P(44) | 31557237.9646              | 0.0042            |
| R(46) | 28622775.0223             | 0.0038            | P(46) | 31584187.5329              | 0.0046            |
| R(48) | 28647468.4672             | 0.0071            | P(48) | 31610533.9656              | 0.0057            |
| R(50) | 28671421.6417             | 0.0148            | P(50) | 31636280.8146              | 0.0088            |
| R(52) | 28694629.5272             | 0.0286            | P(52) | 31661431.7650              | 0.0151            |
| R(54) | 28717086.8993             | 0.0510            | P(54) | 31685990.6298              | 0.0261            |
| R(56) | 28738788.3239             | 0.0852            | P(56) | 31709961.3449              | 0.0434            |



| Line  | Band I frequency<br>(MHz) | Uncertainty (MHz) | Line  | Band II frequency<br>(MHz) | Uncertainty (MHz) |
|-------|---------------------------|-------------------|-------|----------------------------|-------------------|
| R(58) | 28759728.1540             | 0.1355            | P(58) | 31733347.9642              | 0.0693            |
| R(60) | 28779900.5263             | 0.2075            | P(60) | 31756154.6537              | 0.1068            |
| R(62) | 28799299.3572             | 0.3078            | P(62) | 31778385.6867              | 0.1594            |
| R(64) | 28817918.3393             | 0.4447            | P(64) | 31800045.4375              | 0.2317            |
| R(66) | 28835750.9374             | 0.6283            | P(66) | 31821138.3761              | 0.3291            |
| R(68) | 28852790.3843             | 0.8707            | P(68) | 31841669.0622              | 0.4581            |
| R(70) | 28869029.6768             | 1.1863            | P(70) | 31861642.1394              | 0.6268            |

**Frequencies for the  $01^{1^c}1-(11^{1^c}0,03^{1^c}0)_I$  and  $01^{1^c}1-(11^{1^c}0,03^{1^c}0)_{II}$  Bands of  $^{12}C^{16}O_2$  with the Estimated  $2\sigma$  Uncertainties**

|       |               |        |       |               |        |
|-------|---------------|--------|-------|---------------|--------|
| P(59) | 26125213.2723 | 1.6633 | P(59) | 30427055.2899 | 0.1962 |
| P(57) | 26191576.6703 | 1.0880 | P(57) | 30494640.3229 | 0.1332 |
| P(55) | 26257240.7898 | 0.6844 | P(55) | 30561557.5929 | 0.0865 |
| P(53) | 26322208.2302 | 0.4094 | P(53) | 30627802.0344 | 0.0530 |
| P(51) | 26386481.4313 | 0.2286 | P(51) | 30693368.7014 | 0.0306 |
| P(49) | 26450062.6783 | 0.1155 | P(49) | 30758252.7710 | 0.0175 |
| P(47) | 26512954.1076 | 0.0498 | P(47) | 30822449.5469 | 0.0123 |
| P(45) | 26575157.7109 | 0.0191 | P(45) | 30885954.4624 | 0.0114 |
| P(43) | 26636675.3402 | 0.0160 | P(43) | 30948763.0834 | 0.0109 |
| P(41) | 26697508.7115 | 0.0182 | P(41) | 31010871.1119 | 0.0100 |
| P(39) | 26757659.4084 | 0.0177 | P(39) | 31072274.3882 | 0.0091 |
| P(37) | 26817128.8857 | 0.0160 | P(37) | 31132968.8940 | 0.0091 |
| P(35) | 26875918.4726 | 0.0144 | P(35) | 31192950.7549 | 0.0102 |
| P(33) | 26934029.3751 | 0.0131 | P(33) | 31252216.2430 | 0.0118 |
| P(31) | 26991462.6787 | 0.0119 | P(31) | 31310761.7788 | 0.0134 |
| P(29) | 27048219.3509 | 0.0106 | P(29) | 31368583.9339 | 0.0147 |
| P(27) | 27104300.2431 | 0.0096 | P(27) | 31425679.4328 | 0.0155 |
| P(25) | 27159706.0925 | 0.0093 | P(25) | 31482045.1550 | 0.0157 |
| P(23) | 27214437.5237 | 0.0097 | P(23) | 31537678.1367 | 0.0154 |
| P(21) | 27268495.0505 | 0.0104 | P(21) | 31592575.5725 | 0.0147 |
| P(19) | 27321879.0769 | 0.0108 | P(19) | 31646734.8172 | 0.0137 |
| P(17) | 27374589.8987 | 0.0108 | P(17) | 31700153.3868 | 0.0127 |
| P(15) | 27426627.7040 | 0.0104 | P(15) | 31752828.9602 | 0.0119 |
| P(13) | 27477992.5747 | 0.0098 | P(13) | 31804759.3803 | 0.0113 |
| P(11) | 27528684.4867 | 0.0096 | P(11) | 31855942.6551 | 0.0113 |
| P(9)  | 27578703.3113 | 0.0101 | P(9)  | 31906376.9582 | 0.0116 |
| P(7)  | 27628048.8151 | 0.0113 | P(7)  | 31956060.6304 | 0.0122 |
| P(5)  | 27676720.6609 | 0.0127 | P(5)  | 32004992.1796 | 0.0129 |
| P(3)  | 27724718.4080 | 0.0141 | P(3)  | 32053170.2819 | 0.0136 |
| R(1)  | 27841759.7696 | 0.0152 | P(1)  | 32170312.0391 | 0.0149 |
| R(3)  | 27887393.2105 | 0.0146 | P(3)  | 32215845.0845 | 0.0151 |
| R(5)  | 27932349.2934 | 0.0135 | P(5)  | 32260620.8121 | 0.0152 |
| R(7)  | 27976627.0108 | 0.0124 | P(7)  | 32304638.8261 | 0.0152 |
| R(9)  | 28020225.2521 | 0.0115 | P(9)  | 32347898.8990 | 0.0150 |
| R(11) | 28063142.8031 | 0.0110 | P(11) | 32390400.9714 | 0.0148 |
| R(13) | 28105378.3457 | 0.0109 | P(13) | 32432145.1513 | 0.0145 |
| R(15) | 28146930.4576 | 0.0109 | P(15) | 32473131.7137 | 0.0142 |
| R(17) | 28187797.6116 | 0.0107 | P(17) | 32513361.0997 | 0.0140 |
| R(19) | 28227978.1750 | 0.0103 | P(19) | 32552833.9153 | 0.0140 |
| R(21) | 28267470.4088 | 0.0099 | P(21) | 32591550.9309 | 0.0141 |
| R(23) | 28306272.4666 | 0.0099 | P(23) | 32629513.0796 | 0.0143 |
| R(25) | 28344382.3939 | 0.0107 | P(25) | 32666721.4564 | 0.0144 |
| R(27) | 28381798.1267 | 0.0122 | P(27) | 32703177.3164 | 0.0142 |
| R(29) | 28418517.4902 | 0.0141 | P(29) | 32738882.0732 | 0.0136 |
| R(31) | 28454538.1976 | 0.0165 | P(31) | 32773837.2976 | 0.0136 |
| R(33) | 28489857.8477 | 0.0213 | P(33) | 32808044.7156 | 0.0174 |
| R(35) | 28524473.9240 | 0.0312 | P(35) | 32841506.2063 | 0.0279 |
| R(37) | 28558383.7917 | 0.0486 | P(37) | 32874223.8000 | 0.0462 |
| R(39) | 28591584.6963 | 0.0754 | P(39) | 32906199.6761 | 0.0735 |
| R(41) | 28624073.7602 | 0.1131 | P(41) | 32937436.1606 | 0.1114 |
| R(43) | 28655847.9806 | 0.1644 | P(43) | 32967935.7238 | 0.1624 |
| R(45) | 28686904.2261 | 0.2328 | P(45) | 32997700.9775 | 0.2292 |



| Line  | Band I frequency<br>(MHz) | Uncertainty (MHz) | Line  | Band II frequency<br>(MHz) | Uncertainty (MHz) |
|-------|---------------------------|-------------------|-------|----------------------------|-------------------|
| R(47) | 28717239.2334             | 0.3239            | P(47) | 33026734.6728              | 0.3151            |
| R(49) | 28746849.6038             | 0.4465            | P(49) | 33055039.6965              | 0.4238            |
| R(51) | 28775731.7988             | 0.6142            | P(51) | 33082619.0689              | 0.5595            |
| R(53) | 28803882.1361             | 0.8465            | P(53) | 33109475.9403              | 0.7272            |

**Frequencies for the  $01^{16}1-(11^{16}0,03^{16}0)_I$  and  $01^{16}1-(11^{16}0,03^{16}0)_{II}$  Bands of  $^{12}C^{16}O_2$  with the Estimated  $2\sigma$  Uncertainties**

|       |               |        |       |               |        |
|-------|---------------|--------|-------|---------------|--------|
| P(60) | 26051570.0104 | 4.4521 | P(60) | 30355115.0204 | 0.2752 |
| P(58) | 26120964.4932 | 3.0629 | P(58) | 30425283.5969 | 0.1926 |
| P(56) | 26189552.8496 | 2.0516 | P(56) | 30494732.8293 | 0.1301 |
| P(54) | 26257339.6006 | 1.3305 | P(54) | 30563455.6325 | 0.0840 |
| P(52) | 26324329.0344 | 0.8289 | P(52) | 30631445.1076 | 0.0512 |
| P(50) | 26390525.2136 | 0.4901 | P(50) | 30698694.5456 | 0.0292 |
| P(48) | 26455931.9824 | 0.2698 | P(48) | 30765197.4310 | 0.0163 |
| P(46) | 26520552.9722 | 0.1334 | P(46) | 30830947.4444 | 0.0111 |
| P(44) | 26584391.6075 | 0.0551 | P(44) | 30895938.4662 | 0.0104 |
| P(42) | 26647451.1105 | 0.0181 | P(42) | 30960164.5794 | 0.0105 |
| P(40) | 26709734.5057 | 0.0151 | P(40) | 31023620.0723 | 0.0105 |
| P(38) | 26771244.6242 | 0.0174 | P(38) | 31086299.4415 | 0.0107 |
| P(36) | 26831984.1067 | 0.0157 | P(36) | 31148197.3941 | 0.0114 |
| P(34) | 26891955.4069 | 0.0126 | P(34) | 31209308.8510 | 0.0126 |
| P(32) | 26951160.7945 | 0.0105 | P(32) | 31269628.9481 | 0.0138 |
| P(30) | 27009602.3576 | 0.0096 | P(30) | 31329153.0395 | 0.0147 |
| P(28) | 27067282.0045 | 0.0092 | P(28) | 31387876.6994 | 0.0151 |
| P(26) | 27124201.4662 | 0.0090 | P(26) | 31445795.7236 | 0.0149 |
| P(24) | 27180362.2977 | 0.0089 | P(24) | 31502906.1318 | 0.0141 |
| P(22) | 27235765.8792 | 0.0090 | P(22) | 31559204.1695 | 0.0128 |
| P(20) | 27290413.4182 | 0.0093 | P(20) | 31614686.3091 | 0.0113 |
| P(18) | 27344305.9494 | 0.0096 | P(18) | 31669349.2515 | 0.0098 |
| P(16) | 27397444.3368 | 0.0097 | P(16) | 31723189.9280 | 0.0086 |
| P(14) | 27449829.2733 | 0.0096 | P(14) | 31776205.5007 | 0.0081 |
| P(12) | 27501461.2824 | 0.0096 | P(12) | 31828393.3642 | 0.0085 |
| P(10) | 27552340.7179 | 0.0101 | P(10) | 31879751.1463 | 0.0095 |
| P(8)  | 27602467.7649 | 0.0111 | P(8)  | 31930276.7092 | 0.0107 |
| P(6)  | 27651842.4399 | 0.0125 | P(6)  | 31979968.1497 | 0.0120 |
| P(4)  | 27700464.5912 | 0.0139 | P(4)  | 32028823.8002 | 0.0131 |
| P(2)  | 27748333.8988 | 0.0148 | P(2)  | 32076842.2290 | 0.0139 |
| R(2)  | 27864709.8633 | 0.0146 | P(2)  | 32193218.1935 | 0.0150 |
| R(4)  | 27909939.2762 | 0.0135 | P(4)  | 32238298.4853 | 0.0151 |
| R(6)  | 27954412.3294 | 0.0122 | P(6)  | 32282538.0393 | 0.0153 |
| R(8)  | 27998127.7801 | 0.0112 | P(8)  | 32325936.7244 | 0.0153 |
| R(10) | 28041084.2173 | 0.0107 | P(10) | 32368494.6458 | 0.0154 |
| R(12) | 28083280.0620 | 0.0108 | P(12) | 32410212.1438 | 0.0155 |
| R(14) | 28124713.5668 | 0.0110 | P(14) | 32451089.7941 | 0.0155 |
| R(16) | 28165382.8151 | 0.0112 | P(16) | 32491128.4063 | 0.0154 |
| R(18) | 28205285.7213 | 0.0111 | P(18) | 32530329.0234 | 0.0152 |
| R(20) | 28244420.0302 | 0.0110 | P(20) | 32568692.9211 | 0.0149 |
| R(22) | 28282783.3158 | 0.0114 | P(22) | 32606221.6061 | 0.0147 |
| R(24) | 28320372.9812 | 0.0129 | P(24) | 32642916.8154 | 0.0144 |
| R(26) | 28357186.2574 | 0.0149 | P(26) | 32678780.5147 | 0.0140 |
| R(28) | 28393220.2023 | 0.0168 | P(28) | 32713814.8971 | 0.0133 |
| R(30) | 28428471.6994 | 0.0175 | P(30) | 32748022.3813 | 0.0120 |
| R(32) | 28462937.4565 | 0.0165 | P(32) | 32781405.6101 | 0.0106 |
| R(34) | 28496614.0042 | 0.0142 | P(34) | 32813967.4482 | 0.0122 |
| R(36) | 28529497.6934 | 0.0163 | P(36) | 32845710.9809 | 0.0212 |
| R(38) | 28561584.6939 | 0.0309 | P(38) | 32876639.5111 | 0.0385 |
| R(40) | 28592870.9914 | 0.0593 | P(40) | 32906756.5580 | 0.0646 |
| R(42) | 28623352.3850 | 0.1054 | P(42) | 32936065.8540 | 0.1015 |
| R(44) | 28653024.4839 | 0.1779 | P(44) | 32964571.3426 | 0.1518 |
| R(46) | 28681882.7038 | 0.2907 | P(46) | 32992277.1760 | 0.2184 |
| R(48) | 28709922.2632 | 0.4635 | P(48) | 33019187.7118 | 0.3048 |
| R(50) | 28737138.1785 | 0.7231 | P(50) | 33045307.5105 | 0.4152 |

# INFRARED AND FAR-INFRARED ABSORPTION FREQUENCY STANDARDS

Arthur Maki

Aside from the CO<sub>2</sub> laser transitions, the absorption spectrum of CO has been more accurately and thoroughly measured than any other spectrum. A bibliography of earlier measurements on CO is given by Maki and Wells,<sup>1</sup> and the present tables were calculated from the measurements referred to in that work. In addition, some new and very accurate frequency measurements<sup>2,3</sup> have been made and were incorporated in the present tables. The frequencies of the rotational transitions of HF and HCl were calculated from constants obtained from fitting the measurements of Evenson et al.<sup>4,5</sup> and Jennings and Wells.<sup>6</sup>

A new report on infrared wavenumber standards from the International Union of Pure and Applied Chemistry, Commission on Molecular Structure and Spectroscopy, may be found in Reference 7.

## References

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## Wavenumbers for the $\nu = 1 - 0$ Band of CO

| Wavenumber (unc)*/cm <sup>-1</sup> | Transition | Wavenumber (unc)/cm <sup>-1</sup> | Transition |
|------------------------------------|------------|-----------------------------------|------------|
| 2139.426071(01)                    | P(1)       | 2147.081132(01)                   | R(0)       |
| 2135.546178(01)                    | P(2)       | 2150.856006(01)                   | R(1)       |
| 2131.631574(01)                    | P(3)       | 2154.595581(01)                   | R(2)       |
| 2127.682404(01)                    | P(4)       | 2158.299710(01)                   | R(3)       |
| 2123.698816(01)                    | P(5)       | 2161.968245(01)                   | R(4)       |
| 2119.680957(01)                    | P(6)       | 2165.601041(01)                   | R(5)       |
| 2115.628973(01)                    | P(7)       | 2169.197949(01)                   | R(6)       |
| 2111.543012(01)                    | P(8)       | 2172.758824(01)                   | R(7)       |
| 2107.423221(01)                    | P(9)       | 2176.283519(01)                   | R(8)       |
| 2103.269746(01)                    | P(10)      | 2179.771887(01)                   | R(9)       |
| 2099.082734(01)                    | P(11)      | 2183.223782(01)                   | R(10)      |
| 2094.862333(01)                    | P(12)      | 2186.639057(01)                   | R(11)      |
| 2090.608688(01)                    | P(13)      | 2190.017565(01)                   | R(12)      |
| 2086.321947(01)                    | P(14)      | 2193.359161(01)                   | R(13)      |
| 2082.002256(01)                    | P(15)      | 2196.663698(01)                   | R(14)      |
| 2077.649762(01)                    | P(16)      | 2199.931030(01)                   | R(15)      |
| 2073.264612(01)                    | P(17)      | 2203.161010(01)                   | R(16)      |
| 2068.846952(01)                    | P(18)      | 2206.353492(01)                   | R(17)      |
| 2064.396929(01)                    | P(19)      | 2209.508331(02)                   | R(18)      |
| 2059.914688(02)                    | P(20)      | 2212.625379(02)                   | R(19)      |
| 2055.400377(02)                    | P(21)      | 2215.704492(02)                   | R(20)      |
| 2050.854140(02)                    | P(22)      | 2218.745522(02)                   | R(21)      |
| 2046.276126(03)                    | P(23)      | 2221.748326(03)                   | R(22)      |
| 2041.666479(03)                    | P(24)      | 2224.712755(03)                   | R(23)      |
| 2037.025345(03)                    | P(25)      | 2227.638666(03)                   | R(24)      |
| 2032.352870(04)                    | P(26)      | 2230.525912(04)                   | R(25)      |
| 2027.649200(04)                    | P(27)      | 2233.374349(04)                   | R(26)      |
| 2022.914480(04)                    | P(28)      | 2236.183829(04)                   | R(27)      |
| 2018.148857(05)                    | P(29)      | 2238.954210(05)                   | R(28)      |
| 2013.352474(05)                    | P(30)      | 2241.685344(05)                   | R(29)      |
| 2008.525477(06)                    | P(31)      | 2244.377088(06)                   | R(30)      |
| 2003.668012(06)                    | P(32)      | 2247.029296(07)                   | R(31)      |
| 1998.780224(07)                    | P(33)      | 2249.641824(08)                   | R(32)      |
| 1993.862257(09)                    | P(34)      | 2252.214527(10)                   | R(33)      |
| 1988.914257(11)                    | P(35)      | 2254.747262(14)                   | R(34)      |
| 1983.936367(14)                    | P(36)      | 2257.239883(18)                   | R(35)      |
| 1978.928733(18)                    | P(37)      | 2259.692248(24)                   | R(36)      |
| 1973.891500(25)                    | P(38)      | 2262.104213(33)                   | R(37)      |
|                                    |            | 2264.475634(45)                   | R(38)      |

**Wavenumbers for the  $\nu = 1 - 0$  Band of CO**

| Wavenumber (unc)*/cm <sup>-1</sup> | Transition | Wavenumber (unc)/cm <sup>-1</sup> | Transition |
|------------------------------------|------------|-----------------------------------|------------|
| 1968.824811(34)                    | P(39)      | 2266.806368(61)                   | R(39)      |
| 1963.728813(46)                    | P(40)      | 2269.096273(81)                   | R(40)      |
| 1958.603648(61)                    | P(41)      | 2271.345206(106)                  | R(41)      |
| 1953.449462(82)                    | P(42)      | 2273.553027(139)                  | R(42)      |

\* The uncertainty in the last digits (twice the standard error) is given in parentheses.

**Wavenumbers for the  $\nu = 2 - 0$  Band of CO**

| Wavenumber (unc)*/cm <sup>-1</sup> | Transition | Wavenumber (unc)/cm <sup>-1</sup> | Transition |
|------------------------------------|------------|-----------------------------------|------------|
|                                    |            | 4263.837198(02)                   | R(0)       |
| 4256.217140(02)                    | P(1)       | 4267.542066(02)                   | R(1)       |
| 4252.302244(02)                    | P(2)       | 4271.176630(02)                   | R(2)       |
| 4248.317633(02)                    | P(3)       | 4274.740746(02)                   | R(3)       |
| 4244.263453(02)                    | P(4)       | 4278.234264(02)                   | R(4)       |
| 4240.139852(02)                    | P(5)       | 4281.657039(02)                   | R(5)       |
| 4235.946975(02)                    | P(6)       | 4285.008924(02)                   | R(6)       |
| 4231.684972(02)                    | P(7)       | 4288.289772(02)                   | R(7)       |
| 4227.353987(02)                    | P(8)       | 4291.499437(02)                   | R(8)       |
| 4222.954169(02)                    | P(9)       | 4294.637773(02)                   | R(9)       |
| 4218.485665(02)                    | P(10)      | 4297.704631(02)                   | R(10)      |
| 4213.948620(02)                    | P(11)      | 4300.699868(02)                   | R(11)      |
| 4209.343182(02)                    | P(12)      | 4303.623334(02)                   | R(12)      |
| 4204.669499(02)                    | P(13)      | 4306.474886(02)                   | R(13)      |
| 4199.927716(02)                    | P(14)      | 4309.254375(02)                   | R(14)      |
| 4195.117980(02)                    | P(15)      | 4311.961657(02)                   | R(15)      |
| 4190.240439(02)                    | P(16)      | 4314.596584(02)                   | R(16)      |
| 4185.295239(02)                    | P(17)      | 4317.159011(02)                   | R(17)      |
| 4180.282526(02)                    | P(18)      | 4319.648791(02)                   | R(18)      |
| 4175.202447(02)                    | P(19)      | 4322.065779(03)                   | R(19)      |
| 4170.055149(03)                    | P(20)      | 4324.409829(03)                   | R(20)      |
| 4164.840777(03)                    | P(21)      | 4326.680794(03)                   | R(21)      |
| 4159.559478(03)                    | P(22)      | 4328.878530(03)                   | R(22)      |
| 4154.211398(03)                    | P(23)      | 4331.002889(04)                   | R(23)      |
| 4148.796683(04)                    | P(24)      | 4333.053728(04)                   | R(24)      |
| 4143.315479(04)                    | P(25)      | 4335.030899(05)                   | R(25)      |
| 4137.767932(04)                    | P(26)      | 4336.934259(06)                   | R(26)      |
| 4132.154187(05)                    | P(27)      | 4338.763661(07)                   | R(27)      |
| 4126.474391(06)                    | P(28)      | 4340.518961(09)                   | R(28)      |
| 4120.728689(07)                    | P(29)      | 4342.200014(11)                   | R(29)      |
| 4114.917226(09)                    | P(30)      | 4343.806675(16)                   | R(30)      |
| 4109.040148(12)                    | P(31)      | 4345.338799(21)                   | R(31)      |
| 4103.097600(16)                    | P(32)      | 4346.796243(29)                   | R(32)      |
| 4097.089728(21)                    | P(33)      | 4348.178862(40)                   | R(33)      |
| 4091.016676(29)                    | P(34)      | 4349.486513(54)                   | R(34)      |
| 4084.878591(40)                    | P(35)      | 4350.719052(73)                   | R(35)      |
| 4078.675618(54)                    | P(36)      | 4351.876336(96)                   | R(36)      |
| 4072.407901(73)                    | P(37)      | 4352.958224(127)                  | R(37)      |
| 4066.075588(97)                    | P(38)      | 4353.964572(166)                  | R(38)      |
| 4059.678822(127)                   | P(39)      | 4354.895240(214)                  | R(39)      |

\* The uncertainty in the last digits (twice the standard error) is given in parentheses.

**Wavenumbers for the  $\nu = 3 - 0$  Band of CO**

| Wavenumber (unc)*/cm <sup>-1</sup> | Transition | Wavenumber (unc)/cm <sup>-1</sup> | Transition |
|------------------------------------|------------|-----------------------------------|------------|
|                                    |            | 6354.179057(13)                   | R(0)       |
| 6346.594000(13)                    | P(1)       | 6357.813923(13)                   | R(1)       |
| 6342.644103(13)                    | P(2)       | 6361.343487(13)                   | R(2)       |
| 6338.589491(13)                    | P(3)       | 6364.767599(13)                   | R(3)       |
| 6334.430309(13)                    | P(4)       | 6368.086115(13)                   | R(4)       |

Wavenumbers for the  $\nu = 3 - 0$  Band of CO

| Wavenumber (unc) <sup>*</sup> /cm <sup>-1</sup> | Transition | Wavenumber (unc)/cm <sup>-1</sup> | Transition |
|-------------------------------------------------|------------|-----------------------------------|------------|
| 6330.166705(13)                                 | P(5)       | 6371.298887(13)                   | R(5)       |
| 6325.798826(13)                                 | P(6)       | 6374.405768(12)                   | R(6)       |
| 6321.326819(13)                                 | P(7)       | 6377.406611(12)                   | R(7)       |
| 6316.750831(12)                                 | P(8)       | 6380.301271(12)                   | R(8)       |
| 6312.071008(12)                                 | P(9)       | 6383.089600(12)                   | R(9)       |
| 6307.287498(12)                                 | P(10)      | 6385.771452(12)                   | R(10)      |
| 6302.400447(12)                                 | P(11)      | 6388.346680(13)                   | R(11)      |
| 6297.410003(12)                                 | P(12)      | 6390.815139(13)                   | R(12)      |
| 6292.316311(13)                                 | P(13)      | 6393.176681(13)                   | R(13)      |
| 6287.119520(13)                                 | P(14)      | 6395.431160(13)                   | R(14)      |
| 6281.819775(13)                                 | P(15)      | 6397.578430(13)                   | R(15)      |
| 6276.417224(13)                                 | P(16)      | 6399.618344(13)                   | R(16)      |
| 6270.912012(13)                                 | P(17)      | 6401.550757(13)                   | R(17)      |
| 6265.304287(13)                                 | P(18)      | 6403.375523(13)                   | R(18)      |
| 6259.594194(13)                                 | P(19)      | 6405.092495(14)                   | R(19)      |
| 6253.781880(13)                                 | P(20)      | 6406.701527(14)                   | R(20)      |
| 6247.867492(14)                                 | P(21)      | 6408.202474(14)                   | R(21)      |
| 6241.851176(14)                                 | P(22)      | 6409.595189(15)                   | R(22)      |
| 6235.733077(14)                                 | P(23)      | 6410.879527(15)                   | R(23)      |
| 6229.513342(15)                                 | P(24)      | 6412.055343(16)                   | R(24)      |
| 6223.192117(15)                                 | P(25)      | 6413.122491(17)                   | R(25)      |
| 6216.769547(16)                                 | P(26)      | 6414.080825(19)                   | R(26)      |
| 6210.245778(17)                                 | P(27)      | 6414.930201(23)                   | R(27)      |
| 6203.620957(19)                                 | P(28)      | 6415.670474(28)                   | R(28)      |
| 6196.895229(23)                                 | P(29)      | 6416.301500(37)                   | R(29)      |
| 6190.068739(28)                                 | P(30)      | 6416.823133(50)                   | R(30)      |
| 6183.141633(37)                                 | P(31)      | 6417.235231(67)                   | R(31)      |
| 6176.114058(50)                                 | P(32)      | 6417.537649(90)                   | R(32)      |
| 6168.986159(67)                                 | P(33)      |                                   |            |
| 6161.758082(90)                                 | P(34)      |                                   |            |

\* The uncertainty in the last digits (twice the standard error) is given in parentheses.

## Frequencies and Wavenumbers for the Rotational Lines of CO

| Frequency/MHz | Uncertainty <sup>*</sup> /MHz | $J'$ | $J''$ | Wavenumber/cm <sup>-1</sup> | Uncertainty <sup>*</sup> /cm <sup>-1</sup> |
|---------------|-------------------------------|------|-------|-----------------------------|--------------------------------------------|
| 115271.2029   | 0.0004                        | 1    | 0     | 3.84503345                  | 0.00000001                                 |
| 230538.0016   | 0.0008                        | 2    | 1     | 7.68991999                  | 0.00000003                                 |
| 345795.9923   | 0.0012                        | 3    | 2     | 11.53451273                 | 0.00000004                                 |
| 461040.7712   | 0.0016                        | 4    | 3     | 15.37866477                 | 0.00000005                                 |
| 576267.9350   | 0.0019                        | 5    | 4     | 19.22222923                 | 0.00000006                                 |
| 691473.0809   | 0.0021                        | 6    | 5     | 23.06505926                 | 0.00000007                                 |
| 806651.8065   | 0.0023                        | 7    | 6     | 26.90700800                 | 0.00000008                                 |
| 921799.7104   | 0.0025                        | 8    | 7     | 30.74792863                 | 0.00000008                                 |
| 1036912.3919  | 0.0027                        | 9    | 8     | 34.58767438                 | 0.00000009                                 |
| 1151985.4515  | 0.0029                        | 10   | 9     | 38.42609848                 | 0.00000010                                 |
| 1267014.4906  | 0.0031                        | 11   | 10    | 42.26305422                 | 0.00000010                                 |
| 1381995.1119  | 0.0034                        | 12   | 11    | 46.09839491                 | 0.00000011                                 |
| 1496922.9195  | 0.0038                        | 13   | 12    | 49.93197392                 | 0.00000013                                 |
| 1611793.5189  | 0.0042                        | 14   | 13    | 53.76364468                 | 0.00000014                                 |
| 1726602.5173  | 0.0047                        | 15   | 14    | 57.59326065                 | 0.00000016                                 |
| 1841345.5237  | 0.0052                        | 16   | 15    | 61.42067535                 | 0.00000017                                 |
| 1956018.1486  | 0.0057                        | 17   | 16    | 65.24574239                 | 0.00000019                                 |
| 2070616.0050  | 0.0061                        | 18   | 17    | 69.06831542                 | 0.00000020                                 |
| 2185134.7075  | 0.0065                        | 19   | 18    | 72.88824816                 | 0.00000022                                 |
| 2299569.8733  | 0.0069                        | 20   | 19    | 76.70539441                 | 0.00000023                                 |
| 2413917.1217  | 0.0071                        | 21   | 20    | 80.51960806                 | 0.00000024                                 |
| 2528172.0747  | 0.0073                        | 22   | 21    | 84.33074306                 | 0.00000024                                 |
| 2642330.3567  | 0.0074                        | 23   | 22    | 88.13865346                 | 0.00000025                                 |
| 2756387.5949  | 0.0075                        | 24   | 23    | 91.94319341                 | 0.00000025                                 |

## Frequencies and Wavenumbers for the Rotational Lines of CO

| Frequency/MHz | Uncertainty*/MHz | $J'$ | $J''$ | Wavenumber/cm <sup>-1</sup> | Uncertainty*/cm <sup>-1</sup> |
|---------------|------------------|------|-------|-----------------------------|-------------------------------|
| 2870339.4194  | 0.0077           | 25   | 24    | 95.74421713                 | 0.00000026                    |
| 2984181.4631  | 0.0080           | 26   | 25    | 99.54157896                 | 0.00000027                    |
| 3097909.3621  | 0.0085           | 27   | 26    | 103.33513334                | 0.00000028                    |
| 3211518.7558  | 0.0090           | 28   | 27    | 107.12473480                | 0.00000030                    |
| 3325005.2869  | 0.0096           | 29   | 28    | 110.91023800                | 0.00000032                    |
| 3438364.6013  | 0.0102           | 30   | 29    | 114.69149772                | 0.00000034                    |
| 3551592.3489  | 0.0107           | 31   | 30    | 118.46836884                | 0.00000036                    |
| 3664684.1829  | 0.0111           | 32   | 31    | 122.24070637                | 0.00000037                    |
| 3777635.7608  | 0.0118           | 33   | 32    | 126.00836545                | 0.00000039                    |
| 3890442.7435  | 0.0137           | 34   | 33    | 129.77120137                | 0.00000046                    |
| 4003100.7965  | 0.0179           | 35   | 34    | 133.52906952                | 0.00000060                    |
| 4115605.5892  | 0.0254           | 36   | 35    | 137.28182546                | 0.00000085                    |
| 4227952.7954  | 0.0370           | 37   | 36    | 141.02932487                | 0.00000123                    |
| 4340138.0932  | 0.0531           | 38   | 37    | 144.77142361                | 0.00000177                    |
| 4452157.1657  | 0.0746           | 39   | 38    | 148.50797766                | 0.00000249                    |
| 4564005.7001  | 0.1025           | 40   | 39    | 152.23884318                | 0.00000342                    |

\* The uncertainty given is twice the standard error.

## Frequencies and Wavenumbers for the Rotational Lines of HF

| Frequency/MHz | Uncertainty*/MHz | $J'$ | $J''$ | Wavenumber/cm <sup>-1</sup> | Uncertainty*/cm <sup>-1</sup> |
|---------------|------------------|------|-------|-----------------------------|-------------------------------|
| 1232476.21    | 0.12             | 1    | 0     | 41.110981                   | 0.000004                      |
| 2463428.09    | 0.19             | 2    | 1     | 82.171116                   | 0.000006                      |
| 3691334.81    | 0.25             | 3    | 2     | 123.129676                  | 0.000008                      |
| 4914682.58    | 0.51             | 4    | 3     | 163.936165                  | 0.000017                      |
| 6131968.11    | 1.10             | 5    | 4     | 204.540439                  | 0.000037                      |
| 7341702.00    | 2.00             | 6    | 5     | 244.892818                  | 0.000067                      |
| 8542412.1     | 3.21             | 7    | 6     | 284.944197                  | 0.000107                      |
| 9732646.8     | 4.72             | 8    | 7     | 324.646153                  | 0.000157                      |
| 10910978.2    | 6.51             | 9    | 8     | 363.951056                  | 0.000217                      |
| 12076004.8    | 8.55             | 10   | 9     | 402.81216                   | 0.000285                      |
| 13226355.2    | 10.81            | 11   | 10    | 441.18372                   | 0.000361                      |
| 14360689.8    | 13.25            | 12   | 11    | 479.02105                   | 0.00044                       |
| 15477704.4    | 15.86            | 13   | 12    | 516.28065                   | 0.00053                       |
| 16576131.8    | 18.61            | 14   | 13    | 552.92024                   | 0.00062                       |
| 17654744.4    | 21.48            | 15   | 14    | 588.89888                   | 0.00072                       |
| 18712356.5    | 24.44            | 16   | 15    | 624.17703                   | 0.00082                       |
| 19747825.6    | 27.43            | 17   | 16    | 658.71656                   | 0.00092                       |
| 20760054.3    | 30.32            | 18   | 17    | 692.4809                    | 0.00101                       |
| 21747991.7    | 32.91            | 19   | 18    | 725.4349                    | 0.00110                       |
| 22710634.7    | 34.94            | 20   | 19    | 757.5452                    | 0.00117                       |
| 23647028.7    | 36.08            | 21   | 20    | 788.7800                    | 0.00120                       |
| 24556268.8    | 35.93            | 22   | 21    | 819.1090                    | 0.00120                       |
| 25437499.9    | 34.12            | 23   | 22    | 848.5037                    | 0.00114                       |
| 26289917.4    | 30.32            | 24   | 23    | 876.9373                    | 0.00101                       |
| 27112767.2    | 24.41            | 25   | 24    | 904.38457                   | 0.00081                       |
| 27905345.6    | 16.88            | 26   | 25    | 930.82214                   | 0.00056                       |
| 28666999.3    | 10.80            | 27   | 26    | 956.22817                   | 0.00036                       |
| 29397124.8    | 14.65            | 28   | 27    | 980.58253                   | 0.00049                       |
| 30095168.2    | 24.62            | 29   | 28    | 1003.86676                  | 0.00082                       |
| 30760624.2    | 33.36            | 30   | 29    | 1026.0640                   | 0.00111                       |
| 31393035.7    | 36.17            | 31   | 30    | 1047.1590                   | 0.00121                       |

\* The uncertainty given is twice the standard error.

Frequencies and Wavenumbers for the Rotational Lines of H<sup>35</sup>Cl

| Frequency/MHz | Uncertainty*/MHz | $J'$ | $J''$ | Wavenumber/cm <sup>-1</sup> | Uncertainty*/cm <sup>-1</sup> |
|---------------|------------------|------|-------|-----------------------------|-------------------------------|
| 1876226.517   | 0.065            | 3    | 2     | 62.584180                   | 0.000002                      |
| 2499864.439   | 0.066            | 4    | 3     | 83.386502                   | 0.000002                      |
| 3121986.563   | 0.064            | 5    | 4     | 104.138262                  | 0.000002                      |
| 3742216.601   | 0.076            | 6    | 5     | 124.826909                  | 0.000003                      |
| 4360180.042   | 0.098            | 7    | 6     | 145.439951                  | 0.000003                      |
| 4975504.51    | 0.11             | 8    | 7     | 165.964966                  | 0.000004                      |
| 5587820.10    | 0.12             | 9    | 8     | 186.389615                  | 0.000004                      |
| 6196759.76    | 0.22             | 10   | 9     | 206.701656                  | 0.000007                      |
| 6801959.63    | 0.50             | 11   | 10    | 226.888951                  | 0.000017                      |
| 7403059.41    | 1.02             | 12   | 11    | 246.939481                  | 0.000034                      |
| 7999702.7     | 1.8              | 13   | 12    | 266.841359                  | 0.000062                      |
| 8591537.3     | 3.1              | 14   | 13    | 286.582837                  | 0.000103                      |
| 9178215.8     | 4.8              | 15   | 14    | 306.152324                  | 0.000161                      |

\* The uncertainty given is twice the standard error.

Frequencies and Wavenumbers for the Rotational Lines of H<sup>37</sup>Cl

| Frequency/MHz | Uncertainty*/MHz | $J'$ | $J''$ | Wavenumber/cm <sup>-1</sup> | Uncertainty*/cm <sup>-1</sup> |
|---------------|------------------|------|-------|-----------------------------|-------------------------------|
| 1873410.72    | 0.05             | 3    | 2     | 62.490255                   | 0.000002                      |
| 2496115.33    | 0.05             | 4    | 3     | 83.261445                   | 0.000002                      |
| 3117308.69    | 0.05             | 5    | 4     | 103.982225                  | 0.000002                      |
| 3736615.64    | 0.06             | 6    | 5     | 124.640082                  | 0.000002                      |
| 4353662.84    | 0.08             | 7    | 6     | 145.222561                  | 0.000003                      |
| 4968079.04    | 0.09             | 8    | 7     | 165.717279                  | 0.000003                      |
| 5579495.53    | 0.10             | 9    | 8     | 186.111938                  | 0.000003                      |
| 6187546.42    | 0.19             | 10   | 9     | 206.394332                  | 0.000006                      |
| 6791869.04    | 0.45             | 11   | 10    | 226.552365                  | 0.000015                      |
| 7392104.3     | 0.9              | 12   | 11    | 246.574057                  | 0.000030                      |
| 7987896.9     | 1.6              | 13   | 12    | 266.447561                  | 0.000054                      |
| 8578896.1     | 2.7              | 14   | 13    | 286.161170                  | 0.000089                      |

\* The uncertainty given is twice the standard error.

## SENSITIVITY OF THE HUMAN EYE TO LIGHT OF DIFFERENT WAVELENGTHS

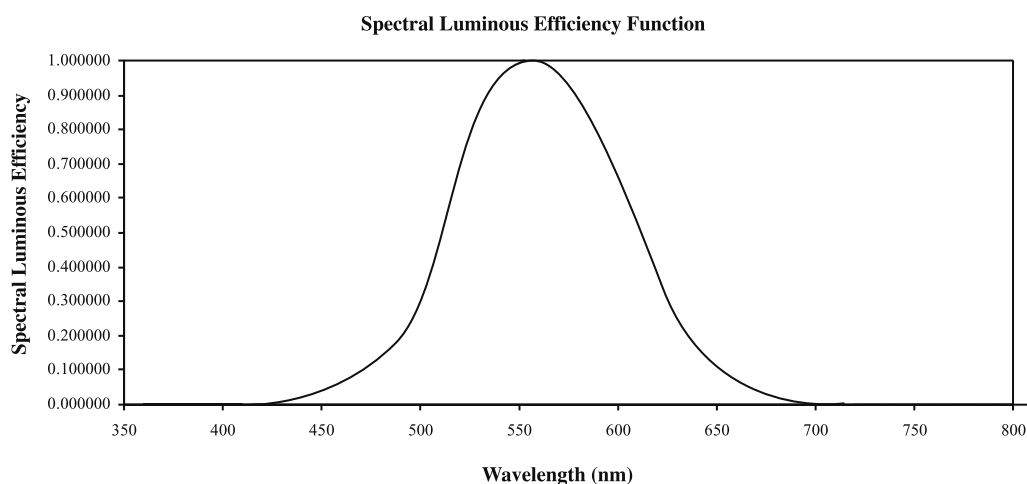
The human eye responds to electromagnetic radiation in the wavelength range from about 360 nm (violet) to 820 nm (red), with a peak sensitivity near 555 nm (green). While the detailed shape of this response curve depends on the individual person, studies on representative samples of human subjects have led to adoption of a standard function relating the perceived brightness (luminous flux) to the actual power of the spectral radiation. This function is referred to as  $V(\lambda)$ , the photopic spectral luminous efficiency function, and it plays an important role in photometry.

The function  $V(\lambda)$ , as adopted by the International Commission on Illumination (CIE), is tabulated and plotted below.

### References

1. *The Basis for Physical Photometry*, CIE Publication #18.2, 1983.
2. *CIE Standard Colorimetric Observers*, ISO/CIE #10527, 1991.
3. *Kaye and Laby Tables of Physical and Chemical Constants, Sixteenth Edition*, Longman Group Ltd., Harlow, Essex, 1995.

| $\lambda/\text{nm}$ | $V(\lambda)$ | $\lambda/\text{nm}$ | $V(\lambda)$ | $\lambda/\text{nm}$ | $V(\lambda)$ |
|---------------------|--------------|---------------------|--------------|---------------------|--------------|
| 360                 | 0.000004     | 520                 | 0.710000     | 670                 | 0.032000     |
| 370                 | 0.000012     | 530                 | 0.862000     | 680                 | 0.017000     |
| 380                 | 0.000039     | 540                 | 0.954000     | 690                 | 0.008210     |
| 390                 | 0.000120     | 550                 | 0.994950     | 700                 | 0.004102     |
| 400                 | 0.000396     | 555                 | 1.000000     | 710                 | 0.002091     |
| 410                 | 0.001210     | 560                 | 0.995000     | 720                 | 0.001047     |
| 420                 | 0.004000     | 570                 | 0.952000     | 730                 | 0.000520     |
| 430                 | 0.011600     | 580                 | 0.870000     | 740                 | 0.000249     |
| 440                 | 0.023000     | 590                 | 0.757000     | 750                 | 0.000120     |
| 450                 | 0.038000     | 600                 | 0.631000     | 760                 | 0.000060     |
| 460                 | 0.060000     | 610                 | 0.503000     | 770                 | 0.000030     |
| 470                 | 0.090980     | 620                 | 0.381000     | 780                 | 0.000015     |
| 480                 | 0.139020     | 630                 | 0.265000     | 790                 | 0.000007     |
| 490                 | 0.208020     | 640                 | 0.175000     | 800                 | 0.000004     |
| 500                 | 0.323000     | 650                 | 0.107000     | 810                 | 0.000002     |
| 510                 | 0.503000     | 660                 | 0.061000     | 820                 | 0.000001     |



# INDEX OF REFRACTION OF INORGANIC CRYSTALS

This table lists the index of refraction of selected crystalline inorganic compounds. When, available, values are give as a function of wavelength in the range from the ultraviolet to the far infrared region. For each compound a value at 589 nm, the wavelength of the principal sodium line, is given. The data have been taken from the references indicated; in many cases, data from a reference have been refitted to generate the index of refraction at the wavelengths used in this table. All values refer to ambient temperature. Entries marked by \* are based on extrapolation beyond the range of available experimental data.

Compounds belonging to the cubic crystal system have only a single refractive index value, but other systems are anisotropic, so that the crystal is characterized by two or three unique indexes. Hexagonal, rhombohedral, and tetragonal crystals have two unique indexes which are traditionally labeled  $n_o$  and  $n_e$  for "ordinary ray" and "extraordinary ray". Orthorhombic, monoclinic, and triclinic crystals are characterized by three indexes which are here called  $n_x$ ,  $n_y$ , and  $n_z$ . The table indicates the crystal system for each entry in order to identify the material uniquely.

The refractive index and other optical properties for metals, semiconductors, and certain other compounds can be found in the tables "Optical Properties of Selected Elements" and "Optical Properties of Selected Inorganic and Organic Solids" in Section 12 of this *Handbook*.

## References

1. Li, H. H., "Refractive Index of Alkali Halides and its Wavelength and Temperature Derivatives", *J. Phys. Chem. Ref. Data* 5, 329, 1976.
2. Li, H. H., "Refractive Index of Alkaline Earth Halides and its Wavelength and Temperature Derivatives", *J. Phys. Chem. Ref. Data* 9, 161, 1980.
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5. Gray, D. E., ed., *American Institute of Physics Handbook*, Sec. 6b, p. 6-12, McGraw-Hill, New York, 1972.
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7. Landolt-Börnstein Numerical Data and Functional Relationships in Science and *Technology*, III/30A, High Frequency Properties of Dielectric Crystals. Piezooptic and Electrooptic Constants, Springer-Verlag, Berlin, 1996.
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| Compound                                    | Crystal system | Ray   | Index of Refraction at the Indicated Wavelength |        |        |           |           |           |            |            | Ref. |
|---------------------------------------------|----------------|-------|-------------------------------------------------|--------|--------|-----------|-----------|-----------|------------|------------|------|
|                                             |                |       | 300 nm                                          | 589 nm | 750 nm | 1 $\mu$ m | 2 $\mu$ m | 5 $\mu$ m | 10 $\mu$ m | 20 $\mu$ m |      |
| AgCl                                        | cub            | $n$   |                                                 | 2.0668 | 2.0401 | 2.0224    | 2.0062    | 1.9975    | 1.9803     | 1.9069     | 5    |
| AlPO <sub>4</sub>                           | rhomb          | $n_o$ |                                                 | 1.5247 | 1.5203 | 1.5161    | 1.5034    |           |            |            | 6    |
|                                             | rhomb          | $n_e$ |                                                 | 1.5338 | 1.5290 | 1.5245    | 1.5116    |           |            |            | 6    |
| Al <sub>2</sub> O <sub>3</sub>              | hex            | $n_o$ |                                                 | 1.7673 |        |           |           |           |            |            | 4    |
|                                             | hex            | $n_e$ |                                                 | 1.7598 |        |           |           |           |            |            | 4    |
| As <sub>2</sub> O <sub>3</sub> <sup>a</sup> | cub            | $n$   |                                                 | 1.7537 |        |           |           |           |            |            | 4    |
| BaF <sub>2</sub>                            | cub            | $n$   | 1.5010                                          | 1.4744 | 1.4712 | 1.4686    | 1.4647    | 1.4511    | 1.4014     |            | 2    |
| BaO                                         | cub            | $n$   |                                                 | 1.9841 |        |           |           |           |            |            | 4    |
| BaSO <sub>4</sub>                           | orth           | $n_x$ |                                                 | 1.6362 |        |           |           |           |            |            | 4    |
|                                             | orth           | $n_y$ |                                                 | 1.6374 |        |           |           |           |            |            | 4    |
|                                             | orth           | $n_z$ |                                                 | 1.6480 |        |           |           |           |            |            | 4    |
| BaTiO <sub>3</sub>                          | tetr           | $n_o$ |                                                 | 2.4405 |        |           |           |           |            |            | 4    |
|                                             | tetr           | $n_e$ |                                                 | 2.3831 |        |           |           |           |            |            | 4    |
| BaWO <sub>4</sub>                           | tetr           | $n_o$ |                                                 | 1.8426 |        |           |           |           |            |            | 4    |
|                                             | tetr           | $n_e$ |                                                 | 1.8405 |        |           |           |           |            |            | 4    |
| BeO                                         | hex            | $n_o$ |                                                 | 1.7184 |        |           |           |           |            |            | 4    |
|                                             | hex            | $n_e$ |                                                 | 1.7342 |        |           |           |           |            |            | 4    |
| BeSO <sub>4</sub> ·4H <sub>2</sub> O        | tetr           | $n_o$ |                                                 | 1.4713 |        |           |           |           |            |            | 4    |
|                                             | tetr           | $n_e$ |                                                 | 1.4328 |        |           |           |           |            |            | 4    |
| CaCO <sub>3</sub> <sup>b</sup>              | hex            | $n_o$ | 1.7216                                          | 1.6584 | 1.6503 | 1.6436    | 1.6249    |           |            |            | 5    |
|                                             | hex            | $n_e$ | 1.5145                                          | 1.4864 | 1.4828 | 1.4801    | 1.4753    |           |            |            | 5    |
| CaF <sub>2</sub>                            | cub            | $n$   | 1.4540                                          | 1.4338 | 1.4311 | 1.4289    | 1.4239    | 1.3990    | 1.299      |            | 2    |
| CaO                                         | cub            | $n$   |                                                 | 1.8396 |        |           |           |           |            |            | 4    |
| CaSO <sub>4</sub>                           | orth           | $n_x$ |                                                 | 1.5698 |        |           |           |           |            |            | 4    |
|                                             | orth           | $n_y$ |                                                 | 1.5755 |        |           |           |           |            |            | 4    |
|                                             | orth           | $n_z$ |                                                 | 1.6137 |        |           |           |           |            |            | 4    |
| CaSO <sub>4</sub> ·2H <sub>2</sub> O        | monocl         | $n_x$ |                                                 | 1.5207 |        |           |           |           |            |            | 4    |
|                                             | monocl         | $n_y$ |                                                 | 1.5227 |        |           |           |           |            |            | 4    |
|                                             | monocl         | $n_z$ |                                                 | 1.5304 |        |           |           |           |            |            | 4    |
| CaWO <sub>4</sub>                           | tetr           | $n_o$ |                                                 | 1.9195 |        |           |           |           |            |            | 4    |
|                                             | tetr           | $n_e$ |                                                 | 1.9355 |        |           |           |           |            |            | 4    |
| CdS                                         | hex            | $n_o$ |                                                 | 2.507  | 2.390  | 2.334     |           |           |            |            | 5    |



| Compound                              | Crystal system | Ray   | Index of Refraction at the Indicated Wavelength |        |        |        |        |        |        |        | Ref. |
|---------------------------------------|----------------|-------|-------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|------|
|                                       |                |       | 300 nm                                          | 589 nm | 750 nm | 1 μm   | 2 μm   | 5 μm   | 10 μm  | 20 μm  |      |
| CdSe                                  | hex            | $n_e$ |                                                 | 2.525  | 2.409  | 2.352  |        |        |        |        | 5    |
|                                       | hex            | $n_o$ |                                                 |        | 2.68*  | 2.5502 | 2.4682 | 2.4483 | 2.4331 |        | 7    |
|                                       | hex            | $n_c$ |                                                 |        | 2.69*  | 2.5696 | 2.4873 | 2.4676 | 2.4514 |        | 7    |
| CdTe                                  | cub            | $n$   |                                                 |        |        |        |        |        | 2.6724 | 2.6302 | 7    |
| CeF <sub>3</sub>                      | hex            | $n_o$ |                                                 | 1.6183 |        |        |        |        |        |        | 4    |
|                                       | hex            | $n_e$ |                                                 | 1.6113 |        |        |        |        |        |        | 4    |
| CsBr                                  | cub            | $n$   | 1.8047                                          | 1.6974 | 1.6861 | 1.6784 | 1.6711 | 1.6678 | 1.6630 | 1.6439 | 1    |
| CsCl                                  | cub            | $n$   | 1.712                                           | 1.640  | 1.631  | 1.626  | 1.620  | 1.616  | 1.606  | 1.563  | 1    |
| CsClO <sub>4</sub>                    | orth           | $n_x$ |                                                 | 1.4752 |        |        |        |        |        |        | 4    |
|                                       | orth           | $n_y$ |                                                 | 1.4788 |        |        |        |        |        |        | 4    |
|                                       | orth           | $n_z$ |                                                 | 1.4804 |        |        |        |        |        |        | 4    |
| CsF                                   | cub            | $n$   | 1.506                                           | 1.477  | 1.474  | 1.472  | 1.469* | 1.461* | 1.436* | 1.32*  | 1    |
| CsI                                   | cub            | $n$   | 1.9790                                          | 1.7873 | 1.7694 | 1.7576 | 1.7465 | 1.7428 | 1.7396 | 1.7280 | 1    |
| Cs <sub>2</sub> SO <sub>4</sub>       | orth           | $n_x$ |                                                 | 1.5598 |        |        |        |        |        |        | 4    |
|                                       | orth           | $n_y$ |                                                 | 1.5644 |        |        |        |        |        |        | 4    |
|                                       | orth           | $n_z$ |                                                 | 1.5662 |        |        |        |        |        |        | 4    |
| CuBr                                  | cub            | $n$   |                                                 | 2.117  |        |        |        |        |        |        | 7    |
| CuCl                                  | cub            | $n$   |                                                 | 1.9727 | 1.9391 |        |        |        | 1.9245 |        | 7    |
| CuSO <sub>4</sub> ·5H <sub>2</sub> O  | tricl          | $n_x$ |                                                 | 1.5140 |        |        |        |        |        |        | 4    |
|                                       | tricl          | $n_y$ |                                                 | 1.5367 |        |        |        |        |        |        | 4    |
|                                       | tricl          | $n_z$ |                                                 | 1.5436 |        |        |        |        |        |        | 4    |
| Dy <sub>2</sub> O <sub>3</sub>        | cub            | $n$   |                                                 | 1.9757 |        |        |        |        |        |        | 4    |
| FeF <sub>2</sub>                      | tetr           | $n_o$ |                                                 | 1.514  |        |        |        |        |        |        | 4    |
|                                       | tetr           | $n_e$ |                                                 | 1.524  |        |        |        |        |        |        | 4    |
| Gd <sub>2</sub> O <sub>3</sub>        | cub            | $n$   |                                                 | 1.96   |        |        |        |        |        |        | 4    |
| HgS                                   | rhomb          | $n_o$ |                                                 | 2.9413 | 2.7770 | 2.7120 | 2.6305 |        | 2.6018 |        | 6    |
|                                       | rhomb          | $n_c$ |                                                 | 3.3072 | 3.0896 | 3.0050 | 2.8776 |        | 2.8522 |        | 6    |
| KBr                                   | cub            | $n$   | 1.6482                                          | 1.5598 | 1.5498 | 1.5444 | 1.5383 | 1.5345 | 1.5264 | 1.4924 | 1    |
| KCl                                   | cub            | $n$   | 1.5455                                          | 1.4902 | 1.4840 | 1.4798 | 1.4753 | 1.4704 | 1.4564 | 1.3946 | 1    |
| KClO <sub>4</sub>                     | orth           | $n_x$ |                                                 | 1.4730 |        |        |        |        |        |        | 4    |
|                                       | orth           | $n_y$ |                                                 | 1.4736 |        |        |        |        |        |        | 4    |
|                                       | orth           | $n_z$ |                                                 | 1.4768 |        |        |        |        |        |        | 4    |
| KF                                    | cub            | $n$   | 1.380                                           | 1.362  | 1.360  | 1.358  | 1.355  | 1.344  | 1.304* | 1.09*  | 1    |
| KH <sub>2</sub> AsO <sub>4</sub>      | tetr           | $n_o$ |                                                 | 1.5674 |        |        |        |        |        |        | 7    |
|                                       | tetr           | $n_e$ |                                                 | 1.5179 |        |        |        |        |        |        | 7    |
| KH <sub>2</sub> PO <sub>4</sub>       | tetr           | $n_o$ | 1.5450                                          | 1.5093 | 1.5030 | 1.4957 |        |        |        |        | 5    |
|                                       | tetr           | $n_c$ | 1.4977                                          | 1.4682 | 1.4641 | 1.4606 |        |        |        |        | 5    |
| KI                                    | cub            | $n$   | 1.834*                                          | 1.665  | 1.650  | 1.640  | 1.631  | 1.627  | 1.620  | 1.593  | 1    |
| KIO <sub>3</sub>                      | tricl          | $n_x$ |                                                 | 1.6959 |        |        |        |        |        |        | 7    |
|                                       | tricl          | $n_y$ |                                                 | 1.8317 |        |        |        |        |        |        | 7    |
|                                       | tricl          | $n_z$ |                                                 | 1.8343 |        |        |        |        |        |        | 7    |
| KIO <sub>4</sub>                      | tetr           | $n_o$ |                                                 | 1.6205 |        |        |        |        |        |        | 4    |
|                                       | tetr           | $n_e$ |                                                 | 1.6476 |        |        |        |        |        |        | 4    |
| KNbO <sub>3</sub>                     | orth           | $n_x$ |                                                 | 2.2480 | 2.3395 | 2.2612 |        |        |        |        | 7    |
|                                       | orth           | $n_y$ |                                                 | 2.3464 | 2.2959 | 2.2622 |        |        |        |        | 7    |
|                                       | orth           | $n_x$ |                                                 | 2.1803 | 2.1457 | 2.1288 |        |        |        |        | 7    |
| K <sub>2</sub> SO <sub>4</sub>        | orth           | $n_x$ |                                                 | 1.4934 |        |        |        |        |        |        | 4    |
|                                       | orth           | $n_y$ |                                                 | 1.4947 |        |        |        |        |        |        | 4    |
|                                       | orth           | $n_z$ |                                                 | 1.4973 |        |        |        |        |        |        | 4    |
| LaF <sub>3</sub>                      | hex            | $n_o$ |                                                 | 1.605  |        |        |        |        |        |        | 4    |
|                                       | hex            | $n_e$ |                                                 | 1.599  |        |        |        |        |        |        | 4    |
| LiBr                                  | cub            | $n$   | 1.810                                           | 1.783  | 1.781  | 1.778  | 1.774* | 1.756* | 1.68*  | 1.33*  | 1    |
| LiCl                                  | cub            | $n$   | 1.677                                           | 1.662  | 1.660  | 1.658  | 1.654* | 1.62*  | 1.53*  |        | 1    |
| LiClO <sub>4</sub> ·3H <sub>2</sub> O | hex            | $n_o$ |                                                 | 1.4832 |        |        |        |        |        |        | 4    |
|                                       | hex            | $n_e$ |                                                 | 1.4384 |        |        |        |        |        |        | 4    |
| LiF                                   | cub            | $n$   | 1.4087                                          | 1.3921 | 1.3895 | 1.3871 | 1.3786 | 1.3266 | 1.1005 |        | 1    |
| LiI                                   | cub            | $n$   | 1.979                                           | 1.955  | 1.952  | 1.950  | 1.948* | 1.940* | 1.91*  | 1.77*  | 1    |
| LiIO <sub>3</sub>                     | hex            | $n_o$ |                                                 | 1.8875 | 1.8713 | 1.8589 | 1.8410 |        |        |        | 6    |
| LiNbO <sub>3</sub>                    | hex            | $n_e$ |                                                 | 1.7400 | 1.7268 | 1.7179 | 1.7062 |        |        |        | 6    |
|                                       | rhomb          | $n_o$ |                                                 | 2.3007 | 2.2632 | 2.2370 |        |        |        |        | 7    |

| Compound                                            | Crystal system | Ray   | Index of Refraction at the Indicated Wavelength |        |        |        |        |        |        |        | Ref. |
|-----------------------------------------------------|----------------|-------|-------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|------|
|                                                     |                |       | 300 nm                                          | 589 nm | 750 nm | 1 μm   | 2 μm   | 5 μm   | 10 μm  | 20 μm  |      |
| LiTaO <sub>3</sub>                                  | rhomb          | $n_e$ |                                                 | 2.2116 | 2.1804 | 2.1567 |        |        |        |        | 7    |
|                                                     | rhomb          | $n_o$ |                                                 | 2.1864 | 2.1590 | 2.1391 | 2.1066 |        |        |        | 7    |
|                                                     | rhomb          | $n_e$ |                                                 | 2.1908 | 2.1634 | 2.1432 | 2.1115 |        |        |        | 7    |
| Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O   | monocl         | $n_x$ |                                                 | 1.4615 |        |        |        |        |        |        | 4    |
|                                                     | monocl         | $n_y$ |                                                 | 1.4765 |        |        |        |        |        |        | 4    |
|                                                     | monocl         | $n_z$ |                                                 | 1.4863 |        |        |        |        |        |        | 4    |
| Lu <sub>2</sub> O <sub>3</sub>                      | cub            | $n$   |                                                 | 1.9349 |        |        |        |        |        |        | 4    |
| MgF <sub>2</sub>                                    | tetr           | $n_o$ | 1.3930                                          | 1.3776 | 1.375  | 1.373  | 1.368  | 1.34   | 1.21   |        | 2    |
|                                                     | tetr           | $n_e$ | 1.4055                                          | 1.3894 | 1.387  | 1.385  | 1.379  | 1.34   | 1.21   |        | 2    |
| MgO                                                 | cub            | $n$   |                                                 | 1.7355 | 1.7283 | 1.7228 | 1.7084 | 1.6361 |        |        | 5    |
| MgSO <sub>4</sub> ·7H <sub>2</sub> O                | orth           | $n_x$ |                                                 | 1.4326 |        |        |        |        |        |        | 4    |
|                                                     | orth           | $n_y$ |                                                 | 1.4555 |        |        |        |        |        |        | 4    |
|                                                     | orth           | $n_z$ |                                                 | 1.4607 |        |        |        |        |        |        | 4    |
| MnF <sub>2</sub>                                    | tetr           | $n_o$ |                                                 | 1.472  |        |        |        |        |        |        | 4    |
|                                                     | tetr           | $n_e$ |                                                 | 1.501  |        |        |        |        |        |        | 4    |
| NH <sub>4</sub> H <sub>2</sub> AsO <sub>4</sub>     | tetr           | $n_o$ | 1.6401                                          | 1.5777 | 1.5704 | 1.5583 |        |        |        |        | 7    |
|                                                     | tetr           | $n_e$ | 1.5754                                          | 1.5232 | 1.5179 | 1.5101 |        |        |        |        | 7    |
| NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>      | tetr           | $n_o$ | 1.5668                                          | 1.5247 | 1.5187 | 1.5084 |        |        |        |        | 7    |
|                                                     | tetr           | $n_e$ | 1.5137                                          | 1.4797 | 1.4754 | 1.4694 |        |        |        |        | 7    |
| NaBr                                                | cub            | $n$   | 1.748                                           | 1.642  | 1.631  | 1.623  | 1.616  | 1.609  | 1.593* | 1.520* | 1    |
| NaBrO <sub>3</sub>                                  | cub            | $n$   |                                                 | 1.6168 |        |        |        |        |        |        | 4    |
| NaCl                                                | cub            | $n$   | 1.6066                                          | 1.5441 | 1.5369 | 1.5320 | 1.5265 | 1.5188 | 1.4947 | 1.382* | 1    |
| NaClO <sub>3</sub>                                  | cub            | $n$   |                                                 | 1.5151 |        |        |        |        |        |        | 7    |
| NaF                                                 | cub            | $n$   | 1.3424                                          | 1.3252 | 1.3231 | 1.3214 | 1.3179 | 1.3017 | 1.2400 |        | 1    |
| NaH <sub>2</sub> PO <sub>4</sub> ·2H <sub>2</sub> O | orth           | $n_x$ |                                                 | 1.4400 |        |        |        |        |        |        | 7    |
|                                                     | orth           | $n_y$ |                                                 | 1.4628 |        |        |        |        |        |        | 7    |
|                                                     | orth           | $n_z$ |                                                 | 1.4814 |        |        |        |        |        |        | 7    |
| NaI                                                 | cub            | $n$   | 1.93*                                           | 1.774  | 1.758  | 1.74   | 1.73*  | 1.73*  | 1.71*  | 1.66*  | 1    |
| NaNO <sub>2</sub>                                   | orth           | $n_x$ |                                                 | 1.6547 |        |        |        |        |        |        | 7    |
|                                                     | orth           | $n_y$ |                                                 | 1.3455 |        |        |        |        |        |        | 7    |
|                                                     | orth           | $n_z$ |                                                 | 1.4125 |        |        |        |        |        |        | 7    |
| NaNO <sub>3</sub>                                   | rhomb          | $n_o$ |                                                 | 1.5840 |        |        |        |        |        |        | 5    |
|                                                     | rhomb          | $n_e$ |                                                 | 1.3340 |        |        |        |        |        |        | 5    |
| Na <sub>2</sub> HPO <sub>4</sub> ·7H <sub>2</sub> O | monocl         | $n_x$ |                                                 | 1.4411 |        |        |        |        |        |        | 4    |
|                                                     | monocl         | $n_y$ |                                                 | 1.4423 |        |        |        |        |        |        | 4    |
|                                                     | monocl         | $n_z$ |                                                 | 1.4525 |        |        |        |        |        |        | 4    |
| Na <sub>2</sub> SO <sub>4</sub>                     | orth           | $n_x$ |                                                 | 1.4669 |        |        |        |        |        |        | 4    |
|                                                     | orth           | $n_y$ |                                                 | 1.4730 |        |        |        |        |        |        | 4    |
|                                                     | orth           | $n_z$ |                                                 | 1.4809 |        |        |        |        |        |        | 4    |
| NdF <sub>3</sub>                                    | hex            | $n_o$ |                                                 | 1.6191 |        |        |        |        |        |        | 4    |
|                                                     | hex            | $n_e$ |                                                 | 1.6132 |        |        |        |        |        |        | 4    |
| Nd <sub>2</sub> O <sub>3</sub>                      | cub            | $n$   |                                                 | 1.92   |        |        |        |        |        |        | 4    |
| NiF <sub>2</sub>                                    | tetr           | $n_o$ |                                                 | 1.526  |        |        |        |        |        |        | 4    |
|                                                     | tetr           | $n_e$ |                                                 | 1.561  |        |        |        |        |        |        | 4    |
| NiSO <sub>4</sub> ·6H <sub>2</sub> O                | tetr           | $n_o$ |                                                 | 1.5107 |        |        |        |        |        |        | 4    |
|                                                     | tetr           | $n_e$ |                                                 | 1.4870 |        |        |        |        |        |        | 4    |
| PbF <sub>2</sub>                                    | cub            | $n$   | 1.94*                                           | 1.767  | 1.754  | 1.745  | 1.73   | 1.70   | 1.66   | 1.32   | 5    |
| PbSO <sub>4</sub>                                   | orth           | $n_x$ |                                                 | 1.8780 |        |        |        |        |        |        | 4    |
|                                                     | orth           | $n_y$ |                                                 | 1.8834 |        |        |        |        |        |        | 4    |
|                                                     | orth           | $n_z$ |                                                 | 1.8945 |        |        |        |        |        |        | 4    |
| PrF <sub>3</sub>                                    | hex            | $n_o$ |                                                 | 1.6207 |        |        |        |        |        |        | 4    |
|                                                     | hex            | $n_e$ |                                                 | 1.6146 |        |        |        |        |        |        | 4    |
| RbBr                                                | cub            | $n$   | 1.639                                           | 1.553  | 1.544  | 1.538  | 1.532  | 1.530  | 1.525  | 1.505* | 1    |
| RbCl                                                | cub            | $n$   | 1.549                                           | 1.493  | 1.487  | 1.483  | 1.479  | 1.475  | 1.465  | 1.424* | 1    |
| RbClO <sub>4</sub>                                  | orth           | $n_x$ |                                                 | 1.4691 |        |        |        |        |        |        | 4    |
|                                                     | orth           | $n_y$ |                                                 | 1.4701 |        |        |        |        |        |        | 4    |
|                                                     | orth           | $n_z$ |                                                 | 1.4732 |        |        |        |        |        |        | 4    |
| RbF                                                 | cub            | $n$   | 1.428*                                          | 1.397  | 1.394  | 1.391  | 1.388  | 1.379  | 1.346  | 1.19*  | 1    |
| RbH <sub>2</sub> AsO <sub>4</sub>                   | tetr           | $n_o$ | 1.6183                                          | 1.5603 | 1.5538 | 1.5432 |        |        |        |        | 7    |
|                                                     | tetr           | $n_e$ | 1.5718                                          | 1.5232 | 1.5184 | 1.5121 |        |        |        |        | 7    |

| Compound                                    | Crystal system | Ray   | Index of Refraction at the Indicated Wavelength |        |        |                 |                 |                 |                  |                  | Ref. |
|---------------------------------------------|----------------|-------|-------------------------------------------------|--------|--------|-----------------|-----------------|-----------------|------------------|------------------|------|
|                                             |                |       | 300 nm                                          | 589 nm | 750 nm | 1 $\mu\text{m}$ | 2 $\mu\text{m}$ | 5 $\mu\text{m}$ | 10 $\mu\text{m}$ | 20 $\mu\text{m}$ |      |
| RbH <sub>2</sub> PO <sub>4</sub>            | tetr           | $n_o$ | 1.5434                                          | 1.5078 | 1.5021 | 1.4941          |                 |                 |                  |                  | 7    |
|                                             | tetr           | $n_e$ | 1.5106                                          | 1.4791 | 1.4754 | 1.4704          |                 |                 |                  |                  | 7    |
| RbI                                         | cub            | $n$   | 1.808                                           | 1.647  | 1.633  | 1.623           | 1.615           | 1.612           | 1.608            | 1.595            | 1    |
| Rb <sub>2</sub> SO <sub>4</sub>             | orth           | $n_x$ |                                                 | 1.5131 |        |                 |                 |                 |                  |                  | 4    |
|                                             | orth           | $n_y$ |                                                 | 1.5133 |        |                 |                 |                 |                  |                  | 4    |
|                                             | orth           | $n_z$ |                                                 | 1.5144 |        |                 |                 |                 |                  |                  | 4    |
| Sb <sub>2</sub> O <sub>3</sub> <sup>c</sup> | cub            | $n$   |                                                 | 2.8017 |        |                 |                 |                 |                  |                  | 4    |
| Sc <sub>2</sub> O <sub>3</sub>              | cub            | $n$   |                                                 | 1.9943 |        |                 |                 |                 |                  |                  | 4    |
| SiO <sub>2</sub> <sup>d</sup>               | hex            | $n_o$ | 1.5733                                          | 1.5442 | 1.5394 | 1.5350          | 1.5209          |                 |                  |                  | 5    |
|                                             | hex            | $n_e$ | 1.5882                                          | 1.5534 | 1.5484 | 1.5438          | 1.5291          |                 |                  |                  | 5    |
| SnO <sub>2</sub>                            | tetr           | $n_o$ |                                                 | 1.993  |        |                 |                 |                 |                  |                  | 4    |
|                                             | tetr           | $n_e$ |                                                 | 2.088  |        |                 |                 |                 |                  |                  | 4    |
| SrF <sub>2</sub>                            | cub            | $n$   | 1.459                                           | 1.4380 | 1.435  | 1.433           | 1.429           | 1.412           | 1.35             |                  | 2    |
| SrO                                         | cub            | $n$   |                                                 | 1.8710 |        |                 |                 |                 |                  |                  | 4    |
| SrSO <sub>4</sub>                           | orth           | $n_x$ |                                                 | 1.6214 |        |                 |                 |                 |                  |                  | 4    |
|                                             | orth           | $n_y$ |                                                 | 1.6231 |        |                 |                 |                 |                  |                  | 4    |
|                                             | orth           | $n_z$ |                                                 | 1.6303 |        |                 |                 |                 |                  |                  | 4    |
| SrTiO <sub>3</sub>                          | cub            | $n$   |                                                 | 2.4082 | 2.3525 | 2.3160          | 2.2676          | 2.1205          |                  |                  | 5    |
| SrWO <sub>4</sub>                           | tetr           | $n_o$ |                                                 | 1.8618 |        |                 |                 |                 |                  |                  | 4    |
|                                             | tetr           | $n_e$ |                                                 | 1.8719 |        |                 |                 |                 |                  |                  | 4    |
| TbF <sub>3</sub>                            | hex            | $n_o$ |                                                 | 1.6034 |        |                 |                 |                 |                  |                  | 4    |
|                                             | hex            | $n_e$ |                                                 | 1.5603 |        |                 |                 |                 |                  |                  | 4    |
| TeO <sub>2</sub>                            | tetr           | $n_o$ |                                                 | 2.2738 |        | 2.2080          |                 |                 |                  |                  | 7    |
|                                             | tetr           | $n_e$ |                                                 | 2.4295 |        | 2.3520          |                 |                 |                  |                  | 7    |
| ThO <sub>2</sub>                            | cub            | $n$   |                                                 | 2.1113 |        |                 |                 |                 |                  |                  | 4    |
| TiO <sub>2</sub> <sup>e</sup>               | tetr           | $n_o$ |                                                 | 2.612  | 2.533  | 2.485           | 2.399           | 2.220           |                  |                  | 5    |
|                                             | tetr           | $n_e$ |                                                 | 2.910  | 2.805  | 2.748           |                 |                 |                  |                  | 5    |
|                                             | tetr           | $n_o$ |                                                 | 2.562  |        |                 |                 |                 |                  |                  | 4    |
|                                             | tetr           | $n_e$ |                                                 | 2.489  |        |                 |                 |                 |                  |                  | 4    |
| TlBr                                        | cub            | $n$   |                                                 | 2.418  | 2.350  | 2.289           | 2.103           | 1.984           | 2.339            | 2.322            | 5    |
| TlCl                                        | cub            | $n$   |                                                 | 2.247  | 2.198  | 2.145           | 1.986           | 1.891           | 2.193            |                  | 5    |
| TlClO <sub>4</sub>                          | orth           | $n_x$ |                                                 | 1.6427 |        |                 |                 |                 |                  |                  | 4    |
|                                             | orth           | $n_y$ |                                                 | 1.6446 |        |                 |                 |                 |                  |                  | 4    |
|                                             | orth           | $n_z$ |                                                 | 1.6542 |        |                 |                 |                 |                  |                  | 4    |
| Tl <sub>2</sub> SO <sub>4</sub>             | orth           | $n_x$ |                                                 | 1.8604 |        |                 |                 |                 |                  |                  | 4    |
|                                             | orth           | $n_y$ |                                                 | 1.8676 |        |                 |                 |                 |                  |                  | 4    |
|                                             | orth           | $n_z$ |                                                 | 1.8857 |        |                 |                 |                 |                  |                  | 4    |
| Y <sub>2</sub> O <sub>3</sub>               | cub            | $n$   |                                                 | 1.930  |        |                 |                 |                 |                  |                  | 4    |
| Yb <sub>2</sub> O <sub>3</sub>              | cub            | $n$   |                                                 | 1.9468 |        |                 |                 |                 |                  |                  | 4    |
| ZnF <sub>2</sub>                            | tetr           | $n_o$ |                                                 | 1.495  |        |                 |                 |                 |                  |                  | 4    |
|                                             | tetr           | $n_e$ |                                                 | 1.525  |        |                 |                 |                 |                  |                  | 4    |
| ZnO                                         | hex            | $n_o$ |                                                 | 2.0036 | 1.9662 | 1.9435          | 1.9197          |                 |                  |                  | 7    |
|                                             | hex            | $n_e$ |                                                 | 2.0199 | 1.9821 | 1.9589          | 1.9330          |                 |                  |                  | 7    |
| ZnS <sup>f</sup>                            | cub            | $n$   |                                                 | 2.3691 | 2.3232 | 2.2932          | 2.2633          |                 |                  |                  | 7    |
| ZnS <sup>g</sup>                            | hex            | $n_o$ |                                                 | 2.372  | 2.331  | 2.303           | 2.26            | 2.25            | 2.20             |                  | 3,5  |
|                                             | hex            | $n_e$ |                                                 | 2.368  | 2.327  | 2.301           |                 |                 |                  |                  | 5    |
| ZnSe                                        | cub            | $n$   |                                                 | 2.6222 | 2.5384 | 2.4888          | 2.4462          | 2.4296          | 2.4065           |                  | 3    |
| ZnTe                                        | cub            | $n$   |                                                 | 3.060  | 2.880  | 2.789           | 2.719           | 2.698           | 2.684            |                  | 3    |
| ZrSiO <sub>4</sub> <sup>h</sup>             | tetr           | $n_o$ |                                                 | 1.9255 |        |                 |                 |                 |                  |                  | 4    |
|                                             | tetr           | $n_e$ |                                                 | 1.9843 |        |                 |                 |                 |                  |                  | 4    |

\* Provisional value based on extrapolation beyond the range of experimental data.

<sup>a</sup> Arsenolite

<sup>b</sup> Calcite

<sup>c</sup> Senarmontite

<sup>d</sup>  $\alpha$ -Quartz

<sup>e</sup> Rutile

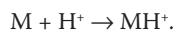
<sup>f</sup> Sphalerite

<sup>g</sup> Wurtzite

<sup>h</sup> Zircon

# PROTON AFFINITIES

Proton affinity is a useful parameter for describing gas phase ion-molecule reactions in fields such as atmospheric chemistry, plasma chemistry, mass spectrometry, and astrophysics. The proton affinity  $E_{\text{pa}}$  (often designated in the literature as PA) of a molecular species M is defined as the negative of the enthalpy change for the gas phase reaction



A closely related quantity is the gas phase basicity  $\Delta_{\text{base}} G^\circ$  (often designated as GB), which is the negative of the Gibbs energy change for the same reaction. Thus the two are related by

$$\Delta_{\text{base}} G^\circ = E_{\text{pa}} + T\Delta S,$$

where  $T$  is the temperature and  $\Delta S$  is the entropy change in the reaction (which can be calculated if the molecular structure of M and  $\text{M}^+$  is known).

Direct measurement of the proton affinity is possible for only a few molecules, mainly olefins and carbonyl compounds. However, these measurements have been used to establish a scale of  $E_{\text{pa}}$  values that permits proton affinities to be determined for many other molecules, including unstable species and reaction intermediates. The basis for this scale is described by Hunter and Lias in Reference 1.

The  $E_{\text{pa}}$  and  $\Delta_{\text{base}} G^\circ$  values at a temperature of 298 K are tabulated below for selected molecules. Many values are given to one decimal place, but the majority are not accurate to better than one or two kilojoules per mole. The methods of measurement are de-

scribed in Reference 1, which contains a much more extensive and detailed tabulation.

Compounds are listed by molecular formula in the Hill order, but with all compounds that do not contain carbon appearing before those that do contain carbon.

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| Molecular formula                            | Name                  | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes |
|----------------------------------------------|-----------------------|---------------------------|------------------------------------------|-------|
| Ar                                           | Argon                 | 369.2                     | 346.3                                    |       |
| AsF <sub>3</sub>                             | Arsenic(III) fluoride | 636.7                     | 604.2                                    |       |
| AsH <sub>3</sub>                             | Arsine                | 747.9                     | 712.0                                    |       |
| BHO <sub>2</sub>                             | Metaboric acid        | 763.0                     | 730.5                                    |       |
| BH <sub>3</sub> O <sub>3</sub>               | Boric acid            | 728.1                     | 698.4                                    |       |
| B <sub>2</sub> H <sub>6</sub>                | Diborane              | 615                       | 586.0                                    |       |
| B <sub>3</sub> H <sub>6</sub> N <sub>3</sub> | Borazine              | 802.5                     | 772.8                                    |       |
| B <sub>4</sub> H <sub>10</sub>               | Tetraborane(10)       | 605                       | 572.5                                    |       |
| B <sub>5</sub> H <sub>9</sub>                | Pentaborane(9)        | 699.4                     | 666.9                                    |       |
| BaO                                          | Barium oxide          | 1215.4                    | 1187.6                                   |       |
| Br                                           | Bromine (atomic)      | 554.4                     | 531.2                                    |       |
| BrH                                          | Hydrogen bromide      | 584.2                     | 557.7                                    |       |
| BrLi                                         | Lithium bromide       | 819                       | 792.5                                    |       |
| CaO                                          | Calcium oxide         | 1190.6                    | 1162.3                                   |       |
| Cl                                           | Chlorine (atomic)     | 513.6                     | 490.1                                    |       |
| ClH                                          | Hydrogen chloride     | 556.9                     | 530.1                                    |       |
| ClLi                                         | Lithium chloride      | 827                       | 800.5                                    |       |
| Co                                           | Cobalt                | 742.7                     | 719.8                                    |       |
| Cr                                           | Chromium              | 791.3                     | 768.4                                    |       |
| CsHO                                         | Cesium hydroxide      | 1117.9                    | 1092.2                                   |       |
| Cs <sub>2</sub> O                            | Cesium oxide          | 1442.9                    | 1412.2                                   |       |
| Cu                                           | Copper                | 655.3                     | 632.4                                    |       |
| F                                            | Fluorine (atomic)     | 340.1                     | 315.1                                    |       |
| FH                                           | Hydrogen fluoride     | 484                       | 456.7                                    |       |
| FO                                           | Fluorine oxide        | 508.7                     | 482.2                                    |       |
| F <sub>2</sub>                               | Fluorine              | 332                       | 305.5                                    |       |
| F <sub>2</sub> O <sub>2</sub> S              | Sulfuryl fluoride     | 605.5                     | 580.5                                    |       |

| Molecular<br>formula                         | Name                     | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes            |
|----------------------------------------------|--------------------------|---------------------------|------------------------------------------|------------------|
| F <sub>3</sub> N                             | Nitrogen trifluoride     | 568.4                     | 538.6                                    |                  |
| F <sub>3</sub> OP                            | Phosphoryl fluoride      | 694.0                     | 664.2                                    |                  |
| F <sub>3</sub> P                             | Phosphorus(III) fluoride | 695.3                     | 662.8                                    |                  |
| F <sub>4</sub> Si                            | Tetrafluorosilane        | 502.9                     | 476.6                                    |                  |
| F <sub>6</sub> S                             | Sulfur hexafluoride      | 575.3                     | 550.7                                    |                  |
| Fe                                           | Iron                     | 754                       | 731.1                                    |                  |
| FeO                                          | Iron(II) oxide           | 907                       | 880.5                                    |                  |
| GeH <sub>4</sub>                             | Germane                  | 713.4                     | 687.1                                    |                  |
| HI                                           | Hydrogen iodide          | 627.5                     | 601.3                                    |                  |
| HKO                                          | Potassium hydroxide      | 1101.8                    | 1075.4                                   |                  |
| HLi                                          | Lithium hydride          | 1021.7                    | 996.4                                    |                  |
| HLiO                                         | Lithium hydroxide        | 1000.1                    | 972.1                                    |                  |
| HNO <sub>3</sub>                             | Nitric acid              | 751.4                     | 731.5                                    |                  |
| HN <sub>3</sub>                              | Hydrazoic acid           | 756.0                     | 723.5                                    |                  |
| HNa                                          | Sodium hydride           | 1095                      | 1070.6                                   |                  |
| HNaO                                         | Sodium hydroxide         | 1071.8                    | 1044.8                                   |                  |
| HO                                           | Hydroxyl                 | 593.2                     | 564.0                                    |                  |
| HO <sub>2</sub>                              | Hydroperoxy              | 660                       | 627.5                                    |                  |
| HP                                           | Phosphorus monohydride   | 670.3                     | 639.6                                    |                  |
| H <sub>2</sub>                               | Hydrogen                 | 422.3                     | 394.7                                    |                  |
| H <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | Nitramide                | 757.4                     | 725.0                                    |                  |
| H <sub>2</sub> O                             | Water                    | 691                       | 660.0                                    |                  |
| H <sub>2</sub> O <sub>2</sub>                | Hydrogen peroxide        | 674.5                     | 643.8                                    |                  |
| H <sub>2</sub> O <sub>4</sub> S              | Sulfuric acid            | 717                       | 681                                      | Ref. 3           |
| H <sub>2</sub> P                             | Phosphino                | 709.2                     | 675.7                                    |                  |
| H <sub>2</sub> S                             | Hydrogen sulfide         | 705                       | 673.8                                    |                  |
| H <sub>2</sub> Se                            | Hydrogen selenide        | 707.8                     | 676.4                                    |                  |
| H <sub>2</sub> Si                            | Silylene                 | 839.2                     | 804.1                                    |                  |
| H <sub>2</sub> Te                            | Hydrogen telluride       | 735.9                     | 704.5                                    |                  |
| H <sub>3</sub> N                             | Ammonia                  | 853.6                     | 819.0                                    |                  |
| H <sub>3</sub> P                             | Phosphine                | 785                       | 750.9                                    |                  |
| H <sub>4</sub> N <sub>2</sub>                | Hydrazine                | 853.2                     | 822.4                                    |                  |
| H <sub>4</sub> Si                            | Silane                   | 639.7                     | 613.4                                    |                  |
| H <sub>6</sub> OSi <sub>2</sub>              | Disiloxane               | 749                       | 718.3                                    |                  |
| He                                           | Helium                   | 177.8                     | 148.5                                    |                  |
| I                                            | Iodine (atomic)          | 608.2                     | 583.5                                    |                  |
| K <sub>2</sub> O                             | Potassium oxide          | 1342.5                    | 1311.8                                   |                  |
| Kr                                           | Krypton                  | 424.6                     | 402.4                                    |                  |
| La                                           | Lanthanum                | 1013                      | 991.9                                    |                  |
| Li <sub>2</sub>                              | Dilithium                | 1162                      | 1133.1                                   |                  |
| Li <sub>2</sub> O                            | Lithium oxide            | 1206                      | 1175.3                                   |                  |
| Lu                                           | Lutetium                 | 992                       | 970.6                                    |                  |
| Mg                                           | Magnesium                | 819.6                     | 797.3                                    |                  |
| MgO                                          | Magnesium oxide          | 988                       | 959.4                                    |                  |
| Mg <sub>2</sub>                              | Dimagnesium              | 919                       | 886.5                                    |                  |
| Mn                                           | Manganese                | 797.3                     | 774.4                                    |                  |
| N                                            | Nitrogen (atomic)        | 342.2                     | 318.7                                    |                  |
| NO                                           | Nitric oxide             | 531.8                     | 505.3                                    |                  |
| NO <sub>2</sub>                              | Nitrogen dioxide         | 591.0                     | 560.3                                    |                  |
| NP                                           | Phosphorus nitride       | 789.4                     | 757.0                                    |                  |
| N <sub>2</sub>                               | Nitrogen                 | 493.8                     | 464.5                                    |                  |
| N <sub>2</sub> O                             | Nitrous oxide            | 549.8                     | 523.3                                    | Protonation at N |
| N <sub>2</sub> O                             | Nitrous oxide            | 575.2                     | 548.7                                    | Protonation at O |
| Na <sub>2</sub>                              | Disodium                 | 1146.8                    | 1118.2                                   |                  |
| Na <sub>2</sub> O                            | Sodium oxide             | 1375.9                    | 1345.2                                   |                  |
| Ne                                           | Neon                     | 198.8                     | 174.4                                    |                  |
| Ni                                           | Nickel                   | 737                       | 714.1                                    |                  |
| O                                            | Oxygen (atomic)          | 485.2                     | 459.6                                    |                  |
| OP                                           | Phosphorus monoxide      | 682                       | 649.5                                    |                  |
| OSi                                          | Silicon monoxide         | 777.8                     | 750.4                                    | Protonation at O |

| Molecular<br>formula              | Name                          | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes             |
|-----------------------------------|-------------------------------|---------------------------|------------------------------------------|-------------------|
| OSi                               | Silicon monoxide              | 533                       | 500.5                                    | Protonation at Si |
| OSr                               | Strontium oxide               | 1209                      | 1180.7                                   |                   |
| O <sub>2</sub>                    | Oxygen                        | 421                       | 396.3                                    |                   |
| O <sub>2</sub> S                  | Sulfur dioxide                | 672.3                     | 643.3                                    |                   |
| O <sub>3</sub>                    | Ozone                         | 625.5                     | 595.9                                    |                   |
| O <sub>3</sub> S                  | Sulfur trioxide               | 588.3                     | 560.3                                    |                   |
| O <sub>4</sub> Os                 | Osmium(VIII) oxide            | 676.9                     | 650.6                                    |                   |
| P                                 | Phosphorus                    | 626.8                     | 604.8                                    |                   |
| Pd                                | Palladium                     | 696                       | 673.4                                    |                   |
| Rh                                | Rhodium                       | 768                       | 745.4                                    |                   |
| Ru                                | Ruthenium                     | 774                       | 751.4                                    |                   |
| S                                 | Sulfur                        | 664.3                     | 640.2                                    |                   |
| SSi                               | Silicon monosulfide           | 627                       | 596.6                                    | Protonation at Si |
| SSi                               | Silicon monosulfide           | 683                       | 660.2                                    | Protonation at S  |
| Sc                                | Scandium                      | 914                       | 892.0                                    |                   |
| Si                                | Silicon                       | 837                       | 814.1                                    |                   |
| Ti                                | Titanium                      | 876                       | 853.7                                    |                   |
| U                                 | Uranium                       | 995.2                     | 973.2                                    |                   |
| V                                 | Vanadium                      | 859.4                     | 836.8                                    |                   |
| Xe                                | Xenon                         | 499.6                     | 478.1                                    |                   |
| Y                                 | Yttrium                       | 967                       | 945.9                                    |                   |
| Zn                                | Zinc                          | 608.6                     | 586.0                                    |                   |
| CBrF <sub>3</sub>                 | Bromotrifluoromethane         | 580.0                     | 550.3                                    |                   |
| CBrN                              | Cyanogen bromide              | 749.8                     | 719.2                                    |                   |
| CClF <sub>3</sub>                 | Chlorotrifluoromethane        | 571.3                     | 541.5                                    |                   |
| CClN                              | Cyanogen chloride             | 722.1                     | 691.5                                    |                   |
| CCl <sub>2</sub>                  | Dichloromethylene             | 861                       | 828.5                                    |                   |
| CCl <sub>2</sub> S                | Carbonothioic dichloride      | 752.5                     | 721.8                                    |                   |
| CFN                               | Cyanogen fluoride             | 632                       | 601.3                                    |                   |
| CF <sub>2</sub>                   | Difluoromethylene             | 765                       | 732.5                                    |                   |
| CF <sub>2</sub> O                 | Carbonyl fluoride             | 666.7                     | 637.0                                    |                   |
| CF <sub>3</sub> I                 | Trifluoroiodomethane          | 628.0                     | 598.2                                    |                   |
| CF <sub>3</sub> NO                | Trifluoronitrosomethane       | 703.3                     | 670.8                                    |                   |
| CF <sub>4</sub>                   | Tetrafluoromethane            | 529.3                     | 503.7                                    |                   |
| CHCl                              | Chloromethylene               | 874.1                     | 839.9                                    |                   |
| CHF                               | Fluoromethylene               | 797.9                     | 763.8                                    |                   |
| CHF <sub>3</sub>                  | Trifluoromethane              | 619.5                     | 589.7                                    |                   |
| CHF <sub>3</sub> O <sub>3</sub> S | Trifluoromethanesulfonic acid | 699.4                     | 666.9                                    |                   |
| CHN                               | Hydrogen cyanide              | 712.9                     | 681.6                                    |                   |
| CHN                               | Hydrogen isocyanide           | 772.3                     | 739.8                                    |                   |
| CHNO                              | Isocyanic acid (HNCO)         | 753                       | 718.8                                    |                   |
| CHNO                              | Fulminic acid                 | 758                       | 725.5                                    |                   |
| CHO                               | Oxomethyl (HCO)               | 636                       | 601.8                                    |                   |
| CHO <sub>2</sub>                  | Formyloxyl                    | 623.4                     | 590.9                                    |                   |
| CH <sub>2</sub> F <sub>2</sub>    | Difluoromethane               | 620.5                     | 589.7                                    |                   |
| CH <sub>2</sub> N <sub>2</sub>    | Diazomethane                  | 858.9                     | 826.7                                    |                   |
| CH <sub>2</sub> N <sub>2</sub>    | Cyanamide                     | 805.6                     | 774.9                                    |                   |
| CH <sub>2</sub> O                 | Formaldehyde                  | 712.9                     | 683.3                                    |                   |
| CH <sub>2</sub> O <sub>2</sub>    | Formic acid                   | 742.0                     | 710.3                                    |                   |
| CH <sub>2</sub> S                 | Thioformaldehyde              | 759.7                     | 730.5                                    |                   |
| CH <sub>2</sub> Se                | Selenoformaldehyde            | 764.0                     | 734.9                                    |                   |
| CH <sub>3</sub> Br                | Bromomethane                  | 664.2                     | 638.0                                    |                   |
| CH <sub>3</sub> Cl                | Chloromethane                 | 647.3                     | 621.1                                    |                   |
| CH <sub>3</sub> F                 | Fluoromethane                 | 598.9                     | 571.5                                    |                   |
| CH <sub>3</sub> I                 | Iodomethane                   | 691.7                     | 665.5                                    |                   |
| CH <sub>3</sub> NO                | Formamide                     | 822.2                     | 791.2                                    |                   |
| CH <sub>3</sub> NO <sub>2</sub>   | Nitromethane                  | 754.6                     | 721.6                                    |                   |
| CH <sub>3</sub> NO <sub>2</sub>   | Methyl nitrite                | 798.9                     | 766.4                                    |                   |
| CH <sub>3</sub> NO <sub>3</sub>   | Methyl nitrate                | 733.6                     | 714.8                                    |                   |
| CH <sub>3</sub> N <sub>3</sub>    | Methyl azide                  | 833                       | 800.5                                    |                   |

| Molecular<br>formula                            | Name                             | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes                    |
|-------------------------------------------------|----------------------------------|---------------------------|------------------------------------------|--------------------------|
| CH <sub>4</sub>                                 | Methane                          | 543.5                     | 520.6                                    |                          |
| CH <sub>4</sub> N                               | Methylamidogen                   | 832.8                     | 801.6                                    |                          |
| CH <sub>4</sub> N <sub>2</sub> O                | Urea                             | 873.5                     | 841.6                                    | Protonation at O; Ref. 8 |
| CH <sub>4</sub> N <sub>2</sub> S                | Thiourea                         | 893.7                     | 863.9                                    |                          |
| CH <sub>4</sub> O                               | Methanol                         | 754.3                     | 724.5                                    |                          |
| CH <sub>4</sub> O <sub>3</sub> S                | Methanesulfonic acid             | 761.3                     | 728.9                                    |                          |
| CH <sub>4</sub> S                               | Methanethiol                     | 773.4                     | 742                                      |                          |
| CH <sub>5</sub> N                               | Methylamine                      | 899.0                     | 864.5                                    |                          |
| CH <sub>5</sub> NO                              | O-Methylhydroxylamine            | 844.8                     | 812.3                                    |                          |
| CH <sub>5</sub> N <sub>3</sub>                  | Guanidine                        | 986.3                     | 949.4                                    |                          |
| CH <sub>5</sub> P                               | Methylphosphine                  | 851.5                     | 817.6                                    |                          |
| CH <sub>6</sub> N <sub>2</sub>                  | Methylhydrazine                  | 898.8                     | 866.4                                    |                          |
| CN                                              | Cyanide                          | >595                      | >564                                     | Protonation at N         |
| CNS                                             | Thiocyanate                      | 751                       | 718.5                                    |                          |
| CO                                              | Carbon monoxide                  | 594                       | 562.8                                    | Protonation at C         |
| CO                                              | Carbon monoxide                  | 426.3                     | 402.2                                    | Protonation at O         |
| COS                                             | Carbon oxysulfide                | 628.5                     | 602.6                                    | Protonation at S         |
| COSe                                            | Carbon oxyselenide               | 670                       | 644.1                                    | Protonation at Se        |
| CO <sub>2</sub>                                 | Carbon dioxide                   | 540.5                     | 515.8                                    |                          |
| CS                                              | Carbon monosulfide               | 791.5                     | 760                                      |                          |
| CS <sub>2</sub>                                 | Carbon disulfide                 | 681.9                     | 657.7                                    |                          |
| CSe                                             | Carbon monoselenide              | 831.8                     | 800.2                                    | Protonation at C         |
| CSe <sub>2</sub>                                | Carbon diselenide                | 725                       | 700.9                                    |                          |
| C <sub>2</sub> ClF <sub>3</sub> O               | Trifluoroacetyl chloride         | 681.6                     | 649.8                                    |                          |
| C <sub>2</sub> Cl <sub>3</sub> N                | Trichloroacetoneitrile           | 723.2                     | 692.6                                    |                          |
| C <sub>2</sub> F <sub>3</sub> N                 | Trifluoroacetoneitrile           | 688.4                     | 657.7                                    |                          |
| C <sub>2</sub> H                                | Ethynyl                          | 753                       | 720.8                                    |                          |
| C <sub>2</sub> HCl <sub>3</sub> O               | Trichloroacetaldehyde            | 722.3                     | 690.5                                    |                          |
| C <sub>2</sub> HCl <sub>3</sub> O <sub>2</sub>  | Trichloroacetic acid             | 770.0                     | 739.1                                    |                          |
| C <sub>2</sub> HF                               | Fluoroacetylene                  | 686                       | 661.3                                    |                          |
| C <sub>2</sub> HF <sub>3</sub>                  | Trifluoroethene                  | 699.4                     | 666.9                                    |                          |
| C <sub>2</sub> HF <sub>3</sub> O <sub>2</sub>   | Trifluoroacetic acid             | 711.7                     | 680.7                                    |                          |
| C <sub>2</sub> H <sub>2</sub>                   | Acetylene                        | 641.4                     | 616.7                                    |                          |
| C <sub>2</sub> H <sub>2</sub> CIN               | Chloroacetoneitrile              | 745.7                     | 715.1                                    |                          |
| C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>    | 1,1-Difluoroethene               | 734                       | 705.1                                    |                          |
| C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>    | <i>trans</i> -1,2-Difluoroethene | 688.6                     | 657.9                                    |                          |
| C <sub>2</sub> H <sub>2</sub> O                 | Ketene                           | 825.3                     | 793.6                                    |                          |
| C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>  | Chloroacetic acid                | 765.4                     | 734.5                                    |                          |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> O | 2,2,2-Trichloroethanol           | 729.3                     | 698.9                                    |                          |
| C <sub>2</sub> H <sub>3</sub> F                 | Fluoroethene                     | 729                       | 700.1                                    |                          |
| C <sub>2</sub> H <sub>3</sub> FO <sub>2</sub>   | Fluoroacetic acid                | 765.4                     | 734.5                                    |                          |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O  | 2,2,2-Trifluoroethanol           | 700.2                     | 669.9                                    |                          |
| C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O  | Methyl trifluoromethyl ether     | 719.2                     | 690.0                                    |                          |
| C <sub>2</sub> H <sub>3</sub> N                 | Acetonitrile                     | 779.2                     | 748                                      |                          |
| C <sub>2</sub> H <sub>3</sub> N                 | Isocyanomethane                  | 839.1                     | 806.6                                    |                          |
| C <sub>2</sub> H <sub>3</sub> NO                | Methyl isocyanate                | 764.4                     | 732.0                                    |                          |
| C <sub>2</sub> H <sub>3</sub> NS                | Methyl thiocyanate               | 796.7                     | 766.1                                    |                          |
| C <sub>2</sub> H <sub>3</sub> NS                | Methyl isothiocyanate            | 799.2                     | 766.7                                    |                          |
| C <sub>2</sub> H <sub>3</sub> N <sub>3</sub>    | 1 <i>H</i> -1,2,3-Triazole       | 879.3                     | 847.4                                    |                          |
| C <sub>2</sub> H <sub>3</sub> N <sub>3</sub>    | 1 <i>H</i> -1,2,4-Triazole       | 886.0                     | 855.9                                    |                          |
| C <sub>2</sub> H <sub>4</sub>                   | Ethylene                         | 680.5                     | 651.5                                    |                          |
| C <sub>2</sub> H <sub>4</sub> F <sub>2</sub> O  | 2,2-Difluoroethanol              | 727.4                     | 697.0                                    |                          |
| C <sub>2</sub> H <sub>4</sub> F <sub>3</sub> N  | 2,2,2-Trifluoroethylamine        | 846.8                     | 812.9                                    |                          |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub>    | Aminoacetoneitrile               | 824.9                     | 791.0                                    |                          |
| C <sub>2</sub> H <sub>4</sub> O                 | Acetaldehyde                     | 768.5                     | 736.5                                    |                          |
| C <sub>2</sub> H <sub>4</sub> O                 | Oxirane                          | 774.2                     | 745.3                                    |                          |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>    | Acetic acid                      | 783.7                     | 752.8                                    |                          |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>    | Methyl formate                   | 782.5                     | 751.5                                    |                          |
| C <sub>2</sub> H <sub>4</sub> S                 | Thiirane                         | 807.4                     | 777.6                                    |                          |
| C <sub>2</sub> H <sub>5</sub> Br                | Bromoethane                      | 696.2                     | 669.7                                    |                          |

| Molecular<br>formula                       | Name                                         | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}}G^\circ$<br>kJ/mol | Notes |
|--------------------------------------------|----------------------------------------------|---------------------------|-----------------------------------------|-------|
| $\text{C}_2\text{H}_5\text{BrO}$           | 2-Bromoethanol                               | 766.1                     | 735.7                                   |       |
| $\text{C}_2\text{H}_5\text{Cl}$            | Chloroethane                                 | 693.4                     | 666.9                                   |       |
| $\text{C}_2\text{H}_5\text{ClO}$           | 2-Chloroethanol                              | 766.1                     | 735.7                                   |       |
| $\text{C}_2\text{H}_5\text{F}$             | Fluoroethane                                 | 683.4                     | 655.8                                   |       |
| $\text{C}_2\text{H}_5\text{FO}$            | 2-Fluoroethanol                              | 715.6                     | 685.2                                   |       |
| $\text{C}_2\text{H}_5\text{I}$             | Iodoethane                                   | 724.8                     | 698.3                                   |       |
| $\text{C}_2\text{H}_5\text{N}$             | Ethenamine                                   | 898.9                     | 866.5                                   |       |
| $\text{C}_2\text{H}_5\text{N}$             | Ethyleneimine                                | 905.5                     | 872.5                                   |       |
| $\text{C}_2\text{H}_5\text{NO}$            | Acetamide                                    | 863.6                     | 832.6                                   |       |
| $\text{C}_2\text{H}_5\text{NO}$            | <i>N</i> -Methylformamide                    | 851.3                     | 820.3                                   |       |
| $\text{C}_2\text{H}_5\text{NO}_2$          | Nitroethane                                  | 765.7                     | 733.2                                   |       |
| $\text{C}_2\text{H}_5\text{NO}_2$          | Ethyl nitrite                                | 818.9                     | 786.4                                   |       |
| $\text{C}_2\text{H}_5\text{NO}_2$          | Glycine                                      | 886.5                     | 852.2                                   |       |
| $\text{C}_2\text{H}_5\text{NO}_2$          | Acetohydroxamic acid                         | 854.0                     | 823.0                                   |       |
| $\text{C}_2\text{H}_5\text{NS}$            | Thioacetamide                                | 884.6                     | 852.8                                   |       |
| $\text{C}_2\text{H}_6$                     | Ethane                                       | 596.3                     | 569.9                                   |       |
| $\text{C}_2\text{H}_6\text{Hg}$            | Dimethyl mercury                             | 771.6                     | 740.8                                   |       |
| $\text{C}_2\text{H}_6\text{N}_2$           | Ethanimidamide                               | 970.7                     | 938.2                                   |       |
| $\text{C}_2\text{H}_6\text{N}_2$           | trans-Dimethyldiazene                        | 865.1                     | 834.4                                   |       |
| $\text{C}_2\text{H}_6\text{N}_2\text{O}$   | 2-Aminoacetamide                             |                           | 882.3                                   |       |
| $\text{C}_2\text{H}_6\text{N}_2\text{O}_2$ | <i>N</i> -Methyl- <i>N</i> -nitromethanamine | 828.3                     | 795.8                                   |       |
| $\text{C}_2\text{H}_6\text{O}$             | Ethanol                                      | 776.4                     | 746                                     |       |
| $\text{C}_2\text{H}_6\text{O}$             | Dimethyl ether                               | 792                       | 764.5                                   |       |
| $\text{C}_2\text{H}_6\text{OS}$            | Dimethyl sulfoxide                           | 884.4                     | 853.7                                   |       |
| $\text{C}_2\text{H}_6\text{O}_2$           | 1,2-Ethanediol                               | 815.9                     | 773.6                                   |       |
| $\text{C}_2\text{H}_6\text{S}$             | Ethanethiol                                  | 789.6                     | 758.4                                   |       |
| $\text{C}_2\text{H}_6\text{S}$             | Dimethyl sulfide                             | 830.9                     | 801.2                                   |       |
| $\text{C}_2\text{H}_6\text{S}_2$           | Dimethyl disulfide                           | 815.3                     | 782.8                                   |       |
| $\text{C}_2\text{H}_7\text{N}$             | Ethylamine                                   | 912.0                     | 878                                     |       |
| $\text{C}_2\text{H}_7\text{N}$             | Dimethylamine                                | 929.5                     | 896.5                                   |       |
| $\text{C}_2\text{H}_7\text{NO}$            | Ethanolamine                                 | 930.3                     | 896.8                                   |       |
| $\text{C}_2\text{H}_7\text{O}_3\text{P}$   | Dimethyl hydrogen phosphite                  | 894.8                     | 862.4                                   |       |
| $\text{C}_2\text{H}_7\text{P}$             | Dimethylphosphine                            | 912.0                     | 877.9                                   |       |
| $\text{C}_2\text{H}_8\text{N}_2$           | 1,2-Ethanediamine                            | 951.6                     | 912.5                                   |       |
| $\text{C}_2\text{H}_8\text{N}_2$           | 1,1-Dimethylhydrazine                        | 927.1                     | 894.7                                   |       |
| $\text{C}_2\text{N}_2$                     | Cyanogen                                     | 674.7                     | 645.8                                   |       |
| $\text{C}_2\text{O}$                       | Dicarbon monoxide                            | 774.7                     | 747.0                                   |       |
| $\text{C}_3$                               | Carbon trimer                                | 767.0                     | 736.3                                   |       |
| $\text{C}_3\text{F}_6\text{O}$             | Perfluoroacetone                             | 670.4                     | 639.7                                   |       |
| $\text{C}_3\text{HN}$                      | Cyanoacetylene                               | 751.2                     | 720.5                                   |       |
| $\text{C}_3\text{H}_2\text{F}_6\text{O}$   | 1,1,1,3,3,3-Hexafluoro-2-propanol            | 686.6                     | 656.2                                   |       |
| $\text{C}_3\text{H}_2\text{N}_2$           | Malononitrile                                | 723.0                     | 694.1                                   |       |
| $\text{C}_3\text{H}_3$                     | 2-Propynyl                                   | 741                       | 708.5                                   |       |
| $\text{C}_3\text{H}_3\text{Cl}_3\text{O}$  | 1,1,1-Trichloro-2-propanone                  | 768.3                     | 736.3                                   |       |
| $\text{C}_3\text{H}_3\text{F}_3\text{O}$   | 1,1,1-Trifluoroacetone                       | 723.9                     | 692.0                                   |       |
| $\text{C}_3\text{H}_3\text{F}_3\text{O}_2$ | Methyl trifluoroacetate                      | 740.5                     | 709.6                                   |       |
| $\text{C}_3\text{H}_3\text{N}$             | Acrylonitrile                                | 784.7                     | 753.7                                   |       |
| $\text{C}_3\text{H}_3\text{NO}$            | Oxazole                                      | 876.4                     | 844.5                                   |       |
| $\text{C}_3\text{H}_3\text{NO}$            | Isoxazole                                    | 848.6                     | 816.8                                   |       |
| $\text{C}_3\text{H}_3\text{NO}$            | 2-Oxopropanenitrile                          | 746.9                     | 716.2                                   |       |
| $\text{C}_3\text{H}_3\text{NS}$            | Thiazole                                     | 904                       | 872.1                                   |       |
| $\text{C}_3\text{H}_3\text{N}_3$           | 1,3,5-Triazine                               | 848.8                     | 819.6                                   |       |
| $\text{C}_3\text{H}_4$                     | Allene                                       | 775.3                     | 745.8                                   |       |
| $\text{C}_3\text{H}_4$                     | Propyne                                      | 748.2                     | 723.0                                   |       |
| $\text{C}_3\text{H}_4$                     | Cyclopropene                                 | 818.5                     | 787.8                                   |       |
| $\text{C}_3\text{H}_4\text{ClN}$           | 3-Chloropropanenitrile                       | 773.1                     | 742.4                                   |       |
| $\text{C}_3\text{H}_4\text{N}_2$           | 1 <i>H</i> -Pyrazole                         | 894.1                     | 860.5                                   |       |
| $\text{C}_3\text{H}_4\text{N}_2$           | Imidazole                                    | 942.8                     | 909.2                                   |       |
| $\text{C}_3\text{H}_4\text{N}_2\text{S}$   | 2-Thiazolamine                               | 930.6                     | 898.7                                   |       |
| $\text{C}_3\text{H}_4\text{O}$             | Acrolein                                     | 797.0                     | 765.1                                   |       |



| Molecular<br>formula                      | Name                              | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes  |
|-------------------------------------------|-----------------------------------|---------------------------|------------------------------------------|--------|
| $\text{C}_3\text{H}_4\text{O}$            | 1-Propen-1-one                    | 834.1                     | 803.4                                    |        |
| $\text{C}_3\text{H}_4\text{O}_3$          | Ethylene carbonate                | 814.2                     | 784.4                                    |        |
| $\text{C}_3\text{H}_5$                    | Allyl                             | 736                       | 707.4                                    |        |
| $\text{C}_3\text{H}_5$                    | Cyclopropyl                       | 738.9                     | 702.0                                    |        |
| $\text{C}_3\text{H}_5\text{ClO}_2$        | Ethyl chloroformate               | 764.8                     | 733.8                                    |        |
| $\text{C}_3\text{H}_5\text{FO}$           | 1-Fluoro-2-propanone              | 795.4                     | 763.5                                    |        |
| $\text{C}_3\text{H}_5\text{F}_3\text{O}$  | 2,2,2-Trifluoroethyl methyl ether | 747.6                     | 718.4                                    |        |
| $\text{C}_3\text{H}_5\text{N}$            | Propanenitrile                    | 794.1                     | 763.0                                    |        |
| $\text{C}_3\text{H}_5\text{N}$            | 2-Propyn-1-amine                  | 887.4                     | 853.5                                    |        |
| $\text{C}_3\text{H}_5\text{N}$            | Ethyl isocyanide                  | 851.3                     | 818.9                                    |        |
| $\text{C}_3\text{H}_5\text{NO}$           | Acrylamide                        | 870.7                     | 839.8                                    |        |
| $\text{C}_3\text{H}_5\text{NO}$           | Methoxyacetoneitrile              | 758.1                     | 727.4                                    |        |
| $\text{C}_3\text{H}_5\text{NO}$           | 2-Azetidinone                     | 852.6                     | 821.7                                    |        |
| $\text{C}_3\text{H}_5\text{NS}$           | (Methylthio)acetoneitrile         | 784.8                     | 754.1                                    |        |
| $\text{C}_3\text{H}_5\text{N}_3$          | 1 <i>H</i> -Pyrazol-3-amine       | 921.5                     | 889.6                                    |        |
| $\text{C}_3\text{H}_5\text{N}_3$          | 1 <i>H</i> -Pyrazol-4-amine       | 907.6                     | 874.0                                    |        |
| $\text{C}_3\text{H}_6$                    | Propene                           | 741.6                     |                                          | Ref. 5 |
| $\text{C}_3\text{H}_6$                    | Cyclopropane                      | 750.3                     | 722.2                                    |        |
| $\text{C}_3\text{H}_6\text{N}_2$          | 3-Aminopropanenitrile             | 866.4                     | 832.5                                    |        |
| $\text{C}_3\text{H}_6\text{N}_2$          | Dimethylcyanamide                 | 852.1                     | 821.4                                    |        |
| $\text{C}_3\text{H}_6\text{N}_2\text{S}$  | 2-Imidazolidinethione             | 921.9                     | 891.2                                    |        |
| $\text{C}_3\text{H}_6\text{O}$            | Methyl vinyl ether                | 859.2                     | 830.3                                    |        |
| $\text{C}_3\text{H}_6\text{O}$            | Propanal                          | 786.0                     | 754.0                                    |        |
| $\text{C}_3\text{H}_6\text{O}$            | Acetone                           | 812                       | 782.1                                    |        |
| $\text{C}_3\text{H}_6\text{O}$            | Oxetane                           | 801.3                     | 773.9                                    |        |
| $\text{C}_3\text{H}_6\text{O}_2$          | Propanoic acid                    | 797.2                     | 766.2                                    |        |
| $\text{C}_3\text{H}_6\text{O}_2$          | Ethyl formate                     | 799.4                     | 768.4                                    |        |
| $\text{C}_3\text{H}_6\text{O}_2$          | Methyl acetate                    | 821.6                     | 790.7                                    |        |
| $\text{C}_3\text{H}_6\text{O}_3$          | Dimethyl carbonate                | 830.2                     | 799.2                                    |        |
| $\text{C}_3\text{H}_6\text{S}$            | (Methylthio)ethene                | 858.2                     | 829.3                                    |        |
| $\text{C}_3\text{H}_6\text{S}$            | Thietane                          | 834.8                     | 805.0                                    |        |
| $\text{C}_3\text{H}_6\text{S}$            | Methylthiirane                    | 833.3                     | 801.5                                    |        |
| $\text{C}_3\text{H}_7\text{N}$            | Allylamine                        | 909.5                     | 875.5                                    |        |
| $\text{C}_3\text{H}_7\text{N}$            | Cyclopropylamine                  | 904.7                     | 869.9                                    |        |
| $\text{C}_3\text{H}_7\text{N}$            | Azetidine                         | 943.4                     | 908.6                                    |        |
| $\text{C}_3\text{H}_7\text{N}$            | 1-Methylaziridine                 | 934.8                     | 904.1                                    |        |
| $\text{C}_3\text{H}_7\text{N}$            | Propyleneimine                    | 925.1                     | 892.1                                    |        |
| $\text{C}_3\text{H}_7\text{NO}$           | <i>N,N</i> -Dimethylformamide     | 887.5                     | 856.6                                    |        |
| $\text{C}_3\text{H}_7\text{NO}$           | <i>N</i> -Methylacetamide         | 888.5                     | 857.6                                    |        |
| $\text{C}_3\text{H}_7\text{NO}$           | Propanamide                       | 876.2                     | 845.3                                    |        |
| $\text{C}_3\text{H}_7\text{NO}_2$         | Isopropyl nitrite                 | 845.5                     | 813.0                                    |        |
| $\text{C}_3\text{H}_7\text{NO}_2$         | <i>L</i> -Alanine                 | 901.6                     | 867.7                                    |        |
| $\text{C}_3\text{H}_7\text{NO}_2$         | Sarcosine                         | 921.2                     | 888.7                                    |        |
| $\text{C}_3\text{H}_7\text{NO}_2\text{S}$ | <i>L</i> -Cysteine                | 903.2                     | 869.3                                    |        |
| $\text{C}_3\text{H}_7\text{NO}_3$         | <i>L</i> -Serine                  | 914.6                     | 880.7                                    |        |
| $\text{C}_3\text{H}_8$                    | Propane                           | 625.7                     | 607.8                                    |        |
| $\text{C}_3\text{H}_8\text{N}_2\text{O}$  | <i>N,N'</i> -Dimethylurea         | 903.3                     | 873.5                                    |        |
| $\text{C}_3\text{H}_8\text{N}_2\text{S}$  | <i>N,N'</i> -Dimethylthiourea     | 926.0                     | 895.1                                    |        |
| $\text{C}_3\text{H}_8\text{O}$            | 1-Propanol                        | 786.5                     | 756.1                                    |        |
| $\text{C}_3\text{H}_8\text{O}$            | 2-Propanol                        | 793.0                     | 762.6                                    |        |
| $\text{C}_3\text{H}_8\text{O}$            | Ethyl methyl ether                | 808.6                     | 781.2                                    |        |
| $\text{C}_3\text{H}_8\text{O}_2$          | 1,3-Propanediol                   | 876.2                     | 825.9                                    |        |
| $\text{C}_3\text{H}_8\text{O}_2$          | 2-Methoxyethanol                  | 768.8                     | 729.8                                    |        |
| $\text{C}_3\text{H}_8\text{O}_3$          | Glycerol                          | 874.8                     | 820                                      |        |
| $\text{C}_3\text{H}_8\text{S}$            | 1-Propanethiol                    | 794.9                     | 763.6                                    |        |
| $\text{C}_3\text{H}_8\text{S}$            | 2-Propanethiol                    | 803.6                     | 772.3                                    |        |
| $\text{C}_3\text{H}_8\text{S}$            | Ethyl methyl sulfide              | 846.5                     | 815.3                                    |        |
| $\text{C}_3\text{H}_9\text{As}$           | Trimethylarsine                   | 897.3                     | 864.9                                    |        |
| $\text{C}_3\text{H}_9\text{BO}_3$         | Trimethyl borate                  | 815.8                     | 783.4                                    |        |
| $\text{C}_3\text{H}_9\text{N}$            | Propylamine                       | 917.8                     | 883.9                                    |        |

| Molecular<br>formula                        | Name                                            | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes   |
|---------------------------------------------|-------------------------------------------------|---------------------------|------------------------------------------|---------|
| $\text{C}_3\text{H}_9\text{N}$              | Isopropylamine                                  | 923.8                     | 889.0                                    |         |
| $\text{C}_3\text{H}_9\text{N}$              | Ethylmethylamine                                | 942.2                     | 909.2                                    |         |
| $\text{C}_3\text{H}_9\text{N}$              | Trimethylamine                                  | 948.9                     | 918.1                                    |         |
| $\text{C}_3\text{H}_9\text{NO}$             | 2-Methoxyethylamine                             | 928.6                     | 894.6                                    |         |
| $\text{C}_3\text{H}_9\text{NO}$             | Trimethylamine oxide                            | 983.2                     | 953.5                                    |         |
| $\text{C}_3\text{H}_9\text{NO}$             | 3-Amino-1-propanol                              | 962.5                     | 917.3                                    |         |
| $\text{C}_3\text{H}_9\text{O}_3\text{P}$    | Trimethyl phosphite                             | 929.7                     | 899.9                                    |         |
| $\text{C}_3\text{H}_9\text{O}_4\text{P}$    | Trimethyl phosphate                             | 890.6                     | 860.8                                    |         |
| $\text{C}_3\text{H}_9\text{P}$              | Trimethylphosphine                              | 958.8                     | 926.3                                    |         |
| $\text{C}_3\text{H}_{10}\text{N}_2$         | 1,3-Propanediamine                              | 987.0                     | 940.0                                    |         |
| $\text{C}_3\text{H}_{10}\text{OSi}$         | Trimethylsilanol                                | 814.0                     | 781.5                                    |         |
| $\text{C}_4\text{F}_8$                      | Perfluorocyclobutane                            | >544                      |                                          | Ref. 6  |
| $\text{C}_4\text{H}_2$                      | 1,3-Butadiyne                                   | 737.2                     | 712.8                                    |         |
| $\text{C}_4\text{H}_4\text{F}_6\text{O}$    | Bis(2,2,2-trifluoroethyl) ether                 | 702.3                     | 674.9                                    |         |
| $\text{C}_4\text{H}_4\text{N}_2$            | Pyrazine                                        | 877.1                     | 847.0                                    |         |
| $\text{C}_4\text{H}_4\text{N}_2$            | Pyrimidine                                      | 885.8                     | 855.7                                    |         |
| $\text{C}_4\text{H}_4\text{N}_2$            | Pyridazine                                      | 907.2                     | 877.1                                    |         |
| $\text{C}_4\text{H}_4\text{N}_2\text{O}_2$  | Uracil                                          | 872.7                     | 841.7                                    |         |
| $\text{C}_4\text{H}_4\text{N}_2\text{S}_2$  | 2,4(1 <i>H</i> ,3 <i>H</i> )-Pyrimidinedithione | 911.4                     | 880.5                                    |         |
| $\text{C}_4\text{H}_4\text{O}$              | Furan                                           | 812                       | 781                                      | Ref. 10 |
| $\text{C}_4\text{H}_4\text{O}_3$            | Succinic anhydride                              | 797                       |                                          | Ref. 9  |
| $\text{C}_4\text{H}_4\text{S}$              | Thiophene                                       | 815.0                     | 784.3                                    |         |
| $\text{C}_4\text{H}_5\text{Cl}_3\text{O}_2$ | Ethyl trichloroacetate                          | 790.4                     | 759.4                                    |         |
| $\text{C}_4\text{H}_5\text{F}_3\text{O}_2$  | Ethyl trifluoroacetate                          | 758.8                     | 727.9                                    |         |
| $\text{C}_4\text{H}_5\text{N}$              | Pyrrole                                         | 875.4                     | 843.8                                    |         |
| $\text{C}_4\text{H}_5\text{N}$              | Cyclopropanecarbonitrile                        | 808.2                     | 777.5                                    |         |
| $\text{C}_4\text{H}_5\text{NO}_2$           | Ethyl cyanoformate                              | 745.7                     | 714.7                                    |         |
| $\text{C}_4\text{H}_5\text{NS}$             | 2-Methylthiazole                                | 930.6                     | 898.7                                    |         |
| $\text{C}_4\text{H}_5\text{N}_3\text{O}$    | Cytosine                                        | 949.9                     | 918                                      |         |
| $\text{C}_4\text{H}_6$                      | 1,2-Butadiene                                   | 778.9                     | 749.8                                    |         |
| $\text{C}_4\text{H}_6$                      | 1,3-Butadiene                                   | 783.4                     | 757.6                                    |         |
| $\text{C}_4\text{H}_6$                      | 2-Butyne                                        | 775.8                     | 745.1                                    |         |
| $\text{C}_4\text{H}_6$                      | Cyclobutene                                     | 784.4                     | 753.6                                    |         |
| $\text{C}_4\text{H}_6\text{F}_3\text{NO}$   | 2,2,2-Trifluoro- <i>N,N</i> -dimethylacetamide  | 849.0                     | 818.0                                    |         |
| $\text{C}_4\text{H}_6\text{N}_2$            | 1-Methylimidazol                                | 959.6                     | 927.7                                    |         |
| $\text{C}_4\text{H}_6\text{N}_2$            | 2-Methyl-1 <i>H</i> -imidazole                  | 963.4                     | 929.6                                    |         |
| $\text{C}_4\text{H}_6\text{N}_2$            | 4-Methyl-1 <i>H</i> -imidazole                  | 952.8                     | 920.9                                    |         |
| $\text{C}_4\text{H}_6\text{N}_2$            | 1-Methyl-1 <i>H</i> -pyrazole                   | 912.0                     | 880.1                                    |         |
| $\text{C}_4\text{H}_6\text{N}_2$            | 3-Methyl-1 <i>H</i> -pyrazole                   | 906.0                     | 874.2                                    |         |
| $\text{C}_4\text{H}_6\text{N}_2$            | 4-Methyl-1 <i>H</i> -pyrazole                   | 906.8                     | 873.4                                    |         |
| $\text{C}_4\text{H}_6\text{O}$              | 2-Methylpropenal                                | 808.7                     | 776.8                                    |         |
| $\text{C}_4\text{H}_6\text{O}$              | 3-Buten-2-one                                   | 834.7                     | 802.8                                    |         |
| $\text{C}_4\text{H}_6\text{O}$              | Cyclobutanone                                   | 802.5                     | 772.7                                    |         |
| $\text{C}_4\text{H}_6\text{O}$              | 2,3-Dihydrofuran                                | 866.9                     | 834.4                                    |         |
| $\text{C}_4\text{H}_6\text{O}$              | 2,5-Dihydrofuran                                | 823.4                     | 796                                      |         |
| $\text{C}_4\text{H}_6\text{O}_2$            | <i>trans</i> -2-Butenoic acid                   | 824.0                     | 793                                      |         |
| $\text{C}_4\text{H}_6\text{O}_2$            | Methacrylic acid                                | 816.7                     | 785.7                                    |         |
| $\text{C}_4\text{H}_6\text{O}_2$            | Cyclopropanecarboxylic acid                     | 821.4                     | 790.4                                    |         |
| $\text{C}_4\text{H}_6\text{O}_2$            | Vinyl acetate                                   | 813.9                     | 782.9                                    |         |
| $\text{C}_4\text{H}_6\text{O}_2$            | Methyl acrylate                                 | 825.8                     | 794.8                                    |         |
| $\text{C}_4\text{H}_6\text{O}_2$            | 2,3-Butanedione                                 | 801.9                     | 770.1                                    |         |
| $\text{C}_4\text{H}_6\text{O}_2$            | $\gamma$ -Butyrolactone                         | 840.0                     | 808.1                                    |         |
| $\text{C}_4\text{H}_6\text{O}_2$            | 2,3-Dihydro-1,4-dioxin                          | 823.5                     | 792.8                                    |         |
| $\text{C}_4\text{H}_6\text{O}_3$            | Acetic anhydride                                | 844                       |                                          | Ref. 9  |
| $\text{C}_4\text{H}_7$                      | 2-Methylallyl                                   | 778                       | 747.3                                    |         |
| $\text{C}_4\text{H}_7\text{N}$              | Butanenitrile                                   | 798.4                     | 767.7                                    |         |
| $\text{C}_4\text{H}_7\text{N}$              | 2-Methylpropanenitrile                          | 803.6                     | 772.8                                    |         |
| $\text{C}_4\text{H}_7\text{N}$              | 1-Isocyanopropane                               | 856.8                     | 824.3                                    |         |
| $\text{C}_4\text{H}_7\text{NO}$             | 2-Butenamide                                    | 887.1                     | 856.1                                    |         |

| Molecular<br>formula                       | Name                                         | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}}G^\circ$<br>kJ/mol | Notes |
|--------------------------------------------|----------------------------------------------|---------------------------|-----------------------------------------|-------|
| $\text{C}_4\text{H}_7\text{NO}$            | 2-Methyl-2-propenamide                       | 880.4                     | 849.4                                   |       |
| $\text{C}_4\text{H}_7\text{NO}_4$          | <i>L</i> -Aspartic acid                      | 908.9                     | 875                                     |       |
| $\text{C}_4\text{H}_8$                     | <i>trans</i> -2-Butene                       | 747                       | 719.9                                   |       |
| $\text{C}_4\text{H}_8$                     | Isobutene                                    | 802.1                     | 775.6                                   |       |
| $\text{C}_4\text{H}_8\text{N}_2$           | (Dimethylamino)acetonitrile                  | 884.5                     | 853.7                                   |       |
| $\text{C}_4\text{H}_8\text{N}_2\text{O}_3$ | <i>L</i> -Asparagine                         | 929                       | 891.5                                   |       |
| $\text{C}_4\text{H}_8\text{N}_2\text{O}_3$ | <i>N</i> -Glycylglycine                      |                           | 882                                     |       |
| $\text{C}_4\text{H}_8\text{O}$             | Ethyl vinyl ether                            | 870.1                     | 840.4                                   |       |
| $\text{C}_4\text{H}_8\text{O}$             | 2-Methoxy-1-propene                          | 894.9                     | 866.1                                   |       |
| $\text{C}_4\text{H}_8\text{O}$             | Butanal                                      | 792.7                     | 760.8                                   |       |
| $\text{C}_4\text{H}_8\text{O}$             | Isobutanal                                   | 797.3                     | 765.5                                   |       |
| $\text{C}_4\text{H}_8\text{O}$             | 2-Butanone                                   | 827.3                     | 795.5                                   |       |
| $\text{C}_4\text{H}_8\text{O}$             | Tetrahydrofuran                              | 822.1                     | 794.7                                   |       |
| $\text{C}_4\text{H}_8\text{O}_2$           | Propyl formate                               | 804.9                     | 773.9                                   |       |
| $\text{C}_4\text{H}_8\text{O}_2$           | Isopropyl formate                            | 811.3                     | 780.3                                   |       |
| $\text{C}_4\text{H}_8\text{O}_2$           | Ethyl acetate                                | 835.7                     | 804.7                                   |       |
| $\text{C}_4\text{H}_8\text{O}_2$           | Methyl propanoate                            | 830.2                     | 799.2                                   |       |
| $\text{C}_4\text{H}_8\text{O}_2$           | 1,3-Dioxane                                  | 825.4                     | 796.2                                   |       |
| $\text{C}_4\text{H}_8\text{O}_2$           | 1,4-Dioxane                                  | 797.4                     | 770.0                                   |       |
| $\text{C}_4\text{H}_8\text{O}_3$           | Ethyl methyl carbonate                       | 842.7                     | 810.8                                   |       |
| $\text{C}_4\text{H}_8\text{S}$             | Tetrahydrothiophene                          | 849.1                     | 819.3                                   |       |
| $\text{C}_4\text{H}_9\text{N}$             | Pyrrolidine                                  | 948.3                     | 915.3                                   |       |
| $\text{C}_4\text{H}_9\text{NO}$            | <i>N</i> -Methylpropanamide                  | 920.4                     | 889.4                                   |       |
| $\text{C}_4\text{H}_9\text{NO}$            | 2-Methylpropanamide                          | 878.6                     | 846.7                                   |       |
| $\text{C}_4\text{H}_9\text{NO}$            | <i>N</i> -Ethylacetamide                     | 898.0                     | 867.0                                   |       |
| $\text{C}_4\text{H}_9\text{NO}$            | <i>N,N</i> -Dimethylacetamide                | 908.0                     | 877.0                                   |       |
| $\text{C}_4\text{H}_9\text{NO}$            | Morpholine                                   | 924.3                     | 891.2                                   |       |
| $\text{C}_4\text{H}_9\text{NO}_2$          | <i>tert</i> -Butyl nitrite                   | 863.9                     | 831.4                                   |       |
| $\text{C}_4\text{H}_9\text{NO}_2$          | Ethyl <i>N</i> -methylcarbamate              | 888.8                     | 857.8                                   |       |
| $\text{C}_4\text{H}_9\text{NO}_3$          | <i>L</i> -Threonine                          | 922.5                     | 888.5                                   |       |
| $\text{C}_4\text{H}_9\text{NS}$            | <i>N,N</i> -Dimethylthioacetamide            | 925.3                     | 894.4                                   |       |
| $\text{C}_4\text{H}_{10}$                  | Isobutane                                    | 677.8                     | 671.3                                   |       |
| $\text{C}_4\text{H}_{10}\text{N}_2$        | Piperazine                                   | 943.7                     | 914.7                                   |       |
| $\text{C}_4\text{H}_{10}\text{N}_2$        | 3-Ethyl-3-methyldiaziridine                  | 903.8                     | 871.3                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}$          | 1-Butanol                                    | 789.2                     | 758.9                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}$          | 2-Butanol                                    | 815.7                     | 784.6                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}$          | 2-Methyl-1-propanol                          | 793.7                     | 762.2                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}$          | 2-Methyl-2-propanol                          | 802.6                     | 772.2                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}$          | Diethyl ether                                | 828.4                     | 801                                     |       |
| $\text{C}_4\text{H}_{10}\text{O}$          | Methyl propyl ether                          | 814.9                     | 785.7                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}$          | Isopropyl methyl ether                       | 826.3                     | 797.1                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}_2$        | 1,4-Butanediol                               | 915.6                     | 854.9                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}_2$        | 1,2-Dimethoxyethane                          | 858.0                     | 820.2                                   |       |
| $\text{C}_4\text{H}_{10}\text{O}_3$        | 1,2,4-Butanetriol                            | 905.9                     | 841                                     |       |
| $\text{C}_4\text{H}_{10}\text{S}$          | 1-Butanethiol                                | 801.7                     | 770.5                                   |       |
| $\text{C}_4\text{H}_{10}\text{S}$          | 2-Methyl-1-propanethiol                      | 802.6                     | 771.4                                   |       |
| $\text{C}_4\text{H}_{10}\text{S}$          | 2-Methyl-2-propanethiol                      | 816.4                     | 785.1                                   |       |
| $\text{C}_4\text{H}_{10}\text{S}$          | Diethyl sulfide                              | 856.7                     | 827.0                                   |       |
| $\text{C}_4\text{H}_{11}\text{N}$          | Butylamine                                   | 921.5                     | 886.6                                   |       |
| $\text{C}_4\text{H}_{11}\text{N}$          | <i>tert</i> -Butylamine                      | 934.1                     | 899.9                                   |       |
| $\text{C}_4\text{H}_{11}\text{N}$          | Isobutylamine                                | 924.8                     | 890.8                                   |       |
| $\text{C}_4\text{H}_{11}\text{N}$          | Diethylamine                                 | 952.4                     | 919.4                                   |       |
| $\text{C}_4\text{H}_{11}\text{N}$          | Isopropylmethylamine                         | 952.4                     | 919.4                                   |       |
| $\text{C}_4\text{H}_{11}\text{N}$          | Ethyldimethylamine                           | 960.1                     | 929.1                                   |       |
| $\text{C}_4\text{H}_{11}\text{NO}$         | <i>N</i> -Ethyl- <i>N</i> -hydroxyethanamine | 914.7                     | 882.2                                   |       |
| $\text{C}_4\text{H}_{11}\text{NO}$         | 4-Amino-1-butanol                            | 984.5                     | 932.1                                   |       |
| $\text{C}_4\text{H}_{11}\text{NO}_2$       | Diethanolamine                               | 953                       | 920                                     |       |
| $\text{C}_4\text{H}_{12}\text{N}_2$        | 1,4-Butanediamine                            | 1005.6                    | 954.3                                   |       |
| $\text{C}_4\text{H}_{12}\text{N}_2$        | <i>N,N'</i> -Dimethyl-1,2-ethanediamine      | 989.2                     | 946.9                                   |       |
| $\text{C}_4\text{H}_{12}\text{Sn}$         | Tetramethylstannane                          | 823.7                     | 797.4                                   |       |

| Molecular<br>formula                       | Name                                | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes  |
|--------------------------------------------|-------------------------------------|---------------------------|------------------------------------------|--------|
| $\text{C}_4\text{H}_{14}\text{OSi}_2$      | 1,1,3,3-Tetramethyldisiloxane       | 845.3                     | 814.6                                    |        |
| $\text{C}_4\text{NiO}_4$                   | Nickel carbonyl                     | 742.3                     | 716.0                                    |        |
| $\text{C}_5\text{F}_5\text{N}$             | Perfluoropyridine                   | 764.9                     | 733.0                                    |        |
| $\text{C}_5\text{FeO}_5$                   | Iron pentacarbonyl                  | 833.0                     | 798.5                                    |        |
| $\text{C}_5\text{H}_3\text{ClN}_4$         | 6-Chloro-1 <i>H</i> -purine         | 873.6                     | 841.7                                    |        |
| $\text{C}_5\text{H}_4\text{BrN}$           | 2-Bromopyridine                     | 904.8                     | 873.0                                    |        |
| $\text{C}_5\text{H}_4\text{BrN}$           | 3-Bromopyridine                     | 910.0                     | 878.2                                    |        |
| $\text{C}_5\text{H}_4\text{BrN}$           | 4-Bromopyridine                     | 917.8                     | 886.0                                    |        |
| $\text{C}_5\text{H}_4\text{ClN}$           | 2-Chloropyridine                    | 900.9                     | 869                                      |        |
| $\text{C}_5\text{H}_4\text{ClN}$           | 3-Chloropyridine                    | 903.4                     | 871.5                                    |        |
| $\text{C}_5\text{H}_4\text{ClN}$           | 4-Chloropyridine                    | 916.1                     | 884.2                                    |        |
| $\text{C}_5\text{H}_4\text{FN}$            | 3-Fluoropyridine                    | 902.0                     | 870.1                                    |        |
| $\text{C}_5\text{H}_4\text{FN}$            | 2-Fluoropyridine                    | 884.6                     | 852.7                                    |        |
| $\text{C}_5\text{H}_4\text{N}_2\text{O}_2$ | 4-Nitropyridine                     | 874.3                     | 842.5                                    |        |
| $\text{C}_5\text{H}_4\text{N}_2\text{O}_3$ | 4-Nitropyridine 1-oxide             | 868.0                     | 837.3                                    |        |
| $\text{C}_5\text{H}_4\text{N}_4$           | 1 <i>H</i> -Purine                  | 920.1                     | 888.2                                    |        |
| $\text{C}_5\text{H}_4\text{N}_4\text{O}$   | Hypoxanthine                        | 912.3                     | 880.5                                    |        |
| $\text{C}_5\text{H}_5$                     | Cyclopentadienyl                    | 831.5                     | 799.1                                    |        |
| $\text{C}_5\text{H}_5\text{N}$             | Pyridine                            | 930                       | 898.1                                    |        |
| $\text{C}_5\text{H}_5\text{NO}$            | 3-Pyridinol                         | 929.5                     | 897.7                                    |        |
| $\text{C}_5\text{H}_5\text{NO}$            | Pyridine-1-oxide                    | 923.6                     | 892.9                                    |        |
| $\text{C}_5\text{H}_5\text{N}_5$           | Adenine                             | 942.8                     | 912.5                                    |        |
| $\text{C}_5\text{H}_5\text{N}_5\text{O}$   | Guanine                             | 959.5                     | 927.6                                    |        |
| $\text{C}_5\text{H}_6$                     | 1,3-Cyclopentadiene                 | 821.6                     | 798.4                                    |        |
| $\text{C}_5\text{H}_6\text{N}_2$           | 2-Pyridinamine                      | 947.2                     | 915.3                                    |        |
| $\text{C}_5\text{H}_6\text{N}_2$           | 3-Pyridinamine                      | 954.4                     | 922.6                                    |        |
| $\text{C}_5\text{H}_6\text{N}_2$           | 4-Pyridinamine                      | 979.7                     | 947.8                                    |        |
| $\text{C}_5\text{H}_6\text{N}_2\text{O}_2$ | Thymine                             | 880.9                     | 850.0                                    |        |
| $\text{C}_5\text{H}_6\text{O}$             | 2-Methylfuran                       | 865.9                     | 833.5                                    |        |
| $\text{C}_5\text{H}_6\text{O}$             | 3-Methylfuran                       | 854.0                     | 821.5                                    |        |
| $\text{C}_5\text{H}_6\text{O}_3$           | Glutaric anhydride                  | 816                       |                                          | Ref. 9 |
| $\text{C}_5\text{H}_6\text{O}_3$           | 3-Methylsuccinic anhydride          | 807                       |                                          | Ref. 9 |
| $\text{C}_5\text{H}_6\text{S}$             | 2-Methylthiophene                   | 859.0                     | 826.5                                    |        |
| $\text{C}_5\text{H}_7\text{F}_3\text{O}_2$ | Propyl trifluoroacetate             | 763.9                     | 732.9                                    |        |
| $\text{C}_5\text{H}_8$                     | <i>trans</i> -1,3-Pentadiene        | 834.1                     | 804.4                                    |        |
| $\text{C}_5\text{H}_8$                     | 2-Methyl-1,3-butadiene              | 826.4                     | 797.6                                    |        |
| $\text{C}_5\text{H}_8$                     | 2-Pentyne                           | 810.2                     | 778.0                                    |        |
| $\text{C}_5\text{H}_8$                     | 3-Methyl-1-butyne                   | 814.9                     | 787.8                                    |        |
| $\text{C}_5\text{H}_8$                     | Cyclopentene                        | 766.3                     | 733.8                                    |        |
| $\text{C}_5\text{H}_8$                     | 1-Methylcyclobutene                 | 841.5                     | 807.3                                    |        |
| $\text{C}_5\text{H}_8$                     | Vinylcyclopropane                   | 816.3                     | 787.5                                    |        |
| $\text{C}_5\text{H}_8$                     | 3,3-Dimethylcyclopropene            | 847.8                     | 817.1                                    |        |
| $\text{C}_5\text{H}_8\text{N}_2$           | 1,3-Dimethyl-1 <i>H</i> -pyrazole   | 933.9                     | 902.3                                    |        |
| $\text{C}_5\text{H}_8\text{N}_2$           | 1,4-Dimethyl-1 <i>H</i> -imidazole  | 976.7                     | 944.9                                    |        |
| $\text{C}_5\text{H}_8\text{N}_2$           | 1,5-Dimethyl-1 <i>H</i> -pyrazole   | 934.3                     | 902.8                                    |        |
| $\text{C}_5\text{H}_8\text{N}_2$           | 3,4-Dimethyl-1 <i>H</i> -pyrazole   | 927.3                     | 895.4                                    |        |
| $\text{C}_5\text{H}_8\text{N}_2$           | 3,5-Dimethyl-1 <i>H</i> -pyrazole   | 933.5                     | 900.1                                    |        |
| $\text{C}_5\text{H}_8\text{N}_2$           | 1,2-Dimethyl-1 <i>H</i> -imidazole  | 984.7                     | 952.6                                    |        |
| $\text{C}_5\text{H}_8\text{N}_2$           | 1,5-Dimethyl-1 <i>H</i> -imidazole  | 977.6                     | 945.8                                    |        |
| $\text{C}_5\text{H}_8\text{O}$             | <i>trans</i> -2-Pentenal            | 839.0                     | 807.2                                    |        |
| $\text{C}_5\text{H}_8\text{O}$             | 3-Methyl-2-butenal                  | 856.9                     | 825.0                                    |        |
| $\text{C}_5\text{H}_8\text{O}$             | 3-Methyl-3-buten-2-one              | 843.1                     | 811.3                                    |        |
| $\text{C}_5\text{H}_8\text{O}$             | Cyclopropyl methyl ketone           | 854.9                     | 823                                      |        |
| $\text{C}_5\text{H}_8\text{O}$             | Cyclopentanone                      | 823.7                     | 794.0                                    |        |
| $\text{C}_5\text{H}_8\text{O}$             | 3,4-Dihydro-2 <i>H</i> -pyran       | 865.8                     | 833.4                                    |        |
| $\text{C}_5\text{H}_8\text{O}_2$           | 3-Methyl-2-butenic acid             | 822.9                     | 791.9                                    |        |
| $\text{C}_5\text{H}_8\text{O}_2$           | <i>cis</i> -2-Methyl-2-butenic acid | 822.5                     | 791.5                                    |        |
| $\text{C}_5\text{H}_8\text{O}_2$           | Cyclobutanecarboxylic acid          | 817.4                     | 786.4                                    |        |
| $\text{C}_5\text{H}_8\text{O}_2$           | Methyl <i>trans</i> -2-butenate     | 851.3                     | 820.4                                    |        |
| $\text{C}_5\text{H}_8\text{O}_2$           | Methyl methacrylate                 | 831.4                     | 800.5                                    |        |

| Molecular<br>formula                          | Name                                        | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes |
|-----------------------------------------------|---------------------------------------------|---------------------------|------------------------------------------|-------|
| $\text{C}_5\text{H}_8\text{O}_2$              | Methyl cyclopropanecarboxylate              | 842.1                     | 811.2                                    |       |
| $\text{C}_5\text{H}_8\text{O}_2$              | 2,4- Pentanedione                           | 873.5                     | 836.8                                    |       |
| $\text{C}_5\text{H}_9\text{N}$                | 2-Isocyano-2-methylpropane                  | 870.7                     | 838.3                                    |       |
| $\text{C}_5\text{H}_9\text{N}$                | 3-(Dimethylamino)-1-propyne                 | 940.3                     | 909.5                                    |       |
| $\text{C}_5\text{H}_9\text{N}$                | Pentanenitrile                              | 802.4                     | 771.7                                    |       |
| $\text{C}_5\text{H}_9\text{N}$                | 2,2-Dimethylpropanenitrile                  | 810.9                     | 780.2                                    |       |
| $\text{C}_5\text{H}_9\text{NO}$               | 3-Ethoxypropanenitrile                      | 807.2                     | 776.5                                    |       |
| $\text{C}_5\text{H}_9\text{NO}$               | <i>N,N</i> -Dimethyl-2-propenamide          | 904.3                     | 873.4                                    |       |
| $\text{C}_5\text{H}_9\text{NO}$               | <i>N</i> -Methyl-2-pyrrolidone              | 923.5                     | 891.6                                    |       |
| $\text{C}_5\text{H}_9\text{NO}_2$             | <i>L</i> -Proline                           | 920.5                     | 886.0                                    |       |
| $\text{C}_5\text{H}_9\text{NO}_4$             | <i>L</i> -Glutamic acid                     | 913.0                     | 879.1                                    |       |
| $\text{C}_5\text{H}_9\text{N}_3$              | Histamine                                   | 999.8                     | 961.9                                    |       |
| $\text{C}_5\text{H}_{10}$                     | 2-Methyl-2-butene                           | 808.8                     | 779.9                                    |       |
| $\text{C}_5\text{H}_{10}\text{N}_2\text{O}$   | 1,3-Dimethyl-2-imidazolidinone              | 918.4                     | 886.0                                    |       |
| $\text{C}_5\text{H}_{10}\text{N}_2\text{O}_3$ | <i>L</i> -Glutamine                         | 937.8                     | 900                                      |       |
| $\text{C}_5\text{H}_{10}\text{O}$             | Allyl ethyl ether                           | 833.7                     | 804.5                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}$             | Pentanal                                    | 796.6                     | 764.8                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}$             | 2-Pentanone                                 | 832.7                     | 800.9                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}$             | 3-Pentanone                                 | 836.8                     | 807                                      |       |
| $\text{C}_5\text{H}_{10}\text{O}$             | 3-Methyl-2-butanone                         | 836.3                     | 804.4                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}$             | Tetrahydropyran                             | 822.8                     | 795.4                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}$             | 2-Methyltetrahydrofuran                     | 840.8                     | 811.6                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}_2$           | Butyl formate                               | 806.0                     | 775                                      |       |
| $\text{C}_5\text{H}_{10}\text{O}_2$           | Propyl acetate                              | 836.6                     | 805.6                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}_2$           | Isopropyl acetate                           | 836.6                     | 805.6                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}_2$           | Methyl butanoate                            | 836.4                     | 805.4                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}_2$           | Methyl isobutanoate                         | 836.6                     | 805.7                                    |       |
| $\text{C}_5\text{H}_{10}\text{O}_2$           | <i>cis</i> -1,2-Cyclopentanediol            | 885.6                     | 853.1                                    |       |
| $\text{C}_5\text{H}_{10}\text{S}$             | Thiacyclohexane                             | 855.8                     | 826.0                                    |       |
| $\text{C}_5\text{H}_{11}\text{N}$             | Allyldimethylamine                          | 957.8                     | 926.8                                    |       |
| $\text{C}_5\text{H}_{11}\text{N}$             | Piperidine                                  | 954.0                     | 921                                      |       |
| $\text{C}_5\text{H}_{11}\text{N}$             | <i>N</i> -Methylpyrrolidine                 | 965.6                     | 934.8                                    |       |
| $\text{C}_5\text{H}_{11}\text{NO}$            | 2,2-Dimethylpropanamide                     | 889.0                     | 857.2                                    |       |
| $\text{C}_5\text{H}_{11}\text{NO}_2$          | <i>L</i> -Valine                            | 910.6                     | 876.7                                    |       |
| $\text{C}_5\text{H}_{11}\text{NO}_2\text{S}$  | <i>L</i> -Methionine                        | 935.4                     | 901.5                                    |       |
| $\text{C}_5\text{H}_{12}\text{N}_2\text{O}$   | Tetramethylurea                             | 930.6                     | 899.6                                    |       |
| $\text{C}_5\text{H}_{12}\text{N}_2\text{S}$   | Tetramethylthiourea                         | 947.6                     | 916.6                                    |       |
| $\text{C}_5\text{H}_{12}\text{O}$             | 2,2-Dimethyl-1-propanol                     | 795.5                     | 765.2                                    |       |
| $\text{C}_5\text{H}_{12}\text{O}$             | Butyl methyl ether                          | 820.3                     | 791.2                                    |       |
| $\text{C}_5\text{H}_{12}\text{O}$             | Methyl tert-butyl ether                     | 841.6                     | 812.4                                    |       |
| $\text{C}_5\text{H}_{12}\text{O}$             | Ethyl isopropyl ether                       | 842.7                     | 813.5                                    |       |
| $\text{C}_5\text{H}_{12}\text{S}$             | 2,2-Dimethyl-1-propanethiol                 | 809.5                     | 778.2                                    |       |
| $\text{C}_5\text{H}_{12}\text{Si}$            | Vinyltrimethylsilane                        | 833                       | 804.1                                    |       |
| $\text{C}_5\text{H}_{13}\text{N}$             | Pentylamine                                 | 923.5                     | 889.5                                    |       |
| $\text{C}_5\text{H}_{13}\text{N}$             | 2-Methyl-2-butanamine                       | 937.8                     | 903.6                                    |       |
| $\text{C}_5\text{H}_{13}\text{N}$             | 2,2-Dimethylpropylamine                     | 928.3                     | 894.0                                    |       |
| $\text{C}_5\text{H}_{13}\text{N}$             | Ethylisopropylamine                         | 960.0                     | 926.7                                    |       |
| $\text{C}_5\text{H}_{13}\text{N}$             | <i>N,N</i> -Dimethyl-1-propanamine          | 962.8                     | 931.9                                    |       |
| $\text{C}_5\text{H}_{13}\text{N}$             | Diethylmethylamine                          | 971.0                     | 940.0                                    |       |
| $\text{C}_5\text{H}_{13}\text{N}_3$           | 1,1,3,3-Tetramethylguanidine                | 1031.6                    | 997.4                                    |       |
| $\text{C}_5\text{H}_{14}\text{N}_2$           | <i>N,N,N',N'</i> -Tetramethylmethanediamine | 952.2                     | 919.8                                    |       |
| $\text{C}_5\text{H}_{14}\text{N}_2$           | <i>N,N</i> -Dimethyl-1,3-propanediamine     | 1025.0                    | 975.3                                    |       |
| $\text{C}_5\text{H}_{14}\text{N}_2$           | 1,5-Pentanediamine                          | 999.6                     | 946.2                                    |       |
| $\text{C}_6\text{CrO}_6$                      | Chromium carbonyl                           | 739.2                     | 714.6                                    |       |
| $\text{C}_6\text{F}_6$                        | Hexafluorobenzene                           | 648.0                     | 624.4                                    |       |
| $\text{C}_6\text{HF}_5$                       | Pentafluorobenzene                          | 690.4                     | 662.7                                    |       |
| $\text{C}_6\text{H}_2\text{F}_4$              | 1,2,3,4-Tetrafluorobenzene                  | 700.4                     | 672.7                                    |       |
| $\text{C}_6\text{H}_2\text{F}_4$              | 1,2,3,5-Tetrafluorobenzene                  | 747.3                     | 719.6                                    |       |
| $\text{C}_6\text{H}_2\text{F}_4$              | 1,2,4,5-Tetrafluorobenzene                  | 746.5                     | 718.8                                    |       |
| $\text{C}_6\text{H}_3\text{F}_3$              | 1,2,3-Trifluorobenzene                      | 724.3                     | 696.6                                    |       |

| Molecular<br>formula                       | Name                               | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}}G^\circ$<br>kJ/mol | Notes  |
|--------------------------------------------|------------------------------------|---------------------------|-----------------------------------------|--------|
| $\text{C}_6\text{H}_3\text{F}_3$           | 1,2,4-Trifluorobenzene             | 729.5                     | 699.4                                   |        |
| $\text{C}_6\text{H}_3\text{F}_3$           | 1,3,5-Trifluorobenzene             | 741.9                     | 715.4                                   |        |
| $\text{C}_6\text{H}_4$                     | Benzynes                           | 841                       | 808.5                                   |        |
| $\text{C}_6\text{H}_4\text{F}_2$           | <i>o</i> -Difluorobenzene          | 731.2                     | 703.5                                   |        |
| $\text{C}_6\text{H}_4\text{F}_2$           | <i>m</i> -Difluorobenzene          | 749.7                     | 722                                     |        |
| $\text{C}_6\text{H}_4\text{F}_2$           | <i>p</i> -Difluorobenzene          | 718.7                     | 692.8                                   |        |
| $\text{C}_6\text{H}_4\text{N}_2$           | 2-Pyridinecarbonitrile             | 872.9                     | 841                                     |        |
| $\text{C}_6\text{H}_4\text{N}_2$           | 3-Pyridinecarbonitrile             | 877.0                     | 845.1                                   |        |
| $\text{C}_6\text{H}_4\text{N}_2$           | 4-Pyridinecarbonitrile             | 880.6                     | 848.8                                   |        |
| $\text{C}_6\text{H}_4\text{O}_2$           | <i>p</i> -Benzoquinone             | 799.1                     | 769.3                                   |        |
| $\text{C}_6\text{H}_5$                     | Phenyl                             | 884                       | 851.5                                   |        |
| $\text{C}_6\text{H}_5\text{Br}$            | Bromobenzene                       | 754.1                     | 725.8                                   |        |
| $\text{C}_6\text{H}_5\text{Cl}$            | Chlorobenzene                      | 753.1                     | 724.6                                   |        |
| $\text{C}_6\text{H}_5\text{F}$             | Fluorobenzene                      | 755.9                     | 726.6                                   |        |
| $\text{C}_6\text{H}_5\text{NO}$            | Nitrosobenzene                     | 854.3                     | 823.6                                   |        |
| $\text{C}_6\text{H}_5\text{NO}$            | 4-Pyridinecarboxaldehyde           | 904.6                     | 872.8                                   |        |
| $\text{C}_6\text{H}_5\text{NO}_2$          | Nitrobenzene                       | 800.3                     | 769.5                                   |        |
| $\text{C}_6\text{H}_5\text{N}_3$           | Azidobenzene                       | 820                       | 787.5                                   |        |
| $\text{C}_6\text{H}_5\text{O}$             | Phenoxy                            | 873.2                     |                                         | Ref. 4 |
| $\text{C}_6\text{H}_6$                     | Benzene                            | 750.4                     | 725.4                                   |        |
| $\text{C}_6\text{H}_6\text{BrN}$           | 3-Bromoaniline                     | 873.2                     | 841.4                                   |        |
| $\text{C}_6\text{H}_6\text{ClN}$           | 3-Chloroaniline                    | 868.1                     | 836.3                                   |        |
| $\text{C}_6\text{H}_6\text{ClN}$           | 4-Chloroaniline                    | 873.8                     | 842.0                                   |        |
| $\text{C}_6\text{H}_6\text{ClN}$           | 2-Chloro-4-methylpyridine          | 921.2                     | 889.4                                   |        |
| $\text{C}_6\text{H}_6\text{ClN}$           | 2-Chloro-6-methylpyridine          | 908.0                     | 876.2                                   |        |
| $\text{C}_6\text{H}_6\text{ClNO}$          | 2-Chloro-6-methoxypyridine         | 909.9                     | 878.0                                   |        |
| $\text{C}_6\text{H}_6\text{FN}$            | 3-Fluoroaniline                    | 867.3                     | 835.5                                   |        |
| $\text{C}_6\text{H}_6\text{FN}$            | 4-Fluoroaniline                    | 871.5                     | 839.7                                   |        |
| $\text{C}_6\text{H}_6\text{IN}$            | 3-Iodoaniline                      | 878.7                     | 846.8                                   |        |
| $\text{C}_6\text{H}_6\text{N}$             | Anilino                            | 949.8                     | 917.4                                   |        |
| $\text{C}_6\text{H}_6\text{N}_2\text{O}$   | 3-Pyridinecarboxamide              | 918.3                     | 886.4                                   |        |
| $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$ | 4-Nitroaniline                     | 866.0                     | 834.2                                   |        |
| $\text{C}_6\text{H}_6\text{N}_4$           | 6-Methyl-1 <i>H</i> -purine        | 939.2                     | 907.3                                   |        |
| $\text{C}_6\text{H}_6\text{O}$             | Bis(2-propynyl) ether              | 783.9                     | 756.5                                   |        |
| $\text{C}_6\text{H}_6\text{O}$             | Phenol                             | 817.3                     | 786.3                                   |        |
| $\text{C}_6\text{H}_7\text{N}$             | Bis(2-propynyl)amine               | 910.0                     | 876.9                                   |        |
| $\text{C}_6\text{H}_7\text{N}$             | Aniline                            | 882.5                     | 850.6                                   |        |
| $\text{C}_6\text{H}_7\text{N}$             | 2-Methylpyridine                   | 949.1                     | 917.3                                   |        |
| $\text{C}_6\text{H}_7\text{N}$             | 3-Methylpyridine                   | 943.4                     | 911.6                                   |        |
| $\text{C}_6\text{H}_7\text{N}$             | 4-Methylpyridine                   | 947.2                     | 915.3                                   |        |
| $\text{C}_6\text{H}_7\text{NO}$            | 1-Methyl-2(1 <i>H</i> )-pyridinone | 925.8                     | 894.8                                   |        |
| $\text{C}_6\text{H}_7\text{NO}$            | 2-Aminophenol                      | 898.8                     | 866.9                                   |        |
| $\text{C}_6\text{H}_7\text{NO}$            | 3-Aminophenol                      | 898.8                     | 866.9                                   |        |
| $\text{C}_6\text{H}_7\text{NO}$            | 2-Methoxypyridine                  | 934.7                     | 902.8                                   |        |
| $\text{C}_6\text{H}_7\text{NO}$            | 3-Methoxypyridine                  | 942.7                     | 910.9                                   |        |
| $\text{C}_6\text{H}_7\text{NO}$            | 4-Methoxypyridine                  | 961.7                     | 929.8                                   |        |
| $\text{C}_6\text{H}_7\text{NO}$            | 3-Methylpyridine-1-oxide           | 935.2                     | 902.8                                   |        |
| $\text{C}_6\text{H}_8$                     | 1,3-Cyclohexadiene                 | 837                       | 804.5                                   |        |
| $\text{C}_6\text{H}_8$                     | 1,4-Cyclohexadiene                 | 837                       | 808.0                                   |        |
| $\text{C}_6\text{H}_8\text{N}_2$           | 1,2-Benzenediamine                 | 896.5                     | 865.8                                   |        |
| $\text{C}_6\text{H}_8\text{N}_2$           | 1,3-Benzenediamine                 | 929.9                     | 899.2                                   |        |
| $\text{C}_6\text{H}_8\text{N}_2$           | 1,4-Benzenediamine                 | 905.9                     | 874.0                                   |        |
| $\text{C}_6\text{H}_8\text{N}_2\text{O}$   | Bis(2-cyanoethyl) ether            | 813.8                     | 786.4                                   |        |
| $\text{C}_6\text{H}_8\text{O}$             | 2,4-Dimethylfuran                  | 894.7                     | 862.3                                   |        |
| $\text{C}_6\text{H}_8\text{O}$             | 2,5-Dimethylfuran                  | 865.9                     | 835.2                                   |        |
| $\text{C}_6\text{H}_8\text{O}$             | 3,4-Dimethylfuran                  | 869.0                     | 838.3                                   |        |
| $\text{C}_6\text{H}_8\text{O}_2$           | 1,3-Cyclohexanedione               | 881.2                     | 849.4                                   |        |
| $\text{C}_6\text{H}_8\text{O}_2$           | 1,4-Cyclohexanedione               | 812.5                     | 782.7                                   |        |
| $\text{C}_6\text{H}_8\text{O}_2$           | 1,2-Cyclohexanedione               | 849.6                     | 818.9                                   |        |
| $\text{C}_6\text{H}_8\text{O}_3$           | 4-Methylglutaric anhydride         | 820                       |                                         | Ref. 9 |

| Molecular<br>formula                          | Name                                           | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes |
|-----------------------------------------------|------------------------------------------------|---------------------------|------------------------------------------|-------|
| $\text{C}_6\text{H}_9\text{F}_3\text{O}_2$    | Butyl trifluoroacetate                         | 764.8                     | 733.8                                    |       |
| $\text{C}_6\text{H}_9\text{N}$                | 2,5-Dimethylpyrrole                            | 918.7                     | 887.1                                    |       |
| $\text{C}_6\text{H}_9\text{N}_3\text{O}_2$    | <i>L</i> -Histidine                            | 988                       | 950.2                                    |       |
| $\text{C}_6\text{H}_{10}$                     | Methylenecyclopentane                          | 832.4                     | 803.5                                    |       |
| $\text{C}_6\text{H}_{10}$                     | (1-Methylvinyl)cyclopropane                    | 871.6                     | 842.7                                    |       |
| $\text{C}_6\text{H}_{10}$                     | 2-Methyl-1,3-pentadiene                        | 864.9                     | 836                                      |       |
| $\text{C}_6\text{H}_{10}$                     | 3-Methyl-1,3-pentadiene                        | 852.3                     | 823.4                                    |       |
| $\text{C}_6\text{H}_{10}$                     | 2,3-Dimethyl-1,3-butadiene                     | 835.0                     | 807.8                                    |       |
| $\text{C}_6\text{H}_{10}$                     | 1-Hexyne                                       | 799.8                     | 774.8                                    |       |
| $\text{C}_6\text{H}_{10}$                     | 2-Hexyne                                       | 806.1                     | 781.1                                    |       |
| $\text{C}_6\text{H}_{10}$                     | Cyclohexene                                    | 784.5                     | 752.0                                    |       |
| $\text{C}_6\text{H}_{10}$                     | 1-Methylcyclopentene                           | 816.5                     | 787.1                                    |       |
| $\text{C}_6\text{H}_{10}\text{N}_2$           | 1,3,5-Trimethyl-1 <i>H</i> -pyrazole           | 949.3                     | 917.4                                    |       |
| $\text{C}_6\text{H}_{10}\text{N}_2$           | 3,4,5-Trimethyl-1 <i>H</i> -pyrazole           | 949.3                     | 916.0                                    |       |
| $\text{C}_6\text{H}_{10}\text{O}$             | 7-Oxabicyclo[2.2.1]heptane                     | 844.2                     | 816.8                                    |       |
| $\text{C}_6\text{H}_{10}\text{O}$             | 7-Oxabicyclo[4.1.0]heptane                     | 848.1                     | 815.6                                    |       |
| $\text{C}_6\text{H}_{10}\text{O}$             | <i>trans</i> -3-Hexen-2-one                    | 865.6                     | 833.8                                    |       |
| $\text{C}_6\text{H}_{10}\text{O}$             | Diallyl ether                                  | 827.4                     | 800.0                                    |       |
| $\text{C}_6\text{H}_{10}\text{O}$             | Cyclohexanone                                  | 841.0                     | 811.2                                    |       |
| $\text{C}_6\text{H}_{10}\text{O}$             | Mesityl oxide                                  | 878.7                     | 846.9                                    |       |
| $\text{C}_6\text{H}_{10}\text{O}_2$           | Cyclopentanecarboxylic acid                    | 817.4                     | 786.4                                    |       |
| $\text{C}_6\text{H}_{10}\text{O}_2$           | 2,5-Hexanedione                                | 892.0                     | 851.8                                    |       |
| $\text{C}_6\text{H}_{11}\text{N}$             | <i>N</i> -Allyl-2-propen-1-amine               | 949.3                     | 916.3                                    |       |
| $\text{C}_6\text{H}_{11}\text{NO}$            | 1-Methyl-2-piperidinone                        | 924.4                     | 892.6                                    |       |
| $\text{C}_6\text{H}_{11}\text{N}_3\text{O}_4$ | <i>N</i> -( <i>N</i> -Glycylglycyl)glycine     | 966.8                     | 916.8                                    |       |
| $\text{C}_6\text{H}_{12}$                     | 1-Hexene                                       | 805.2                     | 776.3                                    |       |
| $\text{C}_6\text{H}_{12}$                     | 2-Methyl-2-pentene                             | 812                       | 783.1                                    |       |
| $\text{C}_6\text{H}_{12}$                     | 2,3-Dimethyl-2-butene                          | 813.9                     | 785.9                                    |       |
| $\text{C}_6\text{H}_{12}$                     | Cyclohexane                                    | 686.9                     | 666.9                                    |       |
| $\text{C}_6\text{H}_{12}\text{N}_2$           | Triethylenediamine                             | 963.4                     | 934.6                                    |       |
| $\text{C}_6\text{H}_{12}\text{N}_2\text{O}_3$ | <i>N</i> - <i>L</i> -Alanyl- <i>L</i> -alanine |                           | 905.6                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}$             | Oxepane                                        | 834.2                     | 806.8                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}$             | 3-Hexanone                                     | 843.2                     | 811.3                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}$             | 3,3-Dimethyl-2-butanone                        | 840.1                     | 808.2                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}_2$           | <i>cis</i> -1,3-Cyclohexanediol                | 882.2                     | 849.7                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}_2$           | <i>trans</i> -1,3-Cyclohexanediol              | 828.6                     | 797.9                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}_2$           | Methyl 2,2-dimethylpropanoate                  | 845.2                     | 814.2                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}_2$           | Diacetone alcohol                              | 822.9                     | 791.1                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}_6$           | $\alpha$ - <i>D</i> -Glucose                   |                           | 778.9                                    |       |
| $\text{C}_6\text{H}_{12}\text{O}_6$           | $\beta$ - <i>D</i> -Glucose                    |                           | 778.9                                    |       |
| $\text{C}_6\text{H}_{13}\text{N}$             | <i>N,N</i> ,2-Trimethylpropenylamine           | 967.0                     | 934.5                                    |       |
| $\text{C}_6\text{H}_{13}\text{N}$             | Cyclohexylamine                                | 934.4                     | 899.6                                    |       |
| $\text{C}_6\text{H}_{13}\text{N}$             | 1-Methylpiperidine                             | 971.1                     | 940.1                                    |       |
| $\text{C}_6\text{H}_{13}\text{N}$             | Hexahydro-1 <i>H</i> -azepine                  | 956.7                     | 923.5                                    |       |
| $\text{C}_6\text{H}_{13}\text{NO}$            | <i>N,N</i> -Dimethylbutanamide                 | 921.7                     | 890.8                                    |       |
| $\text{C}_6\text{H}_{13}\text{NO}$            | <i>N,N</i> -Diethylacetamide                   | 925.4                     | 894.4                                    |       |
| $\text{C}_6\text{H}_{13}\text{NO}_2$          | <i>L</i> -Leucine                              | 914.6                     | 880.6                                    |       |
| $\text{C}_6\text{H}_{13}\text{NO}_2$          | <i>L</i> -Isoleucine                           | 917.4                     | 883.5                                    |       |
| $\text{C}_6\text{H}_{14}\text{N}_2\text{O}_2$ | <i>L</i> -Lysine                               | 996                       | 951.0                                    |       |
| $\text{C}_6\text{H}_{14}\text{N}_4\text{O}_2$ | <i>L</i> -Arginine                             | 1051.0                    | 1006.6                                   |       |
| $\text{C}_6\text{H}_{14}\text{O}$             | Dipropyl ether                                 | 837.9                     | 810.5                                    |       |
| $\text{C}_6\text{H}_{14}\text{O}$             | Diisopropyl ether                              | 855.5                     | 828.1                                    |       |
| $\text{C}_6\text{H}_{14}\text{O}$             | <i>tert</i> -Butyl ethyl ether                 | 856.0                     | 826.9                                    |       |
| $\text{C}_6\text{H}_{14}\text{O}_3$           | Diethylene glycol dimethyl ether               | 918.8                     | 870.9                                    |       |
| $\text{C}_6\text{H}_{14}\text{S}$             | Dipropyl sulfide                               | 864.7                     | 834.9                                    |       |
| $\text{C}_6\text{H}_{14}\text{S}$             | Diisopropyl sulfide                            | 876.4                     | 846.6                                    |       |
| $\text{C}_6\text{H}_{15}\text{N}$             | Butyldimethylamine                             | 969.2                     | 938.2                                    |       |
| $\text{C}_6\text{H}_{15}\text{N}$             | Isobutyldimethylamine                          | 968.7                     | 937.8                                    |       |
| $\text{C}_6\text{H}_{15}\text{N}$             | Hexylamine                                     | 927.5                     | 893.5                                    |       |
| $\text{C}_6\text{H}_{15}\text{N}$             | Dipropylamine                                  | 962.3                     | 929.3                                    |       |



| Molecular<br>formula                         | Name                                            | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes |
|----------------------------------------------|-------------------------------------------------|---------------------------|------------------------------------------|-------|
| $\text{C}_6\text{H}_{15}\text{N}$            | Diisopropylamine                                | 971.9                     | 938.6                                    |       |
| $\text{C}_6\text{H}_{15}\text{N}$            | Triethylamine                                   | 981.8                     | 951                                      |       |
| $\text{C}_6\text{H}_{15}\text{NO}$           | 6-Amino-1-hexanol                               | 969.0                     | 915.7                                    |       |
| $\text{C}_6\text{H}_{15}\text{OP}$           | Triethylphosphine oxide                         | 936.6                     | 906.8                                    |       |
| $\text{C}_6\text{H}_{15}\text{O}_4\text{P}$  | Triethyl phosphate                              | 909.3                     | 879.6                                    |       |
| $\text{C}_6\text{H}_{15}\text{P}$            | Triethylphosphine                               | 984.5                     | 952.0                                    |       |
| $\text{C}_6\text{H}_{16}\text{N}_2$          | 1,6-Hexanediamine                               | 999.5                     | 946.2                                    |       |
| $\text{C}_6\text{H}_{16}\text{N}_2$          | <i>N,N,N',N'</i> -Tetramethyl-1,2-ethanediamine | 1012.8                    | 970.6                                    |       |
| $\text{C}_6\text{H}_{16}\text{OSi}$          | Triethylsilanol                                 | 822.1                     | 794.8                                    |       |
| $\text{C}_6\text{H}_{18}\text{N}_3\text{OP}$ | Hexamethylphosphoric triamide                   | 958.6                     | 928.7                                    |       |
| $\text{C}_6\text{H}_{18}\text{N}_3\text{P}$  | Hexamethylphosphorous triamide                  | 930.1                     | 897.7                                    |       |
| $\text{C}_6\text{H}_{18}\text{OSi}_2$        | Hexamethyldisiloxane                            | 846.4                     | 816.2                                    |       |
| $\text{C}_6\text{MoO}_6$                     | Molybdenum hexacarbonyl                         | 762.6                     | 738.1                                    |       |
| $\text{C}_6\text{O}_6\text{W}$               | Tungsten carbonyl                               | 758.0                     | 733.4                                    |       |
| $\text{C}_7\text{H}_4\text{N}_2\text{O}_2$   | 3-Nitrobenzonitrile                             | 781.4                     | 750.7                                    |       |
| $\text{C}_7\text{H}_4\text{N}_2\text{O}_2$   | 4-Nitrobenzonitrile                             | 775.7                     | 745.1                                    |       |
| $\text{C}_7\text{H}_5\text{ClO}$             | 3-Chlorobenzaldehyde                            | 813.0                     | 781.1                                    |       |
| $\text{C}_7\text{H}_5\text{ClO}$             | 4-Chlorobenzaldehyde                            | 831.3                     | 799.4                                    |       |
| $\text{C}_7\text{H}_5\text{FO}$              | 3-Fluorobenzaldehyde                            | 814.3                     | 782.5                                    |       |
| $\text{C}_7\text{H}_5\text{FO}$              | 4-Fluorobenzaldehyde                            | 827.1                     | 795.3                                    |       |
| $\text{C}_7\text{H}_5\text{N}$               | Benzonitrile                                    | 811.5                     | 780.9                                    |       |
| $\text{C}_7\text{H}_5\text{N}$               | Isocyanobenzene                                 | 868.4                     | 836.0                                    |       |
| $\text{C}_7\text{H}_5\text{NO}$              | Benzoxazole                                     | 891.6                     | 859.8                                    |       |
| $\text{C}_7\text{H}_5\text{NO}_3$            | 4-Nitrobenzaldehyde                             | 795.1                     | 763.2                                    |       |
| $\text{C}_7\text{H}_6\text{ClNO}$            | 3-Chlorobenzamide                               | 877.2                     | 846.3                                    |       |
| $\text{C}_7\text{H}_6\text{ClNO}$            | 4-Chlorobenzamide                               | 877.2                     | 846.3                                    |       |
| $\text{C}_7\text{H}_6\text{F}$               | <i>m</i> -Fluorobenzyl                          | 836.5                     | 804                                      |       |
| $\text{C}_7\text{H}_6\text{FNO}$             | 3-Fluorobenzamide                               | 877.2                     | 846.3                                    |       |
| $\text{C}_7\text{H}_6\text{FNO}$             | 4-Fluorobenzamide                               | 877.2                     | 846.3                                    |       |
| $\text{C}_7\text{H}_6\text{F}_3\text{N}$     | 3-(Trifluoromethyl)aniline                      | 856.9                     | 825.1                                    |       |
| $\text{C}_7\text{H}_6\text{N}_2$             | 1 <i>H</i> -Benzimidazole                       | 953.8                     | 920.5                                    |       |
| $\text{C}_7\text{H}_6\text{N}_2$             | 1 <i>H</i> -Indazole                            | 900.8                     | 868.9                                    |       |
| $\text{C}_7\text{H}_6\text{N}_2$             | 3-Aminobenzonitrile                             | 842.3                     | 810.4                                    |       |
| $\text{C}_7\text{H}_6\text{N}_2$             | 1 <i>H</i> -Pyrrolo[2,3- <i>b</i> ]pyridine     | 940.2                     | 908.3                                    |       |
| $\text{C}_7\text{H}_6\text{N}_2\text{O}_3$   | 4-Nitrobenzamide                                | 845.3                     | 814.4                                    |       |
| $\text{C}_7\text{H}_6\text{N}_2\text{O}_3$   | 3-Nitrobenzamide                                | 854.2                     | 823.2                                    |       |
| $\text{C}_7\text{H}_6\text{O}$               | Benzaldehyde                                    | 834.0                     | 802.1                                    |       |
| $\text{C}_7\text{H}_6\text{O}$               | 2,4,6-Cycloheptatrien-1-one                     | 920.8                     | 891.0                                    |       |
| $\text{C}_7\text{H}_6\text{O}_2$             | Benzoic acid                                    | 821.1                     | 790.1                                    |       |
| $\text{C}_7\text{H}_7$                       | Benzyl                                          | 831.4                     | 800.7                                    |       |
| $\text{C}_7\text{H}_7\text{Br}$              | 2-Bromotoluene                                  | 775.3                     | 745.8                                    |       |
| $\text{C}_7\text{H}_7\text{Br}$              | 3-Bromotoluene                                  | 782.0                     | 752.5                                    |       |
| $\text{C}_7\text{H}_7\text{Br}$              | 4-Bromotoluene                                  | 775.3                     | 745.8                                    |       |
| $\text{C}_7\text{H}_7\text{Cl}$              | 2-Chlorotoluene                                 | 790.5                     | 761.1                                    |       |
| $\text{C}_7\text{H}_7\text{Cl}$              | 3-Chlorotoluene                                 | 783.9                     | 754.5                                    |       |
| $\text{C}_7\text{H}_7\text{Cl}$              | 4-Chlorotoluene                                 | 762.9                     | 735.2                                    |       |
| $\text{C}_7\text{H}_7\text{F}$               | 2-Fluorotoluene                                 | 773.3                     | 743.8                                    |       |
| $\text{C}_7\text{H}_7\text{F}$               | 3-Fluorotoluene                                 | 785.4                     | 756.0                                    |       |
| $\text{C}_7\text{H}_7\text{F}$               | 4-Fluorotoluene                                 | 763.8                     | 736.1                                    |       |
| $\text{C}_7\text{H}_7\text{I}$               | 1-Iodo-2-methylbenzene                          | 780.3                     | 750.8                                    |       |
| $\text{C}_7\text{H}_7\text{N}$               | 4-Vinylpyridine                                 | 944.1                     | 912.3                                    |       |
| $\text{C}_7\text{H}_7\text{NO}$              | 1-(3-Pyridinyl)ethanone                         | 916.2                     | 884.3                                    |       |
| $\text{C}_7\text{H}_7\text{NO}$              | 1-(4-Pyridinyl)ethanone                         | 914.7                     | 882.9                                    |       |
| $\text{C}_7\text{H}_7\text{NO}$              | 4-Aminobenzaldehyde                             | 910.4                     | 878.6                                    |       |
| $\text{C}_7\text{H}_7\text{NO}$              | Benzamide                                       | 892.1                     | 861.2                                    |       |
| $\text{C}_7\text{H}_7\text{NO}_2$            | Methyl 3-pyridinecarboxylate                    | 925.6                     | 893.8                                    |       |
| $\text{C}_7\text{H}_7\text{NO}_2$            | Methyl 4-pyridinecarboxylate                    | 926.6                     | 894.7                                    |       |
| $\text{C}_7\text{H}_7\text{NO}_2$            | Aniline-2-carboxylic acid                       | 901.5                     | 869.0                                    |       |
| $\text{C}_7\text{H}_7\text{NO}_2$            | Aniline-3-carboxylic acid                       | 864.7                     | 832.3                                    |       |



| Molecular<br>formula                       | Name                                              | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes   |
|--------------------------------------------|---------------------------------------------------|---------------------------|------------------------------------------|---------|
| $\text{C}_7\text{H}_7\text{NO}_2$          | Aniline-4-carboxylic acid                         | 864.7                     | 832.3                                    |         |
| $\text{C}_7\text{H}_7\text{NO}_2$          | 4-Nitrotoluene                                    | 815.2                     | 782.7                                    |         |
| $\text{C}_7\text{H}_7\text{NO}_3$          | 4-Nitrobenzenemethanol                            | 810.5                     | 778.0                                    |         |
| $\text{C}_7\text{H}_7\text{N}_3$           | 1-Methyl-1 <i>H</i> -benzotriazole                | 931.2                     | 898.7                                    |         |
| $\text{C}_7\text{H}_7\text{O}$             | 2-Methylphenoxy                                   | 874.5                     | 842                                      |         |
| $\text{C}_7\text{H}_8$                     | Toluene                                           | 784.0                     | 756.3                                    |         |
| $\text{C}_7\text{H}_8$                     | 2,5-Norbornadiene                                 | 849.3                     | 820.3                                    |         |
| $\text{C}_7\text{H}_8\text{N}_2\text{O}$   | 4-Aminobenzamide                                  | 927.9                     | 896.9                                    |         |
| $\text{C}_7\text{H}_8\text{N}_2\text{O}$   | 3-Aminobenzamide                                  | 900.9                     | 869.9                                    |         |
| $\text{C}_7\text{H}_8\text{N}_2\text{O}_2$ | <i>N</i> -Methyl-4-nitroaniline                   | 891.6                     | 865.1                                    |         |
| $\text{C}_7\text{H}_8\text{O}$             | <i>o</i> -Cresol                                  | 832                       | 800                                      | Ref. 10 |
| $\text{C}_7\text{H}_8\text{O}$             | <i>m</i> -Cresol                                  | 841                       | 809                                      | Ref. 10 |
| $\text{C}_7\text{H}_8\text{O}$             | <i>p</i> -Cresol                                  | 814                       | 782                                      | Ref. 10 |
| $\text{C}_7\text{H}_8\text{O}$             | Benzyl alcohol                                    | 778.3                     | 748.0                                    |         |
| $\text{C}_7\text{H}_8\text{O}$             | Anisole                                           | 839.6                     | 807.2                                    |         |
| $\text{C}_7\text{H}_8\text{O}_2$           | 2,6-Dimethyl-4 <i>H</i> -pyran-4-one              | 941.5                     | 907.3                                    |         |
| $\text{C}_7\text{H}_8\text{O}_2\text{S}$   | Methyl phenyl sulfone                             | 812.7                     | 780.3                                    |         |
| $\text{C}_7\text{H}_8\text{S}$             | (Methylthio)benzene                               | 872.6                     | 843.7                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | Benzylamine                                       | 913.3                     | 879.4                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 2-Methylaniline                                   | 890.9                     | 859.1                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 3-Methylaniline                                   | 895.8                     | 864.0                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 4-Methylaniline                                   | 896.7                     | 864.8                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | <i>N</i> -Methylaniline                           | 916.6                     | 890.1                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 2-Ethylpyridine                                   | 952.4                     | 920.6                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 3-Ethylpyridine                                   | 947.4                     | 915.5                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 4-Ethylpyridine                                   | 951.1                     | 919.2                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 2,3-Dimethylpyridine                              | 958.9                     | 927.0                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 2,4-Dimethylpyridine                              | 962.9                     | 930.8                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 2,5-Dimethylpyridine                              | 958.8                     | 926.9                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 2,6-Dimethylpyridine                              | 963.0                     | 931.1                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 3,4-Dimethylpyridine                              | 957.3                     | 925.5                                    |         |
| $\text{C}_7\text{H}_9\text{N}$             | 3,5-Dimethylpyridine                              | 955.4                     | 923.5                                    |         |
| $\text{C}_7\text{H}_9\text{NO}$            | 2-Methoxyaniline                                  | 905.2                     | 873.3                                    |         |
| $\text{C}_7\text{H}_9\text{NO}$            | 3-Methoxyaniline                                  | 913.0                     | 881.1                                    |         |
| $\text{C}_7\text{H}_9\text{NO}$            | 4-Methoxyaniline                                  | 900.3                     | 868.5                                    |         |
| $\text{C}_7\text{H}_{10}$                  | Bicyclo[2.2.1]hept-2-ene                          | 836.5                     | 804.0                                    |         |
| $\text{C}_7\text{H}_{10}\text{N}_2$        | <i>N,N</i> -Dimethyl-2-pyridinamine               | 968.2                     | 941.6                                    |         |
| $\text{C}_7\text{H}_{10}\text{N}_2$        | <i>N,N</i> -Dimethyl-4-pyridinamine               | 997.6                     | 971.1                                    |         |
| $\text{C}_7\text{H}_{10}\text{O}$          | Dicyclopropyl ketone                              | 880.4                     | 850.6                                    |         |
| $\text{C}_7\text{H}_{10}\text{O}$          | Bicyclo[2.2.1]heptan-2-one                        | 847.4                     | 815.5                                    |         |
| $\text{C}_7\text{H}_{11}\text{N}$          | Cyclohexanecarbonitrile                           | 815.0                     | 784.4                                    |         |
| $\text{C}_7\text{H}_{12}$                  | 2,4-Dimethyl-1,3-pentadiene                       | 886.5                     | 857.6                                    |         |
| $\text{C}_7\text{H}_{12}$                  | 1-Methylcyclohexene                               | 825.1                     | 792.6                                    |         |
| $\text{C}_7\text{H}_{12}$                  | 1,2-Dimethylcyclopentene                          | 822.6                     | 791.9                                    |         |
| $\text{C}_7\text{H}_{12}\text{N}_2$        | 2,3,4,6,7,8-Hexahydropyrrolo[1,2-<br>a]pyrimidine | 1038.3                    | 1005.9                                   |         |
| $\text{C}_7\text{H}_{12}\text{O}$          | Cycloheptanone                                    | 845.6                     | 815.9                                    |         |
| $\text{C}_7\text{H}_{12}\text{O}$          | 4-Methylcyclohexanone                             | 844.9                     | 813.0                                    |         |
| $\text{C}_7\text{H}_{12}\text{O}_2$        | Cyclohexanecarboxylic acid                        | 823.8                     | 792.8                                    |         |
| $\text{C}_7\text{H}_{13}\text{N}$          | 1-Azabicyclo[2.2.2]octane                         | 983.3                     | 952.5                                    |         |
| $\text{C}_7\text{H}_{14}$                  | 2,4-Dimethyl-2-pentene                            | 812                       | 783.1                                    |         |
| $\text{C}_7\text{H}_{14}\text{O}$          | Methoxycyclohexane                                | 840.5                     | 811.3                                    |         |
| $\text{C}_7\text{H}_{14}\text{O}$          | 4-Heptanone                                       | 845.0                     | 815.3                                    |         |
| $\text{C}_7\text{H}_{14}\text{O}$          | 2,4-Dimethyl-3-pentanone                          | 850.3                     | 820.5                                    |         |
| $\text{C}_7\text{H}_{14}\text{O}$          | Cyclohexanemethanol                               | 802.1                     | 771.7                                    |         |
| $\text{C}_7\text{H}_{15}\text{N}$          | Cyclohexanemethanamine                            | 926.6                     | 895.8                                    |         |
| $\text{C}_7\text{H}_{16}\text{O}$          | <i>tert</i> -Butyl isopropyl ether                | 870.7                     | 841.5                                    |         |
| $\text{C}_7\text{H}_{17}\text{N}$          | Heptylamine                                       | 923.2                     | 889.3                                    |         |
| $\text{C}_7\text{H}_{17}\text{N}$          | Methyldipropylamine                               | 983.5                     | 950.9                                    |         |
| $\text{C}_7\text{H}_{17}\text{N}$          | Diethylpropylamine                                | 978.8                     | 947.9                                    |         |

| Molecular<br>formula                      | Name                                             | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}}G^\circ$<br>kJ/mol | Notes |
|-------------------------------------------|--------------------------------------------------|---------------------------|-----------------------------------------|-------|
| $\text{C}_7\text{H}_{18}\text{N}_2$       | 1,7-Heptanediamine                               | 998.5                     | 944.9                                   |       |
| $\text{C}_7\text{H}_{18}\text{N}_2$       | <i>N,N,N',N'</i> -Tetramethyl-1,3-propanediamine | 1035.2                    | 985.4                                   |       |
| $\text{C}_8\text{H}_4\text{F}_3\text{N}$  | 3-(Trifluoromethyl)benzonitrile                  | 791.4                     | 760.8                                   |       |
| $\text{C}_8\text{H}_4\text{F}_3\text{N}$  | 4-(Trifluoromethyl)benzonitrile                  | 787.2                     | 758.3                                   |       |
| $\text{C}_8\text{H}_4\text{N}_2$          | <i>m</i> -Dicyanobenzene                         | 779.3                     | 750.4                                   |       |
| $\text{C}_8\text{H}_4\text{N}_2$          | <i>p</i> -Dicyanobenzene                         | 779.0                     | 751.8                                   |       |
| $\text{C}_8\text{H}_5\text{Cl}$           | 1-Chloro-4-ethynylbenzene                        | 832.4                     | 801.7                                   |       |
| $\text{C}_8\text{H}_5\text{Cl}_3\text{O}$ | 2,2,2-Trichloro-1-phenylethanone                 | 818.9                     | 787.0                                   |       |
| $\text{C}_8\text{H}_5\text{F}_3\text{O}$  | 2,2,2-Trifluoro-1-phenylethanone                 | 799.2                     | 767.4                                   |       |
| $\text{C}_8\text{H}_5\text{F}_3\text{O}$  | 4-(Trifluoromethyl)benzaldehyde                  | 805.6                     | 773.8                                   |       |
| $\text{C}_8\text{H}_5\text{NO}$           | 4-Formylbenzonitrile                             | 796.9                     | 766.3                                   |       |
| $\text{C}_8\text{H}_6$                    | Phenylacetylene                                  | 832.0                     | 801.3                                   |       |
| $\text{C}_8\text{H}_6\text{ClN}$          | 4-(Chloromethyl)benzonitrile                     | 812.8                     | 782.1                                   |       |
| $\text{C}_8\text{H}_6\text{ClN}$          | 3-(Chloromethyl)benzonitrile                     | 811.2                     | 780.6                                   |       |
| $\text{C}_8\text{H}_6\text{N}_2$          | Quinoxaline                                      | 903.8                     | 873.7                                   |       |
| $\text{C}_8\text{H}_6\text{N}_2$          | Cinnoline                                        | 936.3                     | 904.4                                   |       |
| $\text{C}_8\text{H}_7\text{Br}$           | 1-Bromo-4-vinylbenzene                           | 838.7                     | 809.8                                   |       |
| $\text{C}_8\text{H}_7\text{Br}$           | 1-Bromo-3-vinylbenzene                           | 822.4                     | 793.5                                   |       |
| $\text{C}_8\text{H}_7\text{ClO}$          | 1-(3-Chlorophenyl)ethanone                       | 846.9                     | 815.1                                   |       |
| $\text{C}_8\text{H}_7\text{ClO}$          | 1-(4-Chlorophenyl)ethanone                       | 856.6                     | 824.8                                   |       |
| $\text{C}_8\text{H}_7\text{ClO}_2$        | Methyl 4-chlorobenzoate                          | 842.1                     | 811.1                                   |       |
| $\text{C}_8\text{H}_7\text{ClO}_2$        | Methyl 3-chlorobenzoate                          | 835.4                     | 804.4                                   |       |
| $\text{C}_8\text{H}_7\text{FO}$           | 1-(4-Fluorophenyl)ethanone                       | 858.6                     | 826.8                                   |       |
| $\text{C}_8\text{H}_7\text{N}$            | Benzeneacetoneitrile                             | 805.5                     | 774.8                                   |       |
| $\text{C}_8\text{H}_7\text{N}$            | 1 <i>H</i> -Indole                               | 933.4                     | 901.9                                   |       |
| $\text{C}_8\text{H}_7\text{NO}_3$         | 1-(4-Nitrophenyl)ethanone                        | 824.3                     | 792.5                                   |       |
| $\text{C}_8\text{H}_7\text{NO}_3$         | 1-(3-Nitrophenyl)ethanone                        | 826.0                     | 794.1                                   |       |
| $\text{C}_8\text{H}_7\text{NO}_4$         | Methyl 3-nitrobenzoate                           | 815.7                     | 784.7                                   |       |
| $\text{C}_8\text{H}_7\text{NO}_4$         | Methyl 4-nitrobenzoate                           | 813.2                     | 782.3                                   |       |
| $\text{C}_8\text{H}_8$                    | Styrene                                          | 839.5                     | 809.2                                   |       |
| $\text{C}_8\text{H}_8\text{N}_2$          | 1-Methyl-1 <i>H</i> -benzimidazole               | 967.0                     | 935.2                                   |       |
| $\text{C}_8\text{H}_8\text{N}_2$          | 2-Methyl-2 <i>H</i> -indazole                    | 941.4                     | 909.6                                   |       |
| $\text{C}_8\text{H}_8\text{N}_2$          | 1-Methyl-1 <i>H</i> -indazole                    | 922.4                     | 890.5                                   |       |
| $\text{C}_8\text{H}_8\text{O}$            | 3-Methylbenzaldehyde                             | 840.0                     | 808.1                                   |       |
| $\text{C}_8\text{H}_8\text{O}$            | 4-Methylbenzaldehyde                             | 851.8                     | 820.0                                   |       |
| $\text{C}_8\text{H}_8\text{O}$            | Acetophenone                                     | 861.1                     | 829.3                                   |       |
| $\text{C}_8\text{H}_8\text{O}_2$          | <i>o</i> -Toluic acid                            | 838.8                     | 807.8                                   |       |
| $\text{C}_8\text{H}_8\text{O}_2$          | <i>m</i> -Toluic acid                            | 829.8                     | 798.8                                   |       |
| $\text{C}_8\text{H}_8\text{O}_2$          | <i>p</i> -Toluic acid                            | 836.7                     | 805.7                                   |       |
| $\text{C}_8\text{H}_8\text{O}_2$          | Methyl benzoate                                  | 850.5                     | 819.5                                   |       |
| $\text{C}_8\text{H}_8\text{O}_2$          | 3-Methoxybenzaldehyde                            | 844.1                     | 812.2                                   |       |
| $\text{C}_8\text{H}_8\text{O}_2$          | 4-Methoxybenzaldehyde                            | 881.1                     | 849.3                                   |       |
| $\text{C}_8\text{H}_8\text{O}_2$          | 1-(3-Hydroxyphenyl)ethanone                      | 863.6                     | 831.8                                   |       |
| $\text{C}_8\text{H}_8\text{O}_2$          | 1-(4-Hydroxyphenyl)ethanone                      | 883.7                     | 851.9                                   |       |
| $\text{C}_8\text{H}_8\text{O}_3$          | Methyl 4-hydroxybenzoate                         | 863.4                     | 832.5                                   |       |
| $\text{C}_8\text{H}_8\text{O}_3$          | Methyl 3-hydroxybenzoate                         | 850.0                     | 819.1                                   |       |
| $\text{C}_8\text{H}_9\text{N}$            | 2,3-Dihydro-1 <i>H</i> -indole                   | 957.1                     | 926.3                                   |       |
| $\text{C}_8\text{H}_9\text{NO}$           | 3-Methylbenzamide                                | 900.9                     | 869.9                                   |       |
| $\text{C}_8\text{H}_9\text{NO}$           | 4-Methylbenzamide                                | 900.9                     | 869.9                                   |       |
| $\text{C}_8\text{H}_9\text{NO}$           | 1-(4-Aminophenyl)ethanone                        | 908.8                     | 877.0                                   |       |
| $\text{C}_8\text{H}_9\text{NO}_2$         | 3-Methoxybenzamide                               | 900.9                     | 869.9                                   |       |
| $\text{C}_8\text{H}_9\text{NO}_2$         | 2,4-Dimethyl-1-nitrobenzene                      | 831.0                     | 798.5                                   |       |
| $\text{C}_8\text{H}_9\text{NO}_2$         | Methyl 4-aminobenzoate                           | 883.9                     | 853.0                                   |       |
| $\text{C}_8\text{H}_9\text{NO}_2$         | 4-Methoxybenzamide                               | 900.3                     | 869.4                                   |       |
| $\text{C}_8\text{H}_{10}$                 | Ethylbenzene                                     | 788.0                     | 760.3                                   |       |
| $\text{C}_8\text{H}_{10}$                 | <i>o</i> -Xylene                                 | 796.0                     | 768.3                                   |       |
| $\text{C}_8\text{H}_{10}$                 | <i>m</i> -Xylene                                 | 812.1                     | 786.2                                   |       |
| $\text{C}_8\text{H}_{10}$                 | <i>p</i> -Xylene                                 | 794.4                     | 766.8                                   |       |
| $\text{C}_8\text{H}_{10}\text{ClN}$       | 4-Chloro- <i>N,N</i> -dimethylaniline            | 922.9                     | 896.4                                   |       |

| Molecular<br>formula                          | Name                                                  | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes   |
|-----------------------------------------------|-------------------------------------------------------|---------------------------|------------------------------------------|---------|
| $\text{C}_8\text{H}_{10}\text{N}_2\text{O}_2$ | <i>N,N</i> -Dimethyl-4-nitroaniline                   | 896.7                     | 870.2                                    |         |
| $\text{C}_8\text{H}_{10}\text{N}_2\text{O}_2$ | <i>N,N</i> -Dimethyl-3-nitroaniline                   | 894.1                     | 867.6                                    |         |
| $\text{C}_8\text{H}_{10}\text{O}$             | Benzyl methyl ether                                   | 816.7                     | 787.5                                    |         |
| $\text{C}_8\text{H}_{10}\text{O}$             | 2-Methylanisole                                       | 850                       | 818                                      | Ref. 10 |
| $\text{C}_8\text{H}_{10}\text{O}$             | 3-Methylanisole                                       | 860                       | 828                                      | Ref. 10 |
| $\text{C}_8\text{H}_{10}\text{O}$             | 4-Methylanisole                                       | 841                       | 809                                      | Ref. 10 |
| $\text{C}_8\text{H}_{11}\text{N}$             | 4-Isopropylpyridine                                   | 955.7                     | 923.8                                    |         |
| $\text{C}_8\text{H}_{11}\text{N}$             | 3-Ethylaniline                                        | 897.9                     | 866.1                                    |         |
| $\text{C}_8\text{H}_{11}\text{N}$             | <i>N</i> -Ethylaniline                                | 924.8                     | 892.9                                    |         |
| $\text{C}_8\text{H}_{11}\text{N}$             | <i>N,N</i> -Dimethylaniline                           | 941.1                     | 909.2                                    |         |
| $\text{C}_8\text{H}_{11}\text{N}$             | 2,6-Dimethylaniline                                   | 901.7                     | 869.8                                    |         |
| $\text{C}_8\text{H}_{11}\text{N}$             | Benzeneethanamine                                     | 936.2                     | 902.3                                    |         |
| $\text{C}_8\text{H}_{11}\text{N}$             | 2-Propylpyridine                                      | 955.7                     | 923.8                                    |         |
| $\text{C}_8\text{H}_{12}$                     | 2-Methyl-2-norbornene                                 | 845                       | 812.5                                    |         |
| $\text{C}_8\text{H}_{12}\text{N}_2$           | <i>N,N</i> -Dimethyl-1,4-benzenediamine               | 955.0                     | 928.4                                    |         |
| $\text{C}_8\text{H}_{12}\text{N}_2\text{O}_2$ | Ethyl 1,5-dimethyl-1 <i>H</i> -pyrazole-3-carboxylate | 933.4                     | 901.5                                    |         |
| $\text{C}_8\text{H}_{14}\text{O}$             | Cyclooctanone                                         | 849.4                     | 819.6                                    |         |
| $\text{C}_8\text{H}_{14}\text{O}$             | 1-Cyclohexylethanone                                  | 841.4                     | 809.5                                    |         |
| $\text{C}_8\text{H}_{14}\text{O}_2$           | Methyl cyclohexanecarboxylate                         | 846.2                     | 815.3                                    |         |
| $\text{C}_8\text{H}_{16}\text{O}$             | 2,2,4-Trimethyl-3-pentanone                           | 856.9                     | 825.0                                    |         |
| $\text{C}_8\text{H}_{17}\text{N}$             | Cyclohexyldimethylamine                               | 983.6                     | 952.6                                    |         |
| $\text{C}_8\text{H}_{18}\text{O}$             | Dibutyl ether                                         | 845.7                     | 818.3                                    |         |
| $\text{C}_8\text{H}_{18}\text{O}$             | Di- <i>sec</i> -butyl ether                           | 865.9                     | 838.5                                    |         |
| $\text{C}_8\text{H}_{18}\text{O}$             | Di- <i>tert</i> -butyl ether                          | 887.4                     | 860.0                                    |         |
| $\text{C}_8\text{H}_{18}\text{O}_4$           | Triethylene glycol dimethyl ether                     | 946.6                     | 892.4                                    |         |
| $\text{C}_8\text{H}_{18}\text{O}_5$           | Tetraethylene glycol                                  |                           | >910                                     |         |
| $\text{C}_8\text{H}_{18}\text{S}$             | Dibutyl sulfide                                       | 871.8                     | 842.1                                    |         |
| $\text{C}_8\text{H}_{18}\text{S}$             | Di- <i>tert</i> -butyl sulfide                        | 893.8                     | 864.0                                    |         |
| $\text{C}_8\text{H}_{19}\text{N}$             | <i>N</i> -Ethyl- <i>N</i> -isopropyl-2-propanamine    | 994.3                     | 963.5                                    |         |
| $\text{C}_8\text{H}_{19}\text{N}$             | Octylamine                                            | 928.9                     | 895.0                                    |         |
| $\text{C}_8\text{H}_{19}\text{N}$             | Dibutylamine                                          | 968.5                     | 935.3                                    |         |
| $\text{C}_8\text{H}_{19}\text{N}$             | Di- <i>sec</i> -butylamine                            | 980.7                     | 947.5                                    |         |
| $\text{C}_8\text{H}_{19}\text{N}$             | Diisobutylamine                                       | 958.1                     | 925.1                                    |         |
| $\text{C}_8\text{H}_{20}\text{N}_2$           | <i>N,N,N',N'</i> -Tetramethyl-1,4-butanediamine       | 1046.3                    | 992.7                                    |         |
| $\text{C}_8\text{H}_{20}\text{N}_2$           | Tetraethylhydrazine                                   | 964.3                     | 935.3                                    |         |
| $\text{C}_9\text{H}_7\text{MnO}_3$            | Manganese 2-methylcyclopentadienyl tricarbonyl        | 833.8                     | 801.3                                    |         |
| $\text{C}_9\text{H}_7\text{N}$                | Quinoline                                             | 953.2                     | 921.4                                    |         |
| $\text{C}_9\text{H}_7\text{N}$                | Isoquinoline                                          | 951.7                     | 919.9                                    |         |
| $\text{C}_9\text{H}_7\text{NO}$               | 4-Acetylbenzonitrile                                  | 826.8                     | 795.0                                    |         |
| $\text{C}_9\text{H}_8$                        | Indene                                                | 848.8                     | 819.6                                    |         |
| $\text{C}_9\text{H}_8\text{O}$                | 2-Methylbenzofuran                                    | 859.6                     | 827.2                                    |         |
| $\text{C}_9\text{H}_8\text{O}_3$              | Methyl 4-formylbenzoate                               | 832.9                     | 801.9                                    |         |
| $\text{C}_9\text{H}_9\text{Cl}$               | 1-Chloro-4-isopropenylbenzene                         | 854.3                     | 825.4                                    |         |
| $\text{C}_9\text{H}_9\text{ClO}_2$            | 3-Chloro-4-methoxyacetophenone                        | 883.7                     | 851.9                                    |         |
| $\text{C}_9\text{H}_{10}$                     | 2-Methylstyrene                                       | 855.2                     | 826.3                                    |         |
| $\text{C}_9\text{H}_{10}$                     | 3-Methylstyrene                                       | 849.4                     | 820.5                                    |         |
| $\text{C}_9\text{H}_{10}$                     | 4-Methylstyrene                                       | 861.7                     | 832.8                                    |         |
| $\text{C}_9\text{H}_{10}$                     | <i>cis</i> -1-Propenylbenzene                         | 836.4                     | 807.5                                    |         |
| $\text{C}_9\text{H}_{10}$                     | <i>trans</i> -1-Propenylbenzene                       | 834.2                     | 805.3                                    |         |
| $\text{C}_9\text{H}_{10}$                     | Isopropenylbenzene                                    | 864.2                     | 835.3                                    |         |
| $\text{C}_9\text{H}_{10}$                     | Cyclopropylbenzene                                    | 834.9                     | 802.4                                    |         |
| $\text{C}_9\text{H}_{10}\text{N}_2$           | 4-(Dimethylamino)benzonitrile                         | 889.1                     | 862.6                                    |         |
| $\text{C}_9\text{H}_{10}\text{O}$             | 1-(3-Methylphenyl)ethanone                            | 868.2                     | 836.4                                    |         |
| $\text{C}_9\text{H}_{10}\text{O}$             | 1-Phenyl-1-propanone                                  | 867.4                     | 835.6                                    |         |
| $\text{C}_9\text{H}_{10}\text{O}$             | 1-Phenyl-2-propanone                                  | 842.6                     | 810.8                                    |         |
| $\text{C}_9\text{H}_{10}\text{O}$             | 4-Methylacetophenone                                  | 875.5                     | 843.6                                    |         |
| $\text{C}_9\text{H}_{10}\text{OS}$            | 4-Acetylthioanisole                                   | 888.2                     | 856.3                                    |         |
| $\text{C}_9\text{H}_{10}\text{O}_2$           | Methyl 2-methylbenzoate                               | 858.3                     | 827.3                                    |         |

| Molecular<br>formula                          | Name                                                                          | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}} G^\circ$<br>kJ/mol | Notes  |
|-----------------------------------------------|-------------------------------------------------------------------------------|---------------------------|------------------------------------------|--------|
| $\text{C}_9\text{H}_{10}\text{O}_2$           | Methyl 3-methylbenzoate                                                       | 857.7                     | 826.8                                    |        |
| $\text{C}_9\text{H}_{10}\text{O}_2$           | 1-(3-Methoxyphenyl)ethanone                                                   | 871.2                     | 839.3                                    |        |
| $\text{C}_9\text{H}_{10}\text{O}_2$           | Methyl 4-methylbenzoate                                                       | 861.5                     | 830.6                                    |        |
| $\text{C}_9\text{H}_{10}\text{O}_2$           | 4-Acetylanisole                                                               | 895.6                     | 863.7                                    |        |
| $\text{C}_9\text{H}_{10}\text{O}_3$           | Methyl 4-methoxybenzoate                                                      | 870.6                     | 839.6                                    |        |
| $\text{C}_9\text{H}_{10}\text{O}_3$           | Methyl 3-methoxybenzoate                                                      | 856.7                     | 825.8                                    |        |
| $\text{C}_9\text{H}_{11}\text{N}$             | 5,6,7,8-Tetrahydroquinoline                                                   | 966.0                     | 934.1                                    |        |
| $\text{C}_9\text{H}_{11}\text{N}$             | 5,6,7,8-Tetrahydroisoquinoline                                                | 966.6                     | 934.7                                    |        |
| $\text{C}_9\text{H}_{11}\text{NO}$            | 4-(Dimethylamino)benzaldehyde                                                 | 924.8                     | 898.3                                    |        |
| $\text{C}_9\text{H}_{11}\text{NO}$            | <i>N,N</i> -Dimethylbenzamide                                                 | 932.7                     | 901.8                                    |        |
| $\text{C}_9\text{H}_{11}\text{NO}_2$          | 1,3,5-Trimethyl-2-nitrobenzene                                                | 823.8                     | 793.1                                    |        |
| $\text{C}_9\text{H}_{11}\text{NO}_2$          | <i>L</i> -Phenylalanine                                                       | 922.9                     | 888.9                                    |        |
| $\text{C}_9\text{H}_{11}\text{NO}_3$          | <i>L</i> -Tyrosine                                                            | 926                       | 892.1                                    |        |
| $\text{C}_9\text{H}_{12}$                     | Propylbenzene                                                                 | 790.1                     | 762.4                                    |        |
| $\text{C}_9\text{H}_{12}$                     | Isopropylbenzene                                                              | 791.6                     | 763.9                                    |        |
| $\text{C}_9\text{H}_{12}$                     | 1,3,5-Trimethylbenzene                                                        | 836.2                     | 808.6                                    |        |
| $\text{C}_9\text{H}_{12}\text{N}_2$           | 3-(2-Pyrrolidinyl)pyridine, (S)-                                              | 964.0                     | 931.0                                    |        |
| $\text{C}_9\text{H}_{12}\text{N}_2\text{O}_6$ | Uridine                                                                       | 947.6                     | 916.6                                    |        |
| $\text{C}_9\text{H}_{12}\text{O}_3$           | 1,3,5-Trimethoxybenzene                                                       | 926.7                     | 898.2                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}$             | <i>N</i> -Ethyl- <i>N</i> -methylaniline                                      | 939.0                     | 912.4                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}$             | 2,6-Diethylpyridine                                                           | 972.3                     | 940.4                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}$             | 4- <i>tert</i> -Butylpyridine                                                 | 957.7                     | 925.8                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}$             | 2- <i>tert</i> -Butylpyridine                                                 | 961.7                     | 929.8                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}$             | 2-Methyl- <i>N,N</i> -dimethylaniline                                         | 951.8                     | 925.3                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}$             | 3-Methyl- <i>N,N</i> -dimethylaniline                                         | 942.1                     | 915.7                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}$             | 4-Methyl- <i>N,N</i> -dimethylaniline                                         | 950.0                     | 918.1                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}$             | <i>N,N</i> -Dimethylbenzylamine                                               | 968.4                     | 937.4                                    |        |
| $\text{C}_9\text{H}_{13}\text{NO}$            | 4-Methoxy- <i>N,N</i> -dimethylaniline                                        | 949.1                     | 922.4                                    |        |
| $\text{C}_9\text{H}_{13}\text{N}_3\text{O}_5$ | Cytidine                                                                      | 982.5                     | 950.0                                    |        |
| $\text{C}_9\text{H}_{14}\text{O}$             | Isophorone                                                                    | 893.5                     | 861.6                                    |        |
| $\text{C}_9\text{H}_{15}\text{N}$             | <i>N,N</i> -Diallyl-2-propen-1-amine                                          | 972.3                     | 941.3                                    |        |
| $\text{C}_9\text{H}_{15}\text{N}$             | <i>N</i> -(1-Cyclopenten-1-yl)pyrrolidine                                     | 1019.2                    | 988.4                                    |        |
| $\text{C}_9\text{H}_{16}\text{O}$             | Cyclononanone                                                                 | 852.6                     | 822.8                                    |        |
| $\text{C}_9\text{H}_{17}\text{N}_3\text{O}_4$ | <i>N</i> -( <i>N</i> - <i>L</i> -Alanyl- <i>L</i> -alanyl)- <i>L</i> -alanine |                           | 924.1                                    |        |
| $\text{C}_9\text{H}_{18}\text{O}$             | 5-Nonanone                                                                    | 853.7                     | 821.9                                    |        |
| $\text{C}_9\text{H}_{18}\text{O}$             | Di- <i>tert</i> -butyl ketone                                                 | 861.3                     | 831.5                                    |        |
| $\text{C}_9\text{H}_{19}\text{N}$             | 1-Isobutylpiperidine                                                          | 974.5                     | 943.5                                    |        |
| $\text{C}_9\text{H}_{19}\text{N}$             | 2,2,6,6-Tetramethylpiperidine                                                 | 987.0                     | 953.9                                    |        |
| $\text{C}_9\text{H}_{21}\text{N}$             | Tripropylamine                                                                | 991.0                     | 960.1                                    |        |
| $\text{C}_{10}\text{H}_8$                     | Naphthalene                                                                   | 802.9                     | 779.4                                    |        |
| $\text{C}_{10}\text{H}_8$                     | Azulene                                                                       | 925.2                     | 896                                      |        |
| $\text{C}_{10}\text{H}_8\text{N}_2$           | 2,2'-Bipyridine                                                               | 965                       |                                          | Ref. 7 |
| $\text{C}_{10}\text{H}_9\text{N}$             | 1-Naphthylamine                                                               | 907.0                     | 875.1                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{Fe}$         | Ferrocene                                                                     | 863.6                     | 841.3                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{N}_2$        | 1,8-Naphthalenediamine                                                        | 944.5                     | 912.1                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{N}_2$        | 1-Methyl-3-phenyl-1 <i>H</i> -pyrazole                                        | 932.6                     | 900.8                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{N}_2$        | 1-Methyl-5-phenyl-1 <i>H</i> -pyrazole                                        | 932.4                     | 900.5                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{Ni}$         | Nickelocene                                                                   | 935.7                     | 907.3                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{O}_2$        | 1,4-Diacetylbenzene                                                           | 850.8                     | 821.0                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{O}_2$        | 1,3-Diacetylbenzene                                                           | 852.0                     | 822.3                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{O}_3$        | 4-Acetylphenyl acetate                                                        | 853.2                     | 821.3                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{O}_4$        | Dimethyl isophthalate                                                         | 843.5                     | 814.3                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{O}_4$        | Dimethyl terephthalate                                                        | 843.2                     | 812.3                                    |        |
| $\text{C}_{10}\text{H}_{10}\text{Ru}$         | Ruthenocene                                                                   | 899.1                     | 876.8                                    |        |
| $\text{C}_{10}\text{H}_{12}$                  | 1-Methyl-3-(1-methylvinyl)benzene                                             | 867.6                     | 838.7                                    |        |
| $\text{C}_{10}\text{H}_{12}$                  | 1-Methyl-4-(1-methylvinyl)benzene                                             | 881.8                     | 852.9                                    |        |
| $\text{C}_{10}\text{H}_{12}$                  | 1-Methyl-2-(1-methylvinyl)benzene                                             | 857.8                     | 828.9                                    |        |
| $\text{C}_{10}\text{H}_{12}$                  | 1,2,3,4-Tetrahydronaphthalene                                                 | 809.7                     | 782.1                                    |        |
| $\text{C}_{10}\text{H}_{12}\text{O}$          | 1-(2,4-Dimethylphenyl)ethanone                                                | 882.6                     | 850.8                                    |        |
| $\text{C}_{10}\text{H}_{12}\text{O}$          | 1-(2,5-Dimethylphenyl)ethanone                                                | 873.5                     | 841.6                                    |        |

| Molecular<br>formula                             | Name                                                   | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}}G^\circ$<br>kJ/mol | Notes |
|--------------------------------------------------|--------------------------------------------------------|---------------------------|-----------------------------------------|-------|
| $\text{C}_{10}\text{H}_{12}\text{O}$             | 1-(3,4-Dimethylphenyl)ethanone                         | 882.8                     | 851.0                                   |       |
| $\text{C}_{10}\text{H}_{12}\text{O}_2$           | Methyl 2,5-dimethylbenzoate                            | 864.7                     | 833.7                                   |       |
| $\text{C}_{10}\text{H}_{12}\text{O}_2$           | Methyl 2,4-dimethylbenzoate                            | 868.2                     | 837.2                                   |       |
| $\text{C}_{10}\text{H}_{12}\text{O}_2$           | Methyl 3,5-dimethylbenzoate                            | 864.3                     | 833.4                                   |       |
| $\text{C}_{10}\text{H}_{13}\text{N}$             | 1-Phenylpyrrolidine                                    | 941.6                     | 915.1                                   |       |
| $\text{C}_{10}\text{H}_{13}\text{NO}$            | 4'-(Dimethylamino)acetophenone                         | 932.8                     | 906.3                                   |       |
| $\text{C}_{10}\text{H}_{13}\text{NO}$            | <i>N,N</i> ,3-Trimethylbenzamide                       | 927.0                     | 896.0                                   |       |
| $\text{C}_{10}\text{H}_{13}\text{NO}$            | <i>N,N</i> ,4-Trimethylbenzamide                       | 927.0                     | 896.0                                   |       |
| $\text{C}_{10}\text{H}_{13}\text{NO}$            | 1-[3-(Dimethylamino)phenyl]ethanone                    | 928.0                     | 901.5                                   |       |
| $\text{C}_{10}\text{H}_{13}\text{N}_5\text{O}_3$ | 2'-Deoxyadenosine                                      | 991.5                     | 959.1                                   |       |
| $\text{C}_{10}\text{H}_{13}\text{N}_5\text{O}_4$ | Adenosine                                              | 989.3                     | 956.8                                   |       |
| $\text{C}_{10}\text{H}_{13}\text{N}_5\text{O}_5$ | Guanosine                                              | 993.4                     | 960.9                                   |       |
| $\text{C}_{10}\text{H}_{14}$                     | Butylbenzene                                           | 791.9                     | 764.2                                   |       |
| $\text{C}_{10}\text{H}_{14}$                     | 1,2,3,5-Tetramethylbenzene                             | 845.6                     | 816.5                                   |       |
| $\text{C}_{10}\text{H}_{14}\text{ClN}$           | 4-Chloro- <i>N,N</i> -diethylaniline                   | 931.0                     | 899.2                                   |       |
| $\text{C}_{10}\text{H}_{14}\text{N}_2$           | <i>L</i> -Nicotine                                     | 963.4                     | 932.6                                   |       |
| $\text{C}_{10}\text{H}_{14}\text{N}_2\text{O}$   | <i>N,N</i> -Diethyl-3-pyridinecarboxamide              | 940.9                     | 909.0                                   |       |
| $\text{C}_{10}\text{H}_{14}\text{N}_2\text{O}_5$ | Thymidine                                              | 948.3                     | 915.9                                   |       |
| $\text{C}_{10}\text{H}_{15}\text{N}$             | <i>N,N</i> ,2,6-Tetramethylaniline                     | 954.1                     | 923.2                                   |       |
| $\text{C}_{10}\text{H}_{15}\text{N}$             | <i>N,N</i> ,3,5-Tetramethylaniline                     | 956.1                     | 924.3                                   |       |
| $\text{C}_{10}\text{H}_{15}\text{N}$             | <i>N,N</i> -Diethylaniline                             | 959.8                     | 927.9                                   |       |
| $\text{C}_{10}\text{H}_{16}\text{N}_2$           | <i>N,N,N',N'</i> -Tetramethyl-1,2-benzenediamine       | 982.6                     | 950.2                                   |       |
| $\text{C}_{10}\text{H}_{17}\text{N}$             | Tricyclo[3.3.1.1 <sup>3,7</sup> ]decan-1-amine         | 948.8                     | 916.3                                   |       |
| $\text{C}_{10}\text{H}_{22}\text{O}$             | Dipentyl ether                                         | 852.7                     | 825.3                                   |       |
| $\text{C}_{10}\text{H}_{22}\text{O}_5$           | Tetraethylene glycol dimethyl ether                    | 953.8                     | 897.8                                   |       |
| $\text{C}_{10}\text{H}_{23}\text{N}$             | Decylamine                                             | 930.4                     | 896.5                                   |       |
| $\text{C}_{10}\text{H}_{24}\text{N}_2$           | <i>N,N,N',N'</i> -Tetramethyl-1,6-hexanediamine        | 1035.8                    | 982.2                                   |       |
| $\text{C}_{11}\text{H}_9\text{N}$                | 4-Phenylpyridine                                       | 939.7                     | 907.8                                   |       |
| $\text{C}_{11}\text{H}_{10}$                     | 1-Methylnaphthalene                                    | 834.8                     | 805.3                                   |       |
| $\text{C}_{11}\text{H}_{10}$                     | 2-Methylnaphthalene                                    | 831.9                     | 802.4                                   |       |
| $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}_2$ | <i>L</i> -Tryptophan                                   | 948.9                     | 915                                     |       |
| $\text{C}_{11}\text{H}_{14}\text{O}_2$           | Methyl 2,4,6-trimethylbenzoate                         | 866.3                     | 835.3                                   |       |
| $\text{C}_{11}\text{H}_{15}\text{N}$             | 1-Phenylpiperidine                                     | 952.9                     | 926.4                                   |       |
| $\text{C}_{11}\text{H}_{15}\text{N}$             | Tricyclo[3.3.1.1 <sup>3,7</sup> ]decane-1-carbonitrile | 834.4                     | 803.8                                   |       |
| $\text{C}_{11}\text{H}_{16}$                     | Pentamethylbenzene                                     | 850.7                     | 823.5                                   |       |
| $\text{C}_{11}\text{H}_{17}\text{N}$             | <i>N,N</i> -Diethyl-4-methylaniline                    | 962.8                     | 931.0                                   |       |
| $\text{C}_{11}\text{H}_{17}\text{N}$             | 2-Hexylpyridine                                        | 963.6                     | 931.7                                   |       |
| $\text{C}_{11}\text{H}_{18}\text{O}$             | 1,4,7,7-Tetramethylbicyclo[2.2.1]heptan-2-one          | 863.3                     | 831.4                                   |       |
| $\text{C}_{11}\text{H}_{24}\text{O}_4$           | 2,6,10,14-Tetraoxapentadecane                          |                           | 895.1                                   |       |
| $\text{C}_{12}\text{H}_8\text{N}_2$              | Phenazine                                              | 938.4                     | 908.3                                   |       |
| $\text{C}_{12}\text{H}_9\text{NO}$               | Phenyl-3-pyridinylmethanone                            | 934.1                     | 902.3                                   |       |
| $\text{C}_{12}\text{H}_{10}$                     | Acenaphthene                                           | 851.7                     | 821.0                                   |       |
| $\text{C}_{12}\text{H}_{10}$                     | Biphenyl                                               | 813.6                     | 782.9                                   |       |
| $\text{C}_{12}\text{H}_{16}\text{O}$             | 1-(4- <i>tert</i> -Butylphenyl)ethanone                | 882.5                     | 850.6                                   |       |
| $\text{C}_{12}\text{H}_{18}$                     | Hexamethylbenzene                                      | 860.6                     | 836.0                                   |       |
| $\text{C}_{12}\text{H}_{18}\text{O}$             | 1-Tricyclo[3.3.1.1 <sup>3,7</sup> ]dec-1-ylethanone    | 864.9                     | 833.1                                   |       |
| $\text{C}_{12}\text{H}_{19}\text{N}$             | <i>N,N</i> -Dipropylaniline                            | 963.0                     | 931.1                                   |       |
| $\text{C}_{12}\text{H}_{20}\text{O}$             | 2,5-Di- <i>tert</i> -butylfuran                        | 894.7                     | 863.9                                   |       |
| $\text{C}_{12}\text{H}_{27}\text{N}$             | Tributylamine                                          | 998.5                     | 967.6                                   |       |
| $\text{C}_{13}\text{H}_9\text{N}$                | Acridine                                               | 972.6                     | 940.7                                   |       |
| $\text{C}_{13}\text{H}_{10}$                     | 9 <i>H</i> -Fluorene                                   | 831.5                     | 803.8                                   |       |
| $\text{C}_{13}\text{H}_{10}\text{O}$             | Benzophenone                                           | 882.3                     | 852.5                                   |       |
| $\text{C}_{13}\text{H}_{12}$                     | 2-Methylbiphenyl                                       | 815.9                     | 783.4                                   |       |
| $\text{C}_{13}\text{H}_{12}$                     | 3-Methylbiphenyl                                       | 828.0                     | 795.5                                   |       |
| $\text{C}_{13}\text{H}_{12}$                     | 4-Methylbiphenyl                                       | 817.9                     | 785.4                                   |       |
| $\text{C}_{13}\text{H}_{12}$                     | Diphenylmethane                                        | 802.0                     | 769.5                                   |       |
| $\text{C}_{13}\text{H}_{13}\text{P}$             | Methyldiphenylphosphine                                | 972.1                     | 939.7                                   |       |

| Molecular<br>formula                   | Name                                                                      | $E_{\text{pa}}$<br>kJ/mol | $\Delta_{\text{base}}G^\circ$<br>kJ/mol | Notes |
|----------------------------------------|---------------------------------------------------------------------------|---------------------------|-----------------------------------------|-------|
| $\text{C}_{13}\text{H}_{21}\text{N}$   | 2,4-Di- <i>tert</i> -butylpyridine                                        | 983.8                     | 952.0                                   |       |
| $\text{C}_{13}\text{H}_{21}\text{N}$   | 2,6-Di- <i>tert</i> -butylpyridine                                        | 982.9                     | 951                                     |       |
| $\text{C}_{13}\text{H}_{21}\text{NO}$  | <i>N,N</i> -Dimethyltricyclo[3.3.1.1 <sup>3,7</sup> ]decane-1-carboxamide | 949.4                     | 917.6                                   |       |
| $\text{C}_{14}\text{H}_{10}$           | Anthracene                                                                | 877.3                     | 846.6                                   |       |
| $\text{C}_{14}\text{H}_{10}$           | Phenanthrene                                                              | 825.7                     | 795.0                                   |       |
| $\text{C}_{14}\text{H}_{12}$           | 1,1-Diphenylethene                                                        | 885.7                     | 856.9                                   |       |
| $\text{C}_{14}\text{H}_{14}$           | 1,2-Diphenylethane                                                        | 801.8                     | 774.1                                   |       |
| $\text{C}_{14}\text{H}_{18}$           | 1,2,3,4,5,6,7,8-Octahydroanthracene                                       | 845.4                     | 814.7                                   |       |
| $\text{C}_{14}\text{H}_{18}$           | 1,2,3,4,5,6,7,8-Octahydrophenanthrene                                     | 846.2                     | 815.5                                   |       |
| $\text{C}_{14}\text{H}_{23}\text{N}$   | 4-Octylaniline                                                            | 894.5                     | 862                                     |       |
| $\text{C}_{15}\text{H}_{12}$           | 2-Methylanthracene                                                        | 887.5                     | 855.1                                   |       |
| $\text{C}_{15}\text{H}_{12}$           | 9-Methylanthracene                                                        | 896.5                     | 865.8                                   |       |
| $\text{C}_{15}\text{H}_{12}\text{N}_2$ | 3,5-Diphenyl-1 <i>H</i> -pyrazole                                         | 946.3                     | 912.7                                   |       |
| $\text{C}_{15}\text{H}_{16}$           | 1,3-Diphenylpropane                                                       | 820.1                     | 787.6                                   |       |
| $\text{C}_{15}\text{H}_{18}$           | 1,4-Dimethyl-7-isopropylazulene                                           | 983.1                     | 950.6                                   |       |
| $\text{C}_{15}\text{H}_{24}$           | 1,3-Di- <i>tert</i> -butyl-5-methylbenzene                                | 853.7                     | 826.0                                   |       |
| $\text{C}_{16}\text{H}_{10}$           | Fluoranthene                                                              | 828.6                     | 800.9                                   |       |
| $\text{C}_{16}\text{H}_{10}$           | Pyrene                                                                    | 869.2                     | 840.1                                   |       |
| $\text{C}_{16}\text{H}_{18}$           | 1,4-Diphenylbutane                                                        | 822.0                     | 779.8                                   |       |
| $\text{C}_{17}\text{H}_{20}$           | 1,5-Diphenylpentane                                                       | 824.7                     | 782.4                                   |       |
| $\text{C}_{18}\text{H}_{12}$           | Chrysene                                                                  | 840.9                     | 810.1                                   |       |
| $\text{C}_{18}\text{H}_{12}$           | Naphthacene                                                               | 905.5                     | 876.5                                   |       |
| $\text{C}_{18}\text{H}_{12}$           | Triphenylene                                                              | 819.2                     | 791.2                                   |       |
| $\text{C}_{18}\text{H}_{15}\text{As}$  | Triphenylarsine                                                           | 908.9                     | 876.4                                   |       |
| $\text{C}_{18}\text{H}_{15}\text{AsO}$ | Triphenylarsine oxide                                                     | 906.2                     | 876.4                                   |       |
| $\text{C}_{18}\text{H}_{15}\text{N}$   | Triphenylamine                                                            | 908.9                     | 876.4                                   |       |
| $\text{C}_{18}\text{H}_{15}\text{OP}$  | Triphenylphosphine oxide                                                  | 906.2                     | 876.4                                   |       |
| $\text{C}_{18}\text{H}_{15}\text{P}$   | Triphenylphosphine                                                        | 972.8                     | 940.4                                   |       |
| $\text{C}_{18}\text{H}_{15}\text{PS}$  | Triphenylphosphine sulfide                                                | 906.2                     | 876.4                                   |       |
| $\text{C}_{18}\text{H}_{15}\text{Sb}$  | Triphenylstibine                                                          | 845.5                     | 813.1                                   |       |
| $\text{C}_{18}\text{H}_{22}$           | 1,6-Diphenylhexane                                                        | 826.1                     | 783.8                                   |       |
| $\text{C}_{18}\text{H}_{30}$           | 1,3,5-Tri- <i>tert</i> -butylbenzene                                      | 848.8                     | 822.3                                   |       |
| $\text{C}_{20}\text{H}_{12}$           | Perylene                                                                  | 888.6                     | 859.6                                   |       |
| $\text{C}_{22}\text{H}_{12}$           | Benzo[ghi]perylene                                                        | 876.0                     | 845.2                                   |       |
| $\text{C}_{22}\text{H}_{14}$           | Picene                                                                    | 851.3                     | 820.6                                   |       |
| $\text{C}_{24}\text{H}_{12}$           | Coronene                                                                  | 861.3                     | 835.0                                   |       |
| $\text{C}_{60}$                        | Carbon (fullerene- $\text{C}_{60}$ )                                      |                           | 827.5                                   |       |
| $\text{C}_{70}$                        | Carbon (fullerene- $\text{C}_{70}$ )                                      |                           | 827.5                                   |       |

## INDEX OF REFRACTION OF GASES

This table gives the index of refraction of several gases at selected wavelengths ranging from the blue to the red region of the spectrum. The entries at 0.5893  $\mu\text{m}$  correspond to the prominent sodium D line in the yellow region. All values refer to gas at a pressure of one atmosphere (101.325 kPa) and at a temperature of 0°C.

### References

1. Gray, D. E., ed., *American Institute of Physics Handbook, 3rd Edition*, p. 6-110, McGraw-Hill, New York, 1972.
2. Forsythe, W. E., *Smithsonian Physical Tables, Ninth Edition*, p. 533, Smithsonian Institution, Washington, 1954.
3. *Kaye and Laby Tables of Physical and Chemical Constants, Sixteenth Edition*, p. 131, Longman Group Ltd., Harlow, Essex, 1995.

| Gas              | Wavelength           |                      |                      |                      |                      |                      |                      |
|------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                  | 0.4360 $\mu\text{m}$ | 0.4861 $\mu\text{m}$ | 0.5461 $\mu\text{m}$ | 0.5790 $\mu\text{m}$ | 0.5893 $\mu\text{m}$ | 0.6563 $\mu\text{m}$ | 0.6709 $\mu\text{m}$ |
| Air              | 1.0002966            | 1.0002947            | 1.0002932            | 1.0002926            | 1.0002924            | 1.0002915            | 1.0002913            |
| Ar               |                      |                      |                      |                      | 1.000281             |                      |                      |
| CH <sub>4</sub>  |                      |                      |                      |                      | 1.000444             |                      |                      |
| Cl <sub>2</sub>  |                      |                      |                      |                      | 1.000773             |                      |                      |
| CO <sub>2</sub>  | 1.0004563            |                      | 1.0004506            |                      | 1.0004493            |                      | 1.0004471            |
| H <sub>2</sub>   | 1.0001418            | 1.0001406            | 1.0001397            | 1.0001393            | 1.0001392            | 1.0001387            | 1.0001385            |
| He               |                      |                      |                      |                      | 1.000036             |                      |                      |
| N <sub>2</sub>   |                      | 1.0003012            | 1.0002998            |                      | 1.0002990            | 1.0002982            |                      |
| N <sub>2</sub> O |                      |                      |                      |                      | 1.000516             |                      |                      |
| NO               |                      |                      |                      |                      | 1.000297             |                      |                      |
| O <sub>2</sub>   | 1.0002743            | 1.0002734            | 1.0002717            | 1.0002710            | 1.0002709            | 1.0002698            | 1.0002683            |
| SO <sub>2</sub>  |                      |                      |                      |                      | 1.000686             |                      |                      |

## SUMMARY TABLES OF PARTICLE PROPERTIES

Extracted from the Particle Listings of the  
*Review of Particle Physics*  
W.-M. Yao et al., *J. Phys. G* **33**, 1 (2006)  
Available at <http://pdg.lbl.gov>

### Particle Data Group

#### Authors of Listings and Reviews:

W.-M. Yao, C. Amsler, D. Asner, R.M. Barnett, J. Beringer, P.R. Burchat,  
C.D. Carone, C. Caso, O. Dahl, G. D'Ambrosio, A. De Gouvea, M. Doser,  
S. Eidelman, J.L. Feng, T. Gherghetta, M. Goodman, C. Grab,  
D.E. Groom, A. Gurtu, K. Hagiwara, K.G. Hayes, J.J. Hernández-Rey,  
K. Hikasa, H. Jawahery, C. Kolda, Y. Kwon, M.L. Mangano,  
A.V. Manohar, A. Masoni, R. Miquel, K. Mönig, H. Murayama,  
K. Nakamura, S. Navas, K.A. Olive, L. Pape, C. Patrignani, A. Piepke,  
G. Punzi, G. Raffelt, J.G. Smith, M. Tanabashi, J. Terning,  
N.A. Törnqvist, T.G. Trippe, P. Vogel, T. Watari, C.G. Wohl,  
R.L. Workman, P.A. Zyla

#### Technical Associates:

B. Armstrong, G. Harper, V.S. Lugovsky, P. Schaffner

#### Authors of Reviews:

M. Artuso, K.S. Babu, H.R. Band, E. Barberio, M. Battaglia, H. Bichsel,  
O. Biebel, P. Bloch, E. Blucher, R.N. Cahn, D. Casper, A. Cattai,  
A. Ceccucci, D. Chakraborty, R.S. Chivukula, G. Cowan, T. Damour,  
T. DeGrand, K. Desler, M.A. Dobbs, M. Drees, A. Edwards,  
D.A. Edwards, V.D. Elvira, J. Erler, V.V. Ezhela, W. Fetscher,  
B.D. Fields, B. Foster, D. Froidevaux, T.K. Gaiser, L. Garren,  
H.-J. Gerber, G. Gerbier, L. Gibbons, F.J. Gilman, G.F. Giudice,  
A.V. Gritsan, M. Grünewald, H.E. Haber, C. Hagmann, I. Hinchliffe,  
A. Höcker, P. Igo-Kemenes, J.D. Jackson, K.F. Johnson, D. Karlen,  
B. Kayser, D. Kirkby, S.R. Klein, K. Kleinknecht, I.G. Knowles,  
R.V. Kowalewski, P. Kreitz, B. Krusche, Yu.V. Kuyanov, O. Lahav,  
P. Langacker, A. Liddle, Z. Ligeti, T.M. Liss, L. Littenberg, J.C. Liu,  
K.S. Lugovsky, S.B. Lugovsky, T. Mannel, D.M. Manley, W.J. Marciano,  
A.D. Martin, D. Milstead, M. Narain, P. Nason, Y. Nir, J.A. Peacock,  
S.A. Prell, A. Quadt, S. Raby, B.N. Ratcliff, E.A. Razuvaev, B. Renk,  
P. Richardson, S. Roesler, G. Rolandi, M.T. Ronan, L.J. Rosenberg,  
C.T. Sachrajda, Y. Sakai, S. Sarkar, M. Schmitt, O. Schneider, D. Scott,  
T. Sjöstrand, G.F. Smoot, P. Sokolsky, S. Spanier, H. Spieler, A. Stahl,  
T. Stanev, R.E. Streitmatter, T. Sumiyoshi, N.P. Tkachenko, G.H. Trilling,  
G. Valencia, K. van Bibber, M.G. Vincet, D.R. Ward, B.R. Webber,  
J.D. Wells, M. Whalley, L. Wolfenstein, J. Womersley, C.L. Woody,  
A. Yamamoto, O.V. Zenin, J. Zhang, R.-Y. Zhu

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## GAUGE AND HIGGS BOSONS

$$\gamma \quad I(J^{PC}) = 0, 1(1^{--})$$

Mass  $m < 6 \times 10^{-17}$  eV  
Charge  $q < 5 \times 10^{-30}$  e  
Mean life  $\tau = \text{Stable}$

$$g \text{ or gluon} \quad I(J^P) = 0(1^-)$$

Mass  $m = 0^{[a]}$   
SU(3) color octet

W

$J = 1$

Charge  $= \pm 1e$   
Mass  $m = 80.403 \pm 0.029$  GeV  
 $m_Z - m_W = 10.785 \pm 0.029$  GeV  
 $m_{W^+} - m_{W^-} = -0.2 \pm 0.6$  GeV  
Full width  $\Gamma = 2.141 \pm 0.041$  GeV  
 $\langle N_{\pi^\pm} \rangle = 15.70 \pm 0.35$   
 $\langle N_{K^\pm} \rangle = 2.20 \pm 0.19$   
 $\langle N_p \rangle = 0.92 \pm 0.14$   
 $\langle N_{\text{charged}} \rangle = 19.41 \pm 0.15$

$W^-$  modes are charge conjugates of the modes below.

| W <sup>+</sup> DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$<br>(MeV/c) |
|----------------------------|--------------------------------|------------------|----------------|
| $\ell^+ \nu$               | [b] (10.80 ± 0.09) %           |                  | –              |
| $e^+ \nu$                  | (10.75 ± 0.13) %               |                  | 40201          |
| $\mu^+ \nu$                | (10.57 ± 0.15) %               |                  | 40201          |
| $\tau^+ \nu$               | (11.25 ± 0.20) %               |                  | 40182          |
| hadrons                    | (67.60 ± 0.27) %               |                  | –              |
| $\pi^+ \gamma$             | $< 8 \times 10^{-5}$           | 95%              | 40201          |
| $D_s^+ \gamma$             | $< 1.3 \times 10^{-3}$         | 95%              | 40177          |
| $c\bar{X}$                 | (33.4 ± 2.6) %                 |                  | –              |
| $c\bar{s}$                 | (31 <sup>±</sup> ) %           |                  | –              |
| invisible                  | [c] (1.4 ± 2.8) %              |                  | –              |

Z

$J = 1$

Charge  $= 0$   
Mass  $m = 91.1876 \pm 0.0021$  GeV<sup>[d]</sup>  
Full width  $\Gamma = 2.4952 \pm 0.0023$  GeV  
 $\Gamma(\ell^+ \ell^-) = 83.984 \pm 0.086$  MeV<sup>[b]</sup>  
 $\Gamma(\text{invisible}) = 499.0 \pm 1.5$  MeV<sup>[e]</sup>  
 $\Gamma(\text{hadrons}) = 1744.4 \pm 2.0$  MeV  
 $\Gamma(\mu^+ \mu^-)/\Gamma(e^+ e^-) = 1.0009 \pm 0.0028$   
 $\Gamma(\tau^+ \tau^-)/\Gamma(e^+ e^-) = 1.0019 \pm 0.0032^{[f]}$

#### Average charged multiplicity

$$\langle N_{\text{charged}} \rangle = 20.76 \pm 0.16 \quad (S = 2.1)$$

#### Couplings to leptons

$$g_V^\ell = -0.03783 \pm 0.00041$$

$$g_A^\ell = -0.50123 \pm 0.00026$$

$$g^{Ve} = 0.53 \pm 0.09$$

$$g^{V\mu} = 0.502 \pm 0.017$$

#### Asymmetry parameters<sup>[g]</sup>

$$A_e = 0.1515 \pm 0.0019$$

$$A_\mu = 0.142 \pm 0.015$$

$$A_\tau = 0.143 \pm 0.004$$

$$A_s = 0.90 \pm 0.09$$

$$A_c = 0.670 \pm 0.027$$

$$A_b = 0.923 \pm 0.020$$

#### Charge asymmetry (%) at Z pole

$$A_{FB}^{(0\ell)} = 1.71 \pm 0.10$$

$$A_{FB}^{(0u)} = 4 \pm 7$$

$$A_{FB}^{(0s)} = 9.8 \pm 1.1$$

$$A_{FB}^{(0c)} = 7.07 \pm 0.35$$

$$A_{FB}^{(0b)} = 9.92 \pm 0.16$$

| Z DECAY MODES                        | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|--------------------------------------|--------------------------------|-----------------------------------|----------------|
| $e^+ e^-$                            | (3.363 ± 0.004) %              |                                   | 45594          |
| $\mu^+ \mu^-$                        | (3.366 ± 0.007) %              |                                   | 45594          |
| $\tau^+ \tau^-$                      | (3.370 ± 0.008) %              |                                   | 45559          |
| $\ell^+ \ell^-$                      | [b] (3.3658 ± 0.0023) %        |                                   | –              |
| invisible                            | (20.00 ± 0.06) %               |                                   | –              |
| hadrons                              | (69.91 ± 0.06) %               |                                   | –              |
| $(u\bar{u} + c\bar{c})/2$            | (11.6 ± 0.6) %                 |                                   | –              |
| $(d\bar{d} + s\bar{s} + b\bar{b})/3$ | (15.6 ± 0.4) %                 |                                   | –              |
| $c\bar{c}$                           | (12.03 ± 0.21) %               |                                   | –              |
| $b\bar{b}$                           | (15.12 ± 0.05) %               |                                   | –              |
| $b\bar{b}b\bar{b}$                   | (3.6 ± 1.3) $\times 10^{-4}$   |                                   | –              |



|                                                    |                                         |                  |          |       |
|----------------------------------------------------|-----------------------------------------|------------------|----------|-------|
| $ggg$                                              | $< 1.1$                                 | %                | CL = 95% | –     |
| $\pi^0 \gamma$                                     | $< 5.2$                                 | $\times 10^{-5}$ | CL = 95% | 45594 |
| $\eta \gamma$                                      | $< 5.1$                                 | $\times 10^{-5}$ | CL = 95% | 45592 |
| $\omega \gamma$                                    | $< 6.5$                                 | $\times 10^{-4}$ | CL = 95% | 45590 |
| $\eta'(958) \gamma$                                | $< 4.2$                                 | $\times 10^{-5}$ | CL = 95% | 45589 |
| $\gamma \gamma$                                    | $< 5.2$                                 | $\times 10^{-5}$ | CL = 95% | 45594 |
| $\gamma \gamma \gamma$                             | $< 1.0$                                 | $\times 10^{-5}$ | CL = 95% | 45594 |
| $\pi^\pm W^\mp$                                    | [b] $< 7$                               | $\times 10^{-5}$ | CL = 95% | 10146 |
| $\rho^\pm W^\mp$                                   | [b] $< 8.3$                             | $\times 10^{-5}$ | CL = 95% | 10120 |
| $J/\psi(1S) X$                                     | $(3.51^{+0.23}_{-0.25}) \times 10^{-3}$ |                  | S = 1.1  | –     |
| $\psi(2S) X$                                       | $(1.60 \pm 0.29) \times 10^{-3}$        |                  | –        | –     |
| $\chi_{c1}(1P) X$                                  | $(2.9 \pm 0.7) \times 10^{-3}$          |                  | –        | –     |
| $\chi_{c2}(1P) X$                                  | $< 3.2$                                 | $\times 10^{-3}$ | CL = 90% | –     |
| $\Upsilon(1S) X + \Upsilon(2S) X + \Upsilon(3S) X$ | $(1.0 \pm 0.5) \times 10^{-4}$          |                  | –        | –     |
| $\Upsilon(1S) X$                                   | $< 4.4$                                 | $\times 10^{-5}$ | CL = 95% | –     |
| $\Upsilon(2S) X$                                   | $< 1.39$                                | $\times 10^{-4}$ | CL = 95% | –     |
| $\Upsilon(3S) X$                                   | $< 9.4$                                 | $\times 10^{-5}$ | CL = 95% | –     |
| $(D^0/\bar{D}^0) X$                                | $(20.7 \pm 2.0) \%$                     |                  | –        | –     |
| $D^\pm X$                                          | $(12.2 \pm 1.7) \%$                     |                  | –        | –     |
| $D^*(2010)^\pm X$                                  | [b] $(11.4 \pm 1.3) \%$                 |                  | –        | –     |
| $D_{s1}(2536)^\pm X$                               | $(3.6 \pm 0.8) \times 10^{-3}$          |                  | –        | –     |
| $D_{sJ}(2573)^\pm X$                               | $(5.8 \pm 2.2) \times 10^{-3}$          |                  | –        | –     |
| $D^{*0}(2629)^\pm X$                               | searched for                            |                  | –        | –     |
| $B^+ X$                                            | $(6.03 \pm 0.15) \%$                    |                  | –        | –     |
| $B_s^0 X$                                          | $(1.55 \pm 0.13) \%$                    |                  | –        | –     |
| $B_c^\pm X$                                        | searched for                            |                  | –        | –     |
| $\Lambda_c^+ X$                                    | $(1.54 \pm 0.33) \%$                    |                  | –        | –     |
| $b$ -baryon X                                      | $(1.51 \pm 0.26) \%$                    |                  | –        | –     |
| anomalous $\gamma$ + hadrons                       | [i] $< 3.2$                             | $\times 10^{-3}$ | CL = 95% | –     |
| $e^+ e^- \gamma$                                   | [i] $< 5.2$                             | $\times 10^{-4}$ | CL = 95% | 45594 |
| $\mu^+ \mu^- \gamma$                               | [i] $< 5.6$                             | $\times 10^{-4}$ | CL = 95% | 45594 |
| $\tau^+ \tau^- \gamma$                             | [i] $< 7.3$                             | $\times 10^{-4}$ | CL = 95% | 45559 |
| $\ell^+ \ell^- \gamma \gamma$                      | [j] $< 6.8$                             | $\times 10^{-6}$ | CL = 95% | –     |
| $q\bar{q}\gamma\gamma$                             | [j] $< 5.5$                             | $\times 10^{-6}$ | CL = 95% | –     |
| $\nu\bar{\nu}\gamma\gamma$                         | [j] $< 3.1$                             | $\times 10^{-6}$ | CL = 95% | 45594 |
| $e^\pm \mu^\mp$                                    | LF [b] $< 1.7$                          | $\times 10^{-6}$ | CL = 95% | 45594 |
| $e^\pm \tau^\mp$                                   | LF [b] $< 9.8$                          | $\times 10^{-6}$ | CL = 95% | 45576 |
| $\mu^\pm \tau^\mp$                                 | LF [b] $< 1.2$                          | $\times 10^{-5}$ | CL = 95% | 45576 |
| $pe$                                               | L, B $< 1.8$                            | $\times 10^{-6}$ | CL = 95% | 45589 |
| $p\mu$                                             | L, B $< 1.8$                            | $\times 10^{-6}$ | CL = 95% | 45589 |

### Higgs Bosons — $H^0$ and $H^\pm$ , Searches for

$H^0$  Mass  $m > 114.4$  GeV, CL = 95%

$H_1^0$  in Supersymmetric Models ( $m_{H_1^0} < m_{H_2^0}$ )

Mass  $m > 89.8$  GeV, CL = 95%

$A^0$  Pseudoscalar Higgs Boson in Supersymmetric Models [k]

Mass  $m > 90.4$  GeV, CL = 95%  $\tan \beta > 0.4$

$H^\pm$  Mass  $m > 79.3$  GeV, CL = 95%

(See the Particle Listings for a Note giving details of Higgs Bosons.)

### Heavy Bosons Other than Higgs Bosons, Searches for

#### Additional W Bosons

$W'$  with standard couplings decaying to  $e\nu, \mu\nu$

Mass  $m > 800$  GeV, CL = 95%

$W_R$  — right-handed W

Mass  $m > 715$  GeV, CL = 90% (electroweak fit)

#### Additional Z Bosons

$Z_{SM}$  with standard couplings

Mass  $m > 825$  GeV, CL = 95% ( $p\bar{p}$  direct search)

Mass  $m > 1500$  GeV, CL = 95% (electroweak fit)

$Z_{LR}$  of  $SU(2)_L \times SU(2)_R \times U(1)$

(with  $g_L = g_R$ )

Mass  $m > 630$  GeV, CL = 95% ( $p\bar{p}$  direct search)

Mass  $m > 860$  GeV, CL = 95% (electroweak fit)

$Z_\chi$  of  $SO(10) \times SU(5) \times U(1)_\chi$  (with  $g_\chi = e \cos \theta_W$ )

Mass  $m > 690$  GeV, CL = 95% ( $p\bar{p}$  direct search)

Mass  $m > 781$  GeV, CL = 95% (electroweak fit)

$Z_\psi$  of  $E_6 \rightarrow SO(10) \times U(1)_\psi$  (with  $g_\psi = e \cos \theta_W$ )

Mass  $m > 675$  GeV, CL = 95% ( $p\bar{p}$  direct search)

Mass  $m > 366$  GeV, CL = 95% (electroweak fit)

$Z_\eta$  of  $E_6 \rightarrow SU(3) \times SU(2) \times U(1) \times U(1)_\eta$  (with  $g_\eta = e \cos \theta_W$ )

Mass  $m > 720$  GeV, CL = 95% ( $p\bar{p}$  direct search)

Mass  $m > 619$  GeV, CL = 95% (electroweak fit)

#### Scalar Leptoquarks

Mass  $m > 256$  GeV, CL = 95% (1st generation, pair prod.)

Mass  $m > 298$  GeV, CL = 95% (1st gener., single prod.)

Mass  $m > 202$  GeV, CL = 95% (2nd gener., pair prod.)

Mass  $m > 73$  GeV, CL = 95% (2nd gener., single prod.)

Mass  $m > 148$  GeV, CL = 95% (3rd gener., pair prod.)

(See the Particle Listings for assumptions on leptoquark quantum numbers and branching fractions.)

### Axions ( $A^0$ ) and Other Very Light Bosons, Searches for

The standard Peccei–Quinn axion is ruled out. Variants with reduced couplings or much smaller masses are constrained by various data. The Particle Listings in the full *Review* contain a Note discussing axion searches.

The best limit for the half-life of neutrinoless double beta decay with Majoron emission is  $> 7.2 \times 10^{24}$  years (CL = 90%).

### NOTES

In this Summary Table:

When a quantity has “(S = ...)” to its right, the error on the quantity has been enlarged by the “scale factor” S, defined as  $S = \sqrt{\chi^2/(N-1)}$ , where N is the number of measurements used in calculating the quantity. We do this when  $S > 1$ , which often indicates that the measurements are inconsistent. When  $S > 1.25$ , we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum  $p$  is given for each decay mode. For a 2-body decay,  $p$  is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay,  $p$  is the largest momentum any of the products can have in this frame.

- [a] Theoretical value. A mass as large as a few MeV may not be precluded.
- [b]  $\ell$  indicates each type of lepton ( $e, \mu$ , and  $\tau$ ), not sum over them.
- [c] This represents the width for the decay of the W boson into a charged particle with momentum below detectability,  $p < 200$  MeV.
- [d] The Z-boson mass listed here corresponds to a Breit–Wigner resonance parameter. It lies approximately 34 MeV above the real part of the position of the pole (in the energy-squared plane) in the Z-boson propagator.
- [e] This partial width takes into account Z decays into  $\nu\bar{\nu}$  and any other possible undetected modes.
- [f] This ratio has not been corrected for the  $\tau$  mass.
- [g] Here  $A \equiv 2g_V g_A / (g_V^2 + g_A^2)$ .
- [h] The value is for the sum of the charge states or particle/antiparticle states indicated.
- [i] See the Z Particle Listings for the  $\gamma$  energy range used in this measurement.
- [j] For  $m_{\gamma\gamma} = (60 \pm 5)$  GeV.
- [k] The limits assume no invisible decays.

# LEPTON SUMMARY TABLE

## LEPTONS

**e**

$$J = \frac{1}{2}$$

Mass  $m = (548.57990945 \pm 0.000000024) \times 10^{-6}$  u  
 Mass  $m = 0.51099892 \pm 0.00000004$  MeV  
 $|m_{e^+} - m_{e^-}|/m < 8 \times 10^{-9}$ , CL = 90%  
 $|q_{e^+} + q_{e^-}|/e < 4 \times 10^{-8}$   
 Magnetic moment  $\mu = 1.0011596521859 \pm 0.0000000000038 \mu_B$   
 $(g_{e^+} - g_{e^-})/g_{\text{average}} = (-0.5 \pm 2.1) \times 10^{-12}$   
 Electric dipole moment  $d = (0.07 \pm 0.07) \times 10^{-26}$  e cm  
 Mean life  $\tau > 4.6 \times 10^{26}$  yr, CL = 90%<sup>[a]</sup>

**$\mu$**

$$J = \frac{1}{2}$$

Mass  $m = 0.1134289264 \pm 0.0000000030$  u  
 Mass  $m = 105.658369 \pm 0.000009$  MeV  
 Mean life  $\tau = (2.19703 \pm 0.00004) \times 10^{-6}$  s  
 $\tau_{\mu^+}/\tau_{\mu^-} = 1.00002 \pm 0.00008$   
 $c\tau = 658.654$  m  
 Magnetic moment  $\mu = 1.0011659208 \pm 0.0000000006 \hbar/2m_\mu$   
 $(g_{\mu^+} - g_{\mu^-})/g_{\text{average}} = (-2.6 \pm 1.6) \times 10^{-8}$   
 Electric dipole moment  $d = (3.7 \pm 3.4) \times 10^{-19}$  e cm

### Decay parameters<sup>[b]</sup>

$\rho = 0.7509 \pm 0.0010$   
 $\eta = 0.001 \pm 0.024$  (S = 2.0)  
 $\delta = 0.7495 \pm 0.0012$   
 $\xi P_\mu = 1.003 \pm 0.008$ <sup>[c]</sup>  
 $\xi P_\mu \delta/\rho > 0.99682$ , CL = 90%<sup>[c]</sup>  
 $\xi' = 1.00 \pm 0.04$   
 $\xi'' = 0.7 \pm 0.4$   
 $\alpha/A = (0 \pm 4) \times 10^{-3}$   
 $\alpha'/A = (0 \pm 4) \times 10^{-3}$   
 $\beta/A = (4 \pm 6) \times 10^{-3}$   
 $\beta'/A = (1 \pm 5) \times 10^{-3}$   
 $\bar{\eta} = 0.02 \pm 0.08$

$\mu^\pm$  modes are charge conjugates of the modes below.

| $\mu^-$ DECAY MODES                              | Fraction ( $\Gamma_i/\Gamma$ )       | Confidence level | $p$<br>(MeV/c) |
|--------------------------------------------------|--------------------------------------|------------------|----------------|
| $e^- \bar{\nu}_e \nu_\mu$                        | $\approx 100\%$                      |                  | 53             |
| $e^- \bar{\nu}_e \nu_\mu \gamma$                 | [d] (1.4 $\pm$ 0.4) %                |                  | 53             |
| $e^- \bar{\nu}_e \nu_\mu e^+ e^-$                | [e] (3.4 $\pm$ 0.4) $\times 10^{-5}$ |                  | 53             |
| <b>Lepton Family number (LF) violating modes</b> |                                      |                  |                |
| $e^- \nu_e \bar{\nu}_\mu$                        | LF [f] < 1.2 %                       | 90%              | 53             |
| $e^- \gamma$                                     | LF < 1.2 $\times 10^{-11}$           | 90%              | 53             |
| $e^- e^+ e^-$                                    | LF < 1.0 $\times 10^{-12}$           | 90%              | 53             |
| $e^- 2\gamma$                                    | LF < 7.2 $\times 10^{-11}$           | 90%              | 53             |

**$\tau$**

$$J = \frac{1}{2}$$

Mass  $m = 1776.99^{+0.29}_{-0.26}$  MeV  
 $(m_{\tau^+} - m_{\tau^-})/m_{\text{average}} < 3.0 \times 10^{-3}$ , CL = 90%  
 Mean life  $\tau = (290.6 \pm 1.0) \times 10^{-15}$  s  
 $c\tau = 87.11 \mu\text{m}$   
 Magnetic moment anomaly  $> -0.052$  and  $< 0.013$ ,  
 CL = 95%  
 $\text{Re}(d_\tau) = -0.22$  to  $0.45 \times 10^{-16}$  e cm, CL = 95%  
 $\text{Im}(d_\tau) = -0.25$  to  $0.008 \times 10^{-16}$  e cm, CL = 95%

### Weak dipole moment

$\text{Re}(d_\tau^W) < 0.50 \times 10^{-17}$  e cm, CL = 95%  
 $\text{Im}(d_\tau^W) < 1.1 \times 10^{-17}$  e cm, CL = 95%

### Weak anomalous magnetic dipole moment

$\text{Re}(\alpha_\tau^W) < 1.1 \times 10^{-3}$ , CL = 95%  
 $\text{Im}(\alpha_\tau^W) < 2.7 \times 10^{-3}$ , CL = 95%

### Decay parameters

See the  $\tau$  Particle Listings for a note concerning  $\tau$ -decay parameters.

$\rho^\tau(e \text{ or } \mu) = 0.745 \pm 0.008$   
 $\rho^\tau(e) = 0.747 \pm 0.010$   
 $\rho^\tau(\mu) = 0.763 \pm 0.020$   
 $\xi^\tau(e \text{ or } \mu) = 0.985 \pm 0.030$   
 $\xi^\tau(e) = 0.994 \pm 0.040$   
 $\xi^\tau(\mu) = 1.030 \pm 0.059$   
 $\eta^\tau(e \text{ or } \mu) = 0.013 \pm 0.020$   
 $\eta^\tau(\mu) = 0.094 \pm 0.073$   
 $(\delta\xi)^\tau(e \text{ or } \mu) = 0.746 \pm 0.021$   
 $(\delta\xi)^\tau(e) = 0.734 \pm 0.028$   
 $(\delta\xi)^\tau(\mu) = 0.778 \pm 0.037$   
 $\xi^\tau(\pi) = 0.993 \pm 0.022$   
 $\xi^\tau(\rho) = 0.994 \pm 0.008$   
 $\xi^\tau(a_1) = 1.001 \pm 0.027$   
 $\xi^\tau(\text{all hadronic modes}) = 0.995 \pm 0.007$

$\tau^\pm$  modes are charge conjugates of the modes below. “ $h^\pm$ ” stands for  $\pi^\pm$  or  $K^\pm$ . “ $\ell$ ” stands for  $e$  or  $\mu$ . “Neutrals” stands for  $\gamma$ 's and/or  $\pi^0$ 's.

| $\tau^-$ DECAY MODES                                              | Fraction ( $\Gamma_i/\Gamma$ )         | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|-------------------------------------------------------------------|----------------------------------------|-----------------------------------|----------------|
| <b>Modes with one charged particle</b>                            |                                        |                                   |                |
| particle $^- \geq 0$ neutrals $\geq 0K^0 \nu_\tau$<br>(“1-prong”) | (85.33 $\pm$ 0.08) %                   | S = 1.4                           | –              |
| particle $^- \geq 0$ neutrals $\geq 0K_L^0 \nu_\tau$              | (84.69 $\pm$ 0.09) %                   | S = 1.4                           | –              |
| $\mu^- \bar{\nu}_\mu \nu_\tau$                                    | [g] (17.36 $\pm$ 0.05) %               |                                   | 885            |
| $\mu^- \bar{\nu}_\mu \nu_\tau \gamma$                             | [e] (3.6 $\pm$ 0.4) $\times 10^{-3}$   |                                   | 885            |
| $e^- \bar{\nu}_e \nu_\tau$                                        | [g] (17.84 $\pm$ 0.05) %               |                                   | 888            |
| $e^- \bar{\nu}_e \nu_\tau \gamma$                                 | [e] (1.75 $\pm$ 0.18) %                |                                   | 888            |
| $h^- \geq 0K_L^0 \nu_\tau$                                        | (12.14 $\pm$ 0.07) %                   | S = 1.1                           | 883            |
| $h^- \nu_\tau$                                                    | (11.59 $\pm$ 0.06) %                   | S = 1.1                           | 883            |
| $\pi^- \nu_\tau$                                                  | [g] (10.90 $\pm$ 0.07) %               | S = 1.1                           | 883            |
| $K^- \nu_\tau$                                                    | [g] (6.91 $\pm$ 0.23) $\times 10^{-3}$ |                                   | 820            |
| $h^- \geq 1$ neutrals $\nu_\tau$                                  | (37.05 $\pm$ 0.12) %                   | S = 1.3                           | –              |
| $h^- \geq 1\pi^0 \nu_\tau$ (ex. $K^0$ )                           | (36.51 $\pm$ 0.12) %                   | S = 1.3                           | –              |
| $h^- \pi^0 \nu_\tau$                                              | (25.95 $\pm$ 0.10) %                   | S = 1.1                           | 878            |
| $\pi^- \pi^0 \nu_\tau$                                            | [g] (25.50 $\pm$ 0.10) %               | S = 1.1                           | 878            |
| $\pi^- \pi^0 \text{non-}\rho(770) \nu_\tau$                       | (3.0 $\pm$ 3.2) $\times 10^{-3}$       |                                   | 878            |
| $K^- \pi^0 \nu_\tau$                                              | [g] (4.52 $\pm$ 0.27) $\times 10^{-3}$ |                                   | 814            |
| $h^- \geq 2\pi^0 \nu_\tau$                                        | (10.81 $\pm$ 0.14) %                   | S = 1.5                           | –              |
| $h^- 2\pi^0 \nu_\tau$                                             | (9.47 $\pm$ 0.12) %                    | S = 1.3                           | 862            |
| $h^- 2\pi^0 \nu_\tau$ (ex. $K^0$ )                                | (9.31 $\pm$ 0.12) %                    | S = 1.3                           | 862            |
| $\pi^- 2\pi^0 \nu_\tau$ (ex. $K^0$ )                              | [g] (9.25 $\pm$ 0.12) %                | S = 1.3                           | 862            |
| $\pi^- 2\pi^0 \nu_\tau$ (ex. $K^0$ ),<br>scalar                   | < 9 $\times 10^{-3}$                   | CL = 95%                          | 862            |
| $\pi^- 2\pi^0 \nu_\tau$ (ex. $K^0$ ),<br>vector                   | < 7 $\times 10^{-3}$                   | CL = 95%                          | 862            |
| $K^- 2\pi^0 \nu_\tau$ (ex. $K^0$ )                                | [g] (5.8 $\pm$ 2.3) $\times 10^{-4}$   |                                   | 796            |
| $h^- \geq 3\pi^0 \nu_\tau$                                        | (1.33 $\pm$ 0.07) %                    | S = 1.1                           | –              |
| $h^- \geq 3\pi^0 \nu_\tau$ (ex. $K^0$ )                           | (1.25 $\pm$ 0.07) %                    | S = 1.1                           | –              |
| $h^- 3\pi^0 \nu_\tau$                                             | (1.17 $\pm$ 0.08) %                    | S = 1.1                           | 836            |
| $\pi^- 3\pi^0 \nu_\tau$ (ex. $K^0$ )                              | [g] (1.04 $\pm$ 0.08) %                | S = 1.1                           | 836            |
| $K^- 3\pi^0 \nu_\tau$ (ex. $K^0$ , $\eta$ )                       | [g] (4.2 $\pm$ 2.1) $\times 10^{-4}$   |                                   | 766            |
| $h^- 4\pi^0 \nu_\tau$ (ex. $K^0$ )                                | (1.6 $\pm$ 0.4) $\times 10^{-3}$       |                                   | 800            |
| $h^- 4\pi^0 \nu_\tau$ (ex. $K^0, \eta$ )                          | [g] (1.0 $\pm$ 0.4) $\times 10^{-3}$   |                                   | 800            |
| $K^- \geq 0\pi^0 \geq 0K^0 \geq 0\gamma \nu_\tau$                 | (1.57 $\pm$ 0.04) %                    | S = 1.1                           | 820            |
| $K^- \geq 1(\pi^0 \text{ or } K^0 \text{ or } \gamma) \nu_\tau$   | (8.78 $\pm$ 0.33) $\times 10^{-3}$     |                                   | –              |
| <b>Modes with <math>K^0</math>'s</b>                              |                                        |                                   |                |
| $K_S^0$ (particles) $\nu_\tau$                                    | (9.27 $\pm$ 0.34) $\times 10^{-3}$     | S = 1.1                           | –              |
| $h^- \bar{K}^0 \nu_\tau$                                          | (1.05 $\pm$ 0.04) %                    | S = 1.1                           | 812            |
| $\pi^- \bar{K}^0 \nu_\tau$                                        | [g] (9.0 $\pm$ 0.4) $\times 10^{-3}$   | S = 1.1                           | 812            |
| $\pi^- \bar{K}^0$                                                 | < 1.7 $\times 10^{-3}$                 | CL = 95%                          | 812            |
| (non- $K^*(892)^-$ ) $\nu_\tau$                                   |                                        |                                   |                |
| $K^- \bar{K}^0 \nu_\tau$                                          | [g] (1.53 $\pm$ 0.16) $\times 10^{-3}$ |                                   | 737            |
| $K^- K^0 \geq 0\pi^0 \nu_\tau$                                    | (3.07 $\pm$ 0.24) $\times 10^{-3}$     |                                   | 737            |

|                                              |                   |                  |              |
|----------------------------------------------|-------------------|------------------|--------------|
| $b^- \bar{K}^0 \pi^0 \nu_\tau$               | (5.3 ± 0.4)       | $\times 10^{-3}$ | 794          |
| $\pi^- \bar{K}^0 \pi^0 \nu_\tau$             | [g] (3.8 ± 0.4)   | $\times 10^{-3}$ | 794          |
| $\bar{K}^0 \rho^- \nu_\tau$                  | (2.2 ± 0.5)       | $\times 10^{-3}$ | 612          |
| $K^- K^0 \pi^0 \nu_\tau$                     | [g] (1.54 ± 0.20) | $\times 10^{-3}$ | 685          |
| $\pi^- \bar{K}^0 \geq 1\pi^0 \nu_\tau$       | (3.2 ± 1.0)       | $\times 10^{-3}$ | –            |
| $\pi^- \bar{K}^0 \pi^0 \pi^0 \nu_\tau$       | (2.6 ± 2.4)       | $\times 10^{-4}$ | 763          |
| $K^- K^0 \pi^0 \pi^0 \nu_\tau$               | < 1.6             | $\times 10^{-4}$ | CL = 95% 619 |
| $\pi^- K^0 \bar{K}^0 \nu_\tau$               | (1.60 ± 0.31)     | $\times 10^{-3}$ | S = 1.2 682  |
| $\pi^- K_S^0 K_L^0 \nu_\tau$                 | [g] (2.4 ± 0.5)   | $\times 10^{-4}$ | 682          |
| $\pi^- K_S^0 K_L^0 \nu_\tau$                 | [g] (1.12 ± 0.30) | $\times 10^{-3}$ | S = 1.2 682  |
| $\pi^- K^0 \bar{K}^0 \pi^0 \nu_\tau$         | (3.1 ± 2.3)       | $\times 10^{-4}$ | 614          |
| $\pi^- K_S^0 K_L^0 \pi^0 \nu_\tau$           | < 2.0             | $\times 10^{-4}$ | CL = 95% 614 |
| $\pi^- K_S^0 K_L^0 \pi^0 \nu_\tau$           | (3.1 ± 1.2)       | $\times 10^{-4}$ | 614          |
| $K^0 b^+ b^- h^- \geq 0$ neutrals $\nu_\tau$ | < 1.7             | $\times 10^{-3}$ | CL = 95% 760 |
| $K^0 b^+ b^- h^- \nu_\tau$                   | (2.3 ± 2.0)       | $\times 10^{-4}$ | 760          |

## Modes with three charged particles

|                                                        |                       |                  |          |     |
|--------------------------------------------------------|-----------------------|------------------|----------|-----|
| $b^-b^-b^+ \geq 0$ neutrals $\geq 0K_L^0 \nu_\tau$     | (15.22 $\pm$ 0.09)    | %                | S = 1.4  | 861 |
| $b^-b^-b^+ \geq 0$ neutrals $\nu_\tau$                 | (14.59 $\pm$ 0.08)    | %                | S = 1.4  | 861 |
| (ex. $K_S^0 \rightarrow \pi^+\pi^-$ )                  |                       |                  |          |     |
| (“3-prong”)                                            |                       |                  |          |     |
| $b^-b^-b^+\nu_\tau$                                    | (9.87 $\pm$ 0.08)     | %                | S = 1.3  | 861 |
| $b^-h^-b^+\nu_\tau$ (ex. $K^0$ )                       | (9.51 $\pm$ 0.08)     | %                | S = 1.3  | 861 |
| $b^-b^-b^+\nu_\tau$ (ex. $K^0, \omega$ )               | (9.47 $\pm$ 0.08)     | %                | S = 1.3  | 861 |
| $\pi^-\pi^+\pi^-\nu_\tau$                              | (9.33 $\pm$ 0.08)     | %                | S = 1.3  | 861 |
| $\pi^-\pi^+\pi^-\nu_\tau$ (ex. $K^0$ )                 | (9.02 $\pm$ 0.08)     | %                | S = 1.3  | 861 |
| $\pi^-\pi^+\pi^-\nu_\tau$ (ex. $K^0$ ),                | < 2.4                 | %                | CL = 95% | 861 |
| non-axial vector                                       |                       |                  |          |     |
| $\pi^-\pi^+\pi^-\nu_\tau$ (ex. $K^0, \omega$ )         | [g] (8.99 $\pm$ 0.08) | %                | S = 1.3  | 861 |
| $b^-b^-b^+ \geq 1$ neutrals $\nu_\tau$                 | (5.34 $\pm$ 0.06)     | %                | S = 1.1  | –   |
| $b^-h^-b^+ \geq 1\pi^0 \nu_\tau$ (ex. $K^0$ )          | (5.06 $\pm$ 0.06)     | %                | S = 1.1  | –   |
| $b^-b^-b^+\pi^0 \nu_\tau$                              | (4.73 $\pm$ 0.07)     | %                | S = 1.2  | 834 |
| $b^-h^-b^+\pi^0 \nu_\tau$ (ex. $K^0$ )                 | (4.55 $\pm$ 0.06)     | %                | S = 1.2  | 834 |
| $b^-h^-b^+\pi^0 \nu_\tau$ (ex. $K^0, \omega$ )         | (2.78 $\pm$ 0.08)     | %                | S = 1.2  | 834 |
| $\pi^-\pi^+\pi^-\pi^0 \nu_\tau$                        | (4.59 $\pm$ 0.07)     | %                | S = 1.2  | 834 |
| $\pi^-\pi^+\pi^-\pi^0 \nu_\tau$ (ex. $K^0$ )           | (4.46 $\pm$ 0.06)     | %                | S = 1.2  | 834 |
| $\pi^-\pi^+\pi^-\pi^0 \nu_\tau$ (ex. $K^0, \omega$ )   | [g] (2.69 $\pm$ 0.08) | %                | S = 1.2  | 834 |
| $b^-b^-b^+ \geq 2\pi^0 \nu_\tau$ (ex. $K^0$ )          | (5.14 $\pm$ 0.34)     | $\times 10^{-3}$ | S = 1.1  | –   |
| $b^-h^-b^+ 2\pi^0 \nu_\tau$                            | (5.02 $\pm$ 0.34)     | $\times 10^{-3}$ | S = 1.1  | 797 |
| $b^-h^-b^+ 2\pi^0 \nu_\tau$ (ex. $K^0$ )               | (4.92 $\pm$ 0.34)     | $\times 10^{-3}$ | S = 1.1  | 797 |
| $b^-h^-b^+ 2\pi^0 \nu_\tau$ (ex. $K^0, \omega, \eta$ ) | [g] (9 $\pm$ 4)       | $\times 10^{-4}$ |          | 797 |
| $b^-h^-b^+ 3\pi^0 \nu_\tau$                            | [g] (2.2 $\pm$ 0.5)   | $\times 10^{-4}$ |          | 749 |
| $K^-h^+b^- \geq 0$ neutrals $\nu_\tau$                 | (6.79 $\pm$ 0.35)     | $\times 10^{-3}$ | S = 1.3  | 794 |
| $K^-h^+\pi^-\nu_\tau$ (ex. $K^0$ )                     | (4.86 $\pm$ 0.32)     | $\times 10^{-3}$ | S = 1.4  | 794 |
| $K^-h^+\pi^-\pi^0 \nu_\tau$ (ex. $K^0$ )               | (8.5 $\pm$ 1.2)       | $\times 10^{-4}$ |          | 763 |
| $K^-\pi^+\pi^- \geq 0$ neutrals $\nu_\tau$             | (5.2 $\pm$ 0.4)       | $\times 10^{-3}$ | S = 1.5  | 794 |
| $K^-\pi^+\pi^- \geq 0\pi^0 \nu_\tau$ (ex. $K^0$ )      | (4.1 $\pm$ 0.4)       | $\times 10^{-3}$ | S = 1.5  | 794 |
| $K^-\pi^+\pi^-\nu_\tau$                                | (3.9 $\pm$ 0.4)       | $\times 10^{-3}$ | S = 1.6  | 794 |
| $K^-\pi^+\pi^-\nu_\tau$ (ex. $K^0$ )                   | [g] (3.33 $\pm$ 0.35) | $\times 10^{-3}$ | S = 1.6  | 794 |
| $K^-\rho^0 \nu_\tau \rightarrow K^-\pi^+\pi^-\nu_\tau$ | (1.6 $\pm$ 0.6)       | $\times 10^{-3}$ |          | –   |
| $K^-\pi^+\pi^-\pi^0 \nu_\tau$                          | (1.32 $\pm$ 0.14)     | $\times 10^{-3}$ |          | 763 |
| $K^-\pi^+\pi^-\pi^0 \nu_\tau$ (ex. $K^0$ )             | (7.9 $\pm$ 1.2)       | $\times 10^{-4}$ |          | 763 |
| $K^-\pi^+\pi^-\pi^0 \nu_\tau$ (ex. $K^0, \eta$ )       | [g] (7.3 $\pm$ 1.2)   | $\times 10^{-4}$ |          | 763 |
| $K^-\pi^+\pi^-\pi^0 \nu_\tau$ (ex. $K^0, \omega$ )     | (3.7 $\pm$ 0.9)       | $\times 10^{-4}$ |          | 763 |
| $K^-\pi^+K^- \geq 0$ neut. $\nu_\tau$                  | < 9                   | $\times 10^{-4}$ | CL = 95% | 685 |
| $K^-K^+\pi^- \geq 0$ neut. $\nu_\tau$                  | (1.59 $\pm$ 0.10)     | $\times 10^{-3}$ | S = 1.4  | 685 |
| $K^-K^+\pi^-\nu_\tau$                                  | [g] (1.53 $\pm$ 0.10) | $\times 10^{-3}$ | S = 1.4  | 685 |
| $K^-K^+\pi^-\pi^0 \nu_\tau$                            | [g] (6.1 $\pm$ 2.0)   | $\times 10^{-5}$ | S = 1.1  | 618 |
| $K^-K^+K^- \geq 0$ neut. $\nu_\tau$                    | < 2.1                 | $\times 10^{-3}$ | CL = 95% | 472 |
| $K^-K^+K^-\nu_\tau$                                    | < 3.7                 | $\times 10^{-5}$ | CL = 90% | 472 |
| $K^-K^+K^-\pi^0 \nu_\tau$                              | < 4.8                 | $\times 10^{-6}$ | CL = 90% | 346 |
| $\pi^-K^+\pi^- \geq 0$ neut. $\nu_\tau$                | < 2.5                 | $\times 10^{-3}$ | CL = 95% | 794 |
| $e^-e^-e^+\bar{\nu}_e \nu_\tau$                        | (2.8 $\pm$ 1.5)       | $\times 10^{-5}$ |          | 888 |
| $\mu^-e^-e^+\bar{\nu}_\mu \nu_\tau$                    | < 3.6                 | $\times 10^{-5}$ | CL = 90% | 885 |

## Modes with five charged particles

|                                         |     |                                  |          |     |
|-----------------------------------------|-----|----------------------------------|----------|-----|
| $3b^- 2b^+ \geq 0$ neutrals $\nu_\tau$  |     | $(1.02 \pm 0.04) \times 10^{-3}$ | S = 1.1  | 794 |
| (ex. $K_S^0 \rightarrow \pi^- \pi^+$ )  |     |                                  |          |     |
| (“5-prong”)                             |     |                                  |          |     |
| $3b^- 2b^+ \nu_\tau$ (ex. $K^0$ )       | [g] | $(8.38 \pm 0.35) \times 10^{-4}$ | S = 1.1  | 794 |
| $3b^- 2h^+ \pi^0 \nu_\tau$ (ex. $K^0$ ) | [g] | $(1.78 \pm 0.27) \times 10^{-4}$ |          | 746 |
| $3b^- 2h^+ 2\pi^0 \nu_\tau$             |     | $< 1.1 \times 10^{-4}$           | CL = 90% | 687 |

## Miscellaneous other allowed modes

|                                        |                   |                  |          |     |
|----------------------------------------|-------------------|------------------|----------|-----|
| $(5\pi)^- \nu_\tau$                    | $(7.6 \pm 0.5)$   | $\times 10^{-3}$ | S = 1.1  | 800 |
| $4b^- 3b^+ \geq 0$ neutrals $\nu_\tau$ | < 3.0             | $\times 10^{-7}$ | CL = 90% | 683 |
| (“7-prong”)                            |                   |                  |          |     |
| $4b^- 3h^+ \nu_\tau$                   | < 4.3             | $\times 10^{-7}$ | CL = 90% | 683 |
| $4b^- 3h^+ \pi^0 \nu_\tau$             | < 2.5             | $\times 10^{-7}$ | CL = 90% | 612 |
| $X^-(S = -1) \nu_\tau$                 | $(2.95 \pm 0.07)$ | %                | S = 1.1  | –   |

|                                                                      |                                        |                  |          |     |
|----------------------------------------------------------------------|----------------------------------------|------------------|----------|-----|
| $K^*(892)^- \geq 0$ neutrals $\geq$                                  | (1.42 ± 0.18)                          | %                | S = 1.4  | 665 |
| $0 K_L^0 \nu_\tau$                                                   |                                        |                  |          |     |
| $K^*(892)^- \nu_\tau$                                                | (1.29 ± 0.05)                          | %                |          | 665 |
| $K^*(892)^0 K^- \geq 0$ neutrals $\nu_\tau$                          | (3.2 ± 1.4)                            | $\times 10^{-3}$ |          | 542 |
| $K^*(892)^0 K^- \nu_\tau$                                            | (2.1 ± 0.4)                            | $\times 10^{-3}$ |          | 542 |
| $\bar{K}^*(892)^0 \pi^- \geq 0$ neutrals $\nu_\tau$                  | (3.8 ± 1.7)                            | $\times 10^{-3}$ |          | 656 |
| $\bar{K}^*(892)^0 \pi^- \nu_\tau$                                    | (2.2 ± 0.5)                            | $\times 10^{-3}$ |          | 656 |
| $(\bar{K}^*(892)\pi)^- \nu_\tau \rightarrow$                         | (1.0 ± 0.4)                            | $\times 10^{-3}$ |          | –   |
| $\pi^- \bar{K}^0 \pi^0 \nu_\tau$                                     |                                        |                  |          |     |
| $K_1(1270)^- \nu_\tau$                                               | (4.7 ± 1.1)                            | $\times 10^{-3}$ |          | 433 |
| $K_1(1400)^- \nu_\tau$                                               | (1.7 ± 2.6)                            | $\times 10^{-3}$ | S = 1.7  | 335 |
| $K^*(1410)^- \nu_\tau$                                               | (1.5 <sup>+1.4</sup> <sub>-1.0</sub> ) | $\times 10^{-3}$ |          | 326 |
| $K_0^*(1430)^- \nu_\tau$                                             | < 5                                    | $\times 10^{-4}$ | CL = 95% | 326 |
| $K_2^*(1430)^- \nu_\tau$                                             | < 3                                    | $\times 10^{-3}$ | CL = 95% | 317 |
| $\eta \pi^- \nu_\tau$                                                | < 1.4                                  | $\times 10^{-4}$ | CL = 95% | 798 |
| $\eta \pi^- \pi^0 \nu_\tau$                                          | [g] (1.77 ± 0.24)                      | $\times 10^{-3}$ |          | 778 |
| $\eta \pi^- \pi^0 \pi^0 \nu_\tau$                                    | (1.5 ± 0.5)                            | $\times 10^{-4}$ |          | 746 |
| $\eta K^- \nu_\tau$                                                  | [g] (2.7 ± 0.6)                        | $\times 10^{-4}$ |          | 720 |
| $\eta K^*(892)^- \nu_\tau$                                           | (2.9 ± 0.9)                            | $\times 10^{-4}$ |          | 511 |
| $\eta K^- \pi^0 \nu_\tau$                                            | (1.8 ± 0.9)                            | $\times 10^{-4}$ |          | 665 |
| $\eta \bar{K}^0 \pi^- \nu_\tau$                                      | (2.2 ± 0.7)                            | $\times 10^{-4}$ |          | 661 |
| $\eta \pi^+ \pi^- \pi^- \geq 0$ neutrals $\nu_\tau$                  | < 3                                    | $\times 10^{-3}$ | CL = 90% | 744 |
| $\eta \pi^- \pi^+ \pi^- \nu_\tau$                                    | (2.3 ± 0.5)                            | $\times 10^{-4}$ |          | 744 |
| $\eta a_1(1260)^- \nu_\tau \rightarrow \eta \pi^- \rho^0 \nu_\tau$   | < 3.9                                  | $\times 10^{-4}$ | CL = 90% | –   |
| $\eta \eta \pi^- \nu_\tau$                                           | < 1.1                                  | $\times 10^{-4}$ | CL = 95% | 637 |
| $\eta \eta \pi^- \pi^0 \nu_\tau$                                     | < 2.0                                  | $\times 10^{-4}$ | CL = 95% | 559 |
| $\eta'(958) \pi^- \nu_\tau$                                          | < 7.4                                  | $\times 10^{-5}$ | CL = 90% | 620 |
| $\eta'(958) \pi^- \pi^0 \nu_\tau$                                    | < 8.0                                  | $\times 10^{-5}$ | CL = 90% | 591 |
| $\phi \pi^- \nu_\tau$                                                | < 2.0                                  | $\times 10^{-4}$ | CL = 90% | 585 |
| $\phi K^- \nu_\tau$                                                  | < 6.7                                  | $\times 10^{-5}$ | CL = 90% | 445 |
| $f_1(1285) \pi^- \nu_\tau$                                           | (4.1 ± 0.8)                            | $\times 10^{-4}$ |          | 408 |
| $f_1(1285) \pi^- \nu_\tau \rightarrow$                               | (1.3 ± 0.4)                            | $\times 10^{-4}$ |          | –   |
| $\eta \pi^- \pi^+ \pi^- \nu_\tau$                                    |                                        |                  |          |     |
| $\pi(1300)^- \nu_\tau \rightarrow (\rho \pi)^- \nu_\tau \rightarrow$ | < 1.0                                  | $\times 10^{-4}$ | CL = 90% | –   |
| $(3\pi)^- \nu_\tau$                                                  |                                        |                  |          |     |
| $\pi(1300)^- \nu_\tau \rightarrow ((\pi \pi)_{S\text{-wave}} \pi)^-$ | < 1.9                                  | $\times 10^{-4}$ | CL = 90% | –   |
| $\nu_\tau \rightarrow (3\pi)^- \nu_\tau$                             |                                        |                  |          |     |
| $b^- \omega \geq 0$ neutrals $\nu_\tau$                              | (2.39 ± 0.09)                          | %                | S = 1.2  | 708 |
| $b^- \omega \nu_\tau$                                                | [g] (1.99 ± 0.08)                      | %                | S = 1.2  | 708 |
| $K^- \omega \nu_\tau$                                                | (4.1 ± 0.9)                            | $\times 10^{-4}$ |          | 610 |
| $b^- \omega \pi^0 \nu_\tau$                                          | [g] (4.1 ± 0.4)                        | $\times 10^{-3}$ |          | 684 |
| $b^- \omega 2\pi^0 \nu_\tau$                                         | (1.4 ± 0.5)                            | $\times 10^{-4}$ |          | 644 |
| $2b^- b^+ \omega \nu_\tau$                                           | (1.20 ± 0.22)                          | $\times 10^{-4}$ |          | 641 |

## Lepton Family number (LF), Lepton number (L), or Baryon number (B) violating modes

$L$  means lepton number violation (e.g.  $\tau^- \rightarrow e^+ \pi^- \pi^-$ ). Following common usage,  $LF$  means lepton family violation and *not* lepton number violation (e.g.,  $\tau^- \rightarrow e^- \pi^+ \pi^-$ ).  $B$  means baryon number violation.

|                          |    |       |                  |          |     |
|--------------------------|----|-------|------------------|----------|-----|
| $e^- \gamma$             | LF | < 1.1 | $\times 10^{-7}$ | CL = 90% | 888 |
| $\mu^- \gamma$           | LF | < 6.8 | $\times 10^{-8}$ | CL = 90% | 885 |
| $e^- \pi^0$              | LF | < 1.9 | $\times 10^{-7}$ | CL = 90% | 883 |
| $\mu^- \pi^0$            | LF | < 4.1 | $\times 10^{-7}$ | CL = 90% | 880 |
| $e^- K^0$                | LF | < 9.1 | $\times 10^{-7}$ | CL = 90% | 819 |
| $\mu^- K_S^0$            | LF | < 9.5 | $\times 10^{-7}$ | CL = 90% | 815 |
| $e^- \eta$               | LF | < 2.4 | $\times 10^{-7}$ | CL = 90% | 804 |
| $\mu^- \eta$             | LF | < 1.5 | $\times 10^{-7}$ | CL = 90% | 800 |
| $e^- \rho^0$             | LF | < 2.0 | $\times 10^{-6}$ | CL = 90% | 719 |
| $\mu^- \rho^0$           | LF | < 6.3 | $\times 10^{-6}$ | CL = 90% | 715 |
| $e^- K^*(892)^0$         | LF | < 5.1 | $\times 10^{-6}$ | CL = 90% | 665 |
| $\mu^- K^*(892)^0$       | LF | < 7.5 | $\times 10^{-6}$ | CL = 90% | 660 |
| $e^- \bar{K}^*(892)^0$   | LF | < 7.4 | $\times 10^{-6}$ | CL = 90% | 665 |
| $\mu^- \bar{K}^*(892)^0$ | LF | < 7.5 | $\times 10^{-6}$ | CL = 90% | 660 |
| $e^- \eta'(958)$         | LF | < 1.0 | $\times 10^{-6}$ | CL = 90% | 630 |
| $\mu^- \eta'(958)$       | LF | < 4.7 | $\times 10^{-7}$ | CL = 90% | 625 |
| $e^- \phi$               | LF | < 6.9 | $\times 10^{-6}$ | CL = 90% | 596 |
| $\mu^- \phi$             | LF | < 7.0 | $\times 10^{-6}$ | CL = 90% | 590 |
| $e^- e^+ e^-$            | LF | < 2.0 | $\times 10^{-7}$ | CL = 90% | 888 |
| $e^- \mu^+ \mu^-$        | LF | < 2.0 | $\times 10^{-7}$ | CL = 90% | 882 |
| $e^+ \mu^- \mu^-$        | LF | < 1.3 | $\times 10^{-7}$ | CL = 90% | 882 |
| $\mu^- e^+ e^-$          | LF | < 1.9 | $\times 10^{-7}$ | CL = 90% | 885 |
| $\mu^+ e^- e^-$          | LF | < 1.1 | $\times 10^{-7}$ | CL = 90% | 885 |
| $\mu^- \mu^+ \mu^-$      | LF | < 1.9 | $\times 10^{-7}$ | CL = 90% | 873 |
| $e^- \pi^+ \pi^-$        | LF | < 1.2 | $\times 10^{-7}$ | CL = 90% | 877 |
| $L$                      | L  | < 2.7 | $\times 10^{-7}$ | CL = 90% | 877 |
| $\mu^- \pi^+ \pi^-$      | LF | < 2.9 | $\times 10^{-7}$ | CL = 90% | 866 |
| $\mu^+ \pi^- \pi^-$      | L  | < 7   | $\times 10^{-8}$ | CL = 90% | 866 |

|                      |     |       |                  |          |     |
|----------------------|-----|-------|------------------|----------|-----|
| $e^- \pi^+ K^-$      | LF  | < 3.2 | $\times 10^{-7}$ | CL = 90% | 813 |
| $e^- \pi^- K^+$      | LF  | < 1.7 | $\times 10^{-7}$ | CL = 90% | 813 |
| $e^+ \pi^- K^-$      | L   | < 1.8 | $\times 10^{-7}$ | CL = 90% | 813 |
| $e^- K^0 K_S^0$      | LF  | < 2.2 | $\times 10^{-6}$ | CL = 90% | 736 |
| $e^- K^+ K^-$        | LF  | < 1.4 | $\times 10^{-7}$ | CL = 90% | 739 |
| $e^+ K^- K^-$        | L   | < 1.5 | $\times 10^{-7}$ | CL = 90% | 739 |
| $\mu^- \pi^+ K^-$    | LF  | < 2.6 | $\times 10^{-7}$ | CL = 90% | 800 |
| $\mu^- \pi^- K^+$    | LF  | < 3.2 | $\times 10^{-7}$ | CL = 90% | 800 |
| $\mu^+ \pi^- K^-$    | L   | < 2.2 | $\times 10^{-7}$ | CL = 90% | 800 |
| $\mu^- K^0 K_S^0$    | LF  | < 3.4 | $\times 10^{-6}$ | CL = 90% | 696 |
| $\mu^- K^+ K^-$      | LF  | < 2.5 | $\times 10^{-7}$ | CL = 90% | 699 |
| $\mu^+ K^- K^-$      | L   | < 4.8 | $\times 10^{-7}$ | CL = 90% | 699 |
| $e^- \pi^0 \pi^0$    | LF  | < 6.5 | $\times 10^{-6}$ | CL = 90% | 878 |
| $\mu^- \pi^0 \pi^0$  | LF  | < 1.4 | $\times 10^{-5}$ | CL = 90% | 867 |
| $e^- \eta \eta$      | LF  | < 3.5 | $\times 10^{-5}$ | CL = 90% | 700 |
| $\mu^- \eta \eta$    | LF  | < 6.0 | $\times 10^{-5}$ | CL = 90% | 654 |
| $e^- \pi^0 \eta$     | LF  | < 2.4 | $\times 10^{-5}$ | CL = 90% | 798 |
| $\mu^- \pi^0 \eta$   | LF  | < 2.2 | $\times 10^{-5}$ | CL = 90% | 784 |
| $\bar{p} \gamma$     | L,B | < 3.5 | $\times 10^{-6}$ | CL = 90% | 641 |
| $\bar{p} \pi^0$      | L,B | < 1.5 | $\times 10^{-5}$ | CL = 90% | 632 |
| $\bar{p} 2\pi^0$     | L,B | < 3.3 | $\times 10^{-5}$ | CL = 90% | 604 |
| $\bar{p} \eta$       | L,B | < 8.9 | $\times 10^{-6}$ | CL = 90% | 475 |
| $\bar{p} \pi^0 \eta$ | L,B | < 2.7 | $\times 10^{-5}$ | CL = 90% | 360 |
| $\Delta \pi^-$       | L,B | < 7.2 | $\times 10^{-8}$ | CL = 90% | 526 |
| $\bar{\Delta} \pi^-$ | L,B | < 1.4 | $\times 10^{-7}$ | CL = 90% | 526 |
| $e^-$ light boson    | LF  | < 2.7 | $\times 10^{-3}$ | CL = 95% | –   |
| $\mu^-$ light boson  | LF  | < 5   | $\times 10^{-3}$ | CL = 95% | –   |

### Heavy Charged Lepton Searches

#### $L^\pm$ – charged lepton

Mass  $m > 100.8$  GeV, CL = 95% <sup>[h]</sup> Decay to  $\nu W$ .

#### $L^\pm$ – stable charged heavy lepton

Mass  $m > 102.6$  GeV, CL = 95%

### Neutrino Properties

See the note on “Neutrino properties listings” in the Particle Listings.

Mass  $m < 2$  eV (tritium decay)

Mean life/mass,  $\tau/m > 300$  s/eV, CL = 90% (reactor)

Mean life/mass,  $\tau/m > 7 \times 10^9$  s/eV (solar)

Mean life/mass,  $\tau/m > 15.4$  s/eV, CL = 90% (accelerator)

Magnetic moment  $\mu < 0.9 \times 10^{-10} \mu_B$ , CL = 90% (reactor)

### Number of Neutrino Types

Number  $N = 2.994 \pm 0.012$  (Standard Model fits to LEP data)

Number  $N = 2.92 \pm 0.06$  (Direct measurement of invisible  $Z$  width)

### Neutrino Mixing

The following values are obtained through data analyses based on the 3-neutrino mixing scheme described in the review “Neutrino mass, mixing, and flavor change” by B. Kayser in this *Review*.

$$\sin^2(2\theta_{12}) = 0.86^{+0.03}_{-0.04}$$

$$\Delta m_{21}^2 = (8.0^{+0.4}_{-0.3}) \times 10^{-5} \text{eV}^2$$

The ranges below for  $\sin^2(2\theta_{23})$  and  $\Delta m_{32}^2$  correspond to the projections onto the appropriate axes of the 90% CL contours

in the  $\sin^2(2\theta_{23})$ - $\Delta m_{32}^2$  plane.

$$\begin{aligned} \sin^2(2\theta_{23}) &> 0.92 \\ \Delta m_{32}^2 &= 1.9 \text{ to } 3.0 \times 10^{-3} \text{eV}^{2[i]} \\ \sin^2(2\theta_{13}) &< 0.19, \text{ CL} = 90\% \end{aligned}$$

### Heavy Neutral Leptons, Searches for

For excited leptons, see Compositeness Limits below (see page A-54).

#### Stable Neutral Heavy Lepton Mass Limits

Mass  $m > 45.0$  GeV, CL = 95% (Dirac)

Mass  $m > 39.5$  GeV, CL = 95% (Majorana)

#### Neutral Heavy Lepton Mass Limits

Mass  $m > 90.3$  GeV, CL = 95%

(Dirac  $\nu_L$  coupling to  $e, \mu, \tau$ ; conservative case( $\tau$ ))

Mass  $m > 80.5$  GeV, CL = 95%

(Majorana  $\nu_L$  coupling to  $e, \mu, \tau$ ; conservative case( $\tau$ ))

### NOTES

In this Summary Table:

When a quantity has “(S = ... )” to its right, the error on the quantity has been enlarged by the “scale factor” S, defined as  $S = \sqrt{\chi^2/(N-1)}$ , where  $N$  is the number of measurements used in calculating the quantity. We do this when  $S > 1$ , which often indicates that the measurements are inconsistent. When  $S > 1.25$ , we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum  $p$  is given for each decay mode. For a 2-body decay,  $p$  is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay,  $p$  is the largest momentum any of the products can have in this frame.

- [a] This is the best limit for the mode  $e^- \rightarrow \nu \gamma$ . The best limit for “electron disappearance” is  $6.4 \times 10^{24}$  yr.
- [b] See the “Note on Muon Decay Parameters” in the  $\mu$  Particle Listings for definitions and details.
- [c]  $P_\mu$  is the longitudinal polarization of the muon from pion decay. In standard  $V-A$  theory,  $P_\mu = 1$  and  $\rho = \delta = 3/4$ .
- [d] This only includes events with the  $\gamma$  energy  $> 10$  MeV. Since the  $e^- \bar{\nu}_e \nu_\mu$  and  $e^- \bar{\nu}_e \nu_\mu \gamma$  modes cannot be clearly separated, we regard the latter mode as a subset of the former.
- [e] See the relevant Particle Listings for the energy limits used in this measurement.
- [f] A test of additive vs. multiplicative lepton family number conservation.
- [g] Basis mode for the  $\tau$ .
- [h]  $L^\pm$  mass limit depends on decay assumptions; see the Full Listings.
- [i] The sign of  $\Delta m_{32}^2$  is not known at this time. The range quoted is for the absolute value.

## QUARK SUMMARY TABLE

### QUARKS

The  $u$ -,  $d$ -, and  $s$ -quark masses are estimates of so-called “current-quark masses,” in a mass-independent subtraction scheme such as  $\overline{\text{MS}}$  at a scale  $\mu \approx 2$  GeV. The  $c$ - and  $b$ -quark masses are the “running” masses in the  $\overline{\text{MS}}$  scheme. For the  $b$ -quark we also quote the 1S mass. These can be different from the heavy quark masses obtained in potential models.

**$u$**

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$$

Mass  $m = 1.5$  to  $3.0$  MeV<sup>[a]</sup> Charge =  $\frac{2}{3}e$   $I_z = +\frac{1}{2}$   
 $m_u/m_d = 0.3$  to  $0.6$

**$d$**

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$$

Mass  $m = 3$  to  $7$  MeV<sup>[a]</sup> Charge =  $-\frac{1}{3}e$   $I_z = -\frac{1}{2}$   
 $m_s/m_d = 17$  to  $22$   
 $\bar{m} = (m_u + m_d)/2 = 2.5$  to  $5.5$  MeV

**$s$**

$$I(J^P) = 0(\frac{1}{2}^+)$$

Mass  $m = 95 \pm 25$  MeV<sup>[a]</sup> Charge =  $-\frac{1}{3}e$  Strangeness =  $-1$   
 $(m_s(m_u + m_d)/2)/(m_d - m_u) = 30$  to  $50$

**$c$**

$$I(J^P) = 0(\frac{1}{2}^+)$$

Mass  $m = 1.25 \pm 0.09$  GeV Charge =  $\frac{2}{3}e$  Charm =  $+1$

**$b$**

$$I(J^P) = 0(\frac{1}{2}^+)$$

Charge =  $\frac{1}{3}e$  Bottom =  $-1$

Mass  $m = 4.20 \pm 0.07$  GeV ( $\overline{\text{MS}}$  mass)  
 Mass  $m = 4.70 \pm 0.07$  GeV (1S mass)

**$t$**

$$I(J^P) = 0(\frac{1}{2}^+)$$

Charge =  $\frac{2}{3}e$  Top =  $+1$

Mass  $m = 174.2 \pm 3.3$  GeV<sup>[b]</sup> (direct observation of top events)  
 Mass  $m = 172.3^{+10.2}_{-7.6}$  GeV (Standard Model electroweak fit)

| $t$ DECAY MODES                                                               | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$<br>(MeV/ $c$ ) |
|-------------------------------------------------------------------------------|--------------------------------|------------------|--------------------|
| $Wq(q = b, s, d)$                                                             |                                |                  | —                  |
| $Wb$                                                                          |                                |                  | —                  |
| $\ell \nu_\ell$ anything                                                      | $[c, d] (9.4 \pm 2.4)$         | %                | —                  |
| $\tau \nu_\tau b$                                                             |                                |                  | —                  |
| $\gamma q(q = u, c)$                                                          | $[e] < 5.9 \times 10^{-3}$     | 95%              | —                  |
| <b><math>\Delta T = 1</math> weak neutral current (<math>T1</math>) modes</b> |                                |                  |                    |
| $Zq(q = u, c)$ $T1$                                                           | $[f] < 13.7\%$                 | 95%              | —                  |

### $b'(4^{th})$ Generation) Quark, Searches for

Mass  $m > 190$  GeV, CL = 95% ( $p\bar{p}$ , quasi-stable  $b'$ )  
 Mass  $m > 199$  GeV, CL = 95% ( $p\bar{p}$ , neutral-current decays)  
 Mass  $m > 128$  GeV, CL = 95% ( $p\bar{p}$ , charged-current decays)  
 Mass  $m > 46.0$  GeV, CL = 95% ( $e^+e^-$ , all decays)

### Free Quark Searches

All searches since 1977 have had negative results.

### NOTES

- [a] The ratios  $m_u/m_d$  and  $m_s/m_d$  are extracted from pion and kaon masses using chiral symmetry. The estimates of  $u$  and  $d$  masses are not without controversy and remain under active investigation. Within the literature there are even suggestions that the  $u$  quark could be essentially massless. The  $s$ -quark mass is estimated from SU(3) splittings in hadron masses.
- [b] Based on published top mass measurements using data from Tevatron Run-I and Run-II. Including also the most recent unpublished results from Run-II, the Tevatron Electroweak Working Group reports a top mass of  $172.5 \pm 1.3 \pm 1.9$  GeV. See the note “The Top Quark” in the Quark Particle Listings of this *Review*.
- [c]  $\ell$  means  $e$  or  $\mu$  decay mode, not the sum over them.
- [d] Assumes lepton universality and  $W$ -decay acceptance.
- [e] This limit is for  $\Gamma(t \rightarrow \gamma q)/\Gamma(t \rightarrow Wb)$ .
- [f] This limit is for  $\Gamma(t \rightarrow Zq)/\Gamma(t \rightarrow Wb)$ .

## MESON SUMMARY TABLE

### LIGHT UNFLAVORED MESONS

$$(S = C = B = 0)$$

For  $I = 1(\pi, b, \rho, a) : u\bar{d}, (u\bar{u} - d\bar{d})/\sqrt{2}, d\bar{u};$   
for  $I = 0(\eta, \eta', b, b', \omega, \phi, f, f') : c_1(u\bar{u} + d\bar{d}) + c_2(s\bar{s})$

$\pi^\pm$

$$I^G(J^{PC}) = 1^-(0^-)$$

Mass  $m = 139.57018 \pm 0.00035$  MeV ( $S = 1.2$ )

Mean life  $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$  s ( $S = 1.2$ )

$c\tau = 7.8045$  m

$\pi^\pm \rightarrow \ell^\pm \nu \gamma$  form factors <sup>[a]</sup>

$F_V = 0.017 \pm 0.008$

$F_A = 0.0115 \pm 0.0005$  ( $S = 1.2$ )

$R = 0.059^{+0.009}_{-0.008}$

$\pi^-$  modes are charge conjugates of the modes below.

For decay limits to particles which are not established, see the appropriate Search sections (Massive Neutrino Peak Search Test,  $A^0$  (axion), and Other Light Boson ( $X^0$ ) Searches, etc.).

| $\pi^+$ DECAY MODES                                            | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level     | $\rho$ (MeV/c) |
|----------------------------------------------------------------|--------------------------------|----------------------|----------------|
| $\mu^+ \nu_\mu$                                                | [b] (99.98770 $\pm$ 0.00004) % | %                    | 30             |
| $\mu^+ \nu_\mu \gamma$                                         | [c] (2.00 $\pm$ 0.25)          | $\times 10^{-4}$     | 30             |
| $e^+ \nu_e$                                                    | [b] (1.230 $\pm$ 0.004)        | $\times 10^{-4}$     | 70             |
| $e^+ \nu_e \gamma$                                             | [c] (1.61 $\pm$ 0.23)          | $\times 10^{-7}$     | 70             |
| $e^+ \nu_e \pi^0$                                              | (1.036 $\pm$ 0.006)            | $\times 10^{-8}$     | 4              |
| $e^+ \nu_e e^+ e^-$                                            | (3.2 $\pm$ 0.5)                | $\times 10^{-9}$     | 70             |
| $e^+ \nu_e \nu \bar{\nu}$                                      | < 5                            | $\times 10^{-6}$ 90% | 70             |
| Lepton Family number (LF) or Lepton number (L) violating modes |                                |                      |                |
| $\mu^+ \bar{\nu}_e$                                            | L [d] < 1.5                    | $\times 10^{-3}$ 90% | 30             |
| $\mu^+ \nu_e$                                                  | LF [d] < 8.0                   | $\times 10^{-3}$ 90% | 30             |
| $\mu^- e^+ e^+ \nu$                                            | LF < 1.6                       | $\times 10^{-6}$ 90% | 30             |

$\pi^0$

$$I^G(J^{PC}) = 1^-(0^{++})$$

Mass  $m = 134.9766 \pm 0.0006$  MeV ( $S = 1.1$ )

$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$  MeV

Mean life  $\tau = (8.4 \pm 0.6) \times 10^{-17}$  s ( $S = 3.0$ )

$c\tau = 25.1$  nm

For decay limits to particles which are not established, see the appropriate Search sections ( $A^0$  (axion) and Other Light Boson ( $X^0$ ) Searches, etc.).

| $\pi^0$ DECAY MODES       | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor/<br>Confidence level | $p$ (MeV/c) |
|---------------------------|--------------------------------|-----------------------------------|-------------|
| $2\gamma$                 | (98.798 $\pm$ 0.032) %         | S = 1.1                           | 67          |
| $e^+ e^- \gamma$          | (1.198 $\pm$ 0.032) %          | S = 1.1                           | 67          |
| $\gamma$ positronium      | (1.82 $\pm$ 0.29)              | $\times 10^{-9}$                  | 67          |
| $e^+ e^+ e^- e^-$         | (3.14 $\pm$ 0.30)              | $\times 10^{-5}$                  | 67          |
| $e^+ e^-$                 | (6.2 $\pm$ 0.5)                | $\times 10^{-8}$                  | 67          |
| $4\gamma$                 | < 2                            | $\times 10^{-8}$                  | 67          |
| $\nu \bar{\nu}$           | [e] < 2.7                      | $\times 10^{-7}$                  | 67          |
| $\nu_e \bar{\nu}_e$       | < 1.7                          | $\times 10^{-6}$                  | 67          |
| $\nu_\mu \bar{\nu}_\mu$   | < 1.6                          | $\times 10^{-6}$                  | 67          |
| $\nu_\tau \bar{\nu}_\tau$ | < 2.1                          | $\times 10^{-6}$                  | 67          |
| $\gamma \nu \bar{\nu}$    | < 6                            | $\times 10^{-4}$                  | 67          |

Charge conjugation (C) or Lepton Family number (LF) violating modes

|                         |                          |                   |             |
|-------------------------|--------------------------|-------------------|-------------|
| $3\gamma$               | C < $3.1 \times 10^{-8}$ | CL = 90% 67       |             |
| $\mu^+ e^-$             | LF < 3.8                 | $\times 10^{-10}$ | CL = 90% 26 |
| $\mu^- e^+$             | LF < 3.4                 | $\times 10^{-9}$  | CL = 90% 26 |
| $\mu^+ e^- + \mu^- e^+$ | LF < 1.72                | $\times 10^{-8}$  | CL = 90% 26 |

$\eta$

$$I^G(J^{PC}) = 0^+(0^{-+})$$

Mass  $m = 547.51 \pm 0.18$  MeV <sup>[f]</sup> ( $S = 5.8$ )

Full width  $\Gamma = 1.30 \pm 0.07$  keV <sup>[g]</sup>

C-nonconserving decay parameters

$\pi^+ \pi^- \pi^0$  Left-right asymmetry =  $(0.09 \pm 0.17) \times 10^{-2}$

$\pi^+ \pi^- \pi^0$  Sextant asymmetry =  $(0.18 \pm 0.16) \times 10^{-2}$

$\pi^+ \pi^- \pi^0$  Quadrant asymmetry =  $(-0.17 \pm 0.17) \times 10^{-2}$

$\pi^+ \pi^- \gamma$  Left-right asymmetry =  $(0.9 \pm 0.4) \times 10^{-2}$

$\pi^+ \pi^- \gamma$   $\beta$  (D-wave) =  $-0.02 \pm 0.07$  ( $S = 1.3$ )

Dalitz plot parameter

$\pi^0 \pi^0 \pi^0$   $\alpha = -0.031 \pm 0.004$  ( $S = 1.1$ )

| $\eta$ DECAY MODES                                                                                                              | Fraction ( $\Gamma_i/\Gamma$ )         | Scale factor/<br>Confidence level | $p$ (MeV/c)  |
|---------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------|--------------|
| Neutral modes                                                                                                                   |                                        |                                   |              |
| neutral modes                                                                                                                   | (71.9 $\pm$ 0.5) %                     | S = 1.3                           | —            |
| $2\gamma$                                                                                                                       | [g] (39.38 $\pm$ 0.26) %               | S = 1.2                           | 274          |
| $3\pi^0$                                                                                                                        | (32.51 $\pm$ 0.28) %                   | S = 1.2                           | 179          |
| $\pi^0 2\gamma$                                                                                                                 | (4.4 $\pm$ 1.6)                        | $\times 10^{-4}$                  | S = 2.0 257  |
| $\pi^0 \pi^0 \gamma \gamma$                                                                                                     | < 1.2                                  | $\times 10^{-3}$                  | CL = 90% 238 |
| other neutral modes                                                                                                             | < 2.8                                  | %                                 | CL = 90% —   |
| Charged modes                                                                                                                   |                                        |                                   |              |
| charged modes                                                                                                                   | (28.0 $\pm$ 0.5) %                     | S = 1.3                           | —            |
| $\pi^+ \pi^- \pi^0$                                                                                                             | (22.7 $\pm$ 0.4) %                     | S = 1.3                           | 174          |
| $\pi^+ \pi^- \gamma$                                                                                                            | (4.69 $\pm$ 0.11) %                    | S = 1.2                           | 236          |
| $e^+ e^- \gamma$                                                                                                                | (6.0 $\pm$ 0.8)                        | $\times 10^{-3}$                  | S = 1.4 274  |
| $\mu^+ \mu^- \gamma$                                                                                                            | (3.1 $\pm$ 0.4)                        | $\times 10^{-4}$                  | 253          |
| $e^+ e^-$                                                                                                                       | < 7.7                                  | $\times 10^{-5}$                  | CL = 90% 274 |
| $\mu^+ \mu^-$                                                                                                                   | (5.8 $\pm$ 0.8)                        | $\times 10^{-6}$                  | 253          |
| $e^+ e^- e^+ e^-$                                                                                                               | < 6.9                                  | $\times 10^{-5}$                  | CL = 90% 274 |
| $\pi^+ \pi^- e^+ e^-$                                                                                                           | (4.0 <sup>+5.3</sup> <sub>-2.5</sub> ) | $\times 10^{-4}$                  | S = 2.1 235  |
| $\pi^+ \pi^- 2\gamma$                                                                                                           | < 2.0                                  | $\times 10^{-3}$                  | 236          |
| $\pi^+ \pi^- \pi^0 \gamma$                                                                                                      | < 5                                    | $\times 10^{-4}$                  | CL = 90% 174 |
| $\pi^0 \mu^+ \mu^- \gamma$                                                                                                      | < 3                                    | $\times 10^{-6}$                  | CL = 90% 210 |
| Charge conjugation (C), Parity (P),<br>Charge conjugation $\times$ Parity (CP), or<br>Lepton Family number (LF) violating modes |                                        |                                   |              |
| $\pi^0 \gamma$                                                                                                                  | C < 9                                  | $\times 10^{-5}$                  | CL = 90% 257 |
| $\pi^+ \pi^-$                                                                                                                   | P, CP < 1.3                            | $\times 10^{-5}$                  | CL = 90% 236 |
| $\pi^0 \pi^0$                                                                                                                   | P, CP < 4.3                            | $\times 10^{-4}$                  | CL = 90% 238 |
| $\pi^0 \pi^0 \gamma$                                                                                                            | C < 5                                  | $\times 10^{-4}$                  | CL = 90% 238 |
| $\pi^0 \pi^0 \pi^0 \gamma$                                                                                                      | C < 6                                  | $\times 10^{-5}$                  | CL = 90% 179 |
| $3\gamma$                                                                                                                       | C < 4                                  | $\times 10^{-5}$                  | CL = 90% 274 |
| $4\pi^0$                                                                                                                        | P, CP < 6.9                            | $\times 10^{-7}$                  | CL = 90% 40  |
| $\pi^0 e^+ e^-$                                                                                                                 | C [h] < 4                              | $\times 10^{-5}$                  | CL = 90% 257 |
| $\pi^0 \mu^+ \mu^-$                                                                                                             | C [h] < 5                              | $\times 10^{-6}$                  | CL = 90% 210 |
| $\mu^+ e^- + \mu^- e^+$                                                                                                         | LF < 6                                 | $\times 10^{-6}$                  | CL = 90% 264 |

$f_0(600)^{[i]}$   
or  $\sigma$

$$I^G(J^{PC}) = 0^+(0^{++})$$

Mass  $m = (400-1200)$  MeV

Full width  $\Gamma = (600-1000)$  MeV

| $f_0(600)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|------------------------|--------------------------------|-------------|
| $\pi\pi$               | dominant                       | —           |
| $\gamma\gamma$         | seen                           | —           |

$\rho(770)^{[I]}$ 

$$I^G(J^{PC}) = 1^+(1^-)$$

Mass  $m = 775.5 \pm 0.4$  MeVFull width  $\Gamma = 149.4 \pm 1.0$  MeV $\Gamma_{ee} = 7.02 \pm 0.11$  keV

| $\rho(770)$ DECAY MODES  | Fraction ( $\Gamma_i/\Gamma$ )                   | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|--------------------------|--------------------------------------------------|-----------------------------------|----------------|
| $\pi\pi$                 | $\sim 100$ %                                     |                                   | 363            |
| $\rho(770)^\pm$ decays   |                                                  |                                   |                |
| $\pi^\pm\gamma$          | $(4.5 \pm 0.5) \times 10^{-4}$                   | $S = 2.2$                         | 375            |
| $\pi^\pm\eta$            | $< 6 \times 10^{-3}$                             | CL = 84%                          | 153            |
| $\pi^\pm\pi^+\pi^-\pi^0$ | $< 2.0 \times 10^{-3}$                           | CL = 84%                          | 254            |
| $\rho(770)^0$ decays     |                                                  |                                   |                |
| $\pi^+\pi^-\gamma$       | $(9.9 \pm 1.6) \times 10^{-3}$                   |                                   | 362            |
| $\pi^0\gamma$            | $(6.0 \pm 0.8) \times 10^{-4}$                   |                                   | 376            |
| $\eta\gamma$             | $(2.95 \pm 0.30) \times 10^{-4}$                 | $S = 1.2$                         | 194            |
| $\pi^0\pi^0\gamma$       | $(4.5 \pm 0.8) \times 10^{-5}$                   |                                   | 363            |
| $\mu^+\mu^-$             | [k] $(4.55 \pm 0.28) \times 10^{-5}$             |                                   | 373            |
| $e^+e^-$                 | [k] $(4.70 \pm 0.08) \times 10^{-5}$             |                                   | 388            |
| $\pi^+\pi^-\pi^0$        | $(1.01^{+0.54}_{-0.36} \pm 0.34) \times 10^{-4}$ |                                   | 323            |
| $\pi^+\pi^-\pi^+\pi^-$   | $(1.8 \pm 0.9) \times 10^{-5}$                   |                                   | 251            |
| $\pi^+\pi^-\pi^0\pi^0$   | $< 4 \times 10^{-5}$                             | CL = 90%                          | 257            |

 $\omega(782)$ 

$$I^G(J^{PC}) = 0^-(1^-)$$

Mass  $m = 782.65 \pm 0.12$  MeV ( $S = 1.9$ )Full width  $\Gamma = 8.49 \pm 0.08$  MeV $\Gamma_{ee} = 0.60 \pm 0.02$  keV

| $\omega(782)$ DECAY MODES              | Fraction ( $\Gamma_i/\Gamma$ )       | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|----------------------------------------|--------------------------------------|-----------------------------------|----------------|
| $\pi^+\pi^-\pi^0$                      | $(89.1 \pm 0.7) \%$                  | $S = 1.1$                         | 327            |
| $\pi^0\gamma$                          | $(8.90^{+0.27}_{-0.23}) \%$          | $S = 1.1$                         | 380            |
| $\pi^+\pi^-$                           | $(1.70 \pm 0.27) \%$                 | $S = 1.4$                         | 366            |
| neutrals (excluding $\pi^0\gamma$ )    | $(1.6^{+7.4}_{-1.1}) \times 10^{-3}$ |                                   | —              |
| $\eta\gamma$                           | $(4.9 \pm 0.5) \times 10^{-4}$       |                                   | 200            |
| $\pi^0 e^+ e^-$                        | $(7.7 \pm 0.9) \times 10^{-4}$       | $S = 1.1$                         | 380            |
| $\pi^0 \mu^+ \mu^-$                    | $(9.6 \pm 2.3) \times 10^{-5}$       |                                   | 349            |
| $e^+ e^-$                              | $(7.18 \pm 0.12) \times 10^{-5}$     | $S = 1.1$                         | 391            |
| $\pi^+\pi^-\pi^0\pi^0$                 | $< 2 \%$                             | CL = 90%                          | 262            |
| $\pi^+\pi^-\gamma$                     | $< 3.6 \times 10^{-3}$               | CL = 95%                          | 366            |
| $\pi^+\pi^-\pi^+\pi^-$                 | $< 1 \times 10^{-3}$                 | CL = 90%                          | 256            |
| $\pi^0\pi^0\gamma$                     | $(6.7 \pm 1.1) \times 10^{-5}$       |                                   | 367            |
| $\eta\pi^0\gamma$                      | $< 3.3 \times 10^{-5}$               | CL = 90%                          | 163            |
| $\mu^+\mu^-$                           | $(9.0 \pm 3.1) \times 10^{-5}$       |                                   | 377            |
| $3\gamma$                              | $< 1.9 \times 10^{-4}$               | CL = 95%                          | 391            |
| Charge conjugation (C) violating modes |                                      |                                   |                |
| $\eta\pi^0$                            | C $< 1 \times 10^{-3}$               | CL = 90%                          | 163            |
| $3\pi^0$                               | C $< 3 \times 10^{-4}$               | CL = 90%                          | 330            |

 $\eta'(958)$ 

$$I^G(J^{PC}) = 0^+(0^{-+})$$

Mass  $m = 957.78 \pm 0.14$  MeVFull width  $\Gamma = 0.203 \pm 0.016$  MeV ( $S = 1.3$ ) $\eta'(958)$  DECAY MODESFraction ( $\Gamma_i/\Gamma$ )Scale factor/  
Confidence level $p$   
(MeV/c)

|                                                             |                                  |           |     |
|-------------------------------------------------------------|----------------------------------|-----------|-----|
| $\pi^+\pi^-\eta$                                            | $(44.5 \pm 1.4) \%$              | $S = 1.1$ | 232 |
| $\rho^0\gamma$ (including non-resonant $\pi^+\pi^-\gamma$ ) | $(29.4 \pm 0.9) \%$              | $S = 1.1$ | 165 |
| $\pi^0\pi^0\eta$                                            | $(20.8 \pm 1.2) \%$              | $S = 1.2$ | 239 |
| $\omega\gamma$                                              | $(3.03 \pm 0.31) \%$             |           | 159 |
| $\gamma\gamma$                                              | $(2.12 \pm 0.14) \%$             | $S = 1.3$ | 479 |
| $3\pi^0$                                                    | $(1.55 \pm 0.26) \times 10^{-3}$ |           | 430 |
| $\mu^+\mu^-\gamma$                                          | $(1.04 \pm 0.26) \times 10^{-4}$ |           | 467 |
| $\pi^+\pi^-\pi^0$                                           | $< 5 \%$                         | CL = 90%  | 428 |
| $\pi^0\rho^0$                                               | $< 4 \%$                         | CL = 90%  | 111 |
| $\pi^+\pi^+\pi^-\pi^-$                                      | $< 1 \%$                         | CL = 90%  | 372 |
| $\pi^+\pi^+\pi^-\pi^-$ neutrals                             | $< 1 \%$                         | CL = 95%  | —   |
| $\pi^+\pi^+\pi^-\pi^-\pi^0$                                 | $< 1 \%$                         | CL = 90%  | 298 |
| $6\pi$                                                      | $< 1 \%$                         | CL = 90%  | 211 |
| $\pi^+\pi^-e^+e^-$                                          | $< 6 \times 10^{-3}$             | CL = 90%  | 458 |
| $\gamma e^+e^-$                                             | $< 9 \times 10^{-4}$             | CL = 90%  | 479 |
| $\pi^0\gamma\gamma$                                         | $< 8 \times 10^{-4}$             | CL = 90%  | 469 |
| $4\pi^0$                                                    | $< 5 \times 10^{-4}$             | CL = 90%  | 380 |
| $e^+e^-$                                                    | $< 2.1 \times 10^{-7}$           | CL = 90%  | 479 |

Charge conjugation (C), Parity (P),  
Lepton family number (LF) violating modes

|                   |                              |          |     |
|-------------------|------------------------------|----------|-----|
| $\pi^+\pi^-$      | $P, CP < 2 \%$               | CL = 90% | 458 |
| $\pi^0\pi^0$      | $P, CP < 9 \times 10^{-4}$   | CL = 90% | 459 |
| $\pi^0 e^+ e^-$   | C $[b] < 1.4 \times 10^{-3}$ | CL = 90% | 469 |
| $\eta e^+ e^-$    | C $[b] < 2.4 \times 10^{-3}$ | CL = 90% | 322 |
| $3\gamma$         | C $< 1.0 \times 10^{-4}$     | CL = 90% | 479 |
| $\mu^+\mu^-\pi^0$ | C $[b] < 6.0 \times 10^{-5}$ | CL = 90% | 445 |
| $\mu^+\mu^-\eta$  | C $[b] < 1.5 \times 10^{-5}$ | CL = 90% | 274 |
| $e\mu$            | LF $< 4.7 \times 10^{-4}$    | CL = 90% | 473 |

 $f_0(980)^{[I]}$ 

$$I^G(J^{PC}) = 0^+(0^{++})$$

Mass  $m = 980 \pm 10$  MeVFull width  $\Gamma = 40$  to 100 MeV

| $f_0(980)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|------------------------|--------------------------------|-------------|
| $\pi\pi$               | dominant                       | 471         |
| $K\bar{K}$             | seen                           | †           |
| $\gamma\gamma$         | seen                           | 490         |

 $a_0(980)^{[I]}$ 

$$I^G(J^{PC}) = 1^-(0^{++})$$

Mass  $m = 984.7 \pm 1.2$  MeV ( $S = 1.5$ )Full width  $\Gamma = 50$  to 100 MeV

| $a_0(980)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|------------------------|--------------------------------|-------------|
| $\eta\pi$              | dominant                       | 322         |
| $K\bar{K}$             | seen                           | †           |
| $\gamma\gamma$         | seen                           | 492         |

 $\phi(1020)$ 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 1019.460 \pm 0.019$  MeVFull width  $\Gamma = 4.26 \pm 0.05$  MeV ( $S = 1.7$ )

| $\phi(1020)$ DECAY MODES      | Fraction ( $\Gamma_i/\Gamma$ )         | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|-------------------------------|----------------------------------------|-----------------------------------|----------------|
| $K^+K^-$                      | $(49.2 \pm 0.6)$ %                     | $S = 1.2$                         | 127            |
| $K_L^0 K_S^0$                 | $(34.0 \pm 0.5)$ %                     | $S = 1.1$                         | 110            |
| $\rho\pi^+ \pi^+ \pi^- \pi^0$ | $(15.3 \pm 0.4)$ %                     | $S = 1.2$                         | -              |
| $\eta\gamma$                  | $(1.301 \pm 0.024)$ %                  | $S = 1.1$                         | 363            |
| $\pi^0\gamma$                 | $(1.25 \pm 0.07)$ $\times 10^{-3}$     |                                   | 501            |
| $e^+e^-$                      | $(2.97 \pm 0.04)$ $\times 10^{-4}$     | $S = 1.1$                         | 510            |
| $\mu^+\mu^-$                  | $(2.86 \pm 0.19)$ $\times 10^{-4}$     |                                   | 499            |
| $\eta e^+e^-$                 | $(1.15 \pm 0.10)$ $\times 10^{-4}$     |                                   | 363            |
| $\pi^+\pi^-$                  | $(7.3 \pm 1.3)$ $\times 10^{-5}$       |                                   | 490            |
| $\omega\pi^0$                 | $(5.2^{+1.3}_{-1.1})$ $\times 10^{-5}$ |                                   | 171            |
| $\omega\gamma$                | < 5 %                                  | CL = 84%                          | 209            |
| $\rho\gamma$                  | < 1.2 $\times 10^{-5}$                 | CL = 90%                          | 215            |
| $\pi^+\pi^-\gamma$            | $(4.1 \pm 1.3)$ $\times 10^{-5}$       |                                   | 490            |
| $f_0(980)\gamma$              | $(4.40 \pm 0.21)$ $\times 10^{-4}$     |                                   | 39             |
| $\pi^0\pi^0\gamma$            | $(1.09 \pm 0.06)$ $\times 10^{-4}$     |                                   | 492            |
| $\pi^+\pi^-\pi^+\pi^-$        | $(3.9^{+2.8}_{-2.2})$ $\times 10^{-6}$ |                                   | 410            |
| $\pi^+\pi^+\pi^-\pi^-\pi^0$   | < 4.6 $\times 10^{-6}$                 | CL = 90%                          | 342            |
| $\pi^0 e^+ e^-$               | $(1.12 \pm 0.28)$ $\times 10^{-5}$     |                                   | 501            |
| $\pi^0\eta\gamma$             | $(8.3 \pm 0.5)$ $\times 10^{-5}$       |                                   | 346            |
| $a_0(980)\gamma$              | $(7.6 \pm 0.6)$ $\times 10^{-5}$       |                                   | 34             |
| $\eta'(958)\gamma$            | $(6.2 \pm 0.7)$ $\times 10^{-5}$       | $S = 1.1$                         | 60             |
| $\eta\pi^0\pi^0\gamma$        | < 2 $\times 10^{-5}$                   | CL = 90%                          | 293            |
| $\mu^+\mu^-\gamma$            | $(1.4 \pm 0.5)$ $\times 10^{-5}$       |                                   | 499            |
| $\rho\gamma\gamma$            | < 5 $\times 10^{-4}$                   | CL = 90%                          | 215            |
| $\eta\pi^+\pi^-$              | < 1.8 $\times 10^{-5}$                 | CL = 90%                          | 288            |
| $\eta\mu^+\mu^-$              | < 9.4 $\times 10^{-6}$                 | CL = 90%                          | 321            |

$$b_1(1170) \quad I^G(J^{PC}) = 0^-(1^{+-})$$

Mass  $m = 1170 \pm 20$  MeV

Full width  $\Gamma = 360 \pm 40$  MeV

| $b_1(1170)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\rho\pi$               | seen                           | 307         |

$$b_1(1235) \quad I^G(J^{PC}) = 1^+(1^{+-})$$

Mass  $m = 1229.5 \pm 3.2$  MeV ( $S = 1.6$ )

Full width  $\Gamma = 142 \pm 9$  MeV ( $S = 1.2$ )

| $b_1(1235)$ DECAY MODES                    | Fraction ( $\Gamma_i/\Gamma$ )   | Confidence level | $p$<br>(MeV/c) |
|--------------------------------------------|----------------------------------|------------------|----------------|
| $\omega\pi$                                | dominant                         |                  | 348            |
| [D/S amplitude ratio = $0.277 \pm 0.027$ ] |                                  |                  |                |
| $\pi^\pm\gamma$                            | $(1.6 \pm 0.4)$ $\times 10^{-3}$ |                  | 607            |
| $\eta\rho$                                 | seen                             |                  | †              |
| $\pi^+\pi^-\pi^+\pi^-$                     | < 50 %                           | 84%              | 535            |
| $(K\bar{K})^\pm\pi^0$                      | < 8 %                            | 90%              | 248            |
| $K_S^0 K_L^0 \pi^\pm$                      | < 6 %                            | 90%              | 235            |
| $K_S^0 K_S^0 \pi^\pm$                      | < 2 %                            | 90%              | 235            |
| $\phi\pi$                                  | < 1.5 %                          | 84%              | 147            |

$$a_1(1260)^{[m]} \quad I^G(J^{PC}) = 1^-(1^{++})$$

Mass  $m = 1230 \pm 40$  MeV<sup>[n]</sup>

Full width  $\Gamma = 250$  to  $600$  MeV

| $a_1(1260)$ DECAY MODES           | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------------|--------------------------------|-------------|
| $(\rho\pi)_{S\text{-wave}}$       | seen                           | 353         |
| $(\rho\pi)_{D\text{-wave}}$       | seen                           | 353         |
| $(\rho(1450)\pi)_{S\text{-wave}}$ | seen                           | †           |
| $(\rho(1450)\pi)_{D\text{-wave}}$ | seen                           | †           |
| $\sigma\pi$                       | seen                           | -           |
| $f_0(980)\pi$                     | not seen                       | 189         |
| $f_0(1370)\pi$                    | seen                           | †           |
| $f_2(1270)\pi$                    | seen                           | †           |
| $K\bar{K}^*(892) + \text{c.c.}$   | seen                           | †           |
| $\pi\gamma$                       | seen                           | 608         |

$$f_2(1270)$$

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass  $m = 1275.4 \pm 1.1$  MeV

Full width  $\Gamma = 185.2^{+3.1}_{-2.5}$  MeV ( $S = 1.5$ )

| $f_2(1270)$ DECAY MODES       | Fraction ( $\Gamma_i/\Gamma$ )     | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|-------------------------------|------------------------------------|-----------------------------------|----------------|
| $\pi\pi$                      | $(84.7^{+2.5}_{-1.2})$ %           | $S = 1.2$                         | 623            |
| $\pi^+\pi^-2\pi^0$            | $(7.1^{+1.4}_{-2.7})$ %            | $S = 1.3$                         | 563            |
| $K\bar{K}$                    | $(4.6 \pm 0.4)$ %                  | $S = 2.7$                         | 404            |
| $2\pi^+2\pi^-$                | $(2.8 \pm 0.4)$ %                  | $S = 1.2$                         | 559            |
| $\eta\eta$                    | $(4.0 \pm 0.8)$ $\times 10^{-3}$   | $S = 2.1$                         | 327            |
| $4\pi^0$                      | $(3.0 \pm 1.0)$ $\times 10^{-3}$   |                                   | 565            |
| $\gamma\gamma$                | $(1.41 \pm 0.13)$ $\times 10^{-5}$ |                                   | 638            |
| $\eta\pi\pi$                  | < 8 $\times 10^{-3}$               | CL = 95%                          | 478            |
| $K^0 K^- \pi^+ + \text{c.c.}$ | < 3.4 $\times 10^{-3}$             | CL = 95%                          | 293            |
| $e^+e^-$                      | < 6 $\times 10^{-10}$              | CL = 90%                          | 638            |

$$f_1(1285)$$

$$I^G(J^{PC}) = 0^+(1^{++})$$

Mass  $m = 1281.8 \pm 0.6$  MeV ( $S = 1.6$ )

Full width  $\Gamma = 24.2 \pm 1.1$  MeV ( $S = 1.3$ )

| $f_1(1285)$ DECAY MODES                                   | Fraction ( $\Gamma_i/\Gamma$ )   | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|-----------------------------------------------------------|----------------------------------|-----------------------------------|----------------|
| $4\pi$                                                    | $(33.1^{+2.1}_{-1.8})$ %         | $S = 1.3$                         | 568            |
| $\pi^0\pi^0\pi^+\pi^-$                                    | $(22.0^{+1.4}_{-1.2})$ %         | $S = 1.3$                         | 566            |
| $2\pi^+2\pi^-$                                            | $(11.0^{+0.7}_{-0.6})$ %         | $S = 1.3$                         | 563            |
| $\rho^0\pi^+\pi^-$                                        | $(11.0^{+0.7}_{-0.6})$ %         | $S = 1.3$                         | 336            |
| $\rho^0\rho^0$                                            | seen                             |                                   | †              |
| $4\pi^0$                                                  | < 7 $\times 10^{-4}$             | CL = 90%                          | 568            |
| $\eta\pi\pi$                                              | $(52 \pm 16)$ %                  |                                   | 482            |
| $a_0(980)\pi$ [ignoring $a_0(980) \rightarrow K\bar{K}$ ] | $(36 \pm 7)$ %                   |                                   | 234            |
| $\eta\pi\pi$ [excluding $a_0(980)\pi$ ]                   | $(16 \pm 7)$ %                   |                                   | 482            |
| $K\bar{K}\pi$                                             | $(9.0 \pm 0.4)$ %                | $S = 1.1$                         | 308            |
| $K\bar{K}^*(892)$                                         | not seen                         |                                   | †              |
| $\gamma\rho^0$                                            | $(5.5 \pm 1.3)$ %                | $S = 2.8$                         | 406            |
| $\phi\gamma$                                              | $(7.4 \pm 2.6)$ $\times 10^{-4}$ |                                   | 236            |

$$\eta(1295)$$

$$I^G(J^{PC}) = 0^+(0^{-+})$$

Mass  $m = 1294 \pm 4$  MeV ( $S = 1.6$ )

Full width  $\Gamma = 55 \pm 5$  MeV

| $\eta(1295)$ DECAY MODES       | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|--------------------------------|--------------------------------|-------------|
| $\eta\pi^+\pi^-$               | seen                           | 487         |
| $a_0(980)\pi$                  | seen                           | 244         |
| $\eta\pi^0\pi^0$               | seen                           | 490         |
| $\eta(\pi\pi)_{S\text{-wave}}$ | seen                           | -           |

$$\pi(1300)$$

$$I^G(J^{PC}) = 1^-(0^{-+})$$

Mass  $m = 1300 \pm 100$  MeV<sup>[n]</sup>

Full width  $\Gamma = 200$  to  $600$  MeV

| $\pi(1300)$ DECAY MODES       | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------------|--------------------------------|-------------|
| $\rho\pi$                     | seen                           | 404         |
| $\pi(\pi\pi)_{S\text{-wave}}$ | seen                           | -           |

$$\pi_2(1320)$$

$$I^G(J^{PC}) = 1^-(2^{++})$$

Mass  $m = 1318.3 \pm 0.6$  MeV ( $S = 1.2$ )

Full width  $\Gamma = 107 \pm 5$  MeV<sup>[n]</sup>



| $a_2(1320)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ )   | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|-------------------------|----------------------------------|-----------------------------------|----------------|
| $\rho\pi$               | $(70.1 \pm 2.7) \%$              | $S = 1.2$                         | 417            |
| $\eta\pi$               | $(14.5 \pm 1.2) \%$              |                                   | 536            |
| $\omega\pi\pi$          | $(10.6 \pm 3.2) \%$              | $S = 1.3$                         | 366            |
| $K\bar{K}$              | $(4.9 \pm 0.8) \%$               |                                   | 437            |
| $\eta'(958)\pi$         | $(5.3 \pm 0.9) \times 10^{-3}$   |                                   | 288            |
| $\pi^\pm\gamma$         | $(2.68 \pm 0.31) \times 10^{-3}$ |                                   | 652            |
| $\gamma\gamma$          | $(9.4 \pm 0.7) \times 10^{-6}$   |                                   | 659            |
| $\pi^+\pi^-\pi^-$       | $< 8 \%$                         | CL = 90%                          | 621            |
| $e^+e^-$                | $< 6 \times 10^{-9}$             | CL = 90%                          | 659            |

 $f_0(1370)^{[l]}$ 

$$I^G(J^{PC}) = 0^+(0^{++})$$

Mass  $m = 1200$  to  $1500$  MeVFull width  $\Gamma = 200$  to  $500$  MeV

| $f_0(1370)$ DECAY MODES     | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $\pi\pi$                    | seen                           | 672         |
| $4\pi$                      | seen                           | 617         |
| $4\pi^0$                    | seen                           | 617         |
| $2\pi^+2\pi^-$              | seen                           | 612         |
| $\pi^+\pi^-2\pi^0$          | seen                           | 615         |
| $\rho\rho$                  | dominant                       | †           |
| $2(\pi\pi)_{S\text{-wave}}$ | seen                           | –           |
| $\pi(1300)\pi$              | seen                           | †           |
| $a_1(1260)\pi$              | seen                           | 35          |
| $\eta\eta$                  | seen                           | 412         |
| $K\bar{K}$                  | seen                           | 475         |
| $\gamma\gamma$              | seen                           | 685         |
| $e^+e^-$                    | not seen                       | 685         |

 $\pi_1(1400)^{[ol]}$ 

$$I^G(J^{PC}) = 1^-(1^{-+})$$

Mass  $m = 1376 \pm 17$  MeVFull width  $\Gamma = 300 \pm 40$  MeV

| $\pi_1(1400)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $\eta\pi^0$               | seen                           | 570         |
| $\eta\pi^-$               | seen                           | 569         |

 $\eta(1405)^{[pl]}$ 

$$I^G(J^{PC}) = 0^+(0^{-+})$$

Mass  $m = 1409.8 \pm 2.5$  MeV<sup>[nl]</sup> ( $S = 2.2$ )Full width  $\Gamma = 51.1 \pm 3.4$  MeV<sup>[nl]</sup> ( $S = 2.0$ )

| $\eta(1405)$ DECAY MODES       | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$<br>(MeV/c) |
|--------------------------------|--------------------------------|------------------|----------------|
| $K\bar{K}\pi$                  | seen                           |                  | 425            |
| $\eta\pi\pi$                   | seen                           |                  | 563            |
| $a_0(980)\pi$                  | seen                           |                  | 342            |
| $\eta(\pi\pi)_{S\text{-wave}}$ | seen                           |                  | –              |
| $f_0(980)\eta$                 | seen                           |                  | †              |
| $4\pi$                         | seen                           |                  | 639            |
| $\rho\rho$                     | $< 58 \%$                      | 99.85%           | †              |
| $K^*(892)K$                    | seen                           |                  | 125            |

 $f_1(1420)^{[ql]}$ 

$$I^G(J^{PC}) = 0^+(1^{++})$$

Mass  $m = 1426.3 \pm 0.9$  MeV ( $S = 1.1$ )Full width  $\Gamma = 54.9 \pm 2.6$  MeV

| $f_1(1420)$ DECAY MODES         | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $K\bar{K}\pi$                   | dominant                       | 438         |
| $K\bar{K}^*(892) + \text{c.c.}$ | dominant                       | 163         |
| $\eta\pi\pi$                    | possibly seen                  | 573         |
| $\phi\gamma$                    | seen                           | 349         |

 $\omega(1420)^{[rl]}$ 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m$  (1400–1450) MeVFull width  $\Gamma$  (180–250) MeV

| $\omega(1420)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $\rho\pi$                  | dominant                       | 486         |
| $\omega\pi\pi$             | seen                           | 444         |
| $b_1(1235)\pi$             | seen                           | 125         |
| $e^+e^-$                   | seen                           | 710         |

 $a_0(1450)^{[ll]}$ 

$$I^G(J^{PC}) = 1^-(0^{++})$$

Mass  $m = 1474 \pm 19$  MeVFull width  $\Gamma = 265 \pm 13$  MeV

| $a_0(1450)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\pi\eta$               | seen                           | 627         |
| $\pi\eta'(958)$         | seen                           | 410         |
| $K\bar{K}$              | seen                           | 547         |
| $\omega\pi\pi$          | seen                           | 484         |

 $\rho(1450)^{[sl]}$ 

$$I^G(J^{PC}) = 1^+(0^{--})$$

Mass  $m = 1459 \pm 11$  MeV<sup>[nl]</sup> ( $S = 3.4$ )Full width  $\Gamma = 147 \pm 40$  MeV<sup>[nl]</sup> ( $S = 4.9$ )

| $\rho(1450)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$<br>(MeV/c) |
|--------------------------|--------------------------------|------------------|----------------|
| $\pi\pi$                 | seen                           |                  | 717            |
| $4\pi$                   | seen                           |                  | 666            |
| $\omega\pi$              | $< 2.0 \%$                     | 95%              | 508            |
| $e^+e^-$                 | seen                           |                  | 730            |
| $\eta\rho$               | $< 4 \%$                       |                  | 304            |
| $a_2(1320)\pi$           | not seen                       |                  | 39             |
| $\phi\pi$                | $< 1 \%$                       |                  | 355            |
| $K\bar{K}$               | $< 1.6 \times 10^{-3}$         | 95%              | 537            |
| $\eta\gamma$             | possibly seen                  |                  | 627            |

 $\eta(1475)^{[pl]}$ 

$$I^G(J^{PC}) = 0^+(0^{-+})$$

Mass  $m = 1476 \pm 4$  MeV ( $S = 1.4$ ).Full width  $\Gamma = 87 \pm 9$  MeV ( $S = 1.6$ )

| $\eta(1475)$ DECAY MODES        | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $K\bar{K}\pi$                   | dominant                       | 477         |
| $K\bar{K}^*(892) + \text{c.c.}$ | seen                           | 245         |
| $a_0(980)\pi$                   | seen                           | 393         |
| $\gamma\gamma$                  | seen                           | 738         |

 $f_0(1500)^{[ol]}$ 

$$I^G(J^{PC}) = 0^+(0^{++})$$

Mass  $m = 1507 \pm 5$  MeV ( $S = 1.2$ )Full width  $\Gamma = 109 \pm 7$  MeV

| $f_0(1500)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor | $p$<br>(MeV/c) |
|-------------------------|--------------------------------|--------------|----------------|
| $\eta\eta'(958)$        | $(1.9 \pm 0.8) \%$             | 1.7          | 37             |
| $\eta\eta$              | $(5.1 \pm 0.9) \%$             | 1.4          | 518            |
| $4\pi$                  | $(49.5 \pm 3.3) \%$            | 1.2          | 692            |
| $4\pi^0$                | seen                           |              | 692            |
| $2\pi^+2\pi^-$          | seen                           |              | 688            |
| $\pi\pi$                | $(34.9 \pm 2.3) \%$            | 1.2          | 741            |
| $\pi^+\pi^-\pi^-$       | seen                           |              | 741            |
| $2\pi^0$                | seen                           |              | 741            |
| $K\bar{K}$              | $(8.6 \pm 1.0) \%$             | 1.1          | 569            |
| $\gamma\gamma$          | not seen                       |              | 754            |

 $f'_2(1525)$ 

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass  $m = 1525 \pm 5$  MeV<sup>[nl]</sup>Full width  $\Gamma = 73^{+6}_{-5}$  MeV<sup>[nl]</sup>

| $f_2'(1525)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ )   | $p$ (MeV/c) |
|--------------------------|----------------------------------|-------------|
| $K\bar{K}$               | $(88.8 \pm 3.1) \%$              | 581         |
| $\eta\eta$               | $(10.3 \pm 3.1) \%$              | 531         |
| $\pi\pi$                 | $(8.2 \pm 1.5) \times 10^{-3}$   | 750         |
| $\gamma\gamma$           | $(1.11 \pm 0.14) \times 10^{-6}$ | 763         |

$$\pi_1(1600)^{[ol]} \quad I^G(J^{PC}) = 1^-(1^{-+})$$

$$\text{Mass } m = 1653_{-15}^{+18} \text{ MeV (S = 1.6)}$$

$$\text{Full width } \Gamma = 225_{-28}^{+45} \text{ MeV (S = 1.5)}$$

| $\pi_1(1600)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $\pi\pi\pi$               | seen                           | 799         |
| $\rho^0\pi^-$             | seen                           | 635         |
| $f_2(1270)\pi^-$          | not seen                       | 310         |
| $b_1(1235)\pi$            | seen                           | 350         |
| $\eta'(958)\pi^-$         | seen                           | 537         |
| $f_1(1285)\pi$            | seen                           | 307         |

$$\eta_2(1645) \quad I^G(J^{PC}) = 0^+(2^{-+})$$

$$\text{Mass } m = 1617 \pm 5 \text{ MeV}$$

$$\text{Full width } \Gamma = 181 \pm 11 \text{ MeV}$$

| $\eta_2(1645)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $a_2(1320)\pi$             | seen                           | 242         |
| $K\bar{K}\pi$              | seen                           | 580         |
| $K^*\bar{K}$               | seen                           | 404         |
| $\eta\pi^+\pi^-$           | seen                           | 685         |
| $a_0(980)\pi$              | seen                           | 496         |
| $f_2(1270)\eta$            | not seen                       | †           |

$$\omega(1650)^{[tl]} \quad I^G(J^{PC}) = 0^-(1^{--})$$

$$\text{Mass } m = 1670 \pm 30 \text{ MeV}$$

$$\text{Full width } \Gamma = 315 \pm 35 \text{ MeV}$$

| $\omega(1650)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $\rho\pi$                  | seen                           | 646         |
| $\omega\pi\pi$             | seen                           | 617         |
| $\omega\eta$               | seen                           | 500         |
| $e^+e^-$                   | seen                           | 835         |

$$\omega_3(1670) \quad I^G(J^{PC}) = 0^-(3^{--})$$

$$\text{Mass } m = 1667 \pm 4 \text{ MeV}$$

$$\text{Full width } \Gamma = 168 \pm 10 \text{ MeV}^{[nl]}$$

| $\omega_3(1670)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|------------------------------|--------------------------------|-------------|
| $\rho\pi$                    | seen                           | 645         |
| $\omega\pi\pi$               | seen                           | 615         |
| $b_1(1235)\pi$               | possibly seen                  | 361         |

$$\pi_2(1670) \quad I^G(J^{PC}) = 1^-(2^{-+})$$

$$\text{Mass } m = 1672.4 \pm 3.2 \text{ MeV}^{[nl]} \text{ (S = 1.4)}$$

$$\text{Full width } \Gamma = 259 \pm 9 \text{ MeV}^{[nl]} \text{ (S = 1.3)}$$

| $\omega_2(1670)$ DECAY MODES    | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
|---------------------------------|--------------------------------|------------------|-------------|
| $3\pi$                          | $(95.8 \pm 1.4) \%$            |                  | 809         |
| $f_2(1270)\pi$                  | $(56.2 \pm 3.2) \%$            |                  | 329         |
| $\rho\pi$                       | $(31 \pm 4) \%$                |                  | 648         |
| $\sigma\pi$                     | $(10.9 \pm 3.4) \%$            |                  | —           |
| $(\pi\pi)_{S\text{-wave}}$      | $(8.7 \pm 3.4) \%$             |                  | —           |
| $K\bar{K}^*(892) + \text{c.c.}$ | $(4.2 \pm 1.4) \%$             |                  | 455         |
| $\omega\rho$                    | $(2.7 \pm 1.1) \%$             |                  | 304         |
| $\rho(1450)\pi$                 | $< 3.6 \times 10^{-3}$         | 97.7%            | 154         |
| $b_1(1235)\pi$                  | $< 1.9 \times 10^{-3}$         | 97.7%            | 366         |
| $f_1(1285)\pi$                  | possibly seen                  |                  | 323         |
| $a_2(1320)\pi$                  | not seen                       |                  | 292         |

$$\phi(1680) \quad I^G(J^{PC}) = 0^-(1^{--})$$

$$\text{Mass } m = 1680 \pm 20 \text{ MeV}^{[nl]}$$

$$\text{Full width } \Gamma = 150 \pm 50 \text{ MeV}^{[nl]}$$

| $\phi(1680)$ DECAY MODES        | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $K\bar{K}^*(892) + \text{c.c.}$ | dominant                       | 462         |
| $K_S^0 K\pi$                    | seen                           | 621         |
| $K\bar{K}$                      | seen                           | 680         |
| $e^+e^-$                        | seen                           | 840         |
| $\omega\pi\pi$                  | not seen                       | 623         |

$$\rho_3(1690) \quad I^G(J^{PC}) = 1^+(3^{--})$$

$$\text{Mass } m = 1688 \pm 2.1 \text{ MeV}^{[nl]}$$

$$\text{Full width } \Gamma = 161 \pm 10 \text{ MeV}^{[nl]} \text{ (S = 1.5)}$$

| $\rho_3(1690)$ DECAY MODES             | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor | $p$ (MeV/c) |
|----------------------------------------|--------------------------------|--------------|-------------|
| $4\pi$                                 | $(71.1 \pm 1.9) \%$            | %            | 790         |
| $\pi^\pm\pi^+\pi^-\pi^0$               | $(67 \pm 22) \%$               | %            | 787         |
| $\omega\pi$                            | $(16 \pm 6) \%$                | %            | 655         |
| $\pi\pi\pi$                            | $(23.6 \pm 1.3) \%$            | %            | 834         |
| $K\bar{K}\pi$                          | $(3.8 \pm 1.2) \%$             | %            | 629         |
| $K\bar{K}$                             | $(1.58 \pm 0.26) \%$           | %            | 685         |
| $\eta\pi^+\pi^-$                       | seen                           |              | 727         |
| $\rho(770)\eta$                        | seen                           |              | 520         |
| $\pi\pi\rho$                           | seen                           |              | 633         |
| Excluding $2\rho$ and $a_2(1320)\pi$ . |                                |              |             |
| $a_2(1320)\pi$                         | seen                           |              | 307         |
| $\rho\rho$                             | seen                           |              | 334         |

$$\rho(1700)^{[sl]} \quad I^G(J^{PC}) = 1^+(1^{--})$$

$$\text{Mass } m = 1720 \pm 20 \text{ MeV}^{[nl]} \text{ (}\eta\rho^0 \text{ and } \pi^+\pi^- \text{ modes)}$$

$$\text{Full width } \Gamma = 250 \pm 100 \text{ MeV}^{[nl]} \text{ (}\eta\rho^0 \text{ and } \pi^+\pi^- \text{ modes)}$$

| $\rho(1700)$ DECAY MODES        | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $2(\pi^+\pi^-)$                 | large                          | 803         |
| $\rho\pi\pi$                    | dominant                       | 653         |
| $\rho^0\pi^+\pi^-$              | large                          | 650         |
| $\rho^\pm\pi^\mp\pi^0$          | large                          | 652         |
| $a_1(1260)\pi$                  | seen                           | 404         |
| $h_1(1170)\pi$                  | seen                           | 447         |
| $\pi(1300)\pi$                  | seen                           | 349         |
| $\rho\rho$                      | seen                           | 372         |
| $\pi^+\pi^-$                    | seen                           | 849         |
| $\pi\pi$                        | seen                           | 849         |
| $K\bar{K}^*(892) + \text{c.c.}$ | seen                           | 496         |
| $\eta\rho$                      | seen                           | 545         |
| $a_2(1320)\pi$                  | not seen                       | 334         |
| $K\bar{K}$                      | seen                           | 704         |
| $e^+e^-$                        | seen                           | 860         |
| $\pi^0\omega$                   | seen                           | 674         |

**$f_0(1710)^{[u]}$** 

$$I^G(J^{PC}) = 0^+(0^{++})$$

Mass  $m = 1718 \pm 6$  MeV ( $S = 1.2$ )Full width  $\Gamma = 137 \pm 8$  MeV ( $S = 1.1$ )

| $f_0(1710)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $K\bar{K}$              | seen                           | 703         |
| $\eta\eta$              | seen                           | 662         |
| $\pi\pi$                | seen                           | 849         |

 **$\pi(1800)$** 

$$I^G(J^{PC}) = 1^-(0^{-+})$$

Mass  $m = 1812 \pm 14$  MeV ( $S = 2.3$ )Full width  $\Gamma = 207 \pm 13$  MeV

| $\pi(1800)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\pi^+\pi^-\pi^-$       | seen                           | 879         |
| $f_0(600)\pi^-$         | seen                           | —           |
| $f_0(980)\pi^-$         | seen                           | 631         |
| $f_0(1370)\pi^-$        | seen                           | 368         |
| $f_0(1500)\pi^-$        | not seen                       | 248         |
| $\rho\pi^-$             | not seen                       | 732         |
| $\eta\eta\pi^-$         | seen                           | 661         |
| $a_0(980)\eta$          | seen                           | 470         |
| $f_0(1500)\pi^-$        | seen                           | 248         |
| $\eta\eta'(958)\pi^-$   | seen                           | 376         |
| $K_0^*(1430)K^-$        | seen                           | †           |
| $K^*(892)K^-$           | not seen                       | 570         |

 **$\phi_3(1850)$** 

$$I^G(J^{PC}) = 0^+(3^{--})$$

Mass  $m = 1812 \pm 7$  MeVFull width  $\Gamma = 87_{-23}^{+28}$  MeV ( $S = 1.2$ )

| $\phi_3(1850)$ DECAY MODES      | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $K\bar{K}$                      | seen                           | 785         |
| $K\bar{K}^*(892) + \text{c.c.}$ | seen                           | 602         |

 **$f_2(1950)$** 

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass  $m = 1944 \pm 12$  MeV ( $S = 1.5$ )Full width  $\Gamma = 472 \pm 18$  MeV

| $f_2(1950)$ DECAY MODES  | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|--------------------------|--------------------------------|-------------|
| $K^*(892)\bar{K}^*(892)$ | seen                           | 387         |
| $\pi^+\pi^-$             | seen                           | 962         |
| $4\pi$                   | seen                           | 925         |
| $\eta\eta$               | seen                           | 803         |
| $K\bar{K}$               | seen                           | 837         |
| $\gamma\gamma$           | seen                           | 972         |

 **$f_2(2010)$** 

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass  $m = 2011_{-80}^{+60}$  MeVFull width  $\Gamma = 202 \pm 60$  MeV

| $f_2(2010)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\phi\phi$              | seen                           | †           |

 **$a_4(2040)$** 

$$I^G(J^{PC}) = 1^-(4^{++})$$

Mass  $m = 2001 \pm 10$  MeVFull width  $\Gamma = 313 \pm 31$  MeV **$a_4(2040)$  DECAY MODES**Fraction ( $\Gamma_i/\Gamma$ ) $p$  (MeV/c)

|                    |      |     |
|--------------------|------|-----|
| $K\bar{K}$         | seen | 870 |
| $\pi^+\pi^-\pi^0$  | seen | 977 |
| $\rho\pi$          | seen | 844 |
| $f_2(1270)\pi$     | seen | 583 |
| $\omega\pi^-\pi^0$ | seen | 822 |
| $\omega\rho$       | seen | 628 |
| $\eta\pi^0$        | seen | 920 |
| $\eta'(958)\pi$    | seen | 764 |

 **$f_4(2050)$** 

$$I^G(J^{PC}) = 0^+(4^{++})$$

Mass  $m = 2025 \pm 10$  MeV ( $S = 1.8$ )Full width  $\Gamma = 225 \pm 18$  MeV ( $S = 1.7$ )

| $f_4(2050)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ )       | $p$ (MeV/c) |
|-------------------------|--------------------------------------|-------------|
| $\omega\omega$          | not seen                             | 642         |
| $\pi\pi$                | $(17.0 \pm 1.5)\%$                   | 1003        |
| $K\bar{K}$              | $(6.8_{-1.8}^{+3.4}) \times 10^{-3}$ | 884         |
| $\eta\eta$              | $(2.1 \pm 0.8) \times 10^{-3}$       | 852         |
| $4\pi^0$                | $< 1.2\%$                            | 967         |
| $a_2(1320)\pi$          | seen                                 | 572         |

 **$f_2(2300)$** 

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass  $m = 2297 \pm 28$  MeVFull width  $\Gamma = 149 \pm 40$  MeV

| $f_2(2300)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\phi\phi$              | seen                           | 529         |
| $K\bar{K}$              | seen                           | 1037        |
| $\gamma\gamma$          | seen                           | 1149        |

 **$f_2(2340)$** 

$$I^G(J^{PC}) = 0^+(2^{++})$$

Mass  $m = 2339 \pm 60$  MeVFull width  $\Gamma = 319_{-70}^{+80}$  MeV

| $f_2(2340)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\phi\phi$              | seen                           | 573         |

**STRANGE MESONS** $(S = \pm 1, C = B = 0)$  $K^+ = u\bar{s}, K^0 = d\bar{s}, \bar{K}^0 = \bar{d}s, K^- = \bar{u}s$ , similarly for  $K^{*}$ 's **$K^\pm$** 

$$I(J^P) = \frac{1}{2}(0^-)$$

Mass  $m = 493.677 \pm 0.016$  MeV $^{[u]}$  ( $S = 2.8$ )Mean life  $\tau = (1.2385 \pm 0.0024) \times 10^{-8}$  s ( $S = 2.0$ ) $c\tau = 3.713$  m**Slope parameter  $g$**  $^{[u]}$ (See Particle Listings for quadratic coefficients an alternative parameterization related to  $\pi\pi$  scattering)

$$K^+ \rightarrow \pi^+\pi^+\pi^- = -0.2154 \pm 0.0035 \quad (S = 1.4)$$

$$K^- \rightarrow \pi^-\pi^-\pi^+ = -0.217 \pm 0.007 \quad (S = 2.5)$$

$$K^\pm \rightarrow \pi^\pm\pi^+\pi^- (g_+ - g_-) / (g_+ + g_-) = (1.5 \pm 2.9) \times 10^{-4}$$

$$K^\pm \rightarrow \pi^\pm\pi^0\pi^0 = 0.626 \pm 0.007$$

$$K^\pm \rightarrow \pi^\pm\pi^0\pi^0 (g_+ - g_-) / (g_+ + g_-) = (0.02 \pm 0.19)\%$$

 **$K^\pm$  decay form factors** $^{[a,x]}$ Assuming  $\mu$ - $e$  universality

$$\lambda_+(K_{\mu 3}^+) = \lambda_+(K_{e 3}^+) = (2.96 \pm 0.05) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^+) = (1.96 \pm 0.12) \times 10^{-2}$$

Not assuming  $\mu$ - $e$  universality

$$\lambda_+(K_{e3}^+) = (2.96 \pm 0.06) \times 10^{-2}$$

$$\lambda_+(K_{\mu 3}^+) = (2.96 \pm 0.17) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^+) = (1.96 \pm 0.13) \times 10^{-2}$$

 $K_{e3}$  form factor quadratic fit

$$\lambda_+^*(K_{e3}^+) \text{ linear coeff.} = (2.48 \pm 0.17) \times 10^{-2}$$

$$\lambda_+^{**}(K_{e3}^+) \text{ quadratic coeff.} = (0.19 \pm 0.09) \times 10^{-2}$$

$$K_{e3}^+ |f_S/f_+| = (-0.3^{+0.8}_{-0.7}) \times 10^{-2}$$

$$K_{e3}^+ |f_T/f_+| = (-1.2 \pm 2.3) \times 10^{-2}$$

$$K_{\mu 3}^+ |f_S/f_+| = (0.2 \pm 0.6) \times 10^{-2}$$

$$K_{\mu 3}^+ |f_T/f_+| = (-0.1 \pm 0.7) \times 10^{-2}$$

$$K^+ \rightarrow e^+ \nu_e \gamma \quad |F_A + F_V| = 0.148 \pm 0.010$$

$$K^+ \rightarrow \mu^+ \nu_\mu \gamma \quad |F_A + F_V| = 0.165 \pm 0.013$$

$$K^+ \rightarrow e^+ \nu_e \gamma \quad |F_A - F_V| < 0.49$$

$$K^+ \rightarrow \mu^+ \nu_\mu \gamma \quad |F_A - F_V| = -0.24 \text{ to } 0.04, \text{ CL} = 90\%$$

Charge radius

$$\langle r \rangle = 0.560 \pm 0.031 \text{ fm}$$

CP violation parameters

$$\Delta(K_{\pi\mu\mu}^\pm) = -0.02 \pm 0.12$$

T violation parameters

$$K^+ \rightarrow \pi^0 \mu^+ \nu_\mu \quad P_T = (-1.7 \pm 2.5) \times 10^{-3}$$

$$K^+ \rightarrow \mu^+ \nu_\mu \gamma \quad P_T = (-0.6 \pm 1.9) \times 10^{-2}$$

$$K^+ \rightarrow \pi^0 \mu^+ \nu_\mu \quad \text{Im}(\xi) = -0.006 \pm 0.008$$

 $K^-$  modes are charge conjugates of the modes below.

| K <sup>+</sup> DECAY MODES                                    | Fraction ( $\Gamma_i/\Gamma$ )              | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|---------------------------------------------------------------|---------------------------------------------|-----------------------------------|----------------|
| <b>Leptonic and semileptonic modes</b>                        |                                             |                                   |                |
| $e^+ \nu_e$                                                   | $(1.55 \pm 0.07) \times 10^{-5}$            |                                   | 247            |
| $\mu^+ \nu_\mu$                                               | $(63.44 \pm 0.14) \%$                       | S = 1.2                           | 236            |
| $\pi^0 e^+ \nu_e$                                             | $(4.98 \pm 0.07) \%$                        | S = 1.3                           | 228            |
| Called $K_{e3}^+$ .                                           |                                             |                                   |                |
| $\pi^0 \mu^+ \nu_\mu$                                         | $(3.32 \pm 0.06) \%$                        | S = 1.2                           | 215            |
| Called $K_{\mu 3}^+$ .                                        |                                             |                                   |                |
| $\pi^0 \pi^0 e^+ \nu_e$                                       | $(2.2 \pm 0.4) \times 10^{-5}$              |                                   | 206            |
| $\pi^+ \pi^- e^+ \nu_e$                                       | $(4.09 \pm 0.09) \times 10^{-5}$            |                                   | 203            |
| $\pi^+ \pi^- \mu^+ \nu_\mu$                                   | $(1.4 \pm 0.9) \times 10^{-5}$              |                                   | 151            |
| $\pi^0 \pi^0 \pi^0 e^+ \nu_e$                                 | $< 3.5 \times 10^{-6}$                      | CL = 90%                          | 135            |
| <b>Hadronic modes</b>                                         |                                             |                                   |                |
| $\pi^+ \pi^0$                                                 | $(20.92 \pm 0.12) \%$                       | S = 1.1                           | 205            |
| $\pi^+ \pi^0 \pi^0$                                           | $(1.757 \pm 0.024) \%$                      | S = 1.1                           | 133            |
| $\pi^+ \pi^+ \pi^-$                                           | $(5.590 \pm 0.031) \%$                      | S = 1.1                           | 125            |
| <b>Leptonic and semileptonic modes with photons</b>           |                                             |                                   |                |
| $\mu^+ \nu_\mu \gamma$                                        | $[y, z] (6.2 \pm 0.8) \times 10^{-3}$       |                                   | 236            |
| $\mu^+ \nu_\mu \gamma (\text{SD}^+)$                          | $[aa] < 3.0 \times 10^{-5}$                 | CL = 90%                          | -              |
| $\mu^+ \nu_\mu \gamma (\text{SD}^+ \text{INT})$               | $[aa] < 2.7 \times 10^{-5}$                 | CL = 90%                          | -              |
| $\mu^+ \nu_\mu \gamma (\text{SD}^- + \text{SD}^- \text{INT})$ | $[aa] < 2.6 \times 10^{-4}$                 | CL = 90%                          | -              |
| $e^+ \nu_e \gamma (\text{SD}^+)$                              | $[aa] (1.52 \pm 0.23) \times 10^{-5}$       |                                   | -              |
| $e^+ \nu_e \gamma (\text{SD}^-)$                              | $[aa] < 1.6 \times 10^{-4}$                 | CL = 90%                          | -              |
| $\pi^0 e^+ \nu_e \gamma$                                      | $[y, z] (2.69 \pm 0.20) \times 10^{-4}$     |                                   | 228            |
| $\pi^0 e^+ \nu_e \gamma (\text{SD})$                          | $[aa] < 5.3 \times 10^{-5}$                 | CL = 90%                          | 228            |
| $\pi^0 \mu^+ \nu_\mu \gamma$                                  | $[y, z] (2.4 \pm 0.8) \times 10^{-5}$       |                                   | 215            |
| $\pi^0 \pi^0 e^+ \nu_e \gamma$                                | $< 5 \times 10^{-6}$                        | CL = 90%                          | 206            |
| <b>Hadronic modes with photons</b>                            |                                             |                                   |                |
| $\pi^+ \pi^0 \gamma$                                          | $[y, z] (2.75 \pm 0.15) \times 10^{-4}$     |                                   | 205            |
| $\pi^+ \pi^0 \gamma (\text{DE})$                              | $[z, bb] (4.4 \pm 0.7) \times 10^{-6}$      |                                   | 205            |
| $\pi^+ \pi^0 \pi^0 \gamma$                                    | $[y, z] (7.6^{+5.6}_{-3.0}) \times 10^{-6}$ |                                   | 133            |
| $\pi^+ \pi^+ \pi^- \gamma$                                    | $[y, z] (1.04 \pm 0.31) \times 10^{-4}$     |                                   | 125            |
| $\pi^+ \gamma \gamma$                                         | $[z] (1.10 \pm 0.32) \times 10^{-6}$        |                                   | 227            |
| $\pi^+ 3\gamma$                                               | $[z] < 1.0 \times 10^{-4}$                  | CL = 90%                          | 227            |

Leptonic modes with  $\ell\bar{\ell}$  pairs

|                              |                                  |          |     |
|------------------------------|----------------------------------|----------|-----|
| $e^+ \nu_e \nu\bar{\nu}$     | $< 6 \times 10^{-5}$             | CL = 90% | 247 |
| $\mu^+ \nu_\mu \nu\bar{\nu}$ | $< 6.0 \times 10^{-6}$           | CL = 90% | 236 |
| $e^+ \nu_e e^+ e^-$          | $(2.48 \pm 0.20) \times 10^{-8}$ |          | 247 |
| $\mu^+ \nu_\mu e^+ e^-$      | $(7.06 \pm 0.31) \times 10^{-8}$ |          | 236 |
| $e^+ \nu_e \mu^+ \mu^-$      | $(1.7 \pm 0.5) \times 10^{-8}$   |          | 223 |
| $\mu^+ \nu_\mu \mu^+ \mu^-$  | $< 4.1 \times 10^{-7}$           | CL = 90% | 185 |

Lepton Family number (LF), Lepton number (L),  $\Delta S = \Delta Q$  (SQ) violating modes, or  $\Delta S = 1$  weak neutral current (S1) modes

|                                   |      |                                       |          |     |
|-----------------------------------|------|---------------------------------------|----------|-----|
| $\pi^+ \pi^+ e^- \bar{\nu}_e$     | SQ   | $< 1.2 \times 10^{-8}$                | CL = 90% | 203 |
| $\pi^+ \pi^+ \mu^- \bar{\nu}_\mu$ | SQ   | $< 3.0 \times 10^{-6}$                | CL = 95% | 151 |
| $\pi^+ e^+ e^-$                   | S1   | $(2.88 \pm 0.13) \times 10^{-7}$      |          | 227 |
| $\pi^+ \mu^+ \mu^-$               | S1   | $(8.1 \pm 1.4) \times 10^{-8}$        | S = 2.7  | 172 |
| $\pi^+ \nu\bar{\nu}$              | S1   | $(1.5^{+1.3}_{-0.9}) \times 10^{-10}$ |          | 227 |
| $\pi^+ \pi^0 \nu\bar{\nu}$        | S1   | $< 4.3 \times 10^{-5}$                | CL = 90% | 205 |
| $\mu^- \nu e^+ e^+$               | LF   | $< 2.0 \times 10^{-8}$                | CL = 90% | 236 |
| $\mu^+ \nu_e$                     | LF   | $[d] < 4 \times 10^{-3}$              | CL = 90% | 236 |
| $\pi^+ \mu^+ e^-$                 | LF   | $< 1.3 \times 10^{-11}$               | CL = 90% | 214 |
| $\pi^+ \mu^- e^+$                 | LF   | $< 5.2 \times 10^{-10}$               | CL = 90% | 214 |
| $\pi^- \mu^+ e^+$                 | L    | $< 5.0 \times 10^{-10}$               | CL = 90% | 214 |
| $\pi^- e^+ e^+$                   | L    | $< 6.4 \times 10^{-10}$               | CL = 90% | 227 |
| $\pi^- \mu^+ \mu^+$               | L    | $[d] < 3.0 \times 10^{-9}$            | CL = 90% | 172 |
| $\mu^+ \bar{\nu}_e$               | L    | $[d] < 3.3 \times 10^{-3}$            | CL = 90% | 236 |
| $\pi^0 e^+ \bar{\nu}_e$           | L    | $< 3 \times 10^{-3}$                  | CL = 90% | 228 |
| $\pi^+ \gamma$                    | [cc] | $< 2.3 \times 10^{-9}$                | CL = 90% | 227 |

 $K^0$ 

$$I(J^P) = \frac{1}{2}(0^-)$$

50%  $K_S$ , 50%  $K_L$ 

$$\text{Mass } m = 497.648 \pm 0.022 \text{ MeV}$$

$$m_{K^0} - m_{K^\pm} = 3.972 \pm 0.027 \text{ MeV} \quad (S = 1.2)$$

Mean square charge radius

$$\langle r^2 \rangle = -0.077 \pm 0.010 \text{ fm}^2$$

T-violation parameters in  $K^0 \bar{K}^0$  mixing<sup>[x]</sup>

$$\text{Asymmetry } A_T \text{ in } K^0 \bar{K}^0 \text{ mixing} = (6.6 \pm 1.6) \times 10^{-3}$$

CPT-violation parameters<sup>[x]</sup>

$$\text{Re } \delta = (2.9 \pm 2.7) \times 10^{-4}$$

$$\text{Im } \delta = (-0.2 \pm 2.0) \times 10^{-5}$$

$$\text{Re}(y), K_{e3} \text{ parameter} = (0.4 \pm 2.5) \times 10^{-3}$$

$$\text{Re}(x_-), K_{e3} \text{ parameter} = (-0.8 \pm 2.5) \times 10^{-3}$$

$$|m_{K^0} - m_{\bar{K}^0}| / m_{\text{average}} < 10^{-18}, \text{ CL} = 90\%^{[dd]}$$

$$(\Gamma_{K^0} - \Gamma_{\bar{K}^0}) / m_{\text{average}} = (8 \pm 8) \times 10^{-18}$$

Tests of  $\Delta S = \Delta Q$ 

$$\text{Re}(x_+), K_{e3} \text{ parameter} = (-0.8 \pm 3.1) \times 10^{-3}$$

 $K_S^0$ 

$$I(J^P) = \frac{1}{2}(0^-)$$

Mean life  $\tau = (0.8953 \pm 0.0005) \times 10^{-10} \text{ s}$  (S = 1.1) Assuming CPTMean life  $\tau = (0.8958 \pm 0.0006) \times 10^{-10} \text{ s}$  (S = 1.2) Not assuming CPT

$$c\tau = 2.6842 \text{ cm} \quad \text{Assuming CPT}$$

CP-violation parameters<sup>[ee]</sup>

$$\text{Im}(\eta_{+-0}) = -0.002 \pm 0.009$$

$$\text{Im}(\eta_{000}) = (-0.1 \pm 1.6) \times 10^{-2}$$

$$|\eta_{000}| = |A(K_S^0 \rightarrow 3\pi^0)/A(K_L^0 \rightarrow 3\pi^0)| < 0.018, \text{ CL} = 90\%$$

$$\text{CP asymmetry } A \text{ in } \pi^+ \pi^- e^+ e^- = (-1 \pm 4) \%$$

| $K_S^0$ DECAY MODES                                                                    | Fraction ( $\Gamma_i/\Gamma$ )               | Confidence level | $p$<br>(MeV/c) |
|----------------------------------------------------------------------------------------|----------------------------------------------|------------------|----------------|
| <b>Hadronic modes</b>                                                                  |                                              |                  |                |
| $\pi^0\pi^0$                                                                           | $(30.69 \pm 0.05) \%$                        |                  | 209            |
| $\pi^+\pi^-$                                                                           | $(69.20 \pm 0.05) \%$                        |                  | 206            |
| $\pi^+\pi^-\pi^0$                                                                      | $(3.5^{+1.1}_{-0.9}) \times 10^{-7}$         |                  | 133            |
| <b>Modes with photons or <math>\ell\bar{\ell}</math> pairs</b>                         |                                              |                  |                |
| $\pi^+\pi^-\gamma$                                                                     | $[y,ff] (1.79 \pm 0.05) \times 10^{-3}$      |                  | 206            |
| $\pi^+\pi^-e^+e^-$                                                                     | $(4.69 \pm 0.30) \times 10^{-5}$             |                  | 206            |
| $\pi^0\gamma\gamma$                                                                    | $[ff] (4.9 \pm 1.8) \times 10^{-8}$          |                  | 231            |
| $\gamma\gamma$                                                                         | $(2.84 \pm 0.07) \times 10^{-6}$             |                  | 249            |
| <b>Semileptonic modes</b>                                                              |                                              |                  |                |
| $\pi^\pm e^\mp \nu_e$                                                                  | $[gg] (7.04 \pm 0.09) \times 10^{-4}$        |                  | 229            |
| <b>CP violating (CP) and <math>\Delta S = 1</math> weak neutral current (S1) modes</b> |                                              |                  |                |
| $3\pi^0$                                                                               | CP < 1.2 $\times 10^{-7}$                    | 90%              | 139            |
| $\mu^+\mu^-$                                                                           | S1 < 3.2 $\times 10^{-7}$                    | 90%              | 225            |
| $e^+e^-$                                                                               | S1 < 1.4 $\times 10^{-7}$                    | 90%              | 249            |
| $\pi^0 e^+ e^-$                                                                        | S1 $[ff] (3.0^{+1.5}_{-1.2}) \times 10^{-9}$ |                  | 231            |
| $\pi^0 \mu^+ \mu^-$                                                                    | S1 $(2.9^{+1.3}_{-1.2}) \times 10^{-9}$      |                  | 177            |

$K_L^0$

$$I(J^P) = \frac{1}{2}(0^-)$$

$$m_{K_L} - m_{K_S} = (0.5292 \pm 0.0009) \times 10^{10} \hbar s^{-1} \quad (S = 1.2) \quad \text{Assuming } CPT$$

$$= (3.483 \pm 0.006) \times 10^{-12} \text{ MeV} \quad \text{Assuming } CPT$$

$$= (0.5290 \pm 0.0016) \times 10^{10} \hbar s^{-1} \quad (S = 1.2) \quad \text{Not assuming } CPT$$

$$\text{Mean life } \tau = (5.114 \pm 0.021) \times 10^{-8} \text{ s}$$

$$c\tau = 15.33 \text{ m}$$

#### Slope parameter $g$ <sup>[w]</sup>

(See Particle Listings for quadratic coefficients)

$$K_L^0 \rightarrow \pi^+\pi^-\pi^0 = 0.678 \pm 0.008 \quad (S = 1.5)$$

#### $K_L$ decay form factors <sup>[x]</sup>

Linear parametrization assuming  $\mu$ - $e$  universality

$$\lambda_+(K_{\mu 3}^0) = \lambda_+(K_{e 3}^0) = (2.84 \pm 0.04) \times 10^{-2}$$

$$\lambda_0(K_{\mu 3}^0) = (1.64 \pm 0.11) \times 10^{-2}$$

Quadratic parametrization assuming  $\mu$ - $e$  universality

$$\lambda'_+(K_{\mu 3}^0) = \lambda'_+(K_{e 3}^0) = (2.42 \pm 0.14) \times 10^{-2} \quad (S = 1.3)$$

$$\lambda''_+(K_{\mu 3}^0) = \lambda''_+(K_{e 3}^0) = (0.18 \pm 0.05) \times 10^{-2} \quad (S = 1.1)$$

$$\lambda_0(K_{\mu 3}^0) = (1.46 \pm 0.13) \times 10^{-2}$$

Pole parametrization assuming  $\mu$ - $e$  universality

$$M_V^u(K_{\mu 3}^0) = M_V^e(K_{e 3}^0) = 877 \pm 5 \text{ MeV} \quad (S = 1.1)$$

$$M_S^u(K_{\mu 3}^0) = 1187 \pm 50$$

$$K_{e 3}^0 |f_S/f_+| = (1.5^{+1.4}_{-1.6}) \times 10^{-2}$$

$$K_{e 3}^0 |f_T/f_+| = (5^{+4}_{-5}) \times 10^{-2}$$

$$K_{\mu 3}^0 |f_T/f_+| = (12 \pm 12) \times 10^{-2}$$

$$K_L \rightarrow e^+e^-\gamma: \alpha_{K^*} = -0.33 \pm 0.05$$

$$K_L \rightarrow \mu^+\mu^-\gamma: \alpha_{K^*} = -0.158 \pm 0.027$$

$$K_L \rightarrow e^+e^-e^+e^-: \alpha_{K^*}^{\text{eff}} = -0.14 \pm 0.22$$

$$K_L \rightarrow \pi^+\pi^-e^+e^-: a_1/a_2 = -0.734 \pm 0.022 \text{ GeV}^2$$

$$K_L \rightarrow \pi^0 2\gamma: a_V = -0.54 \pm 0.12 \quad (S = 2.8)$$

#### CP-violation parameters <sup>[ee]</sup>

$$A_L = (0.332 \pm 0.006) \%$$

$$|\eta_{00}| = (2.225 \pm 0.007) \times 10^{-3}$$

$$|\eta_{+-}| = (2.236 \pm 0.007) \times 10^{-3}$$

$$|\epsilon| = (2.232 \pm 0.007) \times 10^{-3}$$

$$|\eta_{00}/\eta_{+-}| = 0.9950 \pm 0.0008^{[bb]} \quad (S = 1.6)$$

$$\text{Re}(\epsilon'/\epsilon) = (1.66 \pm 0.26) \times 10^{-3}^{[bb]} \quad (S = 1.6)$$

#### Assuming $CPT$

$$\phi_{+-} = (43.52 \pm 0.05)^\circ \quad (S = 1.2)$$

$$\phi_{00} = (43.50 \pm 0.06)^\circ \quad (S = 1.2)$$

$$\phi_\epsilon = \phi_{\text{SW}} = (43.51 \pm 0.05)^\circ \quad (S = 1.1)$$

#### Not assuming $CPT$

$$\phi_{+-} = (43.4 \pm 0.7)^\circ \quad (S = 1.3)$$

$$\phi_{00} = (43.7 \pm 0.8)^\circ \quad (S = 1.2)$$

$$\phi_\epsilon = (43.5 \pm 0.7)^\circ \quad (S = 1.3)$$

$$CP \text{ asymmetry } A \text{ in } K_L^0 \rightarrow \pi^+\pi^-e^+e^- = (13.7 \pm 1.5) \%$$

$$\beta_{CP} \text{ from } K_L^0 \rightarrow e^+e^-e^+e^- = -0.19 \pm 0.07$$

$$\gamma_{CP} \text{ from } K_L^0 \rightarrow e^+e^-e^+e^- = 0.01 \pm 0.11 \quad (S = 1.6)$$

$$j \text{ for } K_L^0 \rightarrow \pi^+\pi^-\pi^0 = 0.0012 \pm 0.0008$$

$$f \text{ for } K_L^0 \rightarrow \pi^+\pi^-\pi^0 = 0.004 \pm 0.006$$

$$|\eta_{+-\gamma}| = (2.35 \pm 0.07) \times 10^{-3}$$

$$\phi_{+-\gamma} = (44 \pm 4)^\circ$$

$$|\epsilon_{+-\gamma}|/\epsilon < 0.3, \text{ CL} = 90 \%$$

#### T-violation parameters

$$\text{Im}(\xi) \text{ in } K_{\mu 3}^0 = -0.007 \pm 0.026$$

#### $CPT$ invariance tests

$$\phi_{00} - \phi_{+-} = (0.2 \pm 0.4)^\circ$$

$$\text{Re}(\frac{2}{3}\eta_{+-} + \frac{1}{3}\eta_{00}) - \frac{\delta_L}{2} = (-3 \pm 35) \times 10^{-6}$$

#### $\Delta S = -\Delta Q$ in $K_{\ell 3}^0$ decay

$$\text{Re } x = -0.002 \pm 0.006$$

$$\text{Im } x = 0.0012 \pm 0.0021$$

| $K_L^0$ DECAY MODES                                                                                                                                                  | Fraction ( $\Gamma_i/\Gamma$ )             | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|-----------------------------------|----------------|
| <b>Semileptonic modes</b>                                                                                                                                            |                                            |                                   |                |
| $\pi^\pm e^\mp \nu_e$                                                                                                                                                | $[gg] (40.53 \pm 0.15) \%$                 | S = 2.1                           | 229            |
| Called $K_{e 3}^0$ .                                                                                                                                                 |                                            |                                   |                |
| $\pi^\pm \mu^\mp \nu_\mu$                                                                                                                                            | $[gg] (27.02 \pm 0.07) \%$                 |                                   | 216            |
| Called $K_{\mu 3}^0$ .                                                                                                                                               |                                            |                                   |                |
| $(\pi\mu\text{atom})\nu$                                                                                                                                             | $(1.05 \pm 0.11) \times 10^{-7}$           |                                   | 188            |
| $\pi^0 \pi^\pm e^\mp \nu$                                                                                                                                            | $[gg] (5.20 \pm 0.11) \times 10^{-5}$      |                                   | 207            |
| <b>Hadronic modes, including Charge conjugation <math>\times</math> Parity violating (CPV) modes</b>                                                                 |                                            |                                   |                |
| $3\pi^0$                                                                                                                                                             | $(19.56 \pm 0.14) \%$                      | S = 1.9                           | 139            |
| $\pi^+\pi^-\pi^0$                                                                                                                                                    | $(12.56 \pm 0.05) \%$                      |                                   | 133            |
| $\pi^+\pi^-$                                                                                                                                                         | CPV $(1.976 \pm 0.008) \times 10^{-3}$     |                                   | 206            |
| $\pi^0\pi^0$                                                                                                                                                         | CPV $(8.69 \pm 0.04) \times 10^{-4}$       | S = 1.1                           | 209            |
| <b>Semileptonic modes with photons</b>                                                                                                                               |                                            |                                   |                |
| $\pi^\pm e^\mp \nu_e \gamma$                                                                                                                                         | $[y,gg,ii] (3.79 \pm 0.08) \times 10^{-3}$ |                                   | 229            |
| $\pi^\pm \mu^\mp \nu_\mu \gamma$                                                                                                                                     | $(5.64 \pm 0.23) \times 10^{-4}$           |                                   | 216            |
| <b>Hadronic modes with photons or <math>\ell\bar{\ell}</math> pairs</b>                                                                                              |                                            |                                   |                |
| $\pi^0\pi^0\gamma$                                                                                                                                                   | < 5.6 $\times 10^{-6}$                     |                                   | 209            |
| $\pi^+\pi^-\gamma$                                                                                                                                                   | $[y,ii] (4.17 \pm 0.15) \times 10^{-5}$    |                                   | 206            |
| $\pi^0 2\gamma$                                                                                                                                                      | $[ii] (1.49 \pm 0.08) \times 10^{-6}$      | S = 2.0                           | 231            |
| $\pi^0\gamma e^+e^-$                                                                                                                                                 | $(2.3 \pm 0.4) \times 10^{-8}$             |                                   | 231            |
| <b>Other modes with photons or <math>\ell\bar{\ell}</math> pairs</b>                                                                                                 |                                            |                                   |                |
| $2\gamma$                                                                                                                                                            | $(5.48 \pm 0.05) \times 10^{-4}$           | S = 1.2                           | 249            |
| $3\gamma$                                                                                                                                                            | < 2.4 $\times 10^{-7}$                     | CL = 90%                          | 249            |
| $e^+e^-\gamma$                                                                                                                                                       | $(10.0 \pm 0.5) \times 10^{-6}$            | S = 1.5                           | 249            |
| $\mu^+\mu^-\gamma$                                                                                                                                                   | $(3.59 \pm 0.11) \times 10^{-7}$           | S = 1.3                           | 225            |
| $e^+e^-\gamma\gamma$                                                                                                                                                 | $[ii] (5.95 \pm 0.33) \times 10^{-7}$      |                                   | 249            |
| $\mu^+\mu^-\gamma\gamma$                                                                                                                                             | $[ii] (1.0^{+0.8}_{-0.6}) \times 10^{-8}$  |                                   | 225            |
| <b>Charge conjugation <math>\times</math> Parity (CP) or Lepton Family number (LF) violating modes, or <math>\Delta S = 1</math> weak neutral current (S1) modes</b> |                                            |                                   |                |
| $\mu^+\mu^-$                                                                                                                                                         | S1 $(6.87 \pm 0.11) \times 10^{-9}$        |                                   | 225            |
| $e^+e^-$                                                                                                                                                             | S1 $(9^{+6}_{-4}) \times 10^{-12}$         |                                   | 249            |
| $\pi^+\pi^-e^+e^-$                                                                                                                                                   | S1 $[ii] (3.11 \pm 0.19) \times 10^{-7}$   |                                   | 206            |
| $\pi^0\pi^0e^+e^-$                                                                                                                                                   | S1 < 6.6 $\times 10^{-9}$                  | CL = 90%                          | 209            |
| $\mu^+\mu^-e^+e^-$                                                                                                                                                   | S1 $(2.69 \pm 0.27) \times 10^{-9}$        |                                   | 225            |
| $e^+e^-e^+e^-$                                                                                                                                                       | S1 $(3.56 \pm 0.21) \times 10^{-8}$        |                                   | 249            |

|                               |          |        |                          |          |     |
|-------------------------------|----------|--------|--------------------------|----------|-----|
| $\pi^0 \mu^+ \mu^-$           | $CP, S1$ | $[jj]$ | $< 3.8 \times 10^{-10}$  | CL = 90% | 177 |
| $\pi^0 e^+ e^-$               | $CP, S1$ | $[jj]$ | $< 2.8 \times 10^{-10}$  | CL = 90% | 231 |
| $\pi^0 \nu \bar{\nu}$         | $CP, S1$ | $[kk]$ | $< .9 \times 10^{-7}$    | CL = 90% | 231 |
| $e^\pm \mu^\mp$               | $LF$     | $[gg]$ | $< 4.7 \times 10^{-12}$  | CL = 90% | 238 |
| $e^\pm e^\pm \mu^\mp \mu^\mp$ | $LF$     | $[gg]$ | $< 4.12 \times 10^{-11}$ | CL = 90% | 225 |
| $\pi^0 \mu^\pm e^\mp$         | $LF$     | $[gg]$ | $< 6.2 \times 10^{-9}$   | CL = 90% | 217 |

|                                                               |                                                |                                                |     |
|---------------------------------------------------------------|------------------------------------------------|------------------------------------------------|-----|
| <b><math>K^*(892)</math></b>                                  | $I(J^P) = \frac{1}{2}(1^-)$                    |                                                |     |
| $K^*(892)^\pm$ mass $m = 891.66 \pm 0.26$ MeV                 |                                                |                                                |     |
| $K^*(892)^0$ mass $m = 896.00 \pm 0.25$ MeV (S = 1.4)         |                                                |                                                |     |
| $K^*(892)^\pm$ full width $\Gamma = 50.8 \pm 0.9$ MeV         |                                                |                                                |     |
| $K^*(892)^0$ full width $\Gamma = 50.3 \pm 0.6$ MeV (S = 1.1) |                                                |                                                |     |
| <b><math>K^*(892)</math> DECAY MODES</b>                      | <b>Fraction (<math>\Gamma_i/\Gamma</math>)</b> | <b>Confidence level <math>p</math> (MeV/c)</b> |     |
| $K\pi$                                                        | $\sim 100$ %                                   |                                                | 289 |
| $K^0\gamma$                                                   | $(2.31 \pm 0.20) \times 10^{-3}$               |                                                | 307 |
| $K^\pm\gamma$                                                 | $(9.9 \pm 0.9) \times 10^{-4}$                 |                                                | 309 |
| $K\pi\pi$                                                     | $< 7$ $\times 10^{-4}$                         | 95%                                            | 223 |

| <div><math>K_1(1270)</math></div>                 | $I(J^P) = \frac{1}{2}(1^+)$      |   |                     |
|---------------------------------------------------|----------------------------------|---|---------------------|
| Mass $m = 1272 \pm 7 \text{ MeV}^{[n]}$           |                                  |   |                     |
| Full width $\Gamma = 90 \pm 20 \text{ MeV}^{[n]}$ |                                  |   |                     |
| $K_1(1270)$ DECAY MODES                           | Fraction ( $\Gamma_i / \Gamma$ ) |   | $p \text{ (MeV}/c)$ |
| $K\rho$                                           | $(42 \pm 6)$                     | % | 45                  |
| $K_0^*(1430)\pi$                                  | $(28 \pm 4)$                     | % | †                   |
| $K^*(892)\pi$                                     | $(16 \pm 5)$                     | % | 302                 |
| $K\omega$                                         | $(11.0 \pm 2.0)$                 | % | †                   |
| $K f_0(1370)$                                     | $(3.0 \pm 2.0)$                  | % | †                   |
| $\gamma K^0$                                      | seen                             |   | 539                 |

|                                                   |                                |             |
|---------------------------------------------------|--------------------------------|-------------|
| <div><math>K_1(1400)</math></div>                 | $I(J^P) = \frac{1}{2}(1^+)$    |             |
| Mass $m = 1402 \pm 7$ MeV                         |                                |             |
| Full width $\Gamma = 174 \pm 13$ MeV    (S = 1.6) |                                |             |
| $K_1(1400)$ DECAY MODES                           | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
| $K^*(892)\pi$                                     | $(94 \pm 6)$ %                 | 402         |
| $K\rho$                                           | $(3.0 \pm 3.0)$ %              | 292         |
| $K f_0(1370)$                                     | $(2.0 \pm 2.0)$ %              | †           |
| $K\omega$                                         | $(1.0 \pm 1.0)$ %              | 284         |
| $K_0^*(1430)\pi$                                  | not seen                       | †           |
| $\gamma K^0$                                      | seen                           | 613         |

**$K^*(1410)$**

$I(J^P) = \frac{1}{2}(1^-)$

Mass  $m = 1414 \pm 15$  MeV (S = 1.3)

Full width  $\Gamma = 232 \pm 21$  MeV (S = 1.1)

| $K^*(1410)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$<br>(MeV/c) |
|-------------------------|--------------------------------|------------------|----------------|
| $K^*(892)\pi$           | > 40 %                         | 95%              | 410            |
| $K\pi$                  | $(6.6 \pm 1.3)$ %              |                  | 612            |
| $K\rho$                 | <7 %                           | 95%              | 305            |
| $\gamma K^0$            | seen                           |                  | 619            |

$K_0^*(1430)^{[II]}$

$I(J^P) = \frac{1}{2}(1^+)$

Mass  $m = 1414 \pm 6$  MeV

Full width  $\Gamma = 290 \pm 21$  MeV

| $K_0^*(1430)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $K\pi$                    | (93 ± 10) %                    | 613         |

$K_2^*(1430)^{[II]}$

$I(J^P) = \frac{1}{2}(2^+)$

$K_2^*(1430)^\pm$  mass  $m = 1425.6 \pm 1.5$  MeV (S = 1.1)

$K_2^*(1430)^0$  mass  $m = 1432.4 \pm 1.3$  MeV

$K_2^*(1430)^\pm$  full width  $\Gamma = 98.5 \pm 2.7$  MeV (S = 1.1)

$K_2^*(1430)^0$  full width  $\Gamma = 109 \pm 5$  MeV (S = 1.9)

| $K_2^*(1430)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|---------------------------|--------------------------------|-----------------------------------|----------------|
| $K\pi$                    | $(49.9 \pm 1.2)$ %             | 619                               |                |
| $K^*(892)\pi$             | $(24.7 \pm 1.5)$ %             |                                   | 419            |
| $K^*(892)\pi\pi$          | $(13.4 \pm 2.2)$ %             | 372                               |                |
| $K\rho$                   | $(8.7 \pm 0.8)$ %              | S = 1.2                           | 318            |
| $K\omega$                 | $(2.9 \pm 0.8)$ %              | 311                               |                |
| $K^+\gamma$               | $(2.4 \pm 0.5)$                | $\times 10^{-3}$ S = 1.1          | 627            |
| $K\eta$                   | $(1.5^{+3.4}_{-1.0})$          | $\times 10^{-3}$ S = 1.3          | 487            |
| $K\omega\pi$              | $< 7.2$                        | $\times 10^{-4}$ CL = 95%         | 100            |
| $K^0\gamma$               | $< 9$                          | $\times 10^{-4}$ CL = 90%         | 626            |

**$K^*(1680)$**

$I(J^P) = \frac{1}{2}(1^-)$

Mass  $m = 1717 \pm 27$  MeV    (S = 1.4)

Full width  $\Gamma = 322 \pm 110$  MeV    (S = 4.2)

| $K^*(1680)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $K\pi$                  | $(38.7 \pm 2.5)$ %             | 781         |
| $K\rho$                 | $(31.4^{+4.7}_{-2.1})$ %       | 570         |
| $K^*(892)\pi$           | $(29.9^{+2.2}_{-4.7})$ %       | 618         |

|                                          |                                  |             |
|------------------------------------------|----------------------------------|-------------|
| <div><math>K_2(1770)^{[mm]}</math></div> | $I(J^P) = \frac{1}{2}(2^-)$      |             |
| Mass $m = 1773 \pm 8$ MeV                |                                  |             |
| Full width $\Gamma = 186 \pm 14$ MeV     |                                  |             |
| $K_2(1770)^{[mm]}$ DECAY MODES           | Fraction ( $\Gamma_i / \Gamma$ ) | $p$ (MeV/c) |
| $K\pi\pi$                                |                                  | 794         |
| $K_2^*(1430)\pi$                         | dominant                         | 288         |
| $K^*(892)\pi$                            | seen                             | 654         |
| $K f_2(1270)$                            | seen                             | 53          |
| $K\phi$                                  | seen                             | 441         |
| $K\omega$                                | seen                             | 607         |

|                                                |                             |
|------------------------------------------------|-----------------------------|
| <div><math>K_3^*(1780)</math></div>            | $I(J^P) = \frac{1}{2}(3^-)$ |
| Mass $m = 1776 \pm 7$ MeV (S = 1.1)            |                             |
| Full width $\Gamma = 159 \pm 21$ MeV (S = 1.3) |                             |

|                           |                                |                  |             |
|---------------------------|--------------------------------|------------------|-------------|
| $K_3^*(1780)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
| $K\rho$                   | $(31 \pm 9)$ %                 |                  | 613         |
| $K^*(892)\pi$             | $(20 \pm 5)$ %                 |                  | 656         |
| $K\pi$                    | $(18.8 \pm 1.0)$ %             |                  | 813         |
| $K\eta$                   | $(30 \pm 13)$ %                |                  | 719         |
| $K_2^*(1430)\pi$          | $< 16$ %                       | 95%              | 291         |

$K_2(1820)^{[mm]}$

$I(J^P) = \frac{1}{2}(2^-)$

Mass  $m = 1816 \pm 13$  MeV

Full width  $\Gamma = 276 \pm 35$  MeV

| $K_2(1820)^{[mmm]}$ DECAY MODES | Fraction ( $\Gamma_i / \Gamma$ ) | $p$ (MeV/c) |
|---------------------------------|----------------------------------|-------------|
| $K_2^*(1430)\pi$                | seen                             | 327         |
| $K^*(892)\pi$                   | seen                             | 681         |
| $K f_2(1270)$                   | seen                             | 185         |
| $K\omega$                       | seen                             | 638         |

**$K_4^*(2045)$** 

$$I(J^P) = \frac{1}{2}(4^+)$$

Mass  $m = 2045 \pm 9$  MeV ( $S = 1.1$ )Full width  $\Gamma = 198 \pm 30$  MeV

| $K_4^*(2045)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $K\pi$                    | $(9.9 \pm 1.2)$ %              | 958         |
| $K^*(892)\pi\pi$          | $(9 \pm 5)$ %                  | 802         |
| $K^*(892)\pi\pi\pi$       | $(7 \pm 5)$ %                  | 768         |
| $\rho K\pi$               | $(5.7 \pm 3.2)$ %              | 741         |
| $\omega K\pi$             | $(5.0 \pm 3.0)$ %              | 738         |
| $\phi K\pi$               | $(2.8 \pm 1.4)$ %              | 594         |
| $\phi K^*(892)$           | $(1.4 \pm 0.7)$ %              | 363         |

**CHARMED MESONS** $(C = \pm 1)$  $D^+ = c\bar{d}, D^0 = c\bar{u}, \bar{D}^0 = \bar{c}u, D^- = \bar{c}d$ , similarly for  $D^{*+}$ 's **$D^{\pm}$** 

$$I(J^P) = \frac{1}{2}(0^-)$$

Mass  $m = 1869.3 \pm 0.4$  MeV ( $S = 1.1$ )Mean life  $\tau = (1040 \pm 7) \times 10^{-15}$  s $c\tau = 311.8 \mu\text{m}$  **$c$ -quark decays**

$$\Gamma(c \rightarrow \ell^+ \text{anything})/\Gamma(c \rightarrow \text{anything}) = 0.096 \pm 0.004^{[\text{lo}]}$$

$$\Gamma(c \rightarrow D^*(2010)^+ \text{anything})/\Gamma(c \rightarrow \text{anything}) = 0.255 \pm 0.017$$

 **$CP$ -violation decay-rate asymmetries**

$$A_{CP}(K_S^0 K^\pm) = -0.016 \pm 0.017$$

$$A_{CP}(K_S^0 K^\pm) = 0.07 \pm 0.06$$

$$A_{CP}(K^\pm K^\mp \pi^\pm) = 0.007 \pm 0.008$$

$$A_{CP}(K^\pm K^{*0}) = 0.005 \pm 0.017$$

$$A_{CP}(\phi \pi^\pm) = -0.001 \pm 0.015$$

$$A_{CP}(\pi^+ \pi^- \pi^\pm) = -0.02 \pm 0.04$$

$$A_{CP}(K_S^0 K^\pm \pi^+ \pi^-) = -0.04 \pm 0.07$$

 **$T$ -violation decay-rate asymmetry**

$$A_T(K_S^0 K^\pm \pi^+ \pi^-) = 0.02 \pm 0.07$$

 **$D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$  form factors**

$$r_\nu = 1.62 \pm 0.08 \quad (S = 1.5)$$

$$r_2 = 0.83 \pm 0.05$$

$$r_3 = 0.0 \pm 0.4$$

$$\Gamma_L/\Gamma_T = 1.13 \pm 0.08$$

$$\Gamma_+/ \Gamma_- = 0.22 \pm 0.06 \quad (S = 1.6)$$

Most decay modes (other than the semileptonic modes) that involve a neutral  $K$  meson are now given as  $K_S^0$  modes, not as  $\bar{K}^0$  modes. Nearly always it is a  $K_S^0$  that is measured, and interference between Cabibbo-allowed and doubly Cabibbo-suppressed modes can invalidate the assumption that  $2\Gamma(K_S^0) = \Gamma(\bar{K}^0)$ .

| $D^+$ DECAY MODES                     | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|---------------------------------------|--------------------------------|-----------------------------------|----------------|
| <b>Inclusive modes</b>                |                                |                                   |                |
| $e^+$ anything                        | $(17.2 \pm 1.9)$ %             | —                                 | —              |
| $K^-$ anything                        | $(27.5 \pm 2.4)$ %             | —                                 | —              |
| $\bar{K}^0$ anything + $K^0$ anything | $(61 \pm 8)$ %                 | —                                 | —              |
| $K^+$ anything                        | $(5.5 \pm 1.6)$ %              | —                                 | —              |
| $\bar{K}^*(892)^0$ anything           | $(23 \pm 5)$ %                 | —                                 | —              |
| $K^*(892)^0$ anything                 | $< 6.6$ %                      | CL = 90%                          | —              |
| $\eta$ anything                       | [pp] $< 13$ %                  | CL = 90%                          | —              |
| $\phi$ anything                       | $< 1.8$ %                      | CL = 90%                          | —              |
| $\phi e^+$ anything                   | $< 1.6$ %                      | CL = 90%                          | —              |

**Leptonic and semileptonic modes**

|                                          |                       |                  |           |     |
|------------------------------------------|-----------------------|------------------|-----------|-----|
| $e^+ \nu_e$                              | $< 2.4$               | $\times 10^{-5}$ | CL = 90%  | 935 |
| $\mu^+ \nu_\mu$                          | $(4.4 \pm 0.7)$       | $\times 10^{-4}$ |           | 932 |
| $\bar{K}^0 e^+ \nu_e$                    | $(8.6 \pm 0.5)$       | %                |           | 868 |
| $\bar{K}^0 \mu^+ \nu_\mu$                | $(9.5 \pm 0.8)$       | %                |           | 865 |
| $K^- \pi^+ e^+ \nu_e$                    | $(4.5^{+1.0}_{-0.8})$ | %                | $S = 1.1$ | 863 |
| $\bar{K}^*(892)^0 e^+ \nu_e$             | $(3.74 \pm 0.21)$     | %                |           | 722 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ |                       |                  |           |     |
| $K^- \pi^+ e^+ \nu_e$ nonresonant        | $< 7$                 | $\times 10^{-3}$ | CL = 90%  | 863 |
| $K^- \pi^+ \mu^+ \nu_\mu$                | $(4.0 \pm 0.5)$       | %                |           | 851 |
| $\bar{K}^*(892)^0 \mu^+ \nu_\mu$         | $(3.7 \pm 0.3)$       | %                |           | 717 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$ |                       |                  |           |     |
| $K^- \pi^+ \mu^+ \nu_\mu$ nonresonant    | $(2.1 \pm 0.6)$       | $\times 10^{-3}$ |           | 851 |
| $(\bar{K}^*(892)\pi)^0 e^+ \nu_e$        | $< 1.2$               | %                | CL = 90%  | 712 |
| $(\bar{K}\pi\pi)^0 e^+ \nu_e$ non-       | $< 9$                 | $\times 10^{-3}$ | CL = 90%  | 846 |
| $\bar{K}^*(892)$                         |                       |                  |           |     |
| $K^- \pi^+ \pi^0 \mu^+ \nu_\mu$          | $< 1.7$               | $\times 10^{-3}$ | CL = 90%  | 825 |
| $\pi^0 e^+ \nu_e$                        | $(4.4 \pm 0.7)$       | $\times 10^{-3}$ |           | 930 |

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

|                                     |                                      |           |     |
|-------------------------------------|--------------------------------------|-----------|-----|
| $\bar{K}^*(892)^0 e^+ \nu_e$        | $(5.61 \pm 0.31) \%$                 | $S = 1.1$ | 722 |
| $\bar{K}^*(892)^0 \mu^+ \nu_\mu$    | $(5.5 \pm 0.5) \%$                   | $S = 1.1$ | 717 |
| $\bar{K}_1(1270)^0 \mu^+ \nu_\mu$   | $< 4 \%$                             | CL = 95%  | 493 |
| $\bar{K}_0^*(1430)^0 \mu^+ \nu_\mu$ | $< 2.5 \times 10^{-4}$               |           | 388 |
| $\bar{K}_S^*(1430)^0 \mu^+ \nu_\mu$ | $< 1.1 \%$                           | CL = 95%  | 380 |
| $\bar{K}^*(1680)^0 \mu^+ \nu_\mu$   | $< 1.6 \times 10^{-3}$               |           | 105 |
| $\rho^0 e^+ \nu_e$                  | $(2.2 \pm 0.4) \times 10^{-3}$       |           | 774 |
| $\rho^0 \mu^+ \nu_\mu$              | $(3.4 \pm 0.8) \times 10^{-3}$       |           | 770 |
| $\omega e^+ \nu_e$                  | $(1.6^{+0.7}_{-0.6}) \times 10^{-3}$ |           | 771 |
| $\phi e^+ \nu_e$                    | $< 2.09 \%$                          | CL = 90%  | 657 |
| $\phi \mu^+ \nu_\mu$                | $< 3.72 \%$                          | CL = 90%  | 651 |
| $\eta \ell^+ \nu_\ell$              | $< 7 \times 10^{-3}$                 |           | 854 |
| $\eta'(958) \mu^+ \nu_\mu$          | $< 1.1 \%$                           | CL = 90%  | 684 |

**Hadronic modes with a  $\bar{K}$  or  $\bar{K}K\bar{K}$** 

|                                                   |                          |                  |     |
|---------------------------------------------------|--------------------------|------------------|-----|
| $K_S^0 \pi^+$                                     | $(1.47 \pm 0.06)$ %      | $S = 1.1$        | 862 |
| $K^- \pi^+ \pi^+$                                 | [qq] $(9.51 \pm 0.34)$ % | $S = 1.1$        | 845 |
| $\bar{K}^*(892)^0 \pi^+$                          | [rr] $(1.33 \pm 0.11)$ % |                  | 714 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$          |                          |                  |     |
| $\bar{K}_0^*(1430)^0 \pi^+$                       | [rr] $(2.41 \pm 0.24)$ % |                  | 382 |
| $\bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$       |                          |                  |     |
| $\bar{K}^*(1680)^0 \pi^+$                         | [rr] $(4.0 \pm 0.8)$     | $\times 10^{-3}$ | 58  |
| $\bar{K}^*(1680)^0 \rightarrow K^- \pi^+$         |                          |                  |     |
| $K^- \pi^+ \pi^+$ nonresonant                     | [rr] $(9.0 \pm 0.7)$ %   |                  | 845 |
| $K_S^0 \pi^+ \pi^0$                               | [qq] $(7.0 \pm 0.5)$ %   | $S = 1.2$        | 845 |
| $K_S^0 \rho^+$                                    | $(4.8 \pm 1.1)$ %        |                  | 677 |
| $\bar{K}^*(892)^0 \pi^+$                          | $(1.3 \pm 0.6)$ %        |                  | 714 |
| $\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$        |                          |                  |     |
| $K_S^0 \pi^+ \pi^0$ nonresonant                   | $(9 \pm 7)$              | $\times 10^{-3}$ | 845 |
| $K^- \pi^+ \pi^+ \pi^0$                           | [qq] $(6.00 \pm 0.28)$ % | $S = 1.1$        | 816 |
| $\bar{K}^*(892)^0 \rho^+$ total,                  | $(1.3 \pm 0.8)$ %        |                  | 422 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$          |                          |                  |     |
| $\bar{K}_1(1400)^0 \pi^+$                         | $(1.8 \pm 0.7)$ %        |                  | 390 |
| $\bar{K}_1(1400)^0 \rightarrow K^- \pi^+ \pi^0$   |                          |                  |     |
| $K^- \rho^+ \pi^+$ total                          | $(2.6 \pm 1.6)$ %        |                  | 613 |
| $K^- \rho^+ \pi^+$ 3-body                         | $(9 \pm 6)$              | $\times 10^{-3}$ | 613 |
| $\bar{K}^*(892)^0 \pi^+ \pi^0$ total,             | $(4.2 \pm 0.6)$ %        |                  | 690 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$          |                          |                  |     |
| $\bar{K}^*(892)^0 \pi^+ \pi^0$ 3-body,            | $(2.7 \pm 0.8)$ %        |                  | 690 |
| $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$          |                          |                  |     |
| $K^*(892)^- \rightarrow K^- \pi^0$                | $(6 \pm 3)$              | $\times 10^{-3}$ | 688 |
| $K^- \pi^+ \pi^+ \pi^0$ nonresonant               | [ss] $(1.0 \pm 0.7)$ %   |                  | 816 |
| $K_S^0 \pi^+ \pi^+ \pi^-$                         | [qq] $(3.11 \pm 0.21)$ % | $S = 1.1$        | 814 |
| $K_S^0 a_1(1260)^+$                               | $(1.8 \pm 0.3)$ %        |                  | 328 |
| $a_1(1260)^+ \rightarrow \pi^+ \pi^+ \pi^-$       |                          |                  |     |
| $\bar{K}_1(1400)^0 \pi^+$                         | $(1.8 \pm 0.7)$ %        |                  | 390 |
| $\bar{K}_1(1400)^0 \rightarrow K_S^0 \pi^+ \pi^-$ |                          |                  |     |
| $K^*(892)^- \pi^+ \pi^+$ 3-body,                  | $(1.3 \pm 0.6)$ %        |                  | 688 |
| $K^*(892)^- \rightarrow K_S^0 \pi^-$              |                          |                  |     |
| $K_S^0 \rho^0 \pi^+$ total                        | $(1.86 \pm 0.34)$ %      | CL = 90%         | 610 |
| $K_S^0 \rho^0 \pi^+$ 3-body                       | $(2.2 \pm 2.2)$          | $\times 10^{-3}$ | 610 |
| $K_S^0 \pi^+ \pi^+ \pi^-$ nonresonant             | $(3.7 \pm 1.9)$          | $\times 10^{-3}$ | 814 |

|                                         |        |                                  |           |     |
|-----------------------------------------|--------|----------------------------------|-----------|-----|
| $K^- 3\pi^+\pi^-$                       | $[qq]$ | $(5.8 \pm 0.6) \times 10^{-3}$   | $S = 1.1$ | 772 |
| $\bar{K}^*(892)^0 \pi^+\pi^+\pi^-$      |        | $(1.2 \pm 0.4) \times 10^{-3}$   |           | 645 |
| $\bar{K}^*(892)^0 \rightarrow K^-\pi^+$ |        |                                  |           |     |
| $\bar{K}^*(892)^0 \rho^0 \pi^+$         |        | $(2.3 \pm 0.4) \times 10^{-3}$   |           | 239 |
| $\bar{K}^*(892)^0 \rightarrow K^-\pi^+$ |        |                                  |           |     |
| $K^-\rho^0 \pi^+\pi^+$                  |        | $(1.75 \pm 0.29) \times 10^{-3}$ |           | 524 |
| $K^- 3\pi^+\pi^-$ nonresonant           |        | $(4.1 \pm 3.0) \times 10^{-4}$   |           | 772 |
| $K^+ 2K_S^0$                            |        | $(4.7 \pm 2.1) \times 10^{-3}$   |           | 545 |
| $K^+ K^- \bar{K}_S^0 \pi^+$             |        | $(2.4 \pm 0.6) \times 10^{-4}$   |           | 435 |

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

|                                               |        |                                |                           |     |
|-----------------------------------------------|--------|--------------------------------|---------------------------|-----|
| $K_S^0 a_1(1260)^+$                           |        | $(3.6 \pm 0.6) \%$             |                           | 328 |
| $K_S^0 a_2(1320)^+$                           |        | $< 1.5$                        | $\times 10^{-3}$ CL = 90% | 199 |
| $\bar{K}^*(892)^0 \rho^+$ total               | $[ss]$ | $(1.8 \pm 1.4) \%$             |                           | 422 |
| $\bar{K}^*(892)^0 \rho^+$ S-wave              | $[ss]$ | $(1.4 \pm 1.5) \%$             |                           | 422 |
| $\bar{K}^*(892)^0 \rho^+$ P-wave              |        | $< 1$                          | $\times 10^{-3}$ CL = 90% | 422 |
| $\bar{K}^*(892)^0 \rho^+$ D-wave              |        | $(8 \pm 7)$                    | $\times 10^{-3}$          | 422 |
| $\bar{K}^*(892)^0 \rho^+$ D-wave longitudinal |        | $< 7$                          | $\times 10^{-3}$ CL = 90% | 422 |
| $\bar{K}_1(1270) \pi^+$                       |        | $< 7$                          | $\times 10^{-3}$ CL = 90% | 487 |
| $\bar{K}_1(1400) \pi^+$                       |        | $(4.3 \pm 1.5) \%$             | $S = 1.2$                 | 390 |
| $\bar{K}^*(892)^0 \pi^+\pi^0$ total           |        | $(5.8 \pm 2.9) \%$             |                           | 690 |
| $\bar{K}^*(892)^0 \pi^+\pi^0$ 3-body          | $[ss]$ | $(3.6 \pm 2.1) \%$             |                           | 690 |
| $K^*(892)^-\pi^+\pi^+$ total                  |        | —                              |                           | 688 |
| $K^*(892)^-\pi^+\pi^+$ 3-body                 |        | $(1.8^{+1.1}_{-0.9}) \%$       | $S = 1.2$                 | 688 |
| $\bar{K}^*(892)^0 a_1(1260)^+$                |        | $(9.4 \pm 1.9) \times 10^{-3}$ |                           | †   |

#### Pionic modes

|                                                    |  |                                  |                           |     |
|----------------------------------------------------|--|----------------------------------|---------------------------|-----|
| $\pi^+\pi^0$                                       |  | $(1.28 \pm 0.09) \times 10^{-3}$ |                           | 925 |
| $\pi^+\pi^+\pi^-$                                  |  | $(3.31 \pm 0.21) \times 10^{-3}$ |                           | 908 |
| $\rho^0 \pi^+$                                     |  | $(1.07 \pm 0.11) \times 10^{-3}$ |                           | 766 |
| $\pi^+(\pi^+\pi^-)_{S\text{-wave}}$                |  | $(1.86 \pm 0.18) \times 10^{-3}$ |                           | 908 |
| $\sigma \pi^+, \sigma \rightarrow \pi^+\pi^-$      |  | $(1.53 \pm 0.32) \times 10^{-3}$ |                           | —   |
| $f_0(980) \pi^+, f_0(980) \rightarrow \pi^+\pi^-$  |  | $(2.1 \pm 0.5) \times 10^{-4}$   |                           | 669 |
| $f_0(1370) \pi^+$                                  |  | $(8 \pm 6) \times 10^{-5}$       |                           | —   |
| $f_0(1370) \rightarrow \pi^+\pi^-$                 |  |                                  |                           |     |
| $f_2(1270) \pi^+$                                  |  | $(4.8 \pm 1.3) \times 10^{-4}$   |                           | 485 |
| $f_2(1270) \rightarrow \pi^+\pi^-$                 |  |                                  |                           |     |
| $\pi^+ 2\pi^0$                                     |  | $(4.8 \pm 0.4) \times 10^{-3}$   |                           | 910 |
| $\pi^+\pi^+\pi^-\pi^0$                             |  | $(1.18 \pm 0.09) \%$             |                           | 883 |
| $\eta \pi^+, \eta \rightarrow \pi^+\pi^-\pi^0$     |  | $(7.9 \pm 0.7) \times 10^{-4}$   |                           | 848 |
| $\omega \pi^+, \omega \rightarrow \pi^+\pi^-\pi^0$ |  | $< 3$                            | $\times 10^{-4}$ CL = 90% | 763 |
| $3\pi^+ 2\pi^-$                                    |  | $(1.68 \pm 0.17) \times 10^{-3}$ | $S = 1.1$                 | 845 |

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

|                     |  |                                  |                           |     |
|---------------------|--|----------------------------------|---------------------------|-----|
| $\eta \pi^+$        |  | $(3.50 \pm 0.32) \times 10^{-3}$ |                           | 848 |
| $\omega \pi^+$      |  | $< 3.4$                          | $\times 10^{-4}$ CL = 90% | 763 |
| $\eta \rho^+$       |  | $< 7$                            | $\times 10^{-3}$ CL = 90% | 655 |
| $\eta'(958) \pi^+$  |  | $(5.3 \pm 1.1) \times 10^{-3}$   |                           | 680 |
| $\eta'(958) \rho^+$ |  | $< 6$                            | $\times 10^{-3}$ CL = 90% | 348 |

#### Hadronic modes with a $K\bar{K}$ pair

|                                                                      |        |                                  |                           |     |
|----------------------------------------------------------------------|--------|----------------------------------|---------------------------|-----|
| $K^+ K_S^0$                                                          |        | $(2.96 \pm 0.19) \times 10^{-3}$ |                           | 792 |
| $K^+ K^- \pi^+$                                                      | $[qq]$ | $(1.00 \pm 0.04) \%$             | $S = 1.2$                 | 744 |
| $\phi \pi^+, \phi \rightarrow K^+ K^-$                               |        | $(3.2 \pm 0.4) \times 10^{-3}$   |                           | 647 |
| $K^+ \bar{K}^*(892)^0$                                               |        | $(3.02 \pm 0.35) \times 10^{-3}$ |                           | 613 |
| $\bar{K}^*(892)^0 \rightarrow K^-\pi^+$                              |        |                                  |                           |     |
| $K^+ \bar{K}_S^0(1430)^0$                                            |        | $(3.7 \pm 0.4) \times 10^{-3}$   |                           | —   |
| $\bar{K}_S^0(1430)^0 \rightarrow K^-\pi^+$                           |        |                                  |                           |     |
| $K_S^0 K_S^0 \pi^+$                                                  |        | —                                |                           | 741 |
| $K^*(892)^+ K_S^0$                                                   |        | $(5.3 \pm 2.3) \times 10^{-3}$   |                           | 611 |
| $K^*(892)^+ \rightarrow K_S^0 \pi^+$                                 |        |                                  |                           |     |
| $K^+ K^- \pi^+ \pi^0$                                                |        | —                                |                           | 682 |
| $\phi \pi^+ \pi^0, \phi \rightarrow K^+ K^-$                         |        | $(1.1 \pm 0.5) \%$               |                           | 619 |
| $\phi \rho^+, \phi \rightarrow K^+ K^-$                              |        | $< 7$                            | $\times 10^{-3}$ CL = 90% | 258 |
| $K^+ K^- \pi^+ \pi^0$ non- $\phi$                                    |        | $(1.5^{+0.7}_{-0.6}) \%$         |                           | 682 |
| $K^+ K_S^0 \pi^+ \pi^-$                                              |        | $(1.75 \pm 0.21) \times 10^{-3}$ |                           | 678 |
| $K_S^0 K^- \pi^+ \pi^+$                                              |        | $(2.39 \pm 0.23) \times 10^{-3}$ |                           | 678 |
| $K^*(892)^+ \bar{K}^*(892)^0$                                        |        | $(5.8 \pm 2.4) \times 10^{-3}$   |                           | 280 |
| $K^{*+} \rightarrow K_S^0 \pi^+, \bar{K}^{*0} \rightarrow K^- \pi^+$ |        |                                  |                           |     |
| $K_S^0 K^- \pi^+ \pi^+$                                              |        | $< 4$                            | $\times 10^{-3}$ CL = 90% | 678 |
| (non- $K^{*+} \bar{K}^{*0}$ )                                        |        |                                  |                           |     |
| $K^+ K^- \pi^+ \pi^+ \pi^-$                                          |        | $(2.3 \pm 1.2) \times 10^{-4}$   |                           | 600 |

|                                                                                                                                |  |                                |              |
|--------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------|--------------|
| Fractions of the following modes with resonances have already appeared above as submodes of particular charged-particle modes. |  |                                |              |
| $\phi \pi^+$                                                                                                                   |  | $(6.5 \pm 0.7) \times 10^{-3}$ | 647          |
| $\phi \pi^+ \pi^0$                                                                                                             |  | $(2.3 \pm 1.0) \%$             | 619          |
| $\phi \rho^+$                                                                                                                  |  | $< 1.5 \%$                     | CL = 90% 259 |
| $K^*(892)^+ K_S^0$                                                                                                             |  | $(1.6 \pm 0.7) \%$             | 611          |
| $K^*(892)^+ \bar{K}^*(892)^0$                                                                                                  |  | $(2.6 \pm 1.1) \%$             | 280          |

#### Doubly Cabibbo-suppressed modes

|                                                  |  |                                |                           |     |
|--------------------------------------------------|--|--------------------------------|---------------------------|-----|
| $K^+ \pi^0$                                      |  | $< 4.2$                        | $\times 10^{-4}$ CL = 90% | 864 |
| $K^+ \pi^+ \pi^-$                                |  | $(6.4 \pm 0.8) \times 10^{-4}$ |                           | 845 |
| $K^+ \rho^0$                                     |  | $(2.5 \pm 0.7) \times 10^{-4}$ |                           | 678 |
| $K^*(892)^0 \pi^+$                               |  | $(3.0 \pm 0.6) \times 10^{-4}$ |                           | 714 |
| $K^*(892)^0 \rightarrow K^+ \pi^-$               |  |                                |                           |     |
| $K^+ f_0(980), f_0(980) \rightarrow \pi^+ \pi^-$ |  | $(5.7 \pm 3.5) \times 10^{-5}$ |                           | —   |
| $K_S^0(1430) \pi^+$                              |  | $(5.2 \pm 3.5) \times 10^{-5}$ |                           | —   |
| $K_S^0(1430)^0 \rightarrow K^+ \pi^-$            |  |                                |                           |     |
| $K^+ K^+ K^-$                                    |  | $(9.0 \pm 2.1) \times 10^{-5}$ |                           | 550 |

#### $\Delta C = 1$ weak neutral current (C1) modes, or Lepton Family number (LF) or Lepton number (L) violating modes

|                                        |        |                                      |                           |     |
|----------------------------------------|--------|--------------------------------------|---------------------------|-----|
| $\pi^+ e^+ e^-$                        | C1     | $< 7.4$                              | $\times 10^{-6}$ CL = 90% | 929 |
| $\pi^+ \phi, \phi \rightarrow e^+ e^-$ | $[tt]$ | $(2.7^{+3.6}_{-1.8}) \times 10^{-6}$ |                           | —   |
| $\pi^+ \mu^+ \mu^-$                    | C1     | $< 8.8$                              | $\times 10^{-6}$ CL = 90% | 917 |
| $\rho^+ \mu^+ \mu^-$                   | C1     | $< 5.6$                              | $\times 10^{-4}$ CL = 90% | 757 |
| $K^+ e^+ e^-$                          | $[uu]$ | $< 6.2$                              | $\times 10^{-6}$ CL = 90% | 869 |
| $K^+ \mu^+ \mu^-$                      | $[uu]$ | $< 9.2$                              | $\times 10^{-6}$ CL = 90% | 856 |
| $\pi^+ e^\pm \mu^\mp$                  | LF     | $[gg] < 3.4$                         | $\times 10^{-5}$ CL = 90% | 926 |
| $K^+ e^\pm \mu^\mp$                    | LF     | $[gg] < 6.8$                         | $\times 10^{-5}$ CL = 90% | 866 |
| $\pi^- e^+ e^+$                        | L      | $< 3.6$                              | $\times 10^{-6}$ CL = 90% | 929 |
| $\pi^- \mu^+ \mu^+$                    | L      | $< 4.8$                              | $\times 10^{-6}$ CL = 90% | 917 |
| $\pi^- e^+ \mu^+$                      | L      | $< 5.0$                              | $\times 10^{-5}$ CL = 90% | 926 |
| $\rho^- \mu^+ \mu^+$                   | L      | $< 5.6$                              | $\times 10^{-4}$ CL = 90% | 757 |
| $K^- e^+ e^+$                          | L      | $< 4.5$                              | $\times 10^{-6}$ CL = 90% | 869 |
| $K^- \mu^+ \mu^+$                      | L      | $< 1.3$                              | $\times 10^{-5}$ CL = 90% | 856 |
| $K^- e^+ \mu^+$                        | L      | $< 1.3$                              | $\times 10^{-4}$ CL = 90% | 866 |
| $K^*(892)^- \mu^+ \mu^+$               | L      | $< 8.5$                              | $\times 10^{-4}$ CL = 90% | 703 |

$D^0$

$$I(J^P) = \frac{1}{2}(0^-)$$

Mass  $m = 1864.5 \pm 0.4$  MeV ( $S = 1.1$ )  
 $m_{D^\pm} - m_{D^0} = 4.78 \pm 0.10$  MeV ( $S = 1.1$ )  
Mean life  $\tau = (410.1 \pm 1.5) \times 10^{-15}$  s  
 $c\tau = 122.9$   $\mu\text{m}$   
 $|m_{D_1^0} - m_{D_2^0}| < 7 \times 10^{10} \hbar s^{-1}$ , CL = 95%<sup>[vv]</sup>  
 $(\Gamma_{D_1^0} - \Gamma_{D_2^0})/\Gamma = 2\gamma = (1.4 \pm 1.0) \times 10^{-2}$   
 $\Gamma(K^+ \ell^- \bar{\nu}_\ell \text{ (via } \bar{D}^0))/\Gamma(K^- \ell^+ \nu_\ell) < 0.005$ , CL = 90%  
 $\Gamma(K^+ \pi^- \text{ (via } \bar{D}^0))/\Gamma(K^- \pi^+) < 4.0 \times 10^{-4}$ , CL = 95%  
 $\Gamma(K_S^0 \pi^+ \pi^- \text{ (in } D^0 \rightarrow \bar{D}^0))/\Gamma(K_S^0 \pi^+ \pi^-) \Gamma_0/\Gamma_0 < 0.0063$ , CL = 95%

#### CP-violation decay-rate asymmetries

$A_{CP}(K^+ K^-) = 0.014 \pm 0.010$   
 $A_{CP}(K_S^0 K_S^0) = -0.23 \pm 0.19$   
 $A_{CP}(\pi^+ \pi^-) = 0.013 \pm 0.012$   
 $A_{CP}(\pi^0 \pi^0) = 0.00 \pm 0.05$   
 $A_{CP}(\pi^+ \pi^- \pi^0) = 0.01^{+0.10}_{-0.09}$   
 $A_{CP}(K_S^0 \phi) = -0.03 \pm 0.09$   
 $A_{CP}(K_S^0 \pi^0) = 0.001 \pm 0.013$   
 $A_{CP}(K^\pm \pi^\mp) = 0.05 \pm 0.04$   
 $A_{CP}(K^\mp \pi^\pm \pi^0) = -0.03 \pm 0.09$   
 $A_{CP}(K^\pm \pi^\mp \pi^0) = 0.00 \pm 0.05$   
 $A_{CP}(K_S^0 \pi^+ \pi^-) = -0.009^{+0.026}_{-0.061}$   
 $A_{CP}(K^\pm \pi^\mp \pi^+ \pi^-) = -0.02 \pm 0.04$   
 $A_{CP}(K^+ K^- \pi^+ \pi^-) = -0.08 \pm 0.07$

#### T-violation decay-rate asymmetry

$A_T(K^+ K^- \pi^+ \pi^-) = 0.01 \pm 0.07$

#### CPT-violation decay-rate asymmetry

$A_{CPT}(K^\mp \pi^\pm) = 0.008 \pm 0.008$



Most decay modes (other than the semileptonic modes) that involve a neutral  $K$  meson are now given as  $K_S^0$  modes, not as  $\bar{K}^0$  modes. Nearly always it is a  $K_S^0$  that is measured, and interference between Cabibbo-allowed and doubly Cabibbo-suppressed modes can invalidate the assumption that  $2\Gamma(K_S^0) = \Gamma(\bar{K}^0)$ .

| $D^*$ DECAY MODES                                                      | Fraction ( $\Gamma_i/\Gamma$ )                                 | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------|----------------|
| <b>Topological modes</b>                                               |                                                                |                                   |                |
| 0-prongs                                                               | [ $ww$ ] (19 ± 6) %                                            | —                                 | —              |
| 2-prongs                                                               | (67 ± 6) %                                                     | —                                 | —              |
| 4-prongs                                                               | [ $xx$ ] (13.8 ± 0.5) %                                        | —                                 | —              |
| 6-prongs                                                               | (1.2 <sup>+1.3</sup> <sub>-0.7</sub> ) × 10 <sup>-3</sup>      | —                                 | —              |
| <b>Inclusive modes</b>                                                 |                                                                |                                   |                |
| $e^+$ anything                                                         | [ $yy$ ] (6.71 ± 0.29) %                                       | —                                 | —              |
| $\mu^+$ anything                                                       | (6.5 ± 0.7) %                                                  | —                                 | —              |
| $K^-$ anything                                                         | (53 ± 4) %                                                     | S = 1.3                           | —              |
| $\bar{K}^0$ anything + $K^0$                                           | (42 ± 5) %                                                     | —                                 | —              |
| anything                                                               | —                                                              | —                                 | —              |
| $K^+$ anything                                                         | (3.4 <sup>+0.6</sup> <sub>-0.4</sub> ) %                       | —                                 | —              |
| $\bar{K}^*(892)^0$ anything                                            | (9 ± 4) %                                                      | —                                 | —              |
| $K^*(892)^0$ anything                                                  | (2.8 ± 1.3) %                                                  | —                                 | —              |
| $\eta$ anything                                                        | [ $pp$ ] < 13 %                                                | CL = 90%                          | —              |
| $\phi$ anything                                                        | (1.7 ± 0.8) %                                                  | —                                 | —              |
| <b>Semileptonic modes</b>                                              |                                                                |                                   |                |
| $K^- e^+ \nu_e$                                                        | (3.51 ± 0.11) %                                                | —                                 | 867            |
| $K^- \mu^+ \nu_\mu$                                                    | (3.19 ± 0.16) %                                                | —                                 | 863            |
| $K^*(892)^- e^+ \nu_e$                                                 | (2.17 ± 0.16) %                                                | —                                 | 719            |
| $K^*(892)^- \mu^+ \nu_\mu$                                             | (1.95 ± 0.25) %                                                | —                                 | 714            |
| $K^- \pi^+ \pi^- \mu^+ \nu_\mu$                                        | < 1.2 × 10 <sup>-3</sup> CL = 90%                              | —                                 | 821            |
| ( $\bar{K}^*(892)\pi^-$ ) $^- \mu^+ \nu_\mu$                           | < 1.4 × 10 <sup>-3</sup> CL = 90%                              | —                                 | 692            |
| $\pi^- e^+ \nu_e$                                                      | (2.81 ± 0.19) × 10 <sup>-3</sup>                               | —                                 | 927            |
| $\pi^- \mu^+ \nu_\mu$                                                  | (2.4 ± 0.4) × 10 <sup>-3</sup>                                 | —                                 | 924            |
| $\rho^- e^+ \nu_e$                                                     | (1.9 ± 0.4) × 10 <sup>-3</sup>                                 | —                                 | 771            |
| <b>Hadronic modes with one <math>\bar{K}</math></b>                    |                                                                |                                   |                |
| $K^- \pi^+$                                                            | (3.80 ± 0.07) %                                                | S = 1.1                           | 861            |
| $K_S^0 \pi^0$                                                          | (1.14 ± 0.12) %                                                | —                                 | 860            |
| $K_S^0 \pi^+ \pi^-$                                                    | [ $qq$ ] (2.90 ± 0.19) %                                       | —                                 | 842            |
| $K_S^0 \rho^0$                                                         | (7.5 <sup>+0.6</sup> <sub>-0.8</sub> ) × 10 <sup>-3</sup>      | —                                 | 674            |
| $K_S^0 \omega, \omega \rightarrow \pi^+ \pi^-$                         | (2.1 ± 0.6) × 10 <sup>-4</sup>                                 | —                                 | 670            |
| $K_S^0 f_0(980), f_0(980) \rightarrow \pi^+ \pi^-$                     | (1.36 <sup>+0.30</sup> <sub>-0.22</sub> ) × 10 <sup>-3</sup>   | —                                 | 549            |
| $K_S^0 f_2(1270), f_2(1270) \rightarrow \pi^+ \pi^-$                   | (1.3 <sup>+1.1</sup> <sub>-0.7</sub> ) × 10 <sup>-4</sup>      | —                                 | 262            |
| $K_S^0 f_0(1370), f_0(1370) \rightarrow \pi^+ \pi^-$                   | (2.5 ± 0.6) × 10 <sup>-3</sup>                                 | †                                 | —              |
| $K^*(892)^- \pi^+, K^*(892)^- \rightarrow K_S^0 \pi^-$                 | (1.91 ± 0.14) %                                                | —                                 | 711            |
| $K^*(892)^+ \pi^-, K^*(892)^+ \rightarrow K_S^0 \pi^+$                 | [ $zz$ ] (10 <sup>+12</sup> <sub>-4</sub> ) × 10 <sup>-5</sup> | —                                 | 711            |
| $K_0^*(1430)^- \pi^+, K_0^*(1430)^- \rightarrow K_S^0 \pi^-$           | (2.8 <sup>+0.6</sup> <sub>-0.4</sub> ) × 10 <sup>-3</sup>      | —                                 | 378            |
| $K_2^*(1430)^- \pi^+, K_2^*(1430)^- \rightarrow K_S^0 \pi^-$           | (3.2 <sup>+2.1</sup> <sub>-1.1</sub> ) × 10 <sup>-4</sup>      | —                                 | 367            |
| $K^*(1680)^- \pi^+, K^*(1680)^- \rightarrow K_S^0 \pi^-$               | (6 ± 5) × 10 <sup>-4</sup>                                     | —                                 | 46             |
| $K_S^0 \pi^+ \pi^-$ nonresonant                                        | (2.6 <sup>+5.9</sup> <sub>-1.6</sub> ) × 10 <sup>-4</sup>      | —                                 | 842            |
| $K^- \pi^+ \pi^0$                                                      | [ $qq$ ] (14.1 ± 0.5) %                                        | S = 1.2                           | 844            |
| $K^- \rho^+$                                                           | (11.0 ± 0.7) %                                                 | —                                 | 675            |
| $K^- \rho(1700)^+, \rho(1700)^+ \rightarrow \pi^+ \pi^0$               | (8.0 ± 1.7) × 10 <sup>-3</sup>                                 | †                                 | —              |
| $K^*(892)^- \pi^+, K^*(892)^- \rightarrow K^- \pi^0$                   | (2.25 <sup>+0.36</sup> <sub>-0.20</sub> ) %                    | —                                 | 711            |
| $\bar{K}^*(892)^0 \pi^0, \bar{K}^*(892)^0 \rightarrow K^- \pi^+$       | (1.91 ± 0.24) %                                                | —                                 | 711            |
| $K_0^*(1430)^- \pi^+, K_0^*(1430)^- \rightarrow K^- \pi^0$             | (4.6 ± 2.2) × 10 <sup>-3</sup>                                 | —                                 | 378            |
| $\bar{K}_0^*(1430)^0 \pi^0, \bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$ | (5.8 <sup>+4.6</sup> <sub>-1.5</sub> ) × 10 <sup>-3</sup>      | —                                 | 379            |
| $K^*(1680)^- \pi^+, K^*(1680)^- \rightarrow K^- \pi^0$                 | (1.8 ± 0.7) × 10 <sup>-3</sup>                                 | —                                 | 46             |

|                                                                                                                                                                                                                                           |                                                           |          |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|----------|-----|
| $K^- \pi^+ \pi^0$ nonresonant                                                                                                                                                                                                             | (1.13 <sup>+0.54</sup> <sub>-0.20</sub> ) %               | —        | 844 |
| $K_S^0 \pi^0 \pi^0$                                                                                                                                                                                                                       | —                                                         | —        | 843 |
| $\bar{K}^*(892)^0 \pi^0, \bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$                                                                                                                                                                        | (6.3 <sup>+1.8</sup> <sub>-1.5</sub> ) × 10 <sup>-3</sup> | —        | 711 |
| $K_S^0 \pi^0 \pi^0$ nonresonant                                                                                                                                                                                                           | [ $qq$ ] (4.2 ± 1.1) × 10 <sup>-3</sup>                   | S = 1.3  | 843 |
| $K^- \pi^+ \pi^+ \pi^-$                                                                                                                                                                                                                   | (7.72 ± 0.28) %                                           | —        | 812 |
| $K^- \pi^+ \rho^0$ total                                                                                                                                                                                                                  | (6.4 ± 0.4) %                                             | —        | 609 |
| $K^- \pi^+ \rho^0$ 3-body                                                                                                                                                                                                                 | (4.9 ± 2.2) × 10 <sup>-3</sup>                            | —        | 609 |
| $\bar{K}^*(892)^0 \rho^0, \bar{K}^*(892)^0 \rightarrow K^- \pi^+$                                                                                                                                                                         | (1.00 ± 0.22) %                                           | —        | 416 |
| $K^- a_1(1260)^+, a_1(1260)^+ \rightarrow \pi^+ \pi^+ \pi^-$                                                                                                                                                                              | (3.6 ± 0.6) %                                             | —        | 327 |
| $\bar{K}^*(892)^0 \pi^+ \pi^-$ total, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$                                                                                                                                                            | (1.5 ± 0.4) %                                             | —        | 685 |
| $\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$                                                                                                                                                           | (9.7 ± 2.1) × 10 <sup>-3</sup>                            | —        | 685 |
| $K_1(1270)^- \pi^+, K_1(1270)^- \rightarrow K^- \pi^+ \pi^-$                                                                                                                                                                              | [ $ss$ ] (2.9 ± 0.3) × 10 <sup>-3</sup>                   | —        | 484 |
| $K^- \pi^+ \pi^+ \pi^-$ nonresonant                                                                                                                                                                                                       | (1.80 ± 0.25) %                                           | —        | 812 |
| $K_S^0 \pi^+ \pi^- \pi^0$                                                                                                                                                                                                                 | [ $qq$ ] (5.3 ± 0.6) %                                    | —        | 812 |
| $K_S^0 \eta, \eta \rightarrow \pi^+ \pi^- \pi^0$                                                                                                                                                                                          | (8.6 ± 1.4) × 10 <sup>-4</sup>                            | —        | 772 |
| $K_S^0 \omega, \omega \rightarrow \pi^+ \pi^- \pi^0$                                                                                                                                                                                      | (9.8 ± 1.8) × 10 <sup>-3</sup>                            | —        | 670 |
| $K^*(892)^- \rho^+, K^*(892)^- \rightarrow K_S^0 \pi^-$                                                                                                                                                                                   | (2.1 ± 0.8) %                                             | —        | 416 |
| $K_1(1270)^- \pi^+, K_1(1270)^- \rightarrow K_S^0 \pi^-$                                                                                                                                                                                  | [ $ss$ ] (2.2 ± 0.6) × 10 <sup>-3</sup>                   | —        | 484 |
| $\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body, $\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$                                                                                                                                                         | (2.4 ± 0.5) × 10 <sup>-3</sup>                            | —        | 685 |
| $K_S^0 \pi^+ \pi^- \pi^0$ nonresonant                                                                                                                                                                                                     | (1.1 ± 1.1) %                                             | —        | 812 |
| $K^- \pi^+ \pi^+ \pi^0$                                                                                                                                                                                                                   | (4.1 ± 0.4) %                                             | —        | 771 |
| $\bar{K}^*(892)^0 \pi^+ \pi^- \pi^0, \bar{K}^*(892)^0 \rightarrow K^- \pi^+$                                                                                                                                                              | (1.2 ± 0.6) %                                             | —        | 643 |
| $K^- \pi^+ \omega, \omega \rightarrow \pi^+ \pi^- \pi^0$                                                                                                                                                                                  | (2.7 ± 0.5) %                                             | —        | 605 |
| $\bar{K}^*(892)^0 \omega, \bar{K}^*(892)^0 \rightarrow K^- \pi^+, \omega \rightarrow \pi^+ \pi^- \pi^0$                                                                                                                                   | (6.5 ± 2.4) × 10 <sup>-3</sup>                            | —        | 410 |
| $K_S^0 \eta \pi^0$                                                                                                                                                                                                                        | (5.2 ± 1.2) × 10 <sup>-3</sup>                            | —        | 721 |
| $K_S^0 a_0(980), a_0(980) \rightarrow \eta \pi^0$                                                                                                                                                                                         | (6.2 ± 2.0) × 10 <sup>-3</sup>                            | —        | —   |
| $\bar{K}^*(892)^0 \eta, \bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$                                                                                                                                                                         | (1.5 ± 0.5) × 10 <sup>-3</sup>                            | —        | —   |
| $K_S^0 2\pi^+ 2\pi^-$                                                                                                                                                                                                                     | (2.75 ± 0.31) × 10 <sup>-3</sup>                          | —        | 768 |
| $K_S^0 \rho^0 \pi^+ \pi^-, \text{no } K^*(892)^-$                                                                                                                                                                                         | (1.1 ± 0.7) × 10 <sup>-3</sup>                            | —        | —   |
| $K^*(892)^- \pi^+ \pi^+ \pi^-, K^*(892)^- \rightarrow K_S^0 \pi^-, \text{no } \rho^0$                                                                                                                                                     | (5 ± 8) × 10 <sup>-4</sup>                                | —        | 642 |
| $K^*(892)^- \rho^0 \pi^+, K^*(892)^- \rightarrow K_S^0 \pi^-$                                                                                                                                                                             | (1.7 ± 0.7) × 10 <sup>-3</sup>                            | —        | 230 |
| $K_S^0 2\pi^+ 2\pi^-$ nonresonant                                                                                                                                                                                                         | < 1.3 × 10 <sup>-3</sup> CL = 90%                         | —        | 768 |
| $K^- 3\pi^+ 2\pi^-$                                                                                                                                                                                                                       | (2.1 ± 0.5) × 10 <sup>-4</sup>                            | —        | 713 |
| Fractions of many of the following modes with resonances have already appeared above as submodes of particular charged-particle modes. (Modes for which there are only upper limits and $\bar{K}^*(892)\rho$ submodes only appear below.) |                                                           |          |     |
| $K_S^0 \eta$                                                                                                                                                                                                                              | (3.8 ± 0.6) × 10 <sup>-3</sup>                            | —        | 772 |
| $K_S^0 \omega$                                                                                                                                                                                                                            | (1.10 ± 0.20) %                                           | —        | 670 |
| $K_S^0 \eta'(958)$                                                                                                                                                                                                                        | (9.1 ± 1.4) × 10 <sup>-3</sup>                            | —        | 565 |
| $K^- a_1(1260)^+$                                                                                                                                                                                                                         | (7.5 ± 1.1) %                                             | —        | 327 |
| $\bar{K}^0 a_1(1260)^0$                                                                                                                                                                                                                   | < 1.9 %                                                   | CL = 90% | 322 |
| $K^- a_2(1320)^+$                                                                                                                                                                                                                         | < 2 × 10 <sup>-3</sup> CL = 90%                           | —        | 197 |
| $\bar{K}^*(892)^0 \pi^+ \pi^-$ total                                                                                                                                                                                                      | (2.3 ± 0.5) %                                             | —        | 685 |
| $\bar{K}^*(892)^0 \pi^+ \pi^-$ 3-body                                                                                                                                                                                                     | (1.46 ± 0.32) %                                           | —        | 685 |
| $\bar{K}^*(892)^0 \rho^0$                                                                                                                                                                                                                 | (1.50 ± 0.33) %                                           | —        | 417 |
| $\bar{K}^*(892)^0 \rho^0$ transverse                                                                                                                                                                                                      | (1.6 ± 0.5) %                                             | —        | 417 |
| $\bar{K}^*(892)^0 \rho^0$ S-wave                                                                                                                                                                                                          | (2.9 ± 0.6) %                                             | —        | 417 |
| $\bar{K}^*(892)^0 \rho^0$ S-wave long.                                                                                                                                                                                                    | < 3 × 10 <sup>-3</sup> CL = 90%                           | —        | 417 |
| $\bar{K}^*(892)^0 \rho^0$ P-wave                                                                                                                                                                                                          | < 3 × 10 <sup>-3</sup> CL = 90%                           | —        | 417 |
| $\bar{K}^*(892)^0 \rho^0$ D-wave                                                                                                                                                                                                          | (2.0 ± 0.6) %                                             | —        | 417 |
| $K^*(892)^- \rho^+$                                                                                                                                                                                                                       | (6.4 ± 2.5) %                                             | —        | 417 |
| $K^*(892)^- \rho^+$ longitudinal                                                                                                                                                                                                          | (3.1 ± 1.2) %                                             | —        | 417 |
| $K^*(892)^- \rho^+$ transverse                                                                                                                                                                                                            | (3.4 ± 2.0) %                                             | —        | 417 |
| $K^*(892)^- \rho^+$ P-wave                                                                                                                                                                                                                | < 1.5 %                                                   | CL = 90% | 417 |
| $K_1(1270)^- \pi^+$                                                                                                                                                                                                                       | [ $ss$ ] (1.12 ± 0.31) %                                  | —        | 484 |
| $K_1(1400)^- \pi^+$                                                                                                                                                                                                                       | < 1.2 %                                                   | CL = 90% | 386 |

|                                      |             |                  |          |     |
|--------------------------------------|-------------|------------------|----------|-----|
| $\bar{K}_1(1400)^0 \pi^0$            | < 3.7       | %                | CL = 90% | 387 |
| $\bar{K}^*(892)^0 \pi^+ \pi^- \pi^0$ | (1.8 ± 0.9) | %                |          | 643 |
| $K^- \pi^+ \omega$                   | (3.0 ± 0.6) | %                |          | 605 |
| $\bar{K}^*(892)^0 \omega$            | (1.1 ± 0.4) | %                |          | 410 |
| $K^- \pi^+ \eta'(958)$               | (7.2 ± 1.8) | $\times 10^{-3}$ |          | 479 |
| $\bar{K}^*(892)^0 \eta'(958)$        | < 1.1       | $\times 10^{-3}$ | CL = 90% | 118 |

Hadronic modes with three  $K$ 's

|                                                                                           |               |                  |          |     |
|-------------------------------------------------------------------------------------------|---------------|------------------|----------|-----|
| $K_S^0 K^+ K^-$                                                                           | (4.58 ± 0.34) | $\times 10^{-3}$ |          | 544 |
| $K_S^0 a_0(980)^0, a_0^0 \rightarrow K^+ K^-$                                             | (3.0 ± 0.4)   | $\times 10^{-3}$ |          | —   |
| $K^- a_0(980)^+, a_0^0 \rightarrow K^+ K_S^0$                                             | (6.1 ± 1.8)   | $\times 10^{-4}$ |          | —   |
| $K^+ a_0(980)^-, a_0^0 \rightarrow K^- K_S^0$                                             | < 1.1         | $\times 10^{-4}$ | CL = 95% | —   |
| $K_S^0 f_0(980), f_0 \rightarrow K^+ K^-$                                                 | < 1.0         | $\times 10^{-4}$ | CL = 95% | —   |
| $K_S^0 \phi, \phi \rightarrow K^+ K^-$                                                    | (2.10 ± 0.16) | $\times 10^{-3}$ |          | 520 |
| $K_S^0 f_0(1400), f_0 \rightarrow K^+ K^-$                                                | (1.7 ± 1.1)   | $\times 10^{-4}$ |          | —   |
| $3K_S^0$                                                                                  | (9.3 ± 1.3)   | $\times 10^{-4}$ |          | 538 |
| $K^+ K^- K^- \pi^+$                                                                       | (2.11 ± 0.31) | $\times 10^{-4}$ |          | 434 |
| $K^+ K^- \bar{K}^*(892)^0, \bar{K}^*(892)^0 \rightarrow K^- \pi^+$                        | (4.2 ± 1.7)   | $\times 10^{-5}$ |          | †   |
| $K^- \pi^+ \phi, \phi \rightarrow K^+ K^-$                                                | (3.8 ± 1.6)   | $\times 10^{-5}$ |          | 422 |
| $\phi \bar{K}^*(892)^0, \phi \rightarrow K^+ K^-, \bar{K}^*(892)^0 \rightarrow K^- \pi^+$ | (1.01 ± 0.20) | $\times 10^{-4}$ |          | †   |
| $K^+ K^- K^- \pi^+$ nonresonant                                                           | (3.2 ± 1.4)   | $\times 10^{-5}$ |          | 434 |
| $K_S^0 K_S^0 K^\pm \pi^\mp$                                                               | (6.1 ± 1.3)   | $\times 10^{-4}$ |          | 427 |

## Pionic modes

|                                                    |                   |                  |          |     |
|----------------------------------------------------|-------------------|------------------|----------|-----|
| $\pi^+ \pi^-$                                      | (1.364 ± 0.032)   | $\times 10^{-3}$ |          | 922 |
| $\pi^0 \pi^0$                                      | (7.9 ± 0.8)       | $\times 10^{-4}$ |          | 922 |
| $\pi^+ \pi^- \pi^0$                                | (1.31 ± 0.06)     | %                |          | 907 |
| $\rho^+ \pi^-$                                     | (10.0 ± 0.6)      | $\times 10^{-3}$ |          | 764 |
| $\rho^0 \pi^0$                                     | (3.2 ± 0.4)       | $\times 10^{-3}$ |          | 764 |
| $\rho^- \pi^+$                                     | (4.5 ± 0.4)       | $\times 10^{-3}$ |          | 764 |
| $f_0(980) \pi^0, f_0(980) \rightarrow \pi^+ \pi^-$ | < 3.4             | $\times 10^{-6}$ | CL = 95% | —   |
| $f_0(600) \pi^0, f_0(600) \rightarrow \pi^+ \pi^-$ | < 2.7             | $\times 10^{-5}$ | CL = 95% | —   |
| $(\pi^+ \pi^-)_{S\text{-wave}} \pi^0$              | < 2.5             | $\times 10^{-4}$ | CL = 95% | 907 |
| $3\pi^0$                                           | < 3.5             | $\times 10^{-4}$ | CL = 90% | 908 |
| $2\pi^+ 2\pi^-$                                    | (7.31 ± 0.27)     | $\times 10^{-3}$ |          | 879 |
| $\pi^+ \pi^- 2\pi^0$                               | (9.8 ± 0.9)       | $\times 10^{-3}$ |          | 882 |
| $\eta \pi^0$                                       | [aaa] (5.6 ± 1.4) | $\times 10^{-4}$ |          | 846 |
| $\omega \pi^0$                                     | [aaa] < 2.6       | $\times 10^{-4}$ | CL = 90% | 761 |
| $2\pi^+ 2\pi^- \pi^0$                              | (4.1 ± 0.5)       | $\times 10^{-3}$ |          | 844 |
| $\eta \pi^+ \pi^-$                                 | [aaa] < 1.9       | $\times 10^{-3}$ | CL = 90% | 827 |
| $\omega \pi^+ \pi^-$                               | [aaa] (1.6 ± 0.5) | $\times 10^{-3}$ |          | 738 |
| $3\pi^+ 3\pi^-$                                    | (4.0 ± 1.1)       | $\times 10^{-4}$ |          | 795 |

Hadronic modes with a  $K\bar{K}$  pair

|                                                                       |                                        |                  |          |     |
|-----------------------------------------------------------------------|----------------------------------------|------------------|----------|-----|
| $K^+ K^-$                                                             | (3.84 ± 0.10)                          | $\times 10^{-3}$ |          | 791 |
| $2K_S^0$                                                              | (3.7 ± 0.7)                            | $\times 10^{-4}$ |          | 788 |
| $K_S^0 K^- \pi^+$                                                     | (3.4 ± 0.5)                            | $\times 10^{-3}$ | S = 1.1  | 739 |
| $\bar{K}^*(892)^0 K_S^0, \bar{K}^*(892)^0 \rightarrow K^- \pi^+$      | < 6                                    | $\times 10^{-4}$ | CL = 90% | 608 |
| $K^*(892)^+ K^-, K^*(892)^+ \rightarrow K_S^0 \pi^+$                  | (1.2 ± 0.3)                            | $\times 10^{-3}$ |          | 610 |
| $K_S^0 K^- \pi^+$ nonresonant                                         | (1.1 ± 1.1)                            | $\times 10^{-3}$ |          | 739 |
| $K_S^0 K^+ \pi^-$                                                     | (2.6 ± 0.5)                            | $\times 10^{-3}$ |          | 739 |
| $K^*(892)^0 K_S^0, K^*(892)^0 \rightarrow K^+ \pi^-$                  | < 3                                    | $\times 10^{-4}$ | CL = 90% | 608 |
| $K^*(892)^- K^+, K^*(892)^- \rightarrow K_S^0 \pi^-$                  | (7 ± 4)                                | $\times 10^{-4}$ |          | 610 |
| $K_S^0 K^+ \pi^-$ nonresonant                                         | (1.9 <sup>+1.1</sup> <sub>-0.8</sub> ) | $\times 10^{-3}$ |          | 739 |
| $K^+ K^- \pi^0$                                                       | (1.3 ± 0.4)                            | $\times 10^{-3}$ |          | 743 |
| $K_S^0 K_S^0 \pi^0$                                                   | < 5.9                                  | $\times 10^{-4}$ |          | 740 |
| $K^+ K^- \pi^+ \pi^-$                                                 | [bbb] (2.32 ± 0.13)                    | $\times 10^{-3}$ |          | 676 |
| $\phi \pi^+ \pi^-$ 3-body, $\phi \rightarrow K^+ K^-$                 | (2.3 ± 2.3)                            | $\times 10^{-5}$ |          | 614 |
| $\phi \rho^0, \phi \rightarrow K^+ K^-$                               | (6.7 ± 0.6)                            | $\times 10^{-4}$ |          | 250 |
| $K^+ K^- \rho^0$ 3-body                                               | (5 ± 7)                                | $\times 10^{-5}$ |          | 302 |
| $f_0(980) \pi^+ \pi^-, f_0 \rightarrow K^+ K^-$                       | (3.5 ± 0.9)                            | $\times 10^{-4}$ |          | —   |
| $K^*(892)^0 K^\mp \pi^\pm$ 3-body, $K^{*0} \rightarrow K^\pm \pi^\mp$ | [ccc] (2.5 ± 0.5)                      | $\times 10^{-4}$ |          | 531 |
| $K^*(892)^0 \bar{K}^*(892)^0, K^{*0} \rightarrow K^\pm \pi^\mp$       | (7 ± 5)                                | $\times 10^{-5}$ |          | 272 |
| $K_1(1270)^\pm K^\mp, K_1(1270)^\pm \rightarrow K^\pm \pi^+ \pi^-$    | (7.6 ± 1.7)                            | $\times 10^{-4}$ |          | —   |

|                                                                    |               |                  |          |     |
|--------------------------------------------------------------------|---------------|------------------|----------|-----|
| $K_1(1400)^\pm K^\mp, K_1(1400)^\pm \rightarrow K^\pm \pi^+ \pi^-$ | (5.1 ± 1.2)   | $\times 10^{-4}$ |          | —   |
| $K_S^0 K_S^0 \pi^+ \pi^-$                                          | (1.26 ± 0.24) | $\times 10^{-3}$ |          | 673 |
| $K_S^0 K^- \pi^+ \pi^+ \pi^-$                                      | < 1.5         | $\times 10^{-4}$ | CL = 90% | 595 |
| $K^+ K^- \pi^+ \pi^- \pi^0$                                        | (3.1 ± 2.0)   | $\times 10^{-3}$ |          | 600 |

Fractions of most of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

|                          |             |                  |          |     |
|--------------------------|-------------|------------------|----------|-----|
| $\bar{K}^*(892)^0 K_S^0$ | < 8         | $\times 10^{-4}$ | CL = 90% | 608 |
| $K^*(892)^+ K^-$         | (3.7 ± 0.8) | $\times 10^{-3}$ |          | 610 |
| $K^*(892)^0 K_S^0$       | < 4         | $\times 10^{-4}$ | CL = 90% | 608 |
| $K^*(892)^- K^+$         | (2.0 ± 1.1) | $\times 10^{-3}$ |          | 610 |
| $\phi \pi^0$             | (7.4 ± 0.5) | $\times 10^{-4}$ |          | 644 |
| $\phi \eta$              | (1.4 ± 0.4) | $\times 10^{-4}$ |          | 489 |
| $\phi \omega$            | < 2.1       | $\times 10^{-3}$ | CL = 90% | 237 |

## Radiative modes

|                           |                                        |                  |          |     |
|---------------------------|----------------------------------------|------------------|----------|-----|
| $\rho^0 \gamma$           | < 2.4                                  | $\times 10^{-4}$ | CL = 90% | 771 |
| $\omega \gamma$           | < 2.4                                  | $\times 10^{-4}$ | CL = 90% | 768 |
| $\phi \gamma$             | (2.4 <sup>+0.7</sup> <sub>-0.6</sub> ) | $\times 10^{-5}$ |          | 654 |
| $\bar{K}^*(892)^0 \gamma$ | < 7.6                                  | $\times 10^{-4}$ | CL = 90% | 719 |

Doubly Cabibbo suppressed (DC) modes or  $\Delta C = 2$  forbidden via mixing (C2M) modes

|                                                          |     |                                           |                  |          |     |
|----------------------------------------------------------|-----|-------------------------------------------|------------------|----------|-----|
| $K^+ \ell^- \bar{\nu}_\ell$ (via $\bar{D}^0$ )           | C2M | < 1.8                                     | $\times 10^{-4}$ | CL = 90% | —   |
| $K^+$ or $K^*(892)^+ e^- \bar{\nu}_e$ (via $\bar{D}^0$ ) | C2M | < 6                                       | $\times 10^{-5}$ | CL = 90% | —   |
| $K^+ \pi^-$                                              | DC  | (1.43 ± 0.04)                             | $\times 10^{-4}$ |          | 861 |
| $K^+ \pi^-$ (via $\bar{D}^0$ )                           | C2M | < 1.5                                     | $\times 10^{-5}$ | CL = 95% | 861 |
| $K_S^0 \pi^+ \pi^-$ (in $D^0 \rightarrow \bar{D}^0$ )    | C2M | < 1.8                                     | $\times 10^{-4}$ | CL = 95% | —   |
| $K^*(892)^+ \pi^-, K^*(892)^+ \rightarrow K_S^0 \pi^+$   | DC  | (10 <sup>+12</sup> <sub>-4</sub> )        | $\times 10^{-5}$ |          | 711 |
| $K^+ \pi^- \pi^0$                                        | DC  | (3.29 <sup>+0.30</sup> <sub>-0.27</sub> ) | $\times 10^{-4}$ |          | 844 |
| $K^+ \pi^- \pi^+ \pi^-$                                  | DC  | (2.49 <sup>+0.21</sup> <sub>-0.15</sub> ) | $\times 10^{-4}$ |          | 812 |
| $K^+ \pi^- \pi^+ \pi^-$ (via $\bar{D}^0$ )               | C2M | < 4                                       | $\times 10^{-4}$ | CL = 90% | 812 |
| $\mu^-$ anything (via $\bar{D}^0$ )                      | C2M | < 4                                       | $\times 10^{-4}$ | CL = 90% | —   |

 $\Delta C = 1$  weak neutral current (C1) modes, Lepton Family number (LF) violating modes, or Lepton number (L) violating modes

|                                     |         |        |                  |          |     |
|-------------------------------------|---------|--------|------------------|----------|-----|
| $\gamma \gamma$                     | C1      | < 2.6  | $\times 10^{-5}$ | CL = 90% | 932 |
| $e^+ e^-$                           | C1      | < 1.2  | $\times 10^{-6}$ | CL = 90% | 932 |
| $\mu^+ \mu^-$                       | C1      | < 1.3  | $\times 10^{-6}$ | CL = 90% | 926 |
| $\pi^0 e^+ e^-$                     | C1      | < 4.5  | $\times 10^{-5}$ | CL = 90% | 927 |
| $\pi^0 \mu^+ \mu^-$                 | C1      | < 1.8  | $\times 10^{-4}$ | CL = 90% | 915 |
| $\eta e^+ e^-$                      | C1      | < 1.1  | $\times 10^{-4}$ | CL = 90% | 852 |
| $\eta \mu^+ \mu^-$                  | C1      | < 5.3  | $\times 10^{-4}$ | CL = 90% | 838 |
| $\pi^+ \pi^- e^+ e^-$               | C1      | < 3.73 | $\times 10^{-4}$ | CL = 90% | 922 |
| $\rho^0 e^+ e^-$                    | C1      | < 1.0  | $\times 10^{-4}$ | CL = 90% | 771 |
| $\pi^+ \pi^- \mu^+ \mu^-$           | C1      | < 3.0  | $\times 10^{-5}$ | CL = 90% | 894 |
| $\rho^0 \mu^+ \mu^-$                | C1      | < 2.2  | $\times 10^{-5}$ | CL = 90% | 754 |
| $\omega e^+ e^-$                    | C1      | < 1.8  | $\times 10^{-4}$ | CL = 90% | 768 |
| $\omega \mu^+ \mu^-$                | C1      | < 8.3  | $\times 10^{-4}$ | CL = 90% | 751 |
| $K^- K^+ e^+ e^-$                   | C1      | < 3.15 | $\times 10^{-4}$ | CL = 90% | 791 |
| $\phi e^+ e^-$                      | C1      | < 5.2  | $\times 10^{-5}$ | CL = 90% | 654 |
| $K^- K^+ \mu^+ \mu^-$               | C1      | < 3.3  | $\times 10^{-5}$ | CL = 90% | 709 |
| $\phi \mu^+ \mu^-$                  | C1      | < 3.1  | $\times 10^{-5}$ | CL = 90% | 631 |
| $\bar{K}^0 e^+ e^-$                 | [uu]    | < 1.1  | $\times 10^{-4}$ | CL = 90% | 866 |
| $\bar{K}^0 \mu^+ \mu^-$             | [uu]    | < 2.6  | $\times 10^{-4}$ | CL = 90% | 852 |
| $K^- \pi^+ e^+ e^-$                 | C1      | < 3.85 | $\times 10^{-4}$ | CL = 90% | 861 |
| $\bar{K}^*(892)^0 e^+ e^-$          | [uu]    | < 4.7  | $\times 10^{-5}$ | CL = 90% | 719 |
| $K^- \pi^+ \mu^+ \mu^-$             | C1      | < 3.59 | $\times 10^{-4}$ | CL = 90% | 829 |
| $\bar{K}^*(892)^0 \mu^+ \mu^-$      | [uu]    | < 2.4  | $\times 10^{-5}$ | CL = 90% | 700 |
| $\pi^+ \pi^- \pi^0 \mu^+ \mu^-$     | C1      | < 8.1  | $\times 10^{-4}$ | CL = 90% | 863 |
| $\mu^\pm e^\mp$                     | LF [gg] | < 8.1  | $\times 10^{-7}$ | CL = 90% | 929 |
| $\pi^0 e^\pm \mu^\mp$               | LF [gg] | < 8.6  | $\times 10^{-5}$ | CL = 90% | 924 |
| $\eta e^\pm \mu^\mp$                | LF [gg] | < 1.0  | $\times 10^{-4}$ | CL = 90% | 848 |
| $\pi^+ \pi^- e^\pm \mu^\mp$         | LF [gg] | < 1.5  | $\times 10^{-5}$ | CL = 90% | 911 |
| $\rho^0 e^\pm \mu^\mp$              | LF [gg] | < 4.9  | $\times 10^{-5}$ | CL = 90% | 767 |
| $\omega e^\pm \mu^\mp$              | LF [gg] | < 1.2  | $\times 10^{-4}$ | CL = 90% | 764 |
| $K^- K^+ e^\pm \mu^\mp$             | LF [gg] | < 1.8  | $\times 10^{-4}$ | CL = 90% | 754 |
| $\phi e^\pm \mu^\mp$                | LF [gg] | < 3.4  | $\times 10^{-5}$ | CL = 90% | 648 |
| $\bar{K}^0 e^\pm \mu^\mp$           | LF [gg] | < 1.0  | $\times 10^{-4}$ | CL = 90% | 862 |
| $K^- \pi^+ e^\pm \mu^\mp$           | LF [gg] | < 5.53 | $\times 10^{-4}$ | CL = 90% | 848 |
| $\bar{K}^*(892)^0 e^\pm \mu^\mp$    | LF [gg] | < 8.3  | $\times 10^{-5}$ | CL = 90% | 714 |
| $\pi^- \pi^- e^+ e^+ + \text{c.c.}$ | L       | < 1.12 | $\times 10^{-4}$ | CL = 90% | 922 |

|                                         |     |                         |          |     |
|-----------------------------------------|-----|-------------------------|----------|-----|
| $\pi^- \pi^- \mu^+ \mu^+ + \text{c.c.}$ | $L$ | $< 2.9 \times 10^{-5}$  | CL = 90% | 894 |
| $K^- \pi^- e^+ e^+ + \text{c.c.}$       | $L$ | $< 2.06 \times 10^{-4}$ | CL = 90% | 861 |
| $K^- \pi^- \mu^+ \mu^+ + \text{c.c.}$   | $L$ | $< 3.9 \times 10^{-4}$  | CL = 90% | 829 |
| $K^- K^- e^+ e^+ + \text{c.c.}$         | $L$ | $< 1.52 \times 10^{-4}$ | CL = 90% | 791 |
| $K^- K^- \mu^+ \mu^+ + \text{c.c.}$     | $L$ | $< 9.4 \times 10^{-5}$  | CL = 90% | 709 |
| $\pi^- \pi^- e^+ \mu^+ + \text{c.c.}$   | $L$ | $< 7.9 \times 10^{-5}$  | CL = 90% | 911 |
| $K^- \pi^- e^+ \mu^+ + \text{c.c.}$     | $L$ | $< 2.18 \times 10^{-4}$ | CL = 90% | 848 |
| $K^- K^- e^+ \mu^+ + \text{c.c.}$       | $L$ | $< 5.7 \times 10^{-5}$  | CL = 90% | 754 |

 **$D^*(2007)^0$** 

$$I(J^P) = \frac{1}{2}(1^-)$$

 $I, J, P$  need confirmation.Mass  $m = 2006.7 \pm 0.4$  MeV ( $S = 1.1$ ) $m_{D^{*0}} - m_{D^0} = 142.12 \pm 0.07$  MeVFull width  $\Gamma < 2.1$  MeV, CL = 90% $\bar{D}^*(2007)^0$  modes are charge conjugates of modes below.

| $D^*(2007)^0$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $D^0 \pi^0$               | (61.9 ± 2.9) %                 | 43          |
| $D^0 \gamma$              | (38.1 ± 2.9) %                 | 137         |

 **$D^*(2010)^\pm$** 

$$I(J^P) = \frac{1}{2}(1^-)$$

 $I, J, P$  need confirmation.Mass  $m = 2010.0 \pm 0.4$  MeV ( $S = 1.1$ ) $m_{D^{*+}(2010)} - m_{D^+} = 140.64 \pm 0.10$  MeV ( $S = 1.1$ ) $m_{D^{*+}(2010)} - m_{D^0} = 145.421 \pm 0.010$  MeV ( $S = 1.1$ )Full width  $\Gamma = 96 \pm 22$  keV $D^*(2010)^-$  modes are charge conjugates of the modes below.

| $D^*(2010)^\pm$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $D^0 \pi^+$                 | (67.7 ± 0.5) %                 | 39          |
| $D^+ \pi^0$                 | (30.7 ± 0.5) %                 | 38          |
| $D^+ \gamma$                | (1.6 ± 0.4) %                  | 136         |

 **$D_1(2420)^0$** 

$$I(J^P) = \frac{1}{2}(1^+)$$

 $I, J, P$  need confirmation.Mass  $m = 2422.3 \pm 1.3$  MeV ( $S = 1.2$ ) $m_{D_1^0} - m_{D^{*+}} = 411.7 \pm 0.8$ Full width  $\Gamma = 20.4 \pm 1.7$  MeV $\bar{D}_1(2420)^0$  modes are charge conjugates of modes below.

| $D_1(2420)^0$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $D^*(2010)^+ \pi^-$       | seen                           | 355         |
| $D^0 \pi^+ \pi^-$         | seen                           | 426         |
| $D^+ \pi^-$               | not seen                       | 474         |
| $D^{*0} \pi^+ \pi^-$      | not seen                       | 281         |

 **$D_2^*(2460)^0$** 

$$I(J^P) = \frac{1}{2}(2^+)$$

 $J^P = 2^+$  assignment strongly favored.Mass  $m = 2461.1 \pm 1.6$  MeV ( $S = 1.3$ ) $m_{D_2^{*0}} - m_{D^+} = 593.9 \pm 0.8$ Full width  $\Gamma = 43 \pm 4$  MeV ( $S = 1.8$ ) $\bar{D}_2^*(2460)^0$  modes are charge conjugates of modes below.

| $D_2^*(2460)^0$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $D^+ \pi^-$                 | seen                           | 506         |
| $D^*(2010)^+ \pi^-$         | seen                           | 389         |
| $D^0 \pi^+ \pi^-$           | not seen                       | 462         |
| $D^{*0} \pi^+ \pi^-$        | not seen                       | 325         |

 **$D_2^*(2460)^\pm$** 

$$I(J^P) = \frac{1}{2}(2^+)$$

 $J^P = 2^+$  assignment strongly favored.Mass  $m = 2459 \pm 4$  MeV ( $S = 1.7$ ) $m_{D_2^*(2460)^\pm} - m_{D_2^*(2460)^0} = 2.4 \pm 1.7$  MeVFull width  $\Gamma = 29 \pm 5$  MeV $D_2^*(2460)^-$  modes are charge conjugates of modes below.

| $D_2^*(2460)^\pm$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------------|--------------------------------|-------------|
| $D^0 \pi^+$                   | seen                           | 507         |
| $D^{*0} \pi^+$                | seen                           | 390         |
| $D^+ \pi^+ \pi^-$             | not seen                       | 456         |
| $D^{*+} \pi^+ \pi^-$          | not seen                       | 319         |

**CHARMED, STRANGE MESONS** $(C = S = \pm 1)$  $D_s^+ = c\bar{s}, D_s^- = \bar{c}s$ , similarly for  $D_s^{* \pm}$  **$D_s^\pm$  was  $F^\mp$** 

$$I(J^P) = 0(0^-)$$

Mass  $m = 1968.2 \pm 0.5$  MeV ( $S = 1.1$ ) $m_{D_s^\pm} - m_{D^\pm} = 98.85 \pm 0.30$  MeV ( $S = 1.4$ )Mean life  $\tau = (500 \pm 7) \times 10^{-15}$  s ( $S = 1.3$ ) $c\tau = 149.9$   $\mu\text{m}$  **$T$ -violation decay-rate asymmetry** $A_T(K_S^0 K^\pm \pi^\mp \pi^\mp) = -0.04 \pm 0.07$  **$D_s^*$  form factors** $r_2 = 1.32 \pm 0.24$  ( $S = 1.2$ ) $r_\nu = 1.72 \pm 0.21$  $\Gamma_L/\Gamma_T = 0.72 \pm 0.18$ 

Unless otherwise noted, the branching fractions for modes with a resonance in the final state include all the decay modes of the resonance.  $D_s^-$  modes are charge conjugates of the modes below.

| $D_s^*$ DECAY MODES                                     | Fraction ( $\Gamma_i/\Gamma$ )        | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|---------------------------------------------------------|---------------------------------------|-----------------------------------|----------------|
| <b>Inclusive modes</b>                                  |                                       |                                   |                |
| $K^-$ anything                                          | (13 <sup>+14</sup> <sub>-12</sub> ) % |                                   | —              |
| $\bar{K}^0$ anything + $K^0$                            | (39 ± 28) %                           |                                   | —              |
| anything                                                |                                       |                                   | —              |
| $K^+$ anything                                          | (20 <sup>+18</sup> <sub>-14</sub> ) % |                                   | —              |
| (non- $K$ $\bar{K}$ ) anything                          | (64 ± 17) %                           |                                   | —              |
| $e^+$ anything                                          | (8 <sup>+6</sup> <sub>-5</sub> ) %    |                                   | —              |
| $\phi$ anything                                         | (18 <sup>+15</sup> <sub>-10</sub> ) % |                                   | —              |
| <b>Leptonic and semileptonic modes</b>                  |                                       |                                   |                |
| $\mu^+ \nu_\mu$                                         | (6.1 ± 1.9) %                         | $\times 10^{-3} S = 1.4$          | 981            |
| $\tau^+ \nu_\tau$                                       | (6.4 ± 1.5) %                         |                                   | 182            |
| $\phi \ell^+ \nu_\ell$                                  | [ddd]                                 | $S = 1.1$                         | 720            |
| $\eta \ell^+ \nu_\ell + \eta'(958) \ell^+ \nu_\ell$     | [ddd]                                 |                                   | —              |
| $\eta \ell^+ \nu_\ell$                                  | [ddd]                                 |                                   | 908            |
| $\eta'(958) \ell^+ \nu_\ell$                            | [ddd]                                 |                                   | 751            |
| <b>Hadronic modes with a <math>K\bar{K}</math> pair</b> |                                       |                                   |                |
| $K^+ \bar{K}^0$                                         | (4.4 ± 0.9) %                         |                                   | 850            |
| $K^+ K^- \pi^+$                                         | [qq]                                  | $S = 1.1$                         | 805            |
| $\phi \pi^+$                                            | [eee]                                 | $S = 1.1$                         | 711            |
| $\phi \pi^+, \phi \rightarrow K^+ K^-$                  | (2.16 ± 0.28) %                       | $S = 1.1$                         | 712            |
| $K^+ \bar{K}^*(892)^0, \bar{K}^{*0} \rightarrow$        | (2.5 ± 0.5) %                         |                                   | 416            |
| $K^- \pi^+$                                             |                                       |                                   |                |
| $f_0(980) \pi^+, f_0 \rightarrow$                       | (5.7 ± 2.5) %                         | $\times 10^{-3}$                  | 732            |
| $K^+ K^-$                                               |                                       |                                   |                |
| $K^+ \bar{K}_0^*(1430)^0,$                              | (4.8 ± 2.5) %                         | $\times 10^{-3}$                  | 218            |
| $\bar{K}_0^* \rightarrow K^- \pi^+$                     |                                       |                                   |                |
| $K^0 \bar{K}^0 \pi^+$                                   |                                       |                                   | 802            |
| $K^*(892)^+ \bar{K}^0$                                  | [eee]                                 | (5.3 ± 1.3) %                     | 683            |
| $K^+ K^- \pi^+ \pi^0$                                   |                                       |                                   | 748            |
| $\phi \pi^+ \pi^0$                                      | [eee]                                 | (11 ± 5) %                        | 686            |

|                                                        |       |                       |                  |          |     |
|--------------------------------------------------------|-------|-----------------------|------------------|----------|-----|
| $\phi \rho^+$                                          | [eee] | $(8.2^{+2.0}_{-2.4})$ | %                |          | 401 |
| $\phi \pi^+ \pi^0$ 3-body                              | [eee] | < 3.1                 | %                | CL = 90% | 686 |
| $K^+ K^- \pi^+ \pi^0$ non- $\phi$                      |       | < 11                  | %                | CL = 90% | 748 |
| $K^+ \bar{K}^0 \pi^+ \pi^-$                            |       | $(3.1 \pm 0.9)$       | %                |          | 744 |
| $K^0 K^- \pi^+ \pi^+$                                  |       | $(5.3 \pm 1.4)$       | %                |          | 744 |
| $K^*(892)^+ \bar{K}^*(892)^0$                          | [eee] | $(7.0 \pm 2.7)$       | %                |          | 416 |
| $K^0 K^- \pi^+ \pi^+$<br>(non- $K^{*+} \bar{K}^{*0}$ ) |       | < 3.5                 | %                | CL = 90% | 744 |
| $K^+ K^- \pi^+ \pi^+ \pi^-$                            |       | $(8.3 \pm 2.0)$       | $\times 10^{-3}$ |          | 673 |
| $\phi \pi^+ \pi^+ \pi^-$                               | [eee] | $(1.18 \pm 0.20)$     | %                |          | 640 |
| $K^+ K^- \rho^0 \pi^+$ non- $\phi$                     |       | < 2.5                 | $\times 10^{-4}$ | CL = 90% | 248 |
| $\phi \rho^0 \pi^+$                                    | [eee] | $(1.24 \pm 0.33)$     | %                |          | 181 |
| $\phi a_1(1260)^+$                                     | [eee] | $(2.9 \pm 0.7)$       | %                |          | †   |
| $K^+ K^- \pi^+ \pi^+ \pi^-$<br>nonresonant             |       | $(8 \pm 7)$           | $\times 10^{-4}$ |          | 673 |
| $K_S^0 K_S^0 \pi^+ \pi^+ \pi^-$                        |       | $(2.7 \pm 1.3)$       | $\times 10^{-3}$ |          | 669 |

Hadronic modes without  $K$ 's

|                                                      |       |                   |                  |          |     |
|------------------------------------------------------|-------|-------------------|------------------|----------|-----|
| $\pi^+ \pi^+ \pi^-$                                  |       | $(1.22 \pm 0.23)$ | %                | S = 1.2  | 959 |
| $\pi^+ (\pi^+ \pi^-)_{S\text{-wave}}$                | [fff] | $(1.06 \pm 0.22)$ | %                |          | 959 |
| $f_2(1270) \pi^+, f_2 \rightarrow \pi^+ \pi^-$       |       | $(1.2 \pm 0.7)$   | $\times 10^{-3}$ |          | 559 |
| $\rho(1450)^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$ |       | $(8 \pm 7)$       | $\times 10^{-4}$ |          | 421 |
| $\pi^+ \pi^+ \pi^- \pi^0$                            |       | < 15              | %                | CL = 90% | 935 |
| $\eta \pi^+$                                         | [eee] | $(2.11 \pm 0.35)$ | %                |          | 902 |
| $\omega \pi^+$                                       | [eee] | $(3.4 \pm 1.2)$   | $\times 10^{-3}$ |          | 822 |
| $3\pi^+ 2\pi^-$                                      |       | $(7.6 \pm 1.6)$   | $\times 10^{-3}$ |          | 899 |
| $\pi^+ \pi^+ \pi^- \pi^0 \pi^0$                      |       | —                 |                  |          | 902 |
| $\eta \rho^+$                                        | [eee] | $(13.1 \pm 2.6)$  | %                |          | 724 |
| $\eta \pi^+ \pi^0$ 3-body                            | [eee] | < 5               | %                | CL = 90% | 885 |
| $3\pi^+ 2\pi^- \pi^0$                                |       | $(4.9 \pm 3.2)$   | %                |          | 856 |
| $\eta'(958) \pi^+$                                   | [eee] | $(4.7 \pm 0.7)$   | %                |          | 743 |
| $3\pi^+ 2\pi^- 2\pi^0$                               |       | —                 |                  |          | 803 |
| $\eta'(958) \rho^+$                                  | [eee] | $(12.2 \pm 2.4)$  | %                |          | 464 |
| $\eta'(958) \pi^+ \pi^0$ 3-body                      | [eee] | < 1.8             | %                | CL = 90% | 720 |

Modes with one or three  $K$ 's

|                                                    |       |                 |                  |          |     |
|----------------------------------------------------|-------|-----------------|------------------|----------|-----|
| $K^0 \pi^+$                                        |       | < 1.9           | $\times 10^{-3}$ | CL = 90% | 916 |
| $K^+ \pi^+ \pi^-$                                  |       | $(6.6 \pm 1.4)$ | $\times 10^{-3}$ |          | 900 |
| $K^+ \rho^0$                                       |       | $(2.6 \pm 0.7)$ | $\times 10^{-3}$ |          | 744 |
| $K^+ \rho(1450)^0, \rho^0 \rightarrow \pi^+ \pi^-$ |       | $(7.0 \pm 2.9)$ | $\times 10^{-4}$ |          | —   |
| $K^*(892)^0 \pi^+, K^{*0} \rightarrow K^+ \pi^-$   |       | $(1.4 \pm 0.4)$ | $\times 10^{-3}$ |          | 775 |
| $K^*(1410)^0 \pi^+, K^{*0} \rightarrow K^+ \pi^-$  |       | $(1.2 \pm 0.4)$ | $\times 10^{-3}$ |          | —   |
| $K^*(1430)^0 \pi^+, K^{*0} \rightarrow K^+ \pi^-$  |       | $(5 \pm 4)$     | $\times 10^{-4}$ |          | —   |
| $K^+ \pi^+ \pi^-$ nonresonant                      |       | $(1.0 \pm 0.4)$ | $\times 10^{-3}$ |          | 900 |
| $K^+ K^+ K^-$                                      |       | $(4.6 \pm 1.8)$ | $\times 10^{-4}$ |          | 627 |
| $\phi K^+$                                         | [eee] | < 6             | $\times 10^{-4}$ | CL = 90% | 606 |

## Doubly Cabibbo-suppressed modes

|                 |  |                 |                  |  |     |
|-----------------|--|-----------------|------------------|--|-----|
| $K^+ K^+ \pi^-$ |  | $(2.7 \pm 1.2)$ | $\times 10^{-4}$ |  | 805 |
|-----------------|--|-----------------|------------------|--|-----|

 $\Delta C = 1$  weak neutral current ( $C1$ ) modes,  
Lepton family number ( $LF$ ), or  
Lepton number ( $L$ ) violating modes

|                          |           |       |                  |          |     |
|--------------------------|-----------|-------|------------------|----------|-----|
| $\pi^+ e^+ e^-$          | [uu]      | < 2.7 | $\times 10^{-4}$ | CL = 90% | 979 |
| $\pi^+ \mu^+ \mu^-$      | [uu]      | < 2.6 | $\times 10^{-5}$ | CL = 90% | 968 |
| $K^+ e^+ e^-$            | $C1$      | < 1.6 | $\times 10^{-3}$ | CL = 90% | 922 |
| $K^+ \mu^+ \mu^-$        | $C1$      | < 3.6 | $\times 10^{-5}$ | CL = 90% | 909 |
| $K^*(892)^+ \mu^+ \mu^-$ | $C1$      | < 1.4 | $\times 10^{-3}$ | CL = 90% | 765 |
| $\pi^+ e^\pm \mu^\mp$    | $LF$ [gg] | < 6.1 | $\times 10^{-4}$ | CL = 90% | 976 |
| $K^+ e^\pm \mu^\mp$      | $LF$ [gg] | < 6.3 | $\times 10^{-4}$ | CL = 90% | 919 |
| $\pi^- e^+ e^+$          | $L$       | < 6.9 | $\times 10^{-4}$ | CL = 90% | 979 |
| $\pi^- \mu^+ \mu^+$      | $L$       | < 2.9 | $\times 10^{-5}$ | CL = 90% | 968 |
| $\pi^- e^+ \mu^+$        | $L$       | < 7.3 | $\times 10^{-4}$ | CL = 90% | 976 |
| $K^- e^+ e^+$            | $L$       | < 6.3 | $\times 10^{-4}$ | CL = 90% | 922 |
| $K^- \mu^+ \mu^+$        | $L$       | < 1.3 | $\times 10^{-5}$ | CL = 90% | 909 |
| $K^- e^+ \mu^+$          | $L$       | < 6.8 | $\times 10^{-4}$ | CL = 90% | 919 |
| $K^*(892)^- \mu^+ \mu^+$ | $L$       | < 1.4 | $\times 10^{-3}$ | CL = 90% | 765 |

 $D_s^{*\pm}$ 

$$I(J^P) = 0(?^?)$$

 $J^P$  is natural, width and decay modes consistent with  $1^-$ .

$$\text{Mass } m = 2112.0 \pm 0.6 \text{ MeV (S = 1.1)}$$

$$m_{D_s^{*\pm}} - m_{D_s^\pm} = 143.8 \pm 0.4 \text{ MeV}$$

$$\text{Full width } \Gamma < 1.9 \text{ MeV, CL = 90\%}$$

 $D_s^{*-}$  modes are charge conjugates of the modes below.

| $D_s^{*+}$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|------------------------|--------------------------------|-------------|
| $D_s^+ \gamma$         | $(94.2 \pm 0.7)\%$             | 139         |
| $D_s^+ \pi^0$          | $(5.8 \pm 0.7)\%$              | 48          |

 $D_{s0}^{*}(2317)^\pm$ 

$$I(J^P) = 0(0^+)$$

 $J, P$  need confirmation. $J^P$  is natural, low mass consistent with  $0^+$ .

$$\text{Mass } m = 2317.3 \pm 0.6 \text{ MeV}$$

$$m_{D_{s0}^{*}(2317)^\pm} - m_{D_s^\pm} = 349.1 \pm 0.6 \text{ MeV}$$

$$\text{Full width } \Gamma < 4.6 \text{ MeV, CL = 90\%}$$

 $D_{s1}^{*}(2460)^\pm$ 

$$I(J^P) = 0(1^+)$$

$$\text{Mass } m = 2458.9 \pm 0.9 \text{ MeV (S = 1.1)}$$

$$m_{D_{s1}^{*}(2460)^\pm} - m_{D_s^{*\pm}} = 346.9 \pm 1.0 \text{ MeV (S = 1.2)}$$

$$m_{D_{s1}^{*}(2460)^\pm} - m_{D_s^\pm} = 490.7 \pm 0.9 \text{ MeV (S = 1.2)}$$

$$\text{Full width } \Gamma < 5.5 \text{ MeV, CL = 90\%}$$

 $D_{s1}^{*}(2536)^\pm$ 

$$I(J^P) = 0(1^+)$$

 $J, P$  need confirmation.

$$\text{Mass } m = 2535.35 \pm 0.34 \pm 0.5 \text{ MeV}$$

$$\text{Full width } \Gamma < 2.3 \text{ MeV, CL = 90\%}$$

 $D_{s1}(2536)^-$  modes are charge conjugates of the modes below.

| $D_{s1}(2536)^\pm$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|--------------------------------|--------------------------------|-------------|
| $D^*(2010)^+ K^0$              | seen                           | 150         |
| $D^*(2007)^0 K^+$              | seen                           | 168         |
| $D^+ K^0$                      | not seen                       | 382         |
| $D^0 K^+$                      | not seen                       | 392         |
| $D_s^\pm \gamma$               | possibly seen                  | 388         |

 $D_{s2}(2573)^\pm$ 

$$I(J^P) = 0(?^?)$$

 $J^P$  is natural, width and decay modes consistent with  $2^+$ .

$$\text{Mass } m = 2573.5 \pm 1.7 \text{ MeV}$$

$$\text{Full width } \Gamma = 15^{+5}_{-4} \text{ MeV}$$

 $D_{s2}(2573)^-$  modes are charge conjugates of the modes below.

| $D_{s2}$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------|--------------------------------|-------------|
| $D^0 K^+$            | seen                           | 436         |
| $D^*(2007)^0 K^+$    | not seen                       | 246         |

## BOTTOM MESONS

(B = ±1)

 $B^+ = u\bar{b}, B^0 = d\bar{b}, \bar{B}^0 = \bar{d}b, B^- = \bar{u}b$ , similarly for  $B^{*s}$ 

## B-particle organization

Many measurements of  $B$  decays involve admixtures of  $B$  hadrons. Previously we arbitrarily included such admixtures in the  $B^\pm$  section, but because of their importance we have created two new sections: “ $B^\pm/B^0$  Admixture” for  $\Upsilon(4S)$  results and “ $B^\pm/B^0/B_s^0/b$ -baryon Admixture” for results at higher energies. Most inclusive decay branching fractions and  $\chi_b$  at high energy are found in the Admixture sections.  $B^0-\bar{B}^0$  mixing data are found in the  $B^0$  section, while  $B_s^0-\bar{B}_s^0$  mixing data and  $B-\bar{B}$  mixing data for a  $B^0/B_s^0$  admixture are found in the  $B_s^0$  section.  $CP$ -violation data are found in the  $B^\pm$ ,  $B^0$ , and  $B^\pm/B^0$  Admixture sections.  $b$ -baryons are found near the end of the Baryon section.

The organization of the  $B$  sections is now as follows, where bullets indicate particle sections and brackets indicate reviews.

- $B^\pm$   
mass, mean life, branching fractions  $CP$  violation
- $B^0$   
mass, mean life, branching fractions  
polarization in  $B^0$  decay,  $B^0-\bar{B}^0$  mixing,  $CP$  violation
- $B^\pm/B^0$  Admixtures  
branching fractions,  $CP$  violation
- $B^\pm/B^0/B_s^0/b$ -baryon Admixtures  
mean life, production fractions, branching fractions  
 $\chi_b$  at high energy,  $V_{cb}$  measurements
- $B^*$   
mass
- $B_s^0$   
mass, mean life, branching fractions  
polarization in  $B_s^0$  decay,  $B_s^0-\bar{B}_s^0$  mixing
- $B_c^\pm$   
mass, mean life, branching fractions

At end of Baryon Listings:

- $\Lambda_b$   
mass, mean life, branching fractions
- $b$ -baryon Admixture  
mean life, branching fractions

 $B^\pm$ 

$$I(J^P) = \frac{1}{2}(0^-)$$

$I, J, P$  need confirmation. Quantum numbers shown are quark-model predictions.

Mass  $m_{B^\pm} = 5279.0 \pm 0.5$  MeV

Mean life  $\tau_{B^\pm} = (1.638 \pm 0.011) \times 10^{-12}$  s

$c\tau = 491.1$   $\mu\text{m}$

## CP violation

$$\begin{aligned} A_{CP}(B^+ \rightarrow J/\psi(1S)K^+) &= -0.024 \pm 0.014 \\ A_{CP}(B^+ \rightarrow J/\psi(1S)\pi^+) &= 0.09 \pm 0.08 \\ A_{CP}(B^+ \rightarrow J/\psi K^*(892)^+) &= 0.048 \pm 0.033 \\ A_{CP}(B^+ \rightarrow \psi(2S)K^+) &= -0.025 \pm 0.024 \\ A_{CP}(B^+ \rightarrow \psi(2S)K^*(892)^+) &= -0.08 \pm 0.21 \\ A_{CP}(B^+ \rightarrow \chi_{c1}K^+) &= 0.00 \pm 0.08 \\ A_{CP}(B^+ \rightarrow \chi_{c1}K^*(892)^+) &= -0.5 \pm 0.5 \\ A_{CP}(B^+ \rightarrow \bar{D}^0\pi^+) &= -0.008 \pm 0.008 \\ A_{CP}(B^+ \rightarrow D_{CP(+1)}\pi^+) &= 0.035 \pm 0.024 \\ A_{CP}(B^+ \rightarrow D_{CP(-1)}\pi^+) &= 0.017 \pm 0.026 \\ A_{CP}(B^+ \rightarrow \bar{D}^0K^+) &= 0.07 \pm 0.04 \\ r_B(B^+ \rightarrow D^0K^+) &= 0.12 \pm 0.09 \\ \delta_B(B^+ \rightarrow D^0K^+) &= 104 \pm 50 \text{ degrees} \\ A_{CP}(B^+ \rightarrow [K^-\pi^+]_D K^+) &= 0.9^{+0.8}_{-0.6} \\ A_{CP}(B^+ \rightarrow [K^-\pi^+]_{\bar{D}} K^*(892)^+) &= -0.2 \pm 0.6 \\ A_{CP}(B^+ \rightarrow [K^-\pi^+]_D \pi^+) &= 0.30^{+0.30}_{-0.26} \\ A_{CP}(B^+ \rightarrow [\pi^+\pi^-\pi^0]_D K^+) &= -0.02 \pm 0.16 \\ A_{CP}(B^+ \rightarrow D_{CP(+1)}K^+) &= 0.22 \pm 0.14(S=1.4) \\ A_{CP}(B^+ \rightarrow D_{CP(-1)}K^+) &= -0.09 \pm 0.10 \\ A_{CP}(B^+ \rightarrow D^{*0}\pi^+) &= -0.014 \pm 0.015 \\ A_{CP}(B^+ \rightarrow (D_{CP(+1)}^*)^0\pi^+) &= -0.02 \pm 0.05 \\ A_{CP}(B^+ \rightarrow (D_{CP(-1)}^*)^0\pi^+) &= -0.09 \pm 0.05 \\ A_{CP}(B^+ \rightarrow D^{*0}K^+) &= -0.09 \pm 0.09 \\ r_B^*(B^+ \rightarrow D^{*0}K^+) &= 0.17 \pm 0.11 \\ \delta_B^*(B^+ \rightarrow D^{*0}K^+) &= -64 \pm 50 \text{ degrees} \\ A_{CP}(B^+ \rightarrow D_{CP(+1)}^{*0}K^+) &= -0.15 \pm 0.16 \\ A_{CP}(B^+ \rightarrow D_{CP(-1)}^{*0}K^+) &= 0.13 \pm 0.31 \\ A_{CP}(B^+ \rightarrow D_{CP(+1)}K^*(892)^+) &= -0.08 \pm 0.21 \\ A_{CP}(B^+ \rightarrow D_{CP(-1)}K^*(892)^+) &= -0.3 \pm 0.4 \\ A_{CP}(B^+ \rightarrow K_S^0\pi^+) &= -0.02 \pm 0.07(S=1.9) \\ A_{CP}(B^+ \rightarrow K^+\pi^0) &= 0.04 \pm 0.04 \\ A_{CP}(B^+ \rightarrow K^+\eta') &= 0.020 \pm 0.025 \\ A_{CP}(B^+ \rightarrow \eta K^+) &= -0.25 \pm 0.14 \\ A_{CP}(B^+ \rightarrow \eta K^*(892)^+) &= 0.13 \pm 0.14 \\ A_{CP}(B^+ \rightarrow \omega K^+) &= -0.02 \pm 0.13 \\ A_{CP}(B^+ \rightarrow K^{*0}\pi^+) &= 0.07 \pm 0.10 \\ A_{CP}(B^+ \rightarrow K^+\pi^-\pi^+) &= -0.01 \pm 0.04 \\ A_{CP}(B^+ \rightarrow f_0(980)K^+) &= 0.09^{+0.14}_{-0.11} \\ A_{CP}(B^+ \rightarrow \rho^0 K^+) &= 0.32 \pm 0.16 \\ A_{CP}(B^+ \rightarrow K_0^*(1430)^0\pi^+) &= -0.06 \pm 0.04 \\ A_{CP}(B^+ \rightarrow K^*(892)^+\pi^0) &= 0.04 \pm 0.29 \\ A_{CP}(B^+ \rightarrow \rho^0 K^*(892)^+) &= 0.20 \pm 0.31 \\ A_{CP}(B^+ \rightarrow K^0 K^+) &= 0.15 \pm 0.33 \\ A_{CP}(B^+ \rightarrow K^+ K_S^0 K_S^0) &= -0.04 \pm 0.11 \\ A_{CP}(B^+ \rightarrow K^+ K^- K^+) &= 0.02 \pm 0.08 \\ A_{CP}(B^+ \rightarrow \phi K^+) &= 0.01 \pm 0.07 \\ A_{CP}(B^+ \rightarrow \phi K^*(892)^+) &= 0.05 \pm 0.11 \\ A_{CP}(B^+ \rightarrow \eta K^+\gamma) &= -0.16 \pm 0.11 \\ A_{CP}(B^+ \rightarrow \pi^+\pi^0) &= -0.02 \pm 0.07 \\ A_{CP}(B^+ \rightarrow \pi^+\pi^-\pi^+) &= -0.01 \pm 0.08 \\ A_{CP}(B^+ \rightarrow \rho^0\pi^+) &= -0.07 \pm 0.13 \\ A_{CP}(B^+ \rightarrow f_2(1270)\pi^+) &= 0.00 \pm 0.25 \\ A_{CP}(B^+ \rightarrow \rho^+\pi^0) &= 0.15 \pm 0.12 \\ A_{CP}(B^+ \rightarrow \rho^+\rho^0) &= -0.09 \pm 0.16 \\ A_{CP}(B^+ \rightarrow \omega\pi^+) &= 0.10 \pm 0.22(S=1.9) \\ A_{CP}(B^+ \rightarrow \omega\rho^+) &= 0.05 \pm 0.26 \\ A_{CP}(B^+ \rightarrow \eta\pi^+) &= -0.05 \pm 0.10 \\ A_{CP}(B^+ \rightarrow \eta'\pi^+) &= 0.14 \pm 0.16 \\ A_{CP}(B^+ \rightarrow \eta\rho^+) &= 0.02 \pm 0.18 \\ A_{CP}(B^+ \rightarrow p\bar{p}\pi^+) &= -0.16 \pm 0.22 \\ A_{CP}(B^+ \rightarrow p\bar{p}K^+) &= -0.05 \pm 0.11 \\ \gamma(B^+ \rightarrow D^{(*)}K^+) &= (75 \pm 20)^\circ \end{aligned}$$

$B^-$  modes are charge conjugates of the modes below. Modes which do not identify the charge state of the  $B$  are listed in the  $B^\pm/B^0$  ADMIXTURE section.

The branching fractions listed below assume 50%  $B^0\bar{B}^0$  and 50%  $B^+B^-$  production at the  $\Upsilon(4S)$ . We have attempted to bring older measurements up to date by rescaling their assumed  $\Upsilon(4S)$  production ratio to 50:50 and their assumed  $D$ ,  $D_s$ ,  $D^*$ , and  $\psi$  branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

For inclusive branching fractions, e.g.,  $B \rightarrow D^\pm$  anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

| $B^+$ DECAY MODES                                                  | Fraction ( $\Gamma_i/\Gamma$ )           | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|--------------------------------------------------------------------|------------------------------------------|-----------------------------------|----------------|
| <b>Semileptonic and leptonic modes</b>                             |                                          |                                   |                |
| $\ell^+ \nu_\ell$ anything                                         | [ggg] (10.9 ± 0.4) %                     |                                   | —              |
| $\bar{D}^0 \ell^+ \nu_\ell$                                        | [ggg] (2.15 ± 0.22) %                    |                                   | 2310           |
| $\bar{D}^*(2007)^0 \ell^+ \nu_\ell$                                | [ggg] (6.5 ± 0.5) %                      |                                   | 2258           |
| $\bar{D}_1(2420)^0 \ell^+ \nu_\ell$                                | (5.6 ± 1.6) × 10 <sup>-3</sup>           |                                   | 2084           |
| $\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell$                              | < 8 × 10 <sup>-3</sup>                   | CL = 90%                          | 2066           |
| $D^- \pi^+ \ell^+ \nu_\ell$                                        | (5.3 ± 1.0) × 10 <sup>-3</sup>           |                                   | 2306           |
| $D^{*-} \pi^+ \ell^+ \nu_\ell$                                     | (6.4 ± 1.5) × 10 <sup>-3</sup>           |                                   | 2254           |
| $\pi^0 \ell^+ \nu_\ell$                                            | (7.4 ± 1.1) × 10 <sup>-5</sup>           |                                   | 2638           |
| $\eta \ell^+ \nu_\ell$                                             | (8 ± 4) × 10 <sup>-5</sup>               |                                   | 2611           |
| $\omega \ell^+ \nu_\ell$                                           | [ggg] (1.3 ± 0.6) × 10 <sup>-4</sup>     |                                   | 2582           |
| $\rho^0 \ell^+ \nu_\ell$                                           | [ggg] (1.24 ± 0.23) × 10 <sup>-4</sup>   |                                   | 2583           |
| $p\bar{p}e^+ \nu_e$                                                | < 5.2 × 10 <sup>-3</sup>                 | CL = 90%                          | 2467           |
| $e^+ \nu_e$                                                        | < 1.5 × 10 <sup>-5</sup>                 | CL = 90%                          | 2640           |
| $\mu^+ \nu_\mu$                                                    | < 6.6 × 10 <sup>-6</sup>                 | CL = 90%                          | 2638           |
| $\tau^+ \nu_\tau$                                                  | < 2.6 × 10 <sup>-4</sup>                 | CL = 90%                          | 2340           |
| $e^+ \nu_e \gamma$                                                 | < 2.0 × 10 <sup>-4</sup>                 | CL = 90%                          | 2640           |
| $\mu^+ \nu_\mu \gamma$                                             | < 5.2 × 10 <sup>-5</sup>                 | CL = 90%                          | 2638           |
| <b>Inclusive modes</b>                                             |                                          |                                   |                |
| $D^0 X$                                                            | (9.8 ± 1.1) %                            |                                   | —              |
| $\bar{D}^0 X$                                                      | (79 ± 5) %                               |                                   | —              |
| $D^+ X$                                                            | (3.8 ± 1.0) %                            |                                   | —              |
| $D^- X$                                                            | (9.8 ± 1.8) %                            |                                   | —              |
| $D_s^+ X$                                                          | (14 <sup>+5</sup> <sub>-4</sub> ) %      |                                   | —              |
| $D_s^- X$                                                          | < 2.2 %                                  | CL = 90%                          | —              |
| $\Lambda_c^+ X$                                                    | (2.9 <sup>+1.4</sup> <sub>-1.1</sub> ) % |                                   | —              |
| $\bar{\Lambda}_c^- X$                                              | (3.5 <sup>+1.5</sup> <sub>-1.2</sub> ) % |                                   | —              |
| $\bar{c} X$                                                        | (98 ± 6) %                               |                                   | —              |
| $c X$                                                              | (33 <sup>+6</sup> <sub>-4</sub> ) %      |                                   | —              |
| $\bar{c} c X$                                                      | (131 <sup>+10</sup> <sub>-8</sub> ) %    |                                   | —              |
| <b><math>D</math>, <math>D^*</math>, or <math>D_s</math> modes</b> |                                          |                                   |                |
| $\bar{D}^0 \pi^+$                                                  | (4.92 ± 0.20) × 10 <sup>-3</sup>         |                                   | 2308           |
| $D_{CP(+1)} \pi^+$                                                 | [bbb] (4.0 ± 0.8) × 10 <sup>-3</sup>     |                                   | —              |
| $D_{CP(-1)} \pi^+$                                                 | [bbb] (3.6 ± 0.8) × 10 <sup>-3</sup>     |                                   | —              |
| $\bar{D}^0 \rho^+$                                                 | (1.34 ± 0.18) %                          |                                   | 2237           |
| $\bar{D}^0 K^+$                                                    | (4.08 ± 0.24) × 10 <sup>-4</sup>         |                                   | 2281           |
| $D_{CP(+1)} K^+$                                                   | [bbb] (3.7 ± 0.6) × 10 <sup>-4</sup>     |                                   | —              |
| $D_{CP(-1)} K^+$                                                   | [bbb] (3.5 ± 0.5) × 10 <sup>-4</sup>     |                                   | —              |
| [ $K^- \pi^+$ ] <sub>D</sub> $\pi^+$                               | [iii] (1.7 ± 0.5) × 10 <sup>-5</sup>     |                                   | —              |
| [ $\pi^+ \pi^- \pi^0$ ] <sub>D</sub> $K^-$                         | (5.5 ± 1.2) × 10 <sup>-6</sup>           |                                   | —              |
| $\bar{D}^0 K^*(892)^+$                                             | (6.3 ± 0.8) × 10 <sup>-4</sup>           |                                   | 2213           |
| $D_{CP(-1)} K^*(892)^+$                                            | [bbb] (2.0 ± 0.9) × 10 <sup>-4</sup>     |                                   | —              |
| $D_{CP(+1)} K^*(892)^+$                                            | [bbb] (6.2 ± 1.5) × 10 <sup>-4</sup>     |                                   | —              |
| $\bar{D}^0 K^+ \bar{K}^0$                                          | (5.5 ± 1.6) × 10 <sup>-4</sup>           |                                   | 2189           |
| $\bar{D}^0 K^+ \bar{K}^*(892)^0$                                   | (7.5 ± 1.7) × 10 <sup>-4</sup>           |                                   | 2071           |
| $\bar{D}^0 \pi^+ \pi^+ \pi^-$                                      | (1.1 ± 0.4) %                            |                                   | 2289           |
| $\bar{D}^0 \pi^+ \pi^- \pi^-$                                      | (5 ± 4) × 10 <sup>-3</sup>               |                                   | 2289           |
| nonresonant $\bar{D}^0 \pi^+ \rho^0$                               | (4.2 ± 3.0) × 10 <sup>-3</sup>           |                                   | 2207           |
| $\bar{D}^0 a_1(1260)^+$                                            | (4 ± 4) × 10 <sup>-3</sup>               |                                   | 2123           |
| $\bar{D}^0 \omega \pi^+$                                           | (4.1 ± 0.9) × 10 <sup>-3</sup>           |                                   | 2206           |
| $D^*(2010)^- \pi^+ \pi^+$                                          | (1.35 ± 0.22) × 10 <sup>-3</sup>         |                                   | 2247           |
| $D^- \pi^+ \pi^+$                                                  | (1.02 ± 0.16) × 10 <sup>-3</sup>         |                                   | 2299           |
| $D^+ K^0$                                                          | < 5.0 × 10 <sup>-6</sup>                 | CL = 90%                          | 2278           |
| $\bar{D}^*(2007)^0 \pi^+$                                          | (4.6 ± 0.4) × 10 <sup>-3</sup>           |                                   | 2256           |

|                                                                                        |                                                           |           |      |
|----------------------------------------------------------------------------------------|-----------------------------------------------------------|-----------|------|
| $\bar{D}^*(2007)^0 \omega \pi^+$                                                       | (4.5 ± 1.2) × 10 <sup>-3</sup>                            |           | 2149 |
| $\bar{D}^*(2007)^0 \rho^+$                                                             | (9.8 ± 1.7) × 10 <sup>-3</sup>                            |           | 2181 |
| $\bar{D}^*(2007)^0 K^+$                                                                | (3.7 ± 0.4) × 10 <sup>-4</sup>                            |           | 2227 |
| $\bar{D}^*(2007)^0 K^*(892)^+$                                                         | (8.1 ± 1.4) × 10 <sup>-4</sup>                            |           | 2156 |
| $\bar{D}^*(2007)^0 K^+ \bar{K}^0$                                                      | < 1.06 × 10 <sup>-3</sup>                                 | CL = 90%  | 2132 |
| $\bar{D}^*(2007)^0 K^+ K^*(892)^0$                                                     | (1.5 ± 0.4) × 10 <sup>-3</sup>                            |           | 2008 |
| $\bar{D}^*(2007)^0 \pi^+ \pi^+ \pi^-$                                                  | (1.03 ± 0.12) %                                           |           | 2236 |
| $\bar{D}^*(2007)^0 a_1(1260)^+$                                                        | (1.9 ± 0.5) %                                             |           | 2063 |
| $\bar{D}^*(2007)^0 \pi^- \pi^+ \pi^+ \pi^0$                                            | (1.8 ± 0.4) %                                             |           | 2219 |
| $\bar{D}^{*0} 3\pi^+ 2\pi^-$                                                           | (5.7 ± 1.2) × 10 <sup>-3</sup>                            |           | 2196 |
| $D^*(2010)^+ \pi^0$                                                                    | < 1.7 × 10 <sup>-4</sup>                                  | CL = 90 % | 2255 |
| $D^*(2010)^+ K^0$                                                                      | < 9.0 × 10 <sup>-6</sup>                                  | CL = 90 % | 2225 |
| $D^*(2010)^- \pi^+ \pi^+ \pi^0$                                                        | (1.5 ± 0.7) %                                             |           | 2235 |
| $D^*(2010)^- \pi^+ \pi^+ \pi^+ \pi^-$                                                  | (2.6 ± 0.4) × 10 <sup>-3</sup>                            |           | 2217 |
| $\bar{D}_1^*(2420)^0 \pi^+$                                                            | (1.5 ± 0.6) × 10 <sup>-3</sup>                            | S = 1.3   | 2081 |
| $\bar{D}_1(2420)^0 \pi^+ \times B(\bar{D}_1^0 \rightarrow \bar{D}^0 \pi^+ \pi^-)$      | (1.9 <sup>+0.5</sup> <sub>-0.6</sub> ) × 10 <sup>-4</sup> |           | 2081 |
| $\bar{D}_2^*(2462)^0 \pi^+$                                                            | (3.4 ± 0.8) × 10 <sup>-4</sup>                            |           | —    |
| $\times B(\bar{D}_2^*(2462)^0 \rightarrow D^- \pi^+)$                                  |                                                           |           |      |
| $\bar{D}_0^*(2308)^0 \pi^+$                                                            | (6.1 ± 1.9) × 10 <sup>-4</sup>                            |           | —    |
| $\times B(\bar{D}_0^*(2308)^0 \rightarrow D^- \pi^+)$                                  |                                                           |           |      |
| $\bar{D}_1(2421)^0 \pi^+$                                                              | (6.8 ± 1.5) × 10 <sup>-4</sup>                            |           | —    |
| $\times B(\bar{D}_1(2421)^0 \rightarrow D^{*-} \pi^+)$                                 |                                                           |           |      |
| $\bar{D}_2^*(2462)^0 \pi^+$                                                            | (1.8 ± 0.5) × 10 <sup>-4</sup>                            |           | —    |
| $\times B(\bar{D}_2^*(2462)^0 \rightarrow D^{*-} \pi^+)$                               |                                                           |           |      |
| $\bar{D}_1(2427)^0 \pi^+$                                                              | (5.0 ± 1.2) × 10 <sup>-4</sup>                            |           | —    |
| $\times B(\bar{D}_1(2427)^0 \rightarrow D^{*-} \pi^+)$                                 |                                                           |           |      |
| $\bar{D}_1(2420)^0 \pi^+ \times B(\bar{D}_1^0 \rightarrow D^{*0} \pi^+ \pi^-)$         | < 6 × 10 <sup>-6</sup>                                    | CL = 90 % | 2081 |
| $\bar{D}_1^*(2420)^0 \rho^+$                                                           | < 1.4 × 10 <sup>-3</sup>                                  | CL = 90 % | 1995 |
| $\bar{D}_2^*(2460)^0 \pi^+$                                                            | < 1.3 × 10 <sup>-3</sup>                                  | CL = 90 % | 2063 |
| $\bar{D}_2^*(2460)^0 \pi^+ \times B(\bar{D}_2^{*0} \rightarrow D^{*0} \pi^+ \pi^-)$    | < 2.2 × 10 <sup>-5</sup>                                  | CL = 90 % | 2063 |
| $\bar{D}_2^*(2460)^0 \rho^+$                                                           | < 4.7 × 10 <sup>-3</sup>                                  | CL = 90 % | 1976 |
| $\bar{D}^0 D_s^+$                                                                      | (1.09 ± 0.27) %                                           |           | 1815 |
| $D_{s0}(2317)^+ \bar{D}^0 \times B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$            | (7.4 <sup>+2.3</sup> <sub>-1.9</sub> ) × 10 <sup>-4</sup> |           | 1605 |
| $D_{s0}(2317)^+ \bar{D}^0 \times B(D_{s0}(2317)^+ \rightarrow D_s^{*+} \gamma)$        | < 7.6 × 10 <sup>-4</sup>                                  | CL = 90 % | 1605 |
| $D_{s0}(2317)^+ \bar{D}^*(2010)^0 \times B(D_{s0}(2317)^+ \rightarrow D_s^+ \pi^0)$    | (9 ± 7) × 10 <sup>-4</sup>                                |           | —    |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \pi^0)$         | (1.4 <sup>+0.6</sup> <sub>-0.5</sub> ) × 10 <sup>-3</sup> | S = 1.3   | —    |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^+ \pi^0)$            | (4.7 <sup>+1.4</sup> <sub>-1.2</sub> ) × 10 <sup>-4</sup> |           | —    |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$           | < 2.2 × 10 <sup>-4</sup>                                  | CL = 90 % | —    |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \pi^0)$         | < 2.7 × 10 <sup>-4</sup>                                  | CL = 90 % | —    |
| $D_{sJ}(2457)^+ \bar{D}^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \gamma)$        | < 9.8 × 10 <sup>-4</sup>                                  | CL = 90 % | —    |
| $D_{sJ}(2457)^+ \bar{D}^*(2010)^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^{*+} \pi^0)$ | (7.6 <sup>+3.6</sup> <sub>-2.9</sub> ) × 10 <sup>-3</sup> |           | —    |
| $D_{sJ}(2457)^+ \bar{D}^*(2010)^0 \times B(D_{sJ}(2457)^+ \rightarrow D_s^+ \gamma)$   | (1.4 <sup>+0.7</sup> <sub>-0.6</sub> ) × 10 <sup>-3</sup> |           | —    |
| $\bar{D}^0 D_{sJ}(2536)^+ \times B(D_{sJ}(2536)^+ \rightarrow D^*(2007)^0 K^+)$        | < 2 × 10 <sup>-4</sup>                                    | CL = 90 % | 1447 |
| $\bar{D}^*(2007)^0 D_{sJ}(2536)^+ \times B(D_{sJ}(2536)^+ \rightarrow D^0 K^+)$        | < 7 × 10 <sup>-4</sup>                                    | CL = 90 % | 1338 |
| $\bar{D}^*(2007)^0 D_{sJ}(2573)^+ \times B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$        | < 2 × 10 <sup>-4</sup>                                    | CL = 90 % | 1416 |
| $\bar{D}^*(2007)^0 D_{sJ}(2573)^+ \times B(D_{sJ}(2573)^+ \rightarrow D^0 K^+)$        | < 5 × 10 <sup>-4</sup>                                    | CL = 90 % | 1305 |
| $\bar{D}^0 D_s^{*+}$                                                                   | (7.2 ± 2.6) × 10 <sup>-3</sup>                            |           | 1734 |
| $\bar{D}^*(2007)^0 D_s^+$                                                              | (10 ± 4) × 10 <sup>-3</sup>                               |           | 1737 |
| $\bar{D}^*(2007)^0 D_s^{*+}$                                                           | (2.2 ± 0.7) %                                             |           | 1651 |
| $D_s^{(*)+} \bar{D}^{*0}$                                                              | (2.7 ± 1.2) %                                             |           | —    |
| $\bar{D}^*(2007)^0 D^*(2010)^+$                                                        | < 1.1 %                                                   | CL = 90 % | 1713 |

|                                                                |                     |                  |          |      |                                                                        |                       |                  |                  |
|----------------------------------------------------------------|---------------------|------------------|----------|------|------------------------------------------------------------------------|-----------------------|------------------|------------------|
| $\bar{D}^0 D^*(2010)^+ + \bar{D}^*(2007)^0 D^+$                | < 1.3               | %                | CL = 90% | 1792 |                                                                        |                       |                  |                  |
| $\bar{D}^0 D^*(2010)^+$                                        | $(4.6 \pm 0.9)$     | $\times 10^{-4}$ |          | 1792 | $\psi(3770)K^+$                                                        | $(4.9 \pm 1.3)$       | $\times 10^{-4}$ | 1220             |
| $\bar{D}^0 D^+$                                                | $(4.8 \pm 1.0)$     | $\times 10^{-4}$ |          | 1866 | $\psi(3770)K^+ \times$<br>$B(\psi(3770) \rightarrow D^0 \bar{D}^0)$    | $(3.4 \pm 0.9)$       | $\times 10^{-4}$ | 1220             |
| $\bar{D}^0 D^+ K^0$                                            | < 2.8               | $\times 10^{-3}$ | CL = 90% | 1571 | $\psi(3770)K^+ \times$<br>$B(\psi(3770) \rightarrow D^+ D^- K^+)$      | $(1.4 \pm 0.8)$       | $\times 10^{-4}$ | 1220             |
| $\bar{D}^*(2007)^0 D^+ K^0$                                    | < 6.1               | $\times 10^{-3}$ | CL = 90% | 1475 |                                                                        |                       |                  |                  |
| $\bar{D}^0 \bar{D}^*(2010)^+ K^0$                              | $(5.2 \pm 1.2)$     | $\times 10^{-3}$ |          | 1476 |                                                                        |                       |                  |                  |
| $\bar{D}^*(2007)^0 D^*(2010)^+ K^0$                            | $(7.8 \pm 2.6)$     | $\times 10^{-3}$ |          | 1362 | $\chi_{c0}\pi^+ \times B(\chi_{c0} \rightarrow \pi^+\pi^-)$            | < 3                   | $\times 10^{-7}$ | CL = 90%<br>-    |
| $\bar{D}^0 D^0 K^+$                                            | $(1.37 \pm 0.32)$   | $\times 10^{-3}$ | S = 1.5  | 1577 | $\chi_{c0}(1P)K^+$                                                     | $(1.6^{+0.5}_{-0.4})$ | $\times 10^{-4}$ | 1478             |
| $\bar{D}^*(2010)^0 D^0 K^+$                                    | < 3.8               | $\times 10^{-3}$ | CL = 90% | -    | $\chi_{c0}K^*(892)^+$                                                  | < 2.86                | $\times 10^{-3}$ | CL = 90%<br>-    |
| $\bar{D}^0 \bar{D}^*(2007)^0 K^+$                              | $(4.7 \pm 1.0)$     | $\times 10^{-3}$ |          | 1481 | $\chi_{c2}K^+$                                                         | < 2.9                 | $\times 10^{-5}$ | CL = 90%<br>-    |
| $\bar{D}^*(2007)^0 D^*(2007)^0 K^+$                            | $(5.3 \pm 1.6)$     | $\times 10^{-3}$ |          | 1368 | $\chi_{c2}K^*(892)^+$                                                  | < 1.2                 | $\times 10^{-5}$ | CL = 90%<br>-    |
| $D^- D^+ K^+$                                                  | < 4                 | $\times 10^{-4}$ | CL = 90% | 1571 | $\chi_{c1}(1P)K^+$                                                     | $(5.3 \pm 0.7)$       | $\times 10^{-4}$ | S = 1.7<br>1411  |
| $D^- D^*(2010)^+ K^+$                                          | < 7                 | $\times 10^{-4}$ | CL = 90% | 1475 | $\chi_{c1}(1P)K^*(892)^+$                                              | $(3.6 \pm 0.9)$       | $\times 10^{-4}$ | 1265             |
| $D^*(2010)^- D^+ K^+$                                          | $(1.5 \pm 0.4)$     | $\times 10^{-3}$ |          | 1475 |                                                                        |                       |                  |                  |
| $D^*(2010)^- D^*(2010)^+ K^+$                                  | < 1.8               | $\times 10^{-3}$ | CL = 90% | 1363 |                                                                        |                       |                  |                  |
| $(\bar{D} + \bar{D}^*)(D + D^*)K$                              | $(3.5 \pm 0.6)$     | %                |          | -    | $K^0\pi^+$                                                             | $(2.41 \pm 0.17)$     | $\times 10^{-5}$ | S = 1.4<br>2614  |
| $D_s^+\pi^0$                                                   | < 1.7               | $\times 10^{-4}$ | CL = 90% | 2270 | $K^+\pi^0$                                                             | $(1.21 \pm 0.08)$     | $\times 10^{-5}$ | 2615             |
| $D_s^{*+}\pi^0$                                                | < 2.7               | $\times 10^{-4}$ | CL = 90% | 2215 | $\eta'K^+$                                                             | $(7.05 \pm 0.35)$     | $\times 10^{-5}$ | 2528             |
| $D_s^+\eta$                                                    | < 4                 | $\times 10^{-4}$ | CL = 90% | 2235 | $\eta'K^*(892)^+$                                                      | < 1.4                 | $\times 10^{-5}$ | CL = 90%<br>2472 |
| $D_s^{*+}\eta$                                                 | < 6                 | $\times 10^{-4}$ | CL = 90% | 2178 | $\eta K^+$                                                             | $(2.6 \pm 0.6)$       | $\times 10^{-6}$ | S = 1.3<br>2588  |
| $D_s^+\rho^0$                                                  | < 3.1               | $\times 10^{-4}$ | CL = 90% | 2197 | $\eta K^*(892)^+$                                                      | $(2.6 \pm 0.4)$       | $\times 10^{-5}$ | 2534             |
| $D_s^{*+}\rho^0$                                               | < 4                 | $\times 10^{-4}$ | CL = 90% | 2138 | $\omega K^+$                                                           | $(5.1 \pm 0.7)$       | $\times 10^{-6}$ | 2557             |
| $D_s^+\omega$                                                  | < 4                 | $\times 10^{-4}$ | CL = 90% | 2195 | $\omega K^*(892)^+$                                                    | < 7.4                 | $\times 10^{-6}$ | CL = 90%<br>2503 |
| $D_s^{*+}\omega$                                               | < 6                 | $\times 10^{-4}$ | CL = 90% | 2136 | $a_1^+K^0$                                                             | < 3.9                 | $\times 10^{-6}$ | CL = 90%<br>-    |
| $D_s^+a_1(1260)^0$                                             | < 1.8               | $\times 10^{-3}$ | CL = 90% | 2079 | $a_0^0K^+$                                                             | < 2.5                 | $\times 10^{-6}$ | CL = 90%<br>-    |
| $D_s^{*+}a_1(1260)^0$                                          | < 1.3               | $\times 10^{-3}$ | CL = 90% | 2015 | $K^*(892)^0\pi^+$                                                      | $(1.16 \pm 0.19)$     | $\times 10^{-5}$ | S = 1.8<br>2562  |
| $D_s^+\phi$                                                    | < 1.9               | $\times 10^{-6}$ | CL = 90% | 2141 | $K^*(892)^+\pi^0$                                                      | $(6.9 \pm 2.4)$       | $\times 10^{-6}$ | 2562             |
| $D_s^{*+}\phi$                                                 | < 1.2               | $\times 10^{-5}$ | CL = 90% | 2079 | $K^+\pi^-\pi^+$                                                        | $(5.6 \pm 0.9)$       | $\times 10^{-5}$ | S = 2.6<br>2609  |
| $D_s^+\bar{K}^0$                                               | < 9                 | $\times 10^{-4}$ | CL = 90% | 2242 | $K^+\pi^-\pi^+$ nonresonant                                            | $(3.1^{+1.0}_{-0.8})$ | $\times 10^{-6}$ | 2609             |
| $D_s^{*+}\bar{K}^0$                                            | < 9                 | $\times 10^{-4}$ | CL = 90% | 2185 | $K^+f_0(980) \times B(f_0 \rightarrow \pi^+\pi^-)$                     | $(8.9 \pm 1.0)$       | $\times 10^{-6}$ | 2524             |
| $D_s^+\bar{K}^*(892)^0$                                        | < 4                 | $\times 10^{-4}$ | CL = 90% | 2172 |                                                                        |                       |                  |                  |
| $D_s^{*+}\bar{K}^*(892)^0$                                     | < 4                 | $\times 10^{-4}$ | CL = 90% | 2112 | $f_2(1270)^0K^+$                                                       | < 2.3                 | $\times 10^{-6}$ | CL = 90%<br>-    |
| $D_s^+\pi^+K^+$                                                | < 7                 | $\times 10^{-4}$ | CL = 90% | 2222 | $f_0^*(1370)^0K^+ \times$<br>$B(f_0^*(1370)^0 \rightarrow \pi^+\pi^-)$ | < 1.07                | $\times 10^{-5}$ | CL = 90%<br>-    |
| $D_s^-\pi^+K^+$                                                | < 9.8               | $\times 10^{-4}$ | CL = 90% | 2164 | $\rho^0(1450)K^+ \times$<br>$B(\rho^0(1450) \rightarrow \pi^+\pi^-)$   | < 1.17                | $\times 10^{-5}$ | CL = 90%<br>-    |
| $D_s^-\pi^+K^*(892)^+$                                         | < 5                 | $\times 10^{-3}$ | CL = 90% | 2138 | $f_0(1500)K^+ \times$<br>$B(f_0(1500) \rightarrow \pi^+\pi^-)$         | < 4.4                 | $\times 10^{-6}$ | CL = 90%<br>2397 |
| $D_s^-\pi^+K^*(892)^+$                                         | < 7                 | $\times 10^{-3}$ | CL = 90% | 2076 | $f_2(1525)K^+ \times$<br>$B(f_2'(1525) \rightarrow \pi^+\pi^-)$        | < 3.4                 | $\times 10^{-6}$ | CL = 90%<br>2392 |
| Charmonium modes                                               |                     |                  |          |      |                                                                        |                       |                  |                  |
| $\eta_c K^+$                                                   | $(9.1 \pm 1.3)$     | $\times 10^{-4}$ |          | 1753 | $K^+\rho^0$                                                            | $(5.0^{+0.7}_{-0.8})$ | $\times 10^{-6}$ | 2558             |
| $\eta_c' K^+$                                                  | $(3.4 \pm 1.8)$     | $\times 10^{-4}$ |          | -    | $K_0^*(1430)^0\pi^+$                                                   | $(3.8 \pm 0.5)$       | $\times 10^{-5}$ | 2448             |
| $J/\psi(1S)K^+$                                                | $(1.008 \pm 0.035)$ | $\times 10^{-3}$ |          | 1683 | $K_2^*(1430)^0\pi^+$                                                   | < 6.9                 | $\times 10^{-6}$ | CL = 90%<br>2445 |
| $J/\psi(1S)K^+\pi^+\pi^-$                                      | $(1.07 \pm 0.19)$   | $\times 10^{-3}$ | S = 1.9  | 1612 | $K^*(1410)^0\pi^+$                                                     | < 4.5                 | $\times 10^{-5}$ | CL = 90%<br>2448 |
| $h_c(1P)K^+ \times B(h_c(1P) \rightarrow J/\psi\pi^+\pi^-)$    | < 3.4               | $\times 10^{-6}$ | CL = 90% | 1401 | $K^*(1680)^0\pi^+$                                                     | < 1.2                 | $\times 10^{-5}$ | CL = 90%<br>2358 |
| $X(3872)K^+$                                                   | < 3.2               | $\times 10^{-4}$ | CL = 90% | 1141 | $K^-\pi^+\pi^+$                                                        | < 1.8                 | $\times 10^{-6}$ | CL = 90%<br>2609 |
| $X(3872)K^+ \times B(X \rightarrow J/\psi\pi^+\pi^-)$          | $(1.14 \pm 0.20)$   | $\times 10^{-5}$ |          | 1141 | $K^-\pi^+\pi^+$ nonresonant                                            | < 5.6                 | $\times 10^{-5}$ | CL = 90%<br>2609 |
| $X(3872)K^+ \times B(X(3872) \rightarrow D^0 \bar{D}^0)$       | < 6.0               | $\times 10^{-5}$ | CL = 90% | 1141 | $K_1(1400)^0\pi^+$                                                     | < 2.6                 | $\times 10^{-3}$ | CL = 90%<br>2451 |
| $X(3872)K^+ \times B(X(3872) \rightarrow D^+ D^-)$             | < 4.0               | $\times 10^{-5}$ | CL = 90% | 1141 | $K^0\pi^+\pi^0$                                                        | < 6.6                 | $\times 10^{-5}$ | CL = 90%<br>2609 |
| $X(3872)K^+ \times B(X(3872) \rightarrow D^0 \bar{D}^0 \pi^0)$ | < 6.0               | $\times 10^{-5}$ | CL = 90% | 1141 | $K^0\rho^+$                                                            | < 4.8                 | $\times 10^{-5}$ | CL = 90%<br>2558 |
| $X(3872)K^+ \times B(X(3872) \rightarrow J/\psi(1S)\eta)$      | < 7.7               | $\times 10^{-6}$ | CL = 90% | 1141 | $K^*(892)^+\pi^+\pi^-$                                                 | < 1.1                 | $\times 10^{-3}$ | CL = 90%<br>2556 |
| $X(3872)^+K^0 \times [jjj]$                                    | < 2.2               | $\times 10^{-5}$ | CL = 90% | -    | $K^*(892)^+\rho^0$                                                     | $(1.1 \pm 0.4)$       | $\times 10^{-5}$ | 2504             |
| $Y(4260)^0K^+ \times B(Y^0 \rightarrow J/\psi\pi^+\pi^-)$      | < 2.9               | $\times 10^{-5}$ | CL = 95% | -    | $K^*(892)^0\rho^+$                                                     | $(8.9 \pm 2.1)$       | $\times 10^{-6}$ | 2504             |
| $J/\psi(1S)K^*(892)^+$                                         | $(1.41 \pm 0.08)$   | $\times 10^{-3}$ |          | 1571 | $K^*(892)^+K^*(892)^0$                                                 | < 7.1                 | $\times 10^{-5}$ | CL = 90%<br>2484 |
| $J/\psi(1S)K(1270)^+$                                          | $(1.8 \pm 0.5)$     | $\times 10^{-3}$ |          | 1390 | $K_1(1400)^+\rho^0$                                                    | < 7.8                 | $\times 10^{-4}$ | CL = 90%<br>2387 |
| $J/\psi(1S)K(1400)^+$                                          | < 5                 | $\times 10^{-4}$ | CL = 90% | 1308 | $K_2^*(1430)^+\rho^0$                                                  | < 1.5                 | $\times 10^{-3}$ | CL = 90%<br>2381 |
| $J/\psi(1S)\eta K^+$                                           | $(1.08 \pm 0.33)$   | $\times 10^{-4}$ |          | 1510 | $K^+\bar{K}^0$                                                         | $(1.20 \pm 0.32)$     | $\times 10^{-6}$ | 2593             |
| $J/\psi(1S)\phi K^+$                                           | $(5.2 \pm 1.7)$     | $\times 10^{-5}$ | S = 1.2  | 1227 | $\bar{K}^0K^+\pi^0$                                                    | < 2.4                 | $\times 10^{-5}$ | CL = 90%<br>2578 |
| $J/\psi(1S)\pi^+$                                              | $(4.9 \pm 0.6)$     | $\times 10^{-5}$ | S = 1.5  | 1727 | $K^+K_S^0K_S^0$                                                        | $(1.15 \pm 0.13)$     | $\times 10^{-5}$ | 2521             |
| $J/\psi(1S)\rho^+$                                             | < 7.7               | $\times 10^{-4}$ | CL = 90% | 1611 | $K_S^0K_S^0\pi^+$                                                      | < 3.2                 | $\times 10^{-6}$ | CL = 90%<br>2577 |
| $J/\psi(1S)a_1(1260)^+$                                        | < 1.2               | $\times 10^{-3}$ | CL = 90% | 1414 | $K^+K^-\pi^+$                                                          | < 6.3                 | $\times 10^{-6}$ | CL = 90%<br>2578 |
| $J/\psi(1S)p\bar{\Lambda}$                                     | $(1.18 \pm 0.31)$   | $\times 10^{-5}$ |          | 567  | $K^+K^-\pi^+$ nonresonant                                              | < 7.5                 | $\times 10^{-5}$ | CL = 90%<br>2578 |
| $J/\psi(1S)\bar{\Sigma}^0 p$                                   | < 1.1               | $\times 10^{-5}$ | CL = 90% | -    | $K^+K^+\pi^-$                                                          | < 1.3                 | $\times 10^{-6}$ | CL = 90%<br>2578 |
| $J/\psi(1S)D^+$                                                | < 1.2               | $\times 10^{-4}$ | CL = 90% | 871  | $K^+K^+\pi^-$ nonresonant                                              | < 8.79                | $\times 10^{-5}$ | CL = 90%<br>2578 |
| $J/\psi(1S)\bar{D}^0\pi^+$                                     | < 2.5               | $\times 10^{-5}$ | CL = 90% | 665  | $K^+K^*(892)^0$                                                        | < 5.3                 | $\times 10^{-6}$ | CL = 90%<br>2540 |
| $\psi(2S)K^+$                                                  | $(6.48 \pm 0.35)$   | $\times 10^{-4}$ |          | 1284 | $K^+K^-K^+$                                                            | $(3.01 \pm 0.19)$     | $\times 10^{-5}$ | 2522             |
| $\psi(2S)K^*(892)^+$                                           | $(6.7 \pm 1.4)$     | $\times 10^{-4}$ | S = 1.3  | 1115 | $K^+\phi$                                                              | $(9.0 \pm 0.8)$       | $\times 10^{-6}$ | S = 1.3<br>2516  |
| $\psi(2S)K^+\pi^+\pi^-$                                        | $(1.9 \pm 1.2)$     | $\times 10^{-3}$ |          | 1178 | $f_0(980)K^+ \times B(f_0(980) \rightarrow K^+K^-)$                    | < 2.9                 | $\times 10^{-6}$ | CL = 90%<br>2524 |
|                                                                |                     |                  |          |      | $a_2(1320)K^+ \times B(a_2(1320) \rightarrow K^+K^-)$                  | < 1.1                 | $\times 10^{-6}$ | CL = 90%<br>2449 |
|                                                                |                     |                  |          |      | $f_2'(1525)K^+ \times B(f_2'(1525) \rightarrow K^+K^-)$                | < 4.9                 | $\times 10^{-6}$ | CL = 90%<br>2392 |
|                                                                |                     |                  |          |      | $\phi(1680)K^+ \times B(\phi(1680) \rightarrow K^+K^-)$                | < 8                   | $\times 10^{-7}$ | CL = 90%<br>2344 |

|                                   |                                         |          |      |
|-----------------------------------|-----------------------------------------|----------|------|
| $K^+K^-K^+$ nonresonant           | $(2.40^{+0.30}_{-0.62}) \times 10^{-5}$ |          | 2522 |
| $K^*(892)^+K^+K^-$                | $< 1.6 \times 10^{-3}$                  | CL = 90% | 2466 |
| $K^*(892)^+\phi$                  | $(9.6 \pm 3.0) \times 10^{-6}$          | S = 1.9  | 2460 |
| $K_1(1400)^+\phi$                 | $< 1.1 \times 10^{-3}$                  | CL = 90% | 2339 |
| $K_2^*(1430)^+\phi$               | $< 3.4 \times 10^{-3}$                  | CL = 90% | 2332 |
| $K^+\phi\phi$                     | $(2.6^{+1.1}_{-0.9}) \times 10^{-6}$    |          | 2306 |
| $K^*(892)^+\gamma$                | $(4.03 \pm 0.26) \times 10^{-5}$        |          | 2564 |
| $K_1(1270)^+\gamma$               | $(4.3 \pm 1.3) \times 10^{-5}$          |          | 2486 |
| $\eta K^+\gamma$                  | $(8.4 \pm 1.8) \times 10^{-6}$          |          | 2588 |
| $\phi K^+\gamma$                  | $(3.4 \pm 1.0) \times 10^{-6}$          |          | 2516 |
| $K^+\pi^-\pi^+\gamma$             | $(2.50 \pm 0.28) \times 10^{-5}$        |          | 2609 |
| $K^*(892)^0\pi^+\gamma$           | $(2.0^{+0.7}_{-0.6}) \times 10^{-5}$    |          | 2562 |
| $K^+\rho^0\gamma$                 | $< 2.0 \times 10^{-5}$                  | CL = 90% | 2558 |
| $K^+\pi^-\pi^+\gamma$ nonresonant | $< 9.2 \times 10^{-6}$                  | CL = 90% | 2609 |
| $K_1(1400)^+\gamma$               | $< 1.5 \times 10^{-5}$                  |          | 2453 |
| $K_2^*(1430)^+\gamma$             | $(1.4 \pm 0.4) \times 10^{-5}$          |          | 2447 |
| $K^*(1680)^+\gamma$               | $< 1.9 \times 10^{-3}$                  | CL = 90% | 2360 |
| $K_3^*(1780)^+\gamma$             | $< 3.9 \times 10^{-5}$                  | CL = 90% | 2341 |
| $K_4^*(2045)^+\gamma$             | $< 9.9 \times 10^{-3}$                  | CL = 90% | 2243 |

## Light unflavored meson modes

|                                                                  |                                  |          |      |
|------------------------------------------------------------------|----------------------------------|----------|------|
| $\rho^+\gamma$                                                   | $< 1.8 \times 10^{-6}$           | CL = 90% | 2583 |
| $\pi^+\pi^0$                                                     | $(5.5 \pm 0.6) \times 10^{-6}$   |          | 2636 |
| $\pi^+\pi^+\pi^-$                                                | $(1.62 \pm 0.15) \times 10^{-5}$ |          | 2630 |
| $\rho^0\pi^+$                                                    | $(8.7 \pm 1.1) \times 10^{-6}$   |          | 2581 |
| $\pi^+f_0(980) \times$<br>$B(f_0(980) \rightarrow \pi^+\pi^-)$   | $< 3.0 \times 10^{-6}$           | CL = 90% | 2547 |
| $\pi^+f_2(1270)$                                                 | $(8.2 \pm 2.5) \times 10^{-6}$   |          | 2483 |
| $\rho(1450)^0\pi^+$                                              | $< 2.3 \times 10^{-6}$           | CL = 90% | 2436 |
| $f_0(1370)\pi^+ \times B(f_0(1370) \rightarrow$<br>$\pi^+\pi^-)$ | $< 3.0 \times 10^{-6}$           | CL = 90% | 2460 |
| $f_0(600)\pi^+ \times B(f_0(600) \rightarrow$<br>$\pi^+\pi^-)$   | $< 4.1 \times 10^{-6}$           | CL = 90% | –    |
| $\pi^+\pi^-\pi^+$ nonresonant                                    | $< 4.6 \times 10^{-6}$           | CL = 90% | 2630 |
| $\pi^+\pi^0\pi^0$                                                | $< 8.9 \times 10^{-4}$           | CL = 90% | 2631 |
| $\rho^+\pi^0$                                                    | $(1.20 \pm 0.19) \times 10^{-5}$ |          | 2581 |
| $\pi^+\pi^-\pi^+\pi^0$                                           | $< 4.0 \times 10^{-3}$           | CL = 90% | 2621 |
| $\rho^+\rho^0$                                                   | $(2.6 \pm 0.6) \times 10^{-5}$   |          | 2523 |
| $a_1(1260)^+\pi^0$                                               | $< 1.7 \times 10^{-3}$           | CL = 90% | 2494 |
| $a_1(1260)^0\pi^+$                                               | $< 9.0 \times 10^{-4}$           | CL = 90% | 2494 |
| $\omega\pi^+$                                                    | $(5.9 \pm 1.0) \times 10^{-6}$   | S = 1.2  | 2580 |
| $\omega\rho^+$                                                   | $(1.3 \pm 0.4) \times 10^{-5}$   |          | 2522 |
| $\eta\pi^+$                                                      | $(4.9 \pm 0.5) \times 10^{-6}$   |          | 2609 |
| $\eta'\pi^+$                                                     | $(4.0 \pm 0.9) \times 10^{-6}$   |          | 2551 |
| $\eta'\rho^+$                                                    | $< 2.2 \times 10^{-5}$           | CL = 90% | 2492 |
| $\eta\rho^+$                                                     | $(8.4 \pm 2.2) \times 10^{-6}$   |          | 2553 |
| $\phi\pi^+$                                                      | $< 4.1 \times 10^{-7}$           | CL = 90% | 2539 |
| $\phi\rho^+$                                                     | $< 1.6 \times 10^{-5}$           |          | 2480 |
| $a_0^0\pi^+$                                                     | $< 5.8 \times 10^{-6}$           | CL = 90% | –    |
| $\pi^+\pi^+\pi^+\pi^-\pi^-$                                      | $< 8.6 \times 10^{-4}$           | CL = 90% | 2608 |
| $\rho^0a_1(1260)^+$                                              | $< 6.2 \times 10^{-4}$           | CL = 90% | 2433 |
| $\rho^0a_2(1320)^+$                                              | $< 7.2 \times 10^{-4}$           | CL = 90% | 2410 |
| $\pi^+\pi^+\pi^+\pi^-\pi^0$                                      | $< 6.3 \times 10^{-3}$           | CL = 90% | 2592 |
| $a_1(1260)^+a_1(1260)^0$                                         | $< 1.3 \%$                       | CL = 90% | 2335 |

Charged particle ( $h^\pm$ ) modes

|                            |                                         |          |      |
|----------------------------|-----------------------------------------|----------|------|
| $h^\pm-k^\pm$ or $\pi^\pm$ |                                         |          |      |
| $h^+\pi^0$                 | $(1.6^{+0.7}_{-0.6}) \times 10^{-5}$    |          | 2636 |
| $\omega h^+$               | $(1.38^{+0.27}_{-0.24}) \times 10^{-5}$ |          | 2580 |
| $h^+X^0$ (Familon)         | $< 4.9 \times 10^{-5}$                  | CL = 90% | –    |

## Baryon modes

|                                                                                   |                                         |          |      |
|-----------------------------------------------------------------------------------|-----------------------------------------|----------|------|
| $p\bar{p}\pi^+$                                                                   | $(3.1^{+0.8}_{-0.7}) \times 10^{-6}$    |          | 2439 |
| $p\bar{p}\pi^+$ nonresonant                                                       | $< 5.3 \times 10^{-5}$                  | CL = 90% | 2439 |
| $p\bar{p}\pi^+\pi^+\pi^-$                                                         | $< 5.2 \times 10^{-4}$                  | CL = 90% | 2369 |
| $p\bar{p}K^+$                                                                     | $(5.6 \pm 1.0) \times 10^{-6}$          | S = 2.4  | 2348 |
| $\Theta(1710)^{++}\bar{p} \times$<br>$B(\Theta(1710)^{++} \rightarrow$<br>$pK^+)$ | $< 9.1 \times 10^{-8}$                  | CL = 90% | –    |
| $f_1(2220)K^+ \times$<br>$B(f_1(2220) \rightarrow p\bar{p})$                      | $< 4.1 \times 10^{-7}$                  | CL = 90% | 2135 |
| $p\bar{\Lambda}(1520)$                                                            | $< 1.5 \times 10^{-6}$                  | CL = 90% | 2322 |
| $p\bar{p}K^+$ nonresonant                                                         | $< 8.9 \times 10^{-5}$                  | CL = 90% | 2348 |
| $p\bar{p}K^*(892)^+$                                                              | $(1.03^{+0.38}_{-0.33}) \times 10^{-5}$ |          | 2215 |
| $p\bar{\Lambda}$                                                                  | $< 4.9 \times 10^{-7}$                  | CL = 90% | 2430 |

|                                                              |                                      |          |      |
|--------------------------------------------------------------|--------------------------------------|----------|------|
| $p\bar{\Lambda}\gamma$                                       | $(2.2 \pm 0.6) \times 10^{-6}$       |          | 2430 |
| $p\bar{\Sigma}\gamma$                                        | $< 4.6 \times 10^{-6}$               | CL = 90% | 2413 |
| $p\bar{\Lambda}\pi^+\pi^-$                                   | $< 2.0 \times 10^{-4}$               | CL = 90% | 2367 |
| $\Lambda\bar{\Lambda}\pi^+$                                  | $< 2.8 \times 10^{-6}$               | CL = 90% | 2358 |
| $\Lambda\bar{\Lambda}K^+$                                    | $(2.9^{+1.0}_{-0.8}) \times 10^{-6}$ |          | 2251 |
| $\bar{\Delta}^0 p$                                           | $< 3.8 \times 10^{-4}$               | CL = 90% | 2402 |
| $\Delta^{++}\bar{p}$                                         | $< 1.5 \times 10^{-4}$               | CL = 90% | 2402 |
| $D^+p\bar{p}$                                                | $< 1.5 \times 10^{-5}$               | CL = 90% | 1860 |
| $D^*(2010)^+p\bar{p}$                                        | $< 1.5 \times 10^{-5}$               | CL = 90% | 1786 |
| $\bar{\Lambda}_c^- p\pi^+$                                   | $(2.1 \pm 0.7) \times 10^{-4}$       |          | 1980 |
| $\bar{\Lambda}_c^- p\pi^+\pi^0$                              | $(1.8 \pm 0.6) \times 10^{-3}$       |          | 1935 |
| $\bar{\Lambda}_c^- p\pi^+\pi^+\pi^-$                         | $(2.3 \pm 0.7) \times 10^{-3}$       |          | 1880 |
| $\bar{\Lambda}_c^- p\pi^+\pi^+\pi^-\pi^0$                    | $< 1.34 \%$                          | CL = 90% | 1822 |
| $\bar{\Sigma}_c^-(2455)^0 p$                                 | $< 8 \times 10^{-5}$                 | CL = 90% | 1938 |
| $\bar{\Sigma}_c^-(2520)^0 p$                                 | $< 4.6 \times 10^{-5}$               | CL = 90% | 1904 |
| $\bar{\Sigma}_c^-(2455)^0 p\pi^0$                            | $(4.4 \pm 1.8) \times 10^{-4}$       |          | 1896 |
| $\bar{\Sigma}_c^-(2455)^0 p\pi^-\pi^+$                       | $(4.4 \pm 1.7) \times 10^{-4}$       |          | 1845 |
| $\bar{\Sigma}_c^-(2455)^{--} p\pi^+\pi^+$                    | $(2.8 \pm 1.2) \times 10^{-4}$       |          | 1845 |
| $\bar{\Lambda}_c^-(2593)^-/\bar{\Lambda}_c^-(2625)^- p\pi^+$ | $< 1.9 \times 10^{-4}$               | CL = 90% | –    |

Lepton Family number (LF) or Lepton number (L) violating modes, or  $\Delta B = 1$  weak neutral current (B1) modes

|                          |          |                                      |          |      |
|--------------------------|----------|--------------------------------------|----------|------|
| $\pi^+e^+e^-$            | B1       | $< 3.9 \times 10^{-3}$               | CL = 90% | 2638 |
| $\pi^+\mu^+\mu^-$        | B1       | $< 9.1 \times 10^{-3}$               | CL = 90% | 2633 |
| $\pi^+\nu\bar{\nu}$      | B1       | $< 1.0 \times 10^{-4}$               | CL = 90% | 2638 |
| $K^+e^+e^-$              | B1       | $(8.0^{+2.2}_{-1.9}) \times 10^{-7}$ | S = 1.4  | 2616 |
| $K^+\mu^+\mu^-$          | B1       | $(3.4^{+1.9}_{-1.4}) \times 10^{-7}$ | S = 1.7  | 2612 |
| $K^+\ell^+\ell^-$        | B1 [ggg] | $(5.3 \pm 1.1) \times 10^{-7}$       |          | 2616 |
| $K^+\bar{\nu}\nu$        | B1       | $< 5.2 \times 10^{-5}$               | CL = 90% | 2616 |
| $K^*(892)^+e^+e^-$       | B1       | $< 4.6 \times 10^{-6}$               | CL = 90% | 2564 |
| $K^*(892)^+\mu^+\mu^-$   | B1       | $< 2.2 \times 10^{-6}$               | CL = 90% | 2560 |
| $K^*(892)^+\ell^+\ell^-$ | B1 [ggg] | $< 2.2 \times 10^{-6}$               | CL = 90% | 2564 |
| $\pi^+e^+\mu^-$          | LF       | $< 6.4 \times 10^{-3}$               | CL = 90% | 2637 |
| $\pi^+e^-\mu^+$          | LF       | $< 6.4 \times 10^{-3}$               | CL = 90% | 2637 |
| $K^+e^+\mu^-$            | LF       | $< 8 \times 10^{-7}$                 | CL = 90% | 2615 |
| $K^+e^-\mu^+$            | LF       | $< 6.4 \times 10^{-3}$               | CL = 90% | 2615 |
| $K^*(892)^+e^\pm\mu^\mp$ | LF       | $< 7.9 \times 10^{-6}$               | CL = 90% | 2563 |
| $\pi^-e^+e^+$            | L        | $< 1.6 \times 10^{-6}$               | CL = 90% | 2638 |
| $\pi^-\mu^+\mu^+$        | L        | $< 1.4 \times 10^{-6}$               | CL = 90% | 2633 |
| $\pi^-e^+\mu^+$          | L        | $< 1.3 \times 10^{-6}$               | CL = 90% | 2637 |
| $\rho^-e^+e^+$           | L        | $< 2.6 \times 10^{-6}$               | CL = 90% | 2583 |
| $\rho^-\mu^+\mu^+$       | L        | $< 5.0 \times 10^{-6}$               | CL = 90% | 2578 |
| $\rho^-e^+\mu^+$         | L        | $< 3.3 \times 10^{-6}$               | CL = 90% | 2581 |
| $K^-e^+e^+$              | L        | $< 1.0 \times 10^{-6}$               | CL = 90% | 2616 |
| $K^-\mu^+\mu^+$          | L        | $< 1.8 \times 10^{-6}$               | CL = 90% | 2612 |
| $K^-e^+\mu^+$            | L        | $< 2.0 \times 10^{-6}$               | CL = 90% | 2615 |
| $K^*(892)^-e^+e^+$       | L        | $< 2.8 \times 10^{-6}$               | CL = 90% | 2564 |
| $K^*(892)^-\mu^+\mu^+$   | L        | $< 8.3 \times 10^{-6}$               | CL = 90% | 2560 |
| $K^*(892)^-e^+\mu^+$     | L        | $< 4.4 \times 10^{-6}$               | CL = 90% | 2563 |

 **$B^0$** 

$$I(J^P) = \frac{1}{2}(0^-)$$

$I, J, P$  need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B^0} = 5279.4 \pm 0.5 \text{ MeV}$$

$$m_{B^0} - m_{B^\pm} = 0.33 \pm 0.28 \text{ MeV} \quad (S = 1.1)$$

$$\text{Mean life } \tau_{B^0} = (1.530 \pm 0.009) \times 10^{-12} \text{ s}$$

$$c\tau = 458.7 \mu\text{m}$$

$$\tau_{B^+}/\tau_{B^0} = 1.071 \pm 0.009 \quad (\text{direct measurements})$$

 **$B^0$ - $\bar{B}^0$  mixing parameters**

$$\chi_d = 0.188 \pm 0.003$$

$$\Delta m_{B^0} = m_{B_H^0} - m_{B_L^0} = (0.507 \pm 0.005) \times 10^{12} \text{ } \hbar s^{-1}$$

$$= (3.337 \pm 0.033) \times 10^{-10} \text{ MeV}$$

$$\kappa_d = \Delta m_{B^0}/\Gamma_{B^0} = 0.776 \pm 0.008$$

$$\text{Re}(\lambda_{CP} / |\lambda_{CP}|) \text{ Re}(z) = 0.01 \pm 0.05$$

$$\text{Re}(z) = 0.00 \pm 0.12$$

$$\text{Im}(z) = -0.002 \pm 0.033 \quad (S = 1.4)$$



**CP violation parameters**

$$\begin{aligned}
& \text{Re}(\epsilon_{B^0})/(1 + |\epsilon_{B^0}|^2) = (-1.3 \pm 2.9) \times 10^{-3} \\
& A_{T/CP} = 0.005 \pm 0.018 \\
& A_{CP}(B^0 \rightarrow D^*(2010)^+ D^-) = 0.03 \pm 0.07 \\
& A_{CP}(B^0 \rightarrow K^*(892)^0 \phi) = 0.01 \pm 0.07 \\
& A_{CP}(B^0 \rightarrow K^+ \pi^-) = -0.113 \pm 0.020 \\
& A_{CP}(B^0 \rightarrow K_S^0 \pi^0) = 0.16 \pm 0.29 \\
& A_{CP}(B^0 \rightarrow \eta K^*(892)^0) = 0.02 \pm 0.11 \\
& A_{CP}(B^0 \rightarrow \rho^+ K^-) = 0.26 \pm 0.15 \\
& A_{CP}(B^0 \rightarrow K^+ \pi^- \pi^0) = 0.07 \pm 0.11 \\
& A_{CP}(B^0 \rightarrow K^*(892)^+ \pi^-) = -0.05 \pm 0.14 \\
& A_{CP}(B^0 \rightarrow \rho^+ \pi^-) = -0.15 \pm 0.08 \\
& A_{CP}(B^0 \rightarrow \rho^- \pi^+) = -0.53 \pm 0.30 \\
& A_{CP}(B^0 \rightarrow K^*(1430) \gamma) = -0.08 \pm 0.15 \\
& C_{D^*(2010)^- D^+}(B^0 \rightarrow D^*(2010)^- D^+) = 0.20 \pm 0.18 \\
& S_{D^*(2010)^- D^+}(B^0 \rightarrow D^*(2010)^- D^+) = -0.53 \pm 0.32 \quad (S = 1.2) \\
& C_{D^*(2010)^+ D^-}(B^0 \rightarrow D^*(2010)^+ D^-) = -0.17 \pm 0.23 \quad (S = 1.3) \\
& S_{D^*(2010)^+ D^-}(B^0 \rightarrow D^*(2010)^+ D^-) = -0.54 \pm 0.27 \\
& C_{D^+ D^-}(B^0 \rightarrow D^+ D^-) = 0.27 \pm 0.17 \\
& S_{D^+ D^-}(B^0 \rightarrow D^+ D^-) = -0.2 \pm 0.4 \quad (S = 1.2) \\
& C_+(B^0 \rightarrow D^{*+} D^{*-}) = 0.06 \pm 0.17 \\
& S_+(B^0 \rightarrow D^{*+} D^{*-}) = -0.75 \pm 0.25 \\
& C_-(B^0 \rightarrow D^{*+} D^{*-}) = -0.2 \pm 0.10 \\
& S_-(B^0 \rightarrow D^{*+} D^{*-}) = -1.8 \pm 1.8 \\
& C_{D^+ D^-}(B^0 \rightarrow D^+ D^-) = 0.1 \pm 0.4 \\
& S_{D^+ D^-}(B^0 \rightarrow D^+ D^-) = -0.3 \pm 0.6 \\
& C_{J/\psi(1S)\pi^0}(B^0 \rightarrow J/\psi(1S)\pi^0) = 0.13 \pm 0.24 \\
& S_{J/\psi(1S)\pi^0}(B^0 \rightarrow J/\psi(1S)\pi^0) = -0.4 \pm 0.4 \quad (S = 1.1) \\
& C_{\omega K_S^0}(B^0 \rightarrow \omega K_S^0) = -0.3 \pm 0.5 \\
& S_{\omega K_S^0}(B^0 \rightarrow \omega K_S^0) = 0.8 \pm 0.7 \\
& C_{\eta'(958)K}(B^0 \rightarrow \eta'(958)K_S^0) = -0.04 \pm 0.20 \quad (S = 2.5) \\
& S_{\eta'(958)K}(B^0 \rightarrow \eta'(958)K_S^0) = 0.43 \pm 0.17 \quad (S = 1.5) \\
& C_{f_0(980)K_S^0}(B^0 \rightarrow f_0(980)K_S^0) = 0.39 \pm 0.28 \\
& S_{f_0(980)K_S^0}(B^0 \rightarrow f_0(980)K_S^0) = 0.5 \pm 0.4 \\
& C_{K_S^0 K_S^0 K_S^0}(B^0 \rightarrow K_S^0 K_S^0 K_S^0) = -0.41 \pm 0.21 \\
& S_{K_S^0 K_S^0 K_S^0}(B^0 \rightarrow K_S^0 K_S^0 K_S^0) = -0.3^{+0.8}_{-0.7} \quad (S = 2.4) \\
& C_{K^+ K^- K_S^0}(B^0 \rightarrow K^+ K^- K_S^0) = 0.09 \pm 0.10 \\
& S_{K^+ K^- K_S^0}(B^0 \rightarrow K^+ K^- K_S^0) = -0.45 \pm 0.13 \\
& C_{\phi K_S^0}(B^0 \rightarrow \phi K_S^0) = -0.04 \pm 0.17 \\
& S_{\phi K_S^0}(B^0 \rightarrow \phi K_S^0) = 0.35 \pm 0.21 \\
& C_{K_S^0 \pi^0}(B^0 \rightarrow K_S^0 \pi^0) = 0.08 \pm 0.14 \\
& S_{K_S^0 \pi^0}(B^0 \rightarrow K_S^0 \pi^0) = 0.34 \pm 0.28 \\
& C_{K_S^0 \pi^0 \gamma}(B^0 \rightarrow K_S^0 \pi^0 \gamma) = -0.3 \pm 0.4 \quad (S = 1.5) \\
& S_{K_S^0 \pi^0 \gamma}(B^0 \rightarrow K_S^0 \pi^0 \gamma) = -0.3^{+0.6}_{-0.5} \quad (S = 1.3) \\
& C_{K^*(892)^0 \gamma}(B^0 \rightarrow K^*(892)^0 \gamma) = -0.40 \pm 0.23 \\
& S_{K^*(892)^0 \gamma}(B^0 \rightarrow K^*(892)^0 \gamma) = -0.39 \pm 0.33 \\
& C_{\pi\pi}(B^0 \rightarrow \pi^+ \pi^-) = -0.36 \pm 0.23 \quad (S = 2.3) \\
& S_{\pi\pi}(B^0 \rightarrow \pi^+ \pi^-) = -0.49 \pm 0.18 \quad (S = 1.5) \\
& C_{\pi^0 \pi^0}(B^0 \rightarrow \pi^0 \pi^0) = -0.3 \pm 0.4 \\
& C_{\rho\pi}(B^0 \rightarrow \rho^+ \pi^-) = 0.30 \pm 0.13 \\
& S_{\rho\pi}(B^0 \rightarrow \rho^+ \pi^-) = -0.04 \pm 0.23 \quad (S = 1.3) \\
& \Delta C_{\rho\pi}(B^0 \rightarrow \rho^+ \pi^-) = 0.33 \pm 0.13 \\
& \Delta S_{\rho\pi}(B^0 \rightarrow \rho^+ \pi^-) = -0.07 \pm 0.22 \quad (S = 1.3) \\
& C_{\rho\rho}(B^0 \rightarrow \rho^+ \rho^-) = -0.02 \pm 0.17 \\
& S_{\rho\rho}(B^0 \rightarrow \rho^+ \rho^-) = -0.22 \pm 0.22 \\
& |\lambda|(B^0 \rightarrow c\bar{c}K^0) = 0.969 \pm 0.028 \\
& |\lambda|(B^0 \rightarrow J/\psi K^*(892)^0) < 0.25, CL=95\% \\
& \cos 2\beta(B^0 \rightarrow J/\psi K^*(892)^0) = 1.7^{+0.7}_{-0.9} \quad (S = 1.6) \\
& (S_+ + S_-)/2(B^0 \rightarrow D^{*-} \pi^+) = -0.028 \pm 0.017 \quad (S = 1.3) \\
& (S_- - S_+)/2(B^0 \rightarrow D^{*-} \pi^+) = -0.001 \pm 0.018 \\
& (S_+ + S_-)/2(B^0 \rightarrow D^- \pi^+) = -0.043 \pm 0.030 \\
& (S_- - S_+)/2(B^0 \rightarrow D^- \pi^+) = -0.01 \pm 0.04 \\
& \sin(2\beta) = 0.725 \pm 0.037 \\
& \sin(2\beta_{\text{eff}})(B^0 \rightarrow \phi K^0) = 0.50 \pm 0.26 \\
& \sin(2\beta_{\text{eff}})(B^0 \rightarrow K^+ K^- K_S^0) = 0.55 \pm 0.25 \\
& |\sin(2\beta + \gamma)| > 0.35, CL = 90\% \\
& \alpha = (96 \pm 10)^\circ
\end{aligned}$$

$\bar{B}^0$  modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing. Modes which do not identify the charge state of the  $B$  are listed in the  $B^\pm/B^0$  ADMIXTURE section.

The branching fractions listed below assume 50%  $B^0 \bar{B}^0$  and 50%  $B^+ B^-$  production at the  $\Upsilon(4S)$ . We have attempted to bring older measurements up to date by rescaling their assumed  $\Upsilon(4S)$  production ratio to 50:50 and their assumed  $D, D_s, D^*$ , and  $\psi$  branching ratios to current values whenever this would affect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

For inclusive branching fractions, e.g.,  $B \rightarrow D^\pm$  anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

| <b><math>B^0</math> DECAY MODES</b>                                | <b>Fraction (<math>\Gamma_i / \Gamma</math>)</b> | <b>Scale factor/<br/>Confidence level</b> | <b><math>p</math><br/>(MeV/c)</b> |
|--------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------|-----------------------------------|
| $\ell^+ \nu_\ell$ anything                                         | [ggg] (10.4 $\pm$ 0.4) %                         |                                           | —                                 |
| $D^- \ell^+ \nu_\ell$                                              | [ggg] (2.12 $\pm$ 0.20) %                        |                                           | 2309                              |
| $D^*(2010)^- \ell^+ \nu_\ell$                                      | [ggg] (5.35 $\pm$ 0.20) %                        |                                           | 2257                              |
| $\bar{D}^0 \pi^+ \ell^+ \nu_\ell$                                  | (3.2 $\pm$ 1.0) $\times 10^{-3}$                 |                                           | 2308                              |
| $\bar{D}^{*0} \pi^+ \ell^+ \nu_\ell$                               | (6.5 $\pm$ 1.5) $\times 10^{-3}$                 |                                           | 2256                              |
| $\rho^- \ell^+ \nu_\ell$                                           | [ggg] (2.3 $\pm$ 0.4) $\times 10^{-4}$           |                                           | 2583                              |
| $\pi^- \ell^+ \nu_\ell$                                            | [ggg] (1.36 $\pm$ 0.15) $\times 10^{-4}$         |                                           | 2638                              |
| <b>Inclusive modes</b>                                             |                                                  |                                           |                                   |
| $K^\pm$ anything                                                   | (78 $\pm$ 8) %                                   |                                           | —                                 |
| $D^0 X$                                                            | (6.3 $\pm$ 2.0) %                                |                                           | —                                 |
| $\bar{D}^0 X$                                                      | (51 $\pm$ 4) %                                   |                                           | —                                 |
| $D^+ X$                                                            | < 5.1 %                                          | CL = 90%                                  | —                                 |
| $D^- X$                                                            | (40 $\pm$ 5) %                                   |                                           | —                                 |
| $D_s^+ X$                                                          | (10.9 $^{+4.4}_{-3.2}$ ) %                       |                                           | —                                 |
| $D_s^- X$                                                          | < 8.7 %                                          | CL = 90%                                  | —                                 |
| $\Lambda_c^+ X$                                                    | < 3.8 %                                          | CL = 90%                                  | —                                 |
| $\bar{\Lambda}_c^- X$                                              | (4.9 $^{+2.5}_{-2.0}$ ) %                        |                                           | —                                 |
| $\bar{c} X$                                                        | (104 $\pm$ 8) %                                  |                                           | —                                 |
| $c X$                                                              | (24 $\pm$ 5) %                                   |                                           | —                                 |
| $\bar{c} c X$                                                      | (128 $^{+11}_{-10}$ ) %                          |                                           | —                                 |
| <b><math>D, D^*,</math> or <math>D_s</math> modes</b>              |                                                  |                                           |                                   |
| $D^- \pi^+$                                                        | (2.83 $\pm$ 0.17) $\times 10^{-3}$               |                                           | 2306                              |
| $D^- \rho^+$                                                       | (7.5 $\pm$ 1.2) $\times 10^{-3}$                 |                                           | 2235                              |
| $D^- K^0 \pi^+$                                                    | (4.9 $\pm$ 0.9) $\times 10^{-4}$                 |                                           | 2259                              |
| $D^- K^*(892)^+$                                                   | (4.5 $\pm$ 0.7) $\times 10^{-4}$                 |                                           | 2211                              |
| $D^- \omega \pi^+$                                                 | (2.8 $\pm$ 0.6) $\times 10^{-3}$                 |                                           | 2204                              |
| $D^- K^+$                                                          | (2.0 $\pm$ 0.6) $\times 10^{-4}$                 |                                           | 2279                              |
| $D^- K^+ \bar{K}^0$                                                | < 3.1 $\times 10^{-4}$                           | CL = 90%                                  | 2188                              |
| $D^- K^+ \bar{K}^*(892)^0$                                         | (8.8 $\pm$ 1.9) $\times 10^{-4}$                 |                                           | 2070                              |
| $\bar{D}^0 \pi^+ \pi^-$                                            | (8.0 $\pm$ 1.6) $\times 10^{-4}$                 |                                           | 2301                              |
| $D^*(2010)^- \pi^+$                                                | (2.76 $\pm$ 0.21) $\times 10^{-3}$               |                                           | 2255                              |
| $D^- \pi^+ \pi^+ \pi^-$                                            | (8.0 $\pm$ 2.5) $\times 10^{-3}$                 |                                           | 2287                              |
| $(D^- \pi^+ \pi^+ \pi^-)$ nonresonant                              | (3.9 $\pm$ 1.9) $\times 10^{-3}$                 |                                           | 2287                              |
| $D^- \pi^+ \rho^0$                                                 | (1.1 $\pm$ 1.0) $\times 10^{-3}$                 |                                           | 2206                              |
| $D^- a_1(1260)^+$                                                  | (6.0 $\pm$ 3.3) $\times 10^{-3}$                 |                                           | 2121                              |
| $D^*(2010)^- \pi^+ \pi^0$                                          | (1.5 $\pm$ 0.5) %                                |                                           | 2248                              |
| $D^*(2010)^- \rho^+$                                               | (6.8 $\pm$ 0.9) $\times 10^{-3}$                 |                                           | 2180                              |
| $D^*(2010)^- K^+$                                                  | (2.14 $\pm$ 0.20) $\times 10^{-4}$               |                                           | 2226                              |
| $D^*(2010)^- K^0 \pi^+$                                            | (3.0 $\pm$ 0.8) $\times 10^{-4}$                 |                                           | 2205                              |
| $D^*(2010)^- K^*(892)^+$                                           | (3.3 $\pm$ 0.6) $\times 10^{-4}$                 |                                           | 2155                              |
| $D^*(2010)^- K^+ \bar{K}^0$                                        | < 4.7 $\times 10^{-4}$                           | CL = 90%                                  | 2131                              |
| $D^*(2010)^- K^+ \bar{K}^*(892)^0$                                 | (1.29 $\pm$ 0.33) $\times 10^{-3}$               |                                           | 2007                              |
| $D^*(2010)^- \pi^+ \pi^+ \pi^-$                                    | (7.0 $\pm$ 0.8) $\times 10^{-3}$                 | S = 1.3                                   | 2235                              |
| $(D^*(2010)^- \pi^+ \pi^+ \pi^-)$ nonresonant                      | (0.0 $\pm$ 2.5) $\times 10^{-3}$                 |                                           | 2235                              |
| $D^*(2010)^- \pi^+ \rho^0$                                         | (5.7 $\pm$ 3.2) $\times 10^{-3}$                 |                                           | 2150                              |
| $D^*(2010)^- a_1(1260)^+$                                          | (1.30 $\pm$ 0.27) %                              |                                           | 2061                              |
| $D^*(2010)^- \pi^+ \pi^+ \pi^- \pi^0$                              | (1.76 $\pm$ 0.27) %                              |                                           | 2218                              |
| $D^{*-} 3\pi^+ 2\pi^-$                                             | (4.7 $\pm$ 0.9) $\times 10^{-3}$                 |                                           | 2195                              |
| $D^*(2010)^- p \bar{p} \pi^+$                                      | (6.5 $\pm$ 1.6) $\times 10^{-4}$                 |                                           | 1708                              |
| $D^*(2010)^- p \bar{p}$                                            | (1.5 $\pm$ 0.4) $\times 10^{-3}$                 |                                           | 1785                              |
| $\bar{D}^*(2010)^- \omega \pi^+$                                   | (2.9 $\pm$ 0.5) $\times 10^{-3}$                 |                                           | 2148                              |
| $D_1(2420)^- \pi^+ \times B(D_1^- \rightarrow D^- \pi^+ \pi^-)$    | (8.9 $^{+2.3}_{-3.5}$ ) $\times 10^{-5}$         |                                           | —                                 |
| $D_1(2420)^- \pi^+ \times B(D_1^- \rightarrow D^{*-} \pi^+ \pi^-)$ | < 3.3 $\times 10^{-5}$                           | CL = 90%                                  | —                                 |

|                                                                               |                                     |                  |          |      |                                                     |                                     |                  |          |      |
|-------------------------------------------------------------------------------|-------------------------------------|------------------|----------|------|-----------------------------------------------------|-------------------------------------|------------------|----------|------|
| $\bar{D}_s^*(2460)^-\pi^+$                                                    | < 2.2                               | $\times 10^{-3}$ | CL = 90% | 2064 | $\bar{D}^0 K^+\pi^-\text{non-resonant}$             | < 3.7                               | $\times 10^{-5}$ | CL = 90% | -    |
| $D_s^*(2460)^-\pi^+\times B((D_2^*)^-\rightarrow D_s^{*-}\pi^+\pi^-)$         | < 2.4                               | $\times 10^{-5}$ | CL = 90% | -    | $\bar{D}^0\pi^0$                                    | $(2.91\pm 0.28)\times 10^{-4}$      |                  |          | 2308 |
| $\bar{D}_s^*(2460)^-\rho^+$                                                   | < 4.9                               | $\times 10^{-3}$ | CL = 90% | 1977 | $\bar{D}^0\rho^0$                                   | $(2.9\pm 1.1)\times 10^{-4}$        |                  |          | 2237 |
| $D^-D^+$                                                                      | $(1.9\pm 0.6)\times 10^{-4}$        |                  |          | 1864 | $\bar{D}^0\eta$                                     | $(2.2\pm 0.5)\times 10^{-4}$        | S = 1.6          |          | 2274 |
| $D^-D_s^+$                                                                    | $(6.5\pm 2.1)\times 10^{-3}$        |                  |          | 1813 | $\bar{D}^0\eta'$                                    | $(1.25\pm 0.23)\times 10^{-4}$      | S = 1.1          |          | 2198 |
| $D^*(2010)^-D_s^+$                                                            | $(8.8\pm 1.6)\times 10^{-3}$        |                  |          | 1735 | $\bar{D}^0\omega$                                   | $(2.5\pm 0.6)\times 10^{-4}$        | S = 1.5          |          | 2235 |
| $D^-D_s^{*+}$                                                                 | $(8.6\pm 3.4)\times 10^{-3}$        |                  |          | 1732 | $D^0K^+\pi^-$                                       | < 1.9                               | $\times 10^{-5}$ | CL = 90% | 2261 |
| $D^*(2010)^-D_s^{*+}$                                                         | $(1.79\pm 0.16)\%$                  |                  |          | 1649 | $D^0K^*(892)^0$                                     | < 1.8                               | $\times 10^{-5}$ | CL = 90% | 2213 |
| $D_{s0}(2317)^+K^-\times B(D_{s0}(2317)^+\rightarrow D_s^{*+}\pi^0)$          | $(4.3\pm 1.5)\times 10^{-5}$        |                  |          | 2097 | $\bar{D}^{*0}\gamma$                                | < 2.5                               | $\times 10^{-5}$ | CL = 90% | 2258 |
| $D_{s0}(2317)^+\pi^-\times B(D_{s0}(2317)^+\rightarrow D_s^{*+}\pi^0)$        | < 2.5                               | $\times 10^{-5}$ | CL = 90% | 2128 | $\bar{D}^*(2007)^0\pi^0$                            | $(2.7\pm 0.5)\times 10^{-4}$        |                  |          | 2256 |
| $D_{sJ}(2457)^+K^-\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\pi^0)$          | < 9.4                               | $\times 10^{-6}$ | CL = 90% | -    | $\bar{D}^*(2007)^0\rho^0$                           | < 5.1                               | $\times 10^{-4}$ | CL = 90% | 2182 |
| $D_{sJ}(2457)^+\pi^-\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\pi^0)$        | < 4.0                               | $\times 10^{-6}$ | CL = 90% | -    | $\bar{D}^*(2007)^0\eta$                             | $(2.6\pm 0.6)\times 10^{-4}$        |                  |          | 2220 |
| $D_s^-D_s^+$                                                                  | < 1.0                               | $\times 10^{-4}$ | CL = 90% | 1759 | $\bar{D}^*(2007)^0\eta'$                            | $(1.23\pm 0.35)\times 10^{-4}$      |                  |          | 2141 |
| $D_s^+D_s^+$                                                                  | < 1.3                               | $\times 10^{-4}$ | CL = 90% | 1674 | $\bar{D}^*(2007)^0\pi^+\pi^-$                       | $(6.2\pm 2.2)\times 10^{-4}$        |                  |          | 2248 |
| $D_s^-D_s^{*+}$                                                               | < 2.4                               | $\times 10^{-4}$ | CL = 90% | 1584 | $\bar{D}^*(2007)^0K^0$                              | < 6.6                               | $\times 10^{-5}$ | CL = 90% | 2227 |
| $D_{s0}(2317)^+D^-\times B(D_{s0}(2317)^+\rightarrow D_s^{*+}\pi^0)$          | $(9.7^{+4.1}_{-3.4})\times 10^{-4}$ | S = 1.4          |          | 1602 | $\bar{D}^*(2007)^0K^*(892)^0$                       | < 6.9                               | $\times 10^{-5}$ | CL = 90% | 2157 |
| $D_{s0}(2317)^+D^-\times B(D_{s0}(2317)^+\rightarrow D_s^{*+}\gamma)$         | < 9.5                               | $\times 10^{-4}$ | CL = 90% | -    | $D^*(2007)^0K^*(892)^0$                             | < 4.0                               | $\times 10^{-5}$ | CL = 90% | 2157 |
| $D_{s0}(2317)^+D^*(2010)^-\times B(D_{s0}(2317)^+\rightarrow D_s^{*+}\pi^0)$  | $(1.5\pm 0.6)\times 10^{-3}$        |                  |          | 1510 | $D^*(2007)^0\pi^+\pi^+\pi^-\pi^-$                   | $(2.7\pm 0.5)\times 10^{-3}$        |                  |          | 2219 |
| $D_{sJ}(2457)^+D^-\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\pi^0)$          | $(2.0^{+0.6}_{-0.5})\times 10^{-3}$ |                  |          | -    | $D^*(2010)^+D^*(2010)^-$                            | $(8.3\pm 1.1)\times 10^{-4}$        |                  |          | 1711 |
| $D_{sJ}(2457)^+D^-\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\pi^0)$          | $(6.6^{+1.8}_{-1.5})\times 10^{-4}$ |                  |          | -    | $\bar{D}^*(2007)^0\omega$                           | $(4.2\pm 1.1)\times 10^{-4}$        |                  |          | 2180 |
| $D_{sJ}(2457)^+D^-\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\gamma)$         | < 6.0                               | $\times 10^{-4}$ | CL = 90% | -    | $D^*(2010)^+D^-$                                    | < 6.3                               | $\times 10^{-4}$ | CL = 90% | 1790 |
| $D_{sJ}(2457)^+D^-\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\gamma)$         | < 2.0                               | $\times 10^{-4}$ | CL = 90% | -    | $D^*(2010)^+D^+\times D^*(2010)^+D^-$               | $(9.3\pm 1.5)\times 10^{-4}$        |                  |          | 1790 |
| $D_{sJ}(2457)^+D^-\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\pi^0)$          | < 3.6                               | $\times 10^{-4}$ | CL = 90% | -    | $D^*(2007)^0\bar{D}^*(2007)^0$                      | < 2.7                               | %                | CL = 90% | 1715 |
| $D_{sJ}(2457)^+D^*(2010)\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\pi^0)$    | $(5.5^{+2.5}_{-2.0})\times 10^{-3}$ |                  |          | -    | $D^-D^0K^+$                                         | $(1.7\pm 0.4)\times 10^{-3}$        |                  |          | 1574 |
| $D_{sJ}(2457)^+D^*(2010)\times B(D_{sJ}(2457)^+\rightarrow D_s^{*+}\gamma)$   | $(2.3^{+0.9}_{-0.7})\times 10^{-3}$ |                  |          | -    | $D^-D^*(2007)^0K^+$                                 | $(4.6\pm 1.0)\times 10^{-3}$        |                  |          | 1478 |
| $D^-D_{sJ}(2536)^+\times B(D_{sJ}(2536)^+\rightarrow D^*(2007)^0K^+)$         | < 5                                 | $\times 10^{-4}$ | CL = 90% | 1444 | $D^*(2010)^-D^0K^+$                                 | $(3.1^{+0.6}_{-0.5})\times 10^{-3}$ |                  |          | 1479 |
| $D^*(2010)^-D_{sJ}(2536)^+\times B(D_{sJ}(2536)^+\rightarrow D^*(2007)^0K^+)$ | < 7                                 | $\times 10^{-4}$ | CL = 90% | 1336 | $D^*(2010)^-D^*(2007)^0K^+$                         | $(1.18\pm 0.20)\%$                  |                  |          | 1366 |
| $D^-D_{sJ}(2573)^+\times B(D_{sJ}(2573)^+\rightarrow D^0K^+)$                 | < 1                                 | $\times 10^{-4}$ | CL = 90% | 1413 | $D^-D^+K^0$                                         | < 1.7                               | $\times 10^{-3}$ | CL = 90% | 1568 |
| $D^*(2010)^-D_{sJ}(2573)^+\times B(D_{sJ}(2573)^+\rightarrow D^0K^+)$         | < 2                                 | $\times 10^{-4}$ | CL = 90% | 1302 | $D^*(2010)^-D^+K^0+D^-D^*(2010)^+K^0$               | $(6.5\pm 1.6)\times 10^{-3}$        |                  |          | 1473 |
| $D_s^{*+}\pi^-$                                                               | $(2.2\pm 0.7)\times 10^{-5}$        |                  |          | 2270 | $D^*(2010)^-D^*(2010)^+K^0$                         | $(8.8\pm 1.9)\times 10^{-3}$        |                  |          | 1360 |
| $D_s^{*+}\pi^-$                                                               | < 4.1                               | $\times 10^{-5}$ | CL = 90% | 2215 | $\bar{D}^0D^0K^0$                                   | < 1.4                               | $\times 10^{-3}$ | CL = 90% | 1575 |
| $D_s^{*+}\rho^-$                                                              | < 6                                 | $\times 10^{-4}$ | CL = 90% | 2197 | $\bar{D}^0D^*(2007)^0K^0+D^*(2007)^0D^0K^0$         | < 3.7                               | $\times 10^{-3}$ | CL = 90% | 1478 |
| $D_s^{*+}\rho^-$                                                              | < 6                                 | $\times 10^{-4}$ | CL = 90% | 2138 | $\bar{D}^*(2007)^0D^*(2007)^0K^0$                   | < 6.6                               | $\times 10^{-3}$ | CL = 90% | 1365 |
| $D_s^{*+}a_1(1260)^-$                                                         | < 2.1                               | $\times 10^{-3}$ | CL = 90% | 2080 | $(\bar{D}^++\bar{D}^+)(D^++D^+)K$                   | $(4.3\pm 0.7)\%$                    |                  |          | -    |
| $D_s^{*+}a_1(1260)^-$                                                         | < 1.8                               | $\times 10^{-3}$ | CL = 90% | 2015 | <b>Charmonium modes</b>                             |                                     |                  |          |      |
| $D_s^{*+}K^+$                                                                 | $(3.1\pm 0.8)\times 10^{-5}$        |                  |          | 2242 | $\eta_c K^0$                                        | $(9.9\pm 1.9)\times 10^{-4}$        |                  |          | 1753 |
| $D_s^{*+}K^+$                                                                 | < 2.5                               | $\times 10^{-5}$ | CL = 90% | 2185 | $\eta_c K^*(892)^0$                                 | $(1.6\pm 0.7)\times 10^{-3}$        |                  |          | 1648 |
| $D_s^{*+}K^*(892)^+$                                                          | < 8                                 | $\times 10^{-4}$ | CL = 90% | 2172 | $J/\psi(1S)K^0$                                     | $(8.72\pm 0.33)\times 10^{-4}$      |                  |          | 1683 |
| $D_s^{*+}K^*(892)^+$                                                          | < 9                                 | $\times 10^{-4}$ | CL = 90% | 2112 | $J/\psi(1S)K^+\pi^-$                                | $(1.2\pm 0.6)\times 10^{-3}$        |                  |          | 1652 |
| $D_s^{*+}\pi^+K^0$                                                            | < 4                                 | $\times 10^{-3}$ | CL = 90% | 2222 | $J/\psi(1S)K^*(892)^0$                              | $(1.33\pm 0.06)\times 10^{-3}$      |                  |          | 1571 |
| $D_s^{*+}\pi^+K^0$                                                            | < 2.6                               | $\times 10^{-3}$ | CL = 90% | 2164 | $J/\psi(1S)\eta K_S^0$                              | $(8\pm 4)\times 10^{-5}$            |                  |          | 1508 |
| $D_s^{*+}\pi^+K^*(892)^0$                                                     | < 3.1                               | $\times 10^{-3}$ | CL = 90% | 2138 | $J/\psi(1S)\phi K^0$                                | $(9.4\pm 2.6)\times 10^{-5}$        |                  |          | 1224 |
| $D_s^{*+}\pi^+K^*(892)^0$                                                     | < 1.7                               | $\times 10^{-3}$ | CL = 90% | 2076 | $J/\psi(1S)K(1270)^0$                               | $(1.3\pm 0.5)\times 10^{-3}$        |                  |          | 1390 |
| $\bar{D}^0K^0$                                                                | $(5.0\pm 1.4)\times 10^{-5}$        |                  |          | 2280 | $J/\psi(1S)\pi^0$                                   | $(2.2\pm 0.4)\times 10^{-5}$        |                  |          | 1728 |
| $\bar{D}^0K^+\pi^-$                                                           | $(8.8\pm 1.7)\times 10^{-5}$        |                  |          | 2261 | $J/\psi(1S)\eta$                                    | < 2.7                               | $\times 10^{-5}$ | CL = 90% | 1672 |
| $\bar{D}^0K^*(892)^0$                                                         | $(5.3\pm 0.8)\times 10^{-5}$        |                  |          | 2213 | $J/\psi(1S)\pi^+\pi^-$                              | $(4.6\pm 0.9)\times 10^{-5}$        |                  |          | 1716 |
| $D_s^*(2460)^-\pi^+\rightarrow \bar{D}^0\pi^-$                                | $(1.8\pm 0.5)\times 10^{-5}$        |                  |          | 2031 | $J/\psi(1S)\rho^0$                                  | $(1.6\pm 0.7)\times 10^{-5}$        |                  |          | 1611 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)\omega$                                  | < 2.7                               | $\times 10^{-4}$ | CL = 90% | 1609 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)\phi$                                    | < 9.2                               | $\times 10^{-6}$ | CL = 90% | 1519 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)\eta'(958)$                              | < 6.3                               | $\times 10^{-5}$ | CL = 90% | 1546 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)K^0\pi^+\pi^-$                           | $(1.0\pm 0.4)\times 10^{-3}$        |                  |          | 1611 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)K^0\rho^0$                               | $(5.4\pm 3.0)\times 10^{-4}$        |                  |          | 1390 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)K^*(892)^+\pi^-$                         | $(8\pm 4)\times 10^{-4}$            |                  |          | 1514 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)K^*(892)^0\pi^+\pi^-$                    | $(6.6\pm 2.2)\times 10^{-4}$        |                  |          | 1447 |
|                                                                               |                                     |                  |          |      | $X(3872)^-K^+$                                      | < 5                                 | $\times 10^{-4}$ | CL = 90% | -    |
|                                                                               |                                     |                  |          |      | $X(3872)^-K^+\times [jjj]$                          | < 5.4                               | $\times 10^{-6}$ | CL = 90% | -    |
|                                                                               |                                     |                  |          |      | $B(X(3872)^-\rightarrow J/\psi(1S)\pi^-\pi^0)$      |                                     |                  |          |      |
|                                                                               |                                     |                  |          |      | $X(3872)K^0\times B(X\rightarrow J/\psi\pi^+\pi^-)$ | < 1.03                              | $\times 10^{-5}$ | CL = 90% | 1140 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)p\bar{p}$                                | < 8.3                               | $\times 10^{-7}$ | CL = 90% | 862  |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)\gamma$                                  | < 1.6                               | $\times 10^{-6}$ | CL = 90% | 1731 |
|                                                                               |                                     |                  |          |      | $J/\psi(1S)\bar{D}^0$                               | < 1.3                               | $\times 10^{-5}$ | CL = 90% | 877  |
|                                                                               |                                     |                  |          |      | $\psi(2S)K^0$                                       | $(6.2\pm 0.6)\times 10^{-4}$        |                  |          | 1283 |
|                                                                               |                                     |                  |          |      | $\psi(2S)K^+\pi^-$                                  | < 1                                 | $\times 10^{-3}$ | CL = 90% | 1238 |
|                                                                               |                                     |                  |          |      | $\psi(2S)K^*(892)^0$                                | $(7.2\pm 0.8)\times 10^{-4}$        |                  |          | 1116 |
|                                                                               |                                     |                  |          |      | $\chi_{c0}(1P)K^0$                                  | < 5.0                               | $\times 10^{-4}$ | CL = 90% | 1477 |
|                                                                               |                                     |                  |          |      | $\chi_{c0}K^*(892)^0$                               | < 7.7                               | $\times 10^{-4}$ | CL = 90% | -    |
|                                                                               |                                     |                  |          |      | $\chi_{c2}K^0$                                      | < 2.6                               | $\times 10^{-5}$ | CL = 90% | -    |
|                                                                               |                                     |                  |          |      | $\chi_{c2}K^*(892)^0$                               | < 3.6                               | $\times 10^{-5}$ | CL = 90% | -    |
|                                                                               |                                     |                  |          |      | $\chi_{c1}(1P)K^0$                                  | $(3.9\pm 0.4)\times 10^{-4}$        |                  |          | 1411 |
|                                                                               |                                     |                  |          |      | $\chi_{c1}(1P)K^*(892)^0$                           | $(3.2\pm 0.6)\times 10^{-4}$        |                  |          | 1265 |

| K or K* modes                  |                                         |                  |               |                                                |                                       |                  |               |
|--------------------------------|-----------------------------------------|------------------|---------------|------------------------------------------------|---------------------------------------|------------------|---------------|
| $K^+\pi^-$                     | $(1.82 \pm 0.08) \times 10^{-5}$        |                  | 2615          | $\omega\eta'$                                  | $< 2.8$                               | $\times 10^{-6}$ | CL = 90% 2491 |
| $K^0\pi^0$                     | $(1.15 \pm 0.10) \times 10^{-5}$        |                  | 2614          | $\omega\rho^0$                                 | $< 3.3$                               | $\times 10^{-6}$ | CL = 90% 2522 |
| $\eta'K^0$                     | $(6.8 \pm 0.4) \times 10^{-5}$          |                  | 2528          | $\omega\omega$                                 | $< 1.9$                               | $\times 10^{-5}$ | CL = 90% 2521 |
| $\eta'K^*(892)^0$              | $< 7.6$                                 | $\times 10^{-6}$ | CL = 90% 2472 | $\phi\pi^0$                                    | $< 1.0$                               | $\times 10^{-6}$ | CL = 90% 2539 |
| $\eta K^*(892)^0$              | $(1.77 \pm 0.23) \times 10^{-5}$        |                  | 2534          | $\phi\eta$                                     | $< 1.0$                               | $\times 10^{-6}$ | CL = 90% 2511 |
| $\eta K^0$                     | $< 2.0$                                 | $\times 10^{-6}$ | CL = 90% 2587 | $\phi\eta'$                                    | $< 4.5$                               | $\times 10^{-6}$ | CL = 90% 2447 |
| $\omega K^0$                   | $(5.5^{+1.2}_{-1.0}) \times 10^{-6}$    |                  | 2557          | $\phi\rho^0$                                   | $< 1.3$                               | $\times 10^{-5}$ | CL = 90% 2480 |
| $a_0^0 K^0$                    | $< 7.8$                                 | $\times 10^{-6}$ | CL = 90% -    | $\phi\omega$                                   | $< 2.1$                               | $\times 10^{-5}$ | CL = 90% 2479 |
| $a_0^- K^+$                    | $< 2.1$                                 | $\times 10^{-6}$ | CL = 90% -    | $\phi\phi$                                     | $< 1.5$                               | $\times 10^{-6}$ | CL = 90% 2435 |
| $K_S^0 X^0$ (Familon)          | $< 5.3$                                 | $\times 10^{-5}$ | CL = 90% -    | $a_0^0 \pi^\pm$                                | $< 5.1$                               | $\times 10^{-6}$ | CL = 90% -    |
| $\omega K^*(892)^0$            | $< 6.0$                                 | $\times 10^{-6}$ | CL = 90% 2503 | $\pi^+\pi^-\pi^0$                              | $< 7.2$                               | $\times 10^{-4}$ | CL = 90% 2631 |
| $K^+K^-$                       | $< 3.7$                                 | $\times 10^{-7}$ | CL = 90% 2593 | $\rho^0\pi^\pm$                                | $(1.8 \pm 0.8)$                       | $\times 10^{-6}$ | S = 1.3 2581  |
| $K^0\bar{K}^0$                 | $(1.13^{+0.38}_{-0.35}) \times 10^{-6}$ |                  | 2592          | $\rho^\mp\pi^\pm$                              | [gg] $(2.28 \pm 0.25) \times 10^{-5}$ |                  | 2581          |
| $K_S^0 K_S^0 K_S^0$            | $(6.2^{+1.2}_{-1.1}) \times 10^{-6}$    | S = 1.3          | 2521          | $\pi^+\pi^-\pi^+\pi^-$                         | $< 2.3$                               | $\times 10^{-4}$ | CL = 90% 2621 |
| $K^+\pi^-\pi^0$                | $(3.7 \pm 0.5) \times 10^{-5}$          |                  | 2609          | $\rho^0\rho^0$                                 | $< 1.1$                               | $\times 10^{-6}$ | CL = 90% 2523 |
| $K^+\rho^-$                    | $(8.5 \pm 2.8) \times 10^{-6}$          | S = 1.7          | 2559          | $a_1(1260)\pi^\pm$                             | [gg] $< 4.9$                          | $\times 10^{-4}$ | CL = 90% 2494 |
| $(K^+\pi^-\pi^0)$ non-resonant | $< 9.4$                                 | $\times 10^{-6}$ | CL = 90% -    | $a_2(1320)\pi^\pm$                             | [gg] $< 3.0$                          | $\times 10^{-4}$ | CL = 90% 2473 |
| $K_S^{*0}\pi^0$                | [III] $(6.1 \pm 1.6) \times 10^{-6}$    |                  | -             | $\pi^+\pi^-\pi^0\pi^0$                         | $< 3.1$                               | $\times 10^{-3}$ | CL = 90% 2622 |
| $K^0\pi^+\pi^-$                | $(4.38 \pm 0.29) \times 10^{-5}$        |                  | 2609          | $\rho^+\rho^-$                                 | $(2.5 \pm 0.4)$                       | $\times 10^{-5}$ | 2523          |
| $K^0\rho^0$                    | $< 3.9$                                 | $\times 10^{-5}$ | CL = 90% 2558 | $a_1(1260)^0\pi^0$                             | $< 1.1$                               | $\times 10^{-3}$ | CL = 90% 2494 |
| $K^0 f_0(980)$                 | $(5.5 \pm 0.9) \times 10^{-6}$          |                  | 2524          | $\omega\pi^0$                                  | $< 1.2$                               | $\times 10^{-6}$ | CL = 90% 2580 |
| $K^*(892)^+\pi^-$              | $(1.18 \pm 0.15) \times 10^{-5}$        |                  | 2562          | $\pi^+\pi^+\pi^-\pi^0$                         | $< 9.0$                               | $\times 10^{-3}$ | CL = 90% 2609 |
| $K_S^{*+}\pi^-$                | [III] $(5.1 \pm 1.6) \times 10^{-6}$    |                  | -             | $a_1(1260)^+\rho^-$                            | $< 3.4$                               | $\times 10^{-3}$ | CL = 90% 2433 |
| $K^*(892)^0\pi^0$              | $< 3.5$                                 | $\times 10^{-6}$ | CL = 90% 2563 | $a_1(1260)^0\rho^0$                            | $< 2.4$                               | $\times 10^{-3}$ | CL = 90% 2433 |
| $K_S^{*0}K^+\pi^-$             | $< 1.8$                                 | $\times 10^{-5}$ | CL = 90% 2445 | $\pi^+\pi^+\pi^+\pi^-\pi^0$                    | $< 3.0$                               | $\times 10^{-3}$ | CL = 90% 2592 |
| $K^0K^-\pi^+$                  | $< 2.1$                                 | $\times 10^{-5}$ | CL = 90% 2578 | $a_1(1260)^+a_1(1260)^-$                       | $< 2.8$                               | $\times 10^{-3}$ | CL = 90% 2336 |
| $K^+K^-\pi^0$                  | $< 1.9$                                 | $\times 10^{-5}$ | CL = 90% 2579 | $\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0$               | $< 1.1$                               | %                | CL = 90% 2572 |
| $K^0K^+K^-$                    | $(2.47 \pm 0.23) \times 10^{-5}$        |                  | 2522          | Baryon modes                                   |                                       |                  |               |
| $K^0\phi$                      | $(8.6^{+1.3}_{-1.1}) \times 10^{-6}$    |                  | 2516          | $p\bar{p}$                                     | $< 2.7$                               | $\times 10^{-7}$ | CL = 90% 2467 |
| $K^-\pi^+\pi^+\pi^-$           | [nnmm] $< 2.3$                          | $\times 10^{-4}$ | CL = 90% 2600 | $p\bar{p}\pi^+\pi^-$                           | $< 2.5$                               | $\times 10^{-4}$ | CL = 90% 2406 |
| $K^*(892)^0\pi^+\pi^-$         | $< 1.4$                                 | $\times 10^{-3}$ | CL = 90% 2557 | $p\bar{p}K^0$                                  | $(2.1^{+0.6}_{-0.4})$                 | $\times 10^{-6}$ | 2347          |
| $K^*(892)^0\rho^0$             | $< 3.4$                                 | $\times 10^{-5}$ | CL = 90% 2504 | $\Theta(1540)^+\bar{p} \times$                 | [mmn] $< 2.3$                         | $\times 10^{-7}$ | CL = 90% 2318 |
| $K^*(892)^0 f_0(980)$          | $< 1.7$                                 | $\times 10^{-4}$ | CL = 90% 2468 | $B(\Theta(1540)^+ \rightarrow$                 |                                       |                  |               |
| $K_1(1400)^+\pi^-$             | $< 1.1$                                 | $\times 10^{-3}$ | CL = 90% 2451 | $pK_S^0)$                                      |                                       |                  |               |
| $K^-a_1(1260)^+$               | [nnmm] $< 2.3$                          | $\times 10^{-4}$ | CL = 90% 2471 | $p\bar{p}K^*(892)^0$                           | $< 7.6$                               | $\times 10^{-6}$ | CL = 90% 2215 |
| $K^*(892)^0K^+K^-$             | $< 6.1$                                 | $\times 10^{-4}$ | CL = 90% 2466 | $p\bar{p}\pi^-$                                | $(2.6 \pm 0.5)$                       | $\times 10^{-6}$ | 2401          |
| $K^*(892)^0\phi$               | $(9.5 \pm 0.9) \times 10^{-6}$          |                  | 2460          | $p\bar{p}K^-$                                  | $< 8.2$                               | $\times 10^{-7}$ | CL = 90% 2308 |
| $\bar{K}^*(892)^0K^*(892)^0$   | $< 2.2$                                 | $\times 10^{-5}$ | CL = 90% 2485 | $p\bar{p}\pi^0$                                | $< 3.8$                               | $\times 10^{-6}$ | CL = 90% 2383 |
| $K^*(892)^0K^*(892)^0$         | $< 3.7$                                 | $\times 10^{-5}$ | CL = 90% 2485 | $\Delta\Delta$                                 | $< 6.9$                               | $\times 10^{-7}$ | CL = 90% 2392 |
| $K^*(892)^+K^*(892)^-$         | $< 1.41$                                | $\times 10^{-4}$ | CL = 90% 2485 | $\Delta^0\bar{\Delta}^0$                       | $< 1.5$                               | $\times 10^{-3}$ | CL = 90% 2335 |
| $K_1(1400)^0\rho^0$            | $< 3.0$                                 | $\times 10^{-3}$ | CL = 90% 2388 | $\Delta^+\bar{\Delta}^--$                      | $< 1.1$                               | $\times 10^{-4}$ | CL = 90% 2335 |
| $K_1(1400)^0\phi$              | $< 5.0$                                 | $\times 10^{-3}$ | CL = 90% 2339 | $\bar{D}^0 p\bar{p}$                           | $(1.18 \pm 0.22)$                     | $\times 10^{-4}$ | 1863          |
| $K_0^*(1430)^0\phi$            | seen                                    |                  | 2336          | $\bar{D}^*(2007)^0 p\bar{p}$                   | $(1.2 \pm 0.4)$                       | $\times 10^{-4}$ | 1788          |
| $K_2^*(1430)^0\rho^0$          | $< 1.1$                                 | $\times 10^{-3}$ | CL = 90% 2381 | $\bar{\Sigma}_c^{--}\Delta^{++}$               | $< 1.0$                               | $\times 10^{-3}$ | CL = 90% 1839 |
| $K_2^*(1430)^0\phi$            | seen                                    |                  | 2333          | $\bar{\Lambda}_c^- p\pi^+\pi^-$                | $(1.3 \pm 0.4)$                       | $\times 10^{-3}$ | 1934          |
| $K^*(892)^0\gamma$             | $(4.01 \pm 0.20) \times 10^{-5}$        |                  | 2564          | $\bar{\Lambda}_c^- p$                          | $(2.2 \pm 0.8)$                       | $\times 10^{-5}$ | 2021          |
| $\eta K^0\gamma$               | $(8.7^{+3.6}_{-3.1}) \times 10^{-6}$    |                  | 2587          | $\bar{\Lambda}_c^- p\pi^0$                     | $< 5.9$                               | $\times 10^{-4}$ | CL = 90% 1982 |
| $K^0\phi\gamma$                | $< 8.3$                                 | $\times 10^{-6}$ | CL = 90% 2516 | $\bar{\Lambda}_c^- p\pi^+\pi^-\pi^0$           | $< 5.07$                              | $\times 10^{-3}$ | CL = 90% 1882 |
| $K^+\pi^-\gamma$               | $(4.6 \pm 1.4) \times 10^{-6}$          |                  | 2615          | $\bar{\Lambda}_c^- p\pi^+\pi^-\pi^+\pi^-$      | $< 2.74$                              | $\times 10^{-3}$ | CL = 90% 1821 |
| $K^*(1410)\gamma$              | $< 1.3$                                 | $\times 10^{-4}$ | CL = 90% 2450 | $\bar{\Sigma}_c(2520)^--p\pi^+$                | $(1.6 \pm 0.7)$                       | $\times 10^{-4}$ | 1860          |
| $K^+\pi^-\gamma$ nonresonant   | $< 2.6$                                 | $\times 10^{-6}$ | CL = 90% 2615 | $\bar{\Sigma}_c(2520)^0 p\pi^-$                | $< 1.21$                              | $\times 10^{-4}$ | CL = 90% 1860 |
| $K^0\pi^+\pi^-\gamma$          | $(2.4 \pm 0.5) \times 10^{-5}$          |                  | 2609          | $\bar{\Sigma}_c(2455)^0 p\pi^-$                | $(10 \pm 8)$                          | $\times 10^{-5}$ | S = 1.7 1895  |
| $K_1(1270)^0\gamma$            | $< 5.8$                                 | $\times 10^{-5}$ | 2486          | $\bar{\Sigma}_c(2455)^--p\pi^+$                | $(2.8 \pm 0.9)$                       | $\times 10^{-4}$ | 1895          |
| $K_1(1400)^0\gamma$            | $< 1.5$                                 | $\times 10^{-5}$ | 2453          | $\bar{\Lambda}_c(2593)^-$                      | $< 1.1$                               | $\times 10^{-4}$ | CL = 90% -    |
| $K_S^{*0}(1430)^0\gamma$       | $(1.24 \pm 0.24) \times 10^{-5}$        |                  | 2447          | $l \bar{\Lambda}_c(2625)^-p$                   |                                       |                  |               |
| $K^*(1680)^0\gamma$            | $< 2.0$                                 | $\times 10^{-3}$ | CL = 90% 2360 | Lepton Family number (LF) violating modes, or  |                                       |                  |               |
| $K_S^{*0}(1780)^0\gamma$       | $< 8.3$                                 | $\times 10^{-5}$ | CL = 90% 2341 | $\Delta B = 1$ weak neutral current (B1) modes |                                       |                  |               |
| $K_4^*(2045)^0\gamma$          | $< 4.3$                                 | $\times 10^{-3}$ | CL = 90% 2244 | $\gamma\gamma$                                 | B1 $< 6.2$                            | $\times 10^{-7}$ | CL = 90% 2640 |
| Light unflavored meson modes   |                                         |                  |               | $e^+e^-$                                       | B1 $< 6.1$                            | $\times 10^{-8}$ | CL = 90% 2640 |
| $\rho^0\gamma$                 | $< 4$                                   | $\times 10^{-7}$ | CL = 90% 2583 | $\mu^+\mu^-$                                   | B1 $< 3.9$                            | $\times 10^{-8}$ | CL = 90% 2638 |
| $\omega\gamma$                 | $< 8$                                   | $\times 10^{-7}$ | CL = 90% 2582 | $K^0 e^+e^-$                                   | B1 $< 5.4$                            | $\times 10^{-7}$ | CL = 90% 2616 |
| $\phi\gamma$                   | $< 8.5$                                 | $\times 10^{-7}$ | CL = 90% 2541 | $K^0\mu^+\mu^-$                                | B1 $(2.0^{+1.3}_{-1.0})$              | $\times 10^{-7}$ | S = 1.6 2612  |
| $\pi^+\pi^-$                   | $(4.6 \pm 0.4) \times 10^{-6}$          |                  | 2636          | $K^0\ell^+\ell^-$                              | B1 [ggg] $< 6.8$                      | $\times 10^{-7}$ | CL = 90% 2616 |
| $\pi^0\pi^0$                   | $(1.5 \pm 0.5) \times 10^{-6}$          | S = 1.7          | 2636          | $K^*(892)^0 e^+e^-$                            | B1 $< 2.4$                            | $\times 10^{-6}$ | CL = 90% 2564 |
| $\eta\pi^0$                    | $< 2.5$                                 | $\times 10^{-6}$ | CL = 90% 2610 | $K^*(892)^0\mu^+\mu^-$                         | B1 $(1.22^{+0.38}_{-0.32})$           | $\times 10^{-6}$ | 2560          |
| $\eta\eta$                     | $< 2.0$                                 | $\times 10^{-6}$ | CL = 90% 2582 | $K^*(892)^0\nu\bar{\nu}$                       | B1 $< 1.0$                            | $\times 10^{-3}$ | CL = 90% 2564 |
| $\eta'\pi^0$                   | $< 3.7$                                 | $\times 10^{-6}$ | CL = 90% 2551 | $K^*(892)^0\ell^+\ell^-$                       | B1 [ggg] $(1.17 \pm 0.30)$            | $\times 10^{-6}$ | 2564          |
| $\eta'\eta'$                   | $< 1.0$                                 | $\times 10^{-5}$ | CL = 90% 2460 | $e^\pm\mu^\mp$                                 | LF [gg] $< 1.7$                       | $\times 10^{-7}$ | CL = 90% 2639 |
| $\eta'\eta$                    | $< 4.6$                                 | $\times 10^{-6}$ | CL = 90% 2522 | $K^0 e^\pm\mu^\mp$                             | LF $< 4.0$                            | $\times 10^{-6}$ | CL = 90% 2615 |
| $\eta'\rho^0$                  | $< 4.3$                                 | $\times 10^{-6}$ | CL = 90% 2492 | $K^*(892)^0 e^\pm\mu^\mp$                      | LF $< 3.4$                            | $\times 10^{-6}$ | CL = 90% 2563 |
| $\eta\rho^0$                   | $< 1.5$                                 | $\times 10^{-6}$ | CL = 90% 2553 | $e^\pm\tau^\mp$                                | LF [gg] $< 1.1$                       | $\times 10^{-4}$ | CL = 90% 2341 |
| $\omega\eta$                   | $< 1.9$                                 | $\times 10^{-6}$ | CL = 90% 2552 | $\mu^\pm\tau^\mp$                              | LF [gg] $< 3.8$                       | $\times 10^{-5}$ | CL = 90% 2339 |
|                                |                                         |                  |               | invisible                                      | B1 $< 2.2$                            | $\times 10^{-4}$ | CL = 90% -    |
|                                |                                         |                  |               | $\nu\bar{\nu}\gamma$                           | B1 $< 4.7$                            | $\times 10^{-5}$ | CL = 90% 2640 |

**$B^\pm/B^0$  ADMIXTURE****CP violation**

$$A_{CP}(B \rightarrow K^*(892)\gamma) = -0.010 \pm 0.028$$

$$A_{CP}(B \rightarrow s\gamma) = 0.00 \pm 0.04$$

$$A_{CP}(b \rightarrow X_s \ell^+ \ell^-) = -0.22 \pm 0.26$$

The branching fraction measurements are for an admixture of  $B$  mesons at the  $\Upsilon(4S)$ . The values quoted assume that  $B(\Upsilon(4S) \rightarrow B\bar{B}) = 100\%$ .

For inclusive branching fractions, e.g.,  $B \rightarrow D^\pm$  anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

$\bar{B}$  modes are charge conjugates of the modes below. Reactions indicate the weak decay vertex and do not include mixing.

| <b><math>B</math> DECAY MODES</b>                                                                                                                                           | <b>Fraction (<math>\Gamma_i/\Gamma</math>)</b> | <b>Scale factor/<br/>Confidence level (MeV/c)</b> | <b><math>p</math></b> | <b><math>B</math> DECAY MODES</b>                        | <b>Fraction (<math>\Gamma_i/\Gamma</math>)</b> | <b>Scale factor/<br/>Confidence level (MeV/c)</b> | <b><math>p</math></b> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------|-----------------------|----------------------------------------------------------|------------------------------------------------|---------------------------------------------------|-----------------------|
| <b>Semileptonic and leptonic modes</b>                                                                                                                                      |                                                |                                                   |                       | <b>Charmonium modes</b>                                  |                                                |                                                   |                       |
| $B \rightarrow e^+ \nu_e$ anything                                                                                                                                          | [ooo] (10.78 $\pm$ 0.18) %                     |                                                   | –                     | $B \rightarrow J/\psi(1S)$ anything                      | (1.094 $\pm$ 0.032) %                          | $S = 1.1$                                         | –                     |
| $B \rightarrow \bar{\nu} e^+ \nu_e$ anything                                                                                                                                | < 5.9 $\times 10^{-4}$                         | CL = 90%                                          | –                     | $B \rightarrow J/\psi(1S)$ (direct)                      | (7.8 $\pm$ 0.4) $\times 10^{-3}$               | $S = 1.1$                                         | –                     |
| $B \rightarrow \mu^+ \nu_\mu$ anything                                                                                                                                      | [ooo] (10.78 $\pm$ 0.18) %                     |                                                   | –                     | anything                                                 |                                                |                                                   |                       |
| $B \rightarrow \ell^+ \nu_\ell$ anything                                                                                                                                    | [ggg,ooo] (10.78 $\pm$ 0.18) %                 |                                                   | –                     | $B \rightarrow \psi(2S)$ anything                        | (3.07 $\pm$ 0.21) $\times 10^{-3}$             |                                                   | –                     |
| $B \rightarrow D^- \ell^+ \nu_\ell$ anything                                                                                                                                | [ggg] (2.8 $\pm$ 0.9) %                        |                                                   | –                     | $B \rightarrow \chi_{c1}(1P)$ anything                   | (3.86 $\pm$ 0.27) $\times 10^{-3}$             |                                                   | –                     |
| $B \rightarrow \bar{D}^0 \ell^+ \nu_\ell$ anything                                                                                                                          | [ggg] (7.2 $\pm$ 1.5) %                        |                                                   | –                     | $B \rightarrow \chi_{c1}(1P)$ (direct)                   | (3.18 $\pm$ 0.25) $\times 10^{-3}$             |                                                   | –                     |
| $B \rightarrow D^{*-} \ell^+ \nu_\ell$ anything                                                                                                                             | [ppp] (6.7 $\pm$ 1.3) $\times 10^{-3}$         |                                                   | –                     | anything                                                 |                                                |                                                   |                       |
| $B \rightarrow \bar{D}^{*0} \ell^+ \nu_\ell$                                                                                                                                | [ggg,qqq] (2.7 $\pm$ 0.7) %                    |                                                   | –                     | $B \rightarrow \chi_{c2}(1P)$ anything                   | (1.3 $\pm$ 0.4) $\times 10^{-3}$               | $S = 1.9$                                         | –                     |
| $B \rightarrow \bar{D}_1(2420) \ell^+ \nu_\ell$                                                                                                                             | (3.8 $\pm$ 1.3) $\times 10^{-3}$               | $S = 2.4$                                         | –                     | $B \rightarrow \chi_{c2}(1P)$ (direct)                   | (1.65 $\pm$ 0.31) $\times 10^{-3}$             |                                                   | –                     |
| anything                                                                                                                                                                    |                                                |                                                   |                       | anything                                                 |                                                |                                                   |                       |
| $B \rightarrow D\pi \ell^+ \nu_\ell$                                                                                                                                        | (2.6 $\pm$ 0.5) %                              | $S = 1.5$                                         | –                     | $B \rightarrow \eta_c(1S)$ anything                      | < 9                                            | $\times 10^{-3}$                                  | CL = 90% –            |
| anything + $D^* \pi \ell^+ \nu_\ell$                                                                                                                                        |                                                |                                                   |                       | $B \rightarrow K \Upsilon(3940) \times$                  | [sss] (7.1 $\pm$ 3.4) $\times 10^{-5}$         |                                                   | 1083                  |
| anything                                                                                                                                                                    |                                                |                                                   |                       | $B(\Upsilon(3940) \rightarrow \omega J/\psi)$            |                                                |                                                   |                       |
| $B \rightarrow D\pi \ell^+ \nu_\ell$ anything                                                                                                                               | (1.5 $\pm$ 0.6) %                              |                                                   | –                     | <b><math>K</math> or <math>K^*</math> modes</b>          |                                                |                                                   |                       |
| $B \rightarrow D^* \pi \ell^+ \nu_\ell$ anything                                                                                                                            | (1.9 $\pm$ 0.4) %                              |                                                   | –                     | $B \rightarrow K^\pm$ anything                           | [gg] (78.9 $\pm$ 2.5) %                        |                                                   | –                     |
| $B \rightarrow \bar{D}_s^*(2460) \ell^+ \nu_\ell$                                                                                                                           | (4.4 $\pm$ 1.6) $\times 10^{-3}$               |                                                   | –                     | $B \rightarrow K^+$ anything                             | (66 $\pm$ 5) %                                 |                                                   | –                     |
| anything                                                                                                                                                                    |                                                |                                                   |                       | $B \rightarrow K^-$ anything                             | (13 $\pm$ 4) %                                 |                                                   | –                     |
| $B \rightarrow D^{*-} \pi^+ \ell^+ \nu_\ell$                                                                                                                                | (1.00 $\pm$ 0.34) %                            |                                                   | –                     | $B \rightarrow K^0/\bar{K}^0$ anything                   | [gg] (64 $\pm$ 4) %                            |                                                   | –                     |
| anything                                                                                                                                                                    |                                                |                                                   |                       | $B \rightarrow K^*(892)^\pm$                             | (18 $\pm$ 6) %                                 |                                                   | –                     |
| $B \rightarrow D_s^- \ell^+ \nu_\ell$ anything                                                                                                                              | [ggg] < 7 $\times 10^{-3}$                     | CL = 90%                                          | –                     | anything                                                 |                                                |                                                   |                       |
| $B \rightarrow D_s^- \ell^+ \nu_\ell K^+$ anything                                                                                                                          | [ggg] < 5 $\times 10^{-3}$                     | CL = 90%                                          | –                     | $B \rightarrow K^*(892)^0 / K^*(892)^0$ anything         | [gg] (14.6 $\pm$ 2.6) %                        |                                                   | –                     |
| $B \rightarrow D_s^- \ell^+ \nu_\ell K^0$ anything                                                                                                                          | [ggg] < 7 $\times 10^{-3}$                     | CL = 90%                                          | –                     | $B \rightarrow K^*(892)\gamma$                           | (4.2 $\pm$ 0.6) $\times 10^{-5}$               |                                                   | 2564                  |
| $B \rightarrow \ell^+ \nu_\ell$ charm                                                                                                                                       | (10.61 $\pm$ 0.17) %                           |                                                   | –                     | $B \rightarrow \eta K \gamma$                            | (8.5 $^{+1.8}_{-1.6}$ ) $\times 10^{-6}$       |                                                   | 2588                  |
| $B \rightarrow X_u \ell^+ \nu_\ell$                                                                                                                                         | (2.33 $\pm$ 0.22) $\times 10^{-3}$             |                                                   | –                     | $B \rightarrow K_1(1400)\gamma$                          | < 1.27 $\times 10^{-4}$                        | CL = 90%                                          | 2453                  |
| $B \rightarrow K^+ \ell^+ \nu_\ell$ anything                                                                                                                                | [ggg] (6.2 $\pm$ 0.6) %                        |                                                   | –                     | $B \rightarrow K_2^*(1430)\gamma$                        | (1.7 $^{+0.6}_{-0.5}$ ) $\times 10^{-5}$       |                                                   | 2447                  |
| $B \rightarrow K^- \ell^+ \nu_\ell$ anything                                                                                                                                | [ggg] (10 $\pm$ 4) $\times 10^{-3}$            |                                                   | –                     | $B \rightarrow K_2(1770)\gamma$                          | < 1.2 $\times 10^{-3}$                         | CL = 90%                                          | 2342                  |
| $B \rightarrow K^0/\bar{K}^0 \ell^+ \nu_\ell$                                                                                                                               | [ggg] (4.6 $\pm$ 0.5) %                        |                                                   | –                     | $B \rightarrow K_3^*(1780)\gamma$                        | < 3.7 $\times 10^{-5}$                         | CL = 90%                                          | 2341                  |
| anything                                                                                                                                                                    |                                                |                                                   |                       | $B \rightarrow K_4^*(2045)\gamma$                        | < 1.0 $\times 10^{-3}$                         | CL = 90%                                          | 2244                  |
| <b><math>D</math>, <math>D^*</math>, or <math>D_s</math> modes</b>                                                                                                          |                                                |                                                   |                       | $B \rightarrow K\eta(958)$                               | (8.3 $\pm$ 1.1) $\times 10^{-5}$               |                                                   | 2528                  |
| $B \rightarrow D^\pm$ anything                                                                                                                                              | (22.8 $\pm$ 1.4) %                             |                                                   | –                     | $B \rightarrow K^*(892)\eta'(958)$                       | < 2.2 $\times 10^{-5}$                         | CL = 90%                                          | 2472                  |
| $B \rightarrow D^0/\bar{D}^0$ anything                                                                                                                                      | (64.0 $\pm$ 3.0) %                             | $S = 1.2$                                         | –                     | $B \rightarrow K\eta$                                    | < 5.2 $\times 10^{-6}$                         | CL = 90%                                          | 2588                  |
| $B \rightarrow D^*(2010)^\pm$                                                                                                                                               | (22.5 $\pm$ 1.5) %                             |                                                   | –                     | $B \rightarrow K^*(892)\eta$                             | (1.8 $\pm$ 0.5) $\times 10^{-5}$               |                                                   | 2534                  |
| anything                                                                                                                                                                    |                                                |                                                   |                       | $B \rightarrow K\phi\phi$                                | (2.3 $\pm$ 0.9) $\times 10^{-6}$               |                                                   | 2306                  |
| $B \rightarrow D^*(2007)^0$                                                                                                                                                 | (26.0 $\pm$ 2.7) %                             |                                                   | –                     | $B \rightarrow \bar{b} \rightarrow \bar{s} \gamma$       | (3.43 $\pm$ 0.29) $\times 10^{-4}$             |                                                   | –                     |
| anything                                                                                                                                                                    |                                                |                                                   |                       | $B \rightarrow \bar{b} \rightarrow \bar{s}$ gluon        | < 6.8 %                                        | CL = 90%                                          | –                     |
| $B \rightarrow D_s^\pm$ anything                                                                                                                                            | [gg] (8.6 $\pm$ 1.2) %                         |                                                   | –                     | $B \rightarrow \eta$ anything                            | < 4.4 $\times 10^{-4}$                         | CL = 90%                                          | –                     |
| $B \rightarrow D_s^{*\pm}$ anything                                                                                                                                         | (6.5 $\pm$ 1.2) %                              |                                                   | –                     | $B \rightarrow \eta'$ anything                           | (4.2 $\pm$ 0.9) $\times 10^{-4}$               |                                                   | –                     |
| $B \rightarrow D_s^\pm \bar{D}^{(*)}$                                                                                                                                       | (3.4 $\pm$ 0.7) %                              |                                                   | –                     | <b>Light unflavored meson modes</b>                      |                                                |                                                   |                       |
| $B \rightarrow D^{(*)} \bar{D}^{(*)} K^0 + D^{(*)} \bar{D}^{(*)} K^\pm$                                                                                                     | [gg,rrr] (7.1 $^{+2.7}_{-1.7}$ ) %             |                                                   | –                     | $B \rightarrow \rho \gamma$                              | < 1.9 $\times 10^{-6}$                         | CL = 90%                                          | 2583                  |
| $b \rightarrow c \bar{c} s$                                                                                                                                                 | (22 $\pm$ 4) %                                 |                                                   | –                     | $B \rightarrow \rho/\omega \gamma$                       | < 1.2 $\times 10^{-6}$                         | CL = 90%                                          | –                     |
| $B \rightarrow D_s^{(*)} \bar{D}^{(*)}$                                                                                                                                     | [gg,rrr] (4.0 $\pm$ 0.6) %                     |                                                   | –                     | $B \rightarrow \pi^\pm$ anything                         | [gg,ttt] (358 $\pm$ 7) %                       |                                                   | –                     |
| $B \rightarrow D^* D^*(2010)^\pm$                                                                                                                                           | [gg] < 5.9 $\times 10^{-3}$                    | CL = 90%                                          | 1711                  | $B \rightarrow \pi^0$ anything                           | (235 $\pm$ 11) %                               |                                                   | –                     |
| $B \rightarrow DD^*(2010)^\pm + D^* D^\pm$                                                                                                                                  | [gg] < 5.5 $\times 10^{-3}$                    | CL = 90%                                          | –                     | $B \rightarrow \eta$ anything                            | (17.6 $\pm$ 1.6) %                             |                                                   | –                     |
| $B \rightarrow DD^\pm$                                                                                                                                                      | [gg] < 3.1 $\times 10^{-3}$                    | CL = 90%                                          | 1866                  | $B \rightarrow \rho^0$ anything                          | (21 $\pm$ 5) %                                 |                                                   | –                     |
| $B \rightarrow D_s^{(*)} \pm \bar{D}^{(*)} X$                                                                                                                               | [gg,rrr] (9 $^{+5}_{-4}$ ) %                   |                                                   | –                     | $B \rightarrow \omega$ anything                          | < 81 %                                         | CL = 90%                                          | –                     |
| $(n\pi^\pm)$                                                                                                                                                                |                                                |                                                   |                       | $B \rightarrow \phi$ anything                            | (3.42 $\pm$ 0.13) %                            |                                                   | –                     |
| $B \rightarrow D^*(2010)\gamma$                                                                                                                                             | < 1.1 $\times 10^{-3}$                         | CL = 90%                                          | 2257                  | $B \rightarrow \phi K^*(892)$                            | < 2.2 $\times 10^{-5}$                         | CL = 90%                                          | 2460                  |
| $B \rightarrow D_s^\pm \pi^-, D_s^{*+} \pi^-, D_s^\pm \pi^0, D_s^{*+} \pi^0, D_s^\pm \eta, D_s^{*+} \eta, D_s^\pm \rho^0, D_s^{*+} \rho^0, D_s^\pm \omega, D_s^{*+} \omega$ | [gg] < 4 $\times 10^{-4}$                      | CL = 90%                                          | –                     | <b>Baryon modes</b>                                      |                                                |                                                   |                       |
| $B \rightarrow D_{s1}(2536)^+$ anything                                                                                                                                     | < 9.5 $\times 10^{-3}$                         | CL = 90%                                          | –                     | $B \rightarrow \Lambda_c^+/\bar{\Lambda}_c^-$ anything   | (6.4 $\pm$ 1.1) %                              |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \bar{\Lambda}_c^- e^+$ anything           | < 3.2 $\times 10^{-3}$                         | CL = 90%                                          | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \bar{\Lambda}_c^- p$ anything             | (3.6 $\pm$ 0.7) %                              |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \bar{\Lambda}_c^- p e^+ \nu_e$            | < 1.5 $\times 10^{-3}$                         | CL = 90%                                          | 2021                  |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \bar{\Sigma}_c^{*-}$ anything             | (4.2 $\pm$ 2.4) $\times 10^{-3}$               |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \bar{\Sigma}_c^{*-}$ anything             | < 9.6 $\times 10^{-3}$                         | CL = 90%                                          | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \bar{\Sigma}_c^{*0}$ anything             | (4.6 $\pm$ 2.4) $\times 10^{-3}$               |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \bar{\Sigma}_c^{*0} N$ ( $N = p$ or $n$ ) | < 1.5 $\times 10^{-3}$                         | CL = 90%                                          | 1938                  |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \Xi_c^0$ anything                         | (1.93 $\pm$ 0.30) $\times 10^{-4}$             | $S = 1.1$                                         | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $\times B(\Xi_c^0 \rightarrow \Xi^- \pi^+)$              |                                                |                                                   |                       |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \Xi_c^+$ anything                         | (4.5 $^{+1.3}_{-1.2}$ ) $\times 10^{-4}$       |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $\times B(\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+)$        |                                                |                                                   |                       |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow p/\bar{p}$ anything                       | [gg] (8.0 $\pm$ 0.4) %                         |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow p/\bar{p}$ (direct)                       | [gg] (5.5 $\pm$ 0.5) %                         |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | anything                                                 |                                                |                                                   |                       |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \Lambda/\bar{\Lambda}$ anything           | [gg] (4.0 $\pm$ 0.5) %                         |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \Xi^-/\bar{\Xi}^+$ anything               | [gg] (2.7 $\pm$ 0.6) $\times 10^{-3}$          |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow$ baryons anything                         | (6.8 $\pm$ 0.6) %                              |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow p\bar{p}$ anything                        | (2.47 $\pm$ 0.23) %                            |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \Lambda\bar{p}/\bar{\Lambda} p$ anything  | [gg] (2.5 $\pm$ 0.4) %                         |                                                   | –                     |
|                                                                                                                                                                             |                                                |                                                   |                       | $B \rightarrow \Lambda\bar{\Lambda}$ anything            | < 5 $\times 10^{-3}$                           | CL = 90%                                          | –                     |

| Lepton Family number (LF) violating modes or<br>$\Delta B = 1$ weak neutral current (B1) modes |          |                                         |          |      |
|------------------------------------------------------------------------------------------------|----------|-----------------------------------------|----------|------|
| $B \rightarrow se^+e^-$                                                                        | B1       | $(4.7 \pm 1.3) \times 10^{-6}$          | —        |      |
| $B \rightarrow s\mu^+\mu^-$                                                                    | B1       | $(4.3 \pm 1.2) \times 10^{-6}$          | —        |      |
| $B \rightarrow s\ell^+\ell^-$                                                                  | B1 [ggg] | $(4.5 \pm 1.0) \times 10^{-6}$          | —        |      |
| $B \rightarrow Ke^+e^-$                                                                        | B1       | $(6.0^{+1.4}_{-1.2}) \times 10^{-7}$    | S = 1.1  | 2617 |
| $B \rightarrow K^*(892)e^+e^-$                                                                 | B1       | $(1.24^{+0.37}_{-0.32}) \times 10^{-6}$ |          | 2564 |
| $B \rightarrow K\mu^+\mu^-$                                                                    | B1       | $(4.7^{+1.1}_{-1.0}) \times 10^{-7}$    |          | 2612 |
| $B \rightarrow K^*(892)\mu^+\mu^-$                                                             | B1       | $(1.19^{+0.34}_{-0.29}) \times 10^{-6}$ |          | 2560 |
| $B \rightarrow K\ell^+\ell^-$                                                                  | B1       | $(5.4 \pm 0.8) \times 10^{-7}$          |          | 2617 |
| $B \rightarrow K^*(892)\ell^+\ell^-$                                                           | B1       | $(1.05 \pm 0.20) \times 10^{-6}$        |          | 2564 |
| $B \rightarrow e^\pm\mu^\mp s$                                                                 | LF [gg]  | $< 2.2 \times 10^{-5}$                  | CL = 90% | —    |
| $B \rightarrow \pi e^\pm\mu^\mp$                                                               | LF       | $< 1.6 \times 10^{-6}$                  | CL = 90% | 2637 |
| $B \rightarrow \rho e^\pm\mu^\mp$                                                              | LF       | $< 3.2 \times 10^{-6}$                  | CL = 90% | 2582 |
| $B \rightarrow Ke^\pm\mu^\mp$                                                                  | LF       | $< 1.6 \times 10^{-6}$                  | CL = 90% | 2616 |
| $B \rightarrow K^*(892)e^\pm\mu^\mp$                                                           | LF       | $< 6.2 \times 10^{-6}$                  | CL = 90% | 2563 |

### $B^\pm/B^0/b$ -baryon ADMIXTURE

These measurements are for an admixture of bottom particles at high energy (LEP, Tevatron,  $S\bar{p}\bar{p}S$ ).

Mean life  $\tau = (1.568 \pm 0.009) \times 10^{-12}$  s

Mean life  $\tau = (1.72 \pm 0.10) \times 10^{-12}$  s Charged  $b$ -hadron admixture

Mean life  $\tau = (1.58 \pm 0.14) \times 10^{-12}$  s Neutral  $b$ -hadron admixture

$\tau_{\text{charged } b\text{-hadron}}/\tau_{\text{neutral } b\text{-hadron}} = 1.09 \pm 0.13$

$|\Delta\tau_b|/\tau_{b,b} = -0.001 \pm 0.014$

The branching fraction measurements are for an admixture of  $B$  mesons and baryons at energies above the  $\Upsilon(4S)$ . Only the highest energy results (LEP, Tevatron,  $S\bar{p}\bar{p}S$ ) are used in the branching fraction averages. In the following, we assume that the production fractions are the same at the LEP and at the Tevatron.

For inclusive branching fractions, e.g.,  $B \rightarrow D^\pm$  anything, the values usually are multiplicities, not branching fractions. They can be greater than one.

The modes below are listed for a  $\bar{b}$  initial state.  $b$  modes are their charge conjugates. Reactions indicate the weak decay vertex and do not include mixing.

| $\bar{b}$ DECAY MODES | Scale factor/<br>Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$<br>(MeV/c) |
|-----------------------|-------------------------------------------------|------------------|----------------|
|-----------------------|-------------------------------------------------|------------------|----------------|

### PRODUCTION FRACTIONS

The production fractions for weakly decaying  $b$ -hadrons at high energy have been calculated from the best values of mean lives, mixing parameters, and branching fractions in this edition by the Heavy Flavor Averaging Group (HFAG) as described in the note “ $B^0$ - $\bar{B}^0$  Mixing” in the  $B^0$  Particle Listings. Values assume

$$B(\bar{b} \rightarrow B^+) = B(\bar{b} \rightarrow B^0)$$

$$B(\bar{b} \rightarrow B^+) + B(\bar{b} \rightarrow B^0) + B(\bar{b} \rightarrow B^0) + B(b \rightarrow b\text{-baryon}) = 100\%.$$

The notation for production fractions varies in the literature ( $f_d, d_{B^0}, f(b \rightarrow \bar{B}^0), B\tau(b \rightarrow \bar{B}^0)$ ). We use our own branching fraction notation here,  $B(\bar{b} \rightarrow B^0)$ .

|             |                     |   |
|-------------|---------------------|---|
| $B^+$       | $(39.8 \pm 1.2) \%$ | — |
| $B^0$       | $(39.8 \pm 1.2) \%$ | — |
| $B_s^0$     | $(10.3 \pm 1.4) \%$ | — |
| $b$ -baryon | $(10.0 \pm 2.0) \%$ | — |
| $B_c$       | —                   | — |

### DECAY MODES

| Semileptonic and leptonic modes         |       |                                |         |
|-----------------------------------------|-------|--------------------------------|---------|
| $\nu$ anything                          | [ggg] | $(23.1 \pm 1.5) \%$            | —       |
| $\ell^+\nu_\ell$ anything               |       | $(10.69 \pm 0.22) \%$          | —       |
| $e^+\nu_e$ anything                     |       | $(10.86 \pm 0.35) \%$          | —       |
| $\mu^+\nu_\mu$ anything                 |       | $(10.95^{+0.29}_{-0.25}) \%$   | —       |
| $D^-\ell^+\nu_\ell$ anything            | [ggg] | $(2.2 \pm 0.4) \%$             | S = 1.9 |
| $D^-\pi^+\ell^+\nu_\ell$ anything       |       | $(4.9 \pm 1.9) \times 10^{-3}$ | —       |
| $D^-\pi^-\ell^+\nu_\ell$ anything       |       | $(2.6 \pm 1.6) \times 10^{-3}$ | —       |
| $\bar{D}^0\ell^+\nu_\ell$ anything      | [ggg] | $(6.90 \pm 0.35) \%$           | —       |
| $\bar{D}^0\pi^-\ell^+\nu_\ell$ anything |       | $(1.07 \pm 0.27) \%$           | —       |
| $\bar{D}^0\pi^+\ell^+\nu_\ell$ anything |       | $(2.3 \pm 1.6) \times 10^{-3}$ | —       |
| $D^{*-}\ell^+\nu_\ell$ anything         | [ggg] | $(2.75 \pm 0.19) \%$           | —       |

|                                                     |           |                                      |          |
|-----------------------------------------------------|-----------|--------------------------------------|----------|
| $D^{*-}\pi^+\ell^+\nu_\ell$                         |           | $(4.8 \pm 1.0) \times 10^{-3}$       | —        |
| anything                                            |           | $(6 \pm 7) \times 10^{-4}$           | —        |
| $D^{*-}\pi^-\ell^+\nu_\ell$                         |           | $(2.6 \pm 0.9) \times 10^{-3}$       | —        |
| $\bar{D}_j^0\ell^+\nu_\ell$ anything $\times$       | [ggg,uuu] | $(7.0 \pm 1.9) \times 10^{-3}$       | —        |
| $B(\bar{D}_j^0 \rightarrow D^{*+}\pi^-)$            |           |                                      | —        |
| $D_j^-\ell^+\nu_\ell$ anything $\times$             | [ggg,uuu] | $(7.0 \pm 1.9) \times 10^{-3}$       | —        |
| $B(D_j^- \rightarrow D^0\pi^-)$                     |           |                                      | —        |
| $\bar{D}_2^*(2460)^0\ell^+\nu_\ell$                 |           | $< 1.4 \times 10^{-3}$               | CL = 90% |
| anything $\times$                                   |           |                                      | —        |
| $B(\bar{D}_2^*(2460)^0 \rightarrow D^{*-}\pi^+)$    |           |                                      | —        |
| $D_2^*(2460)^-\ell^+\nu_\ell$                       |           | $(4.2^{+1.5}_{-1.8}) \times 10^{-3}$ | —        |
| anything $\times$                                   |           |                                      | —        |
| $B(D_2^*(2460)^- \rightarrow D^0\pi^-)$             |           |                                      | —        |
| $\bar{D}_2^*(2460)^0\ell^+\nu_\ell$                 |           | $(160 \pm 80) \%$                    | —        |
| anything $\times$                                   |           |                                      | —        |
| $B(\bar{D}_2^*(2460)^0 \rightarrow D^-\pi^+)$       |           |                                      | —        |
| charmless $\ell\bar{\nu}_\ell$                      | [ggg]     | $(1.7 \pm 0.5) \times 10^{-3}$       | —        |
| $\tau^+\nu_\tau$ anything                           |           | $(2.48 \pm 0.26) \%$                 | —        |
| $D^{*-}\tau\nu_\tau$ anything                       |           | $(9 \pm 4) \times 10^{-3}$           | —        |
| $\bar{c} \rightarrow \ell^-\bar{\nu}_\ell$ anything | [ggg]     | $(8.02 \pm 0.19) \%$                 | —        |
| $c \rightarrow \ell^+\nu$ anything                  |           | $(1.6^{+0.4}_{-0.5}) \%$             | —        |

### Charmed meson and baryon modes

|                               |       |                          |          |
|-------------------------------|-------|--------------------------|----------|
| $\bar{D}^0$ anything          |       | $(61.0 \pm 3.1) \%$      | —        |
| $D^0 D_s^\pm$ anything        | [gg]  | $(9.1^{+3.9}_{-2.8}) \%$ | —        |
| $D^\mp D_s^\pm$ anything      | [gg]  | $(4.0^{+2.3}_{-1.8}) \%$ | —        |
| $\bar{D}^0 D^0$ anything      | [gg]  | $(5.1^{+2.0}_{-1.8}) \%$ | —        |
| $D^0 D^\pm$ anything          | [gg]  | $(2.7^{+1.8}_{-1.6}) \%$ | —        |
| $D^\pm D^\mp$ anything        | [gg]  | $< 9 \times 10^{-3}$     | CL = 90% |
| $D^-$ anything                |       | $(22.4 \pm 1.8) \%$      | —        |
| $D^*(2010)^+$ anything        |       | $(17.3 \pm 2.0) \%$      | —        |
| $D_1(2420)^0$ anything        |       | $(5.0 \pm 1.5) \%$       | —        |
| $D^*(2010)^\mp D_s^\pm$       | [gg]  | $(3.3^{+1.6}_{-1.3}) \%$ | —        |
| anything                      |       |                          | —        |
| $D^0 D^*(2010)^\pm$           | [gg]  | $(3.0^{+1.1}_{-0.9}) \%$ | —        |
| anything                      |       |                          | —        |
| $D^*(2010)^\pm D^\mp$         | [gg]  | $(2.5^{+1.2}_{-1.0}) \%$ | —        |
| anything                      |       |                          | —        |
| $D^*(2010)^\pm D^*(2010)^\mp$ | [gg]  | $(1.2 \pm 0.4) \%$       | —        |
| anything                      |       |                          | —        |
| $\bar{D}D$ anything           |       | $(10^{+11}_{-10}) \%$    | —        |
| $D_2^*(2460)^0$ anything      |       | $(4.7 \pm 2.7) \%$       | —        |
| $D_s^-$ anything              |       | $(15.0 \pm 2.6) \%$      | —        |
| $D_s^+$ anything              |       | $(10.1 \pm 3.1) \%$      | —        |
| $\Lambda_c^+$ anything        |       | $(9.7 \pm 2.9) \%$       | —        |
| $\bar{c}/c$ anything          | [ttt] | $(116.2 \pm 3.2) \%$     | —        |

### Charmonium modes

|                          |  |                                |   |
|--------------------------|--|--------------------------------|---|
| $J/\psi(1S)$ anything    |  | $(1.16 \pm 0.10) \%$           | — |
| $\psi(2S)$ anything      |  | $(4.8 \pm 2.4) \times 10^{-3}$ | — |
| $\chi_{c1}(1P)$ anything |  | $(1.4 \pm 0.4) \%$             | — |

### $K$ or $K^*$ modes

|                        |  |                                |          |
|------------------------|--|--------------------------------|----------|
| $\bar{s}\gamma$        |  | $(3.1 \pm 1.1) \times 10^{-4}$ | —        |
| $\bar{s}\bar{\nu}_\nu$ |  | $< 6.4 \times 10^{-4}$         | CL = 90% |
| $K^\pm$ anything       |  | $(74 \pm 6) \%$                | —        |
| $K_S^0$ anything       |  | $(29.0 \pm 2.9) \%$            | —        |

### Pion modes

|                    |       |                      |   |
|--------------------|-------|----------------------|---|
| $\pi^\pm$ anything |       | $(397 \pm 21) \%$    | — |
| $\pi^0$ anything   | [ttt] | $(278 \pm 60) \%$    | — |
| $\phi$ anything    |       | $(2.82 \pm 0.23) \%$ | — |

### Baryon modes

|                      |  |                     |   |
|----------------------|--|---------------------|---|
| $p/\bar{p}$ anything |  | $(13.1 \pm 1.1) \%$ | — |
|----------------------|--|---------------------|---|

### Other modes

|                         |  |                                      |   |
|-------------------------|--|--------------------------------------|---|
| [ttt]                   |  | $(497 \pm 7) \%$                     | — |
| charged anything        |  | $(1.7^{+1.0}_{-0.7}) \times 10^{-5}$ | — |
| hadron $^+$ hadron $^-$ |  | $(7 \pm 21) \times 10^{-3}$          | — |
| charmless               |  |                                      | — |

### Baryon modes

|                                  |  |                     |   |
|----------------------------------|--|---------------------|---|
| $\Lambda/\bar{\Lambda}$ anything |  | $(5.9 \pm 0.6) \%$  | — |
| $b$ -baryon anything             |  | $(10.2 \pm 2.8) \%$ | — |

$\mu^+ \mu^-$  anything  $\Delta B = 1$  weak neutral current ( $B1$ ) modes  
 $B1$   $< 3.2 \times 10^{-4}$  CL = 90% -

$$B^* \quad I(J^P) = \frac{1}{2}(1^-)$$

$I, J, P$  need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B^*} = 5325.0 \pm 0.6 \text{ MeV}$$

$$m_{B^*} - m_B = 45.78 \pm 0.35 \text{ MeV}$$

| $B^*$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------|--------------------------------|-------------|
| $B\gamma$         | dominant                       | 45          |

### BOTTOM, STRANGE MESONS

$$(B = \pm 1, S = \mp 1)$$

$$B_s^0 = s\bar{b}, \bar{B}_s^0 = \bar{s}b, \text{ similarly for } B_s^{*\pm}$$

$$B_s^0 \quad I(J^P) = 0(0^-)$$

$I, J, P$  need confirmation. Quantum numbers shown are quark-model predictions.

$$\text{Mass } m_{B_s^0} = 5367.5 \pm 1.8 \text{ MeV} \quad (S = 1.1)$$

$$\text{Mean life } \tau = (1.466 \pm 0.059) \times 10^{-12} \text{ s}$$

$$c\tau = 439 \text{ } \mu\text{m}$$

#### $B_s^0 \bar{B}_s^0$ mixing parameters

$$\Delta m_{B_s^0} = m_{B_s^0 H} - m_{B_s^0 L} > 14.4 \times 10^{12} \hbar \text{ s}^{-1}, \text{ CL} = 95\%$$

$$> 94.8 \times 10^{-10} \text{ MeV}, \text{ CL} = 95\%$$

$$x_s = \Delta m_{B_s^0} / \Gamma_{B_s^0} > 19.9, \text{ CL} = 95\%$$

$$\chi_s > 0.49878, \text{ CL} = 95\%$$

These branching fractions all scale with  $B(\bar{b} \rightarrow B_s^0)$ , the LEP  $B_s^0$  production fraction. The first four were evaluated using  $B(\bar{b} \rightarrow B_s^0) = (10.7 \pm 1.4)\%$  and the rest assume  $B(\bar{b} \rightarrow B_s^0) = 12\%$ .

The branching fraction  $B(B_s^0 \rightarrow D_s^- \ell^+ \nu_\ell \text{ anything})$  is not a pure measurement since the measured product branching fraction  $B(\bar{b} \rightarrow B_s^0) \times B(B_s^0 \rightarrow D_s^- \ell^+ \nu_\ell \text{ anything})$  was used to determine  $B(\bar{b} \rightarrow B_s^0)$ , as described in the note on “ $B^0 - \bar{B}^0$  Mixing”

For inclusive branching fractions, e.g.,  $B \rightarrow D^\pm \text{ anything}$ , the values usually are multiplicities, not branching fractions. They can be greater than one.

| $B_s^0$ DECAY MODES              | Fraction ( $\Gamma_i/\Gamma$ )      | Confidence level | $p$ (MeV/c) |
|----------------------------------|-------------------------------------|------------------|-------------|
| $D_s^-$ anything                 | (94 $\pm$ 30)                       | %                | -           |
| $D_s^- \ell^+ \nu_\ell$ anything | (7.9 $\pm$ 2.4)                     | %                | -           |
| $D_s^- \pi^+$                    | < 13                                | %                | 2321        |
| $D_s^{(*)+} D_s^{(*)-}$          | (23 <sup>+21</sup> <sub>-13</sub> ) | %                | -           |
| $J/\psi(1S)\phi$                 | (9.3 $\pm$ 3.3)                     | $\times 10^{-4}$ | 1588        |
| $J/\psi(1S)\pi^0$                | < 1.2                               | $\times 10^{-3}$ | 1787        |
| $J/\psi(1S)\eta$                 | < 3.8                               | $\times 10^{-3}$ | 1734        |
| $\psi(2S)\phi$                   | seen                                |                  | 1121        |
| $\pi^+ \pi^-$                    | < 1.7                               | $\times 10^{-4}$ | 2680        |
| $\pi^0 \pi^0$                    | < 2.1                               | $\times 10^{-4}$ | 2680        |
| $\eta \pi^0$                     | < 1.0                               | $\times 10^{-3}$ | 2654        |
| $\eta \eta$                      | < 1.5                               | $\times 10^{-3}$ | 2627        |
| $\rho^0 \rho^0$                  | < 3.20                              | $\times 10^{-4}$ | 2569        |
| $\phi \rho^0$                    | < 6.17                              | $\times 10^{-4}$ | 2527        |
| $\phi \phi$                      | (1.4 $\pm$ 0.8)                     | $\times 10^{-5}$ | 2483        |
| $\pi^+ K^-$                      | < 2.1                               | $\times 10^{-4}$ | 2659        |
| $K^+ K^-$                        | < 5.9                               | $\times 10^{-5}$ | 2638        |
| $\bar{K}^*(892)^0 \rho^0$        | < 7.67                              | $\times 10^{-4}$ | 2550        |
| $\bar{K}^*(892)^0 K^*(892)^0$    | < 1.681                             | $\times 10^{-3}$ | 2531        |
| $\phi K^*(892)^0$                | < 1.013                             | $\times 10^{-3}$ | 2507        |
| $p \bar{p}$                      | < 5.9                               | $\times 10^{-5}$ | 2514        |
| $\gamma \gamma$                  | < .48                               | $\times 10^{-4}$ | 2684        |
| $\phi \gamma$                    | < 1.2                               | $\times 10^{-4}$ | 2587        |

#### Lepton Family number ( $LF$ ) violating modes or

| $\Delta B = 1$ weak neutral current ( $B1$ ) modes |      |                                      |
|----------------------------------------------------|------|--------------------------------------|
| $\mu^+ \mu^-$                                      | $B1$ | $< 1.5 \times 10^{-7}$ 90% 2682      |
| $e^+ e^-$                                          | $B1$ | $< 5.4 \times 10^{-5}$ 90% 2684      |
| $e^\pm \mu^\mp$                                    | $LF$ | [gg] $< 6.1 \times 10^{-6}$ 90% 2683 |
| $\phi(1020)\mu^+ \mu^-$                            | $B1$ | $< 4.7 \times 10^{-5}$ 90% 2582      |
| $\phi \nu \bar{\nu}$                               | $B1$ | $< 5.4 \times 10^{-3}$ 90% 2587      |

### BOTTOM, CHARMED MESONS

$$(B = C = \pm 1)$$

$$B_c^+ = c\bar{b}, B_c^- = \bar{c}b, \text{ similarly for } B_c^{*s}$$

$$B_c^\pm \quad I(J^P) = 0(0^-)$$

$I, J, P$  need confirmation.

Quantum numbers shown are quark model predictions.

$$\text{Mass } m = 6.286 \pm 0.005 \text{ GeV}$$

$$\text{Mean life } \tau = (0.46_{-0.16}^{+0.18}) \times 10^{-12} \text{ s}$$

$B_c^-$  modes are charge conjugates of the modes below.

| $B_c^\pm$ DECAY MODES                                                                                                             | Fraction ( $\Gamma_i/\Gamma$ )         | Confidence level | $p$ (MeV/c) |
|-----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------------------|-------------|
| The following quantities are not pure branching ratios; rather the fraction $\Gamma_i/\Gamma \times B(\bar{b} \rightarrow B_c)$ . |                                        |                  |             |
| $J/\psi(1S)\ell^+ \nu_\ell$ anything                                                                                              | (5.2 <sup>+2.4</sup> <sub>-2.1</sub> ) | $\times 10^{-5}$ | -           |
| $J/\psi(1S)\pi^+$                                                                                                                 | < 8.2                                  | $\times 10^{-5}$ | 90% 2377    |
| $J/\psi(1S)\pi^+ \pi^+ \pi^-$                                                                                                     | < 5.7                                  | $\times 10^{-4}$ | 90% 2357    |
| $J/\psi(1S)a_1(1260)$                                                                                                             | < 1.2                                  | $\times 10^{-3}$ | 90% 2177    |
| $D^*(2010)^+ \bar{D}^0$                                                                                                           | < 6.2                                  | $\times 10^{-3}$ | 90% 2474    |

### $c\bar{c}$ MESONS

$$\eta_c(1S) \quad I^G(J^{PC}) = 0^+(0^{-+})$$

$$\text{Mass } m = 2980.4 \pm 1.2 \text{ MeV} \quad (S = 1.5)$$

$$\text{Full width } \Gamma = 25.5 \pm 3.4 \text{ MeV} \quad (S = 2.0)$$

| $\eta_c(1S)$ DECAY MODES             | Fraction ( $\Gamma_i/\Gamma$ )         | Confidence level | $p$ (MeV/c) |
|--------------------------------------|----------------------------------------|------------------|-------------|
| Decays involving hadronic resonances |                                        |                  |             |
| $\eta'(958)\pi\pi$                   | (4.1 $\pm$ 1.7)                        | %                | 1321        |
| $\rho\rho$                           | (2.0 $\pm$ 0.7)                        | %                | 1273        |
| $K^*(892)^0 K^- \pi^+ + \text{c.c.}$ | (2.0 $\pm$ 0.7)                        | %                | 1276        |
| $K^*(892)\bar{K}^*(892)$             | (9.2 $\pm$ 3.4)                        | $\times 10^{-3}$ | 1194        |
| $K^{*0}\bar{K}^{*0}\pi^+\pi^-$       | (1.5 $\pm$ 0.8)                        | %                | 1071        |
| $\phi K^+ K^-$                       | (2.9 $\pm$ 1.4)                        | $\times 10^{-3}$ | 1102        |
| $\phi \phi$                          | (2.7 $\pm$ 0.9)                        | $\times 10^{-3}$ | 1087        |
| $\phi 2(\pi^+ \pi^-)$                | < 4.7                                  | $\times 10^{-3}$ | 90% 1249    |
| $a_0(980)\pi$                        | < 2                                    | %                | 90% 1324    |
| $a_2(1320)\pi$                       | < 2                                    | %                | 90% 1194    |
| $K^*(892)\bar{K} + \text{c.c.}$      | < 1.28                                 | %                | 90% 1308    |
| $f_2(1270)\eta$                      | < 1.1                                  | %                | 90% 1143    |
| $\omega\omega$                       | < 3.1                                  | $\times 10^{-3}$ | 90% 1268    |
| $\omega\phi$                         | < 1.7                                  | $\times 10^{-3}$ | 90% 1183    |
| $f_2(1270) f_2(1270)$                | (1.0 <sup>+0.4</sup> <sub>-0.5</sub> ) | %                | 771         |
| Decays into stable hadrons           |                                        |                  |             |
| $K\bar{K}\pi$                        | (7.0 $\pm$ 1.2)                        | %                | 1379        |
| $\eta\pi\pi$                         | (4.9 $\pm$ 1.8)                        | %                | 1427        |
| $\pi^+ \pi^- K^+ K^-$                | (1.5 $\pm$ 0.6)                        | %                | 1343        |
| $K^+ K^- 2(\pi^+ \pi^-)$             | (10 $\pm$ 4)                           | $\times 10^{-3}$ | 1252        |
| $2(K^+ K^-)$                         | (1.5 $\pm$ 0.7)                        | $\times 10^{-3}$ | 1053        |
| $2(\pi^+ \pi^-)$                     | (1.20 $\pm$ 0.30)                      | %                | 1457        |
| $3(\pi^+ \pi^-)$                     | (2.0 $\pm$ 0.7)                        | %                | 1405        |
| $p\bar{p}$                           | (1.3 $\pm$ 0.4)                        | $\times 10^{-3}$ | 1158        |
| $K\bar{K}\eta$                       | < 3.1                                  | %                | 90% 1263    |
| $\pi^+ \pi^- p\bar{p}$               | < 1.2                                  | %                | 90% 1025    |
| $\Lambda\bar{\Lambda}$               | < 2                                    | $\times 10^{-3}$ | 90% 988     |
| Radiative decays                     |                                        |                  |             |
| $\gamma\gamma$                       | (2.8 $\pm$ 0.9)                        | $\times 10^{-4}$ | 1490        |

|               | Charge conjugation (C), Parity (P),<br>Lepton family number (LF) violating modes |     |      |
|---------------|----------------------------------------------------------------------------------|-----|------|
| $\pi^+\pi^-$  | $P, CP < 8.7 \times 10^{-4}$                                                     | 90% | 1484 |
| $\pi^0\pi^0$  | $P, CP < 5.6 \times 10^{-4}$                                                     | 90% | 1484 |
| $K^+K^-$      | $P, CP < 7.6 \times 10^{-4}$                                                     | 90% | 1406 |
| $K_S^0 K_S^0$ | $P, CP < 4.2 \times 10^{-4}$                                                     | 90% | 1405 |

$J/\psi(1S)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 3096.916 \pm 0.011$  MeV

Full width  $\Gamma = 93.4 \pm 2.1$  keV

$\Gamma_{ee} = 5.55 \pm 0.14 \pm 0.02$  keV

| $J/\psi(1S)$ DECAY MODES                                | Fraction ( $\Gamma_i/\Gamma$ )        | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|---------------------------------------------------------|---------------------------------------|-----------------------------------|----------------|
| hadrons                                                 | $(87.7 \pm 0.5) \%$                   |                                   | —              |
| virtual $\gamma \rightarrow$ hadrons                    | $(13.50 \pm 0.30) \%$                 |                                   | —              |
| $e^+e^-$                                                | $(5.94 \pm 0.06) \%$                  |                                   | 1548           |
| $\mu^+\mu^-$                                            | $(5.93 \pm 0.06) \%$                  |                                   | 1545           |
| Decays involving hadronic resonances                    |                                       |                                   |                |
| $\rho\pi$                                               | $(1.69 \pm 0.15) \%$                  | $S = 2.4$                         | 1448           |
| $\rho^0\pi^0$                                           | $(5.6 \pm 0.7) \times 10^{-3}$        |                                   | 1448           |
| $a_2(1320)\rho$                                         | $(1.09 \pm 0.22) \%$                  |                                   | 1123           |
| $\omega\pi^+\pi^+\pi^-\pi^-$                            | $(8.5 \pm 3.4) \times 10^{-3}$        |                                   | 1392           |
| $\omega\pi^+\pi^+\pi^0$                                 | $(4.0 \pm 0.7) \times 10^{-3}$        |                                   | 1418           |
| $\omega\pi^+\pi^-$                                      | $(7.2 \pm 1.0) \times 10^{-3}$        |                                   | 1435           |
| $\omega f_2(1270)$                                      | $(4.3 \pm 0.6) \times 10^{-3}$        |                                   | 1142           |
| $K^*(892)^0 \bar{K}_2^*(1430)^0 + c.c.$                 | $(6.7 \pm 2.6) \times 10^{-3}$        |                                   | 1012           |
| $\omega K^*(892) \bar{K} + c.c.$                        | $(5.3 \pm 2.0) \times 10^{-3}$        |                                   | 1097           |
| $K^+ \bar{K}^*(892)^- + c.c.$                           | $(5.0 \pm 0.4) \times 10^{-3}$        |                                   | 1373           |
| $K^0 \bar{K}^*(892)^0 + c.c.$                           | $(4.2 \pm 0.4) \times 10^{-3}$        |                                   | 1373           |
| $K_1(1400)^\pm K^\mp$                                   | $(3.8 \pm 1.4) \times 10^{-3}$        |                                   | 1171           |
| $\omega\pi^0\pi^0$                                      | $(3.4 \pm 0.8) \times 10^{-3}$        |                                   | 1436           |
| $b_1(1235)^\pm \pi^\mp$                                 | [gg] $(3.0 \pm 0.5) \times 10^{-3}$   |                                   | 1300           |
| $\omega K^\pm K_S^0 \pi^\mp$                            | [gg] $(2.9 \pm 0.7) \times 10^{-3}$   |                                   | 1210           |
| $b_1(1235)^0 \pi^0$                                     | [gg] $(2.3 \pm 0.6) \times 10^{-3}$   |                                   | 1300           |
| $\phi K^*(892) \bar{K} + c.c.$                          | $(2.04 \pm 0.28) \times 10^{-3}$      |                                   | 969            |
| $\omega K \bar{K}$                                      | $(1.9 \pm 0.4) \times 10^{-3}$        |                                   | 1268           |
| $\omega f_0(1710) \rightarrow \omega K \bar{K}$         | $(4.8 \pm 1.1) \times 10^{-4}$        |                                   | 878            |
| $\phi 2(\pi^+\pi^-)$                                    | $(1.66 \pm 0.23) \times 10^{-3}$      |                                   | 1318           |
| $\Delta(1232)^{++} \bar{p}\pi^-$                        | $(1.6 \pm 0.5) \times 10^{-3}$        |                                   | 1030           |
| $\omega\eta$                                            | $(1.74 \pm 0.20) \times 10^{-3}$      | $S = 1.6$                         | 1394           |
| $\phi K \bar{K}$                                        | $(1.83 \pm 0.24) \times 10^{-3}$      | $S = 1.5$                         | 1179           |
| $\phi f_0(1710) \rightarrow \phi K \bar{K}$             | $(3.6 \pm 0.6) \times 10^{-4}$        |                                   | 875            |
| $p \bar{p} \omega$                                      | $(1.30 \pm 0.25) \times 10^{-3}$      | $S = 1.3$                         | 768            |
| $\Delta(1232)^{++} \bar{\Delta}(1232)^{--}$             | $(1.10 \pm 0.29) \times 10^{-3}$      |                                   | 938            |
| $\Sigma(1385)^- \bar{\Sigma}(1385)^+ \text{ (or c.c.)}$ | [gg] $(1.03 \pm 0.13) \times 10^{-3}$ |                                   | 697            |
| $p \bar{p} \eta'(958)$                                  | $(9 \pm 4) \times 10^{-4}$            | $S = 1.7$                         | 596            |
| $\phi f_2'(1525)$                                       | $(8 \pm 4) \times 10^{-4}$            | $S = 2.7$                         | 871            |
| $\phi \pi^+ \pi^-$                                      | $(9.4 \pm 1.5) \times 10^{-4}$        | $S = 1.7$                         | 1365           |
| $\phi K^\pm K_S^0 \pi^\mp$                              | [gg] $(7.2 \pm 0.9) \times 10^{-4}$   |                                   | 1114           |
| $\omega f_1(1420)$                                      | $(6.8 \pm 2.4) \times 10^{-4}$        |                                   | 1062           |
| $\phi\eta$                                              | $(7.4 \pm 0.8) \times 10^{-4}$        | $S = 1.5$                         | 1320           |
| $\Xi(1530)^- \bar{\Xi}^+$                               | $(5.9 \pm 1.5) \times 10^{-4}$        |                                   | 601            |
| $p K^- \bar{\Sigma}(1385)^0$                            | $(5.1 \pm 3.2) \times 10^{-4}$        |                                   | 646            |
| $\omega\pi^0$                                           | $(4.5 \pm 0.5) \times 10^{-4}$        | $S = 1.4$                         | 1446           |
| $\phi\eta'(958)$                                        | $(4.0 \pm 0.7) \times 10^{-4}$        | $S = 2.1$                         | 1192           |
| $\phi f_0(980)$                                         | $(3.2 \pm 0.9) \times 10^{-4}$        | $S = 1.9$                         | 1182           |
| $\Xi(1530)^0 \bar{\Xi}^0$                               | $(3.2 \pm 1.4) \times 10^{-5}$        |                                   | 608            |
| $\Sigma(1385)^- \bar{\Sigma}^+ \text{ (or c.c.)}$       | [gg] $(3.1 \pm 0.5) \times 10^{-4}$   |                                   | 855            |
| $\phi f_1(1285)$                                        | $(2.6 \pm 0.5) \times 10^{-4}$        | $S = 1.1$                         | 1032           |
| $\rho\eta$                                              | $(1.93 \pm 0.23) \times 10^{-4}$      |                                   | 1396           |
| $\omega\eta'(958)$                                      | $(1.82 \pm 0.21) \times 10^{-4}$      |                                   | 1279           |
| $\omega f_0(980)$                                       | $(1.4 \pm 0.5) \times 10^{-4}$        |                                   | 1271           |
| $\rho\eta'(958)$                                        | $(1.05 \pm 0.18) \times 10^{-4}$      |                                   | 1281           |
| $p \bar{p} \phi$                                        | $(4.5 \pm 1.5) \times 10^{-5}$        |                                   | 527            |
| $a_2(1320)^\pm \pi^\mp$                                 | [gg] $< 4.3 \times 10^{-3}$           | CL = 90%                          | 1263           |
| $K \bar{K}_2^*(1430) + c.c.$                            | $< 4.0 \times 10^{-3}$                | CL = 90%                          | 1159           |
| $K_1(1270)^\pm K^\mp$                                   | $< 3.0 \times 10^{-3}$                | CL = 90%                          | 1231           |
| $K_S^*(1430)^0 \bar{K}_2^*(1430)^0$                     | $< 2.9 \times 10^{-3}$                | CL = 90%                          | 604            |
| $K^*(892)^0 \bar{K}^*(892)^0$                           | $< 5 \times 10^{-4}$                  | CL = 90%                          | 1266           |
| $\phi f_2(1270)$                                        | $< 3.7 \times 10^{-4}$                | CL = 90%                          | 1036           |
| $p \bar{p} \rho$                                        | $< 3.1 \times 10^{-4}$                | CL = 90%                          | 774            |
| $\phi\eta(1405) \rightarrow \phi\eta\pi\pi$             | $< 2.5 \times 10^{-4}$                | CL = 90%                          | 946            |
| $\omega f_2'(1525)$                                     | $< 2.2 \times 10^{-4}$                | CL = 90%                          | 1003           |
| $\Sigma(1385)^0 \bar{\Lambda}$                          | $< 2 \times 10^{-4}$                  | CL = 90%                          | 912            |

|                                                                          |         |                  |          |      |
|--------------------------------------------------------------------------|---------|------------------|----------|------|
| $\Delta(1232)^+ \bar{p}$                                                 | $< 1$   | $\times 10^{-4}$ | CL = 90% | 1100 |
| $\Theta(1540) \bar{\Theta}(1540) \rightarrow K_S^0 p K^- \bar{n} + c.c.$ | $< 1.1$ | $\times 10^{-5}$ | CL = 90% | —    |
| $\Theta(1540) K^- \bar{n} \rightarrow K_S^0 p K^- \bar{n}$               | $< 2.1$ | $\times 10^{-5}$ | CL = 90% | —    |
| $\Theta(1540) K_S^0 \bar{p} \rightarrow K_S^0 \bar{p} K^+ n$             | $< 1.6$ | $\times 10^{-5}$ | CL = 90% | —    |
| $\bar{\Theta}(1540) K^+ n \rightarrow K_S^0 \bar{p} K^+ n$               | $< 5.6$ | $\times 10^{-5}$ | CL = 90% | —    |
| $\bar{\Theta}(1540) K_S^0 p \rightarrow K_S^0 p K^- \bar{n}$             | $< 1.1$ | $\times 10^{-5}$ | CL = 90% | —    |
| $\Sigma^0 \bar{\Lambda}$                                                 | $< 9$   | $\times 10^{-5}$ | CL = 90% | 1032 |
| $\phi\pi^0$                                                              | $< 6.4$ | $\times 10^{-6}$ | CL = 90% | 1377 |

#### Decays into stable hadrons

|                                                  |                                       |           |  |      |
|--------------------------------------------------|---------------------------------------|-----------|--|------|
| $2(\pi^+\pi^-)\pi^0$                             | $(3.37 \pm 0.26) \%$                  |           |  | 1496 |
| $3(\pi^+\pi^-)\pi^0$                             | $(2.9 \pm 0.6) \%$                    |           |  | 1433 |
| $\pi^+\pi^-\pi^0$                                | $(2.02 \pm 0.14) \%$                  | $S = 1.7$ |  | 1533 |
| $\pi^+\pi^-\pi^0 K^+ K^-$                        | $(1.20 \pm 0.30) \%$                  |           |  | 1368 |
| $4(\pi^+\pi^-)\pi^0$                             | $(9.0 \pm 3.0) \times 10^{-3}$        |           |  | 1345 |
| $\pi^+\pi^- K^+ K^-$                             | $(6.2 \pm 0.7) \times 10^{-3}$        |           |  | 1407 |
| $K \bar{K} \pi$                                  | $(6.1 \pm 1.0) \times 10^{-3}$        |           |  | 1442 |
| $p \bar{p} \pi^+ \pi^-$                          | $(6.0 \pm 0.5) \times 10^{-3}$        | $S = 1.3$ |  | 1107 |
| $2(\pi^+\pi^-)$                                  | $(3.55 \pm 0.23) \times 10^{-3}$      |           |  | 1517 |
| $3(\pi^+\pi^-)$                                  | $(4.3 \pm 0.4) \times 10^{-3}$        |           |  | 1466 |
| $2(\pi^+\pi^-\pi^0)$                             | $(1.62 \pm 0.21) \%$                  |           |  | 1468 |
| $2(\pi^+\pi^-)\eta$                              | $(2.26 \pm 0.28) \times 10^{-3}$      |           |  | 1446 |
| $3(\pi^+\pi^-)\eta$                              | $(7.2 \pm 1.5) \times 10^{-4}$        |           |  | 1379 |
| $\eta\pi\pi^+\pi^-$                              | $(4 \pm 4) \times 10^{-3}$            |           |  | 1106 |
| $\Sigma^0 \bar{\Sigma}^0$                        | $(1.31 \pm 0.10) \times 10^{-3}$      |           |  | 988  |
| $2(\pi^+\pi^-) K^+ K^-$                          | $(4.7 \pm 0.7) \times 10^{-3}$        | $S = 1.3$ |  | 1320 |
| $p \bar{p} \pi^+ \pi^- \pi^0$                    | $(2.3 \pm 0.9) \times 10^{-3}$        | $S = 1.9$ |  | 1033 |
| $p \bar{p}$                                      | $(2.17 \pm 0.08) \times 10^{-3}$      |           |  | 1232 |
| $p \bar{p} \eta$                                 | $(2.09 \pm 0.18) \times 10^{-3}$      |           |  | 949  |
| $p \bar{n} \pi^-$                                | $(2.00 \pm 0.10) \times 10^{-3}$      |           |  | 1174 |
| $\eta\pi$                                        | $(2.2 \pm 0.4) \times 10^{-3}$        |           |  | 1231 |
| $\Xi \Xi$                                        | $(1.8 \pm 0.4) \times 10^{-3}$        | $S = 1.8$ |  | 818  |
| $\Lambda \bar{\Lambda}$                          | $(1.54 \pm 0.19) \times 10^{-3}$      | $S = 2.2$ |  | 1074 |
| $p \bar{p} \pi^0$                                | $(1.09 \pm 0.09) \times 10^{-3}$      |           |  | 1176 |
| $\Lambda \bar{\Sigma}^- \pi^+ \text{ (or c.c.)}$ | [gg] $(1.06 \pm 0.12) \times 10^{-3}$ |           |  | 950  |
| $p K^- \bar{\Lambda}$                            | $(8.9 \pm 1.6) \times 10^{-4}$        |           |  | 876  |
| $2(K^+ K^-)$                                     | $(7.8 \pm 1.4) \times 10^{-4}$        |           |  | 1131 |
| $p K^- \bar{\Sigma}^0$                           | $(2.9 \pm 0.8) \times 10^{-4}$        |           |  | 819  |
| $K^+ K^-$                                        | $(2.37 \pm 0.31) \times 10^{-4}$      |           |  | 1468 |
| $K_S^0 K_L^0$                                    | $(1.46 \pm 0.26) \times 10^{-4}$      | $S = 2.7$ |  | 1466 |
| $\Lambda \bar{\Lambda} \pi^0$                    | $(2.2 \pm 0.6) \times 10^{-4}$        |           |  | 998  |
| $\pi^+ \pi^-$                                    | $(1.47 \pm 0.23) \times 10^{-4}$      |           |  | 1542 |
| $\Lambda \bar{\Sigma}^+ \text{ c.c.}$            | $< 1.5 \times 10^{-4}$                | CL = 90%  |  | 1034 |
| $K_S^0 K_S^0$                                    | $< 1 \times 10^{-6}$                  | CL = 95%  |  | 1466 |

#### Radiative decays

|                                                               |                                      |           |  |      |
|---------------------------------------------------------------|--------------------------------------|-----------|--|------|
| $\gamma\eta_c(1S)$                                            | $(1.3 \pm 0.4) \%$                   |           |  | 114  |
| $\gamma\pi^+\pi^- 2\pi^0$                                     | $(8.3 \pm 3.1) \times 10^{-3}$       |           |  | 1518 |
| $\gamma\eta\pi\pi$                                            | $(6.1 \pm 1.0) \times 10^{-3}$       |           |  | 1488 |
| $\gamma\eta(1405/1475) \rightarrow \gamma K \bar{K} \pi$      | [p] $(2.8 \pm 0.6) \times 10^{-3}$   | $S = 1.6$ |  | 1223 |
| $\gamma\eta(1405/1475) \rightarrow \gamma\gamma\rho^0$        | $(7.8 \pm 2.0) \times 10^{-6}$       | $S = 1.8$ |  | 1223 |
| $\gamma\eta(1405/1475) \rightarrow \gamma\eta\pi^+\pi^-$      | $(3.0 \pm 0.5) \times 10^{-4}$       |           |  | —    |
| $\gamma\eta(1405/1475) \rightarrow \gamma\gamma\phi$          | $< 8.2 \times 10^{-5}$               | CL = 95%  |  | —    |
| $\gamma\rho\rho$                                              | $(4.5 \pm 0.8) \times 10^{-3}$       |           |  | 1340 |
| $\gamma\eta_2(1870) \rightarrow \gamma\pi^+\pi^-$             | $(6.2 \pm 2.4) \times 10^{-4}$       |           |  | —    |
| $\gamma\eta'(958)$                                            | $(4.71 \pm 0.27) \times 10^{-3}$     | $S = 1.1$ |  | 1400 |
| $\gamma 2\pi^+ 2\pi^-$                                        | $(2.8 \pm 0.5) \times 10^{-3}$       | $S = 1.9$ |  | 1517 |
| $\gamma f_2(1270) f_2(1270)$                                  | $(9.5 \pm 1.7) \times 10^{-4}$       |           |  | 878  |
| $\gamma f_2(1270) f_2(1270)$<br>(non resonant)                | $(8.2 \pm 1.9) \times 10^{-4}$       |           |  | —    |
| $\gamma K^+ K^- \pi^+ \pi^-$                                  | $(2.1 \pm 0.6) \times 10^{-3}$       |           |  | 1407 |
| $\gamma f_4(2050)$                                            | $(2.7 \pm 0.7) \times 10^{-3}$       |           |  | 886  |
| $\gamma\omega\omega$                                          | $(1.59 \pm 0.33) \times 10^{-3}$     |           |  | 1336 |
| $\gamma\eta(1405/1475) \rightarrow \gamma\rho^0\rho^0$        | $(1.7 \pm 0.4) \times 10^{-3}$       | $S = 1.3$ |  | 1223 |
| $\gamma f_2(1270)$                                            | $(1.38 \pm 0.14) \times 10^{-3}$     |           |  | 1286 |
| $\gamma f_0(1710) \rightarrow \gamma K \bar{K}$               | $(8.5^{+1.2}_{-0.9}) \times 10^{-4}$ | $S = 1.2$ |  | 1075 |
| $\gamma\eta$                                                  | $(9.8 \pm 1.0) \times 10^{-4}$       | $S = 1.7$ |  | 1500 |
| $\gamma f_1(1420) \rightarrow \gamma K \bar{K} \pi$           | $(7.9 \pm 1.3) \times 10^{-4}$       |           |  | 1220 |
| $\gamma f_1(1285)$                                            | $(6.1 \pm 0.8) \times 10^{-4}$       |           |  | 1283 |
| $\gamma f_1(1510) \rightarrow \gamma\eta\pi^+\pi^-$           | $(4.5 \pm 1.2) \times 10^{-4}$       |           |  | —    |
| $\gamma f_2'(1525)$                                           | $(4.5^{+0.7}_{-0.4}) \times 10^{-4}$ |           |  | 1173 |
| $\gamma f_2(1950) \rightarrow \gamma K^*(892) \bar{K}^*(892)$ | $(7.0 \pm 2.2) \times 10^{-4}$       |           |  | —    |
| $\gamma K^*(892) \bar{K}^*(892)$                              | $(4.0 \pm 1.3) \times 10^{-3}$       |           |  | 1266 |
| $\gamma\phi\phi$                                              | $(4.0 \pm 1.2) \times 10^{-4}$       | $S = 2.1$ |  | 1166 |

|                                                      |                                      |            |      |
|------------------------------------------------------|--------------------------------------|------------|------|
| $\gamma p \bar{p}$                                   | $(3.8 \pm 1.0) \times 10^{-4}$       |            | 1232 |
| $\gamma \eta(2225)$                                  | $(2.9 \pm 0.6) \times 10^{-4}$       |            | 752  |
| $\gamma \eta(1760) \rightarrow \gamma \rho^0 \rho^0$ | $(1.3 \pm 0.9) \times 10^{-4}$       |            | 1048 |
| $\gamma X(1835)$                                     | $(2.2 \pm 0.6) \times 10^{-4}$       |            | 1006 |
| $\gamma(K \bar{K} \pi)_{J^{PC}=0^{-+}}$              | $(7 \pm 4) \times 10^{-4}$           | S = 2.1    | 1442 |
| $\gamma \pi^0$                                       | $(3.3^{+0.6}_{-0.4}) \times 10^{-5}$ |            | 1546 |
| $\gamma p \bar{p} \pi^+ \pi^-$                       | $< 7.9 \times 10^{-4}$               | CL = 90%   | 1107 |
| $\gamma \gamma$                                      | $< 5 \times 10^{-4}$                 | CL = 90%   | 1548 |
| $\gamma \Lambda \bar{\Lambda}$                       | $< 1.3 \times 10^{-4}$               | CL = 90%   | 1074 |
| $3\gamma$                                            | $< 5.5 \times 10^{-5}$               | CL = 90%   | 1548 |
| $\gamma f_J(2220)$                                   | $> 2.50 \times 10^{-3}$              | CL = 99.9% | 745  |
| $\gamma f_J(2220) \rightarrow \gamma \pi \pi$        | $(8 \pm 4) \times 10^{-5}$           |            | —    |
| $\gamma f_J(2220) \rightarrow \gamma K \bar{K}$      | $(8.1 \pm 3.0) \times 10^{-5}$       |            | —    |
| $\gamma f_J(2220) \rightarrow \gamma p \bar{p}$      | $(1.5 \pm 0.8) \times 10^{-5}$       |            | —    |
| $\gamma f_0(1500)$                                   | $> (5.7 \pm 0.8) \times 10^{-4}$     |            | 1182 |
| $\gamma e^+ e^-$                                     | $(8.8 \pm 1.4) \times 10^{-3}$       |            | 1548 |

**Lepton Family number (LF) violating modes**

|                    |          |                  |          |      |
|--------------------|----------|------------------|----------|------|
| $e^\pm \mu^\mp$    | LF < 1.1 | $\times 10^{-6}$ | CL = 90% | 1547 |
| $e^\pm \tau^\mp$   | LF < 8.3 | $\times 10^{-6}$ | CL = 90% | 1039 |
| $\mu^\pm \tau^\mp$ | LF < 2.0 | $\times 10^{-6}$ | CL = 90% | 1035 |

| $\chi_{c0}(1P)$                                                               | $I^G(J^{PC}) = 0^+(0^{++})$             |                                   |                |      |
|-------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------|----------------|------|
| Mass $m = 3414.76 \pm 0.35$ MeV (S = 1.2)                                     |                                         |                                   |                |      |
| Full width $\Gamma = 10.4 \pm 0.7$ MeV                                        |                                         |                                   |                |      |
| $\chi_{c1}(1P)$ DECAY MODES                                                   | Fraction ( $\Gamma_i/\Gamma$ )          | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |      |
| <b>Hadronic decays</b>                                                        |                                         |                                   |                |      |
| $2(\pi^+\pi^-)$                                                               | $(2.41 \pm 0.23)\%$                     |                                   |                | 1679 |
| $f_0(980)f_0(980) \rightarrow 2\pi^+2\pi^-$                                   | $(7.1 \pm 2.3) \times 10^{-4}$          |                                   |                | —    |
| $\pi^+\pi^-K^+K^-$                                                            | $(2.0 \pm 0.4) \%$                      | S = 1.6                           |                | 1580 |
| $f_0(980)f_0(980) \rightarrow \pi^+\pi^-K^+K^-$                               | $(1.7^{+1.1}_{-1.0}) \times 10^{-4}$    |                                   |                | —    |
| $f_0(980)f_0(2200) \rightarrow \pi^+\pi^-K^+K^-$                              | $(8.4^{+2.2}_{-2.7}) \times 10^{-4}$    |                                   |                | —    |
| $f_0(1370)f_0(1370) \rightarrow \pi^+\pi^-K^+K^-$                             | $< 2.9 \times 10^{-4}$                  | CL = 90%                          |                | —    |
| $f_0(1370)f_0(1500) \rightarrow \pi^+\pi^-K^+K^-$                             | $< 1.8 \times 10^{-4}$                  | CL = 90%                          |                | —    |
| $f_0(1370)f_0(1710) \rightarrow \pi^+\pi^-K^+K^-$                             | $(7.1^{+3.8}_{-2.5}) \times 10^{-4}$    |                                   |                | —    |
| $f_0(1500)f_0(1370) \rightarrow \pi^+\pi^-K^+K^-$                             | $< 1.4 \times 10^{-4}$                  | CL = 90%                          |                | —    |
| $f_0(1500)f_0(1500) \rightarrow \pi^+\pi^-K^+K^-$                             | $< 6 \times 10^{-5}$                    | CL = 90%                          |                | —    |
| $f_0(1500)f_0(1710) \rightarrow \pi^+\pi^-K^+K^-$                             | $< 7 \times 10^{-5}$                    | CL = 90%                          |                | —    |
| $\rho^0\pi^+\pi^-$                                                            | $(1.6 \pm 0.5) \%$                      |                                   |                | 1607 |
| $3(\pi^+\pi^-)$                                                               | $(1.19 \pm 0.18)\%$                     |                                   |                | 1633 |
| $K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$                                      | $(1.2 \pm 0.4) \%$                      |                                   |                | 1523 |
| $K_1(1270)^+K^- + \text{c.c.} \rightarrow \pi^+\pi^-K^+K^-$                   | $(6.7 \pm 2.0) \times 10^{-3}$          |                                   |                | —    |
| $K_1(1400)^+K^- + \text{c.c.} \rightarrow \pi^+\pi^-K^+K^-$                   | $< 2.9 \times 10^{-3}$                  | CL = 90%                          |                | —    |
| $K^*(892)^0\bar{K}^*(892)^0$                                                  | $(1.8 \pm 0.6) \times 10^{-3}$          |                                   |                | 1456 |
| $K_0^*(1430)^0\bar{K}_0^*(1430)^0 \rightarrow \pi^+\pi^-K^+K^-$               | $(1.05^{+0.39}_{-0.30}) \times 10^{-3}$ |                                   |                | —    |
| $K_0^*(1430)^0\bar{K}_2^*(1430)^0 + \text{c.c.} \rightarrow \pi^+\pi^-K^+K^-$ | $(8.5^{+2.1}_{-2.6}) \times 10^{-4}$    |                                   |                | —    |
| $K^+K^-$                                                                      | $(5.4 \pm 0.6) \times 10^{-3}$          |                                   |                | 1634 |
| $\pi\pi$                                                                      | $(7.2 \pm 0.6) \times 10^{-3}$          |                                   |                | 1702 |
| $\eta\eta$                                                                    | $(1.9 \pm 0.5) \times 10^{-3}$          |                                   |                | 1617 |
| $\omega\omega$                                                                | $(2.3 \pm 0.7) \times 10^{-3}$          |                                   |                | 1517 |
| $K^+K^-K_S^0K_S^0$                                                            | $(1.5 \pm 0.5) \times 10^{-3}$          |                                   |                | 1331 |
| $K^+K^-K^+K^-$                                                                | $(2.1 \pm 0.4) \times 10^{-3}$          |                                   |                | 1333 |
| $K_S^0K_S^0$                                                                  | $(2.8 \pm 0.7) \times 10^{-3}$          | S = 1.9                           |                | 1633 |
| $K_S^0K_S^0\pi^+\pi^-$                                                        | $(6.1 \pm 1.1) \times 10^{-3}$          |                                   |                | 1579 |
| $K_S^0K_S^0p\bar{p}$                                                          | $< 8.8 \times 10^{-4}$                  | CL = 90%                          |                | 884  |
| $\pi^+\pi^-p\bar{p}$                                                          | $(2.1 \pm 0.7) \times 10^{-3}$          | S = 1.4                           |                | 1320 |
| $\phi\phi$                                                                    | $(9 \pm 5) \times 10^{-4}$              |                                   |                | 1370 |
| $p\bar{p}$                                                                    | $(2.24 \pm 0.27) \times 10^{-4}$        |                                   |                | 1426 |
| $\Lambda\bar{\Lambda}$                                                        | $(4.4 \pm 1.5) \times 10^{-4}$          |                                   |                | 1292 |
| $\Lambda\bar{\Lambda}\pi^+\pi^-$                                              | $< 4.0 \times 10^{-3}$                  | CL = 90%                          |                | 1153 |
| $\Xi^-\bar{\Xi}^+$                                                            | $< 1.03 \times 10^{-3}$                 | CL = 90%                          |                | 1081 |
| $K_S^0K^+\pi^- + \text{c.c.}$                                                 | $< 7 \times 10^{-4}$                    | CL = 90%                          |                | 1610 |

|                         |                                  |      |  |
|-------------------------|----------------------------------|------|--|
| <b>Radiative decays</b> |                                  |      |  |
| $\gamma J/\psi(1S)$     | $(1.30 \pm 0.11) \%$             | 303  |  |
| $\gamma \gamma$         | $(2.76 \pm 0.33) \times 10^{-4}$ | 1707 |  |

| $\chi_{c1}(1P)$                               | $I^G(J^{PC}) = 0^+(1^{++})$    |                                   |                |  |
|-----------------------------------------------|--------------------------------|-----------------------------------|----------------|--|
| Mass $m = 3510.66 \pm 0.07$ MeV ( $S = 1.5$ ) |                                |                                   |                |  |
| Full width $\Gamma = 0.89 \pm 0.05$ MeV       |                                |                                   |                |  |
| $\chi_{c1}(1P)$ DECAY MODES                   | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |  |
| Hadronic decays                               |                                |                                   |                |  |
| $3(\pi^+\pi^-)$                               | $(5.8 \pm 1.4) \times 10^{-3}$ | $S = 1.2$                         | 1683           |  |
| $2(\pi^+\pi^-)$                               | $(7.6 \pm 2.6) \times 10^{-3}$ |                                   | 1728           |  |
| $\pi^+\pi^-K^+K^-$                            | $(4.5 \pm 1.0) \times 10^{-3}$ |                                   | 1632           |  |
| $\rho^0\pi^+\pi^-$                            | $(3.9 \pm 3.5) \times 10^{-3}$ |                                   | 1657           |  |
| $K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$      | $(3.2 \pm 2.1) \times 10^{-3}$ |                                   | 1577           |  |
| $K^*(892)^0\bar{K}^*(892)^0$                  | $(1.6 \pm 0.4) \times 10^{-3}$ |                                   | 1512           |  |
| $K_S^0K^+\pi^- + \text{c.c.}$                 | $(2.3 \pm 0.7) \times 10^{-3}$ |                                   | 1661           |  |
| $\pi^+\pi^-K_S^0K_S^0$                        | $(7.7 \pm 3.3) \times 10^{-4}$ |                                   | 1630           |  |
| $\pi^+\pi^-p\bar{p}$                          | $(4.9 \pm 1.9) \times 10^{-4}$ |                                   | 1381           |  |
| $K^+K^-K^+K^-$                                | $(3.9 \pm 1.7) \times 10^{-4}$ |                                   | 1393           |  |
| $p\bar{p}$                                    | $(6.7 \pm 0.5) \times 10^{-5}$ |                                   | 1484           |  |
| $\Lambda\bar{\Lambda}$                        | $(2.4 \pm 1.0) \times 10^{-4}$ |                                   | 1355           |  |
| $\Lambda\bar{\Lambda}\pi^+\pi^-$              | $< 1.5 \times 10^{-3}$         | CL = 90%                          | 1223           |  |
| $K_S^0K_S^0p\bar{p}$                          | $< 4.5 \times 10^{-4}$         | CL = 90%                          | 968            |  |
| $\Xi^-\bar{\Xi}^+$                            | $< 3.4 \times 10^{-4}$         | CL = 90%                          | 1156           |  |
| $\pi^+\pi^- + K^+K^-$                         | $< 2.1 \times 10^{-3}$         |                                   | —              |  |
| $K_S^0K_S^0$                                  | $< 7 \times 10^{-5}$           | CL = 90%                          | 1683           |  |
| Radiative decays                              |                                |                                   |                |  |
| $\gamma J/\psi(1S)$                           | $(35.6 \pm 1.9) \%$            |                                   | 389            |  |

| $\chi_{c2}(1P)$                          | $I^G(J^{PC}) = 0^+(2^{++})$      |                                   |                |  |
|------------------------------------------|----------------------------------|-----------------------------------|----------------|--|
| Mass $m = 3556.20 \pm 0.09$ MeV          |                                  |                                   |                |  |
| Full width $\Gamma = 2.06 \pm 0.12$ MeV  |                                  |                                   |                |  |
| $\chi_{c2}(1P)$ DECAY MODES              | Fraction ( $\Gamma_i/\Gamma$ )   | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |  |
| Hadronic decays                          |                                  |                                   |                |  |
| $2(\pi^+\pi^-)$                          | $(1.23 \pm 0.15)\%$              |                                   | 1751           |  |
| $\pi^+\pi^-K^+K^-$                       | $(9.9 \pm 2.5) \times 10^{-3}$   | S = 1.6                           | 1656           |  |
| $3(\pi^+\pi^-)$                          | $(8.6 \pm 1.8) \times 10^{-3}$   |                                   | 1707           |  |
| $\rho^0\pi^+\pi^-$                       | $(7 \pm 4) \times 10^{-3}$       |                                   | 1681           |  |
| $K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$ | $(4.8 \pm 2.8) \times 10^{-3}$   |                                   | 1602           |  |
| $K^*(892)^0\bar{K}^*(892)^0$             | $(3.8 \pm 0.8) \times 10^{-3}$   |                                   | 1538           |  |
| $\phi\phi$                               | $(1.9 \pm 0.7) \times 10^{-3}$   |                                   | 1457           |  |
| $\omega\omega$                           | $(2.0 \pm 0.7) \times 10^{-3}$   |                                   | 1597           |  |
| $\pi\pi$                                 | $(2.14 \pm 0.25) \times 10^{-3}$ |                                   | 1773           |  |
| $\eta\eta$                               | $< 1.2 \times 10^{-3}$           | CL = 90%                          | 1692           |  |
| $\pi^+\pi^-K_S^0K_S^0$                   | $(2.6 \pm 0.6) \times 10^{-3}$   |                                   | 1655           |  |
| $K^+K^-K^+K^-$                           | $(1.41 \pm 0.35) \times 10^{-3}$ |                                   | 1421           |  |
| $\pi^+\pi^-p\bar{p}$                     | $(1.32 \pm 0.34) \times 10^{-3}$ |                                   | 1410           |  |
| $K^+K^-$                                 | $(7.7 \pm 1.4) \times 10^{-4}$   |                                   | 1708           |  |
| $K_S^0K_S^0$                             | $(6.7 \pm 1.1) \times 10^{-4}$   |                                   | 1707           |  |
| $K_S^0K_S^0p\bar{p}$                     | $< 7.9 \times 10^{-4}$           | CL = 90%                          | 1007           |  |
| $p\bar{p}$                               | $(6.6 \pm 0.5) \times 10^{-5}$   |                                   | 1510           |  |
| $\Lambda\bar{\Lambda}$                   | $(2.7 \pm 1.3) \times 10^{-4}$   |                                   | 1385           |  |
| $\Lambda\bar{\Lambda}\pi^+\pi^-$         | $< 3.5 \times 10^{-3}$           | CL = 90%                          | 1255           |  |
| $J/\psi(1S)\pi^+\pi^-\pi^0$              | $< 1.5 \%$                       | CL = 90%                          | 185            |  |
| $K_S^0K^+\pi^- + \text{c.c.}$            | $< 1.0 \times 10^{-3}$           | CL = 90%                          | 1685           |  |
| $\Xi^-\bar{\Xi}^+$                       | $< 3.7 \times 10^{-4}$           | CL = 90%                          | 1190           |  |
| Radiative decays                         |                                  |                                   |                |  |
| $\gamma J/\psi(1S)$                      | $(20.2 \pm 1.0) \%$              |                                   | 430            |  |
| $\gamma\gamma$                           | $(2.59 \pm 0.19) \times 10^{-4}$ |                                   | 1778           |  |



$\eta_c(2S)$ 

$$I^G(J^{PC}) = 0^+(0^{-+})$$

Quantum numbers are quark model predictions.

Mass  $m = 3638 \pm 4$  MeV ( $S = 1.8$ )

Full width  $\Gamma = 14 \pm 7$  MeV

| $\eta_c(2S)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|--------------------------|--------------------------------|-------------|
| $K\bar{K}\pi$            | seen                           | 1729        |
| $\gamma\gamma$           | seen                           | 1819        |

 $\psi(2S)$ 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 3686.093 \pm 0.034$  MeV ( $S = 1.4$ )

Full width  $\Gamma = 337 \pm 13$  keV

$\Gamma_{ee} = 2.48 \pm 0.06$  keV

| $\psi(2S)$ DECAY MODES                       | Fraction ( $\Gamma_i/\Gamma$ )   | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|----------------------------------------------|----------------------------------|-----------------------------------|----------------|
| hadrons                                      | $(97.85 \pm 0.13)\%$             |                                   | —              |
| virtually $\gamma \rightarrow$ hadrons       | $(1.73 \pm 0.14)\%$              | $S = 1.5$                         | —              |
| $e^+e^-$                                     | $(7.35 \pm 0.18) \times 10^{-3}$ |                                   | 1843           |
| $\mu^+\mu^-$                                 | $(7.3 \pm 0.8) \times 10^{-3}$   |                                   | 1840           |
| $\tau^+\tau^-$                               | $(2.8 \pm 0.7) \times 10^{-3}$   |                                   | 489            |
| Decays into $J/\psi(1S)$ and anything        |                                  |                                   |                |
| $J/\psi(1S)$ anything                        | $(56.1 \pm 0.9)\%$               |                                   | —              |
| $J/\psi(1S)$ neutrals                        | $(23.0 \pm 0.4)\%$               |                                   | —              |
| $J/\psi(1S)\pi^+\pi^-$                       | $(31.8 \pm 0.6)\%$               |                                   | 477            |
| $J/\psi(1S)\pi^0\pi^0$                       | $(16.46 \pm 0.35)\%$             |                                   | 481            |
| $J/\psi(1S)\eta$                             | $(3.09 \pm 0.08)\%$              |                                   | 200            |
| $J/\psi(1S)\pi^0$                            | $(1.26 \pm 0.13) \times 10^{-3}$ | $S = 1.3$                         | 528            |
| Hadronic decays                              |                                  |                                   |                |
| $3(\pi^+\pi^-)\pi^0$                         | $(3.5 \pm 1.6) \times 10^{-3}$   |                                   | 1746           |
| $2(\pi^+\pi^-)\pi^0$                         | $(2.66 \pm 0.29) \times 10^{-3}$ |                                   | 1799           |
| $\rho\omega_2(1320)$                         | $(2.6 \pm 0.9) \times 10^{-4}$   |                                   | 1500           |
| $p\bar{p}$                                   | $(2.65 \pm 0.22) \times 10^{-4}$ | $S = 1.4$                         | 1586           |
| $\Delta^{++}\bar{\Delta}^{--}$               | $(1.28 \pm 0.35) \times 10^{-4}$ |                                   | 1371           |
| $\Lambda\bar{\Lambda}$                       | $(2.5 \pm 0.7) \times 10^{-4}$   | $S = 3.1$                         | 1467           |
| $\Sigma^+\bar{\Sigma}^-$                     | $(2.6 \pm 0.8) \times 10^{-4}$   |                                   | 1408           |
| $\Sigma^0\bar{\Sigma}^0$                     | $(2.1 \pm 0.7) \times 10^{-4}$   | $S = 2.0$                         | 1405           |
| $\Sigma(1385)^+\bar{\Sigma}(1385)^-$         | $(1.1 \pm 0.4) \times 10^{-4}$   |                                   | 1218           |
| $\Xi^-\bar{\Xi}^+$                           | $(1.5 \pm 0.7) \times 10^{-4}$   | $S = 3.0$                         | 1285           |
| $\Xi^0\bar{\Xi}^0$                           | $(2.8 \pm 0.9) \times 10^{-4}$   |                                   | 1292           |
| $\Xi(1530)^0\bar{\Xi}(1530)^0$               | $< 8.1 \times 10^{-5}$           | $CL = 90\%$                       | 1025           |
| $\Omega^-\bar{\Omega}^+$                     | $< 7.3 \times 10^{-5}$           | $CL = 90\%$                       | 774            |
| $\pi^0 p\bar{p}$                             | $(1.33 \pm 0.17) \times 10^{-4}$ |                                   | 1543           |
| $\eta p\bar{p}$                              | $(6.0 \pm 1.2) \times 10^{-5}$   |                                   | 1373           |
| $\omega p\bar{p}$                            | $(6.9 \pm 2.1) \times 10^{-5}$   |                                   | 1247           |
| $\phi p\bar{p}$                              | $< 2.4 \times 10^{-5}$           | $CL = 90\%$                       | 1109           |
| $\pi^+\pi^-\pi^0 p\bar{p}$                   | $(6.0 \pm 0.4) \times 10^{-4}$   |                                   | 1491           |
| $2(\pi^+\pi^-\pi^0)$                         | $(4.5 \pm 1.4) \times 10^{-3}$   |                                   | 1776           |
| $\eta\pi^+\pi^-$                             | $< 1.6 \times 10^{-4}$           | $CL = 90\%$                       | 1791           |
| $\eta\pi^+\pi^-\pi^0$                        | $(9.5 \pm 1.7) \times 10^{-4}$   |                                   | 1778           |
| $\eta'\pi^+\pi^-\pi^0$                       | $(4.5 \pm 2.1) \times 10^{-4}$   |                                   | —              |
| $\omega\pi^+\pi^-$                           | $(6.6 \pm 1.7) \times 10^{-4}$   | $S = 2.7$                         | 1748           |
| $b_1^+\pi^-$                                 | $(3.6 \pm 0.6) \times 10^{-4}$   |                                   | 1635           |
| $b_1^0\pi^0$                                 | $(2.4 \pm 0.6) \times 10^{-4}$   |                                   | —              |
| $\omega f_2(1270)$                           | $(2.0 \pm 0.6) \times 10^{-4}$   |                                   | 1515           |
| $\pi^+\pi^-K^+K^-$                           | $(7.2 \pm 0.5) \times 10^{-4}$   |                                   | 1726           |
| $\rho^0 K^+K^-$                              | $(2.2 \pm 0.4) \times 10^{-4}$   |                                   | 1616           |
| $K^*(892)^0\bar{K}^*(1430)^0$                | $(1.9 \pm 0.5) \times 10^{-4}$   |                                   | 1418           |
| $K^+K^-2(\pi^+\pi^-)$                        | $(1.8 \pm 0.9) \times 10^{-3}$   |                                   | 1654           |
| $K_1(1270)^\pm K^\mp$                        | $(1.00 \pm 0.28) \times 10^{-3}$ |                                   | 1581           |
| $K_S^0 K_S^0 \pi^+\pi^-$                     | $(2.2 \pm 0.4) \times 10^{-4}$   |                                   | 1724           |
| $\rho^0 p\bar{p}$                            | $(5.0 \pm 2.2) \times 10^{-5}$   |                                   | 1251           |
| $K^+\bar{K}^*(892)^0\pi^- + c.c.$            | $(6.7 \pm 2.5) \times 10^{-4}$   |                                   | 1674           |
| $2(\pi^+\pi^-)$                              | $(2.4 \pm 0.6) \times 10^{-4}$   | $S = 2.2$                         | 1817           |
| $\rho^0\pi^+\pi^-$                           | $(2.2 \pm 0.6) \times 10^{-4}$   | $S = 1.4$                         | 1750           |
| $K^+K^-\pi^+\pi^-\pi^0$                      | $(1.24 \pm 0.10) \times 10^{-3}$ |                                   | 1694           |
| $\omega f_0(1710) \rightarrow \omega K^+K^-$ | $(5.9 \pm 2.2) \times 10^{-5}$   |                                   | —              |
| $K^*(892)^0 K^-\pi^+\pi^0 + c.c.$            | $(8.6 \pm 2.2) \times 10^{-4}$   |                                   | —              |
| $K^*(892)^+ K^-\pi^+\pi^- + c.c.$            | $(9.6 \pm 2.8) \times 10^{-4}$   |                                   | —              |
| $K^*(892)^+ K^-\rho^0 + c.c.$                | $(7.3 \pm 2.6) \times 10^{-4}$   |                                   | —              |
| $K^*(892)^0 K^-\rho^+ + c.c.$                | $(6.1 \pm 1.8) \times 10^{-4}$   |                                   | —              |
| $\eta K^+K^-$                                | $< 1.3 \times 10^{-4}$           | $CL = 90\%$                       | 1664           |

|                                                           |                                      |             |      |
|-----------------------------------------------------------|--------------------------------------|-------------|------|
| $\omega K^+K^-$                                           | $(1.85 \pm 0.25) \times 10^{-4}$     | $S = 1.1$   | 1614 |
| $3(\pi^+\pi^-)$                                           | $(3.5 \pm 2.0) \times 10^{-4}$       | $S = 2.8$   | 1774 |
| $p\bar{p}\pi^+\pi^-\pi^0$                                 | $(7.3 \pm 0.7) \times 10^{-4}$       |             | 1435 |
| $K^+K^-$                                                  | $(1.0 \pm 0.7) \times 10^{-4}$       |             | 1776 |
| $K_S^0 K_L^0$                                             | $(5.2 \pm 0.7) \times 10^{-5}$       |             | 1775 |
| $\pi^+\pi^-\pi^0$                                         | $(1.68 \pm 0.26) \times 10^{-4}$     | $S = 1.4$   | 1830 |
| $\rho(2150)\pi \rightarrow \pi^+\pi^-\pi^0$               | $(1.9^{+1.2}_{-0.4}) \times 10^{-4}$ |             | —    |
| $\rho(770)\pi \rightarrow \pi^+\pi^-\pi^0$                | $(3.2 \pm 1.2) \times 10^{-5}$       | $S = 1.8$   | —    |
| $\pi^+\pi^-$                                              | $(8 \pm 5) \times 10^{-5}$           |             | 1838 |
| $K_1(1400)^\pm K^\mp$                                     | $< 3.1 \times 10^{-4}$               | $CL = 90\%$ | 1532 |
| $K^+K^-\pi^0$                                             | $< 2.96 \times 10^{-5}$              | $CL = 90\%$ | 1754 |
| $K^+\bar{K}^*(892)^- + c.c.$                              | $(1.7^{+0.8}_{-0.7}) \times 10^{-5}$ |             | 1698 |
| $K^*(892)^0\bar{K}^0 + c.c.$                              | $(1.09 \pm 0.20) \times 10^{-4}$     |             | 1697 |
| $\phi\pi^+\pi^-$                                          | $(1.13 \pm 0.29) \times 10^{-4}$     | $S = 1.7$   | 1690 |
| $\phi f_0(980) \rightarrow \pi^+\pi^-$                    | $(6.0 \pm 2.2) \times 10^{-5}$       |             | —    |
| $2(K^+K^-)$                                               | $(6.0 \pm 1.4) \times 10^{-5}$       |             | 1499 |
| $\phi K^+K^-$                                             | $(7.0 \pm 1.6) \times 10^{-5}$       |             | 1546 |
| $2(K^+K^-)\pi^0$                                          | $(1.10 \pm 0.28) \times 10^{-4}$     |             | 1440 |
| $\phi\eta$                                                | $(2.8^{+1.0}_{-0.8}) \times 10^{-5}$ |             | 1654 |
| $\phi\eta'$                                               | $(3.1 \pm 1.6) \times 10^{-5}$       |             | 1555 |
| $\omega\eta'$                                             | $(3.2^{+2.5}_{-2.1}) \times 10^{-5}$ |             | 1623 |
| $\omega\pi^0$                                             | $(2.1 \pm 0.6) \times 10^{-5}$       |             | 1757 |
| $\rho\eta'$                                               | $(1.9^{+1.7}_{-1.2}) \times 10^{-5}$ |             | 1625 |
| $\rho\eta$                                                | $(2.2 \pm 0.6) \times 10^{-5}$       | $S = 1.1$   | 1717 |
| $\omega\eta$                                              | $< 1.1 \times 10^{-5}$               | $CL = 90\%$ | 1715 |
| $\phi\pi^0$                                               | $< 4 \times 10^{-6}$                 | $CL = 90\%$ | 1699 |
| $p\bar{p}K^+K^-$                                          | $(2.7 \pm 0.7) \times 10^{-5}$       |             | 1118 |
| $\Lambda\bar{\Lambda}\pi^+\pi^-$                          | $(2.8 \pm 0.6) \times 10^{-4}$       |             | 1346 |
| $\Lambda\bar{p}K^+$                                       | $(1.00 \pm 0.14) \times 10^{-4}$     |             | 1327 |
| $\Lambda\bar{p}K^+\pi^+\pi^-$                             | $(1.8 \pm 0.4) \times 10^{-4}$       |             | 1167 |
| $\phi f_2'(1525)$                                         | $(4.4 \pm 1.6) \times 10^{-5}$       |             | 1321 |
| $\Theta(1540)\bar{\Theta}(1540)$                          | $< 8.8 \times 10^{-6}$               | $CL = 90\%$ | —    |
| $K_S^0 pK^-\bar{n} + c.c.$                                |                                      |             |      |
| $\Theta(1540)K^-\bar{n} \rightarrow K_S^0 pK^-\bar{n}$    | $< 1.0 \times 10^{-5}$               | $CL = 90\%$ | —    |
| $\Theta(1540)K_S^0\bar{p} \rightarrow K_S^0\bar{p}K^+n$   | $< 7.0 \times 10^{-6}$               | $CL = 90\%$ | —    |
| $\bar{\Theta}(1540)K^+n \rightarrow K_S^0\bar{p}K^+n$     | $< 2.6 \times 10^{-5}$               | $CL = 90\%$ | —    |
| $\bar{\Theta}(1540)K_S^0 p \rightarrow K_S^0 pK^-\bar{n}$ | $< 6.0 \times 10^{-6}$               | $CL = 90\%$ | —    |
| $K_S^0 K_S^0$                                             | $< 4.6 \times 10^{-6}$               |             | 1775 |

## Radiative decays

|                                                   |                                |                  |
|---------------------------------------------------|--------------------------------|------------------|
| $\gamma X_{c0}(1P)$                               | $(9.2 \pm 0.4)\%$              | 261              |
| $\gamma X_{c1}(1P)$                               | $(8.7 \pm 0.4)\%$              | 171              |
| $\gamma X_{c2}(1P)$                               | $(8.1 \pm 0.4)\%$              | 128              |
| $\gamma\eta_c(1S)$                                | $(2.6 \pm 0.4) \times 10^{-3}$ | 638              |
| $\gamma\eta_c(2S)$                                | $< 2.0 \times 10^{-3}$         | $CL = 90\%$ 47   |
| $\gamma\eta'(958)$                                | $(1.5 \pm 0.4) \times 10^{-4}$ | 1719             |
| $\gamma f_2(1270)$                                | $(2.1 \pm 0.4) \times 10^{-4}$ | 1622             |
| $\gamma f_0(1710) \rightarrow \gamma\pi\pi$       | $(3.0 \pm 1.3) \times 10^{-5}$ | —                |
| $\gamma f_0(1710) \rightarrow \gamma K\bar{K}$    | $(6.0 \pm 1.6) \times 10^{-5}$ | —                |
| $\gamma\gamma$                                    | $< 1.3 \times 10^{-4}$         | $CL = 90\%$ 1843 |
| $\gamma\eta$                                      | $< 9 \times 10^{-5}$           | $CL = 90\%$ 1802 |
| $\gamma\eta(1405) \rightarrow \gamma K\bar{K}\pi$ | $< 1.2 \times 10^{-4}$         | $CL = 90\%$ 1569 |

 $\psi(3770)$ 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 3771.1 \pm 2.4$  MeV

Full width  $\Gamma = 23.0 \pm 2.7$  MeV ( $S = 1.1$ )

$\Gamma_{ee} = 0.242^{+0.027}_{-0.024}$  keV ( $S = 1.1$ )

In addition to the dominant decay mode to  $D\bar{D}$ ,  $\psi(3770)$  was found to decay into the final states containing the  $J/\psi$  (BAI 05, ADAM 06). ADAMS 06 and HUANG 06A searched for various decay modes with light hadrons and found a statistically significant signal for the decay to  $\phi\eta$  only (ADAMS 06).

| $\psi(3770)$ DECAY MODES         | Fraction ( $\Gamma_i/\Gamma$ )   | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|----------------------------------|----------------------------------|-----------------------------------|----------------|
| $D\bar{D}$                       | dominant                         |                                   | 281            |
| $D^0\bar{D}^0$                   | seen                             |                                   | 281            |
| $D^+D^-$                         | seen                             |                                   | 247            |
| $J/\psi\pi^+\pi^-$               | $(1.93 \pm 0.28) \times 10^{-3}$ |                                   | 558            |
| $J/\psi\pi^0\pi^0$               | $(8.0 \pm 3.0) \times 10^{-4}$   |                                   | 562            |
| $J/\psi\eta$                     | $(9 \pm 4) \times 10^{-4}$       |                                   | 357            |
| $J/\psi\pi^0$                    | $< 2.8 \times 10^{-4}$           | CL = 90%                          | 601            |
| $e^+e^-$                         | $(1.05 \pm 0.14) \times 10^{-5}$ | S = 1.1                           | 1886           |
| $K_S^0 K_L^0$                    | $< 2.1 \times 10^{-4}$           | CL = 90%                          | 1819           |
| $2(\pi^+\pi^-)$                  | $< 1.12 \times 10^{-3}$          | CL = 90%                          | 1860           |
| $2(\pi^+\pi^-)\pi^0$             | $< 1.06 \times 10^{-3}$          | CL = 90%                          | 1842           |
| $\eta\pi^+\pi^-$                 | $< 1.24 \times 10^{-3}$          | CL = 90%                          | 1835           |
| $\omega\pi^+\pi^-$               | $< 6.0 \times 10^{-4}$           | CL = 90%                          | 1793           |
| $\eta 3\pi$                      | $< 1.34 \times 10^{-3}$          | CL = 90%                          | 1823           |
| $\eta' 3\pi$                     | $< 2.44 \times 10^{-3}$          | CL = 90%                          | 1739           |
| $K^+K^-\pi^+\pi^-$               | $< 9.0 \times 10^{-4}$           | CL = 90%                          | 1771           |
| $\phi\pi^+\pi^-$                 | $< 4.1 \times 10^{-4}$           | CL = 90%                          | 1736           |
| $\phi f_0(980)$                  | $< 4.5 \times 10^{-4}$           | CL = 90%                          | 1599           |
| $K^+K^-\pi^+\pi^-\pi^0$          | $< 2.36 \times 10^{-3}$          | CL = 90%                          | 1740           |
| $\eta K^+K^-$                    | $< 4.1 \times 10^{-4}$           | CL = 90%                          | 1711           |
| $\omega K^+K^-$                  | $< 3.4 \times 10^{-4}$           | CL = 90%                          | 1663           |
| $2(K^+K^-)$                      | $< 6.0 \times 10^{-4}$           | CL = 90%                          | 1550           |
| $\phi K^+K^-$                    | $< 7.5 \times 10^{-4}$           | CL = 90%                          | 1596           |
| $2(K^+K^-)\pi^0$                 | $< 2.9 \times 10^{-4}$           | CL = 90%                          | 1492           |
| $p\bar{p}\pi^+\pi^-$             | $< 5.8 \times 10^{-4}$           | CL = 90%                          | 1543           |
| $p\bar{p}\pi^+\pi^-\pi^0$        | $< 1.85 \times 10^{-3}$          | CL = 90%                          | 1489           |
| $\eta p\bar{p}$                  | $< 5.4 \times 10^{-4}$           | CL = 90%                          | 1429           |
| $\omega p\bar{p}$                | $< 2.9 \times 10^{-4}$           | CL = 90%                          | 1308           |
| $p\bar{p}K^+K^-$                 | $< 3.2 \times 10^{-4}$           | CL = 90%                          | 1184           |
| $\phi p\bar{p}$                  | $< 1.3 \times 10^{-4}$           | CL = 90%                          | 1176           |
| $\Lambda\bar{\Lambda}$           | $< 1.2 \times 10^{-4}$           | CL = 90%                          | 1520           |
| $\Lambda\bar{\Lambda}\pi^+\pi^-$ | $< 2.5 \times 10^{-4}$           | CL = 90%                          | 1403           |
| $\Lambda\bar{p}K^+$              | $< 2.8 \times 10^{-4}$           | CL = 90%                          | 1385           |
| $\Lambda\bar{p}K^+\pi^+\pi^-$    | $< 6.3 \times 10^{-4}$           | CL = 90%                          | 1232           |
| $\phi\eta$                       | $(3.1 \pm 0.7) \times 10^{-4}$   |                                   | 1702           |
| $\pi^+\pi^-\pi^0$                | not seen                         |                                   | 1873           |
| $\rho\pi$                        | not seen                         |                                   | 1803           |
| $\omega\pi^0$                    | not seen                         |                                   | 1802           |
| $\phi\pi^0$                      | not seen                         |                                   | 1745           |
| $\rho\eta$                       | not seen                         |                                   | 1762           |
| $\omega\eta$                     | not seen                         |                                   | 1761           |
| $\rho\eta'$                      | not seen                         |                                   | 1673           |
| $\omega\eta'$                    | not seen                         |                                   | 1671           |
| $\phi\eta'$                      | not seen                         |                                   | 1605           |
| $K^{*0}\bar{K}^0$                | not seen                         |                                   | 1743           |
| $K^{*+}K^-$                      | not seen                         |                                   | 1744           |
| $b_1\pi$                         | not seen                         |                                   | 1682           |

### $X(3872)$ $I^G(J^{PC}) = 0^2(\chi^2+)$

Quantum numbers not established.

Mass  $m = 3871.2 \pm 0.5$  MeV (S = 1.4)

$m_{X(3872)^\pm} - m_{J/\psi} = 775 \pm 4$  MeV

$m_{X(3872)^\pm} - m_{\psi(2S)}$

Full width  $\Gamma < 2.3$  MeV, CL = 90%

| $X(3872)$ DECAY MODES   | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\pi^+\pi^- J/\psi(1S)$ | seen                           | 649         |
| $D^0\bar{D}^0$          | not seen                       | 520         |
| $D^+D^-$                | not seen                       | 502         |
| $D^0\bar{D}^0\pi^0$     | not seen                       | 117         |

### $\chi_{c2}(2P)$ $I^G(J^{PC}) = 0^+(2^{2++})$

Mass  $m = 3929 \pm 5$  MeV

Full width  $\Gamma = 29 \pm 10$  MeV

### $\psi(4040)^{[xxx]}$ $I^G(J^{PC}) = 0^-(1^{--})$

Mass  $m = 4039 \pm 1$  MeV

Full width  $\Gamma = 80 \pm 10$  MeV

$\Gamma_{ee} = 0.86 \pm 0.07$  keV

| $\psi(4040)$ DECAY MODES       | Fraction ( $\Gamma_i/\Gamma$ )   | Confidence level | $p$<br>(MeV/c) |
|--------------------------------|----------------------------------|------------------|----------------|
| $e^+e^-$                       | $(1.07 \pm 0.16) \times 10^{-5}$ |                  | 2019           |
| $D^0\bar{D}^0$                 | seen                             |                  | 776            |
| $D^*(2007)^0\bar{D}^0 + c.c.$  | seen                             |                  | 576            |
| $D^*(2007)^0\bar{D}^*(2007)^0$ | seen                             |                  | 227            |
| $J/\psi\pi^+\pi^-$             | $< 4 \times 10^{-3}$             | 90%              | 794            |
| $J/\psi\pi^0\pi^0$             | $< 2 \times 10^{-3}$             | 90%              | 797            |
| $J/\psi\eta$                   | $< 7 \times 10^{-3}$             | 90%              | 675            |
| $J/\psi\pi^0$                  | $< 2 \times 10^{-3}$             | 90%              | 823            |
| $J/\psi\pi^+\pi^-\pi^0$        | $< 2 \times 10^{-3}$             | 90%              | 746            |
| $\chi_{c1}\gamma$              | $< 1.1$ %                        | 90%              | 494            |
| $\chi_{c2}\gamma$              | $< 1.7$ %                        | 90%              | 454            |
| $\chi_{c1}\pi^+\pi^-\pi^0$     | $< 1.1$ %                        | 90%              | 306            |
| $\chi_{c2}\pi^+\pi^-\pi^0$     | $< 3.2$ %                        | 90%              | 233            |
| $\phi\pi^+\pi^-$               | $< 3 \times 10^{-3}$             | 90%              | 1880           |

### $\psi(4160)^{[xxx]}$ $I^G(J^{PC}) = 0^-(1^{--})$

Mass  $m = 4153 \pm 3$  MeV

Full width  $\Gamma = 103 \pm 8$  MeV

$\Gamma_{ee} = 0.83 \pm 0.07$  keV

| $\psi(4160)$ DECAY MODES   | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$<br>(MeV/c) |
|----------------------------|--------------------------------|------------------|----------------|
| $e^+e^-$                   | $(8.1 \pm 0.9) \times 10^{-6}$ |                  | 2076           |
| $J/\psi\pi^+\pi^-$         | $< 3 \times 10^{-3}$           | 90%              | 888            |
| $J/\psi\pi^0\pi^0$         | $< 3 \times 10^{-3}$           | 90%              | 891            |
| $J/\psi K^+K^-$            | $< 2 \times 10^{-3}$           | 90%              | 324            |
| $J/\psi\eta$               | $< 8 \times 10^{-3}$           | 90%              | 786            |
| $J/\psi\pi^0$              | $< 1 \times 10^{-3}$           | 90%              | 914            |
| $J/\psi\eta'$              | $< 5 \times 10^{-3}$           | 90%              | 385            |
| $J/\psi\pi^+\pi^-\pi^0$    | $< 1 \times 10^{-3}$           | 90%              | 847            |
| $\psi(2S)\pi^+\pi^-$       | $< 4 \times 10^{-3}$           | 90%              | 353            |
| $\chi_{c1}\gamma$          | $< 7 \times 10^{-3}$           | 90%              | 593            |
| $\chi_{c2}\gamma$          | $< 1.3$ %                      | 90%              | 554            |
| $\chi_{c1}\pi^+\pi^-\pi^0$ | $< 2 \times 10^{-3}$           | 90%              | 452            |
| $\chi_{c2}\pi^+\pi^-\pi^0$ | $< 8 \times 10^{-3}$           | 90%              | 398            |
| $\phi\pi^+\pi^-$           | $< 2 \times 10^{-3}$           | 90%              | 1941           |

### $\psi(4415)^{[xxx]}$ $I^G(J^{PC}) = 0^-(1^{--})$

Mass  $m = 4421 \pm 4$  MeV

Full width  $\Gamma = 62 \pm 20$  MeV

$\Gamma_{ee} = 0.58 \pm 0.07$  keV

| $\psi(4415)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|--------------------------|--------------------------------|-------------|
| hadrons                  | dominant                       | —           |
| $e^+e^-$                 | $(9.4 \pm 3.2) \times 10^{-6}$ | 2210        |

**$b\bar{b}$  MESONS** **$\Upsilon(1S)$** 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 9460.30 \pm 0.26$  MeV ( $S = 3.3$ )Full width  $\Gamma = 54.02 \pm 1.25$  keV $\Gamma_{ee} = 1.340 \pm 0.018$  keV

| $\Upsilon(1S)$ DECAY MODES                              | Fraction ( $\Gamma_i/\Gamma$ )       | Confidence level | $p$ (MeV/c) |
|---------------------------------------------------------|--------------------------------------|------------------|-------------|
| $\tau^+\tau^-$                                          | $(2.67^{+0.14}_{-0.16})\%$           |                  | 4384        |
| $e^+e^-$                                                | $(2.38 \pm 0.11)\%$                  |                  | 4730        |
| $\mu^+\mu^-$                                            | $(2.48 \pm 0.05)\%$                  |                  | 4729        |
| <b>Hadronic decays</b>                                  |                                      |                  |             |
| $\eta'(958)$ anything                                   | $(2.8 \pm 0.4)\%$                    |                  | —           |
| $J/\psi(1S)$ anything                                   | $(6.5 \pm 0.7) \times 10^{-4}$       | 90%              | 4223        |
| $\chi_{c0}$ anything                                    | $< 5 \times 10^{-3}$                 |                  | —           |
| $\chi_{c1}$ anything                                    | $(2.3 \pm 0.7) \times 10^{-4}$       |                  | —           |
| $\chi_{c2}$ anything                                    | $(3.4 \pm 1.0) \times 10^{-4}$       |                  | —           |
| $\psi(2S)$ anything                                     | $(2.7 \pm 0.9) \times 10^{-4}$       |                  | —           |
| $\rho\pi$                                               | $< 2 \times 10^{-4}$                 | 90%              | 4697        |
| $\pi^+\pi^-$                                            | $< 5 \times 10^{-4}$                 | 90%              | 4728        |
| $K^+K^-$                                                | $< 5 \times 10^{-4}$                 | 90%              | 4704        |
| $p\bar{p}$                                              | $< 5 \times 10^{-4}$                 | 90%              | 4636        |
| $\pi^0\pi^+\pi^-$                                       | $< 1.84 \times 10^{-5}$              | 90%              | 4725        |
| <b>Radiative decays</b>                                 |                                      |                  |             |
| $\gamma\pi^+\pi^-$                                      | $(6.3 \pm 1.8) \times 10^{-5}$       |                  | 4728        |
| $\gamma\pi^0\pi^0$                                      | $(1.7 \pm 0.7) \times 10^{-5}$       |                  | 4728        |
| $K^+K^-$ with $2 < m_{K^+K^-} < 3$ GeV                  | $(1.14 \pm 0.13) \times 10^{-5}$     |                  | —           |
| $\gamma p\bar{p}$ with $2 < m_{p\bar{p}} < 3$ GeV       | $< 6 \times 10^{-6}$                 | 90%              | —           |
| $\gamma 2h^+2h^-$                                       | $(7.0 \pm 1.5) \times 10^{-4}$       |                  | 4720        |
| $\gamma 3h^+3h^-$                                       | $(5.4 \pm 2.0) \times 10^{-4}$       |                  | 4703        |
| $\gamma 4h^+4h^-$                                       | $(7.4 \pm 3.5) \times 10^{-4}$       |                  | 4679        |
| $\gamma\pi^+\pi^-K^+K^-$                                | $(2.9 \pm 0.9) \times 10^{-4}$       |                  | 4686        |
| $\gamma 2\pi^+2\pi^-$                                   | $(2.5 \pm 0.9) \times 10^{-4}$       |                  | 4720        |
| $\gamma 3\pi^+3\pi^-$                                   | $(2.5 \pm 1.2) \times 10^{-4}$       |                  | 4703        |
| $\gamma 2\pi^+2\pi^-K^+K^-$                             | $(2.4 \pm 1.2) \times 10^{-4}$       |                  | 4658        |
| $\gamma\pi^+\pi^-p\bar{p}$                              | $(1.5 \pm 0.6) \times 10^{-4}$       |                  | 4604        |
| $\gamma 2\pi^+2\pi^-p\bar{p}$                           | $(4 \pm 6) \times 10^{-5}$           |                  | 4563        |
| $\gamma 2K^+2K^-$                                       | $(2.0 \pm 2.0) \times 10^{-5}$       |                  | 4601        |
| $\gamma\eta'(958)$                                      | $< 1.6 \times 10^{-5}$               | 90%              | 4682        |
| $\gamma\eta$                                            | $< 2.1 \times 10^{-5}$               | 90%              | 4714        |
| $\gamma f_0(980)$                                       | $< 3 \times 10^{-5}$                 | 90%              | 4679        |
| $\gamma f_2'(1525)$                                     | $(3.7^{+1.2}_{-1.1}) \times 10^{-5}$ |                  | 4607        |
| $\gamma f_2(1270)$                                      | $(1.00 \pm 0.10) \times 10^{-4}$     |                  | 4644        |
| $\gamma\eta(1405)$                                      | $< 8.2 \times 10^{-5}$               | 90%              | 4625        |
| $\gamma f_0(1710)$                                      | $< 1.8 \times 10^{-4}$               | 90%              | 4574        |
| $\gamma f_4(2050)$                                      | $< 5.3 \times 10^{-5}$               | 90%              | 4513        |
| $\gamma f_0(2200) \rightarrow \gamma K^+K^-$            | $< 2 \times 10^{-4}$                 | 90%              | 4475        |
| $\gamma f_J(2220) \rightarrow \gamma K^+K^-$            | $< 8 \times 10^{-7}$                 | 90%              | 4469        |
| $\gamma f_J(2220) \rightarrow \gamma\pi^+\pi^-$         | $< 6 \times 10^{-7}$                 | 90%              | —           |
| $\gamma f_J(2220) \rightarrow \gamma p\bar{p}$          | $< 1.1 \times 10^{-6}$               | 90%              | —           |
| $\gamma\eta(2225) \rightarrow \gamma\phi\phi$           | $< 3 \times 10^{-3}$                 | 90%              | 4469        |
| $\gamma X$                                              | $< 3 \times 10^{-5}$                 | 90%              | —           |
| $(X = \text{pseudoscalar with } m < 7.2 \text{ GeV})$   |                                      |                  |             |
| $\gamma X\bar{X}$                                       | $< 1 \times 10^{-3}$                 | 90%              | —           |
| $(X\bar{X} = \text{vectors with } m < 3.1 \text{ GeV})$ |                                      |                  |             |

 **$\chi_{b0}(1P)^{[\gamma\gamma]}$** 

$$I^G(J^{PC}) = 0^+(0^{++})$$

$J$  needs confirmation.

Mass  $m = 9859.44 \pm 0.42 \pm 0.31$  MeV

| $\chi_{b1}(1P)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
|-----------------------------|--------------------------------|------------------|-------------|
| $\gamma\Upsilon(1S)$        | $< 6\%$                        | 90%              | 391         |

 **$\chi_{b1}(1P)^{[\gamma\gamma]}$** 

$$I^G(J^{PC}) = 0^+(1^{++})$$

$J$  needs confirmation.

Mass  $m = 9892.78 \pm 0.26 \pm 0.31$  MeV

| $\chi_{b1}(1P)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $\gamma\Upsilon(1S)$        | $(35 \pm 8)\%$                 | 423         |

 **$\chi_{b2}(1P)^{[\gamma\gamma]}$** 

$$I^G(J^{PC}) = 0^+(2^{++})$$

$J$  needs confirmation.

Mass  $m = 9912.21 \pm 0.26 \pm 0.31$  MeV

| $\chi_{b2}(1P)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $\gamma\Upsilon(1S)$        | $(22 \pm 4)\%$                 | 442         |

 **$\Upsilon_{2S}$** 

$$I^G(J^{PC}) = 0^+(1^{--})$$

Mass  $m = 10.02326 \pm 0.00031$  GeVFull width  $\Gamma = 31.98 \pm 2.63$  keV $\Gamma_{ee} = 0.612 \pm 0.011$  keV

| $\Upsilon(2S)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|----------------------------|--------------------------------|-----------------------------------|----------------|
| $\Upsilon(1S)\pi^+\pi^-$   | $(18.8 \pm 0.6)\%$             |                                   | 475            |
| $\Upsilon(1S)\pi^0\pi^0$   | $(9.0 \pm 0.8)\%$              |                                   | 480            |
| $\tau^+\tau^-$             | $(1.7 \pm 1.6)\%$              |                                   | 4686           |
| $\mu^+\mu^-$               | $(1.93 \pm 0.17)\%$            | $S = 2.2$                         | 5011           |
| $e^+e^-$                   | $(1.91 \pm 0.16)\%$            |                                   | 5012           |
| $\Upsilon(1S)\pi^0$        | $< 1.1 \times 10^{-3}$         | CL = 90%                          | 531            |
| $\Upsilon(1S)\eta$         | $< 2 \times 10^{-3}$           | CL = 90%                          | 127            |
| $J/\psi(1S)$ anything      | $< 6 \times 10^{-3}$           | CL = 90%                          | 4533           |
| <b>Radiative decays</b>    |                                |                                   |                |
| $\gamma\chi_{b1}(1P)$      | $(6.9 \pm 0.4)\%$              |                                   | 130            |
| $\gamma\chi_{b2}(1P)$      | $(7.15 \pm 0.35)\%$            |                                   | 110            |
| $\gamma\chi_{b0}(1P)$      | $(3.8 \pm 0.4)\%$              |                                   | 162            |
| $\gamma f_0(1710)$         | $< 5.9 \times 10^{-4}$         | CL = 90%                          | 4864           |
| $\gamma f_2'(1525)$        | $< 5.3 \times 10^{-4}$         | CL = 90%                          | 4896           |
| $\gamma f_2(1270)$         | $< 2.41 \times 10^{-4}$        | CL = 90%                          | 4930           |
| $\gamma\eta_b(1S)$         | $< 5.1 \times 10^{-4}$         | CL = 90%                          | 697            |

 **$\chi_{b0}(2P)^{[\gamma\gamma]}$** 

$$I^G(J^{PC}) = 0^+(0^{++})$$

$J$  needs confirmation.

Mass  $m = 10.2325 \pm 0.0004 \pm 0.0005$  GeV

| $\chi_{b0}(2P)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $\gamma\Upsilon(2S)$        | $(4.6 \pm 2.1)\%$              | 207         |
| $\gamma\Upsilon(1S)$        | $(9 \pm 6) \times 10^{-3}$     | 743         |

 **$\chi_{b1}(2P)^{[\gamma\gamma]}$** 

$$I^G(J^{PC}) = 0^+(1^{++})$$

$J$  needs confirmation.

Mass  $m = 10.25546 \pm 0.00022 \pm 0.00050$  GeV $m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)} = 23.5 \pm 1.0$  MeV

| $\chi_{b1}(2P)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor | $p$<br>(MeV/c) |
|-----------------------------|--------------------------------|--------------|----------------|
| $\omega\Upsilon(1S)$        | $(1.63^{+0.38}_{-0.34})\%$     |              | 135            |
| $\gamma\Upsilon(2S)$        | $(21 \pm 4)\%$                 | 1.5          | 230            |
| $\gamma\Upsilon(1S)$        | $(8.5 \pm 1.3)\%$              | 1.3          | 764            |
| $\pi\pi\chi_{b1}(1P)$       | $(8.6 \pm 3.1) \times 10^{-3}$ |              | 238            |

 **$\chi_{b2}(2P)^{[\gamma\gamma]}$** 

$$I^G(J^{PC}) = 0^+(2^{++})$$

$J$  needs confirmation.

Mass  $m = 10.26865 \pm 0.00022 \pm 0.00050$  GeV $m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)} = 13.5 \pm 0.6$  MeV

| $\chi_{b2}(2P)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $\omega\Upsilon(1S)$        | $(1.10^{+0.34}_{-0.30})$ %     | 194         |
| $\gamma\Upsilon(2S)$        | $(16.2 \pm 2.4)$ %             | 242         |
| $\gamma\Upsilon(1S)$        | $(7.1 \pm 1.0)$ %              | 777         |
| $\pi\pi\chi_{b2}(1P)$       | $(6.0 \pm 2.1) \times 10^{-3}$ | 229         |

 **$\Upsilon(3S)$** 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 10.3552 \pm 0.0005$  GeVFull width  $\Gamma = 20.32 \pm 1.85$  keV $\Gamma_{ee} = 0.443 \pm 0.008$  keV

| $\Upsilon(3S)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|----------------------------|--------------------------------|-----------------------------------|----------------|
| $\Upsilon(2S)$ anything    | $(10.6 \pm 0.8)$ %             |                                   | 296            |
| $\Upsilon(2S)\pi^+\pi^-$   | $(2.8 \pm 0.6)$ %              | $S = 2.2$                         | 177            |
| $\Upsilon(2S)\pi^0\pi^0$   | $(2.00 \pm 0.32)$ %            |                                   | 190            |
| $\Upsilon(2S)\gamma\gamma$ | $(5.0 \pm 0.7)$ %              |                                   | 327            |
| $\Upsilon(1S)\pi^+\pi^-$   | $(4.48 \pm 0.21)$ %            |                                   | 813            |
| $\Upsilon(1S)\pi^0\pi^0$   | $(2.06 \pm 0.28)$ %            |                                   | 816            |
| $\Upsilon(1S)\pi$          | $< 2.2$ %                      | $CL = 90\%$                       | 677            |
| $\mu^+\mu^-$               | $(2.18 \pm 0.21)$ %            | $S = 2.1$                         | 5177           |
| $e^+e^-$                   | seen                           |                                   | 5178           |
| <b>Radiative decays</b>    |                                |                                   |                |
| $\gamma\chi_{b2}(2P)$      | $(13.1 \pm 1.6)$ %             | $S = 3.4$                         | 86             |
| $\gamma\chi_{b1}(2P)$      | $(12.6 \pm 1.2)$ %             | $S = 2.4$                         | 99             |
| $\gamma\chi_{b0}(2P)$      | $(5.9 \pm 0.6)$ %              | $S = 1.4$                         | 122            |
| $\gamma\chi_{b0}(1P)$      | $(3.0 \pm 1.1) \times 10^{-3}$ |                                   | 484            |
| $\gamma\eta_b(2S)$         | $< 6.2$ %                      | $CL = 90\%$                       | —              |
| $\gamma\eta_b(1S)$         | $< 4.3$ %                      | $CL = 90\%$                       | 1001           |

 **$\Upsilon(4S)$** **or  $\Upsilon(10580)$** 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 10.5794 \pm 0.0012$  GeVFull width  $\Gamma = 20.5 \pm 2.5$  MeV $\Gamma_{ee} = 0.272 \pm 0.029$  keV ( $S = 1.5$ )

| $\Upsilon(4S)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ )   | Confidence level | $p$<br>(MeV/c) |
|----------------------------|----------------------------------|------------------|----------------|
| $B\bar{B}$                 | $> 96$ %                         | $95\%$           | 330            |
| $B^+B^-$                   | $(50.6 \pm 0.8)$ %               |                  | 335            |
| $D_s^+$ anything + c.c.    | $(18.2 \pm 3.2)$ %               |                  | —              |
| $B^0\bar{B}^0$             | $(49.4 \pm 0.8)$ %               |                  | 330            |
| non- $B\bar{B}$            | $< 4$ %                          | $95\%$           | —              |
| $e^+e^-$                   | $(1.57 \pm 0.08) \times 10^{-5}$ |                  | 5290           |
| $J/\psi(1S)$ anything      | $< 1.9$ %                        | $95\%$           | —              |
| $D^{*+}$ anything + c.c.   | $< 7.4$ %                        | $90\%$           | 5099           |
| $\phi$ anything            | $< 2.3$ %                        | $90\%$           | 5240           |
| $\Upsilon(1S)$ anything    | $< 4$ %                          | $90\%$           | 1053           |
| $\Upsilon(1S)\pi^+\pi^-$   | $< 1.2$ %                        | $90\%$           | 1026           |
| $\Upsilon(2S)\pi^+\pi^-$   | $< 3.9$ %                        | $90\%$           | 468            |

 **$\Upsilon(10860)$** 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 10.865 \pm 0.008$  GeV ( $S = 1.1$ )Full width  $\Gamma = 110 \pm 13$  MeV $\Gamma_{ee} = 0.31 \pm 0.07$  keV ( $S = 1.3$ )

| $\Upsilon(10860)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------------|--------------------------------|-------------|
| $e^+e^-$                      | $(2.8 \pm 0.7) \times 10^{-6}$ | 5432        |
| $D_s$ anything + c.c.         | $(45 \pm 11)$ %                | —           |

 **$\Upsilon(11020)$** 

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass  $m = 11.019 \pm 0.008$  GeVFull width  $\Gamma = 79 \pm 16$  MeV $\Gamma_{ee} = 0.130 \pm 0.030$  keV

| $\Upsilon(11020)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------------|--------------------------------|-------------|
| $e^+e^-$                      | $(1.6 \pm 0.5) \times 10^{-6}$ | 5510        |

## NOTES

In this Summary Table:

When a quantity has “( $S = \dots$ )” to its right, the error on the quantity has been enlarged by the “scale factor”  $S$ , defined as  $S = \sqrt{\chi^2/(N-1)}$ , where  $N$  is the number of measurements used in calculating the quantity. We do this when  $S > 1$ , which often indicates that the measurements are inconsistent. When  $S > 1.25$ , we also show in the Particle Listings an ideogram of the measurements. For more about  $S$ , see the Introduction.

A decay momentum  $p$  is given for each decay mode. For a 2-body decay,  $p$  is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay,  $p$  is the largest momentum any of the products can have in this frame.

- [a] See the “Note on  $\pi^\pm \rightarrow \ell^\pm \nu \gamma$  and  $K^\pm \rightarrow \ell^\pm \nu \gamma$  Form Factors” in the  $\pi^\pm$  Particle Listings for definitions and details.
- [b] Measurements of  $\Gamma(e^+ \nu_e)/\Gamma(\mu^+ \nu_\mu)$  always include decays with  $\gamma$ 's, and measurements of  $\Gamma(e^+ \nu_e \gamma)$  and  $\Gamma(\mu^+ \nu_\mu \gamma)$  never include low-energy  $\gamma$ 's. Therefore, since no clean separation is possible, we consider the modes with  $\gamma$ 's to be subreactions of the modes without them, and let  $[\Gamma(e^+ \nu_e) + \Gamma(\mu^+ \nu_\mu)]/\Gamma_{\text{total}} = 100\%$ .
- [c] See the  $\pi^\pm$  Particle Listings for the energy limits used in this measurement; low-energy  $\gamma$ 's are not included.
- [d] Derived from an analysis of neutrino-oscillation experiments.
- [e] Astrophysical and cosmological arguments give limits of order  $10^{-13}$ ; see the  $\pi^0$  Particle Listings.
- [f] Due to a new measurement in the average, this is 0.45 MeV larger than the mass we gave in our 2002 edition,  $547.30 \pm 0.12$  MeV.
- [g] Due to removing an old measurement from the average, this is 0.11 keV larger than the width we gave in our 2002 edition,  $1.18 \pm 0.11$  keV. See the  $\Gamma(2\gamma)$  data block in the Data Listings.
- [h] C parity forbids this to occur as a single-photon process.
- [i] See the “Note on scalar mesons” in the  $f_0(1370)$  Particle Listings. The interpretation of this entry as a particle is controversial.
- [j] See the “Note on  $\rho(770)$ ” in the  $\rho(770)$  Particle Listings.
- [k] The  $\omega\rho$  interference is then due to  $\omega\rho$  mixing only, and is expected to be small. If  $e\mu$  universality holds,  $\Gamma(\rho^0 \rightarrow \mu^+ \mu^-) = \Gamma(\rho^0 \rightarrow e^+ e^-) \times 0.99785$ .
- [l] See the “Note on scalar mesons” in the  $f_0(1370)$  Particle Listings.
- [m] See the “Note on  $a_1(1260)$ ” in the  $a_1(1260)$  Particle Listings.
- [n] This is only an educated guess; the error given is larger than the error on the average of the published values. See the Particle Listings for details.
- [o] See the “Note on non- $q\bar{q}$  mesons” in the Particle Listings (see the index for the page number).
- [p] See the “Note on the  $\eta(1405)$ ” in the  $\eta(1405)$  Particle Listings.
- [q] See the “Note on the  $f_1(1420)$ ” in the  $\eta(1405)$  Particle Listings.
- [r] See also the  $\omega(1650)$  Particle Listings.
- [s] See the “Note on the  $\rho(1450)$  and the  $\rho(1700)$ ” in the  $\rho(1700)$  Particle Listings.
- [t] See also the  $\omega(1420)$  Particle Listings.
- [u] See the “Note on  $f_0(1710)$ ” in the  $f_0(1710)$  Particle Listings.
- [v] See the note in the  $K^\pm$  Particle Listings.
- [w] The definition of the slope parameter  $g$  of the  $K \rightarrow 3\pi$  Dalitz plot is as follows (see also “Note on Dalitz Plot Parameters for  $K \rightarrow 3\pi$  Decays” in the  $K^\pm$  Particle Listings):

$$|M|^2 = 1 + g(s_3 - s_0)/m_{\pi^+}^2 + \dots$$

- [x] For more details and definitions of parameters see the Particle Listings.
- [y] Most of this radiative mode, the low-momentum  $\gamma$  part, is also included in the parent mode listed without  $\gamma$ 's.
- [z] See the  $K^\pm$  Particle Listings for the energy limits used in this measurement.
- [aa] Structure-dependent part.
- [bb] Direct-emission branching fraction.
- [cc] Violates angular-momentum conservation.
- [dd] Derived from measured values of  $\phi_{+-}$ ,  $\phi_{00}$ ,  $|\eta|$ ,  $|m_{K_L^0} - m_{K_S^0}|$ , and  $\tau_{K_S^0}$ , as described in the introduction to “Tests of Conservation Laws.”

- [ee] The  $CP$ -violation parameters are defined as follows (see also “Note on  $CP$  Violation in  $K_S \rightarrow 3\pi$ ” and “Note on  $CP$  Violation in  $K_L^0$  Decay” in the Particle Listings):

$$\begin{aligned}\eta_{+-} &= |\eta_{+-}|e^{i\phi_{+-}} = \frac{A(K_L^0 \rightarrow \pi^+\pi^-)}{A(K_S^0 \rightarrow \pi^+\pi^-)} = \epsilon + \epsilon' \\ \eta_{00} &= |\eta_{00}|e^{i\phi_{00}} = \frac{A(K_L^0 \rightarrow \pi^0\pi^0)}{A(K_S^0 \rightarrow \pi^0\pi^0)} = \epsilon - 2\epsilon' \\ \delta &= \frac{\Gamma(K_L^0 \rightarrow \pi^-\ell^+\nu) - \Gamma(K_L^0 \rightarrow \pi^+\ell^-\nu)}{\Gamma(K_L^0 \rightarrow \pi^-\ell^+\nu) + \Gamma(K_L^0 \rightarrow \pi^+\ell^-\nu)}, \\ \text{Im}(\eta_{+-})^2 &= \frac{\Gamma(K_S^0 \rightarrow \pi^+\pi^-\pi^0)^{CP \text{ viol.}}}{\Gamma(K_L^0 \rightarrow \pi^+\pi^-\pi^0)}, \\ \text{Im}(\eta_{00})^2 &= \frac{\Gamma(K_S^0 \rightarrow \pi^0\pi^0\pi^0)}{\Gamma(K_L^0 \rightarrow \pi^0\pi^0\pi^0)}\end{aligned}$$

where for the last two relations  $CPT$  is assumed valid, i.e.,  $\text{Re}(\eta_{+-}) \simeq 0$  and  $\text{Re}(\eta_{00}) \simeq 0$ .

- [ff] See the  $K_S^0$  Particle Listings for the energy limits used in this measurement.
- [gg] The value is for the sum of the charge states or particle/antiparticle states indicated.
- [hh]  $\text{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon$  to a very good approximation provided the phases satisfy  $CPT$  invariance.
- [ii] See the  $K_L^0$  Particle Listings for the energy limits used in this measurement.
- [jj] Allowed by higher-order electroweak interactions.
- [kk] Violates  $CP$  in leading order. Test of direct  $CP$  violation since the indirect  $CP$ -violating and  $CP$ -conserving contributions are expected to be suppressed.
- [ll] See the “Note on  $f_0(1370)$ ” in the  $f_0(1370)$  Particle Listings and in the 1994 edition.
- [mm] See the note in the  $L(1770)$  Particle Listings in Reviews of Modern Physics 56 No. 2 Pt. II (1984), p. S200. See also the “Note on  $K_2(1770)$  and the  $K_2(1820)$ ” in the  $K_2(1770)$  Particle Listings.
- [nn] See the “Note on  $K_2(1770)$  and the  $K_2(1820)$ ” in the  $K_2(1770)$  Particle Listings.
- [oo] This result applies to  $Z^0 \rightarrow c\bar{c}$  decays only. Here  $\ell^+$  is an average (not a sum) of  $e^+$  and  $\mu^+$  decays.
- [pp] This is a weighted average of  $D^\pm$  (44%) and  $D^0$  (56%) branching fractions. See “ $D^+$  and  $D^0 \rightarrow (\eta \text{ anything})/(\text{total } D^+ \text{ and } D^0)$ ” under “ $D^+$  Branching Ratios” in the Particle Listings.
- [qq] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers in the Particle Listings.
- [rr] These subfractions of the  $K^-\pi^+\pi^+$  mode are uncertain: see the Particle Listings.
- [ss] The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.
- [tt] This is *not* a test for the  $\Delta C = 1$  weak neutral current, but leads to the  $\pi^+e^+e^-$  final state.
- [uu] This mode is not a useful test for a  $\Delta C = 1$  weak neutral current because both quarks must change flavor in this decay.
- [vv] This  $D_1^0 - D_2^0$  limit is inferred from the  $D^0 - \bar{D}^0$  mixing ratio  $\Gamma(K^+\pi^- \text{ (via } \bar{D}^0)) / \Gamma(K^-\pi^+) \text{ near the end of the } D^0 \text{ Listings}$ .
- [uw] This value is obtained by subtracting the branching fractions for 2-, 4- and 6-prongs from unity.
- [xx] This is the sum of our  $K^-\pi^+\pi^+\pi^-$ ,  $K^-\pi^+\pi^+\pi^-\pi^0$ ,  $\bar{K}^0 2\pi^+2\pi^-$ ,  $2\pi^+2\pi^-$ ,  $2\pi^+2\pi^-\pi^0$ ,  $K^+K^-\pi^+\pi^-$ , and  $K^+K^-\pi^+\pi^-\pi^0$ , branching fractions.
- [yy] The branching fractions for the  $K^-e^+\nu_e$ ,  $K^*(892)^-e^+\nu_e$ ,  $\pi^-e^+\nu_e$ , and  $\rho^-e^+\nu_e$  modes add up to  $6.14 \pm 0.20\%$ .
- [zz] This is a doubly Cabibbo-suppressed mode.
- [aaa] This branching fraction includes all the decay modes of the resonance in the final state.
- [bbb] The experiments on the division of this charge mode among its submodes disagree, and the submode branching fractions here add up to considerably more than the charged-mode fraction.
- [ccc] However, these upper limits are in serious disagreement with values obtained in another experiment.
- [ddd] For now, we average together measurements of the  $Xe^+\nu_e$  and  $X\mu^+\nu_\mu$  branching fractions. This is the *average*, not the *sum*.
- [eee] This branching fraction includes all the decay modes of the final-state resonance.
- [fff] This comes from a  $K$ -matrix parametrization of the  $\pi^+\pi^-$   $S$ -wave and is a sum over the  $f_0(980)$ ,  $f_0(1300)$ ,  $f_0(1200-1600)$ ,  $f_0(1500)$ , and  $f_0(1750)$ . Not all of these correspond to particles in our Tables.
- [ggg] An  $\ell$  indicates an  $e$  or a  $\mu$  mode, not a sum over these modes.
- [hhh] An  $CP(\pm 1)$  indicates the  $CP = +1$  and  $CP = -1$  eigenstates of the  $D^0 - \bar{D}^0$  system.
- [iii]  $D$  denotes  $D^0$  or  $\bar{D}^0$ .
- [jjj]  $X(3872)^+$  is a hypothetical charged partner of the  $X(3872)$ .
- [kkk]  $\Theta(1710)^{++}$  is a possible narrow pentaquark state and  $G(2220)$  is a possible glueball resonance.
- [lll] Stands for the possible candidates of  $K^*(1410)$ ,  $K_0^*(1430)$  and  $K_2^*(1430)$ .
- [mmm]  $B^0$  and  $B_s^0$  contributions not separated. Limit is on weighted average of the two decay rates.
- [mmn]  $\Theta(1540)^+$  denotes a possible narrow pentaquark state.
- [ooo] These values are model dependent.
- [ppp] Here “anything” means at least one particle observed.
- [qqq]  $D^{**}$  stands for the sum of the  $D(1^1P_1)$ ,  $D(1^3P_0)$ ,  $D(1^3P_1)$ ,  $D(1^3P_2)$ ,  $D(2^1S_0)$ , and  $D(2^1S_1)$  resonances.
- [rrr]  $D^{(*)}\bar{D}^{(*)}$  stands for the sum of  $D^*\bar{D}^*$ ,  $D^*\bar{D}$ ,  $D\bar{D}^*$ , and  $D\bar{D}$ .
- [sss]  $Y(3940)$  denotes a near-threshold enhancement in the  $\omega J/\psi$  mass spectrum.
- [ttt] Inclusive branching fractions have a multiplicity definition and can be greater than 100%.
- [uuu]  $D_j$  represents an unresolved mixture of pseudoscalar and tensor  $D^{**}$  ( $P$ -wave) states.
- [vvv] Not a pure measurement. See note at head of  $B_s^0$  Decay Modes.
- [www] Includes  $p\bar{p}\pi^+\pi^-\gamma$  and excludes  $p\bar{p}\eta$ ,  $p\bar{p}\omega$ ,  $p\bar{p}\eta'$ .
- [xxx]  $J^{PC}$  known by production in  $e^+e^-$  via single photon annihilation.  $I^G$  is not known; interpretation of this state as a single resonance is unclear because of the expectation of substantial threshold effects in this energy region.
- [yyy] Spectroscopic labeling for these states is theoretical, pending experimental information.

See also the table of suggested  $q\bar{q}$  quark-model assignments in the Quark Model section.

• Indicates particles that appear in the preceding Meson Summary Table. We do not regard the other entries as being established.

† Indicates that the value of  $J$  given is preferred, but needs confirmation.

| LIGHT UNFLAVORED<br>( $S = C = B = 0$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                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                                                                                                                                                           |               |  | STRANGE<br>( $S = \pm 1, C = B = 0$ ) |  | BOTTOM<br>( $B = \pm 1$ ) |  |
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| $I^G(J^{PC})$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | $I^G(J^{PC})$ |  | $I(J^P)$                              |  | $I^G(J^{PC})$             |  |
| <ul style="list-style-type: none"><li>• <math>\pi^\pm</math></li><li>• <math>\pi^0</math></li><li>• <math>\eta</math></li><li>• <math>f_0(600)</math></li><li>• <math>\rho(770)</math></li><li>• <math>\omega(782)</math></li><li>• <math>\eta'(958)</math></li><li>• <math>f_0(980)</math></li><li>• <math>a_0(980)</math></li><li>• <math>\phi(1020)</math></li><li>• <math>b_1(1170)</math></li><li>• <math>b_1(1235)</math></li><li>• <math>a_1(1260)</math></li><li>• <math>f_2(1270)</math></li><li>• <math>f_1(1285)</math></li><li>• <math>\eta(1295)</math></li><li>• <math>\pi(1300)</math></li><li>• <math>a_2(1320)</math></li><li>• <math>f_0(1370)</math></li><li>• <math>b_1(1380)</math></li><li>• <math>\pi_1(1400)</math></li><li>• <math>\eta(1405)</math></li><li>• <math>f_1(1420)</math></li><li>• <math>\omega(1420)</math></li><li>• <math>f_2(1430)</math></li><li>• <math>a_0(1450)</math></li><li>• <math>\rho(1450)</math></li><li>• <math>\eta(1475)</math></li><li>• <math>f_0(1500)</math></li><li>• <math>f_1(1510)</math></li><li>• <math>f_2'(1525)</math></li><li>• <math>f_2'(1565)</math></li><li>• <math>b_1(1595)</math></li><li>• <math>\pi_1(1600)</math></li><li>• <math>a_1(1640)</math></li><li>• <math>f_2(1640)</math></li><li>• <math>\eta_2(1645)</math></li><li>• <math>\omega(1650)</math></li><li>• <math>\omega_3(1670)</math></li></ul> | <ul style="list-style-type: none"><li><math>1^-(0^-)</math></li><li><math>1^-(0^{++})</math></li><li><math>0^+(0^{++})</math></li><li><math>0^+(0^{++})</math></li><li><math>1^+(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^+(0^{++})</math></li><li><math>0^+(0^{++})</math></li><li><math>1^-(0^{++})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>1^+(1^{--})</math></li><li><math>0^+(2^{++})</math></li><li><math>0^+(1^{++})</math></li><li><math>0^+(0^{++})</math></li><li><math>1^-(0^{++})</math></li><li><math>1^-(0^{++})</math></li><li><math>1^-(0^{++})</math></li><li><math>0^+(0^{++})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^+(0^{++})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^+(0^{++})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^+(0^{++})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^+(0^{++})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^+(0^{++})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(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i><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1^{--})</math></li><li><math>0^-(1</math></li></ul> |               |  |                                       |  |                           |  |

This short table gives the name, the quantum numbers (where known), and the status of baryons in the *Review*. Only the baryons with 3- or 4-star status are included in the main Baryon Summary Table. Due to insufficient data or uncertain interpretation, the other entries in the short table are not established as baryons. The names with masses are of baryons that decay strongly. For  $N$ ,  $\Delta$ , and  $\Xi$  resonances, the partial wave is indicated by the symbol  $L_{2i,2j}$ , where  $L$  is the orbital angular momentum ( $S$ ,  $P$ ,  $D$ ,  $\dots$ ),  $I$  is the isospin, and  $J$  is the total angular momentum. For  $\Lambda$  and  $\Sigma$  resonances, the symbol is  $L_{i,2j}$ .

- \*\*\* Existence is certain, and properties are at least fairly well explored.
- \*\*\* Existence ranges from very likely to certain, but further confirmation is desirable and/or quantum numbers, branching fractions, etc. are not well determined.
- \*\* Evidence of existence is only fair.
- \* Evidence of existence is poor.

|                                                                                                                                         |  |
|-----------------------------------------------------------------------------------------------------------------------------------------|--|
| <p style="text-align: center;"><b>N BARYONS</b><br/>(<math>S = 0, I = 1/2</math>)<br/><math>p, N^+ = uud; \quad n, N^0 = udd</math></p> |  |
|-----------------------------------------------------------------------------------------------------------------------------------------|--|

|                                                                                         |                                       |
|-----------------------------------------------------------------------------------------|---------------------------------------|
| <b>p</b>                                                                                | $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ |
| Mass $m = 1.00727646688 \pm 0.00000000013$ u                                            |                                       |
| Mass $m = 938.27203 \pm 0.00008$ MeV <sup>[a]</sup>                                     |                                       |
| $ m_p - m_{\bar{p}} /m_p < 1.0 \times 10^{-8}$ , CL = 90% <sup>[b]</sup>                |                                       |
| $ \frac{q_p}{m_p} /(\frac{q_{\bar{p}}}{m_{\bar{p}}}) = 0.99999999991 \pm 0.00000000009$ |                                       |
| $ q_p + q_{\bar{p}} /e < 1.0 \times 10^{-8}$ , CL = 90% <sup>[b]</sup>                  |                                       |
| $ q_p + q_e /e < 1.0 \times 10^{-21}$ <sup>[c]</sup>                                    |                                       |
| Magnetic moment $\mu = 2.792847351 \pm 0.000000028\mu_N$                                |                                       |
| $(\mu_p + \mu_{\bar{p}})/\mu_p = (-2.6 \pm 2.9) \times 10^{-3}$                         |                                       |
| Electric dipole moment $d < 0.54 \times 10^{-23} e$ cm                                  |                                       |
| Electric polarizability $\alpha = (12.0 \pm 0.6) \times 10^{-4}$ fm <sup>3</sup>        |                                       |
| Magnetic polarizability $\beta = (1.9 \pm 0.5) \times 10^{-4}$ fm <sup>3</sup>          |                                       |
| Charge radius = $0.875 \pm 0.007$ fm                                                    |                                       |
| Mean life $\tau > 1.9 \times 10^{29}$ years, CL = 90% ( $p \rightarrow$ invisible mode) |                                       |
| Mean life $\tau > 10^{31}$ to $10^{33}$ years <sup>[d]</sup> (mode dependent)           |                                       |

See the “Note on Nucleon Decay” in our 1994 edition (*Phys. Rev. D*50, 1673) for a short review.

The “partial mean life” limits tabulated here are the limits on  $\tau/B_i$ , where  $\tau$  is the total mean life and  $B_i$  is the branching fraction for the mode in question. For  $N$  decays,  $p$  and  $n$  indicate proton and neutron partial lifetimes.

| $p$ DECAY MODES                   | Partial mean life<br>( $10^{30}$ years) | Confidence level | $p$<br>(MeV/c) |
|-----------------------------------|-----------------------------------------|------------------|----------------|
| <b>Antilepton + meson</b>         |                                         |                  |                |
| $N \rightarrow e^+ \pi$           | $> 158 (n), > 1600 (p)$                 | 90%              | 459            |
| $N \rightarrow \mu^+ \pi$         | $> 100 (n), > 473 (p)$                  | 90%              | 453            |
| $N \rightarrow \nu \pi$           | $> 112 (n), > 25 (p)$                   | 90%              | 459            |
| $p \rightarrow e^+ \eta$          | $> 313$                                 | 90%              | 309            |
| $p \rightarrow \mu^+ \eta$        | $> 126$                                 | 90%              | 297            |
| $n \rightarrow \nu \eta$          | $> 158$                                 | 90%              | 310            |
| $N \rightarrow e^+ \rho$          | $> 217 (n), > 75 (p)$                   | 90%              | 149            |
| $N \rightarrow \mu^+ \rho$        | $> 228 (n), > 110 (p)$                  | 90%              | 113            |
| $N \rightarrow \nu \rho$          | $> 19 (n), > 162 (p)$                   | 90%              | 149            |
| $p \rightarrow e^+ \omega$        | $> 107$                                 | 90%              | 143            |
| $p \rightarrow \mu^+ \omega$      | $> 117$                                 | 90%              | 105            |
| $n \rightarrow \nu \omega$        | $> 108$                                 | 90%              | 144            |
| $N \rightarrow e^+ K$             | $> 17 (n), > 150 (p)$                   | 90%              | 339            |
| $p \rightarrow e^+ K_S^0$         | $> 120$                                 | 90%              | 337            |
| $p \rightarrow e^+ K_L^0$         | $> 51$                                  | 90%              | 337            |
| $N \rightarrow \mu^+ K$           | $> 26 (n), > 120 (p)$                   | 90%              | 329            |
| $p \rightarrow \mu^+ K_S^0$       | $> 150$                                 | 90%              | 326            |
| $p \rightarrow \mu^+ K_L^0$       | $> 83$                                  | 90%              | 326            |
| $N \rightarrow \nu K$             | $> 86 (n), > 670 (p)$                   | 90%              | 339            |
| $n \rightarrow \nu K_S^0$         | $> 51$                                  | 90%              | 338            |
| $p \rightarrow e^+ K^*(892)^0$    | $> 84$                                  | 90%              | 45             |
| $N \rightarrow \nu K^*(892)$      | $> 78 (n), > 51 (p)$                    | 90%              | 45             |
| <b>Antilepton + mesons</b>        |                                         |                  |                |
| $p \rightarrow e^+ \pi^+ \pi^-$   | $> 82$                                  | 90%              | 448            |
| $p \rightarrow e^+ \pi^0 \pi^0$   | $> 147$                                 | 90%              | 449            |
| $n \rightarrow e^+ \pi^- \pi^0$   | $> 52$                                  | 90%              | 449            |
| $p \rightarrow \mu^+ \pi^+ \pi^-$ | $> 133$                                 | 90%              | 425            |
| $p \rightarrow \mu^+ \pi^0 \pi^0$ | $> 101$                                 | 90%              | 427            |
| $n \rightarrow \mu^+ \pi^- \pi^0$ | $> 74$                                  | 90%              | 427            |
| $n \rightarrow e^+ K^0 \pi^-$     | $> 18$                                  | 90%              | 319            |
| <b>Lepton + meson</b>             |                                         |                  |                |
| $n \rightarrow e^- \pi^+$         | $> 65$                                  | 90%              | 459            |
| $n \rightarrow \mu^- \pi^+$       | $> 49$                                  | 90%              | 453            |
| $n \rightarrow e^- \rho^+$        | $> 62$                                  | 90%              | 150            |
| $n \rightarrow \mu^- \rho^+$      | $> 7$                                   | 90%              | 114            |
| $n \rightarrow e^- K^+$           | $> 32$                                  | 90%              | 340            |
| $n \rightarrow \mu^- K^+$         | $> 57$                                  | 90%              | 330            |

|                                   |         |     |
|-----------------------------------|---------|-----|
| <b>Lepton + mesons</b>            |         |     |
| $p \rightarrow e^- \pi^+ \pi^+$   | $> 30$  | 90% |
| $n \rightarrow e^- \pi^+ \pi^0$   | $> 29$  | 90% |
| $p \rightarrow \mu^- \pi^+ \pi^+$ | $> 17$  | 90% |
| $n \rightarrow \mu^- \pi^+ \pi^0$ | $> 34$  | 90% |
| $p \rightarrow e^- \pi^+ K^+$     | $> 75$  | 90% |
| $p \rightarrow \mu^- \pi^+ K^+$   | $> 245$ | 90% |

|                                   |         |     |
|-----------------------------------|---------|-----|
| <b>Antilepton + photon(s)</b>     |         |     |
| $p \rightarrow e^+ \gamma$        | $> 670$ | 90% |
| $p \rightarrow \mu^+ \gamma$      | $> 478$ | 90% |
| $n \rightarrow \nu \gamma$        | $> 28$  | 90% |
| $p \rightarrow e^+ \gamma \gamma$ | $> 100$ | 90% |
| $n \rightarrow \nu \gamma \gamma$ | $> 219$ | 90% |

|                                   |            |     |
|-----------------------------------|------------|-----|
| <b>Three (or more) leptons</b>    |            |     |
| $p \rightarrow e^+ e^+ e^-$       | $> 793$    | 90% |
| $p \rightarrow e^+ \mu^+ \mu^-$   | $> 359$    | 90% |
| $p \rightarrow e^+ \nu \nu$       | $> 17$     | 90% |
| $n \rightarrow e^+ e^- \nu$       | $> 257$    | 90% |
| $n \rightarrow \mu^+ e^- \nu$     | $> 83$     | 90% |
| $n \rightarrow \mu^+ \mu^- \nu$   | $> 79$     | 90% |
| $p \rightarrow \mu^+ e^+ e^-$     | $> 529$    | 90% |
| $p \rightarrow \mu^+ \mu^+ \mu^-$ | $> 675$    | 90% |
| $p \rightarrow \mu^+ \nu \nu$     | $> 21$     | 90% |
| $p \rightarrow e^- \mu^+ \mu^+$   | $> 6$      | 90% |
| $n \rightarrow 3 \nu$             | $> 0.0005$ | 90% |

|                                    |                |     |
|------------------------------------|----------------|-----|
| <b>Inclusive modes</b>             |                |     |
| $N \rightarrow e^+$ anything       | $> 0.6 (n, p)$ | 90% |
| $N \rightarrow \mu^+$ anything     | $> 12 (n, p)$  | 90% |
| $N \rightarrow e^+ \pi^0$ anything | $> 0.6 (n, p)$ | 90% |

#### $\Delta B = 2$ dinucleon modes

The following are lifetime limits per iron nucleus.

|                                    |                        |     |   |
|------------------------------------|------------------------|-----|---|
| $pp \rightarrow \pi^+ \pi^+$       | $> 0.7$                | 90% | — |
| $pn \rightarrow \pi^+ \pi^0$       | $> 2$                  | 90% | — |
| $nn \rightarrow \pi^+ \pi^-$       | $> 0.7$                | 90% | — |
| $nn \rightarrow \pi^0 \pi^0$       | $> 3.4$                | 90% | — |
| $pp \rightarrow e^+ e^+$           | $> 5.8$                | 90% | — |
| $pp \rightarrow e^+ \mu^+$         | $> 3.6$                | 90% | — |
| $pp \rightarrow \mu^+ \mu^+$       | $> 1.7$                | 90% | — |
| $pn \rightarrow e^+ \bar{\nu}$     | $> 2.8$                | 90% | — |
| $pn \rightarrow \mu^+ \bar{\nu}$   | $> 1.6$                | 90% | — |
| $nn \rightarrow \nu_e \bar{\nu}_e$ | $> 0.000049$           | 90% | — |
| $pn \rightarrow$ invisible         | $> 2.1 \times 10^{-5}$ | 90% | — |
| $pp \rightarrow$ invisible         | $> 0.00005$            | 90% | — |

| $\bar{p}$ DECAY MODES                     | Partial mean life<br>(years) | Confidence level | $\bar{p}$<br>(MeV/c) |
|-------------------------------------------|------------------------------|------------------|----------------------|
| <b><math>\bar{p}</math> DECAY MODES</b>   |                              |                  |                      |
| $\bar{p} \rightarrow e^- \gamma$          | $> 7 \times 10^5$            | 90%              | 469                  |
| $\bar{p} \rightarrow \mu^- \gamma$        | $> 5 \times 10^4$            | 90%              | 463                  |
| $\bar{p} \rightarrow e^- \pi^0$           | $> 4 \times 10^5$            | 90%              | 459                  |
| $\bar{p} \rightarrow \mu^- \pi^0$         | $> 5 \times 10^4$            | 90%              | 453                  |
| $\bar{p} \rightarrow e^- \eta$            | $> 2 \times 10^4$            | 90%              | 309                  |
| $\bar{p} \rightarrow \mu^- \eta$          | $> 8 \times 10^3$            | 90%              | 297                  |
| $\bar{p} \rightarrow e^- K_S^0$           | $> 900$                      | 90%              | 337                  |
| $\bar{p} \rightarrow \mu^- K_S^0$         | $> 4 \times 10^3$            | 90%              | 326                  |
| $\bar{p} \rightarrow e^- K_L^0$           | $> 9 \times 10^3$            | 90%              | 337                  |
| $\bar{p} \rightarrow \mu^- K_L^0$         | $> 7 \times 10^3$            | 90%              | 326                  |
| $\bar{p} \rightarrow e^- \gamma \gamma$   | $> 2 \times 10^4$            | 90%              | 469                  |
| $\bar{p} \rightarrow \mu^- \gamma \gamma$ | $> 2 \times 10^4$            | 90%              | 463                  |
| $\bar{p} \rightarrow e^- \omega$          | $> 200$                      | 90%              | 143                  |



|                                                                                                  |                                       |
|--------------------------------------------------------------------------------------------------|---------------------------------------|
| <b><math>n</math></b>                                                                            | $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ |
| Mass $m = 1.0086649156 \pm 0.0000000006$ u                                                       |                                       |
| Mass $m = 939.56536 \pm 0.00008$ MeV <sup>[a]</sup>                                              |                                       |
| $m_n - m_p = 1.2933317 \pm 0.0000005$ MeV                                                        |                                       |
| $= 0.0013884487 \pm 0.0000000006$ u                                                              |                                       |
| Mean life $\tau = 885.7 \pm 0.8$ s                                                               |                                       |
| $c\tau = 2.655 \times 10^8$ km                                                                   |                                       |
| Magnetic moment $\mu = -1.9130427 \pm 0.0000005\mu_N$                                            |                                       |
| Electric dipole moment $d < 0.63 \times 10^{-25}e$ cm, CL = 90%                                  |                                       |
| Mean-square charge radius $\langle r_n^2 \rangle = -0.1161 \pm 0.0022$ fm <sup>2</sup> (S = 1.3) |                                       |
| Electric polarizability $\alpha = (11.6 \pm 1.5) \times 10^{-4}$ fm <sup>3</sup>                 |                                       |
| Magnetic polarizability $\beta = (3.7 \pm 2.0) \times 10^{-4}$ fm <sup>3</sup>                   |                                       |
| Charge $q = (-0.4 \pm 1.1) \times 10^{-21}e$                                                     |                                       |
| Mean $n\bar{n}$ -oscillation time $> 8.6 \times 10^7$ s, CL = 90% (free $n$ )                    |                                       |
| Mean $n\bar{n}$ -oscillation time $> 1.3 \times 10^8$ s, CL = 90% <sup>[e]</sup> (bound $n$ )    |                                       |

Decay parameters<sup>[f]</sup>

|                      |                                                   |
|----------------------|---------------------------------------------------|
| $pe_e^- \bar{\nu}_e$ | $\lambda = g_A/g_V = -1.2695 \pm 0.0029(S = 2.0)$ |
| "                    | $A = -0.1173 \pm 0.0013(S = 2.3)$                 |
| "                    | $B = 0.981 \pm 0.004(S = 1.1)$                    |
| "                    | $a = -0.103 \pm 0.004$                            |
| "                    | $\phi_{AV} = (180.06 \pm 0.07)^{\circ[\text{g}]}$ |
| "                    | $D = (-4 \pm 6) \times 10^{-4}$                   |

| $n$ DECAY MODES                            | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
|--------------------------------------------|--------------------------------|------------------|-------------|
| $pe^- \bar{\nu}_e$                         | 100 %                          |                  | 1           |
| $pe^- \bar{\nu}_e \gamma$                  | $ b  6.9 \times 10^{-3}$       | 90%              | 1           |
| Charge conservation ( $Q$ ) violating mode |                                |                  |             |
| $pn_e \bar{\nu}_e$                         | $Q < 8 \times 10^{-27}$        | 68%              | 1           |

 **$N(1440)P_{11}$**   $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ 

Breit-Wigner mass = 1420 to 1470 ( $\approx 1440$ ) MeV  
 Breit-Wigner full width = 200 to 450 ( $\approx 300$ ) MeV  
 $p_{\text{beam}} = 0.61$  GeV/c  $4\pi\bar{\lambda}^2 = 31.0$  mb  
 Re(pole position) = 1350 to 1380 ( $\approx 1365$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 160$  to  $220$  ( $\approx 190$ ) MeV

| $N(1440)$ DECAY MODES             | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------------|--------------------------------|-------------|
| $N\pi$                            | 0.55 to 0.75                   | 398         |
| $N\pi\pi$                         | 30–40%                         | 347         |
| $\Delta\pi$                       | 20–30%                         | 147         |
| $N\rho$                           | $< 8\%$                        | †           |
| $N(\pi\pi)_{S\text{-wave}}^{I=0}$ | 5–10%                          | –           |
| $p\gamma$                         | 0.035–0.048%                   | 414         |
| $p\gamma$ , helicity = 1/2        | 0.035–0.048%                   | 414         |
| $n\gamma$                         | 0.009–0.032%                   | 413         |
| $n\gamma$ , helicity = 1/2        | 0.009–0.032%                   | 413         |

 **$N(1520)D_{13}$**   $I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$ 

Breit-Wigner mass = 1515 to 1525 ( $\approx 1520$ ) MeV  
 Breit-Wigner full width = 100 to 125 ( $\approx 115$ ) MeV  
 $p_{\text{beam}} = 0.74$  GeV/c  
 $4\pi\bar{\lambda}^2 = 23.5$  mb  
 Re(pole position) = 1505 to 1515 ( $\approx 1510$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 105$  to  $120$  ( $\approx 110$ ) MeV

| $N(1520)$ DECAY MODES             | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------------|--------------------------------|-------------|
| $N\pi$                            | (0.55 to 0.65)                 | 457         |
| $N\eta$                           | $(2.3 \pm 0.4) \times 10^{-3}$ | 155         |
| $N\pi\pi$                         | 40–50%                         | 414         |
| $\Delta\pi$                       | 15–25%                         | 230         |
| $N\rho$                           | 15–25%                         | †           |
| $N(\pi\pi)_{S\text{-wave}}^{I=0}$ | $< 8\%$                        | –           |
| $p\gamma$                         | 0.46–0.56%                     | 470         |
| $p\gamma$ , helicity = 1/2        | 0.001–0.034%                   | 470         |
| $p\gamma$ , helicity = 3/2        | 0.44–0.53%                     | 470         |
| $n\gamma$                         | 0.30–0.53%                     | 470         |
| $n\gamma$ , helicity = 1/2        | 0.04–0.10%                     | 470         |
| $n\gamma$ , helicity = 3/2        | 0.25–0.45%                     | 470         |

 **$N(1535)S_{11}$**   $I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$ 

Breit-Wigner mass = 1525 to 1545 ( $\approx 1535$ ) MeV  
 Breit-Wigner full width = 125 to 175 ( $\approx 150$ ) MeV  
 $p_{\text{beam}} = 0.76$  GeV/c  $4\pi\bar{\lambda}^2 = 22.5$  mb  
 Re(pole position) = 1490 to 1530 ( $\approx 1510$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 90$  to  $250$  ( $\approx 170$ ) MeV

| $N(1535)$ DECAY MODES             | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------------|--------------------------------|-------------|
| $N\pi$                            | 35–55%                         | 468         |
| $N\eta$                           | 45–60%                         | 186         |
| $N\pi\pi$                         | 1–10%                          | 426         |
| $\Delta\pi$                       | $< 1\%$                        | 244         |
| $N\rho$                           | $< 4\%$                        | †           |
| $N(\pi\pi)_{S\text{-wave}}^{I=0}$ | $< 3\%$                        | –           |
| $N(1440)\pi$                      | $< 7\%$                        | †           |
| $p\gamma$                         | 0.15–0.35%                     | 481         |
| $p\gamma$ , helicity = 1/2        | 0.15–0.35%                     | 481         |
| $n\gamma$                         | 0.004–0.29%                    | 480         |
| $n\gamma$ , helicity = 1/2        | 0.004–0.29%                    | 480         |

 **$N(1650)S_{11}$**   $I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$ 

Breit-Wigner mass = 1645 to 1670 ( $\approx 1655$ ) MeV  
 Breit-Wigner full width = 145 to 185 ( $\approx 165$ ) MeV  
 $p_{\text{beam}} = 0.97$  GeV/c  $4\pi\bar{\lambda}^2 = 16.2$  mb  
 Re(pole position) = 1640 to 1670 ( $\approx 1655$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 150$  to  $180$  ( $\approx 165$ ) MeV

| $N(1650)$ DECAY MODES             | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------------|--------------------------------|-------------|
| $N\pi$                            | 0.60 to 0.95                   | 551         |
| $N\eta$                           | 3–10%                          | 354         |
| $\Lambda K$                       | 3–11%                          | 179         |
| $N\pi\pi$                         | 10–20%                         | 517         |
| $\Delta\pi$                       | 1–7%                           | 349         |
| $N\rho$                           | 4–12%                          | †           |
| $N(\pi\pi)_{S\text{-wave}}^{I=0}$ | $< 4\%$                        | –           |
| $N(1440)\pi$                      | $< 5\%$                        | 156         |
| $p\gamma$                         | 0.04–0.18%                     | 562         |
| $p\gamma$ , helicity = 1/2        | 0.04–0.18%                     | 562         |
| $n\gamma$                         | 0.003–0.17%                    | 561         |
| $n\gamma$ , helicity = 1/2        | 0.003–0.17%                    | 561         |

 **$N(1675)D_{15}$**   $I(J^P) = \frac{1}{2}(\frac{5}{2}^-)$ 

Breit-Wigner mass = 1670 to 1680 ( $\approx 1675$ ) MeV  
 Breit-Wigner full width = 130 to 165 ( $\approx 150$ ) MeV  
 $p_{\text{beam}} = 1.01$  GeV/c  $4\pi\bar{\lambda}^2 = 15.4$  mb  
 Re(pole position) = 1655 to 1665 ( $\approx 1660$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 125$  to  $150$  ( $\approx 135$ ) MeV

| N(1675) DECAY MODES        | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 0.35 to 0.45                   | 564         |
| $N\eta$                    | $(0.0 \pm 1.0)\%$              | 376         |
| $\Lambda K$                | $<1\%$                         | 216         |
| $N\pi\pi$                  | 50–60%                         | 532         |
| $\Delta\pi$                | 50–60%                         | 366         |
| $N\rho$                    | $<1\text{--}3\%$               | †           |
| $p\gamma$                  | 0.004–0.023%                   | 575         |
| $p\gamma$ , helicity = 1/2 | 0.0–0.015%                     | 575         |
| $p\gamma$ , helicity = 3/2 | 0.0–0.011%                     | 575         |
| $n\gamma$                  | 0.02–0.12%                     | 574         |
| $n\gamma$ , helicity = 1/2 | 0.006–0.046%                   | 574         |
| $n\gamma$ , helicity = 3/2 | 0.01–0.08%                     | 574         |

$$\boxed{N(1680)F_{15}} \quad I(J^P) = \frac{1}{2}(\frac{5}{2}^+)$$

Breit–Wigner mass = 1680 to 1690 ( $\approx 1685$ ) MeV  
 Breit–Wigner full width = 120 to 140 ( $\approx 130$ ) MeV  
 $p_{\text{beam}} = 1.02 \text{ GeV}/c \quad 4\pi\bar{\lambda}^2 = 15.0 \text{ mb}$   
 Re(pole position) = 1665 to 1680 ( $\approx 1675$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 110 \text{ to } 135$  ( $\approx 120$ ) MeV

| N(1680) DECAY MODES               | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------------|--------------------------------|-------------|
| $N\pi$                            | 0.65 to 0.70%                  | 571         |
| $N\eta$                           | $(0.0 \pm 1.0)\%$              | 387         |
| $N\pi\pi$                         | 30–40%                         | 539         |
| $\Delta\pi$                       | 5–15%                          | 374         |
| $N\rho$                           | 3–15%                          | †           |
| $N(\pi\pi)_{S\text{-wave}}^{I=0}$ | 5–20%                          | –           |
| $p\gamma$                         | 0.21–0.32%                     | 581         |
| $p\gamma$ , helicity = 1/2        | 0.001–0.011%                   | 581         |
| $p\gamma$ , helicity = 3/2        | 0.20–0.32%                     | 581         |
| $n\gamma$                         | 0.021–0.046%                   | 581         |
| $n\gamma$ , helicity = 1/2        | 0.004–0.029%                   | 581         |
| $n\gamma$ , helicity = 3/2        | 0.01–0.024%                    | 581         |

$$\boxed{N(1700)D_{13}} \quad I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$$

Breit–Wigner mass = 1650 to 1750 ( $\approx 1700$ ) MeV  
 Breit–Wigner full width = 50 to 150 ( $\approx 100$ ) MeV  
 $p_{\text{beam}} = 1.05 \text{ GeV}/c \quad 4\pi\bar{\lambda}^2 = 14.5 \text{ mb}$   
 Re(pole position) = 1630 to 1730 ( $\approx 1680$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 50 \text{ to } 150$  ( $\approx 100$ ) MeV

| N (1700) DECAY MODES       | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 5–15%                          | 581         |
| $N\eta$                    | $(0.0 \pm 1.0)\%$              | 402         |
| $\Lambda K$                | $<3\%$                         | 255         |
| $N\pi\pi$                  | 85–95%                         | 550         |
| $N\rho$                    | $<35\%$                        | †           |
| $p\gamma$                  | 0.01–0.05%                     | 591         |
| $p\gamma$ , helicity = 1/2 | 0.0–0.024%                     | 591         |
| $p\gamma$ , helicity = 3/2 | 0.002–0.026%                   | 591         |
| $n\gamma$                  | 0.01–0.13%                     | 590         |
| $n\gamma$ , helicity = 1/2 | 0.0–0.09%                      | 590         |
| $n\gamma$ , helicity = 3/2 | 0.01–0.05%                     | 590         |

$$\boxed{N(1710)P_{11}} \quad I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$$

Breit–Wigner mass = 1680 to 1740 ( $\approx 1710$ ) MeV  
 Breit–Wigner full width = 50 to 250 ( $\approx 100$ ) MeV  
 $p_{\text{beam}} = 1.07 \text{ GeV}/c \quad 4\pi\bar{\lambda}^2 = 14.2 \text{ mb}$   
 Re(pole position) = 1670 to 1770 ( $\approx 1720$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 80 \text{ to } 380$  ( $\approx 230$ ) MeV

| N (1710) DECAY MODES              | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------------|--------------------------------|-------------|
| $N\pi$                            | 10–20%                         | 588         |
| $N\eta$                           | $(6.2 \pm 1.0)\%$              | 412         |
| $N\omega$                         | $(13.0 \pm 2.0)\%$             | †           |
| $\Lambda K$                       | 5–25%                          | 269         |
| $N\pi\pi$                         | 40–90%                         | 557         |
| $\Delta\pi$                       | 15–40%                         | 394         |
| $N\rho$                           | 5–25%                          | †           |
| $N(\pi\pi)_{S\text{-wave}}^{I=0}$ | 10–40%                         | –           |
| $p\gamma$                         | 0.002–0.05%                    | 598         |
| $p\gamma$ , helicity = 1/2        | 0.002–0.05%                    | 598         |
| $n\gamma$                         | 0.0–0.02%                      | 597         |
| $n\gamma$ , helicity = 1/2        | 0.0–0.02%                      | 597         |

$$\boxed{N(1720)P_{13}} \quad I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$$

Breit–Wigner mass = 1700 to 1750 ( $\approx 1720$ ) MeV  
 Breit–Wigner full width = 150 to 300 ( $\approx 200$ ) MeV  
 $p_{\text{beam}} = 1.09 \text{ GeV}/c \quad 4\pi\bar{\lambda}^2 = 13.9 \text{ mb}$   
 Re(pole position) = 1660 to 1690 ( $\approx 1675$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 115 \text{ to } 275$  MeV

| N (1720) DECAY MODES       | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 10–20%                         | 594         |
| $N\eta$                    | $(4.0 \pm 1.0)\%$              | 422         |
| $\Lambda K$                | 1–15%                          | 283         |
| $N\pi\pi$                  | $>70\%$                        | 564         |
| $N\rho$                    | 70–85%                         | 73          |
| $p\gamma$                  | 0.003–0.10%                    | 604         |
| $p\gamma$ , helicity = 1/2 | 0.003–0.08%                    | 604         |
| $p\gamma$ , helicity = 3/2 | 0.001–0.03%                    | 604         |
| $n\gamma$                  | 0.002–0.39%                    | 603         |
| $n\gamma$ , helicity = 1/2 | 0.0–0.002%                     | 603         |
| $n\gamma$ , helicity = 3/2 | 0.001–0.39%                    | 603         |

$$\boxed{N(2190)G_{17}} \quad I(J^P) = \frac{1}{2}(\frac{7}{2}^-)$$

Breit–Wigner mass = 2100 to 2200 ( $\approx 2190$ ) MeV  
 Breit–Wigner full width = 300 to 700 ( $\approx 500$ ) MeV  
 $p_{\text{beam}} = 2.07 \text{ GeV}/c \quad 4\pi\bar{\lambda}^2 = 6.21 \text{ mb}$   
 Re(pole position) = 2050 to 2100 ( $\approx 2075$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 400 \text{ to } 520$  ( $\approx 450$ ) MeV

| N (2190) DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------|--------------------------------|-------------|
| $N\pi$               | 10–20%                         | 888         |
| $N\eta$              | $(0.0 \pm 1.0)\%$              | 792         |

$$\boxed{N(2220)H_{19}} \quad I(J^P) = \frac{1}{2}(\frac{9}{2}^+)$$

Breit–Wigner mass = 2200 to 2300 ( $\approx 2250$ ) MeV  
 Breit–Wigner full width = 350 to 500 ( $\approx 400$ ) MeV  
 $p_{\text{beam}} = 2.21 \text{ GeV}/c \quad 4\pi\bar{\lambda}^2 = 5.74 \text{ mb}$   
 Re(pole position) = 2130 to 2200 ( $\approx 2170$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 400 \text{ to } 560$  ( $\approx 480$ ) MeV

| N (2220) DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------|--------------------------------|-------------|
| $N\pi$               | 10–20%                         | 924         |

$$\boxed{N(2250)G_{19}} \quad I(J^P) = \frac{1}{2}(\frac{9}{2}^-)$$

Breit–Wigner mass = 2200 to 2350 ( $\approx 2275$ ) MeV  
 Breit–Wigner full width = 230 to 800 ( $\approx 500$ ) MeV  
 $p_{\text{beam}} = 2.27 \text{ GeV}/c \quad 4\pi\bar{\lambda}^2 = 5.56 \text{ mb}$   
 Re(pole position) = 2150 to 2250 ( $\approx 2200$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 350 \text{ to } 550$  ( $\approx 450$ ) MeV

| $N(2250)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------|--------------------------------|-------------|
| $N\pi$                | 5–15%                          | 938         |

 **$N(2600)I_{1,11}$** 

$$I(J^P) = \frac{1}{2}(\frac{11}{2}^-)$$

Breit–Wigner mass = 2550 to 2750 ( $\approx 2600$ ) MeV  
 Breit–Wigner full width = 500 to 800 ( $\approx 650$ ) MeV  
 $p_{\text{beam}} = 3.12\text{GeV}/c$      $4\pi\bar{\lambda}^2 = 3.86$  mb

| $N(2600)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------|--------------------------------|-------------|
| $N\pi$                | 5–10%                          | 1126        |

 **$\Delta$  BARYONS** **$(S=0, I=3/2)$** 

$$\Delta^{++} = uuu, \quad \Delta^+ = uud, \quad \Delta^0 = udd, \quad \Delta^- = ddd$$

 **$\Delta(1232)P_{33}$** 

$$I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$$

Breit–Wigner mass (mixed charges) = 1231 to 1233 ( $\approx 1232$ ) MeV  
 Breit–Wigner full width (mixed charges) = 116 to 120 ( $\approx 118$ ) MeV  
 $p_{\text{beam}} = 0.30\text{GeV}/c$      $4\pi\bar{\lambda}^2 = 94.8$  mb  
 Re(pole position) = 1209 to 1211 ( $\approx 1210$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 98$  to  $102$  ( $\approx 100$ ) MeV

| $\Delta(1232)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 100%                           | 229         |
| $N\gamma$                  | 0.52–0.60%                     | 259         |
| $N\gamma$ , helicity = 1/2 | 0.11–0.13%                     | 259         |
| $N\gamma$ , helicity = 3/2 | 0.41–0.47%                     | 259         |

 **$\Delta(1600)P_{33}$** 

$$I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$$

Breit–Wigner mass = 1550 to 1700 ( $\approx 1600$ ) MeV  
 Breit–Wigner full width = 250 to 450 ( $\approx 350$ ) MeV  
 $p_{\text{beam}} = 0.87\text{GeV}/c$      $4\pi\bar{\lambda}^2 = 18.6$  mb  
 Re(pole position) = 1500 to 1700 ( $\approx 1600$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 200$  to  $400$  ( $\approx 300$ ) MeV

| $\Delta(1600)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 10–25%                         | 513         |
| $N\pi\pi$                  | 75–90%                         | 477         |
| $\Delta\pi$                | 40–70%                         | 303         |
| $N\rho$                    | <25%                           | †           |
| $N(1440)\pi$               | 10–35%                         | 82          |
| $N\gamma$                  | 0.001–0.02%                    | 525         |
| $N\gamma$ , helicity = 1/2 | 0.0–0.02%                      | 525         |
| $N\gamma$ , helicity = 3/2 | 0.001–0.005%                   | 525         |

 **$\Delta(1620)S_{31}$** 

$$I(J^P) = \frac{3}{2}(\frac{1}{2}^-)$$

Breit–Wigner mass = 1600 to 1660 ( $\approx 1630$ ) MeV  
 Breit–Wigner full width = 135 to 150 ( $\approx 145$ ) MeV  
 $p_{\text{beam}} = 0.93\text{GeV}/c$      $4\pi\bar{\lambda}^2 = 17.2$  mb  
 Re(pole position) = 1590 to 1610 ( $\approx 1600$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 115$  to  $120$  ( $\approx 118$ ) MeV

| $\Delta(1620)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 20–30%                         | 534         |
| $N\pi\pi$                  | 70–80%                         | 499         |
| $\Delta\pi$                | 30–60%                         | 328         |
| $N\rho$                    | 7–25%                          | †           |
| $N\gamma$                  | 0.004–0.044%                   | 545         |
| $N\gamma$ , helicity = 1/2 | 0.004–0.044%                   | 545         |

 **$\Delta(1700)D_{33}$** 

$$I(J^P) = \frac{3}{2}(\frac{3}{2}^-)$$

Breit–Wigner mass = 1670 to 1750 ( $\approx 1700$ ) MeV  
 Breit–Wigner full width = 200 to 400 ( $\approx 300$ ) MeV  
 $p_{\text{beam}} = 1.05\text{GeV}/c$      $4\pi\bar{\lambda}^2 = 14.5$  mb  
 Re(pole position) = 1620 to 1680 ( $\approx 1650$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 160$  to  $240$  ( $\approx 200$ ) MeV

| $\Delta(1700)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 10–20%                         | 581         |
| $N\pi\pi$                  | 80–90%                         | 550         |
| $\Delta\pi$                | 30–60%                         | 386         |
| $N\rho$                    | 30–55%                         | †           |
| $N\gamma$                  | 0.12–0.26%                     | 591         |
| $N\gamma$ , helicity = 1/2 | 0.08–0.16%                     | 591         |
| $N\gamma$ , helicity = 3/2 | 0.025–0.12%                    | 591         |

 **$\Delta(1905)F_{35}$** 

$$I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$$

Breit–Wigner mass = 1865 to 1915 ( $\approx 1890$ ) MeV  
 Breit–Wigner full width = 270 to 400 ( $\approx 330$ ) MeV  
 $p_{\text{beam}} = 1.42\text{GeV}/c$      $4\pi\bar{\lambda}^2 = 9.89$  mb  
 Re(pole position) = 1825 to 1835 ( $\approx 1830$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 265$  to  $300$  ( $\approx 280$ ) MeV

| $\Delta(1905)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 0.09 to 0.15                   | 704         |
| $N\pi\pi$                  | 85–95%                         | 680         |
| $\Delta\pi$                | <25%                           | 531         |
| $N\rho$                    | >60 %                          | 397         |
| $N\gamma$                  | 0.01–0.03%                     | 712         |
| $N\gamma$ , helicity = 1/2 | 0.0–0.1%                       | 712         |
| $N\gamma$ , helicity = 3/2 | 0.004–0.03%                    | 712         |

 **$\Delta(1910)P_{31}$** 

$$I(J^P) = \frac{3}{2}(\frac{1}{2}^+)$$

Breit–Wigner mass = 1870 to 1920 ( $\approx 1910$ ) MeV  
 Breit–Wigner full width = 190 to 270 ( $\approx 250$ ) MeV  
 $p_{\text{beam}} = 1.46\text{GeV}/c$      $4\pi\bar{\lambda}^2 = 9.54$  mb  
 Re(pole position) = 1830 to 1880 ( $\approx 1855$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 200$  to  $500$  ( $\approx 350$ ) MeV

| $\Delta(1910)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 15–30%                         | 717         |
| $N\gamma$                  | 0.0–0.2%                       | 725         |
| $N\gamma$ , helicity = 1/2 | 0.0–0.2%                       | 725         |

 **$\Delta(1920)P_{33}$** 

$$I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$$

Breit–Wigner mass = 1900 to 1970 ( $\approx 1920$ ) MeV  
 Breit–Wigner full width = 150 to 300 ( $\approx 200$ ) MeV

$$p_{\text{beam}} = 1.48\text{GeV}/c \quad 4\pi\bar{\lambda}^2 = 9.37 \text{ mb}$$

Re(pole position) = 1850 to 1950 ( $\approx 1900$ ) MeV  
 $-2\text{Im}(\text{pole position}) = 200$  to  $400$  ( $\approx 300$ ) MeV

| $\Delta(1920)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\pi$                     | 5–20%                          | 723         |
| $\Sigma K$                 | ( $2.10 \pm 0.30$ )%           | 431         |

| <b><math>\Delta(1930)D_{35}</math></b>                                   | $I(J^P) = \frac{3}{2}(\frac{5}{2}^-)$      |
|--------------------------------------------------------------------------|--------------------------------------------|
| Breit–Wigner mass = 1900 to 2020 ( $\approx 1960$ ) MeV                  |                                            |
| Breit–Wigner full width = 220 to 500 ( $\approx 360$ ) MeV               |                                            |
| $p_{\text{beam}} = 1.56\text{GeV}/c$ $4\pi\bar{\lambda}^2 = 8.76$ mb     |                                            |
| Re(pole position) = 1840 to 1960 ( $\approx 1900$ ) MeV                  |                                            |
| $-2\text{Im}(\text{pole position}) = 175$ to $360$ ( $\approx 270$ ) MeV |                                            |
| $\Delta(1930)$ DECAY MODES                                               | Fraction ( $\Gamma_i/\Gamma$ ) $p$ (MeV/c) |
| $N\pi$                                                                   | 0.05 to 0.15    748                        |
| $N\gamma$                                                                | 0.0–0.02%    755                           |
| $N\gamma$ , helicity = 1/2                                               | 0.0–0.01%    755                           |
| $N\gamma$ , helicity = 3/2                                               | 0.0–0.01%    755                           |

| <b><math>\Delta(1950)F_{37}</math></b>                                   | $I(J^P) = \frac{3}{2}(\frac{7}{2}^+)$      |
|--------------------------------------------------------------------------|--------------------------------------------|
| Breit–Wigner mass = 1915 to 1950 ( $\approx 1930$ ) MeV                  |                                            |
| Breit–Wigner full width = 235 to 335 ( $\approx 285$ ) MeV               |                                            |
| $p_{\text{beam}} = 1.50\text{GeV}/c$ $4\pi\bar{\lambda}^2 = 9.21$ mb     |                                            |
| Re(pole position) = 1870 to 1890 ( $\approx 1880$ ) MeV                  |                                            |
| $-2\text{Im}(\text{pole position}) = 220$ to $260$ ( $\approx 240$ ) MeV |                                            |
| $\Delta(1950)$ DECAY MODES                                               | Fraction ( $\Gamma_i/\Gamma$ ) $p$ (MeV/c) |
| $N\pi$                                                                   | 0.35 to 0.45    729                        |
| $N\pi\pi$                                                                | 706                                        |
| $\Delta\pi$                                                              | 20–30%    560                              |
| $N\rho$                                                                  | <10%    442                                |
| $N\gamma$                                                                | 0.08–0.13%    737                          |
| $N\gamma$ , helicity = 1/2                                               | 0.03–0.055%    737                         |
| $N\gamma$ , helicity = 3/2                                               | 0.05–0.075%    737                         |

| <b><math>\Delta(2420)H_{3,11}</math></b>                                 | $I(J^P) = \frac{3}{2}(\frac{11}{2}^+)$     |
|--------------------------------------------------------------------------|--------------------------------------------|
| Breit–Wigner mass = 2300 to 2500 ( $\approx 2420$ ) MeV                  |                                            |
| Breit–Wigner full width = 300 to 500 ( $\approx 400$ ) MeV               |                                            |
| $p_{\text{beam}} = 2.64\text{GeV}/c$ $4\pi\bar{\lambda}^2 = 4.68$ mb     |                                            |
| Re(pole position) = 2260 to 2400 ( $\approx 2330$ ) MeV                  |                                            |
| $-2\text{Im}(\text{pole position}) = 350$ to $750$ ( $\approx 550$ ) MeV |                                            |
| $\Delta(2420)$ DECAY MODES                                               | Fraction ( $\Gamma_i/\Gamma$ ) $p$ (MeV/c) |
| $N\pi$                                                                   | 5–15%    1023                              |

|                                                                               |  |
|-------------------------------------------------------------------------------|--|
| <b><math>\Lambda</math> BARYONS</b><br>$(S = -1, I = 0)$<br>$\Lambda^0 = uds$ |  |
|-------------------------------------------------------------------------------|--|

|                                                                                           |                                    |
|-------------------------------------------------------------------------------------------|------------------------------------|
| <b><math>\Lambda</math></b>                                                               | $I(J^P) = 0(\frac{1}{2}^+)$        |
| Mass $m = 1115.683 \pm 0.006$ MeV                                                         |                                    |
| $(m_\Lambda - m_{\bar{\Lambda}})/m_\Lambda = (-0.1 \pm 1.1) \times 10^{-5}$ ( $S = 1.6$ ) |                                    |
| Mean life $\tau = (2.631 \pm 0.020) \times 10^{-10}$ ( $S = 1.6$ )                        |                                    |
| $(\tau_\Lambda - \tau_{\bar{\Lambda}})/\tau_\Lambda = -0.001 \pm 0.009$                   |                                    |
| $c\tau = 7.89$ cm                                                                         |                                    |
| Magnetic moment $\mu = -0.613 \pm 0.004\mu_N$                                             |                                    |
| Electric dipole moment $d < 1.5 \times 10^{-16}e$ cm, CL = 95%                            |                                    |
| <b>Decay parameters</b>                                                                   |                                    |
| $p\pi^-$                                                                                  | $\alpha_- = 0.642 \pm 0.013$       |
| "                                                                                         | $\phi_- = (-6.5 \pm 3.5)^\circ$    |
| "                                                                                         | $\gamma_- = 0.76^{[i]}$            |
| "                                                                                         | $\Delta_- = (8 \pm 4)^\circ^{[i]}$ |
| $n\pi^0$                                                                                  | $\alpha_0 = 0.65 \pm 0.04$         |
| $pe^- \bar{\nu}_e$                                                                        | $g_A/g_V = -0.718 \pm 0.015^{[f]}$ |

| $\Lambda$ DECAY MODES  | Fraction ( $\Gamma_i/\Gamma$ )           | $p$ (MeV/c) |
|------------------------|------------------------------------------|-------------|
| $p\pi^-$               | $(63.9 \pm 0.5)\%$                       | 101         |
| $n\pi^0$               | $(35.8 \pm 0.5)\%$                       | 104         |
| $n\gamma$              | $(1.75 \pm 0.15) \times 10^{-3}$         | 162         |
| $p\pi^- \gamma$        | $[j] \quad (8.4 \pm 1.4) \times 10^{-4}$ | 101         |
| $pe^- \bar{\nu}_e$     | $(8.32 \pm 0.14) \times 10^{-4}$         | 163         |
| $p\mu^- \bar{\nu}_\mu$ | $(1.57 \pm 0.35) \times 10^{-4}$         | 131         |

|                                         |                             |
|-----------------------------------------|-----------------------------|
| <b><math>\Lambda(1405)S_{01}</math></b> | $I(J^P) = 0(\frac{1}{2}^-)$ |
| Mass $m = 1406 \pm 4$ MeV               |                             |
| Full width $\Gamma = 50 \pm 2$ MeV      |                             |
| Below $\bar{K}N$ threshold              |                             |

| $\Lambda(1405)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $\Sigma\pi$                 | 100%                           | 157         |

$\Lambda(1520)D_{03}$

$I(J^P) = 0(\frac{3}{2}^-)$

Mass  $m = 1519.5 \pm 1.0 \text{ MeV}^{[k]}$

Full width  $\Gamma = 15.6 \pm 1.0 \text{ MeV}^{[k]}$

$p_{\text{beam}} = 0.39 \text{ GeV}/c$

$4\pi\bar{\lambda}^2 = 82.8 \text{ mb}$

| $\Lambda(1520)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | $45 \pm 1\%$                   | 243         |
| $\Sigma\pi$                 | $42 \pm 1\%$                   | 268         |
| $\Lambda\pi\pi$             | $10 \pm 1\%$                   | 259         |
| $\Sigma\pi\pi$              | $0.9 \pm 0.1\%$                | 169         |
| $\Lambda\gamma$             | $0.85 \pm 0.15\%$              | 350         |

$\Lambda(1600)P_{01}$

$I(J^P) = 0(\frac{1}{2}^+)$

Mass  $m = 1560$  to  $1700$  ( $\approx 1600$ ) MeV  
 Full width  $\Gamma = 50$  to  $250$  ( $\approx 150$ ) MeV  
 $p_{\text{beam}} = 0.58\text{GeV}/c \qquad 4\pi\bar{\lambda}^2 = 41.6$  mb

| $\Lambda(1600)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 15–30%                         | 343         |
| $\Sigma\pi$                 | 10–60%                         | 338         |

$\Lambda(1670)S_{01}$

$I(J^P) = 0(\frac{1}{2}^-)$

Mass  $m = 1660$  to  $1680$  ( $\approx 1670$ ) MeV

Full width  $\Gamma = 25$  to  $50$  ( $\approx 35$ ) MeV

$p_{\text{beam}} = 0.74\text{GeV}/c$        $4\pi\bar{\lambda}^2 = 28.5$  mb

| $\Lambda(1670)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 20–30%                         | 414         |
| $\Sigma\pi$                 | 25–55%                         | 394         |
| $\Lambda\eta$               | 10–25%                         | 71          |

$\Lambda(1690)D_{03}$

$I(J^P) = 0(\frac{3}{2}^-)$

Mass  $m = 1685$  to  $1695$  ( $\approx 1690$ ) MeV

Full width  $\Gamma = 50$  to  $70$  ( $\approx 60$ ) MeV

$p_{\text{beam}} = 0.78\text{GeV}/c \qquad 4\pi\bar{\lambda}^2 = 26.1 \text{ mb}$

| $\Lambda(1690)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 20–30%                         | 433         |
| $\Sigma\pi$                 | 20–40%                         | 410         |
| $\Lambda\pi\pi$             | $\sim 25\%$                    | 419         |
| $\Sigma\pi\pi$              | $\sim 20\%$                    | 358         |

**$\Lambda(1800)S_{01}$** 

$$I(J^P) = 0(\frac{1}{2}^-)$$

Mass  $m = 1720$  to  $1850$  ( $\approx 1800$ ) MeV

Full width  $\Gamma = 200$  to  $400$  ( $\approx 300$ ) MeV

$$p_{\text{beam}} = 1.01 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 17.5 \text{ mb}$$

| $\Lambda(1800)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 25–40%                         | 528         |
| $\Sigma\pi$                 | seen                           | 494         |
| $\Sigma(1385)\pi$           | seen                           | 349         |
| $N\bar{K}^*(892)$           | seen                           | †           |

 **$\Lambda(1810)P_{01}$** 

$$I(J^P) = 0(\frac{1}{2}^+)$$

Mass  $m = 1750$  to  $1850$  ( $\approx 1810$ ) MeV

Full width  $\Gamma = 50$  to  $250$  ( $\approx 150$ ) MeV

$$p_{\text{beam}} = 1.04 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 17.0 \text{ mb}$$

| $\Lambda(1810)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 20–50%                         | 537         |
| $\Sigma\pi$                 | 10–40%                         | 501         |
| $\Sigma(1385)\pi$           | seen                           | 357         |
| $N\bar{K}^*(892)$           | 30–60%                         | †           |

 **$\Lambda(1820)F_{05}$** 

$$I(J^P) = 0(\frac{5}{2}^+)$$

Mass  $m = 1815$  to  $1825$  ( $\approx 1820$ ) MeV

Full width  $\Gamma = 70$  to  $90$  ( $\approx 80$ ) MeV

$$p_{\text{beam}} = 1.06 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 16.5 \text{ mb}$$

| $\Lambda(1820)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 55–65%                         | 545         |
| $\Sigma\pi$                 | 8–14%                          | 509         |
| $\Sigma(1385)\pi$           | 5–10%                          | 366         |

 **$\Lambda(1830)D_{05}$** 

$$I(J^P) = 0(\frac{5}{2}^-)$$

Mass  $m = 1810$  to  $1830$  ( $\approx 1830$ ) MeV

Full width  $\Gamma = 60$  to  $110$  ( $\approx 95$ ) MeV

$$p_{\text{beam}} = 1.08 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 16.0 \text{ mb}$$

| $\Lambda(1830)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 3–10%                          | 553         |
| $\Sigma\pi$                 | 35–75%                         | 516         |
| $\Sigma(1385)\pi$           | >15%                           | 374         |

 **$\Lambda(1890)P_{03}$** 

$$I(J^P) = 0(\frac{3}{2}^+)$$

Mass  $m = 1850$  to  $1910$  ( $\approx 1890$ ) MeV

Full width  $\Gamma = 60$  to  $200$  ( $\approx 100$ ) MeV

$$p_{\text{beam}} = 1.21 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 13.6 \text{ mb}$$

| $\Lambda(1890)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 20–35%                         | 599         |
| $\Sigma\pi$                 | 3–10%                          | 560         |
| $\Sigma(1385)\pi$           | seen                           | 423         |
| $N\bar{K}^*(892)$           | seen                           | 236         |

 **$\Lambda(2100)G_{07}$** 

$$I(J^P) = 0(\frac{7}{2}^-)$$

Mass  $m = 2090$  to  $2110$  ( $\approx 2100$ ) MeV

Full width  $\Gamma = 100$  to  $250$  ( $\approx 200$ ) MeV

$$p_{\text{beam}} = 1.68 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 8.68 \text{ mb}$$

| $\Lambda(2100)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 25–35%                         | 751         |
| $\Sigma\pi$                 | $\sim 5\%$                     | 705         |
| $\Delta\eta$                | <3%                            | 617         |
| $\Xi K$                     | <3%                            | 491         |
| $\Lambda\omega$             | <8%                            | 443         |
| $N\bar{K}^*(892)$           | 10–20%                         | 515         |

 **$\Lambda(2110)F_{05}$** 

$$I(J^P) = 0(\frac{5}{2}^+)$$

Mass  $m = 2090$  to  $2140$  ( $\approx 2110$ ) MeV

Full width  $\Gamma = 150$  to  $250$  ( $\approx 200$ ) MeV

$$p_{\text{beam}} = 1.70 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 8.53 \text{ mb}$$

| $\Lambda(2110)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | 5–25%                          | 757         |
| $\Sigma\pi$                 | 10–40%                         | 711         |
| $\Lambda\omega$             | seen                           | 455         |
| $\Sigma(1385)\pi$           | seen                           | 591         |
| $N\bar{K}^*(892)$           | 10–60%                         | 525         |

 **$\Lambda(2350)H_{09}$** 

$$I(J^P) = 0(\frac{9}{2}^+)$$

Mass  $m = 2340$  to  $2370$  ( $\approx 2350$ ) MeV

Full width  $\Gamma = 100$  to  $250$  ( $\approx 150$ ) MeV

$$p_{\text{beam}} = 2.29 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 5.85 \text{ mb}$$

| $\Lambda(2350)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------|--------------------------------|-------------|
| $N\bar{K}$                  | $\sim 12\%$                    | 915         |
| $\Sigma\pi$                 | $\sim 10\%$                    | 867         |

 **$\Sigma$  BARYONS**

$$(S = -1, I = 1)$$

$$\Sigma^+ = uus, \quad \Sigma^0 = uds, \quad \Sigma^- = dds$$

 **$\Sigma^+$** 

$$I(J^P) = 1(\frac{1}{2}^+)$$

Mass  $m = 1189.37 \pm 0.07$  MeV ( $S = 2.2$ )

Mean life  $\tau = (0.8018 \pm 0.0026) \times 10^{-10}$  s

$$c\tau = 2.404 \text{ cm}$$

$$(\tau_{\Sigma^+}^+ - \tau_{\Sigma^+}^-)/\tau_{\Sigma^+} = (-0.6 \pm 1.2) \times 10^{-3}$$

Magnetic moment  $\mu = 2.458 \pm 0.010 \mu_N$  ( $S = 2.1$ )

$$\Gamma(\Sigma^+ \rightarrow n\ell^+\nu)/\Gamma(\Sigma^- \rightarrow n\ell^-\bar{\nu}) < 0.043$$

**Decay parameters**

|           |                                             |
|-----------|---------------------------------------------|
| $p\pi^0$  | $\alpha_0 = -0.980^{+0.017}_{-0.015}$       |
| "         | $\phi_0 = (36 \pm 34)^\circ$                |
| "         | $\gamma_0 = 0.16^{[i]}$                     |
| "         | $\Delta_0 = (187 \pm 6)^{\circ[i]}$         |
| $n\pi^+$  | $\alpha_+ = 0.068 \pm 0.013$                |
| "         | $\phi_+ = (167 \pm 20)^\circ$ ( $S = 1.1$ ) |
| "         | $\gamma_+ = -0.97^{[i]}$                    |
| "         | $\Delta_+ = (-73^{+133}_{-10})^{\circ[i]}$  |
| $p\gamma$ | $\alpha_\gamma = -0.76 \pm 0.08$            |

| $\Sigma^+$ DECAY MODES                                                                         | Fraction ( $\Gamma_i/\Gamma$ )     | Confidence level     | $p$ (MeV/c) |
|------------------------------------------------------------------------------------------------|------------------------------------|----------------------|-------------|
| $p\pi^0$                                                                                       | $(51.57 \pm 0.30) \%$              |                      | 189         |
| $n\pi^+$                                                                                       | $(48.31 \pm 0.30) \%$              |                      | 185         |
| $p\gamma$                                                                                      | $(1.23 \pm 0.05) \times 10^{-3}$   |                      | 225         |
| $n\pi^+\gamma$                                                                                 | $[j] (4.5 \pm 0.5) \times 10^{-4}$ |                      | 185         |
| $\Lambda e^+ \nu_e$                                                                            | $(2.0 \pm 0.5) \times 10^{-5}$     |                      | 71          |
| $\Delta S = \Delta Q(SQ)$ violating modes or<br>$\Delta S = 1$ weak neutral current (SI) modes |                                    |                      |             |
| $ne^+ \nu_e$                                                                                   | $SQ < 5$                           | $\times 10^{-6}$ 90% | 224         |
| $n\mu^+ \nu_\mu$                                                                               | $SQ < 3.0$                         | $\times 10^{-5}$ 90% | 202         |
| $pe^+ e^-$                                                                                     | $SI < 7$                           | $\times 10^{-6}$     | 225         |
| $p\mu^+ \mu^-$                                                                                 | $SI (9_{-8}^{+9})$                 | $\times 10^{-8}$     | 121         |

$$\boxed{\Sigma^0} \quad I(J^P) = 1(\frac{1}{2}^+)$$

Mass  $m = 1192.642 \pm 0.024$  MeV

$m_{\Sigma^-} - m_{\Sigma^0} = 4.807 \pm 0.035$  MeV (S = 1.1)

$m_{\Sigma^0} - m_\Lambda = 76.959 \pm 0.023$  MeV

Mean life  $\tau = (7.4 \pm 0.7) \times 10^{-20}$  s

$c\tau = 2.22 \times 10^{-11}$  m

Transition magnetic moment  $|\mu_\Sigma \Lambda| = 1.61 \pm 0.08 \mu_N$

| $\Sigma^0$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
|------------------------|--------------------------------|------------------|-------------|
| $\Lambda\gamma$        | 100%                           |                  | 74          |
| $\Lambda\gamma\gamma$  | $< 3\%$                        | 90%              | 74          |
| $\Lambda e^+ e^-$      | $[I] 5 \times 10^{-3}$         |                  | 74          |

$$\boxed{\Sigma^-} \quad I(J^P) = 1(\frac{1}{2}^+)$$

Mass  $m = 1197.449 \pm 0.030$  MeV (S = 1.2)

$m_{\Sigma^-} - m_{\Sigma^+} = 8.08 \pm 0.08$  MeV (S = 1.9)

$m_{\Sigma^-} - m_\Lambda = 81.766 \pm 0.030$  MeV (S = 1.2)

Mean life  $\tau = (1.479 \pm 0.011) \times 10^{-10}$  s (S = 1.3)

$c\tau = 4.434$  cm

Magnetic moment  $\mu = -1.160 \pm 0.025 \mu_N$  (S = 1.7)

$\Sigma^-$  charge radius =  $0.78 \pm 0.10$  fm

#### Decay parameters

|                           |                                           |
|---------------------------|-------------------------------------------|
| $n\pi^-$                  | $\alpha_- = -0.068 \pm 0.008$             |
| "                         | $\phi_- = (10 \pm 15)^\circ$              |
| "                         | $\gamma_- = 0.98^{[i]}$                   |
| "                         | $\Delta_- = (249_{-120}^{+12})^{e[i]}$    |
| $ne^- \bar{\nu}_e$        | $g_A/g_V = 0.340 \pm 0.017^{[f]}$         |
| "                         | $f_2(0)/f_1(0) = 0.97 \pm 0.14$           |
| "                         | $D = 0.11 \pm 0.10$                       |
| $\Lambda e^- \bar{\nu}_e$ | $g_V/g_A = 0.01 \pm 0.10^{[f]} (S = 1.5)$ |
| "                         | $g_{WM}/g_A = 2.4 \pm 1.7^{[f]}$          |

| $\Sigma^-$ DECAY MODES    | Fraction ( $\Gamma_i/\Gamma$ )     | $p$ (MeV/c) |
|---------------------------|------------------------------------|-------------|
| $n\pi^-$                  | $(99.848 \pm 0.005)\%$             | 193         |
| $n\pi^- \gamma$           | $[j] 4.6 \pm 0.6 \times 10^{-4}$   | 193         |
| $ne^- \bar{\nu}_e$        | $(1.017 \pm 0.034) \times 10^{-3}$ | 230         |
| $n\mu^- \bar{\nu}_\mu$    | $(4.5 \pm 0.4) \times 10^{-4}$     | 210         |
| $\Lambda e^- \bar{\nu}_e$ | $(5.73 \pm 0.27) \times 10^{-5}$   | 79          |

$$\boxed{\Sigma(1385)P_{13}} \quad I(J^P) = 1(\frac{3}{2}^+)$$

$\Sigma(1385)^+$  mass  $m = 1382.8 \pm 0.4$  MeV (S = 2.0)

$\Sigma(1385)^0$  mass  $m = 1383.7 \pm 1.0$  MeV (S = 1.4)

$\Sigma(1385)^-$  mass  $m = 1387.2 \pm 0.5$  MeV (S = 2.2)

$\Sigma(1385)^+$  full width  $\Gamma = 35.8 \pm 0.8$  MeV

$\Sigma(1385)^0$  full width  $\Gamma = 36 \pm 5$  MeV

$\Sigma(1385)^-$  full width  $\Gamma = 39.4 \pm 2.1$  MeV (S = 1.7)

Below  $\bar{K}$  N threshold

| $\Sigma(1385)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level     | $p$ (MeV/c) |
|----------------------------|--------------------------------|----------------------|-------------|
| $\Lambda\pi$               | $(87.0 \pm 1.5) \%$            |                      | 208         |
| $\Sigma\pi$                | $(11.7 \pm 1.5) \%$            |                      | 129         |
| $\Lambda\gamma$            | $(1.3 \pm 0.4) \%$             |                      | 241         |
| $\Sigma^- \gamma$          | $< 2.4$                        | $\times 10^{-4}$ 90% | 173         |

$$\boxed{\Sigma(1660)P_{11}} \quad I(J^P) = 1(\frac{1}{2}^+)$$

Mass  $m = 1630$  to  $1690$  ( $\approx 1660$ ) MeV

Full width  $\Gamma = 40$  to  $200$  ( $\approx 100$ ) MeV

$p_{\text{beam}} = 0.72 \text{ GeV}/c$   $4\pi\lambda^2 = 29.9$  mb

| $\Sigma(1660)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\bar{K}$                 | 10–30%                         | 405         |
| $\Lambda\pi$               | seen                           | 440         |
| $\Sigma\pi$                | seen                           | 387         |

$$\boxed{\Sigma(1670)D_{13}} \quad I(J^P) = 1(\frac{3}{2}^-)$$

Mass  $m = 1665$  to  $1685$  ( $\approx 1670$ ) MeV

Full width  $\Gamma = 40$  to  $80$  ( $\approx 60$ ) MeV

$p_{\text{beam}} = 0.74 \text{ GeV}/c$   $4\pi\lambda^2 = 28.5$  mb

| $\Sigma(1670)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\bar{K}$                 | 7–13%                          | 414         |
| $\Lambda\pi$               | 5–15%                          | 448         |
| $\Sigma\pi$                | 30–60%                         | 394         |

$$\boxed{\Sigma(1750)S_{11}} \quad I(J^P) = 1(\frac{1}{2}^-)$$

Mass  $m = 1730$  to  $1800$  ( $\approx 1750$ ) MeV

Full width  $\Gamma = 60$  to  $160$  ( $\approx 90$ ) MeV

$p_{\text{beam}} = 0.91 \text{ GeV}/c$   $4\pi\lambda^2 = 20.7$  mb

| $\Sigma(1750)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\bar{K}$                 | 10–40%                         | 486         |
| $\Lambda\pi$               | seen                           | 507         |
| $\Sigma\pi$                | $< 8\%$                        | 456         |
| $\Sigma\eta$               | 15–55%                         | 99          |

$$\boxed{\Sigma(1775)D_{15}} \quad I(J^P) = 1(\frac{5}{2}^-)$$

Mass  $m = 1770$  to  $1780$  ( $\approx 1775$ ) MeV

Full width  $\Gamma 105$  to  $135$  ( $\approx 120$ ) MeV

$p_{\text{beam}} = 0.96 \text{ GeV}/c$   $4\pi\lambda^2 = 19.0$  mb

| $\Sigma(1775)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\bar{K}$                 | 37–43%                         | 508         |
| $\Lambda\pi$               | 14–20%                         | 525         |
| $\Sigma\pi$                | 2–5%                           | 475         |
| $\Sigma(1385)\pi$          | 8–12%                          | 327         |
| $\Lambda(1520)\pi$         | 17–23%                         | 201         |

$$\boxed{\Sigma(1915)F_{15}} \quad I(J^P) = 1(\frac{5}{2}^+)$$

Mass  $m = 1900$  to  $1935$  ( $\approx 1915$ ) MeV

Full width  $\Gamma = 80$  to  $160$  ( $\approx 120$ ) MeV

$p_{\text{beam}} = 1.26 \text{ GeV}/c$   $4\pi\lambda^2 = 12.8$  mb

| $\Sigma(1915)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\bar{K}$                 | 5–15%                          | 618         |
| $\Lambda\pi$               | seen                           | 623         |
| $\Sigma\pi$                | seen                           | 577         |
| $\Sigma(1385)\pi$          | $< 5\%$                        | 443         |

**$\Sigma(1940)D_{13}$** 

$$I(J^P) = 1(\frac{3}{2}^-)$$

Mass  $m = 1900$  to  $1950$  ( $\approx 1940$ ) MeVFull width  $\Gamma = 150$  to  $300$  ( $\approx 220$ ) MeV

$$p_{\text{beam}} = 1.32 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 12.1 \text{ mb}$$

| $\Sigma(1940)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\bar{K}$                 | <20%                           | 637         |
| $\Lambda\pi$               | seen                           | 640         |
| $\Sigma\pi$                | seen                           | 595         |
| $\Sigma(1385)\pi$          | seen                           | 463         |
| $\Lambda(1520)\pi$         | seen                           | 355         |
| $\Delta(1232)\bar{K}$      | seen                           | 410         |
| $N\bar{K}^*(892)$          | seen                           | 322         |

 **$\Sigma(2030)F_{17}$** 

$$I(J^P) = 1(\frac{7}{2}^+)$$

Mass  $m = 2025$  to  $2040$  ( $\approx 2030$ ) MeVFull width  $\Gamma = 150$  to  $200$  ( $\approx 180$ ) MeV

$$p_{\text{beam}} = 1.52 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 9.93 \text{ mb}$$

| $\Sigma(2030)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\bar{K}$                 | 17–23%                         | 702         |
| $\Lambda\pi$               | 17–23%                         | 700         |
| $\Sigma\pi$                | 5–10%                          | 657         |
| $\Xi K$                    | <2%                            | 422         |
| $\Sigma(1385)\pi$          | 5–15%                          | 532         |
| $\Lambda(1520)\pi$         | 10–20%                         | 430         |
| $\Delta(1232)\bar{K}$      | 10–20%                         | 498         |
| $N\bar{K}^*(892)$          | <5%                            | 439         |

 **$\Sigma(2250)$** 

$$I(J^P) = 1(?^?)$$

Mass  $m = 2210$  to  $2280$  ( $\approx 2250$ ) MeVFull width  $\Gamma = 60$  to  $150$  ( $\approx 100$ ) MeV

$$p_{\text{beam}} = 2.04 \text{ GeV}/c \quad 4\pi\tilde{\lambda}^2 = 6.76 \text{ mb}$$

| $\Sigma(2250)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------------|--------------------------------|-------------|
| $N\bar{K}$                 | <10%                           | 851         |
| $\Lambda\pi$               | seen                           | 842         |
| $\Sigma\pi$                | seen                           | 803         |

 **$\Xi$  BARYONS**

$$(S = -2, I = 1)2)$$

$$\Xi^0 = uss, \Xi^- = dss$$

 **$\Xi^0$** 

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$$

 $P$  is not yet measured; + is the quark model prediction.Mass  $m = 1314.83 \pm 0.20$  MeV

$$m_{\Xi^-} - m_{\Xi^0} = 6.48 \pm 0.24 \text{ MeV}$$

Mean life  $\tau = (2.90 \pm 0.09) \times 10^{-10}$  s

$$c\tau = 8.71 \text{ cm}$$

$$\text{Magnetic moment } \mu = -1.250 \pm 0.014 \mu_N$$

**Decay parameters**

$$\Lambda\pi^0 \quad \alpha = -0.411 \pm 0.022 \text{ (S = 2.1)}$$

$$” \quad \phi = (21 \pm 12)^\circ$$

$$” \quad \gamma = 0.85^{[i]}$$

$$” \quad \Delta = (218_{-19}^{+12})^\circ [i]$$

$$\Lambda\gamma \quad \alpha = -0.73 \pm 0.17$$

$$\Sigma^0\gamma \quad \alpha = -0.63 \pm 0.09$$

$$\Sigma^+e^-\bar{\nu}_e \quad g_1(0)/f_1(0) = 1.32_{-0.18}^{+0.22}$$

$$\Sigma^+e^-\bar{\nu}_e \quad f_2(0)/f_1(0) = 2.0 \pm 1.3$$

| $\Xi^0$ DECAY MODES          | Fraction ( $\Gamma_i/\Gamma$ )       | Confidence level | $p$ (MeV/c) |
|------------------------------|--------------------------------------|------------------|-------------|
| $\Lambda\pi^0$               | $(99.523 \pm 0.013)\%$               |                  | 135         |
| $\Lambda\gamma$              | $(1.17 \pm 0.07) \times 10^{-3}$     |                  | 184         |
| $\Sigma^0\gamma$             | $(3.33 \pm 0.10) \times 10^{-3}$     |                  | 117         |
| $\Sigma^+e^-\bar{\nu}_e$     | $(2.7 \pm 0.4) \times 10^{-4}$       |                  | 119         |
| $\Sigma^+\mu^-\bar{\nu}_\mu$ | $(4.9_{-1.6}^{+2.1}) \times 10^{-6}$ |                  | 64          |

 $\Delta S = \Delta Q(SQ)$  violating modes or $\Delta S = 2$  forbidden (S2) modes

|                        |            |                  |     |     |
|------------------------|------------|------------------|-----|-----|
| $\Sigma^-e^+\nu_e$     | $SQ < 9$   | $\times 10^{-4}$ | 90% | 112 |
| $\Sigma^-\mu^+\nu_\mu$ | $SQ < 9$   | $\times 10^{-4}$ | 90% | 49  |
| $p\pi^-$               | $S2 < 8$   | $\times 10^{-6}$ | 90% | 299 |
| $p e^-\bar{\nu}_e$     | $S2 < 1.3$ | $\times 10^{-3}$ |     | 323 |
| $p\mu^-\bar{\nu}_\mu$  | $S2 < 1.3$ | $\times 10^{-3}$ |     | 309 |

 **$\Xi^-$** 

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$$

 $P$  is not yet measured; + is the quark model prediction.Mass  $m = 1321.31 \pm 0.13$  MeVMean life  $\tau = (1.639 \pm 0.015) \times 10^{-10}$  s

$$c\tau = 4.91 \text{ cm}$$

$$\text{Magnetic moment } \mu = -0.6507 \pm 0.0025 \mu_N$$

**Decay parameters**

$$\Lambda\pi^- \quad \alpha = -0.458 \pm 0.012 \text{ (S = 1.8)}$$

$$[\alpha(\Xi^-)\alpha_-(\Lambda) - \alpha(\Xi^+)\alpha_+(\bar{\Lambda})]/[\text{sum}] = (0 \pm 7) \times 10^{-4}$$

$$” \quad \phi = (-2.1 \pm 0.8)^\circ$$

$$” \quad \gamma = 0.89^{[i]}$$

$$” \quad \Delta = (175.9 \pm 1.5)^\circ [i]$$

$$\Lambda e^-\bar{\nu}_e \quad g_A/g_V = -0.25 \pm 0.05^{[i]}$$

| $\Xi^-$ DECAY MODES                 | Fraction ( $\Gamma_i/\Gamma$ )       | Confidence level | $p$ (MeV/c) |
|-------------------------------------|--------------------------------------|------------------|-------------|
| $\Lambda\pi^-$                      | $(99.887 \pm 0.035)\%$               |                  | 139         |
| $\Sigma^-\gamma$                    | $(1.27 \pm 0.23) \times 10^{-4}$     |                  | 118         |
| $\Lambda e^-\bar{\nu}_e$            | $(5.63 \pm 0.31) \times 10^{-4}$     |                  | 190         |
| $\Lambda\mu^-\bar{\nu}_\mu$         | $(3.5^{+3.5}_{-2.2}) \times 10^{-4}$ |                  | 163         |
| $\Sigma^0 e^-\bar{\nu}_e$           | $(8.7 \pm 1.7) \times 10^{-5}$       |                  | 122         |
| $\Sigma^0 \mu^-\bar{\nu}_\mu$       | $< 8 \times 10^{-4}$                 | 90%              | 70          |
| $\Xi^0 e^- \nu_e$                   | $< 2.3 \times 10^{-3}$               | 90%              | 6           |
| $\Delta S = 2$ forbidden (S2) modes |                                      |                  |             |
| $n\pi^-$                            | $S2 < 1.9 \times 10^{-5}$            | 90%              | 303         |
| $ne^-\bar{\nu}_e$                   | $S2 < 3.2 \times 10^{-3}$            | 90%              | 327         |
| $n\mu^-\bar{\nu}_\mu$               | $S2 < 1.5 \%$                        | 90%              | 313         |
| $p\pi^-\pi^-$                       | $S2 < 4 \times 10^{-4}$              | 90%              | 223         |
| $p\pi^-e^-\bar{\nu}_e$              | $S2 < 4 \times 10^{-4}$              | 90%              | 304         |
| $p\pi^-\mu^-\bar{\nu}_\mu$          | $S2 < 4 \times 10^{-4}$              | 90%              | 250         |
| $p\mu^-\mu^-$                       | $L < 4 \times 10^{-8}$               | 90%              | 272         |

 **$\Xi(1530)P_{13}$** 

$$I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$$

 $\Xi(1530)^0$  mass  $m = 1531.80 \pm 0.32$  MeV (S = 1.3) $\Xi(1530)^-$  mass  $m = 1535.0 \pm 0.6$  MeV $\Xi(1530)^0$  full width  $\Gamma = 9.1 \pm 0.5$  MeV $\Xi(1530)^-$  full width  $\Gamma = 9.9_{-1.9}^{+1.7}$  MeV

| $\Xi(1530)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
|-------------------------|--------------------------------|------------------|-------------|
| $\Xi\pi$                | 100%                           |                  | 158         |
| $\Xi\gamma$             | < 4%                           | 90%              | 202         |

$\Xi(1690)$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Mass  $m = 1690 \pm 10$  MeV<sup>[k]</sup>

Full width  $\Gamma < 30$  MeV

| $\Xi(1690)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\Lambda \bar{K}$       | seen                           | 240         |
| $\Sigma \bar{K}$        | seen                           | 70          |
| $\Xi\pi$                | seen                           | 311         |
| $\Xi^- \pi^+ \pi^-$     | possibly seen                  | 214         |

$\Xi(1820)D_{13}$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Mass  $m = 1823 \pm 5 \text{ MeV}^{[k]}$   
 Full width  $\Gamma = 24^{+15}_{-10} \text{ MeV}^{[k]}$

| $\Xi(1820)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-------------------------|--------------------------------|-------------|
| $\Lambda \bar{K}$       | large                          | 402         |
| $\Sigma \bar{K}$        | small                          | 324         |
| $\Xi\pi$                | small                          | 421         |
| $\Xi(1530)\pi$          | small                          | 237         |

Ξ(1950)

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$

Mass  $m = 1950 \pm 15$  MeV<sup>[k]</sup>

Full width  $\Gamma = 60 \pm 20$  MeV<sup>[k]</sup>

| Ξ (1950) DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------|--------------------------------|-------------|
| $\Lambda \bar{K}$    | seen                           | 522         |
| $\Sigma \bar{K}$     | possibly seen                  | 460         |
| $\Xi \pi$            | seen                           | 519         |

Ξ(2030)

$I(J^P) = \frac{1}{2}(\geq \frac{5}{2}^-)$

Mass  $m = 2025 \pm 5 \text{ MeV}^{[k]}$

Full width  $\Gamma = 20^{+15}_{-5} \text{ MeV}^{[k]}$

| Ξ (2030) DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|----------------------|--------------------------------|-------------|
| $\Lambda \bar{K}$    | $\sim 20\%$                    | 585         |
| $\Sigma \bar{K}$     | $\sim 80\%$                    | 529         |
| $\Xi\pi$             | small                          | 574         |
| $\Xi(1530)\pi$       | small                          | 416         |
| $\Lambda \bar{K}\pi$ | small                          | 499         |
| $\Sigma \bar{K}\pi$  | small                          | 428         |

|                                    |
|------------------------------------|
| <b><math>\Omega</math> BARYONS</b> |
| $(S = -3, I = 0)$                  |
| $\Omega^- = sss$                   |

|                                                                           |                             |
|---------------------------------------------------------------------------|-----------------------------|
| <b><math>\Omega^-</math></b>                                              | $I(J^P) = 0(\frac{3}{2}^+)$ |
| $J^P$ is not yet measured; $\frac{3}{2}^+$ is the quark model prediction. |                             |
| Mass $m = 1672.45 \pm 0.29$ MeV                                           |                             |
| $(m_{\Omega^-} - m_{\Omega^+})/m_{\Omega^-} = (-1 \pm 8) \times 10^{-5}$  |                             |
| Mean life $\tau = (0.821 \pm 0.011) \times 10^{-10}$ s                    |                             |
| $c\tau = 2.461$ cm                                                        |                             |
| $(\tau_{\Omega^-} - \tau_{\Omega^+})/\tau_{\Omega^-} = -0.002 \pm 0.040$  |                             |
| Magnetic moment $\mu = -2.02 \pm 0.05\mu_N$                               |                             |

|                                                                |                              |
|----------------------------------------------------------------|------------------------------|
| <b>Decay parameters</b>                                        |                              |
| $\Lambda K^-$                                                  | $\alpha = 0.0175 \pm 0.0024$ |
| $\frac{1}{2}[\alpha(\Lambda K^-) + \alpha(\bar{\Lambda} K^+)]$ | $= 0.00 \pm 0.04$            |
| $\Xi^0 \pi^-$                                                  | $\alpha = 0.09 \pm 0.14$     |
| $\Xi^- \pi^0$                                                  | $\alpha = 0.05 \pm 0.21$     |

| $\Omega^-$ DECAY MODES                  | Fraction ( $\Gamma_i/\Gamma$ )       | Confidence level | (MeV/c) |
|-----------------------------------------|--------------------------------------|------------------|---------|
| $\Lambda K^-$                           | $(67.8 \pm 0.7) \%$                  |                  | 211     |
| $\Xi^0 \pi^-$                           | $(23.6 \pm 0.7) \%$                  |                  | 294     |
| $\Xi^- \pi^0$                           | $(8.6 \pm 0.4) \%$                   |                  | 290     |
| $\Xi^- \pi^+ \pi^-$                     | $(4.3^{+3.4}_{-1.3}) \times 10^{-4}$ |                  | 190     |
| $\Xi(1530)^0 \pi^-$                     | $(6.4^{+5.1}_{-2.0}) \times 10^{-4}$ |                  | 17      |
| $\Xi^0 e^- \bar{\nu}_e$                 | $(5.6 \pm 2.8) \times 10^{-3}$       |                  | 319     |
| $\Xi^- \gamma$                          | $< 4.6 \times 10^{-4}$               | 90%              | 314     |
| $\Delta S = 2$ forbidden ( $S2$ ) modes |                                      |                  |         |
| $\Lambda \pi^-$                         | $S2 < 2.9 \times 10^{-6}$            | 90%              | 449     |

|                                    |                             |
|------------------------------------|-----------------------------|
| <b><math>\Omega(2250)^-</math></b> | $I(J^P) = 0(\frac{3}{2}^-)$ |
|------------------------------------|-----------------------------|

Mass  $m = 2252 \pm 9$  MeV  
Full width  $\Gamma = 55 \pm 18$  MeV

| $\Omega(2250)^-$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|------------------------------|--------------------------------|-------------|
| $\Xi^- \pi^+ K^-$            | seen                           | 532         |
| $\Xi(1530)^0 K^-$            | seen                           | 437         |

|                                                                                         |  |
|-----------------------------------------------------------------------------------------|--|
| <b>CHARMED BARYONS (<math>C = +1</math>)</b>                                            |  |
| $\Lambda_c^+ = udc$ , $\Sigma_c^{++} = uuc$ , $\Sigma_c^+ = udc$ , $\Sigma_c^0 = ddc$ , |  |
| $\Xi_c^+ = usc$ , $\Xi_c^0 = dsc$ , $\Omega_c^0 = ssc$                                  |  |

|                                 |                             |
|---------------------------------|-----------------------------|
| <b><math>\Lambda_c^+</math></b> | $I(J^P) = 0(\frac{1}{2}^+)$ |
|---------------------------------|-----------------------------|

$J$  is not well measured;  $\frac{1}{2}$  is the quark-model prediction.  
Mass  $m = 2286.46 \pm 0.14$  MeV  
Mean life  $\tau = (200 \pm 6) \times 10^{-15}$  s ( $S = 1.6$ )  
 $c\tau = 59.9\mu\text{m}$

#### Decay asymmetry parameters

|                                                                                                                                                                                                                      |                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| $\Lambda \pi^+$                                                                                                                                                                                                      | $\alpha = -0.91 \pm 0.15$ |
| $\Sigma^+ \pi^0$                                                                                                                                                                                                     | $\alpha = -0.45 \pm 0.32$ |
| $\Lambda \ell^+ \nu_\ell$                                                                                                                                                                                            | $\alpha = -0.86 \pm 0.04$ |
| $[\alpha(\Lambda_c^+) + \alpha(\bar{\Lambda}_c^-)]/[\alpha(\Lambda_c^+) - \alpha(\bar{\Lambda}_c^-)]$ in $\Lambda_c^+ \rightarrow \Lambda \pi^+$ , $\bar{\Lambda}_c^- \rightarrow \bar{\Lambda} \pi^-$               |                           |
| $\bar{\Lambda} \pi^- = -0.07 \pm 0.31$                                                                                                                                                                               |                           |
| $[\alpha(\Lambda_c^+) + \alpha(\bar{\Lambda}_c^-)]/[\alpha(\Lambda_c^+) - \alpha(\bar{\Lambda}_c^-)]$ in $\Lambda_c^+ \rightarrow \Lambda e^+ \nu_e$ , $\bar{\Lambda}_c^- \rightarrow \bar{\Lambda} e^- \bar{\nu}_e$ |                           |
| $\bar{\nu}_e = 0.00 \pm 0.04$                                                                                                                                                                                        |                           |

Nearly all branching fractions of the  $\Lambda_c^+$  are measured relative to the  $pK^- \pi^+$  mode, but there are no model-independent measurements of this branching fraction. We explain how we arrive at our value of  $B(\Lambda_c^+ \rightarrow pK^- \pi^+)$  in a Note at the beginning of the branching-ratio measurements in the Listings. When this branching fraction is eventually well determined, all the other branching fractions will slide up or down proportionally as the true value differs from the value we use here.

| $\Lambda_c^+$ DECAY MODES                                                     | Fraction ( $\Gamma_i/\Gamma$ ) | Scale factor/<br>Confidence level | $p$<br>(MeV/c) |
|-------------------------------------------------------------------------------|--------------------------------|-----------------------------------|----------------|
| <b>Hadronic modes with a <math>p</math>: <math>S = -1</math> final states</b> |                                |                                   |                |
| $p \bar{K}^0$                                                                 | $(2.3 \pm 0.6) \%$             |                                   | 873            |
| $p K^- \pi^+$                                                                 | $[m] (5.0 \pm 1.3) \%$         |                                   | 823            |
| $p \bar{K}^* (892)^0$                                                         | $[n] (1.6 \pm 0.5) \%$         |                                   | 685            |
| $\Delta(1232)^{++} K^-$                                                       | $(8.6 \pm 3.0) \times 10^{-3}$ |                                   | 710            |
| $\Lambda(1520) \pi^+$                                                         | $[n] (1.8 \pm 0.6) \%$         |                                   | 627            |
| $p K^- \pi^+$ nonresonant                                                     | $(2.8 \pm 0.8) \%$             |                                   | 823            |
| $p \bar{K}^0 \pi^0$                                                           | $(3.3 \pm 1.0) \%$             |                                   | 823            |
| $p \bar{K}^0 \eta$                                                            | $(1.2 \pm 0.4) \%$             |                                   | 568            |
| $p \bar{K}^0 \pi^+ \pi^-$                                                     | $(2.6 \pm 0.7) \%$             |                                   | 754            |
| $p K^- \pi^+ \pi^0$                                                           | $(3.4 \pm 1.0) \%$             |                                   | 759            |
| $p K^* (892)^- \pi^+$                                                         | $[n] (1.1 \pm 0.5) \%$         |                                   | 580            |
| $p(K^- \pi^+)_{\text{nonresonant}} \pi^0$                                     | $(3.6 \pm 1.2) \%$             |                                   | 759            |
| $\Delta(1232) \bar{K}^* (892)$                                                | seen                           |                                   | 419            |
| $p K^- \pi^+ \pi^+ \pi^-$                                                     | $(1.1 \pm 0.8) \times 10^{-3}$ |                                   | 671            |
| $p K^- \pi^+ \pi^0 \pi^0$                                                     | $(8 \pm 4) \times 10^{-3}$     |                                   | 678            |



| Hadronic modes with a $p$ : $S = 0$ final states                                     |                                    |          |     |
|--------------------------------------------------------------------------------------|------------------------------------|----------|-----|
| $p\pi^+\pi^-$                                                                        | $(3.5 \pm 2.0) \times 10^{-3}$     |          | 927 |
| $p\bar{f}_0(980)$                                                                    | $[n] (2.8 \pm 1.9) \times 10^{-3}$ |          | 622 |
| $p\pi^+\pi^+\pi^-\pi^-$                                                              | $(1.8 \pm 1.2) \times 10^{-3}$     |          | 852 |
| $pK^+K^-$                                                                            | $(7.7 \pm 3.5) \times 10^{-4}$     |          | 616 |
| $p\phi$                                                                              | $[n] (8.2 \pm 2.7) \times 10^{-4}$ |          | 590 |
| $pK^+K^-$ non- $\phi$                                                                | $(3.5 \pm 1.7) \times 10^{-4}$     |          | 616 |
| Hadronic modes with a hyperon: $S = -1$ final states                                 |                                    |          |     |
| $\Lambda\pi^+$                                                                       | $(1.01 \pm 0.28)\%$                |          | 864 |
| $\Lambda\pi^+\pi^0$                                                                  | $(3.6 \pm 1.3)\%$                  |          | 844 |
| $\Lambda\rho^+$                                                                      | $< 5\%$                            | CL = 95% | 635 |
| $\Lambda\pi^+\pi^+\pi^-$                                                             | $(2.6 \pm 0.7)\%$                  |          | 807 |
| $\Sigma(1385)^+\pi^+\pi^-, \Sigma^*+ \rightarrow \Lambda\pi^+$                       | $(7 \pm 4) \times 10^{-3}$         |          | 688 |
| $\Sigma(1385)^-\pi^+\pi^+, \Sigma^*- \rightarrow \Lambda\pi^-$                       | $(5.5 \pm 1.7) \times 10^{-3}$     |          | 688 |
| $\Lambda\pi^+\rho^0$                                                                 | $(1.1 \pm 0.5)\%$                  |          | 523 |
| $\Sigma(1385)^+\rho^0, \Sigma^*+ \rightarrow \Lambda\pi^+$                           | $(3.7 \pm 3.1) \times 10^{-3}$     |          | 363 |
| $\Lambda\pi^+\pi^+\pi^-$ nonresonant                                                 | $< 8 \times 10^{-3}$               | CL = 90% | 807 |
| $\Lambda\pi^+\pi^+\pi^0$ total                                                       | $(1.8 \pm 0.8)\%$                  |          | 757 |
| $\Lambda\pi^+\eta$                                                                   | $[n] (1.8 \pm 0.6)\%$              |          | 691 |
| $\Sigma(1385)^+\eta$                                                                 | $[n] (8.5 \pm 3.3) \times 10^{-3}$ |          | 570 |
| $\Lambda\pi^+\omega$                                                                 | $[n] (1.2 \pm 0.5)\%$              |          | 517 |
| $\Lambda\pi^+\pi^+\pi^0$ , no $\eta$ or $\omega$                                     | $< 7 \times 10^{-3}$               | CL = 90% | 757 |
| $\Lambda K + \bar{K}^0$                                                              | $(6.5 \pm 2.0) \times 10^{-3}$     |          | 443 |
| $\Xi(1690)^0 K^+, \Xi^*0 \rightarrow \Sigma^+ K^-$                                   | $(1.9 \pm 0.7) \times 10^{-3}$     |          | 286 |
| $\Sigma^0\pi^+$                                                                      | $(1.04 \pm 0.31)\%$                |          | 825 |
| $\Sigma^+\pi^0$                                                                      | $(1.00 \pm 0.34)\%$                |          | 827 |
| $\Sigma^+\eta$                                                                       | $(5.5 \pm 2.3) \times 10^{-3}$     |          | 714 |
| $\Sigma^+\pi^+\pi^-$                                                                 | $(3.6 \pm 1.0)\%$                  |          | 804 |
| $\Sigma^+\rho^0$                                                                     | $< 1.4\%$                          | CL = 95% | 575 |
| $\Sigma^-\pi^+\pi^+$                                                                 | $(1.9 \pm 0.8)\%$                  |          | 799 |
| $\Sigma^0\pi^+\pi^0$                                                                 | $(1.8 \pm 0.8)\%$                  |          | 803 |
| $\Sigma^0\pi^+\pi^+\pi^-$                                                            | $(8.3 \pm 3.1) \times 10^{-3}$     |          | 763 |
| $\Sigma^+\pi^+\pi^-\pi^0$                                                            | —                                  |          | 767 |
| $\Sigma^+\omega$                                                                     | $[n] (2.7 \pm 1.0)\%$              |          | 569 |
| $\Sigma^+K^+K^-$                                                                     | $(2.8 \pm 0.8) \times 10^{-3}$     |          | 349 |
| $\Sigma^+\phi$                                                                       | $[n] (3.2 \pm 1.0) \times 10^{-3}$ |          | 295 |
| $\Xi(1690)^0 K^+, \Xi^*0 \rightarrow \Sigma^+ K^-$                                   | $(8.2 \pm 3.1) \times 10^{-4}$     |          | 286 |
| $\Sigma^+K^+K^-$ nonresonant                                                         | $< 7 \times 10^{-4}$               | CL = 90% | 349 |
| $\Xi^0 K^+$                                                                          | $(3.9 \pm 1.4) \times 10^{-3}$     |          | 653 |
| $\Xi^- K^+\pi^+$                                                                     | $(4.9 \pm 1.7) \times 10^{-3}$     |          | 566 |
| $\Xi(1530)^0 K^+$                                                                    | $[n] (2.6 \pm 1.0) \times 10^{-3}$ |          | 473 |
| Hadronic modes with a hyperon: $S = 0$ final states                                  |                                    |          |     |
| $\Lambda K^+$                                                                        | $(7.5 \pm 2.6) \times 10^{-4}$     |          | 781 |
| $\Sigma^0 K^+$                                                                       | $(5.8 \pm 2.4) \times 10^{-4}$     |          | 735 |
| $\Sigma^+ K^+\pi^-$                                                                  | $(1.7 \pm 0.7) \times 10^{-3}$     |          | 670 |
| $\Sigma^+ K^*(892)^0$                                                                | $[n] (2.8 \pm 1.1) \times 10^{-3}$ |          | 470 |
| $\Sigma^- K^+\pi^+$                                                                  | $< 1.0 \times 10^{-3}$             | CL = 90% | 664 |
| Doubly Cabibbo-suppressed modes                                                      |                                    |          |     |
| $pK^+\pi^-$                                                                          | $< 2.3 \times 10^{-4}$             | CL = 90% | 823 |
| Semileptonic modes                                                                   |                                    |          |     |
| $\Lambda\ell^+\nu_\ell$                                                              | $[o] (2.0 \pm 0.6)\%$              |          | 871 |
| $\Lambda e^+\nu_e$                                                                   | $(2.1 \pm 0.6)\%$                  |          | 871 |
| $\Lambda\mu^+\nu_\mu$                                                                | $(2.0 \pm 0.7)\%$                  |          | 867 |
| Inclusive modes                                                                      |                                    |          |     |
| $e^+$ anything                                                                       | $(4.5 \pm 1.7)\%$                  |          | —   |
| $pe^+$ anything                                                                      | $(1.8 \pm 0.9)\%$                  |          | —   |
| $p$ anything                                                                         | $(50 \pm 16)\%$                    |          | —   |
| $p$ anything (no $\Lambda$ )                                                         | $(12 \pm 19)\%$                    |          | —   |
| $n$ anything                                                                         | $(50 \pm 16)\%$                    |          | —   |
| $n$ anything (no $\Lambda$ )                                                         | $(29 \pm 17)\%$                    |          | —   |
| $\Lambda$ anything                                                                   | $(35 \pm 11)\%$                    | S = 1.4  | —   |
| $\Sigma^\pm$ anything                                                                | $[p] (10 \pm 5)\%$                 |          | —   |
| 3prongs                                                                              | $(24 \pm 8)\%$                     |          | —   |
| $\Delta C = 1$ weak neutral current (C1) modes, or Lepton number (L) violating modes |                                    |          |     |
| $p\mu^+\mu^-$                                                                        | C1 $< 3.4 \times 10^{-4}$          | CL = 90% | 937 |
| $\Sigma^-\mu^+\mu^+$                                                                 | L $< (7.0) \times 10^{-4}$         | CL = 90% | 812 |

 **$\Lambda_c(2593)^+$** 

$$I(J^P) = 0(\frac{1}{2}^-)$$

The spin-parity follows from the fact that  $\Sigma_c(2455)\pi$  decays, with little available phase space, are dominant. This assumes that  $J^P = 1/2^+$  for the  $\Sigma_c(2455)$ .

$$\text{Mass } m = 2595.4 \pm 0.6 \text{ MeV } (S = 1.1)$$

$$m - m_{\Lambda_c^+} = 308.9 \pm 0.6 \text{ MeV } (S = 1.1)$$

$$\text{Full width } \Gamma = 3.6_{-1.3}^{+2.0} \text{ MeV}$$

$\Lambda_c^+\pi\pi$  and its submode  $\Sigma_c(2455)\pi$  — the latter just barely — are the only strong decays allowed to an excited  $\Lambda_c^+$  having this mass; and the submode seems to dominate.

| $\Lambda_c(2593)^+$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $\Lambda_c^+\pi^+\pi^-$         | $[q] \approx 67\%$             | 124         |
| $\Sigma_c(2455)^{++}\pi^-$      | $24 \pm 7\%$                   | 28          |
| $\Sigma_c(2455)^0\pi^+$         | $24 \pm 7\%$                   | 28          |
| $\Lambda_c^+\pi^+\pi^-$ 3-body  | $18 \pm 10\%$                  | 124         |
| $\Lambda_c^+\pi^0$              | $[r]$ not seen                 | 261         |
| $\Lambda_c^+\gamma$             | not seen                       | 291         |

 **$\Lambda_c(2625)^+$** 

$$I(J^P) = 0(\frac{3}{2}^-)$$

$J^P$  has not been measured;  $\frac{3}{2}^-$  is the quark-model prediction.

$$\text{Mass } m = 2628.1 \pm 0.6 \text{ MeV } (S = 1.5)$$

$$m - m_{\Lambda_c^+} = 341.7 \pm 0.6 \text{ MeV } (S = 1.6)$$

$$\text{Full width } \Gamma < 1.9 \text{ MeV, CL} = 90\%$$

$\Lambda_c^+\pi\pi$  and its submode  $\Sigma(2455)\pi$  are the only strong decays allowed to an excited  $\Lambda_c^+$  having this mass.

| $\Lambda_c(2625)^+$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
|---------------------------------|--------------------------------|------------------|-------------|
| $\Lambda_c^+\pi^+\pi^-$         | $[q] \approx 67\%$             |                  | 184         |
| $\Sigma_c(2455)^{++}\pi^-$      | $< 5$                          | 90%              | 102         |
| $\Sigma_c(2455)^0\pi^+$         | $< 5$                          | 90%              | 102         |
| $\Lambda_c^+\pi^+\pi^-$ 3-body  | large                          |                  | 184         |
| $\Lambda_c^+\pi^0$              | $[r]$ not seen                 |                  | 293         |
| $\Lambda_c^+\gamma$             | not seen                       |                  | 319         |

 **$\Sigma_c(2455)$** 

$$I(J^P) = 1(\frac{1}{2}^+)$$

$J^P$  has not been measured;  $\frac{1}{2}^+$  is the quark-model prediction.

$$\Sigma_c(2455)^{++} \text{ mass } m = 2454.02 \pm 0.18 \text{ MeV}$$

$$\Sigma_c(2455)^+ \text{ mass } m = 2452.9 \pm 0.4 \text{ MeV}$$

$$\Sigma_c(2455)^0 \text{ mass } m = 2453.76 \pm 0.18 \text{ MeV}$$

$$m_{\Sigma_c^{++}} - m_{\Lambda_c^+} = 167.56 \pm 0.11 \text{ MeV}$$

$$m_{\Sigma_c^+} - m_{\Lambda_c^+} = 166.4 \pm 0.4 \text{ MeV}$$

$$m_{\Sigma_c^0} - m_{\Lambda_c^+} = 167.30 \pm 0.11 \text{ MeV}$$

$$m_{\Sigma_c^{++}} - m_{\Sigma_c^0} = 0.27 \pm 0.11 \text{ MeV } (S = 1.1)$$

$$m_{\Sigma_c^+} - m_{\Sigma_c^0} = -0.9 \pm 0.4 \text{ MeV}$$

$$\Sigma_c(2455)^{++} \text{ full width } \Gamma = 2.23 \pm 0.30 \text{ MeV}$$

$$\Sigma_c(2455)^+ \text{ full width } \Gamma < 4.6 \text{ MeV, CL} = 90\%$$

$$\Sigma_c(2455)^0 \text{ full width } \Gamma = 2.2 \pm 0.4 \text{ MeV } (S = 1.4)$$

$\Lambda_c^+\pi$  is the only strong decay allowed to a  $\Sigma_c$  having this mass.

| $\Sigma_c(2455)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|------------------------------|--------------------------------|-------------|
| $\Lambda_c^+\pi$             | $\approx 100\%$                | 94          |

|                                                                                      |                                            |
|--------------------------------------------------------------------------------------|--------------------------------------------|
| $\Sigma_c(2520)$                                                                     | $I(J^P) = 1(\frac{3}{2}^+)$                |
| $J^P$ has not been measured; $\frac{3}{2}^+$ is the quark model prediction.          |                                            |
| $\Sigma_c(2520)^{++}$ mass $m = 2518.4 \pm 0.6$ MeV ( $S = 1.4$ )                    |                                            |
| $\Sigma_c(2520)^+$ mass $m = 2517.5 \pm 2.3$ MeV                                     |                                            |
| $\Sigma_c(2520)^0$ mass $m = 2518.0 \pm 0.5$ MeV                                     |                                            |
| $m_{\Sigma_c(2520)^{++}} - m_{\Lambda_c^+} = 231.9 \pm 0.6$ MeV ( $S = 1.5$ )        |                                            |
| $m_{\Sigma_c(2520)^+} - m_{\Lambda_c^+} = 231.0 \pm 2.3$ MeV                         |                                            |
| $m_{\Sigma_c(2520)^0} - m_{\Lambda_c^+} = 231.6 \pm 0.5$ MeV ( $S = 1.1$ )           |                                            |
| $m_{\Sigma_c(2520)^{++}} - m_{\Sigma_c(2520)^0} = 0.3 \pm 0.6$ MeV ( $S = 1.2$ )     |                                            |
| $\Sigma_c(2520)^{++}$ full width $\Gamma = 14.9 \pm 1.9$ MeV                         |                                            |
| $\Sigma_c(2520)^+$ full width $\Gamma < 17$ MeV, CL = 90%                            |                                            |
| $\Sigma_c(2520)^0$ full width $\Gamma = 16.1 \pm 2.1$ MeV                            |                                            |
| $\Lambda_c^+ \pi$ is the only strong decay allowed to a $\Sigma_c$ having this mass. |                                            |
| $\Sigma_c(2520)$ DECAY MODES                                                         | Fraction ( $\Gamma_i/\Gamma$ ) $p$ (MeV/c) |
| $\Lambda_c^+ \pi$                                                                    | $\approx 100\%$ 180                        |

|                                                             |                                            |
|-------------------------------------------------------------|--------------------------------------------|
| $\Sigma_c(2800)$                                            | $I(J^P) = 1(?^?)$                          |
| $\Sigma_c(2800)^{++}$ mass $m = 2801_{-6}^{+4}$             |                                            |
| $\Sigma_c(2800)^+$ mass $m = 2792_{-5}^{+14}$               |                                            |
| $\Sigma_c(2800)^0$ mass $m = 2802_{-7}^{+4}$                |                                            |
| $m_{\Sigma_c(2800)^{++}} - m_{\Lambda_c^+} = 514_{-6}^{+4}$ |                                            |
| $m_{\Sigma_c(2800)^+} - m_{\Lambda_c^+} = 505_{-5}^{+14}$   |                                            |
| $m_{\Sigma_c(2800)^0} - m_{\Lambda_c^+} = 515_{-7}^{+4}$    |                                            |
| $\Sigma_c(2800)^{++}$ full width $\Gamma = 75_{-17}^{+22}$  |                                            |
| $\Sigma_c(2800)^+$ full width $\Gamma = 62_{-40}^{+60}$     |                                            |
| $\Sigma_c(2800)^0$ full width $\Gamma = 61_{-18}^{+28}$     |                                            |
| $\Sigma_c(2800)$ DECAY MODES                                | Fraction ( $\Gamma_i/\Gamma$ ) $p$ (MeV/c) |
| $\Lambda_c^+ \pi$                                           | seen    443                                |

|                                                                             |                                       |
|-----------------------------------------------------------------------------|---------------------------------------|
| $\Xi_c^+$                                                                   | $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ |
| $J^P$ has not been measured; $\frac{1}{2}^+$ is the quark model prediction. |                                       |
| Mass $m = 2467.9 \pm 0.4$ MeV                                               |                                       |
| Mean life $\tau = (442 \pm 26) \times 10^{-15}$ s ( $S = 1.3$ )             |                                       |
| $c\tau = 132\mu$ m                                                          |                                       |

|                                                                                                                                    |                                |                  |             |
|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------------------|-------------|
| $\Xi_c^+$ DECAY MODES                                                                                                              | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
| No absolute branching fractions have been measured.<br>The following are branching <i>ratios</i> relative to $\Xi^- \pi^+ \pi^+$ . |                                |                  |             |

|                                     |       |                     |     |
|-------------------------------------|-------|---------------------|-----|
| Cabibbo-favored ( $S = -2$ ) decays |       |                     |     |
| $p K_S^0 K_S^0$                     | [s]   | $0.087 \pm 0.022$   | 767 |
| $\Lambda \bar{K}^0 \pi^+$           | —     |                     | 852 |
| $\Sigma(1385)^+ \bar{K}^0$          | [n,s] | $1.0 \pm 0.5$       | 746 |
| $\Lambda K^- \pi^+ \pi^+$           | [s]   | $0.323 \pm 0.033$   | 787 |
| $\Lambda \bar{K}^*(892)^0 \pi^+$    | [n,s] | $< 0.2$             | 608 |
| $\Sigma(1385)^+ K^- \pi^+$          | [n,s] | $< 0.3$             | 678 |
| $\Sigma^+ K^- \pi^+$                | [s]   | $0.94 \pm 0.11$     | 811 |
| $\Sigma^+ \bar{K}^*(892)^0$         | [n,s] | $0.81 \pm 0.15$     | 658 |
| $\Sigma^0 K^- \pi^+ \pi^+$          | [s]   | $0.29 \pm 0.16$     | 735 |
| $\Xi^0 \pi^+$                       | [s]   | $0.55 \pm 0.16$     | 877 |
| $\Xi^- \pi^+ \pi^+$                 | [s]   | DEFINED AS 1        | 851 |
| $\Xi(1530)^0 \pi^+$                 | [n,s] | $< 0.1$             | 750 |
| $\Xi^0 \pi^+ \pi^0$                 | [s]   | $2.34 \pm 0.68$     | 856 |
| $\Xi^0 \pi^+ \pi^+ \pi^-$           | [s]   | $1.74 \pm 0.50$     | 818 |
| $\Xi^0 e^+ \nu_e$                   | [s]   | $2.3_{-0.9}^{+0.7}$ | 884 |
| $\omega^- K^+ \pi^+$                | [s]   | $0.07 \pm 0.04$     | 399 |

|                                                         |       |                 |         |
|---------------------------------------------------------|-------|-----------------|---------|
| Cabibbo-suppressed decays                               |       |                 |         |
| $p K^- \pi^+$                                           | [s]   | $0.21 \pm 0.03$ | 944     |
| $p \bar{K}^*(892)^0$                                    | [n,s] | $0.12 \pm 0.02$ | 828     |
| $\Sigma^+ K^+ K^-$                                      | [s]   | $0.15 \pm 0.07$ | 580     |
| $\Sigma^+ \phi$                                         | [n,s] | $< 0.11$        | 90% 549 |
| $\Xi(1690)^0 K^+, \Xi(1690)^0 \rightarrow \Sigma^+ K^-$ | [s]   | $< 0.05$        | 90% 501 |

|                                                                             |                                       |
|-----------------------------------------------------------------------------|---------------------------------------|
| $\Xi_c^0$                                                                   | $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ |
| $J^P$ has not been measured; $\frac{1}{2}^+$ is the quark-model prediction. |                                       |
| Mass $m = 2471.0 \pm 0.4$ MeV                                               |                                       |
| $m_{\Xi_c^0} - m_{\Xi_c^+} = 3.1 \pm 0.5$ MeV                               |                                       |
| Mean life $\tau = (112_{-10}^{+13}) \times 10^{-15}$ s                      |                                       |
| $c\tau = 33.6\mu$ m                                                         |                                       |

## Decay asymmetry parameters

$$\Xi^- \pi^+ \quad \alpha = -0.6 \pm 0.4$$

No absolute branching fractions have been measured. Several measurements of ratios of fractions may be found in the Listings that follow.

|                                         |                                |             |
|-----------------------------------------|--------------------------------|-------------|
| $\Xi_c^0$ DECAY MODES                   | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
| $p K^- K^- \pi^+$                       | seen                           | 676         |
| $p K^- \bar{K}^*(892)^0$                | seen                           | 413         |
| $p K^- K^- \pi^+$ no $\bar{K}^*(892)^0$ | seen                           | 676         |
| $\Lambda K_S^0$                         | seen                           | 906         |
| $\Lambda \bar{K}^0 \pi^+ \pi^-$         | seen                           | 787         |
| $\Lambda K^- \pi^+ \pi^+ \pi^-$         | seen                           | 703         |
| $\Xi^- \pi^+$                           | seen                           | 875         |
| $\Xi^- \pi^+ \pi^+ \pi^-$               | seen                           | 817         |
| $\Omega^- K^+$                          | seen                           | 523         |
| $\Xi^- e^+ \nu_e$                       | seen                           | 882         |
| $\Xi^- \ell^+$ anything                 | seen                           | —           |

|              |                                       |
|--------------|---------------------------------------|
| $\Xi_c^{*+}$ | $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ |
|--------------|---------------------------------------|

|                                                                                        |  |
|----------------------------------------------------------------------------------------|--|
| $J^P$ has not been measured; $\frac{1}{2}^+$ is the quark-model prediction.            |  |
| Mass $m = 2575.7 \pm 3.1$ MeV                                                          |  |
| $m_{\Xi_c^{*+}} - m_{\Xi_c^+} = 107.8 \pm 3.0$ MeV                                     |  |
| The $\Xi_c^{*+} - \Xi_c^+$ mass difference is too small for any strong decay to occur. |  |

|                          |                                |             |
|--------------------------|--------------------------------|-------------|
| $\Xi_c^{*+}$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
| $\Xi_c^{*+} \gamma$      | seen                           | 106         |

|              |                                       |
|--------------|---------------------------------------|
| $\Xi_c^{*0}$ | $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ |
|--------------|---------------------------------------|

|                                                                                        |  |
|----------------------------------------------------------------------------------------|--|
| $J^P$ has not been measured; $\frac{1}{2}^+$ is the quark model prediction.            |  |
| Mass $m = 2578.0 \pm 2.9$ MeV                                                          |  |
| $m_{\Xi_c^{*0}} - m_{\Xi_c^0} = 107.0 \pm 2.9$ MeV                                     |  |
| The $\Xi_c^{*0} - \Xi_c^0$ mass difference is too small for any strong decay to occur. |  |

|                          |                                |             |
|--------------------------|--------------------------------|-------------|
| $\Xi_c^{*0}$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
| $\Xi_c^{*0} \gamma$      | seen                           | 105         |

**$\Xi_c(2645)$** 

$$I(J^P) = \frac{1}{2}(\frac{3}{2}^+)$$

$J^P$  has not been measured;  $\frac{3}{2}^+$  is the quark-model prediction.  
 $\Xi_c(2645)^+$  mass  $m = 2646.6 \pm 1.4$  MeV (S = 1.6)  
 $\Xi_c(2645)^0$  mass  $m = 2646.1 \pm 1.2$  MeV  
 $m_{\Xi_c(2645)^+} - m_{\Xi_c^0} = 175.6 \pm 1.4$  MeV (S = 1.7)  
 $m_{\Xi_c(2645)^0} - m_{\Xi_c^+} = 178.2 \pm 1.1$  MeV  
 $\Xi_c(2645)^+$  full width  $\Gamma < 3.1$  MeV, CL = 90%  
 $\Xi_c(2645)^0$  full width  $\Gamma < 5.5$  MeV, CL = 90%  
 $\Xi_c\pi$  is the only strong decay allowed to a  $\Xi_c$  resonance having this mass.

| $\Xi_c(2645)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $\Xi_c^0\pi^+$            | seen                           | 102         |
| $\Xi_c^+\pi^-$            | seen                           | 107         |

 **$\Xi_c(2790)$** 

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$$

$J^P$  has not been measured;  $\frac{1}{2}^-$  is the quark-model prediction.  
 $\Xi_c(2790)^+$  mass =  $2789.2 \pm 3.2$  MeV  
 $\Xi_c(2790)^0$  mass =  $2791.9 \pm 3.3$  MeV  
 $m_{\Xi_c(2790)^+} - m_{\Xi_c^0} = 318.2 \pm 3.2$  MeV  
 $m_{\Xi_c(2790)^0} - m_{\Xi_c^+} = 324.0 \pm 3.3$  MeV  
 $\Xi_c(2790)^+$  width  $< 15$  MeV, CL = 90%  
 $\Xi_c(2790)^0$  width  $< 12$  MeV, CL = 90%

| $\Xi_c(2790)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $\Xi_c'\pi$               | seen                           | 159         |

 **$\Xi_c(2815)$** 

$$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$$

$J^P$  has not been measured;  $\frac{3}{2}^-$  is the quark-model prediction.  
 $\Xi_c(2815)^+$  mass  $m = 2816.5 \pm 1.2$  MeV  
 $\Xi_c(2815)^0$  mass  $m = 2818.2 \pm 2.1$  MeV  
 $m_{\Xi_c(2815)^+} - m_{\Xi_c^+} = 348.6 \pm 1.2$  MeV  
 $m_{\Xi_c(2815)^0} - m_{\Xi_c^0} = 347.2 \pm 2.1$  MeV  
 $\Xi_c(2815)^+$  full width  $\Gamma < 3.5$  MeV, CL = 90%  
 $\Xi_c(2815)^0$  full width  $\Gamma < 6.5$  MeV, CL = 90%  
The  $\Xi_c\pi\pi$  modes are consistent with being entirely via  $\Xi_c(2645)\pi$ .

| $\Xi_c(2815)$ DECAY MODES | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $\Xi_c^+\pi^+\pi^-$       | seen                           | 196         |
| $\Xi_c^0\pi^+\pi^-$       | seen                           | 191         |

 **$\Omega_c^0$** 

$$I(J^P) = 0(\frac{1}{2}^+)$$

$J^P$  has not been measured;  $\frac{1}{2}^+$  is the quark-model prediction.  
Mass  $m = 2697.5 \pm 2.6$  MeV (S = 1.2)  
Mean life  $\tau = (69 \pm 12) \times 10^{-15}$  s  
 $c\tau = 21\mu\text{m}$   
No absolute branching fractions have been measured.

| $\Omega_c^0$ DECAY MODES  | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|---------------------------|--------------------------------|-------------|
| $\Sigma^+K^-K^-\pi^+$     | seen                           | 691         |
| $\Xi^0K^-\pi^+$           | seen                           | 903         |
| $\Xi^-K^-\pi^+\pi^+$      | seen                           | 832         |
| $\Omega^-e^+\nu_e$        | seen                           | 830         |
| $\Omega^-\pi^+$           | seen                           | 822         |
| $\Omega^-\pi^+\pi^0$      | seen                           | 798         |
| $\Omega^-\pi^-\pi^+\pi^+$ | seen                           | 754         |

**BOTTOM BARYONS**

$$(B = -1)$$

$$\Lambda_b^0 = udb, \Xi_b^0 = usb, \Xi_b^- = dsb$$

 **$\Lambda_b^0$** 

$$I(J^P) = 0(\frac{1}{2}^+)$$

$I(J^P)$  not yet measured;  $0(\frac{1}{2}^+)$  is the quark model prediction.  
Mass  $m = 5624 \pm 9$  MeV (S = 1.8)  
Mean life  $\tau = (1.230 \pm 0.074) \times 10^{-12}$  s  
 $c\tau = 369\mu\text{m}$

These branching fractions are actually an average over weakly decaying  $b$ -baryons weighted by their production rates in  $Z$  decay (or high-energy  $p\bar{p}$ ), branching ratios, and detection efficiencies. They scale with the LEP  $b$ -baryon production fraction  $B(b \rightarrow b\text{-baryon})$  and are evaluated for our value  $B(b \rightarrow b\text{-baryon}) = (10.0 \pm 2.0)\%$ .

The branching fractions  $B(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell \text{ anything})$  and  $B(\Lambda_b^0 \rightarrow \Lambda_c^+\ell^-\bar{\nu}_\ell \text{ anything})$  are not pure measurements because the underlying measured products of these with  $B(b \rightarrow b\text{-baryon})$  were used to determine  $B(b \rightarrow b\text{-baryon})$ , as described in the note "Production and Decay of  $b$ -Flavored Hadrons."

For inclusive branching fractions, e.g.,  $B \rightarrow D^\pm \text{ anything}$ , the values usually are multiplicities, not branching fractions. They can be greater than one.

| $\Lambda_b^0$ DECAY MODES                          | Fraction ( $\Gamma_i/\Gamma$ ) | Confidence level | $p$ (MeV/c) |
|----------------------------------------------------|--------------------------------|------------------|-------------|
| $J/\psi(1S)\Lambda$                                | $(4.7 \pm 2.8) \times 10^{-4}$ |                  | 1744        |
| $\Lambda_c^+\pi^-$                                 | seen                           |                  | 2345        |
| $\Lambda_c^+a_1(1260)^-$                           | seen                           |                  | 2155        |
| $\Lambda_c^+\ell^-\bar{\nu}_\ell \text{ anything}$ | [t] $(9.1 \pm 2.3)\%$          | %                | -           |
| $\Lambda_c^+\ell^-\bar{\nu}_\ell$                  | $(5.0^{+1.9}_{-1.4})\%$        | %                | 2347        |
| $\Lambda_c^+\pi^+\pi^-\ell^-\bar{\nu}_\ell$        | $(5.6 \pm 3.1)\%$              | %                | 2337        |
| $p\bar{b}^-$                                       | $< 2.3 \times 10^{-5}$         | 90%              | 2732        |
| $p\pi^-$                                           | $< 5.0 \times 10^{-5}$         | 90%              | 2732        |
| $pK^-$                                             | $< 5.0 \times 10^{-5}$         | 90%              | 2711        |
| $\Lambda\gamma$                                    | $< 1.3 \times 10^{-3}$         | 90%              | 2701        |

 **$b$ -baryon ADMIXTURE ( $\Lambda_b^0, \Xi_b^0, \Xi_b^-, \Omega_b^0$ )**

$$\text{Mean life } \tau = (1.209 \pm 0.049) \times 10^{-12} \text{ s}$$

These branching fractions are actually an average over weakly decaying  $b$ -baryons weighted by their production rates in  $Z$  decay (or high-energy  $p\bar{p}$ ), branching ratios, and detection efficiencies. They scale with the LEP  $b$ -baryon production fraction  $B(b \rightarrow b\text{-baryon})$  and are evaluated for our value  $B(b \rightarrow b\text{-baryon}) = (10.0 \pm 2.0)\%$ .

The branching fractions  $B(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell \text{ anything})$  and  $B(\Lambda_b^0 \rightarrow \Lambda_c^+\ell^-\bar{\nu}_\ell \text{ anything})$  are not pure measurements because the underlying measured products of these with  $B(b \rightarrow b\text{-baryon})$  were used to determine  $B(b \rightarrow b\text{-baryon})$ , as described in the note "Production and Decay of  $b$ -Flavored Hadrons."

For inclusive branching fractions, e.g.,  $B \rightarrow D^\pm \text{ anything}$ , the values usually are multiplicities, not branching fractions. They can be greater than one.

| $b$ -baryon ADMIXTURE DECAY MODES ( $\Lambda_b^0, \Xi_b^0, \Xi_b^-, \Omega_b^0$ ) | Fraction ( $\Gamma_i/\Gamma$ ) | $p$ (MeV/c) |
|-----------------------------------------------------------------------------------|--------------------------------|-------------|
| $p\mu^-\bar{\nu}$ anything                                                        | $(4.9^{+2.1}_{-1.3})\%$        | -           |
| $p\ell\bar{\nu}_\ell$ anything                                                    | $(4.7 \pm 1.2)\%$              | -           |
| $p$ anything                                                                      | $(59 \pm 21)\%$                | -           |
| $\Lambda\ell^-\bar{\nu}_\ell$ anything                                            | $(3.2 \pm 0.7)\%$              | -           |
| $\Lambda/\bar{\Lambda}$ anything                                                  | $(33 \pm 8)\%$                 | -           |
| $\Xi^-\ell^-\bar{\nu}_\ell$ anything                                              | $(5.5 \pm 1.6) \times 10^{-3}$ | -           |

## NOTES

This Summary Table only includes established baryons. The Particle Listings include evidence for other baryons. The masses, widths, and branching fractions for the resonances in this Table are Breit–Wigner parameters, but pole positions are also given for most of the  $N$  and  $\Delta$  resonances.

For most of the resonances, the parameters come from various partial-wave analyses of more or less the same sets of data, and it is not appropriate to treat the results of the analyses as independent or to average them together. Furthermore, the systematic errors on the results are not well understood. Thus, we usually only give ranges for the parameters. We then also give a best guess for the mass (as part of the name of the resonance) and for the width. The *Note on  $N$  and  $\Delta$  Resonances* and the *Note on  $\Lambda$  and  $\Sigma$  Resonances* in the Particle Listings review the partial-wave analyses.

When a quantity has “(S = ...)” to its right, the error on the quantity has been enlarged by the “scale factor” S, defined as  $S = \sqrt{\chi^2/(N-1)}$ , where  $N$  is the number of measurements used in calculating the quantity. We do this when  $S > 1$ , which often indicates that the measurements are inconsistent. When  $S > 1.25$ , we also show in the Particle Listings an ideogram of the measurements. For more about S, see the Introduction.

A decay momentum  $p$  is given for each decay mode. For a 2-body decay,  $p$  is the momentum of each decay product in the rest frame of the decaying particle. For a 3-or-more-body decay,  $p$  is the largest momentum any of the products can have in this frame. For any resonance, the *nominal* mass is used in calculating  $p$ . A dagger (“†”) in this column indicates that the mode is forbidden when the nominal masses of resonances are used, but is in fact allowed due to the nonzero widths of the resonances.

- [a] The masses of the  $p$  and  $n$  are most precisely known in u (unified atomic mass units). The conversion factor to MeV,  $1 \text{ u} = 931.494043 \pm 0.000080 \text{ MeV}$ , is less well known than are the masses in u.
- [b] These two results are not independent, and both use the more precise measurement of  $|q_p/m_p|/(q_p/m_p)$ .
- [c] The limit is from neutrality-of-matter experiments; it assumes  $q_n = q_p + q_e$ . See also the charge of the neutron.
- [d] The first limit is for  $p \rightarrow$  anything or “disappearance” modes of a bound proton. The second entry, a rough range of limits, assumes the dominant decay modes are among those investigated. For antiprotons the best limit, inferred from the observation of cosmic ray  $\bar{p}$ ’s is  $\tau_{\bar{p}} > 10^7 \text{ yr}$ , the cosmic-ray storage time, but this limit depends on a number of assumptions. The best direct observation of stored antiprotons gives  $\tau_{\bar{p}}/\text{B}(\bar{p} \rightarrow e^- \gamma) > 7 \times 10^5 \text{ yr}$ .

- [e] There is some controversy about whether nuclear physics and model dependence complicate the analysis for bound neutrons (from which the best limit comes). The first limit here is from reactor experiments with free neutrons.
- [f] The parameters  $g_A, g_V$ , and  $g_{WM}$  for semileptonic modes are defined by  $\bar{B}_f[\gamma_\lambda(g_V + g_A\gamma_5) + i(g_{WM}/m_{B_f})\sigma_{\lambda\nu}q^\nu]B_i$ , and  $\phi_{AV}$  is defined by  $g_A/g_V = |g_A/g_V|e^{i\phi_{AV}}$ . See the “Note on Baryon Decay Parameters” in the neutron Particle Listings.
- [g] Time-reversal invariance requires this to be  $0^\circ$  or  $180^\circ$ .
- [h] This limit is for  $\gamma$  energies between 35 and 100 keV.
- [i] The decay parameters  $\gamma$  and  $\Delta$  are calculated from  $\alpha$  and  $\phi$  using

$$\gamma = \sqrt{1-\alpha^2} \cos \phi, \quad \tan \Delta = -\frac{1}{\alpha} \sqrt{1-\alpha^2} \sin \phi.$$

See the “Note on Baryon Decay Parameters” in the neutron Particle Listings.

- [j] See the Listings for the pion momentum range used in this measurement.
- [k] The error given here is only an educated guess. It is larger than the error on the weighted average of the published values.
- [l] A theoretical value using QED.
- [m] See the note on “ $\Lambda_c^+$  Branching Fractions” in the  $\Lambda_c^+$  Particle Listings.
- [n] This branching fraction includes all the decay modes of the final-state resonance.
- [o] An  $\ell$  indicates an  $e$  or a  $\mu$  mode, not a sum over these modes.
- [p] The value is for the sum of the charge states or particle/antiparticle states indicated.
- [q] Assuming isospin conservation, so that the other third is  $\Lambda_c^+ \pi^0 \pi^0$ .
- [r] A test that the isospin is indeed 0, so that the particle is indeed a  $\Lambda_c^+$ .
- [s] No absolute branching fractions have been measured. The value here is the branching *ratio* relative to  $\Xi^- \pi^+ \pi^+$ .
- [t] Not a pure measurement. See note at head of  $\Lambda_b^0$  Decay Modes.
- [u] Here  $h^-$  means  $\pi^-$  or  $K^-$ .

## SEARCHES SUMMARY TABLE

### SEARCHES FOR MONOPOLES, SUPERSYMMETRY, TECHNICOLOR, COMPOSITENESS, EXTRA DIMENSIONS, etc.

#### Magnetic Monopole Searches

Isolated supermassive monopole candidate events have not been confirmed. The most sensitive experiments obtain negative results.

Best cosmic-ray supermassive monopole flux limit:  
 $< 1.0 \times 10^{-15} \text{ cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$  for  $1.1 \times 10^{-4} < \beta < 0.1$

#### Supersymmetric Particle Searches

Limits are based on the Minimal Supersymmetric Standard Model. Assumptions include: 1)  $\tilde{\chi}_1^0$  (or  $\tilde{\gamma}$ ) is lightest supersymmetric particle; 2) R-parity is conserved; 3) with the exception of  $\tilde{t}$  and  $\tilde{b}$ , all scalar quarks are assumed to be degenerate in mass and  $m_{\tilde{q}_R} = m_{\tilde{q}_L}$ . 4) Limits for sleptons refer to the  $\tilde{\ell}_R$  states.

See the Particle Listings for a Note giving details of supersymmetry.

$\tilde{\chi}_i^0$  — neutralinos (mixtures of  $\tilde{\gamma}$ ,  $\tilde{Z}^0$ , and  $\tilde{H}_i^0$ )

Mass  $m_{\tilde{\chi}_1^0} > 46 \text{ GeV}$ , CL = 95% [all  $\tan\beta$ , all  $\Delta m_0$ , all  $m_0$ ]

Mass  $m_{\tilde{\chi}_2^0} > 62.4 \text{ GeV}$ , CL = 95%

[ $1 < \tan\beta < 40$ , all  $m_0$ , all  $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$ ]

Mass  $m_{\tilde{\chi}_3^0} > 99.9 \text{ GeV}$ , CL = 95%

[ $1 < \tan\beta < 40$ , all  $m_0$ , all  $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$ ]

$\tilde{\chi}_i^\pm$  — charginos (mixtures of  $\tilde{W}^\pm$  and  $\tilde{H}_i^\pm$ )

Mass  $m_{\tilde{\chi}_1^\pm} > 94 \text{ GeV}$ , CL = 95%

[ $\tan\beta < 40$ ,  $m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} > 3 \text{ GeV}$ , all  $m_0$ ]

$\tilde{e}$  — scalar electron (selectron)

Mass  $m > 73 \text{ GeV}$ , CL = 95% [all  $m_{\tilde{e}_R} - m_{\tilde{\chi}_1^0}$ ]

$\tilde{\mu}$  — scalar muon (smuon)

Mass  $m > 94 \text{ GeV}$ , CL = 95%

[ $1 \leq \tan\beta \leq 40$ ,  $m_{\tilde{\mu}_R} - m_{\tilde{\chi}_1^0} > 10 \text{ GeV}$ ]

$\tilde{\tau}$  — scalar tau (stau)

Mass  $m > 81.9 \text{ GeV}$ , CL = 95%

[ $m_{\tilde{\tau}_R} - m_{\tilde{\chi}_1^0} > 15 \text{ GeV}$ , all  $\theta_\tau$ ]

$\tilde{q}$  — scalar quark (squark)

These limits include the effects of cascade decays, evaluated assuming a fixed value of the parameters  $\mu$  and  $\tan\beta$ . The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling.

Mass  $m > 250 \text{ GeV}$ , CL = 95% [ $\tan\beta = 2$ ,  $\mu < 0$ ,  $A = 0$ ]

$\tilde{b}$  — scalar bottom (sbottom)

Mass  $m > 89 \text{ GeV}$ , CL = 95% [ $m_{\tilde{b}_1} - m_{\tilde{\chi}_1^0} > 8 \text{ GeV}$ , all  $\theta_b$ ]

$\tilde{t}$  — scalar top (stop)

Mass  $m > 95.7 \text{ GeV}$ , CL = 95%

[ $\tilde{t} \rightarrow c\tilde{\chi}_1^0$ , all  $\theta_t$ ,  $m_{\tilde{t}} - m_{\tilde{\chi}_1^0} > 10 \text{ GeV}$ ]

$\tilde{g}$  — gluino

The limits summarized here refer to the high-mass region ( $m_{\tilde{g}} \sim 5 \text{ GeV}$ ), and include the effects of cascade decays, evaluated assuming a fixed value of the parameters  $\mu$  and  $\tan\beta$ . The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling,

Mass  $m > 195 \text{ GeV}$ , CL = 95% [any  $m_{\tilde{q}}$ ]

Mass  $m > 300 \text{ GeV}$ , CL = 95% [ $m_{\tilde{q}} = m_{\tilde{g}}$ ]

#### Technicolor

Searches for a color-octet techni- $\rho$  constrain its mass to be greater than 260 to 480 GeV, depending on allowed decay channels. Similar bounds exist on the color-octet techni- $\omega$ .

#### Quark and Lepton Compositeness, Searches for

##### Scale Limits $\Lambda$ for Contact Interactions

(the lowest dimensional interactions with four fermions)

If the Lagrangian has the form

$$\pm \frac{g^2}{2\Lambda^2} \bar{\psi}_L \gamma_\mu \psi_L \bar{\psi}_L \gamma^\mu \psi_L$$

(with  $g^2/4\pi$  set equal to 1), then we define  $\Lambda \equiv \Lambda_{LL}^\pm$ . For the full definitions and for other forms, see the Note in the Listings on Searches for Quark and Lepton Compositeness in the full *Review* and the original literature.

|                                    |                                 |
|------------------------------------|---------------------------------|
| $\Lambda_{LL}^+(eeee)$             | $> 8.3 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(eeee)$             | $> 10.3 \text{ TeV}$ , CL = 95% |
| $\Lambda_{LL}^+(ee\mu\mu)$         | $> 8.5 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(ee\mu\mu)$         | $> 6.3 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^+(ee\tau\tau)$       | $> 5.4 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(ee\tau\tau)$       | $> 6.5 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^+(\ell\ell\ell\ell)$ | $> 9.0 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(\ell\ell\ell\ell)$ | $> 7.8 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^+(eeuu)$             | $> 23.3 \text{ TeV}$ , CL = 95% |
| $\Lambda_{LL}^-(eeuu)$             | $> 12.5 \text{ TeV}$ , CL = 95% |
| $\Lambda_{LL}^+(eedd)$             | $> 11.1 \text{ TeV}$ , CL = 95% |
| $\Lambda_{LL}^-(eedd)$             | $> 26.4 \text{ TeV}$ , CL = 95% |
| $\Lambda_{LL}^+(eccc)$             | $> 1.0 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(eccc)$             | $> 2.1 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^+(eebb)$             | $> 5.6 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(eebb)$             | $> 4.9 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^+(\mu\mu qq)$        | $> 2.9 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(\mu\mu qq)$        | $> 4.2 \text{ TeV}$ , CL = 95%  |
| $\Lambda(\ell\nu\ell\nu)$          | $> 3.10 \text{ TeV}$ , CL = 90% |
| $\Lambda(e\nu qq)$                 | $> 2.81 \text{ TeV}$ , CL = 95% |
| $\Lambda_{LL}^+(qqqq)$             | $> 2.7 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(qqqq)$             | $> 2.4 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^+(\nu\nu qq)$        | $> 5.0 \text{ TeV}$ , CL = 95%  |
| $\Lambda_{LL}^-(\nu\nu qq)$        | $> 5.4 \text{ TeV}$ , CL = 95%  |

**Excited Leptons**

The limits from  $\ell^* \ell^{*-}$  do not depend on  $\lambda$  (where  $\lambda$  is the  $\ell \ell^*$  transition coupling). The  $\lambda$ -dependent limits assume chiral coupling.

$e^{*\pm}$  — excited electron

Mass  $m > 103.2$  GeV, CL = 95% (from  $e^* e^*$ )

Mass  $m > 255$  GeV, CL = 95% (from  $e e^*$ )

Mass  $m > 310$  GeV, CL = 95% (if  $\lambda_\gamma = 1$ )

$\mu^{*\pm}$  — excited muon

Mass  $m > 103.2$  GeV, CL = 95% (from  $\mu^* \mu^*$ )

Mass  $m > 190$  GeV, CL = 95% (from  $\mu \mu^*$ )

$\tau^{*\pm}$  — excited tau

Mass  $m > 103.2$  GeV, CL = 95% (from  $\tau^* \tau^*$ )

Mass  $m > 185$  GeV, CL = 95% (from  $\tau \tau^*$ )

$\nu^*$  — excited neutrino

Mass  $m > 102.6$  GeV, CL = 95% (from  $\nu^* \nu^*$ )

Mass  $m > 190$  GeV, CL = 95% (from  $\nu \nu^*$ )

$q^*$  — excited quark

Mass  $m > 45.6$  GeV, CL = 95% (from  $q^* q^*$ )

Mass  $m$  (from  $q^* X$ )

**Color Sextet and Octet Particles**

Color Sextet Quarks ( $q_6$ )

Mass  $m > 84$  GeV, CL = 95% (Stable  $q_6$ )

Color Octet Charged Leptons ( $\ell_8$ )

Mass  $m > 86$  GeV, CL = 95% (Stable  $\ell_8$ )

Color Octet Neutrinos ( $\nu_8$ )

Mass  $m > 110$  GeV, CL = 90% ( $\nu_8 \rightarrow \nu g$ )

**Extra Dimensions**

Please refer to the Extra Dimensions section of the full *Review* for a discussion of the model-dependence of these bounds, and further constraints.

**Constraints on the fundamental gravity scale**

$M_H > 1.1$  TeV, CL = 95% (dim-8 operators;  $p \bar{p} \rightarrow e^+ e^-, \gamma \gamma$ )

$M_D > 1.1$  TeV, CL = 95% ( $e^+ e^- \rightarrow G \gamma$ ; 2-flat dimensions)

$M_D > 3\text{--}1000$  TeV (astrophys. and cosmology; 2-flat dimensions; limits depend on technique and assumptions)

**Constraints on the radius of the extra dimensions, for the case of two-flat dimensions of equal radii**

$r < 90\text{--}660$  nm (astrophysics; limits depend on technique and assumptions)

$r < 0.22$  mm, CL = 95% (direct tests of Newton's law; cited in Extra Dimensions review)

# TABLE OF THE ISOTOPES

Norman E. Holden

This table presents an evaluated set of values for the experimental quantities that characterize the decay of radioactive nuclides. A list of the major references used in this evaluation is given below. When uncertainties are not listed, they are assumed to be five or less in the last digit quoted. If they exceed five in the last digit, the value is prefaced by an approximate sign. For quasi-stable nu-

clides, the measured width,  $\Gamma$ , of the resonance is given. To estimate the approximate half-life, the Heisenberg relationship may be used, the half-life =  $4.56 \times 10^{-22}$  seconds /  $\Gamma(\text{MeV})$ . The effective literature cutoff date for data in this edition of the Table is December, 2005.

## Table Layout

| Column No. | Column title                 | Description                                                                                                                                                                                                                                                                                                                                    |
|------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1          | Isotope or Element           | For elements, the atomic number and chemical symbol are listed. For nuclides, the mass number and chemical symbol are listed. Isomers are indicated by the addition of m, m1, or m2.                                                                                                                                                           |
| 2          | Isotopic Abundance           | In atom percent.                                                                                                                                                                                                                                                                                                                               |
| 3          | Atomic Mass or Atomic Weight | Atomic mass relative to $^{12}\text{C} = 12$ . Atomic weight of elements is given on the same scale.                                                                                                                                                                                                                                           |
| 4          | Half-life/Resonance Width    | Half-life in decimal notation. $\mu\text{s}$ = microseconds; ms = milliseconds; s = seconds; m = minutes; h = hours; d = days; and y = years. For quasi-stable nuclides, the measured width at half maximum of the energy resonance is given                                                                                                   |
| 5          | Decay Mode/Energy            | Decay modes are $\alpha$ = alpha particle emission; $\beta^-$ = negative beta emission; $\beta^+$ = positron emission; EC = orbital electron capture; IT = isomeric transition from upper to lower isomeric state; n = neutron emission; sf = spontaneous fission; $\beta\beta$ = double beta decay. Total disintegration energy in MeV units. |
| 6          | Particle Energy/Intensity    | End point energies of beta transitions and discrete energies of alpha particles in MeV and their intensities in percent.                                                                                                                                                                                                                       |
| 7          | Spin and Parity              | Nuclear spin or angular momentum of the nuclides in units of $\hbar/2\pi$ ; parity is positive or negative.                                                                                                                                                                                                                                    |
| 8          | Magnetic Dipole Moment       | Magnetic dipole moments in nuclear magneton units.                                                                                                                                                                                                                                                                                             |
| 9          | Electric Quadrupole Moment   | Electric quadrupole moments in barn units ( $10^{-24} \text{ cm}^2$ ).                                                                                                                                                                                                                                                                         |
| 10         | Gamma Ray Energy/Intensity   | Gamma ray energies in MeV and intensities in percent. Ann. rad. refers to the 511.006 keV photons emitted in the annihilation of positrons in matter.                                                                                                                                                                                          |

## General Nuclear Data References

The following references represent the major sources of the nuclear data presented, along with subsequent published journal articles and reports:

- G. Audi, O. Bersillon, J. Blachot, A.H. Wapstra, *The Nubase Evaluation of Nuclear and Decay Properties*, Nuclear Physics A729, 3 (2003).
- G. Audi, A.H. Wapstra, C. Thibault, *The AME2003 Atomic Mass Evaluation (II)*, Nuclear Physics A729, 337 (2003).
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| Elem.<br>or Isot.     | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)                                                                           | Particle Energy/<br>Intensity<br>(MeV/%)         | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                              |
|-----------------------|----------------------------------|--------------------------|----------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------|--------------------------|----------------------------------|------------------------------|-------------------------------------------------------------------------|
| <sup>0</sup> n        |                                  | 1.008664916              | 614. s                                 | $\beta^-$ /0.78235<br>$\beta^-$ , $\gamma$                                                             | 0.782/100.<br>/ < 0.069                          | 1/2+                     | -1.913043                        |                              |                                                                         |
| <b><sub>1</sub>H</b>  |                                  | <b>1.00794(7)</b>        |                                        |                                                                                                        |                                                  |                          |                                  |                              |                                                                         |
| <sup>1</sup> H        | 99.9885(70)                      | 1.007825032              | $> 2.8 \times 10^{23}$ y               |                                                                                                        |                                                  | 1/2+                     | +2.79285                         |                              |                                                                         |
| <sup>2</sup> H        | 0.0115(70)                       | 2.014101778              |                                        |                                                                                                        |                                                  | 1+                       | +0.85744                         | +2.86 mb                     |                                                                         |
| <sup>3</sup> H        |                                  | 3.016049278              | 12.33 y                                | $\beta^-$ /0.01859                                                                                     | 0.01860/100.                                     | 1/2+                     | +2.97896                         |                              |                                                                         |
| <sup>4</sup> H        |                                  | 4.0278                   | $\Gamma \sim 3$                        | n/                                                                                                     | /100                                             | 2-                       |                                  |                              |                                                                         |
| <sup>5</sup> H        |                                  | 5.0353                   | $\Gamma < 0.5$                         | n/                                                                                                     | /100                                             | (1/2+)                   |                                  |                              |                                                                         |
| <sup>6</sup> H        |                                  | 6.0449                   | $\Gamma = 1.6(4)$                      | n/                                                                                                     |                                                  | (2-)                     |                                  |                              |                                                                         |
| <sup>7</sup> H        |                                  | 7.053                    | $\Gamma \sim 20.$                      |                                                                                                        |                                                  |                          |                                  |                              |                                                                         |
| <b><sub>2</sub>He</b> |                                  | <b>4.002602(2)</b>       |                                        |                                                                                                        |                                                  |                          |                                  |                              |                                                                         |
| <sup>3</sup> He       | 0.000134(3)                      | 3.016029319              |                                        |                                                                                                        |                                                  | 1/2+                     | -2.12762                         |                              |                                                                         |
| <sup>4</sup> He       | 99.999866(3)                     | 4.002603254              |                                        |                                                                                                        |                                                  | 0+                       |                                  |                              |                                                                         |
| <sup>5</sup> He       |                                  | 5.01222                  | $\Gamma = 0.60(2)$                     | n, $\alpha$                                                                                            |                                                  | 3/2-                     |                                  |                              |                                                                         |
| <sup>6</sup> He       |                                  | 6.018889                 | 0.807 s                                | $\beta^-$ /3.508<br>$\beta$ , d                                                                        | 3.510/100.<br>/0.00076                           | 0+                       |                                  |                              |                                                                         |
| <sup>7</sup> He       |                                  | 7.02802                  | $\Gamma = 0.15(2)$                     | n                                                                                                      |                                                  | (3/2)-                   |                                  |                              |                                                                         |
| <sup>8</sup> He       |                                  | 8.03392                  | 0.119 s                                | $\beta^-$ /10.65<br>n/<br>$\beta$ , t                                                                  | /84.<br>/16.<br>/0.82                            | 0+                       |                                  |                              | 0.9807/84.<br>0.4776/5.                                                 |
| <sup>9</sup> He       |                                  | 9.04395                  | $\Gamma = 0.10(6)$                     | n                                                                                                      | /100                                             | (1/2-)                   |                                  |                              |                                                                         |
| <sup>10</sup> He      |                                  | 10.0524                  | $\Gamma = 0.3(2)$                      | 2n                                                                                                     | /100                                             | 0+                       |                                  |                              |                                                                         |
| <b><sub>3</sub>Li</b> |                                  | <b>6.941(2)</b>          |                                        |                                                                                                        |                                                  |                          |                                  |                              |                                                                         |
| <sup>4</sup> Li       |                                  | 4.0272                   | $\Gamma = 6.0$                         | p/                                                                                                     | /100                                             | 2-                       |                                  |                              |                                                                         |
| <sup>5</sup> Li       |                                  | 5.01254                  | $\Gamma = 1.2$                         | p/ $\alpha$                                                                                            |                                                  | 3/2-                     |                                  |                              |                                                                         |
| <sup>6</sup> Li       | 7.59(4)                          | 6.01512280               |                                        |                                                                                                        |                                                  | 1+                       | +0.82205                         | -0.8 mb                      |                                                                         |
| <sup>7</sup> Li       | 92.41(4)                         | 7.0160046                |                                        |                                                                                                        |                                                  | 3/2-                     | +3.25644                         | -0.0400                      |                                                                         |
| <sup>8</sup> Li       |                                  | 8.0224874                | 0.840 s                                | $\beta^-$ /16.004<br>$\alpha$ /                                                                        | 12.5/100.<br>$\alpha(1.6)$                       | 2+                       | +1.6536                          | +0.0314                      |                                                                         |
| <sup>9</sup> Li       |                                  | 9.026790                 | 0.178 s                                | $\beta^-$ /13.606<br>$\beta^-$ /                                                                       | 13.5/75.<br>11/25.                               | 3/2-                     | 3.4368                           | -0.0306                      |                                                                         |
| <sup>10</sup> Li      |                                  | 10.03548                 | $\Gamma = 0.11(5)$                     | n                                                                                                      | /7.                                              | 1+                       |                                  |                              |                                                                         |
| <sup>11</sup> Li      |                                  | 11.04380                 | 8.8 ms                                 | $\beta^-$ /20.6<br>$\beta^-$ , n<br>$\beta^-$ , 2n<br>$\beta^-$ , 3n<br>$\beta^-$ , d<br>$\beta^-$ , t | /8.3<br>/85.7<br>/4.1<br>/1.9<br>/>0.01<br>/0.02 | 3/2(-)                   | 3.668                            | -0.031                       | 3.368/33.<br>0.320/7.<br>2.590/8.<br>5.958/3.<br>2.895/1.5<br>2.811/1.1 |
| <sup>12</sup> Li      |                                  | 12.054                   | < 0.01 $\mu$ s                         |                                                                                                        |                                                  |                          |                                  |                              |                                                                         |
| <b><sub>4</sub>Be</b> |                                  | <b>9.012182(3)</b>       |                                        |                                                                                                        |                                                  |                          |                                  |                              |                                                                         |
| <sup>5</sup> Be       |                                  | 5.041                    |                                        | p, <sup>3</sup> He                                                                                     |                                                  | (1/2+)                   |                                  |                              |                                                                         |
| <sup>6</sup> Be       |                                  | 6.01973                  | $\Gamma = 0.092(6)$                    | 2p, $\alpha$                                                                                           |                                                  | 0+                       |                                  |                              |                                                                         |
| <sup>7</sup> Be       |                                  | 7.0169298                | 53.28 d                                | EC/0.8618                                                                                              |                                                  | 3/2-                     | -1.4                             |                              | 0.4776/10.4                                                             |
| <sup>8</sup> Be       |                                  | 8.00530510               | $\Gamma = 6.8(17)$ eV                  | 2 $\alpha$ /0.046                                                                                      |                                                  | 0+                       |                                  |                              |                                                                         |
| <sup>9</sup> Be       | 100.                             | 9.0121822                |                                        |                                                                                                        |                                                  | 3/2-                     | -1.1776                          | +0.0529                      |                                                                         |
| <sup>10</sup> Be      |                                  | 10.0135338               | $1.52 \times 10^6$ y                   | $\beta^-$ /0.5559                                                                                      | 0.555/100.                                       | 0+                       |                                  |                              |                                                                         |
| <sup>11</sup> Be      |                                  | 11.02166                 | 13.8 s                                 | $\beta^-$ , $\beta^- \alpha$ /11.51                                                                    | 11.48/61.                                        | 1/2+                     |                                  |                              | 2.125/35.5                                                              |
| <sup>12</sup> Be      |                                  | 12.02692                 | 22.0 ms                                | $\beta^-$ , (n)/11.71                                                                                  | n/0.5                                            | 0+                       |                                  |                              | (0.95 - 4.4)                                                            |
| <sup>13</sup> Be      |                                  | 13.0357                  | $\Gamma \sim 1.$                       |                                                                                                        |                                                  |                          |                                  |                              |                                                                         |
| <sup>14</sup> Be      |                                  | 14.0429                  | 4.6 ms                                 | $\beta^-$ /16.2<br>$\beta^-$ , n<br>$\beta^-$ , 2n<br>$\beta^-$ , $\alpha$<br>$\beta^-$ , t            | <br>0.288/94.<br>/6.<br>/<0.012<br>/<0.04        | 0+                       |                                  |                              | 3.5346/0.9<br>3.6845/7.                                                 |
| <sup>15</sup> Be      |                                  | 15.053                   | < 0.2 $\mu$ s                          | $\beta^-$                                                                                              |                                                  |                          |                                  |                              |                                                                         |



| Elem.<br>or Isot.    | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)        | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|----------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>16</sup> Be     |                                  | 16.062                   | < 0.2 $\mu$ s                          | $\beta^-$                           |                                          | 0+                       |                                  |                              |                                            |
| <b><sub>5</sub>B</b> |                                  | <b>10.811(7)</b>         |                                        |                                     |                                          |                          |                                  |                              |                                            |
| <sup>7</sup> B       |                                  | 7.0299                   | $\Gamma = 1.4(2)$                      | p, $\alpha$                         |                                          | (3/2-)                   |                                  |                              |                                            |
| <sup>8</sup> B       |                                  | 8.024607                 | 0.770 s                                | $\beta^+$ , 2 $\alpha$ /17.979      | 13.7( $\beta^+$ )/93.                    | 2+                       | 1.0355                           | 0.068                        | ann.rad.                                   |
| <sup>9</sup> B       |                                  | 9.013329                 | $\Gamma = 0.5(2)$ keV                  | p, 2 $\alpha$ /                     |                                          | 3/2-                     |                                  |                              |                                            |
| <sup>10</sup> B      | 19.9(7)                          | 10.0129370               |                                        |                                     |                                          | 3+                       | +1.8006                          | +0.085                       |                                            |
| <sup>11</sup> B      | 80.1(7)                          | 11.0093054               |                                        |                                     |                                          | 3/2-                     | +2.6886                          | +0.0406                      |                                            |
| <sup>12</sup> B      |                                  | 12.014352                | 0.0202 s                               | $\beta^-$ /13.369                   |                                          | 1+                       | +1.0027                          | 0.0132                       | 4.438/1.3                                  |
|                      |                                  |                          |                                        | $\beta^-$ $\alpha$ /1.6/            |                                          |                          |                                  |                              | 3.215/0.00065                              |
| <sup>13</sup> B      |                                  | 13.017780                | 0.0174 s                               | $\beta^-$ /13.437                   | 13.4                                     | 3/2-                     | +3.1778                          | 0.037                        | 3.68/7.6                                   |
|                      |                                  |                          |                                        | $\beta^-$ n/0.25/                   | 2.43(n)/0.09                             |                          |                                  |                              |                                            |
|                      |                                  |                          |                                        |                                     | 3.55(n)/0.16                             |                          |                                  |                              |                                            |
| <sup>14</sup> B      |                                  | 14.02540                 | 14. ms                                 | $\beta^-$ /20.64                    |                                          | 2-                       | 1.185                            | 0.0298                       | 6.094/90.                                  |
| <sup>15</sup> B      |                                  | 15.03110                 | 9.9 ms                                 | $\beta^-$ , (n)/19.09               | n//99.7                                  | (3/2-)                   | 2.66                             | 0.038                        |                                            |
| <sup>16</sup> B      |                                  | 16.0398                  | $\Gamma < 0.1$                         | n                                   |                                          |                          |                                  |                              |                                            |
| <sup>17</sup> B      |                                  | 17.0470                  | 5.1 ms                                 | $\beta^-$ , (n)/22.7                |                                          |                          | 2.54                             | 0.039                        |                                            |
| <sup>18</sup> B      |                                  | 18.056                   | < 0.026 $\mu$ s                        |                                     |                                          | 0-                       |                                  |                              |                                            |
| <sup>19</sup> B      |                                  | 19.0637                  | 2.9 ms                                 | $\beta^-$ , (n)/26.5                | 1n//72.                                  | (3/2-)                   |                                  |                              |                                            |
|                      |                                  |                          |                                        |                                     | 2n//16.                                  |                          |                                  |                              |                                            |
|                      |                                  |                          |                                        |                                     | 3n// < 9.                                |                          |                                  |                              |                                            |
| <b><sub>6</sub>C</b> |                                  | <b>12.0107(8)</b>        |                                        |                                     |                                          |                          |                                  |                              |                                            |
| <sup>8</sup> C       |                                  | 8.03768                  | $\Gamma = 0.25(4)$                     | p                                   |                                          | 0+                       |                                  |                              |                                            |
| <sup>9</sup> C       |                                  | 9.031037                 | 127. ms                                | $\beta^+$ , p, 2 $\alpha$ /16.498   |                                          | (3/2-)                   | -1.391                           |                              | ann.rad.                                   |
| <sup>10</sup> C      |                                  | 10.0168532               | 19.3 s                                 | $\beta^+$ /3.648                    | 1.865                                    | 0+                       |                                  |                              | ann.rad.                                   |
|                      |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.71829/100.                               |
| <sup>11</sup> C      |                                  | 11.011434                | 20.3 m                                 | $\beta^+$ , EC/1.982                | 0.9608/99.                               | 3/2-                     | -0.964                           | 0.0333                       | ann.rad.                                   |
| <sup>12</sup> C      | 98.93(8)                         | 12.000000000             |                                        |                                     |                                          | 0+                       |                                  |                              |                                            |
| <sup>13</sup> C      | 1.07(8)                          | 13.003354838             |                                        |                                     |                                          | $\frac{1}{2}-$           | +0.70241                         |                              |                                            |
| <sup>14</sup> C      |                                  | 14.003241989             | 5715. y                                | $\beta^-$ /0.15648                  | 0.1565/100.                              | 0+                       |                                  |                              |                                            |
| <sup>15</sup> C      |                                  | 15.010599                | 2.45 s                                 | $\beta^-$ /9.772                    | 4.51/68.                                 | $\frac{1}{2}+$           | 1.32                             |                              | 5.298/68.                                  |
|                      |                                  |                          |                                        |                                     | 9.82/32.                                 |                          |                                  |                              | (7.30–9.05)                                |
| <sup>16</sup> C      |                                  | 16.014701                | $\sim 0.750$ s                         | $\beta^-$ /8.012                    | $\beta$ /3.3, 4.3/84, 16                 | 0+                       |                                  |                              |                                            |
|                      |                                  |                          |                                        | $\beta$ , n                         | n/0.8, 1.7/84, 16                        |                          |                                  |                              |                                            |
| <sup>17</sup> C      |                                  | 17.02259                 | 0.19 s                                 | $\beta^-$ /13.17                    |                                          | 3/2+                     |                                  |                              | 1.375                                      |
|                      |                                  |                          |                                        | $\beta^-$ , n                       | n/1.6–3.7/11.                            |                          |                                  |                              | 1.849                                      |
|                      |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 1.906                                      |
| <sup>18</sup> C      |                                  | 18.02676                 | 0.092 s                                | $\beta^-$ /11.81                    |                                          | 0+                       |                                  |                              |                                            |
|                      |                                  |                          |                                        | $\beta^-$ , n                       | n/0.88–4.59/21.                          |                          |                                  |                              |                                            |
| <sup>19</sup> C      |                                  | 19.0348                  | 0.05 s                                 | n                                   |                                          | $\frac{1}{2}+$           |                                  |                              |                                            |
| <sup>20</sup> C      |                                  | 20.0403                  | 0.02 s                                 | $\beta$ ,n                          | 1n// $\sim 65$ .                         | 0+                       |                                  |                              |                                            |
|                      |                                  |                          |                                        |                                     | 2n// < 19.                               |                          |                                  |                              |                                            |
| <sup>21</sup> C      |                                  | 21.049                   | < 0.03 $\mu$ s                         |                                     |                                          |                          |                                  |                              |                                            |
| <sup>22</sup> C      |                                  | 22.057                   | 6 ms                                   | $\beta^-$ , n                       | 1n// $\sim 61$ .                         | 0+                       |                                  |                              |                                            |
|                      |                                  |                          |                                        |                                     | 2n// < 37.                               |                          |                                  |                              |                                            |
| <b><sub>7</sub>N</b> |                                  | <b>14.0067(2)</b>        |                                        |                                     |                                          |                          |                                  |                              |                                            |
| <sup>10</sup> N      |                                  | 10.0417                  | $\Gamma = 2.3(16)$                     |                                     |                                          |                          |                                  |                              |                                            |
| <sup>11</sup> N      |                                  | 11.02609                 | $\Gamma \sim 1$ .                      |                                     |                                          | $\frac{1}{2}+$           |                                  |                              |                                            |
| <sup>12</sup> N      |                                  | 12.018613                | 11.00 ms                               | $\beta^+$ , $\beta^+\alpha$ /17.338 | 16.38/95.                                | 1+                       | +0.457                           | +10. mb                      | ann.rad.                                   |
|                      |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 4.438/2.                                   |
| <sup>13</sup> N      |                                  | 13.0057386               | 9.97 m                                 | $\beta^+$ /2.2204                   | 1.190/100.                               | $\frac{1}{2}-$           | 0.3222                           |                              |                                            |
| <sup>14</sup> N      | 99.636(20)                       | 14.003074005             |                                        |                                     |                                          | 1+                       | +0.40376                         | +0.0200                      |                                            |
| <sup>15</sup> N      | 0.364(20)                        | 15.00010898              |                                        |                                     |                                          | $\frac{1}{2}-$           | -0.28319                         |                              |                                            |
| <sup>16</sup> N      |                                  | 16.006102                | 7.13 s                                 | $\beta^-$ /10.419                   | 4.27/68.                                 | 2-                       |                                  |                              | 6.129/68.8                                 |
|                      |                                  |                          |                                        |                                     | 10.44/26.                                |                          | 1.986                            | 18 mb                        | 7.115/4.7                                  |
|                      |                                  |                          |                                        | $\beta^-$ , $\alpha$                | 1.85/.0012                               |                          |                                  |                              | (0.99–8.87)                                |
| <sup>17</sup> N      |                                  | 17.00845                 | 4.17 s                                 | $\beta^-$ , $\beta^-$ n/8.68        | 3.7/100.                                 | $\frac{1}{2}-$           | 0.352                            |                              | 0.871/3.                                   |

| Elem.<br>or Isot.    | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|----------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                      |                                  |                          |                                        | 0.4–1.7n/95.                 |                                          |                          |                                  |                              | 2.1842/0.3                                 |
|                      |                                  |                          |                                        | $\beta^-$ $\alpha$ /         | 8.0, 8.2                                 |                          |                                  |                              |                                            |
| <sup>18</sup> N      |                                  | 18.01408                 | 0.62 s                                 | $\beta^-$ /13.90             | 9.4/100.                                 | 1-                       | 0.328                            | 0.012                        | 0.822/48.                                  |
|                      |                                  |                          |                                        | $\beta^-$ , $\alpha$         | /12.                                     |                          |                                  |                              | 1.65/47.                                   |
|                      |                                  |                          |                                        | $\beta^-$ , n                | /14                                      |                          |                                  |                              | 1.982/77.                                  |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.535–7.13)                               |
| <sup>19</sup> N      |                                  | 19.01703                 | 0.32 s                                 | $\beta^-$ /12.53             |                                          |                          | < 0.32                           |                              | (0.096–3.14)                               |
| <sup>20</sup> N      |                                  | 20.0234                  | 0.14 s                                 | $\beta^-$ /17.97             |                                          |                          |                                  |                              |                                            |
| <sup>21</sup> N      |                                  | 21.0271                  | 0.08 s                                 |                              |                                          |                          |                                  |                              |                                            |
| <sup>22</sup> N      |                                  | 22.0344                  | 0.02 s                                 | $\beta^-$ , n                | 1n// ~ 41.                               |                          |                                  |                              |                                            |
|                      |                                  |                          |                                        |                              | 2n// < 13.                               |                          |                                  |                              |                                            |
| <sup>23</sup> N      |                                  | 23.0412                  | 15. ms                                 | $\beta^-$ , n                | n// ~ 42.                                |                          |                                  |                              |                                            |
|                      |                                  |                          |                                        |                              | 2n// ~ 8.                                |                          |                                  |                              |                                            |
|                      |                                  |                          |                                        |                              | 3n// < 3.4                               |                          |                                  |                              |                                            |
| <sup>24</sup> N      |                                  | 24.0510                  | < 0.052 $\mu$ s                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>25</sup> N      |                                  | 25.061                   | < 0.26 $\mu$ s                         |                              |                                          |                          |                                  |                              |                                            |
| <b><sub>8</sub>O</b> |                                  | <b>15.9994(3)</b>        |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>12</sup> O      |                                  | 12.03441                 | $\Gamma = 0.51(16)$                    | 2p                           |                                          | 0+                       |                                  |                              |                                            |
| <sup>13</sup> O      |                                  | 13.02481                 | 8.9 ms                                 | $\beta^+$ , p/17.77          | 1.560 (p)                                | (3/2-)                   | 1.389                            | 0.011                        | ann.rad.                                   |
|                      |                                  |                          |                                        |                              | p/(1.00 - 13.5)                          |                          |                                  |                              | 4.438/0.56                                 |
| <sup>14</sup> O      |                                  | 14.0085963               | 70.63 s                                | $\beta^+$ /5.1430            | 1.81/99.                                 | 0+                       |                                  |                              | ann.rad.                                   |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.312/99.4                                 |
| <sup>15</sup> O      |                                  | 15.0030656               | 122.2 s                                | $\beta^+$ /2.754             | 1.723/100.                               | 1/2-                     | 0.7195                           |                              | ann.rad.                                   |
| <sup>16</sup> O      | 99.757(16)                       | 15.9949146196            |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>17</sup> O      | 0.038(1)                         | 16.9991317               |                                        |                              |                                          | 5/2+                     | -1.8938                          | -0.026                       |                                            |
| <sup>18</sup> O      | 0.205(14)                        | 17.999161                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>19</sup> O      |                                  | 19.003580                | 26.9 s                                 | $\beta^-$ /4.820             | 3.25/60.                                 | 5/2+                     | 1.5320                           | 3.7 mb                       | 0.197/95.9                                 |
|                      |                                  |                          |                                        |                              | 4.60/40.                                 |                          |                                  |                              | 1.3569/50.4                                |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.11–4.18)                                |
| <sup>20</sup> O      |                                  | 20.004077                | 13.5 s                                 | $\beta^-$ /3.814             |                                          | 0+                       |                                  |                              | 1.057/100.                                 |
| <sup>21</sup> O      |                                  | 21.00866                 | 3.4 s                                  | $\beta^-$ /8.11              |                                          |                          |                                  |                              | (0.28–4.6)                                 |
| <sup>22</sup> O      |                                  | 22.0100                  | 2.2 s                                  | $\beta^-$ /6.5               |                                          | 0+                       |                                  |                              | 0.072/100                                  |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.638/98                                   |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.862/63                                   |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.918-2.499)                              |
| <sup>23</sup> O      |                                  | 23.0157                  | 0.08 s                                 |                              |                                          |                          |                                  |                              |                                            |
| <sup>24</sup> O      |                                  | 24.0205                  | ~ 65. ms                               | $\beta^-$ , n                | n//18.                                   | 0+                       |                                  |                              | 1.83/28.                                   |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.52/14.                                   |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.31/12.                                   |
| <sup>25</sup> O      |                                  | 25.0295                  | < 0.05 $\mu$ s                         |                              |                                          |                          |                                  |                              |                                            |
| <sup>26</sup> O      |                                  | 26.0383                  | < 0.04 $\mu$ s                         |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>27</sup> O      |                                  | 27.048                   | < 0.026 $\mu$ s                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>28</sup> O      |                                  | 28.058                   | < 0.10 $\mu$ s                         |                              |                                          | 0+                       |                                  |                              |                                            |
| <b><sub>9</sub>F</b> |                                  | <b>18.9984032(5)</b>     |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>14</sup> F      |                                  | 14.0351                  |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>15</sup> F      |                                  | 15.0180                  | $\Gamma = 0.8(3)$                      | p                            |                                          | (1/2+)                   |                                  |                              |                                            |
| <sup>16</sup> F      |                                  | 16.01147                 | $\Gamma = 0.037(14)$                   | p                            |                                          | 0-                       |                                  |                              |                                            |
| <sup>17</sup> F      |                                  | 17.0020952               | 64.5 s                                 | $\beta^+$ /2.761             | 1.75/                                    | 5/2+                     | +4.721                           | 0.058                        | ann.rad.                                   |
| <sup>18</sup> F      |                                  | 18.000938                | 1.829 h                                | $\beta^+$ , EC/1.656         | 0.635/97.                                | 1+                       |                                  |                              | ann.rad.                                   |
| <sup>19</sup> F      | 100.                             | 18.9984032               |                                        |                              |                                          | $\frac{1}{2}+$           | +2.62887                         | 0.072                        |                                            |
| <sup>20</sup> F      |                                  | 19.9999813               | 11.00 s                                | $\beta^-$ /7.0245            | 5.398/100.                               | 2+                       | +2.0934                          | 0.042                        | 1.634/100.                                 |
|                      |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 3.33/0.009                                 |
| <sup>21</sup> F      |                                  | 20.999949                | 4.16 s                                 | $\beta^-$ /5.684             | 3.7/8.                                   | 5/2+                     | 3.9                              |                              | 0.3507/90.                                 |
|                      |                                  |                          |                                        |                              | 5.0/63.                                  |                          |                                  |                              | 1.395/15.                                  |
|                      |                                  |                          |                                        |                              | 5.4/29.                                  |                          |                                  |                              | (1.746–4.684)                              |
| <sup>22</sup> F      |                                  | 22.00300                 | 4.23 s                                 | $\beta^-$ /10.82             | 3.48/15.                                 | 4+                       |                                  |                              | 1.2746/100.                                |
|                      |                                  |                          |                                        |                              | 4.67/7.                                  |                          |                                  |                              | 2.0826/82.                                 |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2 \pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                       |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|---------------------------|----------------------------------|------------------------------|------------------------------------------------------------------|
| <sup>23</sup> F        |                                  | 23.0036                  | 2.2 s                                  | $\beta^-$ /8.5               | 5.50/62.                                 | 5/2+                      |                                  |                              | (0.82–4.37)<br>1.701/48.                                         |
|                        |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 2.129/34.<br>(0.493–3.83)                                        |
| <sup>24</sup> F        |                                  | 24.0081                  | 0.3 s                                  | $\beta^-$ /13.5              |                                          |                           |                                  |                              | 1.9816/                                                          |
| <sup>25</sup> F        |                                  | 25.0121                  | ~ 50. ms                               | $\beta^-$ , (n)              | n//14.                                   |                           |                                  |                              | 1.70/39.<br>(0.57–2.19)                                          |
| <sup>26</sup> F        |                                  | 26.0196                  | 10. ms                                 | $\beta^-$ , (n)              | n//11.                                   |                           |                                  |                              | 2.02/67.<br>1.67/19.                                             |
| <sup>27</sup> F        |                                  | 27.0268                  | 5.0 ms                                 | $\beta^-$ , (n)              | n//90.                                   |                           |                                  |                              | 2.02/18.                                                         |
| <sup>28</sup> F        |                                  | 28.036                   | < 0.04 $\mu$ s                         |                              |                                          |                           |                                  |                              |                                                                  |
| <sup>29</sup> F        |                                  | 29.043                   | 2.5 ms                                 | $\beta^-$ , (n)              | n//100.                                  |                           |                                  |                              |                                                                  |
| <sup>30</sup> F        |                                  | 30.053                   | < 0.26 $\mu$ s                         |                              |                                          |                           |                                  |                              |                                                                  |
| <sup>31</sup> F        |                                  | 31.060                   | > 0.26 $\mu$ s                         |                              |                                          |                           |                                  |                              |                                                                  |
| <b><sup>10</sup>Ne</b> |                                  | <b>20.1797(6)</b>        |                                        |                              |                                          |                           |                                  |                              |                                                                  |
| <sup>16</sup> Ne       |                                  | 16.02576                 | $\Gamma = 0.12(4)$                     | 2p                           |                                          | 0+                        |                                  |                              |                                                                  |
| <sup>17</sup> Ne       |                                  | 17.01767                 | 109. ms                                | $\beta^+$ , p/14.53          | 1.4–10.6/6.9                             | 1/2-                      | 0.787                            |                              | ann.rad./<br>0.495                                               |
|                        |                                  |                          |                                        | $\beta^+$ , $\alpha$         | /0.014                                   |                           |                                  |                              |                                                                  |
| <sup>18</sup> Ne       |                                  | 18.0057082               | 1.668 s                                | $\beta^+$ /4.446             | 3.416/92.                                | 0+                        |                                  |                              | ann.rad./<br>1.0413/7.8<br>(0.658–1.70)                          |
| <sup>19</sup> Ne       |                                  | 19.0018802               | 17.22 s                                | $\beta^+$ /3.238             | 2.24/99.                                 | 1/2+                      | -1.885                           |                              | ann.rad./<br>(0.11–1.55)                                         |
| <sup>20</sup> Ne       | 90.48(3)                         | 19.992440175             |                                        |                              |                                          | 0+                        |                                  |                              |                                                                  |
| <sup>21</sup> Ne       | 0.27(1)                          | 20.99384668              |                                        |                              |                                          | 3/2+                      | -0.66180                         | +0.103                       |                                                                  |
| <sup>22</sup> Ne       | 9.25(3)                          | 21.99138511              |                                        |                              |                                          | 0+                        |                                  | -0.19                        |                                                                  |
| <sup>23</sup> Ne       |                                  | 22.9944669               | 37.2 s                                 | $\beta^-$ /4.376             | 3.95/32.<br>4.39/67.                     | 5/2+                      | -1.08                            | +0.15                        | 0.440/33.<br>(1.64–2.98)                                         |
| <sup>24</sup> Ne       |                                  | 23.9936108               | 3.38 m                                 | $\beta^-$ /2.47              | 1.10/8.<br>1.98/92.                      | 0+                        |                                  |                              | 0.4723/100.<br>0.874/7.9                                         |
| <sup>25</sup> Ne       |                                  | 24.99774                 | 0.61 s                                 | $\beta^-$ /7.30              | 6.3/<br>7.3/                             | 1/2+                      | -1.006                           |                              | 0.0895/96.<br>(0.98–3.69)                                        |
| <sup>26</sup> Ne       |                                  | 26.00046                 | 197 ms                                 | $\beta^-$ , n/7.3            | n//0.13                                  | 0+                        |                                  |                              | 0.082/100<br>1.278/6<br>0.233/5<br>0.151/3<br>1.211/1<br>2.489/1 |
| <sup>27</sup> Ne       |                                  | 27.0076                  | 31. ms                                 | $\beta^-$ , n/12.7           | n//2.                                    | (3/2+)                    |                                  |                              |                                                                  |
| <sup>28</sup> Ne       |                                  | 28.0121                  | 19. ms                                 | $\beta^-$ , n/12.3           | n//12.<br>2n//3.                         | 0+                        |                                  |                              | 2.06/19.<br>0.86/3.                                              |
| <sup>29</sup> Ne       |                                  | 29.0194                  | 15. ms                                 | $\beta^-$ , (n)/15.4         | n//29.                                   | (3/2+)                    |                                  |                              | 2.92/55.<br>(0.22–1.18)                                          |
|                        |                                  |                          |                                        | $\beta^-$ , 2n               | 2n//4.                                   |                           |                                  |                              |                                                                  |
| <sup>30</sup> Ne       |                                  | 30.025                   | 7. ms                                  | $\beta^-$ , (n)              | n//9.                                    | 0+                        |                                  |                              | 0.151/9.                                                         |
| <sup>31</sup> Ne       |                                  | 31.033                   | 3. ms                                  |                              |                                          |                           |                                  |                              |                                                                  |
| <sup>32</sup> Ne       |                                  | 32.040                   | ~ 3.5 ms                               |                              |                                          | 0+                        |                                  |                              |                                                                  |
| <sup>33</sup> Ne       |                                  | 33.049                   | < 0.26 $\mu$ s                         |                              |                                          |                           |                                  |                              |                                                                  |
| <sup>34</sup> Ne       |                                  | 34.057                   | > 1.5 $\mu$ s                          |                              |                                          | 0+                        |                                  |                              |                                                                  |
| <b><sup>11</sup>Na</b> |                                  | <b>22.98976928(2)</b>    |                                        |                              |                                          |                           |                                  |                              |                                                                  |
| <sup>18</sup> Na       |                                  | 18.02597                 | $\Gamma = 0.34(9)$                     |                              |                                          |                           |                                  |                              |                                                                  |
| <sup>19</sup> Na       |                                  | 19.01388                 | 0.03 s                                 | $\beta^+$ , p/11.18          |                                          |                           |                                  |                              |                                                                  |
| <sup>20</sup> Na       |                                  | 20.00735                 | 0.446 s                                | $\beta^+$ /13.89             |                                          | 2+                        | +0.3694                          | ~ + 0.04                     | ann.rad./<br>1.634/79.                                           |
|                        |                                  |                          |                                        | $\alpha$                     | 2.15/                                    |                           |                                  |                              |                                                                  |
| <sup>21</sup> Na       |                                  | 20.997655                | 22.48 s                                | $\beta^+$ /3.547             | 2.50/95.                                 | 3/2+                      | +2.3863                          | ~ +0.05                      | ann.rad./<br>0.351/5.                                            |
| <sup>22</sup> Na       |                                  | 21.9944364               | 2.605 y                                | $\beta^+$ /90/2.842          | 0.545/90.                                | 3+                        | +1.746                           | +0.19                        | ann.rad./<br>1.2745/99.9                                         |
|                        |                                  |                          |                                        | EC/10/                       |                                          |                           |                                  |                              |                                                                  |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>23</sup> Na  | 100.                             | 22.989769281             |                                        |                              |                                          | 3/2+                     | +2.21752                         | +0.106                       |                                            |
| <sup>24m</sup> Na |                                  |                          | 20.2 ms                                | I.T., $\beta^-$              |                                          | 1+                       |                                  |                              | 0.4723/100.                                |
| <sup>24</sup> Na  |                                  | 23.9909628               | 14.96 h                                | $\beta^-$ /5.5158            | 1.389/>99.                               | 4+                       | +1.690                           |                              | 1.3686/100.                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.754/100.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.997–4.238)                              |
| <sup>25</sup> Na  |                                  | 24.989954                | 59.3 s                                 | $\beta^-$ /3.835             | 2.6/7.                                   | 5/2+                     | +3.683                           | ~ -0.06                      | 0.3897/12.7                                |
|                   |                                  |                          |                                        |                              | 3.15/25.                                 |                          |                                  |                              | 0.5850/13.                                 |
|                   |                                  |                          |                                        |                              | 4.0/65.                                  |                          |                                  |                              | 0.9747/14.9                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.836–2.80)                               |
| <sup>26</sup> Na  |                                  | 25.99263                 | 1.071 s                                | $\beta^-$ /9.31              |                                          | 3+                       | +2.851                           | -5.3 mb                      | 1.809/98.9                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.24–7.37)                                |
| <sup>27</sup> Na  |                                  | 26.994077                | 0.290 s                                | $\beta^-$ /9.01              | 7.95/                                    | 5/2+                     | +3.90                            | -7.2 mb                      | 0.9847/87.4                                |
|                   |                                  |                          |                                        | $\beta^-$ , n/               |                                          |                          |                                  |                              | 1.698/11.9                                 |
| <sup>28</sup> Na  |                                  | 27.99894                 | 31. ms                                 | $\beta^-$ /14.0              | 12.3/                                    | 1+                       | +2.42                            | +0.04                        | 1.473/37.                                  |
|                   |                                  |                          |                                        | $\beta^-$ , n/               |                                          |                          |                                  |                              | 2.389/18.6                                 |
| <sup>29</sup> Na  |                                  | 29.00286                 | 44. ms                                 | $\beta^-$ , n/13.3           | 11.5/                                    | 3/2+                     | +2.46                            | +86. mb                      | 2.560/36.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (1.04–3.99)                                |
| <sup>30</sup> Na  |                                  | 30.00898                 | 50. ms                                 | $\beta^-$ , n/17.5           | n//30.                                   | 2+                       | +2.07                            |                              | 1.483/46.                                  |
| <sup>31</sup> Na  |                                  | 31.0136                  | 17.2 ms                                | $\beta^-$ , n/15.9           | n//37.                                   | 3/2-                     | +2.30                            |                              | 1.483/14.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.05–3.54)                                |
| <sup>32</sup> Na  |                                  | 32.0205                  | 13.5 ms                                | $\beta^-$ /19.1              |                                          |                          |                                  |                              | 0.240–3.935                                |
| <sup>33</sup> Na  |                                  | 33.027                   | 8.0 ms                                 | $\beta^-$ /20.               | / ~ 38                                   |                          |                                  |                              | 0.886/16                                   |
|                   |                                  |                          |                                        | $\beta^-$ , n                | 0.8,1.02/47(6)                           |                          |                                  |                              | 0.546/6.4                                  |
|                   |                                  |                          |                                        | $\beta^-$ , 2n               | /13(3)                                   |                          |                                  |                              | 0.050–2.55                                 |
| <sup>34</sup> Na  |                                  | 34.035                   | 5. ms                                  | $\beta^-$ /24.               |                                          |                          |                                  |                              |                                            |
| <sup>35</sup> Na  |                                  | 35.042                   | 1.5 ms                                 | $\beta^-$ /24                |                                          |                          |                                  |                              |                                            |
| <sup>36</sup> Na  |                                  | 36.051                   | < 0.26 $\mu$ s                         |                              |                                          |                          |                                  |                              |                                            |
| <sup>37</sup> Na  |                                  | 37.059                   | > 1.5 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>12</sup> Mg  |                                  | 24.3050(6)               |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>19</sup> Mg  |                                  | 19.0355                  | < 0.02 $\mu$ s                         |                              |                                          |                          |                                  |                              |                                            |
| <sup>20</sup> Mg  |                                  | 20.01886                 | 96. ms                                 | $\beta^+$ /10.73             | /70                                      | 0+                       |                                  |                              |                                            |
|                   |                                  |                          |                                        | $\beta^+$ , p                | /30                                      |                          |                                  |                              |                                            |
| <sup>21</sup> Mg  |                                  | 21.01171                 | 122. ms                                | $\beta^+$ , p/13.10          |                                          | 5/2+                     |                                  |                              | 0.332/51.                                  |
| <sup>22</sup> Mg  |                                  | 21.999574                | 3.876 s                                | $\beta^+$ /4.786             | 3.05/                                    | 0+                       |                                  |                              | 0.0729/60.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5820/100.                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (1.28–1.93)                                |
| <sup>23</sup> Mg  |                                  | 22.994124                | 11.32 s                                | $\beta^+$ /4.057             | 3.09/92.                                 | 3/2+                     | 0.536                            | 1.25                         | 0.440/8.2                                  |
| <sup>24</sup> Mg  | 78.99(4)                         | 23.98504170              |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>25</sup> Mg  | 10.00(1)                         | 24.98583692              |                                        |                              |                                          | 5/2+                     | -0.85545                         | +0.200                       |                                            |
| <sup>26</sup> Mg  | 11.01(3)                         | 25.98259293              |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>27</sup> Mg  |                                  | 26.98434059              | 9.45 m                                 | $\beta^-$ /2.6103            | 1.59/41.                                 | 1/2+                     |                                  |                              | 0.17068/0.9                                |
|                   |                                  |                          |                                        |                              | 1.75/58.                                 |                          |                                  |                              | 0.84376/72.                                |
|                   |                                  |                          |                                        |                              | 2.65/0.3                                 |                          |                                  |                              | 1.01443/28.                                |
| <sup>28</sup> Mg  |                                  | 27.983877                | 20.9 h                                 | $\beta^-$ /1.832             | 0.459/95.                                | 0+                       |                                  |                              | 0.0306/95.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4006/36.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9418/36.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.342/54.                                  |
| <sup>29</sup> Mg  |                                  | 28.98860                 | 1.3 s                                  | $\beta^-$ /7.55              | 5.4/                                     | 3/2+                     |                                  |                              | 0.960/15.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.398/16.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.224/36.                                  |
| <sup>30</sup> Mg  |                                  | 29.99043                 | 0.32 s                                 | $\beta^-$ /7.0               |                                          | 0+                       |                                  |                              | 0.224/85.                                  |
| <sup>31</sup> Mg  |                                  | 30.99655                 | 0.24 s                                 | $\beta^-$ /11.7              | 8.4/29.9                                 | (3/2+)                   | -0.8836                          |                              | 1.613/47.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.947/37.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.666–4.640)                              |
|                   |                                  |                          |                                        | $\beta^-$ , n                | /1.7                                     |                          |                                  |                              |                                            |
| <sup>32</sup> Mg  |                                  | 31.99898                 | 0.12 s                                 | $\beta^-$ /10.3              |                                          | 0+                       |                                  |                              | 2.765/25.                                  |
| <sup>33</sup> Mg  |                                  | 33.00525                 | 91. ms                                 | $\beta^-$ /13.7              | /83.                                     |                          |                                  |                              | 1.848/                                     |
|                   |                                  |                          |                                        | $\beta^-$ , n                | /17.                                     |                          |                                  |                              |                                            |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)  | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>34</sup> Mg       |                                  | 34.0095                  | 0.02 s                                 | $\beta^-$ /11.3               |                                          | 0+                       |                                  |                              |                                            |
| <sup>35</sup> Mg       |                                  | 35.0173                  | 0.07 s                                 |                               |                                          | (7/2-)                   |                                  |                              |                                            |
| <sup>36</sup> Mg       |                                  | 36.023                   | 4. ms                                  |                               |                                          | 0+                       |                                  |                              |                                            |
| <sup>37</sup> Mg       |                                  | 37.031                   | > 0.26 $\mu$ s                         |                               |                                          | (7/2-)                   |                                  |                              |                                            |
| <sup>38</sup> Mg       |                                  | 38.038                   | > 0.26 $\mu$ s                         |                               |                                          | 0+                       |                                  |                              |                                            |
| <sup>39</sup> Mg       |                                  | 39.047                   | < 0.26 $\mu$ s                         |                               |                                          |                          |                                  |                              |                                            |
| <sup>40</sup> Mg       |                                  | 40.054                   |                                        |                               |                                          | 0+                       |                                  |                              |                                            |
| <b><sub>13</sub>Al</b> |                                  | <b>26.9815386(8)</b>     |                                        |                               |                                          |                          |                                  |                              |                                            |
| <sup>21</sup> Al       |                                  | 21.0280                  | < 0.035 $\mu$ s                        |                               |                                          |                          |                                  |                              |                                            |
| <sup>22</sup> Al       |                                  | 22.0195                  | 59. ms                                 | $\beta^+$ /18.6               | p/1.3/18.                                | 4+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | $\beta^+$ , p, 2p, $\alpha$ / | $\alpha$ /3.3/0.3                        |                          |                                  |                              |                                            |
| <sup>23m</sup> Al      |                                  |                          | ~ 0.35 s                               | $\beta^+$ , p/0.17            |                                          |                          |                                  |                              | 0.554                                      |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 0.839                                      |
| <sup>23</sup> Al       |                                  | 23.00727                 | 0.47 s                                 | $\beta^+$ /12.24              |                                          |                          |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | $\beta^+$ , p/                |                                          |                          |                                  |                              |                                            |
| <sup>24m</sup> Al      |                                  |                          | 0.129 s                                | I.T./0.4259                   |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^+$                     | 13.3                                     | 1+                       |                                  |                              | 1.3686/5.3                                 |
| <sup>24</sup> Al       |                                  | 23.999939                | 2.07 s                                 | $\beta^+$ /13.878,p           | 3.40/48.                                 | 4+                       |                                  |                              | 1.078(2)/16.                               |
|                        |                                  |                          |                                        |                               | 4.42/41.                                 |                          |                                  |                              | 1.368(2)/96.                               |
|                        |                                  |                          |                                        |                               | 6.80/3.                                  |                          |                                  |                              | 2.753(2)/43.                               |
|                        |                                  |                          |                                        |                               | 8.74/8.                                  |                          |                                  |                              | 4.315(3)/15.                               |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 5.392(3)/20.                               |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 7.0662(2)/41.                              |
| <sup>25</sup> Al       |                                  | 24.9904281               | 7.17 s                                 | $\beta^+$ /4.277              | 3.27/                                    | 5/2+                     | 3.646                            |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 1.6115(2)/100.                             |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 0.975(2)/5.                                |
| <sup>26m</sup> Al      |                                  |                          | 6.345 s                                | $\beta^+$ /                   | 3.2/                                     | 0+                       |                                  |                              | ann.rad./                                  |
| <sup>26</sup> Al       |                                  | 25.9868917               | 7.1 $\times 10^5$ y                    | $\beta^+$ /82/4.0042          | 1.16/                                    | 5+                       | +2.804                           | +0.17                        | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/18                         |                                          |                          |                                  |                              | 1.8087/99.8                                |
| <sup>27</sup> Al       | 100.                             | 26.9815386               |                                        |                               |                                          | 5/2+                     | +3.64151                         | +0.140                       |                                            |
| <sup>28</sup> Al       |                                  | 27.9819103               | 2.25 m                                 | $\beta^-$ /4.6422             | 2.865/100.                               | 3+                       | 3.24                             | 0.18                         | 1.7778(6)/100.                             |
| <sup>29</sup> Al       |                                  | 28.980445                | 6.5 m                                  | $\beta^-$ /3.680              | 1.4/30.                                  | 5/2+                     |                                  |                              | 1.2732(8)/89.                              |
|                        |                                  |                          |                                        |                               | 2.5/70.                                  |                          |                                  |                              | 2.0282(8)/4.                               |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 2.4262(8)/7.                               |
| <sup>30</sup> Al       |                                  | 29.98296                 | 3.68 s                                 | $\beta^-$ /8.56               | 5.05/                                    | 3+                       | 3.01                             |                              | 1.26313(3)/35.                             |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 2.23525(5)/65.                             |
| <sup>31</sup> Al       |                                  | 30.98395                 | 0.64 s                                 | $\beta^-$ /8.00               | 6.25/                                    | 5/2+                     |                                  |                              | 0.75223(3)/18.                             |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 1.69473(3)/59.                             |
|                        |                                  |                          |                                        |                               |                                          |                          |                                  |                              | 2.31664(4)/73.                             |
| <sup>32</sup> Al       |                                  | 31.9881                  | 33. ms                                 | $\beta^-$ /13.0               |                                          | 1+                       | 1.96                             |                              |                                            |
| <sup>33</sup> Al       |                                  | 32.9908                  | 41.7 ms                                | $\beta^-$ /12.0               | /91.5                                    |                          |                                  |                              | 1.940/2.5                                  |
|                        |                                  |                          |                                        | $\beta^-$ , n                 | /8.5                                     |                          |                                  |                              | (1.01–4.34)                                |
| <sup>34</sup> Al       |                                  | 33.9969                  | 56. ms                                 | $\beta^-$ /17.1               | 4.255/44                                 | 4                        |                                  |                              | 0.929/57                                   |
|                        |                                  |                          |                                        | $\beta^-$ , n                 | /26.                                     |                          |                                  |                              | (0.12–4.26)                                |
| <sup>35</sup> Al       |                                  | 34.9999                  | 38. ms                                 | $\beta^-$ /14.3               | 0.974/48                                 | 5/2+                     |                                  |                              | 0.064/45.                                  |
|                        |                                  |                          |                                        | $\beta^-$ , n                 | / 38.                                    |                          |                                  |                              | (0.12–5.63)                                |
| <sup>36</sup> Al       |                                  | 36.0062                  | 0.09 s                                 | $\beta^-$ /18.3               |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                 | /<31.                                    |                          |                                  |                              |                                            |
| <sup>37</sup> Al       |                                  | 37.0107                  | 11. ms                                 | $\beta^-$ /16.                |                                          |                          |                                  |                              |                                            |
| <sup>38</sup> Al       |                                  | 38.017                   | > 7.6 ms                               |                               |                                          |                          |                                  |                              |                                            |
| <sup>39</sup> Al       |                                  | 39.023                   | > 8. ms                                |                               |                                          |                          |                                  |                              |                                            |
| <sup>40</sup> Al       |                                  | 40.031                   | > 0.26 $\mu$ s                         |                               |                                          |                          |                                  |                              |                                            |
| <sup>41</sup> Al       |                                  | 41.038                   | > 0.26 $\mu$ s                         |                               |                                          |                          |                                  |                              |                                            |
| <b><sub>14</sub>Si</b> |                                  | <b>28.0855(3)</b>        |                                        |                               |                                          |                          |                                  |                              |                                            |
| <sup>22</sup> Si       |                                  | 22.0345                  | 29. ms                                 | $\beta^+$ , p                 | 1.99/20                                  | 0+                       |                                  |                              |                                            |
| <sup>23</sup> Si       |                                  | 23.0255                  | 40.7 ms                                | $\beta^+$ , p/5.9             | 1.32,(0.6–11.6)                          |                          |                                  |                              |                                            |
| <sup>24</sup> Si       |                                  | 24.01155                 | 0.14 s                                 | $\beta^+$ , p/10.81           | 1.44,3.92,1.09                           | 0+                       |                                  |                              | ann.rad./                                  |

| Elem.<br>or Isot.     | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2 \pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-----------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|---------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>25</sup> Si      |                                  | 25.00411                 | 221 ms                                 | $\beta^+$ , p/12.74          | (1.66–4.47)<br>p/4.25/9.5                | 5/2+                      |                                  |                              | ann.rad./                                  |
|                       |                                  |                          |                                        |                              | p/0.40/4.75                              |                           |                                  |                              |                                            |
|                       |                                  |                          |                                        |                              | p/0.56-6.80                              |                           |                                  |                              |                                            |
| <sup>26</sup> Si      |                                  | 25.992330                | 2.23 s                                 | $\beta^+$ /5.066             | 3.282/                                   | 0+                        |                                  |                              | ann.rad./                                  |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 0.8294(8)/22.                              |
| <sup>27</sup> Si      |                                  | 26.9867049               | 4.14 s                                 | $\beta^+$ /4.8118            | 3.85/100.                                | 5/2+                      | -0.8554                          |                              | ann.rad./                                  |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 2.211(5)/0.2                               |
| <sup>28</sup> Si      | 92.223(19)                       | 27.976926533             |                                        |                              |                                          | 0+                        |                                  |                              |                                            |
| <sup>29</sup> Si      | 4.685(8)                         | 28.97649470              |                                        |                              |                                          | 1/2+                      | -0.5553                          |                              |                                            |
| <sup>30</sup> Si      | 3.092(11)                        | 29.97377017              |                                        |                              |                                          | 0+                        |                                  |                              |                                            |
| <sup>31</sup> Si      |                                  | 30.97536323              | 2.62 h                                 | $\beta^-$ /1.4920            | 1.471/99.9                               | 3/2+                      |                                  |                              | 1.2662(5)/0.05                             |
| <sup>32</sup> Si      |                                  | 31.97414808              | $1.6 \times 10^2$ y                    | $\beta^-$ /0.224             | 0.213/100.                               | 0+                        |                                  |                              |                                            |
| <sup>33</sup> Si      |                                  | 32.97800                 | 6.1 s                                  | $\beta^-$ /5.85              | 3.92                                     | (3/2+)                    | 1.21                             |                              | 1.4313(5)/13.                              |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 1.8477/100.                                |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 2.538(2)/10.                               |
| <sup>34</sup> Si      |                                  | 33.97858                 | 2.8 s                                  | $\beta^-$ /4.60              | 3.09/                                    | 0+                        |                                  |                              | 0.42907(5)/60.                             |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 1.17852(2)/64.                             |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 1.60756(5)/36.                             |
| <sup>35</sup> Si      |                                  | 34.98458                 | 0.9 s                                  | $\beta^-$ /10.50             |                                          |                           |                                  |                              |                                            |
| <sup>36</sup> Si      |                                  | 35.9866                  | 0.5 s                                  | $\beta^-$ /7.9               |                                          | 0*                        |                                  |                              |                                            |
|                       |                                  |                          |                                        | $\beta^-$ , n                | /~ 12.                                   |                           |                                  |                              |                                            |
| <sup>37</sup> Si      |                                  | 36.9929                  | ~ 0.09 s                               | $\beta^-$ /12.5              |                                          |                           |                                  |                              |                                            |
|                       |                                  |                          |                                        | $\beta^-$ , n                | /~ 17.                                   |                           |                                  |                              |                                            |
| <sup>38</sup> Si      |                                  | 37.9956                  | > 1 $\mu$ s                            | $\beta^-$ /10.7              |                                          | 0*                        |                                  |                              |                                            |
|                       |                                  |                          |                                        | $\beta^-$ , n                |                                          |                           |                                  |                              |                                            |
| <sup>39</sup> Si      |                                  | 39.0021                  | 48. ms                                 | $\beta^-$ /14.8              |                                          |                           |                                  |                              |                                            |
| <sup>40</sup> Si      |                                  | 40.006                   | 33. ms                                 |                              |                                          | 0*                        |                                  |                              |                                            |
| <sup>41</sup> Si      |                                  | 41.015                   | 20. ms                                 |                              |                                          |                           |                                  |                              |                                            |
| <sup>42</sup> Si      |                                  | 42.020                   | 13. ms                                 |                              |                                          | 0*                        |                                  |                              |                                            |
| <sup>43</sup> Si      |                                  | 43.029                   | > 0.26 $\mu$ s                         |                              |                                          |                           |                                  |                              |                                            |
| <b><sub>15</sub>P</b> |                                  | <b>30.973762(2)</b>      |                                        |                              |                                          |                           |                                  |                              |                                            |
| <sup>24</sup> P       |                                  | 24.034                   |                                        |                              |                                          |                           |                                  |                              |                                            |
| <sup>25</sup> P       |                                  | 25.0203                  | < 0.03 $\mu$ s                         |                              |                                          |                           |                                  |                              |                                            |
| <sup>26</sup> P       |                                  | 26.0118                  | 44. ms                                 | $\beta^+$ , p/18.1           | p/0.41/18.0                              | 3+                        |                                  |                              |                                            |
|                       |                                  |                          |                                        |                              | p/1.98/2.4                               |                           |                                  |                              |                                            |
|                       |                                  |                          |                                        |                              | p/0.78-7.49                              |                           |                                  |                              |                                            |
| <sup>27</sup> P       |                                  | 26.99923                 | 0.3 s                                  | $\beta^+$ , p/11.63          | p/0.73, 0.61/0.07                        | 1/2+                      |                                  |                              |                                            |
| <sup>28</sup> P       |                                  | 27.992315                | 270. ms                                | $\beta^+$ /14.332            | 3.94/13.                                 | 3+                        |                                  |                              | ann.rad./                                  |
|                       |                                  |                          |                                        |                              | 5.25/13.                                 |                           |                                  |                              | 1.779(2)/98.                               |
|                       |                                  |                          |                                        |                              | 6.96/16.                                 |                           |                                  |                              | 2.839(2)/2.8                               |
|                       |                                  |                          |                                        |                              | 8.8/7.                                   |                           |                                  |                              | 3.040(2)/3.2                               |
|                       |                                  |                          |                                        |                              | 11.49/52.                                |                           |                                  |                              | 4.498(2)/12.                               |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 7.537(2)/9.                                |
| <sup>29</sup> P       |                                  | 28.981801                | 4.14 s                                 | $\beta^+$ /4.9431            | 3.945/98.                                | 1/2+                      | 1.2349                           |                              | ann.rad./                                  |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 1.273/1.32                                 |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 2.426/0.39                                 |
| <sup>30</sup> P       |                                  | 29.9783138               | 2.50 m                                 | $\beta^+$ /4.2323            | 3.245/99.9                               | 1+                        |                                  |                              | ann.rad./                                  |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 2.230(3)/0.07                              |
| <sup>31</sup> P       | 100.                             | 30.9737616               |                                        |                              |                                          | 1/2+                      | +1.13160                         |                              |                                            |
| <sup>32</sup> P       |                                  | 31.9739073               | 14.28 d                                | $\beta^-$ /1.7106            | 1.710/100.                               | 1+                        | -0.2524                          |                              |                                            |
| <sup>33</sup> P       |                                  | 32.971726                | 25.3 d                                 | $\beta^-$ /0.249             | 0.249/100.                               | 1/2+                      |                                  |                              |                                            |
| <sup>34</sup> P       |                                  | 33.973636                | 12.4 s                                 | $\beta^-$ /5.374             | 3.2/15.                                  | 1+                        |                                  |                              | 1.78–4.1/                                  |
|                       |                                  |                          |                                        |                              | 5.1/85.                                  |                           |                                  |                              | 2.127(5)/15.                               |
| <sup>35</sup> P       |                                  | 34.973314                | 47. s                                  | $\beta^-$ /3.989             | 2.34/100.                                | 1/2+                      |                                  |                              | 1.572(1)/100.                              |
| <sup>36</sup> P       |                                  | 35.97826                 | 5.7 s                                  | $\beta^-$ /10.41             |                                          |                           |                                  |                              | 0.902/77.                                  |
|                       |                                  |                          |                                        |                              |                                          |                           |                                  |                              | 3.291/100.                                 |
| <sup>37</sup> P       |                                  | 36.97961                 | 2.3 s                                  | $\beta^-$ /7.90              |                                          |                           |                                  |                              | 0.6462/                                    |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>38</sup> P        |                                  | 37.9842                  | 0.6 s                                  | $\beta^-$ /12.4              |                                          |                          |                                  |                              | 1.5829/<br>1.2923/<br>2.224/               |
|                        |                                  |                          |                                        | $\beta^-$ , n                | /~ 12.                                   |                          |                                  |                              |                                            |
| <sup>39</sup> P        |                                  | 38.9862                  | 0.3 s                                  | $\beta^-$ /10.5              |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | /26                                      |                          |                                  |                              |                                            |
| <sup>40</sup> P        |                                  | 39.9913                  | 0.15 s                                 | $\beta^-$ /14.5              |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | /~ 30.                                   |                          |                                  |                              |                                            |
| <sup>41</sup> P        |                                  | 40.9943                  | 0.10 s                                 | $\beta^-$ /~ 13.8            |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | /~ 30.                                   |                          |                                  |                              |                                            |
| <sup>42</sup> P        |                                  | 42.0010                  | 49. ms                                 | $\beta^-$ /17.               |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | / ~ 50.                                  |                          |                                  |                              |                                            |
| <sup>43</sup> P        |                                  | 43.006                   | 36. ms                                 | $\beta^-$ /16.               |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | /100.                                    |                          |                                  |                              |                                            |
| <sup>44</sup> P        |                                  | 44.013                   | 19. ms                                 |                              |                                          |                          |                                  |                              |                                            |
| <sup>45</sup> P        |                                  | 45.019                   | > 0.2 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>46</sup> P        |                                  | 46.027                   | > 0.2 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <b><sub>16</sub>S</b>  |                                  | <b>32.065(5)</b>         |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>26</sup> S        |                                  | 26.0279                  | ~ 10 ms                                |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>27</sup> S        |                                  | 27.0188                  | 16. ms                                 | $\beta^+$ , 2p/18.3          | p/2.26, 7.80                             |                          |                                  |                              |                                            |
| <sup>28</sup> S        |                                  | 28.0044                  | 0.13 s                                 |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>29</sup> S        |                                  | 28.99661                 | 0.188 s                                | $\beta^+$ /13.79             |                                          | 5/2+                     |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | $\beta^+$ , p/               |                                          |                          |                                  |                              |                                            |
| <sup>30</sup> S        |                                  | 29.984903                | 1.18 s                                 | $\beta^+$ /6.138             | 4.42/78.                                 | 0+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              | 5.08/20.                                 |                          |                                  |                              | 0.678/79.                                  |
| <sup>31</sup> S        |                                  | 30.979555                | 2.56 s                                 | $\beta^+$ /5.396             | 4.39/99.                                 | 1/2+                     | 0.48793                          |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.2662(5)/1.2                              |
| <sup>32</sup> S        | 94.99(26)                        | 31.9720710               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>33</sup> S        | 0.75(2)                          | 32.9714588               |                                        |                              |                                          | 3/2+                     | +0.64382                         | -0.068                       |                                            |
| <sup>34</sup> S        | 4.25(24)                         | 33.9678669               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>35</sup> S        |                                  | 34.9690322               | 87.2 d                                 | $\beta^-$ /0.1672            | 0.1674/100.                              | 3/2+                     | +1.00                            | +0.047                       |                                            |
| <sup>36</sup> S        | 0.01(1)                          | 35.9670808               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>37</sup> S        |                                  | 36.9711256               | 5.05 m                                 | $\beta^-$ /4.8653            | 1.64/94.                                 | 7/2-                     |                                  |                              | 0.9083(4)/0.06                             |
|                        |                                  |                          |                                        |                              | 4.75/5.6                                 |                          |                                  |                              | 3.1033(2)/94.2                             |
| <sup>38</sup> S        |                                  | 37.97116                 | 2.84 h                                 | $\beta^-$ /2.94              | 1.00/                                    | 0+                       |                                  |                              | 0.1962(4)/0.2                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.9421(3)/84.                              |
| <sup>39</sup> S        |                                  | 38.97513                 | 11.5 s                                 | $\beta^-$ /6.64              |                                          |                          |                                  |                              | 1.301/52.                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.697/44.                                  |
| <sup>40</sup> S        |                                  | 39.9755                  | 9. s                                   | $\beta^-$ /4.7               |                                          | 0+                       |                                  |                              |                                            |
| <sup>41</sup> S        |                                  | 40.9796                  | ~ 2.6 s                                | $\beta^-$ /8.7               |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                |                                          |                          |                                  |                              |                                            |
| <sup>42</sup> S        |                                  | 41.9810                  | ~ 0.56 s                               | $\beta^-$ /7.8               |                                          | 0+                       |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | / < 4.                                   |                          |                                  |                              |                                            |
| <sup>43</sup> S        |                                  | 42.9872                  | 0.26 s                                 | $\beta^-$ /12.               |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | / ~ 40                                   |                          |                                  |                              |                                            |
| <sup>44</sup> S        |                                  | 43.9902                  | 0.10 s                                 | $\beta^-$ /9.                |                                          | 0+                       |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | /18.                                     |                          |                                  |                              |                                            |
| <sup>45</sup> S        |                                  | 44.997                   | 68. ms                                 | $\beta^-$ /14.               |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^-$ , n                | /54.                                     |                          |                                  |                              |                                            |
| <sup>46</sup> S        |                                  | 46.001                   | 0.05 s                                 |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>47</sup> S        |                                  | 47.009                   | > 0.2 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>48</sup> S        |                                  | 48.014                   | > 0.2 $\mu$ s                          |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>49</sup> S        |                                  | 49.024                   | < 0.2 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <b><sub>17</sub>Cl</b> |                                  | <b>35.453(2)</b>         |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>28</sup> Cl       |                                  | 28.029                   |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>29</sup> Cl       |                                  | 29.0141                  | < 0.02 $\mu$ s                         |                              |                                          |                          |                                  |                              |                                            |
| <sup>30</sup> Cl       |                                  | 30.0048                  | < 0.03 $\mu$ s                         |                              |                                          |                          |                                  |                              |                                            |
| <sup>31</sup> Cl       |                                  | 30.99241                 | 0.15 s                                 | $\beta^+$ , p/11.98          | 0.986, 1.52/0.7                          | 3/2+                     |                                  |                              | ann.rad./                                  |

[illegible]



| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>36</sup> Ar  | 0.3365(30)                       | 35.96754511              |                                        |                              |                                          | 0+                       |                                  |                              | 2.964(1)/0.2                               |
| <sup>37</sup> Ar  |                                  | 36.9667763               | 35.0 d                                 | EC/.813                      |                                          | 3/2+                     | +1.15                            | +0.076                       |                                            |
| <sup>38</sup> Ar  | 0.0632(5)                        | 37.9627324               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>39</sup> Ar  |                                  | 38.964313                | 268. y                                 | $\beta^-$ /0.565             | 0.565/100.                               | 7/2-                     | -1.59                            | -0.12                        |                                            |
| <sup>40</sup> Ar  | 99.6003(30)                      | 39.962383123             |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>41</sup> Ar  |                                  | 40.9645006               | 1.82 h                                 | $\beta^-$ /2.492             | 1.198/                                   | 7/2-                     |                                  |                              | 1.29364(5)/99.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.6770(3)/0.05                             |
| <sup>42</sup> Ar  |                                  | 41.96305                 | 33. y                                  | $\beta^-$ /0.60              | 0.60/100.                                | 0+                       |                                  |                              |                                            |
| <sup>43</sup> Ar  |                                  | 42.96564                 | 5.4 m                                  | $\beta^-$ /4.6               |                                          |                          |                                  |                              | 0.4791(2)/10.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7380(1)/43.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9752(1)/100.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.4400(3)/39.                              |
| <sup>44</sup> Ar  |                                  | 43.964924                | 11.87 m                                | $\beta^-$ /3.55              |                                          | 0+                       |                                  |                              | 0.182–1.866                                |
| <sup>45</sup> Ar  |                                  | 44.968040                | 21.5 s                                 | $\beta^-$ /6.9               |                                          | 7/2-                     |                                  |                              | 0.0610/25.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.020/35.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 3.707/34.                                  |
| <sup>46</sup> Ar  |                                  | 45.96809                 | 8.4 s                                  | $\beta^-$ /5.70              |                                          | 0+                       |                                  |                              | 1.944/                                     |
| <sup>47</sup> Ar  |                                  | 46.9722                  | 1.23 s                                 | $\beta^-$                    |                                          |                          |                                  |                              | 0.36/100                                   |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.66/53                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.74/41                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (2.02 - 4.01)                              |
| <sup>48</sup> Ar  |                                  | 47.9745                  | 0.48 s                                 |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>49</sup> Ar  |                                  | 48.981                   | 0.17 s                                 | $\beta^-$ , n                | n// ~ 65.                                |                          |                                  |                              |                                            |
| <sup>50</sup> Ar  |                                  | 49.984                   | ~ 0.085 s                              | $\beta^-$ , n                | n// ~ 35.                                | 0+                       |                                  |                              |                                            |
| <sup>51</sup> Ar  |                                  | 50.992                   | > 0.2 $\mu$ s                          | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <sup>52</sup> Ar  |                                  | 51.997                   | 10 ms                                  | $\beta^-$                    |                                          | 0+                       |                                  |                              |                                            |
| <sup>53</sup> Ar  |                                  | 53.005                   |                                        | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <sup>19</sup> K   |                                  | 39.0983(1)               |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>32</sup> K   |                                  | 32.022                   |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>33</sup> K   |                                  | 33.0073                  | < 0.025 $\mu$ s                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>34</sup> K   |                                  | 33.9984                  | < 0.04 $\mu$ s                         |                              |                                          |                          |                                  |                              |                                            |
| <sup>35</sup> K   |                                  | 34.98801                 | 0.19 s                                 | $\beta^+$ /11.88             |                                          | 3/2+                     |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+$ , p/               | /0.37                                    |                          |                                  |                              | 1.751/14.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.5698/26.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.9827/51.                                 |
| <sup>36</sup> K   |                                  | 35.98129                 | 0.342 s                                | $\beta^+$ /12.81             | 5.3/42.                                  | 2+                       | +0.548                           |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              | 9.9/44.                                  |                          |                                  |                              | 1.97044(5)/82.                             |
|                   |                                  |                          |                                        | $\beta^+$ , p                | /0.048                                   |                          |                                  |                              | 2.20783(5)/30.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.43343(2)/32.                             |
| <sup>37</sup> K   |                                  | 36.9733759               | 1.23 s                                 | $\beta^+$ /6.149             | 5.13/                                    | 3/2+                     | +0.2032                          |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.7944(8)/2.                               |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 3.602(2)/0.05                              |
| <sup>38m</sup> K  |                                  |                          | 0.924 s                                | $\beta^+$ /6.742             | 5.02/100.                                | 0+                       |                                  |                              | ann.rad./                                  |
| <sup>38</sup> K   |                                  | 37.9690812               | 7.63 m                                 | $\beta^+$ /5.913             | 2.60/99.8                                | 3+                       | +1.37                            |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.1675(3)/99.8                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 3.9356(5)/0.2                              |
| <sup>39</sup> K   | 93.2581(44)                      | 38.9637067               |                                        |                              |                                          | 3/2+                     | +0.39146                         | +0.049                       |                                            |
| <sup>40</sup> K   | 0.0117(1)                        | 39.9639985               | 1.248 $\times 10^9$ y                  | $\beta^-$ /1.3111            | 1.312/89.                                | 4-                       | -1.29810                         | -0.061                       | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+$ , EC/1.505         | 1.50/10.7                                |                          |                                  |                              | 1.4608/10.5                                |
| <sup>41</sup> K   | 6.7302(44)                       | 40.9618258               |                                        |                              |                                          | 3/2+                     | +0.21487                         | +0.060                       |                                            |
| <sup>42</sup> K   |                                  | 41.9624028               | 12.36 h                                | $\beta^-$ /3.525             | 1.97/19.                                 | 2-                       | -1.1425                          |                              | 0.31260(2)/0.3                             |
|                   |                                  |                          |                                        |                              | 3.523/81.                                |                          |                                  |                              | 1.5246(3)/18.1                             |
| <sup>43</sup> K   |                                  | 42.96072                 | 22.3 h                                 | $\beta^-$ /1.82              | 0.465/8.                                 | 3/2+                     | +0.163                           |                              | 0.2211(2)/4.                               |
|                   |                                  |                          |                                        |                              | 0.825/87.                                |                          |                                  |                              | 0.3729(2)/88.                              |
|                   |                                  |                          |                                        |                              | 1.24/3.5                                 |                          |                                  |                              | 0.3971(2)/11.                              |
|                   |                                  |                          |                                        |                              | 1.814/1.3                                |                          |                                  |                              | 0.6178(2)/81.                              |
| <sup>44</sup> K   |                                  | 43.96156                 | 22.1 m                                 | $\beta^-$ /5.66              | 5.66/34.                                 | 2-                       | -0.856                           |                              | 0.36821/2.2                                |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.15700(1)/58.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.15079(2)/22.                             |
| <sup>45</sup> K   |                                  | 44.96070                 | 17.8 m                                 | $\beta^-$ /4.20              | 1.1/23.                                  | 3/2+                     | +0.173                           |                              | 0.1743(5)/80.                              |
|                   |                                  |                          |                                        |                              | 2.1/69.                                  |                          |                                  |                              | 1.2607(8)/7.                               |
|                   |                                  |                          |                                        |                              | 4.0/8.                                   |                          |                                  |                              | 1.7056(6)/69.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.3542(5)/14.                              |
| <sup>46</sup> K   |                                  | 45.96198                 | 1.8 m                                  | $\beta^-$ /7.72              | 6.3/                                     | 2-                       | -1.05                            |                              | 1.347(1)/91.                               |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 3.700(5)/28.                               |
| <sup>47</sup> K   |                                  | 46.96168                 | 17.5 s                                 | $\beta^-$ /6.64              | 4.1/99.                                  | ½+                       | +1.93                            |                              | 0.56474(3)/15.                             |
|                   |                                  |                          |                                        |                              | 6.0/1.                                   |                          |                                  |                              | 0.58575(3)/85.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.0131/100                                 |
| <sup>48</sup> K   |                                  | 47.96551                 | 6.8 s                                  | $\beta^-$ /12.09             | 5.0/                                     | (2-)                     |                                  |                              | 0.67122(1)/4.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6723(5)/20.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.78016(1)/32.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 3.83153(7)/80.                             |
| <sup>49</sup> K   |                                  | 48.9675                  | 1.26 s                                 | $\beta^-$ /11.0              |                                          |                          |                                  |                              | 2.025/                                     |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.252/                                     |
| <sup>50</sup> K   |                                  | 49.9728                  | 0.472 s                                | $\beta^-$ /14.2              |                                          |                          |                                  |                              |                                            |
| <sup>51</sup> K   |                                  | 50.976                   | 0.365 s                                | $\beta^-$ /                  |                                          |                          |                                  |                              |                                            |
| <sup>52</sup> K   |                                  | 51.983                   | 0.105 s                                | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <sup>53</sup> K   |                                  | 52.987                   | 30. ms                                 | $\beta^-$                    |                                          | 3/2+                     |                                  |                              |                                            |
| <sup>54</sup> K   |                                  | 53.994                   | 10. ms                                 | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <sup>20</sup> Ca  |                                  | 40.078(4)                |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>34</sup> Ca  |                                  | 34.0141                  | < 0.035 $\mu$ s                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>35</sup> Ca  |                                  | 35.0049                  | 25.7 ms                                | $\beta^+$ , p/15.6           | p/1.43/49                                |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 1.9–8.8                                  |                          |                                  |                              |                                            |
| <sup>36</sup> Ca  |                                  | 35.99309                 | 0.10 s                                 | $\beta^+$ , (p)/10.99        | 2.52                                     | 0+                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+$ , n/               |                                          |                          |                                  |                              |                                            |
| <sup>37</sup> Ca  |                                  | 36.98587                 | 0.18 s                                 | $\beta^+$ /11.64             | 3.103                                    | 3/2+                     |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+$ , n/               |                                          |                          |                                  |                              | 1.369                                      |
| <sup>38</sup> Ca  |                                  | 37.976318                | 0.44 s                                 | $\beta^+$ /6.74              |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.5677(5)/25.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 3.210(2)/1.                                |
| <sup>39</sup> Ca  |                                  | 38.970720                | 0.861 s                                | $\beta^+$ /6.531             | 5.49/100.                                | 3/2+                     | 1.02168                          |                              | ann.rad./                                  |
| <sup>40</sup> Ca  | 96.941(156)                      | 39.9625910               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>41</sup> Ca  |                                  | 40.9622781               | 1.02 $\times 10^5$ y                   | EC/0.4214                    |                                          | 7/2-                     | -1.5948                          | -0.090                       |                                            |
| <sup>42</sup> Ca  | 0.647(23)                        | 41.9586180               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>43</sup> Ca  | 0.135(10)                        | 42.9587666               |                                        |                              |                                          | 7/2-                     | -1.3173                          | -0.055                       |                                            |
| <sup>44</sup> Ca  | 2.086(110)                       | 43.9554818               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>45</sup> Ca  |                                  | 44.9561866               | 162.7 d                                | $\beta^-$ /0.257             | 0.257/100.                               | 7/2-                     | -1.327                           | +0.05                        |                                            |
| <sup>46</sup> Ca  | 0.004(3)                         | 45.953693                | > 0.4 $\times 10^{16}$ y               | $\beta^-\beta^-$             |                                          | 0+                       |                                  |                              |                                            |
| <sup>47</sup> Ca  |                                  | 46.954546                | 4.536 d                                | $\beta^-$ /1.992             | 0.684/84.                                | 7/2-                     | -1.38                            | +0.02                        | 1.297/75                                   |
|                   |                                  |                          |                                        |                              | 1.98/16.                                 |                          |                                  |                              | (0.041–1.88)                               |
| <sup>48</sup> Ca  | 0.187(21)                        | 47.952534                | 4.3 $\times 10^{19}$ y                 | $\beta^-\beta^-$             |                                          | 0+                       |                                  |                              |                                            |
|                   |                                  |                          | > 7.1 $\times 10^{19}$ y               | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <sup>49</sup> Ca  |                                  | 48.955674                | 8.72 m                                 | $\beta^-$ /5.262             | 0.89/7.                                  | 3/2-                     |                                  |                              | 3.0844(1)/90.7                             |
|                   |                                  |                          |                                        |                              | 1.95/92.                                 |                          |                                  |                              | 4.0719(1)/8.12                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.143 - 4.738)                            |
| <sup>50</sup> Ca  |                                  | 49.95752                 | 14. s                                  | $\beta^-$ /4.97              | 3.12/                                    | 0+                       |                                  |                              | 0.2569/98.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.0715–1.59)                              |
| <sup>51</sup> Ca  |                                  | 50.9615                  | 10. s                                  | $\beta^-$ /7.3               |                                          | (3/2-)                   |                                  |                              |                                            |
| <sup>52</sup> Ca  |                                  | 51.965                   | 4.6 s                                  | $\beta^-$ /8.0               |                                          | 0+                       |                                  |                              |                                            |
| <sup>53</sup> Ca  |                                  | 52.9701                  | 0.09 s                                 | $\beta^-$ /10.9              |                                          |                          |                                  |                              |                                            |
| <sup>54</sup> Ca  |                                  | 53.974                   | > 0.3 $\mu$ s                          |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>55</sup> Ca  |                                  | 54.981                   | > 0.3 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>56</sup> Ca  |                                  | 55.986                   | > 0.3 $\mu$ s                          |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>21</sup> Sc  |                                  | 44.955912(6)             |                                        |                              |                                          |                          |                                  |                              |                                            |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>36</sup> Sc       |                                  | 36.0149                  | 0.102 s                                |                              |                                          |                          |                                  |                              |                                            |
| <sup>37</sup> Sc       |                                  | 37.0031                  | 0.181 s                                |                              |                                          |                          |                                  |                              |                                            |
| <sup>38</sup> Sc       |                                  | 37.9947                  | < 0.3 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>39</sup> Sc       |                                  | 38.98479                 | < 0.3 $\mu$ s                          | p                            |                                          |                          |                                  |                              |                                            |
| <sup>40</sup> Sc       |                                  | 39.977967                | 0.182 s                                | $\beta^+$ /14.320            | 5.73/50.                                 | 4-                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              | 7.53/15.                                 |                          |                                  |                              | 0.752/41.                                  |
|                        |                                  |                          |                                        |                              | 8.76/15.                                 |                          |                                  |                              | 3.732/99.5                                 |
|                        |                                  |                          |                                        |                              | 9.58/20.                                 |                          |                                  |                              | (1.12–3.92)                                |
| <sup>41</sup> Sc       |                                  | 40.9692511               | 0.596 s                                | $\beta^+$ /6.4953            | 5.61/100.                                | 7/2-                     | +5.431                           | -0.156                       | ann.rad./                                  |
| <sup>42m</sup> Sc      |                                  |                          | 61.6 s                                 | $\beta^+$ /                  | 2.82/                                    | 7+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4375(5)/100.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.2270(5)/100.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.5245(5)/100.                             |
| <sup>42</sup> Sc       |                                  | 41.9655164               | 0.682 s                                | $\beta^+$ /6.4259            | 5.32/100.                                | 0+                       |                                  |                              | ann.rad./                                  |
| <sup>43</sup> Sc       |                                  | 42.961151                | 3.89 h                                 | $\beta^+$ , EC/2.221         | 0.82/22.                                 | 7/2-                     | +4.62                            | -0.26                        | ann.rad./                                  |
|                        |                                  |                          |                                        |                              | 1.22/78.                                 |                          |                                  |                              | 0.3729(1)/22.                              |
| <sup>44m</sup> Sc      |                                  |                          | 58.2 h                                 | I.T./0.27                    |                                          | 6+                       | +3.88                            |                              | 0.27124(1)/87.                             |
|                        |                                  |                          |                                        | EC/3.926                     |                                          |                          |                                  |                              | (1.00–1.16)                                |
| <sup>44</sup> Sc       |                                  | 43.959403                | 3.93 h                                 | $\beta^+$ , EC/3.653         | 1.47/                                    | 2+                       | +2.56                            | +0.10                        | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.157/100                                  |
| <sup>45</sup> Sc       | 100.                             | 44.955912                |                                        |                              |                                          | 7/2-                     | +4.75649                         | -0.220                       |                                            |
| <sup>46m</sup> Sc      |                                  |                          | 18.7 s                                 | I.T./0.14253                 |                                          | 1-                       |                                  |                              | 0.14253(2)/62.                             |
| <sup>46</sup> Sc       |                                  | 45.955172                | 83.81 d                                | $\beta^-$ /2.367             | 0.357/100.                               | 4+                       | +3.03                            | +0.12                        | 0.8893/100                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.121/100                                  |
| <sup>47</sup> Sc       |                                  | 46.952408                | 3.349 d                                | $\beta^-$ /0.600             | 0.439/69.                                | 7/2-                     | +5.34                            | -0.22                        | 0.15938(1)/68.                             |
|                        |                                  |                          |                                        |                              | 0.601/31.                                |                          |                                  |                              |                                            |
| <sup>48</sup> Sc       |                                  | 47.95223                 | 43.7 h                                 | $\beta^-$ /3.99              | 0.655/                                   | 6+                       |                                  |                              | 0.9835/100                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.03750(1)/97.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.3121/100                                 |
| <sup>49</sup> Sc       |                                  | 48.950024                | 57.3 m                                 | $\beta^-$ /2.006             | 2.00/99.9.                               | 7/2-                     |                                  |                              | 1.7619(3)/0.05                             |
| <sup>50</sup> Sc       |                                  | 49.95219                 | 1.71 m                                 | $\beta^-$ /6.89              | 3.05/76.                                 | (5+)                     |                                  |                              | 0.5235(1)/88.                              |
|                        |                                  |                          |                                        |                              | 3.60/24.                                 |                          |                                  |                              | 1.1210(1)/100.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.5537(2)/100.                             |
| <sup>51</sup> Sc       |                                  | 50.95360                 | 12.4 s                                 | $\beta^-$ /6.51              | 4.4/                                     | 7/2-                     |                                  |                              | 1.4373(4)/52.                              |
|                        |                                  |                          |                                        |                              | 5.0/                                     |                          |                                  |                              | 0.718–2.144                                |
| <sup>52</sup> Sc       |                                  | 51.9567                  | 8.2 s                                  | $\beta^-$ /9.0               |                                          | (3+)                     |                                  |                              |                                            |
| <sup>53</sup> Sc       |                                  | 52.9596                  | > 3. ms                                | $\beta^-$ /8.1               |                                          |                          |                                  |                              |                                            |
| <sup>54m</sup> Sc      |                                  |                          | $\sim$ 7 $\mu$ s                       | I.T.                         |                                          | (5+)                     |                                  |                              | 0.110/IT                                   |
| <sup>54</sup> Sc       |                                  | 53.9633                  | 0.27 s                                 | $\beta^-$ /11.6              |                                          |                          |                                  |                              | 0.100/50                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.70/40                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.50/40                                    |
| <sup>55</sup> Sc       |                                  | 54.968                   | 0.103 s                                | $\beta^-$ /13                |                                          |                          |                                  |                              | 0.593(1)/40                                |
| <sup>56m</sup> Sc      |                                  |                          | 0.06 s                                 |                              |                                          |                          |                                  |                              | 1.161/21                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.690/19                                   |
| <sup>56</sup> Sc       |                                  | 55.973                   | 35. ms                                 | $\beta^-$                    |                                          | (1+)                     |                                  |                              | 1.129/48                                   |
| <sup>57</sup> Sc       |                                  | 56.978                   | 13. ms                                 | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <sup>58</sup> Sc       |                                  | 57.984                   | 12. ms                                 | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <b><sup>22</sup>Ti</b> |                                  | <b>47.867(1)</b>         |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>38m</sup> Ti      |                                  | 38.0098                  | < 0.12 $\mu$ s                         |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>39</sup> Ti       |                                  | 39.0016                  | 30. ms                                 | $\beta^+$ /15.4              |                                          |                          |                                  |                              |                                            |
| <sup>40</sup> Ti       |                                  | 39.9905                  | 54. ms                                 | $\beta^+$ /11.7              | p/2.16/29                                | 0+                       |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\beta^+$ , p                | 3.73/23                                  |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 1.70/22                                  |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 0.242–5.74                               |                          |                                  |                              |                                            |
| <sup>41</sup> Ti       |                                  | 40.9832                  | 80. ms                                 | $\beta^+$ , p/12.93          | p/4.73/107                               | 3/2+                     |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              | 3.10/67                                  |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 3.75/39                                  |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 0.744–6.73                               |                          |                                  |                              |                                            |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)  | Particle Energy/<br>Intensity<br>(MeV/%)    | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                      |
|-------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------|---------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------------------------------|
| <sup>42</sup> Ti  |                                  | 41.97303                 | 0.20 s                                 | $\beta^+$ /7.000              | 6.0/                                        | 0+                       |                                  |                              | ann.rad./<br>0.6107(5)/56.                                                      |
| <sup>43</sup> Ti  |                                  | 42.96852                 | 0.50 s                                 | $\beta^+$ /6.87               | 5.80/                                       | 7/2-                     | 0.85                             |                              | ann.rad./                                                                       |
| <sup>44</sup> Ti  |                                  | 43.959690                | 60. y                                  | EC/0.268                      |                                             | 0+                       |                                  |                              | 0.06787/91<br>0.07832/97                                                        |
| <sup>45</sup> Ti  |                                  | 44.958126                | 3.078 h                                | $\beta^+$ /86/2.062<br>EC/14/ | 1.04                                        | 7/2-                     | 0.095                            | 0.015                        | ann.rad./<br>(0.36–1.66)                                                        |
| <sup>46</sup> Ti  | 8.25(3)                          | 45.952632                |                                        |                               |                                             | 0+                       |                                  |                              |                                                                                 |
| <sup>47</sup> Ti  | 7.44(2)                          | 46.951763                |                                        |                               |                                             | 5/2-                     | -0.78848                         | +0.30                        |                                                                                 |
| <sup>48</sup> Ti  | 73.72(3)                         | 47.947946                |                                        |                               |                                             | 0+                       |                                  |                              |                                                                                 |
| <sup>49</sup> Ti  | 5.41(2)                          | 48.947870                |                                        |                               |                                             | 7/2-                     | -1.10417                         | +0.24                        |                                                                                 |
| <sup>50</sup> Ti  | 5.18(2)                          | 49.944791                |                                        |                               |                                             | 0+                       |                                  |                              |                                                                                 |
| <sup>51</sup> Ti  |                                  | 50.946615                | 5.76 m                                 | $\beta^-$ /2.471              | 1.50/92.<br>2.13/                           | 3/2-                     |                                  |                              | 0.3197(2)/93.<br>0.6094–0.9291                                                  |
| <sup>52</sup> Ti  |                                  | 51.94690                 | 1.7 m                                  | $\beta^-$ /1.97               | 1.8/100.                                    | 0+                       |                                  |                              | 0.0170(5)/100.<br>0.1245/100                                                    |
| <sup>53</sup> Ti  |                                  | 52.9497                  | 33. s                                  | $\beta^-$ /5.0                | (2.2–3)/                                    | 3/2-                     |                                  |                              | 0.1008(1)/20.<br>0.1276(1)/45.<br>0.2284(1)/39.<br>1.6755(5)/45.<br>(1.72–2.8)/ |
| <sup>54</sup> Ti  |                                  | 53.9511                  | 1.5 s                                  | $\beta^-$ /4.3                |                                             | 0+                       |                                  |                              |                                                                                 |
| <sup>55</sup> Ti  |                                  | 54.9553                  | 1.3 s                                  | $\beta^-$ /7.4                |                                             |                          |                                  |                              | 0.672/44<br>(0.32 - 1.83)                                                       |
| <sup>56</sup> Ti  |                                  | 55.9582                  | 0.20 s                                 | $\beta^-$ /7.0                |                                             | 0+                       |                                  |                              |                                                                                 |
| <sup>57</sup> Ti  |                                  | 56.9640                  | 98. ms                                 | $\beta^-$ /11.                |                                             |                          |                                  |                              |                                                                                 |
| <sup>58</sup> Ti  |                                  | 57.967                   | 53. ms                                 | $\beta^-$                     |                                             | 0+                       |                                  |                              | 0.114                                                                           |
| <sup>59</sup> Ti  |                                  | 58.973                   | 30. ms                                 | $\beta^-$                     |                                             |                          |                                  |                              |                                                                                 |
| <sup>60</sup> Ti  |                                  | 59.978                   | 22. ms                                 | $\beta^-$                     |                                             | 0+                       |                                  |                              |                                                                                 |
| <sup>61</sup> Ti  |                                  | 60.983                   | > 0.3 $\mu$ s                          |                               |                                             |                          |                                  |                              |                                                                                 |
| <sup>23</sup> V   |                                  | 50.9415(1)               |                                        |                               |                                             |                          |                                  |                              |                                                                                 |
| <sup>40</sup> V   |                                  | 40.0111                  |                                        |                               |                                             |                          |                                  |                              |                                                                                 |
| <sup>41</sup> V   |                                  | 40.9998                  |                                        |                               |                                             |                          |                                  |                              |                                                                                 |
| <sup>42</sup> V   |                                  | 41.9912                  | < 0.055 $\mu$ s                        |                               |                                             |                          |                                  |                              |                                                                                 |
| <sup>43</sup> V   |                                  | 42.9807                  | > 0.8 s                                | $\beta^+$ /11.3               |                                             |                          |                                  |                              |                                                                                 |
| <sup>44</sup> V   |                                  | 43.9741                  | 0.09 s                                 | $\beta^+$ , $\alpha$ /13.7    |                                             |                          |                                  |                              | ann.rad./                                                                       |
| <sup>45</sup> V   |                                  | 44.96578                 | 0.54 s                                 | $\beta^+$ /7.13               |                                             | 7/2-                     |                                  |                              |                                                                                 |
| <sup>46</sup> V   |                                  | 45.960201                | 0.4223 s                               | $\beta^+$ /7.051              | 6.03/100.                                   | 0+                       |                                  |                              | ann.rad./                                                                       |
| <sup>47</sup> V   |                                  | 46.954909                | 32.6 m                                 | $\beta^+$ , EC/2.928          | 1.90/99.+                                   | 3/2-                     |                                  |                              | ann.rad./<br>1.7949(8)/0.19<br>(0.2–2.16)                                       |
| <sup>48</sup> V   |                                  | 47.952254                | 15.98 d                                | $\beta^+$ /4.012              | 0.698/50.                                   | 4+                       | 2.01                             |                              | ann.rad./<br>0.9835/100<br>(1.3–2.4)                                            |
| <sup>49</sup> V   |                                  | 48.948516                | 337. d                                 | EC/0.602                      |                                             | 7/2-                     | 4.47                             |                              |                                                                                 |
| <sup>50</sup> V   | 0.250(4)                         | 49.947159                | $1.4 \times 10^{17}$ y                 | EC<br>$\beta^-$               | /82.7<br>/17.3                              | 6+                       | +3.34569                         | +0.21                        |                                                                                 |
| <sup>51</sup> V   | 99.750(4)                        | 50.943960                |                                        |                               |                                             | 7/2-                     | +5.148706                        | -0.04                        |                                                                                 |
| <sup>52</sup> V   |                                  | 51.944776                | 3.76 m                                 | $\beta^-$ /3.976              | 2.47/                                       | 3+                       |                                  |                              | 1.4341(1)/100.                                                                  |
| <sup>53</sup> V   |                                  | 52.944338                | 1.56 m                                 | $\beta^-$ /3.436              | 2.52/                                       | 7/2-                     |                                  |                              | 1.0060(5)/90.<br>1.2891(3)/10.                                                  |
| <sup>54m</sup> V  |                                  |                          | 0.9 $\mu$ s                            | I.T.                          |                                             | (5+)                     |                                  |                              | 0.108/IT                                                                        |
| <sup>54</sup> V   |                                  | 53.94644                 | 49.8 s                                 | $\beta^-$ /7.04               | 1.00/5.<br>2.00/12.<br>2.95/45.<br>5.20/11. | 3+                       |                                  |                              | 0.8348/97.<br>0.9887/80.<br>2.259/46.<br>(0.56–3.38)                            |
| <sup>55</sup> V   |                                  | 54.9472                  | 6.5 s                                  | $\beta^-$ /6.0                | 6.0/                                        | (7/2-)                   |                                  |                              | 0.5177/73.<br>(0.224–1.21)                                                      |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                   |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------------------------|
| <sup>56</sup> V        |                                  | 55.9505                  | 0.22 s                                 | $\beta^-$ /9.1               |                                          |                          |                                  |                              | 1.01/30.<br>0.688/26.<br>(0.82 – 1.32)                       |
| <sup>57</sup> V        |                                  | 56.9526                  | 0.35 s                                 | $\beta^-$ /8.1               |                                          |                          |                                  |                              | 0.268/52.<br>0.692/20.<br>(0.25 – 1.31)                      |
| <sup>58</sup> V        |                                  | 57.9567                  | 0.19 s                                 | $\beta^-$ /11.6              |                                          |                          |                                  |                              | 0.880/62<br>1.056/28<br>2.217/13<br>(1.04 – 1.57)            |
| <sup>59</sup> V        |                                  | 58.9602                  | 97. ms                                 | $\beta^-$ /9.9               |                                          |                          |                                  |                              | 0.90/80.                                                     |
| <sup>60m</sup> V       |                                  |                          | 0.12 s                                 |                              |                                          |                          |                                  |                              |                                                              |
| <sup>60</sup> V        |                                  | 59.9650                  | 0.07 s                                 | $\beta^-$ /14.               |                                          |                          |                                  |                              | 0.102–0.208                                                  |
| <sup>61</sup> V        |                                  | 60.9685                  | 47. ms                                 |                              |                                          |                          |                                  |                              | (0.071-1.144)                                                |
| <sup>62</sup> V        |                                  | 61.9738                  | 34. ms                                 |                              |                                          |                          |                                  |                              |                                                              |
| <sup>63</sup> V        |                                  | 62.978                   | 17. ms                                 |                              |                                          |                          |                                  |                              |                                                              |
| <sup>64</sup> V        |                                  | 63.983                   | > 0.3 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                                              |
| <b><sup>24</sup>Cr</b> |                                  | <b>51.9961(6)</b>        |                                        |                              |                                          |                          |                                  |                              |                                                              |
| <sup>42</sup> Cr       |                                  | 42.0064                  | 13. ms                                 | $\beta^+$ , p                | p/1.90/29<br>p/1.50–3.7                  | 0+                       |                                  |                              |                                                              |
| <sup>43</sup> Cr       |                                  | 42.9977                  | 21. ms                                 | $\beta^+$ , p                | p/3.83/18<br>p/4.29/15<br>p/1.01–4.59    |                          |                                  |                              |                                                              |
| <sup>44</sup> Cr       |                                  | 43.98555                 | 53. ms                                 | $\beta^+$ , (p)/10.3         | p/0.95–3.1                               | 0+                       |                                  |                              |                                                              |
| <sup>45</sup> Cr       |                                  | 44.9796                  | 0.05 s                                 | $\beta^+$ , p/12.5           |                                          | 7/2-                     |                                  |                              | ann.rad./                                                    |
| <sup>46</sup> Cr       |                                  | 45.96836                 | 0.3 s                                  | $\beta^+$ /7.60              |                                          | 0+                       |                                  |                              | ann.rad./                                                    |
| <sup>47</sup> Cr       |                                  | 46.96290                 | 0.51 s                                 | $\beta^+$ /7.45              |                                          | 3/2-                     |                                  |                              | ann.rad./                                                    |
| <sup>48</sup> Cr       |                                  | 47.95403                 | 21.6 h                                 | EC/1.66                      |                                          | 0+                       |                                  |                              | ann.rad./<br>0.116(2)/95.<br>0.305(10)/100.                  |
| <sup>49</sup> Cr       |                                  | 48.951336                | 42.3 m                                 | $\beta^+$ , EC/2.631         | 1.39/<br>1.45/<br>1.54/                  | 5/2-                     | 0.476                            |                              | ann.rad./<br>0.09064(1)/51.<br>0.15293(1)/27.<br>(0.062-1.6) |
| <sup>50</sup> Cr       | 4.345(13)                        | 49.946044                | > 1.3 $\times 10^{18}$ y               | $\beta^+$ EC                 |                                          | 0+                       |                                  |                              |                                                              |
| <sup>51</sup> Cr       |                                  | 50.944767                | 27.70 d                                | EC/0.7527                    |                                          | 7/2-                     | -0.934                           |                              | 0.3201/10.2                                                  |
| <sup>52</sup> Cr       | 83.789(18)                       | 51.940508                |                                        |                              |                                          | 0+                       |                                  |                              |                                                              |
| <sup>53</sup> Cr       | 9.501(17)                        | 52.940649                |                                        |                              |                                          | 3/2-                     | -0.47454                         | -0.15                        |                                                              |
| <sup>54</sup> Cr       | 2.365(7)                         | 53.938880                |                                        |                              |                                          | 0+                       |                                  |                              |                                                              |
| <sup>55</sup> Cr       |                                  | 54.940840                | 3.497 m                                | $\beta^-$ /2.603             | 2.5/                                     | 3/2-                     |                                  |                              | 1.5282(2)/0.04<br>(0.13–2.37)                                |
| <sup>56</sup> Cr       |                                  | 55.940653                | 5.9 m                                  | $\beta^-$ /1.62              | 1.50/100.                                | 0+                       |                                  |                              | 0.026(2)/100.<br>0.083(3)/100.                               |
| <sup>57</sup> Cr       |                                  | 56.943613                | 21. s                                  | $\beta^-$ /5.1               | 3.3/<br>3.5/                             | 3/2-                     | 0.0834                           |                              | 0.850/8.<br>(0.083-2.62)                                     |
| <sup>58</sup> Cr       |                                  | 57.9444                  | 7.0 s                                  | $\beta^-$ /4.0               |                                          | 0+                       |                                  |                              | (0.131–0.683)                                                |
| <sup>59m</sup> Cr      |                                  |                          | 0.10 ms                                | I.T.                         |                                          | (9/2+)                   |                                  |                              | 0.208/IT<br>0.193<br>0.102                                   |
| <sup>59</sup> Cr       |                                  | 58.9486                  | 1.0 s                                  | $\beta^-$ /7.7               |                                          |                          |                                  |                              | 1.236                                                        |
| <sup>60</sup> Cr       |                                  | 59.9500                  | 0.6 s                                  | $\beta^-$ /6.0               |                                          | 0+                       |                                  |                              |                                                              |
| <sup>61</sup> Cr       |                                  | 60.9547                  | 0.26 s                                 | $\beta^-$ /8.8               |                                          |                          |                                  |                              | 0.354–1.860                                                  |
| <sup>62</sup> Cr       |                                  | 61.9566                  | 0.19 s                                 | $\beta^-$ /7.3               |                                          | 0+                       |                                  |                              | (0.156-1.215)                                                |
| <sup>63</sup> Cr       |                                  | 62.9619                  | 0.129 s                                | $\beta^-$                    |                                          |                          |                                  |                              | (0.250-3.454)                                                |
| <sup>64</sup> Cr       |                                  | 63.9644                  | 0.043 s                                | $\beta^-$                    |                                          | 0+                       |                                  |                              | 0.188                                                        |
| <sup>65</sup> Cr       |                                  | 64.9702                  | 0.027 s                                | $\beta^-$                    |                                          |                          |                                  |                              | 0.272, 1.368                                                 |
| <sup>66</sup> Cr       |                                  | 65.973                   | 0.01 s                                 | $\beta^-$                    |                                          | 0+                       |                                  |                              |                                                              |
| <sup>67</sup> Cr       |                                  | 66.980                   | > 0.3 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                                              |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $h/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|----------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>25</sup> Mn  |                                  | 54.938045(5)             |                                        |                              |                                          |                      |                                  |                              |                                            |
| <sup>44</sup> Mn  |                                  | 44.0069                  | < 0.105 $\mu$ s                        |                              |                                          |                      |                                  |                              |                                            |
| <sup>45</sup> Mn  |                                  | 44.9945                  | < 0.07 $\mu$ s                         |                              |                                          |                      |                                  |                              |                                            |
| <sup>46</sup> Mn  |                                  | 45.9867                  | 34. ms                                 | $\beta+$ /17.1               |                                          |                      |                                  |                              |                                            |
|                   |                                  |                          |                                        | $\beta+$ , p                 | // ~ 58                                  |                      |                                  |                              |                                            |
| <sup>47</sup> Mn  |                                  | 46.9761                  | ~ 0.1 s                                | $\beta+$ /12.3               |                                          |                      |                                  |                              |                                            |
| <sup>48</sup> Mn  |                                  | 47.9685                  | 0.15 s                                 | $\beta+$ /13.5               | 5.79/58.                                 | 4+                   |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 4.43/10.                                 |                      |                                  |                              |                                            |
| <sup>49</sup> Mn  |                                  | 48.95962                 | 0.38 s                                 | $\beta+$ /7.72               | 6.69/                                    | 5/2-                 |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              |                                            |
| <sup>50m</sup> Mn |                                  |                          | 1.74 m                                 | $\beta+$ /7.887              | 3.54/                                    | 5+                   |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.0980/94.                                 |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.783/91.                                  |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.66–3.11)                                |
| <sup>50</sup> Mn  |                                  | 49.954238                | 0.283 s                                | $\beta+$ /7.6330             | 6.61/                                    | 0+                   |                                  |                              | ann.rad./                                  |
| <sup>51</sup> Mn  |                                  | 50.948211                | 46.2 m                                 | $\beta+$ , EC/3.208          | 2.2/                                     | 5/2-                 | 3.568                            | 0.4                          | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.7491(1)/0.26                             |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (1.148–1.164)                              |
| <sup>52m</sup> Mn |                                  |                          | 21.1 m                                 | $\beta+$ /98/5.09            | 2.631/                                   | 2+                   | 0.0076                           |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | I.T./2/0.378                 |                                          |                      |                                  |                              | 0.3778 (I.T.)                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.43406(1)/98.                             |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.7–4.8)                                  |
| <sup>52</sup> Mn  |                                  | 51.945566                | 5.591 d                                | $\beta+$ /4.712              | 0.575/                                   | 6+                   | +3.063                           | +0.5                         | ann.rad./                                  |
|                   |                                  |                          |                                        | EC/                          |                                          |                      |                                  |                              | 0.74421(1)/90.                             |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.4341/100                                 |
| <sup>53</sup> Mn  |                                  | 52.941290                | $3.7 \times 10^6$ y                    | EC/0.5970                    |                                          | 7/2-                 | 5.024                            |                              |                                            |
| <sup>54</sup> Mn  |                                  | 53.940359                | 312.1 d                                | EC/1.377                     |                                          | 3+                   | +3.282                           | +0.33                        | 0.8340/100                                 |
|                   |                                  |                          | $6.7 \times 10^8$ y                    | $\beta+$                     | // $1.3 \times 10^{-7}$                  |                      |                                  |                              |                                            |
| <sup>55</sup> Mn  | 100.                             | 54.938045                |                                        |                              |                                          | 5/2-                 | +3.4687                          | +0.32                        |                                            |
| <sup>56</sup> Mn  |                                  | 55.938905                | 2.579 h                                | $\beta^-$ /3.6954            | 0.718/18.                                | 3+                   | +3.2266                          |                              | 0.84675/98.9                               |
|                   |                                  |                          |                                        |                              | 1.028/34.                                |                      |                                  |                              | 1.81072(4)/26.3                            |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 2.113/13.8                                 |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (1.04 – 3.37)                              |
| <sup>57</sup> Mn  |                                  | 56.938285                | 1.45 m                                 | $\beta^-$ /2.691             |                                          | 5/2-                 |                                  |                              |                                            |
| <sup>58</sup> Mn  |                                  | 57.93998                 | 65 s                                   | $\beta^-$ /6.25              | 3.8/                                     | 3+                   |                                  |                              | 0.45916(2)/20.                             |
|                   |                                  |                          |                                        |                              | 5.1/                                     |                      |                                  |                              | 0.81076(1)/82.                             |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.32309(5)/53.                             |
| <sup>59</sup> Mn  |                                  | 58.94044                 | 4.6 s                                  | $\beta^-$ /5.19              | 4.5/                                     | 5/2-                 |                                  |                              | 0.726/                                     |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.473/                                     |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.287–2.35                                 |
| <sup>60m</sup> Mn |                                  |                          | 1.77 s                                 | $\beta^-$ /IT                | 5.7/                                     | 3+                   |                                  |                              | 0.824/                                     |
| <sup>60</sup> Mn  |                                  | 59.9429                  | 50. s                                  | $\beta^-$ /8.6               |                                          | 0+                   |                                  |                              | 1.969/                                     |
| <sup>61</sup> Mn  |                                  | 60.9447                  | 0.67 s                                 | $\beta^-$ /7.4               |                                          | (5/2)-               |                                  |                              |                                            |
| <sup>62</sup> Mn  |                                  | 61.9484                  | 0.67 s                                 | $\beta^-$ /10.4              |                                          | (3+)                 |                                  |                              | 0.877/                                     |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.942–1.299                                |
| <sup>63</sup> Mn  |                                  | 62.9502                  | 0.28 s                                 | $\beta^-$ /8.8               |                                          |                      |                                  |                              | 0.356,0.450                                |
| <sup>64m</sup> Mn |                                  |                          | > 0.1 ms                               |                              |                                          |                      |                                  |                              | 0.135/IT                                   |
| <sup>64</sup> Mn  |                                  | 63.9543                  | 87 ms                                  | $\beta^-$ /11.8              |                                          |                      |                                  |                              | 0.746                                      |
| <sup>65</sup> Mn  |                                  | 64.9563                  | 0.092 s                                | $\beta^-$ /10.               |                                          |                      |                                  |                              | 0.366                                      |
| <sup>66</sup> Mn  |                                  | 65.9611                  | 64 ms                                  |                              |                                          |                      |                                  |                              | 0.471                                      |
| <sup>67</sup> Mn  |                                  | 66.9641                  | 45 ms                                  |                              |                                          |                      |                                  |                              |                                            |
| <sup>68</sup> Mn  |                                  | 67.969                   | ~ 28 ms                                |                              |                                          |                      |                                  |                              |                                            |
| <sup>69</sup> Mn  |                                  | 68.973                   | 14 ms                                  |                              |                                          |                      |                                  |                              |                                            |
| <sup>26</sup> Fe  |                                  | 55.845(2)                |                                        |                              |                                          |                      |                                  |                              |                                            |
| <sup>45</sup> Fe  |                                  | 45.0146                  | 1.8 ms                                 | 2p /1.14                     | p// ~ 59.                                |                      |                                  |                              |                                            |
| <sup>46</sup> Fe  |                                  | 46.0008                  | 11. ms                                 | $\beta+$ /13.1               | p// ~ 36.                                | 0+                   |                                  |                              |                                            |
| <sup>47</sup> Fe  |                                  | 46.9929                  | 21.7 ms                                | $\beta+$ /15.6               | p//87.                                   |                      |                                  |                              |                                            |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>48</sup> Fe  |                                  | 47.9805                  | ~ 44. ms                               | $\beta^+$ /11.2              |                                          | 0+                       |                                  |                              |                                            |
| <sup>49</sup> Fe  |                                  | 48.9736                  | 70. ms                                 | $\beta^+$ /13.0              |                                          | (7/2-)                   |                                  |                              | ann.rad./                                  |
| <sup>50</sup> Fe  |                                  | 49.9630                  | 0.15 s                                 | $\beta^+$ /8.2               |                                          | 0+                       |                                  |                              | 0.651                                      |
| <sup>51</sup> Fe  |                                  | 50.95682                 | 0.31 s                                 | $\beta^+$ /8.02              |                                          | (5/2-)                   |                                  |                              | ann.rad./                                  |
| <sup>52m</sup> Fe |                                  |                          | 46. s                                  | $\beta^+$ /4.4               |                                          | (12+)                    |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.622–2.286)/                             |
| <sup>52</sup> Fe  |                                  | 51.94811                 | 8.28 h                                 | $\beta^+$ /57/2.37           | 0.804/                                   | 0+                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | EC/43/                       |                                          |                          |                                  |                              | 0.16868(1)/99.                             |
|                   |                                  |                          |                                        | I.T./                        |                                          |                          |                                  |                              | 0.377 (I.T.)/                              |
| <sup>53m</sup> Fe |                                  |                          | 2.6 m                                  | I.T./3.0407                  |                                          | 19/2-                    |                                  |                              | 0.7011(1)/99.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.0115(1)/87.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.3281(1)/87.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.3396(1)/13.                              |
| <sup>53</sup> Fe  |                                  | 52.945308                | 8.51 m                                 | $\beta^+$ /3.743             | 2.40/42.                                 | 7/2-                     |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              | 2.80/57.                                 |                          |                                  |                              | 0.3779(1)/42.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (1.2–3.2)                                  |
| <sup>54</sup> Fe  | 5.845(35)                        | 53.939611                | > 3.1 $\times 10^{22}$ y               | EC-EC                        |                                          | 0+                       |                                  |                              |                                            |
| <sup>55</sup> Fe  |                                  | 54.938293                | 2.73 y                                 | EC/0.2314                    |                                          | 3/2-                     |                                  |                              | Mn x-ray                                   |
| <sup>56</sup> Fe  | 91.754(36)                       | 55.934938                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>57</sup> Fe  | 2.119(10)                        | 56.935394                |                                        |                              |                                          | ½-                       | +0.0906                          | 0.16                         |                                            |
| <sup>58</sup> Fe  | 0.282(4)                         | 57.933276                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>59</sup> Fe  |                                  | 58.934876                | 44.51 d                                | $\beta^-$ /1.565             | 0.273/48.                                | 3/2-                     | -0.336                           |                              | 1.099/57                                   |
|                   |                                  |                          |                                        |                              | 0.475/51.                                |                          |                                  |                              | 1.292/43.                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.14–1.48)                                |
| <sup>60</sup> Fe  |                                  | 59.934072                | 1.5 $\times 10^6$ y                    | $\beta^-$ /0.237             | 0.184/100.                               | 0+                       |                                  |                              | 0.0586/100                                 |
| <sup>61m</sup> Fe |                                  |                          | 0.25 $\mu$ s                           | I.T.                         |                                          | (9/2+)                   |                                  |                              | 0.654/IT                                   |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.207                                      |
| <sup>61</sup> Fe  |                                  | 60.93675                 | 6.0 m                                  | $\beta^-$ /3.98              | 2.5/13.                                  |                          |                                  |                              | 1.205/44.                                  |
|                   |                                  |                          |                                        |                              | 2.63/54.                                 |                          |                                  |                              | 1.028/43.                                  |
|                   |                                  |                          |                                        |                              | 2.80/31.                                 |                          |                                  |                              | (0.12–3.37)                                |
| <sup>62</sup> Fe  |                                  | 61.93677                 | 68. s                                  | $\beta^-$ /2.53              | 2.5/100.                                 | 0+                       |                                  |                              | 0.5061(1)/100.                             |
| <sup>63</sup> Fe  |                                  | 62.9404                  | 6. s                                   | $\beta^-$ /6.3               |                                          | 5/2-                     |                                  |                              | 0.995/                                     |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (1.365–1.427)                              |
| <sup>64</sup> Fe  |                                  | 63.9412                  | 2.0 s                                  | $\beta^-$ /4.9               |                                          | 0+                       |                                  |                              |                                            |
| <sup>65m</sup> Fe |                                  |                          | 0.4 $\mu$ s                            | I.T.                         |                                          | (5/2-)                   |                                  |                              | 0.364/IT                                   |
| <sup>65</sup> Fe  |                                  | 64.9454                  | 1.3 s                                  | $\beta^-$ /7.9               |                                          |                          |                                  |                              |                                            |
| <sup>66</sup> Fe  |                                  | 65.9468                  | 0.44 s                                 | $\beta^-$ /5.7               |                                          | 0+                       |                                  |                              | 0.471–1.425                                |
| <sup>67m</sup> Fe |                                  |                          | ~ 0.04 ms                              | I.T.                         |                                          | (5/2-)                   |                                  |                              | 0.367/IT                                   |
| <sup>67</sup> Fe  |                                  | 66.9510                  | 0.48 s                                 | $\beta^-$ /8.8               |                                          |                          |                                  |                              | 0.189                                      |
| <sup>68</sup> Fe  |                                  | 67.954                   | 0.19 s                                 | $\beta^-$ / ~ 7.6            |                                          | 0+                       |                                  |                              |                                            |
| <sup>69</sup> Fe  |                                  | 68.959                   | 0.11 s                                 |                              |                                          |                          |                                  |                              |                                            |
| <sup>70</sup> Fe  |                                  | 69.961                   | 0.10 s                                 |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>71</sup> Fe  |                                  | 70.967                   | > 0.3 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>72</sup> Fe  |                                  | 71.970                   | > 0.3 $\mu$ s                          |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>27</sup> Co  |                                  | <b>58.933195(5)</b>      |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>47</sup> Co  |                                  | 47.0115                  |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>48</sup> Co  |                                  | 48.0018                  |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>49</sup> Co  |                                  | 48.9897                  | < 0.035 $\mu$ s                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>50</sup> Co  |                                  | 49.9815                  | 44. ms                                 | $\beta^+$ /17.0              | 2.03–2.79                                |                          |                                  |                              |                                            |
| <sup>51</sup> Co  |                                  | 50.9707                  | > 0.2 $\mu$ s                          | $\beta^+$ /12.8              |                                          |                          |                                  |                              |                                            |
| <sup>52</sup> Co  |                                  | 51.9636                  | 0.12 s                                 | $\beta^+$ /14.0              |                                          |                          |                                  |                              | 0.849–1.942                                |
| <sup>53m</sup> Co |                                  |                          | 0.25 s                                 | $\beta^+$ , p/               |                                          | 19/2-                    |                                  |                              | ann.rad./                                  |
| <sup>53</sup> Co  |                                  | 52.95422                 | 0.24 s                                 | $\beta^+$ /8.30              |                                          | 7/2-                     |                                  |                              | ann.rad./                                  |
| <sup>54m</sup> Co |                                  |                          | 1.46 m                                 | $\beta^+$ /8.44              | 4.25/100.                                | 7+                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.411(1)/99.                               |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.130(1)/100.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.408(1)/100.                              |
| <sup>54</sup> Co  |                                  | 53.948460                | 0.1932 s                               | $\beta^+$ /8.2430            | 7.34/100.                                | 0+                       |                                  |                              | ann.rad./                                  |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)           | Particle Energy/<br>Intensity<br>(MeV/%)   | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                      |
|--------------------|----------------------------------|--------------------------|----------------------------------------|----------------------------------------|--------------------------------------------|--------------------------|----------------------------------|------------------------------|-----------------------------------------------------------------|
| <sup>55</sup> Co   |                                  | 54.941999                | 17.53 h                                | $\beta^+$ /3.4513<br>EC/               | 0.53/<br>1.03/<br>1.50/                    | 7/2-                     | +4.822                           |                              | ann.rad./<br>0.9312/75.<br>0.4772/20.<br>(0.092–3.11)           |
| <sup>56</sup> Co   |                                  | 55.939839                | 77.3 d                                 | $\beta^+$ /4.566<br>EC/                | 1.459/18.                                  | 4+                       | 3.85                             | +0.25                        | ann.rad./<br>0.8468/99.9<br>1.2383/68.<br>(0.26–3.61)           |
| <sup>57</sup> Co   |                                  | 56.936291                | 271.8 d                                | EC/0.8361                              |                                            | 7/2-                     | +4.72                            | +0.5                         | 0.12206/86<br>(0.014–0.706)                                     |
| <sup>58m</sup> Co  |                                  |                          | 9.1 h                                  | I.T./                                  |                                            | 5+                       |                                  |                              | 0.02489/0.035                                                   |
| <sup>58</sup> Co   |                                  | 57.935753                | 70.88 d                                | $\beta^+$ /2.307<br>EC/                |                                            | 2+                       | +4.04                            | +0.22                        | ann.rad./<br>0.81076/99                                         |
| <sup>59</sup> Co   | 100.                             | 58.933195                |                                        |                                        |                                            | 7/2-                     | +4.63                            | +0.41                        |                                                                 |
| <sup>60m</sup> Co  |                                  |                          | 10.47 m                                | I.T./99.8/0.059<br>$\beta^-$ /0.2/1.56 |                                            | 2+                       | +4.40                            | +0.3                         | 0.0586/2.0                                                      |
| <sup>60</sup> Co   |                                  | 59.933817                | 5.271 y                                | $\beta^-$ /2.824                       | 0.315/99.7                                 | 5+                       | +3.799                           | +0.44                        | 1.1732/100<br>1.3325/100                                        |
| <sup>61</sup> Co   |                                  | 60.932476                | 1.650 h                                | $\beta^-$ /1.322                       | 1.22/95.                                   | 7/2-                     |                                  |                              | 0.0674/86.<br>0.842–0.909                                       |
| <sup>62m</sup> Co  |                                  |                          | 13.9 m                                 | $\beta^-$ /                            | 0.88/25.<br>2.88/75.                       | 5+                       |                                  |                              | 1.1635(3)/70.<br>1.1730(3)/98.<br>2.0039(3)/19.                 |
| <sup>62</sup> Co   |                                  | 61.93405                 | 1.50 m                                 | $\beta^-$ /5.32                        | 1.03/10.<br>1.76/5.<br>2.9/20.<br>4.05/60. | 2+                       |                                  |                              | 1.1292(3)/13.<br>1.1730(3)/83.<br>1.9851(1)/3.<br>2.3020(1)/19. |
| <sup>63</sup> Co   |                                  | 62.93361                 | 27.5 s                                 | $\beta^-$ /3.67                        | 3.6/                                       | 7/2-                     |                                  |                              | 0.08713(1)/49.<br>0.9817(3)/2.6<br>0.156–2.17                   |
| <sup>64</sup> Co   |                                  | 63.93581                 | 0.30 s                                 | $\beta^-$ /7.31                        | 7.0/                                       | 1+                       |                                  |                              |                                                                 |
| <sup>65</sup> Co   |                                  | 64.93648                 | 1.14 s                                 | $\beta^-$ /5.96                        |                                            | (7/2)-                   |                                  |                              |                                                                 |
| <sup>66m2</sup> Co |                                  |                          | > 0.1 ms                               | I.T.                                   |                                            | (8-)                     |                                  |                              | 0.252/IT<br>0.214<br>0.175                                      |
| <sup>66m1</sup> Co |                                  |                          | 1.2 $\mu$ s                            | I.T.                                   |                                            | (5+)                     |                                  |                              | 0.175/IT                                                        |
| <sup>66</sup> Co   |                                  | 65.9398                  | 0.25 s                                 | $\beta^-$ /10.0                        |                                            |                          |                                  |                              | (1.245–1.425)                                                   |
| <sup>67</sup> Co   |                                  | 66.9409                  | 0.43 s                                 | $\beta^-$ /8.4                         |                                            |                          |                                  |                              | 0.694                                                           |
| <sup>68</sup> Co   |                                  | 67.9449                  | 0.19 s                                 | $\beta^-$ /11.7                        |                                            |                          |                                  |                              |                                                                 |
| <sup>69</sup> Co   |                                  | 68.9463                  | 0.20 s                                 | $\beta^-$ /9.3                         |                                            |                          |                                  |                              |                                                                 |
| <sup>70</sup> Co   |                                  | 69.951                   | 0.12 s                                 | $\beta^-$ 13.                          |                                            |                          |                                  |                              | 1.26/102<br>0.97/100<br>(0.45 – 0.92)                           |
| <sup>71</sup> Co   |                                  | 70.953                   | 97. ms                                 | $\beta^-$<br>$\beta^-$ ,n              | // > 3                                     |                          |                                  |                              | 0.566/100<br>(0.25 – 0.77)                                      |
| <sup>72</sup> Co   |                                  | 71.958                   | 60. ms                                 | $\beta^-$<br>$\beta^-$ ,n              | // > 6                                     |                          |                                  |                              | 1.096/100<br>0.845<br>(0.455 – 1.197)                           |
| <sup>73</sup> Co   |                                  | 72.960                   | 41. ms                                 | $\beta^-$<br>$\beta^-$ ,n              | // > 9                                     |                          |                                  |                              | 0.524/100<br>(0.24 – 0.76)                                      |
| <sup>74</sup> Co   |                                  | 73.965                   | 30. ms                                 | $\beta^-$<br>$\beta^-$ ,n              | // > 26                                    |                          |                                  |                              | 0.739<br>1.024                                                  |
| <sup>75</sup> Co   |                                  | 74.968                   | > 0.3 $\mu$ s                          |                                        |                                            |                          |                                  |                              |                                                                 |
| <sup>28</sup> Ni   |                                  | 58.6934(2)               |                                        |                                        |                                            |                          |                                  |                              |                                                                 |
| <sup>48</sup> Ni   |                                  | 48.020                   | ~ 2.1 ms                               | 2p                                     | p// ~ 25                                   | 0+                       |                                  |                              |                                                                 |
| <sup>49</sup> Ni   |                                  | 49.0097                  | 12. ms                                 |                                        |                                            |                          |                                  |                              |                                                                 |
| <sup>50</sup> Ni   |                                  | 49.9959                  | 12. ms                                 | $\beta^+$ , p                          | p//70.                                     | 0+                       |                                  |                              |                                                                 |
| <sup>51</sup> Ni   |                                  | 50.9877                  | > 0.2 $\mu$ s                          | $\beta^+$ /16.0                        |                                            |                          |                                  |                              |                                                                 |



| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>52</sup> Ni       |                                  | 51.9757                  | 38. ms                                 | $\beta^+$ /11.7              |                                          | 0+                       |                                  |                              |                                            |
| <sup>53</sup> Ni       |                                  | 52.9685                  | 0.05 s                                 | $\beta^+$ , p/13.3           |                                          | 7/2-                     |                                  |                              | ann.rad./                                  |
| <sup>54</sup> Ni       |                                  | 53.95791                 | 0.10 s                                 | $\beta^+$ /8.80              |                                          | 0+                       |                                  |                              | 0.937                                      |
| <sup>55</sup> Ni       |                                  | 54.95133                 | 0.20 s                                 | $\beta^+$ /8.70              | 7.66/                                    | 7/2-                     |                                  |                              | ann.rad./                                  |
| <sup>56</sup> Ni       |                                  | 55.94213                 | 6.08 d                                 | EC/2.14                      |                                          | 0+                       |                                  |                              | 0.15838/99                                 |
|                        |                                  |                          |                                        | $\beta^+$ /<10 <sup>-6</sup> |                                          |                          |                                  |                              | 0.81185(3)/87.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2695–0.7500                              |
| <sup>57</sup> Ni       |                                  | 56.939794                | 35.6 h                                 | $\beta^+$ /3.264             | 0.712/10.                                | 3/2-                     | -0.798                           |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/                          | 0.849/76.                                |                          |                                  |                              | 1.3776/78.                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.127–3.177)                              |
| <sup>58</sup> Ni       | 68.0769(89)                      | 57.935343                | >4 × 10 <sup>19</sup> y                | EC-EC                        |                                          | 0+                       |                                  |                              |                                            |
| <sup>59</sup> Ni       |                                  | 58.934347                | ~ 7.6 × 10 <sup>4</sup> y              | EC/                          |                                          | 3/2-                     |                                  |                              |                                            |
| <sup>60</sup> Ni       | 26.2231(77)                      | 59.930786                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>61</sup> Ni       | 1.1399(6)                        | 60.931056                |                                        |                              |                                          | 3/2-                     | -0.75002                         | +0.16                        |                                            |
| <sup>62</sup> Ni       | 3.6345(17)                       | 61.928345                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>63</sup> Ni       |                                  | 62.929669                | 100. y                                 | $\beta^-$ /0.066945          | 0.065/                                   | ½-                       |                                  |                              |                                            |
| <sup>64</sup> Ni       | 0.9256(9)                        | 63.927966                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>65</sup> Ni       |                                  | 64.930084                | 2.517 h                                | $\beta^-$ /2.137             | 0.65/30.                                 | 5/2-                     | 0.69                             |                              | 0.36627(3)/5.                              |
|                        |                                  |                          |                                        |                              | 1.020/11.                                |                          |                                  |                              | 1.11553(4)/16.                             |
|                        |                                  |                          |                                        |                              | 2.140/58.                                |                          |                                  |                              | 1.48184(5)/23.                             |
| <sup>66</sup> Ni       |                                  | 65.929139                | 54.6 h                                 | $\beta^-$ /0.23              |                                          | 0+                       |                                  |                              |                                            |
| <sup>67m</sup> Ni      |                                  |                          | 13.3 μs                                | I.T.                         |                                          | 9/2+                     |                                  |                              | 0.313/IT                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.694                                      |
| <sup>67</sup> Ni       |                                  | 66.931569                | 21. s                                  | $\beta^-$ /3.56              | 3.8/                                     | ½-                       | +0.601                           |                              | 1.0722/100.                                |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.6539/100.                                |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.10–1.98)                                |
| <sup>68m2</sup> Ni     |                                  |                          | 0.34 μs                                |                              |                                          |                          |                                  |                              | 0.511                                      |
| <sup>68m1</sup> Ni     |                                  |                          | 0.86 ms                                | I.T.                         |                                          | (5-)                     |                                  |                              | 0.814/IT                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.033                                      |
| <sup>68</sup> Ni       |                                  | 67.931869                | 29. s                                  | $\beta^-$ /2.06              |                                          | 0+                       |                                  |                              |                                            |
| <sup>69m2</sup> Ni     |                                  |                          | 0.44 μs                                | I.T.                         |                                          | (17/2)                   |                                  |                              | 0.148/IT                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.593                                      |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.959                                      |
| <sup>69m1</sup> Ni     |                                  |                          | 3.5 s                                  |                              |                                          |                          |                                  |                              |                                            |
| <sup>69</sup> Ni       |                                  | 68.935610                | 11. s                                  | $\beta^-$ /5.4               |                                          |                          |                                  |                              | 0.6807(3)/100.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.207–1.213)                              |
| <sup>70m</sup> Ni      |                                  |                          | 0.21 μs                                | I.T.                         |                                          | (8+)                     |                                  |                              | 0.183/IT                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.448                                      |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.970                                      |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.259                                      |
| <sup>70</sup> Ni       |                                  | 69.9365                  | 6.0 s                                  | $\beta^-$ /3.5               |                                          | 0+                       |                                  |                              |                                            |
| <sup>71</sup> Ni       |                                  | 70.9407                  | 2.56 s                                 | $\beta^-$ /6.9               |                                          |                          |                                  |                              |                                            |
| <sup>72</sup> Ni       |                                  | 71.9421                  | 1.6 s                                  | $\beta^-$ /5.2               |                                          | 0+                       |                                  |                              |                                            |
| <sup>73</sup> Ni       |                                  | 72.9465                  | 0.84 s                                 | $\beta^-$ /9.                |                                          |                          |                                  |                              |                                            |
| <sup>74</sup> Ni       |                                  | 73.9481                  | 0.9 s                                  | $\beta^-$ /7.                |                                          | 0+                       |                                  |                              |                                            |
| <sup>75</sup> Ni       |                                  | 74.9529                  | 0.34 s                                 |                              |                                          |                          |                                  |                              |                                            |
| <sup>76</sup> Ni       |                                  | 75.955                   | 0.24 s                                 |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>77</sup> Ni       |                                  | 76.961                   | 0.13 s                                 |                              |                                          |                          |                                  |                              |                                            |
| <sup>78</sup> Ni       |                                  | 77.963                   | ~ 0.11 s                               |                              |                                          | 0+                       |                                  |                              |                                            |
| <b><sub>29</sub>Cu</b> |                                  | <b>63.546(3)</b>         |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>52</sup> Cu       |                                  | 51.9972                  |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>53</sup> Cu       |                                  | 52.9856                  | < 0.3 μs                               |                              |                                          |                          |                                  |                              |                                            |
| <sup>54</sup> Cu       |                                  | 53.9767                  | < 0.075 μs                             |                              |                                          |                          |                                  |                              |                                            |
| <sup>55</sup> Cu       |                                  | 54.9661                  | > 0.2 μs                               | $\beta^+$ /13.2              |                                          |                          |                                  |                              |                                            |
| <sup>56</sup> Cu       |                                  | 55.9586                  | 93. ms                                 | $\beta^+$ /15.3              |                                          |                          |                                  |                              | 0.511/233                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.700/100                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9507–3.287                               |
| <sup>57</sup> Cu       |                                  | 56.94921                 | 196. ms                                | $\beta^+$ /8.77              |                                          | 3/2-                     |                                  |                              | 0.77–3.01                                  |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)                          | Particle Energy/<br>Intensity<br>(MeV/%)   | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                               |
|--------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------------------------------|--------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------------------------------------|
| <sup>58</sup> Cu   |                                  | 57.944539                | 3.21 s                                 | $\beta^+$ /8.563<br>EC/                               | 4.5/15.<br>7.439/83.                       | 1+                       |                                  |                              | ann.rad./<br>0.0403(4)/5.<br>1.4483(2)/11.<br>1.4546(2)/16.              |
| <sup>59</sup> Cu   |                                  | 58.939498                | 1.36 m                                 | $\beta^+$ /4.800                                      | 1.9/<br>3.75/                              | 3/2-                     | + 1.89                           |                              | ann.rad./<br>0.3393(1)/8.<br>0.8780(1)/12.<br>1.3015(1)/15.<br>(0.4–2.6) |
| <sup>60</sup> Cu   |                                  | 59.937365                | 23.7 m                                 | $\beta^+$ /6.127<br>EC/                               | 2.00/69.<br>3.00/18.<br>3.92/6.            | 2+                       | +1.219                           |                              | ann.rad./<br>1.3325/88.<br>1.7915/45.<br>(0.12–5.048)                    |
| <sup>61</sup> Cu   |                                  | 60.933458                | 3.35 h                                 | $\beta^+$ /2.237                                      | 0.56/3.<br>0.94/5.<br>1.15/2.<br>1.220/51. | 3/2-                     | +2.14                            |                              | ann.rad./<br>0.2830/13.<br>0.6560/11.<br>(0.067–2.123)                   |
| <sup>62</sup> Cu   |                                  | 61.932584                | 9.67 m                                 | $\beta^+$ /98/3.948<br>EC/                            | 2.93/98.                                   | 1+                       | -0.380                           |                              | ann.rad./<br>1.17302(1)/0.6<br>(0.87–3.37)                               |
| <sup>63</sup> Cu   | 69.15(15)                        | 62.929598                |                                        |                                                       |                                            | 3/2-                     | +2.2233                          | -0.211                       |                                                                          |
| <sup>64</sup> Cu   |                                  | 63.929764                | 12.701 h                               | $\beta^-$ /38/0.579<br>$\beta^+$ /19/1.6751<br>EC/41/ | 0.578/<br>0.65/                            | 1+                       | -0.217                           |                              | ann.rad./<br>1.3459(3)/0.6                                               |
| <sup>65</sup> Cu   | 30.85(15)                        | 64.927790                |                                        |                                                       |                                            | 3/2-                     | +2.3817                          | -0.195                       |                                                                          |
| <sup>66</sup> Cu   |                                  | 65.928869                | 5.09 m                                 | $\beta^-$ /2.642                                      | 1.65/6.<br>2.7/94.                         | 1+                       | -0.282                           |                              | 0.8330(1)/0.22<br>1.0392(2)/9.2                                          |
| <sup>67</sup> Cu   |                                  | 66.927730                | 2.580 d                                | $\beta^-$ /0.58                                       | 0.395/56.<br>0.484/23.<br>0.577/20.        | 3/2-                     | + 2.54                           |                              | 0.09125(1)/7.<br>0.09325(1)/17.<br>0.18453(1)/47.                        |
| <sup>68m</sup> Cu  |                                  |                          | 3.79 m                                 | I.T./86/<br>$\beta^-$ /14/1.8                         |                                            | 6-                       | +1.24                            |                              | 0.0843(5)/70.<br>0.1112(5)/18.<br>0.5259(5)/74.<br>(0.64–1.34)           |
| <sup>68</sup> Cu   |                                  | 67.929611                | 31. s                                  | $\beta^-$ /4.46                                       | 3.5/40.<br>4.6/31.                         | 1+                       | +2.48                            |                              | 1.0774(5)/58.<br>1.2613(5)/17.<br>(0.15–2.34)                            |
| <sup>69m</sup> Cu  |                                  |                          | 0.36 $\mu$ s                           | I.T.                                                  |                                            | (13/2+)                  |                                  |                              | 0.075/IT<br>0.190/IT<br>0.680<br>1.871                                   |
| <sup>69</sup> Cu   |                                  | 68.929429                | 2.8 m                                  | $\beta^-$ /2.68                                       | 2.48/80.                                   | 3/2-                     | +2.84                            |                              | 0.5307(3)/3.<br>0.8340(5)/6.<br>1.0065(8)/10.                            |
| <sup>70m2</sup> Cu |                                  |                          | 6.6 s                                  | $\beta$ /93<br>IT/7                                   |                                            |                          |                                  |                              | 0.8849/100<br>1.072/19<br>0.141/ IT                                      |
| <sup>70m1</sup> Cu |                                  |                          | 33. s                                  | $\beta^-$ /52<br>IT/48                                | 2.52/10.                                   | 5-                       | +1.9                             |                              | 0.8848(2)/100.<br>0.9017(2)/90.<br>1.2517(5)/60.<br>(0.39–3.06)          |
| <sup>70</sup> Cu   |                                  | 69.932392                | 44.5 s                                 | $\beta^-$ /6.60                                       | 5.42/54.<br>6.09/46.                       | 1+                       | +1.5                             |                              | 0.8848(2)/100.<br>0.9017/99.7<br>(0.438 - 3.062)                         |
| <sup>71m</sup> Cu  |                                  |                          | 0.28 $\mu$ s                           | I.T.                                                  |                                            | (19/2)                   |                                  |                              | 0.133/IT<br>0.494<br>0.939<br>1.189                                      |
| <sup>71</sup> Cu   |                                  | 70.932677                | 20. s                                  | $\beta^-$ /4.56                                       |                                            | 3/2-                     |                                  |                              | 0.490/                                                                   |
| <sup>72m</sup> Cu  |                                  |                          | 1.76 $\mu$ s                           | I.T.                                                  |                                            | (4-)                     |                                  |                              | 0.051/IT                                                                 |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.082                                      |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.138                                      |
| <sup>72</sup> Cu       |                                  | 71.935820                | 6.6 s                                  | $\beta^-$ /8.2               |                                          | (1+)                     |                                  |                              | 0.652/                                     |
| <sup>73</sup> Cu       |                                  | 72.936675                | 4.2 s                                  | $\beta^-$ /6.3               | 5.8/43                                   |                          |                                  |                              | 0.450/100                                  |
|                        |                                  |                          |                                        |                              | 6.25/42                                  |                          |                                  |                              | 0.307–1.559                                |
| <sup>74</sup> Cu       |                                  | 73.93988                 | 1.59 s                                 | $\beta^-$ /9.9               |                                          |                          |                                  |                              |                                            |
| <sup>75</sup> Cu       |                                  | 74.942                   | 1.2 s                                  | $\beta^-$ /7.9               |                                          |                          |                                  |                              |                                            |
| <sup>76m</sup> Cu      |                                  |                          | 1.2 s                                  |                              |                                          |                          |                                  |                              |                                            |
| <sup>76</sup> Cu       |                                  | 75.94528                 | 0.64 s                                 | $\beta^-$ /11.               |                                          |                          |                                  |                              |                                            |
| <sup>77</sup> Cu       |                                  | 76.9479                  | 0.46 s                                 | $\beta^-$ / ~ 10.            |                                          |                          |                                  |                              |                                            |
| <sup>78</sup> Cu       |                                  | 77.9520                  | 0.33 s                                 | $\beta^-$ /12.               |                                          |                          |                                  |                              |                                            |
| <sup>79</sup> Cu       |                                  | 78.9546                  | 0.19 s                                 | $\beta^-$ /11.               |                                          |                          |                                  |                              |                                            |
| <sup>80</sup> Cu       |                                  | 79.961                   | > 0.3 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <b><sub>30</sub>Zn</b> |                                  | <b>69.409(4)</b>         |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>54</sup> Zn       |                                  | 53.9930                  | ~ 3.2 ms                               | 2p                           | p/87                                     | 0+                       |                                  |                              |                                            |
| <sup>55</sup> Zn       |                                  | 54.9840                  | > 1.6 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>56</sup> Zn       |                                  | 55.9724                  | 0.04 s                                 |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>57</sup> Zn       |                                  | 56.9648                  | 0.04 s                                 | $\beta^+$ , p/14.6           |                                          | (7/2-)                   |                                  |                              | ann.rad./                                  |
| <sup>58</sup> Zn       |                                  | 57.95459                 | 0.09 s                                 | $\beta^+$                    |                                          | 0+                       |                                  |                              |                                            |
| <sup>59</sup> Zn       |                                  | 58.94926                 | 183. ms                                | $\beta^+$ , p/9.09           | 8.1/                                     | 3/2-                     |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.491–0.914)                              |
| <sup>60</sup> Zn       |                                  | 59.94183                 | 2.40 m                                 | $\beta^+$ /97/4.16           |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/3/                        |                                          |                          |                                  |                              | 0.669/47.                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.062–0.947)                              |
| <sup>61</sup> Zn       |                                  | 60.93951                 | 1.485 m                                | $\beta^+$ /5.64              | 4.38/68.                                 | 3/2-                     |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4748/17.                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.15–3.52)                                |
| <sup>62</sup> Zn       |                                  | 61.93433                 | 9.22 h                                 | $\beta^+$ /3/1.63            | 0.66/7.                                  | 0+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/93/                       |                                          |                          |                                  |                              | 0.0408/25                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5967/26.                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.20–1.526)/                              |
| <sup>63</sup> Zn       |                                  | 62.933212                | 38.5 m                                 | $\beta^+$ /93/3.367          | 1.02/                                    | 3/2-                     | -0.28164                         | +0.29                        | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/7/                        | 1.40/                                    |                          |                                  |                              | 0.66962(5)/8.4                             |
|                        |                                  |                          |                                        |                              | 1.71/                                    |                          |                                  |                              | 0.96206(5)/6.6                             |
|                        |                                  |                          |                                        |                              | 2.36/84.                                 |                          |                                  |                              | (0.24–3.1)                                 |
| <sup>64</sup> Zn       | 48.268(321)                      | 63.929142                | > 4.3 $\times 10^{18}$ y               | EC- $\beta^+$                |                                          | 0+                       |                                  |                              |                                            |
| <sup>65</sup> Zn       |                                  | 64.929241                | 244.0 d                                | $\beta^+$ /98/1.3514         | 0.325/                                   | 5/2-                     | +0.7690                          | -0.023                       | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/1.5/                      |                                          |                          |                                  |                              | 1.1155/49.8                                |
| <sup>66</sup> Zn       | 27.975(77)                       | 65.926033                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>67</sup> Zn       | 4.102(21)                        | 66.927127                |                                        |                              |                                          | 5/2-                     | +0.8755                          | +0.15                        |                                            |
| <sup>68</sup> Zn       | 19.024(123)                      | 67.924844                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>69m</sup> Zn      |                                  |                          | 13.76 h                                | I.T./99+/0.439               |                                          | 9/2+                     |                                  |                              | 0.4390(2)/95.                              |
| <sup>69</sup> Zn       |                                  | 68.926550                | 56. m                                  | $\beta^-$ /0.906             | 0.905/99.9                               | $\frac{1}{2}-$           |                                  |                              | 0.318/                                     |
| <sup>70</sup> Zn       | 0.631(9)                         | 69.925319                | > 1.3 $\times 10^{16}$ y               | $\beta^-\beta^-$             |                                          | 0+                       |                                  |                              |                                            |
| <sup>71m</sup> Zn      |                                  |                          | 3.97 h                                 | $\beta^-$ /                  | 1.45/                                    | 9/2+                     |                                  |                              | 0.3864/93.                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4874/62.                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6203/57.                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.099–2.489)                              |
| <sup>71</sup> Zn       |                                  | 70.92772                 | 2.4 m                                  | $\beta^-$ /2.81              |                                          | $\frac{1}{2}-$           |                                  |                              | 0.5116(1)/30.                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9103(1)/7.5                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.12–2.29)                                |
| <sup>72</sup> Zn       |                                  | 71.92686                 | 46.5 h                                 | $\beta^-$ /0.46              | 0.25/14.                                 | 0+                       |                                  |                              | 0.0164(3)/8.                               |
|                        |                                  |                          |                                        |                              | 0.30/86.                                 |                          |                                  |                              | 0.1447(1)/83.                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1915(2)/9.4                              |
| <sup>73m</sup> Zn      |                                  |                          | 6. s                                   |                              | I.T./0.196                               | (7/2+)                   |                                  |                              | 0.042                                      |
| <sup>73</sup> Zn       |                                  | 72.92978                 | 24. s                                  | $\beta^-$ /4.29              | 4.7/                                     | (1/2-)                   |                                  |                              | 0.216(1)/100.                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.496–0.911                                |
| <sup>74</sup> Zn       |                                  | 73.92946                 | 1.60 m                                 | $\beta^-$ /2.3               | 2.1/                                     | 0+                       |                                  |                              | 0.0565/                                    |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1401/<br>(0.05–0.35)                     |
| <sup>75</sup> Zn       |                                  | 74.9329                  | 10.2 s                                 | $\beta^-$ /6.0               |                                          |                          |                                  |                              | 0.229/                                     |
| <sup>76</sup> Zn       |                                  | 75.9333                  | 5.7 s                                  | $\beta^-$ /4.2               | 3.6/                                     | 0+                       |                                  |                              | 0.119/                                     |
| <sup>77m</sup> Zn      |                                  |                          | 1.0 s                                  | $\beta^-$ /                  |                                          | (1/2-)                   |                                  |                              | 0.772                                      |
| <sup>77</sup> Zn       |                                  | 76.9370                  | 2.1 s                                  | $\beta^-$ /7.3               | 4.8/                                     |                          |                                  |                              | 0.189/                                     |
| <sup>78m</sup> Zn      |                                  |                          | > 0.03 ms                              |                              |                                          |                          |                                  |                              | 1.070                                      |
| <sup>78</sup> Zn       |                                  | 77.9384                  | 1.5 s                                  | $\beta^-$ /6.4               |                                          | 0+                       |                                  |                              | 0.225/                                     |
| <sup>79</sup> Zn       |                                  | 78.9427                  | 1.0 s                                  | $\beta^-$ /8.6               |                                          |                          |                                  |                              | 0.702/                                     |
| <sup>80</sup> Zn       |                                  | 79.9443                  | 0.54 s                                 | $\beta^-$ /7.3               |                                          | 0+                       |                                  |                              | 0.713/<br>0.2248/                          |
| <sup>81</sup> Zn       |                                  | 80.9505                  | 0.29 s                                 | $\beta^-$ /11.9              |                                          |                          |                                  |                              |                                            |
| <sup>82</sup> Zn       |                                  | 81.9544                  | > 0.15 $\mu$ s                         |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>83</sup> Zn       |                                  | 82.9610                  | > 0.15 $\mu$ s                         |                              |                                          |                          |                                  |                              |                                            |
| <b><sub>31</sub>Ga</b> |                                  | <b>69.723(1)</b>         |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>56</sup> Ga       |                                  | 55.9949                  |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>57</sup> Ga       |                                  | 56.9829                  |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>58</sup> Ga       |                                  | 57.9743                  |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>59</sup> Ga       |                                  | 58.9634                  | < 0.043 $\mu$ s                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>60</sup> Ga       |                                  | 59.9571                  | 0.07 s                                 | $\beta^+$                    |                                          |                          |                                  |                              | 1.004                                      |
|                        |                                  |                          |                                        | $\beta^+$ , p                | // ~ 1.6                                 |                          |                                  |                              | 3.848                                      |
|                        |                                  |                          |                                        | $\beta^+$ , $\alpha$         | // ~ 0.02                                |                          |                                  |                              | 1.555–2.559                                |
| <sup>61</sup> Ga       |                                  | 60.9495                  | 0.17 s                                 | $\beta^+$ /9.0               |                                          | 3/2                      |                                  |                              | 0.088–1.362                                |
| <sup>62</sup> Ga       |                                  | 61.94418                 | 116.0 ms                               | $\beta^+$ /9.17              | 8.3/                                     | 0+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/                          |                                          |                          |                                  |                              | 0.954/0.0012                               |
| <sup>63</sup> Ga       |                                  | 62.939294                | 32. s                                  | $\beta^+$ /5.5               | 4.5/                                     |                          |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/                          |                                          |                          |                                  |                              | 0.6271(2)/10.                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6370(2)/11.                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.0652(4)/45.                              |
| <sup>64m</sup> Ga      |                                  |                          | 0.022 ms                               |                              |                                          |                          |                                  |                              | 0.0429                                     |
| <sup>64</sup> Ga       |                                  | 63.936839                | 2.63 m                                 | $\beta^+$ /7.165             | 2.79/                                    | 0+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              | 6.05/                                    |                          |                                  |                              | 0.80785(1)/14.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.99152(1)/43.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.38727(1)/12.                             |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 3.3659(1)/13.                              |
| <sup>65</sup> Ga       |                                  | 64.932735                | 15.2 m                                 | $\beta^+$ /86/3.255          | 0.82/10.                                 | 3/2-                     |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/                          | 1.39/19.                                 |                          |                                  |                              | 0.1151(2)/55.                              |
|                        |                                  |                          |                                        |                              | 2.113/56.                                |                          |                                  |                              | 0.1530(2)/96.                              |
|                        |                                  |                          |                                        |                              | 2.237/15.                                |                          |                                  |                              | 0.2069(2)/39.                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.06–2.4)                                 |
| <sup>66</sup> Ga       |                                  | 65.931589                | 9.5 h                                  | $\beta^+$ /56/5.175          | 0.74/1.                                  | 0+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/43/                       | 1.84/54.                                 |                          |                                  |                              | 1.03935(8)/38.                             |
|                        |                                  |                          |                                        |                              | 4.153/51.                                |                          |                                  |                              | 2.7523(1)/23.                              |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.28–5.01)                                |
| <sup>67</sup> Ga       |                                  | 66.928202                | 3.261 d                                | EC/1.001                     |                                          | 3/2-                     | +1.8507                          | 0.20                         | 0.09332/37.                                |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.18459/20.                                |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.30024/17.                                |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.091–0.89)                               |
| <sup>68</sup> Ga       |                                  | 67.927980                | 1.130 h                                | $\beta^+$ /90/2.921          | 1.83/                                    | 1+                       | 0.01175                          | 0.028                        | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/10/                       |                                          |                          |                                  |                              | 1.0774(1)/3.                               |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.57–2.33)/                               |
| <sup>69</sup> Ga       | 60.108(9)                        | 68.925574                |                                        |                              |                                          | 3/2-                     | +2.01659                         | +0.17                        |                                            |
| <sup>70</sup> Ga       |                                  | 69.926022                | 21.1 m                                 | EC/0.2/0.655                 |                                          | 1+                       |                                  |                              | 0.1755(5)/0.15                             |
|                        |                                  |                          |                                        | $\beta^-$ /99.8/1.656        | 1.65/99.                                 |                          |                                  |                              | 1.042(5)/0.48                              |
| <sup>71</sup> Ga       | 39.892(9)                        | 70.924701                | > 2.4 $\times 10^{26}$ y               | $\beta^-$                    |                                          | 3/2-                     | +2.56227                         | +0.11                        |                                            |
| <sup>72</sup> Ga       |                                  | 71.926366                | 14.10 h                                | $\beta^-$ /4.001             | 0.64/40.                                 | 3-                       | -0.13224                         | +0.5                         | 0.8340/95.53                               |
|                        |                                  |                          |                                        |                              | 1.51/9.                                  |                          |                                  |                              | 2.202/26.9                                 |
|                        |                                  |                          |                                        |                              | 2.52/8.                                  |                          |                                  |                              | 0.630/26.2                                 |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $h/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|----------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>73</sup> Ga       |                                  | 72.925175                | 74.87 h                                | $\beta^-$ /1.59              | 3.15/11.                                 | 3/2-                 |                                  |                              | (0.113–3.678)                              |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.05344(5)/10.                             |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.29732(5)/47.                             |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.01–1.00)/                               |
| <sup>74m</sup> Ga      |                                  |                          | 10. s                                  | I.T./                        |                                          | 1+                   |                                  |                              | 0.0565(1)/75.                              |
| <sup>74</sup> Ga       |                                  | 73.926946                | 8.1 m                                  | $\beta^-$ /5.4               | 2.6/                                     | 3-                   |                                  |                              | 0.5959/92.                                 |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 2.354/45.                                  |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.23–3.99)                                |
| <sup>75</sup> Ga       |                                  | 74.926500                | 2.10 m                                 | $\beta^-$ /3.39              | 3.3/                                     | 3/2-                 |                                  |                              | 0.2529/                                    |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.5746/                                    |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.12–2.10)                                |
| <sup>76</sup> Ga       |                                  | 75.928828                | 29. s                                  | $\beta^-$ /7.0               |                                          | 3-                   |                                  |                              | 0.5629/66.                                 |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.5455/26.                                 |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.34–4.25)                                |
| <sup>77</sup> Ga       |                                  | 76.929154                | 13.0 s                                 | $\beta^-$ /5.3               | 5.2/                                     |                      |                                  |                              | 0.469/                                     |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.459/                                     |
| <sup>78</sup> Ga       |                                  | 77.931608                | 5.09 s                                 | $\beta^-$ /8.2               |                                          | 3+                   |                                  |                              | 0.619/77.                                  |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.187/20.                                  |
| <sup>79</sup> Ga       |                                  | 78.9329                  | 2.85 s                                 | $\beta^-$ /7.0               | 4.6/                                     |                      |                                  |                              | 0.465/                                     |
| <sup>80</sup> Ga       |                                  | 79.9365                  | 1.68 s                                 | $\beta^-$ /10.4              | 10./                                     |                      |                                  |                              | 0.659/                                     |
| <sup>81</sup> Ga       |                                  | 80.9378                  | 1.22 s                                 | $\beta^-$ /8.3               | 5.1/                                     |                      |                                  |                              | 0.217/                                     |
| <sup>82</sup> Ga       |                                  | 81.9430                  | 0.599 s                                | $\beta^-$ /12.6              |                                          |                      |                                  |                              | 1.348/                                     |
| <sup>83</sup> Ga       |                                  | 82.9470                  | 0.308 s                                | $\beta^-$ /~ 11.5            |                                          |                      |                                  |                              |                                            |
| <sup>84</sup> Ga       |                                  | 83.9527                  | ~ 0.085 s                              | $\beta^-$ /14                |                                          |                      |                                  |                              |                                            |
| <sup>85</sup> Ga       |                                  | 84.9570                  | > 0.3 $\mu$ s                          |                              |                                          |                      |                                  |                              |                                            |
| <sup>86</sup> Ga       |                                  | 85.963                   | > 0.3 $\mu$ s                          |                              |                                          |                      |                                  |                              |                                            |
| <b><sup>32</sup>Ge</b> |                                  | <b>72.64(1)</b>          |                                        |                              |                                          |                      |                                  |                              |                                            |
| <sup>58</sup> Ge       |                                  | 57.9910                  |                                        |                              |                                          | 0+                   |                                  |                              |                                            |
| <sup>59</sup> Ge       |                                  | 58.9818                  |                                        |                              |                                          |                      |                                  |                              |                                            |
| <sup>60</sup> Ge       |                                  | 59.9702                  | > 0.11 $\mu$ s                         |                              |                                          | 0+                   |                                  |                              |                                            |
| <sup>61</sup> Ge       |                                  | 60.9638                  | 0.04 s                                 | $\beta^+$ /13.6              |                                          |                      |                                  |                              |                                            |
| <sup>62</sup> Ge       |                                  | 61.9547                  | 0.13 s                                 |                              |                                          | 0+                   |                                  |                              |                                            |
| <sup>63</sup> Ge       |                                  | 62.9496                  | 0.15 s                                 | $\beta^-$ /9.8               |                                          |                      |                                  |                              |                                            |
| <sup>64</sup> Ge       |                                  | 63.94165                 | 1.06 m                                 | $\beta^+$ /4.4               | 3.0/                                     | 0+                   |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/                          |                                          |                      |                                  |                              | 0.1282(2)/11.                              |
|                        |                                  |                          |                                        | $\beta^+$ , p                |                                          |                      |                                  |                              | 0.4270(3)/37.                              |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.6671(3)/17.                              |
| <sup>65</sup> Ge       |                                  | 64.9394                  | 31. s                                  | $\beta^+$ /6.2               | 0.82/10.                                 |                      |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/                          | 1.39/19.                                 |                      |                                  |                              | 0.0620/27.                                 |
|                        |                                  |                          |                                        | EC, p                        | 2.113/56.                                |                      |                                  |                              | 0.6497/33.                                 |
|                        |                                  |                          |                                        |                              | 2.237/15.                                |                      |                                  |                              | 0.8091/21.                                 |
|                        |                                  |                          |                                        | $\beta^+$ , p                | //0.011                                  |                      |                                  |                              | (0.19–3.28)                                |
| <sup>66</sup> Ge       |                                  | 65.93384                 | 2.26 h                                 | $\beta^+$ /27/2.10           |                                          | 0+                   |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/73/                       |                                          |                      |                                  |                              | 0.0438/29.                                 |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.3819/28.                                 |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.022–1.77)                               |
| <sup>67</sup> Ge       |                                  | 66.932734                | 19.0 m                                 | $\beta^+$ /96/4.225          | 1.6/                                     | $\frac{1}{2}$ -      |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/4/                        | 2.3/                                     |                      |                                  |                              | 0.1670/84.                                 |
|                        |                                  |                          |                                        |                              | 3.15/                                    |                      |                                  |                              | (0.25–3.73)                                |
| <sup>68</sup> Ge       |                                  | 67.92809                 | 270.8 d                                | EC/0.11                      |                                          | 0+                   |                                  |                              | Ga k x-ray/39.                             |
| <sup>69</sup> Ge       |                                  | 68.927965                | 1.63 d                                 | $\beta^+$ /36/2.2273         | 0.70/                                    | 5/2-                 | 0.735                            | 0.02                         | ann.rad./                                  |
|                        |                                  |                          |                                        | EC/64/                       | 1.2/                                     |                      |                                  |                              | 0.574/13.                                  |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.1068/36.                                 |
|                        |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.2–2.04)                                 |
| <sup>70</sup> Ge       | 20.38(18)                        | 69.924247                |                                        |                              |                                          | 0+                   |                                  |                              |                                            |
| <sup>71m</sup> Ge      |                                  |                          | 20.4 ms                                |                              | I.T./0.0234                              | 9/2+                 |                                  |                              | 0.1749                                     |
| <sup>71</sup> Ge       |                                  | 70.924951                | 11.2 d                                 | EC/0.229                     |                                          | $\frac{1}{2}$ -      | +0.547                           |                              |                                            |
| <sup>72</sup> Ge       | 27.31(26)                        | 71.922076                |                                        |                              |                                          | 0+                   |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                      |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-----------------------------------------------------------------|
| <sup>73</sup> Ge   | 7.76(8)                          | 72.923459                | $> 1.8 \times 10^{23}$ y               | $\beta^-$                    |                                          | 9/2+                     | -0.879467                        | -0.17                        |                                                                 |
| <sup>74</sup> Ge   | 36.72(15)                        | 73.921178                |                                        |                              |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>75m</sup> Ge  |                                  |                          | 48. s                                  | I.T./                        |                                          | 7/2+                     |                                  |                              | 0.13968(3)/39.                                                  |
| <sup>75</sup> Ge   |                                  | 74.922859                | 1.380 h                                | $\beta^-$ /1.177             | 1.19/                                    | ½-                       | +0.510                           |                              | 0.26461(5)/11.<br>0.41931(5)/0.2                                |
| <sup>76</sup> Ge   | 7.83(7)                          | 75.921403                | $1.6 \times 10^{21}$ y                 | $\beta-\beta^-$              |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>77m</sup> Ge  |                                  |                          | 53. s                                  | I.T./20/                     |                                          | ½-                       |                                  |                              | 1.605/0.22                                                      |
|                    |                                  |                          |                                        | $\beta^-$ /80/2.861          | 2.9/                                     |                          |                                  |                              | 1.676/0.16                                                      |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.195–1.482                                                     |
| <sup>77</sup> Ge   |                                  | 76.923549                | 11.25 h                                | $\beta^-$ /2.702             | 0.71/23.                                 | 7/2+                     |                                  |                              | 0.2110/29.                                                      |
|                    |                                  |                          |                                        |                              | 1.38/35.                                 |                          |                                  |                              | 0.2155/27.                                                      |
|                    |                                  |                          |                                        |                              | 2.19/42.                                 |                          |                                  |                              | 0.2644/51.                                                      |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.15–2.35)                                                     |
| <sup>78</sup> Ge   |                                  | 77.922853                | 1.45 h                                 | $\beta^-$ /0.95              | 0.70/                                    | 0+                       |                                  |                              | 0.2773(5)/96.<br>0.2939(5)/4.                                   |
| <sup>79m</sup> Ge  |                                  |                          | 39. s                                  | $\beta^-$ /IT                |                                          | 7/2+                     |                                  |                              |                                                                 |
| <sup>79</sup> Ge   |                                  | 78.9254                  | 19.1 s                                 | $\beta^-$ /4.2               | 4.0/20.<br>4.3/80.                       | ½-                       |                                  |                              | 0.1096/21.<br>(0.10–2.59)                                       |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5427(4)/15.                                                   |
| <sup>80</sup> Ge   |                                  | 79.92537                 | 29.5 s                                 | $\beta^-$ /2.67              | 2.4/                                     | 0+                       |                                  |                              | 0.1104(4)/6.<br>0.2656(4)/25.                                   |
| <sup>81m</sup> Ge  |                                  |                          | ~ 7.6 s                                | $\beta^-$ /                  | 3.75/                                    | ½+                       |                                  |                              | 0.3362(4)/<br>0.7935(4)/                                        |
| <sup>81</sup> Ge   |                                  | 80.9288                  | ~ 7.6 s                                | $\beta^-$ /6.2               | 3.44/                                    | 9/2+                     |                                  |                              | 0.1976(4)/21.<br>0.3362(4)/100.                                 |
| <sup>82</sup> Ge   |                                  | 81.9296                  | 4.6 s                                  | $\beta^-$ /4.7               | 1.093/80                                 | 0+                       |                                  |                              | 1.093/                                                          |
| <sup>83</sup> Ge   |                                  | 82.9346                  | 1.9 s                                  | $\beta^-$ /8.9               |                                          |                          |                                  |                              |                                                                 |
| <sup>84</sup> Ge   |                                  | 83.9375                  | 0.98 s                                 | $\beta^-$ /7.7               |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>85</sup> Ge   |                                  | 84.9430                  | 0.54 s                                 | $\beta^-$ /10.               |                                          |                          |                                  |                              |                                                                 |
| <sup>86</sup> Ge   |                                  | 85.9465                  | $> 0.3 \mu\text{s}$                    |                              |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>87</sup> Ge   |                                  | 86.9525                  | $> 0.3 \mu\text{s}$                    |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>88</sup> Ge   |                                  | 87.957                   | $> 0.3 \mu\text{s}$                    |                              |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>89</sup> Ge   |                                  | 88.964                   | $> 0.3 \mu\text{s}$                    |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>33</sup> As   |                                  | 74.92160(2)              |                                        |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>60</sup> As   |                                  | 59.993                   |                                        |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>61</sup> As   |                                  | 60.981                   |                                        |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>62</sup> As   |                                  | 61.9732                  |                                        |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>63</sup> As   |                                  | 62.9637                  | $< 0.043 \mu\text{s}$                  |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>64</sup> As   |                                  | 63.9576                  | 0.02 s                                 |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>65</sup> As   |                                  | 64.9496                  | 0.13 s                                 | $\beta^+$ /9.4               |                                          |                          |                                  |                              |                                                                 |
| <sup>66m2</sup> As |                                  |                          | 8. $\mu\text{s}$                       |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>66m1</sup> As |                                  |                          | 1.1 $\mu\text{s}$                      |                              |                                          |                          |                                  |                              |                                                                 |
| <sup>66</sup> As   |                                  | 65.945                   | 95.8 ms                                | $\beta^+$ /9.55              |                                          |                          |                                  |                              |                                                                 |
| <sup>67</sup> As   |                                  | 66.9392                  | 42. s                                  | $\beta^+$ /6.0               | 5.0/                                     | 5/2-                     |                                  |                              | 0.121/<br>0.123/<br>0.244/                                      |
|                    |                                  |                          |                                        | EC/                          |                                          |                          |                                  |                              |                                                                 |
| <sup>68</sup> As   |                                  | 67.93677                 | 2.53 m                                 | $\beta^+$ /8.1               |                                          | 3+                       |                                  |                              | ann.rad./<br>0.652/32.<br>0.762/33.<br>1.016/77.<br>(0.61–3.55) |
| <sup>69</sup> As   |                                  | 68.93227                 | 15.2 m                                 | $\beta^+$ /98/4.01           | 2.95/                                    | 5/2-                     | + 1.623                          |                              | ann.rad./<br>0.0868(5)/1.5<br>0.1458(3)/2.4                     |
|                    |                                  |                          |                                        | EC/2/                        |                                          |                          |                                  |                              |                                                                 |
| <sup>70</sup> As   |                                  | 69.93092                 | 52.6 m                                 | $\beta^+$ /84/6.22           | 1.44/                                    | 4+                       | +2.1061                          | +0.09                        | ann.rad./<br>1.0395(7)/82.<br>(0.17–4.4)/                       |
|                    |                                  |                          |                                        | EC/16/2.14                   |                                          |                          |                                  |                              |                                                                 |
|                    |                                  |                          |                                        | /2.89                        |                                          |                          |                                  |                              |                                                                 |
| <sup>71</sup> As   |                                  | 70.927112                | 2.72 d                                 | $\beta^+$ /32/2.013          |                                          | 5/2-                     | +1.6735                          | -0.02                        | ann.rad./                                                       |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $h/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|----------------------|----------------------------------|------------------------------|--------------------------------------------|
|                   |                                  |                          |                                        | EC/68/                       |                                          |                      |                                  |                              | 0.1749(2)/84.                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.0957(2)/4.2                              |
| <sup>72</sup> As  |                                  | 71.926752                | 26.0 h                                 | $\beta^+$ /77/4.356          | 0.669/5.                                 | 2-                   | -2.1566                          | -0.08                        | ann.rad./                                  |
|                   |                                  |                          |                                        |                              | 1.884/12.                                |                      |                                  |                              | 0.83395(5)/80.                             |
|                   |                                  |                          |                                        |                              | 2.498/62.                                |                      |                                  |                              | 1.0507(1)/9.6                              |
|                   |                                  |                          |                                        |                              | 3.339/19.                                |                      |                                  |                              | (0.1–4.0)                                  |
| <sup>73</sup> As  |                                  | 72.923825                | 80.3 d                                 | EC/0.341                     |                                          | 3/2-                 |                                  |                              | 0.0133/0.1                                 |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.0534/10.5                                |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | Se k x-ray/90.                             |
| <sup>74</sup> As  |                                  | 73.923829                | 17.78 d                                | $\beta^+$ /31/2.562          | 0.94/26.                                 | 2-                   | -1.597                           |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | EC/37/                       | 1.53/3.                                  |                      |                                  |                              | 0.59588(1)/60.                             |
|                   |                                  |                          |                                        | $\beta^-$ /1.353             | 0.71/16.                                 |                      |                                  |                              | 0.6084(1)/0.6                              |
|                   |                                  |                          |                                        |                              | 1.35/16.                                 |                      |                                  |                              | 0.6348(1)/15.                              |
| <sup>75m</sup> As |                                  |                          | 0.017 s                                |                              |                                          |                      |                                  |                              |                                            |
| <sup>75</sup> As  | 100.                             | 74.921597                |                                        |                              |                                          | 3/2-                 | +1.43947                         | +0.31                        |                                            |
| <sup>76</sup> As  |                                  | 75.922394                | 26.3 h                                 | $\beta^-$ /2.962             | 0.54/3.                                  | 2-                   | -0.903                           |                              | 0.5591(1)/45.                              |
|                   |                                  |                          |                                        |                              | 1.785/8.                                 |                      |                                  |                              | 0.65703(5)/6.2                             |
|                   |                                  |                          |                                        |                              | 2.410/36.                                |                      |                                  |                              | 1.21602(1)/3.4                             |
|                   |                                  |                          |                                        |                              | 2.97/51.                                 |                      |                                  |                              | (0.3–2.67)                                 |
| <sup>77</sup> As  |                                  | 76.920647                | 38.8 h                                 | $\beta^-$ /0.683             | 0.70/98.                                 | 3/2-                 | +1.295                           |                              | 0.2391(2)/1.6                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.2500(3)/0.4                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.5208/0.43                                |
| <sup>78</sup> As  |                                  | 77.92183                 | 1.512 h                                | $\beta^-$ /4.21              | 3.00/12.                                 | 2-                   |                                  |                              | 0.6136(3)/54.                              |
|                   |                                  |                          |                                        |                              | 3.70/17.                                 |                      |                                  |                              | 0.6954(3)/18.                              |
|                   |                                  |                          |                                        |                              | 4.42/37.                                 |                      |                                  |                              | 1.3088(3)/10.                              |
| <sup>79m</sup> As |                                  |                          | 1.21 $\mu$ s                           | I.T.                         |                                          | 9/2+                 |                                  |                              | 0.542/IT                                   |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.231                                      |
| <sup>79</sup> As  |                                  | 78.92095                 | 9.0 m                                  | $\beta^-$ /2.28              | 1.80/95.                                 | 3/2-                 |                                  |                              | 0.0955(5)/16.                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.3645(5)/1.9                              |
| <sup>80</sup> As  |                                  | 79.92253                 | 16. s                                  | $\beta^-$ /5.64              | 3.38/                                    | 1+                   |                                  |                              | 0.6662(2)/42.                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (2.5–3.0)                                  |
| <sup>81</sup> As  |                                  | 80.92213                 | 33. s                                  | $\beta^-$ /3.856             |                                          | 3/2-                 |                                  |                              | 0.4676(2)/20.                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.4911(2)/8.                               |
| <sup>82m</sup> As |                                  |                          | 13.7 s                                 | $\beta^-$ /                  | 3.6/                                     | 5-                   |                                  |                              | 0.6544(1)/77.                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 0.344/65.                                  |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.561 – 1.894)                            |
| <sup>82</sup> As  |                                  | 81.9245                  | 19. s                                  | $\beta^-$ /7.4               | 7.2/80.                                  | (2-)                 |                                  |                              | 0.6544(1)/54.                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.755 – 3.667)                            |
| <sup>83</sup> As  |                                  | 82.9250                  | 13.4 s                                 | $\beta^-$ /5.5               |                                          |                      |                                  |                              | 0.7345/100.                                |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.1131/34.                                 |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 2.0767/28.                                 |
| <sup>84m</sup> As |                                  |                          | 0.6 s                                  | $\beta^-$                    |                                          |                      |                                  |                              |                                            |
| <sup>84</sup> As  |                                  | 83.9291                  | 4. s                                   | $\beta^-$ , n/7.2            |                                          | 1-                   |                                  |                              | 0.6671(2)/21.                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.4439(5)/49.                              |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | (0.325–5.150)                              |
| <sup>85</sup> As  |                                  | 84.9320                  | 2.03 s                                 | $\beta^-$ , n/8.9            |                                          | 3/2-                 |                                  |                              | 0.667(1)/42.                               |
|                   |                                  |                          |                                        |                              |                                          |                      |                                  |                              | 1.4551(2)/100.                             |
| <sup>86</sup> As  |                                  | 85.9365                  | 0.95 s                                 | $\beta^-$ , n/11.4           |                                          |                      |                                  |                              | 0.704/                                     |
| <sup>87</sup> As  |                                  | 86.9399                  | 0.49 s                                 | $\beta^-$ , n/10.            |                                          |                      |                                  |                              | 0.704/                                     |
| <sup>88</sup> As  |                                  | 87.9449                  | > 0.3 $\mu$ s                          |                              |                                          |                      |                                  |                              |                                            |
| <sup>89</sup> As  |                                  | 88.9494                  | > 0.3 $\mu$ s                          |                              |                                          |                      |                                  |                              |                                            |
| <sup>90</sup> As  |                                  | 89.956                   | > 0.3 $\mu$ s                          |                              |                                          |                      |                                  |                              |                                            |
| <sup>91</sup> As  |                                  | 90.960                   | > 0.3 $\mu$ s                          |                              |                                          |                      |                                  |                              |                                            |
| <sup>92</sup> As  |                                  | 91.967                   | > 0.3 $\mu$ s                          |                              |                                          |                      |                                  |                              |                                            |
| <sup>34</sup> Se  |                                  | 78.96(3)                 |                                        |                              |                                          |                      |                                  |                              |                                            |
| <sup>64</sup> Se  |                                  |                          | > 0.18 $\mu$ s                         |                              |                                          | 0+                   |                                  |                              |                                            |
| <sup>65</sup> Se  |                                  | 64.965                   | 0.011 s                                | $\beta^+$ /60/14.            |                                          |                      |                                  |                              |                                            |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                   |                                  |                          |                                        | $\beta^+$ , p                | 3.55/                                    |                          |                                  |                              |                                            |
| <sup>66</sup> Se  |                                  | 65.9552                  | 0.03 s                                 |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>67</sup> Se  |                                  | 66.9501                  | 0.13 s                                 | $\beta^+$ /10.2              |                                          |                          |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+$ , (p)/             |                                          |                          |                                  |                              | 0.352                                      |
| <sup>68</sup> Se  |                                  | 67.94180                 | 36. s                                  | $\beta^+$ /4.7               |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.050–0.426)                              |
| <sup>69</sup> Se  |                                  | 68.93956                 | 27.4 s                                 | $\beta^+$ /6.78              | 5.006/                                   |                          |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | EC/                          |                                          |                          |                                  |                              | 0.0664(4)/27.                              |
|                   |                                  |                          |                                        | $\beta^+$ , p                | // ~ 0.045                               |                          |                                  |                              | 0.0982(4)/63.                              |
| <sup>70</sup> Se  |                                  | 69.9334                  | 41.1 m                                 | $\beta^+$ /2.4               |                                          | 0+                       |                                  |                              | ann.rad                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.04951(5)/35.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4262(2)/29.                              |
| <sup>71</sup> Se  |                                  | 70.93224                 | 4.7 m                                  | $\beta^+$ /4.4               | 3.4/36.                                  | 5/2-                     |                                  |                              | ann.rad                                    |
|                   |                                  |                          |                                        | EC/                          |                                          |                          |                                  |                              | 0.1472(3)/47.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8309(3)/13.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.0960(3)/10.                              |
| <sup>72</sup> Se  |                                  | 71.92711                 | 8.5 d                                  | EC/0.34                      |                                          | 0+                       |                                  |                              | 0.0460(2)/57.                              |
| <sup>73m</sup> Se |                                  |                          | 40. m                                  | I.T./73/0.0257               | 0.85                                     | 3/2-                     |                                  |                              | ann.rad.                                   |
|                   |                                  |                          |                                        | $\beta^+$ /27/2.77           | 1.45/                                    |                          |                                  |                              | 0.0257(2)/27.                              |
|                   |                                  |                          |                                        |                              | 1.70/                                    |                          |                                  |                              | 0.2538(1)/2.5                              |
| <sup>73</sup> Se  |                                  | 72.92677                 | 7.1 h                                  | $\beta^+$ /65/2.74           | 0.80/                                    | 9/2+                     | 0.86                             |                              | ann.rad                                    |
|                   |                                  |                          |                                        | EC/35/                       | 1.32/95.                                 |                          |                                  |                              | 0.0670(1)/72.                              |
|                   |                                  |                          |                                        |                              | 1.68/1.                                  |                          |                                  |                              | 0.3609(1)/97.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.6–1.5)                                  |
| <sup>74</sup> Se  | 0.89(4)                          | 73.922476                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>75</sup> Se  |                                  | 74.922523                | 119.78 d                               | EC/0.864                     |                                          | 5/2+                     | 0.67                             | 1.0                          | 0.13600/55                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.26465/58                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.024–0.821)                              |
| <sup>76</sup> Se  | 9.37(29)                         | 75.919214                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>77m</sup> Se |                                  |                          | 17.4 s                                 | I.T./                        |                                          | 7/2+                     |                                  |                              | 0.1619(2)/52.                              |
| <sup>77</sup> Se  | 7.63(16)                         | 76.919914                |                                        |                              |                                          | ½-                       | +0.53506                         |                              |                                            |
| <sup>78</sup> Se  | 23.77(28)                        | 77.917309                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>79m</sup> Se |                                  |                          | 3.92 m                                 | I.T./                        |                                          |                          |                                  |                              | 0.09573(3)/9.5                             |
| <sup>79</sup> Se  |                                  | 78.918499                | 2.9 × 10 <sup>5</sup> y                | $\beta^-$ /0.151             |                                          | 7/2+                     | -1.018                           | +0.8                         |                                            |
| <sup>80</sup> Se  | 49.61(41)                        | 79.916521                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>81m</sup> Se |                                  |                          | 57.3 m                                 | I.T./99/0.1031               |                                          | 7/2+                     |                                  |                              | 0.1031(3)/9.7                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2602(2)/0.06                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2760/0.06                                |
| <sup>81</sup> Se  |                                  | 80.917993                | 18.5 m                                 | $\beta^-$ /1.585             | 1.6/98.                                  | ½-                       |                                  |                              | 0.2759/0.85                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2901/0.75                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8283/0.32                                |
| <sup>82</sup> Se  | 8.73(22)                         | 81.916699                | ~ 1 × 10 <sup>20</sup> y               | $\beta$ - $\beta^-$          |                                          | 0+                       |                                  |                              |                                            |
| <sup>83m</sup> Se |                                  |                          | 1.17 m                                 | $\beta^-$ /3.96              | 2.88/                                    | ½-                       |                                  |                              | 0.35666(6)/17.                             |
|                   |                                  |                          |                                        |                              | 3.92/                                    |                          |                                  |                              | 0.9879(1)/15.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.0305(1)/21.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.0514(2)/11.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.19–3.1)                                 |
| <sup>83</sup> Se  |                                  | 82.919118                | 22.3 m                                 | $\beta^-$ /3.668             | 0.93/                                    | 9/2+                     |                                  |                              | 0.22516(6)/33.                             |
|                   |                                  |                          |                                        |                              | 1.51/                                    |                          |                                  |                              | 0.35666(6)/69.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.51004(8)/45.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.21–2.42)                                |
| <sup>84</sup> Se  |                                  | 83.91846                 | 3.3 m                                  | $\beta^-$ /1.83              | 1.41/100.                                | 0+                       |                                  |                              | 0.4088(5)/100.                             |
| <sup>85</sup> Se  |                                  | 84.92225                 | 32. s                                  | $\beta^-$ /6.18              | 5.9/                                     | 5/2+                     |                                  |                              | 0.3450(1)/22.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6094(1)/41.                              |
| <sup>86</sup> Se  |                                  | 85.92427                 | 15. s                                  | $\beta^-$ /5.10              |                                          | 0+                       |                                  |                              | 2.0124(1)/24.                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.4433(8)/100.                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.6619(1)/49.                              |
| <sup>87</sup> Se  |                                  | 86.92852                 | 5.4 s                                  | $\beta^-$ /7.28              |                                          | 5/2+                     |                                  |                              | 0.468(1)/100.                              |
|                   |                                  |                          |                                        | n/                           |                                          |                          |                                  |                              | 1.4979(1)/23.                              |
| <sup>88</sup> Se  |                                  | 87.93142                 | 1.5 s                                  | $\beta^-$ , n/6.85           |                                          | 0+                       |                                  |                              | 0.5346/                                    |



| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>89</sup> Se       |                                  | 88.9365                  | 0.41 s                                 | $\beta^-$ , n/9.0            |                                          |                          |                                  |                              |                                            |
| <sup>90</sup> Se       |                                  | 89.9400                  | > 0.3 $\mu$ s                          |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>91</sup> Se       |                                  | 90.9460                  | 0.27 s                                 | $\beta^-$ , n/8.             |                                          |                          |                                  |                              |                                            |
| <sup>92</sup> Se       |                                  | 91.950                   | > 0.3 $\mu$ s                          |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>93</sup> Se       |                                  | 92.956                   | > 0.3 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>94</sup> Se       |                                  | 93.960                   | > 0.3 $\mu$ s                          |                              |                                          | 0+                       |                                  |                              |                                            |
| <b><sub>35</sub>Br</b> |                                  | <b>79.904(1)</b>         |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>67</sup> Br       |                                  | 66.9648                  |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>68</sup> Br       |                                  | 67.9585                  | < 1.5 $\mu$ s                          |                              |                                          |                          |                                  |                              |                                            |
| <sup>69</sup> Br       |                                  | 68.9501                  | < 0.024 $\mu$ s                        | $\beta^+$ /9.6               |                                          |                          |                                  |                              |                                            |
| <sup>70m</sup> Br      |                                  |                          | 2.2 s                                  |                              |                                          | 9+                       |                                  |                              |                                            |
| <sup>70</sup> Br       |                                  | 69.9446                  | ~ 0.08 s                               | $\beta^+$ /10.0              | /0.75                                    |                          |                                  |                              |                                            |
| <sup>71</sup> Br       |                                  | 70.939                   | 21. s                                  | $\beta^+$ /6.9               |                                          |                          |                                  |                              |                                            |
| <sup>72</sup> Br       |                                  | 71.9366                  | 1.31 m                                 | $\beta^+$ /8.7               |                                          | 3                        | ~ 0.55                           |                              | 0.4547–1.3167                              |
| <sup>73</sup> Br       |                                  | 72.93169                 | 3.4 m                                  | $\beta^+$ /4.7               | 3.7/                                     | 3/2-                     |                                  |                              | ann.rad                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.065–0.700                                |
| <sup>74m</sup> Br      |                                  |                          | 46. m                                  | $\beta^+$ /                  | 4.5/                                     | 4-                       | 1.82                             |                              | ann.rad                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6348                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7285                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.2–4.38)                                 |
| <sup>74</sup> Br       |                                  | 73.92989                 | 25.4 m                                 | $\beta^+$ /6.91              |                                          |                          |                                  |                              | ann.rad                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6341                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6348                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.2–4.7)                                  |
| <sup>75</sup> Br       |                                  | 74.92578                 | 1.62 h                                 | $\beta^+$ /76/3.03           |                                          | 3/2-                     | +0.75                            |                              | ann.rad                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.28650                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.1–1.56)                                 |
| <sup>76m</sup> Br      |                                  |                          | 1.4 s                                  | I.T./5.05                    |                                          | 4+                       |                                  |                              | 0.104548                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.05711                                    |
| <sup>76</sup> Br       |                                  | 75.92454                 | 16.0 h                                 | $\beta^+$ /57/4.96           | 1.9/                                     | 1-                       | 0.54821                          | 0.270                        | ann.rad                                    |
|                        |                                  |                          |                                        |                              | 3.68/                                    |                          |                                  |                              | 0.55911                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.85368                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.4–4.6)                                  |
| <sup>77m</sup> Br      |                                  |                          | 4.3 m                                  | I.T./0.1059                  |                                          | 9/2+                     |                                  |                              | 0.1059                                     |
| <sup>77</sup> Br       |                                  | 76.921379                | 2.376 d                                | EC/99/1.365                  |                                          | 3/2-                     | 0.973                            | +0.53                        | ann.rad.                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.23898                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.52069                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.08–1.2)                                 |
| <sup>78</sup> Br       |                                  | 77.921146                | 6.45 m                                 | $\beta^+$ /92/3.574          | 1.2/                                     | 1+                       | 0.13                             |                              | ann.rad.                                   |
|                        |                                  |                          |                                        | EC/8/                        | 2.5/                                     |                          |                                  |                              | 0.61363                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.7–3.0)                                  |
| <sup>79m</sup> Br      |                                  |                          | 4.86 s                                 | I.T./0.207                   |                                          | 9/2+                     |                                  |                              | 0.2072                                     |
| <sup>79</sup> Br       | 50.69(7)                         | 78.918337                |                                        |                              |                                          | 3/2-                     | +2.106400                        | +0.331                       |                                            |
| <sup>80m</sup> Br      |                                  |                          | 4.42 h                                 | I.T./0.04885                 |                                          | 5-                       | +1.3177                          | +0.75                        | Br k x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.03705/39.1                               |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.04885/0.3                                |
| <sup>80</sup> Br       |                                  | 79.918529                | 17.66 m                                | $\beta^-$ /92/2.004          | 1.38 $\beta^-$ /7.6                      | 1+                       | 0.5140                           | 0.196                        | ann.rad.                                   |
|                        |                                  |                          |                                        | EC/5.7/1.8706                | 1.99 $\beta^-$ /82                       |                          |                                  |                              | 0.6169/6.7                                 |
|                        |                                  |                          |                                        | $\beta^+$ /2.6/              | 0.85 $\beta^+$ /2.8                      |                          |                                  |                              | (0.64–1.45)                                |
| <sup>81</sup> Br       | 49.31(7)                         | 80.916291                |                                        |                              |                                          | 3/2-                     | +2.270562                        | +0.276                       |                                            |
| <sup>82m</sup> Br      |                                  |                          | 6.1 m                                  | I.T./98/0.046                |                                          | 2-                       |                                  |                              | 0.046/0.24                                 |
|                        |                                  |                          |                                        | $\beta^-$ /2 /3.139          |                                          |                          |                                  |                              | (0.62–2.66)                                |
| <sup>82</sup> Br       |                                  | 81.916804                | 1.471 d                                | $\beta^-$ /3.093             | 0.444/                                   | 5-                       | +1.6270                          | 0.751                        | 0.5544/71                                  |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.61905/43                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.77649/84                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.013–1.96)                               |
| <sup>83</sup> Br       |                                  | 82.915180                | 2.40 h                                 | $\beta^-$ /0.972             | 0.395/1                                  | 3/2-                     |                                  |                              | 0.52964                                    |
|                        |                                  |                          |                                        |                              | 0.925/99                                 |                          |                                  |                              | (0.12–0.68)                                |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>ħ</i> /2 π) | Nuclear<br>Magnetic<br>Mom. (nm) | Electr.<br>Quadr.<br>Mom. (b) | γ-Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|-------------------------------|------------------------------------|
| <sup>84m</sup> Br |                                  |                          | 6.0 m                                  | β- /4.97                     | 2.2/100                                  | (6-)                     |                                  |                               | 0.4240/100                         |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.8817/98                          |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 1.4637/101                         |
| <sup>84</sup> Br  | 83.91648                         | 31.8 m                   | β- /4.65                               | 2.70/11                      | 2-                                       | 2.                       |                                  |                               | 0.8816/41                          |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 3.81/20                            |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 4.63/34                            |
| <sup>85</sup> Br  | 84.91561                         | 2.87 m                   | β- /2.87                               | 2.57                         | 3/2-                                     |                          |                                  |                               | 0.80241/2.56                       |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.92463/1.6                        |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | (0.09–2.4)                         |
| <sup>86</sup> Br  | 85.91880                         | 55.5 s                   | β- /7.63                               | 3.3                          | (2-)                                     |                          |                                  |                               | 1.56460/64                         |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 7.4                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | (0.5–6.8)                          |
| <sup>87</sup> Br  | 86.92071                         | 55.6 s                   | β- /6.85                               | 6.1/                         | 3/2-                                     |                          |                                  |                               | 1.41983                            |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | n/                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | (0.2–6.1)                          |
| <sup>88m</sup> Br |                                  | 5.1 μs                   |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>88</sup> Br  | 87.92407                         | 16.3 s                   | β- /8.96                               |                              | 1-                                       |                          |                                  |                               | 0.7649                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | n/                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.7753                             |
| <sup>89</sup> Br  | 88.92640                         | 4.35 s                   | β- /8.16                               |                              | 3/2-                                     |                          |                                  |                               | 0.8021                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | (0.1–6.99)                         |
| <sup>90</sup> Br  | 89.9306                          | 1.91 s                   | β- /10.4                               | 8.3/                         | 2-                                       |                          |                                  |                               | 0.7753                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | n/                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 1.0978                             |
| <sup>91</sup> Br  | 90.9340                          | 0.54 s                   | β- /9.80                               |                              |                                          |                          |                                  |                               | 0.6555                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.7071                             |
| <sup>92</sup> Br  | 91.93926                         | 0.31 s                   | β- /12.20                              |                              |                                          |                          |                                  |                               | 1.3626                             |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>93</sup> Br  | 92.9431                          | 0.10 s                   | β- /11                                 |                              |                                          |                          |                                  |                               | 0.263                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.803                              |
| <sup>94</sup> Br  | 93.9487                          | 0.07 s                   | β- n/                                  |                              |                                          |                          |                                  |                               | 0.740                              |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>95</sup> Br  | 94.9529                          | > 0.3 μs                 |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>96</sup> Br  | 95.959                           | > 0.3 μs                 |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>97</sup> Br  | 96.963                           | > 0.3 μs                 |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>36</sup> Kr  | 83.798(2)                        |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>69</sup> Kr  | 68.9652                          | 0.03 s                   | β+, (p)                                | 4.07/                        |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>70</sup> Kr  | 69.9553                          | 0.06 s                   |                                        |                              |                                          | 0+                       |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>71</sup> Kr  | 70.950                           | 100. ms                  | β+, EC/10.1                            |                              |                                          |                          |                                  |                               | (0.198–0.207)                      |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>72</sup> Kr  | 71.94209                         | 17.1 s                   | β+ /5.0                                |                              |                                          | 0+                       |                                  |                               | ann.rad                            |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | EC/                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.3099/15.3                        |
| <sup>73</sup> Kr  | 72.93929                         | 28. s                    | β+ /6.7                                |                              |                                          | 5/2-                     |                                  |                               | 0.4150/12.8                        |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | EC/                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.1781/66                          |
| <sup>74</sup> Kr  | 73.933084                        | 11.5 m                   | β+, p/                                 | /0.25                        |                                          |                          |                                  |                               | (0.305 – 3.305)                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>75</sup> Kr  | 74.93095                         | 4.3 m                    | β+ /4.90                               | 3.2/                         | 5/2+                                     | -0.531                   | +1.1                             |                               | ann.rad.                           |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | EC/                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.08970/31                         |
| <sup>76</sup> Kr  | 75.925910                        | 14.8 h                   | EC/1.31                                |                              |                                          |                          |                                  |                               | 0.2030/20                          |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | (0.010–1.06)                       |
| <sup>77</sup> Kr  |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>78</sup> Kr  |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.1325/68                          |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.1547/21                          |
| <sup>79</sup> Kr  |                                  |                          |                                        |                              |                                          |                          |                                  |                               | (0.02–1.7)                         |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
| <sup>80</sup> Kr  |                                  |                          |                                        |                              |                                          |                          |                                  |                               | Br k x-ray                         |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.270/21                           |
| <sup>81</sup> Kr  |                                  |                          |                                        |                              |                                          |                          |                                  |                               | 0.3158/39                          |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               |                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                               | (0.03–1.07)                        |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>77</sup> Kr  |                                  | 76.924670                | 1.24 h                                 | $\beta^+$ /80/3.06           |                                          | 5/2+                     | -0.583                           | +0.9                         | ann.rad.                                   |
|                   |                                  |                          |                                        | EC/20/                       | 1.55/                                    |                          |                                  |                              | 0.1297/80                                  |
|                   |                                  |                          |                                        |                              | 1.70/                                    |                          |                                  |                              | 0.1465/38                                  |
|                   |                                  |                          |                                        |                              | 1.87/                                    |                          |                                  |                              | (0.02–2.3)                                 |
| <sup>78</sup> Kr  | 0.355(3)                         | 77.920365                | $> 2.3 \times 10^{20}$ y               | EC-EC                        |                                          | 0+                       |                                  |                              |                                            |
| <sup>79m</sup> Kr |                                  |                          | 53. s                                  | I.T./0.1299                  |                                          | 7/2+                     | -0.786                           | +0.40                        | Kr x-ray                                   |
| <sup>79</sup> Kr  |                                  | 78.920082                | 1.455 d                                | $\beta^+$ /7 /1.626          |                                          | ½-                       | +0.536                           |                              | ann.rad.                                   |
|                   |                                  |                          |                                        | EC/93 /                      |                                          |                          |                                  |                              | 0.2613/13                                  |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.39756/19                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6061/8                                   |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.04–1.3)                                 |
| <sup>80</sup> Kr  | 2.286(10)                        | 79.916379                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>81m</sup> Kr |                                  |                          | 13.1 s                                 | I.T./0.1904                  |                                          | ½-                       | +0.586                           |                              | 0.1904                                     |
| <sup>81</sup> Kr  |                                  | 80.916592                | $2.1 \times 10^5$ y                    | EC/0.2807                    |                                          | 7/2+                     | -0.908                           | +0.63                        | Br k x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2760                                     |
| <sup>82</sup> Kr  | 11.593(31)                       | 81.913484                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>83m</sup> Kr |                                  |                          | 1.86 h                                 | I.T./0.0416                  |                                          | ½-                       | +0.591                           |                              | Kr k x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.00940                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.03216                                    |
| <sup>83</sup> Kr  | 11.500(19)                       | 82.914136                |                                        |                              |                                          | 9/2+                     | -0.970699                        | +0.259                       |                                            |
| <sup>84</sup> Kr  | 56.987(15)                       | 83.911507                |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>85m</sup> Kr |                                  |                          | 4.48 h                                 | $\beta^-$ /79 /              | 0.83/79                                  | ½-                       | + 0.633                          |                              | 0.30487                                    |
|                   |                                  |                          |                                        | I.T./21 /0.305               |                                          |                          |                                  |                              | 0.15118                                    |
| <sup>85</sup> Kr  |                                  | 84.912527                | 10.73 y                                | $\beta^-$ /0.687             | 0.15/0.4                                 | 9/2+                     | 1.005                            | +0.43                        | 0.51399                                    |
| <sup>86</sup> Kr  | 17.279(41)                       | 85.9106107               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>87</sup> Kr  |                                  | 86.9133549               | 1.27 h                                 | $\beta^-$ /3.887             | 1.33/8                                   | 5/2+                     | -1.023                           | -0.30                        | 0.40258/49.6                               |
|                   |                                  |                          |                                        |                              | 3.49/43                                  |                          |                                  |                              | 2.5548/9.2                                 |
|                   |                                  |                          |                                        |                              | 3.89/30                                  |                          |                                  |                              | (0.13–3.31)                                |
| <sup>88</sup> Kr  |                                  | 87.91445                 | 2.84 h                                 | $\beta^-$ /2.91              |                                          | 0+                       |                                  |                              | 0.19632/26.                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.392/34.6                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.03–2.8)                                 |
| <sup>89</sup> Kr  |                                  | 88.9176                  | 3.15 m                                 | $\beta^-$ /4.99              | 3.8/                                     | 5/2+                     | -0.330                           | +0.16                        | 0.19746                                    |
|                   |                                  |                          |                                        |                              | 4.6/                                     |                          |                                  |                              | 0.2209/19.9                                |
|                   |                                  |                          |                                        |                              | 4.9/                                     |                          |                                  |                              | 0.5858/16.4                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.4728/6.8                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.2–4.7)                                  |
| <sup>90</sup> Kr  |                                  | 89.91952                 | 32.3 s                                 | $\beta^-$ /4.39              | 2.6/77                                   | 0+                       |                                  |                              | 0.12182/32.9                               |
|                   |                                  |                          |                                        |                              | 2.8/6                                    |                          |                                  |                              | 0.5395/28.6                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.1187/36.2                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.1–4.2)                                  |
| <sup>91</sup> Kr  |                                  | 90.9235                  | 8.6 s                                  | $\beta^-$ /6.4               | 4.33/                                    | 5/2+                     | -0.583                           | +0.30                        | 0.10878/43.5                               |
|                   |                                  |                          |                                        |                              | 4.59/                                    |                          |                                  |                              | 0.50658/19.                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.2–4.4)                                  |
| <sup>92</sup> Kr  |                                  | 91.92616                 | 1.84 s                                 | $\beta^-$ /5.99              |                                          | 0+                       |                                  |                              | 0.1424/66.                                 |
|                   |                                  |                          |                                        | n/                           |                                          |                          |                                  |                              | (0.14–3.7)                                 |
| <sup>93</sup> Kr  |                                  | 92.9313                  | 1.29 s                                 | $\beta^-$ /8.6               | 7.1/                                     | ½+                       | -0.413                           |                              | 0.1820                                     |
|                   |                                  |                          |                                        | n/                           |                                          |                          |                                  |                              | 0.2534/42.                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.32309/24.6                               |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.057–4.03)                               |
| <sup>94</sup> Kr  |                                  | 93.9344                  | 0.21 s                                 | $\beta^-$ /7.3               |                                          | 0+                       |                                  |                              | 0.2196/67                                  |
|                   |                                  |                          |                                        | n                            | n//1.0                                   |                          |                                  |                              | 0.6293/100.                                |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.098–0.985)                              |
| <sup>95</sup> Kr  |                                  | 94.9398                  | 0.10 s                                 | $\beta^-$ /9.7               | n//2.9                                   |                          | - 0.410                          |                              |                                            |
| <sup>96</sup> Kr  |                                  | 95.9431                  | ~ 80 ms                                | $\beta^-$ ,n                 | n//3.7                                   | 0+                       |                                  |                              |                                            |
| <sup>97</sup> Kr  |                                  | 96.9486                  | 0.06 s                                 | $\beta^-$ ,n                 | n//7.                                    |                          |                                  |                              |                                            |
| <sup>98</sup> Kr  |                                  | 97.952                   | 0.05 s                                 | $\beta^-$ ,n                 | n//7.                                    | 0+                       |                                  |                              |                                            |
| <sup>99</sup> Kr  |                                  | 98.958                   | 0.04 s                                 | $\beta^-$ ,n                 | n// ~ 11.                                |                          |                                  |                              |                                            |
| <sup>100</sup> Kr |                                  | 99.9611                  | $> 0.34 \mu\text{s}$                   |                              |                                          | 0+                       |                                  |                              |                                            |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)                         | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)           |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------------------------------------|
| <sup>37</sup> Rb  |                                  | 85.4678(3)               |                                        |                                                      |                                          |                          |                                  |                              |                                                      |
| <sup>71</sup> Rb  |                                  | 70.9653                  |                                        |                                                      |                                          |                          |                                  |                              |                                                      |
| <sup>72</sup> Rb  |                                  | 71.9591                  | < 1.5 $\mu$ s                          |                                                      |                                          |                          |                                  |                              |                                                      |
| <sup>73</sup> Rb  |                                  | 72.9506                  | < 0.03 $\mu$ s                         |                                                      |                                          |                          |                                  |                              |                                                      |
| <sup>74</sup> Rb  |                                  | 73.944265                | 64.8 ms                                | $\beta^+$ /10.4                                      |                                          |                          |                                  |                              | 0.456/0.0025<br>(0.053 – 4.244)                      |
| <sup>75</sup> Rb  |                                  | 74.93857                 | 19. s                                  | $\beta^+$ /7.02                                      | 2.31/                                    |                          |                                  |                              | ann.rad<br>0.179                                     |
| <sup>76</sup> Rb  |                                  | 75.935072                | 39. s                                  | $\beta^+$ /8.50                                      | 4.7/                                     | 1-                       | -0.372623                        | +0.4                         | ann.rad<br>0.4240/92.<br>(0.064–1.68)                |
| <sup>77</sup> Rb  |                                  | 76.93041                 | 3.8 m                                  | $\beta^+$ /5.34                                      | 3.86/                                    | 3/2-                     | +0.654468                        | +0.70                        | ann.rad<br>0.0665/59<br>(0.04–2.82)                  |
| <sup>78m</sup> Rb |                                  |                          | 5.7 m                                  | I.T./0.1034                                          |                                          | 4-                       | +2.549                           | +0.81                        | ann.rad<br>0.4553/81.<br>(0.103–4.01)                |
| <sup>78</sup> Rb  |                                  | 77.92814                 | 17.7 m                                 | $\beta^+$ /7.22<br>EC/                               | 3.4                                      | 0+                       |                                  |                              | ann.rad<br>0.4553/63.<br>(0.42–5.57)                 |
| <sup>79</sup> Rb  |                                  | 78.92399                 | 23. m                                  | $\beta^+$ /84/3.65<br>EC/16 /                        |                                          | 5/2+                     | +0.3358                          | -0.10                        | ann.rad.<br>0.68812/23.<br>(0.017–3.02)              |
| <sup>80</sup> Rb  |                                  | 79.92252                 | 34. s                                  | $\beta^+$ /5.72                                      | 4.1/22<br>4.7/74                         | 1+                       | -0.0836                          | +0.35                        | ann.rad.<br>0.6167/25.                               |
| <sup>81m</sup> Rb |                                  |                          | 30.5 m                                 | I.T./0.85                                            | 1.4                                      | 9/2+                     | +5.598                           | -0.74                        | ann.rad.<br>(0.085–1.9)                              |
| <sup>81</sup> Rb  |                                  | 80.91900                 | 4.57 h                                 | $\beta^+$ /27/2.24<br>EC/73                          | 1.05/                                    | 3/2-                     | +2.060                           | +0.40                        | ann.rad./<br>0.19030/64.<br>(0.05–1.9)               |
| <sup>82m</sup> Rb |                                  |                          | 6.47 h                                 | $\beta^+$ /26/<br>EC/74/                             | 0.80/                                    | 5-                       | +1.5100                          | +1.0                         | ann.rad./<br>0.5544/63.<br>0.7765/85.<br>(0.092–2.3) |
| <sup>82</sup> Rb  |                                  | 81.918209                | 1.258 m                                | $\beta^+$ /96/4.40<br>EC/4/                          | 3.3/                                     | 1+                       | +0.554508                        | +0.19                        | ann.rad./<br>0.7665/13.<br>(0.47–3.96)               |
| <sup>83</sup> Rb  |                                  | 82.91511                 | 86.2 d                                 | EC/0.91                                              |                                          | 5/2-                     | +1.425                           | +0.20                        | Kr x-ray<br>0.5205/46.<br>(0.03–0.80)                |
| <sup>84m</sup> Rb |                                  |                          | 20.3 m                                 | I.T./0.216                                           |                                          | 6-                       | +0.2129                          | +0.6                         | 0.2163/34.<br>0.2482/63.<br>0.4645/32.               |
| <sup>84</sup> Rb  |                                  | 83.914385                | 32.9 d                                 | $\beta^+$ /22/2.681<br>EC/75 /<br>$\beta^-$ /3/0.894 | 0.780/11<br>1.658/11<br>0.893/           | 2-                       | -1.32412                         | -0.015                       | ann.rad./<br>0.8817/68.<br>(1.02–1.9)                |
| <sup>85</sup> Rb  | 72.17(2)                         | 84.91178974              |                                        |                                                      |                                          | 5/2-                     | +1.353                           | +0.23                        |                                                      |
| <sup>86m</sup> Rb |                                  |                          | 1.018 m                                | I.T./0.5560                                          |                                          | 6-                       | +1.815                           | +0.37                        | 0.556/98.                                            |
| <sup>86</sup> Rb  |                                  | 85.9111674               | 18.65 d                                | $\beta^-$ /1.775                                     | 1.774/8.8                                | 2-                       | -1.6920                          | +0.19                        | 1.0768/8.8                                           |
| <sup>87</sup> Rb  | 27.83(2)                         | 86.90918053              | $4.88 \times 10^{10}$ y                | $\beta^-$ /0.283                                     | 0.273/100                                | 3/2-                     | +2.7512                          | +0.13                        |                                                      |
| <sup>88</sup> Rb  |                                  | 87.9113156               | 17.7 m                                 | $\beta^-$ /5.316                                     | 5.31                                     | 2-                       | 0.508                            |                              | 0.8980/14.4<br>1.8360/22.8<br>(0.34–4.85)            |
| <sup>89</sup> Rb  |                                  | 88.91228                 | 15.4 m                                 | $\beta^-$ /4.50                                      | 1.26/38<br>1.9/5<br>2.2/34<br>4.49/18    | 3/2-                     | +2.304                           | +0.14                        | 1.032/58.<br>1.248/42.<br>2.1960/13<br>(0.12–4.09)   |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)    | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                       |
|-------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------------------------------------------------|
| <sup>90m</sup> Rb |                                  |                          | 4.3 m                                  | $\beta^-$ /4.50                 | 1.7/<br>6.5/                             | 4-                       | +1.616                           | +0.20                        | 0.1069(IT)<br>0.8317/94<br>(0.20–5.00)                           |
| <sup>90</sup> Rb  | 89.91480                         |                          | 2.6 m                                  | $\beta^-$ /6.59                 | 6.6                                      | 1-                       |                                  |                              | 0.8317/28.<br>(0.31–5.60)                                        |
| <sup>91</sup> Rb  | 90.91654                         |                          | 58.0 s                                 | $\beta^-$ /5.861                | 5.9                                      | 3/2-                     | +2.182                           | +0.15                        | 0.0936/34.<br>(0.35–4.70)                                        |
| <sup>92</sup> Rb  | 91.91073                         |                          | 4.48 s                                 | $\beta^-$ /8.11                 | 8.1/94                                   | 1-                       |                                  |                              | 0.8148/8.<br>(0.1–6.1)                                           |
| <sup>93</sup> Rb  | 92.92204                         |                          | 5.85 s                                 | $\beta^-$ /7.46<br>n/1          | 7.4/                                     | 5/2-                     | +1.410                           | +0.18                        | 0.2134/4.8<br>0.4326/12.5<br>0.9861/4.9<br>(0.16–5.41)           |
| <sup>94</sup> Rb  | 93.92641                         |                          | 2.71 s                                 | $\beta^-$ /10.31<br>n/10        | 9.5/                                     | 3                        | +1.498                           | +0.16                        | 0.8369/87.<br>1.5775/32.<br>(0.12–6.35)                          |
| <sup>95</sup> Rb  | 94.92930                         |                          | 0.377 s                                | $\beta^-$ /9.30<br>n/8          | 8.6/                                     | 5/2-                     | +1.334                           | +0.21                        | 0.352/65.<br>0.680/22.<br>(0.20–2.27)                            |
| <sup>96m</sup> Rb |                                  |                          | 1.7 $\mu$ s                            |                                 |                                          |                          |                                  |                              | 0.2999<br>0.4612<br>0.2400<br>0.093–0.369                        |
| <sup>96</sup> Rb  | 95.93427                         |                          | 0.199 s                                | $\beta^-$ /11.76<br>n/13/       | 10.8/                                    | 2+                       | +1.466                           | +0.25                        | 0.815/76.<br>(0.20–5.42)                                         |
| <sup>97</sup> Rb  | 96.93735                         |                          | 0.169 s                                | $\beta^-$ /10.42<br>n/27/       | 10.0                                     | 3/2+                     | +1.841                           | +0.58                        | 0.167/100.<br>0.585/79.<br>0.599/56.<br>1.258/52.<br>(0.14–2.08) |
| <sup>98</sup> Rb  | 97.94179                         |                          | 0.107 s                                | $\beta^-$ /12.34<br>n/13        | 0.144/                                   |                          |                                  |                              | (0.07–3.68)                                                      |
| <sup>99</sup> Rb  | 98.9454                          |                          | 59. ms                                 | $\beta^-$ /11.3                 |                                          |                          |                                  |                              |                                                                  |
| <sup>100</sup> Rb | 99.9499                          |                          | 53. ms                                 | $\beta^-$ /13.5                 |                                          |                          |                                  |                              | 0.129<br>(0.058–4.483)                                           |
| <sup>101</sup> Rb | 100.9532                         |                          | 0.03 s                                 | $\beta^-$ /11.8                 |                                          |                          |                                  |                              |                                                                  |
| <sup>102</sup> Rb | 101.9589                         |                          | 0.09 s                                 | $\beta^-$                       |                                          |                          |                                  |                              |                                                                  |
| <sup>38</sup> Sr  | <b>87.62(1)</b>                  |                          |                                        |                                 |                                          |                          |                                  |                              |                                                                  |
| <sup>73</sup> Sr  | 72.966                           |                          | > 25 ms                                |                                 |                                          |                          |                                  |                              |                                                                  |
| <sup>74</sup> Sr  | 73.9563                          |                          | > 1.5 $\mu$ s                          |                                 |                                          | 0+                       |                                  |                              |                                                                  |
| <sup>75</sup> Sr  | 74.9499                          |                          | 88. ms                                 | $\beta^+$ ,p                    | p//5.                                    |                          |                                  |                              | 0.144/4.5                                                        |
| <sup>76</sup> Sr  | 75.94177                         |                          | 7.9 s                                  | $\beta^+$ /6.1                  |                                          | 0+                       |                                  |                              |                                                                  |
| <sup>77</sup> Sr  | 76.93795                         |                          | 9.0 s                                  | $\beta^+$ /6.9<br>$\beta^+$ , p | 5.6<br>//0.08                            |                          | -0.35                            | +1.4                         | 0.147                                                            |
| <sup>78</sup> Sr  | 77.93218                         |                          | 2.7 m                                  | $\beta^+$ /3.76                 |                                          | 0+                       |                                  |                              | (0.047–0.793)                                                    |
| <sup>79</sup> Sr  | 78.92971                         |                          | 2.1 m                                  | $\beta^+$ /5.32                 | 4.1                                      | 3/2-                     | -0.474                           | +0.74                        | ann.rad./<br>0.039/28.<br>0.105/22.<br>(0.135–0.612)             |
| <sup>80</sup> Sr  | 79.92452                         |                          | 1.77 h                                 | $\beta^+$ /1.87                 |                                          | 0+                       |                                  |                              | ann.rad./<br>0.174/10.<br>0.589/39.<br>(0.24–0.55)               |
| <sup>81</sup> Sr  | 80.92321                         |                          | 22.3 m                                 | $\beta^+$ /87/3.93<br>EC/13/    | 2.43/<br>2.68/                           | 1/2-                     | +0.544                           |                              | ann.rad./<br>0.148/31.<br>0.1534/35<br>(0.06–1.7)                |
| <sup>82</sup> Sr  | 81.91840                         |                          | 25.36 d                                | EC/0.18                         |                                          | 0+                       |                                  |                              | Rb x-ray                                                         |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>83m</sup> Sr |                                  |                          | 5.0 s                                  | IT./0.2591                   |                                          | ½-                            | +0.582                           |                              | 0.2591/87.5                                |
| <sup>83</sup> Sr  | 82.91756                         |                          | 1.350 d                                | $\beta$ + /24/2.28           | 0.465/                                   | 7/2+                          | -0.898                           | +0.79                        | ann.rad./                                  |
|                   |                                  |                          |                                        | EC/76/                       | 0.803/                                   |                               |                                  |                              | 0.3816/12.                                 |
|                   |                                  |                          |                                        |                              | 1.227/                                   |                               |                                  |                              | 0.3816                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.7627/30.                                 |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.094–2.15)                               |
| <sup>84</sup> Sr  | 0.56(1)                          | 83.913425                |                                        |                              |                                          | 0+                            |                                  |                              |                                            |
| <sup>85m</sup> Sr |                                  |                          | 1.127 h                                | IT./87/0.2387                |                                          | ½-                            | +0.601                           |                              | 0.2318/84.                                 |
|                   |                                  |                          |                                        | EC/13                        |                                          |                               |                                  |                              | (0.15–0.24)                                |
| <sup>85</sup> Sr  |                                  | 84.912933                | 64.85 d                                | EC/1.065                     |                                          | 9/2+                          | -1.001                           | +0.30                        | 0.51399/99.3                               |
| <sup>86</sup> Sr  | 9.86(1)                          | 85.909260                |                                        |                              |                                          | 0+                            |                                  |                              |                                            |
| <sup>87m</sup> Sr |                                  |                          | 2.81 h                                 | IT./0.3884                   |                                          | ½-                            | +0.63                            |                              | 0.3884(IT)                                 |
| <sup>87</sup> Sr  | 7.00(1)                          | 86.908877                |                                        |                              |                                          | 9/2+                          | -1.093                           | +0.34                        |                                            |
| <sup>88</sup> Sr  | 82.58(1)                         | 87.905612                |                                        |                              |                                          | 0+                            |                                  |                              |                                            |
| <sup>89</sup> Sr  |                                  | 88.907451                | 50.52 d                                | $\beta$ - /1.497             | 1.492/100                                | 5/2+                          | -1.149                           | -0.3                         | 0.9092                                     |
| <sup>90</sup> Sr  |                                  | 89.907738                | 29.1 y                                 | $\beta$ - /0.546             | 0.546/100                                | 0+                            |                                  |                              |                                            |
| <sup>91</sup> Sr  |                                  | 90.910203                | 9.5 h                                  | $\beta$ - /2.70              | 0.61/7                                   | 5/2+                          | -0.887                           | +0.044                       | 0.5556/61.                                 |
|                   |                                  |                          |                                        |                              | 1.09/33                                  |                               |                                  |                              | 0.7498/24.                                 |
|                   |                                  |                          |                                        |                              | 1.36/29                                  |                               |                                  |                              | 1.0243/33.                                 |
|                   |                                  |                          |                                        |                              | 2.66/26                                  |                               |                                  |                              | (0.12–2.4)                                 |
| <sup>92</sup> Sr  |                                  | 91.911038                | 2.71 h                                 | $\beta$ - /1.91              | 0.55/96                                  | 0+                            |                                  |                              | 1.3831/90.                                 |
|                   |                                  |                          |                                        |                              | 1.5/3                                    |                               |                                  |                              | (0.24–1.1)                                 |
| <sup>93</sup> Sr  |                                  | 92.91403                 | 7.4 m                                  | $\beta$ - /4.08              | 2.2/10                                   | 5/2+                          | -0.794                           | +0.26                        | 0.5903/                                    |
|                   |                                  |                          |                                        |                              | 2.6/25                                   |                               |                                  |                              | 0.7104                                     |
|                   |                                  |                          |                                        |                              | 3.2/65                                   |                               |                                  |                              | 0.87573                                    |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.8883/                                    |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.17–3.97)                                |
| <sup>94</sup> Sr  |                                  | 93.91536                 | 1.25 m                                 | $\beta$ - /3.511             | 2.1/                                     | 0+                            |                                  |                              | 0.6219                                     |
|                   |                                  |                          |                                        |                              | 3.3/                                     |                               |                                  |                              | 0.7043                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.7241                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.8064                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.4283                                     |
| <sup>95</sup> Sr  |                                  | 94.91936                 | 25.1 s                                 | $\beta$ - /6.08              |                                          | ½+                            | -0.5379                          |                              | 0.6859                                     |
|                   |                                  |                          |                                        |                              | 6.1/50                                   |                               |                                  |                              | 0.8269                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 2.7173                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 2.9332                                     |
| <sup>96</sup> Sr  |                                  | 95.92170                 | 1.06 s                                 | $\beta$ - /5.37              | 4.2/                                     | 0+                            |                                  |                              | 0.1222                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.5305                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.8094                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.9318                                     |
| <sup>97</sup> Sr  |                                  | 96.92615                 | 0.42 s                                 | $\beta$ - /7.47              | 5.3                                      | (1/2+)                        | -0.500                           |                              | 0.2164                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.3071                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.6522                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.9538                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.2580                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.9050                                     |
| <sup>98</sup> Sr  |                                  | 97.92845                 | 0.65 s                                 | $\beta$ - /5.83              | 5.1                                      | 0+                            |                                  |                              | 0.0365                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1190                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.4286                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.4447                                     |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.5636                                     |
| <sup>99</sup> Sr  |                                  | 98.9332                  | 0.27 s                                 | $\beta$ - /8.0               |                                          |                               | -0.26                            | 0.8                          |                                            |
| <sup>100</sup> Sr |                                  | 99.9354                  | 0.201 s                                | $\beta$ - /7.1               |                                          | 0+                            |                                  |                              |                                            |
| <sup>101</sup> Sr |                                  | 100.9405                 | 0.115 s                                | $\beta$ - /9.5               |                                          |                               |                                  |                              |                                            |
| <sup>102</sup> Sr |                                  | 101.9430                 | 68. ms                                 | $\beta$ - /8.8               |                                          | 0+                            |                                  |                              |                                            |
| <sup>103</sup> Sr |                                  | 102.9490                 | > 0.3 $\mu$ s                          |                              |                                          |                               |                                  |                              |                                            |
| <sup>104</sup> Sr |                                  | 103.952                  | > 0.3 $\mu$ s                          |                              |                                          | 0+                            |                                  |                              |                                            |
| <sup>105</sup> Sr |                                  | 104.959                  | > 0.3 $\mu$ s                          |                              |                                          |                               |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |

[illegible]

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)      | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|--------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.9207                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | (0.1–3.8)                                  |
| <sup>87m</sup> Y  |                                  |                          | 13. h                                  | I.T./98/<br>$\beta^+ / 0.7 /$<br>EC/ | 1.15/0.7                                 | 9/2+                     | 6.1                              |                              | 0.3807                                     |
| <sup>87</sup> Y   |                                  | 86.910876                | 3.35 d                                 | EC/99+/1.862                         | 0.78/                                    | 1/2-                     |                                  |                              | 0.3880                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.4870                                     |
| <sup>88</sup> Y   |                                  | 87.909501                | 106.6 d                                | EC/99+/3.623                         | 0.76/                                    | 4-                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+ / 0.2 /$                    |                                          |                          |                                  |                              | 0.89802                                    |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.83601                                    |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 2.73404                                    |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 3.2190                                     |
| <sup>89m</sup> Y  |                                  |                          | 15.7 s                                 | I.T./0.909                           |                                          | 9/2+                     |                                  |                              | 0.9092(IT)                                 |
| <sup>89</sup> Y   | 100.                             | 88.905848                |                                        |                                      |                                          | 1/2-                     | -0.13742                         |                              |                                            |
| <sup>90m</sup> Y  |                                  |                          | 3.24 h                                 | I.T./99+/<br>$\beta^- / 0.002 /$     | 0.68204                                  | 7+                       | 5.1                              |                              | 0.2025                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.4794                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.6820                                     |
| <sup>90</sup> Y   |                                  | 89.907152                | 2.67 d                                 | $\beta^- / 2.282$                    | 2.28/                                    | 2-                       | -1.630                           | -0.155                       |                                            |
| <sup>91m</sup> Y  |                                  |                          | 49.7 m                                 | I.T./0.555                           |                                          | 9/2+                     | 5.96                             |                              | 0.5556(IT)                                 |
| <sup>91</sup> Y   |                                  | 90.907305                | 58.5 d                                 | $\beta^- / 1.544$                    | 1.545/                                   | 1/2-                     | 0.1641                           |                              | 1.208                                      |
| <sup>92</sup> Y   |                                  | 91.90895                 | 3.54 h                                 | $\beta^- / 3.63$                     | 3.64/                                    | 2-                       |                                  |                              | 0.4485                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.5611                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.9345                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.4054                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | (0.4–3.3)                                  |
| <sup>93m</sup> Y  |                                  |                          | 0.82 s                                 | I.T./0.759                           |                                          | 9/2+                     |                                  |                              | 0.1686(IT)                                 |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.5902                                     |
| <sup>93</sup> Y   |                                  | 92.90958                 | 10.2 h                                 | $\beta^- / 2.87$                     | 2.88/90                                  | 1/2-                     |                                  |                              | 0.2669                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.9471                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.9178                                     |
| <sup>94m</sup> Y  |                                  |                          | 1.4 $\mu$ s                            |                                      |                                          |                          |                                  |                              | 0.4322                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.7699                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.2024                                     |
| <sup>94</sup> Y   |                                  | 93.91160                 | 18.7 m                                 | $\beta^- / 4.919$                    | 4.92/                                    | 2-                       |                                  |                              | 0.3816                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.9188                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.1389                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | (0.3–4.1)                                  |
| <sup>95</sup> Y   |                                  | 94.91282                 | 10.3 m                                 | $\beta^- / 4.42$                     |                                          | 1/2-                     |                                  |                              | 0.4324                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.9542                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 2.1760                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 3.5770                                     |
| <sup>96m</sup> Y  |                                  |                          | 9.6 s                                  | $\beta^- /$                          |                                          | (3+)                     |                                  |                              | 0.1467                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.6174                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.9150                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.1071                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.7507                                     |
| <sup>96</sup> Y   |                                  | 95.91589                 | 6.2 s                                  | $\beta^- / 7.09$                     | 7.12/                                    | 0-                       |                                  |                              | 1.594                                      |
| <sup>97m</sup> Y  |                                  |                          | 1.21 s                                 | $\beta^- / 7.4$                      | 4.8/<br>6.0/                             | 9/2+                     |                                  |                              | 0.1614                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.9700                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.1030                                     |
| <sup>97</sup> Y   |                                  | 96.91813                 | 3.76 s                                 | $\beta^- / 6.69$                     | 6.7                                      | 1/2-                     |                                  |                              | 0.2969                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.9960                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 3.2876                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 3.4013                                     |
| <sup>98m</sup> Y  |                                  |                          | 2.1 s                                  | $\beta^- / 9.8$                      | 5.5/                                     | (4-)                     |                                  |                              | 0.2415                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.6205                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.6473                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.2228                                     |
|                   |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 1.8016                                     |
| <sup>98</sup> Y   |                                  | 97.92220                 | 0.59 s                                 | $\beta^- / 8.83$                     | 8.7/                                     | 1+                       |                                  |                              | 0.2131                                     |



| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.2228                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.5907                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.9413                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 4.4501                                     |
| <sup>99m</sup> Y  |                                  |                          | 0.011 ms                               |                                 |                                          |                          |                                  |                              |                                            |
| <sup>99</sup> Y   | 98.92464                         |                          | 1.47 s                                 | $\beta^-$ /7.57                 |                                          | 1/2-                     |                                  |                              | 0.1218/43.8                                |
|                   |                                  |                          |                                        | n                               | /2.5/                                    |                          |                                  |                              | 0.5362                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7242                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0130                                     |
| <sup>100m</sup> Y |                                  |                          | 0.94 s                                 | $\beta^-$ , n /                 |                                          | 3+                       |                                  |                              |                                            |
| <sup>100</sup> Y  | 99.9278                          |                          | 0.73 s                                 | $\beta^-$ , n/9.3               | n/1.8/                                   | 1+                       |                                  |                              |                                            |
| <sup>101</sup> Y  | 100.9303                         |                          | 0.43 s                                 | $\beta^-$ , n/8.6               | n/1.5/                                   | (5/2+)                   |                                  |                              |                                            |
| <sup>102</sup> Y  | 101.9336                         |                          | 0.36 s                                 | $\beta^-$ , n/9.9               | n/4.0/                                   |                          |                                  |                              |                                            |
| <sup>103</sup> Y  | 102.9367                         |                          | 0.23 s                                 | $\beta^-$ , n                   | n/8.3/                                   |                          |                                  |                              |                                            |
| <sup>104</sup> Y  | 103.9411                         |                          | 0.18 s                                 |                                 |                                          |                          |                                  |                              |                                            |
| <sup>105</sup> Y  | 104.9449                         |                          | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>106</sup> Y  | 105.950                          |                          | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>107</sup> Y  | 106.9414                         |                          | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>108</sup> Y  | 107.959                          |                          | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>40</sup> Zr  | 91.224(2)                        |                          |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>78</sup> Zr  | 77.9552                          |                          | > 0.2 $\mu$ s                          |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>79</sup> Zr  | 78.9492                          |                          | 0.06 s                                 |                                 |                                          |                          |                                  |                              |                                            |
| <sup>80</sup> Zr  | 79.940                           |                          | ~ 4.5 s                                | $\beta^+$ /8.0                  |                                          | 0+                       |                                  |                              | 0.290                                      |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.538                                      |
| <sup>81</sup> Zr  | 80.9372                          |                          | 5.3 s                                  | $\beta^+$ /7.2                  | 6.1                                      | (3/2-)                   |                                  |                              |                                            |
| <sup>82</sup> Zr  | 81.9311                          |                          | 32. s                                  | $\beta^+$ /4.0                  | 3.                                       | 0+                       |                                  |                              | ann.rad./                                  |
| <sup>83m</sup> Zr |                                  |                          | 7. s                                   | $\beta^+$ /7.0                  |                                          | (7/2+)                   |                                  |                              | ann.rad./                                  |
| <sup>83</sup> Zr  | 82.9287                          |                          | 44. s                                  | $\beta^+$ /5.9                  | 4.8                                      | (1/2-)                   |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | EC                              |                                          |                          |                                  |                              | 0.0556                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1050                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2560                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.474                                      |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.525                                      |
| <sup>84</sup> Zr  | 83.9233                          |                          | 26. m                                  | $\beta^+$ /2.7                  |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | EC/                             |                                          |                          |                                  |                              | 0.0449                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1125                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3729                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.667                                      |
| <sup>85m</sup> Zr |                                  |                          | 10.9 s                                 | I.T./0.2922                     |                                          | ½-                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+$ , EC/                 |                                          |                          |                                  |                              | 0.2922(IT)                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4165                                     |
| <sup>85</sup> Zr  | 84.9215                          |                          | 7.9 m                                  | $\beta^+$ /4.7                  | 3.1                                      | 7/2+                     |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | EC/                             |                                          |                          |                                  |                              | 0.2663                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4163                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4543                                     |
| <sup>86</sup> Zr  | 85.91647                         |                          | 16.5 h                                 | EC/1.47                         |                                          | 0+                       |                                  |                              | 0.0280                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.243                                      |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.612                                      |
| <sup>87m</sup> Zr |                                  |                          | 14.0 s                                 | I.T./0.3362                     |                                          | ½-                       | + 0.64                           |                              | 0.1352(IT)                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2010                                     |
| <sup>87</sup> Zr  | 86.91482                         |                          | 1.73 h                                 | $\beta^+$ /3.67                 | 2.26                                     | 9/2+                     | - 0.895                          | + 0.42                       | ann.rad./                                  |
|                   |                                  |                          |                                        | EC/                             |                                          |                          |                                  |                              | 0.3811                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.228                                      |
| <sup>88m</sup> Zr |                                  |                          | 1.4 $\mu$ s                            |                                 |                                          | (8+)                     |                                  |                              | 0.077                                      |
| <sup>88</sup> Zr  | 87.91023                         |                          | 83.4 d                                 | EC/0.67                         |                                          | 0+                       |                                  |                              | 0.3929                                     |
| <sup>89m</sup> Zr |                                  |                          | 4.18 m                                 | I.T./94/0.5877                  |                                          | ½-                       | + 0.80                           |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+$ /1.5/                 |                                          |                          |                                  |                              | 0.5877(IT)                                 |
|                   |                                  |                          |                                        | EC/4.7/                         |                                          |                          |                                  |                              | 1.507                                      |

[illegible]

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                     |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|----------------------------------------------------------------|
| <sup>88</sup> Nb    |                                  | 87.9183                  | 14.3 m                                 | $\beta^+$ /7.6<br>EC/           | 3.2/                                     | 8+                       |                                  |                              | 1.0825<br>ann.rad./<br>1.0570<br>1.0828<br>(0.07–2.5)          |
| <sup>89m</sup> Nb   |                                  |                          | 2.0 h                                  | $\beta^+$ /<br>EC/              | 3.3/                                     | 9/2+                     |                                  |                              | 0.5880/10(D)<br>(0.17–4.0)                                     |
| <sup>89</sup> Nb    |                                  | 88.91342                 | 1.10 h                                 | $\beta^+$ /74/4.29<br>EC/26 /   | 2.8/                                     | 1/2-                     | +6.216                           |                              | ann.rad./<br>0.5074<br>0.5880<br>0.7696<br>1.2775              |
| <sup>90m</sup> Nb   |                                  |                          | 18.8 s                                 | I.T./0.1246                     |                                          | 4-                       |                                  |                              | 0.002<br>0.1225                                                |
| <sup>90</sup> Nb    |                                  | 89.911265                | 14.6 h                                 | $\beta$ /53 /6.111<br>EC/47 /   | 0.86/5<br>1.5/92                         | 8+                       | 4.961                            |                              | ann.rad./<br>0.1412<br>1.1292<br>2.1862<br>2.3189<br>(0.1–3.3) |
| <sup>91m</sup> Nb   |                                  |                          | 62. d                                  | I.T./97 /<br>EC/3 /             |                                          | 1/2-                     |                                  |                              | 0.1045(IT)<br>1.2050                                           |
| <sup>91</sup> Nb    |                                  | 90.906996                | $7 \times 10^2$ y                      | EC/1.253                        |                                          | 9/2+                     |                                  |                              | Mo k x-ray                                                     |
| <sup>92m</sup> Nb   |                                  |                          | 10.13 d                                | EC/99+/                         |                                          | 2+                       | 6.114                            |                              | 0.9126<br>0.9345<br>1.8475                                     |
| <sup>92</sup> Nb    |                                  | 91.907194                | $3.7 \times 10^7$ y                    | EC/2.006                        |                                          | 7+                       |                                  |                              | 0.5611<br>0.9345                                               |
| <sup>93m</sup> Nb   |                                  |                          | 16.1 y                                 | I.T./0.0304                     |                                          | 1/2-                     |                                  |                              | Nb x-ray<br>0.0304                                             |
| <sup>93</sup> Nb    | 100.                             | 92.906378                |                                        |                                 |                                          | 9/2+                     | +6.1705                          | -0.32                        |                                                                |
| <sup>94m</sup> Nb   |                                  |                          | 6.26 m                                 | I.T./99+<br>$\beta^-$ /0.5/     | /2.086                                   | 3+                       |                                  |                              | Nb k x-ray<br>0.0409<br>0.87109                                |
| <sup>94</sup> Nb    |                                  | 93.907284                | $2.4 \times 10^4$ y                    | $\beta^-$ /2.045                | 0.47/                                    | 6+                       |                                  |                              | 0.70263<br>0.87109                                             |
| <sup>95m</sup> Nb   |                                  |                          | 3.61 d                                 | I.T./97.5/<br>$\beta^-$ /2.5 /  | 0.2357                                   | 1/2-                     |                                  |                              | 0.2040<br>0.2356                                               |
| <sup>95</sup> Nb    |                                  | 94.906836                | 34.97 d                                | $\beta^-$ /0.926                | 0.160/                                   | 9/2+                     | 6.141                            |                              | 0.76578                                                        |
| <sup>96</sup> Nb    |                                  | 95.908101                | 23.4 h                                 | $\beta^-$ /3.187                | 0.5/10<br>0.75/90                        | 6+                       | 4.976                            |                              | 0.7782<br>0.2191–1.498                                         |
| <sup>97m</sup> Nb   |                                  |                          | 58.1 s                                 | I.T./0.7434                     | 0.734/98                                 | 1/2-                     |                                  |                              | 0.7434                                                         |
| <sup>97</sup> Nb    |                                  | 96.908099                | 1.23 h                                 | $\beta^-$ /1.934                | 1.27/98                                  | 9/2+                     | 6.15                             |                              | 0.4809<br>0.6579                                               |
| <sup>98m</sup> Nb   |                                  |                          | 51. m                                  | $\beta^-$ /4.67                 |                                          | 5+                       |                                  |                              | 0.7874<br>0.1726–1.89                                          |
| <sup>98</sup> Nb    |                                  | 97.91033                 | 2.9 s                                  | $\beta^-$ /4.59                 | 4.6/                                     | 1+                       |                                  |                              | 0.6451<br>0.7874<br>1.0243                                     |
| <sup>99m</sup> Nb   |                                  |                          | 2.6 m                                  | $\beta^-$ /                     | 3.2/                                     | 1/2-                     |                                  |                              | 0.0978/100<br>(0.138–3.010)                                    |
| <sup>99</sup> Nb    |                                  | 98.91162                 | 15.0 s                                 | $\beta^-$ /3.64                 | 3.5/100                                  | 9/2+                     |                                  |                              | 0.0977<br>0.1378/3.1                                           |
| <sup>100m2</sup> Nb |                                  |                          | 0.013 ms                               |                                 |                                          |                          |                                  |                              |                                                                |
| <sup>100m1</sup> Nb |                                  |                          | 3.0 s                                  | $\beta^-$ /6.74                 | 5.8                                      |                          |                                  |                              | Nb k x-ray<br>0.159<br>0.6364<br>1.0637                        |
| <sup>100</sup> Nb   |                                  | 99.91418                 | 1.5 s                                  | $\beta^-$ /6.25                 | 6.2/<br>5.3/                             |                          |                                  |                              | 0.5354<br>0.6001–1.566                                         |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>101</sup> Nb  |                                  | 100.91525                | 7.1 s                                  | $\beta^-$ /4.57                 | 4.3/                                     |                          |                                  |                              | 0.1105–0.810                               |
| <sup>102m</sup> Nb |                                  |                          | 4.3 s                                  | $\beta^-$ /                     |                                          |                          |                                  |                              |                                            |
| <sup>102</sup> Nb  |                                  | 101.91804                | 1.3 s                                  | $\beta^-$ /7.21                 | 7.2/                                     |                          |                                  |                              | 0.2960–2.184                               |
| <sup>103</sup> Nb  |                                  | 102.9191                 | 1.5 s                                  | $\beta^-$ /5.53                 | 5.3/                                     | 5/2+                     |                                  |                              |                                            |
| <sup>104m</sup> Nb |                                  |                          | 0.9 s                                  | $\beta^-$ , n/                  | n/0.06                                   |                          |                                  |                              |                                            |
| <sup>104</sup> Nb  |                                  | 103.9225                 | 4.8 s                                  | $\beta^-$ , n/8.1               | n/0.05                                   |                          |                                  |                              |                                            |
| <sup>105</sup> Nb  |                                  | 104.9239                 | 3.0 s                                  | $\beta^-$ , n/6.5               | n/1.7                                    |                          |                                  |                              |                                            |
| <sup>106</sup> Nb  |                                  | 105.9280                 | 1.0 s                                  | $\beta^-$ , n/9.3               | n/4.5                                    |                          |                                  |                              |                                            |
| <sup>107</sup> Nb  |                                  | 106.9303                 | 0.30 s                                 | $\beta^-$ , n/7.9               | n/6.0                                    |                          |                                  |                              |                                            |
| <sup>108</sup> Nb  |                                  | 107.9348                 | 0.19 s                                 | $\beta$ , n/                    | n/6.2                                    |                          |                                  |                              | (0.193–0.590)                              |
| <sup>109</sup> Nb  |                                  | 108.9376                 | 0.19 s                                 | $\beta$ , n/                    | n/31                                     |                          |                                  |                              |                                            |
| <sup>110</sup> Nb  |                                  | 109.9424                 | 0.17 s                                 | $\beta$ , n/                    | n/40                                     |                          |                                  |                              |                                            |
| <sup>111</sup> Nb  |                                  | 110.9457                 | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>112</sup> Nb  |                                  | 111.951                  | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>113</sup> Nb  |                                  | 112.955                  | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>42</sup> Mo   |                                  | 95.94(2)                 |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>83</sup> Mo   |                                  | 82.9487                  | ~ 6. ms                                |                                 |                                          |                          |                                  |                              |                                            |
| <sup>84</sup> Mo   |                                  | 83.9401                  | ~ 3.7 s                                | $\beta^+$ /6.                   |                                          | 0+                       |                                  |                              |                                            |
| <sup>85</sup> Mo   |                                  | 84.9366                  | 3.2 s                                  | $\beta^+$ /8.1                  |                                          | $\frac{1}{2}^+$          |                                  |                              |                                            |
| <sup>86</sup> Mo   |                                  | 85.9307                  | 19. s                                  | $\beta^+$ /4.8                  |                                          | 0+                       |                                  |                              |                                            |
| <sup>87</sup> Mo   |                                  | 86.9273                  | 14. s                                  | EC, $\beta^+$ /6.5              |                                          |                          |                                  |                              | (0.752–1.004)                              |
| <sup>88</sup> Mo   |                                  | 87.92195                 | 8.0 m                                  | $\beta^+$ /3.4                  |                                          | 0+                       | +0.5                             |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC                              |                                          |                          |                                  |                              | 0.0800                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1399                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1707                                     |
| <sup>89m</sup> Mo  |                                  |                          | 0.19 s                                 | I.T./0.118                      |                                          | $\frac{1}{2}^-$          |                                  |                              | 0.118(IT)                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.268                                      |
| <sup>89</sup> Mo   |                                  | 88.91948                 | 2.2 m                                  | $\beta^+$ /5.58                 |                                          | 9/2+                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/                             |                                          |                          |                                  |                              | 0.659                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.803                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.155                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.272                                      |
| <sup>90m</sup> Mo  |                                  |                          | 1.2 $\mu$ s                            |                                 |                                          |                          |                                  |                              | 0.063                                      |
| <sup>90</sup> Mo   |                                  | 89.91394                 | 5.7 h                                  | $\beta^+$ /25/2.489             | 1.085/                                   | 0+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/75 /                         |                                          |                          |                                  |                              | 0.04274                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.12237                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.25734                                    |
| <sup>91m</sup> Mo  |                                  |                          | 1.08 m                                 | I.T./50/0.653                   |                                          | $\frac{1}{2}^-$          |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | $\beta^+$ , EC/50 /             | 2.5/                                     |                          |                                  |                              | 0.6529                                     |
|                    |                                  |                          |                                        |                                 | 2.8/                                     |                          |                                  |                              | 1.2081                                     |
|                    |                                  |                          |                                        |                                 | 4.0/                                     |                          |                                  |                              | 1.5080                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.2407                                     |
| <sup>91</sup> Mo   |                                  | 90.91175                 | 15.5 m                                 | $\beta^+$ /94/4.43              | 3.44/94                                  | 9/2-                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/6/                           |                                          |                          |                                  |                              | 1.6373                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.6321                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 3.0286                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.1–4.2)                                  |
| <sup>92</sup> Mo   | 14.77(31)                        | 91.906811                | > 3 $\times$ 10 <sup>17</sup> y        | $\beta^+$ -EC                   |                                          | 0+                       |                                  |                              |                                            |
| <sup>93m</sup> Mo  |                                  |                          | 6.9 h                                  | I.T./99+ /2.425                 |                                          | 21/2+                    | +9.21                            |                              | 0.26306(IT)                                |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.68461                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.47711                                    |
| <sup>93</sup> Mo   |                                  | 92.906813                | 3.5 $\times$ 10 <sup>3</sup> y         | EC/0.405                        |                                          | 5/2+                     |                                  |                              | 0.0304                                     |
| <sup>94</sup> Mo   | 9.23(10)                         | 93.905088                |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>95</sup> Mo   | 15.90(9)                         | 94.905842                |                                        |                                 |                                          | 5/2+                     | -0.9142                          | -0.02                        |                                            |
| <sup>96</sup> Mo   | 16.68(1)                         | 95.904680                |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>97</sup> Mo   | 9.56(5)                          | 96.906022                |                                        |                                 |                                          | 5/2+                     | -0.9335                          | +0.26                        |                                            |
| <sup>98</sup> Mo   | 24.19(26)                        | 97.905408                |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>99</sup> Mo   |                                  | 98.907712                | 2.7476 d                               | $\beta^-$ /1.357                | 0.45/14                                  | $\frac{1}{2}^+$          | 0.375                            |                              | 0.144048                                   |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                        |                                  |                          |                                        |                                 | 0.84/2                                   |                               |                                  |                              | 0.18109                                    |
|                        |                                  |                          |                                        |                                 | 1.21/84                                  |                               |                                  |                              | 0.36644                                    |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.73947                                    |
| <sup>100</sup> Mo      | 9.67(20)                         | 99.90748                 | $\sim 1 \times 10^{19}$ y              | $\beta$ - $\beta$ -             |                                          | 0+                            |                                  |                              |                                            |
| <sup>101</sup> Mo      |                                  | 100.91035                | 14.6 m                                 | $\beta$ - /2.82                 | 2.23/                                    | 1/2+                          |                                  |                              | 0.0063                                     |
|                        |                                  |                          |                                        |                                 | 0.7/                                     |                               |                                  |                              | 0.19193                                    |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.5909                                     |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | (0.0809–2.405)                             |
| <sup>102</sup> Mo      |                                  | 101.91030                | 11.3 m                                 | $\beta$ - /1.01                 | 1.2/                                     | 0+                            |                                  |                              | 0.1493/89.                                 |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2116/100.                                |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2243/32.                                 |
| <sup>103</sup> Mo      |                                  | 102.9132                 | 1.13 m                                 | $\beta$ - /3.8                  |                                          | 3/2+                          |                                  |                              | 0.1028(2)/                                 |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.1440(2)                                  |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2511(2)                                  |
| <sup>104</sup> Mo      |                                  | 103.9138                 | 1.00 m                                 | $\beta$ - /2.16                 |                                          | 0+                            |                                  |                              | 0.0686(1)/100.                             |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.4239(4)/21.                              |
| <sup>105</sup> Mo      |                                  | 104.9170                 | 36. s                                  | $\beta$ - /4.95                 |                                          | 3/2+                          |                                  |                              | 0.0642/                                    |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.0856/                                    |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2495/                                    |
| <sup>106</sup> Mo      |                                  | 105.91814                | 8.4 s                                  | $\beta$ - /3.52                 |                                          | 0+                            |                                  |                              | 0.1894(2)/22.                              |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.3644(2)/6.                               |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.3723(2)/12.                              |
| <sup>107</sup> Mo      |                                  | 106.9217                 | 3.5 s                                  | $\beta$ - /6.2                  |                                          |                               |                                  |                              |                                            |
| <sup>108</sup> Mo      |                                  | 107.9235                 | 1.1 s                                  | $\beta$ - /5.1                  |                                          | 0+                            |                                  |                              | (0.028–0.636)                              |
| <sup>109</sup> Mo      |                                  | 108.9278                 | 0.5 s                                  | $\beta$ - /7.2                  |                                          |                               |                                  |                              |                                            |
| <sup>110</sup> Mo      |                                  | 109.9297                 | 0.27 s                                 | $\beta$ - /5.7                  |                                          | 0+                            |                                  |                              | Tc k x-ray                                 |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.142                                      |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | (0.039–0.599)                              |
| <sup>111</sup> Mo      |                                  | 110.9344                 | > 0.15 $\mu$ s                         |                                 |                                          |                               |                                  |                              |                                            |
| <sup>112</sup> Mo      |                                  | 111.937                  | > 0.15 $\mu$ s                         |                                 |                                          | 0+                            |                                  |                              |                                            |
| <sup>113</sup> Mo      |                                  | 112.942                  | > 0.15 $\mu$ s                         |                                 |                                          |                               |                                  |                              |                                            |
| <sup>114</sup> Mo      |                                  | 113.945                  | > 0.15 $\mu$ s                         |                                 |                                          | 0+                            |                                  |                              |                                            |
| <sup>115</sup> Mo      |                                  | 114.950                  | > 0.15 $\mu$ s                         |                                 |                                          |                               |                                  |                              |                                            |
| <sup>116</sup> Mo      |                                  |                          | > 0.15 $\mu$ s                         |                                 |                                          | 0+                            |                                  |                              |                                            |
| <sup>117</sup> Mo      |                                  |                          | > 0.15 $\mu$ s                         |                                 |                                          |                               |                                  |                              |                                            |
| <b><sup>43</sup>Tc</b> |                                  |                          |                                        |                                 |                                          |                               |                                  |                              |                                            |
| <sup>85</sup> Tc       |                                  | 84.9488                  | < 0.1 ms                               |                                 |                                          |                               |                                  |                              |                                            |
| <sup>86</sup> Tc       |                                  | 85.9429                  | 0.05 s                                 | $\beta$ + /11.9                 |                                          |                               |                                  |                              |                                            |
| <sup>87</sup> Tc       |                                  | 86.9365                  | 2.4 s                                  | $\beta$ + /8.6                  |                                          |                               |                                  |                              |                                            |
| <sup>88</sup> Tc       |                                  | 87.9327                  | 5.8 s                                  | $\beta$ + /10.1                 |                                          |                               |                                  |                              |                                            |
| <sup>89m</sup> Tc      |                                  |                          | 13. s                                  |                                 |                                          |                               |                                  |                              |                                            |
| <sup>89</sup> Tc       |                                  | 88.9272                  | 13. s                                  | $\beta$ + /7.5                  |                                          |                               |                                  |                              |                                            |
| <sup>90m</sup> Tc      |                                  |                          | 49.2 s                                 | $\beta$ +                       | 5.3/                                     | 6+                            |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.9479/                                    |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 1.0542/                                    |
| <sup>90</sup> Tc       |                                  | 89.9236                  | 8.3 s                                  | $\beta$ + /8.9                  | 7.0/15                                   | 1+                            |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                                 | 7.9/95.                                  |                               |                                  |                              | 0.9479/                                    |
| <sup>91m</sup> Tc      |                                  |                          | 3.3 m                                  | $\beta$ +                       |                                          | $\frac{1}{2}$ +               |                                  |                              | ann.rad./170.                              |
|                        |                                  |                          |                                        | EC                              |                                          |                               |                                  |                              | 0.8110(5)/5.                               |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 1.6052(1)/7.8                              |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 1.6339(1)/9.1                              |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 1.9023(1)/6.                               |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 2.4509(1)/13.5                             |
| <sup>91</sup> Tc       |                                  | 90.9184                  | 3.14 m                                 | $\beta$ + /6.2                  | 5.2                                      | 9/2+                          |                                  |                              | ann.rad./200.                              |
| <sup>92</sup> Tc       |                                  | 91.91526                 | 4.4 m                                  | $\beta$ + /7.87                 | 4.1                                      | 8+                            |                                  |                              | ann.rad./200.                              |
|                        |                                  |                          |                                        | EC                              |                                          |                               |                                  |                              | 0.0850/                                    |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.1475                                     |
|                        |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.3293                                     |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7731                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.5096                                     |
| <sup>93m</sup> Tc  |                                  |                          | 43. m                                  | I.T./13                         |                                          | ½-                       |                                  |                              | 0.3924(IT)                                 |
|                    |                                  |                          |                                        | EC/20                           |                                          |                          |                                  |                              | 0.9437                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.6445                                     |
| <sup>93</sup> Tc   | 92.910249                        |                          | 2.73 h                                 | β+ /13/3.201                    | 0.81                                     | 9/2+                     | 6.26                             |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/87/                          |                                          |                          |                                  |                              | 1.3629                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.4771                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.5203                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.1–3.0)                                  |
| <sup>94m</sup> Tc  |                                  |                          | 52. m                                  | β+ /72/4.33                     |                                          | 2+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/28/                          |                                          |                          |                                  |                              | 0.8710                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.8686                                     |
| <sup>94</sup> Tc   | 93.909657                        |                          | 4.88 h                                 | β+ /11/4.256                    |                                          | 7+                       | 5.08                             |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/89/                          |                                          |                          |                                  |                              | 0.4491                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7026                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8496                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8710                                     |
| <sup>95m</sup> Tc  |                                  |                          | 61. d                                  | I.T./4/                         |                                          | 1/2-                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | β+ /0.3                         | 0.5/                                     |                          |                                  |                              | 0.0389(IT)                                 |
|                    |                                  |                          |                                        | EC/96                           | 0.7/                                     |                          |                                  |                              | 0.2041                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5821                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5821                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8351                                     |
| <sup>95</sup> Tc   | 94.90766                         |                          | 20.0 h                                 | EC/100/1.691                    |                                          | 9/2+                     | 5.89                             |                              | 0.7657                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0738                                     |
| <sup>96m</sup> Tc  |                                  |                          | 52. m                                  | I.T./90/                        |                                          | 4+                       |                                  |                              | 0.0342(IT)                                 |
|                    |                                  |                          |                                        | β+, EC/2/                       |                                          |                          |                                  |                              | 0.7782                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.2002                                     |
| <sup>96</sup> Tc   | 95.90787                         |                          | 4.3 d                                  | EC/2.973                        |                                          | 7+                       | +5.04                            |                              | Mo k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7782                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8125                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8498                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.12168                                    |
| <sup>97m</sup> Tc  |                                  |                          | 91. d                                  | I.T./0.0965                     |                                          | 1/2-                     |                                  |                              | Tc k x-ray                                 |
|                    |                                  |                          |                                        | EC                              | /3.9                                     |                          |                                  |                              | 0.0965                                     |
| <sup>97</sup> Tc   | 96.906365                        |                          | 4.2 × 10 <sup>6</sup> y                | EC/100/0.320                    |                                          | 9/2+                     |                                  |                              | Mo k x-ray                                 |
| <sup>98</sup> Tc   | 97.907216                        |                          | ~ 6.6 × 10 <sup>6</sup> y              | β- /1.80                        | 0.40/100                                 | 6+                       |                                  |                              | 0.65241                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.74535                                    |
| <sup>99m</sup> Tc  |                                  |                          | 6.01 h                                 | I.T./100/0.142                  |                                          | 1/2-                     |                                  |                              | Tc k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.14049                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.14261                                    |
| <sup>99</sup> Tc   | 98.906255                        |                          | 2.13 × 10 <sup>5</sup> y               | β- /0.294                       | 0.293/100                                | 9/2+                     | +5.6847                          | -0.129                       |                                            |
| <sup>100</sup> Tc  | 99.907658                        |                          | 15.8 s                                 | β- /3.202                       | 2.2/                                     | 1+                       |                                  |                              | 0.5396                                     |
|                    |                                  |                          |                                        | EC /1.8(10) <sup>-3</sup> /     | 2.9/                                     |                          |                                  |                              | 0.5908                                     |
|                    |                                  |                          |                                        |                                 | 3.3                                      |                          |                                  |                              | (0.3 79–2.30)                              |
| <sup>101</sup> Tc  | 100.90732                        |                          | 14.2 m                                 | β- /1.61                        | 1.32/                                    | 9/2+                     |                                  |                              | 0.1272                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1841                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3068                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5451                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.073–0.969)                              |
| <sup>102m</sup> Tc |                                  |                          | 4.4 m                                  | I.T./2/4.8                      | 1.8/                                     |                          |                                  |                              | 0.4184                                     |
|                    |                                  |                          |                                        | β- /98/                         |                                          |                          |                                  |                              | 0.4752                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6281                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6302                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0464                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.1033                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.6163                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.2447                                     |
| <sup>102</sup> Tc  | 101.90922                        |                          | 5.3 s                                  | β- /4.53                        | 3.4/                                     | 1+                       |                                  |                              | 0.4686                                     |

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| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                           |
|-------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------------------------------------------------|
| <sup>93m</sup> Ru |                                  |                          | 10.8 s                                 | I.T./21/<br>$\beta^+$ , EC/79/  | 5.3/                                     | 1/2-                     |                                  |                              | ann.rad./<br>0.7344<br>1.1112<br>1.3962<br>2.0931                                    |
| <sup>93</sup> Ru  |                                  | 92.9171                  | 1.0 m                                  | $\beta^+$ /6.3<br>EC/           |                                          | 9/2+                     |                                  |                              | ann.rad./<br>0.6807<br>1.4349<br>(0.5–4.2)weak                                       |
| <sup>94</sup> Ru  |                                  | 93.91136                 | 52. m                                  | EC/100/1.59                     |                                          | 0+                       |                                  |                              | 0.3672<br>0.5247<br>0.8922                                                           |
| <sup>95</sup> Ru  |                                  | 94.91041                 | 1.64 h                                 | EC/85/2.57<br>$\beta^+$ /15/    | 1.20/<br>0.91/                           | 5/2+                     | 0.86                             |                              | ann.rad./<br>0.3364<br>0.6268<br>0.036–2.424                                         |
| <sup>96</sup> Ru  | 5.54(14)                         | 95.90760                 | $> 3.1 \times 10^{16}$ y               | $\beta^+\beta^+$                |                                          | 0+                       |                                  |                              |                                                                                      |
| <sup>97</sup> Ru  |                                  | 96.90756                 | 2.89 d                                 | EC/1.12                         |                                          | 5/2+                     | -0.78                            |                              | Tc k x-ray<br>0.2157<br>0.3245<br>0.4606                                             |
| <sup>98</sup> Ru  | 1.87(3)                          | 97.90529                 |                                        |                                 |                                          | 0+                       |                                  |                              |                                                                                      |
| <sup>99</sup> Ru  | 12.76(14)                        | 98.905939                |                                        |                                 |                                          | 5/2+                     | -0.6413                          | +0.079                       |                                                                                      |
| <sup>100</sup> Ru | 12.60(7)                         | 99.904220                |                                        |                                 |                                          | 0+                       |                                  |                              |                                                                                      |
| <sup>101</sup> Ru | 17.06(2)                         | 100.905582               |                                        |                                 |                                          | 5/2+                     | -0.7188                          | +0.46                        |                                                                                      |
| <sup>102</sup> Ru | 31.55(14)                        | 101.904349               |                                        |                                 |                                          | 0+                       |                                  |                              |                                                                                      |
| <sup>103</sup> Ru |                                  | 102.906324               | 39.27 d                                | $\beta^-$ /0.763                | 0.223                                    | 3/2+                     | 0.206                            | +0.62                        | 0.05329<br>0.29498<br>0.4438<br>0.49708<br>0.55704<br>0.61033<br>(0.04–1.6)          |
| <sup>104</sup> Ru | 18.62(27)                        | 103.905433               |                                        |                                 |                                          | 0+                       |                                  |                              |                                                                                      |
| <sup>105</sup> Ru |                                  | 104.907753               | 4.44 h                                 | $\beta^-$ /1.917                | 1.11/22<br>1.134/13<br>1.187/49          | 3/2+                     | -0.3                             |                              | 0.12968<br>0.1491<br>0.2629<br>0.31664<br>0.46943<br>0.67634<br>0.72420<br>(0.1–1.8) |
| <sup>106</sup> Ru |                                  | 105.90733                | 1.020 y                                | $\beta^-$ /0.0394               | 0.0394/100                               | 0+                       |                                  |                              |                                                                                      |
| <sup>107</sup> Ru |                                  | 106.9099                 | 3.8 m                                  | $\beta^-$ /2.9                  | 2.1/<br>3.2/                             |                          |                                  |                              | 0.1939<br>0.3741<br>0.4625<br>0.8488                                                 |
| <sup>108</sup> Ru |                                  | 107.9102                 | 4.5 m                                  | $\beta^-$ /1.4                  | 1.2/                                     | 0+                       |                                  |                              | 0.0923<br>0.1651<br>0.4339<br>0.4975<br>0.6189                                       |
| <sup>109</sup> Ru |                                  | 108.9132                 | 34.5 s                                 | $\beta^-$ /4.2                  |                                          |                          |                                  |                              | 0.1164<br>0.3584                                                                     |
| <sup>110</sup> Ru |                                  | 109.9141                 | 15. s                                  | $\beta^-$ /2.81                 |                                          | 0+                       |                                  |                              | 0.1121<br>0.3737<br>0.4397<br>0.7967                                                 |
| <sup>111</sup> Ru |                                  | 110.9177                 | 1.5 s                                  | $\beta^-$ /5.5                  |                                          |                          |                                  |                              |                                                                                      |
| <sup>112</sup> Ru |                                  | 111.9190                 | 4.5 s                                  | $\beta^-$ /4.5                  |                                          | 0+                       |                                  |                              |                                                                                      |



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| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)           | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                               |
|--------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------------------------------------|
| <sup>97</sup> Rh   |                                  | 96.91134                 | 31.0 m                                 | $\beta^+$ /3.52                           | 2.1/                                     | 9/2+                     |                                  |                              | ann.rad./<br>0.1886<br>0.3892<br>0.4515<br>0.8398<br>0.8788<br>(0.2–3.5) |
| <sup>98m</sup> Rh  |                                  |                          | 3.5 m                                  | $\beta^+$ /                               |                                          | 5+                       |                                  |                              | ann.rad./<br>0.6154<br>0.6524<br>0.7452                                  |
| <sup>98</sup> Rh   |                                  | 97.91071                 | 8.7 m                                  | $\beta^+$ /90/5.06                        | 3.4/                                     | 2+                       |                                  |                              | ann.rad./<br>0.6524<br>0.7623                                            |
| <sup>99m</sup> Rh  |                                  |                          | 4.7 h                                  | $\beta^+$ /8/<br>EC/92/                   | .74/                                     | 9/2+                     | 5.67                             |                              | ann.rad./<br>0.2766/<br>0.3408<br>0.6178<br>1.2612                       |
| <sup>99</sup> Rh   |                                  | 98.90813                 | 16. d                                  | $\beta^+$ /4/2.10<br>EC/97/               | 0.54/<br>0.68/                           | 1/2-                     |                                  |                              | ann.rad./<br>0.0894/<br>0.3530<br>0.5277<br>(0.1–2.0)                    |
| <sup>100m</sup> Rh |                                  |                          | 4.7 m                                  | I.T./99/<br>$\beta^+$ /0.4/               |                                          | 5+                       |                                  |                              | ann.rad./<br>0.0748/<br>0.2647(IT)                                       |
| <sup>100</sup> Rh  |                                  | 99.90812                 | 20.8 h                                 | $\beta^+$ /3.63<br>EC/                    | 2.62/<br>2.07/                           | 1-                       |                                  |                              | 0.4462<br>0.5396<br>0.5882<br>0.8225<br>1.5534<br>2.3761                 |
| <sup>101m</sup> Rh |                                  |                          | 4.35 d                                 | EC/92/<br>I.T./8/0.1573                   |                                          | 9/2+                     | +5.51                            |                              | Rh k x-ray<br>0.1272/<br>0.3069<br>0.5451                                |
| <sup>101</sup> Rh  |                                  | 100.90616                | 3.3 y                                  | EC/0.54                                   |                                          | 1/2-                     |                                  |                              | Ru k x-ray<br>0.1272<br>0.1980<br>0.3252                                 |
| <sup>102m</sup> Rh |                                  |                          | 3.74 y<br>> 1.2 × 10 <sup>6</sup> y    | EC/2.323<br>IT/0.0419<br>$\beta^+$        |                                          | 6 <sup>+</sup>           | 4.04                             |                              | 0.4751<br>0.6313<br>0.6975<br>0.7668<br>1.0466<br>1.1032                 |
| <sup>102</sup> Rh  |                                  | 101.906843               | 207. d                                 | EC/62<br>$\beta^-$ /19/<br>$\beta^+$ /14/ |                                          |                          | 0.5                              |                              | ann.rad./<br>0.4686<br>0.4751<br>0.5566<br>0.6280<br>1.1032<br>(0.4–1.6) |
| <sup>103m</sup> Rh |                                  |                          | 56.12 m                                | IT                                        |                                          | 7/2+                     | 4.54                             |                              |                                                                          |
| <sup>103</sup> Rh  | 100.                             | 102.905504               |                                        |                                           |                                          | 1/2-                     | -0.0884                          |                              |                                                                          |
| <sup>104m</sup> Rh |                                  |                          | 4.36 m                                 | I.T./99+ /<br>$\beta^-$                   |                                          | 5+                       |                                  |                              | Rh k x-ray<br>0.0514<br>0.0971<br>0.5558                                 |

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| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>98</sup> Ag   | 97.9216                          |                          | 47.6 s                                 | $\beta^+$ /8.4                  |                                          | 5+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/                             | /36.                                     |                          |                                  |                              | 0.5711                                     |
|                    |                                  |                          |                                        | $\beta^+$ , p                   | /0.11                                    |                          |                                  |                              | 0.6786                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8631                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.153–1.185)                              |
| <sup>99m</sup> Ag  |                                  |                          | 11. s                                  | I.T./100/                       |                                          | $\frac{1}{2}-$           |                                  |                              | Ag k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1636(IT)                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3426                                     |
| <sup>99</sup> Ag   | 98.9176                          |                          | 2.07 m                                 | $\beta^+$ /87 5.4               |                                          | 9/2+                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/13/                          |                                          |                          |                                  |                              | 0.2199                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2645                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8056                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8323                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.2–3.5)                                  |
| <sup>100m</sup> Ag |                                  |                          | 2.3 m                                  | $\beta^+$ /                     |                                          | 2+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/                             |                                          |                          |                                  |                              | 0.6657                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.6941                                     |
| <sup>100</sup> Ag  | 99.9161                          |                          | 2.0 m                                  | $\beta^+$ /7.1                  | 4.7/                                     | 5+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/                             |                                          |                          |                                  |                              | 0.2807                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4503                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6657                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7508                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7732                                     |
| <sup>101m</sup> Ag |                                  |                          | 3.1 s                                  | I.T./0.23                       |                                          | $\frac{1}{2}-$           |                                  |                              | Ag k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0981                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.176(IT)                                  |
| <sup>101</sup> Ag  | 100.9128                         |                          | 11.1 m                                 | $\beta^+$ /69/4.2               | 2.7/                                     | 9/2+                     | 5.7                              |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/31/                          |                                          |                          |                                  |                              | 0.2610                                     |
|                    |                                  |                          |                                        |                                 | 2.18/                                    |                          |                                  |                              | 0.2747                                     |
|                    |                                  |                          |                                        |                                 | 2.73/                                    |                          |                                  |                              | 0.3269                                     |
|                    |                                  |                          |                                        |                                 | 3.38/                                    |                          |                                  |                              | 0.4392                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6673                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.1739                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.2–3.1)                                  |
| <sup>102m</sup> Ag |                                  |                          | 7.8 m                                  | $\beta^+$ /38/                  | 3.4                                      | 2+                       | +4.14                            |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/13/                          |                                          |                          |                                  |                              | 0.5567                                     |
|                    |                                  |                          |                                        | I.T./49/                        |                                          |                          |                                  |                              | 0.9777                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.8347                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.0545                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.1594                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 3.2386                                     |
| <sup>102</sup> Ag  | 101.91169                        |                          | 13.0 m                                 | $\beta^+$ /78/5.92              | 2.26/                                    | 5+                       | 4.6                              |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/22/                          |                                          |                          |                                  |                              | 0.5564                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7193                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.163–2.242                                |
| <sup>103m</sup> Ag |                                  |                          | 5.7 s                                  | I.T./0.134                      |                                          | 1/2-                     |                                  |                              | Ag k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1344                                     |
| <sup>103</sup> Ag  | 102.90897                        |                          | 1.10 h                                 | $\beta^+$ /28/2.69              | 1.7                                      | 7/2+                     | +4.47                            |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/72/                          | 1.3                                      |                          |                                  |                              | 0.1187                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1482                                     |
| <sup>104m</sup> Ag |                                  |                          | 33. m                                  | $\beta^+$ /64/                  | 2.71/                                    | 2+                       | +3.7                             |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/36/                          |                                          |                          |                                  |                              | 0.5558                                     |
|                    |                                  |                          |                                        | I.T./0.07/                      |                                          |                          |                                  |                              | 0.7657                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.5–3.4)                                  |
| <sup>104</sup> Ag  | 103.90863                        |                          | 69. m                                  | $\beta^+$ /16/4.28              | 0.99/                                    | 5+                       | 3.92                             |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/84/                          |                                          |                          |                                  |                              | 0.5558                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9259                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9416                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.18–2.27)                                |
| <sup>105m</sup> Ag |                                  |                          | 7.2 m                                  | I.T./98/0.0255                  |                                          | 7/2+                     | +4.41                            |                              | Ag x-ray                                   |



| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>115</sup> Ag   |                                  | 114.90876                | 20. m                                  | $\beta^-$ /3.10                 |                                          | 1/2-                     |                                  |                              | 0.1316                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2128                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2291                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4727                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.13–2.49)                                |
| <sup>116m2</sup> Ag |                                  |                          | 20. s                                  | $\beta^-$ ,IT/7                 | IT/0.0479                                |                          |                                  |                              |                                            |
| <sup>116m</sup> Ag  |                                  |                          | 9.8 s                                  | $\beta^-$ /92 /                 | 3.2/                                     | 5+                       |                                  |                              | 0.5134                                     |
|                     |                                  |                          |                                        |                                 | 2.9                                      |                          |                                  |                              | 0.7055                                     |
|                     |                                  |                          |                                        | I.T./8                          | IT/.0809                                 |                          |                                  |                              | 0.255–2.838                                |
| <sup>116</sup> Ag   |                                  | 115.91136                | 2.68 m                                 | $\beta^-$ /6.16                 | 5.3                                      | 2-                       |                                  |                              | 0.5134                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6993                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.4779                                     |
| <sup>117m</sup> Ag  |                                  |                          | 5.3 s                                  | $\beta^-$ /                     | 3.2/                                     | 7/2+                     |                                  |                              | 0.1354                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2981                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3868                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1571                                     |
| <sup>117</sup> Ag   |                                  | 116.91168                | 1.22 m                                 | $\beta^-$ /4.18                 | 2.3                                      | 1/2-                     |                                  |                              | 0.1354                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3377                                     |
| <sup>118m</sup> Ag  |                                  |                          | 2.8 s                                  | $\beta^-$ /59/                  |                                          |                          |                                  |                              | 0.1277                                     |
|                     |                                  |                          |                                        | I.T./41 /0.1277                 |                                          |                          |                                  |                              | 0.4878                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6771                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7709                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.190-2.778)                              |
| <sup>118</sup> Ag   |                                  | 117.9146                 | 4.0 s                                  | $\beta^-$ /7.1                  |                                          |                          |                                  |                              | 0.4878                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6771                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 3.2259                                     |
| <sup>119</sup> Ag   |                                  | 118.9157                 | 2.1 s                                  | $\beta^-$ /5.35                 |                                          | 7/2+                     |                                  |                              | 0.0674                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3662                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3991                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6264                                     |
| <sup>120m</sup> Ag  |                                  |                          | 0.40 s                                 | $\beta^-$ /63.                  |                                          |                          |                                  |                              | 0.2030                                     |
|                     |                                  |                          |                                        | I.T./37.                        |                                          |                          |                                  |                              | 0.5059                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6978                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8300                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.115-1.644)                              |
| <sup>120</sup> Ag   |                                  | 119.9188                 | 1.23 s                                 | $\beta^-$ /8.2                  |                                          |                          |                                  |                              | 0.5059                                     |
|                     |                                  |                          |                                        | $\beta^-$ ,n                    | n//<0.0030%                              |                          |                                  |                              | 0.6978                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8171                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.442-3.044)                              |
| <sup>121</sup> Ag   |                                  | 120.9199                 | 0.78 s                                 | $\beta^-$ /6.4                  |                                          |                          |                                  |                              | 0.1150                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3148                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3537                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3696                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5007                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.5105                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.11–2.5)                                 |
| <sup>122m</sup> Ag  |                                  |                          | 1. s                                   | $\beta^-$ /                     |                                          |                          |                                  |                              |                                            |
| <sup>122</sup> Ag   |                                  | 121.9235                 | 0.44 s                                 | $\beta^-$ /9.2                  |                                          |                          |                                  |                              |                                            |
| <sup>123</sup> Ag   |                                  | 122.9249                 | 0.31 s                                 | $\beta^-$ /7.4                  |                                          |                          |                                  |                              |                                            |
| <sup>124</sup> Ag   |                                  | 123.9286                 | 0.22 s                                 | $\beta^-$ /10.1                 |                                          |                          |                                  |                              |                                            |
| <sup>125</sup> Ag   |                                  | 124.9304                 | 0.17 s                                 | $\beta^-$                       |                                          |                          |                                  |                              |                                            |
| <sup>126</sup> Ag   |                                  | 125.9345                 | 0.11 s                                 | $\beta^-$                       |                                          |                          |                                  |                              |                                            |
| <sup>127</sup> Ag   |                                  | 126.9368                 | 0.11 s                                 | $\beta^-$                       |                                          |                          |                                  |                              |                                            |
| <sup>128</sup> Ag   |                                  | 127.9412                 | 58 ms                                  | $\beta^-$                       |                                          |                          |                                  |                              |                                            |
| <sup>129m</sup> Ag  |                                  |                          | 0.16 s                                 |                                 |                                          |                          |                                  |                              |                                            |
| <sup>129</sup> Ag   |                                  | 128.9437                 | ~ 46. ms                               | $\beta^-$ , n                   |                                          |                          |                                  |                              |                                            |
| <sup>130</sup> Ag   |                                  | 129.9505                 | ~ 35 ms                                |                                 |                                          |                          |                                  |                              |                                            |
| <sup>48</sup> Cd    |                                  | 112.411(8)               |                                        |                                 |                                          |                          |                                  |                              |                                            |



| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $h/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                         |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|----------------------|----------------------------------|------------------------------|--------------------------------------------------------------------|
| <sup>95</sup> Cd   |                                  | 94.950                   |                                        |                                 |                                          |                      |                                  |                              |                                                                    |
| <sup>96</sup> Cd   |                                  | 95.9398                  |                                        |                                 |                                          | 0+                   |                                  |                              |                                                                    |
| <sup>97</sup> Cd   |                                  | 96.9349                  | 3. s                                   | $\beta^+$ , (p)                 |                                          |                      |                                  |                              |                                                                    |
| <sup>98</sup> Cd   |                                  | 97.9274                  | 9.2 s                                  | $\beta^+$ /5.4<br>(p)           | /0.025                                   | 0+                   |                                  |                              |                                                                    |
| <sup>99</sup> Cd   |                                  | 98.9250                  | 16. s                                  | $\beta^+$ , EC/6.9              |                                          |                      |                                  |                              | ann.rad./                                                          |
| <sup>100</sup> Cd  |                                  | 99.9203                  | 1.1 m                                  | $\beta^+$ , EC/3.9              |                                          | 0+                   |                                  |                              | ann.rad./<br>(0.090–1.043)                                         |
| <sup>101</sup> Cd  |                                  | 100.9187                 | 1.2 m                                  | $\beta^+$ /83/5.5<br>EC/17/     | 4.5                                      | 5/2+                 |                                  |                              | In k x-ray<br>0.0985<br>1.7225<br>0.31–2.84)                       |
| <sup>102</sup> Cd  |                                  | 101.91446                | 5.8 m                                  | $\beta^+$ /27/2.59<br>EC/73     |                                          | 0+                   |                                  |                              | ann.rad./<br>0.0974<br>0.4810<br>1.0366<br>1.3598                  |
| <sup>103</sup> Cd  |                                  | 102.91342                | 7.5 m                                  | $\beta^+$ /33/4.14<br>EC/67/    |                                          | 5/2+                 | -0.81                            | -0.8                         | ann.rad./<br>Ag k x-ray<br>1.0799<br>1.4487<br>1.4618<br>(0.1–2.8) |
| <sup>104</sup> Cd  |                                  | 103.90985                | 58. m                                  | EC/1.14                         |                                          | 0+                   |                                  |                              | Ag k x-ray<br>0.0835<br>0.7093                                     |
| <sup>105</sup> Cd  |                                  | 104.90947                | 55.5 m                                 | $\beta^+$ /26/2.739<br>EC/74/   | 1.69/                                    | 5/2+                 | -0.7393                          | +0.43                        | Ag k x-ray<br>0.3469<br>0.6072<br>0.9618<br>1.3025<br>(0.25–2.4)   |
| <sup>106</sup> Cd  | 1.25(6)                          | 105.90646                | $> 5.8 \times 10^{17}$ y               | EC, EC                          |                                          | 0+                   |                                  |                              |                                                                    |
| <sup>107</sup> Cd  |                                  | 106.90662                | 6.52 h                                 | EC/99+/1.417<br>$\beta^+$ /     |                                          | 5/2+                 | -0.615055                        | +0.68                        | Ag k x-ray<br>0.0931<br>0.8289                                     |
| <sup>108</sup> Cd  | 0.89(3)                          | 107.90418                | $>4.1 \times 10^{17}$ y                | EC EC                           |                                          | 0+                   |                                  |                              |                                                                    |
| <sup>109</sup> Cd  |                                  | 108.904982               | 462.0 d                                | EC/0.214                        |                                          | 5/2+                 | -0.827846                        | +0.69                        | Ag k x-ray<br>0.08804                                              |
| <sup>110</sup> Cd  | 12.49(18)                        | 109.903002               |                                        |                                 |                                          | 0+                   |                                  |                              |                                                                    |
| <sup>111m</sup> Cd |                                  |                          | 48.5 m                                 | I.T./                           |                                          | 11/2-                |                                  |                              | Cd k x-ray<br>0.1508(IT)<br>0.2454                                 |
| <sup>111</sup> Cd  | 12.80(12)                        | 110.904178               |                                        |                                 |                                          | 1/2+                 | -0.594886                        |                              |                                                                    |
| <sup>112</sup> Cd  | 24.13(21)                        | 111.902758               |                                        |                                 |                                          | 0+                   |                                  |                              |                                                                    |
| <sup>113m</sup> Cd |                                  |                          | 14.1 y                                 | $\beta^-$ /99.9/0.59            | 0.59/99.9                                | 11/2-                | -1.087                           | -0.71                        | 0.2637                                                             |
| <sup>113</sup> Cd  | 12.22(12)                        | 112.904402               | $8.2 \times 10^{15}$ y                 | $\beta^-$                       |                                          | 1/2+                 | -0.622301                        |                              |                                                                    |
| <sup>114</sup> Cd  | 28.73(42)                        | 113.903359               | $>6.0 \times 10^{17}$ y                | $\beta^-$ - $\beta^-$           |                                          | 0+                   |                                  |                              |                                                                    |
| <sup>115m</sup> Cd |                                  |                          | 44.6 d                                 | $\beta^-$ /1.629                | 0.68/1.6<br>1.62/97                      | 11/2-                | -1.042                           | -0.54                        | 0.48450<br>0.93381<br>1.29064                                      |
| <sup>115</sup> Cd  |                                  | 114.905431               | 2.228 d                                | $\beta^-$ /1.446                | 0.593/42<br>1.11/58                      | 1/2+                 | -0.648426                        |                              | 0.23141<br>0.26085<br>0.33624<br>0.49227<br>0.52780                |
| <sup>116</sup> Cd  | 7.49(18)                         | 115.904756               | $3.8 \times 10^{19}$ y                 | $\beta^-$ - $\beta^-$           |                                          | 0+                   |                                  |                              |                                                                    |
| <sup>117m</sup> Cd |                                  |                          | 3.4 h                                  | $\beta^-$ /2.66                 | 0.72/                                    | 11/2-                |                                  |                              | 0.1586<br>0.5529<br>0.37–2.42                                      |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)     |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------------------------------|
| <sup>117</sup> Cd  |                                  | 116.907219               | 2.49 h                                 | $\beta^-$ /2.52                 | 0.67/51<br>2.2/10                        | 1/2+                     |                                  |                              | 0.2209<br>0.2733<br>0.3445<br>1.3033           |
| <sup>118</sup> Cd  |                                  | 117.90692                | 50.3 m                                 | $\beta^-$ /0.52                 |                                          | 0+                       |                                  |                              |                                                |
| <sup>119m</sup> Cd |                                  |                          | 2.20 m                                 | $\beta^-$ /                     |                                          | 11/2-                    |                                  |                              | 0.1056<br>0.7208<br>1.0250<br>2.0213           |
| <sup>119</sup> Cd  |                                  | 118.9099                 | 2.69 m                                 | $\beta^-$ /3.8                  | $\sim$ 3.5/                              | 1/2+                     |                                  |                              | 0.1340<br>0.2929<br>0.3429                     |
| <sup>120</sup> Cd  |                                  | 119.90985                | 50.8 s                                 | $\beta^-$ /1.76                 | 1.5/                                     | 0+                       |                                  |                              |                                                |
| <sup>121m</sup> Cd |                                  |                          | 8. s                                   | $\beta^-$ /                     |                                          | 11/2-                    |                                  |                              | 0.1008<br>0.9878<br>1.0209<br>1.1815<br>2.0594 |
| <sup>121</sup> Cd  |                                  | 120.9130                 | 13.5 s                                 | $\beta^-$ /4.9                  |                                          | (3/2+)                   |                                  |                              | 0.2102<br>0.3242<br>0.3492<br>1.0403           |
| <sup>122</sup> Cd  |                                  | 121.91333                | 5.3 s                                  | $\beta^-$ /3.0                  |                                          | 0+                       |                                  |                              |                                                |
| <sup>123m</sup> Cd |                                  |                          | 1.9 s                                  | $\beta^-$ /                     |                                          |                          |                                  |                              |                                                |
| <sup>123</sup> Cd  |                                  | 122.91700                | 2.09 s                                 | $\beta^-$ /6.12                 |                                          | 3+                       |                                  |                              |                                                |
| <sup>124</sup> Cd  |                                  | 123.9177                 | 1.24 s                                 | $\beta^-$ /4.17                 |                                          | 0+                       |                                  |                              | 0.0365<br>0.0628<br>0.1799                     |
| <sup>125m</sup> Cd |                                  |                          | 0.66 s                                 | $\beta^-$ /                     |                                          |                          |                                  |                              |                                                |
| <sup>125</sup> Cd  |                                  | 124.9213                 | 0.68 s                                 | $\beta^-$ /7.16                 |                                          | 3/2+                     |                                  |                              |                                                |
| <sup>126</sup> Cd  |                                  | 125.9224                 | 0.52 s                                 | $\beta^-$ /5.49                 |                                          | 0+                       |                                  |                              | 0.2601                                         |
| <sup>127</sup> Cd  |                                  | 126.9264                 | 0.4 s                                  | $\beta^-$ /8.5                  |                                          | 3/2+                     |                                  |                              |                                                |
| <sup>128</sup> Cd  |                                  | 127.9278                 | 0.28 s                                 | $\beta^-$ /7.1                  |                                          | 0+                       |                                  |                              | 0.247                                          |
| <sup>129</sup> Cd  |                                  | 128.9322                 | 0.24 s                                 | $\beta^-$ /5.9                  |                                          |                          |                                  |                              | 0.281                                          |
| <sup>130</sup> Cd  |                                  | 129.9339                 | 0.162 s                                | $\beta^-$ /                     |                                          | 0+                       |                                  |                              |                                                |
|                    |                                  |                          |                                        | $\beta^-$ , n                   | /~ 3.5                                   |                          |                                  |                              |                                                |
| <sup>131</sup> Cd  |                                  | 130.9407                 | 68 ms                                  |                                 |                                          |                          |                                  |                              |                                                |
| <sup>132</sup> Cd  |                                  | 131.9456                 | 0.10 s                                 | $\beta^-$ , n/                  | /60                                      | 0+                       |                                  |                              |                                                |
| <sup>133</sup> Cd  |                                  |                          | 0.06 s                                 |                                 |                                          |                          |                                  |                              |                                                |
| <sup>49</sup> In   |                                  | 114.818(3)               |                                        |                                 |                                          |                          |                                  |                              |                                                |
| <sup>97</sup> In   |                                  | 96.950                   |                                        |                                 |                                          |                          |                                  |                              |                                                |
| <sup>98m</sup> In  |                                  |                          | $\sim$ 0.03 s                          |                                 |                                          |                          |                                  |                              |                                                |
| <sup>98</sup> In   |                                  | 97.9421                  | 1. s                                   |                                 |                                          |                          |                                  |                              |                                                |
| <sup>99</sup> In   |                                  | 98.9342                  | $\sim$ 3.8 s                           | $\beta^+$ /8.9                  |                                          |                          |                                  |                              |                                                |
| <sup>100</sup> In  |                                  | 99.9311                  | 5.9 s                                  | $\beta^+$ , (p)/10.5            |                                          |                          |                                  |                              | (0.297-1.365)                                  |
| <sup>101</sup> In  |                                  | 100.9263                 | 15. s                                  | $\beta^+$ /7.3                  |                                          |                          |                                  |                              |                                                |
| <sup>102</sup> In  |                                  | 101.9241                 | 23. s                                  | EC/8.9                          |                                          | (5)                      |                                  |                              | 0.1566<br>0.7767<br>(0.397–0.923)              |
| <sup>103m</sup> In |                                  |                          | 34. s                                  |                                 |                                          |                          |                                  |                              |                                                |
| <sup>103</sup> In  |                                  | 102.91991                | 1.1 m                                  | $\beta^+$ , EC/6.05<br>EC       | 4.2<br>/45                               | 9/2+                     |                                  |                              | ann.rad./<br>0.1879<br>(0.157–3.98)            |
| <sup>104m</sup> In |                                  |                          | 16. s                                  | IT/0.0935                       |                                          |                          |                                  |                              |                                                |
| <sup>104</sup> In  |                                  | 103.9183                 | 1.84 m                                 | $\beta^+$ , EC/7.9              | 4.8                                      | 5+                       | +4.44                            | +0.7                         | ann.rad./<br>0.6580<br>0.8341<br>0.8781        |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)                   | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                          |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------------------|
| <sup>105m</sup> In |                                  |                          | 43. s                                  | I.T.                                              |                                          | $\frac{1}{2}^-$          |                                  |                              | In k x-ray<br>0.6740                                                |
| <sup>105</sup> In  | 104.91467                        |                          | 5.1 m                                  | $\beta^+$ , EC/4.85                               | 3.7                                      | 9/2+                     | +5.675                           | +0.83                        | 0.1310<br>0.2600<br>0.6038                                          |
| <sup>106m</sup> In |                                  |                          | 5.3 m                                  | $\beta^+$ /85/<br>EC/15/                          | 4.90                                     | 3+                       |                                  |                              | ann.rad./<br>0.6326<br>0.8611<br>1.7164                             |
| <sup>106</sup> In  | 105.91347                        |                          | 6.2 m                                  | $\beta^+$ /65/6.52<br>EC/35/                      | 2.6                                      | 7+                       | +4.92                            | +0.97                        | ann.rad./<br>0.2259<br>0.6327<br>0.8611<br>0.9978<br>1.0091         |
| <sup>107m</sup> In |                                  |                          | 51. s                                  | I.T./0.6786                                       |                                          | $\frac{1}{2}^-$          |                                  |                              | In k x-ray<br>0.6785                                                |
| <sup>107</sup> In  | 106.91030                        |                          | 32.4 m                                 | $\beta^+$ /35/3.43<br>E.C/65/                     | 2.20/                                    | 9/2+                     | +5.59                            | +0.81                        | ann.rad./<br>Cd k x-ray<br>0.2050<br>0.3209<br>0.5055<br>(0.2–2.99) |
| <sup>108m</sup> In |                                  |                          | 57. m                                  | $\beta^+$ /53/<br>EC/47/                          | 1.3                                      | 6+                       | +4.94                            | +0.47                        | ann.rad./<br>Cd k x-ray<br>0.6329<br>1.9863<br>3.4522               |
| <sup>108</sup> In  | 107.90970                        |                          | 40. m                                  | $\beta^+$ /33/5.15<br>EC/67/                      | 3.49/                                    | 3+                       | +4.56                            | +1.01                        | ann.rad./<br>Cd k x-ray<br>0.2429<br>0.6331<br>0.8756               |
| <sup>109m</sup> In |                                  |                          | 1.3 m                                  | I.T./0.650                                        |                                          | $\frac{1}{2}^-$          |                                  |                              | In k x-ray<br>0.6498                                                |
| <sup>109</sup> In  | 108.90715                        |                          | 4.17 h                                 | $\beta^+$ /8/2.02<br>EC/92/                       | 0.79/                                    | 9/2+                     | +5.54                            | +0.84                        | ann.rad./<br>Cd k x-ray<br>0.2035<br>0.6235                         |
| <sup>110m</sup> In |                                  |                          | 4.9 h                                  | EC/                                               |                                          | 7+                       | +4.72                            | +1.00                        | Cd k x-ray<br>0.6577<br>0.8847<br>0.9375<br>(0.1–1.98)              |
| <sup>110</sup> In  | 109.90717                        |                          | 1.15 h                                 | $\beta^+$ /62/3.88<br>EC/38/                      | 2.22/                                    | 2+                       | +4.37                            | +0.35                        | ann.rad./<br>Cd k x-ray<br>0.6577<br>(0.6–3.6)                      |
| <sup>111m</sup> In |                                  |                          | 7.7 m                                  | I.T./0.537                                        |                                          | $\frac{1}{2}^-$          | +5.53                            |                              | In k x-ray<br>0.537                                                 |
| <sup>111</sup> In  | 110.905103                       |                          | 2.8049 d                               | EC/0.866                                          |                                          | 9/2+                     | +5.50                            | +0.80                        | Cd k x-ray<br>0.1712<br>0.2453                                      |
| <sup>112m</sup> In |                                  |                          | 20.8 m                                 | I.T./0.155                                        |                                          | 4+                       |                                  |                              | In k x-ray<br>0.1555                                                |
| <sup>112</sup> In  | 111.90553                        |                          | 14.4 m                                 | $\beta^+$ /22/2.586<br>EC/34/<br>$\beta^-$ /0.663 |                                          | 1+                       | +2.82                            | +0.09                        | ann.rad./<br>Cd k x-ray<br>0.6171                                   |
| <sup>113m</sup> In |                                  |                          | 1.658 h                                | I.T./0.3917                                       |                                          | $\frac{1}{2}^-$          | -0.210                           |                              | In k x-ray<br>0.3917                                                |

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)     | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                  |
|---------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-------------------------------------------------------------|
| <sup>113</sup> In   | 4.29(5)                          | 112.904058               |                                        |                                     |                                          | 9/2+                     | +5.529                           | +0.80                        |                                                             |
| <sup>114m</sup> In  |                                  |                          | 49.51 d                                | I.T./97/0.190<br>EC/3 /             |                                          | 5+                       | +4.65                            | +0.74                        | In k x-ray<br>0.19027                                       |
| <sup>114</sup> In   |                                  | 113.904914               | 1.198 m                                | $\beta^-$ /97/1.989<br>EC/3/1.453   | 1.984/                                   | 1+                       | +2.82                            |                              | Cd k x-ray<br>0.5584<br>0.5727<br>1.2998                    |
| <sup>115m</sup> In  |                                  |                          | 4.486 h                                | I.T./95/0.336<br>$\beta^-$ /5 /0.83 |                                          | $\frac{1}{2}-$           | -0.255                           |                              | In k x-ray<br>0.3362<br>0.4974                              |
| <sup>115</sup> In   | 95.71(5)                         | 114.903878               | $4.4 \times 10^{14}$ y                 | $\beta^-$ /0.495                    |                                          | 9/2+                     | +5.541                           | +0.81                        |                                                             |
| <sup>116m2</sup> In |                                  |                          | 2.16 s                                 | I.T./0.162<br>EC                    | /0.023                                   | 8-                       | +3.22                            | +0.31                        | In k x-ray<br>0.1624                                        |
| <sup>116m1</sup> In |                                  |                          | 54.1 m                                 | $\beta^-$ /                         | 1.0                                      | 5+                       | +4.43                            | +0.80                        | 0.13792<br>0.41688/27<br>1.09723/58.5<br>1.29349/85         |
| <sup>116</sup> In   |                                  | 115.905260               | 14.1 s                                 | $\beta^-$ /3.274                    | 3.3/99                                   | 1+                       | 2.788                            | 0.11                         | 0.46313<br>1.2526<br>1.29349                                |
| <sup>117m</sup> In  |                                  |                          | 1.94 h                                 | $\beta^-$ /53/1.769<br>I.T./47 /    | 1.77/                                    | $\frac{1}{2}-$           | -0.2517                          |                              | In k x-ray<br>0.15855<br>0.31531<br>0.55294                 |
| <sup>117</sup> In   |                                  | 116.90451                | 44. m                                  | $\beta^-$ /1.455                    | 0.74/                                    | 9/2+                     | +5.52                            | +0.83                        | 0.15855<br>0.3966<br>0.55294                                |
| <sup>118m2</sup> In |                                  |                          | 8.5 s                                  | I.T./98/<br>$\beta^-$ /2/           |                                          | (8-)                     | +3.32                            | +0.44                        | In k x-ray<br>0.1382                                        |
| <sup>118m1</sup> In |                                  |                          | 4.40 m                                 | $\beta^-$ /                         | 1.3<br>2.0                               | 5+                       | +4.23                            | +0.80                        | 0.2086<br>0.6833<br>1.2295                                  |
| <sup>118</sup> In   |                                  | 117.90635                | 5.0 s                                  | $\beta^-$ /4.42                     | 4.2/                                     | 1+                       |                                  |                              | 0.5282<br>1.1734<br>1.2295<br>2.0432                        |
| <sup>119m</sup> In  |                                  |                          | 17.9 m                                 | $\beta^-$ /97/<br>I.T./3/0.311      | 2.7/                                     | $\frac{1}{2}-$           | -0.32                            |                              | 0.3114<br>0.7631                                            |
| <sup>119</sup> In   |                                  | 118.90585                | 2.3 m                                  | $\beta^-$ /2.36                     | 1.6/                                     | 9/2+                     | +5.52                            | +0.85                        | 0.0239<br>0.6495<br>0.7631<br>1.2149                        |
| <sup>120m2</sup> In |                                  |                          | 47 s                                   | $\beta^-$ /6.1                      |                                          | 8-                       | +3.692                           | +0.53                        | 1.171<br>1.023                                              |
| <sup>120m1</sup> In |                                  |                          | 46. s                                  | $\beta^-$ /5.8                      | 2.2/                                     | 5+                       | +4.30                            | +0.81                        | 1.171<br>1.023                                              |
| <sup>120</sup> In   |                                  | 119.90796                | 3.1 s                                  | $\beta^-$ /5.37<br>I.T./1/0.313     | 5.6/<br>3.1/                             | (1+)                     |                                  |                              | 0.4146<br>0.5924<br>0.8637<br>1.0232<br>1.1714<br>(0.4–2.7) |
| <sup>121m</sup> In  |                                  |                          | 3.8 m                                  | $\beta^-$ /99/                      | 3.7/                                     | 1/2-                     | -0.36                            |                              | 0.0601<br>0.3136<br>0.9256<br>1.0412<br>1.1022<br>1.1204    |
| <sup>121</sup> In   |                                  | 120.90785                | 23. s                                  | $\beta^-$ /3.36                     | 2.5                                      | 9/2+                     | +5.50                            | +0.81                        | 0.2620<br>0.6573                                            |

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)              |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------|
| <sup>122m</sup> In  |                                  |                          | 10. s                                  | $\beta^-$ /                     | 4.4/                                     | 8-                       | +3.78                            | +0.59                        | 0.9256<br>1.0014                                        |
| <sup>122</sup> In   | 121.91028                        | 1.5 s                    | $\beta^-$ /6.37                        | 5.3/                            | (1+)                                     |                          |                                  |                              | 1.1403<br>0.2391<br>1.0014<br>1.1403<br>1.164<br>1.1903 |
| <sup>123m</sup> In  |                                  | 47. s                    | $\beta^-$ /                            | 4.6/                            | (1/2-)                                   | -0.40                    |                                  |                              | 0.1258<br>1.170<br>3.234                                |
| <sup>123</sup> In   | 122.91044                        | 6.0 s                    | $\beta^-$ /4.39                        | 3.3/                            | (9/2+)                                   | +5.49                    | +0.76                            |                              | 0.6188<br>1.0197<br>1.1305                              |
| <sup>124m</sup> In  |                                  | 3.4 s                    | $\beta^-$                              |                                 | 8-                                       | +3.89                    | +0.66                            |                              | 0.1029<br>0.9699<br>1.0729<br>1.1316                    |
| <sup>124</sup> In   | 123.91318                        | 3.18 s                   | $\beta^-$ /7.36                        | 5/                              | 3+                                       | +4.04                    | +0.61                            |                              | 0.7070<br>0.9978<br>1.1316<br>3.2142<br>(0.3–4.6)       |
| <sup>125m</sup> In  |                                  | 12.2 s                   | $\beta^-$ /                            | 5.5/                            | 1/2-                                     | -0.43                    |                                  |                              | 0.1876                                                  |
| <sup>125</sup> In   | 124.91360                        | 2.33 s                   | $\beta^-$ /5.42                        | 4.1/                            | 9/2+                                     | +5.50                    | +0.71                            |                              | 0.4260<br>1.0318<br>1.3350                              |
| <sup>126m</sup> In  |                                  | 1.53 s                   |                                        | 4.9/                            | 3+                                       | +4.03                    | +0.49                            |                              | 0.9086<br>0.9696<br>1.1411                              |
| <sup>126</sup> In   | 125.91646                        | 1.63 s                   | $\beta^-$ /8.21                        | 4.2/                            | 8-                                       | +4.06                    |                                  |                              | 0.1118<br>0.9086<br>1.1411                              |
| <sup>127m</sup> In  |                                  | 3.73 s                   | $\beta^-$ /                            | 6.4/                            | (1/2-)                                   |                          |                                  |                              | 0.2523<br>3.074                                         |
| <sup>127</sup> In   | 126.91735                        | 1.14 s                   | $\beta^-$ /6.51                        | 4.9/                            | (9/2+)                                   | +5.52                    | +0.59                            |                              | 0.4680<br>0.6461<br>0.8051<br>1.5977                    |
| <sup>128m</sup> In  |                                  | 0.7 s                    | $\beta^-$ /                            | 5.4/                            | (8-)                                     |                          |                                  |                              | 1.8670<br>1.9739<br>(0.1205–2.12)                       |
| <sup>128</sup> In   | 127.92017                        | 0.80 s                   | $\beta^-$ /8.98                        | 5.0/                            | 3+                                       |                          |                                  |                              | 0.9352<br>1.1688<br>3.5198<br>4.2970                    |
| <sup>129m</sup> In  |                                  | 1.23 s                   | $\beta^-$ /98/<br>n/2/                 | ~ 7.5/                          | 1/2-                                     |                          |                                  |                              | 0.3153<br>0.9067<br>1.2220                              |
| <sup>129</sup> In   | 128.9217                         | 0.63 s                   | $\beta^-$ /7.66                        | 5.5/                            | 9/2+                                     |                          |                                  |                              | 0.2853<br>0.7693<br>1.8650<br>2.1180                    |
| <sup>130m2</sup> In |                                  | 0.53 s                   | $\beta^-$ /                            | 8.8/                            | 5+                                       |                          |                                  |                              | 0.0892<br>0.7744<br>1.2212                              |
| <sup>130m1</sup> In |                                  | 0.51 s                   | $\beta^-$ /                            | 6.1/                            | 10-                                      |                          |                                  |                              | 0.0892<br>0.1298<br>0.7744<br>1.2212                    |

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.9052                                     |
| <sup>130</sup> In   |                                  | 129.92497                | 0.29 s                                 | $\beta^-$ /10.25                | 10.0/                                    | 1-                       |                                  |                              |                                            |
| <sup>131m2</sup> In |                                  |                          | 0.3 s                                  | $\beta^-$ /                     |                                          | (21/2+)                  |                                  |                              |                                            |
| <sup>131m1</sup> In |                                  |                          | 0.35 s                                 | $\beta^-$ /                     |                                          | (1/2-)                   |                                  |                              |                                            |
| <sup>131</sup> In   |                                  | 130.92685                | 0.28 s                                 | $\beta^-$ /9.18                 | 6.4/                                     | (9/2+)                   |                                  |                              | 0.3328                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.433                                      |
| <sup>132</sup> In   |                                  | 131.9330                 | $\sim 0.206$ s                         | $\beta^-$ /13.6                 | 6.0/                                     | (7-)                     |                                  |                              | 0.1320                                     |
|                     |                                  |                          |                                        |                                 | 8.8/                                     |                          |                                  |                              | 0.2992                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3747                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 4.0406                                     |
| <sup>133</sup> In   |                                  | 132.9378                 | 0.165 s                                | $\beta^-$ , (n)                 |                                          |                          |                                  |                              |                                            |
| <sup>134</sup> In   |                                  | 133.9442                 | 0.14 s                                 |                                 |                                          |                          |                                  |                              | (0.354–2.005)                              |
| <sup>135</sup> In   |                                  | 134.9493                 | 0.09 s                                 |                                 |                                          |                          |                                  |                              |                                            |
| <sup>50</sup> Sn    |                                  | 118.710(7)               |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>99</sup> Sn    |                                  | 98.949                   |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>100</sup> Sn   |                                  | 99.939                   | 1.0 s                                  | $\beta^+$ /7.3                  | 3.4/                                     | 0+                       |                                  |                              |                                            |
| <sup>101</sup> Sn   |                                  | 100.9361                 | 3. s                                   | $\beta^+$ /9.                   |                                          |                          |                                  |                              |                                            |
| <sup>102</sup> Sn   |                                  | 101.9303                 | 3.8 s                                  | $\beta^+$ /5.8                  |                                          | 0+                       |                                  |                              |                                            |
| <sup>103</sup> Sn   |                                  | 102.9281                 | 7. s                                   | $\beta^+$ /7.7                  |                                          |                          |                                  |                              | 1.3558                                     |
|                     |                                  |                          |                                        | $\beta^+$ ,p                    | p//1.2                                   |                          |                                  |                              | (0.351-2.813)                              |
|                     |                                  |                          |                                        | EC                              | / 20.                                    |                          |                                  |                              |                                            |
| <sup>104</sup> Sn   |                                  | 103.9231                 | 21. s                                  | $\beta^+$ , EC/4.5              |                                          | 0+                       |                                  |                              |                                            |
| <sup>105</sup> Sn   |                                  | 104.9214                 | 28. s                                  | $\beta^+$ /6.3                  |                                          |                          |                                  |                              | In-x-ray                                   |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.2879–3.819)                             |
| <sup>106</sup> Sn   |                                  | 105.91688                | 2.0 m                                  | $\beta^+$ /20/3.18              |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/80/                          |                                          |                          |                                  |                              | In k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3865                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4772                                     |
| <sup>107</sup> Sn   |                                  | 106.9156                 | 2.92 m                                 | EC/5.0                          | 1.2/                                     |                          |                                  |                              | 0.4218                                     |
|                     |                                  |                          |                                        | $\beta^+$ /                     |                                          |                          |                                  |                              | 0.6105                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6785                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0013                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.1290                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.542                                      |
| <sup>108</sup> Sn   |                                  | 107.91193                | 10.3 m                                 | $\beta^+$ /1/2.09               | 0.36/                                    | 0+                       |                                  |                              | In k x-ray                                 |
|                     |                                  |                          |                                        | EC/99/                          |                                          |                          |                                  |                              | 0.2724                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3965                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.105–1.68)                               |
| <sup>109</sup> Sn   |                                  | 108.91128                | 18.0 m                                 | $\beta^+$ /9/3.85               | 1.52/                                    | 7/2+                     | -1.08                            | +0.3                         | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/91/                          |                                          |                          |                                  |                              | In k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6498                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0992                                     |
| <sup>110</sup> Sn   |                                  | 109.90784                | 4.17 h                                 | EC/0.64                         |                                          | 0+                       |                                  |                              | In k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.283                                      |
| <sup>111</sup> Sn   |                                  | 110.90773                | 35. m                                  | $\beta^+$ /31/2.45              | 1.5/                                     | 7/2+                     | +0.61                            | +0.2                         | In k x-ray                                 |
|                     |                                  |                          |                                        | EC/69/                          |                                          |                          |                                  |                              | 0.7620                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.1530                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.9147                                     |
| <sup>112</sup> Sn   | 0.97(1)                          | 111.904818               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>113m</sup> Sn  |                                  |                          | 21.4 m                                 | I.T./92/0.077                   |                                          | 7/2+                     |                                  |                              | Sn k x-ray                                 |
|                     |                                  |                          |                                        | EC/8/                           |                                          |                          |                                  |                              | In x-ray                                   |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0774                                     |
| <sup>113</sup> Sn   |                                  | 112.905171               | 115.1 d                                | EC/1.036                        |                                          | $\frac{1}{2}^+$          | -0.879                           |                              | In k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.25511                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.39169                                    |
| <sup>114</sup> Sn   | 0.66(1)                          | 113.902779               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>115</sup> Sn   | 0.34(1)                          | 114.903342               |                                        |                                 |                                          | $\frac{1}{2}^+$          | -0.9188                          |                              |                                            |
| <sup>116</sup> Sn   | 14.54(9)                         | 115.901741               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>117m</sup> Sn |                                  |                          | 14.0 d                                 | I.T./0.3146                     |                                          | 11/2-                    | -1.396                           | -0.4                         | Sn k x-ray<br>0.15856                      |
| <sup>117</sup> Sn  | 7.68(7)                          | 116.902952               |                                        |                                 |                                          | ½+                       | -1.0010                          |                              |                                            |
| <sup>118</sup> Sn  | 24.22(9)                         | 117.901603               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>119m</sup> Sn |                                  |                          | 293. d                                 | I.T./0.0896                     |                                          | 11/2-                    | -1.4                             | 0.21                         | Sn k x-ray<br>0.02387                      |
| <sup>119</sup> Sn  | 8.59(4)                          | 118.903308               |                                        |                                 |                                          | ½+                       | -1.0473                          |                              |                                            |
| <sup>120</sup> Sn  | 32.58(9)                         | 119.902195               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>121m</sup> Sn |                                  |                          | 44. y                                  | I.T./78/0.006                   |                                          | 11/2-                    | -1.388                           | -0.14                        | Sn k x-ray<br>0.03715                      |
|                    |                                  |                          |                                        | β- /22/                         | 0.354/                                   |                          |                                  |                              |                                            |
| <sup>121</sup> Sn  |                                  | 120.904236               | 1.128 d                                | β- /0.388                       | 0.383/100                                | 3/2+                     | 0.698                            | -0.02                        |                                            |
| <sup>122</sup> Sn  | 4.63(3)                          | 121.903439               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>123m</sup> Sn |                                  |                          | 40.1 m                                 | β- /1.428                       | 1.26/99                                  | 3/2+                     |                                  |                              | 0.1603                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3814                                     |
| <sup>123</sup> Sn  |                                  | 122.905721               | 129.2 d                                | β- /1.404                       | 1.42/99.4                                | 11/2-                    | -1.370                           | +0.03                        | 0.1603                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0302                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0886                                     |
| <sup>124</sup> Sn  | 5.79(5)                          | 123.905274               | > 2.2 × 10 <sup>18</sup> y             | ββ <sup>-</sup>                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>125m</sup> Sn |                                  |                          | 9.51 m                                 | β- /2.387                       | 2.03/98                                  | 3/2+                     | +0.764                           | +0.8                         | 0.3321                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.4040                                     |
| <sup>125</sup> Sn  |                                  | 124.907784               | 9.63 d                                 | β- /2.364                       | 2.35/82                                  | 11/2-                    | -1.35                            | +0.1                         | 1.0671                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.2–2.3)                                  |
| <sup>126</sup> Sn  |                                  | 125.90765                | 2.34 × 10 <sup>5</sup> y               | β- /0.38                        | 0.25/100                                 | 0+                       |                                  |                              | 0.0643                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0876                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4148                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6663                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6950                                     |
| <sup>127m</sup> Sn |                                  |                          | 4.15 m                                 | β- /3.21                        | 2.72/                                    | 3/2+                     | +0.757                           | +0.60                        | 0.4909                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.3480                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.5640                                     |
| <sup>127</sup> Sn  |                                  | 126.91036                | 2.12 h                                 | β- /3.20                        | 2.42/                                    | 11/2-                    | -1.33                            | +0.3                         | 0.8231                                     |
|                    |                                  |                          |                                        |                                 | 3.2/                                     |                          |                                  |                              | 1.0956                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.120–2.84)                               |
| <sup>128m</sup> Sn |                                  |                          | 6.5 s                                  | IT/0.091                        |                                          | (7-)                     |                                  |                              |                                            |
| <sup>128</sup> Sn  |                                  | 127.91054                | 59.1 m                                 | β- /1.27                        | 0.48/                                    | 0+                       |                                  |                              | 0.4823                                     |
|                    |                                  |                          |                                        |                                 | 0.63/                                    |                          |                                  |                              | 0.5573                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6805                                     |
| <sup>129m</sup> Sn |                                  |                          | 6.9 m                                  | β- /                            |                                          | 11/2-                    | -1.30                            | -0.2                         | 1.1611                                     |
| <sup>129</sup> Sn  |                                  | 128.91348                | 2.4 m                                  | β- /4.0                         |                                          | 3/2+                     | +0.754                           | +0.05                        | 0.6456                                     |
| <sup>130m</sup> Sn |                                  |                          | 1.7 m                                  | β- /                            |                                          | (7-)                     | -0.381                           | -0.4                         | 0.1449                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8992                                     |
| <sup>130</sup> Sn  |                                  | 129.91397                | 3.7 m                                  | β- /2.15                        | 1.10/                                    | 0+                       |                                  |                              | 0.0700                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1925                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7798                                     |
| <sup>131m</sup> Sn |                                  |                          | 1.02 m                                 | β- /                            | 3.4/                                     | 11/2-                    | -1.28                            | +0.02                        | 0.3043                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4500                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7985                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.2260                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.08–3.21)                                |
| <sup>131</sup> Sn  |                                  | 130.91700                | 39. s                                  | β- /4.69                        | 3.8/                                     | 3/2+                     | +0.747                           | -0.04                        | see <sup>131m</sup> Sn                     |
| <sup>132</sup> Sn  |                                  | 131.91782                | 40. s                                  | β- /3.12                        | 1.8/                                     | 0+                       |                                  |                              | 0.0855                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2467                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3402                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8985                                     |
| <sup>133</sup> Sn  |                                  | 132.92383                | 1.44 s                                 | β- /7.8                         | 7.5/                                     | 7/2-                     |                                  |                              |                                            |
| <sup>134</sup> Sn  |                                  | 133.9283                 | 1.04 s                                 | β- /6.8                         |                                          | 0+                       |                                  |                              | (0.053-2.417)                              |
| <sup>135</sup> Sn  |                                  | 134.9347                 | 0.53 s                                 | β-                              |                                          |                          |                                  |                              | (0.053-0.830)                              |
|                    |                                  |                          |                                        | β-,n                            | /21.                                     |                          |                                  |                              | 0.733–1.855                                |
| <sup>136</sup> Sn  |                                  | 135.9393                 | 0.25 s                                 | β-, n                           | /30.                                     | 0+                       |                                  |                              |                                            |
| <sup>137</sup> Sn  |                                  | 136.946                  | 0.19 s                                 | β-, n                           | /~ 58                                    |                          |                                  |                              |                                            |

[illegible]



| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)           | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                    |
|---------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-------------------------------------------------------------------------------|
| <sup>118</sup> Sb   |                                  | 117.905529               | 3.6 m                                  | $\beta^+$ /74/3.657<br>EC/26/             | 2.65/                                    | 1+                       | 2.5                              |                              | ann.rad./<br>Sn k x-ray<br>1.22964                                            |
| <sup>119</sup> Sb   |                                  | 118.90394                | 38.1 h                                 | EC/0.59                                   |                                          | 5/2+                     | +3.45                            | -0.4                         | Sn k x-ray<br>0.0239                                                          |
| <sup>120m</sup> Sb  |                                  |                          | 5.76 d                                 | EC/                                       |                                          | 8-                       | 2.34                             |                              | Sn k x-ray<br>0.0898<br>0.19730<br>1.02301<br>1.17121                         |
| <sup>120</sup> Sb   |                                  | 119.90507                | 15.89 m                                | $\beta^+$ /41/2.68<br>EC/59/              | 1.72/                                    | 1+                       | +2.3                             |                              | ann.rad./<br>Sn k x-ray<br>0.7038<br>1.17121                                  |
| <sup>121</sup> Sb   | 57.21(5)                         | 120.903816               |                                        |                                           |                                          | 5/2+                     | +3.363                           | -0.4                         |                                                                               |
| <sup>122m</sup> Sb  |                                  |                          | 4.19 m                                 | I.T./0.162                                |                                          | 8-                       |                                  |                              | Sb x-ray<br>0.0614<br>0.0761                                                  |
| <sup>122</sup> Sb   |                                  | 121.905174               | 2.72 d                                 | $\beta^-$ /98/1.979<br>$\beta^+$ /2/1.620 | 1.414/65<br>1.980/26                     | 2-                       | -1.90                            | +0.9                         | 0.56409<br>0.69277<br>1.14050<br>1.2569                                       |
| <sup>123</sup> Sb   | 42.79(5)                         | 122.904214               |                                        |                                           |                                          | 7/2+                     | +2.550                           | -0.5                         |                                                                               |
| <sup>124m2</sup> Sb |                                  |                          | 20.3 m                                 | I.T./0.035                                |                                          | 8-                       |                                  |                              |                                                                               |
| <sup>124m1</sup> Sb |                                  |                          | 1.6 m                                  | I.T./80/<br>$\beta^-$ /20/                | 1.2/<br>1.7/                             | 5+                       |                                  |                              | 0.4984<br>0.6027<br>0.6458<br>1.1010                                          |
| <sup>124</sup> Sb   |                                  | 123.905936               | 60.20 d                                | $\beta^-$ /2.905                          | 0.61/52<br>2.301/23                      | 3-                       | 1.2                              | +1.9                         | 0.60271/97.8<br>0.64583/7.4<br>0.72277/10.5<br>1.69094/48.2<br>(0.0274–2.808) |
| <sup>125</sup> Sb   |                                  | 124.905254               | 2.758 y                                | $\beta^-$ /0.767                          | 0.13/30<br>0.302/45<br>0.62/13           | 7/2+                     | +2.63                            |                              | 0.0355<br>0.17632<br>0.38044<br>0.42786<br>0.46336<br>0.60060<br>0.63595      |
| <sup>126m2</sup> Sb |                                  |                          | 11. s                                  | I.T./                                     |                                          | 3-                       |                                  |                              | L x-ray<br>0.0227                                                             |
| <sup>126m1</sup> Sb |                                  |                          | 19.0 m                                 | $\beta^-$ /86 /<br>I.T./14 /              | 1.9                                      | 5+                       |                                  |                              | 0.4148<br>0.6663<br>0.6950                                                    |
| <sup>126</sup> Sb   |                                  | 125.90725                | 12.4 d                                 | $\beta^-$ /3.67                           | 1.9                                      | 8-                       | 1.3                              |                              | 0.2786<br>0.4148/83.3<br>0.6663/99.7<br>0.6950/99<br>0.7205                   |
| <sup>127</sup> Sb   |                                  | 126.90692                | 3.84 d                                 | $\beta^-$ /1.581                          | 0.89/<br>1.10/<br>1.50/                  | 7/2+                     | 2.70                             |                              | 0.2524<br>0.2908<br>0.4121<br>0.4370<br>0.6857<br>0.7837                      |
| <sup>128m</sup> Sb  |                                  |                          | 10.1 m                                 | $\beta^-$ /96/<br>I.T./4/                 | 2.6/                                     | 5+                       |                                  |                              | 0.3140<br>0.5941<br>0.7432<br>0.7539                                          |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>128</sup> Sb  |                                  | 127.90917                | 9.1 h                                  | $\beta^-$ /4.38                 | 2.3/                                     | 8-                       | 1.3                              |                              | 0.2148                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3141                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5265                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7433                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7540                                     |
| <sup>129m</sup> Sb |                                  |                          | 17.7 m                                 | $\beta^-$ /                     |                                          |                          |                                  |                              | 0.4338                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6578                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7598                                     |
| <sup>129</sup> Sb  |                                  | 128.90915                | 4.40 h                                 | $\beta^-$ /2.38                 | 0.65/                                    | 7/2-                     | 2.82                             |                              | 0.0278                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1808                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3594                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4596                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5447                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8128                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9146                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0301                                     |
| <sup>130m</sup> Sb |                                  |                          | 6.5 m                                  | $\beta^-$ /2.6                  | 2.12/                                    |                          |                                  |                              | 0.1023                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7934                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8394                                     |
| <sup>130</sup> Sb  |                                  | 129.91166                | 38.4 m                                 | $\beta^-$ /4.96                 | 2.9/                                     | 8-                       |                                  |                              | 0.1823                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3309                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4680                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7394                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8394                                     |
| <sup>131</sup> Sb  |                                  | 130.91198                | 23.0 m                                 | $\beta^-$ /3.20                 | 1.31/                                    | 7/2+                     |                                  |                              | 0.6423                                     |
|                    |                                  |                          |                                        |                                 | 3.0/                                     |                          |                                  |                              | 0.6579                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9331                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9434                                     |
| <sup>132m</sup> Sb |                                  |                          | 2.8 m                                  | $\beta^-$ /                     | 3.9/                                     | 4+                       |                                  |                              | 0.1034                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3538                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6968                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9739                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9896                                     |
| <sup>132</sup> Sb  |                                  | 131.91447                | 4.2 m                                  | $\beta^-$ /5.49                 |                                          | 8-                       |                                  |                              | 0.1034                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1506                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6968                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9739                                     |
| <sup>133</sup> Sb  |                                  | 132.91525                | 2.5 m                                  | $\beta^-$ /4.00                 | 1.20/                                    | 7/2+                     | 3.00                             |                              | 0.4235                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6318                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8165                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0764                                     |
| <sup>134m</sup> Sb |                                  |                          | 10.4 s                                 | $\beta^-$ /                     | 6.1                                      | 7-                       |                                  |                              |                                            |
| <sup>134</sup> Sb  |                                  | 133.92038                | 0.8 s                                  | $\beta^-$ /8.4                  | 8.4                                      | 0-                       |                                  |                              | 0.1152                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2970                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7063                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.2791                                     |
| <sup>135</sup> Sb  |                                  | 134.9252                 | 1.71 s                                 | $\beta^-$ /8.12                 |                                          | 7/2+                     |                                  |                              | 1.127                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.279                                      |
| <sup>136</sup> Sb  |                                  | 135.9304                 | 0.82 s                                 | $\beta^-$ /9.3                  |                                          |                          |                                  |                              |                                            |
| <sup>137</sup> Sb  |                                  | 136.9353                 | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>138</sup> Sb  |                                  | 137.9408                 | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>139</sup> Sb  |                                  | 138.9460                 | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                            |
| <sup>52</sup> Te   |                                  | 127.60(3)                |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>105</sup> Te  |                                  | 104.9436                 |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>106</sup> Te  |                                  | 105.9375                 | 0.07 ms                                | $\alpha$ /4.3                   | /100                                     | 0+                       |                                  |                              |                                            |
| <sup>107</sup> Te  |                                  | 106.9350                 | 3.1 ms                                 | $\alpha$ / 70/                  | 3.86(1)/                                 |                          |                                  |                              | (0.090-0.721)                              |
|                    |                                  |                          |                                        | $\beta^+$ , EC/10.1             |                                          |                          |                                  |                              |                                            |
| <sup>108</sup> Te  |                                  | 107.9294                 | 2.1 s                                  | $\alpha$ /68 /                  | 3.314(4)/                                | 0+                       |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)                | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>109</sup> Te  |                                  | 108.9274                 | 4.6 s                                  | $\beta^+$ , EC/32 /6.8<br>$\beta^+$ EC/96 /8.7 |                                          |                          |                                  |                              | 0.7523                                     |
|                    |                                  |                          |                                        | $\alpha$ /4 /                                  | 3.107(4)/                                |                          |                                  |                              | 0.287–2.045                                |
| <sup>110</sup> Te  |                                  | 109.9224                 | 19. s                                  | $\beta^+$ , EC/4.5                             |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.2191                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.6059                                     |
| <sup>111</sup> Te  |                                  | 110.9211                 | 19.3 s                                 | $\beta^+$ , EC/8.0                             |                                          | (7/2+)                   |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.267                                      |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.322                                      |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.341                                      |
| <sup>112</sup> Te  |                                  | 111.9170                 | 2.0 m                                  | $\beta^+$ , EC/4.3                             |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.2962                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.3727                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.4187                                     |
| <sup>113</sup> Te  |                                  | 112.9159                 | 1.7 s                                  | $\beta^+$ /85/5.7<br>EC/15/                    | 4.5/                                     | (7/2+)                   |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.8144                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 1.0181                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 1.1812                                     |
| <sup>114</sup> Te  |                                  | 113.91209                | 15. m                                  | $\beta^+$ /40/3.2<br>EC/60/                    |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.0838                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.0903                                     |
| <sup>115m</sup> Te |                                  |                          | 6.7 m                                  | $\beta^+$ /45/<br>EC/55/                       |                                          | (1/2+)                   |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.7236                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.7704                                     |
| <sup>115</sup> Te  |                                  | 114.91190                | 5.8 m                                  | $\beta^+$ /45/4.6<br>EC/55/                    | 2.7/                                     | 7/2+                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.7236                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 1.3268                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 1.3806                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | (0.22–2.7)                                 |
| <sup>116</sup> Te  |                                  | 115.90846                | 2.49 h                                 | EC/1.5                                         |                                          | 0+                       |                                  |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.0937                                     |
| <sup>117</sup> Te  |                                  | 116.90865                | 1.03 h                                 | EC/75/3.54<br>$\beta^+$ /25/                   | 1.78/                                    | ½+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.9197                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 1.7164                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 2.3000                                     |
| <sup>118</sup> Te  |                                  | 117.90583                | 6.00 d                                 | EC/0.28                                        |                                          | 0+                       |                                  |                              | Sb k x-ray                                 |
| <sup>119m</sup> Te |                                  |                          | 4.69 d                                 | EC/                                            |                                          | 11/2-                    | 0.89                             |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.15360                                    |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.2705                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 1.21271                                    |
| <sup>119</sup> Te  |                                  | 118.90640                | 16.0 h                                 | $\beta^+$ /2/2.293<br>EC/98/                   | 0.627/                                   | ½+                       | 0.25                             |                              | ann.rad.                                   |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.6440                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.6998                                     |
| <sup>120</sup> Te  | 0.09(1)                          | 119.90402                |                                        |                                                |                                          | 0+                       |                                  |                              |                                            |
| <sup>121m</sup> Te |                                  |                          | ~ 154. d                               | I.T. (89%)<br>EC (11%)                         |                                          | 11/2-                    | 0.90                             |                              | Te k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.2122                                     |
| <sup>121</sup> Te  |                                  | 120.90494                | 16.8 d                                 | EC/1.04                                        |                                          | ½+                       |                                  |                              | Sb k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.5076                                     |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.5731                                     |
| <sup>122</sup> Te  | 2.55(12)                         | 121.903044               |                                        |                                                |                                          | 0+                       |                                  |                              |                                            |
| <sup>123m</sup> Te |                                  |                          | 119.7 d                                | I.T./0.247                                     |                                          | 11/2-                    | -0.93                            |                              | Te k x-ray                                 |
|                    |                                  |                          |                                        |                                                |                                          |                          |                                  |                              | 0.1590/84.1                                |
| <sup>123</sup> Te  | 0.89(3)                          | 122.904270               | > 9.2 × 10 <sup>16</sup> y             | EC/0.051                                       |                                          | ½+                       | -0.73695                         |                              |                                            |
| <sup>124</sup> Te  | 4.74(14)                         | 123.902818               |                                        |                                                |                                          | 0+                       |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>125m</sup> Te |                                  |                          | 58. d                                  | I.T./0.145                      |                                          | 11/2-                    | -0.99                            | -0.06                        | Te k x-ray<br>0.0355                       |
| <sup>125</sup> Te  | 7.07(15)                         | 124.904431               |                                        |                                 |                                          | ½+                       | -0.8885                          |                              |                                            |
| <sup>126</sup> Te  | 18.84(25)                        | 125.903312               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>127m</sup> Te |                                  |                          | 109. d                                 | I.T./98/0.088                   |                                          | 11/2-                    | -1.04                            |                              | Te k x-ray<br>0.0883                       |
|                    |                                  |                          |                                        | β- /2/0.77                      |                                          |                          |                                  |                              |                                            |
| <sup>127</sup> Te  |                                  | 126.905226               | 9.4 h                                  | β- /0.698                       | 0.696/                                   | 3/2+                     | 0.64                             |                              | 0.3603                                     |
| <sup>128</sup> Te  | 31.74(8)                         | 127.904463               | 2.2 × 10 <sup>24</sup> y               | β-β-                            |                                          | 0+                       |                                  |                              |                                            |
| <sup>129m</sup> Te |                                  |                          | 33.6 d                                 | I.T./63/0.105                   |                                          | 11/2-                    | -1.09                            |                              | Te k x-ray<br>0.45984                      |
|                    |                                  |                          |                                        | β- /37/                         | 1.60/                                    |                          |                                  |                              | 0.6959                                     |
| <sup>129</sup> Te  |                                  | 128.906598               | 1.16 h                                 | β- /1.498                       | 0.99/9                                   | 3/2+                     | 0.70                             | 0.06                         | 0.0278                                     |
|                    |                                  |                          |                                        |                                 | 1.45/89                                  |                          |                                  |                              | 0.45984                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.48728                                    |
| <sup>130</sup> Te  | 34.08(62)                        | 129.906224               | 8 × 10 <sup>20</sup> y                 | β-β-                            |                                          | 0+                       |                                  |                              |                                            |
| <sup>131m</sup> Te |                                  |                          | 1.35 d                                 | β- /78/2.4                      | 0.42/                                    | 11/2-                    | -1.04                            |                              | 0.0811                                     |
|                    |                                  |                          |                                        | I.T./22/0.18                    |                                          |                          |                                  |                              | 0.1021                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.14973                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.77369                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.79375                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.85225                                    |
| <sup>131</sup> Te  |                                  | 130.908524               | 25.0 m                                 | β- /2.233                       | 1.35/12                                  | 3/2+                     | 0.70                             |                              | 0.14973                                    |
|                    |                                  |                          |                                        |                                 | 1.69/22                                  |                          |                                  |                              | 0.45327                                    |
|                    |                                  |                          |                                        |                                 | 2.14/60                                  |                          |                                  |                              | 0.49269                                    |
| <sup>132</sup> Te  |                                  | 131.90855                | 3.26 d                                 | β- /0.51                        | 0.215                                    | 0+                       |                                  |                              | 0.049725                                   |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.11198                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.22830                                    |
| <sup>133m</sup> Te |                                  |                          | 55.4 m                                 | β- /82/                         | 2.4/30                                   | 11/2-                    |                                  |                              | Te k x-ray                                 |
|                    |                                  |                          |                                        | I.T./18/0.334                   |                                          |                          |                                  |                              | 0.0949                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1689                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3121                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3341                                     |
| <sup>133</sup> Te  |                                  | 132.91096                | 12.4 m                                 | β- /2.94                        | 2.25/25                                  | 3/2+                     |                                  |                              | 0.3121                                     |
|                    |                                  |                          |                                        |                                 | 2.65                                     |                          |                                  |                              | 0.4079                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.3334                                     |
| <sup>134</sup> Te  |                                  | 133.91137                | 42. m                                  | β- /1.51                        | 0.6/                                     | 0+                       |                                  |                              | 0.7672/29                                  |
|                    |                                  |                          |                                        |                                 | 0.7/                                     |                          |                                  |                              | 0.0794–0.9255                              |
| <sup>135</sup> Te  |                                  | 134.9165                 | 19.0 s                                 | β- /6.0                         | 5.4/                                     |                          |                                  |                              | 0.267                                      |
|                    |                                  |                          |                                        |                                 | 6.0                                      |                          |                                  |                              | 0.603                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.870                                      |
| <sup>136</sup> Te  |                                  | 135.92010                | 17.5 s                                 | β- /5.1                         | 2.5/                                     | 0+                       |                                  |                              | 2.0779/25                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0873–3.235                               |
| <sup>137</sup> Te  |                                  | 136.9253                 | 2.5 s                                  | β- /98 /6.9                     | 6.8                                      | 7/2-                     |                                  |                              | 0.2436                                     |
|                    |                                  |                          |                                        | n/2 /                           |                                          |                          |                                  |                              |                                            |
| <sup>138</sup> Te  |                                  | 137.9292                 | 1.4 s                                  | β- /6.4                         |                                          | 0+                       |                                  |                              |                                            |
| <sup>139</sup> Te  |                                  | 138.9347                 | > 0.15 μs                              |                                 |                                          |                          |                                  |                              |                                            |
| <sup>140</sup> Te  |                                  | 139.9389                 | > 0.15 μs                              |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>141</sup> Te  |                                  | 140.9447                 | > 0.15 μs                              |                                 |                                          |                          |                                  |                              |                                            |
| <sup>142</sup> Te  |                                  | 141.949                  | > 0.15 μs                              |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>53</sup> I    |                                  | 126.90447(3)             |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>108</sup> I   |                                  | 107.9435                 | 0.04 s                                 | α/91/4.                         | 3.95                                     |                          |                                  |                              |                                            |
| <sup>109</sup> I   |                                  | 108.9382                 | 0.11 ms                                | p                               |                                          |                          |                                  |                              | 0.593/100                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.717/63                                   |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.496–1.057                                |
| <sup>110</sup> I   |                                  | 109.9352                 | 0.65 s                                 | β+, EC/83/11.4                  |                                          |                          |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | α/17/~ 3.6                      | 3.457(10)/                               |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | p/11/                           |                                          |                          |                                  |                              |                                            |
| <sup>111</sup> I   |                                  | 110.9303                 | 2.5 s                                  | β+, E.C./8.5                    |                                          |                          |                                  |                              | ann.rad./                                  |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2665                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3215                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3412                                     |
| <sup>112</sup> I  |                                  | 111.9280                 | 3.4 s                                  | $\beta^+$ , EC/10.2             |                                          |                          |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6889                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7869                                     |
| <sup>113</sup> I  |                                  | 112.9236                 | 5.9 s                                  | $\beta^+$ , EC/7.6              |                                          |                          |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4625/100                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6224/74                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0550–1.422                               |
| <sup>114</sup> I  |                                  | 113.9219                 | 2.1 s                                  | $\beta^+$ , EC/8.7              |                                          |                          |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6826                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7088                                     |
| <sup>115</sup> I  |                                  | 114.9181                 | 1.3 m                                  | $\beta^+$ , EC/6.7              |                                          | 5/2+                     |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.275                                      |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.284                                      |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.460                                      |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.709                                      |
| <sup>116</sup> I  |                                  | 115.9168                 | 2.9 s                                  | $\beta^+$ /97/7.8<br>EC/3/      | 6.7/                                     | 1+                       |                                  |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5402                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6789                                     |
| <sup>117</sup> I  |                                  | 116.91365                | 2.22 m                                 | $\beta^+$ , EC/4.7              | 3.2/                                     | (5/2+)                   | 3.1                              |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2744                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3259                                     |
| <sup>118m</sup> I |                                  |                          | 8.5 m                                  | $\beta^+$ , EC/<br>I.T.         | 4.9/                                     | 7-                       | 4.2                              |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.104                                      |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5998                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6052                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6138                                     |
| <sup>118</sup> I  |                                  | 117.91307                | 14. m                                  | $\beta^+$ , EC/7.0              |                                          | 2-                       | 2.0                              |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5448                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6052                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.3384                                     |
| <sup>119</sup> I  |                                  | 118.91007                | 19. m                                  | $\beta^+$ /54/3.5<br>EC/46/     | 2.4/                                     | (5/2+)                   | +2.9                             |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2575                                     |
| <sup>120m</sup> I |                                  |                          | 53. m                                  | $\beta^+$ /80/<br>EC/20/        | 3.8                                      |                          | 4.2                              |                              | ann.rad.                                   |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4257                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5604                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6147                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.3459                                     |
| <sup>120</sup> I  |                                  | 119.91005                | 1.35 h                                 | $\beta^+$ /56/5.62<br>EC/       | 4.03<br>4.60                             | 2-                       | 1.23                             |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5604                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6411                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.5230                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.111–3.1)                                |
| <sup>121</sup> I  |                                  | 120.90737                | 2.12 h                                 | $\beta^+$ /13/2.27<br>EC/87/    | 1.2/                                     | 5/2+                     | 2.3                              |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2122                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.14–1.1)                                 |
| <sup>122</sup> I  |                                  | 121.90759                | 3.6 m                                  | $\beta^+$ /4.234<br>EC/         | 3.1/                                     | 1+                       | +0.94                            |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5641                                     |
| <sup>123</sup> I  |                                  | 122.905589               | 13.2 h                                 | EC/1.242                        |                                          | 5/2+                     | 2.82                             |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1590                                     |
| <sup>124</sup> I  |                                  | 123.906210               | 4.18 d                                 | $\beta^+$ /23/3.160<br>EC/77/   | 1.54/<br>2.14/                           | 2-                       | 1.44                             |                              | ann.rad./                                  |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        |                                 | 0.75/                                    |                          |                                  |                              | 0.6027/62.9                                |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7228/10.3                                |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.6910/11.2                                |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.31–1.73)                                |
| <sup>125</sup> I  |                                  | 124.904630               | 59.4 d                                 | EC/0.1861                       |                                          | 5/2+                     | 2.82                             | -0.89                        | Te k x-ray                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0355                                     |
| <sup>126</sup> I  |                                  | 125.905624               | 13.0 d                                 | EC/                             |                                          | 2-                       | 1.44                             |                              | ann.rad./                                  |
|                   |                                  |                          |                                        | $\beta^+$ /2.155                | 1.13/                                    |                          |                                  |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        | $\beta^-$ /1.258/47             | 0.87/                                    |                          |                                  |                              | 0.3887                                     |
|                   |                                  |                          |                                        |                                 | 1.25/                                    |                          |                                  |                              | 0.6622                                     |
| <sup>127</sup> I  | 100.                             | 126.904473               |                                        |                                 |                                          | 5/2+                     | +2.8133                          | -0.79                        |                                            |
| <sup>128</sup> I  |                                  | 127.905809               | 25.00 m                                | $\beta^-$ /2.118                | 2.13/                                    | 1+                       |                                  |                              | Te k x-ray                                 |
|                   |                                  |                          |                                        | EC/1.251                        |                                          |                          |                                  |                              | 0.44287                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.52658                                    |
| <sup>129</sup> I  |                                  | 128.904988               | $1.7 \times 10^7$ y                    | $\beta^-$ /0.194                | 0.15/                                    | 7/2+                     | +2.621                           | -0.55                        | Xe k x-ray                                 |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0396                                     |
| <sup>130m</sup> I |                                  |                          | 9.0 m                                  | I.T./83/0.048                   |                                          | 2+                       |                                  |                              | I k x-ray                                  |
|                   |                                  |                          |                                        | $\beta^-$ /17/                  |                                          |                          |                                  |                              | 0.5361                                     |
| <sup>130</sup> I  |                                  | 129.906674               | 12.36 h                                | $\beta^-$ /2.949                | 1.04/                                    | 5+                       | 3.35                             |                              | 0.4180                                     |
|                   |                                  |                          |                                        |                                 | 0.62                                     |                          |                                  |                              | 0.5361                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6685                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7395                                     |
| <sup>131</sup> I  |                                  | 130.906125               | 8.021 d                                | $\beta^-$ /0.971                | 0.606/                                   | 7/2+                     | +2.742                           | -0.40                        | 0.08017                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.28431                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.36446                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.63699                                    |
| <sup>132m</sup> I |                                  |                          | 1.39 h                                 | IT                              |                                          | 8-                       |                                  |                              |                                            |
| <sup>132</sup> I  |                                  | 131.90800                | 2.28 h                                 | $\beta^-$ /14/3.58              | 0.80/                                    | 4+                       | 3.09                             | 0.09                         | I k x-ray                                  |
|                   |                                  |                          |                                        | I.T./86/                        | 1.03/                                    |                          |                                  |                              | 0.0980                                     |
|                   |                                  |                          |                                        |                                 | 1.2/                                     |                          |                                  |                              | 0.5059                                     |
|                   |                                  |                          |                                        |                                 | 1.6/                                     |                          |                                  |                              | 0.52264                                    |
|                   |                                  |                          |                                        |                                 | 2.16/                                    |                          |                                  |                              | 0.63019                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6506                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.66768                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.77260                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.95457                                    |
| <sup>133m</sup> I |                                  |                          | 9. s                                   | I.T./1.63                       |                                          | 19/2-                    |                                  |                              | I Kx-ray                                   |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0730                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6474                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9126                                     |
| <sup>133</sup> I  |                                  | 132.907797               | 20.8 h                                 | $\beta^-$ /1.77                 | 1.24/85                                  | 7/2+                     | +2.86                            | -0.27                        | 0.51056                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.52989                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.87537                                    |
| <sup>134m</sup> I |                                  |                          | 3.7 m                                  | I.T./98/0.316                   |                                          | 8-                       |                                  |                              | I k x-ray                                  |
|                   |                                  |                          |                                        | $\beta^-$ /2/                   |                                          |                          |                                  |                              | 0.0444                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2719                                     |
| <sup>134</sup> I  |                                  | 133.90974                | 52.6 m                                 | $\beta^-$ /4.05                 | 1.2/                                     | 4+                       |                                  |                              | 0.1354                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.84702                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.88409                                    |
| <sup>135</sup> I  |                                  | 134.91005                | 6.57 h                                 | $\beta^-$ /2.63                 | 0.9/                                     | 7/2+                     | 2.94                             |                              | 0.2884                                     |
|                   |                                  |                          |                                        |                                 | 1.3/                                     |                          |                                  |                              | 0.41768                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.52658                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.13156                                    |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.26046                                    |
| <sup>136m</sup> I |                                  |                          | 47. s                                  | $\beta^-$ /                     | 4.7/                                     | 6-                       |                                  |                              | 0.1973                                     |
|                   |                                  |                          |                                        |                                 | 5.2/                                     |                          |                                  |                              | 0.3468                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3701                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3814                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.3130                                     |
|                   |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.16–2.36)                                |
| <sup>136</sup> I  |                                  | 135.91465                | 1.39 m                                 | $\beta^-$ /6.93                 | 4.3/                                     | 2-                       |                                  |                              | 0.3447                                     |

[illegible]

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)       | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>119</sup> Xe  |                                  | 118.91541                | 5.8 m                                  | $\beta+$ , EC/5.0                     | 3.5/                                     | 7/2+                     | -0.654                           | +1.31                        | 0.1199                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.0873                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1000                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2318                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.4615                                     |
| <sup>120</sup> Xe  |                                  | 119.91178                | 40. m                                  | $\beta+$ , EC/97/1.96<br>$\beta+$ /3/ |                                          | 0+                       |                                  |                              | I k x-ray                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.0251                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.0726                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1781                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | (0.1–1.03)                                 |
| <sup>121</sup> Xe  |                                  | 120.91146                | 39. m                                  | $\beta+$ /44/3.73<br>EC/56/           | 2.8/                                     | 5/2+                     | -0.701                           | +1.33                        | ann.rad./                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | I k x-ray                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1328                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2527                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.4452                                     |
| <sup>122</sup> Xe  |                                  | 121.90837                | 20.1 h                                 | EC/0.9                                |                                          | 0+                       |                                  |                              | (0.1–3.1)                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | I k x-ray                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.3501                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | I k x-ray                                  |
| <sup>123</sup> Xe  |                                  | 122.90848                | 2.00 h                                 | $\beta+$ /23/2.68<br>EC/77/           | 1.51/                                    | $\frac{1}{2}+$           | -0.150                           |                              | 0.1489                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1781                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | (0.1–2.1)                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>124</sup> Xe  | 0.0952(3)                        | 123.905893               | > 10 <sup>17</sup> y                   | $\beta$ - $\beta$ -                   |                                          | 0+                       |                                  |                              |                                            |
| <sup>125m</sup> Xe |                                  |                          | 57. s                                  | I.T./0.252                            |                                          | (9/2-)                   | -0.745                           | +0.42                        | Xe k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1111                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.141                                      |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>125</sup> Xe  |                                  | 124.906395               | 17.1 h                                 | EC/1.653                              | 0.47/                                    | $\frac{1}{2}+$           | -0.269                           |                              | I k x-ray                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1884                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2434                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>126</sup> Xe  | 0.0890(2)                        | 125.90427                |                                        |                                       |                                          | 0+                       |                                  |                              |                                            |
| <sup>127m</sup> Xe |                                  |                          | 1.15 m                                 | I.T./0.297                            |                                          | (9/2-)                   | -0.884                           | +0.69                        | Xe k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1246                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1725                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>127</sup> Xe  |                                  | 126.905184               | 36.34 d                                | EC/0.662                              |                                          | $\frac{1}{2}+$           | -0.504                           |                              | I k x-ray                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1721                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2029                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.3750                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>128</sup> Xe  | 1.9102(8)                        | 127.903531               |                                        |                                       |                                          | 0+                       |                                  |                              |                                            |
| <sup>129m</sup> Xe |                                  |                          | 8.89 d                                 | I.T./0.236                            |                                          | 11/2-                    | -0.891                           | +0.64                        | Xe k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.0396                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1966                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>129</sup> Xe  | 26.4006(82)                      | 128.904779               |                                        |                                       |                                          | $\frac{1}{2}+$           | -0.7780                          |                              |                                            |
| <sup>130</sup> Xe  | 4.0710(13)                       | 129.903508               |                                        |                                       |                                          | 0+                       |                                  |                              |                                            |
| <sup>131m</sup> Xe |                                  |                          | 11.9 d                                 | I.T./0.164                            |                                          | 11/2-                    | -0.9940                          | +0.73                        | Xe k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.16398                                    |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>131</sup> Xe  | 21.2324(30)                      | 130.905082               |                                        |                                       |                                          | 3/2+                     | +0.69186                         | -0.12                        |                                            |
| <sup>132</sup> Xe  |                                  | 131.904153               |                                        |                                       |                                          | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>133m</sup> Xe |                                  |                          | 2.19 d                                 | I.T./0.233                            |                                          | 11/2-                    | -1.082                           | +0.77                        | Xe k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.23325                                    |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>133</sup> Xe  |                                  | 132.905911               | 5.243 d                                | $\beta$ - /0.427                      | 0.346/99                                 | 3/2+                     | +0.813                           | +0.14                        | Cs k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.080998                                   |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1606                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>134</sup> Xe  | 10.4357(21)                      | 133.905394               | > 1.1 × 10 <sup>16</sup> y             | $\beta$ - $\beta$ -                   |                                          | 0+                       |                                  |                              |                                            |
| <sup>135m</sup> Xe |                                  |                          | 15.3 m                                 | I.T./                                 |                                          | 11/2-                    | 1.103                            | +0.62                        | Xe k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.52658                                    |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>135</sup> Xe  |                                  | 134.907227               | 9.10 h                                 | $\beta$ - /1.15                       | 0.91/                                    | 3/2+                     | 0.903                            | +0.21                        | 0.24975                                    |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.60807                                    |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              |                                            |
| <sup>136</sup> Xe  | 8.8573(44)                       | 135.90722                | > 2.4 × 10 <sup>21</sup> y             | $\beta$ - $\beta$ -                   |                                          | 0+                       |                                  |                              |                                            |
| <sup>137</sup> Xe  |                                  | 136.91156                | 3.82 m                                 | $\beta$ - /4.17                       | 4.1/                                     | 7/2-                     | -0.970                           | -0.49                        | 0.45549                                    |



[illegible]

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $h/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|----------------------|----------------------------------|------------------------------|--------------------------------------------|
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.5865                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.5906                                     |
| <sup>119m</sup> Cs  |                                  |                          | 29. s                                  |                                 |                                          | 3/2                  | +0.84                            | +0.9                         |                                            |
| <sup>119</sup> Cs   |                                  | 118.92238                | 43. s                                  | $\beta^+$ , EC/6.3              |                                          | 9/2+                 | +5.5                             | +2.8                         | ann.rad./                                  |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.169                                      |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.176                                      |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.224                                      |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.257                                      |
| <sup>120m</sup> Cs  |                                  |                          | 60. s                                  | $\beta^+$ , EC/                 |                                          |                      |                                  |                              |                                            |
| <sup>120</sup> Cs   |                                  | 119.92068                | 64. s                                  | $\beta^+$ , EC/7.92             |                                          | 2+                   | +3.87                            | +1.45                        | ann.rad./                                  |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.3224                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.4735                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.5534                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | (0.3–3.28)                                 |
| <sup>121m</sup> Cs  |                                  |                          | 2.0 m                                  | I.T./60/                        |                                          | (9/2+)               | +5.41                            | +2.7                         | ann.rad./                                  |
|                     |                                  |                          |                                        | $\beta^+$ /40/                  | 4.4                                      |                      |                                  |                              | 0.1794                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.1961                                     |
| <sup>121</sup> Cs   |                                  | 120.91723                | 2.3 m                                  | $\beta^+$ , EC/5.40             | 4.38/                                    | 3/2+                 | +0.77                            | +0.84                        | ann.rad./                                  |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.1537                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | (0.08–0.56)                                |
| <sup>122m2</sup> Cs |                                  |                          | 4.4 m                                  | $\beta^+$ , EC                  |                                          | 8-                   | +4.77                            | +3.3                         | ann.rad./                                  |
| <sup>122m1</sup> Cs |                                  |                          | 0.36 s                                 | IT                              |                                          |                      |                                  |                              | 0.3311                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.4971                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.6385                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | (0.27–2.22)                                |
| <sup>122</sup> Cs   |                                  | 121.91611                | 21. s                                  | $\beta^+$ , EC/7.1              | 5.8/                                     | (1+)                 | -0.133                           | -0.19                        | ann.rad./                                  |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.3311                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.5120                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.8179                                     |
| <sup>123m</sup> Cs  |                                  |                          | 1.6 s                                  | I.T./                           |                                          | 11/2-                |                                  |                              | Cs k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.0946                                     |
| <sup>123</sup> Cs   |                                  | 122.91300                | 5.87 m                                 | $\beta^+$ /75/4.20              | 3.0/                                     | 1/2+                 | +1.38                            |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/25/                          |                                          |                      |                                  |                              | Xe k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.0974                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.5964                                     |
| <sup>124m</sup> Cs  |                                  |                          | 6.3 s                                  | IT                              |                                          | 7+                   |                                  |                              |                                            |
| <sup>124</sup> Cs   |                                  | 123.91226                | 30. s                                  | $\beta^+$ /9 /5.92              | ~ 5.                                     | 1+                   | +0.673                           | -0.74                        | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/8 /                          |                                          |                      |                                  |                              | Xe k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.3539                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.4925                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.9418                                     |
| <sup>125</sup> Cs   |                                  | 124.90973                | 45. m                                  | $\beta^+$ /40/3.09              | 2.06/                                    | 1/2+                 | +1.41                            |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/60/                          |                                          |                      |                                  |                              | Xe k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.112                                      |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.526                                      |
| <sup>126</sup> Cs   |                                  | 125.90945                | 1.64 m.                                | $\beta^+$ /81/4.83              | 3.4                                      | 1+                   | +0.78                            | -0.68                        | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/19/                          | 3.7/                                     |                      |                                  |                              | Xe k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.3886                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.4912                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.9252                                     |
| <sup>127</sup> Cs   |                                  | 126.90742                | 6.2 h                                  | $\beta^+$ /96/2.08              | 0.65/                                    | 1/2+                 | +1.46                            |                              | Xe k x-ray                                 |
|                     |                                  |                          |                                        | EC/4/                           | 1.06                                     |                      |                                  |                              | 0.1247                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.4119                                     |
| <sup>128</sup> Cs   |                                  | 127.90775                | 3.62 m                                 | $\beta^+$ /68/3.930             | 2.44/                                    | 1+                   | +0.97                            | -0.57                        | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/32 /                         | 2.88/                                    |                      |                                  |                              | Xe k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.4429                                     |
| <sup>129</sup> Cs   |                                  | 128.90606                | 1.336 d                                | EC/1.195                        |                                          | 1/2+                 | +1.49                            |                              | Xe k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.3719                                     |
|                     |                                  |                          |                                        |                                 |                                          |                      |                                  |                              | 0.4115                                     |
| <sup>130m</sup> Cs  |                                  |                          | 3.5 m                                  | IT, $\beta^+$ , EC              |                                          | 5-                   | +0.629                           | +1.45                        |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)                      | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                        |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-------------------------------------------------------------------|
| <sup>130</sup> Cs  |                                  | 129.90671                | 29.21 m                                | $\beta^+$ /55/2.98<br>EC/43/                         | 1.98/<br>0.44/1.6                        | 1+                       | +1.46                            | -0.06                        | ann.rad./<br>Xe k x-ray<br>0.5361                                 |
| <sup>131</sup> Cs  |                                  | 130.90546                | 9.69 d                                 | EC/0.352                                             |                                          | 5/2+                     | +3.54                            | -0.58                        | Xe k x-ray                                                        |
| <sup>132</sup> Cs  |                                  | 131.906434               | 6.48 d                                 | EC/98/<br>$\beta^+$ /0.3/2.120<br>$\beta^-$ / /1.280 |                                          | 2-                       | +2.22                            | +0.51                        | Xe k x-ray<br>0.4646<br>0.6302<br>0.66769                         |
| <sup>133</sup> Cs  | 100.                             | 132.90545193             |                                        |                                                      |                                          | 7/2+                     | +2.582                           | -0.00355                     |                                                                   |
| <sup>134m</sup> Cs |                                  |                          | 2.91 h                                 | I.T./0.139                                           |                                          | 8-                       | +1.098                           | +1.0                         | Cs k x-ray<br>0.12749                                             |
| <sup>134</sup> Cs  |                                  | 133.90671848             | 2.065 y                                | $\beta^-$ /2.059                                     | 0.089/27<br>0.658/70                     | 4+                       | +2.994                           | +0.39                        | 0.56327<br>0.56935                                                |
|                    |                                  |                          |                                        | EC/1.22                                              |                                          |                          |                                  |                              | 0.60473<br>0.79584                                                |
| <sup>135m</sup> Cs |                                  |                          | 53. m                                  | I.T./1.627                                           |                                          | 19/2-                    | +2.18                            | +0.9                         | 0.7869<br>0.8402                                                  |
| <sup>135</sup> Cs  |                                  | 134.905977               | $2.3 \times 10^6$ y                    | $\beta^-$ /0.269                                     | 0.205/100                                | 7/2+                     | +2.732                           | +0.05                        |                                                                   |
| <sup>136m</sup> Cs |                                  |                          | 19. s                                  | I.T./                                                |                                          | 8-                       | +1.32                            | +0.7                         |                                                                   |
| <sup>136</sup> Cs  |                                  | 135.907312               | 13.16 d                                | $\beta^-$ /2.548                                     | 0.341/                                   | 5+                       | +3.71                            | +0.2                         | 0.06691<br>0.34057<br>0.81850<br>1.04807                          |
| <sup>137</sup> Cs  |                                  | 136.907089               | 30.2 y                                 | $\beta^-$ /1.176                                     | 0.514/95                                 | 7/2+                     | +2.84                            | +0.05                        | Ba k x-ray<br>0.66164                                             |
| <sup>138m</sup> Cs |                                  |                          | 2.9 m                                  | I.T./75<br>$\beta^-$ /25 /                           | /0.080<br>3.3                            | 6-                       | +1.71                            | -0.40                        | Cs k x-ray<br>0.0799<br>0.1917<br>0.4628<br>1.43579               |
| <sup>138</sup> Cs  |                                  | 137.91102                | 32.2 m                                 | $\beta^-$ /5.37                                      | 2.9/                                     | 3-                       | +0.700                           | +0.12                        | 0.1381<br>0.46269<br>1.00969<br>1.43579<br>2.21788                |
| <sup>139</sup> Cs  |                                  | 138.913364               | 9.3 m                                  | $\beta^-$ /4.213                                     | 4.21                                     | 7/2+                     | +2.70                            | -0.07                        | 0.6272<br>1.2832<br>(0.4–3.66)                                    |
| <sup>140</sup> Cs  |                                  | 139.91728                | 1.06 m                                 | $\beta^-$ /6.22                                      | 5.7/<br>6.21/                            | 1-                       | +0.13390                         | -0.11                        | 0.5283<br>0.6023<br>0.9084<br>(0.41–3.94)                         |
| <sup>141</sup> Cs  |                                  | 140.92005                | 24.9 s                                 | $\beta^-$ /5.26                                      | 5.20/                                    | 7/2+                     | +2.44                            | -0.4                         | Ba k x-ray<br>0.0485<br>0.5616<br>0.5887<br>1.1940<br>(0.05–3.33) |
| <sup>142</sup> Cs  |                                  | 141.92430                | 1.8 s                                  | $\beta^-$ /7.31                                      | 6.9/<br>7.28                             |                          |                                  |                              | 0.3596<br>0.9668<br>1.1759<br>1.3265                              |
| <sup>143</sup> Cs  |                                  | 142.92735                | 1.78 s                                 | $\beta^-$ /6.24                                      | 6.1                                      | (3/2+)                   | +0.87                            | +0.47                        | 0.1955<br>0.2324<br>0.3064<br>(0.17–1.98)                         |
| <sup>144</sup> Cs  |                                  | 143.93208                | 1.01 s                                 | $\beta^-$ /8.47                                      | 8.46/<br>7.9/                            | 1                        | -0.546                           | +0.30                        | 0.1993<br>0.5598<br>0.6392<br>0.7587                              |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                |
|------------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-----------------------------------------------------------|
| <sup>145</sup> Cs      |                                  | 144.93553                | 0.59 s                                 | $\beta^-$ /7.89                 | 7.4/<br>7.9/                             | 3/2+                     | +0.784                           | +0.6                         | 0.1126<br>0.1755<br>0.1990                                |
| <sup>146</sup> Cs      |                                  | 145.9403                 | 0.322 s                                | $\beta^-$ , (n)/9.38            | $\sim$ 9.0                               | 2-                       | -0.515                           | +0.22                        |                                                           |
| <sup>147</sup> Cs      |                                  | 146.9442                 | 0.227 s                                | $\beta^-$ , (n)/9.3             |                                          |                          |                                  |                              | (0.024-2.2798)                                            |
| <sup>148</sup> Cs      |                                  | 147.9492                 | 0.15 s                                 | $\beta^-$ , (n)/10.5            |                                          |                          |                                  |                              |                                                           |
| <sup>149</sup> Cs      |                                  | 148.9529                 | > 50 ms                                |                                 |                                          |                          |                                  |                              |                                                           |
| <sup>150</sup> Cs      |                                  | 149.9582                 | > 50 ms                                |                                 |                                          |                          |                                  |                              |                                                           |
| <sup>151</sup> Cs      |                                  | 150.9622                 | > 50 ms                                |                                 |                                          |                          |                                  |                              |                                                           |
| <b><sup>56</sup>Ba</b> |                                  | <b>137.327(7)</b>        |                                        |                                 |                                          |                          |                                  |                              |                                                           |
| <sup>114</sup> Ba      |                                  | 113.9507                 | 0.43 s                                 | $\beta^+$ , (p)<br>$\alpha$     | p/20<br>/0.9                             | 0+                       |                                  |                              |                                                           |
| <sup>115</sup> Ba      |                                  | 114.947                  | 0.45 s                                 | $\beta^+$ , (p)                 | p/<15                                    |                          |                                  |                              |                                                           |
| <sup>116</sup> Ba      |                                  | 115.9414                 | 1.3 s                                  | $\beta^+$ , (p)                 | p/3                                      | 0+                       |                                  |                              |                                                           |
| <sup>117</sup> Ba      |                                  | 116.9385                 | 1.8 s                                  | $\beta^+$ , (p), EC/8.4         | p/16                                     | (3/2-)                   |                                  |                              | (0.0457–0.364)                                            |
| <sup>118</sup> Ba      |                                  | 117.9330                 | 5.2 s                                  | $\beta^+$ ,                     |                                          | 0+                       |                                  |                              | (0.040–0.156)                                             |
| <sup>119</sup> Ba      |                                  | 118.9307                 | 5.4 s                                  | $\beta^+$ , EC/8.               |                                          |                          |                                  |                              |                                                           |
| <sup>120</sup> Ba      |                                  | 119.9260                 | 24. s                                  | $\beta^+$ , EC/5.0              |                                          | 0+                       |                                  |                              | ann.rad./<br>0.140<br>(0.075–0.146)                       |
| <sup>121</sup> Ba      |                                  | 120.9241                 | 30. s                                  | $\beta^+$ , EC/6.8              |                                          | 5/2+                     | +0.660                           | +1.8                         | ann.rad./                                                 |
| <sup>122</sup> Ba      |                                  | 121.91990                | 2.0 m                                  | $\beta^+$ , EC/3.8              |                                          | 0+                       |                                  |                              | ann.rad./                                                 |
| <sup>123</sup> Ba      |                                  | 122.91878                | 2.7 m                                  | $\beta^+$ , EC/5.5              |                                          |                          | -0.68                            | +1.5                         | ann.rad./<br>0.0306<br>0.0927<br>0.1161<br>0.1235         |
| <sup>124</sup> Ba      |                                  | 123.91509                | 12. m                                  | $\beta^+$ , EC/2.65             |                                          | 0+                       |                                  |                              | ann.rad./<br>0.1695<br>0.1888<br>1.2160                   |
| <sup>125m</sup> Ba     |                                  |                          | 8. m                                   | $\beta^+$ , EC/                 | 4.5                                      |                          | 0.174                            |                              |                                                           |
| <sup>125</sup> Ba      |                                  | 124.9145                 | 3.5 m                                  | $\beta^+$ , EC/4.6              | 3.4                                      | ½+                       | +0.18                            |                              | ann.rad./<br>0.0550<br>0.0776<br>0.0854<br>0.1409         |
| <sup>126</sup> Ba      |                                  | 125.91125                | 1.65 h                                 | $\beta^+$ /2/1.67<br>EC/98 /    |                                          | 0+                       |                                  |                              | Cs k x-ray<br>0.2179<br>0.2336<br>0.2576                  |
| <sup>127m</sup> Ba     |                                  |                          | 1.9 s                                  | IT                              |                                          | 7/2-                     | -0.723                           | 1.6                          |                                                           |
| <sup>127</sup> Ba      |                                  | 126.91109                | 12.9 m                                 | $\beta^+$ /54/3.5<br>EC/46/     |                                          | 1/2+                     | +0.083                           |                              | ann.rad./<br>Cs k x-ray<br>0.1148<br>0.1808<br>(0.07–2.5) |
| <sup>128</sup> Ba      |                                  | 127.90832                | 2.43 d                                 | EC/0.52                         |                                          | 0+                       |                                  |                              | Cs k x-ray<br>0.27344                                     |
| <sup>129m</sup> Ba     |                                  |                          | 2.17 h                                 | EC/98/<br>$\beta^+$ /2/         |                                          | 7/2+                     | +0.93                            | +1.6                         | Cs k x-ray<br>0.1769<br>0.1823<br>0.2023<br>1.4593        |
| <sup>129</sup> Ba      |                                  | 128.90868                | 2.2 h                                  | $\beta^+$ /20/2.43<br>EC/80/    | 1.42/                                    | 1/2+                     | -0.40                            |                              | ann.rad./<br>Cs k x-ray<br>0.1291<br>0.2143               |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                   |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------------------------------------------------------------|
| <sup>130m</sup> Ba |                                  |                          | 9.5 ms                                 | I.T./2.475                      | /100.                                    | 8-                       | -0.04                            | +2.8                         | 0.2208<br>0.080–0.802                                                        |
| <sup>130</sup> Ba  | 0.106(1)                         | 129.906321               | $2.2 \times 10^{21}$ y                 | $\beta^+\beta^+$                |                                          | 0+                       |                                  |                              |                                                                              |
| <sup>131m</sup> Ba |                                  |                          | 14.6 m                                 | I.T./0.187                      |                                          | 9/2-                     | -0.87                            | +1.5                         | Ba k x-ray<br>0.1085                                                         |
| <sup>131</sup> Ba  |                                  | 130.906941               | 11.7 d                                 | EC/1.37                         |                                          | 1/2+                     | 0.7081                           |                              | Cs k x-ray<br>0.12381/28.4<br>0.21608/21.3<br>0.49636/42.9<br>(0.0549–1.171) |
| <sup>132</sup> Ba  | 0.101(1)                         | 131.905061               | $1.3 \times 10^{21}$ y                 | EC EC                           |                                          | 0+                       |                                  |                              |                                                                              |
| <sup>133m</sup> Ba |                                  |                          | 1.621 d                                | I.T./0.288                      |                                          | 11/2-                    | -0.91                            | +0.9                         | Ba k x-ray<br>0.2761                                                         |
| <sup>133</sup> Ba  |                                  | 132.906008               | 10.53 y                                | EC/0.517                        |                                          | 1/2+                     | 0.7717                           |                              | Cs k x-ray<br>0.08099<br>0.35600                                             |
| <sup>134</sup> Ba  | 2.417(18)                        | 133.904508               |                                        |                                 |                                          | 0+                       |                                  |                              |                                                                              |
| <sup>135m</sup> Ba |                                  |                          | 1.20 d                                 | I.T./0.2682                     |                                          | 11/2-                    | -1.00                            | +1.0                         | Ba k x-ray<br>0.2682                                                         |
| <sup>135</sup> Ba  | 6.592(12)                        | 134.9056886              |                                        |                                 |                                          | 3/2+                     | +0.838                           | +0.16                        |                                                                              |
| <sup>136m</sup> Ba |                                  |                          | 0.308 s                                | I.T./2.0305                     |                                          | 7-                       |                                  |                              | Ba k x-ray<br>0.8185<br>1.0481                                               |
| <sup>136</sup> Ba  | 7.854(24)                        | 135.9045759              |                                        |                                 |                                          | 0+                       |                                  |                              |                                                                              |
| <sup>137m</sup> Ba |                                  |                          | 2.552 m                                | I.T./0.6617                     |                                          | 11/2-                    | -0.99                            | +0.8                         | Ba k x-ray<br>0.66164                                                        |
| <sup>137</sup> Ba  | 11.232(24)                       | 136.9058274              |                                        |                                 |                                          | 3/2+                     | +0.9374                          | +0.245                       |                                                                              |
| <sup>138</sup> Ba  | 71.698(42)                       | 137.9052472              |                                        |                                 |                                          | 0+                       |                                  |                              |                                                                              |
| <sup>139</sup> Ba  |                                  | 138.9088412              | 1.396 h                                | $\beta^-$ /2.317                | 2.14/27<br>2.27/72                       | 7/2-                     | -0.97                            | -0.57                        | 0.16585<br>1.2544<br>1.42033                                                 |
| <sup>140</sup> Ba  |                                  | 139.91060                | 12.75 d                                | $\beta^-$ /1.05                 | 0.48<br>1.0/<br>1.02/                    | 0+                       |                                  |                              | 0.16268<br>0.30485<br>0.53727                                                |
| <sup>141</sup> Ba  |                                  | 140.91441                | 18.3 m                                 | $\beta^-$ /3.22                 | 2.59/<br>2.73/                           | 3/2-                     | -0.34                            | +0.45                        | 0.1903<br>0.2770<br>0.3042<br>(0.1–2.5)                                      |
| <sup>142</sup> Ba  |                                  | 141.91645                | 10.7 m                                 | $\beta^-$ /2.212                | 1.0/<br>1.10/                            | 0+                       |                                  |                              | 0.23152<br>0.25512<br>0.3090<br>1.2040                                       |
| <sup>143</sup> Ba  |                                  | 142.92063                | 14.3 s                                 | $\beta^-$ /4.24                 | 4.2/                                     | 5/2+                     | +0.44                            | -0.88                        | 0.1786<br>0.21148<br>0.7988<br>(0.17–2.4)                                    |
| <sup>144</sup> Ba  |                                  | 143.92295                | 11.4 s                                 | $\beta^-$ /3.1                  | 2.4/<br>2.9/                             | 0+                       |                                  |                              | La k x-ray<br>0.10386<br>0.1566<br>0.1728<br>0.3882<br>0.43048               |
| <sup>145</sup> Ba  |                                  | 144.9276                 | 4.0 s                                  | $\beta^-$ /4.9                  | 4.9/                                     | (5/2-)                   | -0.28                            | +1.22                        | La k x-ray<br>0.0918<br>0.09709                                              |
| <sup>146</sup> Ba  |                                  | 145.9302                 | 2.20 s                                 | $\beta^-$ /4.12                 | 3.9/                                     | 0+                       |                                  |                              | 0.0644<br>0.2513<br>0.3270<br>0.3329<br>0.3622                               |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                          |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------------------|
| <sup>147</sup> Ba  |                                  | 146.9349                 | 0.892 s                                | $\beta^-$ /5.75                 | 5.5/                                     |                          |                                  |                              |                                                                     |
| <sup>148</sup> Ba  |                                  | 147.9377                 | 0.64 s                                 | $\beta^-$ , n/5.11              |                                          | 0+                       |                                  |                              |                                                                     |
| <sup>149</sup> Ba  |                                  | 148.9426                 | 0.36 s                                 | $\beta^-$ , (n)/7.3             |                                          |                          |                                  |                              |                                                                     |
| <sup>150</sup> Ba  |                                  | 149.9457                 | 0.3 s                                  |                                 |                                          | 0+                       |                                  |                              |                                                                     |
| <sup>151</sup> Ba  |                                  | 150.9508                 | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                                                     |
| <sup>152</sup> Ba  |                                  | 151.9543                 |                                        |                                 |                                          | 0+                       |                                  |                              |                                                                     |
| <sup>153</sup> Ba  |                                  | 151.960                  |                                        |                                 |                                          |                          |                                  |                              |                                                                     |
| <sup>57</sup> La   |                                  | 138.90547(7)             |                                        |                                 |                                          |                          |                                  |                              |                                                                     |
| <sup>117</sup> La  |                                  | 116.9501                 | 23 ms                                  | p                               | 0.806/                                   | 3/2+                     |                                  |                              |                                                                     |
| <sup>118</sup> La  |                                  | 117.9467                 |                                        |                                 |                                          |                          |                                  |                              |                                                                     |
| <sup>119</sup> La  |                                  | 118.9410                 |                                        |                                 |                                          |                          |                                  |                              |                                                                     |
| <sup>120</sup> La  |                                  | 119.9381                 | 2.8 s                                  | EC, $\beta^+$ /11.              |                                          |                          |                                  |                              |                                                                     |
| <sup>121</sup> La  |                                  | 120.9330                 | 5.3 s                                  |                                 |                                          |                          |                                  |                              |                                                                     |
| <sup>122</sup> La  |                                  | 121.9307                 | 9. s                                   | EC, $\beta^+$ /~ 9.7            |                                          |                          |                                  |                              |                                                                     |
| <sup>123</sup> La  |                                  | 122.9262                 | 17. s                                  | EC/7.                           |                                          |                          |                                  |                              |                                                                     |
| <sup>124</sup> La  |                                  | 123.9246                 | 30. s                                  | EC/ ~ 8.8                       |                                          | (7+)                     |                                  |                              |                                                                     |
| <sup>125m</sup> La |                                  |                          | 0.39 s                                 |                                 |                                          |                          |                                  |                              |                                                                     |
| <sup>125</sup> La  |                                  | 124.92082                | 1.2 m                                  | $\beta^+$ , EC/5.6              |                                          | 11/2-                    |                                  |                              | ann.rad./<br>0.0436<br>0.0676                                       |
| <sup>126m</sup> La |                                  |                          | < 50. s                                |                                 |                                          |                          |                                  |                              |                                                                     |
| <sup>126</sup> La  |                                  | 125.9195                 | 54. s                                  | $\beta^+$ , EC/7.6              |                                          |                          |                                  |                              | ann.rad./<br>0.256<br>0.455<br>0.117–3.853                          |
| <sup>127</sup> La  |                                  | 126.91638                | 3.8 m                                  | $\beta^+$ , EC/4.7              |                                          | 3/2+                     |                                  |                              | ann.rad./<br>0.025<br>0.0562                                        |
| <sup>128</sup> La  |                                  | 127.9156                 | 5.0 m                                  | $\beta^+$ /80/6.7<br>EC/20/     |                                          | (5-)                     |                                  |                              | ann.rad./<br>Ba k x-ray<br>0.2841/87<br>0.4793/54<br>(0.315–2.212)  |
| <sup>129m</sup> La |                                  |                          | 0.56 s                                 | IT                              |                                          | (11/2-)                  |                                  |                              |                                                                     |
| <sup>129</sup> La  |                                  | 128.91269                | 11.6 m                                 | $\beta^+$ /58/3.72<br>EC/42/    | 2.42/                                    | 3/2+                     |                                  |                              | ann.rad./<br>Ba k x-ray<br>0.1105<br>0.2786<br>(0.1–1.8)            |
| <sup>130</sup> La  |                                  | 129.91237                | 8.7 m                                  | $\beta^+$ /78/5.6<br>EC/22/     |                                          | 3+                       |                                  |                              | ann.rad./<br>Ba k x-ray<br>0.3573/81<br>0.5506/27<br>(0.1965–1.989) |
| <sup>131</sup> La  |                                  | 130.91007                | 59. m                                  | $\beta^+$ /76/3.0<br>EC/24/     | 1.42/<br>1.94/                           | 3/2+                     |                                  |                              | ann.rad./<br>Ba k x-ray<br>0.1085<br>0.3658<br>0.5263               |
| <sup>132m</sup> La |                                  |                          | 24. m                                  | I.T./76/<br>$\beta^+$ , EC/24/  |                                          | 6-                       |                                  |                              | La k x-ray<br>0.1352<br>0.4645                                      |
| <sup>132</sup> La  |                                  | 131.91010                | 4.8 h                                  | $\beta^+$ /40/4.71<br>EC/60/    | 2.6/<br>3.2<br>3.7/                      | 2-                       |                                  |                              | ann.rad./<br>Ba k x-ray<br>0.4645<br>0.5671                         |
| <sup>133</sup> La  |                                  | 132.90822                | 3.91 h                                 | $\beta^+$ /4/2.2<br>EC/96/      | 1.2/                                     | 5/2+                     |                                  |                              | Ba k x-ray<br>0.2788                                                |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)      |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-------------------------------------------------|
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2901                                          |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3024                                          |
| <sup>134</sup> La  |                                  | 133.90851                | 6.5 m                                  | $\beta^+$ /63/3.71<br>EC/37/    | 2.67/                                    | 1+                       |                                  |                              | ann.rad./<br>Ba k x-ray                         |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6047<br>(0.5–1.9)                             |
| <sup>135</sup> La  |                                  | 134.90698                | 19.5 h                                 | EC/1.20                         |                                          | 5/2+                     |                                  |                              | Ba k x-ray<br>0.4805                            |
| <sup>136</sup> La  |                                  | 135.9076                 | 9.87 m                                 | $\beta^+$ /36/2.9<br>EC/64/     | 1.8/                                     | 1+                       |                                  |                              | ann.rad./<br>Ba k x-ray                         |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8185                                          |
| <sup>137</sup> La  |                                  | 136.90649                | $6 \times 10^4$ y                      | EC/0.60                         |                                          | 7/2+                     | +2.70                            | +0.2                         | 0.2836                                          |
| <sup>138</sup> La  | 0.0888(6)                        | 137.907112               | $1.06 \times 10^{11}$ y                |                                 |                                          | 5+                       | +3.7136                          | +0.4                         | 1.4358/65                                       |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7887/35                                       |
| <sup>139</sup> La  | 99.9112(6)                       | 138.906353               |                                        |                                 |                                          | 7/2+                     | +2.7830                          | +0.20                        |                                                 |
| <sup>140</sup> La  |                                  | 139.909478               | 1.678 d                                | $\beta^-$ /3.762                | 1.35                                     | 3-                       | +0.73                            | +0.09                        |                                                 |
|                    |                                  |                          |                                        |                                 | 1.24/<br>1.67/                           |                          |                                  |                              |                                                 |
| <sup>141</sup> La  |                                  | 140.910962               | 3.90 h                                 | $\beta^-$ /2.502                | 2.43/                                    | 7/2+                     |                                  |                              |                                                 |
| <sup>142</sup> La  |                                  | 141.91408                | 1.54 h                                 | $\beta^-$ /4.505                | 2.11/                                    | 2-                       |                                  |                              |                                                 |
|                    |                                  |                          |                                        |                                 | 2.98/<br>4.52/                           |                          |                                  |                              |                                                 |
| <sup>143</sup> La  |                                  | 142.91606                | 14.1 m                                 | $\beta^-$ /3.43                 | 3.3/                                     | 7/2-                     |                                  |                              |                                                 |
| <sup>144</sup> La  |                                  | 143.91960                | 40.7 s                                 | $\beta^-$ /5.5                  | 4.1/                                     |                          |                                  |                              |                                                 |
| <sup>145</sup> La  |                                  | 144.9216                 | 24. s                                  | $\beta^-$ /4.1                  | 4.1/                                     | 3/2+                     |                                  |                              |                                                 |
| <sup>146m</sup> La |                                  |                          | 10.0 s                                 | $\beta^-$ /6.7                  | 5.5/                                     | (6)                      |                                  |                              |                                                 |
| <sup>146</sup> La  |                                  | 145.9258                 | 6.3 s                                  | $\beta^-$ /6.6                  | 6.2/                                     | (2-)                     |                                  |                              |                                                 |
| <sup>147</sup> La  |                                  | 146.9282                 | 4.02 s                                 | $\beta^-$ /5.0                  | 4.6/                                     |                          |                                  |                              |                                                 |
| <sup>148</sup> La  |                                  | 147.9322                 | 1.1 s                                  | $\beta^-$ /7.26                 |                                          | 2-                       |                                  |                              |                                                 |
| <sup>149</sup> La  |                                  | 148.9347                 | 1.10 s                                 | $\beta^-$ /5.5                  |                                          |                          |                                  |                              | 0.1335<br>0.009–1.709<br>x-ray<br>(0.097–0.209) |
| <sup>150</sup> La  |                                  | 149.9388                 | 0.51 s                                 |                                 |                                          |                          |                                  |                              |                                                 |
| <sup>151</sup> La  |                                  | 150.9417                 | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                                 |
| <sup>152</sup> La  |                                  | 151.9462                 | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                                 |
| <sup>153</sup> La  |                                  | 152.950                  | > 0.15 $\mu$ s                         |                                 |                                          |                          |                                  |                              |                                                 |
| <sup>154</sup> La  |                                  | 153.955                  |                                        |                                 |                                          |                          |                                  |                              |                                                 |
| <sup>155</sup> La  |                                  | 154.958                  |                                        |                                 |                                          |                          |                                  |                              |                                                 |
| <sup>58</sup> Ce   |                                  | 140.116(1)               |                                        |                                 |                                          |                          |                                  |                              |                                                 |
| <sup>119</sup> Ce  |                                  | 118.953                  |                                        |                                 |                                          |                          |                                  |                              |                                                 |
| <sup>120</sup> Ce  |                                  | 119.947                  |                                        |                                 |                                          | 0+                       |                                  |                              |                                                 |
| <sup>121</sup> Ce  |                                  | 120.943                  | 1.1 s                                  | $\beta^+$ , p                   |                                          |                          |                                  |                              |                                                 |
| <sup>122</sup> Ce  |                                  | 121.9379                 |                                        |                                 |                                          | 0+                       |                                  |                              |                                                 |
| <sup>123</sup> Ce  |                                  | 122.9354                 | 3.8 s                                  | $\beta^+$ , EC/~ 8.6            |                                          |                          |                                  |                              | ann.rad./                                       |
| <sup>124</sup> Ce  |                                  | 123.9304                 | 6. s                                   | EC/~ 5.6                        |                                          | 0+                       |                                  |                              |                                                 |
| <sup>125</sup> Ce  |                                  | 124.9284                 | 9.6 s                                  | $\beta^+$ , EC/7.               |                                          | 7/2-                     |                                  |                              | ann.rad./                                       |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1346<br>0.1666<br>0.056–1.329                 |
| <sup>126</sup> Ce  |                                  | 125.92397                | 50. s                                  | EC/4.                           |                                          | 0+                       |                                  |                              |                                                 |
| <sup>127</sup> Ce  |                                  | 126.9227                 | 29. s                                  | $\beta^+$ , EC/6.1              |                                          |                          |                                  |                              | ann.rad./<br>(0.058–1.961)                      |
| <sup>128</sup> Ce  |                                  | 127.91891                | 4.1 m                                  | $\beta^+$ , EC/3.2              |                                          | 0+                       |                                  |                              | ann.rad./<br>(0.023–0.880)                      |
| <sup>129</sup> Ce  |                                  | 128.91810                | 3.5 m                                  | $\beta^+$ , EC/5.6              |                                          |                          |                                  |                              | ann.rad./<br>(0.0675–1.015)                     |
| <sup>130</sup> Ce  |                                  | 129.91474                | 26. m                                  | $\beta^+$ , EC/2.2              |                                          | 0+                       |                                  |                              | ann.rad./<br>La k x-ray                         |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>131m</sup> Ce |                                  |                          | 5. m                                   | $\beta^+$ EC                    |                                          |                          |                                  |                              | 0.047–1.431<br>ann.rad./                   |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2304                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3955                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4213                                     |
| <sup>131</sup> Ce  |                                  | 130.91442                | 10. m                                  | $\beta^+$ , EC/4.0              | 2.8/                                     |                          |                                  |                              | ann.rad.                                   |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.119                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.169                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.414                                      |
| <sup>132m</sup> Ce |                                  |                          | 9.4 ms                                 | IT/2.340                        |                                          |                          |                                  |                              | 0.3255                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.10–0.955                                 |
| <sup>132</sup> Ce  |                                  | 131.91146                | 3.5 h                                  | EC/1.3                          |                                          | 0+                       |                                  |                              | La k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1554                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1821                                     |
| <sup>133m</sup> Ce |                                  |                          | 1.6 h                                  | $\beta^+$ , EC/                 |                                          | $\frac{1}{2}+$           |                                  |                              | ann.rad.                                   |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0769                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0973                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5577                                     |
| <sup>133</sup> Ce  |                                  | 132.91152                | 5.4 h                                  | $\beta^+$ /8/2.9<br>EC/92/      | 1.3/                                     | 9/2-                     |                                  |                              | ann.rad.                                   |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0584                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1308                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4722                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5104                                     |
| <sup>134</sup> Ce  |                                  | 133.90892                | 3.16 d                                 | EC/0.5                          |                                          | 0+                       |                                  |                              | La k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1304                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1623                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6047                                     |
| <sup>135m</sup> Ce |                                  |                          | 20. s                                  | IT./0.446                       |                                          | 11/2-                    |                                  |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0826                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1497                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2134                                     |
| <sup>135</sup> Ce  |                                  | 134.90915                | 17.7 h                                 | $\beta^+$ /1 /2.026<br>EC/99 /  | 0.8/                                     | 1/2+                     |                                  |                              | La k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0345                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2656                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3001                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6068                                     |
| <sup>136</sup> Ce  | 0.185(2)                         | 135.90717                | $> 0.7 \times 10^{14}$ y               | EC EC                           |                                          | 0+                       |                                  |                              |                                            |
| <sup>137m</sup> Ce |                                  |                          | 1.43 d                                 | IT./99 /0.254<br>EC/0.8 /       |                                          | 11/2-                    | 1.0                              |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1693                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2543                                     |
| <sup>137</sup> Ce  |                                  | 136.90781                | 9.0 h                                  | $\beta^+$ /1.222                |                                          | 3/2+                     | 0.96                             |                              | La k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4472                                     |
| <sup>138</sup> Ce  | 0.251(2)                         | 137.90599                | $> 0.9 \times 10^{14}$ y               | EC EC                           |                                          | 0+                       |                                  |                              |                                            |
| <sup>139m</sup> Ce |                                  |                          | 56.4 s                                 | IT./0.7542                      |                                          | 11/2-                    |                                  |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7542                                     |
| <sup>139</sup> Ce  |                                  | 138.90665                | 137.6 d                                | EC/0.28                         |                                          | 3/2+                     | 1.06                             |                              | La k x-ray                                 |
| <sup>140</sup> Ce  | 88.450(51)                       | 139.905439               |                                        |                                 |                                          | 0+                       |                                  |                              | 0.16585                                    |
| <sup>141</sup> Ce  |                                  | 140.908276               | 32.50 d                                | $\beta^-$ /0.581                | 0.436/69<br>0.581/31                     | 7/2-                     | 1.1                              |                              | Pr k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.14544/48.0                               |
| <sup>142</sup> Ce  | 11.114(51)                       | 141.909244               | $> 1.6 \times 10^{17}$ y               | $\beta^-$ $\beta^-$             |                                          | 0+                       |                                  |                              |                                            |
| <sup>143</sup> Ce  |                                  | 142.912386               | 1.38 d                                 | $\beta^-$ /1.462                | 1.404/<br>1.110/47                       | 3/2-                     | 0.43                             |                              | Pr k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0574                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2933                                     |
| <sup>144</sup> Ce  |                                  | 143.913647               | 284.6 d                                | $\beta^-$ /0.319                | 0.185/20<br>0.318/                       | 0+                       |                                  |                              | Pr k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0801                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1335                                     |
| <sup>145</sup> Ce  |                                  | 144.91723                | 3.00 m                                 | $\beta^-$ /2.54                 | 1.7/24<br>1.3                            | 3/2-                     |                                  |                              | Pr k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0627                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7245                                     |
| <sup>146</sup> Ce  |                                  | 145.9188                 | 13.5 m                                 | $\beta^-$ /1.04                 | 0.7/90                                   | 0+                       |                                  |                              | Pr k x-ray                                 |



[illegible]

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.495                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.632                                      |
| <sup>134</sup> Pr  |                                  | 133.91571                | 17. m                                  | $\beta^+$ , EC/6.2              |                                          | 2+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.294                                      |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.495                                      |
| <sup>135</sup> Pr  |                                  | 134.91311                | 24. m                                  | $\beta^+$ , EC/3.7              | 2.5/                                     | 3/2+                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0826                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2135                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2961                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5832                                     |
| <sup>136</sup> Pr  |                                  | 135.91269                | 13.1 m                                 | $\beta^+$ /57 /5.13<br>EC/43    | 2.98/                                    | 2+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5398                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5522                                     |
| <sup>137</sup> Pr  |                                  | 136.91071                | 1.28 h                                 | $\beta^+$ /26 /2.70<br>EC/74 /  | 1.68/                                    | 5/2+                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4339                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5140                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8367                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.16–1.8)                                 |
| <sup>138m</sup> Pr |                                  |                          | 2.1 h                                  | $\beta^+$ /24 /<br>EC/76 /      | 1.65/                                    | 7-                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3027                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7887                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0378                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.07–2.0)                                 |
| <sup>138</sup> Pr  |                                  | 137.91075                | 1.45 m                                 | $\beta^+$ /75 /4.44<br>EC/25 /  | 3.42/                                    | 1+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7887                                     |
| <sup>139</sup> Pr  |                                  | 138.90894                | 4.41 h                                 | $\beta^+$ /8 /2.129<br>EC/92 /  | 1.09/                                    | 5/2+                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2551                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.3473                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.6307                                     |
| <sup>140</sup> Pr  |                                  | 139.90908                | 3.39 m                                 | $\beta^+$ /51 /3.39<br>EC/49 /  | 2.37/                                    | 1+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Ce k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3069                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.5965                                     |
| <sup>141</sup> Pr  | 100.                             | 140.907653               |                                        |                                 |                                          | 5/2+                     | +4.275                           | -0.08                        |                                            |
| <sup>142m</sup> Pr |                                  |                          | 14.6 m                                 | I.T./0.004                      | c.e.                                     | 5-                       | 2.2                              |                              |                                            |
| <sup>142</sup> Pr  |                                  | 141.910045               | 19.12 h                                | $\beta^-$ /2.162<br>EC/0.744    | 0.58/4<br>2.16/96                        | 2-                       | +0.234                           | +0.030                       | 0.5088                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.57580                                    |
| <sup>143</sup> Pr  |                                  | 142.910817               | 13.57 d                                | $\beta^-$ /0.934                | 0.933/                                   | 7/2+                     | +2.70                            | +0.8                         | 0.7420                                     |
| <sup>144m</sup> Pr |                                  |                          | 7.2 m                                  | IT/99+/0.059<br>$\beta^-$ /     |                                          | 3-                       |                                  |                              | Pr k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0590                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6965                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8142                                     |
| <sup>144</sup> Pr  |                                  | 143.913305               | 17.28 m                                | $\beta^-$ /2.998                | 0.807/1<br>2.30/                         | 0-                       |                                  |                              | 0.69649                                    |
|                    |                                  |                          |                                        |                                 | 2.996/98                                 |                          |                                  |                              | 1.48912                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 2.18562                                    |
| <sup>145</sup> Pr  |                                  | 144.91451                | 5.98 h                                 | $\beta^-$ /1.81                 | 1.80/97                                  | 7/2+                     |                                  |                              | 0.0725                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6758                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7483                                     |
| <sup>146</sup> Pr  |                                  | 145.9176                 | 24.2 m                                 | $\beta^-$ /4.2                  | 2.2/30<br>3.7/10<br>4.2/40               | 2-                       |                                  |                              | 0.4539/48                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.5247                                     |
| <sup>147</sup> Pr  |                                  | 146.91900                | 13.4 m                                 | $\beta^-$ /2.69                 | 1.5/                                     | 3/2+                     |                                  |                              | 0.3146/24.                                 |
|                    |                                  |                          |                                        |                                 | 2.1/                                     |                          |                                  |                              | 0.5779/16                                  |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6413/19.                                 |
| <sup>148m</sup> Pr |                                  |                          | 2.0 m                                  | $\beta^-$ /                     | 4.0/                                     | (4)                      |                                  |                              | 0.3016                                     |

[illegible]

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)   | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)              |
|--------------------|----------------------------------|--------------------------|----------------------------------------|-----------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------|
| <sup>138</sup> Nd  |                                  | 137.91195                | 5.1 h                                  | EC/1.1                            |                                          | 0+                       |                                  |                              | Pr k x-ray<br>0.1995<br>0.3258                          |
| <sup>139m</sup> Nd |                                  |                          | 5.5 h                                  | I.T./12 /0.231<br>$\beta^+$ /88 / | 1.17/                                    | 11/2-                    |                                  |                              | Nd k x-ray<br>Pr k x-ray<br>0.1139/34.<br>0.7382/30.    |
| <sup>139</sup> Nd  |                                  | 138.91198                | 30. m                                  | $\beta^+$ /25 /2.79<br>EC/75 /    | 1.77/                                    | 3/2+                     | 0.91                             | +0.3                         | ann.rad./<br>Pr k x-ray<br>0.4050                       |
| <sup>140</sup> Nd  |                                  | 139.90955                | 3.37 d                                 | EC /0.22                          |                                          | 0+                       |                                  |                              | Pr k x-ray                                              |
| <sup>141m</sup> Nd |                                  |                          | 1.04 m                                 | IT/99+/0.756                      |                                          | 11/2-                    |                                  |                              | Nd k x-ray<br>0.7565                                    |
| <sup>141</sup> Nd  |                                  | 140.909610               | 2.49 h                                 | EC/98 /1.823<br>$\beta^+$ /2 /    | 0.802/                                   | 3/2+                     | 1.01                             | +0.3                         | Pr k x-ray<br>(0.15–1.7)                                |
| <sup>142</sup> Nd  | 27.153(39)                       | 141.907723               |                                        |                                   |                                          | 0+                       |                                  |                              |                                                         |
| <sup>143</sup> Nd  | 12.173(27)                       | 142.909814               |                                        |                                   |                                          | 7/2-                     | -1.07                            | -0.60                        |                                                         |
| <sup>144</sup> Nd  | 23.798(18)                       | 143.910087               | $2.1 \times 10^{15}$ y                 | $\alpha$                          | 1.83                                     | 0+                       |                                  |                              |                                                         |
| <sup>145</sup> Nd  | 8.293(12)                        | 144.912574               |                                        |                                   |                                          | 7/2-                     | -0.66                            | -0.31                        |                                                         |
| <sup>146</sup> Nd  | 17.189(33)                       | 145.913117               |                                        |                                   |                                          | 0+                       |                                  |                              |                                                         |
| <sup>147</sup> Nd  |                                  | 146.916100               | 10.98 d                                | $\beta^-$ /0.896                  | 0.805/                                   | 5/2-                     | 0.58                             | 0.9                          | Pr k x-ray<br>0.53102<br>0.09111–0.686                  |
| <sup>148</sup> Nd  | 5.756(21)                        | 147.916893               |                                        |                                   |                                          | 0+                       |                                  |                              |                                                         |
| <sup>149</sup> Nd  |                                  | 148.920149               | 1.73 h                                 | $\beta^-$ /1.691                  | 1.03/25<br>1.13/26<br>1.42/              | 5/2-                     | 0.35                             | 1.3                          | Pr k x-ray<br>0.1143/19.<br>0.2113/27.<br>(0.026–1.6)   |
| <sup>150</sup> Nd  | 5.638(29)                        | 149.920891               | $1.4 \times 10^{20}$ y                 | $\beta^-\beta^-$                  |                                          | 0+                       |                                  |                              |                                                         |
| <sup>151</sup> Nd  |                                  | 150.923829               | 12.4 m                                 | $\beta^-$ /2.442                  | 1.2/                                     | (3/2+)                   |                                  |                              | Pm k x-ray<br>0.1168<br>0.2557<br>1.1806<br>(0.10–1.9)m |
| <sup>152</sup> Nd  |                                  | 151.92468                | 11.4 m                                 | $\beta^-$ /1.1                    |                                          | 0+                       |                                  |                              | 0.2785/29.<br>0.2501/18.<br>(0.016–0.66)                |
| <sup>153</sup> Nd  |                                  | 152.92770                | 28.9 s                                 | $\beta^-$ /3.6                    |                                          |                          |                                  |                              | 0.418                                                   |
| <sup>154</sup> Nd  |                                  | 153.9295                 | 25.9 s                                 | $\beta^-$ /2.8                    |                                          | 0+                       |                                  |                              | 0.1519<br>0.7998                                        |
| <sup>155</sup> Nd  |                                  | 154.9329                 | 8.9 s                                  | $\beta^-$ /5.0                    |                                          |                          |                                  |                              | 0.1807                                                  |
| <sup>156</sup> Nd  |                                  | 155.9350                 | 5.5 s                                  | $\beta^-$ /4.1                    |                                          | 0+                       |                                  |                              | 0.0848                                                  |
| <sup>157</sup> Nd  |                                  | 156.9390                 | > 0.3 $\mu$ s                          |                                   |                                          |                          |                                  |                              |                                                         |
| <sup>158</sup> Nd  |                                  | 157.9416                 | > 0.3 $\mu$ s                          |                                   |                                          | 0+                       |                                  |                              |                                                         |
| <sup>159</sup> Nd  |                                  | 158.946                  |                                        |                                   |                                          |                          |                                  |                              |                                                         |
| <sup>160</sup> Nd  |                                  | 159.949                  |                                        |                                   |                                          | 0+                       |                                  |                              |                                                         |
| <sup>161</sup> Nd  |                                  | 160.954                  |                                        |                                   |                                          |                          |                                  |                              |                                                         |
| <sup>61</sup> Pm   |                                  |                          |                                        |                                   |                                          |                          |                                  |                              |                                                         |
| <sup>128</sup> Pm  |                                  | 127.9484                 | 1.0 s                                  | $\beta^+$ , p                     |                                          |                          |                                  |                              | ann.rad.                                                |
| <sup>129</sup> Pm  |                                  | 128.9432                 | ~ 2.4 s                                |                                   |                                          |                          |                                  |                              |                                                         |
| <sup>130</sup> Pm  |                                  | 129.9405                 | 2.5 s                                  | $\beta^+$ , EC/11.                |                                          |                          |                                  |                              | 0.1589<br>0.326–1.062                                   |
| <sup>131</sup> Pm  |                                  | 130.9359                 | ~ 6.3 s                                | $\beta^+$                         |                                          |                          |                                  |                              | 0.185<br>0.220<br>0.146                                 |
| <sup>132</sup> Pm  |                                  | 131.9338                 | 6. s                                   | $\beta^+$ , EC/10.                |                                          |                          |                                  |                              | ann.rad./                                               |
| <sup>133</sup> Pm  |                                  | 132.92978                | 12. s                                  | $\beta^+$ , EC/~ 7.0              |                                          |                          |                                  |                              | ann.rad./                                               |
| <sup>134</sup> Pm  |                                  | 133.9284                 | 24. s                                  | $\beta^+$ , EC/~ 8.9              |                                          | (5+)                     |                                  |                              | ann.rad./                                               |



| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)  | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)           |
|------------------------|----------------------------------|--------------------------|----------------------------------------|----------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------------------------------------|
| <sup>150</sup> Pm      |                                  | 149.92098                | 2.68 h                                 | $\beta^-$ /3.45                  | 1.6/<br>2.3/<br>1.8/                     | (1-)                     |                                  |                              | 0.3339/69.<br>1.1658/16.<br>1.3245/17.<br>(0.25–2.9) |
| <sup>151</sup> Pm      |                                  | 150.92121                | 1.183 d                                | $\beta^-$ /1.187                 | 0.84/                                    | 5/2+                     | +1.8                             | 1.9                          | 0.1677/8<br>0.2751/7<br>0.3401/22                    |
| <sup>152m2</sup> Pm    |                                  |                          | 15. m                                  | $\beta^-$ , I.T./                |                                          | (>6)                     |                                  |                              | (0.14–1.4)                                           |
| <sup>152m1</sup> Pm    |                                  |                          | 7.5 m                                  | $\beta^-$ /                      |                                          | (4-)                     |                                  |                              | 0.1218<br>0.2447<br>0.3404<br>1.0971<br>1.4375       |
| <sup>152</sup> Pm      |                                  | 151.92350                | 4.1 m                                  | $\beta^-$ /3.5                   | 3.5/20<br>3.50/60                        | 1+                       |                                  |                              | 0.1218<br>(0.12–2.1)                                 |
| <sup>153</sup> Pm      |                                  | 152.92412                | 5.4 m                                  | $\beta^-$ /1.90                  | 1.7/                                     | (5/2-)                   |                                  |                              | 0.0910<br>0.1198<br>0.1273                           |
| <sup>154m</sup> Pm     |                                  |                          | 2.7 m                                  | $\beta^-$ /                      | 2.0/                                     |                          |                                  |                              | 0.0820<br>0.1848<br>1.4403                           |
| <sup>154</sup> Pm      |                                  | 153.92646                | 1.7 m                                  | $\beta^-$ /4.1                   | 1.9/                                     |                          |                                  |                              | 0.0820<br>0.8396<br>1.3940<br>2.0589<br>(0.08–2.8)   |
| <sup>155</sup> Pm      |                                  | 154.92810                | 48. s                                  | $\beta^-$ /3.2                   |                                          | (5/2-)                   |                                  |                              | (0.05–0.78)                                          |
| <sup>156</sup> Pm      |                                  | 155.93106                | 26.7 s                                 | $\beta^-$ /5.16                  |                                          |                          |                                  |                              |                                                      |
| <sup>157</sup> Pm      |                                  | 156.9330                 | 10.9 s                                 | $\beta^-$ /4.6                   |                                          |                          |                                  |                              |                                                      |
| <sup>158</sup> Pm      |                                  | 157.9366                 | 5. s                                   | $\beta^-$ /6.3                   |                                          |                          |                                  |                              |                                                      |
| <sup>159</sup> Pm      |                                  | 158.9390                 | 1.5 s                                  |                                  |                                          |                          |                                  |                              | (0.072-0.261)                                        |
| <sup>160</sup> Pm      |                                  | 159.9430                 |                                        |                                  |                                          |                          |                                  |                              |                                                      |
| <sup>161</sup> Pm      |                                  | 160.9459                 |                                        |                                  |                                          |                          |                                  |                              |                                                      |
| <sup>162</sup> Pm      |                                  | 161.950                  |                                        |                                  |                                          |                          |                                  |                              |                                                      |
| <sup>163</sup> Pm      |                                  | 162.954                  |                                        |                                  |                                          |                          |                                  |                              |                                                      |
| <b><sup>62</sup>Sm</b> |                                  | <b>150.36(2)</b>         |                                        |                                  |                                          |                          |                                  |                              |                                                      |
| <sup>129</sup> Sm      |                                  | 128.954                  | ~ 0.55 s                               | $\beta^+$ , p                    |                                          |                          |                                  |                              |                                                      |
| <sup>130</sup> Sm      |                                  | 129.9489                 |                                        |                                  |                                          | 0+                       |                                  |                              |                                                      |
| <sup>131</sup> Sm      |                                  | 130.9461                 | 1.2 s                                  | $\beta^+$ , EC/                  |                                          |                          |                                  |                              | ann.rad./                                            |
| <sup>132</sup> Sm      |                                  | 131.9407                 | 4.0 s                                  | $\beta^+$                        |                                          | 0+                       |                                  |                              |                                                      |
| <sup>133</sup> Sm      |                                  | 132.9387                 | 2.9 s                                  | $\beta^+$ , EC/~ 8.4             |                                          | 5/2+                     |                                  |                              | ann.rad./<br>0.3696<br>0.0845                        |
| <sup>134</sup> Sm      |                                  | 133.9340                 | 11. s                                  | $\beta^+$ , EC/5.                |                                          | 0+                       |                                  |                              | ann.rad./                                            |
| <sup>135</sup> Sm      |                                  | 134.9325                 | 10. s                                  | $\beta^+$ , EC/7.                |                                          | 7/2+                     |                                  |                              | ann.rad./                                            |
| <sup>136</sup> Sm      |                                  | 135.92828                | 42. s                                  | $\beta^+$ , EC/4.5               |                                          | 0+                       |                                  |                              | ann.rad./                                            |
| <sup>137</sup> Sm      |                                  | 136.92697                | 45. s                                  | $\beta^+$ , EC/6.1               |                                          |                          |                                  |                              | ann.rad./                                            |
| <sup>138</sup> Sm      |                                  | 137.92324                | 3.0 m                                  | $\beta^+$ , EC/3.9               |                                          | 0+                       |                                  |                              | ann.rad./<br>0.0536<br>0.0747                        |
| <sup>139m</sup> Sm     |                                  |                          | 10. s                                  | I.T./94 /0.457<br>$\beta^+$ /6 / | 4.7                                      | (11/2-)                  | 1.1                              |                              | Sm k x-ray<br>0.1118<br>0.1553<br>0.1901<br>0.2673   |
| <sup>139</sup> Sm      |                                  | 138.92230                | 2.6 m                                  | $\beta^+$ /75 /5.5<br>EC/25 /    | 4.1/                                     | ½+                       | -0.53                            |                              | Pm k x-ray<br>0.3678<br>0.4028                       |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>140</sup> Sm  |                                  | 139.91900                | 14.8 m                                 | $\beta^+$ , EC/3.4              | 1.9/                                     | 0+                       |                                  |                              | (0.27–2.4)<br>ann.rad./                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | Pm k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1396                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2255                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.07–1.7)                                 |
| <sup>141m</sup> Sm |                                  |                          | 22.6 m                                 | $\beta^+$ /32 /                 | 1.6/                                     | 11/2-                    | -0.83                            | +1.6                         | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/68 /                         | 2.19/                                    |                          |                                  |                              | Pm k x-ray                                 |
|                    |                                  |                          |                                        | I.T./0.3 /0.1758                |                                          |                          |                                  |                              | 0.1966                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4318                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7774                                     |
| <sup>141</sup> Sm  |                                  | 140.91848                | 10.2 m                                 | $\beta^+$ /52 /4.54             | 3.2/                                     | $\frac{1}{2}+$           | -0.74                            |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/48 /                         |                                          |                          |                                  |                              | Pm k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4382                                     |
| <sup>142</sup> Sm  |                                  | 141.91520                | 1.208 h                                | $\beta^+$ /6 /2.10              | 1.0/                                     | 0+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/94 /                         |                                          |                          |                                  |                              | Pm k x-ray                                 |
| <sup>143m</sup> Sm |                                  |                          | 1.10 m                                 | IT/99/0.7540                    |                                          | 11/2-                    |                                  |                              | Sm k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7540                                     |
| <sup>143</sup> Sm  |                                  | 142.914628               | 8.83 m                                 | $\beta^+$ /46 /3.443            | 2.47/                                    | 3/2+                     | +1.01                            | +0.4                         | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/54 /                         |                                          |                          |                                  |                              | Pm k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.0565                                     |
| <sup>144</sup> Sm  | 3.083(20)                        | 143.911999               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>145</sup> Sm  |                                  | 144.913410               | 340. d                                 | EC/0.617                        |                                          | 7/2-                     | -1.12                            | -0.60                        | Pm k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0613                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4924                                     |
| <sup>146</sup> Sm  |                                  | 145.913041               | $1.03 \times 10^8$ y                   | $\alpha$ /                      | 2.50/                                    | 0+                       |                                  |                              |                                            |
| <sup>147</sup> Sm  | 15.017(75)                       | 146.914898               | $1.06 \times 10^{11}$ y                | $\alpha$ /                      | 2.23/                                    | 7/2-                     | -0.815                           | -0.26                        |                                            |
| <sup>148</sup> Sm  | 11.254(51)                       | 147.914823               | $7 \times 10^{15}$ y                   | $\alpha$ /                      | 1.96/                                    | 0+                       |                                  |                              |                                            |
| <sup>149</sup> Sm  | 13.830(56)                       | 148.917185               | $10^{16}$ y                            | $\alpha$ /                      |                                          | 7/2-                     | -0.672                           | +0.075                       |                                            |
| <sup>150</sup> Sm  | 7.351(36)                        | 149.917276               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>151</sup> Sm  |                                  | 150.919932               | 90. y                                  | $\beta^-$ /0.0768               | 0.076/                                   | 5/2-                     | -0.363                           | +0.7                         | 0.02154                                    |
| <sup>152</sup> Sm  | 26.735(48)                       | 151.919732               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>153</sup> Sm  |                                  | 152.922097               | 1.929 d                                | $\beta^-$ /0.808                | 0.64/                                    | 3/2+                     | -0.0216                          | +1.3                         | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 | 0.69/                                    |                          |                                  |                              | 0.0697/4.7                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.10318/29                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.075–0.714                                |
| <sup>154</sup> Sm  | 22.730(78)                       | 153.922209               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>155</sup> Sm  |                                  | 154.924640               | 22.2 m                                 | $\beta^-$ /1.627                | 1.52                                     | 3/2-                     |                                  | 1.1                          | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1043/75.                                 |
| <sup>156</sup> Sm  |                                  | 155.92553                | 9.4 h                                  | $\beta^-$ /0.72                 | 0.43/                                    | 0+                       |                                  |                              | 0.0872                                     |
|                    |                                  |                          |                                        |                                 | 0.71/                                    |                          |                                  |                              | 0.1657                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2038                                     |
| <sup>157</sup> Sm  |                                  | 156.92836                | 8.0 m                                  | $\beta^-$ /2.7                  | 2.4/                                     | 3/2-                     |                                  |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1964                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1978                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3942                                     |
| <sup>158</sup> Sm  |                                  | 157.9300                 | 5.5 m                                  | $\beta^-$ /2.0                  |                                          | 0+                       |                                  |                              | 0.1894/100.                                |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3636/82.                                 |
| <sup>159</sup> Sm  |                                  | 158.9332                 | 11.3 s                                 | $\beta^-$ /3.8                  |                                          |                          |                                  |                              | 0.1898                                     |
| <sup>160</sup> Sm  |                                  | 159.9351                 | 9.6 s                                  | $\beta^-$ /3.6                  |                                          | 0+                       |                                  |                              | 0.110                                      |
| <sup>161</sup> Sm  |                                  | 160.9388                 | ~ 4.8 s                                |                                 |                                          |                          |                                  |                              | 0.264                                      |
| <sup>162</sup> Sm  |                                  | 161.941                  | 2.4 s                                  |                                 |                                          | 0+                       |                                  |                              | (0.036-0.741)                              |
| <sup>163</sup> Sm  |                                  | 162.945                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>164</sup> Sm  |                                  | 163.948                  |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>165</sup> Sm  |                                  | 164.953                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>63</sup> Eu   |                                  | 151.964(1)               |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>130</sup> Eu  |                                  | 129.964                  | 0.9 ms                                 | p                               | 1.027/                                   |                          |                                  |                              |                                            |
| <sup>131</sup> Eu  |                                  | 130.9578                 | ~ 26. ms                               | $\beta^+$ , p                   | p/0.95                                   |                          |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)              | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                  |
|--------------------|----------------------------------|--------------------------|----------------------------------------|----------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-------------------------------------------------------------|
| <sup>132</sup> Eu  |                                  | 131.9544                 |                                        |                                              |                                          |                          |                                  |                              |                                                             |
| <sup>133</sup> Eu  |                                  | 132.9492                 |                                        |                                              |                                          |                          |                                  |                              |                                                             |
| <sup>134</sup> Eu  |                                  | 133.9465                 | 0.5 s                                  | EC, $\beta^+$                                |                                          |                          |                                  |                              | ann.rad./                                                   |
| <sup>135</sup> Eu  |                                  | 134.9418                 | 1.5 s                                  | EC, $\beta^+$ /~ 8.7                         |                                          |                          |                                  |                              | ann.rad./                                                   |
| <sup>136m</sup> Eu |                                  |                          | ~ 3.2 s                                |                                              |                                          | 7+                       |                                  |                              | 0.255                                                       |
| <sup>136</sup> Eu  |                                  | 135.9396                 | ~ 3.9 s                                | EC, $\beta^+$ /10.                           |                                          | 1+                       |                                  |                              | ann.rad./                                                   |
| <sup>137</sup> Eu  |                                  | 136.9356                 | 11. s                                  | EC/~ 7.5                                     |                                          | 11/2-                    |                                  |                              | ann.rad./                                                   |
| <sup>138</sup> Eu  |                                  | 137.93371                | 12. s                                  | EC, $\beta^+$ /~ 9.2                         |                                          | 7+                       | 5                                |                              | ann.rad./                                                   |
| <sup>139</sup> Eu  |                                  | 138.92979                | 18. s                                  | EC, $\beta^+$ /6.7                           |                                          |                          | 6                                |                              | ann.rad./                                                   |
| <sup>140m</sup> Eu |                                  |                          | 0.125 s                                | EC, $\beta^+$                                |                                          |                          |                                  |                              | ann.rad./                                                   |
| <sup>140</sup> Eu  |                                  | 139.9281                 | 1.51 s                                 | EC, $\beta^+$ /8.4                           |                                          | 1-                       |                                  |                              | ann.rad./                                                   |
| <sup>141m</sup> Eu |                                  |                          | 3.0 s                                  | $\beta^+$ /58 /<br>EC/9 /<br>I.T./33 /0.0964 |                                          | 11/2-                    |                                  |                              | ann.rad./<br>Eu k x-ray<br>(0.09–1.6)                       |
| <sup>141</sup> Eu  |                                  | 140.92493                | 40. s                                  | $\beta^+$ /81 /5.6<br>EC/15 /                |                                          | 5/2+                     | +3.49                            | +0.85                        | ann.rad./<br>Sm k x-ray                                     |
|                    |                                  |                          |                                        |                                              |                                          |                          |                                  |                              | 0.3845<br>0.3940                                            |
| <sup>142m</sup> Eu |                                  |                          | 1.22 m                                 | $\beta^+$ /83 /<br>EC/17 /                   | 4.8/                                     | 8-                       | +2.98                            | +1.4                         | ann.rad./<br>Sm k x-ray                                     |
|                    |                                  |                          |                                        |                                              |                                          |                          |                                  |                              | 0.5566<br>0.7680                                            |
|                    |                                  |                          |                                        |                                              |                                          |                          |                                  |                              | 1.0233                                                      |
| <sup>142</sup> Eu  |                                  | 141.92343                | 2.4 s                                  | $\beta^-$ /94/7.4<br>EC/6 /                  | 7.0/                                     | 1+                       | +1.54                            | +0.12                        | ann.rad./<br>0.7680                                         |
| <sup>143</sup> Eu  |                                  | 142.92030                | 2.62 m                                 | $\beta^+$ /72/5.17<br>EC/28/                 | 4.1/<br>5.1/                             | 5/2+                     | +3.67                            | +0.51                        | ann.rad./<br>Sm k x-ray                                     |
|                    |                                  |                          |                                        |                                              |                                          |                          |                                  |                              | 0.1107/7<br>1.5368/3.<br>1.9127/2.                          |
| <sup>144</sup> Eu  |                                  | 143.91882                | 10.2 s                                 | $\beta^+$ /86 /6.33<br>EC/13 /               | 5.31/                                    | 1+                       | +1.89                            | +0.10                        | ann.rad./<br>Sm k x-ray                                     |
|                    |                                  |                          |                                        |                                              |                                          |                          |                                  |                              | 1.6601                                                      |
| <sup>145</sup> Eu  |                                  | 144.916265               | 5.93 d                                 | $\beta^+$ /2 /2.660<br>EC/98 /1.71           | 0.79/                                    | 5/2+                     | +4.00                            | +0.29                        | ann.rad./<br>Sm k x-ray                                     |
|                    |                                  |                          |                                        |                                              |                                          |                          |                                  |                              | 0.6535<br>0.8937<br>1.6587                                  |
| <sup>146</sup> Eu  |                                  | 145.91721                | 4.57 d                                 | $\beta^+$ /5 /3.88<br>EC/95 /                | 1.47/                                    | 4-                       | +1.42                            | -0.18                        | ann.rad./<br>Sm k x-ray                                     |
|                    |                                  |                          |                                        |                                              |                                          |                          |                                  |                              | 0.6336<br>0.6341<br>0.7470<br>(0.27–2.64)                   |
| <sup>147</sup> Eu  |                                  | 146.916746               | 24.4 d                                 | EC/99. /1.722<br>$\beta^+$ /0.4 /            |                                          | 5/2+                     | +3.72                            | +0.53                        | Sm k x-ray<br>0.12113/20.6<br>0.19725/24.0<br>(0.601–1.077) |
| <sup>148</sup> Eu  |                                  | 147.91809                | 54.5 d                                 | EC/3.11                                      | 0.92                                     | 5-                       | +2.34                            | +0.35                        | Sm k x-ray<br>0.5503/99.<br>0.6299/71.<br>(0.067–2.17)      |
| <sup>149</sup> Eu  |                                  | 148.917931               | 93.1 d                                 | EC/0.692                                     |                                          | 5/2+                     | +3.57                            | +0.75                        | Sm k x-ray<br>0.2770/4.1<br>0.3275/4.8                      |
| <sup>150</sup> Eu  |                                  | 149.91970                | 36. y                                  | EC/2.26                                      |                                          | 5-                       | +2.71                            | +1.13                        | Sm k x-ray<br>0.3340<br>0.4394<br>0.5843<br>(0.25–1.8)      |



| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>150m</sup> Eu  |                                  |                          | 12.8 h                                 | $\beta^-$ /92 /                 | 1.013/                                   | 0-                       |                                  |                              | Sm k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^+$ /0.4 /                | 1.24/                                    |                          |                                  |                              | 0.3339                                     |
|                     |                                  |                          |                                        | EC/8 /                          |                                          |                          |                                  |                              | 0.4065                                     |
| <sup>151</sup> Eu   | 47.81(6)                         | 150.919850               |                                        |                                 |                                          | 5/2+                     | +3.472                           | +0.90                        |                                            |
| <sup>152m2</sup> Eu |                                  |                          | 1.60 h                                 | I.T./0.1478                     |                                          | 8-                       |                                  |                              | Eu k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0898                                     |
| <sup>152m1</sup> Eu |                                  |                          | 9.30 h                                 | $\beta^-$ /72 /                 | 1.85/                                    | 0-                       |                                  |                              | Sm k x-ray                                 |
|                     |                                  |                          |                                        | EC/28 /                         | 0.89/                                    |                          |                                  |                              | 0.12178                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.84153                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.96334                                    |
| <sup>152</sup> Eu   |                                  | 151.921745               | 13.5 y                                 | EC/72 /1.874                    | 0.69/                                    | 3-                       | -1.941                           | +2.71                        | Sm k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^-$ /28 /1.818            | 1.47/                                    |                          |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.12178                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.34427                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.40802                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.252–1.528)                              |
| <sup>153</sup> Eu   | 52.19(6)                         | 152.921230               |                                        |                                 |                                          | 5/2+                     | +1.533                           | +2.41                        |                                            |
| <sup>154m</sup> Eu  |                                  |                          | 46.1 m                                 | I.T./~ 0.16                     |                                          | 8-                       |                                  |                              | Eu k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0682                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1009                                     |
| <sup>154</sup> Eu   |                                  | 153.922979               | 8.59 y                                 | $\beta^-$ /99.9/1.969           | 0.27/29                                  | 3-                       | -2.01                            | +2.8                         | Gd k x-ray                                 |
|                     |                                  |                          |                                        | EC/0.02/0.717                   | 0.58/38                                  |                          |                                  |                              | 0.12299/40.                                |
|                     |                                  |                          |                                        |                                 | 0.84/17                                  |                          |                                  |                              | 0.72331/20.                                |
|                     |                                  |                          |                                        |                                 | 0.98/4                                   |                          |                                  |                              | 1.2745/36                                  |
|                     |                                  |                          |                                        |                                 | 1.87/11                                  |                          |                                  |                              | (0.059-1.90)                               |
| <sup>155</sup> Eu   |                                  | 154.922893               | 4.76 y                                 | $\beta^-$ /0.252                | 0.15/                                    | 5/2+                     | +1.52                            | +2.4                         | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0865/30                                  |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1053/20                                  |
| <sup>156</sup> Eu   |                                  | 155.92475                | 15.2 d                                 | $\beta^-$ /2.451                | 0.30/11                                  | 1+                       | ≈1.1                             |                              | 0.08899/9.                                 |
|                     |                                  |                          |                                        |                                 | 0.49/30                                  |                          |                                  |                              | 0.64623/7.                                 |
|                     |                                  |                          |                                        |                                 | 1.2/12                                   |                          |                                  |                              | 0.723441/6.                                |
|                     |                                  |                          |                                        |                                 | 2.45/31                                  |                          |                                  |                              | 0.8118/10.                                 |
| <sup>157</sup> Eu   |                                  | 156.92542                | 15.13 h                                | $\beta^-$ /1.36                 | 0.98/                                    | (5/2+)                   | +1.50                            | +2.6                         | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 | 1.30/41                                  |                          |                                  |                              | 0.0639/100.                                |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3705/48.                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4107/76.                                 |
| <sup>158</sup> Eu   |                                  | 157.9279                 | 45.9 m                                 | $\beta^-$ /3.5                  | 2.5/                                     | (1-)                     | +1.44                            | +0.7                         | 0.0795                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8976                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9442                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9771                                     |
| <sup>159</sup> Eu   |                                  | 158.92909                | 18.1 m                                 | $\beta^-$ /2.51                 | 2.4/                                     | (5/2+)                   | +1.38                            | +2.7                         | 0.0678                                     |
|                     |                                  |                          |                                        |                                 | 2.57/                                    |                          |                                  |                              | 0.0786                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0957                                     |
| <sup>160</sup> Eu   |                                  | 159.9320                 | 38. s                                  | $\beta^-$ /4.1                  | 2.7/                                     | (0-)                     |                                  |                              | 0.0753                                     |
|                     |                                  |                          |                                        |                                 | 4.1/                                     |                          |                                  |                              | 0.1735                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4131                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5155                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8217                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9110                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9246                                     |
| <sup>161</sup> Eu   |                                  | 160.9337                 | 27. s                                  | $\beta^-$ /3.7                  |                                          |                          |                                  |                              | 0.0719                                     |
| <sup>162</sup> Eu   |                                  | 161.9370                 | 11. s                                  | $\beta^-$ /5.6                  |                                          |                          |                                  |                              |                                            |
| <sup>163</sup> Eu   |                                  | 162.9392                 |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>164</sup> Eu   |                                  | 163.943                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>165</sup> Eu   |                                  | 164.946                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>166</sup> Eu   |                                  | 165.950                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>167</sup> Eu   |                                  | 166.953                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>64</sup> Gd    |                                  | 157.25(3)                |                                        |                                 |                                          |                          |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>135</sup> Gd  |                                  | 134.953                  | 1.1 s                                  | $\beta^+$                       |                                          |                          |                                  |                              | (0.163–0.360)                              |
| <sup>136</sup> Gd  |                                  | 135.9473                 |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>137</sup> Gd  |                                  | 136.9450                 | 7. s                                   | EC, $\beta^+$ /~ 8.8            |                                          |                          |                                  |                              | ann.rad./                                  |
| <sup>138</sup> Gd  |                                  | 137.9401                 | ~ 4.7 s                                | EC, $\beta^+$                   |                                          | 0+                       |                                  |                              | 0.0647                                     |
| <sup>139m</sup> Gd |                                  |                          | ~ 4.8 s                                |                                 |                                          |                          |                                  |                              | 0.1216                                     |
| <sup>139</sup> Gd  |                                  | 138.9382                 | 5. s                                   | EC, $\beta^+$ /~ 7.7            |                                          |                          |                                  |                              | 0.104–0.323                                |
| <sup>140</sup> Gd  |                                  | 139.93367                | 16. s                                  | EC/4.8                          |                                          | 0+                       |                                  |                              | 0.1748                                     |
| <sup>141m</sup> Gd |                                  |                          | 25. s                                  | EC, $\beta^+$ /                 |                                          | 11/2-                    |                                  |                              | ann.rad./                                  |
| <sup>141</sup> Gd  |                                  | 140.93213                | 21. s                                  | $\beta^+$ /7.3                  |                                          | $\frac{1}{2}^+$          |                                  |                              | ann.rad./                                  |
| <sup>142</sup> Gd  |                                  | 141.92812                | 1.17 m                                 | EC, $\beta^+$ /4.2              |                                          | 0+                       |                                  |                              | ann.rad./                                  |
| <sup>143m</sup> Gd |                                  |                          | 1.84 m                                 | $\beta^+$ /67 /                 |                                          | 11/2-                    |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/33 /                         |                                          |                          |                                  |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        | I.T./                           |                                          |                          |                                  |                              | 0.1176                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2719                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.5880                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6681                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7999                                     |
| <sup>143</sup> Gd  |                                  | 142.9268                 | 39. s                                  | $\beta^+$ /82 /6.0              |                                          | 1/2+                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/18 /                         |                                          |                          |                                  |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2048                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2588                                     |
| <sup>144</sup> Gd  |                                  | 143.92296                | 4.5 m                                  | $\beta^+$ /45 /4.3              | 3.3/                                     | 0+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/55 /                         |                                          |                          |                                  |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3332                                     |
| <sup>145m</sup> Gd |                                  |                          | 1.44 m                                 | I.T./95 /0.749                  |                                          | 11/2-                    | -1.0                             |                              | 0.0273                                     |
|                    |                                  |                          |                                        | $\beta^+$ /4 /5.7               |                                          |                          |                                  |                              | 0.3295                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3866                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7214                                     |
| <sup>145</sup> Gd  |                                  | 144.92171                | 23.4 m                                 | $\beta^+$ /33 /5.05             | 2.5/                                     | 1/2+                     | -0.74                            |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/67 /                         |                                          |                          |                                  |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.7579                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.8806                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.32–3.69)                                |
| <sup>146</sup> Gd  |                                  | 145.918311               | 48.3 d                                 | EC/99.9 /1.03                   | 0.35/                                    | 0+                       |                                  |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        | $\beta^+$ /0.2                  |                                          |                          |                                  |                              | 0.1147                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1155                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1546                                     |
| <sup>147</sup> Gd  |                                  | 146.919094               | 1.588 d                                | EC/99.8 /2.188                  | 0.93/                                    | 7/2-                     | 1.0                              |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        | EC/0.2 /                        |                                          |                          |                                  |                              | 0.2293                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3699                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3960                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9289                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.1–1.8)                                  |
| <sup>148</sup> Gd  |                                  | 147.918115               | 71. y                                  | $\alpha$ /3.27                  | 3.1828/                                  | 0+                       |                                  |                              |                                            |
| <sup>149</sup> Gd  |                                  | 148.919341               | 9.3 d                                  | EC/1.32                         |                                          | 7/2-                     | 0.9                              |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1496                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2985                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3465                                     |
| <sup>150</sup> Gd  |                                  | 149.91866                | $1.8 \times 10^6$ y                    | $\alpha$ /2.80                  | 2.73/                                    | 0+                       |                                  |                              |                                            |
| <sup>151</sup> Gd  |                                  | 150.920348               | 124. d                                 | EC/0.464                        |                                          | 7/2-                     | 0.8                              |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1536                                     |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2432                                     |
| <sup>152</sup> Gd  | 0.20(1)                          | 151.919791               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>153</sup> Gd  |                                  | 152.921750               | 240. d                                 | EC/0.485                        |                                          | 3/2-                     | 0.4                              |                              | Eu k x-ray                                 |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.09743                                    |
|                    |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.10318                                    |
| <sup>154</sup> Gd  | 2.18(3)                          | 153.920867               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>155</sup> Gd  | 14.80(12)                        | 154.922622               |                                        |                                 |                                          | 3/2-                     | -0.259                           | +1.30                        |                                            |
| <sup>156</sup> Gd  | 20.47(9)                         | 155.922123               |                                        |                                 |                                          | 0+                       |                                  |                              |                                            |
| <sup>157</sup> Gd  | 15.65(2)                         | 156.923960               |                                        |                                 |                                          | 3/2-                     | -0.340                           | +1.36                        |                                            |



| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>148</sup> Tb   | 147.92427                        | 1.00 h                   | $\beta$ +, EC/5.69                     |                                 |                                          | 2-                            | -1.75                            | -0.3                         | 0.8824                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.4888                                     |
| <sup>149m</sup> Tb  |                                  | 4.16 m                   | EC/88 /<br>$\beta$ + /12 /             |                                 |                                          | 11/2-                         |                                  |                              | 0.7845<br>(0.14–3.8)                       |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.1650                                     |
| <sup>149</sup> Tb   | 148.923246                       | 4.13 h                   | $\beta$ + /4 /3.636<br>$\alpha$ /16/   | 1.8/<br>3.97/                   |                                          | $\frac{1}{2}$ +               | +1.35                            |                              | 0.7960                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.1650                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.3522                                     |
| <sup>150m</sup> Tb  |                                  | 6.0 m                    | $\beta$ + /17 /<br>EC/83 /             |                                 |                                          |                               |                                  |                              | 0.3886<br>(0.1–3.2)                        |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.4384                                     |
| <sup>150</sup> Tb   | 149.92366                        | 3.3 h                    | $\beta$ +, EC/4.66                     |                                 |                                          | 2-                            | -0.90                            |                              | 0.6380                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.6504                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.8275                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | ann.rad./                                  |
| <sup>151m</sup> Tb  |                                  | 25. s                    | I.T./95 /<br>$\beta$ +, EC/7 /         |                                 |                                          | 11/2-                         |                                  |                              | 0.4963                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.6380                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | (0.3–4.29)                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.0229                                     |
| <sup>151</sup> Tb   | 150.923103                       | 17.61 h                  | $\beta$ + /1 /2.565<br>EC/99 /         | 0.70/                           |                                          | 1/2+                          | +0.92                            |                              | 0.0495                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.3797                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.8305                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
| <sup>152m</sup> Tb  |                                  | 4.3 m                    | I.T./79 /0.5018<br>EC/21 /4.35         |                                 |                                          | (8+)                          |                                  |                              | 0.1083                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2517                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2870                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | (0.1–1.8)                                  |
| <sup>152</sup> Tb   | 151.92407                        | 17.5 h                   | $\beta$ + /20 /3.99<br>EC/80 /         | 2.5/<br>2.8/                    |                                          | 2-                            | -0.58                            | +0.3                         | Tb k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2833                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.3443                                     |
| <sup>153</sup> Tb   | 152.923435                       | 2.34 d                   | EC/1.570                               |                                 |                                          | 5/2+                          | +3.44                            | +1.1                         | 0.4111                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2119                                     |
| <sup>154m2</sup> Tb |                                  | 23.1 h                   | EC/98 /<br>I.T./2 /                    |                                 |                                          | (7-)                          | 0.9                              |                              | (0.05–1.1)                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.1231                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2479                                     |
| <sup>154m1</sup> Tb |                                  | 9. h                     | $\beta$ + /78 /<br>I.T./22 /           |                                 |                                          | (3-)                          | 1.7                              | +3.                          | 0.3467                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.1231                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.2479                                     |
| <sup>154</sup> Tb   | 153.92468                        | 21.5 h                   | EC/99 /3.56<br>$\beta$ + /1 /          | 1.86/<br>2.45                   |                                          | 0-                            |                                  |                              | 0.5401<br>(0.12–2.57)                      |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 0.1231                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 1.2744                                     |
|                     |                                  |                          |                                        |                                 |                                          |                               |                                  |                              | 2.1872                                     |

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>155</sup> Tb   |                                  | 154.92351                | 5.3 d                                  | EC/0.82                         |                                          | 3/2+                     | +2.01                            | +1.41                        | (0.12–3.14)<br>Gd k x-ray                  |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.08654                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.10530                                    |
| <sup>156m2</sup> Tb |                                  |                          | 1.02 d                                 | I.T./                           |                                          | (7-)                     |                                  |                              | Tb k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0496                                     |
| <sup>156m1</sup> Tb |                                  |                          | 5.3 h                                  | I.T./0.0884                     |                                          | (0+)                     |                                  |                              | Tb k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0884                                     |
| <sup>156</sup> Tb   |                                  | 155.924747               | 5.3 d                                  | EC/2.444                        |                                          | 3-                       | ~ 1.7                            | +2.                          | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.08896                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.19921                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.53435                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.22245                                    |
| <sup>157</sup> Tb   |                                  | 156.924025               | $1.1 \times 10^2$ y                    | EC/0.0601                       |                                          | 3/2+                     | +2.01                            | +1.4                         | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0545                                     |
| <sup>158m</sup> Tb  |                                  |                          | 10.5 s                                 | I.T./0.11                       |                                          | 0-                       |                                  |                              | Gd k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0110                                     |
| <sup>158</sup> Tb   |                                  | 157.925413               | $1.8 \times 10^2$ y                    | EC/80 /1.220                    |                                          | 3-                       | +1.76                            | +2.7                         | Gd k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^-$ /20 /0.937            |                                          |                          |                                  |                              | 0.0795                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9442                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9621                                     |
| <sup>159</sup> Tb   | 100.                             | 158.925347               |                                        |                                 |                                          | 3/2+                     | +2.014                           | +1.43                        |                                            |
| <sup>160</sup> Tb   |                                  | 159.927168               | 72.3 d                                 | $\beta^-$ /1.835                | 0.57/47                                  | 3-                       | +1.79                            | 3.8                          | Dy k x-ray                                 |
|                     |                                  |                          |                                        |                                 | 0.86/27                                  |                          |                                  |                              | 0.08678                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.29857                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.87936                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.96615                                    |
| <sup>161</sup> Tb   |                                  | 160.927570               | 6.91 d                                 | $\beta^-$ /0.593                | 0.46/23                                  | 3/2+                     | 2.2                              | +1.2                         | Dy k x-ray                                 |
|                     |                                  |                          |                                        |                                 | 0.52/66                                  |                          |                                  |                              | 0.02565                                    |
|                     |                                  |                          |                                        |                                 | 0.6/10                                   |                          |                                  |                              | 0.04892                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.07458                                    |
| <sup>162</sup> Tb   |                                  | 161.92949                | 7.6 m                                  | $\beta^-$ /2.51                 | 1.4                                      | (1/2-)                   |                                  |                              | Dy k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2600                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8075                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8882                                     |
| <sup>163</sup> Tb   |                                  | 162.930648               | 19.5 m                                 | $\beta^-$ /1.785                | 0.80/                                    | 3/2+                     |                                  |                              | Dy k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3511                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3897                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.4945                                     |
| <sup>164</sup> Tb   |                                  | 163.9334                 | 3.0 m                                  | $\beta^-$ /3.9                  | 1.7/                                     | (5+)                     |                                  |                              | Dy k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1689                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2157                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6110                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6885                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7548                                     |
| <sup>165</sup> Tb   |                                  | 164.9349                 | 2.1 m                                  | $\beta^-$ /3.0                  |                                          | 3/2+                     |                                  |                              | 0.5389                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.1785                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.2920                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.6648                                     |
| <sup>166</sup> Tb   |                                  | 165.9380                 | 26 s                                   | $\beta^-$ /                     |                                          |                          |                                  |                              |                                            |
| <sup>167</sup> Tb   |                                  | 166.9401                 | 19 s                                   |                                 |                                          |                          |                                  |                              | 0.057                                      |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.070                                      |
| <sup>168</sup> Tb   |                                  | 167.944                  | 8 s                                    |                                 |                                          |                          |                                  |                              | 0.075–0.227                                |
| <sup>169</sup> Tb   |                                  | 168.946                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>170</sup> Tb   |                                  | 169.950                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>171</sup> Tb   |                                  | 170.953                  |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>66</sup> Dy    |                                  | 162.500(1)               |                                        |                                 |                                          |                          |                                  |                              |                                            |
| <sup>139</sup> Dy   |                                  | 138.960                  | 0.6 s                                  | $\beta^+$ , p                   |                                          |                          |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)                    | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                      |
|--------------------|----------------------------------|--------------------------|----------------------------------------|----------------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------------------------------|
| <sup>140</sup> Dy  |                                  | 139.954                  |                                        |                                                    |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>141</sup> Dy  |                                  | 140.9514                 | 0.9 s                                  | EC, $\beta^+$ /9.                                  |                                          |                          |                                  |                              |                                                                                 |
| <sup>142</sup> Dy  |                                  | 141.9464                 | 2.3 s                                  | EC, $\beta^+$ /7.1                                 |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>143</sup> Dy  |                                  | 142.9438                 | 3.9 s                                  | EC, $\beta^+$ /~ 8.8                               |                                          |                          |                                  |                              |                                                                                 |
| <sup>144</sup> Dy  |                                  | 143.93925                | 9.1 s                                  | EC, $\beta^+$ /~ 6.2                               |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>145m</sup> Dy |                                  | 144.9365                 | 14. s                                  | EC, $\beta^+$                                      |                                          | 11/2-                    |                                  |                              |                                                                                 |
| <sup>146m</sup> Dy |                                  |                          | 0.15 s                                 | I.T.                                               |                                          | 10+                      |                                  |                              |                                                                                 |
| <sup>146</sup> Dy  |                                  | 145.93285                | 30. s                                  | EC, $\beta^+$ /5.2                                 |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>147m</sup> Dy |                                  |                          | 56. s                                  | I.T./40 /<br>$\beta^+$ , EC/60 /                   |                                          | (11/2-)                  | -0.66                            | +0.7                         | Dy k x-ray<br>0.072<br>0.6787                                                   |
| <sup>147</sup> Dy  |                                  | 146.93109                | 75. s                                  | EC, $\beta^+$ /6.37                                |                                          | $\frac{1}{2}+$           | -0.92                            |                              | ann.rad./<br>0.1007<br>0.2534<br>0.3653                                         |
| <sup>148</sup> Dy  |                                  | 147.92715                | 3.1 m                                  | $\beta^+$ /4 /2.68<br>EC/96 /                      | 1.2/                                     | 0+                       |                                  |                              | ann.rad./<br>Tb k x-ray<br>0.6202                                               |
| <sup>149</sup> Dy  |                                  | 148.92731                | 4.2 m                                  | $\beta^+$ , EC/3.81                                |                                          | (7/2-)                   | -0.12                            | -0.62                        | ann.rad./<br>0.1008<br>0.1063<br>0.2534<br>0.6536<br>0.7894<br>1.7765<br>1.8062 |
| <sup>150</sup> Dy  |                                  | 149.925585               | 7.18 m                                 | $\beta^+$ , EC/67 /1.79<br>$\alpha$ /33 /          | 4.233/                                   | 0+                       |                                  |                              | Tb k x-ray<br>0.3967                                                            |
| <sup>151</sup> Dy  |                                  | 150.926185               | 17. m                                  | $\beta^+$ /5 /2.871<br>EC/89 /<br>$\alpha$ /6 /    | 4.067/                                   | 7/2-                     | -0.95                            | -0.30                        | Tb k x-ray<br>0.1764<br>0.3030<br>0.3861<br>0.5463<br>(0.16–2.09)               |
| <sup>152</sup> Dy  |                                  | 151.92472                | 2.37 h                                 | EC/0.60<br>$\alpha$ /                              | 3.63/                                    | 0+                       |                                  |                              | Tb k x-ray<br>0.2569                                                            |
| <sup>153</sup> Dy  |                                  | 152.925765               | 6.3 h                                  | $\beta^+$ /1 /2.171<br>EC/99 /<br>$\alpha$ /0.01 / | 0.89/<br>3.46/                           | (7/2-)                   | -0.78                            | ~-0.15                       | Tb k x-ray<br>0.0807<br>0.0997<br>0.2137<br>(0.08–1.66)                         |
| <sup>154</sup> Dy  |                                  | 153.92442                | $3. \times 10^6$ y                     | $\alpha$ /2.95                                     | 2.87/                                    | 0+                       |                                  |                              |                                                                                 |
| <sup>155</sup> Dy  |                                  | 154.92575                | 9.9 h                                  | $\beta^+$ /2 /2.095<br>EC/98 /                     | 0.845/                                   | 3/2-                     | -0.385                           | +1.04                        | Tb k x-ray<br>0.0655<br>0.2269                                                  |
| <sup>156</sup> Dy  | 0.056(3)                         | 155.92428                |                                        |                                                    |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>157</sup> Dy  |                                  | 156.92547                | 8.1 h                                  | EC/1.34                                            |                                          | 3/2-                     | -0.301                           | +1.30                        | Tb k x-ray<br>(0.0609–1.319)                                                    |
| <sup>158</sup> Dy  | 0.095(3)                         | 157.924409               |                                        |                                                    |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>159</sup> Dy  |                                  | 158.925739               | 144. d                                 | EC/0.366                                           |                                          | 3/2-                     | -0.354                           | +1.37                        | Tb k x-ray<br>0.3262                                                            |
| <sup>160</sup> Dy  | 2.329(18)                        | 159.925198               |                                        |                                                    |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>161</sup> Dy  | 18.889(42)                       | 160.926933               |                                        |                                                    |                                          | 5/2+                     | -0.480                           | +2.51                        |                                                                                 |
| <sup>162</sup> Dy  | 25.475(36)                       | 161.926798               |                                        |                                                    |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>163</sup> Dy  | 24.896(42)                       | 162.928731               |                                        |                                                    |                                          | 5/2-                     | +0.673                           | +2.65                        |                                                                                 |
| <sup>164</sup> Dy  | 28.260(54)                       | 163.929175               |                                        |                                                    |                                          | 0+                       |                                  |                              |                                                                                 |
| <sup>165m</sup> Dy |                                  |                          | 1.26 m                                 | I.T./98 /0.108<br>$\beta^-$ /2 /                   |                                          | 1/2-                     |                                  |                              | Dy k x-ray<br>0.1082<br>0.5155                                                  |
| <sup>165</sup> Dy  |                                  | 164.931703               | 2.33 h                                 | $\beta^-$ /1.286                                   | 1.29/                                    | 7/2+                     | -0.52                            | +3.5                         | Ho k x-ray                                                                      |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV)          | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>166</sup> Dy      |                                  | 165.932807               | 3.400 d                                | $\beta^-$ /0.486                         | 0.40/                                    | 0+                       |                                  |                              | 0.09468/3.8<br>Ho k x-ray                  |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.0282<br>0.0825                           |
| <sup>167</sup> Dy      |                                  | 166.9357                 | 6.2 m                                  | $\beta^-$ /~ 2.35                        | 1.78                                     | (1/2-)                   |                                  |                              | Ho k x-ray                                 |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.2593<br>0.3103<br>0.5697<br>(0.06–1.4)   |
| <sup>168</sup> Dy      |                                  | 167.9371                 | 8.5 m                                  | $\beta^-$ /1.6                           |                                          | 0+                       |                                  |                              | Ho k x-ray                                 |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.1925<br>0.4867                           |
| <sup>169</sup> Dy      |                                  | 168.9403                 | ~ 39. s                                | $\beta^-$ /3.2                           |                                          |                          |                                  |                              |                                            |
| <sup>170</sup> Dy      |                                  | 169.9424                 |                                        |                                          |                                          | 0+                       |                                  |                              |                                            |
| <sup>171</sup> Dy      |                                  | 170.9462                 |                                        |                                          |                                          |                          |                                  |                              |                                            |
| <sup>172</sup> Dy      |                                  | 171.9488                 |                                        |                                          |                                          | 0+                       |                                  |                              |                                            |
| <sup>173</sup> Dy      |                                  | 172.953                  |                                        |                                          |                                          |                          |                                  |                              |                                            |
| <b><sup>67</sup>Ho</b> |                                  | <b>164.93032(2)</b>      |                                        |                                          |                                          |                          |                                  |                              |                                            |
| <sup>140</sup> Ho      |                                  | 139.969                  | 6 ms                                   | p/                                       | p/1.09                                   |                          |                                  |                              |                                            |
| <sup>141m</sup> Ho     |                                  |                          | 8 $\mu$ s                              | p/                                       | p/1.23                                   |                          |                                  |                              |                                            |
| <sup>141</sup> Ho      |                                  | 140.963                  | 4.2 ms                                 | $\beta^+$ , p                            | p/1.71                                   |                          |                                  |                              |                                            |
| <sup>142</sup> Ho      |                                  | 141.960                  | 0.4 s                                  | EC/ $\beta^+$ , p                        |                                          |                          |                                  |                              | 0.307                                      |
| <sup>143</sup> Ho      |                                  | 142.9546                 | > 0.2 $\mu$ s                          |                                          |                                          |                          |                                  |                              |                                            |
| <sup>144</sup> Ho      |                                  | 143.9515                 | 0.7 s                                  | $\beta^+$ , EC/12                        |                                          |                          |                                  |                              |                                            |
| <sup>145</sup> Ho      |                                  | 144.9472                 | 2.4 s                                  | $\beta^+$                                |                                          |                          |                                  |                              |                                            |
| <sup>146</sup> Ho      |                                  | 145.9446                 | 3.3 s                                  | $\beta^+$ , EC/10.7                      |                                          | (10+)                    |                                  |                              | ann.rad./                                  |
| <sup>147</sup> Ho      |                                  | 146.94006                | 5.8 s                                  | $\beta^+$ , EC/8.2                       |                                          | 11/2-                    |                                  |                              | ann.rad./                                  |
| <sup>148m</sup> Ho     |                                  |                          | 9. s                                   | $\beta^+$ , EC/                          |                                          | 4-                       |                                  |                              | ann.rad./                                  |
| <sup>148</sup> Ho      |                                  | 147.9377                 | 2. s                                   | $\beta^+$ , EC/9.4                       |                                          | 1+                       |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.6615<br>1.6883                           |
| <sup>149m</sup> Ho     |                                  |                          | 21. s                                  | $\beta^+$ , EC/                          |                                          | 11/2-                    |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 1.0733<br>1.0911                           |
| <sup>149</sup> Ho      |                                  | 148.93378                | > 30. s                                | $\beta^+$ , EC/6.01                      |                                          | 1/2+                     |                                  |                              |                                            |
| <sup>150m</sup> Ho     |                                  |                          | 25. s                                  | $\beta^+$ , EC/                          |                                          | (9+)                     |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.3939<br>0.5511<br>0.6534<br>0.8034       |
| <sup>150</sup> Ho      |                                  | 149.93350                | 1.3 m                                  | $\beta^+$ , EC/6.6                       |                                          |                          |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.5913<br>0.6534<br>0.8034                 |
| <sup>151m</sup> Ho     |                                  |                          | 47. s                                  | $\beta^+$ , EC/87 /<br>$\alpha$ /13      | 4.605/                                   |                          |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.2102<br>0.4889<br>0.6948<br>0.7762       |
| <sup>151</sup> Ho      |                                  | 150.93169                | 35.2 s                                 | $\beta^+$ , EC/80/5.13<br>$\alpha$ /20 / | 4.519/                                   |                          |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.3522<br>0.5274<br>0.9676<br>1.0471       |
| <sup>152m</sup> Ho     |                                  |                          | 50. s                                  | $\beta^+$ , EC/90/<br>$\alpha$ /10/      | 4.453/                                   | (9+)                     | +5.9                             | -1.                          | ann.rad./                                  |
|                        |                                  |                          |                                        |                                          |                                          |                          |                                  |                              | 0.4929<br>0.6138<br>0.6474                 |

[illegible]



| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy<br>(/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2182                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9488                                     |
| <sup>159m</sup> Ho  |                                  |                          | 8.3 s                                  | IT/0.206                        |                                          | 1/2+                     |                                  |                              | Ho k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1660                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2059                                     |
| <sup>159</sup> Ho   |                                  | 158.927712               | 33.0 m                                 | EC/1.838                        |                                          | 7/2-                     | +4.28                            | +3.2                         | Dy k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1210                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1320                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2529                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.3096                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | (0.06–1.2)                                 |
| <sup>160m2</sup> Ho |                                  |                          | 3. s                                   |                                 |                                          | 1+                       |                                  |                              |                                            |
| <sup>160m</sup> Ho  |                                  |                          | 5.0 h                                  | IT/67/0.060                     |                                          | 2-                       | +2.52                            | +1.8                         | 0.0868                                     |
|                     |                                  |                          |                                        | EC/33/3.35                      |                                          |                          |                                  |                              | 0.1970                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.6464                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7281                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8791                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9619                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9658                                     |
| <sup>160</sup> Ho   |                                  | 159.92873                | 25.6 m                                 | $\beta^+$ , EC/3.29             | 0.57/                                    | 5+                       | +3.71                            | +4.0                         | See Ho[166m]                               |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.7282                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.8794                                     |
| <sup>161m</sup> Ho  |                                  |                          | 6.8 s                                  | IT/0.211                        |                                          |                          |                                  |                              | Ho k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2112                                     |
| <sup>161</sup> Ho   |                                  | 160.927855               | 2.48 h                                 | EC/0.859                        |                                          | 7/2-                     | +4.25                            | +3.2                         | Dy k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0256                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0592                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0774                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1031                                     |
| <sup>162m</sup> Ho  |                                  |                          | 1.12 h                                 | IT/61/                          |                                          | 6-                       | +3.60                            | +4.                          | Dy k x-ray                                 |
|                     |                                  |                          |                                        | EC/39/                          |                                          |                          |                                  |                              | Ho k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0807                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.1850                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2828                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.9372                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.2200                                     |
| <sup>162</sup> Ho   |                                  | 161.929096               | 15. m                                  | EC/96 /0.295                    |                                          | 1+                       |                                  |                              | Dy k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^+$ /4 /                  |                                          |                          |                                  |                              | 0.0807                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.3196                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.3728                                     |
| <sup>163m</sup> Ho  |                                  |                          | 1.09 s                                 | I.T./0.298                      |                                          | (1/2+)                   |                                  |                              | Ho k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.2798                                     |
| <sup>163</sup> Ho   |                                  | 162.928734               | $4.57 \times 10^3$ y                   | EC/0.00258                      |                                          | 7/2-                     | +4.23                            | +3.6                         | Dy M x-rays                                |
| <sup>164m</sup> Ho  |                                  |                          | 38. m                                  | I.T./0.140                      |                                          | (6-)                     |                                  |                              | Ho k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0373                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0566                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0940                                     |
| <sup>164</sup> Ho   |                                  | 163.930234               | 29. m                                  | EC/58 /0.987                    |                                          | 1+                       |                                  |                              | Dy k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^-$ /42 /0.963            |                                          |                          |                                  |                              | 0.0734                                     |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.0914                                     |
| <sup>165</sup> Ho   | 100.                             | 164.930322               |                                        |                                 |                                          | 7/2-                     | +4.17                            | +3.49                        |                                            |
| <sup>166m</sup> Ho  |                                  |                          | $1.2 \times 10^3$ y                    | $\beta^-$ /                     |                                          | 7-                       | 3.6                              | -3.                          | Er k x-ray                                 |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.18407                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.71169                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 0.81031                                    |
| <sup>166</sup> Ho   |                                  | 165.932284               | 1.117 d                                | $\beta^-$ /1.855                | 1.776/48                                 | 0-                       |                                  |                              | Er k x-ray                                 |
|                     |                                  |                          |                                        |                                 | 1.855/51                                 |                          |                                  |                              | 0.08057                                    |
|                     |                                  |                          |                                        |                                 |                                          |                          |                                  |                              | 1.37943                                    |
| <sup>167</sup> Ho   |                                  | 166.93313                | 3.1 h                                  | $\beta^-$ /1.007                | 0.31/43                                  | (7/2-)                   |                                  |                              | Er k x-ray                                 |
|                     |                                  |                          |                                        |                                 | 0.61/21                                  |                          |                                  |                              | 0.0793                                     |



| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)      | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                      |
|--------------------|----------------------------------|--------------------------|----------------------------------------|-----------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-----------------------------------------------------------------|
| <sup>157</sup> Er  |                                  | 156.93192                | 25. m                                  | $\beta^+$ , EC/3.5                |                                          | 3/2-                     | -0.412                           | +0.92                        | ann.rad./<br>0.117<br>0.385<br>1.320<br>1.660<br>1.820<br>2.000 |
| <sup>158</sup> Er  |                                  | 157.92989                | 2.2 h                                  | EC/99.5 /1.78<br>$\beta^+$ /0.5 / | 0.74/                                    | 0+                       |                                  |                              | Ho k x-ray<br>0.0719<br>0.2486<br>0.3868                        |
| <sup>159</sup> Er  |                                  | 158.930684               | 36. m                                  | $\beta^+$ /7 /2.769<br>EC/93 /    |                                          | 3/2-                     | -0.304                           | +1.17                        | ann.rad./<br>Ho k x-ray<br>0.6245<br>0.6493<br>(0.07–2.5)       |
| <sup>160</sup> Er  |                                  | 159.92908                | 1.191 d                                | EC/0.33                           |                                          | 0+                       |                                  |                              | Ho k x-ray<br>(0.05–0.96)                                       |
| <sup>161</sup> Er  |                                  | 160.93000                | 3.21 h                                 | EC/2.00                           |                                          | 3/2-                     | -0.37                            | +1.36                        | Ho k x-ray<br>0.8265<br>(0.07–1.74)                             |
| <sup>162</sup> Er  | 0.139(5)                         | 161.928778               |                                        |                                   |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>163</sup> Er  |                                  | 162.93003                | 1.25 h                                 | EC/1.210                          |                                          | 5/2-                     | +0.557                           | +2.55                        | Ho k x-ray<br>0.4361<br>0.4399<br>1.1135                        |
| <sup>164</sup> Er  | 1.601(3)                         | 163.929200               |                                        |                                   |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>165</sup> Er  |                                  | 164.930726               | 10.36 h                                | EC/0.376                          |                                          | 5/2-                     | +0.643                           | +2.71                        | Ho k x-ray                                                      |
| <sup>166</sup> Er  | 33.503(36)                       | 165.930293               |                                        |                                   |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>167m</sup> Er |                                  |                          | 2.27 s                                 | I.T./0.208                        |                                          | $\frac{1}{2}$ -          |                                  |                              | Er k x-ray<br>0.2078                                            |
| <sup>167</sup> Er  | 22.869(9)                        | 166.932048               |                                        |                                   |                                          | 7/2+                     | -0.5639                          | +3.57                        |                                                                 |
| <sup>168</sup> Er  | 26.978(18)                       | 167.932370               |                                        |                                   |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>169</sup> Er  |                                  | 168.934590               | 9.40 d                                 | $\beta^-$ /0.351                  | 0.35/~ 100                               | $\frac{1}{2}$ -          | +0.485                           |                              | Tm k x-ray<br>0.1098<br>0.1182                                  |
| <sup>170</sup> Er  | 14.910(36)                       | 169.935464               |                                        |                                   |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>171</sup> Er  |                                  | 170.938030               | 7.52 h                                 | $\beta^-$ /1.491                  |                                          | 5/2-                     | 0.66                             | 2.9                          | Tm k x-ray<br>0.11160<br>0.29591<br>0.30832<br>(0.08–1.4)       |
| <sup>172</sup> Er  |                                  | 171.939356               | 2.05 d                                 | $\beta^-$ /0.891                  | 0.28/48<br>0.36/46                       | 0+                       |                                  |                              | Tm k x-ray<br>0.0597<br>0.4073<br>0.6101                        |
| <sup>173</sup> Er  |                                  | 172.9424                 | 1.4 m                                  | $\beta^-$ /2.6                    |                                          | (7/2-)                   |                                  |                              | Tm k x-ray<br>0.1928<br>0.1992<br>0.8952                        |
| <sup>174</sup> Er  |                                  | 173.9442                 | 3.1 m                                  | $\beta^-$ /1.8                    |                                          | 0+                       |                                  |                              | Tm k x-ray<br>(0.100–0.152)                                     |
| <sup>175</sup> Er  |                                  | 174.9478                 | 1.2 m                                  | $\beta^-$                         |                                          |                          |                                  |                              | (0.0765–1.168)                                                  |
| <sup>176</sup> Er  |                                  | 175.9501                 |                                        |                                   |                                          | 0+                       |                                  |                              |                                                                 |
| <sup>177</sup> Er  |                                  | 176.954                  |                                        |                                   |                                          |                          |                                  |                              |                                                                 |
| <sup>69</sup> Tm   |                                  | 168.93421(2)             |                                        |                                   |                                          |                          |                                  |                              |                                                                 |
| <sup>144</sup> Tm  |                                  |                          | ~ 1.9 $\mu$ s                          | p                                 | 1.70, 1.43                               |                          |                                  |                              |                                                                 |
| <sup>145</sup> Tm  |                                  | 144.9701                 | 3.1 $\mu$ s                            | p// ~ 10                          | 1.73/91                                  |                          |                                  |                              |                                                                 |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV)    | Decay Mode/<br>Energy (/MeV)     | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                     |
|--------------------|----------------------------------|--------------------------|-------------------------------------------|----------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------------------------------------------|
| <sup>146m</sup> Tm |                                  |                          | 0.198 s                                   | $\beta^+$ , p                    | 1.4/9<br>p/1.118/100<br>1.01/<br>0.89/8  |                          |                                  |                              |                                                                                |
| <sup>146</sup> Tm  | 145.9664                         | 0.08 s                   | $\beta^+$ /14.<br>p                       | p/1.19/100<br>1.01/28<br>0.94/22 |                                          |                          |                                  |                              |                                                                                |
| <sup>147m</sup> Tm |                                  | 0.4 ms                   | $\beta^+$ , p                             | p/1.115                          |                                          |                          |                                  |                              |                                                                                |
| <sup>147</sup> Tm  | 146.9610                         | 0.56 s                   | EC, $\beta^+$ /85<br>p/15/                | $\sim 10.7$<br>1.052/            |                                          |                          |                                  |                              |                                                                                |
| <sup>148m</sup> Tm | 147.9578                         | 0.7 s                    | $\beta^+$ , EC/12.                        |                                  |                                          |                          |                                  |                              | ann.rad./                                                                      |
| <sup>148</sup> Tm  |                                  |                          |                                           |                                  |                                          |                          |                                  |                              |                                                                                |
| <sup>149</sup> Tm  | 148.9527                         | 0.9 s                    | $\beta^+$ , EC/ $\sim 9.2$                |                                  | 11/2-                                    |                          |                                  |                              |                                                                                |
| <sup>150</sup> Tm  | 149.9500                         | 2.3 s                    | $\beta^+$ , EC/ $\sim 11.5$               |                                  | 6-                                       |                          |                                  |                              | (0.1007–2.177)                                                                 |
| <sup>151</sup> Tm  | 150.94548                        | 4. s                     | $\beta^+$ , EC/7.5                        |                                  |                                          |                          |                                  |                              | ann.rad./                                                                      |
| <sup>152m</sup> Tm |                                  | 8. s                     | $\beta^+$ , EC/                           |                                  | 9+                                       |                          |                                  |                              |                                                                                |
| <sup>152</sup> Tm  | 151.9444                         | 5. s                     | $\beta^+$ , EC/8.8                        |                                  |                                          |                          |                                  |                              | ann.rad./                                                                      |
| <sup>153</sup> Tm  | 152.94201                        | 1.6 s                    | $\beta^+$ , EC/10 /6.46<br>$\alpha$ /90 / | 5.109/                           |                                          |                          |                                  |                              | ann.rad./                                                                      |
| <sup>154m</sup> Tm |                                  | 3.3 s                    | $\beta^+$ , EC/15 /<br>$\alpha$ /         | $\alpha$ /5.031/100<br>4.84/0.24 |                                          |                          |                                  |                              | ann.rad./<br>0.4605–0.7960                                                     |
| <sup>154</sup> Tm  | 153.94157                        | 8.1 s                    | $\beta^+$ , EC/56 /7.4<br>$\alpha$ /44 /  | $\alpha$ /4.956/100<br>4.83/0.45 |                                          |                          |                                  |                              | ann.rad./                                                                      |
| <sup>155</sup> Tm  | 154.93920                        | 30. s                    | $\beta^+$ , EC/5.58<br>$\alpha$ /         | 4.46/                            |                                          |                          |                                  |                              | 0.0315<br>0.0638<br>0.0881<br>0.2268<br>0.5320<br>0.6067                       |
| <sup>156m</sup> Tm |                                  | 19. s                    | $\alpha$ /                                | 4.46/                            |                                          |                          |                                  |                              |                                                                                |
| <sup>156</sup> Tm  | 155.93898                        | 1.40 m                   | $\beta^+$ , EC/7.6<br>$\alpha$ /          | 4.23/                            | 2-                                       | +0.40                    | -0.5                             |                              | ann.rad./<br>0.3446<br>0.4529<br>0.5860                                        |
| <sup>157</sup> Tm  | 156.93697                        | 3.6 m                    | $\beta^+$ , EC/4.5<br>$\alpha$ /          | 2.6<br>3.97/                     | $\frac{1}{2}$                            | +0.48                    |                                  |                              | ann.rad./<br>0.1104<br>0.3484<br>0.3855<br>0.4550<br>(0.1–1.58)                |
| <sup>158</sup> Tm  | 157.93698                        | 4.0 m                    | $\beta^+$ , EC/74 /6.5<br>EC/26 /         |                                  | (2-)                                     | +0.04                    | +0.7                             |                              | ann.rad./<br>Er k x-ray<br>0.1921<br>0.3351<br>0.6280<br>1.1498<br>(0.18–2.81) |
| <sup>159</sup> Tm  | 158.93498                        | 9.1 m                    | $\beta^+$ /23 /3.9<br>EC/77 /             |                                  | 5/2+                                     | +3.42                    | +1.9                             |                              | ann.rad./<br>Er k x-ray<br>0.0591<br>0.0848<br>0.2713<br>(0.05–1.27)           |
| <sup>160m</sup> Tm |                                  | 1.24 m                   | IT                                        |                                  | (5)                                      |                          |                                  |                              |                                                                                |
| <sup>160</sup> Tm  | 159.93526                        | 9.4 m                    | $\beta^+$ /15 /5.9<br>EC/85 /             |                                  | 1-                                       | +0.16                    | +0.58                            |                              | ann.rad./<br>Er k x-ray<br>0.1264<br>0.2642<br>0.7285<br>0.8544                |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8614                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.3685                                     |
| <sup>161</sup> Tm  |                                  | 160.93355                | 31. m                                  | $\beta^+$ , EC/3.2           |                                          | 7/2+                     | +2.40                            | +2.9                         | ann.rad./                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Er k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0595                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0844                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.6481                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.04–2.15)                                |
| <sup>162m</sup> Tm |                                  |                          | 24. s                                  | I.T./90 /                    |                                          | 5+                       |                                  |                              | Tm k x-ray                                 |
|                    |                                  |                          |                                        | $\beta^+$ , EC/10 /          |                                          |                          |                                  |                              | Er k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0669                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8115                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9003                                     |
| <sup>162</sup> Tm  |                                  | 161.93400                | 21.7 m                                 | $\beta^+$ /8 /4.81           |                                          | 1-                       | +0.07                            | +0.69                        | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/92 /                      |                                          |                          |                                  |                              | Er k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1020                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7987                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.1–3.75)                                 |
| <sup>163</sup> Tm  |                                  | 162.93265                | 1.81 h                                 | EC/98 /2.439                 |                                          | ½+                       | -0.082                           |                              | Er k x-ray                                 |
|                    |                                  |                          |                                        | $\beta^+$ /1 /               |                                          |                          |                                  |                              | 0.0692                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1043                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2414                                     |
| <sup>164m</sup> Tm |                                  |                          | 5.1 m                                  | I.T./80 /                    |                                          | 6-                       |                                  |                              | 0.0914                                     |
|                    |                                  |                          |                                        | $\beta^+$ , EC/20 /          |                                          |                          |                                  |                              | 0.1394                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2081                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2405                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3149                                     |
| <sup>164</sup> Tm  |                                  | 163.93356                | 2.0 m                                  | $\beta^+$ /36 /3.96          | 2.94/                                    | 1+                       | +2.38                            | +0.71                        | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/64 /                      |                                          |                          |                                  |                              | Er k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0914                                     |
| <sup>165</sup> Tm  |                                  | 164.932435               | 1.253 d                                | EC/1.593                     |                                          | ½+                       | -0.139                           |                              | Er k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0472                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0544                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.29728                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.80636                                    |
| <sup>166</sup> Tm  |                                  | 165.93355                | 7.70 h                                 | EC/98 /3.04                  |                                          | 2+                       | +0.092                           | +2.14                        | Er k x-ray                                 |
|                    |                                  |                          |                                        | $\beta^+$ /2 /               |                                          |                          |                                  |                              | 0.0806                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1844                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7789                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.2734                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.0524                                     |
| <sup>167</sup> Tm  |                                  | 166.932852               | 9.24 d                                 | EC/0.748                     |                                          | ½+                       | -0.197                           |                              | Er k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0571                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.20778                                    |
| <sup>168</sup> Tm  |                                  | 167.934173               | 93.1 d                                 | EC/1.679                     |                                          | 3+                       | +0.23                            | +3.2                         | Er k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.19825                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4475                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.81595                                    |
| <sup>169</sup> Tm  | 100                              | 168.934213               |                                        |                              |                                          | ½+                       | -0.232                           | -1.2                         |                                            |
| <sup>170</sup> Tm  |                                  | 169.935801               | 128.6 d                                | $\beta^-$ /99.8/0.968        | 0.883/24                                 | 1-                       | +0.247                           | +0.74                        | Yb k x-ray                                 |
|                    |                                  |                          |                                        | EC/0.2 /0.314                | 0.968/76                                 |                          |                                  |                              | 0.08425                                    |
| <sup>171</sup> Tm  |                                  | 170.936429               | 1.92 y                                 | $\beta^-$ /0.096             | 0.03/2                                   | ½+                       | -0.230                           |                              | 0.06674                                    |
|                    |                                  |                          |                                        |                              | 0.096/98                                 |                          |                                  |                              |                                            |
| <sup>172</sup> Tm  |                                  | 171.93840                | 2.65 d                                 | $\beta^-$ /1.88              | 1.79/36                                  | 2-                       |                                  |                              | Yb k x-ray                                 |
|                    |                                  |                          |                                        |                              | 1.88/29                                  |                          |                                  |                              | 0.07879                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.38722                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.46601                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.52982                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.60861                                    |
| <sup>173</sup> Tm  |                                  | 172.939604               | 8.2 h                                  | $\beta^-$ /1.298             | 0.80/21                                  | ½+                       |                                  |                              | Yb k x-ray                                 |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>ħ</i> /2 π) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | γ-Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------------------|
|                    |                                  |                          |                                        |                              |                                          | 0.86/71                  |                                  |                              | 0.3988                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4613                             |
| <sup>174m</sup> Tm |                                  |                          | 2.29 s                                 |                              |                                          |                          |                                  |                              |                                    |
| <sup>174</sup> Tm  | 173.94217                        |                          | 5.4 m                                  | β- /3.08                     | 0.70/14                                  | (4-)                     |                                  |                              | Yb k x-ray                         |
|                    |                                  |                          |                                        |                              |                                          | 1.20/83                  |                                  |                              | 0.07664                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.17669                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.27332                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3666                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.99205                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.08–1.6)                         |
| <sup>175</sup> Tm  | 174.94384                        |                          | 15.2 m                                 | β- /2.39                     | 0.9/36                                   | (1/2+)                   |                                  |                              | Yb k x-ray                         |
|                    |                                  |                          |                                        |                              |                                          | 1.9/23                   |                                  |                              | 0.36396                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.51487                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.94125                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.98247                            |
| <sup>176</sup> Tm  | 175.9470                         |                          | 1.9 m                                  | β-/4.2                       | 2.0/                                     | (4+)                     |                                  |                              | Yb k x-ray                         |
|                    |                                  |                          |                                        |                              |                                          | 1.2/                     |                                  |                              | 0.1898                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3819                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.0691                             |
| <sup>177</sup> Tm  | 176.9490                         |                          | 1.4 m                                  | β-                           |                                          |                          |                                  |                              |                                    |
| <sup>178</sup> Tm  | 177.9526                         |                          |                                        |                              |                                          |                          |                                  |                              |                                    |
| <sup>179</sup> Tm  | 178.955                          |                          |                                        |                              |                                          |                          |                                  |                              |                                    |
| <sup>70</sup> Yb   | 173.04(3)                        |                          |                                        |                              |                                          |                          |                                  |                              |                                    |
| <sup>148</sup> Yb  | 147.967                          |                          |                                        |                              |                                          | 0+                       |                                  |                              |                                    |
| <sup>149</sup> Yb  | 148.964                          | 0.7 s                    |                                        | β+, p                        | p/2.5–6.4/                               |                          |                                  |                              | 0.647                              |
| <sup>150</sup> Yb  | 149.9584                         | > 0.2 μs                 |                                        |                              |                                          | 0+                       |                                  |                              |                                    |
| <sup>151</sup> Yb  | 150.9554                         | 1.6 s                    |                                        | β+ /8.5                      |                                          |                          |                                  |                              |                                    |
| <sup>152</sup> Yb  | 151.9503                         | 3.2 s                    |                                        | β+ EC/5.5                    |                                          | 0+                       |                                  |                              |                                    |
| <sup>153</sup> Yb  | 152.9495                         | 4. s                     |                                        | β+ EC/6.7                    |                                          |                          |                                  |                              |                                    |
| <sup>154</sup> Yb  | 153.94639                        | 0.40 s                   |                                        | β+ EC/7 /4.49                |                                          | 0+                       |                                  |                              | ann.rad./                          |
|                    |                                  |                          |                                        |                              |                                          | α/93 /                   | 5.32/                            |                              |                                    |
| <sup>155</sup> Yb  | 154.9458                         | 1.7 s                    |                                        | β+, EC/16 /6.0               |                                          |                          | -0.8                             | -1.                          | ann.rad./                          |
|                    |                                  |                          |                                        |                              |                                          | α/84 /                   | 5.19/                            |                              |                                    |
| <sup>156</sup> Yb  | 155.94282                        | 26. s                    |                                        | β+, EC/21/3.57               |                                          | 0+                       |                                  |                              | ann.rad./                          |
|                    |                                  |                          |                                        |                              |                                          | α/79 /                   | 4.69/                            |                              |                                    |
| <sup>157</sup> Yb  | 156.94263                        | 39. s                    |                                        | β+, EC/99+/5.5               |                                          |                          | -0.64                            |                              | ann.rad./                          |
|                    |                                  |                          |                                        |                              |                                          | α/0.5/                   | 4.69/                            |                              | 0.231                              |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.035–0.670)                      |
| <sup>158</sup> Yb  | 157.93987                        | 1.5 m                    |                                        | β+, EC/1.9                   |                                          | 0+                       |                                  |                              | ann.rad./                          |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0741                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2526                             |
| <sup>159</sup> Yb  | 158.94005                        | 1.4 m                    |                                        | EC, β+/5.1                   |                                          |                          | -0.37                            | -0.022                       | Tm k x-ray                         |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1661                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1772                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3297                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3903                             |
| <sup>160</sup> Yb  | 159.93755                        | 4.8 m                    |                                        | β+, EC/2.0                   |                                          | 0+                       |                                  |                              | ann.rad./                          |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1404                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1737                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2158                             |
| <sup>161</sup> Yb  | 160.93790                        | 4.2 m                    |                                        | β+, EC/3.9                   |                                          | 3/2-                     | -0.33                            | +1.03                        | ann.rad./                          |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Tm k x-ray                         |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0782                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5999                             |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6315                             |
| <sup>162</sup> Yb  | 161.93577                        | 18.9 m                   |                                        | β+, EC/1.7                   |                                          | 0+                       |                                  |                              | ann.rad./                          |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Tm k x-ray                         |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1188                             |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>163</sup> Yb  |                                  | 162.93633                | 11.1 m                                 | $\beta^+$ /26 /3.4           | 1.4/                                     | 3/2-                     | -0.37                            | +1.24                        | 0.1635<br>ann.rad./                        |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Tm k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0636                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8603                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.06 –1.9)                                |
| <sup>164</sup> Yb  |                                  | 163.93449                | 1.26 h                                 | EC/1.0                       |                                          | 0+                       |                                  |                              | Tm k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0914                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6752                                     |
| <sup>165</sup> Yb  |                                  | 164.93528                | 9.9 m                                  | $\beta^+$ /10 /2.76          | 1.58/                                    | (5/2-)                   | +0.48                            | +2.48                        | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/90 /                      |                                          |                          |                                  |                              | Tm k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0801                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.0903                                     |
| <sup>166</sup> Yb  |                                  | 165.93388                | 2.363 d                                | EC/0.30                      |                                          | 0+                       |                                  |                              | Tm k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0828                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1844                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7789                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.2734                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 2.0524                                     |
| <sup>167</sup> Yb  |                                  | 166.934950               | 17.5 m                                 | $\beta^+$ /0.5 /1.954        | 0.639/                                   | 5/2-                     | +0.62                            | +2.70                        | Tm k x-ray                                 |
|                    |                                  |                          |                                        | EC/99.5 /                    |                                          |                          |                                  |                              | 0.06296                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.10616                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.11337                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.17633                                    |
| <sup>168</sup> Yb  | 0.13(1)                          | 167.933897               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>169m</sup> Yb |                                  |                          | 46. s                                  | I.T./0.0242                  |                                          | 1/2-                     |                                  |                              | Yb L x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0242                                     |
| <sup>169</sup> Yb  |                                  | 168.935190               | 32.02 d                                | EC/0.909                     |                                          | 7/2+                     | -0.63                            | +3.5                         | 0.1979/35.9                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3078/10.05                               |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0207–0.2611                              |
| <sup>170</sup> Yb  | 3.04(15)                         | 169.934762               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>171</sup> Yb  | 14.28(57)                        | 170.936326               |                                        |                              |                                          | 1/2-                     | +0.49367                         |                              |                                            |
| <sup>172</sup> Yb  | 21.83(67)                        | 171.936382               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>173</sup> Yb  | 16.13(27)                        | 172.938211               |                                        |                              |                                          | 5/2-                     | -0.67989                         | +2.80                        |                                            |
| <sup>174</sup> Yb  | 31.83(92)                        | 173.938862               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>175</sup> Yb  |                                  | 174.941277               | 4.19 d                                 | $\beta^-$ /0.470             | 0.466/73                                 | 7/2-                     | 0.77                             |                              | Lu k x-ray                                 |
|                    |                                  |                          |                                        |                              | 0.071/21                                 |                          |                                  |                              | 0.3963/13                                  |
|                    |                                  |                          |                                        |                              | 0.353/6.2                                |                          |                                  |                              | (0.114–0.28)                               |
| <sup>176m</sup> Yb |                                  |                          | 11.4 s                                 | I.T./1.051                   |                                          | (8-)                     |                                  |                              | Yb k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0961                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1901                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2929                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3897                                     |
| <sup>176</sup> Yb  | 12.76(41)                        | 175.942572               | 10 <sup>26</sup> y                     | $\beta^-\beta^-$             |                                          | 0+                       |                                  |                              |                                            |
| <sup>177m</sup> Yb |                                  |                          | 6.41 s                                 | I.T./0.3315                  |                                          | 1/2-                     |                                  |                              | Yb k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1131                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2084                                     |
| <sup>177</sup> Yb  |                                  | 176.945261               | 1.9 h                                  | $\beta^-$ /1.399             | 1.40                                     | 9/2+                     |                                  |                              | Lu k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1504                                     |
| <sup>178</sup> Yb  |                                  | 177.94665                | 1.23 h                                 | $\beta^-$ /0.65              | 0.25/                                    | 0+                       |                                  |                              | 0.1415                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3246                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3516                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3815                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6125                                     |
| <sup>179</sup> Yb  |                                  | 178.9502                 | 8. m                                   | $\beta^-$ /2.4               |                                          |                          |                                  |                              |                                            |
| <sup>180</sup> Yb  |                                  | 179.9523                 | 2. m                                   | $\beta^-$                    |                                          | 0+                       |                                  |                              | 0.1028–0.4423                              |
| <sup>181</sup> Yb  |                                  | 180.9562                 |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>71</sup> Lu   |                                  | 174.967(1)               |                                        |                              |                                          |                          |                                  |                              |                                            |

[illegible]



| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)           | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                      |
|---------------------|----------------------------------|--------------------------|----------------------------------------|----------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------------------------------|
| <sup>166m1</sup> Lu |                                  |                          | 1.4 m                                  | $\beta^+$ , EC/58 /<br>I.T./42 /0.0344 |                                          | (3-)                     |                                  |                              | ann.rad./<br>0.1024<br>0.2281<br>0.2861<br>0.8119<br>0.8301                     |
| <sup>166</sup> Lu   | 165.93986                        | 2.8 m                    |                                        | $\beta^+$ /25 /5.5<br>EC/75 /          |                                          | (6-)                     |                                  |                              | ann.rad./<br>Yb k x-ray<br>0.1024<br>0.2281<br>0.3375<br>0.3679                 |
| <sup>167</sup> Lu   | 166.93827                        | 52. m                    |                                        | $\beta^+$ /2 /3.1<br>EC/98 /           | 2.1/                                     | 7/2+                     |                                  |                              | Yb k x-ray<br>0.0297<br>0.2392<br>(0.03–2.0)                                    |
| <sup>168m1</sup> Lu |                                  | 6.7 m                    |                                        | $\beta^+$ /12 /<br>EC/88 /<br>IT/<0.8  |                                          | 3+                       |                                  |                              | ann.rad./<br>Yb k x-ray<br>0.1988/190<br>0.8960/100<br>0.9792/128<br>0.018–2.65 |
| <sup>168</sup> Lu   | 167.93874                        | 5.5 m                    |                                        | $\beta^+$ /6 /4.5<br>EC/94 /           | 1.2/                                     | (6-)                     |                                  |                              | ann.rad./<br>Yb k x-ray<br>0.1114<br>0.1124<br>0.2286<br>0.3483<br>1.4836       |
| <sup>169m1</sup> Lu |                                  | 2.7 m                    |                                        | I.T./0.0290                            |                                          | 1/2-                     |                                  |                              | Lu L x-ray<br>0.0290                                                            |
| <sup>169</sup> Lu   | 168.93765                        | 1.419 d                  |                                        | EC/2.293                               | 1.271/                                   | 7/2+                     | 2.30                             | 3.5                          | Yb k x-ray<br>0.19121<br>0.9606<br>(0.08–2.1)                                   |
| <sup>170m1</sup> Lu |                                  | 0.7 s                    |                                        | I.T./0.0929                            |                                          | 4-                       |                                  |                              | Lu L x-ray<br>0.04449<br>0.0484                                                 |
| <sup>170</sup> Lu   | 169.93848                        | 2.01 d                   |                                        | EC/3.46                                | 2.44/                                    | 0+                       |                                  |                              | Yb k x-ray<br>0.58711<br>0.5908<br>1.28029<br>(0.1–3.38)                        |
| <sup>171m1</sup> Lu |                                  | 1.31 m                   |                                        | I.T./0.0711                            |                                          | 1/2-                     |                                  |                              | Lu k x-ray<br>0.07119                                                           |
| <sup>171</sup> Lu   | 170.937913                       | 8.24 d                   |                                        | EC/1.479                               | 0.362/                                   | 7/2+                     | 2.30                             | 3.42                         | Yb k x-ray<br>0.01939<br>0.66744<br>(0.02–1.3)                                  |
| <sup>172m1</sup> Lu |                                  | 3.7 m                    |                                        | I.T./0.0419                            |                                          | 1-                       |                                  |                              | Lu L x-rays<br>0.04186                                                          |
| <sup>172</sup> Lu   | 171.939086                       | 6.64 d                   |                                        | EC/2.519                               |                                          | 4-                       | 2.90                             | 3.80                         | Yb k x-ray<br>0.18156<br>1.09367<br>(0.07–2.2)                                  |
| <sup>173</sup> Lu   | 172.938931                       | 1.37 y                   |                                        | EC/0.671                               |                                          | 7/2+                     | 2.28                             | 3.63                         | Yb k x-ray<br>0.07860<br>0.27198                                                |
| <sup>174m1</sup> Lu |                                  | 142. d                   |                                        | IT/99.3/<br>EC/0.7 /                   | 0.17086                                  | 6-                       | 1.50                             |                              | Lu k x-ray<br>0.067055                                                          |

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>174</sup> Lu   |                                  | 173.940338               | 3.3 y                                  | EC/1.374                     |                                          | 1-                            | 1.9                              |                              | Yb k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.07664                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.2419                                     |
| <sup>175</sup> Lu   | 97.41(2)                         | 174.940772               |                                        |                              |                                          | 7/2+                          | +2.2327                          | +3.49                        |                                            |
| <sup>176m</sup> Lu  |                                  |                          | 3.66 h                                 | $\beta^-$ /1.315             | 1.229/<br>1.317/                         | 1-                            | +0.318                           | -1.47                        | Hf k x-ray                                 |
| <sup>176</sup> Lu   | 2.59(2)                          | 175.942686               | 3.73 $\times$ 10 <sup>10</sup> y       | $\beta^-$ /1.192             |                                          | 7-                            | +3.169                           | +4.92                        | Hf k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^+$ / < 0.9            |                                          |                               |                                  |                              | 0.20187                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.30691                                    |
| <sup>177m2</sup> Lu |                                  |                          | 6. m                                   | $\beta^-$                    |                                          | 39/2-                         |                                  |                              | 0.089                                      |
| <sup>177m</sup> Lu  |                                  |                          | 160.7 d                                | IT/22/0.9702                 |                                          | 23/2-                         | 2.33                             | 5.4                          | Lu k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^-$ /78                |                                          |                               |                                  |                              | Hf k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.11295                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.20836                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.37850                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.41853                                    |
| <sup>177</sup> Lu   |                                  | 176.943758               | 6.65 d                                 | $\beta^-$ /0.498             | 0.497/                                   | 7/2+                          | +2.239                           | +3.39                        | 0.11295                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.20836                                    |
| <sup>178m</sup> Lu  |                                  |                          | 23.1 m                                 | $\beta^-$ /                  |                                          | (9-)                          |                                  |                              | 0.2166                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.3317                                     |
| <sup>178</sup> Lu   |                                  | 177.945955               | 28.5 m                                 | $\beta^-$ /2.099             | 2.03/                                    | 1+                            |                                  |                              | Hf k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.0932                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.3099                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.3408                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.09–1.7)                                 |
| <sup>179</sup> Lu   |                                  | 178.94733                | 4.6 h                                  | $\beta^-$ /1.405             | 1.35/                                    | 7/2+                          |                                  |                              | 0.2143                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.3377                                     |
| <sup>180</sup> Lu   |                                  | 179.9499                 | 5.7 m                                  | $\beta^-$ /3.1               | 1.49/                                    |                               |                                  |                              | 0.40795/50.                                |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.07–1.9)                                 |
| <sup>181</sup> Lu   |                                  | 180.9520                 | 3.5 m                                  | $\beta^-$ /2.5               |                                          | (7/2+)                        |                                  |                              | 0.0458                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2059                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.5749                                     |
| <sup>182</sup> Lu   |                                  | 181.9550                 | 2.0 m                                  | $\beta^-$ / $\sim$ 4.1       |                                          |                               |                                  |                              | 0.0978                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.7208                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.8182                                     |
| <sup>183</sup> Lu   |                                  | 182.9576                 | 58. s                                  | $\beta^-$ /                  |                                          | 7/2+                          |                                  |                              |                                            |
| <sup>184</sup> Lu   |                                  | 183.9609                 | 20 s                                   | $\beta^-$                    |                                          |                               |                                  |                              |                                            |
| <sup>72</sup> Hf    |                                  | 178.49(2)                |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>153</sup> Hf   |                                  | 152.971                  | > 0.2 $\mu$ s                          |                              |                                          |                               |                                  |                              |                                            |
| <sup>154</sup> Hf   |                                  | 153.965                  | 2. s                                   | EC, $\beta^+$ /~ 6.7         |                                          | 0+                            |                                  |                              |                                            |
| <sup>155</sup> Hf   |                                  | 154.9634                 | 0.9 s                                  | EC, $\beta^+$ /8.            |                                          |                               |                                  |                              |                                            |
| <sup>156</sup> Hf   |                                  | 155.9594                 | 25. ms                                 | $\alpha$ /                   |                                          | 0+                            |                                  |                              |                                            |
| <sup>157</sup> Hf   |                                  | 156.9584                 | 0.11 s                                 | $\alpha$ /                   |                                          |                               |                                  |                              |                                            |
| <sup>158</sup> Hf   |                                  | 157.95480                | 2.9 s                                  | EC/54 /5.1                   |                                          | 0+                            |                                  |                              |                                            |
|                     |                                  |                          |                                        | $\alpha$ /46 /               | 5.27/                                    |                               |                                  |                              |                                            |
| <sup>159</sup> Hf   |                                  | 158.95400                | 5.6 s                                  | $\beta^+$ , EC/88 /6.9       |                                          |                               |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | $\alpha$ /12 /               | 5.09/                                    |                               |                                  |                              |                                            |
| <sup>160</sup> Hf   |                                  | 159.95068                | $\sim$ 12. s                           | $\beta^+$ , EC/97 /4.9       |                                          | 0+                            |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | $\alpha$ /4.78               |                                          |                               |                                  |                              |                                            |
| <sup>161</sup> Hf   |                                  | 160.95028                | 17. s                                  | $\alpha$ /                   | 4.60/                                    |                               |                                  |                              |                                            |
| <sup>162</sup> Hf   |                                  | 161.94721                | 38. s                                  | $\beta^+$ , EC/3.7           |                                          | 0+                            |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1739                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1963                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.4101                                     |
| <sup>163</sup> Hf   |                                  | 162.94709                | 40. s                                  | $\beta^+$ , EC/5.5           |                                          |                               |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.0454                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.0621                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.0710                                     |

[illegible]

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>178</sup> Hf   | 27.28(7)                         | 177.943699               |                                        |                              |                                          | 0+                       |                                  |                              | 0.42635                                    |
| <sup>179m2</sup> Hf |                                  |                          | 25.1 d                                 | I.T./1.1057                  |                                          | 25/2-                    | 7.4                              |                              | Hf k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1227                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1461                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3626                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4537                                     |
| <sup>179m1</sup> Hf |                                  |                          | 18.7 s                                 | I.T./0.375                   |                                          | ½-                       |                                  |                              | Hf k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1607                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2141                                     |
| <sup>179</sup> Hf   | 13.62(2)                         | 178.945816               |                                        |                              |                                          | 9/2+                     | -0.641                           | +3.79                        |                                            |
| <sup>180m</sup> Hf  |                                  |                          | 5.52 h                                 | I.T./1.1416                  |                                          | 8-                       | +9.                              | +4.6                         | Hf k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2152                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3323                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4432                                     |
| <sup>180</sup> Hf   | 35.08(16)                        | 179.946550               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>181m</sup> Hf  |                                  |                          | 1.5 ms                                 | /1.738                       |                                          | 25/2-                    |                                  |                              |                                            |
| <sup>181</sup> Hf   |                                  | 180.949101               | 42.4 d                                 | β- /1.027                    | 0.408/                                   | 1/2-                     |                                  |                              | Ta k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.13294/54                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.48200/100                                |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3459/20                                  |
| <sup>182m</sup> Hf  |                                  |                          | 62. m                                  | β- /54 /1.60                 | 0.49/43                                  | 8-                       |                                  |                              | Hf k x-ray                                 |
|                     |                                  |                          |                                        | IT/46 /1.173                 | 0.95/10                                  |                          |                                  |                              | 0.0509                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2244                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3441                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4558                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5066                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9428                                     |
| <sup>182</sup> Hf   |                                  | 181.95055                | 8.9 × 10 <sup>6</sup> y                | β- /0.37                     |                                          | 0+                       |                                  |                              | Ta k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2704/79                                  |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.098-0.270)                              |
| <sup>183</sup> Hf   |                                  | 182.95353                | 1.07 h                                 | β- /2.01                     | 1.18/68                                  | 3/2-                     |                                  |                              | Ta k x-ray                                 |
|                     |                                  |                          |                                        |                              | 1.54/25                                  |                          |                                  |                              | 0.0732                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4591                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7837                                     |
| <sup>184</sup> Hf   |                                  | 183.95545                | 4.1 h                                  | β- /1.34                     | 0.74/38                                  | 0+                       |                                  |                              | Ta k x-ray                                 |
|                     |                                  |                          |                                        |                              | 0.85/16                                  |                          |                                  |                              | 0.0414                                     |
|                     |                                  |                          |                                        |                              | 1.10/46                                  |                          |                                  |                              | 0.1391                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3449                                     |
| <sup>185</sup> Hf   |                                  | 184.9588                 | ~ 3.5 m                                | β- /                         |                                          |                          |                                  |                              | 0.165                                      |
| <sup>186</sup> Hf   |                                  | 185.9609                 | ~ 2.6 m                                |                              |                                          | 0+                       |                                  |                              | 0.738                                      |
| <sup>187</sup> Hf   |                                  | 186.9646                 | > 0.3 μs                               |                              |                                          |                          |                                  |                              |                                            |
| <sup>188</sup> Hf   |                                  | 187.967                  | > 0.3 μs                               |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>73</sup> Ta    |                                  | 180.94788(2)             |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>155</sup> Ta   |                                  | 154.975                  | 12 μs                                  | p/1.77                       |                                          |                          |                                  |                              |                                            |
| <sup>156</sup> Ta   |                                  | 155.9723                 | 0.11 s                                 | β+ /~ 11.6                   |                                          |                          |                                  |                              |                                            |
|                     |                                  |                          |                                        | p/                           | 1.02/~ 100                               |                          |                                  |                              |                                            |
| <sup>157</sup> Ta   |                                  | 156.9682                 | 10 ms                                  | α/                           | 6.117                                    |                          |                                  |                              |                                            |
|                     |                                  |                          |                                        | p/                           | 0.927/3.4                                |                          |                                  |                              |                                            |
| <sup>158</sup> Ta   |                                  | 157.9667                 | 37. ms                                 | α/                           | 6.05/100                                 |                          |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 5.97/100                                 |                          |                                  |                              |                                            |
| <sup>159</sup> Ta   |                                  | 158.96302                | 0.6 s                                  | β+, EC/20 /8.5               | α/5.52/34                                |                          |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | α/80 /                       | 5.60/55                                  |                          |                                  |                              |                                            |
| <sup>160</sup> Ta   |                                  | 159.9615                 | 1.4 s                                  | β+, EC/10.1                  |                                          |                          |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | α                            | 5.41/                                    |                          |                                  |                              |                                            |
| <sup>161</sup> Ta   |                                  | 160.9584                 | 3.16 s                                 | β+, EC/7.5                   |                                          |                          |                                  |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | α/                           | 5.15                                     |                          |                                  |                              |                                            |
| <sup>162</sup> Ta   |                                  | 161.9573                 | 4. s                                   | EC/8.6                       |                                          |                          |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>163</sup> Ta  |                                  | 162.95433                | 10.6 s                                 | EC/6.8                       |                                          |                          |                                  |                              |                                            |
| <sup>164</sup> Ta  |                                  | 163.95353                | 14.2 s                                 | $\beta^+$ /8.5               |                                          | 3+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | $\alpha$ /                   | 4.62/                                    |                          |                                  |                              | 0.2110                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3768                                     |
| <sup>165</sup> Ta  |                                  | 164.95077                | 31. s                                  | EC $\beta^+$ /5.9            |                                          |                          |                                  |                              |                                            |
| <sup>166</sup> Ta  |                                  | 165.95051                | 34. s                                  | $\beta^+$ /82 /7.7           |                                          |                          |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/18 /                      |                                          |                          |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1587                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3117                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8101                                     |
| <sup>167</sup> Ta  |                                  | 166.94809                | 1.4 m                                  | $\beta^+$ , EC/5.6           |                                          |                          |                                  |                              | ann.rad./                                  |
| <sup>168</sup> Ta  |                                  | 167.94805                | 2.4 m                                  | $\beta^+$ /77 /6.7           |                                          | 3+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/23 /                      |                                          |                          |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1239                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2615                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7502                                     |
| <sup>169</sup> Ta  |                                  | 168.94601                | 4.9 m                                  | $\beta^+$ , EC/4.4           |                                          |                          |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0288                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1535                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1924                                     |
| <sup>170</sup> Ta  |                                  | 169.94618                | 6.8 m                                  | $\beta^+$ /70 /6.0           |                                          | (3+)                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/35 /                      |                                          |                          |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1008                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2212                                     |
| <sup>171</sup> Ta  |                                  | 170.94448                | 23.3 m                                 | $\beta^+$ , EC/3.7           |                                          | (5/2-)                   |                                  |                              | 0.0496                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5018                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5064                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.05–1.02)                                |
| <sup>172</sup> Ta  |                                  | 171.94490                | 36.8 m                                 | $\beta^+$ /25 /4.9           |                                          | (3-)                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/75 /                      |                                          |                          |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.21396                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.10923                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.09 –3.8)                                |
| <sup>173</sup> Ta  |                                  | 172.94375                | 3.6 h                                  | $\beta^+$ /24 /3.7           |                                          | (5/2-)                   | 1.70                             | -1.9                         | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/76 /                      |                                          |                          |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.06972                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.17219                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.06 –2.7)                                |
| <sup>174</sup> Ta  |                                  | 173.94445                | 1.12 h                                 | $\beta^+$ /27 /3.8           |                                          | (3+)                     |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | EC/73 /                      |                                          |                          |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.09089                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.20638                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.09–3.64)                                |
| <sup>175</sup> Ta  |                                  | 174.94374                | 10.5 h                                 | EC/2.0                       |                                          | 7/2+                     | 2.27                             | +3.7                         | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2077                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2671                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3487                                     |
| <sup>176</sup> Ta  |                                  | 175.94486                | 8.1 h                                  | EC/3.1                       |                                          | 1-                       |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.08837                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.15735                                    |
| <sup>177</sup> Ta  |                                  | 176.944472               | 2.356 d                                | EC/1.166                     |                                          | 7/2+                     | 2.25                             |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.11295                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.07–1.06)                                |
| <sup>178m</sup> Ta |                                  |                          | 2.4 h                                  | EC/                          |                                          | (7-)                     |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.08886                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.21342                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.32555                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.42635                                    |
| <sup>178</sup> Ta  |                                  | 177.94578                | 9.29 m                                 | EC/99 /1.9                   |                                          | 1+                       | +2.74                            | +0.65                        | ann.rad./                                  |
|                    |                                  |                          |                                        | $\beta^+$ /1 /               |                                          |                          |                                  |                              | Hf k x-ray                                 |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.09316                                    |
| <sup>179</sup> Ta  |                                  | 178.945930               | 1.8 y                                  | EC/0.110                     |                                          | 7/2+                          | 2.29                             | 3.37                         | Hf k x-ray                                 |
| <sup>180m</sup> Ta | 0.0120(2)                        |                          | >1.2 $\times$ 10 <sup>15</sup> y       |                              |                                          | (9-)                          | 4.82                             |                              |                                            |
| <sup>180</sup> Ta  |                                  | 179.947465               | 8.15 h                                 | EC/87 /0.854                 |                                          | 1+                            |                                  |                              | Hf k x-ray                                 |
|                    |                                  |                          |                                        | $\beta^-$ /13 /0.708         | 0.61/3                                   |                               |                                  |                              | W k x-ray                                  |
|                    |                                  |                          |                                        |                              | 0.71/10                                  |                               |                                  |                              | 0.09333                                    |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.10340                                    |
| <sup>181</sup> Ta  | 99.9880(2)                       | 180.947996               |                                        |                              |                                          | 7/2+                          | +2.370                           | +3.3                         |                                            |
| <sup>182m</sup> Ta |                                  |                          | 15.8 m                                 | I.T./0.5198                  |                                          | 10-                           |                                  |                              | Ta k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.14678                                    |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.17157                                    |
| <sup>182</sup> Ta  |                                  | 181.950152               | 114.43 d                               | $\beta^-$ /1.814             | 0.25/30                                  | 3-                            | +3.02                            | +2.6                         | W k x-ray                                  |
|                    |                                  |                          |                                        |                              | 0.44/20                                  |                               |                                  |                              | 1.12127/100                                |
|                    |                                  |                          |                                        |                              | 0.52/40                                  |                               |                                  |                              | 1.22138/79                                 |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.085–1.289                                |
| <sup>183</sup> Ta  |                                  | 182.951373               | 5.1 d                                  | $\beta^-$ /1.070             | 0.45/5                                   | 7/2+                          | +2.36                            |                              | W k x-ray                                  |
|                    |                                  |                          |                                        |                              | 0.62/91                                  |                               |                                  |                              | 0.0847                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.0991                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1079                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2461                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.3540                                     |
| <sup>184</sup> Ta  |                                  | 183.95401                | 8.7 h                                  | $\beta^-$ /2.87              | 1.11/15                                  | (5-)                          |                                  |                              | W k x-ray                                  |
|                    |                                  |                          |                                        |                              | 1.17/81                                  |                               |                                  |                              | 0.2528/44.                                 |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.4140/74.                                 |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.09–1.4)                                 |
| <sup>185</sup> Ta  |                                  | 184.95556                | 49. m                                  | $\beta^-$ /1.99              | 1.21/5                                   | (7/2+)                        |                                  |                              | W k x-ray                                  |
|                    |                                  |                          |                                        |                              | 1.77/81                                  |                               |                                  |                              | 0.0697                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1739                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1776                                     |
| <sup>186</sup> Ta  |                                  | 185.9586                 | 10.5 m                                 | $\beta^-$ /3.9               | 2.2/                                     | (3-)                          |                                  |                              | W k x-ray                                  |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1979                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2149                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.5106                                     |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.09–1.5)                                 |
| <sup>187</sup> Ta  |                                  | 186.9605                 | > 0.3 $\mu$ s                          |                              |                                          |                               |                                  |                              |                                            |
| <sup>188</sup> Ta  |                                  | 187.9637                 | 5 $\mu$ s                              |                              |                                          |                               |                                  |                              | 0.292                                      |
| <sup>189</sup> Ta  |                                  | 188.9658                 | > 0.3 $\mu$ s                          |                              |                                          |                               |                                  |                              |                                            |
| <sup>74</sup> W    |                                  | 183.84(1)                |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>158m</sup> W  |                                  |                          | 0.14 ms                                | $\alpha$                     | 8.28(3)/                                 |                               |                                  |                              |                                            |
| <sup>158</sup> W   |                                  | 157.975                  | 1.3 ms                                 | $\alpha$ /                   | 6.433/96                                 | 0+                            |                                  |                              |                                            |
| <sup>159</sup> W   |                                  | 158.9729                 | 7. ms                                  | $\alpha$ /                   |                                          |                               |                                  |                              |                                            |
| <sup>160</sup> W   |                                  | 159.9685                 | 0.08 s                                 | $\alpha$ /                   | 5.92/                                    | 0+                            |                                  |                              |                                            |
| <sup>161</sup> W   |                                  | 160.9674                 | 0.41 s                                 | $\beta^+$ , EC/18 /8.1       |                                          |                               |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /82 /               | 5.78/                                    |                               |                                  |                              |                                            |
| <sup>162</sup> W   |                                  | 161.9635                 | 1.39 s                                 | $\beta^+$ , EC/54 /5.8       |                                          | 0+                            |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /46 /               | 5.54/                                    |                               |                                  |                              |                                            |
| <sup>163</sup> W   |                                  | 162.9625                 | 2.8 s                                  | $\beta^+$ , EC/59 /7.5       |                                          |                               |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /41 /               | 5.38/                                    |                               |                                  |                              |                                            |
| <sup>164</sup> W   |                                  | 163.95895                | 6. s                                   | $\beta^+$ , EC/97 /5.0       |                                          | 0+                            |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | $\alpha$ /3 /                | 5.15/                                    |                               |                                  |                              |                                            |
| <sup>165</sup> W   |                                  | 164.95828                | 5.1 s                                  | $\beta^+$ , EC/99 /7.0       |                                          |                               |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | $\alpha$ /1 /                | 4.91/                                    |                               |                                  |                              |                                            |
| <sup>166</sup> W   |                                  | 165.95503                | 16. s                                  | $\beta^+$ , EC/99 /4.2       |                                          | 0+                            |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | $\alpha$ /1 /                | 4.74/                                    |                               |                                  |                              |                                            |
| <sup>167</sup> W   |                                  | 166.95482                | 20. s                                  | EC/5.6                       |                                          |                               |                                  |                              |                                            |
| <sup>168</sup> W   |                                  | 167.95181                | 53. s                                  | EC/3.8                       |                                          | 0+                            |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | $\alpha$ /10 <sup>-5</sup> / | 4.40(1)                                  |                               |                                  |                              | Ta k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1755                                     |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                         |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------------------------------|
| <sup>169</sup> W  |                                  | 168.95178                | 1.3 m                                  | EC/5.4                       |                                          |                          |                                  |                              | (0.037–0.573)<br>ann.rad./<br>Ta k x-ray<br>0.123<br>(0.097–0.699) |
| <sup>170</sup> W  |                                  | 169.94923                | 2.4 m                                  | EC/2.2                       |                                          | 0+                       |                                  |                              | ann.rad./<br>Ta k x-ray<br>0.3162<br>(0.060–0.144)                 |
| <sup>171</sup> W  |                                  | 170.94945                | 2.4 m                                  | EC/4.6                       |                                          |                          |                                  |                              | ann.rad./<br>Ta k x-ray<br>0.1842<br>(0.052–0.479)                 |
| <sup>172</sup> W  |                                  | 171.94729                | 6.6 m                                  | $\beta^+$ , EC/2.5           |                                          | 0+                       |                                  |                              | ann.rad./<br>Ta k x-ray<br>0.0389<br>(0.034–0.674)                 |
| <sup>173</sup> W  |                                  | 172.94769                | 6.3 m                                  | EC/4.0                       |                                          |                          |                                  |                              | ann.rad./<br>Ta k x-ray<br>0.4576<br>(0.035–0.623)                 |
| <sup>174</sup> W  |                                  | 173.94608                | 35. m                                  | EC/1.9                       |                                          | 0+                       |                                  |                              | ann.rad./<br>Ta k x-ray<br>0.3287<br>0.4288<br>(0.056–0.429)       |
| <sup>175</sup> W  |                                  | 174.94672                | 35. m                                  | EC/2.9                       |                                          | $\frac{1}{2}^-$          |                                  |                              | (0.015–0.27)                                                       |
| <sup>176</sup> W  |                                  | 175.94563                | 2.5 h                                  | $\beta^+$ , EC/0.8           |                                          | 0+                       |                                  |                              | 0.03358<br>0.06129<br>0.09487<br>0.10020                           |
| <sup>177</sup> W  |                                  | 176.94664                | 2.21 h                                 | EC/2.0                       |                                          | (1/2-)                   |                                  |                              | Ta k x-ray<br>0.15505<br>0.18569<br>0.42694                        |
| <sup>178</sup> W  |                                  | 177.94588                | 21.6 d                                 | EC/0.091                     |                                          | 0+                       |                                  |                              | Ta k x-ray                                                         |
| <sup>179m</sup> W |                                  |                          | 6.4 m                                  | IT/99.7/0.222                |                                          | (1/2-)                   |                                  |                              | W k x-ray                                                          |
| <sup>179</sup> W  |                                  | 178.94707                | 38. m                                  | EC/0.3/<br>EC/1.06           |                                          | (7/2-)                   |                                  |                              | 0.2220<br>Ta k x-ray<br>0.0307                                     |
| <sup>180</sup> W  | 0.12(1)                          | 179.946704               | $1.8 \times 10^{18}$ y                 | $\alpha$ /                   |                                          | 0+                       |                                  |                              |                                                                    |
| <sup>181</sup> W  |                                  | 180.948197               | 121.1 d                                | EC/0.188                     |                                          | 9/2+                     |                                  |                              | Ta k x-ray<br>0.13617<br>0.15221                                   |
| <sup>182</sup> W  | 26.50(16)                        | 181.948204               | $> 7.7 \times 10^{21}$ y               | $\alpha$ /                   |                                          | 0+                       |                                  |                              |                                                                    |
| <sup>183m</sup> W |                                  |                          | 5.15 s                                 | I.T./                        |                                          | (11/2+)                  |                                  |                              | W k x-ray<br>0.0465<br>0.0526<br>0.0991<br>0.1605                  |
| <sup>183</sup> W  | 14.31(4)                         | 182.950223               | $> 4.1 \times 10^{21}$ y               | $\alpha$ /                   |                                          | $\frac{1}{2}^-$          | +0.1177848                       |                              |                                                                    |
| <sup>184</sup> W  | 30.64(2)                         | 183.950931               | $> 8.9 \times 10^{21}$ y               | $\alpha$ /                   |                                          | 0+                       |                                  |                              |                                                                    |
| <sup>185m</sup> W |                                  |                          | 1.6 m                                  | I.T./0.1974                  |                                          | 11/2+                    |                                  |                              | W k x-ray<br>0.0659<br>0.1315<br>0.1737                            |
| <sup>185</sup> W  |                                  | 184.953419               | 74.8 d                                 | $\beta^-$ /0.433             | 0.433/99.9                               | 3/2-                     |                                  |                              | 0.12536                                                            |
| <sup>186</sup> W  | 28.43(19)                        | 185.954364               | $> 8.2 \times 10^{21}$ y               | $\alpha$ /                   |                                          | 0+                       |                                  |                              |                                                                    |
| <sup>187m</sup> W |                                  |                          | 1.6 $\mu$ s                            | IT                           | 0.411                                    | 11/2+                    |                                  |                              | (0.014-0.287)                                                      |
| <sup>187</sup> W  |                                  | 186.957161               | 23.9 h                                 | $\beta^-$ /1.311             | 0.624/66                                 | 3/2-                     | 0.62                             |                              | Re k x-ray                                                         |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                        |                                  |                          |                                        |                              | 1.315/16                                 |                               |                                  |                              | 0.68572/33                                 |
|                        |                                  |                          |                                        |                              | 0.081–1.18                               |                               |                                  |                              | 0.134–0.773                                |
| <sup>188</sup> W       |                                  | 187.958489               | 69.78 d                                | $\beta^-$ /0.349             | 0.349/99                                 | 0+                            |                                  |                              | 0.0636                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2271                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2907                                     |
| <sup>189</sup> W       |                                  | 188.9619                 | 9.7 m                                  | $\beta^-$ /2.5               | 1.4/                                     | (3/2-)                        |                                  |                              | 0.2604                                     |
|                        |                                  |                          |                                        |                              | 2.5/                                     |                               |                                  |                              | (0.1262-1.466)                             |
| <sup>190m</sup> W      |                                  |                          | $\sim$ 0.06 ms                         |                              |                                          |                               |                                  |                              | (0.0585-0.694)                             |
| <sup>190</sup> W       |                                  | 189.9632                 | 30. m                                  | $\beta^-$ /1.3               | 0.95/                                    | 0+                            |                                  |                              | Re k x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1576                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1621                                     |
| <sup>191</sup> W       |                                  | 190.9666                 | > 0.3 $\mu$ s                          |                              |                                          |                               |                                  |                              |                                            |
| <sup>192</sup> W       |                                  | 191.968                  | > 0.3 $\mu$ s                          |                              |                                          | 0+                            |                                  |                              |                                            |
| <b><sub>75</sub>Re</b> |                                  | <b>186.207(1)</b>        |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>160</sup> Re      |                                  | 159.9821                 | 0.7 ms                                 | p/<br>$\alpha$ /             | 1.261(6)/91<br>6.54/                     |                               |                                  |                              |                                            |
| <sup>161</sup> Re      |                                  | 160.9776                 | 14 ms                                  | $\alpha$ /                   | 6.24                                     |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        | p                            | 1.35                                     |                               |                                  |                              |                                            |
| <sup>162</sup> Re      |                                  | 161.9760                 | 0.10 s                                 | $\alpha$ /                   | 6.12/94                                  |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.09/94                                  |                               |                                  |                              |                                            |
| <sup>163</sup> Re      |                                  | 162.97208                | 0.26 s                                 | $\beta^+$ , EC/9.0           | $\alpha$ /5.87/32                        |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /                   | 5.92/66                                  |                               |                                  |                              |                                            |
| <sup>164</sup> Re      |                                  | 163.9703                 | 0.9 s                                  | $\beta^+$ , EC/10.7          |                                          |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /                   | 5.78/                                    |                               |                                  |                              |                                            |
| <sup>165m</sup> Re     |                                  |                          | $\sim$ 2.37 s                          | $\alpha$ /                   | 5.502/                                   |                               |                                  |                              |                                            |
| <sup>165</sup> Re      |                                  | 164.96709                | 2.6 s                                  | $\beta^+$ , EC/87 /8.1       |                                          |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /                   | 5.49/ < 5.                               |                               |                                  |                              |                                            |
| <sup>166</sup> Re      |                                  | 165.9658                 | 2.5 s                                  | $\beta^+$ , EC/9.4           |                                          |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /                   | 5.50/                                    |                               |                                  |                              |                                            |
| <sup>167m</sup> Re     |                                  |                          | 6.2 s                                  | $\alpha$ , EC/               |                                          |                               |                                  |                              |                                            |
| <sup>167</sup> Re      |                                  | 166.9626                 | 3.4 s                                  | $\beta^+$ , EC/7.4           |                                          |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /                   | 5.015/                                   |                               |                                  |                              |                                            |
| <sup>168</sup> Re      |                                  | 167.96157                | 4.4 s                                  | $\beta^+$ , EC/9.1           |                                          |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /                   | 4.833/                                   |                               |                                  |                              | 0.1117                                     |
| <sup>169m</sup> Re     |                                  |                          | 8.1 s                                  | $\alpha$                     | 4.70/                                    |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 4.87/                                    |                               |                                  |                              |                                            |
| <sup>169</sup> Re      |                                  | 168.95879                | 16. s                                  |                              |                                          |                               |                                  |                              |                                            |
| <sup>170</sup> Re      |                                  | 169.95822                | 9.2 s                                  | $\beta^+$ , EC/9.0           |                                          |                               |                                  |                              | 0.1560                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.3055                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.4125                                     |
| <sup>171</sup> Re      |                                  | 170.95572                | 15.2 s                                 | EC/ $\sim$ 5.7               |                                          |                               |                                  |                              |                                            |
| <sup>172m</sup> Re     |                                  |                          | 55. s                                  | $\beta^+$ , EC/              |                                          | (2)                           |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1234                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2537                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.3504                                     |
| <sup>172</sup> Re      |                                  | 171.9554                 | 15. s                                  | $\beta^+$ , EC/7.3           |                                          |                               |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1234                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2537                                     |
| <sup>173</sup> Re      |                                  | 172.95324                | 2.0 m                                  | EC/ $\sim$ 3.9               |                                          |                               |                                  |                              | ann.rad./                                  |
| <sup>174</sup> Re      |                                  | 173.95312                | 2.4 m                                  | $\beta^+$ , EC/5.6           |                                          |                               |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1119                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2430                                     |
| <sup>175</sup> Re      |                                  | 174.95138                | 5.8 m                                  | $\beta^+$ , EC/4.3           |                                          |                               |                                  |                              | ann.rad./                                  |
| <sup>176</sup> Re      |                                  | 175.95162                | 5.3 m                                  | $\beta^+$ , EC/5.6           |                                          | (3+)                          |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.1089                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.2406                                     |
| <sup>177</sup> Re      |                                  | 176.95033                | 14. m                                  | EC/78 /3.4                   |                                          | (5/2-)                        |                                  |                              | ann.rad./                                  |
|                        |                                  |                          |                                        | $\beta^+$ /22 /              |                                          |                               |                                  |                              | W k x-ray                                  |



| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)        | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.0797                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.0843                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.1968                                     |
| <sup>178</sup> Re  |                                  | 177.95099                | 13.2 m                                 | $\beta^+$ /11 /4.7<br>EC/89 /       | 3.3/                                     | (3+)                     |                                  |                              | ann.rad./<br>W k x-ray                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.1059                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.2373                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.9391                                     |
| <sup>179m</sup> Re |                                  |                          | 0.47 ms                                |                                     |                                          |                          |                                  |                              |                                            |
| <sup>179</sup> Re  |                                  | 178.94999                | 19.7 m                                 | EC/99 /2.71<br>$\beta^+$ /1 /       | 0.95/                                    | (5/2+)                   | 2.8                              |                              | W k x-ray                                  |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.1199                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.2900                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.4154                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.4302                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 1.6803                                     |
| <sup>180</sup> Re  |                                  | 179.95079                | 2.45 m                                 | EC/92 /3.80<br>$\beta^+$ /8 /       | 1.76/                                    | 1-                       | 1.6                              |                              | ann.rad./<br>W k x-ray                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.1036                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.9028                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | (0.07–2.2)                                 |
| <sup>181</sup> Re  |                                  | 180.95007                | 20. h                                  | EC /1.74                            |                                          | 5/2+                     | 3.19                             |                              | W k x-ray                                  |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.3607                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.3655                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.6390                                     |
| <sup>182m</sup> Re |                                  |                          | 12.7 h                                 | EC/                                 | 0.55/<br>1.74/                           | 2+                       | 3.3                              | +1.8                         | W k x-ray                                  |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.0677                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 1.1214                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 1.2215                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | (0.06–2.2)                                 |
| <sup>182</sup> Re  |                                  | 181.9512                 | 2.67 d                                 | EC/2.8                              |                                          | (7+)                     | 2.8                              | +4.1                         | W k x-ray                                  |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.0678                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.2293                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 1.1213                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 1.2214                                     |
| <sup>183</sup> Re  |                                  | 182.95082                | 70. d                                  | EC/0.56                             |                                          | (5/2+)                   | +3.17                            | +2.3                         | W k x-ray                                  |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.16232                                    |
| <sup>184m</sup> Re |                                  |                          | 165. d                                 | I.T./75 /0.188<br>EC/25 /           |                                          | 8+                       | +2.9                             |                              | Re k x-ray                                 |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.1047                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.2165                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.92093                                    |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | (0.10–1.1)                                 |
| <sup>184</sup> Re  |                                  | 183.952521               | 38. d                                  | EC/1.48                             |                                          | 3-                       | +2.53                            | +2.8                         | W k x-ray                                  |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.79207                                    |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.90328                                    |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | (0.1–1.4)                                  |
| <sup>185</sup> Re  | 37.40(2)                         | 184.952955               |                                        |                                     |                                          | 5/2+                     | +3.1871                          | +2.18                        |                                            |
| <sup>186m</sup> Re |                                  |                          | $2.0 \times 10^5$ y                    | I.T./0.150                          |                                          | 8+                       |                                  |                              | Re k x-ray                                 |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.0590                                     |
| <sup>186</sup> Re  |                                  | 185.954986               | 3.718 d                                | $\beta^-$ /92 /1.070<br>EC/8 /0.582 | 0.973/21<br>1.07/71                      | 1-                       | +1.739                           | +0.62                        | W k x-ray                                  |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.1227/0.6                                 |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.1372/9.5                                 |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | (0.63–0.77)                                |
| <sup>187</sup> Re  | 62.60(2)                         | 186.955753               | $4.2 \times 10^{10}$ y                 | $\beta^-$ /0.00266                  | 0.0025/                                  | 5/2+                     | +3.2197                          | +2.07                        |                                            |
| <sup>188m</sup> Re |                                  |                          | 18.6 m                                 | I.T./0.172                          |                                          | (6-)                     |                                  |                              | Re k x-ray                                 |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.0925                                     |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.1059                                     |
| <sup>188</sup> Re  |                                  | 187.958114               | 17.00 h                                | $\beta^-$ /2.120                    | 1.962/20<br>2.118/79                     | 1-                       | +1.788                           | +0.57                        | Os k x-ray                                 |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.15502                                    |
|                    |                                  |                          |                                        |                                     |                                          |                          |                                  |                              | 0.309–2.022                                |
| <sup>189</sup> Re  |                                  | 188.95923                | 24. h                                  | $\beta^-$ /1.01                     | 1.01/                                    | (5/2+)                   |                                  |                              | 0.1471                                     |

[illegible]

[illegible]

[illegible]

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)    | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                |
|---------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------------------------|
| <sup>186m</sup> Ir  |                                  |                          | 1.7 h                                  | EC /                            |                                          | (2-)                     | 0.64                             | +1.46                        | Os k x-ray<br>0.1371<br>0.7675                                            |
| <sup>186</sup> Ir   |                                  | 185.95795                | 15.7 h                                 | EC/98 /3.83<br>$\beta^+$ /2 /   |                                          | (5+)                     | 3.9                              | -2.55                        | Os k x-ray<br>0.1372<br>0.2968<br>0.4348<br>(0.13–3.0)                    |
| <sup>187</sup> Ir   |                                  | 186.95736                | 10.5 h                                 | EC/1.50                         |                                          | 3/2+                     |                                  | +0.94                        | Os k x-ray<br>0.0743<br>0.4009<br>0.4271<br>0.6109<br>0.9128              |
| <sup>188</sup> Ir   |                                  | 187.95885                | 1.72 d                                 | $\beta^+$ /2.81<br>EC/99+ /     | 1.13/<br>1.64/                           | (2-)                     | 0.30                             | +0.48                        | Os k x-ray<br>0.1550<br>0.4780<br>0.6330<br>2.2146                        |
| <sup>189</sup> Ir   |                                  | 188.95872                | 13.2 d                                 | EC/0.53                         |                                          | 3/2+                     | 0.13                             | +0.88                        | Os k x-ray<br>0.2449                                                      |
| <sup>190m2</sup> Ir |                                  |                          | 3.09 h                                 | $\beta^+$ , EC/95 /<br>I.T./5 / |                                          | (11-)                    |                                  |                              | 0.376                                                                     |
| <sup>190m1</sup> Ir |                                  |                          | 1.12 h                                 | I.T. /0.0263                    |                                          | 7+                       |                                  |                              | Ir L x-ray                                                                |
| <sup>190</sup> Ir   |                                  | 189.960546               | 11.8 d                                 | EC/2.0                          |                                          | (4+)                     | 0.04                             | +2.8                         | Os k x-ray<br>0.1867<br>0.4072<br>0.5186<br>0.5580<br>0.6051<br>(0.2–1.4) |
| <sup>191m</sup> Ir  |                                  |                          | 4.93 s                                 | I.T./0.1714                     |                                          | 11/2-                    | +0.603                           |                              | Ir k x-ray<br>0.1294                                                      |
| <sup>191</sup> Ir   | 37.3(2)                          | 190.960594               |                                        |                                 |                                          | 3/2+                     | +0.151                           | +0.82                        |                                                                           |
| <sup>192m2</sup> Ir |                                  |                          | 241. y                                 | I.T./0.161                      |                                          | (9+)                     |                                  |                              | Ir k x-ray                                                                |
| <sup>192m1</sup> Ir |                                  |                          | 1.44 m                                 | I.T./0.0580                     |                                          | (1+)                     |                                  |                              | Ir L x-ray<br>0.0580<br>0.3165                                            |
| <sup>192</sup> Ir   |                                  | 191.962605               | 73.83 d                                | $\beta^-$ /1.460                |                                          | (4-)                     | +1.92                            | +2.15                        | Pt k x-ray<br>0.31649/83.<br>0.46806/48.                                  |
| <sup>193m</sup> Ir  |                                  |                          | 10.53 d                                | I.T./0.0802                     |                                          | 11/2-                    |                                  |                              | Ir L x-ray<br>0.0803                                                      |
| <sup>193</sup> Ir   | 62.7(2)                          | 192.962926               |                                        |                                 |                                          | 3/2+                     | +0.164                           | +0.75                        |                                                                           |
| <sup>194m</sup> Ir  |                                  |                          | 170. d                                 | $\beta^-$ /                     |                                          | 11                       |                                  |                              | Pt k x-ray<br>0.3284<br>0.4829<br>0.5624                                  |
| <sup>194</sup> Ir   |                                  | 193.965078               | 19.3 h                                 | $\beta^-$ /2.247                | 1.92/9<br>2.25/86                        | 1-                       | +0.39                            | +0.34                        | 0.2935<br>0.3284<br>0.6451<br>(0.1–2.2)                                   |
| <sup>195m</sup> Ir  |                                  |                          | 3.9 h                                  | $\beta^-$ /                     | 0.41/<br>0.97/                           | (11/2-)                  |                                  |                              | Pt k x-ray<br>0.3199/9.6<br>0.3649/9.5<br>0.4329/9.6<br>0.6849/9.6        |
| <sup>195</sup> Ir   |                                  | 194.965980               | 2.8 h                                  | $\beta^-$ /1.120                | 1.0/80<br>1.11/13                        | (3/2+)                   |                                  |                              | Pt k x-ray<br>0.0989/9.7                                                  |
| <sup>196m</sup> Ir  |                                  |                          | 1.40 h                                 | $\beta^-$ /                     | 1.16/                                    |                          |                                  |                              | Pt k x-ray                                                                |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)                | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                                             |                                          |                          |                                  |                              | 0.3557                                     |
|                    |                                  |                          |                                        |                                             |                                          |                          |                                  |                              | 0.3935                                     |
|                    |                                  |                          |                                        |                                             |                                          |                          |                                  |                              | 0.4471                                     |
|                    |                                  |                          |                                        |                                             |                                          |                          |                                  |                              | 0.5214                                     |
|                    |                                  |                          |                                        |                                             |                                          |                          |                                  |                              | 0.6473                                     |
| <sup>196</sup> Ir  |                                  | 195.96840                | 52. s                                  | $\beta^-$ /3.21                             | 2.1/15<br>3.2/80                         | 0-                       |                                  |                              | 0.3329<br>0.3557<br>0.7796                 |
| <sup>197m</sup> Ir |                                  |                          | 8.9 m                                  | $\beta^-$ /<br>I.T./                        |                                          | (11/2-)                  |                                  |                              | 0.3465<br>see Ir[197]                      |
| <sup>197</sup> Ir  |                                  | 196.96965                | 5.8 m                                  | $\beta^-$ /2.16                             | 1.5/<br>2.0/                             | (3/2+)                   |                                  |                              | 0.0531<br>0.1351<br>0.4306                 |
|                    |                                  |                          |                                        |                                             |                                          |                          |                                  |                              | 0.4697                                     |
| <sup>198</sup> Ir  |                                  | 197.9723                 | 8. s                                   | $\beta^-$ /4.1                              |                                          |                          |                                  |                              | 0.4074<br>0.5070                           |
| <sup>199</sup> Ir  |                                  | 198.97380                |                                        |                                             |                                          |                          |                                  |                              |                                            |
| <sup>78</sup> Pt   |                                  | 195.084(9)               |                                        |                                             |                                          |                          |                                  |                              |                                            |
| <sup>166</sup> Pt  |                                  | 165.995                  | 0.3 ms                                 | $\alpha$ /                                  | 7.11/                                    | 0+                       |                                  |                              |                                            |
| <sup>167</sup> Pt  |                                  | 166.930                  | 0.9 ms                                 | $\alpha$ /                                  | 6.98/                                    |                          |                                  |                              |                                            |
| <sup>168</sup> Pt  |                                  | 167.9882                 | 2.1 ms                                 | $\alpha$                                    | 6.82                                     | 0+                       |                                  |                              | 0.582/69<br>0.594/69<br>0.725/62           |
| <sup>169</sup> Pt  |                                  | 168.9867                 | 7.0 ms                                 | $\alpha$                                    | 6.69                                     |                          |                                  |                              |                                            |
| <sup>170</sup> Pt  |                                  | 169.98250                | 14.0 ms                                | $\alpha$                                    | 6.55                                     | 0+                       |                                  |                              | 0.509/100<br>0.662/86<br>0.214–0.726       |
| <sup>171</sup> Pt  |                                  | 170.9812                 | 0.05 s                                 | $\alpha$                                    | 6.45                                     |                          |                                  |                              | 0.4450<br>(0.1564-1.208)                   |
| <sup>172</sup> Pt  |                                  | 171.97735                | 0.10 s                                 | $\alpha$ /                                  | 6.31/94                                  | 0+                       |                                  |                              |                                            |
| <sup>173</sup> Pt  |                                  | 172.9764                 | 0.36 s                                 | $\beta^+$ , EC/8.2<br>$\alpha$ /            | 6.23<br>6.20/                            |                          |                                  |                              |                                            |
| <sup>174</sup> Pt  |                                  | 173.97282                | 0.89 s                                 | $\beta^+$ , EC/17 /5.6<br>$\alpha$ /83 /    | <br>6.040/                               | 0+                       |                                  |                              |                                            |
| <sup>175</sup> Pt  |                                  | 174.97242                | 2.5 s                                  | $\beta^+$ , EC/65 /7.6<br>$\alpha$ /35 /    | <br>5.831/5<br>5.96/54<br>6.038/         |                          |                                  |                              | 0.0774<br>0.1354<br>0.2128                 |
| <sup>176</sup> Pt  |                                  | 175.96895                | 6.3 s                                  | $\beta^+$ , EC/60 /5.1<br>$\alpha$ /40 /    | <br>5.528/0.6<br>5.750/41                | 0+                       |                                  |                              | ann.rad./<br>0.2277                        |
| <sup>177</sup> Pt  |                                  | 176.96847                | 11. s                                  | EC/91 /6.8<br>$\alpha$ /9 /                 | 5.53/<br>5.485/3<br>5.525/6              |                          |                                  |                              | 0.0908                                     |
| <sup>178</sup> Pt  |                                  | 177.96565                | 21. s                                  | EC/93 /4.5<br>$\alpha$ /7 /                 | <br>5.286/0.2<br>5.442/7                 | 0+                       |                                  |                              |                                            |
| <sup>179</sup> Pt  |                                  | 178.96536                | 33. s                                  | $\beta^+$ , EC/5.7<br>$\alpha$ /            | <br>5.16/                                |                          | +0.43                            |                              |                                            |
| <sup>180</sup> Pt  |                                  | 179.96303                | 52. s                                  | $\beta^+$ , EC/99.7 /3.7<br>$\alpha$ /0.3 / | 0+<br>5.140/                             |                          |                                  |                              |                                            |
| <sup>181</sup> Pt  |                                  | 180.96310                | 51. s                                  | $\beta^+$ , EC/5.2                          |                                          |                          | +0.48                            |                              |                                            |
| <sup>182</sup> Pt  |                                  | 181.96117                | 2.7 m                                  | $\beta^+$ , EC/2.9                          |                                          | 0+                       |                                  |                              | ann.rad./<br>0.1360<br>0.1460<br>0.2100    |
| <sup>183m</sup> Pt |                                  |                          | 43. s                                  | $\beta^+$ , EC/<br>I.T./                    |                                          | (7/2-)                   | +0.78                            | +3.4                         | ann.rad./<br>0.3132/26                     |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3164/59                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6296/100                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.058–1.75                                 |
| <sup>183</sup> Pt  |                                  | 182.96160                | 7. m                                   | $\beta^+$ , EC/4.6           |                                          |                          | +0.50                            |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.119/100                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.307/93                                   |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.260/90                                   |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.058–1.377                                |
| <sup>184</sup> Pt  |                                  | 183.95992                | 17.3 m                                 | $\beta^+$ , EC/2.3           |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1549                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1919                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5484                                     |
| <sup>185m</sup> Pt |                                  |                          | 33. m                                  | $\beta^+$ , EC/              |                                          | $\frac{1}{2}^-$          | +0.5                             |                              |                                            |
| <sup>185</sup> Pt  |                                  | 184.96062                | 1.18 h                                 | $\beta^+$ , EC/3.8           |                                          | (9/2+)                   | -0.75                            | +3.7                         | ann.rad./                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1353                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1974                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2296                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2551                                     |
| <sup>186</sup> Pt  |                                  | 185.95935                | 2.0 h                                  | $\beta^+$ , EC/1.38          |                                          | 0+                       |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6115                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6892                                     |
| <sup>187</sup> Pt  |                                  | 186.96059                | 2.35 h                                 | $\beta^+$ , EC/3.1           |                                          | 3/2-                     | -0.41                            | -1.1                         | ann.rad./                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Ir k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1064                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1100                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2015                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2849                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7092                                     |
| <sup>188</sup> Pt  |                                  | 187.95940                | 10.2 d                                 | EC/0.51                      |                                          | 0+                       |                                  |                              | Ir k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1876                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1951                                     |
| <sup>189</sup> Pt  |                                  | 188.96083                | 10.9 h                                 | $\beta^+$ , EC/1.97          |                                          | 3/2-                     | -0.43                            | -1.2                         | Ir k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0943                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6076                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7214                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.09–1.47)                                |
| <sup>190</sup> Pt  | 0.014(1)                         | 189.95993                | $4.5 \times 10^{11}$ y                 |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>191</sup> Pt  |                                  | 190.961677               | 2.86 d                                 | EC/1.02                      |                                          | (3/2-)                   | -0.50                            | -0.9                         | Ir k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3599                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4094                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5389                                     |
| <sup>192</sup> Pt  | 0.782(7)                         | 191.961038               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>193m</sup> Pt |                                  |                          | 4.33 d                                 | I.T./0.1498                  |                                          | 13/2+                    | -0.75                            |                              | Pt k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1355                                     |
| <sup>193</sup> Pt  |                                  | 192.962988               | 60. y                                  | EC/0.0566                    |                                          | (1/2-)                   | +0.60                            |                              | Ir k x-rays                                |
| <sup>194</sup> Pt  | 32.967(99)                       | 193.962680               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>195m</sup> Pt |                                  |                          | 4.01 d                                 | I.T./0.2952                  |                                          | 13/2+                    | -0.61                            | +1.4                         | Pt k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0989                                     |
| <sup>195</sup> Pt  | 33.832(10)                       | 194.964791               |                                        |                              |                                          | 1/2-                     | +0.6095                          |                              |                                            |
| <sup>196</sup> Pt  | 25.242(41)                       | 195.964952               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>197m</sup> Pt |                                  |                          | 1.590 h                                | I.T./97 /<br>$\beta^-$ /3 /  |                                          | 13/2+                    |                                  |                              | Pt k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0530                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3465                                     |
| <sup>197</sup> Pt  |                                  | 196.967340               | 19.9 h                                 | $\beta^-$ /0.719             |                                          | 1/2-                     | 0.51                             |                              | Au k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1914                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2688                                     |
| <sup>198</sup> Pt  | 7.163(55)                        | 197.967893               |                                        |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>199m</sup> Pt |                                  |                          | 13.6 s                                 | I.T./0.424                   |                                          | 13/2+                    |                                  |                              | Pt k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3919                                     |
| <sup>199</sup> Pt  |                                  | 198.970593               | 30.8 m                                 | $\beta^-$ /1.70              | 0.90/18                                  | (5/2-)                   |                                  |                              | 0.3170/3.88                                |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                              | 1.14/14                                  |                          |                                  |                              | 0.49375/4.47                               |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5430/11.7                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.055–1.293)                              |
| <sup>200</sup> Pt  |                                  | 199.971441               | 12.5 h                                 | $\beta^-$ /~ 0.66            |                                          | 0+                       |                                  |                              | Au k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.13590                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.22747                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.24371                                    |
| <sup>201</sup> Pt  |                                  | 200.97451                | 2.5 m                                  | $\beta^-$ /2.66              |                                          | (5/2-)                   |                                  |                              | 0.070                                      |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.152                                      |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.222                                      |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.760                                      |
| <sup>202m</sup> Pt |                                  |                          | 0.3 ms                                 |                              |                                          |                          |                                  |                              | (0.535-0.719)                              |
| <sup>202</sup> Pt  |                                  | 201.9757                 | 1.8 d                                  |                              |                                          | 0+                       |                                  |                              | 0.440                                      |
| <sup>79</sup> Au   |                                  | 196.966569(4)            |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>170m</sup> Au |                                  |                          | 0.62 ms                                | p/58                         | 1.74/                                    |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /42                 | 7.11/                                    |                          |                                  |                              |                                            |
| <sup>170</sup> Au  |                                  | 169.9961                 | 0.30 ms                                | p/89                         | 1.46/                                    |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /11                 | 7.00/                                    |                          |                                  |                              |                                            |
| <sup>171m</sup> Au |                                  |                          | 1.09 ms                                | $\alpha$ /66                 | 6.995                                    |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | p/34                         | 1.694                                    |                          |                                  |                              |                                            |
| <sup>171</sup> Au  |                                  | 170.99188                | 0.022 ms                               | p/100                        | 1.437                                    |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>172</sup> Au  |                                  | 171.9900                 | 4 ms                                   | $\alpha$ /7.02               | 6.86                                     |                          |                                  |                              |                                            |
| <sup>173m</sup> Au |                                  |                          | 15 ms                                  | $\alpha$ /92                 | 6.732                                    |                          |                                  |                              |                                            |
| <sup>173</sup> Au  |                                  | 172.98624                | 0.02 s                                 | $\alpha$ /94                 | 6.672                                    |                          |                                  |                              |                                            |
| <sup>174</sup> Au  |                                  | 173.9848                 | 0.14 s                                 | $\alpha$                     | 6.54                                     |                          |                                  |                              |                                            |
| <sup>175</sup> Au  |                                  | 174.98127                | 0.15 s                                 | $\alpha$                     |                                          |                          |                                  |                              |                                            |
| <sup>176</sup> Au  |                                  | 175.9801                 | 0.9 s                                  | $\beta^+$ , EC/10.5          |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /                   | 6.260/80                                 |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.290/20                                 |                          |                                  |                              |                                            |
| <sup>177</sup> Au  |                                  | 176.97687                | 1.2 s                                  | $\alpha$ /                   | 6.115/                                   |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.150/                                   |                          |                                  |                              |                                            |
| <sup>178</sup> Au  |                                  | 177.9760                 | 2.6 s                                  | $\alpha$ /                   | 5.920/                                   |                          |                                  |                              |                                            |
| <sup>179</sup> Au  |                                  | 178.97321                | 7.5 s                                  | $\alpha$ /                   | 5.85/                                    |                          |                                  |                              |                                            |
| <sup>180</sup> Au  |                                  | 179.97252                | 8.1 s                                  | EC/8.6                       | 5.65                                     |                          |                                  |                              | 0.1522                                     |
|                    |                                  |                          |                                        | $\alpha$ /                   | 5.61                                     |                          |                                  |                              | 0.2564                                     |
|                    |                                  |                          |                                        |                              | 5.50                                     |                          |                                  |                              | 0.5242                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6765                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8084                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8597                                     |
| <sup>181</sup> Au  |                                  | 180.97008                | 11.4 s                                 | EC/97.5/6.3                  | 5.482/                                   |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /2.7/               |                                          |                          |                                  |                              |                                            |
| <sup>182</sup> Au  |                                  | 181.96962                | 21. s                                  | $\beta^+$ , EC/6.9           |                                          |                          |                                  |                              | ann.rad./                                  |
|                    |                                  |                          |                                        | $\alpha$ /0.13/              |                                          |                          |                                  |                              | 0.1549                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2649                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.13–1.4)                                 |
| <sup>183</sup> Au  |                                  | 182.96759                | 42. s                                  | EC/5.5                       |                                          |                          | +1.97                            |                              | 0.1630                                     |
|                    |                                  |                          |                                        | $\alpha$ /0.8/               |                                          |                          |                                  |                              | 0.2730                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3625                                     |
| <sup>184m</sup> Au |                                  |                          | 48 s                                   | I.T.                         |                                          | (2+)                     | +1.44                            | +1.9                         | 0.069(IT)                                  |
| <sup>184</sup> Au  |                                  | 183.96745                | 21. s                                  | EC, $\beta^+$ /7.1           |                                          | (5+)                     | +2.07                            | +4.7                         |                                            |
|                    |                                  |                          |                                        | $\alpha$ /0.013/             |                                          |                          |                                  |                              |                                            |
| <sup>185m</sup> Au |                                  |                          | 6.8 m                                  | $\beta^+$ , EC/              |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | I.T./0.145                   |                                          |                          |                                  |                              |                                            |
| <sup>185</sup> Au  |                                  | 184.96579                | 4.3 m                                  | $\beta^+$ , EC/4.71          |                                          | (5/2-)                   | +2.17                            | -1.1                         | ann.rad./                                  |
|                    |                                  |                          |                                        | $\alpha$ /0.26/              |                                          |                          |                                  |                              |                                            |
| <sup>186m</sup> Au |                                  |                          | < 2. m                                 | $\beta^+$ , EC/              |                                          |                          |                                  |                              | 0.1915                                     |
| <sup>186</sup> Au  |                                  | 185.96595                | 10.7 m                                 | $\beta^+$ , EC/6.0           |                                          | 3-                       | -1.26                            | +3.1                         | ann.rad./                                  |



| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                     |                                  |                          |                                        | $\alpha/8(10)^{-4}/$         |                                          |                          |                                  |                              | 0.1915                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2988                                     |
| <sup>187m</sup> Au  |                                  |                          | 2.3 s                                  | IT                           |                                          | 9/2-                     |                                  |                              |                                            |
| <sup>187</sup> Au   |                                  | 186.96457                | 8.3 m                                  | $\beta^+$ , EC/3.60          |                                          | 1/2+                     | +0.54                            |                              | ann.rad./                                  |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9152                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.2668                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.3321                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.4081                                     |
| <sup>188</sup> Au   |                                  | 187.96532                | 8.8 m                                  | $\beta^+$ , EC/5.3           |                                          | (1-)                     | -0.07                            |                              | ann.rad./                                  |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2660                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3404                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6061                                     |
| <sup>189m</sup> Au  |                                  |                          | 4.6 m                                  | $\beta^+$ , EC/              |                                          | 11/2-                    | +6.19                            |                              | 0.1667                                     |
| <sup>189</sup> Au   |                                  | 188.96395                | 28.7 m                                 | EC/96 /3.2                   |                                          | 1/2+                     | +0.49                            |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | $\beta^+$ /4 /               |                                          |                          |                                  |                              | Pt k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4478                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7133                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8128                                     |
| <sup>190</sup> Au   |                                  | 189.96470                | 43. m                                  | $\beta^+$ /2 /4.44           |                                          | 1-                       | -0.07                            |                              | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/98 /                      |                                          |                          |                                  |                              | Pt k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2958                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3018                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5977                                     |
| <sup>191m</sup> Au  |                                  |                          | 0.9 s                                  | I.T./0.2663                  |                                          | (11/2-)                  | 6.6                              |                              | Au k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2414                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2526                                     |
| <sup>191</sup> Au   |                                  | 190.96370                | 3.2 h                                  | EC/1.83                      |                                          | 3/2+                     | +0.137                           | +0.72                        | Pt k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5864/16                                  |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.088–1.30)                               |
| <sup>192</sup> Au   |                                  | 191.96481                | 4.9 h                                  | $\beta^+$ /5 /3.52           | 2.19/                                    | 1-                       | -0.011                           | -0.23                        | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/95 /                      | 2.49/                                    |                          |                                  |                              | Pt k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2959                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3165                                     |
| <sup>193m</sup> Au  |                                  |                          | 3.9 s                                  | I.T./0.2901                  |                                          | 11/2-                    | 6.2                              | +1.98                        | Au k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2580                                     |
| <sup>193</sup> Au   |                                  | 192.96415                | 17.6 h                                 | EC/1.07                      |                                          | 3/2+                     | +0.140                           | +0.66                        | Pt k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1862                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2556                                     |
| <sup>194</sup> Au   |                                  | 193.96537                | 1.64 d                                 | $\beta^+$ /3 /2.49           | 1.49/                                    | 1-                       | +0.076                           | -0.24                        | ann.rad./                                  |
|                     |                                  |                          |                                        | EC/97 /                      |                                          |                          |                                  |                              | Pt k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2935                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.3284/61                                  |
| <sup>195m</sup> Au  |                                  |                          | 30.5 s                                 | I.T./0.3186                  |                                          | 11/2-                    | 6.2                              | +1.9                         | Au k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2617                                     |
| <sup>195</sup> Au   |                                  | 194.965035               | 186.10 d                               | EC/0.227                     |                                          | 3/2+                     | +0.149                           | +0.61                        | Pt k x-ray                                 |
| <sup>196m2</sup> Au |                                  |                          | 9.7 h                                  | I.T./0.5954                  |                                          | 12-                      | 5.7                              |                              | Au k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1478                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1883                                     |
| <sup>196m1</sup> Au |                                  |                          | 8.1 s                                  | I.T./0.0846                  |                                          | 8+                       |                                  |                              | 0.0847                                     |
| <sup>196</sup> Au   |                                  | 195.966570               | 6.17 d                                 | EC/92 /1.506                 |                                          | 2-                       | +0.591                           | 0.81                         | Pt k x-ray                                 |
| <sup>197m</sup> Au  |                                  |                          | 7.8 s                                  | I.T./0.4094                  |                                          | 11/2-                    | +6.0                             | +1.7                         | Au k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^-$ /8 /0.686          |                                          |                          |                                  |                              | 0.1302                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2790                                     |
| <sup>197</sup> Au   | 100.                             | 196.966569               |                                        |                              |                                          | 3/2+                     | +0.14575                         | +0.55                        |                                            |
| <sup>198m</sup> Au  |                                  |                          | 2.30 d                                 | I.T./0.812                   |                                          | (12-)                    |                                  |                              | Au k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0972                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1803                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2419                                     |
| <sup>198</sup> Au   |                                  | 197.968242               | 2.695 d                                | $\beta^-$ /1.372             | 0.290/1                                  | 2-                       | +0.5934                          | +0.64                        | Hg k x-ray                                 |
|                     |                                  |                          |                                        |                              | 0.961/99                                 |                          |                                  |                              | 0.411794                                   |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)   | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|--------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>199</sup> Au  |                                  | 198.968765               | 3.14 d                                 | $\beta^-$ /0.453               | 0.25/22                                  | 3/2+                     | +0.2715                          | +0.51                        | Hg k x-ray                                 |
|                    |                                  |                          |                                        |                                | 0.292/72                                 |                          |                                  |                              | 0.15837                                    |
|                    |                                  |                          |                                        |                                | 0.462/6                                  |                          |                                  |                              | 0.20820                                    |
| <sup>200m</sup> Au |                                  |                          | 18.7 h                                 | $\beta^-$ /84 /1.0             | 0.56/                                    | 12-                      | 5.9                              |                              | Au k x-ray                                 |
|                    |                                  |                          |                                        | I.T./16 /                      |                                          |                          |                                  |                              | 0.2559/71                                  |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.3680/77                                  |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.4978/73                                  |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.5793/72                                  |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.084–0.904)                               |
| <sup>200</sup> Au  |                                  | 199.97073                | 48.4 m                                 | $\beta^-$ /2.24                | 0.7/15                                   | 1-                       |                                  |                              | 0.3679/19                                  |
|                    |                                  |                          |                                        |                                | 2.2/77                                   |                          |                                  |                              | 1.2254/10.6                                |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | (0.077–1.570)                              |
| <sup>201</sup> Au  |                                  | 200.971657               | 26. m                                  | $\beta^-$ /1.28                | 1.27/82                                  | 3/2+                     |                                  |                              | (0.027–0.732)                              |
| <sup>202</sup> Au  |                                  | 201.9738                 | 29. s                                  | $\beta^-$ /3.0                 |                                          | (1-)                     |                                  |                              | 0.4396                                     |
| <sup>203</sup> Au  |                                  | 202.975155               | 1.0 m                                  | $\beta^-$ /2.14                | ~ 1.9/                                   | 3/2+                     |                                  |                              | (0.04–0.37)                                |
| <sup>204</sup> Au  |                                  | 203.9777                 | 40. s                                  | $\beta^-$ /4.5                 |                                          | (2-)                     |                                  |                              | 0.4366                                     |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 1.5113                                     |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | (0.38–1.33)                                |
| <sup>205</sup> Au  |                                  | 204.9799                 | 31. s                                  | $\beta^-$ /                    |                                          |                          |                                  |                              |                                            |
| <sup>80</sup> Hg   |                                  | 200.59(2)                |                                        |                                |                                          |                          |                                  |                              |                                            |
| <sup>171</sup> Hg  |                                  | 171.0038                 | 0.06 ms                                | $\alpha$                       | 7.49                                     |                          |                                  |                              |                                            |
| <sup>172</sup> Hg  |                                  | 171.9988                 | 0.3 ms                                 | $\alpha$                       | 7.36                                     | 0+                       |                                  |                              |                                            |
| <sup>173</sup> Hg  |                                  | 172.9972                 | 0.8 ms                                 | $\alpha$                       | 7.20                                     |                          |                                  |                              |                                            |
| <sup>174</sup> Hg  |                                  | 173.99286                | 1.9 ms                                 | $\alpha$                       | 7.07                                     | 0+                       |                                  |                              |                                            |
| <sup>175</sup> Hg  |                                  | 174.9914                 | 0.02 s                                 | $\alpha$                       |                                          |                          |                                  |                              |                                            |
| <sup>176</sup> Hg  |                                  | 175.98736                | 21 ms                                  | $\alpha$                       | 6.74/94                                  | 0+                       |                                  |                              |                                            |
| <sup>177m</sup> Hg |                                  |                          | 1.5 $\mu$ s                            | IT                             |                                          |                          |                                  |                              | 0.246                                      |
| <sup>177</sup> Hg  |                                  | 176.9863                 | 0.13 s                                 | $\alpha$                       | 6.58                                     |                          |                                  |                              |                                            |
| <sup>178</sup> Hg  |                                  | 177.98248                | 0.26 s                                 | EC/50 /6.1                     |                                          | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /50 /                 | 6.43/                                    |                          |                                  |                              |                                            |
| <sup>179</sup> Hg  |                                  | 178.98183                | 1.05 s                                 | EC/8.0                         |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /                     | 6.29/                                    |                          |                                  |                              |                                            |
| <sup>180</sup> Hg  |                                  | 179.97827                | 2.6 s                                  | EC/5.5                         |                                          | 0+                       |                                  |                              | 0.1250                                     |
|                    |                                  |                          |                                        | $\alpha$ /                     | 6.12/33                                  |                          |                                  |                              | 0.3005                                     |
|                    |                                  |                          |                                        |                                | 5.69/.03                                 |                          |                                  |                              | 0.3812                                     |
| <sup>181</sup> Hg  |                                  | 180.97782                | 3.6 s                                  | $\beta^+$ EC/76 /~ 7.3         |                                          | (1/2-)                   | +0.507                           |                              | 0.0663                                     |
|                    |                                  |                          |                                        | $\alpha$ /24 /                 |                                          |                          |                                  |                              | 0.0811                                     |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.0924                                     |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.1474                                     |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.1587                                     |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.2142                                     |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.2398                                     |
| <sup>182</sup> Hg  |                                  | 181.97469                | 10.8 s                                 | $\beta^+$ , EC/85/5.0          |                                          | 0+                       |                                  |                              | 0.129/122                                  |
|                    |                                  |                          |                                        | $\alpha$ /15/                  | 5.87/8.6                                 |                          |                                  |                              | 0.2176/66                                  |
|                    |                                  |                          |                                        |                                | 5.45/0.03                                |                          |                                  |                              | 0.0256–0.543                               |
| <sup>183</sup> Hg  |                                  | 182.97445                | 9. s                                   | $\beta^+$ , EC/77/6.3          |                                          | ½-                       | +0.524                           |                              | 0.0714                                     |
|                    |                                  |                          |                                        | $\alpha$ /                     | 5.83/                                    |                          |                                  |                              | 0.0874                                     |
|                    |                                  |                          |                                        |                                | 5.91/                                    |                          |                                  |                              | 0.1538                                     |
| <sup>184</sup> Hg  |                                  | 183.97171                | 30.9 s                                 | $\beta^+$ , EC/99/4.1          |                                          | 0+                       |                                  |                              | 0.1565/102                                 |
|                    |                                  |                          |                                        | $\alpha$ /1/                   | 5.54/1.3                                 |                          |                                  |                              | 0.2367/100                                 |
|                    |                                  |                          |                                        |                                | 5.07/0.002                               |                          |                                  |                              | 0.2384/18                                  |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | (0.018-0.4227)                             |
| <sup>185m</sup> Hg |                                  |                          | 21. s                                  | $\beta^+$ , EC, IT, $\alpha$ / | 5.37/                                    | 13/2+                    | -1.02                            | +0.2                         | 0.211                                      |
|                    |                                  |                          |                                        |                                |                                          |                          |                                  |                              | 0.292                                      |
| <sup>185</sup> Hg  |                                  | 184.97190                | 51. s                                  | $\beta^+$ , EC/95/5.8          |                                          | ½-                       | +0.509                           |                              | 0.02–0.55                                  |
| <sup>186</sup> Hg  |                                  | 185.96936                | 1.4 m                                  | $\beta^+$ , EC/3.3             |                                          | 0+                       |                                  |                              | 0.1119                                     |
|                    |                                  |                          |                                        | $\alpha$                       | 5.09/0.02                                |                          |                                  |                              | 0.2518                                     |
| <sup>187m</sup> Hg |                                  |                          | 1.7 m                                  | $\beta^+$ , EC/                |                                          | 13/2+                    | -1.04                            | +0.5                         | see Hg187                                  |
| <sup>187</sup> Hg  |                                  | 186.96981                | 2.4 m                                  | $\beta^+$ , EC/4.9             |                                          | 3/2-                     | -0.594                           | -0.8                         | 0.1034/32                                  |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)          | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|---------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2334/100                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2403/33                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.27151/31                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.3763/38                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.5254/30                                  |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.10–2.18                                  |
| <sup>188</sup> Hg  |                                  | 187.96758                | 3.2 m                                  | $\beta^+$ , EC/2.3                    |                                          | 0+                       |                                  |                              | 0.0988                                     |
|                    |                                  |                          |                                        | $\alpha$                              | 4.61                                     |                          |                                  |                              | 0.1148                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1424                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1900                                     |
| <sup>189m</sup> Hg |                                  |                          | 8.6 m                                  | EC/                                   |                                          | 13/2+                    | -1.06                            | +0.7                         | 0.0780                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.3210                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.4345                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.5655                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | (0.08–2.170)                               |
| <sup>189</sup> Hg  |                                  | 188.96819                | 7.6 m                                  | EC/4.2                                |                                          | 3/2-                     | -0.6086                          | -0.8                         | 0.2005                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2038                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2386                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2485                                     |
| <sup>190</sup> Hg  |                                  | 189.96632                | 20.0 m                                 | EC/1.5                                |                                          | 0+                       |                                  |                              | 0.1296                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1426                                     |
| <sup>191m</sup> Hg |                                  |                          | 51. m                                  | $\beta^+$ /6 /<br>EC/94 /             |                                          | 13/2+                    | -1.07                            | +0.6                         | ann.rad./<br>Au k x-ray                    |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2741                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.4203                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.5787                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | (0.07–1.9)                                 |
| <sup>191</sup> Hg  |                                  | 190.96716                | 50. m                                  | $\beta^+$ , EC/3.2                    |                                          | (3/2-)                   | -0.62                            | -0.8                         | 0.1963                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2247                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2524                                     |
| <sup>192</sup> Hg  |                                  | 191.96563                | 5.0 h                                  | EC/~ 0.5                              |                                          | 0+                       |                                  |                              | Au k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1572                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2748                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.3065                                     |
| <sup>193m</sup> Hg |                                  |                          | 11.8 h                                 | $\beta^+$ , EC/91 /<br>I.T./9 /0.2901 |                                          | 13/2+                    | -1.05843                         | +0.92                        | Hg k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.1866                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2580                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.4076                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.5733                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.9324                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | (0.1–1.96)                                 |
| <sup>193</sup> Hg  |                                  | 192.96667                | 3.8 h                                  | EC, B+/2.34                           |                                          | 3/2-                     | -0.6276                          | -0.7                         | 0.1866                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2580                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.8611                                     |
| <sup>194</sup> Hg  | 0.15(1)                          | 195.965833               | 520. y                                 | EC/0.04                               |                                          | 0+                       |                                  |                              | Au L x-rays                                |
| <sup>195m</sup> Hg |                                  |                          | 1.67 d                                 | I.T./((54)/0.3186<br>EC/(46)/         |                                          | 13/2+                    | -1.04465                         | +1.1                         | Hg k x-ray<br>Au k x-ray                   |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.2617                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.5603                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.7798                                     |
| <sup>195</sup> Hg  |                                  | 194.96672                | 10.5 h                                 | EC/1.51                               |                                          | 1/2-                     | +0.541475                        |                              | Au k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.0614                                     |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.7798                                     |
| <sup>196</sup> Hg  |                                  |                          |                                        |                                       |                                          | 0+                       |                                  |                              |                                            |
| <sup>197m</sup> Hg |                                  |                          | 23.8 h                                 | I.T./((93)/0.2989                     |                                          | 13/2+                    | -1.02768                         | +1.2                         | Hg k x-ray<br>Au k x-ray                   |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.13398                                    |
| <sup>197</sup> Hg  |                                  | 196.967213               | 2.69 d                                 | EC/0.600                              |                                          | 1/2-                     | +0.527374                        |                              | Au k x-ray                                 |
|                    |                                  |                          |                                        |                                       |                                          |                          |                                  |                              | 0.07735                                    |
| <sup>198</sup> Hg  | 9.97(20)                         | 197.9667690              |                                        |                                       |                                          | 0+                       |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)              | Particle Energy/<br>Intensity<br>(MeV/%)           | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------------------|----------------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>199m</sup> Hg |                                  |                          | 42.7 m                                 | I.T./0.532                                |                                                    | 13/2+                    | -1.014703                        | +1.2                         | Hg k x-ray<br>0.15841                      |
| <sup>199</sup> Hg  | 16.87(22)                        | 198.9682799              |                                        |                                           |                                                    | 1/2-                     | +0.505885                        |                              |                                            |
| <sup>200</sup> Hg  | 23.10(19)                        | 199.9683260              |                                        |                                           |                                                    | 0+                       |                                  |                              |                                            |
| <sup>201</sup> Hg  | 13.18(9)                         | 200.970302               |                                        |                                           |                                                    | 3/2-                     | -0.560226                        | +0.39                        |                                            |
| <sup>202</sup> Hg  | 29.86(26)                        | 201.970643               |                                        |                                           |                                                    | 0+                       |                                  |                              |                                            |
| <sup>203</sup> Hg  |                                  | 202.972873               | 46.61 d                                | $\beta^-$ /0.492                          | 0.213/100                                          | 5/2-                     | +0.8489                          | +0.34                        | Tl k x-ray<br>0.279188                     |
| <sup>204</sup> Hg  | 6.87(15)                         | 203.9734939              |                                        |                                           |                                                    | 0+                       |                                  |                              |                                            |
| <sup>205</sup> Hg  |                                  | 204.976073               | 5.2 m                                  | $\beta^-$ /1.531                          | 1.33/4                                             | 1/2-                     | +0.6010                          |                              | 0.20378<br>(0.2–1.4)                       |
| <sup>206</sup> Hg  |                                  | 205.97751                | 8.2 m                                  | $\beta^-$ /1.31                           | 0.935/34<br>1.3/63                                 | 0+                       |                                  |                              | Tl k x-ray<br>0.3052<br>0.6502             |
| <sup>207</sup> Hg  |                                  | 206.9826                 | 2.9 m                                  | $\beta^-$ /4.8                            |                                                    | (9/2+)                   |                                  |                              |                                            |
| <sup>208</sup> Hg  |                                  | 207.9859                 | 41. m                                  | $\beta^-$                                 |                                                    | 0+                       |                                  |                              | 0.474                                      |
| <sup>209</sup> Hg  |                                  | 208.9910                 | 36 s                                   | $\beta^-$                                 |                                                    |                          |                                  |                              | 0.324                                      |
| <sup>210</sup> Hg  |                                  | 209.9945                 | > 0.3 $\mu$ s                          | $\beta^-$                                 |                                                    | 0+                       |                                  |                              |                                            |
| <sup>81</sup> Tl   |                                  | 204.3833(2)              |                                        |                                           |                                                    |                          |                                  |                              |                                            |
| <sup>176</sup> Tl  |                                  | 176.0006                 | 5 ms                                   | p                                         | 1.26/~ 100                                         |                          |                                  |                              |                                            |
| <sup>177m</sup> Tl |                                  |                          | 0.23 ms                                | p/51<br>$\alpha$ /49                      | 1.95<br>7.48                                       |                          |                                  |                              |                                            |
| <sup>177</sup> Tl  |                                  | 176.99643                | 0.017 s                                | $\alpha$ /73<br>p/27                      |                                                    |                          |                                  |                              |                                            |
| <sup>178</sup> Tl  |                                  | 177.9949                 | 0.25 s                                 | $\alpha$ /                                | 6.704<br>6.785<br>6.62<br>6.859                    |                          |                                  |                              |                                            |
| <sup>179m</sup> Tl |                                  |                          | 1.7 ms                                 | $\alpha$                                  | /7.21/80<br>/7.10/20                               |                          |                                  |                              |                                            |
| <sup>179</sup> Tl  |                                  | 178.99109                | 0.3 s                                  | $\alpha$                                  | 6.57/                                              |                          |                                  |                              |                                            |
| <sup>180</sup> Tl  |                                  | 179.9899                 | 1.5 s                                  | $\alpha$ //8                              | 6.28/30<br>6.36/30<br>6.21/18<br>6.56/15<br>6.47/7 |                          |                                  |                              |                                            |
| <sup>181m</sup> Tl |                                  |                          | 1.4 ms                                 | $\alpha$                                  | 6.58/100                                           |                          |                                  |                              |                                            |
| <sup>181</sup> Tl  |                                  | 180.98626                | 3.2 ms                                 | $\alpha$ / < 10                           | 6.19/100                                           |                          |                                  |                              |                                            |
| <sup>182</sup> Tl  |                                  | 181.9857                 | 3. s                                   | $\beta^+$ , EC/10.9                       |                                                    |                          |                                  |                              | 0.351<br>(0.26–0.41)                       |
| <sup>183m</sup> Tl |                                  |                          | 53. ms                                 | $\alpha$                                  | 6.33/80<br>6.38/16<br>6.46/4                       | 9/2-                     |                                  |                              | 0.0618<br>(0.046-0.0894)                   |
| <sup>183</sup> Tl  |                                  | 182.98219                | 5. s                                   | $\beta^+$ , EC/7.7                        |                                                    | $\frac{1}{2}+$           |                                  |                              | 0.208                                      |
| <sup>184</sup> Tl  |                                  | 183.98187                | 11. s                                  | $\beta^+$ , EC/(98)/9.2<br>$\alpha$ /(2)/ | 6.16/                                              |                          |                                  |                              | 0.2868<br>0.3399<br>0.3667                 |
| <sup>185m</sup> Tl |                                  |                          | 1.8 s                                  | I.T./0.453<br>$\alpha$ /5.97              |                                                    | (9/2-)                   |                                  |                              | 0.1688<br>0.2840                           |
| <sup>185</sup> Tl  |                                  | 184.9788                 | 20. s                                  | EC/ $\beta^+$ /6.6                        |                                                    |                          |                                  |                              |                                            |
| <sup>186m</sup> Tl |                                  |                          | 4. s                                   | I.T./0.374                                |                                                    |                          |                                  |                              | 0.3738                                     |
| <sup>186</sup> Tl  |                                  | 185.9783                 | 28. s                                  | $\beta^+$ , EC/7.5                        |                                                    |                          |                                  |                              | 0.3567<br>0.4026<br>0.4053                 |
| <sup>187m</sup> Tl |                                  |                          | 15.6 s                                 | I.T./~ 0.33<br>$\beta^+$ , EC/6.0         |                                                    | (9/2+)<br>$\frac{1}{2}+$ | +3.8<br>1.6                      | -2.4                         | 0.2995                                     |
| <sup>187</sup> Tl  |                                  | 186.97591                | 50. s                                  | $\beta^+$ , EC/                           |                                                    | (7+)                     |                                  |                              | Hg k x-ray<br>0.4129                       |
| <sup>188m</sup> Tl |                                  |                          | 1.18 m                                 | $\beta^+$ , EC/                           |                                                    |                          |                                  |                              |                                            |

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| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)         | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)     |
|--------------------|----------------------------------|--------------------------|----------------------------------------|--------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------------------------------|
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.6954<br>(0.08–1.0)                           |
| <sup>196</sup> Tl  |                                  | 195.97048                | 1.84 h                                 | $\beta^+$ /(15)/4.4<br>EC/(85)/      |                                          | 2-                       | +0.072                           | -0.18                        | ann.rad./<br>Hg k x-ray                        |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.4257<br>0.6105<br>(0.03–2.4)                 |
| <sup>197m</sup> Tl |                                  |                          | 0.54 s                                 | IT/53/0.608<br>$\beta^+$ , EC/47/    |                                          | 9/2-                     |                                  |                              | Tl k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.2262<br>0.4118<br>0.5872<br>0.6367           |
| <sup>197</sup> Tl  |                                  | 196.96958                | 2.83 h                                 | $\beta^+$ /(1)/2.18<br>EC/(99)/      |                                          | 1/2+                     | +1.58                            |                              | Hg k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.1522/8.2<br>0.4258                           |
| <sup>198m</sup> Tl |                                  |                          | 1.87 h                                 | $\beta^+$ , EC/(53)/<br>IT/47/0.5347 |                                          | 7+                       | +0.64                            |                              | Hg k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | Tl k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.4118<br>0.5872<br>0.6367                     |
| <sup>198</sup> Tl  |                                  | 197.9405                 | 5.3 h                                  | EC, $\beta^+$ /(1)/3.5               | 1.4/<br>2.1/<br>2.4/                     | 2-                       |                                  |                              | Hg k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.4118<br>0.6367<br>0.6759<br>(0.23–2.8)       |
| <sup>199</sup> Tl  |                                  | 198.96988                | 7.4 h                                  | EC/1.4                               |                                          | 1/2-                     | +1.60                            |                              | Hg k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.2082<br>0.2473<br>0.4555                     |
| <sup>200</sup> Tl  |                                  | 199.97096                | 1.087 d                                | EC/2.46                              | 1.07/<br>1.44/                           | 2-                       | 0.04                             |                              | Hg k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.36799<br>1.2057<br>(0.11–2.3)                |
| <sup>201</sup> Tl  |                                  | 200.97082                | 3.038 d                                | EC/0.48                              |                                          | 1/2+                     | +1.605                           |                              | Hg k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.13528<br>0.16740/10.0                        |
| <sup>202</sup> Tl  |                                  | 201.97211                | 12.47 d                                | EC/1.36                              |                                          | 2-                       | 0.06                             |                              | Hg k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.43957                                        |
| <sup>203</sup> Tl  | 29.524(14)                       | 202.972344               |                                        |                                      |                                          | 1/2+                     | +1.622258                        |                              |                                                |
| <sup>204</sup> Tl  |                                  | 203.973864               | 3.78 y                                 | $\beta^-$ /97/0.7637<br>EC/(3)/0.347 | 0.763/97                                 | 2-                       | 0.09                             |                              | Hg k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              |                                                |
| <sup>205</sup> Tl  | 70.476(14)                       | 204.974428               |                                        |                                      |                                          | 1/2+                     | +1.638215                        |                              |                                                |
| <sup>206m</sup> Tl |                                  |                          | 3.76 m                                 | I.T./2.644                           |                                          | 12-                      |                                  |                              | Tl k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.2166<br>0.2661<br>0.4534<br>0.6866<br>1.0219 |
| <sup>206</sup> Tl  |                                  | 205.976110               | 4.20 m                                 | $\beta^-$ /1.533                     | 1.53/99.9                                | 0-                       |                                  |                              | Pb k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.80313                                        |
| <sup>207m</sup> Tl |                                  |                          | 1.3 s                                  | I.T./1.350                           |                                          | 11/2-                    |                                  |                              | Tl k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.3501<br>1.0000                               |
| <sup>207</sup> Tl  |                                  | 206.97742                | 4.77 m                                 | $\beta^-$ /1.423                     | 1.43/99.8                                | 1/2+                     | +1.88                            |                              | 0.89723                                        |
| <sup>208</sup> Tl  |                                  | 207.982019               | 3.053 m                                | $\beta^-$ /5.001                     | 1.28/23<br>1.52/22<br>1.796/51           | (5+)                     | +0.29                            |                              | Pb k x-ray                                     |
|                    |                                  |                          |                                        |                                      |                                          |                          |                                  |                              | 0.27728<br>0.51061<br>0.58302<br>2.61448       |
| <sup>209</sup> Tl  |                                  | 208.98536                | 2.16 m                                 | $\beta^-$ /3.98                      | 1.8 /100                                 | (1/2+)                   |                                  |                              | Pb k x-ray                                     |

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| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)            | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                |
|--------------------|----------------------------------|--------------------------|----------------------------------------|-----------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|-----------------------------------------------------------|
| <sup>193m</sup> Pb |                                  |                          | 5.8 m                                  | $\beta^+$ , EC/                         |                                          | 13/2+                    | -1.15                            | +0.19                        | ann.rad./<br>0.3650<br>0.3922                             |
| <sup>193</sup> Pb  |                                  | 192.97617                | ~ 2. m                                 | EC/5.2                                  |                                          | 3/2 (-)                  |                                  |                              |                                                           |
| <sup>194</sup> Pb  |                                  | 193.97401                | 10. m                                  | $\beta^+$ , EC/2.7                      |                                          | 0+                       |                                  |                              | ann.rad./<br>0.2036                                       |
|                    |                                  |                          |                                        | $\alpha$                                | 4.64                                     |                          |                                  |                              |                                                           |
| <sup>195m</sup> Pb |                                  |                          | 15. m                                  | $\beta^+$ /(8)/<br>EC/(92)/             |                                          | 13/2+                    | -1.132                           | +0.30                        | ann.rad./<br>Tl k x-ray<br>0.3836<br>0.3942<br>0.8784     |
| <sup>195</sup> Pb  |                                  | 194.97454                | ~ 15. m                                | $\beta^+$ , EC/5.8                      |                                          |                          |                                  |                              | ann.rad./<br>0.3836<br>0.3937<br>0.7776                   |
| <sup>196</sup> Pb  |                                  | 195.97277                | 37. m                                  | $\beta^+$ , EC/2.1                      |                                          | 0+                       |                                  |                              | Tl k x-ray<br>0.2531<br>0.5021                            |
| <sup>197m</sup> Pb |                                  |                          | 43. m                                  | EC/79/<br>$\beta^+$ /2/<br>IT/19/0.3193 |                                          | 13/2+                    | -1.104                           | +0.38                        | Tl k x-ray<br>0.3079<br>0.3877<br>0.7743<br>(0.2–2.2)     |
| <sup>197</sup> Pb  |                                  | 196.97343                | ~ 8. m                                 | EC/97/3.6<br>$\beta^+$ /3/              |                                          | (3/2-)                   | -1.075                           | -0.08                        | Tl k x-ray<br>0.3755<br>0.3858<br>0.7611                  |
| <sup>198</sup> Pb  |                                  | 197.97203                | 2.4 h                                  | EC/1.4                                  |                                          | 0+                       |                                  |                              | Tl k x-ray<br>0.1734<br>0.2903<br>0.3654                  |
| <sup>199m</sup> Pb |                                  |                          | 12.2 m                                 | IT/93/0.4248<br>$\beta^+$ , EC/(7)/     |                                          | 13/2+                    |                                  |                              | Pb k x-ray<br>0.4255                                      |
| <sup>199</sup> Pb  |                                  | 198.97292                | 1.5 h                                  | EC/(99)/2.9<br>$\beta^+$ /(1)/          |                                          | 5/2-                     | -1.074                           | +0.08                        | Tl k x-ray<br>0.3534<br>0.7202<br>1.1350<br>(0.22–2.4)    |
| <sup>200</sup> Pb  |                                  | 199.97183                | 21.5 h                                 | EC/0.81                                 |                                          | 0+                       |                                  |                              | Tl k x-ray<br>0.14763                                     |
| <sup>201m</sup> Pb |                                  |                          | 1.02 m                                 | I.T./0.6291                             |                                          | 13/2+                    |                                  |                              | Pb k x-ray<br>0.6288                                      |
| <sup>201</sup> Pb  |                                  | 200.97289                | 9.33 h                                 | EC/1.90                                 |                                          | 5/2-                     | +0.675                           | -0.009                       | Tl k x-ray<br>0.33120<br>0.36131<br>(0.11–1.8)            |
| <sup>202m</sup> Pb |                                  |                          | 3.53 h                                 | IT/90/2.170<br>$\beta^+$ /10/           |                                          | 9-                       | -0.228                           | +0.58                        | Pb k x-ray<br>Tl k x-ray<br>0.42219<br>0.78700<br>0.96271 |
| <sup>202</sup> Pb  |                                  | 201.97216                | $5.3 \times 10^4$ y                    | EC/0.05                                 |                                          | 0+                       |                                  |                              | Tl L x-ray                                                |
| <sup>203m</sup> Pb |                                  |                          | 6.2 s                                  | I.T./0.8252                             |                                          | 13/2+                    |                                  |                              | Pb k x-ray<br>0.8203<br>0.8252                            |
| <sup>203</sup> Pb  |                                  | 202.97339                | 2.163 d                                | EC/0.98                                 |                                          | 5/2-                     | +0.686                           | +0.10                        | Tl k x-ray<br>0.279188                                    |
| <sup>204m</sup> Pb |                                  |                          | 1.13 h                                 | I.T./2.185                              |                                          | 9-                       |                                  |                              | Pb k x-ray<br>0.37481<br>0.89922                          |



| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
| 0.91175            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>204</sup> Pb  | 1.4(1)                           | 203.973044               |                                        |                              |                                          | 0+                            |                                  |                              |                                            |
| <sup>205</sup> Pb  |                                  | 204.974482               | 1.51 $\times 10^7$ y                   | EC/0.0512                    |                                          | 5/2-                          | +0.712                           | +0.23                        | Tl L x-ray                                 |
| <sup>206</sup> Pb  | 24.1(1)                          | 205.974465               |                                        |                              |                                          | 0+                            |                                  |                              |                                            |
| <sup>207m</sup> Pb |                                  |                          | 0.80 s                                 | I.T./1.632                   |                                          | 13/2+                         |                                  |                              | Pb k x-ray                                 |
| 0.56915            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 1.06310            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>207</sup> Pb  | 22.1(1)                          | 206.975897               |                                        |                              |                                          | 1/2-                          | +0.59258                         |                              |                                            |
| <sup>208</sup> Pb  | 52.4(1)                          | 207.976652               | $> 2 \times 10^{19}$ y                 | sf                           |                                          | 0+                            |                                  |                              |                                            |
| <sup>209</sup> Pb  |                                  | 208.981090               | 3.25 h                                 | $\beta^-$ /0.644             | 0.645/100                                | 9/2+                          | -1.474                           | -0.3                         |                                            |
| <sup>210</sup> Pb  |                                  | 209.984189               | 22.6 y                                 | $\beta^-$ /0.0635            | 0.017/81                                 | 0+                            |                                  |                              |                                            |
| 0.061/19           |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| $\alpha$           |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 3.72               |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>211</sup> Pb  |                                  | 210.988737               | 36.1 m                                 | $\beta^-$ /1.37              | 0.57/5                                   | (9/2+)                        | -1.404                           | +0.09                        | 0.40486                                    |
| 1.36/92            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.42700            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.83186            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| (0.09–1.27)        |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>212</sup> Pb  |                                  | 211.991898               | 10.64 h                                | $\beta^-$ /0.574             | 0.28/83                                  | 0+                            |                                  |                              | Bi k x-ray                                 |
| 0.57/12            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.23858            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>213</sup> Pb  |                                  | 212.99658                | 10.2 m                                 | $\beta^-$ /2.1               |                                          |                               |                                  |                              |                                            |
| <sup>214</sup> Pb  |                                  | 213.999805               | 26.9 m                                 | $\beta^-$ /1.0               | 0.67/48                                  | 0+                            |                                  |                              | Bi k x-ray                                 |
| 0.73/42            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.24192            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.29509            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.35187            |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>215</sup> Pb  |                                  | 215.0048                 | 36 s                                   |                              |                                          |                               |                                  |                              |                                            |
| <sup>83</sup> Bi   | 208.98040(1)                     |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>184m</sup> Bi |                                  |                          | 0.007 s                                | $\alpha$                     | (7.22-7.85)                              |                               |                                  |                              | 0.449                                      |
| <sup>184</sup> Bi  |                                  | 184.0011                 | 13. ms                                 | $\alpha$                     |                                          |                               |                                  |                              | 0.124                                      |
| <sup>185</sup> Bi  |                                  | 184.9976                 | 60. $\mu$ s                            | p/90                         | 1.55                                     |                               |                                  |                              |                                            |
| $\alpha$ /10       |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 8.03               |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>186m</sup> Bi |                                  |                          | 15. ms                                 | $\alpha$                     | 7.07-7.23                                |                               |                                  |                              | (0.087-0.520)                              |
| p/<0.5             |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>186</sup> Bi  |                                  | 185.9966                 | 9.8 ms                                 | $\alpha$                     | 7.26                                     |                               |                                  |                              | 0.1085                                     |
| 7.37               |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>187m</sup> Bi |                                  |                          | $\sim 8$ . ms                          | $\alpha$ /12                 |                                          |                               |                                  |                              |                                            |
| <sup>187</sup> Bi  |                                  | 186.99316                | 32. ms                                 | $\alpha$ /7                  | 7.00/88.3                                |                               |                                  |                              |                                            |
| 7.61/8.0           |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 7.37/3.7           |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>188</sup> Bi  |                                  | 187.99227                | 0.271 s                                | $\alpha$                     | 6.81                                     |                               |                                  |                              | (0.071-0.320)                              |
| <sup>189m</sup> Bi |                                  |                          | 7.0 ms                                 | $\alpha$                     | 7.30                                     |                               |                                  |                              |                                            |
| <sup>189</sup> Bi  |                                  | 188.9892                 | 0.68 s                                 | $\alpha$                     |                                          |                               |                                  |                              |                                            |
| <sup>190m</sup> Bi |                                  |                          | 5.7 s                                  | $\alpha$ /90                 | 6.43                                     |                               |                                  |                              | (0.105-0.314)                              |
| (6.23-6.72)        |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>190</sup> Bi  |                                  | 189.9883                 | $\sim 5.9$ s                           | $\beta^+$ , EC/(30)/8.7      | $\alpha$ /6.45                           |                               |                                  |                              | (0.089-0.374)                              |
| $\alpha$ /70       |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| (6.39-6.82)        |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>191m</sup> Bi |                                  |                          | 0.12 ms                                | $\alpha$ /                   | 6.87/100                                 |                               |                                  |                              |                                            |
| <sup>191</sup> Bi  |                                  | 190.98579                | 12.4 s                                 | $\beta^+$ , EC/(60)/7.3      |                                          |                               |                                  |                              |                                            |
| $\alpha$ /(40)/    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 6.31               |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>192</sup> Bi  |                                  | 191.98546                | 40. s                                  | $\beta^+$ , EC/(80)/9.0      |                                          |                               |                                  |                              |                                            |
| $\alpha$ /(20)/    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 6.06/              |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>193m</sup> Bi |                                  |                          | 3.2 s                                  | $\beta^+$ , EC/              |                                          | 1/2+                          |                                  |                              |                                            |
| $\alpha$ /         |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 6.48/              |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>193</sup> Bi  |                                  | 192.98296                | 1.11 m                                 | $\beta^+$ , EC/40/7.1        |                                          | 9/2+                          |                                  |                              |                                            |
| $\alpha$ /(60)/    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 5.91/              |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>194</sup> Bi  |                                  | 193.98283                | 1.8 m                                  | $\beta^+$ , EC/99.9/8.2      |                                          | (10-)                         |                                  |                              | 0.1661                                     |
| $\alpha$ /0.1/     |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.1740             |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.2802             |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| 0.421              |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |

[illegible]

| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.80313                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.88100                                    |
| <sup>207</sup> Bi   |                                  | 206.978471               | 31.55 y                                | EC/2.399                     |                                          | 9/2-                          | 4.08                             | -0.6                         | Pb k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.56915                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.06310                                    |
| <sup>208</sup> Bi   |                                  | 207.979742               | 3.68 $\times 10^5$ y                   | EC/2.880                     |                                          | 5+                            | 4.63                             | -0.64                        | Pb k x-ray                                 |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 2.61435                                    |
| <sup>209</sup> Bi   | 100.                             | 208.980399               | 1.9 $\times 10^{19}$ y                 | $\alpha$                     | 3.13                                     | 9/2-                          | +4.111                           | -0.37                        |                                            |
| <sup>210m</sup> Bi  |                                  |                          | 3.0 $\times 10^6$ y                    | $\alpha$ /                   | 4.420(3)/0.29                            | 9-                            | +2.73                            | -0.47                        | Tl k x-ray                                 |
|                     |                                  |                          |                                        |                              | 4.569(3)/3.9                             |                               |                                  |                              | 0.2661                                     |
|                     |                                  |                          |                                        |                              | 4.584(3)/1.4                             |                               |                                  |                              | 0.3052                                     |
|                     |                                  |                          |                                        |                              | 4.908(4)/39                              |                               |                                  |                              | 0.6502                                     |
|                     |                                  |                          |                                        |                              | 4.946(3)/55                              |                               |                                  |                              |                                            |
| <sup>210</sup> Bi   |                                  | 209.984120               | 5.01 d                                 | $\beta^-$ /1.163             | 1.16/99                                  | 1-                            | -0.0445                          | +0.136                       | 0.2661                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.3.52                                     |
| <sup>211</sup> Bi   |                                  | 210.98727                | 2.14 m                                 | $\alpha$ /(99.7)/            | 6.279/16                                 | 9/2-                          |                                  |                              | Tl k x-ray                                 |
|                     |                                  |                          |                                        | $\beta^-$ /(0.3)/0.58        | 6.623/84                                 |                               |                                  |                              | 0.3501                                     |
| <sup>212m2</sup> Bi |                                  |                          | 7. m                                   | $\beta^-$ /                  |                                          | (15-)                         |                                  |                              |                                            |
| <sup>212m1</sup> Bi |                                  |                          | 25.0 m                                 | $\alpha$ /(93)/              | 6.300/40                                 | (9-)                          |                                  |                              | 0.120                                      |
|                     |                                  |                          |                                        | $\beta^-$ /(7)/              | 6.340/53                                 |                               |                                  |                              | 0.233                                      |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.275                                      |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.404                                      |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.727                                      |
| <sup>212</sup> Bi   |                                  | 211.991286               | 1.009 h                                | $\beta^-$ /(64)/2.254        |                                          | (1-)                          | +0.32                            | +0.1                         | Tl k x-ray                                 |
|                     |                                  |                          |                                        | $\alpha$ /(36)/              | 6.051/25                                 |                               |                                  |                              | Po k x-ray                                 |
|                     |                                  |                          |                                        |                              | 6.090/9.6                                |                               |                                  |                              | 0.2881                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.72725                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.78551                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.62066                                    |
| <sup>213</sup> Bi   |                                  | 212.994385               | 45.6 m                                 | $\beta^-$ /(98)/1.43         | 1.02/31                                  | 9/2-                          | +3.72                            | -0.60                        | Po k x-ray                                 |
|                     |                                  |                          |                                        | $\alpha$ /(2)/               | 1.42/66                                  |                               |                                  |                              | 0.4404                                     |
|                     |                                  |                          |                                        |                              | 5.549/0.16                               |                               |                                  |                              | (0.15–1.328)                               |
|                     |                                  |                          |                                        |                              | 5.869/2.0                                |                               |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.10006                                    |
| <sup>214</sup> Bi   |                                  | 213.99871                | 19.7 m                                 | $\beta^-$ /3.27              |                                          |                               |                                  |                              | 0.60931                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.12027                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.76449                                    |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.19–3.2)                                 |
| <sup>215m</sup> Bi  |                                  |                          | 37. s                                  | $\beta$                      |                                          |                               |                                  |                              | (0.158-0.498)                              |
| <sup>215</sup> Bi   |                                  | 215.00177                | 7.7 m                                  | $\beta^-$ /2.3               |                                          |                               |                                  |                              | 0.2937/35.2                                |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.271–1.399)                              |
| <sup>216</sup> Bi   |                                  | 216.00631                | 2.3 m                                  | $\beta^-$ /4.0               |                                          |                               |                                  |                              | 0.5498                                     |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.4192                                     |
| <sup>217</sup> Bi   |                                  | 217.0095                 | 98 s                                   | $\beta$ /                    |                                          |                               |                                  |                              | 0.2646/100                                 |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.254-1.017)                              |
| <sup>218</sup> Bi   |                                  | 218.0143                 | 33. s                                  | $\beta^-$                    |                                          |                               |                                  |                              | 0.5097/134                                 |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.3857/100                                 |
|                     |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.174-0.703)                              |
| <sup>84</sup> Po    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>188</sup> Po   |                                  | 187.99942                | 0.27 ms                                | $\alpha$                     | 7.91/80                                  | 0+                            |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 7.320                                    |                               |                                  |                              |                                            |
| <sup>189</sup> Po   |                                  | 188.99848                | 5 ms                                   | $\alpha$                     | 7.532/8                                  |                               |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 7.259/80                                 |                               |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 7.309/12                                 |                               |                                  |                              |                                            |
| <sup>190</sup> Po   |                                  | 189.99510                | 2.4 ms                                 | $\alpha$ /                   | 7.53/96.4                                | 0+                            |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 7.01/3.3                                 |                               |                                  |                              |                                            |
| <sup>191m</sup> Po  |                                  |                          | 93. ms                                 | $\alpha$                     | 7.376/50                                 |                               |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 6.888/46                                 |                               |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)                         | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                       |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|------------------------------------------------------------------|
| <sup>191</sup> Po  |                                  | 190.99457                | 22 ms                                  | $\alpha$ /                                           | 7.334/77<br>6.97/8                       |                          |                                  |                              |                                                                  |
| <sup>192</sup> Po  |                                  | 191.99134                | 32. ms                                 | $\alpha$ /8.5                                        | 7.17/98.6<br>6.59/1.4                    | 0+                       |                                  |                              |                                                                  |
| <sup>193m</sup> Po |                                  |                          | $\sim 0.07$ s                          | $\alpha$ /                                           | 7.00                                     |                          |                                  |                              |                                                                  |
| <sup>193</sup> Po  |                                  | 192.99103                | 0.45 s                                 | $\alpha$ /                                           | 6.95                                     |                          |                                  |                              |                                                                  |
| <sup>194</sup> Po  |                                  | 193.98819                | 0.2 s                                  | $\alpha$ /                                           | 6.84/93<br>6.19/0.22                     | 0+                       |                                  |                              |                                                                  |
| <sup>195m</sup> Po |                                  |                          | $\sim 2.8$ s                           | $\alpha$ /                                           | 6.70/                                    |                          |                                  |                              |                                                                  |
| <sup>195</sup> Po  |                                  | 194.98811                | $\sim 3.9$ s                           | $\alpha$ /                                           | 6.62/                                    |                          |                                  |                              |                                                                  |
| <sup>196</sup> Po  |                                  | 195.98554                | 5. s                                   | $\alpha$ /(95)/<br>$\beta$ +, EC/(5)/ $\sim 4.6$     | 6.53/94<br>5.77/0.02                     | 0+                       |                                  |                              |                                                                  |
| <sup>197m</sup> Po |                                  |                          | 25.8 s                                 | $\alpha$ /(84)/<br>$\beta$ +, EC/(16)/               | 6.385(3)/55                              | 13/2+                    |                                  |                              |                                                                  |
| <sup>197</sup> Po  |                                  | 196.98566                | 53. s                                  | $\alpha$ /(44)/<br>$\beta$ +, EC/(56)/6.2            | 6.282(4)/76                              | (3/2-)                   |                                  |                              |                                                                  |
| <sup>198</sup> Po  |                                  | 197.98339                | 1.76 m                                 | $\alpha$ /(70)/<br>$\beta$ +, EC/(30)/4.0            | 6.18/57<br>5.27/7.6 $\times 10^{-4}$     | 0+                       |                                  |                              |                                                                  |
| <sup>199m</sup> Po |                                  |                          | 4.2 m                                  | $\beta$ +, EC/(51)/<br>$\alpha$ /(39)/               |                                          | 13/2+                    | 0.99                             |                              | ann.rad./<br>0.2745<br>0.4998<br>1.0020                          |
| <sup>199</sup> Po  |                                  | 198.98367                | 5.2 m                                  | $\beta$ +, EC/(88)/7.<br>$\alpha$ /(12)/             |                                          | (3/2-)                   |                                  |                              | Bi k x-ray<br>0.1877<br>0.3616<br>1.0214<br>1.0344               |
| <sup>200</sup> Po  |                                  | 199.981780               | 11.5 m                                 | $\beta$ +, EC/85/3.4<br>$\alpha$ /(15)/              |                                          | 0+                       |                                  |                              | 0.14748<br>0.32792<br>0.6176<br>0.6709                           |
| <sup>201m</sup> Po |                                  |                          | 8.9 m                                  | $\beta$ +, EC/(57)/<br>IT/40/0.418<br>$\alpha$ /(3)/ |                                          | 13/2+                    | 1.00                             |                              | Bi k x-ray<br>Po k x-ray<br>0.2726<br>0.4123<br>0.4179<br>0.9670 |
| <sup>201</sup> Po  |                                  | 200.98226                | 15.3 m                                 | $\beta$ +, EC/98/4.9<br>$\alpha$ /(2)/               |                                          | 3/2-                     | 0.94                             |                              | Bi k x-ray<br>0.2056<br>0.2250<br>0.8483<br>0.9048               |
| <sup>202</sup> Po  |                                  | 201.98076                | 45. m                                  | $\beta$ +, EC/98/2.8<br>$\alpha$ /(2)/               |                                          | 0+                       |                                  |                              | 0.0410<br>0.1656<br>0.3158<br>0.6884                             |
| <sup>203m</sup> Po |                                  |                          | 1.2 m                                  | IT/96/0.6414<br>$\beta$ -EC/(4)/                     |                                          | 13/2+                    |                                  |                              | Bi k x-ray<br>Po k x-ray<br>0.6414                               |
| <sup>203</sup> Po  |                                  | 202.98142                | 35. m                                  | $\beta$ +, EC/4.2                                    |                                          | 5/2-                     | +0.74                            |                              | 0.17516<br>0.21477<br>0.89350<br>0.90863<br>1.09095              |
| <sup>204</sup> Po  |                                  | 203.98032                | 3.53 h                                 | EC/2.34<br>$\alpha$                                  |                                          | 0+                       |                                  |                              | Bi k x-ray<br>0.2702<br>0.8844<br>1.0162<br>(0.11–1.9)           |
| <sup>205</sup> Po  |                                  | 204.98120                | 1.7 h                                  | $\beta$ +, EC/3.53                                   |                                          | 5/2-                     | +0.76                            | +0.17                        | Bi k x-ray                                                       |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.83681                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.84983                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.87241                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.00124                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.12–2.7)                                 |
| <sup>206</sup> Po  |                                  | 205.98048                | 8.8 d                                  | EC/(95)/1.85                 |                                          | 0+                       |                                  |                              | Bi k x-ray                                 |
|                    |                                  |                          |                                        | $\alpha$ /(5)/               | 5.223/5.5                                |                          |                                  |                              | 0.28644                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.31156                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.51134                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.80737                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.03228                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.11–1.5)                                 |
| <sup>207m</sup> Po |                                  |                          | 2.8 s                                  | I.T./1.383                   |                                          | 19/2-                    |                                  |                              | Po k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2682                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.30074                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.81448                                    |
| <sup>207</sup> Po  |                                  | 206.98159                | 5.80 h                                 | EC, $\beta$ +/2.91           |                                          | 5/2-                     | +0.79                            | +0.28                        | Bi k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.74263                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.91176                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.99225                                    |
| <sup>208</sup> Po  |                                  | 207.981246               | 2.898 y                                | $\alpha$ /5.213              | 4.233/0.0002                             | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 5.1158/100                               |                          |                                  |                              |                                            |
| <sup>209</sup> Po  |                                  | 208.982430               | 102. y                                 | $\alpha$ /4.976              | 4.624/0.56                               | 1/2-                     | $\sim +0.77$                     |                              | 0.26049                                    |
|                    |                                  |                          |                                        |                              | 4.879/99.2                               |                          |                                  |                              | 0.8964                                     |
| <sup>210</sup> Po  |                                  | 209.982874               | 138.4 d                                | $\alpha$ /5.407              | 4.516/0.001                              | 0+                       |                                  |                              | 0.80313                                    |
|                    |                                  |                          |                                        |                              | 5.304/100                                |                          |                                  |                              |                                            |
| <sup>211m</sup> Po |                                  |                          | 25.2 s                                 | $\alpha$ /                   | 7.273/91                                 | 25/2+                    |                                  |                              | Pb k x-ray                                 |
|                    |                                  |                          |                                        |                              | 7.994/1.7                                |                          |                                  |                              | 0.32808                                    |
|                    |                                  |                          |                                        |                              | 8.316/0.25                               |                          |                                  |                              | 0.56915                                    |
|                    |                                  |                          |                                        |                              | 8.875/7.0                                |                          |                                  |                              | 0.89723                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.06310                                    |
| <sup>211</sup> Po  |                                  | 210.986653               | 0.516 s                                | $\alpha$ /7.594              | 6.570/0.54                               | 9/2+                     |                                  |                              | 0.56915                                    |
|                    |                                  |                          |                                        |                              | 6.892/0.55                               |                          |                                  |                              | 0.89723                                    |
|                    |                                  |                          |                                        |                              | 7.450/98.9                               |                          |                                  |                              |                                            |
| <sup>212m</sup> Po |                                  |                          | 45. s                                  | $\alpha$ /                   | 8.514/2.0                                | 16+                      |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 9.086/1.0                                |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 11.650/97                                |                          |                                  |                              |                                            |
| <sup>212</sup> Po  |                                  | 211.988868               | 0.298 $\mu$ s                          | $\alpha$ /8.953              | 8.784/100                                | 0+                       |                                  |                              |                                            |
| <sup>213</sup> Po  |                                  | 212.992857               | 3.7 $\mu$ s                            | $\alpha$ /8.537              | 7.614/0.003                              | 9/2+                     |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 8.375/100                                |                          |                                  |                              |                                            |
| <sup>214</sup> Po  |                                  | 213.995201               | 163.7 $\mu$ s                          | $\alpha$ /7.833              | 6.904/0.01                               | 0+                       |                                  |                              | 0.7995                                     |
|                    |                                  |                          |                                        |                              | 7.686/99.99                              |                          |                                  |                              | 0.298                                      |
| <sup>215</sup> Po  |                                  | 214.999420               | 1.780 ms                               | $\alpha$ /7.526              | 6.950/0.02                               | (9/2+)                   |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.957/0.03                               |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.386/100                                |                          |                                  |                              |                                            |
| <sup>216</sup> Po  |                                  | 216.001915               | 0.145 s                                | $\alpha$ /6.906              | 5.895/0.002                              | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.778/99.99                              |                          |                                  |                              |                                            |
| <sup>217</sup> Po  |                                  | 217.00634                | 1.53 s                                 | $\alpha$ /6.662              | 6.539/                                   |                          |                                  |                              |                                            |
| <sup>218</sup> Po  |                                  | 218.008973               | 3.04 m                                 | $\alpha$ /6.114              | 6.003/99.999                             | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 5.181/0.11                               |                          |                                  |                              |                                            |
| <sup>219</sup> Po  |                                  | 219.0137                 | $\sim 2$ m                             |                              |                                          |                          |                                  |                              |                                            |
| <sup>220</sup> Po  |                                  | 220.0166                 | $> 0.3 \mu$ s                          |                              |                                          | 0+                       |                                  |                              |                                            |
| <sup>85</sup> At   |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>191m</sup> At |                                  |                          | 2.1 ms                                 | $\alpha$                     | 7.65/98                                  |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.72/2                                   |                          |                                  |                              |                                            |
| <sup>191</sup> At  |                                  |                          | $\sim 1.7$ ms                          | $\alpha$                     | 7.55/100                                 |                          |                                  |                              |                                            |
| <sup>193m</sup> At |                                  |                          | 21 ms                                  | $\alpha$                     | 7.33/98                                  |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.42/2                                   |                          |                                  |                              |                                            |

[illegible]

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.78189                                    |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.79020                                    |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.1–2.6)                                  |
| <sup>210</sup> At      |                                  | 209.98715                | 8.1 h                                  | EC/99.8/3.98                 |                                          | 5+                            |                                  |                              | Po k x-ray                                 |
|                        |                                  |                          |                                        | $\alpha$ /(0.2)/5.632        | 5.361/0.05                               |                               |                                  |                              | 0.24535                                    |
|                        |                                  |                          |                                        |                              | 5.442/0.05                               |                               |                                  |                              | 0.52758                                    |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.18143                                    |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.43678                                    |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.48335                                    |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.04–2.4)                                 |
| <sup>211</sup> At      |                                  | 210.987496               | 7.21 h                                 | EC/(58)/0.787                |                                          | 9/2-                          |                                  |                              | Po k x-ray                                 |
|                        |                                  |                          |                                        | $\alpha$ /(42)/5.980         | 5.211/0.004                              |                               |                                  |                              | 0.66956                                    |
|                        |                                  |                          |                                        |                              | 5.868/42                                 |                               |                                  |                              | 0.6870                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.74263                                    |
| <sup>212m</sup> At     |                                  |                          | 0.119 s                                | $\alpha$ /                   | 7.837/65                                 | (9-)                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.897/33                                 |                               |                                  |                              |                                            |
| <sup>212</sup> At      |                                  | 211.99075                | 0.314 s                                | $\alpha$ /7.828              | 7.058/0.4                                | (1-)                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.088/0.6                                |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.618/15                                 |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.681/84                                 |                               |                                  |                              |                                            |
| <sup>213</sup> At      |                                  | 212.992937               | 0.11 $\mu$ s                           | $\alpha$ /9.254              | 9.080/                                   | 9/2-                          |                                  |                              |                                            |
| <sup>214m</sup> At     |                                  |                          | 0.76 $\mu$ s                           | $\alpha$ /8.762              |                                          | (9-)                          |                                  |                              |                                            |
| <sup>214</sup> At      |                                  | 213.996372               | 0.56 $\mu$ s                           | $\alpha$ /8.987              | 8.819/100                                | (1-)                          |                                  |                              |                                            |
| <sup>215</sup> At      |                                  | 214.99865                | 0.10 ms                                | $\alpha$ /8.178              | 7.626/0.045                              | (9/2-)                        |                                  |                              | 0.40486                                    |
|                        |                                  |                          |                                        |                              | 8.023/99.9                               |                               |                                  |                              |                                            |
| <sup>216</sup> At      |                                  | 216.002423               | 0.30 ms                                | $\alpha$ /7.947              | 7.595/0.2                                | (1-)                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.697/2.1                                |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.800/97                                 |                               |                                  |                              |                                            |
| <sup>217</sup> At      |                                  | 217.004719               | 32. ms                                 | $\alpha$ /7.202              | 6.812/0.06                               | (9/2-)                        |                                  |                              | 0.2595                                     |
|                        |                                  |                          |                                        |                              | 7.067/99.9                               |                               |                                  |                              | 0.3345                                     |
|                        |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 0.5940                                     |
| <sup>218</sup> At      |                                  | 218.00869                | 1.6 s                                  | $\alpha$ /6.883              | 6.654/6                                  |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.695/90                                 |                               |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.748/4                                  |                               |                                  |                              |                                            |
| <sup>219</sup> At      |                                  | 219.011162               | 50. s                                  | $\alpha$ /6.390              | 6.275/                                   |                               |                                  |                              |                                            |
| <sup>220</sup> At      |                                  | 220.0154                 | 3.71 m                                 | $\beta^-$ /3.7               |                                          |                               |                                  |                              | (0.24–0.70)                                |
| <sup>221</sup> At      |                                  | 221.0181                 | 2.3 m                                  | $\beta$                      |                                          |                               |                                  |                              |                                            |
| <sup>222</sup> At      |                                  | 222.0223                 | 0.9 m                                  | $\beta$                      |                                          |                               |                                  |                              |                                            |
| <sup>223</sup> At      |                                  | 223.0252                 | 50. s                                  | $\beta$                      |                                          |                               |                                  |                              |                                            |
| <b><sup>86</sup>Rn</b> |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>195m</sup> Rn     |                                  |                          | 5 ms                                   | $\alpha$                     | 7.56                                     |                               |                                  |                              |                                            |
| <sup>195</sup> Rn      |                                  | 195.00544                | 6 ms                                   | $\alpha$                     | 7.54                                     |                               |                                  |                              |                                            |
| <sup>196</sup> Rn      |                                  | 196.00212                | 4. ms                                  | $\alpha$ /                   | 7.46                                     | 0+                            |                                  |                              |                                            |
| <sup>197m</sup> Rn     |                                  |                          | 0.02 s                                 | $\alpha$                     | 7.36                                     |                               |                                  |                              |                                            |
| <sup>197</sup> Rn      |                                  | 197.0016                 | 0.07 s                                 | $\alpha$ /                   | 7.26                                     |                               |                                  |                              |                                            |
| <sup>198</sup> Rn      |                                  | 197.99868                | 64. ms                                 | $\alpha$                     | 7.205                                    | 0+                            |                                  |                              |                                            |
| <sup>199m</sup> Rn     |                                  |                          | 0.32 s                                 | $\alpha$                     | 7.060                                    | (13/2+)                       |                                  |                              |                                            |
| <sup>199</sup> Rn      |                                  | 198.9984                 | 0.62 s                                 | $\alpha$ /                   | 6.989                                    | 3/2-                          |                                  |                              |                                            |
| <sup>200</sup> Rn      |                                  | 199.99570                | 1.06 s                                 | $\alpha$ /(98)/              | 6.901/                                   | 0+                            |                                  |                              | 0.4329                                     |
|                        |                                  |                          |                                        | EC/(2)/5.                    |                                          |                               |                                  |                              | 0.5043                                     |
| <sup>201m</sup> Rn     |                                  |                          | 3.8 s                                  | EC/(10)/                     |                                          | 13/2+                         |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /(90)/              | 6.773/                                   |                               |                                  |                              |                                            |
| <sup>201</sup> Rn      |                                  | 200.9956                 | 7.0 s                                  | $\alpha$ /(80)/              | 6.725/                                   | (3/2-)                        |                                  |                              |                                            |
|                        |                                  |                          |                                        | EC/(20)/                     | $\alpha$ /6.778                          |                               |                                  |                              |                                            |
| <sup>202</sup> Rn      |                                  | 201.99326                | 9.9 s                                  | $\alpha$ /(12)/              | 6.641/                                   | 0+                            |                                  |                              | 0.5695                                     |
|                        |                                  |                          |                                        | EC/(88)/                     |                                          |                               |                                  |                              | 0.2876–0.6255                              |
| <sup>203m</sup> Rn     |                                  |                          | 28. s                                  | $\alpha$ /                   | 6.551                                    | 13/2+                         | -0.96                            | +1.3                         |                                            |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)                 | Particle Energy/<br>Intensity<br>(MeV/%)                    | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                                 |
|-------------------|----------------------------------|--------------------------|----------------------------------------|----------------------------------------------|-------------------------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------------------------------------------------------|
| <sup>203</sup> Rn |                                  | 202.99339                | 45. s                                  | $\alpha/(66)/6.629$<br>EC/(34)/~ 7.4         | 6.499/                                                      | 3/2-                     |                                  |                              |                                                                                            |
| <sup>204</sup> Rn |                                  | 203.99143                | 1.24 m                                 | $\alpha/(68)/$<br>EC/(32)/3.8                | 6.420/                                                      | 0+                       |                                  |                              |                                                                                            |
| <sup>205</sup> Rn |                                  | 204.99172                | 2.8 m                                  | $\alpha/(23)/6.390$<br>EC/(77)/5.2           | 6.123(3)/0.02<br>6.262(3)/23                                | (5/2-)                   | +0.80                            | +0.06                        | 0.2652<br>0.3553<br>0.4648<br>0.6205<br>0.6753<br>0.7300                                   |
| <sup>206</sup> Rn |                                  | 205.99021                | 5.7 m                                  | $\alpha/(68)/6.384$<br>EC/(32)/3.3           | 6.258(3)/                                                   | 0+                       |                                  |                              | 0.06170<br>0.0968<br>0.3245<br>0.3862<br>0.4822<br>0.4973<br>0.7728                        |
| <sup>207</sup> Rn |                                  | 206.99073                | 9.3 m                                  | $\beta+$ , EC/77/4.6<br>$\alpha/(23)/6.252$  | 5.995(4)/0.02<br>6.068(3)/0.15<br>6.126(3)/22.8             | 5/2-                     | +0.82                            | +0.22                        | At k x-ray<br>0.32947<br>0.34455<br>0.36767<br>0.40267<br>0.74723<br>(0.18–1.4)            |
| <sup>208</sup> Rn |                                  | 207.98964                | 24.3 m                                 | $\alpha/(60)/6.260$<br>EC/(40)/2.85          | 5.469(2)/0.003<br>6.140(2)/60                               | 0+                       |                                  |                              |                                                                                            |
| <sup>209</sup> Rn |                                  | 208.99042                | 29. m                                  | $\beta+$ /(83)/3.93<br>$\alpha/(17)/$        | 2.16/2.3<br>5.887(3)/0.04<br>5.898(3)/0.02<br>6.039(2)/16.9 | 5/2-                     | +0.8388                          | +0.31                        | At k x-ray<br>0.27933<br>0.33753<br>0.40841<br>0.68942<br>0.74594<br>(0.18–3.2)            |
| <sup>210</sup> Rn |                                  | 209.98970                | 2.4 h                                  | $\alpha/(96)/6.157$<br>EC/(4)/2.37           | 5.351(2)/0.005<br>6.039(2)/96                               | 0+                       |                                  |                              | At k x-ray<br>0.19625<br>0.45824<br>0.57104<br>0.64868<br>(0.14–1.7)                       |
| <sup>211</sup> Rn |                                  | 210.99060                | 14.6 h                                 | $\beta+$ , EC/74/2.89<br>$\alpha/(26)/5.964$ | 5.619(1)/0.7<br>5.784(1)/16.4<br>5.851(1)/8.8               | 1/2-                     | +0.60                            |                              | At k x-ray<br>0.16877<br>0.25022<br>0.37049<br>0.67412<br>0.67839<br>1.36298<br>(0.11–2.7) |
| <sup>212</sup> Rn |                                  | 211.990704               | 24. m                                  | $\alpha/6.385$                               | 5.587(4)/0.05<br>6.260(4)/99.95                             | 0+                       |                                  |                              |                                                                                            |
| <sup>213</sup> Rn |                                  | 212.99388                | 19. ms                                 | $\alpha/8.243$                               | 7.552(8)/1.0<br>8.087(8)/98.2<br>7.254/0.8                  | 9/2+                     |                                  |                              | 0.540                                                                                      |
| <sup>214</sup> Rn |                                  | 213.99536                | 0.27 $\mu$ s                           | $\alpha/9.209$                               | 9.037(9)/                                                   | 0+                       |                                  |                              |                                                                                            |
| <sup>215</sup> Rn |                                  | 214.99875                | 2.3 $\mu$ s                            | $\alpha/8.840$                               | 8.674(8)/                                                   | (9/2+)                   |                                  |                              |                                                                                            |
| <sup>216</sup> Rn |                                  | 216.00027                | 45. $\mu$ s                            | $\alpha$                                     |                                                             | 0+                       |                                  |                              |                                                                                            |
| <sup>217</sup> Rn |                                  | 217.003928               | 0.6 ms                                 | $\alpha/7.885$                               | 7.500/0.1<br>7.742(4)/100                                   | 9/2+                     |                                  |                              |                                                                                            |
| <sup>218</sup> Rn |                                  | 218.005601               | 35. ms                                 | $\alpha/7.267$                               | 6.534(1)/0.16<br>7.133(1)/99.8                              | 0+                       |                                  |                              | 0.6093<br>0.6653                                                                           |
| <sup>219</sup> Rn |                                  | 219.009480               | 3.96 s                                 | $\alpha/6.946(1)$                            | 6.3130(5)/0.05                                              | (5/2+)                   | -0.44                            | +0.93                        | Po k x-ray                                                                                 |



| Elem.<br>or Isot.   | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                     |                                  |                          |                                        |                              | 6.425(3)/7.5                             |                          |                                  |                              | 0.13057                                    |
|                     |                                  |                          |                                        |                              | 6.5309(4)/0.12                           |                          |                                  |                              | 0.27113                                    |
|                     |                                  |                          |                                        |                              | 6.5531(3)/12.2                           |                          |                                  |                              | 0.40170                                    |
|                     |                                  |                          |                                        |                              | 6.8193(3)/81                             |                          |                                  |                              | (0.1–1.05)                                 |
| <sup>220</sup> Rn   |                                  | 220.011394               | 55.6 s                                 | $\alpha$ /6.404              | 5.7486(5)/0.07                           | 0+                       |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 6.2883(1)/99.9                           |                          |                                  |                              |                                            |
| <sup>221</sup> Rn   |                                  | 221.01554                | 25. m                                  | $\alpha$ /(22)/6.148         | 5.778(3)/1.8                             | 7/2+                     | -0.020                           | -0.38                        | Fr L x-ray                                 |
|                     |                                  |                          |                                        | $\beta^-$ /(78)/1.2          | 5.788(3)/2.2                             |                          |                                  |                              | 0.07384                                    |
|                     |                                  |                          |                                        |                              | 6.037(3)/18                              |                          |                                  |                              | 0.08323                                    |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0610                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.18639                                    |
| <sup>222</sup> Rn   |                                  | 222.017578               | 3.823 d                                | $\alpha$ /5.590              | 4.987(1)/0.08                            | 0+                       |                                  |                              | 0.510                                      |
|                     |                                  |                          |                                        |                              | 5.4897(3)/99.9                           |                          |                                  |                              |                                            |
| <sup>223</sup> Rn   |                                  | 223.0218                 | 23. m                                  | $\beta^-$ /                  |                                          |                          | -0.78                            | +0.80                        |                                            |
| <sup>224</sup> Rn   |                                  | 224.0241                 | 1.8 h                                  | $\beta^-$ /                  |                                          | 0+                       |                                  |                              | 0.1085                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2601                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2655                                     |
| <sup>225</sup> Rn   |                                  | 225.0284                 | 4.5 m                                  | $\beta^-$ /                  |                                          | 7/2-                     | -0.70                            | +0.84                        |                                            |
| <sup>226</sup> Rn   |                                  | 226.0309                 | 7.4 m                                  | $\beta^-$ /                  |                                          | 0+                       |                                  |                              |                                            |
| <sup>227</sup> Rn   |                                  | 227.0354                 | 2. s                                   | $\beta^-$ /                  |                                          |                          |                                  |                              |                                            |
| <sup>228</sup> Rn   |                                  | 228.0380                 | 65. s                                  | $\beta^-$ /                  |                                          | 0+                       |                                  |                              |                                            |
| <sup>87</sup> Fr    |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>199</sup> Fr   |                                  | 199.00726                | 12 s                                   | $\alpha$                     | 7.66                                     |                          |                                  |                              |                                            |
| <sup>200</sup> Fr   |                                  | 200.0066                 | 49 ms                                  | $\alpha$                     | 7.47                                     |                          |                                  |                              |                                            |
| <sup>201m</sup> Fr  |                                  |                          | ~ 0.02 s                               | $\alpha$ /                   | 7.454                                    |                          |                                  |                              |                                            |
| <sup>201</sup> Fr   |                                  | 201.0039                 | ~ 60 ms                                | $\alpha$ /                   | 7.36/                                    | (9/2-)                   |                                  |                              |                                            |
| <sup>202m</sup> Fr  |                                  |                          | 0.29 s                                 | $\alpha$                     | 7.236/                                   |                          |                                  |                              |                                            |
| <sup>202</sup> Fr   |                                  | 202.00337                | 0.30 s                                 | $\alpha$ /7.590              | 7.24/100                                 |                          |                                  |                              |                                            |
| <sup>203</sup> Fr   |                                  | 203.00093                | 0.54 s                                 | $\alpha$ /7.280              | 7.132(5)/                                | (9/2-)                   |                                  |                              |                                            |
| <sup>204m2</sup> Fr |                                  |                          | 0.8 s                                  | $\alpha$                     | 7.01                                     |                          |                                  |                              |                                            |
| <sup>204m1</sup> Fr |                                  |                          | 2. s                                   | $\alpha$                     | 6.97                                     |                          |                                  |                              |                                            |
| <sup>204</sup> Fr   |                                  | 204.00065                | 1.8 s                                  | $\alpha$ /                   | 7.03/96                                  |                          |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 6.97/90                                  |                          |                                  |                              |                                            |
|                     |                                  |                          |                                        |                              | 7.01/74                                  |                          |                                  |                              |                                            |
| <sup>205</sup> Fr   |                                  | 204.99859                | 3.9 s                                  | $\alpha$ /7.050              | 6.914(5)/                                | (9/2-)                   |                                  |                              |                                            |
| <sup>206m</sup> Fr  |                                  |                          | 0.7 s                                  | $\alpha$ /                   | 6.93                                     |                          |                                  |                              | 0.531(IT)                                  |
| <sup>206</sup> Fr   |                                  | 205.99867                | 16.0 s                                 | $\alpha$ /7.416              | 6.792(5)/84                              |                          |                                  |                              |                                            |
| <sup>207</sup> Fr   |                                  | 206.99695                | 14.8 s                                 | $\alpha$ /6.900              | 6.766(5)/                                | 9/2-                     | +3.9                             | -0.16                        |                                            |
| <sup>208</sup> Fr   |                                  | 207.99714                | 59.1 s                                 | $\alpha$ /(77)/6.770         | 6.636(5)/                                | 7+                       | -4.8                             | +0.004                       |                                            |
|                     |                                  |                          |                                        | EC/(23)/6.99                 |                                          |                          |                                  |                              |                                            |
| <sup>209</sup> Fr   |                                  | 208.99595                | 50.0 s                                 | $\alpha$ /(89)/5.1           | 6.646(3)/                                | 9/2-                     | +3.9                             | -0.24                        | 0.7978                                     |
|                     |                                  |                          |                                        | EC/(11)/5.16                 |                                          |                          |                                  |                              | (0.1103–1.384)                             |
| <sup>210</sup> Fr   |                                  | 209.99641                | 3.2 m                                  | $\alpha$ /6.670/71           | 6.543(5)/99.87                           | 6+                       | +4.4                             | +0.19                        | 0.2030                                     |
|                     |                                  |                          |                                        | EC/6.26                      | (5.90-6.42)                              |                          |                                  |                              | 0.6438                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8175                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9008                                     |
| <sup>211</sup> Fr   |                                  | 210.99554                | 3.10 m                                 | $\alpha$ /6.660/87           | 6.534(5)/99.94                           | 9/2-                     | +4.0                             | -0.19                        | 0.220                                      |
|                     |                                  |                          |                                        | EC/4.61                      | (5.87-6.20)                              |                          |                                  |                              | 0.2799                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5389                                     |
|                     |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9169                                     |
| <sup>212</sup> Fr   |                                  | 211.99620                | 20. m                                  | EC/(57)/5.12                 | 6.261(1)/16                              | (5+)                     | +4.6                             | -0.10                        | Rn x-ray                                   |
|                     |                                  |                          |                                        | $\alpha$ /(43)/6.529         | 6.335(1)/4                               |                          |                                  |                              | 0.08107                                    |
|                     |                                  |                          |                                        |                              | 6.335(1)/4                               |                          |                                  |                              | 0.08378                                    |
|                     |                                  |                          |                                        |                              | 6.343(1)/1.3                             |                          |                                  |                              | 0.2277                                     |
|                     |                                  |                          |                                        |                              | 6.383(1)/10                              |                          |                                  |                              | 1.1856                                     |
|                     |                                  |                          |                                        |                              | 6.406(1)/9.5                             |                          |                                  |                              | 1.2748                                     |
|                     |                                  |                          |                                        |                              | 6.08–6.18                                |                          |                                  |                              | 0.014–1.178                                |
| <sup>213</sup> Fr   |                                  | 212.99619                | 34.6 s                                 | $\alpha$ /6.905              | 8.476(4)/51                              | 9/2-                     | +4.0                             | -0.14                        | (0.408-0.577)                              |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>214m</sup> Fr     |                                  |                          | 3.4 ms                                 | $\alpha$ /                   | 8.547(4)/46                              | 9-                       |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.775–8.046                              |                          |                                  |                              |                                            |
| <sup>214</sup> Fr      | 213.99897                        |                          | 5.0 ms                                 | $\alpha$ /8.587              | 7.409(3)/0.3                             | (1-)                     |                                  |                              | (0.073-0.966)                              |
|                        |                                  |                          |                                        |                              | 7.605(8)/1.0                             |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.940(3)/1.0                             |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 8.355(3)/4.7                             |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 8.427(3)/93                              |                          |                                  |                              |                                            |
| <sup>215</sup> Fr      | 215.00034                        |                          | 0.12 $\mu$ s                           | $\alpha$ /9.537              | 9.360(8)/                                | (9/2-)                   |                                  |                              |                                            |
| <sup>216</sup> Fr      | 216.00320                        |                          | 0.70 $\mu$ s                           | $\alpha$ /9.175              | 9.005(10)/95                             |                          |                                  |                              | (0.045–0.160)                              |
| <sup>217</sup> Fr      | 217.00463                        |                          | 0.016 ms                               | $\alpha$ /8.471              | 8.315(8)/                                | (9/2-)                   |                                  |                              |                                            |
| <sup>218m</sup> Fr     |                                  |                          | 22. ms                                 | $\alpha$                     |                                          |                          |                                  |                              |                                            |
| <sup>218</sup> Fr      | 218.007578                       |                          | 1. ms                                  | $\alpha$ /8.014              | 7.384(10)/0.5                            | (1-)                     |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.542(15)/1.0                            |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.572(10)/5                              |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.732(10)/0.5                            |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.867(2)/93                              |                          |                                  |                              |                                            |
| <sup>219</sup> Fr      | 219.00925                        |                          | 21. ms                                 | $\alpha$ /8.132              | 6.802(2)/0.25                            | (9/2-)                   |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.967(2)/0.6                             |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.146(2)/0.25                            |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 7.313(2)/99                              |                          |                                  |                              |                                            |
| <sup>220</sup> Fr      | 220.012327                       |                          | 27.4 s                                 | $\alpha$ /6.800              | 6.582(1)/10                              | 1+                       | -0.67                            | +0.47                        | 0.0450                                     |
|                        |                                  |                          |                                        |                              | 6.630(2)/6                               |                          |                                  |                              | 0.061                                      |
|                        |                                  |                          |                                        |                              | 6.641(1)/12                              |                          |                                  |                              | 0.1060                                     |
|                        |                                  |                          |                                        |                              | 6.686(1)/61                              |                          |                                  |                              | 0.1539                                     |
|                        |                                  |                          |                                        |                              | 6.39–6.58                                |                          |                                  |                              | 0.1617                                     |
| <sup>221</sup> Fr      | 221.014255                       |                          | 4.8 m                                  | $\alpha$ /6.457              | 5.9393(7)/0.17                           | (5/2-)                   | +1.58                            | -1.0                         | At k x-ray                                 |
|                        |                                  |                          |                                        |                              | 5.9797(7)/0.49                           |                          |                                  |                              | 0.0995                                     |
|                        |                                  |                          |                                        |                              | 6.0751(7)/0.15                           |                          |                                  |                              | 0.21798                                    |
|                        |                                  |                          |                                        |                              | 6.1270(7)/                               |                          |                                  |                              | 0.4091                                     |
|                        |                                  |                          |                                        |                              | 6.2433(3)/1.3                            |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.3410(7)/83.4                           |                          |                                  |                              |                                            |
| <sup>222</sup> Fr      | 222.01755                        |                          | 14.3 m                                 | $\beta^-$ /2.03              | 1.78/                                    | 2-                       | +0.63                            | +0.51                        |                                            |
|                        |                                  |                          |                                        | $\alpha$ /5.850              |                                          |                          |                                  |                              |                                            |
| <sup>223</sup> Fr      | 223.019736                       |                          | 22.0 m                                 | $\beta^-$ /1.149             | $\alpha$ /5.291                          | (3/2+)                   | +1.17                            | +1.17                        | 0.1509                                     |
|                        |                                  |                          |                                        | $\alpha$ /0.006              | 5.314                                    |                          |                                  |                              | 0.0589                                     |
|                        |                                  |                          |                                        |                              | 5.403                                    |                          |                                  |                              | 0.1453                                     |
| <sup>224</sup> Fr      | 224.02325                        |                          | 3.0 m                                  | $\beta^-$ /2.82              |                                          | 1-                       | +0.40                            | +0.517                       | 0.13150                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.21575                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8367                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.1–2.21)                                 |
| <sup>225</sup> Fr      | 225.02557                        |                          | 3.9 m                                  | $\beta^-$ /1.87              |                                          | 3/2                      | +1.07                            | +1.3                         |                                            |
| <sup>226</sup> Fr      | 226.0294                         |                          | 49. s                                  | $\beta^-$ /3.6               |                                          | 1                        | +0.071                           | -1.35                        | 0.18606                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.25373                                    |
| <sup>227</sup> Fr      | 227.0318                         |                          | 2.48 m                                 | $\beta^-$ /2.5               |                                          | 1/2                      | +1.50                            |                              |                                            |
| <sup>228</sup> Fr      | 228.0357                         |                          | 39. s                                  | $\beta^-$ /~ 3.5             |                                          | 2-                       | -0.76                            | +2.4                         |                                            |
| <sup>229</sup> Fr      | 229.03845                        |                          | 50. s                                  | $\beta^-$ /                  |                                          |                          |                                  |                              |                                            |
| <sup>230</sup> Fr      | 230.0425                         |                          | 19. s                                  | $\beta^-$ /                  |                                          | (3)                      |                                  |                              |                                            |
| <sup>231</sup> Fr      | 231.0454                         |                          | 17. s                                  | $\beta^-$ /                  |                                          |                          |                                  |                              |                                            |
| <sup>232</sup> Fr      | 232.050                          |                          | 5. s                                   | $\beta^-$ /                  |                                          |                          |                                  |                              | (0.0545-0.721)                             |
| <b><sup>88</sup>Ra</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>201</sup> Ra      |                                  |                          | ~ 1.6 ms                               | $\alpha$                     | 7.91/                                    |                          |                                  |                              |                                            |
| <sup>202</sup> Ra      | 202.0099                         |                          | ~ 0.02 ms                              | $\alpha$                     | 7.74                                     | 0+                       |                                  |                              |                                            |
| <sup>203m</sup> Ra     |                                  |                          | 24 ms                                  | $\alpha$                     | 7.61                                     |                          |                                  |                              |                                            |
| <sup>203</sup> Ra      | 203.0093                         |                          | ~ 31 ms                                | $\alpha$                     | 7.59                                     |                          |                                  |                              |                                            |
| <sup>204</sup> Ra      | 204.0065                         |                          | 0.06 s                                 | $\alpha$                     | 7.48                                     | 0+                       |                                  |                              |                                            |
| <sup>205m</sup> Ra     |                                  |                          | ~ 0.17 s                               |                              |                                          |                          |                                  |                              |                                            |
| <sup>205</sup> Ra      | 205.0063                         |                          | 0.22 s                                 | $\alpha$                     | 7.34                                     |                          |                                  |                              |                                            |
| <sup>206</sup> Ra      | 206.00383                        |                          | 0.4 s                                  | $\alpha$ /7.416              | 7.272(5)/                                | 0+                       |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>207</sup> Ra  |                                  | 207.0038                 | 1.3 s                                  | $\alpha$ /7.270              | 7.133(5)/                                |                          |                                  |                              |                                            |
| <sup>208</sup> Ra  |                                  | 208.00184                | 1.4 s                                  | $\alpha$ /7.273              | 7.133(5)/                                | 0+                       |                                  |                              |                                            |
| <sup>209</sup> Ra  |                                  | 209.00199                | 4.6 s                                  | $\alpha$ /7.150              | (6.50-7.14)                              | 5/2-                     | +0.87                            | +0.40                        | (0.387-0.634)                              |
| <sup>210m</sup> Ra |                                  |                          | 2.4 $\mu$ s                            |                              |                                          |                          |                                  |                              | (0.0967-0.775)                             |
| <sup>210</sup> Ra  |                                  | 210.00050                | 3.7 s                                  | $\alpha$ /7.610              | 7.020(5)/                                | 0+                       |                                  |                              | 574.9                                      |
| <sup>211m</sup> Ra |                                  |                          | 3.9 $\mu$ s                            |                              |                                          |                          |                                  |                              | (0.396-0.802)                              |
| <sup>211</sup> Ra  |                                  | 211.00090                | 13. s                                  | $\alpha$ /7.046              | 6.907/99.                                | (5/2-)                   | +0.878                           | +0.48                        |                                            |
|                    |                                  |                          |                                        | EC/5.0                       | (6.26-6.79)                              |                          |                                  |                              | (0.120-0.665)                              |
| <sup>212m</sup> Ra |                                  |                          | 8.3 $\mu$ s                            |                              |                                          |                          |                                  |                              | (0.440-0.824)                              |
| <sup>212</sup> Ra  |                                  | 211.99979                | 13.0 s                                 | $\alpha$ /7.033              | 6.901(2)/                                | 0+                       |                                  |                              |                                            |
| <sup>213m</sup> Ra |                                  |                          | 2.1 ms                                 | IT                           |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.160-1.061)                              |
| <sup>213</sup> Ra  |                                  | 213.00038                | 2.7 m                                  | EC/(20)/3.88                 |                                          | (1/2-)                   | +0.613                           |                              | 0.1024                                     |
|                    |                                  |                          |                                        | $\alpha$ /(80)/6.860         | 6.521(3)/4.8                             |                          |                                  |                              | 0.11010                                    |
|                    |                                  |                          |                                        |                              | 6.622(3)/39                              |                          |                                  |                              | 0.2125                                     |
|                    |                                  |                          |                                        |                              | 6.730(3)/36                              |                          |                                  |                              |                                            |
| <sup>214m</sup> Ra |                                  |                          | > 0.015 ms                             |                              |                                          |                          |                                  |                              | (0.181-1.382)                              |
| <sup>214</sup> Ra  |                                  | 214.00011                | 2.46 s                                 | $\alpha$ /7.272              | 7.14/99.8/                               | 0+                       |                                  |                              | 0.642                                      |
|                    |                                  |                          |                                        |                              | 6.51/0.2                                 |                          |                                  |                              |                                            |
| <sup>215m</sup> Ra |                                  |                          | 7.6 $\mu$ s                            |                              |                                          |                          |                                  |                              | (0.196-1.048)                              |
| <sup>215</sup> Ra  |                                  | 215.00272                | 1.64 ms                                | $\alpha$ /8.864              | 7.883(6)/2.8                             | (9/2+)                   |                                  |                              | 0.773/100                                  |
|                    |                                  |                          |                                        |                              | 8.171(3)/1.4                             |                          |                                  |                              | 0.852/74                                   |
|                    |                                  |                          |                                        |                              | 8.700(3)/95.9                            |                          |                                  |                              | 0.055–1.048                                |
| <sup>216</sup> Ra  |                                  | 216.00353                | 0.18 $\mu$ s                           | $\alpha$ /9.526              | 9.349(8)/                                | 0+                       |                                  |                              |                                            |
| <sup>217</sup> Ra  |                                  | 217.00632                | 1.6 $\mu$ s                            | $\alpha$ /9.161              | 8.992(8)/                                | 9/2-                     |                                  |                              |                                            |
| <sup>218</sup> Ra  |                                  | 218.00714                | 26. $\mu$ s                            | $\alpha$ /8.547              | 8.390(8)/                                | 0+                       |                                  |                              |                                            |
| <sup>219</sup> Ra  |                                  | 219.01009                | 0.010 s                                | $\alpha$ /8.132              | 7.680(10)/65                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.982(9)/35                              |                          |                                  |                              |                                            |
| <sup>220</sup> Ra  |                                  | 220.01103                | 18. ms                                 | $\alpha$ /7.593              | 7.39/5                                   | 0+                       |                                  |                              | 0.465                                      |
|                    |                                  |                          |                                        |                              | 7.45/95                                  |                          |                                  |                              |                                            |
| <sup>221</sup> Ra  |                                  | 221.013917               | 29. s                                  | $\alpha$ /6.879              | 6.254(10)/0.7                            | 5/2+                     | -0.180                           | +1.9                         |                                            |
|                    |                                  |                          |                                        |                              | 6.578(5)/3                               |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.585(3)/8                               |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.608(3)/35                              |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.669(3)/21                              |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.758(3)/31                              |                          |                                  |                              |                                            |
| <sup>222</sup> Ra  |                                  | 222.015375               | 36.2 s                                 | $\alpha$ /5.590              | 6.237(2)/3.0                             | 0+                       |                                  |                              | 0.324                                      |
|                    |                                  |                          |                                        |                              | 6.556(2)/97                              |                          |                                  |                              | 0.1448–0.8402                              |
| <sup>223</sup> Ra  |                                  | 223.018502               | 11.43 d                                | $\alpha$ /5.979              | 5.287(1)/0.15                            | (3/2+)                   | +0.271                           | +1.25                        | Rn k x-ray                                 |
|                    |                                  |                          |                                        |                              | 5.338(1)/0.13                            |                          |                                  |                              | 0.12231                                    |
|                    |                                  |                          |                                        |                              | 5.365(1)/0.13                            |                          |                                  |                              | 0.14418                                    |
|                    |                                  |                          |                                        |                              | 5.433(5)/2.3                             |                          |                                  |                              | 0.15418                                    |
|                    |                                  |                          |                                        |                              | 5.502(1)/1.0                             |                          |                                  |                              | 0.15859                                    |
|                    |                                  |                          |                                        |                              | 5.540(1)/9.2                             |                          |                                  |                              | 0.26939                                    |
|                    |                                  |                          |                                        |                              | 5.607(3)/24                              |                          |                                  |                              | 0.32388                                    |
|                    |                                  |                          |                                        |                              | 5.716(3)/52                              |                          |                                  |                              | 0.33328                                    |
|                    |                                  |                          |                                        |                              | 5.747(1)/9                               |                          |                                  |                              | 0.44494                                    |
|                    |                                  |                          |                                        |                              | 5.857(1)/0.32                            |                          |                                  |                              | (0.10–0.7)                                 |
|                    |                                  |                          |                                        |                              | 5.872(1)/0.85                            |                          |                                  |                              |                                            |
| <sup>224</sup> Ra  |                                  | 224.020212               | 3.66 d                                 | $\alpha$ /5.789              | 5.034(10)/0.003                          | 0+                       |                                  |                              | Rn k x-ray                                 |
|                    |                                  |                          |                                        |                              | 5.047(1)/0.007                           |                          |                                  |                              | 0.2407                                     |
|                    |                                  |                          |                                        |                              | 5.164(5)/0.007                           |                          |                                  |                              | 0.4093                                     |
|                    |                                  |                          |                                        |                              | 5.449(2)/4.9                             |                          |                                  |                              | 0.6501                                     |
|                    |                                  |                          |                                        |                              | 5.685(2)/95                              |                          |                                  |                              |                                            |
| <sup>225</sup> Ra  |                                  | 225.023612               | 14.9 d                                 | $\beta^-$ /0.36              | 0.32/100                                 | (3/2+)                   | -0.734                           |                              | Ac k x-ray                                 |
|                    |                                  |                          |                                        | $\alpha$                     | $5.01 \times 10^{-5}$                    |                          |                                  |                              | 0.0434                                     |
|                    |                                  |                          |                                        |                              | $4.98 \times 10^{-6}$                    |                          |                                  |                              |                                            |
| <sup>226</sup> Ra  |                                  | 226.025410               | 1599. y                                | $\alpha$ /4.870              | 4.194(1)/0.001                           | 0+                       |                                  |                              | Rn k x-ray                                 |
|                    |                                  |                          | > $4 \times 10^{18}$ y                 | sf/ $4 \times 10^{-14}$      | 4.343(1)/0.006                           |                          |                                  |                              | 0.1861/3.64                                |
|                    |                                  |                          |                                        |                              | 4.601(1)/6.16                            |                          |                                  |                              | 0.2624                                     |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>227</sup> Ra  |                                  | 227.029178               | 42. m                                  | $\beta^-$ /1.325             | 4.784(1)/93.8                            | (3/2+)                   | -0.404                           | +1.5                         | 0.053–2.448                                |
|                    |                                  |                          |                                        |                              | 1.03/                                    |                          |                                  |                              | Ac L x-ray                                 |
|                    |                                  |                          |                                        |                              | 1.30/                                    |                          |                                  |                              | Ac k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.02739                                    |
| <sup>228</sup> Ra  |                                  | 228.031070               | 5.76 y                                 | $\beta^-$ /0.046             | 0.039/50                                 | 0+                       |                                  |                              | 0.0135                                     |
|                    |                                  |                          |                                        |                              | 0.014/30                                 |                          |                                  |                              | (0.006–0.0306)                             |
|                    |                                  |                          |                                        |                              | 0.026/20                                 |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>229</sup> Ra  |                                  | 229.03496                | 4.0 m                                  | $\beta^-$ /1.76              | 1.76/                                    | (3/2+)                   | +0.503                           | +3.1                         | 0.0145–0.1715                              |
| <sup>230</sup> Ra  |                                  | 230.03706                | 1.5 h                                  | $\beta^-$ /1.0               | 0.7/                                     | 0+                       |                                  |                              | 0.0631                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0720                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2028                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4698                                     |
| <sup>231</sup> Ra  |                                  | 231.0412                 | 1.7 m                                  | $\beta^-$                    |                                          |                          |                                  |                              | 0.4787                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>232</sup> Ra  |                                  | 232.0436                 | 4. m                                   | $\beta^-$                    |                                          | 0+                       |                                  |                              |                                            |
| <sup>233</sup> Ra  |                                  | 233.0481                 | 30. s                                  | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <sup>234</sup> Ra  |                                  | 234.051                  | ~ 30. s                                | $\beta^-$ /                  |                                          | 0+                       |                                  |                              |                                            |
| <sup>89</sup> Ac   |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>206m</sup> Ac |                                  |                          | 0.04 s                                 | $\alpha$                     | 7.79                                     |                          |                                  |                              |                                            |
| <sup>206</sup> Ac  |                                  | 206.0145                 | ~ 26 ms                                | $\alpha$                     | 7.75                                     |                          |                                  |                              |                                            |
| <sup>207</sup> Ac  |                                  | 207.0120                 | 27 ms                                  | $\alpha$ /                   | 7.69                                     |                          |                                  |                              |                                            |
| <sup>208m</sup> Ac |                                  |                          | ~ 25. ms                               | $\alpha$ /                   | 7.72                                     |                          |                                  |                              |                                            |
| <sup>208</sup> Ac  |                                  | 208.0116                 | ~ 0.1 s                                | $\alpha$ /                   | 7.62                                     |                          |                                  |                              |                                            |
| <sup>209</sup> Ac  |                                  | 209.00949                | ~ 0.10 s                               | $\alpha$ /                   | 7.58                                     |                          |                                  |                              |                                            |
| <sup>210</sup> Ac  |                                  | 210.0094                 | 0.34 s                                 | $\alpha$ /7.610              | 7.462(8)/                                |                          |                                  |                              |                                            |
| <sup>211</sup> Ac  |                                  | 211.0077                 | 0.20 s                                 | $\alpha$ /7.620              | 7.480(8)/                                |                          |                                  |                              |                                            |
| <sup>212</sup> Ac  |                                  | 212.0078                 | 0.9 s                                  | $\alpha$ /7.520              | 7.379(8)/                                |                          |                                  |                              |                                            |
| <sup>213</sup> Ac  |                                  | 213.0066                 | 0.73 s                                 | $\alpha$ /7.500              | 7.364(8)/                                | (9/2-)                   |                                  |                              |                                            |
| <sup>214</sup> Ac  |                                  | 214.00690                | 8.2 s                                  | $\alpha$ /(86)/7.350         | 7.215/54                                 | (5+)                     |                                  |                              | (0.0626-0.754)                             |
|                    |                                  |                          |                                        | EC/(14)/6.34                 | 7.081/42                                 |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | (6.48-7.15)                              |                          |                                  |                              |                                            |
| <sup>215</sup> Ac  |                                  | 215.00645                | 0.17 s                                 | $\alpha$ /7.750              | 7.60/99.57                               | (9/2-)                   |                                  |                              | 0.399                                      |
|                    |                                  |                          |                                        |                              | 7.21/0.46                                |                          |                                  |                              | 0.582                                      |
|                    |                                  |                          |                                        |                              | 7.03/0.20                                |                          |                                  |                              | 0.654                                      |
|                    |                                  |                          |                                        |                              | 6.96/0.14                                |                          |                                  |                              |                                            |
| <sup>216m</sup> Ac |                                  |                          | 0.44 ms                                | $\alpha$ /                   | 8.198(8)/1.7                             | (9-)                     |                                  |                              | (0.0826-1.375)                             |
|                    |                                  |                          |                                        |                              | 8.283(8)/2.5                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 9.028(5)/49                              |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 9.106(5)/46                              |                          |                                  |                              |                                            |
| <sup>216</sup> Ac  |                                  | 216.00872                | 44. ms                                 | $\alpha$ /9.241              | 8.990(2)/10                              | (1-)                     |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 9.070(8)/90                              |                          |                                  |                              |                                            |
| <sup>217m</sup> Ac |                                  |                          | 0.7 $\mu$ s                            | $\alpha$ /                   | 10.540/100                               |                          |                                  |                              |                                            |
| <sup>217</sup> Ac  |                                  | 217.00935                | 0.07 $\mu$ s                           | $\alpha$ /9.832              | 9.650(10)/100                            | 9/2-                     |                                  |                              |                                            |
| <sup>218</sup> Ac  |                                  | 218.01164                | 1.1 $\mu$ s                            | $\alpha$ /9.380              | 9.205(15)/                               |                          |                                  |                              |                                            |
| <sup>219</sup> Ac  |                                  | 219.01242                | 0.012 ms                               | $\alpha$ /8.830              | 8.664(10)/                               | (9/2-)                   |                                  |                              |                                            |
| <sup>220</sup> Ac  |                                  | 220.01476                | 26. ms                                 | $\alpha$ /8.350              | 7.610(20)/23                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 4.680(20)/21                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.790(10)/13                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.850(10)/24                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.985(10)/4                              |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 8.005(10)/5                              |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 8.060(10)/6                              |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 8.195(10)/3                              |                          |                                  |                              |                                            |
| <sup>221</sup> Ac  |                                  | 221.01559                | 52. ms                                 | $\alpha$ /7.790              | 7.170(10)/2                              |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.375(10)/10                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.440(15)/20                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.645(10)/70                             |                          |                                  |                              |                                            |
| <sup>222m</sup> Ac |                                  |                          | 63. s                                  | $\alpha$ /(>89)/             | 6.710(20)/7                              |                          |                                  |                              |                                            |

[illegible]

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)         | Particle Energy/<br>Intensity<br>(MeV/%)                                                                        | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                   |
|--------------------|----------------------------------|--------------------------|----------------------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------------------------|
| <sup>229</sup> Ac  |                                  | 229.03302                | 1.04 h                                 | $\beta^-$ /1.10                      | 1.1/                                                                                                            | (3/2+)                        |                                  |                              | 0.09335/2.43<br>0.16451/2.61<br>0.56916/2.24<br>0.0111–0.898 |
| <sup>230</sup> Ac  |                                  | 230.0363                 | 2.03 m                                 | $\beta^-$ /2.7<br>$\beta^-$ , sf     | 1.4/<br>/0.000119                                                                                               | 1+                            |                                  |                              | Th k x-ray<br>0.45497<br>0.50820<br>(0.12–2.5)               |
| <sup>231</sup> Ac  |                                  | 231.0386                 | 7.5 m                                  | $\beta^-$ /2.1                       | 2.1/100                                                                                                         | (1/2+)                        |                                  |                              | 0.14379<br>0.18574<br>0.22140<br>0.28250<br>0.3070           |
| <sup>232</sup> Ac  |                                  | 232.0420                 | 2.0 m                                  | $\beta^-$ /3.7                       |                                                                                                                 | (2-)                          |                                  |                              |                                                              |
| <sup>233</sup> Ac  |                                  | 233.0446                 | 2.4 m                                  | $\beta^-$ /                          |                                                                                                                 | (1/2+)                        |                                  |                              |                                                              |
| <sup>234</sup> Ac  |                                  | 234.0484                 | 40. s                                  | $\beta^-$ /                          |                                                                                                                 | (1+)                          |                                  |                              |                                                              |
| <sup>90</sup> Th   |                                  | 232.03806(2)             |                                        |                                      |                                                                                                                 |                               |                                  |                              |                                                              |
| <sup>209</sup> Th  |                                  | 209.0177                 | ~ 0.01 s                               | $\alpha$                             | 8.08                                                                                                            |                               |                                  |                              |                                                              |
| <sup>210</sup> Th  |                                  | 210.0158                 | ~ 9 ms                                 | $\alpha$                             | 7.90                                                                                                            | 0+                            |                                  |                              |                                                              |
| <sup>211</sup> Th  |                                  | 211.0149                 | 0.04 s                                 | $\alpha$                             | 7.79                                                                                                            |                               |                                  |                              |                                                              |
| <sup>212</sup> Th  |                                  | 212.01298                | ~ 30. ms                               | $\alpha$ /                           | 7.80/                                                                                                           | 0+                            |                                  |                              |                                                              |
| <sup>213</sup> Th  |                                  | 213.0130                 | 0.14 s                                 | $\alpha$ /7.840                      | 7.692(10)/                                                                                                      |                               |                                  |                              |                                                              |
| <sup>214</sup> Th  |                                  | 214.01150                | 0.10 s                                 | $\alpha$ /7.825                      | 7.677(10)/                                                                                                      | 0+                            |                                  |                              |                                                              |
| <sup>215</sup> Th  |                                  | 215.01173                | 1.2 s                                  | $\alpha$ /7.660                      | 7.33(10)/8<br>7.395(8)/52<br>7.524(8)/40                                                                        | (1/2-)                        |                                  |                              | 0.134<br>0.192<br>(0.069-0.295)                              |
| <sup>216m</sup> Th |                                  |                          | 0.14 ms                                | $\alpha$                             | 9.93/74<br>8.00, 9.31                                                                                           |                               |                                  |                              | (0.0905-1.478)                                               |
| <sup>216</sup> Th  |                                  | 216.01106                | 27. ms                                 | $\alpha$ /8.071                      | 7.92/99.46<br>7.30/0.54                                                                                         | 0+                            |                                  |                              | 0.628                                                        |
| <sup>217</sup> Th  |                                  | 217.01311                | 0.25 ms                                | $\alpha$ /9.424                      | 9.27/94.6<br>8.46/3.8<br>8.73/1.6                                                                               |                               |                                  |                              | (0.546-0.822)                                                |
| <sup>218</sup> Th  |                                  | 218.01328                | 0.11 $\mu$ s                           | $\alpha$ /9.847                      | 9.665(10)/                                                                                                      | 0+                            |                                  |                              |                                                              |
| <sup>219</sup> Th  |                                  | 219.01554                | 1.05 $\mu$ s                           | $\alpha$ /9.510                      | 9.340(20)/                                                                                                      |                               |                                  |                              |                                                              |
| <sup>220</sup> Th  |                                  | 220.01575                | 10. $\mu$ s                            | $\alpha$ /8.953                      | 8.790(20)/                                                                                                      | 0+                            |                                  |                              |                                                              |
| <sup>221</sup> Th  |                                  | 221.01818                | 2. ms                                  | $\alpha$ /8.628                      | 7.732/7<br>8.142/72<br>8.469/21                                                                                 |                               |                                  |                              |                                                              |
| <sup>222</sup> Th  |                                  | 222.01847                | 2.24 ms                                | $\alpha$ /8.129                      | 7.980/97.7<br>7.599/2.3                                                                                         | 0+                            |                                  |                              |                                                              |
| <sup>223</sup> Th  |                                  | 223.02081                | 0.60 s                                 | $\alpha$ /7.454                      | 7.29(1)/41(5)<br>7.32(1)/29(5)<br>7.350(15)/20(5)<br>7.390(15)/10(4)                                            |                               |                                  |                              |                                                              |
| <sup>224</sup> Th  |                                  | 224.02147                | 1.05 s                                 | $\alpha$ /7.305                      | 6.768(5)/1.2<br>6.997(5)/19<br>7.170(5)/7                                                                       | 0+                            |                                  |                              |                                                              |
| <sup>225</sup> Th  |                                  | 225.023951               | 8.72 m                                 | EC/(10)/0.68<br>$\alpha$ /(90)/6.920 | 6.441(2)/15<br>6.479(2)/43<br>6.501(3)/14<br>6.627(3)/3<br>6.650(5)/3<br>6.700(5)/2<br>6.743(3)/7<br>6.796(2)/9 | (3/2+)                        |                                  |                              |                                                              |
| <sup>226</sup> Th  |                                  | 226.024903               | 30.83 m                                | $\alpha$ /6.454                      | 6.026(1)/0.2                                                                                                    | 0+                            |                                  |                              | Ra k x-ray                                                   |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                              | 6.041(1)/0.19                            |                          |                                  |                              | 0.1112                                     |
|                    |                                  |                          |                                        |                              | 6.098(1)/1.3                             |                          |                                  |                              | 0.2421                                     |
|                    |                                  |                          |                                        |                              | 6.2283(4)/23                             |                          |                                  |                              | 0.1310                                     |
|                    |                                  |                          |                                        |                              | 6.3375(4)/75                             |                          |                                  |                              | 0.1733–0.9295                              |
| <sup>227</sup> Th  |                                  | 227.027704               | 18.72 d                                | $\alpha$ /6.146              |                                          | (3/2+)                   |                                  |                              | Ra L x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Ra k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.05014                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.23597                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.25624                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.02–1.0)                                 |
| <sup>228</sup> Th  |                                  | 228.028741               | 1.913 y                                | $\alpha$ /5.520              | 5.1770(2)/0.18                           | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 5.2114(1)/0.4                            |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 5.3405(1)/26.7                           |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 5.4233(1)/73                             |                          |                                  |                              |                                            |
| <sup>229m</sup> Th |                                  |                          | 13.9 h                                 | $\alpha$                     | 4.83–5.08                                |                          |                                  |                              |                                            |
| <sup>229</sup> Th  |                                  | 229.031762               | $7.9 \times 10^3$ y                    | $\alpha$ /5.168              | 4.814/9.3                                | 5/2+                     | +0.46                            | +4.                          | 0.1935/4.3                                 |
|                    |                                  |                          |                                        |                              | 4.845(5)/56                              |                          |                                  |                              | 0.21089/277                                |
|                    |                                  |                          |                                        |                              | 4.9008(5)/10.2                           |                          |                                  |                              | 0.13697/1.21                               |
|                    |                                  |                          |                                        |                              | 4.689–5.077                              |                          |                                  |                              | 0.0111–0.6036                              |
| <sup>230</sup> Th  |                                  | 230.033134               | $7.54 \times 10^4$ y                   | $\alpha$ /4.771              | 4.4383(6)/0.03                           | 0+                       |                                  |                              | 0.0677/0.46                                |
|                    |                                  |                          |                                        |                              | 4.4798(6)/0.12                           |                          |                                  |                              | 0.1439/0.078                               |
|                    |                                  |                          | $> 2 \times 10^{18}$ y                 | sf/< $4 \times 10^{-12}$     | 4.6211(6)/23.4                           |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 4.6876(6)/76.3                           |                          |                                  |                              |                                            |
| <sup>231</sup> Th  |                                  | 231.036304               | 1.063 d                                | $\beta^-$ /0.390             | 0.138/22                                 | 5/2+                     |                                  |                              | Pa L x-ray                                 |
|                    |                                  |                          |                                        |                              | 0.218/20                                 |                          |                                  |                              | Pa k x-ray                                 |
|                    |                                  |                          |                                        |                              | 0.305/52                                 |                          |                                  |                              | 0.02564                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.084203/                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.02–0.3)                                 |
| <sup>232</sup> Th  | 100.                             | 232.038055               | $1.40 \times 10^{10}$ y                | $\alpha$ /4.081              | 3.830(10)/0.2                            | 0+                       |                                  |                              | 0.0590                                     |
|                    |                                  |                          | $1.2 \times 10^{21}$ y                 | sf/ $1.1 \times 10^{-9}$     | 3.952(5)/23                              |                          |                                  |                              | 0.124                                      |
|                    |                                  |                          |                                        |                              | 4.010(5)/77                              |                          |                                  |                              |                                            |
| <sup>233</sup> Th  |                                  | 233.041582               | 22.3 m                                 | $\beta^-$ /1.245             | 1.245/                                   | $\frac{1}{2}+$           |                                  |                              | Pa L x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Pa k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.02938                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.08653                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.45930                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.02–1.2)                                 |
| <sup>234</sup> Th  |                                  | 234.043601               | 24.10 d                                | $\beta^-$ /0.273             | 0.102/20                                 | 0+                       |                                  |                              | Pa L x-ray                                 |
|                    |                                  |                          |                                        |                              | 0.198/72                                 |                          |                                  |                              | 0.06329/4.1                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.09235/2.4                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.09278/2.4                                |
| <sup>235</sup> Th  |                                  | 235.04751                | 7.2 m                                  | $\beta^-$ /1.9               |                                          |                          |                                  |                              | 0.4162                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6594                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7272                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.747                                      |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9318                                     |
| <sup>236</sup> Th  |                                  | 236.0499                 | 37.5 m                                 | $\beta^-$ /~ 1.0             |                                          | 0+                       |                                  |                              | Pa k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1107                                     |
| <sup>237</sup> Th  |                                  | 237.0539                 | 5.0 m                                  | $\beta^-$                    |                                          |                          |                                  |                              |                                            |
| <sup>238</sup> Th  |                                  | 238.0565                 | 9.4 m                                  |                              |                                          | 0+                       |                                  |                              | 0.0890                                     |
| <sup>91</sup> Pa   |                                  | 231.03588(2)             |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>212</sup> Pa  |                                  | 212.0232                 | ~ 5 ms                                 | $\alpha$                     | 8.27                                     |                          |                                  |                              |                                            |
| <sup>213</sup> Pa  |                                  | 213.0211                 | 7 ms                                   | $\alpha$                     | 8.24                                     |                          |                                  |                              |                                            |
| <sup>214</sup> Pa  |                                  | 214.0209                 | 17 ms                                  | $\alpha$                     | 8.12                                     |                          |                                  |                              |                                            |
| <sup>215</sup> Pa  |                                  | 215.0192                 | 15. ms                                 | $\alpha$                     | 8.08/100                                 |                          |                                  |                              |                                            |
| <sup>216</sup> Pa  |                                  | 216.0191                 | 0.19 s                                 | $\alpha$ /                   | 7.95/51                                  |                          |                                  |                              | 0.134                                      |
|                    |                                  |                          |                                        |                              | 7.82/45                                  |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.79/4                                   |                          |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>217m</sup> Pa |                                  |                          | 1.08 ms                                | $\alpha$ /                   | 10.16/72                                 |                          |                                  |                              | 0.4504–0.8208                              |
|                    |                                  |                          |                                        |                              | 8.306/11                                 |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 9.55/6                                   |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 9.69/2                                   |                          |                                  |                              |                                            |
| <sup>217</sup> Pa  | 217.0183                         |                          | 3.8 ms                                 | $\alpha$ /8.490              | 8.337/99                                 |                          |                                  |                              | 0.0466–0.634                               |
|                    |                                  |                          |                                        |                              | 7.873/0.4                                |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.728/0.3                                |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.710/0.3                                |                          |                                  |                              |                                            |
| <sup>218</sup> Pa  | 218.02004                        |                          | 0.12 ms                                | $\alpha$ /                   | 9.54/31                                  |                          |                                  |                              | 0.092                                      |
|                    |                                  |                          |                                        |                              | 9.61/69                                  |                          |                                  |                              |                                            |
| <sup>219</sup> Pa  | 219.0199                         |                          | 0.05 $\mu$ s                           | $\alpha$                     |                                          |                          |                                  |                              |                                            |
| <sup>220</sup> Pa  | 220.0219                         |                          | 0.8 $\mu$ s                            | $\alpha$                     |                                          |                          |                                  |                              |                                            |
| <sup>221</sup> Pa  | 221.0219                         |                          | 6. $\mu$ s                             | $\alpha$                     | 9.08(3)                                  |                          |                                  |                              |                                            |
| <sup>222</sup> Pa  | 222.0237                         |                          | ~ 4.3 ms                               | $\alpha$ /8.700              | 8.180/50                                 |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 8.330/20                                 |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 8.540/30                                 |                          |                                  |                              |                                            |
| <sup>223</sup> Pa  | 223.0240                         |                          | ~ 6.5 ms                               | $\alpha$ /8.340              | 8.006(10)/55                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 8.196(10)/45                             |                          |                                  |                              |                                            |
| <sup>224</sup> Pa  | 224.02563                        |                          | 0.84 s                                 | $\alpha$ /7.630              | 7.555(10)/75(3)                          |                          |                                  |                              | 0.1945                                     |
|                    |                                  |                          |                                        |                              | 7.46(1)/25(3)                            |                          |                                  |                              | (0.028–0.412)                              |
| <sup>225</sup> Pa  | 225.0261                         |                          | 1.8 s                                  | $\alpha$ /7.380              | 7.195(10)/30                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.245(10)/70                             |                          |                                  |                              |                                            |
| <sup>226</sup> Pa  | 226.02795                        |                          | 1.8 m                                  | $\alpha$ /(74)/6.987         | 6.728(10)/0.7                            |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | EC/(26)/2.83                 | 6.823(10)/35                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.863(10)/39                             |                          |                                  |                              |                                            |
| <sup>227</sup> Pa  | 227.02881                        |                          | 38.3 m                                 | $\alpha$ /(85)/6.582         | 6.357(4)/7                               | (5/2-)                   |                                  |                              | 0.0649                                     |
|                    |                                  |                          |                                        | EC/(15)/1.02                 | 6.376(10)/2.2                            |                          |                                  |                              | 0.0669                                     |
|                    |                                  |                          |                                        |                              | 6.401(4)/8                               |                          |                                  |                              | 0.1100                                     |
|                    |                                  |                          |                                        |                              | 6.416(4)/13                              |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.423(10)/10                             |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.465(4)/43                              |                          |                                  |                              |                                            |
| <sup>228</sup> Pa  | 228.031051                       |                          | 22. h                                  | EC/(98)/2.111                |                                          | (3+)                     | +3.5                             |                              | Th k x-ray                                 |
|                    |                                  |                          |                                        | $\alpha$ /(2)                | 5.779/0.23                               |                          |                                  |                              | 0.409/100                                  |
|                    |                                  |                          |                                        |                              | 5.805/0.15                               |                          |                                  |                              | 0.4631/222                                 |
|                    |                                  |                          |                                        |                              | 6.078/0.4                                |                          |                                  |                              | 0.91116/242                                |
|                    |                                  |                          |                                        |                              | 6.105/0.25                               |                          |                                  |                              | 0.96464/120                                |
|                    |                                  |                          |                                        |                              | 6.118/0.22                               |                          |                                  |                              | 0.96897/149                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.058–1.96                                 |
| <sup>229</sup> Pa  | 229.032097                       |                          | 1.5 d                                  | EC/(99.8)/0.32               |                                          | (5/2+)                   |                                  |                              | 0.04244                                    |
|                    |                                  |                          |                                        | $\alpha$ /(0.2)/5.836        | 5.536(2)/0.02                            |                          |                                  |                              | (0.024–0.18)                               |
|                    |                                  |                          |                                        |                              | 5.579(2)/0.09                            |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 5.668(2)/0.05                            |                          |                                  |                              |                                            |
| <sup>230</sup> Pa  | 230.034541                       |                          | 17.4 d                                 | EC/(90)/1.310                | 0.51/                                    | (2-)                     | 2.0                              |                              | Th L x-ray                                 |
|                    |                                  |                          |                                        | $\beta^-$ /(10)/0.563        |                                          |                          |                                  |                              | Th k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4437                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.45477                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.89876                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.91856                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.95199                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.053–1.07)                               |
| <sup>231</sup> Pa  | 231.035884                       |                          | $3.25 \times 10^4$ y                   | $\alpha$ /5.148              | 4.6781(5)/1.5                            | 3/2-                     | 2.01                             | -1.7                         | Ac L x-ray                                 |
|                    |                                  |                          |                                        |                              | 4.7102(5)/1.0                            |                          |                                  |                              | Ac k x-ray                                 |
|                    |                                  |                          | $> 2 \times 10^{17}$ y                 | sf/ $< 1.6 \times 10^{-15}$  | 4.7343(5)/8.4                            |                          |                                  |                              | 0.01899                                    |
|                    |                                  |                          |                                        |                              | 4.8513(5)/1.4                            |                          |                                  |                              | 0.027396                                   |
|                    |                                  |                          |                                        |                              | 4.9339(5)/3                              |                          |                                  |                              | 0.03823                                    |
|                    |                                  |                          |                                        |                              | 4.9505(5)/22.8                           |                          |                                  |                              | 0.04639                                    |
|                    |                                  |                          |                                        |                              | 4.9858(5)/1.4                            |                          |                                  |                              | 0.25586                                    |
|                    |                                  |                          |                                        |                              | 5.0131(5)/25.4                           |                          |                                  |                              | 0.26029                                    |
|                    |                                  |                          |                                        |                              | 5.0292(5)/20                             |                          |                                  |                              | 0.28367                                    |
|                    |                                  |                          |                                        |                              | 5.0318(5)/2.5                            |                          |                                  |                              | 0.30007                                    |



| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                    |                                  |                          |                                        |                              | 5.0587(5)/11                             |                          |                                  |                              | 0.30264                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.33007                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.02–0.61)                                |
| <sup>232</sup> Pa  |                                  | 232.03859                | 1.31 d                                 | $\beta^-$ /1.34              |                                          | (2-)                     |                                  |                              | U k x-ray                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.10900                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.15009                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.89439                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.96934                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.10–1.17)                                |
| <sup>233</sup> Pa  |                                  | 233.040247               | 27.0 d                                 | $\beta^-$ /0.571             | 0.15/40                                  | 3/2-                     | +4.0                             | -3.0                         | U L x-ray                                  |
|                    |                                  |                          |                                        |                              | 0.256/60                                 |                          |                                  |                              | U k x-ray                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.30017                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.31201/38.4                               |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.0286-0.456)                             |
| <sup>234m</sup> Pa |                                  |                          | 1.17 m                                 | $\beta^-$ /99.9/2.29         |                                          | (0-)                     |                                  |                              | U k x-ray                                  |
|                    |                                  |                          |                                        | IT/0.13/                     |                                          |                          |                                  |                              | 0.25818/0.07                               |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.76641/0.32                               |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.0009/0.86                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.06–1.96)                                |
| <sup>234</sup> Pa  |                                  | 234.043308               | 6.69 h                                 | $\beta^-$ /2.197             | 0.51/                                    | (4+)                     |                                  |                              | U L x-ray                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | U k x-ray                                  |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1312/0.03                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5695/0.02                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9256/0.02                                |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.02–1.99)                                |
| <sup>235</sup> Pa  |                                  | 235.04544                | 24.4 m                                 | $\beta^-$ /1.41              | 1.4/97                                   | (3/2-)                   |                                  |                              | 0.0308–0.65893                             |
| <sup>236</sup> Pa  |                                  | 236.0487                 | 9.1 m                                  | $\beta^-$ /2.9               | 1.1/40                                   | (1-)                     |                                  |                              | U k x-ray                                  |
|                    |                                  |                          |                                        |                              | 2.0/50                                   |                          |                                  |                              | 0.64235                                    |
|                    |                                  |                          |                                        |                              | 3.1/10                                   |                          |                                  |                              | 0.68759                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.7630                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.04–2.18)                                |
| <sup>237</sup> Pa  |                                  | 237.0512                 | 8.7 m                                  | $\beta^-$ /2.3               | 1.1/60                                   | (1/2+)                   |                                  |                              | 0.4986                                     |
|                    |                                  |                          |                                        |                              | 1.6/30                                   |                          |                                  |                              | 0.5293                                     |
|                    |                                  |                          |                                        |                              | 2.3/10                                   |                          |                                  |                              | 0.5407                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8536                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.8650                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.04–1.4)                                 |
| <sup>238</sup> Pa  |                                  | 238.0545                 | 2.3 m                                  | $\beta^-$ /3.5               | 1.2/                                     | (3-)                     |                                  |                              | 0.10350                                    |
|                    |                                  |                          |                                        |                              | 1.7/                                     |                          |                                  |                              | 0.1785                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4484                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6350                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6800                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.01446                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.04–2.5)                                 |
| <sup>239</sup> Pa  |                                  | 239.0573                 | 1.8 h                                  |                              |                                          |                          |                                  |                              |                                            |
| <sup>92</sup> U    |                                  | 238.02891(3)             |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>217</sup> U   |                                  | 217.0244                 | ~ 0.2 ms                               | $\alpha$                     | 8.02                                     |                          |                                  |                              |                                            |
| <sup>218m</sup> U  |                                  |                          | ~ 0.56 ms                              | $\alpha$                     | 10.68                                    |                          |                                  |                              |                                            |
| <sup>218</sup> U   |                                  | 218.02354                | 0.5 ms                                 | $\alpha$                     | 8.61                                     | 0+                       |                                  |                              |                                            |
| <sup>219</sup> U   |                                  | 219.0249                 | ~ 0.08 ms                              | $\alpha$                     | 9.68(4)/                                 |                          |                                  |                              |                                            |
| <sup>222</sup> U   |                                  | 222.0261                 | ~ 1.μs                                 | $\alpha$                     |                                          | 0+                       |                                  |                              |                                            |
| <sup>223</sup> U   |                                  | 223.0277                 | 0.02 s                                 | $\alpha$ /                   | 8.78(4)/                                 |                          |                                  |                              |                                            |
| <sup>224</sup> U   |                                  | 224.02761                | ~ 1. ms                                | $\alpha$ /                   | 8.46/100                                 | 0+                       |                                  |                              |                                            |
| <sup>225</sup> U   |                                  | 225.02939                | 84. ms                                 | $\alpha$ /                   | 7.87/83                                  |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.82/15                                  |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.63/2                                   |                          |                                  |                              |                                            |
| <sup>226</sup> U   |                                  | 226.02934                | 0.26 s                                 | $\alpha$ /7.560              | 7.56/86                                  | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 7.38/14                                  |                          |                                  |                              |                                            |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>227</sup> U  |                                  | 227.03116                | 1.1 m                                  | $\alpha$ /7.200              | 6.870/                                   |                          |                                  |                              |                                            |
| <sup>228</sup> U  |                                  | 228.03137                | 9.1 m                                  | $\alpha$ /6.803              | 6.404(6)/0.6                             | 0+                       |                                  |                              | 0.095                                      |
|                   |                                  |                          |                                        |                              | 6.440(5)/0.7                             |                          |                                  |                              | 0.152                                      |
|                   |                                  |                          |                                        |                              | 6.589(5)/29                              |                          |                                  |                              | 0.187                                      |
|                   |                                  |                          |                                        |                              | 6.681(6)/70                              |                          |                                  |                              | 0.246                                      |
| <sup>229</sup> U  |                                  | 229.03351                | 58. m                                  | EC/(80)/1.31                 | 6.223/3                                  | (3/2+)                   |                                  |                              |                                            |
|                   |                                  |                          |                                        | $\alpha$ /(20)/6.473         | 6.297(3)/11                              |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 6.332(3)/20                              |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 6.360(3)/64                              |                          |                                  |                              |                                            |
| <sup>230</sup> U  |                                  | 230.033940               | 20.8 d                                 | $\alpha$ /5.992              | 5.5866(3)/0.01                           | 0+                       |                                  |                              | Th L x-ray                                 |
|                   |                                  |                          | $> 4 \times 10^{10}$ y                 | sf/ $< 10^{-10}$             | 5.6624(3)/0.26                           |                          |                                  |                              | 0.07218                                    |
|                   |                                  |                          |                                        |                              | 5.6663(3)/0.38                           |                          |                                  |                              | 0.15421                                    |
|                   |                                  |                          |                                        |                              | 5.8178(3)/32                             |                          |                                  |                              | 0.23034                                    |
|                   |                                  |                          |                                        |                              | 5.8887(3)/67                             |                          |                                  |                              | (0.081–0.8565)                             |
| <sup>231</sup> U  |                                  | 231.036294               | 4.2 d                                  | EC/0.36                      |                                          | (5/2-)                   |                                  |                              | Pa L x-ray                                 |
|                   |                                  |                          |                                        | $\alpha$ /( $10^{-3}$ )      | 5.46/ $1.6 \times 10^{-3}$               |                          |                                  |                              | Pa k x-ray                                 |
|                   |                                  |                          |                                        |                              | 5.47/ $1.4 \times 10^{-3}$               |                          |                                  |                              | 0.02564                                    |
|                   |                                  |                          |                                        |                              | 5.40/ $1. \times 10^{-3}$                |                          |                                  |                              | 0.08420                                    |
| <sup>232</sup> U  |                                  | 232.037156               | 70. y                                  | $\alpha$ /5.414              | 4.9979(1)/0.003                          | 0+                       |                                  |                              |                                            |
|                   |                                  |                          | $2.6 \times 10^{15}$ y                 | sf/ $2.7 \times 10^{-12}$    | 5.1367(1)/0.3                            |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 5.2635(1)/31                             |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 5.3203(1)/69                             |                          |                                  |                              |                                            |
| <sup>233</sup> U  |                                  | 233.039635               | $1.592 \times 10^5$ y                  | $\alpha$ /4.909              | 4.7830(8)/13.2                           | 5/2+                     | +0.59                            | 3.66                         | Th L x-ray                                 |
|                   |                                  |                          | $> 2.7 \times 10^{17}$ y               | sf/ $6 \times 10^{-11}$      | 4.8247(8)/84.4                           |                          |                                  |                              | 0.04244                                    |
|                   |                                  |                          |                                        |                              | 4.510–4.804                              |                          |                                  |                              | 0.09714                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.0252–1.119)                             |
| <sup>234</sup> U  | 0.0054(5)                        | 234.040952               | $2.455 \times 10^5$ y                  | $\alpha$ /4.856              | 4.604(1)/0.24                            | 0+                       |                                  |                              | 0.05323/0.156                              |
|                   |                                  |                          | $1.5 \times 10^{16}$ y                 | sf/ $1.6 \times 10^{-9}$     | 4.7231(1)/27.5                           |                          |                                  |                              | 0.12091                                    |
|                   |                                  |                          |                                        |                              | 4.776(1)/72.5                            |                          |                                  |                              |                                            |
| <sup>235m</sup> U |                                  |                          | 26. m                                  | IT/0.0007                    |                                          | 1/2+                     |                                  |                              |                                            |
| <sup>235</sup> U  | 0.7204(6)                        | 235.043930               | $7.04 \times 10^8$ y                   | $\alpha$ /4.6793             | 4.1525(9)/0.9                            | 7/2-                     | -0.38                            | 4.9                          | Th L x-ray                                 |
|                   |                                  |                          | $1.0 \times 10^{19}$ y                 | sf/ $7 \times 10^{-9}$       | 4.2157(9)/6.                             |                          |                                  |                              | Th k x-ray                                 |
|                   |                                  |                          |                                        |                              | 4.3237(9)/4.6                            |                          |                                  |                              | 0.10917                                    |
|                   |                                  |                          |                                        |                              | 4.3641(9)/19.                            |                          |                                  |                              | 0.14378                                    |
|                   |                                  |                          |                                        |                              | 4.370(4)/6                               |                          |                                  |                              | 0.16338                                    |
|                   |                                  |                          |                                        |                              | 4.3952(9)/57.                            |                          |                                  |                              | 0.18574                                    |
|                   |                                  |                          |                                        |                              | 4.4144(9)/2.1                            |                          |                                  |                              | 0.20213                                    |
|                   |                                  |                          |                                        |                              | 4.5025(9)/1.7                            |                          |                                  |                              | 0.20533                                    |
|                   |                                  |                          |                                        |                              | 4.5558(9)/4.2                            |                          |                                  |                              | 0.22140                                    |
|                   |                                  |                          |                                        |                              | 4.5970(9)/4.8                            |                          |                                  |                              | (0.03–0.79)                                |
| <sup>236</sup> U  |                                  | 236.045568               | $2.342 \times 10^7$ y                  | $\alpha$ /4.569              | 4.332(8)/0.26                            | 0+                       |                                  |                              | Th L x-ray                                 |
|                   |                                  |                          | $2.5 \times 10^{16}$ y                 | sf/ $9 \times 10^{-8}$       | 4.445(5)/26                              |                          |                                  |                              | 0.04946/100                                |
|                   |                                  |                          |                                        |                              | 4.494(3)/74                              |                          |                                  |                              | 0.11279/24.1                               |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.17115/0.080                              |
| <sup>237</sup> U  |                                  | 237.048730               | 6.75 d                                 | $\beta^-$ /0.519             | 0.24/                                    | 1/2+                     |                                  |                              | Np L x-ray                                 |
|                   |                                  |                          |                                        |                              | 0.25/                                    |                          |                                  |                              | Np k x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.05953                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.20801                                    |
| <sup>238</sup> U  | 99.2742(10)                      | 238.050788               | $4.47 \times 10^9$ y                   | $\alpha$                     | 4.0395/0.23                              | 0+                       |                                  |                              | Th L x-ray                                 |
|                   |                                  |                          | $8.2 \times 10^{15}$ y                 | sf/ $5 \times 10^{-5}$       | 4.147(5)/23                              |                          |                                  |                              | 0.04955/.06                                |
|                   |                                  |                          |                                        |                              | 4.196(5)/77                              |                          |                                  |                              | 0.1135/.01                                 |
| <sup>239</sup> U  |                                  | 239.054293               | 23.5 m                                 | $\beta^-$ /1.265             | 1.2/                                     | 5/2+                     |                                  |                              | (0.522–0.681)                              |
|                   |                                  |                          |                                        |                              | 1.3/                                     |                          |                                  |                              |                                            |
| <sup>240</sup> U  |                                  | 240.05659                | 14.1 h                                 | $\beta^-$ /0.39              | 0.36/                                    | 0+                       |                                  |                              | Np L x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.04410                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.05558                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.06760                                    |
| <sup>242</sup> U  |                                  | 242.0629                 | 16.8 m                                 | $\beta^-$ /~ 1.2             |                                          | 0+                       |                                  |                              |                                            |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV)       | Decay Mode/<br>Energy (/MeV)                | Particle Energy/<br>Intensity<br>(MeV/%)                                         | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                                      |
|------------------------|----------------------------------|--------------------------|----------------------------------------------|---------------------------------------------|----------------------------------------------------------------------------------|--------------------------|----------------------------------|------------------------------|---------------------------------------------------------------------------------|
| <b><sup>93</sup>Np</b> |                                  |                          |                                              |                                             |                                                                                  |                          |                                  |                              |                                                                                 |
| <sup>225</sup> Np      |                                  | 225.0339                 | > 2 $\mu$ s                                  |                                             |                                                                                  |                          |                                  |                              |                                                                                 |
| <sup>226</sup> Np      |                                  | 226.0352                 | 0.03 s                                       | $\alpha$ /                                  | 8.04(2)/                                                                         |                          |                                  |                              |                                                                                 |
| <sup>227</sup> Np      |                                  | 227.0350                 | 0.51 s                                       | $\alpha$ /                                  | 7.65(2)/                                                                         |                          |                                  |                              |                                                                                 |
|                        |                                  |                          |                                              |                                             | 7.68(1)/                                                                         |                          |                                  |                              |                                                                                 |
| <sup>228</sup> Np      |                                  | 228.0362                 | 61. s                                        | EC/60(7)/<br>$\alpha$ /40(7)/, sf           |                                                                                  |                          |                                  |                              |                                                                                 |
| <sup>229</sup> Np      |                                  | 229.0363                 | 4.0 m                                        | $\alpha$ /7.010                             | 6.890(20)                                                                        |                          |                                  |                              |                                                                                 |
| <sup>230</sup> Np      |                                  | 230.0378                 | 4.6 m                                        | EC/97 /3.6<br>$\alpha$ /3                   | 6.660(20)                                                                        |                          |                                  |                              |                                                                                 |
| <sup>231</sup> Np      |                                  | 231.03825                | 48.8 m                                       | EC/98 /1.8<br>$\alpha$ /2 /6.368            | 5/2<br>6.280/2                                                                   |                          |                                  |                              | 0.2629<br>0.3475<br>0.3703                                                      |
| <sup>232</sup> Np      |                                  | 232.0401                 | 14.7 m                                       | EC/99 /2.7                                  | (4-)                                                                             |                          |                                  |                              | U L x-ray<br>U k x-ray<br>0.3268<br>0.81925<br>0.86683                          |
| <sup>233</sup> Np      |                                  | 233.04074                | 36.2 m                                       | EC/1.2                                      | (5/2+)                                                                           |                          |                                  |                              | U L x-ray<br>U k x-ray<br>0.29887<br>0.31201                                    |
| <sup>234</sup> Np      |                                  | 234.04290                | 4.4 d                                        | $\beta$ +, EC/1.81                          | 0.79/                                                                            | (0+)                     |                                  |                              | U L x-ray<br>U k x-ray<br>1.5272<br>1.5587<br>1.6022                            |
| <sup>235</sup> Np      |                                  | 235.044063               | 1.085 y                                      | EC/99.9 /0.124<br>$\alpha$ /0.001/5.191     | 5/2+                                                                             |                          |                                  |                              | U k x-ray                                                                       |
| <sup>236m</sup> Np     |                                  |                          | 22.5 h                                       | EC/52 /<br>$\beta$ - /48 /                  | (1-)                                                                             |                          |                                  |                              | U L x-ray<br>Pu L x-ray<br>U k x-ray<br>0.64235<br>0.68759                      |
| <sup>236</sup> Np      |                                  | 236.04657                | $1.55 \times 10^5$ y                         | EC/91 /0.94<br>$\beta$ - /9 /0.49           | (6-)                                                                             |                          |                                  |                              | U L x-ray<br>U k x-ray<br>0.10423<br>0.16031                                    |
| <sup>237</sup> Np      |                                  | 237.048173               | $2.14 \times 10^6$ y<br>$1 \times 10^{18}$ y | $\alpha$ /4.957<br>sf/2.1 $\times 10^{-10}$ | 4.6395(5)/6.5<br>4.766(5)/9.7<br>4.7715(5)/22.7<br>4.7884(5)/47.8<br>4.558–4.873 | 5/2+                     | +3.14                            | +3.89                        | Pa L x-ray<br>Pa k x-ray<br>0.029378/15<br>0.08653/12<br>(0.03–0.28)            |
| <sup>238</sup> Np      |                                  | 238.050946               | 2.117 d                                      | $\beta$ - /1.292                            | 1.2/                                                                             | 2+                       |                                  |                              | Pu L x-ray<br>Pu k x-ray<br>0.98447/25.2<br>1.02855/18.3<br>(.044–1.026)        |
| <sup>239</sup> Np      |                                  | 239.052939               | 2.355 d                                      | $\beta$ - /0.722                            | 0.341/30<br>0.438/48                                                             | 5/2+                     |                                  |                              | Pu L x-ray<br>Pu k x-ray<br>0.10613<br>0.228186/11<br>0.27760/15<br>(0.04–0.50) |
| <sup>240m</sup> Np     |                                  |                          | 7.22 m                                       | $\beta$ - /99.9 /<br>IT/0.1 /               | 2.18/                                                                            | (1+)                     |                                  |                              | 0.25143<br>0.26333<br>0.55454<br>0.59735                                        |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV)         | Decay Mode/<br>Energy (/MeV)               | Particle Energy/<br>Intensity<br>(MeV/%)                                             | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%)                               |
|------------------------|----------------------------------|--------------------------|------------------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------------------------------------|
| <sup>240</sup> Np      |                                  | 240.05616                | 1.032 h                                        | $\beta^-$ /2.20                            | 0.89/                                                                                | 5+                       |                                  |                              | 0.1471/<br>0.5664<br>0.6008                                              |
| <sup>241</sup> Np      |                                  | 241.0583                 | 13.9 m                                         | $\beta^-$ /1.3                             | 1.3/                                                                                 | 5/2+                     |                                  |                              | 0.1330/<br>0.1740<br>0.280                                               |
| <sup>242m</sup> Np     |                                  |                          | 2.2 m                                          | $\beta^-$ /                                |                                                                                      | (1+)                     |                                  |                              | 0.15910<br>0.2651/<br>0.78570<br>0.9448/                                 |
| <sup>242</sup> Np      |                                  | 242.0616                 | 5.5 m                                          | $\beta^-$ /2.7                             | 2.7/                                                                                 | 6+                       |                                  |                              | 0.6209<br>0.73620<br>0.78074<br>1.47340<br>(0.04–2.37)                   |
| <sup>243</sup> Np      |                                  | 243.06428                | 1.9 m                                          |                                            |                                                                                      |                          |                                  |                              |                                                                          |
| <sup>244</sup> Np      |                                  | 244.0679                 | 2.3 m                                          |                                            |                                                                                      |                          |                                  |                              |                                                                          |
| <b><sup>94</sup>Pu</b> |                                  |                          |                                                |                                            |                                                                                      |                          |                                  |                              |                                                                          |
| <sup>228</sup> Pu      |                                  | 228.03874                | ~ 1.1 s                                        | $\alpha$ /                                 | 7.81(2)/                                                                             | 0+                       |                                  |                              |                                                                          |
| <sup>229</sup> Pu      |                                  | 229.0402                 | ~ 1.5 m                                        | $\alpha$ /                                 | 7.46/                                                                                |                          |                                  |                              |                                                                          |
| <sup>230</sup> Pu      |                                  | 230.03965                | 1.7 m                                          | $\alpha$ /                                 | 7.06/81<br>7.00/19                                                                   | 0+                       |                                  |                              |                                                                          |
| <sup>231</sup> Pu      |                                  | 231.04110                | 8.6 m                                          | EC/90<br>$\alpha$ /10                      | 6.72                                                                                 |                          |                                  |                              |                                                                          |
| <sup>232</sup> Pu      |                                  | 232.04119                | 34. m                                          | EC/>80/1.1<br>$\alpha$ / $<20$ /6.716      | 6.542(10)/38<br>6.600(10)/62                                                         | 0+                       |                                  |                              |                                                                          |
| <sup>233</sup> Pu      |                                  | 233.04300                | 20.9 m                                         | EC(99.9)/1.9<br>$\alpha$ /0.1 /6.416       | 6.300(20)/0.1                                                                        |                          |                                  |                              | 0.1503<br>0.1804<br>0.2353<br>0.5002<br>0.5346/<br>1.0352/               |
| <sup>234</sup> Pu      |                                  | 234.04332                | 8.8 h                                          | EC/94 /0.39<br>$\alpha$ /6 /6.310          | 6.035(3)/0.024<br>6.149(3)/1.9<br>6.200(3)/4.                                        | 0+                       |                                  |                              |                                                                          |
| <sup>235</sup> Pu      |                                  | 235.04529                | 25.3 m                                         | EC/99+ /1.2<br>$\alpha$ /0.003/5.957       | 5.850(20)/0.003                                                                      | (5/2+)                   |                                  |                              |                                                                          |
| <sup>236m</sup> Pu     |                                  |                          | 1.2 $\mu$ s                                    |                                            |                                                                                      |                          |                                  |                              |                                                                          |
| <sup>236</sup> Pu      |                                  | 236.046058               | 2.87 y<br>1.5 $\times 10^9$ y                  | $\alpha$ /5.867<br>sf/1.9 $\times 10^{-7}$ | 5.611/0.21<br>5.7210/30.5<br>5.7677(1)/69.3                                          | 0+                       |                                  |                              | 0.0476/0.07<br>0.109/0.02<br>(0.17–0.97)                                 |
| <sup>237</sup> Pu      |                                  | 237.048410               | 45.7 d                                         | EC/99.9 /0.220<br>$\alpha$ /0.003 /5.747   | 5.334(4)/0.0015<br>5.356(4)/0.0006<br>5.650(4)/0.0007                                | 7/2-                     |                                  |                              | Np L x-ray<br>Np k x-ray<br>0.026344<br>0.03319<br>0.05954<br>(0.03–0.5) |
| <sup>238</sup> Pu      |                                  | 238.049560               | 87.7 y<br>4.75 $\times 10^{10}$ y              | $\alpha$ /5.593<br>sf/1.8 $\times 10^{-7}$ | 5.3583(1)/0.10<br>5.465(1)/28.3<br>5.4992(1)/71.6                                    | 0+                       |                                  |                              | U k x-ray<br>0.04347<br>(0.04–1.1)                                       |
| <sup>239</sup> Pu      |                                  | 239.052163               | 2.410 $\times 10^4$ y<br>8. $\times 10^{15}$ y | $\alpha$ /5.244<br>sf/3 $\times 10^{-10}$  | 5.055/0.047<br>5.076/0.078<br>5.106/11.9<br>5.144/17.1<br>5.157/70.8<br>(4.74 –5.03) | 1/2+<br>+0.203           |                                  |                              | U k x-ray<br>0.05162<br>0.05682<br>0.12928<br>0.37502<br>0.41369         |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |                              |                 |                |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|------------------------------|-----------------|----------------|
| <sup>240</sup> Pu  | 240.053814                       | 240.053814               | 6.56 $\times 10^3$ y                   | $\alpha$ /5.255              | 5.0212(1)/0.07                           | 0+                            |                                  |                              | U L x-ray                                  |                              |                 |                |
|                    |                                  |                          | 1.14 $\times 10^{11}$ y                | sf/5.7 $\times 10^{-6}$      | 5.1237(1)/26.4                           |                               |                                  | 0.04524                      |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              | 5.1681(1)/73.5                           |                               |                                  | 0.10423                      |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | (0.04–0.97)                                |                              |                 |                |
| <sup>241</sup> Pu  | 241.056852                       | 241.056852               | 14.3 y                                 | $\beta^-$ /99+ /0.0208       | 4.853/3 $\times 10^{-4}$                 | 5/2+                          | -0.683                           | +6.                          | 0.14854                                    |                              |                 |                |
|                    |                                  |                          |                                        | $\alpha$ /0.002 /5.139       | 4.897/0.002                              |                               |                                  | 0.1600                       |                                            |                              |                 |                |
|                    |                                  |                          | < 6 $\times 10^{16}$ y                 | sf/ > 2.4 $\times 10^{-14}$  |                                          |                               |                                  |                              |                                            |                              |                 |                |
| <sup>242</sup> Pu  | 242.058743                       | 242.058743               | 3.75 $\times 10^5$ y                   | $\alpha$ /4.983              | 4.7546(7)/0.098                          | 0+                            |                                  |                              | U L x-ray                                  |                              |                 |                |
|                    |                                  |                          | 6.77 $\times 10^{10}$ y                | sf/5.5 $\times 10^{-4}$      | 4.8564(7)/22.4                           |                               |                                  | 0.04491                      |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              | 4.9006(7)/78                             |                               |                                  | 0.10350                      |                                            |                              |                 |                |
| <sup>243</sup> Pu  | 243.062003                       | 243.062003               | 4.956 h                                | $\beta^-$ /0.582             | 0.49/21                                  | 7/2+                          |                                  |                              | Am L x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              | 0.58/60                                  |                               |                                  | 0.0417                       |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               | 0.0839                           |                              |                                            |                              |                 |                |
| <sup>244</sup> Pu  | 244.064204                       | 244.064204               | 8.00 $\times 10^7$ y                   | $\alpha$ /99.9/4.665         | 4.546(1)/19.4                            | 0+                            |                                  |                              | U L x-ray                                  |                              |                 |                |
|                    |                                  |                          | 6.6 $\times 10^{10}$ y                 | sf/0.12                      | 4.589(1)/80.5                            |                               |                                  | 0.0439                       |                                            |                              |                 |                |
| <sup>245</sup> Pu  | 245.06775                        | 245.06775                | 10.5 h                                 | $\beta^-$ /1.21              | 0.93/57                                  | (9/2-)                        |                                  |                              | Am L x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              | 1.21/11                                  |                               |                                  | Am k x-ray                   |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  | 0.2804 /                     |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  | 0.30832                      |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  | 0.32752                      |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  | 0.56014                      |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  | (0.03–1.2)                   |                                            |                              |                 |                |
| <sup>246</sup> Pu  | 246.07021                        | 246.07021                | 10.85 d                                | $\beta^-$ /0.40              | 0.150/85                                 | 0+                            |                                  |                              | Am L x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              | 0.35/10                                  |                               |                                  | Am k x-ray                   |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  | 0.04379                      |                                            |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  | 0.22371                      |                                            |                              |                 |                |
| <sup>247</sup> Pu  |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              |                 |                |
| <sup>95</sup> Am   |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              |                 |                |
| <sup>232</sup> Am  | 232.0466                         | 232.0466                 | 0.9 m                                  | EC/ ~ 5.0                    |                                          |                               |                                  |                              |                                            |                              |                 |                |
| <sup>233</sup> Am  | 233.0464                         | 233.0464                 | ~ 3.2 m                                | $\alpha$                     | 6.78                                     |                               |                                  |                              |                                            |                              |                 |                |
| <sup>234</sup> Am  | 234.0478                         | 234.0478                 | 2.3 m                                  | EC/4.2                       |                                          |                               |                                  |                              |                                            |                              |                 |                |
| <sup>235</sup> Am  | 235.0480                         | 235.0480                 | 10.3 m                                 | EC                           |                                          |                               |                                  |                              | Pu K x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | $\alpha$                                   | 6.46/0.4                     | 0.291/100       |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | (0.170-0.828)   |                |
| <sup>236m</sup> Am |                                  |                          | 2.9 m                                  |                              |                                          | (1-)                          |                                  |                              | (0.583-0.713)                              |                              |                 |                |
| <sup>236</sup> Am  | 236.0496                         | 236.0496                 | 3.6 m                                  | EC                           |                                          | (5-)                          |                                  |                              | (0.158-1.038)                              |                              |                 |                |
| <sup>237</sup> Am  | 237.0500                         | 237.0500                 | 1.22 h                                 | EC/99.98 /1.7                |                                          | (5/2-)                        |                                  |                              | Pu k x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | $\alpha$ /0.02 /6.20                       | 6.042(5)/0.02                | 0.14559         |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 0.28026         |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 0.43845         |                |
| <sup>238</sup> Am  | 238.05198                        | 238.05198                | 1.63 h                                 | EC/2.26                      |                                          | 1+                            |                                  |                              | Pu L x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | $\alpha$ /0.0001 /6.04                     | 5.940/0.0001                 | Pu k x-ray      |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 0.91870         |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 0.96278         |                |
| <sup>239</sup> Am  | 239.053025                       | 239.053025               | 11.9 h                                 | EC/99.99/0.803               |                                          | 5/2-                          |                                  |                              | Pu L x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | $\alpha$ /0.01/5.924                       | 5.734(2)/0.001               | Pu k x-ray      |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            | 5.776(2)/0.008               | 0.18172         |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 0.22818         |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 0.27760         |                |
| <sup>240</sup> Am  | 240.05530                        | 240.05530                | 2.12 d                                 | EC/1.38                      |                                          | (3-)                          |                                  |                              | Pu L x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | $\alpha$ /5.592                            | 5.378(1)/16 $\times 10^{-4}$ | Pu k x-ray      |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 0.88878         |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 0.98764         |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | (0.1–1.3)       |                |
| <sup>241</sup> Am  | 241.056829                       | 241.056829               | 432.7 y                                | $\alpha$ /5.637              | 5.2443(1)/0.002                          | 5/2-                          | +1.58                            | +3.1                         | Np L x-ray                                 |                              |                 |                |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              | 1.2 $\times 10^{14}$ y                     | sf/3.6 $\times 10^{-10}$     | 5.3221(1)/0.015 | 0.02634 /0.024 |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 5.3884(1)/1.4   | 0.03319/.00126 |
|                    |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |                              | 5.4431(1)/12.8  | 0.05954/0.359  |

| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                        |                                  |                          |                                        |                              | 5.4857(1)/85.2                           |                          |                                  |                              | (0.03–1.128)                               |
|                        |                                  |                          |                                        |                              | 5.5116(1)/0.20                           |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 5.5442(1)/0.34                           |                          |                                  |                              |                                            |
| <sup>242m</sup> Am     |                                  |                          | 141. y                                 | IT/99.5/0.048                |                                          | 5-                       | +1.0                             | +6.5                         | Am L x-ray                                 |
|                        |                                  |                          |                                        | $\alpha$ /0.5/5.62           | 5.141(4)/0.026                           |                          |                                  |                              | 0.04863                                    |
|                        |                                  |                          | $> 3 \times 10^{12}$ y                 | sf/< 4.7 $\times 10^{-9}$    | 5.2070(2)/0.4                            |                          |                                  |                              | 0.08648                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.10944                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.16304                                    |
| <sup>242</sup> Am      |                                  | 242.059549               | 16.02 h                                | $\beta^-$ /83 /0.665         | 0.63/46                                  | 1-                       | +0.388                           | -2.4                         | Pu L x-ray                                 |
|                        |                                  |                          |                                        | EC/17 /0.750                 | 0.67/37                                  |                          |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Pu k x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0422                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.04453                                    |
| <sup>243</sup> Am      |                                  | 243.061381               | $7.37 \times 10^3$ y                   | $\alpha$ /5.438              | 5.1798(5)/1.1                            | 5/2-                     | +1.5                             | +2.9                         | 0.04354                                    |
|                        |                                  |                          | $2. \times 10^{14}$ y                  | sf/3.7 $\times 10^{-9}$      | 5.2343(5)/11                             |                          |                                  |                              | 0.07467                                    |
|                        |                                  |                          |                                        |                              | 5.2766(5)/88                             |                          |                                  |                              | 0.08657                                    |
|                        |                                  |                          |                                        |                              | 5.394(5)/0.12                            |                          |                                  |                              | 0.11770                                    |
|                        |                                  |                          |                                        |                              | 5.3500(5)/0.16                           |                          |                                  |                              | 0.14197                                    |
| <sup>244m</sup> Am     |                                  |                          | $\sim 26$ . m                          | $\beta^-$ /1.498             |                                          | (1-)                     |                                  |                              | 0.0429                                     |
| <sup>244</sup> Am      |                                  | 244.064285               | 10.1 h                                 | $\beta^-$ /1.428             |                                          |                          |                                  |                              | Am L x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Cm k x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.7460                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9000                                     |
| <sup>245</sup> Am      |                                  | 245.066452               | 2.05 h                                 | $\beta^-$ /0.894             | 0.65/19                                  | (5/2+)                   |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          |                                        |                              | 0.90/77                                  |                          |                                  |                              | Cm k x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.25299                                    |
| <sup>246m</sup> Am     |                                  |                          | 25.0 m                                 | $\beta^-$ /                  | 1.3/79.                                  | 2-                       |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          |                                        |                              | 1.60/14                                  |                          |                                  |                              | Cm k x-ray                                 |
|                        |                                  |                          |                                        |                              | 2.1/7                                    |                          |                                  |                              | 0.27002                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.79881                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.06201                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.07885                                    |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.04–2.29)                                |
| <sup>246</sup> Am      |                                  | 246.06978                | 39. m                                  | $\beta^-$ /2.38              | 1.2/                                     | (7-)                     |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Cm k x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1529                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2046                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6786                                     |
| <sup>247</sup> Am      |                                  | 247.0721                 | 22. m                                  | $\beta^-$ /1.7               |                                          |                          |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Cm k x-ray                                 |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2267 /                                   |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.2853 /                                   |
| <b><sup>96</sup>Cm</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>233</sup> Cm      |                                  | 233.0508                 |                                        | $\alpha$ /                   | 7.34/                                    |                          |                                  |                              |                                            |
| <sup>234</sup> Cm      |                                  | 234.05016                | $\sim 51$ . s                          | $\alpha$                     | 7.24/                                    | 0+                       |                                  |                              |                                            |
| <sup>235</sup> Cm      |                                  | 235.0514                 |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>236</sup> Cm      |                                  | 236.0514                 |                                        | EC/1.7                       |                                          | 0+                       |                                  |                              |                                            |
| <sup>237</sup> Cm      |                                  | 237.0529                 |                                        | EC/2.5                       |                                          |                          |                                  |                              |                                            |
| <sup>238</sup> Cm      |                                  | 238.05303                | 2.4 h                                  | EC/>90 /0.97                 |                                          | 0+                       |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /<10 /6.632         | 6.520(50)/<10                            |                          |                                  |                              |                                            |
| <sup>239</sup> Cm      |                                  | 239.0550                 | $\sim 3$ . h                           | EC/1.7                       |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.0407                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1466                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1874                                     |
| <sup>240</sup> Cm      |                                  | 240.055530               | 27. d                                  | $\alpha$ /6.397              | 5.989/0.014                              | 0+                       |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.147/0.05                               |                          |                                  |                              |                                            |
|                        |                                  |                          | $1.9 \times 10^6$ y                    | sf/3.9 $\times 10^{-6}$      | 6.2478(6) /28.8                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.2906(6) /70.6                          |                          |                                  |                              |                                            |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight              | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)    | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|---------------------------------------|----------------------------------------|---------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>241</sup> Cm |                                  | 241.057653                            | 32.8 d                                 | EC/99 /0.768                    |                                          | 1/2+                          |                                  |                              | Am k x-ray                                 |
|                   |                                  |                                       |                                        | $\alpha$ /1 /6.184              | 5.8842(4)/0.12                           |                               | 0.13241                          |                              |                                            |
|                   |                                  |                                       |                                        |                                 | 5.9291(4)/0.18                           |                               | 0.16505                          |                              |                                            |
|                   |                                  |                                       |                                        |                                 | 5.9389(4)/0.69                           |                               | 0.18028                          |                              |                                            |
|                   |                                  |                                       |                                        |                                 |                                          |                               | 0.43063                          |                              |                                            |
| <sup>242</sup> Cm | 242.058836                       | 162.8 d                               | $\alpha$ /6.216                        | 5.9694(1)/0.035                 | 0+                                       |                               |                                  | Pu L x-ray                   |                                            |
|                   |                                  |                                       |                                        | 6.069(1)/25                     |                                          |                               | 0.04408                          |                              |                                            |
|                   |                                  |                                       |                                        | 7.0 $\times$ 10 <sup>6</sup> y  | sf/6.4 $\times$ 10 <sup>-6</sup>         | 6.1129(1)/74                  |                                  | 0.10189                      |                                            |
|                   |                                  |                                       |                                        |                                 |                                          |                               | (0.04–1.2)                       |                              |                                            |
| <sup>243</sup> Cm | 243.061389                       | 29.1 y                                | $\alpha$ /6.167                        | 5.6815(5) /0.2                  | 5/2+                                     | 0.41                          |                                  | Pu L x-ray                   |                                            |
|                   |                                  |                                       |                                        | 5.6856(5)/1.6                   |                                          |                               | Pu k x-ray                       |                              |                                            |
|                   |                                  |                                       |                                        | 5.5 $\times$ 10 <sup>11</sup> y | sf/5.3 $\times$ 10 <sup>-9</sup>         | 5.7420(5)/10.6                |                                  | 0.10612                      |                                            |
|                   |                                  |                                       |                                        |                                 | 5.7859(5)/73.3                           |                               | 0.20975                          |                              |                                            |
|                   |                                  |                                       |                                        |                                 | 5.9922(5)/6.5                            |                               | 0.22819                          |                              |                                            |
|                   |                                  |                                       |                                        |                                 | 6.0103(5)/1.0                            |                               | 0.27760                          |                              |                                            |
|                   |                                  |                                       |                                        |                                 | 6.0589(5)/5                              |                               | 0.28546                          |                              |                                            |
|                   |                                  |                                       |                                        |                                 | 6.0666(5)/1.5                            |                               | 0.33431                          |                              |                                            |
| <sup>244</sup> Cm | 244.062753                       | 18.1 y                                | $\alpha$ /5.902                        | 5.6656/0.02                     | 0+                                       |                               |                                  | Pu L x-ray                   |                                            |
|                   |                                  |                                       |                                        | 5.7528/23                       |                                          |                               | 0.04282                          |                              |                                            |
|                   |                                  |                                       |                                        | 1.32 $\times$ 10 <sup>7</sup> y | sf/1.4 $\times$ 10 <sup>-4</sup>         | 5.8050/77                     |                                  | 0.09885                      |                                            |
|                   |                                  |                                       |                                        |                                 | 5.515/0.004                              |                               | 0.15262                          |                              |                                            |
| <sup>245</sup> Cm | 245.065491                       | 8.48 $\times$ 10 <sup>3</sup> y       | $\alpha$ /5.623                        | 5.235(10)/0.3                   | 7/2+                                     | 0.5                           |                                  | Pu L x-ray                   |                                            |
|                   |                                  |                                       |                                        | 5.3038(10)/5.0                  |                                          |                               | Pu k x-ray                       |                              |                                            |
|                   |                                  |                                       |                                        | 1.4 $\times$ 10 <sup>12</sup> y | sf/6.1 $\times$ 10 <sup>-7</sup>         | 5.3620(7)/93                  |                                  | 0.04195                      |                                            |
|                   |                                  |                                       |                                        |                                 | 5.4927(11)/0.8                           |                               | 0.13299                          |                              |                                            |
|                   |                                  |                                       |                                        |                                 | 5.5331(11)/0.6                           |                               | 0.13606                          |                              |                                            |
| <sup>246</sup> Cm | 246.067224                       | 4.76 $\times$ 10 <sup>3</sup> y       | $\alpha$ /5.476                        |                                 |                                          |                               |                                  | 0.17494                      |                                            |
|                   |                                  |                                       |                                        | 1.8 $\times$ 10 <sup>7</sup> y  | sf/0.026                                 | 5.343(3)/21                   | 0+                               |                              | Pu L x-ray                                 |
|                   |                                  |                                       |                                        |                                 | 5.386(3)/79                              |                               |                                  | 0.04453                      |                                            |
| <sup>247</sup> Cm | 247.070354                       | 1.56 $\times$ 10 <sup>7</sup> y       | $\alpha$ /5.352                        | 4.818(4)/4.7                    | 9/2-                                     | 0.37                          |                                  | Pu k x-ray                   |                                            |
|                   |                                  |                                       |                                        | 4.8690(20)/71                   |                                          |                               | 0.2792                           |                              |                                            |
|                   |                                  |                                       |                                        | 4.941(4)/1.6                    |                                          |                               | 0.2886                           |                              |                                            |
|                   |                                  |                                       |                                        | 4.9820(20)/2.0                  |                                          |                               | 0.3471                           |                              |                                            |
|                   |                                  |                                       |                                        | 5.1436(20)/1.2                  |                                          |                               | 0.4035                           |                              |                                            |
|                   |                                  |                                       |                                        | 5.2104(20)/5.7                  |                                          |                               |                                  |                              |                                            |
| <sup>248</sup> Cm | 248.072349                       | 3.48 $\times$ 10 <sup>5</sup> y       | $\alpha$ /99.92 /5.162                 | 4.931(5)/0.07                   | 0+                                       |                               |                                  |                              |                                            |
|                   |                                  |                                       |                                        | 5.0349(2)/16.5                  |                                          |                               |                                  |                              |                                            |
|                   |                                  |                                       |                                        | 5.0784(2)/(75)/1                |                                          |                               |                                  |                              |                                            |
| <sup>249</sup> Cm | 249.075953                       | 64.15 m                               | $\beta^-$ /0.900                       | 0.9/                            | 1/2+                                     |                               |                                  | Bk k x-ray                   |                                            |
|                   |                                  |                                       |                                        |                                 |                                          |                               | 0.56039/0.84                     |                              |                                            |
|                   |                                  |                                       |                                        |                                 |                                          |                               | 0.63431/1.5                      |                              |                                            |
| <sup>250</sup> Cm | 250.07836                        | $\sim$ 9.7 $\times$ 10 <sup>3</sup> y | sf/85.8                                |                                 | 0+                                       |                               |                                  | (0.085-0.653)                |                                            |
|                   |                                  |                                       |                                        | $\alpha$ /5.27                  |                                          |                               |                                  |                              |                                            |
|                   |                                  |                                       |                                        |                                 |                                          |                               |                                  |                              |                                            |
| <sup>251</sup> Cm | 251.08229                        | 16.8 m                                | $\beta^-$ /1.42                        | 0.90/16                         | (1/2+)                                   |                               |                                  | 0.3896 /                     |                                            |
|                   |                                  |                                       |                                        |                                 |                                          |                               | 0.5299                           |                              |                                            |
|                   |                                  |                                       |                                        |                                 |                                          |                               | 0.5425                           |                              |                                            |
| <sup>252</sup> Cm | 252.0849                         | < 2 d                                 |                                        |                                 | 0+                                       |                               |                                  |                              |                                            |
| <sup>97</sup> Bk  |                                  |                                       |                                        |                                 |                                          |                               |                                  |                              |                                            |
| <sup>238</sup> Bk | 238.0583                         | 2.4 m                                 | EC/5.0                                 |                                 |                                          |                               |                                  |                              |                                            |
| <sup>239</sup> Bk | 239.0583                         |                                       |                                        |                                 |                                          |                               |                                  |                              |                                            |
| <sup>240</sup> Bk | 240.0598                         | $\sim$ 4.8 m                          |                                        |                                 |                                          |                               |                                  |                              |                                            |
| <sup>241</sup> Bk | 241.0602                         | 4.6 m                                 | EC                                     |                                 |                                          |                               |                                  |                              | (0.152-0.262)                              |
| <sup>242</sup> Bk | 242.0620                         | 7.0 m                                 | EC/3.0                                 |                                 |                                          |                               |                                  |                              |                                            |
| <sup>243</sup> Bk | 243.063008                       | 4.5 h                                 | EC/99.8 /1.508                         | 6.542(4)/0.03                   | (3/2-)                                   |                               |                                  |                              | 0.1466                                     |

| Elem.<br>or Isot. | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                   |                                  |                          |                                        | $\alpha/0.15$ /6.871         | 6.5738(2)/0.04                           |                          |                                  |                              | 0.1874                                     |
|                   |                                  |                          |                                        |                              | 6.7180(22)/0.02                          |                          |                                  |                              | 0.755                                      |
|                   |                                  |                          |                                        |                              | 6.7581(20)/0.02                          |                          |                                  |                              | 0.840                                      |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.946                                      |
| <sup>244</sup> Bk | 244.06518                        | 4.4 h                    | EC/99.99 /2.26                         |                              |                                          | (4-)                     |                                  |                              | 0.1445                                     |
|                   |                                  |                          | $\alpha/0.01$ /6.778                   |                              | 6.625(4)/0.003                           |                          |                                  |                              | 0.1876                                     |
|                   |                                  |                          |                                        |                              | 6.667(4)/0.003                           |                          |                                  |                              | 0.2176                                     |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9815                                     |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9215/                                    |
| <sup>245</sup> Bk | 245.066362                       | 4.94 d                   | EC/99.9 /0.810                         |                              |                                          | 3/2-                     |                                  |                              | Cm L x-ray                                 |
|                   |                                  |                          | $\alpha/0.1$ /6.453                    |                              | 5.8851(5)/0.03                           |                          |                                  |                              | Cm k x-ray                                 |
|                   |                                  |                          |                                        |                              | 6.1176(9)/0.01                           |                          |                                  |                              | 0.25299                                    |
|                   |                                  |                          |                                        |                              | 6.1467(5)/0.02                           |                          |                                  |                              | 0.3809                                     |
|                   |                                  |                          |                                        |                              | 6.3087(5)/0.014                          |                          |                                  |                              | 0.3851                                     |
|                   |                                  |                          |                                        |                              | 6.3492(5)/0.018                          |                          |                                  |                              |                                            |
| <sup>246</sup> Bk | 246.0687                         | 1.80 d                   | EC/1.35                                |                              |                                          | (2-)                     |                                  |                              | Cm L x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Cm k x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.79881                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.08142                                    |
| <sup>247</sup> Bk | 247.07031                        | 1.4 × 10 <sup>3</sup> y  | $\alpha/5.889$                         |                              | 5.465(5)/1.5                             | (3/2-)                   |                                  |                              | 0.04175                                    |
|                   |                                  |                          |                                        |                              | 5.501(5)/7                               |                          |                                  |                              | 0.0839                                     |
|                   |                                  |                          |                                        |                              | 5.532(5)/45                              |                          |                                  |                              | 0.268                                      |
|                   |                                  |                          |                                        |                              | 5.6535(20)/5.5                           |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 5.678(2)/13                              |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 5.712(2)/17                              |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 5.753(2)/4.3                             |                          |                                  |                              |                                            |
|                   |                                  |                          |                                        |                              | 5.794(2)/5.5                             |                          |                                  |                              |                                            |
| <sup>248</sup> Bk | 248.07310                        | 23.7 h                   | $\beta^-$ /70 /0.87                    |                              | 0.86/                                    | (1-)                     |                                  |                              | Cm L x-ray                                 |
|                   |                                  |                          | EC/30 /0.72                            |                              |                                          |                          |                                  |                              | Cf L x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Cm k x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Cf k x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.5507                                     |
| <sup>249</sup> Bk | 249.074987                       | 320. d                   | $\beta^-$ /0.125                       |                              | 0.125/100                                | 7/2+                     | 2.0                              |                              | 0.327/10 <sup>-5</sup>                     |
|                   |                                  |                          | $\alpha/0.001$ /5.525                  |                              | 5.390(1)/0.0002                          |                          |                                  |                              | 0.308/10 <sup>-6</sup>                     |
|                   |                                  | 1.8 × 10 <sup>9</sup> y  | sf/4.9 × 10 <sup>-8</sup>              |                              | 5.4174(6)/0.001                          |                          |                                  |                              |                                            |
| <sup>250</sup> Bk | 250.078317                       | 3.217 h                  | $\beta^-$ /1.780                       |                              | 0.74/                                    | 2-                       |                                  |                              | Cf L x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Cf k x-ray                                 |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.98912                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.03184                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.04–1.6)                                 |
| <sup>251</sup> Bk | 251.08076                        | 56. m                    | $\beta^-$ /1.09                        |                              |                                          | (3/2-)                   |                                  |                              | 0.02481                                    |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1528                                     |
|                   |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.1776                                     |
| <sup>252</sup> Bk | 252.0843                         | 1.8 m                    |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>98</sup> Cf  |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>237</sup> Cf | 237.062                          | 2.1 s                    | $\alpha$ , sf/10                       |                              |                                          |                          |                                  |                              |                                            |
| <sup>238</sup> Cf | 238.0614                         | 21 ms                    | sf/∼ 100                               |                              |                                          | 0+                       |                                  |                              |                                            |
|                   |                                  |                          | $\alpha/\sim 0.2$                      |                              |                                          |                          |                                  |                              |                                            |
| <sup>239</sup> Cf | 239.0624                         | ∼ 0.7 m                  | $\alpha$                               |                              |                                          |                          |                                  |                              |                                            |
| <sup>240</sup> Cf | 240.0623                         | 1.1 m                    | $\alpha/7.719$                         |                              | 7.590(10)/                               | 0+                       |                                  |                              |                                            |
|                   |                                  |                          | sf/ ∼ 2.1                              |                              |                                          |                          |                                  |                              |                                            |
| <sup>241</sup> Cf | 241.0637                         | 4. m                     | EC/3.3                                 |                              |                                          |                          |                                  |                              |                                            |
|                   |                                  |                          | $\alpha/7.60$                          |                              | 7.335(5)/                                |                          |                                  |                              |                                            |
| <sup>242</sup> Cf | 242.06370                        | 3.5 m                    | $\alpha/7.509$                         |                              | 7.351(6)/20                              | 0+                       |                                  |                              |                                            |
|                   |                                  |                          | sf/<0.014                              |                              | 7.385(4)/80                              |                          |                                  |                              |                                            |
| <sup>243</sup> Cf | 243.0654                         | 11. m                    | EC/86 /2.2                             |                              | 7.060(6)/20                              | (1/2+)                   |                                  |                              |                                            |
|                   |                                  |                          | $\alpha/14$ /7.40                      |                              | 7.170/4                                  |                          |                                  |                              |                                            |
| <sup>244</sup> Cf | 244.066001                       | 20. m                    | $\alpha/7.328$                         |                              | 7.168(5)/25                              | 0+                       |                                  |                              |                                            |



| Elem.<br>or Isot.      | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>245</sup> Cf      |                                  | 245.068049               | 44. m                                  | $\alpha$ /36 /7.255          | 7.210(5)/75                              |                          |                                  |                              | Cm K x-ray                                 |
|                        |                                  |                          |                                        | EC/64 /1.569                 | 7.14/91.7                                |                          |                                  |                              | 0.5709                                     |
|                        |                                  |                          |                                        |                              | 6.983/0.31                               |                          |                                  |                              | 0.6014                                     |
|                        |                                  |                          |                                        |                              | 7.09/7                                   |                          |                                  |                              | 0.6163                                     |
| <sup>246</sup> Cf      |                                  | 246.068805               | 1.49 d                                 | $\alpha$ /6.869              | 6.6156(10)/0.18                          | 0+                       |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          |                                        |                              | 6.7086(7)/21.8                           |                          |                                  |                              | 0.04221                                    |
|                        |                                  |                          | $1.8 \times 10^3$ y                    | sf/ $2.3 \times 10^{-4}$     | 6.7501(7)/78.0                           |                          |                                  |                              | 0.0945                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.147                                      |
| <sup>247</sup> Cf      |                                  | 247.07100                | 3.11 h                                 | EC/99.96 /0.65               |                                          | 7/2+                     |                                  |                              | Bk k x-ray                                 |
|                        |                                  |                          |                                        | $\alpha$ /0.04 /6.55         | 6.301(5)/                                |                          |                                  |                              | 0.2941                                     |
|                        |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.4778                                     |
| <sup>248</sup> Cf      |                                  | 248.07219                | 334. d                                 | $\alpha$ /6.369              | 6.220(5)/17                              | 0+                       |                                  |                              |                                            |
|                        |                                  |                          | $3.2 \times 10^4$ y                    | sf/0.0029                    | 6.262(5)/83                              |                          |                                  |                              |                                            |
| <sup>249</sup> Cf      |                                  | 249.074854               | 351. y                                 | $\alpha$ /6.295              | 5.758/3.7                                | 9/2-                     |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          |                                        |                              | 5.812/85.7                               |                          |                                  |                              | Cm k x-ray                                 |
|                        |                                  |                          | $8. \times 10^{10}$ y                  | sf/ $4.4 \times 10^{-7}$     | 5.8488(2)/1.0                            |                          |                                  |                              | 0.25299/2.5                                |
|                        |                                  |                          |                                        |                              | 5.9029(2)/2.8                            |                          |                                  |                              | 0.33351/13.6                               |
|                        |                                  |                          |                                        |                              | 5.9451(2)/4.0                            |                          |                                  |                              | 0.38832/63.6                               |
|                        |                                  |                          |                                        |                              | 6.1401(2)/1.1                            |                          |                                  |                              | (0.0376–1.103)                             |
|                        |                                  |                          |                                        |                              | 6.1940(2)/2.2                            |                          |                                  |                              |                                            |
| <sup>250</sup> Cf      |                                  | 250.076406               | 13.1 y                                 | $\alpha$ /6.129              | 5.8913(4)/0.3                            | 0+                       |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          | $1.7 \times 10^4$ y                    | sf/0.077                     | 5.9889(4)/15                             |                          |                                  |                              | 0.04285                                    |
|                        |                                  |                          |                                        |                              | 6.0310(4)/84.5                           |                          |                                  |                              |                                            |
| <sup>251m</sup> Cf     |                                  |                          | 26.3 $\mu$ s                           |                              |                                          |                          |                                  |                              |                                            |
| <sup>251</sup> Cf      |                                  | 251.079587               | $9.0 \times 10^2$ y                    | $\alpha$ /6.172              | 5.56448(7)/1.5                           | 1/2+                     |                                  |                              | 0.109/19.8                                 |
|                        |                                  |                          |                                        |                              | 5.632(1)/4.5                             |                          |                                  |                              | 0.1775/17.3                                |
|                        |                                  |                          |                                        |                              | 5.648(1)/3.5                             |                          |                                  |                              | (0.0385–0.354)                             |
|                        |                                  |                          |                                        |                              | 5.6773(6)/35                             |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 5.762(3)/3.8                             |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 5.7937(7)/2.0                            |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 5.8124(8)/4.2                            |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 5.8514(6)/27                             |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.0140(7)/11.6                           |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 6.0744(7)/2.7                            |                          |                                  |                              |                                            |
| <sup>252</sup> Cf      |                                  | 252.081626               | 2.65 y                                 | $\alpha$ /96.9 /6.217        | 5.7977(1)/0.23                           | 0+                       |                                  |                              | Cm L x-ray                                 |
|                        |                                  |                          | 86. y                                  | sf/3.1/                      | 6.0756(4)/15.2                           |                          |                                  |                              | 0.04339                                    |
|                        |                                  |                          |                                        |                              | 6.1184(4)/81.6                           |                          |                                  |                              | 0.1002                                     |
| <sup>253</sup> Cf      |                                  | 253.08513                | 17.8 d                                 | $\beta^-$ /99.7 /0.29        | 0.27/100                                 | (7/2+)                   |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /0.3 /6.126         | 5.921(5)/0.02                            |                          |                                  |                              |                                            |
| <sup>254</sup> Cf      |                                  | 254.08732                | 60.5 d                                 | sf/99.7/                     |                                          | 0+                       |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /0.3/5.930          | 5.792(5)/0.05                            |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        |                              | 5.834(5)/0.26                            |                          |                                  |                              |                                            |
| <sup>255</sup> Cf      |                                  | 255.0911                 | 1.4 h                                  | $\beta^-$ /0.7               |                                          |                          |                                  |                              |                                            |
| <sup>256</sup> Cf      |                                  | 256.0934                 | 12. m                                  | sf                           |                                          | 0+                       |                                  |                              |                                            |
| <b><sub>99</sub>Es</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>241</sup> Es      |                                  | 241.0685                 | ~ 8 s                                  | $\alpha$                     | 8.11                                     |                          |                                  |                              |                                            |
| <sup>242</sup> Es      |                                  | 242.0698                 | 16 s                                   | $\alpha$                     | 7.92                                     |                          |                                  |                              |                                            |
| <sup>243</sup> Es      |                                  | 243.0696                 | 21. s                                  | $\alpha$ / $>30$ /           | 7.89/ $>30$                              |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | EC/ $<70$ /4.0               |                                          |                          |                                  |                              |                                            |
| <sup>244</sup> Es      |                                  | 244.0709                 | 37. s                                  | EC/76 /4.6                   |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /4 /                | 7.57/4                                   |                          |                                  |                              |                                            |
| <sup>245</sup> Es      |                                  | 245.0713                 | 1.3 m                                  | $\alpha$ /40 /7.858          | 7.74                                     |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | EC/60 /3.1                   |                                          |                          |                                  |                              |                                            |
| <sup>246</sup> Es      |                                  | 246.0729                 | 7.7 m                                  | EC/90 /3.9                   |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /10 /               | 7.35                                     |                          |                                  |                              |                                            |
| <sup>247</sup> Es      |                                  | 247.07366                | 4.8 m                                  | EC/93 /2.48                  |                                          |                          |                                  |                              |                                            |
|                        |                                  |                          |                                        | $\alpha$ /7 /                | 7.32                                     |                          |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>248</sup> Es  |                                  | 248.0755                 | 26. m                                  | EC/99.7 /3.1                 |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /0.3 /              | 6.87                                     |                          |                                  |                              |                                            |
| <sup>249</sup> Es  |                                  | 249.07641                | 1.70 h                                 | EC/99.4 /1.45                |                                          | (7/2+)                   |                                  |                              | 0.3795                                     |
|                    |                                  |                          |                                        | $\alpha$ /0.6 /              | 6.77                                     |                          |                                  |                              | 0.8132                                     |
| <sup>250m</sup> Es |                                  |                          | 2.2 h                                  | EC/                          |                                          | (1-)                     |                                  |                              | Cf L x-ray                                 |
|                    |                                  |                          |                                        | $\beta$ +                    |                                          |                          |                                  |                              | Cf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.9891                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 1.0319                                     |
| <sup>250</sup> Es  |                                  | 250.0786                 | 8.6 h                                  | EC/2.1                       |                                          | (6+)                     |                                  |                              | Cf L x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | Cf k x-ray                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.30339                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.34948                                    |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.82883                                    |
| <sup>251</sup> Es  |                                  | 251.07999                | 1.38 d                                 | EC/99.5 /0.38                |                                          | (3/2-)                   |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /0.5 /              | 6.462/0.05                               |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        |                              | 6.492/0.4                                |                          |                                  |                              |                                            |
| <sup>252</sup> Es  |                                  | 252.08298                | 1.29 y                                 | $\alpha$ /76 /               | 6.632/61.0                               | (5-)                     |                                  |                              |                                            |
|                    |                                  |                          |                                        | EC/24 /1.26                  | 6.562/10.3                               |                          |                                  |                              |                                            |
| <sup>253</sup> Es  |                                  | 253.084825               | 20.47 d                                | $\alpha$ /                   | 6.633/89.8                               | 7/2+                     | +4.10                            | 7.                           | 0.04180/5.6                                |
|                    |                                  |                          | 6.3 $\times 10^5$ y                    | sf/8.9 $\times 10^{-6}$      | 6.5916/6.6                               |                          |                                  |                              | 0.3892/2.7                                 |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | (0.0309-1.106)                             |
| <sup>254m</sup> Es |                                  |                          | 1.64 d                                 | $\beta$ - /99.6 /            | 0.475                                    | 2+                       | 2.9                              | 3.7                          | Fm L x-ray                                 |
|                    |                                  |                          |                                        | $\alpha$ /0.3 /6.67          | 6.382                                    | 2+                       |                                  |                              | Fm k x-ray                                 |
|                    |                                  |                          | > 10. y                                | sf/0.045                     |                                          |                          |                                  |                              | 0.6488                                     |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.6938                                     |
| <sup>254</sup> Es  |                                  | 254.088022               | 276. d                                 | $\alpha$ /                   | 6.429                                    | (7+)                     |                                  |                              | 0.064                                      |
|                    |                                  |                          | > 2.5 $\times 10^7$ y                  | sf/< 3 $\times 10^{-6}$      |                                          |                          |                                  |                              |                                            |
| <sup>255</sup> Es  |                                  | 255.09027                | 40. d                                  | $\beta$ - /92 /0.29          |                                          | (7/2+)                   |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /8 /                | 6.26                                     |                          |                                  |                              |                                            |
|                    |                                  |                          | 2.6 $\times 10^3$ y                    | sf/0.0042                    | 6.300                                    |                          |                                  |                              |                                            |
| <sup>256m</sup> Es |                                  |                          | 7.6 h                                  | $\beta$ - /                  |                                          | (8+)                     |                                  |                              | 0.218                                      |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.232                                      |
|                    |                                  |                          |                                        |                              |                                          |                          |                                  |                              | 0.862                                      |
| <sup>256</sup> Es  |                                  | 256.0936                 | 25. m                                  | $\beta$ - /1.7               |                                          | (1+)                     |                                  |                              |                                            |
| <sup>257</sup> Es  |                                  | 257.0960                 | 7.7 d                                  | $\beta$ -                    |                                          |                          |                                  |                              |                                            |
| <sup>100</sup> Fm  |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>242</sup> Fm  |                                  | 242.0734                 | 0.8 ms                                 | sf/> 96                      |                                          | 0+                       |                                  |                              |                                            |
| <sup>243</sup> Fm  |                                  | 243.0744                 | 0.2 s                                  | $\alpha$ /                   | 8.55                                     |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | sf/< 0.4                     |                                          |                          |                                  |                              |                                            |
| <sup>244</sup> Fm  |                                  | 244.0741                 | 3.3 ms                                 | sf/> 97                      |                                          | 0+                       |                                  |                              |                                            |
| <sup>245</sup> Fm  |                                  | 245.0754                 | 4. s                                   | $\alpha$ /                   | 8.15/                                    |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | sf/<0.1                      |                                          |                          |                                  |                              |                                            |
| <sup>246</sup> Fm  |                                  | 246.07530                | 1.2 s                                  | $\alpha$ /85/                | 8.24/                                    | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        | sf/15/                       |                                          |                          |                                  |                              |                                            |
| <sup>247m</sup> Fm |                                  |                          | 4.3 s                                  | $\alpha$ /                   | 8.17/                                    |                          |                                  |                              |                                            |
| <sup>247</sup> Fm  |                                  | 247.0769                 | 29. s                                  | $\alpha$ /8.20               | 7.87/70                                  |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | EC/2.9                       | 7.93/30                                  |                          |                                  |                              |                                            |
| <sup>248</sup> Fm  |                                  | 248.07720                | 33. s                                  | $\alpha$ /99.9 /8.001        | 7.83/20                                  | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        | sf/0.1/                      | 7.87/80                                  |                          |                                  |                              |                                            |
| <sup>249</sup> Fm  |                                  | 249.0790                 | 1.6 m                                  | EC/2.4                       |                                          | (7/2+)                   |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /                   | 7.57                                     |                          |                                  |                              |                                            |
| <sup>250m</sup> Fm |                                  |                          | 1.8 s                                  | IT/                          |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | sf/<8 $\times 10^{-5}$       |                                          |                          |                                  |                              |                                            |
| <sup>250</sup> Fm  |                                  | 250.07952                | 30. m                                  | $\alpha$ /                   | 7.43/                                    | 0+                       |                                  |                              |                                            |
|                    |                                  |                          |                                        | EC/0.8                       |                                          |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | sf/0.007                     |                                          |                          |                                  |                              |                                            |
| <sup>251</sup> Fm  |                                  | 251.08158                | 5.3 h                                  | EC/98 /1.47                  |                                          | (9/2-)                   |                                  |                              |                                            |
|                    |                                  |                          |                                        | $\alpha$ /2 /                | 6.833                                    |                          |                                  |                              |                                            |

| Elem.<br>or Isot.  | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)              | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>252</sup> Fm  |                                  | 252.08247                | 1.058 d                                | $\alpha$ /7.154<br>sf/0.0023              | 6.998/15<br>7.039/85                     | 0+                       |                                  |                              |                                            |
| <sup>253</sup> Fm  |                                  | 253.085185               | 3.0 d                                  | EC/88/0.333<br>$\alpha$ /12 /             | 6.676/<br>6.943/                         | $\frac{1}{2}+$           |                                  |                              | Es k x-ray<br>0.2719                       |
| <sup>254</sup> Fm  |                                  | 254.086854               | 3.240 h                                | $\alpha$ /<br>sf/0.059                    | 7.150<br>7.192                           | 0+                       |                                  |                              |                                            |
| <sup>255</sup> Fm  |                                  | 255.089962               | 20.1 h<br>$1.0 \times 10^4$ y          | $\alpha$ /<br>sf/ $2.3 \times 10^{-5}$    | 6.9635(5)/5.0<br>7.0225(5)/93.4          | 7/2+                     |                                  |                              | 0.08148/1.<br>(0.041-0.900)                |
| <sup>256</sup> Fm  |                                  | 256.09177                | 2.63 h                                 | sf/91<br>$\alpha$ /19                     | <br>6.92/                                | 0+                       |                                  |                              |                                            |
| <sup>257</sup> Fm  |                                  | 257.09511                | 100.5 d                                | $\alpha$ /99.79<br>sf/0.21                | 6.519                                    | (9/2+)                   |                                  |                              | 0.1794<br>0.2410                           |
| <sup>258</sup> Fm  |                                  | 258.0971                 | 0.37 ms                                | sf/                                       |                                          | 0+                       |                                  |                              |                                            |
| <sup>259</sup> Fm  |                                  | 259.1006                 | 1.5 s                                  | sf/                                       |                                          |                          |                                  |                              |                                            |
| <sup>260</sup> Fm  |                                  | 260.103                  | ~ 4 ms                                 | sf/                                       |                                          | 0+                       |                                  |                              |                                            |
| <sup>101</sup> Md  |                                  |                          |                                        |                                           |                                          |                          |                                  |                              |                                            |
| <sup>245m</sup> Md |                                  |                          | ~ 0.4 s                                | $\alpha$                                  | 8.64, 8.68                               |                          |                                  |                              |                                            |
| <sup>245</sup> Md  |                                  | 245.0808                 | 0.9 ms                                 | sf                                        |                                          |                          |                                  |                              |                                            |
| <sup>246</sup> Md  |                                  | 246.0819                 | 1.0 s                                  | $\alpha$                                  | 8.74<br>8.50–8.56                        |                          |                                  |                              |                                            |
| <sup>247m</sup> Md |                                  |                          | ~ 0.2 s                                | sf/                                       |                                          |                          |                                  |                              |                                            |
| <sup>247</sup> Md  |                                  | 247.0816                 | 3. s                                   | $\alpha$                                  | 8.43                                     |                          |                                  |                              |                                            |
| <sup>248</sup> Md  |                                  | 248.0828                 | 7. s                                   | EC/80 /5.3<br>$\alpha$ /20 /              | 8.32/15<br>8.36/5                        |                          |                                  |                              |                                            |
|                    |                                  |                          |                                        | sf/<0.05                                  |                                          |                          |                                  |                              |                                            |
| <sup>249</sup> Md  |                                  | 249.0830                 | 24. s                                  | EC>/<80 /3.7<br>$\alpha$ >20 /8.46        | <br>8.030(20)/                           |                          |                                  |                              |                                            |
| <sup>250</sup> Md  |                                  | 250.0844                 | 50. s                                  | EC/94 /4.6<br>$\alpha$ /6 /8.25           | 7.75/4<br>7.83/2                         |                          |                                  |                              |                                            |
| <sup>251</sup> Md  |                                  | 251.0848                 | 4.0 m                                  | EC/>94 /3.1<br>$\alpha$ <6 /              | <br>7.55/                                |                          |                                  |                              |                                            |
| <sup>252</sup> Md  |                                  | 252.0866                 | 2. m                                   | EC/>50 /3.9<br>$\alpha$ <50 /             | <br>7.73/                                |                          |                                  |                              |                                            |
| <sup>253</sup> Md  |                                  | 253.0873                 | ~ 6 m                                  | EC/2.0                                    |                                          |                          |                                  |                              |                                            |
| <sup>254m</sup> Md |                                  |                          | 30. m                                  | EC/                                       |                                          |                          |                                  |                              |                                            |
| <sup>254</sup> Md  |                                  | 254.0897                 | 10. m                                  | EC/2.7                                    |                                          |                          |                                  |                              |                                            |
| <sup>255</sup> Md  |                                  | 255.09108                | 27. m                                  | EC/92 /1.04<br>$\alpha$ /8 /<br>sf/< 0.15 | $\alpha$ /7.33/93<br>7.27/5<br>7.75/1    | (7/2-)                   |                                  |                              | 0.121/100<br>0.115/65<br>0.136/35          |
|                    |                                  |                          |                                        |                                           | 7.71/1                                   |                          |                                  |                              | 0.141–0.453                                |
| <sup>256</sup> Md  |                                  | 256.0941                 | 1.30 h                                 | EC/89 /2.13<br>$\alpha$ /11 /<br>sf/< 2.6 | 7.21/71<br>7.14/22<br>7.68/2.5           |                          |                                  |                              | Fm k x-ray<br>0.121/409<br>0.115/266       |
|                    |                                  |                          |                                        |                                           | 7.25/2.5<br>7.64/2.1                     |                          |                                  |                              | 0.136/143<br>0.634/119                     |
|                    |                                  |                          |                                        |                                           |                                          |                          |                                  |                              | 0.141–1.37                                 |
| <sup>257</sup> Md  |                                  | 257.095541               | 5.5 h                                  | EC/85 /0.41<br>$\alpha$ /15, sf/< 1       | 7.074<br>7.014                           | (7/2-)                   |                                  |                              | Fm k x-ray<br>(0.181–0.389)                |
| <sup>258m</sup> Md |                                  |                          | 57. m                                  | EC/<br>sf/< 30                            |                                          | (1-)                     |                                  |                              | Fm k x-ray                                 |
| <sup>258</sup> Md  |                                  | 258.098431               | 51.5 d                                 | $\alpha$ /7.40<br>sf/< 0.003              | 6.718(2)/<br>6.763(4)/                   | (8-)                     |                                  |                              | 0.3678<br>0.057–0.448                      |
| <sup>259</sup> Md  |                                  | 259.1005                 | 1.64 h                                 | sf/>98.7<br>$\alpha$ <1.3                 |                                          | 7/2+                     |                                  |                              |                                            |
| <sup>260</sup> Md  |                                  | 260.1037                 | ~ 27.8 d                               | sf/ 73–100                                |                                          |                          |                                  |                              |                                            |
| <sup>102</sup> No  |                                  |                          |                                        |                                           |                                          |                          |                                  |                              |                                            |
| <sup>248</sup> No  |                                  | 248.0866                 | < 1.0 $\mu$ s                          | sf                                        |                                          | 0+                       |                                  |                              |                                            |

| Elem.<br>or Isot.       | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>249</sup> No       |                                  | 249.0878                 | 0.05 ms                                | sf                           |                                          |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha/ < 20$               |                                          |                          |                                  |                              |                                            |
| <sup>250</sup> No       |                                  | 250.0875                 | 6. $\mu$ s                             | sf/                          |                                          | 0+                       |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha/ < 10$               |                                          |                          |                                  |                              |                                            |
| <sup>251m</sup> No      |                                  |                          | 0.9 s                                  | $\alpha$                     | 8.67                                     |                          |                                  |                              |                                            |
| <sup>251</sup> No       |                                  | 251.0890                 | 0.78 s                                 | $\alpha/91$                  | 8.62/96                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/0.26                      | 8.58/4                                   |                          |                                  |                              |                                            |
| <sup>252</sup> No       |                                  | 252.08898                | 2.44 s                                 | $\alpha/75/8.551$            | 8.42                                     | 0+                       |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/24/                       | 8.37                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC, $\beta+ / < 1.6$         |                                          |                          |                                  |                              |                                            |
| <sup>253</sup> No       |                                  | 253.0907                 | 1.7 m                                  | $\alpha/$                    | 8.00                                     | (9/2-)                   |                                  |                              | 0.222/100                                  |
|                         |                                  |                          |                                        | EC/3.2                       |                                          |                          |                                  |                              | (0.151-0.280)                              |
| <sup>254m</sup> No      |                                  |                          | 0.28 s                                 | I.T./                        |                                          |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/ < .2                     |                                          |                          |                                  |                              |                                            |
| <sup>254</sup> No       |                                  | 254.09096                | 49. s                                  | $\alpha/$                    | 8.09                                     | 0+                       |                                  |                              | 0.102                                      |
|                         |                                  |                          |                                        | EC/1.1                       |                                          |                          |                                  |                              | 0.152                                      |
|                         |                                  |                          |                                        | sf/0.17                      |                                          |                          |                                  |                              |                                            |
| <sup>255</sup> No       |                                  | 255.09324                | 3.1 m                                  | $\alpha/62 /$                | 8.12/                                    | $\frac{1}{2}+$           |                                  |                              | 0.187                                      |
|                         |                                  |                          |                                        | EC/38/2.01                   | 7.93                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 8.08                                     |                          |                                  |                              |                                            |
| <sup>256</sup> No       |                                  | 256.09428                | 2.9 s                                  | $\alpha/$                    | 8.43                                     | 0+                       |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/0.5                       |                                          |                          |                                  |                              |                                            |
| <sup>257</sup> No       |                                  | 257.09688                | 24.5 s                                 | $\alpha/$                    | 8.222/83                                 | (7/2+)                   |                                  |                              | 0.0770                                     |
|                         |                                  |                          |                                        | sf/ < 1.5                    | 8.27                                     |                          |                                  |                              | 0.1018                                     |
|                         |                                  |                          |                                        |                              | 8.323/17                                 |                          |                                  |                              | 0.1241                                     |
| <sup>258</sup> No       |                                  | 258.0982                 | ~ 1.2 ms                               | sf/                          |                                          | 0+                       |                                  |                              |                                            |
| <sup>259</sup> No       |                                  | 259.1010                 | 58. m                                  | $\alpha/78 /7.794$           | 7.52                                     | (9/2+)                   |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC/22/0.5                    | 7.55                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/ < 9.7                    |                                          |                          |                                  |                              |                                            |
| <sup>260</sup> No       |                                  | 260.1026                 | 0.11 s                                 | sf/                          |                                          | 0+                       |                                  |                              |                                            |
| <sup>262</sup> No       |                                  | 262.1073                 | ~ 8. ms                                | sf/                          |                                          | 0+                       |                                  |                              |                                            |
| <b><sup>103</sup>Lr</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>251</sup> Lr       |                                  | 251.0944                 | 39 m                                   | sf                           |                                          |                          |                                  |                              |                                            |
| <sup>252</sup> Lr       |                                  | 252.0954                 | ~ 0.36 s                               | $\alpha$                     | 9.02/73                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/ < 1                      | 8.97/27                                  |                          |                                  |                              |                                            |
| <sup>253m</sup> Lr      |                                  |                          | ~ 0.57 s                               | $\alpha$                     | 8.79                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/1.3                       |                                          |                          |                                  |                              |                                            |
| <sup>253</sup> Lr       |                                  | 253.0952                 | 1.5 s                                  | $\alpha/$                    | 8.72                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/8                         |                                          |                          |                                  |                              |                                            |
| <sup>254</sup> Lr       |                                  | 254.0965                 | 13. s                                  | $\alpha/$                    | 8.45                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC/5.2                       |                                          |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/ < 0.1                    |                                          |                          |                                  |                              |                                            |
| <sup>255</sup> Lr       |                                  | 255.09669                | 22. s                                  | $\alpha/$                    | 8.37/60                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC/3.2                       | 8.43/40                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/ < 0.1                    |                                          |                          |                                  |                              |                                            |
| <sup>256</sup> Lr       |                                  | 256.0986                 | 27. s                                  | $\alpha/99.7 /8.554$         | 8.43/                                    |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC/4.2                       | 8.39                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/ < 0.03                   |                                          |                          |                                  |                              |                                            |
| <sup>257</sup> Lr       |                                  | 257.0996                 | 0.65 s                                 | $\alpha/$                    | 8.80                                     | 7/2+                     |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC/2.5                       |                                          |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/ < 0.03                   |                                          |                          |                                  |                              |                                            |
| <sup>258</sup> Lr       |                                  | 258.1018                 | 3.9 s                                  | $\alpha/$                    | 8.60/46                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC/3.4                       | 8.62/25                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/ < 5                      | 8.56/20                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 8.65/9                                   |                          |                                  |                              |                                            |
| <sup>259</sup> Lr       |                                  | 259.1029                 | 6.1 s                                  | $\alpha/80$                  | 8.44(1)                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/20                        |                                          |                          |                                  |                              |                                            |
| <sup>260</sup> Lr       |                                  | 260.1055                 | 3. m                                   | $\alpha/$                    | 8.03                                     |                          |                                  |                              |                                            |

| Elem.<br>or Isot.       | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>261</sup> Lr       |                                  | 261.1069                 | 40. m                                  | sf                           |                                          |                          |                                  |                              |                                            |
| <sup>262</sup> Lr       |                                  | 262.1096                 | 3.6 h                                  | EC/2.                        |                                          |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/<10                       |                                          |                          |                                  |                              |                                            |
| <b><sup>104</sup>Rf</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>253</sup> Rf       |                                  | 253.1007                 | ~ 48. $\mu$ s                          | sf                           |                                          |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha$ / $\alpha$ <10      |                                          |                          |                                  |                              |                                            |
| <sup>254</sup> Rf       |                                  | 254.1002                 | 23. $\mu$ s                            | sf/>98.5                     |                                          | 0+                       |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha$ / $\alpha$ <1.5     |                                          |                          |                                  |                              |                                            |
| <sup>255</sup> Rf       |                                  | 255.1013                 | 1.6 s                                  | $\alpha$                     | 8.72/<0.05                               |                          |                                  |                              | 0.203                                      |
|                         |                                  |                          |                                        | sf/52                        | 8.77/94                                  |                          |                                  |                              | 0.142                                      |
|                         |                                  |                          |                                        |                              | 8.67/<0.05                               |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 8.58/<0.05                               |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 8.92/<0.05                               |                          |                                  |                              |                                            |
| <sup>256</sup> Rf       |                                  | 256.10117                | 6.2 ms                                 | sf/99.68                     |                                          | 0+                       |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha$ /0.32               | 8.81                                     |                          |                                  |                              |                                            |
| <sup>257</sup> Rf       |                                  | 257.1030                 | 4.7 s                                  | $\alpha$ /9.22               | 8.77                                     |                          |                                  |                              | 0.117                                      |
|                         |                                  |                          |                                        | EC/11                        | 9.01                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/<1.4                      | 8.95                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 8.62                                     |                          |                                  |                              |                                            |
| <sup>258</sup> Rf       |                                  | 258.1035                 | 12. ms                                 | sf/87                        |                                          | 0+                       |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha$ /13                 |                                          |                          |                                  |                              |                                            |
| <sup>259</sup> Rf       |                                  | 259.1056                 | 3.4 s                                  | $\alpha$ /9.09/93            | 8.77(2)/                                 |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/7                         | 8.86/                                    |                          |                                  |                              |                                            |
| <sup>260</sup> Rf       |                                  | 260.1064                 | 20. ms                                 | sf/                          |                                          | 0+                       |                                  |                              |                                            |
| <sup>261m</sup> Rf      |                                  |                          | 1.3 m                                  | $\alpha$                     | 8.28                                     |                          |                                  |                              |                                            |
| <sup>261</sup> Rf       |                                  | 261.10877                | 5. s                                   | $\alpha$ /60, sf/40          | 8.52/                                    |                          |                                  |                              |                                            |
| <sup>262</sup> Rf       |                                  | 262.1099                 | 2.1 s                                  | sf/>99.2                     |                                          | 0+                       |                                  |                              |                                            |
| <sup>263</sup> Rf       |                                  | 263.1126                 | 10. m                                  | sf, $\alpha$                 |                                          |                          |                                  |                              |                                            |
| <sup>265</sup> Rf       |                                  | 265.1167                 | ~ 13 h                                 | $\alpha$                     |                                          |                          |                                  |                              |                                            |
| <sup>267</sup> Rf       |                                  | 267.122                  | ~ 0.1 d                                | sf                           |                                          |                          |                                  |                              |                                            |
| <b><sup>105</sup>Db</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>255</sup> Db       |                                  | 255.1074                 | ~ 1.5 s                                | $\alpha$ ,                   |                                          |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/~ 20                      |                                          |                          |                                  |                              |                                            |
| <sup>256</sup> Db       |                                  | 256.1081                 | 1.6 s                                  | $\alpha$ /64                 | 9.02/67                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC/35                        | 8.89/11                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/0.05                      | 9.08/11                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 9.12/11                                  |                          |                                  |                              |                                            |
| <sup>257m</sup> Db      |                                  |                          | 0.8 s                                  | $\alpha$                     | 9.16                                     |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/<13                       |                                          |                          |                                  |                              |                                            |
| <sup>257</sup> Db       |                                  | 257.1077                 | 1.5 s                                  | $\alpha$ /                   | 8.97/33                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/<6                        | 9.07/38                                  |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 9.12/5.5                                 |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 8.94/9                                   |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 9.02/9                                   |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 8.89/5.5                                 |                          |                                  |                              |                                            |
| <sup>258</sup> Db       |                                  | 258.1092                 | 4.2 s                                  | $\alpha$ /                   | 9.30/                                    |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | EC/5.3                       | 9.17/                                    |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/<33                       | 9.08/                                    |                          |                                  |                              |                                            |
| <sup>259</sup> Db       |                                  | 259.1096                 | ~ 0.51 s                               | sf/                          |                                          |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha$ /                   | 9.47/                                    |                          |                                  |                              |                                            |
| <sup>260m</sup> Db      |                                  |                          | 0.3 m                                  |                              |                                          |                          |                                  |                              |                                            |
| <sup>260</sup> Db       |                                  | 260.1113                 | 1.5 s                                  | $\alpha$ /                   | 9.05/                                    |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/<9.6                      | 9.08/                                    |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        |                              | 9.13/                                    |                          |                                  |                              |                                            |
| <sup>261</sup> Db       |                                  | 261.1121                 | 1.8 s                                  | $\alpha$ /                   | 8.93/                                    |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | sf/<18                       |                                          |                          |                                  |                              |                                            |
| <sup>262</sup> Db       |                                  | 262.1141                 | 0.5 m                                  | sf/<33                       |                                          |                          |                                  |                              |                                            |

| Elem.<br>or Isot.       | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV)  | Particle Energy/<br>Intensity<br>(MeV/%)          | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|-------------------------|----------------------------------|--------------------------|----------------------------------------|-------------------------------|---------------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                         |                                  |                          |                                        | $\alpha$ /                    | 8.45/<br>8.53/<br>8.67/<br>8.36/<br>8.41/<br>EC/3 |                          |                                  |                              |                                            |
| <sup>263</sup> Db       |                                  | 263.1150                 | ~ 0.45 m                               | sf/57                         |                                                   |                          |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha$ /41                  |                                                   |                          |                                  |                              |                                            |
| <sup>267</sup> Db       |                                  | 267.1224                 | 1.2 h                                  | sf                            |                                                   |                          |                                  |                              |                                            |
| <sup>268</sup> Db       |                                  | 268.125                  | 1.2 d                                  | sf, EC                        |                                                   |                          |                                  |                              |                                            |
| <b><sup>106</sup>Sg</b> |                                  |                          |                                        |                               |                                                   |                          |                                  |                              |                                            |
| <sup>258</sup> Sg       |                                  | 258.1132                 | ~ 2.9 ms                               | sf                            |                                                   | 0+                       |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha$ / $<20$              |                                                   |                          |                                  |                              |                                            |
| <sup>259</sup> Sg       |                                  | 259.1145                 | 0.5 s                                  | $\alpha$ /<br>sf/ $<20$       | 9.62<br>9.35<br>9.03                              |                          |                                  |                              |                                            |
| <sup>260</sup> Sg       |                                  | 260.11442                | 4. ms                                  | $\alpha$ /50<br>sf/50         | 9.76<br>9.72<br>9.81                              | 0+                       |                                  |                              |                                            |
| <sup>261</sup> Sg       |                                  | 261.1161                 | 0.3 s                                  | $\alpha$ , sf/ $<10$          | 9.56                                              |                          |                                  |                              |                                            |
| <sup>262</sup> Sg       |                                  | 262.1164                 | 0.007 s                                | sf                            |                                                   | 0+                       |                                  |                              |                                            |
|                         |                                  |                          |                                        | $\alpha$ / $<22$              |                                                   |                          |                                  |                              |                                            |
| <sup>263m</sup> Sg      |                                  |                          | 0.3 s                                  | $\alpha$                      | 9.2                                               |                          |                                  |                              |                                            |
| <sup>263</sup> Sg       |                                  | 263.1183                 | 0.8 s                                  | $\alpha$                      | 9.06<br>9.25                                      |                          |                                  |                              |                                            |
| <sup>265</sup> Sg       |                                  | 265.1211                 | 8. s                                   | $\alpha$ / $>65$<br>sf/ $<35$ | 8.84/46<br>8.76/23<br>8.94/23<br>8.69/8           |                          |                                  |                              |                                            |
| <sup>266</sup> Sg       |                                  | 266.1221                 | ~ 21. s                                | $\alpha$ /<br>sf/ $<82$       | 8.77/66<br>8.52/33                                | 0+                       |                                  |                              |                                            |
| <sup>271</sup> Sg       |                                  | 271.133                  | ~ 0.04 h                               | $\alpha$ /50<br>sf/50         | 8.53                                              |                          |                                  |                              |                                            |
| <b><sup>107</sup>Bh</b> |                                  |                          |                                        |                               |                                                   |                          |                                  |                              |                                            |
| <sup>260</sup> Bh       |                                  | 260.122                  |                                        | $\alpha$                      |                                                   |                          |                                  |                              |                                            |
| <sup>261</sup> Bh       |                                  | 261.1217                 | 12. ms                                 | $\alpha$ /, sf $<10$          | 10.40<br>10.10<br>10.03                           |                          |                                  |                              |                                            |
| <sup>262m</sup> Bh      |                                  |                          | 8. ms                                  | $\alpha$ /<br>sf/ $<12$       | 10.37<br>10.24                                    |                          |                                  |                              |                                            |
| <sup>262</sup> Bh       |                                  | 262.1229                 | 0.10 s                                 | $\alpha$ /<br>sf/ $<12$       | 10.06<br>9.91<br>9.74                             |                          |                                  |                              |                                            |
| <sup>264</sup> Bh       |                                  | 264.1246                 | 1.0 s                                  | $\alpha$ /<br>sf/             | 9.3 – 9.8                                         |                          |                                  |                              |                                            |
| <sup>265</sup> Bh       |                                  | 265.1252                 | 0.9 s                                  | $\alpha$                      | 9.24                                              |                          |                                  |                              |                                            |
| <sup>266</sup> Bh       |                                  | 266.1269                 | ~ 2 s                                  | $\alpha$                      | 9.08                                              |                          |                                  |                              |                                            |
| <sup>267</sup> Bh       |                                  | 267.1277                 | ~ 17 s                                 | $\alpha$                      | 8.83                                              |                          |                                  |                              |                                            |
| <b><sup>108</sup>Hs</b> |                                  |                          |                                        |                               |                                                   |                          |                                  |                              |                                            |
| <sup>263</sup> Hs       |                                  | 263.1286                 |                                        | $\alpha$ /                    |                                                   |                          |                                  |                              |                                            |
| <sup>264</sup> Hs       |                                  | 264.12839                | ~ 0.08 ms                              | $\alpha$ /, sf/ $\sim 50$     | 11.0                                              | 0+                       |                                  |                              |                                            |
| <sup>265m</sup> Hs      |                                  |                          | ~ 0.75 ms                              | $\alpha$                      | 10.57/63<br>10.73<br>10.52<br>10.34               |                          |                                  |                              |                                            |
| <sup>265</sup> Hs       |                                  | 265.1301                 | 2.0 ms                                 | $\alpha$ /<br>sf/ $<1$        | 10.30/90<br>10.43<br>10.37                        |                          |                                  |                              |                                            |

| Elem.<br>or Isot.        | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( <i>h</i> /2 $\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|--------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------------------------|------------------------------|--------------------------------------------|
|                          |                                  |                          |                                        |                              | 10.25                                    |                               |                                  |                              |                                            |
| <sup>266</sup> Hs        |                                  | 266.1301                 | ~ 2.3 ms                               | $\alpha$                     | 10.2                                     | 0+                            |                                  |                              |                                            |
| <sup>267m</sup> Hs       |                                  |                          | ~ 0.8 s                                |                              |                                          |                               |                                  |                              |                                            |
| <sup>267</sup> Hs        |                                  | 267.1318                 | 0.05 s                                 | $\alpha$ / $>88$             | 9.88                                     |                               |                                  |                              |                                            |
|                          |                                  |                          |                                        |                              | 9.83                                     |                               |                                  |                              |                                            |
|                          |                                  |                          |                                        |                              | 9.75                                     |                               |                                  |                              |                                            |
| <sup>269</sup> Hs        |                                  | 269.1341                 | ~ 14 s                                 | $\alpha$                     | 9.23                                     |                               |                                  |                              |                                            |
|                          |                                  |                          |                                        |                              | 9.18                                     |                               |                                  |                              |                                            |
| <sup>270</sup> Hs        |                                  | 270.1347                 | ~ 3.6 s                                | $\alpha$                     | 9.16                                     | 0+                            |                                  |                              |                                            |
| <sup>275</sup> Hs        |                                  | 275.146                  | ~ 0.15 s                               | $\alpha$                     | 9.3                                      |                               |                                  |                              |                                            |
| <sup>277</sup> Hs        |                                  | 277.150                  | ~ 11 m                                 | sf                           |                                          |                               |                                  |                              |                                            |
| <b><sup>109</sup>Mt</b>  |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>266m</sup> Mt       |                                  |                          | ~ 1.2 ms                               | $\alpha$                     | 10.46–10.81                              |                               |                                  |                              |                                            |
| <sup>266</sup> Mt        |                                  | 266.1373                 | ~ 0.7 ms                               | $\alpha$                     | 10.48–11.31                              |                               |                                  |                              |                                            |
| <sup>267</sup> Mt        |                                  | 267.137                  | 19 ms                                  | $\alpha$                     |                                          |                               |                                  |                              |                                            |
| <sup>268</sup> Mt        |                                  | 268.1387                 | ~ 0.03 s                               | $\alpha$ / $>68$             | 10.3 - 10.8                              |                               |                                  |                              |                                            |
| <sup>270</sup> Mt        |                                  | 270.141                  | 5 ms                                   | $\alpha$                     | 10.0                                     |                               |                                  |                              |                                            |
| <sup>275</sup> Mt        |                                  | 275.149                  | 0.01 s                                 | $\alpha$                     | 10.3                                     |                               |                                  |                              |                                            |
| <sup>276</sup> Mt        |                                  | 276.151                  | ~ 0.7 s                                | $\alpha$                     | 9.7                                      |                               |                                  |                              |                                            |
| <b><sup>110</sup>Ds</b>  |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>267</sup> Ds        |                                  | 267.1443                 | ~ 3 $\mu$ s                            | $\alpha$ / $>32$             | 11.6                                     |                               |                                  |                              |                                            |
| <sup>269</sup> Ds        |                                  | 269.1451                 | 0.17 ms                                | $\alpha$ / $>75$             | 11.11                                    |                               |                                  |                              |                                            |
| <sup>270m</sup> Ds       |                                  |                          | ~ 6 ms                                 | $\alpha$                     | 10.95                                    |                               |                                  |                              |                                            |
|                          |                                  |                          |                                        |                              | 11.15                                    |                               |                                  |                              |                                            |
|                          |                                  |                          |                                        |                              | 12.15                                    |                               |                                  |                              |                                            |
| <sup>270</sup> Ds        |                                  | 270.1447                 | 0.1 ms                                 | $\alpha$                     | 11.03                                    | 0+                            |                                  |                              |                                            |
| <sup>271m</sup> Ds       |                                  |                          | 0.07 s                                 | $\alpha$                     | 9.9                                      |                               |                                  |                              |                                            |
| <sup>271</sup> Ds        |                                  | 271.1461                 | 1.6 ms                                 | $\alpha$                     | 10.8                                     |                               |                                  |                              |                                            |
| <sup>273m</sup> Ds       |                                  |                          | 0.076 ms                               | $\alpha$                     | 11.8                                     |                               |                                  |                              |                                            |
| <sup>273</sup> Ds        |                                  | 273.1489                 | 118 ms                                 | $\alpha$ /                   | 9.73                                     |                               |                                  |                              |                                            |
| <sup>279</sup> Ds        |                                  | 279.159                  | 0.18 s                                 | sf/90                        |                                          |                               |                                  |                              |                                            |
|                          |                                  |                          |                                        |                              | $\alpha$ /10                             | 9.7                           |                                  |                              |                                            |
| <sup>280</sup> Ds        |                                  | 280.160                  | ~ 7.6 s                                | sf/                          |                                          | 0+                            |                                  |                              |                                            |
| <sup>281</sup> Ds        |                                  | 281.162                  | 10. s                                  | sf                           |                                          |                               |                                  |                              |                                            |
| <sup>282</sup> Ds        |                                  |                          | 0.5 ms                                 | sf                           |                                          |                               |                                  |                              |                                            |
| <b><sup>111</sup>Rg</b>  |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>272</sup> Rg        |                                  | 272.1536                 | ~ 2 ms                                 | $\alpha$ / $>68$             | 10.82                                    |                               |                                  |                              |                                            |
| <sup>274</sup> Rg        |                                  | 274.156                  | ~ 65 ms                                | $\alpha$                     | 11.2                                     |                               |                                  |                              |                                            |
| <sup>279</sup> Rg        |                                  | 279.162                  | ~ 0.17 s                               | $\alpha$                     | 10.4                                     |                               |                                  |                              |                                            |
| <sup>280</sup> Rg        |                                  | 280.164                  | ~ 3.6 s                                | $\alpha$                     | ~ 9.75                                   |                               |                                  |                              |                                            |
| <b><sup>112</sup>112</b> |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>277</sup> 112       |                                  | 277.1639                 | ~ 0.24 ms                              | $\alpha$                     | 11.45                                    |                               |                                  |                              |                                            |
|                          |                                  |                          |                                        |                              | 11.65                                    |                               |                                  |                              |                                            |
| <sup>283</sup> 112       |                                  | 283.172                  | ~ 4. s                                 | sf/ $< 10$                   |                                          |                               |                                  |                              |                                            |
|                          |                                  |                          |                                        |                              | $\alpha$ / $\sim 100$                    | 9.5                           |                                  |                              |                                            |
| <sup>284</sup> 112       |                                  | 284.172                  | 0.10 s                                 | sf                           |                                          |                               |                                  |                              |                                            |
| <sup>285</sup> 112       |                                  | 285.174                  | ~ 34. s                                | $\alpha$                     | 9.16                                     |                               |                                  |                              |                                            |
| <b><sup>113</sup>113</b> |                                  |                          |                                        |                              |                                          |                               |                                  |                              |                                            |
| <sup>278</sup> 113       |                                  |                          | 0.24 ms                                | $\alpha$                     | 11.7                                     |                               |                                  |                              |                                            |
| <sup>283</sup> 113       |                                  | 283.176                  | ~ 0.1 s                                | $\alpha$                     | 10.1                                     |                               |                                  |                              |                                            |
| <sup>284</sup> 113       |                                  | 284.178                  | ~ 0.5 s                                | $\alpha$                     | 10.0                                     |                               |                                  |                              |                                            |

| Elem.<br>or Isot.         | Natural<br>Abundance<br>(Atom %) | Atomic Mass or<br>Weight | Half-life/<br>Resonance<br>Width (MeV) | Decay Mode/<br>Energy (/MeV) | Particle Energy/<br>Intensity<br>(MeV/%) | Spin<br>( $\hbar/2\pi$ ) | Nuclear<br>Magnetic<br>Mom. (nm) | Elect.<br>Quadr.<br>Mom. (b) | $\gamma$ -Energy /<br>Intensity<br>(MeV/%) |
|---------------------------|----------------------------------|--------------------------|----------------------------------------|------------------------------|------------------------------------------|--------------------------|----------------------------------|------------------------------|--------------------------------------------|
| <sup>114</sup> <b>114</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>286</sup> 114        |                                  | 286.184                  | 0.16 s                                 | $\alpha/40$                  | 10.2                                     |                          |                                  |                              |                                            |
|                           |                                  |                          |                                        | sf/60                        |                                          |                          |                                  |                              |                                            |
| <sup>287</sup> 114        |                                  | 287.186                  | 0.5 s                                  | $\alpha$                     | 10.0                                     |                          |                                  |                              |                                            |
| <sup>288</sup> 114        |                                  | 288.186                  | 0.8 s                                  | $\alpha$                     | 9.95                                     |                          |                                  |                              |                                            |
| <sup>289</sup> 114        |                                  | 289.187                  | ~ 2.7 s                                | $\alpha$                     | 9.82                                     |                          |                                  |                              |                                            |
| <sup>115</sup> <b>115</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>287</sup> 115        |                                  | 287.191                  | ~ 0.03 s                               | $\alpha$                     | 10.6                                     |                          |                                  |                              |                                            |
| <sup>288</sup> 115        |                                  | 288.192                  | ~ 0.09 s                               | $\alpha$                     | 10.5                                     |                          |                                  |                              |                                            |
| <sup>116</sup> <b>116</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>290</sup> 116        |                                  | 290.199                  | ~ 15 ms                                | $\alpha$                     | 10.9                                     |                          |                                  |                              |                                            |
| <sup>291</sup> 116        |                                  | 291.200                  | ~ 6. ms                                | $\alpha$                     | ~ 10.74                                  |                          |                                  |                              |                                            |
| <sup>292</sup> 116        |                                  | 292.200                  | ~ 18. ms                               | $\alpha$                     | ~ 10.66                                  |                          |                                  |                              |                                            |
| <sup>293</sup> 116        |                                  |                          | ~ 0.05 s                               | $\alpha$                     | 10.5                                     |                          |                                  |                              |                                            |
| <sup>118</sup> <b>118</b> |                                  |                          |                                        |                              |                                          |                          |                                  |                              |                                            |
| <sup>294</sup> 118        |                                  |                          | ~ 2.0 ms                               | $\alpha$                     | 11.7                                     |                          |                                  |                              |                                            |



# NEUTRON SCATTERING AND ABSORPTION PROPERTIES

Norman E. Holden

This table presents an evaluated set of values for experimental quantities that characterize the properties for scattering and absorption of neutrons. The neutron cross section is given for room temperature neutrons, 20.43°C, corresponding to a thermal neutron energy of 0.0253 electron volts (eV) or a neutron velocity of 2200 meters/second. The neutron resonance integral is defined over the energy range from 0.5 eV to  $0.1 \times 10^6$  eV, or 0.1 MeV.

Bound neutron scattering lengths and neutron cross sections averaged over a Maxwellian spectrum at 30 keV for astrophysical applications are also presented. A list of the major references used is given below. The literature cutoff date is January 2003. Uncertainties are given in parentheses. Parentheses with two or more numbers indicate values to the excited state(s) and to the ground state of the product nucleus.

## Table Layout

| Column Number | Column Title                      | Description                                                                                                                                                                                                                                                                                                                    |
|---------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | Isotope/Element                   | For elements, atomic number and chemical symbol are listed. For nuclides, mass number and chemical symbol are listed. Isomers are indicated by the addition of m, m1, or m2.                                                                                                                                                   |
| 2             | Isotopic Abundance                | in atom percent                                                                                                                                                                                                                                                                                                                |
| 3             | Half-life                         | Half-life in decimal notation. $\mu$ s = microsecond; ms = millisecond; s = second; m = minute; h = hour; d = day; y = year.                                                                                                                                                                                                   |
| 4             | Thermal Neutron Cross Sections    | Cross sections for neutron capture reactions in units of barns ( $10^{-24}$ cm <sup>2</sup> ) or millibarns (mb). Proton, alpha production and fission reactions are designated by $\sigma_p$ , $\sigma_\alpha$ , $\sigma_f$ , respectively. Separate values are listed for isomeric production.                               |
| 5             | Neutron Resonance Integrals       | Resonance integrals for neutron capture reactions in barns ( $10^{-24}$ cm <sup>2</sup> ) or millibarns (mb). Proton, alpha production and fission reactions are designated by R.I. <sub>p</sub> , R.I. <sub><math>\alpha</math></sub> , R.I. <sub>f</sub> , respectively. Separate values are listed for isomeric production. |
| 6             | Neutron Scattering Lengths        | Bound coherent scattering lengths for neutron scattering reactions in units of femtometers (fm), which is equal to fermis ( $10^{-13}$ cm).                                                                                                                                                                                    |
| 7             | Maxwellian Averaged Cross Section | Astrophysical Cross Sections, averaged over a stellar neutron maxwellian spectrum characterized by a thermal energy of 30 keV, expressed in barns ( $10^{-24}$ cm <sup>2</sup> ), millibarns (mb) or microbarns ( $\mu$ b).                                                                                                    |

## General Nuclear Data References

The following references represent the major sources of the nuclear data presented:

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Bao, Z.Y., Beer, H., Käppeler, F., Voss, F., Wisshak, K., Raucher, T.; *Neutron Cross Sections for Nucleo-synthesis Studies*, Atomic Data Nuclear Data Tables 76, 70 (2000).

| Elem. or Isot.  | Natural Abundance (%) | Half-Life               | Thermal Neut. Cross-Section (barns)            | Resonance Integral (barns)                | Coh. Scat. Length (fm) | $\sigma$ (30 keV) Maxw. Avg. (barns) |
|-----------------|-----------------------|-------------------------|------------------------------------------------|-------------------------------------------|------------------------|--------------------------------------|
| <sup>1</sup> H  |                       |                         | 0.332(2)                                       | 0.149(1)                                  | -3.739(1)              |                                      |
| <sup>1</sup> H  | 99.9885(70)           | >2.8 $\times 10^{23}$ y | 0.332(2)                                       | 0.149(1)                                  | - 3.741(1)             | 0.25(2) mb*                          |
| <sup>2</sup> H  | 0.0115(70)            |                         | 0.51(1)mb                                      | 0.23(2) mb                                | 6.671(4)               | 2.1(4) $\mu$ b                       |
| <sup>3</sup> H  |                       | 12.33 y                 | < 6. $\mu$ b                                   |                                           | 4.79(3)                |                                      |
| <sup>2</sup> He |                       |                         | < 0.05                                         |                                           | 3.26(3)                |                                      |
| <sup>3</sup> He | 0.000134(3)           |                         | $\sigma_p = 5.33(1) \times 10^3$<br>0.05(1) mb | R.I. <sub>p</sub> = 2.39(1) $\times 10^3$ | 5.74(7)                | 8.(1) $\mu$ b*                       |
| <sup>4</sup> He | 99.999867(3)          |                         |                                                |                                           | 3.26(3)                |                                      |
| <sup>3</sup> Li |                       |                         | 71.(2)                                         | 32.(1)                                    | - 1.90(2)              |                                      |
| <sup>6</sup> Li | 7.59(4)               |                         | $\sigma_t = 9.4(1) \times 10^2$                | R.I. <sub>t</sub> = 422.(4)               | 2.0(1)                 | $\sigma_t \approx 1$ .               |

\*Extrapolated value.

| Elem. or Isot.   | Natural Abundance (%) | Half-Life              | Thermal Neut. Cross-Section (barns)                                                                          | Resonance Integral (barns)                                                         | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns)             |
|------------------|-----------------------|------------------------|--------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------------|-------------------------------------------|
|                  |                       |                        | 39.(5) mb                                                                                                    | 17.(2) mb                                                                          |                        | 0.06(1) mb*                               |
| <sup>7</sup> Li  | 92.41(4)              |                        | 45.(5) mb                                                                                                    | 20.(2) mb                                                                          | - 2.22(2)              | 42.(3) μb                                 |
| <sup>8</sup> Li  |                       | 0.84 s                 |                                                                                                              |                                                                                    |                        | < ≈ 5.5 μb                                |
| <sup>4</sup> Be  |                       |                        | 8.8(4) mb                                                                                                    | 3.9(2) mb                                                                          | 7.79(1)                |                                           |
| <sup>7</sup> Be  |                       | 53.28 d                | σ <sub>p</sub> = 3.9(1)×10 <sup>4</sup><br>σ <sub>α</sub> ≈ 0.1                                              | RI <sub>p</sub> = 1.75(5)×10 <sup>4</sup>                                          |                        | σ <sub>p</sub> = 16(4)*                   |
| <sup>9</sup> Be  | 100.                  |                        | 8.8(4) mb                                                                                                    | 3.9(2) mb                                                                          | 7.79(1)                |                                           |
| <sup>10</sup> Be |                       | 1.52×10 <sup>6</sup> y | <1. mb                                                                                                       |                                                                                    |                        |                                           |
| <sup>5</sup> B   |                       |                        | 7.6(1)×10 <sup>2</sup>                                                                                       | 3.4(1)×10 <sup>2</sup>                                                             | 5.30(4)                |                                           |
| <sup>10</sup> B  | 19.9(7)               |                        | σ <sub>α</sub> = 38.4(1)×10 <sup>2</sup><br>0.3(1)<br>σ <sub>p</sub> = 7.(1) mb<br>σ <sub>i</sub> = 8.(2) mb | RI <sub>α</sub> = 17.3(1)×10 <sup>2</sup><br>0.13(4)                               | - 0.1(3)               |                                           |
| <sup>11</sup> B  | 80.1(7)               |                        | 5.(3) mb                                                                                                     | 2.(1) mb                                                                           | 6.65(4)                |                                           |
| <sup>6</sup> C   |                       |                        | 3.5(1) mb                                                                                                    | 1.6(1) mb                                                                          | 6.646(1)               |                                           |
| <sup>12</sup> C  | 98.93(8)              |                        | 3.5(1) mb                                                                                                    | 1.6(1) mb                                                                          | 6.651(2)               | 16.(1) μb*                                |
| <sup>13</sup> C  | 1.07(8)               |                        | 1.4(1) mb                                                                                                    | 1.7(2) mb                                                                          | 6.19(9)                | 0.021(4) mb                               |
| <sup>14</sup> C  |                       | 5715. y                | <1.4 μb                                                                                                      |                                                                                    |                        | 3.(1) μb*                                 |
| <sup>7</sup> N   |                       |                        | 2.00(6)                                                                                                      | 0.90(3)                                                                            | 9.36(2)                |                                           |
| <sup>14</sup> N  | 99.636(20)            |                        | σ <sub>p</sub> = 1.93(5)<br>0.080(1)                                                                         | RI <sub>p</sub> = 0.87(3)<br>0.034(1)                                              | 9.37(2)                | σ <sub>p</sub> = 1.8(2) mb*<br>0.04(1) mb |
| <sup>15</sup> N  | 0.364(20)             |                        | 0.04(1) mb                                                                                                   | 0.11(3) mb                                                                         | 6.44(3)                | 6.(1) μb*                                 |
| <sup>8</sup> O   |                       |                        | 0.29(1) mb                                                                                                   | 0.40(4) mb                                                                         | 5.805(4)               |                                           |
| <sup>16</sup> O  | 99.757(16)            |                        | 0.19(1) mb                                                                                                   | 0.36(4) mb                                                                         | 5.805(5)               | 34.(4) μb                                 |
| <sup>17</sup> O  | 0.038(1)              |                        | σ <sub>α</sub> = 0.257(10)<br>0.54(7) mb                                                                     | 0.11(1)<br>0.39(5) mb                                                              | 5.8(2)                 | σ <sub>α</sub> = 3.9(5) mb*               |
| <sup>18</sup> O  | 0.205(14)             |                        | 0.16(1) mb                                                                                                   | 0.81(4) mb                                                                         | 5.84(7)                | 9.(1) μb*                                 |
| <sup>9</sup> F   |                       |                        | 9.5(1) mb                                                                                                    | 21.(3) mb                                                                          | 5.65(1)                | 6.(1) mb                                  |
| <sup>19</sup> F  | 100.                  |                        | 9.5(1) mb                                                                                                    | 21.(3) mb                                                                          | 5.65(1)                | 6.(1) mb                                  |
| <sup>10</sup> Ne |                       |                        | 42.(5) mb                                                                                                    | 19.(3) mb                                                                          | 4.566(6)               |                                           |
| <sup>20</sup> Ne | 90.48(3)              |                        | 39.(5) mb                                                                                                    | 18.(3) mb                                                                          | 4.631(6)               | 0.12(1) mb                                |
| <sup>21</sup> Ne | 0.27(1)               |                        | 0.7(1)<br>σ <sub>α</sub> = 0.18(9) mb                                                                        | 0.31(5)                                                                            | 6.7(2)                 | ≈ 1.5 mb                                  |
| <sup>22</sup> Ne | 9.25(3)               |                        | 51.(5) mb                                                                                                    | 23.(3) mb                                                                          | 3.87(1)                | 58.(4) μb*                                |
| <sup>11</sup> Na |                       |                        | 0.53(2)                                                                                                      | 0.32(2)                                                                            | 3.63(2)                | 2.1(2) mb                                 |
| <sup>22</sup> Na |                       | 2.605 y                | σ <sub>p</sub> = 2.8(3)×10 <sup>4</sup><br>σ <sub>α</sub> = 2.6(4)×10 <sup>2</sup>                           | RI <sub>p</sub> < 2.×10 <sup>5</sup><br>RI <sub>α</sub> = 1.2(2) x 10 <sup>2</sup> |                        |                                           |
| <sup>23</sup> Na | 100.                  |                        | σ <sub>m</sub> = 0.43(3)                                                                                     | RI <sub>m</sub> = 0.30(6)                                                          | 3.63(2)                | 2.1(2) mb                                 |
| <sup>12</sup> Mg |                       |                        | 66.(6) mb                                                                                                    | 38.(5) mb                                                                          | 5.375(4)               |                                           |
| <sup>24</sup> Mg | 78.99(4)              |                        | 0.053(6)                                                                                                     | 32.(4) mb                                                                          | 5.7(2)                 | 3.3(4) mb                                 |
| <sup>25</sup> Mg | 10.00(1)              |                        | 0.20(1)                                                                                                      | 98.(15) mb                                                                         | 3.6(2)                 | 6.4(4) mb                                 |
| <sup>26</sup> Mg | 11.01(3)              |                        | 0.038(1)                                                                                                     | 25.(2) mb                                                                          | 4.9(2)                 | 0.13(1) mb*                               |
| <sup>27</sup> Mg |                       | 9.45 m                 | 0.07(2)                                                                                                      | 0.03(1)                                                                            |                        |                                           |
| <sup>13</sup> Al |                       |                        | 0.230(2)                                                                                                     | 0.17(1)                                                                            | 3.45(1)                |                                           |
| <sup>26</sup> Al |                       | 7.1×10 <sup>5</sup> y  | σ <sub>p</sub> = 1.97(10)<br>σ <sub>α</sub> = 0.34(1)                                                        |                                                                                    |                        | 0.14(2)                                   |
| <sup>27</sup> Al | 100.                  |                        | 0.230(2)                                                                                                     | 0.17(1)                                                                            | 3.45(1)                | 2.9(3) mb                                 |
| <sup>14</sup> Si |                       |                        | 0.166(9)                                                                                                     | 0.12(2)                                                                            | 4.15(1)                |                                           |
| <sup>28</sup> Si | 92.223(19)            |                        | 0.17(1)                                                                                                      | 0.11(2)                                                                            | 4.11(1)                | 2.9(3) mb                                 |
| <sup>29</sup> Si | 4.685(8)              |                        | 0.12(1)                                                                                                      | 0.08(2)                                                                            | 4.7(1)                 | 7.9(9) mb                                 |
| <sup>30</sup> Si | 3.092(11)             |                        | 0.107(3)                                                                                                     | 0.62(6)                                                                            | 4.61(1)                | 3.2(3) mb*                                |
| <sup>31</sup> Si |                       | 2.62 h                 | 73.(6) mb                                                                                                    | 33.(3) mb                                                                          |                        |                                           |
| <sup>32</sup> Si |                       | 1.6×10 <sup>2</sup> y  | < 0.5                                                                                                        |                                                                                    |                        |                                           |
| <sup>15</sup> P  |                       |                        | 0.17(1)                                                                                                      | 0.08(1)                                                                            | 5.13(1)                |                                           |
| <sup>31</sup> P  | 100.                  |                        | 0.17(1)                                                                                                      | 0.08(1)                                                                            | 5.13(1)                | 1.7(1) mb                                 |
| <sup>16</sup> S  |                       |                        | 0.54(2)                                                                                                      | 0.24(2)                                                                            | 2.847(1)               |                                           |
| <sup>32</sup> S  | 94.93(31)             |                        | 0.55(5)<br>σ <sub>α</sub> < 0.5 mb                                                                           | 0.25(2)                                                                            | 2.804(2)               | 4.1(2) mb                                 |

\*Extrapolated value.

| Elem. or Isot.   | Natural Abundance (%) | Half-Life              | Thermal Neut. Cross-Section (barns)                                                                                               | Resonance Integral (barns)           | Coh. Scat. Length (fm) | $\sigma$ (30 keV) Maxw. Avg. (barns)                                    |
|------------------|-----------------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|------------------------|-------------------------------------------------------------------------|
| <sup>33</sup> S  | 0.76(2)               |                        | 0.46(3)<br>$\sigma_{\alpha} = 0.12(1)$<br>$\sigma_p = 2. \text{ mb}$                                                              | 0.21(2)<br>$RI_{\alpha} = 0.05(1)$   | 4.7(2)                 | 7.4(15) mb<br>$\sigma_{\alpha} = 0.18(1)$                               |
| <sup>34</sup> S  | 4.29(28)              |                        | 0.25(1)                                                                                                                           | 0.13                                 | 3.48(3)                | 0.23(1) mb                                                              |
| <sup>36</sup> S  | 0.02(1)               |                        | 0.24(2)                                                                                                                           | 0.26(3)                              |                        | 0.17(1) mb*                                                             |
| <sup>17</sup> Cl |                       |                        | 33.6(3)                                                                                                                           | 15.(2)                               | 9.58(1)                |                                                                         |
| <sup>35</sup> Cl | 75.78(4)              |                        | 43.7(4)<br>$\sigma_p = 0.44(1)$<br>$\sigma_{\alpha} \approx 0.08 \text{ mb}$                                                      | 20.(2)<br>$RI_p = 0.2$               | 11.7(1)                | 9.4(3) mb<br>$\sigma_p = 1.7(2) \text{ mb}^*$                           |
| <sup>36</sup> Cl |                       | 3.01×10 <sup>5</sup> y | $\sigma_p = 46.(2) \text{ mb}$<br><10.<br>$\sigma_{\alpha} = 0.59(7) \text{ mb}$<br>(0.05 + 0.38)                                 | $RI_p = 0.02$                        |                        | $\sigma_p = 91.(8) \text{ mb}$<br>$\sigma_{\alpha} = 0.9(2) \text{ mb}$ |
| <sup>37</sup> Cl | 24.22(4)              |                        |                                                                                                                                   | (0.04+0.26)                          | 3.1(1)                 | 2.0(2) mb                                                               |
| <sup>18</sup> Ar |                       |                        | 0.66(3)                                                                                                                           | 0.42(5)                              | 1.91(1)                |                                                                         |
| <sup>36</sup> Ar | 0.3365(30)            |                        | 5.(1)<br>$\sigma_{\alpha} = 5.4(3) \text{ mb}$<br>$\sigma_p < 1.5 \text{ mb}$                                                     | 2.(1)                                | 24.9(1)                |                                                                         |
| <sup>37</sup> Ar |                       | 35.0 d                 | $\sigma_{\alpha} = 1.08(8) \times 10^3$<br>$\sigma_p = 37.(4)$                                                                    | $RI_{\alpha} = 900.$<br>$RI_p = 31.$ |                        | $\sigma_{\alpha} \approx 1.3$<br>$\sigma_p \approx 0.04$                |
| <sup>38</sup> Ar | 0.0632(5)             |                        | 0.8(2)                                                                                                                            | 0.4(1)                               | 3.5(35)                |                                                                         |
| <sup>39</sup> Ar |                       | 268. y                 | 6.(2)×10 <sup>2</sup><br>$\sigma_{\alpha} < 0.29$                                                                                 |                                      |                        |                                                                         |
| <sup>40</sup> Ar | 99.6003(30)           |                        | 0.64(3)                                                                                                                           | 0.41(5)                              | 1.83(1)                | 2.5(3) mb                                                               |
| <sup>41</sup> Ar |                       | 1.82 h                 | 0.5(1)                                                                                                                            | 0.2(1)                               |                        |                                                                         |
| <sup>19</sup> K  |                       |                        | 2.1(1)                                                                                                                            | 1.0(1)                               | 3.67(2)                |                                                                         |
| <sup>39</sup> K  | 93.2581(44)           |                        | 2.1(2)<br>$\sigma_{\alpha} = 4.3(5) \text{ mb}$<br>$\sigma_p < 0.05 \text{ mb}$                                                   | 0.9(1)                               | 3.74(2)                | 11.8(4) mb                                                              |
| <sup>40</sup> K  | 0.0117(1)             | 1.26×10 <sup>9</sup> y | 30.(8)<br>$\sigma_p = 4.4(4)$<br>$\sigma_{\alpha} = 0.42(8)$                                                                      | 13.(4)<br>2.0(2)                     |                        | $\sigma_p = 7.(1) \text{ mb}$<br>$\sigma_{\alpha} = 40.(6) \text{ mb}$  |
| <sup>41</sup> K  | 6.7302(44)            |                        | 1.46(3)                                                                                                                           | 1.4(2)                               | 2.69(8)                | 22.(1) mb                                                               |
| <sup>20</sup> Ca |                       |                        | 0.43(2)                                                                                                                           | 0.23(2)                              | 4.70(2)                |                                                                         |
| <sup>40</sup> Ca | 96.941(156)           |                        | 0.41(3)<br>$\sigma_{\alpha} = 0.13(4) \text{ mb}$<br>$\approx 4.$<br>$\sigma_{\alpha} = 0.18(3)$<br>$\sigma_p = 7.(2) \text{ mb}$ | 0.22(4)                              | 4.80(2)                | 6.7(7) mb                                                               |
| <sup>41</sup> Ca |                       | 1.02×10 <sup>5</sup> y |                                                                                                                                   |                                      |                        |                                                                         |
| <sup>42</sup> Ca | 0.647(23)             |                        | 0.65(10)                                                                                                                          | 0.39(4)                              | 3.4(1)                 | 16.(2) mb                                                               |
| <sup>43</sup> Ca | 0.135(10)             |                        | 6.(1)                                                                                                                             | 3.9(2)                               | - 1.56(9)              | 51.(6) mb                                                               |
| <sup>44</sup> Ca | 2.086(110)            |                        | 0.8(2)                                                                                                                            | 0.56(1)                              | 1.42(6)                | 9.(1) mb                                                                |
| <sup>45</sup> Ca |                       | 162.7 d                | $\approx 15.$                                                                                                                     |                                      |                        |                                                                         |
| <sup>46</sup> Ca | 0.004(3)              | >4×10 <sup>15</sup> y  | 0.70(3)                                                                                                                           | 0.9(1)                               | 3.6(2)                 | 5.3(5) mb*                                                              |
| <sup>48</sup> Ca | 0.187(21)             | 4.3×10 <sup>19</sup> y | 1.0(1)                                                                                                                            | 0.5(1)                               | 0.39(9)                | 0.8(1) mb*                                                              |
| <sup>21</sup> Sc |                       |                        | 27.2(2)                                                                                                                           | 12.(1)                               | 12.3(1)                |                                                                         |
| <sup>45</sup> Sc | 100.                  |                        | (10.+17.)                                                                                                                         | (5.6+6.4)                            | 12.3(1)                | 69.(5) mb                                                               |
| <sup>46</sup> Sc |                       | 83.81 d                | 8.(1)                                                                                                                             | 3.6(5)                               |                        |                                                                         |
| <sup>22</sup> Ti |                       |                        | 6.1(1)                                                                                                                            | 2.8(2)                               | - 3.438(2)             |                                                                         |
| <sup>44</sup> Ti |                       | 60 y                   | 1.1(2)<br>$\sigma_p < 0.2$                                                                                                        |                                      |                        |                                                                         |
| <sup>46</sup> Ti | 8.25(3)               |                        | 0.6(2)                                                                                                                            | 0.4(1)                               | 4.93(6)                | 27.(3) mb                                                               |
| <sup>47</sup> Ti | 7.44(2)               |                        | 1.6(2)                                                                                                                            | 1.6(2)                               | 3.63(1)                | 64.(8) mb                                                               |
| <sup>48</sup> Ti | 73.72(3)              |                        | 7.9(9)                                                                                                                            | 3.6(2)                               | - 6.09(2)              | 32.(5) mb                                                               |
| <sup>49</sup> Ti | 5.41(2)               |                        | 1.9(5)                                                                                                                            | 1.2(2)                               | 1.04(5)                | 22.(2) mb                                                               |
| <sup>50</sup> Ti | 5.18(2)               |                        | 0.179(3)                                                                                                                          | 0.12(2)                              | 6.18(8)                | 3.6(4) mb                                                               |
| <sup>23</sup> V  |                       |                        | 5.0(2)                                                                                                                            | 2.8(1)                               | - 0.382(1)             |                                                                         |
| <sup>50</sup> V  | 0.250(4)              | 1.4×10 <sup>17</sup> y | 21.(4)<br>$\sigma_p = 0.7(4) \text{ mb}$                                                                                          | 50.(20)                              | 7.6(6)                 |                                                                         |

\*Extrapolated value.

| Elem. or Isot.    | Natural Abundance (%) | Half-Life               | Thermal Neut. Cross-Section (barns) | Resonance Integral (barns)                 | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|-------------------|-----------------------|-------------------------|-------------------------------------|--------------------------------------------|------------------------|-------------------------------|
| <sup>51</sup> V   | 99.750(4)             |                         | 4.9(1)                              | 2.7(2)                                     | - 0.402(2)             | 38.(4) mb                     |
| <sup>24</sup> Cr  |                       |                         | 3.0(2)                              | 1.7(1)                                     | 3.635(7)               |                               |
| <sup>50</sup> Cr  | 4.345(13)             | >1.8×10 <sup>17</sup> y | 15.(1)                              | 8.(1)                                      | - 4.5(1)               | 0.05(1)                       |
| <sup>51</sup> Cr  |                       | 27.70 d                 | < 10.                               |                                            |                        |                               |
| <sup>52</sup> Cr  | 83.789(18)            |                         | 0.8(1)                              | 0.6(2)                                     | 4.91(2)                | 8.8(4) mb                     |
| <sup>53</sup> Cr  | 9.501(17)             |                         | 18.(2)                              | 9.(1)                                      | - 4.2(1)               | 0.06(1)                       |
| <sup>54</sup> Cr  | 2.365(7)              |                         | 0.36(4)                             | 0.25(5)                                    | 4.6(1)                 | 7.(2) mb                      |
| <sup>25</sup> Mn  |                       |                         | 13.3(1)                             | 14.0(3)                                    | - 3.75(2)              |                               |
| <sup>53</sup> Mn  |                       | 3.7×10 <sup>6</sup> y   | 70.(10)                             | 32.(5)                                     |                        |                               |
| <sup>54</sup> Mn  |                       | 312.1 d                 | < 10.                               |                                            |                        |                               |
| <sup>55</sup> Mn  | 100.                  |                         | 13.3(1)                             | 14.0(3)                                    | - 3.75(2)              | 40.(3) mb                     |
| <sup>26</sup> Fe  |                       |                         | 2.7(1)                              | 1.4(2)                                     | 9.45(2)                |                               |
| <sup>54</sup> Fe  | 5.845(35)             |                         | 2.3(2)                              | 1.3(2)                                     | 4.2(1)                 | 29.(2) mb                     |
|                   |                       |                         | σ <sub>α</sub> = 10. μb             | RI <sub>α</sub> = 1.1(1) mb                |                        |                               |
| <sup>55</sup> Fe  |                       | 2.73 y                  | 13.(2)                              | 6.(1)                                      |                        |                               |
|                   |                       |                         | σ <sub>α</sub> = 0.01               |                                            |                        |                               |
| <sup>56</sup> Fe  | 91.754(36)            |                         | 2.8(3)                              | 1.4(2)                                     | 9.93(3)                | 11.7(5) mb                    |
| <sup>57</sup> Fe  | 2.119(10)             |                         | 1.4(2)                              | 0.8(4)                                     | 2.3(1)                 | 40.(4) mb                     |
| <sup>58</sup> Fe  | 0.282(4)              |                         | 1.3(1)                              | 1.3(2)                                     | 15.(7)                 | 12.(1) mb                     |
| <sup>59</sup> Fe  |                       | 44.51 d                 | 13.(3)                              | 6.(1)                                      |                        |                               |
| <sup>27</sup> Co  |                       |                         | 37.19(8)                            | 74.(2)                                     | 2.49(2)                |                               |
| <sup>58m</sup> Co |                       | 9.1 h                   | 1.4(1)×10 <sup>5</sup>              | 2.5(10)×10 <sup>5</sup>                    |                        |                               |
| <sup>58</sup> Co  |                       | 70.88 d                 | 1.9(2)×10 <sup>3</sup>              | 7.(1)×10 <sup>3</sup>                      |                        |                               |
| <sup>59</sup> Co  | 100.                  |                         | (20.7+16.5)                         | (39.+35.)                                  | 2.49(2)                | 38.(4) mb                     |
| <sup>60m</sup> Co |                       | 10.47 m                 | 58.(3)                              | 230.(50)                                   |                        |                               |
| <sup>60</sup> Co  |                       | 5.271 y                 | 2.0(2)                              | 4.3(10)                                    |                        |                               |
| <sup>28</sup> Ni  |                       |                         | 4.5(2)                              | 2.3(2)                                     | 10.3(1)                |                               |
| <sup>58</sup> Ni  | 68.0769(89)           | >4×10 <sup>19</sup> y   | 4.6(4)                              | 2.3(2)                                     | 14.4(1)                | 41.(2) mb                     |
|                   |                       |                         | σ <sub>α</sub> < 0.03 mb            |                                            |                        |                               |
| <sup>59</sup> Ni  |                       | ≈ 7.6×10 <sup>4</sup> y | σ <sub>abs</sub> = 92.(4)           | RI <sub>abs</sub> = 1.4(1)×10 <sup>2</sup> |                        |                               |
|                   |                       |                         | σ <sub>α</sub> = 14.(2)             |                                            |                        |                               |
|                   |                       |                         | σ <sub>p</sub> = 2.(1)              |                                            |                        |                               |
| <sup>60</sup> Ni  | 26.2231(77)           |                         | 2.9(3)                              | 1.5(2)                                     | 2.8(1)                 | 25.(1) mb                     |
| <sup>61</sup> Ni  | 1.1399(6)             |                         | 2.5(5)                              | 1.5(4)                                     | 7.60(6)                | 82.(8) mb                     |
|                   |                       |                         | σ <sub>α</sub> = 0.03 mb            |                                            |                        |                               |
| <sup>62</sup> Ni  | 3.6345(17)            |                         | 15.(1)                              | 6.8(3)                                     | - 8.7(2)               | 13.(4) mb                     |
| <sup>63</sup> Ni  |                       | 100. y                  | 20.(5)                              | 9.(2)                                      |                        |                               |
| <sup>64</sup> Ni  | 0.9256(9)             |                         | 1.6(1)                              | 1.2(2)                                     | - 0.37(7)              | 9.(1) mb                      |
| <sup>65</sup> Ni  |                       | 2.517 h                 | 22.(2)                              | 10.(1)                                     |                        |                               |
| <sup>29</sup> Cu  |                       |                         | 3.8(1)                              | 4.1(4)                                     | 7.718(4)               |                               |
| <sup>63</sup> Cu  | 69.15(15)             |                         | 4.5(2)                              | 5.(1)                                      | 6.43(15)               | 0.09(1)                       |
| <sup>64</sup> Cu  |                       | 12.701 h                | ≈ 270.                              |                                            |                        |                               |
| <sup>65</sup> Cu  | 30.85(15)             |                         | 2.17(3)                             | 2.2(1)                                     | 10.61(19)              | 41.(5) mb                     |
| <sup>66</sup> Cu  |                       | 5.09 m                  | 1.4(1)×10 <sup>2</sup>              | 60.(20)                                    |                        |                               |
| <sup>30</sup> Zn  |                       |                         | 1.1(2)                              | 2.8(4)                                     | 5.680(5)               |                               |
| <sup>64</sup> Zn  | 48.27(32)             | >2.3×10 <sup>18</sup> y | 0.74(5)                             | 1.4(3)                                     | 5.23(4)                | 59.(5) mb                     |
|                   |                       |                         | σ <sub>p</sub> < 12. μb             |                                            |                        |                               |
|                   |                       |                         | σ <sub>α</sub> = 11.(3) μb          |                                            |                        |                               |
| <sup>65</sup> Zn  |                       | 243.8 d                 | 66.(8)                              | 30.(4)                                     |                        |                               |
|                   |                       |                         | σ <sub>α</sub> = 2.0(2)             |                                            |                        |                               |
| <sup>66</sup> Zn  | 27.977(77)            |                         | 0.9(3)                              | 1.8(2)                                     | 5.98(5)                | 35.(3) mb                     |
|                   |                       |                         | σ <sub>α</sub> < 0.02 mb            |                                            |                        |                               |
| <sup>67</sup> Zn  | 4.102(21)             |                         | 6.9(1.4)                            | 25.(5)                                     | 7.58(8)                | 0.15(2)                       |
|                   |                       |                         | σ <sub>α</sub> = 0.4 mb             |                                            |                        |                               |
| <sup>68</sup> Zn  | 19.02(12)             |                         | (0.072 + 0.8)                       | (0.2 + 2.9)                                | 6.04(3)                | 19.(2) mb                     |
|                   |                       |                         | σ <sub>α</sub> <0.02 mb             |                                            |                        | σ <sub>m</sub> = 3.(1) mb     |
| <sup>70</sup> Zn  | 0.631(9)              |                         | (8.1+83.) mb                        | 0.9(2)                                     |                        | 0.02(1)                       |
| <sup>31</sup> Ga  |                       |                         | 2.9(1)                              | 22.(3)                                     | 7.288(2)               |                               |

\*Extrapolated value.

| Elem. or Isot.   | Natural Abundance (%) | Half-Life                                                          | Thermal Neut. Cross-Section (barns) | Resonance Integral (barns) | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns)                                      |                                                |  |  |
|------------------|-----------------------|--------------------------------------------------------------------|-------------------------------------|----------------------------|------------------------|--------------------------------------------------------------------|------------------------------------------------|--|--|
| <sup>69</sup> Ga | 60.108(9)             | >2.4×10 <sup>26</sup> y                                            | 1.68(7)                             | 16.(2)                     | 7.88(4)                | 0.14(1)                                                            |                                                |  |  |
| <sup>71</sup> Ga | 39.892(9)             |                                                                    | 4.7(2)                              | 31.(3)                     | 6.40(3)                | 0.12(1)                                                            |                                                |  |  |
|                  |                       |                                                                    | σ <sub>m</sub> = 0.15(5)            |                            |                        |                                                                    |                                                |  |  |
| <sup>32</sup> Ge | 20.370(89)            | 270.8 d                                                            | 2.2(1)                              | 6.(2)                      | 8.19(2)                | 88.(5) mb                                                          |                                                |  |  |
| <sup>68</sup> Ge |                       |                                                                    | 1.0(5)                              |                            |                        |                                                                    |                                                |  |  |
| <sup>70</sup> Ge |                       |                                                                    | (0.3 + 2.7)                         | 2.3(1)                     | 10.0(1)                |                                                                    |                                                |  |  |
| <sup>72</sup> Ge | 27.380(60)            | >1.8×10 <sup>23</sup> y                                            | 0.9(2)                              | 0.8(3)                     | 8.5(1)                 | 0.07(2)                                                            |                                                |  |  |
| <sup>73</sup> Ge | 7.759(78)             |                                                                    | 15.(1)                              | 66.(20)                    | 5.02(4)                | 0.3(1)                                                             |                                                |  |  |
| <sup>74</sup> Ge | 36.656(80)            |                                                                    | (0.14 + 0.28)                       | (0.4+0.5)                  | 7.6(1)                 | 53.(7) mb                                                          |                                                |  |  |
| <sup>76</sup> Ge | 7.835(81)             | 1.6×10 <sup>21</sup> y                                             | (0.09 + 0.06)                       | (1.3+0.6)                  | 8.2(15)                | 0.03(2)                                                            |                                                |  |  |
| <sup>33</sup> As | 100.                  |                                                                    | 4.0(4)                              | 61.(5)                     | 6.58(1)                | 0.57(4)                                                            |                                                |  |  |
| <sup>75</sup> As |                       |                                                                    | 4.0(4)                              | 61.(5)                     | 6.58(1)                |                                                                    |                                                |  |  |
| <sup>34</sup> Se |                       |                                                                    | 12.(1)                              | 14.(3)                     | 7.970(9)               |                                                                    |                                                |  |  |
| <sup>74</sup> Se | 0.89(4)               | 119.78 d                                                           | 50.(2)                              | 520(50)                    | 0.8(3)                 | 0.2(1)                                                             |                                                |  |  |
| <sup>75</sup> Se |                       |                                                                    | 3.3(10)×10 <sup>2</sup>             |                            |                        |                                                                    |                                                |  |  |
| <sup>76</sup> Se | 9.37(29)              |                                                                    | (22. + 63.)                         | (9.+31.)                   | 12.2(1)                | 0.16(1)                                                            |                                                |  |  |
| <sup>77</sup> Se | 7.63(16)              | ≈ 1×10 <sup>20</sup> y                                             | 42.(4)                              | 30.(5)                     | 8.25(8)                | 0.3(1)                                                             |                                                |  |  |
|                  |                       |                                                                    | σ <sub>α</sub> = 0.97(3) μb         |                            |                        |                                                                    |                                                |  |  |
| <sup>78</sup> Se | 23.77(28)             |                                                                    | σ <sub>m</sub> = 0.38(2)            | RI <sub>m</sub> = 4.3(4)   | 8.24(9)                | 0.1                                                                |                                                |  |  |
| <sup>80</sup> Se | 49.61(41)             | ≈ 1×10 <sup>20</sup> y                                             | (0.05+0.54)                         | (0.15+0.85)                | 7.48(3)                | 42.(3) mb                                                          |                                                |  |  |
| <sup>82</sup> Se | 8.73(22)              |                                                                    | (39.+ 5.2) mb                       | 39.(4) mb                  | 6.34(8)                | 0.04(2)                                                            |                                                |  |  |
| <sup>35</sup> Br | 50.69(7)              |                                                                    | 16.0 h                              | 6.8(2)                     | 92.(8)                 | 6.79(2)                                                            | 0.63(4)<br>σ <sub>m</sub> = 0.08(1)<br>0.31(2) |  |  |
| <sup>76</sup> Br |                       | 224.(42)                                                           |                                     |                            |                        |                                                                    |                                                |  |  |
| <sup>79</sup> Br |                       | (2.5+8.3)                                                          |                                     | (36.+96.)                  | 6.79(7)                |                                                                    |                                                |  |  |
| <sup>81</sup> Br | 49.31(7)              |                                                                    | (2.4+0.24)                          | 51.(5)                     | 6.78(7)                |                                                                    |                                                |  |  |
| <sup>36</sup> Kr | 0.353(3)              | >2.3×10 <sup>20</sup> y                                            | 24.(1)                              | 39.(6)                     | 7.81(2)                | (0.11+0.19)<br>(0.09+0.18)<br>90.(6) mb<br>0.24(2)<br>(16.+33.) mb |                                                |  |  |
| <sup>78</sup> Kr |                       |                                                                    | (0.17+6.)                           | 20.(1)                     |                        |                                                                    |                                                |  |  |
| <sup>80</sup> Kr |                       |                                                                    | (4.6+7.)                            | 57.(6)                     |                        |                                                                    |                                                |  |  |
| <sup>82</sup> Kr | 11.593(3)             | (14.+7.)                                                           | 130.(13)                            |                            |                        |                                                                    |                                                |  |  |
| <sup>83</sup> Kr | 11.500(19)            | 183.(30)                                                           | 183.(20)                            |                            |                        |                                                                    |                                                |  |  |
| <sup>84</sup> Kr | 56.987(15)            | (σ <sub>m</sub> + σ <sub>g</sub> ) = 0.11<br>σ <sub>m</sub> = 0.09 | 2.4(3)                              |                            |                        |                                                                    |                                                |  |  |
| <sup>85</sup> Kr | 17.279(41)            | 10.73 y                                                            | 1.7(2)                              | 1.8(10)                    | 0.07(2)                |                                                                    |                                                |  |  |
| <sup>86</sup> Kr |                       |                                                                    | 3.(2) mb                            | ≈ 1. mb                    | 8.1(3)                 | 3.2(4) mb                                                          |                                                |  |  |
| <sup>37</sup> Rb | 72.17(2)              | 32.9 d                                                             | 0.39(4)                             | 6.(3)                      | 7.08(2)                | 0.24(1)                                                            |                                                |  |  |
| <sup>84</sup> Rb |                       | 18.65 d                                                            | σ <sub>p</sub> = 12.(2)             |                            |                        |                                                                    |                                                |  |  |
| <sup>85</sup> Rb |                       |                                                                    | (0.06+0.38)                         | (0.7+7.)                   | 7.0(1)                 |                                                                    |                                                |  |  |
| <sup>86</sup> Rb | 27.83(2)              | 4.88×10 <sup>10</sup> y                                            | <20.                                |                            |                        | 16.(1) mb                                                          |                                                |  |  |
| <sup>87</sup> Rb |                       | 17.7 m                                                             | 0.10(1)                             | 2.3(4)                     | 7.3(1)                 |                                                                    |                                                |  |  |
| <sup>88</sup> Rb |                       |                                                                    | 1.2(3)                              | 0.5(1)                     |                        |                                                                    |                                                |  |  |
| <sup>38</sup> Sr | 0.56(1)               | 50.52 d                                                            | 1.2(1)                              | 10.(1)                     | 7.02(2)                | 0.4(1)<br>(48.+22.) mb                                             |                                                |  |  |
| <sup>84</sup> Sr |                       |                                                                    | (0.6+0.2)                           | (9.+1.)                    |                        |                                                                    |                                                |  |  |
| <sup>86</sup> Sr |                       |                                                                    | σ <sub>m</sub> = 0.81(4)            | RI <sub>m</sub> = 4.(1)    | 5.68(5)                |                                                                    |                                                |  |  |
| <sup>87</sup> Sr | 7.00(1)               | 29.1 y                                                             | 16.(3)                              | 118.(30)                   | 7.41(7)                | 97.(5) mb                                                          |                                                |  |  |
| <sup>88</sup> Sr | 82.58(1)              |                                                                    | 5.8(4) mb                           | 0.07(3)                    | 7.16(6)                | 6.0(2) mb                                                          |                                                |  |  |
| <sup>89</sup> Sr |                       |                                                                    | 0.42(4)                             | 0.2                        |                        |                                                                    |                                                |  |  |
| <sup>90</sup> Sr |                       | 29.1 y                                                             | 10.(1) mb                           | 0.10(2)                    |                        |                                                                    |                                                |  |  |
| <sup>39</sup> Y  | 100.                  | 58.5 d                                                             | 1.25(5)                             | 1.0(1)                     | 7.75(2)                | 19.(1) mb                                                          |                                                |  |  |
| <sup>89</sup> Y  |                       |                                                                    | (0.001+1.25)                        | (0.006+1.0)                | 7.75(2)                |                                                                    |                                                |  |  |
| <sup>90</sup> Y  |                       |                                                                    | <6.5                                |                            |                        |                                                                    |                                                |  |  |
| <sup>91</sup> Y  |                       |                                                                    | 1.4(3)                              | 0.6(1)                     |                        |                                                                    |                                                |  |  |
| <sup>40</sup> Zr | 51.45(40)             | 1.5×10 <sup>6</sup> y                                              | 0.19(1)                             | 0.95(9)                    | 7.16(3)                | 21.(2) mb                                                          |                                                |  |  |
|                  |                       |                                                                    | σ <sub>α</sub> <0.1 mb              |                            |                        |                                                                    |                                                |  |  |
| <sup>90</sup> Zr |                       |                                                                    | ≈ 0.014                             | 0.2(1)                     | 6.4(1)                 |                                                                    |                                                |  |  |
| <sup>91</sup> Zr | 11.22(5)              |                                                                    | 1.2(3)                              | 5.(2)                      | 8.8(1)                 | 60.(8) mb                                                          |                                                |  |  |
| <sup>92</sup> Zr | 17.15(8)              |                                                                    | 0.2(1)                              | 0.6(2)                     | 7.5(2)                 | 33.(4) mb                                                          |                                                |  |  |
| <sup>93</sup> Zr |                       |                                                                    | <4.                                 | 16.(5)                     |                        |                                                                    |                                                |  |  |

\*Extrapolated value.

| Elem. or Isot.     | Natural Abundance (%) | Half-Life               | Thermal Neut. Cross-Section (barns)                                  | Resonance Integral (barns) | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|--------------------|-----------------------|-------------------------|----------------------------------------------------------------------|----------------------------|------------------------|-------------------------------|
| <sup>94</sup> Zr   | 17.38(28)             | >10 <sup>17</sup> y     | 0.049(6)                                                             | 0.25(3)                    | 8.3(2)                 | 26.(1) mb                     |
| <sup>96</sup> Zr   | 2.80(9)               | >1.7×10 <sup>18</sup> y | 0.020(3)                                                             | 5.0(5)                     | 5.5(1)                 | 11.(1) mb                     |
| <sup>41</sup> Nb   |                       |                         | 1.11(1)                                                              | 8.5(6)                     | 7.14(3)                |                               |
| <sup>93</sup> Nb   | 100.                  |                         | σ <sub>α</sub> <0.1 mb<br>1.1                                        | (6.3+2.2)                  | 7.14(3)                | 266.(5) mb                    |
| <sup>94</sup> Nb   |                       | 2.4×10 <sup>4</sup> y   | σ <sub>m</sub> = 0.86<br>(σ <sub>m</sub> + σ <sub>g</sub> ) = 15.(1) | 126.(13)                   |                        |                               |
| <sup>95</sup> Nb   |                       | 34.97 d                 | σ <sub>m</sub> = 0.6(1)<br><7.                                       | <200.                      |                        |                               |
| <sup>42</sup> Mo   |                       |                         | 2.5(1)                                                               | 26.(5)                     | 6.72(2)                |                               |
| <sup>92</sup> Mo   | 14.77(31)             | >3×10 <sup>17</sup> y   | σ <sub>α</sub> <0.1 mb<br>0.06                                       | ≈ 0.8                      | 6.93(8)                | 0.07(1)                       |
| <sup>94</sup> Mo   | 9.226(99)             |                         | σ <sub>m</sub> = 0.2 μb<br>0.02                                      | ≈ 0.8                      | 6.82(7)                | 0.10(2)                       |
| <sup>95</sup> Mo   | 15.900(85)            |                         | 13.4(3)                                                              | 109.(5)                    | 6.93(6)                | 0.29(1)                       |
| <sup>96</sup> Mo   | 16.674(12)            |                         | σ <sub>α</sub> = 30.(4) μb<br>0.5                                    | 17.(3)                     | 6.22(6)                | 0.11(1)                       |
| <sup>97</sup> Mo   | 9.560(50)             |                         | 2.5(2)                                                               | 14.(3)                     | 7.26(8)                | 0.34(1)                       |
| <sup>98</sup> Mo   | 24.20(25)             |                         | σ <sub>α</sub> = 0.4(2) μb<br>0.14(1)                                | 7.2(7)                     | 6.60(7)                | 0.10(1)                       |
| <sup>100</sup> Mo  | 9.67(20)              | ≈ 1×10 <sup>19</sup> y  | 0.19(1)                                                              | 3.6(3)                     | 6.75(7)                | 0.11(1)                       |
| <sup>43</sup> Tc   |                       |                         |                                                                      |                            |                        |                               |
| <sup>98</sup> Tc   |                       | ≈ 6.6×10 <sup>6</sup> y | σ <sub>m</sub> = 0.9(2)                                              |                            |                        |                               |
| <sup>99</sup> Tc   |                       | 2.13×10 <sup>5</sup> y  | 23.(2)                                                               | 4.0(4)×10 <sup>2</sup>     | 6.8(3)                 | 0.93(5)                       |
| <sup>44</sup> Ru   |                       |                         | 2.6 (1)                                                              | 48.(5)                     | 7.03(3)                |                               |
| <sup>96</sup> Ru   | 5.54(14)              | >3.1×10 <sup>16</sup> y | 0.23(4)                                                              | 7.(2)                      |                        | 0.21(1)                       |
| <sup>98</sup> Ru   | 1.87(3)               |                         | < 8.                                                                 |                            |                        | 0.3(1)                        |
| <sup>99</sup> Ru   | 12.76(14)             |                         | 4.(1)                                                                | 195.(20)                   |                        | 1.2(3)                        |
| <sup>100</sup> Ru  | 12.60(7)              |                         | 5.8(6)                                                               | 11.(2)                     |                        | 0.21(1)                       |
| <sup>101</sup> Ru  | 17.06(2)              |                         | 5.(1)                                                                | 1.1(3)×10 <sup>2</sup>     |                        | 1.00(4)                       |
| <sup>102</sup> Ru  | 31.55(14)             |                         | σ <sub>α</sub> <0.15 μb<br>1.2(1)                                    | 4.3(5)                     |                        | 0.15(1)                       |
| <sup>103</sup> Ru  |                       | 39.27 d                 | <20.                                                                 | ≈ 30.                      |                        |                               |
| <sup>104</sup> Ru  | 18.62(27)             |                         | 0.49(2)                                                              | 6.(2)                      |                        | 0.15(1)                       |
| <sup>105</sup> Ru  |                       | 4.44 h                  | 0.29(3)                                                              | 0.13(1)                    |                        |                               |
| <sup>106</sup> Ru  |                       | 1.020 y                 | 0.15(4)                                                              | 2.0(6)                     |                        |                               |
| <sup>45</sup> Rh   |                       |                         | 145.(2)                                                              | 1.2(1)×10 <sup>3</sup>     | 5.88(4)                |                               |
| <sup>103</sup> Rh  | 100.                  |                         | (11.+ 134.)                                                          | (0.08+1.1)×10 <sup>3</sup> | 5.88(4)                | 0.81(1)                       |
| <sup>104m</sup> Rh |                       | 4.36 m                  | 800.(100)                                                            |                            |                        |                               |
| <sup>104</sup> Rh  |                       | 42.3 s                  | 40.(30)                                                              |                            |                        |                               |
| <sup>105</sup> Rh  |                       | 35.4 h                  | 1.1(3)×10 <sup>4</sup>                                               | 1.7(4)×10 <sup>4</sup>     |                        |                               |
| <sup>46</sup> Pd   |                       |                         | 7.(1)                                                                | 82.(8)                     | 5.91(6)                |                               |
| <sup>102</sup> Pd  | 1.02(1)               |                         | 3.2(10)                                                              | 10.(2)                     |                        | 0.3(1)                        |
| <sup>104</sup> Pd  | 11.14(8)              |                         |                                                                      | 16.(2)                     |                        | 0.29(3)                       |
| <sup>105</sup> Pd  | 22.33(8)              |                         | 22.(2)                                                               | 60.(20)                    | 5.5(3)                 | 1.20(6)                       |
| <sup>106</sup> Pd  | 27.33(3)              |                         | σ <sub>α</sub> = 0.5(2) μb<br>(0.013+0.28)                           | (0.2+5.5)                  | 6.4(4)                 | 0.25(3)                       |
| <sup>107</sup> Pd  |                       | 6.5×10 <sup>6</sup> y   | 1.8(2)                                                               | 108.(4)                    |                        | 1.34(6)                       |
| <sup>108</sup> Pd  | 26.46(9)              |                         | (0.19+8.5)                                                           | (2.+240.)                  | 4.1(3)                 | 0.20(2)                       |
| <sup>110</sup> Pd  | 11.72(9)              |                         | (0.033+0.7)                                                          | (0.7+8.)                   |                        | 0.15(2)                       |
| <sup>47</sup> Ag   |                       |                         | 62.(1)                                                               | 767.(60)                   | 5.922(7)               |                               |
| <sup>107</sup> Ag  | 51.839(8)             |                         | (1.+35.)                                                             | (3.+105.)                  | 7.56(1)                | 0.80(3)                       |
| <sup>109</sup> Ag  | 48.161(8)             |                         | (4.1 + 87.)                                                          | (0.7+14.1)×10 <sup>2</sup> | 4.17(1)                | 0.79(3)                       |
| <sup>110m</sup> Ag |                       | 249.8 d                 | 82.(11)                                                              | 20.(4)                     |                        |                               |
| <sup>111</sup> Ag  |                       | 7.47 d                  | 3.(2)                                                                | 105.(20)                   |                        |                               |
| <sup>48</sup> Cd   |                       |                         | 2.52(5)×10 <sup>3</sup>                                              | 73.(8)                     | 4.87(5)                |                               |
| <sup>106</sup> Cd  | 1.25(6)               | >2.6×10 <sup>17</sup> y | 0.20(3)                                                              | 4.(1)                      |                        | 0.30(2)                       |
| <sup>108</sup> Cd  | 0.89(3)               | >4.1×10 <sup>17</sup> y | 1.                                                                   | 14.(3)                     | 5.4(1)                 | 0.20(1)                       |

\*Extrapolated value.

| Elem. or Isot.    | Natural Abundance (%) | Half-Life               | Thermal Neut. Cross-Section (barns)              | Resonance Integral (barns)    | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|-------------------|-----------------------|-------------------------|--------------------------------------------------|-------------------------------|------------------------|-------------------------------|
| <sup>109</sup> Cd |                       | 462.0 d                 | ≈ 180.<br>σ <sub>α</sub> <0.05                   | 6.7(12)×10 <sup>3</sup>       |                        |                               |
| <sup>110</sup> Cd | 12.49(18)             |                         | (0.06+11.)                                       | (6.+34.)                      | 5.9(1)                 | (0.01+0.22)                   |
| <sup>111</sup> Cd | 12.80(12)             |                         | 3.5(20)                                          | 51.(6)                        | 6.5(1)                 | 0.75(1)                       |
| <sup>112</sup> Cd | 24.13(21)             |                         | (0.012+2.2)                                      | 15.                           | 6.4(1)                 | 0.19(1)                       |
| <sup>113</sup> Cd | 12.22(12)             | 7.7×10 <sup>15</sup> y  | 2.06(4)×10 <sup>4</sup><br>σ <sub>α</sub> <1. μb | 390.(40)                      | - 8.0(2)               | 0.67(1)                       |
| <sup>114</sup> Cd | 28.73(42)             |                         | (0.04+0.29)                                      | 16.(7)                        | 7.5(1)                 | (0.01+0.12)                   |
| <sup>116</sup> Cd | 7.49(18)              | 3.8×10 <sup>19</sup> y  | (26.+52.) mb                                     | 1.2                           | 6.3(1)                 | (12.+47.) mb                  |
| <sup>49</sup> In  |                       |                         | 197.(4)                                          | 3.3(2)×10 <sup>3</sup>        | 4.07(2)                |                               |
| <sup>113</sup> In | 4.29(5)               |                         | (3.1+5.0+3.9)                                    | (220.+90.)                    | 5.39(6)                | (0.48+0.31)                   |
| <sup>115</sup> In | 95.71(5)              | 4.4×10 <sup>14</sup> y  | (88.+73.+44.)                                    | (1.5+1.2+0.7)×10 <sup>3</sup> | 4.01(2)                | (0.69+0.02)                   |
| <sup>50</sup> Sn  |                       |                         | 0.61(3)                                          | 8.(2)                         | 6.225(2)               |                               |
| <sup>112</sup> Sn | 0.97(1)               |                         | (0.15+0.40)                                      | (8.+19.)                      |                        | 0.21(1)                       |
| <sup>113</sup> Sn |                       | 115.1 d                 | ≈ 9.                                             | 210.(50)                      |                        |                               |
| <sup>114</sup> Sn | 0.66(1)               |                         | ≈ 0.12                                           | 5.(1)                         | 6.2(3)                 | 134.(3) mb                    |
| <sup>115</sup> Sn | 0.34(1)               |                         | σ <sub>α</sub> = 0.06 mb                         | 29.(6)                        |                        | 0.34(1)                       |
| <sup>116</sup> Sn | 14.54(9)              |                         | (0.006+0.14)                                     | (0.5+11.)                     | 5.93(5)                | 91.(2) mb                     |
| <sup>117</sup> Sn | 7.68(7)               |                         | 1.1(1)                                           | 16.(5)                        | 6.48(5)                | 319.(7) mb                    |
| <sup>118</sup> Sn | 24.22(9)              |                         | σ <sub>m</sub> = 4. mb                           | 4.7(5)                        | 6.07(5)                | 62.(1) mb                     |
| <sup>119</sup> Sn | 8.59(4)               |                         | 2.(1)                                            | 2.9(5)                        | 6.12(5)                | 0.18(1)                       |
| <sup>120</sup> Sn | 32.58(9)              |                         | (0.001+0.13)                                     | 1.2(3)                        | 6.49(5)                | (0.5+36.) mb                  |
| <sup>122</sup> Sn | 4.63(3)               |                         | (0.15+0.001)                                     | 0.81(4)                       | 5.74(5)                | (18.+4.) mb                   |
| <sup>124</sup> Sn | 5.79(5)               | >2.2×10 <sup>18</sup> y | (0.13+0.004)                                     | (8.0+0.08)                    | 5.97(5)                | 12.(2) mb                     |
| <sup>51</sup> Sb  |                       |                         | 5.2(2)                                           | 169.(20)                      | 5.57(3)                |                               |
| <sup>121</sup> Sb | 57.21(5)              |                         | (0.4+5.8)                                        | (13.+192.)                    | 5.71(6)                | 0.53(2)                       |
| <sup>123</sup> Sb | 42.79(5)              |                         | (0.02+0.04+4.0)                                  | (1.+119.)                     | 5.38(7)                | 0.30(1)                       |
| <sup>124</sup> Sb |                       | 60.20 d                 | 17.(3)                                           | ≈ 8.                          |                        |                               |
| <sup>52</sup> Te  |                       |                         | 4.2(1)                                           | 47.(3)                        | 5.80(3)                |                               |
| <sup>120</sup> Te | 0.09(1)               |                         | (1.+5.)                                          | ≈ 1.                          | 5.3(5)                 | 0.4(1)                        |
| <sup>122</sup> Te | 2.55(12)              |                         | (0.4+3.)                                         | (5.+75.)                      | 3.8(2)                 | 295.(3) mb                    |
| <sup>123</sup> Te | 0.89(3)               | >5.3×10 <sup>16</sup> y | 370.(40)<br>σ <sub>α</sub> = 0.05 mb             | 4.5(3)×10 <sup>3</sup>        | - 0.05                 | 0.83(1)                       |
| <sup>124</sup> Te | 4.74(14)              |                         | (1.+6.)                                          | (1.4+4.)                      | 8.0(1)                 | 155.(2) mb                    |
| <sup>125</sup> Te | 7.07(15)              |                         | 1.1(2)                                           | 21.(4)                        | 5.02(8)                | 431.(4) mb                    |
| <sup>126</sup> Te | 18.84(25)             |                         | (0.12+0.8)                                       | (0.6+7.4)                     | 5.56(7)                | (28.+53.) mb                  |
| <sup>128</sup> Te | 31.74(8)              | 2.2×10 <sup>24</sup> y  | (0.03+0.2)                                       | (0.2+1.6)                     | 5.89(7)                | (3.+41.) mb                   |
| <sup>130</sup> Te | 34.08(62)             | 8.×10 <sup>20</sup> y   | (0.01+0.19)                                      | (0.03+0.3)                    | 6.02(7)                | (4.+11.) mb                   |
| <sup>53</sup> I   |                       |                         | 6.2(1)                                           | 1.5(1)×10 <sup>2</sup>        | 5.28(2)                |                               |
| <sup>125</sup> I  |                       | 59.4 d                  | 900.(100)                                        | 1.4(2)×10 <sup>4</sup>        |                        |                               |
| <sup>127</sup> I  | 100.                  |                         | 6.2(1)                                           | 1.5(1)×10 <sup>2</sup>        | 5.28(2)                | 0.64(3)                       |
| <sup>128</sup> I  |                       | 25.00 m                 | 22.(4)                                           | ≈ 10.                         |                        |                               |
| <sup>129</sup> I  |                       | 1.7×10 <sup>7</sup> y   | (20.7+10.3)                                      | 36.(4)                        |                        | 0.44(2)                       |
| <sup>130</sup> I  |                       | 12.36 h                 | 18.(3)                                           | ≈ 8.                          |                        |                               |
| <sup>131</sup> I  |                       | 8.021 d                 | ≈ 0.7                                            | 8.(4)                         |                        |                               |
| <sup>54</sup> Xe  |                       |                         | 25.(1)                                           | 263.(50)                      | 4.92(3)                |                               |
| <sup>124</sup> Xe | 0.0953(27)            | >10 <sup>17</sup> y     | (28.+137.)                                       | (0.6+3.0)×10 <sup>3</sup>     |                        | (0.13+0.51)                   |
| <sup>125</sup> Xe |                       | 17.1 h                  | σ <sub>α</sub> < 0.03                            |                               |                        |                               |
| <sup>126</sup> Xe | 0.0890(14)            |                         | (0.45+3.)                                        | (8.+52.)                      |                        | (0.04+0.32)                   |
| <sup>127</sup> Xe |                       | 36.34 d                 | σ <sub>α</sub> ≤ 0.01                            |                               |                        |                               |
| <sup>128</sup> Xe | 1.910(22)             |                         | σ <sub>m</sub> = 0.48                            | RI <sub>m</sub> = 38.(10)     |                        | 0.26(1)                       |
| <sup>129</sup> Xe | 26.40(18)             |                         | 22.(5)                                           | 250.(50)                      |                        | 0.62(2)                       |
| <sup>130</sup> Xe | 4.071(53)             |                         | σ <sub>m</sub> = 0.45                            | RI <sub>m</sub> = 16.(4)      |                        | 0.132(3)                      |
| <sup>131</sup> Xe | 21.233(62)            |                         | 90.(10)                                          | 9.(1)×10 <sup>2</sup>         |                        | 0.45(8)                       |
| <sup>132</sup> Xe | 26.9087(680)          |                         | (0.05+0.4)                                       | (0.9+3.7)                     |                        | (5.+60.) mb                   |
| <sup>133</sup> Xe |                       | 5.243 d                 | 190.(90)                                         |                               |                        |                               |
| <sup>134</sup> Xe | 10.436(29)            | >1.1×10 <sup>16</sup> y | (0.003 + 0.26)                                   | 0.40(4)                       |                        | 20.(2) mb                     |
| <sup>135</sup> Xe |                       | 9.10 h                  | 2.65(11)×10 <sup>6</sup>                         | 7.6(5)×10 <sup>3</sup>        |                        |                               |

\*Extrapolated value.

| Elem. or Isot.     | Natural Abundance (%) | Half-Life               | Thermal Neut. Cross-Section (barns)               | Resonance Integral (barns) | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|--------------------|-----------------------|-------------------------|---------------------------------------------------|----------------------------|------------------------|-------------------------------|
| <sup>136</sup> Xe  | 8.858(33)             | >8×10 <sup>20</sup> y   | 0.26(2)                                           | 0.7(2)                     |                        | 0.9(1) mb                     |
| <sup>55</sup> Cs   |                       |                         | 30.4(8)                                           | 422.(50)                   | 5.42(2)                |                               |
| <sup>132</sup> Cs  |                       | 6.48 d                  | σ <sub>α</sub> < 0.15                             |                            |                        |                               |
| <sup>133</sup> Cs  | 100.                  |                         | (2.7+27.3)                                        | (32.+360.)                 | 5.42(2)                | (0.04+0.47)                   |
| <sup>134</sup> Cs  |                       | 2.065 y                 | 140.(10)                                          | 54.(9)                     |                        |                               |
| <sup>135</sup> Cs  |                       | 2.3×10 <sup>6</sup> y   | 8.3(3)                                            | 38.(3)                     |                        |                               |
| <sup>137</sup> Cs  |                       | 30.2 y                  | (0.20+0.07)                                       | 0.36(7)                    |                        |                               |
| <sup>56</sup> Ba   |                       |                         | 1.3(2)                                            | 10.(2)                     | 5.07(3)                |                               |
| <sup>130</sup> Ba  | 0.106(1)              | 2.2×10 <sup>21</sup> y  | (1.+8.)                                           | (25.+200.)                 | - 3.6(6)               | 0.76(11)                      |
| <sup>132</sup> Ba  | 0.101(1)              | 1.3×10 <sup>21</sup> y  | (0.84+9.7)                                        | (4.7+24.)                  | 7.8(3)                 | 0.6(1)                        |
| <sup>133</sup> Ba  |                       | 10.53 y                 | 4.(1)                                             | 85.(30)                    |                        |                               |
| <sup>134</sup> Ba  | 2.417(18)             |                         | (0.1+1.3)                                         | (5.6+18.)                  | 5.7(1)                 | 0.18(1)                       |
| <sup>135</sup> Ba  | 6.592(12)             |                         | (0.014+5.8)                                       | (0.47+131.)                | 4.7(1)                 | 0.46(2)                       |
| <sup>136</sup> Ba  | 7.854(24)             |                         | (0.010+0.44)                                      | (0.1+1.5)                  | 4.91(8)                | 61.(2) mb                     |
| <sup>137</sup> Ba  | 11.232(24)            |                         | 5.(1)                                             | 4.(1)                      | 6.8(1)                 | 76.(3) mb                     |
| <sup>138</sup> Ba  | 71.698(42)            |                         | 0.41(2)                                           | 0.4(1)                     | 4.84(8)                | 4.0(2) mb                     |
| <sup>139</sup> Ba  |                       | 1.396 h                 | 5.(1)                                             | 2.2(5)                     |                        |                               |
| <sup>140</sup> Ba  |                       | 12.75 d                 | 1.6(3)                                            | 14.(1)                     |                        |                               |
| <sup>57</sup> La   |                       |                         | 9.2(2)                                            | 12.(1)                     | 8.24(4)                |                               |
| <sup>138</sup> La  | 0.090(1)              | 1.06×10 <sup>11</sup> y | 57.(6)                                            | 4.1(9)×10 <sup>2</sup>     |                        |                               |
| <sup>139</sup> La  | 99.910(1)             |                         | 9.2(2)                                            | 12.(1)                     | 8.24(4)                | 38.(3) mb                     |
| <sup>140</sup> La  |                       | 1.678 d                 | 2.7(3)                                            | 69.(4)                     |                        |                               |
| <sup>58</sup> Ce   |                       |                         | 0.64(4)                                           | 0.71(6)                    | 4.84(2)                |                               |
| <sup>136</sup> Ce  | 0.185(2)              |                         | (1.0+6.5)                                         | 58.(12)                    | 5.80(9)                | (0.028+0.3)                   |
| <sup>138</sup> Ce  | 0.251(2)              |                         | (0.025+1.0)                                       | (1.5+5.2)                  | 6.70(9)                | 179.(5) mb                    |
| <sup>140</sup> Ce  | 88.450(51)            |                         | 0.58(4)                                           | 0.50(5)                    | 4.84(9)                | 11.0(4) mb                    |
| <sup>141</sup> Ce  |                       | 32.50 d                 | 29.(3)                                            | 13.(2)                     |                        |                               |
| <sup>142</sup> Ce  | 11.114(51)            | >1.6×10 <sup>17</sup> y | 0.97(3)                                           | 1.3(3)                     | 4.75(9)                | 28.(1) mb                     |
| <sup>143</sup> Ce  |                       | 1.38 d                  | 6.1(7)                                            | 2.7(3)                     |                        |                               |
| <sup>144</sup> Ce  |                       | 284.6 d                 | 1.0(1)                                            | 2.6(3)                     |                        |                               |
| <sup>59</sup> Pr   |                       |                         | 11.5(4)                                           | 14.(3)                     | 4.58(5)                |                               |
| <sup>141</sup> Pr  | 100.                  |                         | (4.+7.5)                                          | 14.(3)                     | 4.58(5)                | 111.(2) mb                    |
| <sup>142</sup> Pr  |                       | 19.12 h                 | 20.(3)                                            | 9.(1)                      |                        |                               |
| <sup>143</sup> Pr  |                       | 13.57 d                 | 90.(10)                                           | 190.(25)                   |                        |                               |
| <sup>60</sup> Nd   |                       |                         | 51.(2)                                            | 49.(5)                     | 7.69(5)                |                               |
| <sup>142</sup> Nd  | 27.2(5)               |                         | 19.(1)                                            | 34.(11)                    | 7.7(3)                 | 35.(1) mb                     |
| <sup>143</sup> Nd  | 12.2(2)               |                         | 330.(10)                                          | 128.(30)                   |                        | 0.24(1)                       |
|                    |                       |                         | σ <sub>α</sub> = 17. mb                           |                            |                        |                               |
| <sup>144</sup> Nd  | 23.8(3)               | 2.1×10 <sup>15</sup> y  | 3.6(3)                                            | 3.9(5)                     | 2.8(3)                 | 81.(2) mb                     |
| <sup>145</sup> Nd  | 8.3(1)                |                         | 47.(6)                                            | 260.(40)                   |                        | 0.42(1)                       |
|                    |                       |                         | σ <sub>α</sub> = 12. μb                           |                            |                        |                               |
| <sup>146</sup> Nd  | 17.2(3)               |                         | 1.5(2)                                            | 3.0(4)                     | 8.7(2)                 | 91.(1) mb                     |
| <sup>147</sup> Nd  |                       | 10.98 d                 | 440.(150)                                         | 200.                       |                        |                               |
| <sup>148</sup> Nd  | 5.7(1)                |                         | 2.4(1)                                            | 13.(2)                     | 5.7(3)                 | 147.(2) mb                    |
| <sup>150</sup> Nd  | 5.6(2)                | ≈ 1×10 <sup>19</sup> y  | 1.0(1)                                            | 14.(2)                     | 5.3(2)                 | 0.16(1)                       |
| <sup>61</sup> Pm   |                       |                         |                                                   |                            |                        |                               |
| <sup>146</sup> Pm  |                       | 5.53 y                  | 8.4(1.7)×10 <sup>3</sup>                          |                            |                        |                               |
| <sup>147</sup> Pm  |                       | 2.623 y                 | (84.+96.)                                         | (1000.+1280.)              | 12.6(4)                | 2.(1)                         |
| <sup>148m</sup> Pm |                       | 41.3 d                  | 10600.(800)                                       |                            |                        |                               |
| <sup>148</sup> Pm  |                       | 5.37 d                  | ≈ 10 <sup>3</sup>                                 | 2.6(2.4)×10 <sup>3</sup>   |                        |                               |
| <sup>149</sup> Pm  |                       | 2.212 d                 | 1400.(200)                                        |                            |                        |                               |
| <sup>151</sup> Pm  |                       | 1.183 d                 | ≈ 150.                                            |                            |                        |                               |
| <sup>62</sup> Sm   |                       |                         | 5.6(1)×10 <sup>3</sup>                            | 1.4(2)×10 <sup>3</sup>     |                        |                               |
| <sup>144</sup> Sm  | 3.07(7)               |                         | 1.6(1)                                            | 2.4(3)                     |                        | 92.(6) mb                     |
| <sup>145</sup> Sm  |                       | 340. d                  | 280.(20)                                          | 600.(90)                   |                        |                               |
| <sup>147</sup> Sm  | 14.99(18)             | 1.06×10 <sup>11</sup> y | 56.(4), σ <sub>α</sub> = 0.6 mb                   | 710.(50)                   | 14.(3)                 | 0.97(1)                       |
| <sup>148</sup> Sm  | 11.24(10)             | 7×10 <sup>15</sup> y    | 2.4(6)                                            | 27.(14)                    |                        | 241.(2) mb                    |
| <sup>149</sup> Sm  | 13.82(7)              | 10 <sup>16</sup> y      | 4.01(6)×10 <sup>4</sup> , σ <sub>α</sub> = 31. mb | 3.1(5)×10 <sup>3</sup>     |                        | 1.82(2)                       |

\*Extrapolated value.



| Elem. or Isot.      | Natural Abundance (%) | Half-Life               | Thermal Neut. Cross-Section (barns)              | Resonance Integral (barns) | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|---------------------|-----------------------|-------------------------|--------------------------------------------------|----------------------------|------------------------|-------------------------------|
| <sup>150</sup> Sm   | 7.38(1)               |                         | 102.(5)                                          | 290.(30)                   | 14.(3)                 | 422.(4) mb                    |
| <sup>151</sup> Sm   |                       | 90. y                   | 1.52(3)×10 <sup>4</sup>                          | 3520.(60)                  |                        | 2.(1)                         |
| <sup>152</sup> Sm   | 26.75(16)             |                         | 206.(15)                                         | 3.0(3)×10 <sup>3</sup>     | - 5.0(6)               | 473.(4) mb                    |
| <sup>153</sup> Sm   |                       | 1.929 d                 | 420.(180)                                        |                            |                        |                               |
| <sup>154</sup> Sm   | 22.75(29)             |                         | 7.5(3)                                           | 32.(6)                     | 9.(1)                  | 0.21(1)                       |
| <sup>63</sup> Eu    |                       |                         | 4570.(100)                                       | 3.8(5)×10 <sup>3</sup>     | 5.3(3)                 |                               |
| <sup>151</sup> Eu   | 47.81(6)              |                         | (4.+3150.+6000.)<br>σ <sub>α</sub> = 8.7(3) μb   | (2.+4.)×10 <sup>3</sup>    |                        | (1.6+2.2)                     |
| <sup>152m1</sup> Eu |                       | 9.30 h                  | 6.8(15)×10 <sup>4</sup>                          | < 10 <sup>5</sup>          |                        |                               |
| <sup>152</sup> Eu   |                       | 13.5 y                  | 1.1(2)×10 <sup>4</sup>                           | 1.6(2)×10 <sup>3</sup>     |                        | 5.(2)                         |
| <sup>153</sup> Eu   | 52.19(6)              |                         | 300.(20), σ <sub>α</sub> <1. μb                  | 1.8(4)×10 <sup>3</sup>     | 8.2(1)                 | 2.8(1)                        |
| <sup>154</sup> Eu   |                       | 8.59 y                  | 1.5(3)×10 <sup>3</sup>                           | 1.6(2)×10 <sup>3</sup>     |                        | 4.4(7)                        |
| <sup>155</sup> Eu   |                       | 4.76 y                  | 3.9(2)×10 <sup>3</sup>                           | 1.6(2)×10 <sup>4</sup>     |                        | 1.3(1)                        |
| <sup>64</sup> Gd    |                       |                         | 48.8(6)×10 <sup>3</sup>                          | 400.(10)                   | 9.5(2)                 |                               |
| <sup>148</sup> Gd   |                       | 75. y                   | 1.40(14)×10 <sup>4</sup>                         |                            |                        |                               |
| <sup>152</sup> Gd   | 0.20(1)               | 1.1×10 <sup>14</sup> y  | 700.(200), σ <sub>α</sub> <7. mb                 | 700.(200)                  |                        | 1.05(2)                       |
| <sup>153</sup> Gd   |                       | 240. d                  | 2.(1)×10 <sup>4</sup> , σ <sub>α</sub> = 0.03    |                            |                        |                               |
| <sup>154</sup> Gd   | 2.18(3)               |                         | (0.035+60.)                                      | 230.(50)                   |                        | 1.03(1)                       |
| <sup>155</sup> Gd   | 14.80(12)             |                         | 61.(1)×10 <sup>3</sup> , σ <sub>α</sub> = .08 mb | 1540.(100)                 |                        | 2.65(3)                       |
| <sup>156</sup> Gd   | 20.47(9)              |                         | ≈ 2.0                                            | 104.(15)                   | 6.3(4)                 | 615.(5) mb                    |
| <sup>157</sup> Gd   | 15.65(2)              |                         | 2.54(3)×10 <sup>5</sup> , σ <sub>α</sub> <0.05   | 800.(100)                  |                        | 1.37(2)                       |
| <sup>158</sup> Gd   | 24.84(7)              |                         | 2.3(3)                                           | 73.(7)                     | 9.(2)                  | 324.(3) mb                    |
| <sup>160</sup> Gd   | 21.86(19)             | >1.9×10 <sup>19</sup> y | 1.5(7)                                           | 6.(1)                      | 9.15(5)                | 0.15(2)                       |
| <sup>161</sup> Gd   |                       | 3.66 m                  | 2.0(6)×10 <sup>4</sup>                           |                            |                        |                               |
| <sup>65</sup> Tb    |                       |                         | 23.2(5)                                          | 420.(50)                   | 7.34(2)                |                               |
| <sup>159</sup> Tb   | 100.                  |                         | 23.2(5)                                          | 420.(50)                   | 7.34(2)                | 1.6(2)                        |
| <sup>160</sup> Tb   |                       | 72.3 d                  | 570.(110)                                        |                            |                        |                               |
| <sup>66</sup> Dy    |                       |                         | 9.5(2)×10 <sup>2</sup>                           | 1.5(2)×10 <sup>3</sup>     | 16.9(3)                |                               |
| <sup>156</sup> Dy   | 0.056(3)              |                         | 33.(3), σ <sub>α</sub> < 9. mb                   | 1000.(100)                 |                        | 1.6(2)                        |
| <sup>158</sup> Dy   | 0.095(3)              |                         | 43.(6), σ <sub>α</sub> < 6. mb                   | 120.(10)                   | 6.1(5)                 | 0.8(2)                        |
| <sup>159</sup> Dy   |                       | 144. d                  | 8.(2)×10 <sup>3</sup>                            |                            |                        |                               |
| <sup>160</sup> Dy   | 2.39(18)              |                         | 60.(10), σ <sub>α</sub> < 0.3 mb                 | 1100.(200)                 | 6.7(4)                 | 0.89(1)                       |
| <sup>161</sup> Dy   | 18.889(42)            |                         | 600.(50), σ <sub>α</sub> < 1. μb                 | 1100.(100)                 | 10.3(4)                | 1.96(2)                       |
| <sup>162</sup> Dy   | 25.475(36)            |                         | 170.(20)                                         | 2755.(300)                 | - 1.4(5)               | 446.(4) mb                    |
| <sup>163</sup> Dy   | 24.896(42)            |                         | 120.(10), σ <sub>α</sub> < 20. μb                | 1600.(400)                 | 5.0(4)                 | 1.11(1)                       |
| <sup>164</sup> Dy   | 28.260(54)            |                         | (1.7+1.0)×10 <sup>3</sup>                        | (4.+2.)×10 <sup>2</sup>    | 49.4(2)                | 212.(3) mb                    |
| <sup>165m</sup> Dy  |                       | 1.26 m                  | 2.0(6)×10 <sup>3</sup>                           |                            |                        |                               |
| <sup>165</sup> Dy   |                       | 2.33 h                  | 3.5(3)×10 <sup>3</sup>                           | 2.2(3)×10 <sup>4</sup>     |                        |                               |
| <sup>67</sup> Ho    |                       |                         | 61.(2)                                           | 670.(40)                   | 8.01(8)                |                               |
| <sup>163</sup> Ho   |                       | 4.57×10 <sup>3</sup> y  |                                                  |                            |                        | (0.4+1.7)                     |
| <sup>165</sup> Ho   | 100.                  |                         | (3.1+58.), σ <sub>α</sub> < 20. μb               | (?+670.)                   | 8.01(8)                | (0.8+0.5)                     |
| <sup>166m</sup> Ho  |                       | 1.2×10 <sup>3</sup> y   | 3.1(8)×10 <sup>3</sup>                           | 10.(3)×10 <sup>3</sup>     |                        |                               |
| <sup>68</sup> Er    |                       |                         | 1.5(2)×10 <sup>2</sup>                           | 730.(10)                   | 7.79(2)                |                               |
| <sup>162</sup> Er   | 0.139(5)              |                         | 19.(3), σ <sub>α</sub> < 11. mb                  | 480.(50)                   | 8.8(2)                 | 1.6(1)                        |
| <sup>164</sup> Er   | 1.601(3)              |                         | 13.(3), σ <sub>α</sub> < 1.2 mb                  | 105.(10)                   | 8.2(2)                 | 1.08(5)                       |
| <sup>166</sup> Er   | 33.503(36)            |                         | (3.+14.), σ <sub>α</sub> < 70. μb                | 96.(12)                    | 10.6(2)                | 0.56(6)                       |
| <sup>167</sup> Er   | 22.869(9)             |                         | 6.5(8)×10 <sup>2</sup> , σ <sub>α</sub> = 3. μb  | 2970.(70)                  | 3.0(3)                 | 1.4(2)                        |
| <sup>168</sup> Er   | 26.978(18)            |                         | 2.3(3), σ <sub>α</sub> = 0.09 mb                 | 37.(5)                     | 7.4(4)                 | 0.34(4)                       |
| <sup>170</sup> Er   | 14.910(36)            |                         | 8.(2)                                            | 26.(4)                     | 9.6(5)                 | 0.17(1)                       |
| <sup>171</sup> Er   |                       | 7.52 h                  | 370.(40)                                         | 170.(20)                   |                        |                               |
| <sup>69</sup> Tm    |                       |                         | 108.(4)                                          | 1.5(2)×10 <sup>3</sup>     | 7.07(3)                |                               |
| <sup>169</sup> Tm   | 100                   |                         | (8.+100.)                                        | 1.5(2)×10 <sup>3</sup>     | 7.07(3)                | 1.13(6)                       |
| <sup>170</sup> Tm   |                       | 128.6 d                 | 100.(20)                                         | 460.(50)                   |                        |                               |
| <sup>171</sup> Tm   |                       | 1.92 y                  | ≈ 160.                                           | 118.(6)                    |                        |                               |
| <sup>70</sup> Yb    |                       |                         | 52.(10)                                          | 1.7(2)×10 <sup>2</sup>     | 12.43(3)               |                               |
| <sup>168</sup> Yb   | 0.13(1)               |                         | 2.4(2)×10 <sup>3</sup> , σ <sub>α</sub> < 0.1 mb | 2.0(5)×10 <sup>4</sup>     | -4.07(2)               | 0.7(4)                        |
| <sup>169</sup> Yb   |                       | 32.02 d                 | 3.6(3)×10 <sup>3</sup>                           | 5200.(500)                 |                        |                               |
| <sup>170</sup> Yb   | 3.04(15)              |                         | 12.(2), σ <sub>α</sub> < 10. μb                  | 320.(30)                   | 6.8(1)                 | 0.77(1)                       |

\*Extrapolated value.

| Elem. or Isot.      | Natural Abundance (%) | Half-Life                | Thermal Neut. Cross-Section (barns)             | Resonance Integral (barns)              | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|---------------------|-----------------------|--------------------------|-------------------------------------------------|-----------------------------------------|------------------------|-------------------------------|
| <sup>171</sup> Yb   | 14.28(57)             |                          | 53.(5), σ <sub>α</sub> < 1.5 μb                 | 315.(30)                                | 9.7(1)                 | 1.21(1)                       |
| <sup>172</sup> Yb   | 21.83(67)             |                          | ≈ 1.3, σ <sub>α</sub> < 1. μb                   | 25.(3)                                  | 9.4(1)                 | 0.34(1)                       |
| <sup>173</sup> Yb   | 16.13(27)             |                          | 16.(2), σ <sub>α</sub> < 1. μb                  | 380.(30)                                | 9.56(7)                | 0.75(1)                       |
| <sup>174</sup> Yb   | 31.83(92)             |                          | (46.+17.), σ <sub>α</sub> < 0.02 mb             | (13.+16.)                               | 19.3(1)                | 151.(2) mb                    |
| <sup>176</sup> Yb   | 12.76(41)             |                          | 3.1(2), σ <sub>α</sub> < 1. μb                  | 8.(2)                                   | 8.7(1)                 | 116.(2) mb                    |
| <sup>71</sup> Lu    |                       |                          | 78.(7)                                          | 8.3(7)×10 <sup>2</sup>                  | 7.21(3)                |                               |
| <sup>175</sup> Lu   | 97.41(2)              |                          | (16.+8.)                                        | (550.+270.)                             | 7.24(3)                | (1.04+0.11)                   |
| <sup>176</sup> Lu   | 2.59(2)               | 3.73×10 <sup>10</sup> y  | (2.+2100.)                                      | (3.+930.)                               | 6.1(2)                 | 1.53(7)                       |
| <sup>177m</sup> Lu  |                       | 160.7 d                  | 3.2(3)                                          | 1.4(2)                                  |                        |                               |
| <sup>177</sup> Lu   |                       | 6.65 d                   | 1000.(300)                                      |                                         |                        |                               |
| <sup>72</sup> Hf    |                       |                          | 106.(3)                                         | 19.7(5)×10 <sup>2</sup>                 | 7.8(1)                 |                               |
| <sup>174</sup> Hf   | 0.16(1)               | 2.0×10 <sup>15</sup> y   | 600.(50)                                        | 400.(50)                                | 11.(1)                 | 0.8(2)                        |
| <sup>176</sup> Hf   | 5.26(7)               |                          | 23.(4)                                          | 700.(100)                               | 6.6(2)                 | 0.46(2)                       |
| <sup>177</sup> Hf   | 18.60(9)              |                          | (1.+375.), σ <sub>α</sub> < 20. μb              | 7170.(200)                              |                        | 1.5(1)                        |
| <sup>178m2</sup> Hf |                       | 31. y                    | σ <sub>m2</sub> = 45.(5)                        | RI <sub>m2</sub> = 8(1)×10 <sup>2</sup> |                        |                               |
| <sup>178</sup> Hf   | 27.28(7)              |                          | (54.+32.)                                       | (0.9+1.0)×10 <sup>3</sup>               | 5.9(2)                 | 0.31(1)                       |
| <sup>179</sup> Hf   | 13.62(2)              |                          | (0.43+46.)                                      | (6.8+620.)                              | 7.5(2)                 | (0.01+0.95)                   |
| <sup>180</sup> Hf   | 35.08(16)             |                          | 13.0(5), σ <sub>α</sub> < 13. μb                | 32.(1)                                  | 13.2(3)                | 179.(5) mb                    |
| <sup>181</sup> Hf   |                       | 42.4 d                   | 30.(25)                                         |                                         |                        |                               |
| <sup>73</sup> Ta    |                       |                          | 20.(1)                                          | 650(20.)                                | 6.91(7)                |                               |
| <sup>179</sup> Ta   |                       | 1.8 y                    | 9.3(6)×10 <sup>2</sup>                          | 1.22(7)×10 <sup>3</sup>                 |                        |                               |
| <sup>180m</sup> Ta  | 0.012(2)              | > 1.2×10 <sup>15</sup> y | ≈ 560.                                          | 1350.(100)                              |                        |                               |
| <sup>181</sup> Ta   | 99.988(2)             |                          | (0.012 + 20.), σ <sub>α</sub> <1. μb            | (0.4+650.)                              | 6.91(7)                | 0.77(2)                       |
| <sup>182</sup> Ta   |                       | 114.43 d                 | 8200.(600)                                      | 900.(90)                                |                        |                               |
| <sup>74</sup> W     |                       |                          | 18.(1)                                          | 3.6(3)×10 <sup>2</sup>                  | 4.86(2)                |                               |
| <sup>180</sup> W    | 0.12(1)               | 7.4×10 <sup>16</sup> y   | ≈ 4.                                            | 210.(30)                                |                        | 0.54(6)                       |
| <sup>182</sup> W    | 26.50(16)             | 8.3×10 <sup>18</sup> y   | 20.(1)                                          | 600.(90)                                | 6.97(4)                | 274.(8) mb                    |
| <sup>183</sup> W    | 14.31(4)              | 1.9×10 <sup>18</sup> y   | 10.5(3)                                         | 340.(50)                                | 6.53(4)                | 0.52(2)                       |
| <sup>184</sup> W    | 30.64(2)              | 4.0×10 <sup>18</sup> y   | (0.002 + 2.0)                                   | 15.(2)                                  | 7.48(6)                | 0.22(1)                       |
| <sup>185</sup> W    |                       | 74.8 d                   | ≈ 3.3                                           | 300.(50)                                |                        |                               |
| <sup>186</sup> W    | 28.43(19)             | 6.5×10 <sup>18</sup> y   | 37.(2)                                          | 510.(50)                                | - 0.72(4)              | 176.(5) mb                    |
| <sup>187</sup> W    |                       | 23.9 h                   | 70.(10)                                         | 2760.(550)                              |                        |                               |
| <sup>188</sup> W    |                       | 69.78 h                  | 12.(1)                                          |                                         |                        |                               |
| <sup>75</sup> Re    |                       |                          | 90.(4)                                          | 8.4(2)×10 <sup>2</sup>                  | 9.2(3)                 |                               |
| <sup>185</sup> Re   | 37.40(2)              |                          | (0.33+110.)                                     | 1700.(50)                               | 9.0(3)                 | 1.54(6)                       |
| <sup>187</sup> Re   | 62.60(2)              | 4.2×10 <sup>10</sup> y   | (2.+72.)                                        | (9.+310.)                               | 9.3(3)                 | 1.16(6)                       |
| <sup>76</sup> Os    |                       |                          | 17.(1)                                          | 1.5(1)×10 <sup>2</sup>                  | 10.7(2)                |                               |
| <sup>184</sup> Os   | 0.02(1)               | >5.6×10 <sup>13</sup> y  | 3.3(3)×10 <sup>3</sup> , σ <sub>α</sub> <10. mb | 1.4(1)×10 <sup>3</sup>                  |                        | 0.4(2)                        |
| <sup>186</sup> Os   | 1.59(3)               | 2.×10 <sup>15</sup> y    | ≈ 80., σ <sub>α</sub> < 0.1 mb                  | 3.8(9)×10 <sup>2</sup>                  | 12(2)                  | 0.42(2)                       |
| <sup>187</sup> Os   | 1.96(2)               |                          | 2.(1)×10 <sup>2</sup> , σ <sub>α</sub> < 0.1 mb | 5.0(7)×10 <sup>2</sup>                  |                        | 0.90(3)                       |
| <sup>188</sup> Os   | 13.24(8)              |                          | ≈ 5., σ <sub>α</sub> < 30. μb                   | 1.5(2)×10 <sup>2</sup>                  | 7.6(3)                 | 0.40(2)                       |
| <sup>189</sup> Os   | 16.15(5)              |                          | (0.00026+40.),σ <sub>α</sub> <10. μb            | (0.013+670.)                            | 10.7(3)                | 1.17(5)                       |
| <sup>190</sup> Os   | 26.26(2)              |                          | (9.+4.), σ <sub>α</sub> < 20. μb                | (22.+8.)                                | 11.0(3)                | 0.30(5)                       |
| <sup>191</sup> Os   |                       | 15.4 d                   | 3.8(6)×10 <sup>2</sup>                          | 1.7(3)×10 <sup>2</sup>                  |                        |                               |
| <sup>192</sup> Os   | 40.78(19)             |                          | 3.(1), σ <sub>α</sub> < 10. μb                  | 7.(1)                                   | 11.5(4)                | 0.31(5)                       |
| <sup>193</sup> Os   |                       | 30.5 h                   | 2.5(5)×10 <sup>2</sup>                          | 1.1(2)×10 <sup>2</sup>                  |                        |                               |
| <sup>77</sup> Ir    |                       |                          | 4.2(1)×10 <sup>2</sup>                          | 2.8(4)×10 <sup>3</sup>                  | 10.6(3)                |                               |
| <sup>191</sup> Ir   | 37.3(2)               |                          | (0.14+660.+260.)                                | (1.0+4.2)×10 <sup>3</sup>               |                        | 1.35(4)                       |
| <sup>192</sup> Ir   |                       | 73.83 d                  | 1.4(3)×10 <sup>3</sup>                          | 4.8(7)×10 <sup>3</sup>                  |                        |                               |
| <sup>193</sup> Ir   | 62.7(2)               |                          | (0.04+6.+109.)                                  | 1.4(2)×10 <sup>3</sup>                  |                        | 0.99(7)                       |
| <sup>194</sup> Ir   |                       | 19.3 h                   | 1.6(3)×10 <sup>3</sup>                          | 7.(2)×10 <sup>2</sup>                   |                        |                               |
| <sup>78</sup> Pt    |                       |                          | 10.(1)                                          | 1.3(1)×10 <sup>2</sup>                  | 9.60(1)                |                               |
| <sup>190</sup> Pt   | 0.014(1)              | 4.5×10 <sup>11</sup> y   | 1.5(1)×10 <sup>2</sup> , σ <sub>α</sub> < 8. mb | 70.(10)                                 | 9.(1)                  | 0.7(2)                        |
| <sup>192</sup> Pt   | 0.782(7)              |                          | (2.0+6.), σ <sub>α</sub> < 0.2 mb               | 115.(20)                                | 9.9(5)                 | 0.6(1)                        |
| <sup>194</sup> Pt   | 32.967(99)            |                          | (0.1+1.1), σ <sub>α</sub> < 5. μb               | (4.+?)                                  | 10.55(8)               | (0.03+0.34)                   |
| <sup>195</sup> Pt   | 33.832(10)            |                          | 28.(1), σ <sub>α</sub> < 5. μb                  | 365.(50)                                | 8.8(1)                 | 0.9(2)                        |
| <sup>196</sup> Pt   | 25.242(41)            |                          | (0.045+0.55)                                    | 7.(2)                                   | 9.89(8)                | (0.01+0.19)                   |
| <sup>198</sup> Pt   | 7.163(55)             |                          | (0.3+3.1)                                       | (5.+53.)                                | 7.8(1)                 | (3.+79.) mb                   |

\*Extrapolated value.

| Elem. or Isot.     | Natural Abundance (%)                                                            | Half-Life               | Thermal Neut. Cross-Section (barns)                                                            | Resonance Integral (barns)                                               | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|--------------------|----------------------------------------------------------------------------------|-------------------------|------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------|-------------------------------|
| <sup>199</sup> Pt  |                                                                                  | 30.8 m                  | ≈ 15.                                                                                          | ≈ 7.                                                                     |                        |                               |
| <sup>79</sup> Au   | 100.                                                                             |                         | 98.7(1)                                                                                        | 1.55(3)×10 <sup>3</sup>                                                  | 7.63(6)                |                               |
| <sup>197</sup> Au  |                                                                                  |                         | σ <sub>m+g</sub> = 98.7(1)<br>σ <sub>m</sub> = 8.(2) mb                                        | RI <sub>m+g</sub> = 1.55(3)×10 <sup>3</sup><br>RI <sub>m</sub> = 0.06(2) | 7.63(6)                | 582.(9) mb                    |
| <sup>198</sup> Au  |                                                                                  | 2.695 d                 | 26.5(15)×10 <sup>3</sup>                                                                       | ≈ 4.×10 <sup>4</sup>                                                     |                        |                               |
| <sup>199</sup> Au  |                                                                                  | 3.14 d                  | ≈ 30.                                                                                          |                                                                          |                        |                               |
| <sup>80</sup> Hg   | 0.15(1)<br>9.97(8)<br>16.87(10)<br>23.10(16)<br>13.18(8)<br>29.86(20)<br>6.87(4) | >2.5×10 <sup>18</sup> y | 3.7(1)×10 <sup>2</sup>                                                                         | 87.(5)                                                                   | 12.69(2)               |                               |
| <sup>196</sup> Hg  |                                                                                  |                         | (105.+3000.)                                                                                   | (53.+410.)                                                               | 30.(1)                 | 0.4(2)                        |
| <sup>198</sup> Hg  |                                                                                  |                         | (0.017+2.)                                                                                     | (1.7+70.)                                                                |                        | 0.17(2)                       |
| <sup>199</sup> Hg  |                                                                                  |                         | 2.1(2)×10 <sup>3</sup>                                                                         | 435(20)                                                                  | 16.9(4)                | 0.37(2)                       |
| <sup>200</sup> Hg  |                                                                                  |                         | ≈ 1.                                                                                           | 2.1(5)                                                                   |                        | 0.12(1)                       |
| <sup>201</sup> Hg  |                                                                                  |                         | ≈ 8.                                                                                           | 30.(3)                                                                   |                        | 0.26(1)                       |
| <sup>202</sup> Hg  |                                                                                  |                         | 4.9(5)                                                                                         | 4.5(2)                                                                   | 11.(1)                 | 74.(6) mb                     |
| <sup>204</sup> Hg  |                                                                                  |                         | 0.4(1)                                                                                         | 0.8(2)                                                                   |                        | 42.(4) mb                     |
| <sup>81</sup> Tl   |                                                                                  |                         | 3.3(1)                                                                                         | 12.5(8)                                                                  | 8.776(5)               |                               |
| <sup>203</sup> Tl  | 29.524(14)                                                                       | 3.78 y                  | 11.(1), σ <sub>α</sub> < 0.3 mb                                                                | 41.(2)                                                                   | 7.0(2)                 | 124.(8) mb                    |
| <sup>204</sup> Tl  |                                                                                  |                         | 22.(2)                                                                                         | 90.(20)                                                                  |                        | 0.14(5)                       |
| <sup>205</sup> Tl  | 70.476(14)                                                                       |                         | 0.11(2)                                                                                        | 0.6(2)                                                                   | 9.52(7)                | 54.(4) mb                     |
| <sup>82</sup> Pb   | 1.4(1)<br><br>24.1(1)<br>22.1(1)<br>52.4(1)                                      | 1.51×10 <sup>7</sup> y  | 0.172(2)                                                                                       | 0.14(4)                                                                  | 9.402(2)               |                               |
| <sup>204</sup> Pb  |                                                                                  |                         | 0.68(7)                                                                                        | 2.0(2)                                                                   | 10.9(1)                | 90.(6) mb                     |
| <sup>205</sup> Pb  |                                                                                  |                         | ≈ 5.                                                                                           | ≈ 2.                                                                     |                        | 0.06(1)                       |
| <sup>206</sup> Pb  |                                                                                  |                         | 0.027(1)                                                                                       | 0.10(1)                                                                  | 9.23(5)                | 16.(1) mb                     |
| <sup>207</sup> Pb  |                                                                                  | >2×10 <sup>19</sup> y   | 0.61(3)                                                                                        | 0.38(1)                                                                  | 9.28(2)                | 10.(1) mb                     |
| <sup>208</sup> Pb  |                                                                                  |                         | 0.23(1) mb, σ <sub>α</sub> < 8. μb                                                             | 2.0(2) mb                                                                | 9.50(3)                | 0.36(4) mb                    |
| <sup>210</sup> Pb  |                                                                                  | 22.6 y                  | < 0.5                                                                                          |                                                                          |                        |                               |
| <sup>83</sup> Bi   | 100.                                                                             |                         | 0.034(1)                                                                                       | 0.19(2)                                                                  | 8.532(2)               |                               |
| <sup>209</sup> Bi  |                                                                                  |                         | (11.+23.) mb,σ <sub>α</sub> <0.3 μb                                                            | 0.19(2)                                                                  | 8.532(2)               | 2.7(5) mb                     |
| <sup>210m</sup> Bi |                                                                                  | 3.0×10 <sup>6</sup> y   | 54.(4) mb                                                                                      | 0.20(3)                                                                  |                        |                               |
| <sup>84</sup> Po   |                                                                                  | 138.4 d                 | σ <sub>m</sub> <0.5 mb, σ <sub>α</sub> < 2. mb<br>σ <sub>g</sub> <30. mb, σ <sub>f</sub> < 0.1 |                                                                          |                        |                               |
| <sup>210</sup> Po  |                                                                                  |                         |                                                                                                |                                                                          |                        |                               |
| <sup>85</sup> At   |                                                                                  |                         |                                                                                                |                                                                          |                        |                               |
| <sup>86</sup> Rn   |                                                                                  |                         |                                                                                                |                                                                          |                        |                               |
| <sup>220</sup> Rn  |                                                                                  | 55.6 s                  | <0.2                                                                                           |                                                                          |                        |                               |
| <sup>222</sup> Rn  |                                                                                  | 3.823 d                 | 0.74(5)                                                                                        |                                                                          |                        |                               |
| <sup>88</sup> Ra   |                                                                                  |                         |                                                                                                |                                                                          |                        |                               |
| <sup>223</sup> Ra  |                                                                                  | 11.43 d                 | 1.3(2)×10 <sup>2</sup> , σ <sub>f</sub> < 0.7                                                  |                                                                          |                        |                               |
| <sup>224</sup> Ra  |                                                                                  | 3.66 d                  | 12.0(5)                                                                                        |                                                                          |                        |                               |
| <sup>226</sup> Ra  |                                                                                  | 1599. y                 | ≈ 13., σ <sub>f</sub> < 7. μb                                                                  | 280.(50)                                                                 | 10.(1)                 |                               |
| <sup>228</sup> Ra  |                                                                                  | 5.76 y                  | 36.(5), σ <sub>f</sub> < 2.                                                                    |                                                                          |                        |                               |
| <sup>89</sup> Ac   |                                                                                  |                         |                                                                                                |                                                                          |                        |                               |
| <sup>227</sup> Ac  |                                                                                  | 21.77 y                 | 8.8(7)×10 <sup>2</sup> , σ <sub>f</sub> < 0.35 mb                                              | 1.5(4)×10 <sup>3</sup>                                                   |                        |                               |
| <sup>90</sup> Th   |                                                                                  |                         | 7.4                                                                                            | 85.(3)                                                                   | 10.31(3)               |                               |
| <sup>227</sup> Th  |                                                                                  | 18.72 d                 | σ <sub>f</sub> = 2.0(2)×10 <sup>2</sup>                                                        |                                                                          |                        |                               |
| <sup>228</sup> Th  |                                                                                  | 1.913 y                 | 1.2(2)×10 <sup>2</sup> , σ <sub>f</sub> <0.3                                                   | 1014.(400)                                                               |                        |                               |
| <sup>229</sup> Th  |                                                                                  | 7.9×10 <sup>3</sup> y   | ≈ 60.<br>σ <sub>f</sub> = 30.(3)                                                               | 1.0(2)×10 <sup>3</sup><br>RI <sub>f</sub> = 466.(75)                     |                        |                               |
| <sup>230</sup> Th  |                                                                                  | 7.54×10 <sup>4</sup> y  | 23.4(5)<br>σ <sub>f</sub> < 0.5 mb                                                             | 1.0(1)×10 <sup>3</sup>                                                   |                        |                               |
| <sup>232</sup> Th  | 100.                                                                             | 1.40×10 <sup>10</sup> y | 7.37(4)<br>σ <sub>f</sub> = 3.(1) μb<br>σ <sub>α</sub> < 1. μb                                 | 85.(3)                                                                   | 10.31(3)               |                               |
| <sup>233</sup> Th  |                                                                                  | 22.3 m                  | 1.5(1)×10 <sup>3</sup><br>σ <sub>f</sub> = 15.(2)                                              | 4.(1)×10 <sup>2</sup>                                                    |                        |                               |
| <sup>234</sup> Th  |                                                                                  | 24.10 d                 | 1.8(5)<br>σ <sub>f</sub> < 0.01                                                                |                                                                          |                        |                               |

\*Extrapolated value.

| Elem. or Isot.     | Natural Abundance (%) | Half-Life                 | Thermal Neut. Cross-Section (barns)             | Resonance Integral (barns)               | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|--------------------|-----------------------|---------------------------|-------------------------------------------------|------------------------------------------|------------------------|-------------------------------|
| <sup>91</sup> Pa   |                       |                           |                                                 |                                          |                        |                               |
| <sup>230</sup> Pa  |                       | 17.4 d                    | 1.5(3)×10 <sup>3</sup>                          |                                          |                        |                               |
| <sup>231</sup> Pa  |                       | 3.25×10 <sup>4</sup> y    | 2.0(1)×10 <sup>2</sup>                          | 750.(80)                                 | 9.1(3)                 |                               |
|                    |                       |                           | σ <sub>f</sub> = 20.(1) mb                      | RI <sub>f</sub> = 0.05(1)                |                        |                               |
| <sup>232</sup> Pa  |                       | 1.31 d                    | 4.6(10)×10 <sup>2</sup>                         | 300.(70)                                 |                        |                               |
|                    |                       |                           | σ <sub>f</sub> = 1.5(5)×10 <sup>3</sup>         | RI <sub>f</sub> = 1.0(1)×10 <sup>3</sup> |                        |                               |
| <sup>233</sup> Pa  |                       | 27.0 d                    | 39.(2)                                          | (460.+440.)                              |                        |                               |
|                    |                       |                           | σ <sub>m</sub> = 20.(4)                         |                                          |                        |                               |
|                    |                       |                           | σ <sub>g</sub> = 19.(3)                         |                                          |                        |                               |
|                    |                       |                           | σ <sub>f</sub> < 0.1                            |                                          |                        |                               |
| <sup>92</sup> U    |                       |                           | 3.4(3); σ <sub>f</sub> = 4.2(1)                 | 280.(20),RI <sub>f</sub> = 2.0           | 8.417(5)               |                               |
| <sup>230</sup> U   |                       | 20.8 d                    | σ <sub>f</sub> ≈ 25.                            |                                          |                        |                               |
| <sup>231</sup> U   |                       | 4.2 d                     | σ <sub>f</sub> ≈ 250.                           |                                          |                        |                               |
| <sup>232</sup> U   |                       | 70. y                     | 73.(2)                                          | 280.(15)                                 |                        |                               |
|                    |                       |                           | σ <sub>f</sub> = 74.(8)                         | RI <sub>f</sub> = 350.(30)               |                        |                               |
| <sup>233</sup> U   |                       | 1.592×10 <sup>5</sup> y   | 47.(2)                                          | 137.(6)                                  | 10.1(2)                |                               |
|                    |                       |                           | σ <sub>f</sub> = 5.3(1)×10 <sup>2</sup>         | RI <sub>f</sub> = 760.(17)               |                        |                               |
|                    |                       |                           | σ <sub>α</sub> < 0.2 mb                         |                                          |                        |                               |
| <sup>234</sup> U   | 0.0054(5)             | 2.455×10 <sup>5</sup> y   | 96.(2)                                          | 660.(70)                                 | 12.(4)                 |                               |
|                    |                       |                           | σ <sub>f</sub> = 0.07(2)                        | RI <sub>f</sub> = 6.5                    |                        |                               |
| <sup>235</sup> U   | 0.7204(6)             | 7.04×10 <sup>8</sup> y    | 95.(5)                                          | 144.(6)                                  | 10.47(4)               |                               |
|                    |                       |                           | σ <sub>f</sub> = 586.(2)                        | RI <sub>f</sub> = 275(5)                 |                        |                               |
|                    |                       |                           | σ <sub>α</sub> < 0.1 mb                         |                                          |                        |                               |
| <sup>236</sup> U   |                       | 2.342×10 <sup>7</sup> y   | 5.1(3)                                          | 360.(15)                                 |                        |                               |
|                    |                       |                           | σ <sub>f</sub> < 1.3 mb                         | RI <sub>f</sub> = 4.38(50)               |                        |                               |
| <sup>237</sup> U   |                       | 6.75 d                    | ≈ 10 <sup>2</sup>                               | 1200.(200)                               |                        |                               |
|                    |                       |                           | σ <sub>f</sub> < 0.35                           |                                          |                        |                               |
| <sup>238</sup> U   | 99.2742(10)           | 4.47×10 <sup>9</sup> y    | 2.7(1)                                          | 277.(3)                                  | 8.402(5)               |                               |
|                    |                       |                           | σ <sub>f</sub> ≈ 3. μb                          | 1.54(15) mb                              |                        |                               |
|                    |                       |                           | σ <sub>α</sub> = 1.4(5) μb                      |                                          |                        |                               |
| <sup>239</sup> U   |                       | 23.5 m                    | 22.(2)                                          |                                          |                        |                               |
|                    |                       |                           | σ <sub>f</sub> = 15.(3)                         |                                          |                        |                               |
| <sup>93</sup> Np   |                       |                           |                                                 |                                          |                        |                               |
| <sup>234</sup> Np  |                       | 4.4 d                     | σ <sub>f</sub> = 9.(3)×10 <sup>2</sup>          |                                          |                        |                               |
| <sup>235</sup> Np  |                       | 1.085 y                   | 1.6(1)×10 <sup>2</sup>                          |                                          |                        |                               |
| <sup>236m</sup> Np |                       | 22.5 h                    | σ <sub>f</sub> = 2.7(2)×10 <sup>3</sup>         | 7.(4)×10 <sup>2</sup>                    |                        |                               |
| <sup>236</sup> Np  |                       | 1.55×10 <sup>5</sup> y    | σ <sub>f</sub> = 3.0(2)×10 <sup>3</sup>         | 1.35(30)×10 <sup>3</sup>                 |                        |                               |
| <sup>237</sup> Np  |                       | 2.14×10 <sup>6</sup> y    | 1.7(1)×10 <sup>2</sup>                          | 6.5(3)×10 <sup>2</sup>                   | 10.6(1)                |                               |
|                    |                       |                           | σ <sub>f</sub> = 20.(1) mb                      | RI <sub>f</sub> = 4.7                    |                        |                               |
| <sup>238</sup> Np  |                       | 2.117 d                   | σ <sub>f</sub> = 2.6(3)×10 <sup>3</sup>         | 1.4(3)×10 <sup>3</sup>                   |                        |                               |
| <sup>239</sup> Np  |                       | 2.355 d                   | (32.+19.)                                       |                                          |                        |                               |
|                    |                       |                           | σ <sub>f</sub> < 1.                             |                                          |                        |                               |
| <sup>94</sup> Pu   |                       |                           |                                                 |                                          |                        |                               |
| <sup>236</sup> Pu  |                       | 2.87 y                    | σ <sub>f</sub> = 1.6(3)×10 <sup>2</sup>         | 1000.(60)                                |                        |                               |
| <sup>237</sup> Pu  |                       | 45.7 d                    | σ <sub>f</sub> = 2.3(3)×10 <sup>3</sup>         |                                          |                        |                               |
| <sup>238</sup> Pu  |                       | 87.7 y                    | 5.1(2)×10 <sup>2</sup>                          | 1.6(2)×10 <sup>2</sup>                   | 14.1(5)                |                               |
|                    |                       |                           | σ <sub>f</sub> = 17.(1)                         | RI <sub>f</sub> = 26.(2)                 |                        |                               |
| <sup>239</sup> Pu  |                       | 2.410 x 10 <sup>4</sup> y | 2.7(1)×10 <sup>2</sup>                          | 2.0(2)×10 <sup>2</sup>                   | 7.7(1)                 |                               |
|                    |                       |                           | σ <sub>f</sub> = 752.(3)                        | 3.0(1)×10 <sup>2</sup>                   |                        |                               |
|                    |                       |                           | σ <sub>α</sub> ≤ 0.3 mb                         |                                          |                        |                               |
| <sup>240</sup> Pu  |                       | 6.56×10 <sup>3</sup> y    | 2.9(1)×10 <sup>2</sup>                          | 8.4(3)×10 <sup>3</sup>                   | 3.5(1)                 |                               |
|                    |                       |                           | σ <sub>f</sub> ≈ 59. mb                         | RI <sub>f</sub> = 3.2                    |                        |                               |
| <sup>241</sup> Pu  |                       | 14.4 y                    | 3.7(1)×10 <sup>2</sup> , σ <sub>α</sub> <0.2 mb | 1.6(1)×10 <sup>2</sup>                   |                        |                               |
|                    |                       |                           | σ <sub>f</sub> = 1.01(1)×10 <sup>3</sup>        | 5.7(4)×10 <sup>2</sup>                   |                        |                               |
| <sup>242</sup> Pu  |                       | 3.75 x 10 <sup>5</sup> y  | 19.(1)                                          | 1.1(1)×10 <sup>3</sup>                   | 8.1(1)                 |                               |
|                    |                       |                           | σ <sub>f</sub> <0.2                             | RI <sub>f</sub> = 0.23                   |                        |                               |
| <sup>243</sup> Pu  |                       | 4.956 h                   | <100.                                           |                                          |                        |                               |
|                    |                       |                           | σ <sub>f</sub> = 2.0(2)×10 <sup>2</sup>         |                                          |                        |                               |

\*Extrapolated value.

| Elem. or Isot.     | Natural Abundance (%) | Half-Life               | Thermal Neut. Cross-Section (barns)                               | Resonance Integral (barns)                                         | Coh. Scat. Length (fm) | σ (30 keV) Maxw. Avg. (barns) |
|--------------------|-----------------------|-------------------------|-------------------------------------------------------------------|--------------------------------------------------------------------|------------------------|-------------------------------|
| <sup>244</sup> Pu  |                       | 8.00×10 <sup>7</sup> y  | 1.7(1)                                                            | 41.(3)                                                             |                        |                               |
| <sup>245</sup> Pu  |                       | 10.5 h                  | 1.5(3)×10 <sup>2</sup>                                            | 220.(40)                                                           |                        |                               |
| <sup>95</sup> Am   |                       |                         |                                                                   |                                                                    |                        |                               |
| <sup>241</sup> Am  |                       | 432.7 y                 | (0.6+6.4)×10 <sup>2</sup><br>σ <sub>f</sub> = 3.15(10)            | (1.+14.)×10 <sup>2</sup><br>14.(1)                                 |                        |                               |
| <sup>242m</sup> Am |                       | 141. y                  | 1.7(4)×10 <sup>3</sup><br>σ <sub>f</sub> = 5.9(3)×10 <sup>3</sup> | ≈ 200.<br>RI <sub>f</sub> = 1.8(1)×10 <sup>3</sup>                 |                        |                               |
| <sup>242</sup> Am  |                       | 16.02 h                 | σ <sub>f</sub> = 2.1(2)×10 <sup>3</sup><br>3.3(5)×10 <sup>2</sup> | RI <sub>f</sub> = < 300.<br>≈ 1.5×10 <sup>2</sup>                  |                        |                               |
| <sup>243</sup> Am  |                       | 7.37×10 <sup>3</sup> y  | (75.+5.)<br>σ <sub>f</sub> = 79.(2) mb                            | (17.1+1.0)×10 <sup>2</sup><br>RI <sub>f</sub> = 0.056              | 8.3(2)                 |                               |
| <sup>244m</sup> Am |                       | ≈ 26. m                 | σ <sub>f</sub> = 1.6(3)×10 <sup>3</sup>                           |                                                                    |                        |                               |
| <sup>244</sup> Am  |                       | 10.1 h                  | σ <sub>f</sub> = 2.2(3)×10 <sup>3</sup>                           |                                                                    |                        |                               |
| <sup>96</sup> Cm   |                       |                         |                                                                   |                                                                    |                        |                               |
| <sup>242</sup> Cm  |                       | 162.8 d                 | ≈ 20.<br>σ <sub>f</sub> ≈ 5.                                      | 120.(50)                                                           |                        |                               |
| <sup>243</sup> Cm  |                       | 29.1 y                  | 1.3(1)×10 <sup>2</sup><br>σ <sub>f</sub> = 6.2(2)×10 <sup>2</sup> | 214.(20)<br>RI <sub>f</sub> = 1.6(1)×10 <sup>3</sup>               |                        |                               |
| <sup>244</sup> Cm  |                       | 18.1 y                  | 15.(1)<br>σ <sub>f</sub> = 1.1(2)                                 | 640.(50)<br>RI <sub>f</sub> = 10.8(8)                              | 9.5(3)                 |                               |
| <sup>245</sup> Cm  |                       | 8.48×10 <sup>3</sup> y  | 3.5(2)×10 <sup>2</sup><br>σ <sub>f</sub> = 2.1(1)×10 <sup>3</sup> | 110.(10)<br>RI <sub>f</sub> = 8.(1)×10 <sup>2</sup>                |                        |                               |
| <sup>246</sup> Cm  |                       | 4.76×10 <sup>3</sup> y  | 1.2(2)<br>σ <sub>f</sub> = 0.16(7)                                | 120.(10)<br>13.(2)                                                 | 9.3(2)                 |                               |
| <sup>247</sup> Cm  |                       | 1.56×10 <sup>7</sup> y  | 60.(30)<br>σ <sub>f</sub> = 82.(5)                                | 5.(1)×10 <sup>2</sup><br>7.3(7)×10 <sup>2</sup>                    |                        |                               |
| <sup>248</sup> Cm  |                       | 3.48×10 <sup>5</sup> y  | 2.6(3)<br>σ <sub>f</sub> = 0.36(7)                                | 270.(30)<br>13.(2)                                                 | 7.7(2)                 |                               |
| <sup>249</sup> Cm  |                       | 64.15 m                 | ≈ 1.6                                                             |                                                                    |                        |                               |
| <sup>250</sup> Cm  |                       | ≈ 9.7×10 <sup>3</sup> y | ≈ 80.                                                             |                                                                    |                        |                               |
| <sup>97</sup> Bk   |                       |                         |                                                                   |                                                                    |                        |                               |
| <sup>249</sup> Bk  |                       | 320. d                  | 7.(1)×10 <sup>2</sup><br>σ <sub>f</sub> ≈ 0.1                     | 9.(1)×10 <sup>2</sup>                                              |                        |                               |
| <sup>250</sup> Bk  |                       | 3.217 h                 | σ <sub>f</sub> = 1.0(2)×10 <sup>3</sup>                           |                                                                    |                        |                               |
| <sup>98</sup> Cf   |                       |                         |                                                                   |                                                                    |                        |                               |
| <sup>249</sup> Cf  |                       | 351. y                  | 5.0(3)×10 <sup>2</sup><br>σ <sub>f</sub> = 1.7(1)×10 <sup>3</sup> | 7.7(4)×10 <sup>2</sup><br>RI <sub>f</sub> = 2.1(3)×10 <sup>3</sup> |                        |                               |
| <sup>250</sup> Cf  |                       | 13.1 y                  | 2.0(2)×10 <sup>3</sup><br>σ <sub>f</sub> = 110.(90)               | 12.(2)×10 <sup>3</sup><br>RI <sub>f</sub> = 160.(40)               |                        |                               |
| <sup>251</sup> Cf  |                       | 9.0×10 <sup>2</sup> y   | 2.9(2)×10 <sup>3</sup><br>σ <sub>f</sub> = 4.5(5)×10 <sup>3</sup> | 1.6(1)×10 <sup>3</sup><br>RI <sub>f</sub> = 5.5(3)×10 <sup>3</sup> |                        |                               |
| <sup>252</sup> Cf  |                       | 2.65 y                  | 20.(2)<br>σ <sub>f</sub> = 32.(4)                                 | 43.(3)<br>RI <sub>f</sub> = 1.1(3)×10 <sup>2</sup>                 |                        |                               |
| <sup>253</sup> Cf  |                       | 17.8 d                  | 18.(2)<br>σ <sub>f</sub> = 1.3(2)×10 <sup>3</sup>                 | 8.(1)                                                              |                        |                               |
| <sup>254</sup> Cf  |                       | 60.5 d                  | 4.5(10)                                                           | 2.                                                                 |                        |                               |
| <sup>99</sup> Es   |                       |                         |                                                                   |                                                                    |                        |                               |
| <sup>253</sup> Es  |                       | 20.47 d                 | (180.+5.8)                                                        | (37.5+1.1)×10 <sup>2</sup>                                         |                        |                               |
| <sup>254m</sup> Es |                       | 1.64 d                  | σ <sub>f</sub> = 1.8(1)×10 <sup>3</sup>                           |                                                                    |                        |                               |
| <sup>254</sup> Es  |                       | 276. d                  | 28.(3)<br>σ <sub>f</sub> = 1.8(2)×10 <sup>3</sup>                 | 18.(2)<br>RI <sub>f</sub> = 1.2(3)×10 <sup>3</sup>                 |                        |                               |
| <sup>255</sup> Es  |                       | 40. d                   | ≈ 55.                                                             |                                                                    |                        |                               |
| <sup>100</sup> Fm  |                       |                         |                                                                   |                                                                    |                        |                               |
| <sup>255</sup> Fm  |                       | 20.1 h                  | 26.(3)<br>σ <sub>f</sub> = 3.3(2)×10 <sup>3</sup>                 | 14.(2)                                                             |                        |                               |
| <sup>257</sup> Fm  |                       | 100.5 d                 | σ <sub>f</sub> = 3.0(2)×10 <sup>3</sup>                           |                                                                    |                        |                               |

\*Extrapolated value.

# COSMIC RADIATION

A.G. Gregory and R.W. Clay

## The Nature of Cosmic Rays

Primary cosmic radiation, in the form of high energy nuclear particles, electrons and photons from outside the solar system and from the Sun, continually bombards our atmosphere. Secondary radiation, resulting from the interaction of the primary cosmic rays with atmospheric gas, is present at sea-level and throughout the atmosphere.

The secondary radiation is collimated by absorption and scattering in the atmosphere and consists of a number of components associated with different particle species. High energy primary particles can produce large numbers of secondary particles forming an extensive air shower. Thus, a number of particles may then be detected simultaneously at sea-level.

Primary particle energies accessible in the vicinity of the earth range from  $\sim 10^8$  eV to  $\sim 10^{20}$  eV. At the lower energies, the limit is determined by the inability of charged particles to traverse the heliosphere to us through the outward-moving solar wind. The upper energy limit is set by the practicality of building detectors to record particles with the extremely low fluxes found at those energies (J.G. Wilson, 1976; O.C. Allkofer, 1975a).

## Primary Cosmic Rays

### Primary Particle Energy Spectrum

Figure 1 shows the spectrum of primary particle energies. This includes all particle species. In differential form it is roughly a power law of intensity versus energy with an index of  $\sim -3$ . There appears to be a knee (a steepening) at a little above  $10^{15}$  eV and an ankle (a flattening) above  $\sim 10^{18}$  eV. Figure 2 emphasizes the features in the spectrum at the highest energies through multiplying the flux with a strongly rising power law of energy. This figure should be used with caution as errors for the two axes are not now independent.

Data on the high energy cosmic ray spectrum are uncertain largely because of limited event statistics due to the very low flux which might best be measured in particles per square kilometer per century. The highest energy event recorded to 1995 had an energy of  $3 \times 10^{20}$  eV (D.J. Bird et al., 1993).

It is expected that the highest energy cosmic rays will interact with the 2.7 K cosmic microwave background through photoproduction or photodisintegration. These interactions will appreciably reduce the observed flux of cosmic rays with energies above  $5 \times 10^{19}$  eV if they travel further than  $\sim 150$  million light years. This process is known as the Greisen-Zatsepin-Kuz'min (GZK) cut off (P. Sokolsky, 1989).

At energies below  $\sim 10^{13}$  eV, solar system magnetic fields and plasma can modulate the primary component and Figure 3 shows the extent of this modulation between solar maximum and minimum (E. Juliusson, 1975; J. Linsley, 1981).

### Primary Particle Energy Density

If the above spectrum is corrected for solar effects, the energy density above a particle energy of  $10^8$  eV outside the solar system is found to be  $\sim 5 \times 10^5$  eV  $m^{-3}$ . As the threshold energy is increased, the energy density decreases rapidly, being  $2 \times 10^4$  eV  $m^{-3}$  above  $10^{12}$  eV and  $10^2$  eV  $m^{-3}$  above  $10^{15}$  eV. The energy density at lower energies outside the heliosphere is unknown but may be substan-

tially greater if the particle rest mass energy is included together with the kinetic energy (A. W. Wolfendale, 1979).

### Primary Particle Isotropy

This is measured as an anisotropy  $(I_{\max} - I_{\min})/(I_{\max} + I_{\min}) \times 100\%$ , where  $I$ , the intensity ( $m^{-2}s^{-1}sr^{-1}$ ), is usually measured with an angular resolution of a few degrees.

The measured anisotropy is small and energy dependent. It is roughly constant in amplitude at between 0.05 and 0.1% (with a phase of 0 to 6 hours in right ascension) for energies between  $10^{11}$  eV and  $10^{14}$  eV and appears to increase at higher energies roughly as  $0.4 \times (\text{Energy(eV)}/10^{16})^{0.5}$  up to  $\sim 10^{18}$  eV. The latter rise may well be an artifact of the progressively more limited statistics as the flux drops rapidly with energy. It appears possible that a real anisotropy has been observed at the highest energies (above a few times  $10^{19}$  eV) with a directional preference for the supergalactic plane (this plane reflects the directions of galaxies within about 100 million light years) (A.W. Wolfendale, 1979; R.W. Clay, 1987; T. Stanev et al., 1995).

### Primary Particle Composition

The composition of low energy cosmic rays is close to universal nuclear abundances except where propagation effects are present. For example, Li, Be, and B which are spallation products, are over-abundant by about six orders of magnitude.

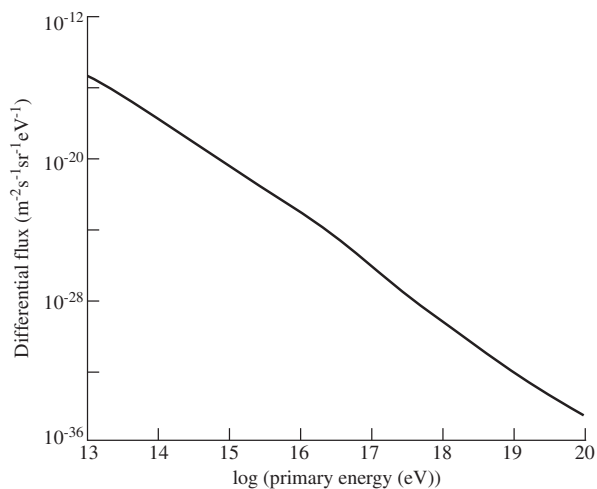
| Composition at $10^{11}$ eV per nucleus |    |    |       |       |         |         |         |
|-----------------------------------------|----|----|-------|-------|---------|---------|---------|
| Charge                                  | 1  | 2  | (3-5) | (6-8) | (10-14) | (16-24) | (26-28) |
| % Composition                           | 50 | 25 | 1     | 12    | 7       | 4       | 4       |
| (10% uncertainty)                       |    |    |       |       |         |         | 0.1     |

Measurements at higher energies indicate that there is an increase in the relative abundances of nuclei with charge greater than 6 at energies above 50 TeV/nucleus (K. Asakimori et al., 1993) ( $1 \text{ TeV} = 10^{12} \text{ eV}$ ).

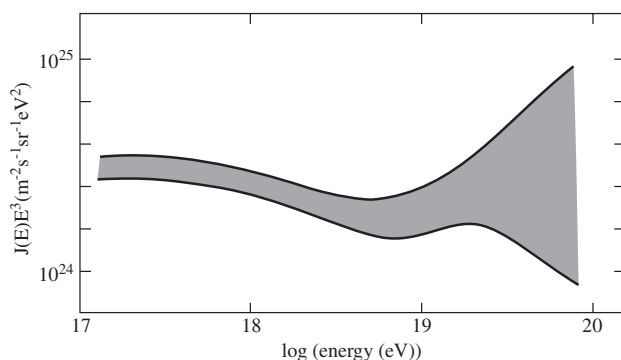
Cosmic ray composition at low energies is often quoted at a fixed energy per nucleon. When presented in this way, protons constitute roughly 90% of the flux, helium nuclei about 10% and the remainder sum to a total of about 1%.

Certain radioactive isotopic ratios show lifetime effects. The ratio of  $Be^{10}/B^9$  abundances is used to measure an "age" of cosmic rays since  $Be^{10}$  is unstable with a half life of about  $1.6 \times 10^6$  years. A ratio of 0.6 is expected in the absence of  $Be^{10}$  decay and a ratio of about 0.2 is found experimentally (E. Juliusson, 1975; P. Meyer, 1981).

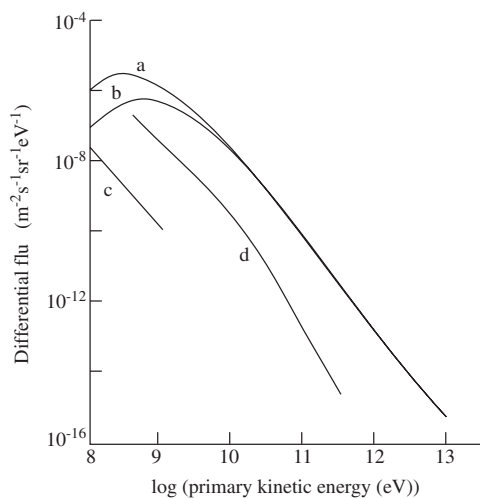
At higher energies, composition determinations are indirect and are rather contradictory and controversial. Experiments aim to differentiate between broad composition models. The measurement technique is based on studies of cosmic ray shower development. A rather direct technique for such studies is to use fluorescence observations of the shower development to determine the atmospheric depth of maximum development of the shower. Such observations suggest a heavy composition (large atomic number) at energies  $\sim 10^{17}$  eV which changes with increasing energy to a light composition (perhaps protonic) above  $\sim 10^{19}$  eV (T. K. Gaisser et al., 1993).



**FIGURE 1.** The energy spectrum of cosmic ray particles. This spectrum is of a differential form and can be converted to an integral spectrum by integration over all energies above a required threshold ( $E$ ). Insofar as the spectrum approximates a power law of index  $-3$ , a simple conversion to the integral at an energy  $E/1.8$  is obtained by multiplying the differential flux by the energy and dividing by  $0.62$ .



**FIGURE 2.** Energy spectrum at the highest energies. This spectrum (after Yoshida et al., 1995) has the differential spectrum multiplied by energy cubed. It is from a compilation of a number of measurements and indicates the good general agreement at the lower energies and a spread due to inadequate statistics at the highest energies.



**FIGURE 3.** Energy spectrum of particles at lower energies. (a) Solar minimum proton energy spectrum. (b) Solar maximum proton energy spectrum. (c) Gamma-ray energy spectrum. (d) Local interstellar electron spectrum.



### Primary Electrons

Primary electrons constitute about 1% of the cosmic ray beam. The positron to negative electron ratio is about 10% (J. M. Clem et al., 1995).

### Antimatter in the Primary Beam

The ratio of antiprotons to protons in the primary cosmic ray beam (at about 400 MeV) is about  $10^{-5}$ . At about 10 GeV the ratio is about  $10^{-3}$ . At the highest measured energies (10 TeV), the upper limit to the ratio is about 20% (S. Orito et al., 1995; M. Amenomori et al., 1995).

### Primary Gamma-Rays

The flux of primary gamma-rays is low at high energies. At 1 GeV the ratio of gamma-rays to protons is about  $10^{-6}$ . The arrival directions of these gamma-rays are strongly concentrated in the plane of the Milky Way although there is a diffuse, near isotropic background flux and some point sources have been detected.

Since the absorption cross section for gamma-rays above 100 MeV is approximately 20 mbarn/electron, less than 10% of gamma-rays reach mountain altitudes (A. W. Wolfendale, 1979; P. F. Michelson, 1994).

### Sea Level Cosmic Radiation

The sea level cosmic ray dose is 300 millirad-yr<sup>-1</sup> and the sea level ionization is  $2.2 \times 10^6$  ion pairs m<sup>-3</sup>s<sup>-1</sup>. The sea level flux has a soft component, which can be absorbed in about 100 mm of lead (about 100 g·cm<sup>-2</sup> of absorber) and a more penetrating (largely muon) hard component. The sea level radiation is largely produced in the atmosphere and is a secondary component from interactions of the primary particles. The steep primary energy spectrum means that most secondaries at sea level are from rather low energy primaries. Thus the secondary flux is dependent on the solar cycle and the geomagnetic latitude of the observer.

### Absolute Flux of the Hard Component

Vertical Integral Intensity  $I(0) \sim 100 \text{ m}^{-2}\text{s}^{-1}\text{sr}^{-1}$

Angular dependence  $I(\theta) \sim I(0) \cos^2(\theta)$

Integrated Intensity  $\sim 200 \text{ m}^{-2}\text{s}^{-1}$

(O.C. Allkofer, 1975b).

### Flux of the Soft Component

In free air, the soft component comprises about one third of the total cosmic ray flux.

### Latitude Effect

The geomagnetic field influences the trajectories of lower energy cosmic rays approaching the Earth. As a result, the background flux is reduced by about 7% at the geomagnetic equator. The effect decreases towards the poles and is negligible at latitudes above about 40°.

### Flux of Protons

The proton component is strongly attenuated by the atmosphere with an attenuation length (reduction by a factor of e) of about 120 g·cm<sup>-2</sup>. It constitutes about 1% of the total vertical sea level flux.

### Absorption

The soft component is absorbed in about 100 g·cm<sup>-2</sup> of matter. The hard component is absorbed much more slowly:

Absorption in lead, 6% per 100 g·cm<sup>-2</sup>

Absorption in rock, 8.5% per 100 g·cm<sup>-2</sup>

Absorption in water, 10% per 100 g·cm<sup>-2</sup>

(Absorption for depths less than 100 g·pd cm<sup>-2</sup> is given by K. Greisen, 1943.)

### Altitude Dependence

The cosmic ray background in the atmosphere has a maximum intensity of about 15 times that at sea level at a depth of about 150 g·cm<sup>-2</sup> (15 km altitude). At maximum intensity, the soft and hard components contribute roughly equally but the hard component is then attenuated more slowly (S. Hayakawa, 1969).

### Cosmic Ray Showers

High energy cosmic rays produce particle cascades in the atmosphere which can be detected at sea level provided that their energy exceeds about 100 GeV (such low energy cascades may be detected by using the most sensitive atmospheric Cerenkov detectors). The primary particle progressively loses energy which is transferred through the production of successive generations of secondary particles to a cascade of hadrons, an electromagnetic shower component (both positively and negatively charged electrons and gamma-rays) and muons. The secondary particles are relativistic and all travel effectively at the speed of light. As a result, they reach sea level at approximately the same time but, due to Coulomb scattering (for the electrons) and production angles (for the pions producing the muons), are spread laterally into a disk-like shower front with a characteristic lateral width of several tens of meters and thickness (near the central shower core) of 2 to 3 m. The number of particles at sea level is roughly proportional to the primary particle energy:

Number of particles at sea level  $\sim 10^{-10} \times \text{energy (eV)}$ .

At altitudes below a few kilometers, the number of particles in a shower attenuates with an *attenuation length* of about 200 g·cm<sup>-2</sup>.

i.e., particle number = original number  $\times \exp[-(\text{depth increase})/200]$

The above applies to an individual shower. The rate of observation of showers of a given size (particle number at the detector) at different depths of absorber attenuates with an *absorption length* of about 100 g·cm<sup>-2</sup> (J.G. Wilson, 1976).

### Atmospheric Background Light from Cosmic Rays

Cosmic ray particles produce Cerenkov light in the atmosphere and produce fluorescent light through the excitation of atmospheric molecules.

### Cerenkov Light

High energy charged particles will cause the emission of Cerenkov light in air if their energies are above about 30 MeV (electrons). This threshold is pressure (and hence altitude) dependent. A typical Cerenkov light pulse (at sea level, 100 m from the central shower core) has a time spread of a few nanoseconds. Over this time, the photon flux between 430 and 530 nm would be  $\sim 10^{14} \text{ m}^{-2}\text{s}^{-1}$  for a primary particle energy of  $10^{16} \text{ eV}$ . For comparison, the night sky background flux is  $\sim 6 \times 10^{11} \text{ photons m}^{-2}\text{s}^{-1}\text{sr}^{-1}$  in the same wavelength band (J.V. Jelley, 1967).

### Fluorescence Light

Cosmic ray particles in the atmosphere excite atmospheric molecules which then emit fluorescence light. This is weak compared to the highly collimated Cerenkov component when viewed in the direction of the incident cosmic ray particle but is emitted



isotropically. Typical pulse widths are longer than 50 ns and may be up to several microseconds for the total pulse from distant large showers (R.M. Baltrusaitis et al., 1985).

## Effects of Cosmic Rays

### Cerenkov Effects in Transparent Media

Background cosmic ray particles will produce Cerenkov light in transparent material with a photon yield between wavelengths  $\lambda_1$  and  $\lambda_2$

$$\sim (2\pi/137)\sin^2(\theta_c) \int_{\lambda_1}^{\lambda_2} d\lambda / \lambda^2 \text{ photons(unit length)}^{-1}$$

where  $\theta_c$  (the Cerenkov angle) =  $\cos^{-1}(1/\text{refractive index})$ .

This background light is known to affect light detectors, e.g., photomultipliers, and can be a major source of background noise (R.W. Clay and A.G. Gregory, 1977).

### Effects on Electronic Components

If background cosmic ray particles pass through electronic components, they may deposit sufficient energy to affect the state of, e.g., a transistor flip-flop. This effect may be significant where reliability is of great importance or the background flux is high. For instance, it has been estimated that, in communication satellite operation, an error rate of about  $2 \times 10^{-3}$  per transistor per year may be found. Permanent damage may also result. A significant error rate may be found even at sea level in large electronic memories. This error rate is dependent on the sensitivity of the component devices to the deposition of electrons in their sensitive volumes (J.F. Ziegler, 1981).

### Biophysical Significance

When cosmic rays interact with living tissue, they produce radiation damage. The amount of the damage depends on the total dose of radiation. At sea level, this dose is small compared with doses from other sources but both the quantity and quality of the radiation change rapidly with altitude. Approximate dose rates under various conditions are:

Dose rates (mrem.yr<sup>-1</sup>)  
 Sea level cosmic rays, 30  
 Cosmic rays at 10 km (subsonic jets), 2000  
 Cosmic rays at 18 km (supersonic transports), 10,000  
 (c.f., mean total sea level dose, 300)

Astronauts would be subject to radiation from galactic (0.05 rads per day) and solar (a few hundred rads per solar flare) cosmic rays as well as large fluxes of low energy radiation when passing through the Van Allen belts (about 0.3 rads per traverse).

Both astronauts and SST travellers would be subject to a small flux of low energy heavy nuclei stopping in the body. Such particles are capable of destroying cell nuclei and could be particularly harmful in the early stages of the development of an embryo. The rates of heavy nuclei stopping in tissue in supersonic transports and spacecraft are approximately as follows:

Stopping nuclei ((cm<sup>3</sup> tissue)<sup>-1</sup> hr<sup>-1</sup>)  
 Supersonic transport (16 km), 0.0005  
 Supersonic transport (20 km), 0.005  
 Spacecraft, 0.15  
 (O. C. Allkofer, 1975a; O. C. Allkofer et al., 1974).

## Carbon Dating

Radiocarbon is produced in the atmosphere due to the action of cosmic ray slow neutrons. Solar cycle modulation of the very low energy cosmic rays causes an anticorrelation of the atmospheric <sup>14</sup>C activity with sunspot number with a mean amplitude of about 0.5%. In the long term, modulation of cosmic rays by a varying magnetic field may be important (A.A. Burchuladze et al., 1979).

## Practical Uses of Cosmic Rays

There are few direct practical uses of cosmic rays. Their attenuation in water and snow have, however, enabled automatic monitors of water and snow depth to be constructed. A search for hidden cavities in pyramids has been carried out using a muon "telescope".

## Other Effects

Stellar X-rays have been observed to affect the transmission times of radio signals between distant stations by altering the depth of the ionospheric reflecting layer. It has also been suggested that variations in ionization of the atmosphere due to solar modulation may have observable effects on climatic conditions.

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# TECHNIQUES FOR MATERIALS CHARACTERIZATION

## Experimental Techniques Used to Determine the Composition, Structure, and Energy States of Solids and Liquids

H.P.R. Frederikse

The many experimental methods, originally designed to study the chemical and physical behavior of solids and liquids, have grown into a new field known as Materials Characterization (or Materials Analysis). During the past 30 years a host of techniques aimed at the study of surfaces and thin films has been added to the many tools for the analysis of bulk samples. The field has benefited particularly from the development of computers and micro-processors, which have vastly increased the speed and accuracy of the measuring devices and the recording of their output. Materials characterization was and is a very important tool in the search for new physical and chemical phenomena. It plays an essential role in new applications of solids and liquids in industry, communications, and medicine. Many of its techniques are used in quality control, in safety regulations, and in the fight against pollution.

In most Materials Characterization experiments the sample is subjected to some kind of radiation: electromagnetic, acoustic, thermal, or particles (electrons, ions, neutrons, etc.). The surface

analysis techniques usually require a high vacuum. As a result of interactions between the solid (or liquid) and the incoming radiation a beam of a similar (or a different) nature will emerge from the sample. Measurement of the physical and/or chemical attributes of this emerging radiation will yield qualitative, and often quantitative, information about the composition and the properties of the material being probed.

The modern tendency of describing practically everything in this world by a combination of a few letters (acronyms) has also penetrated the field of Materials Characterization. The table below gives the meaning of the acronym for every technique listed, the form and size of the required sample (bulk, surface, film, liquid, powder, etc.), the nature of the incoming and of the emerging radiation, the depth and the lateral spatial resolution that can be probed, and the information obtained from the experiment. The last column lists one or two major references to the technique described.

|                                                               | Technique                                                        | Sample                                                                 | In                                        | Out                                                               | Depth                                      | Lateral resolution | Information obtained                                                                                                 | Ref.     |
|---------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------|-------------------------------------------------------------------|--------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------|----------|
| <b>Optical and Mass Spectroscopies for Chemical Analysis</b>  |                                                                  |                                                                        |                                           |                                                                   |                                            |                    |                                                                                                                      |          |
| 1.                                                            | AAS<br>Atomic Absorption Spectroscopy                            | Atomize (flame, electro, thermal, etc.)                                | Light e.g., glow discharge                | Absorption spectrum                                               | —                                          | —                  | Concentration of atomic species (quantitative, using standards)                                                      | 1,2      |
| 2.                                                            | ICP-AES<br>Induct. Coupled Plasma – Atomic Emission Spectroscopy | Atomize (flame, electro, thermal, ICP, etc.)                           | —                                         | Emission spectrum                                                 | —                                          | —                  | Concentration of atomic species (quantitative, using standards)                                                      | 3        |
| 3.                                                            | Dynamic SIMS<br>Dynamic Secondary Ion Mass Spectroscopy          | Surface                                                                | Ion beam (1–20 keV)                       | Secondary ions; analysis with mass spectrometer                   | 2 nm–1 $\mu$ m (or deeper: ion milling)    | 0.50 nm            | Elemental and isotopic analysis; depth profile (all elements); detection limits: ppb–ppm                             | 4        |
| 4.                                                            | Static SIMS<br>Static Secondary Ion Mass Spectroscopy            | Surface                                                                | Ion beam (0.5–20 keV)                     | Secondary ions, analysis with mass spectrometer                   | 0.1–0.5 nm                                 | 10 $\mu$ m         | Elemental analysis of surface layers; molecular analysis; detection limits: ppb–ppm                                  | 4        |
| 5.                                                            | SNMS<br>Sputtered Neutral Mass Spectroscopy                      | Surface, bulk                                                          | Plasma discharge; noble gases: 0.5–20 keV | Sputtered atoms ionized by atoms or electrons; then mass analyzed | 0.1–0.5 nm (or deeper: ion milling)        | 1 cm               | Elemental analysis $Z \geq 3$ ; depth profile; detection limit: ppm                                                  | 4,6      |
| 6.                                                            | SALI<br>Surface Analysis by Laser Ionization                     | Surface                                                                | e-beam, ion-beam, or laser for sputtering | Sputtered atoms ionized by laser; then mass analyzed              | 0.1–0.5 nm up to 3 $\mu$ m in milling mode | 60 nm              | Surface analysis; depth profiling                                                                                    | 7        |
| 7.                                                            | LIMS<br>Laser Ionization Mass Spectroscopy                       | Surface, bulk                                                          | u.v. laser (ns pulses)                    | Ionized species; analyzed with mass spectrometer                  | 50–150 nm                                  | 5 $\mu$ m–1 mm     | Elemental (micro)analysis; detection limits: 1–100 ppm                                                               | 8        |
| 8.                                                            | SSMS<br>Spark Source Mass Spectroscopy                           | Sample in the form of two electrodes                                   | High voltage R.F. spark produces ions     | Ions – analyzed in mass spectrometer                              | 1–5 $\mu$ m                                | —                  | Survey of trace elements; detection limit: 0.01–0.05 ppm                                                             | 9        |
| 9.                                                            | GDMS<br>Glow Discharge Mass Spectroscopy                         | Sample forms the cathode for a D.C. glow discharge                     | Sputtered atoms ionized in plasma         | Ions – analyzed in mass spectrometer                              | 0.1–100 $\mu$ m                            | 3–4 mm             | (Bulk) trace element analysis; detection limit: sub-ppb                                                              | 9,10     |
| 10.                                                           | ICPMS<br>Induct. Coupled Plasma Mass Spectroscopy                | Liquid-dissolved sample carried by gas stream into R.F. induction coil | Ions produced in argon plasma             | Ions – analyzed in quadrupole mass spectrometer                   | —                                          | —                  | High sensitivity analysis of trace elements                                                                          | 11       |
| <b>Photons — Absorption, Reflection and Electron Emission</b> |                                                                  |                                                                        |                                           |                                                                   |                                            |                    |                                                                                                                      |          |
| 11.                                                           | IRS<br>Infrared Spectroscopy                                     | Thin crystal, glass, liquid                                            | I.R. light (W-filament, globar, Hg-arc)   | I.R. spectrum                                                     | —                                          | —                  | Electronic transitions (mainly in semiconductors and superconductors); vibrational modes (in crystals and molecules) | 12,13,14 |
| 12.                                                           | FTIR<br>Fourier Transform I.R. Spectroscopy                      | Solid, liquid; transmission or reflection                              | White light (all frequencies)             | Fourier Transform of spectrum (interferometer)                    | —                                          | —                  | Spectra obtained at higher speed and resolution                                                                      | 15       |
| 13.                                                           | ATR<br>Attenuated Total Reflection                               | Surface or thin crystal                                                | —                                         | —                                                                 | $\mu$ m's                                  | —                  | Atomic or molecular spectra of surfaces and films                                                                    | 16       |
| 14.                                                           | ( $\mu$ )-RS<br>(Micro-) Raman Spectroscopy                      | Solid, liquid (1 $\mu$ m–1 cm)                                         | Laser beam, e.g., Ar-line, YAG-line       | Raman spectra                                                     | 0.5 $\mu$ m                                | 0.5 $\mu$ m        | Molecular and crystal vibrations                                                                                     | 12,14,17 |

|                  | Technique                                                                            | Sample                                             | In                                                                                                         | Out                                                   | Depth                   | Lateral resolution                     | Information obtained                                                                          | Ref.           |
|------------------|--------------------------------------------------------------------------------------|----------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------|----------------|
| 15.              | CARS<br>Coherent Anti-Stokes Raman Spectroscopy                                      | Solid, liquid (50 $\mu\text{m}$ –3 cm)             | Pump beam ( $\omega_p$ )+ probe beam ( $\omega_s$ )                                                        | Anti-Stokes spectrum                                  | –                       | –                                      | High resolution Raman spectra                                                                 | 14             |
| 16.              | Ellipsometry                                                                         | Transparent films, crystals, adsorbed layers       | Polarized light                                                                                            | Change in polarization                                | 0.05 nm–5 $\mu\text{m}$ | 25 $\mu\text{m}$ (or sample thickness) | Refractive index and absorption                                                               | 18,19          |
| 17.              | UPS<br>Ultraviolet Photo-electron Spectroscopy                                       | Surfaces, adsorbed layers                          | u.v. light, 10–100 eV; 200 eV (synchrotron)                                                                | Electrons                                             | 0.2–10 nm               | 0.1–10 nm                              | Energies of electronic states of surfaces and free molecules                                  | 20,21          |
| 18.              | PSD<br>Photon Stimulated Desorption                                                  | Surfaces with adsorbed species                     | Far u.v. light $E > 10$ eV                                                                                 | Ions – analyzed with mass spectrometer                | 0.1–2 nm                | –                                      | Structure and desorption kinetics of adsorbed atoms and molecules                             | 22             |
| <b>X-Rays</b>    |                                                                                      |                                                    |                                                                                                            |                                                       |                         |                                        |                                                                                               |                |
| 19.              | XRD<br>X-Ray Diffraction                                                             | Single crystals, powders, films                    | X-rays: $\lambda = 0.05$ –0.2 nm (6–17 keV)                                                                | Diffacted X-ray beam                                  | 1–1000 $\mu\text{m}$    | 0.1–10 mm                              | Identification of crystallographic structures; all elements (low Z difficult)                 | 23,24          |
| 20.              | XRF/EDS<br>X-Ray Fluorescence/Energy Dispersive Spectroscopy                         | Thin films, single layer                           | Prim. X-ray beam $\lambda = 0.02$ –0.1 nm 12–80 keV                                                        | Fluorescent X-rays                                    | 1–100 $\mu\text{m}$     | 10 mm                                  | Elemental analysis; all elements except H, He, Li – (EDS also used in XRD, SEM, TEM and EPMA) | 25,26          |
| 21.              | EXAFS<br>Extended X-Ray Absorption Fine Structure                                    | Films, foils                                       | High intensity X-rays (synchrotron)                                                                        | Spectrum near absorption edge                         | nm– $\mu\text{m}$       | –                                      | Local atomic structure: order/disorder in vicinity of absorbing atom                          | 27             |
| 22.              | XPS/ESCA<br>X-Ray Photo-electron Spectroscopy/ Electron Spect. for Chemical Analysis | Surfaces, thin films ( $\approx 20$ atomic layers) | Soft X-rays (1–20 keV)                                                                                     | Core electrons; valence electrons                     | 0.5–10 nm               | 5 nm–50 $\mu\text{m}$                  | (Quantitative) identification of all elements in surface layer or film                        | 28,29          |
| <b>Electrons</b> |                                                                                      |                                                    |                                                                                                            |                                                       |                         |                                        |                                                                                               |                |
| 23.              | CL<br>Cathode Luminescence                                                           | Insulators, semiconductors                         | Electrons 5–50 keV                                                                                         | Photons 0.1–5 eV                                      | 1 nm–2 $\mu\text{m}$    | 1 or 2 $\mu\text{m}$                   | Energy levels of impurities and point defects                                                 | 30             |
| 24.              | APS<br>Appearance Potential Spectroscopy                                             | Surface ( $\approx 20$ atomic layers)              | Electrons (energy scan) 50–2000 eV                                                                         | X-rays to pinpoint electron energy threshold          | –                       | –                                      | Identification of surface species                                                             | 21, see also C |
| 25.              | AES<br>Auger Electron Spectroscopy                                                   | Thin films, surfaces                               | Electrons 3–10 keV                                                                                         | Auger electrons 20–2000 eV                            | 0.3–3 nm                | $\approx 30$ nm                        | Elemental composition of surface (except H, He); detection limit 0.1–1%                       | 28,29          |
| 26.              | EELS<br>Electron Energy Loss Spectroscopy                                            | Very thin samples (<200 nm)                        | Electrons (100–400 keV)                                                                                    | (Retarded) electrons; minus 1–1000 eV                 | <200 nm                 | 1–100 nm                               | Local elemental concentration; electronic structure, chem. bonding; interatomic distances     | 31             |
| 27.              | EXELFS<br>Extended Electron Energy Loss Fine Structure                               | Thin films                                         | Electrons (100–400 keV)                                                                                    | Electrons energies 0–30 eV above edge                 | <200 nm                 | 1–100 nm                               | Density of states of valence electrons (above Fermi level)                                    | 27,32          |
| 28.              | ESD<br>Electron Stimulated Desorption                                                | Adsorbed species                                   | Electrons $E > 10$ eV                                                                                      | Ions – analyzed with mass spectrometer                | –                       | –                                      | Structure and desorption properties of adsorbed atoms and molecules                           | 22             |
| 29.              | ESDIAD<br>ESD-Ion Angular Distribution                                               | (See ESD)                                          | (See ESD)                                                                                                  | Directional dependence of emitted ions                | –                       | –                                      | Geometries of adsorbed species (atoms or molecules)                                           | 22             |
| 30.              | EPMA<br>Electron Probe (X-Ray) Micro Analysis                                        | Solid conductors and insulators <1 cm thick        | Electrons 5–30 keV                                                                                         | Characteristic X-ray 0.1–15 keV                       | 100 nm–5 $\mu\text{m}$  | 1 $\mu\text{m}$                        | Elemental analysis, $Z \leq 4$ , major, minor and trace amounts                               | 33,34          |
| 31.              | LEED<br>Low Energy Electron Diffraction                                              | Surface                                            | Mono-energetic electron beam 10–1000 eV                                                                    | Diffacted electrons                                   | 0.4–2 nm                | <5 $\mu\text{m}$                       | Crystallographic structure of surface; resolution: 0.01 nm                                    | 35             |
| 32.              | RHEED<br>Reflection High Energy Electron Diffraction                                 | Surface                                            | Electron beam at grazing angle 5–50 keV                                                                    | Reflected electrons                                   | 0.2–10 nm               | <5 $\mu\text{m}$                       | Surface symmetry                                                                              | 36,37          |
| 33.              | SEM<br>Scanning Electron Microscopy                                                  | Bulk, films (conducting)                           | High energy electrons usually $\approx 30$ keV                                                             | Secondary and backscattered electrons                 | 1 nm–5 $\mu\text{m}$    | 1–20 nm                                | Surface image, defect structure; resolution 5–15 nm; magnification 300,000 $\times$           | 33,34          |
| 34.              | (S)TEM<br>(Scanning) Transmission Electron Microscopy                                | Thin specimen – <200 nm                            | High energy electrons typically 300 keV                                                                    | Transmitted and diffracted electrons                  | (Sample thickness)      | 2–20 nm                                | (Defect) structure of cryst. solids; microchemistry; high resol.: 0.2 nm                      | 33             |
| 35.              | FEM<br>Field Emission Microscopy                                                     | Metals, alloys (sharp point)                       | –                                                                                                          | Electron emission (with appl. electric field – 50 kV) | $\approx 0.5$ nm        | 10–100 nm                              | Surface image, crystallographic structure                                                     | 34             |
| 36.              | STM<br>Scanning Tunneling Microscopy                                                 | Polished or cleaved surface (conducting)           | Tunneling current controls distance between sample and very sharp tip                                      |                                                       | 1–5 nm                  | 2–10 nm                                | Atomic-scale relief map of surface; resolution: vert. 0.002 nm, hor. 0.2 nm                   | 39             |
| 37.              | SPM<br>Scanned Probe Microscopy                                                      | Very flat surface                                  | Any field: e.g. mechan. vibration recorded with laser probe; same with magnetic, electric or thermal field |                                                       | 1–100 nm                | 1–100 nm                               | Surface-magnetic field, surface-thermal conductivity, etc.                                    | 39a            |
| 38.              | AFM<br>Atomic Force Microscopy                                                       | Very flat surface                                  | Similar to STM; force measured with cantilever spring                                                      |                                                       | 0.5–5 nm                | 0.2–130 nm                             | Surface topography with atomic resolution; interatomic force                                  | 40             |

|                          | Technique                                                                | Sample                                                   | In                                                                                            | Out                                                     | Depth      | Lateral resolution | Information obtained                                                                                                                              | Ref.  |
|--------------------------|--------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------|---------------------------------------------------------|------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| <b>Ions and Neutrons</b> |                                                                          |                                                          |                                                                                               |                                                         |            |                    |                                                                                                                                                   |       |
| 39.                      | ISS (or LEIS)<br>Ion Scattering Spectroscopy (Low Energy Ion Scattering) | Surface                                                  | Ion beam He <sup>+</sup> or Ne <sup>+</sup> <3 keV                                            | Sputtered ions (energy analysis)                        | 0.1–0.5 nm | 1–100 μm           | Elemental analysis (better for low Z) detection limits: 0.01–1%                                                                                   | 41    |
| 40.                      | FIM<br>Field Ion Microscopy                                              | Surface: metals, alloys; very sharp tip                  | (He gas above sample)                                                                         | He ions + high electric field produce image             | ≈0.1 nm    | 0.1–2 nm           | Atomic structure of surface                                                                                                                       | 34,42 |
| 41.                      | RBS<br>Rutherford Back Scattering                                        | Solids, thin films                                       | Mono-energetic ions (H <sup>+</sup> or He <sup>+</sup> ) 0.5–3 MeV                            | Backscattered ions                                      | 10 nm–1 μm | 1 mm               | Element identification (Li to U) detection limit: 0.01–1%                                                                                         | 46    |
| 42.                      | NRA<br>Nuclear Reaction Analysis                                         | Solids, thin films                                       | Mono-energetic ions (Li, Be, B, etc.) 200 keV–6 MeV                                           | Protons, deuterons <sup>3</sup> He, α-particles, γ-rays | 0.1–5 μm   | 10 μm–10 mm        | Element identification (all) detection limit: 10 <sup>-12</sup> –10 <sup>-2</sup>                                                                 | 47    |
| 43.                      | PIXE<br>Particle Induced X-ray Emission                                  | Thin films, surface layers                               | High energy ions (H <sup>+</sup> or He <sup>+</sup> )                                         | Characteristic X-rays                                   | <10 μm     | 1 μm–2 mm          | Trace impurities: Z>3 detection limit: 0.1–100 ppm (depending on sample thickness)                                                                | 48    |
| 44.                      | INS<br>Ion Neutralization Spectroscopy                                   | Surface                                                  | He-ions (≈5 eV)                                                                               | Electrons                                               | –          | –                  | Energies of valence electrons                                                                                                                     | 49    |
| 45.                      | NAA<br>Neutron Activation Analysis                                       | Bulk, >0.5 g                                             | Thermal neutrons                                                                              | Characteristic γ-rays, (≈1 MeV)                         | Bulk       | –                  | Trace concentrations (of isotopes) of elements: trans. metals, Pt-group; detection limit: 10 <sup>8</sup> –10 <sup>14</sup> atoms/cm <sup>3</sup> | 43    |
| 46.                      | N(P)D<br>Neutron (Powder) Diffraction                                    | Crystalline solids                                       | Thermal neutrons E ≈0.0025 eV                                                                 | Diffacted neutrons                                      | Bulk       | –                  | Crystallographic structure; porosity, particle size                                                                                               | 44    |
| 47.                      | SANS<br>Small Angle Neutron Scattering                                   | Inhomogeneous solids; powders; porous samples            | Thermal neutrons 2 θ = 10 <sup>-2</sup> –10 <sup>-4</sup>                                     | Scattered neutrons                                      | 1–25 mm    | –                  | Average size of inhomogeneities; range: 1 nm–1 mm                                                                                                 | 45    |
| <b>Acoustic</b>          |                                                                          |                                                          |                                                                                               |                                                         |            |                    |                                                                                                                                                   |       |
| 48.                      | SLAM<br>Scanning Laser Acoustic Microscopy                               | Bulk, film                                               | Acoustic wave produced by laser 1 MHz–1 GHz                                                   | Reflected acoustic wave                                 | μm–cm      | 0.1–20 mm          | Defect structure; thickness measurement                                                                                                           | 50    |
| <b>Thermal</b>           |                                                                          |                                                          |                                                                                               |                                                         |            |                    |                                                                                                                                                   |       |
| 49.                      | DTA<br>Differential Thermal Analysis                                     | Specimen and reference sample                            | Uniform heating                                                                               | Temperature difference                                  | Bulk       | –                  | Phase transitions, crystallization                                                                                                                | 51    |
| 50.                      | DSC<br>Differential Scanning Calorimetry                                 | Specimen and ref. sample                                 | Controlled heating                                                                            | Measure heat required for equal temperature             | Bulk       | –                  | Phase transitions, crystallization; activation energies                                                                                           | 51    |
| 51.                      | TGA<br>Thermo Gravimetric Analysis                                       | Bulk, 1–100 g                                            | Controlled heating                                                                            | Weight as function of temperature (and time)            | Bulk       | –                  | Decomposition, non-stoichiometry, kinetics of reaction                                                                                            | 52    |
| <b>Resonance</b>         |                                                                          |                                                          |                                                                                               |                                                         |            |                    |                                                                                                                                                   |       |
| 52.                      | EPR (ESR)<br>Electron Paramagnetic (Spin) Resonance                      | Paramagnetic solids or liquids                           | Microwave radiation in magnetic field 3–300 GHz; 1–100 kG                                     | Microwave absorption (at resonance)                     | Bulk       | –                  | Local environment of paramagnetic ion; concentration of paramagnetic, species; detection limit: 10 <sup>11</sup> spins/cm <sup>3</sup>            | 53,54 |
| 53.                      | ECR<br>Electron Cyclotron Resonance                                      | Semiconductors, metals; free electrons (low temperature) | Microwave radiation in magnetic field 10–30 GHz; 5–10 kG                                      | Microwave absorption (at resonance)                     | Bulk       | –                  | Electronic energy bands, effective masses                                                                                                         | 55    |
| 54.                      | Mössbauer Effect                                                         | Source and absorber                                      | Mono-energetic γ-rays: 5–100 keV                                                              | Mössbauer spectrum (Doppler shifted (lines)             | 50 m       | 1 cm               | Interaction between nucleus and its environment (local electric, magnetic fields; bonds; valency; diffusion, etc.)                                | 56    |
| 55.                      | NMR (MRI)<br>Nuclear Magnetic Resonance (Magnetic Resonance Imaging)     | Solids, liquids                                          | R.F. radiation + magnetic field; e.g. for protons: 60 MHz, 14 kG                              | R.F. absorption                                         | <1 cm      | 1 cm               | Quant. analysis; local magnetic environment; diffusion; imaging                                                                                   | 58    |
| 56.                      | ENDOR<br>Electron Nuclear Double Resonance                               | Solids, liquids                                          | R.F. + microwave radiation in magn. field.                                                    | Microwave absorption                                    | –          | –                  | Hyperfine interaction → local atomic structure                                                                                                    | 54    |
| 57.                      | NQR<br>Nuclear Quadrupole Resonance                                      | Solids                                                   | R.F. radiation 0.5–1000 MHz                                                                   | R.F. absorption                                         | –          | –                  | Asymmetry of the charge distribution at the nucleus                                                                                               | 55,59 |
| <b>Other</b>             |                                                                          |                                                          |                                                                                               |                                                         |            |                    |                                                                                                                                                   |       |
| 58.                      | BET<br>Brunauer-Emmett-Teller                                            | (Large) surface area 1–20 m <sup>2</sup> /g              | Adsorbed gas (e.g., N <sub>2</sub> at low temp.) as function of pressure (monolayer coverage) |                                                         | –          | –                  | Surface area measurement                                                                                                                          | 60    |

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# SYMMETRY OF CRYSTALS

L. I. Berger

The ability of a body to coincide with itself in its different positions regarding a coordinate system is called its symmetry. This property reveals itself in iteration of the parts of the body in space. The iteration may be done by reflection in mirror planes, rotation about certain axes, inversions and translations. These actions are called the symmetry operations. The planes, axes, points, etc., are known as symmetry elements. Essentially, mirror reflection is the only truly primitive symmetry operation. All other operations may be done by a sequence of reflections in certain mirror planes. Hence, the mirror plane is the only true basic symmetry element. But for clarity, it is convenient to use the other symmetry operations, and accordingly, the other aforementioned symmetry elements. The symmetry elements and operations are presented in Table 1.

The entire set of symmetry elements of a body is called its symmetry class. There are thirty-two symmetry classes that describe all crystals that have ever been noted in mineralogy or been synthesized (more than 150,000). The denominations and symbols of the symmetry classes are presented in Table 2.

There are several known approaches to classification of individual crystals in accordance with their symmetry and crystallochemistry. The particles that form a crystal are distributed in certain points in space. These points are separated by certain distances (translations) equal to each other in any chosen direction in the crystal. Crystal lattice is a diagram that describes the location of particles (individual or groups) in a crystal. The lattice parameters

are three non-coplanar translations that form the crystal lattice. Three basic translations form the unit cell of a crystal. August Bravais (1848) has shown that all possible crystal lattice structures belong to one or another of fourteen lattice types (Bravais lattices). The Bravais lattices, both primitive and non-primitive, are the contents of Table 3.

Among the three-dimensional figures, there is a group of polyhedrons that are called regular, which have all faces of the same shape and all edges of the same size (regular polygons). It has been shown that there are only five regular polyhedrons. Because of their importance in crystallography and solid state physics, a brief description of these polyhedrons is included in Table 4.

The systematic description of crystal structures is presented primarily in the well-known *Strukturbericht*. The classification of crystals by the *Strukturbericht* does not reflect their crystal class, the Bravais lattice, but is based on the crystallochemical type. This makes it inconvenient to use the *Strukturbericht* categories for comparison of some individual crystals. Thus, there have been several attempts to provide a more convenient classification of crystals. Table 5 presents a compilation of different classifications which allows the reader to correlate the *Strukturbericht* type with the international and Schoenflies point and space groups and with Pearson's symbols, based on the Bravais lattice and chemical composition of the class prototype. The information included in Table 5 has been chosen as an introduction to a more detailed crystallophysical and crystallochemical description of solids.

TABLE 1. Symmetry Operations and Elements

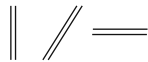
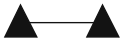
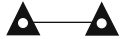
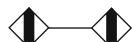
| Symmetry operation                                                          | Symmetry element          |                                       |             | Presentation on the stereographic projection                                          |                                                                                       |
|-----------------------------------------------------------------------------|---------------------------|---------------------------------------|-------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|                                                                             | Name                      | Symbol                                | Schoenflies | Parallel                                                                              | Perpendicular                                                                         |
|                                                                             |                           | International<br>(Hermann-Mauguin)    |             |                                                                                       |                                                                                       |
| Reflection in a plane                                                       | Plane                     | m                                     | $C_s$       |  |  |
| Rotation by angle $\alpha = 360^\circ/n$ about an axis                      | Axis                      | n = 1, 2, 3, 4 or 6                   | $C_n$       |                                                                                       |                                                                                       |
|                                                                             |                           | n = 2                                 | $C_2$       |  |  |
|                                                                             |                           | n = 3                                 | $C_3$       |  |  |
|                                                                             |                           | n = 4                                 | $C_4$       |  |  |
|                                                                             |                           | n = 6                                 | $C_6$       |  |  |
| Rotation about an axis and inversion in a symmetry center lying on the axis | Inversion (improper) axis | $\bar{n} = \bar{3}, \bar{4}, \bar{6}$ | $C_{ni}$    |                                                                                       |                                                                                       |
|                                                                             |                           | $\bar{n} = \bar{3}$                   | $C_{3i}$    |  |  |
|                                                                             |                           | $\bar{n} = \bar{4}$                   | $C_{4i}$    |  |  |

TABLE 1. Symmetry Operations and Elements

| Symmetry operation                                                                 | Name                                              | Symbol                                                               |             | Presentation on the stereographic projection |               |
|------------------------------------------------------------------------------------|---------------------------------------------------|----------------------------------------------------------------------|-------------|----------------------------------------------|---------------|
|                                                                                    |                                                   | International<br>(Hermann-Mauguin)                                   | Schoenflies | Parallel                                     | Perpendicular |
|                                                                                    |                                                   |                                                                      |             |                                              |               |
|                                                                                    |                                                   | $\bar{n} = \bar{6}$                                                  | $C_{6i}$    |                                              |               |
| Inversion in a point                                                               | Center                                            | $\bar{1}$                                                            | $C_i$       |                                              |               |
| Parallel translation                                                               | Translation<br>vector $\vec{a}, \vec{b}, \vec{c}$ |                                                                      |             |                                              |               |
| Reflection in a plane and<br>translation parallel to the<br>plane                  | Glide-plane                                       | a, b, c, n, d                                                        |             |                                              |               |
| Rotation about an axis and<br>translation parallel to the axis                     | Screw axis                                        | $n_m$<br>( $m = 1, 2, \dots, n - 1$ )                                |             |                                              |               |
| Rotation about an axis and<br>reflection in a plane perpen-<br>dicular to the axis | Rotatory-<br>reflection axis                      | $\bar{n}$<br>$\bar{n} = \bar{1}, \bar{2}, \bar{3}, \bar{4}, \bar{6}$ | $S_n$       |                                              |               |

TABLE 2. The Thirty-Two Symmetry Classes  
Class name<sup>a</sup> and its symbol – International (Int) and Schoenflies (Sch)

| Crystal symbol | Primitive |       | Central |          | Planal      |          | Axial |       | Plane-axial |          | Inversion primitive |          | Inversion-planal |          |
|----------------|-----------|-------|---------|----------|-------------|----------|-------|-------|-------------|----------|---------------------|----------|------------------|----------|
|                | Int       | Sch   | Int     | Sch      | Int         | Sch      | Int   | Sch   | Int         | Sch      | Int                 | Sch      | Int              | Sch      |
| Triclinic      | 1         | $C_1$ | 1       | $C_1$    |             |          |       |       |             |          |                     |          |                  |          |
| Monoclinic     |           |       | —       |          | m           | $C_s$    | 2     | $C_2$ | 2/m         | $C_{2h}$ |                     |          |                  |          |
| Orthorhombic   |           |       |         |          | mm2         | $C_{2v}$ | 222   | $D_2$ | mmm         | $D_{2h}$ |                     |          |                  |          |
| Trigonal       | 3         | $C_3$ | 3       | $C_{3i}$ | 3m          | $C_{3v}$ | 32    | $D_3$ | $\bar{3}m$  | $C_{3d}$ |                     |          |                  |          |
| Tetragonal     | 4         | $C_4$ | 4/m     | $C_{4h}$ | 4mm         | $C_{4v}$ | 422   | $D_4$ | 4/mmm       | $D_{4h}$ | $\bar{4}$           | $S_4$    | $\bar{4}2m$      | $D_{2d}$ |
| Hexagonal      | 6         | $C_6$ | 6/m     | $C_{6h}$ | 6mm         | $C_{6v}$ | 622   | $D_6$ | 6/mmm       | $D_{6h}$ | $\bar{6}$           | $C_{3h}$ | $\bar{6}m2$      | $D_{3h}$ |
| Cubic          | 23        | T     | m3      | $T_h$    | $\bar{4}3m$ | $T_d$    | 432   | O     | m3m         | $O_h$    |                     |          |                  |          |

<sup>a</sup> Per Fedorov Institute of Crystallography, Russian Academy of Sciences, nomenclature.

TABLE 3. The Fourteen Possible Space Lattices (Bravais Lattices)

| Crystal system          | Metric category of the system | No. of different lattices in the system | Lattice type <sup>a</sup> (marked by +) |   |   |   |   | No. of identical points per unit cell | Characteristic parameters (marked by +) |   |   |          |         |          | Description of characteristic parameters $a \in X, b \in Y, c \in Z$<br>$\alpha \in (b, c), \beta \in (a, c), \gamma \in (a, b)$ | Symmetry of the lattice |          |
|-------------------------|-------------------------------|-----------------------------------------|-----------------------------------------|---|---|---|---|---------------------------------------|-----------------------------------------|---|---|----------|---------|----------|----------------------------------------------------------------------------------------------------------------------------------|-------------------------|----------|
|                         |                               |                                         | P                                       | C | I | F | R |                                       | a                                       | b | c | $\alpha$ | $\beta$ | $\gamma$ |                                                                                                                                  | Int                     | Sch      |
| Triclinic               | Trimetric                     | 1                                       | +                                       |   |   |   |   | 1                                     | +                                       | + | + | +        | +       | +        | $a \neq b \neq c, \alpha \neq \beta \neq \gamma$                                                                                 | 1                       | C        |
| Monoclinic              | Trimetric                     | 2                                       | +                                       | + |   |   |   | 1 or 2                                | +                                       | + | + |          |         |          | $a \neq b \neq c, \alpha = \gamma = 90^\circ \neq \beta$                                                                         | 2/m                     | $C_{2h}$ |
| Orthorhombic            | Trimetric                     | 4                                       | +                                       | + | + | + |   | 1, 2 or 4                             | +                                       | + | + |          |         |          | $a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ$                                                                            | mmm                     | $D_{2h}$ |
| Trigonal (rhombohedral) | Dimetric                      | 1                                       |                                         |   |   |   | + | 1                                     | +                                       |   |   |          |         | +        | $a = b = c, 120^\circ > \alpha = \beta = \gamma \neq 90^\circ$                                                                   | 3m                      | $D_{3d}$ |
| Tetragonal              | Dimetric                      | 2                                       | +                                       |   | + |   |   | 1 or 2                                | +                                       |   | + |          |         |          | $a = b \neq c, \alpha = \beta = \gamma = 90^\circ$                                                                               | 4/mmm                   | $D_{4h}$ |
| Hexagonal               | Dimetric                      | 1                                       | +                                       |   |   |   |   | 1                                     | +                                       |   | + |          |         |          | $a = b \neq c, \alpha = \beta = 90^\circ, \gamma = 120^\circ$                                                                    | 6/mmm                   | $D_{6h}$ |
| Isometric (cubic)       | Monometric                    | 3                                       | +                                       |   | + | + |   | 1, 2 or 4                             | +                                       |   |   |          |         |          | $a = b = c, \alpha = \beta = \gamma = 90^\circ$                                                                                  | m3m                     | $O_h$    |

<sup>a</sup> Designations of the space-lattice types: P – primitive, C – side-centered (base-centered), I – body-centered, F – face-centered, R – rhombohedral.

TABLE 4. The Five Possible Regular Polyhedrons

| Polyhedron  | Symmetry (Schoenflies) |              | Form of faces        | Number of <sup>a</sup> |           |              |
|-------------|------------------------|--------------|----------------------|------------------------|-----------|--------------|
|             | Class                  | Elements     |                      | Faces (F)              | Edges (E) | Vertices (V) |
| Tetrahedron | T                      | $4C_3, 3C_2$ | Equilateral triangle | 4                      | 6         | 4            |

|                         |   |                    |                      |    |    |    |
|-------------------------|---|--------------------|----------------------|----|----|----|
| Cube (hexahedron)       | O | $3C_4 4C_3 6C_2$   | Square               | 6  | 12 | 8  |
| Octahedron              | O | $3C_4 4C_3 6C_2$   | Equilateral triangle | 8  | 12 | 6  |
| Pentagonal dodecahedron | J | $6C_5 10C_3 15C_2$ | Regular pentagon     | 12 | 30 | 20 |
| Icosahedron             | J | $6C_5 10C_3 15C_2$ | Equilateral triangle | 20 | 30 | 12 |

<sup>a</sup> Per formula by Leonhard Euler:  $F + V - E = 2$

TABLE 5. Classification of Crystals

| Strukturbericht<br>symbol | Structure<br>name       | Symmetry group         |                    | Pearson<br>symbol <sup>a</sup> | Standard ASTM<br>E157-82a<br>symbol <sup>b</sup> |
|---------------------------|-------------------------|------------------------|--------------------|--------------------------------|--------------------------------------------------|
|                           |                         | International          | Schoenflies        |                                |                                                  |
|                           |                         | 3                      | 4                  |                                |                                                  |
| A1                        | Cu                      | Fm3m                   | $O_h^4$            | cF4                            | F                                                |
| A2                        | W                       | Im3m                   | $O_h^9$            | cI2                            | B                                                |
| A3                        | Mg                      | $P6_3/mmc$             | $D_{6h}^4$         | hP2                            | H                                                |
| A4                        | C                       | Fd3m                   | $O_h^7$            | cF8                            | F                                                |
| A5                        | Sn                      | $I4_1/amd$             | $D_{19h}^{19}$     | tI4                            | U                                                |
| A6                        | In                      | $I4_1/mmm$             | $D_{17h}^{17}$     | tI2                            | U                                                |
| A7                        | As                      | $R\bar{3}m$            | $D_{3d}^5$         | hR2                            | R                                                |
| A8                        | Se                      | $P3_1 21$ or $P3_2 21$ | $D_3^4 (D_3^6)$    | hP3                            | H                                                |
| A10                       | Hg                      | $R\bar{3}m$            | $D_{3d}^5$         | hR1                            | R                                                |
| A11                       | Ga                      | Cmca                   | $D_{2h}^{18}$      | oC8                            | Q                                                |
| A12                       | $\alpha$ -Mn            | $I4\bar{3}m$           | $T_d^3$            | cI58                           | B                                                |
| A13                       | $\beta$ -Mn             | $P4_1 32$              | $O^7$              | cP20                           | C                                                |
| A15                       | $OW_3$                  | Pm3n                   | $O_h^3$            | cP8                            | C                                                |
| A20                       | $\alpha$ -U             | Cmcm                   | $D_{2h}^{17}$      | oC4                            | Q                                                |
| B1                        | ClNa                    | Fm3m                   | $O_h^5$            | cF8                            | F                                                |
| B2                        | ClCs                    | Pm3m                   | $O_h^1$            | cP2                            | C                                                |
| B3                        | SZn                     | $F\bar{4}3m$           | $T_d^2$            | cF8                            | F                                                |
| B4                        | SZn                     | $P6_3 mc$              | $C_{6v}^4$         | hP4                            | H                                                |
| B8 <sub>1</sub>           | AsNi                    | $P6_3/mmc$             | $D_{6h}^4$         | hP4                            | H                                                |
| B8 <sub>2</sub>           | InNi <sub>2</sub>       | $P6_3/mmc$             | $D_{6h}^4$         | hP6                            | H                                                |
| B9                        | HgS                     | $P3_1 21$ or $P3_2 21$ | $D_3^4$ or $D_3^6$ | hP6                            | H                                                |
| B10                       | OPb                     | $P4/nmm$               | $D_{4h}^7$         | tP4                            | T                                                |
| B11                       | $\gamma$ -CuTi          | $P4/nmm$               | $D_{4h}^7$         | tP4                            | T                                                |
| B13                       | NiS                     | $R\bar{3}m$            | $D_{3d}^5$         | hR6                            | R                                                |
| B16                       | GeS                     | Pnma                   | $D_{2h}^{16}$      | oP8                            | O                                                |
| B17                       | PtS                     | $P4_2/mmc$             | $D_{4h}^9$         | tP4                            | T                                                |
| B18                       | CuS                     | $P6_3/mmc$             | $D_{6h}^4$         | hP12                           | H                                                |
| B19                       | AuCd                    | Pmma                   | $D_{2h}^5$         | oP4                            | O                                                |
| B20                       | FeSi                    | $P2_1 3$               | $T^4$              | cP8                            | C                                                |
| B27                       | BFe                     | Pnma                   | $D_{2h}^{16}$      | oP8                            | O                                                |
| B31                       | MnP                     | Pnma                   | $D_{2h}^{16}$      | oP8                            | O                                                |
| B32                       | NaTi                    | Fd3m                   | $O_h^7$            | cF16                           | F                                                |
| B34                       | Pds                     | $P4_2/m$               | $C_{4h}^2$         | tP16                           | T                                                |
| B35                       | CoSn                    | $P6/mmm$               | $D_{6h}^1$         | hP6                            | H                                                |
| B37                       | SeTi                    | $I4/mcm$               | $D_{4h}^{18}$      | tI16                           | U                                                |
| B <sub>e</sub>            | CdSb                    | Pbca                   | $D_{2h}^{15}$      | oP16                           | O                                                |
| B <sub>f</sub> (B33)      | $\xi$ -BCr              | Cmcm                   | $D_{2h}^{17}$      | oC8                            | Q                                                |
| B <sub>g</sub>            | BMo                     | $I4_1/amd$             | $D_{19h}^{19}$     | tI4                            | U                                                |
| B <sub>h</sub>            | CW                      | P6m2                   | $D_{3h}^1$         | hP2                            | H                                                |
| B <sub>i</sub>            | $\gamma'$ CMo<br>(AsTi) | $P6_3/mmc$             | $D_{6h}^4$         | hP8                            | H                                                |
| C1                        | CaF <sub>2</sub>        | $Fm\bar{3}m$           | $O_h^5$            | cF12                           | F                                                |
| C1 <sub>b</sub>           | AgAsMg                  | $F\bar{4}3m$           | $T_d^2$            | cF12                           | F                                                |
| C2                        | FeS <sub>2</sub>        | Pa3                    | $T_h^6$            | cP12                           | C                                                |
| C3                        | Cu <sub>2</sub> O       | Pn3m                   | $O_h^4$            | cP6                            | C                                                |
| C4                        | O <sub>2</sub> Ti       | $P4_2/mnm$             | $D_{4h}^{14}$      | tP6                            | T                                                |
| C6                        | CdI <sub>2</sub>        | P3m1                   | $D_{3d}^3$         | hP3                            | H                                                |
| C7                        | MoS <sub>2</sub>        | $P6_3/mmc$             | $D_{6h}^4$         | hP6                            | H                                                |
| C11 <sub>a</sub>          | C <sub>2</sub> Ca       | $I4_1/mmm$             | $D_{17h}^{17}$     | tI6                            | U                                                |
| C11 <sub>b</sub>          | MoSi <sub>2</sub>       | $I4_1/mmm$             | $D_{17h}^{17}$     | tI6                            | U                                                |



TABLE 5. Classification of Crystals

| Strukturbericht<br>symbol | Structure<br>name                        | Symmetry group        |                                                              | Pearson<br>symbol <sup>a</sup> | Standard ASTM<br>E157-82a<br>symbol <sup>b</sup> |
|---------------------------|------------------------------------------|-----------------------|--------------------------------------------------------------|--------------------------------|--------------------------------------------------|
|                           |                                          | International         | Schoenflies                                                  |                                |                                                  |
| 1                         | 2                                        | 3                     | 4                                                            | 5                              | 6                                                |
| C12                       | CaSi <sub>2</sub>                        | R $\bar{3}$ m         | D <sup>5</sup> <sub>3d</sub>                                 | hR6                            | R                                                |
| C14                       | MgZn <sub>2</sub>                        | P6 <sub>3</sub> /mmc  | D <sup>4</sup> <sub>6h</sub>                                 | hP12                           | H                                                |
| C15                       | Cu <sub>2</sub> Mg                       | Fd3m                  | O <sup>7</sup> <sub>h</sub>                                  | cF24                           | F                                                |
| C15 <sub>b</sub>          | AuBe <sub>5</sub>                        | F $\bar{4}$ 3m or F23 | T <sup>2</sup> <sub>d</sub> or T <sup>2</sup>                | cF24                           | F                                                |
| C16                       | Al <sub>2</sub> Cu                       | I4/mcm                | D <sup>18</sup> <sub>4h</sub>                                | tI12                           | U                                                |
| C18                       | FeS <sub>2</sub>                         | Pnnm                  | D <sup>12</sup> <sub>2h</sub>                                | oP6                            | O                                                |
| C19                       | CdCl <sub>2</sub>                        | R $\bar{3}$ m         | D <sup>5</sup> <sub>3d</sub>                                 | hR3                            | R                                                |
| C22                       | Fe <sub>2</sub> P                        | P2 $\bar{6}$ m        | D <sup>1</sup> <sub>3h</sub>                                 | hP9                            | H                                                |
| C23                       | Cl <sub>2</sub> Pb                       | Pnma                  | D <sup>16</sup> <sub>2h</sub>                                | oP12                           | O                                                |
| C32                       | AlB <sub>2</sub>                         | P6/mmm                | D <sup>1</sup> <sub>6h</sub>                                 | hP3                            | H                                                |
| C33                       | Bi <sub>2</sub> STe <sub>2</sub>         | R $\bar{3}$ m         | D <sup>5</sup> <sub>3d</sub>                                 | hR5                            | R                                                |
| C34                       | AuTe <sub>2</sub>                        | C2/m (P2/m)           | C <sup>3</sup> <sub>2h</sub> (C <sup>1</sup> <sub>2h</sub> ) | mC6                            | N                                                |
| C36                       | MgNi <sub>2</sub>                        | P6 <sub>3</sub> /mmc  | D <sup>4</sup> <sub>6h</sub>                                 | hP24                           | H                                                |
| C38                       | Cu <sub>2</sub> Sb                       | P4/nmm                | D <sup>7</sup> <sub>4h</sub>                                 | tP6                            | T                                                |
| C40                       | CrSi <sub>2</sub>                        | P6 <sub>2</sub> 22    | D <sup>4</sup> <sub>6</sub>                                  | hP9                            | H                                                |
| C42                       | SiS <sub>2</sub>                         | Ibam                  | D <sup>26</sup> <sub>2h</sub>                                | oI12                           | P                                                |
| C44                       | GeS <sub>2</sub>                         | Fdd2                  | C <sup>19</sup> <sub>2v</sub>                                | oF72                           | S                                                |
| C46                       | AuTe <sub>2</sub>                        | Pma2                  | C <sup>4</sup> <sub>2v</sub>                                 | oP24                           | O                                                |
| C49                       | Si <sub>2</sub> Zr                       | Cmcm                  | D <sup>17</sup> <sub>2h</sub>                                | oC12                           | Q                                                |
| C54                       | Si <sub>2</sub> Ti                       | Fddd                  | D <sup>24</sup> <sub>2h</sub>                                | oF24                           | S                                                |
| C <sub>c</sub>            | Si <sub>2</sub> Th                       | I4 <sub>1</sub> /amd  | D <sup>19</sup> <sub>4h</sub>                                | tI12                           | U                                                |
| C <sub>e</sub>            | CoGe <sub>2</sub>                        | Aba2                  | C <sup>17</sup> <sub>2v</sub>                                | oC23                           | Q                                                |
| DO <sub>2</sub>           | As <sub>3</sub> Co                       | Im3                   | T <sup>5</sup> <sub>h</sub>                                  | cl32                           | B                                                |
| DO <sub>3</sub>           | BiF <sub>3</sub>                         | Fm3m                  | O <sup>5</sup> <sub>h</sub>                                  | cF16                           | F                                                |
| DO <sub>9</sub>           | O <sub>3</sub> Re                        | Pm3m                  | O <sup>1</sup> <sub>h</sub>                                  | cP4                            | C                                                |
| DO <sub>11</sub>          | CFe <sub>3</sub>                         | Pnma                  | D <sup>16</sup> <sub>2h</sub>                                | oP16                           | O                                                |
| DO <sub>18</sub>          | AsNa <sub>3</sub>                        | P6 <sub>3</sub> /mmc  | D <sup>4</sup> <sub>6h</sub>                                 | hP8                            | H                                                |
| DO <sub>19</sub>          | Ni <sub>3</sub> Sn                       | P6 <sub>3</sub> /mmc  | D <sup>4</sup> <sub>6h</sub>                                 | hP8                            | H                                                |
| DO <sub>20</sub>          | Al <sub>3</sub> Ni                       | Pnma                  | D <sup>16</sup> <sub>2h</sub>                                | oP16                           | O                                                |
| DO <sub>21</sub>          | Cu <sub>3</sub> P                        | P $\bar{3}$ c1        | D <sup>4</sup> <sub>3d</sub>                                 | hP24                           | H                                                |
| DO <sub>22</sub>          | Cu <sub>3</sub> P                        | I4/mmm                | D <sup>17</sup> <sub>4h</sub>                                | tI8                            | U                                                |
| DO <sub>23</sub>          | Al <sub>3</sub> Zr                       | I4/mmm                | D <sup>17</sup> <sub>4h</sub>                                | tI16                           | U                                                |
| DO <sub>24</sub>          | Ni <sub>3</sub> Ti                       | P6 <sub>3</sub> /mmc  | D <sup>4</sup> <sub>6h</sub>                                 | hP16                           | H                                                |
| DO <sub>c</sub>           | SiU <sub>3</sub>                         | I4/mcm                | D <sup>18</sup> <sub>4h</sub>                                | tI16                           | U                                                |
| DO <sub>e</sub>           | Ni <sub>3</sub> P                        | I $\bar{4}$           | S <sup>2</sup> <sub>4</sub>                                  | tI32                           | U                                                |
| D1 <sub>3</sub>           | Al <sub>4</sub> Ba                       | I4/mmm                | D <sup>17</sup> <sub>4h</sub>                                | tI10                           | U                                                |
| D1 <sub>a</sub>           | MoNi <sub>4</sub>                        | I4/m                  | C <sup>5</sup> <sub>4h</sub>                                 | tI10                           | U                                                |
| D1 <sub>b</sub>           | Al <sub>4</sub> U                        | Imma                  | D <sup>28</sup> <sub>2h</sub>                                | oI20                           | P                                                |
| D1 <sub>c</sub>           | PtSn <sub>4</sub>                        | Aba2                  | C <sup>17</sup> <sub>2v</sub>                                | oC20                           | Q                                                |
| D1 <sub>e</sub>           | B <sub>4</sub> Th                        | P4/mbm                | D <sup>5</sup> <sub>4h</sub>                                 | tP20                           | T                                                |
| D1 <sub>f</sub>           | BMn <sub>4</sub>                         | Fddd                  | D <sup>24</sup> <sub>2h</sub>                                | oF40                           | S                                                |
| D2 <sub>1</sub>           | B <sub>6</sub> Ca                        | Pm3m                  | O <sup>1</sup> <sub>h</sub>                                  | cP7                            | C                                                |
| D2 <sub>3</sub>           | NaZn <sub>13</sub>                       | Fm3m                  | O <sup>5</sup> <sub>h</sub>                                  | cF112                          | F                                                |
| D2 <sub>b</sub>           | Mn <sub>12</sub> Th                      | I4/mmm                | D <sup>17</sup> <sub>4h</sub>                                | tI26                           | U                                                |
| D2 <sub>c</sub>           | MnU <sub>6</sub>                         | I4/mcm                | D <sup>18</sup> <sub>4h</sub>                                | tI28                           | U                                                |
| D2 <sub>d</sub>           | CaCu <sub>5</sub>                        | P6/mmm                | D <sup>1</sup> <sub>6h</sub>                                 | hP6                            | H                                                |
| D2 <sub>f</sub>           | B <sub>12</sub> U                        | Fm3m                  | O <sup>5</sup> <sub>h</sub>                                  | cF52                           | F                                                |
| D2 <sub>h</sub>           | Al <sub>6</sub> Mn                       | Cmcm                  | D <sup>17</sup> <sub>2h</sub>                                | oC28                           | Q                                                |
| D5 <sub>1</sub>           | $\alpha$ -Al <sub>2</sub> O <sub>3</sub> | R3c                   | D <sup>6</sup> <sub>3d</sub>                                 | hR10                           | R                                                |
| D5 <sub>2</sub>           | La <sub>2</sub> O <sub>3</sub>           | P $\bar{3}$ m1        | D <sup>3</sup> <sub>3d</sub>                                 | hP5                            | H                                                |
| D5 <sub>3</sub>           | Mn <sub>2</sub> O <sub>3</sub>           | Ia3                   | T <sup>7</sup> <sub>h</sub>                                  | cl80                           | B                                                |
| D5 <sub>8</sub>           | S <sub>3</sub> Sb <sub>2</sub>           | Pnma                  | D <sup>16</sup> <sub>2h</sub>                                | oP20                           | O                                                |
| D5 <sub>9</sub>           | P <sub>2</sub> Zn <sub>3</sub>           | P4 <sub>2</sub> /mmc  | D <sup>9</sup> <sub>4h</sub>                                 | tP40                           | T                                                |
| D5 <sub>10</sub>          | C <sub>2</sub> C <sub>3</sub>            | Pnma                  | D <sup>16</sup> <sub>2h</sub>                                | oP20                           | O                                                |
| D5 <sub>13</sub>          | Al <sub>3</sub> Ni <sub>2</sub>          | P $\bar{3}$ m1        | D <sup>3</sup> <sub>3d</sub>                                 | hP5                            | H                                                |
| D5 <sub>a</sub>           | Si <sub>2</sub> U <sub>3</sub>           | P4/mbm                | D <sup>5</sup> <sub>4h</sub>                                 | tP10                           | T                                                |
| D5 <sub>c</sub>           | C <sub>3</sub> Pu <sub>2</sub>           | I $\bar{4}$ 3d        | T <sup>6</sup> <sub>d</sub>                                  | cl40                           | B                                                |

TABLE 5. Classification of Crystals

| Strukturbericht<br>symbol | Structure<br>name                      | Symmetry group       |                                                             | Pearson<br>symbol <sup>a</sup> | Standard ASTM<br>E157-82a<br>symbol <sup>b</sup> |
|---------------------------|----------------------------------------|----------------------|-------------------------------------------------------------|--------------------------------|--------------------------------------------------|
|                           |                                        | International        | Schoenflies                                                 |                                |                                                  |
| 1                         | 2                                      | 3                    | 4                                                           | 5                              | 6                                                |
| D7 <sub>1</sub>           | Al <sub>4</sub> C <sub>3</sub>         | R $\bar{3}$ m        | D <sup>5</sup> <sub>3d</sub>                                | hR7                            | R                                                |
| D7 <sub>3</sub>           | P <sub>4</sub> Th <sub>3</sub>         | I $\bar{4}$ 3d       | T <sup>6</sup> <sub>d</sub>                                 | cI28                           | B                                                |
| D7 <sub>b</sub>           | B <sub>4</sub> Ta <sub>3</sub>         | Immm                 | D <sup>25</sup> <sub>2h</sub>                               | oI14                           | P                                                |
| D8 <sub>1</sub>           | Fe <sub>3</sub> Zn <sub>10</sub>       | Im3m                 | O <sup>9</sup> <sub>h</sub>                                 | cI52                           | B                                                |
| D8 <sub>2</sub>           | Cu <sub>5</sub> Zn <sub>8</sub>        | I $\bar{4}$ 3m       | T <sup>3</sup> <sub>d</sub>                                 | cI52                           | B                                                |
| D8 <sub>3</sub>           | Al <sub>4</sub> Cu <sub>9</sub>        | P43m                 | T <sup>1</sup> <sub>d</sub>                                 | cP52                           | C                                                |
| D8 <sub>4</sub>           | C <sub>6</sub> Cr <sub>23</sub>        | Fm3m                 | O <sup>5</sup> <sub>h</sub>                                 | cF116                          | F                                                |
| D8 <sub>5</sub>           | Fe <sub>7</sub> W <sub>6</sub>         | R $\bar{3}$ m        | D <sup>5</sup> <sub>3d</sub>                                | hR13                           | R                                                |
| D8 <sub>6</sub>           | Cu <sub>15</sub> Si <sub>4</sub>       | I $\bar{4}$ 3m       | T <sup>3</sup> <sub>d</sub>                                 | cI76                           | B                                                |
| D8 <sub>8</sub>           | Mn <sub>5</sub> Si <sub>3</sub>        | P6 <sub>3</sub> /mcm | D <sup>3</sup> <sub>6h</sub>                                | hP16                           | H                                                |
| D8 <sub>9</sub>           | Co <sub>9</sub> S <sub>8</sub>         | Fm3m                 | O <sup>5</sup> <sub>h</sub>                                 | cF68                           | F                                                |
| D8 <sub>10</sub>          | Al <sub>8</sub> Cr <sub>5</sub>        | R3m                  | C <sup>5</sup> <sub>3v</sub>                                | hR26                           | R                                                |
| D8 <sub>11</sub>          | Al <sub>5</sub> Co <sub>2</sub>        | P6 <sub>3</sub> /mcm | D <sup>3</sup> <sub>6h</sub>                                | hP28                           | H                                                |
| D8 <sub>a</sub>           | Mn <sub>23</sub> Th <sub>6</sub>       | Fm3m                 | O <sup>5</sup> <sub>h</sub>                                 | cF116                          | F                                                |
| D8 <sub>b</sub>           | $\sigma$ -phase of<br>Cr-Fe            | p $\bar{4}_2$ /mnm   | D <sup>14</sup> <sub>4h</sub>                               | tP30                           | T                                                |
| D8 <sub>e</sub>           | (Al,Zn) <sub>49</sub> Mg <sub>32</sub> | Im3                  | T <sup>5</sup> <sub>h</sub>                                 | cI162                          | B                                                |
| D8 <sub>f</sub>           | Ge <sub>7</sub> Ir <sub>3</sub>        | Im3m                 | O <sup>9</sup> <sub>h</sub>                                 | cI40                           | B                                                |
| D8 <sub>h</sub>           | B <sub>5</sub> W <sub>2</sub>          | P6 <sub>3</sub> /mmc | D <sup>4</sup> <sub>6h</sub>                                | hP14                           | H                                                |
| D8 <sub>i</sub>           | B <sub>5</sub> Mo <sub>2</sub>         | R $\bar{3}$ m        | D <sup>5</sup> <sub>3d</sub>                                | hR7                            | R                                                |
| D8 <sub>l</sub>           | B <sub>3</sub> Cr <sub>5</sub>         | I4/mcm               | D <sup>18</sup> <sub>4h</sub>                               | tI32                           | U                                                |
| D8 <sub>m</sub>           | Si <sub>3</sub> W <sub>5</sub>         | I4/mcm               | D <sup>18</sup> <sub>4h</sub>                               | tI32                           | U                                                |
| D10 <sub>1</sub>          | C <sub>3</sub> Cr <sub>7</sub>         | P31c                 | C <sup>4</sup> <sub>3v</sub>                                | hP80                           | H                                                |
| D10 <sub>2</sub>          | Fe <sub>3</sub> Th <sub>7</sub>        | P6 <sub>3</sub> mc   | C <sup>4</sup> <sub>6v</sub>                                | hP20                           | H                                                |
| E0 <sub>1</sub>           | ClFPb                                  | P4/nmm               | D <sup>7</sup> <sub>4h</sub>                                | tP6                            | T                                                |
| E1 <sub>1</sub>           | CuFeS <sub>2</sub>                     | I $\bar{4}$ 2d       | D <sup>12</sup> <sub>2d</sub>                               | tI16                           | U                                                |
| E2 <sub>1</sub>           | CaO <sub>3</sub> Ti                    | Pm3m                 | O <sup>1</sup> <sub>h</sub>                                 | cP5                            | C                                                |
| E2 <sub>4</sub>           | S <sub>3</sub> Sn <sub>2</sub>         | Pnma                 | D <sup>16</sup> <sub>2h</sub>                               | oP20                           | O                                                |
| E3                        | Al <sub>2</sub> CdS <sub>4</sub>       | I $\bar{4}$          | S <sup>2</sup> <sub>4</sub>                                 | tI14                           | U                                                |
| E9 <sub>3</sub>           | SiFe <sub>3</sub> W <sub>3</sub>       | Fd3m                 | O <sup>7</sup> <sub>h</sub>                                 | cF112                          | F                                                |
| E9 <sub>a</sub>           | Al <sub>7</sub> Cu <sub>2</sub> Fe     | P4/mnc               | D <sup>6</sup> <sub>4h</sub>                                | tP40                           | T                                                |
| E9 <sub>b</sub>           | AlLi <sub>3</sub> N <sub>2</sub>       | Ia3                  | T <sup>7</sup> <sub>h</sub>                                 | cI96                           | B                                                |
| F0 <sub>1</sub>           | NiSSb                                  | P2 <sub>1</sub> 3    | T <sup>4</sup>                                              | cP12                           | C                                                |
| F5 <sub>1</sub>           | CrNaS <sub>2</sub>                     | R3m or R32           | D <sup>5</sup> <sub>3d</sub> or D <sup>7</sup> <sub>3</sub> | hR4                            | R                                                |
| F5 <sub>6</sub>           | CuS <sub>2</sub> Sb                    | Pnma                 | D <sup>16</sup> <sub>2h</sub>                               | oP16                           | O                                                |
| H1 <sub>1</sub>           | Al <sub>2</sub> MgO <sub>4</sub>       | Fd3m                 | O <sup>7</sup> <sub>h</sub>                                 | cF56                           | F                                                |
| H2 <sub>4</sub>           | Cu <sub>3</sub> S <sub>4</sub> V       | P43m                 | T <sup>1</sup> <sub>d</sub>                                 | cP8                            | C                                                |
| H2 <sub>5</sub>           | AsCu <sub>3</sub> S <sub>4</sub>       | Pmn2 <sub>1</sub>    | C <sup>7</sup> <sub>2v</sub>                                | oP16                           | O                                                |
| L1 <sub>0</sub>           | AuCu                                   | P4/mmm               | D <sup>1</sup> <sub>4h</sub>                                | tP4                            | T                                                |
| L1 <sub>2</sub>           | AlCu <sub>3</sub>                      | Pm3m                 | O <sup>1</sup> <sub>h</sub>                                 | cP4                            | C                                                |
| L2 <sub>1</sub>           | AlCu <sub>2</sub> Mn                   | Fm3m                 | O <sup>5</sup> <sub>h</sub>                                 | cF16                           | F                                                |
| L2 <sub>2</sub>           | Sb <sub>2</sub> Tl <sub>7</sub>        | Im3m                 | O <sup>9</sup> <sub>h</sub>                                 | cI54                           | B                                                |
| L/2 <sub>b</sub>          | H <sub>2</sub> Th                      | I4/mmm               | D <sup>17</sup> <sub>4h</sub>                               | tI6                            | U                                                |
| L/3                       | Fe <sub>2</sub> N                      | P6 <sub>3</sub> /mmc | D <sup>4</sup> <sub>6h</sub>                                | hP3                            | H                                                |
| L6 <sub>0</sub>           | CuTi <sub>3</sub>                      | P4/mmm               | D <sup>1</sup> <sub>4h</sub>                                | tP4                            | T                                                |

<sup>a</sup> The first letter denotes the crystal system: triclinic (a), monoclinic (m), orthorhombic (o), tetragonal (t), hexagonal (h) and cubic (c). Trigonal (rhombohedral) system is denoted by combination hR. The second letter of Pearson's symbol denotes lattice type: primitive (P), edge-(base-) centered (C), body-centered (I) or face-centered (F). The following number denotes number of atoms in the crystal unit cell.

<sup>b</sup> Standard ASTM E157-82a has the Bravais lattices designations as following: C – primitive cubic; B – body-centered cubic; F – face-centered cubic; T – primitive tetragonal; U – body-centered tetragonal; R – rhombohedral; H – hexagonal; O – primitive orthorhombic; P – body-centered orthorhombic; Q – base-centered orthorhombic; S – face-centered orthorhombic; M – primitive monoclinic; N – centered monoclinic; A – triclinic.

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# IONIC RADII IN CRYSTALS

Ionic radii are a useful tool for predicting and visualizing crystal structures. This table lists a set of ionic radii  $R_i$  in Å units for the most common coordination numbers  $CN$  of positive and negative ions. The values are based on experimental crystal structure determinations, supplemented by empirical relationships, and theoretical calculations. The notation sq after the coordination number indicates a square configuration, while py indicates pyramidal.

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| Ion              | CN  | $R_i/\text{Å}$ | Ion              | CN  | $R_i/\text{Å}$ | Ion              | CN  | $R_i/\text{Å}$ |
|------------------|-----|----------------|------------------|-----|----------------|------------------|-----|----------------|
| <b>Anions</b>    |     |                |                  |     |                |                  |     |                |
| F <sup>-1</sup>  | 6   | 1.33           |                  | 8   | 1.12           | Eu <sup>+3</sup> | 6   | 0.95           |
| Cl <sup>-1</sup> | 6   | 1.81           |                  | 10  | 1.23           |                  | 8   | 1.07           |
| Br <sup>-1</sup> | 6   | 1.96           |                  | 12  | 1.34           | F <sup>+7</sup>  | 6   | 0.08           |
| I <sup>-1</sup>  | 6   | 2.20           | Cd <sup>+2</sup> | 4   | 0.78           | Fe <sup>+2</sup> | 4   | 0.63           |
| OH <sup>-1</sup> | 4   | 1.35           |                  | 6   | 0.95           |                  | 6   | 0.61           |
|                  | 6   | 1.37           |                  | 8   | 1.10           |                  | 8   | 0.92           |
| O <sup>-2</sup>  | 2   | 1.21           |                  | 12  | 1.31           | Fe <sup>+3</sup> | 4   | 0.49           |
|                  | 6   | 1.40           | Ce <sup>+3</sup> | 6   | 1.01           |                  | 6   | 0.55           |
|                  | 8   | 1.42           |                  | 8   | 1.14           |                  | 8   | 0.78           |
| S <sup>-2</sup>  | 6   | 1.84           |                  | 10  | 1.25           | Fr <sup>+1</sup> | 6   | 1.80           |
| Se <sup>-2</sup> | 6   | 1.98           |                  | 12  | 1.34           | Ga <sup>+3</sup> | 4   | 0.47           |
| Te <sup>-2</sup> | 6   | 2.21           | Ce <sup>+4</sup> | 6   | 0.87           |                  | 6   | 0.62           |
| <b>Cations</b>   |     |                |                  | 8   | 0.97           | Gd <sup>+3</sup> | 6   | 0.94           |
| Ac <sup>+3</sup> | 6   | 1.12           |                  | 10  | 1.07           |                  | 8   | 1.05           |
| Ag <sup>+1</sup> | 4   | 1.00           |                  | 12  | 1.14           | Ge <sup>+2</sup> | 6   | 0.73           |
|                  | 6   | 1.15           | Cf <sup>+3</sup> | 6   | 0.95           | Ge <sup>+4</sup> | 4   | 0.39           |
|                  | 8   | 1.28           | Cf <sup>+4</sup> | 6   | 0.82           |                  | 6   | 0.53           |
| Ag <sup>+2</sup> | 4sq | 0.79           |                  | 8   | 0.92           | Hf <sup>+4</sup> | 4   | 0.58           |
|                  | 6   | 0.94           | Cl <sup>+5</sup> | 3py | 0.12           |                  | 6   | 0.71           |
| Al <sup>+3</sup> | 4   | 0.39           |                  | 4   | 0.08           |                  | 8   | 0.83           |
|                  | 5   | 0.48           | Cm <sup>+3</sup> | 6   | 0.97           | Hg <sup>+1</sup> | 6   | 1.19           |
|                  | 6   | 0.54           | Cm <sup>+4</sup> | 6   | 0.85           | Hg <sup>+2</sup> | 2   | 0.69           |
| Am <sup>+3</sup> | 6   | 0.98           |                  | 8   | 0.95           |                  | 4   | 0.96           |
|                  | 8   | 1.09           | Co <sup>+2</sup> | 4   | 0.56           |                  | 6   | 1.02           |
| Am <sup>+4</sup> | 6   | 0.85           |                  | 6   | 0.65           |                  | 8   | 1.14           |
|                  | 8   | 0.95           |                  | 8   | 0.90           | I <sup>+5</sup>  | 3py | 0.44           |
| As <sup>+3</sup> | 6   | 0.58           | Co <sup>+3</sup> | 6   | 0.55           |                  | 6   | 0.95           |
| As <sup>+5</sup> | 4   | 0.34           | Cr <sup>+2</sup> | 6   | 0.73           | I <sup>+7</sup>  | 4   | 0.42           |
|                  | 6   | 0.46           | Cr <sup>+3</sup> | 6   | 0.62           |                  | 6   | 0.53           |
| Au <sup>+1</sup> | 6   | 1.37           | Cr <sup>+4</sup> | 4   | 0.41           | In <sup>+3</sup> | 4   | 0.62           |
| Au <sup>+3</sup> | 4sq | 0.64           |                  | 6   | 0.55           |                  | 6   | 0.80           |
|                  | 6   | 0.85           | Cr <sup>+6</sup> | 4   | 0.26           | Ir <sup>+3</sup> | 6   | 0.68           |
| Ba <sup>+2</sup> | 6   | 1.35           |                  | 6   | 0.44           | Ir <sup>+4</sup> | 6   | 0.63           |
|                  | 8   | 1.42           | Cs <sup>+1</sup> | 6   | 1.67           | Ir <sup>+5</sup> | 6   | 0.57           |
|                  | 12  | 1.61           |                  | 8   | 1.74           | K <sup>+1</sup>  | 4   | 1.37           |
| Be <sup>+2</sup> | 4   | 0.27           |                  | 10  | 1.81           |                  | 6   | 1.38           |
|                  | 6   | 0.45           |                  | 12  | 1.88           |                  | 8   | 1.51           |
| Bi <sup>+3</sup> | 5   | 0.96           | Cu <sup>+1</sup> | 2   | 0.46           |                  | 12  | 1.64           |
|                  | 6   | 1.03           |                  | 4   | 0.60           | La <sup>+3</sup> | 6   | 1.03           |
|                  | 8   | 1.17           |                  | 6   | 0.77           |                  | 8   | 1.16           |
| Bi <sup>+5</sup> | 6   | 0.76           | Cu <sup>+2</sup> | 4sq | 0.57           |                  | 10  | 1.27           |
| Bk <sup>+3</sup> | 6   | 0.96           |                  | 6   | 0.73           |                  | 12  | 1.36           |
| Bk <sup>+4</sup> | 6   | 0.83           | Dy <sup>+2</sup> | 6   | 1.07           | Li <sup>+1</sup> | 4   | 0.59           |
|                  | 8   | 0.93           |                  | 8   | 1.19           |                  | 6   | 0.76           |
| Br <sup>+5</sup> | 3py | 0.31           | Dy <sup>+3</sup> | 6   | 0.91           |                  | 8   | 0.92           |
| Br <sup>+7</sup> | 4   | 0.25           |                  | 8   | 1.03           | Lu <sup>+3</sup> | 6   | 0.86           |
|                  | 6   | 0.39           | Er <sup>+3</sup> | 6   | 0.89           |                  | 8   | 0.97           |
| C <sup>+4</sup>  | 4   | 0.15           |                  | 8   | 1.00           | Mg <sup>+2</sup> | 4   | 0.57           |
|                  | 6   | 0.16           | Eu <sup>+2</sup> | 6   | 1.17           |                  | 6   | 0.72           |
| Ca <sup>+2</sup> | 6   | 1.00           |                  | 8   | 1.25           |                  | 8   | 0.89           |
|                  |     |                |                  | 10  | 1.35           | Mn <sup>+2</sup> | 4   | 0.66           |

| Ion              | CN  | $R_i/\text{\AA}$ | Ion              | CN  | $R_i/\text{\AA}$ | Ion              | CN | $R_i/\text{\AA}$ |
|------------------|-----|------------------|------------------|-----|------------------|------------------|----|------------------|
|                  | 6   | 0.83             | Pr <sup>+3</sup> | 6   | 0.99             | Tc <sup>+4</sup> | 6  | 0.65             |
|                  | 8   | 0.96             |                  | 8   | 1.13             | Te <sup>+4</sup> | 4  | 0.66             |
| Mn <sup>+3</sup> | 6   | 0.58             | Pr <sup>+4</sup> | 6   | 0.85             |                  | 6  | 0.97             |
| Mn <sup>+4</sup> | 4   | 0.39             |                  | 8   | 0.96             | Te <sup>+6</sup> | 4  | 0.43             |
|                  | 6   | 0.53             | Pt <sup>+2</sup> | 4sq | 0.60             |                  | 6  | 0.56             |
| Mn <sup>+5</sup> | 4   | 0.33             |                  | 6   | 0.80             | Th <sup>+4</sup> | 6  | 0.94             |
| Mn <sup>+6</sup> | 4   | 0.26             | Pt <sup>+4</sup> | 6   | 0.63             |                  | 8  | 1.05             |
| Mn <sup>+7</sup> | 4   | 0.25             | Pu <sup>+3</sup> | 6   | 1.00             |                  | 10 | 1.13             |
| Mo <sup>+3</sup> | 6   | 0.69             | Pu <sup>+4</sup> | 6   | 0.86             |                  | 12 | 1.21             |
| Mo <sup>+4</sup> | 6   | 0.65             | Pu <sup>+5</sup> | 6   | 0.74             | Ti <sup>+2</sup> | 6  | 0.86             |
| Mo <sup>+5</sup> | 4   | 0.46             | Pu <sup>+6</sup> | 6   | 0.71             | Ti <sup>+3</sup> | 6  | 0.67             |
|                  | 6   | 0.61             | Ra <sup>+2</sup> | 8   | 1.48             | Ti <sup>+4</sup> | 4  | 0.42             |
| Mo <sup>+6</sup> | 4   | 0.41             |                  | 12  | 1.70             |                  | 6  | 0.61             |
|                  | 6   | 0.59             | Rb <sup>+1</sup> | 6   | 1.52             |                  | 8  | 0.74             |
|                  | 7   | 0.73             |                  | 8   | 1.61             | Tl <sup>+1</sup> | 6  | 1.50             |
| N <sup>+3</sup>  | 6   | 0.16             |                  | 10  | 1.66             |                  | 8  | 1.59             |
| N <sup>+5</sup>  | 6   | 0.13             |                  | 12  | 1.72             |                  | 12 | 1.70             |
| Na <sup>+1</sup> | 4   | 0.99             | Re <sup>+4</sup> | 6   | 0.63             | Tl <sup>+3</sup> | 4  | 0.75             |
|                  | 6   | 1.02             | Re <sup>+5</sup> | 6   | 0.58             |                  | 6  | 0.89             |
|                  | 8   | 1.18             | Re <sup>+6</sup> | 6   | 0.55             |                  | 8  | 0.98             |
|                  | 9   | 1.24             | Re <sup>+7</sup> | 4   | 0.38             | Tm <sup>+2</sup> | 6  | 1.01             |
|                  | 12  | 1.39             |                  | 6   | 0.53             |                  | 7  | 1.09             |
| Nb <sup>+3</sup> | 6   | 0.72             | Rh <sup>+3</sup> | 6   | 0.67             | Tm <sup>+3</sup> | 6  | 0.88             |
|                  | 8   | 0.79             | Rh <sup>+4</sup> | 6   | 0.60             |                  | 8  | 0.99             |
| Nb <sup>+4</sup> | 6   | 0.68             | Rh <sup>+5</sup> | 6   | 0.55             | U <sup>+3</sup>  | 6  | 1.03             |
| Nb <sup>+5</sup> | 4   | 0.48             | Ru <sup>+3</sup> | 6   | 0.68             | U <sup>+4</sup>  | 6  | 0.89             |
|                  | 6   | 0.64             | Ru <sup>+4</sup> | 6   | 0.62             |                  | 8  | 1.00             |
|                  | 8   | 0.74             | Ru <sup>+5</sup> | 6   | 0.57             |                  | 12 | 1.17             |
| Nd <sup>+3</sup> | 6   | 0.98             | Ru <sup>+7</sup> | 4   | 0.38             | U <sup>+5</sup>  | 6  | 0.76             |
|                  | 8   | 1.12             | Ru <sup>+8</sup> | 4   | 0.36             | U <sup>+6</sup>  | 2  | 0.45             |
|                  | 9   | 1.16             | S <sup>+4</sup>  | 6   | 0.37             |                  | 4  | 0.52             |
|                  | 12  | 1.27             | S <sup>+6</sup>  | 4   | 0.12             |                  | 6  | 0.73             |
| Ni <sup>+2</sup> | 4sq | 0.49             |                  | 6   | 0.29             |                  | 8  | 0.86             |
|                  | 6   | 0.69             | Sb <sup>+3</sup> | 4py | 0.76             | V <sup>+2</sup>  | 6  | 0.79             |
| Ni <sup>+3</sup> | 6   | 0.56             |                  | 6   | 0.76             | V <sup>+3</sup>  | 6  | 0.64             |
| Np <sup>+3</sup> | 6   | 1.01             | Sb <sup>+5</sup> | 6   | 0.60             | V <sup>+4</sup>  | 5  | 0.53             |
| Np <sup>+4</sup> | 6   | 0.87             | Sc <sup>+3</sup> | 6   | 0.75             |                  | 6  | 0.58             |
| Np <sup>+5</sup> | 6   | 0.75             |                  | 8   | 0.87             |                  | 8  | 0.72             |
| Np <sup>+6</sup> | 6   | 0.72             | Se <sup>+4</sup> | 6   | 0.50             | V <sup>+5</sup>  | 4  | 0.36             |
| Os <sup>+4</sup> | 6   | 0.63             | Se <sup>+6</sup> | 4   | 0.28             |                  | 5  | 0.46             |
| Os <sup>+5</sup> | 6   | 0.58             |                  | 6   | 0.42             |                  | 6  | 0.54             |
| Os <sup>+6</sup> | 6   | 0.55             | Si <sup>+4</sup> | 4   | 0.26             | W <sup>+4</sup>  | 6  | 0.66             |
| Os <sup>+8</sup> | 4   | 0.39             |                  | 6   | 0.40             | W <sup>+5</sup>  | 6  | 0.62             |
| P <sup>+5</sup>  | 4   | 0.17             | Sm <sup>+2</sup> | 6   | 1.19             | W <sup>+6</sup>  | 4  | 0.42             |
|                  | 6   | 0.38             |                  | 8   | 1.27             |                  | 5  | 0.51             |
| Pa <sup>+3</sup> | 6   | 1.04             | Sm <sup>+3</sup> | 6   | 0.96             |                  | 6  | 0.60             |
| Pa <sup>+4</sup> | 6   | 0.90             |                  | 8   | 1.08             | Y <sup>+3</sup>  | 6  | 0.90             |
| Pa <sup>+5</sup> | 6   | 0.78             |                  | 12  | 1.24             |                  | 8  | 1.02             |
| Pb <sup>+2</sup> | 6   | 1.19             | Sn <sup>+4</sup> | 4   | 0.55             |                  | 9  | 1.08             |
|                  | 8   | 1.29             |                  | 6   | 0.69             | Yb <sup>+2</sup> | 6  | 1.02             |
|                  | 10  | 1.40             |                  | 8   | 0.81             |                  | 8  | 1.14             |
|                  | 12  | 1.49             | Sr <sup>+2</sup> | 6   | 1.18             | Yb <sup>+3</sup> | 8  | 0.99             |
| Pb <sup>+4</sup> | 4   | 0.65             |                  | 8   | 1.26             |                  | 9  | 1.04             |
|                  | 6   | 0.78             |                  | 10  | 1.36             | Zn <sup>+2</sup> | 4  | 0.60             |
|                  | 8   | 0.94             |                  | 12  | 1.44             |                  | 6  | 0.74             |
| Pd <sup>+2</sup> | 4sq | 0.64             | Ta <sup>+3</sup> | 6   | 0.72             |                  | 8  | 0.90             |
|                  | 6   | 0.86             | Ta <sup>+4</sup> | 6   | 0.68             | Zr <sup>+4</sup> | 4  | 0.59             |
| Pd <sup>+3</sup> | 6   | 0.76             | Ta <sup>+5</sup> | 6   | 0.64             |                  | 6  | 0.72             |
| Pd <sup>+4</sup> | 6   | 0.62             | Tb <sup>+3</sup> | 6   | 0.92             |                  | 8  | 0.84             |
| Pm <sup>+3</sup> | 6   | 0.97             |                  | 8   | 1.04             |                  | 9  | 0.89             |
|                  | 8   | 1.09             | Tb <sup>+4</sup> | 6   | 0.76             |                  |    |                  |
| Po <sup>+4</sup> | 6   | 0.97             |                  | 8   | 0.88             |                  |    |                  |

# POLARIZABILITIES OF ATOMS AND IONS IN SOLIDS

H. P. R. Frederikse

The polarization of a solid dielectric medium,  $\mathbf{P}$ , is defined as the dipole moment per unit volume averaged over the volume of a crystal cell. A component of  $\mathbf{P}$  can be expanded as a function of the electric field  $\mathbf{E}$ :

$$P_i = \sum_j a_j E_j + \sum_{jk} b_{jk} E_j E_k$$

For relatively small electric fields in isotropic substances  $\mathbf{P} = \chi_e \mathbf{E}$ , where  $\chi_e$  is the electric susceptibility. If the medium is made up of  $N$  atoms (or ions) per unit volume, the polarization is  $\mathbf{P} = N \mathbf{p}_m$  where  $\mathbf{p}_m$  is the average dipole moment per atom. The polarizability  $\alpha$  can be defined as  $\mathbf{p}_m = \alpha \mathbf{E}_0$ , where  $\mathbf{E}_0$  is the local field at the position of the atom. Using the Lorentz method to calculate the local field one finds:

$$\mathbf{P} = N\alpha(\mathbf{E} + 4\pi\mathbf{P}) = \chi_e \mathbf{E}$$

Together with the definition of the dielectric constant (relative permittivity),  $\epsilon = 1 + 4\pi\chi_e$ , this leads to:

$$\alpha = \frac{3}{4\pi N} \left( \frac{\epsilon - 1}{\epsilon + 2} \right)$$

This expression is known as the Clausius-Mossotti equation.

The total polarization associated with atoms, ions, or molecules is due to three different sources:

1. Electronic polarization arises because the center of the local electronic charge cloud around the nucleus is displaced under the action of the field:  $\mathbf{P}_e = N\alpha_e \mathbf{E}_0$  where  $\alpha_e$  is the *electronic polarizability*.

2. Ionic polarization occurs in ionic materials because the electric field displaces cations and anions in opposite directions:  $\mathbf{P}_i = N\alpha_i \mathbf{E}_0$ , where  $\alpha_i$  is the *ionic polarizability*.
3. Orientational polarization can occur in substances composed of molecules that have permanent electric dipoles. The alignment of these dipoles depends on temperature and leads to an *orientational polarizability* per molecule:  $\alpha_{or} = p^2/3kT$ , where  $p$  is the permanent dipole moment per molecule,  $k$  is the Boltzmann constant, and  $T$  is the temperature.

Because of the different nature of these three polarization processes the response of a dielectric solid to an applied electric field will strongly depend on the frequency of the field. The resonance of the electronic excitation in insulators (dielectrics) takes place in the ultraviolet part of the spectrum; the characteristic frequency of the lattice vibrations is located in the infrared, while the orientation of dipoles requires fields of much lower frequencies (below  $10^{10}$  Hz). This response to electric fields of different frequencies is shown in Figure 1. Values of the electronic polarizabilities for selected atoms and ions are given in Table 1.

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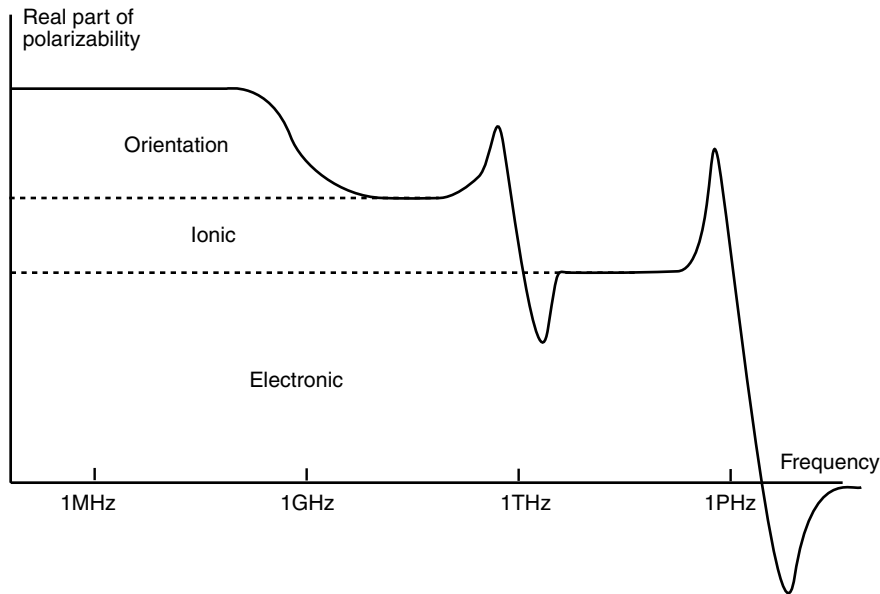


FIGURE 1. Schematic graph of the frequency dependence of the different contributions to polarizability.

TABLE 1. Electronic Polarizabilities in Units of  $10^{-24} \text{ cm}^3$ 

|                                |                                 |                                 |                                  |                                |                               |                   |
|--------------------------------|---------------------------------|---------------------------------|----------------------------------|--------------------------------|-------------------------------|-------------------|
|                                |                                 |                                 |                                  |                                |                               | He<br>0.201       |
| <b>Li<sup>+</sup></b><br>0.029 | <b>Be<sup>2+</sup></b><br>0.008 | <b>B<sup>3+</sup></b><br>0.003  | <b>C<sup>4+</sup></b><br>0.0013  | <b>O<sup>2-</sup></b><br>3.88  | <b>F<sup>-</sup></b><br>1.04  | <b>Ne</b><br>0.39 |
| <b>Na<sup>+</sup></b><br>0.179 | <b>Mg<sup>2+</sup></b><br>0.094 | <b>Al<sup>3+</sup></b><br>0.052 | <b>Si<sup>4+</sup></b><br>0.0165 | <b>S<sup>2-</sup></b><br>10.2  | <b>Cl<sup>-</sup></b><br>3.66 | <b>Ar</b><br>1.62 |
| <b>K<sup>+</sup></b><br>0.83   | <b>Ca<sup>2+</sup></b><br>0.47  | <b>Sc<sup>3+</sup></b><br>0.286 | <b>Ti<sup>4+</sup></b><br>0.185  | <b>Se<sup>2-</sup></b><br>10.5 | <b>Br<sup>-</sup></b><br>4.77 | <b>Kr</b><br>2.46 |
| <b>Rb<sup>+</sup></b><br>1.40  | <b>Sr<sup>2+</sup></b><br>0.86  | <b>Y<sup>3+</sup></b><br>0.55   | <b>Zr<sup>4+</sup></b><br>0.37   | <b>Te<sup>2-</sup></b><br>14.0 | <b>I<sup>-</sup></b><br>7.1   | <b>Xe</b><br>3.99 |
| <b>Cs<sup>+</sup></b><br>2.42  | <b>Ba<sup>2+</sup></b><br>1.55  | <b>La<sup>3+</sup></b><br>1.04  | <b>Ce<sup>4+</sup></b><br>0.73   |                                |                               |                   |

Data from Pauling, L., *Proc. R. Soc. London*, A114, 181, 1927. See also Jaswal, S.S. and Sharma, T.P., *J. Phys. Chem. Solids*, 34, 509, 1973.  
 Values are appropriate for cgs units. To convert to SI, use the relation  $\alpha(\text{SI})/\text{C m}^2\text{V}^{-1} = 1.11265 \cdot 10^{-16} \alpha(\text{cgs})/\text{cm}^3$

# CRYSTAL STRUCTURES AND LATTICE PARAMETERS OF ALLOTROPES OF THE ELEMENTS

H. W. King

The crystal structures of the allotropic forms of the elements are presented in terms of the Pearson symbol, the Strukturbericht designation, and the prototype of the structure. The temperatures of the phase transformations are listed in degrees Celsius and the pressures are in GPa. A consistent nomenclature is used, whereby all allotropes are labeled by Greek letters. The lattice parameters of the units cells are given in nanometers (nm) and are considered to be accurate to  $\pm 2$  in the last reported digit.

This compilation is restricted to changes in crystal structures that occur as a result of a change in temperature or pressure. Low-

temperature structures are included for the diatomic and rare gases, which show many similarities with respect to the metallic elements. The elements identified with an asterisk (\*) have polymorphic structures based on different molecular configurations. The crystal data given for these elements refer to the most stable structure at room temperature.

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| Element         | Temperature,<br>°C | Pressure,<br>GPa | Pearson<br>symbol | Space<br>group | Struktur-<br>bericht<br>designation | Prototype    | Lattice parameters, nm |        |         | Comment,<br>c/a or<br>$\alpha$ or $\beta$ |
|-----------------|--------------------|------------------|-------------------|----------------|-------------------------------------|--------------|------------------------|--------|---------|-------------------------------------------|
|                 |                    |                  |                   |                |                                     |              | a                      | b      | c       |                                           |
| Ac              | 25                 | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.5311                 | ...    | ...     | ...                                       |
| Ag              | 25                 | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.40857                | ...    | ...     | ...                                       |
| $\alpha$ Al     | 25                 | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.40496                | ...    | ...     | ...                                       |
| $\beta$ Al      | 25                 | >20.5            | hP2               | $P6_3/mmc$     | A3                                  | Mg           | 0.2693                 | ...    | 0.4398  | 1.6331                                    |
| $\alpha'$ Am    | 25                 | atm              | hP4               | $P6_3/mmc$     | A3'                                 | $\alpha$ La  | 0.34681                | ...    | 1.1241  | 2*1.621                                   |
| $\alpha$ Am     | >769               | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.4894                 | ...    | ...     | ...                                       |
| $\beta$ Am      | >1074              | atm              | cI2               | Im3m           | A2                                  | W            | ?                      | ...    | ...     | ...                                       |
| $\gamma$ Am     | 25                 | >15              | oC4               | Cmcm           | A20                                 | $\alpha$ U   | 0.3063                 | 0.5968 | 0.5169  | ...                                       |
| $\alpha$ Ar     | <-189.35           | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.5316                 | ...    | ...     | ...                                       |
| ( $\beta$ Ar)   | <-189.40           | atm              | hP2               | $P6_3/mmc$     | A3                                  | Mg           | 0.3760                 | ...    | 0.6141  | 1.633                                     |
| $\alpha$ As     | 25                 | atm              | hR2               | $R\bar{3}m$    | A7                                  | $\alpha$ As  | 0.41319                | ...    | .....   | $\alpha = 54.12^\circ$                    |
| eAs             | >448               | atm              | oC8               | Cmca           | ...                                 | P(black)     | 0.362                  | 1.085  | 0.448   | ...                                       |
| Au              | 25                 | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.40782                | ...    | ...     | ...                                       |
| $\beta$ B       | 25                 | atm              | hR105             | $R3m$          | ...                                 | $\beta$ B    | 1.017                  | ...    | ...     | $\alpha = 65.12^\circ$                    |
| $\alpha$ Ba     | 25                 | atm              | cI2               | Im $\bar{3}m$  | A2                                  | W            | 0.50227                | ...    | ...     | ...                                       |
| $\beta$ Ba      | 25                 | >5.33            | hP2               | $P6_3/mmc$     | A3                                  | Mg           | 0.3901                 | ...    | 0.6154  | 1.5775                                    |
| $\gamma$ Ba     | 25                 | >23              | ?                 | ...            | ...                                 | ...          | ...                    | ...    | ...     | ...                                       |
| $\alpha$ Be     | 25                 | atm              | hP2               | $P6_3/mmc$     | A3                                  | Mg           | 0.22859                | ...    | 0.35845 | 1.5681                                    |
| $\beta$ Be      | >1270              | atm              | cI2               | Im $\bar{3}m$  | A2                                  | W            | 0.25515                | ...    | ...     | ...                                       |
| $\gamma$ Be     | 25                 | >9.3             | ?                 | ...            | ...                                 | ...          | ...                    | ...    | ...     | ...                                       |
| $\alpha$ Bi     | 25                 | atm              | hR2               | $r\bar{3}m$    | A7                                  | $\alpha$ As  | 0.47460                | ...    | ...     | $\alpha = 57.23^\circ$                    |
| $\beta$ Bi      | 25                 | >2.6             | mC4               | C2/m           | ...                                 | $\beta$ Bi   | 0.6674                 | 0.6117 | 0.3304  | $\beta = 110.33^\circ$                    |
| $\gamma$ Bi     | 25                 | >3.0             | mP3               | ?              | ...                                 | ...          | 0.605                  | 0.42   | 0.465   | $\beta = 85.33^\circ$                     |
| $\sigma$ Bi     | 25                 | >4.3             | ?                 | ?              | ...                                 | ...          | ...                    | ...    | ...     | ...                                       |
| eBi             | 25                 | >6.5             | ?                 | ?              | ...                                 | ...          | ...                    | ...    | ...     | ...                                       |
| $\zeta$ Bi      | 25                 | >9.0             | cI2               | Im3m           | A2                                  | W            | 0.3800                 | ...    | ...     | ...                                       |
| $\alpha$ Bk     | 25                 | atm              | hP4               | $P6_3/mmc$     | A3'                                 | $\alpha$ La  | 0.3416                 | ...    | 1.1069  | 2*1.620                                   |
| $\beta$ Bk      | >977               | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.4997                 | ...    | ...     | ...                                       |
| Br              | <7.25              | atm              | oC8               | Cmca           | ...                                 | Cl           | 0.668                  | 0.449  | 0.874   | ...                                       |
| C<br>(graphite) | 25                 | atm              | hP4               | $P6_3/mmc$     | A9                                  | C (graphite) | 0.24612                | ...    | 0.6709  | 2.7258                                    |
| C<br>(diamond)  | 25                 | >60              | cF8               | Fd3m           | A4                                  | C (diamond)  | 0.35669                | ...    | ...     | ...                                       |
| C (hd)          | 25                 | HP               | hP4               | $P6_3/mmc$     | ...                                 | C (hd)       | 0.2522                 | ...    | 0.4119  | 1.633                                     |
| $\alpha$ Ca     | 25                 | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.55884                | ...    | ...     | ...                                       |
| $\beta$ Ca      | >443               | atm              | cI2               | Im3m           | A2                                  | W            | 0.4480                 | ...    | ...     | ...                                       |
| $\gamma$ Ca     | 25                 | >1.5             | ?                 | ...            | ...                                 | ...          | ...                    | ...    | ...     | ...                                       |
| Cd              | 25                 | atm              | hP2               | $P6_3/mmc$     | A3                                  | Mg           | 0.29793                | ...    | 0.56196 | 1.8862                                    |
| $\alpha$ Ce     | <-177              | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.485                  | ...    | ...     | ...                                       |
| $\beta$ Ce      | 25                 | atm              | hP4               | $P6_3/mmc$     | A3'                                 | $\alpha$ La  | 0.36810                | ...    | 1.1857  | 2*1.611                                   |
| $\gamma$ Ce     | 25                 | atm              | cF4               | Fm3m           | A1                                  | Cu           | 0.51610                | ...    | ...     | ...                                       |
| $\delta$ -Ce    | >726               | atm              | cI2               | Im3m           | A2                                  | W            | 0.412                  | ...    | ...     | ...                                       |
| $\alpha'$ Ce    | 25                 | >5.4             | oC4               | Cmcm           | A20                                 | $\alpha$ U   | 0.3049                 | 0.5998 | 0.5215  | ...                                       |



| Element | Temperature,<br>°C | Pressure,<br>GPa | Pearson<br>symbol | Space<br>group | Struktur-<br>bericht<br>designation | Prototype   | Lattice parameters, nm |          |          | Comment,<br>c/a or<br>α or β |
|---------|--------------------|------------------|-------------------|----------------|-------------------------------------|-------------|------------------------|----------|----------|------------------------------|
|         |                    |                  |                   |                |                                     |             | <i>a</i>               | <i>b</i> | <i>c</i> |                              |
| αCf     | 25                 | atm              | <i>hP4</i>        | $P6_3/mmc$     | A3'                                 | αLa         | 0.339                  | ...      | 1.1015   | 2*1.625                      |
| βCf     | >590               | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | ?                      | ...      | ...      | ...                          |
| Cl      | <-102              | atm              | <i>oC8</i>        | $Cmca$         | ...                                 | Cl          | 0.624                  | 0.448    | 0.826    | ...                          |
| αCm     | 25                 | atm              | <i>hP4</i>        | $P6_3/mmc$     | A3'                                 | αLa         | 0.3496                 | ...      | 1.1331   | 2*1.621                      |
| βCm     | >1277              | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.4382                 | ...      | ...      | ...                          |
| eCo     | 25                 | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.25071                | ...      | 0.40686  | 1.6228                       |
| αCo     | >422               | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.35447                | ...      | ...      | ...                          |
| αCr     | 25                 | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.28848                | ...      | ...      | ...                          |
| α'Cr    | 25                 | HP               | <i>tI2</i>        | $I4/mmm$       | ...                                 | α'Cr        | 0.2882                 | ...      | 0.2887   | 1.002                        |
| aCs     | 25                 | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.6141                 | ...      | ...      | ...                          |
| βCs     | 25                 | >2.37            | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.6465                 | ...      | ...      | ...                          |
| β'Cs    | 25                 | >4.22            | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.5800                 | ...      | ...      | ...                          |
| γCs     | 25                 | >4.27            | ?                 | ...            | ...                                 | ...         | ...                    | ...      | ...      | ...                          |
| Cu      | 25                 | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.36146                | ...      | ...      | ...                          |
| α'Dy    | <-187              | atm              | <i>oC4</i>        | $Cmcm$         | ...                                 | α'Dy        | 0.3595                 | 0.6184   | 0.5678   | ...                          |
| αDy     | 25                 | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.35915                | ...      | 0.56501  | 1.5732                       |
| βDy     | >1381              | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.403                  | ...      | ...      | ...                          |
| γDy     | 25                 | >7.5             | <i>hR3</i>        | $R\bar{3}m$    | ...                                 | αSm         | 0.3436                 | ...      | 2.483    | 4.5*1.606                    |
| Er      | 25                 | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.35592                | ...      | 0.55850  | 1.5692                       |
| αEs     | 25                 | atm              | <i>hP4</i>        | $P6_3/mmc$     | A3'                                 | αLa         | ?                      | ...      | ...      | ...                          |
| βEs     | ?                  | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | ?                      | ...      | ...      | ...                          |
| Eu      | 25                 | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.45827                | ...      | ...      | ...                          |
| αF      | <-227.6            | atm              | <i>mC8</i>        | $C2/c$         | ...                                 | αF          | 0.550                  | 0.338    | 0.728    | β = 102.17°                  |
| βF      | <-219.67           | atm              | <i>cP16</i>       | $Pm3n$         | ...                                 | γO          | 0.667                  | ...      | ...      | ...                          |
| αFe     | 25                 | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.28665                | ...      | ...      | ...                          |
| γFe     | >912               | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.36467                | ...      | ...      | ...                          |
| σFe     | >1394              | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.29315                | ...      | ...      | ...                          |
| eFe     | 25                 | >13              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.2468                 | ...      | 0.396    | 1.603                        |
| αGa     | 25                 | atm              | <i>oC8</i>        | $Cmca$         | A11                                 | αGa         | 0.45186                | 0.76570  | 0.45258  | ...                          |
| βGa     | 25                 | >1.2             | <i>tI2</i>        | $I4/mmm$       | A6                                  | In          | 0.2808                 | ...      | 0.4458   | 1.588                        |
| γGa     | -53                | >3.0             | <i>oC40</i>       | $Cmcm$         | ...                                 | γGa         | 1.0593                 | 1.3523   | 0.5203   | ...                          |
| αGd     | 25                 | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.36336                | ...      | 0.57810  | 0.5910                       |
| βGd     | >1235              | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.406                  | ...      | ...      | ...                          |
| γGd     | 25                 | >3.0             | <i>hR3</i>        | $R\bar{3}m$    | ...                                 | αSm         | 0.361                  | ...      | 2.603    | 4*1.60                       |
| αGe     | 25                 | atm              | <i>cF8</i>        | $Fd3m$         | A4                                  | C (diamond) | 0.56574                | ...      | ...      | ...                          |
| βGe     | 25                 | >12              | <i>tI4</i>        | $I4_1/amd$     | A5                                  | βSn         | 0.4884                 | ...      | 0.2692   | 0.551                        |
| γGe     | 25                 | >12→atm          | <i>tP12</i>       | $P4_12_12$     | ...                                 | σGe         | 0.593                  | ...      | 0.698    | 1.18                         |
| σGe     | LT                 | >12              | <i>cI16</i>       | $Im3m$         | ...                                 | γSi         | 0.692                  | ...      | ...      | ...                          |
| αH      | <-271.9            | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.5338                 | ...      | ...      | ...                          |
| βH      | <-259.34           | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.3776                 | ...      | 0.6162   | 1.632                        |
| αHe     | <-268.94           | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.3555                 | ...      | 0.5798   | 1.631                        |
| βHe     | >-258              | 0.125            | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.4240                 | ...      | ...      | ...                          |
| γHe     | <-271.47           | 0.03             | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.4110                 | ...      | ...      | ...                          |
| αHf     | 25                 | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.31946                | ...      | 0.50510  | 1.5811                       |
| βHf     | >1995              | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.3610                 | ...      | ...      | ...                          |
| αHg     | <-38.84            | atm              | <i>hR1</i>        | $R\bar{3}m$    | A10                                 | αHg         | 0.3005                 | ...      | ...      | α = 70.53°                   |
| βHg     | <-194              | HP               | <i>tI2</i>        | $I4/mmm$       | ...                                 | βHg         | 0.3995                 | ...      | 0.2825   | 0.707                        |
| γHg     | <-194              | c.w.             | <i>hR1</i>        | ?              | ...                                 | ...         | ...                    | ...      | ...      | ...                          |
| αHo     | 25                 | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.35778                | ...      | 0.56178  | 1.5702                       |
| βHo     | 25                 | >7.5             | <i>hR3</i>        | $R\bar{3}m$    | ...                                 | αSm         | 0.334                  | ...      | 2.45     | 4.5*1.63                     |
| I       | 25                 | atm              | <i>oC8</i>        | $Cmca$         | ...                                 | Cl          | 0.72697                | 0.47903  | 0.97942  | ...                          |
| In      | 25                 | atm              | <i>tI2</i>        | $I4/mmm$       | A6                                  | In          | 0.3253                 | ...      | 0.49470  | 1.5210                       |
| Ir      | 25                 | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.38392                | ...      | ...      | ...                          |
| K       | 25                 | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.5321                 | ...      | ...      | ...                          |
| Kr      | <-157.39           | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.5810                 | ...      | ...      | ...                          |
| αLa     | 25                 | atm              | <i>hP4</i>        | $P6_3/mmc$     | A3'                                 | αLa         | 0.37740                | ...      | 1.2171   | 2*1.6125                     |
| βLa     | >310               | atm              | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.5303                 | ...      | ...      | ...                          |
| γLa     | >865               | atm              | <i>cI2</i>        | $Im3m$         | A2                                  | W           | 0.426                  | ...      | ...      | ...                          |
| β'La    | 25                 | >2.0             | <i>cF4</i>        | $Fm3m$         | A1                                  | Cu          | 0.517                  | ...      | ...      | ...                          |
| αLi     | <-193              | atm              | <i>hP2</i>        | $P6_3/mmc$     | A3                                  | Mg          | 0.3111                 | ...      | 0.5093   | 1.637                        |

| Element   | Temperature,<br>°C | Pressure,<br>GPa | Pearson<br>symbol | Space<br>group                  | Struktur-<br>bericht<br>designation | Prototype | Lattice parameters, nm |         |         | Comment,<br>c/a or<br>α or β |
|-----------|--------------------|------------------|-------------------|---------------------------------|-------------------------------------|-----------|------------------------|---------|---------|------------------------------|
|           |                    |                  |                   |                                 |                                     |           | a                      | b       | c       |                              |
| βLi       | 25                 | atm              | cI2               | Im3m                            | A2                                  | W         | 0.35093                | ...     | ...     | ...                          |
| γLi       | <-201              | c.w.             | cF4               | Fm3m                            | A1                                  | Cu        | 0.4388                 | ...     | ...     | ...                          |
| Lu        | 25                 | atm              | hP2               | P <sub>6<sub>3</sub></sub> /mmc | A3                                  | Mg        | 0.35052                | ...     | 0.55494 | 1.5832                       |
| Mg        | 25                 | atm              | hP2               | P <sub>6<sub>3</sub></sub> /mmc | A3                                  | Mg        | 0.32094                | ...     | 0.52107 | 1.6236                       |
| αMn       | 25                 | atm              | cl58              | I43m                            | A12                                 | αMn       | 0.89126                | ...     | ...     | ...                          |
| βMn       | >710               | atm              | cP20              | P <sub>4<sub>1</sub></sub> 32   | A13                                 | βMn       | 0.63152                | ...     | ...     | ...                          |
| γMn       | >1079              | atm              | cF4               | Fm3m                            | A1                                  | Cu        | 0.3860                 | ...     | ...     | ...                          |
| σMn       | >1143              | atm              | cl2               | Im3m                            | A2                                  | W         | 0.3080                 | ...     | ...     | ...                          |
| Mo        | 25                 | atm              | cl2               | Im3m                            | A2                                  | W         | 0.31470                | ...     | ...     | ...                          |
| αN        | <-237.6            | atm              | cP8               | Pa3                             | ...                                 | αN        | 0.5661                 | ...     | ...     | ...                          |
| βN        | <-210.00           | atm              | hP4               | P <sub>6<sub>3</sub></sub> /mmc | ...                                 | βN        | 0.4050                 | ...     | 0.6604  | 1.631                        |
| γN        | <-253              | >3.3             | tP4               | P <sub>4<sub>2</sub></sub> /mnm | ...                                 | γN        | 0.3957                 | ...     | 0.5109  | 1.291                        |
| αNa       | <-233              | atm              | hP2               | P <sub>6<sub>3</sub></sub> /mmc | A3                                  | Mg        | 0.3767                 | ...     | 0.6154  | 1.634                        |
| βNa       | 25                 | atm              | cl2               | Im3m                            | A2                                  | W         | 0.42906                | ...     | ...     | ...                          |
| Nb        | 25                 | atm              | cl2               | Im3m                            | A2                                  | W         | 0.33004                | ...     | ...     | ...                          |
| αNd       | 25                 | atm              | hP4               | P <sub>6<sub>3</sub></sub> /mmc | A3'                                 | αLa       | 0.36582                | ...     | 1.17966 | 2*1.6124                     |
| βNd       | >863               | atm              | cl2               | Im3m                            | A2                                  | W         | 0.413                  | ...     | ...     | ...                          |
| γNd       | 25                 | >5.0             | cF4               | Fm3m                            | A1                                  | Cu        | 0.480                  | ...     | ...     | ...                          |
| Ne        | <-243.59           | atm              | cF4               | Fm3m                            | A1                                  | Cu        | 0.4462                 | ...     | ...     | ...                          |
| Ni        | 25                 | atm              | cF4               | Fm3m                            | A1                                  | Cu        | 0.35240                | ...     | ...     | ...                          |
| αNp       | 25                 | atm              | oP8               | Pnma                            | A <sub>c</sub>                      | αNp       | 0.6663                 | 0.4723  | 0.4887  | ...                          |
| βNp       | >280               | atm              | tP4               | P <sub>4<sub>2</sub></sub> 2    | A <sub>d</sub>                      | βNp       | 0.4883                 | ...     | 0.3389  | 0.694                        |
| γNp       | >576               | atm              | cl2               | Im3m                            | A2                                  | W         | 0.352                  | ...     | ...     | ...                          |
| αO        | <-243.3            | atm              | mC4               | C2m                             | ...                                 | αO        | 0.5403                 | 0.3429  | 0.5086  | β = 132.53°                  |
| βO        | <-229.6            | atm              | hR2               | R3m                             | ...                                 | βO        | 0.4210                 | ...     | ...     | α = 46.27°                   |
| γO        | <-218.79           | atm              | cP16              | Pm3n                            | ...                                 | γO        | 0.683                  | ...     | ...     | ...                          |
| Os        | 25                 | atm              | hP2               | P <sub>6<sub>3</sub></sub> /mmc | A3                                  | Mg        | 0.27341                | ...     | 0.43918 | 1.6063                       |
| P (black) | 25                 | atm              | oC8               | Cmca                            | ...                                 | P (black) | 0.33136                | 1.0478  | 0.43763 | ...                          |
| αPa       | 25                 | atm              | tI2               | I4/mmm                          | A <sub>a</sub>                      | αPa       | 0.3921                 | ...     | 0.3235  | 0.825                        |
| βPa       | >1170              | atm              | cl2               | Im3m                            | A2                                  | W         | 0.381                  | ...     | ...     | ...                          |
| αPb       | 25                 | atm              | cF4               | Fm3m                            | A1                                  | Cu        | 0.49502                | ...     | ...     | ...                          |
| βPb       | 25                 | >10.3            | hP2               | P <sub>6<sub>3</sub></sub> /mmc | A3                                  | Mg        | 0.3265                 | ...     | 0.5387  | 1.650                        |
| Pd        | 25                 | atm              | cF4               | Fm3m                            | A1                                  | Cu        | 0.38903                | ...     | ...     | ...                          |
| αPm       | 25                 | atm              | hP4               | P <sub>6<sub>3</sub></sub> /mmc | A3'                                 | αLa       | 0.365                  | ...     | 1.165   | 2*1.60                       |
| βPm       | >890               | atm              | cl2               | Im3m                            | A2                                  | W         | (0.410)                | ...     | ...     | ...                          |
| αPo       | 25                 | atm              | cP1               | Pm3m                            | A <sub>h</sub>                      | αPo       | 0.3366                 | ...     | ...     | ...                          |
| βPo       | >54                | atm              | hR1               | R3m                             | ...                                 | βPo       | 0.3373                 | ...     | ...     | α = 98.08°                   |
| αPr       | 25                 | atm              | hP4               | P <sub>6<sub>3</sub></sub> /mmc | A3'                                 | αLa       | 0.36721                | ...     | 1.18326 | 2*1.6111                     |
| βPr       | >795               | atm              | cl2               | Im3m                            | A2                                  | W         | 0.413                  | ...     | ...     | ...                          |
| γPr       | 25                 | >4.0             | cF4               | Fm3m                            | A1                                  | Cu        | 0.488                  | ...     | ...     | ...                          |
| Pt        | 25                 | atm              | cF4               | Fm3m                            | A1                                  | Cu        | 0.39236                | ...     | ...     | ...                          |
| αPu       | 25                 | atm              | mP16              | P2 <sub>1</sub> /m              | ...                                 | αPu       | 0.6183                 | 0.4822  | 1.0963  | β = 101.97°                  |
| βPu       | >125               | atm              | mI34              | I2/m                            | ...                                 | βPu       | 0.9284                 | 1.0463  | 0.7859  | β = 92.13°                   |
| γPu       | >215               | atm              | oF8               | Fddd                            | ...                                 | γPu       | 0.31587                | 0.57682 | 1.0162  | ...                          |
| σPu       | >320               | atm              | cF4               | Fm3m                            | A1                                  | Cu        | 0.46371                | ...     | ...     | ...                          |
| σ'Pu      | >463               | atm              | tI2               | I4/mmm                          | A6                                  | In        | 0.33261                | ...     | 0.44630 | 1.3418                       |
| ePu       | >483               | atm              | cl2               | Im3m                            | A2                                  | W         | 0.36343                | ...     | ...     | ...                          |
| Ra        | 25                 | atm              | cl2               | Im3m                            | A2                                  | W         | 0.5148                 | ...     | ...     | ...                          |
| αRb       | 25                 | atm              | cl2               | Im3m                            | A2                                  | W         | 0.5705                 | ...     | ...     | ...                          |
| βRb       | 25                 | >1.08            | ?                 | ...                             | ...                                 | ...       | ...                    | ...     | ...     | ...                          |
| γRb       | 25                 | >2.05            | ?                 | ...                             | ...                                 | ...       | ...                    | ...     | ...     | ...                          |
| Re        | 25                 | atm              | hP2               | P <sub>6<sub>3</sub></sub> /mmc | A3                                  | Mg        | 0.27609                | ...     | 0.4458  | 1.6145                       |
| Rh        | 25                 | atm              | cF4               | Fm3m                            | A1                                  | Cu        | 0.38032                | ...     | ...     | ...                          |
| Ru        | 25                 | atm              | hP2               | P <sub>6<sub>3</sub></sub> /mmc | A3                                  | Mg        | 0.27058                | ...     | 0.42816 | 1.5824                       |
| αS        | 25                 | atm              | oF128             | Fddd                            | A16                                 | αS        | 1.0464                 | 1.28660 | 2.44860 | ...                          |
| αSb       | 25                 | atm              | hR2               | R3m                             | A7                                  | αAs       | 0.45067                | ...     | ...     | α = 57.11°                   |
| βSb       | 25                 | >5.0             | cP1               | Pm3m                            | A <sub>h</sub>                      | αPo       | 0.2992                 | ...     | ...     | ...                          |
| γSb       | 25                 | >7.5             | hP2               | P <sub>6<sub>3</sub></sub> /mmc | A3                                  | Mg        | 0.3376                 | ...     | 0.5341  | 1.582                        |
| σSb       | 25                 | >14.0            | mP3               | ?                               | ...                                 | ...       | 0.556                  | 0.404   | 0.422   | β = 86.0°                    |
| αSc       | 25                 | atm              | hP2               | P <sub>6<sub>3</sub></sub> /mm  | A3                                  | Mg        | 0.33088                | ...     | 0.52680 | 1.5921                       |

| Element | Temperature,<br>°C | Pressure,<br>GPa | Pearson<br>symbol | Space<br>group            | Struktur-<br>bericht<br>designation | Prototype   | Lattice parameters, nm |         |         | Comment,<br>c/a or<br>α or β |
|---------|--------------------|------------------|-------------------|---------------------------|-------------------------------------|-------------|------------------------|---------|---------|------------------------------|
|         |                    |                  |                   |                           |                                     |             | a                      | b       | c       |                              |
| βSc     | >1337              | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | (0.373)                | ...     | ...     | ...                          |
| γSe     | 25                 | atm              | <i>hP2</i>        | <i>P3<sub>1</sub>21</i>   | A8                                  | γSe         | 0.43659                | ...     | 0.49537 | 1.1346                       |
| αSi     | 25                 | atm              | <i>cF8</i>        | <i>Fd3m</i>               | A4                                  | C (diamond) | 0.54306                | ...     | ...     | ...                          |
| βSi     | 25                 | >9.5             | <i>tI4</i>        | <i>I4<sub>1</sub>/amd</i> | A5                                  | βSn         | 0.4686                 | ...     | 0.2585  | 0.552                        |
| γSi     | 25                 | >16.0            | <i>cI16</i>       | <i>Im3m</i>               | ...                                 | γSi         | 0.6636                 | ...     | ...     | ...                          |
| σSi     | 25                 | >16→atm          | <i>hP4</i>        | <i>P6<sub>3</sub>/mmc</i> | A3'                                 | αLa         | 0.380                  | ...     | 0.628   | 1.653                        |
| αSm     | 25                 | atm              | <i>hR3</i>        | <i>R3m</i>                | ...                                 | αSm         | 0.36290                | ...     | 2.6207  | 4*1.6048                     |
| βSm     | >734               | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.36630                | ...     | 0.58448 | 1.5956                       |
| γ'Sm    | >922               | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | (0.410)                | ...     | ...     | ...                          |
| σSm     | 25                 | >4.0             | <i>hP4</i>        | <i>P6<sub>3</sub>/mmc</i> | A3'                                 | αLa         | 0.3618                 | ...     | 1.166   | 2*1.611                      |
| αSn     | <13                | atm              | <i>cF8</i>        | <i>Fd3m</i>               | A4                                  | C (diamond) | 0.64892                | ...     | ...     | ...                          |
| βSn     | 25                 | atm              | <i>tI4</i>        | <i>I4<sub>1</sub>/amd</i> | A5                                  | βSn         | 0.58318                | ...     | 0.31818 | 0.5456                       |
| γSn     | 25                 | >9.0             | <i>tI2</i>        | ?                         | ...                                 | γSn         | 0.370                  | ...     | 0.337   | 0.91                         |
| αSr     | 25                 | atm              | <i>cF4</i>        | <i>Fm3m</i>               | A1                                  | Cu          | 0.6084                 | ...     | ...     | ...                          |
| βSr     | >547               | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.487                  | ...     | ...     | ...                          |
| β'Sr    | 25                 | >3.5             | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.4437                 | ...     | ...     | ...                          |
| Ta      | 25                 | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.33030                | ...     | ...     | ...                          |
| α'Tb    | <-53               | atm              | <i>oC4</i>        | <i>Cmcm</i>               | ...                                 | α'Dy        | 0.3605                 | 0.6244  | 0.5706  | ...                          |
| aTb     | 25                 | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.36055                | ...     | 0.56966 | 1.5800                       |
| βTb     | >1289              | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | (0.407)                | ...     | ...     | ...                          |
| γTb     | 25                 | >6.0             | <i>hR3</i>        | <i>R3m</i>                | ...                                 | αSm         | 0.341                  | ...     | 2.45    | 4*1.60                       |
| Tc      | 25                 | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.2738                 | ...     | 0.4393  | 1.604                        |
| αTe     | 25                 | atm              | <i>hP3</i>        | <i>P3<sub>1</sub>21</i>   | A8                                  | γSe         | 0.44566                | ...     | 0.59264 | 1.3298                       |
| βTe     | 25                 | >2.0             | <i>hR2</i>        | <i>R3m</i>                | A7                                  | αAs         | 0.469                  | ...     | ...     | α = 53.30°                   |
| γTe     | 25                 | >7.0             | <i>hR1</i>        | <i>R3m</i>                | ...                                 | βPo         | 0.3002                 | ...     | ...     | α = 103.3°                   |
| αTh     | 25                 | atm              | <i>cF4</i>        | <i>Fm3m</i>               | A1                                  | Cu          | 0.50842                | ...     | ...     | ...                          |
| βTh     | >1360              | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.411                  | ...     | ...     | ...                          |
| αTi     | 25                 | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.29506                | ...     | 0.46835 | 1.59873                      |
| βTi     | >882               | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.33065                | ...     | ...     | ...                          |
| ωTi     | 25                 | HP→atm           | <i>hP3</i>        | <i>P6/mmm</i>             | ...                                 | ωTi         | 0.4625                 | ...     | 0.2813  | 0.6082                       |
| αTl     | 25                 | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.34566                | ...     | 0.55248 | 1.5983                       |
| βTl     | >230               | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.3879                 | ...     | ...     | ...                          |
| γTl     | 25                 | HP               | <i>cF4</i>        | <i>Fm3m</i>               | A1                                  | Cu          | ?                      | ...     | ...     | ...                          |
| Tm      | 25                 | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.35375                | ...     | 0.55540 | 1.5700                       |
| αU      | 25                 | atm              | <i>oC4</i>        | <i>Cmcm</i>               | A20                                 | αU          | 0.28537                | 0.58695 | 0.49548 | ...                          |
| βU      | >668               | atm              | <i>tP30</i>       | <i>P4<sub>2</sub>/mmm</i> | A <sub>b</sub>                      | βU          | 1.0759                 | ...     | 0.5656  | 0.526                        |
| γU      | >776               | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.3524                 | ...     | ...     | ...                          |
| V       | 25                 | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.30240                | ...     | ...     | ...                          |
| W       | 25                 | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.31652                | ...     | ...     | ...                          |
| Xe      | <-111.76           | atm              | <i>cF4</i>        | <i>Fm3m</i>               | A1                                  | Cu          | 0.6350                 | ...     | ...     | ...                          |
| αY      | 25                 | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.36482                | ...     | 0.57318 | 1.5711                       |
| βY      | >1478              | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | (0.410)                | ...     | ...     | ...                          |
| αYb     | <-3                | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.38799                | ...     | 0.63859 | 1.6459                       |
| βYb     | 25                 | atm              | <i>cF4</i>        | <i>Fm3m</i>               | A1                                  | Cu          | 0.54848                | ...     | ...     | ...                          |
| γYb     | >795               | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.444                  | ...     | ...     | ...                          |
| Zn      | 25                 | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.26650                | ...     | 0.49470 | 1.8563                       |
| αZr     | 25                 | atm              | <i>hP2</i>        | <i>P6<sub>3</sub>/mmc</i> | A3                                  | Mg          | 0.32316                | ...     | 0.51475 | 1.5929                       |
| βZr     | >863               | atm              | <i>cI2</i>        | <i>Im3m</i>               | A2                                  | W           | 0.36090                | ...     | ...     | ...                          |
| ωZr     | 25                 | HP→atm           | <i>hP2</i>        | <i>P6/mmm</i>             | ...                                 | ωTi         | 0.5036                 | ...     | 0.3109  | 0.617                        |

# LATTICE ENERGIES

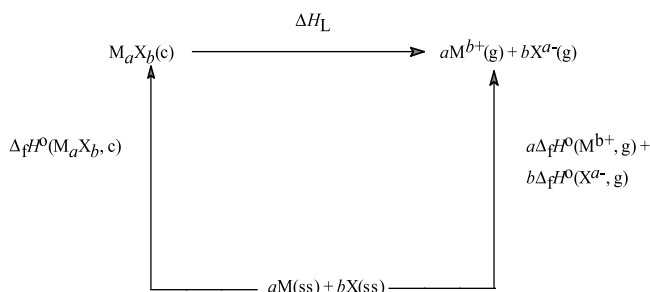
H. D. B. Jenkins and H. K. Roobottom

## THERMOCHEMICAL CYCLE AND CALCULATED VALUES

Table 1 contains calculated values of the lattice energies (total lattice potential energies),  $U_{\text{POT}}$ , of crystalline salts,  $M_aX_b$ .  $U_{\text{POT}}$  is expressed in units of kilojoules per mole,  $\text{kJ mol}^{-1}$ . M and X can be either simple or complex ions. Substances are arranged by chemical class.

Also listed in the table is the lattice energy,  $U_{\text{POT}}^{\text{BFHC}}$ , obtained from the application of the Born - Fajans - Haber cycle (BFHC) described below, using the "Standard Thermochemical Properties of Chemical Substances" table in Section 5 of this *Handbook*, References 1 through 4, and certain other data which are given in Table 3 below.

The lattice enthalpy,  $\Delta H_L$ , is given by the cycle:



where (ss) is the standard state of the element concerned.

The lattice enthalpy,  $\Delta H_L$ , is obtained using the equation:

$$\Delta H_L = a\Delta_f H^\circ(M^{b+}, g) + b\Delta_f H^\circ(X^{a-}, g) - \Delta_f H^\circ(M_aX_b, c)$$

and is further related to the total lattice potential energy,  $U_{\text{POT}}$ , by the relationship:

$$\Delta H_L = U_{\text{POT}} + \left[ a \left( \frac{n_M}{2} - 2 \right) + b \left( \frac{n_X}{2} - 2 \right) \right] RT$$

where  $n_M$  and  $n_X$  equal 3 for monatomic ions, 5 for linear polyatomic ions and 6 for polyatomic non-linear ions.

## METHOD OF ESTIMATION OF VALUES NOT TABULATED

In cases where the lattice energy is not tabulated and we want to furnish an estimate, then the Kapustinskii equation<sup>5</sup> can be used to obtain a value (in  $\text{kJ mol}^{-1}$ ):

$$U_{\text{POT}} = \frac{121.4z_a z_b \nu}{(r_a + r_b)} \left( 1 - \frac{0.0345}{(r_a + r_b)} \right)$$

where  $z_a$  and  $z_b$  are the moduli of the charges on the  $\nu$  ions in the lattice and  $r_a$  and  $r_b$  (in nm) are the thermochemical radii given in Table 2. The  $r_a$  for metal ions is taken to be the Goldschmidt<sup>6</sup> radius.

To cite an example, if we wish to estimate the lattice energy of the salt  $[\text{NH}_4^+][\text{HF}_2^-]$  using the above procedure, we see that Table 2 gives the thermochemical radius ( $r_a$ ) for  $\text{NH}_4^+$  to be 0.136 nm and that for  $\text{HF}_2^-$  ( $r_b$ ) to be 0.172 nm. The lattice potential energy is then estimated to be  $700 \text{ kJ mol}^{-1}$  compared with the calculated value of  $705 \text{ kJ mol}^{-1}$  and the Born - Fajans - Haber cycle value of  $658 \text{ kJ mol}^{-1}$ .

## References

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Table 1. Lattice Energies (kJ mol<sup>-1</sup>)

| Substance                         | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ | Substance                       | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ |
|-----------------------------------|------------------------|--------------------------------|---------------------------------|------------------------|--------------------------------|
| <b>Acetates</b>                   |                        |                                | <b>Acetates</b>                 |                        |                                |
| Li(CH <sub>3</sub> COO)           | —                      | 843                            | HoB <sub>6</sub>                | 7489                   | —                              |
| Na(CH <sub>3</sub> COO)           | 828                    | 807                            | ErB <sub>6</sub>                | 7489                   | —                              |
| K(CH <sub>3</sub> COO)            | 749                    | 726                            | TmB <sub>6</sub>                | 7489                   | —                              |
| Rb(CH <sub>3</sub> COO)           | 715                    | —                              | YbB <sub>6</sub>                | 5146                   | —                              |
| Cs(CH <sub>3</sub> COO)           | 682                    | —                              | LuB <sub>6</sub>                | 7489                   | —                              |
| <b>Acetylides</b>                 |                        |                                | ThB <sub>6</sub>                | 10167                  | —                              |
| CaC <sub>2</sub>                  | 2911                   | 2902                           | <b>Borohydrides</b>             |                        |                                |
| SrC <sub>2</sub>                  | 2788                   | 2782                           | LiBH <sub>4</sub>               | 778                    | —                              |
| BaC <sub>2</sub>                  | 2647                   | 2652                           | NaBH <sub>4</sub>               | 703                    | 694                            |
| <b>Azides</b>                     |                        |                                | KBH <sub>4</sub>                | 655                    | 638                            |
| LiN <sub>3</sub>                  | 861                    | 875                            | RbBH <sub>4</sub>               | 648                    | —                              |
| NaN <sub>3</sub>                  | 770                    | 784                            | CsBH <sub>4</sub>               | 628                    | —                              |
| KN <sub>3</sub>                   | 697                    | —                              | <b>Borohalides</b>              |                        |                                |
| RbN <sub>3</sub>                  | 674                    | 691                            | LiBF <sub>4</sub>               | 699                    | 749                            |
| CsN <sub>3</sub>                  | 665                    | 674                            | NaBF <sub>4</sub>               | 657                    | 674                            |
| AgN <sub>3</sub>                  | 854                    | 910                            | KBF <sub>4</sub>                | 611                    | 616                            |
| TlN <sub>3</sub>                  | 689                    | 742                            | RbBF <sub>4</sub>               | 577                    | 590                            |
| Ca(N <sub>3</sub> ) <sub>2</sub>  | 2186                   | 2316                           | CsBF <sub>4</sub>               | 556                    | 565                            |
| Sr(N <sub>3</sub> ) <sub>2</sub>  | 2056                   | 2187                           | NH <sub>4</sub> BF <sub>4</sub> | 582                    | —                              |
| Ba(N <sub>3</sub> ) <sub>2</sub>  | 2021                   | —                              | KBCl <sub>4</sub>               | 506                    | 497                            |
| Mn(N <sub>3</sub> ) <sub>2</sub>  | 2408                   | 2348                           | RbBCl <sub>4</sub>              | 489                    | 486                            |
| Cu(N <sub>3</sub> ) <sub>2</sub>  | 2730                   | 2738                           | CsBCl <sub>4</sub>              | 473                    | —                              |
| Zn(N <sub>3</sub> ) <sub>2</sub>  | 2840                   | 2970                           | <b>Carbonates</b>               |                        |                                |
| Cd(N <sub>3</sub> ) <sub>2</sub>  | 2446                   | 2576                           | Li <sub>2</sub> CO <sub>3</sub> | 2523                   | 2254                           |
| Pb(N <sub>3</sub> ) <sub>2</sub>  | —                      | 2300                           | Na <sub>2</sub> CO <sub>3</sub> | 2301                   | 2016                           |
| <b>Bihalide Salts</b>             |                        |                                | K <sub>2</sub> CO <sub>3</sub>  | 2084                   | 1846                           |
| LiHF <sub>2</sub>                 | 821                    | 847                            | Rb <sub>2</sub> CO <sub>3</sub> | 2000                   | 1783                           |
| NaHF <sub>2</sub>                 | 755                    | 748                            | Cs <sub>2</sub> CO <sub>3</sub> | 1920                   | 1722                           |
| KHF <sub>2</sub>                  | 657                    | 660                            | MgCO <sub>3</sub>               | 3138                   | 3122                           |
| RbHF <sub>2</sub>                 | 627                    | 631                            | CaCO <sub>3</sub>               | 2804                   | 2811                           |
| CsHF <sub>2</sub>                 | 607                    | —                              | SrCO <sub>3</sub>               | 2720                   | 2688                           |
| NH <sub>4</sub> HF <sub>2</sub>   | 705                    | 658                            | BaCO <sub>3</sub>               | 2615                   | 2554                           |
| CsHCl <sub>2</sub>                | 601                    | —                              | MnCO <sub>3</sub>               | 3046                   | 3092                           |
| Me <sub>4</sub> NHCl <sub>2</sub> | 427                    | —                              | FeCO <sub>3</sub>               | 3121                   | 3169                           |
| Et <sub>4</sub> NHCl <sub>2</sub> | 346                    | —                              | CoCO <sub>3</sub>               | 3443                   | 3235                           |
| Bu <sub>4</sub> NHCl <sub>2</sub> | 290                    | —                              | CuCO <sub>3</sub>               | 3494                   | —                              |
| <b>Bicarbonates</b>               |                        |                                | ZnCO <sub>3</sub>               | 3121                   | 3273                           |
| NaHCO <sub>3</sub>                | 820                    | 656                            | CdCO <sub>3</sub>               | 2929                   | 3052                           |
| KHCO <sub>3</sub>                 | 741                    | 573                            | SnCO <sub>3</sub>               | 2904                   | —                              |
| RbHCO <sub>3</sub>                | 707                    | 522                            | PbCO <sub>3</sub>               | 2728                   | 2750                           |
| CsHCO <sub>3</sub>                | 678                    | 520                            | <b>Cyanates</b>                 |                        |                                |
| NH <sub>4</sub> HCO <sub>3</sub>  | —                      | 577                            | LiNCO                           | 849                    | —                              |
| <b>Borides</b>                    |                        |                                | NaNCO                           | 807                    | 816                            |
| CaB <sub>6</sub>                  | 5146                   | —                              | KNCO                            | 726                    | 734                            |
| SrB <sub>6</sub>                  | 5104                   | —                              | RbNCO                           | 692                    | —                              |
| BaB <sub>6</sub>                  | 5021                   | —                              | CsNCO                           | 661                    | —                              |
| YB <sub>6</sub>                   | 7447                   | —                              | NH <sub>4</sub> NCO             | 724                    | —                              |
| LaB <sub>6</sub>                  | 7406                   | —                              | <b>Cyanides</b>                 |                        |                                |
| CeB <sub>6</sub>                  | 10083                  | —                              | LiCN                            | 874                    | —                              |
| PrB <sub>6</sub>                  | 7447                   | —                              | NaCN                            | 766                    | 759                            |
| NdB <sub>6</sub>                  | 7447                   | —                              | KCN                             | 692                    | 686                            |
| PmB <sub>6</sub>                  | 7406                   | —                              | RbCN                            | 638                    | —                              |
| SmB <sub>6</sub>                  | 7447                   | —                              | CsCN                            | 601                    | —                              |
| EuB <sub>6</sub>                  | 5104                   | —                              | Ca(CN) <sub>2</sub>             | 2268                   | 2240                           |
| GdB <sub>6</sub>                  | 7489                   | —                              | Sr(CN) <sub>2</sub>             | 2138                   | —                              |
| TbB <sub>6</sub>                  | 7489                   | —                              | Ba(CN) <sub>2</sub>             | 2001                   | 2009                           |
| DyB <sub>6</sub>                  | 7489                   | —                              | NH <sub>4</sub> CN              | 617                    | 691                            |
|                                   |                        |                                | AgCN                            | (741)                  | 935                            |

| Substance                           | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ | Substance           | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ |
|-------------------------------------|------------------------|--------------------------------|---------------------|------------------------|--------------------------------|
| Zn(CN) <sub>2</sub>                 | 2809                   | 2817                           | AgI                 | 881                    | 892                            |
| Cd(CN) <sub>2</sub>                 | 2583                   | 2591                           | AuCl                | 1013                   | 1066                           |
| <b>Formates</b>                     |                        |                                | AuBr                | 1029                   | 1059                           |
| Li(HCO <sub>2</sub> )               | 865                    | —                              | AuI                 | 1027                   | 1070                           |
| Na(HCO <sub>2</sub> )               | 791                    | 804                            | InCl                | —                      | 764                            |
| K(HCO <sub>2</sub> )                | 713                    | 722                            | InBr                | —                      | 767                            |
| Rb(HCO <sub>2</sub> )               | 685                    | —                              | InI                 | —                      | 733                            |
| Cs(HCO <sub>2</sub> )               | 651                    | —                              | TlF                 | —                      | 850                            |
| NH <sub>4</sub> (HCO <sub>2</sub> ) | 715                    | —                              | TlCl                | 738                    | 751                            |
| <b>Germanates</b>                   |                        |                                | TlBr                | 720                    | 734                            |
| Mg <sub>2</sub> GeO <sub>4</sub>    | 7991                   | —                              | TlI                 | 692                    | 710                            |
| Ca <sub>2</sub> GeO <sub>4</sub>    | 7301                   | 7306                           | Me <sub>4</sub> NCl | 566                    | —                              |
| Sr <sub>2</sub> GeO <sub>4</sub>    | 6987                   | —                              | Me <sub>4</sub> NBr | 553                    | —                              |
| Ba <sub>2</sub> GeO <sub>4</sub>    | 6653                   | 6643                           | Me <sub>4</sub> NI  | 544                    | —                              |
| <b>Halates</b>                      |                        |                                | PH <sub>4</sub> Br  | 616                    | —                              |
| LiBrO <sub>3</sub>                  | 883                    | 880                            | PH <sub>4</sub> I   | 590                    | —                              |
| NaBrO <sub>3</sub>                  | 803                    | 791                            | BeF <sub>2</sub>    | 3464                   | 3526                           |
| KBrO <sub>3</sub>                   | 740                    | 722                            | BeCl <sub>2</sub>   | 3004                   | 3033                           |
| RbBrO <sub>3</sub>                  | 720                    | 705                            | BeBr <sub>2</sub>   | 2950                   | 2914                           |
| CsBrO <sub>3</sub>                  | 694                    | 681                            | BeI <sub>2</sub>    | 2780                   | 2813                           |
| NaClO <sub>3</sub>                  | 770                    | 785                            | MgF <sub>2</sub>    | 2926                   | 2978                           |
| KClO <sub>3</sub>                   | 711                    | 721                            | MgCl <sub>2</sub>   | 2477                   | 2540                           |
| RbClO <sub>3</sub>                  | 690                    | 703                            | MgBr <sub>2</sub>   | 2406                   | 2451                           |
| CsClO <sub>3</sub>                  | —                      | 679                            | MgI <sub>2</sub>    | 2293                   | 2340                           |
| LiIO <sub>3</sub>                   | 975                    | 974                            | CaF <sub>2</sub>    | 2640                   | 2651                           |
| NaIO <sub>3</sub>                   | 883                    | 876                            | CaCl <sub>2</sub>   | 2268                   | 2271                           |
| KIO <sub>3</sub>                    | 820                    | 780                            | CaBr <sub>2</sub>   | 2132                   | —                              |
| RbIO <sub>3</sub>                   | 791                    | —                              | CaI <sub>2</sub>    | 1971                   | 2087                           |
| CsIO <sub>3</sub>                   | 761                    | —                              | SrF <sub>2</sub>    | 2476                   | 2513                           |
| <b>Halides</b>                      |                        |                                | SrCl <sub>2</sub>   | 2142                   | 2170                           |
| LiF                                 | 1030                   | 1049                           | SrI <sub>2</sub>    | 1984                   | 1976                           |
| LiCl                                | 834                    | 864                            | BaF <sub>2</sub>    | 2347                   | 2373                           |
| LiBr                                | 788                    | 820                            | BaCl <sub>2</sub>   | 2046                   | 2069                           |
| LiI                                 | 730                    | 764                            | BaBr <sub>2</sub>   | 1971                   | 1995                           |
| NaF                                 | 910                    | 930                            | BaI <sub>2</sub>    | 1862                   | 1890                           |
| NaCl                                | 769                    | 790                            | RaF <sub>2</sub>    | 2284                   | —                              |
| NaBr                                | 732                    | 754                            | RaCl <sub>2</sub>   | 2004                   | —                              |
| NaI                                 | 682                    | 705                            | RaBr <sub>2</sub>   | 1929                   | —                              |
| KF                                  | 808                    | 829                            | RaI <sub>2</sub>    | 1803                   | —                              |
| KCl                                 | 701                    | 720                            | ScCl <sub>2</sub>   | 2380                   | —                              |
| KBr                                 | 671                    | 691                            | ScBr <sub>2</sub>   | 2291                   | —                              |
| KI                                  | 632                    | 650                            | ScI <sub>2</sub>    | 2201                   | —                              |
| RbF                                 | 774                    | 795                            | TiF <sub>2</sub>    | 2724                   | —                              |
| RbCl                                | 680                    | 695                            | TiCl <sub>2</sub>   | 2439                   | 2514                           |
| RbBr                                | 651                    | 668                            | TiBr <sub>2</sub>   | 2360                   | 2430                           |
| RbI                                 | 617                    | 632                            | TiI <sub>2</sub>    | 2259                   | 2342                           |
| CsF                                 | 744                    | 759                            | VCl <sub>2</sub>    | 2607                   | 2593                           |
| CsCl                                | 657                    | 670                            | VBr <sub>2</sub>    | —                      | 2534                           |
| CsBr                                | 632                    | 647                            | VI <sub>2</sub>     | —                      | 2470                           |
| CsI                                 | 600                    | 613                            | CrF <sub>2</sub>    | 2778                   | 2939                           |
| FrF                                 | 715                    | —                              | CrCl <sub>2</sub>   | 2540                   | 2601                           |
| FrCl                                | 632                    | —                              | CrBr <sub>2</sub>   | 2377                   | 2536                           |
| FrBr                                | 611                    | —                              | CrI <sub>2</sub>    | 2269                   | 2440                           |
| FrI                                 | 582                    | —                              | MoCl <sub>2</sub>   | 2737                   | 2746                           |
| CuCl                                | 992                    | 996                            | MoBr <sub>2</sub>   | 2742                   | 2753                           |
| CuBr                                | 969                    | 978                            | MoI <sub>2</sub>    | 2630                   | —                              |
| CuI                                 | 948                    | 966                            | MnF <sub>2</sub>    | 2644                   | —                              |
| AgF                                 | 953                    | 974                            | MnCl <sub>2</sub>   | 2510                   | 2551                           |
| AgCl                                | 910                    | 918                            | MnBr <sub>2</sub>   | 2448                   | 2482                           |
| AgBr                                | 897                    | 905                            | MnI <sub>2</sub>    | 2212                   | —                              |
|                                     |                        |                                | FeF <sub>2</sub>    | 2849                   | 2967                           |

| Substance         | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ | Substance         | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ |
|-------------------|------------------------|--------------------------------|-------------------|------------------------|--------------------------------|
| FeCl <sub>2</sub> | 2569                   | 2641                           | CrCl <sub>3</sub> | 5518                   | 5529                           |
| FeBr <sub>2</sub> | 2515                   | 2577                           | CrBr <sub>3</sub> | 5355                   | —                              |
| FeI <sub>2</sub>  | 2439                   | 2491                           | CrI <sub>3</sub>  | 5275                   | 5294                           |
| CoF <sub>2</sub>  | 3004                   | 3042                           | MoF <sub>3</sub>  | 6459                   | —                              |
| CoCl <sub>2</sub> | 2707                   | 2706                           | MoCl <sub>3</sub> | 5246                   | 5253                           |
| CoBr <sub>2</sub> | 2640                   | 2643                           | MoBr <sub>3</sub> | 5156                   | —                              |
| CoI <sub>2</sub>  | 2569                   | 2561                           | MoI <sub>3</sub>  | 5073                   | —                              |
| NiF <sub>2</sub>  | 3098                   | 3089                           | MnF <sub>3</sub>  | 6017                   | —                              |
| NiCl <sub>2</sub> | 2753                   | 2786                           | MnCl <sub>3</sub> | 5544                   | —                              |
| NiBr <sub>2</sub> | 2729                   | 2721                           | MnBr <sub>3</sub> | 5448                   | —                              |
| NiI <sub>2</sub>  | 2607                   | 2637                           | MnI <sub>3</sub>  | 5330                   | —                              |
| PdCl <sub>2</sub> | 2778                   | 2818                           | TcCl <sub>3</sub> | 5270                   | —                              |
| PdBr <sub>2</sub> | 2741                   | 2751                           | TcBr <sub>3</sub> | 5215                   | —                              |
| PdI <sub>2</sub>  | 2748                   | 2760                           | TcI <sub>3</sub>  | 5188                   | —                              |
| CuF <sub>2</sub>  | 3046                   | 3102                           | FeF <sub>3</sub>  | 5870                   | —                              |
| CuCl <sub>2</sub> | 2774                   | 2824                           | FeCl <sub>3</sub> | 5364                   | 5436                           |
| CuBr <sub>2</sub> | 2715                   | 2774                           | FeBr <sub>3</sub> | 5333                   | 5347                           |
| CuI <sub>2</sub>  | 2640                   | —                              | FeI <sub>3</sub>  | 5117                   | —                              |
| AgF <sub>2</sub>  | 2942                   | 2967                           | RuCl <sub>3</sub> | 5245                   | 5257                           |
| ZnF <sub>2</sub>  | 3021                   | 3053                           | RuBr <sub>3</sub> | 5223                   | 5232                           |
| ZnCl <sub>2</sub> | 2703                   | 2748                           | RuI <sub>3</sub>  | 5222                   | 5235                           |
| ZnBr <sub>2</sub> | 2648                   | 2689                           | CoF <sub>3</sub>  | 5991                   | —                              |
| ZnI <sub>2</sub>  | 2581                   | 2619                           | RhCl <sub>3</sub> | 5641                   | 5665                           |
| CdF <sub>2</sub>  | 2809                   | 2830                           | IrF <sub>3</sub>  | (6112)                 | —                              |
| CdCl <sub>2</sub> | 2552                   | 2565                           | IrBr <sub>3</sub> | (4794)                 | —                              |
| CdBr <sub>2</sub> | 2507                   | 2517                           | NiF <sub>3</sub>  | (6111)                 | —                              |
| CdI <sub>2</sub>  | 2441                   | 2455                           | AuF <sub>3</sub>  | (5777)                 | —                              |
| HgF <sub>2</sub>  | 2757                   | —                              | AuCl <sub>3</sub> | (4605)                 | —                              |
| HgCl <sub>2</sub> | 2657                   | 2664                           | ZnCl <sub>3</sub> | 5832                   | —                              |
| HgBr <sub>2</sub> | 2628                   | 2639                           | ZnBr <sub>3</sub> | 5732                   | —                              |
| HgI <sub>2</sub>  | 2628                   | 2624                           | ZnI <sub>3</sub>  | 5636                   | —                              |
| SnF <sub>2</sub>  | 2551                   | —                              | AlF <sub>3</sub>  | 5924                   | 6252                           |
| SnCl <sub>2</sub> | 2297                   | 2310                           | AlCl <sub>3</sub> | 5376                   | 5513                           |
| SnBr <sub>2</sub> | 2251                   | 2256                           | AlBr <sub>3</sub> | 5247                   | 5360                           |
| SnI <sub>2</sub>  | 2193                   | 2206                           | AlI <sub>3</sub>  | 5070                   | 5227                           |
| PbF <sub>2</sub>  | 2535                   | 2543                           | GaF <sub>3</sub>  | 5829                   | 6238                           |
| PbCl <sub>2</sub> | 2270                   | 2282                           | GaCl <sub>3</sub> | 5217                   | 5665                           |
| PbBr <sub>2</sub> | 2219                   | 2230                           | GaBr <sub>3</sub> | 4966                   | 5569                           |
| PbI <sub>2</sub>  | 2163                   | 2177                           | GaI <sub>3</sub>  | 4611                   | 5496                           |
| ScF <sub>3</sub>  | 5492                   | 5540                           | InCl <sub>3</sub> | 4736                   | 5183                           |
| ScCl <sub>3</sub> | 4874                   | 4901                           | InBr <sub>3</sub> | 4535                   | 5117                           |
| ScBr <sub>3</sub> | 4729                   | 4761                           | InI <sub>3</sub>  | 4234                   | 5001                           |
| ScI <sub>3</sub>  | 4640                   | —                              | TlF <sub>3</sub>  | 5493                   | —                              |
| YF <sub>3</sub>   | 4983                   | —                              | TlCl <sub>3</sub> | 5258                   | 5278                           |
| YCl <sub>3</sub>  | 4506                   | 4524                           | TlBr <sub>3</sub> | 5171                   | —                              |
| YI <sub>3</sub>   | 4240                   | 4258                           | TlI <sub>3</sub>  | 5088                   | —                              |
| TiF <sub>3</sub>  | 5644                   | —                              | AsBr <sub>3</sub> | 5497                   | 5365                           |
| TiCl <sub>3</sub> | 5134                   | 5153                           | AsI <sub>3</sub>  | 4824                   | 5295                           |
| TiBr <sub>3</sub> | 5012                   | 5023                           | SbF <sub>3</sub>  | 5295                   | 5324                           |
| TiI <sub>3</sub>  | 4845                   | —                              | SbCl <sub>3</sub> | 5032                   | 4857                           |
| ZrCl <sub>3</sub> | —                      | 4791                           | SbBr <sub>3</sub> | 4954                   | 4776                           |
| ZrBr <sub>3</sub> | —                      | 4758                           | SbI <sub>3</sub>  | 4867                   | 4692                           |
| ZrI <sub>3</sub>  | —                      | 4591                           | BiCl <sub>3</sub> | 4689                   | 4707                           |
| VF <sub>3</sub>   | 5895                   | —                              | BiI <sub>3</sub>  | 3774                   | —                              |
| VCl <sub>3</sub>  | 5322                   | 5329                           | LaF <sub>3</sub>  | 4682                   | —                              |
| VBr <sub>3</sub>  | 5214                   | 5224                           | LaCl <sub>3</sub> | 4263                   | 4242                           |
| VI <sub>3</sub>   | 5121                   | 5136                           | LaBr <sub>3</sub> | 4209                   | —                              |
| NbCl <sub>3</sub> | 5062                   | —                              | LaI <sub>3</sub>  | 3916                   | 3986                           |
| NbBr <sub>3</sub> | 4980                   | —                              | CeCl <sub>3</sub> | 4394                   | 4348                           |
| NbI <sub>3</sub>  | 4860                   | —                              | CeI <sub>3</sub>  | —                      | 4061                           |
| CrF <sub>3</sub>  | 6033                   | 6065                           | PrCl <sub>3</sub> | 4322                   | 4387                           |

| Substance                                      | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ | Substance             | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ |
|------------------------------------------------|------------------------|--------------------------------|-----------------------|------------------------|--------------------------------|
| PrI <sub>3</sub>                               | —                      | 4101                           | RbH                   | 686                    | 684                            |
| NdCl <sub>3</sub>                              | 4343                   | 4415                           | CsH                   | 648                    | 653                            |
| SmCl <sub>3</sub>                              | 4376                   | 4450                           | VH                    | 1184                   | (1344)                         |
| EuCl <sub>3</sub>                              | 4393                   | 4490                           | NbH                   | 1163                   | (1633)                         |
| GdCl <sub>3</sub>                              | 4406                   | 4495                           | PdH                   | 979                    | 1368                           |
| DyCl <sub>3</sub>                              | 4481                   | 4529                           | CuH                   | 828                    | 1254                           |
| HoCl <sub>3</sub>                              | 4501                   | 4572                           | TiH                   | 996                    | 1407                           |
| ErCl <sub>3</sub>                              | 4527                   | 4591                           | ZrH                   | 916                    | 1590                           |
| TmCl <sub>3</sub>                              | 4548                   | 4608                           | HfH                   | 904                    | —                              |
| TmI <sub>3</sub>                               | —                      | 4340                           | LaH                   | 828                    | —                              |
| YbCl <sub>3</sub>                              | —                      | 4651                           | TaH                   | 1021                   | —                              |
| AcCl <sub>3</sub>                              | 4096                   | —                              | CrH                   | 1050                   | —                              |
| UCl <sub>3</sub>                               | 4243                   | —                              | NiH                   | 929                    | —                              |
| NpCl <sub>3</sub>                              | 4268                   | —                              | PtH                   | 937                    | —                              |
| PuCl <sub>3</sub>                              | 4289                   | —                              | AgH                   | 941                    | —                              |
| PuBr <sub>3</sub>                              | (3959)                 | —                              | AuH                   | 1033                   | 1108                           |
| AmCl <sub>3</sub>                              | 4293                   | —                              | TlH                   | 745                    | —                              |
| TiF <sub>4</sub>                               | 10012                  | 9908                           | GeH                   | 950                    | —                              |
| TiCl <sub>4</sub>                              | 9431                   | —                              | PbH                   | 778                    | —                              |
| TiBr <sub>4</sub>                              | 9288                   | 9059                           | BeH <sub>2</sub>      | 3205                   | 3306                           |
| TiI <sub>4</sub>                               | 9108                   | 8918                           | MgH <sub>2</sub>      | 2791                   | 2718                           |
| ZrF <sub>4</sub>                               | 8853                   | 8971                           | CaH <sub>2</sub>      | 2410                   | 2406                           |
| ZrCl <sub>4</sub>                              | 8021                   | 8144                           | SrH <sub>2</sub>      | 2250                   | 2265                           |
| ZrBr <sub>4</sub>                              | 7661                   | 7984                           | BaH <sub>2</sub>      | 2121                   | 2133                           |
| ZrI <sub>4</sub>                               | 7155                   | 7801                           | ScH <sub>2</sub>      | 2711                   | 2744                           |
| MoF <sub>4</sub>                               | 8795                   | —                              | YH <sub>2</sub>       | (2598)                 | 2733                           |
| MoCl <sub>4</sub>                              | 8556                   | 9603                           | LaH <sub>2</sub>      | 2380                   | 2522                           |
| MoBr <sub>4</sub>                              | 8510                   | 9500                           | CeH <sub>2</sub>      | 2414                   | 2509                           |
| MoI <sub>4</sub>                               | 8427                   | —                              | PrH <sub>2</sub>      | 2448                   | 2405                           |
| SnCl <sub>4</sub>                              | 8355                   | 8930                           | NdH <sub>2</sub>      | 2464                   | 2394                           |
| SnBr <sub>4</sub>                              | 7970                   | 8852                           | PmH <sub>2</sub>      | 2519                   | —                              |
| PbF <sub>4</sub>                               | 9519                   | —                              | SmH <sub>2</sub>      | 2510                   | 2389                           |
| CrF <sub>2</sub> Cl                            | 5795                   | —                              | GdH <sub>2</sub>      | 2494                   | 2651                           |
| CrF <sub>2</sub> Br                            | 5753                   | —                              | AcH <sub>2</sub>      | 2372                   | —                              |
| CrF <sub>2</sub> I                             | 5669                   | —                              | ThH <sub>2</sub>      | 2711                   | 2738                           |
| CrCl <sub>2</sub> Br                           | 5448                   | —                              | PuH <sub>2</sub>      | 2519                   | —                              |
| CrCl <sub>2</sub> I                            | 5381                   | 5429                           | AmH <sub>2</sub>      | 2544                   | —                              |
| CrBr <sub>2</sub> I                            | 5330                   | 5370                           | TiH <sub>2</sub>      | 2866                   | 2864                           |
| CuFCl                                          | 2891                   | —                              | ZrH <sub>2</sub>      | 2711                   | 2999                           |
| CuFBr                                          | 2853                   | —                              | CuH <sub>2</sub>      | 2941                   | —                              |
| CuFI                                           | 2803                   | —                              | ZnH <sub>2</sub>      | 2870                   | —                              |
| CuClBr                                         | 2753                   | —                              | HgH <sub>2</sub>      | 2707                   | —                              |
| CuClI                                          | 2694                   | —                              | AlH <sub>3</sub>      | 5924                   | 5969                           |
| CuBrI                                          | 2669                   | —                              | FeH <sub>3</sub>      | 5724                   | —                              |
| FeF <sub>2</sub> Cl                            | 5711                   | —                              | ScH <sub>3</sub>      | 5439                   | —                              |
| FeF <sub>2</sub> Br                            | 5653                   | —                              | YH <sub>3</sub>       | 5063                   | 4910                           |
| FeF <sub>2</sub> I                             | 5569                   | —                              | LaH <sub>3</sub>      | 4895                   | 4493                           |
| FeCl <sub>2</sub> Br                           | 5339                   | —                              | FeH <sub>3</sub>      | 5724                   | —                              |
| FeCl <sub>2</sub> I                            | 5272                   | —                              | GaH <sub>3</sub>      | 5690                   | —                              |
| FeBr <sub>2</sub> I                            | 5209                   | —                              | InH <sub>3</sub>      | 5092                   | —                              |
| LiIO <sub>2</sub> F <sub>2</sub>               | 845                    | —                              | TlH <sub>3</sub>      | 5092                   | —                              |
| NaIO <sub>2</sub> F <sub>2</sub>               | 766                    | 756                            | <b>Hydroselenides</b> |                        |                                |
| KIO <sub>2</sub> F <sub>2</sub>                | 699                    | 689                            | NaHSe                 | 703                    | 732                            |
| RbIO <sub>2</sub> F <sub>2</sub>               | 674                    | —                              | KHSe                  | 644                    | 712                            |
| CsIO <sub>2</sub> F <sub>2</sub>               | 636                    | —                              | RbHSe                 | 623                    | 689                            |
| NH <sub>4</sub> IO <sub>2</sub> F <sub>2</sub> | 678                    | —                              | CsHse                 | 598                    | 669                            |
| AgIO <sub>2</sub> F <sub>2</sub>               | 736                    | 685                            | <b>Hydrosulphides</b> |                        |                                |
| <b>Hydrides</b>                                |                        |                                | LiHS                  | 768                    | 862                            |
| LiH                                            | 916                    | 918                            | NaHS                  | 723                    | 771                            |
| NaH                                            | 807                    | 807                            | RbHS                  | 655                    | 682                            |
| KH                                             | 711                    | 713                            |                       |                        |                                |



| Substance                       | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ | Substance                           | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ |
|---------------------------------|------------------------|--------------------------------|-------------------------------------|------------------------|--------------------------------|
| CsHS                            | 628                    | 657                            | CsNO <sub>3</sub>                   | 648                    | 650                            |
| NH <sub>4</sub> HS              | 661                    | 718                            | AgNO <sub>3</sub>                   | 820                    | 832                            |
| Ca(HS) <sub>2</sub>             | 2184                   | (2171)                         | TlNO <sub>3</sub>                   | 690                    | 707                            |
| Sr(HS) <sub>2</sub>             | 2063                   | —                              | Mg(NO <sub>3</sub> ) <sub>2</sub>   | 2481                   | 2521                           |
| Ba(HS) <sub>2</sub>             | 1979                   | (1956)                         | Ca(NO <sub>3</sub> ) <sub>2</sub>   | 2268                   | 2247                           |
| <b>Hydroxides</b>               |                        |                                | Sr(NO <sub>3</sub> ) <sub>2</sub>   | 2176                   | 2151                           |
| LiOH                            | 1021                   | 1028                           | Ba(NO <sub>3</sub> ) <sub>2</sub>   | 2062                   | 2035                           |
| NaOH                            | 887                    | 892                            | Mn(NO <sub>3</sub> ) <sub>3/2</sub> | 2318                   | 2478                           |
| KOH                             | 789                    | 796                            | Fe(NO <sub>3</sub> ) <sub>2</sub>   | —                      | (2580)                         |
| RbOH                            | 766                    | 765                            | Co(NO <sub>3</sub> ) <sub>2</sub>   | 2560                   | 2647                           |
| CsOH                            | 721                    | 732                            | Ni(NO <sub>3</sub> ) <sub>2</sub>   | —                      | 2729                           |
| Be(OH) <sub>2</sub>             | 3477                   | 3620                           | Cu(NO <sub>3</sub> ) <sub>2</sub>   | —                      | 2739                           |
| Mg(OH) <sub>2</sub>             | 2870                   | 2998                           | Zn(NO <sub>3</sub> ) <sub>2</sub>   | 2376                   | 2649                           |
| Ca(OH) <sub>2</sub>             | 2506                   | 2637                           | Cd(NO <sub>3</sub> ) <sub>2</sub>   | 2238                   | 2462                           |
| Sr(OH) <sub>2</sub>             | 2330                   | 2474                           | Sn(NO <sub>3</sub> ) <sub>2</sub>   | 2155                   | 2254                           |
| Ba(OH) <sub>2</sub>             | 2142                   | 2330                           | Pb(NO <sub>3</sub> ) <sub>2</sub>   | 2067                   | 2208                           |
| Ti(OH) <sub>2</sub>             | —                      | 2953                           | <b>Nitrides</b>                     |                        |                                |
| Mn(OH) <sub>2</sub>             | 2909                   | 3008                           | ScN                                 | 7547                   | 7506                           |
| Fe(OH) <sub>2</sub>             | 2653                   | 3044                           | LaN                                 | 6876                   | 6793                           |
| Co(OH) <sub>2</sub>             | 2786                   | 3109                           | TiN                                 | 8130                   | 8033                           |
| Ni(OH) <sub>2</sub>             | 2832                   | 3186                           | ZrN                                 | 7633                   | 7723                           |
| Pd(OH) <sub>2</sub>             | —                      | 3189                           | VN                                  | 8283                   | 8233                           |
| Cu(OH) <sub>2</sub>             | 2870                   | 3229                           | NbN                                 | 7939                   | 8022                           |
| CuOH                            | 1006                   | —                              | CrN                                 | 8269                   | 8358                           |
| AgOH                            | 918                    | 845                            | <b>Nitrites</b>                     |                        |                                |
| AuOH                            | 1033                   | —                              | NaNO <sub>2</sub>                   | 774                    | 772                            |
| TlOH                            | 705                    | 874                            | KNO <sub>2</sub>                    | 699                    | 687                            |
| Zn(OH) <sub>2</sub>             | 2795                   | 3151                           | RbNO <sub>2</sub>                   | 724                    | 765                            |
| Cd(OH) <sub>2</sub>             | 2607                   | 2909                           | CsNO <sub>2</sub>                   | 690                    | —                              |
| Hg(OH) <sub>2</sub>             | 2669                   | —                              | <b>Oxides</b>                       |                        |                                |
| Sn(OH) <sub>2</sub>             | 2489                   | 2721                           | Li <sub>2</sub> O                   | 2799                   | 2814                           |
| Pb(OH) <sub>2</sub>             | 2376                   | —                              | Na <sub>2</sub> O                   | 2481                   | 2478                           |
| Sc(OH) <sub>3</sub>             | 5063                   | 5602                           | K <sub>2</sub> O                    | 2238                   | 2232                           |
| Y(OH) <sub>3</sub>              | 4707                   | —                              | Rb <sub>2</sub> O                   | 2163                   | 2161                           |
| La(OH) <sub>3</sub>             | 4443                   | —                              | Cs <sub>2</sub> O                   | 2131                   | 2063                           |
| Cr(OH) <sub>3</sub>             | 5556                   | 6299                           | Cu <sub>2</sub> O                   | 3273                   | 3189                           |
| Mn(OH) <sub>3</sub>             | 6213                   | —                              | Ag <sub>2</sub> O                   | 3002                   | 2910                           |
| Al(OH) <sub>3</sub>             | 5627                   | —                              | Tl <sub>2</sub> O                   | 2659                   | 2575                           |
| Ga(OH) <sub>3</sub>             | 5732                   | 6368                           | LiO <sub>2</sub>                    | (878)                  | (872)                          |
| In(OH) <sub>3</sub>             | 5280                   | —                              | NaO <sub>2</sub>                    | 799                    | 821                            |
| Tl(OH) <sub>3</sub>             | 5314                   | —                              | KO <sub>2</sub>                     | 741                    | 751                            |
| Ti(OH) <sub>4</sub>             | 9456                   | —                              | RbO <sub>2</sub>                    | 706                    | 721                            |
| Zr(OH) <sub>4</sub>             | 8619                   | —                              | CsO <sub>2</sub>                    | 679                    | 696                            |
| Mn(OH) <sub>4</sub>             | 10933                  | —                              | Li <sub>2</sub> O <sub>2</sub>      | 2592                   | 2557                           |
| Sn(OH) <sub>4</sub>             | 9188                   | 9879                           | Na <sub>2</sub> O <sub>2</sub>      | 2309                   | 22717                          |
| <b>Imides</b>                   |                        |                                | K <sub>2</sub> O <sub>2</sub>       | 2114                   | 2064                           |
| CaNH                            | 3293                   | —                              | Rb <sub>2</sub> O <sub>2</sub>      | 2025                   | 1994                           |
| SrNH                            | 3146                   | —                              | Cs <sub>2</sub> O <sub>2</sub>      | 1948                   | 1512                           |
| BaNH                            | 2975                   | —                              | MgO <sub>2</sub>                    | 3356                   | 3526                           |
| <b>Metavanadates</b>            |                        |                                | CaO <sub>2</sub>                    | 3144                   | 3132                           |
| Li <sub>3</sub> VO <sub>4</sub> | 3945                   | —                              | SrO <sub>2</sub>                    | 3037                   | 2977                           |
| Na <sub>3</sub> VO <sub>4</sub> | 3766                   | —                              | KO <sub>3</sub>                     | 697                    | 707                            |
| K <sub>3</sub> VO <sub>4</sub>  | 3376                   | —                              | BeO                                 | 4514                   | 4443                           |
| Rb <sub>3</sub> VO <sub>4</sub> | 3243                   | —                              | MgO                                 | 3795                   | 3791                           |
| Cs <sub>3</sub> VO <sub>4</sub> | 3137                   | —                              | CaO                                 | 3414                   | 3401                           |
| <b>Nitrates</b>                 |                        |                                | SrO                                 | 3217                   | 3223                           |
| LiNO <sub>3</sub>               | 848                    | 854                            | BaO                                 | 3029                   | 3054                           |
| NaNO <sub>3</sub>               | 755                    | 763                            | TiO                                 | 3832                   | 3811                           |
| KNO <sub>3</sub>                | 685                    | 694                            | VO                                  | 3932                   | 3863                           |
| RbNO <sub>3</sub>               | 662                    | 671                            | MnO                                 | 3724                   | 3745                           |

| Substance                 | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ | Substance                    | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ |
|---------------------------|------------------------|--------------------------------|------------------------------|------------------------|--------------------------------|
| FeO                       | 3795                   | 3865                           | $\text{Ca}(\text{ClO}_4)_2$  | 1958                   | 1971                           |
| CoO                       | 3837                   | 3910                           | $\text{Sr}(\text{ClO}_4)_2$  | 1862                   | 1862                           |
| NiO                       | 3908                   | 4010                           | $\text{Ba}(\text{ClO}_4)_2$  | 1795                   | 1769                           |
| PdO                       | 3736                   | —                              | <i>Permanganates</i>         |                        |                                |
| CuO                       | 4135                   | 4050                           | $\text{NaMnO}_4$             | 661                    | —                              |
| ZnO                       | 4142                   | 3971                           | $\text{KMnO}_4$              | 607                    | —                              |
| CdO                       | 3806                   | —                              | $\text{RbMnO}_4$             | 586                    | —                              |
| HgO                       | 3907                   | —                              | $\text{CsMnO}_4$             | 565                    | —                              |
| GeO                       | 3919                   | —                              | $\text{Ca}(\text{MnO}_4)_2$  | 1937                   | —                              |
| SnO                       | 3652                   | —                              | $\text{Sr}(\text{MnO}_4)_2$  | 1845                   | —                              |
| PbO                       | 3520                   | —                              | $\text{Ba}(\text{MnO}_4)_2$  | 1778                   | —                              |
| $\text{Sc}_2\text{O}_3$   | 13557                  | 13708                          | <i>Phosphates</i>            |                        |                                |
| $\text{Y}_2\text{O}_3$    | 12705                  | —                              | $\text{Mg}_3(\text{PO}_4)_2$ | 11632                  | 11407                          |
| $\text{La}_2\text{O}_3$   | 12452                  | —                              | $\text{Ca}_3(\text{PO}_4)_2$ | 10602                  | 10479                          |
| $\text{Ce}_2\text{O}_3$   | 12661                  | —                              | $\text{Sr}_3(\text{PO}_4)_2$ | 10125                  | 10075                          |
| $\text{Pr}_2\text{O}_3$   | 12703                  | —                              | $\text{Ba}_3(\text{PO}_4)_2$ | 9652                   | 9654                           |
| $\text{Nd}_2\text{O}_3$   | 12736                  | —                              | $\text{MnPO}_4$              | 7397                   | —                              |
| $\text{Pm}_2\text{O}_3$   | 12811                  | —                              | $\text{FePO}_4$              | 7251                   | 7300                           |
| $\text{Sm}_2\text{O}_3$   | 12878                  | —                              | $\text{BPO}_4$               | 8201                   | —                              |
| $\text{Eu}_2\text{O}_3$   | 12945                  | —                              | $\text{AlPO}_4$              | 7427                   | 7507                           |
| $\text{Gd}_2\text{O}_3$   | 12996                  | —                              | $\text{GaPO}_4$              | 7381                   | —                              |
| $\text{Tb}_2\text{O}_3$   | 13071                  | —                              | <i>Selenides</i>             |                        |                                |
| $\text{Dy}_2\text{O}_3$   | 13138                  | —                              | $\text{Li}_2\text{Se}$       | 2364                   | —                              |
| $\text{Ho}_2\text{O}_3$   | 13180                  | —                              | $\text{Na}_2\text{Se}$       | 2130                   | —                              |
| $\text{Er}_2\text{O}_3$   | 13263                  | —                              | $\text{K}_2\text{Se}$        | 1933                   | —                              |
| $\text{Tm}_2\text{O}_3$   | 13322                  | —                              | $\text{Rb}_2\text{Se}$       | 1837                   | —                              |
| $\text{Yb}_2\text{O}_3$   | 13380                  | —                              | $\text{Cs}_2\text{Se}$       | 1745                   | —                              |
| $\text{Lu}_2\text{O}_3$   | 13665                  | —                              | $\text{Ag}_2\text{Se}$       | 2686                   | —                              |
| $\text{Ac}_2\text{O}_3$   | 12573                  | —                              | $\text{Tl}_2\text{Se}$       | 2209                   | —                              |
| $\text{Ti}_2\text{O}_3$   | —                      | 14149                          | $\text{BeSe}$                | 3431                   | —                              |
| $\text{V}_2\text{O}_3$    | 15096                  | 14520                          | $\text{MgSe}$                | 3071                   | —                              |
| $\text{Cr}_2\text{O}_3$   | 15276                  | 14957                          | $\text{CaSe}$                | 2858                   | 2862                           |
| $\text{Mn}_2\text{O}_3$   | 15146                  | 15035                          | $\text{SrSe}$                | 2736                   | —                              |
| $\text{Fe}_2\text{O}_3$   | 14309                  | 14774                          | $\text{BaSe}$                | 2611                   | —                              |
| $\text{Al}_2\text{O}_3$   | 15916                  | —                              | $\text{MnSe}$                | 3176                   | —                              |
| $\text{Ga}_2\text{O}_3$   | 15590                  | 15220                          | <i>Selenites</i>             |                        |                                |
| $\text{In}_2\text{O}_3$   | 13928                  | —                              | $\text{Li}_2\text{SeO}_3$    | 2171                   | —                              |
| $\text{Pb}_2\text{O}_3$   | (14841)                | —                              | $\text{Na}_2\text{SeO}_3$    | 1950                   | 1916                           |
| $\text{CeO}_2$            | 9627                   | —                              | $\text{K}_2\text{SeO}_3$     | 1774                   | 1749                           |
| $\text{ThO}_2$            | 10397                  | —                              | $\text{Rb}_2\text{SeO}_3$    | 1715                   | 1675                           |
| $\text{PaO}_2$            | 10573                  | —                              | $\text{Cs}_2\text{SeO}_3$    | 1640                   | —                              |
| $\text{VO}_2(\text{g})$   | 10644                  | —                              | $\text{Tl}_2\text{SeO}_3$    | 1879                   | —                              |
| $\text{NpO}_2$            | 10707                  | —                              | $\text{Ag}_2\text{SeO}_3$    | 2113                   | 2148                           |
| $\text{PuO}_2$            | 10786                  | —                              | $\text{BeSeO}_3$             | 3322                   | —                              |
| $\text{AmO}_2$            | 10799                  | —                              | $\text{MgSeO}_3$             | 3012                   | 2998                           |
| $\text{CmO}_2$            | 10832                  | —                              | $\text{CaSeO}_3$             | 2732                   | —                              |
| $\text{TiO}_2$            | 12150                  | —                              | $\text{SrSeO}_3$             | 2586                   | 2588                           |
| $\text{ZrO}_2$            | 11188                  | —                              | $\text{BaSeO}_3$             | 2460                   | 2451                           |
| $\text{MoO}_2$            | 11648                  | —                              | <i>Selenates</i>             |                        |                                |
| $\text{MnO}_2$            | 12970                  | —                              | $\text{Li}_2\text{SeO}_4$    | 2054                   | —                              |
| $\text{SiO}_2$            | 13125                  | —                              | $\text{Na}_2\text{SeO}_4$    | 1879                   | —                              |
| $\text{GeO}_2$            | 12828                  | —                              | $\text{K}_2\text{SeO}_4$     | 1732                   | —                              |
| $\text{SnO}_2$            | 11807                  | —                              | $\text{Rb}_2\text{SeO}_4$    | 1686                   | —                              |
| $\text{PbO}_2$            | 11217                  | —                              | $\text{Cs}_2\text{SeO}_4$    | 1615                   | —                              |
| <i>Perchlorates</i>       |                        |                                | $\text{Cu}_2\text{SeO}_4$    | 2201                   | —                              |
| $\text{LiClO}_4$          | 709                    | 715                            | $\text{Ag}_2\text{SeO}_4$    | 2033                   | —                              |
| $\text{NaClO}_4$          | 643                    | 641                            | $\text{Tl}_2\text{SeO}_4$    | 1766                   | —                              |
| $\text{KClO}_4$           | 599                    | 595                            | $\text{Hg}_2\text{SeO}_4$    | 2163                   | —                              |
| $\text{RbClO}_4$          | 564                    | 576                            | $\text{BeSeO}_4$             | 3448                   | —                              |
| $\text{CsClO}_4$          | 636                    | 550                            |                              |                        |                                |
| $\text{NH}_4\text{ClO}_4$ | 583                    | 580                            |                              |                        |                                |

| Substance                                        | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ | Substance                                         | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ |
|--------------------------------------------------|------------------------|--------------------------------|---------------------------------------------------|------------------------|--------------------------------|
| MgSeO <sub>4</sub>                               | 2895                   | —                              | Cs <sub>2</sub> PdCl <sub>6</sub>                 | 1426                   | —                              |
| CaSeO <sub>4</sub>                               | 2632                   | —                              | Rb <sub>2</sub> PbCl <sub>6</sub>                 | 1343                   | 1343                           |
| SrSeO <sub>4</sub>                               | 2489                   | —                              | Cs <sub>2</sub> PbCl <sub>6</sub>                 | 1344                   | —                              |
| <i>Sulphides</i>                                 |                        |                                | (NH <sub>4</sub> ) <sub>2</sub> PbCl <sub>6</sub> | 1355                   | —                              |
| Li <sub>2</sub> S                                | 2464                   | 2472                           | K <sub>2</sub> PtCl <sub>6</sub>                  | 1468                   | 1471                           |
| Na <sub>2</sub> S                                | 2192                   | 2203                           | Rb <sub>2</sub> PtCl <sub>6</sub>                 | 1464                   | —                              |
| K <sub>2</sub> S                                 | 1979                   | (2052)                         | Cs <sub>2</sub> PtCl <sub>6</sub>                 | 1444                   | —                              |
| Rb <sub>2</sub> S                                | 1929                   | 1949                           | (NH <sub>4</sub> ) <sub>2</sub> PtCl <sub>6</sub> | 1468                   | —                              |
| Cs <sub>2</sub> S                                | 1892                   | 1850                           | Tl <sub>2</sub> PtCl <sub>6</sub>                 | 1546                   | —                              |
| (NH <sub>4</sub> ) <sub>2</sub> S                | 2008                   | (2026)                         | Ag <sub>2</sub> PtCl <sub>6</sub>                 | 1773                   | 1881                           |
| Cu <sub>2</sub> S                                | 2786                   | 2865                           | BaPtCl <sub>6</sub>                               | 2047                   | 2070                           |
| Ag <sub>2</sub> S                                | 2606                   | 2677                           | K <sub>2</sub> PtBr <sub>6</sub>                  | 1423                   | 1392                           |
| Au <sub>2</sub> S                                | 2908                   | —                              | Ag <sub>2</sub> PtBr <sub>6</sub>                 | 1791                   | 2276                           |
| Tl <sub>2</sub> S                                | 2298                   | 2258                           | K <sub>2</sub> PtI <sub>6</sub>                   | 1421                   | —                              |
| <i>Sulphates</i>                                 |                        |                                | K <sub>2</sub> ReCl <sub>6</sub>                  | 1416                   | 1442                           |
| Li <sub>2</sub> SO <sub>4</sub>                  | 2229                   | 2142                           | Rb <sub>2</sub> ReCl <sub>6</sub>                 | 1414                   | —                              |
| Na <sub>2</sub> SO <sub>4</sub>                  | 1827                   | 1938                           | Cs <sub>2</sub> ReCl <sub>6</sub>                 | 1398                   | —                              |
| K <sub>2</sub> SO <sub>4</sub>                   | 1700                   | 1796                           | K <sub>2</sub> ReBr <sub>6</sub>                  | 1375                   | 1375                           |
| Rb <sub>2</sub> SO <sub>4</sub>                  | 1636                   | 1748                           | K <sub>2</sub> SiF <sub>6</sub>                   | 1670                   | 1765                           |
| Cs <sub>2</sub> SO <sub>4</sub>                  | 1596                   | 1658                           | Rb <sub>2</sub> SiF <sub>6</sub>                  | 1639                   | 1673                           |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>  | 1766                   | 1777                           | Cs <sub>2</sub> SiF <sub>6</sub>                  | 1604                   | 1498                           |
| Cu <sub>2</sub> SO <sub>4</sub>                  | 2276                   | 2166                           | Tl <sub>2</sub> SiF <sub>6</sub>                  | 1675                   | —                              |
| Ag <sub>2</sub> SO <sub>4</sub>                  | 2104                   | 1989                           | K <sub>2</sub> SnCl <sub>6</sub>                  | 1363                   | 1390                           |
| Tl <sub>2</sub> SO <sub>4</sub>                  | 1828                   | 1722                           | Rb <sub>2</sub> SnCl <sub>6</sub>                 | 1361                   | 1363                           |
| Hg <sub>2</sub> SO <sub>4</sub>                  | —                      | 2127                           | Cs <sub>2</sub> SnCl <sub>6</sub>                 | 1358                   | —                              |
| CaSO <sub>4</sub>                                | 2489                   | 2480                           | Tl <sub>2</sub> SnCl <sub>6</sub>                 | 1437                   | —                              |
| SrSO <sub>4</sub>                                | 2577                   | 2484                           | (NH <sub>4</sub> ) <sub>2</sub> SnCl <sub>6</sub> | 1370                   | 1344                           |
| BaSO <sub>4</sub>                                | 2469                   | 2374                           | Rb <sub>2</sub> SnBr <sub>6</sub>                 | 1309                   | —                              |
| MnSO <sub>4</sub>                                | 2920                   | 2825                           | Cs <sub>2</sub> SnBr <sub>6</sub>                 | 1306                   | —                              |
| <i>Ternary Salts</i>                             |                        |                                | Rb <sub>2</sub> SnI <sub>6</sub>                  | 1226                   | —                              |
| Cs <sub>2</sub> CuCl <sub>4</sub>                | 1393                   | —                              | Cs <sub>2</sub> SnBr <sub>6</sub>                 | 1243                   | —                              |
| Rb <sub>2</sub> ZnCl <sub>4</sub>                | 1529                   | —                              | K <sub>2</sub> TeCl <sub>6</sub>                  | 1318                   | 1320                           |
| Cs <sub>2</sub> ZnCl <sub>4</sub>                | 1492                   | —                              | Rb <sub>2</sub> TeCl <sub>6</sub>                 | 1321                   | —                              |
| Rb <sub>2</sub> ZnBr <sub>4</sub>                | 1498                   | —                              | Cs <sub>2</sub> TeCl <sub>6</sub>                 | 1323                   | —                              |
| Cs <sub>2</sub> ZnBr <sub>4</sub>                | 1454                   | —                              | Tl <sub>2</sub> TeCl <sub>6</sub>                 | 1392                   | —                              |
| Cs <sub>2</sub> ZnI <sub>4</sub>                 | 1386                   | —                              | (NH <sub>4</sub> ) <sub>2</sub> TeCl <sub>6</sub> | 1318                   | —                              |
| CsGaCl <sub>4</sub>                              | 494                    | —                              | K <sub>2</sub> RuCl <sub>6</sub>                  | 1451                   | —                              |
| NaAlCl <sub>4</sub>                              | 556                    | —                              | Rb <sub>2</sub> CoF <sub>6</sub>                  | 1688                   | —                              |
| CsAlCl <sub>4</sub>                              | 486                    | —                              | Cs <sub>2</sub> CoF <sub>6</sub>                  | 1632                   | —                              |
| NaFeCl <sub>4</sub>                              | 492                    | —                              | K <sub>2</sub> NiF <sub>6</sub>                   | 1721                   | —                              |
| Rb <sub>2</sub> CoCl <sub>4</sub>                | 1447                   | —                              | Rb <sub>2</sub> NiF <sub>6</sub>                  | 1688                   | —                              |
| Cs <sub>2</sub> CoCl <sub>4</sub>                | 1391                   | —                              | Rb <sub>2</sub> SbCl <sub>6</sub>                 | 1357                   | —                              |
| K <sub>2</sub> PtCl <sub>4</sub>                 | 1574                   | 1550                           | Rb <sub>2</sub> SeCl <sub>6</sub>                 | 1409                   | —                              |
| Cs <sub>2</sub> GeF <sub>6</sub>                 | 1573                   | —                              | Cs <sub>2</sub> SeCl <sub>6</sub>                 | 1397                   | —                              |
| (NH <sub>4</sub> ) <sub>2</sub> GeF <sub>6</sub> | 1657                   | —                              | (NH <sub>4</sub> ) <sub>2</sub> SeCl <sub>6</sub> | 1420                   | —                              |
| Cs <sub>2</sub> GeCl <sub>6</sub>                | 1404                   | 1419                           | (NH <sub>4</sub> ) <sub>2</sub> PoCl <sub>6</sub> | 1338                   | —                              |
| K <sub>2</sub> HfCl <sub>6</sub>                 | 1345                   | 1461                           | Cs <sub>2</sub> PoBr <sub>6</sub>                 | 1286                   | —                              |
| K <sub>2</sub> IrCl <sub>6</sub>                 | 1442                   | 1440                           | Cs <sub>2</sub> CrF <sub>6</sub>                  | 1603                   | —                              |
| Na <sub>2</sub> MoCl <sub>6</sub>                | 1526                   | 1504                           | Rb <sub>2</sub> MnF <sub>6</sub>                  | 1688                   | —                              |
| K <sub>2</sub> MoCl <sub>6</sub>                 | 1418                   | 1412                           | Cs <sub>2</sub> MnF <sub>6</sub>                  | 1620                   | —                              |
| Rb <sub>2</sub> MoCl <sub>6</sub>                | 1399                   | 1399                           | K <sub>2</sub> MnCl <sub>6</sub>                  | 1462                   | —                              |
| Cs <sub>2</sub> MoCl <sub>6</sub>                | 1347                   | 1347                           | Rb <sub>2</sub> MnCl <sub>6</sub>                 | 1451                   | —                              |
| K <sub>2</sub> NbCl <sub>6</sub>                 | 1375                   | 1398                           | (NH <sub>4</sub> ) <sub>2</sub> MnCl <sub>6</sub> | 1464                   | —                              |
| Rb <sub>2</sub> NbCl <sub>6</sub>                | 1371                   | 1385                           | Cs <sub>2</sub> TeBr <sub>6</sub>                 | 1306                   | —                              |
| Cs <sub>2</sub> NbCl <sub>6</sub>                | 1381                   | 1344                           | Cs <sub>2</sub> TeI <sub>6</sub>                  | 1246                   | —                              |
| K <sub>2</sub> OsCl <sub>6</sub>                 | 1447                   | 1447                           | K <sub>2</sub> TiCl <sub>6</sub>                  | 1412                   | 1447                           |
| Cs <sub>2</sub> OsCl <sub>6</sub>                | 1409                   | —                              | Rb <sub>2</sub> TiCl <sub>6</sub>                 | 1415                   | 1416                           |
| K <sub>2</sub> OsBr <sub>6</sub>                 | 1396                   | —                              | Cs <sub>2</sub> TiCl <sub>6</sub>                 | 1402                   | 1384                           |
| K <sub>2</sub> PdCl <sub>6</sub>                 | 1481                   | 1493                           | Tl <sub>2</sub> TiCl <sub>6</sub>                 | 1560                   | 1553                           |
| Rb <sub>2</sub> PdCl <sub>6</sub>                | 1449                   | —                              | K <sub>2</sub> TiBr <sub>6</sub>                  | 1379                   | 1379                           |
|                                                  |                        |                                | Rb <sub>2</sub> TiBr <sub>6</sub>                 | 1341                   | 1331                           |

| Substance                         | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ | Substance            | Calc. $U_{\text{POT}}$ | $U_{\text{POT}}^{\text{BHFC}}$ |
|-----------------------------------|------------------------|--------------------------------|----------------------|------------------------|--------------------------------|
| Cs <sub>2</sub> TiBr <sub>6</sub> | 1339                   | 1306                           | <i>Thiocyanates</i>  |                        |                                |
| Na <sub>2</sub> UBr <sub>6</sub>  | 1504                   | —                              | LiCNS                | 764                    | (765)                          |
| K <sub>2</sub> UBr <sub>6</sub>   | 1484                   | —                              | NaCNS                | 682                    | 682                            |
| Rb <sub>2</sub> UBr <sub>6</sub>  | 1473                   | —                              | KCNS                 | 623                    | 616                            |
| Cs <sub>2</sub> UBr <sub>6</sub>  | 1459                   | —                              | RbCNS                | 623                    | 619                            |
| K <sub>2</sub> WCl <sub>6</sub>   | 1398                   | 1423                           | CsCNS                | 623                    | 568                            |
| Rb <sub>2</sub> WCl <sub>6</sub>  | 1397                   | 1434                           | NH <sub>4</sub> CNS  | 605                    | 611                            |
| Cs <sub>2</sub> WCl <sub>6</sub>  | 1392                   | 1366                           | Ca(CNS) <sub>2</sub> | 2184                   | 2118                           |
| K <sub>2</sub> WBr <sub>6</sub>   | 1408                   | 1408                           | Sr(CNS) <sub>2</sub> | 2063                   | 1957                           |
| Rb <sub>2</sub> WBr <sub>6</sub>  | 1361                   | 1391                           | Ba(CNS) <sub>2</sub> | 1979                   | 1852                           |
| Cs <sub>2</sub> WBr <sub>6</sub>  | 1362                   | 1332                           | Mn(CNS) <sub>2</sub> | 2280                   | 2351                           |
| K <sub>2</sub> ZrCl <sub>6</sub>  | 1339                   | 1371                           | Zn(CNS) <sub>2</sub> | 2335                   | 2560                           |
| Rb <sub>2</sub> ZrCl <sub>6</sub> | 1341                   | —                              | Cd(CNS) <sub>2</sub> | 2201                   | 2374                           |
| Cs <sub>2</sub> ZrCl <sub>6</sub> | 1339                   | 1307                           | Hg(CNS) <sub>2</sub> | 2146                   | 2492                           |
| <i>Tellurides</i>                 |                        |                                | Sn(CNS) <sub>2</sub> | 2117                   | 2142                           |
| Li <sub>2</sub> Te                | 2212                   | —                              | Pb(CNS) <sub>2</sub> | 2058                   | —                              |
| Na <sub>2</sub> Te                | 1997                   | 2095                           | <i>Vanadates</i>     |                        |                                |
| K <sub>2</sub> Te                 | 1830                   | —                              | LiVO <sub>3</sub>    | 810                    | —                              |
| Rb <sub>2</sub> Te                | 1837                   | —                              | NaVO <sub>3</sub>    | 761                    | —                              |
| Cs <sub>2</sub> Te                | 1745                   | —                              | KVO <sub>3</sub>     | 686                    | —                              |
| Cu <sub>2</sub> Te                | 2706                   | 2683                           | RbVO <sub>3</sub>    | 657                    | —                              |
| Ag <sub>2</sub> Te                | 2607                   | 2600                           | CsVO <sub>3</sub>    | 628                    | —                              |
| Tl <sub>2</sub> Te                | 2084                   | 2172                           |                      |                        |                                |
| BeTe                              | 3319                   | —                              |                      |                        |                                |
| MgTe                              | 2878                   | 3081                           |                      |                        |                                |
| CaTe                              | 2721                   | —                              |                      |                        |                                |

TABLE 2. Thermochemical Radii (nm)

| Ion                                          | Radius |         | Ion                                              | Radius |         |
|----------------------------------------------|--------|---------|--------------------------------------------------|--------|---------|
| <i>Singly Charged Anions</i>                 |        |         | GaCl <sub>4</sub> <sup>-</sup>                   | 0.328  | ± 0.019 |
| AgF <sub>4</sub> <sup>-</sup>                | 0.231  | ± 0.019 | H <sup>-</sup>                                   | 0.148  | ± 0.019 |
| AlBr <sub>4</sub> <sup>-</sup>               | 0.321  | ± 0.023 | H <sub>2</sub> AsO <sub>4</sub> <sup>-</sup>     | 0.227  | ± 0.019 |
| AlCl <sub>4</sub> <sup>-</sup>               | 0.317  | ± 0.019 | H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>      | 0.213  | ± 0.019 |
| AlF <sub>4</sub> <sup>-</sup>                | 0.214  | ± 0.023 | HCO <sub>2</sub> <sup>-</sup>                    | 0.200  | ± 0.019 |
| AlH <sub>4</sub> <sup>-</sup>                | 0.226  | ± 0.019 | HCO <sub>3</sub> <sup>-</sup>                    | 0.207  | ± 0.019 |
| AlI <sub>4</sub> <sup>-</sup>                | 0.374  | ± 0.019 | HF <sub>2</sub> <sup>-</sup>                     | 0.172  | ± 0.019 |
| AsF <sub>6</sub> <sup>-</sup>                | 0.243  | ± 0.019 | HSO <sub>4</sub> <sup>-</sup>                    | 0.221  | ± 0.019 |
| AsO <sub>2</sub> <sup>-</sup>                | 0.211  | ± 0.019 | I <sup>-</sup>                                   | 0.211  | ± 0.019 |
| Au(CN) <sub>2</sub> <sup>-</sup>             | 0.266  | ± 0.019 | I <sub>2</sub> Br <sup>-</sup>                   | 0.261  | ± 0.019 |
| AuCl <sub>4</sub> <sup>-</sup>               | 0.288  | ± 0.019 | I <sub>3</sub> <sup>-</sup>                      | 0.272  | ± 0.019 |
| AuF <sub>4</sub> <sup>-</sup>                | 0.240  | ± 0.019 | I <sub>4</sub> <sup>-</sup>                      | 0.300  | ± 0.019 |
| AuF <sub>6</sub> <sup>-</sup>                | 0.235  | ± 0.038 | IBr <sub>2</sub> <sup>-</sup>                    | 0.251  | ± 0.019 |
| B(OH) <sub>4</sub> <sup>-</sup>              | 0.229  | ± 0.019 | ICl <sub>2</sub> <sup>-</sup>                    | 0.235  | ± 0.019 |
| BF <sub>4</sub> <sup>-</sup>                 | 0.205  | ± 0.019 | ICl <sub>4</sub> <sup>-</sup>                    | 0.307  | ± 0.019 |
| BH <sub>4</sub> <sup>-</sup>                 | 0.205  | ± 0.019 | IO <sub>2</sub> F <sub>2</sub> <sup>-</sup>      | 0.233  | ± 0.019 |
| Br <sup>-</sup>                              | 0.190  | ± 0.019 | IO <sub>3</sub> <sup>-</sup>                     | 0.218  | ± 0.019 |
| BrF <sub>4</sub> <sup>-</sup>                | 0.231  | ± 0.019 | IO <sub>4</sub> <sup>-</sup>                     | 0.231  | ± 0.019 |
| BrO <sub>3</sub> <sup>-</sup>                | 0.214  | ± 0.019 | IrF <sub>6</sub> <sup>-</sup>                    | 0.242  | ± 0.019 |
| CF <sub>3</sub> SO <sub>3</sub> <sup>-</sup> | 0.230  | ± 0.049 | MnO <sub>4</sub> <sup>-</sup>                    | 0.220  | ± 0.019 |
| CH <sub>3</sub> CO <sub>2</sub> <sup>-</sup> | 0.194  | ± 0.019 | MoF <sub>6</sub> <sup>-</sup>                    | 0.241  | ± 0.019 |
| Cl <sup>-</sup>                              | 0.168  | ± 0.019 | MoOF <sub>5</sub> <sup>-</sup>                   | 0.241  | ± 0.019 |
| ClO <sub>2</sub> <sup>-</sup>                | 0.195  | ± 0.019 | N <sub>3</sub> <sup>-</sup>                      | 0.180  | ± 0.019 |
| ClO <sub>3</sub> <sup>-</sup>                | 0.208  | ± 0.019 | NCO <sup>-</sup>                                 | 0.193  | ± 0.019 |
| ClO <sub>4</sub> <sup>-</sup>                | 0.225  | ± 0.019 | NbCl <sub>6</sub> <sup>-</sup>                   | 0.338  | ± 0.049 |
| ClS <sub>2</sub> O <sub>6</sub> <sup>-</sup> | 0.260  | ± 0.049 | NbF <sub>6</sub> <sup>-</sup>                    | 0.254  | ± 0.019 |
| CN <sup>-</sup>                              | 0.187  | ± 0.023 | Nb <sub>2</sub> F <sub>11</sub> <sup>-</sup>     | 0.311  | ± 0.038 |
| Cr <sub>3</sub> O <sub>8</sub> <sup>-</sup>  | 0.276  | ± 0.019 | NbO <sub>3</sub> <sup>-</sup>                    | 0.194  | ± 0.019 |
| CuBr <sub>4</sub> <sup>-</sup>               | 0.315  | ± 0.019 | NH <sub>2</sub> <sup>-</sup>                     | 0.168  | ± 0.019 |
| F <sup>-</sup>                               | 0.126  | ± 0.019 | NH <sub>2</sub> CH <sub>2</sub> COO <sup>-</sup> | 0.252  | ± 0.019 |
| FeCl <sub>4</sub> <sup>-</sup>               | 0.317  | ± 0.019 | NO <sub>2</sub> <sup>-</sup>                     | 0.187  | ± 0.019 |

| Ion                                | Radius |             | Ion                                        | Radius |             |
|------------------------------------|--------|-------------|--------------------------------------------|--------|-------------|
| $\text{NO}_3^-$                    | 0.200  | $\pm 0.019$ | $\text{MoCl}_6^{2-}$                       | 0.338  | $\pm 0.019$ |
| $\text{O}_2^-$                     | 0.165  | $\pm 0.019$ | $\text{MoF}_6^{2-}$                        | 0.274  | $\pm 0.019$ |
| $\text{O}_3^-$                     | 0.199  | $\pm 0.034$ | $\text{MoO}_4^{2-}$                        | 0.231  | $\pm 0.019$ |
| $\text{OH}^-$                      | 0.152  | $\pm 0.019$ | $\text{NbCl}_6^{2-}$                       | 0.343  | $\pm 0.019$ |
| $\text{OsF}_6^-$                   | 0.252  | $\pm 0.020$ | $\text{NH}_2^-$                            | 0.128  | $\pm 0.019$ |
| $\text{PaF}_6^-$                   | 0.249  | $\pm 0.019$ | $\text{Ni}(\text{CN})_4^{2-}$              | 0.322  | $\pm 0.019$ |
| $\text{PdF}_6^-$                   | 0.252  | $\pm 0.019$ | $\text{NiF}_4^{2-}$                        | 0.211  | $\pm 0.019$ |
| $\text{PF}_6^-$                    | 0.242  | $\pm 0.019$ | $\text{NiF}_6^{2-}$                        | 0.249  | $\pm 0.019$ |
| $\text{PO}_3^-$                    | 0.204  | $\pm 0.019$ | $\text{O}^{2-}$                            | 0.141  | $\pm 0.019$ |
| $\text{PtF}_6^-$                   | 0.247  | $\pm 0.019$ | $\text{O}_2^{2-}$                          | 0.167  | $\pm 0.019$ |
| $\text{PuF}_5^-$                   | 0.239  | $\pm 0.019$ | $\text{OsBr}_6^{2-}$                       | 0.365  | $\pm 0.019$ |
| $\text{ReF}_6^-$                   | 0.240  | $\pm 0.019$ | $\text{OsCl}_6^{2-}$                       | 0.336  | $\pm 0.019$ |
| $\text{ReO}_4^-$                   | 0.227  | $\pm 0.019$ | $\text{OsF}_6^{2-}$                        | 0.276  | $\pm 0.019$ |
| $\text{RuF}_6^-$                   | 0.242  | $\pm 0.019$ | $\text{PbCl}_4^{2-}$                       | 0.279  | $\pm 0.019$ |
| $\text{S}_6^-$                     | 0.305  | $\pm 0.019$ | $\text{PbCl}_6^{2-}$                       | 0.347  | $\pm 0.019$ |
| $\text{SCN}^-$                     | 0.209  | $\pm 0.019$ | $\text{PbF}_6^{2-}$                        | 0.268  | $\pm 0.019$ |
| $\text{SbCl}_6^-$                  | 0.320  | $\pm 0.019$ | $\text{PdBr}_6^{2-}$                       | 0.354  | $\pm 0.019$ |
| $\text{SbF}_6^-$                   | 0.252  | $\pm 0.019$ | $\text{PdCl}_4^{2-}$                       | 0.313  | $\pm 0.019$ |
| $\text{Sb}_2\text{F}_{11}^-$       | 0.312  | $\pm 0.038$ | $\text{PdCl}_6^{2-}$                       | 0.333  | $\pm 0.019$ |
| $\text{Sb}_3\text{F}_{14}^-$       | 0.374  | $\pm 0.038$ | $\text{PdF}_6^{2-}$                        | 0.252  | $\pm 0.019$ |
| $\text{SeCl}_5^-$                  | 0.258  | $\pm 0.038$ | $\text{PoBr}_6^{2-}$                       | 0.380  | $\pm 0.019$ |
| $\text{SeCN}^-$                    | 0.230  | $\pm 0.019$ | $\text{PoI}_6^{2-}$                        | 0.428  | $\pm 0.019$ |
| $\text{SeH}^-$                     | 0.195  | $\pm 0.019$ | $\text{Pt}(\text{NO}_2)_3\text{Cl}_3^{2-}$ | 0.364  | $\pm 0.019$ |
| $\text{SH}^-$                      | 0.191  | $\pm 0.019$ | $\text{Pt}(\text{NO}_2)_4\text{Cl}_2^{2-}$ | 0.383  | $\pm 0.019$ |
| $\text{SO}_3\text{F}^-$            | 0.214  | $\pm 0.019$ | $\text{Pt}(\text{OH})_2^{2-}$              | 0.333  | $\pm 0.019$ |
| $\text{S}_3\text{N}_3^-$           | 0.231  | $\pm 0.038$ | $\text{Pt}(\text{SCN})_6^{2-}$             | 0.451  | $\pm 0.019$ |
| $\text{S}_3\text{N}_3\text{O}_4^-$ | 0.252  | $\pm 0.038$ | $\text{PtBr}_4^{2-}$                       | 0.324  | $\pm 0.019$ |
| $\text{TaCl}_6^-$                  | 0.352  | $\pm 0.019$ | $\text{PtBr}_6^{2-}$                       | 0.363  | $\pm 0.019$ |
| $\text{TaF}_6^-$                   | 0.250  | $\pm 0.019$ | $\text{PtCl}_4^{2-}$                       | 0.307  | $\pm 0.019$ |
| $\text{TaO}_3^-$                   | 0.192  | $\pm 0.019$ | $\text{PtCl}_6^{2-}$                       | 0.333  | $\pm 0.019$ |
| $\text{UF}_6^-$                    | 0.301  | $\pm 0.019$ | $\text{PtF}_6^{2-}$                        | 0.245  | $\pm 0.019$ |
| $\text{VF}_6^-$                    | 0.235  | $\pm 0.019$ | $\text{PuCl}_6^{2-}$                       | 0.349  | $\pm 0.019$ |
| $\text{VO}_3^-$                    | 0.201  | $\pm 0.019$ | $\text{ReBr}_6^{2-}$                       | 0.371  | $\pm 0.019$ |
| $\text{WCl}_6^-$                   | 0.337  | $\pm 0.019$ | $\text{ReCl}_6^{2-}$                       | 0.337  | $\pm 0.019$ |
| $\text{WF}_6^-$                    | 0.246  | $\pm 0.019$ | $\text{ReF}_6^{2-}$                        | 0.256  | $\pm 0.019$ |
| $\text{WOF}_5^-$                   | 0.241  | $\pm 0.019$ | $\text{ReF}_8^{2-}$                        | 0.276  | $\pm 0.019$ |
| <b>Doubly Charged Anions</b>       |        |             | $\text{ReH}_9^{2-}$                        | 0.257  | $\pm 0.019$ |
| $\text{AmF}_6^{2-}$                | 0.255  | $\pm 0.019$ | $\text{ReI}_6^{2-}$                        | 0.421  | $\pm 0.026$ |
| $\text{Bi}_2\text{Br}_8^{2-}$      | 0.392  | $\pm 0.055$ | $\text{RhF}_6^{2-}$                        | 0.240  | $\pm 0.019$ |
| $\text{Bi}_6\text{Cl}_{20}^{2-}$   | 0.501  | $\pm 0.073$ | $\text{RuCl}_6^{2-}$                       | 0.336  | $\pm 0.019$ |
| $\text{CdCl}_4^{2-}$               | 0.307  | $\pm 0.019$ | $\text{RuF}_6^{2-}$                        | 0.248  | $\pm 0.019$ |
| $\text{CeCl}_6^{2-}$               | 0.352  | $\pm 0.019$ | $\text{S}^{2-}$                            | 0.189  | $\pm 0.019$ |
| $\text{CeF}_6^{2-}$                | 0.249  | $\pm 0.019$ | $\text{S}_2\text{O}_3^{2-}$                | 0.251  | $\pm 0.019$ |
| $\text{CO}_3^{2-}$                 | 0.189  | $\pm 0.019$ | $\text{S}_2\text{O}_4^{2-}$                | 0.262  | $\pm 0.019$ |
| $\text{CoCl}_4^{2-}$               | 0.306  | $\pm 0.019$ | $\text{S}_2\text{O}_5^{2-}$                | 0.270  | $\pm 0.019$ |
| $\text{CoF}_4^{2-}$                | 0.209  | $\pm 0.019$ | $\text{S}_2\text{O}_6^{2-}$                | 0.283  | $\pm 0.019$ |
| $\text{CoF}_6^{2-}$                | 0.256  | $\pm 0.019$ | $\text{S}_2\text{O}_7^{2-}$                | 0.275  | $\pm 0.019$ |
| $\text{Cr}_2\text{O}_7^{2-}$       | 0.292  | $\pm 0.019$ | $\text{S}_2\text{O}_8^{2-}$                | 0.291  | $\pm 0.019$ |
| $\text{CrF}_6^{2-}$                | 0.253  | $\pm 0.019$ | $\text{S}_3\text{O}_6^{2-}$                | 0.302  | $\pm 0.019$ |
| $\text{CrO}_4^{2-}$                | 0.229  | $\pm 0.019$ | $\text{S}_4\text{O}_6^{2-}$                | 0.325  | $\pm 0.019$ |
| $\text{CuCl}_4^{2-}$               | 0.304  | $\pm 0.019$ | $\text{S}_6\text{O}_6^{2-}$                | 0.382  | $\pm 0.019$ |
| $\text{CuF}_4^{2-}$                | 0.213  | $\pm 0.019$ | $\text{ScF}_6^{2-}$                        | 0.276  | $\pm 0.019$ |
| $\text{GeCl}_6^{2-}$               | 0.335  | $\pm 0.019$ | $\text{Se}^{2-}$                           | 0.181  | $\pm 0.019$ |
| $\text{GeF}_6^{2-}$                | 0.244  | $\pm 0.019$ | $\text{SeBr}_6^{2-}$                       | 0.363  | $\pm 0.019$ |
| $\text{HfF}_6^{2-}$                | 0.248  | $\pm 0.019$ | $\text{SeCl}_6^{2-}$                       | 0.336  | $\pm 0.019$ |
| $\text{HgI}_4^{2-}$                | 0.377  | $\pm 0.019$ | $\text{SeO}_4^{2-}$                        | 0.229  | $\pm 0.019$ |
| $\text{IrCl}_6^{2-}$               | 0.332  | $\pm 0.019$ | $\text{SiF}_6^{2-}$                        | 0.248  | $\pm 0.019$ |
| $\text{MnCl}_6^{2-}$               | 0.314  | $\pm 0.031$ | $\text{SiO}_3^{2-}$                        | 0.195  | $\pm 0.019$ |
| $\text{MnF}_4^{2-}$                | 0.219  | $\pm 0.019$ | $\text{SmF}_4^{2-}$                        | 0.218  | $\pm 0.019$ |
| $\text{MnF}_6^{2-}$                | 0.241  | $\pm 0.019$ | $\text{Sn}(\text{OH})_6^{2-}$              | 0.279  | $\pm 0.020$ |
| $\text{MoBr}_6^{2-}$               | 0.364  | $\pm 0.019$ | $\text{SnBr}_6^{2-}$                       | 0.374  | $\pm 0.019$ |

| Ion                                             | Radius |         | Ion                                                           | Radius |         |
|-------------------------------------------------|--------|---------|---------------------------------------------------------------|--------|---------|
| SnCl <sub>6</sub> <sup>2-</sup>                 | 0.345  | ± 0.019 | Ni(NO <sub>2</sub> ) <sub>6</sub> <sup>4-</sup>               | 0.383  | ± 0.038 |
| SnF <sub>6</sub> <sup>2-</sup>                  | 0.265  | ± 0.019 | NiF <sub>6</sub> <sup>3-</sup>                                | 0.250  | ± 0.042 |
| SnI <sub>6</sub> <sup>2-</sup>                  | 0.427  | ± 0.019 | O <sup>3-</sup>                                               | 0.288  | ± 0.038 |
| SO <sub>3</sub> <sup>2-</sup>                   | 0.204  | ± 0.019 | P <sup>3-</sup>                                               | 0.224  | ± 0.042 |
| SO <sub>4</sub> <sup>2-</sup>                   | 0.218  | ± 0.019 | PaF <sub>8</sub> <sup>3-</sup>                                | 0.299  | ± 0.042 |
| TcBr <sub>6</sub> <sup>2-</sup>                 | 0.363  | ± 0.019 | PO <sub>4</sub> <sup>3-</sup>                                 | 0.230  | ± 0.042 |
| TcCl <sub>6</sub> <sup>2-</sup>                 | 0.337  | ± 0.019 | PrF <sub>6</sub> <sup>3-</sup>                                | 0.281  | ± 0.038 |
| TcF <sub>6</sub> <sup>2-</sup>                  | 0.244  | ± 0.019 | Rh(NO <sub>2</sub> ) <sub>6</sub> <sup>3-</sup>               | 0.345  | ± 0.038 |
| TcH <sub>9</sub> <sup>2-</sup>                  | 0.260  | ± 0.019 | Rh(SCN) <sub>6</sub> <sup>3-</sup>                            | 0.428  | ± 0.042 |
| TcI <sub>6</sub> <sup>2-</sup>                  | 0.419  | ± 0.019 | TaF <sub>8</sub> <sup>3-</sup>                                | 0.284  | ± 0.042 |
| Te <sup>2-</sup>                                | 0.220  | ± 0.019 | TbF <sub>7</sub> <sup>3-</sup>                                | 0.290  | ± 0.038 |
| TeBr <sub>6</sub> <sup>2-</sup>                 | 0.383  | ± 0.019 | Tc(CN) <sub>6</sub> <sup>5-</sup>                             | 0.410  | ± 0.042 |
| TeCl <sub>6</sub> <sup>2-</sup>                 | 0.353  | ± 0.019 | ThF <sub>7</sub> <sup>3-</sup>                                | 0.282  | ± 0.042 |
| TeI <sub>6</sub> <sup>2-</sup>                  | 0.430  | ± 0.019 | TiBr <sub>6</sub> <sup>3-</sup>                               | 0.315  | ± 0.038 |
| TeO <sub>4</sub> <sup>2-</sup>                  | 0.238  | ± 0.019 | TiF <sub>6</sub> <sup>3-</sup>                                | 0.271  | ± 0.038 |
| Th(NO <sub>3</sub> ) <sub>6</sub> <sup>2-</sup> | 0.424  | ± 0.019 | UF <sub>7</sub> <sup>3-</sup>                                 | 0.285  | ± 0.042 |
| ThCl <sub>6</sub> <sup>2-</sup>                 | 0.360  | ± 0.019 | YF <sub>6</sub> <sup>3-</sup>                                 | 0.275  | ± 0.038 |
| ThF <sub>6</sub> <sup>2-</sup>                  | 0.263  | ± 0.019 | ZrF <sub>7</sub> <sup>3-</sup>                                | 0.273  | ± 0.038 |
| TiBr <sub>6</sub> <sup>2-</sup>                 | 0.356  | ± 0.019 | <i>Singly Charged Cations</i>                                 |        |         |
| TiCl <sub>6</sub> <sup>2-</sup>                 | 0.335  | ± 0.019 | N(CH <sub>3</sub> ) <sub>4</sub> <sup>+</sup>                 | 0.234  | ± 0.019 |
| TiF <sub>6</sub> <sup>2-</sup>                  | 0.252  | ± 0.019 | N <sub>2</sub> H <sub>5</sub> <sup>+</sup>                    | 0.158  | ± 0.019 |
| UCl <sub>6</sub> <sup>2-</sup>                  | 0.354  | ± 0.019 | N <sub>2</sub> H <sub>6</sub> <sup>2+</sup>                   | 0.158  | ± 0.029 |
| UF <sub>6</sub> <sup>2-</sup>                   | 0.256  | ± 0.019 | NH(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> <sup>+</sup>  | 0.274  | ± 0.019 |
| VO <sub>3</sub> <sup>2-</sup>                   | 0.204  | ± 0.019 | NH <sub>3</sub> C <sub>2</sub> H <sub>5</sub> <sup>+</sup>    | 0.193  | ± 0.019 |
| WBr <sub>6</sub> <sup>2-</sup>                  | 0.363  | ± 0.019 | NH <sub>3</sub> C <sub>4</sub> H <sub>7</sub> <sup>+</sup>    | 0.225  | ± 0.019 |
| WCl <sub>6</sub> <sup>2-</sup>                  | 0.339  | ± 0.019 | NH <sub>3</sub> CH <sub>3</sub> <sup>+</sup>                  | 0.177  | ± 0.019 |
| WO <sub>4</sub> <sup>2-</sup>                   | 0.237  | ± 0.019 | NH <sub>3</sub> OH <sup>+</sup>                               | 0.147  | ± 0.019 |
| WOCl <sub>5</sub> <sup>2-</sup>                 | 0.334  | ± 0.019 | NH <sub>4</sub> <sup>+</sup>                                  | 0.136  | ± 0.019 |
| ZnBr <sub>4</sub> <sup>2-</sup>                 | 0.335  | ± 0.019 | NH <sub>3</sub> C <sub>2</sub> H <sub>4</sub> OH <sup>+</sup> | 0.203  | ± 0.019 |
| ZnCl <sub>4</sub> <sup>2-</sup>                 | 0.306  | ± 0.019 | As <sub>3</sub> S <sub>4</sub> <sup>+</sup>                   | 0.244  | ± 0.027 |
| ZnF <sub>4</sub> <sup>2-</sup>                  | 0.219  | ± 0.019 | As <sub>3</sub> Se <sub>4</sub> <sup>+</sup>                  | 0.253  | ± 0.027 |
| ZnI <sub>4</sub> <sup>2-</sup>                  | 0.384  | ± 0.019 | AsCl <sub>4</sub> <sup>+</sup>                                | 0.221  | ± 0.027 |
| ZrBr <sub>4</sub> <sup>2-</sup>                 | 0.334  | ± 0.019 | Br <sub>2</sub> <sup>+</sup>                                  | 0.155  | ± 0.027 |
| ZrCl <sub>4</sub> <sup>2-</sup>                 | 0.306  | ± 0.019 | Br <sub>3</sub> <sup>+</sup>                                  | 0.204  | ± 0.027 |
| ZrCl <sub>6</sub> <sup>2-</sup>                 | 0.348  | ± 0.019 | Br <sub>3</sub> <sup>-</sup>                                  | 0.238  | ± 0.027 |
| ZrF <sub>6</sub> <sup>2-</sup>                  | 0.258  | ± 0.019 | Br <sub>5</sub> <sup>+</sup>                                  | 0.229  | ± 0.027 |
| <i>Multi-Charged Anions</i>                     |        |         | BrClCNH <sub>2</sub> <sup>+</sup>                             | 0.175  | ± 0.027 |
| AlH <sub>6</sub> <sup>3-</sup>                  | 0.256  | ± 0.042 | BrF <sub>2</sub> <sup>+</sup>                                 | 0.183  | ± 0.027 |
| AsO <sub>4</sub> <sup>3-</sup>                  | 0.237  | ± 0.042 | BrF <sub>4</sub> <sup>+</sup>                                 | 0.172  | ± 0.027 |
| CdBr <sub>6</sub> <sup>4-</sup>                 | 0.374  | ± 0.038 | C <sub>10</sub> F <sub>8</sub> <sup>+</sup>                   | 0.265  | ± 0.027 |
| CdCl <sub>6</sub> <sup>4-</sup>                 | 0.352  | ± 0.038 | C <sub>6</sub> F <sub>6</sub> <sup>+</sup>                    | 0.228  | ± 0.027 |
| CeF <sub>6</sub> <sup>3-</sup>                  | 0.278  | ± 0.038 | Cl(SNSCN) <sub>2</sub> <sup>+</sup>                           | 0.347  | ± 0.027 |
| CeF <sub>7</sub> <sup>3-</sup>                  | 0.282  | ± 0.038 | Cl <sub>2</sub> C=NH <sub>2</sub> <sup>+</sup>                | 0.173  | ± 0.027 |
| Co(CN) <sub>6</sub> <sup>3-</sup>               | 0.349  | ± 0.038 | Cl <sub>2</sub> F <sup>+</sup>                                | 0.165  | ± 0.027 |
| Co(NO <sub>2</sub> ) <sub>6</sub> <sup>3-</sup> | 0.343  | ± 0.038 | Cl <sub>3</sub> <sup>+</sup>                                  | 0.182  | ± 0.027 |
| CoCl <sub>5</sub> <sup>3-</sup>                 | 0.320  | ± 0.038 | ClF <sub>2</sub> <sup>+</sup>                                 | 0.147  | ± 0.027 |
| CoF <sub>6</sub> <sup>3-</sup>                  | 0.258  | ± 0.042 | ClO <sub>2</sub> <sup>+</sup>                                 | 0.118  | ± 0.027 |
| Cr(CN) <sub>6</sub> <sup>3-</sup>               | 0.351  | ± 0.038 | GaBr <sub>4</sub> <sup>-</sup>                                | 0.317  | ± 0.038 |
| CrF <sub>6</sub> <sup>3-</sup>                  | 0.254  | ± 0.042 | I <sub>2</sub> <sup>+</sup>                                   | 0.185  | ± 0.027 |
| Cu(CN) <sub>4</sub> <sup>3-</sup>               | 0.312  | ± 0.038 | I <sub>3</sub> <sup>+</sup>                                   | 0.225  | ± 0.027 |
| Fe(CN) <sub>6</sub> <sup>3-</sup>               | 0.347  | ± 0.038 | I <sub>5</sub> <sup>+</sup>                                   | 0.263  | ± 0.027 |
| FeF <sub>6</sub> <sup>3-</sup>                  | 0.298  | ± 0.042 | IBr <sub>2</sub> <sup>+</sup>                                 | 0.196  | ± 0.027 |
| HfF <sub>7</sub> <sup>3-</sup>                  | 0.277  | ± 0.042 | ICl <sub>2</sub> <sup>+</sup>                                 | 0.175  | ± 0.036 |
| InF <sub>6</sub> <sup>3-</sup>                  | 0.268  | ± 0.038 | IF <sub>6</sub> <sup>+</sup>                                  | 0.209  | ± 0.027 |
| Ir(CN) <sub>6</sub> <sup>3-</sup>               | 0.347  | ± 0.038 | N(S <sub>3</sub> N <sub>2</sub> ) <sub>2</sub> <sup>+</sup>   | 0.258  | ± 0.027 |
| Ir(NO <sub>2</sub> ) <sub>6</sub> <sup>3-</sup> | 0.338  | ± 0.038 | N(SCl) <sub>2</sub> <sup>+</sup>                              | 0.186  | ± 0.027 |
| Mn(CN) <sub>6</sub> <sup>3-</sup>               | 0.350  | ± 0.038 | N(SeCl) <sub>2</sub> <sup>+</sup>                             | 0.246  | ± 0.027 |
| Mn(CN) <sub>6</sub> <sup>5-</sup>               | 0.401  | ± 0.042 | N(SF <sub>2</sub> ) <sub>2</sub> <sup>+</sup>                 | 0.214  | ± 0.027 |
| MnCl <sub>6</sub> <sup>4-</sup>                 | 0.349  | ± 0.038 | N <sub>2</sub> F <sup>+</sup>                                 | 0.156  | ± 0.027 |
| N <sup>3-</sup>                                 | 0.180  | ± 0.042 | NO <sup>+</sup>                                               | 0.145  | ± 0.027 |
| Ni(NO <sub>2</sub> ) <sub>6</sub> <sup>3-</sup> | 0.342  | ± 0.038 | NO <sub>2</sub> <sup>+</sup>                                  | 0.153  | ± 0.027 |

| Ion                                                                           | Radius |         | Ion                                                                                        | Radius |         |
|-------------------------------------------------------------------------------|--------|---------|--------------------------------------------------------------------------------------------|--------|---------|
| O <sub>2</sub> <sup>+</sup>                                                   | 0.140  | ± 0.027 | (SNPMe <sub>3</sub> ) <sub>3</sub> <sup>+</sup>                                            | 0.308  | ± 0.027 |
| O <sub>2</sub> (SCCF <sub>3</sub> Cl) <sub>2</sub> <sup>+</sup>               | 0.275  | ± 0.027 | SNSC(CH <sub>3</sub> )N <sup>+</sup>                                                       | 0.225  | ± 0.027 |
| ONCH <sub>3</sub> CF <sub>3</sub> <sup>+</sup>                                | 0.200  | ± 0.027 | SNSC(CN)CH <sup>+</sup>                                                                    | 0.209  | ± 0.027 |
| OsOF <sub>5</sub> <sup>-</sup>                                                | 0.246  | ± 0.038 | SNSC(Ph)N <sup>+</sup>                                                                     | 0.251  | ± 0.027 |
| P(CH <sub>3</sub> ) <sub>3</sub> Cl <sup>+</sup>                              | 0.197  | ± 0.027 | SNSC(Ph)NS <sub>3</sub> N <sub>2</sub> <sup>+</sup>                                        | 0.327  | ± 0.027 |
| P(CH <sub>3</sub> ) <sub>3</sub> D <sup>+</sup>                               | 0.196  | ± 0.027 | SNSC(PhCH <sub>3</sub> )N <sup>+</sup>                                                     | 0.264  | ± 0.027 |
| PCl <sub>4</sub> <sup>+</sup>                                                 | 0.235  | ± 0.027 | (Te(N(SiMe <sub>3</sub> ) <sub>2</sub> ) <sub>2</sub> ) <sup>+</sup>                       | 0.371  | ± 0.027 |
| ReOF <sub>5</sub> <sup>-</sup>                                                | 0.245  | ± 0.038 | Te(N <sub>3</sub> ) <sub>3</sub> <sup>+</sup>                                              | 0.226  | ± 0.027 |
| S(CH <sub>3</sub> ) <sub>2</sub> Cl <sup>+</sup>                              | 0.207  | ± 0.027 | Te <sub>4</sub> Nb <sub>3</sub> O <sub>2</sub> Te <sub>2</sub> I <sub>6</sub> <sup>+</sup> | 0.407  | ± 0.027 |
| S(N(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> ) <sub>3</sub> <sup>+</sup>  | 0.439  | ± 0.027 | TeBr <sub>3</sub> <sup>+</sup>                                                             | 0.235  | ± 0.027 |
| S <sub>2</sub> (CH <sub>3</sub> ) <sub>2</sub> Cl <sup>+</sup>                | 0.265  | ± 0.027 | TeCl <sub>3</sub> <sup>+</sup>                                                             | 0.216  | ± 0.027 |
| S <sub>2</sub> (CH <sub>3</sub> ) <sub>2</sub> CN <sup>+</sup>                | 0.223  | ± 0.027 | TeCl <sub>3</sub> (15-crown-5) <sup>+</sup>                                                | 0.282  | ± 0.027 |
| S <sub>2</sub> (CH <sub>3</sub> ) <sub>3</sub> <sup>+</sup>                   | 0.233  | ± 0.027 | TeI <sub>3</sub> <sup>+</sup>                                                              | 0.243  | ± 0.027 |
| S <sub>2</sub> Br <sub>5</sub> <sup>+</sup>                                   | 0.267  | ± 0.027 | XeF <sub>11</sub> <sup>+</sup>                                                             | 0.266  | ± 0.027 |
| S <sub>2</sub> N <sup>+</sup>                                                 | 0.159  | ± 0.034 | Xe <sub>2</sub> F <sub>3</sub> <sup>+</sup>                                                | 0.221  | ± 0.027 |
| S <sub>2</sub> N <sub>2</sub> C <sub>2</sub> H <sub>3</sub> <sup>+</sup>      | 0.211  | ± 0.027 | XeF <sup>+</sup>                                                                           | 0.174  | ± 0.027 |
| S <sub>2</sub> NC <sub>2</sub> (PhCH <sub>3</sub> ) <sub>2</sub> <sup>+</sup> | 0.310  | ± 0.027 | XeF <sub>3</sub> <sup>+</sup>                                                              | 0.183  | ± 0.027 |
| S <sub>2</sub> NC <sub>3</sub> H <sub>4</sub> <sup>+</sup>                    | 0.218  | ± 0.027 | XeF <sub>5</sub> <sup>+</sup>                                                              | 0.186  | ± 0.027 |
| S <sub>2</sub> NC <sub>4</sub> H <sub>8</sub> <sup>+</sup>                    | 0.225  | ± 0.027 | XeOF <sub>3</sub> <sup>+</sup>                                                             | 0.186  | ± 0.027 |
| S <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub> <sup>+</sup>                   | 0.239  | ± 0.027 | <i>Doubly Charged Cations</i>                                                              |        |         |
| S <sub>3</sub> Br <sub>3</sub> <sup>+</sup>                                   | 0.245  | ± 0.027 | Co <sub>2</sub> S <sub>2</sub> (CO) <sub>6</sub> <sup>2+</sup>                             | 0.263  | ± 0.035 |
| S <sub>3</sub> C <sub>3</sub> H <sub>7</sub> <sup>+</sup>                     | 0.199  | ± 0.027 | FeW(Se) <sub>2</sub> (CO) <sup>2+</sup>                                                    | 0.260  | ± 0.035 |
| S <sub>3</sub> C <sub>4</sub> F <sub>6</sub> <sup>+</sup>                     | 0.261  | ± 0.027 | I <sub>4</sub> <sup>2+</sup>                                                               | 0.207  | ± 0.035 |
| S <sub>3</sub> CF <sub>3</sub> CN <sup>+</sup>                                | 0.263  | ± 0.027 | Mo(Te <sub>3</sub> )(CO) <sub>4</sub> <sup>2+</sup>                                        | 0.234  | ± 0.035 |
| S <sub>3</sub> Cl <sub>3</sub> <sup>+</sup>                                   | 0.233  | ± 0.027 | S <sub>19</sub> <sup>2+</sup>                                                              | 0.292  | ± 0.035 |
| S <sub>3</sub> N <sub>2</sub> <sup>+</sup>                                    | 0.201  | ± 0.027 | S <sub>2</sub> (S(CH <sub>3</sub> ) <sub>2</sub> ) <sub>2</sub> <sup>2+</sup>              | 0.230  | ± 0.035 |
| S <sub>3</sub> N <sub>2</sub> Cl <sup>+</sup>                                 | 0.232  | ± 0.027 | S <sub>2</sub> I <sub>4</sub> <sup>2+</sup>                                                | 0.231  | ± 0.035 |
| S <sub>4</sub> N <sub>3</sub> <sup>+</sup>                                    | 0.231  | ± 0.027 | S <sub>3</sub> N <sub>2</sub> <sup>2+</sup>                                                | 0.184  | ± 0.035 |
| S <sub>4</sub> N <sub>3</sub> (Ph) <sub>2</sub> <sup>+</sup>                  | 0.316  | ± 0.027 | S <sub>3</sub> NCCNS <sub>3</sub> <sup>2+</sup>                                            | 0.220  | ± 0.035 |
| S <sub>4</sub> N <sub>4</sub> H <sup>+</sup>                                  | 0.178  | ± 0.027 | S <sub>3</sub> Se <sup>2+</sup>                                                            | 0.326  | ± 0.035 |
| S <sub>5</sub> N <sub>5</sub> <sup>+</sup>                                    | 0.257  | ± 0.027 | S <sub>4</sub> N <sub>4</sub> <sup>2+</sup>                                                | 0.186  | ± 0.035 |
| S <sub>7</sub> I <sup>+</sup>                                                 | 0.262  | ± 0.027 | S <sub>6</sub> N <sub>4</sub> <sup>2+</sup>                                                | 0.232  | ± 0.035 |
| Sb(NPPh <sub>3</sub> ) <sub>4</sub> <sup>+</sup>                              | 0.518  | ± 0.027 | S <sub>8</sub> <sup>2+</sup>                                                               | 0.182  | ± 0.035 |
| SBr <sub>3</sub> <sup>+</sup>                                                 | 0.220  | ± 0.027 | Se <sub>10</sub> <sup>2+</sup>                                                             | 0.253  | ± 0.035 |
| SCH <sub>3</sub> O <sub>2</sub> <sup>+</sup>                                  | 0.183  | ± 0.027 | Se <sub>17</sub> <sup>2+</sup>                                                             | 0.236  | ± 0.035 |
| SCH <sub>3</sub> P(CH <sub>3</sub> ) <sub>3</sub> <sup>+</sup>                | 0.248  | ± 0.027 | Se <sub>19</sub> <sup>2+</sup>                                                             | 0.296  | ± 0.035 |
| SCH <sub>3</sub> PCH <sub>3</sub> Cl <sub>2</sub> <sup>+</sup>                | 0.205  | ± 0.027 | Se <sub>2</sub> I <sub>4</sub> <sup>2+</sup>                                               | 0.218  | ± 0.035 |
| SCl(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> <sup>+</sup>                 | 0.207  | ± 0.027 | Se <sub>3</sub> N <sub>2</sub> <sup>2+</sup>                                               | 0.182  | ± 0.035 |
| SCl <sub>2</sub> CF <sub>3</sub> <sup>+</sup>                                 | 0.207  | ± 0.027 | Se <sub>4</sub> <sup>2+</sup>                                                              | 0.152  | ± 0.035 |
| SCl <sub>2</sub> CH <sub>3</sub> <sup>+</sup>                                 | 0.204  | ± 0.027 | Se <sub>4</sub> S <sub>2</sub> N <sub>4</sub> <sup>2+</sup>                                | 0.224  | ± 0.035 |
| SCl <sub>3</sub> <sup>+</sup>                                                 | 0.185  | ± 0.027 | Se <sub>8</sub> <sup>2+</sup>                                                              | 0.186  | ± 0.035 |
| Se <sub>3</sub> Br <sub>3</sub> <sup>+</sup>                                  | 0.253  | ± 0.027 | SeN <sub>2</sub> S <sub>2</sub> <sup>2+</sup>                                              | 0.182  | ± 0.035 |
| Se <sub>3</sub> Cl <sub>3</sub> <sup>+</sup>                                  | 0.245  | ± 0.027 | (SNP(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> ) <sub>2</sub> <sup>2+</sup>             | 0.312  | ± 0.035 |
| Se <sub>3</sub> N <sub>2</sub> <sup>+</sup>                                   | 0.288  | ± 0.042 | TaBr <sub>6</sub> <sup>-</sup>                                                             | 0.351  | ± 0.049 |
| Se <sub>3</sub> NC <sub>12</sub> <sup>+</sup>                                 | 0.163  | ± 0.027 | Te(trtu) <sub>4</sub> <sup>2+</sup>                                                        | 0.328  | ± 0.035 |
| Se <sub>6</sub> I <sup>+</sup>                                                | 0.260  | ± 0.027 | Te(tu) <sub>4</sub> <sup>2+</sup>                                                          | 0.296  | ± 0.035 |
| SeBr <sub>3</sub> <sup>+</sup>                                                | 0.182  | ± 0.027 | Te <sub>2</sub> (esu) <sub>4</sub> Br <sub>2</sub> <sup>2+</sup>                           | 0.356  | ± 0.035 |
| SeCl <sub>3</sub> <sup>+</sup>                                                | 0.192  | ± 0.027 | Te <sub>2</sub> (esu) <sub>4</sub> Cl <sub>2</sub> <sup>2+</sup>                           | 0.361  | ± 0.035 |
| SeF <sub>3</sub> <sup>+</sup>                                                 | 0.179  | ± 0.027 | Te <sub>2</sub> (esu) <sub>4</sub> I <sub>2</sub> <sup>2+</sup>                            | 0.342  | ± 0.035 |
| SeI <sub>3</sub> <sup>+</sup>                                                 | 0.238  | ± 0.027 | Te <sub>2</sub> Se <sub>2</sub> <sup>2+</sup>                                              | 0.192  | ± 0.035 |
| SeN <sub>2</sub> Cl <sup>+</sup>                                              | 0.196  | ± 0.027 | Te <sub>2</sub> Se <sub>4</sub> <sup>2+</sup>                                              | 0.222  | ± 0.035 |
| SeNCl <sub>2</sub> <sup>+</sup>                                               | 0.157  | ± 0.027 | Te <sub>2</sub> Se <sub>8</sub> <sup>2+</sup>                                              | 0.252  | ± 0.035 |
| (SeNMe <sub>3</sub> ) <sub>3</sub> <sup>+</sup>                               | 0.406  | ± 0.027 | Te <sub>3</sub> S <sub>3</sub> <sup>2+</sup>                                               | 0.217  | ± 0.035 |
| SeS <sub>2</sub> N <sub>2</sub> <sup>+</sup>                                  | 0.282  | ± 0.042 | Te <sub>3</sub> Se <sup>2+</sup>                                                           | 0.193  | ± 0.035 |
| SF(C <sub>6</sub> F <sub>5</sub> ) <sub>2</sub> <sup>+</sup>                  | 0.294  | ± 0.027 | Te <sub>4</sub> <sup>2+</sup>                                                              | 0.169  | ± 0.035 |
| SF <sub>2</sub> CF <sub>3</sub> <sup>+</sup>                                  | 0.198  | ± 0.027 | Te <sub>8</sub> <sup>2+</sup>                                                              | 0.187  | ± 0.035 |
| SF <sub>2</sub> N(CH <sub>3</sub> ) <sub>2</sub> <sup>+</sup>                 | 0.210  | ± 0.027 | W(CO) <sub>6</sub> (h3-Te) <sup>2+</sup>                                                   | 0.234  | ± 0.035 |
| SF <sub>3</sub> <sup>+</sup>                                                  | 0.172  | ± 0.027 | W <sub>2</sub> (CO) <sub>10</sub> Se <sub>4</sub> <sup>2+</sup>                            | 0.290  | ± 0.035 |
| SFS(C(CF <sub>3</sub> ) <sub>2</sub> ) <sub>2</sub> <sup>+</sup>              | 0.275  | ± 0.027 | <i>Multi-Charged Cations</i>                                                               |        |         |
| SH <sub>2</sub> C <sub>3</sub> H <sub>7</sub> <sup>+</sup>                    | 0.210  | ± 0.027 | I <sub>15</sub> <sup>3+</sup>                                                              | 0.442  | ± 0.051 |
| SN <sup>+</sup>                                                               | 0.158  | ± 0.027 | Te <sub>2</sub> (su) <sub>6</sub> <sup>4+</sup>                                            | 0.453  | ± 0.034 |
| SNCl <sub>5</sub> (CH <sub>3</sub> CN) <sup>-</sup>                           | 0.290  | ± 0.038 |                                                                                            |        |         |

Ligand abbreviations: su = selenourea; esu = ethyleneselenourea; tu = thiourea; ph = phenyl.

TABLE 3. Ancillary Thermochemical Data  
(kJ mol<sup>-1</sup>)

| Species                                                      | State | $\Delta_f H^\circ$ |
|--------------------------------------------------------------|-------|--------------------|
| AsO <sub>4</sub> <sup>3-</sup>                               | g     | (289)              |
| BrO <sub>3</sub> <sup>-</sup>                                | g     | -145               |
| ClO <sub>4</sub> <sup>-</sup>                                | g     | -344               |
| CN <sup>-</sup>                                              | g     | 66                 |
| CO <sub>3</sub> <sup>2-</sup>                                | g     | -321               |
| Fe(NO <sub>3</sub> ) <sub>2</sub>                            | c     | (-448)             |
| HF <sub>2</sub> <sup>-</sup>                                 | g     | -774               |
| HfCl <sub>6</sub> <sup>2-</sup>                              | g     | -1640              |
| IO <sub>2</sub> F <sub>2</sub> <sup>-</sup>                  | g     | -693               |
| IO <sub>3</sub> <sup>-</sup>                                 | g     | -208               |
| IrCl <sub>6</sub> <sup>2-</sup>                              | g     | -785               |
| LiCH <sub>3</sub> O <sub>2</sub>                             | c     | (-745)             |
| NbCl <sub>6</sub> <sup>2-</sup>                              | g     | -1224              |
| NH <sub>2</sub> CH <sub>2</sub> CO <sub>2</sub> <sup>-</sup> | g     | -564               |
| O <sub>2</sub> <sup>2-</sup>                                 | g     | 553                |
| PdCl <sub>6</sub> <sup>2-</sup>                              | g     | -749               |
| PO <sub>4</sub> <sup>3-</sup>                                | g     | 291                |
| PtCl <sub>6</sub> <sup>2-</sup>                              | g     | -774               |
| ReBr <sub>6</sub> <sup>2-</sup>                              | g     | -689               |
| ReCl <sub>6</sub> <sup>2-</sup>                              | g     | -919               |
| Ti(OH) <sub>2</sub>                                          | c     | -778               |



## THE MADELUNG CONSTANT AND CRYSTAL LATTICE ENERGY

If  $U$  is the crystal lattice energy and  $M$  is the Madelung constant, then<sup>a</sup>

$$U = \frac{NMz_iz_j e^2}{r} (1 - 1/n)$$

| Substance                                     | Ion type                             | Crystal form <sup>b</sup> | $M$                  |
|-----------------------------------------------|--------------------------------------|---------------------------|----------------------|
| Sodium chloride, NaCl                         | M <sup>+</sup> , X <sup>-</sup>      | FCC                       | 1.74756              |
| Cesium chloride, CsCl                         | M <sup>+</sup> , X <sup>-</sup>      | BCC                       | 1.76267              |
| Calcium chloride, CaCl <sub>2</sub>           | M <sup>++</sup> , 2X <sup>-</sup>    | Cubic                     | 2.365                |
| Calcium fluoride (fluorite), CaF <sub>2</sub> | M <sup>++</sup> , 2X <sup>-</sup>    | Cubic                     | 2.51939              |
| Cadmium chloride, CdCl <sub>2</sub>           | M <sup>++</sup> , 2X <sup>-</sup>    | Hexagonal                 | 2.244 <sup>c</sup>   |
| Cadmium iodide (α), CdI <sub>2</sub>          | M <sup>++</sup> , 2X <sup>-</sup>    | Hexagonal                 | 2.355 <sup>c</sup>   |
| Magnesium fluoride, MgF <sub>2</sub>          | M <sup>++</sup> , 2X <sup>-</sup>    | Tetragonal                | 2.381 <sup>c</sup>   |
| Cuprous oxide (cuprite), Cu <sub>2</sub> O    | 2M <sup>+</sup> , X <sup>- -</sup>   | Cubic                     | 2.22124              |
| Zinc oxide, ZnO                               | M <sup>++</sup> , X <sup>- -</sup>   | Hexagonal                 | 1.4985 <sup>c</sup>  |
| Sphalerite (zinc blende), ZnS                 | M <sup>++</sup> , X <sup>- -</sup>   | FCC                       | 1.63806              |
| Wurtzite, ZnS                                 | M <sup>++</sup> , X <sup>- -</sup>   | Hexagonal                 | 1.64132 <sup>c</sup> |
| Titanium dioxide (anatase), TiO <sub>2</sub>  | M <sup>4+</sup> , 2X <sup>- -</sup>  | Tetragonal                | 2.400 <sup>c</sup>   |
| Titanium dioxide (rutile), TiO <sub>2</sub>   | M <sup>4+</sup> , 2X <sup>- -</sup>  | Tetragonal                | 2.408 <sup>c</sup>   |
| β-Quartz, SiO <sub>2</sub>                    | M <sup>4+</sup> , 2X <sup>- -</sup>  | Hexagonal                 | 2.2197 <sup>c</sup>  |
| Corundum, Al <sub>2</sub> O <sub>3</sub>      | 2M <sup>3+</sup> , 3X <sup>- -</sup> | Rhombohedral              | 4.1719               |

<sup>a</sup>  $N$  is Avogadro's number,  $z_i$  and  $z_j$  are the integral charges on the ions (in units of  $e$ ), and  $e$  is the charge on the electron in electrostatic units ( $e = 4.803 \times 10^{-10}$  esu).  $r$  is the shortest distance between cation-anion pairs in centimeters. Then  $U$  is in ergs ( $1 \text{ erg} = 10^{-7} \text{ J}$ ).

<sup>b</sup> FCC = face centered cubic; BCC = body centered cubic.

<sup>c</sup> For tetragonal and hexagonal crystals the value of  $M$  depends on the details of the lattice parameters.

The Born Exponent,  $n$  is:

| Ion type                                                | $n$ |
|---------------------------------------------------------|-----|
| He, Li <sup>+</sup>                                     | 5   |
| Ne, Na <sup>+</sup> , F <sup>-</sup>                    | 7   |
| Ar, K <sup>+</sup> , Cu <sup>+</sup> , Cl <sup>-</sup>  | 9   |
| Kr, Rb <sup>+</sup> , Ag <sup>+</sup> , Br <sup>-</sup> | 10  |
| Xe, Cs <sup>+</sup> , Au <sup>+</sup> , I <sup>-</sup>  | 12  |

For a crystal with a mixed-ion type, an average of the values of  $n$  in this table is to be used (6 for LiF, for example).

# ELASTIC CONSTANTS OF SINGLE CRYSTALS

H. P. R. Frederikse

This table gives selected values of elastic constants for single crystals. The values believed most reliable were selected from the original literature. The substances are arranged by crystal system and, within each system, alphabetically by name. A reference to the original literature is given for each value; a useful compilation of published values from many sources may be found in Reference 1 below.

Data are given for the single-crystal density and for the elastic constants  $c_{ij}$ , in units of  $10^{11}$  N/m<sup>2</sup>, which is equivalent to  $10^{12}$  dyn/cm<sup>2</sup>.

## General References

1. Simmons, G., and Wang, H., *Single Crystal Elastic Constants and Calculated Aggregate Properties: A Handbook, Second Edition*, The MIT Press, Cambridge, MA, 1971.
2. Gray, D. E., Ed., *American Institute of Physics Handbook, Third Edition*, McGraw-Hill, New York, 1972.

## CUBIC CRYSTALS

| Name                  | Formula                                                         | $\rho/\text{g cm}^{-3}$ | T/K   | Ref. | $C_{11}$ | $C_{12}$ | $C_{44}$ |
|-----------------------|-----------------------------------------------------------------|-------------------------|-------|------|----------|----------|----------|
| Aluminum              | Al                                                              | 2.6970                  | 298   | 1    | 1.0675   | 0.6041   | 0.2834   |
| Aluminum antimonide   | AlSb                                                            | 4.3600                  | 300   | 2    | 0.8939   | 0.4427   | 0.4155   |
| Ammonium bromide      | NH <sub>4</sub> Br                                              | 2.4314                  | 300   | 3    | 0.3414   | 0.0782   | 0.0722   |
| Ammonium chloride     | NH <sub>4</sub> Cl                                              | 1.5279                  | 290   | 4    | 0.3814   | 0.0866   | 0.0903   |
| Argon                 | Ar                                                              | 1.7710                  | 4.2   | 5    | 0.0529   | 0.0135   | 0.0159   |
| Barium fluoride       | BaF <sub>2</sub>                                                | 4.8860                  | 298   | 6    | 0.9199   | 0.4157   | 0.2568   |
| Barium nitrate        | Ba(NO <sub>3</sub> ) <sub>2</sub>                               | 3.2560                  | 293   | 7    | 0.2925   | 0.2065   | 0.1277   |
| Calcium fluoride      | CaF <sub>2</sub>                                                | 3.810                   | 298   | 8    | 1.6420   | 0.4398   | 0.8406   |
| Calcium telluride     | CaTe                                                            | 5.8544                  | 298   | 9    | 0.5351   | 0.3681   | 0.1994   |
| Cesium                | Cs                                                              | 1.9800                  | 78    | 10   | 0.0247   | 0.0206   | 0.0148   |
| Cesium bromide        | CsBr                                                            | 4.4560                  | 298   | 11   | 0.3063   | 0.0807   | 0.0750   |
| Cesium chloride       | CsCl                                                            | 3.9880                  | 298   | 11   | 0.3644   | 0.0882   | 0.0804   |
| Cesium iodide         | CsI                                                             | 4.5250                  | 298   | 11   | 0.2446   | 0.0661   | 0.0629   |
| Chromite              | FeCr <sub>2</sub> O <sub>4</sub>                                | 4.4500                  | RT    | 12   | 3.2250   | 1.4370   | 1.1670   |
| Chromium              | Cr                                                              | 7.20                    | 298   | 13   | 3.398    | 0.586    | 0.990    |
| Cobalt oxide          | CoO                                                             | 6.44                    | 298   | 14   | 2.6123   | 1.4699   | 0.8300   |
| Cobalt zinc ferrite   | CoZnFeO <sub>2</sub>                                            | 5.43                    | 303   | 12   | 2.660    | 1.530    | 0.780    |
| Copper                | Cu                                                              | 8.932                   | 298   | 15   | 1.683    | 1.221    | 0.757    |
| Gallium antimonide    | GaSb                                                            | 5.6137                  | 298   | 16   | 0.8839   | 0.4033   | 0.4316   |
| Gallium arsenide      | GaAs                                                            | 5.3169                  | 298   | 17   | 1.1877   | 0.5372   | 0.5944   |
| Gallium phosphide     | GaP                                                             | 4.1297                  | 300   | 18   | 1.4120   | 0.6253   | 0.7047   |
| Garnet (yttrium-iron) | Y <sub>3</sub> Fe <sub>2</sub> (FeO <sub>4</sub> ) <sub>3</sub> | 5.17                    | 298   | 19   | 2.680    | 1.106    | 0.766    |
| Germanium             | Ge                                                              | 5.313                   | 298   | 20   | 1.2835   | 0.4823   | 0.6666   |
| Gold                  | Au                                                              | 19.283                  | 296.5 | 21   | 1.9244   | 1.6298   | 0.4200   |
| Indium antimonide     | InSb                                                            | 5.7890                  | 298   | 22   | 0.6720   | 0.3670   | 0.3020   |
| Indium arsenide       | InAs                                                            | 5.6720                  | 293   | 23   | 0.8329   | 0.4526   | 0.3959   |
| Indium phosphide      | InP                                                             | 4.78                    | RT    | 24   | 1.0220   | 0.5760   | 0.4600   |
| Iridium               | Ir                                                              | 22.52                   | 300   | 25   | 5.80     | 2.42     | 2.56     |
| Iron                  | Fe                                                              | 7.8672                  | 298   | 26   | 2.26     | 1.40     | 1.16     |
| Lead                  | Pb                                                              | 11.34                   | 296   | 27   | 0.4966   | 0.4231   | 0.1498   |
| Lead fluoride         | PbF <sub>2</sub>                                                | 7.79                    | 300   | 28   | 0.8880   | 0.4720   | 0.2454   |
| Lead nitrate          | Pb(NO <sub>3</sub> ) <sub>2</sub>                               | 4.547                   | 293   | 29   | 0.3729   | 0.2765   | 0.1347   |
| Lead telluride        | PbTe                                                            | 8.2379                  | 303.2 | 30   | 1.0795   | 0.0764   | 0.1343   |
| Lithium               | Li                                                              | 0.5326                  | 298   | 31   | 0.1350   | 0.1144   | 0.0878   |
| Lithium bromide       | LiBr                                                            | 3.47                    | RT    | 32   | 0.3940   | 0.1880   | 0.1910   |
| Lithium chloride      | LiCl                                                            | 2.068                   | 295   | 33   | 0.4927   | 0.2310   | 0.2495   |
| Lithium fluoride      | LiF                                                             | 2.638                   | RT    | 34   | 1.1397   | 0.4767   | 0.6364   |
| Lithium iodide        | LiI                                                             | 4.061                   | RT    | 32   | 0.2850   | 0.1400   | 0.1350   |
| Magnesium oxide       | MgO                                                             | 3.579                   | 298   | 20   | 2.9708   | 0.9536   | 1.5613   |
| Magnetite             | Fe <sub>3</sub> O <sub>4</sub>                                  | 5.18                    | RT    | 32   | 2.730    | 1.060    | 0.971    |
| Manganese oxide       | MnO                                                             | 5.39                    | 298   | 35   | 2.23     | 1.20     | 0.79     |
| Mercury telluride     | HgTe                                                            | 8.079                   | 290   | 36   | 0.548    | 0.381    | 0.204    |
| Molybdenum            | Mo                                                              | 10.2284                 | 273   | 37   | 4.637    | 1.578    | 1.092    |
| Nickel                | Ni                                                              | 8.91                    | 298   | 15   | 2.481    | 1.549    | 1.242    |

## CUBIC CRYSTALS

| Name               | Formula                           | $\rho/\text{g cm}^{-3}$ | $T/\text{K}$ | Ref. | $C_{11}$ | $C_{12}$ | $C_{44}$ |
|--------------------|-----------------------------------|-------------------------|--------------|------|----------|----------|----------|
| Niobium            | Nb                                | 8.578                   | 300          | 38   | 2.4650   | 1.3450   | 0.2873   |
| Palladium          | Pd                                | 12.038                  | 300          | 39   | 2.2710   | 1.7604   | 0.7173   |
| Platinum           | Pt                                | 21.50                   | 300          | 40   | 3.4670   | 2.5070   | 0.7650   |
| Potassium          | K                                 | 0.851                   | 295          | 41   | 0.0370   | 0.0314   | 0.0188   |
| Potassium bromide  | KBr                               | 2.740                   | 298          | 11   | 0.3468   | 0.0580   | 0.0507   |
| Potassium chloride | KCl                               | 1.984                   | 298          | 11   | 0.4069   | 0.0711   | 0.0631   |
| Potassium cyanide  | KCN                               | 1.553                   | RT           | 32   | 0.1940   | 0.1180   | 0.0150   |
| Potassium fluoride | KF                                | 2.480                   | 295          | 33   | 0.6490   | 0.1520   | 0.1232   |
| Potassium iodide   | KI                                | 3.128                   | 300          | 42   | 0.2710   | 0.0450   | 0.0364   |
| Pyrite             | FeS <sub>2</sub>                  | 5.016                   | RT           | 43   | 3.818    | 0.310    | 1.094    |
| Rubidium           | Rb                                | 1.58                    | 170          | 44   | 0.0296   | 0.0250   | 0.0171   |
| Rubidium bromide   | RbBr                              | 3.350                   | 300          | 45   | 0.3152   | 0.0500   | 0.0380   |
| Rubidium chloride  | RbCl                              | 2.797                   | 300          | 45   | 0.3624   | 0.0612   | 0.0468   |
| Rubidium iodide    | RbI                               | 3.551                   | 300          | 45   | 0.2556   | 0.0382   | 0.0278   |
| Silicon            | Si                                | 2.331                   | 298          | 46   | 1.6578   | 0.6394   | 0.7962   |
| Silver             | Ag                                | 10.50                   | 300          | 47   | 1.2399   | 0.9367   | 0.4612   |
| Silver bromide     | AgBr                              | 5.585                   | 300          | 48   | 0.5920   | 0.3640   | 0.0616   |
| Sodium             | Na                                | 0.971                   | 299          | 49   | 0.0739   | 0.0622   | 0.0419   |
| Sodium bromate     | NaBrO <sub>3</sub>                | 3.339                   | RT           | 32   | 0.5450   | 0.1910   | 0.1500   |
| Sodium bromide     | NaBr                              | 3.202                   | 300          | 33   | 0.3970   | 0.1001   | 0.0998   |
| Sodium chlorate    | NaClO <sub>3</sub>                | 2.485                   | RT           | 50   | 0.4920   | 0.1420   | 0.1160   |
| Sodium chloride    | NaCl                              | 2.163                   | 298          | 11   | 0.4947   | 0.1288   | 0.1287   |
| Sodium fluoride    | NaF                               | 2.804                   | 300          | 51   | 0.9700   | 0.2380   | 0.2822   |
| Sodium iodide      | NaI                               | 3.6689                  | 300          | 52   | 0.3007   | 0.0912   | 0.0733   |
| Spinel             | MgAl <sub>2</sub> O <sub>4</sub>  | 3.6193                  | 298          | 53   | 2.9857   | 1.5372   | 1.5758   |
| Strontium fluoride | SrF <sub>2</sub>                  | 4.277                   | 300          | 54   | 1.2350   | 0.4305   | 0.3128   |
| Strontium nitrate  | Sr(NO <sub>3</sub> ) <sub>2</sub> | 2.989                   | 293          | 29   | 0.4255   | 0.2921   | 0.1590   |
| Strontium oxide    | SrO                               | 4.99                    | 300          | 55   | 1.601    | 0.435    | 0.590    |
| Strontium titanate | SrTiO <sub>3</sub>                | 5.123                   | RT           | 56   | 3.4817   | 1.0064   | 4.5455   |
| Tantalum           | Ta                                | 16.626                  | 298          | 57   | 2.6023   | 1.5446   | 0.8255   |
| Tantalum carbide   | TaC                               | 14.65                   | RT           | 58   | 5.05     | 0.73     | 0.79     |
| Thallium bromide   | TlBr                              | 7.4529                  | 298          | 59   | 0.3760   | 0.1458   | 0.0757   |
| Thorium            | Th                                | 11.694                  | 300          | 60   | 0.7530   | 0.4890   | 0.4780   |
| Thorium oxide      | ThO <sub>2</sub>                  | 9.991                   | 298          | 61   | 3.670    | 1.060    | 0.797    |
| Tin telluride      | SnTe                              | 6.445                   | 300          | 62   | 1.1250   | 0.0750   | 0.1172   |
| Titanium carbide   | TiC                               | 4.940                   | RT           | 107  | 5.00     | 1.13     | 1.75     |
| Tungsten           | W                                 | 19.257                  | 297          | 64   | 5.2239   | 2.0437   | 1.6083   |
| Uranium carbide    | UC                                | 13.63                   | 300          | 65   | 3.200    | 0.850    | 0.647    |
| Uranium dioxide    | UO <sub>2</sub>                   | 10.97                   | 298          | 66   | 3.960    | 1.210    | 0.641    |
| Vanadium           | V                                 | 6.022                   | 300          | 67   | 2.287    | 1.190    | 0.432    |
| Zinc selenide      | ZnSe                              | 5.262                   | 298          | 68   | 0.8096   | 0.4881   | 0.4405   |
| Zinc sulfide       | ZnS                               | 4.088                   | 298          | 68   | 1.0462   | 0.6534   | 0.4613   |
| Zinc telluride     | ZnTe                              | 5.636                   | 298          | 68   | 0.7134   | 0.4078   | 0.3115   |
| Zirconium carbide  | ZrC                               | 6.606                   | 298          | 63   | 4.720    | 0.987    | 1.593    |

## TETRAGONAL CRYSTALS

| Name                                 | Formula                                   | $\rho/\text{g cm}^{-3}$ | T/K | Ref. | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{16}$ | $C_{33}$ | $C_{44}$ | $C_{66}$ |
|--------------------------------------|-------------------------------------------|-------------------------|-----|------|----------|----------|----------|----------|----------|----------|----------|
| Ammonium dihydrogen arsenate (ADA)   | $\text{NH}_4\text{H}_2\text{AsO}_4$       | 2.3110                  | 298 | 69   | 0.6747   | -0.106   | 0.1652   |          | 0.3022   | 0.0685   | 0.0639   |
| Ammonium dihydrogen phosphate (ADP)  | $\text{NH}_4\text{H}_2\text{PO}_4$        | 1.8030                  | 293 | 69   | 0.6200   | -0.050   | 0.1400   |          | 0.3000   | 0.0910   | 0.0610   |
| Barium titanate                      | $\text{BaTiO}_3$                          | 5.9988                  | 298 | 70   | 2.7512   | 1.7897   | 1.5156   |          | 1.6486   | 0.5435   | 1.1312   |
| Calcium molybdate                    | $\text{CaMoO}_4$                          | 4.255                   | 298 | 79   | 1.447    | 0.664    | 0.466    | 0.134    | 1.265    | 0.369    | 0.451    |
| Indium                               | In                                        | 7.300                   | RT  | 71   | 0.4450   | 0.3950   | 0.4050   |          | 0.4440   | 0.0655   | 0.1220   |
| Magnesium fluoride                   | $\text{MgF}_2$                            | 3.177                   | RT  | 72   | 1.237    | 0.732    | 0.536    |          | 1.770    | 0.552    | 0.978    |
| Nickel sulfate hexahydrate           | $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ | 2.070                   | RT  | 73   | 0.3209   | 0.2315   | 0.0209   |          | 0.2931   | 0.1156   | 0.1779   |
| Potassium dihydrogen arsenate (KDA)  | $\text{KH}_2\text{AsO}_4$                 | 2.867                   | RT  | 12   | 0.530    | -0.060   | -0.020   |          | 0.370    | 0.120    | 0.070    |
| Potassium dihydrogen phosphate (KDP) | $\text{KH}_2\text{PO}_4$                  | 2.388                   | RT  | 71   | 0.7140   | -0.049   | 0.1290   |          | 0.5620   | 0.1270   | 0.0628   |
| Rubidium dihydrogen phosphate (RDP)  | $\text{RbH}_2\text{PO}_4$                 | 2.800                   | 298 | 74   | 0.5562   | -0.064   | 0.0279   |          | 0.4398   | 0.1142   | 0.0350   |
| Rutile                               | $\text{TiO}_2$                            | 4.260                   | 298 | 75   | 2.7143   | 1.7796   | 1.4957   |          | 4.8395   | 1.2443   | 1.9477   |
| Tellurium oxide                      | $\text{TeO}_2$                            | 5.99                    | RT  | 76   | 0.5320   | 0.4860   | 0.2120   |          | 1.0850   | 0.2440   | 0.5520   |
| Tin (white)                          | Sn                                        | 7.29                    | 288 | 77   | 0.7529   | 0.6156   | 0.4400   |          | 0.9552   | 0.2193   | 0.2336   |
| Zircon                               | $\text{ZrSiO}_4$                          | 4.70                    | RT  | 78   | 2.585    | 1.791    | 1.542    |          | 3.805    | 0.733    | 1.113    |

## ORTHORHOMBIC CRYSTALS

| Name                           | Formula                                                                 | $\rho/\text{g cm}^{-3}$ | T/K | Ref. | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{22}$ | $C_{23}$ | $C_{33}$ | $C_{44}$ | $C_{55}$ | $C_{66}$ |
|--------------------------------|-------------------------------------------------------------------------|-------------------------|-----|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Acenaphthene                   | $\text{C}_{12}\text{H}_{10}$                                            | 1.220                   | 293 | 80   | 0.1380   | 0.0210   | 0.0410   | 0.1262   | 0.0460   | 0.1117   | 0.0265   | 0.0290   | 0.0185   |
| Ammonium sulfate               | $(\text{NH}_4)_2\text{SO}_4$                                            | 1.774                   | 293 | 81   | 0.3607   | 0.1651   | 0.1580   | 0.2981   | 0.1456   | 0.3534   | 0.1025   | 0.0717   | 0.0974   |
| Aragonite                      | $\text{CaCO}_3$                                                         | 2.93                    | RT  | 82   | 1.5958   | 0.3663   | 0.0197   | 0.8697   | 0.1597   | 0.8503   | 0.4132   | 0.2564   | 0.4274   |
| Barite                         | $\text{BaSO}_4$                                                         | 4.40                    | RT  | 82   | 0.8941   | 0.4614   | 0.2691   | 0.7842   | 0.2676   | 1.0548   | 0.1190   | 0.2874   | 0.2778   |
| Benzene                        | $\text{C}_6\text{H}_6$                                                  | 1.061                   | 250 | 83   | 0.0614   | 0.0352   | 0.0401   | 0.0656   | 0.0390   | 0.0583   | 0.0197   | 0.0378   | 0.0153   |
| Benzophenone                   | $(\text{C}_6\text{H}_5)_2\text{CO}$                                     | 1.219                   | RT  | 32   | 0.1070   | 0.0550   | 0.0169   | 0.1000   | 0.0321   | 0.0710   | 0.0203   | 0.0155   | 0.0353   |
| Bronzite                       | $(\text{MgFe})\text{SiO}_3$                                             | 3.38                    | RT  | 78   | 1.876    | 0.686    | 0.605    | 1.578    | 0.561    | 2.085    | 0.700    | 0.592    | 0.544    |
| Calcium sulfate                | $\text{CaSO}_4$                                                         | 2.962                   | RT  | 84   | 0.9382   | 0.1650   | 0.1520   | 1.845    | 0.3173   | 1.1180   | 0.3247   | 0.2653   | 0.0926   |
| Celestite                      | $\text{SrSO}_4$                                                         | 3.96                    | RT  | 12   | 1.044    | 0.773    | 0.605    | 1.061    | 0.619    | 1.286    | 0.135    | 0.279    | 0.266    |
| Cesium sulfate                 | $\text{Cs}_2\text{SO}_4$                                                | 4.243                   | 293 | 81   | 0.4490   | 0.1958   | 0.1815   | 0.4283   | 0.1800   | 0.3785   | 0.1326   | 0.1319   | 0.1323   |
| Fosterite                      | $\text{Mg}_2\text{SiO}_4$                                               | 3.224                   | 298 | 85   | 3.2848   | 0.6390   | 0.6880   | 1.9980   | 0.7380   | 2.3530   | 0.6515   | 0.8120   | 0.8088   |
| Iodic acid                     | $\text{HIO}_3$                                                          | 4.630                   | RT  | 73   | 0.3030   | 0.1194   | 0.1169   | 0.5448   | 0.0548   | 0.4359   | 0.1835   | 0.2193   | 0.1736   |
| Lithium ammonium tartrate      | $\text{LiNH}_4\text{C}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$ | 1.71                    | RT  | 12   | 0.3864   | 0.1655   | 0.0875   | 0.5393   | 0.2007   | 0.3624   | 0.1190   | 0.0667   | 0.2326   |
| Magnesium sulfate heptahydrate | $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$                               | 1.68                    | RT  | 86   | 0.325    | 0.174    | 0.182    | 0.288    | 0.182    | 0.315    | 0.078    | 0.156    | 0.090    |
| Natrolite                      | $(\text{Na,Al})\text{SiO}_3$                                            | 2.25                    | RT  | 78   | 0.716    | 0.261    | 0.297    | 0.632    | 0.297    | 1.378    | 0.196    | 0.248    | 0.423    |
| Nickel sulfate heptahydrate    | $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$                               | 1.948                   | RT  | 86   | 0.353    | 0.198    | 0.201    | 0.311    | 0.201    | 0.335    | 0.091    | 0.172    | 0.099    |
| Olivine                        | $(\text{MgFe})\text{SiO}_4$                                             | 3.324                   | RT  | 87   | 3.240    | 0.590    | 0.790    | 1.980    | 0.780    | 2.490    | 0.667    | 0.810    | 0.793    |
| Potassium pentaborate          | $\text{KB}_5\text{O}_8 \cdot 4\text{H}_2\text{O}$                       | 1.74                    | RT  | 71   | 0.582    | 0.229    | 0.174    | 0.359    | 0.231    | 0.255    | 0.164    | 0.046    | 0.057    |
| Potassium sulfate              | $\text{K}_2\text{SO}_4$                                                 | 2.665                   | 293 | 81   | 0.5357   | 0.1999   | 0.2095   | 0.5653   | 0.1990   | 0.5523   | 0.195    | 0.1879   | 0.1424   |
| Rochelle salt                  | $\text{NaK}(\text{C}_4\text{H}_4\text{O}_6) \cdot 4\text{H}_2\text{O}$  | 1.79                    | RT  | 71   | 0.255    | 0.141    | 0.116    | 0.381    | 0.146    | 0.371    | 0.134    | 0.032    | 0.098    |
| Rubidium sulfate               | $\text{Rb}_2\text{SO}_4$                                                | 3.621                   | 293 | 81   | 0.5029   | 0.1965   | 0.1999   | 0.5098   | 0.1925   | 0.4761   | 0.1626   | 0.1589   | 0.1407   |
| Sodium ammonium tartrate       | $\text{NaNH}_4\text{C}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$ | 1.587                   | RT  | 12   | 0.3685   | 0.2725   | 0.3083   | 0.5092   | 0.3472   | 0.5541   | 0.1058   | 0.0303   | 0.0870   |
| Sodium tartrate                | $\text{Na}_2\text{C}_4\text{H}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$   | 1.794                   | RT  | 12   | 0.461    | 0.286    | 0.320    | 0.547    | 0.352    | 0.665    | 0.124    | 0.031    | 0.098    |
| Strontium formate dihydrate    | $\text{Sr}(\text{CHO}_2)_2 \cdot 2\text{H}_2\text{O}$                   | 2.25                    | RT  | 12   | 0.4391   | 0.1037   | -0.149   | 0.3484   | -0.014   | 0.3746   | 0.1538   | 0.1075   | 0.1724   |
| Sulfur                         | S                                                                       | 2.07                    | RT  | 12   | 0.240    | 0.133    | 0.171    | 0.205    | 0.159    | 0.483    | 0.043    | 0.087    | 0.076    |
| Thallium sulfate               | $\text{TlSO}_4$                                                         | 6.776                   | 293 | 81   | 0.4106   | 0.2573   | 0.2288   | 0.3885   | 0.2174   | 0.4268   | 0.1125   | 0.1068   | 0.0751   |
| Topaz                          | $\text{Al}_2\text{SiO}_5(\text{OH,F})_2$                                | 3.52                    | RT  | 82   | 2.8136   | 1.2582   | 0.8464   | 3.8495   | 0.8815   | 2.9452   | 1.0811   | 1.3298   | 1.3089   |
| Uranium (alpha)                | U                                                                       | 19.0453                 | 293 | 88   | 2.1486   | 0.4622   | 0.2176   | 1.9983   | 1.0764   | 2.6763   | 1.2479   | 0.7379   | 0.7454   |
| Zinc sulfate heptahydrate      | $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$                               | 1.970                   | RT  | 86   | 0.3320   | 0.1720   | 0.2000   | 0.2930   | 0.1980   | 0.3200   | 0.0780   | 0.1530   | 0.0830   |

## MONOCLINIC CRYSTALS

| Name                            | Formula                                                                                 | $\rho/\text{g cm}^{-3}$ | T/K      | Ref.     | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{15}$ | $C_{22}$ |
|---------------------------------|-----------------------------------------------------------------------------------------|-------------------------|----------|----------|----------|----------|----------|----------|----------|
| Aegirine                        | (NaFe)Si <sub>2</sub> O <sub>6</sub>                                                    | 3.50                    | RT       | 89       | 1.858    | 0.685    | 0.707    | 0.098    | 1.813    |
| Anthracene                      | C <sub>14</sub> H <sub>10</sub>                                                         | 1.258                   | RT       | 90       | 0.0852   | 0.0672   | 0.0590   | −0.0192  | 0.1170   |
| Cobalt sulfate<br>heptahydrate  | CoSO <sub>4</sub> ·7H <sub>2</sub> O                                                    | 1.948                   | RT       | 86       | 0.335    | 0.205    | 0.158    | 0.016    | 0.378    |
| Diopside                        | (CaMg)Si <sub>2</sub> O <sub>6</sub>                                                    | 3.31                    | RT       | 91       | 2.040    | 0.884    | 0.0883   | −0.193   | 1.750    |
| Dipotassium tartrate            | KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                                          | 1.97                    | RT       | 12       | 0.4294   | 0.1399   | 0.3129   | −0.0105  | 0.3460   |
| Feldspar (microceine)           | KAlSi <sub>3</sub> O <sub>8</sub>                                                       | 2.56                    | RT       | 92       | 0.664    | 0.438    | 0.259    | −0.033   | 1.710    |
| Ferrous sulfate<br>heptahydrate | FeSO <sub>4</sub> ·7H <sub>2</sub> O                                                    | 1.898                   | RT       | 86       | 0.349    | 0.208    | 0.174    | −0.020   | 0.376    |
| Lithium sulfate<br>monohydrate  | Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O                                       | 2.221                   | RT       | 32       | 0.5250   | 0.1715   | 0.1730   | −0.0196  | 0.5060   |
| Naphthalene                     | C <sub>10</sub> H <sub>8</sub>                                                          | 1.127                   | RT       | 93       | 0.0780   | 0.0445   | 0.0340   | −0.006   | 0.0990   |
| Potassium tartrate              | K <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                             | 1.987                   | RT       | 32       | 0.3110   | 0.1720   | 0.1690   | 0.0287   | 0.3900   |
| Sodium thiosulfate              | Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>                                           | 1.7499                  | RT       | 12       | 0.3323   | 0.1814   | 0.1875   | 0.0225   | 0.2953   |
| Stilbene                        | (C <sub>6</sub> H <sub>5</sub> CH) <sub>2</sub>                                         | 1.60                    | RT       | 94       | 0.0930   | 0.0570   | 0.0670   | −0.003   | 0.0920   |
| Triglycine sulfate (TGS)        | (NH <sub>2</sub> CH <sub>2</sub> COOH) <sub>3</sub> ·<br>H <sub>2</sub> SO <sub>4</sub> | 1.68                    | RT       | 32       | 0.4550   | 0.1720   | 0.1980   | −0.030   | 0.3210   |
|                                 |                                                                                         |                         |          |          |          |          |          |          |          |
| Name                            | $C_{23}$                                                                                | $C_{25}$                | $C_{33}$ | $C_{35}$ | $C_{44}$ | $C_{46}$ | $C_{55}$ | $C_{66}$ |          |
| Aegirine                        | 0.626                                                                                   | 0.094                   | 2.344    | 0.214    | 0.692    | 0.077    | 0.510    | 0.474    |          |
| Anthracene                      | 0.0375                                                                                  | −0.0170                 | 0.1522   | −0.0187  | 0.0272   | 0.0138   | 0.0242   | 0.0399   |          |
| Cobalt sulfate<br>heptahydrate  | 0.158                                                                                   | −0.018                  | 0.371    | −0.047   | 0.060    | 0.016    | 0.058    | 0.101    |          |
| Diopside                        | 0.482                                                                                   | −0.196                  | 2.380    | −0.336   | 0.675    | −0.113   | 0.588    | 0.705    |          |
| Dipotassium<br>tartrate         | 0.1173                                                                                  | 0.0176                  | 0.6816   | 0.0294   | 0.0961   | −0.0044  | 0.1270   | 0.0841   |          |
| Feldspar (microceine)           | 0.192                                                                                   | −0.148                  | 1.215    | −0.131   | 0.143    | −0.015   | 0.238    | 0.361    |          |
| Ferrous sulfate<br>heptahydrate | 0.172                                                                                   | −0.019                  | 0.360    | −0.014   | 0.064    | 0.001    | 0.056    | 0.096    |          |
| Lithium sulfate<br>monohydrate  | 0.0368                                                                                  | 0.0571                  | 0.5400   | −0.0254  | 0.1400   | −0.0054  | 0.1565   | 0.2770   |          |
| Naphthalene                     | 0.0230                                                                                  | −0.0270                 | 0.1190   | 0.0290   | 0.0330   | −0.0050  | 0.0210   | 0.0415   |          |
| Potassium tartrate              | 0.1330                                                                                  | 0.0182                  | 0.5540   | 0.0710   | 0.0870   | 0.0072   | 0.1040   | 0.0826   |          |
| Sodium thiosulfate              | 0.1713                                                                                  | 0.0983                  | 0.4590   | −0.0678  | 0.0569   | −0.0268  | 0.1070   | 0.0598   |          |
| Stilbene                        | 0.0485                                                                                  | −0.005                  | 0.0790   | −0.005   | 0.0325   | 0.0050   | 0.0640   | 0.0245   |          |
| Triglycine sulfate (TGS)        | 0.2080                                                                                  | −0.0036                 | 0.2630   | −0.0500  | 0.0950   | −0.0026  | 0.1110   | 0.0620   |          |

## HEXAGONAL CRYSTALS

| Name              | Formula                                                    | $\rho/\text{g cm}^{-3}$ | $T/\text{K}$ | Ref. | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{33}$ | $C_{55}$ |
|-------------------|------------------------------------------------------------|-------------------------|--------------|------|----------|----------|----------|----------|----------|
| Apatite           | $\text{Ca}_5(\text{PO}_4)_3(\text{OH},\text{F},\text{Cl})$ | 3.218                   | RT           | 12   | 1.667    | 0.131    | 0.655    | 1.396    | 0.663    |
| Beryl             | $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$           | 2.68                    | RT           | 12   | 2.800    | 0.990    | 0.670    | 2.480    | 0.658    |
| Beryllium         | Be                                                         | 1.8477                  | 300          | 95   | 2.923    | 0.267    | 0.140    | 3.364    | 1.625    |
| Beryllium oxide   | BeO                                                        | 3.01                    | RT           | 96   | 4.70     | 1.68     | 1.19     | 4.94     | 1.53     |
| Cadmium           | Cd                                                         | 8.652                   | 300          | 97   | 1.1450   | 0.3950   | 0.3990   | 0.5085   | 0.1985   |
| Cadmium selenide  | CdSe                                                       | 5.655                   | 298          | 68   | 0.7046   | 0.4516   | 0.3930   | 0.8355   | 0.1317   |
| Cadmium sulfide   | CdS                                                        | 4.824                   | 298          | 98   | 0.8431   | 0.5208   | 0.4567   | 0.9183   | 0.1458   |
| Cobalt            | Co                                                         | 8.836                   | 298          | 99   | 3.071    | 1.650    | 1.027    | 3.581    | 0.755    |
| Dysprosium        | Dy                                                         | 8.560                   | 298          | 100  | 0.7466   | 0.2616   | 0.2233   | 0.7871   | 0.2427   |
| Erbium            | Er                                                         | 9.064                   | 298          | 100  | 0.8634   | 0.3050   | 0.2270   | 0.8554   | 0.2809   |
| Gadolinium        | Gd                                                         | 7.888                   | 298          | 101  | 0.6667   | 0.2499   | 0.2132   | 0.7191   | 0.2089   |
| Hafnium           | Hf                                                         | 12.727                  | 298          | 102  | 1.881    | 0.772    | 0.661    | 1.969    | 0.557    |
| Ice               | $\text{H}_2\text{O}(\text{solid})$                         | 0.920                   | 250          | 103  | 0.1410   | 0.0660   | 0.0624   | 0.1515   | 0.0288   |
| Indium            | In                                                         | 7.2788                  | 300          | 104  | 0.4535   | 0.4006   | 0.4151   | 0.4515   | 0.0651   |
| Magnesium         | Mg                                                         | 1.7364                  | 298          | 105  | 0.5950   | 0.2612   | 0.2180   | 0.6155   | 0.1635   |
| Rhenium           | Re                                                         | 21.024                  | 298          | 100  | 6.1820   | 2.7530   | 2.0780   | 6.8350   | 1.6060   |
| Ruthenium         | Ru                                                         | 12.3615                 | 298          | 100  | 5.6260   | 1.8780   | 1.6820   | 6.2420   | 1.8060   |
| Thallium          | Tl                                                         | 11.560                  | 300          | 106  | 0.4080   | 0.3540   | 0.2900   | 0.5280   | 0.0726   |
| Titanium          | Ti                                                         | 4.5063                  | 298          | 102  | 1.6240   | 0.9200   | 0.6900   | 1.8070   | 0.4670   |
| Titanium diboride | $\text{TiB}_2$                                             | 4.95                    | RT           | 107  | 6.90     | 4.10     | 3.20     | 4.40     | 2.50     |
| Yttrium           | Y                                                          | 4.472                   | 300          | 108  | 0.7790   | 0.2850   | 0.2100   | 0.7690   | 0.2431   |
| Zinc              | Zn                                                         | 7.134                   | 295          | 109  | 1.6368   | 0.3640   | 0.5300   | 0.6347   | 0.3879   |
| Zinc oxide        | ZnO                                                        | 5.6760                  | 298          | 110  | 2.0970   | 1.2110   | 1.0510   | 2.1090   | 0.4247   |
| Zinc sulfide      | ZnS                                                        | 4.089                   | 298          | 96   | 1.2420   | 0.6015   | 0.4554   | 1.4000   | 0.2864   |
| Zirconium         | Zr                                                         | 6.505                   | 298          | 102  | 1.434    | 0.728    | 0.653    | 1.648    | 0.320    |

## TRIGONAL CRYSTALS

| Name               | Formula                 | $\rho/\text{g cm}^{-3}$ | $T/\text{K}$ | Ref. | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{33}$ | $C_{44}$ |
|--------------------|-------------------------|-------------------------|--------------|------|----------|----------|----------|----------|----------|----------|
| Aluminum oxide     | $\text{Al}_2\text{O}_3$ | 3.986                   | 300          | 111  | 4.9735   | 1.6397   | 1.1220   | -0.2358  | 4.9911   | 1.4739   |
| Aluminum phosphate | $\text{AlPO}_4$         | 2.556                   | RT           | 73   | 1.0503   | 0.2934   | 0.6927   | -0.1271  | 1.3353   | 0.2314   |
| Antimony           | Sb                      | 6.70                    | 295          | 112  | 1.0130   | 0.3450   | 0.2920   | 0.2090   | 0.4500   | 0.3930   |
| Bismuth            | Bi                      | 9.80                    | 295          | 112  | 0.6370   | 0.2490   | 0.2470   | 0.0717   | 0.3820   | 0.1123   |
| Calcite            | $\text{CaCO}_3$         | 2.712                   | 300          | 113  | 1.4806   | 0.5578   | 0.5464   | -0.2058  | 0.8557   | 0.3269   |
| Hematite           | $\text{Fe}_2\text{O}_3$ | 5.240                   | RT           | 82   | 2.4243   | 0.5464   | 0.1542   | -0.1247  | 2.2734   | 0.8569   |
| Lithium niobate    | $\text{LiNbO}_3$        | 4.70                    | RT           | 114  | 2.030    | 0.530    | 0.750    | 0.090    | 2.450    | 0.600    |
| Lithium tantalate  | $\text{LiTaO}_3$        | 7.45                    | RT           | 114  | 2.330    | 0.470    | 0.800    | -0.110   | 2.750    | 0.940    |
| Quartz             | $\text{SiO}_2$          | 2.6485                  | 298          | 115  | 0.8680   | 0.0704   | 0.1191   | -0.1804  | 1.0575   | 0.5820   |
| Selenium           | Se                      | 4.838                   | 300          | 116  | 0.1870   | 0.0710   | 0.2620   | 0.0620   | 0.7410   | 0.1490   |
| Sodium nitrate     | $\text{NaNO}_3$         | 2.27                    | RT           | 12   | 0.8670   | 0.1630   | 0.1600   | 0.0820   | 0.3740   | 0.2130   |
| Tourmaline         |                         | 3.05                    | RT           | 82   | 2.7066   | 0.6927   | 0.0872   | -0.0774  | 1.6070   | 0.6682   |

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## ELECTRICAL RESISTIVITY OF PURE METALS

The first part of this table gives the electrical resistivity, in units of  $10^{-8} \Omega \text{ m}$ , for 28 common metallic elements as a function of temperature. The data refer to polycrystalline samples. The number of significant figures indicates the accuracy of the values. However, at low temperatures (especially below 50 K) the electrical resistivity is extremely sensitive to sample purity. Thus the low-temperature values refer to samples of specified purity and treatment. The references should be consulted for further information on this point, as well as for values at additional temperatures.

The second part of the table gives resistivity values in the neighborhood of room temperature for other metallic elements that have not been studied over an extended temperature range.

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### Electrical Resistivity in $10^{-8} \Omega \text{ m}$

| <i>T</i> /K | Aluminum | Barium | Beryllium | Calcium | Cesium | Chromium | Copper  |
|-------------|----------|--------|-----------|---------|--------|----------|---------|
| 1           | 0.000100 | 0.081  | 0.0332    | 0.045   | 0.0026 |          | 0.00200 |
| 10          | 0.000193 | 0.189  | 0.0332    | 0.047   | 0.243  |          | 0.00202 |
| 20          | 0.000755 | 0.94   | 0.0336    | 0.060   | 0.86   |          | 0.00280 |
| 40          | 0.0181   | 2.91   | 0.0367    | 0.175   | 1.99   |          | 0.0239  |
| 60          | 0.0959   | 4.86   | 0.067     | 0.40    | 3.07   |          | 0.0971  |
| 80          | 0.245    | 6.83   | 0.075     | 0.65    | 4.16   |          | 0.215   |
| 100         | 0.442    | 8.85   | 0.133     | 0.91    | 5.28   | 1.6      | 0.348   |
| 150         | 1.006    | 14.3   | 0.510     | 1.56    | 8.43   | 4.5      | 0.699   |
| 200         | 1.587    | 20.2   | 1.29      | 2.19    | 12.2   | 7.7      | 1.046   |
| 273         | 2.417    | 30.2   | 3.02      | 3.11    | 18.7   | 11.8     | 1.543   |
| 293         | 2.650    | 33.2   | 3.56      | 3.36    | 20.5   | 12.5     | 1.678   |
| 298         | 2.709    | 34.0   | 3.70      | 3.42    | 20.8   | 12.6     | 1.712   |
| 300         | 2.733    | 34.3   | 3.76      | 3.45    | 21.0   | 12.7     | 1.725   |
| 400         | 3.87     | 51.4   | 6.76      | 4.7     |        | 15.8     | 2.402   |
| 500         | 4.99     | 72.4   | 9.9       | 6.0     |        | 20.1     | 3.090   |
| 600         | 6.13     | 98.2   | 13.2      | 7.3     |        | 24.7     | 3.792   |
| 700         | 7.35     | 130    | 16.5      | 8.7     |        | 29.5     | 4.514   |
| 800         | 8.70     | 168    | 20.0      | 10.0    |        | 34.6     | 5.262   |
| 900         | 10.18    | 216    | 23.7      | 11.4    |        | 39.9     | 6.041   |

| <i>T</i> /K | Gold   | Hafnium | Iron   | Lead | Lithium | Magnesium | Manganese |
|-------------|--------|---------|--------|------|---------|-----------|-----------|
| 1           | 0.0220 | 1.00    | 0.0225 |      | 0.007   | 0.0062    | 7.02      |
| 10          | 0.0226 | 1.00    | 0.0238 |      | 0.008   | 0.0069    | 18.9      |
| 20          | 0.035  | 1.11    | 0.0287 |      | 0.012   | 0.0123    | 54        |
| 40          | 0.141  | 2.52    | 0.0758 |      | 0.074   | 0.074     | 116       |
| 60          | 0.308  | 4.53    | 0.271  |      | 0.345   | 0.261     | 131       |
| 80          | 0.481  | 6.75    | 0.693  | 4.9  | 1.00    | 0.557     | 132       |
| 100         | 0.650  | 9.12    | 1.28   | 6.4  | 1.73    | 0.91      | 132       |
| 150         | 1.061  | 15.0    | 3.15   | 9.9  | 3.72    | 1.84      | 136       |
| 200         | 1.462  | 21.0    | 5.20   | 13.6 | 5.71    | 2.75      | 139       |
| 273         | 2.051  | 30.4    | 8.57   | 19.2 | 8.53    | 4.05      | 143       |
| 293         | 2.214  | 33.1    | 9.61   | 20.8 | 9.28    | 4.39      | 144       |
| 298         | 2.255  | 33.7    | 9.87   | 21.1 | 9.47    | 4.48      | 144       |
| 300         | 2.271  | 34.0    | 9.98   | 21.3 | 9.55    | 4.51      | 144       |
| 400         | 3.107  | 48.1    | 16.1   | 29.6 | 13.4    | 6.19      | 147       |
| 500         | 3.97   | 63.1    | 23.7   | 38.3 |         | 7.86      | 149       |
| 600         | 4.87   | 78.5    | 32.9   |      |         | 9.52      | 151       |
| 700         | 5.82   |         | 44.0   |      |         | 11.2      | 152       |
| 800         | 6.81   |         | 57.1   |      |         | 12.8      |           |
| 900         | 7.86   |         |        |      |         | 14.4      |           |



| <i>T</i> /K | Molybdenum | Nickel | Palladium | Platinum | Potassium | Rubidium | Silver  |
|-------------|------------|--------|-----------|----------|-----------|----------|---------|
| 1           | 0.00070    | 0.0032 | 0.0200    | 0.002    | 0.0008    | 0.0131   | 0.00100 |
| 10          | 0.00089    | 0.0057 | 0.0242    | 0.0154   | 0.0160    | 0.109    | 0.00115 |
| 20          | 0.00261    | 0.0140 | 0.0563    | 0.0484   | 0.117     | 0.444    | 0.0042  |
| 40          | 0.0457     | 0.068  | 0.334     | 0.409    | 0.480     | 1.21     | 0.0539  |
| 60          | 0.206      | 0.242  | 0.938     | 1.107    | 0.90      | 1.94     | 0.162   |
| 80          | 0.482      | 0.545  | 1.75      | 1.922    | 1.34      | 2.65     | 0.289   |
| 100         | 0.858      | 0.96   | 2.62      | 2.755    | 1.79      | 3.36     | 0.418   |
| 150         | 1.99       | 2.21   | 4.80      | 4.76     | 2.99      | 5.27     | 0.726   |
| 200         | 3.13       | 3.67   | 6.88      | 6.77     | 4.26      | 7.49     | 1.029   |
| 273         | 4.85       | 6.16   | 9.78      | 9.6      | 6.49      | 11.5     | 1.467   |
| 293         | 5.34       | 6.93   | 10.54     | 10.5     | 7.20      | 12.8     | 1.587   |
| 298         | 5.47       | 7.12   | 10.73     | 10.7     | 7.39      | 13.1     | 1.617   |
| 300         | 5.52       | 7.20   | 10.80     | 10.8     | 7.47      | 13.3     | 1.629   |
| 400         | 8.02       | 11.8   | 14.48     | 14.6     |           |          | 2.241   |
| 500         | 10.6       | 17.7   | 17.94     | 18.3     |           |          | 2.87    |
| 600         | 13.1       | 25.5   | 21.2      | 21.9     |           |          | 3.53    |
| 700         | 15.8       | 32.1   | 24.2      | 25.4     |           |          | 4.21    |
| 800         | 18.4       | 35.5   | 27.1      | 28.7     |           |          | 4.91    |
| 900         | 21.2       | 38.6   | 29.4      | 32.0     |           |          | 5.64    |

| <i>T</i> /K | Sodium | Strontium | Tantalum | Tungsten | Vanadium | Zinc   | Zirconium |
|-------------|--------|-----------|----------|----------|----------|--------|-----------|
| 1           | 0.0009 | 0.80      | 0.10     | 0.000016 |          | 0.0100 | 0.250     |
| 10          | 0.0015 | 0.80      | 0.102    | 0.000137 | 0.0145   | 0.0112 | 0.253     |
| 20          | 0.016  | 0.92      | 0.146    | 0.00196  | 0.039    | 0.0387 | 0.357     |
| 40          | 0.172  | 1.70      | 0.751    | 0.0544   | 0.304    | 0.306  | 1.44      |
| 60          | 0.447  | 2.68      | 1.65     | 0.266    | 1.11     | 0.715  | 3.75      |
| 80          | 0.80   | 3.64      | 2.62     | 0.606    | 2.41     | 1.15   | 6.64      |
| 100         | 1.16   | 4.58      | 3.64     | 1.02     | 4.01     | 1.60   | 9.79      |
| 150         | 2.03   | 6.84      | 6.19     | 2.09     | 8.2      | 2.71   | 17.8      |
| 200         | 2.89   | 9.04      | 8.66     | 3.18     | 12.4     | 3.83   | 26.3      |
| 273         | 4.33   | 12.3      | 12.2     | 4.82     | 18.1     | 5.46   | 38.8      |
| 293         | 4.77   | 13.2      | 13.1     | 5.28     | 19.7     | 5.90   | 42.1      |
| 298         | 4.88   | 13.4      | 13.4     | 5.39     | 20.1     | 6.01   | 42.9      |
| 300         | 4.93   | 13.5      | 13.5     | 5.44     | 20.2     | 6.06   | 43.3      |
| 400         |        | 17.8      | 18.2     | 7.83     | 28.0     | 8.37   | 60.3      |
| 500         |        | 22.2      | 22.9     | 10.3     | 34.8     | 10.82  | 76.5      |
| 600         |        | 26.7      | 27.4     | 13.0     | 41.1     | 13.49  | 91.5      |
| 700         |        | 31.2      | 31.8     | 15.7     | 47.2     |        | 104.2     |
| 800         |        | 35.6      | 35.9     | 18.6     | 53.1     |        | 114.9     |
| 900         |        |           | 40.1     | 21.5     | 58.7     |        | 123.1     |

| Element         | <i>T</i> /K | Electrical resistivity<br>10 <sup>-8</sup> Ω m |
|-----------------|-------------|------------------------------------------------|
| Antimony        | 273         | 39                                             |
| Bismuth         | 273         | 107                                            |
| Cadmium         | 273         | 6.8                                            |
| Cerium (β, hex) | 290–300     | 82.8                                           |
| Cerium (γ, cub) | 298         | 74.4                                           |
| Cobalt          | 273         | 5.6                                            |
| Dysprosium      | 290–300     | 92.6                                           |
| Erbium          | 290–300     | 86.0                                           |
| Europium        | 290–300     | 90.0                                           |
| Gadolinium      | 290–300     | 131                                            |
| Gallium         | 273         | 13.6                                           |
| Holmium         | 290–300     | 81.4                                           |
| Indium          | 273         | 8.0                                            |
| Iridium         | 273         | 4.7                                            |
| Lanthanum       | 290–300     | 61.5                                           |
| Lutetium        | 290–300     | 58.2                                           |
| Mercury         | 298         | 96.1                                           |
| Neodymium       | 290–300     | 64.3                                           |
| Niobium         | 273         | 15.2                                           |

| Element      | <i>T</i> /K | Electrical resistivity<br>10 <sup>-8</sup> Ω m |
|--------------|-------------|------------------------------------------------|
| Osmium       | 273         | 8.1                                            |
| Polonium     | 273         | 40                                             |
| Praseodymium | 290–300     | 70.0                                           |
| Promethium   | 290–300     | 75 est.                                        |
| Protactinium | 273         | 17.7                                           |
| Rhenium      | 273         | 17.2                                           |
| Rhodium      | 273         | 4.3                                            |
| Ruthenium    | 273         | 7.1                                            |
| Samarium     | 290–300     | 94.0                                           |
| Scandium     | 290–300     | 56.2                                           |
| Terbium      | 290–300     | 115                                            |
| Thallium     | 273         | 15                                             |
| Thorium      | 273         | 14.7                                           |
| Thulium      | 290–300     | 67.6                                           |
| Tin          | 273         | 11.5                                           |
| Titanium     | 273         | 39                                             |
| Uranium      | 273         | 28                                             |
| Ytterbium    | 290–300     | 25.0                                           |
| Yttrium      | 290–300     | 59.6                                           |

## ELECTRICAL RESISTIVITY OF SELECTED ALLOYS

These values were obtained by fitting all available measurements to a theoretical formulation describing the temperature and composition dependence of the electrical resistivity of metals. Some of the values listed here fall in regions of temperature and composition where no actual measurements exist. Details of the procedure may be found in the reference.

Values of the resistivity are given in units of  $10^{-8} \Omega \text{ m}$ . General comments in the preceding table for pure metals also apply here

### Reference

C. Y. Ho, et al., *J. Phys. Chem. Ref. Data*, 12, 183–322, 1983.

| Wt % Al         | Aluminum-Copper |       |       |       |       |       |
|-----------------|-----------------|-------|-------|-------|-------|-------|
|                 | 100 K           | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>a</sup> | 0.531           | 2.51  | 2.74  | 2.82  | 3.38  | 3.95  |
| 95 <sup>a</sup> | 0.895           | 2.88  | 3.10  | 3.18  | 3.75  | 4.33  |
| 90 <sup>b</sup> | 1.38            | 3.36  | 3.59  | 3.67  | 4.25  | 4.86  |
| 85 <sup>b</sup> | 1.88            | 3.87  | 4.10  | 4.19  | 4.79  | 5.42  |
| 80 <sup>b</sup> | 2.34            | 4.33  | 4.58  | 4.67  | 5.31  | 5.99  |
| 70 <sup>b</sup> | 3.02            | 5.03  | 5.31  | 5.41  | 6.16  | 6.94  |
| 60 <sup>b</sup> | 3.49            | 5.56  | 5.88  | 5.99  | 6.77  | 7.63  |
| 50 <sup>b</sup> | 4.00            | 6.22  | 6.55  | 6.67  | 7.55  | 8.52  |
| 40 <sup>c</sup> |                 | 7.57  | 7.96  | 8.10  | 9.12  | 10.2  |
| 30 <sup>c</sup> |                 | 11.2  | 11.8  | 12.0  | 13.5  | 15.2  |
| 25 <sup>f</sup> |                 | 16.3  | 17.2  | 17.6  | 19.8  | 22.2  |
| 15 <sup>h</sup> |                 |       | 12.3  |       |       |       |
| 10 <sup>g</sup> | 8.71            | 10.8  | 11.0  | 11.1  | 11.7  | 12.3  |
| 5 <sup>c</sup>  | 7.92            | 9.43  | 9.61  | 9.68  | 10.2  | 10.7  |
| 1 <sup>b</sup>  | 3.22            | 4.46  | 4.60  | 4.65  | 5.00  | 5.37  |

| Wt % Al         | Aluminum-Magnesium |       |       |       |       |       |
|-----------------|--------------------|-------|-------|-------|-------|-------|
|                 | 100 K              | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>c</sup> | 0.958              | 2.96  | 3.18  | 3.26  | 3.82  | 4.39  |
| 95 <sup>c</sup> | 3.01               | 5.05  | 5.28  | 5.36  | 5.93  | 6.51  |
| 90 <sup>c</sup> | 5.42               | 7.52  | 7.76  | 7.85  | 8.43  | 9.02  |
| 10 <sup>b</sup> | 14.0               | 17.1  | 17.4  | 17.6  | 18.4  | 19.2  |
| 5 <sup>b</sup>  | 9.93               | 13.1  | 13.4  | 13.5  | 14.3  | 15.2  |
| 1 <sup>a</sup>  | 2.78               | 5.92  | 6.25  | 6.37  | 7.20  | 8.03  |

| Wt % Cu         | Copper-Gold |       |       |       |       |       |
|-----------------|-------------|-------|-------|-------|-------|-------|
|                 | 100 K       | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>c</sup> | 0.520       | 1.73  | 1.86  | 1.91  | 2.24  | 2.58  |
| 95 <sup>c</sup> | 1.21        | 2.41  | 2.54  | 2.59  | 2.92  | 3.26  |
| 90 <sup>c</sup> | 2.11        | 3.29  | 4.42  | 3.46  | 3.79  | 4.12  |
| 85 <sup>c</sup> | 3.01        | 4.20  | 4.33  | 4.38  | 4.71  | 5.05  |
| 80 <sup>c</sup> | 3.95        | 5.15  | 5.28  | 5.32  | 5.65  | 5.99  |
| 70 <sup>c</sup> | 5.91        | 7.12  | 7.25  | 7.30  | 7.64  | 7.99  |
| 60 <sup>c</sup> | 8.04        | 9.18  | 9.13  | 9.36  | 9.70  | 10.05 |
| 50 <sup>c</sup> | 9.88        | 11.07 | 11.20 | 11.25 | 11.60 | 11.94 |
| 40 <sup>c</sup> | 11.44       | 12.70 | 12.85 | 12.90 | 13.27 | 13.65 |
| 30 <sup>c</sup> | 12.43       | 13.77 | 13.93 | 13.99 | 14.38 | 14.78 |
| 25 <sup>c</sup> | 12.59       | 13.93 | 14.09 | 14.14 | 14.54 | 14.94 |
| 15 <sup>c</sup> | 11.38       | 12.75 | 12.91 | 12.96 | 13.36 | 13.77 |
| 10 <sup>c</sup> | 9.33        | 10.70 | 10.86 | 10.91 | 11.31 | 11.72 |
| 5 <sup>c</sup>  | 5.91        | 7.25  | 7.41  | 7.46  | 7.87  | 8.28  |
| 1 <sup>c</sup>  | 2.00        | 3.40  | 3.57  | 3.62  | 4.03  | 4.45  |

| Wt % Cu         | Copper-Nickel |       |       |       |       |       |
|-----------------|---------------|-------|-------|-------|-------|-------|
|                 | 100 K         | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>c</sup> | 1.45          | 2.71  | 2.85  | 2.91  | 3.27  | 3.62  |
| 95 <sup>c</sup> | 6.19          | 7.60  | 7.71  | 7.82  | 8.22  | 8.62  |
| 90 <sup>c</sup> | 12.08         | 13.69 | 13.89 | 13.96 | 14.40 | 14.81 |
| 85 <sup>c</sup> | 18.01         | 19.63 | 19.83 | 19.90 | 20.32 | 20.70 |
| 80 <sup>c</sup> | 23.89         | 25.46 | 25.66 | 25.72 | 26.12 | 26.44 |
| 70 <sup>i</sup> | 35.73         | 36.67 | 36.72 | 36.76 | 36.85 | 36.89 |
| 60 <sup>i</sup> | 45.76         | 45.43 | 45.38 | 43.35 | 45.20 | 45.01 |
| 50 <sup>i</sup> | 50.22         | 50.19 | 50.05 | 50.01 | 49.73 | 49.50 |
| 40 <sup>c</sup> | 36.77         | 47.42 | 47.73 | 47.82 | 48.28 | 48.49 |
| 30 <sup>i</sup> | 26.73         | 40.19 | 41.79 | 42.34 | 44.51 | 45.40 |
| 25 <sup>c</sup> | 22.22         | 33.46 | 35.11 | 35.69 | 39.67 | 42.81 |
| 15 <sup>c</sup> | 13.49         | 22.00 | 23.35 | 23.85 | 27.60 | 31.38 |
| 10 <sup>c</sup> | 9.28          | 16.65 | 17.82 | 18.26 | 21.51 | 25.19 |
| 5 <sup>c</sup>  | 5.20          | 11.49 | 12.50 | 12.90 | 15.69 | 18.78 |
| 1 <sup>c</sup>  | 1.81          | 7.23  | 8.08  | 8.37  | 10.63 | 13.18 |

| Wt % Cu         | Copper-Palladium |       |       |       |       |       |
|-----------------|------------------|-------|-------|-------|-------|-------|
|                 | 100 K            | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>c</sup> | 0.91             | 2.10  | 2.23  | 2.27  | 2.59  | 2.92  |
| 95 <sup>c</sup> | 2.99             | 4.21  | 4.35  | 4.40  | 4.74  | 5.08  |
| 90 <sup>c</sup> | 5.69             | 6.89  | 7.03  | 7.08  | 7.41  | 7.74  |
| 85 <sup>c</sup> | 8.30             | 9.48  | 9.61  | 9.66  | 10.01 | 10.36 |
| 80 <sup>c</sup> | 10.74            | 11.99 | 12.12 | 12.16 | 12.51 | 12.87 |
| 70 <sup>c</sup> | 15.67            | 16.87 | 17.01 | 17.06 | 17.41 | 17.78 |
| 60 <sup>c</sup> | 20.45            | 21.73 | 21.87 | 21.92 | 22.30 | 22.69 |
| 50 <sup>c</sup> | 26.07            | 27.62 | 27.79 | 27.86 | 28.25 | 28.64 |
| 40 <sup>c</sup> | 33.53            | 35.31 | 35.51 | 35.57 | 36.03 | 36.47 |
| 30 <sup>c</sup> | 45.03            | 46.50 | 46.66 | 46.71 | 47.11 | 47.47 |
| 25 <sup>c</sup> | 44.12            | 46.25 | 46.45 | 46.52 | 46.99 | 47.43 |
| 15 <sup>c</sup> | 31.79            | 36.52 | 36.99 | 37.16 | 38.28 | 39.35 |
| 10 <sup>c</sup> | 23.00            | 28.90 | 29.51 | 29.73 | 31.19 | 32.56 |
| 5 <sup>c</sup>  | 13.09            | 20.00 | 20.75 | 21.02 | 22.84 | 24.54 |
| 1 <sup>c</sup>  | 8.97             | 11.90 | 12.67 | 12.93 | 14.82 | 16.68 |

| Wt % Cu         | Copper-Zinc |       |       |       |       |       |
|-----------------|-------------|-------|-------|-------|-------|-------|
|                 | 100 K       | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>b</sup> | 0.671       | 1.84  | 1.97  | 2.02  | 2.36  | 2.71  |
| 95 <sup>b</sup> | 1.54        | 2.78  | 2.92  | 2.97  | 3.33  | 3.69  |
| 90 <sup>b</sup> | 2.33        | 3.66  | 3.81  | 3.86  | 4.25  | 4.63  |
| 85 <sup>b</sup> | 2.93        | 4.37  | 4.54  | 4.60  | 5.02  | 5.44  |
| 80 <sup>b</sup> | 3.44        | 5.01  | 5.19  | 5.26  | 5.71  | 6.17  |
| 70 <sup>b</sup> | 4.08        | 5.87  | 6.08  | 6.15  | 6.67  | 7.19  |

| Wt % Au         | Gold-Palladium |       |       |       |       |       |
|-----------------|----------------|-------|-------|-------|-------|-------|
|                 | 100 K          | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>c</sup> | 1.31           | 2.69  | 2.86  | 2.91  | 3.32  | 3.73  |
| 95 <sup>c</sup> | 3.88           | 5.21  | 5.35  | 5.41  | 5.79  | 6.17  |
| 90 <sup>i</sup> | 6.70           | 8.01  | 8.17  | 8.22  | 8.56  | 8.93  |
| 85 <sup>b</sup> | 9.14           | 10.50 | 10.66 | 10.72 | 11.10 | 11.48 |
| 80 <sup>b</sup> | 11.23          | 12.75 | 12.93 | 12.99 | 13.45 | 13.93 |
| 70 <sup>c</sup> | 16.44          | 18.23 | 18.46 | 18.54 | 19.10 | 19.67 |
| 60 <sup>b</sup> | 24.64          | 26.70 | 26.94 | 27.02 | 27.63 | 28.23 |
| 50 <sup>a</sup> | 23.09          | 27.23 | 27.63 | 27.76 | 28.64 | 29.42 |
| 40 <sup>a</sup> | 19.40          | 24.65 | 25.23 | 25.42 | 26.74 | 27.95 |
| 30 <sup>b</sup> | 14.94          | 20.82 | 21.49 | 21.72 | 23.35 | 24.92 |
| 25 <sup>b</sup> | 12.72          | 18.86 | 19.53 | 19.77 | 21.51 | 23.19 |
| 15 <sup>a</sup> | 8.54           | 15.08 | 15.77 | 16.01 | 17.80 | 19.61 |
| 10 <sup>a</sup> | 6.54           | 13.25 | 13.95 | 14.20 | 16.00 | 17.81 |
| 5 <sup>a</sup>  | 4.58           | 11.49 | 12.21 | 12.46 | 14.26 | 16.07 |
| 1 <sup>a</sup>  | 3.01           | 10.07 | 10.85 | 11.12 | 12.99 | 14.80 |

| Wt % Au         | Gold-Silver |       |       |       |       |       |
|-----------------|-------------|-------|-------|-------|-------|-------|
|                 | 100 K       | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>b</sup> | 1.20        | 2.58  | 2.75  | 2.80  | 3.22  | 3.63  |
| 95 <sup>a</sup> | 3.16        | 4.58  | 4.74  | 4.79  | 5.19  | 5.59  |
| 90 <sup>i</sup> | 5.16        | 6.57  | 6.73  | 6.78  | 7.19  | 7.58  |
| 85 <sup>j</sup> | 6.75        | 8.14  | 8.30  | 8.36  | 8.75  | 9.15  |
| 80 <sup>j</sup> | 7.96        | 9.34  | 9.50  | 9.55  | 9.94  | 10.33 |
| 70 <sup>j</sup> | 9.36        | 10.70 | 10.86 | 10.91 | 11.29 | 11.68 |
| 60 <sup>j</sup> | 9.61        | 10.92 | 11.07 | 11.12 | 11.50 | 11.87 |
| 50 <sup>j</sup> | 8.96        | 10.23 | 10.37 | 10.42 | 10.78 | 11.14 |
| 40 <sup>j</sup> | 7.69        | 8.92  | 9.06  | 9.11  | 9.46  | 9.81  |
| 30 <sup>a</sup> | 6.15        | 7.34  | 7.47  | 7.52  | 7.85  | 8.19  |
| 25 <sup>a</sup> | 5.29        | 6.46  | 6.59  | 6.63  | 6.96  | 7.30  |
| 15 <sup>a</sup> | 3.42        | 4.55  | 4.67  | 4.72  | 5.03  | 5.34  |
| 10 <sup>a</sup> | 2.44        | 3.54  | 3.66  | 3.71  | 4.00  | 4.31  |
| 5 <sup>i</sup>  | 1.44        | 2.52  | 2.64  | 2.68  | 2.96  | 3.25  |
| 1 <sup>b</sup>  | 0.627       | 1.69  | 1.80  | 1.84  | 2.12  | 2.42  |

| Wt % Fe         | Iron-Nickel |       |       |       |       |
|-----------------|-------------|-------|-------|-------|-------|
|                 | 100 K       | 273 K | 293 K | 300 K | 400 K |
| 99 <sup>a</sup> | 3.32        | 10.9  | 12.0  | 12.4  | 18.7  |
| 95 <sup>c</sup> | 10.0        | 18.7  | 19.9  | 20.2  | 26.8  |
| 90 <sup>c</sup> | 14.5        | 24.2  | 25.5  | 25.9  | 33.2  |
| 85 <sup>c</sup> | 17.5        | 27.8  | 29.2  | 29.7  | 37.3  |
| 80 <sup>c</sup> | 19.3        | 30.1  | 31.6  | 32.2  | 40.0  |
| 70 <sup>b</sup> | 20.9        | 32.3  | 33.9  | 34.4  | 42.4  |
| 60 <sup>c</sup> | 28.6        | 53.8  | 57.1  | 58.2  | 73.9  |
| 50 <sup>d</sup> | 12.3        | 28.4  | 30.6  | 31.4  | 43.7  |
| 40 <sup>d</sup> | 7.73        | 19.6  | 21.6  | 22.5  | 34.0  |
| 30 <sup>c</sup> | 5.97        | 15.3  | 17.1  | 17.7  | 27.4  |
| 25 <sup>b</sup> | 5.62        | 14.3  | 15.9  | 16.4  | 25.1  |
| 15 <sup>c</sup> | 4.97        | 12.6  | 13.8  | 14.2  | 21.1  |
| 10 <sup>c</sup> | 4.20        | 11.4  | 12.5  | 12.9  | 18.9  |
| 5 <sup>c</sup>  | 3.34        | 9.66  | 10.6  | 10.9  | 16.1  |
| 1 <sup>b</sup>  | 1.66        | 7.17  | 7.94  | 8.12  | 12.8  |

| Wt % Ag         | Silver-Palladium |       |       |       |       |       |
|-----------------|------------------|-------|-------|-------|-------|-------|
|                 | 100 K            | 273 K | 293 K | 300 K | 350 K | 400 K |
| 99 <sup>b</sup> | 0.839            | 1.891 | 2.007 | 2.049 | 2.35  | 2.66  |
| 95 <sup>b</sup> | 2.528            | 3.58  | 3.70  | 3.74  | 4.04  | 4.34  |
| 90 <sup>b</sup> | 4.72             | 5.82  | 5.94  | 5.98  | 6.28  | 6.59  |
| 85 <sup>k</sup> | 6.82             | 7.92  | 8.04  | 8.08  | 8.38  | 8.68  |
| 80 <sup>k</sup> | 8.91             | 10.01 | 10.13 | 10.17 | 10.47 | 10.78 |
| 70 <sup>k</sup> | 13.43            | 14.53 | 14.65 | 14.69 | 14.99 | 15.30 |
| 60 <sup>i</sup> | 19.4             | 20.9  | 21.1  | 21.2  | 21.6  | 22.0  |
| 50 <sup>k</sup> | 29.3             | 31.2  | 31.4  | 31.5  | 32.0  | 32.4  |
| 40 <sup>m</sup> | 40.8             | 42.2  | 42.2  | 42.2  | 42.3  | 42.3  |
| 30 <sup>b</sup> | 37.1             | 40.4  | 40.6  | 40.7  | 41.3  | 41.7  |
| 25 <sup>k</sup> | 32.4             | 36.67 | 37.06 | 37.19 | 38.1  | 38.8  |
| 15 <sup>i</sup> | 21.0             | 27.08 | 26.68 | 27.89 | 29.3  | 30.6  |
| 10 <sup>i</sup> | 14.95            | 21.69 | 22.39 | 22.63 | 24.3  | 25.9  |
| 5 <sup>b</sup>  | 8.91             | 15.98 | 16.72 | 16.98 | 18.8  | 20.5  |
| 1 <sup>a</sup>  | 3.97             | 11.06 | 11.82 | 12.08 | 13.92 | 15.70 |

<sup>a</sup> Uncertainty in resistivity is  $\pm 2\%$ .

<sup>b</sup> Uncertainty in resistivity is  $\pm 3\%$ .

<sup>c</sup> Uncertainty in resistivity is  $\pm 5\%$ .

<sup>d</sup> Uncertainty in resistivity is  $\pm 7\%$  below 300 K and  $\pm 5\%$  at 300 and 400 K.

<sup>e</sup> Uncertainty in resistivity is  $\pm 7\%$ .

<sup>f</sup> Uncertainty in resistivity is  $\pm 8\%$ .

<sup>g</sup> Uncertainty in resistivity is  $\pm 10\%$ .

<sup>h</sup> Uncertainty in resistivity is  $\pm 12\%$ .

<sup>i</sup> Uncertainty in resistivity is  $\pm 4\%$ .

<sup>j</sup> Uncertainty in resistivity is  $\pm 1\%$ .

<sup>k</sup> Uncertainty in resistivity is  $\pm 3\%$  up to 300 K and  $\pm 4\%$  above 300 K.

<sup>m</sup> Uncertainty in resistivity is  $\pm 2\%$  up to 300 K and  $\pm 4\%$  above 300 K.

# PERMITTIVITY (DIELECTRIC CONSTANT) OF INORGANIC SOLIDS

H. P. R. Frederikse

This table lists the permittivity  $\epsilon$ , frequently called the dielectric constant, of a number of inorganic solids. When the material is not isotropic, the individual components of the permittivity are given. A superscript S indicates a measurement made under constant strain ("clamped" dielectric constant). If the constraint is removed, the measurement yields  $\epsilon^T$ , the "unclamped" or free dielectric constant.

The temperature of the measurement is given when available; the symbol r.t. indicates a value at nominal room temperature. The

frequency of the measurement is given in the last column (i.r. indicates a measurement in the infrared).

Substances are listed in alphabetical order by chemical formula.

## Reference

Young, K. F. and Frederikse, H. P. R., *J. Phys. Chem. Ref. Data*, 2, 313, 1973.

| Formula                                          | Name                              | $\epsilon_{ijk}$                                 | T/K      | $\nu/\text{Hz}$           |
|--------------------------------------------------|-----------------------------------|--------------------------------------------------|----------|---------------------------|
| $\text{Ag}_3\text{AsS}_3$                        | Silver thioarsenate (Proustite)   | $\epsilon_{11}^T = 16.5, \epsilon_{11}^S = 14.5$ | r.t.     | $2 \times 10^7$           |
|                                                  |                                   | $\epsilon_{33}^T = 20.0, \epsilon_{11}^S = 18.0$ | r.t.     | $2 \times 10^7$           |
| AgBr                                             | Silver bromide                    | 12.50                                            | r.t.     |                           |
| AgCN                                             | Silver cyanide                    | 5.6                                              | r.t.     | $10^6$                    |
| AgCl                                             | Silver chloride                   | 11.15                                            | r.t.     |                           |
| $\text{AgNO}_3$                                  | Silver nitrate                    | 9.0                                              | 293      | $5 \times 10^5$           |
| $\text{AgNa}(\text{NO}_2)_2$                     | Silver sodium nitrite             | $4.5 \pm 0.5$                                    | r.t.     | $9.4 \times 10^9$         |
| $\text{Ag}_2\text{O}$                            | Silver oxide                      | 8.8                                              | r.t.     |                           |
| $(\text{AlF})_2\text{SiO}_4$                     | Aluminum fluosilicate (topaz)     | $\epsilon_{11} = 6.62$                           | 297      | $7 \times 10^3$           |
|                                                  |                                   | $\epsilon_{22} = 6.58$                           | 297      | $7 \times 10^3$           |
|                                                  |                                   | $\epsilon_{33} = 6.95$                           | 297      | $7 \times 10^3$           |
|                                                  |                                   | $\epsilon_{11} = \epsilon_{22} = 9.34$           | 298      | $10^2 - 8 \times 10^9$    |
|                                                  |                                   | $\epsilon_{33} = 11.54$                          | 298      | $10^2 - 8 \times 10^9$    |
| $\text{Al}_2\text{O}_3$                          | Aluminum oxide (alumina)          | $\epsilon_{11}^T = 6.05$                         | r.t.     | $10^3$                    |
|                                                  |                                   | 11.21                                            | 300      | i.r.                      |
|                                                  |                                   | 5.7                                              | r.t.     |                           |
|                                                  |                                   | 7.1                                              | r.t.     | i.r.                      |
|                                                  |                                   | 8.53                                             | 291      | $2 \times 10^5$           |
| $\text{Ba}(\text{COOH})_2$                       | Barium formate                    | $\epsilon_{11} = 7.9$                            | r.t.     | $10^3$                    |
|                                                  |                                   | $\epsilon_{22} = 5.9$                            | r.t.     | $10^3$                    |
|                                                  |                                   | $\epsilon_{33} = 7.5$                            | r.t.     | $10^3$                    |
| $\text{BaCl}_2$                                  | Barium chloride                   | 9.81                                             | r.t.     |                           |
| $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$        | Barium chloride dihydrate         | 9.00                                             | r.t.     | $10^3$                    |
| $\text{BaF}_2$                                   | Barium fluoride                   | 7.32                                             | 292      | $5 \times 10^2 - 10^{11}$ |
| $\text{Ba}(\text{NO}_3)_2$                       | Barium nitrate                    | 4.95                                             | 292      | $2 \times 10^5$           |
| $\text{Ba}_2\text{NaNb}_5\text{O}_{15}$          | Barium sodium niobate ("Bananas") | $\epsilon_{11}^S = 222, \epsilon_{11}^T = 235$   | 296      | $10^4$                    |
|                                                  |                                   | $\epsilon_{22}^S = 227, \epsilon_{22}^T = 247$   | 296      |                           |
|                                                  |                                   | $\epsilon_{33}^S = 32, \epsilon_{33}^T = 51$     | 296      |                           |
| BaO                                              | Barium oxide (baria)              | $34 \pm 1$                                       | 248, 333 | $60 \times 10^7$          |
| $\text{BaO}_2$                                   | Barium peroxide                   | 10.7                                             | r.t.     | $2 \times 10^6$           |
| BaS                                              | Barium sulfide                    | 19.23                                            | r.t.     | $7.25 \times 10^6$        |
| $\text{BaSO}_4$                                  | Barium sulfate                    | 11.4                                             | 288      | $10^8$                    |
| $\text{BaSnO}_3$                                 | Barium stannate                   | 18                                               | 298      | $25 \times 10^5$          |
| $\text{BaTiO}_3$                                 | Barium titanate                   | $\epsilon_{11}^T = 3600$                         | 298      | $10^5$                    |
|                                                  |                                   | $\epsilon_{11}^S = 2300$                         | 298      | $2.5 \times 10^8$         |
|                                                  |                                   | $\epsilon_{33}^T = 150$                          | 298      | $10^5$                    |
|                                                  |                                   | $\epsilon_{33}^S = 80$                           | 298      | $2.5 \times 10^8$         |
| $\text{Ba}_6\text{Ti}_2\text{Nb}_8\text{O}_{30}$ | Barium titanium niobate           | $\epsilon_{11} = \epsilon_{22} \approx 190$      | 298      |                           |
|                                                  |                                   | $\epsilon_{33} \approx 220$                      | 298      |                           |
| $\text{BaWO}_4$                                  | Barium tungstate                  | $\epsilon_{11} = \epsilon_{22} = 35.5 \pm 0.2$   | 297.5    | $1.6 \times 10^3$         |
|                                                  |                                   | $\epsilon_{33} = 37.2 \pm 0.2$                   | 297.5    | $1.6 \times 10^3$         |

| Formula                                                                                 | Name                                | $\epsilon_{ijk}$                                  | T/K   | $\nu/\text{Hz}$           |
|-----------------------------------------------------------------------------------------|-------------------------------------|---------------------------------------------------|-------|---------------------------|
| BaZrO <sub>3</sub>                                                                      | Barium zirconate                    | 43                                                | r.t.  |                           |
| Be <sub>3</sub> Al <sub>2</sub> Si <sub>6</sub> O <sub>18</sub>                         | Beryllium aluminum silicate (Beryl) | $\epsilon_{33} = 5.95$                            | 297   | $7 \times 10^3$           |
|                                                                                         |                                     | $\epsilon_{11} = \epsilon_{22} = 6.86$            | 297   | $7 \times 10^3$           |
| BeCO <sub>3</sub>                                                                       | Beryllium carbonate                 | 9.7                                               | 291   | $2 \times 10^5$           |
| BeO                                                                                     | Beryllium oxide (beryllia)          | $7.35 \pm 0.2$                                    | 293   | $2 \times 10^6$           |
| BiFeO <sub>3</sub>                                                                      | Bismuth iron oxide                  | $40 \pm 3$                                        | 300   | $9.4 \times 10^9$         |
|                                                                                         |                                     | $\epsilon_{11}^S = 38$                            | r.t.  |                           |
| Bi <sub>12</sub> GeO <sub>20</sub>                                                      | Bismuth germanite                   | 16                                                | 293   |                           |
| Bi(GeO <sub>4</sub> ) <sub>3</sub>                                                      | Bismuth germanate                   | 18.2                                              | r.t.  | $2 \times 10^6$           |
| Bi <sub>2</sub> O <sub>3</sub>                                                          | Bismuth sesquioxide                 | 112                                               | r.t.  | $10^3$                    |
| Bi <sub>4</sub> Ti <sub>3</sub> O <sub>12</sub>                                         | Bismuth titanate                    |                                                   |       |                           |
| C                                                                                       | Diamond                             |                                                   |       |                           |
|                                                                                         | Type I                              | $5.87 \pm 0.19$                                   | 300   | $10^3$                    |
|                                                                                         | Type IIa                            | $5.66 \pm 0.04$                                   | 300   | $10^3$                    |
| C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>                                            | Tartaric acid                       | $\epsilon_{11} = \epsilon_{22} = 4.3$             | 298   |                           |
|                                                                                         |                                     | $\epsilon_{33} = 4.5$                             | 298   |                           |
|                                                                                         |                                     | $\epsilon_{13} = 0.55$                            | 298   |                           |
| C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>6</sub>                            | Ethylene diamine tartrate (EDT)     | $\epsilon_{11}^T = 5.0$                           | 293   |                           |
|                                                                                         |                                     | $\epsilon_{22}^T = 8.3$                           | 293   |                           |
|                                                                                         |                                     | $\epsilon_{33}^T = 6.0$                           | 293   |                           |
|                                                                                         |                                     | $\epsilon_{13}^T = 0.7$                           | 293   |                           |
| C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> NaBr                                      | Dextrose sodium bromide             | $\epsilon_{11}^T = 4.0$                           | r.t.  | $10^3$                    |
| (CH <sub>3</sub> NH <sub>3</sub> )Al(SO <sub>4</sub> ) <sub>2</sub> · 2H <sub>2</sub> O | Methyl ammonium alum (MASD)         | 19                                                | 197   |                           |
| Ca <sub>2</sub> B <sub>6</sub> O <sub>11</sub> · 5H <sub>2</sub> O                      | Colemanite                          | $\epsilon_{11} = 20$                              | 293   | $10^3$                    |
|                                                                                         |                                     | $\epsilon_{33} = 25$                              | 293   | $10^3$                    |
| CaCO <sub>3</sub>                                                                       | Calcium carbonate                   | $\epsilon_{11} = 8.67$                            | r.t.  | $9.4 \times 10^{10}$      |
|                                                                                         |                                     | $\epsilon_{22} = 8.69$                            | r.t.  | $9.4 \times 10^{10}$      |
|                                                                                         |                                     | $\epsilon_{33} = 8.31$                            | r.t.  | $9.4 \times 10^{10}$      |
| CaCeO <sub>3</sub>                                                                      | Calcium cerate                      | 21                                                | r.t.  |                           |
| CaF <sub>2</sub>                                                                        | Calcium fluoride                    | 6.81                                              | 300   | $5 \times 10^2 - 10^{11}$ |
| CaMoO <sub>4</sub>                                                                      | Calcium molybdate                   | $\epsilon_{11} = \epsilon_{22} = 24.0 \pm 0.2$    | 297.5 | <10                       |
|                                                                                         |                                     | $\epsilon_{33} = 20.0 \pm 0.2$                    | 297.5 | <10                       |
| Ca(NO <sub>3</sub> ) <sub>2</sub>                                                       | Calcium nitrate                     | 6.54                                              | 292   | $2 \times 10^5$           |
| CaNb <sub>2</sub> O <sub>6</sub>                                                        | Calcium niobate                     | $\epsilon_{11} = 22.8 \pm 1.9$                    | r.t.  | $(5-500) \times 10^3$     |
| Ca <sub>2</sub> Nb <sub>2</sub> O <sub>7</sub>                                          | Calcium pyroniobate                 | ~45                                               | r.t.  | $5 \times 10^7$           |
| CaO                                                                                     | Calcium oxide                       | $11.8 \pm 0.3$                                    | 283   | $2 \times 10^6$           |
| CaS                                                                                     | Calcium sulfide                     | 6.699                                             | r.t.  | $7.25 \times 10^6$        |
| CaSO <sub>4</sub> · 2H <sub>2</sub> O                                                   | Calcium sulfate dihydrate           | $\epsilon_{11} = 5.10$                            | r.t.  |                           |
|                                                                                         |                                     | $\epsilon_{22} = 5.24$                            | r.t.  |                           |
|                                                                                         |                                     | $\epsilon_{33} = 10.30$                           | r.t.  |                           |
| CaTiO <sub>3</sub>                                                                      | Calcium titanate                    | 165                                               | r.t.  |                           |
| CaWO <sub>4</sub>                                                                       | Calcium tungstate                   | $\epsilon_{11} = \epsilon_{22} = 11.7 \pm 0.1$    | 297.5 | $1.59 \times 10^3$        |
|                                                                                         |                                     | $\epsilon_{33} = 9.5 \pm 0.2$                     | 297.5 | $1.59 \times 10^3$        |
| Cd <sub>3</sub> As <sub>2</sub>                                                         | Cadmium arsenide                    | $\epsilon_{33} = 18.5$                            | 4     |                           |
| CdBr <sub>2</sub>                                                                       | Cadmium bromide                     | 8.6                                               | 293   | $5 \times 10^5$           |
| CdF <sub>2</sub>                                                                        | Cadmium fluoride                    | $8.33 \pm 0.08$                                   | 300   | $10^5 - 10^7$             |
| CdS                                                                                     | Cadmium sulfide                     | $\epsilon_{11} = \epsilon_{22} = 8.7$             | 300   | i.r.                      |
|                                                                                         |                                     | $\epsilon_{33} = 9.25$                            | 300   | i.r.                      |
|                                                                                         |                                     | $\epsilon_{11} = \epsilon_{22} = 8.37$            | 8     | i.r.                      |
|                                                                                         |                                     | $\epsilon_{33} = 9.00$                            | 8     | i.r.                      |
|                                                                                         |                                     | $\epsilon_{11}^T = 8.48$                          | 77    | $10^4$                    |
|                                                                                         |                                     | $\epsilon_{33}^T = 9.48$                          | 77    | $10^4$                    |
|                                                                                         |                                     | $\epsilon_{11}^S = 9.02, \epsilon_{11}^T = 9.35$  | 298   | $10^4$                    |
|                                                                                         |                                     | $\epsilon_{33}^S = 9.53, \epsilon_{33}^T = 10.33$ | 298   | $10^4$                    |
| CdSe                                                                                    | Cadmium selenide                    | $\epsilon_{11}^S = 9.53, \epsilon_{11}^T = 9.70$  | 298   | $10^4$                    |

| Formula                                                 | Name                              | $\epsilon_{ijk}$                                  | T/K           | $\nu/\text{Hz}$        |
|---------------------------------------------------------|-----------------------------------|---------------------------------------------------|---------------|------------------------|
|                                                         |                                   | $\epsilon_{33}^S = 10.2, \epsilon_{33}^T = 10.65$ | 298           | $10^4$                 |
| CdTe                                                    | Cadmium telluride                 | $\epsilon_{11} = \epsilon_{22} = 10.60 \pm 0.15$  | 297           | i.r.                   |
|                                                         |                                   | $\epsilon_{33} = 7.05 \pm 0.05$                   | 297           | i.r.                   |
| $\text{Cd}_2\text{Nb}_2\text{O}_7$                      | Cadmium pyroniobate               | 500–580                                           | 293           | $10^3$                 |
| $\text{CeO}_2$                                          | Cerium oxide                      | 7.0                                               | r.t.          | $2 \times 10^6$        |
| $\text{CoNb}_2\text{O}_6$                               | Cobalt niobate                    | $\epsilon_{11} = 18.4 \pm 1.1$                    | r.t.          | $(5-500) \times 10^3$  |
|                                                         |                                   | $\epsilon_{22} = 21.4 \pm 1.1$                    | r.t.          | $(5-500) \times 10^3$  |
|                                                         |                                   | $\epsilon_{33} = 33.0 \pm 0.7$                    | r.t.          | $(5-500) \times 10^3$  |
| CoO                                                     | Cobalt oxide                      | 12.9                                              | 298           | $10^2 - 10^{10}$       |
| $\text{Cr}_2\text{O}_3$                                 | Chromic sesquioxide               | $\epsilon_{11} = \epsilon_{22} = 13.3$            | 298.5         | $10^3$                 |
|                                                         |                                   | $\epsilon_{33} = 11.9$                            | 298.5         | $10^3$                 |
|                                                         |                                   | 8                                                 | 315 ( $T_N$ ) | $6 \times 10^{10}$     |
| $\text{CsAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ | Cesium alum                       | 5.0                                               | r.t.          | $20-20 \times 10^3$    |
| CsBr                                                    | Cesium bromide                    | 6.38                                              | 298           | $1.6 \times 10^3$      |
| $\text{Cs}_2\text{CO}_3$                                | Cesium carbonate                  | 6.53                                              | 291           | $2 \times 10^5$        |
| CsCl                                                    | Cesium chloride                   | 7.2                                               | 298           |                        |
| $\text{CsH}_2\text{AsO}_4$                              | Cesium dihydrogen arsenate (CDA)  | 4.8                                               | 273           | $9.5 \times 10^9$      |
| $\text{CsH}_2\text{PO}_4$                               | Cesium dihydrogen phosphate (CDP) | 6.15                                              | 285           | $9.5 \times 10^9$      |
| $\text{CsH}_3(\text{SeO}_3)_2$                          | Cesium trihydrogen selenite       | $\epsilon_{11} = 80$                              | 273           | $10^5$                 |
|                                                         |                                   | $\epsilon_{22} = 63$                              | 273           | $10^5$                 |
|                                                         |                                   | $\epsilon_{33} = 12$                              | 273           | $10^5$                 |
| CsI                                                     | Cesium iodide                     | 6.31                                              | 298           | $1.6 \times 10^3$      |
| $\text{CsNO}_3$                                         | Cesium nitrate                    | $\epsilon_{11} = \epsilon_{22} = 9.4$             | r.t.          | $5 \times 10^5$        |
|                                                         |                                   | $\epsilon_{33} = 8.3$                             | r.t.          | $5 \times 10^5$        |
| $\text{CsPbCl}_3$                                       | Cesium lead chloride              | 14.37                                             | 300           | $10^5-10^6$            |
| CuBr                                                    | Cuprous bromide                   | 8.0                                               | 293           | $5 \times 10^5$        |
| CuCl                                                    | Cuprous chloride                  | $9.8 \pm 0.5$                                     | r.t.          | $10^3$                 |
| CuO                                                     | Cupric oxide                      | 18.1                                              | r.t.          | $2 \times 10^6$        |
| $\text{Cu}_2\text{O}$                                   | Cuprous oxide (Cuprite)           | $7.60 \pm 0.06$                                   | r.t.          | $10^5$                 |
| $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$               | Cupric sulfate pentahydrate       | 6.60                                              | r.t.          |                        |
| $\text{EuF}_2$                                          | Europium fluoride                 | $7.7 \pm 0.2$                                     | 298           | $(1-300) \times 10^3$  |
| $\text{Eu}_2(\text{MoO}_4)_3$                           | Europium molybdate                | 9.5                                               | 298           |                        |
| EuS                                                     | Europium sulfide                  | $13.10 \pm 0.04$                                  | 80            | $5 \times 10^2-10^5$   |
| FeO                                                     | Ferrous oxide                     | 14.2                                              | r.t.          | $2 \times 10^6$        |
| $\text{Fe}_2\text{O}_3$                                 | Ferric sesquioxide                | 4.5                                               | r.t.          | $10^5-10^7$            |
| $\text{Fe}_2\text{O}_3\text{-}\alpha$                   | Ferric sesquioxide (hematite)     | 12                                                |               | $6 \times 10^{10}$     |
| $\text{Fe}_3\text{O}_4$                                 | Ferrosoferric oxide (magnetite)   | 20                                                | r.t.          | $10^5-10^7$            |
| GaAs                                                    | Gallium arsenide                  | 13.13                                             | 300           |                        |
|                                                         |                                   | 12.90                                             | 4             | i.r.                   |
| GaP                                                     | Gallium phosphide                 | 11.1                                              | r.t.          |                        |
|                                                         |                                   | $10.75 \pm 0.1$                                   | 1.6           | i.r.                   |
| GaSb                                                    | Gallium antimonide                | 15.69                                             | r.t.          |                        |
|                                                         |                                   | 15.7                                              | 4             | i.r.                   |
| $\text{Gd}_2(\text{MoO}_4)_3$                           | Gadolinium molybdate              | $\epsilon^T = 10$                                 | 298           |                        |
|                                                         |                                   | $\epsilon^S = 9.5$                                | 298           | $10^3$                 |
| Ge                                                      | Germanium                         | $16.0 \pm 0.3$                                    | 4             | $9.2 \times 10^9$      |
|                                                         |                                   | $15.8 \pm 0.2$                                    | r.t.          | $500-3 \times 10^{10}$ |
| $\text{GeO}_2$                                          | Germanium dioxide                 | $\epsilon_{11} = \epsilon_{22} = 7.44$            | r.t.          | i.r.                   |
| $\text{HIO}_3$                                          | Iodic acid                        | $\epsilon_{11} = 7.5$                             | r.t.          | $10^3$                 |
|                                                         |                                   | $\epsilon_{22} = 12.4$                            | r.t.          | $10^3$                 |
|                                                         |                                   | $\epsilon_{33} = 8.1$                             | r.t.          | $10^3$                 |
| $\text{HNH}_4(\text{ClCH}_2\text{COO})_2$               | Hydrogen ammonium dichloroacetate | $\epsilon_{[102]} = 5.9$                          | r.t.          | $10^5$                 |
| $\text{H}_2\text{O}$                                    | Ice I (P = 0 kbar)                | 99                                                | 243           |                        |
|                                                         | Ice III (P = 3 kbar)              | 117                                               | 243           |                        |
|                                                         | Ice V (P = 5 kbar)                | 114                                               | 243           |                        |
|                                                         | Ice VI (P = 8 kbar)               | 193                                               | 243           |                        |
| HgCl                                                    | Mercurous chloride (Calumel)      | $\epsilon_{11} = \epsilon_{22} = 14.0$            | r.t.          | $10^{12}$              |
| $\text{HgCl}_2$                                         | Mercuric chloride                 | 6.5                                               | r.t.          | $10^{12}$              |
| HgS                                                     | Mercurous sulfide (Cinnabar)      | $\epsilon_{11} = \epsilon_{22} = 18.0$            | r.t.          | i.r.                   |
|                                                         |                                   | $\epsilon_{33} = 32.5$                            | r.t.          | i.r.                   |

| Formula                                                                            | Name                                    | $\epsilon_{ijk}$                             | T/K     | $\nu/\text{Hz}$              |
|------------------------------------------------------------------------------------|-----------------------------------------|----------------------------------------------|---------|------------------------------|
| HgSe                                                                               | Mercurous selenide                      | 25.6                                         | r.t.    | $10^4\text{--}10^6$          |
| I <sub>2</sub>                                                                     | Iodine                                  | $\epsilon_{11} = 6$                          | r.t.    | $5 \times 10^4\text{--}10^7$ |
|                                                                                    |                                         | $\epsilon_{22} = 3$                          | r.t.    | $5 \times 10^4\text{--}10^7$ |
|                                                                                    |                                         | $\epsilon_{33} = 40$                         | r.t.    | $5 \times 10^4\text{--}10^7$ |
| InAs                                                                               | Indium arsenide                         | $14.55 \pm 0.3$                              | r.t.    | i.r.                         |
|                                                                                    |                                         | 15.15                                        | 4       | i.r.                         |
| InP                                                                                | Indium phosphide                        | 12.61                                        | r.t.    | i.r.                         |
| InSb                                                                               | Indium antimonide                       | 17.88                                        | 4       | i.r.                         |
| KAl(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O                            | Potassium alum                          | 6.5                                          | r.t.    | $20\text{--}20 \times 10^3$  |
| KBr                                                                                | Potassium bromide                       | 4.88                                         | 300     |                              |
|                                                                                    |                                         | 4.53                                         | 4.2     |                              |
| KBrO <sub>3</sub>                                                                  | Potassium bromate                       | 7.3                                          | r.t.    | $2 \times 10^6$              |
| KCN                                                                                | Potassium cyanide                       | 6.15                                         | r.t.    | $2 \times 10^6$              |
| K <sub>2</sub> CO <sub>3</sub>                                                     | Potassium carbonate                     | 4.96                                         | 291     | $2 \times 10^5$              |
| K <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> · 1/2 H <sub>2</sub> O | Dipotassium tartrate (DKT)              | $\epsilon_{11} = 6.44$                       | r.t.    |                              |
|                                                                                    |                                         | $\epsilon_{22} = 5.80$                       | r.t.    |                              |
|                                                                                    |                                         | $\epsilon_{33} = 6.49$                       | r.t.    |                              |
|                                                                                    |                                         | $\epsilon_{13} = 0.005$                      | r.t.    |                              |
| KCl                                                                                | Potassium chloride                      | $4.86 \pm 0.02$                              | r.t.    | $5 \times 10^3$              |
|                                                                                    |                                         | 4.50                                         | 4.2     |                              |
| KClO <sub>3</sub>                                                                  | Potassium chlorate                      | 5.1                                          | r.t.    | $2 \times 10^6$              |
| KClO <sub>4</sub>                                                                  | Potassium perchlorate                   | 5.9                                          | r.t.    | $2 \times 10^6$              |
| K <sub>2</sub> CrO <sub>4</sub>                                                    | Potassium chromate                      | 7.3                                          | r.t.    | $6 \times 10^7$              |
| KCr(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O                            | Potassium chrome alum                   | 6.5                                          | 100–240 | $175 \times 10^3$            |
| KD <sub>2</sub> AsO <sub>4</sub>                                                   | Potassium dideuterium arsenate (KDDA)   | $\epsilon_{11} = 70$                         | 298     |                              |
|                                                                                    |                                         | $\epsilon_{33} = 31$                         | 298     |                              |
| KD <sub>2</sub> PO <sub>4</sub>                                                    | Potassium dideuterium phosphate (KDDP)  | $50 \pm 2$                                   | 297     | $10^3$                       |
| KF                                                                                 | Potassium fluoride                      | 6.05                                         |         | $2 \times 10^6$              |
| KH <sub>2</sub> AsO <sub>4</sub>                                                   | Potassium dihydrogen arsenate (KDA)     | $\epsilon_{11} = 60$                         | 298     |                              |
|                                                                                    |                                         | $\epsilon_{33} = 24$                         | 298     |                              |
| KH <sub>2</sub> PO <sub>4</sub>                                                    | Potassium dihydrogen phosphate (KDP)    | 46                                           | 298     | $10^3$                       |
|                                                                                    |                                         | $\epsilon_{11} = 42$                         | r.t.    |                              |
|                                                                                    |                                         | $\epsilon_{33} = 21$                         | r.t.    |                              |
| K <sub>2</sub> HPO <sub>4</sub>                                                    | Dipotassium monohydrogen orthophosphate | 9.05                                         | r.t.    | $2 \times 10^6$              |
| KI                                                                                 | Potassium iodide                        | 5.00                                         | r.t.    | $9.4 \times 10^{10}$         |
| KIO <sub>3</sub>                                                                   | Potassium iodate                        | 170                                          | 255     | $10^5$                       |
|                                                                                    |                                         | 10                                           | 293     | $10^5$                       |
|                                                                                    |                                         | $\epsilon_{[101]} \approx 40,70$             | r.t.    | $10^5$                       |
|                                                                                    |                                         | 16.85                                        | r.t.    | $2 \times 10^6$              |
| (K,H)Al <sub>3</sub> (SiO <sub>3</sub> ) <sub>3</sub>                              | Mica (muscovite)                        | 5.4                                          | 299     | $10^2\text{--}3 \times 10^9$ |
| (K,H)Mg <sub>3</sub> Al(SiO <sub>3</sub> ) <sub>3</sub>                            | Mica (Canadian)                         | $\epsilon_{11} = \epsilon_{32} = 6.9$        | 298     | $10^2\text{--}10^4$          |
|                                                                                    |                                         | $\epsilon_{33} = 7.3$                        | 298     | $10^4$                       |
| KNO <sub>2</sub>                                                                   | Potassium nitrite                       | 25                                           | 305     |                              |
| KNO <sub>3</sub>                                                                   | Potassium nitrate                       | 4.37                                         | 293     | $2 \times 10^5$              |
| KNbO <sub>3</sub>                                                                  | Potassium niobate                       | 700                                          | r.t.    |                              |
| K <sub>3</sub> PO <sub>4</sub>                                                     | Potassium orthophosphate                | 7.75                                         | r.t.    | $2 \times 10^6$              |
| KSCN                                                                               | Potassium thiocyanate                   | 7.9                                          | r.t.    | $2 \times 10^6$              |
| K <sub>2</sub> SO <sub>4</sub>                                                     | Potassium sulfate                       | 6.4                                          | r.t.    | $2 \times 10^6$              |
| K <sub>2</sub> S <sub>3</sub> O <sub>6</sub>                                       | Potassium trithionate                   | 5.7                                          | 293     | $1.8 \times 10^6$            |
| K <sub>2</sub> S <sub>4</sub> O <sub>6</sub>                                       | Potassium tetrathionate                 | 5.5                                          | 293     | $1.8 \times 10^6$            |
| K <sub>2</sub> S <sub>5</sub> O <sub>6</sub> · H <sub>2</sub> O                    | Potassium pentathionate                 | 7.8                                          | 293     | $1.8 \times 10^6$            |
| K <sub>2</sub> S <sub>6</sub> O <sub>6</sub>                                       | Potassium hexathionate                  | 7.8                                          | 293     | $1.8 \times 10^6$            |
| K <sub>2</sub> SeO <sub>4</sub>                                                    | Potassium selenate                      | $\epsilon_{11} = 5.9$                        | r.t.    | $10^3$                       |
|                                                                                    |                                         | $\epsilon_{22} = 7.7$                        | r.t.    | $10^3$                       |
| KSr <sub>2</sub> Nb <sub>3</sub> O <sub>15</sub>                                   | Potassium strontium niobate             | $\epsilon_{11} = \epsilon_{11} \approx 1200$ | 298     |                              |
|                                                                                    |                                         | $\epsilon_{33} \approx 800$                  | 298     |                              |
| KTaNbO <sub>3</sub>                                                                | Potassium tantalate niobate (KTN)       | 34,000                                       | 273     | $10^4$                       |
|                                                                                    |                                         | 6,000                                        | 293     | $10^4$                       |
| KTaO <sub>3</sub>                                                                  | Potassium tantalate                     | 242                                          | 298     | $2 \times 10^5$              |
| LaScO <sub>3</sub>                                                                 | Lanthanum scandate                      | 30                                           | r.t.    |                              |



| Formula                                                            | Name                                     | $\epsilon_{ijk}$                               | T/K   | $\nu/\text{Hz}$               |
|--------------------------------------------------------------------|------------------------------------------|------------------------------------------------|-------|-------------------------------|
| LiBr                                                               | Lithium bromide                          | 12.1                                           | r.t.  | $2 \times 10^6$               |
| Li <sub>2</sub> CO <sub>3</sub>                                    | Lithium carbonate                        | 4.9                                            | 291   | $2 \times 10^5$               |
| LiCl                                                               | Lithium chloride                         | 11.05                                          | r.t.  | $2 \times 10^6$               |
| LiD                                                                | Lithium deuteride                        | $14.0 \pm 0.5$                                 | r.t.  | i.r.                          |
| LiF                                                                | Lithium fluoride                         | 9.00                                           | 298   | $10^2\text{--}10^7$           |
|                                                                    |                                          | 9.11                                           | 353   | $10^2\text{--}10^7$           |
| LiGaO <sub>2</sub>                                                 | Lithium metagallate                      | $\epsilon_{11}^T = 7.0, \epsilon_{22}^T = 6.0$ | r.t.  |                               |
|                                                                    |                                          | $\epsilon_{33}^T = 9.5$                        | r.t.  |                               |
|                                                                    |                                          | $\epsilon_{11}^S = 6.8, \epsilon_{22}^S = 5.8$ | r.t.  |                               |
| Li <sup>6</sup> H                                                  | Lithium-6 hydride                        | $13.2 \pm 0.5$                                 | r.t.  |                               |
| Li <sup>7</sup> H                                                  | Lithium-7 hydride                        | $12.9 \pm 0.5$                                 | r.t.  |                               |
| LiH <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub>                  | Lithium trihydrogen selenite             | 29                                             | 298   | $10^4$                        |
|                                                                    |                                          | $\epsilon_{11} = 13.0$                         | r.t.  |                               |
|                                                                    |                                          | $\epsilon_{22} = 12.9$                         | r.t.  |                               |
|                                                                    |                                          | $\epsilon_{33} = 46$                           | r.t.  |                               |
| LiI                                                                | Lithium iodide                           | 11.03                                          | r.t.  | $2 \times 10^6$               |
| LiIO <sub>3</sub>                                                  | Lithium iodate                           | $\epsilon_{11} = \epsilon_{22} = 65$           | 294.5 | $10^3$                        |
|                                                                    |                                          | $\epsilon_{33} = 554$                          | 298   |                               |
| LiNH <sub>4</sub> C <sub>4</sub> O <sub>6</sub> · H <sub>2</sub> O | Lithium ammonium tartrate (LAT)          | $\epsilon_{11}^T = 7.2$                        | 298   |                               |
|                                                                    |                                          | $\epsilon_{22}^T = 8.0$                        | 298   |                               |
|                                                                    |                                          | $\epsilon_{33}^T = 6.9$                        | 298   |                               |
| LiNa <sub>3</sub> CrO <sub>4</sub> · 6H <sub>2</sub> O             | Lithium trisodium chromate               | 8.0                                            | r.t.  | $10^3$                        |
| LiNa <sub>3</sub> MoO <sub>4</sub> · 6H <sub>2</sub> O             | Lithium trisodium molybdate              | $\epsilon_{11} = 6.7$                          | r.t.  | $10^3$                        |
|                                                                    |                                          | $\epsilon_{33} = 5.3$                          | r.t.  | $10^3$                        |
| LiNbO <sub>3</sub>                                                 | Lithium niobate                          | $\epsilon_{11} = \epsilon_{22} = 82$           | 298   | $10^5$                        |
|                                                                    |                                          | $\epsilon_{33} = 30$                           | 298   | $10^5$                        |
| Li <sub>2</sub> SO <sub>4</sub> · H <sub>2</sub> O                 | Lithium sulfate monohydrate              | $\epsilon_{11} = 5.6$                          | 298   |                               |
|                                                                    |                                          | $\epsilon_{22} = 10.3$                         | 298   |                               |
|                                                                    |                                          | $\epsilon_{33} = 6.5$                          | 298   |                               |
|                                                                    |                                          | $\epsilon_{13} = 0.07$                         | 298   |                               |
| LiTaO <sub>3</sub>                                                 | Lithium tantalate                        | $\epsilon_{11} = \epsilon_{22} = 53$           | r.t.  | $10^5$                        |
|                                                                    |                                          | $\epsilon_{33} = 46$                           | r.t.  | $10^5$                        |
|                                                                    |                                          | $\epsilon_{11}^S = \epsilon_{22}^S = 41$       | r.t.  |                               |
|                                                                    |                                          | $\epsilon_{33}^S = 43$                         | r.t.  |                               |
|                                                                    |                                          | $\epsilon_{11}^T = \epsilon_{22}^T = 51$       | r.t.  |                               |
|                                                                    |                                          | $\epsilon_{33}^T = 45$                         | r.t.  |                               |
| LiTiC <sub>4</sub> O <sub>6</sub> · H <sub>2</sub> O               | Lithium thallium tartrate (LTT)          | $\epsilon_{11} \approx 20$                     | 80    |                               |
| Mg <sub>3</sub> B <sub>7</sub> O <sub>13</sub> Cl                  | Magnesium borate monochloride (boracite) | $\epsilon_{11} = 14.1$                         | r.t.  | $5 \times 10^5$               |
| MgCO <sub>3</sub>                                                  | Magnesium carbonate                      | 8.1                                            | 291   | $2 \times 10^5$               |
| MgNb <sub>2</sub> O <sub>6</sub>                                   | Magnesium niobate                        | $\epsilon_{11} = 16.4 \pm 0.5$                 | r.t.  | $(5\text{--}500) \times 10^3$ |
|                                                                    |                                          | $\epsilon_{22} = 20.9 \pm 0.5$                 | r.t.  | $(5\text{--}500) \times 10^3$ |
|                                                                    |                                          | $\epsilon_{33} = 32.4 \pm 0.5$                 | r.t.  | $(5\text{--}500) \times 10^3$ |
| MgO                                                                | Magnesium oxide (Periclase)              | 9.65                                           | 298   | $10^2\text{--}10^8$           |
| (MgO) <sub>x</sub> Al <sub>2</sub> O <sub>3</sub>                  | Spinel                                   | 8.6                                            | r.t.  |                               |
| MgSO <sub>4</sub>                                                  | Magnesium sulfate                        | 8.2                                            | r.t.  |                               |
| MgSO <sub>4</sub> · 7H <sub>2</sub> O                              | Magnesium sulfate septahydrate           | 5.46                                           | r.t.  |                               |
| MgTiO <sub>3</sub>                                                 | Magnesium titanate                       | 13.5                                           | r.t.  |                               |
| MgWO <sub>4</sub>                                                  | Magnesium tungstate                      | $\epsilon_{11} = 18.0 \pm 1$                   | r.t.  | $(5\text{--}500) \times 10^3$ |
|                                                                    |                                          | $\epsilon_{22} = 18.0 \pm 1$                   | r.t.  | $(5\text{--}500) \times 10^3$ |
| MnNb <sub>2</sub> O <sub>6</sub>                                   | Manganese niobate                        | $\epsilon_{11} = 17.4 \pm 2$                   | r.t.  | $(5\text{--}500) \times 10^3$ |
|                                                                    |                                          | $\epsilon_{22} = 16.1 \pm 0.5$                 | r.t.  | $(5\text{--}500) \times 10^3$ |
|                                                                    |                                          | $\epsilon_{33} = 30.7 \pm 1$                   | r.t.  | $(5\text{--}500) \times 10^3$ |
| MnO                                                                | Manganese oxide (Pyrolusite)             | 12.8                                           | r.t.  | $6 \times 10^{10}$            |
| MnO <sub>2</sub>                                                   | Manganese dioxide                        | $\sim 10^4$                                    | 298   | $10^4$                        |
| Mn <sub>2</sub> O <sub>3</sub>                                     | Manganese sesquioxide                    | 8                                              | r.t.  | $6 \times 10^{10}$            |
| MnWO <sub>4</sub>                                                  | Manganese tungstate                      | $\epsilon_{11} = 19.3 \pm 1.3$                 | r.t.  | $(5\text{--}500) \times 10^3$ |

| Formula                                                                        | Name                                        | $\epsilon_{ijk}$                                         | T/K     | $\nu/\text{Hz}$        |
|--------------------------------------------------------------------------------|---------------------------------------------|----------------------------------------------------------|---------|------------------------|
| $\text{N}(\text{CH}_3)_4\text{HgBr}_3$                                         | Tetramethylammonium tribromomercurate (TTM) | $\epsilon_{22} = 14.3 \pm 0.5$                           | r.t.    | $(5-500) \times 10^3$  |
|                                                                                |                                             | $\epsilon_{33} = 16.5 \pm 1.1$                           | r.t.    | $(5-500) \times 10^3$  |
|                                                                                |                                             | $\sim 10$                                                | 233–373 |                        |
| $\text{N}(\text{CH}_3)_4\text{HgI}_3$                                          | Tetramethylammonium triiodo mercurate (TTM) | $\sim 10$                                                | 233–373 |                        |
| $\text{N}_4(\text{CH}_2)_6$                                                    | Hexamethylene tetramine (HMTA)              | $2.6 \pm 0.2$                                            | r.t.    | $10^9-10^{10}$         |
| $(\text{ND}_4)_2\text{BeF}_4$                                                  | Deuteroammonium fluoberyllate               | $\epsilon_{11} = 10$                                     | r.t.    |                        |
|                                                                                |                                             | $\epsilon_{22} = 9$                                      | r.t.    |                        |
|                                                                                |                                             | $\epsilon_{33} = 9$                                      | r.t.    |                        |
| $(\text{ND}_4)_2\text{SO}_4$                                                   | Deuteroammonium sulfate                     | $\epsilon_{11} = 9$                                      | r.t.    |                        |
|                                                                                |                                             | $\epsilon_{22} = 10$                                     | r.t.    |                        |
|                                                                                |                                             | $\epsilon_{33} = 9$                                      | r.t.    |                        |
| $(\text{NH}_2 \cdot \text{CH}_2\text{COOH})_3 \cdot \text{H}_2\text{SO}_4$     | Triglycine sulfate (TGS)                    | $\epsilon_{11} = 9$                                      | 273     | $10^4$                 |
|                                                                                |                                             | $\epsilon_{22} = 30$                                     | 273     | $10^4$                 |
|                                                                                |                                             | $\epsilon_{33} = 6.5$                                    | 273     | $10^4$                 |
| $(\text{NH}_2 \cdot \text{CH}_2\text{COOH})_3 \cdot \text{H}_2\text{SeO}_4$    | Triglycine selenate (TGSe)                  | 200                                                      | 293     | $1.6 \times 10^3$      |
| $(\text{NH}_2 \cdot \text{CH}_2\text{COOH})_3 \cdot \text{H}_2\text{BeF}_4$    | Triglycine fluorberyllate (TGFB)            | $\epsilon_{22} = 12$                                     | 273     | $10^4$                 |
| $\text{NH}_4\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$               | Ammonium alum                               | 6                                                        | r.t.    | $10^{12}$              |
| $(\text{NH}_4)_2\text{BeF}_4$                                                  | Ammonium fluorberyllate                     | $\epsilon_{11} = \epsilon_{22} = 7.8$                    | 123     | $10^5$                 |
|                                                                                |                                             | $\epsilon_{33} = 7.1$                                    | 123     | $10^5$                 |
|                                                                                |                                             | $\epsilon_{11} = \epsilon_{22} = 8.8$                    | 293     | $10^5$                 |
|                                                                                |                                             | $\epsilon_{33} = 9.2$                                    | 293     | $10^5$                 |
| $\text{NH}_4\text{Br}$                                                         | Ammonium bromide                            | 7.1                                                      | r.t.    | $7 \times 10^5$        |
| $\text{NH}_4\text{I}$                                                          | Ammonium iodide                             | 9.8                                                      | r.t.    |                        |
| $(\text{NH}_4)_2\text{C}_2\text{H}_6\text{O}_6$                                | Ammonium tartrate                           | $\epsilon_{11} = 6.45$                                   | r.t.    | $10^3$                 |
|                                                                                |                                             | $\epsilon_{22} = 6.8$                                    | r.t.    | $10^3$                 |
|                                                                                |                                             | $\epsilon_{33} = 6.0$                                    | r.t.    | $10^3$                 |
| $(\text{NH}_4)_2\text{Cd}_2(\text{SO}_4)_3$                                    | Ammonium cadmium sulfate                    | 10.0                                                     | r.t.    | $10^4$                 |
| $\text{NH}_4\text{Cl}$                                                         | Ammonium chloride                           | 6.9                                                      | r.t.    | $7 \times 10^5$        |
| $\text{NH}_4(\text{ClCH}_2\text{COO})$                                         | Ammonium monochloroacetate                  | 5                                                        | r.t.    | $2 \times 10^6$        |
| $\text{NH}_4\text{Cr}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$               | Ammonium chrome alum                        | 6.5                                                      | r.t.    | $175 \times 10^3$      |
| $\text{NH}_4\text{HSO}_4$                                                      | Ammonium bisulfate                          | 165                                                      | 273     | $5 \times 10^4$        |
| $\text{NH}_4\text{H}_2\text{AsO}_4$                                            | Ammonium dihydrogen arsenate (ADA)          | 5.1                                                      | 265     | $9.5 \times 10^9$      |
|                                                                                |                                             | $\epsilon_{11} = \epsilon_{22} = 85$                     | 298     | $10^3$                 |
|                                                                                |                                             | $\epsilon_{33} = 22$                                     | 298     |                        |
| $\text{NH}_4\text{H}_2\text{PO}_4$                                             | Ammonium dihydrogen phosphate (ADP)         | $\epsilon_{11} = \epsilon_{22} = 57.1 \pm 0.6$           | 294.5   | $10^5-35 \times 10^9$  |
|                                                                                |                                             | $\epsilon_{33} = 14.0 \pm 0.3$                           | 294     | $10^5-36 \times 10^9$  |
| $\text{ND}_4\text{D}_2\text{PO}_4$                                             | Ammonium dideuterium phosphate (ADDP)       | $\epsilon_{11} = \epsilon_{22} = 74, \epsilon_{33} = 24$ | 300     |                        |
| $\text{NH}_4\text{NO}_3$                                                       | Ammonium nitrate                            | 10.7                                                     | 322     | $(5-50) \times 10^3$   |
| $(\text{NH}_4)_2\text{SO}_4$                                                   | Ammonium sulfate                            | $\epsilon_{11} = \epsilon_{22} = 8.0$                    | 123     | $10^5$                 |
|                                                                                |                                             | $\epsilon_{33} = 6.3$                                    | 123     | $10^5$                 |
|                                                                                |                                             | $\epsilon_{11} = \epsilon_{22} = 10.0$                   | 293     | $10^5$                 |
|                                                                                |                                             | $\epsilon_{33} = 9.3$                                    | 293     | $10^5$                 |
| $(\text{NH}_4)_2\text{UO}_2(\text{C}_2\text{O}_4)_2$                           | Ammonium uranyl oxalate                     | 8.03                                                     | r.t.    | $10^4-3.3 \times 10^9$ |
| $(\text{NH}_4)_5\text{UO}_2(\text{C}_2\text{O}_4)_2 \cdot 3\text{H}_2\text{O}$ | Ammonium uranyl oxalate trihydrate          | 6.06                                                     | r.t.    | $10^4-3.3 \times 10^9$ |
| $\text{NaBr}$                                                                  | Sodium bromide                              | 6.44                                                     | 298     | $1.6 \times 10^3$      |
| $\text{NaBrO}_3$                                                               | Sodium bromate                              | $\epsilon_{11}^T = 5.70$                                 | 298     | $10^3$                 |
| $\text{NaCN}$                                                                  | Sodium cyanide                              | 7.55                                                     | 293     | $10^5$                 |
| $\text{NaCO}_3$                                                                | Sodium carbonate                            | 8.75                                                     | 291     | $2 \times 10^5$        |
| $\text{NaCO}_3 \cdot 10\text{H}_2\text{O}$                                     | Sodium carbonate decahydrate                | 5.3                                                      | r.t.    | $6 \times 10^7$        |
| $\text{NaCl}$                                                                  | Sodium chloride                             | 5.9                                                      | 298     | $10^2-10^7$            |
|                                                                                |                                             | 5.45                                                     | 4.2     |                        |
|                                                                                |                                             | $\epsilon_{11}^T = 5.76$                                 | 301     | $10^3$                 |
| $\text{NaClO}_3$                                                               | Sodium chlorate                             | 5.28                                                     | r.t.    | $10^3$                 |

| Formula                                                                          | Name                                                                         | $\epsilon_{ijk}$                            | T/K     | $\nu/\text{Hz}$               |
|----------------------------------------------------------------------------------|------------------------------------------------------------------------------|---------------------------------------------|---------|-------------------------------|
| $\text{NaClO}_4$                                                                 | Sodium perchlorate                                                           | 5.76                                        | r.t.    | $10^3$                        |
| $\text{NaF}$                                                                     | Sodium fluoride                                                              | $5.08 \pm 0.02$                             | r.t.    | $5 \times 10^3$               |
| $\text{NaH}_3(\text{SeO}_3)_2$                                                   | Sodium trihydrogen selenite                                                  | $\epsilon_{11} \approx 75$                  | 273     | $2 \times 10^5$               |
| $\text{NaD}_3(\text{SeO}_3)_2$                                                   | Sodium trideuterium selenite                                                 | $\epsilon_{11} \approx 220$                 | 273     | $2 \times 10^5$               |
| $\text{NaI}$                                                                     | Sodium iodide                                                                | $7.28 \pm 0.03$                             | r.t.    |                               |
| $\text{NaK}(\text{C}_4\text{H}_2\text{D}_2\text{O}_6) \cdot 4\text{D}_2\text{O}$ | Sodium potassium tartrate tetradeutrate<br>(double deuterated Rochelle salt) | $\epsilon_{11} = 70$                        | 273     | $10^3$                        |
|                                                                                  |                                                                              | $\epsilon_{22} = 8.9$                       | 273     | $10^3$                        |
| $\text{NaK}(\text{C}_4\text{H}_4\text{O}_6) \cdot 4\text{H}_2\text{O}$           | Sodium potassium tartrate tetrahydrate<br>(Rochelle salt)                    | $\epsilon_{11} = 170$                       | 273     | $10^3$                        |
|                                                                                  |                                                                              | $\epsilon_{22} = 9.1$                       | 273     | $10^3$                        |
| $\text{NaNH}_4(\text{C}_4\text{H}_4\text{O}_6) \cdot 4\text{H}_2\text{O}$        | Sodium ammonium tartrate<br>(Ammonium Rochelle salt)                         | $\epsilon_{11} = 8.4$                       | 298     |                               |
|                                                                                  |                                                                              | $\epsilon_{22} = 9.2$                       | 298     |                               |
|                                                                                  |                                                                              | $\epsilon_{33} = 9.5$                       | 298     |                               |
| $\text{NaNbO}_3$                                                                 | Sodium niobate                                                               | $\epsilon_{33} = 670 \pm 13$                | r.t.    |                               |
|                                                                                  |                                                                              | $\epsilon_{11} = \epsilon_{22} = 76 \pm 2$  | r.t.    |                               |
| $\text{NaNO}_2$                                                                  | Sodium nitrite                                                               | $\epsilon_{11} = 7.4$                       | r.t.    | $5 \times 10^5$               |
|                                                                                  |                                                                              | $\epsilon_{22} = 5.5$                       | r.t.    | $5 \times 10^5$               |
|                                                                                  |                                                                              | $\epsilon_{33} = 5.0$                       | r.t.    | $5 \times 10^5$               |
| $\text{NaNO}_3$                                                                  | Sodium nitrate                                                               | 6.85                                        | 292     | $2 \times 10^5$               |
| $\text{NaSO}_4$                                                                  | Sodium sulfate                                                               | 7.90                                        | r.t.    |                               |
| $\text{NaSO}_4 \cdot 10\text{H}_2\text{O}$                                       | Sodium sulfate decahydrate                                                   | 5.0                                         | r.t.    |                               |
| $\text{Na}_2\text{SO}_4 \cdot 5\text{H}_2\text{O}$                               | Sodium sulfate pentahydrate                                                  | 7                                           | 250–290 | $300\text{--}10^4$            |
| $\text{Na}_2\text{UO}_2(\text{C}_2\text{O}_4)_2$                                 | Sodium uranyl oxalate                                                        | 5.18                                        | r.t.    |                               |
| $\text{NdAlO}_3$                                                                 | Neodymium aluminate                                                          | 17.5                                        | r.t.    |                               |
| $\text{NdScO}_3$                                                                 | Neodymium scandate                                                           | 27                                          | r.t.    |                               |
| $\text{Ni}_3\text{B}_7\text{O}_{13}\text{I}$                                     | Nickel iodine boracite                                                       | $\epsilon_{11} = 14$                        | 260     |                               |
| $\text{NiNb}_2\text{O}_6$                                                        | Nickel niobate                                                               | $\epsilon_{11} = 16.0 \pm 0.5$              | r.t.    | $(5\text{--}500) \times 10^3$ |
|                                                                                  |                                                                              | $\epsilon_{22} = 23.8 \pm 1.8$              | r.t.    | $(5\text{--}500) \times 10^3$ |
|                                                                                  |                                                                              | $\epsilon_{33} = 31.3 \pm 2.5$              | r.t.    | $(5\text{--}500) \times 10^3$ |
| $\text{NiO}$                                                                     | Nickel oxide                                                                 | 11.9                                        | 298     | $10^5$                        |
| $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$                                        | Nickel sulfate hexahydrate                                                   | $\epsilon_{11} = 6.2$                       | r.t.    |                               |
|                                                                                  |                                                                              | $\epsilon_{33} = 6.8$                       | r.t.    |                               |
| $\text{NiWO}_4$                                                                  | Nickel tungstate                                                             | $\epsilon_{11} = 17.4 \pm 2.4$              | r.t.    | $(5\text{--}500) \times 10^3$ |
|                                                                                  |                                                                              | $\epsilon_{22} = 13.6 \pm 1.0$              | r.t.    | $(5\text{--}500) \times 10^3$ |
|                                                                                  |                                                                              | $\epsilon_{33} = 19.7 \pm 0.6$              | r.t.    | $(5\text{--}500) \times 10^3$ |
| P                                                                                | Phosphorous (red)                                                            | 4.1                                         | r.t.    | $10^8$                        |
|                                                                                  | Phosphorous (yellow)                                                         | 3.6                                         | r.t.    | $10^8$                        |
| $[\text{P}(\text{CH}_3)_4]\text{HgBr}_3$                                         | Tetramethylphosphonium<br>tribromomercurate (TTM)                            | $\sim 10$                                   | 233–373 |                               |
| $\text{PbBr}_2$                                                                  | Lead bromide                                                                 | $>30$                                       | 293     | $(0.5\text{--}3) \times 10^6$ |
| $\text{PbCO}_3$                                                                  | Lead carbonate                                                               | 18.6                                        | 288     | $10.8$                        |
| $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$                                    | Lead acetate                                                                 | 2.6                                         | 290–295 | $10^6$                        |
| $\text{PbCl}_2$                                                                  | Lead chloride                                                                | 33.5                                        | 273     | $(0.5\text{--}3) \times 10^6$ |
| $\text{Pb}_2\text{CoWO}_6$                                                       | Lead cobalt tungstate                                                        | $\sim 250$                                  | r.t.    |                               |
| $\text{PbF}_2$                                                                   | Lead fluoride                                                                | 26.3                                        | r.t.    |                               |
| $\text{PbHfO}_3$                                                                 | Lead hafnate                                                                 | 390                                         | 300     | $10^5$                        |
|                                                                                  |                                                                              | 185                                         | 400     |                               |
| $\text{PbI}_2$                                                                   | Lead iodide                                                                  | 20.8                                        | 293     | $(0.5\text{--}3) \times 10^6$ |
| $\text{Pb}_3\text{MgNb}_2\text{O}_9$                                             | Lead magnesium niobate                                                       | 10,000                                      | 297     |                               |
| $\text{PbMoO}_4$                                                                 | Lead molybdate                                                               | $\epsilon_{11} = 34.0 \pm 0.4$              | 297.5   | $1.6 \pm 10^3$                |
|                                                                                  |                                                                              | $\epsilon_{33} = 40.6 \pm 0.2$              | 297.5   | $1.6 \pm 10^3$                |
| $\text{Pb}(\text{NO}_3)_2$                                                       | Lead nitrate                                                                 | 16.8                                        | r.t.    | $(0.5\text{--}3) \times 10^6$ |
| $\text{PbNb}_2\text{O}_6$                                                        | Lead niobate                                                                 | $\epsilon_{33}^T = 180$                     | 298     |                               |
| $\text{PbO}$                                                                     | Lead oxide                                                                   | 25.9                                        | r.t.    | $2 \times 10^6$               |
| $\text{PbS}$                                                                     | Lead sulfide (Galena)                                                        | 190                                         | 77      | i.r.                          |
|                                                                                  |                                                                              | $200 \pm 35$                                | r.t.    | i.r.                          |
| $\text{PbSO}_4$                                                                  | Lead sulfate                                                                 | 14.3                                        | 290–295 | $10^6$                        |
| $\text{PbSe}$                                                                    | Lead selenide                                                                | 280                                         | r.t.    | i.r.                          |
| $\text{PbTa}_2\text{O}_6$                                                        | Lead metatantalate                                                           | $\epsilon_{11} = \epsilon_{22} \approx 300$ | r.t.    | $10^4$                        |
|                                                                                  |                                                                              | $\epsilon_{33} = 150$                       | r.t.    | $10^4$                        |
| $\text{PbTe}$                                                                    | Lead telluride                                                               | 450                                         | r.t.    | i.r.                          |

| Formula                                                  | Name                                | $\epsilon_{ijk}$                               | T/K     | $\nu/\text{Hz}$                 |
|----------------------------------------------------------|-------------------------------------|------------------------------------------------|---------|---------------------------------|
|                                                          |                                     | 40                                             | 77      | $10^4\text{--}15 \times 10^4$   |
|                                                          |                                     | 430                                            | 4.2     | $10^4\text{--}15 \times 10^4$   |
| PbTiO <sub>3</sub>                                       | Lead titanate                       | ~200                                           | r.t.    | $10^3$                          |
| PbWO <sub>4</sub>                                        | Lead tungstate                      | $\epsilon_{11} = \epsilon_{22} = 23.6 \pm 0.3$ | 297.5   | $1.59 \times 10^3$              |
|                                                          |                                     | $\epsilon_{33} = 31.0 \pm 0.4$                 | 297.5   | $1.59 \times 10^3$              |
| Pb(Zn <sub>1/3</sub> Nb <sub>2/3</sub> )O <sub>3</sub>   | Lead zinc niobate                   | 7                                              | 300     | $10^3, 300 \times 10^3$         |
| PbZrO <sub>3</sub>                                       | Lead zirconate                      | 200                                            | 400     |                                 |
| RbAl(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O | Rubidium alum                       | 5.1                                            | r.t.    | $10^{12}$                       |
| RbBr                                                     | Rubidium bromide                    | 4.83                                           | 300     |                                 |
| Rb <sub>2</sub> CO <sub>3</sub>                          | Rubidium carbonate                  | $4.87 \pm 0.02$                                | r.t.    | $5 \times 10^3$                 |
| RbCl                                                     | Rubidium chloride                   | $4.91 \pm 0.02$                                | r.t.    | $5 \times 10^3$                 |
| RbCr(SO <sub>4</sub> ) <sub>2</sub> · 12H <sub>2</sub> O | Rubidium chrome alum                | 5.0                                            | r.t.    | $10^{12}$                       |
| RbF                                                      | Rubidium fluoride                   | 5.91                                           | r.t.    | $2 \times 10^6$                 |
| RbHSO <sub>4</sub>                                       | Rubidium bisulfate                  | $\epsilon_{11} = 7$                            | r.t.    | $10^5$                          |
|                                                          |                                     | $\epsilon_{22} = 8$                            | r.t.    | $10^5$                          |
|                                                          |                                     | $\epsilon_{33} = 10$                           | r.t.    | $10^5$                          |
| RbH <sub>2</sub> AsO <sub>4</sub>                        | Rubidium dihydrogen arsenate (RDA)  | 3.90                                           | 273     | $9.5 \times 10^9$               |
| RbH <sub>2</sub> PO <sub>4</sub>                         | Rubidium dihydrogen phosphate (RDP) | 6.15                                           | 285     | $9.5 \times 10^9$               |
| RbI                                                      | Rubidium iodide                     | $4.94 \pm 0.02$                                | r.t.    | $5 \times 10^3$                 |
| RbInSO <sub>4</sub>                                      | Rubidium indium sulfate             | 6.85                                           | r.t.    |                                 |
| RbNO <sub>3</sub>                                        | Rubidium nitrate                    | 20—380                                         | 433—488 | $10^6$                          |
|                                                          |                                     | 30                                             | 488—538 | $10^6$                          |
| S                                                        | Sulfur                              | $\epsilon_{11} = 3.75$                         | 298     | $10^2\text{--}10^3$             |
|                                                          |                                     | $\epsilon_{22} = 3.95$                         | 298     | $10^2\text{--}10^3$             |
|                                                          |                                     | $\epsilon_{33} = 4.44$                         | 298     | $10^2\text{--}10^3$             |
|                                                          | sublimed                            | 3.69                                           | 298     | $10^2\text{--}10^3$             |
| SC(NH <sub>2</sub> ) <sub>2</sub>                        | Thiourea                            | $\epsilon_{11} = \epsilon_{22} \approx 3$      | 77—300  | $10^3$                          |
|                                                          |                                     | $\epsilon_{22} = 35$                           | 300     | $10^3$                          |
| Sb <sub>2</sub> O <sub>3</sub>                           | Antimonous sesquioxide              | 12.8                                           | r.t.    | $(1.5\text{--}2) \times 10^3$   |
| Sb <sub>2</sub> S <sub>3</sub>                           | Antimonous sulfide (stibnite)       | $\epsilon_{11} = \epsilon_{33} = 15$           | r.t.    | $10^3$                          |
|                                                          |                                     | $\epsilon_{33} = 180$                          | r.t.    | $10^3$                          |
| Sb <sub>2</sub> Se <sub>3</sub>                          | Antimonous selenide                 | ~110                                           | r.t.    | $(10\text{--}16.5) \times 10^9$ |
| SbSI                                                     | Antimonous sulfide iodide           | 2000                                           | 273     | $10^5$                          |
|                                                          |                                     | $\epsilon_{11} = \epsilon_{22} \approx 25$     | r.t.    | $10^3\text{--}10^5$             |
|                                                          |                                     | $\epsilon_{33} \approx 5 \times 10^4$          | 295     | $10^3\text{--}10^5$             |
| Se                                                       | Selenium (monocrystal)              | $\epsilon_{11} = \epsilon_{22} = 11$           | 300     | $24 \times 10^9$                |
|                                                          |                                     | $\epsilon_{33} = 21$                           | 300     | $24 \times 10^9$                |
|                                                          | (amorphous)                         | 6.0                                            | 298     | $10^2\text{--}10^{10}$          |
| Si                                                       | Silicon                             | 12.1                                           | 4.2     | $10^7\text{--}10^9$             |
| SiC                                                      | Silicon carbide                     |                                                |         |                                 |
|                                                          | cubic                               | 9.72                                           | r.t.    | i.r.                            |
|                                                          | 6H                                  | $\epsilon_{11} = \epsilon_{22} = 9.66$         | r.t.    | i.r.                            |
|                                                          |                                     | $\epsilon_{33} = 10.03$                        | r.t.    | i.r.                            |
|                                                          |                                     | $9.7 \pm 0.1$                                  | 1.8     | i.r.                            |
| Si <sub>3</sub> N <sub>4</sub>                           | Silicon nitride                     | 4.2 (film)                                     | r.t.    | $10^3$                          |
| SiO                                                      | Silicon monoxide                    | 5.8                                            | r.t.    | $10^3$                          |
| SiO <sub>2</sub>                                         | Silicon dioxide                     | $\epsilon_{11} = 4.42$                         | r.t.    | $9.4 \times 10^{10}$            |
|                                                          |                                     | $\epsilon_{22} = 4.41$                         | r.t.    | $9.4 \times 10^{10}$            |
|                                                          |                                     | $\epsilon_{33} = 4.60$                         | r.t.    | $9.4 \times 10^{10}$            |
| Sm <sub>2</sub> (MoO <sub>4</sub> ) <sub>3</sub>         | Samarium molybdate                  | 12                                             | 298     |                                 |
| SnO <sub>2</sub>                                         | Stannic dioxide                     | $\epsilon_{11} = \epsilon_{22} = 14 \pm 2$     | r.t.    | $10^4\text{--}10^{10}$          |
|                                                          |                                     | $\epsilon_{33} = 9.0 \pm 0.5$                  | r.t.    | $10^4\text{--}10^{10}$          |
| SnSb                                                     | Tin antimonide                      | 147                                            | r.t.    | $10^4\text{--}10^6$             |
| SnTe                                                     | Tin telluride                       | $1770 \pm 300$                                 | r.t.    | i.r.                            |
| Sr(COOH) <sub>2</sub> · 2H <sub>2</sub> O                | Strontium formate dihydrate         | 6.1                                            | r.t.    | $10^3$                          |
| SrCO <sub>3</sub>                                        | Strontium carbonate                 | 8.85                                           | 298     | $2 \times 10^5$                 |
| SrCl <sub>2</sub>                                        | Strontium chloride                  | 9.19                                           | r.t.    |                                 |
| SrCl <sub>2</sub> · 6H <sub>2</sub> O                    | Strontium chloride hexahydrate      | 8.52                                           | r.t.    |                                 |
| SrF <sub>2</sub>                                         | Strontium fluoride                  | 6.50                                           | 300     | $5 \times 10^2\text{--}10^{11}$ |
| SrMoO <sub>4</sub>                                       | Strontium molybdate                 | $\epsilon_{11} = \epsilon_{22} = 31.7 \pm 0.2$ | 297.5   | $1.59 \times 10^3$              |

| Formula                            | Name                           | $\epsilon_{ijk}$                                    | T/K     | $\nu/\text{Hz}$               |
|------------------------------------|--------------------------------|-----------------------------------------------------|---------|-------------------------------|
| $\text{Sr}(\text{NO}_3)_2$         | Strontium nitrate              | $\epsilon_{33} = 41.7 \pm 0.2$                      | 297.5   | $1.59 \times 10^3$            |
|                                    |                                | 5.33                                                | 292     | $2 \times 10^5$               |
| $\text{Sr}_2\text{Nb}_2\text{O}_7$ | Strontium niobate              | $\epsilon_{11} = 75$                                | r.t.    | $10^3$                        |
|                                    |                                | $\epsilon_{22} = 46$                                | r.t.    | $10^3$                        |
|                                    |                                | $\epsilon_{33} = 43$                                | r.t.    | $10^3$                        |
|                                    |                                | $13.3 \pm 0.3$                                      | 273     | $2 \times 10^6$               |
| SrO                                | Strontium oxide                | 11.3                                                | r.t.    | $7.25 \times 10^6$            |
| SrS                                | Strontium sulfide              | 11.5                                                | r.t.    |                               |
| $\text{SrSO}_4$                    | Strontium sulfate              | 332                                                 | 298     | $10^3$                        |
| $\text{SrTiO}_3$                   | Strontium titanate             | 2080                                                | 78      | $10^3$                        |
|                                    |                                | $\epsilon_{11} = \epsilon_{22} = 25.7 \pm 0.2$      | 297.5   | $1.6 \times 10^3$             |
| $\text{SrWO}_4$                    | Strontium tungstate            | $\epsilon_{33} = 34.1 \pm 0.2$                      | 297.5   | $1.6 \times 10^3$             |
|                                    |                                |                                                     |         |                               |
|                                    |                                |                                                     |         |                               |
|                                    |                                |                                                     |         |                               |
| $\text{Ta}_2\text{O}_5$            | Tantalum pentoxide (tantala)   |                                                     |         |                               |
|                                    |                                | $\alpha$ phase                                      |         |                               |
|                                    |                                | $\epsilon_{11} = \epsilon_{22} = 30$                | 77      | $10^3$                        |
|                                    |                                | $\epsilon_{33} = 65$                                | 77      | $10^3$                        |
| $\text{Tb}(\text{MoO}_4)_3$        | Terbium molybdate              | $\beta$ phase                                       | 24      | $10^3$                        |
|                                    |                                |                                                     | 298     |                               |
|                                    |                                |                                                     |         |                               |
|                                    |                                |                                                     |         |                               |
| Te                                 | Tellurium                      | $\epsilon_{11} = \epsilon_{22} = 33$                | 100–200 | $9.4 \times 10^9$             |
|                                    |                                | $\epsilon_{33} = 53$                                | 100–200 | $9.4 \times 10^9$             |
|                                    |                                | $\epsilon_{11} = \epsilon_{22} = 33$                | r.t.    |                               |
|                                    |                                | $\epsilon_{33} = 54$                                | r.t.    |                               |
| $\text{ThO}_2$                     | Thorium dioxide                | polycrystalline                                     | 27.5    | r.t.                          |
|                                    |                                | monocrystalline                                     | 28.0    | r.t.                          |
| $\text{TiO}_2$                     | Titanium dioxide (rutile)      | $18.9 \pm 0.4$                                      | r.t.    | $3 \times 10^5$               |
|                                    |                                | $\epsilon_{11} = \epsilon_{22} = 86$                | 300     | $10^4\text{--}10^6$           |
| $\text{Ti}_2\text{O}_3$            | Titanium sesquioxide           | $\epsilon_{33} = 170$                               | 300     | $10^4\text{--}10^6$           |
|                                    |                                | 30                                                  | 77      | $6 \times 10^{10}$            |
| TlBr                               | Thallium bromide               | 30                                                  | 293     | $10^3\text{--}10^7$           |
| TlCl                               | Thallous chloride              | $32.2 \pm 0.2$                                      | 293     | $10^3\text{--}10^5$           |
| TlI                                | Thallous iodide (orthorhombic) | $20.7 \pm 0.2$                                      | 293     | $10^4$                        |
|                                    |                                | 37.3                                                | 193     | $10^7$                        |
| TlNO <sub>3</sub>                  | Thallous nitrate               | 16.5                                                | 293     | $5 \times 10^5$               |
| TlSO <sub>4</sub>                  | Thallous sulfate               | 25.5                                                | 293     | $5 \times 10^5$               |
| UO <sub>2</sub>                    | Uranium dioxide                | 24                                                  | r.t.    | $3 \times 10^5$               |
| WO <sub>3</sub>                    | Tungsten trioxide              | 300                                                 |         |                               |
| YMnO <sub>3</sub>                  | Yttrium manganate              | 20                                                  | r.t.    | $2 \times 10^7$               |
| Y <sub>2</sub> O <sub>3</sub>      | Yttrium sesquioxide            | 10                                                  | r.t.    | $10^6$                        |
| YbMnO <sub>3</sub>                 | Ytterbium manganate            | 20                                                  | r.t.    | $2 \times 10^7$               |
| Yb <sub>2</sub> O <sub>3</sub>     | Ytterbium sesquioxide          | 5.0 (film)                                          | r.t.    | $10^3$                        |
| ZnO                                | Zinc monoxide                  | $\epsilon_{11}^S = 8.33$                            | r.t.    |                               |
|                                    |                                | $\epsilon_{33}^S = 8.84$                            | r.t.    |                               |
|                                    |                                | $\epsilon_{11}^T = 9.26$                            | r.t.    |                               |
|                                    |                                | $\epsilon_{33}^T = 11.0$                            | r.t.    |                               |
|                                    |                                | $\epsilon_{11} = 9.26$                              | r.t.    |                               |
|                                    |                                | $\epsilon_{33} = 8.2$                               | r.t.    |                               |
|                                    |                                | 8.15                                                | r.t.    | i.r.                          |
|                                    |                                | $\epsilon_{11}^S = 8.08 \pm 2\%$                    | 77      | $10^4$                        |
|                                    |                                | $\epsilon_{11}^S = 8.32 \pm 2\%$                    | 298     | $10^4$                        |
|                                    |                                | $\epsilon_{11}^T = 8.14 \pm 2\%$                    | 77      | $10^4$                        |
| ZnS                                | Zinc sulfide                   | $\epsilon_{11}^T = 8.37 \pm 2\%$                    | 298     | $10^4$                        |
|                                    |                                | $\epsilon_{11}^T = \epsilon_{11}^S = 9.12 \pm 2\%$  | 298     | $10^4$                        |
|                                    |                                | $\epsilon_{11}^T = \epsilon_{11}^S = 10.10 \pm 2\%$ | r.t.    |                               |
|                                    |                                | $\epsilon_{22} = 16.1 \pm 0.5$                      | r.t.    | $(5\text{--}500) \times 10^3$ |
| ZnSe                               | Zinc selenide                  | 12.5                                                | r.t.    | $2 \times 10^6$               |
| ZnTe                               | Zinc telluride                 |                                                     |         |                               |
| ZnWO <sub>4</sub>                  | Zinc tungstate                 |                                                     |         |                               |
| ZrO <sub>2</sub>                   | Zirconium dioxide (zirconia)   |                                                     |         |                               |

# CURIE TEMPERATURE OF SELECTED FERROELECTRIC CRYSTALS

H. P. R. Frederikse

The following table lists the major ferroelectric crystals and their Curie temperatures,  $T_C$ .

## Reference

Young, K. F. and Frederikse, H. P. R., *J. Phys. Chem. Ref. Data*, 2, 313, 1973.

| Name or acronym                             | Formula                                                                     | $T_C/K$               |
|---------------------------------------------|-----------------------------------------------------------------------------|-----------------------|
| <i>Potassium dihydrogen phosphate group</i> |                                                                             |                       |
| KDP                                         | $\text{KH}_2\text{PO}_4$                                                    | 123                   |
| KDA                                         | $\text{KH}_2\text{AsO}_4$                                                   | 97                    |
| KDDP                                        | $\text{KD}_2\text{PO}_4$                                                    | 213                   |
| KDDA                                        | $\text{KD}_2\text{AsO}_4$                                                   | 162                   |
| RDP                                         | $\text{RbH}_2\text{PO}_4$                                                   | 146                   |
| RDA                                         | $\text{RbH}_2\text{AsO}_4$                                                  | 111                   |
| RDDP                                        | $\text{RbD}_2\text{PO}_4$                                                   | 218                   |
| RDDA                                        | $\text{RbD}_2\text{AsO}_4$                                                  | 178                   |
| CDP                                         | $\text{CsH}_2\text{PO}_4$                                                   | 159                   |
| CDA                                         | $\text{CsH}_2\text{AsO}_4$                                                  | 143                   |
| CDDA                                        | $\text{CsD}_2\text{AsO}_4$                                                  | 212                   |
| <i>Rochelle salt group</i>                  |                                                                             |                       |
| Rochelle salt                               | $\text{NaKC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$               | 255–297               |
| Deuterated Rochelle salt                    | $\text{NaKC}_4\text{H}_2\text{D}_2\text{O}_6 \cdot 4\text{H}_2\text{O}$     | 251–308               |
| Ammonium Rochelle salt                      | $\text{NaNH}_4\text{C}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$     | 109                   |
| LAT                                         | $\text{LiNH}_4\text{C}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$      | 106                   |
| <i>Triglycine sulfate group</i>             |                                                                             |                       |
| TGS                                         | $(\text{NH}_2\text{CH}_2\text{COOH})_3 \cdot \text{H}_2\text{SO}_4$         | 322                   |
| TGSe                                        | $(\text{NH}_2\text{CH}_2\text{COOH})_3 \cdot \text{H}_2\text{SeO}_4$        | 295                   |
| TGFB                                        | $(\text{NH}_2\text{CH}_2\text{COOH})_3 \cdot \text{H}_2\text{BeF}_4$        | 346                   |
| AFB                                         | $(\text{NH}_4)_2\text{BeF}_4$                                               | 176                   |
| HADA                                        | $\text{HNH}_4(\text{ClCH}_2\text{COO})_2$                                   | 128                   |
| <i>Perovskites and related compounds</i>    |                                                                             |                       |
| Barium titanate                             | $\text{BaTiO}_3$                                                            | 406, 278, 193         |
| Lead titanate                               | $\text{PbTiO}_3$                                                            | 765                   |
| Potassium niobate                           | $\text{KNbO}_3$                                                             | 712                   |
| Potassium tantalate niobate                 | $\text{KTa}_{2/3}\text{Nb}_{1/3}\text{O}_3$                                 | 241, 220, 170         |
| Lithium niobate                             | $\text{LiNbO}_3$                                                            | 1483                  |
| Lithium tantalate                           | $\text{LiTaO}_3$                                                            | 891                   |
| Barium titanium niobate                     | $\text{Ba}_6\text{Ti}_2\text{Nb}_8\text{O}_{30}$                            | 521                   |
| Ba-Na niobate (“Bananas”)                   | $\text{Ba}_2\text{NaNb}_5\text{O}_{15}$                                     | 833                   |
| Potassium iodate                            | $\text{KIO}_3$                                                              | 485, 343, 257–263, 83 |
| Lithium iodate                              | $\text{LiIO}_3$                                                             | 529                   |
| Potassium nitrate                           | $\text{KNO}_3$                                                              | 397                   |
| Sodium nitrate                              | $\text{NaNO}_3$                                                             | 548                   |
| Rubidium nitrate                            | $\text{RbNO}_3$                                                             | 437–487               |
| <i>Miscellaneous compounds</i>              |                                                                             |                       |
| Cesium trihydrogen selenite                 | $\text{CsH}_3(\text{SeO}_3)_2$                                              | 143                   |
| Lithium trihydrogen selenite                | $\text{LiH}_3(\text{SeO}_3)_2$                                              | $T_C > T_{\text{mp}}$ |
| Potassium selenate                          | $\text{K}_2\text{SeO}_4$                                                    | 93                    |
| Methyl ammonium alum (MASD)                 | $\text{CH}_3\text{NH}_3\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ | 177                   |
| Ammonium cadmium sulfate                    | $(\text{NH}_4)_2\text{Cd}_2(\text{SO}_4)_3$                                 | 95                    |
| Ammonium bisulfate                          | $(\text{NH}_4)\text{HSO}_4$                                                 | 271                   |
| Ammonium sulfate                            | $(\text{NH}_4)_2\text{SO}_4$                                                | 224                   |
| Ammonium nitrate                            | $\text{NH}_4\text{NO}_3$                                                    | 398, 357, 305, 255    |
| Colemanite                                  | $\text{CaB}_3\text{O}_4(\text{OH})_3 \cdot \text{H}_2\text{O}$              | 266                   |
| Cadmium pyroniobite                         | $\text{Cd}_2\text{Nb}_2\text{O}_7$                                          | 185                   |
| Gadolinium molybdate                        | $\text{Gd}_2(\text{MoO}_4)_3$                                               | 432                   |

# PROPERTIES OF ANTIFERROELECTRIC CRYSTALS

**H. P. R. Frederikse**

Some important antiferroelectric crystals are listed here with their Curie Temperatures  $T_C$ . The last column gives the constant  $T_0$  which appears in the Curie-Weiss law describing the dielectric constant of these materials above the Curie Temperature:

$$\epsilon = \text{const.}/(T - T_0)$$

| Name or acronym                | Formula                                | $T_C/\text{K}$ | $T_0/\text{K}$ |
|--------------------------------|----------------------------------------|----------------|----------------|
| ADP                            | $\text{NH}_4\text{H}_2\text{PO}_4$     | 148            |                |
| ADA                            | $\text{NH}_4\text{H}_2\text{AsO}_4$    | 216            |                |
| ADDP                           | $\text{NH}_4\text{D}_2\text{PO}_4$     | 242, 245       |                |
| ADDA                           | $\text{NH}_4\text{D}_2\text{AsO}_4$    | 299            |                |
| $\text{A}_d\text{DDP}$         | $\text{ND}_4\text{D}_2\text{PO}_4$     | 243            |                |
| $\text{A}_d\text{DDA}$         | $\text{ND}_4\text{D}_2\text{AsO}_4$    | 304            |                |
| Sodium niobate                 | $\text{NaNbO}_3$                       | 911, 793       |                |
| Lead hafnate                   | $\text{PbHfO}_3$                       | 476            | 378            |
| Lead zirconate                 | $\text{PbZrO}_3$                       | 503            | 475            |
| Lead metaniobate               | $\text{PbNb}_2\text{O}_6$              | 843            | 530            |
| Lead metatantalate             | $\text{PbTa}_2\text{O}_6$              | 543            | 533            |
| Tungsten trioxide              | $\text{WO}_3$                          | 1010           |                |
| Potassium strontium niobate    | $\text{KSr}_2\text{Nb}_5\text{O}_{15}$ | 427            | 413            |
| Sodium nitrite                 | $\text{NaNO}_2$                        | 437            | 437            |
| Sodium trihydrogen selenite    | $\text{NaH}_3(\text{SeO}_3)_2$         | 193            | 192            |
| Sodium trideuterium selenite   | $\text{NaD}_3(\text{SeO}_3)_2$         | 271            | 245            |
| Ammonium trihydrogen periodate | $(\text{NH}_4)_2\text{H}_3\text{IO}_6$ | 245            |                |

## DIELECTRIC CONSTANTS OF GLASSES

| Type                       | Dielectric constant at 100 MHz<br>(20°C) | Volume resistivity<br>(In MΩ cm at 350°C ) | Loss factor <sup>a</sup> |
|----------------------------|------------------------------------------|--------------------------------------------|--------------------------|
| Corning 0010               | 6.32                                     | 10                                         | 0.015                    |
| Corning 0080               | 6.75                                     | 0.13                                       | 0.058                    |
| Corning 0120               | 6.65                                     | 100                                        | 0.012                    |
| Pyrex 1710                 | 6.00                                     | 2,500                                      | 0.025                    |
| Pyrex 3320                 | 4.71                                     | —                                          | 0.019                    |
| Pyrex 7040                 | 4.65                                     | 80                                         | 0.013                    |
| Pyrex 7050                 | 4.77                                     | 16                                         | 0.017                    |
| Pyrex 7052                 | 5.07                                     | 25                                         | 0.019                    |
| Pyrex 7060                 | 4.70                                     | 13                                         | 0.018                    |
| Pyrex 7070                 | 4.00                                     | 1,300                                      | 0.0048                   |
| Vycor 7230                 | 3.83                                     | —                                          | 0.0061                   |
| Pyrex 7720                 | 4.50                                     | 16                                         | 0.014                    |
| Pyrex 7740                 | 5.00                                     | 4                                          | 0.040                    |
| Pyrex 7750                 | 4.28                                     | 50                                         | 0.011                    |
| Pyrex 7760                 | 4.50                                     | 50                                         | 0.0081                   |
| Vycor 7900                 | 3.9                                      | 130                                        | 0.0023                   |
| Vycor 7910                 | 3.8                                      | 1,600                                      | 0.00091                  |
| Vycor 7911                 | 3.8                                      | 4,000                                      | 0.00072                  |
| Corning 8870               | 9.5                                      | 5,000                                      | 0.0085                   |
| G. E. Clear (silica glass) | 3.81                                     | 4,000–30,000                               | 0.00038                  |
| Quartz (fused)             | 3.75 (4.1 at 1 MHz)                      | —                                          | 0.0002 (1 MHz)           |

<sup>a</sup> Power factor × dielectric constant equals loss factor.



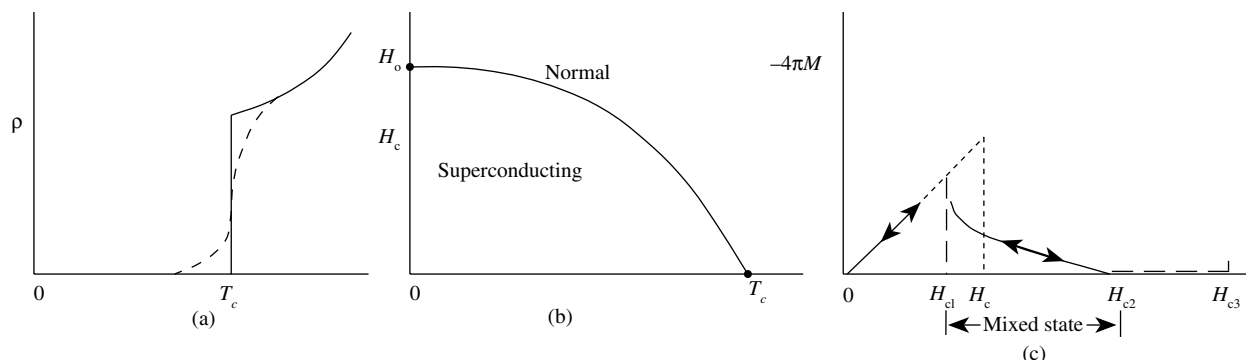
# PROPERTIES OF SUPERCONDUCTORS

L. I. Berger and B. W. Roberts

The following tables include superconductive properties of selected elements, compounds, and alloys. Individual tables are given for thin films, elements at high pressures, superconductors with high critical magnetic fields, and high critical temperature superconductors.

The historically first observed and most distinctive property of a superconductive body is the near total loss of resistance at a critical temperature ( $T_c$ ) that is characteristic of each material. Figure 1(a) below illustrates schematically two types of possible transitions. The sharp vertical discontinuity in resistance is indica-

tive of that found for a single crystal of a very pure element or one of a few well annealed alloy compositions. The broad transition, illustrated by broken lines, suggests the transition shape seen for materials that are not homogeneous and contain unusual strain distributions. Careful testing of the resistivity limit for superconductors shows that it is less than  $4 \times 10^{-23}$  ohm cm, while the lowest resistivity observed in metals is of the order of  $10^{-13}$  ohm cm. If one compares the resistivity of a superconductive body to that of copper at room temperature, the superconductive body is at least  $10^{17}$  times less resistive.



**FIGURE 1.** Physical properties of superconductors. (a) Resistivity vs. temperature for a pure and perfect lattice (solid line); impure and/or imperfect lattice (broken line). (b) Magnetic-field temperature dependence for Type-I or "soft" superconductors. (c) Schematic magnetization curve for "hard" or Type-II superconductors.

The temperature interval  $\Delta T_c$ , over which the transition between the normal and superconductive states takes place, may be of the order of as little as  $2 \times 10^{-5}$  K or several K in width, depending on the material state. The narrow transition width was attained in 99.9999% pure gallium single crystals.

A Type-I superconductor below  $T_c$ , as exemplified by a pure metal, exhibits perfect diamagnetism and excludes a magnetic field up to some critical field  $H_c$ , whereupon it reverts to the normal state as shown in the  $H$ - $T$  diagram of Figure 1(b).

The magnetization of a typical high-field superconductor is shown in Figure 1(c). The discovery of the large current-carrying capability of  $Nb_3Sn$  and other similar alloys has led to an extensive study of the physical properties of these alloys. In brief, a high-field superconductor, or Type-II superconductor, passes from the perfect diamagnetic state at low magnetic fields to a mixed state and finally to a sheathed state before attaining the normal resistive state of the metal. The magnetic field values separating the four stages are given as  $H_{c1}$ ,  $H_{c2}$ , and  $H_{c3}$ . The superconductive state below  $H_{c1}$  is perfectly diamagnetic, identical to the state of most pure metals of the "soft" or Type-I superconductor. Between  $H_{c1}$  and  $H_{c2}$  a "mixed superconductive state" is found in which fluxons (a minimal unit of magnetic flux) create lines of normal flux in a superconductive matrix. The volume of the normal state is proportional to  $-4\pi M$  in the "mixed state" region. Thus at  $H_{c2}$  the fluxon density has become so great as to drive the interior volume of the superconductive body completely normal. Between  $H_{c2}$  and  $H_{c3}$  the superconductor has a sheath of current-carrying superconductive material at the body surface, and above  $H_{c3}$  the normal state exists. With several types of careful measurement, it is possible to determine  $H_{c1}$ ,  $H_{c2}$ , and  $H_{c3}$ . Table 6 contains some of the available data on high-field superconductive materials.

High-field superconductive phenomena are also related to specimen dimension and configuration. For example, the Type-I superconductor, Hg, has entirely different magnetization behavior in high magnetic fields when contained in the very fine sets of filamentary tunnels found in an unprocessed Vycor glass. The great majority of superconductive materials are Type-II. The elements in very pure form and a very few precisely stoichiometric and well annealed compounds are Type I with the possible exceptions of vanadium and niobium.

**Metallurgical Aspects.** The sensitivity of superconductive properties to the material state is most pronounced and has been used in a reverse sense to study and specify the detailed state of alloys. The mechanical state, the homogeneity, and the presence of impurity atoms and other electron-scattering centers are all capable of controlling the critical temperature and the current-carrying capabilities in high-magnetic fields. Well annealed specimens tend to show sharper transitions than those that are strained or inhomogeneous. This sensitivity to mechanical state underlines a general problem in the tabulation of properties for superconductive materials. The occasional divergent values of the critical temperature and of the critical fields quoted for a Type-II superconductor may lie in the variation in sample preparation. Critical temperatures of materials studied early in the history of superconductivity must be evaluated in light of the probable metallurgical state of the material, as well as the availability of less pure starting elements. It has been noted that recent work has given extended consideration to the metallurgical aspects of sample preparation.

Symbols in tables:  $T_c$ : Critical temperature;  $H_0$ : Critical magnetic field in the  $T = 0$  limit;  $\theta_D$ : Debye temperature; and  $\gamma$ : Electronic specific heat.

TABLE 1. Selective Properties of Superconductive Elements

| Element   | $T_c$ (K)       | $H_0$ (oersted)      | $\theta_D$ (K) | $\gamma$ (mJ mol <sup>-1</sup> K <sup>-1</sup> ) |
|-----------|-----------------|----------------------|----------------|--------------------------------------------------|
| Al        | 1.175 ± 0.002   | 104.9 ± 0.3          | 420            | 1.35                                             |
| Am* (α,?) | 0.6             |                      |                |                                                  |
| Am* (β,?) | 1.0             |                      |                |                                                  |
| Be        | 0.026           |                      |                | 0.21                                             |
| Cd        | 0.517 ± 0.002   | 28 ± 1               | 209            | 0.69                                             |
| Ga        | 1.083 ± 0.001   | 58.3 ± 0.2           | 325            | 0.60                                             |
| Ga (β)    | 5.9, 6.2        | 560                  |                |                                                  |
| Ga (γ)    | 7               | 950, HF <sup>a</sup> |                |                                                  |
| Ga (Δ)    | 7.85            | 815, HF              |                |                                                  |
| Hf        | 0.128           | 12.7                 |                | 2.21                                             |
| Hg (α)    | 4.154 ± 0.001   | 411 ± 2              | 87, 71.9       | 1.81                                             |
| Hg (β)    | 3.949           | 339                  | 93             | 1.37                                             |
| In        | 3.408 ± 0.001   | 281.5 ± 2            | 109            | 1.672                                            |
| Ir        | 0.1125 ± 0.001  | 16 ± 0.05            | 425            | 3.19                                             |
| La (α)    | 4.88 ± 0.02     | 800 ± 10             | 151            | 9.8                                              |
| La (β)    | 6.00 ± 0.1      | 1096, 1600           | 139            | 11.3                                             |
| Lu        | 0.1 ± 0.03      | 350 ± 50             |                |                                                  |
| Mo        | 0.915 ± 0.005   | 96 ± 3               | 460            | 1.83                                             |
| Nb        | 9.25 ± 0.02     | 2060 ± 50, HF        | 276            | 7.80                                             |
| Os        | 0.66 ± 0.03     | 70                   | 500            | 2.35                                             |
| Pa        | 1.4             |                      |                |                                                  |
| Pb        | 7.196 ± 0.006   | 803 ± 1              | 96             | 3.1                                              |
| Re        | 1.697 ± 0.006   | 200 ± 5              | 4.5            | 2.35                                             |
| Ru        | 0.49 ± 0.015    | 69 ± 2               | 580            | 2.8                                              |
| Sn        | 3.722 ± 0.001   | 305 ± 2              | 195            | 1.78                                             |
| Ta        | 4.47 ± 0.04     | 829 ± 6              | 258            | 6.15                                             |
| Tc        | 7.8 ± 0.1       | 1410, HF             | 411            | 6.28                                             |
| Th        | 1.38 ± 0.02     | 1.60 ± 3             | 165            | 4.32                                             |
| Ti        | 0.40 ± 0.04     | 56                   | 415            | 3.3                                              |
| Tl        | 2.38 ± 0.02     | 178 ± 2              | 78.5           | 1.47                                             |
| U         | 0.2             |                      |                |                                                  |
| V         | 5.40 ± 0.05     | 1408                 | 383            | 9.82                                             |
| W         | 0.0154 ± 0.0005 | 1.15 ± 0.03          | 383            | 0.90                                             |
| Zn        | 0.85 ± 0.01     | 54 ± 0.3             | 310            | 0.66                                             |
| Zr        | 0.61 ± 0.15     | 47                   | 290            | 2.77                                             |
| Zr (ω)    | 0.65, 0.95      |                      |                |                                                  |

TABLE 2. Range of Critical Temperatures Observed for Superconductive Elements in Thin Films Condensed Usually at Low Temperatures

| Element      | $T_c$ Range (K) | Comments        | Element | $T_c$ Range (K) | Comments        |
|--------------|-----------------|-----------------|---------|-----------------|-----------------|
| Al           | 1.15–5.7        | HF <sup>a</sup> | Nb      | 2.0–10.1        |                 |
| Be           | 5–9.75          | HF              | Pb      | 1.8–7.5         |                 |
| Bi           | 6.17–6.6        |                 | Re      | 1.7–7           |                 |
| Cd           |                 |                 | Sn      | 3.5–6           |                 |
| (Disordered) | 0.79–0.91       |                 | Ta      | <1.7–4.51       | HF <sup>a</sup> |
| (Ordered)    | 0.53–0.59       |                 | Tc      | 4.6–7.7         |                 |
| Ga           | 2.5–8.5         | HF              | Ti      | 1.3 Max         |                 |
| Hg           | 3.87–4.5        |                 | Tl      | 2.33–2.96       |                 |
| In           | 2.2–5.6         | HF              | V       | 1.8–6.02        |                 |
| La           | 3.55–6.74       |                 | W       | <1.0–4.1        |                 |
| Mo           | 3.3–8.0         |                 | Zn      | 0.77–1.9        |                 |

<sup>a</sup> HF denotes high magnetic field superconductive properties.

TABLE 3. Elements Exhibiting Superconductivity Under or After Application of High Pressure

| Element          | $T_c$ Range (K) | Pressure (kbar)  | Element                     | $T_c$ Range (K) | Pressure (kbar) |
|------------------|-----------------|------------------|-----------------------------|-----------------|-----------------|
| Al               | 1.98–0.075      | 0–62             | Pb II                       | 3.55            | 160             |
| As               | 0.31–0.5        | 220–140          | Re II                       | 2.3 Max.        | "Plastic"       |
|                  | 0.2–0.25        | 140–100          |                             |                 | compression     |
| Ba II            | 1–1.8           | 55–85            | Sb (prepared 120            | 2.6–2.7         |                 |
| III              | 1.8–5           | 85–144           | kbar, held below            |                 |                 |
| IV               | 4.5–5.4         | 144–190          | 77K)                        |                 |                 |
| Bi II            | 3.9             | 25–27            | Sb II                       | 3.55–3.40       | 85–150          |
| III              | 6.55–7.25       | 28–38            | Se II                       | 6.75, 6.95      | 130             |
| IV               | 7.0, 8.7–6.0    | 43, 43–62        | Si                          | 6.7–7.1         | 120–130         |
| V                | 6.7, 8.3        | 48–80            | Sn II                       | 5.2–4.85        | 125–160         |
| VI               | 8.55            | 90, 92–101       | III                         | 5.30            | 113             |
| VII(?)           | 8.2             | 30               | Te II                       | 2.4–5.1         | 38–55           |
| Ce ( $\alpha$ )  | 0.020–0.045     | 20–35            |                             | 4.1–4.2         | 53–62           |
| Ce ( $\alpha'$ ) | 1.9–1.3         | 45–125           | IV                          | 4.72–4          | 63–80           |
| Cs V             | 1.5             | >125             | ( )                         | 3.3–2.8         | 100–260         |
| Ga II            | 6.38            | $\geq 35$        | Tl (cubic form)             | 1.45            | 35              |
| II'              | 7.5             | $\geq 35$ then P | (hexagonal form)            | 1.95            | 35              |
|                  |                 | removed          | U                           | 2.4–0.4         | 10–85           |
| Ge               | 5.35            | 115              | Y                           | 1.7–2.5         | 110–160         |
| Lu               | 0.022–1.0       | 45–190           | Zr (omega form, metastable) | 1–1.7           | 60–130          |
| P                | 5.8             | 170              |                             |                 |                 |

TABLE 4. Superconductive Compounds and Alloys

All compositions are denoted on an atomic basis, i.e., AB, AB<sub>2</sub>, or AB<sub>3</sub> for compounds, unless noted. Solid solutions or odd compositions may be denoted as A<sub>x</sub>B<sub>1-x</sub> or A<sub>z</sub>B. A series of three or more alloys is indicated as A<sub>x</sub>B<sub>1-x</sub> or by actual indication of the atomic fraction range, such as A<sub>0-0.6</sub>B<sub>1-0.4</sub>. The critical temperature of such a series of alloys is denoted by a range of values or possibly the maximum value.

The selection of the critical temperature from a transition in the effective permeability, or the change in resistance, or possibly the incremental changes in frequency observed by certain techniques is not often obvious from the literature. Most authors choose the

mid-point of such curves as the probable critical temperature of the idealized material, while others will choose the highest temperature at which a deviation from the normal state property is observed. In view of the previous discussion concerning the variability of the superconductive properties as a function of purity and other metallurgical aspects, it is recommended that appropriate literature be checked to determine the most probable critical temperature or critical field of a given alloy.

A very limited amount of data on critical fields,  $H_c$ , is available for these compounds and alloys; these values are given at the end of the table.

A. Superconductors with  $T_c < 10$  K

| Substance                                                               | $T_c$ , K | Crystal structure type                   | Substance                                                  | $T_c$ , K | Crystal structure type        |
|-------------------------------------------------------------------------|-----------|------------------------------------------|------------------------------------------------------------|-----------|-------------------------------|
| Ag <sub>33</sub> Al                                                     | 0.34      | A12-cl58 (Mn)                            | Ag <sub>7</sub> NO <sub>11</sub>                           | 1.04      | Cubic                         |
| Ag <sub>x</sub> Al <sub>1-x</sub> Zn <sub>1-y</sub>                     | 0.15      | Cubic                                    | Ag <sub>x</sub> Pb <sub>1-x</sub>                          | 7.2 max.  |                               |
| AgBi <sub>2</sub>                                                       | 2.87–3.0  |                                          | Ag <sub>4</sub> Sn                                         | 0.1       | h**                           |
| Ag <sub>77</sub> F <sub>0.25</sub> N <sub>0.75</sub> O <sub>10.25</sub> | 0.85–0.90 |                                          | Ag <sub>x</sub> Sn <sub>1-x</sub>                          | 1.5–3.7   |                               |
| Ag <sub>2</sub> F                                                       | 0.0066    |                                          | Ag <sub>x</sub> Sn <sub>1-x</sub> (film)                   | 2.0–3.8   |                               |
| Ag <sub>7</sub> FO <sub>8</sub>                                         | 0.3       | Cubic                                    | AgTe <sub>3</sub>                                          | 2.6       | Cubic                         |
| Ag <sub>0.8-0.3</sub> Ga <sub>0.2-0.7</sub>                             | 6.5–8     |                                          | AgTh                                                       | 2.2       | C16-t112 (Al <sub>2</sub> Cu) |
| Ag <sub>4</sub> Ge                                                      | 0.85      | Hex., c.p.                               | AgTh <sub>2</sub>                                          | 2.26      | C16                           |
| Ag <sub>0.438</sub> Hg <sub>0.562</sub>                                 | 0.64      | D8 <sub>2</sub>                          | Ag <sub>0.03</sub> Tl <sub>0.97</sub>                      | 2.67      |                               |
| AgIn <sub>2</sub>                                                       | ~2.4      | C16                                      | Ag <sub>0.94</sub> Tl <sub>0.06</sub>                      | 2.32      |                               |
| Ag <sub>0.1</sub> In <sub>0.9</sub> Te ( $n = 1.4 \times 10^{22}$ )     | 1.2–1.89  | B1                                       | AgY                                                        | 0.33      | B2-cP2 (CsCl)                 |
| Ag <sub>0.2</sub> In <sub>0.8</sub> Te ( $n = 1.07 \times 10^{22}$ )    | 0.77–1.00 | B1                                       | Ag <sub>x</sub> Zn <sub>1-x</sub>                          | 0.5–0.845 |                               |
| AgLa                                                                    | 0.94      | B2-cP2 (CsCl)                            | AlAu <sub>4</sub>                                          | 0.4–0.7   | Like A13                      |
| AgLa (9.5 kbar)                                                         | 1.2       | B2                                       | Al <sub>2</sub> Au                                         | 0.1       | C1-cF12 (CaF <sub>2</sub> )   |
| AgLu                                                                    | 0.33      | B2-cP2                                   | Al <sub>2</sub> CMo <sub>3</sub>                           | 9.8–10.2  | A13+trace 2nd. phase          |
| AgMo <sub>4</sub> S <sub>5</sub>                                        | 9.1       | hR15 (Mo <sub>6</sub> PbS <sub>8</sub> ) | Al <sub>2</sub> CaSi                                       | 5.8       |                               |
| Ag <sub>1.2</sub> Mo <sub>6</sub> Se <sub>8</sub>                       | 5.9       | Same                                     | Al <sub>0.131</sub> Cr <sub>0.088</sub> V <sub>0.781</sub> | 1.46      | Cubic                         |
|                                                                         |           |                                          | AlGe <sub>2</sub>                                          | 1.75      |                               |

| Substance                                                          | $T_c$ , K   | Crystal structure type                              | Substance                                  | $T_c$ , K   | Crystal structure type              |
|--------------------------------------------------------------------|-------------|-----------------------------------------------------|--------------------------------------------|-------------|-------------------------------------|
| $\text{Al}_2\text{Ge}_2\text{U}$                                   | 1.6         | $\text{LI}_2\text{-cP4}$ ( $\text{Cu}_3\text{Au}$ ) | $\text{AuPb}_2$                            | 3.15        |                                     |
| $\text{AlLa}_3$                                                    | 5.57        | $\text{DO}_{19}$                                    | $\text{AuPb}_2$ (film)                     | 4.3         |                                     |
| $\text{Al}_2\text{La}$                                             | 3.23        | C15                                                 | $\text{AuPb}_3$                            | 4.40        |                                     |
| $\text{Al}_2\text{Lu}$                                             | 1.02        | C15-cF24 ( $\text{Cu}_2\text{Mg}$ )                 | $\text{AuPb}_3$ (film)                     | 4.25        |                                     |
| $\text{Al}_3\text{Mg}_2$                                           | 0.84        | F.C.C.                                              | $\text{Au}_2\text{Pb}$                     | 1.18; 6–7   | C15                                 |
| $\text{AlMo}_3$                                                    | 0.58        | A15                                                 | $\text{AuSb}_2$                            | 0.58        | C2                                  |
| $\text{AlMo}_6\text{Pd}$                                           | 2.1         |                                                     | $\text{AuSn}$                              | 1.25        | $\text{B8}_1$                       |
| $\text{AlN}$                                                       | 1.55        | B4                                                  | $\text{Au}_x\text{Sn}_{1-x}$ (film)        | 2.0–3.8     |                                     |
| $\text{Al}_2\text{NNb}_3$                                          | 1.3         | A13                                                 | $\text{Au}_5\text{Sn}$                     | 0.7–1.1     | A3                                  |
| $\text{Al}_3\text{Nb}$                                             | 0.64        | tI8 ( $\text{Al}_3\text{Ti}$ )                      | $\text{AuTa}_{4.3}$                        | 0.55        | A15-cP8 ( $\text{Cr}_3\text{Si}$ )  |
| $\text{AlOs}$                                                      | 0.39        | B2                                                  | $\text{Au}_3\text{Te}_5$                   | 1.62        | Cubic                               |
| $\text{Al}_3\text{Os}$                                             | 5.90        |                                                     | $\text{AuTh}_2$                            | 3.08        | C16                                 |
| $\text{AlPb}$ (film)                                               | 1.2–7       |                                                     | $\text{AuTi}$                              | 1.92        |                                     |
| $\text{Al}_2\text{Pt}$                                             | 0.48–0.55   | C1                                                  | $\text{AuV}_3$                             | 0.74        | A15                                 |
| $\text{Al}_5\text{Re}_{24}$                                        | 3.35        | A12                                                 | $\text{Au}_x\text{Zn}_{1-x}$               | 0.50–0.845  |                                     |
| $\text{AlSb}$                                                      | 2.8         | B4-tI4 (Sn)                                         | $\text{AuZn}_3$                            | 1.21        | Cubic                               |
| $\text{Al}_2\text{Sc}$                                             | 1.02        | C15-cF24 ( $\text{Cu}_2\text{Mg}$ )                 | $\text{Au}_x\text{Zr}_y$                   | 1.7–2.8     | A3                                  |
| $\text{Al}_2\text{Si}_2\text{U}$                                   | 1.34        | $\text{LI}_2\text{-cP4}$ ( $\text{Cu}_3\text{Au}$ ) | $\text{AuZr}_3$                            | 0.92        | A15                                 |
| $\text{AlTh}_2$                                                    | 0.1         | C16-tI12 ( $\text{Al}_2\text{Cu}$ )                 | $\text{B}_2\text{Ba}_{0.67}\text{Pt}_3$    | 5.60        | hP12 ( $\text{B}_2\text{BaPt}_3$ )  |
| $\text{Al}_3\text{Th}$                                             | 0.75        | $\text{DO}_{19}$                                    | $\text{BCMo}_2$                            | 5.4         | Orthorhombic                        |
| $\text{Al}_x\text{Ti}_y\text{V}_{1-x-y}$                           | 2.05–3.62   | Cubic                                               | $\text{BCMo}_2$                            | 5.3–7.0     | Same                                |
| $\text{Al}_{0.108}\text{V}_{0.892}$                                | 1.82        | Cubic                                               | $\text{B}_2\text{Ca}_{0.67}\text{Pt}_3$    | 1.57        | hP12                                |
| $\text{Al}_2\text{Y}$                                              | 0.35        | C15-cF24 ( $\text{Cu}_2\text{Mg}$ )                 | $\text{B}_3\text{ErIr}_4$                  | 2.1         | tP18 ( $\text{B}_4\text{CeCo}_4$ )  |
| $\text{Al}_3\text{Yb}$                                             | 0.94        | $\text{LI}_2\text{-cP4}$ ( $\text{Cu}_3\text{Au}$ ) | $\text{B}_4\text{ErRh}_4$                  | 4.3         | oC108 ( $\text{B}_4\text{LuRh}_4$ ) |
| $\text{Al}_x\text{Zn}_{1-x}$                                       | 0.5–0.845   |                                                     | $\text{B}_4\text{ErRh}_4$                  | 8.7         | tP18 ( $\text{B}_4\text{CeCo}_4$ )  |
| $\text{AlZr}_3$                                                    | 0.73        | $\text{LI}_2$                                       | BHf                                        | 3.1         | Cubic                               |
| $\text{AsBiPb}$                                                    | 9.0         |                                                     | $\text{B}_4\text{HoIr}_4$                  | 2.0         | tP18                                |
| $\text{AsBiPbSb}$                                                  | 9.0         |                                                     | $\text{B}_4\text{HoRh}_4$                  | 1.4         | oC108                               |
| $\text{AsHfOs}$                                                    | 3.2         | C22-hP9 ( $\text{Fe}_2\text{P}$ )                   | $\text{B}_2\text{Ir}_3\text{La}$           | 1.65        | hP6 ( $\text{CaCu}_5$ )             |
| $\text{AsHfRu}$                                                    | 4.9         | same                                                | $\text{B}_2\text{Ir}_3\text{Th}$           | 2.09        | Same                                |
| $\text{As}_{0.33}\text{InTe}_{0.67}$ ( $n = 1.24 \times 10^{22}$ ) | 0.85–1.15   | B1                                                  | $\text{B}_4\text{Ir}_4\text{Tm}$           | 1.6         | tP18                                |
| $\text{As}_{0.5}\text{InTe}_{0.5}$ ( $n = 0.97 \times 10^{22}$ )   | 0.44–0.62   | B1                                                  | $\text{B}_6\text{La}$                      | 5.7         |                                     |
| $\text{As}_4\text{La}_3$                                           | 0.6         | cI28 ( $\text{Th}_3\text{P}_4$ )                    | $\text{B}_2\text{LaRh}_3$                  | 2.82        | hP6                                 |
| $\text{AsNb}_3$                                                    | 0.3         | $\text{LI}_2\text{-tP32}$                           | $\text{B}_{12}\text{Lu}$                   | 0.48        |                                     |
| $\text{As}_{0.50}\text{Ni}_{0.06}\text{Pd}_{0.44}$                 | 1.39        | C2                                                  | $\text{B}_2\text{LuOs}$                    | 2.66        | oP16 ( $\text{B}_2\text{LuRu}$ )    |
| $\text{AsNi}_{0.25}\text{Pd}_{0.75}$                               | 1.6         | $\text{B8}_1\text{-hP4}$ ( $\text{NiAs}$ )          | $\text{B}_2\text{LuOs}_3$                  | 4.62        | hP6                                 |
| $\text{AsOsZr}$                                                    | 8.0         | C22-hP9 ( $\text{Fe}_2\text{P}$ )                   | $\text{B}_4\text{LuRh}_4$                  | 6.2         | oC108                               |
| $\text{AsPb}$                                                      | 8.4         |                                                     | $\text{B}_2\text{LuRu}$                    | 9.86        | oP16                                |
| $\text{AsPd}_2$ (low-temp. phase)                                  | 0.60        | Hexagonal                                           | $\text{B}_3\text{LuRu}_4$                  | 2.0         | tI72 ( $\text{B}_4\text{LuRu}_4$ )  |
| $\text{AsPd}_2$ (high-temp. phase)                                 | 1.70        | C22                                                 | BMo                                        | 0.5         |                                     |
| $\text{AsPd}_5$                                                    | 0.46        | Complex                                             |                                            | (extrapol.) |                                     |
| $\text{As}_3\text{Pd}_5$                                           | 1.9         |                                                     | $\text{BMo}_2$                             | 4.74        | C16                                 |
| $\text{AsRh}$                                                      | 0.58        | B31                                                 | $\text{BNb}$                               | 8.25        | $\text{B}_1$                        |
| $\text{AsRh}_{1.4-1.6}$                                            | < 0.03–0.56 | Hexagonal                                           | $\text{B}_4\text{NdRh}_4$                  | 5.3         | tP18                                |
| $\text{AsSn}$                                                      | 4.10        |                                                     | $\text{B}_2\text{OsSc}$                    | 1.34        | oP16                                |
| $\text{AsSn}$ ( $n = 2.14 \times 10^{22}$ )                        | 3.41–3.65   | B1                                                  | $\text{B}_2\text{OsY}$                     | 2.22        | oP16                                |
|                                                                    | 3.5–3.6;    |                                                     | $\text{B}_2\text{Pt}_3\text{Sr}_{0.67}$    | 2.78        | hP12 ( $\text{B}_2\text{BaPt}_3$ )  |
| $\text{As}_{-2}\text{Sn}_{-3}$                                     | 1.21–1.17   |                                                     | $\text{BRe}_2$                             | 2.80; 4.6   |                                     |
| $\text{As}_3\text{Sn}_4$ ( $n = 0.56 \times 10^{22}$ )             | 1.16–1.19   | Rhombohedral                                        | $\text{B}_4\text{Rh}_{3.4}\text{Ru}_{0.6}$ | 8.38        | tI72                                |
| $\text{AsV}_3$                                                     | 0.20        | A15-cP8 ( $\text{Cr}_3\text{Si}$ )                  | $\text{B}_4\text{Rh}_4\text{Sm}$           | 2.7         | tP18                                |
| $\text{Au}_3\text{Ba}$                                             | 0.4–0.7     | $\text{D2}_4$                                       | $\text{B}_4\text{Rh}_4\text{Th}$           | 4.3         | Same                                |
| $\text{AuBe}$                                                      | 2.64        | B20                                                 | $\text{B}_4\text{Rh}_4\text{Tm}$           | 9.8         | Same                                |
| $\text{Au}_2\text{Bi}$                                             | 1.80        | C15                                                 | $\text{B}_4\text{Rh}_4\text{Tm}$           | 5.4         | oC108                               |
| $\text{Au}_5\text{Ca}$                                             | 0.34–0.38   | $\text{C15}_b$                                      | $\text{B}_{0.3}\text{Ru}_{0.7}$            | 2.58        | $\text{D10}_2$                      |
| $\text{AuGa}_2$                                                    | 1.6         | C1-cF12 ( $\text{CaF}_2$ )                          | $\text{B}_4\text{Ru}_4\text{Sc}$           | 7.2         | tI72                                |
| $\text{AuGa}$                                                      | 1.2         | B31                                                 | $\text{B}_2\text{Ru}_3\text{Th}$           | 1.79        | hP6                                 |
| $\text{Au}_{0.40-0.92}\text{Ge}_{0.60-0.08}$                       | < 0.32–1.63 | Complex                                             | $\text{B}_2\text{Ru}_3\text{Y}$            | 2.85        | Same                                |
| $\text{AuIn}_2$                                                    | 0.2         | C1-cF12                                             | $\text{B}_2\text{Ru}_4\text{Y}$            | 7.80        | oP16                                |
| $\text{AuIn}$                                                      | 0.4–0.6     | Complex                                             | $\text{B}_4\text{Ru}_4\text{Y}$            | 1.4         | tI72                                |
| $\text{AuLu}$                                                      | < 0.35      | B2                                                  | $\text{B}_{12}\text{Sc}$                   | 0.39        |                                     |
| $\text{AuNb}_3$                                                    | 1.2         | A2                                                  | BTa                                        | 4.0         | $\text{B}_f$                        |

| Substance                                                                                        | $T_c$ , K | Crystal structure type                   |
|--------------------------------------------------------------------------------------------------|-----------|------------------------------------------|
| B <sub>2</sub> Ta <sub>2</sub>                                                                   | 3.12      | C16-tI12 (Al <sub>2</sub> Cu)            |
| B <sub>6</sub> Th                                                                                | 0.74      |                                          |
| BW <sub>2</sub>                                                                                  | 3.1       | C16                                      |
| B <sub>6</sub> Y                                                                                 | 6.5–7.1   |                                          |
| B <sub>12</sub> Y                                                                                | 4.7       |                                          |
| BZr                                                                                              | 3.4       | Cubic                                    |
| B <sub>12</sub> Zr                                                                               | 5.82      |                                          |
| BaBi <sub>3</sub>                                                                                | 5.69      | Tetragonal                               |
| Ba <sub>2</sub> Mo <sub>15</sub> Se <sub>19</sub>                                                | 2.75      | hP15 (Mo <sub>6</sub> PbS <sub>8</sub> ) |
| Ba <sub>x</sub> O <sub>3</sub> Sr <sub>1-x</sub> Ti (n = 4.2 × 10 <sup>19</sup> )                | <0.1–0.55 |                                          |
| Ba <sub>0.13</sub> O <sub>3</sub> W                                                              | 1.9       | Tetragonal                               |
| Ba <sub>0.14</sub> O <sub>3</sub> W                                                              | <1.25–2.2 | Hexagonal                                |
| BaRh <sub>2</sub>                                                                                | 6.0       | C15                                      |
| Be <sub>22</sub> Mo                                                                              | 2.51      | Cubic (Be <sub>22</sub> Re)              |
| Be <sub>8</sub> Nb <sub>5</sub> Zr <sub>2</sub>                                                  | 5.2       |                                          |
| Be <sub>0.98-0.92</sub> Re <sub>0.02-0.08</sub> (quenched)                                       | 9.5–9.75  | Cubic                                    |
| Be <sub>0.957</sub> Re <sub>0.043</sub>                                                          | 9.62      | Cubic (Be <sub>22</sub> Re)              |
| BeTc                                                                                             | 5.21      | Cubic                                    |
| Be <sub>22</sub> W                                                                               | 4.12      | Cubic (Be <sub>22</sub> Re)              |
| Be <sub>13</sub> W                                                                               | 4.1       | Tetragonal                               |
| Bi <sub>3</sub> Ca                                                                               | 2.0       |                                          |
| Bi <sub>0.5</sub> Cd <sub>0.13</sub> Pb <sub>0.25</sub> Sn <sub>0.12</sub><br>(weight fractions) | 8.2       |                                          |
| BiCo                                                                                             | 0.42–0.49 |                                          |
| Bi <sub>2</sub> Cs                                                                               | 4.75      | C15                                      |
| Bi <sub>x</sub> Cu <sub>1-x</sub> (electrodeposited)                                             | 2.2       |                                          |
| BiCu                                                                                             | 1.33–1.40 |                                          |
| Bi <sub>3</sub> Fe                                                                               | 1.0       | m**                                      |
| Bi <sub>0.019</sub> In <sub>0.981</sub>                                                          | 3.86      |                                          |
| Bi <sub>0.05</sub> In <sub>0.95</sub>                                                            | 4.65      | α-phase                                  |
| Bi <sub>0.10</sub> In <sub>0.90</sub>                                                            | 5.05      | Same                                     |
| Bi <sub>0.15-0.30</sub> In <sub>0.85-0.70</sub>                                                  | 5.3–5.4   | α- and β-phases                          |
| Bi <sub>0.34-0.48</sub> In <sub>0.66-0.52</sub>                                                  | 4.0–4.1   |                                          |
| Bi <sub>3</sub> In <sub>5</sub>                                                                  | 4.1       |                                          |
| BiIn <sub>2</sub>                                                                                | 5.65      | β-phase                                  |
| Bi <sub>2</sub> Ir                                                                               | 1.7–2.3   |                                          |
| Bi <sub>2</sub> Ir (quenched)                                                                    | 3.0–3.96  |                                          |
| BiK                                                                                              | 3.6       |                                          |
| Bi <sub>2</sub> K                                                                                | 3.58      | C15                                      |
| BiLi                                                                                             | 2.47      | L1 <sub>0</sub> α-phase                  |
| Bi <sub>4-9</sub> Mg                                                                             | 0.7–~1.0  |                                          |
| Bi <sub>3</sub> Mo                                                                               | 3–3.7     |                                          |
| BiNa                                                                                             | 2.25      | L1 <sub>0</sub>                          |
| BiNb <sub>3</sub>                                                                                | 4.5       | A15-cP8 (Cr <sub>3</sub> Si)             |
| BiNb <sub>3</sub> (high pressure and temperature)                                                | 3.05      | A15                                      |
| BiNi                                                                                             | 4.25      | B8 <sub>1</sub>                          |
| Bi <sub>3</sub> Ni                                                                               | 4.06      | Orthorhombic                             |
| BiNi <sub>0.5</sub> Rh <sub>0.5</sub>                                                            | 3.0       | B8 <sub>1</sub> -hP4 (AsNi)              |
| Bi <sub>0.5</sub> NiSb <sub>0.5</sub>                                                            | 2.0       | Same                                     |
| Bi <sub>1-0</sub> Pb <sub>0-1</sub>                                                              | 7.26–9.14 |                                          |
| Bi <sub>1-0</sub> Pb <sub>0-1</sub> (film)                                                       | 7.25–8.67 |                                          |
| Bi <sub>0.05-0.40</sub> Pb <sub>0.95-0.60</sub>                                                  | 7.35–8.4  | H.C.P. to ε-phase                        |
| Bi <sub>2</sub> Pb                                                                               | 4.25      | t**                                      |
| BiPbSb                                                                                           | 8.9       |                                          |
| Bi <sub>0.5</sub> Pb <sub>0.31</sub> Sn <sub>0.19</sub> (weight fractions)                       | 8.5       |                                          |
| Bi <sub>0.5</sub> Pb <sub>0.25</sub> Sn <sub>0.25</sub>                                          | 8.5       |                                          |
| BiPd <sub>2</sub>                                                                                | 4.0       |                                          |
| Bi <sub>0.4</sub> Pd <sub>0.6</sub>                                                              | 3.7–4     | Hexagonal, ordered                       |
| BiPd                                                                                             | 3.7       | Orthorhombic                             |

| Substance                                            | $T_c$ , K   | Crystal structure type                     |
|------------------------------------------------------|-------------|--------------------------------------------|
| Bi <sub>2</sub> Pd                                   | 1.70        | Monoclinic, α-phase                        |
| Bi <sub>2</sub> Pd                                   | 4.25        | Tetragonal, β-phase                        |
| BiPd <sub>0.45</sub> Pt <sub>0.55</sub>              | 3.7         | B8 <sub>1</sub> -hP4 (NiAs)                |
| BiPdSe                                               | 1.0         | C2                                         |
| BiPdTe                                               | 1.2         | C2                                         |
| BiPt                                                 | 1.21        | B8 <sub>1</sub>                            |
| Bi <sub>0.1</sub> PtSb <sub>0.9</sub>                | 2.05; 1.5   | B8 <sub>1</sub> -hP4 (NiAs)                |
| BiPtSe                                               | 1.45        | C2                                         |
| BiPtTe                                               | 1.15        | C2                                         |
| Bi <sub>2</sub> Pt                                   | 0.155       | Hexagonal                                  |
| Bi <sub>2</sub> Rb                                   | 4.25        | C15                                        |
| BiRe <sub>2</sub>                                    | 1.9–2.2     |                                            |
| BiRh                                                 | 2.06        | B8 <sub>1</sub>                            |
| Bi <sub>3</sub> Rh                                   | 3.2         | Orthorhombic (NiB <sub>3</sub> )           |
| Bi <sub>4</sub> Rh                                   | 2.7         | Hexagonal                                  |
| BiRu                                                 | 5.7         | m**                                        |
| Bi <sub>3</sub> Sn                                   | 3.6–3.8     |                                            |
| BiSn                                                 | 3.8         |                                            |
| Bi <sub>x</sub> Sn <sub>y</sub>                      | 3.85–4.18   |                                            |
| Bi <sub>3</sub> Sr                                   | 5.62        | L1 <sub>2</sub>                            |
| Bi <sub>3</sub> Te                                   | 0.75–1.0    |                                            |
| Bi <sub>5</sub> Tl <sub>3</sub>                      | 6.4         |                                            |
| Bi <sub>0.26</sub> Tl <sub>0.74</sub>                | 4.4         | Cubic, disordered                          |
| Bi <sub>0.26</sub> Tl <sub>0.74</sub>                | 4.15        | L1 <sub>2</sub> , ordered (?)              |
| Bi <sub>2</sub> Y <sub>3</sub>                       | 2.25        |                                            |
| Bi <sub>3</sub> Zn                                   | 0.8–0.9     |                                            |
| Bi <sub>0.3</sub> Zr <sub>0.7</sub>                  | 1.51        |                                            |
| BiZr <sub>3</sub>                                    | 2.4–2.8     |                                            |
| BrMo <sub>6</sub> Se <sub>7</sub>                    | 7.1         | hP15 (Mo <sub>6</sub> PbS <sub>8</sub> )   |
| Br <sub>3</sub> Mo <sub>6</sub> Se <sub>5</sub>      | 7.1         | Same                                       |
| CCs <sub>x</sub>                                     | 0.020–0.135 | Hexagonal                                  |
| CFe <sub>3</sub>                                     | 1.30        | DO <sub>11</sub> -oP16 (Fe <sub>3</sub> C) |
| CGaMo <sub>2</sub>                                   | 3.7–4.1     | Hexagonal                                  |
| CHf <sub>0.5</sub> Mo <sub>0.5</sub>                 | 3.4         | B1                                         |
| CHf <sub>0.3</sub> Mo <sub>0.7</sub>                 | 5.5         | B1                                         |
| CHf <sub>0.25</sub> Mo <sub>0.75</sub>               | 6.6         | B1                                         |
| CHf <sub>0.7</sub> Nb <sub>0.3</sub>                 | 6.1         | B1                                         |
| CHf <sub>0.6</sub> Nb <sub>0.4</sub>                 | 4.5         | B1                                         |
| CHf <sub>0.5</sub> Nb <sub>0.5</sub>                 | 4.8         | B1                                         |
| CHf <sub>0.4</sub> Nb <sub>0.6</sub>                 | 5.6         | B1                                         |
| CHf <sub>0.25</sub> Nb <sub>0.75</sub>               | 7.0         | B1                                         |
| CHf <sub>0.2</sub> Nb <sub>0.8</sub>                 | 7.8         | B1                                         |
| CHf <sub>0.9-0.1</sub> Ta <sub>0.1-0.9</sub>         | 5.0–9.0     | B1                                         |
| CK (excess K)                                        | 0.55        | Hexagonal                                  |
| C <sub>8</sub> K                                     | 0.39        | Hexagonal                                  |
| C <sub>2</sub> La                                    | 1.66        | tI6 (CaC <sub>2</sub> )                    |
| C <sub>2</sub> Lu                                    | 3.33        | Same                                       |
| C <sub>0.40-0.44</sub> Mo <sub>0.60-0.56</sub>       | 9–13        |                                            |
| C <sub>3</sub> MoRe                                  | 3.8         | B1-cF8                                     |
| C <sub>0.6</sub> Mo <sub>0.4</sub> Si <sub>0.3</sub> | 7.6         | D8 <sub>8</sub>                            |
| CMo <sub>0.2</sub> Ta <sub>0.8</sub>                 | 7.5         | B1                                         |
| CMo <sub>0.5</sub> Ta <sub>0.5</sub>                 | 7.7         | B1                                         |
| CMo <sub>0.75</sub> Ta <sub>0.25</sub>               | 8.5         | B1                                         |
| CMo <sub>0.8</sub> Ta <sub>0.2</sub>                 | 8.7         | B1                                         |
| CMo <sub>0.85</sub> Ta <sub>0.15</sub>               | 8.9         | B1                                         |
| CMo <sub>x</sub> V <sub>1-x</sub>                    | 2.9–9.3     | B1                                         |
| CMo <sub>x</sub> Zr <sub>1-x</sub>                   | 9.8         | B1                                         |
| C <sub>0.984</sub> Nb                                | 9.8         | B1                                         |
| CNb <sub>2</sub>                                     | 9.1         |                                            |
| CNb <sub>x</sub> Ti <sub>1-x</sub>                   | <4.2–8.8    | B1                                         |
| CNb <sub>0.1-0.9</sub> Zr <sub>0.9-0.1</sub>         | 4.2–8.4     | B1                                         |

| Substance                                                                            | $T_c$ , K   | Crystal structure type                                   | Substance                                                     | $T_c$ , K  | Crystal structure type                                   |
|--------------------------------------------------------------------------------------|-------------|----------------------------------------------------------|---------------------------------------------------------------|------------|----------------------------------------------------------|
| CRb <sub>x</sub> (Au)                                                                | 0.023–0.151 | Hexagonal                                                | Co <sub>2</sub> Sc <sub>5</sub> Si <sub>10</sub>              | 5.0        | tP38 (Co <sub>4</sub> Sc <sub>5</sub> Si <sub>10</sub> ) |
| CRe <sub>0.06</sub> W                                                                | 5.0         |                                                          | CoSi <sub>2</sub>                                             | 1.40; 1.22 | C1                                                       |
| CRu                                                                                  | 2.00        | hP2 (CW)                                                 | Co <sub>x</sub> Sn <sub>y</sub> Yb                            | 2.5        | cP40                                                     |
| C <sub>0.98</sub> 7Ta                                                                | 9.7         |                                                          | Co <sub>3</sub> Th <sub>7</sub>                               | 1.83       | D10 <sub>2</sub>                                         |
| C <sub>0.848–0.987</sub>                                                             | 2.04–9.7    |                                                          | Co <sub>x</sub> Ti <sub>1–x</sub>                             | 2.8 (max.) | Co in α-Ti                                               |
| CTa (film)                                                                           | 5.09        | B1                                                       | Co <sub>x</sub> Ti <sub>1–x</sub>                             | 3.8 (max.) | Co in β-Ti                                               |
| CTa <sub>2</sub>                                                                     | 3.26        | L' <sub>3</sub>                                          | CoTi <sub>2</sub>                                             | 3.44       | E9 <sub>3</sub>                                          |
| CTa <sub>0.4</sub> Ti <sub>0.6</sub>                                                 | 4.8         | B1                                                       | CoTi                                                          | 0.71       | A2                                                       |
| Cta <sub>1–0.4</sub> W <sub>0–0.6</sub>                                              | 8.5–10.5    | B1                                                       | CoU                                                           | 1.7        | B2, distorted                                            |
| CTa <sub>0.2–0.9</sub> Zr <sub>0.8–0.1</sub>                                         | 4.6–8.3     | B1                                                       | CoU <sub>6</sub>                                              | 2.29       | D2 <sub>c</sub>                                          |
| CTc (excess C)                                                                       | 3.85        | Cubic                                                    | Co <sub>0.28</sub> Y <sub>0.72</sub>                          | 0.34       |                                                          |
| CTi <sub>0.5–0.7</sub> W <sub>0.5–0.3</sub>                                          | 6.7–2.1     | B1                                                       | CoY <sub>3</sub>                                              | <0.34      |                                                          |
| CW                                                                                   | 1.0         |                                                          | CoZr <sub>2</sub>                                             | 6.3        | C16                                                      |
| CW <sub>2</sub>                                                                      | 2.74        | L' <sub>3</sub>                                          | Co <sub>0.1</sub> Zr <sub>0.9</sub>                           | 3.9        | A3                                                       |
| CW <sub>2</sub>                                                                      | 5.2         | F.C.C.                                                   | Cr <sub>0.6</sub> Ir <sub>0.4</sub>                           | 0.4        | H.C.P.                                                   |
| C <sub>2</sub> Y                                                                     | 3.88        | tl6 (CaC <sub>2</sub> )                                  | Cr <sub>0.65</sub> Ir <sub>0.35</sub>                         | 0.59       | H.C.P.                                                   |
| Ca <sub>3</sub> Co <sub>4</sub> Sn <sub>13</sub>                                     | 5.9         | cP40 (Pr <sub>3</sub> Rh <sub>2</sub> Sn <sub>13</sub> ) | Cr <sub>0.7</sub> Ir <sub>0.3</sub>                           | 0.76       | H.C.P.                                                   |
| Ca <sub>3</sub> Ge <sub>13</sub> Rh <sub>4</sub>                                     | 2.1         | Same                                                     | Cr <sub>0.72</sub> Ir <sub>0.28</sub>                         | 0.83       |                                                          |
| CaHg                                                                                 | 1.6         | B2-cP2 (CsCl)                                            | Cr <sub>3</sub> Ir                                            | 0.45       | A15                                                      |
| CaHg <sub>3</sub>                                                                    | 1.6         | hP8 (Ni <sub>3</sub> Sn)                                 | Cr <sub>0–0.1</sub> Nb <sub>1–0.9</sub>                       | 4.6–9.2    | A2                                                       |
| CaIr <sub>2</sub>                                                                    | 6.15        | C15                                                      | Cr <sub>0.80</sub> Os <sub>0.20</sub>                         | 2.5        | Cubic                                                    |
| Ca <sub>3</sub> Ir <sub>4</sub> Sn <sub>13</sub>                                     | 7.1         | cP40                                                     | Cr <sub>3</sub> Os                                            | 4.68       | A15-cP8 (Cr <sub>3</sub> Si)                             |
| Ca <sub>x</sub> O <sub>3</sub> Sr <sub>1–x</sub> Ti (n = 3.7–11 × 10 <sup>19</sup> ) | < 0.1–0.55  |                                                          | Cr <sub>x</sub> Re <sub>1–x</sub>                             | 1.2–5.2    |                                                          |
| Ca <sub>0.1</sub> O <sub>3</sub> W                                                   | 1.4–3.4     | Hexagonal                                                | Cr <sub>0.4</sub> Re <sub>0.6</sub>                           | 2.15       | D8 <sub>b</sub>                                          |
| CaPb                                                                                 | 7.0         |                                                          | Cr <sub>0.8–0.6</sub> Rh <sub>0.2–0.4</sub>                   | 0.5–1.10   | A3                                                       |
| CaRh <sub>2</sub>                                                                    | 6.40        | C15                                                      | Cr <sub>3</sub> Rh                                            | 0.3        | A15-cP8                                                  |
| CaRh <sub>1.2</sub> Sn <sub>4.5</sub>                                                | 8.7         | cP40                                                     | Cr <sub>3</sub> Ru (annealed)                                 | 3.3        | A15                                                      |
| CaTi <sub>3</sub>                                                                    | 2.0         | B2-cP2                                                   | Cr <sub>2</sub> Ru                                            | 2.02       | D8 <sub>b</sub>                                          |
| Cd <sub>0.3–0.5</sub> Hg <sub>0.7–0.5</sub>                                          | 1.70–1.92   |                                                          | Cr <sub>3</sub> Ru <sub>2</sub>                               | 2.10       | D8 <sub>b</sub> -tP30 (CrFe)                             |
| CdHg                                                                                 | 1.77; 2.15  | Tetragonal                                               | Cr <sub>0.1–0.5</sub> Ru <sub>0.9–0.5</sub>                   | 0.34–1.65  | A3                                                       |
| Cd <sub>0.0075–0.05</sub> In <sub>0.9925–0.95</sub>                                  | 3.24–3.36   | Tetragonal                                               | Cr <sub>x</sub> Ti <sub>1–x</sub>                             | 3.6 (max.) | Cr in α-Ti                                               |
| Cd <sub>0.97</sub> Pb <sub>0.03</sub>                                                | 4.2         |                                                          | Cr <sub>x</sub> Ti <sub>1–x</sub>                             | 4.2 (max.) | Cr in β-Ti                                               |
| CdSn                                                                                 | 3.65        |                                                          | Cr <sub>0.1</sub> Ti <sub>0.3</sub> V <sub>0.6</sub>          | 5.6        |                                                          |
| Cd <sub>0.17</sub> Tl <sub>0.83</sub>                                                | 2.3         |                                                          | Cr <sub>0.0175</sub> U <sub>0.9825</sub>                      | 0.75       | β-phase                                                  |
| Cd <sub>0.18</sub> Tl <sub>0.82</sub>                                                | 2.54        |                                                          | Cs <sub>0.32</sub> O <sub>3</sub> W                           | 1.12       | Hexagonal                                                |
| CeCo <sub>2</sub>                                                                    | 0.84        | C15                                                      | Cu <sub>0.15</sub> In <sub>0.85</sub> (film)                  | 3.75       |                                                          |
| CeCo <sub>1.67</sub> Ni <sub>0.33</sub>                                              | 0.46        | C15                                                      | Cu <sub>0.04–0.08</sub> In <sub>0.94–0.92</sub>               | 4.4        |                                                          |
| CeCo <sub>1.67</sub> Rh <sub>0.33</sub>                                              | 0.47        | C15                                                      | CuLa                                                          | 5.85       |                                                          |
| Ce <sub>x</sub> Gd <sub>1–x</sub> Ru <sub>2</sub>                                    | 3.2–5.2     | C15                                                      | Cu <sub>2</sub> Mo <sub>6</sub> O <sub>2</sub> S <sub>6</sub> | 9          | hR15 (Mo <sub>6</sub> PbS <sub>8</sub> )                 |
| CeIr <sub>3</sub>                                                                    | 3.34        |                                                          | Cu <sub>2</sub> Mo <sub>6</sub> Se <sub>8</sub>               | 5.9        | Same                                                     |
| CeIr <sub>5</sub>                                                                    | 1.82        |                                                          | Cu <sub>x</sub> Pb <sub>1–x</sub>                             | 5.7–7.7    |                                                          |
| Ce <sub>0.005</sub> La <sub>0.995</sub>                                              | 4.6         |                                                          | CuS                                                           | 1.62       | B18                                                      |
| Ce <sub>x</sub> La <sub>1–x</sub>                                                    | 1.3–6.3     |                                                          | CuS <sub>2</sub>                                              | 1.48–1.53  | C18                                                      |
| Ce <sub>x</sub> Pr <sub>1–x</sub> Ru <sub>2</sub>                                    | 1.4–5.3     | C15                                                      | CuSSe                                                         | 1.5–2.0    | C18                                                      |
| Ce <sub>x</sub> Pt <sub>1–x</sub>                                                    | 0.7–1.55    |                                                          | CuSe <sub>2</sub>                                             | 2.3–2.43   | C18                                                      |
| CeRu <sub>2</sub>                                                                    | 6.0         | C15                                                      | CuSeTe                                                        | 1.6–2.0    | C18                                                      |
| Ce <sub>3</sub> Mo <sub>6</sub> Se <sub>5</sub>                                      | 5.7         | hR15 (Mo <sub>6</sub> PbS <sub>8</sub> )                 | Cu <sub>x</sub> Sn <sub>1–x</sub>                             | 3.2–3.7    |                                                          |
| Ce <sub>2</sub> Mo <sub>6</sub> Te <sub>6</sub>                                      | 1.7         | Same                                                     | Cu <sub>x</sub> Sn <sub>1–x</sub> (film, made at 10K)         | 3.6–7      |                                                          |
| Co <sub>x</sub> Fe <sub>1–x</sub> Si <sub>2</sub>                                    | 1.4 (max.)  | C1                                                       | Cu <sub>x</sub> Sn <sub>1–x</sub> (film, made at 300K)        | 2.8–3.7    |                                                          |
| CoHf <sub>2</sub>                                                                    | 0.56        | E9 <sub>3</sub>                                          | CuTe <sub>2</sub>                                             | <1.25–1.3  | C18                                                      |
| CoLa <sub>3</sub>                                                                    | 4.28        |                                                          | CuTh <sub>2</sub>                                             | 3.49       | C16                                                      |
| Co <sub>4</sub> La <sub>3</sub> Sn <sub>13</sub>                                     | 2.8         | cP40                                                     | Cu <sub>0–0.027</sub> V                                       | 3.9–5.3    | A2                                                       |
| CoLu <sub>3</sub>                                                                    | ~0.35       |                                                          | CuY                                                           | 0.33       | B2-cP2 (CsCl)                                            |
| Co <sub>x</sub> LuSn <sub>y</sub>                                                    | 1.5         | cP40                                                     | Cu <sub>x</sub> Zn <sub>1–x</sub>                             | 0.5–0.845  |                                                          |
| Co <sub>0–0.01</sub> Mo <sub>0.8</sub> Re <sub>0.2</sub>                             | 2–10        |                                                          | DyMo <sub>6</sub> S <sub>8</sub>                              | 2.1        | hR15                                                     |
| Co <sub>0.02–0.10</sub> Nb <sub>3</sub> Rh <sub>0.98–0.90</sub>                      | 2.28–1.90   | A15                                                      | Er <sub>x</sub> La <sub>1–x</sub>                             | 1.4–6.3    |                                                          |
| Co <sub>x</sub> Ni <sub>1–x</sub> Si <sub>2</sub>                                    | 1.4 (max.)  | C1                                                       | ErMo <sub>6</sub> S <sub>8</sub>                              | 2.2        | hR15                                                     |
| Co <sub>0.5</sub> Rh <sub>0.5</sub> Si <sub>2</sub>                                  | 2.5         |                                                          | ErMo <sub>6</sub> Se <sub>8</sub>                             | 6.2        | hR15                                                     |
| Co <sub>x</sub> Rh <sub>1–x</sub> Si <sub>2</sub>                                    | 3.65 (max.) |                                                          | Fe <sub>3</sub> Lu <sub>2</sub> Si <sub>5</sub>               | 6.1        | tP40 (Fe <sub>3</sub> Sc <sub>2</sub> Si <sub>5</sub> )  |
| Co <sub>–0.3</sub> So <sub>–0.7</sub>                                                | ~0.35       |                                                          | Fe <sub>0–0.04</sub> Mo <sub>0.8</sub> Re <sub>0.2</sub>      | 1–10       |                                                          |
|                                                                                      |             |                                                          | Fe <sub>0.05</sub> Ni <sub>0.05</sub> Zr <sub>0.90</sub>      | ~3.9       |                                                          |

| Substance                                                            | $T_c$ , K  | Crystal structure type                               | Substance                                                                     | $T_c$ , K   | Crystal structure type                      |
|----------------------------------------------------------------------|------------|------------------------------------------------------|-------------------------------------------------------------------------------|-------------|---------------------------------------------|
| $\text{Fe}_3\text{Re}_2$                                             | 6.55       | $\text{D8}_b\text{-tP30 (FeCr)}$                     | $\text{GeV}_3$                                                                | 6.01        | A15                                         |
| $\text{Fe}_3\text{Sc}_2\text{Si}_5$                                  | 4.52       | tP40                                                 | $\text{Ge}_2\text{Y}$                                                         | 3.80        | $\text{C}_c$                                |
| $\text{Fe}_3\text{Si}_5\text{Ti}$                                    | 1.3        | Same                                                 | $\text{Ge}_{1.62}\text{Y}$                                                    | 2.4         |                                             |
| $\text{Fe}_3\text{Si}_5\text{Y}_2$                                   | 2.4        | Same                                                 | $\text{Ge}_2\text{Zr}$                                                        | 0.30        | oC12 ( $\text{ZrSi}_2$ )                    |
| $\text{Fe}_3\text{Th}_7$                                             | 1.86       | D10                                                  | $\text{GeZr}_3$                                                               | 0.4         | $\text{L1}_2\text{-tP32 (Ti}_3\text{P)}$    |
| $\text{Fe}_x\text{Ti}_{1-x}$                                         | 3.2 (max.) | Fe in $\alpha\text{-Ti}$                             | $\text{H}_{0.33}\text{Nb}_{0.67}$                                             | 7.28        | B.C.C.                                      |
| $\text{Fe}_x\text{Ti}_{1-x}$                                         | 3.7 (max.) | Fe in $\beta\text{-Ti}$                              | $\text{H}_{0.1}\text{Nb}_{0.9}$                                               | 7.38        | Same                                        |
| $\text{Fe}_x\text{Ti}_{0.6}\text{V}_{1-x}$                           | 6.8 (max.) |                                                      | $\text{H}_{0.05}\text{Nb}_{0.95}$                                             | 7.83        | Same                                        |
| $\text{FeU}_6$                                                       | 3.86       | $\text{D2}_c$                                        | $\text{H}_{0.12}\text{Ta}_{0.88}$                                             | 2.81        | B.C.C.                                      |
| $\text{Fe}_{0.1}\text{Zr}_{0.9}$                                     | 1.0        | A3                                                   | $\text{H}_{0.08}\text{Ta}_{0.92}$                                             | 3.26        | Same                                        |
| $\text{Ga}_{0.5}\text{Ge}_{0.5}\text{Nb}_3$                          | 7.3        | A15                                                  | $\text{H}_{0.04}\text{Ta}_{0.96}$                                             | 3.62        | Same                                        |
| $\text{Ga}_2\text{Ge}_2\text{U}$                                     | 0.87       | B2-cP2                                               | HfIrSi                                                                        | 3.50        | C37-cP12 ( $\text{Co}_2\text{Si}$ )         |
| $\text{GaHf}_2$                                                      | 0.21       | C16-tI12 ( $\text{Al}_2\text{Cu}$ )                  | $\text{HfMo}_2$                                                               | 0.05        | hP24 ( $\text{Ni}_2\text{Mn}$ )             |
| $\text{GaLa}_3$                                                      | 5.84       |                                                      | HfN <sub>0.989</sub>                                                          | 6.6         | B1                                          |
| $\text{Ga}_3\text{Lu}$                                               | 2.3        | B2-cP2                                               | $\text{Hf}_{0-0.5}\text{Nb}_{1-0.5}$                                          | 8.3–9.5     | A2                                          |
| $\text{Ga}_2\text{Mo}$                                               | 9.5        |                                                      | $\text{Hf}_{0.75}\text{Nb}_{0.25}$                                            | > 4.2       |                                             |
| $\text{GaMo}_3$                                                      | 0.76       | A15                                                  | HfOs <sub>2</sub>                                                             | 2.69        | C14                                         |
| GaN (black)                                                          | 5.85       | B4                                                   | HfOsP                                                                         | 6.1         | C22-hP9 ( $\text{Fe}_2\text{P}$ )           |
| $\text{Ga}_{0.7}\text{Pt}_{0.3}$                                     | 2.9        | C1                                                   | HfPRu                                                                         | 9.9         | Same                                        |
| GaPt                                                                 | 1.74       | B20                                                  | HfRe <sub>2</sub>                                                             | 4.80        | C14                                         |
| GaSb (120kbar, 77K, annealed)                                        | 4.24       | A5                                                   | $\text{Hf}_{0.14}\text{Re}_{0.86}$                                            | 5.86        | A12                                         |
| GaSb (unannealed)                                                    | ~5.9       |                                                      | $\text{Hf}_{0.99-0.96}\text{Rh}_{0.01-0.04}$                                  | 0.85–1.51   |                                             |
| $\text{Ga}_{0-1}\text{Sn}_{1-0}$ (quenched)                          | 3.47–4.18  |                                                      | $\text{Hf}_{0-0.55}\text{Ta}_{1-0.45}$                                        | 4.4–6.5     | A2                                          |
| $\text{Ga}_{0-1}\text{Sn}_{1-0}$ (annealed)                          | 2.6–3.85   |                                                      | HfV <sub>2</sub>                                                              | 8.9–9.6     | C15                                         |
| GaTe                                                                 | 0.17       | mC24 (GaTe)                                          | $\text{Hg}_x\text{In}_{1-x}$                                                  | 3.14–4.55   |                                             |
| $\text{Ga}_5\text{V}_2$                                              | 3.55       | Tetragonal ( $\text{Mn}_2\text{Hg}_5$ )              | HgIn                                                                          | 3.81        |                                             |
| GaV <sub>4.5</sub>                                                   | 9.15       |                                                      | HgK                                                                           | 1.20        | Orthorhombic                                |
| $\text{Ga}_3\text{Zr}$                                               | 1.38       |                                                      | $\text{Hg}_3\text{K}$                                                         | 3.18        |                                             |
| $\text{Ga}_3\text{Zr}_5$                                             | 3.8        | $\text{D8}_b\text{-hP16 (Mn}_5\text{Si}_3)$          | $\text{Hg}_4\text{K}$                                                         | 3.27        |                                             |
| $\text{Gd}_x\text{La}_{1-x}$                                         | < 1.0–5.5  |                                                      | $\text{Hg}_8\text{K}$                                                         | 3.42        |                                             |
| $\text{GdMo}_6\text{S}_8$                                            | 3.5        | hR15                                                 | $\text{Hg}_3\text{Li}$                                                        | 1.7         | Hexagonal                                   |
| $\text{GdMo}_6\text{Se}_8$                                           | 5.6        | hR15                                                 | $\text{HgMg}_3$                                                               | 0.17        | hP8 ( $\text{Na}_3\text{As}$ )              |
| $\text{Gd}_x\text{Os}_2\text{Y}_{1-x}$                               | 1.4–4.7    |                                                      | $\text{Hg}_2\text{Mg}$                                                        | 4.0         | tI6 ( $\text{MoSi}_2$ )                     |
| $\text{Gd}_x\text{Ru}_2\text{Th}_{1-x}$                              | 3.6 (max.) | C15                                                  | $\text{Hg}_3\text{Mg}_5$                                                      | 0.48        | $\text{D8}_b\text{-hP16 (Mn}_5\text{Si}_3)$ |
| $\text{Ge}_{10}\text{As}_4\text{Y}_5$                                | 9.06       | tP38 ( $\text{Co}_4\text{Sc}_5\text{Si}_{10}$ )      | $\text{Hg}_2\text{Na}$                                                        | 1.62        | Hexagonal                                   |
| GeIr                                                                 | 4.7        | B31                                                  | $\text{Hg}_4\text{Na}$                                                        | 3.05        |                                             |
| GeIrLa                                                               | 1.64       | tI12 (LaPtSi)                                        | $\text{Hg}_x\text{Pb}_{1-x}$                                                  | 4.14–7.26   |                                             |
| $\text{Ge}_{10}\text{Ir}_4\text{Lu}_5$                               | 2.60       | tP38                                                 | HgSn                                                                          | 4.2         |                                             |
| $\text{Ge}_{10}\text{Ir}_4\text{Y}_5$                                | 2.62       | tP38                                                 | $\text{Hg}_x\text{Ti}_{1-x}$                                                  | 2.30–4.19   |                                             |
| $\text{Ge}_2\text{La}$                                               | 1.49; 2.2  | Orthorhombic, distorted ( $\text{Mn}_2\text{Hg}_5$ ) | $\text{Hg}_5\text{Ti}_2$                                                      | 3.86        |                                             |
| GeLaPt                                                               | 3.53       | tI12                                                 | $\text{Ho}_x\text{La}_{1-x}$                                                  | 1.3–6.3     |                                             |
| $\text{Ge}_{13}\text{Lu}_3\text{Os}_4$                               | 3.6        | cP40 ( $\text{Pr}_3\text{Rh}_2\text{Sn}_{13}$ )      | $\text{Ho}_{1.2}\text{Mo}_6\text{Se}_8$                                       | 6.1         | $\text{D10}_2\text{-hR12 (Be}_3\text{Nb)}$  |
| $\text{Ge}_{10}\text{Lu}_5\text{Rh}_4$                               | 2.79       | tP38                                                 | $\text{In}_{1-0.86}\text{Mg}_{0-0.14}$                                        | 3.395–3.363 |                                             |
| $\text{Ge}_{13}\text{Lu}_3\text{Ru}_4$                               | 2.3        | cP40                                                 | $\text{In}_2\text{Mo}_6\text{Te}_6$                                           | 2.6         | hR15 ( $\text{Mo}_6\text{PbS}_8$ )          |
| $\text{GeMo}_3$                                                      | 1.43       | A15                                                  | InNb <sub>3</sub> (high pressure and temp.)                                   | 4–8; 9.2    | A15                                         |
| $\text{GeNb}_2$                                                      | 1.9        |                                                      | $\text{In}_{0.5}\text{Nb}_3\text{Zr}_{0.5}$                                   | 6.4         |                                             |
| $\text{Ge}_{0.29}\text{Nb}_{0.71}$                                   | 6          | A15                                                  | $\text{In}_{0.11}\text{O}_3\text{W}$                                          | < 1.25–2.8  | Hexagonal                                   |
| GePt                                                                 | 0.40       | B31                                                  | $\text{In}_{0.95-0.85}\text{Pb}_{0.05-0.15}$                                  | 3.6–5.05    |                                             |
| $\text{Ge}_3\text{Rh}_5$                                             | 2.12       | Orthorhombic, related to InNi <sub>2</sub>           | $\text{In}_{0.98-0.91}\text{Pb}_{0.02-0.09}$                                  | 3.45–4.2    |                                             |
| GeRh                                                                 | 0.96       | B31-oP8 (MnP)                                        | InPb                                                                          | 6.65        |                                             |
| $\text{Ge}_{13}\text{Rh}_4\text{Sc}_3$                               | 1.9        | c P40                                                | InPd                                                                          | 0.7         | B2                                          |
| $\text{Ge}_{10}\text{Rh}_4\text{Y}_5$                                | 1.35       | tP38                                                 | InSb (quenched from 170 kbar into liquid N <sub>2</sub> )                     | 4.8         | Like A5                                     |
| $\text{Ge}_{13}\text{Ru}_4\text{Y}_3$                                | 1.7        | cP40                                                 | InSb                                                                          | 2.1         | B4                                          |
| $\text{Ge}_2\text{So}$                                               | 1.3        |                                                      | (InSb) <sub>0.95-0.10</sub> Sn <sub>0.05-0.90</sub> (various heat treatments) | 3.8–5.1     |                                             |
| $\text{GeTa}_3$                                                      | 8.0        | A15-cP8 ( $\text{Cr}_3\text{Si}$ )                   | (InSb) <sub>0-0.07</sub> Sn <sub>1-0.93</sub>                                 | 3.67–3.74   |                                             |
| $\text{Ge}_3\text{Te}_4$ ( $n = 1.06 \times 10^{22}$ )               | 1.55–1.80  | Rhombohedral                                         | In <sub>3</sub> Sn                                                            | ~5.5        |                                             |
| $\text{Ge}_x\text{Te}_{1-x}$ ( $n = 8.5\text{--}64 \times 10^{20}$ ) | 0.07–0.41  | R1                                                   | $\text{In}_x\text{Sn}_{1-x}$                                                  | 3.4–7.3     |                                             |

| Substance                                                        | $T_c$ , K  | Crystal structure type                          | Substance                                     | $T_c$ , K  | Crystal structure type                                |
|------------------------------------------------------------------|------------|-------------------------------------------------|-----------------------------------------------|------------|-------------------------------------------------------|
| $\text{In}_{0.82-1}\text{Te}$ ( $n = 0.83-1.71 \times 10^{22}$ ) | 1.02–3.45  | B1                                              | $\text{Ir}_2\text{Y}_3$                       | 1.61       |                                                       |
| $\text{In}_{1.000}\text{Te}_{1.002}$                             | 3.5–3.7    | B1                                              | $\text{Ir}_3\text{Y}$                         | 3.50       | $\text{D}10_2\text{-hR13}$ ( $\text{Be}_3\text{Nb}$ ) |
| $\text{In}_3\text{Te}_4$ ( $n = 4.7 \times 10^{21}$ )            | 1.15–1.25  | Rhombohedral                                    | $\text{Ir}_x\text{Y}_{1-x}$                   | 0.3–3.7    |                                                       |
| $\text{In}_x\text{Tl}_{1-x}$                                     | 2.7–3.374  |                                                 | $\text{Ir}_2\text{Zr}$                        | 4.10       | C15                                                   |
| $\text{In}_{0.8}\text{Tl}_{0.2}$                                 | 3.223      |                                                 | $\text{Ir}_{0.1}\text{Zr}_{0.9}$              | 5.5        | A3                                                    |
| $\text{In}_{0.62}\text{Tl}_{0.38}$                               | 2.760      |                                                 | $\text{K}_2\text{Mo}_{15}\text{S}_{19}$       | 3.32       | hR15                                                  |
| $\text{In}_{0.78-0.69}\text{Tl}_{0.22-0.31}$                     | 3.18–3.32  | Tetragonal                                      | $\text{K}_{0.27-0.31}\text{O}_3\text{W}$      | 0.50       | Hexagonal                                             |
| $\text{In}_{0.69-0.62}\text{Tl}_{0.31-0.38}$                     | 2.98–3.3   | F.C.C.                                          | $\text{K}_{0.40-0.57}\text{O}_3\text{W}$      | 1.5        | Tetragonal                                            |
| $\text{Ir}_2\text{La}$                                           | 0.48       | C15                                             | $\text{La}_{0.55}\text{Lu}_{0.45}$            | 2.2        | Hexagonal, La type                                    |
| $\text{Ir}_3\text{La}$                                           | 2.32       | $\text{D}10_2$                                  | $\text{La}_{0.8}\text{Lu}_{0.2}$              | 3.4        | Same                                                  |
| $\text{Ir}_3\text{La}_7$                                         | 2.24       | $\text{D}10_2$                                  | $\text{LaMg}_2$                               | 1.05       | C15                                                   |
| $\text{Ir}_5\text{La}$                                           | 2.13       |                                                 | $\text{LaMo}_6\text{S}_8$                     | 7.1        | hR15                                                  |
| $\text{IrLaSi}_2$                                                | 2.03       | oC16 ( $\text{CeNiSi}_2$ )                      | $\text{LaN}$                                  | 1.35       |                                                       |
| $\text{IrLaSi}_3$                                                | 2.7        | tI10 ( $\text{BaNiSn}_3$ )                      | $\text{LaOs}_2$                               | 6.5        | C15                                                   |
| $\text{Ir}_2\text{Lu}$                                           | 2.47       | C15                                             | $\text{LaPt}_2$                               | 0.46       | C15                                                   |
| $\text{Ir}_3\text{Lu}$                                           | 2.89       | C15                                             | $\text{La}_{0.28}\text{Pt}_{0.72}$            | 0.54       | C15                                                   |
| $\text{Ir}_4\text{Lu}_5\text{Si}_{10}$                           | 3.9        | tP38 ( $\text{Co}_4\text{Sc}_5\text{Si}_{10}$ ) | $\text{LaPtSi}$                               | 3.48       | tI12                                                  |
| $\text{IrMo}$                                                    | < 1.0      | A3                                              | $\text{LaRh}_3$                               | 2.60       |                                                       |
| $\text{IrMo}_3$                                                  | 9.6        | A15                                             | $\text{LaRh}_5$                               | 1.62       |                                                       |
| $\text{IrMo}_3$                                                  | 6.8        | $\text{D}8_b$                                   | $\text{La}_7\text{Rh}_3$                      | 2.58       | $\text{D}10_2$                                        |
| $\text{IrNb}_3$                                                  | 1.9        | A15                                             | $\text{LaRhSi}_2$                             | 3.42       | oC16 ( $\text{CeNiSi}_2$ )                            |
| $\text{Ir}_{0.4}\text{Nb}_{0.6}$                                 | 9.8        | $\text{D}8_b$                                   | $\text{La}_2\text{Rh}_3\text{Si}_5$           | 4.45       | oI40 ( $\text{Co}_3\text{Si}_5\text{U}_2$ )           |
| $\text{Ir}_{0.37}\text{Nb}_{0.63}$                               | 2.32       | $\text{D}8_b$                                   | $\text{LaRhSi}_3$                             | 2.7        | tI10 ( $\text{BaNiSn}_3$ )                            |
| $\text{IrNb}$                                                    | 7.9        | $\text{D}8_b$                                   | $\text{LaRh}_2\text{Si}_2$                    | 3.90       | tI10 ( $\text{Al}_4\text{Ba}$ )                       |
| $\text{Ir}_{1.15}\text{Nb}_{0.85}$                               | 4.6        | oP12 ( $\text{IrTa}$ )                          | $\text{LaRu}_2$                               | 1.63       | C15                                                   |
| $\text{Ir}_{0.02}\text{Nb}_3\text{Rh}_{0.98}$                    | 2.43       | A15                                             | $\text{La}_3\text{S}_4$                       | 6.5        | $\text{D}7_3$                                         |
| $\text{Ir}_{0.05}\text{Nb}_3\text{Rh}_{0.95}$                    | 2.38       | A15                                             | $\text{La}_3\text{Se}_4$                      | 8.6        | $\text{D}7_3$                                         |
| $\text{Ir}_{0.287}\text{O}_{0.14}\text{Ti}_{0.573}$              | 5.5        | $\text{E}9_3$                                   | $\text{LaSi}_2$                               | 2.3        | $\text{C}_c$                                          |
| $\text{Ir}_{0.265}\text{O}_{0.035}\text{Ti}_{0.65}$              | 2.30       | $\text{E}9_3$                                   | $\text{LaY}_{x-1-x}$                          | 1.7–5.4    |                                                       |
| $\text{Ir}_x\text{Os}_{1-x}$                                     | 0.3–0.98   |                                                 | $\text{LaZn}$                                 | 1.04       | B2                                                    |
| $\text{Ir}_{1.5}\text{Os}_{0.5}$                                 | 2.4        | C14                                             | $\text{Li}_2\text{Mo}_6\text{S}_8$            | 4.2        | hR15                                                  |
| $\text{IrOsY}$                                                   | 2.6        | C15                                             | $\text{LiPb}$                                 | 7.2        |                                                       |
| $\text{IrSiY}$                                                   | 2.70       | C37-oP12 ( $\text{Co}_2\text{Si}$ )             | $\text{LuOs}_2$                               | 3.49       | C14                                                   |
| $\text{IrSiZr}$                                                  | 2.04       | Same                                            | $\text{Lu}_{0.275}\text{Rh}_{0.725}$          | 1.27       | C15                                                   |
| $\text{Ir}_2\text{Sc}$                                           | 2.07       | C15                                             | $\text{LuRh}_5$                               | 0.49       |                                                       |
| $\text{Ir}_{2.5}\text{Sc}$                                       | 2.46       | C15                                             | $\text{Lu}_5\text{Rh}_4\text{Si}_{10}$        | 3.95       | tP38 ( $\text{Co}_4\text{So}_5\text{Si}_{10}$ )       |
| $\text{Ir}_4\text{Sc}_5\text{Si}_{10}$                           | 8.46       | tP38                                            | $\text{LuRu}_2$                               | 0.86       | C14                                                   |
| $\text{Ir}_2\text{Si}_2\text{Th}$                                | 2.14       | tI10                                            | $\text{Mg}_{1.14}\text{Mo}_{6.6}\text{S}_8$   | 3.5        | hR15                                                  |
| $\text{IrSi}_3\text{Th}$                                         | 1.75       | tI10                                            | $\text{Mg}_2\text{Nb}$                        | 5.6        |                                                       |
| $\text{IrSiTh}$                                                  | 6.50       | tI12 ( $\text{LaPtSi}$ )                        | $\text{Mg}_{-0.47}\text{Tl}_{-0.53}$          | 2.75       | B2                                                    |
| $\text{Ir}_2\text{Si}_2\text{Y}$                                 | 2.60       | tI10 ( $\text{Al}_4\text{Ba}$ )                 | $\text{MgZn}$                                 | 0.9        | A3-oP4 ( $\text{AuCd}$ )                              |
| $\text{Ir}_4\text{Si}_{10}\text{Y}_5$                            | 3.10       | tP38                                            | $\text{Mn}_x\text{Ti}_{1-x}$                  | 2.3 (max.) | Mn in -Ti                                             |
| $\text{Ir}_3\text{Si}_5\text{Y}_2$                               | 2.83       | oI40                                            | $\text{Mn}_x\text{Ti}_{1-x}$                  | 1.1–3.0    | Mn in -Ti                                             |
| $\text{IrSn}_2$                                                  | 0.65–0.78  | C1                                              | $\text{MnU}_6$                                | 2.32       | $\text{D}2_c$                                         |
| $\text{Ir}_2\text{Sr}$                                           | 5.70       | C15                                             | $\text{Mo}_2\text{N}$                         | 5.0        | F.C.C.                                                |
| $\text{Ir}_7\text{Ta}_{13}$                                      | 1.2        | $\text{D}8_b\text{-tP30}$ ( $\text{FeCr}$ )     | $\text{Mo}_6\text{Na}_2\text{S}_8$            | 8.6        | hR15                                                  |
| $\text{Ir}_{0.5}\text{Te}_{0.5}$                                 | ~3         |                                                 | $\text{Mo}_x\text{Nb}_{1-x}$                  | 0.016–9.2  |                                                       |
| $\text{IrTe}_3$                                                  | 1.18       | C2                                              | $\text{Mo}_{5.25}\text{Nb}_{0.75}\text{Se}_8$ | 6.2        | hR15                                                  |
| $\text{IrTh}$                                                    | < 0.37     | $\text{B}_f$                                    | $\text{Mo}_6\text{NdSa}_8$                    | 8.2        | hR15                                                  |
| $\text{Ir}_2\text{Th}$                                           | 6.50       | C15                                             | $\text{Mo}_3\text{Os}$                        | 7.2        | A15                                                   |
| $\text{Ir}_3\text{Th}$                                           | 4.71       |                                                 | $\text{Mo}_{0.62}\text{Cs}_{0.38}$            | 5.65       | $\text{D}8_b$                                         |
| $\text{Ir}_3\text{Th}_7$                                         | 1.52       | $\text{D}10_2$                                  | $\text{Mo}_3\text{P}$                         | 5.31       | $\text{DO}_e$                                         |
| $\text{Ir}_5\text{Th}$                                           | 3.93       | $\text{D}2_d$                                   | $\text{Mo}_6\text{Pb}_{1.2}\text{Se}_8$       | 6.75       | hR15                                                  |
| $\text{IrTi}_3$                                                  | 5.40       | A15                                             | $\text{Mo}_{0.5}\text{Pd}_{0.5}$              | 3.52       | A3                                                    |
| $\text{IrV}_2$                                                   | 1.39       | A15                                             | $\text{Mo}_6\text{PrSe}_8$                    | 9.2        | hR15                                                  |
| $\text{IrW}_3$                                                   | 3.82       |                                                 | $\text{MoRe}$                                 | 7.8        | $\text{D}8_b\text{-tP30}$                             |
| $\text{Ir}_{0.28}\text{W}_{0.72}$                                | 4.49       |                                                 | $\text{MoRe}_3$                               | 9.25; 9.89 | A12                                                   |
| $\text{Ir}_2\text{Y}$                                            | 2.18; 1.38 | C15                                             | $\text{Mo}_x\text{Re}_{1-x}$                  | 1.2–12.2   |                                                       |
| $\text{Ir}_{0.69}\text{Y}_{0.31}$                                | 1.98; 1.44 | C15                                             | $\text{Mo}_{0.42}\text{Re}_{0.58}$            | 6.35       | $\text{D}8_b$                                         |
| $\text{Ir}_{0.70}\text{Y}_{0.30}$                                | 2.16       | C15                                             | $\text{MoRh}$                                 | 1.97       | A3                                                    |
|                                                                  |            |                                                 | $\text{Mo}_x\text{Rh}_{1-x}$                  | 1.5–8.2    | B.C.C.                                                |



| Substance                                                       | $T_c$ , K  | Crystal structure type                    |
|-----------------------------------------------------------------|------------|-------------------------------------------|
| MoRu                                                            | 9.5–10.5   | A3                                        |
| Mo <sub>0.61</sub> Ru <sub>0.39</sub>                           | 7.18       | D8 <sub>b</sub>                           |
| Mo <sub>0.2</sub> Ru <sub>0.8</sub>                             | 1.66       | A3                                        |
| Mo <sub>3</sub> Ru <sub>2</sub>                                 | 7.0        | D8 <sub>b</sub> -tP30                     |
| Mo <sub>4</sub> Ru <sub>2</sub> Te <sub>8</sub>                 | 1.7        | hR15                                      |
| Mo <sub>6</sub> S <sub>8</sub>                                  | 1.85       | hR15                                      |
| Mo <sub>6</sub> S <sub>8</sub> Sc                               | 3.6        | hR15                                      |
| Mo <sub>6</sub> S <sub>8</sub> Sm <sub>1.2</sub>                | 2.9        | hR15                                      |
| Mo <sub>6</sub> S <sub>8</sub> Tb                               | 2.0        | hR15                                      |
| Mo <sub>6</sub> S <sub>8</sub> Tl                               | 8.7        | hR15                                      |
| Mo <sub>6</sub> S <sub>8</sub> Tm <sub>1.2</sub>                | 2.1        | hR15                                      |
| Mo <sub>6</sub> S <sub>8</sub> Y <sub>1.2</sub>                 | 3.0        | hR15                                      |
| Mo <sub>6</sub> S <sub>8</sub> Yb                               | 9.2        | hR15                                      |
| Mo <sub>6.6</sub> S <sub>8</sub> Zn <sub>11</sub>               | 3.6        | hR15                                      |
| Mo <sub>3</sub> Sb <sub>4</sub>                                 | 2.1        |                                           |
| Mo <sub>6</sub> Se <sub>8</sub>                                 | 6.3        | hR15                                      |
| Mo <sub>6</sub> Se <sub>8</sub> Sm <sub>1.2</sub>               | 6.8        | hR15                                      |
| Mo <sub>6</sub> Se <sub>8</sub> Sn <sub>1.2</sub>               | 6.8        | hR15                                      |
| Mo <sub>6</sub> Se <sub>8</sub> Tb                              | 5.7        | hR15                                      |
| Mo <sub>3</sub> Se <sub>3</sub> Tl                              | 4.0        | hP14                                      |
| Mo <sub>6</sub> Se <sub>8</sub> Tm <sub>1.2</sub>               | 6.3        | hR15                                      |
| Mo <sub>6</sub> Se <sub>8</sub> Yb                              | 6.2        | hR15                                      |
| Mo <sub>3</sub> Si                                              | 1.30       | A15                                       |
| MoSi <sub>0.7</sub>                                             | 1.34       |                                           |
| Mo <sub>x</sub> SiV <sub>3-x</sub>                              | 4.54–16.0  | A15                                       |
| Mo <sub>5.25</sub> Ta <sub>0.75</sub> Te <sub>8</sub>           | 1.7        | hR15                                      |
| Mo <sub>6</sub> Te <sub>8</sub>                                 | 1.7        | hR15                                      |
| Mo <sub>0.16</sub> Ti <sub>0.84</sub>                           | 4.18; 4.25 |                                           |
| Mo <sub>0.913</sub> Ti <sub>0.087</sub>                         | 2.95       |                                           |
| Mo <sub>0.04</sub> Ti <sub>0.96</sub>                           | 2.0        | Cubic                                     |
| Mo <sub>0.025</sub> Ti <sub>0.975</sub>                         | 1.8        |                                           |
| Mo <sub>x</sub> U <sub>1-x</sub>                                | 0.7–2.1    |                                           |
| Mo <sub>x</sub> V <sub>1-x</sub>                                | 0–~5.3     |                                           |
| Mo <sub>2</sub> Zr                                              | 4.25–4.75  | C15                                       |
| NNb (film)                                                      | 6–9        | B1                                        |
| N <sub>x</sub> O <sub>y</sub> Ti <sub>z</sub>                   | 2.9–5.6    | Cubic                                     |
| N <sub>x</sub> O <sub>y</sub> V <sub>z</sub>                    | 5.8–8.2    | Cubic                                     |
| N <sub>0.34</sub> Re                                            | 4–5        | F.C.C.                                    |
| NTa (film)                                                      | 4.84       | B1                                        |
| N <sub>0.6–0.987</sub> Ti                                       | < 1.17–5.8 | B1                                        |
| N <sub>0.82–0.99</sub> V                                        | 2.9–7.9    | B1                                        |
| NZr                                                             | 9.8        | B1                                        |
| N <sub>0.906–0.984</sub> Zr                                     | 3.0–9.5    | B1                                        |
| Na <sub>0.28–0.35</sub> O <sub>3</sub> W                        | 0.56       | Tetragonal                                |
| Na <sub>0.28</sub> Pb <sub>0.72</sub>                           | 7.2        |                                           |
| NbO                                                             | 1.25       |                                           |
| NbOs <sub>2</sub>                                               | 2.52       | A12                                       |
| Nb <sub>3</sub> Os                                              | 1.05       | A15                                       |
| Nb <sub>0.6</sub> Os <sub>0.4</sub>                             | 1.89; 1.78 | D8 <sub>b</sub>                           |
| Nb <sub>3</sub> Os <sub>0.02–0.10</sub> Rh <sub>0.98–0.90</sub> | 2.42–2.30  | A15                                       |
| Nb <sub>3</sub> P                                               | 1.8        | L1 <sub>2</sub> -tP32 (Ti <sub>3</sub> P) |
| NbPRh                                                           | 4.08       | C37-oP12 (Co <sub>2</sub> Si)             |
| Nb <sub>0.6</sub> Pd <sub>0.4</sub>                             | 1.60       | D8 <sub>f</sub> plus cubic                |
| Nb <sub>3</sub> Pd <sub>0.02–0.10</sub> Rh <sub>0.92–0.90</sub> | 2.49–2.55  | A15                                       |
| Nb <sub>0.62</sub> Pt <sub>0.38</sub>                           | 4.21       | D8 <sub>b</sub>                           |
| Nb <sub>5</sub> Pt <sub>3</sub>                                 | 3.73       | D8 <sub>b</sub>                           |
| Nb <sub>3</sub> Pt <sub>0.02–0.98</sub> Rh <sub>0.98–0.02</sub> | 2.52–9.6   | A15                                       |
| NbRe <sub>3</sub>                                               | 5.27       | D8 <sub>b</sub> -tP30 (FeCr)              |
| Nb <sub>0.38–0.18</sub> Re <sub>0.62–0.82</sub>                 | 2.43–9.70  | A15                                       |
| NbRe                                                            | 3.8        | D8 <sub>b</sub> -tP30                     |
| NbReSi                                                          | 5.1        | ol36 (FeTiSi)                             |

| Substance                                                       | $T_c$ , K   | Crystal structure type                    |
|-----------------------------------------------------------------|-------------|-------------------------------------------|
| Nb <sub>3</sub> Rh                                              | 2.64        | A15                                       |
| Nb <sub>0.6</sub> Rh <sub>0.40</sub>                            | 4.21        | D8 <sub>b</sub> plus other                |
| Nb <sub>0.9</sub> Rh <sub>1.1</sub>                             | 3.07        | A3-oP4 (AuCd)                             |
| Nb <sub>3</sub> Rh <sub>0.98–0.90</sub> Ru <sub>0.02–0.10</sub> | 2.42–2.44   | A15                                       |
| Nb <sub>x</sub> Ru <sub>1-x</sub>                               | 1.2–4.8     |                                           |
| NbRuSi                                                          | 2.65        | ol36                                      |
| NbS <sub>2</sub>                                                | 6.1–6.3     | Hexagonal, NbSe <sub>2</sub> type         |
| NbS <sub>2</sub>                                                | 5.0–5.5     | Hexagonal, three-layer type               |
| Nb <sub>3</sub> Sb                                              | 0.2         | L1 <sub>2</sub> -tP32 (Ti <sub>3</sub> P) |
| Nb <sub>3</sub> Sb <sub>0–0.7</sub> Sn <sub>1–0.3</sub>         | 6.8–18      | A15                                       |
| NbSe <sub>2</sub>                                               | 5.15–5.62   | Hexagonal                                 |
| Nb <sub>1–1.05</sub> Se <sub>2</sub>                            | 2.2–7.0     | Same                                      |
| Nb <sub>3</sub> Se <sub>4</sub>                                 | 2.0         | hP14                                      |
| Nb <sub>3</sub> Si                                              | 1.5         | L1 <sub>2</sub>                           |
| Nb <sub>3</sub> SiSnV <sub>3</sub>                              | 4.0         |                                           |
| NbSn <sub>2</sub>                                               | 2.60        | Orthorhombic                              |
| Nb <sub>6</sub> Sn <sub>5</sub>                                 | 2.8         | ol44 (Sn <sub>5</sub> Ti <sub>6</sub> )   |
| NbSnTaV                                                         | 6.2         | A15                                       |
| NbSnV <sub>2</sub>                                              | 5.5         | A15                                       |
| Nb <sub>2</sub> SnV                                             | 9.8         | A15                                       |
| Nb <sub>x</sub> Ta <sub>1-x</sub>                               | 4.4–9.2     | A2                                        |
| Nb <sub>3</sub> Te <sub>4</sub>                                 | 1.8         | hP14                                      |
| Nb <sub>x</sub> Ti <sub>1-x</sub>                               | 0.6–9.8     |                                           |
| Nb <sub>0.6</sub> Ti <sub>0.4</sub>                             | 9.8         |                                           |
| Nb <sub>x</sub> U <sub>1-x</sub>                                | 1.95 (max.) |                                           |
| Nb <sub>0.88</sub> V <sub>0.12</sub>                            | 5.7         | A2                                        |
| Nb <sub>0.5</sub> V <sub>1.5</sub> Zr                           | 4.3         | C15-hP12 (MgZn <sub>2</sub> )             |
| Ni <sub>0.3</sub> Th <sub>0.7</sub>                             | 1.98        | D10 <sub>2</sub>                          |
| NiZr <sub>2</sub>                                               | 1.52        |                                           |
| Ni <sub>0.1</sub> Zr <sub>0.9</sub>                             | 1.5         | A3                                        |
| O <sub>3</sub> Rb <sub>0.27–0.29</sub> W                        | 1.98        | Hexagonal                                 |
| OSn                                                             | 3.81        | tP4 (PbO)                                 |
| O <sub>3</sub> SrTi (n = 1.7–12.0 × 10 <sup>19</sup> )          | 0.12–0.37   |                                           |
| O <sub>3</sub> SrTi (n = 10 <sup>18</sup> –10 <sup>21</sup> )   | 0.05–0.47   |                                           |
| O <sub>3</sub> SrTi (n = 10 <sup>20</sup> )                     | 0.47        |                                           |
| O <sub>3</sub> Sr <sub>0.08</sub> W                             | 2–4         | Hexagonal                                 |
| OTi                                                             | 0.58        |                                           |
| O <sub>3</sub> Ti <sub>0.30</sub> W                             | 2.0–2.14    | Hexagonal                                 |
| OV <sub>3</sub> Zr <sub>3</sub>                                 | 7.5         | E9 <sub>3</sub>                           |
| OW <sub>3</sub> (film)                                          | 3.35; 1.1   | A15                                       |
| OsPt <sub>i</sub>                                               | 1.2         | C22-hP9 (Fe <sub>2</sub> P)               |
| OsPZr                                                           | 7.4         | Same                                      |
| OsReY                                                           | 2.0         | C14                                       |
| Os <sub>2</sub> Sc                                              | 4.6         | C14                                       |
| OsTa                                                            | 1.95        | A12                                       |
| Os <sub>3</sub> Th <sub>7</sub>                                 | 1.51        | D10 <sub>2</sub>                          |
| Os <sub>x</sub> W <sub>1-x</sub>                                | 0.9–4.1     |                                           |
| OsW <sub>3</sub>                                                | ~3          |                                           |
| Os <sub>2</sub> Y                                               | 4.7         | C14                                       |
| Os <sub>2</sub> Zr                                              | 3.0         | C14                                       |
| Os <sub>x</sub> Zr <sub>1-x</sub>                               | 1.5–5.6     |                                           |
| PPb                                                             | 7.8         |                                           |
| OsW <sub>2</sub>                                                | 3.81        | D8 <sub>b</sub> -tP30 (FeCr)              |
| PPd <sub>3.0–3.2</sub>                                          | <0.35–0.7   | DO <sub>11</sub>                          |
| P <sub>3</sub> Pd <sub>7</sub> (high temperature)               | 1.0         | Rhombohedral                              |
| P <sub>3</sub> Pd <sub>7</sub> (low temperature)                | 0.70        | Complex                                   |
| PRh                                                             | 1.22        |                                           |
| PRh <sub>2</sub>                                                | 1.3         | C1                                        |
| P <sub>4</sub> Rh <sub>5</sub>                                  | 1.22        | oP28 (CaFe <sub>2</sub> O <sub>4</sub> )  |
| PRhTa                                                           | 4.41        | C37-oP12 (Co <sub>2</sub> Si)             |

| Substance                                               | $T_c$ K    | Crystal structure type                    | Substance                                        | $T_c$ K     | Crystal structure type                                  |
|---------------------------------------------------------|------------|-------------------------------------------|--------------------------------------------------|-------------|---------------------------------------------------------|
| PRhZr                                                   | 1.55       | Same                                      | PtV <sub>3.5</sub>                               | 1.26        | A15                                                     |
| PRuTi                                                   | 1.3        | C22-hP9 (Fe <sub>2</sub> P)               | Pt <sub>0.5</sub> W <sub>0.5</sub>               | 1.45        | A1                                                      |
| PRuZr                                                   | 3.46       | C37-oP12                                  | Pt <sub>x</sub> W <sub>1-x</sub>                 | 0.4–2.7     |                                                         |
| PW <sub>3</sub>                                         | 2.26       | DO <sub>e</sub>                           | Pt <sub>2</sub> Y <sub>3</sub>                   | 0.90        |                                                         |
| Pb <sub>2</sub> Pd                                      | 2.95       | C16                                       | Pt <sub>2</sub> Y                                | 1.57; 1.70  | C15                                                     |
| Pb <sub>4</sub> Pt                                      | 2.80       | Related to C16                            | Pt <sub>3</sub> Y <sub>7</sub>                   | 0.82        | D10 <sub>2</sub>                                        |
| Pb <sub>2</sub> Rh                                      | 2.66       | C16                                       | PtZr                                             | 3.0         | A3                                                      |
| PbSb                                                    | 6.6        |                                           | Re <sub>2</sub> Sc                               | 4.2         | C15-hP12 (MgZn <sub>2</sub> )                           |
| PbTe (plus 0.1 w/o Pb)                                  | 5.19       |                                           | Re <sub>24</sub> Sc <sub>5</sub>                 | 2.2         | A12-cl58 (Mg)                                           |
| PbTe (plus 0.1 w/o Te)                                  | 5.24–5.27  |                                           | ReSiTa                                           | 4.4         | oI36 (FeTiSi)                                           |
| PbTl <sub>0.27</sub>                                    | 6.43       |                                           | Re <sub>3</sub> Si <sub>1.5</sub> Y <sub>2</sub> | 1.76        | tP40 (Fe <sub>3</sub> Sc <sub>2</sub> Si <sub>3</sub> ) |
| PbTl <sub>0.17</sub>                                    | 6.73       |                                           | Re <sub>3</sub> Ta <sub>2</sub>                  | 1.4         | D8 <sub>b</sub> -tP30 (FeCr)                            |
| PbTl <sub>0.12</sub>                                    | 6.88       |                                           | Re <sub>0.64</sub> Ta <sub>0.36</sub>            | 1.46        | A12                                                     |
| PbTl <sub>0.075</sub>                                   | 6.98       |                                           | Re <sub>3</sub> Ta                               | 6.78        | A12-cl58 (Mn)                                           |
| PbTl <sub>0.04</sub>                                    | 7.06       |                                           | Re <sub>24</sub> Ti <sub>5</sub>                 | 6.60        | A12                                                     |
| Pb <sub>1-0.26</sub> Tl <sub>0-0.74</sub>               | 7.20–3.68  |                                           | Re <sub>x</sub> Ti <sub>1-x</sub>                | 6.6 (max.)  |                                                         |
| PbTl <sub>2</sub>                                       | 3.75–4.1   |                                           | Re <sub>0.76</sub> V <sub>0.24</sub>             | 4.52        | D8 <sub>b</sub>                                         |
| Pb <sub>3</sub> Zr <sub>5</sub>                         | 4.60       | D8 <sub>8</sub>                           | Re <sub>3</sub> V                                | 6.26        | D8 <sub>b</sub> -tP30                                   |
| PbZr <sub>3</sub>                                       | 0.76       | A15                                       | Re <sub>0.92</sub> V <sub>0.08</sub>             | 6.8         | A3                                                      |
| Pd <sub>0.9</sub> Pt <sub>0.1</sub> Te <sub>2</sub>     | 1.65       | C6                                        | Re <sub>0.6</sub> W <sub>0.4</sub>               | 6.0         |                                                         |
| Pd <sub>0.05</sub> Ru <sub>0.05</sub> Zr <sub>0.9</sub> | ~9         |                                           | Re <sub>0.5</sub> W <sub>0.5</sub>               | 5.12        | D8 <sub>b</sub>                                         |
| Pd <sub>2.2</sub> S (quenched)                          | 1.63       | Cubic                                     | Re <sub>13</sub> W <sub>12</sub>                 | 5.2         | D8 <sub>b</sub> -tP30                                   |
| PdSb <sub>2</sub>                                       | 1.25       | C2                                        | Re <sub>3</sub> W                                | 9.0         | A12-cl58                                                |
| PdSb                                                    | 1.5        | B8 <sub>1</sub>                           | Re <sub>2</sub> Y                                | 1.83        | C14                                                     |
| PdSbSe                                                  | 1.0        | C2                                        | Re <sub>2</sub> Zr                               | 5.9         | C14                                                     |
| PdSbTe                                                  | 1.2        | C2                                        | Re <sub>3</sub> Zr                               | 7.40        | A12-cl58                                                |
| Pd <sub>4</sub> Se                                      | 0.42       | Tetragonal                                | Re <sub>6</sub> Zr                               | 7.40        | Same                                                    |
| Pd <sub>6-7</sub> Se                                    | 0.66       | Like Pd <sub>4</sub> Te                   | Rh <sub>17</sub> S <sub>15</sub>                 | 5.8         | Cubic                                                   |
| Pd <sub>2.8</sub> Se                                    | 2.3        |                                           | Rh <sub>-0.24</sub> Sc <sub>-0.76</sub>          | 0.88; 0.92  |                                                         |
| Pd <sub>x</sub> Se <sub>1-x</sub>                       | 2.5 (max.) |                                           | Rh <sub>4</sub> Sc <sub>5</sub> Si <sub>10</sub> | 8.54        | tP38                                                    |
| PdSi                                                    | 0.93       | B31                                       | Rh <sub>4</sub> Sc <sub>3</sub> Sn <sub>13</sub> | 4.5         | cP40                                                    |
| PdSn                                                    | 0.41       | B31                                       | Rh <sub>x</sub> Se <sub>1-x</sub>                | 6.0 (max.)  |                                                         |
| PdSn <sub>2</sub>                                       | 3.34       |                                           | RhSi <sub>3</sub> Th                             | 1.76        | tI10                                                    |
| Pd <sub>2</sub> Sn                                      | 0.41       | C37                                       | Rh <sub>0.86</sub> Sc <sub>1.04</sub> Th         | 6.45        | tI12                                                    |
| Pd <sub>3</sub> Sn                                      | 0.47–0.64  | B8 <sub>2</sub>                           | Rh <sub>2</sub> Si <sub>2</sub> Y                | 3.11        | tI10                                                    |
| Pd <sub>2</sub> SnTm                                    | 1.77       | DO <sub>3</sub> -cF16 (BiF <sub>3</sub> ) | Rh <sub>3</sub> Si <sub>5</sub> Y <sub>2</sub>   | 2.70        | oI40                                                    |
| Pd <sub>2</sub> SnY                                     | 4.92       | Same                                      | Rh <sub>4</sub> Sn <sub>13</sub> Sr <sub>3</sub> | 4.3         | cP40                                                    |
| Pd <sub>2</sub> SnYb                                    | 1.79       | Same                                      | Rh <sub>x</sub> Sn <sub>y</sub> Th               | 1.9         | cl2 (W)                                                 |
| PdTe                                                    | 2.3; 3.85  | B8 <sub>1</sub>                           | Rh <sub>x</sub> Sn <sub>y</sub> Tm               | 2.3         | cP40                                                    |
| PdTe <sub>1.02-1.08</sub>                               | 2.56–1.88  | B8 <sub>1</sub>                           | Rh <sub>4</sub> Sn <sub>13</sub> Y <sub>3</sub>  | 3.2         | cP40                                                    |
| PdTe <sub>2</sub>                                       | 1.69       | C6                                        | Rh <sub>2</sub> Sr                               | 6.2         | C15                                                     |
| PdTe <sub>2.1</sub>                                     | 1.89       | C6                                        | Rh <sub>0.4</sub> Ta <sub>0.6</sub>              | 2.35        | D8 <sub>b</sub>                                         |
| PdTe <sub>2.3</sub>                                     | 1.85       | C6                                        | RhTe <sub>2</sub>                                | 1.51        | C2                                                      |
| Pd <sub>1.1</sub> Te                                    | 4.07       | B8 <sub>1</sub>                           | Rh <sub>0.67</sub> Te <sub>0.33</sub>            | 0.49        |                                                         |
| Pd <sub>3</sub> Te                                      | 0.76       | cl2 (W)                                   | Rh <sub>x</sub> Te <sub>1-x</sub>                | 1.51 (max.) |                                                         |
| PdTh <sub>2</sub>                                       | 0.85       | C16                                       | RhTh                                             | 0.36        | B <sub>I</sub>                                          |
| Pd <sub>0.1</sub> Zr <sub>0.9</sub>                     | 7.5        | A3                                        | Rh <sub>3</sub> Th <sub>7</sub>                  | 2.15        | D10 <sub>2</sub>                                        |
| PtSb                                                    | 2.1        | B8 <sub>1</sub>                           | Rh <sub>5</sub> Th                               | 1.07        |                                                         |
| PtSi                                                    | 0.88       | B31                                       | Rh <sub>x</sub> Ti <sub>1-x</sub>                | 2.25–3.95   |                                                         |
| PtSn                                                    | 0.37       | B8 <sub>1</sub>                           | Rh <sub>0.02</sub> U <sub>0.98</sub>             | 0.96        |                                                         |
| PtSn <sub>4</sub>                                       | 2.38       | C16-oC20 (PdSn <sub>4</sub> )             | RhV <sub>3</sub>                                 | 0.38        | A15                                                     |
| Pt <sub>3</sub> Ta <sub>7</sub>                         | 1.5        | D8 <sub>b</sub> -tP30                     | RhW                                              | ~3.4        | A3                                                      |
| PtTa <sub>3</sub>                                       | 0.4        | A15-cP8 (Cr <sub>3</sub> Si)              | RhY <sub>3</sub>                                 | 0.65        |                                                         |
| PtTe                                                    | 0.59       | Orthorhombic                              | Rh <sub>2</sub> Y <sub>3</sub>                   | 1.48        |                                                         |
| PtTh                                                    | 0.44       | B <sub>I</sub>                            | Rh <sub>3</sub> Y                                | 1.07        | C15                                                     |
| Pt <sub>3</sub> Th <sub>7</sub>                         | 0.98       | D10 <sub>2</sub>                          | Rh <sub>5</sub> Y                                | 0.56        |                                                         |
| Pt <sub>5</sub> Th                                      | 3.13       |                                           | Rh <sub>3</sub> Y <sub>7</sub>                   | 0.32        | hP20 (Fe <sub>3</sub> Th <sub>7</sub> )                 |
| PtTi <sub>3</sub>                                       | 0.58       | A15                                       | Rh <sub>0.005</sub> Zr (annealed)                | 5.8         |                                                         |
| Pt <sub>0.02</sub> U <sub>0.98</sub>                    | 0.87       | β-phase                                   | Rh <sub>0-0.45</sub> Zr <sub>1-0.55</sub>        | 2.1–10.8    |                                                         |
| PtV <sub>2.5</sub>                                      | 1.36       | A15                                       | Rh <sub>0.1</sub> Zr <sub>0.9</sub>              | 9.0         | H.C.P.                                                  |
| PtV <sub>3</sub>                                        | 2.87–3.20  | A15                                       | Ru <sub>2</sub> Sc                               | 1.67        | C14                                                     |
|                                                         |            |                                           | RuSiTa                                           | 3.15        | oI36                                                    |

| Substance                                                     | $T_c$ , K  | Crystal structure type                        |
|---------------------------------------------------------------|------------|-----------------------------------------------|
| $\text{Ru}_3\text{Si}_2\text{Th}$                             | 3.98       | hP12                                          |
| $\text{Ru}_3\text{Si}_2\text{Y}$                              | 3.51       | hP12                                          |
| $\text{Ru}_{1.1}\text{Sn}_{3.1}\text{Y}$                      | 1.3        | cP40                                          |
| $\text{Ru}_2\text{Th}$                                        | 3.56       | C15                                           |
| $\text{RuTi}$                                                 | 1.07       | B2                                            |
| $\text{Ru}_{0.05}\text{Ti}_{0.95}$                            | 2.5        |                                               |
| $\text{Ru}_{0.1}\text{Ti}_{0.9}$                              | 3.5        |                                               |
| $\text{Ru}_x\text{Ti}_{0.6}\text{V}_y$                        | 6.6 (max.) |                                               |
| $\text{Ru}_3\text{U}$                                         | 0.15       | $\text{L1}_2$ -cP4                            |
| $\text{Ru}_{0.45}\text{V}_{0.55}$                             | 4.0        | B2                                            |
| $\text{RuW}$                                                  | 7.5        | A3                                            |
| $\text{Ru}_2\text{Y}$                                         | 1.52       | C14                                           |
| $\text{Ru}_2\text{Zr}$                                        | 1.84       | C14                                           |
| $\text{Ru}_{0.1}\text{Zr}_{0.9}$                              | 5.7        | A3                                            |
| $\text{STh}$                                                  | 0.5        | B1-cF8 (NaCl)                                 |
| $\text{SbSn}$                                                 | 1.30–1.42  | B1 or distorted                               |
| $\text{SbTa}_3$                                               | 0.72       | A15-cP8 ( $\text{Cr}_3\text{Si}$ )            |
| $\text{SbTi}_3$                                               | 5.8        | Same                                          |
| $\text{Sb}_2\text{Ti}_7$                                      | 5.2        |                                               |
| $\text{Sb}_{0.01-0.03}\text{V}_{0.99-0.97}$                   | 3.76–2.63  | A2                                            |
| $\text{SbV}_3$                                                | 0.80       | A15                                           |
| $\text{SeTh}$                                                 | 1.7        | B1-cF8                                        |
| $\text{SiMo}_3$                                               | 1.4        | A15-cP8                                       |
| $\text{Si}_2\text{Th}$                                        | 3.2        | $C_\alpha$ , $\alpha$ -phase                  |
| $\text{Si}_2\text{Th}$                                        | 2.4        | C32, $\beta$ -phase                           |
| $\text{SiV}_{2.7}\text{Ru}_{0.3}$                             | 2.9        | A15                                           |
| $\text{Si}_2\text{W}_3$                                       | 2.8; 2.84  |                                               |
| $\text{SiZr}_3$                                               | 0.5        | $\text{L1}_2$ -tP32 ( $\text{Ti}_3\text{P}$ ) |
| $\text{Sn}_{0.174-0.104}\text{Ta}_{0.826-0.896}$              | 6.5–< 4.2  | A15                                           |
| $\text{SnTa}_3$                                               | 8.35       | A15, highly ordered                           |
| $\text{SnTa}_3$                                               | 6.2        | A15, partially ordered                        |
| $\text{SnTaV}_2$                                              | 2.8        | A15                                           |
| $\text{SnTa}_2\text{V}$                                       | 3.7        | A15                                           |
| $\text{Sn}_x\text{Te}_{1-x}$ ( $n = 10.5-20 \times 10^{20}$ ) | 0.07–0.22  | B1                                            |
| $\text{Sn}_3\text{Th}$                                        | 3.33       | $\text{L1}_2$ -cP4                            |
| $\text{SnTi}_3$                                               | 5.80       | A15-cP8                                       |
| $\text{Sn}_x\text{Ti}_{1-x}$                                  | 2.37–5.2   |                                               |
| $\text{SnV}_3$                                                | 3.8        | A15                                           |
| $\text{Sn}_{0.02-0.057}\text{V}_{0.98-0.943}$                 | 2.87–~1.6  | A2                                            |
| $\text{SnZr}_3$                                               | 0.92       | A15-cP8                                       |
| $\text{Ta}_{0.025}\text{Ti}_{0.975}$                          | 1.3        | Hexagonal                                     |
| $\text{Ta}_{0.05}\text{Ti}_{0.95}$                            | 2.9        | Hexagonal                                     |
| $\text{Ta}_{0.05-0.75}\text{V}_{0.95-0.25}$                   | 4.30–2.65  | A2                                            |
| $\text{Ta}_{0.8-1}\text{W}_{0.2-0}$                           | 1.2–4.4    | A2                                            |
| $\text{Tc}_{0.1-0.4}\text{W}_{0.9-0.6}$                       | 1.25–7.18  | Cubic                                         |
| $\text{Tc}_{0.50}\text{W}_{0.50}$                             | 7.52       | $\alpha$ plus                                 |
| $\text{Tc}_{0.60}\text{W}_{0.40}$                             | 7.88       | plus $\alpha$                                 |
| $\text{Tc}_6\text{Zr}$                                        | 9.7        | A12                                           |
| $\text{TeY}$                                                  | 1.02       | B1-cF8                                        |
| $\text{ThTi}_3$                                               | 0.87       | $\text{L1}_2$ -cP4                            |
| $\text{Th}_{0-0.55}\text{V}_{1-0.45}$                         | 1.2–1.8    |                                               |
| $\text{Ti}_{0.70}\text{V}_{0.30}$                             | 6.14       | Cubic                                         |
| $\text{Ti}_x\text{V}_{1-x}$                                   | 0.2–7.5    |                                               |
| $\text{Ti}_{0.5}\text{Zr}_{0.5}$ (annealed)                   | 1.23       |                                               |
| $\text{Ti}_{0.5}\text{Zr}_{0.5}$ (quenched)                   | 2.0        |                                               |
| $\text{Ti}_3\text{Y}$                                         | 1.52       | $\text{L1}_2$ -cP4                            |
| $\text{V}_2\text{Zr}$                                         | 8.80       | C15                                           |
| $\text{V}_{0.26}\text{Zr}_{0.74}$                             | 5.9        |                                               |
| $\text{W}_2\text{Zr}$                                         | 2.16       | C15                                           |
| $\text{YZn}$                                                  | 0.33       | B2-cP2 ( $\text{CsCl}$ )                      |

\* n denotes current carriers concentration in  $\text{cm}^{-3}$ .

B. Superconductors with  $T_c > 10\text{K}$ 

| Substance                                                         | $T_c$ , K  | Crystal structure type            |
|-------------------------------------------------------------------|------------|-----------------------------------|
| $\text{Al}_2\text{CMo}_3$                                         | 10.0       | A13                               |
| $\text{Al}_{0.5}\text{Ge}_{0.5}\text{Nb}$                         | 12.6       | A15                               |
| $\text{Al}_{-0.8}\text{Ge}_{-0.2}\text{Nb}_3$                     | 20.7       | A15                               |
| $\text{AlNb}_3$                                                   | 18.0       | A15 ( $\text{Cr}_3\text{Si}$ )    |
| $\text{AlNb}_3$                                                   | 12.0       | (FeCr)                            |
| $\text{Al}_x\text{Nb}_{1-x}$                                      | <4.2–13.5  | $\text{D8}_b$                     |
| $\text{Al}_x\text{Nb}_{1-x}$                                      | 12–17.5    | A15                               |
| $\text{Al}_{0.27}\text{Nb}_{0.73-0.48}\text{V}_{0-0.25}$          | 14.5–17.5  | A15                               |
| $\text{AlNb}_x\text{V}_{1-x}$                                     | 4.4–13.5   |                                   |
| $\text{Al}_{0.1}\text{Si}_{0.9}\text{V}_3$                        | 14.05      |                                   |
| $\text{AlV}_3$                                                    | 11.8       | A15 ( $\text{Cr}_3\text{Si}$ )    |
| $\text{AuNb}_3$                                                   | 11.5       | A15                               |
| $\text{Au}_{0-0.3}\text{Nb}_{1-0.7}$                              | 1.1–11.0   |                                   |
| $\text{Au}_{0.02-0.98}\text{Nb}_{0.98-0.02}\text{Rh}_{0.98-0.02}$ | 2.53–10.9  | A15                               |
| $\text{AuNb}_{3(1-x)}\text{V}_{3x}$                               | 1.5–11.0   | A15                               |
| $\text{B}_{0.03}\text{C}_{0.51}\text{Mo}_{0.47}$                  | 12.5       |                                   |
| $\text{B}_4\text{LuRh}_4$                                         | 11.7       | ( $\text{B}_4\text{CeCo}_4$ )     |
| $\text{B}_2\text{LuRu}$                                           | 10         |                                   |
| $\text{B}_4\text{Rh}_4\text{Y}$                                   | 11.3       | ( $\text{B}_4\text{CeCo}_4$ )     |
| $\text{B}_{0.1}\text{Si}_{0.9}\text{V}_3$                         | 15.8       | A15                               |
| $\text{BaBi}_{0.2}\text{O}_{0.8}\text{Pb}_{0.8}$                  | 13.2       |                                   |
| $\text{Ba}_2\text{CaCu}_2\text{O}_8\text{Tl}_2$                   | 120        |                                   |
| $\text{Ba}_2\text{Cu}_3\text{LaO}_6$                              | 80         |                                   |
| $\text{Ba}_2\text{Cu}_3\text{O}_7\text{Tm}$                       | 101        |                                   |
| $\text{Ba}_2\text{Cu}_3\text{O}_7\text{Y}$                        | 90         |                                   |
| $(\text{Ba},\text{La})_2\text{CuO}_4$                             | 36         | A15 ( $\text{K}_2\text{NiF}_4$ )  |
| $\text{Bi}_2\text{CaCu}_2\text{O}_8\text{Sr}_2$                   | 110        |                                   |
| $\text{Br}_2\text{Mo}_6\text{S}_6$                                | 13.8       | ( $\text{Mo}_6\text{PbS}_8$ )     |
| $\text{C}_3\text{La}$                                             | 11.0       | ( $\text{C}_3\text{Pu}_2$ )       |
| $\text{CMo}$                                                      | 14.3       | B1 ( $\text{NaCl}$ )              |
| $\text{CMo}_3$                                                    | 12.2       | $o^{**}$                          |
| $\text{C}_{0.5}\text{Mo}_x\text{Nb}_{1-x}$                        | 10.8–12.5  | B1                                |
| $\text{CMo}_x\text{Ti}_{1-x}$                                     | 10.2(max)  | B1                                |
| $\text{CMo}_{0.83}\text{Ti}_{0.17}$                               | 10.2       | B1                                |
| $\text{C}_{0-0.38}\text{Nb}_{1-0.62}\text{Ta}$                    | 10.0–11.3  |                                   |
| $\text{CNb}$ (whiskers)                                           | 7.5–10.5   |                                   |
| $\text{CNb}$                                                      | 11.5       | B1                                |
| $\text{C}_{0.7-1.0}\text{Nb}_{0.3-0}$                             | 6–11       | B1                                |
| $\text{CNb}_x\text{Ta}_{1-x}$                                     | 8.2–13.9   |                                   |
| $\text{CNb}_{0.6-0.9}\text{W}_{0.4-0.1}$                          | 12.5–11.6  | B1                                |
| $\text{C}_{0.1}\text{Si}_{0.9}\text{V}_3$                         | 16.4       | A15                               |
| $\text{CTa}$                                                      | 10.3       | B1                                |
| $\text{CTa}_{1-0.4}\text{W}_{0-0.6}$                              | 8.5–10.5   | B1                                |
| $\text{C}_{0.66}\text{Th}_{0.13}\text{Y}_{0.21}$                  | 17         | ( $\text{C}_3\text{Pu}_2$ )       |
| $\text{C}_3\text{Y}_2$                                            | 11.5       | ( $\text{C}_3\text{Pu}_2$ )       |
| $\text{CW}$                                                       | 10         | B1                                |
| $(\text{Ca},\text{La})_2\text{CuO}_4$                             | 18         | ( $\text{K}_2\text{NiF}_4$ )      |
| $\text{Cu}(\text{La},\text{Sr})_2\text{O}_4$                      | 39         |                                   |
| $\text{Cu}_{1.8}\text{Mo}_6\text{S}_8$                            | 10.8       | ( $\text{Mo}_6\text{PbS}_8$ )     |
| $\text{Cr}_{0.3}\text{SiV}_{2.7}$                                 | 11.3       | A15                               |
| $\text{GaNb}_3$                                                   | 14.5       | A15 ( $\text{Cr}_3\text{Si}$ )    |
| $\text{Ga}_x\text{Nb}_3\text{Sn}_{1-x}$                           | 14–18.37   | A15                               |
| $\text{GaV}_3$                                                    | 16.8       | A15                               |
| $\text{GaV}_{2.1-3.5}$                                            | 6.3–14.45  | A15                               |
| $\text{GeNb}_3$                                                   | 23.2       | A15                               |
| $\text{GeNb}_3$ (quenched)                                        | 6–17       | A15                               |
| $\text{Ge}_x\text{Nb}_3\text{Sn}_{1-x}$                           | 17.6–18.0  | A15                               |
| $\text{Ge}_{0.5}\text{Nb}_3\text{Sn}_{0.5}$                       | 11.3       |                                   |
| $\text{Ge}_{0.1}\text{Si}_{0.9}\text{V}_3$                        | 14.0       | A15                               |
| $\text{GeV}_3$                                                    | 11         | A15                               |
| $\text{InLa}_3$                                                   | 9.83; 10.4 | $\text{Li}_2$ ( $\text{AuCu}_3$ ) |

| Substance                                         | $T_c$ , K  | Crystal structure type        | Substance                                                        | $T_c$ , K   | Crystal structure type     |
|---------------------------------------------------|------------|-------------------------------|------------------------------------------------------------------|-------------|----------------------------|
| $\text{In}_{0.0-0.3}\text{Nb}_3\text{Sn}_{1-0.7}$ | 18.0–18.19 | A15                           | $\text{N}_{100-42\text{w/o}}\text{Nb}_{0-58\text{w/o}}\text{Ti}$ | 15–16.8     |                            |
| $\text{InV}_3$                                    | 13.9       | A15                           | $\text{N}_{100-75\text{w/o}}\text{Nb}_{0-25\text{w/o}}\text{Zr}$ | 12.5–16.35  |                            |
| $\text{Ir}_{0.4}\text{Nb}_{0.6}$                  | 10         | (FeCr)                        | $\text{NNb}_x\text{Zr}_{1-x}$                                    | 9.8–13.8    | B1                         |
| $\text{LaMo}_6\text{Se}_8$                        | 11.4       | ( $\text{Mo}_6\text{PbS}_8$ ) | $\text{N}_{0.93}\text{Nb}_{0.85}\text{Zr}_{0.15}$                | 13.8        | B1                         |
| $\text{LiO}_4\text{Ti}_2$                         | 13.7       | ( $\text{Al}_2\text{MgO}_4$ ) | $\text{NTa}$                                                     | 12–14       | B1                         |
| $\text{MgB}_2$                                    | 39.0±0.5   | C32                           | $\text{NZr}$                                                     | 10.7        | B1                         |
| $\text{MoN}$                                      | 12; 14.8   | $h^*$                         | $\text{Nb}_3\text{Pt}$                                           | 10.9        | A15                        |
| $\text{Mo}_3\text{Os}$                            | 12.7       | A15                           | $\text{Nb}_{0.18}\text{Re}_{0.82}$                               | 10          | (Mn)                       |
| $\text{Mo}_6\text{Pb}_{0.9}\text{S}_{7.5}$        | 15.2       | ( $\text{Mo}_6\text{PbS}_8$ ) | $\text{Nb}_3\text{Si}$                                           | 19          | A15                        |
| $\text{Mo}_3\text{Re}$                            | 10.0; 15   | A15                           | $\text{Nb}_{0.3}\text{SiV}_{2.7}$                                | 12.8        | A15                        |
| $\text{Mo}_x\text{Re}_{1-x}$                      | 1.2–12.2   |                               | $\text{Nb}_3\text{Sn}$                                           | 18.05       | A15                        |
| $\text{Mo}_{0.52}\text{Re}_{0.48}$                | 11.1       |                               | $\text{Nb}_{0.8}\text{Sn}_{0.2}$                                 | 18.18; 18.5 | A15                        |
| $\text{Mo}_{0.57}\text{Re}_{0.43}$                | 14.0       |                               | $\text{Nb}_x\text{Sn}_{1-x}$ (film)                              | 2.6–18.5    | $o^*$                      |
| $\text{Mo}_{0.60}\text{Re}_{0.395}$               | 10.6       |                               | $\text{Nb}_3\text{Sn}_2$                                         | 16.6        | $t^*$                      |
| $\text{MoRu}$                                     | 9.5–10.5   | A3                            | $\text{NbSnTa}_2$                                                | 10.8        | A15                        |
| $\text{Mo}_3\text{Ru}$                            | 10.6       | A15                           | $\text{Nb}_2\text{SnTa}$                                         | 16.4        | A15                        |
| $\text{Mo}_6\text{Se}_8\text{Tl}$                 | 12.2       | ( $\text{Mo}_6\text{PbS}_8$ ) | $\text{Nb}_{2.5}\text{SnTa}_{0.5}$                               | 17.6        | A15                        |
| $\text{Mo}_{0.3}\text{SiV}_{2.7}$                 | 11.7       | A15                           | $\text{Nb}_{2.75}\text{SnTa}_{0.25}$                             | 17.8        | A15                        |
| $\text{Mn}_3\text{Si}$                            | 12.5       | A15                           | $\text{Nb}_{3x}\text{SnTa}_{3(1-x)}$                             | 6.0–18.0    |                            |
| $\text{Mo}_3\text{Tc}$                            | 15         | A15                           | $\text{Nb}_2\text{SnTa}_{0.5}\text{V}_{0.5}$                     | 12.2        | A15                        |
| $\text{Mo}_{0.3}\text{Tc}_{0.7}$                  | 12.0       | A15                           | $\text{NbTc}_3$                                                  | 10.5        | A12                        |
| $\text{Mo}_x\text{Tc}_{1-x}$                      | 10.8–15.8  |                               | $\text{Nb}_{0.75}\text{Zr}_{0.25}$                               | 10.8        |                            |
| $\text{MoTc}_3$                                   | 15.8       |                               | $\text{Nb}_{0.66}\text{Zr}_{0.33}$                               | 10.8        |                            |
| NNb (whiskers)                                    | 10–14.5    |                               | $\text{PbTa}_3$                                                  | 17          | A15                        |
| NNb (diffusion wires)                             | 16.10      |                               | $\text{RhTa}_3$                                                  | 10          | A15                        |
| $\text{N}_{0.988}\text{Nb}$                       | 14.9; 17.3 | B1                            | $\text{RhZr}_2$                                                  | 10.8; 11.3  | C16                        |
| $\text{N}_{0.824-0.988}\text{Nb}$                 | 14.4–15.3  | B1                            | $\text{Rh}_{0-0.45}\text{Zr}_{1-0.55}$                           | 2.1–10.8    | ( $\text{Al}_2\text{Cu}$ ) |
| $\text{N}_{0.7-0.795}\text{Nb}$                   | 11.3–12.9  |                               | $\text{SiTi}_{0.3}\text{V}_{2.7}$                                | 10.9        | A15                        |
| $\text{NNb}_x\text{O}_y$                          | 13.5–17.0  | B1                            | $\text{SiV}_3$                                                   | 17.1        | A15                        |
| $\text{NNb}_x\text{O}_y$                          | 6.0–11     |                               | $\text{SiV}_{2.7}\text{Zr}_{0.3}$                                | 13.2        | A15                        |

TABLE 5. Critical Field Data

| Substance                                      | $H_0$ (oersteds) | Substance                          | $H_0$ (oersteds) |
|------------------------------------------------|------------------|------------------------------------|------------------|
| $\text{Ag}_2\text{F}$                          | 2.5              | $\text{InSb}$                      | 1100             |
| $\text{Ag}_2\text{NO}_{11}$                    | 57               | $\text{In}_x\text{Tl}_{1-x}$       | 252–284          |
| $\text{Al}_2\text{CMo}_3$                      | 1700             | $\text{In}_{0.8}\text{Tl}_{0.2}$   | 252              |
| $\text{BaBi}_3$                                | 740              | $\text{Mg}_{0.47}\text{Tl}_{0.53}$ | 220              |
| $\text{Bi}_2\text{Pt}$                         | 10               | $\text{Mo}_{0.16}\text{Tl}_{0.84}$ | <985             |
| $\text{Bi}_3\text{Sr}$                         | 530              | $\text{NbSn}_2$                    | 620              |
| $\text{Bi}_5\text{Tl}_3$                       | >400             | $\text{PbTl}_{0.27}$               | 756              |
| $\text{CdSn}$                                  | >266             | $\text{PbTl}_{0.17}$               | 796              |
| $\text{CoSi}_2$                                | 105              | $\text{PbTl}_{0.12}$               | 849              |
| $\text{Cr}_{0.1}\text{Ti}_{0.3}\text{V}_{0.6}$ | 1360             | $\text{PbTl}_{0.075}$              | 880              |
| $\text{In}_{1-0.86}\text{Mg}_{0-0.14}$         | 272.4–259.2      | $\text{PbTl}_{0.04}$               | 864              |

TABLE 6. High Critical Magnetic-Field Superconductive Compounds and Alloys

| Substance                                                                 | $T_c$ , K | $H_{c1}$ , kOe | $H_{c2}$ , kOe       | $H_{c3}$ , kOe | $T_{obs}$ , K <sup>a</sup> |
|---------------------------------------------------------------------------|-----------|----------------|----------------------|----------------|----------------------------|
| Al <sub>2</sub> CMo <sub>3</sub>                                          | 9.8–10.2  | 0.091          | 156                  |                | 1.2                        |
| AlNb <sub>3</sub>                                                         |           | 0.375          |                      |                |                            |
| Ba <sub>x</sub> O <sub>3</sub> Sr <sub>1-x</sub> Ti                       | <0.1–0.55 | 0.0039 max.    |                      |                |                            |
| Bi <sub>0.5</sub> Cd <sub>0.1</sub> Pb <sub>0.27</sub> Sn <sub>0.13</sub> |           |                | >24                  |                | 3.06                       |
| Bi <sub>x</sub> Pb <sub>1-x</sub>                                         | 7.35–8.4  | 0.122 max.     | 30 max.              |                | 4.2                        |
| Bi <sub>0.56</sub> Pb <sub>0.44</sub>                                     | 8.8       |                | 15                   |                | 4.2                        |
| Bi <sub>7.5w/o</sub> Pb <sub>92.5w/o</sub> <sup>b</sup>                   |           |                | 2.32                 |                |                            |
| Bi <sub>0.099</sub> Pb <sub>0.901</sub>                                   |           | 0.29           | 2.8                  |                |                            |
| Bi <sub>0.02</sub> Pb <sub>0.98</sub>                                     |           | 0.46           | 0.73                 |                |                            |
| Bi <sub>0.53</sub> Pb <sub>0.32</sub> Sn <sub>0.16</sub>                  |           |                | >25                  |                | 3.06                       |
| Bi <sub>1-0.93</sub> Sn <sub>0-0.07</sub>                                 |           |                | 0–0.032              |                | 3.7                        |
| Bi <sub>5</sub> Tl <sub>3</sub>                                           | 6.4       |                | >5.6                 |                | 3.35                       |
| C <sub>8</sub> K (excess K)                                               | 0.55      |                | 0.160 (H⊥c)          |                | 0.32                       |
|                                                                           |           |                | 0.730 (H c)          |                | 0.32                       |
| C <sub>8</sub> K                                                          | 0.39      |                | 0.025 (H⊥c)          |                | 0.32                       |
|                                                                           |           |                | 0.250 (H c)          |                | 0.32                       |
| C <sub>0.44</sub> Mo <sub>0.56</sub>                                      | 12.5–13.5 | 0.087          | 98.5                 |                | 1.2                        |
| CNb                                                                       | 8–10      | 0.12           | 16.9                 |                | 4.2                        |
| CNb <sub>0.4</sub> Ta <sub>0.6</sub>                                      | 10–13.6   | 0.19           | 14.1                 |                | 1.2                        |
| CTa                                                                       | 9–11.4    | 0.22           | 4.6                  |                | 1.2                        |
| Ca <sub>x</sub> O <sub>3</sub> Sr <sub>1-x</sub> Ti                       | <0.1–0.55 | 0.002–0.004    |                      |                |                            |
| Cd <sub>0.1</sub> Hg <sub>0.9</sub><br>(by weight)                        |           | 0.23           | 0.34                 |                | 2.04                       |
| Cd <sub>0.05</sub> Hg <sub>0.95</sub>                                     |           | 0.28           | 0.31                 |                | 2.16                       |
| Cr <sub>0.10</sub> Ti <sub>0.30</sub> V <sub>0.60</sub>                   | 5.6       | 0.071          | 84.4                 |                | 0                          |
| GaN                                                                       | 5.85      | 0.725          |                      |                | 4.2                        |
| Ga <sub>x</sub> Nb <sub>1-x</sub>                                         |           |                | >28                  |                | 4.2                        |
| GaSb (annealed)                                                           | 4.24      |                | 2.64                 |                | 3.5                        |
| GaV <sub>1.95</sub>                                                       | 5.3       |                | 73 <sup>c</sup>      |                |                            |
| GaV <sub>2.1-3.5</sub>                                                    | 6.3–14.45 |                | 230–300 <sup>d</sup> |                | 0                          |
| GaV <sub>3</sub>                                                          |           | 0.4            | 350 <sup>e</sup>     |                | 0                          |
|                                                                           |           |                | 500 <sup>d</sup>     |                |                            |
| GaV <sub>4.5</sub>                                                        | 9.15      |                | 121 <sup>c</sup>     |                | 0                          |
| Hf <sub>x</sub> Nb <sub>y</sub>                                           |           |                | >52–>102             |                | 1.2                        |
| Hf <sub>x</sub> Ta <sub>y</sub>                                           |           |                | >28–>86              |                | 1.2                        |
| Hg <sub>0.05</sub> Pb <sub>0.95</sub>                                     |           | 0.235          | 2.3                  |                |                            |
| Hg <sub>0.101</sub> Pb <sub>0.899</sub>                                   |           | 0.23           | 4.3                  |                | 4.2                        |
| Hg <sub>0.15</sub> Pb <sub>0.85</sub>                                     | 6.75      |                | >13                  |                | 2.93                       |
| In <sub>0.98</sub> Pb <sub>0.02</sub>                                     | 3.45      | 0.1            |                      | 0.12           | 2.76                       |
| In <sub>0.96</sub> Pb <sub>0.04</sub>                                     | 3.68      | 0.1            | 0.12                 | 0.25           | 2.94                       |
| In <sub>0.94</sub> Pb <sub>0.06</sub>                                     | 3.90      | 0.095          | 0.18                 | 0.35           | 3.12                       |
| In <sub>0.913</sub> Pb <sub>0.087</sub>                                   | 4.2       | ~10.17         | 0.55                 | 2.65           |                            |
| In <sub>0.316</sub> Pb <sub>0.684</sub>                                   |           | 0.155          | 3.7                  |                | 4.2                        |
| In <sub>0.17</sub> Pb <sub>0.83</sub>                                     |           |                | 2.8                  | 5.5            | 4.2                        |
| In <sub>1.000</sub> Te <sub>1.002</sub>                                   | 3.5–3.7   |                | 1.2 <sup>c</sup>     |                | 0                          |
| In <sub>0.95</sub> Tl <sub>0.05</sub>                                     |           | 0.263          | 0.263                |                | 3.3                        |
| In <sub>0.90</sub> Tl <sub>0.10</sub>                                     |           | 0.257          | 0.257                |                | 3.25                       |
| In <sub>0.83</sub> Tl <sub>0.17</sub>                                     |           | 0.242          | 0.39                 |                | 3.21                       |
| In <sub>0.75</sub> Tl <sub>0.25</sub>                                     |           | 0.216          | 0.50                 |                | 3.16                       |
| LaN                                                                       | 1.35      | 0.45           |                      |                | 0.76                       |
| La <sub>3</sub> S <sub>4</sub>                                            | 6.5       | ≈0.15          | >25                  |                | 1.3                        |
| La <sub>3</sub> Se <sub>4</sub>                                           | 8.6       | ≈0.2           | >25                  |                | 1.25                       |
| Mo <sub>0.52</sub> Re <sub>0.48</sub>                                     | 11.1      |                | 14–21                | 22–33          | 4.2                        |
|                                                                           |           |                | 18–28                | 37–43          | 1.3                        |
| Mo <sub>0.6</sub> Re <sub>0.395</sub>                                     | 10.6      |                | 14–20                | 20–37          | 4.2                        |
|                                                                           |           |                | 19–26                | 26–37          | 1.3                        |
| Mo <sub>0.5</sub> Ti <sub>0.5</sub>                                       |           |                | 75 <sup>c</sup>      |                | 0                          |
| Mo <sub>0.16</sub> Ti <sub>0.84</sub>                                     | 4.18      | 0.028          | 98.7 <sup>c</sup>    |                | 0                          |
|                                                                           |           |                | 36–38                |                | 3.0                        |
| Mo <sub>0.913</sub> Ti <sub>0.087</sub>                                   | 2.95      | 0.060          | 15                   |                | 4.2                        |
| Mo <sub>0.1-0.3</sub> U <sub>0.9-0.7</sub>                                | 1.85–2.06 |                | >25                  |                |                            |
| Mo <sub>0.17</sub> Zr <sub>0.83</sub>                                     |           |                | 30                   |                |                            |

| Substance                                                          | $T_c$ , K | $H_{c1}$ , kOe       | $H_{c2}$ , kOe     | $H_{c3}$ , kOe | $T_{obs}$ , K <sup>a</sup> |
|--------------------------------------------------------------------|-----------|----------------------|--------------------|----------------|----------------------------|
| N <sub>(12.8 w/o)</sub> Nb                                         | 15.2      |                      | >9.5               |                | 13.2                       |
| NNb (wires)                                                        | 16.1      |                      | 153 <sup>c</sup>   |                | 0                          |
|                                                                    |           |                      | 132                |                | 4.2                        |
|                                                                    |           |                      | 95                 |                | 8                          |
|                                                                    |           |                      | 53                 |                | 12                         |
| NNb <sub>x</sub> O <sub>1-x</sub>                                  | 13.5–17.0 |                      | 38                 |                |                            |
| NNb <sub>x</sub> Zr <sub>1-x</sub>                                 | 9.8–13.8  |                      | 4– >130            |                | 4.2                        |
| N <sub>0.93</sub> Nb <sub>0.85</sub> Zr <sub>0.15</sub>            | 13.8      |                      | >130               |                | 4.2                        |
| Na <sub>0.086</sub> Pb <sub>0.914</sub>                            |           | 0.19                 | 6.0                |                |                            |
| Na <sub>0.016</sub> Pb <sub>0.984</sub>                            |           | 0.28                 | 2.05               |                |                            |
| Nb                                                                 | 9.15      |                      | 2.020              |                | 1.4                        |
|                                                                    |           |                      | 1.710              |                | 4.2                        |
| Nb                                                                 |           | 0.4–1.1              | 3–5.5              |                | 4.2                        |
| Nb (unstrained)                                                    |           | 1.1–1.8              | 3.40               | 6–9.1          | 4.2                        |
| Nb (strained)                                                      |           | 1.25–1.92            | 3.44               | 6.0–8.7        | 4.2                        |
| Nb (cold-drawn wire)                                               |           | 2.48                 | 4.10               | ≈10            | 4.2                        |
| Nb (film)                                                          |           |                      | >25                |                | 4.2                        |
| NbSc                                                               |           |                      | >30                |                |                            |
| Nb <sub>3</sub> Sn                                                 |           | 0.170                | 221                |                | 4.2                        |
|                                                                    |           |                      | 70                 |                | 14.15                      |
|                                                                    |           |                      | 54                 |                | 15                         |
|                                                                    |           |                      | 34                 |                | 16                         |
|                                                                    |           |                      | 17                 |                | 17                         |
| Nb <sub>0.1</sub> Ta <sub>0.9</sub>                                |           | 0.084                | 0.154              |                | 4.195                      |
| Nb <sub>0.2</sub> Ta <sub>0.8</sub>                                |           |                      | 10                 |                | 4.2                        |
| Nb <sub>0.65-0.73</sub> Ta <sub>0.02-0.10</sub> Zr <sub>0.25</sub> |           |                      | >70–>90            |                | 4.2                        |
| NbTi <sub>x</sub> 1-x                                              |           |                      | 148 max.           |                | 1.2                        |
|                                                                    |           |                      | 120 max.           |                | 4.2                        |
| Nb <sub>0.222</sub> U <sub>0.778</sub>                             |           | 1.98                 | 23                 |                | 1.2                        |
| Nb <sub>x</sub> Zr <sub>1-x</sub>                                  |           |                      | 127 max.           |                | 1.2                        |
|                                                                    |           |                      | 94 max.            |                | 4.2                        |
| O <sub>3</sub> SrTi                                                | 0.43      | 0.0049 <sup>c</sup>  | 0.504 <sup>c</sup> |                | 0                          |
| O <sub>3</sub> SrTi                                                | 0.33      | 0.00195 <sup>c</sup> | 0.420 <sup>c</sup> |                | 0                          |
| PbSb <sub>1 w/o</sub> (quenched)                                   |           |                      | >1.5               |                | 4.2                        |
| PbSb <sub>1 w/o</sub> (annealed)                                   |           |                      | >0.7               |                | 4.2                        |
| PbSb <sub>2.8 w/o</sub> (quenched)                                 |           |                      | >2.3               |                | 4.2                        |
| PbSb <sub>2.8 w/o</sub> (annealed)                                 |           |                      | >0.7               |                | 4.2                        |
| Pb <sub>0.871</sub> Sn <sub>0.129</sub>                            |           | 0.45                 | 1.1                |                |                            |
| Pb <sub>0.965</sub> Sn <sub>0.035</sub>                            |           | 0.53                 | 0.56               |                |                            |
| Pb <sub>1-0.26</sub> Tl <sub>0-0.74</sub>                          | 7.20–3.68 |                      | 2–6.9 <sup>c</sup> |                | 0                          |
| PbTl <sub>0.17</sub>                                               | 6.73      |                      | 4.5 <sup>c</sup>   |                | 0                          |
| Re <sub>0.26</sub> W <sub>0.74</sub>                               |           |                      | >30                |                |                            |
| Sb <sub>0.93</sub> Sn <sub>0.07</sub>                              |           |                      | 0.12               |                | 3.7                        |
| SiV <sub>3</sub>                                                   | 17.0      | 0.55                 | 156 <sup>c</sup>   |                |                            |
| Sn <sub>x</sub> Te <sub>1-x</sub>                                  |           | 0.00043–0.00236      | 0.005–0.0775       |                | 0.012–0.079                |
| Ta (99.95%)                                                        |           | 0.425                | 1.850              |                | 1.3                        |
|                                                                    |           | 0.325                | 1.425              |                | 2.27                       |
|                                                                    |           | 0.275                | 1.175              |                | 2.66                       |
|                                                                    |           | 0.090                | 0.375              |                | 3.72                       |
| Ta <sub>0.5</sub> Nb <sub>0.5</sub>                                |           |                      | 3.55               |                | 4.2                        |
| Ta <sub>0.65-0</sub> Ti <sub>0.35-1</sub>                          | 4.4–7.8   |                      | >14–138            |                | 1.2                        |
| Ta <sub>0.5</sub> Ti <sub>0.5</sub>                                |           |                      | 138                |                | 1.2                        |
| Te                                                                 | 3.3       | 0.25 <sup>c</sup>    |                    |                | 0                          |
| TcW <sub>x</sub> 1-x                                               | 5.75–7.88 |                      | 8–44               |                | 4.2                        |
| Ti                                                                 |           |                      |                    | 2.7            | 4.2                        |
| Ti <sub>0.75</sub> V <sub>0.25</sub>                               | 5.3       | 0.029 <sup>c</sup>   | 199 <sup>c</sup>   |                | 0                          |
| Ti <sub>0.775</sub> V <sub>0.225</sub>                             | 4.7       | 0.024 <sup>c</sup>   | 172 <sup>c</sup>   |                | 0                          |
| Ti <sub>0.615</sub> V <sub>0.385</sub>                             | 7.07      | 0.050                | 34                 |                | 4.2                        |
| Ti <sub>0.516</sub> V <sub>0.484</sub>                             | 7.20      | 0.062                | 28                 |                | 4.2                        |
| Ti <sub>0.415</sub> V <sub>0.585</sub>                             | 7.49      | 0.078                | 25                 |                | 4.2                        |
| Ti <sub>0.12</sub> V <sub>0.88</sub>                               |           |                      | 17.3               | 28.1           | 4.2                        |
| Ti <sub>0.09</sub> V <sub>0.91</sub>                               |           |                      | 14.3               | 16.4           | 4.2                        |
| Ti <sub>0.06</sub> V <sub>0.94</sub>                               |           |                      | 8.2                | 12.7           | 4.2                        |

| Substance                            | $T_c$ , K | $H_{c1}$ , kOe | $H_{c2}$ , kOe | $H_{c3}$ , kOe | $T_{obs}^a$ , K <sup>a</sup> |
|--------------------------------------|-----------|----------------|----------------|----------------|------------------------------|
| Ti <sub>0.03</sub> V <sub>0.97</sub> |           |                | 3.8            | 6.8            | 4.2                          |
| Ti <sub>x</sub> V <sub>1-x</sub>     |           |                | 108 max.       |                | 1.2                          |
| V                                    | 5.31      | 0.8            | 3.4            |                | 1.79                         |
|                                      |           | 0.75           | 3.15           |                | 2                            |
|                                      |           | 0.45           | 2.2            |                | 3                            |
|                                      |           | 0.30           | 1.2            |                | 4                            |
| V <sub>0.26</sub> Zr <sub>0.74</sub> | ≈5.9      | 0.238          |                |                | 1.05                         |
|                                      |           | 0.227          |                |                | 1.78                         |
|                                      |           | 0.185          |                |                | 3.04                         |
|                                      |           | 0.165          |                |                | 3.5                          |
| W (film)                             | 1.7–4.1   |                | >34            |                | 1                            |

<sup>a</sup> Temperature of critical field measurement.

<sup>b</sup> w/o denotes weight percent.

<sup>c</sup> Extrapolated.

<sup>d</sup> Linear extrapolation.

<sup>e</sup> Parabolic extrapolation

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# HIGH TEMPERATURE SUPERCONDUCTORS

C. N. R. Rao and A. K. Raychaudhuri

The following tables give properties of a number of high temperature superconductors. Table 1 lists the crystal structure (space group and lattice constants) and the critical transition temperature  $T_c$  for the more important high temperature superconductors so far studied. Table 2 gives energy gap, critical current density, and penetration depth in the superconducting state. Table 3 gives electrical and thermal properties of some of these materials in the normal state. The tables were prepared in November 1992 and updated in November 1994.

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**TABLE 1. Structural Parameters and Approximate  $T_c$  Values of High-Temperature Superconductors**

| Material                                                                       | Structure                                                                                  | $T_c$ /K (maximum value) |
|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------|
| $\text{La}_2\text{CuO}_{4+\delta}$                                             | Bmab; $a = 5.355$ , $b = 5.401$ , $c = 13.15$ Å                                            | 39                       |
| $\text{La}_{2-x}\text{Sr}_x(\text{Ba}_x)\text{CuO}_4$                          | I4/mmm; $a = 3.779$ , $c = 13.23$ Å                                                        | 35                       |
| $\text{La}_2\text{Ca}_{1-x}\text{Sr}_x\text{Cu}_2\text{O}_6$                   | I4/mmm; $a = 3.825$ , $c = 19.42$ Å                                                        | 60                       |
| $\text{YBa}_2\text{Cu}_3\text{O}_7$                                            | Pmmm; $a = 3.821$ , $b = 3.885$ , $c = 11.676$ Å                                           | 93                       |
| $\text{YBa}_2\text{Cu}_4\text{O}_8$                                            | Ammm; $a = 3.84$ , $b = 3.87$ , $c = 27.24$ Å                                              | 80                       |
| $\text{Y}_2\text{Ba}_4\text{Cu}_7\text{O}_{15}$                                | Ammm; $a = 3.851$ , $b = 3.869$ , $c = 50.29$ Å                                            | 93                       |
| $\text{Bi}_2\text{Sr}_2\text{CuO}_6$                                           | Amaa; $a = 5.362$ , $b = 5.374$ , $c = 24.622$ Å                                           | 10                       |
| $\text{Bi}_2\text{CaSr}_2\text{Cu}_2\text{O}_8$                                | $A_2aa$ ; $a = 5.409$ , $b = 5.420$ , $c = 30.93$ Å                                        | 92                       |
| $\text{Bi}_2\text{Ca}_2\text{Sr}_2\text{Cu}_3\text{O}_{10}$                    | $A_2aa$ ; $a = 5.39$ , $b = 5.40$ , $c = 37$ Å                                             | 110                      |
| $\text{Bi}_2\text{Sr}_2(\text{Ln}_{1-x}\text{Ce}_x)_2\text{Cu}_2\text{O}_{10}$ | P4/mmm; $a = 3.888$ , $c = 17.28$ Å                                                        | 25                       |
| $\text{Tl}_2\text{Ba}_2\text{CuO}_6$                                           | $A_2aa$ ; $a = 5.468$ , $b = 5.472$ , $c = 23.238$ Å; I4/mmm; $a = 3.866$ , $c = 23.239$ Å | 92                       |
| $\text{Tl}_2\text{CaBa}_2\text{Cu}_2\text{O}_8$                                | I4/mmm; $a = 3.855$ , $c = 29.318$ Å                                                       | 119                      |
| $\text{Tl}_2\text{Ca}_2\text{Ba}_2\text{Cu}_3\text{O}_{10}$                    | I4/mmm; $a = 3.85$ , $c = 35.9$ Å                                                          | 128                      |
| $\text{Tl}(\text{BaLa})\text{CuO}_5$                                           | P4/mmm; $a = 3.83$ , $c = 9.55$ Å                                                          | 40                       |
| $\text{Tl}(\text{SrLa})\text{CuO}_5$                                           | P4/mmm; $a = 3.7$ , $c = 9$ Å                                                              | 40                       |
| $(\text{Tl}_{0.5}\text{Pb}_{0.5})\text{Sr}_2\text{CuO}_5$                      | P4/mmm; $a = 3.738$ , $c = 9.01$ Å                                                         | 40                       |
| $\text{TlCaBa}_2\text{Cu}_2\text{O}_7$                                         | P4/mmm; $a = 3.856$ , $c = 12.754$ Å                                                       | 103                      |
| $(\text{Tl}_{0.5}\text{Pb}_{0.5})\text{CaSr}_2\text{Cu}_2\text{O}_7$           | P4/mmm; $a = 3.80$ , $c = 12.05$ Å                                                         | 90                       |
| $\text{TlSr}_2\text{Y}_{0.5}\text{Ca}_{0.5}\text{Cu}_2\text{O}_7$              | P4/mmm; $a = 3.80$ , $c = 12.10$ Å                                                         | 90                       |
| $\text{TlCa}_2\text{Ba}_2\text{Cu}_3\text{O}_8$                                | P4/mmm; $a = 3.853$ , $c = 15.913$ Å                                                       | 110                      |
| $(\text{Tl}_{0.5}\text{Pb}_{0.5})\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_9$  | P4/mmm; $a = 3.81$ , $c = 15.23$ Å                                                         | 120                      |
| $\text{TlBa}_2(\text{La}_{1-x}\text{Ce}_x)_2\text{Cu}_2\text{O}_9$             | I4/mmm; $a = 3.8$ , $c = 29.5$ Å                                                           | 40                       |
| $\text{Pb}_2\text{Sr}_2\text{La}_{0.5}\text{Ca}_{0.5}\text{Cu}_3\text{O}_8$    | Cmmm; $a = 5.435$ , $b = 5.463$ , $c = 15.817$ Å                                           | 70                       |
| $\text{Pb}_2(\text{SrLa})_2\text{Cu}_2\text{O}_6$                              | P22 <sub>2</sub> ; $a = 5.333$ , $b = 5.421$ , $c = 12.609$ Å                              | 32                       |
| $(\text{Pb,Cu})\text{Sr}_2(\text{La,Ca})\text{Cu}_2\text{O}_7$                 | P4/mmm; $a = 3.820$ , $c = 11.826$ Å                                                       | 50                       |
| $(\text{Pb,Cu})(\text{Sr,Eu})(\text{Eu,Ce})\text{Cu}_2\text{O}_x$              | I4/mmm; $a = 3.837$ , $c = 29.01$ Å                                                        | 25                       |
| $\text{Nd}_{2-x}\text{Ce}_x\text{CuO}_4$                                       | I4/mmm; $a = 3.95$ , $c = 12.07$ Å                                                         | 30                       |
| $\text{Ca}_{1-x}\text{Sr}_x\text{CuO}_2$                                       | P4/mmm; $a = 3.902$ , $c = 3.35$ Å                                                         | 110                      |
| $\text{Sr}_{1-x}\text{Nd}_x\text{CuO}_2$                                       | P4/mmm; $a = 3.942$ , $c = 3.393$ Å                                                        | 40                       |
| $\text{Ba}_{0.6}\text{K}_{0.4}\text{BiO}_3$                                    | Pm3m; $a = 4.287$ Å                                                                        | 31                       |
| $\text{Rb}_2\text{CsC}_{60}$                                                   | $a = 14.493$ Å                                                                             | 31                       |
| $\text{NdBa}_2\text{Cu}_3\text{O}_7$                                           | Pmmm; $a = 3.878$ , $b = 3.913$ , $c = 11.753$                                             | 58                       |
| $\text{SmBaSrCu}_3\text{O}_7$                                                  | I4/mmm; $a = 3.854$ , $c = 11.62$                                                          | 84                       |
| $\text{EuBaSrCu}_3\text{O}_7$                                                  | I4/mmm; $a = 3.845$ , $c = 11.59$                                                          | 88                       |
| $\text{GdBaSrCu}_3\text{O}_7$                                                  | I4/mmm; $a = 3.849$ , $c = 11.53$                                                          | 86                       |
| $\text{DyBaSrCu}_3\text{O}_7$                                                  | Pmmm; $a = 3.802$ , $b = 3.850$ , $c = 11.56$                                              | 90                       |
| $\text{HoBaSrCu}_3\text{O}_7$                                                  | Pmmm; $a = 3.794$ , $b = 3.849$ , $c = 11.55$                                              | 87                       |
| $\text{ErBaSrCu}_3\text{O}_7$ (multiphase)                                     | Pmmm; $a = 3.787$ , $b = 3.846$ , $c = 11.54$                                              | 82                       |
| $\text{TmBaSrCu}_3\text{O}_7$ (multiphase)                                     | Pmmm; $a = 3.784$ , $b = 3.849$ , $c = 11.55$                                              | 88                       |
| $\text{YBaSrCu}_3\text{O}_7$                                                   | Pmmm; $a = 3.803$ , $b = 3.842$ , $c = 11.54$                                              | 84                       |
| $\text{HgBa}_2\text{CuO}_4$                                                    | I4/mmm; $a = 3.878$ , $c = 9.507$                                                          | 94                       |
| $\text{HgBa}_2\text{CaCu}_2\text{O}_6$ (annealed in $\text{O}_2$ )             | I4/mmm; $a = 3.862$ , $c = 12.705$                                                         | 127                      |
| $\text{HgBa}_2\text{Ca}_2\text{Cu}_3\text{O}_8$                                | Pmmm; $a = 3.85$ , $c = 15.85$                                                             | 133                      |
| $\text{HgBa}_2\text{Ca}_3\text{Cu}_4\text{O}_{10}$                             | Pmmm; $a = 3.854$ , $c = 19.008$                                                           | 126                      |

**TABLE 2. Superconducting Properties** $J_c(0)$ : Critical current density extrapolated to 0 K $\lambda_{ab}$ : Penetration depth in  $a$ - $b$  plane $k_B$ : Boltzmann constant

| Material                                                         | Form           | Energy gap ( $\Delta$ )  |                           | $10^{-6} \times J_c(0)/A\text{ cm}^{-2}$ | $\lambda_{ab}/\text{\AA}$ |
|------------------------------------------------------------------|----------------|--------------------------|---------------------------|------------------------------------------|---------------------------|
|                                                                  |                | $2\Delta_{pp}/k_B T_c^*$ | $2\Delta_{fit}/k_B T_c^+$ |                                          |                           |
| YBa <sub>2</sub> Cu <sub>3</sub> O <sub>7</sub>                  | Single Crystal | 5–6                      | 4–5                       | 30 (film)                                | 1400                      |
| Bi <sub>2</sub> Sr <sub>2</sub> CaCu <sub>2</sub> O <sub>8</sub> | Single Crystal | 8–9                      | 5.5–6.5                   | 2                                        | 2700                      |
| Tl <sub>2</sub> Ba <sub>3</sub> CaCu <sub>2</sub> O <sub>8</sub> | Ceramic        | 6–7                      | 4–6                       | 10 (film, 80 K)                          | 2000                      |
| La <sub>2-x</sub> Sr <sub>x</sub> CuO <sub>4</sub> , $x = 0.15$  | Ceramic        | 7–9                      | 4–6                       |                                          |                           |
| Nd <sub>2-x</sub> Ce <sub>x</sub> CuO <sub>4</sub>               | Ceramic        | 8                        | 4–5                       | 0.2 (film)                               |                           |

\* Obtained from peak to peak value.

+ Obtained from fit to BCS-type relation.

**TABLE 3. Normal State Properties** $\rho_{ab}$ : Resistivity in the  $a$ - $b$  plane $\rho_c$ : Resistivity along the  $c$  axis+ve:  $\rho_c$  has positive temperature coefficient of resistivity-ve:  $\rho_c$  has negative temperature coefficient of resistivity $n_H$ : Hall density $k$ : Thermal conductivityin plane: Along  $a$ - $b$  planeout of plane: Perpendicular to  $a$ - $b$  plane

| Material                                                                        | Form           | $\rho_{ab}/\mu\Omega\text{ cm}$ |        | $\rho_c/\text{m}\Omega\text{ cm}$ | $d\rho_c/dT$               | $10^{-21} \times n_H/\text{cm}^{-3}$ |               | $k/(\text{mW}/\text{cm K})$ at 300 K |              |
|---------------------------------------------------------------------------------|----------------|---------------------------------|--------|-----------------------------------|----------------------------|--------------------------------------|---------------|--------------------------------------|--------------|
|                                                                                 |                | 300 K                           | 100 K  | 300 K                             |                            | 300 K                                | 100 K         | in plane                             | out of plane |
| YBa <sub>2</sub> Cu <sub>3</sub> O <sub>7</sub>                                 | Single crystal | 110                             | 35     | 5                                 | +ve                        | 11–16                                | 4–6           | 120                                  | 3            |
|                                                                                 | Film           | 200–300                         | 60–100 |                                   |                            | 5–9                                  | 2–3           |                                      |              |
| YBa <sub>2</sub> Cu <sub>4</sub> O <sub>8</sub>                                 | Single crystal | 75                              | 20     | 10                                | -ve                        | 14                                   |               |                                      |              |
|                                                                                 | Film           | 100–200                         | 20–50  |                                   |                            | 22                                   | 17            |                                      |              |
| Bi <sub>2</sub> Sr <sub>2</sub> CuO <sub>6</sub>                                | Single crystal | 300                             | 150    | 5000                              | -ve                        | 6                                    | 5             |                                      |              |
| Bi <sub>2</sub> Sr <sub>2</sub> CaCu <sub>2</sub> O <sub>8</sub>                | Single crystal | 150                             | 50     | >1000                             | -ve                        | 4                                    | 3             | 60                                   | 8            |
| Tl <sub>2</sub> Ba <sub>2</sub> CuO <sub>6</sub>                                | Single crystal | 300–400                         | 50–75  | 200–300                           | +ve                        | 3.1                                  | 2.5           |                                      |              |
| Tl <sub>2</sub> Ba <sub>2</sub> Ca <sub>2</sub> Cu <sub>3</sub> O <sub>10</sub> | Ceramic        | ***                             | **     |                                   |                            |                                      | $\approx 2^*$ |                                      |              |
| La <sub>2-x</sub> Sr <sub>x</sub> CuO <sub>4</sub> , $x = 0.12$                 | Single crystal | 900                             | 350    | 200                               | +ve for $T > 225\text{ K}$ | 2.5                                  |               |                                      |              |
| La <sub>2-x</sub> Sr <sub>x</sub> CuO <sub>4</sub> , $x = 0.20$                 | Single crystal | 400                             | 200    | 80                                | +ve for $T > 150\text{ K}$ | 10                                   |               | 50 (for $x = 0.04$ )                 | 20           |
|                                                                                 | Film           | 400                             | 160    |                                   |                            | 8.4                                  | 6.3           |                                      |              |
| Nd <sub>2-x</sub> Ce <sub>x</sub> CuO <sub>4</sub> , $x = 0.17$                 | Single crystal | 500                             | 275    |                                   |                            | 53                                   | 17            |                                      |              |
|                                                                                 | Film           | 140–180                         | 35     |                                   |                            | 32                                   | 11            | 250 (for $x = 0.15$ )                |              |

\* At 200 K

\*\*  $\rho \sim 0.4\text{ m}\Omega\text{ cm}$  at 120 K\*\*\*  $\rho \sim 1.5\text{ m}\Omega\text{ cm}$  at 300 K

# ORGANIC SUPERCONDUCTORS

H.P.R. Frederikse

Although the vast majority of organic compounds are insulators, a small number of organic solids show considerable electrical conductivity. Some of these materials appear to be superconductors. The superconducting organics fall primarily into two groups: those containing fulvalenes (pentagonal rings containing sulfur or selenium) and those based on fullerenes, involving the nearly spherical cluster  $C_{60}$ .

The transition temperatures  $T_c$  of the fulvalene derivatives are shown in Table 1. The abbreviations of the various molecular groups are listed in Table 2 and their chemical structures are depicted in Figure 1. Most of the  $T_c$ 's are between 1 and 12 K. Several of the compounds only show superconductivity under pressure.

The fullerenes are  $A_3C_{60}$  compounds, where A represents a single or a combination of alkali atoms. The  $C_{60}$  cluster is shown in

Figure 2a, while Figure 2b illustrates how the alkali atoms fit into the  $A_3C_{60}$  molecule to form the A15 crystallographic structure. Their superconducting transition temperatures range from 8 to 31.3 K (see Table 3).

## References

1. Ishigura, T. and Yamaji, K., *Organic Superconductors*, Springer-Verlag, Berlin, 1990.
2. Williams, Jack M. et al., *Organic Superconductors (Including Fullerenes)*, Prentice Hall, Englewood Cliffs, N.J., 1992.
3. *The Fullerenes*, Ed.: Krato, H. W., Fisher, J. E., and Cox, D. E., Pergamon Press, Oxford, 1993.
4. Schluter, M. et al., in *The Fullerenes* (Ref. 3), p. 303.

TABLE 1. Critical Pressure and Maximum Critical Temperature of Organic Superconductors

| Material                                                    | $P_c$ /kbar | $T_c$ /K | Material                               | $P_c$ /kbar | $T_c$ /K         |
|-------------------------------------------------------------|-------------|----------|----------------------------------------|-------------|------------------|
| (TMTSF) $_2$ PF $_6$                                        | 6.5         | 1.2      | $\beta$ -(ET) $_2$ IBr $_2$            | 0           | 2.8              |
| (TMTSF) $_2$ AsF $_6$                                       | 9           | 1.3      | $\beta$ -(ET) $_2$ AuI $_2$            | 0           | 4.8              |
| (TMTSF) $_2$ SbF $_6$                                       | 11          | 0.4      | (ET) $_4$ Hg $_{2.89}$ Cl $_8$         | 0           | 4.2              |
| (TMTSF) $_2$ TaF $_6$                                       | 12          | 1.4      | (ET) $_4$ Hg $_{2.89}$ Br $_8$         | 12          | 1.8              |
| (TMTSF) $_2$ ClO $_4$                                       | 0           | 1.4      | (ET) $_3$ Cl $_2$ (H $_2$ O) $_2$      | 16          | 2                |
| (TMTSF) $_2$ ReO $_4$                                       | 9.5         | 1.3      | $\kappa$ -(ET) $_2$ Cu(NCS) $_2$       | 0           | 10.4             |
| (TMTSF) $_2$ FSO $_3$                                       | 5           | 3        | $\kappa$ -(d-ET) $_2$ Cu(NCS) $_2$     | 0           | 11.4             |
| (ET) $_4$ (ReO $_4$ ) $_2$                                  | 4.5         | 2        | (DMET) $_2$ Au(CN) $_2$                | 1.5         | 0.9              |
| $\beta_L$ -(ET) $_2$ I $_3$                                 | 0           | 1.4      | (DMET) $_2$ AuI $_2$                   | 5           | 0.6              |
| $\beta_H$ -(ET) $_2$ I $_3$                                 | 0           | 8.1      | (DMET) $_2$ AuBr $_2$                  | 0           | 1.9              |
| $\gamma$ -(ET) $_3$ I $_{2.5}$                              | 0           | 2.5      | (DMET) $_2$ AuCl $_2$                  | 0           | 0.9              |
| $\epsilon$ -(ET) $_2$ I $_3$ (I $_8$ ) $_{0.5}$             | 0           | 2.5      | (DMET) $_2$ I $_3$                     | 0           | 0.6              |
| $\alpha$ -(ET) $_2$ I $_3$ I $_2$ -doped                    | 0           | 3.3      | (DMET) $_2$ IBr $_2$                   | 0           | 0.7              |
| $\alpha_t$ -(ET) $_2$ I $_3$                                | 0           | 8        | (MDT-TTF) $_2$ AuI $_2$                | 0           | 3.5              |
| $\epsilon \rightarrow \beta$ -(ET) $_2$ I $_3$ <sup>a</sup> | 0           | 6        | TTF[Ni(dmit) $_2$ ] $_2$               | 2           | 1.6 <sup>b</sup> |
| $\theta$ -(ET) $_2$ I $_3$                                  | 0           | 3.6      | TTF[Pd(dmit) $_2$ ] $_2$               | 20          | 6.5              |
| $\kappa$ -(ET) $_2$ I $_3$                                  | 0           | 3.6      | (CH $_3$ ) $_4$ N[Ni(dmit) $_2$ ] $_2$ | 7           | 5                |

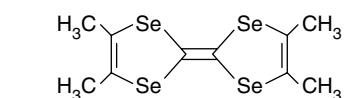
<sup>a</sup> Converted from  $\epsilon$ -type to  $\beta$ -type by thermal treatment.

<sup>b</sup> For 7 kbar.

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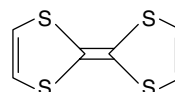
TABLE 2. List of Symbols and Abbreviations

|                  |                                                          |
|------------------|----------------------------------------------------------|
| TTF              | tetrathiafulvalene                                       |
| TMTSF            | tetramethyltetraselenafulvalene                          |
| BEDT-TTF or "ET" | bis(ethylenedithio)tetrathiafulvalene                    |
| MDT-TTF          | methylenedithiotetrathiafulvalene                        |
| DMET             | [dimethyl(ethylenedithio)diselenadithiafulvalene]        |
| dmit             | 4,5-dimercapto-1,3-dithiole-2-thione                     |
| $T_c$            | transition temperature to superconducting state          |
| $P_c$            | minimum pressure required for superconducting transition |



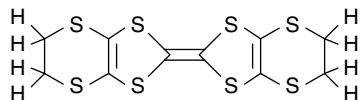
TMTSF

Tetramethyltetraselenafulvalene



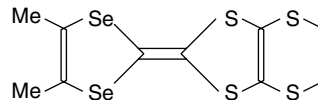
TTF

Tetrathiafulvalene



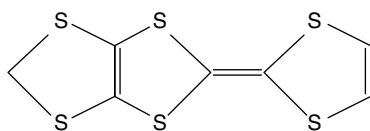
BEDT – TTF or ET

Bis(ethylenedithio)tetrathiafulvalene



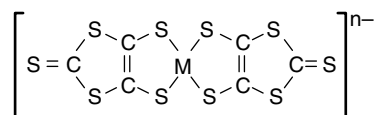
DMET

Dimethyl(ethylenedithio)diselenadithiafulvalene



MDT – TTF

Methylenedithiotetrathiafulvalene



M=Ni, Pd, Pt

M(dmit)<sub>2</sub><sup>2-</sup>

Ligand is 4,5-dimercapto-1,3-dithiole-2-thione

FIGURE 1. Structures of various donor molecules and acceptor species.

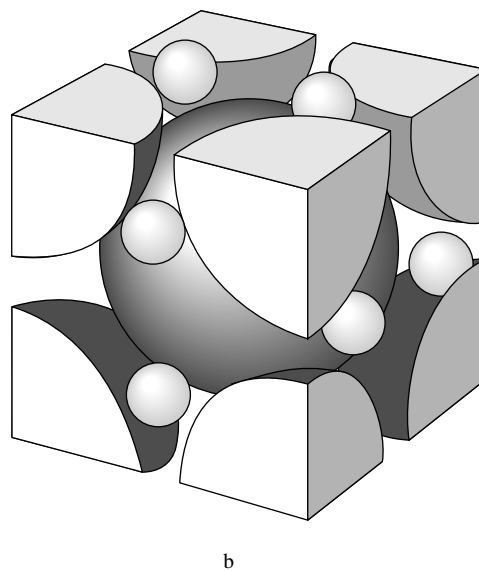
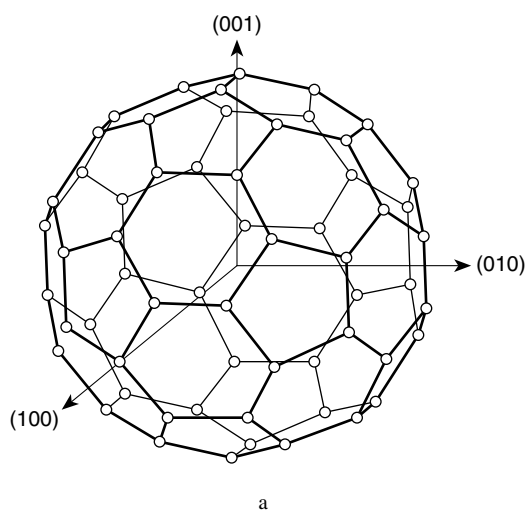


FIGURE 2. (a)  $C_{60}$  cluster placed in a fcc lattice. Each crystal axis crosses a double bond shared by two hexagons. (b) A hypothetical  $A_3C_{60}$  with the A15 structure. The structure can be seen to be an ordered defect structure of  $A_6C_{60}$ .

**TABLE 3. Unit Cell and  $T_c$  for FCC- $A_3C_{60}$** 

|                                   | Lattice parameter(s) (Å) | $T_c$ /K |
|-----------------------------------|--------------------------|----------|
| $Na_2Rb_{0.5}Cs_{0.5}C_{60}$      | 14.148(3)                | 8.0      |
| $Na_2CsC_{60}$ No. 1 <sup>a</sup> | 14.132(2)                | 10.5     |
| $Na_2CsC_{60}$ No. 2 <sup>a</sup> | 14.176(9)                | 14.0     |
| $K_3C_{60}$                       | 14.253(3)                | 19.3     |
| $K_2RbC_{60}$                     | 14.299(2)                | 21.8     |
| $Rb_2KC_{60}$ No. 1 <sup>a</sup>  | 14.336(1)                | 24.4     |
| $Rb_2KC_{60}$ No. 2 <sup>a</sup>  | 14.364(5)                | 26.4     |
| $Rb_3C_{60}$                      | 14.436(2)                | 29.4     |
| $Rb_2CsC_{60}$                    | 14.493(2)                | 31.3     |

<sup>a</sup> Samples labeled No. 1 and No. 2 have the same nominal composition.

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# PROPERTIES OF SEMICONDUCTORS

L. I. Berger

The term *semiconductor* is applied to a material in which electric current is carried by electrons or holes and whose electrical conductivity, when extremely pure, rises exponentially with temperature and may be increased from its low “intrinsic” value by many orders of magnitude by “doping” with electrically active impurities.

Semiconductors are characterized by an energy gap in the allowed energies of electrons in the material that separates the normally filled energy levels of the *valence band* (where “missing” electrons behave like positively charged current carriers “holes”) and the *conduction band* (where electrons behave rather like a gas of free negatively charged carriers with an effective mass dependent on the material and the direction of the electrons’ motion). This energy gap depends on the nature of the material and varies with direction in anisotropic crystals. It is slightly dependent on

temperature and pressure, and this dependence is usually almost linear at normal temperatures and pressures.

Data are presented in five tables. Table 1 lists the main crystallographic and semiconducting properties of a large number of semiconducting materials in three main categories: “Tetrahedral Semiconductors” in which every atom is tetrahedrally coordinated to four nearest neighbor atoms (or atomic sites) as for example in the diamond structure; “Octahedral Semiconductors” in which every atom is octahedrally coordinated to six nearest neighbor atoms—as for example the halite structure; and “Other Semiconductors.”

Table 2 gives electrical, magnetic, and optical properties, while Tables 3 and 4 give more details on the semiconducting properties and band structures of the most common semiconductors. Table 5 lists semiconducting minerals with typical resistivity ranges.

TABLE 1. Physico-Chemical Properties of Semiconductors (Listed by Crystal Structure)

| Substance                                                                                                                           | Molecular weight | Average atomic weight | Lattice parameters (Å, room temp.) | Density (g/cm <sup>3</sup> ) | Melting point (K)                                   | Microhardness, N/mm <sup>2</sup> (M-Mohs Scale) | Specific heat, J/kg-K (300 K) | Debye temp. (K) | Coefficient of thermal linear expansion [10 <sup>-6</sup> K <sup>-1</sup> (300K)] | Thermal conductivity [mW/cm-K (300K)] |
|-------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------|------------------------------------|------------------------------|-----------------------------------------------------|-------------------------------------------------|-------------------------------|-----------------|-----------------------------------------------------------------------------------|---------------------------------------|
| <b>1.1. Tetrahedral (Adamantine) Semiconductors</b>                                                                                 |                  |                       |                                    |                              |                                                     |                                                 |                               |                 |                                                                                   |                                       |
| <i>1.1.1. Diamond Structure Elements (Strukturbericht symbol A4, Space Group Fd3m-O<sub>h</sub><sup>2</sup>)</i>                    |                  |                       |                                    |                              |                                                     |                                                 |                               |                 |                                                                                   |                                       |
| C (Diamond)                                                                                                                         |                  | 12.01                 | 3.56683                            | 3.513                        | ≈4713<br>(12.4 GPa)<br>Transition to graphite > 980 | 10 (M)                                          | 471.5                         | 2340            | 1.18                                                                              | 9900(I)<br>23200(IIA)<br>13600(IIB)   |
| Si                                                                                                                                  |                  | 28.09                 | 5.43072                            | 2.329                        | 1687                                                | 11270                                           | 702                           | 645             | 2.6                                                                               | 1240                                  |
| Ge                                                                                                                                  |                  | 72.64                 | 5.65754                            | 5.323                        | 1211.35                                             | 7644                                            | 321.9                         | 374             | 5.8                                                                               | 640                                   |
| α-Sn                                                                                                                                |                  | 118.71                | 6.4912                             | 5.769                        | 505.1<br>(Tr. 286.4)                                |                                                 | 213                           | 230             | 5.4 (220 K)                                                                       |                                       |
| <i>1.1.2. Sphalerite (Zinc Blende) Structure Compounds (Strukturbericht symbol B3 Space Group F-4 3m-T<sub>d</sub><sup>2</sup>)</i> |                  |                       |                                    |                              |                                                     |                                                 |                               |                 |                                                                                   |                                       |
| <b>I-VII Compounds</b>                                                                                                              |                  |                       |                                    |                              |                                                     |                                                 |                               |                 |                                                                                   |                                       |
| CuF                                                                                                                                 | 82.54            | 41.27                 | 4.255                              |                              | 1181                                                |                                                 |                               |                 |                                                                                   |                                       |
| CuCl                                                                                                                                | 98.99            | 49.49                 | 5.4057                             | 3.53                         | 695                                                 | 2.3 (M)                                         | 490                           | 240             | 12.1                                                                              | 8.4                                   |
| CuBr                                                                                                                                | 143.45           | 71.73                 | 5.6905                             | 4.98                         | 770                                                 | 2.5 (M)                                         | 381                           | 207             | 15.4                                                                              | 12.5                                  |
| CuI                                                                                                                                 | 190.45           | 95.23                 | 6.60427                            | 5.63                         | 878                                                 |                                                 | 276                           | 181             | 19.2                                                                              | 16.8                                  |
| AgBr                                                                                                                                | 187.77           | 93.89                 |                                    | 6.473                        | >1570 (Tr. 410)                                     | 2.5 (M)                                         | 270                           |                 |                                                                                   |                                       |
| AgI                                                                                                                                 | 234.77           | 117.39                | 6.502                              | 5.67                         | 831                                                 | 2.5 (M)                                         | 232                           | 134             | -2.5                                                                              | 4.2                                   |
| <b>II-VI Compounds</b>                                                                                                              |                  |                       |                                    |                              |                                                     |                                                 |                               |                 |                                                                                   |                                       |
| BeS                                                                                                                                 | 41.08            | 20.54                 | 4.865                              | 2.36                         | dec.                                                |                                                 |                               |                 |                                                                                   |                                       |
| BeSe                                                                                                                                | 87.97            | 43.99                 | 5.139                              | 4.315                        |                                                     |                                                 |                               |                 |                                                                                   |                                       |
| BeTe                                                                                                                                | 136.61           | 68.31                 | 5.626                              | 5.090                        |                                                     |                                                 |                               |                 |                                                                                   |                                       |
| BePo                                                                                                                                | (2318)           | (109)                 | 5.838                              | 7.3                          |                                                     |                                                 |                               |                 |                                                                                   |                                       |
| ZnO                                                                                                                                 | 81.39            | 40.69                 | 4.63                               | 5.675                        | 2248                                                | 5.0 (M)                                         | 494                           | 416             | 2.9                                                                               | 234                                   |
| ZnS                                                                                                                                 | 97.46            | 48.72                 | 5.4093                             | 4.079                        | 2100<br>(Tr. 1295)                                  | 1780                                            | 472                           | 530             | 6.36                                                                              | 251                                   |

| Substance | Molecular weight | Average atomic weight | Lattice parameters (Å, room temp.) | Density (g/cm <sup>3</sup> ) | Melting point (K) | Microhardness, N/mm <sup>2</sup> (M-Mohs Scale) | Specific heat, J/kg·K (300 K) | Debye temp. (K) | Coefficient of thermal linear expansion [10 <sup>-6</sup> K <sup>-1</sup> (300K)] | Thermal conductivity [mW/cm·K (300K)] |
|-----------|------------------|-----------------------|------------------------------------|------------------------------|-------------------|-------------------------------------------------|-------------------------------|-----------------|-----------------------------------------------------------------------------------|---------------------------------------|
| ZnSe      | 144.34           | 72.17                 | 5.6676                             | 5.42                         | 1790              | 1350                                            | 339                           | 400             | 7.2                                                                               | 140                                   |
| ZnTe      | 192.99           | 96.5                  | 6.101                              | 6.34                         | 1568              | 900                                             | 264                           | 223             | 8.19                                                                              | 108                                   |
| ZnPo      | (274)            | (137)                 | 6.309                              |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| CdS       | 144.48           | 72.24                 | 5.832                              | 4.826                        | 1750              | 1250                                            | 330                           | 219             | 4.7                                                                               | 200                                   |
| CdSe      | 191.37           | 95.68                 | 6.05                               | 5.674                        | 1512              | 1300                                            | 255                           | 181             | 3.8                                                                               | 90                                    |
| CdTe      | 240.01           | 120.00                | 6.477                              | 5.86                         | 1365              | 600                                             | 205                           | 200             | 4.9                                                                               | 58.5                                  |
| CdPo      | (321)            | (161)                 | 6.665                              |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| HgS       | 232.66           | 116.33                | 5.8517                             | 7.73                         | 1820              | 3 (M)                                           | 210                           |                 |                                                                                   |                                       |
| HgSe      | 279.55           | 139.78                | 6.084                              | 8.25                         | 1070              | 2.5 (M)                                         | 178                           | 151             | 5.46                                                                              | 10                                    |
| HgTe      | 328.19           | 164.10                | 6.4623                             | 8.17                         | 943               | 300                                             | 164                           | 242             | 4.6                                                                               | 20                                    |

III-V Compounds

|          |        |        |         |       |            |         |     |       |     |     |
|----------|--------|--------|---------|-------|------------|---------|-----|-------|-----|-----|
| BN       | 24.82  | 12.41  | 3.615   | 3.49  | 3239       | 10 (M)  | 793 | ≈1900 |     | 200 |
| BP(L.T.) | 41.78  | 20.87  | 4.538   | 2.9   | 1398 (dec) | 37000   |     | ≈980  |     |     |
| BAs      | 85.73  | 42.87  | 4.777   |       | ≈2300      | 19000   |     | ≈625  |     |     |
| AlP      | 57.95  | 28.98  | 5.451   | 2.42  | ≈2100      | 5.5 (M) |     | 588   |     | 920 |
| AlAs     | 101.90 | 50.95  | 5.6622  | 3.81  | 2013       | 5000    |     | 417   | 3.5 | 840 |
| AlSb     | 148.74 | 74.37  | 6.1355  | 4.218 | 1330       | 4000    |     | 292   | 4.2 | 600 |
| GaP      | 100.70 | 50.35  | 5.4905  | 4.13  | 1750       | 9450    |     | 446   | 5.3 | 752 |
| GaAs     | 144.64 | 72.32  | 5.65315 | 5.316 | 1510       | 7500    |     | 344   | 5.4 | 560 |
| GaSb     | 191.48 | 95.74  | 6.0954  | 5.619 | 980        | 4480    | 320 | 265   | 6.1 | 270 |
| InP      | 145.79 | 72.90  | 5.86875 | 4.787 | 1330       | 4100    |     | 321   | 4.6 | 800 |
| InAs     | 189.74 | 94.87  | 6.05838 | 5.66  | 1215       | 3300    | 268 | 249   | 4.7 | 290 |
| InSb     | 236.58 | 118.29 | 6.47877 | 5.775 | 798        | 2200    | 144 | 202   | 4.7 | 160 |

Other sphalerite structure compounds

|                                        |        |        |       |      |      |      |  |  |     |     |
|----------------------------------------|--------|--------|-------|------|------|------|--|--|-----|-----|
| MnS                                    | 87.00  | 43.5   | 5.011 |      |      |      |  |  |     |     |
| MnSe                                   | 133.90 | 66.95  | 5.82  |      |      |      |  |  |     |     |
| β-SiC (3-C SiC)                        | 40.10  | 20.1   | 4.348 | 3.21 | 3070 |      |  |  | 2.9 | 4.9 |
| Ga <sub>2</sub> Se <sub>3</sub>        | 376.32 | 75.26  | 5.429 | 4.92 | 1020 | 3160 |  |  | 8.9 | 50  |
| Ga <sub>2</sub> Te <sub>3</sub>        | 522.24 | 104.45 | 5.899 | 5.75 | 1063 | 2370 |  |  |     | 47  |
| In <sub>2</sub> Te <sub>3</sub> (H.T.) | 608.44 | 121.7  | 6.173 | 5.8  | 940  | 1660 |  |  |     | 69  |
| MgGeP <sub>2</sub>                     | 158.84 | 39.71  | 5.652 |      |      |      |  |  |     |     |
| ZnSnP <sub>2</sub>                     | 246.00 | 61.5   | 5.65  |      | 1200 |      |  |  |     |     |
| ZnSnAs <sub>2</sub> (H.T.)             | 333.90 | 82.38  | 5.851 | 5.53 | 1050 |      |  |  |     | 76  |
| ZnSnSb <sub>2</sub>                    | 427.56 | 106.89 | 6.281 | 5.67 | 870  | 2500 |  |  |     | 76  |

1.1.3. Wurtzite (Zincite) Structure Compounds (Strukturbericht symbol B4, Space Group P 6<sub>3</sub>mc-C<sub>6v</sub><sup>d</sup>)

I-VII Compounds

|      |        |        |       |       |     |  |  |  |  |  |
|------|--------|--------|-------|-------|-----|--|--|--|--|--|
| CuCl | 99.0   | 49.5   | 3.91  | 6.42  | 703 |  |  |  |  |  |
| CuBr | 143.45 | 71.73  | 4.06  | 6.66  | 770 |  |  |  |  |  |
| CuI  | 190.45 | 95.23  | 4.31  | 7.09  |     |  |  |  |  |  |
| AgI  | 234.77 | 117.40 | 4.580 | 7.494 |     |  |  |  |  |  |

II-VI Compounds

|      |       |       |         |        |      |       |  |  |  |     |
|------|-------|-------|---------|--------|------|-------|--|--|--|-----|
| BeO  | 25.01 | 12.51 | 2.698   | 4.380  | 2800 |       |  |  |  |     |
| MgTe | 151.9 | 76.0  | 4.54    | 7.39   | 3.85 | ≈2800 |  |  |  |     |
| ZnO  | 81.37 | 40.69 | 3.24950 | 5.2069 | 5.66 | 2250  |  |  |  | 600 |
| ZnS  | 97.43 | 48.72 | 3.8140  | 6.2576 | 4.1  | 2100  |  |  |  | 460 |

| Substance                                                                                                               | Molecular weight | Average atomic weight | Lattice parameters (Å, room temp.) |        | Density (g/cm <sup>3</sup> ) | Melting point (K) | Microhardness, N/mm <sup>2</sup> (M-Mohs Scale) | Specific heat, J/kg·K (300 K) | Debye temp. (K) | Coefficient of thermal linear expansion [10 <sup>-6</sup> K <sup>-1</sup> (300K)] | Thermal conductivity [mW/cm·K (300K)] |
|-------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------|------------------------------------|--------|------------------------------|-------------------|-------------------------------------------------|-------------------------------|-----------------|-----------------------------------------------------------------------------------|---------------------------------------|
|                                                                                                                         |                  |                       |                                    |        |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| ZnTe                                                                                                                    | 192.99           | 46.50                 | 4.27                               | 6.99   |                              | 1568              |                                                 |                               |                 |                                                                                   |                                       |
| CdS                                                                                                                     | 144.48           | 72.23                 | 4.1348                             | 6.7490 | 4.82                         | 1748              |                                                 |                               |                 |                                                                                   | 401                                   |
| CdSe                                                                                                                    | 191.37           | 95.68                 | 4.299                              | 7.010  | 5.66                         | 1512              |                                                 |                               |                 |                                                                                   | 316                                   |
| CdTe                                                                                                                    | 240.01           | 120.00                | 4.57                               | 7.47   |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| III-V Compounds                                                                                                         |                  |                       |                                    |        |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| BP(H.T.)                                                                                                                | 41.79            | 20.90                 | 3.562                              | 5.900  |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| AlN                                                                                                                     | 40.99            | 20.50                 | 3.111                              | 4.978  | 3.26                         | ≈2500             |                                                 |                               |                 |                                                                                   | 823                                   |
| GaN                                                                                                                     | 83.73            | 41.87                 | 3.190                              | 5.189  | 6.10                         | 1500              |                                                 |                               |                 |                                                                                   | 656                                   |
| InN                                                                                                                     | 128.83           | 64.42                 | 3.533                              | 5.693  | 6.88                         | 1200              |                                                 |                               |                 |                                                                                   | 556                                   |
| Other wurtzite structure compounds                                                                                      |                  |                       |                                    |        |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| MnS                                                                                                                     | 87.00            | 43.5                  | 3.985                              | 6.45   | 3.248                        |                   |                                                 |                               |                 |                                                                                   |                                       |
| MnSe                                                                                                                    | 133.90           | 66.95                 | 4.12                               | 6.72   |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| SiC                                                                                                                     | 40.10            | 20.1                  | 3.076                              | 5.048  |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| MnTe                                                                                                                    | 182.54           | 91.27                 | 4.078                              | 6.701  |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| Al <sub>2</sub> S <sub>3</sub>                                                                                          | 150.14           | 30.03                 | 3.579                              | 5.829  | 2.55                         | 1400              |                                                 |                               |                 |                                                                                   |                                       |
| Al <sub>2</sub> Se <sub>3</sub>                                                                                         | 290.84           | 58.17                 | 3.890                              | 6.30   | 3.91                         | 1250              |                                                 |                               |                 |                                                                                   |                                       |
| 1.1.4. Chalcopyrite Structure Compounds (Strukturbericht symbol E1, Space Group I 4̄ 2d-D <sub>2d</sub> <sup>12</sup> ) |                  |                       |                                    |        |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| I-III-VI <sub>2</sub> Compounds                                                                                         |                  |                       |                                    |        |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| CuAlS <sub>2</sub>                                                                                                      | 154.65           | 38.66                 | 5.323                              | 10.44  | 3.47                         | 2500              |                                                 |                               |                 |                                                                                   |                                       |
| CuAlSe <sub>2</sub>                                                                                                     | 248.45           | 62.11                 | 5.617                              | 10.92  | 4.70                         | 2260              |                                                 |                               |                 |                                                                                   |                                       |
| CuAlTe <sub>2</sub>                                                                                                     | 345.73           | 86.43                 | 5.976                              | 11.80  | 5.50                         | 2550              |                                                 |                               |                 |                                                                                   |                                       |
| CuGaS <sub>2</sub>                                                                                                      | 197.39           | 49.53                 | 5.360                              | 10.49  | 4.35                         | 2300              |                                                 |                               |                 |                                                                                   |                                       |
| CuGaSe <sub>2</sub>                                                                                                     | 291.19           | 72.80                 | 5.618                              | 11.01  | 5.56                         | 1970              | 4200                                            |                               | 275             | 5.4                                                                               | 42                                    |
| CuGaTe <sub>2</sub>                                                                                                     | 388.47           | 97.12                 | 6.013                              | 11.93  | 5.99                         | 2400              | 3500                                            |                               |                 | 6.9                                                                               | 27                                    |
| CuInS <sub>2</sub>                                                                                                      | 242.49           | 60.62                 | 5.528                              | 11.08  | 4.75                         | 1400              | 2550                                            |                               |                 |                                                                                   |                                       |
| CuInSe <sub>2</sub>                                                                                                     | 336.29           | 84.07                 | 5.785                              | 11.56  | 5.77                         | 1600              | 2050                                            |                               |                 | 6.6                                                                               | 37                                    |
| CuInTe <sub>2</sub>                                                                                                     | 433.57           | 108.39                | 6.179                              | 12.365 | 6.10                         | 1660              | 400                                             |                               | 195             | 7.1                                                                               | 49                                    |
| CuTlS <sub>2</sub>                                                                                                      | 322.05           | 83.01                 | 5.580                              | 11.17  | 6.32                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| CuTlSe <sub>2</sub> (L.T.)                                                                                              | 425.85           | 106.46                | 5.844                              | 11.65  | 7.11                         | 900               |                                                 |                               |                 |                                                                                   |                                       |
| CuFeS <sub>2</sub>                                                                                                      | 183.51           | 45.88                 | 5.29                               | 10.32  | 4.088                        | 1135              |                                                 |                               |                 |                                                                                   |                                       |
| CuFeSe <sub>2</sub>                                                                                                     | 277.31           | 69.33                 |                                    |        |                              | 850               |                                                 |                               |                 |                                                                                   |                                       |
| CuLaS <sub>2</sub>                                                                                                      | 266.58           | 66.65                 | 5.65                               | 10.86  |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| AgAlS <sub>2</sub>                                                                                                      | 198.97           | 49.74                 | 5.707                              | 10.28  | 3.94                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| AgAlSe <sub>2</sub>                                                                                                     | 292.77           | 73.19                 | 5.968                              | 10.77  | 5.07                         | 1220              |                                                 |                               |                 |                                                                                   |                                       |
| AgAlTe <sub>2</sub>                                                                                                     | 390.05           | 97.51                 | 6.309                              | 11.85  | 6.18                         | 1000              |                                                 |                               |                 |                                                                                   |                                       |
| AgGaS <sub>2</sub>                                                                                                      | 241.71           | 60.43                 | 5.755                              | 10.28  | 4.72                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| AgGaSe <sub>2</sub>                                                                                                     | 335.51           | 83.88                 | 5.985                              | 10.90  | 5.84                         | 1120              | 4400                                            |                               |                 |                                                                                   |                                       |
| AgGaTe <sub>2</sub>                                                                                                     | 432.79           | 108.2                 | 6.301                              | 11.96  | 6.05                         | 990               | 1800                                            |                               | 212             |                                                                                   | 10                                    |
| AgInS <sub>2</sub> (L.T.)                                                                                               | 286.87           | 71.70                 | 5.828                              | 11.19  | 5.00                         |                   | 2250                                            |                               |                 |                                                                                   |                                       |
| AgInSe <sub>2</sub>                                                                                                     | 380.61           | 95.15                 | 6.102                              | 11.69  | 5.81                         | 1053              | 1850                                            |                               |                 |                                                                                   | 30                                    |
| AgInTe <sub>2</sub>                                                                                                     | 477.89           | 119.47                | 6.42                               | 12.59  | 6.12                         | 965               |                                                 |                               |                 | 9.49, 0.69                                                                        |                                       |
| AgFeS <sub>2</sub>                                                                                                      | 227.83           | 56.96                 | 5.66                               | 10.30  | 4.53                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| II-IV-V <sub>2</sub> Compounds                                                                                          |                  |                       |                                    |        |                              |                   |                                                 |                               |                 |                                                                                   |                                       |
| ZnSiP <sub>2</sub>                                                                                                      | 155.40           | 38.85                 | 5.400                              | 10.441 | 3.39                         | 1640              | 1100                                            |                               |                 |                                                                                   |                                       |
| ZnGeP <sub>2</sub>                                                                                                      | 199.90           | 49.98                 | 5.465                              | 10.771 | 4.17                         | 1295              | 8100                                            |                               |                 |                                                                                   | 180                                   |
| ZnSnP <sub>2</sub>                                                                                                      | 246.00           | 61.5                  |                                    |        |                              |                   | 6500                                            |                               |                 |                                                                                   |                                       |
| CdSiP <sub>2</sub>                                                                                                      | 202.43           | 50.61                 | 5.678                              | 10.431 | 4.00                         | ≈1470             | 10500                                           |                               | 282             |                                                                                   |                                       |



| Substance           | Molecular weight | Average atomic weight | Lattice parameters (Å, room temp.) |        | Density (g/cm <sup>3</sup> ) | Melting point (K) | Microhardness, N/mm <sup>2</sup> (M-Mohs Scale) | Specific heat, J/kg·K (300 K) | Debye temp. (K) | Coefficient of thermal linear expansion [10 <sup>-6</sup> K <sup>-1</sup> (300K)] | Thermal conductivity [mW/cm·K (300K)] |
|---------------------|------------------|-----------------------|------------------------------------|--------|------------------------------|-------------------|-------------------------------------------------|-------------------------------|-----------------|-----------------------------------------------------------------------------------|---------------------------------------|
| CdGeP <sub>2</sub>  | 246.94           | 61.74                 | 5.741                              | 10.775 | 4.48                         | 1049              | 5650                                            |                               |                 |                                                                                   | 110                                   |
| CdSnP <sub>2</sub>  | 243.03           | 73.26                 | 5.900                              | 11.518 |                              | 840               | 5000                                            |                               | 195             |                                                                                   | 140                                   |
| ZnSiAs <sub>2</sub> | 242.20           | 60.55                 | 5.61                               | 10.88  | 4.70                         | 1311              | 9200                                            |                               |                 |                                                                                   |                                       |
| ZnGeAs <sub>2</sub> | 287.80           | 71.95                 | 5.672                              | 11.153 | 5.32                         | 1150              | 6800                                            |                               | 263             |                                                                                   | 110                                   |
| ZnSnAs <sub>2</sub> | 333.90           | 83.48                 | 5.8515                             | 11.704 | 5.53                         | 1048              | 4550                                            |                               | 271             |                                                                                   | 150                                   |
| CdSiAs <sub>2</sub> | 290.34           | 72.58                 | 5.884                              | 10.882 |                              | >1120             | 6850                                            |                               |                 |                                                                                   |                                       |
| CdGeAs <sub>2</sub> | 334.83           | 83.71                 | 5.9427                             | 11.217 | 5.60                         | 938               | 4700                                            |                               |                 |                                                                                   | 48                                    |
| CdSnAs <sub>2</sub> | 380.93           | 95.23                 | 6.0944                             | 11.918 | 5.72                         | 880               | 3450                                            |                               |                 |                                                                                   | 40                                    |

1.1.5. Other Ternary Semiconductors with Tetrahedral Coordination

| I <sub>2</sub> -IV-VI <sub>3</sub> Compounds  |        |        |       |        |       |      |      |     |      |      |      |
|-----------------------------------------------|--------|--------|-------|--------|-------|------|------|-----|------|------|------|
| Cu <sub>2</sub> SiS <sub>3</sub> (H.T.)       | 251.36 | 41.89  | 3.684 | 6.004  | 3.81  | 1200 |      |     |      |      | 23   |
| Cu <sub>2</sub> SiS <sub>3</sub> (L.T.)       |        |        | 5.290 | 10.156 | 3.63  |      |      |     |      |      |      |
| Cu <sub>2</sub> SiTe <sub>3</sub>             | 537.98 | 89.66  | 5.93  |        | 5.47  |      |      |     |      |      |      |
| Cu <sub>2</sub> GeS <sub>3</sub> (H.T.)       | 295.88 | 49.31  | 5.317 |        | 4.45  | 1210 | 4550 | 510 | 254  | 7.2  | 12   |
| Cu <sub>2</sub> GeS <sub>3</sub> (L.T.)       |        |        | 5.327 | 5.215  | 4.46  |      |      |     |      |      |      |
| Cu <sub>2</sub> GeSe <sub>3</sub>             | 436.56 | 72.76  | 5.589 | 5.485  | 5.57  | 1030 | 3840 | 340 | 168  | 8.4  | 24   |
| Cu <sub>2</sub> GeTe <sub>3</sub>             | 582.51 | 97.09  | 5.958 | 5.935  | 5.92  |      | 2890 |     |      |      | 130  |
| Cu <sub>2</sub> SnS <sub>3</sub>              | 341.98 | 57.00  | 5.436 |        | 5.02  | 1110 | 2770 | 440 | 214  | 7.8  | 28   |
| CuSnSe <sub>3</sub>                           | 482.66 | 80.44  | 5.687 |        | 5.94  | 960  | 2510 | 310 | 148  | 8.9  | 35   |
| Cu <sub>2</sub> SnTe <sub>3</sub>             | 628.61 | 104.77 | 6.048 |        | 6.51  | 680  | 1970 |     |      |      | 144  |
| Ag <sub>2</sub> GeSe <sub>3</sub>             | 525.21 | 87.54  |       |        |       | 810  |      |     |      |      |      |
| Ag <sub>2</sub> SnSe <sub>3</sub>             | 571.31 | 95.22  |       |        |       |      |      |     |      |      |      |
| Ag <sub>2</sub> GeTe <sub>3</sub>             | 671.13 | 111.86 |       |        |       | 600  |      |     |      |      |      |
| Ag <sub>2</sub> SnTe <sub>3</sub>             | 717.23 | 119.54 |       |        |       |      |      |     |      |      |      |
| I <sub>3</sub> -V -VI <sub>4</sub> -Compounds |        |        |       |        |       |      |      |     |      |      |      |
| Cu <sub>3</sub> PS <sub>4</sub>               | 349.85 | 40.73  | 7.44  | 6.19   |       |      |      |     |      |      |      |
| Cu <sub>3</sub> AsS <sub>4</sub>              | 393.79 | 49.22  | 6.43  | 6.14   | 4.37  | 931  |      |     |      | 3.2  | 30.2 |
| Cu <sub>3</sub> AsSe <sub>4</sub>             | 581.37 | 72.67  | 5.570 | 10.957 | 5.61  | 733  |      |     | 169  | 9.5  | 19   |
| Cu <sub>3</sub> SbS <sub>4</sub>              | 440.64 | 55.08  | 5.38  | 16.76  | 4.90  | 830  |      |     |      |      |      |
| Cu <sub>3</sub> SbSe <sub>4</sub>             | 628.22 | 78.53  | 5.654 | 11.256 | 6.0   | 700  |      |     | 131  | 12.4 | 14.6 |
| I-IV <sub>2</sub> -V <sub>3</sub> Compounds   |        |        |       |        |       |      |      |     |      |      |      |
| CuSi <sub>2</sub> P <sub>3</sub>              | 212.64 | 35.44  | 5.25  |        |       |      |      |     |      |      |      |
| CuGe <sub>2</sub> P <sub>3</sub>              | 301.65 | 50.28  | 5.375 |        | 4.318 | 1113 | 8500 | 429 | 8.21 | 37.6 |      |
| AgGe <sub>2</sub> P <sub>3</sub>              | 345.97 | 57.66  |       |        |       | 1015 | 6150 |     |      |      |      |

1.1.6. "Defect Chalcopyrite" Structure Compounds (Strukturbericht symbol E3, Space Group I  $\bar{4}$ -S<sub>4</sub><sup>2</sup>)

|                                       |        |        |       |       |      |      |  |  |  |  |  |
|---------------------------------------|--------|--------|-------|-------|------|------|--|--|--|--|--|
| ZnAl <sub>2</sub> Se <sub>4</sub>     | 435.18 | 62.17  | 5.503 | 10.90 | 4.37 |      |  |  |  |  |  |
| ZnAl <sub>2</sub> Te <sub>4</sub> (?) | 629.74 | 84.96  | 5.904 | 12.05 | 4.95 |      |  |  |  |  |  |
| ZnGa <sub>2</sub> S <sub>4</sub> (?)  | 333.06 | 47.58  | 5.274 | 10.44 | 3.80 |      |  |  |  |  |  |
| ZnGa <sub>2</sub> Se <sub>4</sub> (?) | 520.66 | 74.38  | 5.496 | 10.99 | 5.21 |      |  |  |  |  |  |
| ZnGa <sub>2</sub> Te <sub>4</sub> (?) | 715.22 | 102.17 | 5.937 | 11.87 | 5.67 |      |  |  |  |  |  |
| ZnIn <sub>2</sub> Se <sub>4</sub>     | 610.86 | 87.27  | 5.711 | 11.42 | 5.44 | 1250 |  |  |  |  |  |
| ZnIn <sub>2</sub> Te <sub>4</sub>     | 805.42 | 115.06 | 6.122 | 12.24 | 5.83 | 1075 |  |  |  |  |  |
| CdAl <sub>2</sub> S <sub>4</sub>      | 294.61 | 42.09  | 5.564 | 10.32 | 3.06 |      |  |  |  |  |  |
| CdAl <sub>2</sub> Se <sub>4</sub>     | 482.21 | 68.89  | 5.747 | 10.68 | 4.54 |      |  |  |  |  |  |
| CdAl <sub>2</sub> Te <sub>4</sub> (?) | 676.77 | 97.68  | 6.011 | 12.21 | 5.10 |      |  |  |  |  |  |

| Substance                             | Molecular weight | Average atomic weight | Lattice parameters (Å, room temp.) |       | Density (g/cm <sup>3</sup> ) | Melting point (K) | Microhardness, N/mm <sup>2</sup> (M-Mohs Scale) | Specific heat, J/kg·K (300 K) | Debye temp. (K) | Coefficient of thermal linear expansion [10 <sup>-6</sup> K <sup>-1</sup> (300K)] | Thermal conductivity [mW/cm·K (300K)] |
|---------------------------------------|------------------|-----------------------|------------------------------------|-------|------------------------------|-------------------|-------------------------------------------------|-------------------------------|-----------------|-----------------------------------------------------------------------------------|---------------------------------------|
| CdGa <sub>2</sub> S <sub>4</sub>      | 380.09           | 54.30                 | 5.577                              | 10.08 | 4.03                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| CdGa <sub>2</sub> Se <sub>4</sub>     | 567.69           | 81.10                 | 5.743                              | 10.73 | 5.32                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| CdGa <sub>2</sub> Te <sub>4</sub>     | 762.25           | 108.89                | 6.093                              | 11.81 | 5.77                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| CdIn <sub>2</sub> Te <sub>4</sub>     | 852.45           | 121.78                | 6.205                              | 12.41 | 5.9                          | 1060              |                                                 |                               |                 |                                                                                   |                                       |
| HgAl <sub>2</sub> S <sub>4</sub>      | 382.79           | 54.68                 | 5.488                              | 10.26 | 4.11                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| HgAl <sub>2</sub> Se <sub>4</sub>     | 570.39           | 82.48                 | 5.708                              | 10.74 | 5.05                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| HgAl <sub>2</sub> Te <sub>4</sub> (?) | 764.48           | 109.28                | 6.004                              | 12.11 | 5.81                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| HgGa <sub>2</sub> S <sub>4</sub>      | 468.27           | 66.90                 | 5.507                              | 10.23 | 5.00                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| HgGa <sub>2</sub> Se <sub>4</sub>     | 655.87           | 93.70                 | 5.715                              | 10.78 | 6.18                         |                   |                                                 |                               |                 |                                                                                   |                                       |
| HgIn <sub>2</sub> Se <sub>4</sub>     | 746.07           | 106.58                | 5.764                              | 11.80 | 6.3                          | 1100              |                                                 |                               |                 |                                                                                   |                                       |
| HgIn <sub>2</sub> Te <sub>4</sub> (?) | 940.63           | 134.38                | 6.186                              | 12.37 | 6.3                          | 980               |                                                 |                               |                 |                                                                                   |                                       |

### 1.1.7. Other Adamantine Compounds

|                                                 |         |        |               |       |      |      |  |  |  |  |  |
|-------------------------------------------------|---------|--------|---------------|-------|------|------|--|--|--|--|--|
| α-SiC                                           | 40.10   | 20.10  | 3.0817        | 15.12 | 3.21 | 3070 |  |  |  |  |  |
| Hg <sub>5</sub> Ga <sub>2</sub> Te <sub>8</sub> | 2163.19 | 144.21 | 6.235         |       |      |      |  |  |  |  |  |
| Hg <sub>5</sub> In <sub>2</sub> Te <sub>8</sub> | 2253.39 | 150.23 | 6.328         |       |      |      |  |  |  |  |  |
| CdIn <sub>2</sub> Se <sub>4</sub>               | 657.89  | 93.98  | a = c = 5.823 |       |      |      |  |  |  |  |  |

## 1.2. Octahedral Semiconductors

### 1.2.1. Halite Structure Semiconductors (Strukturbericht symbol B1, Space Group Fm3m-O<sub>h</sub><sup>5</sup>)

|      |        |        |        |  |      |            |  |  |  |  |    |
|------|--------|--------|--------|--|------|------------|--|--|--|--|----|
| GeTe | 200.21 | 100.10 | 5.98   |  | 6.14 |            |  |  |  |  |    |
| SnSe | 197.67 | 98.83  | 6.020  |  |      | 1133       |  |  |  |  |    |
| SnTe | 246.31 | 123.15 | 6.313  |  | 6.45 | 1080 (max) |  |  |  |  | 91 |
| PbS  | 239.3  | 119.63 | 5.9362 |  | 7.61 | 1390       |  |  |  |  | 23 |
| PbSe | 286.2  | 143.08 | 6.1243 |  | 8.15 | 1340       |  |  |  |  | 17 |
| PbTe | 334.8  | 167.4  | 6.454  |  | 8.16 | 1180       |  |  |  |  | 23 |

### 1.2.2. Selected Other Binary Halites

|      |        |        |        |  |       |      |  |  |  |  |     |
|------|--------|--------|--------|--|-------|------|--|--|--|--|-----|
| BiSe | 287.94 | 143.97 | 5.99   |  | 7.98  | 880  |  |  |  |  |     |
| BiTe | 336.58 | 168.29 | 6.47   |  |       |      |  |  |  |  |     |
| EuSe | 230.92 | 115.46 | 6.191  |  |       | 2300 |  |  |  |  | 2.4 |
| GdSe | 236.21 | 118.11 | 5.771  |  |       | 2400 |  |  |  |  |     |
| NiO  | 74.69  | 37.35  | 4.1684 |  | 6.6   | 2260 |  |  |  |  |     |
| CdO  | 128.41 | 64.21  | 4.6953 |  |       | 1700 |  |  |  |  | 7   |
| SrS  | 119.69 | 59.84  | 6.0199 |  | 3.643 | 3000 |  |  |  |  |     |

## 1.3. Other Semiconductors

### 1.3.1. Antifluorite Structure Compounds (Fm3m-O<sub>h</sub><sup>5</sup>)

|                    |        |       |       |  |      |      |  |  |  |      |    |
|--------------------|--------|-------|-------|--|------|------|--|--|--|------|----|
| Mg <sub>2</sub> Si | 76.70  | 25.57 | 6.338 |  | 1.88 | 1375 |  |  |  | 11.5 |    |
| Mg <sub>2</sub> Ge | 121.22 | 40.4  | 6.380 |  | 3.08 | 1388 |  |  |  | 15.0 |    |
| Mg <sub>2</sub> Sn | 167.32 | 55.77 | 6.765 |  | 3.53 | 1051 |  |  |  | 9.9  | 92 |
| Mg <sub>2</sub> Pb | 225.81 | 85.27 | 6.836 |  | 5.1  | 823  |  |  |  | 10.0 |    |

### 1.3.2. Tetradymite Structure Compounds ( $\bar{R}3m-D_{3d}^5$ )

|                                 |        |        |      |       |      |     |     |    |  |  |    |
|---------------------------------|--------|--------|------|-------|------|-----|-----|----|--|--|----|
| Sb <sub>2</sub> Te <sub>3</sub> | 626.3  | 125.26 | 4.25 | 30.3  | 6.44 | 895 |     |    |  |  |    |
| Bi <sub>2</sub> Se <sub>3</sub> | 654.84 | 130.97 | 4.14 | 28.7  | 7.51 | 979 | 167 |    |  |  | 24 |
| Bi <sub>2</sub> Te <sub>3</sub> | 800.76 | 160.15 | 4.38 | 30.45 | 7.73 | 858 | 155 | 16 |  |  | 30 |

| Substance                                                                                   | Molecular weight | Average atomic weight | Lattice parameters (Å, room temp.) | Density (g/cm³) | Melting point (K) | Microhardness, N/mm² (M-Mohs Scale) | Specific heat, J/kg·K (300 K) | Debye temp. (K) | Coefficient of thermal linear expansion [10 <sup>-6</sup> K <sup>-1</sup> (300K)] | Thermal conductivity [mW/cm·K (300K)] |     |
|---------------------------------------------------------------------------------------------|------------------|-----------------------|------------------------------------|-----------------|-------------------|-------------------------------------|-------------------------------|-----------------|-----------------------------------------------------------------------------------|---------------------------------------|-----|
| 1.3.3. Skutterudite Structure Compounds ( <i>Im</i> 3– <i>T</i> <sub>h</sub> <sup>5</sup> ) |                  |                       |                                    |                 |                   |                                     |                               |                 |                                                                                   |                                       |     |
| CoP <sub>3</sub>                                                                            | 151.85           | 37.96                 | 7.7073                             |                 | >1270             |                                     |                               |                 |                                                                                   |                                       |     |
| CoAs <sub>3</sub>                                                                           | 286.70           | 71.65                 | 8.2060                             | 6.73            | 1230              |                                     |                               |                 |                                                                                   |                                       |     |
| CoSb <sub>3</sub>                                                                           | 424.18           | 106.05                | 9.0385                             |                 | 1123              |                                     |                               | 307             |                                                                                   | 50                                    |     |
| NiAs <sub>3</sub>                                                                           | 283.45           | 70.86                 | 8.330                              | 6.43            |                   |                                     |                               |                 |                                                                                   |                                       |     |
| RhP <sub>3</sub>                                                                            | 195.83           | 48.96                 | 7.9951                             |                 | >1470             |                                     |                               |                 |                                                                                   |                                       |     |
| RhAs <sub>3</sub>                                                                           | 327.67           | 81.92                 | 8.4427                             |                 | >1270             |                                     |                               |                 |                                                                                   | 100                                   |     |
| RhSb <sub>3</sub>                                                                           | 468.16           | 117.04                | 9.2322                             |                 | 1170              |                                     |                               |                 |                                                                                   |                                       |     |
| IrP <sub>3</sub>                                                                            | 285.14           | 71.29                 | 8.0151                             | 7.36            | >1470             |                                     |                               |                 |                                                                                   |                                       |     |
| IrAs <sub>3</sub>                                                                           | 416.98           | 104.25                | 8.4673                             | 9.12            | >1470             |                                     |                               |                 |                                                                                   | 90                                    |     |
| IrSb <sub>3</sub>                                                                           | 557.47           | 139.37                | 9.2533                             | 9.35            | 1170              |                                     |                               | 303             |                                                                                   |                                       |     |
| 1.3.4. Selected Multinary Compounds                                                         |                  |                       |                                    |                 |                   |                                     |                               |                 |                                                                                   |                                       |     |
| AgSbSe <sub>2</sub>                                                                         | 387.54           | 96.88                 | 5.786                              | 6.60            | 910               |                                     |                               |                 |                                                                                   | 10.5                                  |     |
| AgSbTe <sub>2</sub> (or Ag <sub>19</sub> Sb <sub>29</sub> Te <sub>52</sub> )                | 484.82           | 121.2                 | 6.078                              | 7.12            | 830               |                                     |                               |                 |                                                                                   | 86                                    |     |
| AgBiS <sub>2</sub> (H.T.)                                                                   | 380.97           | 95.24                 | 5.648                              |                 |                   |                                     |                               |                 |                                                                                   |                                       |     |
| AgBiSe <sub>2</sub> (H.T.)                                                                  | 474.77           | 118.69                | 5.82                               |                 |                   |                                     |                               |                 |                                                                                   |                                       |     |
| AgBiTe <sub>2</sub> (H.T.)                                                                  | 572.05           | 143.01                | 6.155                              |                 |                   |                                     |                               |                 |                                                                                   |                                       |     |
| Cu <sub>2</sub> CdSnS <sub>4</sub>                                                          | 486.43           | 60.80                 | 5.586                              | 10.83           |                   |                                     |                               |                 |                                                                                   |                                       |     |
| 1.3.5. Some Elemental Semiconductors                                                        |                  |                       |                                    |                 |                   |                                     |                               |                 |                                                                                   |                                       |     |
| B                                                                                           |                  | 10.81                 | 4.91                               | 12.6            | 2.34              | 2348                                | 9.5 (M)                       | 1277            | 1370                                                                              | 8.3                                   | 600 |
| Se(gray)                                                                                    |                  | 78.96                 | 4.36                               | 4.95            | 4.81              | 493                                 | 350                           | 292.6           | (  C) 17.89<br>(⊥C) 74.09                                                         | (  C) 45.2<br>(⊥C) 13.1               |     |
| Te                                                                                          |                  | 127.60                | 4.45                               | 5.91            | 6.23              | 723                                 |                               | 196.5           | 16.8                                                                              | (  C) 33.8<br>(⊥C) 19.7               |     |

TABLE 2. Basic Thermodynamic, Electrical, and Magnetic Properties of Semiconductors (Listed by Crystal Structure)

| Substance                                                                                                       | Heat of formation<br>[kJ/mol<br>(300K)] | Volume compressibility<br>(10 <sup>-10</sup> m <sup>2</sup> /N) | Static dielectric constant | Atomic magnetic susceptibility<br>(10 <sup>-6</sup> cgs) | Index of refraction | Minimum room temperature energy gap (eV) | Mobility (room temp.)  |       | Optical transition | Breakdown voltage kV/mm | Remarks   |
|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------------------------------------------|----------------------------|----------------------------------------------------------|---------------------|------------------------------------------|------------------------|-------|--------------------|-------------------------|-----------|
|                                                                                                                 |                                         |                                                                 |                            |                                                          |                     |                                          | (cm <sup>2</sup> /V.s) |       |                    |                         |           |
|                                                                                                                 |                                         |                                                                 |                            |                                                          |                     |                                          | Electrons              | Holes |                    |                         |           |
| 2.1. Adamantine Semiconductors                                                                                  |                                         |                                                                 |                            |                                                          |                     |                                          |                        |       |                    |                         |           |
| 2.1.1. Diamond Structure Elements (Strukturbericht symbol A4, Space Group $Fd\bar{3}m-O_h^7$ )                  |                                         |                                                                 |                            |                                                          |                     |                                          |                        |       |                    |                         |           |
| C                                                                                                               | 714.4                                   | 18                                                              | 5.7                        | -5.88                                                    | 2.419<br>(589 nm)   | 5.4                                      | 1800                   | 1400  | i*                 | 500                     |           |
| Si                                                                                                              | 324                                     | 0.306                                                           | 11.9                       | -3.9                                                     | 3.49<br>(589 nm)    | 1.12                                     | 1900                   | 500   | i                  | 30                      |           |
| Ge                                                                                                              | 291                                     | 0.768                                                           | 16                         | -0.12                                                    | 3.99<br>(589 nm)    | 0.67                                     | 3800                   | 1820  | i                  |                         |           |
| α-Sn                                                                                                            | 267.5                                   |                                                                 | 24                         |                                                          | 2.75<br>(589 nm)    | 0.0; 0.8                                 | 2500                   | 2400  |                    |                         |           |
| 2.1.2. Sphalerite (Zinc Blende) Structure Compounds (Strukturbericht symbol B3 Space Group $F\bar{4}3m-T_d^2$ ) |                                         |                                                                 |                            |                                                          |                     |                                          |                        |       |                    |                         |           |
| I-VII Compounds                                                                                                 |                                         |                                                                 |                            |                                                          |                     |                                          |                        |       |                    |                         |           |
| CuF                                                                                                             |                                         |                                                                 |                            |                                                          |                     |                                          |                        |       |                    |                         |           |
| CuCl                                                                                                            | 481                                     | 0.26                                                            | 7.9                        |                                                          | 1.93                | 3.17                                     |                        |       | d                  |                         | Nantokite |

| Substance                                                                                                                                   | Heat of formation<br>[kJ/mol<br>(300K)] | Volume<br>compressibility<br>(10 <sup>-10</sup> m <sup>2</sup> /N) | Static<br>dielectric<br>constant | Atomic<br>magnetic<br>susceptibility<br>(10 <sup>-6</sup> cgs) | Index of<br>refraction | Minimum<br>room<br>temperature<br>energy gap<br>(eV) | Mobility (room temp.)<br>(cm <sup>2</sup> /V·s) |          | Optical<br>transition | Breakdown<br>voltage<br>kV/mm | Remarks             |
|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------|----------------------------------|----------------------------------------------------------------|------------------------|------------------------------------------------------|-------------------------------------------------|----------|-----------------------|-------------------------------|---------------------|
|                                                                                                                                             |                                         |                                                                    |                                  |                                                                |                        |                                                      | Electrons                                       | Holes    |                       |                               |                     |
| CuBr                                                                                                                                        | 481                                     | 0.26                                                               | 7.9                              |                                                                | 2.12                   | 2.91                                                 |                                                 |          | d                     |                               |                     |
| CuI                                                                                                                                         | 439                                     | 0.27                                                               | 6.5                              |                                                                | 2.346                  | 2.95                                                 |                                                 |          | d                     |                               | Marshallite         |
| AgBr                                                                                                                                        | 486                                     |                                                                    | 12.4                             |                                                                | 2.253                  | 2.50                                                 | 4000                                            |          | i                     |                               | Bromirite           |
| AgI                                                                                                                                         | 389                                     | 0.41                                                               | 10                               |                                                                | 2.22                   | 2.22                                                 | 30                                              |          | d                     |                               | Miersite            |
| <b>II-VI Compounds</b>                                                                                                                      |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| BeS                                                                                                                                         |                                         |                                                                    |                                  |                                                                | 4.17                   |                                                      |                                                 |          | i                     |                               |                     |
| BeSe                                                                                                                                        |                                         |                                                                    |                                  |                                                                | 3.61                   |                                                      |                                                 |          | i                     |                               |                     |
| BeTe                                                                                                                                        |                                         |                                                                    |                                  |                                                                | 1.45                   |                                                      | 20                                              |          | d                     |                               |                     |
| BePo                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| ZnO                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               | See 2.1.3.          |
| ZnS                                                                                                                                         | 477                                     |                                                                    | 8.9                              | -9.9                                                           | 2.356                  | 3.54                                                 | 180                                             | 5(400°C) | d                     |                               | See also<br>2.1.3.  |
| ZnSe                                                                                                                                        | 422                                     |                                                                    | 9.2                              |                                                                | 2.89                   | 2.58                                                 | 540                                             | 28       | d                     |                               |                     |
| ZnTe                                                                                                                                        | 376                                     |                                                                    | 10.4                             |                                                                | 3.56                   | 2.26                                                 | 340                                             | 100      | d                     |                               |                     |
| ZnP                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| CdS                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               | See 2.1.3.          |
| CdSe                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               | See 2.1.3.          |
| CdTe                                                                                                                                        | 339                                     |                                                                    | 7.2                              |                                                                | 2.50                   | 1.44                                                 | 1200                                            | 50       | d                     |                               |                     |
| CdPo                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| HgS                                                                                                                                         |                                         |                                                                    |                                  |                                                                | 2.85                   |                                                      | 250                                             |          | d                     |                               | Metacinnabarite     |
| HgSe                                                                                                                                        | 247                                     |                                                                    |                                  |                                                                |                        | 2.10 (α)                                             | 20000                                           | ≈1.5     | s                     |                               | Tiemannite          |
| HgTe                                                                                                                                        | 242                                     |                                                                    |                                  |                                                                |                        | -0.06                                                | 25000                                           | 350      | s                     |                               | Coloradoite         |
| <b>III-V Compounds</b>                                                                                                                      |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| BN                                                                                                                                          | 815                                     |                                                                    |                                  |                                                                |                        | 4.6                                                  |                                                 |          |                       |                               | Borazone            |
| BP(L.T.)                                                                                                                                    |                                         |                                                                    |                                  |                                                                |                        | ≈2.1                                                 | 500                                             | 70       |                       |                               | Ignites 470K        |
| BAs                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | ≈1.5                                                 |                                                 |          |                       |                               |                     |
| AlP                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 2.45                                                 | 80                                              |          | i                     |                               |                     |
| AlAs                                                                                                                                        | 627                                     |                                                                    | 10.9                             |                                                                |                        | 2.16                                                 | 1200                                            | 420      | i                     |                               |                     |
| AlSb                                                                                                                                        | 585                                     | 0.571                                                              | 11                               |                                                                | 3.2                    | 1.60                                                 | 200-400                                         | 550      | i                     |                               |                     |
| GaP                                                                                                                                         | 635                                     | 0.110                                                              | 11.1                             | -13.8                                                          | 3.2                    | 2.24                                                 | 300                                             | 150      | i                     |                               |                     |
| GaAs                                                                                                                                        | 535                                     | 0.771                                                              | 13.2                             | -16.2                                                          | 3.30                   | 1.35                                                 | 8800                                            | 400      | d                     |                               |                     |
| GaSb                                                                                                                                        | 493                                     | 0.457                                                              | 15.7                             | -14.2                                                          | 3.8                    | 0.67                                                 | 4000                                            | 1400     | d                     |                               |                     |
| InP                                                                                                                                         | 560                                     | 0.735                                                              | 12.4                             | -22.8                                                          | 3.1                    | 1.27                                                 | 4600                                            | 150      | d                     |                               |                     |
| InAs                                                                                                                                        | 477                                     | 0.549                                                              | 14.6                             | -27.7                                                          | 3.5                    | 0.36                                                 | 33000                                           | 460      | d                     |                               |                     |
| InSb                                                                                                                                        | 447                                     | 0.442                                                              | 17.7                             | -32.9                                                          | 3.96                   | 0.163                                                | 78000                                           | 750      | d                     |                               |                     |
| <b>Other sphalerite structure compounds</b>                                                                                                 |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| MnS                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               | See also<br>2.1.3.  |
| MnSe                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               | See also<br>2.1.3.  |
| β-SiC                                                                                                                                       |                                         |                                                                    |                                  |                                                                | 2.697                  | 2.3                                                  | 4000                                            |          |                       |                               |                     |
| Ga <sub>2</sub> Te <sub>3</sub>                                                                                                             | 271                                     |                                                                    |                                  | -13.5                                                          |                        | 1.35                                                 | 50                                              |          |                       |                               |                     |
| In <sub>2</sub> Te <sub>3</sub> (H.T.)                                                                                                      | 198                                     |                                                                    |                                  | -13.6                                                          |                        | 1.04                                                 | 50                                              |          |                       |                               |                     |
| MgGeP <sub>2</sub>                                                                                                                          |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               | El-T <sup>d12</sup> |
| ZnSnP <sub>2</sub>                                                                                                                          |                                         |                                                                    |                                  |                                                                |                        | 2.1                                                  |                                                 |          |                       |                               | Same                |
| ZnSnAs <sub>2</sub> (H. T.)                                                                                                                 |                                         |                                                                    |                                  |                                                                |                        | ≈0.7                                                 |                                                 |          |                       |                               | Same                |
| ZnSnSb <sub>2</sub>                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 0.4                                                  |                                                 |          |                       |                               | Same                |
| <b>2.1.3. Wurtzite (Zincite) Structure Compounds (Strukturbericht symbol B4, Space Group P 6<sub>3</sub> mc-C<sub>6v</sub><sup>4</sup>)</b> |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| <b>I-VII Compounds</b>                                                                                                                      |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| CuCl                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| CuBr                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| CuI                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| AgI                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 2.63                                                 |                                                 |          |                       |                               | Iodargirite         |
| <b>II-VI Compounds</b>                                                                                                                      |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| BeO                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| MgTe                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |
| ZnO                                                                                                                                         | -350                                    |                                                                    |                                  |                                                                |                        | 3.2                                                  | 180                                             |          |                       |                               |                     |
| ZnS                                                                                                                                         | -206                                    |                                                                    |                                  |                                                                |                        | 3.67                                                 |                                                 |          |                       |                               |                     |
| ZnTe                                                                                                                                        | -163                                    |                                                                    |                                  |                                                                |                        |                                                      |                                                 |          |                       |                               |                     |

\* i = indirect, d = direct, s = semimetal.

| Substance                                                                                                                                   | Heat of formation<br>[kJ/mol<br>(300K)] | Volume<br>compressibility<br>(10 <sup>-10</sup> m <sup>2</sup> /N) | Static<br>dielectric<br>constant | Atomic<br>magnetic<br>susceptibility<br>(10 <sup>-6</sup> cgs) | Index of<br>refraction | Minimum<br>room<br>temperature<br>energy gap<br>(eV) | Mobility (room temp.)<br>(cm <sup>2</sup> /V·s) |       | Optical<br>transition | Breakdown<br>voltage<br>kV/mm | Remarks               |
|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------|----------------------------------|----------------------------------------------------------------|------------------------|------------------------------------------------------|-------------------------------------------------|-------|-----------------------|-------------------------------|-----------------------|
|                                                                                                                                             |                                         |                                                                    |                                  |                                                                |                        |                                                      | Electrons                                       | Holes |                       |                               |                       |
| CdS                                                                                                                                         |                                         |                                                                    |                                  | 8.45; 9.12                                                     | 2.32                   | 2.42                                                 | 350                                             | 40    | d                     |                               | Greenockide           |
| CdSe                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        | 1.74                                                 | 900                                             | 50    | d                     |                               | Cadmoselite           |
| CdTe                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        | 1.50                                                 | 650                                             |       |                       |                               |                       |
| III-V Compounds                                                                                                                             |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| BP(H.T.)                                                                                                                                    |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| AlN                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 6.02                                                 |                                                 |       |                       |                               |                       |
| GaN                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 3.34                                                 |                                                 |       |                       |                               |                       |
| InN                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 2.0                                                  |                                                 |       |                       |                               |                       |
| Other wurtzite structure compounds                                                                                                          |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| MnS                                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| MnSe                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| SiC                                                                                                                                         |                                         |                                                                    |                                  |                                                                | 2.654                  |                                                      |                                                 |       |                       |                               |                       |
| MnTe                                                                                                                                        |                                         |                                                                    |                                  |                                                                |                        | ≈1.0                                                 |                                                 |       |                       |                               |                       |
| Al <sub>2</sub> S <sub>3</sub>                                                                                                              | 426                                     |                                                                    |                                  |                                                                |                        | 4.1                                                  |                                                 |       |                       |                               |                       |
| Al <sub>2</sub> Se <sub>3</sub>                                                                                                             | 367                                     |                                                                    |                                  |                                                                |                        | 3.1                                                  |                                                 |       |                       |                               |                       |
| 2.1.4 Chalcopyrite Structure Compounds (Strukturbericht symbol E1 <sub>9</sub> , Space Group I $\bar{4}$ 2d-D <sub>2d</sub> <sup>12</sup> ) |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| I-III-VI <sub>2</sub> Compounds                                                                                                             |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| CuAlS <sub>2</sub>                                                                                                                          |                                         | 0.106                                                              |                                  |                                                                |                        | 2.5                                                  |                                                 |       |                       |                               |                       |
| CuAlSe <sub>2</sub>                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 2.67                                                 |                                                 |       |                       |                               |                       |
| CuAlTe <sub>2</sub>                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 0.88                                                 |                                                 |       |                       |                               |                       |
| CuCaS <sub>2</sub>                                                                                                                          |                                         | 0.106                                                              |                                  |                                                                |                        | 2.38                                                 |                                                 |       |                       |                               |                       |
| CuGaSe <sub>2</sub>                                                                                                                         |                                         | 0.141                                                              |                                  |                                                                |                        | 0.96, 1.63                                           |                                                 |       |                       |                               |                       |
| CuGaTe <sub>2</sub>                                                                                                                         |                                         | 0.227                                                              |                                  |                                                                |                        | 0.82, 1.0                                            |                                                 |       |                       |                               |                       |
| CuInS <sub>2</sub>                                                                                                                          |                                         | 0.141                                                              |                                  |                                                                |                        | 1.2                                                  |                                                 |       |                       |                               |                       |
| CuInSe <sub>2</sub>                                                                                                                         |                                         | 0.187                                                              |                                  |                                                                |                        | 0.86, 0.92                                           |                                                 |       |                       |                               |                       |
| CuInTe <sub>2</sub>                                                                                                                         |                                         | 0.278                                                              |                                  |                                                                |                        | 0.95                                                 |                                                 |       |                       |                               |                       |
| CuTlS <sub>2</sub>                                                                                                                          |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| CuTlSe <sub>2</sub>                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 1.07                                                 |                                                 |       |                       |                               |                       |
| (L.T.)                                                                                                                                      |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| CuFeS <sub>2</sub>                                                                                                                          |                                         |                                                                    |                                  |                                                                |                        | 0.53                                                 |                                                 |       |                       |                               | Chalcopyrite          |
| CuFeSe <sub>2</sub>                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 0.16                                                 |                                                 |       |                       |                               |                       |
| CuLaS <sub>2</sub>                                                                                                                          |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| AgAlS <sub>2</sub>                                                                                                                          |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| AgAlSe <sub>2</sub>                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 0.7                                                  |                                                 |       |                       |                               |                       |
| AgAlTe <sub>2</sub>                                                                                                                         |                                         |                                                                    |                                  |                                                                |                        | 0.56                                                 |                                                 |       |                       |                               |                       |
| AgGaS <sub>2</sub>                                                                                                                          |                                         | 0.150                                                              |                                  |                                                                |                        | 1.66                                                 |                                                 |       |                       |                               |                       |
| AgGaSe <sub>2</sub>                                                                                                                         |                                         | 0.182                                                              |                                  |                                                                |                        | 1.1                                                  |                                                 |       |                       |                               |                       |
| AgGaTe <sub>2</sub>                                                                                                                         |                                         | 0.280                                                              |                                  |                                                                |                        | 1.9                                                  |                                                 |       |                       |                               |                       |
| AgInS <sub>2</sub>                                                                                                                          |                                         | 0.185                                                              |                                  |                                                                |                        | 1.18                                                 |                                                 |       |                       |                               |                       |
| (L.T.)                                                                                                                                      |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| AgInSe <sub>2</sub>                                                                                                                         |                                         | 0.238                                                              |                                  |                                                                |                        | 0.96, 0.52                                           |                                                 |       |                       |                               |                       |
| AgInTe <sub>2</sub>                                                                                                                         |                                         | 0.338                                                              |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| AgFeS <sub>2</sub>                                                                                                                          |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| II-IV-V <sub>2</sub> Compounds                                                                                                              |                                         |                                                                    |                                  |                                                                |                        |                                                      |                                                 |       |                       |                               |                       |
| ZnSiP <sub>2</sub>                                                                                                                          | 312                                     |                                                                    |                                  |                                                                |                        | 2.3                                                  | 1000                                            |       |                       |                               |                       |
| ZnGeP <sub>2</sub>                                                                                                                          | 293                                     |                                                                    |                                  |                                                                |                        | 2.2                                                  |                                                 |       |                       |                               |                       |
| ZnSnP <sub>2</sub>                                                                                                                          | 275                                     |                                                                    |                                  |                                                                |                        | 1.45                                                 |                                                 |       |                       |                               |                       |
| CdSiP <sub>2</sub>                                                                                                                          |                                         | 0.103                                                              |                                  |                                                                |                        | 2.2                                                  | 1000                                            |       |                       |                               |                       |
| CdGeP <sub>2</sub>                                                                                                                          | 289                                     |                                                                    |                                  |                                                                |                        | 1.8                                                  |                                                 |       |                       |                               |                       |
| CdSnP <sub>2</sub>                                                                                                                          | 270                                     |                                                                    |                                  |                                                                |                        | 1.5                                                  |                                                 |       |                       |                               |                       |
| ZnSiAs <sub>2</sub>                                                                                                                         | 290                                     |                                                                    |                                  |                                                                |                        | 1.7                                                  |                                                 | 50    |                       |                               |                       |
| ZnGeAs <sub>2</sub>                                                                                                                         | 271                                     |                                                                    |                                  | -14.4                                                          |                        | 0.85                                                 |                                                 |       |                       |                               |                       |
| ZnSnAs <sub>2</sub>                                                                                                                         | 252                                     |                                                                    |                                  | -18.4                                                          |                        | 0.65                                                 |                                                 | 300   |                       |                               | Disorders at<br>910 K |
| CdSiAs <sub>2</sub>                                                                                                                         |                                         | 0.143                                                              |                                  |                                                                |                        | 1.6                                                  |                                                 |       |                       |                               |                       |
| CdGeAs <sub>2</sub>                                                                                                                         | 266                                     |                                                                    |                                  | -23.4                                                          |                        | 0.53                                                 | 70                                              | 25    |                       |                               | Disorders at<br>903 K |
| CdSnAs <sub>2</sub>                                                                                                                         | 247                                     |                                                                    | 13.7                             | -21.5                                                          |                        | 0.26                                                 | 22000                                           | 250   |                       |                               |                       |

| Substance                                                                                                                           | Heat of<br>formation | Volume                                                   | Static                 | Atomic                                               | Index of<br>refraction | Minimum                                   | Mobility (room temp.)  |  | Optical<br>transition | Breakdown<br>voltage<br>kV/mm | Remarks                 |
|-------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------------------------------------------|------------------------|------------------------------------------------------|------------------------|-------------------------------------------|------------------------|--|-----------------------|-------------------------------|-------------------------|
|                                                                                                                                     | [kJ/mol<br>(300K)]   | compressibility<br>(10 <sup>-10</sup> m <sup>2</sup> /N) | dielectric<br>constant | magnetic<br>susceptibility<br>(10 <sup>-6</sup> cgs) |                        | room<br>temperature<br>energy gap<br>(eV) | (cm <sup>2</sup> /V·s) |  |                       |                               |                         |
| 2.1.5. Other Ternary Semiconductors with Tetrahedral Coordination                                                                   |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| II <sub>2</sub> -IV-VI <sub>3</sub> Compounds                                                                                       |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| Cu <sub>2</sub> SiS <sub>3</sub><br>(H.T.)                                                                                          |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               | Wurtzite                |
| Cu <sub>2</sub> SiS <sub>3</sub><br>(L.T.)                                                                                          |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               | Tetragonal              |
| Cu <sub>2</sub> SiTe <sub>3</sub>                                                                                                   |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               | Cubic                   |
| Cu <sub>2</sub> GeS <sub>3</sub><br>(H.T.)                                                                                          |                      |                                                          |                        | -18.7                                                |                        |                                           |                        |  |                       |                               | Cubic                   |
| Cu <sub>2</sub> GeS <sub>3</sub><br>(L.T.)                                                                                          |                      |                                                          |                        |                                                      |                        |                                           | 360                    |  |                       |                               | Tetragonal              |
| Cu <sub>2</sub> GeSe <sub>3</sub>                                                                                                   | 211.5                |                                                          |                        | -21.3                                                |                        | 0.94                                      | 238                    |  |                       |                               | Same                    |
| Cu <sub>2</sub> GeTe <sub>3</sub>                                                                                                   | 190.2                |                                                          |                        | -23.4                                                |                        |                                           |                        |  |                       |                               | Same                    |
| Cu <sub>2</sub> SnS <sub>3</sub>                                                                                                    |                      |                                                          |                        | -18.2                                                |                        | 0.91                                      | 405                    |  |                       |                               | Cubic                   |
| CuSnSe <sub>3</sub>                                                                                                                 |                      |                                                          |                        | -21.0                                                |                        | 0.66                                      | 870                    |  |                       |                               | Cubic                   |
| Cu <sub>2</sub> SnTe <sub>3</sub>                                                                                                   |                      |                                                          |                        | -28.4                                                |                        |                                           |                        |  |                       |                               | Cubic                   |
| Ag <sub>2</sub> GeSe <sub>3</sub>                                                                                                   |                      |                                                          |                        | -29.6                                                |                        | 0.91 (77K)                                |                        |  |                       |                               |                         |
| Ag <sub>2</sub> SnSe <sub>3</sub>                                                                                                   |                      |                                                          |                        | -29.5                                                |                        | 0.81                                      |                        |  |                       |                               |                         |
| Ag <sub>2</sub> GeTe <sub>3</sub>                                                                                                   |                      |                                                          |                        | -31.4                                                |                        | 0.25                                      |                        |  |                       |                               |                         |
| Ag <sub>2</sub> SnTe <sub>3</sub>                                                                                                   |                      |                                                          |                        | -31.0                                                |                        | 0.08                                      |                        |  |                       |                               |                         |
| II <sub>3</sub> -V-VI <sub>4</sub> Compounds                                                                                        |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| Cu <sub>3</sub> PS <sub>4</sub>                                                                                                     |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               | Enargite                |
| Cu <sub>3</sub> AsS <sub>4</sub>                                                                                                    | 269.6                |                                                          |                        | -15.8                                                |                        | 1.24                                      |                        |  |                       |                               |                         |
| Cu <sub>3</sub> AsSe <sub>4</sub>                                                                                                   | 161.3                |                                                          |                        | -13.1                                                |                        | 0.88                                      |                        |  |                       |                               | Famatinite              |
| Cu <sub>3</sub> SbS <sub>4</sub>                                                                                                    |                      |                                                          |                        | -8.3                                                 |                        | 0.74                                      |                        |  |                       |                               | Famatinite              |
| Cu <sub>3</sub> SbSe <sub>4</sub>                                                                                                   | 127.1                |                                                          |                        | -20.5                                                |                        | 0.31                                      |                        |  |                       |                               |                         |
| II-IV <sub>2</sub> -V <sub>3</sub> Compounds                                                                                        |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| CuSi <sub>2</sub> P <sub>3</sub>                                                                                                    |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               | El                      |
| CuGe <sub>2</sub> P <sub>3</sub>                                                                                                    |                      | 0.12                                                     |                        |                                                      |                        | 0.90                                      |                        |  |                       |                               | El                      |
| AgGe <sub>2</sub> P <sub>3</sub>                                                                                                    |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| 2.1.6. “Defect Chalcopyrite” Structure Compounds (Strukturbericht symbol E3, Space Group I $\bar{4}$ -S <sub>6</sub> <sup>2</sup> ) |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| ZnAl <sub>2</sub> Se <sub>4</sub>                                                                                                   |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| ZnAl <sub>2</sub> Te <sub>4</sub> (?)                                                                                               |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| ZnGa <sub>2</sub> S <sub>4</sub><br>(?)                                                                                             |                      |                                                          |                        |                                                      |                        | ≈3.4                                      |                        |  |                       |                               |                         |
| ZnGa <sub>2</sub> Se <sub>4</sub> (?)                                                                                               |                      |                                                          |                        |                                                      |                        | ≈2.2                                      |                        |  |                       |                               |                         |
| ZnGa <sub>2</sub> Te <sub>4</sub> (?)                                                                                               |                      |                                                          |                        |                                                      |                        | 1.35                                      |                        |  |                       |                               |                         |
| ZnIn <sub>2</sub> Se <sub>4</sub>                                                                                                   | 206                  |                                                          |                        |                                                      |                        | 1.82                                      | 35                     |  |                       |                               |                         |
| ZnIn <sub>2</sub> Te <sub>4</sub>                                                                                                   | 198                  |                                                          |                        |                                                      |                        | 1.2                                       |                        |  |                       |                               |                         |
| CdAl <sub>2</sub> S <sub>4</sub>                                                                                                    |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| CdAl <sub>2</sub> Se <sub>4</sub>                                                                                                   |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| CdAl <sub>2</sub> Te <sub>4</sub> (?)                                                                                               |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| CdGa <sub>2</sub> S <sub>4</sub>                                                                                                    | 256                  |                                                          |                        |                                                      |                        | 3.44                                      | 60                     |  |                       |                               |                         |
| CdGa <sub>2</sub> Se <sub>4</sub>                                                                                                   | 216                  |                                                          |                        |                                                      |                        | 2.43                                      | 33                     |  |                       |                               |                         |
| CdGa <sub>2</sub> Te <sub>4</sub>                                                                                                   |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| CdIn <sub>2</sub> Te <sub>4</sub>                                                                                                   | 195                  |                                                          |                        |                                                      |                        | (1.26 or 0.9)                             | 4000                   |  |                       |                               |                         |
| HgAl <sub>2</sub> S <sub>4</sub>                                                                                                    |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| HgAl <sub>2</sub> Se <sub>4</sub>                                                                                                   |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| HgAl <sub>2</sub> Te <sub>4</sub> (?)                                                                                               |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| HgGa <sub>2</sub> S <sub>4</sub>                                                                                                    | 249                  |                                                          |                        |                                                      |                        | 2.84                                      |                        |  |                       |                               |                         |
| HgGa <sub>2</sub> Se <sub>4</sub>                                                                                                   | 204                  |                                                          |                        |                                                      |                        | 1.95                                      | 400                    |  |                       |                               |                         |
| HgIn <sub>2</sub> Se <sub>4</sub>                                                                                                   | 196                  |                                                          |                        |                                                      |                        | 0.6                                       | 290                    |  |                       |                               |                         |
| HgIn <sub>2</sub> Te <sub>4</sub> (?)                                                                                               | 188                  |                                                          |                        |                                                      |                        | 0.86                                      | 200                    |  |                       |                               |                         |
| 2.1.7. Other Adamantine Compounds                                                                                                   |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               |                         |
| α-SiC                                                                                                                               |                      |                                                          | 10.2                   | -6.4                                                 | 2.67                   | 2.86                                      | 400                    |  |                       |                               | 6H structure            |
| Hg <sub>5</sub> Ga <sub>2</sub> Te <sub>8</sub>                                                                                     |                      |                                                          |                        |                                                      |                        |                                           |                        |  |                       |                               | B3 with<br>superlattice |
| Hg <sub>5</sub> In <sub>2</sub> Te <sub>8</sub>                                                                                     |                      |                                                          |                        |                                                      |                        | 0.7                                       | 2000                   |  |                       |                               | B3 with<br>superlattice |
| CdIn <sub>2</sub> Se <sub>4</sub>                                                                                                   |                      |                                                          |                        |                                                      |                        | 1.55                                      |                        |  |                       |                               |                         |

| Substance | Heat of formation<br>[kJ/mol<br>(300K)] | Volume<br>compressibility<br>(10 <sup>-10</sup> m <sup>2</sup> /N) | Static<br>dielectric<br>constant | Atomic<br>magnetic<br>susceptibility<br>(10 <sup>-6</sup> cgs) | Index of<br>refraction | Minimum<br>room<br>temperature<br>energy gap<br>(eV) | Mobility (room temp.)<br>(cm <sup>2</sup> /V·s) |       | Optical<br>transition | Breakdown<br>voltage<br>kV/mm | Remarks |
|-----------|-----------------------------------------|--------------------------------------------------------------------|----------------------------------|----------------------------------------------------------------|------------------------|------------------------------------------------------|-------------------------------------------------|-------|-----------------------|-------------------------------|---------|
|           |                                         |                                                                    |                                  |                                                                |                        |                                                      | Electrons                                       | Holes |                       |                               |         |

2.2. Octahedral Semiconductors

2.2.1. Halite Structure Semiconductors (Strukturbericht symbol B1, Space Group Fm3m-O<sub>h</sub><sup>5</sup>)

|      |     |  |     |  |  |      |      |     |  |  |         |
|------|-----|--|-----|--|--|------|------|-----|--|--|---------|
| GeTe |     |  |     |  |  |      |      |     |  |  |         |
| SnSe |     |  |     |  |  |      |      |     |  |  |         |
| SnTe |     |  |     |  |  |      |      |     |  |  |         |
| PbS  | 435 |  |     |  |  | 0.5  | 600  | 600 |  |  |         |
| PbSe | 393 |  | 161 |  |  | 0.37 | 1000 | 900 |  |  |         |
| PbTe | 393 |  | 280 |  |  | 0.26 | 1600 | 600 |  |  | Altaite |
|      |     |  | 360 |  |  | 0.25 |      |     |  |  |         |

2.2.2. Selected Other Binary Halites

|      |     |  |  |  |  |            |     |  |  |  |  |
|------|-----|--|--|--|--|------------|-----|--|--|--|--|
| BiSe |     |  |  |  |  |            |     |  |  |  |  |
| BiTe |     |  |  |  |  | 0.4        |     |  |  |  |  |
| EuSe |     |  |  |  |  |            |     |  |  |  |  |
| GdSe |     |  |  |  |  | 1.8        | 4   |  |  |  |  |
| NiO  |     |  |  |  |  | 2.0 or 3.7 | 100 |  |  |  |  |
| CdO  | 531 |  |  |  |  | 2.5        |     |  |  |  |  |
| SrS  |     |  |  |  |  | 4.1        |     |  |  |  |  |

2.3. Other Semiconductors

2.3.1. Antifluorite Structure Compounds (Fm3m-O<sub>h</sub><sup>5</sup>)

|                    |       |  |  |  |  |      |     |     |  |  |  |
|--------------------|-------|--|--|--|--|------|-----|-----|--|--|--|
| Mg <sub>2</sub> Si | 79.08 |  |  |  |  | 0.77 | 405 | 70  |  |  |  |
| Mg <sub>2</sub> Ge |       |  |  |  |  | 0.74 | 520 | 110 |  |  |  |
| Mg <sub>2</sub> Sn | 76.57 |  |  |  |  | 0.36 | 320 | 260 |  |  |  |
| Mg <sub>2</sub> Pb | 52.72 |  |  |  |  | 0.1  |     |     |  |  |  |

2.3.2. Tetradymite Structure Compounds (R3m-D<sub>3d</sub><sup>5</sup>)

|                                 |  |  |  |  |  |      |      |     |  |  |           |
|---------------------------------|--|--|--|--|--|------|------|-----|--|--|-----------|
| Sb <sub>2</sub> Te <sub>3</sub> |  |  |  |  |  | 0.3  |      | 360 |  |  |           |
| Bi <sub>2</sub> Se <sub>3</sub> |  |  |  |  |  | 0.35 | 600  |     |  |  |           |
| Bi <sub>2</sub> Te <sub>3</sub> |  |  |  |  |  | 0.21 | 1140 | 680 |  |  | R3m (166) |

2.3.3. Skutterudite Structure Compounds (Im3-T<sub>h</sub><sup>5</sup>)

|                   |  |  |  |  |  |      |    |       |  |  |  |
|-------------------|--|--|--|--|--|------|----|-------|--|--|--|
| CoP <sub>3</sub>  |  |  |  |  |  | 0.43 |    |       |  |  |  |
| CoAs <sub>3</sub> |  |  |  |  |  | 0.69 |    | ~4000 |  |  |  |
| CoSb <sub>3</sub> |  |  |  |  |  | 0.63 | 70 | ~3000 |  |  |  |
| RhP <sub>3</sub>  |  |  |  |  |  |      |    | 700   |  |  |  |
| RhAs <sub>3</sub> |  |  |  |  |  | 0.85 |    | ~3000 |  |  |  |
| RhSb <sub>3</sub> |  |  |  |  |  | 0.80 |    | ~7000 |  |  |  |
| IrSb <sub>3</sub> |  |  |  |  |  | 1.18 |    | 1500  |  |  |  |

2.3.4. Selected Multinary Compounds

|                                                          |  |  |  |  |  |           |    |  |  |  |  |
|----------------------------------------------------------|--|--|--|--|--|-----------|----|--|--|--|--|
| AgSbSe <sub>2</sub>                                      |  |  |  |  |  | 0.58      |    |  |  |  |  |
| AgSbTe <sub>2</sub>                                      |  |  |  |  |  | 0.7, 0.27 |    |  |  |  |  |
| (or Ag <sub>19</sub> Sb <sub>29</sub> Te <sub>52</sub> ) |  |  |  |  |  |           |    |  |  |  |  |
| AgBiS <sub>2</sub>                                       |  |  |  |  |  |           |    |  |  |  |  |
| (H.T.)                                                   |  |  |  |  |  |           |    |  |  |  |  |
| AgBiSe <sub>2</sub>                                      |  |  |  |  |  |           |    |  |  |  |  |
| (H.T.)                                                   |  |  |  |  |  |           |    |  |  |  |  |
| AgBiTe <sub>2</sub>                                      |  |  |  |  |  |           |    |  |  |  |  |
| (H.T.)                                                   |  |  |  |  |  |           |    |  |  |  |  |
| Cu <sub>2</sub> CdSnS <sub>4</sub>                       |  |  |  |  |  | 1.16      | <2 |  |  |  |  |

2.3.5. Some Elemental Semiconductors

|          |       |  |           |       |     |      |      |      |  |  |                         |
|----------|-------|--|-----------|-------|-----|------|------|------|--|--|-------------------------|
| B        | 397.1 |  |           | -6.7  | 3.4 | 1.55 | 10   |      |  |  |                         |
| Se(gray) |       |  | 6.6       | -22.1 | 2.5 | 1.5  |      | 5    |  |  | P3 <sub>1</sub> 21(152) |
|          |       |  | (0.1 GHz) |       |     |      |      |      |  |  |                         |
| Te       |       |  |           | -39.5 | 3.3 | 0.33 | 1700 | 1200 |  |  | Same                    |





TABLE 4. Band Properties of Semiconductors

4.1. Data on Valence Bands of Semiconductors (Room Temperature)

| Substance                                                                                 | Band curvature effective mass<br>(Expressed as fraction of free electron mass) |             |                        | Energy separation of<br>“split-off” band (eV) | Measured (light) hole<br>mobility (cm <sup>2</sup> /V·s) |
|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------|------------------------|-----------------------------------------------|----------------------------------------------------------|
|                                                                                           | Heavy holes                                                                    | Light holes | “Split-off” band holes |                                               |                                                          |
| 4.1.1. Semiconductors with Valence Band Maximum at the Center of the Brillouin Zone (“F”) |                                                                                |             |                        |                                               |                                                          |
| Si                                                                                        | 0.52                                                                           | 0.16        | 0.25                   | 0.044                                         | 500                                                      |
| Ge                                                                                        | 0.34                                                                           | 0.043       | 0.08                   | 0.3                                           | 1820                                                     |
| Sn                                                                                        | 0.3                                                                            |             |                        |                                               | 2400                                                     |
| AlAs                                                                                      |                                                                                |             |                        |                                               |                                                          |
| AlSb                                                                                      | 0.4                                                                            |             |                        | 0.7                                           | 550                                                      |
| GaP                                                                                       |                                                                                |             |                        | 0.13                                          | 100                                                      |
| GaAs                                                                                      | 0.8                                                                            | 0.12        | 0.20                   | 0.34                                          | 400                                                      |
| GaSb                                                                                      | 0.23                                                                           | 0.06        |                        | 0.7                                           | 1400                                                     |
| InP                                                                                       |                                                                                |             |                        | 0.21                                          | 150                                                      |
| InAs                                                                                      | 0.41                                                                           | 0.025       | 0.083                  | 0.43                                          | 460                                                      |
| InSb                                                                                      | 0.4                                                                            | 0.015       |                        | 0.85                                          | 750                                                      |
| CdTe                                                                                      | 0.35                                                                           |             |                        |                                               | 50                                                       |
| HgTe                                                                                      | 0.5                                                                            |             |                        |                                               | 350                                                      |

4.1.2. Semiconductors with Multiple Band Maxima

| Substance                       | Number of equivalent<br>valleys and direction | Band curvature effective masses |                  | Anistrophy<br>$K = m_L/m_T$ | Measured (light) hole<br>mobility (cm <sup>2</sup> /V·s) |
|---------------------------------|-----------------------------------------------|---------------------------------|------------------|-----------------------------|----------------------------------------------------------|
|                                 |                                               | Longitudinal $m_L$              | Transverse $m_T$ |                             |                                                          |
| PbSe                            | 4 “L” [111]                                   | 0.095                           | 0.047            | 2.0                         | 1500                                                     |
| PbTe                            | 4 “L” [111]                                   | 0.27                            | 0.02             | 10                          | 750                                                      |
| Bi <sub>2</sub> Te <sub>3</sub> | 6                                             | 0.207                           | ~0.045           | 4.5                         | 515                                                      |

4.2. Data on Conduction Bands of Semiconductors (Room Temperature Data)

4.2.1. Single Valley Semiconductors

| Substance | Energy gap (eV) | Effective mass ( $m_o$ ) | Mobility (cm <sup>2</sup> /V·s) | Comments                                                                             |
|-----------|-----------------|--------------------------|---------------------------------|--------------------------------------------------------------------------------------|
| GaAs      | 1.35            | 0.067                    | 8500                            | 3(or 6?) equivalent [100] valleys 0.36 eV above this maximum with a mobility of ~50. |
| InP       | 1.27            | 0.067                    | 5000                            | 3(or 6?) equivalent [100] valleys 0.4 eV above this minimum.                         |
| InAs      | 0.36            | 0.022                    | 33,000                          | Equivalent valleys ~1.0 eV above this minimum.                                       |
| InSb      | 0.165           | 0.014                    | 78,000                          |                                                                                      |
| CdTe      | 1.44            | 0.11                     | 1000                            | 4(or 8?) equivalent [111] valleys 0.51 eV above this minimum.                        |

4.2.2. Multivalley Semiconductors

| Substance                       | Energy gap | Number of<br>equivalent valleys<br>and direction | Band curvature effective mass |                  | Anisotropy<br>$K = m_L/m_T$ |
|---------------------------------|------------|--------------------------------------------------|-------------------------------|------------------|-----------------------------|
|                                 |            |                                                  | Longitudinal $m_L$            | Transverse $m_T$ |                             |
| Si                              | 1.107      | 6 in [100] “Δ”                                   | 0.00                          | 0.192            | 4.7                         |
| Ge                              | 0.67       | 4 in [111] at “L”                                | 1.588                         | 0.0815           | 19.5                        |
| GaSb                            | 0.67       | as Ge (?)                                        | ~1.0                          | ~0.2             | ~5                          |
| PbSe                            | 0.26       | 4 in [111] at “L”                                | 0.085                         | 0.05             | 1.7                         |
| PbTe                            | 0.25       | 4 in [111] at “L”                                | 0.21                          | 0.029            | 5.5                         |
| Bi <sub>2</sub> Te <sub>3</sub> | 0.13       | 6                                                |                               |                  | ~0.05                       |

TABLE 5. Resistivity of Semiconducting Minerals

| Mineral                                                          | $\rho$ (ohm · m)                                 | Mineral                                                                     | $\rho$ (ohm · m)                                |
|------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------------------------|
| Diamond (C)                                                      | 2.7                                              | Pentlandite, (Fe, Ni) <sub>4</sub> S <sub>4</sub>                           | 1 to 11 × 10 <sup>-6</sup>                      |
| Sulfides                                                         |                                                  | Pyrrhotite, Fe <sub>7</sub> S <sub>4</sub>                                  | 2 to 160 × 10 <sup>-6</sup>                     |
| Argentite, Ag <sub>2</sub> S                                     | 1.5 to 2.0 × 10 <sup>-3</sup>                    | Pyrite, FeS <sub>2</sub>                                                    | 1.2 to 600 × 10 <sup>-3</sup>                   |
| Bismuthinite, Bi <sub>2</sub> S <sub>3</sub>                     | 3 to 570                                         | Sphalerite, ZnS                                                             | 2.7 × 10 <sup>-3</sup> to 1.2 × 10 <sup>4</sup> |
| Bornite, Fe <sub>2</sub> S <sub>3</sub> · $n$ Cu <sub>2</sub> S  | 1.6 to 6000 × 10 <sup>-6</sup>                   | Antimony-sulfur compounds                                                   |                                                 |
| Chalcocite, Cu <sub>2</sub> S                                    | 80 to 100 × 10 <sup>-6</sup>                     | Berthierite, FeSb <sub>2</sub> S <sub>4</sub>                               | 0.0083 to 2.0                                   |
| Chalcopyrite, Fe <sub>2</sub> S <sub>3</sub> · Cu <sub>2</sub> S | 150 to 9000 × 10 <sup>-6</sup>                   | Boulangerite, Pb <sub>5</sub> Sb <sub>3</sub> S <sub>11</sub>               | 2 × 10 <sup>3</sup> to 4 × 10 <sup>4</sup>      |
| Covellite, CuS                                                   | 0.30 to 83 × 10 <sup>-6</sup>                    | Cylindrite, Pb <sub>3</sub> Sn <sub>4</sub> Sb <sub>2</sub> S <sub>14</sub> | 2.5 to 60                                       |
| Galena, PbS                                                      | 6.8 × 10 <sup>-6</sup> to 9.0 × 10 <sup>-2</sup> | Franckeite, Pb <sub>5</sub> Sn <sub>3</sub> Sb <sub>2</sub> S <sub>14</sub> | 1.2 to 4                                        |
| Haverite, MnS <sub>2</sub>                                       | 10 to 20                                         | Hauchecornite, Ni <sub>4</sub> (Bi, Sb) <sub>2</sub> S <sub>14</sub>        | 1 to 83 × 10 <sup>-6</sup>                      |
| Marcasite, FeS <sub>2</sub>                                      | 1 to 150 × 10 <sup>-3</sup>                      | Jamesonite, Pb <sub>4</sub> FeSb <sub>6</sub> S <sub>14</sub>               | 0.020 to 0.15                                   |
| Metacinnabarite, HgS                                             | 2 × 10 <sup>-6</sup> to 1 × 10 <sup>-3</sup>     | Tetrahedrite, Cu <sub>3</sub> SbS <sub>3</sub>                              | 0.30 to 30,000                                  |
| Millerite, NiS                                                   | 2 to 4 × 10 <sup>-7</sup>                        | Arsenic-sulfur compounds                                                    |                                                 |

| Mineral                                    | $\rho$ (ohm · m)             |
|--------------------------------------------|------------------------------|
| Molybdenite, MoS <sub>2</sub>              | 0.12 to 7.5                  |
| Cobaltite, CoAsS                           | 6.5 to $130 \times 10^{-3}$  |
| Enargite, Cu <sub>3</sub> AsS <sub>4</sub> | 0.2 to $40 \times 10^{-3}$   |
| Gersdorffite, NiAsS                        | 1 to $160 \times 10^{-6}$    |
| Glaucoodote, (Co, Fe)AsS                   | 5 to $100 \times 10^{-6}$    |
| Antimonide                                 |                              |
| Dyscrasite, Ag <sub>3</sub> Sb             | 0.12 to $1.2 \times 10^{-6}$ |
| Arsenides                                  |                              |
| Allemontite, SbAs <sub>3</sub>             | 70 to 60,000                 |
| Lollingite, FeAs <sub>2</sub>              | 2 to $270 \times 10^{-6}$    |
| Nicollite, NiAs                            | 0.1 to $2 \times 10^{-6}$    |
| Skutterudite, CoAs <sub>3</sub>            | 1 to $400 \times 10^{-6}$    |
| Smaltite, CoAs <sub>2</sub>                | 1 to $12 \times 10^{-6}$     |
| Tellurides                                 |                              |
| Altaite, PbTe                              | 20 to $200 \times 10^{-6}$   |
| Calavarite, AuTe <sub>2</sub>              | 6 to $12 \times 10^{-6}$     |
| Coloradoite, HgTe                          | 4 to $100 \times 10^{-6}$    |

| Mineral                                                            | $\rho$ (ohm · m)               |
|--------------------------------------------------------------------|--------------------------------|
| Arsenopyrite, FeAsS                                                | 20 to $300 \times 10^{-6}$     |
| Hessite, Ag <sub>2</sub> Te                                        | 4 to $100 \times 10^{-6}$      |
| Nagyagite, Pb <sub>6</sub> Au(S,Te) <sub>14</sub>                  | 20 to $80 \times 10^{-6}$      |
| Sylvanite, AgAuTe <sub>4</sub>                                     | 4 to $20 \times 10^{-6}$       |
| Oxides                                                             |                                |
| Braunite, Mn <sub>2</sub> O <sub>3</sub>                           | 0.16 to 1.0                    |
| Cassiterite, SnO <sub>2</sub>                                      | $4.5 \times 10^{-4}$ to 10,000 |
| Cuprite, Cu <sub>2</sub> O                                         | 10 to 50                       |
| Hollandite, (Ba, Na, K) Mn <sub>8</sub> O <sub>16</sub>            | 2 to $100 \times 10^{-3}$      |
| Ilmenite, FeTiO <sub>3</sub>                                       | 0.001 to 4                     |
| Magnetite, Fe <sub>3</sub> O <sub>4</sub>                          | $52 \times 10^{-6}$            |
| Manganite, MnO · OH                                                | 0.018 to 0.5                   |
| Melaconite, CuO                                                    | 6000                           |
| Psilomelane, BaMn <sub>9</sub> O <sub>18</sub> · 2H <sub>2</sub> O | 0.04 to 6000                   |
| Pyrolusite, MnO <sub>2</sub>                                       | 0.007 to 30                    |
| Rutile, TiO <sub>2</sub>                                           | 29 to 910                      |
| Uraninite, UO <sub>2</sub>                                         | 1.5 to 200                     |

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# DIFFUSION DATA FOR SEMICONDUCTORS

B. L. Sharma

The diffusion coefficient  $D$  in many semiconductors may be expressed by an Arrhenius-type relation

$$D = D_0 \exp(-Q/kT)$$

where  $D_0$  is a frequency factor,  $Q$  is the activation energy for diffusion,  $k$  is the Boltzmann constant, and  $T$  is the absolute temperature. This table lists  $D_0$  and  $Q$  for various diffusants in common semiconductors.

Abbreviations used in the table are

- AES – Auger Electron Spectroscopy
- DLTS – Deep Level Transient Spectroscopy
- SEM – Scanning Electron Microscopy
- SIMS – Secondary Ion Mass Spectrometry
- $D(c)$  – Concentration Dependent Diffusion Coefficient
- $D_{\max}$  – Maximum Diffusion Coefficient
- (f) – Fast Diffusion Component
- (i) – Interstitial Diffusion Component
- (s) – Slow Diffusion Component
- (||) – Parallel to  $c$  Direction
- ( $\perp$ ) – Perpendicular to  $c$  Direction

| Semiconductor | Diffusant | Frequency factor,<br>$D_0$ (cm <sup>2</sup> /s) | Activation energy,<br>$Q$ (eV) | Temperature range (°C) | Method of measurement           | Ref. |
|---------------|-----------|-------------------------------------------------|--------------------------------|------------------------|---------------------------------|------|
| Si            | H         | $6 \times 10^{-1}$                              | 1.03                           | 120–1207               | Electrical and SIMS             | 1    |
|               | Li        | $2.5 \times 10^{-3}$                            | 0.65                           | 25–1350                | Electrical                      | 2    |
|               | Na        | $1.65 \times 10^{-3}$                           | 0.72                           | 530–800                | Electrical and flame photometry | 3    |
|               | K         | $1.1 \times 10^{-3}$                            | 0.76                           | 740–800                | Electrical and flame photometry | 3    |
|               | Cu        | $4 \times 10^{-2}$                              | 1.0                            | 800–1100               | Radioactive                     | 4    |
|               |           | $4.7 \times 10^{-3}$                            | 0.43 (i)                       | 300–700                | Radioactive                     | 5    |
|               | Ag        | $2 \times 10^{-3}$                              | 1.6                            | 1100–1350              | Radioactive                     | 6    |
|               | Au        | $2.4 \times 10^{-4}$                            | 0.39 (i)                       | 700–1300               | Radioactive                     | 7    |
|               |           | $2.75 \times 10^{-3}$                           | 2.05 (s)                       |                        |                                 |      |
|               | Be        | $(D \sim 10^{-7})$                              | –                              | 1050                   | Electrical                      | 8    |
|               | Ca        | $(D \sim 6 \times 10^{-14})$                    | –                              | 1100                   | Electrical and SIMS             | 1    |
|               | Zn        | $1 \times 10^{-1}$                              | 1.4                            | 980–1270               | Electrical                      | 9    |
|               | B         | 2.46                                            | 3.59                           | 1100–1250              | Electrical                      | 10   |
|               |           | $2.4 \times 10^1$                               | 3.87                           | 840–1250               | Electrical                      | 11   |
|               | Al        | 1.38                                            | 3.41                           | 1119–1390              | Electrical                      | 12   |
|               |           | 1.8                                             | 3.2                            | 1025–1175              | Electrical                      | 13   |
|               | Ga        | $3.74 \times 10^{-1}$                           | 3.39                           | 1143–1393              | Electrical                      | 12   |
|               |           | $6 \times 10^1$                                 | 3.89                           | 900–1050               | Radioactive                     | 14   |
|               | In        | $7.85 \times 10^{-1}$                           | 3.63                           | 1180–1389              | Electrical                      | 12   |
|               |           | $1.94 \times 10^1$                              | 3.86                           | 1150–1242              | Radioactive                     | 15   |
|               | Tl        | 1.37                                            | 3.7                            | 1244–1338              | Electrical                      | 12   |
|               |           | $1.65 \times 10^1$                              | 3.9                            | 1105–1360              | Electrical                      | 16   |
|               | Sc        | $8 \times 10^{-2}$                              | 3.2                            | 1100–1250              | Radioactive                     | 1    |
|               | Ce        | $(D \sim 3.9 \times 10^{-13})$                  | –                              | 1050                   | SIMS                            | 1    |
|               | Pr        | $2.5 \times 10^{-7}$                            | 1.74                           | 1100–1280              | Electrical                      | 1    |
|               | Pm        | $7.5 \times 10^{-9}$                            | 1.2 (s)                        | 730–1270               | Radioactive                     | 1    |
|               |           | $4.2 \times 10^{-12}$                           | 0.13 (f)                       |                        |                                 |      |
|               | Er        | $2 \times 10^{-3}$                              | 2.9                            | 1100–1250              | Radioactive                     | 1    |
|               | Tm        | $8 \times 10^{-3}$                              | 3.0                            | 1100–1280              | Radioactive                     | 1    |
|               | Yb        | $2.8 \times 10^{-5}$                            | 0.95                           | 947–1097               | Neutron activation              | 1    |
|               | Ti        | $1.45 \times 10^{-2}$                           | 1.79                           | 950–1200               | DLTS                            | 17   |
|               | C         | $3.3 \times 10^{-1}$                            | 2.92                           | 1070–1400              | Radioactive                     | 18   |
|               | Si (self) | $1.54 \times 10^2$                              | 4.65                           | 855–1175               | SIMS                            | 19   |
|               |           | $1.6 \times 10^3$                               | 4.77                           | 1200–1400              | Radioactive                     | 20   |
|               | Ge        | $3.5 \times 10^{-1}$                            | 3.92                           | 855–1000               | Radioactive                     | 21   |
|               |           | $2.5 \times 10^3$                               | 4.97                           | 1030–1302              | Radioactive                     | 21   |
|               |           | $7.55 \times 10^3$                              | 5.08                           | 1100–1300              | SIMS                            | 22   |
|               | Sn        | $3.2 \times 10^1$                               | 4.25                           | 1050–1294              | Neutron activation              | 23   |
|               | N         | $2.7 \times 10^{-3}$                            | 2.8                            | 800–1200               | Out Diffusion; SIMS             | 1    |

| Semiconductor | Diffusant | Frequency factor,<br>$D_0$ (cm <sup>2</sup> /s)     | Activation energy,<br>$Q$ (eV) | Temperature range (°C) | Method of measurement         | Ref.   |
|---------------|-----------|-----------------------------------------------------|--------------------------------|------------------------|-------------------------------|--------|
| Ge            | P         | $2.02 \times 10^1$                                  | 3.87                           | 1100–1250              | Electrical                    | 10     |
|               |           | 1.1                                                 | 3.4                            | 900–1200               | Radioactive                   | 24     |
|               |           | $7.4 \times 10^{-2}$                                | 3.3                            | 1130–1405              | Electrical                    | 25     |
|               | As        | $6.0 \times 10^1$                                   | 4.2                            | 950–1350               | Radioactive                   | 26     |
|               |           | $6.55 \times 10^{-2}$                               | 3.44                           | 1167–1394              | Electrical                    | 27     |
|               |           | $2.29 \times 10^1$                                  | 4.1                            | 900–1250               | Electrical                    | 28     |
|               | Sb        | $1.29 \times 10^1$                                  | 3.98                           | 1190–1398              | Radioactive                   | 29     |
|               |           | $2.14 \times 10^{-1}$                               | 3.65                           | 1190–1405              | Electrical                    | 27     |
|               | Bi        | $1.03 \times 10^3$                                  | 4.64                           | 1220–1380              | Electrical                    | 16     |
|               |           | 1.08                                                | 3.85                           | 1190–1394              | Electrical                    | 27     |
|               | Cr        | $1 \times 10^{-2}$                                  | 1                              | 1100–1250              | Radioactive                   | 30     |
|               | Mo        | $(D \sim 2 \times 10^{-10})$                        | —                              | 1000                   | DLTS                          | 1      |
|               | W         | $(D \sim 10^{-12})$                                 | —                              | 1100                   | DLTS                          | 1      |
|               | O         | $7 \times 10^{-2}$                                  | 2.44                           | 700–1250               | SIMS                          | 31     |
|               |           | $1.4 \times 10^{-1}$                                | 2.53                           | 700–1160               | SIMS                          | 32     |
|               | S         | $5.95 \times 10^{-3}$                               | 1.83                           | 975–1200               | Radioactive                   | 33     |
|               | Se        | $9.5 \times 10^{-1}$                                | 2.6                            | 1050–1250              | Electrical                    | 34     |
|               | Te        | $5 \times 10^{-1}$                                  | 3.34                           | 900–1250               | SIMS                          | 1      |
|               | Mn        | $6.9 \times 10^{-4}$                                | 0.63                           | 900–1200               | Radioactive                   | 35     |
|               | Fe        | $1.3 \times 10^{-3}$                                | 0.68                           | 30–1250                | Radioactive                   | 36     |
|               | Co        | $2 \times 10^{-3}$                                  | 0.69                           | 700–1300               | Radioactive                   | 37     |
|               | Ni        | $2 \times 10^{-3}$                                  | 0.47                           | 800–1300               | Radioactive                   | 38     |
|               | Ru        | $(D \sim 5 \times 10^{-7}$<br>$- 5 \times 10^{-6})$ | —                              | 1000–1280              | Electrical                    | 1      |
|               | Rh        | $(D \sim 10^{-6}-10^{-4})$                          | —                              | 1000–1200              | Electrical                    | 39     |
|               | Pd        | $2.95 \times 10^{-4}$                               | 0.22 (i)                       | 702–1320               | Nuclear Activation            | 1      |
|               | Pt        | $1.5 \times 10^2$                                   | 2.22                           | 800–1000               | Electrical                    | 1      |
|               | Os        | $(D \sim 2 \times 10^{-6})$                         | —                              | 1280                   | Electrical                    | 40     |
|               | Ir        | $4.2 \times 10^{-2}$                                | 1.3                            | 950–1250               | Electrical                    | 41     |
|               | Li        | $1.3 \times 10^{-3}$                                | 0.46                           | 350–800                | Electrical                    | 42     |
|               |           | $9.1 \times 10^{-3}$                                | 0.57                           | 800–500                | Electrical                    | 43     |
|               | Na        | $3.95 \times 10^{-1}$                               | 2.03                           | 700–850                | Radioactive                   | 44     |
|               | Cu        | $1.9 \times 10^{-4}$                                | 0.18 (i)                       | 750–900                | Radioactive                   | 45     |
|               |           | $4 \times 10^{-2}$                                  | 0.99 (s)                       | 600–700                |                               |        |
|               |           | $4 \times 10^{-3}$                                  | 0.33 (i)                       | 350–750                | Radioactive                   | 5      |
|               | Ag        | $4.4 \times 10^{-2}$                                | 1.0 (i)                        | 700–900                | Radioactive                   | 46, 47 |
|               |           | $4 \times 10^{-2}$                                  | 2.23 (s)                       | 800–900                | Radioactive                   | 48     |
|               | Au        | $2.25 \times 10^2$                                  | 2.5                            | 600–900                | Radioactive                   | 49     |
|               | Be        | $5 \times 10^{-1}$                                  | 2.5                            | 720–900                | Electrical                    | 50     |
|               | Mg        | $(D \sim 8 \times 10^{-9})$                         | —                              | 900                    | Electrical                    | 1      |
|               | Zn        | 5                                                   | 2.7                            | 600–900                | Radioactive and<br>electrical | 51     |
|               | Cd        | $1.75 \times 10^9$                                  | 4.4                            | 760–915                | Radioactive                   | 52     |
|               | B         | $1.8 \times 10^9$                                   | 4.55                           | 600–900                | Electrical                    | 51     |
|               | Al        | $1.0 \times 10^3$                                   | 3.45                           | 554–905                | SIMS                          | 53     |
|               |           | $\sim 1.6 \times 10^2$                              | $\sim 3.24$                    | 750–850                | Electrical                    | 54     |
|               | Ga        | $1.4 \times 10^2$                                   | 3.35                           | 554–916                | SIMS                          | 55     |
|               |           | $3.4 \times 10^1$                                   | 3.1                            | 600–900                | Electrical                    | 51     |
|               | In        | $1.8 \times 10^4$                                   | 3.67                           | 554–919                | SIMS                          | 56     |
|               |           | $3.3 \times 10^1$                                   | 3.02                           | 700–855                | Radioactive                   | 57     |
|               | Tl        | $1.7 \times 10^3$                                   | 3.4                            | 800–930                | Radioactive                   | 58     |
|               | Si        | $2.4 \times 10^{-1}$                                | 2.9                            | 650–900                | ( $\gamma$ ) resonance        | 59     |
|               | Ge (self) | $2.48 \times 10^1$                                  | 3.14                           | 549–891                | Radioactive                   | 60     |
|               |           | 7.8                                                 | 2.95                           | 766–928                | Radioactive                   | 61     |
|               | Sn        | $1.7 \times 10^{-2}$                                | 1.9                            | —                      | Radioactive                   | 45     |
|               | P         | 3.3                                                 | 2.5                            | 600–900                | Electrical                    | 51     |
|               | As        | 2.1                                                 | 2.39                           | 700–900                | Electrical                    | 62     |
|               | Sb        | 3.2                                                 | 2.41                           | 700–855                | Radioactive                   | 57     |
|               |           | $1.0 \times 10^1$                                   | 2.5                            | 600–900                | Radioactive and<br>electrical | 51     |

| Semiconductor | Diffusant | Frequency factor,<br>$D_0$ (cm <sup>2</sup> /s)       | Activation energy,<br>$Q$ (eV) | Temperature range (°C) | Method of measurement              | Ref. |
|---------------|-----------|-------------------------------------------------------|--------------------------------|------------------------|------------------------------------|------|
| GaAs          | Bi        | 3.3                                                   | 2.57                           | 650–850                | —                                  | 63   |
|               | O         | $4 \times 10^{-1}$                                    | 2.08                           | —                      | Optical                            | 64   |
|               | S         | $(D \sim 10^{-9})$                                    | —                              | 920                    | —                                  | 65   |
|               | Se        | $(D \sim 10^{-10})$                                   | —                              | 920                    | —                                  | 65   |
|               | Te        | 5.6                                                   | 2.43                           | 750–900                | Radioactive                        | 66   |
|               | Fe        | $1.3 \times 10^{-1}$                                  | 1.08                           | 750–900                | Radioactive                        | 67   |
|               | Co        | $1.6 \times 10^{-1}$                                  | 1.12                           | 750–850                | Radioactive                        | 47   |
|               | Ni        | $8 \times 10^{-1}$                                    | 0.9                            | 670–900                | Electrical                         | 68   |
|               | Li        | $5.3 \times 10^{-1}$                                  | 1.0                            | 250–500                | Electrical and<br>chemical         | 69   |
|               | Cu        | $3 \times 10^{-2}$                                    | 0.53                           | 100–500                | Radioactive                        | 69   |
|               |           | $6 \times 10^{-2}$                                    | 0.98                           | 450–750                | Ultrasonic                         | 69   |
|               |           | $1.5 \times 10^{-3}$                                  | 0.6                            | 800–1000               | Radioactive                        | 69   |
|               | Ag        | $4 \times 10^{-4}$                                    | 0.8                            | 500–1150               | Radioactive                        | 69   |
|               | Au        | $1 \times 10^{-3}$                                    | 1.0                            | 740–1025               | Radioactive                        | 69   |
|               | Be        | $7.3 \times 10^{-6}$                                  | 1.2                            | 800–990                | Electrical                         | 69   |
|               | Mg        | $4 \times 10^{-5}$                                    | 1.22                           | 800–1200               | Electrical                         | 69   |
|               |           | $1.5 \times 10^1$                                     | 2.49                           | 600–980                | Radioactive                        | 69   |
|               | Zn        | $2.5 \times 10^{-1}$                                  | 3.0                            | 750–1000               | Radioactive                        | 69   |
|               |           | $1.3 \times 10^{-3}$                                  | 2.2                            | 800–1100               | Radioactive                        | 69   |
|               | Cd        | $5 \times 10^{-2}$                                    | 2.43                           | 868–1149               | Radioactive                        | 69   |
|               |           | $(D \sim 5 \times 10^{-14})$                          | —                              | 1100                   | Radioactive                        | 69   |
|               | Hg        | $(D \sim 4 \times 10^{-18} - 10^{-14})$               | 4.3                            | 850–1100               | AES                                | 70   |
|               | Al        | $4 \times 10^{-5}$                                    | 2.6                            | 1025–1100              | Radioactive                        | 69   |
|               |           | $1 \times 10^7$                                       | 5.6                            | 1125–1230              | Radioactive                        | 69   |
|               | In        | $(D \sim 7 \times 10^{-11})$                          | —                              | 1000                   | Radioactive                        | 69   |
|               | C         | $(D \sim 1.04 \times 10^{-16})$                       | —                              | 825                    | SIMS                               | 69   |
|               | Si        | $1.1 \times 10^{-1}$                                  | 2.5                            | 850–1050               | SIMS                               | 69   |
|               | Ge        | $1.6 \times 10^{-5}$                                  | 2.06                           | 650–850                | SIMS                               | 69   |
|               | Sn        | $6 \times 10^{-4}$                                    | 2.5                            | 1060–1200              | Radioactive                        | 69   |
|               |           | $1 \times 10^{-5}$                                    | 2                              | 800–1000               | Radioactive                        | 69   |
|               | P         | $(D \sim 10^{-12} - 10^{-10})$                        | 2.9                            | 800–1150               | Reflectance<br>measurements        | 69   |
|               | As (self) | $7 \times 10^{-1}$                                    | 3.2                            | —                      | Radioactive                        | 69   |
|               | Cr        | $2.04 \times 10^{-6}$                                 | 0.83 (f)                       | 750–1000               | SIMS                               | 69   |
|               |           |                                                       | 1.7 (s)                        | 700–900                |                                    |      |
|               |           | $7.9 \times 10^{-3}$                                  | 2.2                            | 800–1100               | Chemical analysis                  | 69   |
|               | O         | $2 \times 10^{-3}$                                    | 1.1                            | 700–900                | Mass spectroscopy                  | 69   |
|               | S         | $1.85 \times 10^{-2}$                                 | 2.6                            | 1000–1300              | Radioactive                        | 69   |
|               |           | $1.1 \times 10^1$                                     | 2.95                           | 750–900                | Electrical                         | 69   |
|               | Se        | $3 \times 10^3$                                       | 4.16                           | 1025–1200              | Radioactive                        | 69   |
|               | Te        | $1.5 \times 10^{-1}$                                  | 3.5                            | 1000–1150              | Radioactive                        | 69   |
|               | Mn        | $6.5 \times 10^{-1}$                                  | 2.49                           | 850–1100               | Radioactive                        | 69   |
|               | Fe        | $4.2 \times 10^{-2}$                                  | 1.8                            | 850–1150               | Radioactive                        | 69   |
|               |           | $2.2 \times 10^{-3}$                                  | 2.32                           | 750–1050               | Radioactive                        | 69   |
|               | Co        | $5 \times 10^2$                                       | 2.5                            | 800–1000               | Radioactive                        | 69   |
|               |           | $1.2 \times 10^{-1}$                                  | 2.64                           | 750–1050               | Radioactive                        | 69   |
|               | Tm        | $2.3 \times 10^{-16}$                                 | 1.0                            | 800–1000               | Radioactive                        | 69   |
| GaSb          | Li        | $2.3 \times 10^{-4}$                                  | 1.9 (s)                        | 527–657                | Electrical and flame<br>photometry | 69   |
|               |           | $1.2 \times 10^{-1}$                                  | 0.7 (f)                        | 277–657                |                                    |      |
|               | Cu        | $4.7 \times 10^{-3}$                                  | 0.9                            | 470–650                | Radioactive                        | 69   |
|               | Zn        | $(D \sim 2 \times 10^{-13} - 1 \times 10^{-11})$      | 2                              | 510–600                | Radioactive                        | 69   |
|               | Cd        | $1.5 \times 10^{-6}$                                  | 0.72                           | 640–800                | Electrical                         | 69   |
|               | Ga (self) | $3.2 \times 10^3$                                     | 3.15                           | 658–700                | Radioactive                        | 69   |
|               |           | $1.2 \times 10^{-7}$                                  | 0.53                           | 320–650                | Radioactive                        | 69   |
|               | Sn        | $2.4 \times 10^{-5}$                                  | 0.8                            | 320–650                | Radioactive                        | 69   |
|               |           | $1.3 \times 10^{-5}$                                  | 1.1                            | 500–650                | Radioactive                        | 69   |
|               | Sb (self) | $3.4 \times 10^4$                                     | 3.45                           | 658–700                | Radioactive                        | 69   |
|               | Se        | $(D \sim 2.4 \times 10^{-13} - 1.37 \times 10^{-11})$ | —                              | 400–500                | Radioactive                        | 69   |

| Semiconductor | Diffusant | Frequency factor,<br>$D_0$ (cm <sup>2</sup> /s)           | Activation energy,<br>$Q$ (eV) | Temperature range (°C) | Method of measurement                   | Ref. |
|---------------|-----------|-----------------------------------------------------------|--------------------------------|------------------------|-----------------------------------------|------|
| GaP           | Te        | $3.8 \times 10^{-4}$                                      | 1.20                           | 320–650                | Radioactive                             | 69   |
|               | Fe        | $5 \times 10^{-2}$                                        | 1.9 (I)                        | 500–650                | Radioactive                             | 69   |
|               |           | $5 \times 10^2$                                           | 2.3 (II)                       | 500–650                |                                         |      |
|               | Ag        | —                                                         | —                              | 1000–1300              | Radioactive                             | 69   |
|               | Au        | 8                                                         | 2.5 (I)                        | 1050–1250              | Radioactive                             | 69   |
|               |           | 20                                                        | 2.4 (II)                       | 1100–1250              | Diffusion (I) A face<br>and (II) B face |      |
|               | Be        | $(D_{\max} \sim 2.4 \times 10^{-9} - 8.5 \times 10^{-8})$ | —                              | 900–1000               | Atomic absorption<br>analysis           | 69   |
|               | Mg        | $5 \times 10^{-5}$                                        | 1.4                            | 700–1050               | Electrical                              | 69   |
|               | Zn        | 1.0                                                       | 2.1                            | 700–1300               | Radioactive                             | 69   |
|               | Ge        | —                                                         | —                              | 900–1000               | Radioactive                             | 69   |
|               | Cr        | $6.2 \times 10^{-4}$                                      | 1.2                            | 900–1130               | Radioactive; ESR                        | 69   |
|               | S         | $3.2 \times 10^3$                                         | 4.7                            | 1120–1305              | Radioactive                             | 69   |
|               | Mn        | $2.1 \times 10^9$                                         | 4.7                            | T < 950                | Radioactive; ESR                        | 69   |
|               |           | $1.1 \times 10^{-6}$                                      | 0.9                            | 950–1130               |                                         |      |
| InP           | Fe        | $1.6 \times 10^{-1}$                                      | 2.3                            | 980–1180               | Radioactive                             | 69   |
|               | Co        | $2.8 \times 10^{-3}$                                      | 2.9                            | 850–1100               | Radioactive                             | 69   |
|               | Cu        | $3.8 \times 10^{-3}$                                      | 0.69                           | 600–900                | Radioactive                             | 69   |
|               | Ag        | $3.6 \times 10^{-4}$                                      | 0.59                           | 500–900                | Radioactive                             | 69   |
|               | Au        | $1.32 \times 10^{-5}$                                     | 0.48                           | 600–820                | Radioactive                             | 69   |
|               |           | $1.37 \times 10^{-4}$                                     | 0.73                           | 600–900                | Radioactive                             | 69   |
|               | Zn        | $1.6 \times 10^{-8}$                                      | 0.3                            | 750–900                | Electrical                              | 69   |
|               |           | $(D \sim 2 \times 10^{-9} - 4 \times 10^{-8})$            | —                              | 700–900                | Radioactive                             | 69   |
|               | Cd        | 1.8                                                       | 1.9                            | 700–900                | Radioactive                             | 69   |
|               |           | $1.1 \times 10^{-7}$                                      | 0.72                           | 700–900                | Electrical                              | 69   |
|               |           | $(D \sim 7 \times 10^{-13} - 2 \times 10^{-10})$          | —                              | 450–650                | Electrical                              | 69   |
|               | In (self) | $1 \times 10^5$                                           | 3.85                           | 830–990                | Radioactive                             | 69   |
|               | Sn        | $(D \sim 3 \times 10^{-8})$                               | —                              | 550                    | Etching and cathodo-<br>luminescence    | 69   |
|               | P (self)  | $7 \times 10^{10}$                                        | 5.65                           | 900–1000               | Radioactive                             | 69   |
|               | Cr        | —                                                         | —                              | 600–900                | Radioactive                             | 69   |
| InAs          | S         | $3.6 \times 10^{-4}$                                      | 1.94                           | 585–708                | Electrical                              | 69   |
|               | Se        | $(D \sim 2 \times 10^{-8})$                               | —                              | 550                    | Cathodoluminescence                     | 69   |
|               | Mn        | —                                                         | 2.9                            | 650–750                | SIMS                                    | 69   |
|               | Fe        | 3                                                         | 2                              | 600–950                | Radioactive                             | 69   |
|               |           | $6.8 \times 10^5$                                         | 3.4                            | 600–700                | SIMS                                    | 69   |
|               | Co        | $9 \times 10^{-1}$                                        | 1.8                            | 600–950                | Radioactive                             | 69   |
|               | Cu        | $3.6 \times 10^{-3}$                                      | 0.52                           | 342–875                | Radioactive                             | 69   |
|               |           | $2.2 \times 10^{-2}$                                      | 0.54                           | 525–890                | Radioactive                             | 69   |
|               | Ag        | $7.3 \times 10^{-4}$                                      | 0.26                           | 450–900                | Radioactive                             | 69   |
|               | Au        | $5.8 \times 10^{-3}$                                      | 0.65                           | 600–900                | Radioactive                             | 69   |
|               | Mg        | $1.98 \times 10^{-6}$                                     | 1.17                           | 600–900                | Electrical                              | 69   |
|               | Zn        | $4.2 \times 10^{-3}$                                      | 0.96                           | 600–900                | Radioactive                             | 69   |
|               |           | $3.11 \times 10^{-3}$                                     | 1.17                           | 600–900                | Electrical                              | 69   |
|               | Cd        | $7.4 \times 10^{-4}$                                      | 1.15                           | 650–900                | Radioactive                             | 69   |
|               | Hg        | $1.45 \times 10^{-5}$                                     | 1.32                           | 650–850                | Radioactive                             | 69   |
| InSb          | In (self) | $6 \times 10^5$                                           | 4.0                            | 740–900                | Radioactive                             | 69   |
|               | Ge        | $3.74 \times 10^{-6}$                                     | 1.17                           | 600–900                | Electrical                              | 69   |
|               | Sn        | $1.49 \times 10^{-6}$                                     | 1.17                           | 600–900                | Electrical                              | 69   |
|               | As (self) | $3 \times 10^7$                                           | 4.45                           | 740–900                | Radioactive                             | 69   |
|               | S         | 6.78                                                      | 2.2                            | 600–900                | Electrical                              | 69   |
|               | Se        | 12.6                                                      | 2.2                            | 600–900                | Electrical                              | 69   |
|               | Te        | $3.43 \times 10^{-5}$                                     | 1.28                           | 600–900                | Electrical                              | 69   |
|               | Li        | $7 \times 10^{-4}$                                        | 0.28                           | 0–210                  | Electrical                              | 69   |
|               | Cu        | $9 \times 10^{-4}$                                        | 1.08                           | 200–500                | Radioactive                             | 69   |
|               |           | $3 \times 10^{-5}$                                        | 0.37                           | 230–490                | Radioactive                             | 69   |
|               | Ag        | $1 \times 10^{-7}$                                        | 0.25                           | 440–510                | Radioactive                             | 69   |
|               | Au        | $7 \times 10^{-4}$                                        | 0.32                           | 140–510                | Radioactive                             | 69   |
|               | Zn        | $5 \times 10^{-1}$                                        | 1.35                           | 362–508                | Radioactive                             | 69   |

| Semiconductor | Diffusant | Frequency factor,<br>$D_0$ (cm <sup>2</sup> /s)    | Activation energy,<br>$Q$ (eV) | Temperature range (°C) | Method of measurement         | Ref. |
|---------------|-----------|----------------------------------------------------|--------------------------------|------------------------|-------------------------------|------|
| AlAs          | —         | —                                                  | 1.5                            | 355–455                | SIMS                          | 69   |
|               | Cd        | $1 \times 10^{-5}$                                 | 1.1                            | 250–500                | Radioactive                   | 69   |
|               |           | $1.3 \times 10^{-4}$                               | 1.2                            | 360–500                | Electrical                    | 69   |
|               | Hg        | $4 \times 10^{-6}$                                 | 1.17                           | 425–500                | Radioactive                   | 69   |
|               | In (self) | $6 \times 10^{-7}$                                 | 1.45                           | 400–500                | Radioactive                   | 69   |
|               |           | $1.8 \times 10^{13}$                               | 4.3                            | 475–517                | Radioactive                   | 69   |
|               | Sn        | $5.5 \times 10^{-8}$                               | 0.75                           | 390–512                | Radioactive                   | 69   |
|               | Pb        | $(D \sim 2.7 \times 10^{-15})$                     | —                              | 500                    | Radioactive                   | 71   |
|               | Sb (self) | $5.35 \times 10^{-4}$                              | 1.91                           | 400–500                | Radioactive                   | 69   |
|               |           | $3.1 \times 10^{13}$                               | 4.3                            | 475–517                | Radioactive                   | 69   |
|               | S         | $9 \times 10^{-2}$                                 | 1.4                            | 360–500                | Electrical                    | 69   |
|               | Se        | 1.6                                                | 1.87                           | 380–500                | Electrical                    | 69   |
|               | Te        | $1.7 \times 10^{-7}$                               | 0.57                           | 300–500                | Radioactive                   | 69   |
|               | Fe        | $1 \times 10^{-7}$                                 | 0.25                           | 440–510                | Radioactive                   | 69   |
|               | Co        | $2.7 \times 10^{-11}$                              | 0.39                           | 420–500                | Radioactive                   | 69   |
|               | Ga        | $(D \sim 2 \times 10^{-18} - 10^{-15})$            | 3.6                            | 850–1100               | AES                           | 70   |
|               | Zn        | $(D \sim 9 \times 10^{-11})$                       | —                              | 557                    | SEM                           | 69   |
|               | Cu        | $3.5 \times 10^{-3}$                               | 0.36                           | 150–500                | Radioactive                   | 69   |
|               | Zn        | $3.3 \times 10^{-1}$                               | 1.93                           | 660–860                | Radioactive                   | 69   |
|               | Cd        | $D(c) \sim 4 \times 10^{-12} - 3 \times 10^{-10}$  | —                              | 900                    | Radioactive                   | 69   |
| ZnS           | Al (self) | 2                                                  | 1.88                           | 570–620                | X-ray                         | 69   |
|               | Sb (self) | 1                                                  | 1.7                            | 570–620                | X-ray                         | 69   |
|               | Cu        | $2.6 \times 10^{-3}$                               | 0.79                           | 470–750                | Radioactive                   | 69   |
|               |           | $4.3 \times 10^{-4}$                               | 0.64                           | 250–1200               | Electroluminescence           | 69   |
|               |           | $9.75 \times 10^{-3}$                              | 1.04                           | 400–800                | Luminescence                  | 69   |
|               | Au        | $1.75 \times 10^{-4}$                              | 1.16                           | 500–800                | Radioactive                   | 69   |
|               | Zn (self) | $3 \times 10^{-4}$                                 | 1.5                            | $925 < T < 940$        | Radioactive                   | 69   |
|               |           | $1.5 \times 10^4$                                  | 3.26                           | $940 < T < 1030$       |                               |      |
|               |           | $1 \times 10^{16}$                                 | 6.5                            | $1030 < T < 1075$      |                               |      |
|               | Cd        | $(D \sim 10^{-10})$                                | —                              | 1100                   | Luminescence                  | 72   |
| ZnSe          | Al        | $5.69 \times 10^{-4}$                              | 1.28                           | 800–1000               | Luminescence                  | 69   |
|               | In        | $3 \times 10^1$                                    | 2.2                            | 750–1000               | Radioactive                   | 69   |
|               | S (self)  | $2.16 \times 10^4$                                 | 3.15                           | 600–800                | Radioactive                   | 69   |
|               |           | $8 \times 10^{-5}$                                 | 2.2                            | 740–1100               | Radioactive                   | 69   |
|               | Se        | $(D \sim 5 \times 10^{-13})$                       | —                              | 1070                   | X-ray microprobe              | 69   |
|               | Mn        | $2.3 \times 10^3$                                  | 2.46                           | 500–800                | Radioactive                   | 69   |
|               | Li        | $2.66 \times 10^{-6}$                              | 0.49                           | 950–980                | Electrical                    | 69   |
|               | Cu        | $1 \times 10^{-4}$                                 | 0.66                           | 400–800                | Luminescence                  | 69   |
|               |           | $1.7 \times 10^{-5}$                               | 0.56                           | 200–570                | Radioactive                   | 69   |
|               | Ag        | $2.2 \times 10^{-2}$                               | 1.18                           | 400–800                | Luminescence                  | 69   |
|               | Zn (self) | 9.8                                                | 3.0                            | 760–1150               | Radioactive                   | 69   |
|               | Cd        | $6.39 \times 10^{-4}$                              | 1.87                           | 700–950                | Photoluminescence             | 69   |
|               | Al        | $2.3 \times 10^{-2}$                               | 1.8                            | 800–1100               | Luminescence                  | 69   |
|               | Ga        | $1.81 \times 10^2$                                 | 3.0                            | 900–1100               | Luminescence                  | 69   |
|               |           | —                                                  | 1.3                            | 700–850                | Electron probe                | 69   |
|               | In        | $(D \sim 2 \times 10^{-12})$                       | —                              | 940                    | —                             | 69   |
|               | S         | $(D \sim 8 \times 10^{-12})$                       | —                              | 1060                   | X-ray microprobe              | 69   |
|               | Se (self) | $1.3 \times 10^1$                                  | 2.5                            | 860–1020               | Radioactive                   | 69   |
| ZnTe          |           | $2.3 \times 10^{-1}$                               | 2.7                            | 1000–1050              | Radioactive                   | 69   |
|               | Ni        | $(D \sim 1.5 \times 10^{-8} - 1.7 \times 10^{-7})$ | —                              | 740–910                | Luminescence                  | 69   |
|               | Li        | $2.9 \times 10^{-2}$                               | 1.22 (s)                       | 400–700                | Nuclear and chemical analysis | 69   |
|               |           | $1.7 \times 10^{-4}$                               | 0.78 (f)                       |                        |                               |      |
|               | Zn (self) | 2.34                                               | 2.56                           | 760–860                | Radioactive                   | 69   |
|               |           | $1.4 \times 10^1$                                  | 2.69                           | 667–1077               | Radioactive                   | 69   |
|               | Al        | —                                                  | 2.0                            | 700–1000               | Electrical and optical        | 69   |
|               | In        | 4                                                  | 1.96                           | 1100–1300              | Radioactive                   | 69   |
|               | Te (self) | $2 \times 10^4$                                    | 3.8                            | 727–977                | Radioactive                   | 69   |
|               | Li        | $3 \times 10^{-6}$                                 | 0.68                           | 610–960                | Microhardness                 | 69   |
| CdS           | Na        | $(D \sim 3 \times 10^{-7})$                        | —                              | 800                    | Radioactive                   | 69   |

| Semiconductor | Diffusant | Frequency factor,<br>$D_0$ (cm <sup>2</sup> /s)        | Activation energy,<br>$Q$ (eV) | Temperature range (°C) | Method of measurement                                        | Ref. |
|---------------|-----------|--------------------------------------------------------|--------------------------------|------------------------|--------------------------------------------------------------|------|
| CdSe          | Cu        | $1.5 \times 10^{-3}$                                   | 0.76                           | 400–700                | Radioactive                                                  | 69   |
|               |           | $1.2 \times 10^{-2}$                                   | 1.05                           | 300–700                | Ultrasonic                                                   | 69   |
|               |           | $8 \times 10^{-5}$                                     | 0.72                           | 20–200                 | Electrical                                                   | 69   |
|               | Ag        | $2.5 \times 10^1$                                      | 1.2 (s)                        | 300–500                | Radioactive                                                  | 69   |
|               |           | $2.4 \times 10^{-1}$                                   | 0.8 (f)                        |                        |                                                              |      |
|               | Au        | $2 \times 10^2$                                        | 1.8                            | 500–800                | Radioactive                                                  | 69   |
|               | Zn        | $1.27 \times 10^{-9}$                                  | 0.86 (s)                       | 720–1000               | Radioactive                                                  | 69   |
|               |           | $1.22 \times 10^{-8}$                                  | 0.66 (f)                       |                        |                                                              |      |
|               | Cd (self) | 3.4                                                    | 2.0                            | 700–1100               | Radioactive                                                  | 69   |
|               | Ga        | —                                                      | —                              | 667–967                | Optical and microprobe                                       | 69   |
|               | In        | $6 \times 10^1$                                        | 2.3 (  )                       | 650–930                | Radioactive, optical and microprobe                          | 69   |
|               |           | $1 \times 10^1$                                        | 2.03 (⊥)                       |                        |                                                              |      |
|               | P         | $6.5 \times 10^{-4}$                                   | 1.6                            | 800–1100               | Radioactive                                                  | 69   |
|               | S (self)  | $1.6 \times 10^{-2}$                                   | 2.05                           | 800–900                | Radioactive                                                  | 69   |
|               |           | —                                                      | 2.4                            | 750–1050               | Radioactive                                                  | 69   |
|               | Se        | ( $D \sim 1.2 \times 10^{-9}$ )                        | —                              | 900                    | Radioactive                                                  | 69   |
|               | Te        | $1.3 \times 10^{-7}$                                   | 10.4                           | 700–1000               | Radioactive                                                  | 69   |
|               | Cl        | ( $D \sim 3 \times 10^{-10}$ )                         | —                              | 800                    | Electrical                                                   | 69   |
|               | I         | ( $D \sim 5 \times 10^{-12}$ )                         | —                              | 1000                   | Radioactive                                                  | 69   |
|               | Ni        | $6.75 \times 10^{-3}$                                  | 10.9                           | 570–900                | Luminescence                                                 | 69   |
|               | Yb        | ( $D \sim 1.3 \times 10^{-9}$ )                        | —                              | 960                    | Photoluminescence                                            | 69   |
|               | Ag        | $2 \times 10^{-4}$                                     | 0.53                           | 22–400                 | Ultrasonic                                                   | 69   |
|               | Cd (self) | $1.6 \times 10^{-3}$                                   | 1.5                            | 700–1000               | Radioactive                                                  | 69   |
|               |           | $6.3 \times 10^{-2}$                                   | 1.25 (I)                       | 600–900                | Radioactive;                                                 | 69   |
|               |           | $4.12 \times 10^{-2}$                                  | 2.18 (II)                      | 600–900                | (I) saturated Cd and (II) saturated Se pressure              | 69   |
|               | P         | ( $D \sim 5.3 \times 10^{-12}$ – $6 \times 10^{-11}$ ) | —                              | 900–1000               | Radioactive                                                  | 69   |
|               | Se (self) | $2.6 \times 10^3$                                      | 1.55                           | 700–1000               | Radioactive; saturated Se pressure                           | 69   |
|               |           |                                                        |                                |                        |                                                              |      |
| CdTe          | Li        | ( $D \sim 1.5 \times 10^{-10}$ )                       | —                              | 300                    | Ion microprobe                                               | 69   |
|               | Cu        | $3.7 \times 10^{-4}$                                   | 0.67                           | 97–300                 | Radioactive                                                  | 69   |
|               |           | $8.2 \times 10^{-8}$                                   | 0.64                           | 290–350                | Ion backscattering                                           | 69   |
|               | Ag        | —                                                      | —                              | 700–800                | Electrical and photo-luminescence                            | 69   |
|               |           |                                                        |                                |                        |                                                              |      |
|               | Au        | $6.7 \times 10^1$                                      | 2.0                            | 600–1000               | Radioactive                                                  | 69   |
|               | Cd (self) | 1.26                                                   | 2.07                           | 700–1000               | Radioactive                                                  | 69   |
|               |           | $3.26 \times 10^2$                                     | 2.67 (I)                       | 650–900                | Radioactive;                                                 | 69   |
|               |           | $1.58 \times 10^1$                                     | 2.44 (II)                      |                        | (I) saturated Cd and (II) saturated Te pressure              | 69   |
|               |           |                                                        |                                |                        |                                                              |      |
|               | In        | $8 \times 10^{-2}$                                     | 1.61                           | 650–1000               | Radioactive                                                  | 69   |
|               |           | $1.17 \times 10^2$                                     | 2.21 (I)                       | 500–850                | Radioactive; (I) saturated Cd and (II) saturated Te pressure | 69   |
|               |           | $6.48 \times 10^{-4}$                                  | 1.15 (II)                      |                        |                                                              |      |
|               | Sn        | $8.3 \times 10^{-2}$                                   | 2.2                            | 700–925                | Radioactive                                                  | 69   |
|               | P         | ( $D \sim 1.2 \times 10^{-10}$ )                       | —                              | 900                    | Radioactive                                                  | 69   |
|               | As        | —                                                      | —                              | 850                    | —                                                            | 69   |
|               | O         | $5.6 \times 10^{-9}$                                   | 1.22                           | 200–650                | Mass spectrometry                                            | 69   |
|               |           | $6.0 \times 10^{-10}$                                  | 0.29                           | 650–900                |                                                              |      |
|               | Se        | $1.7 \times 10^{-4}$                                   | 1.35                           | 700–1000               | Radioactive                                                  | 69   |
|               | Te (self) | $8.54 \times 10^{-7}$                                  | 1.42 (I)                       | 600–900                | Radioactive; (I) saturated Cd and (II) saturated Te pressure | 69   |
|               |           |                                                        |                                |                        |                                                              |      |
|               |           | $1.66 \times 10^{-4}$                                  | 1.38 (II)                      | 500–800                |                                                              |      |
|               | Cl        | $7.1 \times 10^{-2}$                                   | 1.6                            | 520–800                | Radioactive                                                  | 69   |
|               | Fe        | ( $D \sim 4 \times 10^{-8}$ )                          | 0.77                           | 900                    | Radioactive                                                  | 69   |



| Semiconductor | Diffusant | Frequency factor,<br>$D_0$ (cm <sup>2</sup> /s) | Activation energy,<br>$Q$ (eV) | Temperature range (°C) | Method of measurement | Ref. |
|---------------|-----------|-------------------------------------------------|--------------------------------|------------------------|-----------------------|------|
| HgSe          | Sb        | $6.3 \times 10^{-5}$                            | 0.85                           | 540–630                | Radioactive           | 69   |
|               | Se (self) | —                                               | —                              | 200–400                | Radioactive           | 69   |
| HgTe          | Ag        | $6 \times 10^{-4}$                              | 0.8                            | 250–350                | Radioactive           | 69   |
|               | Zn        | $5 \times 10^{-8}$                              | 0.6                            | 250–350                | Radioactive           | 69   |
|               | Cd        | $3.1 \times 10^{-4}$                            | 0.66                           | 250–350                | Radioactive           | 69   |
|               | Hg (self) | $2 \times 10^{-8}$                              | 0.6                            | 200–350                | Radioactive           | 69   |
|               | In        | $6 \times 10^{-6}$                              | 0.9                            | 200–300                | Radioactive           | 69   |
|               | Sn        | $1.72 \times 10^{-6}$                           | 0.66 (s)                       | 200–300                | Radioactive           | 69   |
|               |           | $1.8 \times 10^{-3}$                            | 0.80 (f)                       |                        |                       |      |
|               | Te (self) | $10^{-6}$                                       | 1.4                            | 200–400                | Radioactive           | 69   |
| PbS           | Mn        | $1.5 \times 10^{-4}$                            | 1.3                            | 250–350                | Radioactive           | 69   |
|               | Cu        | $4.6 \times 10^{-4}$                            | 0.36                           | 150–450                | Electrical            | 69   |
|               |           | $5 \times 10^{-3}$                              | 0.31                           | 100–400                | Electrical            | 69   |
|               | Pb (self) | $8.6 \times 10^{-5}$                            | 1.52                           | 500–800                | Radioactive           | 69   |
|               | S (self)  | $6.8 \times 10^{-5}$                            | 1.38                           | 500–750                | Radioactive           | 69   |
|               | Ni        | $1.78 \times 10^1$                              | 0.95                           | 200–500                | Electrical            | 69   |
|               | Na        | $1.5 \times 10^1$                               | 1.74 (s)                       | 400–850                | Radioactive           | 69   |
|               |           | $5.6 \times 10^{-6}$                            | 0.4 (f)                        |                        |                       |      |
| PbSe          | Cu        | $2 \times 10^{-5}$                              | 0.31                           | 93–520                 | Radioactive           | 69   |
|               | Ag        | $7.4 \times 10^{-4}$                            | 0.35                           | 400–850                | Radioactive           | 69   |
|               | Pb (self) | $4.98 \times 10^{-6}$                           | 0.83                           | 400–800                | Radioactive           | 69   |
|               | Sb        | $3.4 \times 10^{-1}$                            | 2.0                            | 650–850                | Radioactive           | 69   |
|               | Se (self) | $2.1 \times 10^{-5}$                            | 1.2                            | 650–850                | Radioactive           | 69   |
|               | Cl        | $1.6 \times 10^{-8}$                            | 0.45                           | 400–850                | Radioactive           | 69   |
|               | Ni        | $(D \sim 1 \times 10^{-10})$                    | —                              | 700                    | Radioactive           | 69   |
|               | Na        | $1.7 \times 10^{-1}$                            | 1.91                           | 600–850                | Radioactive           | 69   |
|               | Sn        | $3.1 \times 10^{-2}$                            | 1.56                           | 500–800                | Radioactive           | 69   |
|               | Pb (self) | $2.9 \times 10^{-5}$                            | 0.6                            | 250–500                | Radioactive           | 69   |
|               | Sb        | $4.9 \times 10^{-2}$                            | 1.54                           | 500–800                | Radioactive           | 69   |
|               | Te        | $2.7 \times 10^{-6}$                            | 0.75                           | 500–800                | Radioactive           | 69   |
|               | Cl        | $(D > 2.3 \times 10^{-10})$                     | —                              | 700                    | Radioactive           | 69   |
|               | Ni        | $(D > 1 \times 10^{-6})$                        | —                              | 700                    | Radioactive           | 69   |

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# PROPERTIES OF MAGNETIC MATERIALS

H. P. R. Frederikse

## Glossary of Symbols

| Quantity                            | Symbol                 | Units                           |                      |
|-------------------------------------|------------------------|---------------------------------|----------------------|
|                                     |                        | SI                              | emu                  |
| Magnetic field                      | $H$                    | $\text{A m}^{-1}$               | Oe (oersted)         |
| Magnetic induction                  | $B$                    | T (tesla)                       | G (gauss)            |
| Magnetization                       | $M$                    | $\text{A m}^{-1}$               | $\text{emu cm}^{-3}$ |
| Spontaneous magnetization           | $M_s$                  | $\text{A m}^{-1}$               | $\text{emu cm}^{-3}$ |
| Saturation magnetization            | $M_0$                  | $\text{A m}^{-1}$               | $\text{emu cm}^{-3}$ |
| Magnetic flux                       | $\Phi$                 | Wb (weber)                      | maxwell              |
| Magnetic moment                     | $m, \mu$               | $\text{A m}^2$                  | erg/G                |
| Coercive field                      | $H_c$                  | $\text{A m}^{-1}$               | Oe                   |
| Remanence                           | $B_r$                  | T                               | G                    |
| Saturation magnetic polarization    | $J_s$                  | T                               | G                    |
| Magnetic susceptibility             | $\chi$                 |                                 |                      |
| Magnetic permeability               | $\mu$                  | $\text{H m}^{-1}$ (henry/meter) |                      |
| Magnetic permeability of free space | $\mu_0$                | $\text{H m}^{-1}$               |                      |
| Saturation magnetostriction         | $\lambda (\Delta l/l)$ |                                 |                      |
| Curie temperature                   | $T_C$                  | K                               | K                    |
| Néel temperature                    | $T_N$                  | K                               | K                    |

Magnetic moment  $\mu = \gamma \hbar J = g \mu_B J$

where

$\gamma$  = gyromagnetic ratio;  $J$  = angular momentum;  $g$  = spectroscopic splitting factor ( $\sim 2$ )

$\mu_B$  = bohr magneton =  $9.2741 \cdot 10^{-24} \text{ J/T} = 9.2741 \cdot 10^{-21} \text{ erg/G}$

Earth's magnetic field  $H = 56 \text{ A m}^{-1} = 0.7 \text{ Oe}$

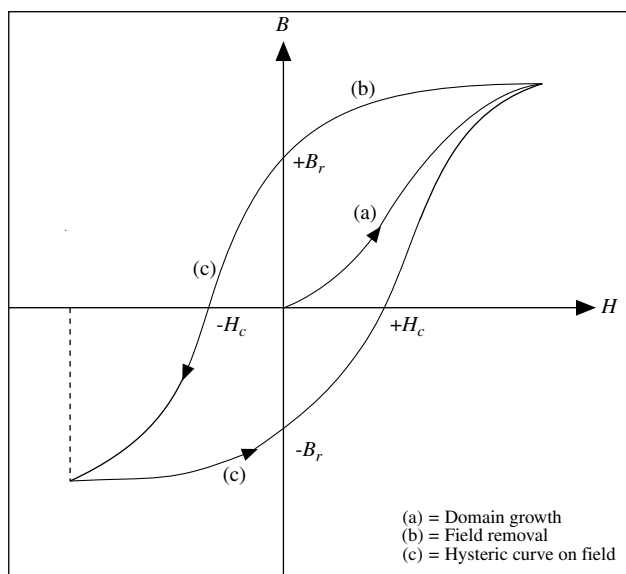
For iron:  $M_0 = 1.7 \cdot 10^6 \text{ A m}^{-1}$ ;  $B_r = 0.8 \cdot 10^6 \text{ A m}^{-1}$

$1 \text{ Oe} = (1000/4\pi) \text{ A m}^{-1}$ ;  $1 \text{ G} = 10^{-4} \text{ T}$ ;  $1 \text{ emu cm}^{-3} = 10^3 \text{ A m}^{-1}$

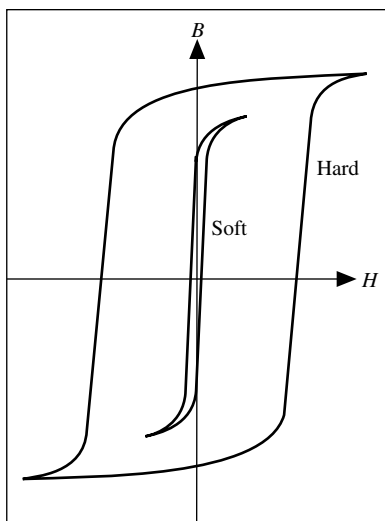
$1 \text{ maxwell} = 10^{-8} \text{ Wb}$

$\mu_0 = 4\pi \cdot 10^{-7} \text{ H m}^{-1}$

## Relation Between Magnetic Induction and Magnetic Field



**FIGURE 1.** Typical curve representing the dependence of magnetic induction  $B$  on magnetic field  $H$  for a ferromagnetic material. When  $H$  is first applied,  $B$  follows curve **a** as the favorably oriented magnetic domains grow. This curve flattens as saturation is approached. When  $H$  is then reduced,  $B$  follows curve **b**, but retains a finite value (the remanence  $B_r$ ) at  $H = 0$ . In order to demagnetize the material, a negative field  $-H_c$  (where  $H_c$  is called the coercive field or coercivity) must be applied. As  $H$  is further decreased and then increased to complete the cycle (curve **c**), a hysteresis loop is obtained. The area within this loop is a measure of the energy loss per cycle for a unit volume of the material.

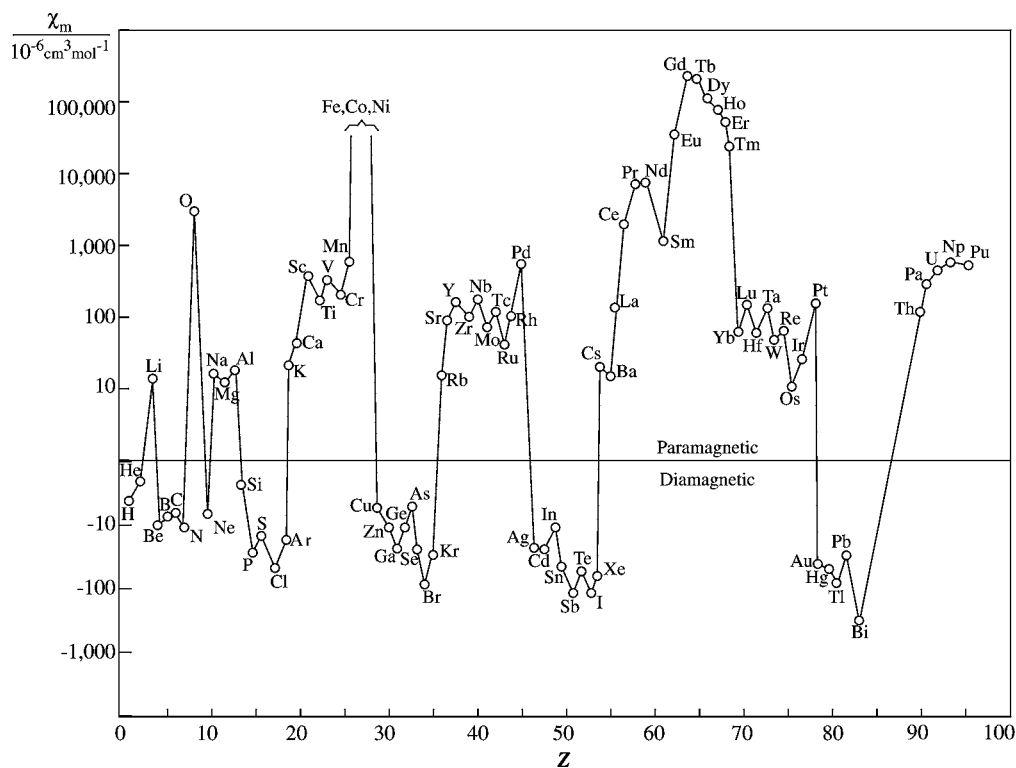


**FIGURE 2.** Schematic curve illustrating the  $B$  vs.  $H$  dependence for hard and soft magnetic materials. Hard materials have a larger remanence and coercive field, and a correspondingly large hysteresis loss.

## Reference

Ralls, K. M., Courtney, T. H., and Wulff, J., *Introduction to Materials Science and Engineering*, J. Wiley & Sons, New York, 1976, p. 577, 582. With permission.

## Magnetic Susceptibility of the Elements



**FIGURE 3.** Molar susceptibility of the elements at room temperature (cgs units of  $10^{-6} \text{ cm}^3/\text{mol}$ ). Values are not available for  $Z = 9, 61$ , and  $84-89$ ; Fe, Co, and Ni ( $Z = 26-28$ ) are ferromagnetic. Data taken from the table "Magnetic Susceptibility of the Elements and Inorganic Compounds" in Section 4.

## Reference

Gray, D. E., Ed., *American Institute of Physics Handbook, Third Edition*, McGraw Hill, New York, 1972, p. 5-224. With permission.

Ground State of Ions with Partly Filled *d* or *f* Shells

| <i>Z</i>                     | Element          | <i>n</i> | <i>S</i> | <i>L</i> | <i>J</i> | Gr. state                      | $p_{\text{calc}}^{\text{a}}$ | $p_{\text{calc}}^{\text{b}}$ | $p_{\text{meas}}$ |
|------------------------------|------------------|----------|----------|----------|----------|--------------------------------|------------------------------|------------------------------|-------------------|
| 22                           | Ti <sup>3+</sup> | 1        | 1/2      | 2        | 3/2      | <sup>2</sup> D <sub>3/2</sub>  | 1.73                         | 1.55                         | 1.8               |
| 23                           | V <sup>4+</sup>  | 1        | 1/2      | 2        | 3/2      | <sup>2</sup> D <sub>3/2</sub>  | 1.73                         | 1.55                         | 1.8               |
| 23                           | V <sup>3+</sup>  | 2        | 1        | 3        | 2        | <sup>3</sup> F <sub>2</sub>    | 2.83                         | 1.63                         | 2.8               |
| 23                           | V <sup>2+</sup>  | 3        | 3/2      | 3        | 3/2      | <sup>4</sup> F <sub>3/2</sub>  | 3.87                         | 0.77                         | 3.8               |
| 24                           | Cr <sup>3+</sup> | 3        | 3/2      | 3        | 3/2      | <sup>4</sup> F <sub>3/2</sub>  | 3.87                         | 0.77                         | 3.7               |
| 25                           | Mn <sup>4+</sup> | 3        | 3/2      | 3        | 3/2      | <sup>4</sup> F <sub>3/2</sub>  | 3.87                         | 0.77                         | 4.0               |
| 24                           | Cr <sup>2+</sup> | 4        | 2        | 2        | 0        | <sup>5</sup> D <sub>0</sub>    | 4.90                         | 0                            | 4.9               |
| 25                           | Mn <sup>3+</sup> | 4        | 2        | 2        | 0        | <sup>5</sup> D <sub>0</sub>    | 4.90                         | 0                            | 5.0               |
| 25                           | Mn <sup>2+</sup> | 5        | 5/2      | 0        | 5/2      | <sup>6</sup> S <sub>5/2</sub>  | 5.92                         | 5.92                         | 5.9               |
| 26                           | Fe <sup>3+</sup> | 5        | 5/2      | 0        | 5/2      | <sup>6</sup> S <sub>5/2</sub>  | 5.92                         | 5.92                         | 5.9               |
| 26                           | Fe <sup>2+</sup> | 6        | 2        | 2        | 4        | <sup>5</sup> D <sub>4</sub>    | 4.90                         | 6.70                         | 5.4               |
| 27                           | Co <sup>2+</sup> | 7        | 3/2      | 3        | 9/2      | <sup>4</sup> F <sub>9/2</sub>  | 3.87                         | 6.54                         | 4.8               |
| 28                           | Ni <sup>2+</sup> | 8        | 1        | 3        | 4        | <sup>3</sup> F <sub>4</sub>    | 2.83                         | 5.59                         | 3.2               |
| 29                           | Cu <sup>2+</sup> | 9        | 1/2      | 2        | 5/2      | <sup>2</sup> D <sub>5/2</sub>  | 1.73                         | 3.55                         | 1.9               |
| $p_{\text{calc}}^{\text{c}}$ |                  |          |          |          |          |                                |                              |                              |                   |
| 58                           | Ce <sup>3+</sup> | 1        | 1/2      | 3        | 5/2      | <sup>2</sup> F <sub>5/2</sub>  | 2.54                         |                              | 2.4               |
| 59                           | Pr <sup>3+</sup> | 2        | 1        | 5        | 4        | <sup>3</sup> H <sub>4</sub>    | 3.58                         |                              | 3.5               |
| 60                           | Nd <sup>3+</sup> | 3        | 3/2      | 6        | 9/2      | <sup>4</sup> I <sub>9/2</sub>  | 3.62                         |                              | 3.5               |
| 61                           | Pm <sup>3+</sup> | 4        | 2        | 6        | 4        | <sup>5</sup> I <sub>4</sub>    | 2.68                         |                              |                   |
| 62                           | Sm <sup>3+</sup> | 5        | 5/2      | 5        | 5/2      | <sup>6</sup> H <sub>5/2</sub>  | 0.84                         |                              | 1.5               |
| 63                           | Eu <sup>3+</sup> | 6        | 3        | 3        | 0        | <sup>7</sup> F <sub>0</sub>    | 0.0                          |                              | 3.4               |
| 64                           | Gd <sup>3+</sup> | 7        | 7/2      | 0        | 7/2      | <sup>8</sup> S <sub>7/2</sub>  | 7.94                         |                              | 8.0               |
| 65                           | Tb <sup>3+</sup> | 8        | 3        | 3        | 6        | <sup>7</sup> F <sub>6</sub>    | 9.72                         |                              | 9.5               |
| 66                           | Dy <sup>3+</sup> | 9        | 5/2      | 5        | 15/2     | <sup>6</sup> H <sub>15/2</sub> | 10.63                        |                              | 10.6              |
| 67                           | Ho <sup>3+</sup> | 10       | 2        | 6        | 8        | <sup>5</sup> I <sub>8</sub>    | 10.60                        |                              | 10.4              |
| 68                           | Er <sup>3+</sup> | 11       | 3/2      | 6        | 15/2     | <sup>4</sup> I <sub>15/2</sub> | 9.59                         |                              | 9.5               |
| 69                           | Tm <sup>3+</sup> | 12       | 1        | 5        | 6        | <sup>3</sup> H <sub>6</sub>    | 7.57                         |                              | 7.3               |
| 70                           | Yb <sup>3+</sup> | 13       | 1/2      | 3        | 7/2      | <sup>2</sup> F <sub>7/2</sub>  | 4.54                         |                              | 4.5               |

<sup>a</sup>  $p_{\text{calc}} = 2[S(S+1)]^{1/2}$

<sup>b</sup>  $p_{\text{calc}} = 2[J(J+1)]^{1/2}$

<sup>c</sup>  $p_{\text{calc}} = g[J(J+1)]^{1/2}$

## References

1. Jiles, D., *Magnetism and Magnetic Materials*, Chapman & Hall, London, 1991, p. 243.
2. Kittel, C., *Introduction to Solid State Physics*, 6th Edition, J. Wiley & Sons, New York, 1986, pp. 405–406.
3. Ashcroft, N. W. and Mermin, N. D., *Solid State Physics*, Holt, Rinehart, and Winston, New York, 1976, p. 652.

**Ferro- and Antiferromagnetic Elements**

$M_0$  is the saturation magnetization at  $T = 0$  K  
 $n_B$  is the number of Bohr magnetons per atom

$T_C$  is the Curie temperature  
 $T_N$  is the Néel temperature

|    | $M_0/\text{gauss}$ | $n_B$ | $T_C/\text{K}$ | $T_N/\text{K}$ | Comments                                                    |
|----|--------------------|-------|----------------|----------------|-------------------------------------------------------------|
| Fe | 22020              | 2.22  | 1043           |                |                                                             |
| Co | 18170              | 1.72  | 1388           |                |                                                             |
| Ni | 6410               | 0.62  | 627            |                |                                                             |
| Cr |                    |       |                | 311            |                                                             |
| Mn |                    |       |                | 100            |                                                             |
| Ce |                    |       |                | 12.5           | <i>c</i> -Axis antiferromagnetic                            |
| Nd |                    |       |                | 19.2           | Basal plane modulation on hexagonal sites                   |
|    |                    |       |                | 7.8            | Cubic sites order (periodicity different from high-T phase) |
| Sm |                    |       |                | 106            | Ordering on hexagonal sites                                 |
|    |                    |       |                | 13.8           | Cubic site order                                            |
| Eu |                    |       |                | 90.5           | Spiral along cube axis                                      |
| Gd | 24880              | 7     | 293            |                |                                                             |
| Tb |                    | 9     | 220            |                | Basal plane ferromagnet                                     |
|    |                    |       |                | 230.2          | Basal plane spiral                                          |
| Dy |                    | 10    | 87             |                | Basal plane ferromagnet                                     |
|    |                    |       |                | 176            | Basal plane spiral                                          |
| Ho |                    | 10    | 20             |                | Bunched cone structure                                      |
|    |                    |       |                | 133            | Basal plane spiral                                          |
| Er |                    | 9     | 32             |                | <i>c</i> -Axis ferrimagnetic cone structure                 |
|    |                    |       |                | 80             | <i>c</i> -Axis modulated structure                          |
| Tm |                    | 7     | 32             |                | <i>c</i> -Axis ferrimagnetic cone structure                 |
|    |                    |       |                | 56             | <i>c</i> -Axis modulated structure                          |

**References**

1. Ashcroft, N. W., and Mermin, N. D., *Solid State Physics*, Holt, Rinehart, and Winston, New York, 1976, p.652.
2. Gschneidner, K. A., and Eyring, L., *Handbook on the Physics and Chemistry of Rare Earths*, North Holland Publishing Co., Amsterdam, 1978.

**Selected Ferromagnetic Compounds**

$M_0$  is the saturation magnetization at  $T = 293$  K

$T_C$  is the Curie temperature

| Compound          | $M_0/\text{gauss}$ | $T_C/\text{K}$ | Crystal system            |
|-------------------|--------------------|----------------|---------------------------|
| MnB               | 152                | 578            | orthorh(FeB)              |
| MnAs              | 670                | 318            | hex(FeB)                  |
| MnBi              | 620                | 630            | hex(FeB)                  |
| MnSb              | 710                | 587            | hex(FeB)                  |
| Mn <sub>4</sub> N | 183                | 743            |                           |
| MnSi              |                    | 34             | cub(FeSi)                 |
| CrTe              | 247                | 339            | hex(NiAs)                 |
| CrBr <sub>3</sub> | 270                | 37             | hex(BiI <sub>3</sub> )    |
| CrI <sub>3</sub>  |                    | 68             | hex(BiI <sub>3</sub> )    |
| CrO <sub>2</sub>  | 515                | 386            | tetr(TiO <sub>2</sub> )   |
| EuO               | 1910*              | 77             | cub                       |
| EuS               | 1184*              | 16.5           | cub                       |
| GdCl <sub>3</sub> | 550*               | 2.2            | orthorh                   |
| FeB               |                    | 598            | orthorh                   |
| Fe <sub>2</sub> B |                    | 1043           | tetr (CuAl <sub>2</sub> ) |
| FeBe <sub>5</sub> |                    | 75             | cub(MgCu <sub>2</sub> )   |
| Fe <sub>3</sub> C |                    | 483            | orthorh                   |
| FeP               |                    | 215            | orthorh (MnP)             |

\* At  $T = 0$  K

**References**

1. Kittel, C., *Introduction to Solid State Physics, 6th Edition*, J. Wiley & Sons, New York, 1986.
2. Ashcroft, N. W., and Mermin, N. D., *Solid State Physics*, Holt, Rinehart, and Winston, New York, 1976.

### Magnetic Properties of High-Permeability Metals and Alloys (Soft)

$\mu_i$  is the initial permeability

$\mu_m$  is the maximum permeability

$H_c$  is the coercive force

$J_s$  is the saturation polarization

$W_H$  is the hysteresis loss per cycle

$T_C$  is the Curie temperature

| Material                     | Composition (mass %) | $\mu_i/\mu_0$ | $\mu_m/\mu_0$ | $H_c/A\ m^{-1}$ | $J_s/T$ | $W_H/J\ m^{-3}$ | $T_C/K$ |
|------------------------------|----------------------|---------------|---------------|-----------------|---------|-----------------|---------|
| Iron                         | Commercial 99Fe      | 200           | 6000          | 70              | 2.16    | 500             | 1043    |
| Iron                         | Pure 99.9Fe          | 25000         | 350000        | 0.8             | 2.16    | 60              | 1043    |
| Silicon-iron                 | 96Fe-4Si             | 500           | 7000          | 40              | 1.95    | 50–150          | 1008    |
| Silicon-iron (110) [001]     | 97Fe-3Si             | 9000          | 40000         | 12              | 2.01    | 35–140          | 1015    |
| Silicon-iron {100} <100>     | 97Fe-3Si             |               | 100000        | 6               | 2.01    |                 | 1015    |
| Mild steel                   | Fe-0.1C-0.1Si-0.4Mn  | 800           | 1100          | 200             |         |                 |         |
| Hypernik                     | 50Fe-50Ni            | 4000          | 70000         | 4               | 1.60    | 22              | 753     |
| Deltamax {100} <100>         | 50Fe-50Ni            | 500           | 200000        | 16              | 1.55    |                 | 773     |
| Isoperm {100} <100>          | 50Fe-50Ni            | 90            | 100           | 480             | 1.60    |                 |         |
| 78 Permalloy                 | 78Ni-22Fe            | 4000          | 100000        | 4               | 1.05    | 50              | 651     |
| Supermalloy                  | 79Ni-16Fe-5Mo        | 100000        | 1000000       | 0.15            | 0.79    | 2               | 673     |
| Mumetal                      | 77Ni-16Fe-5Cu-2Cr    | 20000         | 100000        | 4               | 0.75    | 20              | 673     |
| Hyperco                      | 64Fe-35Co-0.5Cr      | 650           | 10000         | 80              | 2.42    | 300             | 1243    |
| Permendur                    | 50Fe-50Co            | 500           | 6000          | 160             | 2.46    | 1200            | 1253    |
| 2V-Permendur                 | 49Fe-49Co-2V         | 800           | 4000          | 160             | 2.45    | 600             | 1253    |
| Supermendur                  | 49Fe-49Co-2V         |               | 60000         | 16              | 2.40    | 1150            | 1253    |
| 25Perminvar                  | 45Ni-30Fe-25Co       | 400           | 2000          | 100             | 1.55    |                 |         |
| 7Perminvar                   | 70Ni-23Fe-7Co        | 850           | 4000          | 50              | 1.25    |                 |         |
| Perminvar (magnet. annealed) | 43Ni-34Fe-23Co       |               | 400000        | 2.4             | 1.50    |                 |         |
| Alfenol (or Alperm)          | 84Fe-16Al            | 3000          | 55000         | 3.2             | 0.8     |                 | 723     |
| Alfer                        | 87Fe-13Al            | 700           | 3700          | 53              | 1.20    |                 | 673     |
| Aluminum-Iron                | 96.5Fe-3.5Al         | 500           | 19000         | 24              | 1.90    |                 |         |
| Sendust                      | 85Fe-10Si-5Al        | 36000         | 120000        | 1.6             | 0.89    |                 | 753     |

### References

1. McCurrie, R. A., *Structure and Properties of Ferromagnetic Materials*, Academic Press, London, 1994, p. 42.

2. Gray, D. E., Ed., *American Institute of Physics Handbook, Third Edition*, McGraw Hill, New York, 1972, p. 5–224.

### Applications of High-Permeability Materials

#### Applications

#### Requirements

##### Power applications

Distribution and power transformers

Low core losses, high permeability, high saturation magnetic polarization

High-quality motors and generators, stators and armatures, switched-mode power supplies

##### Instrument transformers

Audiofrequency transformers

Low core losses, high permeability, high magnetic polarization

Pulse transformers

High permeability

##### Cores for inductor coils

Audiofrequency

Low hysteresis, high permeability

Carrier frequency

Very low hysteresis and eddy current loss

Radiofrequency

High permeability at low fields

##### Miscellaneous

Relays, switches  
Earth leakage circuit }

High permeability, low remanence, low coercivity

Magnetic shielding

Low core loss for AC applications

## Applications of High-Permeability Materials

| Applications                                                                                        | Requirements                                                                             |
|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Magnetic recording heads                                                                            | High initial permeability, low or zero remanence                                         |
| Magnetic amplifiers<br>Saturable reactors<br>Saturable transformers<br>Transformer cores            | Rectangular hysteresis loops, low hysteresis loss                                        |
| Magnetic shunts for temperature compensation in magnetic circuits                                   | Low Curie temperature, appropriate decrease in permeability with increase in temperature |
| Electromagnets in indicating instruments, fire detection, quartz watches, electromechanical devices | High permeability, high saturation magnetic polarization                                 |
| Magnetic yokes in permanent magnet devices, such as lifting and holding magnets, loudspeakers       | High permeability, high saturation magnetic polarization                                 |

## Reference

McCurrie, R. A., *Structure and Properties of Ferromagnetic Materials*, Academic Press, London, 1994. With permission.

## Saturation Magnetostriction of Selected Materials

The tabulated parameter  $\lambda_s$  is related to the fractional change in length  $\Delta l/l$  by  $\Delta l/l = (3/2)\lambda_s(\cos^2\theta - 1/3)$ , where  $\theta$  is the angle of rotation.

| Material                                                         | $\lambda_s \times 10^6$ |
|------------------------------------------------------------------|-------------------------|
| Iron                                                             | -7                      |
| Fe - 3.2% Si                                                     | +9                      |
| Nickel                                                           | -33                     |
| Cobalt                                                           | -62                     |
| 45 Permalloy, 45% Ni - 55% Fe                                    | +27                     |
| Permalloy, 82% Ni - 18% Fe                                       | 0                       |
| Permendur, 49% Co - 49% Fe - 2% V                                | +70                     |
| Alfer, 87% Fe - 13% Al                                           | +30                     |
| Magnetite, $\text{Fe}_3\text{O}_4$                               | +40                     |
| Cobalt ferrite, $\text{CoFe}_2\text{O}_4$                        | -110                    |
| $\text{SmFe}_2$                                                  | -1560                   |
| $\text{TbFe}_2$                                                  | +1753                   |
| $\text{Tb}_{0.3}\text{Dy}_{0.7}\text{Fe}_{1.93}$ (Terfenol D)    | +2000                   |
| $\text{Fe}_{66}\text{Co}_{18}\text{B}_{15}\text{Si}$ (amorphous) | +35                     |
| $\text{Co}_{72}\text{Fe}_3\text{B}_6\text{A}_{13}$ (amorphous)   | 0                       |

## Reference

McCurrie, R.A., *Structure and Properties of Ferromagnetic Materials*, Academic Press, London, 1994, p. 91; additional data provided by A.E. Clark, Adelphi, MD.

## Properties of Various Permanent Magnetic Materials (Hard)

$B_r$  is the remanence

$H_c$  is the flux coercivity

$H_i$  is the intrinsic coercivity

$(BH)_{\max}$  is the maximum energy product

$T_c$  is the Curie temperature

$T_{\max}$  is the maximum operating temperature

| Composition                         | $B_r/\text{T}$ | $H_c/10^3 \text{ A m}^{-1}$ | $H_i/10^3 \text{ A m}^{-1}$ | $(BH)_{\max}/\text{kJ m}^{-3}$ | $T_c/^\circ\text{C}$ | $T_{\max}/^\circ\text{C}$ |
|-------------------------------------|----------------|-----------------------------|-----------------------------|--------------------------------|----------------------|---------------------------|
| Alnico1 20Ni;12Al;5Co               | 0.72           |                             | 35                          | 25                             |                      |                           |
| Alnico2 17Ni;10Al;12.5Co;6Cu        | 0.72           |                             | 40-50                       | 13-14                          |                      |                           |
| Alnico3 24-30Ni;12-14Al;0-3Cu       | 0.5-0.6        |                             | 40-54                       | 10                             |                      |                           |
| Alnico4 21-28Ni;11-13Al;3-5Co;2-4Cu | 0.55-0.75      |                             | 36-56                       | 11-12                          |                      |                           |
| Alnico5 14Ni;8Al;24Co;3Cu           | 1.25           | 53                          | 54                          | 40                             | 850                  | 520                       |
| Alnico6 16Ni;8Al;24Co;3Cu;2Ti       | 1.05           |                             | 75                          | 52                             |                      |                           |
| Alnico8 15Ni;7Al;35Co;4Cu;5Ti       | 0.83           | 1.6                         | 160                         | 45                             |                      |                           |
| Alnico9 15Ni;7Al;35Co;4Cu;5Ti       | 1.10           | 1.45                        | 1.45                        | 75                             | 850                  | 520                       |
| Alnico12 13.5Ni;8Al;24.5Co;2Nb      | 1.20           |                             | 64                          | 76.8                           |                      |                           |



| Composition                                                                                     | $B_i/T$ | $\mu_r H_c/10^3 \text{ A m}^{-1}$ | $H_c/10^3 \text{ A m}^{-1}$ | $(BH)_{\max}/\text{kJ m}^{-3}$ | $T_c/^\circ\text{C}$ | $T_{\max}/^\circ\text{C}$ |
|-------------------------------------------------------------------------------------------------|---------|-----------------------------------|-----------------------------|--------------------------------|----------------------|---------------------------|
| BaFe <sub>12</sub> O <sub>19</sub> (Ferroxdur)                                                  | 0.4     | 1.6                               | 192                         | 29                             | 450                  | 400                       |
| SrFe <sub>12</sub> O <sub>19</sub>                                                              | 0.4     | 2.95                              | 3.3                         | 30                             | 450                  | 400                       |
| LaCo <sub>5</sub>                                                                               | 0.91    |                                   |                             | 164                            | 567                  |                           |
| CeCo <sub>5</sub>                                                                               | 0.77    |                                   |                             | 117                            | 380                  |                           |
| PrCo <sub>5</sub>                                                                               | 1.20    |                                   |                             | 286                            | 620                  |                           |
| NdCo <sub>5</sub>                                                                               | 1.22    |                                   |                             | 295                            | 637                  |                           |
| SmCo <sub>5</sub>                                                                               | 1.00    | 7.9                               | 696                         | 196                            | 700                  | 250                       |
| Sm(Co <sub>0.76</sub> Fe <sub>0.10</sub> Cu <sub>0.14</sub> ) <sub>6.8</sub>                    | 1.04    | 4.8                               | 5                           | 212                            | 800                  | 300                       |
| Sm(Co <sub>0.65</sub> Fe <sub>0.28</sub> Cu <sub>0.05</sub> Zr <sub>0.02</sub> ) <sub>7.7</sub> | 1.2     | 10                                | 16                          | 264                            | 800                  | 300                       |
| Nd <sub>2</sub> Fe <sub>14</sub> B sintered                                                     | 1.22    | 8.4                               | 1120                        | 280                            | 300                  | 100                       |
| Fe;52Co;14V (Vicalloy II)                                                                       | 1.0     | 42                                |                             | 28                             | 700                  | 500                       |
| Fe;24Cr;15Co;3Mo (anisotropic)                                                                  | 1.54    | 67                                |                             | 76                             | 630                  | 500                       |
| Fe;28Cr;10.5Co (Chromindur II)                                                                  | 0.98    | 32                                |                             | 16                             | 630                  | 500                       |
| Fe;23Cr;15Co;3V;2Ti                                                                             | 1.35    | 4                                 |                             | 44                             | 630                  | 500                       |
| Cu;20Ni;20Fe (Cunife)                                                                           | 0.55    | 4                                 |                             | 12                             | 410                  | 350                       |
| Cu;21Ni;29Fe (Cunico)                                                                           | 0.34    | 0.5                               |                             | 8                              |                      |                           |
| Pt;23Co                                                                                         | 0.64    | 4                                 |                             | 76                             | 480                  | 350                       |
| Mn;29.5Al;0.5C (anisotropic)                                                                    | 0.61    | 2.16                              | 2.4                         | 56                             | 300                  | 120                       |

## References

1. McCurrie, R. A., *Structure and Properties of Ferromagnetic Materials*, Academic Press, London, 1994, p. 204.
2. Gray, D. E., Ed., *American Institute of Physics Handbook, Third Edition*, McGraw Hill, New York, 1972, p. 5–165.
3. Jiles, D., *Magnetism and Magnetic Materials*, Chapman & Hall, London, 1991.

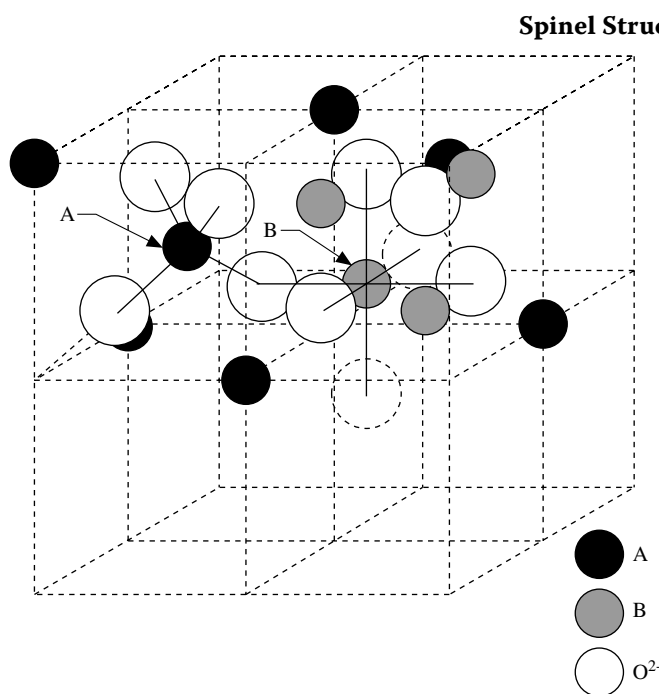
## Selected Ferrites

$J_s$  is the saturation magnetic polarization  
 $T_c$  is the Curie temperature  
 $\Delta H$  is the line width

| Material                                                                               | $J_s/T$ | $T_c/^\circ\text{C}$ | $\Delta H/\text{kA m}^{-1}$ | Applications                  |
|----------------------------------------------------------------------------------------|---------|----------------------|-----------------------------|-------------------------------|
| <b>Spinels</b>                                                                         |         |                      |                             |                               |
| $\gamma\text{-Fe}_2\text{O}_3$                                                         | 0.52    | 575                  |                             |                               |
| Fe <sub>3</sub> O <sub>4</sub>                                                         | 0.60    | 585                  |                             |                               |
| NiFe <sub>2</sub> O <sub>4</sub>                                                       | 0.34    | 575                  | 350                         | Microwave devices             |
| MgFe <sub>2</sub> O <sub>4</sub>                                                       | 0.14    | 440                  | 70                          |                               |
| NiZnFe <sub>2</sub> O <sub>4</sub>                                                     | 0.50    | 375                  | 120                         | Transformer cores             |
| MnFe <sub>2</sub> O <sub>4</sub>                                                       | 0.50    | 300                  | 50                          | Microwave devices             |
| NiCoFe <sub>2</sub> O <sub>4</sub>                                                     | 0.31    | 590                  | 140                         | Microwave devices             |
| NiCoAlFe <sub>2</sub> O <sub>4</sub>                                                   | 0.15    | 450                  | 330                         | Microwave devices             |
| NiAl <sub>0.35</sub> Fe <sub>1.65</sub> O <sub>4</sub>                                 | 0.12    | 430                  | 67                          | Microwave devices             |
| NiAlFe <sub>2</sub> O <sub>4</sub>                                                     | 0.05    | 1860                 | 32                          | Microwave devices             |
| Mg <sub>0.9</sub> Mn <sub>0.1</sub> Fe <sub>2</sub> O <sub>4</sub>                     | 0.25    | 290                  | 56                          | Microwave devices             |
| Ni <sub>0.5</sub> Zn <sub>0.5</sub> Al <sub>0.8</sub> Fe <sub>1.2</sub> O <sub>4</sub> | 0.14    |                      | 17                          | Microwave devices             |
| CuFe <sub>2</sub> O <sub>4</sub>                                                       | 0.17    | 455                  |                             | Electromechanical transducers |
| CoFe <sub>2</sub> O <sub>4</sub>                                                       | 0.53    | 520                  |                             |                               |
| LiFe <sub>5</sub> O <sub>8</sub>                                                       | 0.39    | 670                  |                             | Microwave devices             |
| <b>Garnets</b>                                                                         |         |                      |                             |                               |
| Y <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub>                                         | 0.178   | 280                  | 55                          | Microwave devices             |
| Y <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub> (single crys.)                          | 0.178   | 292                  | 0.5                         | Microwave devices             |
| (Y,Al) <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub>                                    | 0.12    | 250                  | 80                          | Microwave devices             |
| (Y,Gd) <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub>                                    | 0.06    | 250                  | 150                         | Microwave devices             |
| Sm <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub>                                        | 0.170   | 305                  |                             | Microwave devices             |
| Eu <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub>                                        | 0.116   | 293                  |                             | Microwave devices             |
| GdFe <sub>5</sub> O <sub>12</sub>                                                      | 0.017   | 291                  |                             | Microwave devices             |
| <b>Hexagonal crystals</b>                                                              |         |                      |                             |                               |
| BaFe <sub>12</sub> O <sub>19</sub>                                                     | 0.45    | 430                  | 1.5                         | Permanent magnets             |
| Ba <sub>3</sub> Co <sub>2</sub> Fe <sub>24</sub> O <sub>41</sub>                       | 0.34    | 470                  | 12                          | Microwave devices             |
| Ba <sub>2</sub> Zn <sub>2</sub> Fe <sub>12</sub> O <sub>22</sub>                       | 0.28    | 130                  | 25                          | Microwave devices             |
| Ba <sub>3</sub> Co <sub>1.35</sub> Zn <sub>0.65</sub> Fe <sub>24</sub> O <sub>41</sub> |         | 390                  | 16                          | Microwave devices             |
| Ba <sub>2</sub> Ni <sub>2</sub> Fe <sub>12</sub> O <sub>22</sub>                       | 0.16    | 500                  | 8                           | Microwave devices             |
| SrFe <sub>12</sub> O <sub>19</sub>                                                     | 0.4     | 450                  |                             | Permanent magnets             |

## Reference

McCurrie, R. A., *Structure and Properties of Ferromagnetic Materials*, Academic Press, London, 1994.



**FIGURE 4.** Arrangement of metal ions in the two octants A and B, showing tetrahedrally (A) and octahedrally (B) coordinated sites. (Reprinted from McCurrie, R.A., *Ferromagnetic Materials*, Academic Press, London, 1994. With permission.)

### Selected Antiferromagnetic Solids

$T_N$  is the Néel temperature

| Material                         | Structure | $T_N/K$ | Material                                     | Structure | $T_N/K$ |
|----------------------------------|-----------|---------|----------------------------------------------|-----------|---------|
| <b>Binary oxides</b>             |           |         | $ZnCr_2O_4$                                  | cub       | 15      |
| MnO                              | cub(fcc)  | 122     | $ZnFe_2O_4$                                  | cub       | 9       |
| FeO                              | cub(fcc)  | 198     | $GeFe_2O_4$                                  | cub       | 10      |
| CoO                              | cub(fcc)  | 291     | $MgV_2O_4$                                   | cub       | 45      |
| NiO                              | cub(fcc)  | 525     | $MnGa_2O_4$                                  | cub       | 33      |
| $\alpha$ - $Mn_2O_3$             | cub       | 90      | <b>NiAs and related structures</b>           |           |         |
| CuO                              | monocl    | 230     | CrAs                                         | orth      | 300     |
| UO <sub>2</sub>                  | cub       | 30.8    | CrSb                                         | hex       | 705–723 |
| Er <sub>2</sub> O <sub>3</sub>   | cub       | 3.4     | CrSe                                         | hex       | 300     |
| Gd <sub>2</sub> O <sub>3</sub>   | cub       | 1.6     | MnTe                                         | hex       | 320–323 |
| <b>Perovskites</b>               |           |         | NiS                                          | hex       | 263     |
| LaCrO <sub>3</sub>               | orth      | 282     | CrS                                          | monocl    | 460     |
| LaMnO <sub>3</sub>               | orth      | 100     | <b>Rutile and related structures</b>         |           |         |
| LaFeO <sub>3</sub>               | orth      | 750     | CoF <sub>2</sub>                             | tetr      | 38      |
| NdCrO <sub>3</sub>               | orth      | 224     | CrF <sub>2</sub>                             | monocl    | 53      |
| NdFeO <sub>3</sub>               | orth      | 760     | FeF <sub>2</sub>                             | tetr      | 79      |
| YbCrO <sub>3</sub>               | orth      | 118     | MnF <sub>2</sub>                             | tetr      | 67      |
| CaMnO <sub>3</sub>               | cub       | 110     | NiF <sub>2</sub>                             | tetr      | 83      |
| EuTiO <sub>3</sub>               | cub       | 5.3     | CrCl <sub>2</sub>                            | orth      | 20      |
| YCrO <sub>3</sub>                | orth      | 141     | MnO <sub>2</sub>                             | tetr      | 84      |
| BiFeO <sub>3</sub>               | cub*      | 673     | FeOF                                         | tetr      | 315     |
| KCoF <sub>3</sub>                | cub       | 125     | <b>Corundum and related structures</b>       |           |         |
| KMnF <sub>3</sub>                | cub*      | 88.3    | Cr <sub>2</sub> O <sub>3</sub>               | rhomb     | 318     |
| KFeF <sub>3</sub>                | cub       | 115     | $\alpha$ -Fe <sub>2</sub> O <sub>3</sub>     | rhomb     | 948     |
| KNiF <sub>3</sub>                | cub       | 275     | FeTiO <sub>3</sub>                           | rhomb     | 68      |
| NaMnF <sub>3</sub>               | cub*      | 60      | MnTiO <sub>3</sub>                           | rhomb     | 41      |
| NaNiF <sub>3</sub>               | orth      | 149     | CoTiO <sub>3</sub>                           | rhomb     | 38      |
| RbMnF <sub>3</sub>               | cub       | 82      | <b>VF<sub>3</sub> and related structures</b> |           |         |
| Spinel                           |           |         | CoF <sub>3</sub>                             | rhomb     | 460     |
| Co <sub>3</sub> O <sub>4</sub>   | cub       | 40      | CrF <sub>3</sub>                             | rhomb     | 80      |
| NiCr <sub>2</sub> O <sub>4</sub> | tetr      | 65      |                                              |           |         |

| Material                         | Structure | $T_N/K$ |
|----------------------------------|-----------|---------|
| FeF <sub>3</sub>                 | rhomb     | 394     |
| MnF <sub>3</sub>                 | monocl    | 43      |
| MoF <sub>3</sub>                 | rhomb     | 185     |
| <i>Miscellaneous</i>             |           |         |
| K <sub>2</sub> NiF <sub>4</sub>  | tetr      | 97      |
| MnI <sub>2</sub>                 | hex       | 3.4     |
| CoUO <sub>4</sub>                | orth      | 12      |
| CaMn <sub>2</sub> O <sub>4</sub> | orth      | 225     |
| CrN                              | cub*      | 273     |
| CeC <sub>2</sub>                 | tetr      | 33      |
| FeSn                             | hex       | 373     |
| Mn <sub>2</sub> P                | hex       | 103     |

\* Distorted.

## References

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# ELECTRON WORK FUNCTION OF THE ELEMENTS

The electron work function  $\Phi$  is a measure of the minimum energy required to extract an electron from the surface of a solid. It is defined more precisely as the energy difference between the state in which an electron has been removed to a distance from the surface of a single crystal face that is large enough that the image force is negligible but small compared to the distance to any other face (typically about  $10^{-4}$  cm) and the state in which the electron is in the bulk solid. In general,  $\Phi$  differs for each face of a mono-crystalline sample.

Since  $\Phi$  is dependent on the cleanliness of the surface, measurements reported in the literature often cover a considerable range. This table contains selected values for the electron work function of the elements which may be regarded as typical values for a reasonably clean surface. The method of measurement is indicated for each value. The following abbreviations appear:

TE – Thermionic emission  
PE – Photoelectric effect  
FE – Field emission  
CPD – Contact potential difference  
polycr – Polycrystalline sample  
amorp – Amorphous sample

Values in parentheses are only approximate.

## References

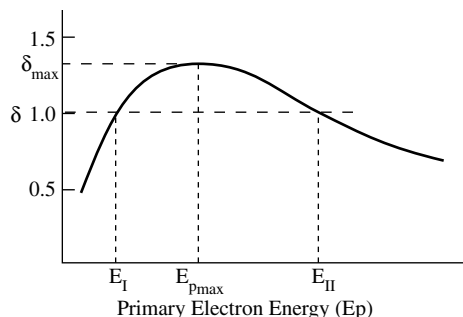
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2. Riviere, J. C., Work Function: Measurements and Results, in *Solid State Surface Science, Vol.1*, Green, M., Ed., Decker, New York, 1969.
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| Element | Plane  | Φ/eV   | Method | Element | Plane  | Φ/eV   | Method | Element | Plane  | Φ/eV   | Method |
|---------|--------|--------|--------|---------|--------|--------|--------|---------|--------|--------|--------|
| Ag      | 100    | 4.64   | PE     | K       | 210    | 5.00   | PE     | Ru      | polycr | 4.71   | PE     |
|         | 110    | 4.52   | PE     |         | polycr | 2.29   | PE     | Sb      | amorp  | 4.55   |        |
|         | 111    | 4.74   | PE     |         | La     | polycr | 3.5    | PE      | 100    | 4.7    |        |
| Al      | 100    | 4.20   | PE     | Li      | polycr | 2.93   | FE     | Sc      | polycr | 3.5    | PE     |
|         | 110    | 4.06   | PE     | Lu      | polycr | (3.3)  | CPD    | Se      | polycr | 5.9    | PE     |
|         | 111    | 4.26   | PE     | Mg      | polycr | 3.66   | PE     | Si      | n      | 4.85   | CPD    |
| As      | polycr | (3.75) | PE     | Mn      | polycr | 4.1    | PE     |         | p 100  | (4.91) | CPD    |
| Au      | 100    | 5.47   | PE     | Mo      | 100    | 4.53   | PE     |         | p 111  | 4.60   | PE     |
|         | 110    | 5.37   | PE     |         | 110    | 4.95   | PE     | Sm      | polycr | 2.7    | PE     |
|         | 111    | 5.31   | PE     |         | 111    | 4.55   | PE     | Sn      | polycr | 4.42   | CPD    |
| B       | polycr | (4.45) | TH     |         | 112    | 4.36   | PE     | Sr      | polycr | (2.59) | TH     |
| Ba      | polycr | 2.52   | TH     |         | 114    | 4.50   | PE     | Ta      | polycr | 4.25   | TH     |
| Be      | polycr | 4.98   | PE     |         | 332    | 4.55   | PE     |         | 100    | 4.15   | TH     |
| Bi      | polycr | 4.34   | PE     | Na      | polycr | 2.36   | PE     |         | 110    | 4.80   | TH     |
| C       | polycr | (5.0)  | CPD    | Nb      | 001    | 4.02   | TH     |         | 111    | 4.00   | TH     |
| Ca      | polycr | 2.87   | PE     |         | 110    | 4.87   | TH     | Tb      | polycr | 3.0    | PE     |
| Cd      | polycr | 4.08   | CPD    |         | 111    | 4.36   | TH     | Te      | polycr | 4.95   | PE     |
| Ce      | polycr | 2.9    | PE     |         | 112    | 4.63   | TH     | Th      | polycr | 3.4    | TH     |
| Co      | polycr | 5.0    | PE     |         | 113    | 4.29   | TH     | Ti      | polycr | 4.33   | PE     |
| Cr      | polycr | 4.5    | PE     |         | 116    | 3.95   | TH     | Tl      | polycr | (3.84) | CPD    |
| Cs      | polycr | 1.95   | PE     |         | 310    | 4.18   | TH     | U       | polycr | 3.63   | PE     |
| Cu      | 100    | 5.10   | FE     | Nd      | polycr | 3.2    | PE     | 100     | 3.73   | PE     |        |
|         | 110    | 4.48   | PE     |         | Ni     | 100    | 5.22   | PE      | 110    | 3.90   | PE     |
|         | 111    | 4.94   | PE     |         |        | 110    | 5.04   | PE      | 113    | 3.67   | PE     |
|         | 112    | 4.53   | PE     |         | 111    | 5.35   | PE     | V       | polycr | 4.3    | PE     |
| Eu      | polycr | 2.5    | PE     | Os      | polycr | 5.93   | PE     | W       | polycr | 4.55   | CPD    |
| Fe      | 100    | 4.67   | PE     | Pb      | polycr | 4.25   | PE     | 100     | 4.63   | FE     |        |
|         | 111    | 4.81   | PE     | Pd      | polycr | 5.22   | PE     | 110     | 5.22   | FE     |        |
| Ga      | polycr | 4.32   | PE     |         | 111    | 5.6    | PE     | 111     | 4.45   | FE     |        |
| Gd      | polycr | 2.90   | CPD    | Pt      | polycr | 5.64   | PE     | 113     | 4.46   | FE     |        |
| Ge      | polycr | 5.0    | CPD    |         | 110    | 5.84   | FE     | 116     | 4.32   | TH     |        |
| Hf      | polycr | 3.9    | PE     |         | 111    | 5.93   | FE     | Y       | polycr | 3.1    | PE     |
| Hg      | liquid | 4.475  | PE     |         | 320    | 5.22   | FE     | Zn      | polycr | 3.63   | PE     |
| In      | polycr | 4.09   | PE     |         | 331    | 5.12   | FE     |         | polycr | (4.9)  | CPD    |
| Ir      | 100    | 5.67   | PE     | Rb      | polycr | 2.261  | PE     | Zr      | polycr | 4.05   | PE     |
|         | 110    | 5.42   | PE     | Re      | polycr | 4.72   | TE     |         |        |        |        |
|         | 111    | 5.76   | PE     | Rh      | polycr | 4.98   | PE     |         |        |        |        |

## SECONDARY ELECTRON EMISSION

The secondary emission yield, or secondary emission ratio,  $\delta$ , is the average number of secondary electrons emitted from a bombarded material for every incident primary electron. It is a function of the primary electron energy  $E_p$ . The maximum yield  $\delta_{\max}$  corresponds to a primary electron energy  $E_{p\max}$  (see figure). The two primary electron energies corresponding to a yield of unity are denoted the first and second crossovers ( $E_I$  and  $E_{II}$ ). An insulat-

ing target, or a conducting target that is electrically floating, will charge positively or negatively depending on the primary electron energy. For  $E_I < E_p < E_{II}$ ,  $\delta > 1$  and the surface charges positively provided there is a collector present that is positive with respect to the target. For  $E_p < E_I$  or  $E_p > E_{II}$ ,  $\delta < 1$ , and the surface charges negatively with respect to the potential of the source of primary electrons.



| Element      | $\delta_{\max}$ | $E_{p\max}$ (eV) | $E_I$ (eV) | $E_{II}$ (eV) | Element | $\delta_{\max}$ | $E_{p\max}$ (eV) | $E_I$ (eV) | $E_{II}$ (eV) |
|--------------|-----------------|------------------|------------|---------------|---------|-----------------|------------------|------------|---------------|
| Ag           | 1.5             | 800              | 200        | >2000         | Li      | 0.5             | 85               | None       | None          |
| Al           | 1.0             | 300              | 300        | 300           | Mg      | 0.95            | 300              | None       | None          |
| Au           | 1.4             | 800              | 150        | >2000         | Mo      | 1.25            | 375              | 150        | 1200          |
| B            | 1.2             | 150              | 50         | 600           | Na      | 0.82            | 300              | None       | None          |
| Ba           | 0.8             | 400              | None       | None          | Nb      | 1.2             | 375              | 150        | 1050          |
| Bi           | 1.2             | 550              | None       | None          | Ni      | 1.3             | 550              | 150        | >1500         |
| Be           | 0.5             | 200              | None       | None          | Pb      | 1.1             | 500              | 250        | 1000          |
| C (diamond)  | 2.8             | 750              | None       | >5000         | Pd      | >1.3            | >250             | 120        | None          |
| C (graphite) | 1.0             | 300              | 300        | 300           | Pt      | 1.8             | 700              | 350        | 3000          |
| C (soot)     | 0.45            | 500              | None       | None          | Rb      | 0.9             | 350              | None       | None          |
| Cd           | 1.1             | 450              | 300        | 700           | Sb      | 1.3             | 600              | 250        | 2000          |
| Co           | 1.2             | 600              | 200        | None          | Si      | 1.1             | 250              | 125        | 500           |
| Cs           | 0.7             | 400              | None       | None          | Sn      | 1.35            | 500              | None       | None          |
| Cu           | 1.3             | 600              | 200        | 1500          | Ta      | 1.3             | 600              | 250        | >2000         |
| Fe           | 1.3             | 400              | 120        | 1400          | Th      | 1.1             | 800              | None       | None          |
| Ga           | 1.55            | 500              | 75         | None          | Ti      | 0.9             | 280              | None       | None          |
| Ge           | 1.15            | 500              | 150        | 900           | Tl      | 1.7             | 650              | 70         | >1500         |
| Hg           | 1.3             | 600              | 350        | >1200         | W       | 1.4             | 650              | 250        | >1500         |
| K            | 0.7             | 200              | None       | None          | Zr      | 1.1             | 350              | None       | None          |

| Compound                               | $\delta_{\max}$ | $E_{p\max}$ (eV) | Compound                  | $\delta_{\max}$ | $E_{p\max}$ (eV) |
|----------------------------------------|-----------------|------------------|---------------------------|-----------------|------------------|
| Alkali halides                         |                 |                  | BeO                       | 3.4             | 2000             |
| CsCl                                   | 6.5             |                  | CaO                       | 2.2             | 500              |
| KBr (crystal)                          | 14              | 1800             | Cu <sub>2</sub> O         | 1.2             | 400              |
| KCl (crystal)                          | 12              | 1600             | MgO (crystal)             | 20–25           | 1500             |
| KCl (layer)                            | 7.5             | 1200             | MgO (layer)               | 3–15            | 400–1500         |
| KI (crystal)                           | 10              | 1600             | MoO <sub>2</sub>          | 1.2             |                  |
| KI (layer)                             | 5.6             |                  | SiO <sub>2</sub> (quartz) | 2.1–4           | 400              |
| LiF (crystal)                          | 8.5             |                  | SnO <sub>2</sub>          | 3.2             | 640              |
| LiF (layer)                            | 5.6             | 700              | Sulfides                  |                 |                  |
| NaBr (crystal)                         | 24              | 1800             | MoS <sub>2</sub>          | 1.1             |                  |
| NaBr (layer)                           | 6.3             |                  | PbS                       | 1.2             | 500              |
| NaCl (crystal)                         | 14              | 1200             | WS <sub>2</sub>           | 1.0             |                  |
| NaCl (layer)                           | 6.8             | 600              | ZnS                       | 1.8             | 350              |
| NaF (crystal)                          | 14              | 1200             | Others                    |                 |                  |
| NaF (layer)                            | 5.7             |                  | BaF <sub>2</sub> (layer)  | 4.5             |                  |
| NaI (crystal)                          | 19              | 1300             | CaF <sub>2</sub> (layer)  | 3.2             |                  |
| NaI (layer)                            | 5.5             |                  | BiCs <sub>3</sub>         | 6               | 1000             |
| RbCl (layer)                           | 5.8             |                  | BiCs                      | 1.9             | 1000             |
| Oxides                                 |                 |                  | GeCs                      | 7               | 700              |
| Ag <sub>2</sub> O                      | 1.0             |                  | Rb <sub>2</sub> Sb        | 7.1             | 450              |
| Al <sub>2</sub> O <sub>3</sub> (layer) | 2–9             |                  | SbCs <sub>3</sub>         | 6               | 700              |
| BaO (layer)                            | 2.3–4.8         | 400              | Mica                      | 2.4             | 350              |
|                                        |                 |                  | Glasses                   | 2–3             | 300–450          |

# OPTICAL PROPERTIES OF SELECTED ELEMENTS

J. H. Weaver and H. P. R. Frederikse

These tables list the index of refraction  $n$ , the extinction coefficient  $k$ , and the normal incidence reflection  $R$  ( $\phi = 0$ ) as a function of photon energy  $E$ , which is expressed in electron volts (eV). To convert the energy in eV to the wavelength in  $\mu\text{m}$ , use  $\lambda = 1.2398/E$ . To compute the dielectric function  $\tilde{\epsilon} = \epsilon_1 + i\epsilon_2$  from the complex index of refraction  $\tilde{N} = n + ik$ , use  $\epsilon_1 = n^2 - k^2$  and  $\epsilon_2 = 2nk$ .

The optical constants in these tables are abridged from three more extensive tabulations:

- *Optical Properties of Metals* (OPM), Volumes I and II, *Physics Data*, Nr. 18-1 and 18-2, J. H. Weaver, C. Krafka, D. W. Lynch, and E. E. Koch, Fachinformationzentrum, Karlsruhe, Germany.
- *Handbook of Optical Constants* (HOC), Vol. I, 1985, and Vol. II, 1991. E. D. Palik, Ed., Academic Press, Inc., London.
- *American Institute of Physics Handbook* (AIPH), 3rd Edition, D. E. Gray, Ed., McGraw-Hill, New York, 1972.

The first two of these major sources provide detailed comparisons of all optical data available in the literature at the time of the compilation. For critical applications the reader should refer to the original work. References for individual metals and semiconduc-

tors are listed at the end of the tables. Generally, tabulated values for the optical properties are accurate to better than 10%. Data in parentheses are extrapolated or interpolated values. For most elements the spectral range covered is from the far infrared (0.010 or 0.10 eV) to the far ultraviolet (10, 30 or 300 eV). The intervals between successive energies in the tables are chosen in such a way that the major spectral features are preserved.

Very small values of  $k$  are expressed in exponential notation, e.g., 1.23E-5 means  $1.23 \times 10^{-5}$ .

The following table is convenient for associating the energy entries in these tables with the corresponding wavelengths:

| $\lambda$         | E/eV    | $\lambda$ | E/eV   |
|-------------------|---------|-----------|--------|
| 1 mm              | 0.00124 | 6000 Å    | 2.066  |
| 500 $\mu\text{m}$ | 0.00248 | 5000 Å    | 2.480  |
| 100 $\mu\text{m}$ | 0.01240 | 4000 Å    | 3.100  |
| 50 $\mu\text{m}$  | 0.02480 | 3000 Å    | 4.133  |
| 10 $\mu\text{m}$  | 0.12398 | 2000 Å    | 6.199  |
| 5 $\mu\text{m}$   | 0.24797 | 1000 Å    | 12.398 |
| 1 $\mu\text{m}$   | 1.240   | 400 Å     | 30.996 |

| Energy<br>(eV)   | $n$    | $k$     | $R(\phi = 0)$ | Energy<br>(eV) | $n$   | $k$   | $R(\phi = 0)$ | Energy<br>(eV) | $n$   | $k$   | $R(\phi = 0)$ |
|------------------|--------|---------|---------------|----------------|-------|-------|---------------|----------------|-------|-------|---------------|
| <i>Aluminum'</i> |        |         |               | 2.200          | 1.018 | 6.846 | 0.9200        | 14.400         | 0.058 | 0.327 | 0.8102        |
| 0.040            | 98.595 | 203.701 | 0.9923        | 2.400          | 0.826 | 6.283 | 0.9228        | 14.600         | 0.067 | 0.273 | 0.7802        |
| 0.050            | 74.997 | 172.199 | 0.9915        | 2.600          | 0.695 | 5.800 | 0.9238        | 14.800         | 0.086 | 0.211 | 0.7202        |
| 0.060            | 62.852 | 150.799 | 0.9906        | 2.800          | 0.598 | 5.385 | 0.9242        | 15.000         | 0.125 | 0.153 | 0.6119        |
| 0.070            | 53.790 | 135.500 | 0.9899        | 3.000          | 0.523 | 5.024 | 0.9241        | 15.200         | 0.178 | 0.108 | 0.4903        |
| 0.080            | 45.784 | 123.734 | 0.9895        | 3.200          | 0.460 | 4.708 | 0.9243        | 15.400         | 0.234 | 0.184 | 0.3881        |
| 0.090            | 39.651 | 114.102 | 0.9892        | 3.400          | 0.407 | 4.426 | 0.9245        | 15.600         | 0.280 | 0.073 | 0.3182        |
| 0.100            | 34.464 | 105.600 | 0.9889        | 3.600          | 0.363 | 4.174 | 0.9246        | 15.800         | 0.318 | 0.065 | 0.2694        |
| 0.125            | 24.965 | 89.250  | 0.9884        | 3.800          | 0.326 | 3.946 | 0.9247        | 16.000         | 0.351 | 0.060 | 0.2326        |
| 0.150            | 18.572 | 76.960  | 0.9882        | 4.000          | 0.294 | 3.740 | 0.9248        | 16.200         | 0.380 | 0.055 | 0.2031        |
| 0.175            | 14.274 | 66.930  | 0.9879        | 4.200          | 0.267 | 3.552 | 0.9248        | 16.400         | 0.407 | 0.050 | 0.1789        |
| 0.200            | 11.733 | 59.370  | 0.9873        | 4.400          | 0.244 | 3.380 | 0.9249        | 16.750         | 0.448 | 0.045 | 0.1460        |
| 0.250            | 8.586  | 48.235  | 0.9858        | 4.600          | 0.223 | 3.222 | 0.9249        | 17.000         | 0.474 | 0.042 | 0.1278        |
| 0.300            | 6.759  | 40.960  | 0.9844        | 4.800          | 0.205 | 3.076 | 0.9249        | 17.250         | 0.498 | 0.040 | 0.1129        |
| 0.350            | 5.438  | 35.599  | 0.9834        | 5.000          | 0.190 | 2.942 | 0.9244        | 17.500         | 0.520 | 0.038 | 0.1005        |
| 0.400            | 4.454  | 31.485  | 0.9826        | 6.000          | 0.130 | 2.391 | 0.9257        | 17.750         | 0.540 | 0.036 | 0.0899        |
| 0.500            | 3.072  | 25.581  | 0.9817        | 6.500          | 0.110 | 2.173 | 0.9260        | 18.000         | 0.558 | 0.035 | 0.0809        |
| 0.600            | 2.273  | 21.403  | 0.9806        | 7.000          | 0.095 | 1.983 | 0.9262        | 18.500         | 0.591 | 0.032 | 0.0664        |
| 0.700            | 1.770  | 18.328  | 0.9794        | 7.500          | 0.082 | 1.814 | 0.9265        | 19.000         | 0.620 | 0.030 | 0.0554        |
| 0.800            | 1.444  | 15.955  | 0.9778        | 8.000          | 0.072 | 1.663 | 0.9269        | 19.500         | 0.646 | 0.028 | 0.0467        |
| 0.900            | 1.264  | 14.021  | 0.9749        | 8.500          | 0.063 | 1.527 | 0.9272        | 20.000         | 0.668 | 0.027 | 0.0398        |
| 1.000            | 1.212  | 12.464  | 0.9697        | 9.000          | 0.056 | 1.402 | 0.9277        | 20.500         | 0.689 | 0.025 | 0.0342        |
| 1.100            | 1.201  | 11.181  | 0.9630        | 9.500          | 0.049 | 1.286 | 0.9282        | 21.000         | 0.707 | 0.024 | 0.0296        |
| 1.200            | 1.260  | 10.010  | 0.9521        | 10.000         | 0.044 | 1.178 | 0.9286        | 21.500         | 0.724 | 0.023 | 0.0258        |
| 1.300            | 1.468  | 8.949   | 0.9318        | 10.500         | 0.040 | 1.076 | 0.9293        | 22.000         | 0.739 | 0.022 | 0.0226        |
| 1.400            | 2.237  | 8.212   | 0.8852        | 11.000         | 0.036 | 0.979 | 0.9298        | 22.500         | 0.753 | 0.021 | 0.0199        |
| 1.500            | 2.745  | 8.309   | 0.8678        | 11.500         | 0.033 | 0.883 | 0.9283        | 23.000         | 0.766 | 0.021 | 0.0177        |
| 1.600            | 2.625  | 8.597   | 0.8794        | 12.000         | 0.033 | 0.791 | 0.9224        | 23.500         | 0.778 | 0.020 | 0.0157        |
| 1.700            | 2.143  | 8.573   | 0.8972        | 12.500         | 0.034 | 0.700 | 0.9118        | 24.000         | 0.789 | 0.019 | 0.0140        |
| 1.800            | 1.741  | 8.205   | 0.9069        | 13.000         | 0.038 | 0.609 | 0.8960        | 24.500         | 0.799 | 0.018 | 0.0126        |
| 1.900            | 1.488  | 7.821   | 0.9116        | 13.500         | 0.041 | 0.517 | 0.8789        | 25.000         | 0.809 | 0.018 | 0.0113        |
| 2.000            | 1.304  | 7.479   | 0.9148        | 14.000         | 0.048 | 0.417 | 0.8486        | 25.500         | 0.817 | 0.017 | 0.0102        |
|                  |        |         |               | 14.200         | 0.053 | 0.373 | 0.8312        | 26.000         | 0.826 | 0.016 | 0.0092        |

| Energy<br>(eV)                      | $n$    | $k$      | $R(\phi = 0)$ | Energy<br>(eV) | $n$    | $k$      | $R(\phi = 0)$ | Energy<br>(eV)                         | $n$   | $k$   | $R(\phi = 0)$ |
|-------------------------------------|--------|----------|---------------|----------------|--------|----------|---------------|----------------------------------------|-------|-------|---------------|
| 27.000                              | 0.840  | 0.015    | 0.0076        | 0.36           |        | 2.47E-05 |               | 7.30                                   | 3.376 | 0.473 | 0.303         |
| 28.000                              | 0.854  | 0.014    | 0.0063        | 0.37           |        | 2.80E-05 |               | 7.40                                   | 3.335 | 0.515 | 0.300         |
| 29.000                              | 0.865  | 0.014    | 0.0053        | 0.38           |        | 3.11E-05 |               | 7.50                                   | 3.321 | 0.533 | 0.299         |
| 30.000                              | 0.876  | 0.013    | 0.0044        | 0.39           |        | 3.67E-05 |               | 7.60                                   | 3.306 | 0.592 | 0.300         |
| 35.000                              | 0.915  | 0.010    | 0.0020        | 0.40           |        | 3.58E-05 |               | 7.80                                   | 3.276 | 0.659 | 0.300         |
| 40.000                              | 0.940  | 0.008    | 0.0010        | 0.41           |        | 3.25E-05 |               | 8.00                                   | 3.251 | 0.712 | 0.300         |
| 45.000                              | 0.957  | 0.007    | 0.0005        | 0.4133         | 2.3795 |          | 0.167         | 8.25                                   | 3.232 | 0.765 | 0.301         |
| 50.000                              | 0.969  | 0.006    | 0.0003        | 0.42           |        | 2.94E-05 |               | 8.50                                   | 3.228 | 0.806 | 0.303         |
| 55.000                              | 0.979  | 0.005    | 0.0001        | 0.43           |        | 2.87E-05 |               | 8.75                                   | 3.247 | 0.855 | 0.308         |
| 60.000                              | 0.987  | 0.004    | 0.0000        | 0.44           |        | 3.14E-05 |               | 9.00                                   | 3.272 | 0.910 | 0.314         |
| 65.000                              | 0.995  | 0.004    | 0.0000        | 0.45           |        | 3.62E-05 |               | 9.25                                   | 3.308 | 0.978 | 0.322         |
| 70.000                              | 1.006  | 0.004    | 0.0000        | 0.46           |        | 3.22E-05 |               | 9.50                                   | 3.348 | 1.055 | 0.331         |
| 72.500                              | 1.025  | 0.004    | 0.0002        | 0.47           |        | 1.57E-05 |               | 9.75                                   | 3.398 | 1.147 | 0.342         |
| 75.000                              | 1.011  | 0.024    | 0.0002        | 0.48           |        | 6.17E-06 |               | 10.00                                  | 3.453 | 1.258 | 0.355         |
| 77.500                              | 1.008  | 0.025    | 0.0002        | 0.4959         | 2.3801 |          | 0.167         | 10.25                                  | 3.514 | 1.403 | 0.371         |
| 80.000                              | 1.007  | 0.024    | 0.0002        | 0.6199         | 2.3813 |          | 0.167         | 10.50                                  | 3.565 | 1.581 | 0.389         |
| 85.000                              | 1.007  | 0.028    | 0.0002        | 0.8266         | 2.3837 |          | 0.167         | 10.75                                  | 3.600 | 1.813 | 0.411         |
| 90.000                              | 1.005  | 0.031    | 0.0002        | 1.240          | 2.3905 |          | 0.168         | 11.00                                  | 3.582 | 2.078 | 0.434         |
| 95.000                              | 0.999  | 0.036    | 0.0003        | 1.378          | 2.3934 |          | 0.169         | 11.25                                  | 3.507 | 2.380 | 0.460         |
| 100.000                             | 0.991  | 0.030    | 0.0002        | 1.459          | 2.3953 |          | 0.169         | 11.50                                  | 3.346 | 2.693 | 0.488         |
| 110.000                             | 0.994  | 0.025    | 0.0002        | 1.550          | 2.3975 |          | 0.169         | 11.75                                  | 3.090 | 2.986 | 0.518         |
| 120.000                             | 0.991  | 0.024    | 0.0002        | 1.653          | 2.4003 |          | 0.170         | 12.00                                  | 2.736 | 3.228 | 0.551         |
| 130.000                             | 0.987  | 0.021    | 0.0001        | 1.771          | 2.4036 |          | 0.170         | 12.20                                  | 2.383 | 3.354 | 0.580         |
| 140.000                             | 0.989  | 0.016    | 0.0001        | 1.889          | 2.4073 |          | 0.171         | 12.40                                  | 1.983 | 3.382 | 0.610         |
| 150.000                             | 0.990  | 0.015    | 0.0001        | 1.926          | 2.4084 |          | 0.171         | 12.60                                  | 1.532 | 3.265 | 0.641         |
| 160.000                             | 0.989  | 0.014    | 0.0001        | 2.066          | 2.4133 |          | 0.171         | 12.80                                  | 1.312 | 2.953 | 0.627         |
| 170.000                             | 0.989  | 0.011    | 0.0001        | 2.105          | 2.4147 |          | 0.172         | 13.00                                  | 1.223 | 2.722 | 0.604         |
| 180.000                             | 0.990  | 0.010    | 0.0000        | 2.271          | 2.4210 |          | 0.173         | 13.50                                  | 1.129 | 2.379 | 0.557         |
| 190.000                             | 0.990  | 0.009    | 0.0000        | 2.480          | 2.4299 |          | 0.174         | 14.00                                  | 1.070 | 2.178 | 0.526         |
| 200.000                             | 0.991  | 0.007    | 0.0000        | 2.650          | 2.4380 |          | 0.175         | 14.50                                  | 1.018 | 2.034 | 0.504         |
| 220.000                             | 0.992  | 0.006    | 0.0000        | 2.845          |        | 3.82E-07 |               | 15.00                                  | 0.972 | 1.929 | 0.489         |
| 240.000                             | 0.993  | 0.005    | 0.0000        | 3.100          | 2.4627 |          | 0.178         | 15.50                                  | 0.917 | 1.845 | 0.482         |
| 260.000                             | 0.993  | 0.004    | 0.0000        | 3.434          | 2.4849 |          | 0.182         | 16.00                                  | 0.861 | 1.767 | 0.477         |
| 280.000                             | 0.994  | 0.003    | 0.0000        | 3.576          | 2.4955 |          | 0.183         | 16.50                                  | 0.805 | 1.692 | 0.474         |
| 300.000                             | 0.995  | 0.002    | 0.0000        | 3.961          |        | 8.97E-07 |               | 17.00                                  | 0.753 | 1.619 | 0.471         |
| <i>Carbon (diamond)<sup>2</sup></i> |        |          |               | 4.160          | 2.5465 |          | 0.190         | 17.50                                  | 0.707 | 1.546 | 0.467         |
| 0.06199                             | 2.3741 |          | 0.166         | 4.511          |        | 1.29E-06 |               | 18.00                                  | 0.665 | 1.476 | 0.463         |
| 0.06888                             | 2.3741 |          | 0.166         | 4.8187         | 2.6205 | 1.47E-06 | 0.200         | 18.50                                  | 0.626 | 1.408 | 0.459         |
| 0.07749                             | 2.3745 |          | 0.166         | 5.00           | 2.6383 |          | 0.203         | 19.00                                  | 0.589 | 1.341 | 0.455         |
| 0.08856                             | 2.3750 |          | 0.166         | 5.30           |        | 2.98E-06 |               | 19.50                                  | 0.557 | 1.273 | 0.449         |
| 0.1033                              | 2.3757 |          | 0.166         | 5.35           |        | 6.45E-06 |               | 20.00                                  | 0.527 | 1.203 | 0.442         |
| 0.1240                              | 2.3765 |          | 0.166         | 5.40           |        | 1.04E-05 |               | 21.00                                  | 0.487 | 1.052 | 0.413         |
| 0.1550                              | 2.3772 |          | 0.166         | 5.50           |        | 3.41E-05 |               | 22.00                                  | 0.518 | 0.888 | 0.330         |
| 0.1907                              |        | 3.1 E-05 |               | 5.55           |        | 5.48E-04 |               | 23.00                                  | 0.597 | 0.850 | 0.270         |
| 0.2066                              | 2.3779 | 5.7 E-05 | 0.166         | 5.60           | 2.740  | 1.48E-03 | 0.216         | 24.00                                  | 0.586 | 0.829 | 0.268         |
| 0.22                                |        | 1.21E-04 |               | 5.80           | 2.780  | 5.02E-03 | 0.222         | 25.00                                  | 0.562 | 0.787 | 0.265         |
| 0.23                                |        | 2.36E-04 |               | 6.00           | 2.826  | 7.99E-03 | 0.228         | 26.00                                  | 0.538 | 0.736 | 0.260         |
| 0.24                                |        | 3.82E-04 |               | 6.10           | 2.852  | 8.62E-03 | 0.231         | 27.00                                  | 0.516 | 0.679 | 0.252         |
| 0.25                                |        | 5.21E-04 |               | 6.20           | 2.879  | 9.30E-03 | 0.235         | 28.00                                  | 0.501 | 0.616 | 0.239         |
| 0.26                                |        | 2.96E-04 |               | 6.30           | 2.910  | 9.74E-03 | 0.239         | 29.00                                  | 0.494 | 0.552 | 0.221         |
| 0.27                                |        | 4.39E-04 |               | 6.40           | 2.944  | 9.87E-03 | 0.243         | 30.00                                  | 0.493 | 0.490 | 0.201         |
| 0.28                                |        | 2.75E-04 |               | 6.50           | 2.985  | 1.10E-02 | 0.248         | <i>Cesium (evaporated)<sup>3</sup></i> |       |       |               |
| 0.29                                |        | 7.82E-05 |               | 6.60           | 3.031  | 1.47E-02 | 0.254         | 2.145                                  | 0.264 | 1.123 | 0.631         |
| 0.30                                |        | 1.32E-04 |               | 6.70           | 3.085  | 2.20E-02 | 0.261         | 2.271                                  | 0.278 | 0.950 | 0.561         |
| 0.31                                | 2.3787 | 1.30E-04 | 0.167         | 6.80           | 3.146  | 3.44E-02 | 0.268         | 2.845                                  | 0.425 | 0.438 | 0.235         |
| 0.32                                |        | 1.11E-04 |               | 6.90           | 3.220  | 5.24E-02 | 0.277         | 3.064                                  | 0.540 | 0.320 | 0.127         |
| 0.33                                |        | 2.99E-05 |               | 7.00           | 3.322  | 9.35E-02 | 0.289         | 3.397                                  | 0.671 | 0.233 | 0.057         |
| 0.34                                |        | 1.89E-05 |               | 7.10           | 3.444  | 0.210    | 0.304         | 3.966                                  | 0.827 | 0.174 | 0.018         |
| 0.35                                |        | 2.11E-05 |               | 7.15           | 3.464  | 0.307    | 0.308         | 4.889                                  | 0.916 | 0.143 | 0.007         |
|                                     |        |          |               | 7.20           | 3.437  | 0.388    | 0.307         |                                        |       |       |               |

| Energy<br>(eV)               | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV)                                                          | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV)                                                      | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) |
|------------------------------|----------|----------|-------------------------|-------------------------------------------------------------------------|----------|----------|-------------------------|---------------------------------------------------------------------|----------|----------|-------------------------|
| <i>Chromium</i> <sup>d</sup> |          |          |                         | 11.00                                                                   | 1.05     | 0.69     | 0.103                   | 2.20                                                                | 2.07     | 3.70     | 0.642                   |
| 0.06                         | 21.19    | 42.00    | 0.962                   | 11.50                                                                   | 1.09     | 0.69     | 0.100                   | 2.30                                                                | 2.01     | 3.59     | 0.634                   |
| 0.10                         | 11.81    | 29.76    | 0.955                   | 12.00                                                                   | 1.13     | 0.70     | 0.101                   | 2.40                                                                | 1.95     | 3.49     | 0.627                   |
| 0.14                         | 15.31    | 26.36    | 0.936                   | 12.50                                                                   | 1.15     | 0.73     | 0.108                   | 2.50                                                                | 1.88     | 3.40     | 0.622                   |
| 0.18                         | 8.73     | 25.37    | 0.53                    | 13.00                                                                   | 1.15     | 0.77     | 0.119                   | 2.60                                                                | 1.81     | 3.32     | 0.618                   |
| 0.22                         | 5.30     | 20.62    | 0.954                   | 13.50                                                                   | 1.12     | 0.80     | 0.128                   | 2.70                                                                | 1.73     | 3.24     | 0.615                   |
| 0.26                         | 3.91     | 17.12    | 0.951                   | 14.00                                                                   | 1.09     | 0.82     | 0.135                   | 2.80                                                                | 1.66     | 3.13     | 0.607                   |
| 0.30                         | 3.15     | 14.28    | 0.943                   | 14.50                                                                   | 1.03     | 0.82     | 0.142                   | 2.90                                                                | 1.61     | 3.05     | 0.600                   |
| 0.42                         | 3.47     | 8.97     | 0.862                   | 15.00                                                                   | 1.00     | 0.82     | 0.143                   | 3.00                                                                | 1.55     | 2.96     | 0.594                   |
| 0.54                         | 3.92     | 7.06     | 0.788                   | 15.50                                                                   | 0.96     | 0.80     | 0.141                   | 3.20                                                                | 1.46     | 2.80     | 0.579                   |
| 0.66                         | 3.96     | 5.95     | 0.736                   | 16.00                                                                   | 0.92     | 0.77     | 0.139                   | 3.40                                                                | 1.38     | 2.64     | 0.563                   |
| 0.78                         | 4.13     | 5.03     | 0.680                   | 16.50                                                                   | 0.31     | 0.75     | 0.134                   | 3.60                                                                | 1.31     | 2.48     | 0.544                   |
| 0.90                         | 4.43     | 4.60     | 0.650                   | 17.00                                                                   | 0.90     | 0.73     | 0.132                   | 3.80                                                                | 1.28     | 2.33     | 0.519                   |
| 1.00                         | 4.47     | 4.43     | 0.639                   | 17.50                                                                   | 0.88     | 0.72     | 0.130                   | 4.00                                                                | 1.26     | 2.20     | 0.495                   |
| 1.12                         | 4.53     | 4.31     | 0.631                   | 18.00                                                                   | 0.87     | 0.70     | 0.129                   | 4.20                                                                | 1.25     | 2.10     | 0.471                   |
| 1.24                         | 4.50     | 4.28     | 0.629                   | 18.50                                                                   | 0.84     | 0.69     | 0.130                   | 4.40                                                                | 1.24     | 2.01     | 0.452                   |
| 1.36                         | 4.42     | 4.30     | 0.631                   | 19.00                                                                   | 0.82     | 0.68     | 0.131                   | 4.60                                                                | 1.24     | 1.94     | 0.435                   |
| 1.46                         | 4.31     | 4.32     | 0.632                   | 20.00                                                                   | 0.77     | 0.64     | 0.130                   | 4.80                                                                | 1.23     | 1.88     | 0.423                   |
| 1.77                         | 3.84     | 4.37     | 0.639                   | 20.5                                                                    | 0.76     | 0.63     | 0.129                   | 5.00                                                                | 1.22     | 1.83     | 0.411                   |
| 2.00                         | 3.48     | 4.36     | 0.644                   | 21.0                                                                    | 0.74     | 0.58     | 0.121                   | 5.20                                                                | 1.21     | 1.79     | 0.403                   |
| 2.20                         | 3.18     | 4.41     | 0.656                   | 21.5                                                                    | 0.72     | 0.55     | 0.116                   | 5.40                                                                | 1.19     | 1.77     | 0.399                   |
| 2.40                         | 2.75     | 4.46     | 0.677                   | 22.0                                                                    | 0.71     | 0.52     | 0.112                   | 5.60                                                                | 1.16     | 1.75     | 0.400                   |
| 2.60                         | 2.22     | 4.36     | 0.698                   | 22.5                                                                    | 0.70     | 0.50     | 0.109                   | 5.80                                                                | 1.10     | 1.73     | 0.406                   |
| 2.80                         | 1.80     | 4.06     | 0.703                   | 23.0                                                                    | 0.69     | 0.48     | 0.105                   | 6.00                                                                | 1.03     | 1.68     | 0.407                   |
| 3.00                         | 1.54     | 3.71     | 0.695                   | 23.5                                                                    | 0.68     | 0.45     | 0.101                   | 6.20                                                                | 0.97     | 1.62     | 0.401                   |
| 3.20                         | 1.44     | 3.40     | 0.670                   | 24.0                                                                    | 0.68     | 0.43     | 0.096                   | 6.40                                                                | 0.94     | 1.53     | 0.386                   |
| 3.40                         | 1.39     | 3.24     | 0.657                   | 24.5                                                                    | 0.67     | 0.39     | 0.089                   | 6.60                                                                | 0.91     | 1.46     | 0.368                   |
| 3.60                         | 1.26     | 3.12     | 0.661                   | 25.0                                                                    | 0.68     | 0.36     | 0.080                   | 6.80                                                                | 0.91     | 1.38     | 0.345                   |
| 3.80                         | 1.12     | 2.95     | 0.660                   | 25.5                                                                    | 0.68     | 0.33     | 0.072                   | 7.00                                                                | 0.91     | 1.32     | 0.326                   |
| 4.00                         | 1.02     | 2.76     | 0.651                   | 26.0                                                                    | 0.70     | 0.31     | 0.063                   | 7.00                                                                | 0.91     | 1.26     | 0.305                   |
| 4.20                         | 0.94     | 2.58     | 0.639                   | 26.5                                                                    | 0.71     | 0.28     | 0.055                   | 7.40                                                                | 0.92     | 1.21     | 0.286                   |
| 4.40                         | 0.90     | 2.42     | 0.620                   | 27.0                                                                    | 0.72     | 0.26     | 0.048                   | 7.60                                                                | 0.93     | 1.17     | 0.269                   |
| 4.50                         | 0.89     | 2.35     | 0.607                   | 27.5                                                                    | 0.73     | 0.25     | 0.043                   | 7.80                                                                | 0.94     | 1.13     | 0.253                   |
| 4.60                         | 0.88     | 2.28     | 0.598                   | 28.0                                                                    | 0.75     | 0.23     | 0.037                   | 8.00                                                                | 0.95     | 1.09     | 0.239                   |
| 4.70                         | 0.86     | 2.21     | 0.586                   | 29.0                                                                    | 0.77     | 0.22     | 0.032                   | <i>Cobalt, single crystal, <math>\vec{E} \perp \vec{c}^s</math></i> |          |          |                         |
| 4.80                         | 0.86     | 2.13     | 0.572                   | 30.0                                                                    | 0.78     | 0.21     | 0.030                   | 0.10                                                                | 5.83     | 32.36    | 0.979                   |
| 4.90                         | 0.86     | 2.07     | 0.557                   | <i>Cobalt, single crystal, <math>\vec{E} \parallel \vec{c}^s</math></i> |          |          |                         | 0.15                                                                | 4.24     | 21.37    | 0.965                   |
| 5.00                         | 0.85     | 2.01     | 0.542                   | 0.10                                                                    | 6.71     | 37.87    | 0.982                   | 0.20                                                                | 3.87     | 15.53    | 0.042                   |
| 5.10                         | 0.86     | 1.94     | 0.523                   | 0.15                                                                    | 4.66     | 25.47    | 0.973                   | 0.30                                                                | 4.34     | 10.01    | 0.865                   |
| 5.20                         | 0.87     | 1.87     | 0.503                   | 0.20                                                                    | 3.55     | 18.78    | 0.962                   | 0.40                                                                | 4.66     | 7.39     | 0.785                   |
| 5.40                         | 0.93     | 1.80     | 0.466                   | 0.25                                                                    | 3.98     | 14.59    | 0.933                   | 0.50                                                                | 5.17     | 5.75     | 0.709                   |
| 5.60                         | 0.95     | 1.74     | 0.443                   | 0.30                                                                    | 4.04     | 12.16    | 0.907                   | 0.60                                                                | 5.77     | 5.17     | 0.682                   |
| 5.80                         | 0.97     | 1.74     | 0.437                   | 0.40                                                                    | 4.24     | 9.13     | 0.847                   | 0.70                                                                | 6.15     | 5.20     | 0.685                   |
| 6.00                         | 0.94     | 1.73     | 0.444                   | 0.50                                                                    | 4.41     | 7.19     | 0.782                   | 0.80                                                                | 6.08     | 5.61     | 0.702                   |
| 6.20                         | 0.89     | 1.69     | 0.446                   | 0.60                                                                    | 4.91     | 6.13     | 0.729                   | 0.90                                                                | 5.57     | 5.93     | 0.715                   |
| 6.40                         | 0.85     | 1.66     | 0.447                   | 0.70                                                                    | 5.24     | 5.85     | 0.713                   | 1.00                                                                | 4.83     | 5.94     | 0.721                   |
| 6.60                         | 0.80     | 1.59     | 0.444                   | 0.80                                                                    | 5.17     | 5.89     | 0.716                   | 1.10                                                                | 4.31     | 5.60     | 0.711                   |
| 6.80                         | 0.75     | 1.51     | 0.439                   | 0.90                                                                    | 4.94     | 5.95     | 0.720                   | 1.20                                                                | 4.02     | 5.34     | 0.701                   |
| 7.00                         | 0.74     | 1.45     | 0.425                   | 1.00                                                                    | 4.46     | 5.86     | 0.722                   | 1.30                                                                | 3.78     | 5.16     | 0.694                   |
| 7.20                         | 0.71     | 1.39     | 0.414                   | 1.10                                                                    | 4.07     | 5.61     | 0.715                   | 1.40                                                                | 3.55     | 5.05     | 0.692                   |
| 7.40                         | 0.69     | 1.33     | 0.404                   | 1.20                                                                    | 3.81     | 5.36     | 0.706                   | 1.50                                                                | 3.26     | 4.93     | 0.692                   |
| 7.60                         | 0.66     | 1.23     | 0.378                   | 1.30                                                                    | 3.60     | 5.20     | 0.701                   | 1.60                                                                | 3.03     | 4.74     | 0.687                   |
| 7.80                         | 0.67     | 1.15     | 0.347                   | 1.40                                                                    | 3.37     | 5.09     | 0.701                   | 1.70                                                                | 2.83     | 4.60     | 0.684                   |
| 8.00                         | 0.68     | 1.07     | 0.315                   | 1.50                                                                    | 3.10     | 4.96     | 0.701                   | 1.80                                                                | 2.61     | 4.45     | 0.683                   |
| 8.20                         | 0.71     | 1.00     | 0.278                   | 1.60                                                                    | 2.84     | 4.77     | 0.697                   | 1.90                                                                | 2.41     | 4.27     | 0.677                   |
| 8.50                         | 0.74     | 0.92     | 0.235                   | 1.70                                                                    | 2.66     | 4.57     | 0.690                   | 2.00                                                                | 2.25     | 4.09     | 0.670                   |
| 9.0                          | 0.83     | 0.81     | 0.170                   | 1.80                                                                    | 2.45     | 4.41     | 0.687                   | 2.10                                                                | 2.13     | 3.89     | 0.659                   |
| 9.50                         | 0.92     | 0.74     | 0.132                   | 1.90                                                                    | 2.31     | 4.18     | 0.675                   | 2.20                                                                | 2.04     | 3.72     | 0.646                   |
| 10.00                        | 0.98     | 0.73     | 0.120                   | 2.00                                                                    | 2.21     | 4.00     | 0.664                   | 2.30                                                                | 1.99     | 3.56     | 0.632                   |
| 10.50                        | 1.01     | 0.72     | 0.112                   | 2.10                                                                    | 2.13     | 3.85     | 0.654                   | 2.40                                                                | 1.95     | 3.44     | 0.620                   |



| Energy<br>(eV)             | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV) | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV)                                | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) |
|----------------------------|----------|----------|-------------------------|----------------|----------|----------|-------------------------|-----------------------------------------------|----------|----------|-------------------------|
| 2.50                       | 1.90     | 3.34     | 0.611                   | 5.60           | 1.18     | 1.74     | 0.391                   | 58.00                                         | 0.96     | 0.11     | 0.004                   |
| 2.60                       | 1.86     | 3.26     | 0.605                   | 5.80           | 1.10     | 1.67     | 0.389                   | 59.00                                         | 0.97     | 0.11     | 0.003                   |
| 2.70                       | 1.79     | 3.19     | 0.602                   | 6.00           | 1.04     | 1.59     | 0.380                   | 60.00                                         | 0.97     | 0.11     | 0.003                   |
| 2.80                       | 1.72     | 3.11     | 0.596                   | 6.50           | 0.96     | 1.37     | 0.329                   | 61.00                                         | 0.97     | 0.11     | 0.003                   |
| 2.90                       | 1.66     | 3.03     | 0.591                   | 7.00           | 0.97     | 1.20     | 0.271                   | 62.00                                         | 0.97     | 0.11     | 0.003                   |
| 3.00                       | 1.60     | 2.94     | 0.586                   | 7.50           | 1.00     | 1.09     | 0.230                   | 63.00                                         | 0.96     | 0.10     | 0.003                   |
| 3.20                       | 1.50     | 2.78     | 0.571                   | 8.00           | 1.03     | 1.03     | 0.206                   | 64.00                                         | 0.96     | 0.10     | 0.003                   |
| 3.40                       | 1.42     | 2.62     | 0.553                   | 8.50           | 1.03     | 0.98     | 0.189                   | 65.00                                         | 0.97     | 0.10     | 0.003                   |
| 3.60                       | 1.36     | 2.47     | 0.533                   | 9.00           | 1.03     | 0.92     | 0.171                   | 66.00                                         | 0.97     | 0.10     | 0.003                   |
| 3.80                       | 1.33     | 2.33     | 0.511                   | 9.50           | 1.03     | 0.87     | 0.154                   | 67.00                                         | 0.97     | 0.09     | 0.003                   |
| 4.00                       | 1.31     | 2.21     | 0.488                   | 10.00          | 1.04     | 0.82     | 0.139                   | 68.00                                         | 0.97     | 0.09     | 0.002                   |
| 4.20                       | 1.28     | 2.12     | 0.471                   | 11.00          | 1.07     | 0.75     | 0.118                   | 69.00                                         | 0.97     | 0.09     | 0.002                   |
| 4.40                       | 1.27     | 2.03     | 0.452                   | 12.00          | 1.09     | 0.73     | 0.111                   | 70.00                                         | 0.97     | 0.09     | 0.002                   |
| 4.60                       | 1.26     | 1.95     | 0.435                   | 13.00          | 1.08     | 0.72     | 0.109                   | 75.00                                         | 0.98     | 0.09     | 0.002                   |
| 4.80                       | 1.25     | 1.90     | 0.423                   | 14.00          | 1.06     | 0.72     | 0.111                   | 80.00                                         | 0.98     | 0.09     | 0.002                   |
| 5.00                       | 1.24     | 1.84     | 0.411                   | 14.50          | 1.03     | 0.72     | 0.111                   | 85.00                                         | 0.97     | 0.09     | 0.002                   |
| 5.20                       | 1.22     | 1.80     | 0.403                   | 15.00          | 1.01     | 0.71     | 0.111                   | 90.00                                         | 0.96     | 0.08     | 0.002                   |
| 5.40                       | 1.21     | 1.78     | 0.399                   | 15.50          | 0.98     | 0.69     | 0.109                   | <i>Gallium (liquid)</i> <sup>7</sup>          |          |          |                         |
| 5.60                       | 1.17     | 1.76     | 0.400                   | 16.00          | 0.95     | 0.67     | 0.106                   | 1.425                                         | 2.40     | 9.20     | 0.900                   |
| 5.80                       | 1.11     | 1.74     | 0.406                   | 17.00          | 0.91     | 0.62     | 0.097                   | 1.550                                         | 2.09     | 8.50     | 0.898                   |
| 6.00                       | 1.04     | 1.69     | 0.407                   | 18.00          | 0.89     | 0.56     | 0.084                   | 1.771                                         | 1.65     | 7.60     | 0.898                   |
| 6.20                       | 0.98     | 1.62     | 0.401                   | 19.00          | 0.88     | 0.51     | 0.071                   | 2.066                                         | 1.25     | 6.60     | 0.897                   |
| 6.40                       | 0.94     | 1.54     | 0.386                   | 20.00          | 0.88     | 0.45     | 0.059                   | 2.480                                         | 0.89     | 5.60     | 0.898                   |
| 6.60                       | 0.92     | 1.46     | 0.368                   | 21.00          | 0.90     | 0.41     | 0.048                   | 3.100                                         | 0.59     | 4.50     | 0.896                   |
| 6.80                       | 0.91     | 1.38     | 0.345                   | 22.00          | 0.92     | 0.38     | 0.040                   | <i>Germanium, single crystal</i> <sup>8</sup> |          |          |                         |
| 7.00                       | 0.91     | 1.32     | 0.326                   | 23.00          | 0.94     | 0.37     | 0.035                   | 0.01240                                       | (4.0065) | 3.00E-03 | 0.361                   |
| 7.20                       | 0.91     | 1.26     | 0.305                   | 24.00          | 0.96     | 0.37     | 0.035                   | 0.01364                                       | 4.0063   | 2.40E-03 | 0.361                   |
| 7.40                       | 0.92     | 1.21     | 0.285                   | 25.00          | 0.96     | 0.40     | 0.040                   | 0.01488                                       | (4.0060) | 1.70E-03 | 0.361                   |
| 7.60                       | 0.93     | 1.17     | 0.269                   | 26.00          | 0.92     | 0.40     | 0.044                   | 0.01612                                       | (4.0060) | 1.55E-03 | 0.361                   |
| 7.80                       | 0.94     | 1.13     | 0.253                   | 27.00          | 0.88     | 0.38     | 0.043                   | 0.01736                                       | (4.0060) | 1.50E-03 | 0.361                   |
| <i>Copper</i> <sup>6</sup> |          |          |                         | 28.00          | 0.86     | 0.35     | 0.039                   | 0.01860                                       |          | 1.50E-03 |                         |
| 0.10                       | 29.69    | 71.57    | 0.980                   | 29.00          | 0.85     | 0.30     | 0.032                   | 0.01984                                       |          | 1.60E-03 |                         |
| 0.50                       | 1.71     | 17.63    | 0.979                   | 30.00          | 0.86     | 0.26     | 0.025                   | 0.02108                                       |          | 1.60E-03 |                         |
| 1.00                       | 0.44     | 8.48     | 0.976                   | 31.00          | 0.88     | 0.24     | 0.020                   | 0.02232                                       |          | 1.55E-03 |                         |
| 1.50                       | 0.26     | 5.26     | 0.965                   | 32.00          | 0.89     | 0.22     | 0.017                   | 0.02356                                       |          | 1.53E-03 |                         |
| 1.70                       | 0.22     | 4.43     | 0.958                   | 33.00          | 0.90     | 0.21     | 0.015                   | 0.02480                                       |          | 1.50E-03 |                         |
| 1.75                       | 0.21     | 4.25     | 0.956                   | 34.00          | 0.91     | 0.20     | 0.014                   | 0.02604                                       |          | 1.25E-03 |                         |
| 1.80                       | 0.21     | 4.04     | 0.952                   | 35.00          | 0.92     | 0.20     | 0.013                   | 0.02728                                       |          | 8.50E-04 |                         |
| 1.85                       | 0.22     | 3.85     | 0.947                   | 36.00          | 0.92     | 0.19     | 0.012                   | 0.02852                                       |          | 6.50E-04 |                         |
| 1.90                       | 0.21     | 3.67     | 0.943                   | 37.00          | 0.92     | 0.19     | 0.011                   | 0.02976                                       |          | 7.00E-04 |                         |
| 2.00                       | 0.27     | 3.24     | 0.910                   | 38.00          | 0.93     | 0.18     | 0.010                   | 0.03100                                       | 3.9827   | 8.50E-04 | 0.358                   |
| 2.10                       | 0.47     | 2.81     | 0.814                   | 39.00          | 0.93     | 0.17     | 0.009                   | 0.03224                                       |          | 1.55E-03 |                         |
| 2.20                       | 0.83     | 2.60     | 0.673                   | 40.00          | 0.93     | 0.17     | 0.009                   | 0.03348                                       |          | 2.75E-03 |                         |
| 2.30                       | 1.04     | 2.59     | 0.618                   | 41.00          | 0.94     | 0.16     | 0.008                   | 0.03472                                       |          | 3.55E-03 |                         |
| 2.40                       | 1.12     | 2.60     | 0.602                   | 42.00          | 0.94     | 0.16     | 0.007                   | 0.03596                                       | (3.9900) | 3.05E-03 | 0.359                   |
| 2.60                       | 1.15     | 2.50     | 0.577                   | 43.00          | 0.94     | 0.15     | 0.007                   | 0.03720                                       |          | 2.75E-03 |                         |
| 2.80                       | 1.17     | 2.36     | 0.545                   | 44.00          | 0.95     | 0.15     | 0.007                   | 0.03844                                       |          | 2.70E-03 |                         |
| 3.00                       | 1.18     | 2.21     | 0.509                   | 45.00          | 0.95     | 0.15     | 0.006                   | 0.03968                                       | (3.9930) | 2.90E-03 | 0.359                   |
| 3.20                       | 1.23     | 2.07     | 0.468                   | 46.00          | 0.95     | 0.15     | 0.006                   | 0.04092                                       |          | 2.95E-03 |                         |
| 3.40                       | 1.27     | 1.95     | 0.434                   | 47.00          | 0.95     | 0.14     | 0.006                   | 0.04215                                       |          | 3.20E-03 |                         |
| 3.60                       | 1.31     | 1.87     | 0.407                   | 48.00          | 0.95     | 0.14     | 0.006                   | 0.04339                                       |          | 6.30E-03 |                         |
| 3.80                       | 1.34     | 1.81     | 0.387                   | 49.00          | 0.95     | 0.14     | 0.005                   | 0.04463                                       |          | 3.40E-03 |                         |
| 4.00                       | 1.34     | 1.72     | 0.364                   | 50.00          | 0.95     | 0.13     | 0.005                   | 0.04587                                       | (3.9955) | 2.50E-03 | 0.360                   |
| 4.20                       | 1.42     | 1.64     | 0.336                   | 51.00          | 0.95     | 0.13     | 0.005                   | 0.04711                                       |          | 2.10E-03 |                         |
| 4.40                       | 1.49     | 1.64     | 0.329                   | 52.00          | 0.95     | 0.13     | 0.005                   | 0.04835                                       |          | 2.00E-03 |                         |
| 4.60                       | 1.52     | 1.67     | 0.334                   | 53.00          | 0.96     | 0.12     | 0.004                   | 0.04959                                       |          | 8.00E-04 |                         |
| 4.80                       | 1.53     | 1.71     | 0.345                   | 54.00          | 0.96     | 0.12     | 0.004                   | 0.05083                                       |          | 1.40E-03 |                         |
| 5.00                       | 1.47     | 1.78     | 0.366                   | 55.00          | 0.96     | 0.12     | 0.004                   | 0.05207                                       |          | 1.35E-03 |                         |
| 5.20                       | 1.38     | 1.80     | 0.380                   | 56.00          | 0.96     | 0.11     | 0.004                   | 0.05331                                       |          | 1.10E-03 |                         |
| 5.40                       | 1.28     | 1.78     | 0.389                   | 57.00          | 0.96     | 0.11     | 0.004                   | 0.05455                                       |          | 8.00E-04 |                         |

| Energy<br>(eV) | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV)                                     | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV) | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) |
|----------------|----------|----------|-------------------------|----------------------------------------------------|----------|----------|-------------------------|----------------|----------|----------|-------------------------|
| 0.05579        |          | 6.00E-04 |                         | 3.7                                                | 3.958    | 2.863    | 0.517                   | 2.20           | 0.24     | 2.54     | 0.880                   |
| 0.05703        |          | 9.0 E-04 |                         | 3.8                                                | 3.936    | 2.986    | 0.527                   | 2.40           | 0.50     | 1.86     | 0.647                   |
| 0.05827        |          | 6.5 E-04 |                         | 3.9                                                | 3.920    | 3.137    | 0.539                   | 2.50           | 0.82     | 1.59     | 0.438                   |
| 0.05951        |          | 4.6 E-04 |                         | 4.0                                                | 3.905    | 3.336    | 0.556                   | 2.60           | 1.24     | 1.54     | 0.331                   |
| 0.06075        |          | 4.0 E-04 |                         | 4.1                                                | 3.869    | 3.614    | 0.579                   | 2.70           | 1.43     | 1.72     | 0.356                   |
| 0.06199        | 3.9992   | 3.98E-04 | 0.360                   | 4.2                                                | 3.745    | 4.009    | 0.612                   | 2.80           | 1.46     | 1.77     | 0.368                   |
| 0.06323        |          | 4.0 E-04 |                         | 4.3                                                | 3.338    | 4.507    | 0.659                   | 2.90           | 1.50     | 1.79     | 0.368                   |
| 0.06447        |          | 4.3 E-04 |                         | 4.4                                                | 2.516    | 4.669    | 0.705                   | 3.00           | 1.54     | 1.80     | 0.369                   |
| 0.06571        |          | 4.4 E-04 |                         | 4.5                                                | 1.953    | 4.297    | 0.713                   | 3.10           | 1.54     | 1.81     | 0.371                   |
| 0.06695        | (4.0000) | 4.3 E-04 | 0.360                   | 4.6                                                | 1.720    | 3.960    | 0.702                   | 3.20           | 1.54     | 1.80     | 0.368                   |
| 0.06819        |          | 3.1 E-04 |                         | 4.7                                                | 1.586    | 3.709    | 0.690                   | 3.30           | 1.55     | 1.78     | 0.362                   |
| 0.06943        |          | 3.3 E-04 |                         | 4.8                                                | 1.498    | 3.509    | 0.677                   | 3.40           | 1.56     | 1.76     | 0.356                   |
| 0.07067        |          | 3.8 E-04 |                         | 4.9                                                | 1.435    | 3.342    | 0.664                   | 3.50           | 1.58     | 1.73     | 0.349                   |
| 0.07191        |          | 3.3 E-04 |                         | 5.0                                                | 1.394    | 3.197    | 0.650                   | 3.60           | 1.62     | 1.73     | 0.346                   |
| 0.07315        |          | 2.5 E-04 |                         | 5.1                                                | 1.370    | 3.073    | 0.636                   | 3.70           | 1.64     | 1.75     | 0.351                   |
| 0.07439        |          | 1.9 E-04 |                         | 5.2                                                | 1.364    | 2.973    | 0.622                   | 3.80           | 1.63     | 1.79     | 0.360                   |
| 0.07514        |          | 1.58E-04 |                         | 5.3                                                | 1.371    | 2.897    | 0.609                   | 3.90           | 1.59     | 1.81     | 0.366                   |
| 0.07749        | 4.0009   | 9.55E-05 | 0.360                   | 5.4                                                | 1.383    | 2.854    | 0.600                   | 4.00           | 1.55     | 1.81     | 0.369                   |
| 0.07999        | 4.0011   | 1.71E-04 | 0.360                   | 5.5                                                | 1.380    | 2.842    | 0.598                   | 4.10           | 1.51     | 1.79     | 0.368                   |
| 0.08266        | 4.0013   | 9.78E-05 | 0.360                   | 5.6                                                | 1.360    | 2.846    | 0.602                   | 4.20           | 1.48     | 1.78     | 0.367                   |
| 0.08551        | 4.0015   | 5.77E-05 | 0.360                   | 5.7                                                | 1.293    | 2.163    | 0.479                   | 4.30           | 1.45     | 1.77     | 0.368                   |
| 0.08920        |          | 3.98E-05 |                         | 5.8                                                | 1.209    | 2.873    | 0.632                   | 4.40           | 1.41     | 1.76     | 0.370                   |
| 0.09460        |          | 4.59E-05 |                         | 5.9                                                | 1.108    | 2.813    | 0.641                   | 4.50           | 1.35     | 1.74     | 0.370                   |
| 0.09840        |          | 3.51E-05 |                         | 6.0                                                | 1.30     | 2.34     | 0.517                   | 4.60           | 1.30     | 1.69     | 0.364                   |
| 0.1            | 4.0063   | 3.70E-05 | 0.361                   | 6.5                                                | 1.10     | 2.05     | 0.489                   | 4.70           | 1.27     | 1.64     | 0.354                   |
| 0.2            | 4.0108   |          | 0.361                   | 7.0                                                | 1.00     | 1.80     | 0.448                   | 4.80           | 1.25     | 1.59     | 0.344                   |
| 0.3            | 4.0246   |          | 0.362                   | 7.5                                                |          | 1.60     |                         | 4.90           | 1.23     | 1.54     | 0.332                   |
| 0.4            | 4.0429   |          | 0.364                   | 8.0                                                | 0.92     | 1.40     | 0.348                   | 5.00           | 1.22     | 1.49     | 0.319                   |
| 0.5            | (4.074)  |          | 0.367                   | 8.5                                                | 0.92     | 1.20     | 0.282                   | 5.20           | 1.21     | 1.40     | 0.295                   |
| 0.6            | (4.104)  | 6.58E-07 | 0.370                   | 9.0                                                | 0.92     | 1.14     | 0.262                   | 5.40           | 1.21     | 1.33     | 0.275                   |
| 0.7            | 4.180    | 1.27E-04 | 0.377                   | 9.5                                                |          | 1.00     |                         | 5.60           | 1.21     | 1.27     | 0.256                   |
| 0.8            | 4.275    | 5.67E-03 | 0.385                   | 10.0                                               | 0.93     | 0.86     | 0.167                   | 5.80           | 1.21     | 1.20     | 0.236                   |
| 0.9            | 4.285    | 7.45E-02 | 0.386                   | 20.0                                               |          | 0.237    |                         | 6.00           | 1.22     | 1.14     | 0.218                   |
| 1.0            | 4.325    | 8.09E-02 | 0.390                   | 22.0                                               |          | 0.179    |                         | 6.20           | 1.24     | 1.09     | 0.203                   |
| 1.1            | 4.385    | 0.103    | 0.395                   | 24.0                                               |          | 0.144    |                         | 6.40           | 1.25     | 1.05     | 0.190                   |
| 1.2            | 4.420    | 0.123    | 0.398                   | 26.0                                               |          | 0.110    |                         | 6.60           | 1.27     | 1.01     | 0.177                   |
| 1.3            | 4.495    | 0.167    | 0.405                   | 28.0                                               |          | 0.0747   |                         | 6.80           | 1.30     | 0.97     | 0.167                   |
| 1.4            | 4.560    | 0.190    | 0.411                   | 30.0                                               |          | 0.1020   |                         | 7.00           | 1.34     | 0.95     | 0.162                   |
| 1.5            | 4.635    | 0.298    | 0.418                   | 32.0                                               |          | 0.0999   |                         | 7.20           | 1.36     | 0.95     | 0.161                   |
| 1.6            | 4.763    | 0.345    | 0.428                   | 34.0                                               |          | 0.0856   |                         | 7.40           | 1.38     | 0.96     | 0.164                   |
| 1.7            | 4.897    | 0.401    | 0.439                   | 36.0                                               |          | 0.0740   |                         | 7.60           | 1.38     | 0.98     | 0.169                   |
| 1.8            | 5.067    | 0.500    | 0.453                   | 38.0                                               |          | 0.0651   |                         | 7.80           | 1.35     | 0.99     | 0.171                   |
| 1.9            | 5.380    | 0.540    | 0.475                   | 40.0                                               |          | 0.0604   |                         | 8.00           | 1.31     | 0.96     | 0.165                   |
| 2.0            | 5.588    | 0.933    | 0.495                   | <i>Gold, electropolished, Au (110)<sup>9</sup></i> |          |          |                         | 8.20           | 1.30     | 0.92     | 0.155                   |
| 2.1            | 5.748    | 1.634    | 0.523                   | 0.10                                               | 8.17     | 82.83    | 0.995                   | 8.40           | 1.30     | 0.89     | 0.147                   |
| 2.2            | 5.283    | 2.049    | 0.516                   | 0.20                                               | 2.13     | 41.73    | 0.995                   | 8.60           | 1.31     | 0.88     | 0.144                   |
| 2.3            | 5.062    | 2.318    | 0.519                   | 0.30                                               | 0.99     | 27.82    | 0.995                   | 8.80           | 1.31     | 0.86     | 0.140                   |
| 2.4            | 4.610    | 2.455    | 0.508                   | 0.40                                               | 0.59     | 20.83    | 0.995                   | 9.00           | 1.30     | 0.83     | 0.133                   |
| 2.5            | 4.340    | 2.384    | 0.492                   | 0.50                                               | 0.39     | 16.61    | 0.994                   | 9.20           | 1.31     | 0.81     | 0.126                   |
| 2.6            | 4.180    | 2.309    | 0.480                   | 0.60                                               | 0.28     | 13.78    | 0.994                   | 9.40           | 1.33     | 0.78     | 0.122                   |
| 2.7            | 4.082    | 2.240    | 0.471                   | 0.70                                               | 0.22     | 11.75    | 0.994                   | 9.60           | 1.36     | 0.78     | 0.121                   |
| 2.8            | 4.035    | 2.181    | 0.464                   | 0.80                                               | 0.18     | 10.21    | 0.993                   | 9.80           | 1.37     | 0.79     | 0.124                   |
| 2.9            | 4.037    | 2.140    | 0.461                   | 0.90                                               | 0.15     | 9.01     | 0.993                   | 10.00          | 1.37     | 0.80     | 0.126                   |
| 3.0            | 4.082    | 2.145    | 0.463                   | 1.00                                               | 0.13     | 8.03     | 0.992                   | 10.20          | 1.36     | 0.80     | 0.127                   |
| 3.1            | 4.141    | 2.215    | 0.471                   | 1.20                                               | 0.10     | 6.54     | 0.991                   | 10.40          | 1.35     | 0.80     | 0.125                   |
| 3.2            | 4.157    | 2.340    | 0.482                   | 1.40                                               | 0.08     | 5.44     | 0.989                   | 10.60          | 1.34     | 0.79     | 0.123                   |
| 3.3            | 4.128    | 2.469    | 0.490                   | 1.60                                               | 0.08     | 4.56     | 0.986                   | 10.80          | 1.34     | 0.77     | 0.120                   |
| 3.4            | 4.070    | 2.579    | 0.497                   | 1.80                                               | 0.09     | 3.82     | 0.979                   | 11.00          | 1.34     | 0.76     | 0.116                   |
| 3.5            | 4.020    | 2.667    | 0.502                   | 2.00                                               | 0.13     | 3.16     | 0.953                   | 11.20          | 1.34     | 0.74     | 0.113                   |
| 3.6            | 3.985    | 2.759    | 0.509                   | 2.10                                               | 0.18     | 2.84     | 0.925                   | 11.40          | 1.35     | 0.73     | 0.111                   |

| Energy<br>(eV)                                                              | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV) | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV)                                                              | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) |
|-----------------------------------------------------------------------------|----------|----------|-------------------------|----------------|----------|----------|-------------------------|-----------------------------------------------------------------------------|----------|----------|-------------------------|
| 11.60                                                                       | 1.36     | 0.72     | 0.109                   | 1.10           | 4.28     | 3.08     | 0.547                   | 9.20                                                                        | 1.50     | 1.10     | 0.201                   |
| 11.80                                                                       | 1.38     | 0.71     | 0.108                   | 1.20           | 4.08     | 3.10     | 0.544                   | 9.40                                                                        | 1.48     | 1.14     | 0.211                   |
| 12.00                                                                       | 1.39     | 0.71     | 0.109                   | 1.30           | 3.87     | 3.04     | 0.536                   | 9.60                                                                        | 1.46     | 1.18     | 0.222                   |
| 12.40                                                                       | 1.44     | 0.73     | 0.115                   | 1.40           | 3.72     | 2.95     | 0.525                   | 9.80                                                                        | 1.41     | 1.21     | 0.230                   |
| 12.80                                                                       | 1.45     | 0.79     | 0.127                   | 1.50           | 3.60     | 2.85     | 0.514                   | 10.00                                                                       | 1.36     | 1.22     | 0.235                   |
| 13.20                                                                       | 1.42     | 0.84     | 0.137                   | 1.60           | 3.52     | 2.73     | 0.500                   | 10.20                                                                       | 1.32     | 1.22     | 0.238                   |
| 13.60                                                                       | 1.37     | 0.86     | 0.140                   | 1.70           | 3.52     | 2.61     | 0.488                   | 10.40                                                                       | 1.28     | 1.22     | 0.240                   |
| 14.00                                                                       | 1.33     | 0.86     | 0.140                   | 1.80           | 3.57     | 2.56     | 0.485                   | 10.60                                                                       | 1.24     | 1.21     | 0.241                   |
| 14.40                                                                       | 1.29     | 0.86     | 0.139                   | 1.90           | 3.63     | 2.59     | 0.489                   | 10.80                                                                       | 1.20     | 1.20     | 0.242                   |
| 14.80                                                                       | 1.26     | 0.84     | 0.135                   | 2.00           | 3.65     | 2.67     | 0.498                   | 11.00                                                                       | 1.16     | 1.19     | 0.242                   |
| 15.20                                                                       | 1.24     | 0.83     | 0.132                   | 2.10           | 3.64     | 2.81     | 0.511                   | 11.20                                                                       | 1.13     | 1.17     | 0.241                   |
| 15.60                                                                       | 1.22     | 0.81     | 0.127                   | 2.20           | 3.53     | 2.99     | 0.526                   | 11.40                                                                       | 1.10     | 1.16     | 0.241                   |
| 16.00                                                                       | 1.21     | 0.79     | 0.123                   | 2.30           | 3.34     | 3.09     | 0.534                   | 11.60                                                                       | 1.07     | 1.14     | 0.239                   |
| 16.40                                                                       | 1.20     | 0.78     | 0.119                   | 2.40           | 3.15     | 3.11     | 0.537                   | 11.80                                                                       | 1.04     | 1.12     | 0.238                   |
| 16.80                                                                       | 1.19     | 0.76     | 0.116                   | 2.50           | 2.99     | 3.13     | 0.540                   | 12.00                                                                       | 1.02     | 1.10     | 0.236                   |
| 17.20                                                                       | 1.19     | 0.75     | 0.114                   | 2.60           | 2.83     | 3.12     | 0.542                   | 12.40                                                                       | 0.96     | 1.06     | 0.232                   |
| 17.60                                                                       | 1.19     | 0.74     | 0.111                   | 2.70           | 2.68     | 3.10     | 0.542                   | 12.80                                                                       | 0.92     | 1.01     | 0.225                   |
| 18.00                                                                       | 1.19     | 0.74     | 0.109                   | 2.80           | 2.54     | 3.08     | 0.543                   | 13.20                                                                       | 0.88     | 0.96     | 0.218                   |
| 18.40                                                                       | 1.19     | 0.73     | 0.109                   | 2.90           | 2.40     | 3.04     | 0.544                   | 13.60                                                                       | 0.84     | 0.90     | 0.205                   |
| 18.80                                                                       | 1.20     | 0.74     | 0.110                   | 3.00           | 2.27     | 3.00     | 0.544                   | 14.00                                                                       | 0.83     | 0.83     | 0.186                   |
| 19.20                                                                       | 1.21     | 0.76     | 0.116                   | 3.10           | 2.14     | 2.95     | 0.544                   | 14.40                                                                       | 0.83     | 0.80     | 0.172                   |
| 19.60                                                                       | 1.21     | 0.80     | 0.125                   | 3.20           | 2.00     | 2.89     | 0.544                   | 14.80                                                                       | 0.81     | 0.76     | 0.167                   |
| 20.00                                                                       | 1.18     | 0.83     | 0.133                   | 3.30           | 1.87     | 2.79     | 0.538                   | 15.20                                                                       | 0.79     | 0.70     | 0.153                   |
| 20.40                                                                       | 1.14     | 0.85     | 0.141                   | 3.40           | 1.78     | 2.68     | 0.528                   | 15.60                                                                       | 0.79     | 0.64     | 0.132                   |
| 20.80                                                                       | 1.10     | 0.87     | 0.149                   | 3.50           | 1.71     | 2.58     | 0.517                   | 16.00                                                                       | 0.83     | 0.60     | 0.111                   |
| 21.20                                                                       | 1.05     | 0.88     | 0.156                   | 3.60           | 1.66     | 2.48     | 0.503                   | 16.40                                                                       | 0.81     | 0.60     | 0.114                   |
| 21.60                                                                       | 1.00     | 0.88     | 0.162                   | 3.70           | 1.63     | 2.40     | 0.491                   | 16.80                                                                       | 0.79     | 0.55     | 0.105                   |
| 22.00                                                                       | 0.94     | 0.86     | 0.164                   | 3.80           | 1.60     | 2.33     | 0.481                   | 17.20                                                                       | 0.79     | 0.50     | 0.089                   |
| 22.40                                                                       | 0.89     | 0.83     | 0.163                   | 3.90           | 1.56     | 2.27     | 0.473                   | 17.60                                                                       | 0.80     | 0.46     | 0.077                   |
| 22.80                                                                       | 0.85     | 0.79     | 0.157                   | 4.00           | 1.52     | 2.21     | 0.466                   | 18.00                                                                       | 0.81     | 0.42     | 0.064                   |
| 23.20                                                                       | 0.82     | 0.75     | 0.149                   | 4.10           | 1.48     | 2.14     | 0.455                   | 18.40                                                                       | 0.84     | 0.38     | 0.051                   |
| 23.60                                                                       | 0.80     | 0.70     | 0.138                   | 4.20           | 1.45     | 2.07     | 0.442                   | 18.80                                                                       | 0.87     | 0.34     | 0.040                   |
| 24.00                                                                       | 0.80     | 0.66     | 0.125                   | 4.30           | 1.43     | 2.01     | 0.431                   | 19.00                                                                       | 0.89     | 0.33     | 0.036                   |
| 24.40                                                                       | 0.80     | 0.62     | 0.113                   | 4.40           | 1.41     | 1.95     | 0.420                   | 19.60                                                                       | 0.93     | 0.32     | 0.030                   |
| 24.80                                                                       | 0.80     | 0.58     | 0.101                   | 4.50           | 1.39     | 1.89     | 0.407                   | 20.00                                                                       | 0.94     | 0.31     | 0.027                   |
| 25.20                                                                       | 0.82     | 0.56     | 0.090                   | 4.60           | 1.39     | 1.83     | 0.394                   | 20.60                                                                       | 0.97     | 0.30     | 0.023                   |
| 25.60                                                                       | 0.83     | 0.54     | 0.084                   | 4.70           | 1.39     | 1.79     | 0.382                   | 21.00                                                                       | 0.99     | 0.29     | 0.022                   |
| 26.00                                                                       | 0.84     | 0.52     | 0.079                   | 4.80           | 1.38     | 1.75     | 0.373                   | 21.60                                                                       | 1.01     | 0.28     | 0.020                   |
| 26.40                                                                       | 0.85     | 0.51     | 0.074                   | 4.90           | 1.38     | 1.71     | 0.364                   | 22.00                                                                       | 1.03     | 0.28     | 0.020                   |
| 26.80                                                                       | 0.85     | 0.50     | 0.071                   | 5.00           | 1.37     | 1.68     | 0.356                   | 22.60                                                                       | 1.06     | 0.28     | 0.020                   |
| 27.20                                                                       | 0.86     | 0.49     | 0.068                   | 5.20           | 1.36     | 1.61     | 0.341                   | 23.00                                                                       | 1.07     | 0.28     | 0.021                   |
| 27.60                                                                       | 0.86     | 0.49     | 0.065                   | 5.40           | 1.35     | 1.55     | 0.324                   | 23.60                                                                       | 1.09     | 0.29     | 0.022                   |
| 28.00                                                                       | 0.87     | 0.48     | 0.063                   | 5.60           | 1.35     | 1.51     | 0.314                   | 24.00                                                                       | 1.09     | 0.30     | 0.023                   |
| 28.40                                                                       | 0.88     | 0.48     | 0.062                   | 5.80           | 1.32     | 1.48     | 0.308                   | 24.60                                                                       | 1.10     | 0.31     | 0.024                   |
| 28.80                                                                       | 0.88     | 0.48     | 0.062                   | 6.00           | 1.28     | 1.41     | 0.295                   | <i>Hafnium, single crystal, <math>\vec{E} \parallel \hat{c}^{10}</math></i> |          |          |                         |
| 29.20                                                                       | 0.88     | 0.48     | 0.062                   | 6.20           | 1.26     | 1.35     | 0.278                   | 0.52                                                                        | 2.25     | 4.65     | 0.723                   |
| 29.60                                                                       | 0.87     | 0.48     | 0.064                   | 6.40           | 1.26     | 1.28     | 0.258                   | 0.56                                                                        | 2.34     | 3.66     | 0.623                   |
| 30.00                                                                       | 0.86     | 0.48     | 0.064                   | 6.60           | 1.27     | 1.22     | 0.240                   | 0.60                                                                        | 2.84     | 2.89     | 0.512                   |
| <i>Hafnium, single crystal, <math>\vec{E} \parallel \hat{c}^{10}</math></i> |          |          |                         | 6.80           | 1.28     | 1.16     | 0.224                   | 0.66                                                                        | 3.71     | 2.35     | 0.469                   |
| 0.52                                                                        | 1.48     | 4.11     | 0.747                   | 7.00           | 1.31     | 1.13     | 0.212                   | 0.70                                                                        | 4.26     | 2.21     | 0.482                   |
| 0.56                                                                        | 1.84     | 3.29     | 0.615                   | 7.20           | 1.33     | 1.10     | 0.204                   | 0.76                                                                        | 4.97     | 2.33     | 0.521                   |
| 0.60                                                                        | 2.34     | 2.62     | 0.486                   | 7.40           | 1.34     | 1.07     | 0.197                   | 0.80                                                                        | 5.41     | 2.62     | 0.554                   |
| 0.66                                                                        | 3.21     | 2.13     | 0.428                   | 7.60           | 1.36     | 1.05     | 0.191                   | 0.86                                                                        | 5.46     | 3.36     | 0.593                   |
| 0.70                                                                        | 3.70     | 2.03     | 0.441                   | 7.80           | 1.37     | 1.02     | 0.183                   | 0.90                                                                        | 5.22     | 3.62     | 0.601                   |
| 0.76                                                                        | 4.31     | 2.10     | 0.476                   | 8.00           | 1.40     | 1.01     | 0.179                   | 0.95                                                                        | 4.95     | 3.72     | 0.602                   |
| 0.80                                                                        | 4.61     | 2.31     | 0.504                   | 8.20           | 1.43     | 1.01     | 0.178                   | 1.00                                                                        | 4.76     | 3.76     | 0.602                   |
| 0.86                                                                        | 4.71     | 2.70     | 0.533                   | 8.40           | 1.45     | 1.01     | 0.180                   | 1.10                                                                        | 4.43     | 3.80     | 0.601                   |
| 0.90                                                                        | 4.64     | 2.85     | 0.541                   | 8.60           | 1.47     | 1.02     | 0.183                   | 1.20                                                                        | 4.07     | 3.74     | 0.594                   |
| 0.95                                                                        | 4.54     | 2.96     | 0.545                   | 8.80           | 1.48     | 1.04     | 0.186                   | 1.30                                                                        | 3.79     | 3.55     | 0.578                   |
| 1.00                                                                        | 4.45     | 3.00     | 0.545                   | 9.00           | 1.49     | 1.07     | 0.193                   | 1.40                                                                        | 3.61     | 3.36     | 0.561                   |

| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)              | $n$   | $k$   | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ |
|----------------|------|------|---------------|-----------------------------|-------|-------|---------------|----------------|------|------|---------------|
| 1.50           | 3.55 | 3.13 | 0.540         | 10.00                       | 1.32  | 1.21  | 0.230         | 1.60           | 2.68 | 5.08 | 0.728         |
| 1.60           | 3.58 | 3.01 | 0.529         | 10.20                       | 1.27  | 1.21  | 0.234         | 1.70           | 2.69 | 4.92 | 0.716         |
| 1.70           | 3.63 | 2.98 | 0.526         | 10.40                       | 1.23  | 1.20  | 0.235         | 1.80           | 2.64 | 4.81 | 0.710         |
| 1.80           | 3.66 | 3.02 | 0.530         | 10.60                       | 1.19  | 1.20  | 0.237         | 1.90           | 2.57 | 4.68 | 0.704         |
| 1.90           | 3.63 | 3.14 | 0.541         | 10.80                       | 1.15  | 1.19  | 0.237         | 2.00           | 2.50 | 4.57 | 0.699         |
| 2.00           | 3.51 | 3.26 | 0.551         | 11.00                       | 1.12  | 1.17  | 0.237         | 2.10           | 2.40 | 4.48 | 0.697         |
| 2.10           | 3.35 | 3.33 | 0.558         | 11.20                       | 1.08  | 1.16  | 0.237         | 2.20           | 2.29 | 4.38 | 0.695         |
| 2.20           | 3.18 | 3.36 | 0.563         | 11.40                       | 1.05  | 1.14  | 0.236         | 2.30           | 2.18 | 4.26 | 0.692         |
| 2.30           | 2.99 | 3.39 | 0.568         | 11.60                       | 1.03  | 1.12  | 0.235         | 2.40           | 2.07 | 4.14 | 0.689         |
| 2.40           | 2.78 | 3.35 | 0.569         | 11.80                       | 1.00  | 1.10  | 0.233         | 2.50           | 1.98 | 4.00 | 0.682         |
| 2.50           | 2.65 | 3.26 | 0.562         | 12.00                       | 0.97  | 1.08  | 0.231         | 2.60           | 1.91 | 3.86 | 0.673         |
| 2.60           | 2.54 | 3.22 | 0.560         | 12.40                       | 0.92  | 1.04  | 0.226         | 2.70           | 1.85 | 3.73 | 0.665         |
| 2.70           | 2.42 | 3.17 | 0.559         | 12.80                       | 0.88  | 0.99  | 0.219         | 2.80           | 1.81 | 3.61 | 0.655         |
| 2.80           | 2.31 | 3.13 | 0.558         | 13.20                       | 0.83  | 0.94  | 0.211         | 2.90           | 1.77 | 3.51 | 0.646         |
| 2.90           | 2.20 | 3.08 | 0.558         | 13.60                       | 0.80  | 0.88  | 0.196         | 3.00           | 1.73 | 3.43 | 0.640         |
| 3.00           | 2.08 | 3.05 | 0.561         | 14.00                       | 0.79  | 0.81  | 0.177         | 3.20           | 1.62 | 3.26 | 0.629         |
| 3.10           | 1.94 | 2.98 | 0.560         | 14.40                       | 0.80  | 0.77  | 0.160         | 3.40           | 1.53 | 3.05 | 0.610         |
| 3.20           | 1.83 | 2.88 | 0.555         | 14.80                       | 0.77  | 0.73  | 0.154         | 3.60           | 1.52 | 2.81 | 0.573         |
| 3.30           | 1.74 | 2.78 | 0.547         | 15.20                       | 0.76  | 0.68  | 0.140         | 3.80           | 1.61 | 2.69 | 0.541         |
| 3.40           | 1.68 | 2.69 | 0.538         | 15.60                       | 0.76  | 0.61  | 0.119         | 4.00           | 1.64 | 2.68 | 0.535         |
| 3.50           | 1.62 | 2.61 | 0.529         | 16.00                       | 0.81  | 0.58  | 0.099         | 4.20           | 1.58 | 2.71 | 0.549         |
| 3.60           | 1.57 | 2.52 | 0.519         | 16.40                       | 0.78  | 0.57  | 0.102         | 4.40           | 1.45 | 2.68 | 0.561         |
| 3.70           | 1.53 | 2.45 | 0.510         | 16.80                       | 0.77  | 0.53  | 0.092         | 4.60           | 1.31 | 2.60 | 0.567         |
| 3.80           | 1.49 | 2.38 | 0.501         | 17.20                       | 0.77  | 0.48  | 0.077         | 4.80           | 1.18 | 2.49 | 0.570         |
| 3.90           | 1.45 | 2.32 | 0.493         | 17.60                       | 0.79  | 0.44  | 0.065         | 5.00           | 1.10 | 2.35 | 0.559         |
| 4.00           | 1.41 | 2.25 | 0.484         | 18.00                       | 0.80  | 0.39  | 0.053         | 5.20           | 1.04 | 2.22 | 0.543         |
| 4.10           | 1.38 | 2.18 | 0.474         | 18.40                       | 0.82  | 0.36  | 0.041         | 5.40           | 1.00 | 2.09 | 0.522         |
| 4.20           | 1.35 | 2.11 | 0.462         | 18.80                       | 0.86  | 0.33  | 0.032         | 5.60           | 0.98 | 1.98 | 0.499         |
| 4.30           | 1.33 | 2.05 | 0.451         | 19.00                       | 0.88  | 0.32  | 0.030         | 5.80           | 0.96 | 1.86 | 0.474         |
| 4.40           | 1.31 | 1.99 | 0.438         | 19.60                       | 0.91  | 0.31  | 0.025         | 6.00           | 0.95 | 1.78 | 0.454         |
| 4.50           | 1.30 | 1.93 | 0.427         | 20.00                       | 0.93  | 0.30  | 0.023         | 6.20           | 0.94 | 1.68 | 0.427         |
| 4.60           | 1.29 | 1.88 | 0.415         | 20.60                       | 0.96  | 0.29  | 0.021         | 6.40           | 0.94 | 1.59 | 0.401         |
| 4.70           | 1.28 | 1.82 | 0.402         | 21.00                       | 0.97  | 0.29  | 0.020         | 6.60           | 0.94 | 1.50 | 0.375         |
| 4.80           | 1.28 | 1.77 | 0.389         | 21.60                       | 1.00  | 0.28  | 0.019         | 6.80           | 0.95 | 1.42 | 0.345         |
| 4.90           | 1.27 | 1.73 | 0.379         | 22.00                       | 1.01  | 0.28  | 0.019         | 7.00           | 0.97 | 1.34 | 0.318         |
| 5.00           | 1.27 | 1.69 | 0.367         | 22.60                       | 1.03  | 0.27  | 0.018         | 7.20           | 0.99 | 1.27 | 0.290         |
| 5.20           | 1.27 | 1.62 | 0.349         | 23.00                       | 1.05  | 0.28  | 0.019         | 7.40           | 1.02 | 1.20 | 0.262         |
| 5.40           | 1.27 | 1.57 | 0.335         | 23.60                       | 1.06  | 0.28  | 0.020         | 7.60           | 1.03 | 1.14 | 0.241         |
| 5.60           | 1.26 | 1.52 | 0.322         | 24.00                       | 1.07  | 0.29  | 0.021         | 7.80           | 1.08 | 1.06 | 0.208         |
| 5.80           | 1.24 | 1.48 | 0.313         | 24.60                       | 1.09  | 0.30  | 0.022         | 8.00           | 1.13 | 1.03 | 0.191         |
| 6.00           | 1.21 | 1.42 | 0.302         | <i>Iridium<sup>II</sup></i> |       |       |               | 8.20           | 1.18 | 1.00 | 0.179         |
| 6.20           | 1.19 | 1.36 | 0.285         | 0.10                        | 28.49 | 60.62 | 0.975         | 8.40           | 1.22 | 0.98 | 0.171         |
| 6.40           | 1.18 | 1.29 | 0.265         | 0.15                        | 15.32 | 45.15 | 0.973         | 8.60           | 1.26 | 0.96 | 0.164         |
| 6.60           | 1.19 | 1.22 | 0.244         | 0.20                        | 9.69  | 35.34 | 0.972         | 8.80           | 1.29 | 0.95 | 0.160         |
| 6.80           | 1.21 | 1.18 | 0.230         | 0.25                        | 6.86  | 28.84 | 0.969         | 9.00           | 1.33 | 0.94 | 0.157         |
| 7.00           | 1.22 | 1.14 | 0.217         | 0.30                        | 5.16  | 24.25 | 0.967         | 9.20           | 1.36 | 0.95 | 0.159         |
| 7.20           | 1.23 | 1.10 | 0.206         | 0.35                        | 4.11  | 20.79 | 0.964         | 9.40           | 1.39 | 0.95 | 0.161         |
| 7.40           | 1.26 | 1.06 | 0.194         | 0.40                        | 3.42  | 18.06 | 0.960         | 9.60           | 1.42 | 0.97 | 0.163         |
| 7.60           | 1.28 | 1.04 | 0.187         | 0.45                        | 3.05  | 15.82 | 0.954         | 9.80           | 1.44 | 0.99 | 0.169         |
| 7.80           | 1.30 | 1.02 | 0.180         | 0.50                        | 2.98  | 14.06 | 0.944         | 10.00          | 1.45 | 1.01 | 0.175         |
| 8.00           | 1.33 | 1.00 | 0.174         | 0.60                        | 2.79  | 11.58 | 0.925         | 10.20          | 1.45 | 1.04 | 0.182         |
| 8.20           | 1.35 | 0.99 | 0.173         | 0.70                        | 2.93  | 9.78  | 0.895         | 10.40          | 1.44 | 1.07 | 0.187         |
| 8.40           | 1.38 | 0.99 | 0.173         | 0.80                        | 3.14  | 8.61  | 0.862         | 10.60          | 1.43 | 1.09 | 0.193         |
| 8.60           | 1.40 | 1.00 | 0.174         | 0.90                        | 3.19  | 7.88  | 0.840         | 10.80          | 1.41 | 1.12 | 0.200         |
| 8.80           | 1.42 | 1.02 | 0.178         | 1.00                        | 3.15  | 7.31  | 0.822         | 11.00          | 1.38 | 1.13 | 0.206         |
| 9.00           | 1.43 | 1.04 | 0.184         | 1.10                        | 3.04  | 6.84  | 0.808         | 11.20          | 1.34 | 1.14 | 0.208         |
| 9.20           | 1.45 | 1.08 | 0.193         | 1.20                        | 2.96  | 6.41  | 0.791         | 11.40          | 1.31 | 1.13 | 0.208         |
| 9.40           | 1.43 | 1.12 | 0.204         | 1.30                        | 2.85  | 6.07  | 0.779         | 11.60          | 1.28 | 1.12 | 0.206         |
| 9.60           | 1.40 | 1.16 | 0.214         | 1.40                        | 2.72  | 5.74  | 0.767         | 11.80          | 1.25 | 1.10 | 0.203         |
| 9.80           | 1.37 | 1.19 | 0.223         | 1.50                        | 2.65  | 5.39  | 0.750         | 12.00          | 1.24 | 1.08 | 0.199         |

| Energy<br>(eV)           | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ |
|--------------------------|------|------|---------------|----------------|------|------|---------------|----------------|------|------|---------------|
| 12.40                    | 1.21 | 1.05 | 0.191         | 1.20           | 3.24 | 4.26 | 0.641         | 9.50           | 0.90 | 1.02 | 0.226         |
| 12.80                    | 1.19 | 1.01 | 0.181         | 1.30           | 3.16 | 4.07 | 0.626         | 9.67           | 0.90 | 1.00 | 0.221         |
| 13.20                    | 1.18 | 0.98 | 0.173         | 1.40           | 3.12 | 3.87 | 0.609         | 9.83           | 0.89 | 0.99 | 0.218         |
| 13.60                    | 1.17 | 0.95 | 0.165         | 1.50           | 3.05 | 3.77 | 0.601         | 10.00          | 0.88 | 0.97 | 0.213         |
| 14.00                    | 1.16 | 0.91 | 0.155         | 1.60           | 3.00 | 3.60 | 0.585         | 10.17          | 0.87 | 0.94 | 0.203         |
| 14.40                    | 1.17 | 0.88 | 0.147         | 1.70           | 2.98 | 3.52 | 0.577         | 10.33          | 0.87 | 0.91 | 0.196         |
| 14.80                    | 1.18 | 0.87 | 0.142         | 1.80           | 2.92 | 3.46 | 0.573         | 10.50          | 0.87 | 0.89 | 0.189         |
| 15.20                    | 1.19 | 0.84 | 0.136         | 1.90           | 2.89 | 3.37 | 0.563         | 10.67          | 0.88 | 0.87 | 0.179         |
| 15.60                    | 1.20 | 0.83 | 0.133         | 2.00           | 2.85 | 3.36 | 0.563         | 10.83          | 0.89 | 0.85 | 0.170         |
| 16.00                    | 1.21 | 0.83 | 0.131         | 2.10           | 2.80 | 3.34 | 0.562         | 11.00          | 0.91 | 0.83 | 0.162         |
| 16.40                    | 1.23 | 0.82 | 0.129         | 2.20           | 2.74 | 3.33 | 0.563         | 11.17          | 0.92 | 0.83 | 0.159         |
| 16.80                    | 1.25 | 0.82 | 0.127         | 2.30           | 2.65 | 3.34 | 0.567         | 11.33          | 0.93 | 0.84 | 0.159         |
| 17.20                    | 1.28 | 0.83 | 0.131         | 2.40           | 2.56 | 3.31 | 0.567         | 11.50          | 0.93 | 0.84 | 0.160         |
| 17.60                    | 1.30 | 0.87 | 0.140         | 2.50           | 2.46 | 3.31 | 0.570         | 11.67          | 0.93 | 0.84 | 0.162         |
| 18.00                    | 1.30 | 0.93 | 0.154         | 2.60           | 2.34 | 3.30 | 0.576         | 11.83          | 0.92 | 0.84 | 0.163         |
| 18.40                    | 1.27 | 0.97 | 0.166         | 2.70           | 2.23 | 3.25 | 0.575         | 12.00          | 0.91 | 0.84 | 0.163         |
| 18.80                    | 1.24 | 1.00 | 0.176         | 2.80           | 2.12 | 3.23 | 0.580         | 12.17          | 0.90 | 0.84 | 0.165         |
| 19.20                    | 1.20 | 1.03 | 0.187         | 2.90           | 2.01 | 3.17 | 0.580         | 12.33          | 0.89 | 0.83 | 0.164         |
| 19.60                    | 1.15 | 1.05 | 0.197         | 3.00           | 1.88 | 3.12 | 0.583         | 12.50          | 0.98 | 0.83 | 0.165         |
| 20.00                    | 1.10 | 1.06 | 0.205         | 3.10           | 1.78 | 3.04 | 0.580         | 12.67          | 0.87 | 0.82 | 0.166         |
| 20.50                    | 1.04 | 1.05 | 0.210         | 3.20           | 1.70 | 2.96 | 0.576         | 12.83          | 0.86 | 0.81 | 0.166         |
| 21.00                    | 0.99 | 1.04 | 0.215         | 3.30           | 1.62 | 2.87 | 0.572         | 13.00          | 0.85 | 0.80 | 0.162         |
| 21.50                    | 0.94 | 1.02 | 0.220         | 3.40           | 1.55 | 2.79 | 0.565         | 13.17          | 0.84 | 0.79 | 0.161         |
| 22.00                    | 0.89 | 1.00 | 0.222         | 3.50           | 1.50 | 2.70 | 0.556         | 13.33          | 0.84 | 0.78 | 0.160         |
| 22.50                    | 0.84 | 0.99 | 0.228         | 3.60           | 1.47 | 2.63 | 0.548         | 13.50          | 0.83 | 0.77 | 0.159         |
| 23.00                    | 0.79 | 0.96 | 0.232         | 3.70           | 1.43 | 2.56 | 0.542         | 13.67          | 0.82 | 0.76 | 0.157         |
| 23.50                    | 0.76 | 0.92 | 0.228         | 3.83           | 1.38 | 2.49 | 0.534         | 13.83          | 0.81 | 0.75 | 0.154         |
| 24.00                    | 0.73 | 0.87 | 0.223         | 4.00           | 1.30 | 2.39 | 0.527         | 14.00          | 0.81 | 0.73 | 0.151         |
| 24.50                    | 0.70 | 0.83 | 0.218         | 4.17           | 1.26 | 2.27 | 0.510         | 14.17          | 0.80 | 0.72 | 0.149         |
| 25.00                    | 0.69 | 0.79 | 0.209         | 4.33           | 1.23 | 2.18 | 0.494         | 14.33          | 0.80 | 0.71 | 0.146         |
| 25.50                    | 0.68 | 0.76 | 0.200         | 4.50           | 1.20 | 2.10 | 0.482         | 14.50          | 0.79 | 0.79 | 0.144         |
| 26.00                    | 0.67 | 0.72 | 0.192         | 4.67           | 1.16 | 2.02 | 0.470         | 14.67          | 0.79 | 0.69 | 0.141         |
| 26.50                    | 0.67 | 0.69 | 0.181         | 4.83           | 1.14 | 1.93 | 0.451         | 14.83          | 0.78 | 0.67 | 0.138         |
| 27.00                    | 0.66 | 0.66 | 0.174         | 5.00           | 1.14 | 1.87 | 0.435         | 15.00          | 0.78 | 0.66 | 0.135         |
| 27.50                    | 0.66 | 0.63 | 0.166         | 5.17           | 1.12 | 1.81 | 0.425         | 15.17          | 0.78 | 0.65 | 0.131         |
| 28.00                    | 0.66 | 0.61 | 0.158         | 5.33           | 1.11 | 1.75 | 0.408         | 15.33          | 0.78 | 0.64 | 0.238         |
| 28.50                    | 0.66 | 0.59 | 0.151         | 5.50           | 1.09 | 1.17 | 0.401         | 15.50          | 0.77 | 0.63 | 0.126         |
| 29.00                    | 0.65 | 0.57 | 0.148         | 5.67           | 1.09 | 1.65 | 0.383         | 15.67          | 0.77 | 0.62 | 0.123         |
| 29.50                    | 0.64 | 0.55 | 0.145         | 5.83           | 1.10 | 1.61 | 0.373         | 15.83          | 0.77 | 0.61 | 0.119         |
| 30.00                    | 0.64 | 0.53 | 0.140         | 6.00           | 1.09 | 1.59 | 0.366         | 16.00          | 0.77 | 0.60 | 0.116         |
| 32.00                    | 0.62 | 0.44 | 0.119         | 6.17           | 1.08 | 1.57 | 0.365         | 16.17          | 0.78 | 0.58 | 0.112         |
| 34.00                    | 0.64 | 0.35 | 0.091         | 6.33           | 1.04 | 1.55 | 0.365         | 16.33          | 0.78 | 0.58 | 0.110         |
| 36.00                    | 0.69 | 0.27 | 0.059         | 6.50           | 1.02 | 1.51 | 0.358         | 16.50          | 0.78 | 0.57 | 0.107         |
| 38.00                    | 0.73 | 0.24 | 0.044         | 6.67           | 1.00 | 1.47 | 0.351         | 16.67          | 0.77 | 0.56 | 0.106         |
| 40.00                    | 0.76 | 0.22 | 0.034         | 6.83           | 0.97 | 1.43 | 0.346         | 16.83          | 0.78 | 0.55 | 0.103         |
| <i>Iron</i> <sup>5</sup> |      |      |               | 7.00           | 0.96 | 1.39 | 0.333         | 17.00          | 0.78 | 0.55 | 0.102         |
|                          |      |      |               | 7.17           | 0.94 | 1.35 | 0.327         | 17.17          | 0.78 | 0.54 | 0.100         |
|                          | 0.10 | 6.41 | 33.07         | 7.33           | 0.94 | 1.30 | 0.311         | 17.33          | 0.78 | 0.54 | 0.098         |
|                          | 0.15 | 6.26 | 22.82         | 7.50           | 0.94 | 1.26 | 0.298         | 17.50          | 0.77 | 0.53 | 0.097         |
|                          | 0.20 | 3.68 | 18.23         | 7.67           | 0.94 | 1.23 | 0.288         | 17.67          | 0.77 | 0.52 | 0.095         |
|                          | 0.26 | 4.98 | 13.68         | 7.83           | 0.94 | 1.21 | 0.279         | 17.83          | 0.78 | 0.51 | 0.092         |
|                          | 0.30 | 4.87 | 12.05         | 8.00           | 0.94 | 1.18 | 0.272         | 18.00          | 0.78 | 0.51 | 0.091         |
|                          | 0.36 | 4.68 | 10.44         | 8.17           | 0.94 | 1.16 | 0.265         | 18.17          | 0.78 | 0.51 | 0.090         |
|                          | 0.40 | 4.42 | 9.75          | 8.33           | 0.94 | 1.14 | 0.258         | 18.33          | 0.78 | 0.50 | 0.089         |
|                          | 0.50 | 4.14 | 8.02          | 8.50           | 0.94 | 1.12 | 0.251         | 18.50          | 0.77 | 0.50 | 0.089         |
|                          | 0.60 | 3.93 | 6.95          | 8.67           | 0.94 | 1.10 | 0.246         | 18.67          | 0.77 | 0.50 | 0.088         |
|                          | 0.70 | 3.78 | 6.17          | 8.83           | 0.92 | 1.08 | 0.240         | 18.83          | 0.77 | 0.49 | 0.087         |
|                          | 0.80 | 3.65 | 5.60          | 9.00           | 0.93 | 1.07 | 0.236         | 19.00          | 0.77 | 0.49 | 0.087         |
|                          | 0.90 | 3.52 | 5.16          | 9.17           | 0.92 | 1.06 | 0.233         | 19.17          | 0.76 | 0.49 | 0.088         |
|                          | 1.00 | 3.43 | 4.79          | 9.33           | 0.91 | 1.04 | 0.231         | 19.33          | 0.76 | 0.48 | 0.087         |
|                          | 1.10 | 3.33 | 4.52          |                |      |      |               |                |      |      |               |

| Energy<br>(eV)              | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV)                             | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV)                       | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) |
|-----------------------------|----------|----------|-------------------------|--------------------------------------------|----------|----------|-------------------------|--------------------------------------|----------|----------|-------------------------|
| 19.50                       | 0.75     | 0.47     | 0.086                   | 6.15                                       | 0.376    | 0.522    | 0.306                   | 4.24                                 | 1.85     | 2.14     | 0.417                   |
| 19.67                       | 0.75     | 0.47     | 0.085                   | 6.45                                       | 0.408    | 0.460    | 0.256                   | 4.36                                 | 1.85     | 2.08     | 0.406                   |
| 19.83                       | 0.75     | 0.46     | 0.084                   | 6.75                                       | 0.440    | 0.407    | 0.214                   | 4.49                                 | 1.86     | 2.03     | 0.395                   |
| 20.00                       | 0.74     | 0.45     | 0.083                   | 7.05                                       | 0.466    | 0.364    | 0.183                   | 4.61                                 | 1.85     | 1.99     | 0.388                   |
| 20.17                       | 0.74     | 0.44     | 0.081                   | 7.35                                       | 0.492    | 0.320    | 0.155                   | 4.74                                 | 1.84     | 1.94     | 0.378                   |
| 20.33                       | 0.74     | 0.44     | 0.081                   | 7.65                                       | 0.517    | 0.282    | 0.131                   | 4.86                                 | 1.83     | 1.91     | 0.372                   |
| 20.50                       | 0.74     | 0.42     | 0.080                   | 7.95                                       | 0.545    | 0.246    | 0.109                   | 4.98                                 | 1.82     | 1.86     | 0.362                   |
| 20.67                       | 0.73     | 0.43     | 0.079                   | 8.25                                       | 0.572    | 0.214    | 0.091                   | 5.11                                 | 1.82     | 1.82     | 0.354                   |
| 20.83                       | 0.73     | 0.42     | 0.078                   | 8.55                                       | 0.601    | 0.189    | 0.075                   | 5.23                                 | 1.81     | 1.79     | 0.348                   |
| 21.00                       | 0.73     | 0.41     | 0.077                   | 8.85                                       | 0.624    | 0.163    | 0.063                   | 5.36                                 | 1.78     | 1.76     | 0.342                   |
| 21.17                       | 0.72     | 0.40     | 0.076                   | 9.15                                       | 0.657    | 0.144    | 0.050                   | 5.48                                 | 1.74     | 1.73     | 0.337                   |
| 21.33                       | 0.72     | 0.39     | 0.074                   | 9.45                                       | 0.680    | 0.130    | 0.042                   | 5.60                                 | 1.73     | 1.70     | 0.331                   |
| 21.50                       | 0.72     | 0.38     | 0.073                   | 9.75                                       | 0.708    | 0.119    | 0.034                   | 5.73                                 | 1.72     | 1.67     | 0.325                   |
| 21.67                       | 0.72     | 0.38     | 0.071                   | 10.1                                       | 0.726    | 0.108    | 0.029                   | 5.85                                 | 1.70     | 1.64     | 0.319                   |
| 21.83                       | 0.72     | 0.37     | 0.070                   | 10.4                                       | 0.743    | 0.102    | 0.025                   | 5.98                                 | 1.67     | 1.61     | 0.313                   |
| 22.00                       | 0.72     | 0.36     | 0.068                   | 10.6                                       | 0.753    | 0.080    | 0.022                   | 6.10                                 | 1.63     | 1.58     | 0.307                   |
| 22.17                       | 0.71     | 0.35     | 0.067                   | <i>Magnesium (evaporated)<sup>13</sup></i> |          |          |                         | 6.22                                 | 1.62     | 1.55     | 0.301                   |
| 22.33                       | 0.72     | 0.34     | 0.064                   | 2.145                                      | 0.48     | 3.71     | 0.880                   | 6.35                                 | 1.59     | 1.52     | 0.295                   |
| 22.50                       | 0.72     | 0.34     | 0.063                   | 2.270                                      | 0.57     | 3.47     | 0.843                   | 6.47                                 | 1.55     | 1.50     | 0.292                   |
| 22.67                       | 0.72     | 0.33     | 0.062                   | 2.522                                      | 0.53     | 2.92     | 0.805                   | 6.60                                 | 1.48     | 1.47     | 0.288                   |
| 22.83                       | 0.72     | 0.32     | 0.059                   | 2.845                                      | 0.52     | 2.65     | 0.777                   | <i>Mercury (liquid)<sup>15</sup></i> |          |          |                         |
| 23.00                       | 0.72     | 0.31     | 0.058                   | 3.064                                      | 0.52     | 2.05     | 0.681                   | 0.2                                  | 13.99    | 14.27    | 0.869                   |
| 23.17                       | 0.72     | 0.30     | 0.056                   | 5.167                                      | 0.10     | 1.60     | 0.894                   | 0.3                                  | 11.37    | 11.95    | 0.846                   |
| 23.33                       | 0.72     | 0.29     | 0.054                   | 5.636                                      | 0.15     | 1.50     | 0.832                   | 0.4                                  | 9.741    | 10.65    | 0.830                   |
| 23.50                       | 0.73     | 0.28     | 0.050                   | 6.200                                      | 0.20     | 1.40     | 0.765                   | 0.5                                  | 8.528    | 9.805    | 0.818                   |
| 23.67                       | 0.73     | 0.28     | 0.049                   | 6.889                                      | 0.25     | 1.30     | 0.693                   | 0.6                                  | 7.574    | 9.195    | 0.808                   |
| 23.83                       | 0.74     | 0.27     | 0.047                   | 7.750                                      | 0.20     | 1.20     | 0.722                   | 0.8                                  | 6.086    | 8.312    | 0.796                   |
| 24.00                       | 0.74     | 0.27     | 0.045                   | 8.857                                      | 0.15     | 0.95     | 0.730                   | 1.0                                  | 4.962    | 7.643    | 0.789                   |
| 24.17                       | 0.74     | 0.26     | 0.044                   | 10.335                                     | 0.25     | 0.40     | 0.419                   | 1.2                                  | 4.050    | 7.082    | 0.786                   |
| 24.33                       | 0.74     | 0.26     | 0.043                   | <i>Manganese<sup>14</sup></i>              |          |          |                         | 1.4                                  | 3.324    | 6.558    | 0.785                   |
| 24.50                       | 0.74     | 0.25     | 0.042                   | 0.64                                       | 3.89     | 5.95     | 0.738                   | 1.6                                  | 2.746    | 6.054    | 0.783                   |
| 24.67                       | 0.75     | 0.25     | 0.040                   | 0.77                                       | 3.78     | 5.41     | 0.710                   | 1.8                                  | 2.284    | 5.582    | 0.782                   |
| 24.83                       | 0.75     | 0.24     | 0.039                   | 0.89                                       | 3.65     | 5.02     | 0.688                   | 2.0                                  | 1.910    | 5.150    | 0.782                   |
| 25.00                       | 0.75     | 0.24     | 0.038                   | 1.02                                       | 3.48     | 4.74     | 0.673                   | 2.2                                  | 1.620    | 4.751    | 0.780                   |
| 26.00                       | 0.76     | 0.21     | 0.031                   | 1.14                                       | 3.30     | 4.53     | 0.662                   | 2.4                                  | 1.384    | 4.407    | 0.779                   |
| 27.00                       | 0.78     | 0.18     | 0.026                   | 1.26                                       | 3.10     | 4.35     | 0.653                   | 2.6                                  | 1.186    | 4.090    | 0.779                   |
| 28.00                       | 0.79     | 0.16     | 0.021                   | 1.39                                       | 2.97     | 4.18     | 0.643                   | 2.8                                  | 1.027    | 3.802    | 0.779                   |
| 29.00                       | 0.81     | 0.14     | 0.017                   | 1.51                                       | 2.83     | 4.03     | 0.634                   | 3.0                                  | 0.898    | 3.538    | 0.777                   |
| 30.00                       | 0.82     | 0.13     | 0.014                   | 1.64                                       | 2.70     | 3.91     | 0.627                   | 3.2                                  | 0.798    | 3.294    | 0.773                   |
| <i>Lithium<sup>12</sup></i> |          |          |                         | 1.76                                       | 2.62     | 3.78     | 0.617                   | 3.4                                  | 0.713    | 3.074    | 0.770                   |
| 0.14                        | 0.659    | 38.0     | 0.998                   | 1.88                                       | 2.56     | 3.65     | 0.606                   | 3.6                                  | 0.644    | 2.860    | 0.763                   |
| 0.54                        | 0.661    | 12.6     | 0.984                   | 2.01                                       | 2.51     | 3.54     | 0.596                   | 3.8                                  | 0.589    | 2.665    | 0.755                   |
| 0.75                        | 0.561    | 7.68     | 0.963                   | 2.13                                       | 2.47     | 3.43     | 0.585                   | 4.0                                  | 0.542    | 2.502    | 0.749                   |
| 1.05                        | 0.448    | 5.58     | 0.946                   | 2.26                                       | 2.39     | 3.33     | 0.577                   | 4.2                                  | 0.507    | 2.341    | 0.738                   |
| 1.35                        | 0.338    | 4.36     | 0.935                   | 2.38                                       | 2.32     | 3.23     | 0.567                   | 4.4                                  | 0.477    | 2.195    | 0.727                   |
| 1.65                        | 0.265    | 3.55     | 0.925                   | 2.50                                       | 2.25     | 3.14     | 0.559                   | 4.6                                  | 0.452    | 2.058    | 0.715                   |
| 1.95                        | 0.221    | 2.94     | 0.913                   | 2.63                                       | 2.19     | 3.06     | 0.552                   | 4.8                                  | 0.431    | 1.929    | 0.701                   |
| 2.25                        | 0.206    | 2.48     | 0.892                   | 2.75                                       | 2.11     | 2.98     | 0.545                   | 5.0                                  | 0.414    | 1.806    | 0.685                   |
| 2.55                        | 0.217    | 2.11     | 0.854                   | 2.88                                       | 2.06     | 2.90     | 0.536                   | 5.2                                  | 0.401    | 1.687    | 0.666                   |
| 2.85                        | 0.247    | 1.82     | 0.797                   | 3.00                                       | 2.00     | 2.82     | 0.528                   | 5.4                                  | 0.394    | 1.569    | 0.642                   |
| 3.15                        | 0.304    | 1.60     | 0.715                   | 3.12                                       | 1.96     | 2.74     | 0.518                   | 5.6                                  | 0.386    | 1.454    | 0.617                   |
| 3.45                        | 0.334    | 1.45     | 0.656                   | 3.25                                       | 1.92     | 2.67     | 0.509                   | 5.7                                  | 0.386    | 1.396    | 0.601                   |
| 3.75                        | 0.345    | 1.32     | 0.611                   | 3.37                                       | 1.89     | 2.59     | 0.498                   | 5.8                                  | 0.386    | 1.341    | 0.585                   |
| 4.05                        | 0.346    | 1.21     | 0.578                   | 3.50                                       | 1.89     | 2.51     | 0.484                   | 5.9                                  | 0.385    | 1.287    | 0.569                   |
| 4.35                        | 0.333    | 1.11     | 0.557                   | 3.62                                       | 1.87     | 2.45     | 0.475                   | 6.0                                  | 0.386    | 1.232    | 0.551                   |
| 4.65                        | 0.317    | 1.01     | 0.540                   | 3.74                                       | 1.86     | 2.38     | 0.463                   | 6.1                                  | 0.388    | 1.176    | 0.531                   |
| 4.95                        | 0.302    | 0.906    | 0.520                   | 3.87                                       | 1.86     | 2.32     | 0.451                   | 6.2                                  | 0.390    | 1.118    | 0.510                   |
| 5.25                        | 0.299    | 0.795    | 0.484                   | 3.99                                       | 1.86     | 2.25     | 0.438                   | 6.3                                  | 0.399    | 1.058    | 0.481                   |
| 5.55                        | 0.310    | 0.688    | 0.434                   | 4.12                                       | 1.86     | 2.19     | 0.427                   | 6.4                                  | 0.412    | 1.002    | 0.450                   |
| 5.85                        | 0.342    | 0.594    | 0.365                   |                                            |          |          |                         | 6.5                                  | 0.428    | 0.949    | 0.418                   |



| Energy<br>(eV)                  | $n$   | $k$   | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ |
|---------------------------------|-------|-------|---------------|----------------|------|------|---------------|----------------|------|------|---------------|
| 6.6                             | 0.436 | 0.898 | 0.392         | 0.70           | 1.48 | 8.99 | 0.932         | 8.80           | 0.65 | 1.41 | 0.450         |
| 6.7                             | 0.438 | 0.836 | 0.367         | 0.74           | 1.51 | 8.38 | 0.921         | 9.00           | 0.65 | 1.33 | 0.420         |
| 6.8                             | 0.459 | 0.756 | 0.320         | 0.78           | 1.60 | 7.83 | 0.906         | 9.20           | 0.67 | 1.25 | 0.385         |
| 6.9                             | 0.510 | 0.676 | 0.255         | 0.82           | 1.64 | 7.35 | 0.892         | 9.40           | 0.69 | 1.19 | 0.355         |
| 7.0                             | 0.585 | 0.617 | 0.191         | 0.86           | 1.70 | 6.89 | 0.876         | 9.60           | 0.71 | 1.12 | 0.320         |
| 7.1                             | 0.663 | 0.589 | 0.148         | 9.90           | 1.74 | 6.48 | 0.859         | 9.80           | 0.74 | 1.05 | 0.285         |
| 7.2                             | 0.717 | 0.584 | 0.128         | 1.00           | 1.94 | 5.58 | 0.805         | 10.00          | 0.77 | 0.99 | 0.250         |
| 7.3                             | 0.769 | 0.575 | 0.111         | 1.10           | 2.15 | 4.85 | 0.743         | 10.20          | 0.81 | 0.93 | 0.217         |
| 7.4                             | 0.817 | 0.574 | 0.100         | 1.20           | 2.44 | 4.22 | 0.671         | 10.40          | 0.86 | 0.88 | 0.188         |
| 7.5                             | 0.860 | 0.580 | 0.094         | 1.30           | 2.77 | 3.74 | 0.608         | 10.60          | 0.91 | 0.83 | 0.162         |
| 7.6                             | 0.893 | 0.597 | 0.093         | 1.40           | 3.15 | 3.40 | 0.562         | 10.80          | 0.98 | 0.79 | 0.138         |
| 7.8                             | 0.929 | 0.623 | 0.096         | 1.50           | 3.53 | 3.30 | 0.550         | 11.00          | 1.05 | 0.77 | 0.125         |
| 8.0                             | 0.946 | 0.639 | 0.098         | 1.60           | 3.77 | 3.41 | 0.562         | 11.20          | 1.12 | 0.78 | 0.123         |
| 8.2                             | 0.952 | 0.645 | 0.099         | 1.70           | 3.84 | 3.51 | 0.570         | 11.40          | 1.18 | 0.80 | 0.125         |
| 8.4                             | 0.953 | 0.638 | 0.097         | 1.80           | 3.81 | 3.58 | 0.576         | 11.60          | 1.23 | 0.85 | 0.135         |
| 8.6                             | 0.956 | 0.624 | 0.093         | 1.90           | 3.74 | 3.58 | 0.576         | 11.80          | 1.25 | 0.89 | 0.145         |
| 8.8                             | 0.965 | 0.607 | 0.087         | 2.00           | 3.68 | 3.52 | 0.571         | 12.00          | 1.26 | 0.92 | 0.154         |
| 9.0                             | 0.975 | 0.588 | 0.082         | 2.10           | 3.68 | 3.45 | 0.565         | 12.40          | 1.25 | 0.98 | 0.168         |
| 9.2                             | 0.988 | 0.568 | 0.076         | 2.20           | 3.76 | 3.41 | 0.562         | 12.80          | 1.23 | 1.00 | 0.178         |
| 9.4                             | 1.009 | 0.548 | 0.069         | 2.30           | 3.79 | 3.61 | 0.578         | 13.20          | 1.20 | 1.02 | 0.185         |
| 9.6                             | 1.044 | 0.541 | 0.066         | 2.40           | 3.59 | 3.78 | 0.594         | 13.60          | 1.17 | 1.02 | 0.187         |
| 9.8                             | 1.061 | 0.557 | 0.069         | 2.50           | 3.36 | 3.73 | 0.591         | 14.00          | 1.15 | 1.01 | 0.185         |
| 10.0                            | 1.062 | 0.567 | 0.071         | 2.60           | 3.22 | 3.61 | 0.582         | 14.40          | 1.13 | 1.00 | 0.182         |
| 10.2                            | 1.054 | 0.569 | 0.072         | 2.70           | 3.13 | 3.51 | 0.573         | 14.80          | 1.13 | 0.99 | 0.179         |
| 10.4                            | 1.045 | 0.561 | 0.070         | 2.80           | 3.08 | 3.42 | 0.565         | 15.00          | 1.14 | 0.99 | 0.179         |
| 10.6                            | 1.041 | 0.550 | 0.068         | 2.90           | 3.05 | 3.33 | 0.566         | 15.60          | 1.15 | 1.01 | 0.184         |
| 10.8                            | 1.039 | 0.537 | 0.065         | 3.00           | 3.04 | 3.27 | 0.550         | 16.00          | 1.14 | 1.04 | 0.194         |
| 11.0                            | 1.039 | 0.523 | 0.062         | 3.10           | 3.03 | 3.21 | 0.544         | 16.60          | 1.10 | 1.10 | 0.216         |
| 11.5                            | 1.050 | 0.491 | 0.055         | 3.20           | 3.05 | 3.18 | 0.540         | 17.00          | 1.04 | 1.12 | 0.233         |
| 12.0                            | 1.064 | 0.467 | 0.050         | 3.30           | 3.06 | 3.18 | 0.540         | 17.60          | 0.94 | 1.14 | 0.257         |
| 12.5                            | 1.078 | 0.445 | 0.045         | 3.40           | 3.06 | 3.19 | 0.541         | 18.00          | 0.87 | 1.12 | 0.270         |
| 13.0                            | 1.092 | 0.430 | 0.042         | 3.50           | 3.06 | 3.21 | 0.543         | 18.60          | 0.77 | 1.08 | 0.283         |
| 13.5                            | 1.104 | 0.416 | 0.040         | 3.60           | 3.05 | 3.23 | 0.546         | 19.00          | 0.71 | 1.02 | 0.284         |
| 14.0                            | 1.115 | 0.404 | 0.038         | 3.70           | 3.04 | 3.27 | 0.550         | 19.60          | 0.66 | 0.94 | 0.275         |
| 14.5                            | 1.125 | 0.394 | 0.037         | 3.80           | 3.04 | 3.31 | 0.554         | 20.00          | 0.64 | 0.89 | 0.264         |
| 15.0                            | 1.135 | 0.383 | 0.035         | 3.90           | 3.04 | 3.40 | 0.564         | 20.60          | 0.62 | 0.81 | 0.245         |
| 15.5                            | 1.146 | 0.374 | 0.034         | 4.00           | 3.01 | 3.51 | 0.576         | 21.00          | 0.61 | 0.77 | 0.234         |
| 16.0                            | 1.159 | 0.368 | 0.034         | 4.20           | 2.77 | 3.77 | 0.610         | 21.60          | 0.61 | 0.71 | 0.215         |
| 16.5                            | 1.170 | 0.367 | 0.034         | 4.40           | 2.39 | 3.88 | 0.640         | 22.00          | 0.60 | 0.69 | 0.207         |
| 17.0                            | 1.177 | 0.367 | 0.034         | 4.60           | 2.06 | 3.84 | 0.658         | 22.60          | 0.59 | 0.63 | 0.195         |
| 17.5                            | 1.184 | 0.366 | 0.034         | 4.80           | 1.75 | 3.76 | 0.678         | 23.00          | 0.58 | 0.60 | 0.185         |
| 18.0                            | 1.191 | 0.367 | 0.035         | 5.00           | 1.46 | 3.62 | 0.695         | 23.60          | 0.58 | 0.53 | 0.166         |
| 18.5                            | 1.195 | 0.367 | 0.035         | 5.20           | 1.22 | 3.42 | 0.706         | 24.00          | 0.58 | 0.49 | 0.151         |
| 19.0                            | 1.200 | 0.366 | 0.035         | 5.40           | 1.07 | 3.20 | 0.706         | 24.60          | 0.60 | 0.43 | 0.124         |
| 19.5                            | 1.208 | 0.364 | 0.035         | 5.60           | 0.96 | 2.99 | 0.700         | 25.00          | 0.62 | 0.39 | 0.106         |
| <i>Molybdenum</i> <sup>16</sup> |       |       |               | 5.80           | 0.89 | 2.80 | 0.688         | 25.60          | 0.66 | 0.35 | 0.085         |
| 0.10                            | 18.53 | 68.51 | 0.985         | 6.00           | 0.85 | 2.64 | 0.674         | 26.00          | 0.68 | 0.33 | 0.072         |
| 0.15                            | 8.78  | 47.54 | 0.985         | 6.20           | 0.81 | 2.50 | 0.660         | 26.50          | 0.71 | 0.31 | 0.060         |
| 0.20                            | 5.10  | 35.99 | 0.985         | 6.40           | 0.79 | 2.36 | 0.641         | 27.00          | 0.73 | 0.29 | 0.050         |
| 0.25                            | 3.36  | 28.75 | 0.984         | 6.60           | 0.78 | 2.24 | 0.619         | 27.50          | 0.76 | 0.28 | 0.041         |
| 0.30                            | 2.44  | 23.80 | 0.983         | 6.80           | 0.78 | 2.13 | 0.592         | 28.00          | 0.79 | 0.27 | 0.036         |
| 0.34                            | 2.00  | 20.84 | 0.982         | 7.00           | 0.80 | 2.04 | 0.568         | 28.50          | 0.81 | 0.26 | 0.031         |
| 0.38                            | 1.70  | 18.44 | 0.980         | 7.20           | 0.81 | 1.98 | 0.548         | 29.00          | 0.83 | 0.26 | 0.028         |
| 0.42                            | 1.57  | 16.50 | 0.978         | 7.40           | 0.81 | 1.95 | 0.542         | 29.50          | 0.86 | 0.26 | 0.025         |
| 0.46                            | 1.46  | 14.91 | 0.975         | 7.60           | 0.75 | 1.90 | 0.552         | 30.00          | 0.88 | 0.26 | 0.023         |
| 0.50                            | 1.37  | 13.55 | 0.971         | 7.80           | 0.71 | 1.81 | 0.542         | 31.00          | 0.92 | 0.29 | 0.024         |
| 0.54                            | 1.35  | 12.36 | 0.966         | 8.00           | 0.69 | 1.73 | 0.530         | 32.00          | 0.92 | 0.32 | 0.030         |
| 0.58                            | 1.34  | 11.34 | 0.960         | 8.20           | 0.67 | 1.65 | 0.512         | 33.00          | 0.90 | 0.33 | 0.032         |
| 0.62                            | 1.38  | 10.44 | 0.952         | 8.40           | 0.66 | 1.57 | 0.495         | 34.00          | 0.91 | 0.34 | 0.034         |
| 0.66                            | 1.43  | 9.67  | 0.942         | 8.60           | 0.65 | 1.49 | 0.475         | 35.00          | 0.87 | 0.37 | 0.043         |

| Energy<br>(eV)              | $n$  | $k$   | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)               | $n$   | $k$   | $R(\phi = 0)$ |
|-----------------------------|------|-------|---------------|----------------|------|------|---------------|------------------------------|-------|-------|---------------|
| 36.00                       | 0.82 | 0.34  | 0.043         | 6.60           | 1.01 | 1.40 | 0.325         | 25.00                        | 0.89  | 0.42  | 0.050         |
| 37.00                       | 0.81 | 0.30  | 0.038         | 6.80           | 1.02 | 1.35 | 0.308         | 26.00                        | 0.88  | 0.39  | 0.046         |
| 38.00                       | 0.81 | 0.27  | 0.033         | 7.00           | 1.03 | 1.30 | 0.291         | 27.00                        | 0.87  | 0.37  | 0.042         |
| 39.00                       | 0.82 | 0.25  | 0.029         | 7.20           | 1.03 | 1.27 | 0.282         | 28.00                        | 0.87  | 0.35  | 0.040         |
| 40.00                       | 0.83 | 0.23  | 0.025         | 7.40           | 1.03 | 1.24 | 0.273         | 29.00                        | 0.86  | 0.34  | 0.037         |
| <i>Nickel</i> <sup>17</sup> |      |       |               | 7.60           | 1.02 | 1.22 | 0.265         | 30.00                        | 0.86  | 0.32  | 0.034         |
| 0.10                        | 9.54 | 45.82 | 0.983         | 7.80           | 1.01 | 1.18 | 0.256         | 35.00                        | 0.86  | 0.24  | 0.022         |
| 0.15                        | 5.45 | 30.56 | 0.978         | 8.00           | 1.01 | 1.15 | 0.248         | 40.00                        | 0.87  | 0.18  | 0.014         |
| 0.20                        | 4.12 | 22.48 | 0.969         | 8.20           | 1.00 | 1.13 | 0.242         | 45.00                        | 0.88  | 0.13  | 0.008         |
| 0.25                        | 4.25 | 17.68 | 0.950         | 8.40           | 0.99 | 1.11 | 0.235         | 50.00                        | 0.92  | 0.10  | 0.004         |
| 0.30                        | 4.19 | 15.05 | 0.934         | 8.60           | 0.98 | 1.08 | 0.228         | 60.00                        | 0.96  | 0.08  | 0.002         |
| 0.35                        | 4.03 | 13.05 | 0.918         | 8.80           | 0.97 | 1.05 | 0.220         | 65.00                        | 0.98  | 0.09  | 0.002         |
| 0.40                        | 3.84 | 11.43 | 0.900         | 9.00           | 0.97 | 1.01 | 0.211         | 68.00                        | 0.96  | 0.12  | 0.004         |
| 0.50                        | 4.03 | 9.64  | 0.864         | 9.20           | 0.96 | 0.99 | 0.203         | 70.00                        | 0.94  | 0.11  | 0.004         |
| 0.60                        | 3.84 | 8.35  | 0.835         | 9.40           | 0.95 | 0.96 | 0.194         | 75.00                        | 0.94  | 0.09  | 0.003         |
| 0.70                        | 3.59 | 7.48  | 0.813         | 9.60           | 0.95 | 0.93 | 0.185         | 80.00                        | 0.94  | 0.07  | 0.002         |
| 0.80                        | 3.38 | 6.82  | 0.794         | 9.80           | 0.95 | 0.89 | 0.175         | 90.00                        | 0.94  | 0.06  | 0.002         |
| 0.90                        | 3.18 | 6.23  | 0.774         | 10.00          | 0.95 | 0.87 | 0.166         | <i>Niobium</i> <sup>18</sup> |       |       |               |
| 1.00                        | 3.06 | 5.74  | 0.753         | 10.20          | 0.95 | 0.83 | 0.155         | 0.12                         | 15.99 | 53.20 | 0.979         |
| 1.10                        | 2.97 | 5.38  | 0.734         | 10.40          | 0.95 | 0.80 | 0.145         | 0.20                         | 7.25  | 34.14 | 0.976         |
| 1.20                        | 2.85 | 5.10  | 0.721         | 10.60          | 0.97 | 0.76 | 0.129         | 0.24                         | 5.47  | 28.88 | 0.975         |
| 1.30                        | 2.74 | 4.85  | 0.708         | 10.80          | 0.99 | 0.75 | 0.123         | 0.28                         | 4.26  | 24.95 | 0.974         |
| 1.40                        | 2.65 | 4.63  | 0.695         | 11.00          | 1.01 | 0.73 | 0.115         | 0.35                         | 3.11  | 20.03 | 0.970         |
| 1.50                        | 2.53 | 4.47  | 0.688         | 11.25          | 1.04 | 0.72 | 0.111         | 0.45                         | 2.28  | 15.58 | 0.964         |
| 1.60                        | 2.43 | 4.31  | 0.679         | 11.50          | 1.05 | 0.71 | 0.109         | 0.55                         | 1.83  | 12.67 | 0.956         |
| 1.70                        | 2.28 | 4.18  | 0.677         | 11.75          | 1.07 | 0.71 | 0.108         | 0.65                         | 1.57  | 10.59 | 0.947         |
| 1.80                        | 2.14 | 4.01  | 0.670         | 12.00          | 1.07 | 0.71 | 0.108         | 0.75                         | 1.41  | 9.00  | 0.935         |
| 1.90                        | 2.02 | 3.82  | 0.659         | 12.25          | 1.07 | 0.71 | 0.107         | 0.85                         | 1.35  | 7.74  | 0.918         |
| 2.00                        | 1.92 | 3.65  | 0.649         | 12.50          | 1.08 | 0.71 | 0.106         | 0.95                         | 1.35  | 6.70  | 0.893         |
| 2.10                        | 1.85 | 3.48  | 0.634         | 12.75          | 1.08 | 0.71 | 0.106         | 1.05                         | 1.44  | 5.86  | 0.857         |
| 2.20                        | 1.80 | 3.33  | 0.620         | 13.00          | 1.08 | 0.71 | 0.105         | 1.15                         | 1.55  | 5.18  | 0.814         |
| 2.30                        | 1.75 | 3.19  | 0.605         | 13.25          | 1.08 | 0.71 | 0.105         | 1.25                         | 1.65  | 4.63  | 0.768         |
| 2.40                        | 1.71 | 3.06  | 0.590         | 13.50          | 1.07 | 0.70 | 0.105         | 1.35                         | 1.76  | 4.13  | 0.715         |
| 2.50                        | 1.67 | 2.93  | 0.575         | 13.75          | 1.07 | 0.70 | 0.105         | 1.45                         | 1.95  | 3.68  | 0.650         |
| 2.60                        | 1.65 | 2.81  | 0.557         | 14.00          | 1.07 | 0.71 | 0.106         | 1.55                         | 2.15  | 3.37  | 0.595         |
| 2.70                        | 1.64 | 2.71  | 0.542         | 14.25          | 1.06 | 0.70 | 0.106         | 1.65                         | 2.36  | 3.13  | 0.552         |
| 2.80                        | 1.63 | 2.61  | 0.525         | 14.50          | 1.05 | 0.70 | 0.106         | 1.75                         | 2.54  | 2.99  | 0.527         |
| 2.90                        | 1.62 | 2.52  | 0.509         | 14.75          | 1.04 | 0.70 | 0.107         | 1.85                         | 2.69  | 2.89  | 0.510         |
| 3.00                        | 1.61 | 2.44  | 0.495         | 15.00          | 1.03 | 0.70 | 0.107         | 1.95                         | 2.82  | 2.86  | 0.505         |
| 3.10                        | 1.61 | 2.36  | 0.480         | 15.25          | 1.02 | 0.69 | 0.106         | 2.05                         | 2.89  | 2.87  | 0.505         |
| 3.20                        | 1.61 | 2.30  | 0.467         | 15.50          | 1.01 | 0.69 | 0.105         | 2.15                         | 2.92  | 2.87  | 0.505         |
| 3.30                        | 1.61 | 2.23  | 0.454         | 15.75          | 1.00 | 0.68 | 0.104         | 2.25                         | 2.93  | 2.87  | 0.505         |
| 3.40                        | 1.62 | 2.17  | 0.441         | 16.00          | 0.99 | 0.67 | 0.103         | 2.35                         | 2.92  | 2.88  | 0.506         |
| 3.50                        | 1.63 | 2.11  | 0.428         | 16.50          | 0.98 | 0.66 | 0.101         | 2.45                         | 2.89  | 2.90  | 0.509         |
| 3.60                        | 1.64 | 2.07  | 0.416         | 17.00          | 0.96 | 0.64 | 0.098         | 2.55                         | 2.83  | 2.92  | 0.512         |
| 3.70                        | 1.66 | 2.02  | 0.405         | 17.50          | 0.94 | 0.63 | 0.096         | 2.65                         | 2.74  | 2.90  | 0.511         |
| 3.80                        | 1.69 | 1.99  | 0.397         | 18.00          | 0.92 | 0.61 | 0.092         | 2.75                         | 2.66  | 2.86  | 0.507         |
| 3.90                        | 1.72 | 1.98  | 0.393         | 18.50          | 0.91 | 0.58 | 0.087         | 2.85                         | 2.58  | 2.80  | 0.500         |
| 4.00                        | 1.73 | 1.98  | 0.392         | 19.00          | 0.90 | 0.56 | 0.082         | 3.00                         | 2.51  | 2.68  | 0.485         |
| 4.20                        | 1.74 | 2.01  | 0.396         | 19.50          | 0.90 | 0.54 | 0.077         | 3.10                         | 2.48  | 2.60  | 0.475         |
| 4.40                        | 1.71 | 2.06  | 0.409         | 20.00          | 0.89 | 0.51 | 0.071         | 3.20                         | 2.45  | 2.53  | 0.465         |
| 4.60                        | 1.63 | 2.09  | 0.421         | 20.50          | 0.89 | 0.49 | 0.066         | 3.30                         | 2.44  | 2.45  | 0.453         |
| 4.80                        | 1.53 | 2.11  | 0.435         | 21.00          | 0.90 | 0.47 | 0.061         | 3.40                         | 2.46  | 2.38  | 0.442         |
| 5.00                        | 1.40 | 2.10  | 0.449         | 21.50          | 0.91 | 0.46 | 0.057         | 3.50                         | 2.48  | 2.33  | 0.435         |
| 5.20                        | 1.27 | 2.04  | 0.454         | 22.00          | 0.91 | 0.45 | 0.055         | 3.60                         | 2.52  | 2.29  | 0.428         |
| 5.40                        | 1.16 | 1.94  | 0.449         | 22.50          | 0.91 | 0.44 | 0.053         | 3.70                         | 2.56  | 2.27  | 0.426         |
| 5.60                        | 1.09 | 1.83  | 0.435         | 23.00          | 0.92 | 0.44 | 0.051         | 3.80                         | 2.59  | 2.28  | 0.427         |
| 5.80                        | 1.04 | 1.73  | 0.417         | 23.50          | 0.91 | 0.44 | 0.052         | 3.90                         | 2.62  | 2.29  | 0.429         |
| 6.20                        | 1.00 | 1.54  | 0.371         | 24.00          | 0.90 | 0.43 | 0.051         | 4.00                         | 2.64  | 2.33  | 0.434         |
| 6.40                        | 1.01 | 1.46  | 0.345         | 24.50          | 0.90 | 0.43 | 0.051         | 4.20                         | 2.64  | 2.42  | 0.447         |



| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)                              | $n$  | $k$   | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ |
|----------------|------|------|---------------|---------------------------------------------|------|-------|---------------|----------------|------|------|---------------|
| 4.40           | 2.53 | 2.56 | 0.467         | 20.60                                       | 0.71 | 0.55  | 0.119         | 2.20           | 4.58 | 1.62 | 0.457         |
| 4.60           | 2.39 | 2.56 | 0.470         | 21.00                                       | 0.72 | 0.50  | 0.100         | 2.30           | 4.84 | 1.76 | 0.479         |
| 4.80           | 2.32 | 2.52 | 0.465         | 21.60                                       | 0.75 | 0.43  | 0.075         | 2.40           | 5.10 | 2.01 | 0.506         |
| 5.00           | 2.26 | 2.57 | 0.475         | 22.00                                       | 0.78 | 0.40  | 0.063         | 2.50           | 5.28 | 2.38 | 0.532         |
| 5.20           | 2.16 | 2.62 | 0.487         | 22.60                                       | 0.82 | 0.35  | 0.045         | 2.60           | 5.36 | 2.82 | 0.557         |
| 5.40           | 2.00 | 2.68 | 0.505         | 23.00                                       | 0.85 | 0.33  | 0.038         | 2.70           | 5.30 | 3.29 | 0.580         |
| 5.60           | 1.81 | 2.67 | 0.518         | 23.60                                       | 0.88 | 0.30  | 0.029         | 2.80           | 5.07 | 3.78 | 0.603         |
| 5.80           | 1.63 | 2.60 | 0.522         | 24.00                                       | 0.91 | 0.29  | 0.025         | 2.90           | 4.65 | 4.18 | 0.624         |
| 6.00           | 1.49 | 2.49 | 0.520         | 24.60                                       | 0.94 | 0.28  | 0.022         | 3.00           | 4.05 | 4.40 | 0.639         |
| 6.20           | 1.38 | 2.38 | 0.512         | 25.00                                       | 0.96 | 0.27  | 0.020         | 3.20           | 3.29 | 3.96 | 0.614         |
| 6.40           | 1.31 | 2.25 | 0.496         | 25.60                                       | 0.99 | 0.26  | 0.018         | 3.40           | 2.93 | 3.79 | 0.607         |
| 6.60           | 1.26 | 2.14 | 0.480         | 26.00                                       | 1.00 | 0.26  | 0.017         | 3.60           | 2.75 | 3.45 | 0.577         |
| 6.80           | 1.24 | 2.04 | 0.460         | 26.60                                       | 1.03 | 0.25  | 0.016         | 3.80           | 2.73 | 3.32 | 0.562         |
| 7.00           | 1.23 | 1.96 | 0.441         | 27.00                                       | 1.04 | 0.25  | 0.015         | 4.00           | 2.71 | 3.34 | 0.565         |
| 7.20           | 1.22 | 1.91 | 0.430         | 27.60                                       | 1.06 | 0.25  | 0.015         | 4.20           | 2.53 | 3.44 | 0.584         |
| 7.40           | 1.20 | 1.88 | 0.427         | 28.00                                       | 1.08 | 0.24  | 0.015         | 4.40           | 2.24 | 3.44 | 0.599         |
| 7.60           | 1.14 | 1.85 | 0.430         | 28.60                                       | 1.11 | 0.24  | 0.016         | 4.60           | 2.01 | 3.31 | 0.598         |
| 7.80           | 1.07 | 1.78 | 0.428         | 29.00                                       | 1.13 | 0.25  | 0.017         | 4.80           | 1.88 | 3.19 | 0.592         |
| 8.00           | 1.02 | 1.69 | 0.412         | 29.60                                       | 1.16 | 0.26  | 0.020         | 5.00           | 1.74 | 3.12 | 0.596         |
| 8.20           | 1.00 | 1.60 | 0.390         | 30.00                                       | 1.18 | 0.28  | 0.023         | 5.20           | 1.58 | 3.00 | 0.597         |
| 8.40           | 0.99 | 1.51 | 0.365         | 31.00                                       | 1.18 | 0.31  | 0.026         | 5.40           | 1.46 | 2.88 | 0.593         |
| 8.60           | 0.99 | 1.43 | 0.340         | 32.00                                       | 1.20 | 0.34  | 0.031         | 5.60           | 1.36 | 2.77 | 0.589         |
| 8.70           | 0.99 | 1.39 | 0.328         | 33.00                                       | 1.21 | 0.38  | 0.038         | 5.80           | 1.27 | 2.65 | 0.582         |
| 8.80           | 1.00 | 1.36 | 0.315         | 34.00                                       | 1.20 | 0.42  | 0.044         | 6.00           | 1.20 | 2.54 | 0.575         |
| 9.00           | 1.01 | 1.29 | 0.290         | 35.20                                       | 1.17 | 0.47  | 0.051         | 6.20           | 1.13 | 2.44 | 0.571         |
| 9.20           | 1.04 | 1.22 | 0.265         | 36.00                                       | 1.15 | 0.50  | 0.056         | 6.40           | 1.06 | 2.33 | 0.562         |
| 9.40           | 1.07 | 1.18 | 0.245         | 37.50                                       | 1.07 | 0.53  | 0.064         | 6.60           | 1.01 | 2.21 | 0.548         |
| 9.60           | 1.10 | 1.13 | 0.227         | 39.50                                       | 0.95 | 0.50  | 0.063         | 6.80           | 0.97 | 2.11 | 0.532         |
| 9.80           | 1.13 | 1.09 | 0.209         | 40.50                                       | 0.92 | 0.47  | 0.059         | 7.00           | 0.95 | 2.00 | 0.514         |
| 10.00          | 1.18 | 1.05 | 0.194         | <i>Osmium (Polycrystalline)<sup>9</sup></i> |      |       |               | 7.20           | 0.92 | 1.91 | 0.497         |
| 10.20          | 1.23 | 1.04 | 0.187         | 0.10                                        | 4.08 | 50.23 | 0.994         | 7.40           | 0.91 | 1.81 | 0.476         |
| 10.40          | 1.27 | 1.04 | 0.185         | 0.15                                        | 2.90 | 33.60 | 0.990         | 7.60           | 0.90 | 1.72 | 0.451         |
| 10.60          | 1.30 | 1.06 | 0.190         | 0.20                                        | 2.44 | 25.11 | 0.985         | 7.80           | 0.90 | 1.63 | 0.426         |
| 10.80          | 1.32 | 1.08 | 0.195         | 0.25                                        | 2.35 | 19.99 | 0.977         | 8.00           | 0.91 | 1.55 | 0.400         |
| 11.00          | 1.32 | 1.10 | 0.200         | 0.30                                        | 2.23 | 16.54 | 0.969         | 8.20           | 0.91 | 1.48 | 0.375         |
| 11.20          | 1.31 | 1.12 | 0.204         | 0.35                                        | 2.33 | 14.06 | 0.955         | 8.40           | 0.94 | 1.40 | 0.344         |
| 11.40          | 1.30 | 1.13 | 0.207         | 0.40                                        | 2.45 | 12.32 | 0.940         | 8.60           | 0.96 | 1.34 | 0.319         |
| 11.60          | 1.28 | 1.13 | 0.209         | 0.45                                        | 2.43 | 11.02 | 0.927         | 8.80           | 0.98 | 1.29 | 0.296         |
| 11.80          | 1.27 | 1.13 | 0.210         | 0.50                                        | 2.41 | 9.97  | 0.913         | 9.00           | 1.01 | 1.24 | 0.274         |
| 12.00          | 1.25 | 1.12 | 0.209         | 0.55                                        | 2.33 | 9.12  | 0.901         | 9.20           | 1.04 | 1.19 | 0.255         |
| 12.40          | 1.24 | 1.10 | 0.204         | 0.60                                        | 2.21 | 8.37  | 0.890         | 9.40           | 1.08 | 1.16 | 0.238         |
| 12.80          | 1.24 | 1.09 | 0.200         | 0.65                                        | 2.11 | 7.68  | 0.877         | 9.60           | 1.10 | 1.14 | 0.229         |
| 13.20          | 1.24 | 1.09 | 0.201         | 0.70                                        | 2.02 | 7.04  | 0.862         | 9.80           | 1.13 | 1.11 | 0.217         |
| 13.60          | 1.23 | 1.12 | 0.208         | 0.75                                        | 2.00 | 6.46  | 0.842         | 10.00          | 1.16 | 1.10 | 0.209         |
| 14.00          | 1.20 | 1.13 | 0.216         | 0.80                                        | 2.00 | 5.95  | 0.820         | 10.20          | 1.19 | 1.08 | 0.203         |
| 14.40          | 1.16 | 1.15 | 0.225         | 0.85                                        | 2.01 | 5.51  | 0.796         | 10.30          | 1.20 | 1.08 | 0.201         |
| 14.80          | 1.11 | 1.16 | 0.234         | 0.90                                        | 2.03 | 5.10  | 0.769         | 10.40          | 1.22 | 1.08 | 0.200         |
| 15.00          | 1.08 | 1.16 | 0.238         | 0.95                                        | 2.05 | 4.74  | 0.742         | 10.50          | 1.23 | 1.09 | 0.201         |
| 15.60          | 0.99 | 1.14 | 0.247         | 1.00                                        | 2.09 | 4.41  | 0.712         | 10.60          | 1.24 | 1.10 | 0.203         |
| 16.00          | 0.92 | 1.11 | 0.250         | 1.10                                        | 2.15 | 3.84  | 0.651         | 10.80          | 1.25 | 1.11 | 0.206         |
| 16.60          | 0.85 | 1.04 | 0.245         | 1.20                                        | 2.16 | 3.35  | 0.592         | 11.00          | 1.24 | 1.13 | 0.213         |
| 17.00          | 0.80 | 0.99 | 0.240         | 1.30                                        | 2.25 | 2.77  | 0.506         | 11.20          | 1.23 | 1.14 | 0.217         |
| 17.20          | 0.79 | 0.96 | 0.236         | 1.40                                        | 2.49 | 2.23  | 0.419         | 11.40          | 1.19 | 1.15 | 0.223         |
| 17.40          | 0.77 | 0.93 | 0.230         | 1.50                                        | 2.84 | 1.80  | 0.369         | 11.60          | 1.17 | 1.12 | 0.216         |
| 17.80          | 0.75 | 0.87 | 0.217         | 1.60                                        | 3.36 | 1.62  | 0.379         | 11.80          | 1.16 | 1.10 | 0.211         |
| 18.00          | 0.74 | 0.85 | 0.209         | 1.70                                        | 3.70 | 1.75  | 0.411         | 12.00          | 1.15 | 1.08 | 0.205         |
| 18.60          | 0.73 | 0.77 | 0.185         | 1.80                                        | 3.78 | 1.83  | 0.423         | 12.40          | 1.14 | 1.03 | 0.191         |
| 19.00          | 0.72 | 0.72 | 0.170         | 1.90                                        | 3.81 | 1.75  | 0.418         | 12.80          | 1.15 | 1.01 | 0.183         |
| 19.60          | 0.72 | 0.66 | 0.150         | 2.00                                        | 3.98 | 1.60  | 0.418         | 13.20          | 1.16 | 0.98 | 0.174         |
| 20.00          | 0.72 | 0.62 | 0.137         | 2.10                                        | 4.26 | 1.54  | 0.432         | 13.60          | 1.17 | 0.97 | 0.170         |

| Energy<br>(eV)                 | $n$  | $k$   | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$   | $R(\phi = 0)$ | Energy<br>(eV)                | $n$   | $k$   | $R(\phi = 0)$ |
|--------------------------------|------|-------|---------------|----------------|------|-------|---------------|-------------------------------|-------|-------|---------------|
| 14.00                          | 1.17 | 0.96  | 0.169         | 0.56           | 3.92 | 10.49 | 0.883         | 9.50                          | 1.12  | 0.65  | 0.089         |
| 14.40                          | 1.16 | 0.94  | 0.165         | 0.60           | 3.80 | 9.96  | 0.876         | 10.00                         | 1.14  | 0.65  | 0.088         |
| 14.80                          | 1.16 | 0.91  | 0.156         | 0.72           | 3.51 | 8.70  | 0.854         | 10.50                         | 1.16  | 0.65  | 0.087         |
| 15.20                          | 1.17 | 0.89  | 0.148         | 0.80           | 3.35 | 8.06  | 0.840         | 11.00                         | 1.18  | 0.64  | 0.086         |
| 15.60                          | 1.20 | 0.86  | 0.140         | 1.00           | 2.99 | 6.89  | 0.811         | 11.50                         | 1.19  | 0.65  | 0.087         |
| 16.00                          | 1.25 | 0.87  | 0.140         | 1.10           | 2.81 | 6.46  | 0.800         | 12.00                         | 1.20  | 0.66  | 0.089         |
| 16.40                          | 1.28 | 0.90  | 0.147         | 1.20           | 2.65 | 6.10  | 0.790         | 12.50                         | 1.19  | 0.67  | 0.091         |
| 16.80                          | 1.28 | 0.94  | 0.157         | 1.30           | 2.50 | 5.78  | 0.781         | 13.00                         | 1.18  | 0.67  | 0.091         |
| 17.20                          | 1.27 | 0.97  | 0.167         | 1.40           | 2.34 | 5.50  | 0.774         | 13.50                         | 1.18  | 0.67  | 0.092         |
| 17.60                          | 1.26 | 1.01  | 0.178         | 1.50           | 2.17 | 5.22  | 0.767         | 14.00                         | 1.17  | 0.67  | 0.093         |
| 18.00                          | 1.23 | 1.04  | 0.189         | 1.60           | 2.08 | 4.95  | 0.755         | 14.50                         | 1.15  | 0.68  | 0.095         |
| 18.40                          | 1.19 | 1.08  | 0.200         | 1.70           | 2.00 | 4.72  | 0.745         | 15.00                         | 1.13  | 0.69  | 0.098         |
| 18.80                          | 1.14 | 1.10  | 0.210         | 1.80           | 1.92 | 4.54  | 0.737         | 15.50                         | 1.10  | 0.68  | 0.096         |
| 19.20                          | 1.10 | 1.10  | 0.219         | 1.90           | 1.82 | 4.35  | 0.729         | 16.00                         | 1.08  | 0.66  | 0.092         |
| 19.60                          | 1.05 | 1.11  | 0.227         | 2.00           | 1.75 | 4.18  | 0.721         | 16.50                         | 1.06  | 0.63  | 0.086         |
| 20.00                          | 0.96 | 1.10  | 0.239         | 2.10           | 1.67 | 4.03  | 0.714         | 17.00                         | 1.07  | 0.61  | 0.081         |
| 20.40                          | 0.93 | 1.09  | 0.240         | 2.20           | 1.60 | 3.88  | 0.707         | 17.50                         | 1.06  | 0.61  | 0.080         |
| 20.80                          | 0.89 | 1.05  | 0.240         | 2.30           | 1.53 | 3.75  | 0.700         | 18.00                         | 1.07  | 0.59  | 0.077         |
| 21.20                          | 0.86 | 1.02  | 0.237         | 2.40           | 1.47 | 3.61  | 0.693         | 18.50                         | 1.07  | 0.59  | 0.077         |
| 21.60                          | 0.83 | 0.99  | 0.235         | 2.50           | 1.41 | 3.48  | 0.685         | 19.00                         | 1.08  | 0.59  | 0.077         |
| 22.00                          | 0.80 | 0.96  | 0.230         | 2.60           | 1.37 | 3.36  | 0.676         | 19.50                         | 1.08  | 0.61  | 0.080         |
| 22.40                          | 0.78 | 0.93  | 0.226         | 2.70           | 1.32 | 3.25  | 0.668         | 20.00                         | 1.07  | 0.65  | 0.090         |
| 22.80                          | 0.77 | 0.90  | 0.220         | 2.80           | 1.29 | 3.13  | 0.658         | 20.50                         | 1.03  | 0.67  | 0.098         |
| 23.20                          | 0.75 | 0.88  | 0.217         | 2.90           | 1.26 | 3.03  | 0.648         | 21.00                         | 0.99  | 0.67  | 0.103         |
| 23.60                          | 0.75 | 0.86  | 0.211         | 3.00           | 1.23 | 2.94  | 0.639         | 21.50                         | 0.95  | 0.66  | 0.103         |
| 24.00                          | 0.73 | 0.84  | 0.209         | 3.10           | 1.20 | 2.85  | 0.630         | 22.00                         | 0.91  | 0.64  | 0.103         |
| 24.40                          | 0.72 | 0.82  | 0.207         | 3.20           | 1.17 | 2.77  | 0.622         | 22.50                         | 0.88  | 0.62  | 0.101         |
| 24.80                          | 0.70 | 0.80  | 0.205         | 3.30           | 1.14 | 2.68  | 0.613         | 23.00                         | 0.86  | 0.59  | 0.097         |
| 25.20                          | 0.69 | 0.77  | 0.202         | 3.40           | 1.12 | 2.60  | 0.602         | 23.50                         | 0.85  | 0.56  | 0.091         |
| 25.60                          | 0.67 | 0.75  | 0.199         | 3.50           | 1.10 | 2.52  | 0.591         | 24.00                         | 0.84  | 0.54  | 0.086         |
| 26.00                          | 0.66 | 0.72  | 0.195         | 3.60           | 1.08 | 2.45  | 0.581         | 25.00                         | 0.81  | 0.51  | 0.084         |
| 26.40                          | 0.65 | 0.69  | 0.189         | 3.70           | 1.07 | 2.38  | 0.570         | 26.40                         | 0.80  | 0.43  | 0.066         |
| 26.80                          | 0.63 | 0.66  | 0.183         | 3.80           | 1.06 | 2.31  | 0.558         | 27.80                         | 0.81  | 0.38  | 0.052         |
| 27.20                          | 0.65 | 0.62  | 0.165         | 3.90           | 1.05 | 2.25  | 0.547         | 29.20                         | 0.82  | 0.35  | 0.046         |
| 28.00                          | 0.64 | 0.59  | 0.156         | 4.00           | 1.03 | 2.19  | 0.537         | <i>Platinum</i> <sup>20</sup> |       |       |               |
| 28.40                          | 0.64 | 0.57  | 0.148         | 4.20           | 1.04 | 2.09  | 0.510         | 0.10                          | 13.21 | 44.72 | 0.976         |
| 28.80                          | 0.65 | 0.55  | 0.140         | 4.40           | 1.03 | 2.01  | 0.493         | 0.15                          | 8.18  | 31.16 | 0.969         |
| 29.20                          | 0.65 | 0.53  | 0.134         | 4.60           | 1.03 | 1.94  | 0.476         | 0.20                          | 5.90  | 23.95 | 0.962         |
| 29.60                          | 0.65 | 0.51  | 0.128         | 4.80           | 1.01 | 1.90  | 0.470         | 0.25                          | 4.70  | 19.40 | 0.954         |
| 30.00                          | 0.65 | 0.49  | 0.121         | 5.00           | 0.96 | 1.86  | 0.472         | 0.30                          | 3.92  | 16.16 | 0.945         |
| 31.00                          | 0.65 | 0.45  | 0.111         | 5.20           | 0.90 | 1.79  | 0.474         | 0.35                          | 3.28  | 13.66 | 0.936         |
| 32.00                          | 0.66 | 0.41  | 0.095         | 5.40           | 0.85 | 1.70  | 0.463         | 0.40                          | 2.81  | 11.38 | 0.922         |
| 33.00                          | 0.68 | 0.37  | 0.079         | 5.60           | 0.81 | 1.62  | 0.449         | 0.45                          | 3.03  | 9.31  | 0.882         |
| 34.00                          | 0.70 | 0.34  | 0.068         | 5.80           | 0.78 | 1.54  | 0.437         | 0.50                          | 3.91  | 7.71  | 0.813         |
| 35.00                          | 0.72 | 0.31  | 0.057         | 6.00           | 0.76 | 1.45  | 0.418         | 0.55                          | 4.58  | 7.14  | 0.777         |
| 36.00                          | 0.74 | 0.29  | 0.048         | 6.20           | 0.74 | 1.37  | 0.397         | 0.60                          | 5.13  | 6.75  | 0.753         |
| 37.00                          | 0.77 | 0.27  | 0.040         | 6.40           | 0.73 | 1.29  | 0.375         | 0.65                          | 5.52  | 6.66  | 0.746         |
| 38.00                          | 0.79 | 0.26  | 0.035         | 6.60           | 0.72 | 1.21  | 0.350         | 0.70                          | 5.71  | 6.83  | 0.751         |
| 39.00                          | 0.81 | 0.26  | 0.031         | 6.80           | 0.73 | 1.13  | 0.316         | 0.75                          | 5.57  | 7.02  | 0.759         |
| 40.00                          | 0.84 | 0.26  | 0.026         | 7.00           | 0.73 | 1.05  | 0.287         | 0.80                          | 5.31  | 7.04  | 0.762         |
| <i>Palladium</i> <sup>19</sup> |      |       |               | 7.20           | 0.75 | 0.98  | 0.255         | 0.85                          | 5.05  | 6.98  | 0.763         |
| 0.10                           | 4.13 | 54.15 | 0.994         | 7.40           | 0.77 | 0.91  | 0.223         | 0.90                          | 4.77  | 6.91  | 0.765         |
| 0.15                           | 3.13 | 35.82 | 0.990         | 7.60           | 0.79 | 0.85  | 0.195         | 0.95                          | 4.50  | 6.77  | 0.763         |
| 0.20                           | 3.07 | 26.59 | 0.983         | 7.80           | 0.83 | 0.78  | 0.163         | 1.00                          | 4.25  | 6.62  | 0.762         |
| 0.26                           | 3.11 | 20.15 | 0.971         | 8.00           | 0.88 | 0.73  | 0.133         | 1.10                          | 3.86  | 6.24  | 0.753         |
| 0.30                           | 3.56 | 17.27 | 0.955         | 8.20           | 0.94 | 0.70  | 0.117         | 1.20                          | 3.55  | 5.92  | 0.746         |
| 0.36                           | 3.98 | 14.41 | 0.932         | 8.40           | 0.96 | 0.70  | 0.114         | 1.30                          | 3.29  | 5.61  | 0.736         |
| 0.40                           | 4.27 | 13.27 | 0.916         | 8.60           | 1.00 | 0.65  | 0.097         | 1.40                          | 3.10  | 5.32  | 0.725         |
| 0.46                           | 4.27 | 12.11 | 0.902         | 8.80           | 1.04 | 0.65  | 0.094         | 1.50                          | 2.92  | 5.07  | 0.716         |
| 0.50                           | 4.10 | 11.44 | 0.896         | 9.00           | 1.07 | 0.64  | 0.090         | 1.60                          | 2.76  | 4.84  | 0.706         |

| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)                 | $n$   | $k$   | $R(\phi = 0)$ | Energy<br>(eV)                                                           | $n$  | $k$   | $R(\phi = 0)$ |
|----------------|------|------|---------------|--------------------------------|-------|-------|---------------|--------------------------------------------------------------------------|------|-------|---------------|
| 1.70           | 2.63 | 4.64 | 0.697         | 12.80                          | 1.29  | 0.94  | 0.158         | 4.00                                                                     | 0.34 | 0.08  | 0.245         |
| 1.80           | 2.51 | 4.43 | 0.686         | 13.20                          | 1.31  | 0.93  | 0.155         | 4.065                                                                    | 0.38 | 0.07  | 0.204         |
| 1.90           | 2.38 | 4.26 | 0.678         | 13.60                          | 1.31  | 0.93  | 0.155         | 4.133                                                                    | 0.41 | 0.07  | 0.177         |
| 2.00           | 2.30 | 4.07 | 0.664         | 14.00                          | 1.31  | 0.93  | 0.155         | 4.203                                                                    | 0.45 | 0.06  | 0.145         |
| 2.10           | 2.23 | 3.92 | 0.654         | 14.40                          | 1.30  | 0.93  | 0.156         | 4.275                                                                    | 0.48 | 0.06  | 0.125         |
| 2.20           | 2.17 | 3.77 | 0.642         | 14.80                          | 1.27  | 0.93  | 0.157         | 4.350                                                                    | 0.52 | 0.05  | 0.101         |
| 2.30           | 2.10 | 3.67 | 0.636         | 15.20                          | 1.27  | 0.93  | 0.155         | 4.428                                                                    | 0.55 | 0.05  | 0.085         |
| 2.40           | 2.03 | 3.54 | 0.626         | 15.60                          | 1.25  | 0.92  | 0.151         | 4.509                                                                    | 0.58 | 0.05  | 0.072         |
| 2.50           | 1.96 | 3.42 | 0.616         | 16.00                          | 1.24  | 0.89  | 0.146         | 4.592                                                                    | 0.61 | 0.05  | 0.060         |
| 2.60           | 1.91 | 3.30 | 0.605         | 16.50                          | 1.24  | 0.87  | 0.142         | 4.679                                                                    | 0.64 | 0.04  | 0.049         |
| 2.70           | 1.87 | 3.20 | 0.595         | 17.00                          | 1.25  | 0.86  | 0.138         | 4.769                                                                    | 0.66 | 0.04  | 0.043         |
| 2.80           | 1.83 | 3.10 | 0.585         | 17.50                          | 1.27  | 0.85  | 0.135         | 4.862                                                                    | 0.68 | 0.04  | 0.037         |
| 2.90           | 1.79 | 3.01 | 0.575         | 18.00                          | 1.31  | 0.88  | 0.142         | 4.959                                                                    | 0.70 | 0.04  | 0.032         |
| 3.00           | 1.75 | 2.92 | 0.565         | 18.50                          | 1.30  | 0.94  | 0.157         | 5.061                                                                    | 0.72 | 0.04  | 0.027         |
| 3.20           | 1.68 | 2.76 | 0.546         | 19.00                          | 1.28  | 0.99  | 0.171         | 5.166                                                                    | 0.74 | 0.04  | 0.023         |
| 3.40           | 1.63 | 2.62 | 0.527         | 19.50                          | 1.23  | 1.03  | 0.184         | 5.276                                                                    | 0.76 | 0.04  | 0.019         |
| 3.60           | 1.58 | 2.48 | 0.507         | 20.00                          | 1.18  | 1.06  | 0.197         | 5.391                                                                    | 0.78 | 0.04  | 0.016         |
| 3.80           | 1.53 | 2.37 | 0.491         | 20.50                          | 1.11  | 1.09  | 0.212         | 5.510                                                                    | 0.79 | 0.05  | 0.015         |
| 4.00           | 1.49 | 2.25 | 0.472         | 21.00                          | 1.03  | 1.10  | 0.226         | 5.637                                                                    | 0.81 | 0.05  | 0.012         |
| 4.20           | 1.45 | 2.14 | 0.452         | 21.50                          | 0.94  | 1.08  | 0.238         | 5.767                                                                    | 0.83 | 0.05  | 0.009         |
| 4.40           | 1.43 | 2.04 | 0.432         | 22.00                          | 0.87  | 1.04  | 0.240         | 6.048                                                                    | 0.85 | 0.05  | 0.007         |
| 4.60           | 1.39 | 1.95 | 0.415         | 22.50                          | 0.81  | 0.98  | 0.235         | 6.199                                                                    | 0.87 | 0.05  | 0.006         |
| 4.80           | 1.38 | 1.85 | 0.392         | 23.00                          | 0.77  | 0.92  | 0.226         | 6.358                                                                    | 0.88 | 0.05  | 0.005         |
| 5.00           | 1.36 | 1.76 | 0.372         | 23.50                          | 0.75  | 0.87  | 0.213         | 6.526                                                                    | 0.90 | 0.06  | 0.004         |
| 5.20           | 1.36 | 1.67 | 0.350         | 24.00                          | 0.74  | 0.82  | 0.201         | 6.702                                                                    | 0.91 | 0.06  | 0.003         |
| 5.40           | 1.36 | 1.61 | 0.332         | 24.50                          | 0.73  | 0.77  | 0.187         | 6.888                                                                    | 0.92 | 0.06  | 0.003         |
| 5.60           | 1.36 | 1.54 | 0.315         | 25.00                          | 0.73  | 0.73  | 0.174         | 7.085                                                                    | 0.92 | 0.06  | 0.003         |
| 5.80           | 1.36 | 1.47 | 0.295         | 25.50                          | 0.73  | 0.70  | 0.162         | 7.293                                                                    | 0.93 | 0.06  | 0.002         |
| 6.00           | 1.38 | 1.40 | 0.276         | 26.00                          | 0.74  | 0.67  | 0.150         | 7.514                                                                    | 0.93 | 0.06  | 0.002         |
| 6.20           | 1.39 | 1.35 | 0.261         | 26.50                          | 0.74  | 0.65  | 0.142         | 7.749                                                                    | 0.94 | 0.06  | 0.002         |
| 6.40           | 1.42 | 1.29 | 0.246         | 27.00                          | 0.74  | 0.63  | 0.136         | 7.999                                                                    | 0.94 | 0.06  | 0.002         |
| 6.60           | 1.45 | 1.26 | 0.236         | 27.50                          | 0.74  | 0.62  | 0.130         | 8.260                                                                    | 0.94 | 0.06  | 0.002         |
| 6.80           | 1.48 | 1.24 | 0.231         | 28.00                          | 0.75  | 0.60  | 0.125         | 8.551                                                                    | 0.94 | 0.06  | 0.002         |
| 7.00           | 1.50 | 1.24 | 0.230         | 28.50                          | 0.75  | 0.59  | 0.121         | 8.856                                                                    | 0.94 | 0.05  | 0.002         |
| 7.20           | 1.50 | 1.25 | 0.231         | 29.00                          | 0.75  | 0.58  | 0.118         | 9.184                                                                    | 0.94 | 0.05  | 0.002         |
| 7.40           | 1.49 | 1.23 | 0.228         | 29.50                          | 0.74  | 0.58  | 0.120         | 9.537                                                                    | 0.94 | 0.04  | 0.001         |
| 7.60           | 1.48 | 1.22 | 0.225         | 30.00                          | 0.73  | 0.58  | 0.124         | 9.919                                                                    | 0.94 | 0.04  | 0.001         |
| 7.80           | 1.48 | 1.20 | 0.221         |                                |       |       |               | 10.33                                                                    | 0.94 | 0.03  | 0.001         |
| 8.00           | 1.47 | 1.18 | 0.216         | <i>Potassium</i> <sup>21</sup> |       |       |               | 11.0                                                                     |      | 0.03  |               |
| 8.20           | 1.47 | 1.17 | 0.212         | 0.55                           | 0.139 | 7.10  | 0.989         | 12.0                                                                     |      | 0.028 |               |
| 8.40           | 1.47 | 1.15 | 0.209         | 0.58                           | 0.119 | 6.72  | 0.990         |                                                                          |      |       |               |
| 8.60           | 1.47 | 1.14 | 0.205         | 0.63                           | 0.106 | 6.32  | 0.990         | <i>Rhenium, single crystal, <math>\bar{E} \parallel \bar{c}^0</math></i> |      |       |               |
| 8.80           | 1.47 | 1.13 | 0.202         | 0.67                           | 0.091 | 5.79  | 0.990         | 0.10                                                                     | 6.06 | 51.03 | 0.991         |
| 9.00           | 1.48 | 1.12 | 0.200         | 0.73                           | 0.079 | 5.30  | 0.989         | 0.15                                                                     | 4.66 | 33.96 | 0.984         |
| 9.20           | 1.49 | 1.11 | 0.198         | 0.81                           | 0.066 | 4.75  | 0.989         | 0.20                                                                     | 4.16 | 25.36 | 0.975         |
| 9.40           | 1.49 | 1.12 | 0.200         | 0.92                           | 0.056 | 4.19  | 0.988         | 0.25                                                                     | 4.03 | 20.10 | 0.962         |
| 9.60           | 1.49 | 1.13 | 0.203         | 1.05                           | 0.044 | 3.58  | 0.987         | 0.30                                                                     | 4.37 | 16.69 | 0.943         |
| 9.80           | 1.48 | 1.15 | 0.207         | 1.23                           | 0.040 | 3.04  | 0.985         | 0.35                                                                     | 4.50 | 14.53 | 0.925         |
| 10.00          | 1.46 | 1.15 | 0.209         | 1.44                           | 0.040 | 2.56  | 0.979         | 0.40                                                                     | 4.53 | 12.96 | 0.909         |
| 10.20          | 1.43 | 1.16 | 0.211         | 1.65                           | 0.044 | 2.19  | 0.970         | 0.45                                                                     | 4.53 | 11.78 | 0.893         |
| 10.40          | 1.40 | 1.15 | 0.210         | 1.87                           | 0.050 | 1.84  | 0.955         | 0.50                                                                     | 4.53 | 10.88 | 0.878         |
| 10.60          | 1.37 | 1.14 | 0.207         | 2.07                           | 0.053 | 1.62  | 0.943         | 0.55                                                                     | 4.50 | 10.26 | 0.867         |
| 10.80          | 1.35 | 1.12 | 0.203         | 2.27                           | 0.049 | 1.43  | 0.938         | 0.60                                                                     | 4.29 | 9.75  | 0.861         |
| 11.00          | 1.33 | 1.10 | 0.199         | 2.45                           | 0.046 | 1.28  | 0.933         | 0.65                                                                     | 4.07 | 9.35  | 0.856         |
| 11.20          | 1.31 | 1.08 | 0.194         | 2.64                           | 0.043 | 1.14  | 0.928         | 0.70                                                                     | 3.80 | 8.94  | 0.853         |
| 11.40          | 1.30 | 1.06 | 0.188         | 2.82                           | 0.043 | 1.02  | 0.919         | 0.75                                                                     | 3.48 | 8.55  | 0.850         |
| 11.60          | 1.29 | 1.04 | 0.183         | 2.95                           | 0.041 | 0.898 | 0.913         | 0.80                                                                     | 3.21 | 8.10  | 0.846         |
| 11.80          | 1.29 | 1.01 | 0.177         | 3.06                           | 0.041 | 0.799 | 0.905         | 0.85                                                                     | 2.96 | 7.68  | 0.841         |
| 12.00          | 1.29 | 1.00 | 0.173         | 3.40                           | 0.052 | 0.549 | 0.852         | 0.90                                                                     | 2.73 | 7.24  | 0.835         |
| 12.40          | 1.29 | 0.97 | 0.165         | 3.71                           | 0.089 | 0.288 | 0.719         | 0.95                                                                     | 2.56 | 6.79  | 0.826         |
|                |      |      |               | 3.97                           | 0.287 | 0.091 | 0.310         | 1.00                                                                     | 2.45 | 6.36  | 0.813         |

| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)                                                 | $n$  | $k$   | $R(\phi = 0)$ |
|----------------|------|------|---------------|----------------|------|------|---------------|----------------------------------------------------------------|------|-------|---------------|
| 1.10           | 2.38 | 5.61 | 0.778         | 11.40          | 1.28 | 1.28 | 0.252         | 50.00                                                          | 0.80 | 0.30  | 0.038         |
| 1.20           | 2.35 | 5.02 | 0.742         | 11.60          | 1.26 | 1.28 | 0.252         | 52.00                                                          | 0.78 | 0.30  | 0.044         |
| 1.30           | 2.39 | 4.54 | 0.702         | 11.80          | 1.24 | 1.26 | 0.249         | 54.00                                                          | 0.72 | 0.30  | 0.055         |
| 1.40           | 2.44 | 4.13 | 0.662         | 12.00          | 1.23 | 1.24 | 0.244         | 56.00                                                          | 0.66 | 0.24  | 0.061         |
| 1.50           | 2.50 | 3.79 | 0.624         | 12.40          | 1.22 | 1.21 | 0.237         | 58.00                                                          | 0.65 | 0.16  | 0.055         |
| 1.60           | 2.59 | 3.49 | 0.587         | 12.80          | 1.21 | 1.18 | 0.230         | <i>Rhenium, single crystal, <math>\vec{E} \perp c^0</math></i> |      |       |               |
| 1.70           | 2.70 | 3.27 | 0.557         | 13.20          | 1.22 | 1.16 | 0.222         | 0.10                                                           | 4.25 | 42.83 | 0.991         |
| 1.80           | 2.82 | 3.10 | 0.535         | 13.60          | 1.22 | 1.13 | 0.215         | 0.15                                                           | 3.28 | 28.08 | 0.984         |
| 1.90           | 2.90 | 3.00 | 0.520         | 14.00          | 1.24 | 1.12 | 0.209         | 0.20                                                           | 3.28 | 20.66 | 0.971         |
| 2.00           | 2.97 | 2.91 | 0.510         | 14.40          | 1.27 | 1.11 | 0.204         | 0.25                                                           | 3.47 | 16.27 | 0.951         |
| 2.10           | 3.03 | 2.86 | 0.504         | 14.80          | 1.29 | 1.15 | 0.213         | 0.30                                                           | 3.73 | 13.44 | 0.926         |
| 2.20           | 3.06 | 2.84 | 0.501         | 15.20          | 1.29 | 1.19 | 0.225         | 0.35                                                           | 3.93 | 11.54 | 0.900         |
| 2.30           | 3.07 | 2.82 | 0.499         | 15.60          | 1.26 | 1.22 | 0.236         | 0.40                                                           | 3.99 | 10.15 | 0.875         |
| 2.40           | 3.06 | 2.81 | 0.498         | 16.00          | 1.23 | 1.25 | 0.248         | 0.45                                                           | 4.17 | 9.03  | 0.846         |
| 2.50           | 3.02 | 2.80 | 0.497         | 16.40          | 1.19 | 1.27 | 0.259         | 0.50                                                           | 4.34 | 8.26  | 0.821         |
| 2.60           | 2.96 | 2.77 | 0.493         | 16.80          | 1.14 | 1.29 | 0.269         | 0.55                                                           | 4.45 | 7.73  | 0.801         |
| 2.70           | 2.89 | 2.68 | 0.482         | 17.00          | 1.12 | 1.30 | 0.275         | 0.60                                                           | 4.53 | 7.40  | 0.788         |
| 2.80           | 2.89 | 2.57 | 0.468         | 17.40          | 1.07 | 1.30 | 0.286         | 0.65                                                           | 4.44 | 7.26  | 0.784         |
| 2.90           | 2.99 | 2.47 | 0.457         | 18.00          | 0.99 | 1.30 | 0.300         | 0.70                                                           | 4.13 | 7.09  | 0.784         |
| 3.00           | 3.11 | 2.57 | 0.470         | 18.40          | 0.93 | 1.29 | 0.311         | 0.75                                                           | 3.77 | 6.75  | 0.779         |
| 3.20           | 2.90 | 2.68 | 0.482         | 18.80          | 0.87 | 1.28 | 0.321         | 0.80                                                           | 3.55 | 6.32  | 0.766         |
| 3.40           | 2.83 | 2.50 | 0.459         | 19.20          | 0.81 | 1.25 | 0.330         | 0.85                                                           | 3.39 | 5.95  | 0.752         |
| 3.60           | 2.93 | 2.48 | 0.457         | 19.60          | 0.77 | 1.21 | 0.332         | 0.90                                                           | 3.26 | 5.61  | 0.737         |
| 3.80           | 2.86 | 2.56 | 0.467         | 20.00          | 0.73 | 1.18 | 0.333         | 0.95                                                           | 3.17 | 5.27  | 0.719         |
| 4.00           | 2.81 | 2.51 | 0.460         | 20.40          | 0.70 | 1.14 | 0.332         | 1.00                                                           | 3.09 | 4.96  | 0.701         |
| 4.20           | 2.86 | 2.55 | 0.466         | 20.80          | 0.67 | 1.11 | 0.332         | 1.10                                                           | 3.05 | 4.39  | 0.658         |
| 4.40           | 2.81 | 2.74 | 0.489         | 21.20          | 0.64 | 1.08 | 0.334         | 1.20                                                           | 3.08 | 3.89  | 0.613         |
| 4.60           | 2.56 | 2.83 | 0.504         | 21.60          | 0.61 | 1.04 | 0.335         | 1.30                                                           | 3.20 | 3.56  | 0.578         |
| 4.80           | 2.41 | 2.71 | 0.493         | 22.00          | 0.58 | 1.01 | 0.340         | 1.40                                                           | 3.23 | 3.38  | 0.559         |
| 5.00           | 2.39 | 2.68 | 0.488         | 22.40          | 0.55 | 0.97 | 0.341         | 1.50                                                           | 3.23 | 3.12  | 0.532         |
| 5.20           | 2.34 | 2.75 | 0.500         | 22.80          | 0.53 | 0.93 | 0.338         | 1.60                                                           | 3.29 | 2.88  | 0.507         |
| 5.40           | 2.20 | 2.81 | 0.515         | 23.20          | 0.51 | 0.89 | 0.334         | 1.70                                                           | 3.38 | 2.72  | 0.491         |
| 5.60           | 2.02 | 2.84 | 0.530         | 23.60          | 0.50 | 0.85 | 0.329         | 1.80                                                           | 3.47 | 2.59  | 0.480         |
| 5.80           | 1.83 | 2.80 | 0.538         | 24.00          | 0.48 | 0.80 | 0.319         | 1.90                                                           | 3.54 | 2.50  | 0.473         |
| 6.00           | 1.65 | 2.71 | 0.541         | 24.40          | 0.48 | 0.76 | 0.207         | 2.00                                                           | 3.63 | 2.43  | 0.469         |
| 6.20           | 1.54 | 2.59 | 0.532         | 24.80          | 0.47 | 0.72 | 0.296         | 2.10                                                           | 3.74 | 2.40  | 0.470         |
| 6.40           | 1.45 | 2.50 | 0.526         | 25.20          | 0.47 | 0.68 | 0.282         | 2.20                                                           | 3.83 | 2.38  | 0.472         |
| 6.80           | 1.32 | 2.31 | 0.508         | 25.60          | 0.47 | 0.65 | 0.270         | 2.30                                                           | 3.93 | 2.44  | 0.481         |
| 7.00           | 1.26 | 2.23 | 0.500         | 26.00          | 0.47 | 0.61 | 0.255         | 2.40                                                           | 4.00 | 2.55  | 0.492         |
| 7.20           | 1.20 | 2.15 | 0.493         | 26.40          | 0.48 | 0.57 | 0.240         | 2.50                                                           | 4.01 | 2.70  | 0.505         |
| 7.40           | 1.16 | 2.06 | 0.480         | 26.80          | 0.48 | 0.54 | 0.225         | 2.60                                                           | 3.90 | 2.84  | 0.514         |
| 7.60           | 1.12 | 1.99 | 0.470         | 27.20          | 0.49 | 0.51 | 0.208         | 2.70                                                           | 3.74 | 2.92  | 0.517         |
| 7.80           | 1.08 | 1.89 | 0.454         | 27.60          | 0.50 | 0.48 | 0.193         | 2.80                                                           | 3.57 | 2.88  | 0.511         |
| 8.00           | 1.05 | 1.80 | 0.435         | 28.00          | 0.51 | 0.45 | 0.176         | 2.90                                                           | 3.49 | 2.75  | 0.497         |
| 8.20           | 1.05 | 1.71 | 0.411         | 29.00          | 0.54 | 0.39 | 0.145         | 3.00                                                           | 3.53 | 2.71  | 0.493         |
| 8.40           | 1.05 | 1.62 | 0.386         | 30.00          | 0.57 | 0.33 | 0.114         | 3.20                                                           | 3.55 | 2.84  | 0.506         |
| 8.60           | 1.06 | 1.55 | 0.360         | 31.00          | 0.62 | 0.29 | 0.086         | 3.40                                                           | 3.34 | 2.88  | 0.508         |
| 8.80           | 1.09 | 1.48 | 0.336         | 32.00          | 0.66 | 0.26 | 0.065         | 3.60                                                           | 3.25 | 2.83  | 0.501         |
| 9.00           | 1.11 | 1.43 | 0.317         | 33.00          | 0.68 | 0.24 | 0.054         | 3.80                                                           | 3.24 | 2.84  | 0.502         |
| 9.20           | 1.13 | 1.39 | 0.301         | 34.00          | 0.72 | 0.21 | 0.041         | 4.00                                                           | 3.19 | 2.94  | 0.513         |
| 9.40           | 1.16 | 1.34 | 0.281         | 35.00          | 0.76 | 0.20 | 0.031         | 4.20                                                           | 3.05 | 3.06  | 0.526         |
| 9.60           | 1.18 | 1.32 | 0.274         | 36.00          | 0.79 | 0.20 | 0.025         | 4.40                                                           | 2.88 | 3.15  | 0.539         |
| 9.80           | 1.20 | 1.29 | 0.264         | 37.00          | 0.82 | 0.19 | 0.021         | 4.60                                                           | 2.67 | 3.18  | 0.548         |
| 10.00          | 1.23 | 1.26 | 0.252         | 38.00          | 0.85 | 0.20 | 0.018         | 4.80                                                           | 2.44 | 3.17  | 0.554         |
| 10.20          | 1.25 | 1.25 | 0.246         | 39.00          | 0.89 | 0.21 | 0.016         | 5.00                                                           | 2.25 | 3.12  | 0.556         |
| 10.40          | 1.28 | 1.25 | 0.242         | 40.00          | 0.88 | 0.26 | 0.022         | 5.20                                                           | 2.10 | 3.04  | 0.555         |
| 10.60          | 1.29 | 1.25 | 0.242         | 42.00          | 0.88 | 0.26 | 0.022         | 5.40                                                           | 1.96 | 2.96  | 0.553         |
| 10.80          | 1.30 | 1.26 | 0.244         | 44.00          | 0.89 | 0.29 | 0.026         | 5.60                                                           | 1.84 | 2.88  | 0.551         |
| 11.00          | 1.30 | 1.27 | 0.247         | 46.00          | 0.85 | 0.32 | 0.035         | 5.80                                                           | 1.73 | 2.81  | 0.549         |
| 11.20          | 1.29 | 1.28 | 0.249         | 48.00          | 0.82 | 0.30 | 0.036         | 6.00                                                           | 1.61 | 2.74  | 0.549         |

| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)              | $n$   | $k$   | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ |
|----------------|------|------|---------------|-----------------------------|-------|-------|---------------|----------------|------|------|---------------|
| 6.20           | 1.51 | 2.64 | 0.545         | 24.80                       | 0.48  | 0.75  | 0.303         | 3.10           | 1.41 | 4.20 | 0.760         |
| 6.40           | 1.42 | 2.56 | 0.541         | 25.20                       | 0.47  | 0.72  | 0.295         | 3.20           | 1.30 | 4.09 | 0.764         |
| 6.80           | 1.28 | 2.37 | 0.526         | 25.60                       | 0.47  | 0.68  | 0.286         | 3.30           | 1.20 | 3.97 | 0.767         |
| 7.00           | 1.22 | 2.28 | 0.517         | 26.00                       | 0.46  | 0.64  | 0.276         | 3.40           | 1.11 | 3.84 | 0.769         |
| 7.20           | 1.16 | 2.19 | 0.508         | 26.40                       | 0.46  | 0.61  | 0.263         | 3.50           | 1.04 | 3.71 | 0.768         |
| 7.40           | 1.12 | 2.08 | 0.493         | 26.80                       | 0.46  | 0.57  | 0.249         | 3.60           | 0.99 | 3.58 | 0.764         |
| 7.60           | 1.12 | 1.98 | 0.468         | 27.20                       | 0.47  | 0.53  | 0.231         | 3.70           | 0.95 | 3.45 | 0.759         |
| 7.80           | 1.08 | 1.93 | 0.463         | 27.60                       | 0.48  | 0.50  | 0.216         | 3.80           | 0.91 | 3.34 | 0.753         |
| 8.00           | 1.05 | 1.83 | 0.443         | 28.00                       | 0.49  | 0.47  | 0.198         | 3.90           | 0.88 | 3.23 | 0.747         |
| 8.20           | 1.05 | 1.74 | 0.418         | 29.00                       | 0.51  | 0.41  | 0.164         | 4.00           | 0.86 | 3.12 | 0.739         |
| 8.40           | 1.05 | 1.66 | 0.397         | 30.00                       | 0.55  | 0.34  | 0.129         | 4.20           | 0.83 | 2.94 | 0.722         |
| 8.60           | 1.06 | 1.58 | 0.372         | 31.00                       | 0.59  | 0.29  | 0.097         | 4.40           | 0.80 | 2.76 | 0.706         |
| 8.80           | 1.07 | 1.52 | 0.351         | 32.00                       | 0.64  | 0.26  | 0.072         | 4.60           | 0.78 | 2.60 | 0.684         |
| 9.00           | 1.09 | 1.46 | 0.327         | 33.00                       | 0.67  | 0.24  | 0.060         | 4.80           | 0.79 | 2.46 | 0.659         |
| 9.20           | 1.11 | 1.41 | 0.309         | 34.00                       | 0.70  | 0.22  | 0.047         | 5.00           | 0.79 | 2.34 | 0.635         |
| 9.40           | 1.14 | 1.36 | 0.290         | 35.00                       | 0.74  | 0.20  | 0.036         | 5.20           | 0.79 | 2.23 | 0.613         |
| 9.60           | 1.17 | 1.31 | 0.273         | 36.00                       | 0.77  | 0.19  | 0.029         | 5.40           | 0.80 | 2.14 | 0.591         |
| 9.80           | 1.20 | 1.27 | 0.258         | 37.00                       | 0.80  | 0.19  | 0.023         | 5.60           | 0.80 | 2.06 | 0.573         |
| 10.00          | 1.24 | 1.24 | 0.244         | 38.00                       | 0.84  | 0.19  | 0.018         | 5.80           | 0.79 | 2.00 | 0.561         |
| 10.20          | 1.29 | 1.22 | 0.234         | 39.00                       | 0.88  | 0.21  | 0.016         | 6.00           | 0.76 | 1.93 | 0.556         |
| 10.40          | 1.33 | 1.23 | 0.233         | 40.00                       | 0.87  | 0.25  | 0.023         | 6.20           | 0.73 | 1.85 | 0.544         |
| 10.60          | 1.36 | 1.25 | 0.238         | 42.00                       | 0.87  | 0.25  | 0.023         | 6.40           | 0.70 | 1.77 | 0.534         |
| 10.80          | 1.38 | 1.28 | 0.245         | 44.00                       | 0.88  | 0.28  | 0.026         | 6.60           | 0.68 | 1.69 | 0.518         |
| 11.00          | 1.37 | 1.31 | 0.253         | 46.00                       | 0.84  | 0.31  | 0.035         | 6.80           | 0.67 | 1.60 | 0.498         |
| 11.20          | 1.36 | 1.33 | 0.259         | 48.00                       | 0.82  | 0.30  | 0.036         | 7.00           | 0.66 | 1.52 | 0.476         |
| 11.40          | 1.33 | 1.34 | 0.264         | 50.00                       | 0.80  | 0.30  | 0.039         | 7.20           | 0.66 | 1.43 | 0.452         |
| 11.60          | 1.31 | 1.34 | 0.266         | 52.00                       | 0.77  | 0.30  | 0.044         | 7.40           | 0.66 | 1.35 | 0.423         |
| 11.80          | 1.28 | 1.33 | 0.266         | 54.00                       | 0.71  | 0.29  | 0.055         | 7.60           | 0.67 | 1.27 | 0.394         |
| 12.00          | 1.26 | 1.32 | 0.264         | 56.00                       | 0.66  | 0.23  | 0.061         | 7.80           | 0.68 | 1.20 | 0.363         |
| 12.40          | 1.23 | 1.29 | 0.257         | 58.00                       | 0.64  | 0.16  | 0.055         | 8.00           | 0.69 | 1.12 | 0.329         |
| 12.80          | 1.22 | 1.26 | 0.251         | <i>Rhodium<sup>II</sup></i> |       |       |               | 8.20           | 0.71 | 1.04 | 0.288         |
| 13.20          | 1.20 | 1.23 | 0.245         | 0.10                        | 18.48 | 69.43 | 0.986         | 8.40           | 0.74 | 0.97 | 0.252         |
| 13.60          | 1.19 | 1.20 | 0.236         | 0.20                        | 8.66  | 37.46 | 0.977         | 8.60           | 0.78 | 0.89 | 0.212         |
| 14.00          | 1.20 | 1.16 | 0.225         | 0.30                        | 5.85  | 25.94 | 0.967         | 8.80           | 0.83 | 0.83 | 0.179         |
| 14.40          | 1.22 | 1.13 | 0.214         | 0.40                        | 4.74  | 19.80 | 0.955         | 9.00           | 0.88 | 0.77 | 0.148         |
| 14.80          | 1.27 | 1.12 | 0.207         | 0.50                        | 4.20  | 16.07 | 0.941         | 9.20           | 0.95 | 0.73 | 0.125         |
| 15.20          | 1.31 | 1.17 | 0.218         | 0.60                        | 3.87  | 13.51 | 0.925         | 9.40           | 1.01 | 0.71 | 0.110         |
| 15.60          | 1.31 | 1.23 | 0.234         | 0.70                        | 3.67  | 11.72 | 0.908         | 9.60           | 1.07 | 0.69 | 0.102         |
| 16.00          | 1.28 | 1.28 | 0.251         | 0.80                        | 3.63  | 10.34 | 0.887         | 9.80           | 1.12 | 0.69 | 0.098         |
| 16.40          | 1.24 | 1.33 | 0.270         | 0.90                        | 3.62  | 9.36  | 0.867         | 10.00          | 1.17 | 0.69 | 0.098         |
| 16.80          | 1.17 | 1.37 | 0.288         | 1.00                        | 3.71  | 8.67  | 0.848         | 10.60          | 1.26 | 0.73 | 0.106         |
| 17.00          | 1.14 | 1.38 | 0.297         | 1.10                        | 3.67  | 8.26  | 0.837         | 11.00          | 1.29 | 0.76 | 0.113         |
| 17.40          | 1.06 | 1.39 | 0.314         | 1.20                        | 3.51  | 7.94  | 0.832         | 11.60          | 1.32 | 0.80 | 0.124         |
| 18.00          | 0.95 | 1.38 | 0.334         | 1.30                        | 3.26  | 7.63  | 0.829         | 12.00          | 1.32 | 0.82 | 0.127         |
| 18.40          | 0.88 | 1.36 | 0.346         | 1.40                        | 3.01  | 7.31  | 0.827         | 12.60          | 1.32 | 0.82 | 0.129         |
| 18.80          | 0.82 | 1.33 | 0.355         | 1.50                        | 2.78  | 6.97  | 0.823         | 13.00          | 1.32 | 0.83 | 0.131         |
| 19.20          | 0.76 | 1.29 | 0.360         | 1.60                        | 2.60  | 6.64  | 0.818         | 13.60          | 1.32 | 0.85 | 0.134         |
| 19.60          | 0.72 | 1.25 | 0.363         | 1.70                        | 2.42  | 6.33  | 0.813         | 14.00          | 1.32 | 0.86 | 0.138         |
| 20.00          | 0.67 | 1.21 | 0.369         | 1.80                        | 2.30  | 6.02  | 0.805         | 14.60          | 1.30 | 0.89 | 0.144         |
| 20.40          | 0.64 | 1.15 | 0.364         | 1.90                        | 2.20  | 5.76  | 0.798         | 15.00          | 1.28 | 0.90 | 0.147         |
| 20.80          | 0.61 | 1.10 | 0.357         | 2.00                        | 2.12  | 5.51  | 0.789         | 15.60          | 1.25 | 0.90 | 0.147         |
| 21.20          | 0.60 | 1.06 | 0.349         | 2.10                        | 2.05  | 5.30  | 0.780         | 16.00          | 1.24 | 0.89 | 0.147         |
| 21.60          | 0.58 | 1.02 | 0.342         | 2.20                        | 2.00  | 5.11  | 0.772         | 16.50          | 1.23 | 0.88 | 0.145         |
| 22.00          | 0.57 | 0.98 | 0.336         | 2.30                        | 1.94  | 4.94  | 0.765         | 17.00          | 1.22 | 0.88 | 0.144         |
| 22.40          | 0.56 | 0.95 | 0.328         | 2.40                        | 1.90  | 4.78  | 0.756         | 17.50          | 1.22 | 0.87 | 0.143         |
| 22.80          | 0.55 | 0.92 | 0.325         | 2.50                        | 1.88  | 4.65  | 0.748         | 18.00          | 1.23 | 0.88 | 0.145         |
| 23.20          | 0.53 | 0.89 | 0.322         | 2.60                        | 1.85  | 4.55  | 0.743         | 18.50          | 1.25 | 0.92 | 0.155         |
| 23.60          | 0.52 | 0.85 | 0.317         | 2.70                        | 1.80  | 4.49  | 0.742         | 19.00          | 1.24 | 0.98 | 0.172         |
| 24.00          | 0.50 | 0.82 | 0.314         | 2.90                        | 1.63  | 4.36  | 0.748         | 19.50          | 1.18 | 1.05 | 0.193         |
| 24.40          | 0.49 | 0.79 | 0.309         | 3.00                        | 1.53  | 4.29  | 0.753         | 20.00          | 1.10 | 1.09 | 0.213         |

| Energy<br>(eV)                                                             | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV) | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) | Energy<br>(eV)                                                         | <i>n</i> | <i>k</i> | <i>R</i> ( $\phi = 0$ ) |
|----------------------------------------------------------------------------|----------|----------|-------------------------|----------------|----------|----------|-------------------------|------------------------------------------------------------------------|----------|----------|-------------------------|
| 20.50                                                                      | 1.00     | 1.09     | 0.230                   | 3.30           | 2.00     | 3.91     | 0.671                   | 17.50                                                                  | 1.32     | 0.93     | 0.155                   |
| 21.00                                                                      | 0.91     | 1.05     | 0.234                   | 3.40           | 1.87     | 3.83     | 0.673                   | 18.00                                                                  | 1.26     | 0.99     | 0.173                   |
| 21.50                                                                      | 0.86     | 1.00     | 0.228                   | 3.50           | 1.76     | 3.74     | 0.674                   | 18.50                                                                  | 1.18     | 1.02     | 0.185                   |
| 22.00                                                                      | 0.83     | 0.95     | 0.219                   | 3.60           | 1.66     | 3.65     | 0.675                   | 19.00                                                                  | 1.11     | 1.02     | 0.192                   |
| 22.50                                                                      | 0.81     | 0.92     | 0.214                   | 3.70           | 1.57     | 3.55     | 0.673                   | 19.50                                                                  | 1.05     | 1.02     | 0.199                   |
| 23.00                                                                      | 0.79     | 0.90     | 0.213                   | 3.80           | 1.49     | 3.45     | 0.672                   | 20.00                                                                  | 0.99     | 1.02     | 0.208                   |
| 23.50                                                                      | 0.75     | 0.87     | 0.214                   | 3.90           | 1.42     | 3.35     | 0.668                   | 20.50                                                                  | 0.92     | 0.99     | 0.212                   |
| 24.00                                                                      | 0.73     | 0.84     | 0.210                   | 4.00           | 1.37     | 3.24     | 0.661                   | 21.00                                                                  | 0.86     | 0.94     | 0.209                   |
| 24.50                                                                      | 0.70     | 0.81     | 0.208                   | 4.20           | 1.29     | 3.08     | 0.649                   | 21.50                                                                  | 0.83     | 0.90     | 0.203                   |
| 25.00                                                                      | 0.69     | 0.77     | 0.202                   | 4.40           | 1.22     | 2.93     | 0.639                   | 22.00                                                                  | 0.81     | 0.86     | 0.193                   |
| 25.50                                                                      | 0.67     | 0.74     | 0.195                   | 4.60           | 1.16     | 2.79     | 0.628                   | 23.00                                                                  | 0.77     | 0.79     | 0.182                   |
| 26.00                                                                      | 0.66     | 0.70     | 0.188                   | 4.80           | 1.11     | 2.67     | 0.617                   | 24.00                                                                  | 0.74     | 0.74     | 0.171                   |
| 26.50                                                                      | 0.65     | 0.66     | 0.176                   | 5.00           | 1.06     | 2.56     | 0.607                   | 25.00                                                                  | 0.71     | 0.69     | 0.163                   |
| 27.00                                                                      | 0.65     | 0.64     | 0.168                   | 5.20           | 1.01     | 2.46     | 0.600                   | 26.00                                                                  | 0.68     | 0.63     | 0.154                   |
| 27.50                                                                      | 0.65     | 0.61     | 0.159                   | 5.40           | 0.95     | 2.35     | 0.593                   | 27.00                                                                  | 0.67     | 0.57     | 0.140                   |
| 28.00                                                                      | 0.65     | 0.59     | 0.152                   | 5.60           | 0.92     | 2.23     | 0.576                   | 28.00                                                                  | 0.66     | 0.51     | 0.124                   |
| 29.00                                                                      | 0.65     | 0.54     | 0.137                   | 5.80           | 0.90     | 2.14     | 0.559                   | 29.00                                                                  | 0.67     | 0.46     | 0.107                   |
| 30.00                                                                      | 0.66     | 0.51     | 0.127                   | 6.00           | 0.88     | 2.05     | 0.545                   | 30.00                                                                  | 0.67     | 0.43     | 0.097                   |
| 31.00                                                                      | 0.64     | 0.49     | 0.127                   | 6.20           | 0.87     | 1.98     | 0.531                   | 31.00                                                                  | 0.67     | 0.37     | 0.084                   |
| 32.00                                                                      | 0.61     | 0.44     | 0.126                   | 6.40           | 0.84     | 1.91     | 0.521                   | 32.00                                                                  | 0.69     | 0.33     | 0.070                   |
| 33.00                                                                      | 0.60     | 0.37     | 0.110                   | 6.60           | 0.82     | 1.84     | 0.510                   | 33.00                                                                  | 0.71     | 0.30     | 0.058                   |
| 34.00                                                                      | 0.65     | 0.30     | 0.074                   | 6.80           | 0.79     | 1.77     | 0.500                   | 34.00                                                                  | 0.73     | 0.27     | 0.048                   |
| 35.00                                                                      | 0.69     | 0.28     | 0.058                   | 7.00           | 0.76     | 1.69     | 0.489                   | 35.00                                                                  | 0.75     | 0.25     | 0.039                   |
| 36.00                                                                      | 0.73     | 0.27     | 0.049                   | 7.20           | 0.75     | 1.61     | 0.472                   | 36.00                                                                  | 0.77     | 0.24     | 0.035                   |
| 37.00                                                                      | 0.74     | 0.28     | 0.047                   | 7.40           | 0.73     | 1.54     | 0.455                   | 37.00                                                                  | 0.79     | 0.23     | 0.039                   |
| 38.00                                                                      | 0.74     | 0.27     | 0.045                   | 7.60           | 0.73     | 1.46     | 0.433                   | 38.00                                                                  | 0.80     | 0.22     | 0.027                   |
| 39.00                                                                      | 0.75     | 0.25     | 0.041                   | 7.80           | 0.73     | 1.39     | 0.411                   | 39.00                                                                  | 0.82     | 0.22     | 0.024                   |
| <i>Ruthenium, single crystal, <math>\vec{E} \parallel \vec{c}^o</math></i> |          |          |                         | 8.00           | 0.72     | 1.33     | 0.391                   | 40.00                                                                  | 0.83     | 0.22     | 0.022                   |
| 0.10                                                                       | 11.50    | 51.38    | 0.984                   | 8.20           | 0.72     | 1.26     | 0.366                   | <i>Ruthenium, single crystal, <math>\vec{E} \perp \vec{c}^o</math></i> |          |          |                         |
| 0.20                                                                       | 5.93     | 27.14    | 0.970                   | 8.40           | 0.73     | 1.20     | 0.342                   | 0.10                                                                   | 11.85    | 50.81    | 0.983                   |
| 0.30                                                                       | 4.33     | 18.50    | 0.953                   | 8.60           | 0.74     | 1.14     | 0.318                   | 0.20                                                                   | 6.68     | 27.18    | 0.966                   |
| 0.40                                                                       | 3.60     | 13.97    | 0.933                   | 8.80           | 0.74     | 1.08     | 0.295                   | 0.30                                                                   | 4.94     | 18.92    | 0.950                   |
| 0.50                                                                       | 3.18     | 11.04    | 0.909                   | 9.00           | 0.75     | 1.02     | 0.267                   | 0.40                                                                   | 3.90     | 14.51    | 0.933                   |
| 0.60                                                                       | 3.28     | 8.89     | 0.865                   | 9.20           | 0.77     | 0.97     | 0.243                   | 0.50                                                                   | 3.27     | 11.63    | 0.915                   |
| 0.70                                                                       | 3.62     | 7.73     | 0.822                   | 9.40           | 0.79     | 0.91     | 0.217                   | 0.60                                                                   | 2.98     | 9.54     | 0.888                   |
| 0.80                                                                       | 3.42     | 7.02     | 0.801                   | 9.60           | 0.82     | 0.86     | 0.190                   | 0.70                                                                   | 2.82     | 7.99     | 0.856                   |
| 0.90                                                                       | 3.25     | 6.12     | 0.766                   | 9.80           | 0.85     | 0.81     | 0.167                   | 0.80                                                                   | 2.73     | 6.71     | 0.815                   |
| 1.00                                                                       | 3.39     | 5.33     | 0.715                   | 10.00          | 0.88     | 0.76     | 0.144                   | 0.90                                                                   | 2.82     | 5.54     | 0.751                   |
| 1.10                                                                       | 3.66     | 4.83     | 0.675                   | 10.20          | 0.92     | 0.72     | 0.125                   | 1.00                                                                   | 3.17     | 4.59     | 0.670                   |
| 1.20                                                                       | 3.84     | 4.57     | 0.654                   | 10.40          | 0.96     | 0.69     | 0.110                   | 1.10                                                                   | 3.69     | 3.91     | 0.604                   |
| 1.30                                                                       | 3.94     | 4.38     | 0.638                   | 10.60          | 1.01     | 0.67     | 0.100                   | 1.20                                                                   | 4.28     | 3.66     | 0.585                   |
| 1.40                                                                       | 4.02     | 4.19     | 0.624                   | 10.80          | 1.05     | 0.66     | 0.094                   | 1.30                                                                   | 4.66     | 3.72     | 0.593                   |
| 1.50                                                                       | 4.16     | 4.07     | 0.614                   | 11.00          | 1.09     | 0.65     | 0.090                   | 1.40                                                                   | 4.86     | 3.79     | 0.601                   |
| 1.60                                                                       | 4.33     | 4.08     | 0.615                   | 11.20          | 1.12     | 0.65     | 0.088                   | 1.50                                                                   | 4.99     | 3.89     | 0.609                   |
| 1.70                                                                       | 4.42     | 4.21     | 0.624                   | 11.40          | 1.15     | 0.65     | 0.087                   | 1.60                                                                   | 5.08     | 4.03     | 0.618                   |
| 1.80                                                                       | 4.40     | 4.38     | 0.636                   | 11.60          | 1.18     | 0.65     | 0.088                   | 1.70                                                                   | 5.12     | 4.22     | 0.629                   |
| 1.90                                                                       | 4.29     | 4.61     | 0.651                   | 11.80          | 1.21     | 0.66     | 0.090                   | 1.80                                                                   | 5.10     | 4.45     | 0.642                   |
| 2.00                                                                       | 4.04     | 4.81     | 0.667                   | 12.00          | 1.23     | 0.67     | 0.092                   | 1.90                                                                   | 4.96     | 4.78     | 0.660                   |
| 2.10                                                                       | 3.69     | 4.90     | 0.679                   | 12.40          | 1.26     | 0.69     | 0.098                   | 2.00                                                                   | 4.61     | 5.06     | 0.677                   |
| 2.20                                                                       | 3.35     | 4.82     | 0.683                   | 12.80          | 1.27     | 0.72     | 0.104                   | 2.10                                                                   | 4.21     | 5.09     | 0.682                   |
| 2.30                                                                       | 3.09     | 4.70     | 0.681                   | 13.20          | 1.28     | 0.74     | 0.108                   | 2.20                                                                   | 3.94     | 5.00     | 0.681                   |
| 2.40                                                                       | 2.89     | 4.55     | 0.677                   | 13.60          | 1.28     | 0.75     | 0.111                   | 2.30                                                                   | 3.69     | 4.97     | 0.684                   |
| 2.50                                                                       | 2.74     | 4.40     | 0.671                   | 14.00          | 1.28     | 0.76     | 0.114                   | 2.40                                                                   | 3.44     | 4.88     | 0.684                   |
| 2.60                                                                       | 2.64     | 4.25     | 0.663                   | 14.40          | 1.27     | 0.76     | 0.114                   | 2.50                                                                   | 3.27     | 4.77     | 0.681                   |
| 2.70                                                                       | 2.58     | 4.14     | 0.656                   | 14.80          | 1.27     | 0.76     | 0.114                   | 2.60                                                                   | 3.14     | 4.66     | 0.677                   |
| 2.80                                                                       | 2.54     | 4.05     | 0.650                   | 15.00          | 1.27     | 0.76     | 0.114                   | 2.70                                                                   | 3.06     | 4.59     | 0.674                   |
| 2.90                                                                       | 2.48     | 4.03     | 0.650                   | 15.60          | 1.28     | 0.77     | 0.115                   | 2.80                                                                   | 2.99     | 4.59     | 0.676                   |
| 3.00                                                                       | 2.38     | 4.03     | 0.656                   | 16.00          | 1.30     | 0.78     | 0.118                   | 2.90                                                                   | 2.87     | 4.64     | 0.686                   |
| 3.10                                                                       | 2.26     | 4.00     | 0.661                   | 16.50          | 1.32     | 0.80     | 0.123                   | 3.00                                                                   | 2.64     | 4.69     | 0.701                   |
| 3.20                                                                       | 2.13     | 3.96     | 0.666                   | 17.00          | 1.34     | 0.85     | 0.136                   | 3.10                                                                   | 2.40     | 4.64     | 0.710                   |



| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)                                                               | $n$   | $k$      | $R(\phi = 0)$ | Energy<br>(eV)                                                           | $n$    | $k$      | $R(\phi = 0)$ |
|----------------|------|------|---------------|------------------------------------------------------------------------------|-------|----------|---------------|--------------------------------------------------------------------------|--------|----------|---------------|
| 3.20           | 2.18 | 4.55 | 0.717         | 17.00                                                                        | 1.28  | 0.94     | 0.158         | 0.4959                                                                   | 3.442  | 1.41E-04 | 0.302         |
| 3.30           | 2.00 | 4.43 | 0.721         | 17.50                                                                        | 1.25  | 1.00     | 0.175         | 0.6199                                                                   | 3.462  | 1.12E-04 | 0.304         |
| 3.40           | 1.84 | 4.30 | 0.723         | 18.00                                                                        | 1.19  | 1.04     | 0.190         | 0.7439                                                                   | 3.486  | 9.42E-05 | 0.307         |
| 3.50           | 1.71 | 4.16 | 0.723         | 18.50                                                                        | 1.12  | 1.05     | 0.200         | 0.8679                                                                   | 3.516  | 8.07E-05 | 0.310         |
| 3.60           | 1.60 | 4.03 | 0.722         | 19.00                                                                        | 1.07  | 1.05     | 0.205         | 0.9919                                                                   | 3.551  | 7.11E-05 | 0.314         |
| 3.70           | 1.50 | 3.90 | 0.721         | 19.50                                                                        | 1.02  | 1.04     | 0.212         | 1.116                                                                    | 3.592  | 6.37E-05 | 0.319         |
| 3.80           | 1.41 | 3.77 | 0.718         | 20.00                                                                        | 0.97  | 1.04     | 0.219         | 1.240                                                                    | 3.640  | 5.81E-05 | 0.324         |
| 3.90           | 1.35 | 3.64 | 0.713         | 20.50                                                                        | 0.91  | 1.03     | 0.228         | 1.50                                                                     |        | 1.33E-04 |               |
| 4.00           | 1.29 | 3.53 | 0.707         | 21.00                                                                        | 0.85  | 1.01     | 0.234         | 1.60                                                                     |        | 1.59E-04 |               |
| 4.20           | 1.21 | 3.31 | 0.694         | 21.50                                                                        | 0.80  | 0.97     | 0.234         | 1.70                                                                     |        | 6.27E-04 |               |
| 4.40           | 1.16 | 3.13 | 0.679         | 22.00                                                                        | 0.77  | 0.94     | 0.233         | 1.80                                                                     | 4.46   | 2.20E-02 | 0.402         |
| 4.60           | 1.13 | 2.97 | 0.662         | 23.00                                                                        | 0.71  | 0.87     | 0.229         | 2.0                                                                      | 4.79   | 0.76     | 0.438         |
| 4.80           | 1.09 | 2.86 | 0.652         | 24.00                                                                        | 0.67  | 0.79     | 0.218         | 2.2                                                                      | 4.49   | 1.19     | 0.431         |
| 5.00           | 1.03 | 2.75 | 0.648         | 25.00                                                                        | 0.64  | 0.73     | 0.205         | 2.4                                                                      | 4.28   | 1.21     | 0.417         |
| 5.20           | 0.97 | 2.64 | 0.643         | 26.00                                                                        | 0.61  | 0.66     | 0.194         | 2.6                                                                      | 4.40   | 1.32     | 0.430         |
| 5.40           | 0.91 | 2.52 | 0.635         | 27.00                                                                        | 0.60  | 0.59     | 0.177         | 2.8                                                                      | 4.59   | 1.70     | 0.462         |
| 5.60           | 0.88 | 2.40 | 0.622         | 28.00                                                                        | 0.60  | 0.53     | 0.155         | 3.0                                                                      | 4.44   | 2.29     | 0.490         |
| 5.80           | 0.86 | 2.29 | 0.605         | 29.00                                                                        | 0.61  | 0.48     | 0.134         | 3.2                                                                      | 3.92   | 2.59     | 0.493         |
| 6.00           | 0.84 | 2.20 | 0.591         | 30.00                                                                        | 0.62  | 0.45     | 0.123         | 3.4                                                                      | 3.69   | 2.76     | 0.502         |
| 6.20           | 0.82 | 2.11 | 0.576         | 31.00                                                                        | 0.61  | 0.40     | 0.114         | 3.6                                                                      | 3.39   | 3.01     | 0.521         |
| 6.40           | 0.81 | 2.04 | 0.564         | 32.00                                                                        | 0.63  | 0.34     | 0.093         | 3.8                                                                      | (3.00) |          |               |
| 6.60           | 0.78 | 1.97 | 0.556         | 33.00                                                                        | 0.65  | 0.31     | 0.077         | 4.0                                                                      | (2.65) |          |               |
| 6.80           | 0.76 | 1.89 | 0.545         | 34.00                                                                        | 0.67  | 0.28     | 0.065         | 4.2                                                                      | (2.30) |          |               |
| 7.00           | 0.73 | 1.82 | 0.538         | 35.00                                                                        | 0.70  | 0.26     | 0.054         | 4.5                                                                      | 1.92   | 2.78     | 0.528         |
| 7.20           | 0.70 | 1.75 | 0.527         | 36.00                                                                        | 0.72  | 0.25     | 0.047         | 5.0                                                                      | 1.50   | 2.31     | 0.482         |
| 7.40           | 0.68 | 1.67 | 0.513         | 37.00                                                                        | 0.73  | 0.23     | 0.041         | 6.0                                                                      | 1.57   | 1.49     | 0.288         |
| 7.60           | 0.67 | 1.59 | 0.496         | 38.00                                                                        | 0.75  | 0.22     | 0.035         | 7.0                                                                      | 1.84   | 1.45     | 0.276         |
| 7.80           | 0.66 | 1.51 | 0.476         | 39.00                                                                        | 0.77  | 0.22     | 0.031         | 8.0                                                                      | 1.35   | 1.68     | 0.353         |
| 8.00           | 0.66 | 1.44 | 0.454         | 40.00                                                                        | 0.79  | 0.22     | 0.028         | 9.0                                                                      | 1.35   | 1.64     | 0.342         |
| 8.20           | 0.65 | 1.36 | 0.430         | <i>Selenium, single crystal, <math>\vec{E} \parallel \vec{c}^{22}</math></i> |       |          |               | 10.0                                                                     | 0.92   | 1.07     | 0.238         |
| 8.40           | 0.66 | 1.29 | 0.403         | 0.01364                                                                      | 2.914 | 0.248    | 0.242         | 12.0                                                                     | 1.00   | 1.10     | 0.232         |
| 8.60           | 0.66 | 1.22 | 0.378         | 0.01488                                                                      | 3.175 | 9.95E-02 | 0.272         | 14.0                                                                     | 0.81   | 0.91     | 0.211         |
| 8.80           | 0.68 | 1.15 | 0.346         | 0.01612                                                                      | 3.263 | 2.13E-03 | 0.282         | 16.0                                                                     | 0.65   | 0.61     | 0.160         |
| 9.00           | 0.69 | 1.09 | 0.317         | 0.01736                                                                      | 3.306 | 3.81E-02 | 0.287         | 18.0                                                                     | 0.65   | 0.48     | 0.120         |
| 9.20           | 0.70 | 1.02 | 0.286         | 0.01860                                                                      | 3.330 | 7.04E-03 | 0.290         | 20.0                                                                     | 0.69   | 0.36     | 0.076         |
| 9.40           | 0.73 | 0.95 | 0.251         | 0.01984                                                                      | 3.346 | 4.23E-02 | 0.291         | 22.0                                                                     | 0.81   | 0.25     | 0.030         |
| 9.60           | 0.77 | 0.89 | 0.216         | 0.02108                                                                      | 3.358 | 3.40E-03 | 0.293         | 24.0                                                                     | 0.91   | 0.18     | 0.011         |
| 9.80           | 0.82 | 0.84 | 0.185         | 0.02232                                                                      | 3.366 | 5.31E-02 | 0.294         | 26.0                                                                     | 0.86   | 0.15     | 0.012         |
| 10.00          | 0.86 | 0.81 | 0.163         | 0.02356                                                                      | 3.372 | 1.96E-03 | 0.294         | 28.0                                                                     | 0.85   | 0.13     | 0.011         |
| 10.20          | 0.90 | 0.77 | 0.143         | 0.02480                                                                      | 3.377 | 2.39E-02 | 0.295         | 30.0                                                                     | 0.87   | 0.11     | 0.008         |
| 10.40          | 0.94 | 0.74 | 0.127         | 0.02604                                                                      | 3.380 |          | 0.295         | <i>Selenium, single crystal, <math>\vec{E} \perp \vec{c}^{22}</math></i> |        |          |               |
| 10.60          | 0.99 | 0.72 | 0.115         | 0.02728                                                                      |       | 1.16E-02 |               | 0.01364                                                                  | 2.854  | 0.0239   | 0.231         |
| 10.80          | 1.04 | 0.71 | 0.108         | 0.02976                                                                      |       | 7.96E-03 |               | 0.01488                                                                  | 2.932  | 0.0325   | 0.241         |
| 11.00          | 1.08 | 0.70 | 0.104         | 0.03224                                                                      |       | 8.57E-03 |               | 0.01612                                                                  | 3.140  | 0.1750   | 0.269         |
| 11.20          | 1.11 | 0.70 | 0.102         | 0.03472                                                                      |       | 2.70E-02 |               | 0.01736                                                                  | 2.959  | 1.3300   | 0.321         |
| 11.40          | 1.14 | 0.70 | 0.101         | 0.03720                                                                      | 3.397 | 1.72E-02 | 0.297         | 0.01860                                                                  | 2.111  | 0.2550   | 0.133         |
| 11.60          | 1.17 | 0.71 | 0.102         | 0.04463                                                                      |       | 1.13E-02 |               | 0.01984                                                                  | 2.356  | 0.0746   | 0.164         |
| 11.80          | 1.20 | 0.72 | 0.104         | 0.04959                                                                      | 3.403 | 2.79E-03 | 0.298         | 0.02108                                                                  | 2.462  | 0.0276   | 0.178         |
| 12.00          | 1.22 | 0.73 | 0.107         | 0.05703                                                                      |       | 1.56E-03 |               | 0.02232                                                                  | 2.502  | 0.0442   | 0.184         |
| 12.40          | 1.25 | 0.76 | 0.113         | 0.06199                                                                      | 3.405 | 1.35E-03 | 0.298         | 0.02356                                                                  | 2.543  | 0.0097   | 0.190         |
| 12.80          | 1.26 | 0.78 | 0.118         | 0.06819                                                                      |       | 5.79E-04 |               | 0.02480                                                                  | 2.550  | 0.0239   | 0.191         |
| 13.20          | 1.27 | 0.81 | 0.124         | 0.07439                                                                      | 3.407 | 4.44E-04 | 0.298         | 0.02604                                                                  | 2.582  |          | 0.195         |
| 13.60          | 1.27 | 0.83 | 0.129         | 0.08059                                                                      |       | 4.41E-04 |               | 0.02728                                                                  | 2.600  | 0.0101   | 0.198         |
| 14.00          | 1.26 | 0.84 | 0.132         | 0.08679                                                                      | 3.408 | 4.32E-04 | 0.298         | 0.02976                                                                  | 2.576  | 9.95E-03 | 0.194         |
| 14.40          | 1.25 | 0.84 | 0.132         | 0.09299                                                                      |       | 2.44E-04 |               | 0.03224                                                                  | 2.598  | 1.16E-02 | 0.197         |
| 14.80          | 1.25 | 0.84 | 0.133         | 0.09919                                                                      | 3.409 | 3.23E-04 | 0.299         | 0.03472                                                                  | 2.607  | 1.68E-02 | 0.199         |
| 15.00          | 1.25 | 0.84 | 0.133         | 0.1116                                                                       | 3.409 | 2.87E-04 | 0.299         | 0.03720                                                                  | 2.613  | 1.54E-02 | 0.199         |
| 15.60          | 1.25 | 0.85 | 0.134         | 0.1240                                                                       | 3.410 | 2.71E-04 | 0.299         | 0.04463                                                                  |        | 1.17E-02 |               |
| 16.00          | 1.27 | 0.85 | 0.134         | 0.2480                                                                       | 3.417 | 2.67E-04 | 0.299         | 0.04959                                                                  | 2.627  | 3.58E-03 | 0.201         |
| 16.50          | 1.28 | 0.89 | 0.145         | 0.3720                                                                       | 3.427 | 1.90E-04 | 0.301         | 0.05703                                                                  |        | 8.65E-04 |               |

| Energy<br>(eV) | $n$   | $k$      | $R(\phi = 0)$ | Energy<br>(eV) | $n$      | $k$      | $R(\phi = 0)$ | Energy<br>(eV) | $n$   | $k$   | $R(\phi = 0)$ |
|----------------|-------|----------|---------------|----------------|----------|----------|---------------|----------------|-------|-------|---------------|
| 0.06199        | 2.632 | 2.07E-03 | 0.202         | 0.04959        | 3.4201   | 9.15E-05 | 0.300         | 3.6            | 5.296 | 2.987 | 0.564         |
| 0.06819        |       | 2.89E-04 |               | 0.05703        |          | 1.56E-04 |               | 3.7            | 5.156 | 3.058 | 0.563         |
| 0.07439        | 2.635 | 1.59E-04 | 0.202         | 0.06199        | 3.4204   | 2.86E-04 | 0.300         | 3.8            | 5.065 | 3.182 | 0.568         |
| 0.08059        |       | 1.35E-04 |               | 0.06943        |          | 3.84E-04 |               | 3.9            | 5.016 | 3.346 | 0.577         |
| 0.08679        | 2.636 | 1.42E-04 | 0.202         | 0.07439        |          | 7.16E-04 |               | 4.0            | 5.010 | 3.587 | 0.591         |
| 0.09299        |       | 1.04E-04 |               | 0.08059        | (3.4207) | 1.52E-04 | 0.300         | 4.1            | 5.020 | 3.979 | 0.614         |
| 0.09919        | 2.637 | 8.95E-05 | 0.203         | 0.08679        |          | 1.02E-04 |               | 4.2            | 4.888 | 4.639 | 0.652         |
| 0.1116         | 2.638 | 8.84E-05 | 0.203         | 0.09299        |          | 2.59E-04 |               | 4.3            | 4.086 | 5.395 | 0.703         |
| 0.1240         | 2.639 | 8.51E-05 | 0.203         | 0.09919        |          | 1.77E-04 |               | 4.4            | 3.120 | 5.344 | 0.726         |
| 0.2480         | 2.645 | 5.97E-05 | 0.204         | 0.1054         |          | 1.53E-04 |               | 4.5            | 2.451 | 5.082 | 0.740         |
| 0.3720         | 2.652 | 5.44E-05 | 0.205         | 0.1116         |          | 2.02E-04 |               | 4.6            | 1.988 | 4.678 | 0.742         |
| 0.4959         | 2.654 | 4.58E-05 | 0.205         | 0.1178         |          | 1.22E-04 |               | 4.7            | 1.764 | 4.278 | 0.728         |
| 0.6199         | 2.675 | 3.82E-05 | 0.208         | 0.1240         | 3.4215   | 6.76E-05 | 0.300         | 4.8            | 1.658 | 3.979 | 0.710         |
| 0.7439         | 2.692 | 3.32E-05 | 0.210         | 0.1364         |          | 5.49E-05 |               | 4.9            | 1.597 | 3.749 | 0.693         |
| 0.8679         | 2.713 | 2.96E-05 | 0.213         | 0.1488         |          | 2.41E-05 |               | 5.0            | 1.570 | 3.565 | 0.675         |
| 0.9919         | 2.739 | 2.69E-05 | 0.216         | 0.1612         |          | 2.49E-05 |               | 5.1            | 1.571 | 3.429 | 0.658         |
| 1.116          | 2.772 | 2.48E-05 | 0.221         | 0.1736         | (3.4230) | 1.68E-05 | 0.300         | 5.2            | 1.589 | 3.354 | 0.646         |
| 1.240          | 2.816 | 2.31E-05 | 0.226         | 0.1798         |          | 2.45E-05 |               | 5.3            | 1.579 | 3.353 | 0.647         |
| 1.50           |       | 7.37E-05 |               | 0.1860         |          | 2.66E-06 |               | 5.4            | 1.471 | 3.366 | 0.663         |
| 1.60           |       | 8.63E-05 |               | 0.1922         |          | 1.74E-06 |               | 5.5            | 1.340 | 3.302 | 0.673         |
| 1.70           |       | 3.60E-04 |               | 0.1984         |          | 8.46E-07 |               | 5.6            | 1.247 | 3.206 | 0.675         |
| 1.80           | 3.32  | 0.11     | 0.289         | 0.2046         |          | 5.64E-07 |               | 5.7            | 1.180 | 3.112 | 0.673         |
| 2.00           | 3.38  | 0.65     | 0.310         | 0.2108         | (3.4244) | 4.17E-07 | 0.300         | 5.8            | 1.133 | 3.045 | 0.672         |
| 2.20           | 3.07  | 0.73     | 0.282         | 0.2170         |          | 4.05E-07 |               | 5.9            | 1.083 | 2.982 | 0.673         |
| 2.40           | 2.93  | 0.61     | 0.259         | 0.2232         |          | 3.94E-07 |               | 6.0            | 1.010 | 2.909 | 0.677         |
| 2.60           | 3.00  | 0.53     | 0.263         | 0.2294         |          | 3.26E-07 |               | 6.5            | 0.847 | 2.73  | 0.688         |
| 2.80           | 3.12  | 0.58     | 0.279         | 0.2356         |          | 2.97E-07 |               | 7.0            | 0.682 | 2.45  | 0.691         |
| 3.00           | 3.30  | 0.70     | 0.305         | 0.2418         |          | 2.82E-07 |               | 7.5            | 0.563 | 2.21  | 0.693         |
| 3.20           | 3.35  | 1.01     | 0.328         | 0.2480         | 3.4261   | 1.99E-07 | 0.300         | 8.0            | 0.478 | 2.00  | 0.691         |
| 3.40           | 3.22  | 1.24     | 0.334         | 0.3100         | 3.4294   |          | 0.301         | 8.5            | 0.414 | 1.82  | 0.688         |
| 3.60           | 3.06  | 1.47     | 0.344         | 0.3626         | 3.4327   |          | 0.301         | 9.0            | 0.367 | 1.66  | 0.683         |
| 3.80           | 2.84  | 1.66     | 0.351         | 0.4568         | 3.4393   | 2.50E-09 | 0.302         | 9.5            | 0.332 | 1.51  | 0.672         |
| 4.00           | 2.51  | 1.81     | 0.356         | 0.6199         | 3.4490   |          | 0.303         | 10.0           | 0.306 | 1.38  | 0.661         |
| 4.20           | 2.18  | 1.83     | 0.352         | 0.8093         | 3.4784   |          | 0.306         | 12.0           | 0.257 | 0.963 |               |



| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)              | $n$   | $k$  | $R(\phi = 0)$ | Energy<br>(eV)                | $n$   | $k$   | $R(\phi = 0)$ |
|----------------|------|------|---------------|-----------------------------|-------|------|---------------|-------------------------------|-------|-------|---------------|
| 3.50           | 0.21 | 1.42 | 0.756         | 46.00                       | 0.90  | 0.32 | 0.031         | 11.08                         | 0.870 |       | 0.005         |
| 3.60           | 0.23 | 1.13 | 0.671         | 48.00                       | 0.89  | 0.31 | 0.030         | 11.83                         | 0.887 |       | 0.004         |
| 3.70           | 0.30 | 0.77 | 0.475         | 50.00                       | 0.88  | 0.29 | 0.027         | 12.73                         | 0.907 |       | 0.002         |
| 3.77           | 0.53 | 0.40 | 0.154         | 52.00                       | 0.89  | 0.28 | 0.024         | 13.05                         | 0.913 |       | 0.002         |
| 3.80           | 0.73 | 0.30 | 0.053         | 54.00                       | 0.88  | 0.17 | 0.024         | 13.42                         | 0.914 |       | 0.002         |
| 3.90           | 1.30 | 0.36 | 0.040         | 56.00                       | 0.87  | 0.26 | 0.024         | 13.73                         | 0.917 |       | 0.002         |
| 4.00           | 1.61 | 0.60 | 0.103         | 58.00                       | 0.87  | 0.24 | 0.021         | 14.07                         | 0.922 |       | 0.002         |
| 4.10           | 1.73 | 0.85 | 0.153         | 60.00                       | 0.87  | 0.22 | 0.018         | 14.83                         | 0.934 |       | 0.001         |
| 4.20           | 1.75 | 1.06 | 0.194         | 62.00                       | 0.88  | 0.21 | 0.016         | 15.05                         | 0.936 |       | 0.001         |
| 4.30           | 1.73 | 1.13 | 0.208         | 64.00                       | 0.88  | 0.21 | 0.016         | 15.46                         | 0.942 |       | 0.001         |
| 4.50           | 1.69 | 1.28 | 0.238         | 66.00                       | 0.88  | 0.21 | 0.016         | 16.21                         | 0.948 |       | 0.001         |
| 4.75           | 1.61 | 1.34 | 0.252         | 68.00                       | 0.87  | 0.21 | 0.017         | 18.10                         | 0.964 |       | 0.000         |
| 5.00           | 1.55 | 1.36 | 0.257         | 70.00                       | 0.83  | 0.20 | 0.021         | 21.12                         | 0.979 |       | 0.000         |
| 5.50           | 1.45 | 1.34 | 0.257         | 72.00                       | 0.85  | 0.18 | 0.016         | 25.51                         | 0.993 |       | 0.000         |
| 6.00           | 1.34 | 1.28 | 0.246         | 74.00                       | 0.85  | 0.17 | 0.014         | 26.95                         | 1.00  |       | 0.000         |
| 6.50           | 1.25 | 1.18 | 0.225         | 76.00                       | 0.85  | 0.16 | 0.013         | 27.68                         | 1.01  |       | 0.000         |
| 7.00           | 1.18 | 1.06 | 0.196         | 78.00                       | 0.85  | 0.15 | 0.013         | 28.37                         | 1.01  |       | 0.000         |
| 7.50           | 1.14 | 0.91 | 0.157         | 80.00                       | 0.85  | 0.14 | 0.012         | 29.52                         | 1.02  |       | 0.000         |
| 8.00           | 1.16 | 0.75 | 0.114         | 85.00                       | 0.85  | 0.11 | 0.011         | <i>Tantalum</i> <sup>16</sup> |       |       |               |
| 9.00           | 1.33 | 0.56 | 0.074         | 90.00                       | 0.85  | 0.08 | 0.009         | 0.10                          | 10.14 | 66.39 | 0.984         |
| 10.00          | 1.46 | 0.56 | 0.082         | 95.00                       | 0.86  | 0.06 | 0.007         | 0.15                          | 9.45  | 46.41 | 0.9834        |
| 11.00          | 1.52 | 0.56 | 0.088         | 100.00                      | 0.87  | 0.04 | 0.005         | 0.20                          | 5.77  | 35.46 | 0.982         |
| 12.00          | 1.61 | 0.59 | 0.100         | <i>Sodium</i> <sup>24</sup> |       |      |               | 0.26                          | 3.67  | 27.53 | 0.981         |
| 13.00          | 1.66 | 0.64 | 0.112         |                             |       |      |               | 0.30                          | 2.87  | 23.90 | 0.980         |
| 14.00          | 1.72 | 0.78 | 0.141         | 0.55                        | 0.262 | 9.97 | 0.990         | 0.38                          | 2.03  | 18.87 | 0.978         |
| 14.50          | 1.64 | 0.88 | 0.152         | 0.58                        | 0.241 | 9.45 | 0.989         | 0.50                          | 1.37  | 14.26 | 0.974         |
| 15.00          | 1.56 | 0.92 | 0.156         | 0.63                        | 0.207 | 8.80 | 0.990         | 0.58                          | 1.15  | 12.19 | 0.970         |
| 16.00          | 1.42 | 0.91 | 0.151         | 0.67                        | 0.175 | 8.09 | 0.990         | 0.70                          | 0.96  | 9.92  | 0.962         |
| 17.00          | 1.33 | 0.86 | 0.139         | 0.73                        | 0.147 | 7.42 | 0.990         | 0.78                          | 0.89  | 8.77  | 0.956         |
| 18.00          | 1.28 | 0.80 | 0.124         | 0.81                        | 0.123 | 6.67 | 0.989         | 0.90                          | 0.84  | 7.38  | 0.942         |
| 19.00          | 1.27 | 0.75 | 0.111         | 0.92                        | 0.099 | 5.82 | 0.989         | 1.00                          | 0.89  | 6.47  | 0.992         |
| 20.00          | 1.29 | 0.71 | 0.103         | 1.05                        | 0.078 | 5.11 | 0.989         | 1.10                          | 0.93  | 5.75  | 0.899         |
| 21.00          | 1.35 | 0.75 | 0.112         | 1.23                        | 0.064 | 4.35 | 0.987         | 1.20                          | 0.98  | 5.14  | 0.872         |
| 21.50          | 1.37 | 0.80 | 0.124         | 1.44                        | 0.053 | 3.72 | 0.986         | 1.30                          | 1.00  | 4.62  | 0.842         |
| 22.00          | 1.34 | 0.87 | 0.141         | 1.65                        | 0.050 | 3.22 | 0.983         | 1.40                          | 1.04  | 4.15  | 0.805         |
| 22.50          | 1.26 | 0.93 | 0.157         | 1.87                        | 0.049 | 2.76 | 0.978         | 1.50                          | 1.09  | 3.73  | 0.762         |
| 23.00          | 1.17 | 0.94 | 0.163         | 2.07                        | 0.053 | 2.48 | 0.971         | 1.60                          | 1.15  | 3.33  | 0.707         |
| 23.50          | 1.10 | 0.93 | 0.165         | 2.27                        | 0.059 | 2.23 | 0.961         | 1.70                          | 1.24  | 2.95  | 0.640         |
| 24.00          | 1.04 | 0.90 | 0.165         | 2.45                        | 0.063 | 2.07 | 0.953         | 1.80                          | 1.35  | 2.60  | 0.560         |
| 24.50          | 0.99 | 0.87 | 0.160         | 2.64                        | 0.066 | 1.88 | 0.943         | 1.90                          | 1.57  | 2.24  | 0.460         |
| 25.00          | 0.95 | 0.83 | 0.154         | 2.82                        | 0.068 | 1.76 | 0.936         | 2.00                          | 1.83  | 1.99  | 0.388         |
| 25.50          | 0.91 | 0.78 | 0.144         | 2.95                        | 0.068 | 1.63 | 0.928         | 2.10                          | 2.10  | 1.84  | 0.354         |
| 26.00          | 0.90 | 0.74 | 0.133         | 3.06                        | 0.069 | 1.54 | 0.921         | 2.20                          | 2.36  | 1.81  | 0.351         |
| 26.50          | 0.89 | 0.69 | 0.121         | 3.20                        | 0.065 | 1.47 | 0.921         | 2.30                          | 2.56  | 1.86  | 0.365         |
| 27.00          | 0.89 | 0.65 | 0.109         | 3.40                        | 0.061 | 1.33 | 0.916         | 2.40                          | 2.68  | 1.92  | 0.378         |
| 27.50          | 0.89 | 0.62 | 0.099         | 3.71                        | 0.055 | 1.13 | 0.908         | 2.50                          | 2.75  | 1.98  | 0.388         |
| 28.00          | 0.90 | 0.59 | 0.090         | 3.97                        | 0.049 | 1.01 | 0.908         | 2.60                          | 2.80  | 2.02  | 0.395         |
| 28.50          | 0.91 | 0.57 | 0.084         | 6.199                       | 0.390 |      | 0.193         | 2.70                          | 2.84  | 2.08  | 0.405         |
| 29.00          | 0.92 | 0.56 | 0.079         | 6.358                       | 0.454 |      | 0.141         | 2.80                          | 2.85  | 2.14  | 0.412         |
| 30.00          | 0.93 | 0.54 | 0.074         | 6.526                       | 0.485 |      | 0.120         | 2.90                          | 2.84  | 2.20  | 0.420         |
| 31.00          | 0.93 | 0.53 | 0.072         | 6.702                       | 0.533 |      | 0.093         | 3.00                          | 2.81  | 2.24  | 0.425         |
| 32.00          | 0.92 | 0.53 | 0.072         | 6.888                       | 0.574 |      | 0.073         | 3.20                          | 2.73  | 2.31  | 0.432         |
| 33.00          | 0.90 | 0.51 | 0.071         | 7.130                       | 0.616 |      | 0.056         | 3.40                          | 2.61  | 2.33  | 0.435         |
| 34.00          | 0.88 | 0.49 | 0.067         | 7.328                       | 0.641 |      | 0.048         | 3.60                          | 2.49  | 2.30  | 0.430         |
| 35.00          | 0.86 | 0.45 | 0.061         | 7.583                       | 0.674 |      | 0.038         | 3.80                          | 2.40  | 2.22  | 0.418         |
| 36.00          | 0.89 | 0.44 | 0.055         | 7.847                       | 0.700 |      | 0.031         | 4.00                          | 2.36  | 2.14  | 0.406         |
| 38.00          | 0.89 | 0.39 | 0.043         | 8.015                       | 0.710 |      | 0.029         | 4.20                          | 2.35  | 2.06  | 0.392         |
| 40.00          | 0.90 | 0.37 | 0.039         | 8.634                       | 0.762 |      | 0.018         | 4.40                          | 2.39  | 2.01  | 0.384         |
| 42.00          | 0.90 | 0.35 | 0.036         | 9.143                       | 0.800 |      | 0.012         | 4.60                          | 2.45  | 2.00  | 0.384         |
| 44.00          | 0.90 | 0.33 | 0.033         | 9.709                       | 0.819 |      | 0.010         | 4.80                          | 2.53  | 2.06  | 0.394         |
|                |      |      |               | 10.20                       | 0.843 |      | 0.007         |                               |       |       |               |

| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)                                                | $n$   | $k$      | $R(\phi = 0)$ | Energy<br>(eV)                                            | $n$    | $k$      | $R(\phi = 0)$ |
|----------------|------|------|---------------|---------------------------------------------------------------|-------|----------|---------------|-----------------------------------------------------------|--------|----------|---------------|
| 5.00           | 2.58 | 2.20 | 0.416         | 23.00                                                         | 0.73  | 0.24     | 0.043         | 0.7                                                       | 7.00   | 0.24     | 0.563         |
| 5.20           | 2.52 | 2.44 | 0.450         | 23.60                                                         | 0.80  | 0.26     | 0.033         | 0.8                                                       | 7.23   | 0.48     | 0.574         |
| 5.40           | 2.31 | 2.61 | 0.480         | 24.00                                                         | 0.80  | 0.26     | 0.034         | 0.9                                                       | 7.48   | 0.94     | 0.589         |
| 5.60           | 2.06 | 2.67 | 0.501         | 24.60                                                         | 0.82  | 0.25     | 0.029         | 1.0                                                       | 7.70   | 1.56     | 0.606         |
| 5.80           | 1.83 | 2.63 | 0.510         | 25.00                                                         | 0.83  | 0.25     | 0.026         | 1.2                                                       | 6.99   | 2.22     | 0.593         |
| 6.00           | 1.63 | 2.56 | 0.515         | 25.60                                                         | 0.86  | 0.24     | 0.022         | 1.4                                                       | 7.11   | 2.46     | 0.604         |
| 6.20           | 1.48 | 2.45 | 0.512         | 26.00                                                         | 0.88  | 0.25     | 0.022         | 1.6                                                       | 6.75   | 2.91     | 0.606         |
| 6.40           | 1.37 | 2.33 | 0.504         | 26.60                                                         | 0.87  | 0.26     | 0.023         | 1.8                                                       | 6.89   | 3.70     | 0.637         |
| 6.60           | 1.29 | 2.22 | 0.492         | 27.00                                                         | 0.87  | 0.25     | 0.022         | 2.0                                                       | 4.67   | 4.67     | 0.654         |
| 6.80           | 1.23 | 2.11 | 0.478         | 27.60                                                         | 0.89  | 0.23     | 0.019         | 2.2                                                       | 4.94   | 5.16     | 0.681         |
| 7.00           | 1.18 | 2.01 | 0.462         | 28.00                                                         | 0.90  | 0.23     | 0.017         | 2.4                                                       | 3.94   | 5.08     | 0.686         |
| 7.20           | 1.15 | 1.91 | 0.445         | 28.60                                                         | 0.91  | 0.22     | 0.015         | 2.6                                                       | 3.25   | 4.77     | 0.681         |
| 7.40           | 1.13 | 1.82 | 0.425         | 29.00                                                         | 0.92  | 0.22     | 0.014         | 2.8                                                       | 2.73   | 4.42     | 0.674         |
| 7.60           | 1.12 | 1.75 | 0.406         | 29.60                                                         | 0.94  | 0.22     | 0.014         | 3.0                                                       | 2.30   | 4.16     | 0.674         |
| 7.80           | 1.11 | 1.68 | 0.390         | 30.00                                                         | 0.95  | 0.22     | 0.014         | 3.5                                                       | 1.69   | 3.44     | 0.646         |
| 8.00           | 1.11 | 1.61 | 0.370         | 31.00                                                         | 0.97  | 0.23     | 0.014         | 4.0                                                       | 1.33   | 2.64     | 0.571         |
| 8.20           | 1.12 | 1.55 | 0.350         | 32.00                                                         | 0.98  | 0.24     | 0.015         | 4.5                                                       | 1.32   | 1.96     | 0.428         |
| 8.40           | 1.13 | 1.50 | 0.332         | 33.00                                                         | 0.98  | 0.25     | 0.015         | 5.0                                                       | 1.63   | 1.60     | 0.312         |
| 8.60           | 1.14 | 1.45 | 0.317         | 34.00                                                         | 0.99  | 0.25     | 0.016         | 5.5                                                       | 1.72   | 1.57     | 0.302         |
| 8.80           | 1.17 | 1.41 | 0.301         | 35.00                                                         | 0.99  | 0.26     | 0.017         | 6.0                                                       | 1.73   | 1.45     | 0.276         |
| 9.00           | 1.19 | 1.40 | 0.294         | 36.00                                                         | 0.99  | 0.27     | 0.018         | 6.5                                                       | 1.78   | 1.36     | 0.257         |
| 9.20           | 1.21 | 1.38 | 0.289         | 37.00                                                         | 0.99  | 0.28     | 0.019         | 7.0                                                       | 1.83   | 1.36     | 0.257         |
| 9.40           | 1.21 | 1.38 | 0.287         | 38.00                                                         | 0.98  | 0.28     | 0.021         | 7.5                                                       | 1.72   | 1.51     | 0.289         |
| 9.60           | 1.21 | 1.38 | 0.285         | 39.00                                                         | 0.97  | 0.29     | 0.022         | 8.0                                                       | 1.54   | 1.37     | 0.260         |
| 9.80           | 1.21 | 1.37 | 0.285         | 40.00                                                         | 0.95  | 0.29     | 0.023         | 8.5                                                       | 1.55   | 1.23     | 0.226         |
| 10.00          | 1.20 | 1.37 | 0.286         | <i>Tellurium, <math>\vec{E} \parallel \hat{c}^{25}</math></i> |       |          |               | 9.0                                                       | 0.99   | 0.93     | 0.179         |
| 10.20          | 1.19 | 1.37 | 0.286         | 0.01364                                                       | 4.82  | 0.118    | 0.431         | 9.5                                                       | 1.47   | 1.25     | 0.233         |
| 10.40          | 1.18 | 1.37 | 0.287         | 0.01488                                                       | 5.26  | 0.0505   | 0.463         | 10.0                                                      | 0.86   | 0.86     | 0.181         |
| 10.60          | 1.16 | 1.36 | 0.288         | 0.01612                                                       | 5.47  | 0.0278   | 0.477         | 11.0                                                      | 0.80   | 0.77     | 0.165         |
| 10.80          | 1.15 | 1.36 | 0.289         | 0.01736                                                       | 5.59  | 0.0174   | 0.485         | 12.0                                                      | 0.79   | 0.76     | 0.164         |
| 11.00          | 1.13 | 1.35 | 0.290         | 0.01860                                                       |       | 0.0796   |               | 14.0                                                      | 0.67   | 0.59     | 0.146         |
| 11.20          | 1.11 | 1.35 | 0.292         | 0.01984                                                       |       | 0.0696   |               | 16.0                                                      | 0.59   | 0.49     | 0.147         |
| 11.40          | 1.09 | 1.34 | 0.293         | 0.02108                                                       |       | 0.0749   |               | 18.0                                                      | 0.48   | 0.31     | 0.160         |
| 11.60          | 1.07 | 1.33 | 0.294         | 0.02232                                                       |       | 0.1900   |               | 20.0                                                      | 0.74   | 0.20     | 0.035         |
| 11.80          | 1.05 | 1.32 | 0.295         | 0.02356                                                       |       | 0.2220   |               | 22.0                                                      | 0.83   | 0.18     | 0.018         |
| 12.00          | 1.02 | 1.31 | 0.296         | 0.02480                                                       |       | 0.0716   |               | 24.0                                                      | 0.85   | 0.15     | 0.013         |
| 12.20          | 1.00 | 1.29 | 0.295         | 0.02604                                                       |       | 0.0682   |               | 26.0                                                      | 0.87   | 0.12     | 0.009         |
| 12.40          | 0.98 | 1.28 | 0.294         | 0.02728                                                       |       | 0.0832   |               | 28.0                                                      | 0.89   | 0.090    | 0.006         |
| 12.60          | 0.96 | 1.26 | 0.292         | 0.02976                                                       |       | 0.0149   |               | 30.0                                                      | 0.90   | 0.045    | 0.003         |
| 12.80          | 0.94 | 1.24 | 0.289         | 0.03224                                                       |       | 2.14E-03 |               | <i>Tellurium, <math>\vec{E} \perp \hat{c}^{25}</math></i> |        |          |               |
| 13.00          | 0.93 | 1.22 | 0.286         | 0.03472                                                       |       | 1.71E-02 |               | 0.01364                                                   | 2.61   | 0.2980   | 0.204         |
| 13.60          | 0.91 | 1.16 | 0.272         | 0.03720                                                       | 5.94  | 3.71E-03 | 0.507         | 0.01488                                                   | 3.65   | 0.0894   | 0.325         |
| 14.00          | 0.90 | 1.15 | 0.272         | 0.03968                                                       |       | 2.44E-03 |               | 0.01612                                                   | 4.10   | 0.0535   | 0.370         |
| 14.60          | 0.85 | 1.15 | 0.285         | 0.04339                                                       | 5.96  | 1.59E-03 | 0.508         | 0.01736                                                   | 4.63   | 0.4990   | 0.420         |
| 15.00          | 0.80 | 1.13 | 0.293         | 0.04711                                                       |       | 7.85E-04 |               | 0.01860                                                   |        | 0.1170   |               |
| 15.60          | 0.72 | 1.08 | 0.301         | 0.05083                                                       |       | 7.38E-04 |               | 0.01984                                                   |        | 0.0343   |               |
| 16.00          | 0.68 | 1.04 | 0.304         | 0.05579                                                       |       | 3.89E-04 |               | 0.02108                                                   | (4.42) | 0.0421   | 0.398         |
| 16.60          | 0.63 | 0.97 | 0.301         | 0.06199                                                       | 5.98  | 3.09E-04 | 0.509         | 0.02232                                                   |        | 0.1060   |               |
| 17.00          | 0.60 | 0.92 | 0.296         | 0.07439                                                       |       | 2.52E-04 |               | 0.02356                                                   |        | 0.0880   |               |
| 17.60          | 0.60 | 0.92 | 0.296         | 0.08679                                                       |       | 2.96E-04 |               | 0.02480                                                   |        | 0.0458   |               |
| 18.00          | 0.55 | 0.79 | 0.274         | 0.09919                                                       |       | 3.68E-04 |               | 0.02604                                                   |        | 0.0928   |               |
| 18.60          | 0.53 | 0.71 | 0.254         | 0.12400                                                       | 6.246 | 3.34E-04 | 0.524         | 0.02728                                                   |        | 0.0886   |               |
| 19.00          | 0.53 | 0.65 | 0.236         | 0.15500                                                       | 6.253 |          | 0.525         | 0.02976                                                   |        | 0.0232   |               |
| 19.60          | 0.53 | 0.57 | 0.207         | 0.20660                                                       | 6.286 |          | 0.526         | 0.03224                                                   |        | 3.06E-03 |               |
| 20.00          | 0.54 | 0.52 | 0.185         | 0.24800                                                       | 6.316 | 7.48E-05 | 0.528         | 0.03472                                                   |        | 1.25E-02 |               |
| 20.60          | 0.55 | 0.44 | 0.153         | 0.31                                                          | 6.372 | 1.18E-05 | 0.531         | 0.03720                                                   | 4.71   | 2.65E-03 | 0.422         |
| 21.00          | 0.57 | 0.39 | 0.127         | 0.35                                                          |       | 4.93E-04 |               | 0.03968                                                   |        | 1.89E-03 |               |
| 21.60          | 0.64 | 0.34 | 0.089         | 0.41                                                          |       | 6.74E-03 |               | 0.04339                                                   | 4.74   | 1.41E-03 | 0.425         |
| 22.00          | 0.64 | 0.32 | 0.081         | 0.5                                                           | 6.53  | 2.30E-02 | 0.539         | 0.04711                                                   |        | 8.38E-04 |               |
| 22.60          | 0.69 | 0.27 | 0.058         | 0.6                                                           | 6.71  | 7.50E-02 | 0.549         | 0.05083                                                   |        | 6.79E-04 |               |

| Energy<br>(eV)                                 | $n$   | $k$      | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ |
|------------------------------------------------|-------|----------|---------------|----------------|------|------|---------------|----------------|------|------|---------------|
| 0.05579                                        |       | 1.59E-04 |               | 0.40           | 2.49 | 4.68 | 0.708         | 8.40           | 1.08 | 0.95 | 0.175         |
| 0.06199                                        | 4.77  | 1.16E-04 | 0.427         | 0.45           | 3.35 | 3.25 | 0.545         | 8.60           | 1.04 | 0.96 | 0.181         |
| 0.07439                                        |       | 7.23E-05 |               | 0.50           | 4.43 | 3.22 | 0.555         | 8.80           | 1.02 | 0.95 | 0.181         |
| 0.08679                                        |       | 5.34E-05 |               | 0.60           | 4.71 | 3.77 | 0.597         | 9.00           | 1.00 | 0.94 | 0.182         |
| 0.09919                                        |       | 4.28E-05 |               | 0.70           | 4.38 | 3.89 | 0.603         | 9.20           | 0.97 | 0.93 | 0.182         |
| 0.1240                                         | 4.796 | 3.18E-05 | 0.429         | 0.80           | 4.04 | 3.82 | 0.596         | 9.40           | 0.95 | 0.91 | 0.181         |
| 0.1550                                         | 4.809 |          | 0.430         | 0.90           | 3.80 | 3.65 | 0.582         | 9.60           | 0.94 | 0.90 | 0.179         |
| 0.2066                                         | 4.838 |          | 0.432         | 1.00           | 3.62 | 3.52 | 0.570         | 9.80           | 0.91 | 0.88 | 0.179         |
| 0.2480                                         | 4.864 | 2.19E-05 | 0.434         | 1.10           | 3.47 | 3.40 | 0.560         | 10.00          | 0.89 | 0.88 | 0.180         |
| 0.31                                           | 4.929 | 3.18E-05 | 0.439         | 1.20           | 3.35 | 3.30 | 0.550         | 10.20          | 0.86 | 0.85 | 0.178         |
| 0.35                                           |       | 7.89E-02 |               | 1.30           | 3.28 | 3.25 | 0.546         | 10.40          | 0.85 | 0.83 | 0.175         |
| 0.41                                           |       | 0.149    |               | 1.40           | 3.17 | 3.28 | 0.549         | 10.60          | 0.81 | 0.79 | 0.167         |
| 0.5                                            | 4.90  |          | 0.437         | 1.50           | 2.98 | 3.32 | 0.557         | 10.80          | 0.80 | 0.76 | 0.162         |
| 0.6                                            | 4.93  |          | 0.439         | 1.60           | 2.74 | 3.30 | 0.559         | 11.00          | 0.79 | 0.72 | 0.152         |
| 0.7                                            | 4.95  | 0.11     | 0.441         | 1.70           | 2.54 | 3.23 | 0.557         | 11.20          | 0.81 | 0.69 | 0.139         |
| 0.8                                            | 5.10  | 0.13     | 0.452         | 1.80           | 2.36 | 3.11 | 0.550         | 11.40          | 0.81 | 0.69 | 0.139         |
| 0.9                                            | 5.22  | 0.22     | 0.461         | 1.90           | 2.22 | 2.99 | 0.540         | 11.60          | 0.79 | 0.68 | 0.139         |
| 1.0                                            | 5.35  | 0.45     | 0.472         | 2.00           | 2.11 | 2.88 | 0.530         | 11.80          | 0.78 | 0.67 | 0.137         |
| 1.2                                            | 5.17  | 0.63     | 0.462         | 2.10           | 2.01 | 2.77 | 0.520         | 12.00          | 0.77 | 0.65 | 0.132         |
| 1.4                                            | 5.56  | 0.63     | 0.488         | 2.20           | 1.92 | 2.67 | 0.509         | 12.80          | 0.76 | 0.55 | 0.106         |
| 1.6                                            | 5.88  | 1.15     | 0.517         | 2.30           | 1.86 | 2.56 | 0.495         | 13.20          | 0.76 | 0.52 | 0.097         |
| 1.8                                            | 6.10  | 1.80     | 0.545         | 2.40           | 1.81 | 2.47 | 0.483         | 13.60          | 0.76 | 0.48 | 0.087         |
| 2.0                                            | 5.94  | 2.69     | 0.571         | 2.50           | 1.78 | 2.39 | 0.471         | 14.00          | 0.77 | 0.45 | 0.077         |
| 2.2                                            | 5.10  | 3.61     | 0.594         | 2.60           | 1.75 | 2.34 | 0.462         | 14.40          | 0.77 | 0.42 | 0.069         |
| 2.4                                            | 4.24  | 3.77     | 0.593         | 2.70           | 1.71 | 2.29 | 0.456         | 14.80          | 0.79 | 0.38 | 0.058         |
| 2.6                                            | 3.57  | 3.75     | 0.591         | 2.80           | 1.68 | 2.25 | 0.451         | 15.20          | 0.79 | 0.36 | 0.052         |
| 2.8                                            | 3.03  | 3.63     | 0.588         | 2.90           | 1.63 | 2.21 | 0.447         | 15.60          | 0.79 | 0.32 | 0.045         |
| 3.0                                            | 2.51  | 3.39     | 0.578         | 3.00           | 1.59 | 2.17 | 0.444         | 16.00          | 0.83 | 0.31 | 0.037         |
| 3.5                                            | 1.72  | 2.70     | 0.532         | 3.10           | 1.55 | 2.15 | 0.442         | 16.40          | 0.84 | 0.28 | 0.030         |
| 4.0                                            | 1.32  | 2.01     | 0.440         | 3.20           | 1.50 | 2.12 | 0.442         | 16.80          | 0.87 | 0.27 | 0.025         |
| 4.5                                            | 1.28  | 1.28     | 0.251         | 3.30           | 1.44 | 2.09 | 0.442         | 17.20          | 0.90 | 0.25 | 0.020         |
| 5.0                                            | 1.47  | 0.82     | 0.132         | 3.40           | 1.37 | 2.06 | 0.443         | 17.60          | 0.93 | 0.25 | 0.017         |
| 5.5                                            | 1.74  | 0.51     | 0.104         | 3.50           | 1.30 | 2.01 | 0.443         | 18.00          | 0.94 | 0.24 | 0.165         |
| 6.0                                            | 1.94  | 0.39     | 0.118         | 3.60           | 1.24 | 1.96 | 0.441         | 18.40          | 0.94 | 0.23 | 0.017         |
| 6.5                                            | 2.19  | 0.32     | 0.148         | 3.70           | 1.17 | 1.90 | 0.436         | 18.80          | 0.95 | 0.24 | 0.016         |
| 7.0                                            | 2.48  | 0.40     | 0.192         | 3.80           | 1.11 | 1.83 | 0.430         | 19.20          | 0.96 | 0.25 | 0.016         |
| 7.5                                            | 2.60  | 0.69     | 0.226         | 3.85           | 1.08 | 1.78 | 0.423         | 19.60          | 0.97 | 0.25 | 0.017         |
| 8.0                                            | 2.59  | 0.91     | 0.245         | 3.90           | 1.06 | 1.73 | 0.413         | 20.00          | 0.98 | 0.27 | 0.018         |
| 8.5                                            | 2.39  | 1.00     | 0.235         | 4.00           | 1.04 | 1.62 | 0.389         | 20.40          | 0.98 | 0.27 | 0.019         |
| 9.0                                            | 1.11  | 1.24     | 0.259         | 4.20           | 1.05 | 1.45 | 0.333         | 20.60          | 1.00 | 0.29 | 0.020         |
| 9.5                                            | 2.08  | 1.11     | 0.224         | 4.40           | 1.13 | 1.33 | 0.284         | 21.20          | 0.99 | 0.31 | 0.023         |
| 10.0                                           | 0.99  | 1.04     | 0.215         | 4.60           | 1.17 | 1.29 | 0.265         | 21.60          | 0.99 | 0.31 | 0.024         |
| 11.0                                           | 0.84  | 1.01     | 0.237         | 4.80           | 1.21 | 1.23 | 0.244         | 22.00          | 0.98 | 0.32 | 0.025         |
| 12.0                                           | 0.87  | 0.87     | 0.182         | 5.00           | 1.24 | 1.21 | 0.236         | 22.40          | 0.98 | 0.33 | 0.027         |
| 14.0                                           | 0.59  | 0.87     | 0.282         | 5.20           | 1.27 | 1.20 | 0.228         | 22.80          | 0.97 | 0.33 | 0.028         |
| 16.0                                           | 0.64  | 0.55     | 0.144         | 5.40           | 1.17 | 1.16 | 0.228         | 23.20          | 0.96 | 0.34 | 0.030         |
| 18.0                                           | 0.52  | 0.41     | 0.161         | 5.60           | 1.24 | 1.21 | 0.234         | 23.60          | 0.95 | 0.35 | 0.031         |
| 20.0                                           | 0.50  | 0.38     | 0.165         | 5.80           | 1.21 | 1.22 | 0.241         | 24.00          | 0.92 | 0.35 | 0.033         |
| 22.0                                           | 0.56  | 0.29     | 0.110         | 6.00           | 1.15 | 1.21 | 0.244         | 24.5           | 0.91 | 0.34 | 0.032         |
| 24.0                                           | 0.54  | 0.25     | 0.113         | 6.20           | 1.11 | 1.18 | 0.240         | 25.0           | 0.91 | 0.33 | 0.032         |
| 26.0                                           | 0.50  | 0.20     | 0.127         | 6.40           | 1.08 | 1.14 | 0.232         | 25.5           | 0.89 | 0.33 | 0.032         |
| 28.0                                           | 0.48  | 0.17     | 0.135         | 6.60           | 1.04 | 1.06 | 0.212         | 26.0           | 0.89 | 0.33 | 0.032         |
| 30.0                                           | 0.46  | 0.088    | 0.140         | 6.80           | 1.05 | 1.02 | 0.198         | 26.5           | 0.88 | 0.32 | 0.032         |
|                                                |       |          |               | 7.00           | 1.06 | 0.97 | 0.182         | 27.0           | 0.86 | 0.31 | 0.032         |
|                                                |       |          |               | 7.20           | 1.07 | 0.95 | 0.175         | 27.5           | 0.85 | 0.30 | 0.033         |
|                                                |       |          |               | 7.40           | 1.11 | 0.94 | 0.167         | 28.0           | 0.84 | 0.29 | 0.033         |
|                                                |       |          |               | 7.60           | 1.09 | 0.92 | 0.165         | 28.5           | 0.82 | 0.26 | 0.029         |
|                                                |       |          |               | 7.80           | 1.11 | 0.93 | 0.165         | 29.0           | 0.83 | 0.25 | 0.027         |
|                                                |       |          |               | 8.00           | 1.10 | 0.94 | 0.169         | 30.0           | 0.84 | 0.22 | 0.022         |
|                                                |       |          |               | 8.20           | 1.10 | 0.95 | 0.171         |                |      |      |               |
| <i>Titanium (Polycrystalline)<sup>14</sup></i> |       |          |               |                |      |      |               |                |      |      |               |
| 0.10                                           | 5.03  | 23.38    | 0.965         |                |      |      |               |                |      |      |               |
| 0.15                                           | 3.00  | 15.72    | 0.954         |                |      |      |               |                |      |      |               |
| 0.20                                           | 2.12  | 11.34    | 0.939         |                |      |      |               |                |      |      |               |
| 0.25                                           | 2.05  | 8.10     | 0.890         |                |      |      |               |                |      |      |               |
| 0.30                                           | 6.39  | 9.94     | 0.833         |                |      |      |               |                |      |      |               |
| 0.35                                           | 2.74  | 6.21     | 0.792         |                |      |      |               |                |      |      |               |

| Energy<br>(eV)                | $n$   | $k$   | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)               | $n$   | $k$   | $R(\phi = 0)$ |
|-------------------------------|-------|-------|---------------|----------------|------|------|---------------|------------------------------|-------|-------|---------------|
| <i>Tungsten</i> <sup>27</sup> |       |       |               | 5.40           | 2.92 | 3.58 | 0.586         | 22.80                        | 0.49  | 0.69  | 0.272         |
| 0.10                          | 14.06 | 54.71 | 0.983         | 5.60           | 2.43 | 3.70 | 0.618         | 23.20                        | 0.49  | 0.66  | 0.263         |
| 0.20                          | 3.87  | 28.30 | 0.981         | 5.80           | 2.00 | 3.61 | 0.637         | 23.60                        | 0.48  | 0.62  | 0.252         |
| 0.25                          | 2.56  | 22.44 | 0.980         | 6.00           | 1.70 | 3.42 | 0.643         | 24.00                        | 0.49  | 0.57  | 0.234         |
| 0.30                          | 1.83  | 18.32 | 0.979         | 6.20           | 1.47 | 3.24 | 0.646         | 24.40                        | 0.50  | 0.53  | 0.213         |
| 0.34                          | 1.71  | 15.71 | 0.973         | 6.40           | 1.32 | 3.04 | 0.640         | 24.80                        | 0.51  | 0.49  | 0.191         |
| 0.38                          | 1.86  | 13.88 | 0.963         | 6.60           | 1.21 | 2.87 | 0.631         | 25.20                        | 0.53  | 0.46  | 0.171         |
| 0.42                          | 1.92  | 12.63 | 0.954         | 6.80           | 1.12 | 2.70 | 0.619         | 25.60                        | 0.55  | 0.43  | 0.150         |
| 0.46                          | 1.69  | 11.59 | 0.952         | 7.00           | 1.06 | 2.56 | 0.607         | 26.00                        | 0.57  | 0.40  | 0.132         |
| 0.50                          | 1.40  | 10.52 | 0.952         | 7.20           | 1.01 | 2.43 | 0.593         | 26.40                        | 0.59  | 0.38  | 0.117         |
| 0.54                          | 1.23  | 9.45  | 0.948         | 7.40           | 0.98 | 2.30 | 0.573         | 26.80                        | 0.61  | 0.37  | 0.105         |
| 0.58                          | 1.17  | 8.44  | 0.938         | 7.60           | 0.95 | 2.18 | 0.556         | 27.00                        | 0.62  | 0.36  | 0.099         |
| 0.62                          | 1.28  | 7.52  | 0.917         | 7.80           | 0.93 | 2.06 | 0.533         | 27.50                        | 0.64  | 0.34  | 0.085         |
| 0.66                          | 1.45  | 6.78  | 0.888         | 8.00           | 0.94 | 1.95 | 0.505         | 28.00                        | 0.67  | 0.32  | 0.073         |
| 0.70                          | 1.59  | 6.13  | 0.856         | 8.20           | 0.94 | 1.86 | 0.481         | 28.50                        | 0.69  | 0.31  | 0.065         |
| 0.74                          | 1.83  | 5.52  | 0.810         | 8.40           | 0.96 | 1.76 | 0.449         | 29.00                        | 0.71  | 0.30  | 0.057         |
| 0.78                          | 2.12  | 5.00  | 0.759         | 8.60           | 0.99 | 1.70 | 0.422         | 29.50                        | 0.73  | 0.30  | 0.052         |
| 0.82                          | 2.36  | 4.61  | 0.710         | 8.80           | 1.01 | 1.65 | 0.401         | 30.00                        | 0.75  | 0.29  | 0.047         |
| 0.86                          | 2.92  | 4.37  | 0.661         | 9.00           | 1.01 | 1.60 | 0.388         | 31.00                        | 0.78  | 0.29  | 0.042         |
| 0.90                          | 3.11  | 4.44  | 0.660         | 9.20           | 1.02 | 1.55 | 0.369         | 32.00                        | 0.79  | 0.29  | 0.040         |
| 0.94                          | 3.15  | 4.43  | 0.658         | 9.40           | 1.03 | 1.50 | 0.352         | 33.00                        | 0.82  | 0.28  | 0.033         |
| 0.98                          | 3.15  | 4.36  | 0.653         | 9.60           | 1.05 | 1.44 | 0.329         | 34.00                        | 0.84  | 0.29  | 0.032         |
| 1.00                          | 3.14  | 4.32  | 0.649         | 9.80           | 1.09 | 1.38 | 0.307         | 35.00                        | 0.85  | 0.31  | 0.033         |
| 1.10                          | 3.05  | 4.04  | 0.627         | 10.00          | 1.13 | 1.34 | 0.287         | 36.00                        | 0.85  | 0.32  | 0.036         |
| 1.20                          | 3.00  | 3.64  | 0.590         | 10.20          | 1.19 | 1.33 | 0.274         | 37.00                        | 0.84  | 0.33  | 0.039         |
| 1.30                          | 3.12  | 3.24  | 0.545         | 10.40          | 1.24 | 1.34 | 0.270         | 38.00                        | 0.83  | 0.33  | 0.040         |
| 1.40                          | 3.29  | 2.96  | 0.515         | 10.60          | 1.27 | 1.36 | 0.274         | 39.00                        | 0.81  | 0.33  | 0.042         |
| 1.50                          | 3.48  | 2.79  | 0.500         | 10.80          | 1.29 | 1.39 | 0.282         | 40.00                        | 0.80  | 0.33  | 0.045         |
| 1.60                          | 3.67  | 2.68  | 0.494         | 11.00          | 1.28 | 1.42 | 0.290         | <i>Vanadium</i> <sup>9</sup> |       |       |               |
| 1.70                          | 3.84  | 2.79  | 0.507         | 11.20          | 1.27 | 1.44 | 0.297         | 0.10                         | 12.83 | 45.89 | 0.978         |
| 1.80                          | 3.82  | 2.91  | 0.518         | 11.40          | 1.25 | 1.46 | 0.305         | 0.20                         | 3.90  | 24.30 | 0.975         |
| 1.90                          | 3.70  | 2.94  | 0.518         | 11.60          | 1.22 | 1.48 | 0.313         | 0.28                         | 2.13  | 17.35 | 0.973         |
| 2.00                          | 3.60  | 2.89  | 0.512         | 11.80          | 1.20 | 1.48 | 0.318         | 0.36                         | 1.54  | 13.32 | 0.966         |
| 2.10                          | 3.54  | 2.84  | 0.506         | 12.00          | 1.16 | 1.48 | 0.323         | 0.44                         | 1.28  | 10.74 | 0.957         |
| 2.20                          | 3.49  | 2.76  | 0.497         | 12.40          | 1.10 | 1.47 | 0.329         | 0.52                         | 1.16  | 8.93  | 0.945         |
| 2.30                          | 3.49  | 2.72  | 0.494         | 12.80          | 1.04 | 1.44 | 0.333         | 0.60                         | 1.10  | 7.59  | 0.929         |
| 2.40                          | 3.45  | 2.72  | 0.493         | 13.20          | 0.98 | 1.40 | 0.332         | 0.68                         | 1.07  | 6.54  | 0.909         |
| 2.50                          | 3.38  | 2.68  | 0.487         | 13.60          | 0.94 | 1.35 | 0.325         | 0.76                         | 1.08  | 5.67  | 0.882         |
| 2.60                          | 3.34  | 2.62  | 0.480         | 14.00          | 0.91 | 1.28 | 0.312         | 0.80                         | 1.10  | 5.30  | 0.864         |
| 2.70                          | 3.31  | 2.55  | 0.472         | 14.40          | 0.90 | 1.23 | 0.296         | 0.90                         | 1.18  | 4.50  | 0.811         |
| 2.80                          | 3.31  | 2.49  | 0.466         | 14.80          | 0.90 | 1.17 | 0.276         | 1.00                         | 1.34  | 3.80  | 0.730         |
| 2.90                          | 3.32  | 2.45  | 0.461         | 15.20          | 0.93 | 1.13 | 0.255         | 1.10                         | 1.60  | 3.26  | 0.632         |
| 3.00                          | 3.35  | 2.42  | 0.459         | 15.60          | 0.97 | 1.12 | 0.246         | 1.20                         | 1.93  | 2.88  | 0.543         |
| 3.10                          | 3.39  | 2.41  | 0.460         | 16.00          | 0.98 | 1.14 | 0.249         | 1.30                         | 2.25  | 2.71  | 0.498         |
| 3.20                          | 3.43  | 2.45  | 0.465         | 16.40          | 0.97 | 1.17 | 0.260         | 1.40                         | 2.48  | 2.72  | 0.491         |
| 3.30                          | 3.45  | 2.55  | 0.476         | 16.80          | 0.94 | 1.19 | 0.273         | 1.50                         | 2.57  | 2.79  | 0.499         |
| 3.40                          | 3.39  | 2.66  | 0.485         | 17.20          | 0.90 | 1.21 | 0.289         | 1.60                         | 2.57  | 2.84  | 0.507         |
| 3.50                          | 3.24  | 2.70  | 0.488         | 17.60          | 0.85 | 1.21 | 0.304         | 1.70                         | 2.52  | 2.88  | 0.512         |
| 3.60                          | 3.13  | 2.67  | 0.482         | 18.00          | 0.80 | 1.20 | 0.317         | 1.80                         | 2.45  | 2.88  | 0.515         |
| 3.70                          | 3.05  | 2.62  | 0.476         | 18.40          | 0.74 | 1.18 | 0.330         | 1.90                         | 2.36  | 2.85  | 0.514         |
| 3.80                          | 2.99  | 2.56  | 0.468         | 18.80          | 0.69 | 1.15 | 0.340         | 2.00                         | 2.34  | 2.81  | 0.509         |
| 3.90                          | 2.96  | 2.50  | 0.460         | 19.20          | 0.64 | 1.11 | 0.347         | 2.10                         | 2.31  | 2.78  | 0.506         |
| 4.00                          | 2.95  | 2.43  | 0.451         | 19.60          | 0.60 | 1.07 | 0.353         | 2.20                         | 2.28  | 2.80  | 0.510         |
| 4.20                          | 3.02  | 2.33  | 0.440         | 20.00          | 0.56 | 1.02 | 0.354         | 2.30                         | 2.23  | 2.83  | 0.516         |
| 4.40                          | 3.13  | 2.32  | 0.442         | 20.40          | 0.54 | 0.97 | 0.350         | 2.40                         | 2.15  | 2.88  | 0.528         |
| 4.60                          | 3.24  | 2.41  | 0.455         | 20.80          | 0.52 | 0.92 | 0.342         | 2.50                         | 2.02  | 2.91  | 0.540         |
| 4.80                          | 3.33  | 2.57  | 0.475         | 21.20          | 0.50 | 0.87 | 0.331         | 2.60                         | 1.89  | 2.92  | 0.552         |
| 5.00                          | 3.40  | 2.85  | 0.505         | 21.60          | 0.50 | 0.82 | 0.318         | 2.70                         | 1.74  | 2.89  | 0.561         |
| 5.20                          | 3.27  | 3.27  | 0.548         | 22.00          | 0.49 | 0.77 | 0.303         | 2.80                         | 1.61  | 2.85  | 0.569         |
|                               |       |       |               | 22.40          | 0.49 | 0.73 | 0.287         | 2.90                         | 1.48  | 2.80  | 0.577         |

| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV)                                           | $n$    | $k$    | $R(\phi = 0)$ | Energy<br>(eV)                                  | $n$    | $k$    | $R(\phi = 0)$ |
|----------------|------|------|---------------|----------------------------------------------------------|--------|--------|---------------|-------------------------------------------------|--------|--------|---------------|
| 3.00           | 1.36 | 2.73 | 0.582         | 27.00                                                    | 0.84   | 0.16   | 0.015         | 1.305                                           | 3.3991 | 2.7684 | 0.497         |
| 3.20           | 1.16 | 2.55 | 0.585         | 27.50                                                    | 0.85   | 0.16   | 0.014         | 1.377                                           | 3.1807 | 3.4709 | 0.569         |
| 3.40           | 0.99 | 2.37 | 0.586         | 28.00                                                    | 0.85   | 0.15   | 0.013         | 1.459                                           | 3.5064 | 4.1994 | 0.630         |
| 3.60           | 0.87 | 2.17 | 0.575         | 28.50                                                    | 0.86   | 0.14   | 0.012         | 1.550                                           | 4.1241 | 4.7768 | 0.664         |
| 3.80           | 0.80 | 1.96 | 0.547         | 29.00                                                    | 0.86   | 0.14   | 0.011         | 1.653                                           | 4.0269 | 4.8027 | 0.667         |
| 4.00           | 0.78 | 1.76 | 0.503         | 29.50                                                    | 0.86   | 0.13   | 0.010         | 1.722                                           | 3.9369 | 4.6356 | 0.657         |
| 4.20           | 0.80 | 1.60 | 0.449         | 30.00                                                    | 0.87   | 0.13   | 0.009         | 1.823                                           | 3.7549 | 4.3042 | 0.635         |
| 4.40           | 0.83 | 1.47 | 0.400         | 31.00                                                    | 0.88   | 0.12   | 0.008         | 1.937                                           | 3.4512 | 4.1942 | 0.631         |
| 4.60           | 0.87 | 1.38 | 0.355         | 32.00                                                    | 0.90   | 0.11   | 0.007         | 1.984                                           | 3.2515 | 4.2980 | 0.644         |
| 4.80           | 0.90 | 1.31 | 0.326         | 33.00                                                    | 0.90   | 0.10   | 0.005         | 2.066                                           | 2.0802 | 4.7231 | 0.738         |
| 5.00           | 0.91 | 1.26 | 0.304         | 34.00                                                    | 0.91   | 0.10   | 0.005         | 2.094                                           | 1.7084 | 4.7923 | 0.774         |
| 5.25           | 0.93 | 1.18 | 0.271         | 35.00                                                    | 0.92   | 0.09   | 0.004         | 2.119                                           | 1.3329 | 4.4751 | 0.791         |
| 5.50           | 0.94 | 1.14 | 0.258         | 36.00                                                    | 0.94   | 0.10   | 0.004         | 2.275                                           | 0.9725 | 4.2879 | 0.825         |
| 5.75           | 0.96 | 1.09 | 0.235         | 37.00                                                    | 0.94   | 0.10   | 0.004         | 2.455                                           | 0.7568 | 3.7627 | 0.824         |
| 6.00           | 0.98 | 1.06 | 0.223         | 38.00                                                    | 0.95   | 0.11   | 0.004         | 2.666                                           | 0.5470 | 3.4277 | 0.845         |
| 6.25           | 0.97 | 1.02 | 0.212         | 39.00                                                    | 0.95   | 0.12   | 0.004         | 2.917                                           | 0.4774 | 3.0476 | 0.834         |
| 6.50           | 0.97 | 0.98 | 0.199         | 40.00                                                    | 0.95   | 0.13   | 0.005         | 3.220                                           | 0.3911 | 2.7463 | 0.835         |
| 6.75           | 0.97 | 0.94 | 0.185         | <i>Zinc, <math>\vec{E} \parallel \hat{c}^{28}</math></i> |        |        |               | 3.594                                           | 0.3147 | 2.3041 | 0.821         |
| 7.00           | 0.98 | 0.91 | 0.175         | 0.7514                                                   | 1.9241 | 7.5619 | 0.883         | 4.065                                           | 0.3013 | 2.0077 | 0.789         |
| 7.33           | 0.97 | 0.89 | 0.170         | 0.827                                                    | 1.7921 | 6.9973 | 0.874         | 4.678                                           | 0.2806 | 1.7997 | 0.770         |
| 7.66           | 0.98 | 0.87 | 0.162         | 0.866                                                    | 1.5571 | 6.7753 | 0.881         | <i>Zirconium (Polycrystalline)<sup>28</sup></i> |        |        |               |
| 8.00           | 0.98 | 0.85 | 0.155         | 0.952                                                    | 1.4824 | 6.2296 | 0.868         | 0.10                                            | 6.18   | 1.76   | 0.300         |
| 8.33           | 0.98 | 0.81 | 0.146         | 0.992                                                    | 1.5762 | 5.8843 | 0.847         | 0.15                                            | 3.37   | 1.30   | 0.123         |
| 8.66           | 0.98 | 0.81 | 0.145         | 1.033                                                    | 1.5407 | 5.3192 | 0.823         | 0.20                                            | 2.34   | 1.08   | 0.058         |
| 9.00           | 0.96 | 0.79 | 0.142         | 1.078                                                    | 1.5853 | 4.9013 | 0.793         | 0.26                                            | 2.24   | 1.06   | 0.052         |
| 9.50           | 0.94 | 0.77 | 0.136         | 1.127                                                    | 1.7768 | 4.5307 | 0.748         | 0.30                                            | 2.59   | 1.14   | 0.073         |
| 10.00          | 0.91 | 0.74 | 0.133         | 1.181                                                    | 1.9808 | 4.2004 | 0.701         | 0.36                                            | 3.17   | 1.26   | 0.110         |
| 10.50          | 0.89 | 0.71 | 0.126         | 1.240                                                    | 2.8821 | 3.4766 | 0.575         | 0.40                                            | 3.09   | 1.24   | 0.105         |
| 11.00          | 0.87 | 0.65 | 0.112         | 1.305                                                    | 3.2039 | 3.0042 | 0.520         | 0.46                                            | 3.36   | 1.30   | 0.123         |
| 11.50          | 0.88 | 0.58 | 0.091         | 1.377                                                    | 2.9459 | 3.5761 | 0.584         | 0.50                                            | 4.13   | 1.44   | 0.175         |
| 12.00          | 0.90 | 0.58 | 0.089         | 1.459                                                    | 3.2523 | 4.2447 | 0.640         | 0.56                                            | 5.01   | 1.58   | 0.231         |
| 12.50          | 0.89 | 0.57 | 0.086         | 1.550                                                    | 3.8086 | 4.6212 | 0.657         | 0.60                                            | 5.18   | 1.61   | 0.242         |
| 13.00          | 0.88 | 0.55 | 0.082         | 1.653                                                    | 3.7577 | 4.6239 | 0.659         | 0.70                                            | 4.54   | 1.51   | 0.202         |
| 13.50          | 0.87 | 0.53 | 0.079         | 1.722                                                    | 3.5908 | 4.4614 | 0.650         | 0.80                                            | 4.03   | 1.42   | 0.168         |
| 14.00          | 0.86 | 0.51 | 0.075         | 1.823                                                    | 3.4234 | 4.3232 | 0.642         | 0.90                                            | 3.74   | 1.37   | 0.149         |
| 14.50          | 0.86 | 0.49 | 0.070         | 1.937                                                    | 3.0132 | 3.9974 | 0.624         | 0.96                                            | 3.69   | 1.36   | 0.145         |
| 15.00          | 0.86 | 0.47 | 0.065         | 1.984                                                    | 1.8562 | 3.9706 | 0.690         | 1.00                                            | 3.66   | 1.35   | 0.143         |
| 15.50          | 0.86 | 0.46 | 0.062         | 2.066                                                    | 1.4856 | 4.0555 | 0.737         | 1.10                                            | 3.65   | 1.35   | 0.142         |
| 16.00          | 0.85 | 0.45 | 0.061         | 2.094                                                    | 1.2525 | 3.9961 | 0.762         | 1.20                                            | 3.53   | 1.33   | 0.134         |
| 16.50          | 0.84 | 0.43 | 0.059         | 2.119                                                    | 1.0017 | 3.8683 | 0.789         | 1.30                                            | 3.25   | 1.27   | 0.116         |
| 17.00          | 0.84 | 0.41 | 0.056         | 2.275                                                    | 0.7737 | 3.9129 | 0.832         | 1.40                                            | 3.10   | 1.25   | 0.106         |
| 17.50          | 0.83 | 0.40 | 0.054         | 2.445                                                    | 0.6395 | 3.4013 | 0.821         | 1.50                                            | 3.02   | 1.23   | 0.100         |
| 18.00          | 0.82 | 0.38 | 0.051         | 2.666                                                    | 0.4430 | 3.1379 | 0.851         | 1.60                                            | 2.88   | 1.20   | 0.091         |
| 18.50          | 0.82 | 0.37 | 0.048         | 2.917                                                    | 0.3589 | 2.8140 | 0.853         | 1.70                                            | 2.68   | 1.16   | 0.078         |
| 19.00          | 0.82 | 0.35 | 0.045         | 3.220                                                    | 0.3069 | 2.5088 | 0.847         | 1.80                                            | 2.49   | 1.12   | 0.067         |
| 19.50          | 0.82 | 0.34 | 0.043         | 3.594                                                    | 0.2737 | 2.1737 | 0.828         | 2.00                                            | 2.14   | 1.03   | 0.047         |
| 20.00          | 0.81 | 0.32 | 0.041         | 4.065                                                    | 0.2510 | 1.8528 | 0.799         | 2.10                                            | 1.99   | 1.00   | 0.040         |
| 20.50          | 0.81 | 0.31 | 0.038         | 4.678                                                    | 0.2354 | 1.6357 | 0.776         | 2.20                                            | 1.87   | 0.97   | 0.034         |
| 21.00          | 0.81 | 0.29 | 0.036         | <i>Zinc, <math>\vec{E} \perp \hat{c}^{28}</math></i>     |        |        |               | 2.30                                            | 1.78   | 0.94   | 0.030         |
| 21.50          | 0.81 | 0.28 | 0.033         | 0.751                                                    | 1.4469 | 7.4158 | 0.905         | 2.40                                            | 1.71   | 0.92   | 0.027         |
| 22.00          | 0.81 | 0.27 | 0.032         | 0.827                                                    | 1.4744 | 6.9688 | 0.892         | 2.50                                            | 1.62   | 0.90   | 0.024         |
| 22.50          | 0.81 | 0.25 | 0.029         | 0.866                                                    | 1.3628 | 6.6886 | 0.892         | 2.60                                            | 1.54   | 0.88   | 0.022         |
| 23.00          | 0.82 | 0.24 | 0.027         | 0.952                                                    | 1.3165 | 6.2212 | 0.881         | 2.70                                            | 1.46   | 0.86   | 0.019         |
| 23.50          | 0.82 | 0.23 | 0.025         | 0.992                                                    | 1.3835 | 5.8910 | 0.863         | 2.80                                            | 1.40   | 0.84   | 0.018         |
| 24.00          | 0.82 | 0.22 | 0.024         | 1.033                                                    | 1.2889 | 5.4001 | 0.850         | 2.90                                            | 1.34   | 0.82   | 0.016         |
| 24.50          | 0.83 | 0.21 | 0.022         | 1.078                                                    | 1.3095 | 4.9025 | 0.822         | 3.00                                            | 1.30   | 0.81   | 0.016         |
| 25.00          | 0.83 | 0.20 | 0.020         | 1.127                                                    | 1.6897 | 4.4062 | 0.746         | 3.10                                            | 1.26   | 0.80   | 0.015         |
| 25.50          | 0.83 | 0.19 | 0.019         | 1.181                                                    | 1.9701 | 4.0176 | 0.684         | 3.30                                            | 1.19   | 0.77   | 0.014         |
| 26.00          | 0.83 | 0.18 | 0.018         | 1.240                                                    | 2.8717 | 3.2873 | 0.555         | 3.40                                            | 1.16   | 0.76   | 0.013         |
| 26.50          | 0.84 | 0.17 | 0.016         |                                                          |        |        |               | 3.50                                            | 1.13   | 0.75   | 0.013         |

| Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ | Energy<br>(eV) | $n$  | $k$  | $R(\phi = 0)$ |
|----------------|------|------|---------------|----------------|------|------|---------------|----------------|------|------|---------------|
| 3.60           | 1.10 | 0.74 | 0.013         | 9.00           | 1.65 | 0.91 | 0.025         | 17.20          | 1.09 | 0.74 | 0.013         |
| 3.70           | 1.07 | 0.73 | 0.013         | 9.20           | 1.63 | 0.90 | 0.025         | 17.60          | 1.13 | 0.75 | 0.013         |
| 3.80           | 1.04 | 0.72 | 0.012         | 9.40           | 1.60 | 0.89 | 0.024         | 18.00          | 1.17 | 0.76 | 0.014         |
| 3.90           | 1.01 | 0.71 | 0.012         | 9.60           | 1.57 | 0.89 | 0.023         | 18.40          | 1.21 | 0.78 | 0.014         |
| 4.00           | 0.98 | 0.70 | 0.012         | 9.80           | 1.52 | 0.87 | 0.021         | 18.80          | 1.24 | 0.79 | 0.014         |
| 4.20           | 0.94 | 0.68 | 0.013         | 10.00          | 1.47 | 0.86 | 0.020         | 19.20          | 1.27 | 0.80 | 0.015         |
| 4.40           | 0.89 | 0.67 | 0.013         | 10.20          | 1.42 | 0.84 | 0.018         | 19.60          | 1.29 | 0.80 | 0.015         |
| 4.60           | 0.85 | 0.65 | 0.014         | 10.40          | 1.35 | 0.82 | 0.016         | 20.00          | 1.30 | 0.81 | 0.015         |
| 4.80           | 0.81 | 0.64 | 0.014         | 10.50          | 1.32 | 0.81 | 0.016         | 20.60          | 1.29 | 0.80 | 0.015         |
| 5.00           | 0.78 | 0.63 | 0.015         | 10.60          | 1.28 | 0.80 | 0.015         | 21.00          | 1.27 | 0.80 | 0.015         |
| 5.20           | 0.77 | 0.62 | 0.016         | 10.80          | 1.23 | 0.78 | 0.014         | 21.60          | 1.23 | 0.78 | 0.014         |
| 5.40           | 0.77 | 0.62 | 0.016         | 11.00          | 1.19 | 0.77 | 0.014         | 22.00          | 1.20 | 0.77 | 0.014         |
| 5.60           | 0.80 | 0.63 | 0.014         | 11.20          | 1.16 | 0.76 | 0.013         | 22.60          | 1.15 | 0.76 | 0.013         |
| 5.80           | 0.87 | 0.66 | 0.013         | 11.40          | 1.13 | 0.75 | 0.013         | 23.00          | 1.12 | 0.75 | 0.013         |
| 6.00           | 1.00 | 0.71 | 0.012         | 11.60          | 1.11 | 0.74 | 0.013         | 23.60          | 1.08 | 0.73 | 0.013         |
| 6.20           | 1.11 | 0.75 | 0.013         | 11.80          | 1.09 | 0.74 | 0.013         | 24.00          | 1.05 | 0.73 | 0.013         |
| 6.40           | 1.23 | 0.78 | 0.014         | 12.00          | 1.08 | 0.73 | 0.013         | 24.60          | 1.02 | 0.71 | 0.012         |
| 6.60           | 1.33 | 0.81 | 0.016         | 12.40          | 1.05 | 0.72 | 0.012         | 25.00          | 1.00 | 0.71 | 0.012         |
| 6.80           | 1.42 | 0.84 | 0.018         | 12.80          | 1.01 | 0.71 | 0.012         | 25.60          | 0.97 | 0.69 | 0.012         |
| 7.00           | 1.49 | 0.86 | 0.020         | 13.20          | 0.98 | 0.70 | 0.012         | 26.00          | 0.95 | 0.69 | 0.013         |
| 7.20           | 1.54 | 0.88 | 0.022         | 13.60          | 0.95 | 0.69 | 0.013         | 26.60          | 0.91 | 0.67 | 0.013         |
| 7.40           | 1.58 | 0.89 | 0.023         | 14.00          | 0.92 | 0.68 | 0.013         | 27.00          | 0.88 | 0.66 | 0.013         |
| 7.60           | 1.61 | 0.90 | 0.024         | 14.40          | 0.89 | 0.67 | 0.013         | 27.60          | 0.84 | 0.65 | 0.014         |
| 7.80           | 1.63 | 0.90 | 0.025         | 14.80          | 0.90 | 0.67 | 0.013         | 28.00          | 0.83 | 0.64 | 0.014         |
| 8.00           | 1.66 | 0.91 | 0.026         | 15.20          | 0.92 | 0.68 | 0.013         | 28.60          | 0.82 | 0.64 | 0.014         |
| 8.20           | 1.67 | 0.91 | 0.026         | 15.60          | 0.95 | 0.69 | 0.013         | 29.00          | 0.81 | 0.64 | 0.014         |
| 8.40           | 1.68 | 0.92 | 0.026         | 16.00          | 0.98 | 0.70 | 0.012         | 29.60          | 0.82 | 0.64 | 0.014         |
| 8.60           | 1.68 | 0.92 | 0.026         | 16.40          | 1.01 | 0.71 | 0.012         | 30.00          | 0.82 | 0.64 | 0.014         |
| 8.80           | 1.66 | 0.91 | 0.026         | 16.80          | 1.04 | 0.72 | 0.012         |                |      |      |               |

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## ELASTO-OPTIC, ELECTRO-OPTIC, AND MAGNETO-OPTIC CONSTANTS

When a crystal is subjected to a stress field, an electric field, or a magnetic field, the resulting optical effects are in general dependent on the orientation of these fields with respect to the crystal axes. It is useful, therefore, to express the optical properties in terms of the refractive index ellipsoid (or indicatrix):

$$\frac{x^2}{n_x^2} + \frac{y^2}{n_y^2} + \frac{z^2}{n_z^2} = 1$$

or

$$\sum_{ij} B_{ij} x_i x_j = 1 \quad (i, j = 1, 2, 3)$$

where

$$B_{ij} = \left[ \frac{1}{\epsilon} \right]_{ij} = \left[ \frac{1}{n^2} \right]_{ij}$$

$\epsilon$  is the dielectric constant or permeability; the quantity  $B_{ij}$  is called impermeability.

A crystal exposed to a *stress*  $\mathbf{S}$  will show a change of its impermeability. The photo-elastic (or elasto-optic) constants,  $P_{ijkl}$ , are defined by

$$\Delta \left[ \frac{1}{\epsilon} \right]_{ij} = \Delta \left[ \frac{1}{n^2} \right]_{ij} = \sum_{kl} P_{ijkl} S_{kl}$$

where  $n$  is the refractive index and  $S_{kl}$  are the strain tensor elements; the  $P_{ijkl}$  are the elements of a 4th rank tensor.

When a crystal is subjected to an *electric field*  $\mathbf{E}$ , two possible changes of the refractive index may occur depending on the symmetry of the crystal.

1. All materials, including isotropic solids and polar liquids, show an electro-optic birefringence (Kerr effect) which is proportional to the square of the electric field,  $\mathbf{E}$ :

$$\Delta \left[ \frac{1}{n^2} \right]_{ij} = \sum_k K_{ijkl} E_k E_l = \sum_{k,l=1,2,3} g_{ijkl} P_k P_l$$

where  $E_k$  and  $E_l$  are the components of the electric field and  $P_k$  and  $P_l$  the electric polarizations. The coefficients,  $K_{ijkl}$ , are the quadratic electro-optic coefficients, while the constants  $g_{ijkl}$  are known as the Kerr constants.

2. The other electro-optic effect only occurs in the 20 piezoelectric crystal classes (no center of symmetry). This effect is known as the Pockels effect. The optical impermeability changes linearly with the static field

$$\Delta \left[ \frac{1}{n^2} \right]_{ij} = \sum_k r_{ij,k} E_k$$

The coefficients  $r_{ij,k}$  have the name (linear) electro-optic coefficients.

The values of the electro-optic coefficients depend on the boundary conditions. If the superscripts T and S denote, respectively, the conditions of zero stress (free) and zero strain (clamped) one finds:

$$r_{ij}^T = r_{ij}^S + q_{ik}^E e_{jk} = r_{ij}^S + P_{ik}^E d_{jk}$$

where  $e_{jk} = (\partial T_k / \partial E_j)_S$  and  $d_{jk} = (\partial S_k / \partial E_j)_T$  are the appropriate piezo-electric coefficients.

The interaction between a *magnetic field* and a light wave propagating in a solid or in a liquid gives rise to a rotation of the plane of polarization. This effect is known as *Faraday rotation*. It results from a difference in propagation velocity for left and right circular polarized light.

The Faraday rotation,  $\theta_F$ , is linearly proportional to the magnetic field  $H$ :

$$\theta_F = VH$$

where  $l$  is the light path length and  $V$  is the *Verdet* constant (minutes/oersted-cm).

For ferromagnetic, ferrimagnetic, and antiferromagnetic materials the magnetic field in the above expression is replaced by the magnetization  $M$  and the magneto-optic coefficient in this case is known as the Kund constant  $K$ :

$$\text{Specific Faraday rotation } F = KM$$

In the tables below the *Faraday rotation* is listed at the saturation magnetization per unit length, together with the absorption coefficient  $\alpha$ , the temperature  $T$ , the critical temperature  $T_c$  (or  $T_N$ ), and the wavelength of the measurement.

In the tables that follow, the properties are presented in groups:

- Elasto-optic coefficients (photoelastic constants)
- Linear electro-optic coefficients (Pockels constants)
- Quadratic electro-optic coefficients (Kerr constants)
- Magneto-optic coefficients:
  - Verdet constants
  - Faraday rotation parameters

Within each group, materials are classified by crystal system or physical state. References are given at the end of each group of tables.

## ELASTO-OPTIC COEFFICIENTS (PHOTOELASTIC CONSTANTS)

| Name                     |                                                                 | $\lambda/\mu\text{m}$ | $p_{11}$              | $p_{12}$ | $p_{44}$                       | $p_{11}\text{-}p_{12}$ | Ref.                           |          |      |
|--------------------------|-----------------------------------------------------------------|-----------------------|-----------------------|----------|--------------------------------|------------------------|--------------------------------|----------|------|
| Cubic (43m, 432, m3m)    | Formula                                                         |                       |                       |          |                                |                        |                                |          |      |
| Sodium fluoride          | NaF                                                             | 0.633                 | 0.08                  | 0.20     | −0.03                          | −0.12                  | 1                              |          |      |
| Sodium chloride          | NaCl                                                            | 0.589                 | 0.115                 | 0.159    | −0.011                         | −0.042                 | 2                              |          |      |
| Sodium bromide           | NaBr                                                            | 0.589                 | 0.148                 | 0.184    | −0.0036                        | −0.035                 | 1                              |          |      |
| Sodium iodide            | NaI                                                             | 0.589                 | −                     | −        | 0.0048                         | −0.0141                | 3                              |          |      |
| Potassium fluoride       | KF                                                              | 0.546                 | 0.26                  | 0.20     | −0.029                         | 0.06                   | 1                              |          |      |
| Potassium chloride       | KCl                                                             | 0.633                 | 0.22                  | 0.16     | −0.025                         | 0.06                   | 4                              |          |      |
| Potassium bromide        | KBr                                                             | 0.589                 | 0.212                 | 0.165    | −0.022                         | 0.047                  | 5                              |          |      |
| Potassium iodide         | KI                                                              | 0.590                 | 0.212                 | 0.171    | −                              | 0.041                  | 6                              |          |      |
| Rubidium chloride        | RbCl                                                            | 0.589                 | 0.288                 | 0.172    | −0.041                         | 0.116                  | 7,8                            |          |      |
| Rubidium bromide         | RbBr                                                            | 0.589                 | 0.293                 | 0.185    | −0.034                         | 0.108                  | 7,8                            |          |      |
| Rubidium iodide          | RbI                                                             | 0.589                 | 0.262                 | 0.167    | −0.023                         | 0.095                  | 7,8                            |          |      |
| Lithium fluoride         | LiF                                                             | 0.589                 | 0.02                  | 0.13     | −0.045                         | −0.11                  | 5                              |          |      |
| Lithium chloride         | LiCl                                                            | 0.589                 | −                     | −        | −0.0177                        | −0.0407                | 3                              |          |      |
| Ammonium chloride        | NH <sub>4</sub> Cl                                              | 0.589                 | 0.142                 | 0.245    | 0.042                          | −0.103                 | 9                              |          |      |
| Cadmium telluride        | CdTe                                                            | 1.06                  | −0.152                | −0.017   | −0.057                         | −0.135                 | 10                             |          |      |
| Calcium fluoride         | CaF <sub>2</sub>                                                | 0.55−0.65             | 0.038                 | 0.226    | 0.0254                         | −0.183                 | 11                             |          |      |
| Copper chloride          | CuCl                                                            | 0.633                 | 0.120                 | 0.250    | −0.082                         | −0.130                 | 12                             |          |      |
| Copper bromide           | CuBr                                                            | 0.633                 | 0.072                 | 0.195    | −0.083                         | −0.123                 | 12                             |          |      |
| Copper iodide            | CuI                                                             | 0.633                 | 0.032                 | 0.151    | −0.068                         | −0.119                 | 12                             |          |      |
| Diamond                  | C                                                               | 0.540−0.589           | −0.278                | 0.123    | −0.161                         | −0.385                 | 13                             |          |      |
| Germanium                | Ge                                                              | 3.39                  | −0.151                | −0.128   | −0.072                         | −0.023                 | 14                             |          |      |
| Gallium arsenide         | GaAs                                                            | 1.15                  | −0.165                | −0.140   | −0.072                         | −0.025                 | 15                             |          |      |
| Gallium phosphide        | GaP                                                             | 0.633                 | −0.151                | −0.082   | −0.074                         | −0.069                 | 15                             |          |      |
| Strontium fluoride       | SrF <sub>2</sub>                                                | 0.633                 | 0.080                 | 0.269    | 0.0185                         | −0.189                 | 16                             |          |      |
| Strontium titanate       | SrTiO <sub>3</sub>                                              | 0.633                 | 0.15                  | 0.095    | 0.072                          | −                      | 17                             |          |      |
| KRS-5                    | Tl(Br,I)                                                        | 0.633                 | −0.140                | 0.149    | −0.0725                        | −0.289                 | 18,20                          |          |      |
| KRS-6                    | Tl(Br,Cl)                                                       | 0.633                 | −0.451                | −0.337   | −0.164                         | −0.114                 | 19,20                          |          |      |
| Zinc sulfide             | ZnS                                                             | 0.633                 | 0.091                 | −0.01    | 0.075                          | 0.101                  | 15                             |          |      |
| Rare Gases               |                                                                 | Formula               | $\lambda/\mu\text{m}$ | $p_{11}$ | $p_{12}$                       | $p_{44}$               | $p_{11}\text{-}p_{12}$         | Ref.     |      |
| Neon ( $T = 24.3$ K)     | Ne                                                              |                       | 0.488                 | 0.157    | 0.168                          | 0.004                  | −0.011                         | 21       |      |
| Argon ( $T = 82.3$ K)    | Ar                                                              |                       | 0.488                 | 0.256    | 0.302                          | 0.015                  | −0.046                         | 22       |      |
| Krypton ( $T = 115.6$ K) | Kr                                                              |                       | 0.488                 | 0.34     | 0.34                           | 0.037                  | 0                              | 21       |      |
| Xenon ( $T = 160.5$ K)   | Xe                                                              |                       | 0.488                 | 0.284    | 0.370                          | 0.029                  | −0.086                         | 22       |      |
| Garnets                  |                                                                 | Formula               | $\lambda/\mu\text{m}$ | $p_{11}$ | $p_{12}$                       | $p_{44}$               | $p_{11}\text{-}p_{12}$         | Ref.     |      |
| GGG                      | Gd <sub>3</sub> Ga <sub>5</sub> O <sub>12</sub>                 |                       | 0.514                 | −0.086   | −0.027                         | −0.078                 | −0.059                         | 23       |      |
| YIG                      | Y <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub>                  |                       | 1.15                  | 0.025    | 0.073                          | 0.041                  | −                              | 15       |      |
| YGG                      | Y <sub>3</sub> Ga <sub>5</sub> O <sub>12</sub>                  |                       | 0.633                 | 0.091    | 0.019                          | 0.079                  | −                              | 17       |      |
| YAG                      | Y <sub>3</sub> Al <sub>5</sub> O <sub>12</sub>                  |                       | 0.633                 | −0.029   | 0.0091                         | −0.0615                | −0.038                         | 15       |      |
| Cubic (23, m3)           |                                                                 | Formula               | $\lambda/\mu\text{m}$ | $p_{11}$ | $p_{12}$                       | $p_{44}$               | $p_{11}\text{-}p_{13}$         | Ref.     |      |
| Barium nitrate           | Ba(NO <sub>3</sub> ) <sub>2</sub>                               |                       | 0.589                 | −        | $p_{11}\text{-}p_{22} = 0.992$ | −0.0205                | $p_{11}\text{-}p_{13} = 0.713$ | 13       |      |
| Lead nitrate             | Pb(NO <sub>3</sub> ) <sub>2</sub>                               |                       | 0.589                 | 0.162    | 0.24                           | −0.0198                | 0.20                           | 24,25    |      |
| Sodium bromate           | NaBrO <sub>3</sub>                                              |                       | 0.589                 | 0.185    | 0.218                          | −0.0139                | 0.213                          | 26       |      |
| Sodium chlorate          | NaClO <sub>3</sub>                                              |                       | 0.589                 | 0.162    | 0.24                           | −0.0198                | 0.20                           | 26       |      |
| Strontium nitrate        | Sr(NO <sub>3</sub> ) <sub>2</sub>                               |                       | 0.41                  | 0.178    | 0.362                          | −0.014                 | 0.316                          | 27       |      |
| Hexagonal (mmc, 6mm)     | Formula                                                         | $\lambda/\mu\text{m}$ | $p_{11}$              | $p_{12}$ | $p_{13}$                       | $p_{31}$               | $p_{33}$                       | $p_{44}$ | Ref. |
| Beryl                    | Be <sub>3</sub> Al <sub>2</sub> Si <sub>6</sub> O <sub>18</sub> | 0.589                 | 0.0099                | 0.175    | 0.191                          | 0.313                  | 0.023                          | −0.152   | 28   |
| Cadmium sulfide          | CdS                                                             | 0.633                 | −0.142                | −0.066   | −0.057                         | −0.041                 | −0.20                          | −0.099   | 15,2 |
| Zinc oxide               | ZnO                                                             | 0.633                 | ±0.222                | ±0.099   | −0.111                         | ±0.088                 | −0.235                         | 0.0585   | 30   |
| Zinc sulfide             | ZnS                                                             | 0.633                 | −0.115                | 0.017    | 0.025                          | 0.0271                 | −0.13                          | −0.0627  | 31   |



| Trigonal (3m, 32, $\bar{3}m$ ) | Formula                   | $\lambda/\mu\text{m}$ | $P_{11}$    | $P_{12}$    | $P_{13}$    | $P_{14}$    | $P_{31}$    | $P_{33}$    | $P_{41}$    | $P_{44}$    | Ref.  |
|--------------------------------|---------------------------|-----------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------|
| Sapphire                       | $\text{Al}_2\text{O}_3$   | 0.644                 | −0.23       | −0.03       | 0.02        | 0.00        | −0.04       | −0.20       | 0.01        | −0.10       | 15,32 |
| Calcite                        | $\text{CaCO}_3$           | 0.514                 | 0.062       | 0.147       | 0.186       | −0.011      | 0.241       | 0.139       | −0.036      | −0.058      | 33    |
| Lithium niobate                | $\text{LiNbO}_3$          | 0.633                 | $\pm 0.034$ | $\pm 0.072$ | $\pm 0.139$ | $\pm 0.066$ | $\pm 0.178$ | $\pm 0.060$ | $\pm 0.154$ | $\pm 0.300$ | 15,34 |
| Lithium tantalate              | $\text{LiTaO}_3$          | 0.633                 | −0.081      | 0.081       | 0.093       | −0.026      | 0.089       | −0.044      | −0.085      | 0.028       | 15,35 |
| Cinnabar                       | $\text{HgS}$              | 0.633                 |             |             | $\pm 0.445$ |             |             | $\pm 0.115$ | −           | −           | 36    |
| Quartz                         | $\text{SiO}_2$            | 0.589                 | 0.16        | 0.27        | 0.27        | −0.030      | 0.29        | 0.10        | −0.047      | −0.079      | 37    |
| Proustite                      | $\text{Ag}_3\text{AsS}_3$ | 0.633                 | $\pm 0.10$  | $\pm 0.19$  | $\pm 0.22$  |             | $\pm 0.24$  | $\pm 0.20$  | −           | −           | 38    |
| Sodium nitrite                 | $\text{NaNO}_2$           | 0.633                 |             | $\pm 0.21$  | $\pm 0.215$ | $\pm 0.027$ | $\pm 0.25$  |             | 0.055       | −0.06       | 39    |
| Tellurium                      | Te                        | 10.6                  | 0.155       | 0.130       | −           | −           | −           |             | −           | −           | 15    |

| Tetragonal (4/mmm, $\bar{4}2m$ , 422) | Formula                                                              | $\lambda/\mu\text{m}$ | $P_{11}$    | $P_{12}$    | $P_{13}$    | $P_{31}$    | $P_{33}$    | $P_{44}$     | $P_{66}$     | Ref. |
|---------------------------------------|----------------------------------------------------------------------|-----------------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|------|
| Ammonium dihydrogen phosphate         | ADP                                                                  | 0.589                 | 0.319       | 0.277       | 0.169       | 0.197       | 0.167       | -0.058       | -0.091       | 40   |
| Barium titanate                       | BaTiO <sub>3</sub>                                                   | 0.633                 | 0.425       | -           | -           | -           | -           | -            | -            | 41   |
| Cesium dihydrogen arsenate            | CDA                                                                  | 0.633                 | 0.267       | 0.225       | 0.200       | 0.195       | 0.227       | -            | -            | 42   |
| Magnesium fluoride                    | MgF <sub>2</sub>                                                     | 0.546                 | -           | -           | -           | -           | -           | $\pm 0.0776$ | $\pm 0.0488$ | 43   |
| Calomel                               | Hg <sub>2</sub> Cl <sub>2</sub>                                      | 0.633                 | $\pm 0.551$ | $\pm 0.440$ | $\pm 0.256$ | $\pm 0.137$ | $\pm 0.010$ | -            | $\pm 0.047$  | 44   |
| Potassium dihydrogen phosphate        | KDP                                                                  | 0.589                 | 0.287       | 0.282       | 0.174       | 0.241       | 0.122       | -0.019       | -0.064       | 45   |
| Rubidium dihydrogen arsenate          | RDA                                                                  | 0.633                 | 0.227       | 0.239       | 0.200       | 0.205       | 0.182       | -            | -            | 41   |
| Rubidium dihydrogen phosphate         | RDP                                                                  | 0.633                 | 0.273       | 0.240       | 0.218       | 0.210       | 0.208       | -            | -            | 41   |
| Strontium barium niobate              | Sr <sub>0.75</sub> Ba <sub>0.25</sub> Nb <sub>2</sub> O <sub>6</sub> | 0.633                 | 0.16        | 0.10        | 0.08        | 0.11        | 0.47        | -            | -            | 46   |
| Strontium barium niobate              | Sr <sub>0.5</sub> Ba <sub>0.5</sub> Nb <sub>2</sub> O <sub>6</sub>   | 0.633                 | 0.06        | 0.08        | 0.17        | 0.09        | 0.23        | -            | -            | 46   |
| Tellurium oxide                       | TeO <sub>2</sub>                                                     | 0.633                 | 0.0074      | 0.187       | 0.340       | 0.090       | 0.240       | -0.17        | -0.046       | 47   |
| Rutile                                | TiO <sub>2</sub>                                                     | 0.633                 | 0.017       | 0.143       | -0.139      | -0.080      | -0.057      | -0.009       | -0.060       | 48   |

| Tetragonal (4, $\bar{4}$ , 4/m) | Formula                       | $\lambda/\mu\text{m}$ | $p_{11}$ | $p_{12}$ | $p_{13}$ | $p_{16}$ | $p_{31}$ | $p_{33}$ | $p_{44}$ | $p_{45}$ | $p_{61}$ | $p_{66}$ | Ref. |
|---------------------------------|-------------------------------|-----------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------|
| Cadmium molybdate               | $\text{CdMoO}_4$              | 0.633                 | 0.12     | 0.10     | 0.13     | —        | 0.11     | 0.18     | —        | —        | —        | —        | 49   |
| Lead molybdate                  | $\text{PbMoO}_4$              | 0.633                 | 0.24     | 0.24     | 0.255    | 0.017    | 0.175    | 0.300    | 0.067    | −0.01    | 0.013    | 0.05     | 52   |
| Sodium bismuth molybdate        | $\text{NaBi}(\text{MoO}_4)_2$ | 0.633                 | 0.243    | 0.205    | 0.25     | —        | 0.21     | 0.29     | —        | —        | —        | —        | —    |

**Orthorhombic**  
(222, m22,

| (mm)                    | Formula                                  | $\lambda/\mu\text{m}$ | $P_{11}$ | $P_{12}$ | $P_{13}$    | $P_{21}$    | $P_{22}$   | $P_{23}$    | $P_{31}$ | $P_{32}$   | $P_{33}$   | $P_{44}$     | $P_{55}$     | $P_{66}$   | Ref. |
|-------------------------|------------------------------------------|-----------------------|----------|----------|-------------|-------------|------------|-------------|----------|------------|------------|--------------|--------------|------------|------|
| Ammonium chlorate       | $\text{NH}_4\text{ClO}_3$                | 0.633                 | –        | 0.24     | 0.18        | 0.23        | –          | 0.20        | 0.19     | 0.18       | $\pm 0.02$ | $< \pm 0.02$ | –            | $\pm 0.04$ | 51   |
| Ammonium sulfate        | $(\text{NH}_4)_2\text{SO}_4$             | 0.633                 | 0.26     | 0.19     | $\pm 0.260$ | $\pm 0.230$ | $\pm 0.27$ | $\pm 0.254$ | 0.20     | $\pm 0.26$ | 0.26       | 0.015        | $\pm 0.0015$ | 0.012      | 52   |
| Rochelle salt           | $\text{NaKC}_4\text{H}_4\text{O}_6$      | 0.589                 | 0.35     | 0.41     | 0.42        | 0.37        | 0.28       | 0.34        | 0.36     | 0.35       | 0.36       | –0.030       | 0.0046       | –0.025     | 53   |
| Iodic acid ( $\alpha$ ) | $\text{HIO}_3$                           | 0.633                 | 0.302    | 0.496    | 0.339       | 0.263       | 0.412      | 0.304       | 0.251    | 0.345      | 0.336      | 0.084        | –0.030       | 0.098      | 54   |
| Sulfur ( $\alpha$ )     | S                                        | 0.633                 | 0.324    | 0.307    | 0.268       | 0.272       | 0.301      | 0.310       | 0.203    | 0.232      | 0.270      | 0.143        | 0.019        | 0.118      | 54   |
| Barite                  | $\text{BaSO}_4$                          | 0.589                 | 0.21     | 0.25     | 0.16        | 0.34        | 0.24       | 0.19        | 0.28     | 0.22       | 0.31       | 0.002        | –0.012       | 0.037      | 55   |
| Topaz                   | $\text{Al}_2\text{SiO}_5(\text{OH,F})_2$ | –                     | –0.085   | 0.069    | 0.052       | 0.095       | –0.120     | 0.065       | 0.095    | 0.085      | –0.083     | –0.095       | –0.031       | 0.098      | 28   |

**Monoclinic (2, m, 2/m)**

| Monoclinic (2, m, 2/m) | Formula                                   | $\lambda/\mu\text{m}$ |                  |                    |                   |
|------------------------|-------------------------------------------|-----------------------|------------------|--------------------|-------------------|
| Taurine                | $\text{C}_2\text{H}_7\text{NO}_3\text{S}$ | 0.589                 | $p_{11} = 0.313$ | $p_{25} = -0.0025$ | $p_{51} = -0.014$ |
|                        |                                           |                       | $p_{12} = 0.251$ | $p_{31} = 0.362$   | $p_{52} = 0.006$  |
|                        |                                           |                       | $p_{13} = 0.270$ | $p_{32} = 0.275$   | $p_{53} = 0.0048$ |
|                        |                                           |                       | $p_{15} = -0.10$ | $p_{33} = 0.308$   | $p_{55} = 0.047$  |
|                        |                                           |                       | $p_{21} = 0.281$ | $p_{35} = -0.003$  | $p_{64} = 0.0024$ |
|                        |                                           |                       | $p_{22} = 0.252$ | $p_{44} = 0.0025$  | $p_{66} = 0.0028$ |
|                        |                                           |                       | $p_{23} = 0.272$ | $p_{46} = -0.0056$ |                   |

| Isotropic                         | Formula                        | $\lambda/\mu\text{m}$ | $p_{11}$    | $p_{12}$    | $p_{44}$ | Ref. |
|-----------------------------------|--------------------------------|-----------------------|-------------|-------------|----------|------|
| Fused silica                      | $\text{SiO}_2$                 | 0.633                 | 0.121       | 0.270       | -0.075   | 15   |
| Water                             | $\text{H}_2\text{O}$           | 0.633                 | $\pm 0.31$  | $\pm 0.31$  |          | 15   |
| Polystyrene                       |                                | 0.633                 | $\pm 0.30$  | $\pm 0.31$  |          | 25   |
| Lucite                            |                                | 0.633                 | $\pm 0.30$  | 0.28        |          | 25   |
| Orpiment                          | $\text{As}_2\text{S}_3$ -glass | 1.15                  | 0.308       | 0.299       | 0.0045   | 15   |
| Tellurium oxide                   | $\text{TeO}_2$ -glass          | 0.633                 | 0.257       | 0.241       | 0.0079   | 56   |
| Laser glasses                     | LGS-247-2                      | 0.488                 | $\pm 0.168$ | $\pm 0.230$ |          | 57   |
|                                   | LGS-250-3                      |                       | $\pm 0.135$ | $\pm 0.198$ |          |      |
|                                   | LGS-1                          |                       | $\pm 0.214$ | $\pm 0.250$ |          |      |
|                                   | KGSS-1621                      |                       | $\pm 0.205$ | $\pm 0.239$ |          |      |
| Dense flint glasses<br>(examples) | LaSF                           | 0.633                 | 0.088       | 0.147       | -0.030   | 58   |
|                                   | $\text{SF}_6$                  |                       | 0.215       | 0.243       | -0.014   |      |
|                                   | U10502                         |                       | 0.172       | 0.179       | -0.004   |      |
|                                   | TaF $\text{d}_7$               |                       | 0.099       | 0.138       | -0.020   |      |

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## LINEAR ELECTRO-OPTIC COEFFICIENTS

| Name                         |                                       | $\lambda/\mu\text{m}$ | $r_{41}$ |  |
|------------------------------|---------------------------------------|-----------------------|----------|--|
| Cubic ( $\bar{4}3\text{m}$ ) | Formula                               |                       | pm/V     |  |
| Cuprous bromide              | CuBr                                  | 0.525                 | 0.85     |  |
| Cuprous chloride             | CuCl                                  | 0.633                 | 3.6      |  |
| Cuprous iodide               | CuI                                   | 0.55                  | −5.0     |  |
| Eulytite (BSO)               | $\text{Bi}_4\text{Si}_3\text{O}_{12}$ | 0.63                  | 0.54     |  |
| Germanium eulytite (BGO)     | $\text{Bi}_4\text{Ge}_3\text{O}_{12}$ | 0.63                  | 1.0      |  |
| Gallium arsenide             | GaAs                                  | 10.6                  | 1.6      |  |
| Gallium phosphide            | GaP                                   | 0.56                  | −1.07    |  |
| Hexamethylenetetramine       | $\text{C}_6\text{H}_{12}\text{N}_4$   | 0.633                 | 0.78     |  |
| Sphalerite                   | ZnS                                   | 0.65                  | 2.1      |  |
| Zinc selenide                | ZnSe                                  | 0.546                 | 2.0      |  |
| Zinc telluride               | ZnTe                                  | 3.41                  | 4.2      |  |
| Cadmium telluride            | CdTe                                  | 3.39                  | 6.8      |  |

| Cubic (23)                      |                                                                   | $\lambda/\mu\text{m}$ | $r_{41}$ |  |
|---------------------------------|-------------------------------------------------------------------|-----------------------|----------|--|
|                                 | Formula                                                           |                       | pm/V     |  |
| Ammonium chloride (77 K)        | $\text{NH}_4\text{Cl}$                                            | —                     | 1.5      |  |
| Ammonium cadmium langbeinite    | $(\text{NH}_4)_2\text{Cd}_2(\text{SO}_4)_3$                       | 0.546                 | 0.70     |  |
| Ammonium manganese langbeinite  | $(\text{NH}_4)_2\text{Mn}_2(\text{SO}_4)_3$                       | 0.546                 | 0.53     |  |
| Thallium cadmium langbeinite    | $\text{Ti}_2\text{Cd}_2(\text{SO}_4)_3$                           | 0.546                 | 0.37     |  |
| Potassium magnesium langbeinite | $\text{K}_2\text{Mg}_2(\text{SO}_4)_3$                            | 0.546                 | 0.40     |  |
| Bismuth monogermanate           | $\text{Bi}_{12}\text{GeO}_{20}$                                   | —                     | 3.3      |  |
| Bismuth monosilicate            | $\text{Bi}_{12}\text{SiO}_{20}$                                   | —                     | 3.3      |  |
| Sodium chlorate                 | $\text{NaClO}_3$                                                  | 0.589                 | 0.4      |  |
| Sodium uranyl acetate           | $\text{NaUO}_2(\text{CH}_3\text{COO})_3$                          | 0.546                 | 0.87     |  |
| Trenhydrobromide                | $\text{N}(\text{CH}_2\text{CH}_2\text{NH}_2)_3 \cdot 3\text{HBr}$ | —                     | 1.5      |  |
| Trenhydrochloride               | $\text{N}(\text{CH}_2\text{CH}_2\text{NH}_2)_3 \cdot 3\text{HCl}$ | —                     | 1.7      |  |

| Tetragonal ( $\bar{4}2\text{m}$ )      |                                     | $T_{\text{tran}}$<br>K | $r_{41}$ |       | $r_{63}$<br>pm/V |
|----------------------------------------|-------------------------------------|------------------------|----------|-------|------------------|
|                                        | Formula                             |                        | pm/V     |       |                  |
| Ammonium dihydrogen phosphate (ADP)    | $\text{NH}_4\text{H}_2\text{PO}_4$  | 148                    | 24.5     | −8.5  |                  |
| Ammonium dideuterium phosphate (AD*P)  | $\text{NH}_4\text{D}_2\text{PO}_4$  | 242                    | —        | 11.9  |                  |
| Ammonium dihydrogen arsenate (ADA)     | $\text{NH}_4\text{H}_2\text{AsO}_4$ | —                      | —        | 9.2   |                  |
| Cesium dihydrogen arsenate (CsDA)      | $\text{CsH}_2\text{AsO}_4$          | 143                    | —        | 18.6  |                  |
| Cesium dideuterium arsenate (CsD*A)    | $\text{CsD}_2\text{AsO}_4$          | 212                    | —        | 36.6  |                  |
| Potassium dihydrogen phosphate (KDP)   | $\text{KH}_2\text{PO}_4$            | 123                    | 8.6      | −10.5 |                  |
| Potassium dideuterium phosphate (KD*P) | $\text{KD}_2\text{PO}_4$            | 222                    | 8.8      | 23.8  |                  |
| Potassium dihydrogen arsenate (KDA)    | $\text{KH}_2\text{AsO}_4$           | 97                     | 12.5     | 10.9  |                  |
| Potassium dideuterium arsenate (KD*A)  | $\text{KD}_2\text{AsO}_4$           | 162                    | —        | 18.2  |                  |
| Rubidium dihydrogen phosphate (RDP)    | $\text{RbH}_2\text{PO}_4$           | 147                    | —        | 15.5  |                  |
| Rubidium dihydrogen arsenate (RDA)     | $\text{RbH}_2\text{AsO}_4$          | 110                    | —        | 13.0  |                  |
| Rubidium dideuterium arsenate (RD*A)   | $\text{RbD}_2\text{AsO}_4$          | 178                    | —        | 21.4  |                  |

| Tetragonal (4mm)                 |                                                         | $T_{\text{tran}}$<br>K | $r_{13}$<br>pm/V | $r_{33}$<br>pm/V | $r_{51}$<br>pm/V |
|----------------------------------|---------------------------------------------------------|------------------------|------------------|------------------|------------------|
|                                  | Formula                                                 |                        |                  |                  |                  |
| Barium titanate                  | $\text{BaTiO}_3$                                        | 406                    | 8                | 28               | —                |
| Potassium lithium niobate        | $\text{K}_3\text{Li}_2\text{Nb}_5\text{O}_{15}$         | 693                    | 8.9              | 5.9              | —                |
| Lead titanate                    | $\text{PbTiO}_3$                                        | 765                    | 13.8             | 5.9              | —                |
| Strontium barium niobate (SBN75) | $\text{Sr}_{0.75}\text{Ba}_{0.25}\text{Nb}_2\text{O}_6$ | 330                    | 6.7              | 1340             | 42               |
| Strontium barium niobate (SBN46) | $\text{Sr}_{0.46}\text{Ba}_{0.54}\text{Nb}_2\text{O}_6$ | 602                    | ~180             | 35               | —                |

| Hexagonal (6mm)             |  | Formula | $r_{13}$<br>pm/V | $r_{33}$<br>pm/V | $r_{42}$<br>pm/V | $r_{51}$<br>pm/V |
|-----------------------------|--|---------|------------------|------------------|------------------|------------------|
| Greenockite                 |  | CdS     | 3.1              | 2.9              | 2.0              | 3.7              |
| Greenockite (const. strain) |  | CdS     | 1.1              | 2.4              | —                | —                |
| Wurzite                     |  | ZnS     | 0.9              | 1.8              | —                | —                |
| Zincite                     |  | ZnO     | −1.4             | +2.6             | —                | —                |

| Hexagonal (6)             |  | Formula            | $r_{13}$<br>pm/V    | $r_{33}$<br>pm/V | $r_{42}$<br>pm/V | $r_{51}$<br>pm/V |
|---------------------------|--|--------------------|---------------------|------------------|------------------|------------------|
| Lithium iodate            |  | LiIO <sub>3</sub>  | 4.1                 | 6.4              | 1.4              | 3.3              |
| Lithium potassium sulfate |  | LiKSO <sub>4</sub> | $r_{13}-r_{33}=1.6$ | —                | —                | —                |

| Trigonal (3m)          |  | Formula             | $T_{\text{tran}}$<br>K | $r_{13}$<br>pm/V | $r_{22}$<br>pm/V | $r_{33}$<br>pm/V | $r_{42}$<br>pm/V |
|------------------------|--|---------------------|------------------------|------------------|------------------|------------------|------------------|
| Cesium nitrate         |  | CsNO <sub>3</sub>   | 425                    | —                | 0.43             | —                | —                |
| Lithium niobate        |  | LiNbO <sub>3</sub>  | 1483                   | 8.6              | 7.0              | 30.8             | 28               |
| Lithium tantalate      |  | LiTaO <sub>3</sub>  | 890                    | 8.4              | —                | 30.5             | —                |
| Lithium sodium sulfate |  | LiNaSO <sub>4</sub> | —                      | —                | <0.02            | —                | —                |
| Tourmaline             |  | —                   | —                      | —                | 0.3              | —                | —                |

| Trigonal (32)        |  | Formula                                                      | $T_{\text{tran}}$<br>K | $r_{11}$<br>pm/V | $r_{41}$<br>pm/V |
|----------------------|--|--------------------------------------------------------------|------------------------|------------------|------------------|
| Cesium tartrate      |  | Cs <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> | —                      | 1.0              | —                |
| Cinnabar             |  | HgS                                                          | 659                    | 3.1              | 1.5              |
| Potassium dithionate |  | K <sub>2</sub> S <sub>2</sub> O <sub>6</sub>                 | —                      | 0.26             | —                |
| Strontium dithionate |  | SrS <sub>2</sub> O <sub>6</sub> ·4H <sub>2</sub> O           | —                      | 0.1              | —                |
| Quartz               |  | SiO <sub>2</sub>                                             | 1140                   | −0.47            | 0.2              |
| Selenium             |  | Se                                                           | 398                    | 2.5              | —                |

| Orthorhombic (222) |  | Formula                                                                          | $T_{\text{tran}}$<br>K     | $r_{41}$<br>pm/V | $r_{52}$<br>pm/V | $r_{63}$<br>pm/V |
|--------------------|--|----------------------------------------------------------------------------------|----------------------------|------------------|------------------|------------------|
| Ammonium oxalate   |  | (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·4H <sub>2</sub> O | —                          | 230              | 330              | 250              |
| Rochelle salt      |  | KNaC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ·4H <sub>2</sub> O               | $T_u = 297$<br>$T_l = 255$ | −2.0             | −1.7             | +0.32            |

| Orthorhombic (mm2)          |  | Formula                             | $T_{\text{trans}}$<br>K | $r_{13}$<br>pm/V | $r_{23}$<br>pm/V | $r_{33}$<br>pm/V | $r_{42}$<br>pm/V | $r_{51}$<br>pm/V |
|-----------------------------|--|-------------------------------------|-------------------------|------------------|------------------|------------------|------------------|------------------|
| Barium sodium niobate (BSN) |  | Ba <sub>2</sub> NaNbO <sub>15</sub> | 833                     | 15               | 13               | 48               | 92               | 90               |
| Potassium niobate           |  | KNbO <sub>3</sub>                   | 476                     | 28               | 1.3              | 64               | 380              | 105              |

| Monoclinic (2)           |  | Formula                                                                             | $T_{\text{trans}}$<br>K | $r_{22}$<br>pm/V | $r_{32}$<br>pm/V |
|--------------------------|--|-------------------------------------------------------------------------------------|-------------------------|------------------|------------------|
| Calcium pyroniobate      |  | Ca <sub>2</sub> Nb <sub>2</sub> O <sub>7</sub>                                      | —                       | 0.33             | 13.7             |
| Triglycine sulfate (TGS) |  | (NH <sub>2</sub> CH <sub>2</sub> COOH) <sub>3</sub> ·H <sub>2</sub> SO <sub>4</sub> | 322                     | 7.2              | 13.6             |

## References

1. Narasimhamurty, T. S., *Photoelastic and Electro-Optic Properties of Crystals*, Plenum Press, New York, 1981, pp. 405–407.
2. Weber, M. J., Ed., *CRC Handbook of Laser Science and Technology*, Vol. IV, CRC Press, Boca Raton, FL, 1986, pp. 258–278.

## QUADRATIC ELECTRO-OPTIC COEFFICIENTS

Kerr Constants of Ferroelectric Crystals<sup>1,2</sup>

| Name                        | Formula                                                            | $T_{\text{tran}}$<br>K | $\lambda$<br>$\mu\text{m}$ | $g_{11}$<br>$10^{10}$ esu | $g_{12}$<br>$10^{10}$ esu | $g_{11}-g_{12}$<br>$10^{10}$ esu | $g_{44}$<br>$10^{10}$ esu |
|-----------------------------|--------------------------------------------------------------------|------------------------|----------------------------|---------------------------|---------------------------|----------------------------------|---------------------------|
| Barium titanate             | BaTiO <sub>3</sub>                                                 | 406                    | 0.633                      | 1.33                      | -0.11                     | 1.44                             |                           |
| Strontium titanate          | SrTiO <sub>3</sub>                                                 | —                      | 0.633                      | —                         | —                         | 1.56                             | —                         |
| Potassium tantalate niobate | KTa <sub>0.65</sub> Nb <sub>0.35</sub> O <sub>3</sub>              | 330                    | 0.633                      | 1.50                      | -0.42                     | 1.92                             | 1.63                      |
| Potassium tantalate         | KTaO <sub>3</sub>                                                  | 13                     | 0.633                      | —                         | —                         | 1.77                             | 1.33                      |
| Lithium niobate             | LiNbO <sub>3</sub>                                                 | 1483                   | —                          | 0.94                      | 0.25                      | 0.7                              | 0.6                       |
| Lithium tantalate           | LiTaO <sub>3</sub>                                                 | 938                    | —                          | 1.0                       | 0.17                      | 0.8                              | 0.7                       |
| Barium sodium niobate (BSN) | Ba <sub>0.8</sub> Na <sub>0.4</sub> Nb <sub>2</sub> O <sub>6</sub> | 833                    | —                          | 1.55                      | 0.44                      | 1.11                             |                           |

Kerr Constants of Selected Liquids<sup>2</sup>

$K$  is the Kerr constant at a wavelength of 589 nm and at room temperature;  $\epsilon$  is the static dielectric constant;  $t_m$  is the melting point; and  $t_b$  is the normal boiling point

| Name                         | Molecular<br>formula                             | $K$<br>$10^{-7}$ esu | $\epsilon$        | $t_m$<br>°C | $t_b$<br>°C |
|------------------------------|--------------------------------------------------|----------------------|-------------------|-------------|-------------|
| Carbon disulfide             | CS <sub>2</sub>                                  | +3.23                | 2.63              | -111.5      | +46.3       |
| Acetone                      | C <sub>3</sub> H <sub>6</sub> O                  | +16.3                | 21.0              | -94.8       | +56.1       |
| Methyl ethyl ketone          | C <sub>4</sub> H <sub>8</sub> O                  | +13.6                | 18.56             | -86.67      | +79.6       |
| Pyridine                     | C <sub>5</sub> H <sub>5</sub> N                  | +20.4                | 13.26             | -42         | +115.23     |
| Ethyl cyanoacetate           | C <sub>5</sub> H <sub>7</sub> NO <sub>2</sub>    | +38.8                | 31.6              | -22.5       | 205         |
| <i>o</i> -Dichlorobenzene    | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>    | +42.6                | 10.12             | -16.7       | 180         |
| Benzenesulfonyl chloride     | C <sub>6</sub> H <sub>5</sub> ClO <sub>2</sub> S | +89.9                | 28.90             | +14.5       | 247         |
| Nitrobenzene                 | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>    | +326                 | 35.6              | +5.7        | 210.8       |
| Ethyl 3-aminocrotonate       | C <sub>6</sub> H <sub>11</sub> NO <sub>2</sub>   | +31.0                | —                 | +33.9       | 210         |
| Paraldehyde                  | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>    | -23.0                | 14.7              | +12.6       | 124         |
|                              |                                                  |                      | 12.0 <sup>a</sup> |             |             |
| Benzaldehyde                 | C <sub>7</sub> H <sub>6</sub> O                  | +80.8                | 17.85             | -26         | 179.05      |
|                              |                                                  |                      | 14.1 <sup>a</sup> |             |             |
| <i>p</i> -Chlorotoluene      | C <sub>7</sub> H <sub>7</sub> Cl                 | +23.0                | 6.25              | +7.5        | 162.4       |
| <i>o</i> -Nitrotoluene       | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>    | +174                 | 26.26             | -10         | 222.3       |
| <i>m</i> -Nitrotoluene       | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>    | +177                 | 24.95             | +15.5       | 232         |
| <i>p</i> -Nitrotoluene       | C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>    | +222                 | 22.2              | +51.6       | 238.3       |
| Benzyl alcohol               | C <sub>7</sub> H <sub>8</sub> O                  | -15.4                | 11.92             | -15.3       | 205.8       |
|                              |                                                  |                      | 10.8 <sup>a</sup> |             |             |
| <i>m</i> -Cresol             | C <sub>7</sub> H <sub>8</sub> O                  | +21.2                | 12.44             | +11.8       | 202.27      |
|                              |                                                  |                      | 5.0 <sup>a</sup>  |             |             |
| <i>m</i> -Chloroacetophenone | C <sub>8</sub> H <sub>7</sub> ClO                | +69.1                |                   |             |             |
| Acetophenone                 | C <sub>8</sub> H <sub>8</sub> O                  | +66.6                | 17.44             | +19.7       | 202.3       |
|                              |                                                  |                      | 15.8 <sup>a</sup> |             |             |
| Quinoline                    | C <sub>9</sub> H <sub>7</sub> N                  | +15.0                | 9.16              | -14.78      | 237.16      |
| Ethyl salicylate             | C <sub>9</sub> H <sub>10</sub> O <sub>3</sub>    | +19.6                | 8.48              | +1.3        | 231.5       |
| Carvone                      | C <sub>10</sub> H <sub>14</sub> O                | +23.6                | 11.2              | <0          | 230         |
| Ethyl benzoylacetate         | C <sub>11</sub> H <sub>12</sub> O <sub>3</sub>   | +16.0                | 13.50             | <0          | 270         |
| Water                        | H <sub>2</sub> O                                 | +4.0                 | 80.10             | 0.00        | 100.0       |

<sup>a</sup> Dielectric constant at radio frequencies (108–109 Hz).

## References

1. Narasimhamurty, T. S., *Photoelastic and Electro-Optic Properties of Crystals*, Plenum Press, New York, 1981, p. 408.
2. Gray, D. E., Ed., *AIP Handbook of Physics*, McGraw Hill, New York, 1972, p. 6–241.

## MAGNETO-OPTIC CONSTANTS

Verdet Constants of Non-Magnetic Crystals<sup>1</sup>

$V$  is the Verdet constant;  $n$  is the refractive index; and  $\lambda$  is the wavelength. "min" is minutes of angle.

| Material                                               | $T$<br>K | $\lambda$<br>nm | $n$   | $V$<br>min/Oe cm |
|--------------------------------------------------------|----------|-----------------|-------|------------------|
| Al <sub>2</sub> O <sub>3</sub>                         | 300      | 546.1           | 1.771 | 0.0240           |
|                                                        | 300      | 589.3           | 1.768 | 0.0210           |
| BaTaO <sub>3</sub>                                     | 403      | 427             |       | 0.95             |
|                                                        | 403      | 496             |       | 0.38             |
|                                                        | 403      | 620             |       | 0.18             |
|                                                        | 403      | 826             |       | 0.072            |
| Bi <sub>4</sub> Ge <sub>3</sub> O <sub>12</sub>        | 300      | 442             | 2.077 | 0.289            |
|                                                        | 300      | 632.8           | 2.048 | 0.099            |
|                                                        | 300      | 1064            | 2.031 | 0.026            |
| C (diamond)                                            | 300      | 589.3           | 2.417 | 0.0233           |
| CaCO <sub>3</sub>                                      | 300      | 589.3           | 1.658 | 0.019            |
| CaF <sub>2</sub>                                       | 300      | 589.3           | 1.434 | 0.0088           |
| Cd <sub>0.55</sub> Mn <sub>0.45</sub> Te               | 300      | 632.8           |       | 6.87             |
| CuCl                                                   | 300      | 546.1           | 1.93  | 0.20             |
| GaSe                                                   | 298      | 632.8           |       | 0.80             |
| KAl(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O | 300      | 589.3           | 1.456 | 0.0124           |
| KBr                                                    | 300      | 546.1           | 1.564 | 0.0500           |
|                                                        | 300      | 589.3           | 1.560 | 0.0425           |
| KCl                                                    | 300      | 589.3           | 1.490 | 0.0275           |
| KI                                                     | 300      | 546.1           | 1.673 | 0.083            |
|                                                        | 300      | 589.3           | 1.666 | 0.070            |
| KTaO <sub>3</sub>                                      | 296      | 352             |       | 0.44             |
|                                                        | 296      | 413             |       | 0.19             |
|                                                        | 296      | 496             |       | 0.096            |
|                                                        | 296      | 620             |       | 0.051            |
|                                                        | 296      | 826             |       | 0.022            |
| LaF <sub>3</sub><br>(H  c)                             | 300      | 325             | 1.639 | 0.054            |
|                                                        | 300      | 442             | 1.615 | 0.028            |
|                                                        | 300      | 632.8           | 1.601 | 0.012            |
|                                                        | 300      | 1064            | 1.592 | 0.006            |
| MgAl <sub>2</sub> O <sub>4</sub>                       | 300      | 589.3           | 1.718 | 0.021            |
| NH <sub>4</sub> AlSO <sub>4</sub> ·12H <sub>2</sub> O  | 300      | 589.3           | 1.459 | 0.0128           |
| NH <sub>4</sub> Br                                     | 300      | 589.3           | 1.711 | 0.0504           |
| NH <sub>4</sub> Cl                                     | 300      | 546.1           |       | 0.0410           |
|                                                        | 300      | 589.3           | 1.643 | 0.0362           |
| NaBr                                                   | 300      | 546.1           |       | 0.0621           |
|                                                        | 300      | 546.1           |       | 0.0410           |
| NaCl                                                   | 300      | 589.3           | 1.544 | 0.0345           |
|                                                        | 300      | 546.1           |       | 0.0105           |
| NaClO <sub>3</sub>                                     | 300      | 589.3           | 1.515 | 0.0081           |
|                                                        | 297      | 546.1           |       | 0.0256           |
| NiSO <sub>4</sub> ·6H <sub>2</sub> O                   | 297      | 589.3           | 1.511 | 0.0221           |
|                                                        | 300      | 546.1           | 1.546 | 0.0195           |
| SiO <sub>2</sub>                                       | 300      | 589.3           | 1.544 | 0.0166           |
|                                                        | 298      | 413             | 2.627 | 0.78             |
| SrTiO <sub>3</sub>                                     | 298      | 496             |       | 0.31             |
|                                                        | 298      | 620             |       | 0.14             |
|                                                        | 298      | 826             |       | 0.066            |
|                                                        | 300      | 546.1           |       | 0.287            |
| ZnS                                                    | 300      | 589.3           | 2.368 | 0.226            |
| ZnSe                                                   | 300      | 476             | 2.826 | 1.50             |
|                                                        | 300      | 496             | 2.759 | 1.04             |
|                                                        | 300      | 514             | 2.721 | 0.839            |
|                                                        | 300      | 587             | 2.627 | 0.529            |
|                                                        | 300      | 632.8           | 2.592 | 0.406            |

Verdet Constants of Rare-Earth Aluminum Garnets at Various Wavelengths<sup>1</sup>

The absorption coefficient  $\alpha$  for these materials ranges from 0.2 to 0.6 cm<sup>-1</sup> at 300 K.

| Material                                        | T/K  | V in min/Oe cm             |         |         |         |         |         |        |        |
|-------------------------------------------------|------|----------------------------|---------|---------|---------|---------|---------|--------|--------|
|                                                 |      | $\lambda = 405 \text{ nm}$ | 450 nm  | 480 nm  | 520 nm  | 546 nm  | 578 nm  | 635 nm | 670 nm |
| Tb <sub>2</sub> Al <sub>5</sub> O <sub>12</sub> | 300  | -2.266                     | -1.565  | -1.290  | -1.039  | -0.912  | -0.787  | -0.620 | -0.542 |
|                                                 | 77   |                            | -102.16 | -83.45  | -3.425  | -3.051  | -2.603  | -2.008 | -1.815 |
|                                                 | 4.2  |                            |         |         | -64.80  | -58.35  | -53.77  | 48.39  | -45.15 |
|                                                 | 1.45 |                            | -200.95 | -172.52 | -139.28 | -125.07 | -111.27 | 97.47  | -93.42 |
| Dy <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> | 300  | -1.241                     | -0.942  | -0.803  | -0.667  | -0.592  | -0.518  | -0.411 | -0.359 |
| Ho <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> | 300  | -0.709                     | -0.320  | -0.260  | -0.335  | -0.304  | -0.299  |        | -0.206 |
| Er <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> | 300  | -0.189                     | -0.240  | -0.154  | -0.162  | -0.157  | -0.145  | -0.105 | -0.089 |
| Tm <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> | 300  | +0.151                     | +0.103  | +0.093  | 0.076   | 0.069   | +0.059  | +0.048 |        |
| Yb <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> | 298  | 0.287                      | 0.215   | 0.186   | 0.140   | 0.133   | 0.116   | 0.094  |        |
|                                                 | 77   | 0.718                      | 0.540   | 0.481   | 0.393   | 0.342   | 0.302   | 0.239  |        |

Verdet Constants for KDP-Type Crystals<sup>1</sup>

Measurements refer to  $T = 298 \text{ K}$  and  $\lambda = 632.8 \text{ nm}$ , with  $k \parallel [001]$ .

| Material                                                   | V<br>min/Oe cm |
|------------------------------------------------------------|----------------|
| KH <sub>2</sub> PO <sub>4</sub> (KDP)                      | 0.0124         |
| KH <sub>0.3</sub> D <sub>1.7</sub> PO <sub>4</sub> (KD*P)  | 0.145          |
| NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> (ADP)       | 0.138          |
| KH <sub>2</sub> AsO <sub>4</sub> (KDA)                     | 0.238          |
| KH <sub>0.1</sub> D <sub>1.9</sub> AsO <sub>4</sub> (KD*A) | 0.245          |
| NH <sub>4</sub> H <sub>2</sub> AsO <sub>4</sub> (ADH)      | 0.244          |

Verdet Constants of Gases<sup>2</sup>

Values refer to  $T = 0 \text{ }^\circ\text{C}$  and  $P = 101.325 \text{ kPa}$  (760 mmHg);  $n_D$  is the refractive index at a wavelength of 589 nm.

| Gas                                      | $(n_D - 1) \times 10^3$ | $10^6 \times V$<br>min/Oe cm |
|------------------------------------------|-------------------------|------------------------------|
| He                                       | 0.036                   | +0.40                        |
| Ar                                       | 2.81                    | +9.36                        |
| H <sub>2</sub>                           |                         | +6.29                        |
| N <sub>2</sub>                           | 0.297                   | +6.46                        |
| O <sub>2</sub>                           | 0.272                   | +5.69                        |
| Air                                      | 0.293                   | +6.27                        |
| Cl <sub>2</sub>                          | 0.773                   | +31.9                        |
| HCl                                      | 0.447                   | +21.5                        |
| H <sub>2</sub> S                         | 0.63                    | +41.5                        |
| NH <sub>3</sub>                          | 0.376                   | +19.0                        |
| CO                                       | 0.34                    | +11.0                        |
| CO <sub>2</sub>                          | 0.45                    | +9.39                        |
| NO                                       | 0.297                   | -58                          |
| CH <sub>4</sub>                          | 0.444                   | +17.4                        |
| <i>n</i> -C <sub>4</sub> H <sub>10</sub> |                         | +44.0                        |

Verdet Constants of Liquids<sup>2</sup>

$n_D$  is the refractive index at a wavelength of 589 nm and a temperature of 20 °C, unless otherwise indicated.  $V$  is the Verdet constant.

| Liquid                         | $\lambda/\text{nm}$ | $t/^\circ\text{C}$ | $10^2 \times V$<br>min/Oe cm | $n_D$          |
|--------------------------------|---------------------|--------------------|------------------------------|----------------|
| P                              | 589                 | 33                 | +13.3                        |                |
| S                              | 589                 | 114                | +8.1                         | 1.929 (110 °C) |
| H <sub>2</sub> O               | 589                 | 20                 | +1.309                       | 1.3328         |
| D <sub>2</sub> O               | 589                 | 19.7               | +1.257                       | 1.3384         |
| H <sub>3</sub> PO <sub>4</sub> | 578                 | 97.4               | +1.35                        |                |
| CS <sub>2</sub>                | 589                 | 20                 | +4.255                       | 1.6255         |
| CCl <sub>4</sub>               | 578-589             | 25.1               | +1.60                        | 1.463 (15 °C)  |
| SbCl <sub>3</sub>              | 578                 | 18                 | +7.45                        | 1.601 (14 °C)  |
| TiCl <sub>4</sub>              | 578                 | 17                 | -1.65                        | 1.61           |
| TiBr <sub>4</sub>              | 578                 | 46                 | -5.3                         |                |
| Methanol                       | 589                 | 18.7               | +0.958                       | 1.3289         |
| Acetone                        | 578-589             | 20.0               | +1.116                       | 1.3585         |
| Toluene                        | 578-589             | 15.0               | +2.71                        | 1.4950         |
| Benzene                        | 578-589             | 15.0               | +3.00                        | 1.5005         |
| Chlorobenzene                  | 589                 | 15                 | +2.92                        | 1.5246         |
| Nitrobenzene                   | 589                 | 15                 | +2.17                        | 1.5523         |
| Bromoform                      | 589                 | 17.9               | +3.13                        | 1.5960         |

Verdet Constants of Rare-Earth Paramagnetic Crystals<sup>1</sup>

$n$  is the refractive index, and  $V$  is the Verdet constant at the wavelength and temperature indicated.

| Rare Earth       | Host             | $T/K$ | $\lambda/nm$ | $n$   | $V$<br>min/Oe cm |
|------------------|------------------|-------|--------------|-------|------------------|
| $Ce^{3+}$ (30%)  | $CaF_2$          | 300   | 325          | 1.516 | -0.956           |
|                  |                  | 300   | 442          | 1.502 | -0.297           |
|                  |                  | 300   | 633          | 1.494 | -0.111           |
|                  |                  | 300   | 1064         | 1.489 | -0.035           |
| $Ce^{3+}$        | $CeF_3$          | 300   | 442          | 1.613 | -1.05            |
|                  |                  | 300   | 633          | 1.598 | -0.406           |
|                  |                  | 77    | 633          |       | -1.418           |
|                  |                  | 300   | 1064         | 1.589 | -0.113           |
| $Pr^{3+}$ (5%)   | $CaF_2$          | 300   | 266          | 1.471 | -0.172           |
|                  |                  | 300   | 325          | 1.461 | -0.0818          |
|                  |                  | 300   | 442          | 1.451 | -0.0089          |
|                  |                  | 300   | 633          | 1.445 | -0.0168          |
| $Nd^{3+}$ (2.9%) | $CaF_2$          | 300   | 1064         | 1.441 | -0.0045          |
|                  |                  | 4.2   | 426          |       | -0.19            |
| $Nd^{3+}$        | $NdF_3$          | 300   | 442          | 1.60  | -0.553           |
|                  |                  | 290   | 633          | 1.59  | -0.209           |
|                  |                  | 77    | 633          |       | -0.755           |
|                  |                  | 300   | 1064         | 1.58  | -0.097           |
| $Eu^{3+}$ (3%)   | $CaF_2$          | 4.2   | 430          |       | 29               |
|                  |                  | 4.2   | 440          |       | 22               |
| $Eu^{2+}$        | $EuF_2$          | 300   | 450          |       | -4.5             |
|                  |                  | 300   | 500          |       | -2.6             |
|                  |                  | 300   | 550          |       | -1.6             |
|                  |                  | 300   | 600          |       | -1.1             |
|                  |                  | 300   | 650          |       | -0.8             |
| $Tb^{3+}$        | $KTb_3F_{10}$    | 300   | 1064         |       | -0.19            |
|                  |                  | 300   | 325          | 1.531 | -2.174           |
|                  |                  | 300   | 442          | 1.518 | -0.933           |
|                  |                  | 300   | 633          | 1.510 | -0.386           |
|                  |                  | 77    | 633          |       | -1.94            |
| $Tb^{3+}$        | $LiTbF_4$        | 300   | 1064         | 1.505 | -0.114           |
|                  |                  | 300   | 325          | 1.493 | -1.9             |
|                  |                  | 300   | 442          | 1.481 | -0.98            |
|                  |                  | 300   | 633          | 1.473 | -0.44            |
|                  |                  | 300   | 1064         | 1.469 | -0.13            |
| $Tb^{3+}$        | $Tb_3Ga_5O_{12}$ | 300   | 500          | 1.989 | -0.749           |
|                  |                  | 300   | 570          | 1.981 | -0.581           |
|                  |                  | 300   | 633          | 1.976 | -0.461           |
|                  |                  | 300   | 830          | 1.967 | -0.21            |
|                  |                  | 300   | 1060         | 1.954 | -0.12            |



**Verdet Constants of Paramagnetic Glasses<sup>1</sup>**

The Verdet constant  $V$  is given at room temperature for the wavelengths indicated.

Rare-earth phosphate glasses of composition  $R_2O_3 \cdot xP_2O_5$ , where  $x$  is given in the second column

|    |      | Verdet constant $V$ in min/Oe cm |                       |                       |                       |                       |                       |                       |                       |                       |                       |
|----|------|----------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| R  | $x$  | $\lambda = 405$<br>nm            | $\lambda = 436$<br>nm | $\lambda = 480$<br>nm | $\lambda = 500$<br>nm | $\lambda = 520$<br>nm | $\lambda = 546$<br>nm | $\lambda = 578$<br>nm | $\lambda = 600$<br>nm | $\lambda = 635$<br>nm | $\lambda = 670$<br>nm |
| La |      | 0.037                            | 0.030                 | 0.024                 | 0.022                 | 0.020                 | 0.018                 | 0.015                 | -0.014                | 0.013                 | –                     |
| Ce | 2.67 | -0.672                           | 0.510                 | -0.366                | -0.326                | -0.287                | -0.253                | -0.217                | -0.197                | -0.173                | -0.150                |
| Pr | 3.09 | -0.447                           | -0.332                | -0.283                | -0.261                | -0.236                | -0.208                | -0.182                | -0.170                | -0.150                | -0.132                |
| Nd | 2.92 | -0.250                           | -0.209                | -0.167                | -0.155                | -0.136                | -0.134                | -0.094                | -0.080                | -0.080                | -0.071                |
| Sm | 2.87 | 0.026                            | 0.024                 | 0.020                 | 0.020                 | 0.017                 | 0.015                 | 0.014                 | 0.012                 | 0.011                 | 0.010                 |
| Eu | 2.93 | -0.025                           | -0.017                | -0.010                | -0.006                | -0.006                | -0.005                | -0.004                | -0.003                | -0.002                | -0.002                |
| Gd | 3.01 | 0.018                            | 0.015                 | 0.014                 | 0.012                 | 0.012                 | 0.011                 | 0.011                 | 0.010                 | 0.009                 | 0.009                 |
| Tb | 2.94 | -0.560                           | -0.458                | -0.357                | -0.323                | -0.295                | -0.261                | -0.226                | -0.206                | -0.190                | -0.164                |
| Dy | 2.51 | -0.540                           | -0.453                | -0.359                | -0.331                | -0.301                | 0.268                 | -0.237                | -0.217                | -0.197                | -0.173                |
| Ho | 2.94 | -0.299                           | -0.313                | -0.156                | -0.153                | -0.138                | -0.138                | -0.119                | -0.110                | -0.098                | -0.084                |
| Er | 3.01 | -0.139                           | -0.121                | -0.100                | -0.111                | -0.095                | -0.062                | -0.060                | -0.057                | -0.051                | -0.044                |
| Tm | 2.79 | 0.019                            | 0.013                 | 0.012                 | 0.009                 | 0.008                 | 0.006                 | 0.005                 | 0.004                 | 0.004                 | 0.007                 |
| Yb | 3.01 | 0.087                            | 0.072                 | 0.056                 | 0.050                 | 0.045                 | 0.041                 | 0.036                 | 0.032                 | 0.029                 | 0.024                 |

The following are rare-earth borate glasses with composition:

for La and Pr:  $R_2O_3 \cdot xP_2O_5$ ; for Tb–Pr and Dy–Pr:  $R_2O_3 \cdot xB_2O_3$ ; and for other elements:  $R_2O_3 \cdot 0.85La_3O_3 \cdot xB_2O_3$ .

|       |      |        |        |        |        |        |        |        |        |        |        |
|-------|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| La    | 3.04 | 0.043  | 0.036  | 0.029  | 0.026  | 0.023  | 0.022  | 0.019  | 0.018  | 0.016  | 0.014  |
| Pr-La | 5.44 | -0.380 | -0.307 | -0.230 | -0.220 | -0.201 | -0.178 | -0.153 | -0.146 | -0.128 | -0.110 |
| Nd-La | 5.41 | -0.180 | -0.147 | -0.120 | -0.111 | -0.096 | -0.094 | -0.100 | -0.059 | -0.056 | -0.046 |
| Sm-La | 4.97 | 0.032  | 0.030  | 0.025  | 0.024  | 0.022  | 0.019  | 0.017  | 0.016  | 0.014  | 0.012  |
| Eu-La | 4.69 | -0.081 | -0.060 | -0.038 | -0.033 | -0.029 | -0.024 | 0.019  | -0.016 | 0.014  | -0.012 |
| Gd-La | 4.71 | 0.032  | 0.026  | 0.024  | 0.022  | 0.021  | 0.020  | 0.018  | 0.017  | 0.015  | 0.013  |
| Tb-La | 4.73 | -0.512 | -0.419 | -0.319 | -0.288 | -0.262 | -0.234 | -0.205 | -0.186 | -0.167 | -0.142 |
| Dy-La | 4.88 | -0.436 | -0.361 | -0.299 | -0.273 | -0.246 | -0.220 | -0.193 | -0.177 | -0.159 | -0.138 |
| Ho-La | 4.36 | -0.269 | -0.252 | -0.123 | -0.131 | -0.112 | -0.128 | -0.104 | -0.096 | –      | -0.074 |
| Er-La | 4.50 | -0.093 | -0.078 | -0.068 | -0.082 | –      | -0.045 | -0.042 | -0.040 | -0.035 | -0.034 |
| Tm-La | 4.75 | 0.060  | 0.046  | 0.039  | 0.034  | 0.031  | 0.026  | 0.023  | 0.021  | 0.018  | 0.016  |
| Yb-La | 8.58 | 0.115  | 0.094  | 0.073  | 0.066  | 0.060  | 0.054  | 0.046  | 0.043  | 0.037  | 0.033  |
| Tb-Pr | 4.99 | -0.940 | -0.786 | -0.560 | -0.536 | -0.489 | -0.436 | -0.380 | -0.348 | -0.306 | -0.265 |
| Dy-Pr | 4.63 | -0.850 | –      | –      | -0.497 | -0.465 | -0.413 | -0.358 | -0.332 | -0.290 | -0.252 |
| Pr    | 2.56 | -0.843 | -0.646 | -0.471 | -0.480 | -0.432 | -0.390 | -0.334 | -0.317 | -0.271 | -0.243 |

**Verdet Constants of Diamagnetic Glasses<sup>1</sup>**

The Verdet constant  $V$  is given at room temperature for the wavelengths indicated.

| Glass                         |                                                                                                                                          | Verdet constant $V$ in min/Oe cm |                    |                    |                     |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|--------------------|--------------------|---------------------|
| type                          | Composition (wt. %)                                                                                                                      | $\lambda = 325$ nm               | $\lambda = 442$ nm | $\lambda = 633$ nm | $\lambda = 1064$ nm |
| SiO <sub>2</sub>              | 100% SiO <sub>2</sub>                                                                                                                    |                                  |                    | 0.013              |                     |
| B <sub>2</sub> O <sub>3</sub> | 100% B <sub>2</sub> O <sub>3</sub>                                                                                                       |                                  |                    | 0.010              |                     |
| CdO                           | 47.5% CdO, 52.5% P <sub>2</sub> O <sub>5</sub>                                                                                           | 0.079                            | 0.033              | 0.022              |                     |
| ZnO                           | 36.4% ZnO, 63.6% P <sub>2</sub> O <sub>5</sub>                                                                                           | 0.072                            | 0.044              | 0.020              |                     |
| TeO <sub>2</sub>              | 88.9% TeO <sub>2</sub> , 11.1% P <sub>2</sub> O <sub>5</sub>                                                                             |                                  | 0.196              | 0.076              | 0.022               |
| ZrF <sub>4</sub>              | 63.1% ZrF <sub>4</sub> , 14.9% BaF <sub>2</sub> ,<br>7.2% LaF <sub>3</sub> , 1.9% AlF <sub>3</sub> ,<br>9.1% PbF <sub>2</sub> , 3.8% LiF |                                  |                    | 0.011              |                     |

|                         |                                                                                                                  | $\lambda = 700 \text{ nm}$ | $\lambda = 853 \text{ nm}$ | $\lambda = 1060 \text{ nm}$ |
|-------------------------|------------------------------------------------------------------------------------------------------------------|----------------------------|----------------------------|-----------------------------|
| $\text{Bi}_2\text{O}_3$ | 95% $\text{Bi}_2\text{O}_3$ , 5% $\text{B}_2\text{O}_3$                                                          | 0.086                      | 0.051                      | 0.033                       |
| $\text{PbO}$            | 95% $\text{PbO}$ , 5% $\text{B}_2\text{O}_3$                                                                     | 0.093                      | 0.061                      | 0.031                       |
|                         | 82% $\text{PbO}$ , 18% $\text{SiO}_2$                                                                            | 0.077                      | 0.045                      | 0.027                       |
|                         | 50% $\text{PbO}$ , 15% $\text{K}_2\text{O}$ , 35% $\text{SiO}_2$                                                 | 0.032                      | 0.020                      | 0.011                       |
| $\text{Ti}_2\text{O}_3$ | 95% $\text{Ti}_2\text{O}_3$ , 5% $\text{B}_2\text{O}_3$                                                          | 0.092                      | 0.061                      | 0.032                       |
|                         | 82% $\text{Ti}_2\text{O}_3$ , 18% $\text{SiO}_2$                                                                 | 0.100                      | 0.067                      | 0.043                       |
|                         | 50% $\text{Ti}_2\text{O}_3$ , 15% $\text{K}_2\text{O}$ , 35% $\text{SiO}_2$                                      | 0.036                      | 0.022                      | 0.012                       |
| $\text{SnO}$            | 76% $\text{SnO}$ , 13% $\text{B}_2\text{O}_3$ , 11% $\text{SiO}_2$                                               | 0.071                      | 0.046                      | 0.026                       |
| $\text{TeO}_3$          | 75% $\text{TeO}_2$ , 25% $\text{Sb}_2\text{O}_3$                                                                 | 0.076                      | 0.052                      | 0.032                       |
|                         | 80% $\text{TeO}_2$ , 20% $\text{ZnCl}_2$                                                                         | 0.073                      | 0.046                      | 0.025                       |
|                         | 84% $\text{TeO}_2$ , 16% $\text{BaO}$                                                                            | 0.056                      | 0.041                      | 0.029                       |
|                         | 70% $\text{TeO}_2$ , 30% $\text{WO}_3$                                                                           | 0.052                      | 0.035                      | 0.022                       |
|                         | 20% $\text{TeO}_2$ , 80% $\text{PbO}$                                                                            | 0.128                      | 0.075                      | 0.048                       |
| $\text{Sb}_2\text{O}_3$ | 25% $\text{Sb}_2\text{O}_3$ , 75% $\text{TeO}_2$                                                                 | 0.076                      | 0.050                      | 0.032                       |
|                         | 75% $\text{Sb}_2\text{O}_3$ , 75% $\text{Cs}_2\text{O}$ , 5% $\text{Al}_2\text{O}_3$                             | 0.074                      | 0.044                      | 0.025                       |
|                         | 75% $\text{Sb}_2\text{O}_3$ , 10% $\text{Cs}_2\text{O}$ , 10% $\text{Rb}_2\text{O}$ , 5% $\text{Al}_2\text{O}_3$ | 0.078                      | 0.052                      | 0.030                       |

### Verdet Constants of Commercial Glasses<sup>1</sup>

This table gives the density,  $\rho$ , refractive index at 589 nm,  $n_D$ , and Verdet constant,  $V$ , for the wavelengths indicated; the data refer to room temperature.

| Glass type | $\rho$<br>g/cm <sup>3</sup> | $n_D$  | $V$ in min/Oe cm             |                              |                              |                              |                              |
|------------|-----------------------------|--------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
|            |                             |        | $\lambda = 365.0 \text{ nm}$ | $\lambda = 404.7 \text{ nm}$ | $\lambda = 435.8 \text{ nm}$ | $\lambda = 546.1 \text{ nm}$ | $\lambda = 578.0 \text{ nm}$ |
| BSC        | 2.49                        | 1.5096 | 0.0499                       | 0.0392                       | 0.0333                       | 0.02034                      | 0.01798                      |
| HC         | 2.53                        | 1.5189 | 0.0561                       | 0.0440                       | 0.0372                       | 0.0225                       | 0.01995                      |
| LBC        | 2.87                        | 1.5406 | 0.0609                       | 0.0477                       | 0.0403                       | 0.0245                       | 0.0216                       |
| LF         | 3.23                        | 1.5785 | 0.1143                       | 0.0850                       | 0.0693                       | 0.0394                       | 0.0344                       |
| BLF        | 3.48                        | 1.6047 | 0.1112                       | 0.0832                       | 0.0685                       | 0.0393                       | 0.0344                       |
| DBC        | 3.56                        | 1.6122 | 0.0662                       | 0.0517                       | 0.0435                       | 0.0261                       | 0.0231                       |
| DF         | 3.63                        | 1.6203 | 0.1473                       | 0.1076                       | 0.0872                       | 0.0485                       | 0.0423                       |
| EDF        | 3.9                         | 1.6533 | 0.1725                       | 0.1248                       | 0.1007                       | 0.0556                       | 0.0483                       |

The composition of the glasses in weight percent is:

| Glass type | $\text{SiO}_2$ | $\text{B}_2\text{O}_3$ | $\text{K}_2\text{O}$ | $\text{CaO}$ | $\text{Al}_2\text{O}_3$ | $\text{As}_2\text{O}_3$ | $\text{Na}_2\text{O}$ | $\text{BaO}$ | $\text{ZnO}$ | $\text{PbO}$ |
|------------|----------------|------------------------|----------------------|--------------|-------------------------|-------------------------|-----------------------|--------------|--------------|--------------|
| BSC        | 69.6           | 6.7                    | 20.5                 | 2.9          | 0.3                     | 0.1                     | —                     | —            | —            | —            |
| HC         | 72.0           | —                      | 10.1                 | 11.4         | 0.3                     | 0.2                     | 6.1                   | —            | —            | —            |
| LBC        | 57.1           | 1.8                    | 13.7                 | 0.3          | 0.2                     | 0.1                     | —                     | 26.9         | —            | —            |
| LF         | 52.5           | —                      | 9.5                  | 0.3          | 0.2                     | 0.1                     | —                     | —            | —            | 37.6         |
| BLF        | 45.2           | —                      | 7.8                  | —            | —                       | 0.4                     | —                     | 16.0         | 8.3          | 22.2         |
| DBC        | 36.2           | 7.7                    | 0.2                  | 0.2          | 3.5                     | 0.7                     | —                     | 44.6         | 6.7          | —            |
| DF         | 46.3           | —                      | 1.1                  | 0.3          | 0.2                     | 0.1                     | 5.0                   | —            | —            | 47.0         |
| EDF        | 40.6           | —                      | 7.5                  | 0.2          | 0.2                     | 0.2                     | 0.1                   | —            | —            | 51.5         |

### References

1. Weber, M. J., *CRC Handbook of Laser Science and Technology*, Vol. IV, Part 2, CRC Press, Boca Raton, FL, 1988, pp. 299–310.
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## FARADAY ROTATION

## Ferro-, Ferri-, and Antiferromagnetic Solids

| Material                                                         | $T_c$<br>K               | $4\pi M_s$<br>gauss | $F$<br>deg/cm                                                                    | $\alpha$<br>cm <sup>-1</sup>                                                     | $2F/\alpha$<br>deg                        | $T$<br>K                        | $\lambda$<br>nm                      |
|------------------------------------------------------------------|--------------------------|---------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-------------------------------------------|---------------------------------|--------------------------------------|
| Fe                                                               | 1043                     | 21,800              | $4.4 \times 10^5$<br>$6.5 \times 10^5$<br>$7 \times 10^5$<br>$7 \times 10^5$     | $6.5 \times 10^5$<br>$5.0 \times 10^5$<br>$4.2 \times 10^5$<br>$3.5 \times 10^5$ | 1.4<br>2.6<br>3.3<br>4.0                  | 300<br>300<br>300<br>300        | 500<br>1000<br>1500<br>2000          |
| Co                                                               | 1390                     | 18,200              | $2.9 \times 10^5$<br>$5.5 \times 10^5$<br>$5.5 \times 10^5$<br>$5.5 \times 10^5$ | —<br>$6.1 \times 10^5$<br>$4.5 \times 10^5$<br>$3.6 \times 10^5$                 | —<br>1.8<br>2.4<br>2.7                    | 300<br>300<br>300<br>300        | 500<br>1000<br>1500<br>2000          |
| Ni                                                               | 633                      | 6,400               | $0.8 \times 10^5$<br>$2.6 \times 10^5$<br>$1.5 \times 10^5$<br>$1 \times 10^5$   | —<br>$5.8 \times 10^5$<br>$4.8 \times 10^5$<br>$4.1 \times 10^5$                 | —<br>0.9<br>0.6<br>0.25                   | 300<br>300<br>300<br>300        | 500<br>1000<br>1500<br>2000          |
| Permalloy<br>(Ni/Fe = 82/18)                                     | 803                      | 10,700              | $1.2 \times 10^5$                                                                | $6 \times 10^5$                                                                  | 0.4                                       | 300                             | 500                                  |
| Ni/Fe = 100/0                                                    |                          | 6,000               | $1.2 \times 10^5$                                                                | $7.05 \times 10^5$                                                               | 0.34                                      | 300                             | 632.8                                |
| Ni/Fe = 80/20                                                    |                          | 10,800              | $2.2 \times 10^5$                                                                | $7.10 \times 10^5$                                                               | 0.62                                      | 300                             | 632.8                                |
| Ni/Fe = 60/40                                                    |                          | 14,900              | $2.9 \times 10^5$                                                                | $7.54 \times 10^5$                                                               | 0.77                                      | 300                             | 632.8                                |
| Ni/Fe = 40/60                                                    |                          | 14,400              | $2.2 \times 10^5$                                                                | $8.17 \times 10^5$                                                               | 0.54                                      | 300                             | 632.8                                |
| Ni/Fe = 20/80                                                    |                          | 19,400              | $3.3 \times 10^5$                                                                | $8.10 \times 10^5$                                                               | 0.81                                      | 300                             | 632.8                                |
| Ni/Fe = 0/100                                                    | 639                      | 21,600              | $3.5 \times 10^5$                                                                | $8.13 \times 10^5$                                                               | 0.86                                      | 300                             | 632.8                                |
| MnBi                                                             |                          | 7,700               | $4.2 \times 10^5$<br>$7.5 \times 10^5$                                           | $6.1 \times 10^5$<br>$4.2 \times 10^5$                                           | 1.4<br>3.6                                | 300<br>300                      | 450<br>900                           |
| MnAs                                                             | 313                      | —                   | $0.44 \times 10^5$<br>$0.62 \times 10^5$                                         | $5.0 \times 10^5$<br>$4.4 \times 10^5$                                           | 0.174<br>0.28                             | 300<br>300                      | 500<br>900                           |
| CrTe                                                             | 334                      | 1015                | $0.5 \times 10^5$<br>$0.4 \times 10^5$                                           | $2.0 \times 10^5$<br>$1.2 \times 10^5$                                           | 0.5<br>0.7                                | 300<br>300                      | 550<br>900                           |
| FeRh                                                             | 333                      | —                   | $0.9 \times 10^5$                                                                | $3.3 \times 10^5$                                                                | 0.56                                      | 348                             | 700                                  |
| Y <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub> (YIG)             | 560                      | 2500                | 2400<br>1250<br>750<br>175                                                       | 1500<br>1400<br>450<br><0.06                                                     | 3.2<br>1.8<br>3.3<br>>3 × 10 <sup>3</sup> | 300<br>300<br>300<br>300        | 555<br>625<br>770<br>5000<br>to 1500 |
| Gd <sub>3</sub> Fe <sub>5</sub> O <sub>12</sub> (GdIG)           | $T_n = 564$<br>$T = 286$ | 7300                | −2000<br>−1050<br>−300<br>−80                                                    | 6000<br>900<br>100<br>70                                                         | 0.6<br>2.3<br>6.0<br>2.3                  | 300<br>300<br>300<br>300        | 500<br>600<br>800<br>1000            |
| NiFe <sub>2</sub> O <sub>4</sub>                                 | 858                      | 3350                | $2.0 \times 10^4$<br>$-1.0 \times 10^4$<br>−120<br>+75<br>+110                   | $5.9 \times 10^4$<br>$10 \times 10^4$<br>38<br>15<br>32                          | 0.7<br>0.2<br>6<br>10<br>7                | 300<br>300<br>300<br>300<br>300 | 286<br>500<br>1500<br>3000<br>5000   |
| CoFe <sub>2</sub> O <sub>4</sub>                                 | 793                      | 4930                | $2.75 \times 10^4$<br>$3.6 \times 10^4$<br>$-2.5 \times 10^4$                    | $12 \times 10^4$<br>$17 \times 10^4$<br>$6 \times 10^4$                          | 0.5<br>0.4<br>0.8                         | 300<br>300<br>300               | 286<br>400<br>660                    |
| MgFe <sub>2</sub> O <sub>4</sub>                                 | 593-713°                 | 1450°               | −60<br>0<br>+35                                                                  | 100<br>12<br>6                                                                   | 1<br>0<br>11                              | 300<br>300<br>300               | 2500<br>4000<br>6000                 |
| Li <sub>0.5</sub> Fe <sub>2.5</sub> O <sub>4</sub>               | 863–953°                 | 3240°<br>to 3900    | −440<br>+10<br>+110<br>+135                                                      | 150<br>85<br>44<br>80                                                            | 6<br>0.2<br>5<br>3                        | 300<br>300<br>300<br>300        | 1500<br>3000<br>5000<br>7000         |
| BaFe <sub>12</sub> O <sub>19</sub>                               | 723                      | —                   | −50<br>+75<br>+150<br>+165                                                       | −38<br>20<br>20<br>22                                                            | 3<br>7.5<br>15<br>15                      | 300<br>300<br>300<br>300        | 2000<br>3000<br>5000<br>7000         |
| Ba <sub>2</sub> Zn <sub>2</sub> Fe <sub>12</sub> O <sub>19</sub> | —                        | —                   | 90                                                                               | 120                                                                              | 1.5                                       | 300                             | 5000                                 |

| Material                                               | $T_c$<br>K | $4\pi M_s$<br>gauss | $F$<br>deg/cm          | $\alpha$<br>cm <sup>-1</sup> | $2F/\alpha$<br>deg    | $T$<br>K | $\lambda$<br>nm    |
|--------------------------------------------------------|------------|---------------------|------------------------|------------------------------|-----------------------|----------|--------------------|
| RbNiF <sub>3</sub>                                     | 220        | 1250                | 75                     | 65                           | 2.0                   | 300      | 7000               |
|                                                        |            |                     | 360                    | 35                           | 20                    | 77       | 450 <sup>a</sup>   |
|                                                        |            |                     | 70                     | 10                           | 14                    | 77       | 600 <sup>a</sup>   |
|                                                        |            |                     | 310                    | 70                           | 9                     | 77       | 800 <sup>a</sup>   |
|                                                        |            |                     | 75                     | 25                           | 6                     | 77       | 1000 <sup>a</sup>  |
| RbNi <sub>0.75</sub> Co <sub>0.25</sub> F <sub>3</sub> | 109        | —                   | 180                    | 9                            | 40                    | 77       | 600 <sup>b</sup>   |
| RbFeF <sub>3</sub>                                     | 102        | —                   | 3400                   | 7                            | 900                   | 82       | 300 <sup>c</sup>   |
|                                                        |            |                     | 1600                   | 3                            | 1100                  | 82       | 400 <sup>c</sup>   |
|                                                        |            |                     | 620                    | 1.5                          | 830                   | 82       | 600 <sup>c</sup>   |
|                                                        |            |                     | 300                    | 2.5                          | 240                   | 82       | 800 <sup>c</sup>   |
| FeF <sub>3</sub>                                       | 365        | 40                  | 670                    | 14                           | 95                    | 300      | 349 <sup>d</sup>   |
|                                                        |            |                     | at 300 K               | 180                          | 4.4                   | 300      | 522.5 <sup>d</sup> |
| CrCl <sub>3</sub>                                      | 16.8       | 3880                | 2000                   | 200                          | 20                    | 1.5      | 410                |
|                                                        |            |                     | −500                   | 300                          | 3                     | 1.5      | 450                |
|                                                        |            |                     | −1000                  | 70                           | 30                    | 1.5      | 590                |
|                                                        |            |                     | 3 × 10 <sup>5</sup>    | 3 × 10 <sup>3</sup>          | 200                   | 1.5      | 478                |
| CrBr <sub>3</sub>                                      | 32.5       | 3390                | 1.6 × 10 <sup>5</sup>  | 1.4 × 10 <sup>4</sup>        | 23                    | 1.5      | 500                |
|                                                        |            |                     | 1.1 × 10 <sup>5</sup>  | 6.3 × 10 <sup>3</sup>        | 35                    | 1.5      | 970                |
|                                                        |            |                     | 0.8 × 10 <sup>5</sup>  | 3 × 10 <sup>3</sup>          | 53                    | 1.5      | 1000               |
| CrI <sub>3</sub>                                       | 68         | 2690                | 3200                   | 140                          | 45                    | 300      | 500                |
|                                                        |            |                     | 450                    | 38                           | 24                    | 300      | 700                |
| FeBO <sub>3</sub>                                      | 348        | 115                 | at 300 K               | 450                          | 38                    | 24       | 300                |
|                                                        |            |                     | 23700                  | −1.0 × 10 <sup>5</sup>       | 0.5 × 10 <sup>4</sup> | 40       | 5                  |
| EuO                                                    | 69         | 23700               | 5 × 10 <sup>5</sup>    | 9.7 × 10 <sup>4</sup>        | 10                    | 5        | 1100               |
|                                                        |            |                     | 0.5 × 10 <sup>5</sup>  | 7.8 × 10 <sup>4</sup>        | 1.3                   | 5        | 700                |
|                                                        |            |                     | 3 × 10 <sup>4</sup>    | >0.5                         | ~105                  | 20       | 500                |
|                                                        |            |                     | 660                    | >1.0                         | 1300                  | 20       | 2500               |
|                                                        |            |                     | −1.6 × 10 <sup>5</sup> | 0                            | —                     | 20       | 10600              |
| EuS                                                    | 16.3       | —                   | −9.6 × 10 <sup>5</sup> | 3.3 × 10 <sup>4</sup>        | 58                    | 6        | 825                |
|                                                        |            |                     | +5.5 × 10 <sup>5</sup> | 1.2 × 10 <sup>5</sup>        | 9.2                   | 6        | 690                |
|                                                        |            |                     | 1.45 × 10 <sup>5</sup> | 80                           | 3600                  | 6        | 563                |
| EuSe                                                   | 7.0        | 13,200              | 0.95 × 10 <sup>5</sup> | 60                           | 3170                  | 4.2      | 750                |
|                                                        |            |                     |                        |                              |                       | 4.2      | 800                |

<sup>a</sup> Measured along the C-axis (magnetic hard axis).

<sup>b</sup> Measured along the C-axis (magnetic easy axis).

<sup>c</sup> Measured along the C-axis ([100]-direction at room temperature).

<sup>d</sup> Strong natural birefringence interferes with the Faraday effect.

<sup>e</sup> Depends on heat treatment.

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# NONLINEAR OPTICAL CONSTANTS

H. P. R. Frederikse

The relation between the polarization density  $P$  of a dielectric medium and the electric field  $E$  is linear when  $E$  is small, but becomes nonlinear as  $E$  acquires values comparable with interatomic electric fields ( $10^5$  to  $10^8$  V/cm). Under these conditions the relation between  $P$  and  $E$  can be expanded in a Taylor's series

$$P = \epsilon_0 \chi^{(1)} E + 2\chi^{(2)} E^2 + 4\chi^{(3)} E^3 + \dots \quad (1)$$

where  $\epsilon_0$  is the permittivity of free space, while  $\chi^{(1)}$  is the linear and  $\chi^{(2)}$ ,  $\chi^{(3)}$  etc. the nonlinear optical susceptibilities.

If we consider two optical fields, the first  $E_j^{\omega_1}$  (along the  $j$ -direction at frequency  $\omega_1$ ) and the second  $E_k^{\omega_2}$  (along the  $k$ -direction at frequency  $\omega_2$ ) one can write the second term of the Taylor's series as follows

$$P_i(\omega_1, \omega_2) = 2\chi_{ijk}^{\omega_3=\omega_1 \pm \omega_2} E_j^{\omega_1} E_k^{\omega_2}$$

When  $\omega_1 \neq \omega_2$  the (parametric) mixing of the two fields gives rise to two new polarizations at the frequencies  $\omega_3 = \omega_1 + \omega_2$  and  $\omega_3' = \omega_1 - \omega_2$ . When the two frequencies are equal,  $\omega_1 = \omega_2 = \omega$ , the result is Second Harmonic Generation (SHG):  $\chi_{ijk}(2\omega, \omega, \omega)$ , while equal and opposite frequencies,  $\omega_1 = \omega$  and  $\omega_2 = -\omega$  leads to Optical Rectification (OR):  $\chi_{ijk}(0, \omega, -\omega)$ . In the SHG case the following convention is adopted: the second order nonlinear coefficient  $d$  is equal to one half of the second order nonlinear susceptibility

$$d_{ijk} = 1/2\chi^{(2)}$$

Because of the symmetry of the indices  $j$  and  $k$  one can replace these two by a single index (subscript)  $m$ . Consequently the notation for the SHG nonlinear coefficient in reduced form is  $d_{im}$  where  $m$  takes the values 1 to 6. Only noncentrosymmetric crystals can possess a nonvanishing  $d_{ijk}$  tensor (third rank). The unit of the SHG coefficients is m/V (in the MKSQ/SI system).

In centrosymmetric media the dominant nonlinearity is of the third order. This effect is represented by the third term in the Taylor's series (Equation 1); it is the result of the interaction of a number of optical fields (one to three) producing a new frequency  $\omega_4 = \omega_1 + \omega_2 + \omega_3$ . The third order polarization is given by

$$P_i(\omega_1, \omega_2, \omega_3) = g_4 \chi_{iklm} E_k^{\omega_1} E_l^{\omega_2} E_m^{\omega_3}$$

Third Harmonic Generation (THG) is achieved when  $\omega_1 = \omega_2 = \omega_3 = \omega$ . In this case the constant  $g_4 = 1/4$ . The third order nonlinear coefficient  $C$  is related to the third order susceptibility as follows:

$$C_{jklm} = 1/4\chi_{jklm}$$

This coefficient is a fourth rank tensor. In the THG case the matrices must be invariant under permutation of the indices  $k$ ,  $l$ , and  $m$ ; as a result the notation for the third order nonlinear coefficient can be simplified to  $C_{jm}$ . The unit of  $C_{jm}$  is  $\text{m}^2\text{V}^{-2}$  (in the MKSQ/SI system).

Applications of second order nonlinear optical materials include the generation of higher (up to sixth) optical harmonics, the mixing of monochromatic waves to generate sum or difference frequencies (frequency conversion), the use of two monochromatic waves to amplify a third wave (parametric amplification) and the addition of feedback to such an amplifier to create an oscillation (parametric oscillation).

Third order nonlinear optical materials are used for THG, self-focusing, four wave mixing, optical amplification, and optical conjugation. Many of these effects – as well as the variation and modulation of optical propagation caused by mechanical, electric, and magnetic fields (see the preceeding table on “Elasto-Optic, Electro-Optic, and Magneto-Optic Constants”) are used in the areas of optical communication, optical computing, and optical imaging.

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## Selected SHG Coefficients of NLO Crystals\*

| Material                                                                           | Symmetry<br>class  | $d_{im} \times 10^{12}$<br>m/V | $\lambda$<br>$\mu\text{m}$ | Material                                                                                 | Symmetry<br>class  | $d_{im} \times 10^{12}$<br>m/V | $\lambda$<br>$\mu\text{m}$ |
|------------------------------------------------------------------------------------|--------------------|--------------------------------|----------------------------|------------------------------------------------------------------------------------------|--------------------|--------------------------------|----------------------------|
| GaAs                                                                               | $\bar{4}3\text{m}$ | $d_{14} = 134.1 \pm 42$        | 10.6                       | AgGaSe <sub>2</sub>                                                                      | $\bar{4}2\text{m}$ | $d_{36} = 37.4 \pm 6.0$        | 10.6                       |
| GaP                                                                                | $\bar{4}3\text{m}$ | $d_{14} = 71.8 \pm 12.3$       | 1.058                      | (NH <sub>2</sub> ) <sub>2</sub> CO (urea)                                                | $\bar{4}2\text{m}$ | $d_{36} = 1.3$                 | 1.06                       |
| InAs                                                                               | $\bar{4}3\text{m}$ | $d_{14} = 364 \pm 47$          | 1.058                      | AlPO <sub>4</sub>                                                                        | 32                 | $d_{11} = 0.35 \pm 0.03$       | 1.058                      |
|                                                                                    |                    | $d_{14} = 210$                 | 10.6                       | Se                                                                                       | 32                 | $d_{11} = 97 \pm 25$           | 10.6                       |
| ZnSe                                                                               | $\bar{4}3\text{m}$ | $d_{14} = 78.4 \pm 29.3$       | 10.6                       | Te                                                                                       | 32                 | $d_{11} = 650 \pm 30$          | 10.6                       |
|                                                                                    |                    | $d_{36} = 26.6 \pm 1.7$        | 1.058                      | SiO <sub>2</sub> (quartz)                                                                | 32                 | $d_{11} = 0.335$               | 1.064                      |
| $\beta$ -ZnS                                                                       | $\bar{4}3\text{m}$ | $d_{14} = 30.6 \pm 8.4$        | 10.6                       | HgS                                                                                      | 32                 | $d_{11} = 50.3 \pm 17$         | 10.6                       |
|                                                                                    |                    | $d_{36} = 20.7 \pm 1.3$        | 1.058                      | (C <sub>6</sub> H <sub>5</sub> CO) <sub>2</sub> [benzil]                                 | 32                 | $d_{11} = 3.6 \pm 0.5$         | 1.064                      |
| ZnTe                                                                               | $\bar{4}3\text{m}$ | $d_{14} = 92.2 \pm 33.5$       | 10.6                       | $\beta$ -BaB <sub>2</sub> O <sub>4</sub> [BBO]                                           | 3 m                | $d_{22} = 2.22 \pm 0.09$       | 1.06                       |
|                                                                                    |                    | $d_{14} = 83.2 \pm 8.4$        | 1.058                      |                                                                                          |                    | $d_{31} = 0.16 \pm 0.08$       | 1.06                       |
|                                                                                    |                    | $d_{36} = 89.6 \pm 5.7$        | 1.058                      | LiNbO <sub>3</sub>                                                                       | 3 m                | $d_{33} = 34.4$                | 1.06                       |
| CdTe                                                                               | $\bar{4}3\text{m}$ | $d_{14} = 167.6 \pm 63$        | 10.6                       |                                                                                          |                    | $d_{31} = -5.95$               | 1.06                       |
| Bi <sub>4</sub> GeO <sub>12</sub>                                                  | $\bar{4}3\text{m}$ | $d_{14} = 1.28$                | 1.064                      |                                                                                          |                    | $d_{22} = 2.76$                | 1.06                       |
| N <sub>4</sub> (CH <sub>2</sub> ) <sub>6</sub> (hexamine)                          | $\bar{4}3\text{m}$ | $d_{14} = 4.1$                 | 1.06                       | LiTaO <sub>3</sub>                                                                       | 3 m                | $d_{33} = -16.4 \pm 2$         | 1.058                      |
| LiIO <sub>3</sub>                                                                  | 6                  | $d_{33} = -7.02$               | 1.06                       |                                                                                          |                    | $d_{31} = -1.07 \pm 0.2$       | 1.058                      |
|                                                                                    |                    | $d_{31} = -5.53 \pm 0.3$       | 1.064                      |                                                                                          |                    | $d_{22} = +1.76 \pm 0.2$       | 1.058                      |
| ZnO                                                                                | 6 mm               | $d_{33} = -5.86 \pm 0.16$      | 1.058                      | Ag <sub>3</sub> AsS <sub>3</sub> [proustite]                                             | 3 m                | $d_{31} = 11.3 \pm 2.5$        | 10.6                       |
|                                                                                    |                    | $d_{31} = 1.76 \pm 0.16$       | 1.058                      |                                                                                          |                    | $d_{22} = 18.0 \pm 2.5$        | 10.6                       |
|                                                                                    |                    | $d_{15} = 1.93 \pm 0.16$       | 1.058                      | Ag <sub>3</sub> SbS <sub>3</sub> [pyrargirite]                                           | 3m                 | $d_{31} = 12.6 \pm 4$          | 10.6                       |
| $\alpha$ -ZnS                                                                      | 6 mm               | $d_{33} = 11.37 \pm 0.07$      | 1.058                      |                                                                                          |                    | $d_{22} = 13.4 \pm 4$          | 10.6                       |
|                                                                                    |                    | $d_{33} = 37.3 \pm 12.6$       | 10.6                       | $\alpha$ -HIO <sub>3</sub>                                                               | 222                | $d_{36} = 5.15 \pm 0.16$       | 1.064                      |
|                                                                                    |                    | $d_{31} = -18.9 \pm 6.3$       | 10.6                       | NO <sub>2</sub> · CH <sub>3</sub> NOC <sub>5</sub> H <sub>4</sub> · (POM)                | 222                | $d_{36} = 6.4 \pm 1.0$         | 1.064                      |
|                                                                                    |                    | $d_{15} = 21.37 \pm 8.4$       | 10.6                       | Ba <sub>2</sub> NaNb <sub>5</sub> O <sub>15</sub> [Banana]                               | mm 2               | $d_{33} = -17.6 \pm 1.28$      | 1.064                      |
| CdS                                                                                | 6 mm               | $d_{33} = 25.8 \pm 1.6$        | 1.058                      |                                                                                          |                    | $d_{31} = -12.8 \pm 1.28$      | 1.064                      |
|                                                                                    |                    | $d_{31} = -13.1 \pm 0.8$       | 1.058                      |                                                                                          |                    | $d_{32} = 0.74$                | 1.064                      |
|                                                                                    |                    | $d_{15} = 14.4 \pm 0.8$        | 1.058                      | C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> ) <sub>2</sub> [MDB]                      | mm 2               | $d_{32} = 2.7$                 | 1.064                      |
| CdSe                                                                               | 6 mm               | $d_{33} = 54.5 \pm 12.6$       | 10.6                       |                                                                                          |                    | $d_{31} = 1.78$                | 1.064                      |
|                                                                                    |                    | $d_{31} = -26.8 \pm 2.7$       | 10.6                       | Gd <sub>2</sub> (MoO <sub>4</sub> ) <sub>3</sub>                                         | mm 2               | $d_{33} = -0.044 \pm 0.008$    | 1.064                      |
| BaTiO <sub>3</sub>                                                                 | 4 mm               | $d_{33} = 6.8 \pm 1.0$         | 1.064                      |                                                                                          |                    | $d_{32} = +2.42 \pm 0.36$      | 1.064                      |
|                                                                                    |                    | $d_{31} = 15.7 \pm 1.8$        | 1.064                      |                                                                                          |                    | $d_{31} = -2.49 \pm 0.37$      | 1.064                      |
|                                                                                    |                    | $d_{15} = 17.0 \pm 1.8$        | 1.064                      | KNbO <sub>3</sub>                                                                        | mm 2               | $d_{33} = -19.58 \pm 1.03$     | 1.064                      |
| PbTiO <sub>3</sub>                                                                 | 4 mm               | $d_{33} = 7.5 \pm 1.2$         | 1.064                      |                                                                                          |                    | $d_{32} = +11.34 \pm 1.03$     | 1.064                      |
|                                                                                    |                    | $d_{31} = 37.6 \pm 5.6$        | 1.064                      |                                                                                          |                    | $d_{31} = -12.88 \pm 1.03$     | 1.064                      |
|                                                                                    |                    | $d_{15} = 33.3 \pm 5$          | 1.064                      | KTiOPO <sub>4</sub> [KTP]                                                                | mm 2               | $d_{33} = 13.7$                | 1.06                       |
| K <sub>3</sub> Li <sub>2</sub> Nb <sub>5</sub> O <sub>15</sub>                     | 4 mm               | $d_{33} = 11.2 \pm 1.6$        | 1.064                      |                                                                                          |                    | $d_{32} = \pm 5.0$             | 1.06                       |
|                                                                                    |                    | $d_{31} = 6.18 \pm 1.28$       | 1.064                      |                                                                                          |                    | $d_{31} = \pm 6.5$             | 1.06                       |
|                                                                                    |                    | $d_{15} = 5.45 \pm 0.54$       | 1.064                      | NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub> · NH <sub>2</sub> [mNA]                    | mm 2               | $d_{33} = 13.12 \pm 1.28$      | 1.064                      |
| K <sub>0.8</sub> Na <sub>0.2</sub> Ba <sub>2</sub> Nb <sub>5</sub> O <sub>15</sub> | 4 mm               | $d_{31} = 13.6 \pm 1.6$        | 1.064                      |                                                                                          |                    | $d_{32} = 1.02 \pm 0.22$       | 1.064                      |
| SrBaNb <sub>5</sub> O <sub>15</sub>                                                | 4 mm               | $d_{33} = 11.3 \pm 3.3$        | 1.064                      |                                                                                          |                    | $d_{31} = 12.48 \pm 1.28$      | 1.064                      |
|                                                                                    |                    | $d_{31} = 4.31 \pm 1.32$       | 1.064                      | C <sub>10</sub> H <sub>12</sub> N <sub>3</sub> O <sub>6</sub> [MAP]                      | 2                  | $d_{23} = 10.67 \pm 1.3$       | 1.064                      |
|                                                                                    |                    | $d_{15} = 5.98 \pm 2$          | 1.064                      |                                                                                          |                    | $d_{22} = 11.7 \pm 1.3$        | 1.064                      |
| NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> (ADP)                               | $\bar{4}2\text{m}$ | $d_{36} = 0.53$                | 1.064                      |                                                                                          |                    | $d_{21} = 2.35 \pm 0.5$        | 1.064                      |
|                                                                                    |                    | $d_{36} = 0.85$                | 0.694                      | (NH <sub>2</sub> CH <sub>2</sub> COOH) <sub>3</sub> H <sub>2</sub> SO <sub>4</sub> [TGS] | 2                  | $d_{25} = -0.35 \pm 0.3$       | 1.064                      |
| KH <sub>2</sub> PO <sub>4</sub> (KDP)                                              | $\bar{4}2\text{m}$ | $d_{36} = 0.44$                | 1.064                      |                                                                                          |                    | $d_{23} = 0.32$                | 0.694                      |
|                                                                                    |                    | $d_{36} = 0.47 \pm 0.07$       | 0.694                      |                                                                                          |                    |                                |                            |
| KD <sub>2</sub> PO <sub>4</sub> (KD*P)                                             | $\bar{4}2\text{m}$ | $d_{36} = 0.38 \pm 0.016$      | 1.058                      |                                                                                          |                    |                                |                            |
|                                                                                    |                    | $d_{36} = 0.34 \pm 0.06$       | 0.694                      |                                                                                          |                    |                                |                            |
|                                                                                    |                    | $d_{14} = 0.37$                | 1.058                      |                                                                                          |                    |                                |                            |
| KH <sub>2</sub> AsO <sub>4</sub> (KDA)                                             | $\bar{4}2\text{m}$ | $d_{36} = 0.43 \pm 0.025$      | 1.06                       |                                                                                          |                    |                                |                            |
|                                                                                    |                    | $d_{36} = 0.39 \pm 0.4$        | 0.694                      |                                                                                          |                    |                                |                            |
| CdGeAs <sub>2</sub>                                                                | $\bar{4}2\text{m}$ | $d_{36} = 351 \pm 105$         | 10.6                       |                                                                                          |                    |                                |                            |
| AgGaS <sub>2</sub>                                                                 | $\bar{4}2\text{m}$ | $d_{36} = 18 \pm 2.7$          | 10.6                       |                                                                                          |                    |                                |                            |

\* These data are taken from References 1 and 2.

Selected THG Coefficients of Some NLO Materials\*

| Material                                          | NLO process                           | $C_{jm} \times 10^{20}$<br>$\text{m}^2/\text{V}^{-2}$ | $\lambda$<br>$\mu\text{m}$ |
|---------------------------------------------------|---------------------------------------|-------------------------------------------------------|----------------------------|
| $\text{NH}_4\text{H}_2\text{PO}_4$ [ADP]          | $(-3\omega, \omega, \omega, \omega)$  | $C_{11} = 0.0104$                                     | 1.06                       |
|                                                   |                                       | $C_{18} = 0.0098$                                     | 1.06                       |
| $\text{C}_6\text{H}_6$ [benzene]                  | $(-3\omega, \omega, \omega, \omega)$  | $C_{11} = 0.0184 \pm 0.0042$                          | 1.89                       |
| $\text{CdGeAs}_2$                                 | $(-3\omega, \omega, \omega, \omega)$  | $C_{11} = 182 \pm 84$                                 | 10.6                       |
| p-type: $5 \times 10^{16} \text{ cm}^{-3}$        |                                       | $C_{16} = 175$                                        | 10.6                       |
|                                                   |                                       | $C_{18} = -35$                                        | 10.6                       |
| $\text{C}_{40}\text{H}_{56}$ [ $\beta$ -carotene] | $(-3\omega, \omega, \omega, \omega)$  | $C_{11} = 0.263 \pm 0.08$                             | 1.89                       |
| GaAs high-resistivity                             | $(-3\omega, \omega, \omega, -\omega)$ | $C_{11} = 62 \pm 31$                                  | 1.06                       |
| Ge                                                | $(-3\omega, \omega, \omega, -\omega)$ | $C_{11} = 23.5 \pm 12$                                | 1.06                       |
| $\text{LiIO}_3$                                   | $(-3\omega, \omega, \omega, -\omega)$ | $C_{12} = 0.2285$                                     | 1.06                       |
|                                                   |                                       | $C_{35} = 6.66 \pm 1$                                 | 1.06                       |
| KBr                                               | $(-3\omega, \omega, \omega, -\omega)$ | $C_{11} = 0.0392$                                     | 1.06                       |
|                                                   |                                       | $C_{18}/C_{11} = 0.3667$                              | 1.06                       |
| KCl                                               | $(-3\omega, \omega, \omega, -\omega)$ | $C_{11} = 0.0168$                                     | 1.06                       |
|                                                   |                                       | $C_{18}/C_{11} = 0.28$                                | 1.06                       |
| $\text{KH}_2\text{PO}_4$ [KDP]                    | $(-3\omega, \omega, \omega, -\omega)$ | $C_{11} - 3C_{18} = 0.04$                             | 1.06                       |
| Si p-type: $10^{14} \text{ cm}^{-3}$              | $(-3\omega, \omega, \omega, -\omega)$ | $C_{11} = 82.8 \pm 25$                                | 1.06                       |
| NaCl                                              | $(-3\omega, \omega, \omega, -\omega)$ | $C_{11} = 0.0168$                                     | 1.06                       |
|                                                   |                                       | $C_{18}/C_{11} = 0.4133$                              | 1.06                       |
| NaF                                               | $(-3\omega, \omega, \omega, -\omega)$ | $C_{11} = 0.0035$                                     | 1.06                       |

\* These data are taken from Reference 1.

# PHASE DIAGRAMS

H. P. R. Frederikse

A phase is a structurally homogeneous portion of matter. Regardless of the number of chemical constituents of a gas, there is only one vapor phase. This is true also for the liquid form of a pure substance, although a mixture of several liquid substances may exist as one or several phases, depending on the interactions among the substances. On the other hand a pure solid may exist in several phases at different temperatures and pressures because of differences in crystal structure (Reference 1). At the phase transition temperature,  $T_{tr}$ , the chemical composition of the solid remains the same, but a change in the physical properties often will take place. Such changes are found in ferroelectric crystals (example  $\text{BaTiO}_3$ ) which develop a spontaneous polarization below  $T_{tr}$ , in superconductors (example Pb) which lose all electrical resistance below the transition point, and in many other classes of solids.

In quite a few cases it is difficult to bring about the phase transition, and the high- (or low-) temperature phase persists in its metastable form. Many liquids remain in the liquid state for shorter or longer periods of time when cooled below the melting point (supercooling). However, often the slightest disturbance will cause solidification. Persistence of the high temperature phase in solid-solid transitions is usually of much longer duration. An example of this behavior is found in white tin; although gray tin is the thermodynamically stable form below  $T_{tr}$  (286.4 K), the metal remains in its undercooled, white tin state all the way to  $T = 0$  K, and crystals of gray tin are very difficult to produce.

A *phase diagram* is a map that indicates the areas of stability of the various phases as a function of external conditions (temperature and pressure). Pure materials, such as mercury, helium, water, and methyl alcohol are considered one-component systems and they have *unary* phase diagrams. The equilibrium phases in two-component systems are presented in *binary* phase diagrams. Because many important materials consist of three, four, and more components, many attempts have been made to deduce their multicomponent phase diagrams. However, the vast majority of systems with three or more components are very complex, and no overall maps of the phase relationships have been worked out.

It has been shown during the last 20 to 25 years that very useful partial phase diagrams of complex systems can be obtained by means of thermodynamic modeling (References 2, 3). Especially for complicated, multicomponent alloy systems the CALPHAD method has proved to be a successful approach for producing valuable portions of very intricate phase diagrams (Reference 4). With this method thermodynamic descriptions of the free energy functions of various phases are obtained that are consistent with existing (binary) phase diagram information and other thermodynamic data. Extrapolation methods are then used to extend the thermodynamic functions into a ternary system. Comparison of the results of this procedure with available experimental data is then used to fine-tune the phase diagram and add ternary interaction functions if necessary. In principle this approximation strategy can be extended to four, five, and more component systems.

The nearly two dozen phase diagrams shown below present the reader with examples of some important types of single and multicomponent systems, especially for ceramics and metal alloys. This makes it possible to draw attention to certain features like the kinetic aspects of phase transitions (see Figure 22, which presents a time-temperature-transformation, or TTT, diagram for the precipitation of  $\alpha$ -phase particles from the  $\beta$ -phase in a Ti-Mo alloy; Reference 1, pp. 358–360). The general references listed below and the references to individual figures contain phase diagrams for many additional systems.

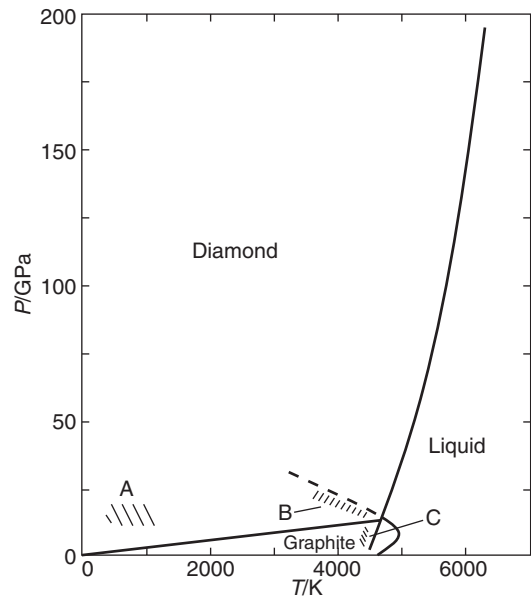
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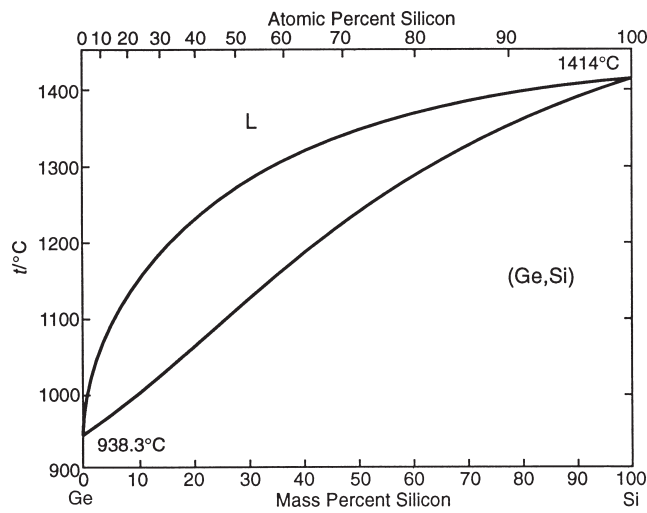
## References to Individual Phase Diagrams

- Figure 1. Carbon: Reference 7, Vol. X (1994), Figure 8930. Reprinted with permission.
- Figure 2. Si-Ge: Ref. 5, p. 2.231. Reprinted with permission.
- Figure 3.  $\text{H}_2\text{O}$  (ice): See figure.
- Figure 4.  $\text{SiO}_2$ : Reference 7, Vol. XI (1995), Figure 9174. Reprinted with permission.
- Figure 5. Fe-O: Darken, L.S., and Gurry, R.W., *J. Am. Chem. Soc.*, 68, 798, 1946. Reprinted with permission.
- Figure 6. Ti-O: Reference 5, p. 2.324. Reprinted with permission.
- Figure 7. BaO-TiO<sub>2</sub>: Reference 7, Vol. III (1975), Figure 4302. Reprinted with permission.
- Figure 8. MgO-Al<sub>2</sub>O<sub>3</sub>: Reference 7, Vol. XI (1995), Figure 9239. Reprinted with permission.
- Figure 9. Y<sub>2</sub>O<sub>3</sub>-ZrO<sub>2</sub>: Reference 7, Vol. XI (1995), Figure 9348. Reprinted with permission.
- Figure 10. Si-N-Al-O (Sialon): Reference 7, Vol. X (1994), Figure 8759. Reprinted with permission.
- Figure 11. PbO-ZrO<sub>2</sub>-TiO<sub>2</sub> (PZT): Reference 7, Vol. III (1975), Figure 4587. Reprinted with permission.
- Figure 12. Al-Si-Ca-O: Reference 7 (1964), Vol. I, Figure 630. Reprinted with permission.
- Figure 13. Y-Ba-Cu-O: Whitler, J.D., and Roth, R.S., *Phase Diagrams for High  $T_c$  Superconductors*, Figure S-082, American Ceramic Society, Waterville, OH, 1990. Reprinted with permission.
- Figure 14. Al-Cu: Reference 5, p. 2.44. Reprinted with permission.
- Figure 15. Fe-C: Ralls, K.M., Courtney, T.H., and Wulff, J., *Introduction to Materials Science and Engineering*, Figure 16.13, John Wiley & Sons, New York, 1976. Reprinted with permission.
- Figure 16. Fe-Cr: Reference 5, p. 2.152. Reprinted with permission.
- Figure 17. Cu-Sn: Reference 5, p. 2.178. Reprinted with permission.
- Figure 18. Cu-Ni: Reference 5, p. 2.173. Reprinted with permission.
- Figure 19. Pb-Sn (solder): Reference 5, p. 2.335. Reprinted with permission.
- Figure 20. Cu-Zn (brass): Subramanian, P.R., Chakrabarti, D.J., and Laughlin, D.E., Eds., *Phase Diagrams of Binary Copper Alloys*, p. 487, ASM International, Materials Park, OH, 1994. Reprinted with permission.
- Figure 21. Co-Sm: Reference 5, p. 2.148. Reprinted with permission.
- Figure 22. Ti-Mo: Reference 5, p. 2.296; Reference 1, p. 359. Reprinted with permission.
- Figure 23. Fe-Cr-Ni: Reference 5, Figure 48. Reprinted with permission.



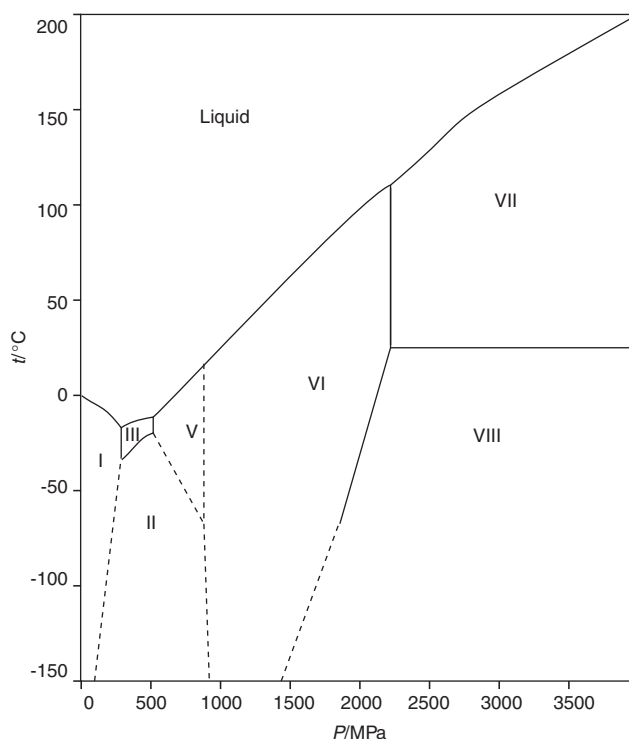


**FIGURE 1.** Phase diagram of carbon. (A) Martensitic transition: hex graphite → hex diamond. (B) Fast graphite-to-diamond transition. (C) Fast diamond-to-graphite transition.



**FIGURE 2.** Si-Ge system.

| Phase                | Composition,<br>mass % Si | Pearson<br>symbol | Space<br>group            |
|----------------------|---------------------------|-------------------|---------------------------|
| (Ge,Si)              | 0 to 100                  | <i>cF8</i>        | <i>Fd3̄m</i>              |
| High-pressure phases |                           |                   |                           |
| GeII                 | –                         | <i>tI4</i>        | <i>I4<sub>1</sub>/amd</i> |
| SiII                 | –                         | <i>tI4</i>        | <i>I4<sub>1</sub>/amd</i> |



**FIGURE 3.** Diagram of the principal phases of ice. Solid lines are measured boundaries between stable phases; dotted lines are extrapolated. Ice IV is a metastable phase that exists in the region of ice V. Ice IX exists in the region below  $-100^{\circ}\text{C}$  and pressures in the range 200–400 MPa. Ice X exists at pressures above 44 GPa. See Table 1 for the coordinates of the triple points, where liquid water is in equilibrium with two adjacent solid phases.

**TABLE 1. Crystal Structure, Density, and Transition Temperatures for the Phases of Ice**

| Phase | Crystal system | Cell parameters                                        | Z  | n | $\rho/\text{g cm}^{-3}$ | Triple points                               |
|-------|----------------|--------------------------------------------------------|----|---|-------------------------|---------------------------------------------|
| Ih    | Hexagonal      | $a = 4.513; c = 7352$                                  | 4  | 4 | 0.93                    | I-III: $-21.99^{\circ}\text{C}$ , 209.9 MPa |
| Ic    | Cubic          | $a = 6.35$                                             | 8  | 4 | 0.94                    |                                             |
| II    | Rhombohedral   | $a = 7.78; \alpha = 113.1^{\circ}$                     | 12 | 4 | 1.18                    | III-V: $-16.99^{\circ}\text{C}$ , 350.1 MPa |
| III   | Tetragonal     | $a = 6.73; c = 6.83$                                   | 12 | 4 | 1.15                    |                                             |
| IV    | Rhombohedral   | $a = 7.60; \alpha = 70.1^{\circ}$                      | 16 | 4 | 1.27                    | V-VI: $0.16^{\circ}\text{C}$ , 632.4 MPa    |
| V     | Monoclinic     | $a = 9.22; b = 7.54, c = 10.35; \beta = 109.2^{\circ}$ | 28 | 4 | 1.24                    |                                             |
| VI    | Tetragonal     | $a = 6.27; c = 5.79$                                   | 10 | 4 | 1.31                    | VI-VII: $82^{\circ}\text{C}$ , 2216 MPa     |
| VII   | Cubic          | $a = 3.41$                                             | 2  | 8 | 1.56                    |                                             |
| VIII  | Tetragonal     | $a = 4.80; c = 6.99$                                   | 8  | 8 | 1.56                    |                                             |
| IX    | Tetragonal     | $a = 6.73; c = 6.83$                                   | 12 | 4 | 1.16                    |                                             |
| X     | Cubic          | $a = 2.83$                                             | 2  | 8 | 2.51                    |                                             |

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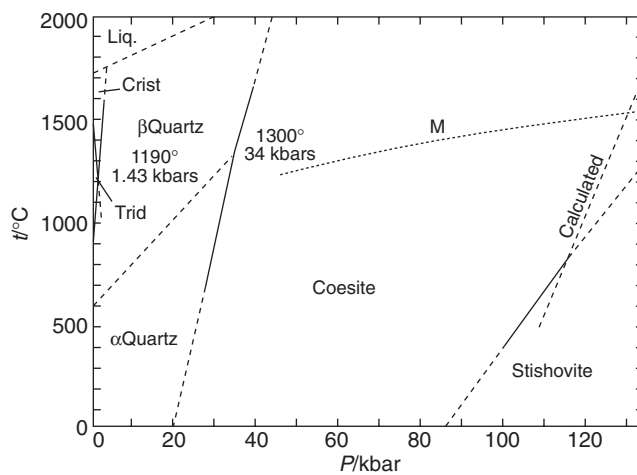


FIGURE 4. SiO<sub>2</sub> system. Crist = cristobalite; Trid = tridymite.

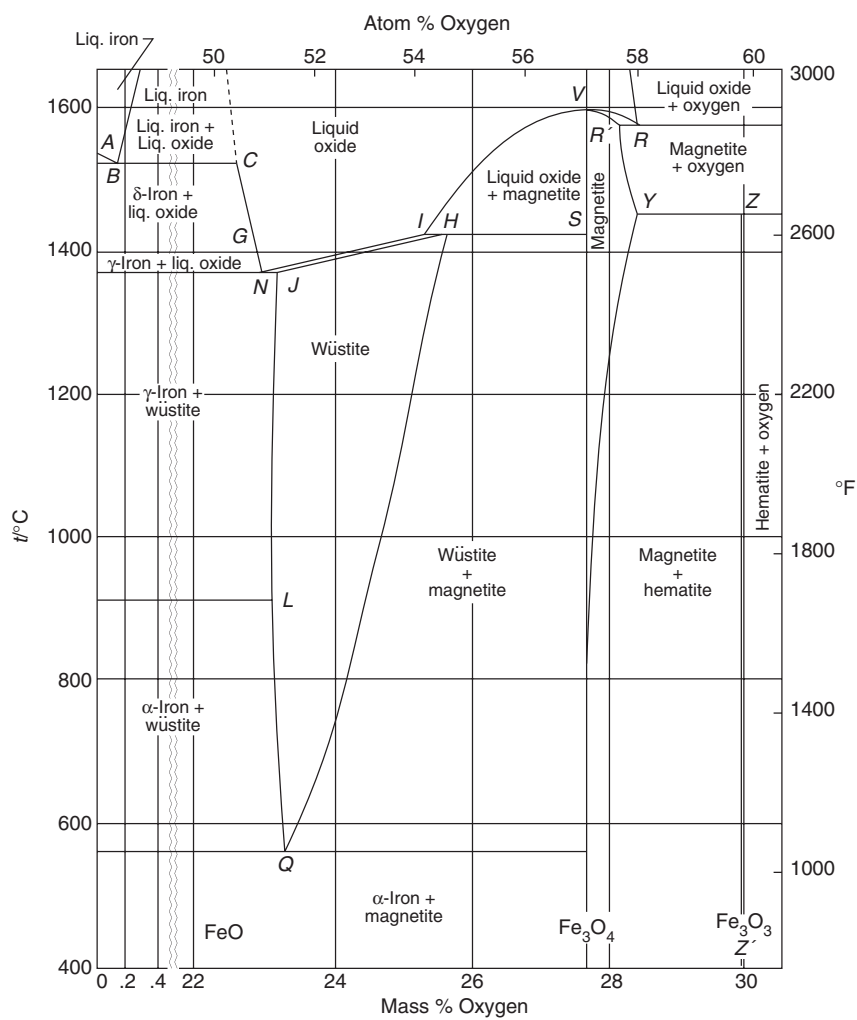


FIGURE 5. Fe-O system.

| Point | $t/^{\circ}\text{C}$ | % O   | $p_{\text{CO}_2}/p_{\text{CO}}$ | Point | $t/^{\circ}\text{C}$ | % O   | $p_{\text{CO}_2}/p_{\text{CO}}$ | $p_{\text{O}_2}/\text{atm}$ |
|-------|----------------------|-------|---------------------------------|-------|----------------------|-------|---------------------------------|-----------------------------|
| A     | 1539                 |       |                                 | Q     | 560                  | 23.26 | 1.05                            |                             |
| B     | 1528                 | 0.16  | 0.209                           | R     | 1583                 | 28.30 |                                 | 1                           |
| C     | 1528                 | 22.60 | 0.209                           | R'    | 1583                 | 28.07 |                                 | 1                           |
| G     | 1400 <sup>a</sup>    | 22.84 | 0.263                           | S     | 1424                 | 27.64 | 16.2                            |                             |
| H     | 1424                 | 25.60 | 16.2                            | V     | 1597                 | 27.64 |                                 | 0.0575                      |
| I     | 1424                 | 25.31 | 16.2                            | Y     | 1457                 | 28.36 |                                 | 1                           |
| J     | 1371                 | 23.16 | 0.282                           | Z     | 1457                 | 30.04 |                                 | 1                           |
| L     | 911 <sup>a</sup>     | 23.10 | 0.447                           | Z'    |                      | 30.6  |                                 |                             |
| N     | 1371                 | 22.91 | 0.282                           |       |                      |       |                                 |                             |

<sup>a</sup> Values for pure iron.

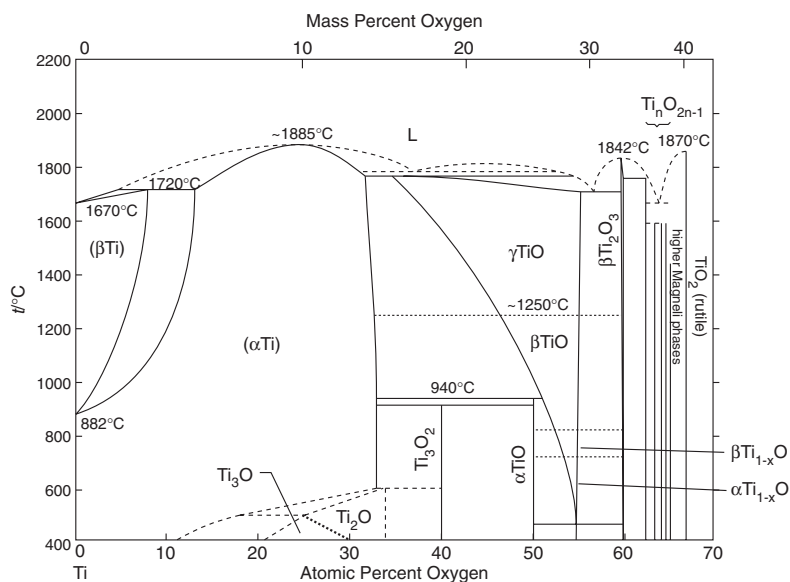
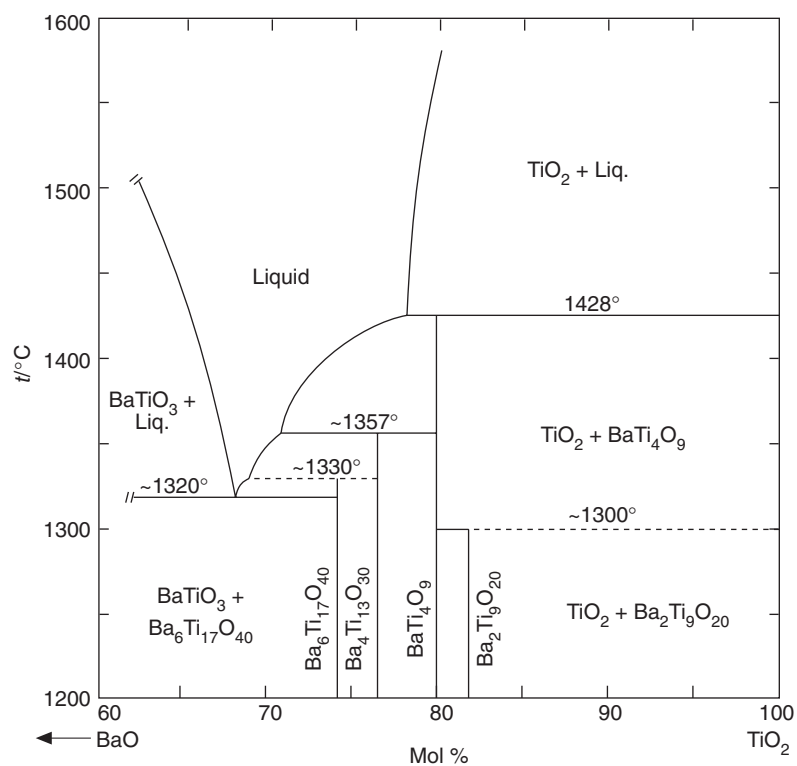
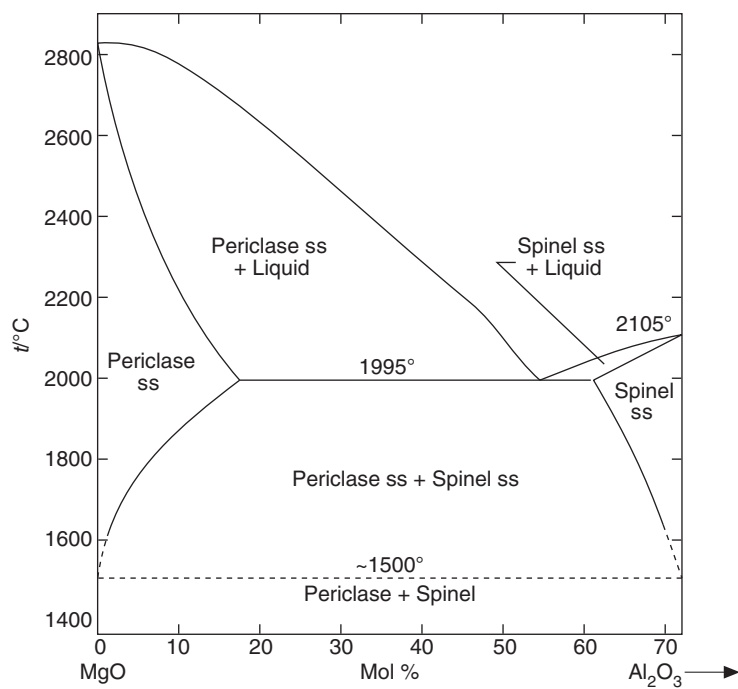
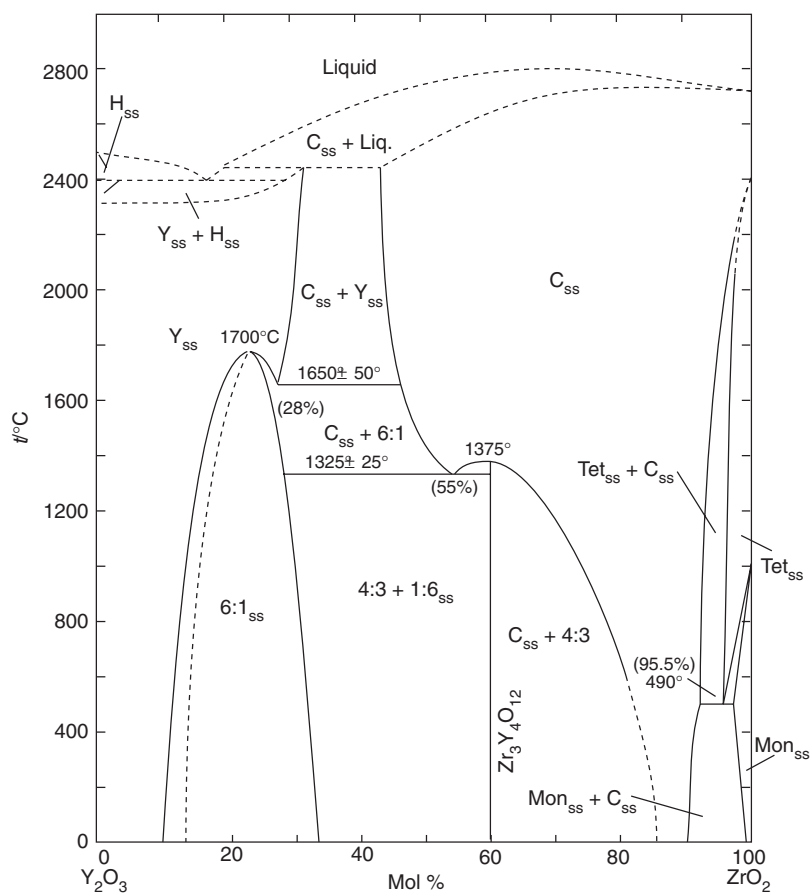


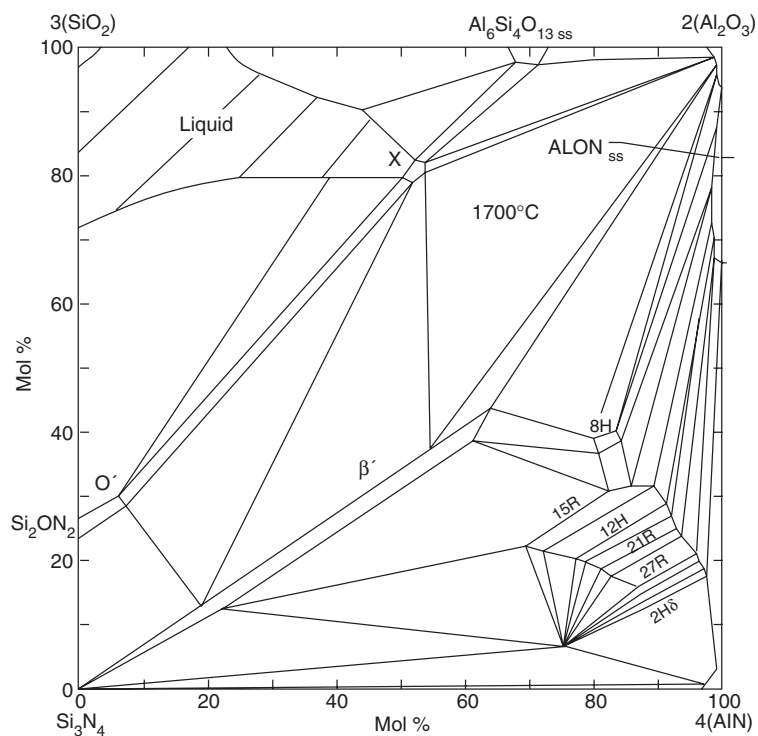
FIGURE 6. Ti-O system.

| Phase                            | Composition, mass % O | Pearson symbol | Space group                |
|----------------------------------|-----------------------|----------------|----------------------------|
| (βTi)                            | 0 to 3                | <i>cI2</i>     | <i>Im</i> $\bar{3}m$       |
| (αTi)                            | 0 to 13.5             | <i>hP2</i>     | <i>P63/mmc</i>             |
| Ti <sub>3</sub> O                | ~8 to ~13             | <i>hP~16</i>   | <i>P3c</i>                 |
| Ti <sub>2</sub> O                | ~10 to 14.4           | <i>hP3</i>     | <i>P3m1</i>                |
| γTiO                             | 15.2 to 29.4          | <i>cF8</i>     | <i>Fm</i> $\bar{3}m$       |
| Ti <sub>3</sub> O <sub>2</sub>   | ~18                   | <i>hP~5</i>    | <i>P6/mmm</i>              |
| βTiO                             | ~24 to ~29.4          | <i>c**</i>     | —                          |
| αTiO                             | ~25.0                 | <i>mC16</i>    | <i>A2/m</i> or <i>B*/*</i> |
| βTi <sub>1-x</sub> O             | ~29.5                 | <i>oI12</i>    | <i>I222</i>                |
| αTi <sub>1-x</sub> O             | ~29.5                 | <i>tI18</i>    | <i>I4/m</i>                |
| βTi <sub>2</sub> O <sub>3</sub>  | 33.2 to 33.6          | <i>hR30</i>    | <i>R3c</i>                 |
| αTi <sub>2</sub> O <sub>3</sub>  | 33.2 to 33.6          | <i>hR30</i>    | <i>R3c</i>                 |
| βTi <sub>3</sub> O <sub>5</sub>  | 35.8                  | <i>m**</i>     | —                          |
| αTi <sub>3</sub> O <sub>5</sub>  | 35.8                  | <i>mC32</i>    | <i>C2/m</i>                |
| α'Ti <sub>3</sub> O <sub>5</sub> | 35.8                  | <i>mC32</i>    | <i>Cc</i>                  |
| γTi <sub>4</sub> O <sub>7</sub>  | 36.9                  | <i>aP44</i>    | <i>P1</i>                  |
| βTi <sub>4</sub> O <sub>7</sub>  | 36.9                  | <i>aP44</i>    | <i>P1</i>                  |
| αTi <sub>4</sub> O <sub>7</sub>  | 36.9                  | <i>aP44</i>    | <i>P1</i>                  |
| γTi <sub>5</sub> O <sub>9</sub>  | 37.6                  | <i>aP28</i>    | <i>P1</i>                  |
| βTi <sub>6</sub> O <sub>11</sub> | 38.0                  | <i>aC68</i>    | <i>A1</i>                  |
| Ti <sub>7</sub> O <sub>13</sub>  | 38.3                  | <i>aP40</i>    | <i>P1</i>                  |
| Ti <sub>8</sub> O <sub>15</sub>  | 38.5                  | <i>aC92</i>    | <i>A1</i>                  |
| Ti <sub>9</sub> O <sub>17</sub>  | 38.7                  | <i>aP52</i>    | <i>P1</i>                  |
| Rutile TiO <sub>2</sub>          | 40.1                  | <i>tP6</i>     | <i>P4<sub>2</sub>/mnm</i>  |
| Metastable phases                |                       |                |                            |
| Anatase                          | —                     | <i>tI12</i>    | <i>I4<sub>1</sub>/amd</i>  |
| Brookite                         | —                     | <i>oP24</i>    | <i>Pbca</i>                |
| High-pressure phases             |                       |                |                            |
| TiO <sub>2</sub> -II             | —                     | <i>oP12</i>    | <i>Pbcn</i>                |
| TiO <sub>2</sub> -III            | —                     | <i>hP~48</i>   | —                          |

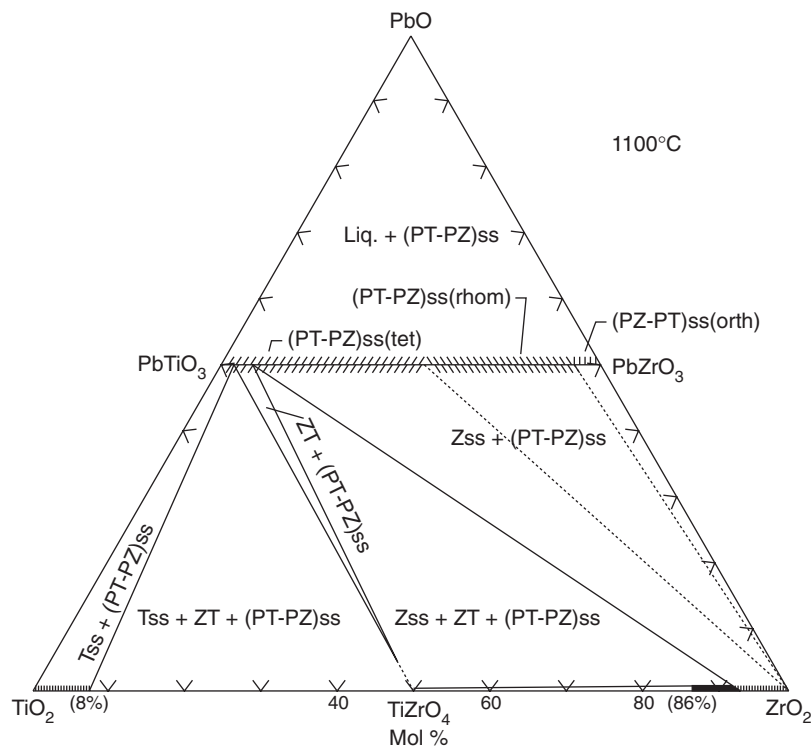
FIGURE 7. BaO-TiO<sub>2</sub> system.FIGURE 8. MgO-Al<sub>2</sub>O<sub>3</sub> system.



**FIGURE 9.**  $\text{Y}_2\text{O}_3$ - $\text{ZrO}_2$  system.  $\text{C}_{\text{ss}}$  = cubic  $\text{ZrO}_2$  ss (fluorite-type ss);  $\text{Y}_{\text{ss}}$  = cubic  $\text{Y}_2\text{O}_3$  ss;  $\text{Tet}_{\text{ss}}$  = tetragonal  $\text{ZrO}_2$  ss;  $\text{Mon}_{\text{ss}}$  = monoclinic  $\text{ZrO}_2$  ss;  $\text{H}_{\text{ss}}$  = hexagonal  $\text{Y}_2\text{O}_3$  ss;  $3:4 = \text{Zr}_3\text{Y}_4\text{O}_{12}$ ;  $1:6 = \text{ZrY}_6\text{O}_{11}$  ss.



**FIGURE 10.**  $3(\text{SiO}_2)\text{-Si}_3\text{N}_4\text{-4(AlN)-2(Al}_2\text{O}_3)$  system. "Behavior" diagram at  $1700^\circ\text{C}$ . The labels 8H, 15R, 12H, 21R, 27R,  $2\text{H}^6$  indicate defect AlN polytypes.  $\beta'$  = 3-sialon ( $\text{Si}_{6-x}\text{Al}_x\text{O}_8\text{N}_{8-x}$ );  $\text{O}'$  = sialon of  $\text{Si}_2\text{ON}_2$  type; X =  $\text{SiAlO}_2\text{N}$  ("nitrogen mullite"). ALON ss = aluminum oxynitride ss extending from approximately  $\text{Al}_7\text{O}_9\text{N}$  to  $\text{Al}_3\text{O}_3\text{N}$ .

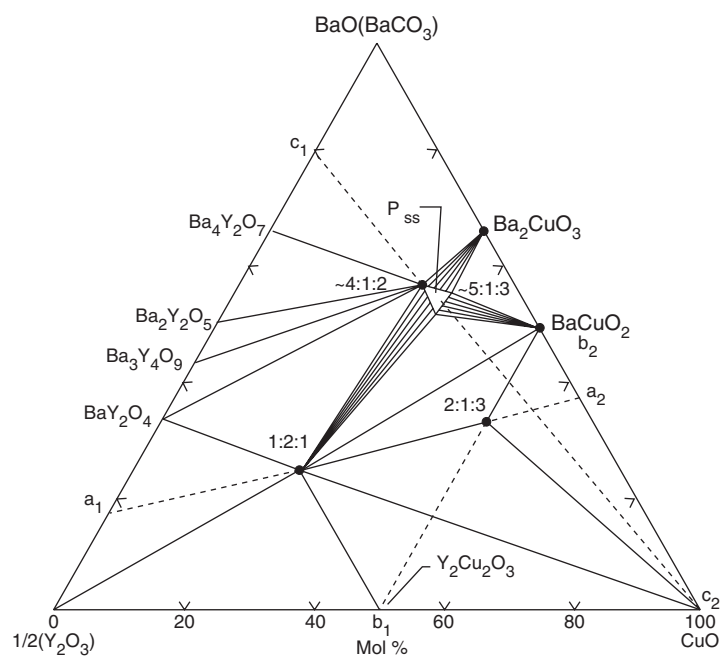


**FIGURE 11.**  $\text{PbO-ZrO}_2\text{-TiO}_2$  (PZT) system, subsolidus at  $1100^\circ\text{C}$ . P = PbO; T =  $\text{TiO}_2$ ; Z =  $\text{ZrO}_2$ .

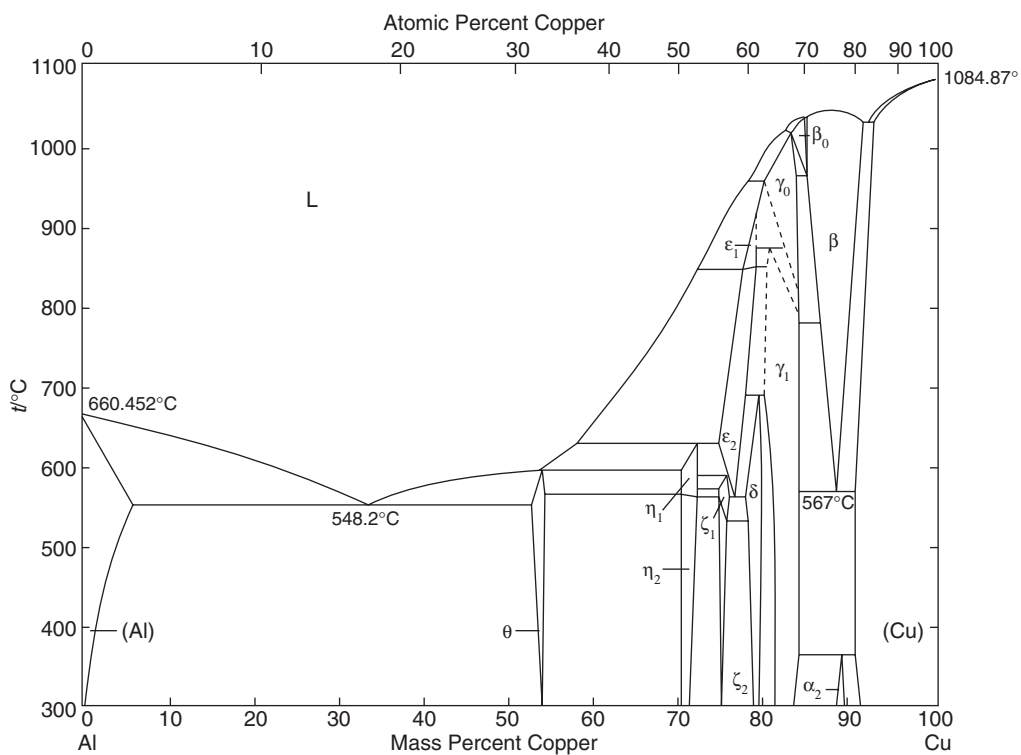


Temperatures up to approximately 1550°C are on the Geophysical Laboratory Scale; those above 1550°C are on the 1948 International Scale.





**FIGURE 13.** BaO-Y<sub>2</sub>O<sub>3</sub>-CuO system. 2:1:3 = Ba<sub>2</sub>YCu<sub>3</sub>O<sub>7-x</sub>; 1:2:1 = BaY<sub>2</sub>CuO<sub>5</sub>; 4:1:2 = Ba<sub>4</sub>YCu<sub>2</sub>O<sub>7.5+x</sub>; and 5:1:3 = Ba<sub>5</sub>YCu<sub>3</sub>O<sub>9.5+x</sub>. The superconducting 2:1:3 phase was prepared using barium peroxide.



**FIGURE 14.** Al-Cu system.

| Phase             | Composition, wt % Cu | Pearson symbol             | Space group                |
|-------------------|----------------------|----------------------------|----------------------------|
| (Al)              | 0 to 5.65            | <i>cF4</i>                 | <i>Fm</i> $\bar{3}m$       |
| $\theta$          | 52.5 to 53.7         | <i>tI12</i>                | <i>I4/mcm</i>              |
| $\eta_1$          | 70.0 to 72.2         | <i>oP16</i> or <i>oC16</i> | <i>Pban</i> or <i>Cmmm</i> |
| $\eta_2$          | 70.0 to 72.1         | <i>mC20</i>                | <i>C2/m</i>                |
| $\zeta_1$         | 74.4 to 77.8         | <i>hP42</i>                | <i>P6/mmm</i>              |
| $\zeta_2$         | 74.4 to 75.2         | (a)                        | —                          |
| $\epsilon_1$      | 77.5 to 79.4         | (b)                        | —                          |
| $\epsilon_2$      | 72.2 to 78.7         | <i>hP4</i>                 | <i>P63/mmc</i>             |
| $\delta$          | 77.4 to 78.3         | (c)                        | <i>R</i> $\bar{3}m$        |
| $\gamma_0$        | 77.8 to 84           | (d)                        | —                          |
| $\gamma_1$        | 79.7 to 84           | <i>cP52</i>                | <i>P</i> $\bar{4}3m$       |
| $\beta_0$         | 83.1 to 84.7         | (d)                        | —                          |
| $\beta$           | 85.0 to 91.5         | <i>cI2</i>                 | <i>Im</i> $\bar{3}m$       |
| $\alpha_2$        | 88.5 to 89           | (e)                        | —                          |
| (Cu)              | 90.6 to 100          | <i>cF4</i>                 | <i>Fm</i> $\bar{3}m$       |
| Metastable phases |                      |                            |                            |
| $\theta'$         | —                    | <i>tP6</i>                 | —                          |
| $\beta'$          | —                    | <i>cF16</i>                | <i>Fm</i> $\bar{3}m$       |
| $Al_3Cu_2$        | 61 to 70             | <i>hP5</i>                 | <i>P</i> $\bar{3}m1$       |

(a) Monoclinic? (b) Cubic? (c) Rhombohedral. (d) Unknown. (e)  $D0_{22}$ -type long-period superlattice.

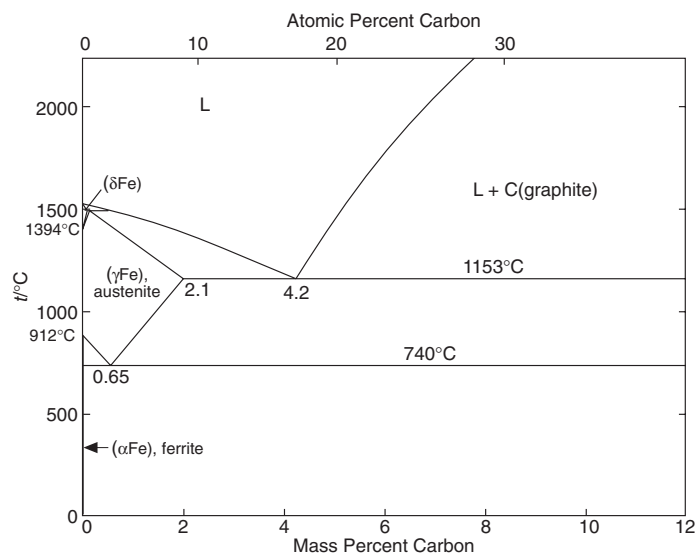


FIGURE 15. Fe-C system.

| Phase                           | Composition, mass % C | Pearson symbol | Space group          |
|---------------------------------|-----------------------|----------------|----------------------|
| ( $\delta$ Fe)                  | 0 to 0.09             | <i>cI2</i>     | <i>Im</i> $\bar{3}m$ |
| ( $\gamma$ Fe)                  | 0 to 2.1              | <i>cF4</i>     | <i>Fm</i> $\bar{3}m$ |
| ( $\alpha$ Fe)                  | 0 to 0.021            | <i>cI2</i>     | <i>Im</i> $\bar{3}m$ |
| (C)                             | 100                   | <i>hP4</i>     | <i>P63/mmc</i>       |
| Metastable/high-pressure phases |                       |                |                      |
| ( $\epsilon$ Fe)                | 0                     | <i>hP2</i>     | <i>P63/mmc</i>       |
| Martensite                      | < 2.1                 | <i>tI4</i>     | <i>I4/mmm</i>        |
| $Fe_4C$                         | 5.1                   | <i>cP5</i>     | <i>P</i> $\bar{4}3m$ |
| $Fe_3C$ ( $\theta$ )            | 6.7                   | <i>oP16</i>    | <i>Pnma</i>          |
| $Fe_5C_2$ ( $\chi$ )            | 7.9                   | <i>mC28</i>    | <i>C2/c</i>          |
| $Fe_7C_3$                       | 8.4                   | <i>hP20</i>    | <i>P63mc</i>         |
| $Fe_7C_3$                       | 8.4                   | <i>oP40</i>    | <i>Pnma</i>          |
| $Fe_2C$ ( $\eta$ )              | 9.7                   | <i>oP6</i>     | <i>Pnnm</i>          |
| $Fe_2C$ ( $\epsilon$ )          | 9.7                   | <i>hP*</i>     | <i>P6322</i>         |
| $Fe_2C$                         | 9.7                   | <i>hP*</i>     | <i>P</i> $\bar{3}m1$ |
| (C)                             | 100                   | <i>cF8</i>     | <i>Fd</i> $\bar{3}m$ |

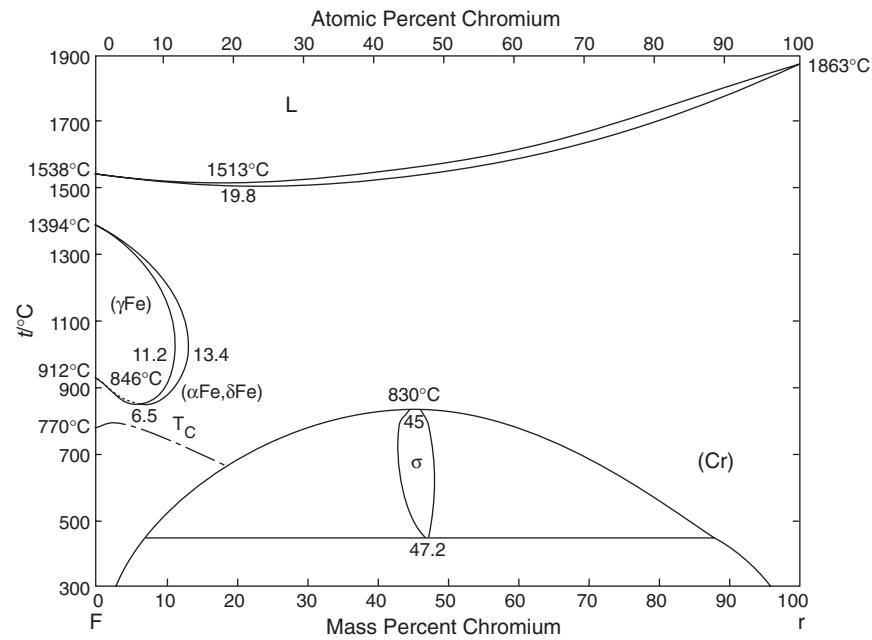


FIGURE 16. Fe-Cr system.

| Phase     | Composition, mass % Cr | Pearson symbol | Space group                         |
|-----------|------------------------|----------------|-------------------------------------|
| (aFe, Cr) | 0 to 100               | <i>cI2</i>     | <i>Im</i> $\bar{3}m$                |
| (γFe)     | 0 to 11.2              | <i>cF4</i>     | <i>Fm</i> $\bar{3}m$                |
| σ         | 42.7 to 48.2           | <i>tP30</i>    | <i>P4</i> <sub>2</sub> / <i>mmm</i> |

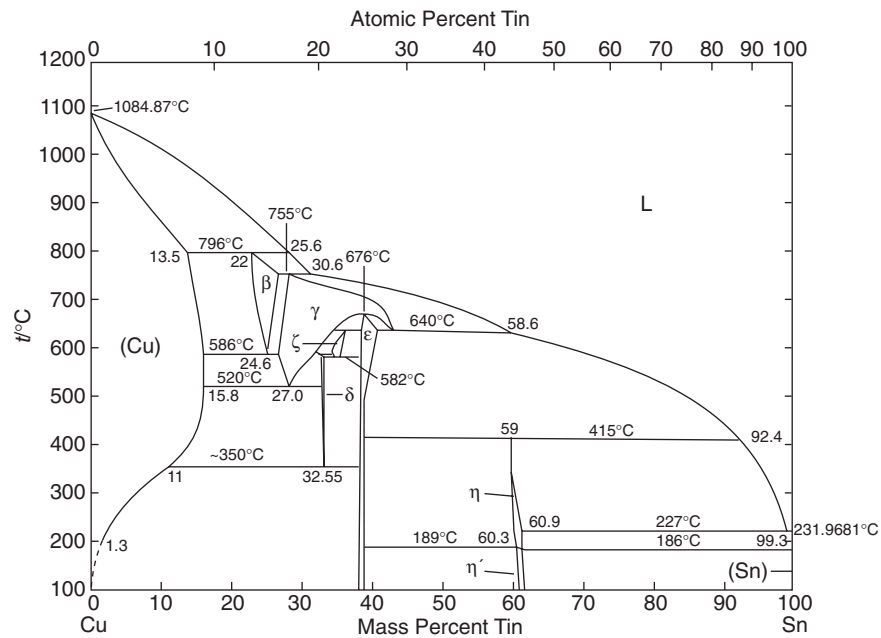


FIGURE 17. Cu-Sn system.

| Phase          | Composition, mass % Sn | Pearson symbol | Space group  |
|----------------|------------------------|----------------|--------------|
| $\alpha$       | 0 to 15.8              | $cF4$          | $Fm\bar{3}m$ |
| $\beta$        | 22.0 to 27.0           | $cI2$          | $Im\bar{3}m$ |
| $\gamma$       | 25.5 to 41.5           | $cF16$         | $Fm\bar{3}m$ |
| $\delta$       | 32 to 33               | $cF416$        | $F\bar{4}3m$ |
| $\zeta$        | 32.2 to 35.2           | $hP26$         | $P6_3$       |
| $\epsilon$     | 27.7 to 39.5           | $oC80$         | $Cmcm$       |
| $\eta$         | 59.0 to 60.9           | $hP4$          | $P6_3/mmc$   |
| $\eta'$        | 44.8 to 60.9           | (a)            | —            |
| ( $\beta$ Sn)  | ~100                   | $tI4$          | $I4_1/amd$   |
| ( $\alpha$ Sn) | 100                    | $cF8$          | $Fd\bar{3}m$ |

(a) Hexagonal; superlattice based on NiAs-type structure.

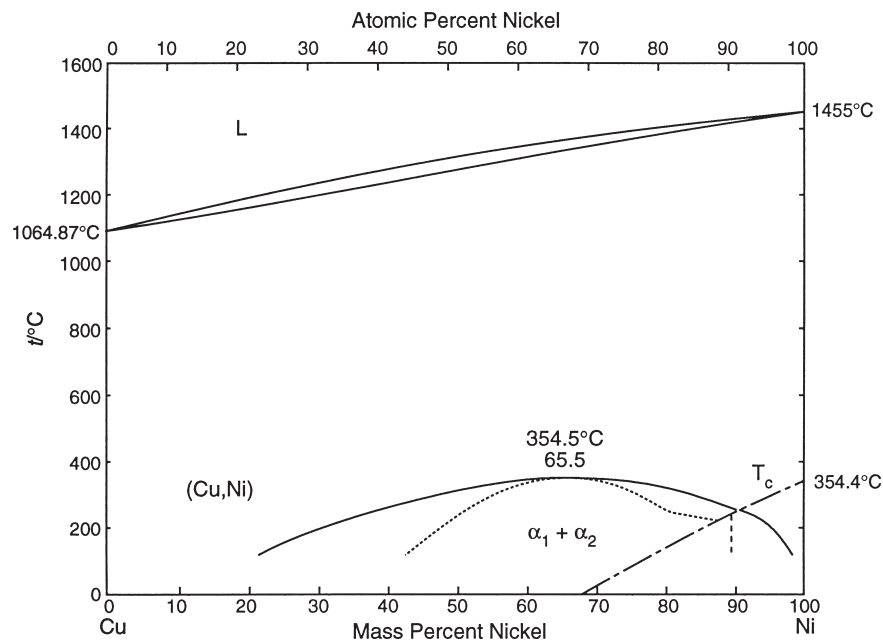


FIGURE 18. Cu-Ni system.

| Phase                    | Composition, mass % Ni | Pearson symbol | Space group  |
|--------------------------|------------------------|----------------|--------------|
| (Cu, Ni) (above 354.5°C) | 0 to 100               | $cF4$          | $Fm\bar{3}m$ |

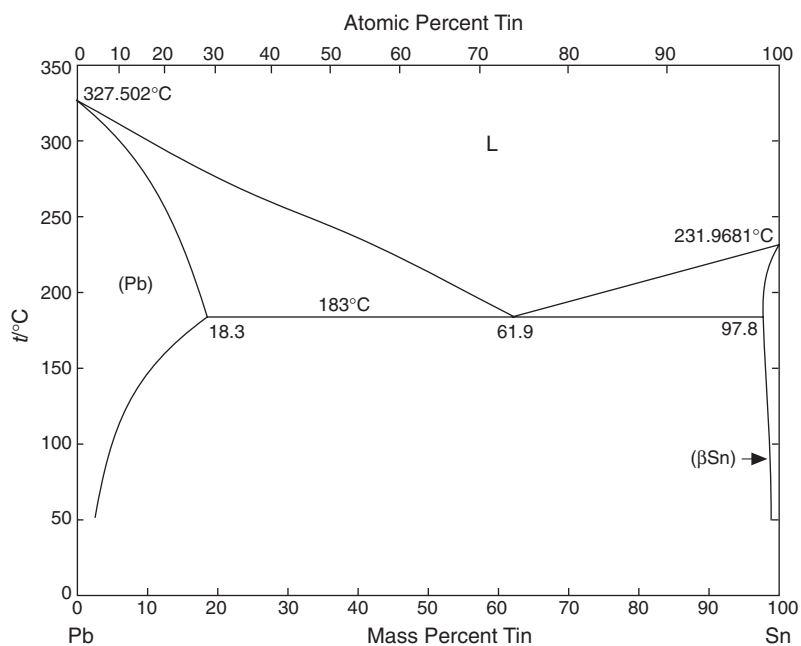


FIGURE 19. Pb-Sn system.

| Phase                 | Composition,<br>mass % Sn | Pearson<br>symbol | Space<br>group |
|-----------------------|---------------------------|-------------------|----------------|
| (Pb)                  | 0 to 18.3                 | $cF4$             | $Fm\bar{3}m$   |
| ( $\beta\text{Sn}$ )  | 97.8 to 100               | $tI4$             | $I4_1/amd$     |
| ( $\alpha\text{Sn}$ ) | 100                       | $cF8$             | $Fd\bar{3}m$   |
| High-pressure phases  |                           |                   |                |
| $\epsilon(a)$         | 52 to 74                  | $hP1$             | $P6/mmm$       |
| $\epsilon'(b)$        | 52                        | $hP2$             | $P6_3/mmc$     |

(a) From phase diagram calculated at 2500 MPa. (b) This phase was claimed for alloys at 350°C and 5500 MPa.

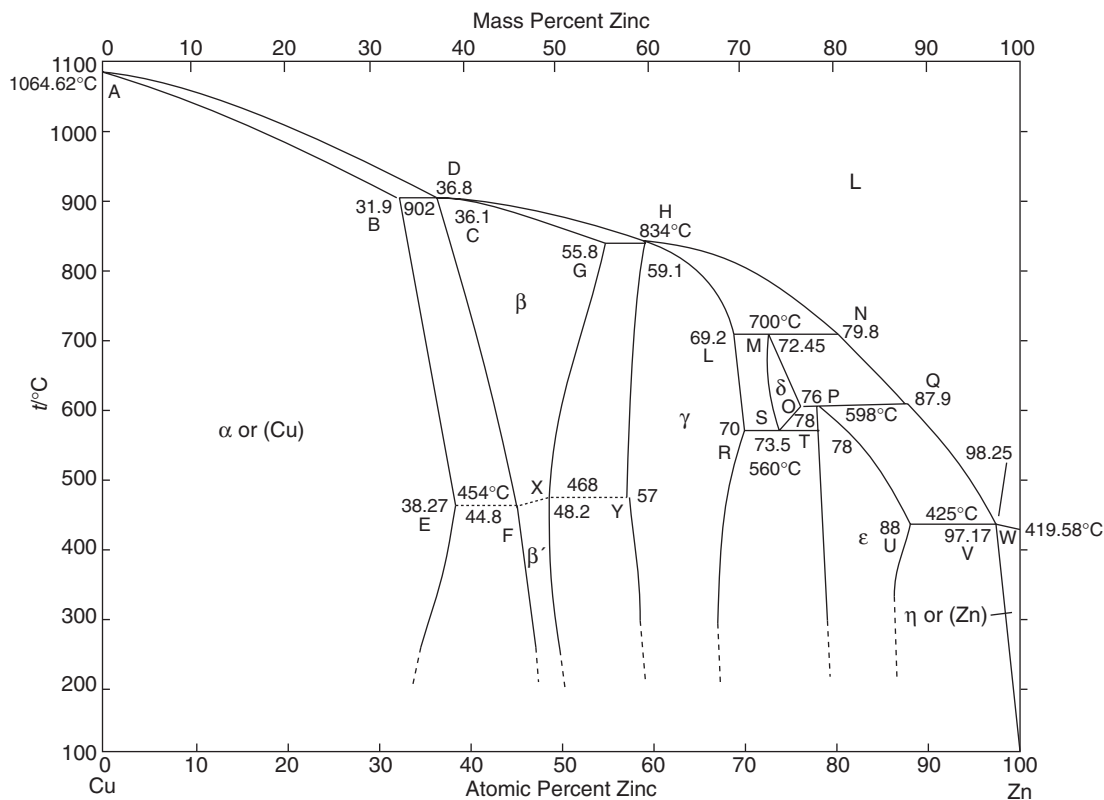


FIGURE 20. Cu-Zn system.

| Phase            | Composition, mass % Zn | Pearson symbol | Space group  |
|------------------|------------------------|----------------|--------------|
| $\alpha$ or (Cu) | 0 to 38.95             | $cF4$          | $Fm\bar{3}m$ |
| $\beta$          | 36.8 to 56.5           | $cI2$          | $Im\bar{3}m$ |
| $\beta'$         | 45.5 to 50.7           | $cP2$          | $Pm\bar{3}m$ |
| $\gamma$         | 57.7 to 70.6           | $cI52$         | $I\bar{4}3m$ |
| $\delta$         | 73.02 to 76.5          | $hP3$          | $P\bar{6}$   |
| $\epsilon$       | 78.5 to 88.3           | $hP2$          | $P6_3/mmc$   |
| $\eta$ or (Zn)   | 97.25 to 100           | $hP2$          | $P6_3/mmc$   |

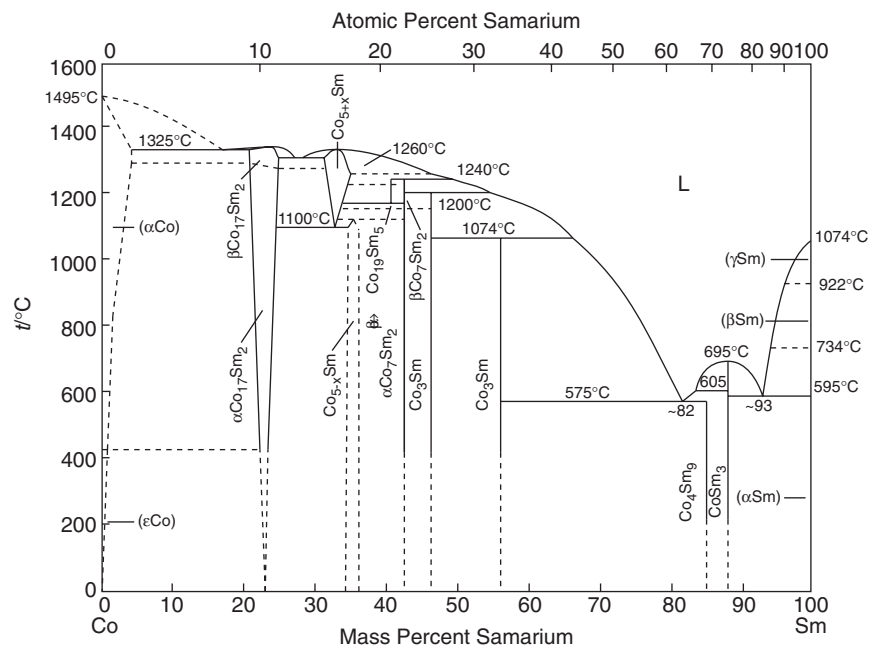


FIGURE 21. Co-Sm system.

| Phase                             | Composition,<br>mass % Sm | Pearson<br>symbol | Space<br>group                      |
|-----------------------------------|---------------------------|-------------------|-------------------------------------|
| (αCo)                             | 0 to ~3.7                 | <i>cF4</i>        | <i>Fm</i> $\bar{3}m$                |
| (εCo)                             | ~0                        | <i>hP2</i>        | <i>P6</i> <sub>3</sub> / <i>mmc</i> |
| βCo <sub>17</sub> Sm <sub>2</sub> | ~23.0                     | <i>hP38</i>       | <i>P6</i> <sub>3</sub> / <i>mmc</i> |
| αCo <sub>17</sub> Sm <sub>2</sub> | ~23.0                     | <i>hR19</i>       | <i>R</i> $\bar{3}m$                 |
|                                   |                           | <i>hP8</i>        | <i>P6/mmm</i>                       |
| Co <sub>5+x</sub> Sm              | ~33 to 34                 | —                 | —                                   |
| Co <sub>5-x</sub> Sm              | ~34 to 35                 | —                 | —                                   |
| Co <sub>19</sub> Sm <sub>5</sub>  | ~40.1                     | <i>hR24</i>       | <i>R</i> $\bar{3}m$                 |
|                                   |                           | <i>hP48</i>       | <i>P6</i> <sub>3</sub> / <i>mmc</i> |
| αCo <sub>7</sub> Sm <sub>2</sub>  | ~42.1                     | <i>hR18</i>       | <i>R</i> $\bar{3}m$                 |
| βCo <sub>7</sub> Sm <sub>2</sub>  | ~42.1                     | <i>hP36</i>       | <i>P6</i> <sub>3</sub> / <i>mmc</i> |
| Co <sub>3</sub> Sm                | 46                        | <i>hR12</i>       | <i>R</i> $\bar{3}m$                 |
| Co <sub>2</sub> Sm                | 56.0                      | <i>hR4</i>        | <i>R</i> $\bar{3}m$                 |
|                                   |                           | <i>cF24</i>       | <i>Fd</i> $\bar{3}m$                |
| Co <sub>4</sub> Sm <sub>9</sub>   | ~85.1                     | <i>o**</i>        | —                                   |
| CoSm <sub>3</sub>                 | 88                        | <i>oP16</i>       | <i>Pnma</i>                         |
| (γSm)                             | ~100                      | <i>cI2</i>        | <i>Im</i> $\bar{3}m$                |
| (βSm)                             | ~100                      | <i>hP2</i>        | <i>P6</i> <sub>3</sub> / <i>mmc</i> |
| (αSm)                             | ~100                      | <i>hR3</i>        | <i>R</i> $\bar{3}m$                 |
| <b>Other reported phases</b>      |                           |                   |                                     |
| Co <sub>5</sub> Sm                | ~33.8                     | <i>hP6</i>        | <i>P6/mmm</i>                       |
| Co <sub>2</sub> Sm <sub>5</sub>   | ~86.4                     | <i>mC28</i>       | <i>C2/c</i>                         |

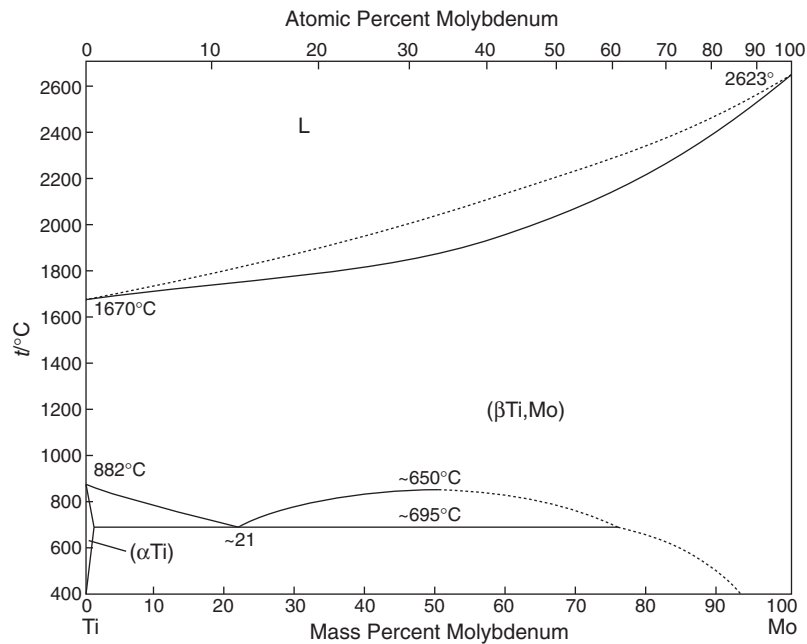
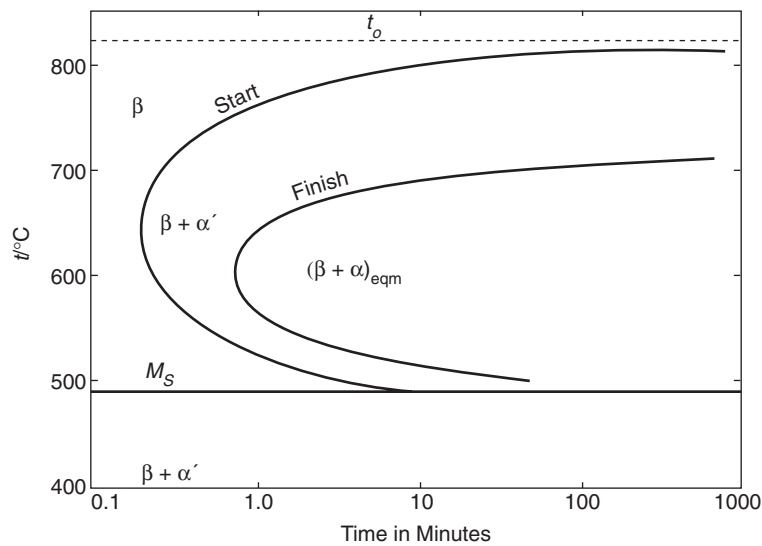


FIGURE 22. Ti-Mo system.

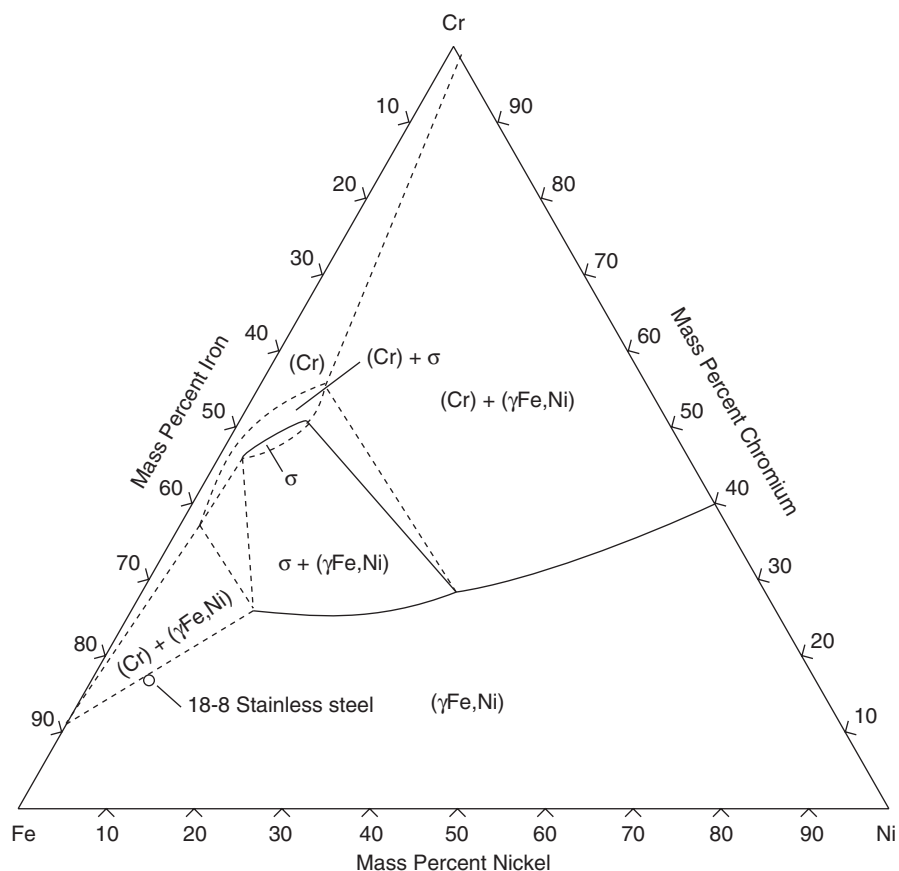
| Phase                  | Composition, mass % Mo | Pearson symbol | Space group  |
|------------------------|------------------------|----------------|--------------|
| $(\beta\text{Ti, Mo})$ | 0 to 100               | $cI2$          | $Im\bar{3}m$ |
| $(\alpha\text{Ti})$    | 0 to 0.8               | $hP2$          | $P6_3/mmc$   |
| $\alpha'$              | (a)                    | $hP2$          | $P6_3/mmc$   |
| $\alpha''$             | (a)                    | $oC4$          | $Cmcm$       |
| $\omega$               | (a)                    | $hP3$          | $P6/mmm$     |

(a) Metastable.



Experimental time-temperature-transformation (TTT) diagram for Ti-Mo. The start and finish times of the isothermal precipitation reaction vary with temperature as a result of the temperature dependence of the nucleation and growth processes. Precipitation is complete, at any temperature, when the equilibrium fraction of  $\alpha$  is established in accordance with the lever rule. The solid horizontal line represents the athermal (or nonthermally activated) martensitic transformation that occurs when the  $\beta$  phase is quenched.





**FIGURE 23.** The isothermal section at 900°C (1652°F) of the iron-chromium-nickel ternary phase diagram, showing the nominal composition of 18-8 stainless steel.

## HEAT CAPACITY OF SELECTED SOLIDS

This table gives the molar heat capacity at constant pressure of representative metals, semiconductors, and other crystalline solids as a function of temperature in the range 200 to 600 K.

- Garvin, D., Parker, V. B., and White, H. J., *CODATA Thermodynamic Tables*, Hemisphere Press, New York, 1987.
- DIPPR Database of Pure Compound Properties, Design Institute for Physical Properties Data, American Institute of Chemical Engineers, New York, 1987.

### References

- Chase, M. W., et al., *JANAF Thermochemical Tables, 3rd ed.*, *J. Phys. Chem. Ref. Data*, 14, Suppl. 1, 1985.

| Name               | $C_p$ in J/mol K |       |       |        |        |        |        |
|--------------------|------------------|-------|-------|--------|--------|--------|--------|
|                    | 200 K            | 250 K | 300 K | 350 K  | 400 K  | 500 K  | 600 K  |
| Aluminum           | 21.33            | 23.08 | 24.25 | 25.11  | 25.78  | 26.84  | 27.89  |
| Aluminum oxide     | 51.12            | 67.05 | 79.45 | 88.91  | 96.14  | 106.17 | 112.55 |
| Anthracene         | 138.6            | 173.9 | 210.7 | 248.8  | 288.4  |        |        |
| Benzoic acid       | 102.7            | 123.5 | 147.4 | 172.0  |        |        |        |
| Beryllium          | 9.98             | 13.58 | 16.46 | 18.53  | 19.95  | 21.94  | 23.34  |
| Biphenyl           | 131.0            | 162.5 | 197.2 |        |        |        |        |
| Boron              | 5.99             | 8.82  | 11.40 | 13.65  | 15.69  | 18.72  | 20.78  |
| Calcium            | 24.54            | 25.41 | 25.94 | 26.32  | 26.87  | 28.49  | 30.38  |
| Calcium carbonate  | 66.50            | 75.66 | 83.82 | 91.51  | 96.97  | 104.52 | 109.86 |
| Calcium oxide      | 33.64            | 38.59 | 42.18 | 45.07  | 46.98  | 49.33  | 50.72  |
| Cesium chloride    | 50.13            | 51.34 | 52.48 | 53.58  | 54.68  | 56.90  | 59.10  |
| Chromium           | 19.86            | 22.30 | 23.47 | 24.39  | 25.23  | 26.63  | 27.72  |
| Cobalt             | 22.23            | 23.98 | 24.83 | 25.68  | 26.53  | 28.20  | 29.66  |
| Copper             | 22.63            | 23.77 | 24.48 | 24.95  | 25.33  | 25.91  | 26.48  |
| Copper oxide       | 34.80            |       | 42.41 | 44.95  | 46.78  | 49.19  | 50.83  |
| Copper sulfate     | 77.01            | 89.25 | 99.25 | 107.65 | 114.93 | 127.19 | 136.31 |
| Germanium          |                  |       | 23.25 | 23.85  | 24.31  | 24.96  | 25.45  |
| Gold               |                  |       | 25.41 | 25.37  | 25.51  | 26.06  | 26.65  |
| Graphite           | 5.01             | 6.82  | 8.58  | 10.24  | 11.81  | 14.62  | 16.84  |
| Hexachlorobenzene  | 162.7            | 183.6 | 202.4 |        |        |        |        |
| Iodine             | 51.57            | 53.24 | 54.51 | 58.60  |        |        |        |
| Iron               | 21.59            | 23.74 | 25.15 | 26.28  | 27.39  | 29.70  | 32.05  |
| Lead               | 25.87            | 26.36 | 26.85 | 27.30  | 27.72  | 28.55  | 29.40  |
| Lithium            | 21.57            | 23.42 | 24.64 | 25.96  | 27.60  | 29.28  |        |
| Lithium chloride   | 43.35            | 46.08 | 48.10 | 49.66  | 50.97  | 53.34  | 55.59  |
| Magnesium          | 22.72            | 24.02 | 24.90 | 25.57  | 26.14  | 27.17  | 28.18  |
| Magnesium oxide    |                  |       | 37.38 | 40.59  | 42.77  | 45.56  | 47.30  |
| Manganese          | 23.05            | 24.95 | 26.35 | 27.52  | 28.53  | 30.29  | 31.90  |
| Naphthalene        | 105.8            | 134.1 | 167.8 | 204.1  |        |        |        |
| Potassium          | 27.00            | 28.01 | 29.60 |        |        |        |        |
| Potassium chloride | 48.44            | 50.10 | 51.37 | 52.31  | 53.08  | 54.71  | 56.35  |
| Silicon            | 15.64            | 18.22 | 20.04 | 21.28  | 22.14  | 23.33  | 24.15  |
| Silicon dioxide    | 32.64            | 39.21 | 44.77 | 49.47  | 53.43  | 59.64  | 64.42  |
| Silver             |                  |       | 25.36 | 25.55  | 25.79  | 26.36  | 26.99  |
| Sodium             | 22.45            | 27.01 | 28.20 | 30.14  |        |        |        |
| Sodium chloride    | 46.89            | 48.85 | 50.21 | 51.25  | 52.14  | 53.96  | 55.81  |
| Tantalum           | 24.08            | 24.86 | 25.31 | 25.60  | 25.84  | 26.35  | 26.84  |
| Titanium           | 22.37            | 24.07 | 25.28 | 26.17  | 26.86  | 27.88  | 28.60  |
| Tungsten           | 22.49            | 23.69 | 24.30 | 24.65  | 24.92  | 25.36  | 25.79  |
| Vanadium           | 21.88            | 23.70 | 24.93 | 25.68  | 26.23  | 26.94  | 27.49  |
| Zinc               | 24.05            | 25.02 | 25.45 | 25.88  | 26.35  | 27.39  | 28.59  |
| Zirconium          | 23.87            | 24.69 | 25.22 | 25.61  | 25.93  | 26.56  | 27.28  |

# THERMAL AND PHYSICAL PROPERTIES OF PURE METALS

This table gives the following properties for the metallic elements:

|                           |                                                                                                            |
|---------------------------|------------------------------------------------------------------------------------------------------------|
| $t_m$ :                   | Melting point in °C                                                                                        |
| $t_b$ :                   | Normal boiling point in °C, at a pressure of 101.325 kPa (760 Torr)                                        |
| $\Delta_{\text{fus}} H$ : | Enthalpy of fusion at the melting point in J/g                                                             |
| $\rho_{25}$ :             | Density at 25 °C in g/cm <sup>3</sup>                                                                      |
| $\alpha$ :                | Coefficient of linear expansion at 25 °C in K <sup>-1</sup> (the quantity listed is $10^6 \times \alpha$ ) |
| $c_p$ :                   | Specific heat capacity at constant pressure at 25 °C in J/g K                                              |
| $\lambda$ :               | Thermal conductivity at 27 °C in W/cm K                                                                    |

## References

- Dinsdale, A. T., *CALPHAD*, 15, 317, 1991 (melting points, enthalpy of fusion).
- Touloukian, Y. S., *Thermophysical Properties of Matter*, Vol. 12, Thermal Expansion, IFI/Plenum, New York, 1975 (coefficient of expansion, density).
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- Glushko, V. P., Ed., *Thermal Constants of Substances*, VINITI, Moscow, (enthalpy of fusion, heat capacity).
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- Hellwege, K. H., Ed., *Landolt Börnstein, Numerical Values and Functions in Physics, Chemistry, Astronomy, Geophysics, and Technology*, Vol. 2, Part 1, Mechanical-Thermal Properties of State, 1971 (density).
- Physical Encyclopedic Dictionary*, Vol. 1–5, Encyclopedia Publishing House, Moscow, 1960–66.

| Metal<br>(symbol) | Atomic<br>weight | $t_m$<br>°C | $t_b$<br>°C | $\Delta_{\text{fus}} H$<br>J/g | $\rho_{25}$<br>g/cm <sup>3</sup> | $\alpha \times 10^6$<br>K <sup>-1</sup> | $c_p$<br>J/g K | $\lambda$<br>W/cm K |
|-------------------|------------------|-------------|-------------|--------------------------------|----------------------------------|-----------------------------------------|----------------|---------------------|
| Actinium (Ac)     |                  | 1050        | 3198        |                                | 10                               |                                         | 0.12           |                     |
| Aluminum (Al)     | 26.98            | 660.32      | 2519        | 399.9                          | 2.70                             | 23.1                                    | 0.897          | 2.37                |
| Antimony (Sb)     | 121.76           | 630.628     | 1587        | 162.5                          | 6.68                             | 11.0                                    | 0.207          | 0.243               |
| Barium (Ba)       | 137.33           | 727         | 1897        | 51.8                           | 3.62                             | 20.6                                    | 0.205          | 0.184               |
| Beryllium (Be)    | 9.01             | 1287        | 2471        | 876.0                          | 1.85                             | 11.3                                    | 1.82           | 2.00                |
| Bismuth (Bi)      | 208.98           | 271.406     | 1564        | 53.3                           | 9.79                             | 13.4                                    | 0.122          | 0.0787              |
| Cadmium (Cd)      | 112.41           | 321.069     | 767         | 55.2                           | 8.69                             | 30.8                                    | 0.231          | 0.968               |
| Calcium (Ca)      | 40.08            | 842         | 1484        | 213.1                          | 1.54                             | 22.3                                    | 0.646          | 2.00                |
| Cerium (Ce)       | 140.11           | 799         | 3443        | 39.0                           | 6.77                             | 6.3                                     | 0.192          | 0.113               |
| Cesium (Cs)       | 132.91           | 28.44       | 671         | 15.7                           | 1.93                             | 97                                      | 0.242          | 0.359               |
| Chromium (Cr)     | 52.00            | 1907        | 2671        | 404                            | 7.15                             | 4.9                                     | 0.450          | 0.937               |
| Cobalt (Co)       | 58.93            | 1495        | 2927        | 272.5                          | 8.86                             | 13.0                                    | 0.421          | 1.00                |
| Copper (Cu)       | 63.55            | 1084.62     | 2562        | 203.5                          | 8.96                             | 16.5                                    | 0.384          | 4.01                |
| Dysprosium (Dy)   | 162.50           | 1412        | 2567        | 68.1                           | 8.55                             | 9.9                                     | 0.170          | 0.107               |
| Erbium (Er)       | 167.26           | 1529        | 2868        | 119                            | 9.07                             | 12.2                                    | 0.168          | 0.145               |
| Europium (Eu)     | 151.96           | 822         | 1529        | 60.6                           | 5.24                             | 35.0                                    | 0.182          | 0.139 <sup>a</sup>  |
| Gadolinium (Gd)   | 157.25           | 1313        | 3273        | 63.6                           | 7.90                             | 9.4 <sup>b</sup>                        | 0.235          | 0.105               |
| Gallium (Ga)      | 69.72            | 29.7666     | 2204        | 80.0                           | 5.91                             | 18                                      | 0.374          | 0.406               |
| Gold (Au)         | 196.97           | 1064.18     | 2856        | 64.6                           | 19.3                             | 14.2                                    | 0.129          | 3.17                |
| Hafnium (Hf)      | 178.49           | 2233        | 4603        | 152.4                          | 13.3                             | 5.9                                     | 0.144          | 0.230               |
| Holmium (Ho)      | 164.93           | 1472        | 2700        | 103 <sup>a</sup>               | 8.80                             | 11.2                                    | 0.165          | 0.162               |
| Indium (In)       | 114.82           | 156.60      | 2072        | 28.6                           | 7.31                             | 32.1                                    | 0.233          | 0.816               |
| Iridium (Ir)      | 192.22           | 2446        | 4428        | 213.9                          | 22.5                             | 6.4                                     | 0.131          | 1.47                |
| Iron (Fe)         | 55.85            | 1538        | 2861        | 247.3                          | 7.87                             | 11.8                                    | 0.449          | 0.802               |
| Lanthanum (La)    | 138.91           | 920         | 3464        | 44.6                           | 6.15                             | 12.1                                    | 0.195          | 0.134               |
| Lead (Pb)         | 207.20           | 327.462     | 1749        | 23.1                           | 11.3                             | 28.9                                    | 0.127          | 0.353               |
| Lithium (Li)      | 6.94             | 180.5       | 1342        | 432                            | 0.534                            | 46                                      | 3.57           | 0.847               |
| Lutetium (Lu)     | 174.97           | 1663        | 3402        | 126 <sup>a</sup>               | 9.84                             | 9.9                                     | 0.154          | 0.164               |
| Magnesium (Mg)    | 24.30            | 650         | 1090        | 348.9                          | 1.74                             | 24.8                                    | 1.024          | 1.56                |
| Manganese (Mn)    | 54.94            | 1246        | 2061        | 235.0                          | 7.3                              | 21.7                                    | 0.479          | 0.0782              |
| Mercury (Hg)      | 200.59           | -38.8290    | 356.62      | 11.4                           | 13.5336                          | 60.4                                    | 0.139          | 0.0834              |
| Molybdenum (Mo)   | 95.94            | 2623        | 4639        | 390.7                          | 10.2                             | 4.8                                     | 0.251          | 1.38                |
| Neodymium (Nd)    | 144.24           | 1016        | 3074        | 49.5                           | 7.01                             | 9.6                                     | 0.191          | 0.165               |
| Neptunium (Np)    |                  | 644         |             | 13.5                           | 20.2                             |                                         |                | 0.063               |
| Nickel (Ni)       | 58.69            | 1455        | 2913        | 290.3                          | 8.90                             | 13.4                                    | 0.445          | 0.907               |

| Metal<br>(symbol) | Atomic<br>weight | $t_m$<br>°C | $t_b$<br>°C       | $\Delta_{fus} H$<br>J/g | $\rho_{25}$<br>g/cm <sup>3</sup> | $\alpha \times 10^6$<br>K <sup>-1</sup> | $c_p$<br>J/g K    | $\lambda$<br>W/cm K |
|-------------------|------------------|-------------|-------------------|-------------------------|----------------------------------|-----------------------------------------|-------------------|---------------------|
| Niobium (Nb)      | 92.91            | 2477        | 4744              | 323                     | 8.57                             | 7.3                                     | 0.265             | 0.537               |
| Osmium (Os)       | 190.23           | 3033        | 5012              | 304.1                   | 22.59                            | 5.1                                     | 0.130             | 0.876               |
| Palladium (Pd)    | 106.42           | 1554.8      | 2963              | 157.3                   | 12.0                             | 11.8                                    | 0.244             | 0.718               |
| Platinum (Pt)     | 195.08           | 1768.2      | 3825              | 113.6                   | 21.5                             | 8.8                                     | 0.133             | 0.716               |
| Plutonium (Pu)    |                  | 640         | 3228              | 11.6                    | 19.7                             | 46.7                                    |                   | 0.0674              |
| Polonium (Po)     |                  | 254         | 962               |                         | 9.20                             | 23.5                                    |                   | 0.20                |
| Potassium (K)     | 39.10            | 63.38       | 759               | 59.6                    | 0.89                             | 83.3                                    | 0.757             | 1.024               |
| Praseodymium (Pr) | 140.91           | 931         | 3520              | 48.9                    | 6.77                             | 6.7                                     | 0.193             | 0.125               |
| Promethium (Pm)   |                  | 1042        | 3000 <sup>a</sup> |                         | 7.26                             | 11 <sup>a</sup>                         | 0.19 <sup>a</sup> | 0.15 <sup>a</sup>   |
| Protactinium (Pa) | 231.04           | 1572        |                   | 53.4                    | 15.4                             |                                         |                   |                     |
| Radium (Ra)       |                  | 696         |                   |                         | 5                                |                                         |                   |                     |
| Rhenium (Re)      | 186.21           | 3185        | 5596              | 324.5                   | 20.8                             | 6.2                                     | 0.137             | 0.479               |
| Rhodium (Rh)      | 102.91           | 1964        | 3695              | 258.4                   | 12.4                             | 8.2                                     | 0.243             | 1.50                |
| Rubidium (Rb)     | 85.47            | 39.30       | 688               | 25.6                    | 1.53                             |                                         | 0.364             | 0.582               |
| Ruthenium (Ru)    | 101.07           | 2333        | 4150              | 381.8                   | 12.1                             | 6.4                                     | 0.238             | 1.17                |
| Samarium (Sm)     | 150.36           | 1072        | 1794              | 57.3                    | 7.52                             | 12.7                                    | 0.196             | 0.133               |
| Scandium (Sc)     | 44.96            | 1541        | 2836              | 314                     | 2.99                             | 10.2                                    | 0.567             | 0.158               |
| Silver (Ag)       | 107.87           | 961.78      | 2162              | 104.6                   | 10.5                             | 18.9                                    | 0.235             | 4.29                |
| Sodium (Na)       | 22.99            | 97.794      | 882.94            | 113.1                   | 0.97                             | 71                                      | 1.225             | 1.41                |
| Strontium (Sr)    | 87.62            | 777         | 1382              | 84.8                    | 2.64                             | 22.5                                    | 0.306             | 0.353               |
| Tantalum (Ta)     | 180.95           | 3017        | 5458              | 202.1                   | 16.4                             | 6.3                                     | 0.140             | 0.575               |
| Technetium (Tc)   |                  | 2157        | 4265              | 339.7                   | 11                               |                                         |                   | 0.506               |
| Terbium (Tb)      | 158.93           | 1359        | 3230              | 67.9                    | 8.23                             | 10.3                                    | 0.182             | 0.111               |
| Thallium (Tl)     | 204.38           | 304         | 1473              | 20.3                    | 11.8                             | 29.9                                    | 0.129             | 0.461               |
| Thorium (Th)      | 232.04           | 1750        | 4788              | 59.5                    | 11.7                             | 11.0                                    | 0.118             | 0.540               |
| Thulium (Tm)      | 168.93           | 1545        | 1950              | 99.7                    | 9.32                             | 13.3                                    | 0.160             | 0.169               |
| Tin (Sn)          | 118.71           | 231.93      | 2602              | 60.4                    | 7.26                             | 22.0                                    | 0.227             | 0.666               |
| Titanium (Ti)     | 47.88            | 1668        | 3287              | 295.6                   | 4.51                             | 8.6                                     | 0.522             | 0.219               |
| Tungsten (W)      | 183.84           | 3422        | 5555              | 284.5                   | 19.3                             | 4.5                                     | 0.132             | 1.74                |
| Uranium (U)       | 238.03           | 1135        | 4131              | 38.4                    | 19.1                             | 13.9                                    | 0.116             | 0.276               |
| Vanadium (V)      | 50.94            | 1910        | 3407              | 422                     | 6.0                              | 8.4                                     | 0.489             | 0.307               |
| Ytterbium (Yb)    | 173.04           | 824         | 1196              | 44.3                    | 6.90                             | 26.3                                    | 0.154             | 0.385               |
| Yttrium (Y)       | 88.91            | 1522        | 3345              | 128                     | 4.47                             | 10.6                                    | 0.298             | 0.172               |
| Zinc (Zn)         | 65.39            | 419.53      | 907               | 108.1                   | 7.14                             | 30.2                                    | 0.388             | 1.16                |
| Zirconium (Zr)    | 91.22            | 1854.7      | 4409              | 230.2                   | 6.52                             | 5.7                                     | 0.278             | 0.227               |

<sup>a</sup> Estimated.<sup>b</sup> At 100 °C.

# THERMAL CONDUCTIVITY OF METALS AND SEMICONDUCTORS AS A FUNCTION OF TEMPERATURE

This table gives the temperature dependence of the thermal conductivity of several metals and of carbon, germanium, and silicon. For graphite, separate entries are given for the thermal conductivity parallel ( $\parallel$ ) and perpendicular ( $\perp$ ) to the layer planes. The thermal conductivity of all these materials is very sensitive to impurities at low temperatures, especially below 100 K. Therefore, the values given here should be regarded as typical values for a highly purified specimen; the thermal conductivity of different specimens can vary by more than an order of magnitude in the low-temperature range. See Reference 2 for details.

## References

1. Ho, C. Y., Powell, R. W., and Liley, P. E., *J. Phys. Chem. Ref. Data*, 1, 279, 1972.
2. White, G. K., and Minges, M. L., *Thermophysical Properties of Some Key Solids*, CODATA Bulletin No. 59, 1985.

| Thermal Conductivity in W/cm K |       |      |      |                |        |         |                    |         |        |      |
|--------------------------------|-------|------|------|----------------|--------|---------|--------------------|---------|--------|------|
| Carbon (C)                     |       |      |      |                |        |         |                    |         |        |      |
| T/K                            | Ag    | Al   | Au   | Diamond (type) |        |         | Pyrolytic graphite |         | Cr     | Cu   |
|                                |       |      |      | I              | IIa    | IIb     |                    | ⊥       |        |      |
| 1                              | 39.4  | 41.1 | 5.46 |                |        |         |                    |         | 0.402* | 42.2 |
| 2                              | 78.3  | 81.8 | 10.9 | 0.0138*        | 0.033* | 0.0200* |                    |         | 0.803  | 84.0 |
| 3                              | 115   | 121  | 16.1 | 0.0461         | 0.111  | 0.0676  |                    |         | 1.20   | 125  |
| 4                              | 147   | 157  | 20.9 | 0.108          | 0.261  | 0.160   |                    |         | 1.60   | 162  |
| 5                              | 172   | 188  | 25.2 | 0.206          | 0.494  | 0.307   |                    |         | 2.00   | 195  |
| 6                              | 187   | 213  | 28.5 | 0.344          | 0.820  | 0.510   |                    |         | 2.39   | 222  |
| 7                              | 193   | 229  | 30.9 | 0.523          | 1.24   | 0.778   |                    |         | 2.27   | 239  |
| 8                              | 190   | 237  | 32.3 | 0.762          | 1.77   | 1.12    |                    |         | 3.14   | 248  |
| 9                              | 181   | 239  | 32.7 | 1.05           | 2.41   | 1.53    |                    |         | 3.50   | 249  |
| 10                             | 168   | 235  | 32.4 | 1.40           | 3.17   | 2.03    | 0.811              | 0.0116  | 3.85   | 243  |
| 15                             | 96.0  | 176  | 24.6 | 3.96           | 8.65   | 5.66    |                    |         | 5.24   | 171  |
| 20                             | 51.0  | 117  | 15.8 | 7.87           | 16.8   | 11.2    | 4.20               | 0.0397  | 5.93   | 108  |
| 30                             | 19.3  | 49.5 | 7.55 | 18.8           | 38.9   | 26.5    | 9.86               | 0.0786  | 5.49   | 44.5 |
| 40                             | 10.5  | 24.0 | 5.15 | 29.4           | 65.9   | 44.0    | 16.4               | 0.120   | 4.25   | 21.7 |
| 50                             | 7.0   | 13.5 | 4.21 | 35.3           | 92.1   | 59.1    | 23.1               | 0.152   | 3.17   | 12.5 |
| 60                             | 5.5   | 8.5  | 3.74 | 37.4           | 112    | 67.5    | 29.8               | 0.173   | 2.48   | 8.29 |
| 70                             | 4.97  | 5.85 | 3.48 | 36.9           | 119    | 69.1    | 36.6               | 0.181   | 2.07   | 6.47 |
| 80                             | 4.71  | 4.32 | 3.32 | 35.1           | 117    | 65.7    | 42.8               | 0.181   | 1.84   | 5.57 |
| 90                             | 4.60  | 3.42 | 3.28 | 32.7           | 109    | 60.0    | 47.5               | 0.176   | 1.69   | 5.08 |
| 100                            | 4.50  | 3.02 | 3.27 | 30.0           | 100    | 54.2    | 49.7               | 0.168   | 1.59   | 4.82 |
| 150                            | 4.32  | 2.48 | 3.25 | 19.5           | 60.2   | 32.5    | 45.1               | 0.125   | 1.29   | 4.29 |
| 200                            | 4.30  | 2.37 | 3.23 | 14.1           | 40.3   | 22.6    | 32.3               | 0.0923  | 1.11   | 4.13 |
| 250                            | 4.29  | 2.35 | 3.21 | 11.0           | 29.7   | 17.0    | 24.4               | 0.0711  | 1.00   | 4.06 |
| 300                            | 4.29  | 2.37 | 3.17 | 8.95           | 23.0   | 13.5    | 19.5               | 0.0570  | 0.937  | 4.01 |
| 350                            | 4.27  | 2.40 | 3.14 | 7.55*          | 18.5*  | 11.1*   | 16.2               | 0.0477  | 0.929  | 3.96 |
| 400                            | 4.25  | 2.40 | 3.11 | 6.5*           | 15.4*  | 9.32*   | 13.9               | 0.0409  | 0.909  | 3.93 |
| 500                            | 4.19  | 2.36 | 3.04 |                |        |         | 10.8               | 0.0322  | 0.860  | 3.86 |
| 600                            | 4.12  | 2.31 | 2.98 |                |        |         | 8.92               | 0.0268  | 0.807  | 3.79 |
| 800                            | 3.96  | 2.18 | 2.84 |                |        |         | 6.67               | 0.0201  | 0.713  | 3.66 |
| 1000                           | 3.79  |      | 2.70 |                |        |         | 5.34               | 0.0160  | 0.654  | 3.52 |
| 1200                           | 3.61* |      | 2.55 |                |        |         | 4.48               | 0.0134  | 0.619  | 3.39 |
| 1400                           |       |      |      |                |        |         | 3.84               | 0.0116  | 0.588  |      |
| 1600                           |       |      |      |                |        |         | 3.33               | 0.0100  | 0.556  |      |
| 1800                           |       |      |      |                |        |         | 2.93               | 0.00895 | 0.526* |      |
| 2000                           |       |      |      |                |        |         | 2.62               | 0.00807 | 0.494* |      |

| <i>T</i> /K | Fe     | Ge <sup>a</sup> | Mg    | Ni    | Pb    | Pt     | Si <sup>a</sup> | Sn    | Ti      | W    |
|-------------|--------|-----------------|-------|-------|-------|--------|-----------------|-------|---------|------|
| 1           | 1.71   | 0.274           | 9.86  | 2.17  | 27.9  | 2.31   | 0.0693*         | 183   | 0.0144* | 14.4 |
| 2           | 3.42   | 2.06            | 19.6  | 4.34  | 44.6  | 4.60   | 0.454           | 323   | 0.0288* | 28.7 |
| 3           | 5.11   | 5.35            | 29.0  | 6.49  | 35.8  | 6.79   | 1.38            | 297   | 0.0432  | 42.8 |
| 4           | 6.77   | 8.77            | 37.6  | 8.59  | 22.2  | 8.8    | 2.97            | 181   | 0.0575  | 56.3 |
| 5           | 8.39   | 11.6            | 45.0  | 10.6  | 13.8  | 10.5   | 5.27            | 117   | 0.0719  | 68.7 |
| 6           | 9.93   | 13.9            | 50.8  | 12.5  | 8.10  | 11.8   | 8.23            | 76    | 0.0863  | 79.5 |
| 7           | 11.4   | 15.5            | 54.7  | 14.2  | 4.86  | 12.6   | 11.7            | 52    | 0.101   | 88.0 |
| 8           | 12.7   | 16.6            | 56.7  | 15.8  | 3.20  | 12.9   | 15.5            | 36    | 0.115   | 93.8 |
| 9           | 13.9   | 17.3            | 57.0  | 17.1  | 2.30  | 12.8   | 19.5            | 26    | 0.129   | 96.8 |
| 10          | 14.8   | 17.7            | 55.8  | 18.1  | 1.78  | 12.3   | 23.3            | 19.3  | 0.143   | 97.1 |
| 15          | 17.0   | 17.3            | 41.1  | 19.5  | 0.845 | 8.41   | 41.6            | 6.3   | 0.212   | 72.0 |
| 20          | 15.4   | 14.9            | 27.2  | 16.5  | 0.591 | 4.95   | 49.8            | 3.2   | 0.275   | 40.5 |
| 30          | 10.0   | 10.8            | 12.9  | 9.56  | 0.477 | 2.15   | 48.1            | 1.79  | 0.365   | 14.4 |
| 40          | 6.23   | 7.98            | 7.19  | 5.82  | 0.451 | 1.39   | 35.3            | 1.33  | 0.390   | 6.92 |
| 50          | 4.05   | 6.15            | 4.65  | 4.00  | 0.436 | 1.09   | 26.8            | 1.15  | 0.374   | 4.27 |
| 60          | 2.85   | 4.87            | 3.27  | 3.08  | 0.425 | 0.947  | 21.1            | 1.04  | 0.355   | 3.14 |
| 70          | 2.16   | 3.93            | 2.49  | 2.50  | 0.416 | 0.862  | 16.8            | 0.96  | 0.340   | 2.58 |
| 80          | 1.75   | 3.25            | 2.02  | 2.10  | 0.409 | 0.815  | 13.4            | 0.915 | 0.326   | 2.29 |
| 90          | 1.50   | 2.70            | 1.78  | 1.83  | 0.403 | 0.789  | 10.8            | 0.880 | 0.315   | 2.17 |
| 100         | 1.34   | 2.32            | 1.69  | 1.64  | 0.397 | 0.775  | 8.84            | 0.853 | 0.305   | 2.08 |
| 150         | 1.04   | 1.32            | 1.61  | 1.22  | 0.379 | 0.740  | 4.09            | 0.779 | 0.270   | 1.92 |
| 200         | 0.94   | 0.968           | 1.59  | 1.07  | 0.367 | 0.726  | 2.64            | 0.733 | 0.245   | 1.85 |
| 250         | 0.865  | 0.749           | 1.57  | 0.975 | 0.360 | 0.718  | 1.91            | 0.696 | 0.229   | 1.80 |
| 300         | 0.802  | 0.599           | 1.56  | 0.907 | 0.353 | 0.716  | 1.48            | 0.666 | 0.219   | 1.74 |
| 350         | 0.744  | 0.495           | 1.55  | 0.850 | 0.347 | 0.717  | 1.19            | 0.642 | 0.210   | 1.67 |
| 400         | 0.695  | 0.432           | 1.53  | 0.802 | 0.340 | 0.718  | 0.989           | 0.622 | 0.204   | 1.59 |
| 500         | 0.613  | 0.338           | 1.51  | 0.722 | 0.328 | 0.723  | 0.762           | 0.596 | 0.197   | 1.46 |
| 600         | 0.547  | 0.273           | 1.49  | 0.656 | 0.314 | 0.732  | 0.619           |       | 0.194   | 1.37 |
| 800         | 0.433  | 0.198           | 1.46* | 0.676 |       | 0.756  | 0.422           |       | 0.197   | 1.25 |
| 1000        | 0.323  | 0.174           |       | 0.718 |       | 0.787  | 0.312           |       | 0.207   | 1.18 |
| 1200        | 0.283  | 0.174           |       | 0.762 |       | 0.826  | 0.257           |       | 0.220   | 1.12 |
| 1400        | 0.312  |                 |       | 0.804 |       | 0.871  | 0.235           |       | 0.236   | 1.08 |
| 1600        | 0.330  |                 |       |       |       | 0.919  | 0.221           |       | 0.253   | 1.04 |
| 1800        | 0.345* |                 |       |       |       | 0.961  |                 |       | 0.270*  | 1.01 |
| 2000        |        |                 |       |       |       | 0.994* |                 |       |         | 0.98 |

<sup>a</sup> Values below 300 K are typical values.

\* Extrapolated.

# THERMAL CONDUCTIVITY OF ALLOYS AS A FUNCTION OF TEMPERATURE

This table lists the thermal conductivity of selected alloys at various temperatures. The indicated compositions refer to weight percent. Since the thermal conductivity is sensitive to exact composition and processing history, especially at low temperatures, these values should be considered approximate.

## References

1. Powell, R. L., and Childs, G. E., in *American Institute of Physics Handbook, 3rd Edition*, Gray, D. E., Ed., McGraw-Hill, New York, 1972.
2. Ho, C. Y., et al., *J. Phys. Chem. Ref. Data*, 7, 959, 1978.

|           |                               | Thermal conductivity in W/m K |      |      |       |       |       |       |       |
|-----------|-------------------------------|-------------------------------|------|------|-------|-------|-------|-------|-------|
|           | Alloy                         | 4 K                           | 20 K | 77 K | 194 K | 273 K | 373 K | 573 K | 973 K |
| Aluminum: | 1100                          | 50                            | 240  | 270  | 220   | 220   |       |       |       |
|           | 2024                          | 3.2                           | 17   | 56   | 95    | 130   |       |       |       |
|           | 3003                          | 11                            | 58   | 140  | 150   | 160   |       |       |       |
|           | 5052                          | 4.8                           | 25   | 77   | 120   | 140   |       |       |       |
|           | 5083, 5086                    | 3                             | 17   | 55   | 95    | 120   |       |       |       |
|           | Duralumin                     | 5.5                           | 30   | 91   | 140   | 160   | 180   |       |       |
| Bismuth:  | Rose metal                    |                               | 5.5  | 8.3  | 14    | 16    |       |       |       |
|           | Wood's metal                  | 4                             | 17   | 23   |       |       |       |       |       |
| Copper:   | electrolytic tough pitch      | 330                           | 1300 | 550  | 400   | 390   | 380   | 370   | 350   |
|           | free cutting, leaded          | 200                           | 800  | 460  | 380   | 380   |       |       |       |
|           | phosphorus, deoxidized        | 7.5                           | 42   | 120  | 190   | 220   |       |       |       |
|           | brass, leaded                 | 2.3                           | 12   | 39   | 70    | 120   |       |       |       |
|           | bronze, 68% Cu; 32% Zn        | 2.3                           | 16   | 48   | 92    | 110   |       |       |       |
|           | beryllium                     | 2                             | 17   | 36   | 70    | 90    | 113   | 172   |       |
|           | german silver                 | 0.75                          | 7.5  | 17   | 20    | 23    | 25    | 30    | 40    |
|           | silicon bronze A              |                               | 3.4  | 11   | 23    | 30    |       |       |       |
|           | manganin                      | 0.48                          | 3.2  | 14   | 17    | 22    |       |       |       |
|           | constantan                    | 0.9                           | 8.6  | 17   | 19    | 22    |       |       |       |
| Ferrous:  | commercial pure iron          | 15                            | 72   | 106  | 82    | 76    | 66    | 54    | 34    |
|           | plain carbon steel(AISI 1020) | 13                            | 20   | 58   | 65    | 65    |       |       |       |
|           | plain carbon steel(AISI 1095) |                               | 8.5  | 31   | 41    | 45    |       |       |       |
|           | 3% Ni; 0.7% Cr; 0.6% Mo       |                               | 6    | 22   |       | 33    | 35    | 36    | 30    |
|           | 4% Si                         |                               |      |      |       | 20    | 24    | 28    | 26    |
|           | stainless steel               | 0.3                           | 2    | 8    | 13    | 14    | 16    | 19    | 25    |
|           | 27% Ni; 15% Cr                |                               | 1.7  | 55   |       | 11    | 12    | 16    | 21    |
| Gold:     | colbalt thermocouple          | 1.2                           | 8.6  | 20   |       |       |       |       |       |
|           | 65% Au; 35% Ag                |                               | 12   | 24   |       | 61    | 89    |       |       |
| Indium:   | 85.5% In; 14.5% Pb            | 1.9                           | 7.8  | 24   | 41    |       |       |       |       |
| Lead:     | 60% Pb; 40% Sn (soft solder)  |                               | 28   | 44   |       |       |       |       |       |
|           | 64.35% Pb; 35.65% In          | 0.8                           | 3.26 | 9.1  |       | 20.2  |       |       |       |
| Nickel:   | 80% Ni; 20% Cr                |                               |      |      |       | 12    | 14    | 17    | 23    |
|           | contracid                     | 0.2                           | 2    | 7.3  | 9.5   | 13    |       |       |       |
|           | inconel                       | 0.5                           | 4.2  | 12.5 | 13    | 15    | 16    | 19    | 26    |
|           | monel                         | 0.9                           | 7.1  | 15   | 20    | 21    | 24    | 30    | 43    |
| Platinum: | 90% Pt; 10% Ir                |                               |      |      |       | 31    | 31.4  |       |       |
|           | 90% Pt; 10% Rh                |                               |      |      |       | 30.1  | 30.5  |       |       |
| Silver:   | silver solder                 |                               | 12   | 34   | 58    |       |       |       |       |
|           | normal Ag thermocouple        | 48                            | 230  | 310  |       |       |       |       |       |
| Tin:      | 60% Sn; 40% Pb                | 16                            | 55   | 51   |       |       |       |       |       |
| Titanium: | 5.5% Al; 2.5% Sn;0.2% Fe      |                               | 1.8  | 4.3  | 6.4   | 7.8   | 8.4   | 10.8  |       |
|           | 4.7% Mn; 3.99% Al; 0.14% C    |                               | 1.7  | 4.5  | 6.5   | 8.5   |       |       |       |

# THERMAL CONDUCTIVITY OF CRYSTALLINE DIELECTRICS

This table lists the thermal conductivity of a number of crystalline dielectrics, including some which find use as optical materials. Values are given at temperatures for which data are available.

## Reference

Powell, R. L., and Childs, G. E., in *American Institute of Physics Handbook, 3rd Edition*, Gray, D. E., Ed., McGraw-Hill, New York, 1972.

| Material                                   | T/K  | Ther. cond.<br>W/m K |
|--------------------------------------------|------|----------------------|
| AgCl                                       | 223  | 1.3                  |
|                                            | 273  | 1.2                  |
|                                            | 323  | 1.1                  |
|                                            | 373  | 1.1                  |
| Al,B silicate (tourmaline)                 | 398  | 2.9                  |
| to c axis                                  | 540  | 3.2                  |
|                                            | 723  | 3.5                  |
| Al,Be silicate (beryl)                     | 315  | 6.4                  |
| Al,F silicate (topaz)                      | 315  | 17.7                 |
| to c axis                                  | 358  | 15.6                 |
|                                            | 417  | 13.3                 |
| Al,Fe silicate (garnet)                    | 315  | 35.8                 |
|                                            | 358  | 35.4                 |
|                                            | 377  | 35.6                 |
| Al <sub>2</sub> O <sub>3</sub> (sapphire): |      |                      |
| 36° to c axis                              | 4.2  | 110                  |
|                                            | 20   | 3500                 |
|                                            | 35   | 6000                 |
|                                            | 77   | 1100                 |
| ⊥ to c axis                                | 373  | 2.6                  |
|                                            | 523  | 3.9                  |
|                                            | 773  | 5.8                  |
| Al <sub>2</sub> O <sub>3</sub> (sintered)  | 4.2  | 0.5                  |
|                                            | 20   | 23                   |
|                                            | 77   | 150                  |
|                                            | 194  | 48                   |
|                                            | 273  | 35                   |
|                                            | 373  | 26                   |
|                                            | 973  | 8                    |
| Ar                                         | 8    | 6.0                  |
|                                            | 10   | 3.7                  |
|                                            | 20   | 1.4                  |
|                                            | 77   | 0.31                 |
| As <sub>2</sub> S <sub>3</sub> (glass)     | 283  | 0.16                 |
|                                            | 323  | 0.21                 |
|                                            | 373  | 0.27                 |
| BN                                         | 1047 | 36.2                 |
|                                            | 1475 | 22.7                 |
|                                            | 1928 | 21.9                 |
|                                            | 2111 | 18.5                 |
| BaF <sub>2</sub>                           | 225  | 20                   |
|                                            | 260  | 13.4                 |
|                                            | 305  | 10.9                 |
|                                            | 370  | 10.5                 |
| BaTiO <sub>3</sub>                         | 5    | 4.2                  |
|                                            | 30   | 24.0                 |
|                                            | 40   | 25.0                 |
|                                            | 100  | 12.0                 |
|                                            | 250  | 4.8                  |
|                                            | 300  | 6.2                  |
| BeO                                        | 4.2  | 0.3                  |

| Material                                   | T/K   | Ther. cond.<br>W/m K |
|--------------------------------------------|-------|----------------------|
|                                            | 20    | 16                   |
|                                            | 77    | 270                  |
|                                            | 373   | 210                  |
|                                            | 573   | 120                  |
|                                            | 1273  | 29                   |
| Bi <sub>2</sub> Te <sub>3</sub>            | 80    | 6.4                  |
|                                            | 204   | 2.8                  |
|                                            | 303   | 3.6                  |
|                                            | 370   | 4.6                  |
| C (diamond)                                | 4.2   | 13                   |
| type I                                     | 20    | 800                  |
|                                            | 77    | 3550                 |
|                                            | 194   | 1450                 |
|                                            | 273   | 1000                 |
| CaCO <sub>3</sub>                          |       |                      |
| to c axis                                  | 83    | 25                   |
|                                            | 273   | 5.5                  |
| ⊥ to c axis                                | 83    | 17                   |
|                                            | 194   | 6.5                  |
|                                            | 273   | 4.6                  |
|                                            | 373   | 3.6                  |
| CaF <sub>2</sub>                           | 83    | 39                   |
|                                            | 223   | 18                   |
|                                            | 273   | 10                   |
|                                            | 323   | 9.2                  |
|                                            | 373   | 9                    |
| CaWO <sub>4</sub> (scheelite)              | 422   | 11.3                 |
| CdTe                                       | 160   | 7.0                  |
|                                            | 297   | 3.6                  |
|                                            | 422   | 2.9                  |
| CsBr                                       | 223   | 1.2                  |
|                                            | 273   | 0.94                 |
|                                            | 323   | 0.81                 |
|                                            | 373   | 0.77                 |
| CsI                                        | 223   | 1.4                  |
|                                            | 273   | 1.2                  |
|                                            | 323   | 1                    |
|                                            | 373   | 0.95                 |
| Cu <sub>2</sub> O (cuprite)                | 102   | 3.74                 |
|                                            | 163   | 7.76                 |
|                                            | 299   | 5.58                 |
|                                            | 360   | 4.86                 |
| Fe <sub>3</sub> O <sub>4</sub> (magnetite) | 4.5   | 27.4                 |
|                                            | 20.5  | 293.0                |
|                                            | 126.5 | 7.4                  |
|                                            | 304   | 7.0                  |
| Glass:                                     |       |                      |
| phoenix                                    | 4.2   | 0.095                |
|                                            | 20    | 0.13                 |
|                                            | 77    | 0.37                 |
| plastic perspex                            | 4.2   | 0.058                |



| Material                                    | T/K | Ther. cond.<br>W/m K | Material                                       | T/K             | Ther. cond.<br>W/m K |
|---------------------------------------------|-----|----------------------|------------------------------------------------|-----------------|----------------------|
| pyrex                                       | 20  | 0.074                | NaCl                                           | 4.2             | 440                  |
|                                             | 77  | 0.44                 |                                                | 20              | 300                  |
|                                             | 194 | 0.88                 |                                                | 77              | 30                   |
|                                             | 273 | 1                    |                                                | 273             | 6.4                  |
| H <sub>2</sub> (para + 0.5% ortho)          | 2.5 | 100                  | NaF                                            | 323             | 5.6                  |
|                                             | 3   | 150                  |                                                | 373             | 5.4                  |
|                                             | 4   | 200                  |                                                | 5               | 1100                 |
|                                             | 6   | 30                   |                                                | 50              | 250                  |
| H <sub>2</sub> O (ice)                      | 10  | 3                    | Ne                                             | 100             | 90                   |
|                                             | 173 | 3.5                  |                                                | 2               | 3.0                  |
|                                             | 223 | 2.8                  |                                                | 3               | 4.6                  |
|                                             | 273 | 2.2                  |                                                | 4.2             | 4.2                  |
| He <sup>3</sup> (high pressure)             | 0.6 | 25                   | NH <sub>4</sub> Cl                             | 10              | 0.8                  |
|                                             | 1   | 2                    |                                                | 20              | 0.3                  |
|                                             | 1.5 | 0.57                 |                                                | 77              | 17                   |
|                                             | 2   | 0.21                 |                                                | 194             | 23                   |
| He <sup>4</sup> (high pressure)             | 0.5 | 42                   | NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> | 230             | 38                   |
|                                             | 0.8 | 120                  |                                                | 273             | 27                   |
|                                             | 1   | 24                   |                                                | to optic axis   | 0.71                 |
|                                             | 2   | 0.18                 |                                                |                 |                      |
| I <sub>2</sub>                              | 300 | 0.45                 | NiO                                            | 339             | 0.71                 |
|                                             | 325 | 0.42                 |                                                | ⊥ to optic axis | 1.26                 |
|                                             | 350 | 0.4                  |                                                |                 |                      |
|                                             |     |                      |                                                | 342             | 1.34                 |
| KBr                                         | 2   | 150                  | SiO <sub>2</sub> (quartz)                      | 4.2             | 5.9                  |
|                                             | 4.2 | 360                  |                                                | 40              | 400                  |
|                                             | 100 | 12                   |                                                | 194             | 82                   |
|                                             | 273 | 5                    |                                                | to c axis       | 720                  |
| KCl                                         | 323 | 4.8                  |                                                |                 |                      |
|                                             | 373 | 4.8                  | SiO <sub>2</sub> (fused silica)                | 194             | 20                   |
|                                             | 4.2 | 500                  |                                                | 273             | 12                   |
|                                             | 25  | 140                  |                                                | ⊥ to c axis     | 370                  |
| KI                                          | 80  | 35                   |                                                |                 |                      |
|                                             | 194 | 10                   | SrTiO <sub>3</sub>                             | 194             | 10                   |
|                                             | 273 | 7.0                  |                                                | 273             | 6.8                  |
|                                             | 323 | 6.5                  |                                                | 4.2             | 0.25                 |
| Kr                                          | 373 | 6.3                  |                                                | 20              | 0.7                  |
|                                             | 4.2 | 700                  |                                                | 77              | 0.8                  |
|                                             | 80  | 13                   | TiBr                                           | 194             | 1.2                  |
|                                             | 194 | 4.6                  |                                                | 273             | 1.4                  |
| LaF <sub>3</sub>                            | 273 | 3.1                  |                                                | 373             | 1.6                  |
|                                             | 4.2 | 0.48                 |                                                | 673             | 1.8                  |
|                                             | 10  | 1.7                  | TiCl                                           | 5               | 2.4                  |
|                                             | 20  | 1.2                  |                                                | 30              | 21.0                 |
| LiF                                         | 77  | 0.36                 |                                                | 40              | 19.2                 |
|                                             | 78  | 7.8                  |                                                | 100             | 18.5                 |
|                                             | 197 | 5.0                  | TiO <sub>2</sub> (rutile)                      | 250             | 12.5                 |
|                                             | 274 | 5.4                  |                                                | 300             | 11.2                 |
| MgO·Al <sub>2</sub> O <sub>3</sub> (spinel) | 4.2 | 620                  |                                                | 316             | 0.59                 |
|                                             | 20  | 1800                 |                                                | 311             | 0.75                 |
|                                             | 77  | 150                  | to optic axis                                  | 4.2             | 200                  |
|                                             | 373 | 13                   |                                                |                 |                      |
| MnO                                         | 773 | 8.5                  |                                                | 20              | 1000                 |
|                                             | 4.2 | 0.25                 |                                                | 273             | 13                   |
|                                             | 40  | 55                   | ⊥ to optic axis                                | 4.2             | 160                  |
|                                             | 120 | 8                    |                                                | 20              | 690                  |
|                                             | 573 | 3.5                  |                                                | 273             | 9                    |

# THERMAL CONDUCTIVITY OF CERAMICS AND OTHER INSULATING MATERIALS

Thermal conductivity values for ceramics, refractory oxides, and miscellaneous insulating materials are given here. The thermal conductivity refers to samples with density indicated in the second column. Since most of these materials are highly variable, the values should only be considered as a rough guide.

## References

1. Powell, R. L., and Childs, G. E., in *American Institute of Physics Handbook, 3rd Edition*, Gray, D. E., Ed., McGraw-Hill, New York, 1972.
2. Perry, R. H., and Green, D., *Perry's Chemical Engineers' Handbook, Sixth Edition*, McGraw-Hill, New York, 1984.

| Material                                  | Dens.<br>g/cm <sup>3</sup> | t<br>°C | Ther. cond.<br>W/m K | Material                | Dens.<br>g/cm <sup>3</sup> | t<br>°C    | Ther. cond.<br>W/m K |
|-------------------------------------------|----------------------------|---------|----------------------|-------------------------|----------------------------|------------|----------------------|
| Alumina (Al <sub>2</sub> O <sub>3</sub> ) | 3.8                        | 100     | 30                   |                         | 0.5                        | 400        | 0.09                 |
|                                           |                            | 400     | 13                   |                         |                            | 0          | 0.09                 |
|                                           |                            | 1300    | 6                    |                         |                            | 400        | 0.16                 |
|                                           |                            | 1800    | 7.4                  |                         |                            |            |                      |
|                                           | 3.5                        | 100     | 17                   | Ebonite                 | 1.2                        | 0          | 0.16                 |
|                                           |                            | 800     | 7.6                  | Felt, flax              | 0.2                        | 30         | 0.05                 |
|                                           |                            |         |                      |                         | 0.3                        | 30         | 0.04                 |
|                                           |                            |         |                      | Fuller's earth          | 0.53                       | 30         | 0.1                  |
| Al <sub>2</sub> O <sub>3</sub> + MgO      |                            | 100     | 15                   | Glass wool              | 0.2                        | −200 to 20 | 0.005                |
|                                           |                            | 400     | 10                   |                         |                            | 50         | 0.04                 |
|                                           |                            | 1000    | 5.6                  |                         |                            | 100        | 0.05                 |
|                                           |                            |         |                      |                         |                            | 300        | 0.08                 |
| Asbestos                                  | 0.4                        | −100    | 0.07                 | Graphite                | 0.48                       | 40         | 0.18                 |
|                                           |                            | 0       | 0.09                 |                         |                            | 20-40 mesh | 1.29                 |
|                                           |                            | 100     | 0.10                 |                         |                            | 20         | 0.08                 |
|                                           |                            |         |                      |                         |                            | 100        | 36                   |
| Asbestos + 85% MgO                        | 0.3                        | 30      | 0.08                 | Magnesia (MgO)          |                            | 400        | 18                   |
| Asphalt                                   | 2.1                        | 20      | 0.06                 |                         |                            | 1200       | 5.8                  |
| Beryllia (BeO)                            | 2.8                        | 100     | 210                  |                         |                            | 1700       | 9.2                  |
|                                           |                            | 400     | 90                   |                         |                            | 100        | 5.3                  |
|                                           |                            | 1000    | 20                   | MgO + SiO <sub>2</sub>  |                            | 400        | 3.5                  |
|                                           |                            | 1800    | 15                   |                         |                            | 1500       | 2.3                  |
|                                           | 1.85                       | 50      | 64                   |                         |                            |            |                      |
|                                           |                            | 200     | 40                   | Mica:                   |                            | 100        | 0.72                 |
|                                           |                            | 600     | 23                   |                         |                            | 300        | 0.65                 |
| Brick, dry                                | 1.54                       | 0       | 0.04                 |                         |                            | 600        | 0.69                 |
|                                           |                            |         |                      |                         |                            | 100        | 0.66                 |
|                                           |                            |         |                      |                         |                            | 300        | 0.19                 |
|                                           |                            |         |                      |                         |                            | 600        | 0.2                  |
| Brick, refractory:                        |                            | 1000    | 1.3                  | Micanite                | 0.15                       | 30         | 0.04                 |
|                                           |                            | 400     | 1.2                  |                         |                            | −200 to 20 | 0.002                |
|                                           |                            | 1000    | 1.3                  | Plastics:               |                            | 20         | 1.4                  |
|                                           |                            |         |                      |                         |                            | 30         | 0.02                 |
| alosite                                   | 1.99                       | 100     | 0.2                  |                         |                            | −200 to 20 | 0.033                |
|                                           |                            | 500     | 0.24                 |                         |                            | −200 to 20 | 0.0001               |
|                                           |                            | 100     | 0.08                 |                         |                            | −253       | 0.10                 |
|                                           |                            | 500     | 0.1                  |                         |                            | −193       | 0.23                 |
| aluminous                                 | 0.77                       | 100     | 0.08                 | celluloid               | 1.4                        | 25         | 0.30                 |
|                                           |                            | 500     | 0.24                 |                         |                            | −253       | 0.13                 |
|                                           |                            | 100     | 0.08                 |                         |                            | −193       | 0.16                 |
|                                           |                            | 500     | 0.1                  |                         |                            | 25         | 0.26                 |
| diatomaceous                              | 0.4                        | 100     | 0.08                 | polystyrene foam        | 0.05                       | 230        | 2.5                  |
|                                           |                            | 500     | 0.24                 |                         |                            | 20         | 0.06                 |
|                                           |                            | 100     | 0.08                 |                         |                            | 90         | 1                    |
|                                           |                            | 500     | 0.1                  |                         |                            |            |                      |
| fireclay                                  | 2                          | 400     | 1                    | mylar foil              | 0.05                       | 20         | 2                    |
|                                           |                            | 1000    | 1.2                  |                         |                            | 20         | 0.92                 |
|                                           |                            | 200     | 2                    |                         |                            |            |                      |
|                                           |                            | 600     | 2.4                  |                         |                            |            |                      |
| silicon carbide                           | 2                          | 200     | 0.26                 | nylon                   |                            |            |                      |
|                                           |                            | 600     | 0.31                 |                         |                            |            |                      |
|                                           |                            | 200     | 0.26                 |                         |                            |            |                      |
|                                           |                            | 600     | 0.31                 |                         |                            |            |                      |
| vermiculite                               | 0.77                       | 100     | 16                   | polytetrafluoroethylene | 0.07                       |            |                      |
|                                           |                            | 400     | 9                    |                         |                            |            |                      |
|                                           |                            | 1000    | 7.5                  |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |
| Calcium oxide                             |                            | 90      | 0.55                 | urethane foam           |                            |            |                      |
|                                           |                            | 20      | 0.055                |                         |                            |            |                      |
|                                           |                            | 20      | 0.26                 |                         |                            |            |                      |
|                                           |                            | 0       | 0.8                  |                         |                            |            |                      |
| Cement mortar                             | 2                          | 0       | 0.03                 | Porcelain               |                            |            |                      |
|                                           |                            | 0       | 0.03                 |                         |                            |            |                      |
|                                           |                            | 100     | 0.04                 |                         |                            |            |                      |
|                                           |                            | 0       | 0.06                 |                         |                            |            |                      |
| Charcoal                                  | 0.2                        | 100     | 0.08                 | Rock:                   |                            |            |                      |
|                                           |                            | 30      | 0.04                 |                         |                            |            |                      |
|                                           |                            | 0       | 0.05                 |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |
| Coal                                      | 1.35                       | 20      | 0.26                 | basalt                  |                            |            |                      |
|                                           |                            | 0       | 0.8                  |                         |                            |            |                      |
|                                           |                            | 0       | 0.03                 |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |
| Concrete                                  | 1.6                        | 0       | 0.03                 | chalk                   |                            |            |                      |
|                                           |                            | 0       | 0.03                 |                         |                            |            |                      |
|                                           |                            | 100     | 0.04                 |                         |                            |            |                      |
|                                           |                            | 0       | 0.06                 |                         |                            |            |                      |
| Cork                                      | 0.05                       | 100     | 0.08                 |                         |                            |            |                      |
|                                           |                            | 30      | 0.04                 |                         |                            |            |                      |
|                                           |                            | 0       | 0.05                 |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |
| Cotton wool                               | 0.08                       | 30      | 0.04                 |                         |                            |            |                      |
|                                           |                            | 0       | 0.05                 |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |
| Diatomite                                 | 0.2                        | 0       | 0.05                 |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |
|                                           |                            |         |                      |                         |                            |            |                      |

| Material                   | Dens.<br>g/cm <sup>3</sup> | <i>t</i><br>°C | Ther. cond.<br>W/m K | Material                     | Dens.<br>g/cm <sup>3</sup> | <i>t</i><br>°C | Ther. cond.<br>W/m K |
|----------------------------|----------------------------|----------------|----------------------|------------------------------|----------------------------|----------------|----------------------|
| granite                    | 2.8                        | 20             | 2.2                  | Uranium dioxide              |                            | 100            | 9.8                  |
| limestone                  | 2                          | 20             | 1                    |                              |                            | 400            | 5.5                  |
| sandstone                  | 2.2                        | 20             | 1.3                  |                              |                            | 1000           | 3.4                  |
| slate, ⊥                   |                            | 95             | 1.4                  | Wood:                        |                            |                |                      |
| slate,                     |                            | 95             | 2.5                  | balsa, ⊥                     | 0.11                       | 30             | 0.04                 |
| Rubber:                    |                            |                |                      | fir, ⊥                       | 0.54                       | 20             | 0.14                 |
| sponge                     | 0.2                        | 20             | 0.05                 | fir,                         | 0.54                       | 20             | 0.35                 |
| 92 percent                 |                            | 25             | 0.16                 | oak                          |                            | 20             | 0.16                 |
| Sand, dry                  | 1.5                        | 20             | 0.33                 | plywood                      |                            | 20             | 0.11                 |
| Sawdust                    | 0.2                        | 30             | 0.06                 | pine, ⊥                      | 0.45                       | 60             | 0.11                 |
| Shellac                    |                            | 20             | 0.23                 | pine,                        | 0.45                       | 60             | 0.26                 |
| Silica aerogel             | 0.1                        | −200 to 20     | 0.003                | walnut, ⊥                    | 0.65                       | 20             | 0.14                 |
| Snow                       | 0.25                       | 0              | 0.16                 | Wool                         | 0.09                       | 30             | 0.04                 |
| Steel wool                 | 0.1                        | 55             | 0.09                 | Zinc oxide                   |                            | 200            | 17                   |
| Thoria (ThO <sub>2</sub> ) |                            | 100            | 10                   |                              |                            | 800            | 5.3                  |
|                            |                            | 400            | 5.8                  | Zirconia (ZrO <sub>2</sub> ) |                            | 100            | 2                    |
|                            |                            | 1500           | 2.4                  |                              |                            | 400            | 2                    |
| Titanium dioxide           |                            | 100            | 6.5                  |                              |                            | 1500           | 2.5                  |
|                            |                            | 400            | 3.8                  | Zirconia + silica            |                            | 200            | 5.6                  |
|                            |                            | 1200           | 3.3                  |                              |                            | 600            | 4.6                  |
|                            |                            |                |                      |                              |                            | 1500           | 3.7                  |

## THERMAL CONDUCTIVITY OF GLASSES

This table gives the composition of various types of glasses and of the variability of glasses, the data should be regarded as only the thermal conductivity  $k$  as a function of temperature. Because approximate.

| Type of glass                                        | Composition               |                                                                                           | $t$<br>°C | $k$<br>W/m K |
|------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------------|-----------|--------------|
|                                                      | SiO <sub>2</sub><br>(wt%) | Other oxides<br>(wt%)                                                                     |           |              |
| Vitreous silica                                      | 100                       |                                                                                           | -150      | 0.85         |
|                                                      |                           |                                                                                           | -100      | 1.05         |
|                                                      |                           |                                                                                           | -50       | 1.20         |
|                                                      |                           |                                                                                           | 0         | 1.30         |
|                                                      |                           |                                                                                           | 50        | 1.40         |
|                                                      |                           |                                                                                           | 100       | 1.50         |
| Vycor glass                                          | 96                        | B <sub>2</sub> O <sub>3</sub> 3                                                           | -100      | 1.00         |
|                                                      |                           |                                                                                           | 0         | 1.25         |
|                                                      |                           |                                                                                           | 100       | 1.40         |
| Pyrex type chemically-resistant borosilicate glasses | 80–81                     | B <sub>2</sub> O <sub>3</sub> 12–13                                                       | -100      | 0.90         |
|                                                      |                           | Na <sub>2</sub> O 4                                                                       | 0         | 1.10         |
|                                                      |                           | Al 2                                                                                      | 100       | 1.25         |
| Borosilicate crown glasses                           | 60–65                     | B <sub>2</sub> O <sub>3</sub> 15–20                                                       | -100      | 0.65–0.75    |
|                                                      |                           |                                                                                           | 0         | 0.90–0.95    |
|                                                      |                           |                                                                                           | 100       | 1.00–1.05    |
|                                                      | 65–70                     | B <sub>2</sub> O <sub>3</sub> 10–15                                                       | -100      | 0.75–0.80    |
|                                                      |                           |                                                                                           | 0         | 0.95–1.00    |
|                                                      |                           |                                                                                           | 100       | 1.05–1.15    |
|                                                      | 70–75                     | B <sub>3</sub> O <sub>3</sub> 5–10                                                        | -100      | 0.80–0.85    |
|                                                      |                           |                                                                                           | 0         | 1.05–1.10    |
|                                                      |                           |                                                                                           | 100       | 1.15–1.20    |
| Zinc crown glasses (i)                               | 55–65                     | ZnO 5–15<br>Remainder:<br>B <sub>2</sub> O <sub>3</sub> , Al <sub>2</sub> O <sub>3</sub>  | -100      | 0.88–0.92    |
|                                                      |                           |                                                                                           | 0         | 1.10–1.15    |
|                                                      |                           |                                                                                           | 100       | 1.15–1.25    |
|                                                      |                           | ZnO 5–15<br>Remainder:<br>Na <sub>2</sub> O, K <sub>2</sub> O                             | -100      | 0.60–0.70    |
|                                                      |                           |                                                                                           | 0         | 0.70–0.90    |
|                                                      |                           |                                                                                           | 100       | 0.85–0.95    |
|                                                      |                           | ZnO 15–25<br>Remainder:<br>B <sub>2</sub> O <sub>3</sub> , Al <sub>2</sub> O <sub>3</sub> | -100      | 0.88–0.92    |
|                                                      |                           |                                                                                           | 0         | 1.10–1.15    |
|                                                      |                           |                                                                                           | 100       | 1.15–1.20    |
|                                                      |                           | ZnO 15–25<br>Remainder:<br>Na <sub>2</sub> O, K <sub>2</sub> O                            | -100      | 0.65–0.80    |
|                                                      |                           |                                                                                           | 0         | 0.85–0.95    |
|                                                      |                           |                                                                                           | 100       | 0.90–1.05    |
| Zinc crown glasses (ii)                              | 65–75                     | ZnO 5–15<br>Remainder:<br>B <sub>2</sub> O <sub>3</sub> , Al <sub>2</sub> O <sub>3</sub>  | -100      | 0.88–0.92    |
|                                                      |                           |                                                                                           | 0         | 1.15–1.15    |
|                                                      |                           |                                                                                           | 100       | 1.20–1.30    |
|                                                      |                           | ZnO 5–15<br>Remainder:<br>Na <sub>2</sub> O, K <sub>2</sub> O                             | -100      | 0.70–0.85    |
|                                                      |                           |                                                                                           | 0         | 0.90–1.05    |
|                                                      |                           |                                                                                           | 100       | 1.00–1.15    |
|                                                      |                           | ZnO 15–25                                                                                 | -100      | 0.90–0.95    |

| Type of glass            | Composition               |                                                                              |                               | $t$<br>°C | $k$<br>W/m K |      |
|--------------------------|---------------------------|------------------------------------------------------------------------------|-------------------------------|-----------|--------------|------|
|                          | SiO <sub>2</sub><br>(wt%) | Other oxides<br>(wt%)                                                        |                               |           |              |      |
|                          |                           | Remainder:<br>B <sub>2</sub> O <sub>3</sub> , Al <sub>2</sub> O <sub>3</sub> |                               |           |              |      |
| Barium crown glasses     | 31                        | ZnO 15–25                                                                    |                               | –100      | 0.65–0.85    |      |
|                          |                           | Remainder:<br>Na <sub>2</sub> O, K <sub>2</sub> O                            |                               | 0         | 0.85–1.00    |      |
|                          |                           |                                                                              |                               | 100       | 1.05–1.20    |      |
|                          |                           |                                                                              |                               |           |              |      |
|                          |                           |                                                                              |                               |           |              |      |
|                          |                           |                                                                              |                               |           |              |      |
|                          | 41                        | B <sub>2</sub> O <sub>3</sub>                                                | 12                            | –100      | 0.55         |      |
|                          |                           | Al <sub>2</sub> O <sub>3</sub>                                               | 8                             | 0         | 0.70         |      |
|                          |                           | BaO                                                                          | 48                            | 100       | 0.80         |      |
|                          |                           |                                                                              |                               |           |              |      |
|                          | 47                        | B <sub>2</sub> O <sub>3</sub>                                                | 6                             | –100      | 0.60         |      |
|                          |                           | Al <sub>2</sub> O <sub>3</sub>                                               | 2                             | 0         | 0.75         |      |
|                          |                           | ZnO                                                                          | 8                             | 100       | 0.85         |      |
|                          |                           | BaO                                                                          | 43                            |           |              |      |
|                          | 65                        | B <sub>2</sub> O <sub>3</sub>                                                | 4                             | –100      | 0.65         |      |
|                          |                           | Na <sub>2</sub> O                                                            | 1                             | 0         | 0.75         |      |
|                          |                           | K <sub>2</sub> O                                                             | 7                             | 100       | 0.90         |      |
|                          |                           | ZnO                                                                          | 8                             |           |              |      |
|                          |                           | BaO                                                                          | 32                            |           |              |      |
|                          | Borate glasses            | 9                                                                            | B <sub>2</sub> O <sub>3</sub> | 2         | –100         | 0.70 |
|                          |                           |                                                                              | Na <sub>2</sub> O             | 5         | 0            | 0.90 |
|                          |                           |                                                                              | K <sub>2</sub> O              | 15        | 100          | 1.00 |
| ZnO                      |                           |                                                                              | 2                             |           |              |      |
| BaO                      |                           |                                                                              | 10                            |           |              |      |
| Borate flint glass       | 0                         | B <sub>2</sub> O <sub>3</sub>                                                | 36                            | –100      | 0.55         |      |
|                          |                           | Na <sub>2</sub> O                                                            | 1                             | 0         | 0.65         |      |
|                          |                           | K <sub>2</sub> O                                                             | 2                             | 100       | 0.80         |      |
|                          |                           | PbO                                                                          | 36                            |           |              |      |
|                          |                           | Al <sub>2</sub> O <sub>3</sub>                                               | 10                            |           |              |      |
|                          |                           | ZnO                                                                          | 6                             |           |              |      |
| Borate flint glass       | 0                         | B <sub>2</sub> O <sub>3</sub>                                                | 56                            | –100      | 0.50         |      |
|                          |                           | Al <sub>2</sub> O <sub>3</sub>                                               | 12                            | 0         | 0.65         |      |
|                          |                           | PbO                                                                          | 32                            | 100       | 0.85         |      |
| Borate flint glass       | 0                         | B <sub>2</sub> O <sub>3</sub>                                                | 43                            | –100      | 0.40         |      |
|                          |                           | Al <sub>2</sub> O <sub>3</sub>                                               | 5                             | 0         | 0.55         |      |
|                          |                           | PbO                                                                          | 52                            | 100       | 0.70         |      |
| Borate glass             | 4                         | B <sub>2</sub> O <sub>3</sub>                                                | 55                            | –100      | 0.65         |      |
|                          |                           | Al <sub>2</sub> O <sub>3</sub>                                               | 14                            | 0         | 0.80         |      |
|                          |                           | PbO                                                                          | 11                            | 100       | 0.90         |      |
|                          |                           | K <sub>2</sub> O                                                             | 4                             |           |              |      |
|                          |                           | ZnO                                                                          | 12                            |           |              |      |
| Borate crown glass       | 0                         | B <sub>2</sub> O <sub>3</sub>                                                | 64                            | –100      | 0.50         |      |
|                          |                           | Na <sub>2</sub> O                                                            | 8                             | 0         | 0.65         |      |
|                          |                           | K <sub>2</sub> O                                                             | 3                             | 100       | 0.85         |      |
|                          |                           | BaO                                                                          | 4                             |           |              |      |
|                          |                           | PbO                                                                          | 3                             |           |              |      |
|                          |                           | Al <sub>2</sub> O <sub>3</sub>                                               | 18                            |           |              |      |
| Light borate crown glass | 0                         | B <sub>2</sub> O <sub>3</sub>                                                | 69                            | –100      | 0.55         |      |
|                          |                           | Na <sub>2</sub> O                                                            | 8                             | 0         | 0.70         |      |

| Type of glass               | Composition               |                                | $t$<br>°C | $k$<br>W/m K |           |
|-----------------------------|---------------------------|--------------------------------|-----------|--------------|-----------|
|                             | SiO <sub>2</sub><br>(wt%) | Other oxides                   |           |              |           |
|                             |                           | (wt%)                          |           |              |           |
| Zinc borate glass           | 0                         | BaO                            | 5         | 100          | 0.90      |
|                             |                           | Al <sub>2</sub> O <sub>3</sub> | 18        |              |           |
|                             |                           | B <sub>2</sub> O <sub>3</sub>  | 40        | −100         | 0.65      |
|                             |                           | ZnO                            | 60        | 0            | 0.75      |
|                             |                           |                                |           | 100          | 0.85      |
| Phosphate crown glasses     |                           |                                |           |              |           |
| Potash phosphate glass      | 0                         | P <sub>2</sub> O <sub>5</sub>  | 70        | 0            | 0.75      |
|                             |                           | B <sub>2</sub> O <sub>3</sub>  | 3         | 100          | 0.85      |
|                             |                           | K <sub>2</sub> O               | 12        |              |           |
|                             |                           | Al <sub>2</sub> O <sub>3</sub> | 10        |              |           |
|                             |                           | MgO                            | 4         |              |           |
| Baryta phosphate glass      | 0                         | P <sub>2</sub> O <sub>5</sub>  | 60        | 45           | 0.75      |
|                             |                           | B <sub>2</sub> O <sub>3</sub>  | 3         |              |           |
|                             |                           | Al <sub>2</sub> O <sub>3</sub> | 8         |              |           |
|                             |                           | BaO                            | 28        |              |           |
| Soda-lime glasses           | 75                        | Na <sub>2</sub> O              | 17        | −100         | 0.75      |
|                             |                           | CaO                            | 8         | 0            | 0.95      |
|                             |                           |                                |           | 100          | 1.10      |
|                             | 75                        | Na <sub>2</sub> O              | 12        | −100         | 0.90      |
|                             |                           | CaO                            | 13        | 0            | 1.10      |
|                             |                           |                                |           | 100          | 1.15      |
|                             | 72                        | Na <sub>2</sub> O              | 15        | −100         | 0.80      |
|                             |                           | CaO                            | 11        | 0            | 1.00      |
|                             |                           | Al <sub>2</sub> O <sub>3</sub> | 2         | 100          | 1.15      |
|                             | 65                        | Na <sub>2</sub> O              | 25        | −100         | 0.65      |
|                             |                           | CaO                            | 10        | 0            | 0.85      |
|                             |                           |                                |           | 100          | 0.95      |
|                             | 65                        | Na <sub>2</sub> O              | 15        | −100         | 0.85      |
|                             |                           | CaO                            | 20        | 0            | 1.00      |
|                             |                           |                                |           | 100          | 1.10      |
|                             | 60                        | Na <sub>2</sub> O              | 20        | −100         | 0.75      |
|                             |                           | CaO                            | 20        | 0            | 0.90      |
|                             |                           |                                |           | 100          | 1.00      |
| Other crown glasses         |                           |                                |           |              |           |
| Crown glass                 | 75                        | Na <sub>2</sub> O              | 9         | −100         | 0.80      |
|                             |                           | K <sub>2</sub> O               | 11        | 0            | 1.00      |
|                             |                           | CaO                            | 5         | 100          | 1.10      |
| High dispersion crown glass | 68                        | Na <sub>2</sub> O              | 16        | −100         | 0.65      |
|                             |                           | ZnO                            | 3         | 0            | 0.85      |
|                             |                           | PbO                            | 13        | 100          | 1.00      |
| Miscellaneous flint glasses |                           |                                |           |              |           |
| (i) Silicate flint glasses  |                           |                                |           |              |           |
| Light flint glasses         | 65                        | PbO                            | 25        | −100         | 0.65–0.70 |
|                             |                           | Others                         | 10        | 0            | 0.88–0.92 |
|                             |                           |                                |           | 100          | 1.00–1.05 |
|                             | 55                        | PbO                            | 35        | −100         | 0.60–0.65 |

| Type of glass                 | Composition               |                                   | $t$<br>°C | $k$<br>W/m K |
|-------------------------------|---------------------------|-----------------------------------|-----------|--------------|
|                               | SiO <sub>2</sub><br>(wt%) | Other oxides                      |           |              |
|                               |                           | (wt%)                             |           |              |
|                               |                           | Others 10                         | 0         | 0.75–0.85    |
|                               |                           |                                   | 100       | 0.88–0.92    |
| Ordinary flint glass          | 45                        | PbO 45                            | –100      | 0.50–0.60    |
|                               |                           | Others 10                         | 0         | 0.65–0.75    |
|                               |                           |                                   | 100       | 0.80–0.85    |
| Heavy flint glass             | 35                        | PbO 60                            | –100      | 0.45–0.50    |
|                               |                           | Others 5                          | 0         | 0.60–0.65    |
|                               |                           |                                   | 100       | 0.70–0.75    |
| Very heavy flint glasses      | 25                        | PbO 73                            | –100      | 0.40–0.45    |
|                               |                           | Others 2                          | 0         | 0.55–0.60    |
|                               |                           |                                   | 100       | 0.63–0.67    |
|                               | 20                        | PbO 80                            | –100      | 0.40         |
|                               |                           |                                   | 0         | 0.50         |
|                               |                           |                                   | 100       | 0.60         |
| (ii) Borosilicate flint glass | 33                        | B <sub>2</sub> O <sub>3</sub> 31  | –100      | 0.65         |
|                               |                           | PbO 25                            | 0         | 0.85         |
|                               |                           | Al <sub>2</sub> O <sub>3</sub> 7  | 100       | 0.95         |
|                               |                           | K <sub>2</sub> O 3                |           |              |
|                               |                           | Na <sub>2</sub> O 1               |           |              |
| (iii) Barium flint glass      | 50                        | BaO 24                            | –100      | 0.60         |
|                               |                           | PbO 6                             | 0         | 0.70         |
|                               |                           | K <sub>2</sub> O 8                | 100       | 0.85         |
|                               |                           | Na <sub>2</sub> O 3               |           |              |
|                               |                           | ZnO 8                             |           |              |
|                               |                           | Sb <sub>2</sub> O <sub>3</sub> 1  |           |              |
| Other glasses                 |                           |                                   |           |              |
| Potassium glass               | 59                        | K <sub>2</sub> O 33               | 50        | 0.88–0.92    |
|                               |                           | CaO 8                             |           |              |
| Iron glasses                  | 63                        | Fe <sub>2</sub> O <sub>3</sub> 10 | –100      | 0.80         |
|                               |                           | Na <sub>2</sub> O 17              | 0         | 0.95         |
|                               |                           | MgO 4                             | 100       | 1.05         |
|                               |                           | CaO 3                             |           |              |
|                               |                           | Al <sub>2</sub> O <sub>3</sub> 2  |           |              |
|                               | 67                        | Fe <sub>2</sub> O <sub>3</sub> 15 | 0         | 0.88–0.92    |
|                               |                           | Na <sub>2</sub> O <sub>3</sub> 18 | 100       | 1.00–1.05    |
|                               | 62                        | Fe <sub>2</sub> O <sub>3</sub> 20 | 0         | 0.85–0.90    |
|                               |                           | Na <sub>2</sub> O 18              | 100       | 0.95–1.00    |
|                               |                           |                                   |           |              |
| Rock glasses                  |                           |                                   |           |              |
| Obsidian                      |                           |                                   | 0         | 1.35         |
| Artificial diabase            |                           |                                   | 100       | 1.25         |

## PROPERTIES OF COMMERCIAL METALS AND ALLOYS

This table gives typical values of mechanical, thermal, and electrical properties of several common commercial metals and alloys. Values refer to ambient temperature (0 to 25 °C). All values should be regarded as typical, since these properties are dependent on the particular type of alloy, heat treatment, and other factors. Values for individual specimens can vary widely.

### References

1. *ASM Metals Reference Book, Second Edition*, American Society for Metals, Metals Park, OH, 1983.
2. Lynch, C. T., *CRC Practical Handbook of Materials Science*, CRC Press, Boca Raton, FL, 1989.
3. Shackelford, J. F., and Alexander, W., *CRC Materials Science and Engineering Handbook*, CRC Press, Boca Raton, FL, 1991.

| Common name                         | Thermal conductivity<br>W/cm K | Density<br>g/cm <sup>3</sup> | Coeff. of linear expansion<br>10 <sup>-6</sup> /°C | Electrical resistivity<br>μΩ cm | Modulus of elasticity<br>GPa | Tensile strength<br>MPa | Approx. melting point<br>°C |
|-------------------------------------|--------------------------------|------------------------------|----------------------------------------------------|---------------------------------|------------------------------|-------------------------|-----------------------------|
| Ingot iron                          | 0.7                            | 7.86                         | 11.7                                               | 9.7                             | 205                          | –                       | 1540                        |
| Plain carbon steel<br>AISI-SAE 1020 | 0.52                           | 7.86                         | 11.7                                               | 18                              | 205                          | 450                     | 1515                        |
| Stainless steel type 304            | 0.15                           | 7.9                          | 17.3                                               | 72                              | 195                          | 550                     | 1425                        |
| Cast gray iron                      | 0.47                           | 7.2                          | 10.5                                               | 67                              | 90                           | 180                     | 1175                        |
| Malleable iron                      |                                | 7.3                          | 12                                                 | 30                              | 170                          | 345                     | 1230                        |
| Hastelloy C                         | 0.12                           | 8.94                         | 11.3                                               | 125                             | 200                          | 780                     | 1350                        |
| Inconel                             | 0.15                           | 8.25                         | 11.5                                               | 103                             | 200                          | 800                     | 1370                        |
| Aluminum alloy 3003, rolled         | 1.9                            | 2.73                         | 23.2                                               | 3.7                             | 70                           | 110                     | 650                         |
| Aluminum alloy 2014, annealed       | 1.9                            | 2.8                          | 23.0                                               | 3.4                             | 70                           | 185                     | 650                         |
| Aluminum alloy 360                  | 1.5                            | 2.64                         | 21.0                                               | 7.5                             | 70                           | 325                     | 565                         |
| Copper, electrolytic (ETP)          | 3.9                            | 8.94                         | 16.5                                               | 1.7                             | 120                          | 300                     | 1080                        |
| Yellow brass (high brass)           | 1.2                            | 8.47                         | 20.3                                               | 6.4                             | 100                          | 300-800                 | 930                         |
| Aluminum bronze                     | 0.7                            | 7.8                          | 16.4                                               | 12                              | 120                          | 400-600                 | 1050                        |
| Beryllium copper 25                 | 0.8                            | 8.23                         | 17.8                                               | 7                               | 130                          | 500-1400                | 925                         |
| Cupronickel 30%                     | 0.3                            | 8.94                         | 16.2                                               |                                 | 150                          | 400-600                 | 1200                        |
| Red brass, 85%                      | 1.6                            | 8.75                         | 18.7                                               | 11                              | 90                           | 300-700                 | 1000                        |
| Chemical lead                       | 0.35                           | 11.34                        | 29.3                                               | 21                              | 13                           | 17                      | 327                         |
| Antimonial lead (hard lead)         | 0.3                            | 10.9                         | 26.5                                               | 23                              | 20                           | 47                      | 290                         |
| Solder 50-50                        | 0.5                            | 8.89                         | 23.4                                               | 15                              | –                            | 42                      | 215                         |
| Magnesium alloy AZ31B               | 1.0                            | 1.77                         | 26                                                 | 9                               | 45                           | 260                     | 620                         |
| Monel                               | 0.3                            | 8.84                         | 14.0                                               | 58                              | 180                          | 545                     | 1330                        |
| Nickel (commercial)                 | 0.9                            | 8.89                         | 13.3                                               | 10                              | 200                          | 460                     | 1440                        |
| Cupronickel 55-45 (constantan)      | 0.2                            | 8.9                          | 18.8                                               | 49                              | 160                          | –                       | 1260                        |
| Titanium (commercial)               | 1.8                            | 4.5                          | 8.5                                                | 43                              | 110                          | 330-500                 | 1670                        |
| Zinc (commercial)                   | 1.1                            | 7.14                         | 32.5                                               | 6                               | –                            | 130                     | 419                         |
| Zirconium (commercial)              | 0.2                            | 6.5                          | 5.85                                               | 41                              | 95                           | 450                     | 1855                        |



## HARDNESS OF MINERALS AND CERAMICS

There are several hardness scales for describing the resistance of a material to indentation or scratching. This table lists a number of common materials in order of increasing hardness. Values are given, when available, on three different hardness scales: the original Mohs Scale (range 1 to 10); the modified Mohs Scale (range 1

to 15), and the Knoop Hardness Scale. In the last case, a load of 100 g is assumed.

### Reference

Shackelford, J. F. and Alexander, W., *CRC Materials Science and Engineering Handbook*, CRC Press, Boca Raton, FL, 1991.

| Material                      | Formula                                                            | Mohs | Modified mohs | Knoop |
|-------------------------------|--------------------------------------------------------------------|------|---------------|-------|
| Graphite                      | C                                                                  | 0.5  |               |       |
| Talc                          | 3MgO·4SiO <sub>2</sub> ·H <sub>2</sub> O                           | 1    | 1             |       |
| Alabaster                     | CaSO <sub>4</sub> ·2H <sub>2</sub> O                               | 1.7  |               |       |
| Gypsum                        | CaSO <sub>4</sub> ·2H <sub>2</sub> O                               | 2    | 2             | 32    |
| Halite (rock salt)            | NaCl                                                               | 2    |               |       |
| Stibnite (antimonite)         | Sb <sub>2</sub> S <sub>3</sub>                                     | 2.0  |               |       |
| Galena                        | PbS                                                                | 2.5  |               |       |
| Mica                          |                                                                    | 2.8  |               |       |
| Calcite                       | CaCO <sub>3</sub>                                                  | 3    | 3             | 135   |
| Barite                        | BaSO <sub>4</sub>                                                  | 3.3  |               |       |
| Marble                        |                                                                    | 3.5  |               |       |
| Aragonite                     | CaCO <sub>3</sub>                                                  | 3.5  |               |       |
| Dolomite                      | CaMg(CO <sub>3</sub> ) <sub>2</sub>                                | 3.5  |               |       |
| Fluorite                      | CaF <sub>2</sub>                                                   | 4    | 4             | 163   |
| Magnesia                      | MgO                                                                | 5    |               | 370   |
| Apatite                       | CaF <sub>2</sub> ·3Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> | 5    | 5             | 430   |
| Opal                          |                                                                    | 5    |               |       |
| Feldspar (orthoclase)         | K <sub>2</sub> O·Al <sub>2</sub> O <sub>3</sub> ·6SiO <sub>2</sub> | 6    | 6             | 560   |
| Augite                        |                                                                    | 6    |               |       |
| Hematite                      | Fe <sub>2</sub> O <sub>3</sub>                                     | 6    |               | 750   |
| Magnetite                     | Fe <sub>3</sub> O <sub>4</sub>                                     | 6    |               |       |
| Rutile                        | TiO <sub>2</sub>                                                   | 6.2  |               |       |
| Pyrite                        | FeS <sub>2</sub>                                                   | 6.3  |               |       |
| Agate                         | SiO <sub>2</sub>                                                   | 6.5  |               |       |
| Uranium dioxide               | UO <sub>2</sub>                                                    | 6.7  |               | 600   |
| Silica (fused)                | SiO <sub>2</sub>                                                   |      | 7             |       |
| Quartz                        | SiO <sub>2</sub>                                                   | 7    | 8             | 820   |
| Flint                         |                                                                    | 7    |               |       |
| Silicon                       | Si                                                                 | 7    |               |       |
| Andalusite                    | Al <sub>2</sub> OSiO <sub>4</sub>                                  | 7.5  |               |       |
| Zircon                        | ZrSiO <sub>4</sub>                                                 | 7.5  |               |       |
| Zirconia                      | ZrO <sub>2</sub>                                                   |      |               | 1200  |
| Aluminum nitride              | AlN                                                                |      |               | 1225  |
| Beryl                         | Be <sub>3</sub> Al <sub>2</sub> Si <sub>6</sub> O <sub>18</sub>    | 7.8  |               |       |
| Beryllia                      | BeO                                                                |      |               | 1300  |
| Topaz                         | Al <sub>2</sub> SiO <sub>4</sub> (OH,F) <sub>2</sub>               | 8    | 9             | 1340  |
| Garnet                        | Al <sub>2</sub> O <sub>3</sub> ·3FeO·3SiO <sub>2</sub>             |      | 10            | 1360  |
| Emery                         | Al <sub>2</sub> O <sub>3</sub> (impure)                            | 8    |               |       |
| Zirconium nitride             | ZrN                                                                | 8+   |               | 1510  |
| Zirconium boride              | ZrB <sub>2</sub>                                                   |      |               | 1560  |
| Titanium nitride              | TiN                                                                | 9    |               | 1770  |
| Zirconia (fused)              | ZrO <sub>2</sub>                                                   |      | 11            |       |
| Tantalum carbide              | TaC                                                                |      |               | 1800  |
| Tungsten carbide              | WC                                                                 |      |               | 1880  |
| Corundum (alumina)            | Al <sub>2</sub> O <sub>3</sub>                                     | 9    |               | 2025  |
| Zirconium carbide             | ZrC                                                                |      |               | 2150  |
| Alumina (fused)               | Al <sub>2</sub> O <sub>3</sub>                                     |      | 12            |       |
| Beryllium carbide             | Be <sub>2</sub> C                                                  |      |               | 2400  |
| Titanium carbide              | TiC                                                                |      |               | 2470  |
| Carborundum (silicon carbide) | SiC                                                                | 9.3  | 13            | 2500  |
| Aluminum boride               | AlB                                                                |      |               | 2500  |
| Tantalum boride               | TaB <sub>2</sub>                                                   |      |               | 2600  |
| Boron carbide                 | B <sub>4</sub> C                                                   |      | 14            | 2800  |
| Boron                         | B                                                                  | 9.5  |               |       |
| Titanium boride               | TiB <sub>2</sub>                                                   |      |               | 2850  |
| Diamond                       | C                                                                  | 10   | 15            | 7000  |

# ORGANIC MAGNETS

J.S. Miller

Magnetic ordering, e.g., ferromagnetism, like superconductivity, is a property of a solid, not of an individual molecule or ion, and very rarely occurs for organic compounds. In contrast to superconductivity, where all electron spins pair to form a perfect diamagnetic material, magnetic ordering requires unpaired electron spins; hence, superconductivity and ferromagnetism are mutually exclusive.

The vast majority of organic compounds are diamagnetic (i.e., all electron spins are paired), and a relative few possess unpaired electrons (designated by an arrow,  $\uparrow$ ) and are paramagnetic (PM), i.e., they are oriented in random directions. A few organic solids, however, exhibit strong magnetic behavior and magnetically order as ferromagnets (FO) with all spins aligned in the same direc-

tion. In some cases the spins align in the opposite direction and compensate to form an antiferromagnet (AF). In some cases these spins are not opposed to each other and do not compensate and lead to a canted antiferromagnet or weak ferromagnet (WF). If the number of spins that align in one direction differs from the number of spins that align in the opposite direction, the spins cannot compensate and a ferrimagnet (FI) results. Metamagnets (MM) are antiferromagnets in which all the spins become aligned like a ferromagnet in an applied magnetic field. Above the ordering or critical temperature,  $T_c$ , all magnets are paramagnets (PM). Organic magnets all possess electron spins in  $p$ -orbitals, but these may be in conjunction with metal ion-based spins.

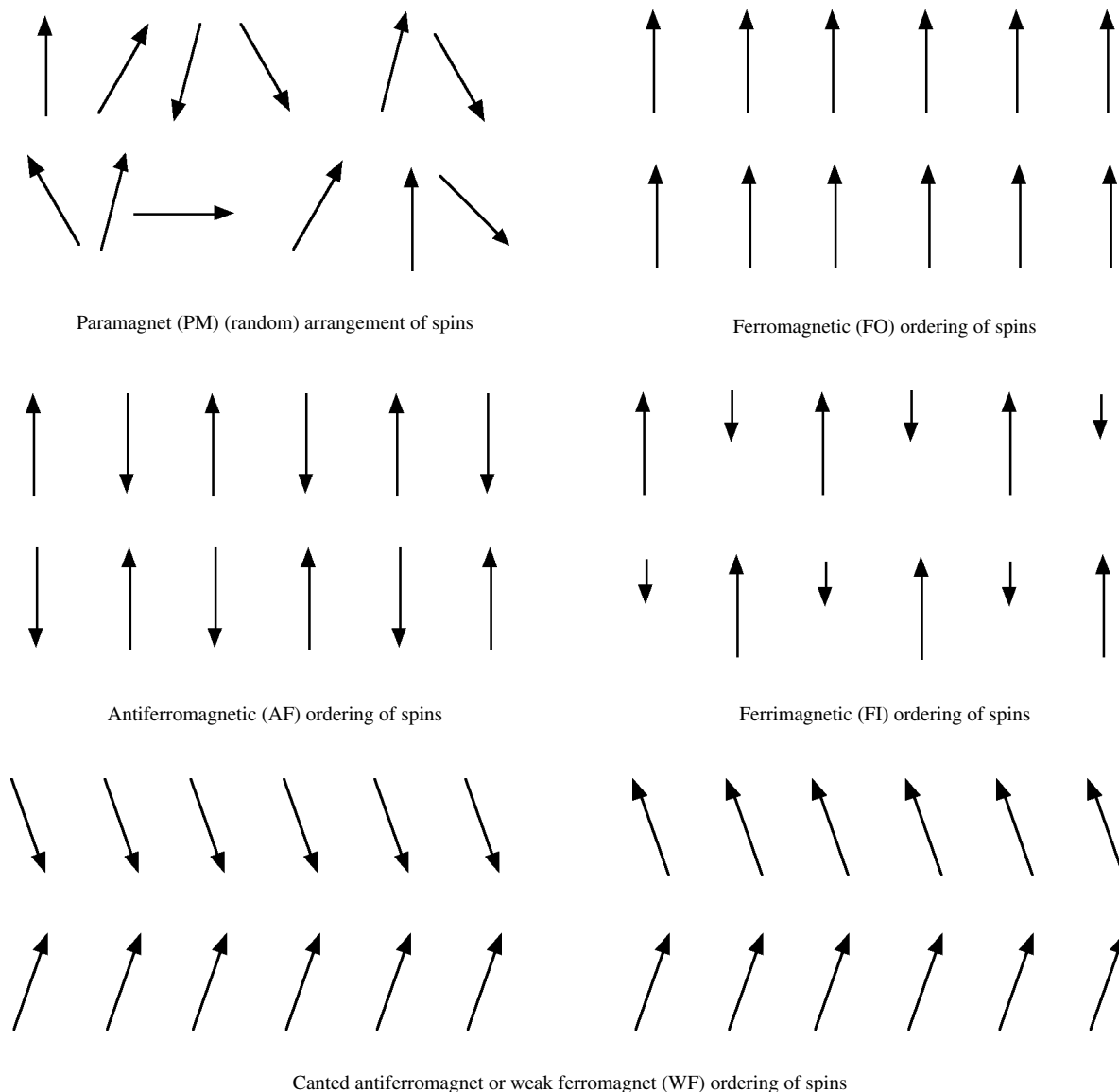


FIGURE 1. Schematic illustration of the different types of magnetic behavior.

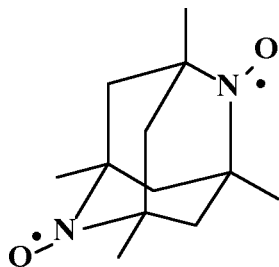
**Summary of the Critical Temperature,  $T_c$ , Saturation Magnetization,  $M_s$ , Coercive Field,  $H_{cr}$ , and Remanent Magnetization,  $M_r$ , for Selected Organic-Based Magnets**

| Magnet                                                                                                                                                  | Type | $T_c$ /K | $M_s$ /A m <sup>-1</sup> | $H_{cr}$ /T    | $M_r$ /A m <sup>-1</sup> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------|--------------------------|----------------|--------------------------|
| $\alpha$ -1,3,5,7-Tetramethyl-2,6-diazaadamantane- $N,N'$ -doxyl                                                                                        | FO   | 1.48     | 48,300                   | <0.00001       | —                        |
| $\beta$ -2-(4'-Nitrophenyl)-4,4,5,5-tetramethyl-4,5-dihydro-1H-imidazol-1-oxyl-3- $N$ -oxide                                                            | FO   | 0.6      | 22,300                   | 0.00008        | <200                     |
| {Fe <sup>III</sup> [C <sub>5</sub> (CH <sub>3</sub> ) <sub>5</sub> ] <sub>2</sub> }[TCNE]                                                               | FO   | 4.8      | 37,600                   | 0.10           | 2,300                    |
| {Mn <sup>III</sup> [C <sub>5</sub> (CH <sub>3</sub> ) <sub>5</sub> ] <sub>2</sub> }[TCNE]                                                               | FO   | 8.8      | 58,200                   | 0.12           | 3,700                    |
| {Cr <sup>III</sup> [C <sub>5</sub> (CH <sub>3</sub> ) <sub>5</sub> ] <sub>2</sub> }[TCNE]                                                               | FO   | 3.65     | 46,300                   | —              | —                        |
| $\alpha$ -{Fe <sup>III</sup> [C <sub>5</sub> (CH <sub>3</sub> ) <sub>5</sub> ] <sub>2</sub> }[TCNQ]                                                     | MM   | 2.55     | 34,200                   | —              | —                        |
| $\beta$ -{Fe <sup>III</sup> [C <sub>5</sub> (CH <sub>3</sub> ) <sub>5</sub> ] <sub>2</sub> }[TCNQ]                                                      | FO   | 3.0      | 21,600                   | —              | —                        |
| Tanol subarate                                                                                                                                          | MM   | 0.38     | 20,700                   | —              | —                        |
| NCC <sub>6</sub> F <sub>4</sub> CN <sub>2</sub> S <sub>2</sub>                                                                                          | WF   | 35.5     | 45                       | 0.00009        | —                        |
| Mn <sup>II</sup> (hfac) <sub>2</sub> NITC <sub>2</sub> H <sub>5</sub>                                                                                   | FI   | 7.8      | 39,400                   | 0.03           | 27,600                   |
| Mn <sup>II</sup> (hfac) <sub>2</sub> NIT( <i>i</i> -C <sub>3</sub> H <sub>8</sub> )                                                                     | FI   | 7.6      | 42,400                   | <0.0005        | <420                     |
| [Mn(hfac) <sub>2</sub> ] <sub>3</sub> {[ON[C <sub>6</sub> H <sub>3</sub> ( <i>t</i> -C(CH <sub>3</sub> ) <sub>3</sub> ) <sub>2</sub> NO] <sub>2</sub> } | FI   | 46       | 24,400                   | —              | —                        |
| [MnTPP][TCNE]·2C <sub>6</sub> H <sub>5</sub> CH <sub>3</sub>                                                                                            | FI   | 13       | 18,400                   | 2.4            | 10,300                   |
| V[TCNE] <sub><i>x,y</i></sub> CH <sub>2</sub> Cl <sub>2</sub> ( <i>x</i> ~ 2; <i>y</i> ~ 0.5)                                                           | FI   | ~400     | 28,200                   | 0.0015 - 0.006 | 1,650                    |
| Mn[TCNE] <sub><i>x,y</i></sub> CH <sub>2</sub> Cl <sub>2</sub> ( <i>x</i> ~ 2; <i>y</i> ~ 0.5)                                                          | FI   | 75       | 52,000                   | 0.002          | 270                      |
| Fe[TCNE] <sub><i>x,y</i></sub> CH <sub>2</sub> Cl <sub>2</sub> ( <i>x</i> ~ 2; <i>y</i> ~ 0.5)                                                          | FI   | 97       | 46,300                   | 0.23           | 3                        |
| Co[TCNE] <sub><i>x,y</i></sub> CH <sub>2</sub> Cl <sub>2</sub> ( <i>x</i> ~ 2; <i>y</i> ~ 0.5)                                                          | FI   | 44       | 22,000                   | 0.65           | —                        |

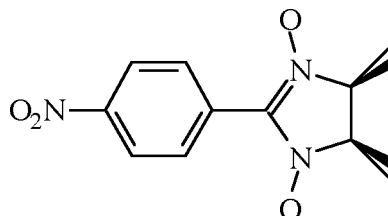
#### List of Symbols and Abbreviations

|          |                                              |
|----------|----------------------------------------------|
| $M_s$    | Saturation magnetization at 2 K              |
| $H_{cr}$ | Coercive Field                               |
| $T_c$    | Critical Temperature                         |
| $M_r$    | Remanent magnetization at 2 K                |
| TCNE     | Tetracyanoethylene                           |
| TCNQ     | 7,7,8,8-Tetracyano- <i>p</i> -quinodimethane |

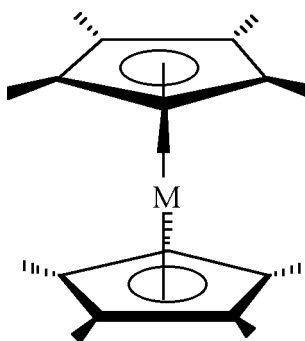
|      |                    |
|------|--------------------|
| hfac | Hexafluoroacetate  |
| NIT  | Nitronyl nitroxide |
| FO   | Ferromagnet        |
| FI   | Ferrimagnet        |
| MM   | Metamagnet         |
| WF   | Weak ferromagnet   |



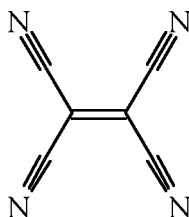
1,3,5,7-Tetramethyl-2,6-diazaadamantane- $N,N'$ -doxyl



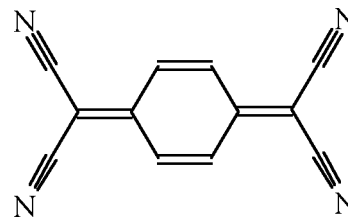
2-(4'-Nitrophenyl)-4,4,5,5-tetramethyl-4,5-dihydro-1H-imidazol-1-oxyl-3- $N$ -oxide



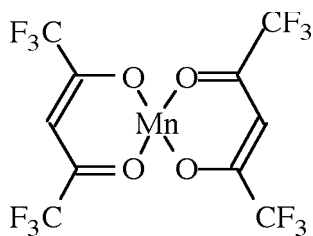
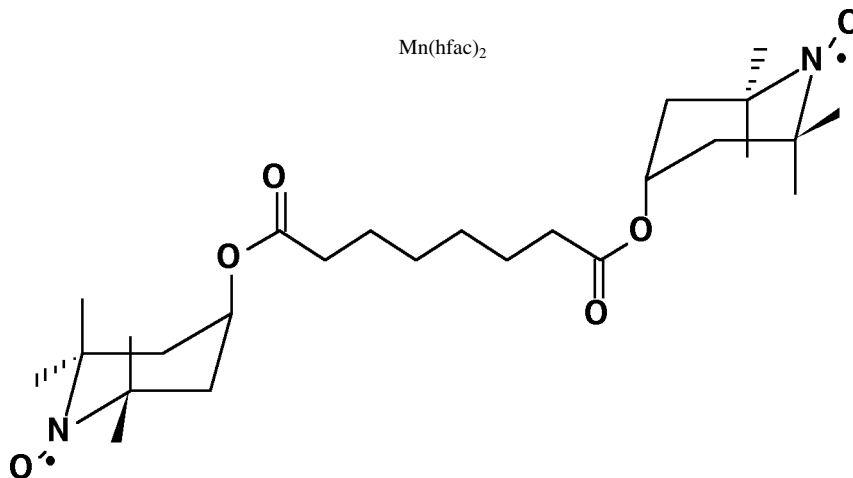
$M[C_5(CH_3)_5]_2$  ( $M = Cr, Mn, Fe$ )



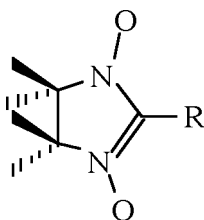
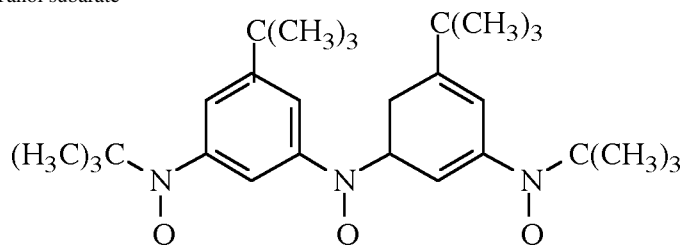
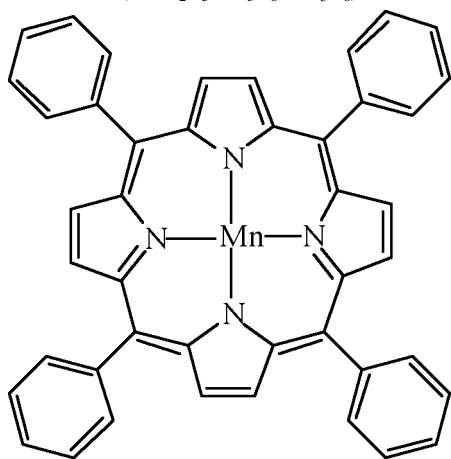
TCNE



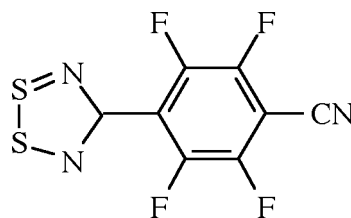
TCNQ

Mn(hfac)<sub>2</sub>

Tanol subarate

NITR (R = C<sub>2</sub>H<sub>5</sub>, *i*-C<sub>3</sub>H<sub>8</sub>, *n*-C<sub>3</sub>H<sub>8</sub>){ON[C<sub>6</sub>H<sub>3</sub>(*t*-C(CH<sub>3</sub>)<sub>3</sub>)<sub>2</sub>NO]<sub>2</sub>}

MnTPP

NCC<sub>6</sub>F<sub>4</sub>CN<sub>2</sub>S<sub>2</sub>

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# OPTICAL PROPERTIES OF SELECTED INORGANIC AND ORGANIC SOLIDS

L. I. Berger

Optical properties of materials are closely related to their dielectric properties. The complex dielectric function (relative permittivity) of a material is equal to

$$\varepsilon(\omega) = \varepsilon'(\omega) - j\varepsilon''(\omega),$$

where  $\varepsilon'(\omega)$  and  $\varepsilon''(\omega)$  are its real and imaginary parts, respectively, and  $\omega$  is the angular frequency of the applied electric field. For a non-absorbing medium, the index of refraction is  $n = (\varepsilon\mu)^{1/2}$ , where  $\mu$  is the relative magnetic permeability of the medium (material); in the majority of dielectrics,  $\mu \approx 1$ .

For many applications, the most important optical properties of materials are the index of refraction, the extinction coefficient,  $k$ , and the reflectivity,  $R$ . The common index of refraction of a material is equal to the ratio of the phase velocity of propagation of an electromagnetic wave of a given frequency in vacuum to that in the material. Hence,  $n \geq 1$ . The optical properties of highly conductive materials like metals and semiconductors (at photon energy range above the energy gap) differ from those of optically transparent media. Free electrons absorb the incident electromagnetic wave in a thin surface layer (a few hundred nanometers thick) and then release the absorbed energy in the form of secondary waves reflected from the surface. Thus, the light reflection becomes very strong; for example, highly conductive sodium reflects 99.8% of the incident wave (at 589 nm). Introduction of the effective index of refraction,  $n_{\text{eff}} = (\varepsilon')^{1/2} = n - jk$ , where  $\varepsilon' = \varepsilon - j\delta/\omega \varepsilon_0$ ,  $\delta$  is the electrical conductivity of the material in S/m, and  $\varepsilon_0 = 8.8542 \cdot 10^{-12}$  F/m is the permittivity of vacuum, allows one to apply the expressions of the optics of transparent media to the conductive materials. It is clear that the effective index of refraction may be smaller than 1. For example,  $n = 0.05$  for pure sodium and  $n = 0.18$  for pure silver (at 589.3 nm). At very high photon energies, the quantum effects, such as the internal photoeffect, start playing a greater role, and the optical properties of these materials become similar to those of insulators (low reflectance, existence of Brewster's angle, etc.).

The extinction coefficient characterizes absorption of the electromagnetic wave energy in the process of propagation of a wave through a material. The wave intensity,  $I$ , after it passes a distance  $x$  in an isotropic medium is equal to

$$I = I_0 \exp(-\alpha x),$$

where  $I_0$  is the intensity at  $x = 0$  and  $\alpha$  is called the absorption coefficient. For many applications, the extinction coefficient,  $k$ , which is equal to

$$k = \alpha \frac{\lambda}{4\pi},$$

where  $\lambda$  is the wavelength of the wave in the medium, is more commonly used for characterization of the electromagnetic losses in materials.

Reflection of an electromagnetic wave from the interface between two media depends on the media indices of refraction and on the angle of incidence. It is characterized by the reflectivity, which is equal to the ratio of the intensity of the wave reflected back into the first medium to the intensity of the wave approaching the interface. For polarized light and two non-absorbing media,

$$R = \frac{(N_1 - N_2)^2}{(N_1 + N_2)^2},$$

where  $N_1 = n_1/\cos\theta_1$  and  $N_2 = n_2/\cos\theta_2$  for the wave polarized in the plane of incidence, and  $N_1 = n_1\cos\theta_1$  and  $N_2 = n_2\cos\theta_2$  for the wave polarized normal to the plane of incidence;  $\theta_1$  and  $\theta_2$  are the angles between the normal to the interface in the point of incidence and the directions of the beams in the first and second medium, respectively. The reflectivity at normal incidence in this case is

$$R = [(n_1 - n_2)/(n_1 + n_2)]^2$$

For any two opaque (absorbing) media, the normal incidence reflectivity is

$$R = \frac{(n_1 - n_2)^2 + k_2^2}{(n_1 + n_2)^2 + k_2^2}.$$

In the majority of experiments, the first medium is air ( $n \approx 1$ ), and hence,

$$R = \frac{(1 - n)^2 + k^2}{(1 + n)^2 + k^2}.$$

The data on  $n$  and  $k$  in the following table are abridged from the sources listed in the references. The reflectivity at normal incidence,  $R$ , has been calculated from the last equation. For convenience, the energy  $E$ , wavenumber  $\bar{\nu}$ , and wavelength  $\lambda$  are given for the incidence radiation.

| <i>E</i> /eV                                                              | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n<sub>a</sub></i> | <i>n<sub>c</sub></i> | <i>k</i> | <i>k<sub>a</sub></i> | <i>k<sub>c</sub></i> | <i>R</i> | <i>R<sub>a</sub></i> | <i>R<sub>c</sub></i> |
|---------------------------------------------------------------------------|-------------------------------|---------------|----------|----------------------|----------------------|----------|----------------------|----------------------|----------|----------------------|----------------------|
| Crystalline Arsenic Selenide (As <sub>2</sub> Se <sub>3</sub> ) [Ref. 1]* |                               |               |          |                      |                      |          |                      |                      |          |                      |                      |
| 2.194                                                                     | 17700                         | 0.565         |          |                      |                      |          | 0.30                 |                      |          |                      |                      |
| 2.168                                                                     | 17480                         | 0.572         |          |                      |                      |          | 0.25                 |                      |          |                      |                      |
| 2.141                                                                     | 17270                         | 0.579         |          |                      |                      |          | 0.20                 |                      |          |                      |                      |
| 2.123                                                                     | 17120                         | 0.584         |          |                      |                      |          | 0.17                 |                      |          |                      |                      |
| 2.098                                                                     | 16920                         | 0.591         |          |                      |                      |          | 0.13                 |                      |          |                      |                      |
| 2.094                                                                     | 16890                         | 0.592         |          |                      |                      |          |                      | 0.26                 |          |                      |                      |
| 2.091                                                                     | 16860                         | 0.593         |          |                      |                      |          |                      | 0.26                 |          |                      |                      |
| 2.073                                                                     | 16720                         | 0.598         |          |                      |                      |          | 0.10                 | 0.23                 |          |                      |                      |
| 2.060                                                                     | 16610                         | 0.602         |          |                      |                      |          |                      | 0.20                 |          |                      |                      |
| 2.049                                                                     | 16530                         | 0.605         |          |                      |                      |          | 0.079                | 0.17                 |          |                      |                      |
| 2.036                                                                     | 16420                         | 0.609         |          |                      |                      |          |                      | 0.15                 |          |                      |                      |
| 2.023                                                                     | 16310                         | 0.613         |          |                      |                      |          |                      | 0.12                 |          |                      |                      |
| 2.013                                                                     | 16230                         | 0.616         |          |                      |                      |          | 0.050                |                      |          |                      |                      |
| 2.009                                                                     | 16210                         | 0.617         |          |                      |                      |          |                      | 0.097                |          |                      |                      |
| 2.000                                                                     | 16130                         | 0.620         |          |                      |                      |          |                      | 0.082                |          |                      |                      |
| 1.987                                                                     | 16030                         | 0.624         |          |                      |                      |          |                      | 0.063                |          |                      |                      |
| 1.977                                                                     | 15940                         | 0.627         |          |                      |                      |          | 0.031                |                      |          |                      |                      |
| 1.974                                                                     | 15920                         | 0.628         |          |                      |                      |          |                      | 0.051                |          |                      |                      |
| 1.962                                                                     | 15820                         | 0.632         |          |                      |                      |          |                      | 0.038                |          |                      |                      |
| 1.953                                                                     | 15750                         | 0.635         |          |                      |                      |          |                      | 0.030                |          |                      |                      |
| 1.949                                                                     | 15720                         | 0.636         |          |                      |                      |          | 0.020                |                      |          |                      |                      |
| 1.937                                                                     | 15630                         | 0.640         |          |                      |                      |          |                      | 0.022                |          |                      |                      |
| 1.925                                                                     | 15530                         | 0.644         |          |                      |                      |          |                      | 0.017                |          |                      |                      |
| 1.922                                                                     | 15500                         | 0.645         |          |                      |                      |          | 0.012                |                      |          |                      |                      |
| 1.905                                                                     | 15360                         | 0.651         |          |                      |                      |          | 8.6·10 <sup>-3</sup> |                      |          |                      |                      |
| 1.893                                                                     | 15270                         | 0.655         |          |                      |                      |          | 6.4                  |                      |          |                      |                      |
| 1.881                                                                     | 15170                         | 0.659         |          |                      |                      |          | 5.2                  |                      |          |                      |                      |
| 1.859                                                                     | 14990                         | 0.667         |          |                      |                      |          | 3.1                  |                      |          |                      |                      |
| 1.848                                                                     | 14900                         | 0.671         |          |                      |                      |          |                      | 1.7·10 <sup>-3</sup> |          |                      |                      |
| 1.845                                                                     | 14880                         | 0.672         |          |                      |                      |          | 2.0                  |                      |          |                      |                      |
| 1.842                                                                     | 14860                         | 0.673         |          |                      |                      |          |                      | 1.2·10 <sup>-3</sup> |          |                      |                      |
| 1.831                                                                     | 14770                         | 0.677         |          |                      |                      |          | 1.3·10 <sup>-3</sup> | 9.0·10 <sup>-4</sup> |          |                      |                      |
| 1.826                                                                     | 14730                         | 0.679         |          |                      |                      |          |                      | 6.4                  |          |                      |                      |
| 1.821                                                                     | 14680                         | 0.681         |          |                      |                      |          |                      | 4.7                  |          |                      |                      |
| 1.818                                                                     | 14660                         | 0.682         |          |                      |                      |          | 8.6·10 <sup>-4</sup> |                      |          |                      |                      |
| 1.815                                                                     | 14640                         | 0.683         |          |                      |                      |          |                      | 3.4                  |          |                      |                      |
| 1.807                                                                     | 14580                         | 0.686         |          |                      |                      |          | 5.5                  |                      |          |                      |                      |
| 1.802                                                                     | 14530                         | 0.688         |          |                      |                      |          | 4.1                  |                      |          |                      |                      |
| 0.06199                                                                   | 500.0                         | 20.0          |          | 3.2                  | 2.9                  |          | 1.7·10 <sup>-3</sup> | 1.8·10 <sup>-3</sup> |          | 0.27                 | 0.24                 |
| 0.05904                                                                   | 476.2                         | 21.0          |          | 3.1                  | 2.9                  |          | 2.1·10 <sup>-3</sup> | 2.2·10 <sup>-3</sup> |          | 0.26                 | 0.24                 |
| 0.05636                                                                   | 454.5                         | 22.0          |          | 3.1                  | 2.9                  |          | 2.5·10 <sup>-3</sup> | 2.6·10 <sup>-3</sup> |          | 0.26                 | 0.24                 |
| 0.05391                                                                   | 434.8                         | 23.0          |          | 3.1                  | 2.9                  |          | 3.0·10 <sup>-3</sup> | 3.1·10 <sup>-3</sup> |          |                      |                      |
| 0.04592                                                                   | 370.4                         | 27.0          |          | 3.0                  | 2.8                  |          | 6.3·10 <sup>-3</sup> | 6.4·10 <sup>-3</sup> |          | 0.25                 | 0.22                 |
| 0.04428                                                                   | 357.1                         | 28.0          |          | 3.0                  | 2.8                  |          | 7.6·10 <sup>-3</sup> | 7.7·10 <sup>-3</sup> |          | 0.25                 | 0.22                 |
| 0.04275                                                                   | 344.8                         | 29.0          |          | 3.0                  | 2.8                  |          | 0.0092               | 0.0093               |          | 0.25                 | 0.22                 |
| 0.04133                                                                   | 333.3                         | 30.0          |          | 3.0                  | 2.7                  |          | 0.011                | 0.011                |          | 0.25                 | 0.21                 |
| 0.03542                                                                   | 285.7                         | 35.0          |          | 2.7                  | 2.5                  |          |                      | 0.037                | 0.034    | 0.21                 | 0.18                 |
| 0.03100                                                                   | 250.0                         | 40.0          |          | 1.9                  | 1.7                  |          |                      | 0.38                 | 1.0      | 0.19                 | 0.18                 |
| 0.03061                                                                   | 247.0                         | 40.5          |          | 2.0                  | 2.6                  |          |                      | 0.33                 | 0.95     | 0.12                 | 0.25                 |
| 0.03024                                                                   | 244.0                         | 41.0          |          | 1.7                  | 2.4                  |          |                      | 0.41                 | 0.46     | 0.088                | 0.18                 |
| 0.02883                                                                   | 232.6                         | 43.0          |          | 1.2                  | 1.3                  |          |                      | 2.2                  | 0.94     | 0.50                 | 0.16                 |
| 0.02850                                                                   | 229.9                         | 43.5          |          | 1.6                  | 1.2                  |          |                      | 2.8                  | 1.4      | 0.56                 | 0.29                 |
| 0.02818                                                                   | 227.3                         | 44.0          |          | 2.3                  | 1.2                  |          | 3.3                  | 2.0                  |          | 0.58                 | 0.48                 |
| 0.02755                                                                   | 222.2                         | 45.0          |          | 4.2                  | 2.0                  |          | 2.5                  | 3.3                  |          | 0.50                 | 0.60                 |
| 0.02480                                                                   | 200.0                         | 50.0          |          | 6.5                  | 4.0                  |          | 3.6                  | 0.26                 |          | 0.62                 | 0.36                 |
| 0.02254                                                                   | 181.8                         | 55.0          |          | 4.5                  | 3.5                  |          | 0.17                 | 0.10                 |          | 0.40                 | 0.31                 |
| 0.02066                                                                   | 166.7                         | 60.0          |          | 4.0                  | 3.2                  |          | 0.089                | 0.10                 |          | 0.36                 | 0.27                 |
| 0.01907                                                                   | 153.8                         | 65.0          |          | 3.8                  | 3.1                  |          | 0.097                | 0.16                 |          | 0.34                 | 0.26                 |
| 0.01771                                                                   | 142.9                         | 70.0          |          | 3.6                  | 3.0                  |          | 0.19                 | 0.30                 |          | 0.32                 | 0.25                 |

| <i>E</i> /eV | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i> | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|--------------|-------------------------------|---------------|----------|-----------------------|-----------------------|----------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 0.01653      | 133.3                         | 75.0          |          | 3.7                   | 3.0                   |          | 0.41                  | 0.44                  |          | 0.34                  | 0.26                  |
| 0.01550      | 125.0                         | 80.0          |          | 3.8                   | 3.1                   |          | 0.29                  | 0.40                  |          | 0.34                  | 0.27                  |
| 0.01459      | 117.6                         | 85.0          |          | 3.6                   | 2.9                   |          | 0.20                  | 0.34                  |          | 0.32                  | 0.24                  |
| 0.01378      | 111.1                         | 90.0          |          | 3.2                   | 2.6                   |          | 0.43                  | 0.49                  |          | 0.28                  | 0.21                  |
| 0.01305      | 105.3                         | 95.0          |          | 4.7                   | 3.0                   |          | 1.5                   | 1.5                   |          | 0.46                  | 0.34                  |
| 0.01240      | 100.0                         | 100.0         |          | 4.4                   | 2.7                   |          | 0.22                  | 0.81                  |          | 0.40                  | 0.25                  |
| 0.01181      | 95.24                         | 105.0         |          | 4.2                   | 3.0                   |          | 0.094                 | 3.9                   |          | 0.38                  | 0.62                  |
| 0.01127      | 90.91                         | 110.0         |          | 4.1                   | 5.3                   |          | 0.059                 | 0.70                  |          | 0.37                  | 0.47                  |
| 0.01033      | 83.33                         | 120.0         |          | 3.9                   | 4.2                   |          | 0.034                 | 0.13                  |          | 0.35                  | 0.38                  |
| 0.009537     | 76.92                         | 130.0         |          | 3.9                   | 4.0                   |          | 0.024                 | 0.069                 |          | 0.35                  | 0.36                  |
| 0.008856     | 71.43                         | 140.0         |          | 3.9                   | 3.8                   |          | 0.019                 | 0.048                 |          | 0.35                  | 0.34                  |
| 0.007749     | 63.50                         | 160.0         |          | 3.8                   | 3.7                   |          | 0.014                 | 0.032                 |          | 0.34                  | 0.33                  |
| 0.006888     | 55.55                         | 180.0         |          | 3.8                   | 3.7                   |          | 0.011                 | 0.024                 |          | 0.34                  | 0.33                  |
| 0.006199     | 50.0                          | 200.0         |          | 3.8                   | 3.6                   |          | 0.0091                | 0.019                 |          | 0.34                  | 0.32                  |

\*Indices a and c relate to the radiation electric field parallel to the a and c axes of the crystal, respectively.

| Vitreous Arsenic Selenide (As <sub>2</sub> Se <sub>3</sub> ) [Ref. 1] |       |       |      |  |  |  |                      |  |      |  |  |
|-----------------------------------------------------------------------|-------|-------|------|--|--|--|----------------------|--|------|--|--|
| 2.056                                                                 | 16580 | 0.603 |      |  |  |  | 0.12                 |  |      |  |  |
| 2.026                                                                 | 16340 | 0.612 |      |  |  |  | 0.11                 |  |      |  |  |
| 2.006                                                                 | 16180 | 0.618 |      |  |  |  | 0.099                |  |      |  |  |
| 1.990                                                                 | 16050 | 0.623 |      |  |  |  | 9.0                  |  |      |  |  |
| 1.925                                                                 | 15530 | 0.644 |      |  |  |  | 5.6                  |  |      |  |  |
| 1.826                                                                 | 14730 | 0.679 |      |  |  |  | 1.4                  |  |      |  |  |
| 1.810                                                                 | 14600 | 0.685 |      |  |  |  | 0.012                |  |      |  |  |
| 1.794                                                                 | 14470 | 0.691 |      |  |  |  | 0.0089               |  |      |  |  |
| 1.771                                                                 | 14290 | 0.700 |      |  |  |  | 6.2                  |  |      |  |  |
| 1.715                                                                 | 13830 | 0.723 |      |  |  |  | 2.6                  |  |      |  |  |
| 1.701                                                                 | 13720 | 0.729 |      |  |  |  | 0.0022               |  |      |  |  |
| 1.647                                                                 | 13280 | 0.753 |      |  |  |  | 0.00046              |  |      |  |  |
| 1.629                                                                 | 13140 | 0.761 | 3.07 |  |  |  | 4.0                  |  | 0.62 |  |  |
| 1.596                                                                 | 12870 | 0.777 | 3.06 |  |  |  | 2.7                  |  | 0.49 |  |  |
| 1.579                                                                 | 12740 | 0.785 | 3.05 |  |  |  | 1.9                  |  | 0.39 |  |  |
| 1.562                                                                 | 12590 | 0.794 | 3.05 |  |  |  | 0.00013              |  | 0.26 |  |  |
| 1.544                                                                 | 12450 | 0.803 | 3.04 |  |  |  | 0.000094             |  | 0.25 |  |  |
| 1.529                                                                 | 12330 | 0.811 | 3.03 |  |  |  | 6.3                  |  | 0.78 |  |  |
| 1.512                                                                 | 12200 | 0.820 | 3.03 |  |  |  | 4.2                  |  | 0.64 |  |  |
| 1.494                                                                 | 12050 | 0.830 | 3.02 |  |  |  | 2.8                  |  | 0.50 |  |  |
| 1.476                                                                 | 11910 | 0.840 | 3.01 |  |  |  | 1.8                  |  | 0.38 |  |  |
| 1.378                                                                 | 11110 | 0.90  | 2.98 |  |  |  |                      |  |      |  |  |
| 1.240                                                                 | 10000 | 1.00  | 2.93 |  |  |  |                      |  |      |  |  |
| 1.127                                                                 | 9091  | 1.10  | 2.90 |  |  |  |                      |  |      |  |  |
| 1.051                                                                 | 8475  | 1.18  | 2.89 |  |  |  |                      |  |      |  |  |
| 1.033                                                                 | 8333  | 1.20  | 2.88 |  |  |  |                      |  |      |  |  |
| 0.2555                                                                | 1980  | 5.05  |      |  |  |  | 1.6·10 <sup>-7</sup> |  |      |  |  |
| 0.2380                                                                | 1919  | 5.21  |      |  |  |  | 9.9·10 <sup>-8</sup> |  |      |  |  |
| 0.2344                                                                | 1890  | 5.29  |      |  |  |  | 1.1·10 <sup>-7</sup> |  |      |  |  |
| 0.1345                                                                | 1085  | 9.22  |      |  |  |  | 4.4                  |  |      |  |  |
| 0.1339                                                                | 1080  | 9.26  |      |  |  |  | 3.7                  |  |      |  |  |
| 0.1333                                                                | 1075  | 9.30  |      |  |  |  | 4.4                  |  |      |  |  |
| 0.1308                                                                | 1055  | 9.48  |      |  |  |  | 4.5                  |  |      |  |  |
| 0.1215                                                                | 980   | 10.20 |      |  |  |  | 8.9                  |  |      |  |  |
| 0.1203                                                                | 970   | 10.31 |      |  |  |  | 9.9·10 <sup>-7</sup> |  |      |  |  |
| 0.1196                                                                | 965   | 10.36 |      |  |  |  | 1.0·10 <sup>-6</sup> |  |      |  |  |
| 0.1178                                                                | 950   | 10.53 |      |  |  |  | 1.1                  |  |      |  |  |
| 0.1116                                                                | 900   | 11.11 |      |  |  |  | 1.8                  |  |      |  |  |
| 0.1004                                                                | 810   | 12.35 |      |  |  |  | 4.9                  |  |      |  |  |
| 0.09919                                                               | 800   | 12.50 |      |  |  |  | 7.0·10 <sup>-6</sup> |  |      |  |  |
| 0.09795                                                               | 790   | 12.66 |      |  |  |  | 1.0·10 <sup>-5</sup> |  |      |  |  |
| 0.09671                                                               | 780   | 12.82 |      |  |  |  | 1.5                  |  |      |  |  |
| 0.09299                                                               | 750   | 13.33 |      |  |  |  | 3.7                  |  |      |  |  |
| 0.08555                                                               | 690   | 14.49 |      |  |  |  | 6.9                  |  |      |  |  |

| <i>E</i> /eV                                                          | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>             | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|-----------------------------------------------------------------------|-------------------------------|---------------|----------|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 0.08431                                                               | 680                           | 14.71         |          |                       |                       | 5.9                  |                       |                       |          |                       |                       |
| 0.08059                                                               | 650                           | 15.38         |          |                       |                       | 6.1                  |                       |                       |          |                       |                       |
| 0.07811                                                               | 630                           | 15.87         |          |                       |                       | 6.3                  |                       |                       |          |                       |                       |
| 0.07687                                                               | 620                           | 16.13         |          |                       |                       | 7.7                  |                       |                       |          |                       |                       |
| 0.07563                                                               | 610                           | 16.39         |          |                       |                       | 7.8                  |                       |                       |          |                       |                       |
| 0.07439                                                               | 600                           | 16.67         |          |                       |                       | 9.3·10 <sup>-5</sup> |                       |                       |          |                       |                       |
| 0.07315                                                               | 590                           | 16.95         | 2.8      |                       |                       | 1.2·10 <sup>-4</sup> |                       |                       | 0.22     |                       |                       |
| 0.07191                                                               | 580                           | 17.24         | 2.8      |                       |                       | 1.4                  |                       |                       | 0.32     |                       |                       |
| 0.07067                                                               | 570                           | 17.54         | 2.8      |                       |                       | 1.8                  |                       |                       | 0.37     |                       |                       |
| 0.06943                                                               | 560                           | 17.86         | 2.8      |                       |                       | 2.8                  |                       |                       | 0.50     |                       |                       |
| 0.06633                                                               | 535                           | 18.69         | 2.8      |                       |                       | 5.2                  |                       |                       | 0.73     |                       |                       |
| 0.06571                                                               | 530                           | 18.87         | 2.8      |                       |                       | 7.2·10 <sup>-4</sup> |                       |                       | 0.22     |                       |                       |
| 0.06509                                                               | 525                           | 19.05         | 2.8      |                       |                       | 1.2·10 <sup>-3</sup> |                       |                       | 0.22     |                       |                       |
| 0.06447                                                               | 520                           | 19.23         | 2.8      |                       |                       | 1.7                  |                       |                       | 0.35     |                       |                       |
| 0.06075                                                               | 490                           | 20.41         | 2.7      |                       |                       | 4.9                  |                       |                       | 0.71     |                       |                       |
| 0.06024                                                               | 485.9                         | 20.58         | 2.7      |                       |                       | 5.2                  |                       |                       | 0.73     |                       |                       |
| 0.05331                                                               | 430                           | 23.26         | 2.7      |                       |                       | 1.4                  |                       |                       | 0.31     |                       |                       |
| 0.05269                                                               | 425                           | 23.53         | 2.7      |                       |                       | 1.1·10 <sup>-3</sup> |                       |                       | 0.21     |                       |                       |
| 0.05207                                                               | 420                           | 23.81         | 2.7      |                       |                       | 8.5·10 <sup>-4</sup> |                       |                       | 0.21     |                       |                       |
| 0.05145                                                               | 415                           | 24.10         | 2.7      |                       |                       | 7.3                  |                       |                       | 0.84     |                       |                       |
| 0.05083                                                               | 410                           | 24.39         | 2.7      |                       |                       | 8.3                  |                       |                       | 0.87     |                       |                       |
| 0.05021                                                               | 405                           | 24.69         | 2.7      |                       |                       | 9.4·10 <sup>-4</sup> |                       |                       | 0.21     |                       |                       |
| 0.04959                                                               | 400                           | 25.0          | 2.7      |                       |                       | 1.2·10 <sup>-3</sup> |                       |                       | 0.21     |                       |                       |
| 0.04862                                                               | 392.2                         | 25.5          | 2.6      |                       |                       | 1.6                  |                       |                       | 0.33     |                       |                       |
| 0.04679                                                               | 377.4                         | 26.5          | 2.6      |                       |                       | 5.0                  |                       |                       | 0.73     |                       |                       |
| 0.04592                                                               | 370.4                         | 27.0          | 2.6      |                       |                       | 8.0·10 <sup>-3</sup> |                       |                       | 0.20     |                       |                       |
| 0.04509                                                               | 363.6                         | 27.5          | 2.6      |                       |                       | 1.2·10 <sup>-2</sup> |                       |                       | 0.20     |                       |                       |
| 0.04428                                                               | 357.1                         | 28.0          | 2.6      |                       |                       | 1.7                  |                       |                       | 0.34     |                       |                       |
| 0.03875                                                               | 312.5                         | 32.0          | 2.5      |                       |                       | 8.2                  |                       |                       | 0.87     |                       |                       |
| 0.03815                                                               | 307.7                         | 32.5          | 2.5      |                       |                       | 9.3·10 <sup>-3</sup> |                       |                       | 0.18     |                       |                       |
| 0.03757                                                               | 303.0                         | 33.0          | 2.4      |                       |                       | 0.11                 |                       |                       | 0.17     |                       |                       |
| 0.02988                                                               | 241.0                         | 41.5          | 2.2      |                       |                       | 0.89                 |                       |                       | 0.20     |                       |                       |
| 0.02952                                                               | 238.1                         | 42.0          | 2.2      |                       |                       | 1.0                  |                       |                       | 0.22     |                       |                       |
| 0.02725                                                               | 219.8                         | 45.5          | 3.2      |                       |                       | 1.8                  |                       |                       | 0.39     |                       |                       |
| 0.02362                                                               | 190.5                         | 52.5          | 3.6      |                       |                       | 0.30                 |                       |                       | 0.32     |                       |                       |
| 0.01937                                                               | 156.2                         | 64.0          | 3.2      |                       |                       | 0.10                 |                       |                       | 0.27     |                       |                       |
| 0.01922                                                               | 155.0                         | 64.5          | 3.2      |                       |                       | 9.6·10 <sup>-2</sup> |                       |                       | 0.27     |                       |                       |
| 0.01907                                                               | 153.8                         | 65.0          | 3.2      |                       |                       | 9.4                  |                       |                       | 0.88     |                       |                       |
| 0.01734                                                               | 139.9                         | 71.5          | 3.1      |                       |                       | 8.7                  |                       |                       | 0.87     |                       |                       |
| 0.01653                                                               | 133.3                         | 75.0          | 3.1      |                       |                       | 9.4                  |                       |                       | 0.88     |                       |                       |
| 0.01642                                                               | 132.5                         | 75.5          | 3.1      |                       |                       | 0.096                |                       |                       | 0.26     |                       |                       |
| 0.01494                                                               | 120.5                         | 83.0          | 3.0      |                       |                       | 0.15                 |                       |                       | 0.25     |                       |                       |
| 0.01246                                                               | 100.5                         | 99.5          | 3.2      |                       |                       | 0.60                 |                       |                       | 0.26     |                       |                       |
| 0.007606                                                              | 61.35                         | 163.0         | 3.3      |                       |                       | 0.12                 |                       |                       | 0.29     |                       |                       |
| 0.006199                                                              | 50.00                         | 200.0         | 3.2      |                       |                       |                      |                       |                       |          |                       |                       |
| 0.004592                                                              | 37.04                         | 270.0         | 3.1      |                       |                       | 0.072                |                       |                       | 0.26     |                       |                       |
| 0.002799                                                              | 22.57                         | 443.0         | 3.0      |                       |                       | 4.5                  |                       |                       | 0.67     |                       |                       |
| 0.001826                                                              | 14.73                         | 679.0         | 3.0      |                       |                       | 2.8                  |                       |                       | 0.50     |                       |                       |
| 0.001273                                                              | 10.27                         | 974.0         | 3.0      |                       |                       | 2.1                  |                       |                       | 0.41     |                       |                       |
| 0.0006491                                                             | 5.236                         | 1910.0        | 3.0      |                       |                       | 1.1·10 <sup>-2</sup> |                       |                       | 0.25     |                       |                       |
| 0.0004376                                                             | 3.530                         | 2833.0        | 3.0      |                       |                       | 7.5·10 <sup>-3</sup> |                       |                       | 0.25     |                       |                       |
| 0.0002903                                                             | 2.341                         | 4271.0        | 3.0      |                       |                       | 5.0                  |                       |                       | 0.71     |                       |                       |
| 0.0001716                                                             | 1.384                         | 7224.0        | 3.0      |                       |                       | 3.1                  |                       |                       | 0.53     |                       |                       |
| 0.00009047                                                            | 0.7297                        | 13704         | 3.0      |                       |                       | 1.6·10 <sup>-3</sup> |                       |                       | 0.25     |                       |                       |
| 0.00005621                                                            | 0.4534                        | 22056         | 3.0      |                       |                       | 9.9·10 <sup>-4</sup> |                       |                       | 0.25     |                       |                       |
| 0.00002774                                                            | 0.2237                        | 44699         | 3.0      |                       |                       | 5.2                  |                       |                       | 0.72     |                       |                       |
| 0.00001439                                                            | 0.1161                        | 86153         | 3.0      |                       |                       | 2.6                  |                       |                       | 0.47     |                       |                       |
| Vitreous Arsenic Sulfide (As <sub>2</sub> S <sub>3</sub> ) - [Ref. 2] |                               |               |          |                       |                       |                      |                       |                       |          |                       |                       |
| 4.959                                                                 | 40000                         | 0.2500        | 2.48     |                       |                       | 1.21                 |                       |                       | 0.27     |                       |                       |
| 3.100                                                                 | 25000                         | 0.40          | 3.09     |                       |                       | 0.34                 |                       |                       | 0.27     |                       |                       |



| <i>E</i> /eV            | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm      | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>             | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|-------------------------|-------------------------------|--------------------|----------|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 2.48                    | 20000                         | 0.4999             | 2.83     |                       |                       | 0.013                |                       |                       | 0.23     |                       |                       |
| 1.879                   | 15150                         | 0.66               | 2.59     |                       |                       | 1.7·10 <sup>-6</sup> |                       |                       | 0.20     |                       |                       |
| 1.240                   | 10000                         | 1.0                | 2.48     |                       |                       | 2.4·10 <sup>-7</sup> |                       |                       | 0.18     |                       |                       |
| 0.6199                  | 5000                          | 2.0                | 2.43     |                       |                       |                      |                       |                       | 0.17     |                       |                       |
| 0.3100                  | 2500                          | 4.0                | 2.41     |                       |                       |                      |                       |                       | 0.17     |                       |                       |
| 0.2480                  | 2000                          | 5.0                | 2.41     |                       |                       |                      |                       |                       | 0.17     |                       |                       |
| 0.1736                  | 1400                          | 7.143              | 2.40     |                       |                       | 7.4·10 <sup>-7</sup> |                       |                       | 0.17     |                       |                       |
| 0.1240                  | 1000                          | 10.00              | 2.38     |                       |                       | 1.3·10 <sup>-4</sup> |                       |                       | 0.17     |                       |                       |
| 0.09299                 | 750                           | 13.33              | 2.35     |                       |                       | 3.0·10 <sup>-3</sup> |                       |                       | 0.16     |                       |                       |
| 0.07439                 | 600                           | 16.67              | 2.31     |                       |                       | 4.6·10 <sup>-4</sup> |                       |                       | 0.16     |                       |                       |
| 0.04959                 | 400.0                         | 25.0               | 1.79     |                       |                       | 0.2                  |                       |                       | 0.085    |                       |                       |
| 0.03757                 | 303.0                         | 33.0               | 3.59     |                       |                       | 1.4                  |                       |                       | 0.38     |                       |                       |
| 0.03100                 | 250.0                         | 40.0               | 2.98     |                       |                       | 0.15                 |                       |                       | 0.25     |                       |                       |
| 0.02480                 | 200.0                         | 50                 | 2.66     |                       |                       | 0.11                 |                       |                       | 0.21     |                       |                       |
| 0.02066                 | 166.7                         | 60                 | 2.64     |                       |                       | 0.57                 |                       |                       | 0.22     |                       |                       |
| 0.01771                 | 142.9                         | 70                 | 2.99     |                       |                       | 0.17                 |                       |                       | 0.25     |                       |                       |
| 0.01550                 | 125.0                         | 80                 | 2.89     |                       |                       | 0.14                 |                       |                       | 0.24     |                       |                       |
| 0.01378                 | 111.1                         | 90                 | 2.84     |                       |                       | 0.12                 |                       |                       | 0.23     |                       |                       |
| 0.01240                 | 100                           | 100                | 2.81     |                       |                       | 0.10                 |                       |                       | 0.23     |                       |                       |
| 0.008183                | 66                            | 152                | 2.76     |                       |                       | 0.072                |                       |                       | 0.22     |                       |                       |
| 0.004029                | 32.5                          | 308                | 2.74     |                       |                       | 0.044                |                       |                       | 0.22     |                       |                       |
| 0.002418                | 19.5                          | 513                | 2.74     |                       |                       | 0.031                |                       |                       | 0.22     |                       |                       |
| 0.001984                | 16                            | 625                | 2.74     |                       |                       | 0.025                |                       |                       | 0.22     |                       |                       |
| 0.001048                | 8.45                          | 1180               | 2.73     |                       |                       | 8.8·10 <sup>-3</sup> |                       |                       | 0.22     |                       |                       |
| 0.0001033               | 0.833                         | 12000              | 2.73     |                       |                       | 1.3·10 <sup>-3</sup> |                       |                       | 0.22     |                       |                       |
| 4.129·10 <sup>-12</sup> | 3.33·10 <sup>-8</sup>         | 3·10 <sup>11</sup> | 2.73     |                       |                       |                      |                       |                       | 0.22     |                       |                       |

Cadmium Telluride (CdTe) - [Ref. 3]

|       |       |        |        |  |  |                       |  |  |      |  |  |
|-------|-------|--------|--------|--|--|-----------------------|--|--|------|--|--|
| 4.9   | 39520 | 0.2530 | 2.48   |  |  | 2.04                  |  |  | 0.39 |  |  |
| 4.1   | 33070 | 0.3024 | 2.33   |  |  | 1.59                  |  |  | 0.32 |  |  |
| 3.9   | 31460 | 0.3179 | 2.57   |  |  | 1.90                  |  |  | 0.37 |  |  |
| 3.5   | 28230 | 0.3542 | 2.89   |  |  | 1.52                  |  |  | 0.34 |  |  |
| 3.1   | 25000 | 0.4000 | 3.43   |  |  | 1.02                  |  |  | 0.34 |  |  |
| 3.0   | 24200 | 0.4133 | 3.37   |  |  | 0.861                 |  |  | 0.32 |  |  |
| 2.755 | 22220 | 0.45   | 3.080  |  |  | 0.485                 |  |  | 0.27 |  |  |
| 2.75  | 22180 | 0.4509 | 3.23   |  |  | 0.636                 |  |  | 0.29 |  |  |
| 2.610 | 21050 | 0.475  | 3.045  |  |  |                       |  |  |      |  |  |
| 2.5   | 20160 | 0.4959 | 3.14   |  |  | 0.525                 |  |  | 0.28 |  |  |
| 2.25  | 18150 | 0.5510 | 3.05   |  |  | 0.411                 |  |  | 0.26 |  |  |
| 1.771 | 14290 | 0.70   | 2.861  |  |  | 0.210                 |  |  | 0.23 |  |  |
| 1.512 | 12200 | 0.82   | 2.880  |  |  | 0.040                 |  |  | 0.23 |  |  |
| 1.50  | 12100 | 0.8266 | 2.98   |  |  | 0.319                 |  |  | 0.25 |  |  |
| 1.475 | 11900 | 0.840  | 2.905  |  |  | 0.00134               |  |  | 0.24 |  |  |
| 1.47  | 11860 | 0.8434 |        |  |  | 0.000671              |  |  |      |  |  |
| 1.465 | 11820 | 0.8463 |        |  |  | 3.37                  |  |  |      |  |  |
| 1.46  | 11780 | 0.8492 |        |  |  | 1.89                  |  |  |      |  |  |
| 1.459 | 11760 | 0.850  | 2.948  |  |  |                       |  |  | 0.24 |  |  |
| 1.455 | 11740 | 0.8521 |        |  |  | 1.08·10 <sup>-4</sup> |  |  |      |  |  |
| 1.45  | 11690 | 0.8551 | 2.9565 |  |  | 5.10·10 <sup>-5</sup> |  |  | 0.24 |  |  |
| 1.445 | 11650 | 0.8580 |        |  |  | 2.73                  |  |  |      |  |  |
| 1.442 | 11630 | 0.860  | 2.952  |  |  |                       |  |  | 0.24 |  |  |
| 1.44  | 11610 | 0.8610 | 2.9479 |  |  | 1.37                  |  |  | 0.32 |  |  |
| 1.43  | 11530 | 0.8670 | 2.9402 |  |  |                       |  |  | 0.24 |  |  |
| 1.30  | 10490 | 0.9537 | 2.8720 |  |  |                       |  |  | 0.23 |  |  |
| 1.24  | 10000 | 1.0    | 2.840  |  |  |                       |  |  | 0.23 |  |  |
| 1.20  | 9679  | 1.033  | 2.8353 |  |  |                       |  |  | 0.23 |  |  |
| 1.10  | 8872  | 1.127  | 2.8050 |  |  |                       |  |  | 0.23 |  |  |
| 1.00  | 8065  | 1.240  | 2.7793 |  |  |                       |  |  | 0.22 |  |  |
| 0.90  | 7259  | 1.378  | 2.7537 |  |  |                       |  |  | 0.22 |  |  |
| 0.80  | 6452  | 1.550  | 2.7384 |  |  |                       |  |  | 0.22 |  |  |
| 0.70  | 5646  | 1.771  | 2.7223 |  |  |                       |  |  | 0.21 |  |  |

| <i>E</i> /eV | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|--------------|-------------------------------|---------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 0.60         | 4839                          | 2.066         | 2.7086   |                       |                       |                       |                       |                       | 0.21     |                       |                       |
| 0.50         | 4033                          | 2.480         | 2.6972   |                       |                       |                       |                       |                       | 0.21     |                       |                       |
| 0.40         | 3226                          | 3.100         | 2.6878   |                       |                       |                       |                       |                       | 0.21     |                       |                       |
| 0.30         | 2420                          | 4.133         | 2.6800   |                       |                       |                       |                       |                       | 0.21     |                       |                       |
| 0.20         | 1613                          | 6.199         | 2.6722   |                       |                       |                       |                       |                       | 0.21     |                       |                       |
| 0.10         | 806.5                         | 12.40         | 2.6535   |                       |                       |                       |                       |                       | 0.20     |                       |                       |
| 0.09         | 725.9                         | 13.78         | 2.6482   |                       |                       |                       |                       |                       | 0.20     |                       |                       |
| 0.06819      | 550                           | 18.18         | 2.623    |                       |                       |                       |                       |                       | 0.20     |                       |                       |
| 0.0573       | 462                           | 21.6          |          |                       |                       | 3.8·10 <sup>-6</sup>  |                       |                       |          |                       |                       |
| 0.05         | 403.3                         | 24.80         | 2.5801   |                       |                       |                       |                       |                       | 0.19     |                       |                       |
| 0.0469       | 378                           | 26.5          |          |                       |                       | 8.0·10 <sup>-5</sup>  |                       |                       |          |                       |                       |
| 0.04592      | 370.3                         | 27            |          |                       |                       | 9.88·10 <sup>-5</sup> |                       |                       |          |                       |                       |
| 0.04133      | 333.3                         | 30            | 2.55916  |                       |                       | 2.86·10 <sup>-4</sup> |                       |                       | 0.19     |                       |                       |
| 0.04092      | 330                           | 30.30         | 2.531    |                       |                       | 3.34                  |                       |                       | 0.57     |                       |                       |
| 0.03720      | 300                           | 33.33         | 2.494    |                       |                       | 4.97                  |                       |                       | 0.73     |                       |                       |
| 0.03647      | 294.1                         | 34.00         |          |                       |                       | 8.93                  |                       |                       |          |                       |                       |
| 0.03596      | 290                           | 34.48         | 2.478    |                       |                       | 5.77·10 <sup>-3</sup> |                       |                       | 0.18     |                       |                       |
| 0.03493      | 281.7                         | 35.5          |          |                       |                       | 7.91                  |                       |                       |          |                       |                       |
| 0.03472      | 280                           | 35.71         | 2.459    |                       |                       | 6.76                  |                       |                       | 0.83     |                       |                       |
| 0.03100      | 250                           | 40            | 2.378    |                       |                       | 1.18·10 <sup>-2</sup> |                       |                       | 0.17     |                       |                       |
| 0.02917      | 235.3                         | 42.5          |          |                       |                       | 6.93                  |                       |                       |          |                       |                       |
| 0.02852      | 230                           | 43.48         | 2.289    |                       |                       | 1.87                  |                       |                       | 0.36     |                       |                       |
| 0.02728      | 220                           | 45.45         | 2.224    |                       |                       | 2.47·10 <sup>-2</sup> |                       |                       | 0.14     |                       |                       |
| 0.02604      | 210                           | 47.62         | 2.137    |                       |                       | 3.4·10 <sup>-2</sup>  |                       |                       | 0.13     |                       |                       |
| 0.02480      | 200                           | 50.00         | 2.013    |                       |                       | 4.97·10 <sup>-2</sup> |                       |                       | 0.11     |                       |                       |
| 0.02384      | 192.3                         | 52.0          |          |                       |                       | 6.21                  |                       |                       |          |                       |                       |
| 0.01798      | 145                           | 68.97         | 1.8      |                       |                       | 5.2                   |                       |                       | 0.79     |                       |                       |
| 0.01736      | 140                           | 71.43         | 6.778    |                       |                       | 4.50                  |                       |                       | 0.66     |                       |                       |
| 0.01550      | 125                           | 80.0          | 4.598    |                       |                       | 0.294                 |                       |                       | 0.41     |                       |                       |
| 0.01364      | 110                           | 90.91         | 3.868    |                       |                       | 9.47·10 <sup>-2</sup> |                       |                       | 0.35     |                       |                       |
| 0.01240      | 100                           | 100           | 3.649    |                       |                       | 5.68·10 <sup>-2</sup> |                       |                       | 0.32     |                       |                       |
| 0.009919     | 80                            | 125           | 3.415    |                       |                       | 0.0262                |                       |                       | 0.30     |                       |                       |
| 0.008679     | 70                            | 142.9         | 3.348    |                       |                       | 0.0189                |                       |                       | 0.29     |                       |                       |
| 0.007439     | 60                            | 166.7         | 3.299    |                       |                       | 1.39                  |                       |                       | 0.35     |                       |                       |
| 0.006199     | 50                            | 200           | 3.263    |                       |                       | 1.03                  |                       |                       | 0.32     |                       |                       |
| 0.004959     | 40                            | 250           | 3.236    |                       |                       | 7.52·10 <sup>-3</sup> |                       |                       | 0.28     |                       |                       |
| 0.003720     | 30                            | 333.3         | 3.217    |                       |                       |                       |                       |                       | 0.28     |                       |                       |
| 0.023015     | 18.563                        |               | 538.71   |                       |                       | 3.2096                |                       |                       | 0.28     |                       |                       |
| 0.001550     | 12.50                         | 800           |          |                       |                       | 6.18                  |                       |                       |          |                       |                       |

Gallium Arsenide (GaAs) - [Ref. 4]

|      |       |          |       |  |  |        |  |  |      |  |  |
|------|-------|----------|-------|--|--|--------|--|--|------|--|--|
| 155  |       | 0.007999 |       |  |  | 0.0181 |  |  |      |  |  |
| 145  |       | 0.008551 |       |  |  | 0.0203 |  |  |      |  |  |
| 130  |       | 0.009537 |       |  |  | 0.0224 |  |  |      |  |  |
| 110  |       | 0.01127  |       |  |  | 0.0278 |  |  |      |  |  |
| 90   |       | 0.01378  |       |  |  | 0.0323 |  |  |      |  |  |
| 70   |       | 0.01771  |       |  |  | 0.0376 |  |  |      |  |  |
| 40   |       | 0.03100  |       |  |  | 0.0426 |  |  |      |  |  |
| 23   |       | 0.05391  | 1.037 |  |  | 0.228  |  |  |      |  |  |
| 7.0  |       | 0.1771   | 1.063 |  |  | 1.838  |  |  |      |  |  |
| 6.0  | 48390 | 0.2066   | 1.264 |  |  | 2.472  |  |  | 0.61 |  |  |
| 5.00 | 40330 | 0.2480   | 2.273 |  |  | 4.084  |  |  | 0.67 |  |  |
| 4.00 | 32260 | 0.3100   | 3.601 |  |  | 1.920  |  |  | 0.42 |  |  |
| 3.00 | 24200 | 0.4133   | 4.509 |  |  | 1.948  |  |  | 0.47 |  |  |

| <i>E</i> /eV                       | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|------------------------------------|-------------------------------|---------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 2.50                               | 20160                         | 0.4959        | 4.333    |                       |                       | 0.441                 |                       |                       | 0.39     |                       |                       |
| 2.00                               | 16130                         | 0.6199        | 3.878    |                       |                       | 0.211                 |                       |                       | 0.35     |                       |                       |
| 1.80                               | 14520                         | 0.8888        | 3.785    |                       |                       | 0.151                 |                       |                       | 0.34     |                       |                       |
| 1.60                               | 12900                         | 0.7749        | 3.700    |                       |                       | 0.091                 |                       |                       | 0.33     |                       |                       |
| 1.50                               | 12100                         | 0.8266        | 3.666    |                       |                       | 0.080                 |                       |                       | 0.33     |                       |                       |
| 1.40                               | 11290                         | 0.8856        | 3.6140   |                       |                       | 1.69·10 <sup>-3</sup> |                       |                       | 0.32     |                       |                       |
| 1.20                               | 9679                          | 1.033         | 3.4920   |                       |                       |                       |                       |                       | 0.31     |                       |                       |
| 1.00                               | 8065                          | 1.240         | 3.4232   |                       |                       |                       |                       |                       | 0.30     |                       |                       |
| 0.80                               | 6452                          | 1.550         | 3.3737   |                       |                       |                       |                       |                       | 0.29     |                       |                       |
| 0.50                               | 4033                          | 2.480         | 3.3240   |                       |                       |                       |                       |                       | 0.29     |                       |                       |
| 0.25                               | 2016                          | 4.959         | 3.2978   |                       |                       |                       |                       |                       | 0.29     |                       |                       |
| 0.15                               | 1210                          | 8.266         | 3.2831   |                       |                       |                       |                       |                       | 0.28     |                       |                       |
| 0.100                              | 806.5                         | 12.40         | 3.2597   |                       |                       | 4.93·10 <sup>-6</sup> |                       |                       | 0.28     |                       |                       |
| 0.090                              | 725.9                         | 13.78         | 3.2493   |                       |                       | 1.64·10 <sup>-5</sup> |                       |                       | 0.28     |                       |                       |
| 0.070                              | 564.6                         | 17.71         | 3.2081   |                       |                       | 2.32·10 <sup>-4</sup> |                       |                       | 0.28     |                       |                       |
| 0.060                              | 483.9                         | 20.66         | 3.1609   |                       |                       | 3.45·10 <sup>-3</sup> |                       |                       | 0.27     |                       |                       |
| 0.0495                             | 399.2                         | 25.05         | 3.058    |                       |                       | 2.07·10 <sup>-3</sup> |                       |                       | 0.26     |                       |                       |
| 0.03968                            | 320                           | 31.25         | 2.495    |                       |                       | 2.43·10 <sup>-2</sup> |                       |                       | 0.18     |                       |                       |
| 0.03496                            | 282                           | 35.46         | 0.307    |                       |                       | 294·10 <sup>-2</sup>  |                       |                       |          |                       |                       |
| 0.02976                            | 240                           | 41.67         | 4.57     |                       |                       | 4.26·10 <sup>-2</sup> |                       |                       | 0.41     |                       |                       |
| 0.02066                            | 166.7                         | 60            | 3.77     |                       |                       | 3.89·10 <sup>-3</sup> |                       |                       | 0.34     |                       |                       |
| 0.01550                            | 125                           | 80            | 3.681    |                       |                       | 1.84·10 <sup>-3</sup> |                       |                       | 0.33     |                       |                       |
| 0.008266                           | 66.67                         | 150           | 3.62     |                       |                       | 2.14·10 <sup>-3</sup> |                       |                       | 0.32     |                       |                       |
| 0.002480                           | 20                            | 500           | 3.607    |                       |                       | 1.3·10 <sup>-3</sup>  |                       |                       | 0.32     |                       |                       |
| 0.001240                           | 10                            | 1000          | 3.606    |                       |                       |                       |                       |                       | 0.32     |                       |                       |
| Gallium Phosphide (GaP) - [Ref. 5] |                               |               |          |                       |                       |                       |                       |                       |          |                       |                       |
| 154.0                              |                               | 0.00805       |          |                       |                       | 1.7·10 <sup>-2</sup>  |                       |                       |          |                       |                       |
| 110.0                              |                               | 0.0113        |          |                       |                       | 2.15·10 <sup>-2</sup> |                       |                       |          |                       |                       |
| 100.0                              |                               | 0.0124        |          |                       |                       | 215·10 <sup>-2</sup>  |                       |                       |          |                       |                       |
| 80.0                               |                               | 0.0155        |          |                       |                       | 3.0·10 <sup>-2</sup>  |                       |                       |          |                       |                       |
| 50.0                               |                               | 0.0248        |          |                       |                       | 4.7·10 <sup>-2</sup>  |                       |                       |          |                       |                       |
| 27.0                               |                               | 0.0459        |          |                       |                       | 9.3·10 <sup>-2</sup>  |                       |                       |          |                       |                       |
| 25.0                               |                               | 0.0496        |          |                       |                       | 0.122                 |                       |                       |          |                       |                       |
| 20.0                               |                               | 0.0620        |          |                       |                       | 0.180                 |                       |                       |          |                       |                       |
| 15.0                               |                               | 0.0826        | 0.748    |                       |                       | 0.628                 |                       |                       |          |                       |                       |
| 5.5                                | 44360                         | 0.2254        | 1.543    |                       |                       | 3.556                 |                       |                       | 0.68     |                       |                       |
| 4.68                               | 37750                         | 0.2649        | 4.181    |                       |                       | 2.634                 |                       |                       | 0.50     |                       |                       |
| 3.50                               | 28230                         | 0.3542        | 5.050    |                       |                       | 0.819                 |                       |                       | 0.46     |                       |                       |
| 3.00                               | 24200                         | 0.4133        | 4.081    |                       |                       | 0.224                 |                       |                       | 0.37     |                       |                       |
| 2.78                               | 22420                         | 0.4460        | 3.904    |                       |                       | 0.103                 |                       |                       | 0.35     |                       |                       |
| 2.621                              | 21140                         | 0.473         | 3.73     |                       |                       | 6.37·10 <sup>-3</sup> |                       |                       | 0.33     |                       |                       |
| 2.480                              | 20000                         | 0.500         | 3.590    |                       |                       | 2.47·10 <sup>-3</sup> |                       |                       | 0.32     |                       |                       |
| 2.18                               | 17580                         | 0.5687        | 3.411    |                       |                       | 2.8·10 <sup>-7</sup>  |                       |                       | 0.30     |                       |                       |
| 2.000                              | 16130                         | 0.62          | 3.3254   |                       |                       |                       |                       |                       | 0.29     |                       |                       |
| 1.6                                | 12900                         | 0.7749        | 3.209    |                       |                       |                       |                       |                       | 0.28     |                       |                       |
| 1.240                              | 10000                         | 1.0           | 3.1192   |                       |                       |                       |                       |                       | 0.26     |                       |                       |
| 0.6888                             | 5556                          | 1.8           | 3.0439   |                       |                       |                       |                       |                       | 0.26     |                       |                       |
| 0.4769                             | 3846                          | 2.6           | 3.0271   |                       |                       |                       |                       |                       | 0.25     |                       |                       |
| 0.1907                             | 1538                          | 6.5           | 2.995    |                       |                       | 4.29·10 <sup>-4</sup> |                       |                       | 0.25     |                       |                       |
| 0.1550                             | 1250                          | 8.0           | 2.984    |                       |                       |                       |                       |                       | 0.25     |                       |                       |
| 0.1240                             | 1000                          | 10            | 2.964    |                       |                       |                       |                       |                       | 0.25     |                       |                       |
| 0.06199                            | 500                           | 20            | 2.615    |                       |                       | 7.16·10 <sup>-3</sup> |                       |                       | 0.20     |                       |                       |
| 0.03100                            | 250                           | 40            | 3.594    |                       |                       | 1.81·10 <sup>-2</sup> |                       |                       | 0.32     |                       |                       |

| <i>E</i> /eV | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n<sub>a</sub></i> | <i>n<sub>c</sub></i> | <i>k</i>              | <i>k<sub>a</sub></i> | <i>k<sub>c</sub></i> | <i>R</i> | <i>R<sub>a</sub></i> | <i>R<sub>c</sub></i> |
|--------------|-------------------------------|---------------|----------|----------------------|----------------------|-----------------------|----------------------|----------------------|----------|----------------------|----------------------|
| 0.02480      | 200                           | 50            | 3.461    |                      |                      | 5.77·10 <sup>-3</sup> |                      |                      | 0.30     |                      |                      |
| 0.01727      | 139.27                        | 71.80         | 3.3922   |                      |                      | 4.34·10 <sup>-3</sup> |                      |                      | 0.30     |                      |                      |
| 0.01168      | 94.21                         | 106.1         | 3.3621   |                      |                      | 4.26·10 <sup>-3</sup> |                      |                      | 0.29     |                      |                      |
| 0.006199     | 50.00                         | 200           | 3.3447   |                      |                      | 1.3·10 <sup>-4</sup>  |                      |                      | 0.29     |                      |                      |
| 0.004133     | 33.33                         | 300           | 3.3413   |                      |                      |                       |                      |                      | 0.29     |                      |                      |
| 0.001240     | 10.00                         | 1000          | 3.3319   |                      |                      |                       |                      |                      | 0.29     |                      |                      |

Indium Antimonide (InSb) - [Ref. 6]

|          |       |          |       |  |  |                       |  |  |      |  |  |
|----------|-------|----------|-------|--|--|-----------------------|--|--|------|--|--|
| 155      |       | 0.007999 |       |  |  | 4.77·10 <sup>-3</sup> |  |  |      |  |  |
| 60       |       | 0.02066  |       |  |  | 7.30·10 <sup>-2</sup> |  |  |      |  |  |
| 25       |       | 0.04959  | 1.15  |  |  | .015                  |  |  |      |  |  |
| 24       |       | 0.05166  | 1.15  |  |  | 0.18                  |  |  |      |  |  |
| 15       |       | 0.08266  | 0.97  |  |  | 0.230                 |  |  |      |  |  |
| 10       |       | 0.1240   | 0.74  |  |  | 0.88                  |  |  |      |  |  |
| 5.00     | 40330 | 0.2480   | 1.307 |  |  | 2.441                 |  |  | 0.53 |  |  |
| 4.50     | 36290 | 0.2755   | 1.443 |  |  | 2.894                 |  |  | 0.60 |  |  |
| 4.00     | 32260 | 0.3100   | 2.632 |  |  | 3.694                 |  |  | 0.61 |  |  |
| 3.34     | 26940 | 0.3712   | 3.528 |  |  | 2.280                 |  |  | 0.45 |  |  |
| 2.84     | 22910 | 0.4366   | 3.340 |  |  | 2.021                 |  |  | 0.45 |  |  |
| 1.80     | 14520 | 0.6888   | 4.909 |  |  | 1.396                 |  |  | 0.47 |  |  |
| 1.50     | 12100 | 0.8266   | 4.418 |  |  | 0.643                 |  |  | 0.41 |  |  |
| 0.6      | 4839  | 2.066    | 4.03  |  |  |                       |  |  | 0.36 |  |  |
| 0.2480   | 2000  | 5.0      | 4.14  |  |  | 9.1·10 <sup>-2</sup>  |  |  | 0.37 |  |  |
| 0.1907   | 1538  | 6.5      | 4.30  |  |  | 6.3·10 <sup>-2</sup>  |  |  | 0.39 |  |  |
| 0.1653   | 1333  | 7.5      | 4.18  |  |  | 2.7·10 <sup>-2</sup>  |  |  | 0.38 |  |  |
| 0.06199  | 500   | 20.00    | 3.869 |  |  | 2.0·10 <sup>-3</sup>  |  |  | 0.35 |  |  |
| 0.03100  | 250   | 40.00    | 2.98  |  |  | 2.6·10 <sup>-3</sup>  |  |  | 0.25 |  |  |
| 0.02480  | 200   | 50.00    | 2.22  |  |  | 0.165                 |  |  | 0.14 |  |  |
| 0.02244  | 181   | 55.25    | 3.05  |  |  | 7.59                  |  |  | 0.84 |  |  |
| 0.02207  | 178   | 56.18    | 9.61  |  |  | 4.20                  |  |  | 0.70 |  |  |
| 0.02033  | 164   | 60.98    | 4.94  |  |  | 0.140                 |  |  | 0.44 |  |  |
| 0.01054  | 85    | 117.6    | 2.12  |  |  | 0.423                 |  |  | 0.14 |  |  |
| 0.005579 | 45    | 222.2    | 1.02  |  |  | 5.59                  |  |  | 0.88 |  |  |
| 0.001860 | 15    | 666.7    | 6.03  |  |  | 17.9                  |  |  | 0.93 |  |  |
| 0.001240 | 10    | 1000     | 10.7  |  |  | 24.0                  |  |  | 0.94 |  |  |

Indium Arsenide (InAs) - [Ref. 7]

|         |       |         |       |  |  |                       |  |  |       |  |  |
|---------|-------|---------|-------|--|--|-----------------------|--|--|-------|--|--|
| 25      |       | 0.04959 |       |  |  | 1.139                 |  |  | 0.168 |  |  |
| 20      |       | 0.06199 |       |  |  | 1.125                 |  |  | 0.225 |  |  |
| 15      |       | 0.08266 |       |  |  | 0.894                 |  |  | 0.336 |  |  |
| 10      |       | 0.1240  |       |  |  | 0.835                 |  |  | 1.071 |  |  |
| 6       | 48390 | 0.2066  | 1.434 |  |  | 2.112                 |  |  | 0.45  |  |  |
| 5.0     | 40330 | 0.2480  | 1.524 |  |  | 2.871                 |  |  | 0.58  |  |  |
| 4.0     | 32260 | 0.3100  | 3.313 |  |  | 1.799                 |  |  | 0.39  |  |  |
| 3.5     | 28230 | 0.3542  | 3.008 |  |  | 1.754                 |  |  | 0.37  |  |  |
| 3.0     | 24200 | 0.4133  | 3.197 |  |  | 2.034                 |  |  | 0.41  |  |  |
| 2.5     | 20160 | 0.4959  | 4.364 |  |  | 1.786                 |  |  | 0.45  |  |  |
| 2.44    | 19680 | 0.5081  | 4.489 |  |  | 1.446                 |  |  | 0.44  |  |  |
| 1.86    | 15000 | 0.6666  | 3.889 |  |  | 0.554                 |  |  | 0.36  |  |  |
| 1.8     | 14520 | 0.6888  | 3.851 |  |  | 0.530                 |  |  | 0.35  |  |  |
| 1.7     | 13710 | 0.7293  | 3.798 |  |  | 0.493                 |  |  | 0.35  |  |  |
| 1.6     | 12900 | 0.7749  | 3.755 |  |  | 0.463                 |  |  | 0.34  |  |  |
| 1.5     | 12100 | 0.8266  | 3.714 |  |  | 0.432                 |  |  | 0.34  |  |  |
| 1.2     | 9679  | 1.033   | 3.613 |  |  |                       |  |  | 0.32  |  |  |
| 1.0     | 8065  | 1.240   | 3.548 |  |  |                       |  |  | 0.31  |  |  |
| 0.6     | 4839  | 2.066   |       |  |  | 0.161                 |  |  |       |  |  |
| 0.35    | 2823  | 3.542   | 3.608 |  |  | 9.58·10 <sup>-3</sup> |  |  | 0.32  |  |  |
| 0.32    | 2581  | 3.875   | 3.512 |  |  | 1.23·10 <sup>-4</sup> |  |  | 0.31  |  |  |
| 0.20    | 1613  | 6.199   | 3.427 |  |  |                       |  |  | 0.30  |  |  |
| 0.1240  | 1000  | 10.00   | 3.402 |  |  |                       |  |  | 0.30  |  |  |
| 0.06199 | 500   | 20.00   | 3.334 |  |  |                       |  |  | 0.29  |  |  |
| 0.04959 | 400   | 25.00   | 3.264 |  |  |                       |  |  | 0.28  |  |  |

| <i>E</i> /eV | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|--------------|-------------------------------|---------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 0.04339      | 350                           | 28.57         | 3.182    |                       |                       | 5.46·10 <sup>-3</sup> |                       |                       | 0.27     |                       |                       |
| 0.03720      | 300                           | 33.33         | 2.988    |                       |                       |                       |                       |                       | 0.25     |                       |                       |
| 0.03100      | 250                           | 40.00         | 1.970    |                       |                       | 6.37·10 <sup>-2</sup> |                       |                       | 0.11     |                       |                       |
| 0.02765      | 222                           | 44.84         | 5.90     |                       |                       | 6.53                  |                       |                       | 0.74     |                       |                       |
| 0.02480      | 200                           | 50.00         | 6.91     |                       |                       | 0.30                  |                       |                       | 0.56     |                       |                       |
| 0.01984      | 160                           | 62.50         | 5.27     |                       |                       | 0.41                  |                       |                       | 0.47     |                       |                       |
| 0.01860      | 150                           | 66.67         | 5.27     |                       |                       | 0.51                  |                       |                       | 0.47     |                       |                       |
| 0.01736      | 140                           | 71.43         | 3.99     |                       |                       | 1.1·10 <sup>-2</sup>  |                       |                       | 0.36     |                       |                       |
| 0.01488      | 120                           | 83.33         | 3.91     |                       |                       | 6.6·10 <sup>-3</sup>  |                       |                       | 0.35     |                       |                       |
| 0.01240      | 100                           | 100.0         | 3.85     |                       |                       | 4.3·10 <sup>-3</sup>  |                       |                       | 0.35     |                       |                       |
| 0.009919     | 80                            | 125.0         | 3.817    |                       |                       |                       |                       |                       | 0.34     |                       |                       |
| 0.007439     | 60                            | 166.7         | 3.793    |                       |                       |                       |                       |                       | 0.34     |                       |                       |
| 0.004959     | 40                            | 250.0         | 3.778    |                       |                       |                       |                       |                       | 0.34     |                       |                       |
| 0.002480     | 20                            | 500           | 3.769    |                       |                       |                       |                       |                       | 0.37     |                       |                       |
| 0.001240     | 10                            | 1000          | 3.766    |                       |                       |                       |                       |                       | 0.34     |                       |                       |

Indium Phosphide (InP) - [Ref. 8]

|          |       |         |       |  |  |                       |  |  |      |  |  |
|----------|-------|---------|-------|--|--|-----------------------|--|--|------|--|--|
| 20       |       | 0.06199 | 0.793 |  |  | 0.494                 |  |  |      |  |  |
| 15       |       | 0.08266 | 0.695 |  |  | 0.574                 |  |  |      |  |  |
| 10       |       | 0.1240  | 0.806 |  |  | 1.154                 |  |  |      |  |  |
| 5.5      | 44360 | 0.2254  | 1.426 |  |  | 2.562                 |  |  | 0.79 |  |  |
| 5.0      | 40330 | 0.2480  | 2.131 |  |  | 3.495                 |  |  | 0.61 |  |  |
| 4.0      | 32260 | 0.3100  | 3.141 |  |  | 1.730                 |  |  | 0.38 |  |  |
| 3.0      | 24200 | 0.4133  | 4.395 |  |  | 1.247                 |  |  | 0.43 |  |  |
| 2.0      | 16130 | 0.6199  | 3.549 |  |  | 0.317                 |  |  | 0.32 |  |  |
| 1.5      | 12100 | 0.8266  | 3.456 |  |  | 0.203                 |  |  | 0.31 |  |  |
| 1.25     | 10085 | 0.9915  | 3.324 |  |  |                       |  |  | 0.29 |  |  |
| 1.00     | 8068  | 1.239   | 3.220 |  |  |                       |  |  | 0.28 |  |  |
| 0.50     | 4034  | 2.479   | 3.114 |  |  |                       |  |  | 0.26 |  |  |
| 0.30     | 2420  | 4.131   | 3.089 |  |  |                       |  |  | 0.26 |  |  |
| 0.10     | 806.8 | 12.39   | 3.012 |  |  |                       |  |  | 0.25 |  |  |
| 0.075    | 605.1 | 16.53   | 2.932 |  |  |                       |  |  | 0.24 |  |  |
| 0.060    | 484.1 | 20.66   | 2.780 |  |  | 1.46·10 <sup>-2</sup> |  |  | 0.22 |  |  |
| 0.050    | 403.4 | 24.79   | 2.429 |  |  | 3.35·10 <sup>-2</sup> |  |  | 0.17 |  |  |
| 0.03992  | 322   | 31.06   | 0.307 |  |  | 3.57                  |  |  |      |  |  |
| 0.03496  | 282   | 35.46   | 3.89  |  |  | 0.282                 |  |  | 0.35 |  |  |
| 0.03100  | 250   | 40.00   | 4.27  |  |  | 3.0·10 <sup>-2</sup>  |  |  | 0.39 |  |  |
| 0.02728  | 220   | 45.45   | 3.93  |  |  | 1.3·10 <sup>-2</sup>  |  |  | 0.35 |  |  |
| 0.02480  | 200   | 50.0    | 3.81  |  |  | 8.7·10 <sup>-3</sup>  |  |  | 0.34 |  |  |
| 0.02418  | 195   | 51.28   | 3.19  |  |  |                       |  |  | 0.27 |  |  |
| 0.02232  | 180   | 55.56   | 3.19  |  |  |                       |  |  | 0.27 |  |  |
| 0.01860  | 150   | 66.67   | 3.65  |  |  |                       |  |  | 0.32 |  |  |
| 0.01240  | 100   | 100     | 3.57  |  |  |                       |  |  | 0.32 |  |  |
| 0.009919 | 80    | 125.0   | 3.551 |  |  |                       |  |  | 0.31 |  |  |
| 0.007439 | 60    | 166.7   | 3.538 |  |  |                       |  |  | 0.31 |  |  |
| 0.004959 | 40    | 250.0   | 3.529 |  |  |                       |  |  | 0.31 |  |  |
| 0.002480 | 20    | 500     | 3.523 |  |  |                       |  |  | 0.31 |  |  |
| 0.001240 | 10    | 1000.0  | 3.522 |  |  |                       |  |  | 0.31 |  |  |

Lead Selenide (PbSe) - [Ref. 9]

|      |       |         |      |  |  |       |  |  |      |  |  |
|------|-------|---------|------|--|--|-------|--|--|------|--|--|
| 14.5 |       | 0.08551 | 0.72 |  |  | 0.20  |  |  |      |  |  |
| 10   |       | 0.1240  | 0.68 |  |  | 0.50  |  |  |      |  |  |
| 5    | 40330 | 0.2480  | 0.54 |  |  | 1.2   |  |  |      |  |  |
| 2.0  | 16130 | 0.6199  | 3.65 |  |  | 2.9   |  |  | 0.51 |  |  |
| 1.65 | 13310 | 0.7514  | 4.51 |  |  | 1.73  |  |  | 0.46 |  |  |
| 1.5  | 12100 | 0.8266  | 4.64 |  |  | 2.64  |  |  | 0.52 |  |  |
| 1.0  | 8065  | 1.240   | 4.65 |  |  | 1.1   |  |  | 0.44 |  |  |
| 0.75 | 6049  | 1.653   |      |  |  | 0.269 |  |  |      |  |  |
| 0.62 | 5001  | 2.000   | 4.59 |  |  | 0.770 |  |  | 0.42 |  |  |
| 0.48 | 3871  | 2.583   | 4.90 |  |  |       |  |  | 0.44 |  |  |
| 0.40 | 3226  | 3.100   | 4.91 |  |  |       |  |  | 0.44 |  |  |
| 0.32 | 2581  | 3.875   | 4.98 |  |  | 0.173 |  |  | 0.44 |  |  |

| <i>E</i> /eV | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|--------------|-------------------------------|---------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 0.20         | 1613                          | 6.199         | 4.82     |                       |                       |                       |                       |                       | 0.43     |                       |                       |
| 0.1190       | 960                           | 10.42         | 4.74     |                       |                       | 1.20·10 <sup>-3</sup> |                       |                       | 0.42     |                       |                       |
| 0.09919      | 800                           | 12.50         | 4.72     |                       |                       | 2.09·10 <sup>-3</sup> |                       |                       | 0.42     |                       |                       |
| 0.07935      | 640                           | 15.63         | 4.68     |                       |                       | 4.12·10 <sup>-3</sup> |                       |                       | 0.42     |                       |                       |
| 0.05951      | 480                           | 20.83         | 4.59     |                       |                       | 1.00·10 <sup>-2</sup> |                       |                       | 0.41     |                       |                       |
| 0.04959      | 400                           | 25.00         | 4.49     |                       |                       | 1.77·10 <sup>-2</sup> |                       |                       | 0.40     |                       |                       |
| 0.03968      | 320                           | 31.25         | 4.31     |                       |                       | 3.62·10 <sup>-2</sup> |                       |                       | 0.39     |                       |                       |
| 0.02976      | 240                           | 41.67         | 3.89     |                       |                       | 9.61·10 <sup>-2</sup> |                       |                       | 0.24     |                       |                       |
| 0.01984      | 160                           | 62.50         | 2.34     |                       |                       | 0.56                  |                       |                       | 0.18     |                       |                       |
| 0.009919     | 80                            | 125.0         | 1.73     |                       |                       | 7.38                  |                       |                       | 0.88     |                       |                       |
| 0.007935     | 64                            | 156.3         | 2.91     |                       |                       | 10.1                  |                       |                       | 0.90     |                       |                       |
| 0.004959     | 40                            | 250.0         | 11.2     |                       |                       | 14.6                  |                       |                       | 0.88     |                       |                       |
| 0.002480     | 20                            | 500.0         | 12.6     |                       |                       | 12.2                  |                       |                       |          |                       |                       |
| 0.001736     | 14                            | 714.3         | 14.1     |                       |                       | 16.6                  |                       |                       |          |                       |                       |
| 0.001240     | 10                            | 1000          | 17.4     |                       |                       | 21.1                  |                       |                       |          |                       |                       |

Lead Sulfide (PbS) - [Ref. 10]

|           |       |          |       |  |  |                       |  |  |      |  |  |
|-----------|-------|----------|-------|--|--|-----------------------|--|--|------|--|--|
| 150       |       | 0.008266 |       |  |  | 3.86·10 <sup>-3</sup> |  |  |      |  |  |
| 125       |       | 0.009919 |       |  |  | 5.59·10 <sup>-3</sup> |  |  |      |  |  |
| 100       |       | 0.01240  |       |  |  | 1.54·10 <sup>-2</sup> |  |  |      |  |  |
| 80        |       | 0.01550  |       |  |  | 2.88·10 <sup>-2</sup> |  |  |      |  |  |
| 60        |       | 0.02066  |       |  |  | 6.17·10 <sup>-2</sup> |  |  |      |  |  |
| 25        |       | 0.04959  | 0.845 |  |  | 0.171                 |  |  |      |  |  |
| 18.0      |       | 0.06888  | 0.846 |  |  | 0.294                 |  |  |      |  |  |
| 14.0      |       | 0.08856  | 0.651 |  |  | 0.665                 |  |  |      |  |  |
| 10.0      |       | 0.1240   | 0.879 |  |  | 1.050                 |  |  |      |  |  |
| 4.95      | 39920 | 0.2505   | 1.52  |  |  | 2.10                  |  |  | 0.43 |  |  |
| 4.0       | 32260 | 0.3100   | 1.73  |  |  | 2.83                  |  |  | 0.55 |  |  |
| 3.00      | 24200 | 0.4133   | 3.88  |  |  | 3.00                  |  |  | 0.53 |  |  |
| 2.90      | 23390 | 0.4275   | 4.12  |  |  | 2.70                  |  |  | 0.51 |  |  |
| 2.75      | 22180 | 0.4509   | 4.25  |  |  | 2.33                  |  |  | 0.48 |  |  |
| 2.55      | 20570 | 0.4862   | 4.35  |  |  | 2.00                  |  |  | 0.47 |  |  |
| 2.00      | 16130 | 0.6199   | 4.29  |  |  | 1.48                  |  |  | 0.43 |  |  |
| 1.60      | 12910 | 0.7749   | 4.62  |  |  | 0.94                  |  |  | 0.43 |  |  |
| 1.24      | 10000 | 1.00     | 4.43  |  |  | 0.597                 |  |  | 0.41 |  |  |
| 1.03      | 8333  | 1.2      | 4.30  |  |  | 0.458                 |  |  | 0.39 |  |  |
| 0.650     | 5263  | 1.9      | 4.24  |  |  | 0.318                 |  |  | 0.39 |  |  |
| 0.496     | 4000  | 2.5      | 4.30  |  |  | 0.235                 |  |  | 0.39 |  |  |
| 0.400     | 3226  | 3.1      | 4.30  |  |  | 2.27·10 <sup>-2</sup> |  |  | 0.39 |  |  |
| 0.3100    | 2500  | 4.0      | 4.16  |  |  | 6.38·10 <sup>-4</sup> |  |  | 0.38 |  |  |
| 0.2480    | 2000  | 5        | 4.115 |  |  | 9.25·10 <sup>-4</sup> |  |  | 0.37 |  |  |
| 0.1240    | 1000  | 10       | 4.01  |  |  | 6.32·10 <sup>-3</sup> |  |  | 0.36 |  |  |
| 0.1033    | 833.3 | 12       | 3.90  |  |  | 1.14·10 <sup>-2</sup> |  |  | 0.35 |  |  |
| 0.08059   | 650   | 15.38    | 3.90  |  |  |                       |  |  | 0.35 |  |  |
| 0.06819   | 550   | 18.18    | 3.81  |  |  |                       |  |  | 0.34 |  |  |
| 0.04959   | 400   | 25.00    | 3.53  |  |  |                       |  |  | 0.31 |  |  |
| 0.03720   | 300   | 33.33    | 2.99  |  |  |                       |  |  | 0.25 |  |  |
| 0.02480   | 200.0 | 50       | 0.514 |  |  | 1.59                  |  |  |      |  |  |
| 0.01378   | 111.1 | 90       | 1.175 |  |  | 8.48                  |  |  | 0.94 |  |  |
| 0.01240   | 100.0 | 100      | 1.79  |  |  | 10.51                 |  |  | 0.94 |  |  |
| 0.008856  | 71.43 | 140      | 17.41 |  |  | 17.94                 |  |  | 0.89 |  |  |
| 0.006199  | 50.0  | 200      | 16.27 |  |  | 2.20                  |  |  | 0.79 |  |  |
| 0.003100  | 25.00 | 400      | 12.96 |  |  | 0.495                 |  |  | 0.73 |  |  |
| 0.001653  | 13.33 | 750      | 12.44 |  |  | 0.228                 |  |  | 0.72 |  |  |
| 0.001240  | 10.00 | 1000     | 12.35 |  |  | 0.167                 |  |  | 0.72 |  |  |
| 0.0006199 | 5.000 | 2000     | 12.27 |  |  | 0.0815                |  |  | 0.72 |  |  |

Lead Telluride (PbTe) - [Ref. 11]

|     |  |          |  |  |  |                       |  |  |  |  |  |
|-----|--|----------|--|--|--|-----------------------|--|--|--|--|--|
| 150 |  | 0.008266 |  |  |  | 2.37·10 <sup>-3</sup> |  |  |  |  |  |
| 125 |  | 0.009919 |  |  |  | 9.71·10 <sup>-3</sup> |  |  |  |  |  |
| 100 |  | 0.01240  |  |  |  | 4.39·10 <sup>-2</sup> |  |  |  |  |  |
| 75  |  | 0.01653  |  |  |  | 6.43·10 <sup>-2</sup> |  |  |  |  |  |

| <i>E</i> /eV | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|--------------|-------------------------------|---------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 50           |                               | 0.02480       |          |                       |                       | 6.87·10 <sup>-2</sup> |                       |                       |          |                       |                       |
| 30           |                               | 0.04133       |          |                       |                       | 7.77·10 <sup>-2</sup> |                       |                       |          |                       |                       |
| 15           |                               | 0.08266       | 0.72     |                       |                       | 0.17                  |                       |                       |          |                       |                       |
| 10           |                               | 0.1240        | 0.66     |                       |                       | 0.60                  |                       |                       |          |                       |                       |
| 7.5          |                               | 0.1653        | 0.8      |                       |                       | 0.92                  |                       |                       |          |                       |                       |
| 5.0          | 40330                         | 0.2480        | 0.72     |                       |                       | 1.0                   |                       |                       |          |                       |                       |
| 3.0          | 24200                         | 0.4133        | 1.0      |                       |                       | 2.2                   |                       |                       |          |                       |                       |
| 2.5          | 20160                         | 0.4959        | 1.35     |                       |                       | 2.86                  |                       |                       | 0.61     |                       |                       |
| 1.5          | 12100                         | 0.8266        | 3.8      |                       |                       | 3.1                   |                       |                       | 0.53     |                       |                       |
| 1.0          | 8065                          | 1.240         | 4.55     |                       |                       | 2.2                   |                       |                       | 0.49     |                       |                       |
| 0.80         | 6452                          | 1.550         | 6.25     |                       |                       | 0.71                  |                       |                       | 0.53     |                       |                       |
| 0.60         | 4839                          | 2.066         | 6.10     |                       |                       | 0.521                 |                       |                       | 0.52     |                       |                       |
| 0.40         | 3226                          | 3.100         | 6.075    |                       |                       | 0.331                 |                       |                       | 0.52     |                       |                       |
| 0.30         | 2420                          | 4.133         | 5.95     |                       |                       | 3.55·10 <sup>-2</sup> |                       |                       | 0.51     |                       |                       |
| 0.20         | 1613                          | 6.199         | 5.77     |                       |                       |                       |                       |                       | 0.50     |                       |                       |
| 0.15         | 1210                          | 8.266         | 5.76     |                       |                       |                       |                       |                       | 0.50     |                       |                       |
| 0.1017       | 820                           | 12.20         | 5.47     |                       |                       | 9.16·10 <sup>-3</sup> |                       |                       | 0.48     |                       |                       |
| 0.08927      | 720                           | 13.89         | 5.38     |                       |                       | 1.37·10 <sup>-2</sup> |                       |                       | 0.47     |                       |                       |
| 0.06943      | 560                           | 17.86         | 5.13     |                       |                       | 3.06·10 <sup>-2</sup> |                       |                       | 0.45     |                       |                       |
| 0.04959      | 400                           | 25.00         | 4.50     |                       |                       | 9.6·10 <sup>-2</sup>  |                       |                       | 0.40     |                       |                       |
| 0.03968      | 320                           | 31.25         | 3.58     |                       |                       | 0.23                  |                       |                       | 0.32     |                       |                       |
| 0.02976      | 240                           | 41.67         | 1.01     |                       |                       | 1.9                   |                       |                       |          |                       |                       |
| 0.009919     | 80                            | 125.0         | 2.95     |                       |                       | 16.6                  |                       |                       | 0.96     |                       |                       |
| 0.007439     | 60                            | 166.7         | 4.9      |                       |                       | 22.5                  |                       |                       | 0.96     |                       |                       |
| 0.006199     | 50                            | 200.0         | 6.9      |                       |                       | 27.2                  |                       |                       | 0.97     |                       |                       |
| 0.004959     | 40                            | 250.0         | 11.6     |                       |                       | 34.8                  |                       |                       | 0.97     |                       |                       |
| 0.003720     | 30                            | 333.3         | 27.7     |                       |                       | 35.7                  |                       |                       | 0.95     |                       |                       |
| 0.002480     | 20                            | 500.0         | 27.6     |                       |                       | 39.1                  |                       |                       | 0.95     |                       |                       |
| 0.001240     | 10                            | 1000          | 45.1     |                       |                       | 57.8                  |                       |                       | 0.97     |                       |                       |

Lithium Fluoride (LiF) - [Ref. 12]

|        |       |                        |           |  |  |                       |  |  |      |  |  |
|--------|-------|------------------------|-----------|--|--|-----------------------|--|--|------|--|--|
| 2000   |       | 6.199·10 <sup>-4</sup> | 0.9999347 |  |  | 4.33·10 <sup>-6</sup> |  |  |      |  |  |
| 1496   |       | 8.287·10 <sup>-4</sup> | 0.999883  |  |  | 1.28·10 <sup>-5</sup> |  |  |      |  |  |
| 1016   |       | 1.220·10 <sup>-3</sup> | 0.999757  |  |  | 5.18·10 <sup>-5</sup> |  |  |      |  |  |
| 725    |       | 1.710·10 <sup>-3</sup> | 0.999643  |  |  | 1.62·10 <sup>-4</sup> |  |  |      |  |  |
| 504    |       | 2.460·10 <sup>-3</sup> | 0.999162  |  |  | 4.96·10 <sup>-5</sup> |  |  |      |  |  |
| 303    |       | 4.092·10 <sup>-3</sup> | 0.99752   |  |  | 3.12·10 <sup>-4</sup> |  |  |      |  |  |
| 250    |       | 4.959·10 <sup>-3</sup> | 0.99632   |  |  | 6.17·10 <sup>-5</sup> |  |  |      |  |  |
| 200    |       | 6.199·10 <sup>-3</sup> |           |  |  | 2.12·10 <sup>-3</sup> |  |  |      |  |  |
| 150    |       | 8.265·10 <sup>-3</sup> | 0.9899    |  |  | 3.54·10 <sup>-3</sup> |  |  |      |  |  |
| 100    |       | 1.240·10 <sup>-2</sup> | 0.9801    |  |  | 1.32·10 <sup>-2</sup> |  |  |      |  |  |
| 75     |       | 1.653·10 <sup>-2</sup> |           |  |  | 2.63·10 <sup>-2</sup> |  |  |      |  |  |
| 50     |       | 2.480·10 <sup>-2</sup> |           |  |  | 7.89·10 <sup>-2</sup> |  |  |      |  |  |
| 25     |       | 4.959·10 <sup>-2</sup> | 0.558     |  |  | 0.521                 |  |  |      |  |  |
| 20     |       | 6.199·10 <sup>-2</sup> | 1.20      |  |  | 0.58                  |  |  | 0.10 |  |  |
| 15.1   |       | 8.211·10 <sup>-2</sup> | 1.08      |  |  | 0.68                  |  |  | 0.10 |  |  |
| 13     |       | 9.537·10 <sup>-2</sup> | 1.04      |  |  | 1.64                  |  |  |      |  |  |
| 12.0   |       | 0.1033                 | 2.28      |  |  | 0.11                  |  |  | 0.15 |  |  |
| 11.0   |       | 0.1127                 | 1.77      |  |  | 8.07·10 <sup>-7</sup> |  |  | 0.08 |  |  |
| 10.00  |       | 0.12398                | 1.606     |  |  | 7.70·10 <sup>-7</sup> |  |  | 0.05 |  |  |
| 9      |       | 0.1375                 | 1.53      |  |  |                       |  |  | 0.04 |  |  |
| 7      |       | 0.1771                 | 1.46      |  |  |                       |  |  |      |  |  |
| 4.959  | 40000 | 0.250                  | 1.4189    |  |  |                       |  |  | 0.03 |  |  |
| 4.000  | 32260 | 0.31                   | 1.4073    |  |  |                       |  |  | 0.03 |  |  |
| 2.952  | 23810 | 0.42                   | 1.3978    |  |  |                       |  |  | 0.03 |  |  |
| 2.000  | 16130 | 0.62                   | 1.3915    |  |  |                       |  |  | 0.03 |  |  |
| 0.9919 | 8000  | 1.25                   | 1.3851    |  |  |                       |  |  |      |  |  |
| 0.7999 | 6452  | 1.55                   | 1.3858    |  |  |                       |  |  | 0.03 |  |  |
| 0.4959 | 4000  | 2.5                    | 1.3731    |  |  |                       |  |  | 0.02 |  |  |
| 0.4000 | 3226  | 3.1                    | 1.3650    |  |  |                       |  |  |      |  |  |
| 0.3100 | 2500  | 4.0                    | 1.3493    |  |  |                       |  |  |      |  |  |

| <i>E</i> /eV           | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm         | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|------------------------|-------------------------------|-----------------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 0.2480                 | 2000                          | 5.0                   | 1.3266   |                       |                       | 1.8·10 <sup>-6</sup>  |                       |                       | 0.02     |                       |                       |
| 0.2000                 | 1613                          | 6.2                   | 1.2912   |                       |                       |                       |                       |                       |          |                       |                       |
| 0.1698                 | 1370                          | 7.3                   | 1.2499   |                       |                       |                       |                       |                       |          |                       |                       |
| 0.1494                 | 1205                          | 8.3                   | 1.2036   |                       |                       |                       |                       |                       |          |                       |                       |
| 0.1240                 | 1000                          | 10.0                  | 1.1005   |                       |                       | 2.6·10 <sup>-3</sup>  |                       |                       |          |                       |                       |
| 0.1127                 | 909.1                         | 11.0                  | 1.0208   |                       |                       | 8.0·10 <sup>-3</sup>  |                       |                       |          |                       |                       |
| 0.1033                 | 833.3                         | 12.0                  |          |                       |                       | 1.9·10 <sup>-2</sup>  |                       |                       |          |                       |                       |
| 0.09537                | 769.2                         | 13.0                  |          |                       |                       | 3.7·10 <sup>-2</sup>  |                       |                       |          |                       |                       |
| 0.08679                | 700                           | 14.29                 | 0.508    |                       |                       | 7.74·10 <sup>-2</sup> |                       |                       |          |                       |                       |
| 0.07439                | 600                           | 16.67                 | 0.124    |                       |                       | 0.804                 |                       |                       |          |                       |                       |
| 0.06199                | 500                           | 20.00                 | 0.306    |                       |                       | 1.47                  |                       |                       | 0.68     |                       |                       |
| 0.05579                | 450                           | 22.22                 | 0.191    |                       |                       | 1.88                  |                       |                       | 0.85     |                       |                       |
| 0.04959                | 400                           | 25.00                 | 0.208    |                       |                       | 2.71                  |                       |                       | 0.91     |                       |                       |
| 0.03720                | 300                           | 33.33                 | 8.76     |                       |                       | 3.91                  |                       |                       | 0.68     |                       |                       |
| 0.03100                | 250                           | 40.00                 | 4.64     |                       |                       | 0.287                 |                       |                       | 0.42     |                       |                       |
| 0.02480                | 200                           | 50.00                 | 3.69     |                       |                       | 0.102                 |                       |                       | 0.33     |                       |                       |
| 0.01240                | 100.0                         | 100                   | 3.067    |                       |                       | 0.106                 |                       |                       | 0.26     |                       |                       |
| 0.06199                | 50.0                          | 200                   | 3.067    |                       |                       | 4.0·10 <sup>-2</sup>  |                       |                       | 0.26     |                       |                       |
| 0.04959                | 40.00                         | 250                   | 3.067    |                       |                       | 2.2·10 <sup>-2</sup>  |                       |                       | 0.26     |                       |                       |
| 0.02480                | 20.00                         | 500                   | 3.067    |                       |                       | 6.3·10 <sup>-3</sup>  |                       |                       |          |                       |                       |
| 0.01378                | 11.11                         | 900                   |          |                       |                       | 3.1·10 <sup>-3</sup>  |                       |                       |          |                       |                       |
| 4.798·10 <sup>-4</sup> | 3.870                         | 2584                  | 3.023    |                       |                       | 1.19·10 <sup>-3</sup> |                       |                       | 0.25     |                       |                       |
| 1.464·10 <sup>-4</sup> | 1.181                         | 8469                  | 3.023    |                       |                       | 6.20·10 <sup>-4</sup> |                       |                       | 0.25     |                       |                       |
| 4.053·10 <sup>-5</sup> | 0.3269                        | 30590                 | 3.023    |                       |                       | 2.63·10 <sup>-4</sup> |                       |                       | 0.25     |                       |                       |
| 1.861·10 <sup>-7</sup> | 1.501·10 <sup>-3</sup>        | 6.662·10 <sup>6</sup> | 3.018    |                       |                       | 1.6·10 <sup>-5</sup>  |                       |                       |          |                       |                       |
| 3.718·10 <sup>-8</sup> | 2.999·10 <sup>-4</sup>        | 3.335·10 <sup>7</sup> | 3.018    |                       |                       | 1.6·10 <sup>-5</sup>  |                       |                       |          |                       |                       |

Potassium Chloride (KCl) - [Ref. 13]

|        |       |                         |         |  |  |                       |  |  |                       |  |  |
|--------|-------|-------------------------|---------|--|--|-----------------------|--|--|-----------------------|--|--|
| 2860.3 |       | 4.3347·10 <sup>-4</sup> |         |  |  | 3.93·10 <sup>-6</sup> |  |  |                       |  |  |
| 2855.3 |       | 4.3423·10 <sup>-4</sup> |         |  |  | 3.39·10 <sup>-6</sup> |  |  |                       |  |  |
| 2849.3 |       | 4.3514·10 <sup>-4</sup> |         |  |  | 4.61·10 <sup>-6</sup> |  |  |                       |  |  |
| 2835.8 |       | 4.3721·10 <sup>-4</sup> |         |  |  | 5.85·10 <sup>-6</sup> |  |  |                       |  |  |
| 2832.3 |       | 4.3775·10 <sup>-4</sup> |         |  |  | 5.85·10 <sup>-6</sup> |  |  |                       |  |  |
| 2829.8 |       | 4.3814·10 <sup>-4</sup> |         |  |  | 1.57·10 <sup>-6</sup> |  |  |                       |  |  |
| 2828.3 |       | 4.3837·10 <sup>-4</sup> |         |  |  | 4.19·10 <sup>-7</sup> |  |  |                       |  |  |
| 219    |       | 5.661·10 <sup>-3</sup>  |         |  |  | 1.82·10 <sup>-3</sup> |  |  |                       |  |  |
| 215    |       | 5.767·10 <sup>-3</sup>  |         |  |  | 1.84·10 <sup>-3</sup> |  |  |                       |  |  |
| 212.5  |       | 5.834·10 <sup>-3</sup>  |         |  |  | 2.19·10 <sup>-3</sup> |  |  |                       |  |  |
| 211    |       | 5.876·10 <sup>-3</sup>  |         |  |  | 1.82·10 <sup>-3</sup> |  |  |                       |  |  |
| 185.1  |       | 6.7·10 <sup>-3</sup>    | 0.99874 |  |  |                       |  |  | 1.01·10 <sup>-3</sup> |  |  |
| 109.7  |       | 1.13·10 <sup>-2</sup>   | 0.99578 |  |  |                       |  |  | 4.22·10 <sup>-3</sup> |  |  |
| 43     |       | 0.02883                 | 0.96    |  |  | 3.0·10 <sup>-2</sup>  |  |  |                       |  |  |
| 40     |       | 0.03179                 | 0.925   |  |  | 1.8·10 <sup>-2</sup>  |  |  |                       |  |  |
| 29.9   |       | 0.04147                 | 0.756   |  |  | 0.145                 |  |  |                       |  |  |
| 20.1   |       | 0.06168                 | 0.910   |  |  | 0.495                 |  |  |                       |  |  |
| 15.1   |       | 0.08211                 | 0.965   |  |  | 0.344                 |  |  |                       |  |  |
| 10.0   |       | 0.1240                  | 1.16    |  |  | 0.38                  |  |  | 0.035                 |  |  |
| 9.0    |       | 0.1378                  | 1.99    |  |  | 0.50                  |  |  | 0.13                  |  |  |
| 8.0    |       | 0.1550                  | 1.15    |  |  | 0.46                  |  |  | 0.048                 |  |  |
| 7.0    |       | 0.1771                  | 2.0     |  |  | 8.46·10 <sup>-7</sup> |  |  | 0.11                  |  |  |
| 6.199  | 50000 | 0.20                    | 1.71739 |  |  |                       |  |  | 0.070                 |  |  |
| 4.959  | 40000 | 0.25                    | 1.58972 |  |  |                       |  |  |                       |  |  |
| 3.999  | 32260 | 0.31                    | 1.54005 |  |  |                       |  |  |                       |  |  |
| 2.952  | 23810 | 0.42                    | 1.50701 |  |  |                       |  |  |                       |  |  |
| 2.695  | 21740 | 0.46                    | 1.50115 |  |  |                       |  |  | 0.040                 |  |  |
| 2.616  | 21100 | 0.474                   |         |  |  | 7.6·10 <sup>-11</sup> |  |  |                       |  |  |
| 2.384  | 19230 | 0.52                    | 1.49501 |  |  |                       |  |  |                       |  |  |
| 2.066  | 16670 | 0.60                    | 1.48969 |  |  |                       |  |  | 0.039                 |  |  |
| 1.550  | 12500 | 0.80                    | 1.48291 |  |  |                       |  |  | 0.038                 |  |  |
| 1.033  | 8333  | 1.2                     | 1.47813 |  |  |                       |  |  | 0.037                 |  |  |
| 0.5166 | 4167  | 2.4                     | 1.47464 |  |  |                       |  |  | 0.037                 |  |  |



| <i>E</i> /eV | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|--------------|-------------------------------|---------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 0.2480       | 2000                          | 5.0           | 1.47048  |                       |                       |                       |                       |                       | 0.036    |                       |                       |
| 0.2000       | 1.613                         | 6.2           | 1.46796  |                       |                       |                       |                       |                       | 0.036    |                       |                       |
| 0.1512       | 1220                          | 8.2           | 1.46260  |                       |                       |                       |                       |                       | 0.035    |                       |                       |
| 0.09999      | 806.5                         | 12.4          | 1.44611  |                       |                       |                       |                       |                       | 0.033    |                       |                       |
| 0.07560      | 609.8                         | 16.4          | 1.42295  |                       |                       |                       |                       |                       | 0.030    |                       |                       |
| 0.04959      | 400.0                         | 25.0          | 1.34059  |                       |                       | 6.57·10 <sup>-4</sup> |                       |                       | 0.021    |                       |                       |
| 0.03999      | 322.6                         | 31.0          | 1.2431   |                       |                       |                       |                       |                       | 0.012    |                       |                       |
| 0.02976      | 240                           | 41.67         | 0.85     |                       |                       | 0.16                  |                       |                       |          |                       |                       |
| 0.02728      | 220                           | 45.45         | 0.53     |                       |                       | 0.35                  |                       |                       |          |                       |                       |
| 0.02232      | 180                           | 55.56         | 0.31     |                       |                       | 1.05                  |                       |                       |          |                       |                       |
| 0.01860      | 150                           | 66.67         | 0.44     |                       |                       | 4.0                   |                       |                       |          |                       |                       |
| 0.01612      | 130                           | 76.92         | 4.1      |                       |                       | 0.32                  |                       |                       | 0.37     |                       |                       |
| 0.01240      | 100                           | 100.0         | 2.7      |                       |                       | 0.11                  |                       |                       | 0.21     |                       |                       |
| 0.008679     | 70                            | 142.9         | 2.4      |                       |                       | 9.2·10 <sup>-2</sup>  |                       |                       | 0.17     |                       |                       |
| 0.006199     | 50                            | 200.0         | 2.2      |                       |                       |                       |                       |                       | 0.14     |                       |                       |
| 0.001240     | 10.00                         | 1000          |          |                       |                       | 9.0·10 <sup>-3</sup>  |                       |                       |          |                       |                       |
| 0.0006199    | 5.000                         | 2000          |          |                       |                       | 3.7·10 <sup>-3</sup>  |                       |                       |          |                       |                       |
| 0.0004133    | 3.333                         | 3000          |          |                       |                       | 2.0·10 <sup>-3</sup>  |                       |                       |          |                       |                       |

Silicon Dioxide (Glass) - [Ref. 14]

|        |         |                        |         |  |  |                        |  |  |       |  |  |
|--------|---------|------------------------|---------|--|--|------------------------|--|--|-------|--|--|
| 2000   |         | 6.199·10 <sup>-4</sup> | 0.99993 |  |  | 1.503·10 <sup>-5</sup> |  |  |       |  |  |
| 1860   |         | 6.665·10 <sup>-4</sup> | 0.99991 |  |  | 1.936·10 <sup>-5</sup> |  |  |       |  |  |
| 1609   |         | 7.705·10 <sup>-4</sup> | 0.99989 |  |  | 9.941·10 <sup>-6</sup> |  |  |       |  |  |
| 1496   |         | 8.287·10 <sup>-4</sup> | 0.99987 |  |  | 1.308·10 <sup>-5</sup> |  |  |       |  |  |
| 1204   |         | 1.030·10 <sup>-3</sup> | 0.99980 |  |  | 2.916·10 <sup>-5</sup> |  |  |       |  |  |
| 1093   |         | 1.134·10 <sup>-3</sup> | 0.99975 |  |  | 4.155·10 <sup>-5</sup> |  |  |       |  |  |
| 1016   |         | 1.220·10 <sup>-3</sup> | 0.99971 |  |  | 5.423·10 <sup>-5</sup> |  |  |       |  |  |
| 798    |         | 1.554·10 <sup>-3</sup> | 0.99954 |  |  | 1.289·10 <sup>-4</sup> |  |  |       |  |  |
| 597    |         | 2.077·10 <sup>-3</sup> | 0.99917 |  |  | 3.560·10 <sup>-4</sup> |  |  |       |  |  |
| 396    |         | 3.131·10 <sup>-3</sup> | 0.99812 |  |  | 4.04·10 <sup>-4</sup>  |  |  |       |  |  |
| 303    |         | 4.092·10 <sup>-3</sup> | 0.99678 |  |  | 9.91·10 <sup>-4</sup>  |  |  |       |  |  |
| 201    |         | 6.168·10 <sup>-3</sup> | 0.99269 |  |  | 3.63·10 <sup>-3</sup>  |  |  |       |  |  |
| 151.2  |         | 8.2·10 <sup>-3</sup>   | 0.9871  |  |  | 7.3·10 <sup>-3</sup>   |  |  |       |  |  |
| 99.99  |         | 1.24·10 <sup>-2</sup>  | 0.9813  |  |  | 7.0·10 <sup>-3</sup>   |  |  |       |  |  |
| 49.59  |         | 2.50·10 <sup>-2</sup>  | 0.9164  |  |  | 6.5·10 <sup>-2</sup>   |  |  |       |  |  |
| 40.00  |         | 3.10·10 <sup>-2</sup>  | 0.907   |  |  | 9.2·10 <sup>-2</sup>   |  |  |       |  |  |
| 31.00  |         | 4.00·10 <sup>-2</sup>  | 0.851   |  |  | 0.156                  |  |  |       |  |  |
| 25.00  |         | 0.04959                | 0.733   |  |  | 0.325                  |  |  |       |  |  |
| 20.00  |         | 0.06199                | 0.859   |  |  | 0.585                  |  |  |       |  |  |
| 15.00  |         | 0.08266                | 1.168   |  |  | 0.711                  |  |  | 0.10  |  |  |
| 13.00  |         | 0.09537                | 1.368   |  |  | 0.747                  |  |  | 0.11  |  |  |
| 11.00  |         | 0.1127                 | 1.739   |  |  | 0.569                  |  |  | 0.11  |  |  |
| 10.00  |         | 0.1240                 | 2.330   |  |  | 0.323                  |  |  | 0.17  |  |  |
| 9.00   |         | 0.1378                 | 1.904   |  |  | 1.89·10 <sup>-2</sup>  |  |  | 0.097 |  |  |
| 7.00   |         | 0.1771                 | 1.600   |  |  |                        |  |  | 0.053 |  |  |
| 6.00   | 48390   | 0.2066                 | 1.543   |  |  |                        |  |  | 0.046 |  |  |
| 4.9939 | 40278.4 | 0.248272               | 1.50841 |  |  |                        |  |  | 0.041 |  |  |
| 4.1034 | 33096.1 | 0.302150               | 1.48719 |  |  |                        |  |  | 0.038 |  |  |
| 3.0640 | 24712.3 | 0.404656               | 1.46961 |  |  |                        |  |  | 0.036 |  |  |
| 2.5504 | 20570.5 | 0.486133               | 1.46313 |  |  |                        |  |  | 0.035 |  |  |
| 2.4379 | 19662.5 | 0.508582               | 1.46187 |  |  |                        |  |  | 0.035 |  |  |
| 2.2705 | 18312.5 | 0.546074               | 1.46008 |  |  |                        |  |  | 0.035 |  |  |
| 2.1489 | 17332.3 | 0.576959               | 1.45885 |  |  |                        |  |  | 0.035 |  |  |
| 2.1411 | 17269.2 | 0.579065               | 1.45877 |  |  |                        |  |  | 0.035 |  |  |
| 2.1102 | 17019.5 | 0.587561               | 1.45847 |  |  |                        |  |  | 0.035 |  |  |
| 2.1041 | 16970.4 | 0.589262               | 1.45841 |  |  |                        |  |  | 0.035 |  |  |
| 1.9257 | 15531.6 | 0.643847               | 1.45671 |  |  |                        |  |  | 0.035 |  |  |
| 1.8892 | 15237.6 | 0.656272               | 1.45637 |  |  |                        |  |  | 0.035 |  |  |
| 1.8566 | 14974.2 | 0.667815               | 1.45608 |  |  |                        |  |  | 0.034 |  |  |
| 1.7549 | 14153.9 | 0.706519               | 1.45515 |  |  |                        |  |  | 0.034 |  |  |
| 1.4550 | 11735.6 | 0.852111               | 1.45248 |  |  |                        |  |  | 0.034 |  |  |

| <i>E</i> /eV                                  | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|-----------------------------------------------|-------------------------------|---------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| 1.0985                                        | 8860.06                       | 1.12866       | 1.44888  |                       |                       |                       |                       |                       | 0.034    |                       |                       |
| 0.60243                                       | 4858.9                        | 2.0581        | 1.43722  |                       |                       |                       |                       |                       | 0.032    |                       |                       |
| 0.35354                                       | 2851.4                        | 3.5070        | 1.40568  |                       |                       |                       |                       |                       | 0.028    |                       |                       |
| 0.2976                                        | 2400                          | 4.176         | 1.383    |                       |                       | 1.07·10 <sup>-4</sup> |                       |                       | 0.026    |                       |                       |
| 0.2728                                        | 2200                          | 4.545         | 1.365    |                       |                       | 2.56·10 <sup>-4</sup> |                       |                       | 0.024    |                       |                       |
| 0.2480                                        | 2000                          | 5.000         | 1.342    |                       |                       | 3.98·10 <sup>-3</sup> |                       |                       | 0.021    |                       |                       |
| 0.2232                                        | 1800                          | 5.556         | 1.306    |                       |                       | 5.63·10 <sup>-3</sup> |                       |                       |          |                       |                       |
| 0.1984                                        | 1600                          | 6.250         | 1.239    |                       |                       | 6.52·10 <sup>-3</sup> |                       |                       |          |                       |                       |
| 0.1736                                        | 1400                          | 7.143         | 1.053    |                       |                       | 1.06·10 <sup>-2</sup> |                       |                       |          |                       |                       |
| 0.1674                                        | 1350                          | 7.407         | 0.9488   |                       |                       | 1.48·10 <sup>-2</sup> |                       |                       |          |                       |                       |
| 0.1612                                        | 1300                          | 7.692         | 0.7719   |                       |                       | 3.72·10 <sup>-2</sup> |                       |                       |          |                       |                       |
| 0.1500                                        | 1210                          | 8.265         | 0.4530   |                       |                       | 0.704                 |                       |                       | 0.30     |                       |                       |
| 0.1401                                        | 1130                          | 8.850         | 0.3563   |                       |                       | 1.53                  |                       |                       | 0.66     |                       |                       |
| 0.1302                                        | 1050                          | 9.524         | 2.760    |                       |                       | 1.65                  |                       |                       | 0.35     |                       |                       |
| 0.1209                                        | 975                           | 10.26         | 2.448    |                       |                       | 0.231                 |                       |                       | 0.18     |                       |                       |
| 0.1091                                        | 880                           | 11.36         | 1.784    |                       |                       | 7.75·10 <sup>-2</sup> |                       |                       | 0.079    |                       |                       |
| 0.09919                                       | 800                           | 12.50         | 1.753    |                       |                       | 0.343                 |                       |                       | 0.089    |                       |                       |
| 0.08989                                       | 725                           | 13.79         | 1.698    |                       |                       | 0.175                 |                       |                       | 0.071    |                       |                       |
| 0.06943                                       | 560                           | 17.86         | 1.337    |                       |                       | 0.298                 |                       |                       | 0.036    |                       |                       |
| 0.06199                                       | 500                           | 20.00         | 0.6616   |                       |                       |                       |                       |                       | 0.882    |                       |                       |
| 0.04959                                       | 400                           | 25.0          | 2.739    |                       |                       | 0.397                 |                       |                       | 0.23     |                       |                       |
| 0.03720                                       | 300                           | 33.33         | 2.210    |                       |                       | 6.7·10 <sup>-2</sup>  |                       |                       | 0.14     |                       |                       |
| 0.01240                                       | 100                           | 100.0         | 1.967    |                       |                       | 1.59·10 <sup>-2</sup> |                       |                       | 0.11     |                       |                       |
| 0.007439                                      | 60                            | 166.7         | 1.959    |                       |                       | 8.62·10 <sup>-3</sup> |                       |                       | 0.11     |                       |                       |
| 0.002480                                      | 20                            | 500.0         | 1.955    |                       |                       | 7.96·10 <sup>-3</sup> |                       |                       | 0.10     |                       |                       |
| Silicon Monoxide (Noncrystalline) - [Ref. 15] |                               |               |          |                       |                       |                       |                       |                       |          |                       |                       |
| 25                                            |                               | 0.04959       | 0.8690   |                       |                       | 0.2717                |                       |                       |          |                       |                       |
| 20                                            |                               | 0.06199       | 0.8853   |                       |                       | 0.4919                |                       |                       |          |                       |                       |
| 17.5                                          |                               | 0.07085       | 0.9825   |                       |                       | 0.5961                |                       |                       |          |                       |                       |
| 15                                            |                               | 0.08266       | 1.132    |                       |                       | 0.6651                |                       |                       | 0.092    |                       |                       |
| 12.5                                          |                               | 0.09919       | 1.283    |                       |                       | 0.6523                |                       |                       | 0.090    |                       |                       |
| 10                                            |                               | 0.1240        | 1.378    |                       |                       | 0.6843                |                       |                       | 0.10     |                       |                       |
| 7.5                                           |                               | 0.1653        | 1.593    |                       |                       | 0.7473                |                       |                       | 0.12     |                       |                       |
| 5                                             | 40330                         | 0.2480        | 2.001    |                       |                       | 0.6052                |                       |                       | 0.15     |                       |                       |
| 4                                             | 32260                         | 0.3100        | 2.141    |                       |                       | 0.4006                |                       |                       | 0.15     |                       |                       |
| 3                                             | 24200                         | 0.4133        | 2.116    |                       |                       | 0.1211                |                       |                       | 0.13     |                       |                       |
| 2.8                                           | 22580                         | 0.4428        | 2.085    |                       |                       | 0.08374               |                       |                       | 0.12     |                       |                       |
| 2.6                                           | 20970                         | 0.4769        | 2.053    |                       |                       | 0.05544               |                       |                       | 0.12     |                       |                       |
| 2.4                                           | 19360                         | 0.5166        | 2.021    |                       |                       | 0.03533               |                       |                       | 0.11     |                       |                       |
| 2.2                                           | 17740                         | 0.5636        | 1.994    |                       |                       | 0.02153               |                       |                       | 0.11     |                       |                       |
| 2                                             | 16130                         | 0.6199        | 1.969    |                       |                       | 0.01175               |                       |                       | 0.11     |                       |                       |
| 1.8                                           | 14520                         | 0.6888        | 1.948    |                       |                       | 0.00523               |                       |                       | 0.10     |                       |                       |
| 1.6                                           | 12900                         | 0.7749        | 1.929    |                       |                       | 0.00151               |                       |                       | 0.10     |                       |                       |
| 1.240                                         | 10000                         | 1.000         | 1.87     |                       |                       |                       |                       |                       | 0.092    |                       |                       |
| 0.6199                                        | 5000                          | 2.000         | 1.84     |                       |                       |                       |                       |                       | 0.087    |                       |                       |
| 0.3100                                        | 2500                          | 4.000         | 1.80     |                       |                       |                       |                       |                       | 0.082    |                       |                       |
| 0.2480                                        | 2000                          | 5.000         | 1.75     |                       |                       |                       |                       |                       | 0.074    |                       |                       |
| 0.2066                                        | 1667                          | 6.000         | 1.70     |                       |                       |                       |                       |                       | 0.067    |                       |                       |
| 0.1771                                        | 1492                          | 7.000         | 1.60     |                       |                       |                       |                       |                       | 0.053    |                       |                       |
| 0.1653                                        | 1333                          | 7.500         | 1.42     |                       |                       |                       |                       |                       |          |                       |                       |
| 0.1459                                        | 1176                          | 8.500         | 0.90     |                       |                       | 0.18                  |                       |                       |          |                       |                       |
| 0.1305                                        | 1053                          | 9.500         | 1.20     |                       |                       | 1.20                  |                       |                       | 0.024    |                       |                       |
| 0.1240                                        | 1000                          | 10.00         | 2.00     |                       |                       | 1.38                  |                       |                       | 0.27     |                       |                       |
| 0.1181                                        | 952.4                         | 10.50         | 2.85     |                       |                       | 0.90                  |                       |                       | 0.27     |                       |                       |
| 0.1153                                        | 930.2                         | 10.75         | 2.86     |                       |                       | 0.58                  |                       |                       | 0.25     |                       |                       |
| 0.1127                                        | 909.1                         | 11.00         | 2.82     |                       |                       | 0.40                  |                       |                       | 0.24     |                       |                       |
| 0.1078                                        | 869.6                         | 11.50         | 2.50     |                       |                       | 0.20                  |                       |                       | 0.19     |                       |                       |
| 0.1033                                        | 833.3                         | 12.00         | 2.13     |                       |                       | 0.14                  |                       |                       | 0.13     |                       |                       |
| 0.09537                                       | 769.2                         | 13.00         | 2.04     |                       |                       | 0.20                  |                       |                       | 0.12     |                       |                       |
| 0.08856                                       | 714.3                         | 14.00         | 2.01     |                       |                       | 0.30                  |                       |                       | 0.12     |                       |                       |

| <i>E</i> /eV                                                                 | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm          | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>              | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i> | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|------------------------------------------------------------------------------|-------------------------------|------------------------|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------|-----------------------|-----------------------|
| Noncrystalline Silicon Nitride (Si <sub>3</sub> N <sub>4</sub> ) - [Ref. 16] |                               |                        |          |                       |                       |                       |                       |                       |          |                       |                       |
| 24                                                                           |                               | 0.05166                | 0.655    |                       |                       | 0.420                 |                       |                       | 0.28     |                       |                       |
| 23                                                                           |                               | 0.05391                | 0.625    |                       |                       | 0.481                 |                       |                       | 0.22     |                       |                       |
| 22                                                                           |                               | 0.05636                | 0.611    |                       |                       | 0.560                 |                       |                       | 0.16     |                       |                       |
| 21                                                                           |                               | 0.05904                | 0.617    |                       |                       | 0.647                 |                       |                       | 0.19     |                       |                       |
| 20                                                                           |                               | 0.06199                | 0.635    |                       |                       | 0.743                 |                       |                       | 0.21     |                       |                       |
| 19                                                                           |                               | 0.06526                | 0.676    |                       |                       | 0.841                 |                       |                       | 0.23     |                       |                       |
| 18                                                                           |                               | 0.06888                | 0.735    |                       |                       | 0.936                 |                       |                       | 0.26     |                       |                       |
| 17                                                                           |                               | 0.07293                | 0.810    |                       |                       | 1.03                  |                       |                       | 0.25     |                       |                       |
| 16                                                                           |                               | 0.07749                | 0.902    |                       |                       | 1.11                  |                       |                       | 0.26     |                       |                       |
| 15                                                                           |                               | 0.08266                | 1.001    |                       |                       | 1.18                  |                       |                       | 0.26     |                       |                       |
| 14                                                                           |                               | 0.08856                | 1.111    |                       |                       | 1.26                  |                       |                       | 0.26     |                       |                       |
| 13                                                                           |                               | 0.09537                | 1.247    |                       |                       | 1.35                  |                       |                       | 0.27     |                       |                       |
| 12                                                                           | 96790                         | 0.1033                 | 1.417    |                       |                       | 1.43                  |                       |                       | 0.28     |                       |                       |
| 11                                                                           | 88720                         | 0.1127                 | 1.657    |                       |                       | 1.52                  |                       |                       | 0.29     |                       |                       |
| 10.5                                                                         | 84690                         | 0.1181                 | 1.827    |                       |                       | 1.53                  |                       |                       | 0.29     |                       |                       |
| 10                                                                           | 80650                         | 0.1240                 | 2.000    |                       |                       | 1.49                  |                       |                       | 0.29     |                       |                       |
| 9.5                                                                          | 76620                         | 0.1305                 | 2.162    |                       |                       | 1.44                  |                       |                       | 0.28     |                       |                       |
| 9                                                                            | 72590                         | 0.1378                 | 2.326    |                       |                       | 1.32                  |                       |                       | 0.27     |                       |                       |
| 8                                                                            | 64520                         | 0.1550                 | 2.651    |                       |                       | 0.962                 |                       |                       | 0.26     |                       |                       |
| 7                                                                            | 56460                         | 0.1771                 | 2.752    |                       |                       | 0.493                 |                       |                       | 0.23     |                       |                       |
| 6                                                                            | 48390                         | 0.2066                 | 2.541    |                       |                       | 0.102                 |                       |                       | 0.19     |                       |                       |
| 5                                                                            | 40330                         | 0.2480                 | 2.278    |                       |                       | 4.9·10 <sup>-3</sup>  |                       |                       | 0.15     |                       |                       |
| 4.75                                                                         | 38310                         | 0.2610                 | 2.234    |                       |                       | 1.2·10 <sup>-3</sup>  |                       |                       | 0.15     |                       |                       |
| 4.5                                                                          | 36290                         | 0.2755                 | 2.198    |                       |                       | 2.2·10 <sup>-4</sup>  |                       |                       | 0.14     |                       |                       |
| 4                                                                            | 32260                         | 0.3100                 | 2.141    |                       |                       |                       |                       |                       | 0.13     |                       |                       |
| 3.5                                                                          | 28230                         | 0.3542                 | 2.099    |                       |                       |                       |                       |                       | 0.13     |                       |                       |
| 3                                                                            | 24200                         | 0.4133                 | 2.066    |                       |                       |                       |                       |                       | 0.12     |                       |                       |
| 2.5                                                                          | 20160                         | 0.4959                 | 2.041    |                       |                       |                       |                       |                       | 0.12     |                       |                       |
| 2                                                                            | 16130                         | 0.6199                 | 2.022    |                       |                       |                       |                       |                       | 0.11     |                       |                       |
| 1.5                                                                          | 12100                         | 0.8266                 | 2.008    |                       |                       |                       |                       |                       | 0.11     |                       |                       |
| 1                                                                            | 8065                          | 1.240                  | 1.998    |                       |                       |                       |                       |                       | 0.11     |                       |                       |
| Sodium Chloride (NaCl) - [Ref. 17]                                           |                               |                        |          |                       |                       |                       |                       |                       |          |                       |                       |
| 209.5                                                                        |                               | 5.918·10 <sup>-3</sup> |          |                       |                       | 2.54·10 <sup>-3</sup> |                       |                       |          |                       |                       |
| 206                                                                          |                               | 6.019·10 <sup>-3</sup> |          |                       |                       | 2.62·10 <sup>-3</sup> |                       |                       |          |                       |                       |
| 203                                                                          |                               | 6.107·10 <sup>-3</sup> |          |                       |                       | 2.08·10 <sup>-3</sup> |                       |                       |          |                       |                       |
| 200                                                                          |                               | 6.199·10 <sup>-3</sup> |          |                       |                       | 1.92·10 <sup>-3</sup> |                       |                       |          |                       |                       |
| 26.0                                                                         |                               | 0.04769                | 0.83     |                       |                       | 0.15                  |                       |                       | 0.015    |                       |                       |
| 25.0                                                                         |                               | 0.04959                | 0.83     |                       |                       | 0.18                  |                       |                       | 0.018    |                       |                       |
| 22.0                                                                         |                               | 0.05636                | 0.83     |                       |                       | 0.31                  |                       |                       | 0.057    |                       |                       |
| 20.0                                                                         |                               | 0.06199                | 0.88     |                       |                       | 0.34                  |                       |                       | 0.036    |                       |                       |
| 18.0                                                                         |                               | 0.06888                | 0.89     |                       |                       | 0.33                  |                       |                       | 0.033    |                       |                       |
| 16.1                                                                         |                               | 0.07700                | 0.74     |                       |                       | 0.45                  |                       |                       | 0.084    |                       |                       |
| 14.0                                                                         |                               | 0.08856                | 0.98     |                       |                       | 0.89                  |                       |                       | 0.17     |                       |                       |
| 12.0                                                                         |                               | 0.1033                 | 1.22     |                       |                       | 0.79                  |                       |                       | 0.12     |                       |                       |
| 10.0                                                                         |                               | 0.1240                 | 1.55     |                       |                       | 0.71                  |                       |                       | 0.12     |                       |                       |
| 8.00                                                                         |                               | 0.1550                 | 1.38     |                       |                       | 1.10                  |                       |                       | 0.20     |                       |                       |
| 6.00                                                                         | 48390                         | 0.2066                 | 1.75     |                       |                       |                       |                       |                       | 0.074    |                       |                       |
| 5.00                                                                         | 40330                         | 0.2480                 | 1.65     |                       |                       |                       |                       |                       | 0.060    |                       |                       |
| 2.952                                                                        | 23810                         | 0.42                   | 1.56324  |                       |                       |                       |                       |                       | 0.048    |                       |                       |
| 2.480                                                                        | 20000                         | 0.50                   | 1.55157  |                       |                       |                       |                       |                       | 0.047    |                       |                       |
| 2.214                                                                        | 17860                         | 0.56                   | 1.54613  |                       |                       |                       |                       |                       | 0.046    |                       |                       |
| 2.000                                                                        | 16130                         | 0.62                   | 1.54228  |                       |                       |                       |                       |                       | 0.045    |                       |                       |
| 1.771                                                                        | 14290                         | 0.70                   | 1.53865  |                       |                       |                       |                       |                       | 0.045    |                       |                       |
| 1.675                                                                        | 13510                         | 0.74                   | 1.53728  |                       |                       |                       |                       |                       | 0.045    |                       |                       |
| 1.550                                                                        | 12500                         | 0.80                   | 1.53560  |                       |                       |                       |                       |                       | 0.045    |                       |                       |
| 1.240                                                                        | 10000                         | 1.00                   | 1.53200  |                       |                       |                       |                       |                       | 0.044    |                       |                       |
| 1.033                                                                        | 8333                          | 1.2                    | 1.53000  |                       |                       |                       |                       |                       | 0.044    |                       |                       |
| 0.6888                                                                       | 5556                          | 1.8                    | 1.52712  |                       |                       |                       |                       |                       | 0.043    |                       |                       |
| 0.4959                                                                       | 4000                          | 2.5                    | 1.52531  |                       |                       |                       |                       |                       | 0.043    |                       |                       |

| <i>E</i> /eV                         | $\bar{\nu}$ /cm <sup>-1</sup> | $\lambda$ /μm          | <i>n</i> | <i>n</i> <sub>a</sub> | <i>n</i> <sub>c</sub> | <i>k</i>                       | <i>k</i> <sub>a</sub> | <i>k</i> <sub>c</sub> | <i>R</i>             | <i>R</i> <sub>a</sub> | <i>R</i> <sub>c</sub> |
|--------------------------------------|-------------------------------|------------------------|----------|-----------------------|-----------------------|--------------------------------|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|
| 0.4000                               | 3226                          | 3.1                    | 1.52395  |                       |                       |                                |                       |                       | 0.043                |                       |                       |
| 0.3263                               | 2632                          | 3.8                    | 1.52226  |                       |                       | (1.8±0.2)<br>·10 <sup>-9</sup> |                       |                       | 0.043                |                       |                       |
| 0.2952                               | 2381                          | 4.2                    | 1.52121  |                       |                       |                                |                       |                       | 0.043                |                       |                       |
| 0.2755                               | 2222                          | 4.5                    | 1.52036  |                       |                       |                                |                       |                       | 0.043                |                       |                       |
| 0.2480                               | 2000                          | 5.0                    | 1.51883  |                       |                       |                                |                       |                       | 0.042                |                       |                       |
| 0.1240                               | 1000                          | 10.0                   | 1.49473  |                       |                       |                                |                       |                       | 0.039                |                       |                       |
| 0.1033                               | 833.3                         | 12.0                   | 1.48000  |                       |                       |                                |                       |                       | 0.037                |                       |                       |
| 0.08856                              | 714.3                         | 14.0                   | 1.46188  |                       |                       |                                |                       |                       | 0.035                |                       |                       |
| 0.07749                              | 625.0                         | 16.0                   | 1.4399   |                       |                       |                                |                       |                       | 0.033                |                       |                       |
| 0.06888                              | 555.5                         | 18.0                   | 1.41364  |                       |                       |                                |                       |                       | 0.029                |                       |                       |
| 0.06199                              | 500.0                         | 20.0                   | 1.3822   |                       |                       |                                |                       |                       | 0.026                |                       |                       |
| 0.04959                              | 400                           | 25.0                   | 1.27     |                       |                       | 3.5·10 <sup>-3</sup>           |                       |                       | 0.014                |                       |                       |
| 0.04215                              | 340                           | 29.41                  | 1.12     |                       |                       | 1.7·10 <sup>-2</sup>           |                       |                       | 0.0032               |                       |                       |
| 0.03720                              | 300                           | 33.33                  | 0.85     |                       |                       | 0.85                           |                       |                       | 0.18                 |                       |                       |
| 0.03410                              | 275                           | 36.36                  | 0.59     |                       |                       | 0.22                           |                       |                       | 0.084                |                       |                       |
| 0.03286                              | 265                           | 37.74                  | 0.42     |                       |                       | 0.50                           |                       |                       | 0.26                 |                       |                       |
| 0.03224                              | 260                           | 38.46                  | 0.45     |                       |                       | 0.45                           |                       |                       | 0.22                 |                       |                       |
| 0.02480                              | 200                           | 50.00                  | 0.14     |                       |                       | 1.99                           |                       |                       | 0.89                 |                       |                       |
| 0.02108                              | 170                           | 58.82                  | 1.35     |                       |                       | 6.03                           |                       |                       | 0.87                 |                       |                       |
| 0.01984                              | 160                           | 62.50                  | 6.92     |                       |                       | 2.14                           |                       |                       | 0.59                 |                       |                       |
| 0.01922                              | 155                           | 64.52                  | 5.50     |                       |                       | 0.87                           |                       |                       | 0.49                 |                       |                       |
| 0.01860                              | 150                           | 66.67                  | 4.52     |                       |                       | 0.380                          |                       |                       | 0.41                 |                       |                       |
| 0.01736                              | 140                           | 71.43                  | 3.72     |                       |                       | 0.219                          |                       |                       | 0.33                 |                       |                       |
| 0.01612                              | 130                           | 76.92                  | 3.31     |                       |                       | 0.135                          |                       |                       | 0.29                 |                       |                       |
| 0.01488                              | 120                           | 83.33                  | 3.02     |                       |                       | 0.110                          |                       |                       | 0.25                 |                       |                       |
| 0.01240                              | 100                           | 100.0                  | 2.74     |                       |                       | 0.087                          |                       |                       | 0.22                 |                       |                       |
| 0.009919                             | 80                            | 125.0                  | 2.57     |                       |                       | 0.077                          |                       |                       | 0.19                 |                       |                       |
| 0.07439                              | 60                            | 166.7                  | 2.48     |                       |                       | 0.055                          |                       |                       | 0.18                 |                       |                       |
| 0.04959                              | 40                            | 250.00                 | 2.44     |                       |                       | 0.041                          |                       |                       | 0.18                 |                       |                       |
| 0.002480                             | 20                            | 500.0                  | 2.43     |                       |                       | 0.024                          |                       |                       | 0.17                 |                       |                       |
| 0.001240                             | 10                            | 1000                   | 2.43     |                       |                       | 0.006                          |                       |                       | 0.17                 |                       |                       |
| 0.001033                             | 8.333                         | 1200                   |          |                       |                       | 8.8·10 <sup>-3</sup>           |                       |                       |                      |                       |                       |
| 0.0006888                            | 5.556                         | 1800                   |          |                       |                       | 5.4·10 <sup>-3</sup>           |                       |                       |                      |                       |                       |
| 0.0006199                            | 5.000                         | 2000                   | 2.43     |                       |                       |                                |                       |                       | 0.17                 |                       |                       |
| 0.0004959                            | 4.000                         | 2500                   |          |                       |                       | 4.4·10 <sup>-3</sup>           |                       |                       |                      |                       |                       |
| 0.0004797                            | 3.869                         | 2584                   | 2.43     |                       |                       | 2.1·10 <sup>-3</sup>           |                       |                       | 0.17                 |                       |                       |
| 0.0003875                            | 3.125                         | 3200                   |          |                       |                       | 3.3·10 <sup>-3</sup>           |                       |                       |                      |                       |                       |
| 0.0001464                            | 1.181                         | 8469                   | 2.43     |                       |                       | 5.8·10 <sup>-4</sup>           |                       |                       | 0.17                 |                       |                       |
| 0.00004053                           | 0.3269                        | 30590                  | 2.43     |                       |                       | 2.5·10 <sup>-4</sup>           |                       |                       |                      |                       |                       |
| Cubic Zinc Sulfide (ZnS) - [Ref. 18] |                               |                        |          |                       |                       |                                |                       |                       |                      |                       |                       |
| 2000                                 |                               | 6.199·10 <sup>-4</sup> | 0.999904 |                       |                       | 1.76·10 <sup>-5</sup>          |                       |                       |                      |                       |                       |
| 1204                                 |                               | 1.030·10 <sup>-3</sup> | 0.999777 |                       |                       | 1.00·10 <sup>-4</sup>          |                       |                       |                      |                       |                       |
| 1016                                 |                               | 1.220·10 <sup>-3</sup> | 0.999838 |                       |                       | 3.61·10 <sup>-5</sup>          |                       |                       |                      |                       |                       |
| 901                                  |                               | 1.376·10 <sup>-3</sup> | 0.999647 |                       |                       | 5.42·10 <sup>-5</sup>          |                       |                       |                      |                       |                       |
| 798                                  |                               | 1.554·10 <sup>-3</sup> | 0.999520 |                       |                       | 8.28·10 <sup>-5</sup>          |                       |                       |                      |                       |                       |
| 707                                  |                               | 1.754·10 <sup>-3</sup> | 0.999372 |                       |                       | 1.25·10 <sup>-4</sup>          |                       |                       |                      |                       |                       |
| 597                                  |                               | 2.077·10 <sup>-3</sup> | 0.999160 |                       |                       | 2.19·10 <sup>-4</sup>          |                       |                       |                      |                       |                       |
| 377                                  |                               | 9.50·10 <sup>-3</sup>  | 0.99789  |                       |                       | 9.50·10 <sup>-4</sup>          |                       |                       |                      |                       |                       |
| 201                                  |                               | 6.168·10 <sup>-3</sup> | 0.99553  |                       |                       | 4.82·10 <sup>-3</sup>          |                       |                       |                      |                       |                       |
| 100                                  |                               | 1.240·10 <sup>-2</sup> | 0.99061  |                       |                       | 1.17·10 <sup>-2</sup>          |                       |                       |                      |                       |                       |
| 61.99                                |                               | 2.000·10 <sup>-2</sup> | 0.964    |                       |                       | 3.32·10 <sup>-2</sup>          |                       |                       | 6.2·10 <sup>-4</sup> |                       |                       |
| 41.33                                |                               | 3.000·10 <sup>-2</sup> | 0.941    |                       |                       | 5.10·10 <sup>-2</sup>          |                       |                       |                      |                       |                       |
| 31.00                                |                               | 4.000·10 <sup>-2</sup> | 0.847    |                       |                       | 9.95·10 <sup>-2</sup>          |                       |                       |                      |                       |                       |
| 24.80                                |                               | 5.000·10 <sup>-2</sup> | 0.796    |                       |                       | 0.171                          |                       |                       | 2.2·10 <sup>-2</sup> |                       |                       |
| 17.71                                |                               | 7.000·10 <sup>-2</sup> | 0.747    |                       |                       | 0.431                          |                       |                       | 7.7·10 <sup>-2</sup> |                       |                       |
| 13.78                                |                               | 9.000·10 <sup>-2</sup> | 0.758    |                       |                       | 0.824                          |                       |                       | 0.20                 |                       |                       |
| 12.40                                |                               | 0.1000                 | 0.862    |                       |                       | 0.876                          |                       |                       | 0.19                 |                       |                       |
| 9.919                                |                               | 0.125                  | 1.02     |                       |                       | 1.36                           |                       |                       | 0.31                 |                       |                       |
| 8.266                                |                               | 0.150                  | 1.41     |                       |                       | 1.47                           |                       |                       | 0.29                 |                       |                       |



| $E/\text{eV}$ | $\bar{\nu}/\text{cm}^{-1}$ | $\lambda/\mu\text{m}$ | $n$ | $n_a$ | $n_c$ | $k$ | $k_a$ | $k_c$ | $R$   | $R_a$ | $R_c$ |
|---------------|----------------------------|-----------------------|-----|-------|-------|-----|-------|-------|-------|-------|-------|
| 0.8267        | 6667                       | 1.500                 |     |       |       |     |       |       | 0.989 |       |       |
| 0.8000        | 6452                       | 1.550                 |     |       |       |     |       |       | 0.988 |       |       |
| 0.7750        | 6250                       | 1.600                 |     |       |       |     |       |       | 0.988 |       |       |
| 0.7515        | 6061                       | 1.650                 |     |       |       |     |       |       | 0.987 |       |       |
| 0.7294        | 5882                       | 1.700                 |     |       |       |     |       |       | 0.986 |       |       |
| 0.7086        | 5714                       | 1.750                 |     |       |       |     |       |       | 0.986 |       |       |
| 0.6889        | 5556                       | 1.800                 |     |       |       |     |       |       | 0.985 |       |       |
| 0.6703        | 5405                       | 1.850                 |     |       |       |     |       |       | 0.980 |       |       |
| 0.6526        | 5263                       | 1.900                 |     |       |       |     |       |       | 0.978 |       |       |
| 0.6359        | 51282                      | 1.950                 |     |       |       |     |       |       | 0.978 |       |       |
| 0.6200        | 5000                       | 2.000                 |     |       |       |     |       |       | 0.970 |       |       |
| 0.6049        | 4878                       | 2.050                 |     |       |       |     |       |       | 0.959 |       |       |
| 0.5905        | 4762                       | 2.100                 |     |       |       |     |       |       | 0.951 |       |       |
| 0.5767        | 4651                       | 2.150                 |     |       |       |     |       |       | 0.946 |       |       |
| 0.5636        | 4545                       | 2.200                 |     |       |       |     |       |       | 0.966 |       |       |
| 0.5511        | 44444                      | 2.250                 |     |       |       |     |       |       | 0.965 |       |       |
| 0.5487        | 44247                      | 2.260                 |     |       |       |     |       |       | 0.964 |       |       |
| 0.5439        | 4386                       | 2.280                 |     |       |       |     |       |       | 0.963 |       |       |
| 0.5415        | 4367                       | 2.290                 |     |       |       |     |       |       | 0.961 |       |       |
| 0.5368        | 4329                       | 2.310                 |     |       |       |     |       |       | 0.959 |       |       |
| 0.5345        | 4310                       | 2.320                 |     |       |       |     |       |       | 0.957 |       |       |
| 0.5322        | 4292                       | 2.330                 |     |       |       |     |       |       | 0.956 |       |       |
| 0.5299        | 4274                       | 2.340                 |     |       |       |     |       |       | 0.954 |       |       |
| 0.5277        | 4255                       | 2.350                 |     |       |       |     |       |       | 0.951 |       |       |
| 0.5232        | 4219                       | 2.370                 |     |       |       |     |       |       | 0.950 |       |       |
| 0.5188        | 4184                       | 2.390                 |     |       |       |     |       |       | 0.949 |       |       |
| 0.5167        | 4167                       | 2.400                 |     |       |       |     |       |       | 0.947 |       |       |
| 0.5061        | 4082                       | 2.450                 |     |       |       |     |       |       | 0.946 |       |       |
| 0.4960        | 4000                       | 2.500                 |     |       |       |     |       |       | 0.945 |       |       |

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# FERMI ENERGY AND RELATED PROPERTIES OF METALS

## Lev. I. Berger

In the classical Drude theory of metals, the Maxwell-Boltzmann velocity distribution of electrons is used. It states that the number of electrons per unit volume with velocities in the range of  $d\vec{v}$  about any magnitude  $\vec{v}$  at temperature  $T$  is

$$f_B(\vec{v})d\vec{v} = n \left( \frac{m}{2\pi k_B T} \right)^{3/2} \exp \left( -\frac{mv^2}{2k_B T} \right) d\vec{v}$$

where  $n$  is the total number of conduction electrons in a unit volume of a metal,  $m$  is the free electron mass, and  $k_B$  is the Boltzmann constant. In an attempt to explain a substantial discrepancy between the experimental data on the specific heat of metals and the values calculated on the basis of the Drude model, Sommerfeld suggested a model of the metal in which the Pauli exclusion principle is applied to free electrons. In this case, the Maxwell-Boltzmann distribution is replaced by the Fermi-Dirac distribution:

$$f(\vec{v})d\vec{v} = 2 \left( \frac{m}{h} \right)^3 d\vec{v} \left\{ \exp \left[ \left( \frac{mv^2}{2} - k_B T_0 \right) / k_B T \right] + 1 \right\}^{-1}$$

Here  $h$  is the Planck constant and  $T_0$  is a characteristic temperature which is determined by the normalization condition

$$n = \int d\vec{v} \cdot f(\vec{v})$$

The magnitude of  $T_0$  is quite high; usually,  $T_0 > 10^4$  K. So, at common temperatures ( $T < 10^3$  K), the free electron density of a metal is much smaller than in the case of the Maxwell-Boltzmann distribution. This allows us to explain why the experimental data on specific heat for metals are close to those for insulators.

The maximum kinetic energy the electrons of a metal may possess at  $T = 0$  K is called the Fermi energy, e.g.,

$$E_F = \frac{\hbar^2 k_F^2}{2m} = \left( \frac{e^2}{2k_B} \right) (k_F r_B)^2$$

where  $k_F$  is the Fermi momentum or the Fermi wave vector

$$k_F = (3\pi^2 n)^{1/3}$$

$e$  is the electron charge, and  $r_B$  is the Bohr radius

$$r_B = \hbar^2 / me^2 = 0.529 \cdot 10^{-10} \text{ m}$$

Another, more common expression for the Fermi energy is

$$E_F = \frac{1}{2} m v_F^2$$

where  $v_F = \hbar k_F / m$  is the Fermi velocity which can be expressed using the concept of the electron radius,  $r_s$ . It is equal to radius of a sphere occupied by one free electron. If the total volume of a metal sample is  $V$  and the number of conduction electrons in this volume is  $N$ , then the volume per electron is equal to

$$\frac{V}{N} = \frac{1}{n} = \frac{4}{3} \pi r_s^3$$

and

$$r_s = \left( \frac{3}{4\pi n} \right)^{1/3}$$

The following table contains information pertinent to the Sommerfeld model for some metals. The magnitudes of  $T_0$  are calculated using the expression

$$T_0 = \frac{E_F}{k_B} = \frac{58.2 \cdot 10^4}{(r_s / r_B)^2} \text{ K}$$

Ground State Properties of the Electron Gas in Some Metals

| Metal           | Valency | $n/10^{28} \text{ m}^{-3}$ | $r_s/\text{pm}$ | $r_s/r_B$ | $E_F/\text{eV}$ | $T_0/10^4 \text{ K}$ | $k_F/10^{10} \text{ m}^{-1}$ | $v_F/10^6 \text{ m s}^{-1}$ |
|-----------------|---------|----------------------------|-----------------|-----------|-----------------|----------------------|------------------------------|-----------------------------|
| Li <sup>a</sup> | 1       | 4.70                       | 172             | 3.25      | 4.74            | 5.51                 | 1.12                         | 1.29                        |
| Na <sup>b</sup> | 1       | 2.65                       | 208             | 3.93      | 3.24            | 3.77                 | 0.92                         | 1.07                        |
| K <sup>b</sup>  | 1       | 1.40                       | 257             | 4.86      | 2.12            | 2.46                 | 0.75                         | 0.86                        |
| Rb <sup>b</sup> | 1       | 1.15                       | 275             | 5.20      | 1.85            | 2.15                 | 0.70                         | 0.81                        |
| Cs <sup>b</sup> | 1       | 0.91                       | 298             | 5.62      | 1.59            | 1.84                 | 0.65                         | 0.75                        |
| Cu              | 1       | 8.47                       | 141             | 2.67      | 7.00            | 8.16                 | 1.36                         | 1.57                        |
| Ag              | 1       | 5.86                       | 160             | 3.02      | 5.49            | 6.38                 | 1.20                         | 1.39                        |
| Au              | 1       | 5.90                       | 159             | 3.01      | 5.53            | 6.42                 | 1.21                         | 1.40                        |
| Be              | 2       | 24.7                       | 99              | 1.87      | 14.3            | 16.6                 | 1.94                         | 2.25                        |
| Mg              | 2       | 8.61                       | 141             | 2.66      | 7.08            | 8.23                 | 1.36                         | 1.58                        |
| Ca              | 2       | 4.61                       | 173             | 3.27      | 4.69            | 5.44                 | 1.11                         | 1.28                        |
| Sr              | 2       | 3.55                       | 189             | 3.57      | 3.93            | 4.57                 | 1.02                         | 1.18                        |
| Ba              | 2       | 3.15                       | 196             | 3.71      | 3.64            | 4.23                 | 0.98                         | 1.13                        |
| Nb              | 1       | 5.56                       | 163             | 3.07      | 5.32            | 6.18                 | 1.18                         | 1.37                        |
| Fe              | 2       | 17.0                       | 112             | 2.12      | 11.1            | 13.0                 | 1.71                         | 1.98                        |
| Mn <sup>c</sup> | 2       | 16.5                       | 113             | 2.14      | 10.9            | 12.7                 | 1.70                         | 1.96                        |
| Zn              | 2       | 13.2                       | 122             | 2.30      | 9.47            | 11.0                 | 1.58                         | 1.83                        |
| Cd              | 2       | 9.27                       | 137             | 2.59      | 7.47            | 8.68                 | 1.40                         | 1.62                        |



| Metal           | Valency | $n/10^{28} \text{ m}^{-3}$ | $r_s/\text{pm}$ | $r_s/r_B$ | $E_F/\text{eV}$ | $T_0/10^4 \text{ K}$ | $k_F/10^{10} \text{ m}^{-1}$ | $v_F/10^6 \text{ m s}^{-1}$ |
|-----------------|---------|----------------------------|-----------------|-----------|-----------------|----------------------|------------------------------|-----------------------------|
| Hg <sup>a</sup> | 2       | 8.65                       | 140             | 2.65      | 7.13            | 8.29                 | 1.37                         | 1.58                        |
| Al              | 3       | 18.1                       | 110             | 2.07      | 11.7            | 13.6                 | 1.75                         | 2.03                        |
| Ga              | 3       | 15.4                       | 116             | 2.19      | 10.4            | 12.1                 | 1.66                         | 1.92                        |
| In              | 3       | 11.5                       | 127             | 2.41      | 8.63            | 10.0                 | 1.51                         | 1.74                        |
| Tl              | 3       | 10.5                       | 131             | 2.48      | 8.15            | 9.46                 | 1.46                         | 1.69                        |
| Sn              | 4       | 14.8                       | 117             | 2.22      | 10.2            | 11.8                 | 1.64                         | 1.90                        |
| Pb              | 4       | 13.2                       | 122             | 2.30      | 9.47            | 11.0                 | 1.58                         | 1.83                        |
| Bi              | 5       | 14.1                       | 119             | 2.25      | 9.90            | 11.5                 | 1.61                         | 1.87                        |
| Sb              | 5       | 16.5                       | 113             | 2.14      | 10.9            | 12.7                 | 1.70                         | 1.96                        |

<sup>a</sup> At 78 K.  
<sup>b</sup> At 5 K.  
<sup>c</sup>  $\alpha$ -phase.  
The data in the table are for atmospheric pressure and room temperature unless otherwise noted.

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# ELECTRON INELASTIC MEAN FREE PATHS

Cedric J. Powell

The inelastic mean free path (IMFP) of electrons is defined as the average of distances, measured along the trajectories, that electrons with a given energy travel between inelastic collisions in the substance. It is an important parameter in analyzing results from surface-characterization techniques such as Auger electron spectroscopy, x-ray photoelectron spectroscopy, low-energy electron diffraction, and others. IMFPs can be measured by the elastic-peak electron spectroscopy technique and other methods, and they can be calculated from optical data. A detailed analysis of the experimental and theoretical considerations in obtaining reliable IMFP values can be found in reference 4.

The table below gives recommended IMFP values for several elements, simple inorganic compounds, and organic materials. Values are given in Ångström units ( $1 \text{ Å} = 10^{-10} \text{ m}$ ) for a range of

electron energies. Substances are given in alphabetical order by name, with elements and inorganic compounds listed before the organic materials.

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## Electron Inelastic Mean Free Path in Å

### Electron Energy in eV

| Substance                  | Formula                                      | 50  | 100 | 150 | 200  | 300  | 400  | 600  | 800  | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | Ref. |
|----------------------------|----------------------------------------------|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|
| Aluminum                   | Al                                           | 3.5 | 4.6 | 5.7 | 6.8  | 8.9  | 10.9 | 14.5 | 18.0 | 21.3 | 24.6 | 27.8 | 31.0 | 34.1 | 37.2 | 5    |
| Bismuth                    | Bi                                           | 4.9 | 5.5 | 6.3 | 7.2  | 8.8  | 10.6 | 14.0 | 17.2 | 20.2 | 23.2 | 26.1 | 28.9 | 31.6 | 34.4 | 1    |
| Carbon                     | C                                            | 5.9 | 6.4 | 7.5 | 8.8  | 11.2 | 13.7 | 18.4 | 22.8 | 27.0 | 31.1 | 35.2 | 39.1 | 43.0 | 46.8 | 1    |
| Chromium                   | Cr                                           | 4.4 | 4.3 | 5.0 | 5.7  | 7.2  | 8.6  | 11.4 | 14.0 | 16.6 | 19.1 | 21.6 | 24.0 | 26.3 | 28.6 | 1    |
| Copper                     | Cu                                           | 5.2 | 5.0 | 5.4 | 6.0  | 7.3  | 8.6  | 11.3 | 13.9 | 16.5 | 18.9 | 21.3 | 23.7 | 26.0 | 28.3 | 4    |
| Gallium phosphide          | GaP                                          | 5.6 | 6.5 | 7.8 | 9.0  | 11.4 | 13.7 | 18.1 | 22.3 | 26.3 | 30.2 | 34.1 | 37.8 | 41.5 | 45.2 | 2    |
| Gold                       | Au                                           | 6.3 | 4.7 | 4.7 | 5.1  | 6.1  | 7.2  | 9.5  | 11.7 | 13.8 | 15.8 | 17.8 | 19.7 | 21.6 | 23.4 | 4    |
| Hafnium                    | Hf                                           | 5.8 | 6.2 | 7.1 | 8.0  | 10.2 | 12.0 | 15.6 | 19.0 | 22.2 | 25.3 | 28.4 | 31.4 | 34.4 | 37.3 | 1    |
| Indium phosphide           | InP                                          | 4.8 | 4.9 | 5.6 | 6.4  | 8.1  | 9.7  | 12.8 | 15.7 | 18.7 | 21.4 | 24.2 | 26.8 | 29.4 | 32.0 | 2    |
| Iridium                    | Ir                                           | 5.3 | 4.3 | 4.7 | 5.2  | 6.4  | 7.5  | 9.7  | 11.8 | 13.8 | 15.7 | 17.6 | 19.4 | 21.2 | 22.9 | 1    |
| Iron                       | Fe                                           | 4.3 | 4.4 | 5.1 | 5.8  | 7.2  | 8.5  | 11.2 | 13.7 | 16.2 | 18.6 | 20.9 | 23.2 | 25.5 | 27.7 | 1    |
| Lead(II) sulfide           | PbS                                          | 4.8 | 5.6 | 6.7 | 7.8  | 10.0 | 12.1 | 16.1 | 19.8 | 23.6 | 27.1 | 30.6 | 33.9 | 37.2 | 40.5 | 2    |
| Lead(II) telluride         | PbTe                                         | 4.3 | 5.5 | 6.6 | 7.7  | 9.8  | 11.9 | 15.8 | 19.6 | 23.4 | 26.9 | 30.3 | 33.7 | 37.0 | 40.2 | 2    |
| Magnesium                  | Mg                                           | 4.0 | 5.4 | 6.8 | 8.2  | 10.7 | 13.0 | 17.5 | 21.7 | 25.9 | 29.9 | 33.9 | 37.7 | 41.6 | 45.3 | 1    |
| Molybdenum                 | Mo                                           | 5.1 | 4.5 | 5.0 | 5.6  | 7.1  | 8.5  | 11.3 | 14.0 | 16.5 | 18.9 | 21.2 | 23.5 | 25.8 | 28.0 | 1    |
| Nickel                     | Ni                                           | 4.9 | 4.5 | 4.9 | 5.4  | 6.5  | 7.7  | 10.1 | 12.4 | 14.6 | 16.7 | 18.8 | 20.8 | 22.8 | 24.7 | 4    |
| Niobium                    | Nb                                           | 6.0 | 6.0 | 6.7 | 7.7  | 9.7  | 11.7 | 15.6 | 19.2 | 22.6 | 25.9 | 29.1 | 32.3 | 35.3 | 38.4 | 1    |
| Osmium                     | Os                                           | 5.5 | 4.3 | 4.5 | 5.0  | 6.0  | 7.1  | 9.1  | 11.1 | 12.9 | 14.7 | 16.4 | 18.1 | 19.8 | 21.5 | 1    |
| Palladium                  | Pd                                           | 4.8 | 4.8 | 5.4 | 6.2  | 7.8  | 9.4  | 12.5 | 15.4 | 18.2 | 20.9 | 23.5 | 26.0 | 28.4 | 30.9 | 1    |
| Platinum                   | Pt                                           | 5.0 | 4.2 | 4.5 | 4.9  | 6.0  | 7.1  | 9.2  | 11.2 | 13.1 | 14.9 | 16.7 | 18.5 | 20.2 | 21.9 | 1    |
| Potassium chloride         | KCl                                          | 7.5 | 7.8 | 9.3 | 10.9 | 14.2 | 17.3 | 23.2 | 28.7 | 34.0 | 39.2 | 44.2 | 49.1 | 54.0 | 58.8 | 2    |
| Rhenium                    | Re                                           | 5.2 | 3.8 | 3.9 | 4.3  | 5.1  | 6.0  | 7.7  | 9.4  | 10.9 | 12.5 | 14.0 | 15.4 | 16.9 | 18.3 | 1    |
| Rhodium                    | Rh                                           | 4.8 | 4.1 | 4.5 | 5.0  | 6.1  | 7.3  | 9.7  | 12.0 | 14.1 | 16.2 | 18.2 | 20.1 | 22.0 | 23.9 | 1    |
| Ruthenium                  | Ru                                           | 4.9 | 4.2 | 4.6 | 5.2  | 6.5  | 7.8  | 10.4 | 12.8 | 15.1 | 17.4 | 19.5 | 21.6 | 23.7 | 25.7 | 1    |
| Silicon                    | Si                                           | 4.1 | 5.3 | 6.5 | 7.8  | 10.3 | 12.5 | 16.6 | 20.6 | 24.4 | 28.2 | 31.8 | 35.4 | 39.0 | 42.5 | 1    |
| Silicon carbide            | SiC                                          | 4.7 | 4.9 | 5.8 | 6.8  | 8.7  | 10.5 | 13.9 | 17.1 | 20.3 | 23.3 | 26.3 | 29.2 | 32.1 | 35.0 | 2    |
| Silicon dioxide (vitreous) | SiO <sub>2</sub>                             | 8.0 | 7.7 | 8.8 | 10.0 | 12.6 | 15.2 | 20.0 | 24.7 | 29.3 | 33.7 | 38.0 | 42.2 | 46.4 | 50.5 | 2    |
| Silver                     | Ag                                           | 6.4 | 4.7 | 4.8 | 5.2  | 6.4  | 7.7  | 10.2 | 12.6 | 14.9 | 17.2 | 19.3 | 21.4 | 23.5 | 25.5 | 4    |
| Tantalum                   | Ta                                           | 4.8 | 4.5 | 5.0 | 5.5  | 6.8  | 8.0  | 10.4 | 12.7 | 14.8 | 16.9 | 19.0 | 21.0 | 22.9 | 24.9 | 1    |
| Titanium                   | Ti                                           | 4.5 | 5.1 | 6.2 | 7.3  | 9.5  | 11.6 | 15.6 | 19.5 | 23.2 | 26.8 | 30.2 | 33.6 | 36.9 | 40.2 | 1    |
| Tungsten                   | W                                            | 5.0 | 4.1 | 4.5 | 5.0  | 6.1  | 7.3  | 9.4  | 11.4 | 13.4 | 15.2 | 17.1 | 18.9 | 20.6 | 22.4 | 1    |
| Vanadium                   | V                                            | 4.2 | 4.9 | 5.9 | 6.8  | 8.8  | 10.7 | 14.3 | 17.7 | 21.0 | 24.3 | 27.4 | 30.5 | 33.5 | 36.4 | 1    |
| Yttrium                    | Y                                            | 5.0 | 5.5 | 6.4 | 7.5  | 9.8  | 11.9 | 16.0 | 19.8 | 23.4 | 27.0 | 30.4 | 33.8 | 37.1 | 40.4 | 1    |
| Zinc sulfide               | ZnS                                          | 5.8 | 6.5 | 7.7 | 8.9  | 11.3 | 13.6 | 17.9 | 22.0 | 26.0 | 29.8 | 33.6 | 37.3 | 40.9 | 44.5 | 2    |
| Zirconium                  | Zr                                           | 4.4 | 4.8 | 5.7 | 6.6  | 8.6  | 10.5 | 14.1 | 17.5 | 20.7 | 23.8 | 26.9 | 29.9 | 32.8 | 35.7 | 1    |
| Adenine                    | C <sub>5</sub> H <sub>5</sub> N <sub>5</sub> | 6.4 | 6.6 | 7.8 | 9.2  | 11.8 | 14.4 | 19.2 | 24.1 | 28.6 | 33.1 | 37.4 | 41.6 | 45.8 | 49.9 | 3    |
| Bovine plasma albumin      |                                              | 7.3 | 7.2 | 8.5 | 9.9  | 12.7 | 15.4 | 20.7 | 25.8 | 30.8 | 35.6 | 40.2 | 44.8 | 49.4 | 53.8 | 3    |
| β-Carotene                 | C <sub>40</sub> H <sub>56</sub>              | 6.4 | 7.0 | 8.5 | 10.0 | 13.0 | 15.9 | 21.4 | 26.9 | 32.0 | 37.0 | 41.9 | 46.6 | 51.3 | 56.0 | 3    |

| Substance                     | Formula        | 50  | 100 | 150 | 200  | 300  | 400  | 600  | 800  | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | Ref. |
|-------------------------------|----------------|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|
| Deoxyribonucleic acid (DNA)   |                | 7.3 | 7.3 | 8.5 | 9.8  | 12.6 | 15.4 | 20.7 | 25.9 | 30.8 | 35.6 | 40.3 | 44.9 | 49.4 | 53.8 | 3    |
| 1,6-Diphenyl-1,3,5-hexatriene | $C_{18}H_{16}$ | 6.4 | 7.0 | 8.4 | 9.9  | 12.9 | 15.8 | 21.3 | 26.7 | 31.8 | 36.8 | 41.7 | 46.4 | 51.1 | 55.7 | 3    |
| Guanine                       | $C_5H_5N_5O$   | 6.2 | 6.2 | 7.2 | 8.4  | 10.8 | 13.1 | 17.5 | 21.8 | 25.9 | 29.9 | 33.8 | 37.6 | 41.4 | 45.1 | 3    |
| Hexacosane                    | $C_{26}H_{54}$ | 7.0 | 7.6 | 9.2 | 10.9 | 14.1 | 17.2 | 23.2 | 29.2 | 34.7 | 40.1 | 45.4 | 50.6 | 55.7 | 60.7 | 3    |
| Kapton                        |                | 7.0 | 6.8 | 7.9 | 9.2  | 11.7 | 14.2 | 19.0 | 23.7 | 28.2 | 32.5 | 36.7 | 40.9 | 44.9 | 49.0 | 3    |
| Polyacetylene                 |                | 5.3 | 5.7 | 6.8 | 7.9  | 10.2 | 12.5 | 16.9 | 21.1 | 25.1 | 29.0 | 32.8 | 36.5 | 40.2 | 43.8 | 3    |
| Poly(butene-1-sulfone)        |                | 7.1 | 7.2 | 8.5 | 9.9  | 12.7 | 15.4 | 20.7 | 25.8 | 30.6 | 35.3 | 39.9 | 44.4 | 48.8 | 53.2 | 3    |
| Polyethylene                  |                | 6.9 | 7.2 | 8.6 | 10.1 | 13.0 | 15.9 | 21.4 | 26.8 | 31.8 | 36.8 | 41.6 | 46.3 | 51.0 | 55.6 | 3    |
| Poly(methyl methacrylate)     |                | 7.8 | 7.9 | 9.3 | 10.8 | 13.9 | 16.9 | 22.7 | 28.3 | 33.7 | 38.8 | 43.9 | 48.9 | 53.8 | 58.6 | 3    |
| Polystyrene                   |                | 6.9 | 7.3 | 8.7 | 10.2 | 13.2 | 16.1 | 21.6 | 27.1 | 32.2 | 37.2 | 42.1 | 46.9 | 51.6 | 56.2 | 3    |
| Poly(2-vinylpyridine)         |                | 6.9 | 7.3 | 8.7 | 10.3 | 13.3 | 16.2 | 21.8 | 27.3 | 32.5 | 37.5 | 42.4 | 47.3 | 52.0 | 56.7 | 3    |

# SELECTED PROPERTIES OF SEMICONDUCTOR SOLID SOLUTIONS

L.I. Berger

| Alloy system                                                       | Limits of solubility                         | Energy gap in eV (300 K)                                 | Remarks, references                                             |
|--------------------------------------------------------------------|----------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------|
| <b>Adamantine Semiconductors IV-IV</b>                             |                                              |                                                          |                                                                 |
| $\text{Si}_x\text{Ge}_{1-x}$                                       | $0 \leq x \leq 1$                            | $0.8941+0.0421x+0.1691x^2$<br>$0.7596+1.0860x+0.3306x^2$ | Transition $\Gamma$ - X [Ref.1]<br>Trans. $\Gamma$ - L [Ref. 1] |
| <b>Adamantine Semiconductors III-V/III-V</b>                       |                                              |                                                          |                                                                 |
| <i>Common Anion</i>                                                |                                              |                                                          |                                                                 |
| $\text{Al}_x\text{Ga}_{1-x}\text{N}$                               | $0 \leq x \leq 1$                            |                                                          | Wurtzite Structure [Ref. 2 & 3]                                 |
| $\text{Al}_x\text{Ga}_{1-x}\text{P}$                               | $0 \leq x \leq 0.5$                          | $2.28+0.16x$                                             | [Ref. 2]                                                        |
| $\text{Al}_x\text{In}_{1-x}\text{P}$                               | $0 \leq x \leq 0.44$                         | at $\Gamma$ : $1.34+2.23x$ ; at X: $2.24+0.18x$          | [Ref. 2]                                                        |
| $\text{Al}_x\text{Ga}_{1-x}\text{As}$                              | $0 \leq x \leq 0.5$                          | $1.42=0.75x$ [Ref.3]; $1.424+1.429x-0.14x^2$ [Ref.4]     |                                                                 |
| $\text{Al}_x\text{In}_{1-x}\text{As}$                              | $0 \leq x \leq 1$                            | at $\Gamma$ : $0.37+1.91x+0.74x^2$ ; at X: $1.8+0.4x$    | [Ref. 2 and 6]                                                  |
| $\text{Al}_x\text{Ga}_{1-x}\text{Sb}$                              | $0 \leq x \leq 1$                            | $0.73+1.10x+0.47x^2$                                     | Trans. $\Gamma_{8v}$ - $\Gamma_{6c}$ [Ref. 2]                   |
| $\text{Al}_x\text{In}_{1-x}\text{Sb}$                              | $0 \leq x \leq 1$                            |                                                          | [Ref. 6]                                                        |
| $\text{Ga}_x\text{In}_{1-x}\text{N}$                               | $0 \leq x \leq 1$                            | $1.950+1.487x-1.000x(1-x)$                               | Wurtzite [Ref. 8 and 10]                                        |
| $\text{Ga}_x\text{In}_{1-x}\text{P}$                               | $0 \leq x \leq 1$                            |                                                          | [Ref. 2]                                                        |
| $\text{Ga}_x\text{In}_{1-x}\text{As}$                              | $0 \leq x \leq 1$                            | $0.360+0.629x+0.436x^2$                                  | [Ref. 5]                                                        |
| $\text{Ga}_x\text{In}_{1-x}\text{Sb}$                              | $0 < x < 1$                                  | $0.235+0.1653x+0.413x^2$                                 | [Ref. 2, see also Ref. 9]                                       |
| <i>Common Cation</i>                                               |                                              |                                                          |                                                                 |
| $\text{GaN}_x\text{As}_{1-x}$                                      | $0 \leq x \leq 0.05$                         | $1.42-9.9x$                                              | [Ref. 2]                                                        |
| $\text{GaP}_x\text{As}_{1-x}$                                      | $0 < x < 1$                                  | $2.270-0.846x$                                           | [Ref. 2]                                                        |
| $\text{GaP}_x\text{As}_{1-x}$                                      | $0 \leq x \leq 0.05$                         | $1.515+1.172x+0.186x^2$                                  | (at 2K, $\Gamma-\Gamma$ ) [Ref. 7]                              |
|                                                                    |                                              | $1.9715+0.144x+0.211x^2$                                 | [Ref. 2]                                                        |
| $\text{GaAs}_x\text{Sb}_{1-x}$                                     | $0 \leq x \leq 0.45, 0.6 \leq x \leq 1$      | $1.43-1.9x+1.2x^2$                                       | [Ref. 5]                                                        |
| $\text{InP}_x\text{As}_{1-x}$                                      | $0 < x < 1$                                  | $0.356+0.675x+0.32x^2$                                   | [Ref. 2]                                                        |
| <b>Adamantine Binary Semiconductors II-VI/II-VI [Ref. 3 and 6]</b> |                                              |                                                          |                                                                 |
| <i>Common Anion</i>                                                |                                              |                                                          |                                                                 |
| $\text{Zn}_x\text{Cd}_{1-x}\text{S}$                               | $0 \leq x \leq 1$                            |                                                          | Wurtzite Structure                                              |
| $\text{Zn}_x\text{Hg}_{1-x}\text{S}$                               | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $\text{Cd}_x\text{Hg}_{1-x}\text{S}$                               | $0 \leq x \leq 1$                            |                                                          | Wurtzite Structure at $x < 0.6$                                 |
| $\text{Zn}_x\text{Cd}_{1-x}\text{Se}$                              | $0.7 \leq x \leq 1$                          |                                                          |                                                                 |
| $\text{Zn}_x\text{Hg}_{1-x}\text{Se}$                              | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $\text{Cd}_x\text{Hg}_{1-x}\text{Se}$                              | $0 \leq x \leq 0.7$ and $0.75 \leq x \leq 1$ |                                                          | $x^*$ - Wurtzite Structure                                      |
| $\text{Zn}_x\text{Cd}_{1-x}\text{Te}$                              | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $\text{Zn}_x\text{Hg}_{1-x}\text{Te}$                              | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$                              | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| <i>Common Cation</i>                                               |                                              |                                                          |                                                                 |
| $\text{ZnS}_x\text{Se}_{1-x}$                                      | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $\text{ZnS}_x\text{Te}_{1-x}$                                      | $0 \leq x \leq 0.1$ and $0.9 \leq x \leq 1$  |                                                          | $x^*$ - Wurtzite Structure                                      |
| $\text{ZnSe}_x\text{Te}_{1-x}$                                     | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $\text{CdS}_x\text{Se}_{1-x}$                                      | $0 \leq x \leq 1$                            |                                                          | Wurtzite Structure                                              |
| $\text{CdS}_x\text{Te}_{1-x}$                                      | $0 \leq x \leq 0.25$ and $0.8 \leq x \leq 1$ |                                                          | $x^*$ - Wurtzite Structure                                      |
| $\text{CdSe}_x\text{Te}_{1-x}$                                     | $0 \leq x \leq 0.4$ and $0.6 \leq x \leq 1$  |                                                          | $x^*$ - Wurtzite Structure                                      |
| $\text{HgS}_x\text{Se}_{1-x}$                                      | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $\text{HgS}_x\text{Te}_{1-x}$                                      | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $\text{HgSe}_x\text{Te}_{1-x}$                                     | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| <b>Quaternary Adamantine Semiconductors II-VI/III-V [Ref. 6]</b>   |                                              |                                                          |                                                                 |
| $(\text{ZnS})_x(\text{AlP})_{1-x}$                                 | $0.99 \leq x \leq 1$                         |                                                          |                                                                 |
| $(\text{ZnSe})_x(\text{GaAs})_{1-x}$                               | $0 \leq x < 1$                               |                                                          |                                                                 |
| $(\text{CdTe})_x(\text{InAs})_{1-x}$                               | $0 < x \leq 0.2$ and $0.7 \leq x \leq 1$     |                                                          |                                                                 |
| $(\text{CdTe})_x(\text{AlSb})_{1-x}$                               | $0 \leq x \leq 1$                            |                                                          |                                                                 |
| $(\text{HgTe})_x(\text{InAs})_{1-x}$                               | $0 \leq x \leq 1$                            |                                                          |                                                                 |

| Alloy system                                                                                                | Limits of solubility | Energy gap in eV (300 K)                                                                                           | Remarks, references |
|-------------------------------------------------------------------------------------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------|---------------------|
| <b>Quaternary Adamantine Semiconductors III<sub>x</sub>-III<sub>1-x</sub>-V<sub>y</sub>-V<sub>1-y</sub></b> |                      |                                                                                                                    |                     |
| Ga <sub>x</sub> In <sub>1-x</sub> As <sub>y</sub> P <sub>1-y</sub>                                          | 0≤x≤1, 0≤y≤1         | 1.35+0.668x-1.068y+0.758x <sup>2</sup> +0.078y <sup>2</sup> -<br>0.069xy-0.322x <sup>2</sup> y+0.03xy <sup>2</sup> | [Ref. 2 and 6]      |
| <b>Quaternary Adamantine Semiconductors III<sub>1-x-y</sub>-III<sub>x</sub>-III<sub>y</sub>-V</b>           |                      |                                                                                                                    |                     |
| Al <sub>x</sub> Ga <sub>y</sub> In <sub>1-x-y</sub> Sb                                                      | 0≤x≤1, 0≤y≤1         | 0.095+1.76x+0.28y+0.345(x <sup>2</sup> +y <sup>2</sup> )+0.085(1-x-y) <sup>2</sup> +xy(1-x-y)(23-28y)              | [Ref. 2 and 6]      |

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# PROPERTIES OF ORGANIC SEMICONDUCTORS

L. I. Berger

| Substance                                   | Energy Gap, $E$ ,<br>(in $E/2kT$ )<br>eV | Room Temperature<br>Electrical Resistivity,<br>ohm · cm | Mobility,<br>$\mu$ ,<br>cm <sup>2</sup> /V · s | Sign of<br>Majority<br>Carriers | Temperature<br>Range,<br>°C | Ref. |
|---------------------------------------------|------------------------------------------|---------------------------------------------------------|------------------------------------------------|---------------------------------|-----------------------------|------|
| <i>Metal-Free Molecular Crystals</i>        |                                          |                                                         |                                                |                                 |                             |      |
| 3-Acetylamino- <i>N</i> -methylphthalimide  | 3.46                                     |                                                         |                                                |                                 | 67 to 100                   | 1    |
| 3-Acetylamino- <i>N</i> -phenylphthalimide  | 3.50                                     |                                                         |                                                |                                 | 54 to 124                   | 1    |
| 4-Amino- <i>N</i> -cyclomethylphthalimide   | 2.90                                     |                                                         |                                                |                                 | 73 to 100                   | 1    |
| 4-Aminophthalimide                          | 2.78                                     |                                                         |                                                |                                 | 123 to 151                  | 1    |
| Acridine                                    | 3.90                                     |                                                         |                                                |                                 |                             | 1    |
| Anthanthrene                                | 1.67                                     | $1.5 \cdot 10^{19}$                                     |                                                |                                 | 40 to 105                   | 1    |
| Anthanthrene                                | 0.84                                     | $1.5 \cdot 10^{19}$ (15°C)                              |                                                |                                 |                             | 2    |
| Anthanthrone                                | 1.70                                     | $7.7 \cdot 10^{18}$                                     |                                                |                                 | 20 to 150                   | 1    |
| Anthracene                                  | 0.83                                     | $1.3 \cdot 10^{14}$ (15°C)                              |                                                |                                 |                             | 2    |
| Anthracene                                  | 2.50                                     | $1.5 \cdot 10^{11}$                                     | 2.3                                            | +                               | 20 to 130                   | 1    |
| Anthracene                                  | 3.88 to 4.1                              | $>10^{15}$                                              | 1.74(n), 2.07(p)                               | + & -                           |                             | 4    |
| 1,2-Benzanthracene                          | 1.04                                     | $10^{16}$ (30°C)                                        |                                                |                                 |                             | 2    |
| Benzanthrone                                | 3.12                                     | $1.6 \cdot 10^{16}$                                     |                                                |                                 |                             | 1    |
| Benzene (liquid)                            | 0.41                                     |                                                         |                                                |                                 |                             | 2    |
| Benzene (amorphous)                         | 0.84                                     | $10^{15}$                                               |                                                |                                 | -14 to 5                    | 1    |
| Benzene (cryst.)                            | 7                                        |                                                         | 2                                              | -                               | -23                         | 4    |
| Benzimidazole                               | 3.0 to 4.0                               | $5 \cdot 10^{13}$                                       |                                                |                                 | 84 to 144                   | 1    |
| Benzophenone                                | 3.34                                     |                                                         |                                                |                                 | -23 to 14                   | 1    |
| Benzo[f]quinoline                           | 2.77                                     |                                                         |                                                |                                 | 30 to 50                    | 1    |
| Benzo[h]quinoline                           | 2.72                                     |                                                         |                                                |                                 |                             | 1    |
| 3-Benzoylamino- <i>N</i> -methylphthalimide | 3.28                                     |                                                         |                                                |                                 | 84 to 112                   | 1    |
| Benzpentacene                               | 1.72                                     |                                                         |                                                |                                 | 0 to 150                    | 1    |
| Biphenyl                                    | 1.46                                     | $1.7 \cdot 10^{15}$ (50°C)                              |                                                |                                 |                             | 2    |
| Biphenyl                                    | 1.45                                     |                                                         |                                                |                                 | 20 to 70                    | 1    |
| <i>o</i> -Chloranil                         | 3.0                                      | $10^{15}$                                               |                                                |                                 |                             | 1    |
| <i>p</i> -Chloranil                         | 0.61                                     |                                                         |                                                |                                 |                             | 1    |
| Chlorpromazine                              | 2.1                                      | $10^{12}$ (32°C)                                        |                                                | + & -                           | 32 to 80                    | 1    |
| Chrysene                                    | 1.1                                      | $4 \cdot 10^{19}$ (15°C)                                |                                                |                                 |                             | 2    |
| Chrysene                                    | 2.20                                     | $4 \cdot 10^{19}$                                       |                                                |                                 | 25 to 90                    | 1    |
| Circumanthracene                            | 1.8                                      | $6 \cdot 10^{12}$                                       |                                                |                                 |                             | 1    |
| Coronene                                    | 1.7                                      | $1.7 \cdot 10^{17}$                                     |                                                |                                 | 60 to 80                    | 1    |
| Coronene                                    | 0.85                                     | $1.7 \cdot 10^{17}$ (15°C)                              |                                                |                                 |                             | 2    |
| Cyananthrone                                | 0.20                                     | $1.2 \cdot 10^7$                                        |                                                |                                 | 30 to 125                   | 1    |
| 1,6-Diaminopyrene                           | 0.6                                      | $10^8$                                                  |                                                |                                 |                             |      |
| Dibenzpentacene                             | 1.50                                     |                                                         |                                                |                                 | 0 to 150                    | 1    |
| Dinaphthopyrene                             | 1.60                                     |                                                         |                                                |                                 | 25 to 90                    | 1    |
| 1,8-Diphenyl-1,3,5,7-octatetraene           | 1.7                                      |                                                         |                                                |                                 | 72 to 191                   | 1    |
| Diphenylpentacene                           | 1.60                                     |                                                         |                                                |                                 | 0 to 150                    | 1    |
| 4,4'-Diphenylstilbene                       | 1.56                                     |                                                         |                                                |                                 | 160 to 280                  | 1    |
| 4,4'-Diphenylstilbene                       | 0.80                                     |                                                         |                                                |                                 |                             | 2    |
| Ferrocene                                   | 1.22                                     | $10^{14}$                                               |                                                | +                               |                             | 1    |
| Flavanthrene                                | 0.70                                     | $1.4 \cdot 10^{11}$                                     |                                                |                                 |                             | 1    |
| Fluorene                                    | 2.7                                      |                                                         |                                                |                                 |                             | 2    |
| Fluorene                                    | 1.4                                      |                                                         |                                                |                                 |                             | 2    |
| Fluoridine                                  | 1.6                                      | $6 \cdot 10^{13}$                                       |                                                | +                               | 20 to 140                   | 1    |
| Hexacene                                    | 0.57                                     | $3.8 \cdot 10^{10}$ (50°C)                              |                                                |                                 |                             | 2    |
| Hexacene                                    | 1.3                                      |                                                         |                                                |                                 |                             | 1    |
| Hexamethylbenzene                           | 1.86                                     |                                                         |                                                | +                               | 20 to 140                   | 1    |
| 3-Hydroxy- <i>N</i> -methylphthalimide      | 3.80                                     |                                                         |                                                |                                 | 60 to 91                    | 1    |
| Imidazole                                   | 2.6                                      | $10^{11}$                                               |                                                |                                 | 28 to 68                    | 1    |

| Substance                                | Energy Gap, $E$ ,<br>(in $E/2kT$ )<br>eV | Room Temperature<br>Electrical Resistivity,<br>ohm · cm | Mobility,<br>$\mu$ ,<br>cm <sup>2</sup> /V · s | Sign of<br>Majority<br>Carriers | Temperature<br>Range,<br>°C | Ref. |
|------------------------------------------|------------------------------------------|---------------------------------------------------------|------------------------------------------------|---------------------------------|-----------------------------|------|
| Indanthrazine                            | 0.66                                     | $1.4 \cdot 10^{15}$                                     |                                                |                                 | 30 to 125                   | 1    |
| Indanthrone                              | 0.64                                     | $7.5 \cdot 10^{14}$                                     |                                                |                                 | 30 to 125                   | 1    |
| Indanthrone (black)                      | 0.56                                     | $2.5 \cdot 10^8$                                        |                                                |                                 | 30 to 125                   | 1    |
| Mesitylene (liquid)                      | 0.19                                     |                                                         |                                                |                                 |                             | 2    |
| Mesonaphthodanthracene                   | 0.6                                      | $4.0 \cdot 10^{18}$ (15°C)                              |                                                |                                 |                             | 2    |
| Mesonaphthodanthrene                     | 1.48                                     |                                                         |                                                |                                 | 45 to 250                   | 1    |
| Mesonaphthodanthrone                     | 0.86                                     |                                                         |                                                |                                 | 5 to 110                    | 1    |
| 3-Methoxy- <i>N</i> -methyl-phthalimide  | 3.18                                     |                                                         |                                                |                                 | 54 to 78                    | 1    |
| Naphthacene                              | 1.7                                      | $1 \cdot 10^{15}$                                       |                                                |                                 |                             | 1    |
| Naphthalene                              | 3.5                                      | $10^{14}$                                               |                                                |                                 | 27 to 47                    | 1    |
| Naphthalene                              | 1.15                                     | $2.8 \cdot 10^{14}$ (50°C)                              |                                                |                                 |                             | 2    |
| Naphthalene                              | 4.9 to 5.1                               |                                                         | 0.64(n), 1.50(p)                               | + & -                           |                             | 4    |
| <i>m</i> -Naphthodanthrene               | 1.20                                     | $4 \cdot 10^{18}$                                       |                                                |                                 | 40 to 150                   | 1    |
| <i>m</i> -Naphthodanthrone               | 1.30                                     | $1.5 \cdot 10^{18}$                                     |                                                |                                 | 40 to 150                   | 1    |
| $\beta$ -Naphthol                        | 2.36                                     | $2 \cdot 10^5$                                          |                                                |                                 | 60 to 110                   | 1    |
| $\beta$ -Naphthoquinoline                | 2.77                                     |                                                         |                                                |                                 |                             | 1    |
| 1-Naphthylamine                          | 2.2                                      |                                                         |                                                |                                 | 25 to 42                    | 1    |
| 1-Naphthylamine picrate                  | 2.7                                      |                                                         |                                                |                                 | 28 to 98                    | 1    |
| 2-Naphthylphenyl sulphone                | 3.5                                      |                                                         |                                                |                                 | 67 to 102                   | 1    |
| 1-Nitronaphthalene                       | 2.5                                      |                                                         |                                                |                                 | 25 to 44                    | 1    |
| Ovalene                                  | 1.13                                     | $2.3 \cdot 10^{15}$                                     |                                                |                                 |                             | 1    |
| Pentacene                                | 0.58                                     | $2.4 \cdot 10^9$ (50°C)                                 |                                                |                                 |                             | 2    |
| Pentacene                                | 1.5                                      | $6 \cdot 10^{13}$                                       |                                                |                                 | 20 to 140                   | 1    |
| Perylene                                 | 2.1                                      | $4.1 \cdot 10^{13}$                                     |                                                |                                 | 40 to 100                   | 1    |
| Perylene                                 | 3.10                                     |                                                         | 5.53(n), 87.4(p)                               | + & -                           | -213                        | 4    |
| Phenanthrene                             | 1.15                                     | $1.3 \cdot 10^{14}$                                     |                                                |                                 | 12 to 72                    | 1    |
| Phenanthrene                             | 0.65                                     |                                                         |                                                |                                 |                             | 2    |
| 1,10-Phenanthroline                      | 2.73                                     |                                                         |                                                |                                 | 50 to 90                    | 1    |
| Phenazine                                | 2.1                                      | $7 \cdot 10^{14}$ (100°C)                               |                                                |                                 | 98 to 143                   | 1    |
| Phenazine                                | 1.1                                      |                                                         |                                                | -                               |                             | 4    |
| Phenothiazine                            | 1.6                                      | $10^{11}$                                               |                                                |                                 | 50 to 150                   | 1    |
| Phenothiazine                            |                                          |                                                         | 2.45(n), 0.02(p)                               | + & -                           |                             | 4    |
| Phenylanthranilic acid                   | 3.30                                     |                                                         |                                                |                                 | 87 to 119                   | 1    |
| 4-Phenylstilbene                         | 1.74                                     |                                                         |                                                |                                 | 140 to 220                  | 1    |
| 4-Phenylstilbene                         | 0.86                                     |                                                         |                                                |                                 |                             | 2    |
| Phosphonitrilic chloride trimer          | 1.68                                     | $10^{15}$                                               |                                                |                                 |                             | 1    |
| Phthalocyanine, $\text{PcH}_2$           | 1.66                                     | $10^{13}$                                               | 0.1 to 0.4                                     | +                               | 26 to 350                   | 1    |
| Phthalocyanine, $\text{PcH}_2$           | 2                                        | $10^7$                                                  | 1.2(n), 1.1(p)                                 | + & -                           | 100                         | 4    |
| Pyranthrene                              | 1.11                                     | $1 \cdot 10^{15}$                                       |                                                |                                 |                             | 1    |
| Pyranthrene                              | 0.51                                     | $4.5 \cdot 10^{16}$ (15°C)                              |                                                |                                 |                             | 2    |
| Pyranthrone                              | 1.06                                     | $3.9 \cdot 10^{15}$                                     |                                                |                                 | 40 to 150                   | 1    |
| Pyrene                                   | 2.02                                     | $5 \cdot 10^{17}$                                       |                                                | -                               |                             | 1    |
| Pyrene                                   |                                          |                                                         | 0.50                                           | +                               |                             | 4    |
| 5,6- <i>N</i> -Pyridine-1,9-benzanthrone | 1.60                                     |                                                         |                                                |                                 |                             | 2    |
| <i>p</i> -Quaterphenyl                   | 0.89                                     | $1.0 \cdot 10^{15}$ (50°C)                              |                                                |                                 |                             | 2    |
| Quaterylene                              | 0.6                                      | $10^5$                                                  |                                                | -                               |                             | 1    |
| <i>p</i> -Quinquiphenyl                  | 0.91                                     | $2.0 \cdot 10^{15}$ (50°C)                              |                                                |                                 |                             | 2    |
| $\alpha$ -Resorcin                       | 2.10                                     | $2 \cdot 10^{16}$                                       |                                                |                                 | 30 to 94                    | 1    |
| $\beta$ -Resorcin                        | 3.27                                     | $2 \cdot 10^{18}$                                       |                                                |                                 | 30 to 94                    | 1    |
| Salanil                                  | 4.1                                      | $10^4$                                                  |                                                |                                 | 20 to 40                    | 1    |
| <i>p</i> -Sexiphenyl                     | 0.91                                     | $7.0 \cdot 10^{14}$ (50°C)                              |                                                |                                 |                             | 2    |
| <i>cis</i> -Stilbene                     | 2.4                                      |                                                         |                                                | +                               | at 20                       | 1    |
| <i>trans</i> -Stilbene                   | 1.80                                     |                                                         | 2.4                                            | +                               | 70 to 120                   | 1    |
| <i>trans</i> -Stilbene                   | 0.91                                     |                                                         |                                                |                                 |                             | 2    |
| <i>trans</i> -Stilbene                   | 1.4                                      |                                                         |                                                | +                               |                             | 4    |
| <i>o</i> -Terphenyl                      |                                          | $3 \cdot 10^{-5}$                                       |                                                | +                               |                             | 1    |
| <i>m</i> -Terphenyl                      |                                          |                                                         | $10^{-5}$                                      | +                               |                             | 1    |
| <i>p</i> -Terphenyl                      | 0.6                                      | $10^{14}$ (25°C)                                        |                                                |                                 |                             | 2    |
| <i>p</i> -Terphenyl                      | 1.2                                      |                                                         | 0.025                                          | +                               |                             | 1    |

| Substance                                                      | Energy Gap, $E$ ,<br>(in $E/2kT$ )<br>eV | Room Temperature<br>Electrical Resistivity,<br>ohm · cm | Mobility,<br>$\mu$ ,<br>cm <sup>2</sup> /V · s | Sign of<br>Majority<br>Carriers | Temperature<br>Range,<br>°C | Ref. |
|----------------------------------------------------------------|------------------------------------------|---------------------------------------------------------|------------------------------------------------|---------------------------------|-----------------------------|------|
| <i>p</i> -Terphenyl                                            |                                          |                                                         | 1.2(n), 0.80(p)                                | + & –                           |                             | 4    |
| Tetracene                                                      | 0.66                                     | $3.2 \cdot 10^{12}$ (50°C)                              |                                                |                                 |                             | 2    |
| Tetracene                                                      | 1.7                                      |                                                         |                                                |                                 |                             | 1    |
| Tetracene                                                      | 3.4                                      |                                                         | 0.85                                           | +                               |                             | 4    |
| 1,1,10,10-Tetracyanodecapentaene                               | 2.24                                     | $10^{13}$                                               |                                                |                                 | >68                         | 1    |
| 1,1,6,6-Tetracyanohexatriene                                   | 1.54                                     | $10^{14}$                                               |                                                | –                               |                             | 1    |
| Tetracyanoethylene                                             |                                          |                                                         | 0.26(max)                                      | +                               |                             | 4    |
| 7,7,8,8-Tetracyanoquinodimethane                               |                                          |                                                         | 0.65                                           | –                               |                             | 4    |
| 1,1,8,8-Tetracyanooctatetraene                                 | 1.42                                     | $10^{12}$                                               |                                                | –                               |                             | 1    |
| Tetraphenylpentacene                                           | 1.62                                     |                                                         |                                                |                                 | 0 to 150                    | 1    |
| Tetrathiotetracene                                             | 0.46                                     | $10^4$                                                  |                                                |                                 |                             | 1    |
| Triphenodioxazine                                              | 1.65                                     | $5 \cdot 10^{14}$                                       |                                                | –                               | 20 to 140                   | 1    |
| Triphenyldiamine                                               |                                          |                                                         | $2 \cdot 10^{-2}$                              |                                 | at 20                       | 1    |
| Violanthrene                                                   | 0.85                                     | $2.1 \cdot 10^{14}$                                     |                                                |                                 | 40 to 105                   | 1    |
| Isoviolanthrene                                                | 0.82                                     | $8.4 \cdot 10^{13}$                                     |                                                |                                 | 40 to 150                   | 1    |
| Violanthrone                                                   | 0.78                                     | $2.3 \cdot 10^{10}$                                     |                                                |                                 | 40 to 150                   | 1    |
| Isoviolanthrone                                                | 0.76                                     | $5.7 \cdot 10^9$                                        |                                                |                                 | 40 to 150                   | 1    |
| <i>o</i> -Xylene (liquid)                                      | 0.45                                     |                                                         |                                                |                                 |                             | 2    |
| <i>m</i> -Xylene (liquid)                                      | 0.41                                     |                                                         |                                                |                                 |                             | 2    |
| <i>p</i> -Xylene (liquid)                                      | 0.41                                     |                                                         |                                                |                                 |                             | 2    |
| <b>Long-Chain Compounds and Polymers</b>                       |                                          |                                                         |                                                |                                 |                             |      |
| Acrylic acid-amyproparylaniline copolymers                     |                                          | $10^9$ – $10^{10}$                                      |                                                |                                 |                             | 3    |
| Acrylic acid-methylproparylaniline copolymers                  |                                          | $10^9$ – $10^{10}$                                      |                                                |                                 |                             | 3    |
| Acrylic acid-octylproparylaniline copolymers                   |                                          | $10^9$ – $10^{10}$                                      |                                                |                                 |                             | 3    |
| Anthrone polymers                                              |                                          | $0.28 \geq 100$ at 1.8 kbar<br>$\geq 2$ at 33 kbar      |                                                |                                 |                             | 3    |
| $[\text{CH}(\text{AsF}_6)_{0.1}]_x$                            |                                          | 0.0005                                                  |                                                | +                               |                             | 3    |
| $[\text{CH} \cdot \text{I}_{0.22}]_x$                          | 1.9                                      | <i>trans</i> $10^5$ , <i>cis</i> $10^9$                 |                                                |                                 |                             | 3    |
| 1,6-Diacetylenes (cyclopolymerized)                            |                                          | $10^{10}$ – $10^{14}$                                   |                                                |                                 |                             | 3    |
| Ionene elastomers                                              |                                          | $2.7 \cdot 10^7$ to $2.2 \cdot 10^8$                    |                                                |                                 | –80 to 60                   | 3    |
| 1,3,4-Oxydiazole polymers                                      | 0.81                                     | $3 \cdot 10^{12}$                                       |                                                |                                 | 20 to 140                   | 3    |
| Oxypyrrole polymer films                                       |                                          | 0.125                                                   |                                                |                                 |                             | 3    |
| Phenylformaldehyde polymeric pyrolysates                       |                                          |                                                         |                                                |                                 |                             | 3    |
| a) Pyrolysis Temperature 600°C                                 |                                          | 27                                                      | 0.0014                                         | –                               |                             |      |
| b) 1200°C                                                      |                                          | 0.0044                                                  | 7.84                                           | +                               |                             |      |
| Phenylthiocyanate polymers                                     | 0.5 to 0.8                               | $10^5$ – $10^8$                                         |                                                |                                 |                             | 3    |
| Polyacetylene (undoped)                                        |                                          | $10^{10}$                                               |                                                |                                 |                             | 3    |
| Polyacetylene ( $\text{I}_2$ doped)                            |                                          | 0.04                                                    |                                                |                                 |                             | 3    |
| Polyacetylene ( <i>cis</i> -rich, undoped)                     |                                          | $10^7$                                                  |                                                |                                 |                             | 3    |
| <i>trans</i> -Polyacetylene ( $\text{I}_2$ doped, 0.22 mole %) |                                          |                                                         |                                                | +                               |                             | 3    |
| Polyacrylonitrile (heat treated 700°C)                         |                                          |                                                         | 0.01                                           | –                               | –100 to 100                 | 3    |
| Poly-5,5'-biisatyl                                             | air 0.84                                 | air $2.6 \cdot 10^9$                                    |                                                | +                               | 20 to 140                   | 3    |
| thiophene-indophene                                            | vacuum 1.0                               | vacuum $3.1 \cdot 10^9$                                 |                                                |                                 |                             |      |
| Poly bis(amino)-phosphazenes                                   | 1.75                                     | $1.8 \cdot 10^{11}$                                     |                                                |                                 | 20 to 180                   | 3    |
| Poly-5,5'-diisatylmetane-thiophene-indophenine                 | 0.45                                     | $7.3 \cdot 10^4$                                        |                                                | +                               | 20 to 140                   | 3    |
| Polyethylene                                                   | 2.74                                     |                                                         |                                                |                                 | 20 to 70                    | 3    |
| Polyethylene (low density)                                     | 0.17                                     | $4 \cdot 10^9$                                          |                                                |                                 | above $T_g$                 | 3    |
| Polyimide                                                      | 2.84                                     |                                                         |                                                |                                 |                             | 3    |
| Polymalonitrile                                                | 1.72                                     |                                                         |                                                | –                               |                             | 3    |
| Poly(metalphthalocyanines) :Cu                                 | 0.12                                     | $7 \cdot 10^6$                                          |                                                |                                 |                             | 3    |
| :Fe                                                            | 0.15                                     | $1.1 \cdot 10^6$                                        |                                                |                                 |                             | 3    |
| :Ni                                                            | 0.46                                     | 100                                                     |                                                |                                 |                             | 3    |
| :Sb                                                            |                                          | $3.1 \cdot 10^6$                                        |                                                |                                 |                             | 3    |
| :Zn                                                            | 0.12                                     | $5.3 \cdot 10^3$                                        |                                                |                                 |                             | 3    |
| Poly- <i>N</i> -methylpyrrole                                  |                                          | $2 \cdot 10^6$                                          |                                                |                                 |                             | 3    |
| Polyoxypyrrole (black)                                         | 0.044                                    | 1790                                                    |                                                |                                 | –173 to 27                  | 3    |
| Polyphthalocyanines                                            | 0.01                                     | 7 to 58                                                 |                                                |                                 |                             | 3    |
| Polypyrrole                                                    | 0.01                                     |                                                         |                                                |                                 | –193 to 250                 | 3    |



| Substance                                  | Energy Gap, $E$ ,<br>(in $E/2kT$ )<br>eV | Room Temperature<br>Electrical Resistivity,<br>ohm · cm | Mobility,<br>$\mu$ ,<br>cm <sup>2</sup> /V · s | Sign of<br>Majority<br>Carriers | Temperature<br>Range,<br>°C | Ref. |
|--------------------------------------------|------------------------------------------|---------------------------------------------------------|------------------------------------------------|---------------------------------|-----------------------------|------|
| Polypyrroline II                           | 1.74                                     |                                                         |                                                |                                 |                             | 3    |
| Polyselenomethylene                        | 0.7 to 2.62                              | $>10^{13}$                                              |                                                |                                 | 20 to 120                   | 3    |
| Poly(2-vinylpyridine):I <sub>2</sub> (1:2) | 0.12                                     | 1000                                                    |                                                |                                 | -73 to 27                   | 3    |
| PVC (commercial)                           | 2.84–3.04                                |                                                         |                                                |                                 | $T < T_g$                   | 3    |
| PVC (commercial)                           | 1.24–1.96                                |                                                         |                                                |                                 | $T > T_g$                   | 3    |
| PVC (pure)                                 | 1.0±0.1                                  |                                                         |                                                |                                 | 0 to 30                     | 3    |
| Salicylal- <i>N</i> -alkyliminate-Cu       | 1.62                                     | $1.7 \cdot 10^{14}$                                     |                                                |                                 |                             | 4    |
| TTF-acetylacetonate polymers               |                                          | $1.6 \cdot 10^4$                                        |                                                |                                 |                             | 3    |
| TTF-metal polymers                         |                                          | $1.6 \cdot 10^4$                                        |                                                |                                 |                             | 3    |

## References

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2. Y. Okamoto and W. Brenner, *Organic Semiconductors*, Reinhold Publ. Corp., New York, 1964.
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## PHASE TRANSITIONS IN THE SOLID ELEMENTS AT ATMOSPHERIC PRESSURE

This table gives the phase transition temperatures for the elements that can exist in two or more crystalline forms (allotropes). The crystal phases are labeled by Greek letters in the most common conventions, although some variation is found. All data refer to normal atmospheric pressure.

### References

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2. Cordfunke, E. H. P., and Konings, R. J. M., Eds., *Thermochemical Data for Reactor Materials and Fission Products*, North-Holland, Amsterdam, 1990.
3. Greenwood, N. N., and Earnshaw, A., *Chemistry of the Elements, Second Edition*, Butterworth-Heinemann, Oxford, 1997.
4. Rhyne, J. J., "Magnetic Phase Transitions of the Elements", *Bull. Alloy Phase Diag.* 3, 402, 1982.

| Element     | Symbol         | Transition                      | $t/^{\circ}\text{C}$ | Comments                                                                                   |
|-------------|----------------|---------------------------------|----------------------|--------------------------------------------------------------------------------------------|
| Americium   | Am             | $\alpha \rightarrow \beta$      | 769                  |                                                                                            |
|             | Am             | $\beta \rightarrow \gamma$      | 1077                 |                                                                                            |
|             | Am             | $\gamma \rightarrow \text{liq}$ | 1176                 |                                                                                            |
| Beryllium   | Be             | $\alpha \rightarrow \beta$      | 1270                 |                                                                                            |
|             | Be             | $\beta \rightarrow \text{liq}$  | 1287                 |                                                                                            |
| Boron       | B              | $\alpha \rightarrow \beta$      | 1100                 |                                                                                            |
|             | B              | $\beta \rightarrow \gamma$      | 1500                 |                                                                                            |
|             | B              | $\gamma \rightarrow \text{liq}$ | 2075                 |                                                                                            |
| Calcium     | Ca             | $\alpha \rightarrow \beta$      | 443                  |                                                                                            |
|             | Ca             | $\beta \rightarrow \text{liq}$  | 842                  |                                                                                            |
| Californium | Cf             | $\alpha \rightarrow \beta$      | 590                  |                                                                                            |
|             | Cf             | $\beta \rightarrow \text{liq}$  | 900                  |                                                                                            |
| Cerium      | Ce             | $\alpha \rightarrow \beta$      | -177                 |                                                                                            |
|             | Ce             | $\beta \rightarrow \gamma$      | 61                   | $\beta$ -Ce and $\gamma$ -Ce are magnetic                                                  |
|             | Ce             | $\gamma \rightarrow \delta$     | 726                  |                                                                                            |
|             | Ce             | $\delta \rightarrow \text{liq}$ | 799                  |                                                                                            |
| Cobalt      | Co             | $\epsilon \rightarrow \alpha$   | 422                  | magnetic transition at 1115 $^{\circ}\text{C}$                                             |
|             | Co             | $\alpha \rightarrow \text{liq}$ | 1495                 |                                                                                            |
| Curium      | Cm             | $\alpha \rightarrow \beta$      | 1277                 | magnetic transition at -221 $^{\circ}\text{C}$                                             |
|             | Cm             | $\beta \rightarrow \text{liq}$  | 1345                 |                                                                                            |
| Dysprosium  | Dy             | $\alpha' \rightarrow \alpha$    | -187                 |                                                                                            |
|             | Dy             | $\alpha \rightarrow \beta$      | 1381                 | magnetic transitions in $\alpha$ -Dy at -184 $^{\circ}\text{C}$ and -94 $^{\circ}\text{C}$ |
|             | Dy             | $\beta \rightarrow \text{liq}$  | 1412                 |                                                                                            |
| Fluorine    | F <sub>2</sub> | $\alpha \rightarrow \beta$      | -227.60              |                                                                                            |
|             | F <sub>2</sub> | $\beta \rightarrow \text{liq}$  | -219.67              |                                                                                            |
| Gadolinium  | Gd             | $\alpha \rightarrow \beta$      | 1235                 |                                                                                            |
|             | Gd             | $\beta \rightarrow \text{liq}$  | 1313                 |                                                                                            |
| Hafnium     | Hf             | $\alpha \rightarrow \beta$      | 1743                 |                                                                                            |
|             | Hf             | $\beta \rightarrow \text{liq}$  | 2233                 |                                                                                            |
| Iron        | Fe             | $\alpha \rightarrow \gamma$     | 912                  | magnetic transition in $\alpha$ -Fe at 771 $^{\circ}\text{C}$                              |
|             | Fe             | $\gamma \rightarrow \delta$     | 1394                 |                                                                                            |
|             | Fe             | $\delta \rightarrow \text{liq}$ | 1538                 |                                                                                            |
| Lanthanum   | La             | $\alpha \rightarrow \beta$      | 277                  |                                                                                            |
|             | La             | $\beta \rightarrow \gamma$      | 860                  |                                                                                            |
|             | La             | $\gamma \rightarrow \text{liq}$ | 920                  |                                                                                            |
| Lithium     | Li             | $\alpha \rightarrow \beta$      | -193                 |                                                                                            |
|             | Li             | $\beta \rightarrow \text{liq}$  | 180.50               |                                                                                            |
| Manganese   | Mn             | $\alpha \rightarrow \beta$      | 727                  | magnetic transition in $\alpha$ -Mn at -100 $^{\circ}\text{C}$                             |
|             | Mn             | $\beta \rightarrow \gamma$      | 1100                 |                                                                                            |
|             | Mn             | $\gamma \rightarrow \delta$     | 1138                 |                                                                                            |
|             | Mn             | $\delta \rightarrow \text{liq}$ | 1246                 |                                                                                            |
| Neodymium   | Nd             | $\alpha \rightarrow \beta$      | 855                  | magnetic transition in $\alpha$ -Nd at -253 $^{\circ}\text{C}$                             |
|             | Nd             | $\beta \rightarrow \text{liq}$  | 1016                 |                                                                                            |
| Neptunium   | Np             | $\alpha \rightarrow \beta$      | 280                  |                                                                                            |
|             | Np             | $\beta \rightarrow \gamma$      | 576                  |                                                                                            |
|             | Np             | $\gamma \rightarrow \text{liq}$ | 644                  |                                                                                            |

| Element      | Symbol       | Transition                                  | $t/^{\circ}\text{C}$ | Comments                                                       |
|--------------|--------------|---------------------------------------------|----------------------|----------------------------------------------------------------|
| Nitrogen     | $\text{N}_2$ | $\alpha \rightarrow \beta$                  | -237.54              |                                                                |
|              | $\text{N}_2$ | $\beta \rightarrow \text{liq}$              | -210.0               |                                                                |
| Oxygen       | $\text{O}_2$ | $\alpha \rightarrow \beta$                  | -249.29              |                                                                |
|              | $\text{O}_2$ | $\beta \rightarrow \gamma$                  | -229.35              |                                                                |
|              | $\text{O}_2$ | $\gamma \rightarrow \text{liq}$             | -218.79              |                                                                |
| Phosphorus   | P            | brown $\rightarrow \beta$ -white            | -190                 | several amorphous phases (red, black, gray) exist (Ref. 3)     |
|              | P            | $\beta$ -white $\rightarrow \alpha$ -white  | -76.9                |                                                                |
|              | P            | $\alpha$ -white $\rightarrow \text{liq}$    | 44.15                |                                                                |
| Plutonium    | Pu           | $\alpha \rightarrow \beta$                  | 124.5                |                                                                |
|              | Pu           | $\beta \rightarrow \gamma$                  | 214.8                |                                                                |
|              | Pu           | $\gamma \rightarrow \delta$                 | 320.0                |                                                                |
|              | Pu           | $\delta \rightarrow \delta'$                | 462.9                |                                                                |
|              | Pu           | $\delta' \rightarrow \epsilon$              | 482.6                |                                                                |
|              | Pu           | $\epsilon \rightarrow \text{liq}$           | 640                  |                                                                |
| Polonium     | Po           | $\alpha \rightarrow \beta$                  | 54                   |                                                                |
|              | Po           | $\beta \rightarrow \text{liq}$              | 254                  |                                                                |
| Praseodymium | Pr           | $\alpha \rightarrow \beta$                  | 795                  |                                                                |
|              | Pr           | $\beta \rightarrow \text{liq}$              | 931                  |                                                                |
| Promethium   | Pm           | $\alpha \rightarrow \beta$                  | 890                  | magnetic transition in $\alpha$ -Pm at -175 $^{\circ}\text{C}$ |
|              | Pm           | $\beta \rightarrow \text{liq}$              | 1042                 |                                                                |
| Protactinium | Pa           | $\alpha \rightarrow \beta$                  | 1170                 |                                                                |
|              | Pa           | $\beta \rightarrow \text{liq}$              | 1572                 |                                                                |
| Samarium     | Sm           | $\alpha \rightarrow \beta$                  | 734                  | magnetic transition in $\alpha$ -Sm at -167 $^{\circ}\text{C}$ |
|              | Sm           | $\beta \rightarrow \gamma$                  | 922                  |                                                                |
|              | Sm           | $\gamma \rightarrow \text{liq}$             | 1072                 |                                                                |
| Scandium     | Sc           | $\alpha \rightarrow \beta$                  | 1337                 |                                                                |
|              | Sc           | $\beta \rightarrow \text{liq}$              | 1541                 |                                                                |
| Selenium     | Se           | $\alpha$ -red $\rightarrow$ gray            | 180                  | many allotropes exist (Ref. 3)                                 |
|              | Se           | gray $\rightarrow \text{liq}$               | 220.8                |                                                                |
| Sodium       | Na           | $\alpha \rightarrow \beta$                  | -233                 |                                                                |
|              | Na           | $\beta \rightarrow \text{liq}$              | 97.794               |                                                                |
| Strontium    | Sr           | $\alpha \rightarrow \beta$                  | 547                  |                                                                |
|              | Sr           | $\beta \rightarrow \text{liq}$              | 777                  |                                                                |
| Sulfur       | S            | $\alpha \rightarrow \beta$                  | 95.3                 | many allotropes exist (Ref. 3)                                 |
|              | S            | $\beta \rightarrow \text{liq}$              | 115.21               |                                                                |
| Terbium      | Tb           | $\alpha' \rightarrow \alpha$                | -53                  | magnetic transition in $\alpha$ -Tb at -230 $^{\circ}\text{C}$ |
|              | Tb           | $\alpha \rightarrow \beta$                  | 1289                 |                                                                |
|              | Tb           | $\beta \rightarrow \text{liq}$              | 1359                 |                                                                |
| Thallium     | Tl           | $\alpha \rightarrow \beta$                  | 230                  |                                                                |
|              | Tl           | $\beta \rightarrow \text{liq}$              | 304                  |                                                                |
| Thorium      | Th           | $\alpha \rightarrow \beta$                  | 1360                 |                                                                |
|              | Th           | $\beta \rightarrow \text{liq}$              | 1750                 |                                                                |
| Tin          | Sn           | $\alpha$ (gray) $\rightarrow \beta$ (white) | 13.2                 | defining fixed point on ITS-90                                 |
|              | Sn           | $\beta$ (white) $\rightarrow \text{liq}$    | 231.928              |                                                                |
| Titanium     | Ti           | $\alpha \rightarrow \beta$                  | 882                  |                                                                |
|              | Ti           | $\beta \rightarrow \text{liq}$              | 1668                 |                                                                |
| Uranium      | U            | $\alpha \rightarrow \beta$                  | 669                  |                                                                |
|              | U            | $\beta \rightarrow \gamma$                  | 776                  |                                                                |
|              | U            | $\gamma \rightarrow \text{liq}$             | 1135                 |                                                                |
| Ytterbium    | Yb           | $\alpha \rightarrow \beta$                  | 3                    |                                                                |
|              | Yb           | $\beta \rightarrow \gamma$                  | 795                  |                                                                |
|              | Yb           | $\gamma \rightarrow \text{liq}$             | 824                  |                                                                |
| Yttrium      | Y            | $\alpha \rightarrow \beta$                  | 1478                 |                                                                |
|              | Y            | $\beta \rightarrow \text{liq}$              | 1522                 |                                                                |
| Zirconium    | Zr           | $\alpha \rightarrow \beta$                  | 866                  |                                                                |
|              | Zr           | $\beta \rightarrow \text{liq}$              | 1854.7               |                                                                |

## THERMOPHYSICAL PROPERTIES OF STAINLESS STEEL 310

Stainless steel is used in a wide variety of applications, especially at high temperatures. This table gives properties of a reference standard Stainless Steel 310 certified by the U. K. National Physical Laboratory. The properties are:

$a$ : thermal diffusivity in  $\text{mm}^2 \text{s}^{-1}$   
 $c_p$ : specific heat capacity at constant pressure in  $\text{J g}^{-1} \text{K}^{-1}$   
 $\rho$ : density in  $\text{g cm}^{-3}$   
 $k$ : thermal conductivity in  $\text{W m}^{-1} \text{K}^{-1}$

With kind permission from Springer Science+Business Media: International Journal of Thermophysics, 28, 674, 2007, Table II.

### Reference

Blumm, J., Lindemann, A. Niedrig, B., and Campbell, R., *Int. J. Thermophys.* 28, 674, 2007.

| $t/^{\circ}\text{C}$ | $a/\text{mm}^2 \text{s}^{-1}$ | $c_p/\text{J g}^{-1} \text{K}^{-1}$ | $\rho/\text{g cm}^{-3}$ | $k/\text{W m}^{-1} \text{K}^{-1}$ |
|----------------------|-------------------------------|-------------------------------------|-------------------------|-----------------------------------|
| -125                 | 3.170                         | 0.376                               | 7.878                   | 9.39                              |
| -100                 | 3.130                         | 0.411                               | 7.871                   | 10.12                             |
| -75                  | 3.145                         | 0.435                               | 7.863                   | 10.76                             |
| -50                  | 3.170                         | 0.451                               | 7.855                   | 11.23                             |
| -25                  | 3.210                         | 0.464                               | 7.846                   | 11.69                             |
| 0                    | 3.256                         | 0.475                               | 7.838                   | 12.12                             |
| 25                   | 3.352                         | 0.483                               | 7.829                   | 12.67                             |
| 50                   | 3.439                         | 0.490                               | 7.820                   | 13.18                             |
| 101                  | 3.611                         | 0.501                               | 7.801                   | 14.11                             |
| 150                  | 3.763                         | 0.512                               | 7.782                   | 14.99                             |
| 200                  | 3.917                         | 0.518                               | 7.762                   | 15.75                             |
| 250                  | 4.075                         | 0.525                               | 7.742                   | 16.56                             |
| 300                  | 4.205                         | 0.533                               | 7.722                   | 17.31                             |
| 350                  | 4.331                         | 0.541                               | 7.701                   | 18.04                             |
| 400                  | 4.455                         | 0.548                               | 7.681                   | 18.75                             |
| 450                  | 4.571                         | 0.555                               | 7.660                   | 19.43                             |
| 500                  | 4.686                         | 0.562                               | 7.639                   | 20.12                             |
| 550                  | 4.806                         | 0.570                               | 7.618                   | 20.86                             |
| 600                  | 4.920                         | 0.595                               | 7.596                   | 22.24                             |
| 651                  | 5.058                         | 0.601                               | 7.574                   | 23.02                             |
| 701                  | 5.179                         | 0.607                               | 7.551                   | 23.74                             |
| 750                  | 5.207                         | 0.611                               | 7.529                   | 23.95                             |
| 800                  | 5.288                         | 0.617                               | 7.506                   | 24.49                             |
| 850                  | 5.404                         | 0.624                               | 7.483                   | 25.23                             |
| 901                  | 5.506                         | 0.633                               | 7.460                   | 26.00                             |
| 950                  | 5.618                         | 0.645                               | 7.436                   | 26.94                             |
| 1000                 | 5.707                         | 0.655                               | 7.411                   | 27.70                             |

# THERMOELECTRIC PROPERTIES OF METALS AND SEMICONDUCTORS

L. I. Berger

There are three thermoelectric phenomena that result from correlation between propagation of heat through a conductor and displacement of the current carriers in the conductor. The Seebeck effect (Ref. 1) consists of formation of an electric current in an electrical circuit formed by two dissimilar conductors if the contacts between the conductors are held at different temperatures. A reverse phenomenon, the Peltier effect (Ref. 2), consists of formation of a temperature difference between the contacts in a circuit of this type if an electric current is created in the circuit by an external current source to which the circuit is connected. W. Thomson (Lord Kelvin), who explained both effects (Refs. 3,4), predicted and experimentally confirmed the existence of another thermoelectric phenomenon, named the Thomson effect, which consists of absorption or release of heat in a uniform conductor with a current passing through it when a temperature gradient (positive or negative) is present along the current direction.

The electromotive force,  $\Delta U$ , which creates the Seebeck current in the circuit, is the algebraic sum of the emf's created in each of the conductors, and is proportional to the temperature difference,  $\Delta T$ , between the electrical contact points:  $\Delta U = \Delta U_1 + \Delta U_2 = \alpha_1 \Delta T + \alpha_2 \Delta T$ . The coefficient of proportionality,  $\alpha$ , called the Seebeck coefficient or thermoelectric power or thermal electromotive force (thermal emf), of each of the two materials depends on the electrical properties and temperature of the material. The Peltier effect is measured by the amount of heat,  $\Delta Q$ , released or absorbed in a unit of time (in addition to the Joule heat) at a contact of two dissimilar conductors with electric current  $\Delta I$  passing through the contact:  $\Delta Q = \Pi \Delta I$ . Thomson showed that  $\Pi = \alpha T$ . The Thomson effect's heat,  $dQ$ , released or absorbed in a unit of time along a part of a conductor of length  $dx$  is proportional to the current magnitude  $I$ , the temperature gradient along the conductor  $\partial T/\partial x$ , and the increment  $dx$ :  $dQ = \tau I (\partial T/\partial x) dx$ . Thomson showed that the magnitude of the coefficient of proportionality,  $\tau$ , later named the Thomson coefficient, depends on only the properties of the conductor and the ambient temperature and correlates with the other thermoelectric parameters of a material through the equation  $\tau = T(\partial \alpha/\partial T)$ .

Another thermoelectric phenomenon, called the Bridgman effect or the internal Peltier effect (Ref. 5), occurs when an electric current passes through an anisotropic crystal, resulting in absorption or liberation of heat because of non-uniformity in current distribution.

In view of the correlations between  $\alpha$ ,  $\Pi$ , and  $\tau$ , we need only to present data for one of these parameters, namely, thermal emf  $\alpha$

and its dependence on temperature. These values are presented below, first for metals and then for semiconductors. In accordance with modern theory of solids, thermal emf in semiconductors is up to three or even four orders of magnitude higher than that in metals (Ref. 9).

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## Thermoelectric Properties of Elemental Metals

|    | Thermal emf $\alpha(T)$ in $\mu\text{V/K}$ at Temperature $T$ |       |       |        |        |
|----|---------------------------------------------------------------|-------|-------|--------|--------|
|    | 100 K                                                         | 300 K | 500 K | 1000 K | 1500 K |
| Ag | 0.73                                                          | 1.51  | 2.82  | 7.95   |        |
| Al | –2.2                                                          | –1.66 | 1.96  |        |        |
| Au | 0.82                                                          | 1.94  | 2.86  | 3.85   |        |
| Ba | –4                                                            | 12.1  | 28.5  |        |        |
| Be | –2.5                                                          | 1.7   | 2.7   | 7.9    |        |
| Ca | 1.05                                                          | 10.3  | 17.1  |        |        |
| Cd | –0.05                                                         | 2.55  |       |        |        |
| Ce | 13.6                                                          | 6.2   | 5.2   | –4.8   |        |
| Co | –8.43                                                         | –30.8 | –44.8 | –35.9  | –7.8   |
| Cr | 5                                                             | 21.8  | 16.6  | 17.9   | 5.7    |

|    | Thermal emf $\alpha(T)$ in $\mu\text{V/K}$ at Temperature $T$ |       |       |        |        |
|----|---------------------------------------------------------------|-------|-------|--------|--------|
|    | 100 K                                                         | 300 K | 500 K | 1000 K | 1500 K |
| Cs |                                                               | –0.9  |       |        |        |
| Cu | 1.19                                                          | 1.83  | 2.83  | 5.36   |        |
| Dy | –4.1                                                          | –1.8  | 0.9   | 2.3    |        |
| Er | –3.8                                                          | –0.1  | 1.9   | 4.2    |        |
| Eu | 5.3                                                           | 24.5  | 46    |        |        |
| Fe | 11.6                                                          | 15    | 3     | 0.4    |        |
| Ga | 0.5                                                           |       |       |        |        |
| Gd | –4.6                                                          | –1.6  | –0.5  | –0.8   |        |
| Hf | 0                                                             | 5.5   | 5.7   | –0.5   |        |
| Ho | –6.7                                                          | –1.6  | 1.4   | 2.8    |        |

|    | Thermal emf $\alpha(T)$ in $\mu\text{V/K}$ at Temperature $T$ |       |       |        |        |    | Thermal emf $\alpha(T)$ in $\mu\text{V/K}$ at Temperature $T$ |       |       |        |        |
|----|---------------------------------------------------------------|-------|-------|--------|--------|----|---------------------------------------------------------------|-------|-------|--------|--------|
|    | 100 K                                                         | 300 K | 500 K | 1000 K | 1500 K |    | 100 K                                                         | 300 K | 500 K | 1000 K | 1500 K |
| In | 0.56                                                          | 1.68  |       |        |        | Re | -1.4                                                          | -5.9  | -5.9  | -1.9   | 1.8    |
| Ir | 1.42                                                          | 0.86  | -0.1  | -2.7   | -5.7   | Rh | 0.8                                                           | 0.6   | 0.5   | -1.5   |        |
| K  | -5.2                                                          | -13.7 |       |        |        | Ru | 0.3                                                           | -1.4  | -1.8  | -4.2   | -7.5   |
| La | 0.1                                                           | 1.7   | 2     | -1.7   |        | Sc | -14.3                                                         | -19   | -17.5 | -5.4   | 10.2   |
| Li | 4.3                                                           |       |       |        |        | Sm | 0.7                                                           | 1.2   | 0.6   | -3     |        |
| Lu | -6.9                                                          | -4.3  | -2.6  | 0      |        | Sn | -0.04                                                         | -1    |       |        |        |
| Mg | -2.1                                                          | -1.46 |       |        |        | Sr | -3                                                            | 1.1   | 4.2   |        |        |
| Mn | -2.5                                                          | -9.8  | -8.4  | -1.5   |        | Ta | 0.7                                                           | -1.9  | -2.3  | 1.6    | 7.2    |
| Mo | 0.1                                                           | 5.6   | 11.4  | 17.4   | 13.7   | Tb | -1.6                                                          | -1    | 0.3   | 0.6    |        |
| Na | -2.6                                                          | -6.3  |       |        |        | Th | 0.6                                                           | -3.2  | -9.2  | -14.3  | -10.4  |
| Nb | 1.05                                                          | -0.44 | -1.1  | 0.45   | 3.2    | Ti | -2                                                            | 9.1   | 5.3   | -3.1   | -0.5   |
| Nd | -4                                                            | -2.3  | 0     | -1.2   |        | Tl | 0.6                                                           | 0.3   | -1.5  |        |        |
| Ni | -8.5                                                          | -19.5 | -25.8 | -29.9  |        | Tm | -1.3                                                          | 1.9   | 2.7   | 2.2    |        |
| Np | 8.9                                                           | -3.1  |       |        |        | U  | 3                                                             | 7.1   | 11    | 16.7   |        |
| Os | -3.2                                                          | -4.4  | -4.7  | -6.3   | -8.5   | V  | 2.9                                                           | 0.23  | 1.1   | 4.6    |        |
| Pb | -0.58                                                         | -1.05 | -1.5  |        |        | W  | -4.4                                                          | 0.9   | 9     | 19.8   | 21.3   |
| Pd | 1.1                                                           | -10.7 | -16.3 | -32.3  | -46.4  | Y  | -5.1                                                          | -0.7  | 0.3   | 2.9    | 6.6    |
| Pt | 4.1                                                           | -5.3  | -7.9  | -8.2   |        | Yb | 5.1                                                           | 30    | 20.3  | 12.3   |        |
| Pu | 12                                                            |       |       |        |        | Zn | 0.7                                                           | 2.4   |       |        |        |
| Rb | -3.6                                                          | -10   |       |        |        | Zr | 4.4                                                           | 8.9   | 4.6   | -3     | 1.1    |

Thermoelectric Properties of Selected Semiconductors; Values Near Room Temperature unless Otherwise Indicated

| Material                         | $\alpha/\mu\text{V K}^{-1}$ | Material                          | $\alpha/\mu\text{V K}^{-1}$ | Material                          | $\alpha/\mu\text{V K}^{-1}$ |
|----------------------------------|-----------------------------|-----------------------------------|-----------------------------|-----------------------------------|-----------------------------|
| <i>Elemental Semiconductors</i>  |                             |                                   |                             |                                   |                             |
| B                                | 600 (500 K)                 | n-Si                              | 300                         | p-Si                              | -500                        |
| n-Ge                             | 600                         | p-Ge                              | -830                        | $\alpha$ -Sn                      | -40 (250 K)                 |
| <i>I-VI Compounds</i>            |                             |                                   |                             |                                   |                             |
| Cu <sub>2</sub> S                | 327                         | Cu <sub>2</sub> Se                | 135                         | Cu <sub>2</sub> Te                | 40                          |
| Ag <sub>2</sub> Te               | 120                         |                                   |                             |                                   |                             |
| <i>II-VI Compounds</i>           |                             |                                   |                             |                                   |                             |
| ZnO                              | 300                         | CdS                               | 700                         | ZnSe                              | 55                          |
| CdSe                             | 200                         |                                   |                             |                                   |                             |
| <i>III-V Compounds</i>           |                             |                                   |                             |                                   |                             |
| GaN                              | 70                          | GaP                               | 1200                        | InP                               | -400                        |
| AlAs                             | 70                          | n-GaAs                            | 380                         | p-GaAs                            | -310                        |
| InAs                             | 200                         | AlSb                              | 500                         | n-GaSb                            | 250                         |
| p-GaSb                           | -55                         | n-InSb                            | 240                         | p-InSb                            | 200                         |
| <i>V-VI Compounds</i>            |                             |                                   |                             |                                   |                             |
| Sb <sub>2</sub> Te <sub>3</sub>  | 110                         | n-Bi <sub>2</sub> Te <sub>3</sub> | 224                         | p-Bi <sub>2</sub> Te <sub>3</sub> | -227                        |
| <i>I-III-VI Compounds</i>        |                             |                                   |                             |                                   |                             |
| CuAlS <sub>2</sub>               | 50                          | AgInSe <sub>2</sub>               | -370                        | CuTlTe <sub>2</sub>               | 80                          |
| CuGaSe                           | 40                          | AgTlSe <sub>2</sub>               | 800                         | AgAlTe <sub>2</sub>               | 321                         |
| CuInSe <sub>2</sub>              | 340                         | CuGaTe <sub>2</sub>               | 340                         | AgGaTe <sub>2</sub>               | 950                         |
| CuTlSe <sub>2</sub>              | -5                          | CuInTe <sub>2</sub>               | 260                         | AgInTe <sub>2</sub>               | 298                         |
| AgGaSe <sub>2</sub>              | 90                          | CuTlTe <sub>2</sub>               | 80                          |                                   |                             |
| <i>I-IV-VI Compounds</i>         |                             |                                   |                             |                                   |                             |
| Cu <sub>2</sub> GeS <sub>3</sub> | 300                         | Cu <sub>2</sub> GeSe <sub>3</sub> | 100                         | Cu <sub>2</sub> GeTe <sub>3</sub> | 10                          |
| Cu <sub>2</sub> SnS <sub>3</sub> | 600                         | Cu <sub>2</sub> SnSe <sub>3</sub> | 250                         | Cu <sub>2</sub> SnTe <sub>3</sub> | 30                          |
| <i>I-V-VI Compounds</i>          |                             |                                   |                             |                                   |                             |
| Cu <sub>3</sub> AsS <sub>4</sub> | 130                         | Cu <sub>3</sub> AsSe <sub>4</sub> | 120                         | Cu <sub>3</sub> SbSe <sub>4</sub> | 200                         |
| <i>II-IV-V Compounds</i>         |                             |                                   |                             |                                   |                             |
| ZnGeP <sub>2</sub>               | 1200                        | ZnSiAs <sub>2</sub>               | 1100                        | CdGeAs <sub>2</sub>               | 190                         |
| CdSnAs <sub>2</sub>              | 600                         |                                   |                             |                                   |                             |

# NOMENCLATURE FOR ORGANIC POLYMERS

Robert B. Fox and Edward S. Wilks

Organic polymers have traditionally been named on the basis of the monomer used, a hypothetical monomer, or a semi-systematic structure. Alternatively, they may be named in the same way as organic compounds, i.e., on the basis of a structure as drawn. The former method, often called “source-based nomenclature” or “monomer-based nomenclature”, sometimes results in ambiguity and multiple names for a single material. The latter method, termed “structure-based nomenclature”, generates a sometimes cumbersome unique name for a given polymer, independent of its source. Within their limitations, both types of names are acceptable and well-documented.<sup>1</sup> The use of stereochemical descriptors with both types of polymer nomenclature has been published.<sup>2</sup>

## Traditional Polymer Names

### Monomer-Based Names

“Polystyrene” is the name of a homopolymer made from the single monomer styrene. When the name of a monomer comprises two or more words, the name should be enclosed in parentheses, as in “poly(methyl methacrylate)” or “poly(4-bromostyrene)” to identify the monomer more clearly. This method can result in several names for a given polymer: thus, “poly(ethylene glycol)”, “poly(ethylene oxide)”, and “poly(oxirane)” describe the same polymer. Sometimes, the name of a hypothetical monomer is used, as in “poly(vinyl alcohol)”. Even though a name like “polyethylene” covers a multitude of materials, the system does provide understandable names when a single monomer is involved in the synthesis of a single polymer. When one monomer can yield more than one polymer, e.g. 1,3-butadiene or acrolein, some sort of structural notation must be used to identify the product, and one is not far from a formal structure-based name.

*Copolymers, Block Polymers, and Graft Polymers.* When more than one monomer is involved, monomer-based names are more complex. Some common polymers have been given names based on an apparent structure, as with “poly(ethylene terephthalate)”. A better system has been approved by the IUPAC.<sup>1</sup> With this method, the arrangement of the monomeric units is introduced through use of an italicized connective placed between the names of the monomers. For monomer names represented by A, B, and C, the various types of arrangements are shown in Table 1.

Table 2 contains examples of common or semi-systematic names of copolymers. The systematic names of comonomers may also be used; thus, the polyacrylonitrile-*block*-polybutadiene-*block*-polystyrene polymer in Table 2 may also be named poly(prop-2-enenitrile)-*block*-polybuta-1,3-diene-*block*-poly(ethenylbenzene). IUPAC does not require alphabetized names of comonomers within a polymer name; many names are thus possible for some copolymers.

These connectives may be used in combination and with small, non-repeating (i.e. non-polymeric) junction units; see, for example, Table 2, line 8. A long dash may be used in place of the con-

nective *-block-*; thus, in Table 2, the polymers of lines 7 and 8 may also be written as shown on lines 9 and 10.

IUPAC also recommends an alternative scheme for naming copolymers that comprises use of “copoly” as a prefix followed by the names of the comonomers, a solidus (an oblique stroke) to separate comonomer names, and addition before “copoly” of any applicable connectives listed in Table 2 except *-co-*.

Table 3 gives the same examples shown in Table 2 but with the alternative format. Comonomer names need not be parenthesized.

TABLE 1. IUPAC Source-Based Copolymer Classification

| No. | Copolymer type                                            | Connective     | Example                               |
|-----|-----------------------------------------------------------|----------------|---------------------------------------|
| 1   | Unspecified or unknown                                    | <i>-co-</i>    | poly(A- <i>co</i> -B)                 |
| 2   | Random (obeys Bernoullian distribution)                   | <i>-ran-</i>   | poly(A- <i>ran</i> -B)                |
| 3   | Statistical (obeys known statistical laws)                | <i>-stat-</i>  | poly(A- <i>stat</i> -B)               |
| 4   | Alternating (for two monomeric units)                     | <i>-alt-</i>   | poly(A- <i>alt</i> -B)                |
| 5   | Periodic (ordered sequence for 2 or more monomeric units) | <i>-per-</i>   | poly(A- <i>per</i> -B- <i>per</i> -C) |
| 6   | Block (linear block arrangement)                          | <i>-block-</i> | polyA- <i>block</i> -polyB            |
| 7   | Graft (side chains connected to main chains)              | <i>-graft-</i> | polyA- <i>graft</i> -polyB            |

TABLE 2. Examples of Source-Based Copolymer Nomenclature

| No. | Copolymer name                                                                    |
|-----|-----------------------------------------------------------------------------------|
| 1   | poly(propene- <i>co</i> -methacrylonitrile)                                       |
| 2   | poly[(acrylic acid)- <i>ran</i> -(ethyl acrylate)]                                |
| 3   | poly(butene- <i>stat</i> -ethylene- <i>stat</i> -styrene)                         |
| 4   | poly[(sebacic acid)- <i>alt</i> -butanediol]                                      |
| 5   | poly[(ethylene oxide)- <i>per</i> -(ethylene oxide)- <i>per</i> -tetrahydrofuran] |
| 6   | polyisoprene- <i>graft</i> -poly(methacrylic acid)                                |
| 7   | polyacrylonitrile- <i>block</i> -polybutadiene- <i>block</i> -polystyrene         |
| 8   | polystyrene- <i>block</i> -dimethylsilylene- <i>block</i> -polybutadiene          |
| 9   | polyacrylonitrile—polybutadiene—polystyrene                                       |
| 10  | polystyrene—dimethylsilylene—polybutadiene                                        |

TABLE 3. Examples of Source-Based Copolymer Nomenclature (Alternative Format)

| No. | Polymer name                                                      |
|-----|-------------------------------------------------------------------|
| 1   | copoly(propene/methacrylonitrile)                                 |
| 2   | <i>ran</i> -copoly(acrylic acid/ethyl acrylate)                   |
| 3   | <i>stat</i> -copoly(butene/ethylene/styrene)                      |
| 4   | <i>alt</i> -copoly(sebacic acid/butanediol)                       |
| 5   | <i>block</i> -copoly(acrylonitrile/butadiene/styrene)             |
| 6   | <i>per</i> -copoly(ethylene oxide/ethylene oxide/tetrahydrofuran) |
| 7   | <i>graft</i> -copoly(isoprene/methacrylic acid)                   |

Source-based nomenclature for non-linear macromolecules and macromolecular assemblies is covered by a 1997 IUPAC document.<sup>11</sup> The types of polymers in these classes, together with their connectives, are given in Table 4; the terms shown may be used as connectives, prefixes, or both to designate the features present.

**TABLE 4. Connectives for Non-Linear Macromolecules and Macromolecular Assemblies**

| No. | Type                                          | Connective            |
|-----|-----------------------------------------------|-----------------------|
| 1   | Branched (type unspecified)                   | branch                |
| 2   | Branched with branch point of functionality f | f-branch              |
| 3   | Comb                                          | comb                  |
| 4   | Cross-link                                    | <i>ι</i> (Greek iota) |
| 5   | Cyclic                                        | cyclo                 |
| 6   | Interpenetrating polymer network              | ipn                   |
| 7   | Long-chain branched                           | l-branch              |
| 8   | Network                                       | net                   |
| 9   | Polymer blend                                 | blend                 |
| 10  | Polymer-polymer complex                       | compl                 |
| 11  | Semi-interpenetrating polymer network         | sipn                  |
| 12  | Short-chain branched                          | sh-branch             |
| 13  | Star                                          | star                  |
| 14  | Star with f arms                              | f-star                |

Non-linear polymers are named by using the italicized connective as a *prefix* to the source-based name of the polymer component or components to which the prefix applies; some examples are listed in Table 5.

**TABLE 5. Non-Linear Macromolecules**

| No. | Polymer name                                                          | Polymer structural features                                                                                      |
|-----|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| 1   | poly(methacrylic acid)- <i>comb</i> -polyacrylonitrile                | Comb polymer with a poly(methacrylic acid) backbone and polyacrylonitrile side chains                            |
| 2   | <i>comb</i> -poly[ethylene- <i>stat</i> -(vinyl chloride)]            | Comb polymer with unspecified backbone composition and statistical ethylene/vinyl chloride copolymer side chains |
| 3   | polybutadiene- <i>comb</i> -(polyethylene; polypropene)               | Comb polymer with butadiene backbone and side chains of polyethylene and polypropene                             |
| 4   | <i>star</i> -(polyA; polyB; polyC; polyD; polyE)                      | Star polymer with arms derived from monomers A, B, C, D, and E, respectively                                     |
| 5   | <i>star</i> -(polyA- <i>block</i> -polyB- <i>block</i> -polyC)        | Star polymer with every arm comprising a tri-block segment derived from comonomers A, B, and C                   |
| 6   | <i>star</i> -poly(propylene oxide)                                    | A star polymer prepared from propylene oxide                                                                     |
| 7   | 5- <i>star</i> -poly(propylene oxide)                                 | A 5-arm star polymer prepared from propylene oxide                                                               |
| 8   | <i>star</i> -(polyacrylonitrile; polypropylene) ( $M_r$ 10000: 25000) | A star polymer containing polyacrylonitrile arms of MW 10000 and polypropylene arms of MW 25000                  |

Macromolecular assemblies held together by forces other than covalent bonds are named by inserting the appropriate italicized connective between names of individual components; Table 6 gives examples.

**TABLE 6. Examples of Polymer Blends and Nets**

| No. | Polymer name                                                                                                                     |
|-----|----------------------------------------------------------------------------------------------------------------------------------|
| 1   | polyethylene- <i>blend</i> -polypropene                                                                                          |
| 2   | poly(methacrylic acid)- <i>blend</i> -poly(ethyl acrylate)                                                                       |
| 3   | <i>net</i> -poly(4-methylstyrene- <i>i</i> -divinylbenzene)                                                                      |
| 4   | <i>net</i> -poly[styrene- <i>alt</i> -(maleic anhydride)]- <i>i</i> -(polyethylene glycol; polypropylene glycol)                 |
| 5   | <i>net</i> -poly(ethyl methacrylate)- <i>sipn</i> -polyethylene                                                                  |
| 6   | [ <i>net</i> -poly(butadiene- <i>stat</i> -styrene)]- <i>ipn</i> -[ <i>net</i> -poly(4-methylstyrene- <i>i</i> -divinylbenzene)] |

## Structure-Based Polymer Nomenclature

### Regular Single-Strand Polymers

Structure-based nomenclature has been approved by the IUPAC<sup>4</sup> and is currently being updated; it is used by *Chemical Abstracts*.<sup>5</sup> Monomer names are not used. To the extent that a polymer chain can be described by a repeating unit in the chain, it can be named “poly(repeating unit)”. For regular single-strand polymers, “repeating unit” is a bivalent group; for regular double-strand (ladder and spiro) polymers, “repeating unit” is usually a tetravalent group.<sup>9</sup>

Since there are usually many possible repeating units in a given chain, it is necessary to select one, called the “constitutional repeating unit” (CRU) to provide a unique and unambiguous name, “poly(CRU)”, where “CRU” is a recitation of the names of successive units as one proceeds through the CRU from left to right. For this purpose, a portion of the main chain structure that includes at least two repeating sequences is written out. These sequences will typically be composed of bivalent subunits such as  $-\text{CH}_2-$ ,  $-\text{O}-$ , and groups from ring systems, each of which can be named by the usual nomenclature rules.<sup>6,7</sup>

Where a chain is simply one long sequence comprising repetition of a single subunit, that subunit is itself the CRU, as in “poly(methylene)” or “poly(1,4-phenylene)”. In chains having more than one kind of subunit, a seniority system is used to determine the beginning of the CRU and the direction in which to move along the main chain atoms (following the shortest path in rings) to complete the CRU. Determination of the first, most senior, subunit, is based on a descending order of seniority: (1) heterocyclic rings, (2) hetero atoms, (3) carbocyclic rings, and, lowest, (4) acyclic carbon chains.

Within each of these classes, there is a further order of seniority that follows the usual rules of nomenclature.

**Heterocycles:** A nitrogen-containing ring system is senior to a ring system not containing nitrogen.<sup>4,9</sup> Further descending order of seniority is determined by:

- the highest number of rings in the ring system
- the largest individual ring in the ring system
- the largest number of hetero atoms
- the greatest variety of hetero atoms

**Hetero atoms:** The senior bivalent subunit is the one nearest the top, right-hand corner of the Periodic Table; the order of seniority is: O, S, Se, Te, N, P, As, Sb, Bi, Si, Ge, Sn, Pb, B, Hg.

**Carbocycles:** Seniority<sup>4</sup> is determined by:

- the highest number of rings in the ring system
- the largest individual ring in the ring system
- degree of ring saturation; an unsaturated ring is senior to a saturated ring of the same size

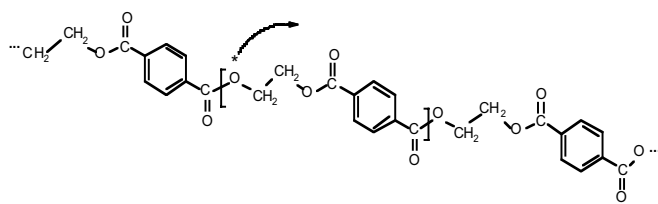


**Carbon chains:** Descending order of seniority is determined by:

- (i) chain length (longer is senior to shorter)
- (ii) highest degree of unsaturation
- (iii) number of substituents (higher number is senior to lower number)
- (iv) ascending order of locants
- (v) alphabetical order of names of substituent groups

Among equivalent ring systems, preference is given to the one having lowest locants for the free valences in the subunit, and among otherwise identical ring systems, the one having least hydrogenation is senior. Lowest locants in unsaturated chains are also given preference. Lowest locants for substituents are the final determinant of seniority.

Direction within the repeating unit depends upon the shortest path, which is determined by counting main chain atoms, both cyclic and acyclic, from the most senior subunit to another subunit of the same kind or to a subunit next lower in seniority. When identification and orientation of the CRU have been accomplished, the CRU is named by writing, in sequence, the names of the largest possible subunits within the CRU from left to right. For example, the main chain of the polymer traditionally named “poly(ethylene terephthalate)” has the structure shown in Figure 1.



**Figure 1.** Structure-based name: poly(oxyethyleneoxyterephthaloyl); traditional name: poly(ethylene terephthalate).

The CRU in Figure 1 is enclosed in brackets and read from left to right. It is selected because (1) either backbone oxygen atom qualifies as the “most senior subunit”, (2) the shortest path length from either -O- to the other -O- is via the ethylene subunit. Orientation of the CRU is thus defined by (1) beginning at the -O- marked with an asterisk, and (2) reading in the direction of the arrow. The structure-based name of this polymer is therefore “poly(oxyethyleneoxyterephthaloyl)”, not much longer than the traditional name and much more adaptable to the complexities of substitution. As organic nomenclature evolves, more systematic names may be used for subunits, e.g. “ethane-1,2-diyl” instead of “ethylene”. IUPAC still prefers “ethylene” for the -CH<sub>2</sub>-CH<sub>2</sub>- unit, however, but also accepts “ethane-1,2-diyl”.

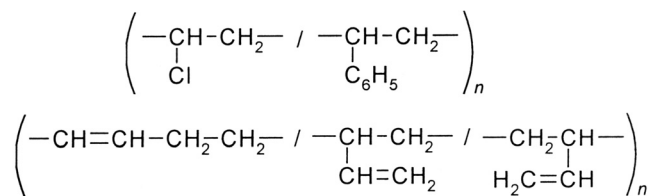
Structure-based nomenclature can also be used when the CRU backbone has no carbon atoms. An example is the polymer traditionally named “poly(dimethylsiloxane)”, which on the basis of structure would be named “poly(oxydimethylsilylene)” or “poly(oxydimethylsilanediy)”. This nomenclature method has also been applied to inorganic and coordination polymers<sup>8</sup> and to double-strand (ladder and spiro) organic polymers.<sup>9</sup>

### Irregular Single-Strand Polymers

Polymers that cannot be described by the repetition of a single CRU or comprise units not all connected identically in a directional sense can also be named on a structure basis.<sup>10</sup> These include copolymers, block and graft polymers, and star polymers. They are given names of the type “poly(A/B/C...)”, where A, B, C, etc. are the names of the component constitutional units, the

number of which are minimized. The constitutional units may include regular or irregular blocks as well as atoms or atomic groupings, and each is named by the method described above or by the rules of organic nomenclature.

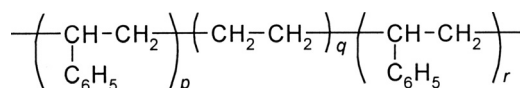
The solidus denotes an unspecified arrangement of the units within the main chain.<sup>10</sup> For example, a statistical copolymer derived from styrene and vinyl chloride with the monomeric units joined head-to-tail is named “poly(1-chloroethylene/1-phenylethylene)”. A polymer obtained by 1,4-polymerization and both head-to-head and head-to-tail 1,2- polymerization of 1,3-butadiene would be named “poly(but-1-ene-1,4-diyl/1-vinylethylene/2-vinylethylene)”.<sup>12</sup> In graphic representations of these polymers, shown in Figure 2, the hyphens or dashes at each end of each CRU depiction are shown *completely within* the enclosing parentheses; this indicates that they are not necessarily the terminal bonds of the macromolecule.



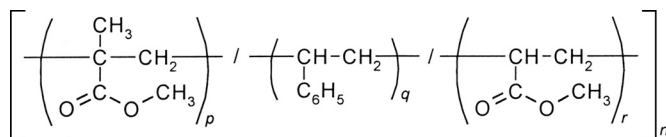
**Figure 2.** Graphic representations of copolymers.

A long hyphen is used to separate components in names of block polymers, as in “poly(A)—poly(B)—poly(C)”, or “poly(A)—X—poly(B)” in which X is a non-polymeric junction unit, e.g. dimethylsilylene.

In graphic representations of these polymers, the blocks are shown connected when the bonding is known (Figure 3, for example); when the bonding between the blocks is unknown, the blocks are separated by solidi and are shown *completely within* the outer set of enclosing parentheses (Figure 4, for example).<sup>10,13</sup>



**Figure 3.** polystyrene—polyethylene—polystyrene.



**Figure 4.** poly[poly(methyl methacrylate)—polystyrene—poly(methyl acrylate)].

Graft polymers are named in the same way as a substituted polymer but without the ending “yl” for the grafted chain; the name of a regular polymer, comprising Z units in which some have grafts of “poly(A)”, is “poly[Z/poly(A)Z]”. Star polymers are treated as a central unit with substituent blocks, as in “tetraakis(polymethylene)silane”.<sup>10,13</sup>

### Other Nomenclature Articles and Publications

In addition to the *Chemical Abstracts* and IUPAC documents cited above and listed below, other articles on polymer nomenclature are available. A 1999 article lists significant documents on polymer nomenclature published during the last 50 years in books, encyclopedias, and journals by *Chemical Abstracts*,

IUPAC, and individual authors.<sup>14</sup> A comprehensive review of source-based and structure-based nomenclature for all of the major classes of polymers,<sup>15</sup> and a short tutorial on the correct identification, orientation, and naming of most commonly encountered constitutional repeating units were both published in 2000.<sup>16</sup>

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10. International Union of Pure and Applied Chemistry, Structure-Based Nomenclature for Irregular Single-Strand Organic Polymers (Recommendations 1994), *Pure Appl. Chem.*, **66**, 873-889 (1994).
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12. Poly(1,3-butadiene) obtained by polymerization of 1,3-butadiene in the so-called 1,4- mode is frequently drawn incorrectly in publications as  $-(\text{CH}_2-\text{CH}=\text{CH}-\text{CH}_2)_n-$ ; the double bond should be assigned the lowest locant possible, i.e. the structure should be drawn as  $-(\text{CH}=\text{CH}-\text{CH}_2-\text{CH}_2)_n-$ .
13. International Union of Pure and Applied Chemistry, "Graphic Representations (Chemical Formulae) of Macromolecules (Recommendations 1994)." *Pure Appl. Chem.*, **66**, 2469-2482 (1994).
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16. Wilks, E. S. Macromolecular Nomenclature Note No. 18: "SRUs: Using the Rules." *Polym. Prepr.* **41**(1), 6a-11a (2000); also available at [www.chem.umr.edu/~poly/nomenclature.html](http://www.chem.umr.edu/~poly/nomenclature.html); a .pdf format version is also available.

## SOLVENTS FOR COMMON POLYMERS

### Abbreviations:

HC: hydrocarbons

MEK: methyl ethyl ketone

THF: tetrahydrofuran

DMF: dimethylformamide

DMSO: dimethylsulfoxide

|                                              |                                                           |
|----------------------------------------------|-----------------------------------------------------------|
| Polyethylene (HDPE)                          | HC and halogenated HC                                     |
| Polypropylene (atactic)                      | HC and halogenated HC                                     |
| Polybutadiene                                | HC, THF, ketones                                          |
| Polystyrene                                  | ethylbenzene, $\text{CHCl}_3$ , $\text{CCl}_4$ , THF, MEK |
| Polyacrylates                                | aromatic HC, chlorinated HC, THF, esters, ketones         |
| Polymethacrylates                            | aromatic HC, chlorinated HC, THF, esters, MEK             |
| Polyacrylamide                               | water                                                     |
| Poly(vinyl ethers)                           | halogenated HC, MEK, butanol                              |
| Poly(vinyl alcohol)                          | glycols (hot), DMF                                        |
| Poly(vinyl acetate)                          | aromatic HC, chlorinated HC, THF, esters, DMF             |
| Poly(vinyl chloride)                         | THF, DMF, DMSO                                            |
| Poly(vinylidene chloride)                    | THF (hot), dioxane, DMF                                   |
| Poly(vinyl fluoride)                         | DMF, DMSO (hot)                                           |
| Polyacrylonitrile                            | DMF, DMSO                                                 |
| Poly(oxyethylene)                            | aromatic HC, $\text{CHCl}_3$ , alcohols, esters, DMF      |
| Poly(2,6-dimethylphenylene oxide)            | aromatic HC, halogenated HC                               |
| Poly(ethylene terephthalate)                 | phenol, DMSO (hot)                                        |
| Polyurethanes (linear)                       | aromatic HC, THF, DMF                                     |
| Polyureas                                    | phenol, formic acid                                       |
| Polysiloxanes                                | HC, THF, DMF                                              |
| Poly[bis(2,2,2-trifluoroethoxy)-phosphazene] | THF, ketones, ethyl acetate                               |

# GLASS TRANSITION TEMPERATURE FOR SELECTED POLYMERS

Robert B. Fox

Polymer names are based on the IUPAC structure-based nomenclature system described in the table "Naming Organic Polymers". Within each category, names are listed in alphabetical order. Source-based and trivial names are also given (in italics) for the most common polymers. The table does not include polymers for which  $T_g$  is not clearly defined because of variability of structure or because of reactions taking place near the glass transition.

All values of  $T_g$  cited in this table have been determined by differential scanning calorimetry (DSC) except those values indicated by:

(D) dynamic method  
(Dil) dilatometry  
(M) mechanical method

| Polymer name                                                                                  | Glass transition temperature ( $T_g$ /K) |
|-----------------------------------------------------------------------------------------------|------------------------------------------|
| ACYCLIC CARBON CHAINS                                                                         |                                          |
| <i>Polyalkadienes</i>                                                                         |                                          |
| Poly(alkenylene) <i>Polyalkadiene</i> $-\text{[CH=CHCH}_2\text{CH}_2\text{]}-$                |                                          |
| Poly( <i>cis</i> -1-butenylene)                                                               | 171                                      |
| <i>cis</i> -1,3-polybutadiene [PBD]                                                           |                                          |
| Poly( <i>trans</i> -1-butenylene)                                                             | 215                                      |
| <i>trans</i> -1,3-polybutadiene [PBD]                                                         |                                          |
| Poly(1-chloro- <i>cis</i> -1-butenylene)                                                      | 253                                      |
| <i>cis</i> -1,3-polychloroprene                                                               |                                          |
| Poly(1-chloro- <i>trans</i> -1-butenylene)                                                    | 233                                      |
| <i>trans</i> -1,3-polychloroprene                                                             |                                          |
| Poly(1-methyl- <i>cis</i> -1-butenylene)                                                      | 200                                      |
| <i>cis</i> -1,3-polyisoprene                                                                  |                                          |
| Poly(1-methyl- <i>trans</i> -1-butenylene)                                                    | 207                                      |
| <i>trans</i> -1,3-polyisoprene                                                                |                                          |
| Poly(1,4,4-trifluoro-1-butenylene)                                                            | 238                                      |
| <i>Polyalkenes</i>                                                                            |                                          |
| Poly(alkylethylene) <i>Poly(alkylethylene)</i> $-\text{[RCHCH}_2\text{]}-$                    |                                          |
| Poly(1-benzylethylene)                                                                        | 333                                      |
| Poly(1-butyloethylene)                                                                        | 223                                      |
| Poly(1-cyclohexylethylene) (atactic)                                                          | 393                                      |
| Poly(1-cyclohexylethylene) (isotactic)                                                        | 406 (D)                                  |
| Poly(1,1-dimethylethylene)                                                                    | 200                                      |
| <i>Polyisobutylene</i> [PIB]                                                                  |                                          |
| Poly(ethylene)                                                                                | 148                                      |
| Poly(methylene)                                                                               | 155                                      |
| Poly(1-phenethylethylene)                                                                     | 283                                      |
| Poly(propylene) (isotactic)                                                                   | 272                                      |
| Poly(propylene) (syndiotactic)                                                                | ca. 265                                  |
| Poly[1-(2-pyridyl)ethylene]                                                                   | 377                                      |
| Poly[1-(4-pyridyl)ethylene]                                                                   | 415                                      |
| Poly(1-vinylethylene)                                                                         | 273                                      |
| <i>Polyacrylics</i>                                                                           |                                          |
| Poly[1-(alkoxycarbonyl)ethylene] <i>Poly(alkyl acrylate)</i> $-\text{[(ROCO)CHCH}_2\text{]}-$ |                                          |
| Poly[1-(benzyloxycarbonyl)ethylene]                                                           | 279                                      |
| Poly[1-(butoxycarbonyl)ethylene]                                                              | 219 (M)                                  |
| <i>Poly(butyl acrylate)</i> [PBA]                                                             |                                          |
| Poly[1-( <i>sec</i> -butoxycarbonyl)ethylene]                                                 | 251                                      |
| Poly[1-(butoxycarbonyl)-1-cyanoethylene]                                                      | 358                                      |
| Poly[1-(butylcarbamoylethylene)]                                                              | 319 (M)                                  |
| Poly(1-carbamoylethylene)                                                                     | 438                                      |
| <i>Polyacrylamide</i> [PAM]                                                                   |                                          |
| Poly(1-carboxyethylene)                                                                       | 379                                      |

| Polymer name                                                                                                            | Glass transition temperature ( $T_g$ /K) |
|-------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| <i>Poly(acrylic acid)</i> [PAA]                                                                                         |                                          |
| Poly[1-(2-chlorophenoxy)carbonyl]ethylene]                                                                              | 326                                      |
| Poly[1-(4-chlorophenoxy)carbonyl]ethylene]                                                                              | 331                                      |
| Poly[1-(4-cyanobenzoyloxy)carbonyl]ethylene]                                                                            | 317                                      |
| Poly[1-(2-cyanoethoxy)carbonyl]ethylene]                                                                                | 277                                      |
| Poly[1-(cyanomethoxy)carbonyl]ethylene]                                                                                 | 433 Dil                                  |
| Poly[1-(4-cyanophenoxy)carbonyl]ethylene]                                                                               | 363                                      |
| Poly[1-(cyclohexyloxy)carbonyl]ethylene]                                                                                | 292                                      |
| Poly[1-(2,4-dichlorophenoxy)carbonyl]ethylene]                                                                          | 333                                      |
| Poly[1-(dimethylcarbamoyl)ethylene]                                                                                     | 362                                      |
| Poly[1-(ethoxycarbonyl)ethylene]                                                                                        | 249                                      |
| <i>Poly(ethyl acrylate)</i> [PEA]                                                                                       |                                          |
| Poly[1-(ethoxycarbonyl)-1-fluoroethylene]                                                                               | 316                                      |
| Poly[1-(2-ethoxycarbonylphenoxy)carbonyl]ethylene]                                                                      | 303                                      |
| Poly[1-(3-ethoxycarbonylphenoxy)carbonyl]ethylene]                                                                      | 297                                      |
| Poly[1-(4-ethoxycarbonylphenoxy)carbonyl]ethylene]                                                                      | 310                                      |
| Poly[1-(2-ethoxyethoxy)carbonyl]ethylene]                                                                               | 223                                      |
| Poly[1-(3-ethoxypropoxy)carbonyl]ethylene]                                                                              | 218                                      |
| Poly[1-(isopropoxy)carbonyl]ethylene]                                                                                   | 267-270                                  |
| Poly[1-(methoxycarbonyl)ethylene]                                                                                       | 283                                      |
| <i>Poly(methyl acrylate)</i> [PMA]                                                                                      |                                          |
| Poly[1-(2-methoxycarbonylphenoxy)carbonyl]ethylene]                                                                     | 319                                      |
| Poly[1-(3-methoxycarbonylphenoxy)carbonyl]ethylene]                                                                     | 311                                      |
| Poly[1-(4-methoxycarbonylphenoxy)carbonyl]ethylene]                                                                     | 340                                      |
| Poly[1-(2-methoxyethoxy)carbonyl]ethylene]                                                                              | 223                                      |
| Poly[1-(4-methoxyphenoxy)carbonyl]ethylene]                                                                             | 324                                      |
| Poly[1-(3-methoxypropoxy)carbonyl]ethylene]                                                                             | 198                                      |
| Poly[1-(2-naphthyloxy)carbonyl]ethylene]                                                                                | 358                                      |
| Poly[1-(pentachlorophenoxy)carbonyl]ethylene]                                                                           | 420                                      |
| Poly[1-(phenethoxy)carbonyl]ethylene]                                                                                   | 270                                      |
| Poly[1-(phenoxy)carbonyl]ethylene]                                                                                      | 330                                      |
| Poly[1-( <i>m</i> -tolyl)oxy)carbonyl]ethylene]                                                                         | 298                                      |
| Poly[1-( <i>o</i> -tolyl)oxy)carbonyl]ethylene]                                                                         | 325                                      |
| Poly[1-( <i>p</i> -tolyl)oxy)carbonyl]ethylene]                                                                         | 316                                      |
| Poly[1-(2,2,2-trifluoroethoxy)carbonyl]ethylene]                                                                        | 263                                      |
| <i>Polymethacrylics</i>                                                                                                 |                                          |
| Poly[1-(alkoxycarbonyl)-1-methylethylene] <i>Poly(alkyl methacrylate)</i> –[(ROCO)(Me)CCH <sub>2</sub> ] <sub>n</sub> – |                                          |
| Poly[1-(benzyloxy)carbonyl]-1-methylethylene]                                                                           | 327                                      |
| Poly[1-(2-bromoethoxy)carbonyl]-1-methylethylene]                                                                       | 325                                      |
| Poly[1-(butoxy)carbonyl]-1-methylethylene]                                                                              | 293                                      |
| <i>Poly(butyl methacrylate)</i> [PBMA]                                                                                  |                                          |
| Poly[1-( <i>sec</i> -butoxy)carbonyl]-1-methylethylene]                                                                 | 333                                      |
| Poly[1-( <i>tert</i> -butoxy)carbonyl]-1-methylethylene]                                                                | 391                                      |
| Poly[1-(2-chloroethoxy)carbonyl]-1-methylethylene]                                                                      | ca 315                                   |
| Poly[1-(2-cyanoethoxy)carbonyl]-1-methylethylene]                                                                       | 364                                      |
| Poly[1-(4-cyanophenoxy)carbonyl]-1-methylethylene]                                                                      | 428                                      |
| Poly[1-(cyclohexyloxy)carbonyl]-1-methylethylene] (atactic)                                                             | 356                                      |
| Poly[1-(cyclohexyloxy)carbonyl]-1-methylethylene] (isotactic)                                                           | 324                                      |
| Poly[1-(dimethylaminoethoxy)carbonyl]-1-methylethylene]                                                                 | 292                                      |
| Poly[1-(ethoxycarbonyl)-1-ethylethylene]                                                                                | 300                                      |
| Poly[1-(ethoxycarbonyl)-1-methylethylene] (atactic) <i>Poly(ethyl methacrylate)</i> [PEMA]                              | 338                                      |
| Poly[1-(ethoxycarbonyl)-1-methylethylene] (isotactic)                                                                   | 285                                      |
| Poly[1-(ethoxycarbonyl)-1-methylethylene] (syndiotactic)                                                                | 339                                      |
| Poly[1-(hexyloxy)carbonyl]-1-methylethylene]                                                                            | 268                                      |
| Poly[1-(isobutoxy)carbonyl]-1-methylethylene]                                                                           | 326                                      |
| Poly[1-(isopropoxy)carbonyl]-1-methylethylene]                                                                          | 354                                      |
| Poly[1-(methoxycarbonyl)-1-methylethylene] (atactic) <i>Poly(methyl methacrylate)</i> [PMMA]                            | 378                                      |
| Poly[1-(methoxycarbonyl)-1-methylethylene] (isotactic)                                                                  | 311                                      |
| Poly[1-(methoxycarbonyl)-1-methylethylene] (syndiotactic)                                                               | 378                                      |
| Poly[1-(4-methoxycarbonylphenoxy)-1-methylethylene]                                                                     | 379                                      |

| Polymer name                                                                          | Glass transition temperature ( $T_g$ /K) |
|---------------------------------------------------------------------------------------|------------------------------------------|
| Poly[1-(methoxycarbonyl)-1-phenylethylene] (atactic)                                  | 391                                      |
| Poly[1-(methoxycarbonyl)-1-phenylethylene] (isotactic)                                | 397                                      |
| Poly[1-methyl-1-(phenethoxycarbonyl)ethylene]                                         | 299                                      |
| Poly[1-methyl-1-(phenoxycarbonyl)ethylene]                                            | 383                                      |
| <i>Polyvinyl ethers, alcohols, and ketones</i>                                        |                                          |
| Poly(1-alkoxyethylene) <i>Poly(alkyl vinyl ether)</i> –[ROCHCH <sub>2</sub> ]–        |                                          |
| Poly(1-hydroxyethylene) <i>Poly(vinyl alcohol)</i> –[HOCHCH <sub>2</sub> ]–           |                                          |
| Poly(1-alkanoylethylene) <i>Poly(alkyl vinyl ketone)</i> –[RCOCHCH <sub>2</sub> ]–    |                                          |
| Poly(1-butoxyethylene)                                                                | 218                                      |
| Poly(1- <i>sec</i> -butoxyethylene)                                                   | 253                                      |
| Poly(1- <i>tert</i> -butoxyethylene)                                                  | 361                                      |
| Poly[1-(butylthio)ethylene]                                                           | 253                                      |
| Poly(1-ethoxyethylene)                                                                | 230                                      |
| Poly[1-(4-ethylbenzoyl)ethylene]                                                      | 325                                      |
| Poly(1-hydroxyethylene)                                                               | 358 (D)                                  |
| <i>Poly(vinyl alcohol)</i> [PVA]                                                      |                                          |
| Poly(hydroxymethylene)                                                                | 407                                      |
| Poly(1-isopropoxyethylene)                                                            | 270                                      |
| Poly[1-(4-methoxybenzoyl)ethylene]                                                    | 319 (M)                                  |
| Poly(1-methoxyethylene)                                                               | 242                                      |
| <i>Poly(methyl vinyl ether)</i> [PMVE]                                                |                                          |
| Poly[1-(methylthio)ethylene]                                                          | 272                                      |
| Poly(1-propoxyethylene)                                                               | 224                                      |
| Poly[1-(trifluoromethoxy)trifluoroethylene]                                           | 268                                      |
| <i>Polyvinyl halides and nitriles</i>                                                 |                                          |
| Poly(1-haloethylene) <i>Poly(vinyl halide)</i> –[XCHCH <sub>2</sub> ]–                |                                          |
| Poly(1-cyanoethylene) <i>Poly(acrylonitrile)</i> –[NCCHCH <sub>2</sub> ]–             |                                          |
| Poly(1-chloroethylene)                                                                | 354                                      |
| <i>Poly(vinyl chloride)</i> [PVC]                                                     |                                          |
| Poly(chlorotrifluoroethylene)                                                         | 373                                      |
| Poly(1-cyanoethylene)                                                                 | 370                                      |
| <i>Polyacrylonitrile</i> [PAN]                                                        |                                          |
| Poly(1-cyano-1-methylethylene)                                                        | 393                                      |
| <i>Polymethacrylonitrile</i>                                                          |                                          |
| Poly(1,1-dichloroethylene)                                                            | 255                                      |
| <i>Poly(vinylidene chloride)</i>                                                      |                                          |
| Poly(1,1-difluoroethylene)                                                            | ca 233                                   |
| <i>Poly(vinylidene fluoride)</i>                                                      |                                          |
| Poly(1-fluoroethylene)                                                                | 314 (M)                                  |
| <i>Poly(vinyl fluoride)</i>                                                           |                                          |
| Poly(1-hexafluoropropylene)                                                           | 425                                      |
| Poly[1-(2-iodoethyl)ethylene]                                                         | 343                                      |
| Poly(tetrafluoroethylene)                                                             | (160)                                    |
| Poly[1-(trifluoromethyl)ethylene]                                                     | 300                                      |
| <i>Polyvinyl esters</i>                                                               |                                          |
| Poly[1-(alkanoyloxy)ethylene] <i>Poly(vinyl alkanoate)</i> –[RCOOCHCH <sub>2</sub> ]– |                                          |
| Poly(1-acetoxyethylene)                                                               | 305                                      |
| <i>Poly(vinyl acetate)</i> [PVAc]                                                     |                                          |
| Poly[1-(benzoyloxy)ethylene]                                                          | 344                                      |
| Poly[1-(4-bromobenzoyloxy)ethylene]                                                   | 365                                      |
| Poly[1-(2-chlorobenzoyloxy)ethylene]                                                  | 335                                      |
| Poly[1-(3-chlorobenzoyloxy)ethylene]                                                  | 338                                      |
| Poly[1-(4-chlorobenzoyloxy)ethylene]                                                  | 357                                      |
| Poly[1-(cyclohexanoyloxy)ethylene]                                                    | 349 (M)                                  |
| Poly[1-(4-ethoxybenzoyloxy)ethylene]                                                  | 343                                      |
| Poly[1-(4-ethylbenzoyloxy)ethylene]                                                   | 326                                      |

| Polymer name                                                                             | Glass transition temperature ( $T_g$ /K) |
|------------------------------------------------------------------------------------------|------------------------------------------|
| Poly[1-(4-isopropylbenzoyloxy)ethylene]                                                  | 342                                      |
| Poly[1-(2-methoxybenzoyloxy)ethylene]                                                    | 338                                      |
| Poly[1-(3-methoxybenzoyloxy)ethylene]                                                    | ca 317                                   |
| Poly[1-(4-methoxybenzoyloxy)ethylene]                                                    | 360                                      |
| Poly[1-(4-methylbenzoyloxy)ethylene]                                                     | 343                                      |
| Poly[1-(4-nitrobenzoyloxy)ethylene]                                                      | 395                                      |
| Poly[1-(propionoyloxy)ethylene]                                                          | 283 (M)                                  |
| <i>Polystyrenes</i>                                                                      |                                          |
| Poly(1-phenylethylene) <i>Polystyrene</i> $-\text{[C}_6\text{H}_5\text{CHCH}_2\text{]}-$ |                                          |
| Poly[1-(4-acetylphenyl)ethylene]                                                         | 389 (M)                                  |
| Poly[1-(4-benzoylphenyl)ethylene]                                                        | 371 (M)                                  |
| Poly[1-(4-bromophenyl)ethylene]                                                          | 391                                      |
| Poly[1-(4-butoxyphenyl)ethylene]                                                         | ca 320 (M)                               |
| Poly[1-(4-butoxycarbonylphenyl)ethylene]                                                 | 349 (M)                                  |
| Pol[(1-(4-butylphenyl)ethylene]                                                          | 279                                      |
| Poly[1-(4-carboxyphenyl)ethylene]                                                        | 386 (M)                                  |
| Poly[1-(2-chlorophenyl)ethylene]                                                         | 392                                      |
| Poly[1-(3-chlorophenyl)ethylene]                                                         | 363                                      |
| Poly[1-(4-chlorophenyl)ethylene]                                                         | 383                                      |
| Poly[1-(2,4-dichlorophenyl)ethylene]                                                     | 406                                      |
| Poly[1-(2,5-dichlorophenyl)ethylene]                                                     | 379                                      |
| Poly[1-(2,6-dichlorophenyl)ethylene]                                                     | 440                                      |
| Poly[1-(3,4-dichlorophenyl)ethylene]                                                     | 401                                      |
| Poly[1-(2,4-dimethylphenyl)ethylene]                                                     | 385                                      |
| Poly[1-(4-(dimethylamino)phenyl)ethylene]                                                | 398 (M)                                  |
| Poly[1-(4-ethoxyphenyl)ethylene]                                                         | ca 359 (M)                               |
| Poly[1-(4-ethoxycarbonylphenyl)ethylene]                                                 | 367 (M)                                  |
| Poly[1-(4-fluorophenyl)ethylene]                                                         | 368                                      |
| Poly[1-(4-iodophenyl)ethylene]                                                           | 429                                      |
| Poly[1-(4-methoxyphenyl)ethylene]                                                        | 386                                      |
| Poly[1-(4-methoxycarbonylphenyl)ethylene]                                                | 386 (M)                                  |
| Poly(1-methyl-1-phenylethylene)                                                          | 373                                      |
| <i>Poly(<math>\alpha</math>-methylstyrene)</i>                                           |                                          |
| Poly[1-(2-(methylamino)phenyl)ethylene]                                                  | 462 (M)                                  |
| Poly(1-phenylethylene)                                                                   | 373                                      |
| <i>Polystyrene</i> [PS]                                                                  |                                          |
| Poly[1-(4-propoxyphenyl)ethylene]                                                        | 343 (M)                                  |
| Poly[1-(4-propoxycarbonylphenyl)ethylene]                                                | 365 (M)                                  |
| Poly(1- <i>o</i> -tolylethylene)                                                         | 409                                      |

## CHAINS WITH CARBOCYCLIC UNITS

|                                                              |            |
|--------------------------------------------------------------|------------|
| Poly(arylenealkylene) $-\text{[Ar-(CH}_2\text{)}_n\text{]}-$ |            |
| Poly[1-(2-bromo-1,4-phenylene)ethylene]                      | 353 (M)    |
| Poly[1-(2-chloro-1,4-phenylene)ethylene]                     | 343 (M)    |
| Poly[1-(2-cyano-1,4-phenylene)ethylene]                      | 363 (M)    |
| Poly[1-(2,5-dimethyl-1,4-phenylene)ethylene]                 | 373 (M)    |
| Poly[1-(2-ethyl-1,4-phenylene)ethylene]                      | 298 (M)    |
| Poly[1-(1,4-naphthylene)ethylene]                            | 433 (M)    |
| Poly[1-(1,4-phenylene)ethylene]                              | ca 353 (M) |

## CHAINS WITH HETEROATOM UNITS

*Main chain oxide units*

|                                                                                    |     |
|------------------------------------------------------------------------------------|-----|
| Poly(oxyalkylene) <i>Poly(alkylene oxide)</i> $-\text{[O(CH}_2\text{)}_n\text{]}-$ |     |
| Poly[oxy(1,1-bis(chloromethyl)trimethylene)]                                       | 265 |
| Poly[oxy(1-(bromomethyl)ethylene)]                                                 | 259 |
| Poly[oxy(1-(butoxymethyl)ethylene)]                                                | 194 |
| Poly[oxy(1-butylethylene)]                                                         | 203 |
| Poly[oxy(1- <i>tert</i> -butylethylene)]                                           | 308 |
| Poly[oxy(1-(chloromethyl)ethylene)]                                                | 251 |

| Polymer name                                                                                                                                         | Glass transition temperature ( $T_g$ /K) |
|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| <i>Poly(epichlorohydrin)</i>                                                                                                                         |                                          |
| Poly[oxy(2,6-dimethoxy-1,4-phenylene)]                                                                                                               | 440                                      |
| Poly[oxy(1,1-dimethylethylene)]                                                                                                                      | 264                                      |
| Poly[oxy(2,6-dimethyl-1,4-phenylene)]                                                                                                                | 482                                      |
| Poly[oxy(2,6-diphenyl-1,4-phenylene)]                                                                                                                | 493                                      |
| Poly[oxy(1-ethylethylene)]                                                                                                                           | 203                                      |
| Poly(oxyethylidene)                                                                                                                                  | 243                                      |
| <i>Polyacetaldehyde</i>                                                                                                                              |                                          |
| Poly[oxy(1-(methoxymethyl)ethylene)]                                                                                                                 | 211                                      |
| Poly[oxy(2-methyl-6-phenyl-1,4-phenylene)]                                                                                                           | 428                                      |
| Poly[oxy(1-methyltrimethylene)]                                                                                                                      | 223 (D)                                  |
| Poly[oxy(2-methyltrimethylene)]                                                                                                                      | 218                                      |
| Poly(oxy-1,4-phenylene)                                                                                                                              | 358                                      |
| <i>Poly(phenylene oxide)</i> [PPO]                                                                                                                   |                                          |
| Poly[oxy(1-phenylethylene)]                                                                                                                          | 313                                      |
| Poly(oxytetramethylene)                                                                                                                              | 189                                      |
| <i>Poly(tetrahydrofuran)</i> [PTMO]                                                                                                                  |                                          |
| Poly(oxytrimethylene)                                                                                                                                | 195                                      |
| <i>Main-chain ester or anhydride units</i>                                                                                                           |                                          |
| Poly(oxyalkyleneoxyalkanedioyl) <i>Poly(alkylene alkanedioate)</i> —[O(CH <sub>2</sub> ) <sub>m</sub> OCO(CH <sub>2</sub> ) <sub>n</sub> CO]—        |                                          |
| Poly(oxyadipoyloxydecamethylene)                                                                                                                     | 217                                      |
| Poly(oxyadipoyloxy-1,4-phenyleneisopropylidene-1,4-phenylene)                                                                                        | 341                                      |
| Poly(oxycarbonyloxy-1,4-phenylene-isopropylidene-1,4-phenylene)                                                                                      | 422                                      |
| <i>Bisphenol A polycarbonate</i>                                                                                                                     |                                          |
| Poly(oxycarbonylpentamethylene)                                                                                                                      | 213                                      |
| Poly(oxycarbonyl-1,4-phenylenemethylene-1,4-phenylene)                                                                                               | 395                                      |
| Poly(oxycarbonyl-1,4-phenyleneisopropylidene-1,4-phenylene)                                                                                          | 333                                      |
| Poly[oxy(2,6-dimethyl-1,4-phenyleneisopropylidene-3,5-dimethyl-1,4-phenylene)oxysebacoyl]                                                            | 318                                      |
| Poly(oxyethylenecarbonyl-1,4-cyclohexylenecarbonyl) (trans)                                                                                          | 291                                      |
| Poly(oxyethyleneoxycarbonyl-1,4-naphthylenecarbonyl)                                                                                                 | 337                                      |
| Poly(oxyethyleneoxycarbonyl-1,5-naphthylenecarbonyl)                                                                                                 | 344                                      |
| Poly(oxyethyleneoxycarbonyl-2,6-naphthylenecarbonyl)                                                                                                 | 386                                      |
| Poly(oxyethyleneoxycarbonyl-2,7-naphthylenecarbonyl)                                                                                                 | 392                                      |
| Poly(oxyethyleneoxyterephthaloyl)                                                                                                                    | 342                                      |
| <i>Poly(ethylene terephthalate)</i> [PET]                                                                                                            |                                          |
| Poly(oxyisophthaloyl)                                                                                                                                | 403 (D)                                  |
| Poly(oxy(1-oxo-2,2-dimethyltrimethylene))                                                                                                            | 263                                      |
| <i>Poly(pivalolactone)</i>                                                                                                                           |                                          |
| Poly(oxy-1,4-phenyleneisopropylidene-1,4-phenyleneoxysebacoyl)                                                                                       | 280                                      |
| Poly(oxy-1,4-phenyleneoxy-1,4-phenyleneoxy-carbonyl-1,4-phenylene) [PEEK]                                                                            | 416                                      |
| Poly(oxypropyleneoxyterephthaloyl)                                                                                                                   | 341                                      |
| Poly[oxyterephthaloyloxy(2,6-dimethyl-1,4-phenyleneisopropylidene-3,5-dimethyl-1,4-(D)phenylene)]                                                    | 498                                      |
| Poly(oxyterephthaloyloxyoctamethylene)                                                                                                               | 318 (D)                                  |
| Poly(oxyterephthaloyloxy-1,4-phenyleneisopropylidene-1,4-phenylene)                                                                                  | 478                                      |
| <i>Poly(bisphenol A terephthalate)</i>                                                                                                               |                                          |
| Poly(oxytetramethyleneoxyterephthaloyl)                                                                                                              | 323                                      |
| <i>Poly(butylene terephthalate)</i> [PBT]                                                                                                            |                                          |
| <i>Main-chain amide units</i>                                                                                                                        |                                          |
| Poly(iminoalkyleneiminoalkanedioyl) <i>Poly(alkylene alkanediamide)</i> —[NH(CH <sub>2</sub> ) <sub>m</sub> NHCO(CH <sub>2</sub> ) <sub>n</sub> CO]— |                                          |
| Poly(iminoadipoyliminodecamethylene)                                                                                                                 | 313                                      |
| <i>Nylon 10,6</i>                                                                                                                                    |                                          |
| Poly(iminoadipoyliminohexamethylene)                                                                                                                 | ca 323                                   |
| <i>Nylon 6,6</i>                                                                                                                                     |                                          |
| Poly(iminoadipoyliminooctamethylene)                                                                                                                 | 318                                      |
| <i>Nylon 8,6</i>                                                                                                                                     |                                          |
| Poly(iminoadipoyliminotrimethylene(methylimino)trimethylene]                                                                                         | 278                                      |
| Poly(iminocarbonyl-1,4-cyclohexylenemethylene)                                                                                                       | 466                                      |
| Poly(iminocarbonyl-1,4-phenylene(2-oxoethylene)iminohexamethylene]                                                                                   | 377                                      |
| Poly(iminoethylene-1,4-phenyleneethyleneiminosebacoyl)                                                                                               | 378 (D)                                  |



| Polymer name                                                                                                                         | Glass transition temperature ( $T_g$ /K) |
|--------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| Poly(iminohexamethyleneiminoazelaoyl)<br><i>Nylon 6,9</i>                                                                            | 331                                      |
| Poly(iminohexamethyleneiminododecanedioyl)<br><i>Nylon 6, 12</i>                                                                     | 319                                      |
| Poly(iminohexamethyleneiminopimeloyl)<br><i>Nylon 6,7</i>                                                                            | 331                                      |
| Poly(iminohexamethyleneiminosebacoyl)<br><i>Nylon 6,10</i>                                                                           | 323                                      |
| Poly(iminohexamethyleneiminosuberoyl)<br><i>Nylon 6,8</i>                                                                            | 330                                      |
| Poly(iminoisophthaloylimino-4,4'-biphenylene)                                                                                        | 558                                      |
| Poly(iminoisophthaloyliminohexamethylene)                                                                                            | 390                                      |
| Poly(iminoisophthaloyliminomethylene-1,4-cyclohexylenemethylene)                                                                     | 481                                      |
| Poly(iminoisophthaloyliminomethylene-1,3-phenylenemethylene)                                                                         | 438 (M)                                  |
| Poly[iminomethylene(2,5-dimethyl-1,4-phenylene)methyleneiminosuberoyl]                                                               | 351                                      |
| Poly(imino-1,5-naphthyleneiminoisophthaloyl)                                                                                         | 598                                      |
| Poly(imino-1,5-naphthyleneiminoterephthaloyl)                                                                                        | 578                                      |
| Poly(iminooctamethyleneiminodecanedioyl)<br><i>Nylon 8,10</i>                                                                        | 333                                      |
| Poly(iminooxalyliminohexamethylene)<br><i>Nylon 6,2</i>                                                                              | 430                                      |
| Poly[imino(1-oxohexamethylene)]<br><i>Nylon 6</i>                                                                                    | 326                                      |
| Poly[imino(1-oxodecamethylene)]<br><i>Nylon 10</i>                                                                                   | 315                                      |
| Poly[imino(1-oxoheptamethylene)]<br><i>Nylon 7</i>                                                                                   | 325                                      |
| Poly[imino(1-oxo-3-methyltrimethylene)]                                                                                              | 369                                      |
| Poly[imino(1-oxononamethylene)]<br><i>Nylon 9</i>                                                                                    | 319                                      |
| Poly[imino(1-oxooctamethylene)]<br><i>Nylon 8</i>                                                                                    | 323                                      |
| Poly[imino(1-oxotrimethylene)]<br><i>Nylon 3</i>                                                                                     | 384                                      |
| Poly(iminopentamethyleneiminoadipoyl)<br><i>Nylon 5,6</i>                                                                            | 318                                      |
| Poly[iminopentamethyleneiminocarbonyl-1,4-phenylene(2-oxoethylene)]                                                                  | 376                                      |
| Poly(imino-1,3-phenyleneiminoisophthaloyl)                                                                                           | 553 (M)                                  |
| Poly(imino-1,4-phenyleneiminoterephthaloyl)                                                                                          | 618                                      |
| Poly(iminopimeloyliminoheptamethylene)<br><i>Nylon 7,7</i>                                                                           | 328                                      |
| Poly(iminoterephthaloylimino-4,4'-biphenylene)                                                                                       | 613                                      |
| Poly(iminotetramethyleneiminoadipoyl)<br><i>Nylon 4,6</i>                                                                            | 316                                      |
| Poly[iminotetramethyleneiminocarbonyl-1,4-phenylene(2-oxoethylene)]                                                                  | 357                                      |
| Poly(iminotrimethyleneiminoadipoyliminotrimethylene)                                                                                 | 307                                      |
| Poly[iminotrimethyleneiminocarbonyl-1,4-phenylene(2-oxoethylene)]                                                                    | 382                                      |
| Poly(oxy-1,4-phenyleneiminoterephthaloyl-imino-1,4-phenylene)                                                                        | 613                                      |
| Poly(sulfonylimino-1,4-phenyleneiminoadipoylimino-1,4-phenylene)                                                                     | 467                                      |
| <i>Main-chain urethane units</i>                                                                                                     |                                          |
| Poly(oxyalkyleneoxycarbonyliminoalkyleneiminocarbonyl)-[O(CH <sub>2</sub> ) <sub>m</sub> OCONH(CH <sub>2</sub> ) <sub>n</sub> NHCO]- |                                          |
| Poly(oxyethyleneoxycarbonyliminohexamethyleneiminocarbonyl)                                                                          | 329                                      |
| Poly[oxyethyleneoxycarbonylimino(6-methyl-1,3-phenylene)iminocarbonyl]                                                               | 325                                      |
| Poly(oxyethyleneoxycarbonylimino-1,4-phenylenemethylene-1,4-phenyleneiminocarbonyl)                                                  | 412                                      |
| Poly(oxyhexamethyleneoxycarbonyliminohexamethyleneiminocarbonyl)                                                                     | 332                                      |
| Poly[oxyhexamethyleneoxycarbonylimino(6-methyl-1,3-phenylene)iminocarbonyl]                                                          | 305                                      |
| Poly(oxyhexamethyleneoxycarbonylimino-1,4-phenylenemethylene-1,4-phenyleneiminocarbonyl)                                             | 364                                      |
| Poly(oxyoctamethyleneoxycarbonyliminohexamethyleneiminocarbonyl)                                                                     | 331                                      |
| Poly[oxyoctamethyleneoxycarbonylimino(6-methyl-1,3-phenylene)iminocarbonyl]                                                          | 337                                      |
| Poly(oxyoctamethyleneoxycarbonylimino-1,4-phenylenemethylene-1,4-phenyleneiminocarbonyl)                                             | 352                                      |

| Polymer name                                                                                                           | Glass transition temperature ( $T_g$ /K) |
|------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| Poly(oxytetramethyleneoxycarbonyliminohexamethyleneiminocarbonyl)                                                      | 332                                      |
| Poly[oxytetramethyleneoxycarbonylimino(6-methyl-1,3-phenylene)iminocarbonyl]                                           | 315                                      |
| Poly(oxytetramethyleneoxycarbonylimino-1,4-phenylenemethylene-1,4-phenyleneiminocarbonyl)                              | 382                                      |
| <i>Main-chain siloxanes</i>                                                                                            |                                          |
| Poly[oxy(dialkylsilylene)] <i>Poly(dialkylsiloxane)</i> –[O(R <sub>2</sub> Si)–                                        |                                          |
| Poly[oxy(dimethylsilylene)]                                                                                            | 148                                      |
| <i>Poly(dimethylsiloxane)</i> [PDMS]                                                                                   |                                          |
| Poly[oxy(dimethylsilylene)oxy-1,4-phenylene]                                                                           | 363 (M)                                  |
| Poly[oxy(dimethylsilylene)oxy-1,4-phenyleneisopropylidene-1,4-phenylene]                                               | 318 (M)                                  |
| Poly[oxy(diphenylsilylene)]                                                                                            | 238                                      |
| <i>Poly(diphenylsiloxane)</i>                                                                                          |                                          |
| Poly[oxy(diphenylsilylene)-1,3-phenylene]                                                                              | ca 331                                   |
| Poly[oxy((methyl)phenylsilylene)]                                                                                      | 187                                      |
| Poly[oxy((methyl)-3,3,3-trifluoropropylsilylene)]                                                                      | <193                                     |
| <i>Main-chain sulfur-containing units</i>                                                                              |                                          |
| Poly(dithioethylene)                                                                                                   | 223                                      |
| Poly(dithiomethylene-1,4-phenylenemethylene)                                                                           | 296                                      |
| Poly(oxy-4,4'-biphenylene-1,4-phenylenesulfonyl-1,4-phenylene)                                                         | 503 (M)                                  |
| Poly(oxycarbonyloxy-1,4-phenylenethio-1,4-phenylene)                                                                   | ca 383                                   |
| Poly(oxyethylenedithioethylene)                                                                                        | 220 (M)                                  |
| Poly[oxy(2-hydroxytrimethylene)oxy-1,4-phenylenesulfonyl-1,4-phenylene]                                                | 428                                      |
| Poly(oxymethyleneoxyethylenedithioethylene)                                                                            | 214                                      |
| Poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenylenecarbonyl-1,4-phenylene)                                   | 478 (M)                                  |
| Poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenyleneisopropylidene-1,4-phenylene)                             | 438 (M)                                  |
| Poly(oxy-1,4-phenylenesulfonyl-1,4-phenylene)                                                                          | 487                                      |
| Poly(oxy-1,4-phenylenesulfonyl-4,4'-biphenylenesulfonyl-1,4-phenylene)                                                 | 533                                      |
| Poly[oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy(2,6-dimethyl-1,4-phenylene)isopropylidene(3,5-dimethyl-1,4-phenylene)] | 508 (M)                                  |
| Poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenylenecarbonyl-1,4-phenylene)                                   | 478 (M)                                  |
| Poly[oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenylene(hexafluoroisopropylidene)1,4-phenylene]                  | 478 (M)                                  |
| Poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenyleneisopropylidene-1,4-phenylene)                             | 449                                      |
| Poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenylenemethylene-1,4-phenylene)                                  | 453 (M)                                  |
| Poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenylenethio-1,4-phenylene)                                       | 448 (M)                                  |
| Poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxyterephthaloyl)                                                          | 522                                      |
| Poly(oxytetramethylenedithiotetramethylene)                                                                            | 197                                      |
| Poly(sulfonyl-1,2-cyclohexylene)                                                                                       | 401                                      |
| Poly(sulfonyl-1,3-cyclohexylene)                                                                                       | 381                                      |
| Poly(sulfonyl-1,4-phenylenemethylene-1,4-phenylene)                                                                    | 497                                      |
| Poly(thio-1,3-cyclohexylene)                                                                                           | 221                                      |
| Poly[thio(difluoromethylene)]                                                                                          | 155                                      |
| Poly(thioethylene)                                                                                                     | 223                                      |
| Poly[thio(1-ethylethylene)]                                                                                            | 218                                      |
| Poly[thio(1-methyl-3-oxotrimethylene)]                                                                                 | 285                                      |
| Poly[thio(1-methyltrimethylene)]                                                                                       | 214                                      |
| Pol[(thio(1-oxohexamethylene)]                                                                                         | 292                                      |
| Poly(thio-1,4-phenylene)                                                                                               | 370                                      |
| Poly(thiopropylene)                                                                                                    | 226                                      |
| <i>Main-chain heterocyclic units</i>                                                                                   |                                          |
| Poly(1,3-dioxo-4,6-cyclohexylenemethylene)                                                                             | 378                                      |
| <i>Poly(vinyl formal)</i>                                                                                              |                                          |
| Poly[(2,6-dioxopiperidine-1,4-diyl)trimethylene]                                                                       | 363                                      |
| Poly[(2-methyl-1,3-dioxo-4,6-cyclohexylene)methylene]                                                                  | 355                                      |
| <i>Poly(vinyl acetal)</i>                                                                                              |                                          |
| Poly(1,4-piperazinediylcarbonyloxyethyleneoxycarbonyl)                                                                 | 333                                      |
| Poly(1,4-piperazinediylisophthaloyl)                                                                                   | 465 (M)                                  |
| Poly[(2-propyl-1,3-dioxo-4,6-cyclohexylene)methylene]                                                                  | 322                                      |
| <i>Poly(vinyl butyral)</i>                                                                                             |                                          |
| Poly(3,6-pyridazinediyl-1,4-phenyleneisopropylidene-1,4-phenyleneoxy)                                                  | 453 (M)                                  |
| Poly(2,5-pyridinediylcarbonyliminohexamethyleneiminocarbonyl)                                                          | 322                                      |

## DIELECTRIC CONSTANT OF SELECTED POLYMERS

This table lists typical values of the dielectric constant (more properly called relative permittivity) of some important polymers. Values are given for frequencies of 1 kHz, 1 MHz, and 1 GHz; in most cases the dielectric constant at frequencies below 1 kHz does not differ significantly from the value at 1 kHz. Since the dielectric constant of a polymeric material can vary with density, degree of crystallinity, and other details of a particular sample, the values given here should be regarded as only typical or average values.

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| Name                                 | <i>t</i> /°C | 1 kHz | 1 MHz | 1 GHz |
|--------------------------------------|--------------|-------|-------|-------|
| Polyacrylonitrile                    | 25           | 5.5   | 4.2   |       |
| Polyamides (nylons)                  | 25           | 3.50  | 3.14  | 2.8   |
|                                      | 84           | 11    | 4.4   | 2.8   |
| Polybutadiene                        | 25           | 2.5   |       |       |
| Polycarbonate                        | 23           | 2.92  | 2.8   |       |
| Polychloroprene (neoprene)           | 25           | 6.6   | 6.3   | 4.2   |
| Polychlorotrifluoroethylene          | 23           | 2.65  | 2.46  | 2.39  |
| Polyethylene                         | 23           | 2.3   |       |       |
| Poly(ethylene terephthalate) (Mylar) | 23           | 3.25  | 3.0   | 2.8   |
| Polyisoprene (natural rubber)        | 27           | 2.6   | 2.5   | 2.4   |
| Poly(methyl methacrylate)            | 27           | 3.12  | 2.76  | 2.6   |
|                                      | 80           | 3.80  | 2.7   | 2.6   |
| Polyoxymethylene (polyformaldehyde)  | 25           | 3.8   |       |       |
| Poly(phenylene oxide)                | 23           | 2.59  | 2.59  |       |
| Polypropylene                        | 25           | 2.3   | 2.3   | 2.3   |
| Polystyrene                          | 25           | 2.6   | 2.6   | 2.6   |
| Polysulfones                         | 25           | 3.13  | 2.10  |       |
| Polytetrafluoroethylene (teflon)     | 25           | 2.1   | 2.1   | 2.1   |
| Poly(vinyl acetate)                  | 50           |       | 3.5   |       |
|                                      | 150          |       | 8.3   |       |
| Poly(vinyl chloride)                 | 25           | 3.39  | 2.9   | 2.8   |
|                                      | 100          | 5.3   | 3.3   | 2.7   |
| Poly(vinylidene chloride)            | 23           | 4.6   | 3.2   | 2.7   |
| Poly(vinylidene fluoride)            | 23           | 12.2  | 8.9   | 4.7   |

# PRESSURE-VOLUME-TEMPERATURE RELATIONSHIP FOR POLYMER MELTS

Christian Wohlfarth

Numerous theoretical equations of state for polymer liquids have been developed. These, at the minimum, have to provide accurate fitting functions to experimental data. However, for the purpose of this table, the empirical Tait equation along with a polynomial expression for the zero pressure isobar is used. This equation is able to represent the experimental data for the melt state within the limits of experimental errors, i.e., the maximum deviations between measured and calculated specific volumes are about 0.001-0.002 cm<sup>3</sup>/g.

The general form of the Tait equation is:

$$V(P,T) = V(0,T)\{1 - C \ln[1 + P/B(T)]\} \quad (1)$$

where the coefficient  $C$  is usually taken to be a universal constant equal to 0.0894.  $T$  is the absolute temperature in K and  $P$  the pressure in MPa. The volume  $V$  is the specific volume in cm<sup>3</sup>/g. The Tait parameter  $B(T)$  has the very simple meaning that it is inversely proportional to the compressibility  $\kappa$  at constant temperature and zero pressure:

$$\kappa(0,T) = -[1/V(0,T)](dV/dP) = C/B(T) \quad (2)$$

The  $B(T)$  function is usually given by:

$$B(T) = B_0 \exp[-B_1(T-273.15)] \quad (3)$$

but, sometimes a polynomial expression is used:

$$B(T) = b_0 + b_1(T-273.15) + b_2(T-273.15)^2 \quad (4)$$

The zero-pressure isobar  $V(0,T)$  is usually given by:

$$V(0,T) = A_0 + A_1(T-273.15) + A_2(T-273.15)^2 \quad (5)$$

where  $A_0, A_1, A_2$  are specific constants for a given polymer (the expression  $T-273.15$  is used because fitting to the zero-pressure isobar is usually done in terms of Celsius temperature). Other forms for  $V(0,T)$  are also found in the literature, such as

$$V(0,T) = A_3 \exp[A_4(T-273.15)] \quad (6)$$

or

$$V(0,T) = A_5 \exp(A_6 T^{1.5}) \quad (7)$$

where  $A_3$  and  $A_4$  or  $A_5$  and  $A_6$  are again specific constants for a given polymer.

The Tait equation is particularly useful to calculate derivative quantities, such as the isothermal compressibility and the thermal expansivity coefficients. The isothermal compressibility  $\kappa(P,T)$  is derived from equation (1) as:

$$\kappa(P,T) = -(1/V)(dV/dP) = 1/[P + B(T)][1/C - \ln(1 + P/B(T))] \quad (8)$$

and the thermal expansivity  $\alpha(P,T)$  as:

$$\alpha(P,T) = (1/V)(dV/dT) = \alpha(0,T) - PB_1\kappa(P,T) \quad (9)$$

where  $\alpha(0,T)$  represents the thermal expansivity at zero (atmospheric) pressure and is calculated from any suitable fit for the zero-pressure volume, such as equations (5) through (7) above.

Because polymer melt PVT-behavior depends only slightly on polymer molar mass above the oligomeric region, usually no information is given in the original literature for the average molar mass of the polymers.

Table 1 summarizes the polymers or copolymers considered here and the experimental ranges of pressure and temperature over which data are available. In Table 2 the Tait-equation functions, with parameters obtained from the fit, are given for 90 polymer or copolymer melts.

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**TABLE 1. Names of the Polymers, Abbreviation Used, and Range of Experimental Data Applied in the Determination of the Equation Constants**

| Polymer                               | Symbol  | T/K     | P/MPa   | Ref. |
|---------------------------------------|---------|---------|---------|------|
| Ethylene/propylene copolymer (50 wt%) | EP50    | 413-523 | 0.1-63  | 4    |
| Ethylene/vinyl acetate copolymer      |         |         |         |      |
| 18 wt% vinyl acetate                  | EVA18   | 385-491 | 0.1-177 | 4    |
| 25 wt% vinyl acetate                  | EVA25   | 367-506 | 0.1-177 | 4    |
| 28 wt% vinyl acetate                  | EVA28   | 367-508 | 0.1-177 | 4    |
| 40 wt% vinyl acetate                  | EVA40   | 348-508 | 0.1-177 | 4    |
| Polyamide-6                           | PA6     | 509-569 | 0.1-196 | 4    |
| Polyamide-11                          | PA11    | 478-542 | 0.1-200 | 5    |
| Polyamide-66                          | PA66    | 519-571 | 0.1-196 | 4    |
| <i>cis</i> -1,4-Polybutadiene         | cPBD    | 277-328 | 0.1-284 | 4    |
| Polybutadiene, 8% 1,2-content         | PBD-8   | 298-473 | 0.1-200 | 6    |
| Polybutadiene, 24% 1,2-content        | PBD-24  | 298-473 | 0.1-200 | 6    |
| Polybutadiene, 40% 1,2-content        | PBD-40  | 298-473 | 0.1-200 | 6    |
| Polybutadiene, 50% 1,2-content        | PBD-50  | 298-473 | 0.1-200 | 6    |
| Polybutadiene, 87% 1,2-content        | PBD-87  | 298-473 | 0.1-200 | 6    |
| Poly(1-butene), isotactic             | iPB     | 406-519 | 0.1-196 | 4    |
| Poly(butyl methacrylate)              | PnBMA   | 307-473 | 0.1-200 | 4    |
| Poly(butylene terephthalate)          | PBT     | 508-576 | 0.1-200 | 3    |
| Poly( $\epsilon$ -caprolactone)       | PCL     | 373-421 | 0.1-200 | 4    |
| Polycarbonate-bisphenol-A             | PC      | 424-613 | 0.1-177 | 4    |
| Polycarbonate-bisphenol-chloral       | BCPC    | 428-557 | 0.1-200 | 4    |
| Polycarbonate-hexafluorobisphenol-A   | HFPC    | 432-553 | 0.1-200 | 4    |
| Polycarbonate-tetramethylbisphenol-A  | TMPC    | 491-563 | 0.1-160 | 4    |
| Poly(cyclohexyl methacrylate)         | PcHMA   | 396-471 | 0.1-200 | 4    |
| Poly(2,5-dimethylphenylene oxide)     | PPO     | 473-593 | 0.1-177 | 4    |
| Poly(dimethyl siloxane)               | PDMS    | 298-343 | 0.1-100 | 4    |
| Poly(dimethyl siloxane) $M_n = 1000$  | PDMS-10 | 304-420 | 0.1-250 | 10   |
| Poly(dimethyl siloxane) $M_n = 4000$  | PDMS-40 | 298-418 | 0.1-250 | 10   |
| Poly(dimethyl siloxane) $M_n = 6000$  | PDMS-60 | 291-423 | 0.1-250 | 10   |
| Poly(epichlorohydrin)                 | PECH    | 333-413 | 0.1-200 | 4    |
| Poly(ether ether ketone)              | PEEK    | 619-671 | 0.1-200 | 4    |
| Poly(ethyl acrylate)                  | PEA     | 310-490 | 0.1-196 | 4    |
| Poly(ethyl methacrylate)              | PEMA    | 386-434 | 0.1-196 | 4    |
| Polyethylene, high density            | HDPE    | 413-476 | 0.1-196 | 4    |
| Polyethylene, linear                  | LPE     | 415-473 | 0.1-200 | 4    |
| Polyethylene, linear, high MW         | HMLPE   | 410-473 | 0.1-200 | 4    |
| Polyethylene, branched                | BPE     | 398-471 | 0.1-200 | 4    |
| Polyethylene, low density             | LDPE    | 394-448 | 0.1-196 | 4    |
| Polyethylene, low density, type A     | LDPE-A  | 385-498 | 0.1-196 | 1    |
| Polyethylene, low density, type B     | LDPE-B  | 385-498 | 0.1-196 | 1    |
| Polyethylene, low density, type C     | LDPE-C  | 385-498 | 0.1-196 | 1    |
| Poly(ethylene oxide)                  | PEO     | 361-497 | 0.1- 68 | 4    |
| Poly(ethylene terephthalate)          | PET     | 547-615 | 0.1-196 | 4    |
| Poly(4-hexylstyrene)                  | P4HS    | 303-403 | 30-100  | 4    |
| Polyisobutylene                       | PIB     | 326-383 | 0.1-100 | 4    |
| Polyisoprene, 8% 3,4-content          | PI-8    | 298-473 | 0.1-200 | 6    |
| Polyisoprene, 14% 3,4-content         | PI-14   | 298-473 | 0.1-200 | 6    |
| Polyisoprene, 41% 3,4-content         | PI-41   | 298-473 | 0.1-200 | 6    |
| Polyisoprene, 56% 3,4-content         | PI-56   | 298-473 | 0.1-200 | 6    |
| Poly(methyl acrylate)                 | PMA     | 310-493 | 0.1-196 | 4    |
| Poly(methyl methacrylate)             | PMMA    | 387-432 | 0.1-200 | 4    |
| Poly(4-methyl-1-pentene)              | P4MP    | 514-592 | 0.1-196 | 4    |
| Poly( $\alpha$ -methylstyrene)        | PaMS    | 473-533 | 0.1-170 | 7    |
| Poly( <i>o</i> -methylstyrene)        | PoMS    | 412-471 | 0.1-180 | 4    |
| Polyoxymethylene                      | POM     | 463-493 | 0.1-196 | 2    |
| Phenoxy <sup>a</sup>                  | PH      | 341-573 | 0.1-177 | 4    |
| Polysulfone <sup>b</sup>              | PSF     | 475-644 | 0.1-196 | 4    |
| Polyarylate <sup>c</sup>              | PAr     | 450-583 | 0.1-177 | 4    |
| Polypropylene, atactic                | aPP     | 353-393 | 0.1-100 | 4    |

| Polymer                                    | Symbol | T/K     | P/MPa   | Ref. |
|--------------------------------------------|--------|---------|---------|------|
| Polypropylene, isotactic                   | iPP    | 443-570 | 0.1-196 | 4    |
| Polystyrene                                | PS     | 388-469 | 0.1-200 | 4    |
| Poly(tetrafluoroethylene)                  | PTFE   | 603-645 | 0.1- 39 | 4    |
| Poly(tetrahydrofuran)                      | PTHF   | 335-439 | 0.1- 78 | 4    |
| Poly(vinyl acetate)                        | PVAc   | 308-373 | 0.1- 80 | 4    |
| Poly(vinyl chloride)                       | PVC    | 373-423 | 0.1-200 | 4    |
| Poly(vinyl methyl ether)                   | PVME   | 303-471 | 0.1-200 | 4    |
| Poly(vinylidene fluoride)                  | PVdF   | 451-521 | 0.1-200 | 5    |
| Styrene/acrylonitrile copolymer            |        |         |         |      |
| 2.7 wt% acrylonitrile                      | SAN3   | 378-539 | 0.1-200 | 4    |
| 5.7 wt% acrylonitrile                      | SAN6   | 370-540 | 0.1-200 | 4    |
| 15.3 wt% acrylonitrile                     | SAN15  | 405-531 | 0.1-200 | 4    |
| 18.0 wt% acrylonitrile                     | SAN18  | 377-528 | 0.1-200 | 4    |
| 40 wt% acrylonitrile                       | SAN40  | 373-543 | 0.1-200 | 4    |
| 70 wt% acrylonitrile                       | SAN70  | 373-544 | 0.1-200 | 4    |
| Styrene/butadiene copolymer                |        |         |         |      |
| 10 wt% styrene                             | SBR10  | 393-533 | 0.1-196 | 8    |
| 23.5 wt% styrene                           | SBR23  | 393-533 | 0.1-196 | 8    |
| 60 wt% styrene                             | SBR60  | 393-533 | 0.1-196 | 8    |
| 85 wt% styrene                             | SBR85  | 393-533 | 0.1-196 | 8    |
| Styrene/methyl methacrylate copolymer      |        |         |         |      |
| 20 wt% methyl methacrylate                 | SMMA20 | 383-543 | 0.1-200 | 4    |
| 60 wt% methyl methacrylate                 | SMMA60 | 383-543 | 0.1-200 | 4    |
| N-Vinylcarbazole/4-ethylstyrene copolymer  |        |         |         |      |
| 50 mol% ethylstyrene                       | VCES50 | 393-443 | 30-100  | 9    |
| N-Vinylcarbazole/4-hexylstyrene copolymer  |        |         |         |      |
| 80 mol% hexylstyrene                       | VCHS80 | 313-423 | 30-100  | 9    |
| 67 mol% hexylstyrene                       | VCHS67 | 333-423 | 30-100  | 9    |
| 60 mol% hexylstyrene                       | VCHS60 | 383-453 | 30-100  | 9    |
| 50 mol% hexylstyrene                       | VCHS50 | 373-443 | 30-100  | 9    |
| 40 mol% hexylstyrene                       | VCHS40 | 423-493 | 30-100  | 9    |
| 33 mol% hexylstyrene                       | VCHS33 | 463-523 | 30-100  | 9    |
| 20 mol% hexylstyrene                       | VCHS20 | 473-523 | 30-100  | 9    |
| N-Vinylcarbazole/4-octylstyrene copolymer  |        |         |         |      |
| 50 mol% octylstyrene                       | VCOS50 | 403-453 | 30-100  | 9    |
| N-Vinylcarbazole/4-pentylstyrene copolymer |        |         |         |      |
| 50 mol% pentylstyrene                      | VCPS50 | 383-443 | 30-100  | 9    |

<sup>a</sup> Phenoxy = Poly(oxy-2-hydroxytrimethyleneoxy-1,4-phenyleneisopropylidene-1,4-phenylene)

<sup>b</sup> Polysulfone = Poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenyleneisopropylidene-1,4-phenylene)

<sup>c</sup> Polyarylate = Poly(oxyterephthaloyl/isophthaloyl T/I=50/50)oxy-1,4-phenyleneisopropylidene-1,4-phenylene

TABLE 2. Tait Equation Parameter Functions for Polymer Melts

| Polymer | $V(0,T)/\text{cm}^3\text{g}^{-1}$                                                                                | $B(T)/\text{MPa}$                                             |
|---------|------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| EP50    | $1.2291 + 5.799 \cdot 10^{-5}(T-273.15) + 1.964 \cdot 10^{-6}(T-273.15)^2$                                       | $487.0 \exp[-8.103 \cdot 10^{-3}(T-273.15)]$                  |
| EVA18   | $1.02391 \exp(2.173 \cdot 10^{-5}T^{1.5})$                                                                       | $188.2 \exp[-4.537 \cdot 10^{-3}(T-273.15)]$                  |
| EVA25   | $1.00416 \exp(2.244 \cdot 10^{-5}T^{1.5})$                                                                       | $184.4 \exp[-4.734 \cdot 10^{-3}(T-273.15)]$                  |
| EVA28   | $1.00832 \exp(2.241 \cdot 10^{-5}T^{1.5})$                                                                       | $183.5 \exp[-4.457 \cdot 10^{-3}(T-273.15)]$                  |
| EVA40   | $1.06332 \exp(2.288 \cdot 10^{-5}T^{1.5})$                                                                       | $205.1 \exp[-4.989 \cdot 10^{-3}(T-273.15)]$                  |
| PA6     | $0.7597 \exp[4.701 \cdot 10^{-4}(T-273.15)]$                                                                     | $376.7 \exp[-4.660 \cdot 10^{-3}(T-273.15)]$                  |
| PA11    | $0.9581 \exp[6.664 \cdot 10^{-4}(T-273.15)]$                                                                     | $254.7 \exp[-4.178 \cdot 10^{-3}(T-273.15)]$                  |
| PA66    | $0.7657 \exp[6.600 \cdot 10^{-4}(T-273.15)]$                                                                     | $316.4 \exp[-5.040 \cdot 10^{-3}(T-273.15)]$                  |
| cPBD    | $1.0970 \exp[6.600 \cdot 10^{-4}(T-273.15)]$                                                                     | $177.7 \exp[-3.593 \cdot 10^{-3}(T-273.15)]$                  |
| PBD-8   | $1.1004 + 6.718 \cdot 10^{-4}(T-273.15) + 6.584 \cdot 10^{-7}(T-273.15)^2$                                       | $200.0 \exp[-4.606 \cdot 10^{-3}(T-273.15)]$                  |
| PBD-24  | $1.1049 + 6.489 \cdot 10^{-4}(T-273.15) + 7.099 \cdot 10^{-7}(T-273.15)^2$                                       | $193.0 \exp[-4.519 \cdot 10^{-3}(T-273.15)]$                  |
| PBD-40  | $1.1013 + 6.593 \cdot 10^{-4}(T-273.15) + 5.776 \cdot 10^{-7}(T-273.15)^2$                                       | $188.0 \exp[-4.437 \cdot 10^{-3}(T-273.15)]$                  |
| PBD-50  | $1.1037 + 5.955 \cdot 10^{-4}(T-273.15) + 7.789 \cdot 10^{-7}(T-273.15)^2$                                       | $183.0 \exp[-4.425 \cdot 10^{-3}(T-273.15)]$                  |
| PBD-87  | $1.1094 + 6.729 \cdot 10^{-4}(T-273.15) + 4.470 \cdot 10^{-7}(T-273.15)^2$                                       | $175.0 \exp[-4.538 \cdot 10^{-3}(T-273.15)]$                  |
| iPB     | $1.1417 \exp[6.751 \cdot 10^{-4}(T-273.15)]$                                                                     | $167.5 \exp[-4.533 \cdot 10^{-3}(T-273.15)]$                  |
| PnBMA   | $0.9341 + 5.5254 \cdot 10^{-4}(T-273.15) + 6.5803 \cdot 10^{-6}(T-273.15)^2 + 1.5691 \cdot 10^{-10}(T-273.15)^3$ | $226.7 \exp[-5.344 \cdot 10^{-3}(T-273.15)]$                  |
| PBT     | $0.9640 - 1.017 \cdot 10^{-3}(T-273.15) + 3.065 \cdot 10^{-6}(T-273.15)^2$                                       | $263.0 \exp[-3.444 \cdot 10^{-3}(T-273.15)]$                  |
| PCL     | $0.9049 \exp[6.392 \cdot 10^{-4}(T-273.15)]$                                                                     | $189.0 \exp[-3.931 \cdot 10^{-3}(T-273.15)]$                  |
| PC      | $0.73565 \exp(1.859 \cdot 10^{-5}T^{1.5})$                                                                       | $310.0 \exp[-4.078 \cdot 10^{-3}(T-273.15)]$                  |
| BCPC    | $0.6737 + 3.634 \cdot 10^{-4}(T-273.15) + 2.370 \cdot 10^{-7}(T-273.15)^2$                                       | $363.4 \exp[-4.921 \cdot 10^{-3}(T-273.15)]$                  |
| HFPC    | $0.6111 + 4.898 \cdot 10^{-4}(T-273.15) + 1.730 \cdot 10^{-7}(T-273.15)^2$                                       | $236.6 \exp[-5.156 \cdot 10^{-3}(T-273.15)]$                  |
| TMPC    | $0.8497 + 5.073 \cdot 10^{-4}(T-273.15) + 3.832 \cdot 10^{-7}(T-273.15)^2$                                       | $231.4 \exp[-4.242 \cdot 10^{-3}(T-273.15)]$                  |
| PcHMA   | $0.8793 + 4.0504 \cdot 10^{-4}(T-273.15) + 7.774 \cdot 10^{-7}(T-273.15)^2 - 7.7534 \cdot 10^{-10}(T-273.15)^3$  | $295.2 \exp[-5.220 \cdot 10^{-3}(T-273.15)]$                  |
| PPO     | $0.78075 \exp(2.151 \cdot 10^{-5}T^{1.5})$                                                                       | $227.8 \exp[-4.290 \cdot 10^{-3}(T-273.15)]$                  |
| PDMS    | $1.0079 \exp[9.121 \cdot 10^{-4}(T-273.15)]$                                                                     | $89.4 \exp[-5.701 \cdot 10^{-3}(T-273.15)]$                   |
| PDMS-10 | $0.8343 + 5.991 \cdot 10^{-4}(T-273.15) + 5.734 \cdot 10^{-7}(T-273.15)^2$                                       | $542.63 \exp[-6.69 \cdot 10^{-3}(T-273.15)]$                  |
| PDMS-40 | $0.8018 + 7.072 \cdot 10^{-4}(T-273.15) + 3.635 \cdot 10^{-7}(T-273.15)^2$                                       | $482.73 \exp[-6.09 \cdot 10^{-3}(T-273.15)]$                  |
| PDMS-60 | $0.8146 + 5.578 \cdot 10^{-4}(T-273.15) + 5.774 \cdot 10^{-7}(T-273.15)^2$                                       | $482.73 \exp[-6.09 \cdot 10^{-3}(T-273.15)]$                  |
| PECH    | $0.7216 \exp[5.825 \cdot 10^{-4}(T-273.15)]$                                                                     | $238.3 \exp[-4.171 \cdot 10^{-3}(T-273.15)]$                  |
| PEEK    | $0.7158 \exp[6.690 \cdot 10^{-4}(T-273.15)]$                                                                     | $388.0 \exp[-4.124 \cdot 10^{-3}(T-273.15)]$                  |
| PEA     | $0.8756 \exp[7.241 \cdot 10^{-4}(T-273.15)]$                                                                     | $193.2 \exp[-4.839 \cdot 10^{-3}(T-273.15)]$                  |
| PEMA    | $0.8614 \exp[7.468 \cdot 10^{-4}(T-273.15)]$                                                                     | $260.9 \exp[-5.356 \cdot 10^{-3}(T-273.15)]$                  |
| HDPE    | $1.1595 + 8.0394 \cdot 10^{-4}(T-273.15)$                                                                        | $179.9 \exp[-4.739 \cdot 10^{-3}(T-273.15)]$                  |
| LPE     | $0.9172 \exp[7.806 \cdot 10^{-4}(T-273.15)]$                                                                     | $176.7 \exp[-4.661 \cdot 10^{-3}(T-273.15)]$                  |
| HMLPE   | $0.8992 \exp[8.502 \cdot 10^{-4}(T-273.15)]$                                                                     | $168.3 \exp[-4.292 \cdot 10^{-3}(T-273.15)]$                  |
| BPE     | $0.9399 \exp[7.341 \cdot 10^{-4}(T-273.15)]$                                                                     | $177.1 \exp[-4.699 \cdot 10^{-3}(T-273.15)]$                  |
| LDPE    | $1.1944 + 2.841 \cdot 10^{-4}(T-273.15) + 1.872 \cdot 10^{-6}(T-273.15)^2$                                       | $202.2 \exp[-5.243 \cdot 10^{-3}(T-273.15)]$                  |
| LDPE-A  | $1.1484 \exp[6.950 \cdot 10^{-4}(T-273.15)]$                                                                     | $192.9 \exp[-4.701 \cdot 10^{-3}(T-273.15)]$                  |
| LDPE-B  | $1.1524 \exp[6.700 \cdot 10^{-4}(T-273.15)]$                                                                     | $196.6 \exp[-4.601 \cdot 10^{-3}(T-273.15)]$                  |
| LDPE-C  | $1.1516 \exp[6.730 \cdot 10^{-4}(T-273.15)]$                                                                     | $186.7 \exp[-4.391 \cdot 10^{-3}(T-273.15)]$                  |
| PEO     | $0.8766 \exp[7.087 \cdot 10^{-4}(T-273.15)]$                                                                     | $207.7 \exp[-3.947 \cdot 10^{-3}(T-273.15)]$                  |
| PET     | $0.6883 + 5.90 \cdot 10^{-4}(T-273.15)$                                                                          | $369.7 \exp[-4.150 \cdot 10^{-3}(T-273.15)]$                  |
| P4HS    | $0.8251 + 6.77 \cdot 10^{-4}T$                                                                                   | $103.1 \exp[-2.417 \cdot 10^{-3}(T-273.15)]$                  |
| PIB     | $1.0750 \exp[5.651 \cdot 10^{-4}(T-273.15)]$                                                                     | $200.3 \exp[-4.329 \cdot 10^{-3}(T-273.15)]$                  |
| PI-8    | $1.1030 + 6.488 \cdot 10^{-4}(T-273.15) + 5.125 \cdot 10^{-7}(T-273.15)^2$                                       | $188.0 \exp[-4.541 \cdot 10^{-3}(T-273.15)]$                  |
| PI-14   | $1.0943 + 6.293 \cdot 10^{-4}(T-273.15) + 6.231 \cdot 10^{-7}(T-273.15)^2$                                       | $202.0 \exp[-4.653 \cdot 10^{-3}(T-273.15)]$                  |
| PI-41   | $1.0951 + 6.188 \cdot 10^{-4}(T-273.15) + 6.629 \cdot 10^{-7}(T-273.15)^2$                                       | $199.0 \exp[-4.622 \cdot 10^{-3}(T-273.15)]$                  |
| PI-56   | $1.0957 + 6.655 \cdot 10^{-4}(T-273.15) + 5.661 \cdot 10^{-7}(T-273.15)^2$                                       | $200.0 \exp[-4.644 \cdot 10^{-3}(T-273.15)]$                  |
| PMA     | $0.8365 \exp[6.795 \cdot 10^{-4}(T-273.15)]$                                                                     | $235.8 \exp[-4.493 \cdot 10^{-3}(T-273.15)]$                  |
| PMMA    | $0.8254 + 2.8383 \cdot 10^{-4}(T-273.15) + 7.792 \cdot 10^{-7}(T-273.15)^2$                                      | $287.5 \exp[-4.146 \cdot 10^{-3}(T-273.15)]$                  |
| P4MP    | $1.4075 - 9.095 \cdot 10^{-4}(T-273.15) + 3.497 \cdot 10^{-6}(T-273.15)^2$                                       | $37.67 + 0.2134(T-273.15) - 7.0445 \cdot 10^{-4}(T-273.15)^2$ |
| PaMS    | $0.89365 + 3.4864 \cdot 10^{-4}(T-273.15) + 5.0184 \cdot 10^{-7}(T-273.15)^2$                                    | $297.7 \exp[-4.074 \cdot 10^{-3}(T-273.15)]$                  |
| PoMS    | $0.9396 \exp[5.306 \cdot 10^{-4}(T-273.15)]$                                                                     | $261.9 \exp[-4.114 \cdot 10^{-3}(T-273.15)]$                  |
| POM     | $0.7484 \exp[6.770 \cdot 10^{-4}(T-273.15)]$                                                                     | $305.6 \exp[-4.326 \cdot 10^{-3}(T-273.15)]$                  |
| PH      | $0.76644 \exp(1.921 \cdot 10^{-5}T^{1.5})$                                                                       | $359.9 \exp[-4.378 \cdot 10^{-3}(T-273.15)]$                  |
| PSF     | $0.7644 + 3.419 \cdot 10^{-4}(T-273.15) + 3.126 \cdot 10^{-7}(T-273.15)^2$                                       | $365.9 \exp[-3.757 \cdot 10^{-3}(T-273.15)]$                  |
| PAr     | $0.73381 \exp(1.626 \cdot 10^{-5}T^{1.5})$                                                                       | $296.9 \exp[-3.375 \cdot 10^{-3}(T-273.15)]$                  |
| aPP     | $1.1841 - 1.091 \cdot 10^{-4}(T-273.15) + 5.286 \cdot 10^{-6}(T-273.15)^2$                                       | $162.1 \exp[-6.604 \cdot 10^{-3}(T-273.15)]$                  |
| iPP     | $1.1606 \exp[6.700 \cdot 10^{-4}(T-273.15)]$                                                                     | $149.1 \exp[-4.177 \cdot 10^{-3}(T-273.15)]$                  |

| Polymer | $V(0,T)/\text{cm}^3\text{g}^{-1}$                                           | $B(T)/\text{MPa}$                             |
|---------|-----------------------------------------------------------------------------|-----------------------------------------------|
| PS      | $0.9287 \exp[5.131 \cdot 10^{-4}(T-273.15)]$                                | $216.9 \exp[-3.319 \cdot 10^{-3}(T-273.15)]$  |
| PTFE    | $0.3200 + 9.5862 \cdot 10^{-4}(T-273.15)$                                   | $425.2 \exp[-9.380 \cdot 10^{-3}(T-273.15)]$  |
| PTHF    | $1.0043 \exp[6.691 \cdot 10^{-4}(T-273.15)]$                                | $178.6 \exp[-4.223 \cdot 10^{-3}(T-273.15)]$  |
| PVAc    | $0.82496 + 5.820 \cdot 10^{-4}(T-273.15) + 2.940 \cdot 10^{-7}(T-273.15)^2$ | $204.9 \exp[-4.346 \cdot 10^{-3}(T-273.15)]$  |
| PVC     | $0.7196 + 5.581 \cdot 10^{-5}(T-273.15) + 1.468 \cdot 10^{-6}(T-273.15)^2$  | $294.2 \exp[-5.321 \cdot 10^{-3}(T-273.15)]$  |
| PVME    | $0.9585 \exp[6.653 \cdot 10^{-4}(T-273.15)]$                                | $215.8 \exp[-4.588 \cdot 10^{-3}(T-273.15)]$  |
| PVdF    | $0.5790 \exp[8.051 \cdot 10^{-4}(T-273.15)]$                                | $244.0 \exp[-5.210 \cdot 10^{-3}(T-273.15)]$  |
| SAN3    | $0.9233 + 3.936 \cdot 10^{-4}(T-273.15) + 5.685 \cdot 10^{-7}(T-273.15)^2$  | $239.8 \exp[-4.376 \cdot 10^{-3}(T-273.15)]$  |
| SAN6    | $0.9211 + 4.370 \cdot 10^{-4}(T-273.15) + 5.846 \cdot 10^{-7}(T-273.15)^2$  | $226.9 \exp[-4.286 \cdot 10^{-3}(T-273.15)]$  |
| SAN15   | $0.9044 + 4.207 \cdot 10^{-4}(T-273.15) + 4.077 \cdot 10^{-7}(T-273.15)^2$  | $238.4 \exp[-3.943 \cdot 10^{-3}(T-273.15)]$  |
| SAN18   | $0.9016 + 4.036 \cdot 10^{-4}(T-273.15) + 4.206 \cdot 10^{-7}(T-273.15)^2$  | $240.4 \exp[-3.858 \cdot 10^{-3}(T-273.15)]$  |
| SAN40   | $0.8871 + 3.406 \cdot 10^{-4}(T-273.15) + 4.938 \cdot 10^{-7}(T-273.15)^2$  | $289.3 \exp[-4.431 \cdot 10^{-3}(T-273.15)]$  |
| SAN70   | $0.8528 + 3.616 \cdot 10^{-4}(T-273.15) + 2.634 \cdot 10^{-7}(T-273.15)^2$  | $335.4 \exp[-3.923 \cdot 10^{-3}(T-273.15)]$  |
| SBR10   | $0.9053 \exp(2.437 \cdot 10^{-5}T^{1.5})$                                   | $530.3 \exp[-3.99 \cdot 10^{-3}(T-273.15)]$   |
| SBR23   | $0.8986 \exp(2.317 \cdot 10^{-5}T^{1.5})$                                   | $551.6 \exp[-4.17 \cdot 10^{-3}(T-273.15)]$   |
| SBR60   | $0.8812 \exp(2.031 \cdot 10^{-5}T^{1.5})$                                   | $486.0 \exp[-4.34 \cdot 10^{-3}(T-273.15)]$   |
| SBR85   | $0.8704 \exp(1.846 \cdot 10^{-5}T^{1.5})$                                   | $356.7 \exp[-4.24 \cdot 10^{-3}(T-273.15)]$   |
| SMMA20  | $0.9063 + 3.570 \cdot 10^{-4}(T-273.15) + 6.532 \cdot 10^{-7}(T-273.15)^2$  | $232.0 \exp[-4.143 \cdot 10^{-3}(T-273.15)]$  |
| SMMA60  | $0.8610 + 3.350 \cdot 10^{-4}(T-273.15) + 6.980 \cdot 10^{-7}(T-273.15)^2$  | $261.0 \exp[-4.611 \cdot 10^{-3}(T-273.15)]$  |
| VCES50  | $0.6676 + 6.63 \cdot 10^{-4}T$                                              | $5281.7 \exp[-9.264 \cdot 10^{-3}(T-273.15)]$ |
| VCHS80  | $0.7753 + 6.17 \cdot 10^{-4}T$                                              | $247.6 \exp[-2.604 \cdot 10^{-3}(T-273.15)]$  |
| VCHS67  | $0.8028 + 6.50 \cdot 10^{-4}T$                                              | $581.7 \exp[-4.553 \cdot 10^{-3}(T-273.15)]$  |
| VCHS60  | $0.8213 + 6.23 \cdot 10^{-4}T$                                              | $229.1 \exp[-2.133 \cdot 10^{-3}(T-273.15)]$  |
| VCHS50  | $0.7827 + 5.05 \cdot 10^{-4}T$                                              | $136.0 \exp[-1.083 \cdot 10^{-3}(T-273.15)]$  |
| VCHS40  | $0.7805 + 4.92 \cdot 10^{-4}T$                                              | $155.0 \exp[-1.605 \cdot 10^{-3}(T-273.15)]$  |
| VCHS33  | $0.7710 + 4.86 \cdot 10^{-4}T$                                              | $460.4 \exp[-3.453 \cdot 10^{-3}(T-273.15)]$  |
| VCHS20  | $0.6416 + 5.42 \cdot 10^{-4}T$                                              | $489.8 \exp[-3.193 \cdot 10^{-3}(T-273.15)]$  |
| VCOS50  | $0.7081 + 7.40 \cdot 10^{-4}T$                                              | $666.5 \exp[-4.503 \cdot 10^{-3}(T-273.15)]$  |
| VCPS50  | $0.7814 + 4.36 \cdot 10^{-4}T$                                              | $880.1 \exp[-4.393 \cdot 10^{-3}(T-273.15)]$  |



# UPPER CRITICAL (UCST) AND LOWER CRITICAL (LCST) SOLUTION TEMPERATURES OF BINARY POLYMER SOLUTIONS

Christian Wohlfarth

Liquid-liquid demixing in solutions of polymers in low molar mass solvents is not a rare phenomenon. Demixing depends on concentration, temperature, pressure, molar mass and molar mass distribution function of the polymer, chain branching and end groups of the polymer, the chemical nature of the solvent, isotope substitution in solvents or polymers, chemical composition of copolymers and its distributions, and other variables. Phase diagrams of polymer solutions can therefore show a quite complicated behavior when they have to be considered in detail (see Ref. 1a).

Polymer solutions can undergo demixing when cooling a homogeneous solution as well as when heating such a solution. The corresponding cloud-point curves show a maximum (UCST behavior) or a minimum (LCST behavior). For common polymer solutions, the LCST region is at higher temperatures (in many cases near the critical temperature of the solvent) than the UCST region. The temperature range between both extrema provides the essential information where the one-phase region of a polymer solution can be found. In the case of monodisperse polymers the extrema are equal to the critical points. However, in the case of polydisperse polymers with distribution functions, these extrema are threshold temperatures whereas the critical point shifts to higher concentrations on the shoulder of the cloud-point curve. Usually, the critical concentration is much more strongly influenced than the critical temperature. Thus, the table below does not distinguish between threshold and critical temperatures.

UCST and LCST values depend somewhat on pressure. LCST values in the table are usually given at the vapor pressure of the solvent at this temperature. UCST values are measured in most cases at normal pressure; data at higher pressures are neglected here. The interested reader can find such information, for example, in Refs. 76, 84, 104, 157, 165, 177, 185-187, or 192.

However, UCST and LCST values of a given polymer/solvent pair depend strongly on the molar mass of the polymer. In the case of monodisperse polymers, this dependency can be described in good approximation by the so-called Shultz-Flory plot (see Refs. 6 and 8):

$$\frac{1}{T_{\text{crit}}} = \frac{1}{\theta} \left[ 1 + \text{const.} \left( \frac{1}{\sqrt{r}} - \frac{1}{2r} \right) \right] \quad (1)$$

where  $r$  denotes the number of segments of a polymer (being proportional to the degree of polymerization or to the molar mass or molar volume of the polymer). Extrapolation to  $r \rightarrow \infty$ , i.e., to infinite molar mass, leads to the value of the  $\theta$ -temperature. This  $\theta$ -temperature is the highest temperature for UCST behavior or the lowest temperature for LCST behavior and a given polymer/solvent pair. In the case of polydisperse polymers, the segment number in equation (1) is to be replaced by its weight average,  $r_w$  (related to  $M_w$ ). The constant in equation (1) reflects further thermodynamic properties of the given polymer/solvent pair, but should not depend on molar mass. A detailed discussion can be found in Ref. 1b.

The printed table in the *Handbook* provides only one data line for a given polymer/solvent pair and does not show the molar mass dependence of UCST or LCST data. The entire table with all data at different molar masses for many of the systems is given in the electronic version, however. Nevertheless, the necessary molar mass information for a system is always provided in the table by the corresponding number average,  $M_n$ , mass average,  $M_w$ , or viscosity average,  $M_\eta$ , values of the polymer as given in the original sources.

| Polymer                                                                       | $M_n/\text{g mol}^{-1}$ | $M_w/\text{g mol}^{-1}$ | $M_\eta/\text{g mol}^{-1}$ | Solvent                           | UCST/K | LCST/K | Ref |
|-------------------------------------------------------------------------------|-------------------------|-------------------------|----------------------------|-----------------------------------|--------|--------|-----|
| Acrylonitrile/butadiene copolymer                                             |                         |                         |                            |                                   |        |        |     |
| (18% Acrylonitrile)                                                           |                         |                         | 840000                     | Ethyl acetate                     |        | 427    | 220 |
| (26% Acrylonitrile)                                                           |                         |                         | 1000000                    | Ethyl acetate                     |        | 412    | 220 |
| Butadiene/ $\alpha$ -methylstyrene copolymer                                  |                         |                         |                            |                                   |        |        |     |
| (10% $\alpha$ -Methylstyrene)                                                 |                         |                         | 100000                     | Ethyl acetate                     | 387    | 393    | 220 |
| Carbon monoxide/ethylene copolymer<br>(1:1, alternating)                      |                         | 1000000                 |                            | 1,1,1,3,3,3-Hexafluoro-2-propanol |        | 453    | 159 |
| Cellulose diacetate                                                           |                         |                         | 120000                     | Benzyl alcohol                    | 372    |        | 86  |
|                                                                               | 59900                   | 75500                   |                            | 2-Butanone                        | 279.7  | 471.5  | 111 |
|                                                                               | 59300                   |                         |                            | 2-Propanone                       | 216.2  | 438.2  | 42  |
| Cellulose diacetate/styrene graft copolymer<br>(77.4 wt% grafted polystyrene) |                         | 750000                  |                            | <i>N,N</i> -Dimethylformamide     | 262    | 399    | 106 |
|                                                                               |                         | 750000                  |                            | Tetrahydrofuran                   |        | 363    | 106 |
| Cellulose nitrate (13.3 wt% N)                                                | unknown                 |                         |                            | 2-Propanone                       | 328    | 182    | 148 |

| Polymer                                                                                         | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent                       | UCST/K | LCST/K | Ref |
|-------------------------------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------|-------------------------------|--------|--------|-----|
| Cellulose triacetate                                                                            |                            | 100500                     | 20000                         | Benzyl alcohol                | 322    |        | 86  |
|                                                                                                 |                            |                            |                               | 2-Propanone                   | 290.0  | 472.0  | 42  |
| Cellulose tricaprylate                                                                          | infinite                   |                            |                               | <i>N,N</i> -Dimethylformamide | 413    |        | 5   |
|                                                                                                 | infinite                   |                            |                               | 3-Phenyl-1-propanol           | 321    |        | 5   |
| Decamethyltetrasiloxane                                                                         | 310.69                     |                            |                               | Tetradecafluorohexane         | 332.59 |        | 195 |
| <i>N,N</i> -Dimethylacrylamide/2-butoxyethyl acrylate copolymer (50 wt% 2-butoxyethyl acrylate) |                            |                            |                               |                               |        |        |     |
|                                                                                                 |                            |                            |                               | Water                         |        | <273.2 | 164 |
| <i>N,N</i> -Dimethylacrylamide/butyl acrylate copolymer                                         |                            |                            |                               |                               |        |        |     |
| (15 wt% Butyl acrylate)                                                                         |                            |                            |                               | Water                         |        | 346.2  | 164 |
| (20 wt% Butyl acrylate)                                                                         |                            |                            |                               | Water                         |        | 323.2  | 164 |
| (30 wt% Butyl acrylate)                                                                         |                            |                            |                               | Water                         |        | 294.2  | 164 |
| (35 wt% Butyl acrylate)                                                                         |                            |                            |                               | Water                         |        | 281.2  | 164 |
| <i>N,N</i> -Dimethylacrylamide/2-ethoxyethyl acrylate copolymer                                 |                            |                            |                               |                               |        |        |     |
|                                                                                                 |                            |                            |                               | Water                         |        | 319.2  | 164 |
| (50 wt% 2-Ethoxyethyl acrylate)                                                                 |                            |                            |                               | Water                         |        | 285.2  | 164 |
| (75 wt% 2-Ethoxyethyl acrylate)                                                                 |                            |                            |                               | Water                         |        |        |     |
| <i>N,N</i> -Dimethylacrylamide/ethyl acrylate copolymer                                         |                            |                            |                               |                               |        |        |     |
| (25 wt% Ethyl acrylate)                                                                         |                            |                            |                               | Water                         |        | 347.2  | 164 |
| (30 wt% Ethyl acrylate)                                                                         |                            |                            |                               | Water                         |        | 334.2  | 164 |
| (50 wt% Ethyl acrylate)                                                                         |                            |                            |                               | Water                         |        | 287.2  | 164 |
| (55 wt% Ethyl acrylate)                                                                         |                            |                            |                               | Water                         |        | <273.2 | 164 |
| <i>N,N</i> -Dimethylacrylamide/2-methoxyethyl acrylate copolymer                                |                            |                            |                               |                               |        |        |     |
|                                                                                                 |                            |                            |                               | Water                         |        | 353    | 184 |
|                                                                                                 |                            |                            |                               | Water                         |        | 333    | 184 |
|                                                                                                 |                            |                            |                               | Water                         |        | 315    | 184 |
|                                                                                                 |                            |                            |                               | Water                         |        | 305    | 184 |
|                                                                                                 |                            |                            |                               | Water                         |        | 288    | 184 |
| (92 mol% 2-Methoxyethyl acrylate)                                                               |                            |                            |                               | Water                         |        | 283    | 184 |
| <i>N,N</i> -Dimethylacrylamide/methyl acrylate copolymer                                        |                            |                            |                               |                               |        |        |     |
|                                                                                                 |                            |                            |                               | Water                         |        | 371.2  | 164 |
|                                                                                                 |                            |                            |                               | Water                         |        | 338.2  | 164 |
|                                                                                                 |                            |                            |                               | Water                         |        | 314.2  | 164 |
|                                                                                                 |                            |                            |                               | Water                         |        | 294.2  | 164 |
|                                                                                                 |                            |                            |                               | Water                         |        | 279.2  | 164 |
|                                                                                                 |                            |                            |                               | Water                         |        | <273.2 | 164 |
| <i>N,N</i> -Dimethylacrylamide/propyl acrylate copolymer                                        |                            |                            |                               |                               |        |        |     |
|                                                                                                 |                            |                            |                               | Water                         |        | 353.2  | 164 |
|                                                                                                 |                            |                            |                               | Water                         |        | 337.2  | 164 |
|                                                                                                 |                            |                            |                               | Water                         |        | 294.2  | 164 |
|                                                                                                 |                            |                            |                               | Water                         |        | 281.2  | 164 |
| Dimethylsiloxane/methylphenylsiloxane copolymer (15 wt% methylphenylsiloxane)                   | 9100                       | 41200                      |                               | Anisole                       | 291.45 |        | 198 |

| Polymer                                            | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | Solvent                    | UCST/K                 | LCST/K | Ref |
|----------------------------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|------------------------|--------|-----|
| Ethylene/propylene copolymer<br>(33 mol% ethylene) | 9100                       | 41200                      |                            | 2-Propanone                | 282.45                 |        | 198 |
|                                                    |                            |                            |                            |                            |                        |        |     |
|                                                    |                            |                            |                            | Cyclohexane                |                        | 534    | 101 |
|                                                    |                            |                            |                            | Cyclopentane               |                        | 490    | 101 |
|                                                    |                            |                            |                            | 2,2-Dimethylbutane         |                        | 428    | 101 |
|                                                    |                            |                            |                            | 2,3-Dimethylbutane         |                        | 452    | 101 |
|                                                    |                            |                            |                            | 3,4-Dimethylhexane         |                        | 541    | 101 |
|                                                    |                            |                            |                            | 2,2-Dimethylpentane        |                        | 472    | 101 |
|                                                    |                            |                            |                            | 2,3-Dimethylpentane        |                        | 500    | 101 |
|                                                    |                            |                            |                            | 2,4-Dimethylpentane        |                        | 464    | 101 |
|                                                    |                            |                            |                            | 3-Ethylpentane             |                        | 511    | 101 |
|                                                    |                            |                            |                            | Heptane                    |                        | 502    | 101 |
|                                                    |                            |                            |                            | Hexane                     |                        | 455    | 101 |
|                                                    |                            |                            |                            | 2-Methylbutane             |                        | 396    | 101 |
|                                                    |                            |                            |                            | Methylcyclohexane          |                        | 558    | 101 |
|                                                    |                            |                            |                            | Methylcyclopentane         |                        | 512    | 101 |
|                                                    |                            |                            |                            | 2-Methylhexane             |                        | 486    | 101 |
|                                                    |                            |                            |                            | Nonane                     |                        | 558    | 101 |
|                                                    |                            |                            |                            | Octane                     |                        | 528    | 101 |
|                                                    |                            |                            |                            | Pentane                    |                        | 409    | 101 |
|                                                    |                            |                            |                            | 2,2,4,4-Tetramethylpentane |                        | 539    | 101 |
|                                                    |                            |                            |                            | 2,2,3-Trimethylbutane      |                        | 500    | 101 |
|                                                    |                            |                            |                            | 2,2,4-Trimethylpentane     |                        | 503    | 101 |
| Ethylene/propylene copolymer<br>(43 mol% ethylene) | 70000                      | 140000                     |                            | Hexane                     |                        | 436    | 127 |
|                                                    |                            |                            |                            | 2-Methylpentane            |                        | 474    | 127 |
|                                                    |                            |                            |                            | Pentane                    |                        | 441    | 127 |
| Ethylene/propylene copolymer<br>(53 mol% ethylene) |                            |                            |                            |                            |                        |        |     |
|                                                    |                            |                            |                            |                            |                        |        |     |
|                                                    |                            |                            |                            | 154000                     | 2,2-Dimethylbutane     | 407    | 101 |
|                                                    |                            |                            |                            | 154000                     | 2,3-Dimethylbutane     | 437    | 101 |
|                                                    |                            |                            |                            | 154000                     | 2,2-Dimethylpentane    | 453    | 101 |
|                                                    |                            |                            |                            | 154000                     | 2,3-Dimethylpentane    | 488    | 101 |
|                                                    |                            |                            |                            | 154000                     | 2,4-Dimethylpentane    | 445    | 101 |
|                                                    |                            |                            |                            | 154000                     | 3-Ethylpentane         | 500    | 101 |
|                                                    |                            |                            |                            | 154000                     | Heptane                | 493    | 101 |
|                                                    |                            |                            |                            | 154000                     | Hexane                 | 443    | 101 |
|                                                    |                            |                            |                            | 154000                     | Pentane                | 395    | 101 |
|                                                    |                            |                            |                            | 154000                     | 2,2,3-Trimethylbutane  | 488    | 101 |
|                                                    |                            |                            |                            | 154000                     | 2,3,4-Trimethylhexane  | 565    | 101 |
|                                                    |                            |                            |                            | 154000                     | 2,2,4-Trimethylpentane | 484    | 101 |
| Ethylene/propylene copolymer<br>(63 mol% ethylene) |                            |                            |                            |                            |                        |        |     |
|                                                    |                            |                            |                            |                            |                        |        |     |
|                                                    |                            |                            |                            | 236000                     | Cyclohexane            | 526    | 101 |
|                                                    |                            |                            |                            | 236000                     | Cyclopentane           | 481    | 101 |
|                                                    |                            |                            |                            | 236000                     | 2,3-Dimethylbutane     | 429    | 101 |
|                                                    |                            |                            |                            | 236000                     | 3,4-Dimethylhexane     | 530    | 101 |
|                                                    |                            |                            |                            | 236000                     | 2,2-Dimethylpentane    | 444    | 101 |
|                                                    |                            |                            |                            | 236000                     | 2,3-Dimethylpentane    | 482    | 101 |
|                                                    |                            |                            |                            | 236000                     | 2,4-Dimethylpentane    | 434    | 101 |

| Polymer                                                      | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent                    | UCST/K | LCST/K | Ref |
|--------------------------------------------------------------|----------------------------|----------------------------|-------------------------------|----------------------------|--------|--------|-----|
| Ethylene/propylene copolymer<br>(75 mol% ethylene)           |                            |                            | 236000                        | 3-Ethylpentane             |        | 492    | 101 |
|                                                              |                            |                            | 236000                        | Heptane                    |        | 485    | 101 |
|                                                              |                            |                            | 236000                        | Hexane                     |        | 436    | 101 |
|                                                              |                            |                            | 236000                        | 2-Methylbutane             |        | 348    | 101 |
|                                                              |                            |                            | 236000                        | Methylcyclopentane         |        | 498    | 101 |
|                                                              |                            |                            | 236000                        | Nonane                     |        | 547    | 101 |
|                                                              |                            |                            | 236000                        | Octane                     |        | 512    | 101 |
|                                                              |                            |                            | 236000                        | Pentane                    |        | 387    | 101 |
|                                                              |                            |                            | 236000                        | 2,2,4,4-Tetramethylpentane |        | 528    | 101 |
|                                                              |                            |                            | 236000                        | 2,2,3-Trimethylbutane      |        | 479    | 101 |
|                                                              |                            |                            | 236000                        | 2,2,4-Trimethylpentane     |        | 479    | 101 |
|                                                              |                            |                            | 109000                        | 2,2-Dimethylpentane        |        | 431    | 101 |
|                                                              |                            |                            | 109000                        | 2,4-Dimethylpentane        |        | 425    | 101 |
| Ethylene/propylene copolymer (81 mol% ethylene)              |                            |                            | 109000                        | Heptane                    |        | 475    | 101 |
|                                                              |                            |                            | 109000                        | Hexane                     |        | 427    | 101 |
|                                                              |                            |                            | 109000                        | Nonane                     |        | 542    | 101 |
|                                                              |                            |                            | 109000                        | Octane                     |        | 509    | 101 |
|                                                              |                            |                            | 109000                        | Pentane                    |        | 378    | 101 |
|                                                              |                            |                            | 109000                        | 2,2,4,4-Tetramethylpentane |        | 523    | 101 |
|                                                              |                            |                            | 109000                        | 2,2,4-Trimethylpentane     |        | 469    | 101 |
|                                                              |                            |                            | 195000                        | Cyclohexane                |        | 522    | 101 |
|                                                              |                            |                            | 195000                        | Cyclopentane               |        | 474    | 101 |
|                                                              |                            |                            | 195000                        | 2,2-Dimethylbutane         |        | 381    | 101 |
|                                                              |                            |                            | 195000                        | 2,3-Dimethylbutane         |        | 413    | 101 |
|                                                              |                            |                            | 195000                        | 2,4-Dimethylhexane         |        | 478    | 101 |
|                                                              |                            |                            | 195000                        | 2,5-Dimethylhexane         |        | 466    | 101 |
|                                                              |                            |                            | 195000                        | 3,4-Dimethylhexane         |        | 522    | 101 |
|                                                              |                            |                            | 195000                        | 2,2-Dimethylpentane        |        | 425    | 101 |
|                                                              |                            |                            | 195000                        | 2,3-Dimethylpentane        |        | 471    | 101 |
|                                                              |                            |                            | 195000                        | 2,4-Dimethylpentane        |        | 420    | 101 |
|                                                              |                            |                            | 195000                        | 3-Ethylpentane             |        | 478    | 101 |
|                                                              |                            |                            | 195000                        | Heptane                    |        | 468    | 101 |
|                                                              |                            |                            | 195000                        | Hexane                     |        | 425    | 101 |
|                                                              |                            |                            | 195000                        | 2-Methylbutane             |        | 327    | 101 |
|                                                              |                            |                            | 195000                        | Methylcyclohexane          |        | 541    | 101 |
|                                                              |                            |                            | 195000                        | Methylcyclopentane         |        | 493    | 101 |
|                                                              |                            |                            | 195000                        | 2-Methylhexane             |        | 453    | 101 |
|                                                              |                            |                            | 195000                        | 3-Methylhexane             |        | 459    | 101 |
|                                                              |                            |                            | 195000                        | Nonane                     |        | 540    | 101 |
|                                                              |                            |                            | 195000                        | Octane                     |        | 506    | 101 |
|                                                              |                            |                            | 195000                        | Pentane                    |        | 370    | 101 |
|                                                              |                            |                            | 195000                        | 2,2,4,4-Tetramethylpentane |        | 519    | 101 |
|                                                              |                            |                            | 195000                        | 2,2,3-Trimethylbutane      |        | 461    | 101 |
|                                                              |                            |                            | 195000                        | 2,2,4-Trimethylpentane     |        | 460    | 101 |
| Ethylene/vinyl acetate copolymer<br>( 2.3 wt% Vinyl acetate) | 52000                      | 465000                     |                               | Diphenyl ether             | 404.2  |        | 143 |
|                                                              |                            |                            |                               | Diphenyl ether             | 392.5  |        | 143 |
| Ethylene/vinyl acetate copolymer<br>( 4.0 wt% Vinyl acetate) | 47000                      | 280000                     |                               | Diphenyl ether             |        |        | 143 |

| Polymer                                                                                              | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent        | UCST/K | LCST/K | Ref |
|------------------------------------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------|----------------|--------|--------|-----|
| ( 7.1 wt% Vinyl acetate)                                                                             | 34000                      | 460000                     |                               | Diphenyl ether | 378.2  |        | 143 |
| ( 9.5 wt% Vinyl acetate)                                                                             | 53000                      | 350000                     |                               | Diphenyl ether | 367.3  |        | 143 |
| ( 9.7 wt% Vinyl acetate)                                                                             | 55000                      | 490000                     |                               | Diphenyl ether | 370.8  |        | 143 |
| (12.1 wt% Vinyl acetate)                                                                             | 66000                      | 300000                     |                               | Diphenyl ether | 360.4  |        | 143 |
| (42.6 mol% Vinyl acetate)                                                                            | 14800                      | 41500                      |                               | Methyl acetate | 307.0  |        | 130 |
| Ethylene/vinyl alcohol copolymer                                                                     |                            |                            |                               |                |        |        |     |
| (87.2 mol% Vinyl alcohol)                                                                            |                            |                            | infinite                      | Water          | 463.55 | 285.65 | 44  |
| (88.9 mol% Vinyl alcohol)                                                                            |                            |                            | infinite                      | Water          | 449.15 | 290.75 | 44  |
| (91.0 mol% Vinyl alcohol)                                                                            |                            |                            | infinite                      | Water          | 428.45 | 302.95 | 44  |
| (94.1 mol% Vinyl alcohol)                                                                            |                            |                            | infinite                      | Water          | 389.25 | 324.45 | 44  |
| Ethylene oxide/propylene oxide copolymer                                                             |                            |                            |                               |                |        |        |     |
| (20.0 mol% Ethylene oxide)                                                                           | 3400                       |                            |                               | Water          |        | 303    | 211 |
| (27.0 mol% Ethylene oxide)                                                                           | 3000                       |                            |                               | Water          |        | 309    | 210 |
| (30.0 mol% Ethylene oxide)                                                                           | 5400                       |                            |                               | Water          |        | 313    | 211 |
| (38.5 mol% Ethylene oxide)                                                                           | 5000                       |                            |                               | Water          |        | 309    | 210 |
| (50.0 mol% Ethylene oxide)                                                                           | 3900                       |                            |                               | Water          |        | 323    | 211 |
| (58.8 mol% Ethylene oxide)                                                                           | 3000                       |                            |                               | Water          |        | 326.65 | 210 |
| (72.4 mol% Ethylene oxide)                                                                           |                            | 36000                      |                               | Water          |        | 333    | 153 |
| (79.5 mol% Ethylene oxide)                                                                           |                            | 30800                      |                               | Water          |        | 345    | 153 |
| (86.6 mol% Ethylene oxide)                                                                           |                            | 30100                      |                               | Water          |        | 355.5  | 153 |
| Gutta Percha                                                                                         |                            |                            |                               |                |        |        |     |
|                                                                                                      |                            |                            | 194000                        | Propyl acetate | 318.95 |        | 7   |
| Hydroxypropylcellulose                                                                               |                            |                            |                               |                |        |        |     |
|                                                                                                      |                            | 75000                      |                               | Water          |        | 318.45 | 43  |
|                                                                                                      |                            | 300000                     |                               | Water          |        | 331.25 | 43  |
| <i>N</i> -Isopropylacrylamide/acrylamide copolymer                                                   |                            |                            |                               |                |        |        |     |
| (15 mol% Acrylamide)                                                                                 |                            | 3100000                    |                               | Water          |        | 315.15 | 172 |
| (30 mol% Acrylamide)                                                                                 |                            | 4500000                    |                               | Water          |        | 326.15 | 172 |
| (45 mol% Acrylamide)                                                                                 |                            | 3900000                    |                               | Water          |        | 347.15 | 172 |
| <i>N</i> -Isopropylacrylamide/1-deoxy-1-methacrylamido- <i>D</i> -glucitol                           |                            |                            |                               |                |        |        |     |
| (12.9 mol% Glucitol)                                                                                 | 78000                      | 170000                     |                               | Water          |        | 311.3  | 218 |
| (13.7 mol% Glucitol)                                                                                 | 51600                      | 110000                     |                               | Water          |        | 314.9  | 218 |
| (14.0 mol% Glucitol)                                                                                 | 145000                     | 432000                     |                               | Water          |        | 307.5  | 218 |
| <i>N</i> -Isopropylacrylamide/ <i>N</i> -isopropylmethacrylamide copolymer                           |                            |                            |                               |                |        |        |     |
| (10.56 mol% <i>N</i> -Isopropylmethacrylamide)                                                       | 55300                      | 177000                     |                               | Water          |        | 307.15 | 212 |
| (30.00 mol% <i>N</i> -Isopropylmethacrylamide)                                                       | 28800                      | 92000                      |                               | Water          |        | 309.75 | 212 |
| (39.99 mol% <i>N</i> -Isopropylmethacrylamide)                                                       | 23100                      | 74000                      |                               | Water          |        | 311.05 | 212 |
| (59.89 mol% <i>N</i> -Isopropylmethacrylamide)                                                       | 23100                      | 74000                      |                               | Water          |        | 314.65 | 212 |
| (79.81 mol% <i>N</i> -Isopropylmethacrylamide)                                                       | 16600                      | 53000                      |                               | Water          |        | 317.35 | 212 |
| (89.99 mol% <i>N</i> -Isopropylmethacrylamide)                                                       | 14700                      | 47000                      |                               | Water          |        | 318.75 | 212 |
| Methylcellulose (about 30 mol% methyl substitution)                                                  |                            |                            |                               |                |        |        |     |
|                                                                                                      |                            |                            | 70000                         | Water          |        | 324.75 | 47  |
| Methylcellulose/hydroxypropylcellulose copolymer (25 mol% methyl, 8 mol% hydroxypropyl substitution) |                            |                            | 80000                         | Water          |        | 340.15 | 63  |
| Natural rubber                                                                                       |                            |                            |                               |                |        |        |     |
|                                                                                                      |                            | 300000                     |                               | Pentane        |        | 403    | 10  |
|                                                                                                      |                            |                            | 74500                         | 2-Pentanone    | 274.45 |        | 7   |

| Polymer                                                                          | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | Solvent                    | UCST/K | LCST/K | Ref |
|----------------------------------------------------------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|--------|--------|-----|
| Phenol-formaldehyde resin (acetylated)                                           |                            |                            |                            | 2-Ethoxyethanol            | 378.2  |        | 200 |
| Poly(acrylic acid)                                                               |                            | 120000                     |                            | Tetrahydrofuran            |        | 268.3  | 189 |
| Poly[bis(2,3-dimethoxypropanoxy)phosphazene]                                     | 1070000                    | 1500000                    |                            | Water                      |        | 317.15 | 183 |
| Poly[bis(2-(2'-methoxyethoxy)ethoxy)phosphazene]                                 | 667000                     | 1000000                    |                            | Water                      |        | 338.15 | 183 |
| Poly[bis(2,3-bis(2-methoxyethoxy)propanoxy)phosphazene]                          | 714000                     | 1000000                    |                            | Water                      |        | 311.15 | 183 |
| Poly[bis(2,3-bis(2-(2'-methoxyethoxy)ethoxy)propanoxy)phosphazene]               | 1420000                    | 1700000                    |                            | Water                      |        | 322.65 | 183 |
| Poly[bis(2,3-bis(2-(2'-(2''-dimethoxyethoxy)ethoxy)ethoxy)propanoxy)phosphazene] | 857000                     | 1200000                    |                            | Water                      |        | 334.65 | 183 |
| Poly(1-butene) (atactic)                                                         | infinite                   |                            |                            | Anisole                    | 359.4  |        | 11  |
|                                                                                  | infinite                   |                            |                            | Toluene                    | 356.2  |        | 28  |
| Poly(1-butene) (isotactic)                                                       | infinite                   |                            |                            | Anisole                    | 362.3  |        | 11  |
|                                                                                  |                            |                            | 530000                     | Cyclopentane               |        | 498    | 102 |
|                                                                                  |                            |                            | 530000                     | 2,2-Dimethylbutane         |        | 444    | 102 |
|                                                                                  |                            |                            | 530000                     | 2,5-Dimethylhexane         |        | 519    | 102 |
|                                                                                  |                            |                            | 530000                     | 3,4-Dimethylhexane         |        | 559    | 102 |
|                                                                                  |                            |                            | 530000                     | 2,3-Dimethylpentane        |        | 517    | 102 |
|                                                                                  |                            |                            | 530000                     | 2,4-Dimethylpentane        |        | 480    | 102 |
|                                                                                  |                            |                            | 530000                     | 3-Ethylpentane             |        | 523    | 102 |
|                                                                                  |                            |                            | 530000                     | Heptane                    |        | 509    | 102 |
|                                                                                  | infinite                   |                            |                            | Hexane                     |        | 464    | 102 |
|                                                                                  |                            |                            | 530000                     | 2-Methylbutane             |        | 416    | 102 |
|                                                                                  | infinite                   |                            |                            | Nonane                     |        | 564    | 102 |
|                                                                                  |                            |                            | 530000                     | Octane                     |        | 540    | 102 |
|                                                                                  | infinite                   |                            |                            | Pentane                    |        | 421    | 102 |
|                                                                                  |                            |                            | 530000                     | 2,2,3-Trimethylbutane      |        | 507    | 102 |
| Poly(butyl methacrylate)                                                         | 278000                     | 470000                     |                            | 1-Butanol                  | 287.15 |        | 132 |
|                                                                                  | 278000                     | 470000                     |                            | Decane                     | 357.25 |        | 132 |
|                                                                                  | 278000                     | 470000                     |                            | Ethanol                    | 315.25 |        | 132 |
|                                                                                  | 278000                     | 470000                     |                            | Heptane                    | 342.55 |        | 132 |
|                                                                                  | 278000                     | 470000                     |                            | Octane                     | 345.80 |        | 132 |
|                                                                                  | 278000                     | 470000                     |                            | 1-Pentanol                 | 286.30 |        | 132 |
|                                                                                  | 278000                     | 470000                     |                            | 2-Propanol                 | 294.90 |        | 132 |
|                                                                                  | 278000                     | 470000                     |                            | 2,2,4-Trimethylpentane     | 347.50 |        | 132 |
| Poly(2-chlorostyrene)                                                            | infinite                   |                            |                            | Benzene                    |        | 298    | 40  |
| Poly(4-chlorostyrene)                                                            | infinite                   |                            |                            | Benzene                    | 274.0  |        | 22  |
|                                                                                  | infinite                   |                            |                            | 2-(Butoxyethoxy)ethanol    |        | 323.25 | 46  |
|                                                                                  | infinite                   |                            |                            | Butyl acetate              |        | 502.4  | 22  |
|                                                                                  | infinite                   |                            |                            | <i>tert</i> -Butyl acetate |        | 338.55 | 46  |

| Polymer                       | $M_w$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | Solvent                 | UCST/K | LCST/K | Ref      |
|-------------------------------|----------------------------|----------------------------|----------------------------|-------------------------|--------|--------|----------|
|                               | infinite                   |                            |                            | Chlorobenzene           | 128.8  |        | 22       |
|                               | infinite                   |                            |                            | 2-(Ethoxyethoxy)ethanol |        | 300.95 | 46       |
|                               | infinite                   |                            |                            | Ethyl acetate           |        | 613.2  | 22       |
|                               | infinite                   |                            |                            | Ethylbenzene            | 283.2  |        | 22       |
|                               | infinite                   |                            |                            | Ethylbenzene            | 258.45 |        | 46       |
|                               | infinite                   |                            |                            | Ethyl chloroacetate     | 271.35 |        | 46       |
|                               | infinite                   |                            |                            | Isopropyl acetate       |        | 348.65 | 46       |
|                               | infinite                   |                            |                            | Isopropylbenzene        | 332.15 |        | 46       |
|                               | infinite                   |                            |                            | Isopropyl chloroacetate | 264.95 |        | 46       |
|                               | infinite                   |                            |                            | Methyl chloroacetate    | 337.75 |        | 46       |
|                               | infinite                   |                            |                            | Propyl acetate          |        | 908.7  | 22       |
|                               | infinite                   |                            |                            | Tetrachloroethene       | 317.55 |        | 46       |
|                               | infinite                   |                            |                            | Tetrachloromethane      | 323.85 |        | 46       |
|                               | infinite                   |                            |                            | Toluene                 | 236.8  |        | 22       |
| Poly(decyl methacrylate)      | 390000                     | 468000                     |                            | 1-Butanol               | 304.85 |        | 113      |
|                               | 390000                     | 468000                     |                            | 1-Pentanol              | 278.40 |        | 113      |
|                               | 220000                     | 252000                     |                            | 2-Propanol              | 346.85 |        | 132      |
| Polydimethylsiloxane (cyclic) | 9810                       | 10300                      |                            | 2,2-Dimethylpropane     |        | 433    | 133      |
|                               | 9810                       | 10300                      |                            | Tetramethylsilane       |        | 448    | 133, 171 |
| Polydimethylsiloxane          |                            |                            | 626000                     | Butane                  |        | 392.95 | 53       |
|                               | infinite                   |                            |                            | Decane                  |        | 603    | 30       |
|                               | 14750                      | 16370                      |                            | 2,2-Dimethylpropane     |        | 428    | 133      |
|                               | infinite                   |                            |                            | Dodecane                |        | 643    | 30       |
|                               |                            |                            | 626000                     | Ethane                  |        | 259.65 | 53       |
|                               |                            |                            | 100000                     | Ethoxybenzene           | 341.99 |        | 108      |
|                               | infinite                   |                            |                            | Heptane                 |        | 528    | 30       |
|                               | infinite                   |                            |                            | Hexadecane              |        | 708    | 30       |
|                               | infinite                   |                            |                            | Hexane                  |        | 493    | 30       |
|                               | infinite                   |                            |                            | Octane                  |        | 553    | 30       |
|                               | infinite                   |                            |                            | Pentane                 |        | 453    | 30       |
|                               |                            |                            | 203000                     | Propane                 |        | 340.15 | 53       |
|                               | 14750                      | 16370                      |                            | Tetramethylsilane       |        | 443    | 133, 171 |
| Poly(ethyl acrylate)          |                            |                            | 48000                      | 1-Butanol               | 310.05 |        | 27       |
|                               |                            |                            | 48000                      | Ethanol                 | 301.15 |        | 27       |
|                               |                            |                            | 380000                     | Methanol                | 287.25 |        | 27       |
|                               |                            |                            | 48000                      | 1-Propanol              | 305.15 |        | 27       |
| Polyethylene (branched)       | 8400                       | 32000                      |                            | Diphenyl ether          | 384.7  |        | 95, 98   |
|                               | 24000                      | 123000                     |                            | Diphenyl ether          | 396.7  |        | 95, 98   |
|                               | 65000                      | 425000                     |                            | Diphenyl ether          | 415.3  |        | 95, 98   |
| Polyethylene (linear)         |                            |                            | 20000                      | Anisole                 | 368.15 |        | 24       |
|                               |                            |                            | 20000                      | Benzyl acetate          | 459.65 |        | 24       |
|                               |                            |                            | 20000                      | Benzyl phenyl ether     | 437.15 |        | 24       |
|                               |                            |                            | 20000                      | Benzyl propionate       | 436.15 |        | 24       |
|                               |                            |                            | 50900                      | Biphenyl                | 383.55 |        | 25       |
|                               |                            |                            | 61100                      | Butyl acetate           | 448    | 497    | 70       |

| Polymer                                                                                                          | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent                      | UCST/K | LCST/K | Ref    |
|------------------------------------------------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------|------------------------------|--------|--------|--------|
|                                                                                                                  |                            |                            | 20000                         | 4- <i>tert</i> -Butylphenol  | 466.15 |        | 24     |
|                                                                                                                  |                            |                            | 134000                        | Cyclohexane                  |        | 518    | 101    |
|                                                                                                                  |                            |                            | 20000                         | Cyclohexanone                | 389.65 |        | 24     |
|                                                                                                                  |                            |                            | 134000                        | Cyclopentane                 |        | 472    | 101    |
|                                                                                                                  |                            |                            | 36700                         | Decane                       |        | 563.75 | 91     |
|                                                                                                                  |                            |                            | 20000                         | 1-Decanol                    | 400.15 |        | 24     |
|                                                                                                                  |                            |                            | 20000                         | Dibenzyl ether               | 448.65 |        | 24     |
|                                                                                                                  |                            |                            | 134000                        | 3,4-Dimethylhexane           |        | 515    | 101    |
|                                                                                                                  |                            |                            | 134000                        | 2,2-Dimethylpentane          |        | 399    | 101    |
|                                                                                                                  |                            |                            | 134000                        | 2,3-Dimethylpentane          |        | 463    | 101    |
|                                                                                                                  |                            |                            | 134000                        | 2,4-Dimethylpentane          |        | 395    | 101    |
|                                                                                                                  |                            |                            | 12000                         | Diphenyl ether               | 416.2  |        | 95, 98 |
|                                                                                                                  |                            |                            | 97200                         | Diphenylmethane              | 400.25 |        | 25     |
|                                                                                                                  |                            |                            | 60400                         | Dodecane                     |        | 610.85 | 91     |
|                                                                                                                  |                            |                            | 218000                        | 1-Dodecanol                  | 405.15 |        | 141    |
|                                                                                                                  |                            |                            | 134000                        | 3-Ethylpentane               |        | 471    | 101    |
|                                                                                                                  |                            |                            | 36700                         | Heptane                      |        | 464.70 | 91     |
|                                                                                                                  |                            |                            | 20000                         | 1-Heptanol                   | 440.15 |        | 24     |
|                                                                                                                  |                            |                            | 36700                         | Hexane                       |        | 414.65 | 91     |
|                                                                                                                  |                            |                            | 7900                          | 1-Hexanol                    | 458.15 |        | 154    |
|                                                                                                                  |                            |                            |                               | 2-Methoxynaphthalene         | 427.65 |        | 24     |
|                                                                                                                  |                            |                            |                               | 3-Methylbutyl acetate        | 407.15 |        | 24     |
|                                                                                                                  |                            |                            | 134000                        | Methylcyclohexane            |        | 537    | 101    |
|                                                                                                                  |                            |                            | 134000                        | Methylcyclopentane           |        | 488    | 101    |
|                                                                                                                  |                            |                            | 60400                         | Nonane                       |        | 531.90 | 91     |
|                                                                                                                  |                            |                            | 20000                         | 1-Nonanol                    | 431.15 |        | 24     |
|                                                                                                                  |                            |                            | 20000                         | 4-Nonylphenol                | 410.15 |        | 24     |
|                                                                                                                  |                            |                            | 36700                         | Octane                       |        | 502.40 | 91     |
|                                                                                                                  |                            |                            | 7900                          | 1-Octanol                    | 426.65 |        | 154    |
|                                                                                                                  |                            |                            | 20000                         | 4-Octylphenol                | 424.65 |        | 24     |
|                                                                                                                  |                            |                            | 134000                        | Pentane                      |        | 353    | 101    |
|                                                                                                                  |                            |                            | 20000                         | 1-Pentanol                   | 445.15 |        | 24     |
|                                                                                                                  |                            |                            | 175000                        | Pentyl acetate               | 421    | 528    | 70     |
|                                                                                                                  |                            |                            | 20000                         | 4- <i>tert</i> -Pentylphenol | 443.65 |        | 24     |
|                                                                                                                  |                            |                            | 20000                         | Phenetole                    | 366.65 |        | 24     |
|                                                                                                                  |                            |                            | 134000                        | 2,2,4,4-Tetramethylpentane   |        | 513    | 101    |
|                                                                                                                  |                            |                            | 60400                         | Tridecane                    |        | 639.30 | 91     |
|                                                                                                                  |                            |                            | 134000                        | 2,2,3-Trimethylbutane        |        | 444    | 101    |
|                                                                                                                  |                            |                            | 134000                        | 2,3,4-Trimethylhexane        |        | 545    | 101    |
|                                                                                                                  |                            |                            | 134000                        | 2,2,4-Trimethylpentane       |        | 495    | 101    |
|                                                                                                                  |                            |                            | 97700                         | Undecane                     |        | 583.95 | 91     |
| Poly(ethylene glycol)                                                                                            |                            |                            | 8000                          | <i>tert</i> -Butyl acetate   | 321.2  | 464.2  | 83     |
|                                                                                                                  |                            |                            | 21200                         | <i>tert</i> -Butyl acetate   | 353.2  | 431.2  | 83     |
|                                                                                                                  |                            |                            | 6100                          | Water                        |        | 404.79 | 185    |
|                                                                                                                  |                            |                            | 10457                         | Water                        |        | 394.33 | 205    |
|                                                                                                                  |                            |                            | 40800                         | Water                        |        | 378.25 | 205    |
|                                                                                                                  |                            |                            |                               |                              |        |        |        |
| Poly(ethylene oxide)-b-poly[bis(methoxyethoxyethoxy)-phosphazene] block copolymer (about 67 mol% Ethylene oxide) |                            |                            | 22000                         | Water                        |        | 338    | 222    |
|                                                                                                                  |                            |                            |                               |                              |        |        |        |



| Polymer                                                                                                               | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent             | UCST/K | LCST/K | Ref    |
|-----------------------------------------------------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------|---------------------|--------|--------|--------|
| Poly(ethylene oxide)-b-poly(propylene oxide)-b-poly(ethylene oxide) triblock copolymer (about 30 mol% Ethylene oxide) |                            | 4400                       |                               | Water               |        | 286.65 | 209    |
|                                                                                                                       | 48000                      | 52000                      |                               | Diphenyl ether      | 411.2  |        | 95, 98 |
| Polyethylethylene                                                                                                     | infinite                   |                            |                               | 2-Butanone          | 302.6  |        | 135    |
| Poly(2-hydroxyethyl methacrylate)                                                                                     |                            |                            | 77400                         | 1-Butanol           | 337.25 |        | 35     |
|                                                                                                                       |                            |                            | 233600                        | 2-Butanol           | 287    |        | 35     |
|                                                                                                                       |                            |                            | 233600                        | 2-Metyl-1-propanol  | 342    |        | 35     |
|                                                                                                                       |                            |                            | 77400                         | 1,2,3-Propanetriol  | 345    |        | 35     |
|                                                                                                                       |                            |                            | 77400                         | 1-Propanol          | 311    |        | 35     |
| Polyisobutylene                                                                                                       | infinite                   |                            |                               | Anisole             | 377    |        | 3      |
|                                                                                                                       |                            | 72000                      |                               | Benzene             |        | 540.5  | 39     |
|                                                                                                                       |                            | 703000                     |                               | Butane              |        | 264.75 | 53     |
|                                                                                                                       | infinite                   |                            |                               | Cycloheptane        |        | 572    | 34     |
|                                                                                                                       |                            | 1500000                    |                               | Cyclohexane         |        | 412    | 10     |
|                                                                                                                       | infinite                   |                            |                               | Cyclooctane         |        | 637    | 34     |
|                                                                                                                       |                            | 1500000                    |                               | Cyclopentane        |        | 344    | 10     |
|                                                                                                                       | infinite                   |                            |                               | Decane              |        | 535    | 34     |
|                                                                                                                       |                            | 1500000                    |                               | 2,2-Dimethylbutane  |        | 376    | 10     |
|                                                                                                                       |                            | 1500000                    |                               | 2,3-Dimethylbutane  |        | 404    | 10     |
|                                                                                                                       | infinite                   |                            |                               | 2,2-Dimethylhexane  |        | 454    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 2,4-Dimethylhexane  |        | 458    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 2,5-Dimethylhexane  |        | 446    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 3,4-Dimethylhexane  |        | 497    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 2,2-Dimethylpentane |        | 404    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 2,3-Dimethylpentane |        | 451    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 2,4-Dimethylpentane |        | 403    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 3,3-Dimethylpentane |        | 451    | 34     |
|                                                                                                                       | infinite                   |                            |                               | Diphenyl ether      | 306    |        | 3      |
|                                                                                                                       | infinite                   |                            |                               | Decane              |        | 585    | 30     |
|                                                                                                                       | infinite                   |                            |                               | Dodecane            |        | 582    | 34     |
|                                                                                                                       | infinite                   |                            |                               | Ethylbenzene        | 249    |        | 3      |
|                                                                                                                       | infinite                   |                            |                               | Ethylcyclopentane   |        | 524    | 34     |
|                                                                                                                       | infinite                   |                            |                               | Ethyl heptanoate    | 306    |        | 3      |
|                                                                                                                       | infinite                   |                            |                               | Ethyl hexanoate     | 330    |        | 3      |
|                                                                                                                       | infinite                   |                            |                               | 3-Ethylpentane      |        | 458    | 34     |
|                                                                                                                       | infinite                   |                            |                               | Heptane             |        | 442    | 34     |
|                                                                                                                       |                            | 72000                      |                               | Hexane              |        | 428.5  | 39     |
|                                                                                                                       |                            | 6030                       |                               | 2-Methylbutane      |        | 357.85 | 53     |
|                                                                                                                       | infinite                   |                            |                               | Methylcyclohexane   |        | 526    | 34     |
|                                                                                                                       | infinite                   |                            |                               | Methylcyclopentane  |        | 478    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 2-Methylheptane     |        | 466    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 3-Methylheptane     |        | 478    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 2-Methylhexane      |        | 426    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 3-Methylhexane      |        | 446    | 34     |
|                                                                                                                       | infinite                   |                            |                               | 2-Methylpentane     |        | 376    | 34     |

| Polymer                                                                                                                            | $M_n$ /g mol <sup>-1</sup>                                                                                                         | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent                    | UCST/K | LCST/K | Ref |
|------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------|----------------------------|--------|--------|-----|
| 1,4- <i>cis</i> -Polyisoprene                                                                                                      | infinite                                                                                                                           |                            |                               | 3-Methylpentane            |        | 405    | 34  |
|                                                                                                                                    |                                                                                                                                    |                            | 470                           | 2-Methylpropane            |        | 387    | 10  |
|                                                                                                                                    |                                                                                                                                    |                            | 72000                         | Octane                     |        | 506.0  | 39  |
|                                                                                                                                    |                                                                                                                                    |                            | 6030                          | Pentane                    |        | 403.55 | 53  |
|                                                                                                                                    |                                                                                                                                    |                            | 72000                         | Pentane                    |        | 373.5  | 39  |
|                                                                                                                                    | infinite                                                                                                                           |                            |                               | Phenetole                  | 357    |        | 3   |
|                                                                                                                                    |                                                                                                                                    |                            | 470                           | Propane                    |        | 358    | 10  |
|                                                                                                                                    | infinite                                                                                                                           |                            |                               | Propylcyclopentane         |        | 547    | 34  |
|                                                                                                                                    | infinite                                                                                                                           |                            |                               | Toluene                    | 260    |        | 3   |
|                                                                                                                                    | infinite                                                                                                                           |                            |                               | 2,2,3-Trimethylbutane      |        | 445    | 34  |
|                                                                                                                                    | infinite                                                                                                                           |                            |                               | 2,2,4-Trimethylpentane     |        | 435    | 34  |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | 2,5-Dimethylhexane         |        | 474.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | 3,4-Dimethylhexane         |        | 520.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | 2,2-Dimethylpentane        |        | 445.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | 2,3-Dimethylpentane        |        | 484.15 | 140 |
| 1,4- <i>trans</i> -Polyisoprene                                                                                                    |                                                                                                                                    |                            | 780000                        | 2,4-Dimethylpentane        |        | 442.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | 3-Methylpentane            |        | 483.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | Heptane                    |        | 488.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | Hexane                     |        | 434.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | Nonane                     |        | 541.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | Octane                     |        | 509.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | 2,2,4,4-Tetramethylpentane |        | 518.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | 2,3,4-Trimethylhexane      |        | 548.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 780000                        | 2,2,4-Trimethylpentane     |        | 471.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | 2,5-Dimethylhexane         |        | 451.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | 3,4-Dimethylhexane         |        | 521.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | 2,2-Dimethylpentane        |        | 405.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | 2,3-Dimethylpentane        |        | 460.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | 2,4-Dimethylpentane        |        | 404.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | 3-Methylpentane            |        | 473.15 | 140 |
| Poly( <i>N</i> -isopropylacrylamide)                                                                                               |                                                                                                                                    |                            | 180000                        | Heptane                    |        | 467.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | Hexane                     |        | 407.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | Nonane                     |        | 540.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | Octane                     |        | 503.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | 2,2,4,4-Tetramethylpentane |        | 519.15 | 140 |
|                                                                                                                                    |                                                                                                                                    |                            | 180000                        | 2,3,4-Trimethylhexane      |        | 548.15 | 140 |
|                                                                                                                                    | 5400                                                                                                                               | 14000                      |                               | Water                      |        | 307.45 | 146 |
|                                                                                                                                    | 146000                                                                                                                             | 530000                     |                               | Water                      |        | 305.85 | 146 |
|                                                                                                                                    | Poly( <i>N</i> -isopropylacrylamide)-poly[( <i>N</i> -acetylimino)ethylene] block copolymer (80 wt% <i>N</i> -Isopropylacrylamide) |                            |                               |                            |        |        |     |
|                                                                                                                                    | 5500                                                                                                                               |                            |                               | Water                      |        | 306.2  | 223 |
| Poly( <i>N</i> -isopropylacrylamide)-poly[( <i>N</i> -acetylimino)ethylene] graft copolymer (75 wt% <i>N</i> -Isopropylacrylamide) |                                                                                                                                    |                            |                               |                            |        |        |     |
|                                                                                                                                    | 6030                                                                                                                               |                            |                               | Water                      |        | 306.2  | 223 |
| Poly( <i>N</i> -isopropylmethacrylamide)                                                                                           | 6250                                                                                                                               | 20000                      |                               | Water                      |        | 319.95 | 212 |
| Poly(methyl methacrylate)                                                                                                          |                                                                                                                                    |                            |                               |                            |        |        |     |

| Polymer                               | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | Solvent                     | UCST/K | LCST/K                 | Ref    |     |     |
|---------------------------------------|----------------------------|----------------------------|----------------------------|-----------------------------|--------|------------------------|--------|-----|-----|
| Poly(methyl methacrylate) (isotactic) | 200000                     | 264000                     | 127000                     | Acetonitrile                | 267.15 |                        | 16     |     |     |
|                                       |                            |                            | 970000                     | Acetonitrile                | 303.15 |                        | 16     |     |     |
|                                       |                            |                            | 50000                      | 1-Butanol                   | 353.25 |                        | 2      |     |     |
|                                       |                            |                            | infinite                   | 2-Butanone                  |        | 482                    | 80     |     |     |
|                                       |                            |                            | infinite                   | 1-Chlorobutane              | 320    | 463                    | 80     |     |     |
|                                       |                            |                            | 970000                     | 2,2-Dimethyl-3-pentanone    | 301.55 |                        | 16     |     |     |
|                                       |                            |                            | 127000                     | 2,4-Dimethyl-3-pentanone    | 280.15 |                        | 16     |     |     |
|                                       |                            |                            | 200000                     | 2-Ethoxyethanol             | 312.15 |                        | 196    |     |     |
|                                       |                            |                            | 77000                      | Ethyl acetate               | 290    | 533                    | 190    |     |     |
|                                       |                            |                            | 127000                     | 2-Ethylbutanal              | 264.65 |                        | 16     |     |     |
|                                       |                            |                            | infinite                   | 3-Heptanone                 | 307.7  |                        | 126    |     |     |
|                                       |                            |                            | 970000                     | 4-Heptanone                 | 299.95 |                        | 16     |     |     |
|                                       |                            |                            | infinite                   | 3-Hexanone                  |        | 522                    | 80     |     |     |
|                                       |                            |                            | infinite                   | Methyl acetate              |        | 451                    | 80     |     |     |
|                                       |                            |                            | 50000                      | 1-Methyl-4-isopropylbenzene | 400.15 |                        | 2      |     |     |
|                                       |                            |                            | 1400000                    | 2-Octanone                  | 321.15 |                        | 16     |     |     |
|                                       |                            |                            | 572400                     | 3-Octanone                  | 329.88 |                        | 166    |     |     |
|                                       |                            |                            | infinite                   | 3-Pentanone                 |        | 506                    | 80     |     |     |
|                                       |                            |                            | 50000                      | 1-Propanol                  | 349.95 |                        | 2      |     |     |
|                                       |                            |                            | infinite                   | 2-Propanone                 |        | 439                    | 80     |     |     |
|                                       |                            |                            | 200000                     | 264000                      |        | Tetra(ethylene glycol) | 390.15 |     | 196 |
|                                       |                            |                            | 400000                     |                             |        | Toluene                | 225.35 |     | 2   |
|                                       |                            |                            | 50000                      |                             |        | Trichloromethane       | 231.15 |     | 2   |
|                                       |                            |                            | 200000                     | 264000                      |        | Tri(ethylene glycol)   | 407.15 |     | 196 |
|                                       |                            |                            | infinite                   |                             |        | Acetonitrile           | 301    | 461 | 80  |
|                                       |                            |                            | infinite                   |                             |        | 2-Butanone             |        | 464 | 80  |
|                                       |                            |                            | infinite                   |                             |        | 1-Chlorobutane         | 309    | 454 | 80  |
|                                       |                            |                            | infinite                   |                             |        | 4-Heptanone            | 319    | 522 | 80  |
|                                       |                            |                            | infinite                   |                             |        | 3-Hexanone             | 279    | 511 | 80  |
|                                       |                            |                            | infinite                   |                             |        | Methyl acetate         |        | 441 | 80  |
|                                       |                            |                            | infinite                   |                             |        | 3-Pentanone            |        | 497 | 80  |
|                                       |                            |                            | infinite                   |                             |        | 2-Propanone            |        | 428 | 80  |
| Poly(4-methyl-1-pentene) (isotactic)  | 152000                     | 152000                     | 152000                     | Butane                      |        | 388                    | 102    |     |     |
|                                       |                            |                            | 152000                     | Cyclopentane                |        | 505                    | 102    |     |     |
|                                       |                            |                            | 152000                     | 2,2-Dimethylbutane          |        | 462                    | 102    |     |     |
|                                       |                            |                            | 152000                     | 2,2-Dimethylpentane         |        | 499                    | 102    |     |     |
|                                       |                            |                            | 152000                     | 2,4-Dimethylpentane         |        | 499                    | 102    |     |     |
|                                       |                            |                            | infinite                   | Diphenyl                    | 467.8  |                        | 62     |     |     |
|                                       |                            |                            | infinite                   | Diphenyl ether              | 483.2  |                        | 62     |     |     |
|                                       |                            |                            | infinite                   | Diphenylmethane             | 449.8  |                        | 62     |     |     |
|                                       |                            |                            | 152000                     | 3-Ethylpentane              |        | 532                    | 102    |     |     |
|                                       |                            |                            | 152000                     | Heptane                     |        | 522                    | 102    |     |     |
|                                       |                            |                            | 152000                     | Hexane                      |        | 487                    | 102    |     |     |
|                                       |                            |                            | 152000                     | 2-Methylbutane              |        | 431                    | 102    |     |     |
|                                       |                            |                            | 152000                     | Nonane                      |        | 579                    | 102    |     |     |
|                                       |                            |                            | 152000                     | Octane                      |        | 553                    | 102    |     |     |
|                                       |                            |                            | 152000                     | Pentane                     |        | 441                    | 102    |     |     |
|                                       |                            |                            | 152000                     | 2,2,3-Trimethylbutane       |        | 521                    | 102    |     |     |

| Polymer                        | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent                            | UCST/K | LCST/K | Ref |
|--------------------------------|----------------------------|----------------------------|-------------------------------|------------------------------------|--------|--------|-----|
| Poly( $\alpha$ -methylstyrene) | 58500                      | 61400                      |                               | Butyl acetate                      | 262.05 | 457.15 | 181 |
|                                | 99100                      | 113000                     |                               | Cyclohexane                        | 293.55 |        | 152 |
|                                | 26000                      | 31200                      |                               | Cyclopentane                       | 276.7  | 435.95 | 181 |
|                                |                            | 289000                     |                               | <i>trans</i> -Decahydronaphthalene | 273    |        | 181 |
|                                | 69500                      | 76500                      |                               | Hexyl acetate                      | 285.05 | 508.15 | 181 |
|                                | 72000                      | 75600                      |                               | Methylcyclohexane                  | 328.9  |        | 203 |
|                                | 58500                      | 61400                      |                               | Pentyl acetate                     | 287.1  | 484.6  | 181 |
|                                |                            |                            |                               |                                    |        |        |     |
| Poly(2-methyl-5-vinylpyridine) |                            |                            | 600000                        | Butyl acetate                      | 287.95 |        | 20  |
|                                |                            |                            | 263000                        | Ethyl butyrate                     | 319.05 |        | 20  |
|                                |                            |                            | 335000                        | Ethyl propionate                   | 293.55 |        | 20  |
|                                |                            |                            | 275000                        | 3-Methylbutyl acetate              | 314.75 |        | 20  |
|                                |                            |                            | 335000                        | 4-Methyl-2-pentanone               | 299.95 |        | 20  |
|                                |                            |                            | 170000                        | 2-Methylpropyl acetate             | 312.35 |        | 20  |
|                                |                            |                            | 165000                        | Pentyl acetate                     | 316.95 |        | 20  |
|                                |                            |                            | 284000                        | Propionitrile                      | 262.35 |        | 20  |
|                                |                            |                            | 152000                        | Propyl acetate                     | 282.65 |        | 20  |
|                                |                            |                            | 181000                        | Propyl propionate                  | 312.15 |        | 20  |
|                                |                            |                            | 233000                        | Tetrahydronaphthalene              | 316.95 |        | 20  |
|                                |                            |                            |                               |                                    |        |        |     |
| Poly(1-pentene) (isotactic)    |                            |                            | 4500000                       | Cyclopentane                       |        | 502    | 102 |
|                                |                            |                            | 4500000                       | 2,2-Dimethylbutane                 |        | 457    | 102 |
|                                |                            |                            | 4500000                       | 3,4-Dimethylhexane                 |        | >569   | 102 |
|                                |                            |                            | 4500000                       | 2,2-Dimethylpentane                |        | 502    | 102 |
|                                |                            |                            | 4500000                       | 2,3-Dimethylpentane                |        | 529    | 102 |
|                                |                            |                            | 4500000                       | 2,4-Dimethylpentane                |        | 493    | 102 |
|                                |                            |                            | 4500000                       | 3-Ethylpentane                     |        | 537    | 102 |
|                                |                            |                            | 4500000                       | Heptane                            |        | 522    | 102 |
|                                |                            |                            | 4500000                       | Hexane                             |        | 482    | 102 |
|                                |                            |                            | 4500000                       | 2-Methylbutane                     |        | 422    | 102 |
|                                |                            |                            | 4500000                       | Octane                             |        | 556    | 102 |
|                                |                            |                            | 4500000                       | Pentane                            |        | 433    | 102 |
|                                |                            |                            | 4500000                       | 2,2,4-Trimethylpentane             |        | 527    | 102 |
|                                |                            |                            |                               |                                    |        |        |     |
|                                |                            |                            |                               |                                    |        |        |     |
| Polypropylene (atactic)        | infinite                   |                            |                               | Diphenyl ether                     | 426.5  |        | 9   |
|                                | infinite                   |                            |                               | Diethyl ether                      |        | 383    | 68  |
|                                |                            |                            | 242000                        | Heptane                            |        | 511    | 101 |
|                                | infinite                   |                            |                               | Hexane                             |        | 441    | 68  |
|                                |                            |                            | 242000                        | 2-Methylbutane                     |        | 413    | 101 |
|                                |                            |                            | 242000                        | Methylcyclohexane                  |        | 564    | 101 |
|                                | infinite                   |                            |                               | Pentane                            |        | 397    | 68  |
|                                |                            |                            |                               |                                    |        |        |     |
| Polypropylene (isotactic)      |                            |                            | 28000                         | Benzyl phenyl ether                | 429.2  |        | 31  |
|                                |                            |                            | 28000                         | Benzyl propionate                  | 405.2  |        | 31  |
|                                |                            |                            | 28000                         | 1-Butanol                          | 395.2  |        | 31  |
|                                |                            |                            | 28000                         | 4- <i>tert</i> -Butylphenol        | 413.2  |        | 31  |
|                                |                            |                            | 242000                        | Cyclohexane                        |        | 540    | 101 |
|                                |                            |                            | 242000                        | Cyclopentane                       |        | 495    | 101 |
|                                |                            |                            | 28000                         | Dibenzyl ether                     | 433.2  |        | 31  |
|                                |                            |                            |                               |                                    |        |        |     |

| Polymer                | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent                         | UCST/K                     | LCST/K | Ref |
|------------------------|----------------------------|----------------------------|-------------------------------|---------------------------------|----------------------------|--------|-----|
|                        |                            |                            |                               | 242000                          | 2,2-Dimethylbutane         | 441    | 101 |
|                        |                            |                            |                               | 242000                          | 2,3-Dimethylbutane         | 465    | 101 |
|                        |                            |                            |                               | 242000                          | 3,4-Dimethylhexane         | 553    | 101 |
|                        |                            |                            |                               | 242000                          | 2,2-Dimethylpentane        | 489    | 101 |
|                        |                            |                            |                               | 242000                          | 2,3-Dimethylpentane        | 513    | 101 |
|                        |                            |                            |                               | 242000                          | 2,4-Dimethylpentane        | 481    | 101 |
|                        |                            |                            |                               | 28000                           | Diphenyl                   | 388.2  | 31  |
|                        |                            |                            |                               | 28000                           | Diphenyl ether             | 395.2  | 31  |
|                        |                            |                            |                               | 28000                           | Diphenylmethane            | 389.7  | 31  |
|                        |                            |                            |                               | 242000                          | 3-Ethylpentane             | 520    | 101 |
|                        |                            |                            |                               | 28000                           | 4-Ethylphenol              | 457.2  | 31  |
|                        |                            |                            |                               | 242000                          | Heptane                    | 511    | 101 |
|                        |                            |                            |                               | 242000                          | Hexane                     | 470    | 101 |
|                        |                            |                            |                               | 242000                          | 2-Methylbutane             | 413    | 101 |
|                        |                            |                            |                               | 28000                           | 3-Methylbutyl benzyl ether | 384.2  | 31  |
|                        |                            |                            |                               | 242000                          | Methylcyclohexane          | 564    | 101 |
|                        |                            |                            |                               | 242000                          | Methylcyclopentane         | 518    | 101 |
|                        |                            |                            |                               | 28000                           | 4-Methylphenol             | 479.2  | 31  |
|                        |                            |                            |                               | 28000                           | 2-Methyl-1-propanol        | 395.2  | 31  |
|                        |                            |                            |                               | 242000                          | Nonane                     | 571    | 101 |
|                        |                            |                            |                               | 242000                          | Octane                     | 542    | 101 |
|                        |                            |                            |                               | 28000                           | 4-Octylphenol              | 379.2  | 31  |
|                        |                            |                            |                               | 28000                           | 4-Isooctylphenol           | 383.2  | 31  |
|                        |                            |                            |                               | 242000                          | Pentane                    | 422    | 101 |
|                        |                            |                            |                               | 242000                          | 2,2,4,4-Tetramethylpentane | 548    | 101 |
|                        |                            |                            |                               | 242000                          | 2,2,3-Trimethylbutane      | 511    | 101 |
|                        |                            |                            |                               | 242000                          | 2,3,4-Trimethylhexane      | 585    | 101 |
|                        |                            |                            |                               | 242000                          | 2,2,4-Trimethylpentane     | 510    | 101 |
| Poly(propylene glycol) | 1000                       |                            |                               | Hexane                          | 288.15                     |        | 88  |
|                        | 575                        |                            |                               | Water                           |                            | 318.2  | 65  |
| Polystyrene            | 34900                      | 37000                      |                               | Benzene                         |                            | 538.7  | 61  |
|                        |                            |                            |                               | Butanedioic acid dimethyl ester | 335.15                     |        | 2   |
|                        | 3700                       | 4000                       |                               | 1-Butanol                       | 383.45                     |        | 154 |
|                        | 91700                      | 97200                      |                               | 2-Butanone                      |                            | 448.8  | 61  |
|                        | 545500                     | 600000                     |                               | Butyl acetate                   |                            | 489    | 181 |
|                        | 104000                     | 110000                     |                               | <i>tert</i> -Butyl acetate      | 250.0                      | 417.9  | 74  |
|                        |                            |                            | 62600                         | Butyl stearate                  | 387.15                     |        | 2   |
|                        | 18400                      | 19200                      |                               | 1-Chlorododecane                | 274.65                     |        | 154 |
|                        | 18400                      | 19200                      |                               | 1-Chlorohexadecane              | 337.05                     |        | 154 |
|                        | 18400                      | 19200                      |                               | 1-Chlorooctadecane              | 365.55                     |        | 154 |
|                        | 18400                      | 19200                      |                               | 1-Chlorotetradecane             | 309.35                     |        | 154 |
|                        | 46400                      | 51000                      |                               | Cyclodecane                     | 278.9                      |        | 128 |
|                        | 46400                      | 51000                      |                               | Cycloheptane                    | 276.2                      |        | 128 |
|                        | 34900                      | 37000                      |                               | Cyclohexane                     | 285.6                      | 510.9  | 60  |
|                        |                            |                            |                               | Cyclohexanol                    | 353.5                      |        | 8   |
|                        | 46400                      | 51000                      |                               | Cyclooctane                     | 275.2                      |        | 128 |
|                        | 91700                      | 97200                      |                               | Cyclopentane                    | 275.2                      | 445.5  | 61  |

| Polymer | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup>          | Solvent                            | UCST/K | LCST/K | Ref |
|---------|----------------------------|----------------------------|-------------------------------------|------------------------------------|--------|--------|-----|
|         | 91500                      | 97000                      |                                     | <i>trans</i> -Decahydronaphthalene | 281.95 |        | 81  |
|         |                            | 4800                       |                                     | Decane                             | 360.95 |        | 154 |
|         | 3700                       | 4000                       |                                     | 1-Decanol                          | 375.15 |        | 154 |
|         |                            |                            | 570000                              | Decyl acetate                      |        | 650    | 64  |
|         | 18700                      | 19800                      |                                     | Diethyl ether                      | 235.6  | 314.5  | 51  |
|         | 187000                     | 200000                     |                                     | Diethyl malonate                   | 285.8  | 589.6  | 74  |
|         | 47200                      | 50000                      |                                     | Diethyl oxalate                    | 280.05 |        | 131 |
|         | 151000                     | 160000                     |                                     | Dimethoxymethane                   |        | 401.2  | 51  |
|         |                            | 240000                     |                                     | 1,4-Dimethylcyclohexane            | 387    | 482    | 116 |
|         |                            |                            | 62600                               | Dimethyl malonate                  | 409.15 |        | 2   |
|         |                            |                            | 62600                               | Dimethyl oxalate                   | 453.15 |        | 2   |
|         | 116000                     | 123000                     | Dodecadeutero-cyclohexane           | 298.10                             |        | 224    |     |
|         |                            | 25000                      | Dodecadeuteromethyl-cyclopentane    | 310.07                             |        | 180    |     |
|         |                            | 4800                       | Dodecane                            | 368.65                             |        | 154    |     |
|         | 3700                       | 4000                       | 1-Dodecanol                         | 379.75                             |        | 154    |     |
|         | infinite                   |                            | Dodecyl acetate                     | 285.2                              |        | 206    |     |
|         | 104000                     | 110000                     | Ethyl acetate                       | 213.9                              | 435.4  | 72     |     |
|         | 104000                     | 110000                     | Ethyl butanoate                     |                                    | 490.8  | 74     |     |
|         | 221000                     | 239000                     | Ethylcyclohexane                    | 330.52                             |        | 18     |     |
|         | 9440                       | 10000                      | Ethyl formate                       | 272                                | 451    | 74     |     |
|         |                            | 900000                     | Bis(2-ethylhexyl) phthalate         | 283.05                             |        | 136    |     |
|         | 4530                       | 4800                       | Heptane                             | 359                                | 477    | 112    |     |
|         | 3700                       | 4000                       | 1-Dexadecanol                       | 386.25                             |        | 154    |     |
|         | 5500                       | 5770                       | 1,1,1,3,3,3-Hexadeutero-2-propanone | 270                                | 436    | 157    |     |
|         | 1920                       | 2030                       | Hexane                              | 318                                | 470    | 112    |     |
|         |                            |                            | 62600                               | Hexanoic acid                      | 448.15 |        | 2   |
|         | 3700                       | 4000                       | 1-Hexanol                           | 372.15                             |        | 154    |     |
|         |                            |                            | 62600                               | 3-Hexanol                          | 396.65 |        | 2   |
|         |                            |                            | 90000                               | Hexyl acetate                      |        | 578    | 64  |
|         | 104000                     | 110000                     | Methyl acetate                      | 284.2                              | 415.7  | 72     |     |
|         | 104000                     | 110000                     | 3-Methyl-1-butyl acetate            | 210.1                              | 510.1  | 72     |     |
|         | 91700                      | 97200                      | Methylcyclohexane                   | 321.8                              | 505.9  | 60     |     |
|         | 10750                      | 11500                      | Methylcyclopentane                  | 295                                | 480    | 157    |     |
|         | 104000                     | 110000                     | 2-Methyl-1-propyl acetate           | 210.4                              | 468.5  | 72     |     |
|         |                            | 48000                      | Nitroethane                         | 303.1                              |        | 151    |     |
|         |                            | 4800                       | Octadecane                          | 403.55                             |        | 154    |     |
|         | 3700                       | 4000                       | 1-Octadecanol                       | 390.55                             |        | 154    |     |
|         | 4530                       | 4800                       | Octane                              | 353                                | 527    | 112    |     |
|         | 3700                       | 4000                       | 1-Octanol                           | 372.35                             |        | 154    |     |
|         |                            |                            | 62600                               | 1-Octene                           | 355.15 |        | 2   |
|         |                            | 4800                       | Pentadecane                         | 385.25                             |        | 154    |     |
|         |                            | 1100                       | Pentane                             | 292                                |        | 137    |     |
|         | 3700                       | 4000                       | 1-Pentanol                          | 375.05                             |        | 154    |     |
|         | 219800                     | 233000                     | Pentyl acetate                      |                                    | 519    | 181    |     |
|         |                            | 100000                     | 1-Phenyldecane                      | 283.60                             |        | 105    |     |
|         | 5500                       | 5770                       | 2-Propanone                         | 251                                | 452    | 157    |     |
|         | 12750                      | 13500                      | Propionitrile                       | 312                                |        | 187    |     |
|         | 104000                     | 110000                     | Propyl acetate                      | 183.7                              | 469.0  | 72     |     |
|         | 104000                     | 110000                     | 2-Propyl acetate                    | 220.9                              | 414.2  | 72     |     |

| Polymer                                                                        | $M_n$ /g mol <sup>-1</sup> | $M_w$ /g mol <sup>-1</sup> | $M_\eta$ /g mol <sup>-1</sup> | Solvent                               | UCST/K | LCST/K | Ref |
|--------------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------|---------------------------------------|--------|--------|-----|
| Polystyrene (three-arm star)                                                   | 3700                       | 4000                       | 62600                         | 1-Tetradecanol                        | 383.25 |        | 154 |
|                                                                                | 34900                      | 37000                      |                               | Toluene                               |        | 567.2  | 60  |
|                                                                                |                            |                            |                               | Vinyl acetate                         | 384.15 |        | 2   |
|                                                                                |                            | 230000                     |                               | Cyclohexane                           | 297.1  | 496.8  | 93  |
|                                                                                |                            | 155000                     |                               | Cyclohexane                           | 294.13 |        | 199 |
|                                                                                |                            | infinite                   |                               | Cyclohexane                           | 300    |        | 79  |
|                                                                                |                            | 40000                      |                               | Water                                 |        | 514    | 45  |
|                                                                                |                            | 150000                     |                               | Water                                 |        | 306.45 | 217 |
|                                                                                | 55000                      |                            |                               | Dibutyl phthalate                     | 353    |        | 114 |
|                                                                                | 55000                      |                            |                               | Tricresyl phosphate                   | 383    |        | 114 |
| Poly( <i>N</i> -vinylisobutyramide)                                            |                            |                            | 85000                         | Dimethyl phthalate                    | 355    |        | 219 |
|                                                                                | 66000                      | 105600                     |                               | Water                                 |        | 313.25 | 208 |
|                                                                                |                            |                            |                               |                                       |        |        |     |
| Poly(vinyl methyl ether)                                                       | 46500                      | 98600                      |                               | Deuterium oxide                       |        | 307.2  | 173 |
|                                                                                | 83000                      | 155000                     |                               | Water                                 |        | 306.95 | 146 |
|                                                                                |                            |                            |                               |                                       |        |        |     |
| Poly( <i>N</i> -vinyl- <i>N</i> -propylacetamide)                              |                            |                            | 30000                         | Water                                 |        | 313.5  | 176 |
|                                                                                |                            |                            |                               |                                       |        |        |     |
|                                                                                |                            |                            |                               |                                       |        |        |     |
| Styrene/acrylonitrile copolymer<br>(21.1 wt% acrylonitrile)                    | infinite                   |                            |                               | Toluene                               | 325.4  |        | 52  |
|                                                                                | infinite                   |                            |                               | Toluene                               | 355.1  |        | 52  |
|                                                                                | 90000                      | 147000                     |                               | Toluene                               | 313.15 |        | 198 |
|                                                                                |                            | 347000                     |                               | Ethyl acetate                         |        | 344.15 | 107 |
| Styrene/methyl methacrylate copolymer<br>(52.0 mol% Styrene)                   |                            |                            |                               |                                       |        |        |     |
|                                                                                |                            | infinite                   |                               | Cyclohexanol                          | 334.65 |        | 38  |
| Styrene/ $\alpha$ -methylstyrene copolymer<br>(20.0 mol% Styrene)              |                            |                            |                               |                                       |        |        |     |
|                                                                                | 100000                     | 114000                     |                               | Butyl acetate                         | 288.85 | 453.05 | 181 |
|                                                                                | 100000                     | 114000                     |                               | Cyclohexane                           | 285.85 | 484.85 | 181 |
|                                                                                | 100000                     | 114000                     |                               | Cyclopentane                          | 290.95 | 421.05 | 181 |
|                                                                                | 100000                     | 114000                     |                               | <i>trans</i> -Decahydronaphthalene    | 264.15 |        | 181 |
|                                                                                | 100000                     | 114000                     |                               | Hexyl acetate                         | 288.55 | 514.15 | 181 |
|                                                                                | 100000                     | 114000                     |                               | Pentyl acetate                        | 303.15 | 480.65 | 181 |
| Trifluoronitrosomethane/<br>tetrafluoroethylene copolymer (1:1)<br>alternating |                            |                            |                               |                                       |        |        |     |
|                                                                                | infinite                   |                            |                               | 1,1,2-Trichloro-1,2,2-trifluoroethane | 301.6  |        | 12  |
| <i>N</i> -Vinylacetamide/vinyl acetate copolymer<br>(58 mol% Vinyl acetate)    |                            |                            |                               |                                       |        |        |     |
|                                                                                | 30000                      | 57000                      |                               | Water                                 |        | 340.15 | 225 |
|                                                                                | 27000                      | 48600                      |                               | Water                                 |        | 323.15 | 225 |
|                                                                                | 26000                      | 46800                      |                               | Water                                 |        | 282.15 | 225 |
| Vinyl alcohol/vinyl butyrate copolymer<br>(7.5 mol% Butyralized PVA)           |                            |                            |                               |                                       |        |        |     |
|                                                                                | infinite                   |                            |                               | Water                                 | 408.0  | 298.25 | 121 |

| Polymer                                                                              | $M_n/g\text{ mol}^{-1}$ | $M_w/g\text{ mol}^{-1}$ | $M_v/g\text{ mol}^{-1}$ | Solvent | UCST/K | LCST/K | Ref |
|--------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|---------|--------|--------|-----|
| <i>N</i> -Vinylcaprolactam/ <i>N</i> -vinylamine<br>copolymer (3.8 mol% Vinyl amine) |                         |                         | 160000                  | Water   |        | 308.8  | 176 |
| <i>N</i> -Vinylformamide/vinyl acetate copolymer                                     |                         |                         |                         |         |        |        |     |
| (60 mol% Vinyl acetate)                                                              | 24000                   | 45600                   |                         | Water   |        | 310.15 | 225 |
| (66 mol% Vinyl acetate)                                                              | 25000                   | 47500                   |                         | Water   |        | 291.15 | 225 |
| (73 mol% Vinyl acetate)                                                              | 23000                   | 50600                   |                         | Water   |        | 277.15 | 225 |

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# VAPOR PRESSURES (SOLVENT ACTIVITIES) FOR BINARY POLYMER SOLUTIONS

Christian Wohlfarth

The vapor pressure of a binary polymer solution is given by the activity of the solvent A,  $a_A$ . Solvent activities in polymer solutions are measured either by the isopiestic method applying a reference system whose solvent activity is precisely known or by determining the solvent partial pressure,  $P_A$ , and calculating the activity of the solvent by equation (1):

$$a_A = (P_A/P_A^s) \exp \left[ \frac{(B_{AA} - V_A^L)(P - P_A^s)}{RT} \right] \quad (1)$$

where  $B_{AA}$  is the second virial coefficient,  $P_A^s$  is the saturation vapor pressure, and  $V_A^L$  is the molar volume of the pure solvent A at the measuring temperature  $T$ . The exponential term is neglected in quite a lot of original papers, however, and only the reduced vapor pressures are given (such data are indicated by an asterisk in the table below). Vapor pressures of polymer solutions have been measured since the 1940s, but the amount of experimental data for polymer solutions is still relatively small in comparison to low-molecular mixtures and solutions. The data scatter with respect to temperature, concentration, molar mass, and other polymer characterization variables. Furthermore, the concentration range for measuring vapor pressures in good thermodynamic quality is often limited to the polymer mass fraction range between 0.4 and 0.85. A recent review on methods for the measurement of vapor pressures/solvent activities of polymer solutions and on related problems is given in Ref. [1]. Experimental data have been collected in several books [2-6].

The table in this *Handbook* provides data for a number of polymer solutions as smoothed values over the complete range of solvent activities between 0 (polymer mass fraction = 1) and 1 (polymer mass fraction = 0). For this purpose, the data were selected from data books [4-6] as well as from a number of original sources [7-22] which are not included in these books. The appropriate data were smoothed. The final table provides then the polymer mass fractions at given fixed solvent activities between 0.1 and 0.9. Of course, the user must keep in mind that the activity vs. concentration range of the experimental data is sometimes smaller than the below given complete range, thus the smoothed data should be used with sufficient care.

Generally, vapor pressures or solvent activities of binary polymer solutions depend on molar mass. However, for high molecular weight polymers (well above the oligomer region), this molar-mass dependence can be neglected in many cases. Therefore, the table below presents only data for polymer solutions where the number average molar mass,  $M_n$ , is in the order of  $10^5$  g/mol or even higher, therefore, the molar mass is not specified. The temperature is

stated, even though the temperature dependence of  $a_A$  is relatively small for the temperature ranges where most of the experimental data exist.

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Solvent Activity  $a_A$  as Function of Temperature and Mass Fraction

| Polymer/<br>solvents                                          | $a_A$ :<br>T/K | 0.1   | 0.2   | 0.3   | 0.4   | 0.5   | 0.6   | 0.7   | 0.8   | 0.9   |
|---------------------------------------------------------------|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mass Fraction of the Polymer                                  |                |       |       |       |       |       |       |       |       |       |
| <i>Acrylonitrile/Styrene Copolymer (28 wt% Acrylonitrile)</i> |                |       |       |       |       |       |       |       |       |       |
| Benzene <sup>a)</sup>                                         | 343.15         | 0.982 | 0.962 | 0.940 | 0.915 | 0.886 | 0.851 | 0.809 | 0.753 | 0.670 |
| 1,2-Dimethylbenzene <sup>a)</sup>                             | 398.15         | 0.983 | 0.964 | 0.942 | 0.918 | 0.890 | 0.857 | 0.817 | 0.764 | 0.685 |
| 1,3-Dimethylbenzene <sup>a)</sup>                             | 398.15         | 0.983 | 0.965 | 0.944 | 0.921 | 0.893 | 0.861 | 0.821 | 0.769 | 0.690 |
| 1,4-Dimethylbenzene <sup>a)</sup>                             | 398.15         | 0.983 | 0.964 | 0.942 | 0.918 | 0.890 | 0.857 | 0.817 | 0.763 | 0.684 |
| Propylbenzene <sup>a)</sup>                                   | 398.15         | 0.987 | 0.972 | 0.955 | 0.935 | 0.913 | 0.885 | 0.851 | 0.804 | 0.732 |
| Toluene <sup>a)</sup>                                         | 343.15         | 0.982 | 0.962 | 0.940 | 0.915 | 0.886 | 0.851 | 0.809 | 0.753 | 0.669 |

| Polymer/<br>solvents                                       | $a_A$ :<br>T/K | 0.1   | 0.2   | 0.3   | 0.4   | 0.5   | 0.6   | 0.7   | 0.8   | 0.9   |
|------------------------------------------------------------|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mass Fraction of the Polymer                               |                |       |       |       |       |       |       |       |       |       |
| <b><i>Butadiene/Styrene Copolymer (41 wt% Styrene)</i></b> |                |       |       |       |       |       |       |       |       |       |
| Benzene <sup>a)</sup>                                      | 343.15         | 0.968 | 0.934 | 0.896 | 0.853 | 0.805 | 0.748 | 0.680 | 0.591 | 0.461 |
| Cyclohexane <sup>a)</sup>                                  | 343.15         | 0.978 | 0.953 | 0.925 | 0.893 | 0.856 | 0.811 | 0.754 | 0.678 | 0.556 |
| Ethylbenzene <sup>a)</sup>                                 | 398.15         | 0.974 | 0.945 | 0.912 | 0.875 | 0.831 | 0.779 | 0.713 | 0.625 | 0.491 |
| Mesitylene <sup>a)</sup>                                   | 398.15         | 0.977 | 0.950 | 0.921 | 0.887 | 0.847 | 0.799 | 0.738 | 0.656 | 0.526 |
| Toluene <sup>a)</sup>                                      | 343.15         | 0.970 | 0.936 | 0.899 | 0.857 | 0.808 | 0.751 | 0.682 | 0.591 | 0.456 |
| <b><i>Cellulose Triacetate</i></b>                         |                |       |       |       |       |       |       |       |       |       |
| Dichloromethane                                            | 298.15         | 0.979 | 0.956 | 0.930 | 0.899 | 0.863 | 0.819 | 0.762 | 0.683 | 0.554 |
| Trichloromethane                                           | 298.15         | 0.978 | 0.953 | 0.924 | 0.892 | 0.853 | 0.806 | 0.747 | 0.665 | 0.533 |
| <b><i>Dextran</i></b>                                      |                |       |       |       |       |       |       |       |       |       |
| Water                                                      | 313.15         | 0.988 | 0.975 | 0.960 | 0.942 | 0.921 | 0.894 | 0.860 | 0.810 | 0.725 |
| <b><i>Hydroxyethylcellulose</i></b>                        |                |       |       |       |       |       |       |       |       |       |
| Water                                                      | 368.15         | 0.988 | 0.974 | 0.958 | 0.939 | 0.915 | 0.884 | 0.841 | 0.775 | 0.650 |
| <b><i>Hydroxypropylstarch</i></b>                          |                |       |       |       |       |       |       |       |       |       |
| Water                                                      | 293.15         | 0.989 | 0.977 | 0.963 | 0.947 | 0.927 | 0.903 | 0.872 | 0.827 | 0.749 |
| <b><i>Nitrocellulose</i></b>                               |                |       |       |       |       |       |       |       |       |       |
| Ethyl acetate                                              | 293.15         | 0.938 | 0.885 | 0.835 | 0.786 | 0.737 | 0.685 | 0.627 | 0.560 | 0.471 |
| Ethyl formate                                              | 293.15         | 0.958 | 0.916 | 0.873 | 0.828 | 0.780 | 0.728 | 0.668 | 0.595 | 0.494 |
| Ethyl propionate                                           | 293.15         | 0.941 | 0.889 | 0.839 | 0.789 | 0.739 | 0.685 | 0.625 | 0.555 | 0.460 |
| Methyl acetate                                             | 293.15         | 0.890 | 0.820 | 0.763 | 0.711 | 0.660 | 0.609 | 0.554 | 0.490 | 0.406 |
| 2-Propanone                                                | 293.15         | 0.922 | 0.861 | 0.807 | 0.756 | 0.706 | 0.653 | 0.596 | 0.530 | 0.443 |
| Propyl acetate                                             | 293.15         | 0.937 | 0.881 | 0.827 | 0.775 | 0.722 | 0.665 | 0.602 | 0.528 | 0.426 |
| <b><i>Polybutadiene (random cis-trans-vinyl)</i></b>       |                |       |       |       |       |       |       |       |       |       |
| Benzene                                                    | 298.15         | 0.964 | 0.925 | 0.884 | 0.839 | 0.788 | 0.731 | 0.663 | 0.578 | 0.455 |
| Cyclohexane                                                | 298.15         | 0.974 | 0.945 | 0.913 | 0.876 | 0.833 | 0.782 | 0.719 | 0.635 | 0.507 |
| Dichloromethane                                            | 298.15         | 0.951 | 0.902 | 0.852 | 0.800 | 0.745 | 0.684 | 0.616 | 0.532 | 0.415 |
| Hexane                                                     | 298.15         | 0.984 | 0.965 | 0.943 | 0.916 | 0.881 | 0.837 | 0.775 | 0.683 | 0.534 |
| Tetrachloromethane                                         | 298.15         | 0.932 | 0.865 | 0.799 | 0.731 | 0.660 | 0.585 | 0.503 | 0.409 | 0.288 |
| Toluene                                                    | 298.15         | 0.969 | 0.935 | 0.898 | 0.856 | 0.809 | 0.754 | 0.688 | 0.603 | 0.476 |
| Trichloromethane                                           | 298.15         | 0.925 | 0.855 | 0.788 | 0.720 | 0.650 | 0.578 | 0.498 | 0.406 | 0.289 |
| <b><i>1,4-cis-Polybutadiene</i></b>                        |                |       |       |       |       |       |       |       |       |       |
| Benzene                                                    | 298.15         | 0.966 | 0.930 | 0.890 | 0.846 | 0.796 | 0.738 | 0.668 | 0.580 | 0.450 |
| Cyclohexane                                                | 298.15         | 0.977 | 0.951 | 0.922 | 0.888 | 0.849 | 0.803 | 0.747 | 0.677 | 0.581 |
| Dichloromethane                                            | 298.15         | 0.948 | 0.898 | 0.848 | 0.796 | 0.742 | 0.683 | 0.616 | 0.536 | 0.424 |
| Hexane                                                     | 298.15         | 0.983 | 0.963 | 0.941 | 0.916 | 0.886 | 0.850 | 0.804 | 0.741 | 0.639 |
| Tetrachloromethane                                         | 298.15         | 0.936 | 0.871 | 0.805 | 0.736 | 0.665 | 0.588 | 0.505 | 0.409 | 0.287 |
| Toluene                                                    | 298.15         | 0.969 | 0.936 | 0.900 | 0.860 | 0.815 | 0.763 | 0.701 | 0.622 | 0.506 |
| Trichloromethane                                           | 298.15         | 0.915 | 0.840 | 0.770 | 0.702 | 0.634 | 0.562 | 0.485 | 0.396 | 0.283 |
| <b><i>Poly(butyl acrylate)</i></b>                         |                |       |       |       |       |       |       |       |       |       |
| Benzene                                                    | 298.15         | 0.964 | 0.926 | 0.887 | 0.845 | 0.799 | 0.749 | 0.691 | 0.619 | 0.519 |
| Dichloromethane                                            | 298.15         | 0.868 | 0.801 | 0.744 | 0.690 | 0.636 | 0.577 | 0.511 | 0.430 | 0.318 |
| Tetrachloromethane                                         | 298.15         | 0.932 | 0.868 | 0.805 | 0.742 | 0.677 | 0.607 | 0.529 | 0.438 | 0.317 |
| Toluene                                                    | 298.15         | 0.967 | 0.932 | 0.893 | 0.849 | 0.801 | 0.744 | 0.676 | 0.590 | 0.463 |
| Trichloromethane                                           | 298.15         | 0.901 | 0.811 | 0.733 | 0.662 | 0.595 | 0.529 | 0.459 | 0.381 | 0.282 |
| <b><i>Poly(butyl methacrylate)</i></b>                     |                |       |       |       |       |       |       |       |       |       |
| Benzene                                                    | 313.15         | 0.971 | 0.939 | 0.902 | 0.861 | 0.813 | 0.756 | 0.685 | 0.592 | 0.453 |
| 1-Butanol                                                  | 313.15         | 0.991 | 0.980 | 0.968 | 0.953 | 0.936 | 0.914 | 0.885 | 0.842 | 0.762 |
| 2-Butanol                                                  | 313.15         | 0.992 | 0.982 | 0.969 | 0.953 | 0.933 | 0.906 | 0.869 | 0.815 | 0.719 |
| 2-Butanone                                                 | 313.15         | 0.982 | 0.963 | 0.940 | 0.914 | 0.884 | 0.846 | 0.799 | 0.732 | 0.623 |
| Butyl acetate <sup>a)</sup>                                | 308.15         | 0.982 | 0.961 | 0.936 | 0.908 | 0.875 | 0.836 | 0.789 | 0.730 | 0.652 |
| Cyclohexane                                                | 313.15         | 0.985 | 0.968 | 0.948 | 0.925 | 0.899 | 0.866 | 0.823 | 0.764 | 0.666 |
| Cyclopentane                                               | 313.15         | 0.984 | 0.965 | 0.944 | 0.918 | 0.886 | 0.846 | 0.792 | 0.714 | 0.579 |
| Diethyl ether <sup>a)</sup>                                | 298.15         | 0.987 | 0.973 | 0.956 | 0.937 | 0.914 | 0.885 | 0.848 | 0.795 | 0.703 |
| 1,4-Dimethylbenzene                                        | 333.15         | 0.971 | 0.940 | 0.905 | 0.866 | 0.822 | 0.770 | 0.706 | 0.622 | 0.497 |
| Ethylbenzene                                               | 333.15         | 0.969 | 0.935 | 0.899 | 0.859 | 0.815 | 0.764 | 0.704 | 0.627 | 0.517 |
| Methyl acetate                                             | 313.15         | 0.984 | 0.965 | 0.944 | 0.920 | 0.891 | 0.856 | 0.811 | 0.748 | 0.645 |

| Polymer/<br>solvents                           | $a_1$ :<br>T/K | 0.1   | 0.2   | 0.3   | 0.4   | 0.5   | 0.6   | 0.7   | 0.8   | 0.9   |
|------------------------------------------------|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mass Fraction of the Polymer                   |                |       |       |       |       |       |       |       |       |       |
| 2-Methyl-1-propanol                            | 333.15         | 0.988 | 0.974 | 0.958 | 0.940 | 0.919 | 0.893 | 0.860 | 0.815 | 0.744 |
| Octane                                         | 313.15         | 0.988 | 0.974 | 0.959 | 0.942 | 0.921 | 0.896 | 0.865 | 0.823 | 0.758 |
| 1-Propanol                                     | 333.15         | 0.990 | 0.980 | 0.967 | 0.952 | 0.934 | 0.911 | 0.881 | 0.834 | 0.746 |
| 2-Propanol                                     | 313.15         | 0.991 | 0.981 | 0.970 | 0.956 | 0.939 | 0.918 | 0.889 | 0.845 | 0.755 |
| 2-Propanone                                    | 313.15         | 0.989 | 0.976 | 0.961 | 0.944 | 0.921 | 0.892 | 0.850 | 0.783 | 0.647 |
| Propyl acetate                                 | 313.15         | 0.980 | 0.957 | 0.932 | 0.903 | 0.870 | 0.830 | 0.780 | 0.714 | 0.612 |
| Toluene                                        | 313.15         | 0.971 | 0.939 | 0.903 | 0.863 | 0.818 | 0.764 | 0.698 | 0.613 | 0.485 |
| <i>Poly(<math>\epsilon</math>-caprolacton)</i> |                |       |       |       |       |       |       |       |       |       |
| Tetrachloromethane <sup>*)</sup>               | 338.15         | 0.956 | 0.910 | 0.864 | 0.815 | 0.762 | 0.704 | 0.637 | 0.554 | 0.438 |
| <i>Poly(dimethylsiloxane)</i>                  |                |       |       |       |       |       |       |       |       |       |
| Chlorodifluoromethane                          | 298.15         | 0.976 | 0.950 | 0.921 | 0.888 | 0.850 | 0.805 | 0.750 | 0.677 | 0.565 |
| Cyclohexane                                    | 303.15         | 0.979 | 0.955 | 0.928 | 0.898 | 0.863 | 0.822 | 0.770 | 0.702 | 0.596 |
| Hexane                                         | 303.15         | 0.982 | 0.962 | 0.939 | 0.912 | 0.880 | 0.842 | 0.793 | 0.724 | 0.611 |
| Pentane                                        | 308.15         | 0.982 | 0.962 | 0.940 | 0.913 | 0.881 | 0.842 | 0.791 | 0.720 | 0.600 |
| Pentane                                        | 423.15         | 0.984 | 0.966 | 0.946 | 0.922 | 0.893 | 0.858 | 0.813 | 0.749 | 0.641 |
| <i>Poly(ethyl acrylate)</i>                    |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 298.15         | 0.970 | 0.939 | 0.904 | 0.866 | 0.823 | 0.774 | 0.716 | 0.641 | 0.533 |
| Dichloromethane                                | 298.15         | 0.900 | 0.830 | 0.768 | 0.709 | 0.648 | 0.584 | 0.512 | 0.427 | 0.313 |
| Tetrachloromethane                             | 298.15         | 0.950 | 0.900 | 0.848 | 0.794 | 0.736 | 0.672 | 0.598 | 0.509 | 0.385 |
| Toluene                                        | 298.15         | 0.972 | 0.942 | 0.910 | 0.874 | 0.833 | 0.786 | 0.730 | 0.659 | 0.555 |
| Trichloromethane                               | 298.15         | 0.866 | 0.776 | 0.701 | 0.632 | 0.566 | 0.499 | 0.428 | 0.349 | 0.248 |
| <i>Poly(ethylene oxide)</i>                    |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 323.15         | 0.972 | 0.942 | 0.908 | 0.869 | 0.824 | 0.771 | 0.706 | 0.620 | 0.490 |
| 2-Butanone                                     | 353.15         | 0.981 | 0.959 | 0.934 | 0.902 | 0.863 | 0.813 | 0.746 | 0.651 | 0.503 |
| Cyclohexane                                    | 353.15         | 0.989 | 0.976 | 0.960 | 0.943 | 0.921 | 0.893 | 0.855 | 0.798 | 0.688 |
| Methanol                                       | 303.15         | 0.964 | 0.927 | 0.887 | 0.844 | 0.797 | 0.744 | 0.682 | 0.604 | 0.494 |
| 2-Propanone                                    | 353.15         | 0.979 | 0.947 | 0.896 | 0.815 | 0.719 | 0.625 | 0.532 | 0.434 | 0.315 |
| Water                                          | 293.15         | 0.977 | 0.951 | 0.923 | 0.890 | 0.852 | 0.806 | 0.748 | 0.671 | 0.550 |
| <i>Poly(ethylenimine)</i>                      |                |       |       |       |       |       |       |       |       |       |
| Water                                          | 353.15         | 0.975 | 0.947 | 0.917 | 0.883 | 0.845 | 0.801 | 0.748 | 0.680 | 0.581 |
| <i>Poly(ethyl methacrylate)</i>                |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 298.15         | 0.970 | 0.938 | 0.903 | 0.864 | 0.821 | 0.771 | 0.712 | 0.637 | 0.529 |
| Dichloromethane                                | 298.15         | 0.912 | 0.838 | 0.769 | 0.703 | 0.636 | 0.567 | 0.491 | 0.404 | 0.292 |
| Tetrachloromethane                             | 298.15         | 0.935 | 0.873 | 0.812 | 0.750 | 0.686 | 0.616 | 0.540 | 0.449 | 0.328 |
| Toluene                                        | 298.15         | 0.974 | 0.945 | 0.913 | 0.877 | 0.836 | 0.787 | 0.727 | 0.647 | 0.527 |
| Trichloromethane                               | 298.15         | 0.859 | 0.760 | 0.678 | 0.604 | 0.533 | 0.464 | 0.392 | 0.313 | 0.217 |
| <i>Polyisobutylene</i>                         |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 313.15         | 0.984 | 0.965 | 0.945 | 0.921 | 0.892 | 0.858 | 0.813 | 0.751 | 0.645 |
| Cyclohexane                                    | 313.15         | 0.976 | 0.950 | 0.921 | 0.888 | 0.850 | 0.805 | 0.749 | 0.676 | 0.563 |
| Cyclopentane                                   | 313.15         | 0.977 | 0.952 | 0.924 | 0.892 | 0.855 | 0.812 | 0.758 | 0.687 | 0.579 |
| 1,4-Dimethylbenzene                            | 313.15         | 0.979 | 0.955 | 0.929 | 0.899 | 0.863 | 0.821 | 0.767 | 0.694 | 0.579 |
| 2,2-Dimethylbutane                             | 298.15         | 0.983 | 0.964 | 0.942 | 0.917 | 0.887 | 0.852 | 0.806 | 0.743 | 0.640 |
| Ethylbenzene                                   | 313.15         | 0.979 | 0.955 | 0.927 | 0.895 | 0.857 | 0.810 | 0.750 | 0.668 | 0.535 |
| Heptane                                        | 298.15         | 0.983 | 0.964 | 0.942 | 0.917 | 0.887 | 0.851 | 0.804 | 0.741 | 0.637 |
| Hexane                                         | 298.15         | 0.980 | 0.959 | 0.934 | 0.906 | 0.873 | 0.834 | 0.784 | 0.715 | 0.606 |
| Octane                                         | 298.15         | 0.983 | 0.963 | 0.940 | 0.914 | 0.883 | 0.845 | 0.797 | 0.729 | 0.617 |
| Tetrachloromethane                             | 298.15         | 0.962 | 0.921 | 0.877 | 0.829 | 0.776 | 0.715 | 0.643 | 0.552 | 0.423 |
| Toluene                                        | 313.15         | 0.984 | 0.966 | 0.944 | 0.918 | 0.884 | 0.840 | 0.779 | 0.688 | 0.537 |
| Trichloromethane                               | 298.15         | 0.969 | 0.935 | 0.899 | 0.858 | 0.813 | 0.761 | 0.698 | 0.619 | 0.503 |
| 2,4,4-Trimethylpentane                         | 298.15         | 0.981 | 0.961 | 0.937 | 0.911 | 0.879 | 0.842 | 0.794 | 0.730 | 0.628 |
| <i>1,4-cis-Polyisoprene</i>                    |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 313.15         | 0.982 | 0.962 | 0.937 | 0.908 | 0.873 | 0.827 | 0.766 | 0.679 | 0.537 |
| 2-Butanone                                     | 353.15         | 0.986 | 0.970 | 0.953 | 0.933 | 0.910 | 0.883 | 0.850 | 0.808 | 0.746 |
| Cyclohexane                                    | 313.15         | 0.978 | 0.954 | 0.928 | 0.899 | 0.865 | 0.825 | 0.778 | 0.716 | 0.625 |
| Dichloromethane                                | 298.15         | 0.969 | 0.935 | 0.898 | 0.857 | 0.811 | 0.757 | 0.693 | 0.610 | 0.488 |
| 1,4-Dimethylbenzene                            | 313.15         | 0.977 | 0.951 | 0.923 | 0.892 | 0.857 | 0.816 | 0.767 | 0.704 | 0.613 |

| Polymer/<br>solvents                           | $a_1$ :<br>T/K | 0.1   | 0.2   | 0.3   | 0.4   | 0.5   | 0.6   | 0.7   | 0.8   | 0.9   |
|------------------------------------------------|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mass Fraction of the Polymer                   |                |       |       |       |       |       |       |       |       |       |
| Ethylbenzene                                   | 313.15         | 0.978 | 0.954 | 0.928 | 0.898 | 0.864 | 0.823 | 0.774 | 0.709 | 0.612 |
| Methyl acetate                                 | 313.15         | 0.968 | 0.935 | 0.900 | 0.862 | 0.820 | 0.773 | 0.717 | 0.649 | 0.554 |
| Octane                                         | 313.15         | 0.984 | 0.967 | 0.948 | 0.926 | 0.901 | 0.871 | 0.834 | 0.785 | 0.711 |
| Propyl acetate                                 | 333.15         | 0.983 | 0.964 | 0.942 | 0.916 | 0.886 | 0.850 | 0.803 | 0.738 | 0.633 |
| Tetrachloromethane                             | 298.15         | 0.929 | 0.864 | 0.800 | 0.737 | 0.672 | 0.602 | 0.526 | 0.435 | 0.316 |
| Toluene                                        | 313.15         | 0.978 | 0.954 | 0.927 | 0.898 | 0.865 | 0.827 | 0.782 | 0.725 | 0.645 |
| Trichloromethane                               | 298.15         | 0.930 | 0.867 | 0.807 | 0.747 | 0.685 | 0.620 | 0.547 | 0.462 | 0.346 |
| <i>Poly(methyl acrylate)</i>                   |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 298.15         | 0.979 | 0.956 | 0.930 | 0.901 | 0.867 | 0.826 | 0.776 | 0.710 | 0.608 |
| Dichloromethane                                | 298.15         | 0.917 | 0.851 | 0.791 | 0.732 | 0.671 | 0.605 | 0.532 | 0.444 | 0.326 |
| Tetrachloromethane                             | 298.15         | 0.963 | 0.924 | 0.882 | 0.838 | 0.788 | 0.733 | 0.668 | 0.586 | 0.470 |
| Toluene                                        | 298.15         | 0.981 | 0.960 | 0.936 | 0.909 | 0.878 | 0.840 | 0.792 | 0.727 | 0.626 |
| Trichloromethane                               | 298.15         | 0.912 | 0.830 | 0.753 | 0.678 | 0.603 | 0.527 | 0.446 | 0.357 | 0.248 |
| <i>Poly(methyl methacrylate)</i>               |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 298.15         | 0.982 | 0.961 | 0.938 | 0.912 | 0.881 | 0.843 | 0.795 | 0.729 | 0.622 |
| 2-Butanone <sup>a)</sup>                       | 308.15         | 0.989 | 0.976 | 0.961 | 0.945 | 0.925 | 0.900 | 0.869 | 0.825 | 0.751 |
| Cyclohexanone <sup>a)</sup>                    | 323.15         | 0.978 | 0.954 | 0.928 | 0.899 | 0.866 | 0.827 | 0.781 | 0.723 | 0.640 |
| Dichloromethane                                | 298.15         | 0.939 | 0.882 | 0.825 | 0.766 | 0.704 | 0.637 | 0.560 | 0.468 | 0.343 |
| Ethyl acetate <sup>a)</sup>                    | 308.15         | 0.986 | 0.969 | 0.950 | 0.928 | 0.902 | 0.869 | 0.826 | 0.763 | 0.649 |
| Toluene                                        | 298.15         | 0.981 | 0.959 | 0.935 | 0.908 | 0.877 | 0.841 | 0.795 | 0.736 | 0.646 |
| Trichloromethane                               | 298.15         | 0.924 | 0.848 | 0.771 | 0.694 | 0.616 | 0.536 | 0.451 | 0.358 | 0.246 |
| <i>Poly(<math>\alpha</math>-methylstyrene)</i> |                |       |       |       |       |       |       |       |       |       |
| Cumene                                         | 338.15         | 0.984 | 0.965 | 0.944 | 0.918 | 0.887 | 0.848 | 0.796 | 0.721 | 0.593 |
| $\alpha$ -Methylstyrene                        | 338.15         | 0.978 | 0.954 | 0.927 | 0.896 | 0.859 | 0.816 | 0.761 | 0.687 | 0.570 |
| <i>Poly(propylene oxide)</i>                   |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 333.15         | 0.967 | 0.932 | 0.893 | 0.850 | 0.801 | 0.744 | 0.675 | 0.588 | 0.460 |
| Methanol                                       | 298.15         | 0.992 | 0.982 | 0.970 | 0.955 | 0.936 | 0.910 | 0.872 | 0.812 | 0.689 |
| <i>Polystyrene</i>                             |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 333.15         | 0.978 | 0.953 | 0.924 | 0.891 | 0.852 | 0.804 | 0.742 | 0.657 | 0.521 |
| 2-Butanone <sup>a)</sup>                       | 298.15         | 0.986 | 0.971 | 0.954 | 0.935 | 0.912 | 0.885 | 0.851 | 0.804 | 0.724 |
| Cyclohexane                                    | 313.15         | 0.990 | 0.978 | 0.965 | 0.949 | 0.931 | 0.908 | 0.877 | 0.833 | 0.754 |
| Cyclohexanone <sup>a)</sup>                    | 313.15         | 0.970 | 0.937 | 0.900 | 0.858 | 0.810 | 0.753 | 0.684 | 0.593 | 0.459 |
| Dichloromethane                                | 298.15         | 0.949 | 0.899 | 0.849 | 0.797 | 0.743 | 0.684 | 0.617 | 0.536 | 0.423 |
| 1,3-Dimethylbenzene <sup>a)</sup>              | 323.15         | 0.980 | 0.956 | 0.926 | 0.891 | 0.846 | 0.791 | 0.723 | 0.638 | 0.524 |
| 1,4-Dimethylbenzene                            | 423.15         | 0.974 | 0.944 | 0.911 | 0.872 | 0.826 | 0.770 | 0.698 | 0.601 | 0.452 |
| Ethyl acetate <sup>a)</sup>                    | 313.15         | 0.976 | 0.948 | 0.918 | 0.882 | 0.841 | 0.791 | 0.728 | 0.642 | 0.507 |
| Hexane                                         | 423.15         | 0.980 | 0.958 | 0.933 | 0.904 | 0.869 | 0.827 | 0.772 | 0.697 | 0.574 |
| 2-Propanone                                    | 323.15         | 0.991 | 0.980 | 0.969 | 0.955 | 0.938 | 0.918 | 0.892 | 0.854 | 0.788 |
| Propyl acetate                                 | 343.15         | 0.983 | 0.965 | 0.943 | 0.919 | 0.891 | 0.858 | 0.815 | 0.758 | 0.667 |
| Tetrachloromethane                             | 298.15         | 0.961 | 0.917 | 0.869 | 0.814 | 0.751 | 0.678 | 0.592 | 0.486 | 0.344 |
| Toluene                                        | 313.15         | 0.981 | 0.959 | 0.933 | 0.901 | 0.861 | 0.809 | 0.738 | 0.638 | 0.481 |
| Trichloromethane                               | 298.15         | 0.949 | 0.898 | 0.847 | 0.793 | 0.736 | 0.675 | 0.604 | 0.519 | 0.400 |
| <i>Poly(tetramethylene glycol)</i>             |                |       |       |       |       |       |       |       |       |       |
| Methanol                                       | 303.15         | 0.981 | 0.961 | 0.938 | 0.913 | 0.883 | 0.849 | 0.806 | 0.751 | 0.671 |
| <i>Poly(vinyl acetate)</i>                     |                |       |       |       |       |       |       |       |       |       |
| Benzene                                        | 313.15         | 0.985 | 0.967 | 0.945 | 0.919 | 0.886 | 0.844 | 0.784 | 0.696 | 0.548 |
| 1-Butanol                                      | 313.15         | 0.992 | 0.982 | 0.971 | 0.958 | 0.942 | 0.923 | 0.896 | 0.856 | 0.779 |
| 2-Butanol                                      | 313.15         | 0.987 | 0.972 | 0.956 | 0.937 | 0.915 | 0.889 | 0.856 | 0.813 | 0.747 |
| 2-Butanone                                     | 313.15         | 0.980 | 0.958 | 0.934 | 0.906 | 0.873 | 0.835 | 0.787 | 0.724 | 0.626 |
| 1,2-Dichloroethane <sup>a)</sup>               | 300.15         | 0.955 | 0.906 | 0.851 | 0.790 | 0.722 | 0.644 | 0.556 | 0.450 | 0.315 |
| 1,4-Dimethylbenzene                            | 313.15         | 0.990 | 0.978 | 0.964 | 0.948 | 0.928 | 0.903 | 0.868 | 0.814 | 0.705 |
| Ethylbenzene                                   | 313.15         | 0.990 | 0.979 | 0.966 | 0.950 | 0.932 | 0.910 | 0.880 | 0.836 | 0.759 |
| Methanol                                       | 333.15         | 0.990 | 0.978 | 0.965 | 0.949 | 0.931 | 0.908 | 0.877 | 0.834 | 0.757 |
| Methyl acetate                                 | 313.15         | 0.976 | 0.949 | 0.919 | 0.886 | 0.849 | 0.805 | 0.752 | 0.684 | 0.583 |
| 2-Methyl-1-propanol                            | 353.15         | 0.984 | 0.966 | 0.946 | 0.924 | 0.899 | 0.868 | 0.832 | 0.784 | 0.715 |
| 1-Propanol                                     | 353.15         | 0.987 | 0.972 | 0.955 | 0.936 | 0.914 | 0.888 | 0.856 | 0.815 | 0.753 |
| 2-Propanol                                     | 353.15         | 0.988 | 0.974 | 0.958 | 0.940 | 0.919 | 0.894 | 0.863 | 0.820 | 0.754 |

| Polymer/<br>solvents                                                 | $a_A$ :<br>T/K | 0.1   | 0.2   | 0.3   | 0.4   | 0.5   | 0.6   | 0.7   | 0.8   | 0.9   |
|----------------------------------------------------------------------|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mass Fraction of the Polymer                                         |                |       |       |       |       |       |       |       |       |       |
| 2-Propanone                                                          | 333.15         | 0.983 | 0.963 | 0.940 | 0.913 | 0.880 | 0.838 | 0.784 | 0.707 | 0.578 |
| Propyl acetate                                                       | 333.15         | 0.979 | 0.955 | 0.930 | 0.901 | 0.869 | 0.831 | 0.786 | 0.728 | 0.645 |
| Tetrahydrofuran                                                      | 323.15         | 0.973 | 0.943 | 0.911 | 0.874 | 0.831 | 0.781 | 0.720 | 0.640 | 0.519 |
| Toluene                                                              | 333.15         | 0.983 | 0.965 | 0.944 | 0.920 | 0.891 | 0.857 | 0.815 | 0.756 | 0.664 |
| <i>Poly(vinyl chloride)</i>                                          |                |       |       |       |       |       |       |       |       |       |
| 2-Butanone <sup>a)</sup>                                             | 313.15         | 0.976 | 0.949 | 0.920 | 0.887 | 0.849 | 0.804 | 0.749 | 0.676 | 0.566 |
| Cyclohexanone <sup>a)</sup>                                          | 333.15         | 0.971 | 0.934 | 0.889 | 0.839 | 0.781 | 0.714 | 0.635 | 0.536 | 0.397 |
| <i>Poly(vinyl methyl ether)</i>                                      |                |       |       |       |       |       |       |       |       |       |
| Benzene <sup>a)</sup>                                                | 298.15         | 0.969 | 0.935 | 0.897 | 0.855 | 0.807 | 0.751 | 0.683 | 0.596 | 0.466 |
| Chlorobenzene <sup>a)</sup>                                          | 343.15         | 0.972 | 0.941 | 0.906 | 0.867 | 0.822 | 0.769 | 0.705 | 0.620 | 0.494 |
| 1,2-Dimethylbenzene <sup>a)</sup>                                    | 363.15         | 0.973 | 0.943 | 0.910 | 0.871 | 0.826 | 0.772 | 0.705 | 0.616 | 0.478 |
| Ethylbenzene <sup>a)</sup>                                           | 343.15         | 0.978 | 0.954 | 0.927 | 0.895 | 0.857 | 0.811 | 0.753 | 0.672 | 0.542 |
| Propylbenzene <sup>a)</sup>                                          | 373.15         | 0.977 | 0.951 | 0.923 | 0.890 | 0.852 | 0.808 | 0.752 | 0.678 | 0.563 |
| <i>Poly(4-vinylpyridine)</i>                                         |                |       |       |       |       |       |       |       |       |       |
| Methanol                                                             | 343.15         | 0.986 | 0.971 | 0.953 | 0.931 | 0.905 | 0.871 | 0.825 | 0.756 | 0.627 |
| 2-Propanol                                                           | 343.15         | 0.989 | 0.977 | 0.964 | 0.948 | 0.928 | 0.904 | 0.872 | 0.826 | 0.743 |
| <i>Poly(1-vinyl-2-pyrrolidinone)</i>                                 |                |       |       |       |       |       |       |       |       |       |
| Water                                                                | 368.15         | 0.984 | 0.966 | 0.946 | 0.924 | 0.899 | 0.870 | 0.835 | 0.790 | 0.727 |
| <i>Starch (amorphous)</i>                                            |                |       |       |       |       |       |       |       |       |       |
| Water                                                                | 383.15         | 0.991 | 0.981 | 0.970 | 0.956 | 0.939 | 0.918 | 0.889 | 0.845 | 0.754 |
| <i>Styrene/Methyl methacrylate Copolymer (41.45 wt% Styrene)</i>     |                |       |       |       |       |       |       |       |       |       |
| Benzene <sup>a)</sup>                                                | 308.15         | 0.982 | 0.963 | 0.940 | 0.913 | 0.881 | 0.841 | 0.789 | 0.716 | 0.590 |
| <i>Vinyl acetate/Vinyl chloride Copolymer (12 wt% Vinyl acetate)</i> |                |       |       |       |       |       |       |       |       |       |
| Benzene                                                              | 398.15         | 0.976 | 0.949 | 0.918 | 0.883 | 0.841 | 0.791 | 0.728 | 0.643 | 0.509 |
| Chlorobenzene                                                        | 398.15         | 0.984 | 0.965 | 0.944 | 0.920 | 0.891 | 0.856 | 0.810 | 0.746 | 0.638 |
| 1,4-Dimethylbenzene                                                  | 398.15         | 0.989 | 0.977 | 0.963 | 0.946 | 0.926 | 0.899 | 0.863 | 0.807 | 0.692 |
| Ethylbenzene                                                         | 398.15         | 0.989 | 0.976 | 0.961 | 0.944 | 0.924 | 0.899 | 0.866 | 0.818 | 0.735 |
| Octane                                                               | 398.15         | 0.992 | 0.982 | 0.971 | 0.958 | 0.942 | 0.922 | 0.893 | 0.847 | 0.739 |

<sup>a)</sup>  $a_A = P_A / P_A^S$

# SPECIFIC ENTHALPIES OF SOLUTION OF POLYMERS AND COPOLYMERS

Christian Wohlfarth

Enthalpies of solution or mixing, expressed as the enthalpy change per unit mass of polymer, are given in the table at infinite dilution, i.e., a very small amount of polymer and a large excess of solvent were mixed isothermally to form a homogeneous solution. By thermodynamics,  $\Delta_{\text{sol}} H_{\text{B}}^{\infty}$  or  $\Delta_{\text{M}} H_{\text{B}}^{\infty}$  are obtained from the following derivatives:

$$\Delta_{\text{sol}} H_{\text{B}}^{\infty} = \lim_{m_{\text{B}} \rightarrow 0} (\partial \Delta_{\text{sol}} h / \partial m_{\text{B}})_{P,T,m_{\text{J} \neq \text{B}}} \quad (1)$$

$$\Delta_{\text{M}} H_{\text{B}}^{\infty} = \lim_{m_{\text{B}} \rightarrow 0} (\partial \Delta_{\text{M}} h / \partial m_{\text{B}})_{P,T,m_{\text{J} \neq \text{B}}} \quad (2)$$

with a unit of J/g. Thus, they are the partial specific enthalpies of solution or mixing of the polymer B at infinite dilution where  $\Delta_{\text{sol}} h$  or  $\Delta_{\text{M}} h$  is the extensive enthalpy of the solution or mixing process.

The state of the polymer before dissolution can significantly affect the enthalpy of solution. The dissolving of a semicrystalline polymer requires an additional amount of heat associated with the disordering of crystalline regions. Consequently, its enthalpy of

solution is usually positive and depends on the degree of crystallinity of the given polymer sample. An amorphous polymer below its glass transition temperature,  $T_{\text{g}}$  (see the  $T_{\text{g}}$ -table of this Section), often dissolves with the release of heat. The enthalpy of solution of a glassy polymer is additionally dependent to some extent on the thermal history of the glass-forming process. An amorphous polymer above  $T_{\text{g}}$  can show endothermic or exothermic dissolution behavior depending on the nature of the solvent and the interaction energies involved as is the case for any enthalpy of mixing. This enthalpy of mixing is then independent of any crystalline or glassy aspects of the polymer. It can be obtained without difficulties for liquid/molten polymers mixed with a solvent. Therefore, the enthalpies given in the table are either enthalpies of solution or enthalpies of mixing, depending on the state of the polymer.

The enthalpies depend on temperature and molar mass. The necessary molar mass information for a system is provided in the table (if available) by the corresponding number average,  $M_{\text{n}}$ , mass average,  $M_{\text{w}}$ , or viscosity average,  $M_{\text{v}}$ , values of the polymer as given in the original sources. Outside the oligomer range, specific enthalpies of solution or mixing do not remarkably depend on molar mass, however. More enthalpy data of polymer-solvent systems can be found in Ref. 106.

| Polymer                                       | $M_{\text{n}}/\text{g/mol}$ | $M_{\text{w}}/\text{g/mol}$ | $M_{\text{v}}/\text{g/mol}$ | Solvent               | $T/\text{K}$ | $\Delta H_{\text{B}}^{\infty}/\text{J/g}$ | Ref. |
|-----------------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------|--------------|-------------------------------------------|------|
| <b>Acrylonitrile/butadiene copolymer</b>      |                             |                             |                             |                       |              |                                           |      |
| (18 wt% Acrylonitrile)                        |                             |                             |                             | Benzene               | 298.15       | 0.0                                       | 18   |
| (26 wt% Acrylonitrile)                        |                             |                             |                             | Benzene               | 298.15       | −1.9                                      | 18   |
| (40 wt% Acrylonitrile)                        |                             |                             |                             | Benzene               | 298.15       | −2.9                                      | 18   |
| <b>Acrylonitrile/isoprene copolymer</b>       |                             |                             |                             |                       |              |                                           |      |
| (15 mol% Isoprene)                            |                             |                             |                             | N,N-Dimethylformamide | 323.15       | −32                                       | 66   |
| <b>Acrylonitrile/vinyl chloride copolymer</b> |                             |                             |                             |                       |              |                                           |      |
| (13 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 293.15       | −38                                       | 35   |
| (13 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 308.15       | −22                                       | 35   |
| (13 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 323.15       | −18                                       | 35   |
| (13 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 338.15       | −15                                       | 35   |
| (13 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 353.15       | −12                                       | 35   |
| (29 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 295.15       | −42                                       | 35   |
| (29 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 308.15       | −27                                       | 35   |
| (29 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 323.15       | −21                                       | 35   |
| (29 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 338.15       | −19                                       | 35   |
| (29 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 353.15       | −16                                       | 35   |
| (40 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 295.15       | −47                                       | 35   |
| (40 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 308.15       | −30                                       | 35   |
| (40 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 323.15       | −28                                       | 35   |
| (40 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 338.15       | −18                                       | 35   |
| (40 wt% Acrylonitrile)                        |                             |                             |                             | N,N-Dimethylformamide | 353.15       | −17                                       | 35   |
| <b>Benzylcellulose</b>                        |                             |                             |                             |                       |              |                                           |      |
|                                               |                             |                             |                             | Benzene               | 298.15       | −11                                       | 8    |
|                                               |                             |                             |                             | Cyclohexanone         | 298.15       | −15                                       | 25   |
|                                               |                             |                             |                             | Trichloromethane      | 298.15       | −38                                       | 25   |



| Polymer                                                                          | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                       | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|----------------------------------------------------------------------------------|------------------|------------------|---------------------|-------------------------------|--------|------------------------------|------|
| <b><i>Bisphenol A-isophthaloyl chloride/terephthaloyl chloride</i></b>           |                  |                  |                     |                               |        |                              |      |
| (50/50 Iso/terephthaloyl chloride)                                               |                  |                  |                     | <i>N,N</i> -Dimethylacetamide | 298.15 | −56                          | 69   |
| (50/50 Iso/terephthaloyl chloride)                                               |                  |                  |                     | 1,1,2,2-Tetrachloroethane     | 298.15 | +72                          | 69   |
| <b><i>Butadiene/styrene copolymer</i></b>                                        |                  |                  |                     |                               |        |                              |      |
| (10 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 293.65 | 4.9                          | 17   |
| (30 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 293.65 | 3.0                          | 17   |
| (30 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 298.15 | 3.0                          | 25   |
| (50 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 293.65 | 1.8                          | 17   |
| (60 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 293.65 | 0.0                          | 17   |
| (70 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 293.65 | 0.0                          | 17   |
| (75 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 298.15 | 1.5                          | 7    |
| (80 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 293.65 | −0.6                         | 17   |
| (90 wt% Styrene)                                                                 |                  |                  |                     | Benzene                       | 293.65 | −4.9                         | 17   |
| <b><i>Butyl methacrylate/isobutyl methacrylate copolymer (50 wt%/50 wt%)</i></b> |                  |                  |                     |                               |        |                              |      |
| Glass                                                                            |                  | 150000           |                     | Cyclohexanone                 | 303.15 | 5.9                          | 98   |
| Liquid                                                                           |                  | 150000           |                     | Cyclohexanone                 | 303.15 | 14.0                         | 98   |
| <b><i>Butyl methacrylate/methyl methacrylate copolymer (45 wt%/55 wt%)</i></b>   |                  |                  |                     |                               |        |                              |      |
| Glass                                                                            | 107000           | 250000           |                     | Cyclohexanone                 | 304.15 | −5.4                         | 99   |
| Liquid                                                                           | 107000           | 250000           |                     | Cyclohexanone                 | 304.15 | +9.1                         | 99   |
| <b><i>Cellulose acetate</i></b>                                                  |                  |                  |                     |                               |        |                              |      |
| (52.2 wt% Acetate)                                                               |                  |                  |                     | Formic acid                   | 298.15 | −30                          | 10   |
| (55.8 wt% Acetate)                                                               |                  |                  |                     | Formic acid                   | 298.15 | −44                          | 10   |
| (52.5 wt% Acetate)                                                               |                  |                  |                     | Methyl acetate                | 298.15 | −80                          | 1    |
| (48 wt% Acetate)                                                                 |                  |                  |                     | 2-Propanone                   | 298.15 | −35                          | 25   |
| (52.2 wt% Acetate)                                                               |                  |                  |                     | 2-Propanone                   | 298.15 | −30                          | 10   |
| (55.8 wt% Acetate)                                                               |                  |                  |                     | 2-Propanone                   | 298.15 | −26                          | 10   |
| (56 wt% Acetate)                                                                 |                  |                  |                     | 2-Propanone                   | 298.15 | −45                          | 25   |
| (56 wt% Acetate)                                                                 |                  |                  |                     | 2-Propanone                   | 298.15 | −30                          | 4    |
| <b><i>Cellulose triacetate</i></b>                                               |                  |                  |                     |                               |        |                              |      |
|                                                                                  |                  |                  |                     | 2-Propanone                   | 298.15 | −29                          | 4    |
|                                                                                  |                  |                  |                     | Trichloromethane              | 298.15 | −47                          | 4    |
| <b><i>Dextran</i></b>                                                            |                  |                  |                     |                               |        |                              |      |
|                                                                                  | 8200             | 10400            |                     | Dimethylsulfoxide             | 298.15 | −185                         | 75   |
|                                                                                  | 75900            | 101000           |                     | Dimethylsulfoxide             | 298.15 | −187                         | 70   |
|                                                                                  | 75900            | 101000           |                     | 1,2-Ethanediol                | 298.15 | −98                          | 70   |
|                                                                                  | 75900            | 101000           |                     | Formamide                     | 298.15 | −228                         | 70   |
|                                                                                  | 8200             | 10400            |                     | Water                         | 298.15 | −140                         | 75   |
|                                                                                  | 75900            | 101000           |                     | Water                         | 298.15 | −150                         | 75   |
| (amorph)                                                                         |                  |                  |                     | Water                         | 298.15 | −123                         | 65   |
| <b><i>Ethylene/propylene copolymer</i></b>                                       |                  |                  |                     |                               |        |                              |      |
| (33 mol% Ethylene)                                                               |                  |                  |                     | Cyclohexane                   | 298.15 | 1.4                          | 74   |
| (63 mol% Ethylene)                                                               |                  |                  |                     | Cyclohexane                   | 298.15 | 8.1                          | 74   |
| (75 mol% Ethylene)                                                               |                  |                  |                     | Cyclohexane                   | 298.15 | 11.8                         | 74   |
| (33 mol% Ethylene)                                                               |                  |                  |                     | Cyclooctane                   | 298.15 | 1.2                          | 74   |

| Polymer            | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                             | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|--------------------|------------------|------------------|---------------------|-------------------------------------|--------|------------------------------|------|
| (63 mol% Ethylene) |                  |                  |                     | Cyclooctane                         | 298.15 | 6.9                          | 74   |
| (75 mol% Ethylene) |                  |                  |                     | Cyclooctane                         | 298.15 | 8.6                          | 74   |
| (33 mol% Ethylene) |                  |                  |                     | Cyclopentane                        | 298.15 | -3.5                         | 74   |
| (63 mol% Ethylene) |                  |                  |                     | Cyclopentane                        | 298.15 | 1.1                          | 74   |
| (33 mol% Ethylene) |                  |                  |                     | <i>cis</i> -Decahydronaphthalene    | 298.15 | -2.4                         | 74   |
| (63 mol% Ethylene) |                  |                  |                     | <i>cis</i> -Decahydronaphthalene    | 298.15 | 2.4                          | 74   |
| (75 mol% Ethylene) |                  |                  |                     | <i>cis</i> -Decahydronaphthalene    | 298.15 | 3.9                          | 74   |
| (33 mol% Ethylene) |                  |                  |                     | <i>trans</i> -Decahydronaphthalene  | 298.15 | -4.8                         | 74   |
| (63 mol% Ethylene) |                  |                  |                     | <i>trans</i> -Decahydronaphthalene  | 298.15 | -1.3                         | 74   |
| (75 mol% Ethylene) |                  |                  |                     | <i>trans</i> -Decahydronaphthalene  | 298.15 | -0.3                         | 74   |
| (63 mol% Ethylene) |                  |                  |                     | 3,3-Diethylpentane                  | 298.15 | -1.4                         | 74   |
| (75 mol% Ethylene) |                  |                  |                     | 3,3-Diethylpentane                  | 298.15 | <0.1                         | 74   |
| (63 mol% Ethylene) |                  |                  |                     | 2,2-Dimethylpentane                 | 298.15 | 5.3                          | 74   |
| (75 mol% Ethylene) |                  |                  |                     | 2,2-Dimethylpentane                 | 298.15 | 2.3                          | 74   |
| (63 mol% Ethylene) |                  |                  |                     | 2,3-Dimethylpentane                 | 298.15 | 0.7                          | 74   |
| (75 mol% Ethylene) |                  |                  |                     | 2,3-Dimethylpentane                 | 298.15 | 0.4                          | 74   |
| (33 mol% Ethylene) |                  |                  |                     | 2,4-Dimethylpentane                 | 298.15 | -1.2                         | 74   |
| (63 mol% Ethylene) |                  |                  |                     | 2,4-Dimethylpentane                 | 298.15 | 3.0                          | 74   |
| (75 mol% Ethylene) |                  |                  |                     | 2,4-Dimethylpentane                 | 298.15 | 0.2                          | 74   |
| (33 mol% Ethylene) |                  |                  |                     | 3,3-Dimethylpentane                 | 298.15 | -2.7                         | 74   |
| (63 mol% Ethylene) |                  |                  |                     | 3,3-Dimethylpentane                 | 298.15 | 0.3                          | 74   |
| (33 mol% Ethylene) |                  |                  |                     | Dodecane                            | 298.15 | -0.1                         | 73   |
| (63 mol% Ethylene) |                  |                  |                     | Dodecane                            | 298.15 | 0.8                          | 73   |
| (75 mol% Ethylene) |                  |                  |                     | Dodecane                            | 298.15 | -4.0                         | 73   |
| (63 mol% Ethylene) |                  |                  |                     | 3-Ethylpentane                      | 298.15 | 2.6                          | 74   |
| (75 mol% Ethylene) |                  |                  |                     | 3-Ethylpentane                      | 298.15 | -0.6                         | 74   |
| (33 mol% Ethylene) |                  |                  |                     | 2,2,4,4,6,8,8-<br>Heptamethylnonane | 298.15 | -0.5                         | 73   |
| (63 mol% Ethylene) |                  |                  |                     | 2,2,4,4,6,8,8-<br>Heptamethylnonane | 298.15 | 2.2                          | 73   |
| (75 mol% Ethylene) |                  |                  |                     | 2,2,4,4,6,8,8-<br>Heptamethylnonane | 298.15 | -0.9                         | 73   |
| (33 mol% Ethylene) |                  |                  |                     | Hexadecane                          | 298.15 | 0.7                          | 73   |
| (63 mol% Ethylene) |                  |                  |                     | Hexadecane                          | 298.15 | -1.1                         | 73   |
| (75 mol% Ethylene) |                  |                  |                     | Hexadecane                          | 298.15 | -4.6                         | 73   |
| (63 mol% Ethylene) |                  |                  |                     | 3-Methylhexane                      | 298.15 | 0.7                          | 74   |
| (75 mol% Ethylene) |                  |                  |                     | 3-Methylhexane                      | 298.15 | 1.7                          | 74   |
| (33 mol% Ethylene) |                  |                  |                     | Octane                              | 298.15 | -1.6                         | 73   |
| (63 mol% Ethylene) |                  |                  |                     | Octane                              | 298.15 | 3.6                          | 73   |
| (75 mol% Ethylene) |                  |                  |                     | Octane                              | 298.15 | 0.3                          | 73   |
| (33 mol% Ethylene) |                  |                  |                     | 2,2,4,6,6-Pentamethylheptane        | 298.15 | -0.3                         | 73   |
| (63 mol% Ethylene) |                  |                  |                     | 2,2,4,6,6-Pentamethylheptane        | 298.15 | 3.6                          | 73   |
| (75 mol% Ethylene) |                  |                  |                     | 2,2,4,6,6-Pentamethylheptane        | 298.15 | 0.0                          | 73   |
| (63 mol% Ethylene) |                  |                  |                     | 2,2,4,4-Tetramethylpentane          | 298.15 | 2.7                          | 74   |
| (75 mol% Ethylene) |                  |                  |                     | 2,2,4,4-Tetramethylpentane          | 298.15 | 3.1                          | 74   |
| (33 mol% Ethylene) |                  |                  |                     | 2,2,4-Trimethylpentane              | 298.15 | -0.2                         | 73   |
| (63 mol% Ethylene) |                  |                  |                     | 2,2,4-Trimethylpentane              | 298.15 | 1.9                          | 73   |
| (75 mol% Ethylene) |                  |                  |                     | 2,2,4-Trimethylpentane              | 298.15 | 3.5                          | 73   |

| Polymer                                                                    | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent           | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|----------------------------------------------------------------------------|------------------|------------------|---------------------|-------------------|--------|------------------------------|------|
| <i>Ethylene/vinylacetate copolymer</i>                                     |                  |                  |                     |                   |        |                              |      |
| (85 wt% Vinyl acetate)                                                     |                  |                  |                     | Cyclopentanone    | 298.15 | −0.5                         | 104  |
| (70 wt% Vinyl acetate)                                                     |                  | 220000           |                     | Tetrahydrofuran   | 304.65 | −1.3                         | 93   |
| <i>Gelatine</i>                                                            |                  |                  |                     |                   |        |                              |      |
|                                                                            |                  |                  |                     | Water             | 293.15 | −92                          | 29   |
|                                                                            |                  |                  |                     | Water             | 323.15 | −63                          | 29   |
| <i>Guttapercha</i>                                                         |                  |                  |                     |                   |        |                              |      |
|                                                                            |                  |                  |                     | Trichloromethane  | 303.15 | 47                           | 22   |
| <i>Isobutyl methacrylate/methyl methacrylate copolymer (51 wt%/49 wt%)</i> |                  |                  |                     |                   |        |                              |      |
| Glass                                                                      |                  | 150000           |                     | Cyclohexanone     | 303.15 | −11                          | 98   |
| Liquid                                                                     |                  | 150000           |                     | Cyclohexanone     | 303.15 | 15                           | 98   |
| <i>Natural rubber</i>                                                      |                  |                  |                     |                   |        |                              |      |
|                                                                            |                  |                  |                     | Benzene           | 298.15 | 10                           | 25   |
|                                                                            |                  |                  |                     | Benzene           | 298.15 | 12                           | 20   |
| <i>Nitrocellulose</i>                                                      |                  |                  |                     |                   |        |                              |      |
|                                                                            |                  |                  | 16600               | 2-Butanone        | 298.15 | −80                          | 4    |
|                                                                            |                  |                  | 23000               | 2-Butanone        | 298.15 | −81                          | 4    |
|                                                                            |                  |                  | 40000               | 2-Butanone        | 298.15 | −81                          | 4    |
|                                                                            |                  |                  |                     | Butyl acetate     | 293.15 | −75                          | 23   |
|                                                                            |                  |                  |                     | Butyl acetate     | 298.15 | −75                          | 23   |
|                                                                            |                  |                  |                     | Butyl acetate     | 298.15 | −73                          | 26   |
|                                                                            |                  |                  |                     | Butyl acetate     | 303.15 | −75                          | 23   |
|                                                                            |                  |                  |                     | Butyl acetate     | 308.15 | −71                          | 23   |
|                                                                            |                  |                  |                     | Butyl acetate     | 313.15 | −65                          | 23   |
|                                                                            |                  |                  |                     | Butyl acetate     | 313.15 | −67                          | 26   |
|                                                                            |                  |                  |                     | Butyl acetate     | 318.15 | −59                          | 23   |
|                                                                            |                  |                  |                     | Butyl acetate     | 323.15 | −54                          | 23   |
|                                                                            |                  |                  |                     | Butyl acetate     | 328.15 | −50                          | 23   |
|                                                                            |                  |                  |                     | Butyl acetate     | 333.15 | −59                          | 26   |
|                                                                            |                  |                  |                     | Butyl acetate     | 343.15 | −55                          | 26   |
|                                                                            |                  |                  |                     | Butyl acetate     | 353.15 | −47                          | 26   |
|                                                                            |                  |                  |                     | Diethyl ether     | 295.15 | −62                          | 3    |
|                                                                            |                  |                  |                     | Dibutyl phthalate | 273.15 | −45                          | 26   |
|                                                                            |                  |                  |                     | Dibutyl phthalate | 298.15 | −46                          | 26   |
|                                                                            |                  |                  |                     | Dibutyl phthalate | 313.15 | −46                          | 26   |
|                                                                            |                  |                  |                     | Dibutyl phthalate | 333.15 | −42                          | 26   |
|                                                                            |                  |                  |                     | Ethanol           | 295.15 | −46                          | 3    |
|                                                                            |                  |                  |                     | Ethyl acetate     | 293.15 | −76                          | 23   |
|                                                                            |                  |                  |                     | Ethyl acetate     | 298.15 | −75                          | 23   |
|                                                                            |                  |                  |                     | Ethyl acetate     | 303.15 | −69                          | 23   |
|                                                                            |                  |                  |                     | Ethyl acetate     | 308.15 | −61                          | 23   |
|                                                                            |                  |                  |                     | Ethyl acetate     | 313.15 | −54                          | 23   |
|                                                                            |                  |                  |                     | Ethyl acetate     | 318.15 | −50                          | 23   |
|                                                                            |                  |                  |                     | Ethyl acetate     | 323.15 | −50                          | 23   |
|                                                                            |                  |                  |                     | Ethyl acetate     | 328.15 | −50                          | 23   |
|                                                                            |                  |                  |                     | Methanol          | 293.15 | −69                          | 23   |

| Polymer                     | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                          | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|-----------------------------|------------------|------------------|---------------------|----------------------------------|--------|------------------------------|------|
|                             |                  |                  |                     | Methanol                         | 298.15 | -56                          | 23   |
|                             |                  |                  |                     | Methanol                         | 303.15 | -50                          | 23   |
|                             |                  |                  |                     | Methanol                         | 308.15 | -50                          | 23   |
|                             |                  |                  |                     | Methanol                         | 313.15 | -50                          | 23   |
|                             |                  |                  |                     | Methanol                         | 318.15 | -50                          | 23   |
|                             |                  |                  |                     | Methanol                         | 323.15 | -50                          | 23   |
|                             |                  |                  |                     | Methanol                         | 328.15 | -50                          | 23   |
|                             |                  |                  |                     | 2,4-Pentanedione                 | 298.15 | -74                          | 4    |
|                             |                  |                  |                     | 2-Pentanone                      | 298.15 | -64                          | 4    |
|                             |                  |                  |                     | 2-Propanone                      | 273.15 | -75                          | 26   |
|                             |                  |                  |                     | 2-Propanone                      | 293.15 | -75                          | 23   |
|                             |                  |                  |                     | 2-Propanone                      | 298.15 | -83                          | 2    |
|                             |                  |                  |                     | 2-Propanone                      | 298.15 | -68                          | 4    |
|                             |                  |                  |                     | 2-Propanone                      | 298.15 | -71                          | 8    |
|                             |                  |                  |                     | 2-Propanone                      | 298.15 | -74                          | 23   |
|                             |                  |                  |                     | 2-Propanone                      | 298.15 | -79                          | 25   |
|                             |                  |                  |                     | 2-Propanone                      | 298.15 | -75                          | 26   |
|                             |                  |                  |                     | 2-Propanone                      | 303.15 | -60                          | 23   |
|                             |                  |                  |                     | 2-Propanone                      | 308.15 | -51                          | 23   |
|                             |                  |                  |                     | 2-Propanone                      | 313.15 | -50                          | 23   |
|                             |                  |                  |                     | 2-Propanone                      | 313.15 | -65                          | 26   |
|                             |                  |                  |                     | 2-Propanone                      | 318.15 | -50                          | 23   |
|                             |                  |                  |                     | 2-Propanone                      | 323.15 | -50                          | 23   |
|                             |                  |                  |                     | 2-Propanone                      | 323.15 | -50                          | 26   |
|                             |                  |                  |                     | 2-Propanone                      | 328.15 | -50                          | 23   |
|                             |                  |                  |                     | Pyridine                         | 298.15 | -106                         | 2    |
|                             |                  |                  |                     | Tri(4-methylphenyl)<br>phosphate | 298.15 | -16                          | 26   |
|                             |                  |                  |                     | Tri(4-methylphenyl)<br>phosphate | 313.15 | -28                          | 26   |
|                             |                  |                  |                     | Tri(4-methylphenyl)<br>phosphate | 333.15 | -41                          | 26   |
|                             |                  |                  |                     | Tri(4-methylphenyl)<br>phosphate | 343.15 | -44                          | 26   |
|                             |                  |                  |                     | Tri(4-methylphenyl)<br>phosphate | 353.15 | -47                          | 26   |
| <i>Nylon-6 (unoriented)</i> |                  |                  |                     | Formic acid                      | 295.15 | -53                          | 24   |
|                             |                  |                  |                     | Tricresol                        | 323.55 | -66                          | 22   |
|                             |                  |                  |                     | Tricresol                        | 345.55 | -66                          | 22   |
| <i>Poly(acrylonitrile)</i>  |                  |                  |                     | Benzene                          | 298.15 | 0.0                          | 18   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide    | 295.15 | -23                          | 35   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide    | 298.15 | -21                          | 18   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide    | 298.15 | -43                          | 42   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide    | 308.15 | -17                          | 35   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide    | 323.15 | -13                          | 35   |

| Polymer                                             | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                            | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|-----------------------------------------------------|------------------|------------------|---------------------|------------------------------------|--------|------------------------------|------|
| <i>Poly(<math>\gamma</math>-benzyl-L-glutamate)</i> |                  |                  |                     | <i>N,N</i> -Dimethylformamide      | 323.15 | -15                          | 66   |
|                                                     |                  |                  |                     | <i>N,N</i> -Dimethylformamide      | 338.15 | -10                          | 35   |
|                                                     |                  |                  |                     | Dimethylsulfoxide                  | 298.15 | -70                          | 42   |
|                                                     |                  |                  |                     |                                    |        |                              |      |
| <i>Polybutadiene</i>                                |                  | 160000           |                     | Dichloroacetic acid                | 303.15 | -35                          | 46   |
|                                                     |                  | 160000           |                     | 1,2-Dichloroethane                 | 303.15 | -1.6                         | 46   |
| <i>1,4-cis-Polybutadiene</i>                        |                  |                  |                     | Benzene                            | 298.15 | 6.1                          | 7    |
|                                                     |                  |                  |                     | Benzene                            | 298.15 | 7.1                          | 25   |
|                                                     |                  |                  |                     | Benzene                            | 298.15 | 10.5                         | 32   |
|                                                     |                  |                  |                     | 2,2,4-Trimethylpentane             | 298.15 | 1.1                          | 32   |
| <i>1,4-cis-Polybutadiene</i>                        | low              |                  |                     | Cyclohexane                        | 298.15 | 5.4                          | 74   |
|                                                     |                  |                  |                     | Cyclooctane                        | 298.15 | 5.8                          | 74   |
|                                                     |                  |                  |                     | Cyclopentane                       | 298.15 | <0.1                         | 74   |
|                                                     |                  |                  |                     | <i>cis</i> -Decahydronaphthalene   | 298.15 | 4.2                          | 74   |
|                                                     |                  |                  |                     | <i>trans</i> -Decahydronaphthalene | 298.15 | 2.6                          | 74   |
|                                                     |                  |                  |                     | 3,3-Diethylpentane                 | 298.15 | 5.2                          | 74   |
|                                                     |                  |                  |                     | 2,2-Dimethylpentane                | 298.15 | 4.1                          | 74   |
|                                                     |                  |                  |                     | 2,3-Dimethylpentane                | 298.15 | 4.5                          | 74   |
|                                                     |                  |                  |                     | 2,4-Dimethylpentane                | 298.15 | 3.2                          | 74   |
|                                                     |                  |                  |                     | 3,3-Dimethylpentane                | 298.15 | 3.2                          | 74   |
|                                                     |                  |                  |                     | Dodecane                           | 298.15 | 4.2                          | 74   |
|                                                     |                  |                  |                     | 3-Ethylpentane                     | 298.15 | 3.7                          | 74   |
|                                                     |                  |                  |                     | 2,2,4,4,6,8,8-Heptamethylnonane    | 298.15 | 4.8                          | 74   |
|                                                     |                  |                  |                     | Hexadecane                         | 298.15 | 4.9                          | 74   |
|                                                     |                  |                  |                     | 3-Methylhexane                     | 298.15 | 3.6                          | 74   |
|                                                     |                  |                  |                     | Octane                             | 298.15 | 4.3                          | 74   |
|                                                     |                  |                  |                     | 2,2,4,6,6-Pentamethylheptane       | 298.15 | 5.0                          | 74   |
|                                                     |                  |                  |                     | 2,2,4,4-Tetramethylpentane         | 298.15 | 5.8                          | 74   |
|                                                     |                  |                  |                     | 2,3,3,4-Tetramethylpentane         | 298.15 | 5.1                          | 74   |
| <i>Poly(1-butene)</i>                               |                  |                  | 20000               | Cyclohexane                        | 298.15 | 1.0                          | 74   |
|                                                     |                  |                  | 20000               | Cyclooctane                        | 298.15 | 1.8                          | 74   |
|                                                     |                  |                  | 20000               | Cyclopentane                       | 298.15 | -2.9                         | 74   |
|                                                     |                  |                  | 20000               | <i>cis</i> -Decahydronaphthalene   | 298.15 | <0.1                         | 74   |
|                                                     |                  |                  | 20000               | <i>trans</i> -Decahydronaphthalene | 298.15 | -2.0                         | 74   |
|                                                     |                  |                  | 20000               | Decane                             | 298.15 | 1.2                          | 62   |
|                                                     |                  |                  | 20000               | 3,3-Diethylpentane                 | 298.15 | -2.6                         | 74   |
|                                                     |                  |                  | 20000               | 2,2-Dimethylpentane                | 298.15 | -4.0                         | 74   |
|                                                     |                  |                  | 20000               | 2,3-Dimethylpentane                | 298.15 | -2.8                         | 74   |
|                                                     |                  |                  | 20000               | 2,4-Dimethylpentane                | 298.15 | -2.3                         | 74   |
|                                                     |                  |                  | 20000               | 3,3-Dimethylpentane                | 298.15 | -2.2                         | 74   |
|                                                     |                  |                  | 20000               | Dodecane                           | 298.15 | 2.1                          | 74   |

| Polymer                                   | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                            | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|-------------------------------------------|------------------|------------------|---------------------|------------------------------------|--------|------------------------------|------|
|                                           |                  |                  | 20000               | 3-Ethylpentane                     | 298.15 | −2.8                         | 74   |
|                                           |                  |                  | 20000               | Heptane                            | 298.15 | 0.0                          | 73   |
|                                           |                  |                  | 20000               | Hexadecane                         | 298.15 | 3.0                          | 62   |
|                                           |                  |                  | 20000               | Hexane                             | 298.15 | −1.2                         | 62   |
|                                           |                  |                  | 20000               | 3-Methylhexane                     | 298.15 | −2.1                         | 74   |
|                                           |                  |                  | 20000               | Nonane                             | 298.15 | 0.9                          | 73   |
|                                           |                  |                  | 20000               | Octane                             | 298.15 | 0.4                          | 73   |
|                                           |                  |                  | 20000               | 2,2,4,6,6-Pentamethylheptane       | 298.15 | 0.6                          | 73   |
|                                           |                  |                  | 20000               | Pentane                            | 298.15 | −2.6                         | 62   |
|                                           |                  |                  | 20000               | Tetradecane                        | 298.15 | 2.7                          | 62   |
|                                           |                  |                  | 20000               | 2,2,4,4-Tetramethylpentane         | 298.15 | −1.4                         | 74   |
|                                           |                  |                  | 20000               | 2,3,3,4-Tetramethylpentane         | 298.15 | −2.2                         | 74   |
|                                           |                  |                  | 20000               | 2,2,4-Trimethylpentane             | 298.15 | −0.5                         | 73   |
|                                           |                  |                  |                     |                                    |        |                              |      |
| <i>Poly(butyl acrylate)</i>               |                  |                  |                     | 2-Propanone                        | 298.15 | 0.8                          | 25   |
| <i>Poly(butyl methacrylate)</i>           |                  |                  |                     |                                    |        |                              |      |
| Glass                                     | 91300            | 210000           |                     | Cyclohexanone                      | 304.15 | 7.7                          | 99   |
| Liquid                                    | 91300            | 210000           |                     | Cyclohexanone                      | 304.15 | 8.2                          | 99   |
|                                           |                  |                  |                     | 2-Propanone                        | 298.15 | 19.5                         | 25   |
| <i>Polychloroprene</i>                    |                  |                  |                     |                                    |        |                              |      |
|                                           |                  |                  |                     | Benzene                            | 298.15 | 0.5                          | 7    |
| <i>Poly(2,6-dimethyl phenylene oxide)</i> |                  |                  |                     |                                    |        |                              |      |
|                                           | 17000            | 46400            |                     | 1,2-Dichlorobenzene                | 303.05 | 55                           | 89   |
| <i>Poly(dimethylsiloxane)</i>             |                  |                  |                     |                                    |        |                              |      |
|                                           | 13000            |                  |                     | Benzene                            | 298.15 | 11.2                         | 50   |
|                                           |                  |                  | 20000               | Benzene                            | 298.15 | 13.5                         | 61   |
|                                           |                  |                  | 100000              | Benzene                            | 298.15 | 14.2                         | 40   |
|                                           |                  |                  | 170000              | Bromocyclohexane                   | 303.15 | 10.2                         | 51   |
|                                           |                  |                  | 80000               | 2-Butanone                         | 293.15 | 14.4                         | 77   |
|                                           | 30900            |                  |                     | 2-Butanone                         | 303.15 | 14.2                         | 44   |
|                                           |                  |                  | 170000              | 2-Butanone                         | 303.15 | 14.7                         | 51   |
|                                           |                  |                  | 80000               | 2-Butanone                         | 308.15 | 14.3                         | 77   |
|                                           |                  |                  | 80000               | 2-Butanone                         | 323.15 | 14.3                         | 77   |
|                                           |                  |                  | 80000               | Butyl acetate                      | 298.15 | 6.1                          | 41   |
|                                           |                  |                  | 80000               | Butyl propanoate                   | 298.15 | 4.9                          | 41   |
|                                           |                  |                  | 100000              | Chlorobenzene                      | 298.15 | 7.5                          | 40   |
|                                           | 13000            |                  |                     | Cyclohexane                        | 298.15 | 3.0                          | 50   |
|                                           |                  |                  | 20000               | Cyclohexane                        | 298.15 | 5.2                          | 74   |
|                                           |                  |                  | 100000              | Cyclohexane                        | 298.15 | 5.2                          | 40   |
|                                           |                  |                  | 20000               | Cyclooctane                        | 298.15 | 6.8                          | 74   |
|                                           |                  |                  | 20000               | Cyclopentane                       | 298.15 | 1.0                          | 74   |
|                                           |                  |                  | 20000               | <i>cis</i> -Decahydronaphthalene   | 298.15 | 7.1                          | 74   |
|                                           |                  |                  | 20000               | <i>trans</i> -Decahydronaphthalene | 298.15 | 4.3                          | 74   |
|                                           |                  |                  | 20000               | Decamethyltetrasiloxane            | 297.65 | 0.45                         | 37   |
|                                           |                  |                  | 20000               | Decane                             | 298.15 | 3.8                          | 37   |
|                                           |                  |                  | 20000               | Decane                             | 298.15 | 3.9                          | 61   |

| Polymer | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                         | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|---------|------------------|------------------|---------------------|---------------------------------|--------|------------------------------|------|
|         |                  |                  | 80000               | Decane                          | 298.15 | 3.8                          | 41   |
|         |                  |                  | 80000               | Decyl acetate                   | 298.15 | 4.5                          | 41   |
|         |                  |                  | 80000               | Dibutyl ether                   | 298.15 | 0.6                          | 41   |
|         |                  |                  | 80000               | Diethoxymethane                 | 298.15 | 1.8                          | 41   |
|         |                  |                  | 80000               | Diethyl ether                   | 298.15 | -1.3                         | 41   |
|         |                  |                  | 20000               | 3,3-Diethylpentane              | 298.15 | 1.9                          | 74   |
|         |                  |                  | 80000               | Dihexyl ether                   | 298.15 | 3.0                          | 41   |
|         |                  |                  | 80000               | 1,2-Dimethoxyethane             | 298.15 | 12.2                         | 41   |
|         |                  |                  | 80000               | Dimethoxymethane                | 298.15 | 7.4                          | 41   |
|         | 13000            |                  |                     | 1,2-Dimethylbenzene             | 298.15 | 4.3                          | 50   |
|         | 13000            |                  |                     | 1,3-Dimethylbenzene             | 298.15 | 3.0                          | 50   |
|         | 13000            |                  |                     | 1,4-Dimethylbenzene             | 298.15 | 3.2                          | 50   |
|         |                  |                  | 20000               | 1,4-Dimethylbenzene             | 298.15 | 4.2                          | 61   |
|         |                  |                  | 80000               | 2,6-Dimethyl-4-heptanone        | 293.15 | 6.1                          | 77   |
|         |                  |                  | 20000               | 2,2-Dimethylpentane             | 298.15 | 0.8                          | 74   |
|         |                  |                  | 20000               | 2,3-Dimethylpentane             | 298.15 | 1.4                          | 74   |
|         |                  |                  | 20000               | 2,4-Dimethylpentane             | 298.15 | 1.6                          | 74   |
|         |                  |                  | 20000               | 3,3-Dimethylpentane             | 298.15 | 0.5                          | 74   |
|         |                  |                  | 80000               | Dipentyl ether                  | 298.15 | 2.1                          | 41   |
|         |                  |                  | 80000               | Dipropyl ether                  | 298.15 | -1.2                         | 41   |
|         |                  |                  | 20000               | Dodecamethylpentasiloxane       | 297.65 | -0.3                         | 37   |
|         |                  |                  | 20000               | Dodecane                        | 297.65 | 4.5                          | 37   |
|         |                  |                  | 20000               | Dodecane                        | 298.15 | 4.4                          | 73   |
|         |                  |                  | 80000               | Dodecane                        | 298.15 | 4.5                          | 41   |
|         |                  |                  | 80000               | Ethyl acetate                   | 298.15 | 12.7                         | 41   |
|         |                  |                  | 170000              | Ethyl acetate                   | 303.15 | 13.7                         | 51   |
|         | 13000            |                  |                     | Ethylbenzene                    | 298.15 | 6.4                          | 50   |
|         |                  |                  | 20000               | Ethylbenzene                    | 298.15 | 6.2                          | 61   |
|         |                  |                  | 80000               | Ethyl butanoate                 | 298.15 | 6.0                          | 41   |
|         |                  |                  | 80000               | Ethyl decanoate                 | 298.15 | 3.8                          | 41   |
|         |                  |                  | 80000               | Ethyl dodecanoate               | 298.15 | 3.8                          | 41   |
|         |                  |                  | 80000               | Ethyl heptanoate                | 298.15 | 4.1                          | 41   |
|         |                  |                  | 80000               | Ethyl hexanoate                 | 298.15 | 4.3                          | 41   |
|         |                  |                  | 80000               | Ethyl nonanoate                 | 298.15 | 3.7                          | 41   |
|         |                  |                  | 80000               | Ethyl octanoate                 | 298.15 | 3.8                          | 41   |
|         |                  |                  | 20000               | 3-Ethylpentane                  | 298.15 | 0.6                          | 74   |
|         |                  |                  | 80000               | Ethyl propanoate                | 298.15 | 8.0                          | 41   |
|         |                  |                  | 20000               | 2,2,4,4,6,8,8-Heptamethylnonane | 298.15 | 3.5                          | 74   |
|         | 13000            |                  |                     | Heptane                         | 298.15 | 1.8                          | 50   |
|         |                  |                  | 20000               | Heptane                         | 298.15 | 1.9                          | 73   |
|         |                  |                  | 20000               | Heptane                         | 297.65 | 2.0                          | 37   |
|         |                  |                  | 20000               | Heptane                         | 298.15 | 2.0                          | 61   |
|         |                  |                  | 80000               | Heptane                         | 298.15 | 2.0                          | 41   |
|         |                  |                  | 100000              | Heptane                         | 298.15 | 2.1                          | 40   |
|         |                  |                  | 170000              | Heptane                         | 303.15 | 1.9                          | 51   |
|         |                  |                  | 80000               | 3-Heptanone                     | 308.15 | 8.8                          | 77   |
|         |                  |                  | 80000               | 3-Heptanone                     | 323.15 | 8.8                          | 77   |

| Polymer | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                      | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|---------|------------------|------------------|---------------------|------------------------------|--------|------------------------------|------|
|         |                  |                  | 20000               | Hexadecane                   | 297.65 | 5.5                          | 37   |
|         |                  |                  | 20000               | Hexadecane                   | 298.15 | 5.5                          | 73   |
|         |                  |                  | 20000               | Hexamethyldisiloxane         | 298.15 | −1.2                         | 37   |
|         |                  |                  | 20000               | Hexamethyldisiloxane         | 298.15 | −1.6                         | 61   |
|         |                  |                  | 170000              | Hexamethyldisiloxane         | 303.15 | −1.5                         | 51   |
|         |                  |                  | 20000               | Hexane                       | 297.65 | 0.7                          | 37   |
|         |                  |                  | 20000               | Hexane                       | 298.15 | 0.7                          | 61   |
|         |                  |                  | 80000               | Hexane                       | 298.15 | 0.7                          | 41   |
|         |                  |                  | 170000              | Hexane                       | 303.15 | 0.3                          | 51   |
|         |                  |                  | 80000               | Hexyl acetate                | 298.15 | 5.0                          | 41   |
|         |                  |                  | 13000               | Isopropylbenzene             | 298.15 | 4.1                          | 50   |
|         |                  |                  | 80000               | Methyl butanoate             | 298.15 | 8.6                          | 41   |
|         |                  |                  | 13000               | Methylcyclohexane            | 298.15 | 2.9                          | 50   |
|         |                  |                  | 100000              | Methylcyclohexane            | 298.15 | 1.9                          | 40   |
|         |                  |                  | 80000               | Methyl decanoate             | 298.15 | 4.8                          | 41   |
|         |                  |                  | 20000               | 3-Methylhexane               | 298.15 | 1.3                          | 74   |
|         |                  |                  | 80000               | Methyl hexanoate             | 298.15 | 5.3                          | 41   |
|         |                  |                  | 80000               | Methyl octanoate             | 298.15 | 5.0                          | 41   |
|         |                  |                  | 80000               | 4-Methyl-2-pentanone         | 293.15 | 9.9                          | 77   |
|         |                  |                  | 80000               | 4-Methyl-2-pentanone         | 308.15 | 9.0                          | 77   |
|         |                  |                  | 80000               | Methyl propanoate            | 298.15 | 12.1                         | 41   |
|         |                  |                  | 20000               | Nonane                       | 297.65 | 3.4                          | 37   |
|         |                  |                  | 20000               | Nonane                       | 298.15 | 3.3                          | 73   |
|         |                  |                  | 80000               | Nonane                       | 298.15 | 3.4                          | 41   |
|         |                  |                  | 80000               | Octamethylcyclotetrasiloxane | 293.15 | −0.4                         | 78   |
|         |                  |                  | 20000               | Octamethyltrisiloxane        | 297.65 | −0.6                         | 37   |
|         |                  |                  | 20000               | Octamethyltrisiloxane        | 298.15 | −0.8                         | 61   |
|         |                  |                  | 170000              | Octamethyltrisiloxane        | 303.15 | −1.0                         | 51   |
|         |                  |                  | 20000               | Octane                       | 297.65 | 2.6                          | 37   |
|         |                  |                  | 20000               | Octane                       | 298.15 | 2.4                          | 73   |
|         |                  |                  | 20000               | Octane                       | 298.15 | 2.6                          | 61   |
|         |                  |                  | 80000               | Octane                       | 298.15 | 2.6                          | 41   |
|         |                  |                  | 20000               | 2,2,4,6,6-Pentamethylheptane | 298.15 | 2.7                          | 73   |
|         |                  |                  | 20000               | Pentane                      | 298.15 | −0.9                         | 37   |
|         |                  |                  | 20000               | Pentane                      | 298.15 | −0.9                         | 61   |
|         |                  |                  | 80000               | Pentane                      | 298.15 | −1.0                         | 41   |
|         |                  |                  | 80000               | Pentyl acetate               | 298.15 | 5.8                          | 41   |
|         |                  |                  | 80000               | Pentyl propanoate            | 298.15 | 3.8                          | 41   |
|         |                  |                  | 80000               | Propyl acetate               | 298.15 | 8.6                          | 41   |
|         |                  |                  | 170000              | Propyl acetate               | 303.15 | 9.9                          | 51   |
|         |                  |                  | 80000               | Propyl propanoate            | 298.15 | 5.6                          | 41   |
|         |                  |                  | 100000              | Tetrachloromethane           | 298.15 | 2.4                          | 40   |
|         |                  |                  | 20000               | Tetradecane                  | 297.65 | 5.1                          | 37   |
|         |                  |                  | 20000               | Tetradecane                  | 298.15 | 5.1                          | 61   |
|         |                  |                  | 80000               | Tetradecane                  | 298.15 | 5.1                          | 41   |
|         |                  |                  | 20000               | 2,2,4,4-Tetramethylpentane   | 298.15 | 2.1                          | 73   |
|         |                  |                  | 20000               | 2,2,4,4-Tetramethylpentane   | 298.15 | 2.3                          | 74   |



| Polymer             | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                         | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|---------------------|------------------|------------------|---------------------|---------------------------------|--------|------------------------------|------|
|                     |                  |                  | 20000               | 2,3,3,4-Tetramethylpentane      | 298.15 | 1.9                          | 74   |
|                     | 13000            |                  |                     | Toluene                         | 298.15 | 5.5                          | 50   |
|                     |                  |                  | 20000               | Toluene                         | 298.15 | 6.7                          | 61   |
|                     |                  |                  | 20000               | Tridecane                       | 297.65 | 4.8                          | 37   |
|                     |                  |                  | 80000               | Tridecane                       | 298.15 | 4.8                          | 41   |
|                     | 13000            |                  |                     | 1,3,5-Trimethylbenzene          | 298.15 | 3.7                          | 50   |
|                     |                  |                  | 20000               | 2,2,4-Trimethylpentane          | 298.15 | 1.4                          | 73   |
|                     |                  |                  | 20000               | Undecane                        | 297.65 | 4.2                          | 37   |
|                     |                  |                  | 80000               | Undecane                        | 298.15 | 4.3                          | 41   |
| <b>Polyethylene</b> |                  |                  |                     |                                 |        |                              |      |
| Semicrystalline     |                  | 65000            |                     | 1-Chloronaphthalene             | 373.15 | 780                          | 47   |
| Semicrystalline     |                  | 65000            |                     | 1-Chloronaphthalene             | 383.15 | 980                          | 47   |
| Semicrystalline     |                  | 65000            |                     | 1-Chloronaphthalene             | 393.15 | 800                          | 47   |
| Liquid              |                  | 65000            |                     | 1-Chloronaphthalene             | 403.15 | 49                           | 47   |
| Semicrystalline     |                  | 144000           |                     | 1-Chloronaphthalene             | 383.15 | 920                          | 47   |
| Semicrystalline     |                  | 144000           |                     | 1-Chloronaphthalene             | 393.15 | 990                          | 47   |
| Semicrystalline     |                  | 144000           |                     | 1-Chloronaphthalene             | 403.15 | 690                          | 47   |
| Liquid              |                  | 144000           |                     | 1-Chloronaphthalene             | 413.15 | 67                           | 47   |
| Liquid              |                  | 144000           |                     | 1-Chloronaphthalene             | 423.15 | 85                           | 47   |
| Semicrystalline     |                  | 670000           |                     | 1-Chloronaphthalene             | 363.15 | 380                          | 47   |
| Semicrystalline     |                  | 670000           |                     | 1-Chloronaphthalene             | 373.15 | 430                          | 47   |
| Semicrystalline     |                  | 670000           |                     | 1-Chloronaphthalene             | 383.15 | 165                          | 47   |
| Liquid              |                  | 670000           |                     | 1-Chloronaphthalene             | 393.15 | 39                           | 47   |
| Liquid              |                  | 670000           |                     | 1-Chloronaphthalene             | 403.15 | 36                           | 47   |
| Semicrystalline     |                  | 900000           |                     | 1-Chloronaphthalene             | 391.80 | 245                          | 105  |
| Semicrystalline     |                  | 900000           |                     | Cyclohexane                     | 379.50 | 205                          | 105  |
| Semicrystalline     |                  | 900000           |                     | Cyclopentane                    | 380.00 | 190                          | 105  |
| Alkathene           |                  |                  |                     | Decahydronaphthalene            | 349.85 | 142                          | 56   |
| Rigidex-3           |                  |                  |                     | Decahydronaphthalene            | 366.65 | 180                          | 56   |
| Rigidex-50          |                  |                  |                     | Decahydronaphthalene            | 374.05 | 233                          | 56   |
| Semicrystalline     |                  | 900000           |                     | Decahydronaphthalene            | 384.00 | 260                          | 105  |
| Semicrystalline     |                  |                  |                     | 1,2-Dichloroethane              | 333.15 | 30                           | 27   |
| Semicrystalline     |                  |                  |                     | 1,2-Dichloroethane              | 338.15 | 38                           | 27   |
| Semicrystalline     |                  |                  |                     | 1,2-Dichloroethane              | 343.15 | 54                           | 27   |
| Semicrystalline     |                  |                  |                     | 1,2-Dichloroethane              | 348.15 | 65                           | 27   |
| Semicrystalline     |                  |                  | 10000               | 1,4-Dimethylbenzene             | 354.15 | 139                          | 5    |
| Semicrystalline     |                  |                  | 11800               | 1,4-Dimethylbenzene             | 352.15 | 139                          | 5    |
| Semicrystalline     |                  |                  | 15600               | 1,4-Dimethylbenzene             | 353.65 | 154                          | 5    |
| Semicrystalline     |                  |                  | 15600               | 1,4-Dimethylbenzene             | 363.65 | 113                          | 5    |
| Semicrystalline     |                  |                  | 15600               | 1,4-Dimethylbenzene             | 368.65 | 104                          | 5    |
| Semicrystalline     |                  | 900000           |                     | 2,4-Dimethylpentane             | 393.00 | 230                          | 105  |
| Semicrystalline     |                  | 900000           |                     | 2,2,4,4,6,8,8-Heptamethylnonane | 399.50 | 170                          | 105  |
| Semicrystalline     |                  | 900000           |                     | Hexadecane                      | 399.50 | 262                          | 105  |
| Semicrystalline     |                  | 900000           |                     | 2-Methylbutane                  | 394.20 | 165                          | 105  |
| Semicrystalline     |                  | 65000            |                     | 1,2,3,4-Tetrahydronaphthalene   | 373.15 | 940                          | 47   |

| Polymer                      | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                       | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|------------------------------|------------------|------------------|---------------------|-------------------------------|--------|------------------------------|------|
| Semicrystalline              |                  | 65000            |                     | 1,2,3,4-Tetrahydronaphthalene | 383.15 | 990                          | 47   |
| Semicrystalline              |                  | 65000            |                     | 1,2,3,4-Tetrahydronaphthalene | 393.15 | 790                          | 47   |
| Liquid                       |                  | 65000            |                     | 1,2,3,4-Tetrahydronaphthalene | 403.15 | 58                           | 47   |
| Semicrystalline              |                  | 84000            |                     | 1,2,3,4-Tetrahydronaphthalene | 373.15 | 835                          | 47   |
| Semicrystalline              |                  | 130000           |                     | 1,2,3,4-Tetrahydronaphthalene | 353.15 | 630                          | 47   |
| Semicrystalline              |                  | 130000           |                     | 1,2,3,4-Tetrahydronaphthalene | 373.15 | 520                          | 47   |
| Liquid                       |                  | 130000           |                     | 1,2,3,4-Tetrahydronaphthalene | 393.15 | 69                           | 47   |
| Semicrystalline              |                  | 144000           |                     | 1,2,3,4-Tetrahydronaphthalene | 373.15 | 610                          | 47   |
| Semicrystalline              |                  | 144000           |                     | 1,2,3,4-Tetrahydronaphthalene | 383.15 | 1200                         | 47   |
| Semicrystalline              |                  | 144000           |                     | 1,2,3,4-Tetrahydronaphthalene | 393.15 | 1130                         | 47   |
| Semicrystalline              |                  | 144000           |                     | 1,2,3,4-Tetrahydronaphthalene | 403.15 | 800                          | 47   |
| Liquid                       |                  | 144000           |                     | 1,2,3,4-Tetrahydronaphthalene | 413.15 | 136                          | 47   |
| Liquid                       |                  | 144000           |                     | 1,2,3,4-Tetrahydronaphthalene | 423.15 | 88                           | 47   |
| Semicrystalline              |                  | 310000           |                     | 1,2,3,4-Tetrahydronaphthalene | 343.15 | 485                          | 47   |
| Semicrystalline              |                  | 670000           |                     | 1,2,3,4-Tetrahydronaphthalene | 353.15 | 560                          | 47   |
| Semicrystalline              |                  | 670000           |                     | 1,2,3,4-Tetrahydronaphthalene | 363.15 | 560                          | 47   |
| Semicrystalline              |                  | 670000           |                     | 1,2,3,4-Tetrahydronaphthalene | 373.15 | 460                          | 47   |
| Semicrystalline              |                  | 670000           |                     | 1,2,3,4-Tetrahydronaphthalene | 383.15 | 155                          | 47   |
| Liquid                       |                  | 670000           |                     | 1,2,3,4-Tetrahydronaphthalene | 393.15 | 67                           | 47   |
| Liquid                       |                  | 670000           |                     | 1,2,3,4-Tetrahydronaphthalene | 403.15 | 39                           | 47   |
| Semicrystalline              |                  |                  | 16000               | Toluene                       | 353.15 | 110                          | 22   |
| Semicrystalline              |                  |                  | 22000               | Toluene                       | 358.35 | 118                          | 22   |
| Semicrystalline              |                  |                  | 22000               | Toluene                       | 367.35 | 106                          | 22   |
| Semicrystalline              |                  | 900000           |                     | 1,2,4-Trichlorobenzene        | 386.50 | 255                          | 105  |
| <i>Poly(ethylene glycol)</i> |                  |                  |                     |                               |        |                              |      |
|                              | 180              |                  |                     | Benzene                       | 303.15 | 110                          | 71   |
|                              | 385              |                  |                     | Benzene                       | 303.15 | 60                           | 71   |
|                              | 560              |                  |                     | Benzene                       | 303.15 | 40                           | 71   |
|                              | 1050             |                  |                     | Benzene                       | 303.15 | 90                           | 71   |
|                              | 1610             |                  |                     | Benzene                       | 303.15 | 140                          | 71   |
|                              | 1940             |                  |                     | Benzene                       | 303.15 | 215                          | 71   |
|                              | 3200             |                  |                     | Benzene                       | 303.15 | 195                          | 71   |
|                              | 4330             |                  |                     | Benzene                       | 303.15 | 195                          | 71   |

| Polymer                                        | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent            | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|------------------------------------------------|------------------|------------------|---------------------|--------------------|--------|------------------------------|------|
|                                                | 5850             |                  |                     | Benzene            | 303.15 | 190                          | 71   |
|                                                | 9950             |                  |                     | Benzene            | 303.15 | 195                          | 71   |
|                                                |                  |                  | 43400               | Benzene            | 303.15 | 190                          | 71   |
|                                                | 400              | 420              |                     | Trichloromethane   | 303.15 | -79                          | 95   |
|                                                | 590              | 615              |                     | Trichloromethane   | 303.15 | -88                          | 95   |
|                                                | 180              |                  |                     | Water              | 303.15 | -136                         | 71   |
|                                                | 200              |                  |                     | Water              | 321.35 | -125                         | 83   |
|                                                | 355              |                  |                     | Water              | 303.15 | -159                         | 71   |
|                                                | 400              |                  |                     | Water              | 321.35 | -150                         | 83   |
|                                                | 560              |                  |                     | Water              | 303.15 | -150                         | 71   |
|                                                | 990              |                  |                     | Water              | 321.35 | -101                         | 83   |
|                                                | 1050             |                  |                     | Water              | 303.15 | -106                         | 71   |
|                                                | 1460             |                  |                     | Water              | 321.35 | -137                         | 83   |
|                                                | 1610             |                  |                     | Water              | 303.15 | -6                           | 71   |
|                                                | 1940             |                  |                     | Water              | 303.15 | 57                           | 71   |
|                                                | 3200             |                  |                     | Water              | 303.15 | 58                           | 71   |
|                                                | 4330             |                  |                     | Water              | 303.15 | 28                           | 71   |
|                                                | 5850             |                  |                     | Water              | 303.15 | 39                           | 71   |
|                                                | 9950             |                  |                     | Water              | 303.15 | 30                           | 71   |
|                                                |                  |                  | 14000               | Water              | 303.15 | 7                            | 55   |
|                                                |                  |                  | 14000               | Water              | 313.15 | 27                           | 55   |
|                                                |                  |                  | 20300               | Water              | 303.15 | 45                           | 71   |
|                                                |                  |                  | 34500               | Water              | 303.15 | 34                           | 71   |
|                                                |                  |                  | 43300               | Water              | 303.15 | +40                          | 71   |
| <i>Poly(ethylene glycol) dimethyl ether</i>    |                  |                  |                     |                    |        |                              |      |
|                                                | 250              |                  |                     | Tetrachloromethane | 303.15 | -12                          | 95   |
|                                                | 250              |                  |                     | Tetrachloromethane | 318.15 | -7.6                         | 95   |
|                                                | 400              |                  |                     | Tetrachloromethane | 303.15 | -12                          | 95   |
|                                                | 520              | 550              |                     | Tetrachloromethane | 303.15 | -12                          | 95   |
|                                                | 520              | 550              |                     | Tetrachloromethane | 303.15 | -7.6                         | 95   |
|                                                | 250              |                  |                     | Trichloromethane   | 303.15 | -184                         | 95   |
|                                                | 520              | 550              |                     | Trichloromethane   | 303.15 | -135                         | 95   |
| <i>Poly(ethylene glycol) monododecyl ether</i> |                  |                  |                     |                    |        |                              |      |
|                                                | 230              |                  |                     | Dodecane           | 302.15 | 42                           | 68   |
|                                                | 274              |                  |                     | Dodecane           | 302.15 | 23                           | 68   |
|                                                | 318              |                  |                     | Dodecane           | 302.15 | 34                           | 68   |
|                                                | 362              |                  |                     | Dodecane           | 302.15 | 37                           | 68   |
|                                                | 406              |                  |                     | Dodecane           | 302.15 | 42                           | 68   |
| <i>Poly(ethylene glycol) monomethyl ether</i>  |                  |                  |                     |                    |        |                              |      |
|                                                | 353              | 377              |                     | Trichloromethane   | 303.15 | -125                         | 95   |
|                                                | 550              | 580              |                     | Trichloromethane   | 303.15 | -117                         | 95   |
| <i>Poly(ethylene oxide)</i>                    |                  |                  |                     |                    |        |                              |      |
| Semicrystalline                                | 6000             |                  |                     | Dichloromethane    | 303.15 | +84                          | 58   |
| Liquid                                         | 6000             |                  |                     | Dichloromethane    | 303.15 | -160                         | 58   |

| Polymer                | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                     | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|------------------------|------------------|------------------|---------------------|-----------------------------|--------|------------------------------|------|
| Semicrystalline        | 6000             |                  |                     | Trichloromethane            | 303.15 | +52                          | 58   |
| Liquid                 | 6000             |                  |                     | Trichloromethane            | 303.15 | -186                         | 58   |
| Quenched               | 1520             | 1720             |                     | Water                       | 293.15 | -403                         | 64   |
| Annealed               | 1520             | 1720             |                     | Water                       | 293.15 | -392                         | 64   |
| Quenched               | 1520             | 1720             |                     | Water                       | 298.15 | -180                         | 64   |
| Annealed               | 1520             | 1720             |                     | Water                       | 298.15 | -150                         | 64   |
| Quenched               | 1520             | 1720             |                     | Water                       | 303.15 | +68                          | 64   |
| Annealed               | 1520             | 1720             |                     | Water                       | 303.15 | +109                         | 64   |
| Liquid                 | 6000             |                  |                     | Water                       | 303.15 | -50                          | 58   |
| Quenched               | 6840             | 7525             |                     | Water                       | 293.15 | -28                          | 64   |
| Annealed               | 6840             | 7525             |                     | Water                       | 293.15 | +209                         | 64   |
| Quenched               | 6840             | 7525             |                     | Water                       | 298.15 | +241                         | 64   |
| Annealed               | 6840             | 7525             |                     | Water                       | 298.15 | +540                         | 64   |
| Quenched               | 16600            | 19600            |                     | Water                       | 293.15 | -160                         | 64   |
| Annealed               | 16600            | 19600            |                     | Water                       | 293.15 | -143                         | 64   |
| Quenched               | 16600            | 19600            |                     | Water                       | 298.15 | +59                          | 64   |
| Annealed               | 16600            | 19600            |                     | Water                       | 298.15 | +155                         | 64   |
| Quenched               | 16600            | 19600            |                     | Water                       | 303.15 | +353                         | 64   |
| Annealed               | 16600            | 19600            |                     | Water                       | 303.15 | +490                         | 64   |
| Semicrystalline        |                  | 20000            |                     | Water                       | 298.15 | +10                          | 84   |
| <i>Polyindene</i>      |                  |                  |                     |                             |        |                              |      |
|                        | 765              | 1023             |                     | Anisole                     | 299.15 | 2.1                          | 102  |
|                        | 765              | 1023             |                     | Benzene                     | 299.15 | -0.04                        | 102  |
|                        | 765              | 1023             |                     | Benzonitrile                | 299.15 | -4.4                         | 102  |
|                        | 765              | 1023             |                     | Bromobenzene                | 299.15 | -3.9                         | 102  |
|                        | 765              | 1023             |                     | 2-Butanone                  | 299.15 | 1.9                          | 102  |
|                        | 765              | 1023             |                     | Chlorobenzene               | 299.15 | -3.9                         | 102  |
|                        | 765              | 1023             |                     | 1-Chlorobutane              | 299.15 | -4.0                         | 102  |
|                        | 765              | 1023             |                     | 1-Chloroheptane             | 299.15 | 1.5                          | 102  |
|                        | 765              | 1023             |                     | Cyclohexane                 | 299.15 | 15                           | 102  |
|                        | 765              | 1023             |                     | <i>N,N</i> -dimethylaniline | 299.15 | -8.2                         | 102  |
|                        | 765              | 1023             |                     | Ethyl acetate               | 299.15 | 4.2                          | 102  |
|                        | 765              | 1023             |                     | Ethylbenzene                | 299.15 | -1.4                         | 102  |
|                        | 765              | 1023             |                     | Ethyl benzoate              | 299.15 | -0.7                         | 102  |
|                        | 765              | 1023             |                     | Nitrobenzene                | 299.15 | 4.6                          | 102  |
|                        | 765              | 1023             |                     | 1-Nitropropane              | 299.15 | 8.4                          | 102  |
|                        | 765              | 1023             |                     | Pyridine                    | 299.15 | -6.7                         | 102  |
|                        | 765              | 1023             |                     | 1,1,2,2-Tetrachloroethane   | 299.15 | -19                          | 102  |
|                        | 765              | 1023             |                     | Tetrachloromethane          | 299.15 | -2.5                         | 102  |
|                        | 765              | 1023             |                     | 1,1,1-Trichloroethane       | 299.15 | -1.8                         | 102  |
|                        | 765              | 1023             |                     | Trichloromethane            | 299.15 | -20                          | 102  |
| <i>Polyisobutylene</i> |                  |                  |                     |                             |        |                              |      |
|                        | 360              |                  | 700                 | Benzene                     | 298.15 | 30                           | 67   |
|                        | 1000             |                  | 2000                | Benzene                     | 298.15 | 25                           | 67   |
|                        | 1300             |                  | 2500                | Benzene                     | 298.15 | 23                           | 67   |
|                        |                  |                  | 30000               | Benzene                     | 297.65 | 19                           | 38   |
|                        |                  |                  | 30000               | Benzene                     | 298.15 | 19                           | 40   |

| Polymer | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                            | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|---------|------------------|------------------|---------------------|------------------------------------|--------|------------------------------|------|
|         | 44700            |                  |                     | Benzene                            | 303.15 | 16                           | 44   |
|         |                  |                  | 48000               | Benzene                            | 303.4  | 19                           | 72   |
|         |                  |                  | 50000               | Benzene                            | 303.15 | 16                           | 45   |
|         |                  |                  | 72000               | Benzene                            | 300.15 | 19                           | 53   |
|         |                  |                  | 72000               | Benzene                            | 323.15 | 18                           | 53   |
|         |                  |                  | 72000               | Benzene                            | 343.15 | 16                           | 53   |
|         |                  |                  | 72000               | Benzene                            | 375.15 | 13                           | 53   |
|         |                  |                  | 72000               | Benzene                            | 394.15 | 9.2                          | 53   |
|         |                  |                  | 72000               | Benzene                            | 423.15 | 3.5                          | 53   |
|         |                  |                  | 72000               | Benzene                            | 437.15 | -0.5                         | 53   |
|         |                  |                  | 72000               | Benzene                            | 453.15 | -4.7                         | 53   |
|         |                  |                  | 90000               | Benzene                            | 298.15 | 6.7                          | 32   |
|         |                  |                  | 160000              | Benzene                            | 303.15 | 16                           | 51   |
|         |                  |                  | 560000              | Benzene                            | 298.15 | 18                           | 34   |
|         |                  |                  |                     | Benzene                            | 298.15 | 6.8                          | 7    |
|         |                  |                  |                     | Benzene                            | 298.15 | 6.8                          | 10   |
|         |                  |                  | 30000               | Chlorobenzene                      | 297.65 | 12                           | 38   |
|         |                  |                  | 30000               | Chlorobenzene                      | 298.15 | 13                           | 40   |
|         |                  |                  | 50000               | Chlorobenzene                      | 303.15 | 12                           | 45   |
|         |                  |                  | 160000              | Chlorobenzene                      | 303.15 | 12                           | 51   |
|         |                  |                  | 560000              | Chlorobenzene                      | 298.15 | 12                           | 34   |
|         | 360              |                  | 700                 | Cyclohexane                        | 298.15 | 3.8                          | 67   |
|         | 1000             |                  | 2000                | Cyclohexane                        | 298.15 | 1.2                          | 67   |
|         | 1300             |                  | 2500                | Cyclohexane                        | 298.15 | 1.1                          | 67   |
|         |                  |                  | 4500                | Cyclohexane                        | 298.15 | -0.6                         | 74   |
|         |                  |                  | 30000               | Cyclohexane                        | 297.65 | -0.7                         | 38   |
|         |                  |                  | 30000               | Cyclohexane                        | 298.15 | -0.6                         | 40   |
|         |                  |                  | 50000               | Cyclohexane                        | 303.15 | -0.7                         | 45   |
|         |                  |                  | 160000              | Cyclohexane                        | 303.15 | -0.6                         | 51   |
|         |                  |                  | 1990000             | Cyclohexane                        | 298.15 | -0.7                         | 39   |
|         |                  |                  | 4500                | Cyclooctane                        | 298.15 | +0.3                         | 74   |
|         |                  |                  | 4500                | Cyclopentane                       | 298.15 | -5.9                         | 74   |
|         |                  |                  | 4500                | <i>cis</i> -Decahydronaphthalene   | 298.15 | 0.2                          | 74   |
|         |                  |                  | 4500                | <i>trans</i> -Decahydronaphthalene | 298.15 | -0.8                         | 74   |
|         |                  |                  | 30000               | Decane                             | 297.65 | -0.5                         | 38   |
|         |                  |                  | 50000               | Decane                             | 303.15 | -0.5                         | 45   |
|         |                  |                  | 30000               | Dibutyl ether                      | 297.65 | 1.2                          | 37   |
|         |                  |                  | 30000               | Diethyl ether                      | 297.65 | 2.8                          | 37   |
|         |                  |                  | 30000               | Diethyl ether                      | 297.65 | 2.8                          | 38   |
|         |                  |                  | 4500                | 3,3-Diethylpentane                 | 298.15 | -1.4                         | 74   |
|         |                  |                  | 30000               | Dihexyl ether                      | 297.65 | 0.9                          | 37   |
|         |                  |                  | 4500                | 2,2-Dimethylpentane                | 298.15 | -1.1                         | 74   |
|         |                  |                  | 4500                | 2,3-Dimethylpentane                | 298.15 | -1.9                         | 74   |
|         |                  |                  | 4500                | 2,4-Dimethylpentane                | 298.15 | -1.1                         | 74   |
|         |                  |                  | 4500                | 3,3-Dimethylpentane                | 298.15 | -1.7                         | 74   |
|         |                  |                  | 30000               | Dipentyl ether                     | 297.65 | 1.0                          | 37   |
|         |                  |                  | 30000               | Dipropyl ether                     | 297.65 | 1.8                          | 37   |

| Polymer | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                             | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|---------|------------------|------------------|---------------------|-------------------------------------|--------|------------------------------|------|
|         | 360              |                  | 700                 | Dodecane                            | 298.15 | 1.9                          | 67   |
|         | 1000             |                  | 2000                | Dodecane                            | 298.15 | 0.7                          | 67   |
|         | 1300             |                  | 2500                | Dodecane                            | 298.15 | 0.5                          | 67   |
|         |                  |                  | 4500                | Dodecane                            | 298.15 | 0.2                          | 73   |
|         |                  |                  | 30000               | Dodecane                            | 297.65 | -0.1                         | 38   |
|         |                  |                  | 30000               | Dodecane                            | 298.15 | -0.1                         | 40   |
|         |                  |                  | 48000               | Ethylbenzene                        | 291.15 | 9.5                          | 72   |
|         |                  |                  | 48000               | Ethylbenzene                        | 343.15 | 3.6                          | 72   |
|         |                  |                  | 30000               | Ethyl decanoate                     | 297.65 | 3.0                          | 37   |
|         |                  |                  | 30000               | Ethyl heptanoate                    | 297.65 | 5.6                          | 37   |
|         |                  |                  | 30000               | Ethyl hexadecanoate                 | 297.65 | 1.3                          | 37   |
|         |                  |                  | 30000               | Ethyl hexanoate                     | 297.65 | 6.7                          | 37   |
|         |                  |                  | 30000               | Ethyl nonanoate                     | 297.65 | 3.7                          | 37   |
|         |                  |                  | 30000               | Ethyl octanoate                     | 297.65 | 4.6                          | 37   |
|         |                  |                  | 4500                | 3-Ethylpentane                      | 298.15 | -2.0                         | 74   |
|         |                  |                  | 30000               | Ethyl tetradecanoate                | 297.65 | 1.8                          | 37   |
|         |                  |                  | 4500                | 2,2,4,4,6,8,8-<br>Heptamethylnonane | 298.15 | -0.5                         | 74   |
|         | 360              |                  | 700                 | Heptane                             | 298.15 | -0.5                         | 67   |
|         | 1000             |                  | 2000                | Heptane                             | 298.15 | -1.0                         | 67   |
|         | 1300             |                  | 2500                | Heptane                             | 298.15 | -1.4                         | 67   |
|         |                  |                  | 4500                | Heptane                             | 298.15 | -1.7                         | 73   |
|         |                  |                  | 30000               | Heptane                             | 297.65 | -1.8                         | 38   |
|         |                  |                  | 30000               | Heptane                             | 298.15 | -2.0                         | 40   |
|         |                  |                  | 50000               | Heptane                             | 303.15 | -1.8                         | 45   |
|         |                  |                  | 160000              | Heptane                             | 303.15 | -1.6                         | 51   |
|         |                  |                  |                     | Heptane                             | 298.15 | -1.4                         | 7    |
|         |                  |                  |                     | Heptane                             | 298.15 | -1.4                         | 10   |
|         | 360              |                  | 700                 | Hexadecane                          | 298.15 | 4.5                          | 67   |
|         | 1000             |                  | 2000                | Hexadecane                          | 298.15 | 2.1                          | 67   |
|         | 1300             |                  | 2500                | Hexadecane                          | 298.15 | 1.0                          | 67   |
|         |                  |                  | 4500                | Hexadecane                          | 298.15 | 0.9                          | 73   |
|         |                  |                  | 30000               | Hexadecane                          | 297.65 | 0.04                         | 38   |
|         |                  |                  | 30000               | Hexane                              | 297.65 | -2.5                         | 38   |
|         |                  |                  | 30000               | Hexane                              | 298.15 | -2.6                         | 40   |
|         |                  |                  | 50000               | Hexane                              | 303.15 | -2.5                         | 45   |
|         |                  |                  | 72000               | Hexane                              | 303.15 | -1.8                         | 53   |
|         |                  |                  | 72000               | Hexane                              | 324.15 | -2.3                         | 53   |
|         |                  |                  | 72000               | Hexane                              | 348.15 | -2.9                         | 53   |
|         |                  |                  | 72000               | Hexane                              | 373.15 | -3.7                         | 53   |
|         |                  |                  | 72000               | Hexane                              | 393.15 | -5.3                         | 53   |
|         |                  |                  | 72000               | Hexane                              | 408.15 | -6.7                         | 53   |
|         |                  |                  | 72000               | Hexane                              | 423.15 | -9.0                         | 53   |
|         |                  |                  | 72000               | Hexane                              | 433.15 | -9.9                         | 53   |
|         |                  |                  | 160000              | Hexane                              | 303.15 | -2.5                         | 51   |
|         |                  |                  | 30000               | 2-Methylbutane                      | 297.65 | -3.1                         | 38   |
|         |                  |                  | 30000               | Methylcyclohexane                   | 297.65 | -1.2                         | 38   |
|         |                  |                  | 50000               | Methylcyclohexane                   | 303.15 | -1.2                         | 45   |

| Polymer                            | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                      | $T$ /K                     | $\Delta H_B^\infty$ /<br>J/g | Ref.  |    |
|------------------------------------|------------------|------------------|---------------------|------------------------------|----------------------------|------------------------------|-------|----|
|                                    |                  |                  | 160000              | Methylcyclohexane            | 303.15                     | −1.2                         | 51    |    |
|                                    |                  |                  | 4500                | 3-Methylhexane               | 298.15                     | −1.0                         | 74    |    |
|                                    |                  |                  | 30000               | 3-Methylpentane              | 297.65                     | −2.8                         | 38    |    |
|                                    |                  |                  | 30000               | Nonane                       | 297.65                     | −0.8                         | 38    |    |
|                                    |                  |                  | 4500                | Nonane                       | 298.15                     | −0.8                         | 73    |    |
|                                    |                  |                  | 4500                | Octane                       | 298.15                     | −1.1                         | 73    |    |
|                                    |                  |                  | 30000               | Octane                       | 297.65                     | −1.2                         | 38    |    |
|                                    |                  |                  | 72000               | Octane                       | 303.15                     | −0.3                         | 53    |    |
|                                    |                  |                  | 72000               | Octane                       | 324.15                     | −0.8                         | 53    |    |
|                                    |                  |                  | 72000               | Octane                       | 348.15                     | −0.9                         | 53    |    |
|                                    |                  |                  | 72000               | Octane                       | 373.15                     | −1.1                         | 53    |    |
|                                    |                  |                  | 72000               | Octane                       | 393.15                     | −1.3                         | 53    |    |
|                                    |                  |                  | 72000               | Octane                       | 423.15                     | −3.6                         | 53    |    |
|                                    |                  |                  | 4500                | 2,2,4,6,6-Pentamethylheptane | 298.15                     | −0.1                         | 73    |    |
|                                    |                  |                  | 360                 | 700                          | Pentane                    | 298.15                       | −1.9  | 67 |
|                                    |                  |                  | 1000                | 2000                         | Pentane                    | 298.15                       | −2.9  | 67 |
|                                    |                  |                  | 1300                | 2500                         | Pentane                    | 298.15                       | −3.2  | 67 |
|                                    |                  |                  |                     | 30000                        | Pentane                    | 297.65                       | −3.6  | 38 |
|                                    |                  |                  |                     | 72000                        | Pentane                    | 303.15                       | −2.8  | 53 |
|                                    |                  |                  |                     | 72000                        | Pentane                    | 333.15                       | −3.4  | 53 |
|                                    |                  |                  |                     | 72000                        | Pentane                    | 352.15                       | −4.5  | 53 |
|                                    |                  |                  |                     | 72000                        | Pentane                    | 365.15                       | −5.5  | 53 |
|                                    |                  |                  | 360                 | 700                          | Tetrachloromethane         | 298.15                       | 5.9   | 67 |
|                                    |                  |                  | 1000                | 2000                         | Tetrachloromethane         | 298.15                       | 5.8   | 67 |
|                                    |                  |                  | 1300                | 2500                         | Tetrachloromethane         | 298.15                       | 5.0   | 67 |
|                                    |                  |                  |                     | 1990000                      | Tetrachloromethane         | 298.15                       | 4.1   | 39 |
|                                    |                  |                  |                     | 30000                        | Tetradecane                | 297.65                       | 0.0   | 38 |
|                                    |                  |                  |                     | 4500                         | 2,2,4,4-Tetramethylpentane | 298.15                       | −0.6  | 74 |
|                                    |                  |                  |                     | 4500                         | 2,3,3,4-Tetramethylpentane | 298.15                       | −2.3  | 74 |
|                                    |                  |                  |                     | 50000                        | Toluene                    | 303.15                       | 7.4   | 45 |
|                                    |                  |                  |                     | 160000                       | Toluene                    | 303.15                       | 7.4   | 51 |
|                                    |                  |                  |                     | 1990000                      | Toluene                    | 298.15                       | 8.8   | 39 |
|                                    |                  |                  |                     |                              | Toluene                    | 298.15                       | 1.8   | 7  |
|                                    |                  |                  |                     |                              | Toluene                    | 298.15                       | 1.8   | 10 |
|                                    |                  |                  |                     | 30000                        | Tridecane                  | 297.65                       | −0.04 | 38 |
|                                    |                  |                  |                     | 4500                         | 2,2,4-Trimethylpentane     | 298.15                       | −0.4  | 73 |
|                                    |                  |                  |                     | 30000                        | 2,2,4-Trimethylpentane     | 297.65                       | −0.6  | 38 |
|                                    |                  |                  |                     | 1990000                      | 2,2,4-Trimethylpentane     | 298.15                       | 0.0   | 39 |
|                                    |                  |                  |                     |                              | 2,2,4-Trimethylpentane     | 298.15                       | 0.0   | 7  |
|                                    |                  |                  |                     |                              | 2,2,4-Trimethylpentane     | 298.15                       | 0.0   | 10 |
|                                    |                  |                  |                     | 30000                        | Undecane                   | 297.65                       | −0.4  | 38 |
| <i>Poly(isobutyl methacrylate)</i> |                  |                  |                     |                              |                            |                              |       |    |
| Glass                              |                  | 260000           |                     | Cyclohexanone                | 303.15                     | −5.2                         | 98    |    |
| Liquid                             |                  | 260000           |                     | Cyclohexanone                | 303.15                     | 13                           | 98    |    |
| <i>Poly(methyl acrylate)</i>       |                  |                  |                     |                              |                            |                              |       |    |
|                                    |                  |                  |                     | 2-Propanone                  | 298.15                     | 0.0                          | 25    |    |

| Polymer                                        | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                       | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|------------------------------------------------|------------------|------------------|---------------------|-------------------------------|--------|------------------------------|------|
| <i>Poly(methyl methacrylate)</i>               |                  |                  |                     |                               |        |                              |      |
| Glass                                          | 73900            | 170000           |                     | Cyclohexanone                 | 304.15 | -14                          | 98   |
| Liquid                                         | 73900            | 170000           |                     | Cyclohexanone                 | 304.15 | 17                           | 98   |
|                                                | 1930             |                  |                     | 1,2-Dichloroethane            | 298.15 | -20                          | 32   |
|                                                | 240000           |                  |                     | 1,2-Dichloroethane            | 298.15 | -27                          | 32   |
|                                                |                  |                  | 53000               | Ethylbenzene                  | 298.15 | -31                          | 28   |
|                                                |                  |                  | 180000              | Ethylbenzene                  | 298.15 | -29                          | 28   |
|                                                | 28900            | 35900            |                     | 4-Methyl-2-pentanone          | 303.15 | -21                          | 76   |
|                                                | 93940            | 101000           |                     | 4-Methyl-2-pentanone          | 303.15 | -24                          | 76   |
|                                                | 137000           | 215000           |                     | 4-Methyl-2-pentanone          | 303.15 | -28                          | 76   |
|                                                |                  |                  |                     | 2-Propanone                   | 298.15 | -30                          | 25   |
|                                                | 93940            | 101000           |                     | Toluene                       | 303.15 | -22                          | 76   |
|                                                | 689000           | 782000           |                     | Toluene                       | 303.15 | -24                          | 76   |
|                                                |                  |                  | 12000               | Trichloromethane              | 298.15 | -65                          | 52   |
|                                                |                  |                  | 54000               | Trichloromethane              | 298.15 | -80                          | 52   |
|                                                |                  |                  | 80000               | Trichloromethane              | 298.15 | -81                          | 52   |
|                                                |                  |                  | 100000              | Trichloromethane              | 298.15 | -84                          | 52   |
|                                                |                  |                  | 320000              | Trichloromethane              | 298.15 | -83                          | 52   |
|                                                | 93940            | 101000           |                     | Trichloromethane              | 303.15 | -71                          | 76   |
|                                                | 689000           | 782000           |                     | Trichloromethane              | 303.15 | -72                          | 76   |
|                                                |                  | 2320000          |                     | Trichloromethane              | 303.15 | -73                          | 76   |
| <i>Poly(4-methyl-1-pentene)</i>                |                  |                  |                     |                               |        |                              |      |
| Semicrystalline                                |                  |                  | 350000              | Cyclohexane                   | 303.15 | 30                           | 79   |
| <i>Poly(<math>\alpha</math>-methylstyrene)</i> |                  |                  |                     |                               |        |                              |      |
|                                                | 1030             | 1180             |                     | Toluene                       | 298.15 | -7.1                         | 43   |
|                                                |                  | 1430             |                     | Toluene                       | 298.15 | -30                          | 43   |
|                                                | 1820             | 2230             |                     | Toluene                       | 298.15 | -34                          | 43   |
|                                                | 1920             |                  |                     | Toluene                       | 298.15 | -37                          | 43   |
|                                                | 2700             | 3300             |                     | Toluene                       | 298.15 | -39                          | 43   |
|                                                | 3280             |                  |                     | Toluene                       | 298.15 | -46                          | 43   |
|                                                | 5260             |                  |                     | Toluene                       | 298.15 | -46                          | 43   |
|                                                | 8600             |                  |                     | Toluene                       | 298.15 | -45                          | 43   |
|                                                | 12200            |                  |                     | Toluene                       | 298.15 | -46                          | 43   |
|                                                |                  | 10500            |                     | Toluene                       | 310.15 | -8.4                         | 92   |
|                                                |                  | 53000            |                     | Toluene                       | 310.15 | -13                          | 92   |
|                                                |                  | 55000            |                     | Toluene                       | 333.15 | -16                          | 96   |
|                                                |                  | 87000            |                     | Toluene                       | 298.15 | -17                          | 90   |
|                                                |                  | 87000            |                     | Toluene                       | 310.15 | -16                          | 92   |
|                                                |                  | 87000            |                     | Toluene                       | 333.15 | -11                          | 90   |
| <i>Poly(2-methyl-5-vinyltetrazole)</i>         |                  |                  |                     |                               |        |                              |      |
|                                                |                  |                  |                     | Acetic acid                   | 298.15 | 47                           | 100  |
|                                                |                  |                  |                     | Acetonitrile                  | 298.15 | 14                           | 100  |
|                                                |                  |                  |                     | 1,2-Dichloroethane            | 298.15 | 17                           | 100  |
|                                                |                  |                  |                     | <i>N,N</i> -Diethylacetamide  | 298.15 | 17                           | 100  |
|                                                |                  |                  |                     | <i>N,N</i> -Dimethylformamide | 298.15 | 33                           | 100  |
|                                                |                  |                  |                     | Dimethylsulfoxide             | 298.15 | 10                           | 100  |



| Polymer                                | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                            | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|----------------------------------------|------------------|------------------|---------------------|------------------------------------|--------|------------------------------|------|
|                                        |                  |                  |                     | Formamide                          | 298.15 | 12                           | 100  |
|                                        |                  |                  |                     | Formic acid                        | 298.15 | 110                          | 100  |
|                                        |                  |                  |                     | Nitromethane                       | 298.15 | 10                           | 100  |
|                                        |                  |                  |                     | Pyridine                           | 298.15 | 16                           | 100  |
| <i>Poly(octamethylene oxide)</i>       |                  |                  |                     |                                    |        |                              |      |
|                                        | 7000             |                  |                     | Benzene                            | 298.15 | 20                           | 64   |
|                                        | 7000             |                  |                     | Benzene                            | 303.15 | 22                           | 64   |
|                                        | 7000             |                  |                     | Benzene                            | 308.15 | 25                           | 64   |
| <i>Polypentenamer</i>                  |                  |                  |                     |                                    |        |                              |      |
|                                        |                  |                  | 50000               | Cyclohexane                        | 298.15 | 4.6                          | 74   |
|                                        |                  |                  | 50000               | Cyclooctane                        | 298.15 | 5.1                          | 74   |
|                                        |                  |                  | 50000               | Cyclopentane                       | 298.15 | −2.3                         | 74   |
|                                        |                  |                  | 50000               | <i>cis</i> -Decahydronaphthalene   | 298.15 | 2.6                          | 74   |
|                                        |                  |                  | 50000               | <i>trans</i> -Decahydronaphthalene | 298.15 | <0.1                         | 74   |
|                                        |                  |                  | 50000               | 3,3-Diethylpentane                 | 298.15 | 2.4                          | 74   |
|                                        |                  |                  | 50000               | 2,2-Dimethylpentane                | 298.15 | 3.3                          | 74   |
|                                        |                  |                  | 50000               | 2,3-Dimethylpentane                | 298.15 | 2.2                          | 74   |
|                                        |                  |                  | 50000               | 2,4-Dimethylpentane                | 298.15 | 3.3                          | 74   |
|                                        |                  |                  | 50000               | 3,3-Dimethylpentane                | 298.15 | 2.7                          | 74   |
|                                        |                  |                  | 50000               | Dodecane                           | 298.15 | 2.9                          | 74   |
|                                        |                  |                  | 50000               | 3-Ethylpentane                     | 298.15 | 2.1                          | 74   |
|                                        |                  |                  | 50000               | 2,2,4,4,6,8,8-Heptamethylnonane    | 298.15 | 3.2                          | 74   |
|                                        |                  |                  | 50000               | Hexadecane                         | 298.15 | 2.6                          | 74   |
|                                        |                  |                  | 50000               | 3-Methylhexane                     | 298.15 | 2.4                          | 74   |
|                                        |                  |                  | 50000               | Octane                             | 298.15 | 2.2                          | 74   |
|                                        |                  |                  | 50000               | 2,2,4,6,6-Pentamethylheptane       | 298.15 | 3.8                          | 74   |
|                                        |                  |                  | 50000               | 2,2,4,4-Tetramethylpentane         | 298.15 | 4.5                          | 74   |
|                                        |                  |                  | 50000               | 2,3,3,4-Tetramethylpentane         | 298.15 | 2.4                          | 74   |
|                                        |                  |                  | 50000               | 2,2,4-Trimethylpentane             | 298.15 | 4.3                          | 74   |
| <i>Poly(m-phenyleneisophthalamide)</i> |                  |                  |                     |                                    |        |                              |      |
| Glass                                  |                  |                  |                     | <i>N,N</i> -Dimethylacetamide      | 298.15 | −171                         | 60   |
| Semicrystalline                        |                  |                  |                     | <i>N,N</i> -Dimethylacetamide      | 298.15 | −128                         | 60   |
| Glass                                  |                  |                  |                     | <i>N,N</i> -Dimethylformamide      | 298.15 | −149                         | 60   |
| Semicrystalline                        |                  |                  |                     | <i>N,N</i> -Dimethylformamide      | 298.15 | −125                         | 60   |
| Glass                                  |                  |                  |                     | 1-Methyl-2-pyrrolidone             | 298.15 | −177                         | 60   |
| Semicrystalline                        |                  |                  |                     | 1-Methyl-2-pyrrolidone             | 298.15 | −118                         | 60   |
| <i>Polypropylene (atactic)</i>         |                  |                  |                     |                                    |        |                              |      |
|                                        |                  |                  | 18000               | Benzene                            | 298.15 | 31                           | 80   |
|                                        |                  |                  | 6000                | Cyclohexane                        | 298.15 | 2.3                          | 74   |
|                                        |                  |                  | 18000               | Cyclohexane                        | 298.15 | 3.9                          | 80   |
|                                        |                  |                  | 6000                | Cyclooctane                        | 298.15 | 3.0                          | 74   |
|                                        |                  |                  | 6000                | Cyclopentane                       | 298.15 | −2.3                         | 74   |
|                                        |                  |                  | 6000                | <i>cis</i> -Decahydronaphthalene   | 298.15 | 0.5                          | 74   |

| Polymer                          | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                             | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|----------------------------------|------------------|------------------|---------------------|-------------------------------------|--------|------------------------------|------|
|                                  | 6000             |                  |                     | <i>trans</i> -Decahydronaphthalene  | 298.15 | -2.4                         | 74   |
|                                  | 18000            |                  |                     | Decane                              | 298.15 | 3.1                          | 80   |
|                                  | 6000             |                  |                     | 3,3-Diethylpentane                  | 298.15 | -3.9                         | 74   |
|                                  | 18000            |                  |                     | 1,2-Dimethylbenzene                 | 298.15 | 13                           | 80   |
|                                  | 18000            |                  |                     | 1,3-Dimethylbenzene                 | 298.15 | 12                           | 80   |
|                                  | 18000            |                  |                     | 1,4-Dimethylbenzene                 | 298.15 | 10                           | 80   |
|                                  | 6000             |                  |                     | 2,2-Dimethylpentane                 | 298.15 | -2.2                         | 74   |
|                                  | 6000             |                  |                     | 2,3-Dimethylpentane                 | 298.15 | -2.5                         | 74   |
|                                  | 6000             |                  |                     | 2,4-Dimethylpentane                 | 298.15 | -1.8                         | 74   |
|                                  | 6000             |                  |                     | 3,3-Dimethylpentane                 | 298.15 | -3.0                         | 74   |
|                                  | 6000             |                  |                     | Dodecane                            | 298.15 | 1.7                          | 73   |
|                                  | 18000            |                  |                     | Ethylbenzene                        | 298.15 | 14                           | 80   |
|                                  | 6000             |                  |                     | 3-Ethylpentane                      | 298.15 | -2.5                         | 74   |
|                                  | 6000             |                  |                     | 2,2,4,4,6,8,8-<br>Heptamethylnonane | 298.15 | -0.7                         | 73   |
|                                  | 6000             |                  |                     | Heptane                             | 298.15 | -1.6                         | 73   |
|                                  | 18000            |                  |                     | Heptane                             | 298.15 | 0.5                          | 80   |
|                                  | 6000             |                  |                     | Hexadecane                          | 298.15 | 2.3                          | 73   |
|                                  | 18000            |                  |                     | Hexane                              | 298.15 | -1.4                         | 80   |
|                                  | 6000             |                  |                     | 3-Methylhexane                      | 298.15 | -1.8                         | 74   |
|                                  | 6000             |                  |                     | Nonane                              | 298.15 | 0.8                          | 73   |
|                                  | 18000            |                  |                     | Nonane                              | 298.15 | 2.4                          | 80   |
|                                  | 6000             |                  |                     | Octane                              | 298.15 | -1.2                         | 73   |
|                                  | 18000            |                  |                     | Octane                              | 298.15 | 1.0                          | 80   |
|                                  | 6000             |                  |                     | 2,2,4,6,6-Pentamethylheptane        | 298.15 | -0.2                         | 73   |
|                                  | 18000            |                  |                     | Pentane                             | 298.15 | -4.7                         | 80   |
|                                  | 18000            |                  |                     | Tetrachloromethane                  | 298.15 | 6.6                          | 80   |
|                                  | 6000             |                  |                     | 2,2,4,4-Tetramethylpentane          | 298.15 | -0.8                         | 74   |
|                                  | 6000             |                  |                     | 2,3,3,4-Tetramethylpentane          | 298.15 | -3.1                         | 74   |
|                                  | 18000            |                  |                     | Toluene                             | 298.15 | 17                           | 80   |
|                                  | 18000            |                  |                     | Trichloromethane                    | 298.15 | 17                           | 80   |
|                                  | 6000             |                  |                     | 2,2,4-Trimethylpentane              | 298.15 | -1.0                         | 73   |
| <i>Polypropylene (isotactic)</i> |                  |                  |                     | 1-Chloronaphthalene                 | 383.15 | 26                           | 47   |
|                                  |                  |                  |                     | 1-Chloronaphthalene                 | 393.15 | 170                          | 47   |
|                                  |                  |                  |                     | 1-Chloronaphthalene                 | 403.15 | 245                          | 47   |
|                                  |                  |                  |                     | 1-Chloronaphthalene                 | 423.15 | 275                          | 47   |
|                                  |                  |                  |                     | 1,2,3,4-<br>Tetrahydronaphthalene   | 373.15 | 140                          | 47   |
|                                  |                  |                  |                     | 1,2,3,4-<br>Tetrahydronaphthalene   | 383.15 | 215                          | 47   |
|                                  |                  |                  |                     | 1,2,3,4-<br>Tetrahydronaphthalene   | 393.15 | 330                          | 47   |
|                                  |                  |                  |                     | 1,2,3,4-<br>Tetrahydronaphthalene   | 403.15 | 330                          | 47   |
|                                  |                  |                  |                     | 1,2,3,4-<br>Tetrahydronaphthalene   | 413.15 | 335                          | 47   |
|                                  |                  |                  |                     | 1,2,3,4-<br>Tetrahydronaphthalene   | 423.15 | 290                          | 47   |

| Polymer                       | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent            | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|-------------------------------|------------------|------------------|---------------------|--------------------|--------|------------------------------|------|
| <i>Poly(propylene glycol)</i> |                  |                  |                     |                    |        |                              |      |
|                               | 150              |                  |                     | Benzene            | 321.35 | 200                          | 103  |
|                               | 425              |                  |                     | Benzene            | 321.35 | 80                           | 103  |
|                               | 2025             |                  |                     | Benzene            | 321.35 | 45                           | 103  |
|                               | 150              |                  |                     | Ethanol            | 321.35 | 40                           | 103  |
|                               | 425              |                  |                     | Ethanol            | 321.35 | 60                           | 103  |
|                               | 2025             |                  |                     | Ethanol            | 321.35 | 65                           | 103  |
|                               | 396              | 412              |                     | Tetrachloromethane | 303.15 | 4.7                          | 95   |
|                               | 396              | 412              |                     | Tetrachloromethane | 318.15 | 5.2                          | 95   |
|                               | 1900             |                  |                     | Tetrachloromethane | 303.15 | -8.2                         | 95   |
|                               | 1900             |                  |                     | Tetrachloromethane | 318.15 | 11                           | 95   |
|                               | 1900             |                  |                     | Trichloromethane   | 303.15 | -81                          | 95   |
|                               |                  | 400              |                     | Water              | 298.15 | -165                         | 97   |
|                               | 150              |                  |                     | Water              | 321.35 | -90                          | 103  |
|                               | 425              |                  |                     | Water              | 321.35 | -95                          | 103  |
| <i>Polystyrene</i>            |                  |                  |                     |                    |        |                              |      |
|                               |                  | 600              |                     | Benzene            | 298.15 | -1.3                         | 54   |
|                               |                  | 600              |                     | Benzene            | 313.15 | -2.5                         | 54   |
|                               |                  | 900              |                     | Benzene            | 291.15 | -10                          | 54   |
|                               |                  | 900              |                     | Benzene            | 318.15 | -5.8                         | 54   |
|                               |                  | 2000             |                     | Benzene            | 291.15 | -16                          | 54   |
|                               |                  | 2000             |                     | Benzene            | 318.15 | -6.8                         | 54   |
|                               |                  | 5000             |                     | Benzene            | 291.15 | -23                          | 54   |
|                               |                  | 5000             |                     | Benzene            | 318.15 | -12                          | 54   |
|                               |                  | 10300            |                     | Benzene            | 291.15 | -26                          | 54   |
|                               |                  | 10300            |                     | Benzene            | 318.15 | -18                          | 54   |
|                               |                  |                  | 18000               | Benzene            | 298.15 | -4.1                         | 19   |
|                               | 20000            |                  |                     | Benzene            | 296.15 | -15                          | 9    |
|                               |                  |                  | 29000               | Benzene            | 298.15 | -5.0                         | 19   |
|                               |                  |                  | 30000               | Benzene            | 298.15 | -7.5                         | 19   |
|                               |                  |                  | 59000               | Benzene            | 298.15 | -13                          | 19   |
|                               |                  |                  | 91000               | Benzene            | 298.15 | -15                          | 19   |
|                               |                  | 97200            |                     | Benzene            | 318.15 | -21                          | 54   |
|                               |                  |                  | 142000              | Benzene            | 298.15 | -17                          | 19   |
|                               |                  |                  | 190000              | Benzene            | 303.15 | -18                          | 51   |
|                               | 214000           |                  |                     | Benzene            | 300.15 | -16                          | 85   |
|                               |                  |                  | 216000              | Benzene            | 298.15 | -18                          | 19   |
|                               |                  |                  | 272000              | Benzene            | 298.15 | -21                          | 19   |
|                               |                  |                  | 300000              | Benzene            | 298.15 | -21                          | 12   |
|                               |                  |                  |                     | Benzene            | 298.15 | -27                          | 25   |
|                               |                  |                  |                     | Benzene            | 298.15 | -10                          | 7    |
|                               | 20000            |                  |                     | Butyl acetate      | 296.15 | -13                          | 9    |
|                               | 20000            |                  |                     | 2-Butanone         | 296.15 | -15                          | 9    |
|                               |                  |                  | 142000              | 2-Butanone         | 296.15 | -17                          | 30   |
|                               |                  |                  | 190000              | Butylbenzene       | 303.15 | -14                          | 51   |
|                               | 150000           |                  |                     | Chlorobenzene      | 293.15 | -32                          | 49   |
|                               |                  |                  | 266000              | Chlorobenzene      | 298.15 | 5.4                          | 34   |

| Polymer | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent              | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|---------|------------------|------------------|---------------------|----------------------|--------|------------------------------|------|
|         |                  |                  |                     | Chlorobenzene        | 293.15 | -39                          | 21   |
|         | 1260             |                  |                     | Cyclohexane          | 298.15 | 10                           | 16   |
|         | 1910             |                  |                     | Cyclohexane          | 298.15 | 5.4                          | 16   |
|         | 3160             |                  |                     | Cyclohexane          | 298.15 | -5.4                         | 16   |
|         | 3980             |                  |                     | Cyclohexane          | 298.15 | -6.9                         | 16   |
|         | 5630             |                  |                     | Cyclohexane          | 298.15 | -9.3                         | 16   |
|         | 9070             |                  |                     | Cyclohexane          | 298.15 | -11                          | 16   |
|         | 20000            |                  |                     | Cyclohexane          | 296.15 | 2.5                          | 9    |
|         |                  |                  | 190000              | Cyclohexane          | 303.15 | -2.1                         | 51   |
|         |                  |                  |                     | Cyclohexane          | 293.15 | -14                          | 21   |
|         | 22400            |                  |                     | Cyclohexanone        | 298.15 | -29                          | 25   |
|         | 20000            |                  |                     | Cyclohexene          | 296.15 | -9.4                         | 9    |
|         |                  |                  | 190000              | Decahydronaphthalene | 303.15 | 3.8                          | 51   |
|         | 110000           | 115000           |                     | 1,2-Dichlorobenzene  | 303.05 | 26                           | 89   |
|         | 20000            |                  |                     | 1,2-Dimethylbenzene  | 296.15 | -13                          | 9    |
|         | 20000            |                  |                     | 1,3-Dimethylbenzene  | 296.15 | -12                          | 9    |
|         |                  |                  | 190000              | 1,3-Dimethylbenzene  | 303.15 | -15                          | 51   |
|         |                  |                  | 190000              | 1,4-Dioxane          | 303.15 | -12                          | 51   |
|         | 20000            |                  |                     | Ethyl acetate        | 296.15 | -11                          | 9    |
|         |                  |                  | 142000              | Ethyl acetate        | 296.15 | -13                          | 30   |
|         |                  |                  | 785                 | Ethylbenzene         | 298.15 | 0.0                          | 14   |
|         |                  |                  | 18000               | Ethylbenzene         | 298.15 | -3.8                         | 14   |
|         |                  |                  | 18000               | Ethylbenzene         | 298.15 | -3.9                         | 19   |
|         |                  |                  | 30000               | Ethylbenzene         | 298.15 | -5.7                         | 19   |
|         |                  |                  | 35000               | Ethylbenzene         | 298.15 | -6.5                         | 19   |
|         |                  |                  | 45000               | Ethylbenzene         | 298.15 | -8.4                         | 19   |
|         |                  |                  | 91000               | Ethylbenzene         | 298.15 | -11                          | 19   |
|         |                  |                  | 142000              | Ethylbenzene         | 298.15 | -13                          | 19   |
|         |                  |                  | 216000              | Ethylbenzene         | 298.15 | -17                          | 19   |
|         | 60000            |                  |                     | Ethylbenzene         | 303.15 | -22                          | 57   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 306.65 | -24                          | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 317.15 | -19                          | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 337.15 | -11                          | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 347.15 | -6.4                         | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 350.65 | -4.9                         | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 366.65 | -2.3                         | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 367.15 | -2.1                         | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 368.65 | -2.6                         | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 372.15 | -4.2                         | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 378.15 | -4.6                         | 63   |
|         | 113000           | 122000           |                     | Ethylbenzene         | 385.15 | -5.7                         | 63   |
|         | 150000           |                  |                     | Ethylbenzene         | 293.15 | -34                          | 49   |
|         |                  |                  | 190000              | Ethylbenzene         | 303.15 | -15                          | 51   |
|         |                  |                  | 272000              | Ethylbenzene         | 298.15 | -18                          | 14   |
|         |                  |                  | 272000              | Ethylbenzene         | 298.15 | -18                          | 19   |
|         |                  |                  | 413000              | Ethylbenzene         | 298.15 | -24                          | 39   |
|         |                  |                  |                     | Ethylbenzene         | 293.15 | -34                          | 21   |

| Polymer | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent            | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|---------|------------------|------------------|---------------------|--------------------|--------|------------------------------|------|
|         |                  |                  |                     | Ethylbenzene       | 298.15 | -17                          | 11   |
|         |                  |                  |                     | Ethylbenzene       | 298.15 | -30                          | 28   |
|         | 1260             |                  |                     | 2-Propanone        | 298.15 | -0.6                         | 16   |
|         | 1910             |                  |                     | 2-Propanone        | 298.15 | -7.7                         | 16   |
|         | 3160             |                  |                     | 2-Propanone        | 298.15 | -16                          | 16   |
|         | 3980             |                  |                     | 2-Propanone        | 298.15 | -17                          | 16   |
|         | 5630             |                  |                     | 2-Propanone        | 298.15 | -19                          | 16   |
|         | 9070             |                  |                     | 2-Propanone        | 298.15 | -21                          | 16   |
|         | 20000            |                  |                     | 2-Propanone        | 296.15 | -11                          | 9    |
|         |                  |                  | 190000              | Propylbenzene      | 303.15 | -14                          | 51   |
|         | 20000            |                  |                     | Styrene            | 296.15 | -18                          | 9    |
|         |                  |                  |                     | Styrene            | 296.15 | -35                          | 6    |
|         |                  |                  | 413000              | Tetrachloromethane | 298.15 | -22                          | 39   |
|         | 600              |                  |                     | Toluene            | 296.15 | -2.1                         | 16   |
|         | 600              |                  |                     | Toluene            | 309.15 | -1.8                         | 16   |
|         | 600              |                  |                     | Toluene            | 318.15 | -1.5                         | 16   |
|         | 1260             |                  |                     | Toluene            | 296.15 | -11                          | 16   |
|         | 1260             |                  |                     | Toluene            | 303.15 | -8.0                         | 16   |
|         | 1260             |                  |                     | Toluene            | 309.15 | -5.9                         | 16   |
|         | 1260             |                  |                     | Toluene            | 318.15 | -3.4                         | 16   |
|         | 1260             |                  |                     | Toluene            | 328.15 | -2.3                         | 16   |
|         | 1260             |                  |                     | Toluene            | 338.15 | -1.9                         | 16   |
|         | 1260             |                  |                     | Toluene            | 346.65 | -1.3                         | 16   |
|         | 1910             |                  |                     | Toluene            | 298.15 | -16                          | 16   |
|         | 1910             |                  |                     | Toluene            | 318.15 | -6.7                         | 16   |
|         | 1910             |                  |                     | Toluene            | 338.15 | -3.4                         | 16   |
|         | 1910             |                  |                     | Toluene            | 348.15 | -2.5                         | 16   |
|         | 3160             |                  |                     | Toluene            | 298.15 | -23                          | 16   |
|         | 3980             |                  |                     | Toluene            | 298.15 | -24                          | 16   |
|         | 3980             |                  |                     | Toluene            | 318.15 | -17                          | 16   |
|         | 3980             |                  |                     | Toluene            | 338.15 | -10                          | 16   |
|         | 5630             |                  |                     | Toluene            | 298.15 | -26                          | 16   |
|         | 9070             |                  |                     | Toluene            | 298.15 | -28                          | 16   |
|         | 270000           |                  |                     | Toluene            | 298.15 | -33                          | 16   |
|         |                  | 600              |                     | Toluene            | 298.15 | -1.4                         | 54   |
|         |                  | 600              |                     | Toluene            | 313.15 | -3.2                         | 54   |
|         |                  | 900              |                     | Toluene            | 291.15 | -7.3                         | 54   |
|         |                  | 900              |                     | Toluene            | 318.15 | -6.6                         | 54   |
|         |                  | 2000             |                     | Toluene            | 291.15 | -11                          | 54   |
|         |                  | 2000             |                     | Toluene            | 318.15 | -7.2                         | 54   |
|         |                  | 5000             |                     | Toluene            | 291.15 | -21                          | 54   |
|         |                  | 5000             |                     | Toluene            | 318.15 | -11                          | 54   |
|         |                  | 10300            |                     | Toluene            | 291.15 | -24                          | 54   |
|         |                  | 10300            |                     | Toluene            | 318.15 | -15                          | 54   |
|         |                  | 97200            |                     | Toluene            | 318.15 | -17                          | 54   |
|         |                  | 9000             |                     | Toluene            | 310.15 | -9.2                         | 92   |
|         | 20000            |                  |                     | Toluene            | 296.15 | -17                          | 9    |

| Polymer | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                | $T$ /K | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|---------|------------------|------------------|---------------------|------------------------|--------|------------------------------|------|
|         | 20400            |                  |                     | Toluene                | 298.15 | -8.2                         | 90   |
|         | 20400            |                  |                     | Toluene                | 310.15 | -8.4                         | 92   |
|         | 20400            |                  |                     | Toluene                | 333.15 | -6.4                         | 90   |
|         | 47000            |                  |                     | Toluene                | 310.15 | -5.0                         | 92   |
|         | 50000            |                  |                     | Toluene                | 333.15 | -6.8                         | 96   |
|         | 60000            |                  |                     | Toluene                | 303.15 | -21                          | 57   |
|         | 113000           | 122000           |                     | Toluene                | 304.15 | -29                          | 63   |
|         | 113000           | 122000           |                     | Toluene                | 306.15 | -27                          | 63   |
|         | 113000           | 122000           |                     | Toluene                | 306.65 | -26                          | 63   |
|         | 113000           | 122000           |                     | Toluene                | 316.15 | -23                          | 63   |
|         | 113000           | 122000           |                     | Toluene                | 333.15 | -15                          | 63   |
|         | 113000           | 122000           |                     | Toluene                | 337.15 | -12                          | 63   |
|         | 113000           | 122000           |                     | Toluene                | 346.15 | -8.3                         | 63   |
|         | 113000           | 122000           |                     | Toluene                | 347.15 | -7.8                         | 63   |
|         | 113000           | 122000           |                     | Toluene                | 348.15 | -8.2                         | 63   |
|         | 113000           | 122000           |                     | Toluene                | 350.65 | -6.5                         | 63   |
|         | 113000           | 122000           |                     | Toluene                | 359.15 | -4.3                         | 63   |
|         | 113000           | 122000           |                     | Toluene                | 362.15 | -2.7                         | 63   |
|         | 113000           | 122000           |                     | Toluene                | 369.15 | -3.3                         | 63   |
|         | 113000           | 122000           |                     | Toluene                | 372.15 | -2.8                         | 63   |
|         | 115000           |                  |                     | Toluene                | 310.15 | -5.0                         | 92   |
|         | 150000           |                  |                     | Toluene                | 293.15 | -34                          | 49   |
|         |                  |                  | 190000              | Toluene                | 303.15 | -18                          | 51   |
|         | 214000           |                  |                     | Toluene                | 300.15 | -19                          | 85   |
|         |                  |                  | 250000              | Toluene                | 303.15 | -18                          | 51   |
|         |                  |                  |                     | Toluene                | 293.15 | -34                          | 21   |
|         |                  |                  |                     | Toluene                | 298.65 | -39                          | 27   |
|         |                  |                  |                     | Toluene                | 308.15 | -34                          | 27   |
|         |                  |                  |                     | Toluene                | 318.15 | -30                          | 27   |
|         |                  |                  |                     | Toluene                | 333.15 | -23                          | 27   |
|         |                  |                  |                     | Toluene                | 343.15 | -13                          | 27   |
|         |                  |                  |                     | Toluene                | 353.15 | -13                          | 27   |
|         |                  | 600              |                     | Trichloromethane       | 298.15 | -13                          | 54   |
|         |                  | 600              |                     | Trichloromethane       | 313.15 | -9.9                         | 54   |
|         |                  | 900              |                     | Trichloromethane       | 291.15 | -22                          | 54   |
|         |                  | 900              |                     | Trichloromethane       | 313.15 | -15                          | 54   |
|         |                  | 2000             |                     | Trichloromethane       | 291.15 | -28                          | 54   |
|         |                  | 2000             |                     | Trichloromethane       | 313.15 | -16                          | 54   |
|         |                  | 5000             |                     | Trichloromethane       | 291.15 | -30                          | 54   |
|         |                  | 5000             |                     | Trichloromethane       | 313.15 | -18                          | 54   |
|         |                  | 10300            |                     | Trichloromethane       | 291.15 | -33                          | 54   |
|         |                  | 10300            |                     | Trichloromethane       | 313.15 | -23                          | 54   |
|         | 22400            |                  |                     | Trichloromethane       | 298.15 | -17                          | 25   |
|         |                  | 97200            |                     | Trichloromethane       | 313.15 | -25                          | 54   |
|         | 20000            |                  |                     | 1,3,5-Trimethylbenzene | 296.15 | -11                          | 9    |
|         |                  |                  | 190000              | 1,3,5-Trimethylbenzene | 303.15 | -13                          | 51   |

*Poly(tetramethylene oxide)*

| Polymer                    | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|----------------------------|------------------|------------------|---------------------|------------------------|--------|------------------------------|------|
|                            | 650              |                  |                     | Benzene                | 313.15 | 4.0                          | 86   |
|                            | 1000             |                  |                     | Benzene                | 313.15 | 2.0                          | 86   |
|                            | 2000             |                  |                     | Benzene                | 313.15 | 1.1                          | 86   |
|                            | 650              |                  |                     | 1,2-Dichloroethane     | 313.35 | 3.1                          | 88   |
|                            | 2000             |                  |                     | 1,2-Dichloroethane     | 313.35 | 0.3                          | 88   |
|                            | 650              |                  |                     | 1,2-Dimethylbenzene    | 313.15 | 5.9                          | 87   |
|                            | 1000             |                  |                     | 1,2-Dimethylbenzene    | 313.15 | 1.8                          | 87   |
|                            | 2000             |                  |                     | 1,2-Dimethylbenzene    | 313.15 | 0.9                          | 87   |
|                            | 650              |                  |                     | 1,3-Dimethylbenzene    | 313.15 | 6.4                          | 87   |
|                            | 1000             |                  |                     | 1,3-Dimethylbenzene    | 313.15 | 0.6                          | 87   |
|                            | 2000             |                  |                     | 1,3-Dimethylbenzene    | 313.15 | 0.8                          | 87   |
|                            | 650              |                  |                     | 1,4-Dimethylbenzene    | 313.15 | 4.3                          | 87   |
|                            | 1000             |                  |                     | 1,4-Dimethylbenzene    | 313.15 | 1.8                          | 87   |
|                            | 2000             |                  |                     | 1,4-Dimethylbenzene    | 313.15 | 0.7                          | 87   |
|                            | 650              |                  |                     | 1,4-Dioxane            | 321.35 | 4.0                          | 81   |
|                            | 1000             |                  |                     | 1,4-Dioxane            | 321.35 | 2.3                          | 81   |
|                            | 2000             |                  |                     | 1,4-Dioxane            | 321.35 | 1.0                          | 81   |
|                            | 650              |                  |                     | Ethylbenzene           | 313.15 | 6.9                          | 86   |
|                            | 1000             |                  |                     | Ethylbenzene           | 313.15 | 3.4                          | 86   |
|                            | 2000             |                  |                     | Ethylbenzene           | 313.15 | -0.05                        | 86   |
|                            | 650              |                  |                     | Propylbenzene          | 313.15 | 5.8                          | 86   |
|                            | 1000             |                  |                     | Propylbenzene          | 313.15 | 1.3                          | 86   |
|                            | 2000             |                  |                     | Propylbenzene          | 313.15 | 0.9                          | 86   |
|                            | 650              |                  |                     | Tetrachloromethane     | 313.15 | 3.3                          | 88   |
|                            | 1000             |                  |                     | Tetrachloromethane     | 313.15 | 1.4                          | 88   |
|                            | 2000             |                  |                     | Tetrachloromethane     | 321.35 | 0.7                          | 82   |
|                            | 650              |                  |                     | Toluene                | 313.15 | 4.3                          | 86   |
|                            | 1000             |                  |                     | Toluene                | 313.15 | 2.0                          | 86   |
|                            | 2000             |                  |                     | Toluene                | 313.15 | 0.9                          | 86   |
|                            | 650              |                  |                     | 1,3,5-Trimethylbenzene | 313.15 | 6.1                          | 87   |
|                            | 1000             |                  |                     | 1,3,5-Trimethylbenzene | 313.15 | 2.7                          | 87   |
|                            | 2000             |                  |                     | 1,3,5-Trimethylbenzene | 313.15 | 0.6                          | 87   |
| <i>Poly(vinyl acetate)</i> |                  |                  |                     |                        |        |                              |      |
|                            |                  |                  | 140000              | Benzene                | 298.15 | 2.3                          | 13   |
|                            |                  |                  | 350000              | 2-Butanone             | 303.15 | -1.7                         | 51   |
|                            |                  |                  | 350000              | Butyl acetate          | 303.15 | 1.0                          | 51   |
|                            |                  |                  | 135000              | Chlorobenzene          | 298.15 | 5.0                          | 34   |
|                            |                  |                  | 350000              | Ethyl acetate          | 303.15 | -6.7                         | 51   |
|                            |                  |                  |                     | Ethyl acetate          | 303.15 | 0.0                          | 11   |
|                            |                  |                  | 26000               | 3-Heptanone            | 303.15 | 7.0                          | 44   |
|                            |                  |                  | 350000              | 3-Heptanone            | 303.15 | 4.9                          | 51   |
|                            |                  |                  | 140000              | Methanol               | 298.15 | -45                          | 13   |
|                            |                  |                  | 350000              | Methyl acetate         | 303.15 | -9.7                         | 51   |
|                            |                  |                  | 350000              | 2-Pentanone            | 303.15 | 0.0                          | 51   |
|                            |                  |                  | 93000               | 2-Propanone            | 303.15 | -0.4                         | 32   |
|                            |                  |                  | 350000              | 2-Propanone            | 303.15 | -3.9                         | 51   |
|                            |                  |                  |                     | 2-Propanone            | 303.15 | -2.9                         | 25   |

| Polymer                     | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                       | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|-----------------------------|------------------|------------------|---------------------|-------------------------------|--------|------------------------------|------|
|                             |                  | 150000           | 350000              | Propyl acetate                | 303.15 | −2.7                         | 51   |
|                             |                  |                  |                     | Tetrahydrofuran               | 304.65 | 4.5                          | 93   |
|                             |                  |                  | 140000              | Trichloromethane              | 298.15 | 28                           | 13   |
| <i>Poly(vinyl alcohol)</i>  |                  |                  |                     |                               |        |                              |      |
|                             |                  |                  |                     | Ethanol                       | 298.15 | 3.8                          | 11   |
|                             |                  |                  |                     | Ethanol                       | 298.15 | 9.6                          | 31   |
|                             | 7260             |                  |                     | Water                         | 303.15 | −34                          | 15   |
|                             | 17000            |                  |                     | Water                         | 303.15 | −18                          | 32   |
|                             | 61600            |                  |                     | Water                         | 303.15 | −41                          | 15   |
|                             |                  |                  |                     | Water                         | 303.15 | −8.4                         | 11   |
| <i>Poly(vinyl chloride)</i> |                  |                  |                     |                               |        |                              |      |
|                             |                  |                  |                     | Chlorobenzene                 | 298.15 | −17                          | 36   |
| Glass                       | 23200            |                  |                     | Cyclohexanone                 | 303.15 | −27                          | 59   |
| Liquid                      | 23200            |                  |                     | Cyclohexanone                 | 303.15 | −7.5                         | 59   |
| Glass                       | 38700            |                  |                     | Cyclohexanone                 | 303.15 | −29                          | 59   |
| Liquid                      | 38700            |                  |                     | Cyclohexanone                 | 303.15 | −6.6                         | 59   |
| Glass                       | 53500            |                  |                     | Cyclohexanone                 | 303.15 | −28                          | 59   |
| Liquid                      | 53500            |                  |                     | Cyclohexanone                 | 303.15 | −6.3                         | 59   |
| Glass                       | 66700            |                  |                     | Cyclohexanone                 | 303.15 | −29                          | 59   |
| Liquid                      | 66700            |                  |                     | Cyclohexanone                 | 303.15 | −6.1                         | 59   |
| Glass                       | 136000           |                  |                     | Cyclohexanone                 | 303.15 | −31                          | 59   |
| Liquid                      | 136000           |                  |                     | Cyclohexanone                 | 303.15 | −5.8                         | 59   |
| Glass                       | 155400           |                  |                     | Cyclohexanone                 | 303.15 | −32                          | 59   |
| Liquid                      | 155400           |                  |                     | Cyclohexanone                 | 303.15 | −5.8                         | 59   |
|                             | 48000            |                  |                     | Cyclopentanone                | 298.15 | −28                          | 104  |
|                             |                  |                  |                     | 1,2-Dichloroethane            | 323.65 | 24                           | 27   |
|                             |                  |                  |                     | 1,2-Dichloroethane            | 328.15 | 34                           | 27   |
|                             |                  |                  |                     | 1,2-Dichloroethane            | 333.15 | 38                           | 27   |
|                             |                  |                  |                     | 1,2-Dichloroethane            | 368.15 | 44                           | 27   |
|                             |                  |                  |                     | 1,2-Dichloroethane            | 373.15 | 46                           | 27   |
|                             |                  |                  |                     | 1,2-Dichloroethane            | 378.15 | 46                           | 27   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide | 293.15 | −28                          | 35   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide | 308.15 | −19                          | 35   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide | 323.15 | −14                          | 35   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide | 338.15 | −7.5                         | 35   |
|                             |                  |                  |                     | <i>N,N</i> -Dimethylformamide | 353.15 | 2.4                          | 35   |
| Glass                       | 23200            |                  |                     | Tetrahydrofuran               | 303.15 | −34                          | 59   |
| Liquid                      | 23200            |                  |                     | Tetrahydrofuran               | 303.15 | −14                          | 59   |
| Glass                       | 38700            |                  |                     | Tetrahydrofuran               | 303.15 | −35                          | 59   |
| Liquid                      | 38700            |                  |                     | Tetrahydrofuran               | 303.15 | −14                          | 59   |
| Glass                       | 53500            |                  |                     | Tetrahydrofuran               | 303.15 | −39                          | 59   |
| Liquid                      | 53500            |                  |                     | Tetrahydrofuran               | 303.15 | −14                          | 59   |
| Glass                       | 66700            |                  |                     | Tetrahydrofuran               | 303.15 | −36                          | 59   |
| Liquid                      | 66700            |                  |                     | Tetrahydrofuran               | 303.15 | −14                          | 59   |
| Glass                       | 136000           |                  |                     | Tetrahydrofuran               | 303.15 | −39                          | 59   |
| Liquid                      | 136000           |                  |                     | Tetrahydrofuran               | 303.15 | −14                          | 59   |
| Glass                       | 155400           |                  |                     | Tetrahydrofuran               | 303.15 | −39                          | 59   |



| Polymer                                          | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent                       | $T/K$  | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|--------------------------------------------------|------------------|------------------|---------------------|-------------------------------|--------|------------------------------|------|
| Liquid                                           | 155400           |                  |                     | Tetrahydrofuran               | 303.15 | -14                          | 59   |
| <i>Poly(1-vinyl-3,5-dimethyl-1,2,4-triazole)</i> |                  |                  |                     |                               |        |                              |      |
|                                                  |                  |                  |                     | <i>N,N</i> -Dimethylformamide | 298.15 | -28                          | 94   |
|                                                  |                  |                  |                     | Water                         | 298.15 | -139                         | 94   |
| <i>Poly(1-vinylimidazole)</i>                    |                  |                  |                     |                               |        |                              |      |
|                                                  | 20700            |                  |                     | Acetic acid                   | 298.15 | -393                         | 94   |
|                                                  | 20700            |                  |                     | Butanoic acid                 | 298.15 | -322                         | 94   |
|                                                  | 20700            |                  |                     | <i>N,N</i> -Dimethylacetamide | 298.15 | -48                          | 94   |
|                                                  | 20700            |                  |                     | <i>N,N</i> -Dimethylformamide | 298.15 | -48                          | 94   |
|                                                  | 20700            |                  |                     | 1-Methyl-2-pyrrolidinone      | 298.15 | -54                          | 91   |
|                                                  | 20700            |                  |                     | Pentanoic acid                | 298.15 | -325                         | 94   |
|                                                  | 20700            |                  |                     | Propanoic acid                | 298.15 | -278                         | 94   |
|                                                  | 20700            |                  |                     | Water                         | 298.15 | -119                         | 91   |
| <i>Poly(1-vinylpyrazole)</i>                     |                  |                  |                     |                               |        |                              |      |
|                                                  | 18900            |                  |                     | Acetic acid                   | 298.15 | -88                          | 94   |
|                                                  | 18900            |                  |                     | Butanoic acid                 | 298.15 | -60                          | 94   |
|                                                  | 18900            |                  |                     | <i>N,N</i> -Dimethylacetamide | 298.15 | -26                          | 94   |
|                                                  | 18900            |                  |                     | <i>N,N</i> -Dimethylformamide | 298.15 | -28                          | 94   |
|                                                  | 18900            |                  |                     | Pentanoic acid                | 298.15 | -52                          | 94   |
|                                                  | 18900            |                  |                     | Propanoic acid                | 298.15 | -36                          | 94   |
| <i>Poly(1-vinyl-2-pyrrolidone)</i>               |                  |                  |                     |                               |        |                              |      |
|                                                  |                  |                  | 32000               | Trichloromethane              | 298.15 | -75                          | 48   |
|                                                  |                  |                  | 32000               | Water                         | 298.15 | -150                         | 48   |
| <i>Poly(1-vinyl-1,2,4-triazole)</i>              |                  |                  |                     |                               |        |                              |      |
|                                                  | 69500            |                  |                     | Acetic acid                   | 298.15 | -85                          | 94   |
|                                                  | 69500            |                  |                     | Butanoic acid                 | 298.15 | -74                          | 94   |
|                                                  | 69500            |                  |                     | <i>N,N</i> -Dimethylacetamide | 298.15 | -49                          | 94   |
|                                                  | 69500            |                  |                     | <i>N,N</i> -Dimethylformamide | 298.15 | -47                          | 94   |
|                                                  | 69500            |                  |                     | 1-Methyl-2-pyrrolidinone      | 298.15 | -55                          | 91   |
|                                                  | 69500            |                  |                     | Pentanoic acid                | 298.15 | -75                          | 94   |
|                                                  | 69500            |                  |                     | Propanoic acid                | 298.15 | -72                          | 94   |
|                                                  | 69500            |                  |                     | Water                         | 298.15 | -68                          | 91   |
| <i>Vinyl acetate/vinyl alcohol copolymer</i>     |                  |                  |                     |                               |        |                              |      |
| (9 wt% Vinyl acetate)                            |                  |                  |                     | 2-Propanone                   | 298.15 | 6.3                          | 33   |
| (44 wt% Vinyl acetate)                           |                  |                  |                     | 2-Propanone                   | 298.15 | 4.6                          | 33   |
| (57 wt% Vinyl acetate)                           |                  |                  |                     | 2-Propanone                   | 298.15 | 0.0                          | 33   |
| (67 wt% Vinyl acetate)                           |                  |                  |                     | 2-Propanone                   | 298.15 | -1.3                         | 33   |
| (4.2 mol% Vinyl acetate)<br>7560                 |                  |                  |                     | Water                         | 303.15 | -41                          | 15   |
| (4.3 mol% Vinyl acetate)<br>64300                |                  |                  |                     | Water                         | 303.15 | -49                          | 15   |
| (9.0 mol% Vinyl acetate)<br>66900                |                  |                  |                     | Water                         | 303.15 | -55                          | 15   |
| (10.3 mol% Vinyl acetate)<br>7970                |                  |                  |                     | Water                         | 303.15 | -41                          | 15   |
| (15.3 mol% Vinyl acetate)<br>8300                |                  |                  |                     | Water                         | 303.15 | -60                          | 15   |

| Polymer                                                               | $M_n$ /<br>g/mol | $M_w$ /<br>g/mol | $M_\eta$ /<br>g/mol | Solvent          | T/K    | $\Delta H_B^\infty$ /<br>J/g | Ref. |
|-----------------------------------------------------------------------|------------------|------------------|---------------------|------------------|--------|------------------------------|------|
| (15.4 mol% Vinyl acetate)<br>70700                                    |                  |                  |                     | Water            | 303.15 | -65                          | 15   |
| (19.5 mol% Vinyl acetate)<br>73100                                    |                  |                  |                     | Water            | 303.15 | -66                          | 15   |
| (22.1 mol% Vinyl acetate)<br>8800                                     |                  |                  |                     | Water            | 303.15 | -60                          | 15   |
| (26.2 mol% Vinyl acetate)<br>77000                                    |                  |                  |                     | Water            | 303.15 | -64                          | 15   |
| (30.6 mol% Vinyl acetate)<br>9370                                     |                  |                  |                     | Water            | 303.15 | -53                          | 15   |
| (34.0 mol% Vinyl acetate)<br>81600                                    |                  |                  |                     | Water            | 303.15 | -60                          | 15   |
| (34.7 mol% Vinyl acetate)<br>9670                                     |                  |                  |                     | Water            | 303.15 | -44                          | 15   |
| <b>Vinyl acetate/vinyl chloride copolymer (90 wt% Vinyl chloride)</b> |                  |                  |                     |                  |        |                              |      |
| Glass                                                                 | 12400            | 26000            |                     | Cyclohexanone    | 304.15 | -37                          | 101  |
| Liquid                                                                | 12400            | 26000            |                     | Cyclohexanone    | 304.15 | -16                          | 101  |
| <b>Vinyl chloride/vinylidene chloride copolymer</b>                   |                  |                  |                     |                  |        |                              |      |
|                                                                       |                  |                  |                     | Trichloromethane | 297.15 | -17                          | 2    |

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# SOLUBILITY PARAMETERS OF SELECTED POLYMERS

Christian Wohlfarth

The concept of cohesive energy density and solubility parameter was introduced by Hildebrand:

$$\delta^2 = \frac{\Delta U_m^{LV}}{V_m} = \frac{\Delta H_m^{LV} - RT}{V_m} \quad (1)$$

$V_m$  is the molar volume,  $\Delta U_m^{LV}$  is the molar energy of vaporization, and  $\Delta H_m^{LV}$  is the molar enthalpy of vaporization. Units for the solubility parameter are  $(\text{MPa})^{1/2} = (\text{J}/\text{cm}^3)^{1/2} = 0.4887(\text{cal}/\text{cm}^3)^{1/2}$ . The energy of vaporization is not accessible for polymers, but cohesive energy density of polymers can be determined from  $PVT$ -data. However, common ways for determining polymer solubility parameters use thermodynamic properties of polymer solutions and their relations to excess enthalpy or excess Gibbs energy per unit volume. These excess quantities are related to the (square) difference between the solubility parameters of solvents and polymers, i.e.  $(\delta_1 - \delta_2)^2$ .

$$\frac{H^E}{V} \sim (\delta_1 - \delta_2)^2 \quad \text{or} \quad \frac{G^E}{V} \sim (\delta_1 - \delta_2)^2 \quad (2)$$

Often, the Flory-Huggins solvent-polymer interaction parameter is applied instead of  $H^E$  or  $G^E$ . There are some books (Refs. 1–3) giving details for such procedures as well as extensive tables of polymer solubility parameters from which the table below is extracted. Methods for calculating solubility parameters can be found in Refs. 4–7.

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| Polymer                           | T/K | $\delta/(\text{J}/\text{cm}^3)^{1/2}$ |
|-----------------------------------|-----|---------------------------------------|
| Benzyl cellulose                  | 298 | 25.2                                  |
| Butadiene/acrylonitrile copolymer |     |                                       |
| (25 wt % acrylonitrile)           | 298 | 19.4                                  |
| (30 wt % acrylonitrile)           | 298 | 19.2                                  |
| (34 wt % acrylonitrile)           | 298 | 20.4                                  |
| (39 wt % acrylonitrile)           | 298 | 21.35                                 |
| Butadiene/styrene copolymer       |     |                                       |
| (6 wt % styrene)                  | 298 | 16.5                                  |
| (12.5 wt % styrene)               | 298 | 16.5                                  |
| (15 wt % styrene)                 | 298 | 17.5                                  |
| (25 wt % styrene)                 | 298 | 17.6                                  |
| (40 wt % styrene)                 | 298 | 17.8                                  |
| Cellulose                         | 298 | 26.0                                  |
| Cellulose acetate                 | 298 | 25.1                                  |
| Cellulose diacetate               | 298 | 22.3                                  |
| Cellulose nitrate                 | 298 | 22.0                                  |
| Cellulose triacetate              | 298 | 19.0                                  |
| Ethyl cellulose                   | 298 | 21.1                                  |
| Ethylene/1-octene copolymer       |     |                                       |
| (2.0 wt% 1-octene)                | 473 | 17.2                                  |
| (7.5 wt% 1-octene)                | 473 | 16.7                                  |
| (12.0 wt% 1-octene)               | 473 | 16.5                                  |
| (25.0 wt% 1-octene)               | 473 | 16.5                                  |
| (39.4 wt% 1-octene)               | 473 | 16.4                                  |
| (55.0 wt% 1-octene)               | 473 | 16.3                                  |
| (64.0 wt% 1-octene)               | 473 | 16.3                                  |
| Ethylene/vinyl acetate copolymer  |     |                                       |

| Polymer                          | T/K | $\delta/(\text{J}/\text{cm}^3)^{1/2}$ |
|----------------------------------|-----|---------------------------------------|
| (11 wt% vinyl acetate)           | 323 | 16.6                                  |
| (16 wt% vinyl acetate)           | 323 | 17.1                                  |
| (24 wt% vinyl acetate)           | 323 | 16.8                                  |
| (37 wt% vinyl acetate)           | 323 | 17.0                                  |
| (42 wt% vinyl acetate)           | 323 | 17.2                                  |
| Gelatine                         | 298 | 24.6                                  |
| Hydroxypropyl cellulose          | 298 | 26.8                                  |
| Natural rubber                   | 298 | 16.6                                  |
| Poly(acrylonitrile)              | 298 | 26.0                                  |
| Polyamide 4                      | 298 | 24.0                                  |
| Polyamide 6                      | 298 | 21.7                                  |
| Polyamide 66                     | 298 | 22.9                                  |
| Polyamide 7                      | 298 | 24.1                                  |
| Polyamide 8                      | 298 | 20.3                                  |
| Polyamide 9                      | 298 | 22.6                                  |
| Polyamide 10                     | 298 | 19.4                                  |
| Polyamide 11                     | 298 | 22.9                                  |
| Polyamide 12                     | 298 | 20.8                                  |
| Poly( <i>p</i> -benzamide)       | 298 | 23.0                                  |
| Poly(benzyl methacrylate)        | 298 | 15.3                                  |
| Polybutadiene                    | 298 | 16.6                                  |
| 1,2-Polybutadiene                | 298 | 16.5                                  |
| 1,4- <i>cis</i> -Polybutadiene   | 298 | 16.5                                  |
| Poly(1-butene), <i>isotactic</i> | 298 | 16.0                                  |
| Poly(butyl acrylate)             | 298 | 18.0                                  |
| Poly(butyl methacrylate)         | 298 | 17.9                                  |
| Poly(2-butyl methacrylate)       | 413 | 14.7                                  |

| Polymer                                | T/K | $\delta/(\text{J}/\text{cm}^3)^{1/2}$ | Polymer                                | T/K | $\delta/(\text{J}/\text{cm}^3)^{1/2}$ |
|----------------------------------------|-----|---------------------------------------|----------------------------------------|-----|---------------------------------------|
| Poly( $\epsilon$ -caprolactone)        | 298 | 19.9                                  | Poly(methylvinylsiloxane)              | 298 | 15.65                                 |
| Polycarbonate bisphenol-A              | 298 | 20.0                                  | Polynorbornene                         | 298 | 14.0                                  |
| Polycarbonate hexafluorobisphenol-A    | 298 | 20.1                                  | Poly(1-octene)                         | 298 | 16.6                                  |
| Poly(chloroprene)                      | 298 | 17.6                                  | Poly(octyl methacrylate)               | 298 | 18.0                                  |
| Poly(4-chlorostyrene)                  | 298 | 19.3                                  | Poly(propyl acrylate)                  | 298 | 18.4                                  |
| Poly(cyclohexyl methacrylate)          | 298 | 19.8                                  | Poly(propyl methacrylate)              | 298 | 16.0                                  |
| Poly(3,3-diethyloxetane)               | 298 | 16.2                                  | Polypropylene, <i>atactic</i>          | 298 | 15.5                                  |
| Poly(3,3-dimethyloxetane)              | 298 | 16.2                                  | Polypropylene, <i>isotactic</i>        | 298 | 17.5                                  |
| Poly(2,6-dimethyl-1,4-phenylene ether) | 298 | 18.1                                  | Polypropylene, <i>syndiotactic</i>     | 298 | 17.6                                  |
| Poly(dimethylsiloxane)                 | 298 | 15.4                                  | Poly(propylene glycol)                 | 298 | 19.5                                  |
| Poly(1,3-dioxepane)                    | 298 | 18.8                                  | Poly(propylene oxide)                  | 298 | 18.5                                  |
| Poly(1,3-dioxolane)                    | 298 | 20.7                                  | Poly(propyl methacrylate)              | 298 | 20.0                                  |
| Poly(dodecyl methacrylate)             | 298 | 16.8                                  | Polystyrene                            | 298 | 19.0                                  |
| Poly(epichlorohydrin)                  | 298 | 16.2                                  | Polysulfone                            | 298 | 19.9                                  |
| Poly(ethoxyethyl methacrylate)         | 298 | 18.4                                  | Poly(tetrafluoroethylene)              | 298 | 19.6                                  |
| Poly(ethyl acrylate)                   | 298 | 19.2                                  | Poly(tetramethylene oxide)             | 298 | 16.8                                  |
| Polyethylene, branched                 | 298 | 16.2                                  | Poly(thioethylene)                     | 298 | 18.8                                  |
| Polyethylene, linear                   | 298 | 16.2                                  | Poly(trimethylene sulfide)             | 298 | 23.0                                  |
| Poly(ethylene adipate)                 | 298 | 19.8                                  | Poly(vinyl acetate)                    | 298 | 20.6                                  |
| Poly(ethylene glycol)                  | 298 | 23.7                                  | Poly(vinyl alcohol)                    | 298 | 22.0                                  |
| Poly(ethylene oxide)                   | 298 | 20.5                                  | Poly(vinyl bromide)                    | 298 | 19.4                                  |
| Poly(ethylene terephthalate)           | 298 | 21.9                                  | Poly(vinyl butyl ether)                | 298 | 19.2                                  |
| Poly(ethyl methacrylate)               | 298 | 18.3                                  | Poly( <i>N</i> -vinylcarbazole)        | 298 | 19.2                                  |
| Poly(hexyl methacrylate)               | 298 | 17.7                                  | Poly(vinyl chloride)                   | 298 | 19.6                                  |
| Poly(4-hydroxystyrene)                 | 298 | 24.0                                  | Poly(vinyl ethyl ether)                | 298 | 19.5                                  |
| Poly(isobornyl acrylate)               | 298 | 16.8                                  | Poly(vinylidene fluoride)              | 298 | 23.2                                  |
| Poly(isobornyl methacrylate)           | 298 | 17.0                                  | Poly(vinyl methyl ether)               | 298 | 21.0                                  |
| Poly(isobutylene)                      | 298 | 16.2                                  | Poly(vinyl phenyl ether)               | 298 | 20.2                                  |
| Poly(isobutyl methacrylate)            | 413 | 14.6                                  | Poly(vinyl propionate)                 | 298 | 18.1                                  |
| 1,4- <i>cis</i> -Poly(isoprene)        | 298 | 16.5                                  | Poly(vinyl propyl ether)               | 298 | 19.3                                  |
| Poly( <i>N</i> -isopropylacrylamide)   | 298 | 23.5                                  | Poly(1-vinyl-2-pyrrolidinone)          | 298 | 25.6                                  |
| Poly( <i>DL</i> -lactic acid)          | 298 | 20.5                                  | Vinyl acetate/vinyl alcohol copolymer  |     |                                       |
| Poly( <i>L</i> -lactide)               | 298 | 19.3                                  | (43.4 mol% vinyl acetate)              | 298 | 21.8                                  |
| Poly(methacrylonitrile)                | 298 | 21.0                                  | (60.9 mol% vinyl acetate)              | 298 | 21.4                                  |
| Poly(methyl acrylate)                  | 298 | 20.5                                  | (74.4 mol% vinyl acetate)              | 298 | 20.9                                  |
| Poly(methyl methacrylate)              | 298 | 19.3                                  | (94.8 mol% vinyl acetate)              | 298 | 20.2                                  |
| Poly(4-methyl-1-pentene)               | 298 | 15.3                                  | Vinyl acetate/vinyl chloride copolymer |     |                                       |
| Poly(2-methylpropene)                  | 298 | 17.7                                  | (3 wt% vinyl acetate)                  | 298 | 18.8                                  |
| Poly(2-methylstyrene)                  | 298 | 18.4                                  | (10 wt% vinyl acetate)                 | 298 | 17.3                                  |
| Poly(4-methylstyrene)                  | 298 | 19.3                                  | (17 wt% vinyl acetate)                 | 298 | 19.1                                  |

# ASTRONOMICAL CONSTANTS

Victor Abalakin

The constants in this table are based originally on the set of constants adopted by the International Astronomical Union (IAU) in 1976. Updates have been made when new data were available. All values are given in SI Units; thus masses are expressed in kilograms and distances in meters.

The astronomical unit of time is a time interval of one day (1 d) equal to 86400 s. An interval of 36525 d is one Julian century (1 cy).

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### Defining constants

Gaussian gravitational constant

$$k = 0.01720209895 \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$$

Speed of light

$$c = 299792458 \text{ m s}^{-1}$$

### Primary constants

Light-time for unit distance (1 ua)

$$\tau_A = 499.004786 \text{ s}$$

Equatorial radius of Earth

$$a_e = 6378140 \text{ m}$$

Equatorial radius of Earth (IUGG value)

$$a_e = 6378136 \text{ m}$$

Dynamical form-factor for Earth

$$J_2 = 0.001082636$$

Geocentric gravitational constant

$$GE = 3.986004 \times 10^{14} \text{ m}^3 \text{ s}^{-2}$$

Constant of gravitation

$$G = 6.67428 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$$

Ratio of mass of moon to that of Earth

$$\mu = 0.01230002$$

$$1/\mu = 81.300587$$

General precession in longitude, per Julian century, at standard epoch J2000

$$\rho = 5028''.796$$

Obliquity of the ecliptic at standard epoch J2000

$$\varepsilon = 23^\circ 26' 21''.448$$

### Derived constants

Constant of nutation at standard epoch J2000

$$N = 9''.2025$$

Unit distance ( $ua = c\tau_A$ )

$$ua = 1.49597871464 \times 10^{11} \text{ m}$$

Solar parallax ( $\pi_0 = \arcsin(a_e/ua)$ )

$$\pi_0 = 8''.794143$$

Constant of aberration for standard epoch J2000

$$\kappa = 20''.49552$$

Flattening factor for the Earth

$$f = 1/298.256 = 0.00335282$$

Heliocentric gravitational constant ( $GS = A^3 k^2 / D^2$ )

$$GS = 1.32712438 \times 10^{20} \text{ m}^3 \text{ s}^{-2}$$

Ratio of mass of sun to that of the Earth ( $S/E = (GS)/(GE)$ )

$$S/E = 332946.0$$

Ratio of mass of sun to that of Earth + moon

$$(S/E)/(1 + \mu) = 328900.56$$

Mass of the sun ( $S = (GS)/G$ )

$$S = 1.98844 \times 10^{30} \text{ kg}$$

### Ratios of mass of sun to masses of the planets

Mercury

$$6023600$$

Venus

$$408523.7$$

Earth + moon

$$328900.56$$

Mars

$$3098708$$

Jupiter

$$1047.349$$

Saturn

$$3497.898$$

Uranus

$$22902.98$$

Neptune

$$19412.24$$

## PROPERTIES OF THE SOLAR SYSTEM

The following tables give various properties of the planets and characteristics of their orbits in the solar system. Certain properties of the sun and of the earth's moon are also included.

Explanations of the column headings:

- *Mass*: mass of the planet in units of  $10^{24}$  kg
- *Radius*: radius at the equator in km
- *Density*: mean density in  $\text{g/cm}^3$
- *Flattening*: degree of oblateness, defined as  $(r_e - r_p)/r_e$ , where  $r_e$  and  $r_p$  are the equatorial and polar radii, respectively
- *Potential coefficients*: coefficients in the spherical harmonic representation of the gravitational potential  $U$  by the equation

$$U(r, \phi) = (GM/r) [1 - \sum_n (a/r)^n P_n(\sin \phi)],$$

where  $G$  is the gravitational constant,  $r$  the distance from the center of the planet,  $a$  the radius of the planet,  $M$  the mass,  $\phi$  the latitude, and  $P_n$  the Legendre polynomial of degree  $n$ .

- *Gravity*: acceleration due to gravity at the surface
- *Escape vel.*: velocity needed at the surface of the planet to escape the gravitational pull
- *Dist. to sun*: semi-major axis of the elliptical orbit in astronomical units (1 ua  $\approx 1.496 \cdot 10^8$  km)
- $e$ : eccentricity of the orbit
- *Ecliptic angle*: angle between the planetary orbit and the plane of the earth's orbit around the sun
- *Inclin.*: angle between the equatorial plane of the planet and the plane of the planetary orbit
- *Orbit period*: period of revolution around the sun measured in years
- *Rotation period*: period of rotation of the planet measured in hours. A negative value indicates retrograde rotation.
- *Albedo*: ratio of the light reflected from the planet to the light incident on it
- *No. of satellites*: Number of confirmed satellites; this includes satellites that have not been named.
- $T_{\text{sur}}$ : mean temperature at the surface
- $P_{\text{sur}}$ : pressure of the atmosphere at the surface

The last four entries in the table are *dwarf planets* as defined by the International Astronomical Union. These are bodies in orbit around the sun that are massive enough to adopt a near-spherical shape as a result of their self-gravity, but are appreciably smaller than the major planets. *Plutoids* form a subset of the dwarf plan-

ets; their orbits are larger than that of Neptune (see Ref. 9). As of 2008, the IAU has recognized the names for three plutoids: Pluto, Eris, and Makemake.

The following general information on the solar system is of interest:

Mass of the earth =  $M_e = 5.9736 \cdot 10^{24}$  kg  
 Total mass of planetary system =  $2.669 \cdot 10^{27}$  kg =  $447 M_e$   
 Total angular momentum of planetary system =  $3.148 \cdot 10^{43}$  kg m<sup>2</sup> s<sup>-1</sup>  
 Total kinetic energy of the planets =  $1.99 \cdot 10^{35}$  J  
 Total rotational energy of planets =  $0.7 \cdot 10^{35}$  J

Properties of the sun:

Mass =  $1.9884 \cdot 10^{30}$  kg =  $332943 M_e$   
 Radius =  $6.9551 \cdot 10^8$  m  
 Surface area =  $6.079 \cdot 10^{18}$  m<sup>2</sup>  
 Volume =  $1.409 \cdot 10^{27}$  m<sup>3</sup>  
 Mean density =  $1.411$  g/cm<sup>3</sup>  
 Gravity at surface =  $27398$  cm/s<sup>2</sup>  
 Escape velocity at surface =  $6.177 \cdot 10^5$  m/s  
 Effective temperature =  $5780$  K  
 Total radiant power emitted (luminosity) =  $3.8427 \cdot 10^{26}$  W  
 Surface flux of radiant energy =  $6.322 \cdot 10^7$  W/m<sup>2</sup>  
 Flux of radiant energy at the earth (Solar Constant) =  $1366.4$  W/m<sup>2</sup> (Ref. 8)

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| Planet                | Mass<br>10 <sup>24</sup> kg | Radius<br>km | Density<br>g/cm <sup>3</sup> | Flattening | Potential coefficients         |                                |                                | Gravity<br>cm/s <sup>2</sup> | Escape vel.<br>km/s |
|-----------------------|-----------------------------|--------------|------------------------------|------------|--------------------------------|--------------------------------|--------------------------------|------------------------------|---------------------|
|                       |                             |              |                              |            | 10 <sup>3</sup> J <sub>2</sub> | 10 <sup>6</sup> J <sub>3</sub> | 10 <sup>6</sup> J <sub>4</sub> |                              |                     |
| Mercury               | 0.33022                     | 2439.7       | 5.43                         | 0.0000     |                                |                                |                                | 370                          | 4.25                |
| Venus                 | 4.8685                      | 6051.8       | 5.24                         | 0.000      | 0.027                          |                                |                                | 887                          | 10.36               |
| Earth                 | 5.9736                      | 6378.14      | 5.52                         | 0.00335364 | 1.08263                        | −2.54                          | −1.61                          | 980                          | 11.18               |
| (Moon)                | 0.07349                     | 1738.1       | 3.35                         | 0.0012     | 0.2027                         |                                |                                | 162                          | 2.38                |
| Mars                  | 0.64185                     | 3396.2       | 3.93                         | 0.0064763  | 1.964                          | 36                             |                                | 371                          | 5.03                |
| Jupiter               | 1898.6                      | 71492        | 1.33                         | 0.0648744  | 14.75                          | −580                           |                                | 2312                         | 59.54               |
| Saturn                | 568.46                      | 60268        | 0.69                         | 0.09796    | 16.45                          | −1000                          |                                | 896                          | 35.5                |
| Uranus                | 86.832                      | 25559        | 1.27                         | 0.02293    | 3.343                          |                                |                                | 869                          | 21.29               |
| Neptune               | 102.43                      | 24764        | 1.64                         | 0.01708    | 3.41                           |                                |                                | 1100                         | 23.5                |
| <i>Dwarf planets:</i> |                             |              |                              |            |                                |                                |                                |                              |                     |
| Pluto                 | 0.0125                      | 1195         | 1.75                         | 0          |                                |                                |                                | 58                           | 1.2                 |
| Eris                  | 0.0166                      | 1225         |                              |            |                                |                                |                                | ≈80                          |                     |
| Makemake              | ≈0.004                      | 750          | ≈2                           |            |                                |                                |                                | ≈47                          | ≈0.84               |
| Ceres                 | 0.000943                    | 471          | 2.08                         |            |                                |                                |                                | 27                           | 0.51                |

| Planet                | Dist. to sun<br>ua | $\epsilon$ | Ecliptic<br>angle | Inclin. | Orbit<br>period (yr) | Rotation<br>period (hr) | Albedo | No. of<br>satellites |
|-----------------------|--------------------|------------|-------------------|---------|----------------------|-------------------------|--------|----------------------|
| Mercury               | 0.38710            | 0.2056     | 7.00°             | 0.01°   | 0.2408467            | 1407.6                  | 0.106  | 0                    |
| Venus                 | 0.72333            | 0.0068     | 3.39°             | 177.36° | 0.61519726           | −5832.5                 | 0.65   | 0                    |
| Earth                 | 1.00000            | 0.0167     | 0                 | 23.45°  | 1.0000174            | 23.9345                 | 0.367  | 1                    |
| Mars                  | 1.52366            | 0.0934     | 1.85°             | 25.19°  | 1.8808476            | 24.6229                 | 0.150  | 2                    |
| Jupiter               | 5.20336            | 0.0484     | 1.305°            | 3.12°   | 11.862615            | 9.9250                  | 0.52   | 63                   |
| Saturn                | 9.53707            | 0.0542     | 2.48°             | 26.73°  | 29.447498            | 10.656                  | 0.47   | 60                   |
| Uranus                | 19.19126           | 0.0472     | 0.77°             | 97.86°  | 84.016846            | −17.24                  | 0.51   | 27                   |
| Neptune               | 30.06896           | 0.0086     | 1.77°             | 28.32°  | 164.79132            | 16.11                   | 0.41   | 13                   |
| <i>Dwarf planets:</i> |                    |            |                   |         |                      |                         |        |                      |
| Pluto                 | 39.48168           | 0.2488     | 17.14°            | 118°    | 247.92065            | −153.29                 | 0.6    | 3                    |
| Eris                  | 67.7               | 0.44       |                   | 44.19°  | 557                  |                         | 0.8    | 1                    |
| Makemake              | 45.79              | 0.159      |                   | 28.96°  | 309.88               |                         |        |                      |
| Ceres                 | 2.77               | 0.08       |                   | 10.59°  | 4.599                | 9.074                   | 0.090  |                      |

[illegible]



## SATELLITES OF THE PLANETS

This table gives characteristics of the known satellites of the planets. The parameters covered are:

- Orbital period in units of earth days. An R following the value indicates a retrograde motion.
- Distance from the planet, as measured by the semi-major axis of the orbit
- Eccentricity of the orbit
- Inclination of the satellite orbit with respect to the equator of the planet
- Mass of the satellite in kilograms
- Radius of the satellite in kilometers
- Geometric albedo, which is a measure of the fraction of incident sunlight reflected by the satellite.

Since this is a very active field of research, the Internet sites listed below should be consulted for the most recent data.

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| Planet  |        | Satellite  | Orb. period<br>Earth days | Distance<br>10 <sup>3</sup> km | Eccentricity | Inclination  | Mass<br>kg              | Radius<br>km  | Albedo |
|---------|--------|------------|---------------------------|--------------------------------|--------------|--------------|-------------------------|---------------|--------|
| Earth   |        | Moon       | 27.321661                 | 384.400                        | 0.054900489  | 18.28–28.58° | 7.3483·10 <sup>22</sup> | 1737.5        | 0.12   |
| Mars    | I      | Phobos     | 0.31891023                | 9.378                          | 0.0151       | 1.0°         | 1.06·10 <sup>16</sup>   | 13.5×10.8×9.4 | 0.07   |
|         | II     | Deimos     | 1.2624407                 | 23.460                         | 0.0005       | 0.9–2.7°     | 2.4·10 <sup>15</sup>    | 7.5×6.1×5.5   | 0.07   |
| Jupiter | I      | Io         | 1.769137786               | 421.8                          | 0.0041       | 0.04°        | 8.932·10 <sup>22</sup>  | 1821.6        | 0.63   |
|         | II     | Europa     | 3.551181041               | 671.1                          | 0.0101       | 0.47°        | 4.8·10 <sup>22</sup>    | 1560.8        | 0.67   |
|         | III    | Ganymede   | 7.15455296                | 1070.4                         | 0.0015       | 0.21°        | 1.4819·10 <sup>23</sup> | 2631.2        | 0.43   |
|         | IV     | Callisto   | 16.6890184                | 1882.7                         | 0.007        | 0.51°        | 1.0759·10 <sup>23</sup> | 2410.3        | 0.17   |
|         | V      | Amalthea   | 0.49817905                | 181.4                          | 0.003        | 0.40°        | 7.17·10 <sup>18</sup>   | 131×73×67     | 0.09   |
|         | VI     | Himalia    | 250.5662                  | 11460                          | 0.162        | 27.63°       | 9.56·10 <sup>18</sup>   | 85            | 0.04   |
|         | VII    | Elara      | 259.6528                  | 11737                          | 0.217        | 24.77°       | 7.77·10 <sup>17</sup>   | 40            | 0.04   |
|         | VIII   | Pasiphae   | 743.63 R                  | 23620                          | 0.409        | 145°         | 1.91·10 <sup>17</sup>   | 18            | 0.04   |
|         | IX     | Sinope     | 758.90 R                  | 23940                          | 0.250        | 153°         | 7.77·10 <sup>16</sup>   | 14            | 0.04   |
|         | X      | Lysithea   | 259.20                    | 11720                          | 0.112        | 29.02°       | 7.77·10 <sup>16</sup>   | 12            | 0.04   |
|         | XI     | Carme      | 734.17 R                  | 23400                          | 0.253        | 164°         | 9.56·10 <sup>16</sup>   | 15            | 0.04   |
|         | XII    | Ananke     | 629.77 R                  | 21280                          | 0.244        | 147°         | 3.82·10 <sup>16</sup>   | 10            | 0.04   |
|         | XIII   | Leda       | 240.92                    | 11170                          | 0.164        | 26.07°       | 5.68·10 <sup>15</sup>   | 5             | 0.04   |
|         | XIV    | Thebe      | 0.6745                    | 221.9                          | 0.018        | 0.8°         | 7.77·10 <sup>17</sup>   | 55×45         | 0.05   |
|         | XV     | Adrastea   | 0.29826                   | 129                            | 0.0015       |              | 1.91·10 <sup>16</sup>   | 13×10×8       | 0.10   |
|         | XVI    | Metis      | 0.29478                   | 128                            | 0.0002       |              | 9.56·10 <sup>16</sup>   | 20            | 0.06   |
|         | XVII   | Callirrhoe | 758.77                    | 24100                          | 0.283        |              | 8.7·10 <sup>14</sup>    | 4             | 0.04   |
|         | XVIII  | Themisto   | 130.02                    | 7507                           | 0.242        |              | 6.9·10 <sup>14</sup>    | 4             | 0.04   |
|         | XIX    | Megaclite  | 752.86                    | 23810                          | 0.425        |              | 2.1·10 <sup>14</sup>    | 2.7           | 0.04   |
|         | XX     | Taygete    | 732.41                    | 23360                          | 0.251        |              | 1.6·10 <sup>14</sup>    | 2.5           | 0.04   |
|         | XXI    | Chaldene   | 723.72                    | 23180                          | 0.238        |              | 7.5·10 <sup>13</sup>    | 1.9           | 0.04   |
|         | XXII   | Harpalyke  | 623.32                    | 21110                          | 0.227        |              | 1.2·10 <sup>14</sup>    | 2.2           | 0.04   |
|         | XXIII  | Kalyke     | 742.06                    | 23580                          | 0.243        |              | 1.9·10 <sup>14</sup>    | 2.6           | 0.04   |
|         | XXIV   | Iocaste    | 631.60                    | 21270                          | 0.218        |              | 1.9·10 <sup>14</sup>    | 2.6           | 0.04   |
|         | XXV    | Erinome    | 728.46                    | 23280                          | 0.270        |              | 4.5·10 <sup>13</sup>    | 1.6           | 0.04   |
|         | XXVI   | Isonoe     | 726.63                    | 23220                          | 0.261        |              | 7.5·10 <sup>13</sup>    | 1.9           | 0.04   |
|         | XVII   | Praxidike  | 625.39                    | 21150                          | 0.220        |              | 4.3·10 <sup>14</sup>    | 3.4           | 0.04   |
|         | XXVIII | Autonoe    | 760.95                    | 23039                          | 0.334        |              | 9.0·10 <sup>13</sup>    | 2.0           | 0.04   |
|         | XXIX   | Thyone     | 627.21                    | 20940                          | 0.229        |              | 9.0·10 <sup>13</sup>    | 2.0           | 0.04   |
|         | XXX    | Hermippe   | 633.90                    | 21131                          | 0.210        |              | 9.0·10 <sup>13</sup>    | 2.0           | 0.04   |
|         | XXXI   | Aitne      | 730.18                    | 23231                          | 0.264        |              | 4.5·10 <sup>13</sup>    | 1.5           | 0.04   |
|         | XXXII  | Eurydome   | 717.33                    | 22685                          | 0.276        |              | 4.5·10 <sup>13</sup>    | 1.5           | 0.04   |
|         | XXXIII | Euanthe    | 620.49                    | 20721                          | 0.232        |              | 4.5·10 <sup>13</sup>    | 1.5           | 0.04   |
|         | XXXIV  | Euporie    | 550.74                    | 19302                          | 0.144        |              | 1.5·10 <sup>13</sup>    | 1             | 0.04   |
|         | XXXV   | Orthosie   | 622.56                    | 20721                          | 0.281        |              | 1.5·10 <sup>13</sup>    | 1             | 0.04   |
|         | XXXVI  | Sponde     | 748.34                    | 23487                          | 0.312        |              | 1.5·10 <sup>13</sup>    | 1             | 0.04   |

| Planet | Satellite         | Orb. period<br>Earth days | Distance<br>10 <sup>3</sup> km | Eccentricity | Inclination | Mass<br>kg              | Radius<br>km | Albedo |
|--------|-------------------|---------------------------|--------------------------------|--------------|-------------|-------------------------|--------------|--------|
|        | XXXVII Kale       | 729.47                    | 23217                          | 0.260        |             | 1.5·10 <sup>13</sup>    | 1            | 0.04   |
|        | XXXVIII Pasithee  | 719.44                    | 23096                          | 0.267        |             | 1.5·10 <sup>13</sup>    | 1            | 0.04   |
|        | XXXIX Hegemone    | 739.6                     | 23947                          | 0.328        |             | 4.5·10 <sup>13</sup>    | 1.5          |        |
|        | XL Mneme          | 620.0                     | 21069                          | 0.227        |             | 1.5·10 <sup>13</sup>    | 1            |        |
|        | XLI Aoede         | 761.5                     | 23981                          | 0.432        |             | 9.0·10 <sup>13</sup>    | 2.0          |        |
|        | XLII Thelxinoe    | 628.1                     | 21162                          | 0.221        |             | 1.5·10 <sup>13</sup>    | 1            |        |
|        | XLIII Arche       | 723.9                     | 22931                          | 0.259        |             | 4.5·10 <sup>13</sup>    | 1.5          |        |
|        | XLIV Kallichore   | 764.7                     | 24043                          | 0.264        |             | 1.5·10 <sup>13</sup>    | 1            |        |
|        | XLV Helike        | 634.8                     | 21263                          | 0.156        |             | 9.0·10 <sup>13</sup>    | 2.0          |        |
|        | XLVI Carpo        | 456.1                     | 16989                          | 0.430        |             | 4.5·10 <sup>13</sup>    | 1.5          |        |
|        | XLVII Eukelade    | 746.4                     | 23661                          | 0.272        |             | 9.0·10 <sup>13</sup>    | 2.0          |        |
|        | XLVIII Cyllene    | 737.8                     | 24349                          | 0.319        |             | 1.5·10 <sup>13</sup>    | 1            |        |
|        | XLIX Kore         | 779.2                     | 24543                          | 0.325        |             |                         | 1            |        |
| Saturn | I Mimas           | 0.942421813               | 185.52                         | 0.0202       | 1.53°       | 3.75·10 <sup>19</sup>   | 196          | 0.5    |
|        | II Enceladus      | 1.370217855               | 238.02                         | 0.00452      | 1.86°       | 6.50·10 <sup>19</sup>   | 250          | 1.0    |
|        | III Tethys        | 1.887802160               | 294.66                         | 0.00000      | 1.86°       | 6.27·10 <sup>20</sup>   | 530          | 0.9    |
|        | IV Dione          | 2.736914742               | 377.40                         | 0.002230     | 0.02°       | 1.10·10 <sup>21</sup>   | 560          | 0.7    |
|        | V Rhea            | 4.517500436               | 527.04                         | 0.00100      | 0.35°       | 2.31·10 <sup>21</sup>   | 765          | 0.7    |
|        | VI Titan          | 15.94542068               | 1221.83                        | 0.029192     | 0.33°       | 1.3455·10 <sup>23</sup> | 2575         | 0.21   |
|        | VII Hyperion      | 21.2766088                | 1481.1                         | 0.104        | 0.43°       | 1.59·10 <sup>19</sup>   | 205×130×110  | 0.3    |
|        | VIII Iapetus      | 79.3301825                | 3561.3                         | 0.02828      | 14.72°      | 1.59·10 <sup>21</sup>   | 730          | 0.6    |
|        | IX Phoebe         | 550.31 R                  | 12952                          | 0.16326      | 177°        | 7.2·10 <sup>18</sup>    | 110          | 0.08   |
|        | X Janus           | 0.6945                    | 151.472                        | 0.007        | 0.14°       | 1.92·10 <sup>18</sup>   | 110×100×80   | 0.6    |
|        | XI Epimetheus     | 0.6942                    | 151.422                        | 0.009        | 0.34°       | 5.4·10 <sup>17</sup>    | 70×60×50     | 0.5    |
|        | XII Helene        | 2.7369                    | 377.40                         | 0.005        | 0.0°        | 2.5·10 <sup>16</sup>    | 18×16×15     | 0.6    |
|        | XIII Telesto      | 1.8878                    | 294.66                         |              |             | 7.2·10 <sup>15</sup>    | 17×14×13     | 1.0    |
|        | XIV Calypso       | 1.8878                    | 294.66                         |              |             | 3.6·10 <sup>15</sup>    | 17×11×11     | 0.7    |
|        | XV Atlas          | 0.6019                    | 137.670                        |              | 0.3°        | 1.1·10 <sup>16</sup>    | 20×10        | 0.4    |
|        | XVI Prometheus    | 0.6130                    | 139.353                        | 0.0024       | 0.0°        | 3.3·10 <sup>17</sup>    | 70×50×40     | 0.6    |
|        | XVII Pandora      | 0.6285                    | 141.70                         | 0.0042       | 0.0°        | 1.9·10 <sup>17</sup>    | 55×45×35     | 0.5    |
|        | XVIII Pan         | 0.5750                    | 133.583                        |              |             | 2.7·10 <sup>15</sup>    | 10           | 0.5    |
|        | XIX Ymir          | 1315.14                   | 23096                          | 0.470        |             | 4.9·10 <sup>15</sup>    | 8            | 0.06   |
|        | XX Paaliaq        | 686.95                    | 15199                          | 0.364        |             | 8.2·10 <sup>15</sup>    | 9.5          | 0.06   |
|        | XXI Tarvos        | 926.23                    | 18247                          | 0.536        |             | 2.7·10 <sup>15</sup>    | 6.5          | 0.06   |
|        | XXII Ijiraq       | 451.42                    | 11440                          | 0.322        |             | 1.2·10 <sup>15</sup>    | 5            | 0.06   |
|        | XXIII Suttungr    | 1016.67                   | 19463                          | 0.114        |             | 2.1·10 <sup>14</sup>    | 2.8          | 0.06   |
|        | XXIV Kiviuq       | 449.22                    | 11365                          | 0.334        |             | 3.3·10 <sup>15</sup>    | 7            | 0.06   |
|        | XXV Mundilfari    | 952.77                    | 18709                          | 0.208        |             | 2.1·10 <sup>14</sup>    | 2.8          | 0.06   |
|        | XXVI Albiorix     | 783.45                    | 16404                          | 0.478        |             | 2.1·10 <sup>16</sup>    | 13           | 0.06   |
|        | XXVII Skathi      | 728.20                    | 15647                          | 0.270        |             | 3.1·10 <sup>14</sup>    | 3.2          | 0.06   |
|        | XXVIII Erriapus   | 871.19                    | 17616                          | 0.474        |             | 7.6·10 <sup>14</sup>    | 4.3          | 0.06   |
|        | XXIX Siarnaq      | 895.53                    | 18160                          | 0.295        |             | 3.9·10 <sup>16</sup>    | 16           | 0.06   |
|        | XXX Thrymr        | 1094.11                   | 20382                          | 0.470        |             | 2.1·10 <sup>14</sup>    | 2.8          | 0.06   |
|        | XXXI Narvi        | 1003.86                   | 19007                          | 0.431        |             | 4.9·10 <sup>15</sup>    | 3.3          | 0.04   |
|        | XXXII Methone     | 1.010                     | 194                            |              |             | 1.65·10 <sup>13</sup>   | 1.5          |        |
|        | XXXIII Pallene    | 1.154                     | 211                            |              |             | 3.92·10 <sup>13</sup>   | 2            |        |
|        | XXXIV Polydeuces  | 2.737                     | 377.4                          |              |             |                         | 4            |        |
|        | XXXV Daphnis      | 0.594                     | 136.5                          |              |             |                         | 3.5          |        |
|        | XXXVI Aegir       | 1117.52                   | 20735                          |              |             |                         | 3.5          |        |
|        | XXXVII Bebhionn   | 834.84                    | 17119                          |              |             |                         | 3            |        |
|        | XXXVIII Bergelmir | 1005.74                   | 19338                          |              |             |                         | 3            |        |
|        | XXXIX Bestla      | 1088.72                   | 20129                          |              |             |                         | 3.5          |        |
|        | XL Farbauti       | 1085.55                   | 20390                          |              |             |                         | 2.5          |        |
|        | XLI Fenrir        | 1260.35                   | 22453                          |              |             |                         | 2            |        |
|        | XLII Fornjot      | 1494.20                   | 25108                          |              |             |                         | 3            |        |
|        | XLIII Hati        | 1038.61                   | 19856                          |              |             |                         | 3            |        |
|        | XLIV Hyrrokkin    | 931.86                    | 18437                          |              |             |                         | 4            |        |
|        | XLV Kari          | 1230.97                   | 22118                          |              |             |                         | 3.5          |        |
|        | XLVI Loge         | 1311.36                   | 23065                          |              |             |                         | 3            |        |
|        | XLVII Skoll       | 878.29                    | 17665                          |              |             |                         | 3            |        |

| Planet    | Satellite      | Orb. period<br>Earth days | Distance<br>10 <sup>3</sup> km | Eccentricity | Inclination | Mass<br>kg             | Radius<br>km | Albedo |
|-----------|----------------|---------------------------|--------------------------------|--------------|-------------|------------------------|--------------|--------|
| Uranus    | XLVIII Surtur  | 1297.36                   | 22707                          |              |             |                        | 3            |        |
|           | XLIX Anthe     |                           | 197.7                          |              |             |                        | 1            |        |
|           | L Jarnsaxa     |                           | 18600                          |              |             |                        | 3            |        |
|           | LI Greip       |                           | 18105                          |              |             |                        | 3            |        |
|           | LII Tarqeq     |                           | 19720                          |              |             |                        | 3.5          |        |
|           | I Ariel        | 2.52037935                | 191.02                         | 0.0034       | 0.3°        | 1.35·10 <sup>21</sup>  | 579          | 0.39   |
|           | II Umbriel     | 4.1441772                 | 266.30                         | 0.0050       | 0.36°       | 1.17·10 <sup>21</sup>  | 584.7        | 0.21   |
|           | III Titania    | 8.7058717                 | 435.91                         | 0.0022       | 0.14°       | 3.52·10 <sup>21</sup>  | 788.9        | 0.27   |
|           | IV Oberon      | 13.4632389                | 583.52                         | 0.0008       | 0.10°       | 3.01·10 <sup>21</sup>  | 761.4        | 0.23   |
|           | V Miranda      | 1.41347925                | 129.39                         | 0.0027       | 4.2°        | 6.59·10 <sup>19</sup>  | 236          | 0.32   |
|           | VI Cordelia    | 0.335033                  | 49.77                          | 0.0003       | 0.1°        | 5.4·10 <sup>16</sup>   | 20.1         | 0.07   |
|           | VII Ophelia    | 0.376409                  | 53.79                          | 0.0099       | 0.1°        | 5.4·10 <sup>16</sup>   | 21.4         | 0.07   |
|           | VIII Bianca    | 0.434577                  | 59.17                          | 0.0009       | 0.2°        | 9.3·10 <sup>16</sup>   | 25.7         | 0.07   |
|           | IX Cressida    | 0.463570                  | 61.78                          | 0.0004       | 0.0°        | 3.4·10 <sup>17</sup>   | 39.8         | 0.07   |
|           | X Desdemona    | 0.473651                  | 62.68                          | 0.0001       | 0.2°        | 1.8·10 <sup>17</sup>   | 32.0         | 0.07   |
|           | XI Juliet      | 0.493066                  | 64.35                          | 0.0007       | 0.1°        | 5.6·10 <sup>17</sup>   | 46.8         | 0.07   |
|           | XII Portia     | 0.513196                  | 66.09                          | 0.0001       | 0.1°        | 1.7·10 <sup>18</sup>   | 67.6         | 0.07   |
|           | XIII Rosalind  | 0.558459                  | 69.94                          | 0.0001       | 0.3°        | 2.6·10 <sup>17</sup>   | 36.0         | 0.07   |
|           | XIV Belinda    | 0.623525                  | 75.26                          | 0.0001       | 0.0°        | 3.6·10 <sup>17</sup>   | 40.3         | 0.07   |
|           | XV Puck        | 0.761832                  | 86.01                          | 0.0001       | 0.31°       | 2.9·10 <sup>18</sup>   | 81.0         | 0.07   |
|           | XVI Caliban    | 579.73                    | 7231                           | 0.1587       |             | 7.4·10 <sup>17</sup>   | 49           | 0.07   |
|           | XVII Sycorax   | 1288.30                   | 12179                          | 0.5224       |             | 5.4·10 <sup>18</sup>   | 95           | 0.07   |
|           | XVIII Prospero | 1978.29                   | 16256                          | 0.4448       |             | 2.1·10 <sup>16</sup>   | 15           | 0.07   |
|           | XIX Setebos    | 2225.21                   | 17418                          | 0.5914       |             | 2.1·10 <sup>16</sup>   | 15           | 0.07   |
|           | XX Stephano    | 677.36                    | 8004                           | 0.2292       |             | 6.0·10 <sup>15</sup>   | 10           | 0.07   |
|           | XXI Trinculo   | 749.24                    | 8504                           | 0.2200       |             | 7.5·10 <sup>14</sup>   | 5            | 0.04   |
|           | XXII Francisco | 266.56                    | 4276                           | 0.146        |             | 1.3·10 <sup>15</sup>   | 11           |        |
|           | XXIII Margaret | 1687.01                   | 14345                          | 0.661        |             | 1.0·10 <sup>15</sup>   | 5.5          |        |
|           | XXIV Ferdinand | 2887.21                   | 20901                          | 0.368        |             | 1.3·10 <sup>15</sup>   | 6            |        |
|           | XXV Perdita    | 0.638                     | 76.42                          | 0.0          |             | 4.0·10 <sup>17</sup>   | 40           |        |
|           | XXVI Mab       | 0.923                     | 97.73                          | 0.0          |             | 4.0·10 <sup>15</sup>   | 8            |        |
|           | XXVII Cupid    | 0.613                     | 74.8                           | 0.0          |             | 1.2·10 <sup>15</sup>   | 6            |        |
| Neptune   | I Triton       | 5.8768541 R               | 354.76                         | 0.000016     | 157.345°    | 2.147·10 <sup>22</sup> | 1353.4       | 0.76   |
|           | II Nereid      | 360.13619                 | 5513.4                         | 0.7512       | 27.6°       | 3.1·10 <sup>19</sup>   | 170          | 0.15   |
|           | III Naiad      | 0.294396                  | 48.227                         | 0.0003       | 4.74°       | 1.3·10 <sup>17</sup>   | 33           | 0.07   |
|           | IV Thalassa    | 0.311485                  | 50.075                         | 0.0002       | 0.21°       | 3.5·10 <sup>17</sup>   | 41           | 0.09   |
|           | V Despina      | 0.334655                  | 52.526                         | 0.0001       | 0.07°       | 2.3·10 <sup>18</sup>   | 75           | 0.09   |
|           | VI Galatea     | 0.428745                  | 61.953                         | 0.0001       | 0.05°       | 2.7·10 <sup>18</sup>   | 88           | 0.08   |
|           | VII Larissa    | 0.554654                  | 73.548                         | 0.0014       | 0.20°       | 4.8·10 <sup>18</sup>   | 104×89       | 0.09   |
|           | VIII Proteus   | 1.122315                  | 117.647                        | 0.0004       | 0.55°       | 4.9·10 <sup>19</sup>   | 218×208×201  | 0.10   |
|           | IX Halimede    | 1879.08                   | 16611                          | 0.2646       |             |                        |              |        |
|           | X Psamathe     | 9074.30                   | 48096                          | 0.3809       |             | 1.5·10 <sup>16</sup>   | 14           |        |
|           | XI Sao         | 2912.72                   | 22228                          | 0.1365       |             |                        |              |        |
|           | XII Laomedeia  | 3171.33                   | 23567                          | 0.3969       |             |                        |              |        |
|           | XIII Neso      | 9740.73                   | 49285                          | 0.5714       |             |                        |              |        |
| Plutoids* |                |                           |                                |              |             |                        |              |        |
| Pluto     | I Charon       | 6.387                     | 17.536                         | 0.0022       | 99°         | 1.6·10 <sup>21</sup>   | 593          | 0.37   |
|           | II Nix         | 24.86                     | 48.708                         | 0.0030       |             | 5·10 <sup>16</sup>     | 22–65        |        |
|           | III Hydra      | 38.20                     | 64.749                         | 0.0051       |             | 5·10 <sup>16</sup>     | 22–65        |        |
| Eris      | I Dysnomia     |                           | 30                             |              |             |                        | 100–200      |        |

\* In June 2008 the International Astronomical Union decided on the name *plutoid* for the category of transneptunian dwarf planets. Plutoids are celestial bodies in orbit around the sun at a semimajor axis greater than that of Neptune and sufficiently massive to adopt a near-spherical shape. See <[www.iau.org/public\\_press/news/release/iau0804/](http://www.iau.org/public_press/news/release/iau0804/)>.

# MASS, DIMENSIONS, AND OTHER PARAMETERS OF THE EARTH

This table is a collection of data on various properties of the Earth. Most of the values are given in SI units. Note that 1 ua (astronomical unit) = 149,597,870 km.

## References

1. Seidelmann, P. K., Ed., *Explanatory Supplement to the Astronomical Almanac*, University Science Books, Mill Valley, CA, 1992.
2. Lang, K. R., *Astrophysical Data: Planets and Stars*, Springer-Verlag, New York, 1992.

| Quantity                                                                                                        | Symbol                  | Value                            | Unit                  |
|-----------------------------------------------------------------------------------------------------------------|-------------------------|----------------------------------|-----------------------|
| Mass                                                                                                            | $M$                     | $5.9723 \cdot 10^{27}$           | g                     |
| Major orbital semi-axis                                                                                         | $a_{\text{orb}}$        | 1.000000                         | ua                    |
|                                                                                                                 |                         | $1.4959787 \cdot 10^8$           | km                    |
| Distance from sun at perihelion                                                                                 | $r_{\pi}$               | 0.9833                           | ua                    |
| Distance from sun at aphelion                                                                                   | $r_{\alpha}$            | 1.0167                           | ua                    |
| Moment of perihelion passage                                                                                    | $T_{\pi}$               | Jan. 2, 4 h 52 min               |                       |
| Moment of aphelion passage                                                                                      | $T_{\alpha}$            | July 4, 5 h 05 min               |                       |
| Siderial rotation period around sun                                                                             | $P_{\text{orb}}$        | $31.5581 \cdot 10^6$             | s                     |
|                                                                                                                 |                         | 365.25636                        | d                     |
| Mean rotational velocity                                                                                        | $U_{\text{orb}}$        | 29.78                            | km/s                  |
| Mean equatorial radius                                                                                          | $\bar{a}$               | 6378.140                         | km                    |
| Mean polar compression (flattening factor)                                                                      | $\alpha$                | 1/298.257                        |                       |
| Difference in equatorial and polar semi-axes                                                                    | $a - c$                 | 21.385                           | km                    |
| Compression of meridian of major equatorial axis                                                                | $\alpha_a$              | 1/295.2                          |                       |
| Compression of meridian of minor equatorial axis                                                                | $\alpha_b$              | 1/298.0                          |                       |
| Equatorial compression                                                                                          | $\epsilon$              | 1/30 000                         |                       |
| Difference in equatorial semi-axes                                                                              | $a - b$                 | 213                              | m                     |
| Difference in polar semi-axes                                                                                   | $c_N - c_S$             | ~70                              | m                     |
| Polar asymmetry                                                                                                 | $\eta$                  | $\sim 1 \cdot 10^{-5}$           |                       |
| Mean acceleration of gravity at equator                                                                         | $g_e$                   | 9.78036                          | m/s <sup>2</sup>      |
| Mean acceleration of gravity at poles                                                                           | $g_p$                   | 9.83208                          | m/s <sup>2</sup>      |
| Difference in acceleration of gravity at pole and at equator                                                    | $g_p - g_e$             | 5.172                            | cm/s <sup>2</sup>     |
| Mean acceleration of gravity for entire surface of terrestrial ellipsoid                                        | $g$                     | 9.7978                           | m/s <sup>2</sup>      |
| Mean radius                                                                                                     | $R$                     | 6371.0                           | km                    |
| Area of surface                                                                                                 | $S$                     | $5.10 \cdot 10^8$                | km <sup>2</sup>       |
| Volume                                                                                                          | $V$                     | $1.0832 \cdot 10^{12}$           | km <sup>3</sup>       |
| Mean density                                                                                                    | $\rho$                  | 5.515                            | g/cm <sup>3</sup>     |
| Siderial rotational period                                                                                      | $P$                     | 86,164.09                        | s                     |
| Rotational angular velocity                                                                                     | $\omega$                | $7.292116 \cdot 10^{-5}$         | rad/s                 |
| Mean equatorial rotational velocity                                                                             | $v$                     | 0.46512                          | km/s                  |
| Rotational angular momentum                                                                                     | $L$                     | $5.861 \cdot 10^{33}$            | J s                   |
| Rotational energy                                                                                               | $E$                     | $2.137 \cdot 10^{29}$            | J                     |
| Ratio of centrifugal force to force of gravity at equator                                                       | $q_c$                   | $0.0034677 = 1/288$              |                       |
| Moment of inertia                                                                                               | $I$                     | $8.070 \cdot 10^{37}$            | kg m <sup>2</sup>     |
| Relative braking of earth's rotation due to tidal friction                                                      | $\Delta\omega_e/\omega$ | $-4.2 \cdot 10^{-8}$             | century <sup>-1</sup> |
| Relative secular acceleration of earth's rotation                                                               | $\Delta\omega_l/\omega$ | $+1.4 \cdot 10^{-8}$             | century <sup>-1</sup> |
| Not secular braking of earth's rotation                                                                         | $\Delta\omega/\omega$   | $-2.8 \cdot 10^{-8}$             | century <sup>-1</sup> |
| Probable value of total energy of tectonic deformation of earth                                                 | $E_t$                   | $\sim 1 \cdot 10^{23}$           | J/century             |
| Secular loss of heat of earth through radiation into space                                                      | $\Delta E_k$            | $1 \cdot 10^{23}$                | J/century             |
| Portion of earth's kinetic energy transformed into heat as a result of lunar and solar tides in the hydrosphere | $\Delta''E_k$           | $1.3 \cdot 10^{23}$              | J/century             |
| Differences in duration of days in March and August                                                             | $\Delta P$              | 0.0025 (March-August)            | s                     |
| Corresponding relative annual variation in earth's rotational velocity                                          | $\Delta^*\omega/\omega$ | $2.9 \cdot 10^{-8}$ (Aug.-March) |                       |
| Presumed variation in earth's radius between August and March                                                   | $\Delta^*R$             | -9.2 (Aug.-March)                | cm                    |
| Annual variation in level of world ocean                                                                        | $\Delta h_o$            | ~10 (Sept.-March)                | cm                    |
| Area of continents                                                                                              | $S_c$                   | $1.49 \cdot 10^8$                | km <sup>2</sup>       |
|                                                                                                                 |                         | 29.2                             | % of surface          |

| Quantity                                                                           | Symbol                | Value                 | Unit                   |
|------------------------------------------------------------------------------------|-----------------------|-----------------------|------------------------|
| Area of world ocean                                                                | $S_o$                 | $3.61 \cdot 10^8$     | $\text{km}^2$          |
| Mean height of continents above sea level                                          | $h_c$                 | 70.8                  | % of surface           |
| Mean depth of world ocean                                                          | $h_o$                 | 875                   | m                      |
| Mean thickness of lithosphere within the limits of the continents                  | $h_{c.l.}$            | 3794                  | m                      |
| Mean thickness of lithosphere within the limits of the ocean                       | $h_{o.l.}$            | 35                    | km                     |
| Mean rate of thickening of continental lithosphere                                 | $\Delta h / \Delta t$ | 4.7                   | km                     |
| Mean rate of horizontal extension of continental lithosphere                       | $\Delta l / \Delta t$ | 10 – 40               | m/ $10^6$ y            |
| Mass of crust                                                                      | $m_l$                 | 0.75 – 20             | km/ $10^6$ y           |
| Mass of mantle                                                                     |                       | $2.36 \cdot 10^{22}$  | kg                     |
| Amount of water released from the mantle and core in the course of geological time |                       | $4.05 \cdot 10^{24}$  | kg                     |
| Total reserve of water in the mantle                                               |                       | $3.40 \cdot 10^{21}$  | kg                     |
| Present content of free and bound water in the earth's lithosphere                 |                       | $2 \cdot 10^{23}$     | kg                     |
| Mass of hydrosphere                                                                | $m_h$                 | $2.4 \cdot 10^{21}$   | kg                     |
| Amount of oxygen bound in the earth's crust                                        |                       | $1.664 \cdot 10^{21}$ | kg                     |
| Amount of free oxygen                                                              |                       | $1.300 \cdot 10^{21}$ | kg                     |
| Mass of atmosphere                                                                 | $m_a$                 | $1.5 \cdot 10^{18}$   | kg                     |
| Mass of biosphere                                                                  | $m_b$                 | $5.136 \cdot 10^{18}$ | kg                     |
| Mass of living matter in the biosphere                                             |                       | $1.148 \cdot 10^{16}$ | kg                     |
| Density of living matter on dry land                                               |                       | $3.6 \cdot 10^{14}$   | kg                     |
| Density of living matter in ocean                                                  |                       | 0.1                   | $\text{g}/\text{cm}^2$ |
| Age of the earth                                                                   |                       | $15 \cdot 10^{-8}$    | $\text{g}/\text{cm}^3$ |
| Age of oldest rocks                                                                |                       | $4.55 \cdot 10^9$     | y                      |
| Age of most ancient fossils                                                        |                       | $4.0 \cdot 10^9$      | y                      |
|                                                                                    |                       | $3.4 \cdot 10^9$      | y                      |

## GEOLOGICAL TIME SCALE

| Period or epoch                | Beginning and end, in 10 <sup>6</sup> years | Key events                          |
|--------------------------------|---------------------------------------------|-------------------------------------|
| <b><i>Cenozoic era</i></b>     |                                             |                                     |
| Quaternian                     |                                             |                                     |
| Contemporary                   | 0–10,000 y ± 2,000 y                        |                                     |
| Pleistocene                    | 10,000–1,000,000 y ± 50,000 y               | Homo Erectus breakout               |
| Tertiary                       |                                             |                                     |
| Pliocene                       | 1.8–5.3                                     | Ape man fossils                     |
| Miocene                        | 5–25                                        | Origin of grass                     |
| Oligocene                      | 25–37                                       | Rise of cats, dogs, pigs            |
| Eocene                         | 37–55                                       | Debut of hoofed mammals             |
| Paleocene                      | 55–67                                       | Earliest primates                   |
| <b><i>Mesozoic era</i></b>     |                                             |                                     |
| Cretaceous                     | 67–138                                      | Demise of dinosaurs                 |
| Jurassic                       | 138–208                                     | First birds                         |
| Triassic                       | 208–245                                     | Appearance of dinosaurs             |
| <b><i>Paleozoic era</i></b>    |                                             |                                     |
| Permian                        | 245–290                                     | Flowers, insect pollination         |
| Carboniferous                  | 290–360                                     | First conifers                      |
| Devonian                       | 360–410                                     | First vertebrates ashore            |
| Silurian                       | 410–435                                     | Spore-bearing plants                |
| Ordovician                     | 435–520                                     | First animals ashore                |
| Cambrian                       | 520–570                                     | Vertebrates appear                  |
| <b><i>Pre-Cambrian</i></b>     |                                             |                                     |
| Pre-Cambrian III (Proterozoic) | 570–2500                                    | First plants, jellyfish             |
| Pre-Cambrian II (Archean)      | 2500–3800                                   | Photosynthetic bacteria             |
| Pre-Cambrian I (Hadean)        | 3800–4450                                   | Earth formed 4600 million years ago |

Reference: Calder, N., *Timescale - An Atlas of the Fourth Dimension*, Viking Press, New York, 1983.

## ACCELERATION DUE TO GRAVITY

The acceleration due to gravity is tabulated here as a function of latitude and height above the earth's surface. Values were calculated from the expression

$$g/(\text{m/s}^2) = 9.780356 (1 + 0.0052885 \sin^2 \phi - 0.0000059 \sin^2 2 \phi) - 0.003086 H$$

where  $\phi$  is the latitude and  $H$  is the height in kilometers.

## Reference

Jursa, A. S., Ed., *Handbook of Geophysics and the Space Environment*, 4th ed., Air Force Geophysics Laboratory, 1985, p. 14–17.

| $\phi$ | $H = 0$ | $H = 1 \text{ km}$ | $H = 5 \text{ km}$ | $H = 10 \text{ km}$ |
|--------|---------|--------------------|--------------------|---------------------|
| 0      | 9.78036 | 9.77727            | 9.76493            | 9.74950             |
| 5      | 9.78075 | 9.77766            | 9.76532            | 9.74989             |
| 10     | 9.78191 | 9.77882            | 9.76648            | 9.75105             |
| 15     | 9.78381 | 9.78072            | 9.76838            | 9.75295             |
| 20     | 9.78638 | 9.78330            | 9.77095            | 9.75552             |
| 25     | 9.78956 | 9.78647            | 9.77413            | 9.75870             |
| 30     | 9.79324 | 9.79016            | 9.77781            | 9.76238             |
| 35     | 9.79732 | 9.79424            | 9.78189            | 9.76646             |
| 40     | 9.80167 | 9.79858            | 9.78624            | 9.77081             |
| 45     | 9.80616 | 9.80307            | 9.79073            | 9.77530             |
| 50     | 9.81065 | 9.80757            | 9.79522            | 9.77979             |
| 55     | 9.81501 | 9.81193            | 9.79958            | 9.78415             |
| 60     | 9.81911 | 9.81602            | 9.80368            | 9.78825             |
| 65     | 9.82281 | 9.81972            | 9.80738            | 9.79195             |
| 70     | 9.82601 | 9.82292            | 9.81058            | 9.79515             |
| 75     | 9.82860 | 9.82551            | 9.81317            | 9.79774             |
| 80     | 9.83051 | 9.82743            | 9.81508            | 9.79965             |
| 85     | 9.83168 | 9.82860            | 9.81625            | 9.80082             |
| 90     | 9.83208 | 9.82899            | 9.81665            | 9.80122             |

# DENSITY, PRESSURE, AND GRAVITY AS A FUNCTION OF DEPTH WITHIN THE EARTH

This table gives the density  $\rho$ , pressure  $p$ , and acceleration due to gravity  $g$  as a function of depth below the earth's surface, as calculated from the model of the structure of the earth in Reference 1. The model assumes a radius of 6371 km for the earth. The boundary between the crust and mantle (the Mohorovicic discontinuity) is taken as 21 km, while in reality it varies considerable with location.

## References

1. Anderson, D. L., and Hart, R. S., *J. Geophys. Res.*, 81, 1461, 1976.
2. Carmichael, R. S., *CRC Practical Handbook of Physical Properties of Rocks and Minerals*, p. 467, CRC Press, Boca Raton, FL, 1989.

| Depth<br>km           | $\rho$<br>g/cm <sup>3</sup> | $p$<br>kbar | $g$<br>cm/s <sup>2</sup> | Depth<br>km                | $\rho$<br>g/cm <sup>3</sup> | $p$<br>kbar | $g$<br>cm/s <sup>2</sup> |
|-----------------------|-----------------------------|-------------|--------------------------|----------------------------|-----------------------------|-------------|--------------------------|
| <i>Crust</i>          |                             |             |                          | 1771                       | 4.96                        | 752         | 994                      |
| 0                     | 1.02                        | 0           | 981                      | 2071                       | 5.12                        | 903         | 1002                     |
| 3                     | 1.02                        | 3           | 982                      | 2371                       | 5.31                        | 1061        | 1017                     |
| 3                     | 2.80                        | 3           | 982                      | 2671                       | 5.45                        | 1227        | 1042                     |
| 21                    | 2.80                        | 5           | 983                      | 2886                       | 5.53                        | 1352        | 1069                     |
| <i>Mantle (solid)</i> |                             |             |                          | <i>Outer core (liquid)</i> |                             |             |                          |
| 21                    | 3.49                        | 5           | 983                      | 2886                       | 9.96                        | 1352        | 1069                     |
| 41                    | 3.51                        | 12          | 983                      | 2971                       | 10.09                       | 1442        | 1050                     |
| 61                    | 3.52                        | 19          | 984                      | 3371                       | 10.63                       | 1858        | 953                      |
| 81                    | 3.48                        | 26          | 984                      | 3671                       | 11.00                       | 2154        | 874                      |
| 101                   | 3.44                        | 33          | 984                      | 4071                       | 11.36                       | 2520        | 760                      |
| 121                   | 3.40                        | 39          | 985                      | 4471                       | 11.69                       | 2844        | 641                      |
| 171                   | 3.37                        | 56          | 987                      | 4871                       | 11.99                       | 3116        | 517                      |
| 221                   | 3.34                        | 73          | 989                      | 5156                       | 12.12                       | 3281        | 427                      |
| 271                   | 3.37                        | 89          | 991                      | <i>Inner core (solid)</i>  |                             |             |                          |
| 321                   | 3.47                        | 106         | 993                      | 5156                       | 12.30                       | 3281        | 427                      |
| 371                   | 3.59                        | 124         | 994                      | 5371                       | 12.48                       | 3385        | 355                      |
| 571                   | 3.95                        | 199         | 999                      | 5771                       | 12.52                       | 3529        | 218                      |
| 871                   | 4.54                        | 328         | 997                      | 6071                       | 12.53                       | 3592        | 122                      |
| 1171                  | 4.67                        | 466         | 992                      | 6371                       | 12.58                       | 3617        | 0                        |
| 1471                  | 4.81                        | 607         | 991                      |                            |                             |             |                          |



## OCEAN PRESSURE AS A FUNCTION OF DEPTH AND LATITUDE

The following table is based upon an ocean model which takes into account the equation of state of standard seawater and the dependence on latitude of the acceleration of gravity. The tabulated pressure value is the excess pressure over the ambient atmospheric pressure at the surface.

### References

1. *International Oceanographic Tables, Volume 4*, Unesco Technical Papers in Marine Science No. 40, Unesco, Paris, 1987.
2. Saunders, P. M., and Fofonoff, N. P., *Deep-Sea Res.* 23, 109–111, 1976.

| Depth<br>(meters) | Pressure in MPa at the Specified Latitude |          |          |          |          |          |          |
|-------------------|-------------------------------------------|----------|----------|----------|----------|----------|----------|
|                   | 0°                                        | 15°      | 30°      | 45°      | 60°      | 75°      | 90°      |
| 0                 | 0.0000                                    | 0.0000   | 0.0000   | 0.0000   | 0.0000   | 0.0000   | 0.0000   |
| 500               | 5.0338                                    | 5.0355   | 5.0404   | 5.0471   | 5.0537   | 5.0586   | 5.0605   |
| 1000              | 10.0796                                   | 10.0832  | 10.0930  | 10.1064  | 10.1198  | 10.1296  | 10.1333  |
| 1500              | 15.1376                                   | 15.1431  | 15.1577  | 15.1778  | 15.1980  | 15.2127  | 15.2182  |
| 2000              | 20.2076                                   | 20.2148  | 20.2344  | 20.2613  | 20.2882  | 20.3080  | 20.3153  |
| 2500              | 25.2895                                   | 25.2985  | 25.3231  | 25.3568  | 25.3905  | 25.4153  | 25.4244  |
| 3000              | 30.3831                                   | 30.3940  | 30.4236  | 30.4641  | 30.5047  | 30.5345  | 30.5453  |
| 3500              | 35.4886                                   | 35.5012  | 35.5358  | 35.5832  | 35.6307  | 35.6654  | 35.6782  |
| 4000              | 40.6056                                   | 40.6201  | 40.6598  | 40.7140  | 40.7683  | 40.8082  | 40.8229  |
| 4500              | 45.7342                                   | 45.7505  | 45.7952  | 45.8564  | 45.9176  | 45.9626  | 45.9791  |
| 5000              | 50.8742                                   | 50.8924  | 50.9421  | 51.0102  | 51.0785  | 51.1285  | 51.1469  |
| 5500              | 56.0255                                   | 56.0456  | 56.1004  | 56.1755  | 56.2508  | 56.3059  | 56.3262  |
| 6000              | 61.1882                                   | 61.2100  | 61.2700  | 61.3521  | 61.4344  | 61.4947  | 61.5168  |
| 6500              | 66.3619                                   | 66.3857  | 66.4508  | 66.5399  | 66.6292  | 66.6947  | 66.7187  |
| 7000              | 71.5467                                   | 71.5724  | 71.6427  | 71.7388  | 71.8352  | 71.9059  | 71.9318  |
| 7500              | 76.7426                                   | 76.7701  | 76.8456  | 76.9488  | 77.0523  | 77.1282  | 77.1560  |
| 8000              | 81.9493                                   | 81.9788  | 82.0594  | 82.1697  | 82.2804  | 82.3614  | 82.3911  |
| 8500              | 87.1669                                   | 87.1983  | 87.2841  | 87.4016  | 87.5193  | 87.6057  | 87.6373  |
| 9000              | 92.3950                                   | 92.4284  | 92.5194  | 92.6440  | 92.7689  | 92.8606  | 92.8941  |
| 9500              | 97.6346                                   | 97.6698  | 97.7661  | 97.8978  | 98.0300  | 98.1269  | 98.1624  |
| 10000             | 102.8800                                  | 102.9170 | 103.0185 | 103.1572 | 103.2961 | 103.3981 | 103.4355 |

## PROPERTIES OF SEAWATER

In addition to the dependence on temperature and pressure, the physical properties of seawater vary with the concentration of the dissolved constituents. A convenient parameter for describing the composition is the salinity,  $S$ , which is defined in terms of the electrical conductivity of the seawater sample. The defining equation for the practical salinity is:

$$S = a_0 + a_1 K^{1/2} + a_2 K + a_3 K^{3/2} + a_4 K^2 + a_5 K^{5/2},$$

where  $K$  is the ratio of the conductivity of the seawater sample at 15°C and atmospheric pressure to the conductivity of a potassium chloride solution in which the mass fraction of KCl is 0.0324356, at the same temperature and pressure. The values of the coefficients are:

$$\begin{aligned} a_0 &= 0.0080 & a_3 &= 14.0941 \\ a_1 &= -0.1692 & a_4 &= -7.0261 \\ a_2 &= 25.3851 & a_5 &= 2.7081 \\ \Sigma a_i &= 35.0000 \end{aligned}$$

Thus when  $K = 1$ ,  $S = 35$  exactly ( $S$  is normally quoted in units of ‰, i.e., parts per thousand). The value of  $S$  can be roughly equated with the mass of dissolved material in grams per kilogram of seawater. Salinity values in the open oceans at mid latitudes typically fall between 34 and 36.

It is customary in oceanography to define the pressure at a given point as the pressure due to the column of water between that point and the surface. Thus by convention  $P = 0$  at the sea surface. To a good approximation the pressure in decibars (dbar) can be equated to the depth in meters. Thus at 45° latitude the pressure is 5000 dbar at 4902 m, 10000 dbar at 9700 m.

The first table below gives several properties of seawater as a function of temperature for a salinity of 35. The second and third give density and electrical conductivity as a function of salinity at several temperatures, and the fourth lists typical concentrations of the main constituents of seawater as a function of salinity. The final table gives the freezing point as a function of salinity and pressure.

## References

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2. Kennish, M. J., *CRC Practical Handbook of Marine Science*, CRC Press, Boca Raton, FL, 1989.
3. Poisson, A. *IEEE J. Ocean. Eng.* OE-5, 50, 1981.
4. Webster, F., in *AIP Physics Desk Reference*, E. R. Cohen, D. R. Lide and G. L. Trigg, Eds., Springer-Verlag, New York, 2003.

## Properties of Seawater as a Function of Temperature at Salinity $S = 35$ and Normal Atmospheric Pressure

$\rho$  = density in g/cm<sup>3</sup>

$\beta = (1/\rho) (d\rho/dS)$  = fractional change in density per unit change in salinity

$\alpha = -(1/\rho) (d\rho/dt)$  = fractional change in density per unit change in temperature (°C<sup>-1</sup>)

$\kappa$  = electrical conductivity in S/cm

$\eta$  = viscosity in mPa s (equal to cP)

$c_p$  = specific heat in J/kg °C

$\nu$  = speed of sound in m/s

| $t/^\circ\text{C}$ | $\rho/\text{g cm}^{-3}$ | $10^3\beta$ | $10^7\alpha/^\circ\text{C}^{-1}$ | $\kappa/\text{S cm}^{-1}$ | $\eta/\text{mPa s}$ | $c_p/\text{J kg}^{-1}^\circ\text{C}^{-1}$ | $\nu/\text{m s}^{-1}$ |
|--------------------|-------------------------|-------------|----------------------------------|---------------------------|---------------------|-------------------------------------------|-----------------------|
| 0                  | 1.028106                | 7854        | 526                              | 0.029048                  | 1.892               | 3986.5                                    | 1449.1                |
| 5                  | 1.027675                | 7717        | 1136                             | 0.033468                  | 1.610               |                                           |                       |
| 10                 | 1.026952                | 7606        | 1668                             | 0.038103                  | 1.388               | 3986.3                                    | 1489.8                |
| 15                 | 1.025973                | 7516        | 2141                             | 0.042933                  | 1.221               |                                           |                       |
| 20                 | 1.024763                | 7444        | 2572                             | 0.047934                  | 1.085               | 3993.9                                    | 1521.5                |
| 25                 | 1.023343                | 7385        | 2970                             | 0.053088                  | 0.966               |                                           |                       |
| 30                 | 1.021729                | 7338        | 3341                             | 0.058373                  | 0.871               | 4000.7                                    | 1545.6                |
| 35                 | 1.019934                | 7300        | 3687                             |                           |                     |                                           |                       |
| 40                 |                         | 7270        | 4004                             |                           |                     | 4003.5                                    | 1563.2                |

## Density of Surface Seawater in g/cm<sup>3</sup> as a Function of Temperature and Salinity

| $t/^\circ\text{C}$ | $S = 0$  | $S = 5$  | $S = 10$ | $S = 15$ | $S = 20$ | $S = 25$ | $S = 30$ | $S = 35$ | $S = 40$ |
|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 0.999843 | 1.003913 | 1.007955 | 1.011986 | 1.016014 | 1.020041 | 1.024072 | 1.028106 | 1.032147 |
| 5                  | 0.999967 | 1.003949 | 1.007907 | 1.011858 | 1.015807 | 1.019758 | 1.023714 | 1.027675 | 1.031645 |
| 10                 | 0.999702 | 1.003612 | 1.007501 | 1.011385 | 1.015269 | 1.019157 | 1.023051 | 1.026952 | 1.030862 |
| 15                 | 0.999102 | 1.002952 | 1.006784 | 1.010613 | 1.014443 | 1.018279 | 1.022122 | 1.025973 | 1.029834 |
| 20                 | 0.998206 | 1.002008 | 1.005793 | 1.009576 | 1.013362 | 1.017154 | 1.020954 | 1.024763 | 1.028583 |
| 25                 | 0.997048 | 1.000809 | 1.004556 | 1.008301 | 1.012050 | 1.015806 | 1.019569 | 1.023343 | 1.027128 |
| 30                 | 0.995651 | 0.999380 | 1.003095 | 1.006809 | 1.010527 | 1.014252 | 1.017985 | 1.021729 | 1.025483 |
| 35                 | 0.994036 | 0.997740 | 1.001429 | 1.005118 | 1.008810 | 1.012509 | 1.016217 | 1.019934 | 1.023662 |
| 40                 | 0.992220 | 0.995906 | 0.999575 | 1.003244 | 1.006915 | 1.010593 | 1.014278 | 1.017973 | 1.021679 |

**Electrical Conductivity of Seawater in S/cm as a Function of Temperature and Salinity**

| <i>t</i> /°C | <i>S</i> = 5 | <i>S</i> = 10 | <i>S</i> = 15 | <i>S</i> = 20 | <i>S</i> = 25 | <i>S</i> = 30 | <i>S</i> = 35 | <i>S</i> = 40 |
|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 0            | 0.004808     | 0.009171      | 0.013357      | 0.017421      | 0.021385      | 0.025257      | 0.029048      | 0.032775      |
| 5            | 0.005570     | 0.010616      | 0.015441      | 0.020118      | 0.024674      | 0.029120      | 0.033468      | 0.037734      |
| 10           | 0.006370     | 0.012131      | 0.017627      | 0.022947      | 0.028123      | 0.033171      | 0.038103      | 0.042935      |
| 15           | 0.007204     | 0.013709      | 0.019905      | 0.025894      | 0.031716      | 0.037391      | 0.042933      | 0.048355      |
| 20           | 0.008068     | 0.015346      | 0.022267      | 0.028948      | 0.035438      | 0.041762      | 0.047934      | 0.053968      |
| 25           | 0.008960     | 0.017035      | 0.024703      | 0.032097      | 0.039276      | 0.046267      | 0.053088      | 0.059751      |
| 30           | 0.009877     | 0.018771      | 0.027204      | 0.035330      | 0.043213      | 0.050888      | 0.058373      | 0.065683      |

**Composition of Seawater and Ionic Strength at Various Salinities (Ref. 2)**

| Constituent                     | Expressed as molality |               |               | As grams per kilogram of seawater |               |               |
|---------------------------------|-----------------------|---------------|---------------|-----------------------------------|---------------|---------------|
|                                 | <i>S</i> = 30         | <i>S</i> = 35 | <i>S</i> = 40 | <i>S</i> = 30                     | <i>S</i> = 35 | <i>S</i> = 40 |
| Cl <sup>-</sup>                 | 0.482                 | 0.562         | 0.650         | 16.58                             | 19.33         | 22.36         |
| Br <sup>-</sup>                 | 0.00074               | 0.00087       | 0.00100       | 0.057                             | 0.067         | 0.078         |
| F <sup>-</sup>                  |                       | 0.00007       |               |                                   | 0.001         |               |
| SO <sub>4</sub> <sup>2-</sup>   | 0.0104                | 0.0114        | 0.0122        | 0.97                              | 1.06          | 1.14          |
| HCO <sub>3</sub> <sup>-</sup>   | 0.00131               | 0.00143       | 0.00100       | 0.078                             | 0.085         | 0.059         |
| NaSO <sub>4</sub> <sup>-</sup>  | 0.0085                | 0.0108        | 0.0139        | 0.98                              | 1.25          | 1.60          |
| KSO <sub>4</sub> <sup>-</sup>   | 0.00010               | 0.00012       | 0.00015       | 0.013                             | 0.016         | 0.020         |
| Na <sup>+</sup>                 | 0.405                 | 0.472         | 0.544         | 9.03                              | 10.53         | 12.13         |
| K <sup>+</sup>                  | 0.00892               | 0.01039       | 0.01200       | 0.338                             | 0.394         | 0.455         |
| Mg <sup>2+</sup>                | 0.0413                | 0.0483        | 0.0561        | 0.974                             | 1.139         | 1.323         |
| Ca <sup>2+</sup>                | 0.00131               | 0.00143       | 0.00154       | 0.051                             | 0.056         | 0.060         |
| Sr <sup>2+</sup>                | 0.00008               | 0.00009       | 0.00011       | 0.007                             | 0.008         | 0.009         |
| MgHCO <sub>3</sub> <sup>+</sup> | 0.00028               | 0.00036       | 0.00045       | 0.023                             | 0.030         | 0.037         |
| MgSO <sub>4</sub>               | 0.00498               | 0.00561       | 0.00614       | 0.582                             | 0.655         | 0.717         |
| CaSO <sub>4</sub>               | 0.00102               | 0.00115       | 0.00126       | 0.135                             | 0.152         | 0.166         |
| NaHCO <sub>3</sub>              | 0.00015               | 0.00020       | 0.00024       | 0.012                             | 0.016         | 0.020         |
| H <sub>3</sub> BO <sub>3</sub>  | 0.00032               | 0.00037       | 0.00042       | 0.019                             | 0.022         | 0.025         |
| Ionic strength                  | 0.5736                | 0.6675        | 0.7701        |                                   |               |               |

**Freezing Point of Seawater in °C as a Function of Salinity and Pressure**

| <i>P</i> /dbar | <i>S</i> = 0 | 5      | 10     | 15     | 20     | 25     | 30     | 35     | 40     |
|----------------|--------------|--------|--------|--------|--------|--------|--------|--------|--------|
| 0              | 0.000        | -0.274 | -0.542 | -0.812 | -1.083 | -1.358 | -1.638 | -1.922 | -2.212 |
| 50             | -0.038       | -0.311 | -0.580 | -0.849 | -1.121 | -1.396 | -1.676 | -1.960 | -2.250 |
| 100            | -0.075       | -0.349 | -0.618 | -0.887 | -1.159 | -1.434 | -1.713 | -1.998 | -2.287 |
| 500            | -0.377       | -0.650 | -0.919 | -1.188 | -1.460 | -1.735 | -2.014 | -2.299 | -2.589 |

## ABUNDANCE OF ELEMENTS IN THE EARTH'S CRUST AND IN THE SEA

This table gives the estimated abundance of the elements in the continental crust (in mg/kg, equivalent to parts per million by mass) and in seawater near the surface (in mg/L). Values represent the median of reported measurements. The concentrations of the less abundant elements may vary with location by several orders of magnitude.

### References

1. Carmichael, R. S., Ed., *CRC Practical Handbook of Physical Properties of Rocks and Minerals*, CRC Press, Boca Raton, FL, 1989.
2. Bodek, I., et al., *Environmental Inorganic Chemistry*, Pergamon Press, New York, 1988.
3. Ronov, A. B., and Yaroshevsky, A. A., "Earth's Crust Geochemistry", in *Encyclopedia of Geochemistry and Environmental Sciences*, Fairbridge, R. W., Ed., Van Nostrand, New York, 1969.

| Element | Abundance             |                      |
|---------|-----------------------|----------------------|
|         | Crust<br>mg/kg        | Sea<br>mg/L          |
| Ac      | $5.5 \times 10^{-10}$ |                      |
| Ag      | $7.5 \times 10^{-2}$  | $4 \times 10^{-5}$   |
| Al      | $8.23 \times 10^4$    | $2 \times 10^{-3}$   |
| Ar      | 3.5                   | $4.5 \times 10^{-1}$ |
| As      | 1.8                   | $3.7 \times 10^{-3}$ |
| Au      | $4 \times 10^{-3}$    | $4 \times 10^{-6}$   |
| B       | $1.0 \times 10^1$     | 4.44                 |
| Ba      | $4.25 \times 10^2$    | $1.3 \times 10^{-2}$ |
| Be      | 2.8                   | $5.6 \times 10^{-6}$ |
| Bi      | $8.5 \times 10^{-3}$  | $2 \times 10^{-5}$   |
| Br      | 2.4                   | $6.73 \times 10^1$   |
| C       | $2.00 \times 10^2$    | $2.8 \times 10^1$    |
| Ca      | $4.15 \times 10^4$    | $4.12 \times 10^2$   |
| Cd      | $1.5 \times 10^{-1}$  | $1.1 \times 10^{-4}$ |
| Ce      | $6.65 \times 10^1$    | $1.2 \times 10^{-6}$ |
| Cl      | $1.45 \times 10^2$    | $1.94 \times 10^4$   |
| Co      | $2.5 \times 10^1$     | $2 \times 10^{-5}$   |
| Cr      | $1.02 \times 10^2$    | $3 \times 10^{-4}$   |
| Cs      | 3                     | $3 \times 10^{-4}$   |
| Cu      | $6.0 \times 10^1$     | $2.5 \times 10^{-4}$ |
| Dy      | 5.2                   | $9.1 \times 10^{-7}$ |
| Er      | 3.5                   | $8.7 \times 10^{-7}$ |
| Eu      | 2.0                   | $1.3 \times 10^{-7}$ |
| F       | $5.85 \times 10^2$    | 1.3                  |
| Fe      | $5.63 \times 10^4$    | $2 \times 10^{-3}$   |
| Ga      | $1.9 \times 10^1$     | $3 \times 10^{-5}$   |
| Gd      | 6.2                   | $7 \times 10^{-7}$   |
| Ge      | 1.5                   | $5 \times 10^{-5}$   |
| H       | $1.40 \times 10^3$    | $1.08 \times 10^5$   |
| He      | $8 \times 10^{-3}$    | $7 \times 10^{-6}$   |
| Hf      | 3.0                   | $7 \times 10^{-6}$   |
| Hg      | $8.5 \times 10^{-2}$  | $3 \times 10^{-5}$   |
| Ho      | 1.3                   | $2.2 \times 10^{-7}$ |
| I       | $4.5 \times 10^{-1}$  | $6 \times 10^{-2}$   |
| In      | $2.5 \times 10^{-1}$  | $2 \times 10^{-2}$   |
| Ir      | $1 \times 10^{-3}$    |                      |
| K       | $2.09 \times 10^4$    | $3.99 \times 10^2$   |
| Kr      | $1 \times 10^{-4}$    | $2.1 \times 10^{-4}$ |
| La      | $3.9 \times 10^1$     | $3.4 \times 10^{-6}$ |
| Li      | $2.0 \times 10^1$     | $1.8 \times 10^{-1}$ |
| Lu      | $8 \times 10^{-1}$    | $1.5 \times 10^{-7}$ |
| Mg      | $2.33 \times 10^4$    | $1.29 \times 10^3$   |
| Mn      | $9.50 \times 10^2$    | $2 \times 10^{-4}$   |
| Mo      | 1.2                   | $1 \times 10^{-2}$   |

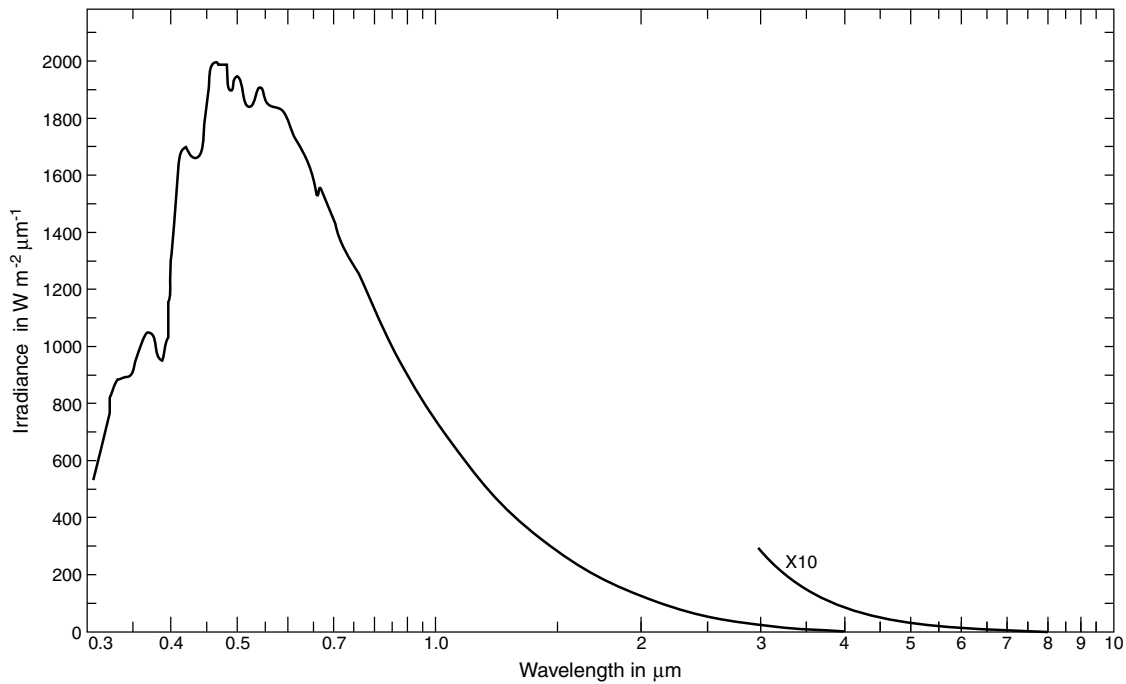
| Element | Abundance            |                       |
|---------|----------------------|-----------------------|
|         | Crust<br>mg/kg       | Sea<br>mg/L           |
| N       | $1.9 \times 10^1$    | $5 \times 10^{-1}$    |
| Na      | $2.36 \times 10^4$   | $1.08 \times 10^4$    |
| Nb      | $2.0 \times 10^1$    | $1 \times 10^{-5}$    |
| Nd      | $4.15 \times 10^1$   | $2.8 \times 10^{-6}$  |
| Ne      | $5 \times 10^{-3}$   | $1.2 \times 10^{-4}$  |
| Ni      | $8.4 \times 10^1$    | $5.6 \times 10^{-4}$  |
| O       | $4.61 \times 10^5$   | $8.57 \times 10^5$    |
| Os      | $1.5 \times 10^{-3}$ |                       |
| P       | $1.05 \times 10^3$   | $6 \times 10^{-2}$    |
| Pa      | $1.4 \times 10^{-6}$ | $5 \times 10^{-11}$   |
| Pb      | $1.4 \times 10^1$    | $3 \times 10^{-5}$    |
| Pd      | $1.5 \times 10^{-2}$ |                       |
| Po      | $2 \times 10^{-10}$  | $1.5 \times 10^{-14}$ |
| Pr      | 9.2                  | $6.4 \times 10^{-7}$  |
| Pt      | $5 \times 10^{-3}$   |                       |
| Ra      | $9 \times 10^{-7}$   | $8.9 \times 10^{-11}$ |
| Rb      | $9.0 \times 10^1$    | $1.2 \times 10^{-1}$  |
| Re      | $7 \times 10^{-4}$   | $4 \times 10^{-6}$    |
| Rh      | $1 \times 10^{-3}$   |                       |
| Rn      | $4 \times 10^{-13}$  | $6 \times 10^{-16}$   |
| Ru      | $1 \times 10^{-3}$   | $7 \times 10^{-7}$    |
| S       | $3.50 \times 10^2$   | $9.05 \times 10^2$    |
| Sb      | $2 \times 10^{-1}$   | $2.4 \times 10^{-4}$  |
| Sc      | $2.2 \times 10^1$    | $6 \times 10^{-7}$    |
| Se      | $5 \times 10^{-2}$   | $2 \times 10^{-4}$    |
| Si      | $2.82 \times 10^5$   | 2.2                   |
| Sm      | 7.05                 | $4.5 \times 10^{-7}$  |
| Sn      | 2.3                  | $4 \times 10^{-6}$    |
| Sr      | $3.70 \times 10^2$   | 7.9                   |
| Ta      | 2.0                  | $2 \times 10^{-6}$    |
| Tb      | 1.2                  | $1.4 \times 10^{-7}$  |
| Te      | $1 \times 10^{-3}$   |                       |
| Th      | 9.6                  | $1 \times 10^{-6}$    |
| Ti      | $5.65 \times 10^3$   | $1 \times 10^{-3}$    |
| Tl      | $8.5 \times 10^{-1}$ | $1.9 \times 10^{-5}$  |
| Tm      | $5.2 \times 10^{-1}$ | $1.7 \times 10^{-7}$  |
| U       | 2.7                  | $3.2 \times 10^{-3}$  |
| V       | $1.20 \times 10^2$   | $2.5 \times 10^{-3}$  |
| W       | 1.25                 | $1 \times 10^{-4}$    |
| Xe      | $3 \times 10^{-5}$   | $5 \times 10^{-5}$    |
| Y       | $3.3 \times 10^1$    | $1.3 \times 10^{-5}$  |
| Yb      | 3.2                  | $8.2 \times 10^{-7}$  |
| Zn      | $7.0 \times 10^1$    | $4.9 \times 10^{-3}$  |
| Zr      | $1.65 \times 10^2$   | $3 \times 10^{-5}$    |

## SOLAR SPECTRAL IRRADIANCE

The solar luminosity (total radiant power emitted) is  $3.86 \cdot 10^{26}$  W, of which  $1373 \text{ W/m}^2$  reaches the top of the earth's atmosphere. To a zeroth approximation the sun can be considered a black body with an effective temperature of 5780 K, which implies a peak in the radiation at around  $0.520 \text{ }\mu\text{m}$  ( $5200 \text{ }\text{\AA}$ ). The actual solar spectral emission is more complex, especially at ultraviolet and shorter wavelengths. The graph below, which was taken from Reference 1, summarizes the solar irradiance at the top of the atmosphere in the range 0.3 to  $10 \text{ }\mu\text{m}$ .

### References

1. Jursa, A. S., Ed., *Handbook of Geophysics and the Space Environment*, Air Force Geophysics Laboratory, 1985.
2. Pierce, A. K., and Allen, R. G., "The Solar Spectrum between 0.3 and  $10 \text{ }\mu\text{m}$ ", in *The Solar Output and Its Variation*, White, O. R., Ed., Colorado Associated University Press, Boulder, CO, 1977.
3. Lang, K. R., *Astrophysical Data. Planets and Stars*, Springer-Verlag, New York, 1992.



## U.S. STANDARD ATMOSPHERE (1976)

A Standard Atmosphere is a hypothetical vertical distribution of atmospheric temperature, pressure, and density that is roughly representative of year-round, midlatitude conditions. Typical uses are to serve as a basis for pressure altimeter calibrations, aircraft performance calculations, aircraft and rocket design, ballistic tables, meteorological diagrams, and various types of atmospheric modeling. The air is assumed to be dry and to obey the perfect gas law and the hydrostatic equation which, taken together, relate temperature, pressure, and density with vertical position. The atmosphere is considered to rotate with the Earth and to be an average over the diurnal cycle, the semiannual variation, and the range from active to quiet geomagnetic and sunspot conditions.

The U.S. Standard Atmosphere (1976) is an idealized, steady-state representation of mean annual conditions of the Earth's atmosphere from the surface to 1000 km at latitude 45° N, as it is assumed to exist during a period with moderate solar activity. The defining meteorological elements are sea-level temperature and pressure and a temperature-height profile to 1000 km. The 1976 Standard Atmosphere uses the following sea-level values that have been standard for many decades:

Temperature — 288.15 K (15 °C)  
Pressure — 101325 Pa (1013.25 mbar, 760 mm of Hg, or 29.92 in. of Hg)

Density — 1225 g/m<sup>3</sup> (1.225 g/L)  
Mean molar mass — 28.964 g/mol

The parameters included in this condensed version of the U.S. Standard Atmosphere are:

$Z$  — Height (geometric) above mean sea level in meters  
 $T$  — Temperature in kelvins  
 $P$  — Pressure in pascals (1 Pa = 0.01 millibars)  
 $\rho$  — Density in kilograms per cubic meter (1 kg/m<sup>3</sup> = 1 g/L)  
 $n$  — Number density in molecules per cubic meter  
 $\nu$  — Mean collision frequency in collisions per second  
 $l$  — Mean free path in meters  
 $\eta$  — Absolute viscosity in pascal seconds (1 Pa s = 1000 cP)  
 $k$  — Thermal conductivity in joules per meter second kelvin (W/m K)  
 $\nu_s$  — Speed of sound in meters per second  
 $g$  — Acceleration of gravity in meters per second square

The sea-level composition (percent by volume) is taken to be:

|                          |                          |
|--------------------------|--------------------------|
| N <sub>2</sub> — 78.084% | He — 0.000524            |
| O <sub>2</sub> — 20.9476 | Kr — 0.000114            |
| Ar — 0.934               | Xe — 0.0000087           |
| CO <sub>2</sub> — 0.0314 | CH <sub>4</sub> — 0.0002 |
| Ne — 0.001818            | H <sub>2</sub> — 0.00005 |

The  $T$  and  $P$  columns for the troposphere and lower stratosphere were generated from the following formulas:

|                                            | $T/K$                      | $P/\text{Pa}$                       |
|--------------------------------------------|----------------------------|-------------------------------------|
| $H \leq 11000 \text{ m}$                   | $288.15 - 0.0065 H$        | $101325(288.15/T)^{-5.25577}$       |
| $11000 \text{ m} < H \leq 20000 \text{ m}$ | 216.65                     | $22632 e^{-0.00015768832(H-11000)}$ |
| $20000 \text{ m} < H \leq 32000 \text{ m}$ | $216.65 + 0.0010(H-20000)$ | $5474.87(216.65/T)^{34.16319}$      |

where  $H = rZ/(r + Z)$  is the geopotential height in meters and  $r$  is the mean Earth radius at 45° N latitude, taken as 6356766 m. For altitudes up to 32 km,  $\rho = 0.003483677(P/T)$  in the units used here. Formulas for the other quantities may be found in the references.

## References

1. COESA, *U.S. Standard Atmosphere*, 1976, U.S. Government Printing Office, Washington, D.C., 1976.
2. Jursa, A. S., Ed., *Handbook of Geophysics and the Space Environment*, Air Force Geophysics Laboratory, 1985.

| Z/m   | T/K    | P/Pa      | $\rho/\text{kg m}^{-3}$ | $n/\text{m}^{-3}$ | $v/\text{s}^{-1}$ | $l/\text{m}$ | $\eta/\text{Pa s}$ | $W \text{ m}^{-1} \text{ K}^{-1}$ | $v_s/\text{m s}^{-1}$ | $g/\text{m s}^{-2}$ |
|-------|--------|-----------|-------------------------|-------------------|-------------------|--------------|--------------------|-----------------------------------|-----------------------|---------------------|
| -5000 | 320.68 | 1.778E+05 | 1.931                   | 4.015E+25         | 1.151E+10         | 4.208E-08    | 1.942E-05          | 0.02788                           | 359.0                 | 9.822               |
| -4500 | 317.42 | 1.685E+05 | 1.849                   | 3.845E+25         | 1.096E+10         | 4.395E-08    | 1.927E-05          | 0.02763                           | 357.2                 | 9.830               |
| -4000 | 314.17 | 1.596E+05 | 1.770                   | 3.680E+25         | 1.044E+10         | 4.592E-08    | 1.912E-05          | 0.02738                           | 355.3                 | 9.819               |
| -3500 | 310.91 | 1.511E+05 | 1.693                   | 3.520E+25         | 9.933E+09         | 4.800E-08    | 1.897E-05          | 0.02713                           | 353.5                 | 9.818               |
| -3000 | 307.66 | 1.430E+05 | 1.619                   | 3.366E+25         | 9.448E+09         | 5.019E-08    | 1.882E-05          | 0.02688                           | 351.6                 | 9.816               |
| -2500 | 304.41 | 1.352E+05 | 1.547                   | 3.217E+25         | 8.982E+09         | 5.252E-08    | 1.867E-05          | 0.02663                           | 349.8                 | 9.814               |
| -2000 | 301.15 | 1.278E+05 | 1.478                   | 3.102E+25         | 8.623E+09         | 5.447E-08    | 1.852E-05          | 0.02638                           | 347.9                 | 9.813               |
| -1500 | 297.90 | 1.207E+05 | 1.411                   | 2.935E+25         | 8.106E+09         | 5.757E-08    | 1.836E-05          | 0.02613                           | 346.0                 | 9.811               |
| -1000 | 294.65 | 1.139E+05 | 1.347                   | 2.801E+25         | 7.693E+09         | 6.032E-08    | 1.821E-05          | 0.02587                           | 344.1                 | 9.810               |
| -500  | 291.40 | 1.075E+05 | 1.285                   | 2.672E+25         | 7.298E+09         | 6.324E-08    | 1.805E-05          | 0.02562                           | 342.2                 | 9.808               |
| 0     | 288.15 | 1.013E+05 | 1.225                   | 2.547E+25         | 6.919E+09         | 6.633E-08    | 1.789E-05          | 0.02533                           | 340.3                 | 9.807               |
| 500   | 284.90 | 9.546E+04 | 1.167                   | 2.427E+25         | 6.556E+09         | 6.961E-08    | 1.774E-05          | 0.02511                           | 338.4                 | 9.805               |
| 1000  | 281.65 | 8.988E+04 | 1.112                   | 2.311E+25         | 6.208E+09         | 7.310E-08    | 1.758E-05          | 0.02485                           | 336.4                 | 9.804               |
| 1500  | 278.40 | 8.456E+04 | 1.058                   | 2.200E+25         | 5.874E+09         | 7.680E-08    | 1.742E-05          | 0.02459                           | 334.5                 | 9.802               |
| 2000  | 275.15 | 7.950E+04 | 1.007                   | 2.093E+25         | 5.555E+09         | 8.073E-08    | 1.726E-05          | 0.02433                           | 332.5                 | 9.801               |
| 2500  | 271.91 | 7.469E+04 | 0.957                   | 1.990E+25         | 5.250E+09         | 8.491E-08    | 1.710E-05          | 0.02407                           | 330.6                 | 9.799               |
| 3000  | 268.66 | 7.012E+04 | 0.909                   | 1.891E+25         | 4.959E+09         | 8.937E-08    | 1.694E-05          | 0.02381                           | 328.6                 | 9.797               |
| 3500  | 265.41 | 6.579E+04 | 0.863                   | 1.795E+25         | 4.680E+09         | 9.411E-08    | 1.678E-05          | 0.02355                           | 326.6                 | 9.796               |
| 4000  | 262.17 | 6.166E+04 | 0.819                   | 1.704E+25         | 4.414E+09         | 9.917E-08    | 1.661E-05          | 0.02329                           | 324.6                 | 9.794               |
| 4500  | 258.92 | 5.775E+04 | 0.777                   | 1.616E+25         | 4.160E+09         | 1.046E-07    | 1.645E-05          | 0.02303                           | 322.6                 | 9.793               |
| 5000  | 255.68 | 5.405E+04 | 0.736                   | 1.531E+25         | 3.918E+09         | 1.103E-07    | 1.628E-05          | 0.02277                           | 320.6                 | 9.791               |
| 5500  | 252.43 | 5.054E+04 | 0.697                   | 1.450E+25         | 3.687E+09         | 1.165E-07    | 1.612E-05          | 0.02250                           | 318.5                 | 9.790               |
| 6000  | 249.19 | 4.722E+04 | 0.660                   | 1.373E+25         | 3.467E+09         | 1.231E-07    | 1.595E-05          | 0.02224                           | 316.5                 | 9.788               |
| 6500  | 245.94 | 4.408E+04 | 0.664                   | 1.299E+25         | 3.258E+09         | 1.302E-07    | 1.578E-05          | 0.02197                           | 314.4                 | 9.787               |
| 7000  | 242.70 | 4.111E+04 | 0.590                   | 1.227E+25         | 3.058E+09         | 1.377E-07    | 1.561E-05          | 0.02170                           | 312.3                 | 9.785               |
| 7500  | 239.46 | 3.830E+04 | 0.557                   | 1.159E+25         | 2.869E+09         | 1.458E-07    | 1.544E-05          | 0.02144                           | 310.2                 | 9.784               |
| 8000  | 236.22 | 3.565E+04 | 0.526                   | 1.093E+25         | 2.689E+09         | 1.545E-07    | 1.527E-05          | 0.02117                           | 308.1                 | 9.782               |
| 8500  | 232.97 | 3.315E+04 | 0.496                   | 1.031E+25         | 2.518E+09         | 1.639E-07    | 1.510E-05          | 0.02090                           | 306.0                 | 9.781               |
| 9000  | 229.73 | 3.080E+04 | 0.467                   | 9.711E+24         | 2.356E+09         | 1.740E-07    | 1.493E-05          | 0.02063                           | 303.9                 | 9.779               |
| 9500  | 226.49 | 2.858E+04 | 0.440                   | 9.141E+24         | 2.202E+09         | 1.848E-07    | 1.475E-05          | 0.02036                           | 301.7                 | 9.777               |
| 10000 | 223.25 | 2.650E+04 | 0.414                   | 8.598E+24         | 2.056E+09         | 1.965E-07    | 1.458E-05          | 0.02009                           | 299.5                 | 9.776               |
| 10500 | 220.01 | 2.454E+04 | 0.389                   | 8.079E+24         | 1.918E+09         | 2.091E-07    | 1.440E-05          | 0.01982                           | 297.4                 | 9.774               |
| 11000 | 216.77 | 2.270E+04 | 0.365                   | 7.585E+24         | 1.787E+09         | 2.227E-07    | 1.422E-05          | 0.01954                           | 295.2                 | 9.773               |
| 11500 | 216.65 | 2.098E+04 | 0.337                   | 7.016E+24         | 1.653E+09         | 2.408E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.771               |
| 12000 | 216.65 | 1.940E+04 | 0.312                   | 6.486E+24         | 1.528E+09         | 2.605E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.770               |
| 12500 | 216.65 | 1.793E+04 | 0.288                   | 5.996E+24         | 1.412E+09         | 2.818E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.768               |
| 13000 | 216.65 | 1.658E+04 | 0.267                   | 5.543E+24         | 1.306E+09         | 3.048E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.767               |
| 13500 | 216.65 | 1.533E+04 | 0.246                   | 5.124E+24         | 1.207E+09         | 3.297E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.765               |
| 14000 | 216.65 | 1.417E+04 | 0.228                   | 4.738E+24         | 1.116E+09         | 3.566E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.764               |
| 14500 | 216.65 | 1.310E+04 | 0.211                   | 4.380E+24         | 1.032E+09         | 3.857E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.762               |
| 15000 | 216.65 | 1.211E+04 | 0.195                   | 4.049E+24         | 9.538E+08         | 4.172E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.761               |
| 16000 | 216.65 | 1.035E+04 | 0.166                   | 3.461E+24         | 8.153E+08         | 4.881E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.758               |
| 17000 | 216.65 | 8.850E+03 | 0.142                   | 2.959E+24         | 6.969E+08         | 5.710E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.754               |
| 18000 | 216.65 | 7.565E+03 | 0.122                   | 2.529E+24         | 5.958E+08         | 6.680E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.751               |
| 19000 | 216.65 | 6.467E+03 | 0.104                   | 2.162E+24         | 5.093E+08         | 7.814E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.748               |
| 20000 | 216.65 | 5.529E+03 | 8.891E-02               | 1.849E+24         | 4.354E+08         | 9.139E-07    | 1.422E-05          | 0.01953                           | 295.1                 | 9.745               |
| 21000 | 217.58 | 4.729E+03 | 7.572E-02               | 1.574E+24         | 3.716E+08         | 1.073E-06    | 1.427E-05          | 0.01961                           | 295.1                 | 9.742               |
| 22000 | 218.57 | 4.048E+03 | 6.451E-02               | 1.341E+24         | 3.173E+08         | 1.260E-06    | 1.432E-05          | 0.01970                           | 296.4                 | 9.739               |
| 23000 | 219.57 | 3.467E+03 | 5.501E-02               | 1.144E+24         | 2.712E+08         | 1.477E-06    | 1.438E-05          | 0.01978                           | 297.1                 | 9.736               |
| 24000 | 220.56 | 2.972E+03 | 4.694E-02               | 9.759E+23         | 2.319E+08         | 1.731E-06    | 1.443E-05          | 0.01986                           | 297.7                 | 9.733               |
| 25000 | 221.55 | 2.549E+03 | 4.008E-02               | 8.334E+23         | 1.985E+08         | 2.027E-06    | 1.448E-05          | 0.01995                           | 298.4                 | 9.730               |
| 26000 | 222.54 | 2.188E+03 | 3.426E-02               | 7.123E+23         | 1.700E+08         | 2.372E-06    | 1.454E-05          | 0.02003                           | 299.1                 | 9.727               |
| 27000 | 223.54 | 1.880E+03 | 2.930E-02               | 6.092E+23         | 1.458E+08         | 2.773E-06    | 1.459E-05          | 0.02011                           | 299.7                 | 9.724               |
| 28000 | 224.53 | 1.610E+03 | 2.508E-02               | 5.214E+23         | 1.250E+08         | 3.240E-06    | 1.465E-05          | 0.02020                           | 300.4                 | 9.721               |
| 29000 | 225.52 | 1.390E+03 | 2.148E-02               | 4.466E+23         | 1.073E+08         | 3.783E-06    | 1.470E-05          | 0.02028                           | 301.1                 | 9.718               |
| 30000 | 226.51 | 1.197E+03 | 1.841E-02               | 3.828E+23         | 9.219E+07         | 4.414E-06    | 1.475E-05          | 0.02036                           | 301.7                 | 9.715               |
| 31000 | 227.50 | 1.031E+03 | 1.579E-02               | 3.283E+23         | 7.925E+07         | 5.146E-06    | 1.481E-05          | 0.02044                           | 302.4                 | 9.712               |
| 32000 | 228.49 | 8.891E+02 | 1.356E-02               | 2.813E+23         | 6.818E+07         | 5.995E-06    | 1.486E-05          | 0.02053                           | 303.0                 | 9.709               |
| 33000 | 230.97 | 7.673E+02 | 1.157E-02               | 2.406E+23         | 5.852E+07         | 7.021E-06    | 1.499E-05          | 0.02073                           | 304.7                 | 9.706               |
| 34000 | 233.74 | 6.634E+02 | 9.887E-03               | 2.056E+23         | 5.030E+07         | 8.218E-06    | 1.514E-05          | 0.02096                           | 306.5                 | 9.703               |
| 35000 | 236.51 | 5.746E+02 | 8.463E-03               | 1.760E+23         | 4.331E+07         | 9.601E-06    | 1.529E-05          | 0.02119                           | 308.3                 | 9.700               |

| Z/m     | T/K     | P/Pa      | $\rho/\text{kg m}^{-3}$ | $n/\text{m}^{-3}$ | $v/\text{s}^{-1}$ | $l/\text{m}$ | $\eta/\text{Pa s}$ | $W \text{ m}^{-1} \text{ K}^{-1}$ | $v_s/\text{m s}^{-1}$ | $g/\text{m s}^{-2}$ |
|---------|---------|-----------|-------------------------|-------------------|-------------------|--------------|--------------------|-----------------------------------|-----------------------|---------------------|
| 36000   | 239.28  | 4.985E+02 | 7.258E-03               | 1.509E+23         | 3.736E+07         | 1.120E-05    | 1.543E-05          | 0.02142                           | 310.1                 | 9.697               |
| 38000   | 244.82  | 3.771E+02 | 5.367E-03               | 1.116E+23         | 2.794E+07         | 1.514E-05    | 1.572E-05          | 0.02188                           | 313.7                 | 9.690               |
| 40000   | 250.35  | 2.871E+02 | 3.996E-03               | 8.308E+22         | 2.104E+07         | 2.034E-05    | 1.601E-05          | 0.02233                           | 317.2                 | 9.684               |
| 42000   | 255.88  | 2.200E+02 | 2.995E-03               | 6.227E+22         | 1.594E+07         | 2.713E-05    | 1.629E-05          | 0.02278                           | 320.7                 | 9.678               |
| 44000   | 261.40  | 1.695E+02 | 2.259E-03               | 4.697E+22         | 1.215E+07         | 3.597E-05    | 1.657E-05          | 0.02323                           | 324.1                 | 9.672               |
| 46000   | 266.93  | 1.313E+02 | 1.714E-03               | 3.564E+22         | 9.318E+06         | 4.740E-05    | 1.685E-05          | 0.02376                           | 327.5                 | 9.666               |
| 48000   | 270.65  | 1.023E+02 | 1.317E-03               | 2.738E+22         | 7.208E+06         | 6.171E-05    | 1.704E-05          | 0.02397                           | 329.8                 | 9.660               |
| 50000   | 270.65  | 7.978E+01 | 1.027E-03               | 2.135E+22         | 5.620E+06         | 7.913E-05    | 1.703E-05          | 0.02397                           | 329.8                 | 9.654               |
| 52000   | 269.03  | 6.221E+01 | 8.056E-04               | 1.675E+22         | 4.397E+06         | 1.009E-04    | 1.696E-05          | 0.02384                           | 328.8                 | 9.648               |
| 54000   | 263.52  | 4.834E+01 | 6.390E-04               | 1.329E+22         | 3.452E+06         | 1.272E-04    | 1.660E-05          | 0.02340                           | 325.4                 | 9.642               |
| 56000   | 258.02  | 3.736E+01 | 5.045E-04               | 1.049E+22         | 2.696E+06         | 1.611E-04    | 1.640E-05          | 0.02296                           | 322.0                 | 9.636               |
| 58000   | 252.52  | 2.872E+01 | 3.963E-04               | 8.239E+21         | 2.095E+06         | 2.051E-04    | 1.612E-05          | 0.02251                           | 318.6                 | 9.632               |
| 60000   | 247.02  | 2.196E+01 | 3.097E-04               | 6.439E+21         | 1.620E+06         | 2.624E-04    | 1.584E-05          | 0.02206                           | 315.1                 | 9.624               |
| 65000   | 233.29  | 1.093E+01 | 1.632E-04               | 3.393E+21         | 8.294E+05         | 4.979E-04    | 1.512E-05          | 0.02093                           | 306.2                 | 9.609               |
| 70000   | 219.59  | 5.221     | 8.283E-05               | 1.722E+21         | 4.084E+05         | 9.810E-04    | 1.438E-05          | 0.01978                           | 297.1                 | 9.594               |
| 75000   | 208.40  | 2.388     | 3.992E-05               | 8.300E+20         | 1.918E+05         | 2.035E-03    | 1.376E-05          | 0.01883                           | 289.4                 | 9.579               |
| 80000   | 198.64  | 1.052     | 1.846E-05               | 3.838E+20         | 8.656E+04         | 4.402E-03    | 1.321E-05          | 0.01800                           | 282.5                 | 9.564               |
| 85000   | 188.89  | 4.457E-01 | 8.220E-06               | 1.709E+20         | 3.766E+04         | 9.886E-03    | 1.265E-05          | 0.01716                           | 275.5                 | 9.550               |
| 90000   | 186.87  | 1.836E-01 | 3.416E-06               | 7.116E+19         | 1.560E+04         | 2.370E-02    |                    |                                   |                       | 9.535               |
| 95000   | 188.42  | 7.597E-02 | 1.393E-06               | 2.920E+19         | 6.440E+03         | 5.790E-02    |                    |                                   |                       | 9.520               |
| 100000  | 195.08  | 3.201E-02 | 5.604E-07               | 1.189E+19         | 2.680E+03         | 1.420E-01    |                    |                                   |                       | 9.505               |
| 110000  | 240.00  | 7.104E-03 | 9.708E-08               | 2.144E+18         | 5.480E+02         | 7.880E-01    |                    |                                   |                       | 9.476               |
| 120000  | 360.00  | 2.538E-03 | 2.222E-08               | 5.107E+17         | 1.630E+02         | 3.310        |                    |                                   |                       | 9.447               |
| 130000  | 469.27  | 1.251E-03 | 8.152E-09               | 1.930E+17         | 7.100E+01         | 8.800        |                    |                                   |                       | 9.418               |
| 140000  | 559.63  | 7.203E-04 | 3.831E-09               | 9.322E+16         | 3.800E+01         | 1.800E+01    |                    |                                   |                       | 9.389               |
| 150000  | 634.39  | 4.542E-04 | 2.076E-09               | 5.186E+16         | 2.300E+01         | 3.300E+01    |                    |                                   |                       | 9.360               |
| 160000  | 696.29  | 3.040E-04 | 1.233E-09               | 3.162E+16         | 1.500E+01         | 5.300E+01    |                    |                                   |                       | 9.331               |
| 170000  | 747.57  | 2.121E-04 | 7.815E-10               | 2.055E+16         | 1.000E+01         | 8.200E+01    |                    |                                   |                       | 9.302               |
| 180000  | 790.07  | 1.527E-04 | 5.194E-10               | 1.400E+16         | 7.200             | 1.200E+02    |                    |                                   |                       | 9.274               |
| 190000  | 825.16  | 1.127E-04 | 3.581E-10               | 9.887E+15         | 5.200             | 1.700E+02    |                    |                                   |                       | 9.246               |
| 200000  | 854.56  | 8.474E-05 | 2.541E-10               | 7.182E+15         | 3.900             | 2.400E+02    |                    |                                   |                       | 9.218               |
| 220000  | 899.01  | 5.015E-05 | 1.367E-10               | 4.040E+15         | 2.300             | 4.200E+02    |                    |                                   |                       | 9.162               |
| 240000  | 929.73  | 3.106E-05 | 7.858E-11               | 2.420E+15         | 1.400             | 7.000E+02    |                    |                                   |                       | 9.106               |
| 260000  | 950.99  | 1.989E-05 | 4.742E-11               | 1.515E+15         | 9.300E-01         | 1.100E+03    |                    |                                   |                       | 9.051               |
| 280000  | 965.75  | 1.308E-05 | 2.971E-11               | 9.807E+14         | 6.100E-01         | 1.700E+03    |                    |                                   |                       | 8.997               |
| 300000  | 976.01  | 8.770E-06 | 1.916E-11               | 6.509E+14         | 4.200E-01         | 2.600E+03    |                    |                                   |                       | 8.943               |
| 320000  | 983.16  | 5.980E-06 | 1.264E-11               | 4.405E+14         | 2.900E-01         | 3.800E+03    |                    |                                   |                       | 8.889               |
| 340000  | 988.15  | 4.132E-06 | 8.503E-12               | 3.029E+14         | 2.000E-01         | 5.600E+03    |                    |                                   |                       | 8.836               |
| 360000  | 991.65  | 2.888E-06 | 5.805E-12               | 2.109E+14         | 1.400E-01         | 8.000E+03    |                    |                                   |                       | 8.784               |
| 380000  | 994.10  | 2.038E-06 | 4.013E-12               | 1.485E+14         | 1.000E-01         | 1.100E+04    |                    |                                   |                       | 8.732               |
| 400000  | 995.83  | 1.452E-06 | 2.803E-12               | 1.056E+14         | 7.200E-02         | 1.600E+04    |                    |                                   |                       | 8.680               |
| 450000  | 998.22  | 6.447E-07 | 1.184E-12               | 4.678E+13         | 3.300E-02         | 3.600E+04    |                    |                                   |                       | 8.553               |
| 500000  | 999.24  | 3.024E-07 | 5.215E-13               | 2.192E+13         | 1.600E-02         | 7.700E+04    |                    |                                   |                       | 8.429               |
| 550000  | 999.67  | 1.514E-07 | 2.384E-13               | 1.097E+13         | 8.400E-03         | 1.500E+05    |                    |                                   |                       | 8.307               |
| 600000  | 999.85  | 8.213E-08 | 1.137E-13               | 5.950E+12         | 4.800E-03         | 2.800E+05    |                    |                                   |                       | 8.188               |
| 650000  | 999.93  | 4.887E-08 | 5.712E-14               | 3.540E+12         | 3.100E-03         | 4.800E+05    |                    |                                   |                       | 8.072               |
| 700000  | 999.97  | 3.191E-08 | 3.070E-14               | 2.311E+12         | 2.200E-03         | 7.300E+05    |                    |                                   |                       | 7.958               |
| 750000  | 999.98  | 2.260E-08 | 1.788E-14               | 1.637E+12         | 1.700E-03         | 1.000E+06    |                    |                                   |                       | 7.846               |
| 800000  | 999.99  | 1.704E-08 | 1.136E-14               | 1.234E+12         | 1.400E-03         | 1.400E+06    |                    |                                   |                       | 7.737               |
| 850000  | 1000.00 | 1.342E-08 | 7.824E-15               | 9.717E+11         | 1.200E-03         | 1.700E+06    |                    |                                   |                       | 7.630               |
| 900000  | 1000.00 | 1.087E-08 | 5.759E-15               | 7.876E+11         | 1.000E-03         | 2.100E+06    |                    |                                   |                       | 7.525               |
| 950000  | 1000.00 | 8.982E-09 | 4.453E-15               | 6.505E+11         | 8.700E-04         | 2.600E+06    |                    |                                   |                       | 7.422               |
| 1000000 | 1000.00 | 7.514E-09 | 3.561E-15               | 5.442E+11         | 7.500E-04         | 3.100E+06    |                    |                                   |                       | 7.322               |



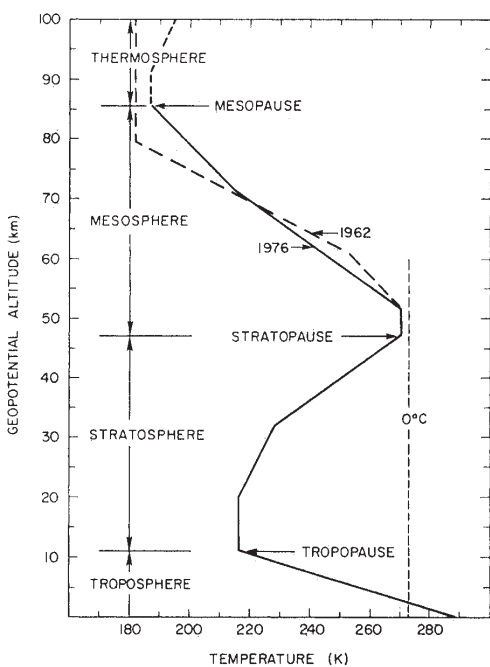


FIGURE 1. Temperature-height profile for U.S. Standard Atmosphere.

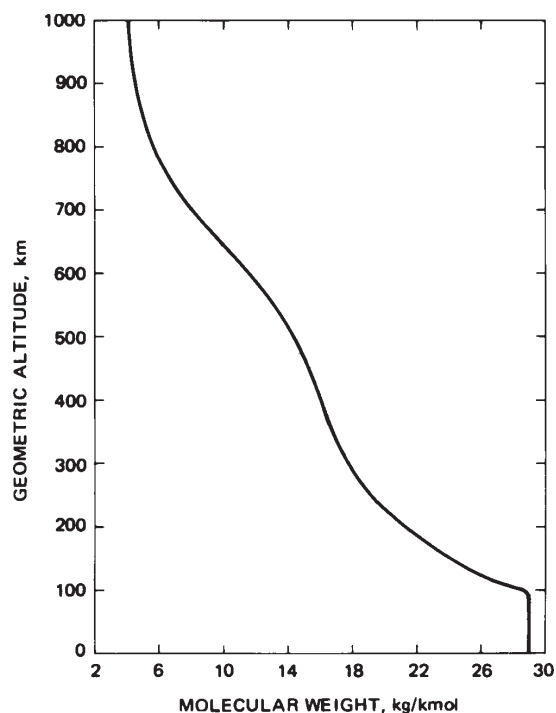


FIGURE 3. Mean molecular weight as a function of geometric altitude.

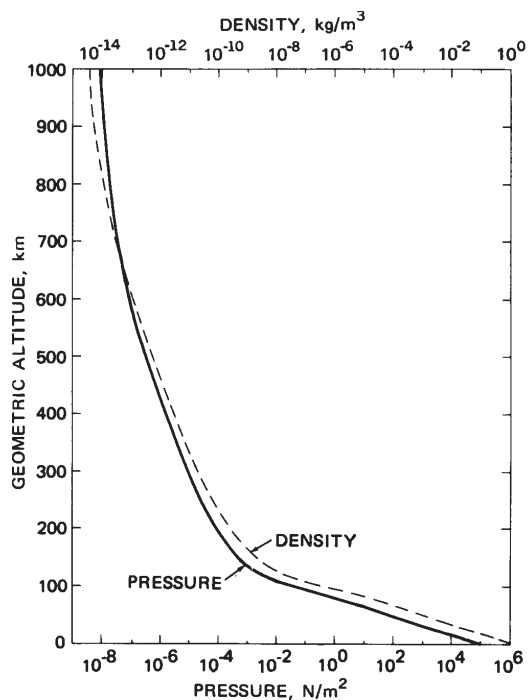


FIGURE 2. Total pressure and mass density as a function of geometric altitude.

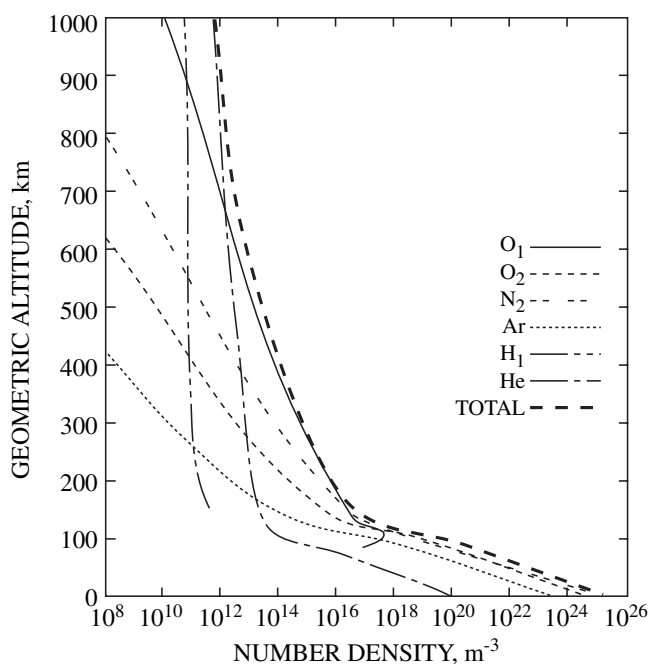


FIGURE 4. Number density of individual species and total number density as a function of geometric altitude.

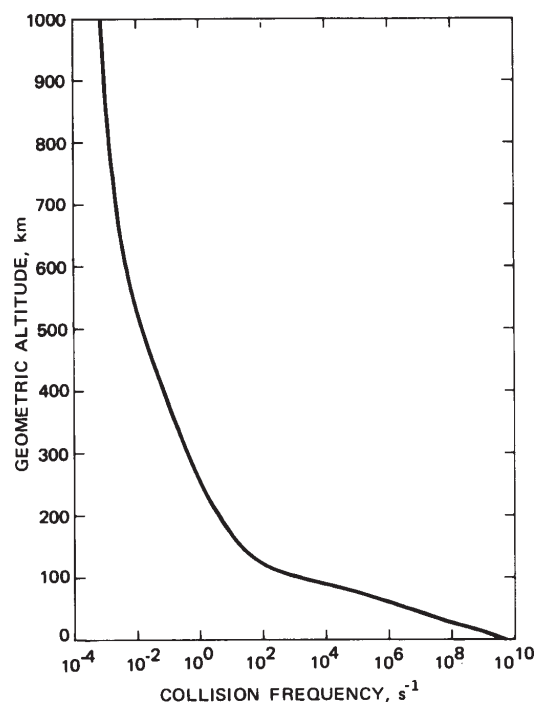


FIGURE 5. Collision frequency as a function of geometric altitude.

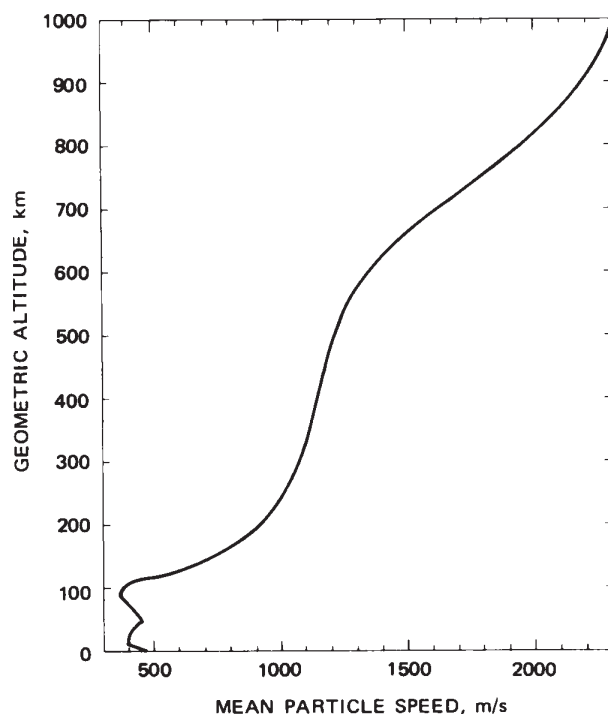


FIGURE 7. Mean air-particle speed as a function of geometric altitude.

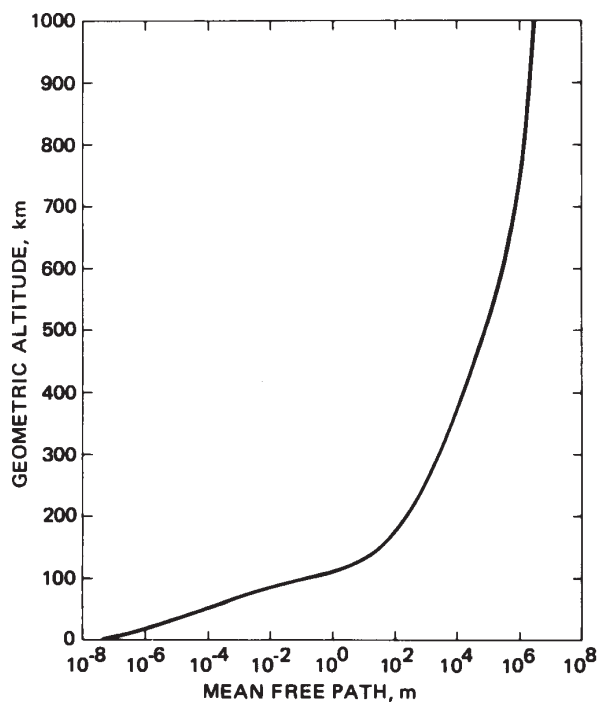


FIGURE 6. Mean free path as a function of geometric altitude.

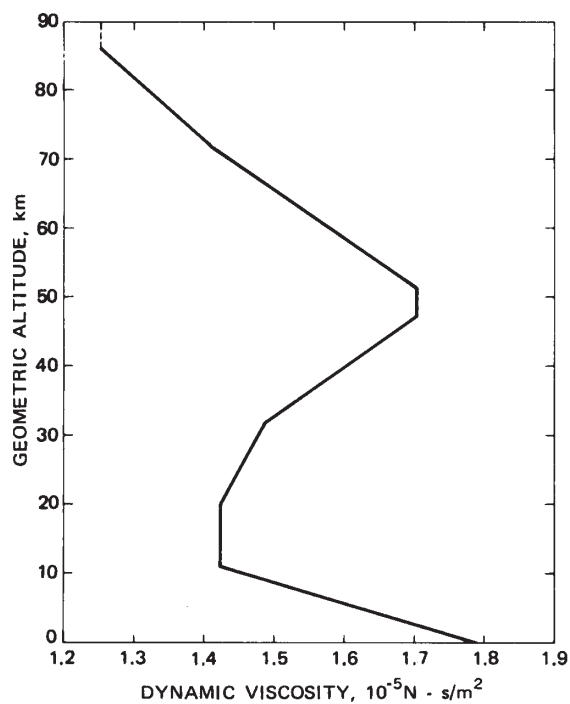


FIGURE 8. Dynamic viscosity as a function of geometric altitude.

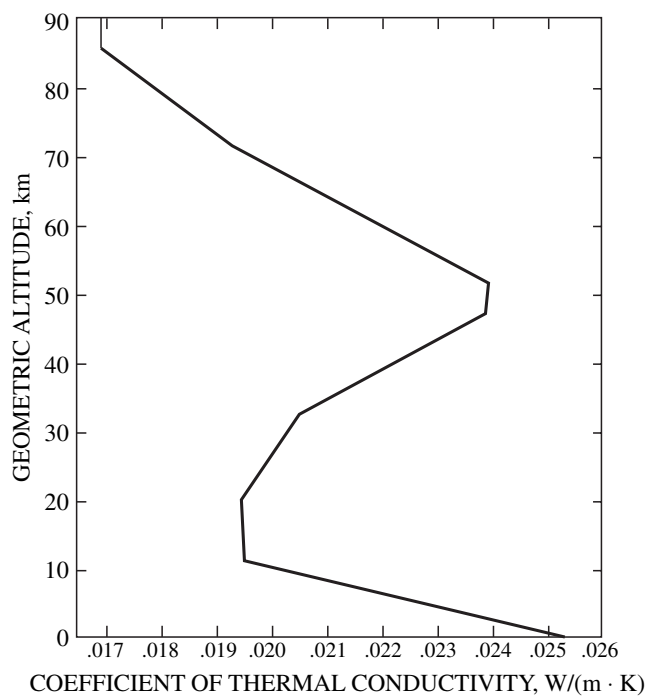


FIGURE 9. Coefficient of thermal conductivity as a function of geometric altitude.

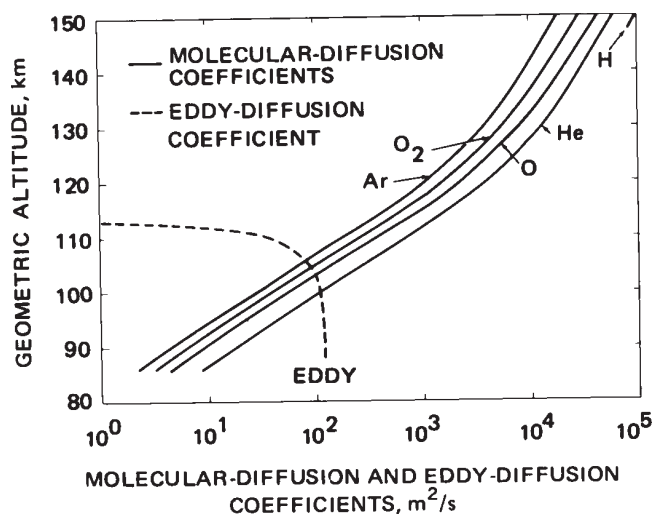


FIGURE 11. Molecular-diffusion and eddy-diffusion coefficients as a function of geometric altitude.

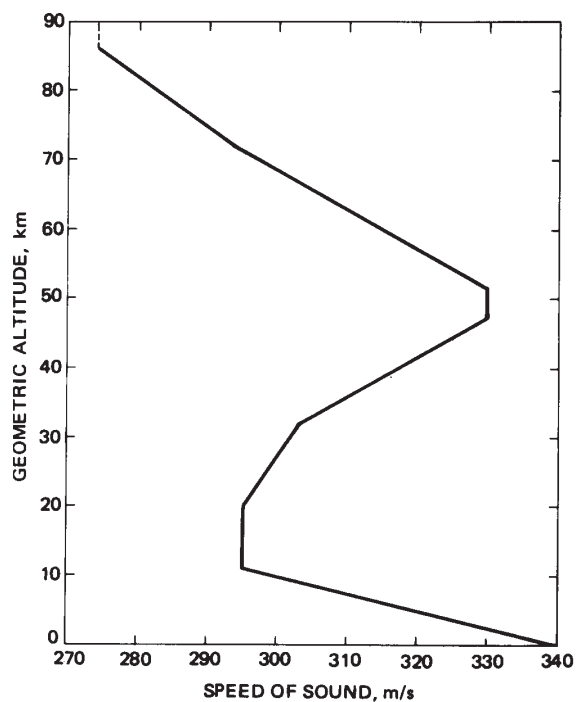


FIGURE 10. Speed of sound as a function of geometric altitude.

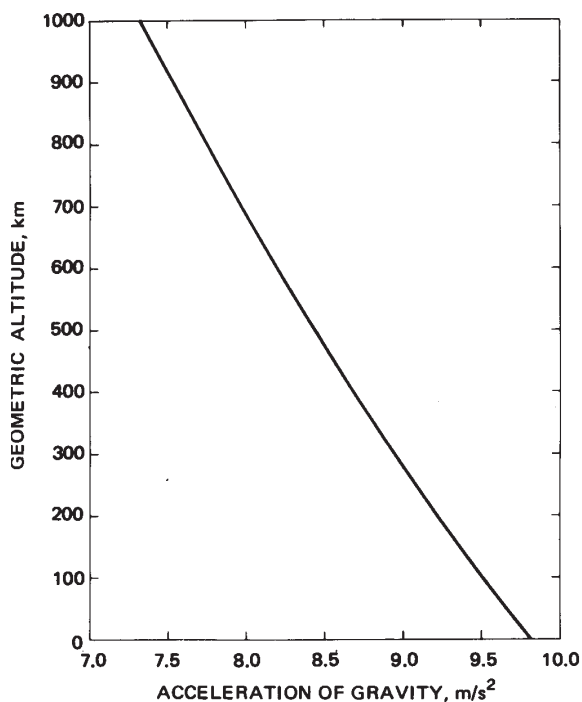


FIGURE 12. Acceleration of gravity as a function of geometric altitude.

## GEOGRAPHICAL AND SEASONAL VARIATION IN SOLAR RADIATION

This table gives the amount of solar radiation reaching a unit area at the top of the earth's atmosphere per day as a function of latitude and approximate date. It is based upon a solar constant (total energy per unit area at the earth's average orbital distance) of 1373 W/m<sup>2</sup>. Absorption of radiation by the atmosphere is not taken into consideration.

### Reference

List, R. J., *Smithsonian Meteorological Tables, Seventh Edition*, Smithsonian Institution Press, Washington, D.C., 1962.

| Daily Solar Radiation in MJ/m <sup>2</sup> |         |         |       |        |        |         |        |         |
|--------------------------------------------|---------|---------|-------|--------|--------|---------|--------|---------|
| Lat.                                       | Mar. 21 | Apr. 13 | May 6 | May 29 | Jun. 2 | Jul. 15 | Aug. 8 | Aug. 31 |
| 90°                                        |         | 18.0    | 32.8  | 42.4   | 45.7   | 42.2    | 32.5   | 17.7    |
| 80                                         | 6.6     | 18.0    | 32.3  | 41.8   | 45.0   | 41.6    | 32.0   | 17.7    |
| 70                                         | 13.0    | 22.3    | 31.8  | 39.9   | 43.0   | 39.7    | 31.5   | 22.0    |
| 60                                         | 19.0    | 27.0    | 34.4  | 39.7   | 41.6   | 39.4    | 34.0   | 26.7    |
| 50                                         | 24.4    | 31.1    | 36.8  | 40.7   | 42.0   | 40.5    | 36.5   | 30.8    |
| 40                                         | 29.1    | 34.3    | 38.6  | 41.3   | 42.1   | 41.1    | 38.3   | 33.9    |
| 30                                         | 32.9    | 36.7    | 39.4  | 41.1   | 41.4   | 40.8    | 39.1   | 36.3    |
| 20                                         | 35.7    | 38.0    | 39.2  | 39.7   | 39.7   | 39.5    | 38.9   | 37.5    |
| 10                                         | 37.4    | 38.1    | 37.9  | 37.4   | 37.1   | 37.2    | 37.6   | 37.7    |
| 0                                          | 38.0    | 37.1    | 35.5  | 34.1   | 33.5   | 34.0    | 35.2   | 36.6    |
| -10                                        | 37.4    | 35.0    | 32.3  | 30.0   | 29.2   | 29.9    | 32.0   | 34.6    |
| -20                                        | 35.7    | 31.8    | 28.0  | 25.2   | 24.1   | 25.1    | 27.8   | 31.5    |
| -30                                        | 32.9    | 27.8    | 23.1  | 19.7   | 18.5   | 19.7    | 22.8   | 27.4    |
| -40                                        | 29.1    | 22.8    | 17.5  | 14.0   | 12.6   | 13.9    | 17.4   | 22.6    |
| -50                                        | 24.4    | 17.3    | 11.7  | 8.2    | 7.0    | 8.2     | 11.6   | 17.2    |
| -60                                        | 19.0    | 11.4    | 5.9   | 2.9    | 2.0    | 2.9     | 5.9    | 11.3    |
| -70                                        | 13.0    | 5.4     | 1.0   |        |        |         | 1.0    | 5.3     |
| -80                                        | 6.6     | 0.3     |       |        |        |         |        | 0.3     |
| -90                                        |         |         |       |        |        |         |        |         |

| Lat. | Sep. 23 | Oct. 16 | Nov. 8 | Nov. 30 | Dec. 22 | Jan. 13 | Feb. 4 | Feb. 26 |
|------|---------|---------|--------|---------|---------|---------|--------|---------|
| 90°  |         |         |        |         |         |         |        |         |
| 80   | 6.5     | 0.3     |        |         |         |         |        | 0.3     |
| 70   | 12.9    | 5.5     | 1.0    |         |         |         | 1.0    | 5.6     |
| 60   | 18.8    | 11.6    | 6.2    | 3.1     | 2.1     | 3.1     | 6.2    | 11.7    |
| 50   | 24.1    | 17.6    | 12.1   | 8.7     | 7.5     | 8.7     | 12.3   | 17.8    |
| 40   | 28.7    | 23.1    | 18.2   | 14.8    | 13.5    | 14.9    | 18.4   | 23.5    |
| 30   | 32.5    | 28.2    | 23.9   | 20.9    | 19.8    | 21.0    | 24.1   | 28.4    |
| 20   | 35.3    | 32.3    | 29.1   | 26.6    | 25.7    | 26.7    | 29.3   | 32.7    |
| 10   | 37.0    | 35.5    | 33.5   | 31.8    | 31.1    | 31.9    | 33.8   | 35.9    |
| 0    | 37.6    | 37.6    | 36.9   | 36.1    | 35.8    | 36.3    | 37.3   | 38.0    |
| -10  | 37.0    | 38.6    | 39.4   | 39.5    | 39.6    | 39.7    | 39.7   | 39.1    |
| -20  | 35.3    | 38.5    | 40.7   | 42.0    | 42.4    | 42.2    | 41.1   | 39.0    |
| -30  | 32.5    | 37.2    | 40.9   | 43.3    | 44.2    | 43.5    | 41.3   | 37.7    |
| -40  | 28.7    | 34.8    | 40.1   | 43.6    | 45.0    | 43.8    | 40.5   | 35.2    |
| -50  | 24.1    | 31.5    | 38.3   | 43.1    | 44.8    | 43.2    | 38.6   | 31.9    |
| -60  | 18.8    | 27.3    | 35.7   | 41.9    | 44.4    | 42.1    | 36.0   | 27.7    |
| -70  | 12.9    | 22.6    | 33.0   | 42.2    | 45.9    | 42.4    | 33.3   | 22.9    |
| -80  | 6.5     | 18.2    | 33.5   | 44.2    | 48.1    | 44.4    | 33.8   | 18.4    |
| -90  |         | 18.2    | 34.0   | 44.8    | 48.8    | 45.1    | 34.4   | 18.4    |

## INFRARED ABSORPTION BY THE EARTH'S ATMOSPHERE

Several constituents of the earth's atmosphere absorb infrared radiation. At ground level the strongest absorbers are  $\text{H}_2\text{O}$  and  $\text{CO}_2$ , but 30 to 40 other compounds can make significant contributions. The centers of the most important absorption bands are listed below:

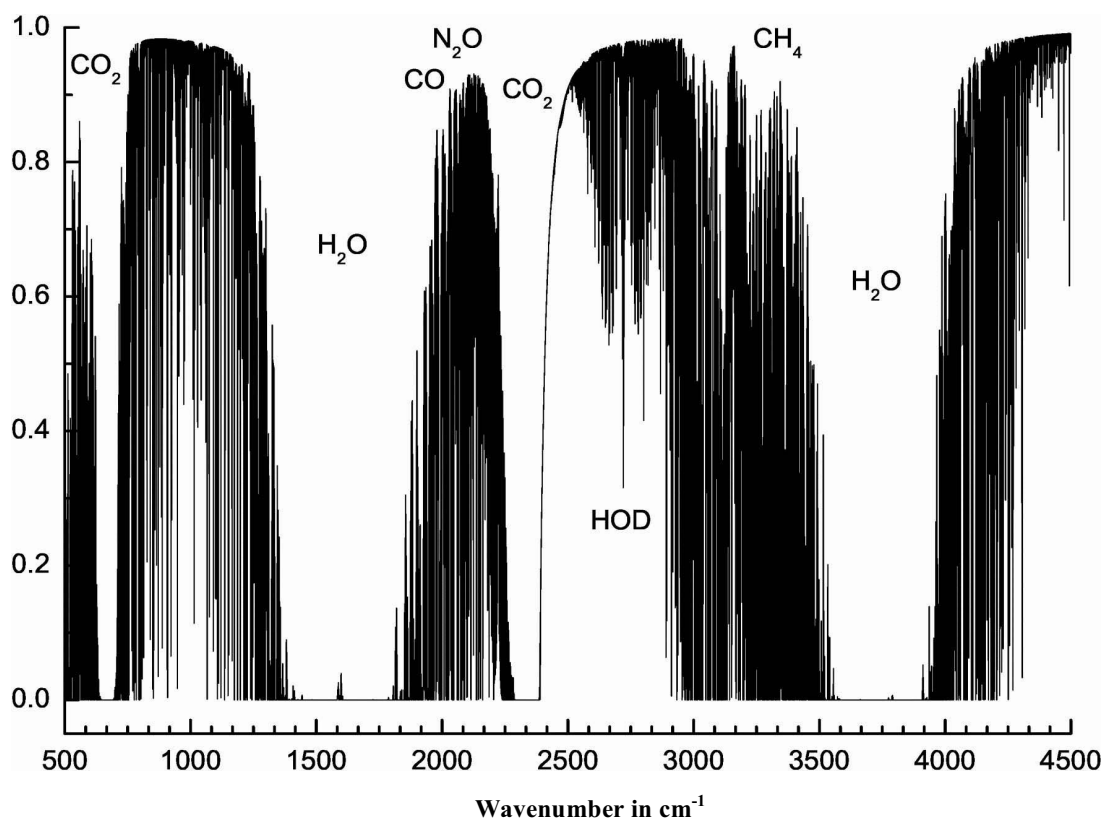
| Molecule             | Vibrational mode          | Band center in $\text{cm}^{-1}$ |
|----------------------|---------------------------|---------------------------------|
| $\text{H}_2\text{O}$ | Bend                      | 1595                            |
| $\text{H}_2\text{O}$ | Symmetric O-H stretch     | 3657                            |
| $\text{H}_2\text{O}$ | Antisymmetric O-H stretch | 3756                            |
| $\text{CO}_2$        | Bend                      | 667                             |
| $\text{CO}_2$        | Antisymmetric C-O stretch | 2349                            |
| $\text{O}_3$         | Bend                      | 701                             |
| $\text{O}_3$         | Antisymmetric O-O stretch | 1042                            |
| $\text{O}_3$         | Symmetric O-O stretch     | 1103                            |
| $\text{N}_2\text{O}$ | Bend                      | 589                             |
| $\text{N}_2\text{O}$ | N-O stretch               | 1285                            |
| $\text{N}_2\text{O}$ | N-N stretch               | 2224                            |
| $\text{CO}$          | C-O stretch               | 2143                            |
| $\text{CH}_4$        | Degenerate deformation    | 1306                            |
| $\text{CH}_4$        | Degenerate stretch        | 3019                            |

The HITRAN Molecular Spectroscopy Database (References 1 and 2) is a compilation of wavenumbers and intensities of more than 1.7 million spectral lines of atmospheric constituents. It is a valuable resource for calculating transmission of the atmosphere, radiative energy transfer, and other phenomena. The graph below, which was supplied by Walter J. Lafferty (Reference 3), gives the transmittance of the atmosphere for one set of conditions.

### References

1. Rothman, L. S., et al., *J. Quant. Spectros. Radiat. Transfer* 82, 5, 2003; *ibid.*, to be published, 2005.
2. HITRAN Molecular Spectroscopy Database, <<http://cfa-www.harvard.edu/HITRAN/hitranda04/>>.
3. Lafferty, W. J., Some Aspects of High Resolution Molecular Spectroscopy, in *Lectures on Molecular Physics*, Institute for the Structure of Matter, Centro de Fisica Miguel A. Catalan, Madrid, 1997.

Transmittance of U.S. Standard Atmosphere at Ground Level for a Path of 1 km at 296 K



## ATMOSPHERIC CONCENTRATION OF CARBON DIOXIDE, 1958–2004

The data in this table were taken at the Mauna Loa Observatory in Hawaii and represent averages adjusted to the 15th of each month. The last column gives the average over the year. The concentration of CO<sub>2</sub> is given in parts per million by volume. Data from other measurement sites may be found in Reference 1.

The first graph illustrates the seasonal variation of CO<sub>2</sub> concentration and the steady increase over the last 45 years. The second graph summarizes the growth in the emissions of CO<sub>2</sub> into the atmosphere as a result of burning of fossil fuels (Reference 2).

### References

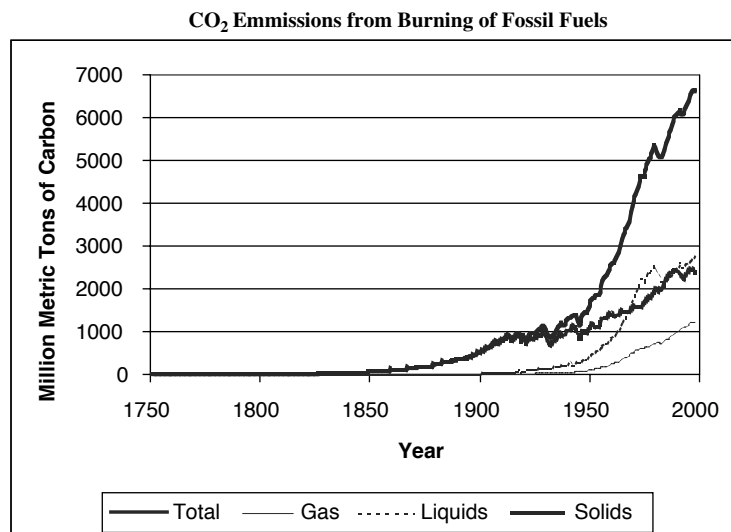
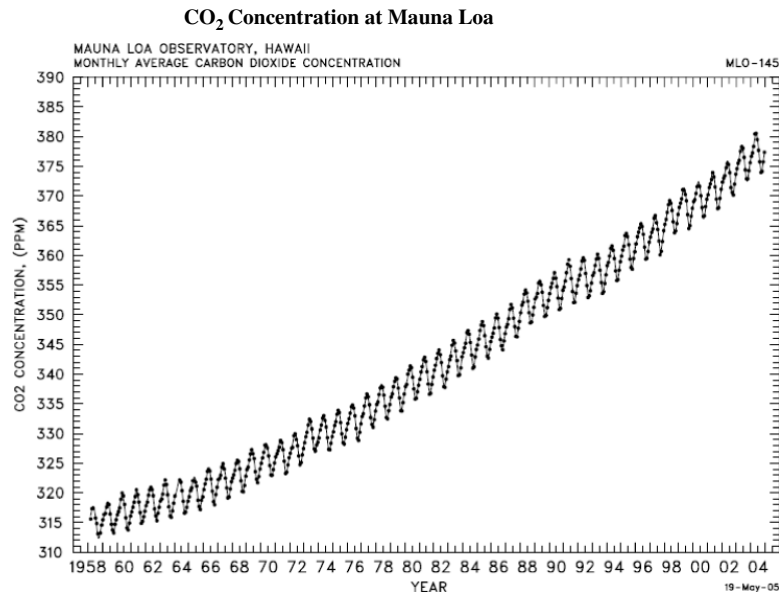
1. Keeling, C.D., and Whorf, T.P., Atmospheric carbon dioxide record from Mauna Loa, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, TN, 2005; <cdiac.esd.ornl.gov/trends/co2/sio-mlo.htm>.
2. Marland, G., Boden, T. A., and Andres, R. J., Global, Regional, and National CO<sub>2</sub> Emissions. In *Trends: A Compendium of Data on Global Change, 2001*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, TN; <cdiac.esd.ornl.gov/trends/emis/tre\_glob.htm>.

### CO<sub>2</sub> Concentration in ppm at Mauna Loa

| Year | Jan.   | Feb.   | March  | April  | May    | June   | July   | Aug.   | Sept.  | Oct.   | Nov.   | Dec.   | Annual |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1958 |        |        | 315.71 | 317.45 | 317.50 |        | 315.85 | 314.93 | 313.19 |        | 313.34 | 314.67 |        |
| 1959 | 315.58 | 316.47 | 316.65 | 317.72 | 318.29 | 318.16 | 316.55 | 314.80 | 313.84 | 313.34 | 314.82 | 315.59 | 315.98 |
| 1960 | 316.43 | 316.97 | 317.58 | 319.03 | 320.03 | 319.59 | 318.18 | 315.91 | 314.16 | 313.84 | 315.00 | 316.19 | 316.91 |
| 1961 | 316.89 | 317.70 | 318.54 | 319.48 | 320.58 | 319.77 | 318.58 | 316.79 | 314.99 | 315.31 | 316.10 | 317.01 | 317.65 |
| 1962 | 317.94 | 318.56 | 319.69 | 320.58 | 321.01 | 320.61 | 319.61 | 317.40 | 316.26 | 315.42 | 316.69 | 317.69 | 318.45 |
| 1963 | 318.74 | 319.08 | 319.86 | 321.39 | 322.24 | 321.47 | 319.74 | 317.77 | 316.21 | 315.99 | 317.06 | 318.36 | 318.99 |
| 1964 | 319.57 |        |        |        | 322.24 | 321.89 | 320.44 | 318.70 | 316.70 | 316.87 | 317.68 | 318.71 |        |
| 1965 | 319.44 | 320.44 | 320.89 | 322.13 | 322.16 | 321.87 | 321.21 | 318.87 | 317.81 | 317.30 | 318.87 | 319.42 | 320.03 |
| 1966 | 320.62 | 321.59 | 322.39 | 323.70 | 324.07 | 323.75 | 322.41 | 320.37 | 318.64 | 318.10 | 319.79 | 321.03 | 321.37 |
| 1967 | 322.33 | 322.50 | 323.04 | 324.42 | 325.00 | 324.09 | 322.55 | 320.92 | 319.26 | 319.39 | 320.72 | 321.96 | 322.18 |
| 1968 | 322.57 | 323.15 | 323.89 | 325.03 | 325.57 | 325.36 | 324.14 | 322.11 | 320.33 | 320.25 | 321.33 | 322.90 | 323.05 |
| 1969 | 324.00 | 324.42 | 325.64 | 326.66 | 327.38 | 326.70 | 325.89 | 323.67 | 322.38 | 321.78 | 322.85 | 324.12 | 324.62 |
| 1970 | 325.06 | 325.98 | 326.93 | 328.14 | 328.07 | 327.66 | 326.35 | 324.69 | 323.10 | 323.07 | 324.01 | 325.13 | 325.68 |
| 1971 | 326.17 | 326.68 | 327.18 | 327.78 | 328.92 | 328.57 | 327.37 | 325.43 | 323.36 | 323.57 | 324.80 | 326.01 | 326.32 |
| 1972 | 326.77 | 327.63 | 327.75 | 329.72 | 330.07 | 329.09 | 328.05 | 326.32 | 324.84 | 325.20 | 326.50 | 327.55 | 327.46 |
| 1973 | 328.54 | 329.56 | 330.30 | 331.50 | 332.48 | 332.07 | 330.87 | 329.31 | 327.51 | 327.18 | 328.16 | 328.64 | 329.68 |
| 1974 | 329.35 | 330.71 | 331.48 | 332.65 | 333.08 | 332.25 | 331.18 | 329.40 | 327.44 | 327.37 | 328.46 | 329.58 | 330.25 |
| 1975 | 330.40 | 331.41 | 332.04 | 333.31 | 333.96 | 333.59 | 331.91 | 330.06 | 328.56 | 328.34 | 329.49 | 330.76 | 331.15 |
| 1976 | 331.74 | 332.56 | 333.50 | 334.58 | 334.87 | 334.34 | 333.05 | 330.94 | 329.30 | 328.94 | 330.31 | 331.68 | 332.15 |
| 1977 | 332.92 | 333.41 | 334.70 | 336.07 | 336.74 | 336.27 | 334.93 | 332.75 | 331.58 | 331.16 | 332.40 | 333.85 | 333.90 |
| 1978 | 334.97 | 335.39 | 336.64 | 337.76 | 338.01 | 337.89 | 336.54 | 334.68 | 332.76 | 332.54 | 333.92 | 334.95 | 335.50 |
| 1979 | 336.23 | 336.76 | 337.96 | 338.89 | 339.47 | 339.29 | 337.73 | 336.09 | 333.91 | 333.86 | 335.29 | 336.73 | 336.85 |
| 1980 | 338.01 | 338.36 | 340.08 | 340.77 | 341.46 | 341.17 | 339.56 | 337.60 | 335.88 | 336.02 | 337.10 | 338.21 | 338.69 |
| 1981 | 339.23 | 340.47 | 341.38 | 342.51 | 342.91 | 342.25 | 340.49 | 338.43 | 336.69 | 336.85 | 338.36 | 339.61 | 339.93 |
| 1982 | 340.75 | 341.61 | 342.70 | 343.57 | 344.13 | 343.35 | 342.06 | 339.82 | 337.97 | 337.86 | 339.26 | 340.49 | 341.13 |
| 1983 | 341.37 | 342.52 | 343.10 | 344.94 | 345.75 | 345.32 | 343.99 | 342.39 | 339.86 | 339.99 | 341.16 | 342.99 | 342.78 |
| 1984 | 343.70 | 344.50 | 345.29 | 347.08 | 347.43 | 346.79 | 345.40 | 343.28 | 341.07 | 341.35 | 342.98 | 344.22 | 344.42 |
| 1985 | 344.97 | 346.00 | 347.43 | 348.35 | 348.93 | 348.25 | 346.56 | 344.69 | 343.09 | 342.80 | 344.24 | 345.56 | 345.91 |
| 1986 | 346.29 | 346.96 | 347.86 | 349.55 | 350.21 | 349.54 | 347.94 | 345.91 | 344.86 | 344.17 | 345.66 | 346.90 | 347.15 |
| 1987 | 348.02 | 348.47 | 349.42 | 350.99 | 351.84 | 351.25 | 349.52 | 348.11 | 346.44 | 346.36 | 347.81 | 348.96 | 348.93 |
| 1988 | 350.43 | 351.72 | 352.22 | 353.59 | 354.22 | 353.79 | 352.39 | 350.44 | 348.72 | 348.88 | 350.07 | 351.34 | 351.48 |
| 1989 | 352.76 | 353.07 | 353.68 | 355.42 | 355.67 | 355.13 | 353.90 | 351.67 | 349.80 | 349.99 | 351.30 | 352.53 | 352.91 |
| 1990 | 353.66 | 354.70 | 355.39 | 356.20 | 357.16 | 356.22 | 354.82 | 352.91 | 350.96 | 351.18 | 352.83 | 354.21 | 354.19 |
| 1991 | 354.72 | 355.75 | 357.16 | 358.60 | 359.33 | 358.24 | 356.18 | 354.03 | 352.16 | 352.21 | 353.75 | 354.99 | 355.59 |
| 1992 | 355.98 | 356.72 | 357.81 | 359.15 | 359.66 | 359.25 | 357.03 | 355.00 | 353.01 | 353.31 | 354.16 | 355.40 | 356.37 |
| 1993 | 356.70 | 357.16 | 358.38 | 359.46 | 360.28 | 359.59 | 357.58 | 355.52 | 353.70 | 353.98 | 355.33 | 356.80 | 357.04 |
| 1994 | 358.36 | 358.91 | 359.97 | 361.27 | 361.68 | 360.94 | 359.55 | 357.49 | 355.84 | 355.99 | 357.58 | 359.04 | 358.89 |
| 1995 | 359.96 | 361.00 | 361.64 | 363.45 | 363.79 | 363.26 | 361.90 | 359.46 | 358.06 | 357.75 | 359.56 | 360.70 | 360.88 |
| 1996 | 362.05 | 363.25 | 364.03 | 364.72 | 365.41 | 364.97 | 363.65 | 361.49 | 359.46 | 359.60 | 360.76 | 362.33 | 362.64 |
| 1997 | 363.18 | 364.00 | 364.57 | 366.35 | 366.80 | 365.62 | 364.47 | 362.51 | 360.19 | 360.77 | 362.43 | 364.28 | 363.76 |
| 1998 | 365.32 | 366.15 | 367.31 | 368.61 | 369.29 | 368.87 | 367.64 | 365.77 | 363.90 | 364.23 | 365.46 | 366.97 | 366.63 |
| 1999 | 368.15 | 368.87 | 369.59 | 371.14 | 371.00 | 370.35 | 369.27 | 366.94 | 364.63 | 365.12 | 366.67 | 368.01 | 368.31 |
| 2000 | 369.14 | 369.46 | 370.52 | 371.66 | 371.82 | 371.70 | 370.12 | 368.12 | 366.62 | 366.73 | 368.29 | 369.53 | 369.48 |
| 2001 | 370.28 | 371.50 | 372.12 | 372.87 | 374.02 | 373.30 | 371.62 | 369.55 | 367.96 | 368.09 | 369.68 | 371.24 | 371.02 |

# Atmospheric Concentration of Carbon Dioxide, 1958–2004

| Year | Jan.   | Feb.   | March  | April  | May    | June   | July   | Aug.   | Sept.  | Oct.   | Nov.   | Dec.   | Annual |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 2002 | 372.43 | 373.09 | 373.52 | 374.86 | 375.55 | 375.40 | 374.02 | 371.49 | 370.71 | 370.24 | 372.08 | 373.78 | 373.10 |
| 2003 | 374.68 | 375.63 | 376.11 | 377.65 | 378.35 | 378.13 | 376.62 | 374.50 | 372.99 | 373.00 | 374.35 | 375.70 | 375.64 |
| 2004 | 376.79 | 377.37 | 378.41 | 380.52 | 380.63 | 379.57 | 377.79 | 375.86 | 374.06 | 374.24 | 375.86 | 377.48 | 377.38 |



## MEAN TEMPERATURES IN THE UNITED STATES, 1900–1992

Historical records of atmospheric temperatures have been analyzed to obtain mean temperatures in °C for 23 climatically distinct regions of the United States. The table below gives the average over these 23 regions, which cover completely the contiguous 48 states. Data for the individual regions and for other parts of the world may be found in the references.

The data are presented as temperature anomalies, i.e., as deviations (in °C) from the average temperature at each individual recording station over a 1961–1990 reference period. The trend in the temperature anomaly thus gives an indication of the long-term variation in average temperatures.

CY Mean: Calendar year mean (January–December)

Winter: December–February

Spring: March–May

Summer: June–August

Fall: September–November

### References

1. Karl, T. R., Easterling, D. R., Knight, R. W., and Hughes, P. Y., in *Trends '93: A Compendium of Data on Global Change*, p. 686, Boden, T. A., Kaiser, D. P., Sepanski, R. J., and Stoss, F. W., Eds., ORNL/CDIAC-65, Oak Ridge National Laboratory, Oak Ridge, TN, 1994.
2. Carbon Dioxide Information Analysis Center, WWW site <<http://cdiac.esd.ornl.gov/ftp/trends93>>.

| Year | CY Mean | Winter | Spring | Summer | Fall  |
|------|---------|--------|--------|--------|-------|
| 1900 | 0.46    |        | 0.21   | 0.27   | 0.85  |
| 1901 | −0.21   | 0.07   | −0.46  | 0.48   | −0.28 |
| 1902 | −0.14   | −0.69  | 0.48   | −0.58  | 0.12  |
| 1903 | −0.77   | −0.84  | 0.10   | −0.83  | −1.02 |
| 1904 | −0.72   | −1.86  | −0.39  | −0.92  | −0.21 |
| 1905 | −0.45   | −1.86  | 0.67   | −0.32  | −0.25 |
| 1906 | −0.04   | 0.23   | −0.69  | −0.42  | −0.10 |
| 1907 | −0.23   | 1.09   | −0.61  | −0.85  | −0.39 |
| 1908 | −0.11   | 0.73   | 0.36   | −0.64  | −0.59 |
| 1909 | −0.36   | 0.82   | −1.06  | 0.06   | 0.01  |
| 1910 | −0.14   | −2.08  | 0.95   | −0.55  | 0.13  |
| 1911 | 0.02    | 0.52   | 0.20   | −0.19  | −0.62 |
| 1912 | −0.88   | −1.50  | −0.75  | −0.76  | −0.51 |
| 1913 | −0.23   | −0.74  | −0.65  | −0.07  | 0.22  |
| 1914 | −0.05   | 0.48   | 0.04   | 0.14   | 0.32  |
| 1915 | −0.11   | −0.37  | −0.18  | −1.16  | 0.31  |
| 1916 | −0.77   | −0.29  | −0.36  | −0.30  | −1.23 |
| 1917 | −1.34   | −1.93  | −1.75  | −0.73  | −1.04 |
| 1918 | −0.14   | −2.02  | 0.30   | 0.03   | −0.09 |
| 1919 | −0.16   | 0.69   | 0.00   | 0.12   | −0.13 |
| 1920 | −0.37   | −0.83  | −0.96  | −0.67  | 0.02  |
| 1921 | 0.87    | 1.56   | 0.83   | 0.52   | 0.32  |
| 1922 | 0.01    | −0.44  | 0.15   | 0.16   | 0.41  |
| 1923 | −0.10   | 0.23   | −1.02  | −0.07  | −0.09 |
| 1924 | −1.01   | 0.13   | −1.27  | −0.64  | −0.53 |
| 1925 | 0.20    | −0.44  | 0.57   | 0.05   | −0.41 |
| 1926 | −0.01   | 0.97   | −0.58  | −0.27  | 0.02  |
| 1927 | 0.20    | 1.11   | 0.41   | −0.83  | 0.83  |
| 1928 | −0.08   | −0.40  | −0.28  | −0.43  | −0.08 |
| 1929 | −0.68   | −1.94  | 0.30   | −0.39  | −0.78 |
| 1930 | −0.12   | 0.07   | 0.09   | −0.07  | −0.25 |
| 1931 | 0.81    | 1.16   | −0.71  | 0.51   | 1.41  |
| 1932 | −0.14   | 1.75   | −0.58  | 0.26   | −0.78 |
| 1933 | 0.35    | −0.60  | −0.08  | 0.45   | 0.54  |
| 1934 | 0.86    | 1.45   | 0.77   | 0.86   | 0.82  |
| 1935 | 0.12    | 0.84   | 0.12   | 0.31   | −0.47 |
| 1936 | −0.10   | −2.23  | 0.48   | 1.00   | −0.32 |
| 1937 | −0.13   | −0.65  | −0.24  | 0.66   | −0.03 |
| 1938 | 0.71    | 1.31   | 0.98   | 0.39   | 0.08  |
| 1939 | 0.38    | 0.36   | 0.34   | 0.18   | 0.15  |
| 1940 | 0.06    | 0.03   | −0.10  | 0.18   | 0.12  |
| 1941 | 0.79    | 1.56   | 0.44   | 0.28   | 0.85  |



## Mean Temperatures in the United States, 1900-1992

| Year | CY Mean | Winter | Spring | Summer | Fall  |
|------|---------|--------|--------|--------|-------|
| 1942 | 0.01    | 0.35   | 0.22   | 0.08   | 0.06  |
| 1943 | -0.17   | 0.20   | -0.46  | 0.54   | -0.79 |
| 1944 | 0.04    | 0.61   | -0.38  | -0.20  | 0.43  |
| 1945 | -0.02   | 0.30   | 0.25   | -0.47  | 0.08  |
| 1946 | 0.53    | -0.26  | 1.21   | -0.21  | 0.18  |
| 1947 | 0.10    | 0.47   | -0.42  | 0.03   | 0.85  |
| 1948 | -0.22   | -0.67  | -0.01  | 0.02   | -0.15 |
| 1949 | 0.05    | -0.77  | 0.39   | 0.33   | 0.23  |
| 1950 | -0.37   | 0.39   | -1.02  | -0.86  | 0.13  |
| 1951 | -0.45   | 0.05   | -0.69  | -0.30  | -0.70 |
| 1952 | 0.03    | 0.68   | -0.40  | 0.49   | -1.22 |
| 1953 | 0.61    | 1.91   | 0.03   | 0.31   | 0.31  |
| 1954 | 0.57    | 1.47   | -0.22  | 0.36   | 0.70  |
| 1955 | -0.25   | -0.33  | 0.12   | 0.19   | -0.60 |
| 1956 | -0.05   | -0.16  | -0.42  | 0.01   | -0.37 |
| 1957 | 0.45    | 1.02   | 0.44   | 0.25   | -0.13 |
| 1958 | 0.14    | 0.93   | 0.06   | 0.11   | 0.45  |
| 1959 | 0.12    | -0.60  | 0.16   | 0.50   | -0.52 |
| 1960 | -0.27   | 0.43   | -0.98  | 0.01   | 0.56  |
| 1961 | -0.01   | -0.02  | -0.17  | 0.18   | -0.29 |
| 1962 | -0.04   | -0.52  | -0.09  | -0.41  | 0.65  |
| 1963 | -0.06   | -1.35  | 0.61   | 0.12   | 1.38  |
| 1964 | -0.27   | -1.30  | -0.24  | -0.08  | -0.40 |
| 1965 | -0.03   | -0.07  | -0.56  | -0.42  | 0.28  |
| 1966 | -0.34   | -0.31  | -0.25  | -0.07  | -0.13 |
| 1967 | -0.13   | 0.23   | -0.05  | -0.37  | -0.32 |
| 1968 | -0.28   | -0.31  | -0.16  | -0.12  | 0.01  |
| 1969 | -0.06   | -0.36  | -0.54  | 0.12   | -0.16 |
| 1970 | -0.12   | -0.17  | -0.44  | 0.32   | -0.07 |
| 1971 | -0.04   | -0.08  | -0.99  | 0.01   | 0.56  |
| 1972 | -0.13   | 0.20   | 0.26   | -0.19  | 0.05  |
| 1973 | 0.48    | -0.23  | 0.47   | 0.22   | 0.90  |
| 1974 | 0.16    | 0.52   | 0.74   | -0.32  | -0.39 |
| 1975 | -0.09   | 0.63   | -0.79  | 0.03   | -0.20 |
| 1976 | -0.62   | 0.88   | -0.09  | -0.54  | -1.72 |
| 1977 | 0.32    | -1.95  | 1.07   | 0.60   | 0.68  |
| 1978 | -0.37   | -1.31  | 0.23   | 0.09   | 0.21  |
| 1979 | -0.53   | -2.92  | 0.09   | -0.21  | -0.07 |
| 1980 | 0.18    | 0.72   | -0.25  | 0.43   | -0.04 |
| 1981 | 0.64    | 0.90   | 0.80   | 0.57   | 0.36  |
| 1982 | -0.08   | -0.86  | 0.03   | -0.11  | 0.06  |
| 1983 | 0.40    | 2.33   | -0.36  | 0.58   | 0.94  |
| 1984 | 0.21    | -0.78  | -0.30  | 0.31   | 0.07  |
| 1985 | -0.26   | -0.78  | 1.24   | -0.23  | 0.05  |
| 1986 | 0.93    | 0.22   | 1.22   | 0.45   | 0.49  |
| 1987 | 0.67    | 1.52   | 0.97   | 0.33   | -0.17 |
| 1988 | -0.07   | -0.26  | -0.06  | 0.57   | 0.04  |
| 1989 | -0.30   | -0.28  | 0.36   | 0.12   | -0.27 |
| 1990 | 0.72    | 0.41   | 0.72   | 0.41   | 0.66  |
| 1991 | 0.77    | 0.32   | 1.36   | 0.56   | -0.31 |
| 1992 |         | 2.48   | 0.82   | -0.70  |       |

## GLOBAL TEMPERATURE TREND, 1856–2004

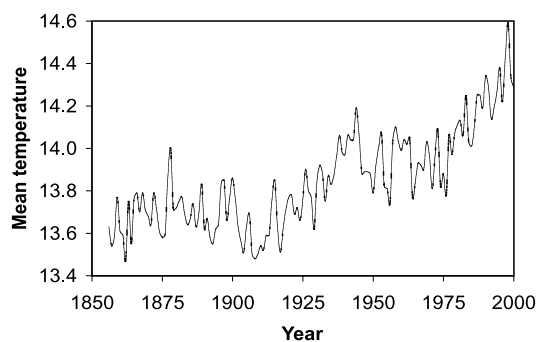
This table and graph summarize the trend in annual mean global surface temperature from 1856 to 2004. The values were calculated from mean temperature anomalies by assuming an absolute global mean of 14.00°C, which is the best estimate for the 1961–1990 period. The 95% confidence interval for the annual mean temperature values since 1951 is  $\pm 0.12^{\circ}\text{C}$ ; prior to 1900 this interval is  $\pm 0.18^{\circ}\text{C}$ .

### Reference

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| Year | $t/^{\circ}\text{C}$ | Year | $t/^{\circ}\text{C}$ | Year | $t/^{\circ}\text{C}$ | Year | $t/^{\circ}\text{C}$ | Year | $t/^{\circ}\text{C}$ |
|------|----------------------|------|----------------------|------|----------------------|------|----------------------|------|----------------------|
| 1856 | 13.621               | 1887 | 13.657               | 1918 | 13.590               | 1949 | 13.903               | 1980 | 14.102               |
| 1857 | 13.538               | 1888 | 13.689               | 1919 | 13.708               | 1950 | 13.790               | 1981 | 14.133               |
| 1858 | 13.584               | 1889 | 13.800               | 1920 | 13.707               | 1951 | 13.907               | 1982 | 14.019               |
| 1859 | 13.775               | 1890 | 13.587               | 1921 | 13.783               | 1952 | 13.975               | 1983 | 14.226               |
| 1860 | 13.628               | 1891 | 13.647               | 1922 | 13.677               | 1953 | 14.045               | 1984 | 14.031               |
| 1861 | 13.596               | 1892 | 13.593               | 1923 | 13.701               | 1954 | 13.830               | 1985 | 14.014               |
| 1862 | 13.473               | 1893 | 13.551               | 1924 | 13.653               | 1955 | 13.811               | 1986 | 14.096               |
| 1863 | 13.727               | 1894 | 13.586               | 1925 | 13.754               | 1956 | 13.728               | 1987 | 14.253               |
| 1864 | 13.526               | 1895 | 13.638               | 1926 | 13.884               | 1957 | 13.994               | 1988 | 14.240               |
| 1865 | 13.733               | 1896 | 13.801               | 1927 | 13.782               | 1958 | 14.061               | 1989 | 14.163               |
| 1866 | 13.777               | 1897 | 13.814               | 1928 | 13.773               | 1959 | 14.014               | 1990 | 14.310               |
| 1867 | 13.709               | 1898 | 13.661               | 1929 | 13.639               | 1960 | 13.972               | 1991 | 14.251               |
| 1868 | 13.775               | 1899 | 13.750               | 1930 | 13.848               | 1961 | 14.015               | 1992 | 14.116               |
| 1869 | 13.695               | 1900 | 13.808               | 1931 | 13.901               | 1962 | 14.008               | 1993 | 14.179               |
| 1870 | 13.704               | 1901 | 13.744               | 1932 | 13.863               | 1963 | 14.039               | 1994 | 14.232               |
| 1871 | 13.649               | 1902 | 13.651               | 1933 | 13.761               | 1964 | 13.767               | 1995 | 14.373               |
| 1872 | 13.734               | 1903 | 13.555               | 1934 | 13.861               | 1965 | 13.834               | 1996 | 14.227               |
| 1873 | 13.673               | 1904 | 13.557               | 1935 | 13.828               | 1966 | 13.916               | 1997 | 14.411               |
| 1874 | 13.624               | 1905 | 13.629               | 1936 | 13.879               | 1967 | 13.907               | 1998 | 14.579               |
| 1875 | 13.576               | 1906 | 13.708               | 1937 | 13.976               | 1968 | 13.895               | 1999 | 14.340               |
| 1876 | 13.548               | 1907 | 13.495               | 1938 | 14.076               | 1969 | 14.040               | 2000 | 14.290               |
| 1877 | 13.789               | 1908 | 13.523               | 1939 | 13.962               | 1970 | 13.969               | 2001 | 14.422               |
| 1878 | 13.943               | 1909 | 13.553               | 1940 | 13.917               | 1971 | 13.813               | 2002 | 14.475               |
| 1879 | 13.713               | 1910 | 13.558               | 1941 | 14.028               | 1972 | 13.959               | 2003 | 14.475               |
| 1880 | 13.704               | 1911 | 13.535               | 1942 | 13.980               | 1973 | 14.093               | 2004 | 14.455               |
| 1881 | 13.754               | 1912 | 13.594               | 1943 | 14.001               | 1974 | 13.829               |      |                      |
| 1882 | 13.738               | 1913 | 13.607               | 1944 | 14.158               | 1975 | 13.877               |      |                      |
| 1883 | 13.682               | 1914 | 13.752               | 1945 | 14.039               | 1976 | 13.800               |      |                      |
| 1884 | 13.651               | 1915 | 13.841               | 1946 | 13.880               | 1977 | 14.057               |      |                      |
| 1885 | 13.650               | 1916 | 13.627               | 1947 | 13.895               | 1978 | 13.964               |      |                      |
| 1886 | 13.746               | 1917 | 13.505               | 1948 | 13.907               | 1979 | 14.067               |      |                      |

Annual Mean Global Temperature in  $^{\circ}\text{C}$



# ATMOSPHERIC ELECTRICITY

Hans Dolezalek, Hannes Tammet, John Latham, and Martin A. Uman

## I. SURVEY AND GLOBAL CIRCUIT

Hans Dolezalek

The science of atmospheric electricity originated in 1752 by an experimental proof of a related earlier hypothesis (that lightning is an electrical event). In spite of a large effort, in part by such eminent physicists as Coulomb, Lord Kelvin, and many others, an overall, proven theory able to generate models with sufficient resolution is not yet available. Generally accepted and encompassing text books are now more than 20 years old. The voluminous proceedings of the, so far, nine international atmospheric electricity conferences (1954 to 1992) give much valuable detail and demonstrate impressive progress, as do a number of less comprehensive textbooks published in the last 20 years, but a general theory as indicated above is not yet created. Only now, certain related measuring techniques and mathematical possibilities are emerging.

Applications to practical purposes do exist in the field of lightning research (including the electromagnetic radiation emanating from lightning) by the establishment of lightning-location networks and by the now developing possibility to detect electrified clouds which pose hazards to aircraft. Application of atmospheric electricity to other parts of meteorology seems to be promising but so far has seldom been instituted. Because some atmospheric electric signals propagate around the earth and because of the existence of a global circuit, applications for the monitoring of global change processes and conditions are now being proposed. Significant secular changes in the global circuit would indicate a change in the global climate; the availability of many old data (about a span of 100 years) could help detect a long-term trend.

The concept of the "global circuit" is based on the theory of the global spherical capacitor: both, the solid (and liquid) earth as one electrode, and the high atmospheric layers (about the ionosphere) as the other, are by orders of magnitude more electrically conductive than the atmosphere between them. According to the "classical picture of atmospheric electricity", this capacitor is continuously charged by the common action of all thunderstorms to a d.c. voltage difference of several hundred kilovolts, the earth being negative. The much smaller but still existing conductivity of the atmosphere allows a current flowing from the ionosphere to the ground, integrated for all sink areas of the whole earth, of the order of 1.5 kA. In this way, a global circuit is created with many generators and sink-areas both interspaced and distributed over the whole globe, all connected to two nodes: ionosphere and ground. Within the scope of the global circuit, for each location, the current density (order of several pA/m<sup>2</sup>) is determined by the voltage difference between ionosphere and ground (which is the same for all locations but varying in time) and the columnar resistance reaching from the ground up to the ionosphere (in the order of  $10^{17} \Omega\text{m}^2$ ).

Natural processes, especially meteorological processes and some human activity, which produce or move electric charges ("space charges") or affect the ion distribution, constitute local generators and thereby "local circuits", horizontally and/or in parallel or antiparallel to the local part of the global circuit. In many cases, the local currents are much stronger than the global ones, making the measurement of the global current at a given location and/or during a period of time very difficult or, often, impossible. The strongest local circuits usually occur with certain weather conditions (precipitation, fog, high wind, blown-up dust or snow, heavy cloudiness) which make measurement of the global circuit impossible everywhere: but even in their absence local generators exist in varying magnitudes and of different characters. The separation

of the local and global shares in the measured values of current density is a central problem of the science of atmospheric electricity. Aerological measurements are of high value in this regard.

The above description is within the "classical picture" of atmospheric electricity, a group of hypotheses to explain the electrification of the atmosphere. It is probably fundamentally correct but certainly not complete; it has not yet been confirmed by systems of measurements resulting in no inner contradictions. In particular, extraterrestrial influences must be permitted; their general significance is still under debate.

Within this "classical picture" a kind of electric standard atmosphere may be constructed as shown in Table 1.

Values with a star, \*, are rough average values from measurement. A star in parentheses, (\*), points to a typical value from one or a few measurements. All other values have been calculated from starred values, under the assumption that at 2 km 50% and at 12 km 90% of the columnar resistance is reached. Voltage drop along one of the partial columns can be calculated by subtracting the value for the lower column from that of the upper one. Columnar resistances, conductances, and capacitances are valid for that particular part of the column which is indicated at the left. Capacitances are calculated with the formula for plate capacitors, and this fact must be considered also for the time constants for columns.

According to measurements,  $U$ , the potential difference between 0 m and 65 km may vary by a factor of approximately 2. The total columnar resistance,  $R_c$ , is estimated to vary up to a factor of 3, the variation being due to either reduction of conductivity in the exchange layer (about lowest 2 km of this table) or to the presence of high mountains; in both cases the variation is caused in the troposphere. Smaller variations in the stratosphere and mesosphere are being discussed because of aerosols there. The air-earth current density in fair weather varies by a factor of 3 to 6 accordingly. Conductivity near the ground varies by a factor of about 3 but only decreasing; increase of conductivity due to extraordinary radioactivity is a singular event. The field strength near the ground varies as a consequence of variations of air-earth current density and conductivity from about 1/3 to about 10 times of the value quoted in the table. Conductivity near the ground shows a diurnal and an annual variation which depends strongly on the locality: air-earth current density shows a diurnal and annual variation because the earth-ionosphere potential difference undergoes such variations, and also because the columnar resistance is supposed to have a diurnal and probably an annual variation.

Conductivities and air-earth current densities on high mountains are greater than at sea level by factors of up to 10. Conductivity decreases when atmospheric humidity increases. Values for space charges are not quoted because measurements are too few to allow calculation of average values. Values of parameters over the oceans are still rather uncertain.

Theoretically, in fair-weather conditions, Ohm's law must be fulfilled for the electric field, the conduction current density, and the electrical conductivity of the atmosphere. Deviations point to shortcomings in the applied measuring techniques. Data which are representative for a large area (in the extreme, "globally representative data", i.e. data on the global circuit), can on the ground be obtained only by stations on an open plane and only if local generators are either small or constant or are independently measured. Certain measurements with instrumented aircraft provide globally representative information valid for the period of the actual measurement.

**TABLE 1. Electrical Parameters of the Clear (Fair-Weather) Atmosphere, Pertinent to the Classical Picture of Atm. Electricity (Electric Standard Atmosphere)**

| Part of atmosphere for which the values are calculated (elements are in free, cloudless atmosphere) | Currents, $I$ , in A; and current densities, $i$ , in A/m <sup>2</sup> | Potential differences, $U$ , in V; field strength $E$ in V/m; $U = 0$ at sea level | Resistances, $R$ , in $\Omega$ ; columnar resistances, $R_c$ , in $\Omega$ m <sup>2</sup> and resistivities, $\rho$ , in $\Omega$ m | Conductances, $G$ , in $\Omega^{-1}$ ; columnar conductances $G_c$ , in $\Omega^{-1}$ m <sup>2</sup> ; total conductivities, $\gamma$ , in $\Omega^{-1}$ m <sup>-1</sup> | Capacitances, $C$ , in F; columnar capacitances, $C_c$ , in F m <sup>-2</sup> and capacitivities, $\epsilon$ , in F m <sup>-1</sup> | Time constants $\tau$ , in seconds |
|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| Volume element at about sea level, 1 m <sup>3</sup>                                                 | $i = 3 \times 10^{-12}$                                                | $E_0 = 1.2 \times 10^{2*}$                                                         | $\rho_0 = 4 \times 10^{13}$                                                                                                         | $\gamma_0 = 2.5 \times 10^{-14}$                                                                                                                                         | $\epsilon_0 = 8.9 \times 10^{-12*}$                                                                                                 | $\tau_0 = 3.6 \times 10^2$         |
| Lower column of 1 m <sup>2</sup> cross section from sea level to 2 km height                        | $i = 3 \times 10^{-12}$                                                | At upper end: $U_1 = 1.8 \times 10^5$                                              | $R_{c1} = 6 \times 10^{16}$                                                                                                         | $G_{c1} = 1.7 \times 10^{-17}$                                                                                                                                           | $C_{c1} = 4.4 \times 10^{-15}$                                                                                                      | $\tau_{c1} = 2.6 \times 10^2$      |
| Volume element at about 2 km height, 1 m <sup>3</sup>                                               | $i = 3 \times 10^{-12}$                                                | $E_2 = 6.6 \times 10^1$                                                            | $\rho_2 = 2.2 \times 10^{13(*)}$                                                                                                    | $\gamma_2 = 4.5 \times 10^{-14}$                                                                                                                                         | $\epsilon_2 = 8.9 \times 10^{-12*}$                                                                                                 | $\tau_2 = 2 \times 10^2$           |
| Center column of 1 m <sup>2</sup> cross section from 2 to 12 km                                     | $i = 3 \times 10^{-12}$                                                | At upper end: $U_m = 3.15 \times 10^5$                                             | $R_{cm} = 4.5 \times 10^{16}$                                                                                                       | $G_{cm} = 5 \times 10^{-17}$                                                                                                                                             | $C_{cm} = 8.8 \times 10^{-16}$                                                                                                      | $\tau_{cm} = 1.8 \times 10^1$      |
| Volume element at about 12 km height, 1 m <sup>3</sup>                                              | $i = 3 \times 10^{-12}$                                                | $E_{12} = 3.9 \times 10^0$                                                         | $\rho_{12} = 1.3 \times 10^{12(*)}$                                                                                                 | $\gamma_{12} = 7.7 \times 10^{-13}$                                                                                                                                      | $\epsilon_{12} = 8.9 \times 10^{-12}$                                                                                               | $\tau_{12} = 1.2 \times 10^1$      |
| Upper column of 1 m <sup>2</sup> cross section from 12 to 65 km height                              | $i = 3 \times 10^{-12}$                                                | At upper end: $U_u = 3.5 \times 10^5$                                              | $R_{cu} = 1.5 \times 10^{16}$                                                                                                       | $G_{cu} = 2.5 \times 10^{-17}$                                                                                                                                           | $C_{cu} = 1.67 \times 10^{-16}$                                                                                                     | $\tau_{cu} = 6.7 \times 10^0$      |
| Whole column of 1 m <sup>2</sup> cross section from 0 to 65 km height                               | $i = 3 \times 10^{-12}$                                                | At upper end: $U = 3.5 \times 10^5$                                                | $R_c = 1.2 \times 10^{17}$                                                                                                          | $G_c = 8.3 \times 10^{-18}$                                                                                                                                              | $C_c = 1.36 \times 10^{-16}$                                                                                                        | $\tau_c = 1.64 \times 10^1$        |
| Total spherical capacitor area: $5 \times 10^{14}$ m <sup>2</sup>                                   | $i = 1.5 \times 10^3$                                                  | $U = 3.5 \times 10^{5*}$                                                           | $R = 2.4 \times 10^2$                                                                                                               | $G = 4.2 \times 10^{-3}$                                                                                                                                                 | $C = 6.8 \times 10^{-2}$                                                                                                            | $\tau = 1.64 \times 10^1$          |

Note: All currents and fields listed are part of the global circuit, i.e., circuits of local generators are not included. Values are subject to variations due to latitude and altitude of the point of observation above sea level, locality with respect to sources of disturbances, meteorological and climatological factors, and man-made changes. For more explanations, see text.

## II. AIR IONS

### Hannes Tammet

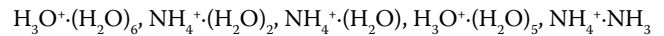
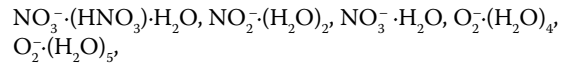
The term "air ions" signifies all airborne particles which are the carriers of the electrical current in the air and have drift velocities determined by the electric field.

The probability of electrical dissociation of molecules in the atmospheric air under thermodynamic equilibrium is near to zero. The average ionization at the ground level over the ocean is  $2 \cdot 10^6$  ion pairs  $\text{m}^{-3}\text{s}^{-1}$ . This ionization is produced mainly by cosmic rays. Over the continents the ionizing radiation from soil and from radioactive substances in the air each add about  $4 \cdot 10^6 \text{ m}^{-3}\text{s}^{-1}$ . The total average ionization rate of  $10^7 \text{ m}^{-3}\text{s}^{-1}$  is equivalent to  $17 \mu\text{R/h}$  which is a customary expression of the background level of the ionizing radiations. The ionization rate over the ground varies in space due to the radioactivity of soil, and in time depending on the exchange of air between the atmosphere and radon-containing soil. Radioactive pollution increases the ionization rate. A temporary increase of about 10 times was registered in Sweden after the Chernobyl accident in 1986. The emission of  $\text{Kr}^{85}$  from nuclear power plants can noticeably increase the global ionization rate in the next century. The ionization rate decreases with altitude near the ground and increases at higher altitudes up to 15 km, where it has a maximum of about  $5 \cdot 10^7 \text{ m}^{-3}\text{s}^{-1}$ . Solar X-ray and extreme UV radiation cause a new increase at altitudes over 60 km.

Local sources of air ions are point discharges in strong electric fields, fluidization of charged drops from waves, etc.

The enhanced chemical activity of an ion results in a chain of ion-molecule reactions with the colliding neutrals, and, in the first microsecond of the life of an air ion, a charged molecular cluster called the *cluster ion* is formed. According to theoretical calculations

in the air free from exotic trace gases the following cluster ions should be dominant:



A measurable parameter of air ions is the electrical mobility  $k$ , characterizing the drift velocity in the unit electric field. The mobility is inversely proportional to the density of air, and the results of measurements are as a rule reduced to normal conditions. According to mobility the air ions are called: fast or small or light ions with mobility  $k > 5 \cdot 10^{-5} \text{ m}^2\text{V}^{-1}\text{s}^{-1}$ , intermediate ions, and slow or large or heavy ions with mobility  $k > 10^{-6} \text{ m}^2\text{V}^{-1}\text{s}^{-1}$ . The boundary between intermediate and slow ions is conventional.

Cluster ions are fast ions. The masses of cluster ions may be measured with mass spectrometers, but the possible ion-molecule reactions during the passage of the air through nozzles to the vacuum chamber complicate the measurement. Mass and mobility of cluster ions are highly correlated. The experimental results<sup>5</sup> can be expressed by the empirical formula

$$m \approx \frac{850 \text{ u}}{[0.3 + k / (10^{-4} \text{ m}^2\text{V}^{-1}\text{s}^{-1})]^3}$$

where  $u$  is the unified atomic mass unit.

The value of the transport cross-section of a cluster ion is needed to calculate its mobility according to the kinetic theory of Chapman and Enskog. The theoretical estimation of transport cross-sections is rough and cannot be used to identify the chemi-

cal structures of cluster ions. Mass spectrometry is the main technique of identification of cluster ions.<sup>2</sup>

Märk and Castleman<sup>4</sup> presented an overview of over 1000 publications on the experimental studies of cluster ions. Most of them present information about ions of millisecond age range. The low concentration makes it difficult to get detailed information about masses and mobilities of the natural atmospheric ions at ground level. The results of a 1-year continuous measurement<sup>6</sup> are as follows:

|                                | + ions | - ions | unit                                          |
|--------------------------------|--------|--------|-----------------------------------------------|
| Average mobility               | 1.36   | 1.56   | $10^{-4}\text{m}^2\text{V}^{-1}\text{s}^{-1}$ |
| The corresponding mass         | 190    | 130    | u                                             |
| The corresponding diameter     | 0.69   | 0.61   | nm                                            |
| The average concentration      | 400    | 360    | $10^6\text{m}^{-3}$                           |
| The corresponding conductivity | 8.7    | 9.0    | fS                                            |

The distribution of tropospheric cluster ions according to the mobility and estimated mass is depicted in Figure 1.

The problems and results of direct mass spectrometry of natural cluster ions are analyzed by Eisele<sup>2</sup> for ground level and by Meyerott, Reagan and Joiner<sup>5</sup> for stratospheric measurements. Air ions in the high atmosphere are a subject of ionospheric physics.

During its lifetime (about 1 min), a cluster ion at ground level collides with nearly  $10^{12}$  molecules. Thus the cluster ions are able to concentrate trace gases of very low concentration if they have an extra high electron or proton affinity. For example, Eisele<sup>2</sup> demon-

strated that a considerable fraction of positive atmospheric cluster ions in the unpolluted atmosphere at ground level probably consist of a molecule derived from pyridine. The concentration of these constituents is estimated to be about  $10^{-12}$ . Therefore, air-ion mass and mobility spectrometry is considered as a promising technique for trace analysis in the air. Mass and mobility spectrometry of millisecond-age air ions has been developed as a technique of chemical analysis known as "plasma chromatography".<sup>1</sup> The sensitivity of the detection grows with the age of the cluster ions measured.

The mechanisms of annihilation of cluster ions are ion-ion recombination (on the average 3%) and sedimentation on aerosol particles (on the average 97% of cluster ions at ground level). The result of the combination of a cluster ion and neutral particle is a charged particle called an *aerosol ion*. In conditions of detailed thermodynamic equilibrium the probability that a spherical particle of diameter  $d$  carries  $q$  elementary charges is calculated from the Boltzmann distribution:

$$p_q(d) = (2\pi d/d_0)^{1/2} \exp(-q^2 d_0/2d)$$

where  $d_0 = 115$  nm (at  $18^\circ\text{C}$ ). The supposition about the detailed equilibrium is an approximation and the formula is not valid for particles less than  $d_0$ . On the basis of numerical calculations by Hoppel and Frick<sup>3</sup> the following charge probabilities can be derived:

| $d$          | 3     | 10   | 30  | 100 | 300 | 1000 | 3000 | nm                                            |
|--------------|-------|------|-----|-----|-----|------|------|-----------------------------------------------|
| $P_0$        | 98    | 90   | 70  | 42  | 24  | 14   | 8    | %                                             |
| $P_{-1}+P_1$ | 2     | 10   | 30  | 48  | 41  | 25   | 15   | %                                             |
| $P_{-2}+P_2$ | 0     | 0    | 0   | 10  | 23  | 21   | 14   | %                                             |
| $P_{q>2}$    | 0     | 0    | 0   | 0   | 12  | 40   | 63   | %                                             |
| $k_1$        | 15000 | 1900 | 250 | 28  | 5.1 | 1.11 | 0.33 | $10^{-9}\text{m}^2\text{V}^{-1}\text{s}^{-1}$ |

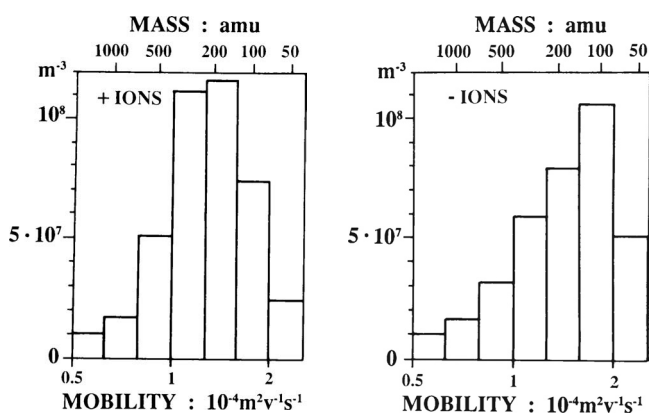


FIGURE 1. Average mobility and mass spectra of natural tropospheric cluster ions. Concentrations of the mobility fractions were measured in a rural site every 5 min over 1 year.<sup>6</sup> Ion mass is estimated according to the above empirical formula.

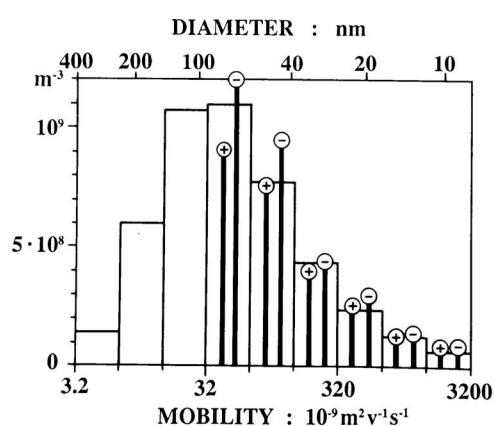


FIGURE 2. Mobility and size spectra of tropospheric aerosol ions.<sup>6</sup> The wide bars mark the fraction concentrations theoretically estimated on the basis of the standard size distribution of tropospheric aerosol. The pin bars with head + and - mark average values of positive and negative aerosol ion fraction concentrations measured in a rural site every 5 min during 4 months.

The last line of the table presents the mobility of a particle carrying one elementary charge. The distribution of the atmospheric aerosol ions over mobility is demonstrated in Figure 2.

Although the concentration of aerosol in continental air at ground level is an order of magnitude higher than the concentration of cluster ions, the mobilities of aerosol ions are so small that their percentage in air conductivity is less than 1%.

A specific class of aerosol ions are condensed aerosol ions produced as a result of the condensation of gaseous matter on the cluster ions. In aerosol physics the process is called ion-induced nucleation; it is considered as one among the processes of gas-to-particle conversion. The condensed aerosol ions have an inherent charge. Their sizes and mobilities are between the sizes and mobilities of cluster ions and of ordinary aerosol ions. Water and standard constituents of atmospheric air are not able to condense on the cluster ions in the real atmosphere. Thus the concentration of condensed aerosol ions depends on the trace constituents in the air and is very low in unpolluted air. Knowledge about condensed aerosol ions is poor because of measurement difficulties.

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## III. THUNDERSTORM ELECTRICITY

**John Latham**

The development of improved radar techniques and instruments for in-cloud electrical and physical measurements, coupled with a much clearer recognition by the research community that establishment of the mechanism or mechanisms responsible for electric field development in thunderclouds, culminating in lightning, is inextricably linked to the concomitant dynamical and microphysical evolution of the clouds, has led to significant progress over the past decade.

Field studies indicate that in most thunderclouds the electrical development is associated with the process of glaciation, which can occur in a variety of incompletely understood ways. In the absence of ice, field growth is slow, individual hydrometeor charges are low, and lightning is produced only rarely. Precipitation — in the solid form, as graupel — also appears to be a necessary ingredient for significant electrification, as does significant convective activity and mixing between the clouds and their environments, via entrainment.

Increasingly, the view is being accepted that charge transfer leading to field-growth is largely a consequence of rebounding collisions between graupel pellets and smaller vapor-grown ice crystals, followed by the separation under gravity of these two types

of hydrometeor. These collisions occur predominantly within the temperature range  $-15$  to  $-30^{\circ}\text{C}$ , and for significant charge transfer need to occur in the presence of supercooled cloud droplets.

The field evidence is inconsistent with an inductive mechanism, and extensive laboratory studies indicate that the principal charging mechanism is non-inductive and associated — in ways yet to be identified — with differences in surface characteristics of the interacting hydrometeors.

Laboratory studies indicate that the two most favored sites for corona emission leading to the lightning discharge are the tips of ephemeral liquid filaments, produced during the glancing collisions of supercooled raindrops, and protuberances on large ice crystals or graupel pellets. The relative importance of these alternatives will depend on the hydrometeor characteristics and the temperature in the regions of strongest fields; these features are themselves dependent on air-mass characteristics and climatological considerations.

A recently identified but unresolved question is why, in continental Northern Hemisphere thunderclouds at least, the sign of the charge brought to ground by lightning is predominantly negative in summer but more evenly balanced in winter.

## IV. LIGHTNING

**Martin A. Uman**

From both ground-based weather-station data and satellite measurements, it has been estimated that there are about 100 lightning discharges, both cloud and ground flashes, over the whole earth each second; representing an average global lightning flash density of about  $6\text{ km}^{-2}\text{yr}^{-1}$ . Most of this lightning occurs over the earth's land masses. For example, in central Florida, where thunderstorms occur about 90 days/yr, the flash density for discharges to earth is about  $15\text{ km}^{-2}\text{yr}^{-1}$ . Some tropical areas of the earth have thunderstorms up to 300 days/yr.

Lightning can be defined as a transient, high-current electric discharge whose path length is measured in kilometers and whose most common source is the electric charge separated in the ordinary thunderstorm or cumulonimbus cloud. Well over half of all lightning discharges occur totally within individual thunderstorm clouds and are referred to as intracloud discharges. Cloud-to-ground lightning, however, has been studied more extensively than any other lightning form because of its visibility and its more practical interest. Cloud-to-cloud and cloud-to-air discharges are less common than intracloud or cloud-to-ground lightning.

Lightning between the cloud and earth can be categorized in terms of the direction of motion, upward or downward, and the sign of the charge, positive or negative, of the developing discharge (called a *leader*) which initiates the overall event. Over 90% of the worldwide cloud-to-ground discharges is initiated in the thundercloud by downward-moving negatively charged leaders and subsequently results in the lowering of negative charge to earth. Cloud-to-ground lightning can also be initiated by downward-moving positive leaders, less than 10% of the worldwide cloud-to-ground lightning being of this type although the exact percentage is a function of season and latitude. Lightning between cloud and ground can also be initiated by leaders which develop upward from the earth. These upward-initiated discharges are relatively rare, may be of either polarity, and generally occur from mountaintops and tall man-made structures.

We discuss next the most common type of cloud-to-ground lightning. A negative cloud-to-ground discharge or *flash* has an overall duration of some tenths of a second and is made up of vari-

ous components, among which are typically three or four high-current pulses called *strokes*. Each stroke lasts about a millisecond, the separation time between strokes being typically several tens of milliseconds. Such lightning often appears to “flicker” because the human eye can just resolve the individual light pulse associated with each stroke. A drawing of the components of a negative cloud-to-ground flash is found in Figure 3. Some values for salient parameters are found in Table 1. The negatively charged *stepped leader* initiates the first stroke in a flash by propagating from cloud to ground through virgin air in a series of discrete steps. Photographically observed leader steps in clear air are typically 1  $\mu$ s in duration and tens of meters in length, with a pause time between steps of about 50  $\mu$ s. A fully developed stepped leader lowers up to 10 or more coulombs of negative cloud charge toward ground in tens of milliseconds with an average downward speed of about  $2 \times 10^5$  m/s. The average leader current is in the 100 to 1000 A range. The steps have pulse currents of at least 1 kA. Associated with these currents are electric- and magnetic-field pulses with widths of about 1  $\mu$ s or less and risetimes of about 0.1  $\mu$ s or less. The stepped leader, during its trip toward ground, branches in a downward direction, resulting in the characteristic downward-branched geometrical structure commonly observed. The electric potential of the bottom of the negatively charged leader channel with respect to ground has a magnitude in excess of  $10^7$  V. As the leader tip nears ground, the electric field at sharp objects on the ground or at irregularities of the ground itself exceeds the breakdown value of air, and one or more upward-moving discharges (often called upward leaders) are initiated from those points, thus beginning the *attachment process*. An understanding of the physics of the attachment process is central to an understanding of the operation of lightning protection of ground-based objects and the effects of lightning on humans and animals, since it is the attachment process that determines where the lightning connects to objects on the ground and the value of the early currents which flow. When one of the upward-moving discharges from the ground (or from a lightning rod or an individual) contacts the tip of the downward-moving stepped leader, typically some tens of meters above the ground, the leader tip is effectively connected to ground potential. The negatively charged leader channel is then discharged to earth when a ground potential wave, referred to as the first *return stroke*, propagates continuously up the leader path. The upward speed of a return stroke near the ground is typically near one third the speed of light, and the speed decreases with height. The first return stroke produces a peak current near ground of typically 30 kA, with a time from zero to peak of a few microseconds. Currents measured at the ground fall to half of the peak value in about 50  $\mu$ s, and currents of the order of hundreds of amperes may flow for times of a few milliseconds up to several hundred milliseconds. The longer-lasting currents are known as *continuing currents*. The rapid release of return stroke energy heats the leader channel to a temperature near 30,000 K and creates a high-pressure channel which expands and generates the shock waves that eventually become thunder, as further discussed later. The return stroke effectively lowers to ground the charge originally deposited onto the stepped-leader channel and additionally initiates the lowering of other charges which may be available to the top of its channel. First return-stroke electric fields exhibit a microsecond scale rise to peak with a typical peak value of 5 V/m, normalized to a distance of 100 km by an inverse distance relationship. Roughly half of the field rise to peak, the so-called “fast transition”, takes place in tenths of a microsecond, an observation that can only be made if the field propagation is over a highly conducting surface such as salt water.

After the first return-stroke current has ceased to flow, the flash, including charge motion in the cloud, may end. The lightning is then called a single-stroke flash. On the other hand, if additional charge is made available to the top of the channel, a continuous or *dart leader* may propagate down the residual first-stroke channel at a typical speed of about  $1 \times 10^7$  m/s. The dart leader lowers a charge of the order of 1 C by virtue of a current of about 1 kA. The dart leader then initiates the second (or any subsequent) return stroke. Subsequent return-stroke currents generally have faster zero-to-peak rise times than do first-stroke currents, but similar maximum rates of change, about 100 kA/ $\mu$ s. Some leaders begin as dart leaders, but toward the end of their trip toward ground become stepped leaders. These leaders are known as *dart-stepped leaders* and may have different ground termination points (and separate upward leaders) from the first stroke. Most often the dart-stepped leaders are associated with the second stroke of the flash. Nearly half of all flashes exhibit more than one termination point on ground with the distance between separate terminations being up to several kilometers. Subsequent return-stroke radiated electric and magnetic fields are similar to, but usually a factor of two or so smaller, than first return-stroke fields. About one third of all multiple-stroke flashes has at least one subsequent stroke which is larger than the first stroke.

Cloud-to-ground flashes that lower positive charge, though not common, are of considerable practical interest because their peak currents and total charge transfer can be much larger than for the more common negative ground flash. The largest recorded peak currents, those in the 200- to 300-kA range, are due to the return strokes of positive lightning. Such positive flashes to ground are initiated by downward-moving leaders which do not exhibit the distinct steps of their negative counterparts. Rather, they show a luminosity which is more or less continuous but modulated in intensity. Positive flashes are generally composed of a single stroke followed by a period of continuing current. Positive flashes are probably initiated from the upper positive charge in the thundercloud charge dipole when that cloud charge is horizontally separated from the negative charge beneath it, the source of the usual negative cloud-to-ground lightning. Positive flashes are relatively common in winter thunderstorms (snow storms), which produce few flashes overall, and are relatively uncommon in summer thunderstorms. The fraction of positive lightning in summer thunderstorms apparently increases with increasing latitude and with increasing height of the ground above sea level.

Distant lightning return stroke fields are often referred to as sferics (called “atmospherics” in the older literature). The peak in the sferics frequency spectrum is near 5 kHz due to the bipolar or ringing nature of the distant return-stroke electromagnetic signal and to the effects of propagation.

Thunder, the acoustic radiation associated with lightning, is sometimes divided into the categories “audible”, sounds that one can hear, and “infrasonic”, below a few tens of hertz, a frequency range that is inaudible. This division is made because it is thought that the mechanisms that produce audible and infrasonic thunder are different. Audible thunder is thought to be due to the expansion of a rapidly heated return stroke channel, as noted earlier, whereas infrasonic thunder is thought to be associated with the conversion to sound of the energy stored in the electrostatic field of the thundercloud when lightning rapidly reduces that cloud field.

The technology of artificially initiating lightning by firing upward small rocket trailing grounded wire of a few hundred meters length has been well-developed during the past decade. Such “triggered” flashes are similar to natural upward-initiated discharges from tall structure. They often contain subsequent strokes which,

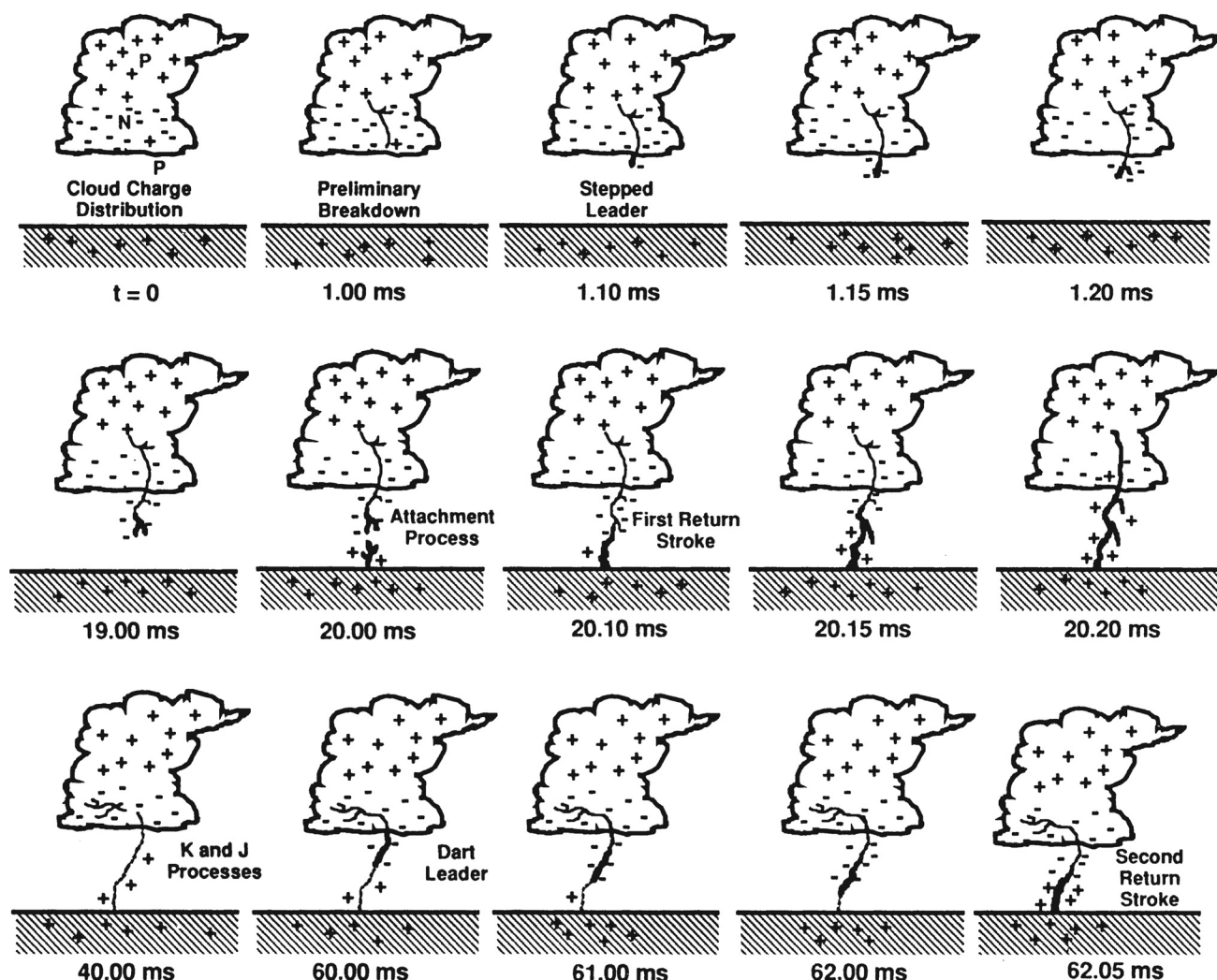


FIGURE 3. Sequence of steps in cloud-to-ground lightning.

when they occur, are similar to the subsequent strokes in natural lightning. These triggered subsequent strokes have been the subject of considerable recent research.

Also in the past 10 years or so sophisticated lightning locating equipment has been installed throughout the world. For example, all ground flashes in the U.S. are now centrally monitored for research, for better overall weather prediction, and for hazard warning for aviation, electric utilities and other lightning-sensitive facilities.

Information on lightning physics can be found in M. A. Uman, *The Lightning Discharge*, Academic Press, San Diego, 1987; on lightning death and injury in *Medical Aspects of Lightning Injury*, C. Andrews, M. A. Cooper, M. Darveniza, and D. Mackerras, Eds.,

CRC Press, 1992. Ground flash location information for the U.S., in real time or archived, is available from Geomet Data Service of Tucson, AZ, which is also a source of the names of providers of those data in other countries.

Table 2 has data for cloud-to-ground lightning discharges bringing negative charge to earth. The values listed are intended to convey a rough feeling for the various physical parameters of lightning. No great accuracy is claimed since the results of different investigators are often not in good agreement. These values may, in fact, depend on the particular environment in which the lightning discharge is generated. The choice of some of the entries in the table is arbitrary.



**TABLE 2. Data for Cloud-to-Ground Lightning Discharges**

|                                                                    | Minimum <sup>a</sup> | Representative values | Maximum <sup>a</sup> |
|--------------------------------------------------------------------|----------------------|-----------------------|----------------------|
| Stepped leader                                                     |                      |                       |                      |
| Length of step, m                                                  | 3                    | 50                    | 200                  |
| Time interval between steps, $\mu\text{s}$                         | 30                   | 50                    | 125                  |
| Average speed of propagation of stepped leader, $\text{m/s}^b$     | $1.0 \times 10^5$    | $2.0 \times 10^5$     | $3.0 \times 10^6$    |
| Charged deposited on stepped-leader channel, coulombs              | 3                    | 5                     | 20                   |
| Dart leader                                                        |                      |                       |                      |
| Speed of propagation, $\text{m/s}^b$                               | $1.0 \times 10^6$    | $1.0 \times 10^7$     | $2.4 \times 10^7$    |
| Charged deposited on dart-leader channel, coulombs                 | 0.2                  | 1                     | 6                    |
| Return stroke <sup>c</sup>                                         |                      |                       |                      |
| Speed of propagation, $\text{m/s}^b$                               | $2.0 \times 10^7$    | $1.0 \times 10^8$     | $2.0 \times 10^8$    |
| Maximum current rate of increase, $\text{kA}/\mu\text{s}$          | <1                   | 100                   | 400                  |
| Time to peak current, $\mu\text{s}$                                | <1                   | 2                     | 30                   |
| Peak current, kA                                                   | 2                    | 30                    | 200                  |
| Time to half of peak current, $\mu\text{s}$                        | 10                   | 50                    | 250                  |
| Charge transferred excluding continuing current, coulombs          | 0.02                 | 3                     | 20                   |
| Channel length, km                                                 | 2                    | 5                     | 15                   |
| Lightning flash                                                    |                      |                       |                      |
| Number of strokes per flash                                        | 1                    | 4                     | 26                   |
| Time interval between strokes in absence of continuing current, ms | 3                    | 60                    | 100                  |
| Time duration of flash, s                                          | $10^{-2}$            | 0.5                   | 2                    |
| Charge transferred including continuing current, coulombs          | 3                    | 30                    | 200                  |

<sup>a</sup> The words maximum and minimum are used in the sense that most measured values fall between these limits.

<sup>b</sup> Speeds of propagation are generally determined from photographic data and are "two-dimensional". Since many lightning flashes are not vertical, values stated are probably slight underestimates of actual values.

<sup>c</sup> First return strokes have longer times to current peak and generally larger charge transfer than do subsequent return strokes.

Adapted from Uman, M.A., *Lightning*, Dover Paperbook, New York, 1986, and Uman, M.A., *The Lightning Discharge*, Academic Press, San Diego, 1987.

## SPEED OF SOUND IN VARIOUS MEDIA

The speed of sound in various solids, liquids, and gases is given in these tables. While only a single parameter  $v$  is needed for liquids and gases, sound propagation in isotropic solids is characterized by three velocity parameters. For a solid of infinite extent (or of finite extent if all dimensions are much larger than a wavelength), there are two relevant quantities,

$v_l$ : velocity of longitudinal waves  
 $v_s$ : velocity of shear waves.

For a cylindrical rod with diameter much smaller than a wavelength,

$v_{\text{ext}}$ : velocity of extensional waves along the rod. (Torsional waves in the rod are propagated at the same speed as shear waves in an infinite solid.)

Table 1 lists values for a variety of solid materials. Table 2 covers gases liquids and gases; values for cryogenic liquids are given at the normal boiling point. Table 3 gives the speed of sound in pure

water and in seawater of salinity  $S = 3.5\%$  as a function of temperature. All values are in meters per second and are given for normal atmospheric pressure.

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**TABLE 1. Speed of Sound in Solids at Room Temperature**

| Name                 | $v_l/\text{m s}^{-1}$ | $v_s/\text{m s}^{-1}$ | $v_{\text{ext}}/\text{m s}^{-1}$ | Name                        | $v_l/\text{m s}^{-1}$ | $v_s/\text{m s}^{-1}$ | $v_{\text{ext}}/\text{m s}^{-1}$ |
|----------------------|-----------------------|-----------------------|----------------------------------|-----------------------------|-----------------------|-----------------------|----------------------------------|
| <b>Metals</b>        |                       |                       |                                  | Steel, K9                   | 5940                  | 3250                  | 5250                             |
| Aluminum, rolled     | 6420                  | 3040                  | 5000                             | Tin, rolled                 | 3320                  | 1670                  | 2730                             |
| Beryllium            | 12890                 | 8880                  | 12870                            | Titanium                    | 6070                  | 3125                  | 5090                             |
| Brass (70 Cu, 30 Zn) | 4700                  | 2110                  | 3480                             | Tungsten, annealed          | 5220                  | 2890                  | 4620                             |
| Constantan           | 5177                  | 2625                  | 4270                             | Tungsten, drawn             | 5410                  | 2640                  | 4320                             |
| Copper, annealed     | 4760                  | 2325                  | 3810                             | Zinc, rolled                | 4210                  | 2440                  | 3850                             |
| Copper, rolled       | 5010                  | 2270                  | 3750                             | <b>Other materials</b>      |                       |                       |                                  |
| Duralumin 17S        | 6320                  | 3130                  | 5150                             | Fused silica                | 5968                  | 3764                  | 5760                             |
| Gold, hard-drawn     | 3240                  | 1200                  | 2030                             | Glass, heavy silicate flint | 3980                  | 2380                  | 3720                             |
| Iron, cast           | 4994                  | 2809                  | 4480                             | Glass, light borate crown   | 5100                  | 2840                  | 4540                             |
| Iron, electrolytic   | 5950                  | 3240                  | 5120                             | Glass, pyrex                | 5640                  | 3280                  | 5170                             |
| Iron, Armco          | 5960                  | 3240                  | 5200                             | Lucite                      | 2680                  | 1100                  | 1840                             |
| Lead, annealed       | 2160                  | 700                   | 1190                             | Nylon 6-6                   | 2620                  | 1070                  | 1800                             |
| Lead, rolled         | 1960                  | 690                   | 1210                             | Polyethylene                | 1950                  | 540                   | 920                              |
| Magnesium, annealed  | 5770                  | 3050                  | 4940                             | Polystyrene                 | 2350                  | 1120                  | 1840                             |
| Molybdenum           | 6250                  | 3350                  | 5400                             | Rubber, butyl               | 1830                  |                       |                                  |
| Monel metal          | 5350                  | 2720                  | 4400                             | Rubber, gum                 | 1550                  |                       |                                  |
| Nickel               | 6040                  | 3000                  | 4900                             | Rubber, neoprene            | 1600                  |                       |                                  |
| Platinum             | 3260                  | 1730                  | 2800                             | Tungsten carbide            | 6655                  | 3980                  | 6220                             |
| Silver               | 3650                  | 1610                  | 2680                             |                             |                       |                       |                                  |
| Steel (1% C)         | 5940                  | 3220                  | 5180                             |                             |                       |                       |                                  |
| Steel, 347 Stainless | 5790                  | 3100                  | 5000                             |                             |                       |                       |                                  |

TABLE 2. Speed of Sound in Liquids and Gases

| Name              | $t/^{\circ}\text{C}$ | $v/\text{m s}^{-1}$ | Name                      | $t/^{\circ}\text{C}$ | $v/\text{m s}^{-1}$ |
|-------------------|----------------------|---------------------|---------------------------|----------------------|---------------------|
| <b>Liquids</b>    |                      |                     | 1-Pentadecene             | 20                   | 1351                |
| Acetone           | 20                   | 1203                | Pentane                   | 20                   | 1008                |
| Argon             | -185.9               | 813                 | Propane                   | -42.1                | 1158                |
| Benzene           | 25                   | 1310                | 1-Propanol                | 20                   | 1223                |
| Bromobenzene      | 20                   | 1169                | Tetrachloromethane        | 25                   | 930                 |
| Butane            | -0.5                 | 1034                | Trichloromethane          | 25                   | 987                 |
| 1-Butanol         | 20                   | 1258                | 1-Undecene                | 20                   | 1275                |
| Carbon disulphide | 25                   | 1140                | Water                     | 25                   | 1497                |
| Chlorobenzene     | 20                   | 1311                | Water (sea, $S = 3.5\%$ ) | 25                   | 1535                |
| Cyclohexane       | 19                   | 1280                | <b>Gases at 1 atm</b>     |                      |                     |
| 1-Decene          | 20                   | 1250                | Air, dry                  | 25                   | 346                 |
| Diethyl ether     | 25                   | 976                 | Ammonia                   | 0                    | 415                 |
| Ethane            | -88.6                | 1326                | Argon                     | 27                   | 323                 |
| Ethanol           | 20                   | 1162                | Carbon monoxide           | 0                    | 338                 |
| Ethylene          | -103.8               | 1309                | Carbon dioxide            | 0                    | 259                 |
| Ethylene glycol   | 25                   | 1658                | Chlorine                  | 0                    | 206                 |
| Fluorobenzene     | 20                   | 1183                | Deuterium                 | 0                    | 890                 |
| Glycerol          | 25                   | 1904                | Ethane                    | 27                   | 312                 |
| Helium            | -268.9               | 180                 | Ethylene                  | 27                   | 331                 |
| Heptane           | 20                   | 1162                | Helium                    | 0                    | 965                 |
| 1-Heptene         | 20                   | 1128                | Hydrogen                  | 27                   | 1310                |
| Hexane            | 20                   | 1083                | Hydrogen bromide          | 0                    | 200                 |
| Hydrogen          | -252.9               | 1101                | Hydrogen chloride         | 0                    | 296                 |
| Iodobenzene       | 20                   | 1114                | Hydrogen iodide           | 0                    | 157                 |
| Mercury           | 25                   | 1450                | Hydrogen sulfide          | 0                    | 289                 |
| Methane           | -161.5               | 1337                | Methane                   | 27                   | 450                 |
| Methanol          | 20                   | 1121                | Neon                      | 0                    | 435                 |
| Nitrobenzene      | 25                   | 1463                | Nitric oxide              | 10                   | 325                 |
| Nitrogen          | -195.8               | 939                 | Nitrogen                  | 27                   | 353                 |
| 1-Nonene          | 20                   | 1218                | Nitrous oxide             | 0                    | 263                 |
| Octane            | 20                   | 1197                | Oxygen                    | 27                   | 330                 |
| 1-Octene          | 20                   | 1184                | Sulfur dioxide            | 0                    | 213                 |
| Oxygen            | -183.0               | 906                 | Water (steam)             | 100                  | 473                 |

TABLE 3. Speed of Sound in Water and Seawater ( $S = 3.5\%$ ) at Different Temperatures

| $t/^{\circ}\text{C}$ | $v/\text{m s}^{-1}$ |          |
|----------------------|---------------------|----------|
|                      | Water               | Seawater |
| 0                    | 1401.0              | 1449.4   |
| 10                   | 1447.8              | 1490.4   |
| 20                   | 1483.2              | 1522.2   |
| 25                   | 1497.4              | 1535.1   |
| 30                   | 1509.5              | 1546.2   |
| 40                   | 1528.4              |          |
| 50                   | 1541.4              |          |
| 60                   | 1549.5              |          |
| 70                   | 1553.2              |          |
| 80                   | 1552.8              |          |

# ATTENUATION AND SPEED OF SOUND IN AIR AS A FUNCTION OF HUMIDITY AND FREQUENCY

This table gives the attenuation and speed of sound as a function of frequency at various values of relative humidity. All values refer to still air at 20 °C.

## References

1. Tables of Absorption and Velocity of Sound in Still Air at 68 °F (20 °C), AD-738576, National Technical Information Service, Springfield, VA.
2. Evans, L. B., Bass, H. E., and Sutherland, L. C., *J. Acoust. Soc. Am.*, 51, 1565, 1972.

| Frequency<br>(Hz)            | Attenuation<br>(dB/km) | Speed<br>(m/s) | Frequency<br>(Hz)             | Attenuation<br>(dB/km) | Speed<br>(m/s) |
|------------------------------|------------------------|----------------|-------------------------------|------------------------|----------------|
| <i>Relative humidity 0%</i>  |                        |                | <i>Relative humidity 60%</i>  |                        |                |
| 20                           | 0.51                   | 343.477        | 20                            | 0.02                   | 344.182        |
| 40                           | 1.07                   | 343.514        | 40                            | 0.06                   | 344.183        |
| 50                           | 1.26                   | 343.525        | 50                            | 0.09                   | 344.183        |
| 63                           | 1.43                   | 343.536        | 63                            | 0.15                   | 344.184        |
| 100                          | 1.67                   | 343.550        | 100                           | 0.34                   | 344.185        |
| 200                          | 1.84                   | 343.559        | 200                           | 0.99                   | 344.190        |
| 400                          | 1.96                   | 343.561        | 400                           | 1.94                   | 344.197        |
| 630                          | 2.11                   | 343.562        | 630                           | 2.57                   | 344.200        |
| 800                          | 2.27                   | 343.562        | 800                           | 2.94                   | 344.201        |
| 1250                         | 2.82                   | 343.562        | 1250                          | 4.01                   | 344.202        |
| 2000                         | 4.14                   | 343.562        | 2000                          | 6.55                   | 344.203        |
| 4000                         | 8.84                   | 343.564        | 4000                          | 18.73                  | 344.204        |
| 6300                         | 14.89                  | 343.565        | 6300                          | 42.51                  | 344.204        |
| 10000                        | 26.28                  | 343.566        | 10000                         | 101.84                 | 344.206        |
| 12500                        | 35.81                  | 343.566        | 12500                         | 155.67                 | 344.208        |
| 16000                        | 52.15                  | 343.567        | 16000                         | 247.78                 | 344.211        |
| 20000                        | 75.37                  | 343.567        | 20000                         | 373.78                 | 344.215        |
| 40000                        | 267.01                 | 343.567        | 40000                         | 1195.37                | 344.238        |
| 63000                        | 644.66                 | 343.567        | 63000                         | 2220.64                | 344.262        |
| 80000                        | 1032.14                | 343.567        | 80000                         | 2951.71                | 344.274        |
| <i>Relative humidity 30%</i> |                        |                | <i>Relative humidity 100%</i> |                        |                |
| 20                           | 0.03                   | 343.807        | 20                            | 0.01                   | 344.685        |
| 40                           | 0.11                   | 343.808        | 40                            | 0.04                   | 344.685        |
| 50                           | 0.17                   | 343.810        | 50                            | 0.06                   | 344.685        |
| 63                           | 0.25                   | 343.810        | 63                            | 0.09                   | 344.685        |
| 100                          | 0.50                   | 343.814        | 100                           | 0.22                   | 344.686        |
| 200                          | 1.01                   | 343.821        | 200                           | 0.77                   | 344.689        |
| 400                          | 1.59                   | 343.826        | 400                           | 2.02                   | 344.695        |
| 630                          | 2.24                   | 343.827        | 630                           | 3.05                   | 344.699        |
| 800                          | 2.85                   | 343.828        | 800                           | 3.57                   | 344.701        |
| 1250                         | 5.09                   | 343.828        | 1250                          | 4.59                   | 344.704        |
| 2000                         | 10.93                  | 343.829        | 2000                          | 6.29                   | 344.705        |
| 4000                         | 38.89                  | 343.831        | 4000                          | 13.58                  | 344.706        |
| 6300                         | 90.61                  | 343.836        | 6300                          | 27.72                  | 344.706        |
| 10000                        | 204.98                 | 343.846        | 10000                         | 63.49                  | 344.706        |
| 12500                        | 294.08                 | 343.854        | 12500                         | 96.63                  | 344.707        |
| 16000                        | 422.51                 | 343.865        | 16000                         | 154.90                 | 344.708        |
| 20000                        | 563.66                 | 343.877        | 20000                         | 237.93                 | 344.709        |
| 40000                        | 1110.97                | 343.911        | 40000                         | 884.28                 | 344.718        |
| 63000                        | 1639.47                | 343.924        | 63000                         | 1973.62                | 344.731        |
| 80000                        | 2083.08                | 343.929        | 80000                         | 2913.01                | 344.742        |

## SPEED OF SOUND IN DRY AIR

Eric W. Lemmon

These values were calculated from the equation of state for dry air (average molecular weight 28.96) treated as a real gas. Values refer to standard atmospheric pressure. The speed of sound varies only slightly with pressure; at two atmospheres and  $-100\text{ }^{\circ}\text{C}$  the value decreases by 0.16%, while at two atmospheres and  $80\text{ }^{\circ}\text{C}$  the speed increases by 0.05%. For additional values, see the table in Section 6 labeled "Thermophysical Properties of Air."

### Reference

Lemmon, E.W., Jacobsen, R.T., Penoncello, S.G., and Friend, D.G., Thermodynamic Properties of Air and Mixtures of Nitrogen, Argon, and Oxygen from 60 to 2000 K at Pressures to 2000 MPa, *J. Phys. Chem. Ref. Data* 29, 331, 2000.

| $t/^{\circ}\text{C}$ | $v_s/\text{m s}^{-1}$ | $t/^{\circ}\text{C}$ | $v_s/\text{m s}^{-1}$ | $t/^{\circ}\text{C}$ | $v_s/\text{m s}^{-1}$ |
|----------------------|-----------------------|----------------------|-----------------------|----------------------|-----------------------|
| -100                 | 263.5                 | -30                  | 312.7                 | 40                   | 354.9                 |
| -95                  | 267.3                 | -25                  | 315.9                 | 45                   | 357.7                 |
| -90                  | 271.1                 | -20                  | 319.1                 | 50                   | 360.4                 |
| -85                  | 274.8                 | -15                  | 322.2                 | 55                   | 363.2                 |
| -80                  | 278.5                 | -10                  | 325.4                 | 60                   | 365.9                 |
| -75                  | 282.1                 | -5                   | 328.4                 | 65                   | 368.7                 |
| -70                  | 285.7                 | 0                    | 331.5                 | 70                   | 371.3                 |
| -65                  | 289.2                 | 5                    | 334.5                 | 75                   | 374.0                 |
| -60                  | 292.7                 | 10                   | 337.5                 | 80                   | 376.7                 |
| -55                  | 296.1                 | 15                   | 340.5                 | 85                   | 379.3                 |
| -50                  | 299.5                 | 20                   | 343.4                 | 90                   | 381.9                 |
| -45                  | 302.9                 | 25                   | 346.3                 | 95                   | 384.5                 |
| -40                  | 306.2                 | 30                   | 349.2                 | 100                  | 387.0                 |
| -35                  | 309.5                 | 35                   | 352.0                 |                      |                       |

# MUSICAL SCALES

## Equal Tempered Chromatic Scale

A<sub>4</sub> = 440 Hz

### International Concert Pitch

| Note            | Frequency | Note            | Frequency | Note            | Frequency | Note            | Frequency |
|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|
| C <sub>0</sub>  | 16.35     | C <sub>2</sub>  | 65.41     | C <sub>4</sub>  | 261.63    | C <sub>6</sub>  | 1046.50   |
| C# <sub>0</sub> | 17.32     | C# <sub>2</sub> | 69.30     | C# <sub>4</sub> | 277.18    | C# <sub>6</sub> | 1108.73   |
| D <sub>0</sub>  | 18.35     | D <sub>2</sub>  | 73.42     | D <sub>4</sub>  | 293.66    | D <sub>6</sub>  | 1174.66   |
| D# <sub>0</sub> | 19.45     | D# <sub>2</sub> | 77.78     | D# <sub>4</sub> | 311.13    | D# <sub>6</sub> | 1244.51   |
| E <sub>0</sub>  | 20.60     | E <sub>2</sub>  | 82.41     | E <sub>4</sub>  | 329.63    | E <sub>6</sub>  | 1318.51   |
| F <sub>0</sub>  | 21.83     | F <sub>2</sub>  | 87.31     | F <sub>4</sub>  | 349.23    | F <sub>6</sub>  | 1396.91   |
| F# <sub>0</sub> | 23.12     | F# <sub>2</sub> | 92.50     | F# <sub>4</sub> | 369.99    | F# <sub>6</sub> | 1479.98   |
| G <sub>0</sub>  | 24.50     | G <sub>2</sub>  | 98.00     | G <sub>4</sub>  | 392.00    | G <sub>6</sub>  | 1567.98   |
| G# <sub>0</sub> | 25.96     | G# <sub>2</sub> | 103.83    | G# <sub>4</sub> | 415.30    | G# <sub>6</sub> | 1661.22   |
| A <sub>0</sub>  | 27.50     | A <sub>2</sub>  | 110.00    | A <sub>4</sub>  | 440.00    | A <sub>6</sub>  | 1760.00   |
| A# <sub>0</sub> | 29.14     | A# <sub>2</sub> | 116.54    | A# <sub>4</sub> | 466.16    | A# <sub>6</sub> | 1864.66   |
| B <sub>0</sub>  | 30.87     | B <sub>2</sub>  | 123.47    | B <sub>4</sub>  | 493.88    | B <sub>6</sub>  | 1975.53   |
| C <sub>1</sub>  | 32.70     | C <sub>3</sub>  | 130.81    | C <sub>5</sub>  | 523.25    | C <sub>7</sub>  | 2093.00   |
| C# <sub>1</sub> | 34.65     | C# <sub>3</sub> | 138.59    | C# <sub>5</sub> | 554.37    | C# <sub>7</sub> | 2217.46   |
| D <sub>1</sub>  | 36.71     | D <sub>3</sub>  | 146.83    | D <sub>5</sub>  | 587.33    | D <sub>7</sub>  | 2349.32   |
| D# <sub>1</sub> | 38.89     | D# <sub>3</sub> | 155.56    | D# <sub>5</sub> | 622.25    | D# <sub>7</sub> | 2489.02   |
| E <sub>1</sub>  | 41.20     | E <sub>3</sub>  | 164.81    | E <sub>5</sub>  | 659.26    | E <sub>7</sub>  | 2637.02   |
| F <sub>1</sub>  | 43.65     | F <sub>3</sub>  | 174.61    | F <sub>5</sub>  | 698.46    | F <sub>7</sub>  | 2793.83   |
| F# <sub>1</sub> | 46.25     | F# <sub>3</sub> | 185.00    | F# <sub>5</sub> | 739.99    | F# <sub>7</sub> | 2959.96   |
| G <sub>1</sub>  | 49.00     | G <sub>3</sub>  | 196.00    | G <sub>5</sub>  | 783.99    | G <sub>7</sub>  | 3135.96   |
| G# <sub>1</sub> | 51.91     | G# <sub>3</sub> | 207.65    | G# <sub>5</sub> | 830.61    | G# <sub>7</sub> | 3322.44   |
| A <sub>1</sub>  | 55.00     | A <sub>3</sub>  | 220.00    | A <sub>5</sub>  | 880.00    | A <sub>7</sub>  | 3520.00   |
| A# <sub>1</sub> | 58.27     | A# <sub>3</sub> | 233.08    | A# <sub>5</sub> | 932.33    | A# <sub>7</sub> | 3729.31   |
| B <sub>1</sub>  | 61.74     | B <sub>3</sub>  | 246.94    | B <sub>5</sub>  | 987.77    | B <sub>7</sub>  | 3951.07   |
|                 |           |                 |           |                 |           | C <sub>8</sub>  | 4186.01   |

### Scientific or Just Scale

C<sub>4</sub> = 256 Hz

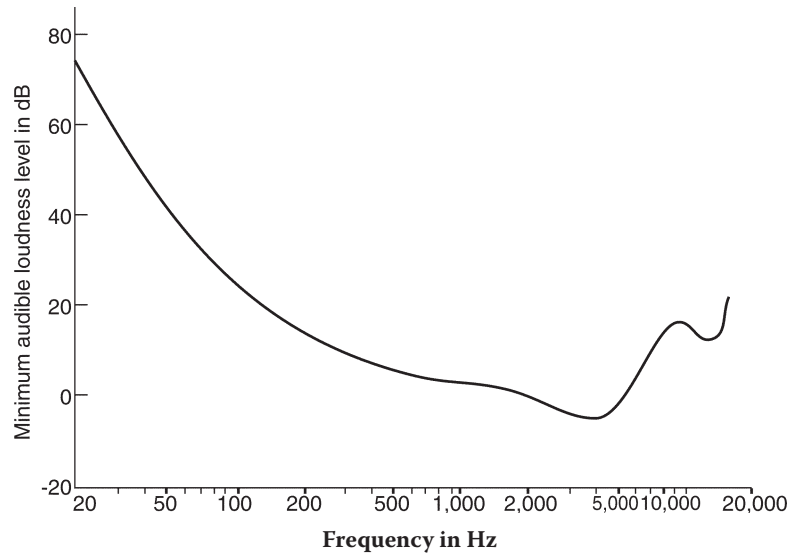
| Note           | Frequency | Note           | Frequency | Note           | Frequency | Note           | Frequency |
|----------------|-----------|----------------|-----------|----------------|-----------|----------------|-----------|
| C <sub>0</sub> | 16        | C <sub>2</sub> | 64        | C <sub>4</sub> | 256       | C <sub>6</sub> | 1024      |
| D <sub>0</sub> | 18        | D <sub>2</sub> | 72        | D <sub>4</sub> | 288       | D <sub>6</sub> | 1152      |
| E <sub>0</sub> | 20        | E <sub>2</sub> | 80        | E <sub>4</sub> | 320       | E <sub>6</sub> | 1280      |
| F <sub>0</sub> | 21.33     | F <sub>2</sub> | 85.33     | F <sub>4</sub> | 341.33    | F <sub>6</sub> | 1365.33   |
| G <sub>0</sub> | 24        | G <sub>2</sub> | 96        | G <sub>4</sub> | 384       | G <sub>6</sub> | 1536      |
| A <sub>0</sub> | 26.67     | A <sub>2</sub> | 106.67    | A <sub>4</sub> | 426.67    | A <sub>6</sub> | 1706.67   |
| B <sub>0</sub> | 30        | B <sub>2</sub> | 120       | B <sub>4</sub> | 480       | B <sub>6</sub> | 1920      |
| C <sub>1</sub> | 32        | C <sub>3</sub> | 128       | C <sub>5</sub> | 512       | C <sub>7</sub> | 2048      |
| D <sub>1</sub> | 36        | D <sub>3</sub> | 144       | D <sub>5</sub> | 576       | D <sub>7</sub> | 2304      |
| E <sub>1</sub> | 40        | E <sub>3</sub> | 160       | E <sub>5</sub> | 640       | E <sub>7</sub> | 2560      |
| F <sub>1</sub> | 42.67     | F <sub>3</sub> | 170.67    | F <sub>5</sub> | 682.67    | F <sub>7</sub> | 2730.67   |
| G <sub>1</sub> | 48        | G <sub>3</sub> | 192       | G <sub>5</sub> | 768       | G <sub>7</sub> | 3072      |
| A <sub>1</sub> | 53.33     | A <sub>3</sub> | 213.33    | A <sub>5</sub> | 853.33    | A <sub>7</sub> | 3413.33   |
| B <sub>1</sub> | 60        | B <sub>3</sub> | 240       | B <sub>5</sub> | 960       | B <sub>7</sub> | 3840      |
|                |           |                |           |                |           | C <sub>8</sub> | 4096      |

## CHARACTERISTICS OF HUMAN HEARING

The human ear is sensitive to sound waves with frequencies in the range from a few hertz to almost 20 kHz. Auditory response is usually expressed in terms of the *loudness level* of a sound, which is a measure of the sound pressure. The reference level, which is given in the unit *phon*, is a pure tone of frequency 1000 Hz with sound pressure of 20  $\mu\text{Pa}$  (in cgs units,  $2 \cdot 10^{-4} \text{ dyn/cm}^2$ ); loudness level is usually expressed in decibels (dB) relative to this reference level. If a normal observer perceives an arbitrary sound to

be equally loud as this reference sound, the sound is said to have the loudness level of the reference. The sensitivity of the typical human ear ranges from about 0 dB, the threshold loudness level, to about 140 dB, the level at which pain sets in. The minimum detectable level thus represents a sound wave of pressure 20  $\mu\text{Pa}$  and intensity (power density)  $10^{-16} \text{ W/cm}^2$ .

The following figure illustrates the frequency dependence of the threshold for an average young adult.



The relation between loudness level and frequency for a typical person is expressed by the following table:

| Sound pressure level<br>in dB relative to 20 $\mu\text{Pa}$ | Frequency in Hz |     |      |      |      |       |
|-------------------------------------------------------------|-----------------|-----|------|------|------|-------|
|                                                             | 125             | 500 | 1000 | 4000 | 8000 | 10000 |
| 10                                                          |                 |     | 10   | 18   |      |       |
| 20                                                          |                 | 16  | 20   | 28   | 11   |       |
| 30                                                          | 4               | 27  | 30   | 37   | 21   | 17    |
| 40                                                          | 17              | 39  | 40   | 45   | 30   | 26    |
| 50                                                          | 34              | 52  | 50   | 54   | 38   | 35    |
| 60                                                          | 52              | 65  | 60   | 64   | 47   | 44    |
| 70                                                          | 70              | 76  | 70   | 73   | 56   | 54    |
| 80                                                          | 86              | 86  | 80   | 83   | 66   | 64    |
| 90                                                          | 98              | 96  | 90   | 94   | 77   | 74    |
| 100                                                         | 108             | 105 | 100  | 106  | 88   | 86    |

Thus, a 10,000 Hz tone at a pressure level of 50 dB seems equally loud as a 1000 Hz tone at a pressure of 35 dB.

The term *noise* refers to any unwanted sound, either a pure tone or a mixture of frequencies. Since the sensitivity of the ear is fre-

quency dependent, as illustrated by the above table, noise level is expressed in a frequency-weighted scale, known as A-weighting. Decibel readings on this scale are designated as dBA. Typical noise levels from various sources are illustrated in this table:

| Source                             | Noise level in dBa |
|------------------------------------|--------------------|
| Rocket engine                      | 200                |
| Jet aircraft engine                | 160                |
| Light aircraft, cruising           | 140                |
| Tractor, 150 hp                    | 115                |
| Electric motor, 100 hp at 2600 rpm | 105                |
| Pneumatic drill                    | 100                |
| Subway train                       | 90                 |
| Vacuum cleaner                     | 85                 |
| Heavy automobile traffic           | 75                 |
| Conversational speech              | 65                 |
| Whispered speech                   | 40                 |
| Background noise, recording studio | 25-30              |

Recommended noise thresholds in the workplace have been established by the American Conference of Government Industrial

Hygienists. Some examples of the maximum safe levels for different daily exposure times are given below.

| Duration of exposure | Max. level in dBa |
|----------------------|-------------------|
| 24 h                 | 80                |
| 8 h                  | 85                |
| 4 h                  | 88                |
| 1 h                  | 94                |
| 30 min               | 97                |
| 15 min               | 100               |
| 2 min                | 109               |
| 28 s                 | 115               |
| 0.11 s               | 139               |

No exposure greater than 140 dBa is permitted. Further details may be found in Reference 3.

## References

1. Anderson, H. L., Ed., *A Physicist's Desk Reference*, American Institute of Physics, New York, 1989, chap. 2.
2. Gray, D. E., Ed., *American Institute of Physics Handbook, Third Edition*, McGraw Hill, New York, 1972, chap. 3.
3. *Threshold Limit Values for Chemical Substances and Physical Agents; Biological Exposure Indices*, 2008 Edition, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-1634; <www.acgih.org>.



# INTERSTELLAR MOLECULES

Frank J. Lovas and Lewis E. Snyder

A number of molecules have been detected in the interstellar medium, in circumstellar envelopes around evolved stars, and comae and tails of comets through observation of their microwave, infrared, or optical spectra. The following list gives the molecules and the particular isotopic species that have been reported so far. Molecules are listed by molecular formula in the Hill order. All species not footnoted otherwise are observed in interstellar clouds, while some are also found in comets and circumstellar clouds. The list was last updated in October 2008 and lists 162 molecules (298 isotopic forms).

## References

1. Lovas, F. J., Recommended Rest Frequencies for Observed Interstellar Molecule Microwave Transitions — 2002 Revision, *J. Phys. Chem. Ref. Data* 33, 177–355 (2004); and update appearing at <http://physics.nist.gov/PhysRefData/micro/html/contents.html>
2. Snyder, L. E., Cometary Molecules, Internat. Astron. Union Symposium No. 150, *Astrochemistry of Cosmic Phenomena*, ed. P. D. Singh, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 427–434 (1992).

| Molecular formula              | Name                    | Isotopic species                                                                                                                                                                 |
|--------------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AlCl                           | Aluminum monochloride   | Al <sup>35</sup> Cl <sup>a</sup><br>Al <sup>37</sup> Cl <sup>a</sup>                                                                                                             |
| AlF                            | Aluminum monofluoride   | AlF <sup>a</sup>                                                                                                                                                                 |
| AlN                            | Aluminum isocyanide     | AlNC <sup>a</sup>                                                                                                                                                                |
| CF <sup>+</sup>                | Fluoromethylidynium ion | CF <sup>+</sup>                                                                                                                                                                  |
| CH                             | Methylidyne             | CH                                                                                                                                                                               |
| CH <sup>+</sup>                | Methylumylidene         | CH <sup>+</sup>                                                                                                                                                                  |
| CHN                            | Hydrogen cyanide        | HCN<br>H <sup>13</sup> CN<br>HC <sup>15</sup> N<br>DCN<br>HNC<br>H <sup>15</sup> NC<br>HN <sup>13</sup> C<br>DNC<br>D <sup>15</sup> NC                                           |
| CHN                            | Hydrogen isocyanide     | HNC                                                                                                                                                                              |
| CHNO                           | Isocyanic acid          | HNCO<br>DNCO                                                                                                                                                                     |
| CHNO                           | Hydroxyl cyanide        | HOCN                                                                                                                                                                             |
| CHNS                           | Isothiocyanic acid      | HNCS                                                                                                                                                                             |
| CHO                            | Oxomethyl               | HCO                                                                                                                                                                              |
| CHO <sup>+</sup>               | Oxomethylum             | HCO <sup>+</sup><br>H <sup>13</sup> CO <sup>+</sup><br>HC <sup>17</sup> O <sup>+</sup><br>HC <sup>18</sup> O <sup>+</sup><br>DCO <sup>+</sup><br>D <sup>13</sup> CO <sup>+</sup> |
| CHO <sup>+</sup>               | Hydroxymethylidyne      | HOC <sup>+</sup>                                                                                                                                                                 |
| CHO <sub>2</sub> <sup>+</sup>  | Hydroxyoxomethylum      | HOCO <sup>+</sup>                                                                                                                                                                |
| CHP                            | Phosphaethyne           | HCP <sup>a</sup>                                                                                                                                                                 |
| CHS <sup>+</sup>               | Thiooxomethylum         | HCS <sup>+</sup>                                                                                                                                                                 |
| CH <sub>2</sub>                | Methylene               | CH <sub>2</sub>                                                                                                                                                                  |
| CH <sub>2</sub> N <sup>+</sup> | Iminomethylum           | HCNH <sup>+</sup>                                                                                                                                                                |
| CH <sub>2</sub> N              | Methylene amidogen      | CH <sub>2</sub> N                                                                                                                                                                |
| CH <sub>2</sub> N <sub>2</sub> | Cyanamide               | NH <sub>2</sub> CN                                                                                                                                                               |
| CH <sub>2</sub> O              | Formaldehyde            | H <sub>2</sub> CO<br>H <sub>2</sub> <sup>13</sup> CO<br>H <sub>2</sub> C <sup>18</sup> O<br>HDCO<br>D <sub>2</sub> CO                                                            |
| CH <sub>2</sub> O <sub>2</sub> | Formic acid             | HCOOH<br>H <sup>13</sup> COOH                                                                                                                                                    |

| Molecular formula              | Name                 | Isotopic species                                                                                                                                                                     |
|--------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                |                      | HCOOD<br>DCOOH                                                                                                                                                                       |
| CH <sub>2</sub> S              | Thioformaldehyde     | H <sub>2</sub> CS<br>H <sub>2</sub> <sup>13</sup> CS<br>H <sub>2</sub> C <sup>34</sup> S<br>HDCS<br>D <sub>2</sub> CS                                                                |
| CH <sub>3</sub>                | Methyl               | CH <sub>3</sub> <sup>a</sup>                                                                                                                                                         |
| CH <sub>3</sub> N              | Methanimine          | CH <sub>2</sub> NH<br><sup>13</sup> CH <sub>2</sub> NH                                                                                                                               |
| CH <sub>3</sub> NO             | Formamide            | NH <sub>2</sub> CHO<br>NH <sub>2</sub> <sup>13</sup> CHO                                                                                                                             |
| CH <sub>3</sub> O <sup>+</sup> | Hydroxymethylum ion  | H <sub>2</sub> COH <sup>+</sup>                                                                                                                                                      |
| CH <sub>4</sub>                | Methane              | CH <sub>4</sub>                                                                                                                                                                      |
| CH <sub>4</sub> O              | Methanol             | CH <sub>3</sub> OH<br><sup>13</sup> CH <sub>3</sub> OH<br>CH <sub>3</sub> <sup>18</sup> OH<br>CH <sub>2</sub> DOH<br>CH <sub>3</sub> OD<br>CHD <sub>2</sub> OH<br>CD <sub>3</sub> OH |
| CH <sub>4</sub> S              | Methanethiol         | CH <sub>3</sub> SH                                                                                                                                                                   |
| CH <sub>5</sub> N              | Methylamine          | CH <sub>3</sub> NH <sub>2</sub>                                                                                                                                                      |
| CMgN                           | Magnesium cyanide    | MgCN <sup>a</sup>                                                                                                                                                                    |
| CMgN                           | Magnesium isocyanide | <sup>24</sup> MgNC <sup>a</sup><br><sup>25</sup> MgNC <sup>a</sup><br><sup>26</sup> MgNC <sup>a</sup>                                                                                |
| CN                             | Cyanide radical      | CN<br><sup>13</sup> CN<br>C <sup>15</sup> N                                                                                                                                          |
| CN <sup>+</sup>                | Cyanide radical ion  | CN <sup>+</sup> <sup>b</sup>                                                                                                                                                         |
| CNNa                           | Sodium cyanide       | NaCN <sup>a</sup>                                                                                                                                                                    |
| CNSi                           | Silicon cyanide      | SiCN <sup>a</sup>                                                                                                                                                                    |
| CNSi                           | Silicon isocyanide   | SiNC <sup>a</sup>                                                                                                                                                                    |
| CN <sub>2</sub>                | Cyanoimidogen        | NCN <sup>b</sup>                                                                                                                                                                     |
| CO                             | Carbon monoxide      | CO<br><sup>13</sup> CO<br>C <sup>17</sup> O<br>C <sup>18</sup> O<br><sup>13</sup> C <sup>17</sup> O<br><sup>13</sup> C <sup>18</sup> O<br><sup>14</sup> CO                           |

| Molecular formula                            | Name                   | Isotopic species                             | Molecular formula                            | Name                           | Isotopic species                                 |
|----------------------------------------------|------------------------|----------------------------------------------|----------------------------------------------|--------------------------------|--------------------------------------------------|
| CO <sup>+</sup>                              | Carbon monoxide ion    | CO <sup>+</sup>                              | C <sub>3</sub>                               | Tricarbon                      | C <sub>3</sub>                                   |
| COS                                          | Carbon oxysulfide      | OCS                                          | C <sub>3</sub> H                             | Cyclopropenylidyne             | <i>c</i> -C <sub>3</sub> H                       |
|                                              |                        | OC <sup>34</sup> S                           |                                              |                                | <i>c</i> -CC <sup>13</sup> CH                    |
|                                              |                        | O <sup>13</sup> CS                           | C <sub>3</sub> H                             | Propenylidyne                  | <i>l</i> -C <sub>3</sub> H                       |
|                                              |                        | <sup>18</sup> OCS                            | C <sub>3</sub> HN                            | Cyanoacetylene                 | HCCCN                                            |
| CO <sub>2</sub>                              | Carbon dioxide         | CO <sub>2</sub>                              |                                              |                                | H <sup>13</sup> CCCN                             |
| CO <sub>2</sub> <sup>+</sup>                 | Carbon dioxide ion     | CO <sub>2</sub> <sup>+</sup> <sup>b</sup>    |                                              |                                | HC <sup>13</sup> CCN                             |
| CP                                           | Carbon phosphide       | CP <sup>a</sup>                              |                                              |                                | HCC <sup>13</sup> CN                             |
| CS                                           | Carbon monosulfide     | CS                                           |                                              |                                | HCCC <sup>15</sup> N                             |
|                                              |                        | C <sup>33</sup> S                            |                                              |                                | DCCCN                                            |
|                                              |                        | C <sup>34</sup> S                            | C <sub>3</sub> HN                            | Isocyanoacetylene              | HCCNC                                            |
|                                              |                        | C <sup>36</sup> S                            | C <sub>3</sub> HN                            | 3-Imino-1,2-propadienylidene   | HNCCC                                            |
|                                              |                        | <sup>13</sup> CS                             | C <sub>3</sub> H <sub>2</sub>                | Cyclopropenylidene             | <i>c</i> -C <sub>3</sub> H <sub>2</sub>          |
|                                              |                        | <sup>13</sup> C <sup>34</sup> S              |                                              |                                | <i>c</i> -H <sup>13</sup> CCCH                   |
| CSi                                          | Silicon carbide        | SiC <sup>a</sup>                             |                                              |                                | <i>c</i> -HC <sup>13</sup> CCH                   |
| C <sub>2</sub>                               | Dicarbon               | C <sub>2</sub>                               |                                              |                                | <i>c</i> -C <sub>3</sub> HD                      |
| C <sub>2</sub> H                             | Ethynyl                | C <sub>2</sub> H                             | C <sub>3</sub> H <sub>2</sub>                | Propadienylidene               | <i>l</i> -H <sub>2</sub> CCC                     |
|                                              |                        | <sup>13</sup> CCH                            | C <sub>3</sub> H <sub>2</sub> N <sup>+</sup> | Protonated cyanoacetylene      | HCCCNH <sup>+</sup>                              |
|                                              |                        | C <sup>13</sup> CH                           | C <sub>3</sub> H <sub>2</sub> O              | 2-Propynal                     | HCCCHO                                           |
|                                              |                        | C <sub>2</sub> D                             | C <sub>3</sub> H <sub>2</sub> O              | Cyclopropenone                 | <i>c</i> -C <sub>3</sub> H <sub>2</sub> O        |
| C <sub>2</sub> HN                            | Cyanomethylene         | HCCN                                         | C <sub>3</sub> H <sub>3</sub> N              | Acrylonitrile (vinyl cyanide)  | CH <sub>2</sub> CHCN                             |
| C <sub>2</sub> HNO                           | Cyanoformaldehyde      | CNCHO                                        |                                              |                                | <sup>13</sup> CH <sub>2</sub> CHCN               |
| C <sub>2</sub> H <sub>2</sub>                | Acetylene              | HCCH                                         |                                              |                                | CH <sub>2</sub> <sup>13</sup> CHCN               |
| C <sub>2</sub> H <sub>2</sub> N              | Cyanomethyl            | CH <sub>2</sub> CN                           | C <sub>3</sub> H <sub>4</sub>                | Propyne                        | CH <sub>3</sub> CCH                              |
| C <sub>2</sub> H <sub>2</sub> O              | Ketene                 | H <sub>2</sub> CCO                           |                                              |                                | CH <sub>3</sub> C <sup>13</sup> CH               |
| C <sub>2</sub> H <sub>3</sub> N              | Acetonitrile           | CH <sub>3</sub> CN                           |                                              |                                | <sup>13</sup> CH <sub>3</sub> CCH                |
|                                              |                        | <sup>13</sup> CH <sub>3</sub> CN             |                                              |                                | CH <sub>2</sub> DCCH                             |
|                                              |                        | CH <sub>3</sub> <sup>13</sup> CN             |                                              |                                | CH <sub>3</sub> CCD                              |
|                                              |                        | CH <sub>3</sub> C <sup>15</sup> N            | C <sub>3</sub> H <sub>4</sub> O              | Propenal                       | CH <sub>2</sub> CHCHO                            |
|                                              |                        | CH <sub>2</sub> DCN                          | C <sub>3</sub> H <sub>5</sub> N              | Propanenitrile (ethyl cyanide) | CH <sub>3</sub> CH <sub>2</sub> CN               |
|                                              |                        | CH <sub>3</sub> NC                           |                                              |                                | <sup>13</sup> CH <sub>3</sub> CH <sub>2</sub> CN |
| C <sub>2</sub> H <sub>3</sub> N              | Isocyanomethane        | CH <sub>2</sub> CNH                          |                                              |                                | CH <sub>3</sub> <sup>13</sup> CH <sub>2</sub> CN |
| C <sub>2</sub> H <sub>3</sub> N              | Keteneimine            | H <sub>2</sub> CCH <sub>2</sub>              |                                              |                                | CH <sub>3</sub> CH <sub>2</sub> <sup>13</sup> CN |
| C <sub>2</sub> H <sub>4</sub>                | Ethylene               | NH <sub>2</sub> CH <sub>2</sub> CN           | C <sub>3</sub> H <sub>6</sub>                | Propylene                      | CH <sub>2</sub> CHCH <sub>3</sub>                |
| C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> | Aminoacetonitrile      | CH <sub>3</sub> CHO                          | C <sub>3</sub> H <sub>6</sub> O              | Acetone                        | (CH <sub>3</sub> ) <sub>2</sub> CO               |
| C <sub>2</sub> H <sub>4</sub> O              | Acetaldehyde           | <i>c</i> -C <sub>2</sub> H <sub>4</sub> O    | C <sub>3</sub> H <sub>6</sub> O              | Propanal                       | CH <sub>3</sub> CH <sub>2</sub> CHO              |
| C <sub>2</sub> H <sub>4</sub> O              | Ethylene oxide         | <i>a</i> -CH <sub>2</sub> CHOH               | C <sub>3</sub> N                             | Cyanoethynyl                   | CCCN                                             |
| C <sub>2</sub> H <sub>4</sub> O              | <i>anti</i> -Ethenol   | <i>s</i> -CH <sub>2</sub> CHOH               |                                              |                                | <sup>13</sup> CCCN                               |
| C <sub>2</sub> H <sub>4</sub> O              | <i>syn</i> -Ethenol    | CH <sub>3</sub> OCHO                         |                                              |                                | C <sup>13</sup> CCN                              |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> | Methyl formate         | CH <sub>3</sub> COOH                         |                                              |                                | CC <sup>13</sup> CN                              |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> | Acetic acid            | CH <sub>2</sub> OHCHO                        | C <sub>3</sub> N <sup>-</sup>                | Cyanoethynyl anion             | CCCN <sup>-</sup>                                |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> | Glycolaldehyde         | CH <sub>3</sub> CONH <sub>2</sub>            | C <sub>3</sub> O                             | 1,2-Propadienylidene, 3-oxo    | CCCO                                             |
| C <sub>2</sub> H <sub>5</sub> NO             | Acetamide              | CH <sub>3</sub> CH <sub>3</sub> <sup>b</sup> | C <sub>3</sub> S                             | 1,2-Propadienylidene, 3-thioxo | CCCS                                             |
| C <sub>2</sub> H <sub>6</sub>                | Ethane                 | <i>t</i> -CH <sub>3</sub> CH <sub>2</sub> OH |                                              |                                | CCC <sup>34</sup> S                              |
| C <sub>2</sub> H <sub>6</sub> O              | <i>trans</i> -Ethanol  | <i>g</i> -CH <sub>3</sub> CH <sub>2</sub> OH |                                              |                                | C <sup>13</sup> CCS                              |
| C <sub>2</sub> H <sub>6</sub> O              | <i>gauche</i> -Ethanol | CH <sub>3</sub> OCH <sub>3</sub>             | C <sub>3</sub> Si                            | Silicon tricarbon              | SiC <sub>3</sub>                                 |
| C <sub>2</sub> H <sub>6</sub> O              | Dimethyl ether         | HOCH <sub>2</sub> CH <sub>2</sub> OH         | C <sub>4</sub> H                             | 1,3-Butadiynyl radical         | HCCCC                                            |
| C <sub>2</sub> H <sub>6</sub> O <sub>2</sub> | Ethylene glycol        | CCO                                          |                                              |                                | H <sup>13</sup> CCCC                             |
| C <sub>2</sub> O                             | Oxoethenylidene        | CCP <sup>a</sup>                             |                                              |                                | HC <sup>13</sup> CCC                             |
| C <sub>2</sub> P                             | Phosphaethenylidene    | CCS                                          |                                              |                                | HCC <sup>13</sup> CC                             |
| C <sub>2</sub> S                             | Thioxoethenylidene     | CC <sup>34</sup> S                           |                                              |                                | HCCC <sup>13</sup> C                             |
|                                              |                        | <sup>13</sup> CCS                            |                                              |                                | DCCCC                                            |
|                                              |                        | C <sup>13</sup> CS                           | C <sub>4</sub> H <sup>-</sup>                | 1,3-Butadiynyl anion           | HCCCC <sup>-</sup>                               |
| C <sub>2</sub> Si                            | Silicon dicarbide      | <i>c</i> -SiC <sub>2</sub>                   | C <sub>4</sub> HN                            | 3-Cyano-1,2-propadienylidene   | HCCCCN                                           |
|                                              |                        | <i>c</i> - <sup>29</sup> SiC <sub>2</sub>    | C <sub>4</sub> H <sub>2</sub>                | Butatrienylidene               | H <sub>2</sub> CCCC                              |
|                                              |                        | <i>c</i> - <sup>30</sup> SiC <sub>2</sub>    | C <sub>4</sub> H <sub>2</sub>                | 1,3-Butadiyne                  | HCCCCH <sup>a</sup>                              |
|                                              |                        | <i>c</i> -Si <sup>13</sup> CC                | C <sub>4</sub> H <sub>3</sub> N              | 2-Butynenitrile                | CH <sub>3</sub> CCCN                             |

| Molecular formula               | Name                             | Isotopic species                  | Molecular formula             | Name                | Isotopic species                           |
|---------------------------------|----------------------------------|-----------------------------------|-------------------------------|---------------------|--------------------------------------------|
| C <sub>4</sub> H <sub>3</sub> N | Cyanoallene                      | CH <sub>2</sub> CCHCN             | H <sub>2</sub> O              | Water               | H <sub>2</sub> O                           |
| C <sub>4</sub> Si               | Silicon tetracarbide             | SiC <sub>4</sub> <sup>a</sup>     |                               |                     | H <sub>2</sub> <sup>18</sup> O             |
|                                 |                                  | SiCCCC <sup>13</sup> C            |                               |                     | HDO                                        |
| C <sub>5</sub>                  | Pentacarbon                      | C <sub>5</sub> <sup>a</sup>       |                               |                     | D <sub>2</sub> O                           |
| C <sub>5</sub> H                | 2,4-Pentadiynylidyne             | HCCCCC                            | H <sub>2</sub> O <sup>+</sup> | Oxoniumyl           | H <sub>2</sub> O <sup>+</sup> <sup>b</sup> |
| C <sub>5</sub> HN               | 2,4-Pentadiynenitrile            | HCCCCCN                           | H <sub>2</sub> S              | Hydrogen sulfide    | H <sub>2</sub> S                           |
|                                 |                                  | H <sup>13</sup> CCCCCN            |                               |                     | H <sub>2</sub> <sup>34</sup> S             |
|                                 |                                  | HC <sup>13</sup> CCCCN            |                               |                     | HDS                                        |
|                                 |                                  | HCC <sup>13</sup> CCCN            |                               |                     | D <sub>2</sub> S                           |
|                                 |                                  | HCCC <sup>13</sup> CCN            | H <sub>3</sub> <sup>+</sup>   | Trihydrogen ion     | H <sub>3</sub> <sup>+</sup>                |
|                                 |                                  | HCCCC <sup>13</sup> CN            |                               |                     | H <sub>2</sub> D <sup>+</sup>              |
|                                 |                                  | DCCCCCN                           |                               |                     | D <sub>2</sub> H <sup>+</sup>              |
| C <sub>5</sub> H <sub>4</sub>   | 1,3-Pentadiyne                   | CH <sub>3</sub> C <sub>4</sub> H  | H <sub>3</sub> N              | Ammonia             | NH <sub>3</sub>                            |
| C <sub>5</sub> N                | 1,3-Butadiynylum, 4-cyano        | C <sub>5</sub> N                  |                               |                     | <sup>15</sup> NH <sub>3</sub>              |
| C <sub>6</sub> H                | 1,3,5-Hexatriynyl                | HCCCCCC                           |                               |                     | NH <sub>2</sub> D                          |
| C <sub>6</sub> H <sup>-</sup>   | 1,3,5-Hexatriynyl anion          | HCCCCCC <sup>-</sup>              |                               |                     | NHD <sub>2</sub>                           |
| C <sub>6</sub> H <sub>2</sub>   | 1,3,5-Hexatriyne                 | HCCCCCCH <sup>a</sup>             |                               |                     | ND <sub>3</sub>                            |
| C <sub>6</sub> H <sub>2</sub>   | 1,2,3,4,5-Hexapentaenylidene     | H <sub>2</sub> CCCCCC             | H <sub>3</sub> O <sup>+</sup> | Oxonium hydride     | H <sub>3</sub> O <sup>+</sup>              |
| C <sub>6</sub> H <sub>3</sub> N | Methylcyanodiacetylene           | CH <sub>3</sub> C <sub>4</sub> CN | H <sub>4</sub> Si             | Silane              | SiH <sub>4</sub> <sup>a</sup>              |
| C <sub>6</sub> H <sub>6</sub>   | Benzene                          | C <sub>6</sub> H <sub>6</sub>     | NO                            | Nitric oxide        | NO                                         |
| C <sub>7</sub> H                | 2,4,6-Heptatriynylidyne          | HCCCCCCC                          | NP                            | Phosphorous nitride | PN                                         |
| C <sub>7</sub> HN               | 2,4,6-Heptatriynenitrile         | HC <sub>7</sub> N                 | NS                            | Nitrogen sulfide    | NS                                         |
| C <sub>7</sub> H <sub>4</sub>   | Methyltriacetylene               | CH <sub>3</sub> C <sub>6</sub> H  |                               |                     | N <sup>34</sup> S                          |
| C <sub>8</sub> H                | 1,3,5,7-Octatetraynyl            | HC <sub>8</sub>                   | NSi                           | Silicon nitride     | SiN                                        |
| C <sub>8</sub> H <sup>-</sup>   | 1,3,5,7-Octatetraynyl anion      | HC <sub>8</sub> <sup>-</sup>      | N <sub>2</sub>                | Nitrogen            | N <sub>2</sub>                             |
| C <sub>9</sub> HN               | 2,4,6,8-Nonatetraynenitrile      | HC <sub>9</sub> N                 | N <sub>2</sub> <sup>+</sup>   | Nitrogen ion        | N <sub>2</sub> <sup>+</sup> <sup>b</sup>   |
| C <sub>11</sub> HN              | 2,4,6,8,10-Undecapentaynenitrile | HC <sub>11</sub> N                | N <sub>2</sub> O              | Nitrous oxide       | N <sub>2</sub> O                           |
| ClH                             | Hydrogen chloride                | H <sup>35</sup> Cl                | OP                            | Phosphorus monoxide | PO <sup>a</sup>                            |
|                                 |                                  | H <sup>37</sup> Cl                | OS                            | Sulfur monoxide     | SO                                         |
| ClK                             | Potassium chloride               | K <sup>35</sup> Cl <sup>a</sup>   |                               |                     | <sup>34</sup> SO                           |
|                                 |                                  | K <sup>37</sup> Cl <sup>a</sup>   |                               |                     | <sup>33</sup> SO                           |
| ClNa                            | Sodium chloride                  | Na <sup>35</sup> Cl <sup>a</sup>  |                               |                     | S <sup>18</sup> O                          |
|                                 |                                  | Na <sup>37</sup> Cl <sup>a</sup>  | OS <sup>+</sup>               | Sulfur monoxide ion | SO <sup>+</sup>                            |
| FH                              | Hydrogen fluoride                | HF                                | OSi                           | Silicon monoxide    | SiO                                        |
| FeO                             | Iron monoxide                    | FeO                               |                               |                     | Si <sup>18</sup> O                         |
| HLi                             | Lithium hydride                  | <sup>7</sup> LiH                  |                               |                     | <sup>29</sup> SiO                          |
| HN                              | Imidogen                         | HN                                |                               |                     | <sup>30</sup> SiO                          |
| HNO                             | Nitrosyl hydride                 | HNO                               | O <sub>2</sub>                | Oxygen              | O <sub>2</sub>                             |
| HN <sub>2</sub> <sup>+</sup>    | Hydrodinitrogen(1+)              | N <sub>2</sub> H <sup>+</sup>     | O <sub>2</sub> S              | Sulfur dioxide      | SO <sub>2</sub>                            |
|                                 |                                  | <sup>15</sup> NNH <sup>+</sup>    |                               |                     | <sup>33</sup> SO <sub>2</sub>              |
|                                 |                                  | N <sup>15</sup> NH <sup>+</sup>   |                               |                     | <sup>34</sup> SO <sub>2</sub>              |
|                                 |                                  | N <sub>2</sub> D <sup>+</sup>     |                               |                     | OS <sup>17</sup> O                         |
| HO                              | Hydroxyl                         | OH                                |                               |                     | OS <sup>18</sup> O                         |
|                                 |                                  | <sup>17</sup> OH                  | SSi                           | Silicon monosulfide | SiS                                        |
|                                 |                                  | <sup>18</sup> OH                  |                               |                     | Si <sup>33</sup> S                         |
| HO <sup>+</sup>                 | Oxoniumylidene                   | OH <sup>+</sup> <sup>b</sup>      |                               |                     | Si <sup>34</sup> S                         |
| HS                              | Mercapto                         | SH                                |                               |                     | <sup>29</sup> SiS                          |
| H <sub>2</sub>                  | Hydrogen                         | H <sub>2</sub>                    |                               |                     | <sup>29</sup> Si <sup>34</sup> S           |
| H <sub>2</sub> N                | Amidogen                         | NH <sub>2</sub>                   |                               |                     | <sup>30</sup> SiS                          |
|                                 |                                  |                                   |                               |                     | <sup>30</sup> Si <sup>34</sup> S           |
|                                 |                                  |                                   | S <sub>2</sub>                | Sulfur              | S <sub>2</sub> <sup>b</sup>                |

*l*- before the isotopic species indicates a linear configuration, while *c*- indicates a cyclic molecule.

<sup>a</sup> Reported only in circumstellar clouds.

<sup>b</sup> Reported only in comets.

## WEATHER-RELATED SCALES

### Saffir-Simpson Hurricane Scale

- **Tropical Storm**  
Winds 39–73 mph
- **Category 1 Hurricane** — winds 74–95 mph (64–82 knots); pressure greater than 980 mbar; storm surge 3–5 ft (1.0–1.7 m)  
No real damage to buildings. Damage to unanchored mobile homes. Some damage to poorly constructed signs. Also, some coastal flooding and minor pier damage.  
— Examples: Irene 1999 and Allison 1995
- **Category 2 Hurricane** — winds 96–110 mph (83–95 knots); pressure 979–965 mbar; storm surge 6–8 ft (1.8–2.6 m)  
Some damage to building roofs, doors and windows. Considerable damage to mobile homes. Flooding damages piers and small craft in unprotected moorings may break their moorings. Some trees blown down.  
— Examples: Bonnie 1998, Georges (FL & LA) 1998 and Gloria 1985
- **Category 3 Hurricane** — winds 111–130 mph (96–113 knots); pressure 964–945 mbar; storm surge 9–12 ft (2.7–3.8 m)  
Some structural damage to small residences and utility buildings. Large trees blown down. Mobile homes and poorly built signs destroyed. Flooding near the coast destroys smaller structures with larger structures damaged by floating debris. Terrain may be flooded well inland.  
— Examples: Keith 2000, Fran 1996, Opal 1995, Alicia 1983 and Betsy 1965

- **Category 4 Hurricane** — winds 131–155 mph (114–135 knots); pressure 944–920 mbar; storm surge 13–18 ft (3.9–5.6 m)  
More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland.  
— Examples: Hugo 1989 and Donna 1960
- **Category 5 Hurricane** — winds 156 mph and up (135+ knots); pressure less than 920 mbar; storm surge 19+ ft (5.7+ m)  
Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required.  
— Examples: Andrew (FL) 1992, Camille 1969 and Labor Day 1935

### Fujita Tornado Damage Scale

The original Fujita Scale was modified by NOAA in February 2007 and is now called the Enhanced Fujita Scale (EF). It is an operational scale based on the estimated speed of three-second wind gusts, as indicated by typical damage levels. The table below describes the damage levels according to the original scale. In the enhanced scale, the damage is measured by a more elaborate set of criteria (see <http://www.spc.noaa.gov/efscale/ef-scale.html>).

| EF Number | 3 s Gusts (mph) | Typical damage (according to the original Fujita Scale)                                                                                                                                                                |
|-----------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0         | 65–85           | <b>Light damage.</b> Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.                                                                                        |
| 1         | 86–110          | <b>Moderate damage.</b> Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.                                                                                      |
| 2         | 111–135         | <b>Considerable damage.</b> Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.                        |
| 3         | 136–165         | <b>Severe damage.</b> Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.                                            |
| 4         | 166–200         | <b>Devastating damage.</b> Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.                                                       |
| 5         | Over 200        | <b>Incredible damage.</b> Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yd); trees debarked; incredible phenomena will occur. |

### Beaufort Wind Scale

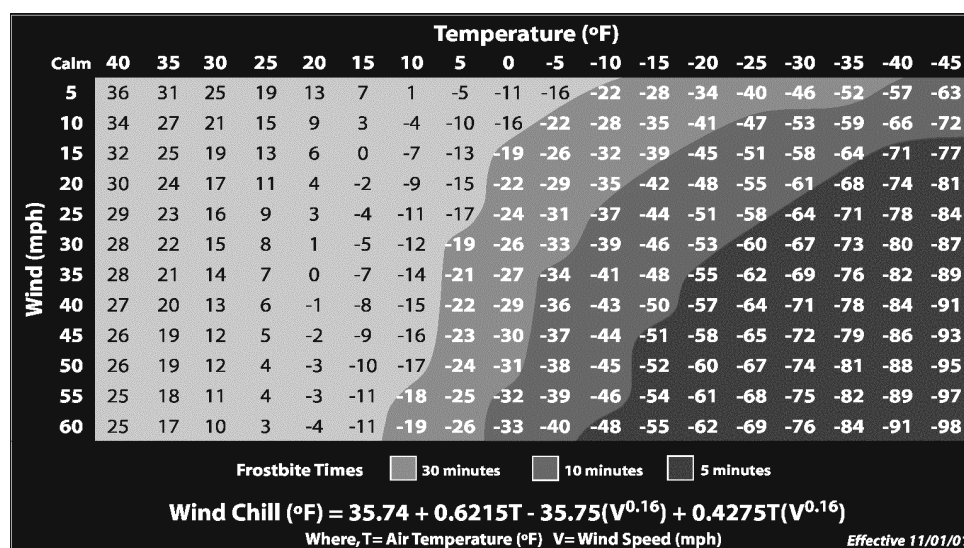
The Beaufort Wind Scale was devised by British Rear-Admiral Sir Francis Beaufort in 1805 based on observations of the effects of the wind.

| Force | Wind (knots) | WMO classification | Appearance of wind effects                                 |                                                                |
|-------|--------------|--------------------|------------------------------------------------------------|----------------------------------------------------------------|
|       |              |                    | On the water                                               | On land                                                        |
| 0     | < 1          | Calm               | Sea surface smooth and mirror-like                         | Calm, smoke rises vertically                                   |
| 1     | 1–3          | Light Air          | Scaly ripples, no foam crests                              | Smoke drift indicates wind direction, still wind vanes         |
| 2     | 4–6          | Light Breeze       | Small wavelets, crests glassy, no breaking                 | Wind felt on face, leaves rustle, vanes begin to move          |
| 3     | 7–10         | Gentle Breeze      | Large wavelets, crests begin to break, scattered whitecaps | Leaves and small twigs constantly moving, light flags extended |

| Force | Wind (knots) | WMO classification | Appearance of wind effects                                                                                               |                                                                                        |
|-------|--------------|--------------------|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
|       |              |                    | On the water                                                                                                             | On land                                                                                |
| 4     | 11–16        | Moderate Breeze    | Small waves 1–4 ft. becoming longer, numerous whitecaps                                                                  | Dust, leaves, and loose paper lifted, small tree branches move                         |
| 5     | 17–21        | Fresh Breeze       | Moderate waves 4–8 ft taking longer form, many whitecaps, some spray                                                     | Small trees in leaf begin to sway                                                      |
| 6     | 22–27        | Strong Breeze      | Larger waves 8–13 ft, whitecaps common, more spray                                                                       | Larger tree branches moving, whistling in wires                                        |
| 7     | 28–33        | Near Gale          | Sea heaps up, waves 13–20 ft, white foam streaks off breakers                                                            | Whole trees moving, resistance felt walking against wind                               |
| 8     | 34–40        | Gale               | Moderately high (13–20 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks | Whole trees in motion, resistance felt walking against wind                            |
| 9     | 41–47        | Strong Gale        | High waves (20 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility                               | Slight structural damage occurs, slate blows off roofs                                 |
| 10    | 48–55        | Storm              | Very high waves (20–30 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility | Seldom experienced on land, trees broken or uprooted, "considerable structural damage" |
| 11    | 56–63        | Violent Storm      | Exceptionally high (30–45 ft) waves, foam patches cover sea, visibility more reduced                                     |                                                                                        |
| 12    | 64+          | Hurricane          | Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced              |                                                                                        |

### Wind Chill

The following chart prepared by the U. S. National Weather Service gives the temperature perceived by an average person as a function of the real air temperature and the wind speed. The current scale was adopted in 2001.



### Reference

National Oceanic and Atmospheric Administration, <http://www.noaa.gov>

## GLOBAL WARMING POTENTIAL OF GREENHOUSE GASES

The Global Warming Potential (GWP) of a gas is a measure of the degree, relative to carbon dioxide, to which the presence of that gas in the atmosphere will contribute to a long-term increase in global temperature. The calculation of the GWP for a given gas takes into account the efficiency of the gas in absorbing solar radiation (primarily determined by the infrared spectrum of the compound) and the time the compound will remain in the atmosphere before it is removed by natural processes. Thus if a pulse of 1 kg of the gas is emitted to the atmosphere at the same time as a pulse of 1 kg of CO<sub>2</sub>, the GWP compares the warming effect of the gas relative to CO<sub>2</sub> over various time horizons.

This table, which is taken from the 2007 report of the Intergovernmental Panel of Climate Change (IPCC), gives the life-time in years and the radiative efficiency in watts per square meter for a concentration of one part per billion for the major compounds identified in the Kyoto Protocol as contributing to global climate change. Radiative efficiency is a measure of the radiative forcing that influences the energy balance in the Earth-atmosphere system. The last four columns of the table give the Global Warming Potential, first as estimated in 1995 for a 100 year time horizon, and then as estimated with improved data in 2007 for 20-,

100-, and 500-year horizons. The calculation of a GWP involves a number of assumptions, and other measures have been proposed (see Reference).

The list of compounds includes those identified in the Montreal Protocol as contributing to ozone depletion, since these compounds also contribute to global warming. It also includes compounds used or proposed as replacements for the ozone-depleting compounds but which still have global warming potential.

### Reference

Forster, P., V. Ramaswamy, P. Artaxo, T. Bernsten, R. Betts, D. W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz, and R. Van Dorland, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Sin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H.L. Miller (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Available on the Internet at < <http://ipcc-wg1.ucar.edu/wg1/wg1-report.html> >.

| Compound                                              | Synonym/Code         | Formula                                            | Lifetime<br>(years) | Rad. eff.<br>W m <sup>-2</sup> ppb <sup>-1</sup> | GWP for given time horizon |                  |        |        |
|-------------------------------------------------------|----------------------|----------------------------------------------------|---------------------|--------------------------------------------------|----------------------------|------------------|--------|--------|
|                                                       |                      |                                                    |                     |                                                  | 1995<br>100 yr             | Current estimate |        |        |
|                                                       |                      |                                                    |                     |                                                  |                            | 20 yr            | 100 yr | 500 yr |
| <b>Natural atmospheric constituents</b>               |                      |                                                    |                     |                                                  |                            |                  |        |        |
| Carbon dioxide                                        |                      | CO <sub>2</sub>                                    |                     | 1.4×10 <sup>-5</sup>                             | 1                          | 1                | 1      | 1      |
| Methane                                               |                      | CH <sub>4</sub>                                    | 12                  | 3.7×10 <sup>-4</sup>                             | 21                         | 72               | 25     | 7.6    |
| Nitrous oxide                                         |                      | N <sub>2</sub> O                                   | 114                 | 3.03×10 <sup>-3</sup>                            | 310                        | 289              | 298    | 153    |
| <b>Substances controlled by the Montreal Protocol</b> |                      |                                                    |                     |                                                  |                            |                  |        |        |
| Trichlorofluoromethane                                | CFC-11               | CCl <sub>3</sub> F                                 | 45                  | 0.25                                             | 3800                       | 6730             | 4750   | 1620   |
| Dichlorodifluoromethane                               | CFC-12               | CCl <sub>2</sub> F <sub>2</sub>                    | 100                 | 0.32                                             | 8100                       | 11000            | 10900  | 5200   |
| Chlorotrifluoromethane                                | CFC-13               | CClF <sub>3</sub>                                  | 640                 | 0.25                                             |                            | 10800            | 14400  | 16400  |
| 1,1,2-Trichloro-1,2,2-trifluoroethane                 | CFC-113              | CCl <sub>2</sub> FCF <sub>2</sub>                  | 85                  | 0.3                                              | 4800                       | 6540             | 6130   | 2700   |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane                | CFC-114              | CClF <sub>2</sub> CCF <sub>2</sub>                 | 300                 | 0.31                                             |                            | 8040             | 10000  | 8730   |
| Chloropentafluoroethane                               | CFC-115              | CClF <sub>2</sub> CF <sub>3</sub>                  | 1700                | 0.18                                             |                            | 5310             | 7370   | 9990   |
| Bromotrifluoromethane                                 | Halon-1301           | CBrF <sub>3</sub>                                  | 65                  | 0.32                                             | 5400                       | 8480             | 7140   | 2760   |
| Bromochlorodifluoromethane                            | Halon-1211           | CBrClF <sub>2</sub>                                | 16                  | 0.3                                              |                            | 4750             | 1890   | 575    |
| 1,2-Dibromotetrafluoroethane                          | Halon-2402           | CBrF <sub>2</sub> CBrF <sub>2</sub>                | 20                  | 0.33                                             |                            | 3680             | 1640   | 503    |
| Tetrachloromethane                                    | Carbon tetrachloride | CCl <sub>4</sub>                                   | 26                  | 0.13                                             | 1400                       | 2700             | 1400   | 435    |
| Bromomethane                                          | Methyl bromide       | CH <sub>3</sub> Br                                 | 0.7                 | 0.01                                             |                            | 17               | 5      | 1      |
| 1,1,1-Trichloroethane                                 | Methyl chloroform    | CH <sub>3</sub> CCl <sub>3</sub>                   | 5                   | 0.06                                             |                            | 506              | 146    | 45     |
| Chlorodifluoromethane                                 | HCFC-22              | CHClF <sub>2</sub>                                 | 12                  | 0.2                                              | 1500                       | 5160             | 1810   | 549    |
| 2,2-Dichloro-1,1,1-trifluoroethane                    | HCFC-123             | CHCl <sub>2</sub> CF <sub>3</sub>                  | 1.3                 | 0.14                                             | 90                         | 273              | 77     | 24     |
| 1-Chloro-1,2,2,2-tetrafluoroethane                    | HCFC-124             | CHClF <sub>2</sub> CF <sub>3</sub>                 | 5.8                 | 0.22                                             | 470                        | 2070             | 609    | 185    |
| 1,1-Dichloro-1-fluoroethane                           | HCFC-141b            | CH <sub>3</sub> CCl <sub>2</sub> F                 | 9.3                 | 0.14                                             |                            | 2250             | 725    | 220    |
| 1-Chloro-1,1-difluoroethane                           | HCFC-142b            | CH <sub>3</sub> CClF <sub>2</sub>                  | 17.9                | 0.2                                              | 1800                       | 5490             | 2310   | 705    |
| 3,3-Dichloro-1,1,1,2,2-pentafluoropropane             | HCFC-225ca           | CHCl <sub>2</sub> CF <sub>2</sub> CF <sub>3</sub>  | 1.9                 | 0.2                                              |                            | 429              | 122    | 37     |
| 1,3-Dichloro-1,1,2,2,3-pentafluoropropane             | HCFC-225cb           | CHClF <sub>2</sub> CF <sub>2</sub> CF <sub>2</sub> | 5.8                 | 0.32                                             |                            | 2030             | 595    | 181    |
| <b>Hydrofluorocarbons</b>                             |                      |                                                    |                     |                                                  |                            |                  |        |        |
| Trifluoromethane                                      | HFC-23               | CHF <sub>3</sub>                                   | 270                 | 0.19                                             | 11700                      | 12000            | 14800  | 12200  |
| Difluoromethane                                       | HFC-32               | CH <sub>2</sub> F <sub>2</sub>                     | 4.9                 | 0.11                                             | 650                        | 2330             | 675    | 205    |
| Pentafluoroethane                                     | HFC-125              | CHF <sub>2</sub> CF <sub>3</sub>                   | 29                  | 0.23                                             | 2800                       | 6350             | 3500   | 1100   |

| Compound                                                                           | Synonym/Code                      | Formula                                                                                | Lifetime<br>(years) | Rad. eff.<br>W m <sup>-2</sup> ppb <sup>-1</sup> | GWP for given time horizon |                  |        |        |
|------------------------------------------------------------------------------------|-----------------------------------|----------------------------------------------------------------------------------------|---------------------|--------------------------------------------------|----------------------------|------------------|--------|--------|
|                                                                                    |                                   |                                                                                        |                     |                                                  | 1995                       | Current estimate |        |        |
|                                                                                    |                                   |                                                                                        |                     |                                                  | 100 yr                     | 20 yr            | 100 yr | 500 yr |
| 1,1,1,2-Tetrafluoroethane                                                          | HFC-134a                          | CH <sub>2</sub> FCF <sub>3</sub>                                                       | 14                  | 0.16                                             | 1300                       | 3830             | 1430   | 435    |
| 1,1,1-Trifluoroethane                                                              | HFC-143a                          | CH <sub>3</sub> CF <sub>3</sub>                                                        | 52                  | 0.13                                             | 3800                       | 5890             | 4470   | 1590   |
| 1,1-Difluoroethane                                                                 | HFC-152a                          | CH <sub>3</sub> CHF <sub>2</sub>                                                       | 1.4                 | 0.09                                             | 140                        | 437              | 124    | 38     |
| 1,1,1,2,3,3,3-Heptafluoropropane                                                   | HFC-227ea                         | CF <sub>3</sub> CHFCF <sub>3</sub>                                                     | 34.2                | 0.26                                             | 2900                       | 5310             | 3220   | 1040   |
| 1,1,1,3,3,3-Hexafluoropropane                                                      | HFC-236fa                         | CF <sub>3</sub> CH <sub>2</sub> CF <sub>3</sub>                                        | 240                 | 0.28                                             | 6300                       | 8100             | 9810   | 7660   |
| 1,1,1,3,3-Pentafluoropropane                                                       | HFC-245fa                         | CHF <sub>2</sub> CH <sub>2</sub> CF <sub>3</sub>                                       | 7.6                 | 0.28                                             |                            | 3380             | 1030   | 314    |
| 1,1,1,3,3-Pentafluorobutane                                                        | HFC-365mfc                        | CH <sub>3</sub> CF <sub>2</sub> CH <sub>2</sub> CF <sub>3</sub>                        | 8.6                 | 0.21                                             |                            | 2520             | 794    | 241    |
| 1,1,1,2,3,4,4,5,5,5-Decafluoropentane                                              | HFC-43-10mee                      | CF <sub>3</sub> CHFCF <sub>2</sub> CF <sub>3</sub>                                     | 15.9                | 0.4                                              | 1300                       | 4140             | 1640   | 500    |
| <b>Perfluorinated compounds</b>                                                    |                                   |                                                                                        |                     |                                                  |                            |                  |        |        |
| Sulfur hexafluoride                                                                |                                   | SF <sub>6</sub>                                                                        | 3200                | 0.52                                             | 23900                      | 16300            | 22800  | 32600  |
| Nitrogen trifluoride                                                               |                                   | NF <sub>3</sub>                                                                        | 740                 | 0.21                                             |                            | 12300            | 17200  | 20700  |
| Tetrafluoromethane                                                                 | PFC-14                            | CF <sub>4</sub>                                                                        | 50000               | 0.10                                             | 6500                       | 5210             | 7390   | 11200  |
| Hexafluoroethane                                                                   | PFC-116                           | C <sub>2</sub> F <sub>6</sub>                                                          | 10000               | 0.26                                             | 9200                       | 8630             | 12200  | 18200  |
| Perfluoropropane                                                                   | PFC-218                           | C <sub>3</sub> F <sub>8</sub>                                                          | 2600                | 0.26                                             | 7000                       | 6310             | 8830   | 12500  |
| Perfluorocyclobutane                                                               | PFC-318                           | c-C <sub>4</sub> F <sub>8</sub>                                                        | 3200                | 0.32                                             | 8700                       | 7310             | 10300  | 14700  |
| Perfluorobutane                                                                    | PFC-3-1-10                        | C <sub>4</sub> F <sub>10</sub>                                                         | 2600                | 0.33                                             | 7000                       | 6330             | 8860   | 12500  |
| Perfluoropentane                                                                   | PFC-4-1-12                        | C <sub>5</sub> F <sub>12</sub>                                                         | 4100                | 0.41                                             |                            | 6510             | 9160   | 13300  |
| Perfluorohexane                                                                    | PFC-5-1-14                        | C <sub>6</sub> F <sub>14</sub>                                                         | 3200                | 0.49                                             | 7400                       | 6600             | 9300   | 13300  |
| Perfluorodecalin                                                                   | PFC-9-1-18                        | C <sub>10</sub> F <sub>18</sub>                                                        | >1,000              | 0.56                                             |                            | >5500            | >7500  | >9500  |
| (Trifluoromethyl)sulfur pentafluoride                                              |                                   | SF <sub>5</sub> CF <sub>3</sub>                                                        | 800                 | 0.57                                             |                            | 13200            | 17700  | 21200  |
| <b>Fluorinated ethers</b>                                                          |                                   |                                                                                        |                     |                                                  |                            |                  |        |        |
| Trifluoromethyl difluoromethyl ether                                               | HFE-125                           | CHF <sub>2</sub> OCF <sub>3</sub>                                                      | 136                 | 0.44                                             |                            | 13800            | 14900  | 8490   |
| Bis(difluoromethyl) ether                                                          | HFE-134                           | CHF <sub>2</sub> OCHF <sub>2</sub>                                                     | 26                  | 0.45                                             |                            | 12200            | 6320   | 1960   |
| Methyl trifluoromethyl ether                                                       | HFE-143a                          | CH <sub>3</sub> OCF <sub>3</sub>                                                       | 4.3                 | 0.27                                             |                            | 2630             | 756    | 230    |
| 2-Chloro-2-(difluoromethoxy)-1,1,1-trifluoroethane                                 | HCFE-235da2                       | CHF <sub>2</sub> OCHClCF <sub>3</sub>                                                  | 2.6                 | 0.38                                             |                            | 1230             | 350    | 106    |
| Methyl 1,1,2,2-tetrafluoroethyl ether                                              | HFE-245cb2                        | CH <sub>3</sub> OCF <sub>2</sub> CHF <sub>2</sub>                                      | 5.1                 | 0.32                                             |                            | 2440             | 708    | 215    |
| 2-(Difluoromethoxy)-1,1,1-trifluoroethane                                          | HFE-245fa2                        | CHF <sub>2</sub> OCH <sub>2</sub> CF <sub>3</sub>                                      | 4.9                 | 0.31                                             |                            | 2280             | 659    | 200    |
| Methyl pentafluoroethyl ether                                                      | HFE-254cb2                        | CH <sub>3</sub> OCF <sub>2</sub> CHF <sub>2</sub>                                      | 2.6                 | 0.28                                             |                            | 1260             | 359    | 109    |
| Perfluoropropyl methyl ether                                                       | HFE-347mcc3                       | CH <sub>3</sub> OCF <sub>2</sub> CF <sub>2</sub> CF <sub>3</sub>                       | 5.2                 | 0.34                                             |                            | 1980             | 575    | 175    |
| 1,1,2,2-Tetrafluoroethyl 1,1,1-trifluoroethyl ether                                | HFE-347pcf2                       | CHF <sub>2</sub> CF <sub>2</sub> OCH <sub>2</sub> CF <sub>3</sub>                      | 7.1                 | 0.25                                             |                            | 1900             | 580    | 175    |
| 1-Methoxy-1,1,2,2,3,3-hexafluoropropane                                            | HFE-356pcc3                       | CH <sub>3</sub> OCF <sub>2</sub> CF <sub>2</sub> CHF <sub>2</sub>                      | 0.33                | 0.93                                             |                            | 386              | 110    | 33     |
| Methyl nonafluorobutyl ether                                                       | HFE-449sl (HFE-7100)              | C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub>                                         | 3.8                 | 0.31                                             |                            | 1040             | 297    | 90     |
| 1-Ethoxy-1,1,2,2,3,3,4,4,4-nonafluorobutane                                        | HFE-569sf2 (HFE-7200)             | C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> H <sub>5</sub>                           | 0.77                | 0.3                                              |                            | 207              | 59     | 18     |
| 1-(Difluoromethoxy)-2-[(difluoromethoxy)difluoromethoxy]-1,1,2,2-tetrafluoroethane | HFE-43-10pccc124 (H-Galden 1040x) | CHF <sub>2</sub> OCF <sub>2</sub> OC <sub>2</sub> F <sub>4</sub> OCHF <sub>2</sub>     | 6.3                 | 1.37                                             |                            | 6320             | 1870   | 569    |
| Bis(difluoromethoxy)difluoromethane                                                | HFE-236ca12 (HG-10)               | CHF <sub>2</sub> OCF <sub>2</sub> OCHF <sub>2</sub>                                    | 12.1                | 0.66                                             |                            | 8000             | 2800   | 860    |
| 1,2-Bis(difluoromethoxy)-1,1,2,2-tetrafluoroethane                                 | HFE-338pcc13 (HG-01)              | CHF <sub>2</sub> OCF <sub>2</sub> CF <sub>2</sub> OCHF <sub>2</sub>                    | 6.2                 | 0.87                                             |                            | 5100             | 1500   | 460    |
| Perfluoropolymethylisopropyl ether                                                 | PFPME                             | CF <sub>3</sub> OCF(CF <sub>3</sub> )CF <sub>2</sub> OCF <sub>2</sub> OCF <sub>3</sub> | 800                 | 0.65                                             |                            | 7620             | 10300  | 12400  |
| <b>Other compounds - Direct effects</b>                                            |                                   |                                                                                        |                     |                                                  |                            |                  |        |        |
| Dimethyl ether                                                                     | Methyl ether                      | CH <sub>3</sub> OCH <sub>3</sub>                                                       | 0.015               | 0.02                                             |                            | 1                | 1      | <<1    |
| Dichloromethane                                                                    | Methylene chloride                | CH <sub>2</sub> Cl <sub>2</sub>                                                        | 0.38                | 0.03                                             |                            | 31               | 8.7    | 2.7    |
| Chloromethane                                                                      | Methyl chloride                   | CH <sub>3</sub> Cl                                                                     | 1                   | 0.01                                             |                            | 45               | 13     | 4      |

## MAJOR WORLD EARTHQUAKES

The United States Geological Survey maintains a database of historic earthquakes throughout the world (Reference 1). The table below is extracted from that database; it includes about 300 major earthquakes, based upon the magnitude and the degree of destruction. All recorded earthquakes of magnitude 7.5 or greater are listed, even if the fatalities are unknown or small. The death toll is often a rough estimate; in many cases the true toll could be much greater. More details on the exact location and degree of destruction can be found in References 2 and 3.

The magnitude is given on the Richter scale, which was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is measured by the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included for the variation in the distance between the various seismographs and the epicenter of the earthquake. On

the Richter Scale, magnitude is expressed in whole numbers and decimal fractions, e.g. 6.3. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a ten-fold increase in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

### References

1. Historic Worldwide Earthquakes, <http://earthquake.usgs.gov/regional/world/historical.php>.
2. Most Destructive Known Earthquakes on Record in the World, [http://earthquake.usgs.gov/regional/world/most\\_destructive.php](http://earthquake.usgs.gov/regional/world/most_destructive.php).
3. Earthquakes with 1,000 or More Deaths since 1900, [http://earthquake.usgs.gov/regional/world/world\\_deaths.php](http://earthquake.usgs.gov/regional/world/world_deaths.php).

| Date       | Location                                              | Magnitude | Fatalities | Date       | Location                                | Magnitude | Fatalities  |
|------------|-------------------------------------------------------|-----------|------------|------------|-----------------------------------------|-----------|-------------|
| 856/12/22  | Damghan, Iran                                         |           | 200,000    | 1868/08/13 | Arica, Peru (now Chile)                 | 9.0       | 400         |
| 893/03/23  | Ardabil, Iran                                         |           | 150,000    | 1872/03/26 | Owens Valley, California                | 7.4       | 27          |
| 1138/08/09 | Aleppo, Syria                                         |           | 230,000    | 1877/05/10 | Offshore Tarapaca, Chile                | 8.3       | 34          |
| 1268       | Silicia, Asia Minor                                   |           | 60,000     | 1886/09/01 | Charleston, South Carolina              | 7.3       | 60          |
| 1290/09/27 | Chihli, China                                         |           | 100,000    | 1887/05/03 | Northern Sonora, Mexico                 | 7.4       | 51          |
| 1556/01/23 | Shensi, China                                         | 8.0       | 830,000    | 1891/10/27 | Mino-Owari, Japan                       | 8.0       |             |
| 1619/02/14 | Trujillo, Peru                                        | 7.7       | 350        | 1892/02/24 | Imperial Valley, California             | 7.8       |             |
| 1667/11    | Shemakha, Caucasia                                    |           | 80,000     | 1896/06/15 | Sanriku, Japan                          | 8.5       | 28,000      |
| 1668/08/17 | Anatolia, Turkey                                      | 8.0       |            | 1897/06/12 | Assam, India                            | 8.3       | 1,500       |
| 1687/10/20 | Lima, Peru                                            | 8.5       |            | 1899/09/04 | Cape Yakataga, Alaska                   | 7.9       |             |
| 1693/01/11 | Sicily, Italy                                         | 7.5       | 60,000     | 1899/09/10 | Yakutat Bay, Alaska                     | 8.0       |             |
| 1700/01/26 | Cascadia Subduction Zone (Oregon to British Columbia) | 9.0       |            | 1900/10/09 | Kodiak Island, Alaska                   | 7.7       |             |
| 1727/11/18 | Tabriz, Iran                                          |           | 77,000     | 1902/04/19 | Quezaltenango and San Marcos, Guatemala | 7.5       | 2,000       |
| 1730/07/08 | Valparasio, Chile                                     | 8.7       |            | 1902/12/16 | Eastern Uzbekistan (Turkestan)          | 6.4       | 4,700       |
| 1755/11/01 | Lisbon, Portugal                                      | 8.7       | 70,000     | 1903/04/28 | Malazgirt, Turkey                       | 7.0       | 3,500       |
| 1783/02/04 | Calabria, Italy                                       |           | 50,000     | 1903/05/28 | Gole, Turkey (Ottoman Empire)           | 5.8       | 1,000       |
| 1787/05/02 | Puerto Rico                                           | 8.0       |            | 1903/08/11 | Southern Greece                         | 8.3       |             |
| 1811/12/16 | New Madrid Region, Missouri                           | 8.1       |            | 1905/04/04 | Kangra, India                           | 7.5       | 19,000      |
| 1812/02/07 | New Madrid Region, Missouri                           | 8.0       |            | 1905/07/09 | Mongolia                                | 8.4       |             |
| 1812/03/26 | Caracas, Venezuela                                    | 7.7       |            | 1905/09/08 | Calabria, Italy                         | 7.9       | 557         |
| 1812/12/08 | Southwest of San Bernardino County, California        | 6.9       | 40         | 1906/01/31 | Off the Coast of Esmeraldas, Ecuador    | 8.8       | 1,000       |
| 1812/12/21 | West of Ventura, California                           | 7.1       | 1          | 1906/03/16 | Chia-i, Taiwan                          | 6.8       | 1,250       |
| 1821/07/10 | Camana, Peru                                          | 8.2       | 162        | 1906/04/18 | San Francisco, California               | 7.8       | 3,000       |
| 1835/02/20 | Concepcion, Chile                                     | 8.2       | 500        | 1906/08/17 | Valparaiso, Chile                       | 8.2       | 20,000      |
| 1843/02/08 | Leeward Islands                                       | 8.3       |            | 1907/01/14 | Kingston, Jamaica                       | 6.5       | 800-1,000   |
| 1855/01/23 | Wellington, New Zealand                               | 8.0       | 4          | 1907/04/15 | Guerrero, Mexico                        | 7.7       |             |
| 1857/01/09 | Fort Tejon, California                                | 7.9       | 1          | 1907/10/21 | Qaratog, Tajikistan, Russia             | 8.0       | 12,000      |
| 1868/04/03 | Ka'u District, Island of Hawaii                       | 7.9       | 77         | 1908/12/12 | Off the Coast of Central Peru           | 8.2       |             |
|            |                                                       |           |            | 1908/12/28 | Messina, Italy                          | 7.2       | 72,000      |
|            |                                                       |           |            | 1909/01/23 | Silakhor, Iran (Persia)                 | 7.3       | 5,000-6,000 |



| Date       | Location                                        | Magnitude | Fatalities | Date       | Location                                          | Magnitude | Fatalities |
|------------|-------------------------------------------------|-----------|------------|------------|---------------------------------------------------|-----------|------------|
| 1910/04/12 | Taiwan region                                   | 7.6       |            | 1940/05/24 | Callao, Peru                                      | 8.2       | 249        |
| 1911/01/03 | Chong-Kemin, Kyrgyzstan                         | 7.8       | 450        | 1940/11/10 | Vrancea, Romania                                  | 7.3       | 1,000      |
| 1911/02/18 | Sarez, Tajikistan                               | 7.4       | 90         | 1942/08/06 | Guatemala                                         | 7.9       | 38         |
| 1911/06/07 | Off Guerrero, Mexico                            | 7.7       | 45         | 1942/08/24 | Off the coast of central Peru                     | 8.2       | 30         |
| 1912/08/09 | Murefte, Turkey (Ottoman Empire)                | 7.8       | 2,800      | 1942/11/26 | Turkey                                            | 7.6       |            |
| 1914/10/03 | Burdur, Turkey (Ottoman Empire)                 | 7.0       | 4,000      | 1942/12/20 | Erbaa, Turkey                                     | 7.3       | 1,100      |
| 1915/01/13 | Avezzano, Italy                                 | 7.0       | 32,610     | 1943/04/06 | Illapel — Salamanca, Chile                        | 8.2       | 25         |
| 1917/01/20 | Bali, Indonesia                                 |           | 1,500      | 1943/09/10 | Tottori, Japan                                    | 7.4       | 1,190      |
| 1917/07/30 | Daguan, Yunnan, China                           | 7.5       | 1,800      | 1943/11/26 | Ladik, Turkey                                     | 7.6       | 4,000      |
| 1918/02/13 | Nan'ao, Guangdong, (Kwangtung), China           | 7.3       | 1,000      | 1944/01/15 | San Juan, Argentina                               | 7.4       | 8,000      |
| 1918/10/11 | Mona Passage                                    | 7.5       | 116        | 1944/02/01 | Gerede, Turkey                                    | 7.4       | 2,790      |
| 1920/06/05 | Taiwan region                                   | 8.0       |            | 1944/12/07 | Tonankai, Japan                                   | 8.1       | 998        |
| 1920/12/16 | Haiyuan, Ningxia, China                         | 7.8       | 200,000    | 1945/01/12 | Mikawa, Japan                                     | 7.1       | 1,961      |
| 1922/11/11 | Chile-Argentina Border                          | 8.5       | 100        | 1945/11/27 | Makran Coast, Pakistan                            | 8.0       | 4,000      |
| 1923/02/03 | Kamchatka Peninsula                             | 8.5       |            | 1946/04/01 | Unimak Island, Alaska                             | 8.1       | 165        |
| 1923/03/24 | Near Luhuo, Sichuan, China                      | 7.3       | 3,500      | 1946/05/31 | Ustukran, Turkey                                  | 5.9       | 840-1,300  |
| 1923/05/25 | Torbat-e Heydariyeh, Iran                       | 5.7       | 2,200      | 1946/08/04 | Samana, Dominican Republic                        | 8.0       | 100        |
| 1923/09/01 | Kanto (Kwanto), Japan                           | 7.9       | 142,800    | 1946/11/10 | Ancash, Peru                                      | 7.3       | 1,400      |
| 1925/03/16 | Yunnan, China                                   | 7.1       | 5,800      | 1946/12/20 | Nankaido, Japan                                   | 8.1       | 1,362      |
| 1927/03/07 | Tango, Japan                                    | 7.6       | 3,020      | 1947/11/01 | Satipo, Peru                                      | 7.3       | 233        |
| 1927/05/22 | Tsinghai (Kansu), China                         | 7.6       | 40,900     | 1948/05/11 | Moquegua, Peru                                    | 7.4       | 70         |
| 1928/12/01 | Talca, Chile                                    | 7.6       | 225        | 1948/05/25 | Sichuan, China                                    | 7.3       | 800        |
| 1929/03/07 | Fox Islands, Aleutian Islands, Alaska           | 7.8       |            | 1948/06/28 | Fukui, Japan                                      | 7.3       | 3,769      |
| 1929/05/01 | Koppeh Dagh, Iran (Persia)                      | 7.4       | 3,800      | 1948/10/05 | Ashgabat, Turkmenistan                            | 7.3       | 110,000    |
| 1930/05/06 | Salmas, Iran (Persia)                           | 7.2       | 2,500      | 1949/04/13 | Puget Sound, Washington                           | 7.1       | 8          |
| 1930/07/23 | Irpinia, Italy                                  | 6.5       | 1,400      | 1949/07/10 | Khait, Tajikistan                                 | 7.5       | 12,000     |
| 1931/01/15 | Oaxaca, Mexico                                  | 7.8       | 114        | 1949/08/05 | Ambato, Ecuador                                   | 6.8       | 5,050      |
| 1931/02/02 | Hawke's Bay, New Zealand                        | 7.9       | 256        | 1949/08/22 | Queen Charlotte Islands, British Columbia, Canada | 8.1       |            |
| 1931/03/31 | Managua, Nicaragua                              | 6.0       | 2,500      | 1950/08/15 | Assam — Tibet                                     | 8.6       | 1,526      |
| 1931/04/27 | Zangezur Mountains, Armenia — Azerbaijan border | 5.7       | 2,800      | 1951/08/02 | Cosiguina, Nicaragua                              | 5.8       | 1,000      |
| 1931/08/10 | Xinjiang, China                                 | 8.0       | 10,000     | 1952/07/21 | Kern County, California                           | 7.3       | 12         |
| 1932/06/03 | Jalisco, Mexico                                 | 8.1       | 45         | 1952/11/04 | Kamchatka Peninsula                               | 9.0       |            |
| 1932/06/18 | Colima, Mexico                                  | 7.8       |            | 1953/02/12 | Torud, Iran                                       | 6.5       | 970        |
| 1932/12/25 | Gansu, China                                    | 7.6       | 275        | 1953/03/18 | Yenice-Gonen, Turkey                              | 7.3       | 1,070      |
| 1933/03/02 | Sanriku, Japan                                  | 8.4       | 3,000      | 1953/08/12 | Kefallinia, Greece                                | 7.1       | 455        |
| 1933/03/11 | Long Beach, California                          | 6.4       | 115        | 1953/12/12 | Tumbes, Peru                                      | 7.4       | 7          |
| 1933/08/25 | Sichuan, China                                  | 7.4       | 9,300      | 1954/03/29 | Spain                                             | 7.9       |            |
| 1934/01/15 | Bihar, India — Nepal                            | 8.1       | 10,700     | 1954/04/30 | Greece                                            | 7.1       | 31         |
| 1935/04/20 | Taiwan (Formosa)                                | 7.1       | 3,270      | 1954/09/09 | Orleansville, Algeria                             | 6.8       | 1,250      |
| 1935/05/30 | Quetta, Pakistan                                | 7.5       | 30,000     | 1957/03/09 | Andreanof Islands, Alaska                         | 8.6       |            |
| 1935/07/16 | Taiwan (Formosa)                                | 6.5       | 2,740      | 1957/04/25 | Fethiye, Turkey                                   | 7.1       | 15         |
| 1938/02/01 | Banda Sea, Indonesia                            | 8.5       |            | 1957/05/26 | Bolu Province, Turkey                             | 7.1       | 66         |
| 1938/11/10 | Shumagin Islands, Alaska                        | 8.2       |            | 1957/06/27 | Stanovoy Mountains, Russia (USSR)                 | 7.6       | 1,200      |
| 1939/01/25 | Chillan, Chile                                  | 7.8       | 28,000     | 1957/07/02 | Mazandaran, Iran                                  | 7.1       | 1,200      |
| 1939/12/26 | Erzincan, Turkey                                | 7.8       | 32,700     | 1957/07/28 | Guerrero, Mexico                                  | 7.9       | 68         |
| 1940/05/19 | Imperial Valley, California                     | 7.1       | 9          | 1957/12/04 | Gobi-Altay, Mongolia                              | 8.1       | 30         |
|            |                                                 |           |            | 1957/12/13 | Sahneh, Iran                                      | 7.1       | 1,130      |

| Date       | Location                       | Magnitude | Fatalities    | Date       | Location                                  | Magnitude | Fatalities |
|------------|--------------------------------|-----------|---------------|------------|-------------------------------------------|-----------|------------|
| 1958/01/15 | Arequipa, Peru                 | 7.3       | 26            | 1974/10/08 | Leeward Islands                           | 7.5       |            |
| 1958/07/10 | Lituya Bay, Alaska             | 7.7       | 5             | 1974/12/28 | Northern Pakistan                         | 6.2       | 5,300      |
| 1958/11/06 | Kuril Islands                  | 8.3       |               | 1975/02/02 | Near Islands, Alaska                      | 7.6       |            |
| 1959/04/26 | Taiwan region                  | 7.5       | 2             | 1975/02/04 | Haicheng, China                           | 7.0       | 2,000      |
| 1959/08/18 | Hebgen Lake, Montana           | 7.3       | 28            | 1975/09/06 | Diyarbakir Province, Turkey               | 6.7       | 2,300      |
| 1960/01/13 | Arequipa, Peru                 | 7.5       | 57            | 1975/11/29 | Kalapana, Hawaii                          | 7.2       | 2          |
| 1960/02/29 | Agadir, Morocco                | 5.7       | 12,000-15,000 | 1976/02/04 | Guatemala                                 | 7.5       | 23,000     |
| 1960/05/21 | Arauco Peninsula, Chile        | 7.9       |               | 1976/05/06 | Northeastern Italy                        | 6.5       | 1,000      |
| 1960/05/22 | Chile (off coast)              | 9.5       | 1,655         | 1976/06/25 | Papua, Indonesia                          | 7.1       | 422        |
| 1962/05/11 | Guerrero, Mexico               | 7.0       | 4             | 1976/07/27 | Tangshan, China                           | 7.5       | 255,000    |
| 1962/05/19 | Guerrero, Mexico               | 7.1       | 3             | 1976/08/16 | Mindanao, Philippines                     | 7.9       | 8,000      |
| 1962/09/01 | Qazvin, Iran                   | 7.1       | 12,225        | 1976/11/24 | Turkey-Iran border region                 | 7.3       | 5,000      |
| 1963/07/26 | Skopje, Macedonia              | 6.0       | 1,100         | 1977/03/04 | Romania                                   | 7.2       | 1,500      |
| 1963/10/13 | Kuril Islands                  | 8.5       |               | 1978/09/16 | Iran                                      | 7.8       | 15,000     |
| 1964/03/28 | Prince William Sound, Alaska   | 9.2       | 128           | 1979/02/28 | Mt. St. Elias, Alaska                     | 7.5       |            |
| 1964/06/16 | Niigata, Japan                 | 7.5       | 26            | 1980/10/10 | El Asnam (formerly Orleansville), Algeria | 7.7       | 5,000      |
| 1964/10/06 | Western Turkey                 | 7.0       | 36            | 1981/02/24 | Greece                                    | 6.8       | 3,000      |
| 1965/01/24 | Sanana, Indonesia (Ceram Sea)  | 7.6       | 71            | 1981/06/11 | Southern Iran                             | 6.9       | 3,000      |
| 1965/02/04 | Rat Islands, Alaska            | 8.7       |               | 1981/07/28 | Southern Iran                             | 7.3       | 1,500      |
| 1965/03/14 | Hindu Kush, Afghanistan        | 7.8       |               | 1982/12/13 | Yemen                                     | 6.0       | 2,800      |
| 1965/03/28 | La Ligua, Chile                | 7.4       | 400           | 1983/10/30 | Erzurum Province, Turkey                  | 6.9       | 1,342      |
| 1965/03/31 | Central Greece                 | 7.1       | 6             | 1985/03/03 | Offshore Valparaiso, Chile                | 7.8       | 177        |
| 1965/08/23 | Oaxaca, Mexico                 | 7.3       | 6             | 1985/09/19 | Michoacan, Mexico                         | 8.0       | 9,500      |
| 1966/03/07 | Hebei, China                   | 7.0       | 1,000         | 1986/05/07 | Andreanof Islands, Alaska                 | 7.9       |            |
| 1966/03/22 | Hebei, China                   | 6.9       | 1,000         | 1986/10/10 | El Salvador                               | 5.5       | 1,000      |
| 1966/08/19 | Varto, Turkey                  | 6.8       | 2,529         | 1987/03/06 | Colombia-Ecuador                          | 7.0       | 1,000      |
| 1966/10/17 | Near the Coast of Peru         | 8.1       | 125           | 1987/11/30 | Gulf of Alaska                            | 7.8       |            |
| 1967/07/22 | Mudurnu Valley, Turkey         | 7.3       | 173           | 1988/03/06 | Gulf of Alaska                            | 7.7       |            |
| 1968/05/23 | Inangahua, New Zealand         | 7.1       | 2             | 1988/08/20 | Nepal-India border region                 | 6.8       | 1,000      |
| 1968/08/02 | Oaxaca, Mexico                 | 7.1       | 18            | 1988/12/07 | Spitak, Armenia                           | 6.8       | 25,000     |
| 1968/08/31 | Dasht-e Bayaz, Iran            | 7.3       | 12,000        | 1989/10/18 | Loma Prieta, California                   | 6.9       | 63         |
| 1969/02/28 | Portugal-Morocco area          | 7.8       | 13            | 1990/06/20 | Western Iran                              | 7.4       | 50,000     |
| 1969/07/25 | Guangdong, China               | 5.9       | 3,000         | 1990/07/16 | Luzon, Philippine Islands                 | 7.7       | 1,621      |
| 1970/01/04 | Yunnan Province, China         | 7.5       | 10,000        | 1991/04/22 | Costa Rica                                | 7.6       | 47         |
| 1970/03/28 | Gediz, Turkey                  | 6.9       | 1,086         | 1991/10/19 | Northern India                            | 6.8       | 2,000      |
| 1970/05/31 | Chimbote, Peru                 | 7.9       | 70,000        | 1992/09/02 | Nicaragua                                 | 7.6       | 116        |
| 1970/07/31 | Colombia                       | 8.0       | 1             | 1992/12/12 | Flores Region, Indonesia                  | 7.8       | 2,500      |
| 1971/02/09 | San Fernando, California       | 6.6       | 65            | 1993/08/08 | South of the Mariana Islands              | 7.8       |            |
| 1971/05/22 | Eastern Turkey                 | 6.9       | 1,000         | 1993/09/29 | Latur-Killari, India                      | 6.2       | 9,748      |
| 1971/07/09 | Valparaiso region, Chile       | 7.5       | 90            | 1994/01/17 | Northridge, California                    | 6.7       | 60         |
| 1972/01/25 | Taiwan region                  | 7.5       |               | 1994/06/09 | Bolivia                                   | 8.2       | 10         |
| 1972/04/10 | Southern Iran                  | 7.1       | 5,054         | 1995/01/16 | Kobe, Japan                               | 6.9       | 5,502      |
| 1972/04/24 | Taiwan region                  | 7.2       | 4             | 1995/05/27 | Sakhalin Island                           | 7.1       | 1,989      |
| 1972/07/30 | Sitka, Alaska                  | 7.6       |               | 1996/06/10 | Andreanof Islands, Alaska                 | 7.9       |            |
| 1972/12/23 | Nicaragua                      | 6.2       | 5,000         | 1997/05/10 | Northern Iran                             | 7.3       | 1,567      |
| 1974/05/10 | Near Zhaotong, China           | 6.8       | 20,000        | 1997/10/14 | South of Fiji Islands                     | 7.8       |            |
| 1974/07/13 | Panama-Colombia border region  | 7.3       | 11            | 1997/12/05 | Near East Coast of Kamchatka              | 7.8       |            |
| 1974/10/03 | Near the Coast of Central Peru | 8.1       | 78            | 1998/01/04 | Loyalty Islands Region                    | 7.5       |            |

| Date       | Location                                               | Magnitude | Fatalities | Date       | Location                                  | Magnitude | Fatalities |
|------------|--------------------------------------------------------|-----------|------------|------------|-------------------------------------------|-----------|------------|
| 1998/02/04 | Afghanistan-Tajikistan<br>Border Region                | 5.9       | 2,323      | 2003/09/25 | Hokkaido, Japan Region                    | 8.3       |            |
| 1998/03/25 | Balleny Islands Region (off<br>Antarctica)             | 8.1       |            | 2003/09/27 | Southwestern Siberia,<br>Russia           | 7.3       | 3          |
| 1998/05/03 | Southeast of Taiwan                                    | 7.5       |            | 2003/11/17 | Rat Islands, Aleutian<br>Islands, Alaska  | 7.8       |            |
| 1998/05/30 | Afghanistan-Tajikistan<br>Border Region                | 6.6       | 4,000      | 2003/12/26 | Southeastern Iran                         | 6.6       | 31,000     |
| 1998/07/17 | Near North Coast of New<br>Guinea, Papua New<br>Guinea | 7.0       | 2,183      | 2004/02/05 | Irian Jaya, Indonesia                     | 7.0       | 37         |
| 1999/01/25 | Colombia                                               | 6.1       | 1,185      | 2004/11/11 | Kepulauan Alor, Indonesia                 | 7.5       | 34         |
| 1999/08/17 | Izmit, Turkey                                          | 7.6       | 17,118     | 2004/11/26 | Papua, Indonesia                          | 7.1       | 32         |
| 1999/09/20 | Taiwan                                                 | 7.6       | 2,400      | 2004/12/23 | North of Macquarie<br>Island, New Zealand | 8.1       |            |
| 1999/09/30 | Oaxaca, Mexico                                         | 7.5       |            | 2004/12/26 | Sumatra-Andaman<br>Islands                | 9.1       | 227,898    |
| 1999/11/12 | Duzce, Turkey                                          | 7.2       | 894        | 2005/03/28 | Northern Sumatra,<br>Indonesia            | 8.6       | 1,313      |
| 2000/06/04 | Southern Sumatera,<br>Indonesia                        | 7.9       | 103        | 2005/06/13 | Tarapaca, Chile                           | 7.8       | 11         |
| 2000/06/18 | South Indian Ocean                                     | 7.9       |            | 2005/09/09 | New Ireland Region,<br>Papua New Guinea   | 7.6       |            |
| 2000/11/16 | New Ireland Region,<br>Papua New Guinea                | 8.0       | 2          | 2005/09/26 | Northern Peru                             | 7.5       | 5          |
| 2001/01/01 | Mindanao, Philippines                                  | 7.5       |            | 2005/10/08 | Pakistan                                  | 7.6       | 86,000     |
| 2001/01/13 | El Salvador                                            | 7.7       | 852        | 2006/01/27 | Banda Sea                                 | 7.6       |            |
| 2001/01/26 | Gujarat, India                                         | 7.6       | 20,085     | 2006/02/22 | Mozambique                                | 7.0       | 4          |
| 2001/02/13 | El Salvador                                            | 6.6       | 315        | 2006/04/20 | Koryakia, Russia                          | 7.6       |            |
| 2001/06/23 | Near the Coast of Peru                                 | 8.4       | 138        | 2006/05/03 | Tonga                                     | 8.0       |            |
| 2002/03/03 | Hindu Kush Region,<br>Afghanistan                      | 7.4       | 166        | 2006/05/26 | Java, Indonesia                           | 6.3       | 5,749      |
| 2002/03/05 | Mindanao, Philippines                                  | 7.5       | 15         | 2006/07/17 | South of Java, Indonesia                  | 7.7       | 730        |
| 2002/03/25 | Hindu Kush Region,<br>Afghanistan                      | 6.1       | 1,000      | 2006/11/15 | Kuril Islands                             | 8.3       |            |
| 2002/03/31 | Taiwan region                                          | 7.1       | 5          | 2006/12/26 | Taiwan Region                             | 7.1       | 2          |
| 2002/08/19 | Fiji Islands                                           | 7.7       |            | 2007/01/13 | East of the Kuril Islands                 | 8.1       |            |
| 2002/09/08 | New Guinea, Papua New<br>Guinea                        | 7.6       |            | 2007/01/21 | Molucca Sea                               | 7.5       |            |
| 2002/10/10 | Irian Jaya, Indonesia                                  | 7.6       | 8          | 2007/04/01 | Solomon Islands                           | 8.1       | 40         |
| 2002/11/02 | Northern Sumatera,<br>Indonesia                        | 7.4       | 3          | 2007/08/08 | Java, Indonesia                           | 7.5       |            |
| 2002/11/03 | Denali Fault, Alaska                                   | 7.9       |            | 2007/08/15 | Near the Coast of Central<br>Peru         | 8.0       | 514        |
| 2003/01/22 | Offshore Colima, Mexico                                | 7.6       | 29         | 2007/09/12 | Southern Sumatra,<br>Indonesia            | 8.5       | 25         |
| 2003/05/21 | Northern Algeria                                       | 6.8       | 2,226      | 2007/09/12 | Kepulauan Mentawai<br>region, Indonesia   | 7.9       |            |
| 2003/05/26 | Halmahera, Indonesia                                   | 7.0       | 1          | 2007/09/28 | Mariana Islands region                    | 7.5       |            |
| 2003/07/15 | Carlsberg Ridge                                        | 7.6       |            | 2007/11/14 | Antofagasta, Chile                        | 7.7       | 2          |
| 2003/08/04 | Scotia Sea                                             | 7.6       |            | 2007/12/09 | South of the Fiji Islands                 | 7.8       |            |
|            |                                                        |           |            | 2008/05/12 | Eastern Sichuan, China                    | 7.9       | 87,652     |
|            |                                                        |           |            | 2008/07/05 | Sea of Okhotsk                            | 7.7       |            |

## STANDARD ITS-90 THERMOCOUPLE TABLES

The Instrument Society of America (ISA) has assigned standard letter designations to a number of thermocouple types having specified emf-temperature relations. These designations and the approximate metal compositions which meet the required relations, as well as the useful temperature ranges, are given below:

|        |                                                      |                |
|--------|------------------------------------------------------|----------------|
| Type B | (Pt + 30% Rh) vs. (Pt + 6% Rh)                       | 0 to 1820°C    |
| Type E | (Ni + 10% Cr) vs. (Cu + 43% Ni)                      | –270 to 1000°C |
| Type J | Fe vs. (Cu + 43% Ni)                                 | –210 to 1200°C |
| Type K | (Ni + 10% Cr) vs. (Ni + 2% Al + 2% Mn + 1% Si)       | –270 to 1372°C |
| Type N | (Ni + 14% Cr + 1.5% Si) vs. (Ni + 4.5% Si + 0.1% Mg) | –270 to 1300°C |
| Type R | (Pt + 13% Rh) vs. Pt                                 | –50 to 1768°C  |
| Type S | (Pt + 10% Rh) vs. Pt                                 | –50 to 1768°C  |
| Type T | Cu vs. (Cu + 43% Ni)                                 | –270 to 400°C  |

The compositions are given in weight percent, and the positive leg is listed first. It should be emphasized that the standard letter

designations do not imply a precise composition but rather that the specified emf-temperature relation is satisfied.

The first set of tables below lists, for each thermocouple type, the emf as a function of temperature on the International Temperature Scale of 1990 (ITS-90). The coefficients in the equation used to generate the table are also given. The second set of tables gives the inverse relationships, i.e., the coefficients in the polynomial equation which expresses the temperature as a function of thermocouple emf. The accuracy of these equations is also stated.

Further details and tables at closer intervals may be found in Reference 1.

### References

1. Burns, G. W., Seroger, M. G., Strouse, G. F., Croarkin, M. C., and Guthrie, W. F., *Temperature-Electromotive Force Reference Functions and Tables for the Letter-Designated Thermocouple Types Based on the ITS-90*, Natl. Inst. Stand. Tech. (U.S.) Monogr. 175, 1993.
2. Schooley, J. F., *Thermometry*, CRC Press, Boca Raton, FL, 1986.

### Type B Thermocouples: emf-Temperature (°C) Reference Table and Equations

Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| °C   | emf in Millivolts |        |        |        |        | Reference junctions at 0 °C |        |        |        |        |        |
|------|-------------------|--------|--------|--------|--------|-----------------------------|--------|--------|--------|--------|--------|
|      | 0                 | 10     | 20     | 30     | 40     | 50                          | 60     | 70     | 80     | 90     | 100    |
| 0    | 0.000             | –0.002 | –0.003 | –0.002 | –0.000 | 0.002                       | 0.006  | 0.011  | 0.017  | 0.025  | 0.033  |
| 100  | 0.033             | 0.043  | 0.053  | 0.065  | 0.078  | 0.092                       | 0.107  | 0.123  | 0.141  | 0.159  | 0.178  |
| 200  | 0.178             | 0.199  | 0.220  | 0.243  | 0.267  | 0.291                       | 0.317  | 0.344  | 0.372  | 0.401  | 0.431  |
| 300  | 0.431             | 0.462  | 0.494  | 0.527  | 0.561  | 0.596                       | 0.632  | 0.669  | 0.707  | 0.746  | 0.787  |
| 400  | 0.787             | 0.828  | 0.870  | 0.913  | 0.957  | 1.002                       | 1.048  | 1.095  | 1.143  | 1.192  | 1.242  |
| 500  | 1.242             | 1.293  | 1.344  | 1.397  | 1.451  | 1.505                       | 1.561  | 1.617  | 1.675  | 1.733  | 1.792  |
| 600  | 1.792             | 1.852  | 1.913  | 1.975  | 2.037  | 2.101                       | 2.165  | 2.230  | 2.296  | 2.363  | 2.431  |
| 700  | 2.431             | 2.499  | 2.569  | 2.639  | 2.710  | 2.782                       | 2.854  | 2.928  | 3.002  | 3.078  | 3.154  |
| 800  | 3.154             | 3.230  | 3.308  | 3.386  | 3.466  | 3.546                       | 3.626  | 3.708  | 3.790  | 3.873  | 3.957  |
| 900  | 3.957             | 4.041  | 4.127  | 4.213  | 4.299  | 4.387                       | 4.475  | 4.564  | 4.653  | 4.743  | 4.834  |
| 1000 | 4.834             | 4.926  | 5.018  | 5.111  | 5.205  | 5.299                       | 5.394  | 5.489  | 5.585  | 5.682  | 5.780  |
| 1100 | 5.780             | 5.878  | 5.976  | 6.075  | 6.175  | 6.276                       | 6.377  | 6.478  | 6.580  | 6.683  | 6.786  |
| 1200 | 6.786             | 6.890  | 6.995  | 7.100  | 7.205  | 7.311                       | 7.417  | 7.524  | 7.632  | 7.740  | 7.848  |
| 1300 | 7.848             | 7.957  | 8.066  | 8.176  | 8.286  | 8.397                       | 8.508  | 8.620  | 8.731  | 8.844  | 8.956  |
| 1400 | 8.956             | 9.069  | 9.182  | 9.296  | 9.410  | 9.524                       | 9.639  | 9.753  | 9.868  | 9.984  | 10.099 |
| 1500 | 10.099            | 10.215 | 10.331 | 10.447 | 10.563 | 10.679                      | 10.796 | 10.913 | 11.029 | 11.146 | 11.263 |
| 1600 | 11.263            | 11.380 | 11.497 | 11.614 | 11.731 | 11.848                      | 11.965 | 12.082 | 12.199 | 12.316 | 12.433 |
| 1700 | 12.433            | 12.549 | 12.666 | 12.782 | 12.898 | 13.014                      | 13.130 | 13.246 | 13.361 | 13.476 | 13.591 |
| 1800 | 13.591            | 13.706 | 13.820 |        |        |                             |        |        |        |        |        |

Temperature ranges and coefficients of equations used to compute the above table: The equations are of the form:  $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots + c_n t^n$ , where E is the emf in millivolts, t is the tem-

perature in degrees Celsius (ITS- 90), and  $c_0, c_1, c_2, c_3$ , etc. are the coefficients. These coefficients are extracted from Reference 1.

| 0 °C to 630.615 °C |   |                                       | 630.615 °C to 1820 °C |   |                                       |
|--------------------|---|---------------------------------------|-----------------------|---|---------------------------------------|
| $c_0$              | = | 0.000 000 000 0                       |                       | = | -3.893 816 862 1 ...                  |
| $c_1$              | = | $-2.465\,081\,834\,6 \times 10^{-4}$  |                       | = | $2.857\,174\,747\,0 \times 10^{-2}$   |
| $c_2$              | = | $5.904\,042\,117\,1 \times 10^{-6}$   |                       | = | $-8.488\,510\,478\,5 \times 10^{-5}$  |
| $c_3$              | = | $-1.325\,793\,163\,6 \times 10^{-9}$  |                       | = | $1.578\,528\,016\,4 \times 10^{-7}$   |
| $c_4$              | = | $1.566\,829\,190\,1 \times 10^{-12}$  |                       | = | $-1.683\,534\,486\,4 \times 10^{-10}$ |
| $c_5$              | = | $-1.694\,452\,924\,0 \times 10^{-15}$ |                       | = | $1.110\,979\,401\,3 \times 10^{-13}$  |
| $c_6$              | = | $6.299\,034\,709\,4 \times 10^{-19}$  |                       | = | $-4.451\,543\,103\,3 \times 10^{-17}$ |
| $c_7$              | = | .....                                 |                       | = | $9.897\,564\,082\,1 \times 10^{-21}$  |
| $c_8$              | = | .....                                 |                       | = | $-9.379\,133\,028\,9 \times 10^{-25}$ |

**Type E Thermocouples: emf-Temperature (°C) Reference Table and Equations**  
 Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| emf in Millivolts |        | Reference junctions at 0 °C |        |        |        |        |        |        |        |        |        |
|-------------------|--------|-----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| °C                | 0      | -10                         | -20    | -30    | -40    | -50    | -60    | -70    | -80    | -90    | -100   |
| -200              | -8.825 | -9.063                      | -9.274 | -9.455 | -9.604 | -9.718 | -9.797 | -9.835 |        |        |        |
| -100              | -5.237 | -5.681                      | -6.107 | -6.516 | -6.907 | -7.279 | -7.632 | -7.963 | -8.273 | -8.561 | -8.825 |
| 0                 | 0.000  | -0.582                      | -1.152 | -1.709 | -2.255 | -2.787 | -3.306 | -3.811 | -4.302 | -4.777 | -5.237 |
| °C                | 0      | 10                          | 20     | 30     | 40     | 50     | 60     | 70     | 80     | 90     | 100    |
| 0                 | 0.000  | 0.591                       | 1.192  | 1.801  | 2.420  | 3.048  | 3.685  | 4.330  | 4.985  | 5.648  | 6.319  |
| 100               | 6.319  | 6.998                       | 7.685  | 8.379  | 9.081  | 9.789  | 10.503 | 11.224 | 11.951 | 12.684 | 13.421 |
| 200               | 13.421 | 14.164                      | 14.912 | 15.664 | 16.420 | 17.181 | 17.945 | 18.713 | 19.484 | 20.259 | 21.036 |
| 300               | 21.036 | 21.817                      | 22.600 | 23.386 | 24.174 | 24.964 | 25.757 | 26.552 | 27.348 | 28.146 | 28.946 |
| 400               | 28.946 | 29.747                      | 30.550 | 31.354 | 32.159 | 32.965 | 33.772 | 34.579 | 35.387 | 36.196 | 37.005 |
| 500               | 37.005 | 37.815                      | 38.624 | 39.434 | 40.243 | 41.053 | 41.862 | 42.671 | 43.479 | 44.286 | 45.093 |
| 600               | 45.093 | 45.900                      | 46.705 | 47.509 | 48.313 | 49.116 | 49.917 | 50.718 | 51.517 | 52.315 | 53.112 |
| 700               | 53.112 | 53.908                      | 54.703 | 55.497 | 56.289 | 57.080 | 57.870 | 58.659 | 59.446 | 60.232 | 61.017 |
| 800               | 61.017 | 61.801                      | 62.583 | 63.364 | 64.144 | 64.922 | 65.698 | 66.473 | 67.246 | 68.017 | 68.787 |
| 900               | 68.787 | 69.554                      | 70.319 | 71.082 | 71.844 | 72.603 | 73.360 | 74.115 | 74.869 | 75.621 | 76.373 |
| 1000              | 76.373 |                             |        |        |        |        |        |        |        |        |        |

Temperature ranges and coefficients of equations used to compute the above table: The equations are of the form:  $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots + c_n t^n$ , where E is the emf in millivolts, t is the tem-

perature in degrees Celsius (ITS- 90), and  $c_0, c_1, c_2, c_3$ , etc. are the coefficients. These coefficients are extracted from Reference 1.

| -270 to 0°C |   |                                       | 0°C to 1000°C |   |                                       |
|-------------|---|---------------------------------------|---------------|---|---------------------------------------|
| $c_0$       | = | 0.000 000 000 0 ...                   |               | = | 0.000 000 000 0 ...                   |
| $c_1$       | = | $5.866\,550\,870\,8 \times 10^{-2}$   |               | = | $5.866\,550\,871\,0 \times 10^{-2}$   |
| $c_2$       | = | $4.541\,097\,712\,4 \times 10^{-5}$   |               | = | $4.503\,227\,558\,2 \times 10^{-5}$   |
| $c_3$       | = | $-7.799\,804\,868\,6 \times 10^{-7}$  |               | = | $2.890\,840\,721\,2 \times 10^{-8}$   |
| $c_4$       | = | $-2.580\,016\,084\,3 \times 10^{-8}$  |               | = | $-3.305\,689\,665\,2 \times 10^{-10}$ |
| $c_5$       | = | $-5.945\,258\,305\,7 \times 10^{-10}$ |               | = | $6.502\,440\,327\,0 \times 10^{-13}$  |
| $c_6$       | = | $-9.321\,405\,866\,7 \times 10^{-12}$ |               | = | $-1.919\,749\,550\,4 \times 10^{-16}$ |
| $c_7$       | = | $-1.028\,760\,553\,4 \times 10^{-13}$ |               | = | $-1.253\,660\,049\,7 \times 10^{-18}$ |
| $c_8$       | = | $-8.037\,012\,362\,1 \times 10^{-16}$ |               | = | $2.148\,921\,756\,9 \times 10^{-21}$  |
| $c_9$       | = | $-4.397\,949\,739\,1 \times 10^{-18}$ |               | = | $-1.438\,804\,178\,2 \times 10^{-24}$ |
| $c_{10}$    | = | $-1.641\,477\,635\,5 \times 10^{-20}$ |               | = | $3.596\,089\,948\,1 \times 10^{-28}$  |
| $c_{11}$    | = | $-3.967\,361\,951\,6 \times 10^{-23}$ |               | = | .....                                 |
| $c_{12}$    | = | $-5.582\,732\,872\,1 \times 10^{-26}$ |               | = | .....                                 |
| $c_{13}$    | = | $-3.465\,784\,201\,3 \times 10^{-29}$ |               | = | .....                                 |

**Type J Thermocouples: emf-Temperature (°C) Reference Table and Equations**  
 Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| emf in Millivolts |        | Reference junctions at 0 °C |        |        |        |        |        |        |        |        |        |
|-------------------|--------|-----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| °C                | 0      | -10                         | -20    | -30    | -40    | -50    | -60    | -70    | -80    | -90    | -100   |
| -200              | -7.890 | -8.095                      |        |        |        |        |        |        |        |        |        |
| -100              | -4.633 | -5.037                      | -5.426 | -5.801 | -6.159 | -6.500 | -6.821 | -7.123 | -7.403 | -7.659 | -7.890 |
| 0                 | 0.000  | -0.501                      | -0.995 | -1.482 | -1.961 | -2.431 | -2.893 | -3.344 | -3.786 | -4.215 | -4.633 |

| °C   | emf in Millivolts |        |        |        |        |        |        |        | Reference junctions at 0 °C |        |        |
|------|-------------------|--------|--------|--------|--------|--------|--------|--------|-----------------------------|--------|--------|
|      | 0                 | 10     | 20     | 30     | 40     | 50     | 60     | 70     | 80                          | 90     | 100    |
| 0    | 0.000             | 0.507  | 1.019  | 1.537  | 2.059  | 2.585  | 3.116  | 3.650  | 4.187                       | 4.726  | 5.269  |
| 100  | 5.269             | 5.814  | 6.360  | 6.909  | 7.459  | 8.010  | 8.562  | 9.115  | 9.669                       | 10.224 | 10.779 |
| 200  | 10.779            | 11.334 | 11.889 | 12.445 | 13.000 | 13.555 | 14.110 | 14.665 | 15.219                      | 15.773 | 16.327 |
| 300  | 16.327            | 16.881 | 17.434 | 17.986 | 18.538 | 19.090 | 19.642 | 20.194 | 20.745                      | 21.297 | 21.848 |
| 400  | 21.848            | 22.400 | 22.952 | 23.504 | 24.057 | 24.610 | 25.164 | 25.720 | 26.276                      | 26.834 | 27.393 |
| 500  | 27.393            | 27.953 | 28.516 | 29.080 | 29.647 | 30.216 | 30.788 | 31.362 | 31.939                      | 32.519 | 33.102 |
| 600  | 33.102            | 33.689 | 34.279 | 34.873 | 35.470 | 36.071 | 36.675 | 37.284 | 37.896                      | 38.512 | 39.132 |
| 700  | 39.132            | 39.755 | 40.382 | 41.012 | 41.645 | 42.281 | 42.919 | 43.559 | 44.203                      | 44.848 | 45.494 |
| 800  | 45.494            | 46.141 | 46.786 | 47.431 | 48.074 | 48.715 | 49.353 | 49.989 | 50.622                      | 51.251 | 51.877 |
| 900  | 51.877            | 52.500 | 53.119 | 53.735 | 54.347 | 54.956 | 55.561 | 56.164 | 56.763                      | 57.360 | 57.953 |
| 1000 | 57.953            | 58.545 | 59.134 | 59.721 | 60.307 | 60.890 | 61.473 | 62.054 | 62.634                      | 63.214 | 63.792 |
| 1100 | 63.792            | 64.370 | 64.948 | 65.525 | 66.102 | 66.679 | 67.255 | 67.831 | 68.406                      | 68.980 | 69.553 |
| 1200 | 69.553            |        |        |        |        |        |        |        |                             |        |        |

Temperature ranges and coefficients of equations used to compute the above table: The equations are of the form:  $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots c_n t^n$ , where E is the emf in millivolts, t is the tem-

perature in degrees Celsius (ITS-90), and  $c_0, c_1, c_2, c_3$ , etc. are the coefficients. These coefficients are extracted from Reference 1.

|       | -260°C to 760°C                         | 760°C to 1200°C                       |
|-------|-----------------------------------------|---------------------------------------|
| $c_0$ | = 0.000 000 000 0 ...                   | $2.964\ 562\ 568\ 1 \times 10^2$      |
| $c_1$ | = $5.038\ 118\ 781\ 5 \times 10^{-2}$   | $-1.497\ 612\ 778\ 6 \dots$           |
| $c_2$ | = $3.047\ 583\ 693\ 0 \times 10^{-5}$   | $3.178\ 710\ 392\ 4 \times 10^{-3}$   |
| $c_3$ | = $-8.568\ 106\ 572\ 0 \times 10^{-8}$  | $-3.184\ 768\ 670\ 1 \times 10^{-6}$  |
| $c_4$ | = $1.322\ 819\ 529\ 5 \times 10^{-10}$  | $1.572\ 081\ 900\ 4 \times 10^{-9}$   |
| $c_5$ | = $-1.705\ 295\ 833\ 7 \times 10^{-13}$ | $-3.069\ 136\ 905\ 6 \times 10^{-13}$ |
| $c_6$ | = $2.094\ 809\ 069\ 7 \times 10^{-16}$  | .....                                 |
| $c_7$ | = $-1.253\ 839\ 533\ 6 \times 10^{-19}$ | .....                                 |
| $c_8$ | = $1.563\ 172\ 569\ 7 \times 10^{-23}$  | .....                                 |

### Type K Thermocouples: emf-Temperature (°C) Reference Table and Equations

#### Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| °C   | emf in Millivolts |        |        |        |        |        |        |        | Reference junctions at 0 °C |        |        |
|------|-------------------|--------|--------|--------|--------|--------|--------|--------|-----------------------------|--------|--------|
|      | 0                 | -10    | -20    | -30    | -40    | -50    | -60    | -70    | -80                         | -90    | -100   |
| -200 | -5.891            | -6.035 | -6.158 | -6.262 | -6.344 | -6.404 | -6.441 | -6.458 | -5.550                      | -5.730 | -5.891 |
| -100 | -3.554            | -3.852 | -4.138 | -4.411 | -4.669 | -4.913 | -5.141 | -5.354 | -5.550                      | -5.730 | -5.891 |
| 0    | 0.000             | -0.392 | -0.778 | -1.156 | -1.527 | -1.889 | -2.243 | -2.587 | -2.920                      | -3.243 | -3.554 |
| °C   | 0                 | 10     | 20     | 30     | 40     | 50     | 60     | 70     | 80                          | 90     | 100    |
| 0    | 0.000             | 0.397  | 0.798  | 1.203  | 1.612  | 2.023  | 2.436  | 2.851  | 3.267                       | 3.682  | 4.096  |
| 100  | 4.096             | 4.509  | 4.920  | 5.328  | 5.735  | 6.138  | 6.540  | 6.941  | 7.340                       | 7.739  | 8.138  |
| 200  | 8.138             | 8.539  | 8.940  | 9.343  | 9.747  | 10.153 | 10.561 | 10.971 | 11.382                      | 11.795 | 12.209 |
| 300  | 12.209            | 12.624 | 13.040 | 13.457 | 13.874 | 14.293 | 14.713 | 15.133 | 15.554                      | 15.975 | 16.397 |
| 400  | 16.397            | 16.820 | 17.243 | 17.667 | 18.091 | 18.516 | 18.941 | 19.366 | 19.792                      | 20.218 | 20.644 |
| 500  | 20.644            | 21.071 | 21.497 | 21.924 | 22.350 | 22.776 | 23.203 | 23.629 | 24.055                      | 24.480 | 24.905 |
| 600  | 24.905            | 25.330 | 25.755 | 26.179 | 26.602 | 27.025 | 27.447 | 27.869 | 28.289                      | 28.710 | 29.129 |
| 700  | 29.129            | 29.548 | 29.965 | 30.382 | 30.798 | 31.213 | 31.628 | 32.041 | 32.453                      | 32.865 | 33.275 |
| 800  | 33.275            | 33.685 | 34.093 | 34.501 | 34.908 | 35.313 | 35.718 | 36.121 | 36.524                      | 36.925 | 37.326 |
| 900  | 37.326            | 37.725 | 38.124 | 38.522 | 38.918 | 39.314 | 39.708 | 40.101 | 40.494                      | 40.885 | 41.276 |
| 1000 | 41.276            | 41.665 | 42.053 | 42.440 | 42.826 | 43.211 | 43.595 | 43.978 | 44.359                      | 44.740 | 45.119 |
| 1100 | 45.119            | 45.497 | 45.873 | 46.249 | 46.623 | 46.995 | 47.367 | 47.737 | 48.105                      | 48.473 | 48.838 |
| 1200 | 48.838            | 49.202 | 49.565 | 49.926 | 50.286 | 50.644 | 51.000 | 51.355 | 51.708                      | 52.060 | 52.410 |
| 1300 | 52.410            | 52.759 | 53.106 | 53.451 | 53.795 | 54.138 | 54.479 | 54.819 |                             |        |        |

Temperature ranges and coefficients of equations used to compute the above table: The equations are of the form:  $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots c_n t^n$ , where E is the emf in millivolts, t is the temperature in degrees Celsius (ITS-90), and  $c_0, c_1, c_2, c_3$ , etc. are the coefficients. In the 0°C to 1372°C range there is also an exponen-

tial term that must be evaluated and added to the equation. The exponential term is of the form:  $c_0 e^{c_1 (t-126.9686)^2}$ , where t is the temperature in °C, e is the natural logarithm base, and  $c_0$  and  $c_1$  are the coefficients. These coefficients are extracted from Reference 1.

|          |   | -270°C to 0°C                         | 0°C to 1372°C                         | 0°C to 1372°C (Exponential term) |
|----------|---|---------------------------------------|---------------------------------------|----------------------------------|
| $c_0$    | = | 0.000 000 000 0                       | $-1.760\,041\,368\,6 \times 10^{-2}$  | $1.185\,976 \times 10^{-1}$      |
| $c_1$    | = | $3.945\,012\,802\,5 \times 10^{-2}$   | $3.892\,120\,497\,5 \times 10^{-2}$   | $-1.183\,432 \times 10^{-4}$     |
| $c_2$    | = | $2.362\,237\,359\,8 \times 10^{-5}$   | $1.855\,877\,003\,2 \times 10^{-5}$   | .....                            |
| $c_3$    | = | $-3.285\,890\,678\,4 \times 10^{-7}$  | $-9.945\,759\,287\,4 \times 10^{-8}$  | .....                            |
| $c_4$    | = | $-4.990\,482\,877\,7 \times 10^{-9}$  | $3.184\,094\,571\,9 \times 10^{-10}$  | .....                            |
| $c_5$    | = | $-6.750\,905\,917\,3 \times 10^{-11}$ | $-5.607\,284\,488\,9 \times 10^{-13}$ | .....                            |
| $c_6$    | = | $-5.741\,032\,742\,8 \times 10^{-13}$ | $5.607\,505\,905\,9 \times 10^{-16}$  | .....                            |
| $c_7$    | = | $-3.108\,887\,289\,4 \times 10^{-15}$ | $-3.202\,072\,000\,3 \times 10^{-19}$ | .....                            |
| $c_8$    | = | $-1.045\,160\,936\,5 \times 10^{-17}$ | $9.715\,114\,715\,2 \times 10^{-23}$  | .....                            |
| $c_9$    | = | $-1.988\,926\,687\,8 \times 10^{-20}$ | $-1.210\,472\,127\,5 \times 10^{-26}$ | .....                            |
| $c_{10}$ | = | $-1.632\,269\,748\,6 \times 10^{-23}$ | .....                                 | .....                            |

**Type N Thermocouples: emf-Temperature (°C) Reference Table and Equations**  
 Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| °C   | emf in Millivolts |        |        |        |        |        |        |        | Reference junctions at 0 °C |        |        |
|------|-------------------|--------|--------|--------|--------|--------|--------|--------|-----------------------------|--------|--------|
|      | 0                 | -10    | -20    | -30    | -40    | -50    | -60    | -70    | -80                         | -90    | -100   |
| -200 | 3.990             | -4.083 | -4.162 | -4.226 | -4.277 | -4.313 | -4.336 | -4.345 |                             |        |        |
| -100 | -2.407            | -2.612 | 2.808  | 2.994  | 3.171  | 3.336  | -3.491 | 3.634  | -3.766                      | -3.884 | -3.990 |
| 0    | 0.000             | -0.260 | -0.518 | -0.772 | -1.023 | -1.269 | -1.509 | 1.744  | -1.972                      | -2.193 | -2.407 |
| °C   | 0                 | 10     | 20     | 30     | 40     | 50     | 60     | 70     | 80                          | 90     | 100    |
| 0    | 0.000             | 0.261  | 0.525  | 0.793  | 1.065  | 1.340  | 1.619  | 1.902  | 2.189                       | 2.480  | 2.774  |
| 100  | 2.774             | 3.072  | 3.374  | 3.680  | 3.989  | 4.302  | 4.618  | 4.937  | 5.259                       | 5.585  | 5.913  |
| 200  | 5.913             | 6.245  | 6.579  | 6.916  | 7.255  | 7.597  | 7.941  | 8.288  | 8.637                       | 8.988  | 9.341  |
| 300  | 9.341             | 9.696  | 10.054 | 10.413 | 10.774 | 11.136 | 11.501 | 11.867 | 12.234                      | 12.603 | 12.974 |
| 400  | 12.974            | 13.346 | 13.719 | 14.094 | 14.469 | 14.846 | 15.225 | 15.604 | 15.984                      | 16.366 | 16.748 |
| 500  | 16.748            | 17.131 | 17.515 | 17.900 | 18.286 | 18.672 | 19.059 | 19.447 | 19.835                      | 20.224 | 20.613 |
| 600  | 20.613            | 21.003 | 21.393 | 21.784 | 22.175 | 22.566 | 22.958 | 23.350 | 23.742                      | 24.134 | 24.527 |
| 700  | 24.527            | 24.919 | 25.312 | 25.705 | 26.098 | 26.491 | 26.883 | 27.276 | 27.669                      | 28.062 | 28.455 |
| 800  | 28.455            | 28.847 | 29.239 | 29.632 | 30.024 | 30.416 | 30.807 | 31.199 | 31.590                      | 31.981 | 32.371 |
| 900  | 32.371            | 32.761 | 33.151 | 33.541 | 33.930 | 34.319 | 34.707 | 35.095 | 35.482                      | 35.869 | 36.256 |
| 1000 | 36.256            | 36.641 | 37.027 | 37.411 | 37.795 | 38.179 | 38.562 | 38.944 | 39.326                      | 39.706 | 40.087 |
| 1100 | 40.087            | 40.466 | 40.845 | 41.223 | 41.600 | 41.976 | 42.352 | 42.727 | 43.101                      | 43.474 | 43.846 |
| 1200 | 43.846            | 44.218 | 44.588 | 44.958 | 45.326 | 45.694 | 46.060 | 46.425 | 46.789                      | 47.152 | 47.513 |
| 1300 | 47.513            |        |        |        |        |        |        |        |                             |        |        |

Temperature ranges and coefficients of equations used to compute the above table: The equations are of the form:  $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots + c_n t^n$ , where E is the emf in millivolts, t is the tem-

perature in degrees Celsius (ITS-90), and  $c_0, c_1, c_2, c_3$ , etc. are the coefficients. These coefficients are extracted from Reference 1.

|          |   | -270°C to 0°C                         | 0°C to 1300°C                         |
|----------|---|---------------------------------------|---------------------------------------|
| $c_0$    | = | 0.000 000 000 0 ...                   | 0.000 000 000 0...                    |
| $c_1$    | = | $2.615\,910\,596\,2 \times 10^{-2}$   | $2.592\,939\,460\,1 \times 10^{-2}$   |
| $c_2$    | = | $1.095\,748\,422\,8 \times 10^{-5}$   | $1.571\,014\,188\,0 \times 10^{-5}$   |
| $c_3$    | = | $-9.384\,111\,155\,4 \times 10^{-8}$  | $4.382\,562\,723\,7 \times 10^{-8}$   |
| $c_4$    | = | $-4.641\,203\,975\,9 \times 10^{-11}$ | $-2.526\,116\,979\,4 \times 10^{-10}$ |
| $c_5$    | = | $-2.630\,335\,771\,6 \times 10^{-12}$ | $6.431\,181\,933\,9 \times 10^{-13}$  |
| $c_6$    | = | $-2.265\,343\,800\,3 \times 10^{-14}$ | $-1.006\,347\,151\,9 \times 10^{-15}$ |
| $c_7$    | = | $-7.608\,930\,079\,1 \times 10^{-17}$ | $9.974\,533\,899\,2 \times 10^{-19}$  |
| $c_8$    | = | $-9.341\,966\,783\,5 \times 10^{-20}$ | $-6.086\,324\,560\,7 \times 10^{-22}$ |
| $c_9$    | = | .....                                 | $2.084\,922\,933\,9 \times 10^{-25}$  |
| $c_{10}$ | = | .....                                 | $-3.068\,219\,615\,1 \times 10^{-29}$ |

**Type R Thermocouples: emf-Temperature (°C) Reference Table and Equations**

Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| °C   | emf in Millivolts |        |        |        |        | Reference junctions at 0 °C |        |        |        |        |        |
|------|-------------------|--------|--------|--------|--------|-----------------------------|--------|--------|--------|--------|--------|
|      | 0                 | -10    | -20    | -30    | -40    | -50                         | -60    | -70    | -80    | -90    | -100   |
| 0    | 0.000             | -0.051 | -0.100 | -0.145 | -0.188 | -0.226                      |        |        |        |        |        |
| °C   | 0                 | 10     | 20     | 30     | 40     | 50                          | 60     | 70     | 80     | 90     | 100    |
| 0    | 0.000             | 0.054  | 0.111  | 0.171  | 0.232  | 0.296                       | 0.363  | 0.431  | 0.501  | 0.573  | 0.647  |
| 100  | 0.647             | 0.723  | 0.800  | 0.879  | 0.959  | 1.041                       | 1.124  | 1.208  | 1.294  | 1.381  | 1.469  |
| 200  | 1.469             | 1.558  | 1.648  | 1.739  | 1.831  | 1.923                       | 2.017  | 2.112  | 2.207  | 2.304  | 2.401  |
| 300  | 2.401             | 2.498  | 2.597  | 2.696  | 2.796  | 2.896                       | 2.997  | 3.099  | 3.201  | 3.304  | 3.408  |
| 400  | 3.408             | 3.512  | 3.616  | 3.721  | 3.827  | 3.933                       | 4.040  | 4.147  | 4.255  | 4.363  | 4.471  |
| 500  | 4.471             | 4.580  | 4.690  | 4.800  | 4.910  | 5.021                       | 5.133  | 5.245  | 5.357  | 5.470  | 5.583  |
| 600  | 5.583             | 5.697  | 5.812  | 5.926  | 6.041  | 6.157                       | 6.273  | 6.390  | 6.507  | 6.625  | 6.743  |
| 700  | 6.743             | 6.861  | 6.980  | 7.100  | 7.220  | 7.340                       | 7.461  | 7.583  | 7.705  | 7.827  | 7.950  |
| 800  | 7.950             | 8.073  | 8.197  | 8.321  | 8.446  | 8.571                       | 8.697  | 8.823  | 8.950  | 9.077  | 9.205  |
| 900  | 9.205             | 9.333  | 9.461  | 9.590  | 9.720  | 9.850                       | 9.980  | 10.111 | 10.242 | 10.374 | 10.506 |
| 1000 | 10.506            | 10.638 | 10.771 | 10.905 | 11.039 | 11.173                      | 11.307 | 11.442 | 11.578 | 11.714 | 11.850 |
| 1100 | 11.850            | 11.986 | 12.123 | 12.260 | 12.397 | 12.535                      | 12.673 | 12.812 | 12.950 | 13.089 | 13.228 |
| 1200 | 13.228            | 13.367 | 13.507 | 13.646 | 13.786 | 13.926                      | 14.066 | 14.207 | 14.347 | 14.488 | 14.629 |
| 1300 | 14.629            | 14.770 | 14.911 | 15.052 | 15.193 | 15.334                      | 15.475 | 15.616 | 15.758 | 15.899 | 16.040 |
| 1400 | 16.040            | 16.181 | 16.323 | 16.464 | 16.605 | 16.746                      | 16.887 | 17.028 | 17.169 | 17.310 | 17.451 |
| 1500 | 17.451            | 17.591 | 17.732 | 17.872 | 18.012 | 18.152                      | 18.292 | 18.431 | 18.571 | 18.710 | 18.849 |
| 1600 | 18.849            | 18.988 | 19.126 | 19.264 | 19.402 | 19.540                      | 19.677 | 19.814 | 19.951 | 20.087 | 20.222 |
| 1700 | 20.222            | 20.356 | 20.488 | 20.620 | 20.749 | 20.877                      | 21.003 |        |        |        |        |

Temperature ranges and coefficients of equations used to compute the above table: The equations are of the form:  $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots + c_n t^n$ , where E is the emf in millivolts, t is the tem-

perature in degrees Celsius (ITS-90), and  $c_0, c_1, c_2, c_3$ , etc. are the coefficients. These coefficients are extracted from Reference 1.

|       | -50°C to 1064.18°C                       | 1064.18°C to 1664.5°C                  | 1664.5°C to 1768.1°C                   |
|-------|------------------------------------------|----------------------------------------|----------------------------------------|
| $c_0$ | = 0.000 000 000 00 ...                   | 2.951 579 253 16 ...                   | $1.522\ 321\ 182\ 09 \times 10^2$      |
| $c_1$ | = $5.289\ 617\ 297\ 65 \times 10^{-3}$   | $-2.520\ 612\ 513\ 32 \times 10^{-3}$  | $-2.688\ 198\ 885\ 45 \times 10^{-1}$  |
| $c_2$ | = $1.391\ 665\ 897\ 82 \times 10^{-5}$   | $1.595\ 645\ 018\ 65 \times 10^{-5}$   | $1.712\ 802\ 804\ 71 \times 10^{-4}$   |
| $c_3$ | = $-2.388\ 556\ 930\ 17 \times 10^{-8}$  | $-7.640\ 859\ 475\ 76 \times 10^{-9}$  | $-3.458\ 957\ 064\ 53 \times 10^{-8}$  |
| $c_4$ | = $3.569\ 160\ 010\ 63 \times 10^{-11}$  | $2.053\ 052\ 910\ 24 \times 10^{-12}$  | $-9.346\ 339\ 710\ 46 \times 10^{-15}$ |
| $c_5$ | = $-4.623\ 476\ 662\ 98 \times 10^{-14}$ | $-2.933\ 596\ 681\ 73 \times 10^{-16}$ | .....                                  |
| $c_6$ | = $5.007\ 774\ 410\ 34 \times 10^{-17}$  | .....                                  | .....                                  |
| $c_7$ | = $-3.731\ 058\ 861\ 91 \times 10^{-20}$ | .....                                  | .....                                  |
| $c_8$ | = $1.577\ 164\ 823\ 67 \times 10^{-23}$  | .....                                  | .....                                  |
| $c_9$ | = $-2.810\ 386\ 252\ 51 \times 10^{-27}$ | .....                                  | .....                                  |

**Type S Thermocouples: emf-Temperature (°C) Reference Table and Equations.**

Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| °C   | emf in Millivolts |        |        |        |        | Reference junctions at 0 °C |        |        |        |        |        |
|------|-------------------|--------|--------|--------|--------|-----------------------------|--------|--------|--------|--------|--------|
|      | 0                 | -10    | -20    | -30    | -40-   | -50                         | -60    | -70    | -80    | -90    | -100   |
| 0    | 0.000             | -0.053 | -0.103 | -0.150 | -0.194 | -0.236                      |        |        |        |        |        |
| °C   | 0                 | 10     | 20     | 30     | 40     | 50                          | 60     | 70     | 80     | 90     | 100    |
| 0    | 0.000             | 0.055  | 0.113  | 0.173  | 0.235  | 0.299                       | 0.365  | 0.433  | 0.502  | 0.573  | 0.646  |
| 100  | 0.646             | 0.720  | 0.795  | 0.872  | 0.950  | 1.029                       | 1.110  | 1.191  | 1.273  | 1.357  | 1.441  |
| 200  | 1.441             | 1.526  | 1.612  | 1.698  | 1.786  | 1.874                       | 1.962  | 2.052  | 2.141  | 2.232  | 2.323  |
| 300  | 2.323             | 2.415  | 2.507  | 2.599  | 2.692  | 2.786                       | 2.880  | 2.974  | 3.069  | 3.164  | 3.259  |
| 400  | 3.259             | 3.355  | 3.451  | 3.548  | 3.645  | 3.742                       | 3.840  | 3.938  | 4.036  | 4.134  | 4.233  |
| 500  | 4.233             | 4.332  | 4.432  | 4.532  | 4.632  | 4.732                       | 4.833  | 4.934  | 5.035  | 5.137  | 5.239  |
| 600  | 5.239             | 5.341  | 5.443  | 5.546  | 5.649  | 5.753                       | 5.857  | 5.961  | 6.065  | 6.170  | 6.275  |
| 700  | 6.275             | 6.381  | 6.486  | 6.593  | 6.699  | 6.806                       | 6.913  | 7.020  | 7.128  | 7.236  | 7.345  |
| 800  | 7.345             | 7.454  | 7.563  | 7.673  | 7.783  | 7.893                       | 8.003  | 8.114  | 8.226  | 8.337  | 8.449  |
| 900  | 8.449             | 8.562  | 8.674  | 8.787  | 8.900  | 9.014                       | 9.128  | 9.242  | 9.357  | 9.472  | 9.587  |
| 1000 | 9.587             | 9.703  | 9.819  | 9.935  | 10.051 | 10.168                      | 10.285 | 10.403 | 10.520 | 10.638 | 10.757 |
| 1100 | 10.757            | 10.875 | 10.994 | 11.113 | 11.232 | 11.351                      | 11.471 | 11.590 | 11.710 | 11.830 | 11.951 |
| 1200 | 11.951            | 12.071 | 12.191 | 12.312 | 12.433 | 12.554                      | 12.675 | 12.796 | 12.917 | 13.038 | 13.159 |



**Type S Thermocouples: emf-Temperature (°C) Reference Table and Equations.**

Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| °C   | emf in Millivolts |        |        |        |        |        |        | Reference junctions at 0 °C |        |        |        |
|------|-------------------|--------|--------|--------|--------|--------|--------|-----------------------------|--------|--------|--------|
|      | 0                 | -10    | -20    | -30    | -40    | -50    | -60    | -70                         | -80    | -90    | -100   |
| 1300 | 13.159            | 13.280 | 13.402 | 13.523 | 13.644 | 13.766 | 13.887 | 14.009                      | 14.130 | 14.251 | 14.373 |
| 1400 | 14.373            | 14.494 | 14.615 | 14.736 | 14.857 | 14.978 | 15.099 | 15.220                      | 15.341 | 15.461 | 15.582 |
| 1500 | 15.582            | 15.702 | 15.822 | 15.942 | 16.062 | 16.182 | 16.301 | 16.420                      | 16.539 | 16.658 | 16.777 |
| 1600 | 16.777            | 16.895 | 17.013 | 17.131 | 17.249 | 17.366 | 17.483 | 17.600                      | 17.717 | 17.832 | 17.947 |
| 1700 | 17.947            | 18.061 | 18.174 | 18.285 | 18.395 | 18.503 | 18.609 |                             |        |        |        |

Temperature ranges and coefficients of equations used to compute the above table: The equations are of the form:  $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots c_n t^n$ , where E is the emf in millivolts, t is the tem-

perature in degrees Celsius (ITS-90), and  $c_0, c_1, c_2, c_3$ , etc. are the coefficients. These coefficients are extracted from Reference 1.

|       | -50°C to 1064.18°C                       | 1064.18°C to 1664.5°C                 | 1664.5°C to 1768.1°C                   |
|-------|------------------------------------------|---------------------------------------|----------------------------------------|
| $c_0$ | = 0.000 000 000 00 ...                   | 1.329 004 440 85 ...                  | $1.466\ 282\ 326\ 36 \times 10^2$      |
| $c_1$ | = $5.403\ 133\ 086\ 31 \times 10^{-3}$   | $3.345\ 093\ 113\ 44 \times 10^{-3}$  | $-2.584\ 305\ 167\ 52 \times 10^{-1}$  |
| $c_2$ | = $1.259\ 342\ 897\ 40 \times 10^{-5}$   | $6.548\ 051\ 928\ 18 \times 10^{-6}$  | $1.636\ 935\ 746\ 41 \times 10^{-4}$   |
| $c_3$ | = $-2.324\ 779\ 686\ 89 \times 10^{-8}$  | $-1.648\ 562\ 592\ 09 \times 10^{-9}$ | $-3.304\ 390\ 469\ 87 \times 10^{-8}$  |
| $c_4$ | = $3.220\ 288\ 230\ 36 \times 10^{-11}$  | $1.299\ 896\ 051\ 74 \times 10^{-14}$ | $-9.432\ 236\ 906\ 12 \times 10^{-15}$ |
| $c_5$ | = $-3.314\ 651\ 963\ 89 \times 10^{-14}$ | .....                                 | .....                                  |
| $c_6$ | = $2.557\ 442\ 517\ 86 \times 10^{-17}$  | .....                                 | .....                                  |
| $c_7$ | = $-1.250\ 688\ 713\ 93 \times 10^{-20}$ | .....                                 | .....                                  |
| $c_8$ | = $2.714\ 431\ 761\ 45 \times 10^{-24}$  | .....                                 | .....                                  |

**Type T Thermocouples: emf-Temperature (°C) Reference Table and Equations.**

Thermocouple emf as a Function of Temperature in Degrees Celsius (ITS-90)

| °C   | emf in Millivolts |        |        |        |        |        |        | Reference junctions at 0 °C |        |        |        |
|------|-------------------|--------|--------|--------|--------|--------|--------|-----------------------------|--------|--------|--------|
|      | 0                 | -10    | -20    | -30    | -40    | -50    | -60    | -70                         | -80    | -90    | -100   |
| -200 | -5.603            | -5.753 | -5.888 | -6.007 | -6.105 | -6.180 | -6.232 | -6.258                      |        |        |        |
| -100 | -3.379            | -3.657 | -3.923 | -4.177 | -4.419 | -4.648 | -4.865 | -5.070                      | -5.261 | -5.439 | -5.603 |
| 0    | 0.000             | -0.383 | -0.757 | -1.121 | -1.475 | -1.819 | -2.153 | -2.476                      | -2.788 | -3.089 | -3.379 |
| °C   | 0                 | 10     | 20     | 30     | 40     | 50     | 60     | 70                          | 80     | 90     | 100    |
| 0    | 0.000             | 0.391  | 0.790  | 1.196  | 1.612  | 2.036  | 2.468  | 2.909                       | 3.358  | 3.814  | 4.279  |
| 100  | 4.279             | 4.750  | 5.228  | 5.714  | 6.206  | 6.704  | 7.209  | 7.720                       | 8.237  | 8.759  | 9.288  |
| 200  | 9.288             | 9.822  | 10.362 | 10.907 | 11.458 | 12.013 | 12.574 | 13.139                      | 13.709 | 14.283 | 14.862 |
| 300  | 14.862            | 15.445 | 16.032 | 16.624 | 17.219 | 17.819 | 18.422 | 19.030                      | 19.641 | 20.255 | 20.872 |
| 400  | 20.872            |        |        |        |        |        |        |                             |        |        |        |

Temperature ranges and coefficients of equations used to compute the above table: The equations are of the form:  $E = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + \dots c_n t^n$ , where E is the emf in millivolts, t is the tem-

perature in degrees Celsius (ITS-90), and  $c_0, c_1, c_2, c_3$ , etc. are the coefficients. These coefficients are extracted from Reference 1.

|          | 270 °C to 0 °C                         | 0 °C to 400 °C                        |
|----------|----------------------------------------|---------------------------------------|
| $c_0$    | = 0.000 000 000 0 ...                  | 0.000 000 000 0 ...                   |
| $c_1$    | = $3.874\ 810\ 636\ 4 \times 10^{-2}$  | $3.874\ 810\ 636\ 4 \times 10^{-2}$   |
| $c_2$    | = $4.419\ 443\ 434\ 7 \times 10^{-5}$  | $3.329\ 222\ 788\ 0 \times 10^{-5}$   |
| $c_3$    | = $1.184\ 432\ 310\ 5 \times 10^{-7}$  | $2.061\ 824\ 340\ 4 \times 10^{-7}$   |
| $c_4$    | = $2.003\ 297\ 355\ 4 \times 10^{-8}$  | $-2.188\ 225\ 684\ 6 \times 10^{-9}$  |
| $c_5$    | = $9.013\ 801\ 955\ 9 \times 10^{-10}$ | $1.099\ 688\ 092\ 8 \times 10^{-11}$  |
| $c_6$    | = $2.265\ 115\ 659\ 3 \times 10^{-11}$ | $-3.081\ 575\ 877\ 2 \times 10^{-14}$ |
| $c_7$    | = $3.607\ 115\ 420\ 5 \times 10^{-13}$ | $4.547\ 913\ 529\ 0 \times 10^{-17}$  |
| $c_8$    | = $3.849\ 393\ 988\ 3 \times 10^{-15}$ | $-2.751\ 290\ 167\ 3 \times 10^{-20}$ |
| $c_9$    | = $2.821\ 352\ 192\ 5 \times 10^{-17}$ | .....                                 |
| $c_{10}$ | = $1.425\ 159\ 477\ 9 \times 10^{-19}$ | .....                                 |
| $c_{11}$ | = $4.876\ 866\ 228\ 6 \times 10^{-22}$ | .....                                 |
| $c_{12}$ | = $1.079\ 553\ 927\ 0 \times 10^{-24}$ | .....                                 |
| $c_{13}$ | = $1.394\ 502\ 706\ 2 \times 10^{-27}$ | .....                                 |
| $c_{14}$ | = $7.979\ 515\ 392\ 7 \times 10^{-31}$ | .....                                 |

**Type B Thermocouples: Coefficients ( $c_i$ ) of Polynomials for the Computation of Temperatures in °C as a Function of the Thermocouple emf in Various Temperature and emf Ranges**

| Temperature range: | 250 °C to 700 °C             | 700 °C to 1820 °C               |
|--------------------|------------------------------|---------------------------------|
| emf range:         | 0.291 mV to 2.431 mV         | 2.431 mV to 13.820 mV           |
| $c_0 =$            | $9.842\,332\,1 \times 10^1$  | $2.131\,507\,1 \times 10^2$     |
| $c_1 =$            | $6.997\,150\,0 \times 10^2$  | $2.851\,050\,4 \times 10^2$     |
| $c_2 =$            | $-8.476\,530\,4 \times 10^2$ | $-5.274\,288\,7 \times 10^1$    |
| $c_3 =$            | $1.005\,264\,4 \times 10^3$  | $9.916\,080\,4 \dots$           |
| $c_4 =$            | $-8.334\,595\,2 \times 10^2$ | $-1.296\,530\,3 \dots$          |
| $c_5 =$            | $4.550\,854\,2 \times 10^2$  | $1.119\,587\,0 \times 10^{-1}$  |
| $c_6 =$            | $-1.552\,303\,7 \times 10^2$ | $-6.062\,519\,9 \times 10^{-3}$ |
| $c_7 =$            | $2.988\,675\,0 \times 10^1$  | $1.866\,169\,6 \times 10^{-4}$  |
| $c_8 =$            | $-2.474\,286\,0 \dots$       | $-2.487\,858\,5 \times 10^{-6}$ |

NOTE— The above coefficients are extracted from Reference 1 and are for an expression of the form shown in Section 10.3.2. They yield approximate values of temperature that agree within  $\pm 0.03$  °C with the values given in Table 10.2.

**Type E Thermocouples: Coefficients ( $c_i$ ) of Polynomials for the Computation of Temperatures in °C as a Function of the Thermocouple emf in Various Temperature and emf Ranges**

| Temperature range: | -200 °C TO 0 °C                 | 0 °C to 1000 °C                  |
|--------------------|---------------------------------|----------------------------------|
| emf range:         | -8.825 mV to 0.0 mV             | 0.0 mV to 76.373 mV              |
| $c_0 =$            | 0.000 000 0 ...                 | 0.000 000 0 ...                  |
| $c_1 =$            | $1.697\,728\,8 \times 10^1$     | $1.705\,703\,5 \times 10^1$      |
| $c_2 =$            | $-4.351\,497\,0 \times 10^{-1}$ | $-2.330\,175\,9 \times 10^{-1}$  |
| $c_3 =$            | $-1.585\,969\,7 \times 10^{-1}$ | $6.543\,558\,5 \times 10^{-3}$   |
| $c_4 =$            | $-9.250\,287\,1 \times 10^{-2}$ | $-7.356\,274\,9 \times 10^{-5}$  |
| $c_5 =$            | $-2.608\,431\,4 \times 10^{-2}$ | $-1.789\,600 \times 10^{-6}$     |
| $c_6 =$            | $-4.136\,019\,9 \times 10^{-3}$ | $8.403\,616\,5 \times 10^{-8}$   |
| $c_7 =$            | $-3.403\,403\,0 \times 10^{-4}$ | $-1.373\,587\,9 \times 10^{-9}$  |
| $c_8 =$            | $-1.156\,489\,0 \times 10^{-5}$ | $1.062\,982\,3 \times 10^{-11}$  |
| $c_9 =$            | .....                           | $-3.244\,708\,7 \times 10^{-14}$ |

NOTE— The above coefficients are extracted from Reference 1 and are for an expression of the form shown in Section 10.3.2. They yield approximate values of temperature that agree within  $\pm 0.02$  °C with the values given in Table 10.4

**Type J Thermocouples: Coefficients ( $c_i$ ) of Polynomials for the Computation of Temperatures in °C as a Function of the Thermocouple emf in Various Temperature and emf Ranges**

| Temperature range: | -210 °C to 0 °C                 | 0 °C to 760 °C               | 760 °C to 1200 °C               |
|--------------------|---------------------------------|------------------------------|---------------------------------|
| emf Range:         | -8.095 mV to 0.0 mV             | 0.0 mV to 42.919 mV          | 42.919 mV to 69.553 mV          |
| $c_0 =$            | 0.000 000 0...                  | 0.000 000 ...                | $-3.113\,581\,87 \times 10^3$   |
| $c_1 =$            | $1.952\,826\,8 \times 10^1$     | $1.978\,425 \times 10^1$     | $3.005\,436\,84 \times 10^2$    |
| $c_2 =$            | $-1.228\,618\,5 \dots$          | $-2.001\,204 \times 10^{-1}$ | $-9.947\,732\,30 \dots$         |
| $c_3 =$            | $-1.075\,217\,8 \dots$          | $1.036\,969 \times 10^{-2}$  | $1.702\,766\,30 \times 10^{-1}$ |
| $c_4 =$            | $-5.908\,693\,3 \times 10^{-1}$ | $-2.549\,687 \times 10^{-4}$ | $1.430\,334\,68 \times 10^{-3}$ |
| $c_5 =$            | $-1.725\,671\,3 \times 10^{-1}$ | $3.585\,153 \times 10^{-6}$  | $4.438\,860\,84 \times 10^{-6}$ |
| $c_6 =$            | $-2.813\,151\,3 \times 10^{-2}$ | $-5.344\,285 \times 10^{-8}$ | .....                           |
| $c_7 =$            | $-2.396\,337\,0 \times 10^{-3}$ | $5.099\,890 \times 10^{-10}$ | .....                           |
| $c_8 =$            | $-8.382\,332\,1 \times 10^{-5}$ | .....                        | .....                           |

NOTE— The above coefficients are extracted from Reference 1 and are for an expression of the form shown in Section 10.3.2. They yield approximate values of temperature that agree within  $\pm 0.5$  °C with the values given in Table 10.6.

**Type K Thermocouples: Coefficients ( $c_i$ ) of Polynomials for the Computation of Temperatures in °C  
as a Function of the Thermocouple emf in Various Temperature and emf Ranges**

| Temperature range: | – 200 °C to 0 °C                | 0 °C to 500 °C               | 500 °C to 1372 °C            |
|--------------------|---------------------------------|------------------------------|------------------------------|
| emf Range:         | – 5.891 mV to 0.0 mV            | 0.0 mV to 20.644 mV          | 20.644 mV to 54.886 mV       |
| $c_0 =$            | 0.000 000 0 ...                 | 0.000 000 ...                | $-1.318\,058 \times 10^2$    |
| $c_1 =$            | $2.517\,346\,2 \times 10^1$     | $2.508\,355 \times 10^1$     | $4.830\,222 \times 10^1$     |
| $c_2 =$            | $-1.166\,287\,8 ...$            | $7.860\,106 \times 10^{-2}$  | $-1.646\,031 ...$            |
| $c_3 =$            | $-1.083\,363\,8 ...$            | $-2.503\,131 \times 10^{-1}$ | $5.464\,731 \times 10^{-2}$  |
| $c_4 =$            | $-8.977\,354\,0 \times 10^{-1}$ | $8.315\,270 \times 10^{-2}$  | $-9.650\,715 \times 10^{-4}$ |
| $c_5 =$            | $-3.734\,237\,7 \times 10^{-1}$ | $-1.228\,034 \times 10^{-2}$ | $8.802\,193 \times 10^{-6}$  |
| $c_6 =$            | $-8.663\,264\,3 \times 10^{-2}$ | $9.804\,036 \times 10^{-4}$  | $3.110\,810 \times 10^{-8}$  |
| $c_7 =$            | $-1.045\,059\,8 \times 10^{-2}$ | $-4.413\,030 \times 10^{-5}$ | .....                        |
| $c_8 =$            | $-5.192\,057\,7 \times 10^{-4}$ | $1.057\,734 \times 10^{-6}$  | .....                        |
| $c_9 =$            | .....                           | $-1.052\,755 \times 10^{-8}$ | .....                        |

NOTE—The above coefficients are extracted from Reference 1 and are for an expression of the form shown in Section 10.3.2. They yield approximate values of temperature that agree within  $\pm 0.05$  °C with the values given in Table 10.8.

**Type N Thermocouples: Coefficients ( $c_i$ ) of Polynomials for the Computation of Temperatures in  
°C as a Function of the Thermocouple emf in Various Temperature and emf Ranges**

| Temperature range: | –200 °C to 0 °C                | 0 °C to 600 °C              | 600 °C to 1300 °C            |
|--------------------|--------------------------------|-----------------------------|------------------------------|
| emf Range:         | –3.990 mV to 0.0 mV            | 0.0 mV to 20.613 mV         | 20.613 mV to 47.513 mV       |
| $c_0 =$            | 0.000 000 0 ...                | 0.000 00 ...                | $1.972\,485 \times 10^1$     |
| $c_1 =$            | $3.843\,684\,7 \times 10^1$    | $3.868\,96 \times 10^1$     | $3.300\,943 \times 10^1$     |
| $c_2 =$            | $1.101\,048\,5 ...$            | $-1.082\,67 ...$            | $-3.915\,159 \times 10^{-1}$ |
| $c_3 =$            | $5.222\,931\,2 ...$            | $4.702\,05 \times 10^{-2}$  | $9.855\,391 \times 10^{-3}$  |
| $c_4 =$            | $7.206\,052\,5 ...$            | $-2.121\,69 \times 10^{-6}$ | $-1.274\,371 \times 10^{-4}$ |
| $c_5 =$            | $5.848\,858\,6 ...$            | $-1.172\,72 \times 10^{-4}$ | $7.767\,022 \times 10^{-7}$  |
| $c_6 =$            | $2.775\,491\,6 ...$            | $5.392\,80 \times 10^{-6}$  | .....                        |
| $c_7 =$            | $7.707\,516\,6 \times 10^{-1}$ | $-7.981\,56 \times 10^{-8}$ | .....                        |
| $c_8 =$            | $1.158\,266\,5 \times 10^{-1}$ | .....                       | .....                        |
| $c_9 =$            | $7.313\,886\,8 \times 10^{-3}$ | .....                       | .....                        |

NOTE—The above coefficients are extracted from Reference 1 and are for an expression of the form shown in Section 10.3.2. They yield approximate values of temperature that agree within  $\pm 0.04$  °C with the values given in Table 10.10.

**Type R Thermocouples: Coefficients ( $c_i$ ) of Polynomials for the Computation of Temperatures in °C as a Function of  
the Thermocouple emf in Various Temperature and emf Ranges**

| Temperature range: | – 50 °C to 250 °C            | 250 °C to 1200 °C                 | 1064 °C to 1664.5 °C              | 1664.5 °C to 1768.1 °C           |
|--------------------|------------------------------|-----------------------------------|-----------------------------------|----------------------------------|
| emf Range:         | – 0.226 mV to 1.923 mV       | 1.923 mV to 13.228 mV             | 11.361 mV to 19.739 mV            | 19.739 mV to 21.103 mV           |
| $c_0 =$            | 0.000 000 0 ...              | $1.334\,584\,505 \times 10^1$     | $-8.199\,599\,416 \times 10^1$    | $3.406\,177\,836 \times 10^4$    |
| $c_1 =$            | $1.889\,138\,0 \times 10^2$  | $1.472\,644\,573 \times 10^2$     | $1.553\,962\,042 \times 10^2$     | $-7.023\,729\,171 \times 10^3$   |
| $c_2 =$            | $-9.383\,529\,0 \times 10^1$ | $-1.844\,024\,844 \times 10^1$    | $-8.342\,197\,663$                | $5.582\,903\,813 \times 10^2$    |
| $c_3 =$            | $1.306\,861\,9 \times 10^2$  | $4.031\,129\,726 ...$             | $4.279\,433\,549 \times 10^{-1}$  | $-1.952\,394\,635 \times 10^1$   |
| $c_4 =$            | $-2.270\,358\,0 \times 10^2$ | $-6.249\,428\,360 \times 10^{-1}$ | $-1.191\,577\,910 \times 10^{-2}$ | $2.560\,740\,231 \times 10^{-1}$ |
| $c_5 =$            | $3.514\,565\,9 \times 10^2$  | $6.468\,412\,046 \times 10^{-2}$  | $1.492\,290\,091 \times 10^{-4}$  | .....                            |
| $c_6 =$            | $-3.895\,390\,0 \times 10^2$ | $-4.458\,750\,426 \times 10^{-3}$ | .....                             | .....                            |
| $c_7 =$            | $2.823\,947\,1 \times 10^2$  | $1.994\,710\,149 \times 10^{-4}$  | .....                             | .....                            |
| $c_8 =$            | $-1.260\,728\,1 \times 10^2$ | $-5.313\,401\,790 \times 10^{-6}$ | .....                             | .....                            |
| $c_9 =$            | $3.135\,361\,1 \times 10^1$  | $6.481\,976\,217 \times 10^{-8}$  | .....                             | .....                            |
| $c_{10} =$         | $-3.318\,776\,9 ...$         | .....                             | .....                             | .....                            |

NOTE—The above coefficients are extracted from Reference 1 and are for an expression of the form shown in Section 10.3.2. They yield approximate values of temperature that agree within  $\pm 0.02$  °C with the values given in Table 10.12.

**Type S Thermocouples: Coefficients ( $c_i$ ) of Polynomials for the Computation of Temperatures in °C as a Function of the Thermocouple emf in Various Temperature and emf Ranges**

| Temperature range: | -50 °C to 250 °C              | 250 °C to 1200 °C                 | 1064 °C to 1664.5 °C              | 1664.5 °C to 1768.1 °C           |
|--------------------|-------------------------------|-----------------------------------|-----------------------------------|----------------------------------|
| emf Range:         | -0.235 mV to 1.874 mV         | 1.874 mV to 11.950 mV             | 10.332 mV to 17.536 mV            | 17.536 mV to 18.693 mV           |
| $c_0 =$            | 0.000 000 00 . . .            | $1.291\ 507\ 177 \times 10^1$     | $-8.087\ 801\ 117 \times 10^1$    | $5.333\ 875\ 126 \times 10^4$    |
| $c_1 =$            | $1.849\ 494\ 60 \times 10^2$  | $1.466\ 298\ 863 \times 10^2$     | $1.621\ 573\ 104 \times 10^2$     | $-1.235\ 892\ 298 \times 10^4$   |
| $c_2 =$            | $-8.005\ 040\ 62 \times 10^1$ | $-1.534\ 713\ 402 \times 10^1$    | $-8.536\ 869\ 453 . . .$          | $1.092\ 657\ 613 \times 10^3$    |
| $c_3 =$            | $1.022\ 374\ 30 \times 10^2$  | $3.145\ 945\ 973 . . .$           | $4.719\ 686\ 976 \times 10^{-1}$  | $-4.265\ 693\ 686 \times 10^1$   |
| $c_4 =$            | $-1.522\ 485\ 92 \times 10^2$ | $-4.163\ 257\ 839 \times 10^{-1}$ | $-1.441\ 693\ 666 \times 10^{-2}$ | $6.247\ 205\ 420 \times 10^{-1}$ |
| $c_5 =$            | $1.888\ 213\ 43 \times 10^2$  | $3.187\ 963\ 771 \times 10^{-2}$  | $2.081\ 618\ 890 \times 10^{-4}$  | .....                            |
| $c_6 =$            | $-1.590\ 859\ 41 \times 10^2$ | $-1.291\ 637\ 500 \times 10^{-3}$ | .....                             | .....                            |
| $c_7 =$            | $8.230\ 278\ 80 \times 10^1$  | $2.183\ 475\ 087 \times 10^{-5}$  | .....                             | .....                            |
| $c_8 =$            | $-2.341\ 819\ 44 \times 10^1$ | $-1.447\ 379\ 511 \times 10^{-7}$ | .....                             | .....                            |
| $c_9 =$            | $2.797\ 862\ 60 . . .$        | $8.211\ 272\ 125 \times 10^{-9}$  | .....                             | .....                            |

NOTE—The above coefficients are extracted from Reference 1 and are for an expression of the form shown in Section 10.3.2. They yield approximate values of temperature that agree within  $\pm 0.02$  °C with the values given in Table 10.14.

**Type T Thermocouples: Coefficients ( $c_i$ ) of Polynomials for the Computation of temperatures in °C as a Function of the Thermocouple emf in Various Temperature and emf Ranges**

| Temperature range: | -200 °C to 0 °C                 | 0 °C to 400 °C               |
|--------------------|---------------------------------|------------------------------|
| emf Range:         | -5.603 mV to 0.0 mV             | 0.0 mV to 20.872 mV          |
| $c_0 =$            | 0.000 000 0 . . .               | 0.000 000 . . .              |
| $c_1 =$            | $2.594\ 919\ 2 \times 10^1$     | $2.592\ 800 \times 10^1$     |
| $c_2 =$            | $-2.131\ 696\ 7 \times 10^{-1}$ | $-7.602\ 961 \times 10^{-1}$ |
| $c_3 =$            | $7.901\ 869\ 2 \times 10^{-1}$  | $4.637\ 791 \times 10^{-2}$  |
| $c_4 =$            | $4.252\ 777\ 7 \times 10^{-1}$  | $-2.165\ 394 \times 10^{-3}$ |
| $c_5 =$            | $1.330\ 447\ 3 \times 10^{-1}$  | $6.048\ 144 \times 10^{-5}$  |
| $c_6 =$            | $2.024\ 144\ 6 \times 10^{-2}$  | $-7.293\ 422 \times 10^{-7}$ |
| $c_7 =$            | $1.266\ 817\ 1 \times 10^{-3}$  | .....                        |

NOTE—The above coefficients are extracted from Reference 1 and are for an expression of the form shown in Section 10.3.2. They yield approximate values of temperature that agree within  $\pm 0.04$  °C with the values given in Table 10.16.

# LABORATORY SOLVENTS AND OTHER LIQUID REAGENTS

This table summarizes the properties of 575 liquids that are commonly used in the laboratory as solvents or chemical reagents.

The properties tabulated are:

|              |                                                                                                                       |
|--------------|-----------------------------------------------------------------------------------------------------------------------|
| $M_r$ :      | Molecular weight                                                                                                      |
| $t_m$ :      | Melting point in °C                                                                                                   |
| $t_b$ :      | Normal boiling point in °C                                                                                            |
| $\rho$ :     | Density in g/mL at the temperature in °C indicated by the superscript                                                 |
| $\eta$ :     | Viscosity in mPa s (1 mPa s = 1 centipoise) at 25 °C                                                                  |
| $\epsilon$ : | Dielectric constant at ambient temperature (15 to 30 °C)                                                              |
| $\mu$ :      | Dipole moment in D                                                                                                    |
| $c_p$ :      | Specific heat capacity of the liquid at constant pressure at 25 °C in J/g K                                           |
| vp:          | Vapor pressure at 25 °C in kPa (1 kPa = 7.50 mmHg)                                                                    |
| FP:          | Flash point in °C                                                                                                     |
| Fl.Lim:      | Flammable (explosive) limit in air in percent by volume                                                               |
| IT:          | Autoignition temperature in °C                                                                                        |
| TLV:         | Threshold limit for allowable airborne concentration in parts per million by volume at 25 °C and atmospheric pressure |

Data on the temperature dependence of viscosity, dielectric constant, and vapor pressure can be found in the pertinent tables in this *Handbook*.

## References

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3. Riddick, J. A., Bunger, W. B., and Sakano, T. K., *Organic Solvents, Fourth Edition*, John Wiley & Sons, New York, 1986.
4. *Fire Protection Guide to Hazardous Materials, 11th Edition*, National Fire Protection Association, Quincy, MA, 1994.
5. Urben, P. G., Ed., *Bretherick's Handbook of Reactive Chemical Hazards, 5th Edition*, Butterworth-Heinemann, Oxford, 1995.
6. *2004 TLVs and BEIs*, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 2004.

| Name                        | Mol. form.                                 | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | vp/kPa | FP/<br>°C | Fl. lim.  | IT/°C | TLV/ppm |
|-----------------------------|--------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|--------|-----------|-----------|-------|---------|
| Acetaldehyde                | $\text{C}_2\text{H}_4\text{O}$             | 44.052  | -123.37              | 20.1                 | 0.7834 <sup>18</sup>    |                     | 21.0       | 2.750          | 2.020                              | 120    | -39       | 4-60%     | 175   | 25      |
| Acetic acid                 | $\text{C}_2\text{H}_4\text{O}_2$           | 60.052  | 16.64                | 117.9                | 1.0446 <sup>25</sup>    | 1.056               | 6.20       | 1.70           | 2.053                              | 2.07   | 39        | 4-20%     | 463   | 10      |
| Acetic anhydride            | $\text{C}_4\text{H}_6\text{O}_3$           | 102.089 | -74.1                | 139.5                | 1.082 <sup>20</sup>     | 0.843               | 22.45      | $\approx 2.8$  | 1.648                              | 0.680  | 49        | 2.7-10.3% | 316   | 5       |
| Acetone                     | $\text{C}_3\text{H}_6\text{O}$             | 58.079  | -94.7                | 56.05                | 0.7845 <sup>25</sup>    | 0.306               | 21.01      | 2.88           | 2.175                              | 30.8   | -20       | 3-13%     | 465   | 500     |
| Acetone cyanohydrin         | $\text{C}_4\text{H}_7\text{NO}$            | 85.105  | -19                  | 95                   | 0.932 <sup>19</sup>     |                     |            |                |                                    |        | 74        | 2.2-12%   | 688   | 4.6     |
| Acetonitrile                | $\text{C}_2\text{H}_3\text{N}$             | 41.052  | -43.82               | 81.65                | 0.7857 <sup>20</sup>    | 0.369               | 36.64      | 3.92           | 2.229                              | 11.9   | 6         | 3-16%     | 524   | 20      |
| Acetophenone                | $\text{C}_8\text{H}_8\text{O}$             | 120.149 | 20.5                 | 202                  | 1.0281 <sup>20</sup>    | 1.681               | 17.44      | 3.02           | 1.703                              | 0.049  | 77        |           | 570   | 10      |
| Acetyl bromide              | $\text{C}_2\text{H}_3\text{BrO}$           | 122.948 | -96                  | 76                   | 1.6625 <sup>16</sup>    |                     |            |                |                                    | 16.2   |           |           |       |         |
| Acetyl chloride             | $\text{C}_2\text{H}_3\text{ClO}$           | 78.497  | -112.8               | 50.7                 | 1.1051 <sup>20</sup>    | 0.368               | 15.8       | 2.72           | 1.491                              | 38.4   | 4         |           | 390   |         |
| Acrolein                    | $\text{C}_3\text{H}_4\text{O}$             | 56.063  | -87.7                | 52.6                 | 0.840 <sup>20</sup>     |                     |            | 3.1            |                                    | 36.2   | -26       | 2.8-31%   | 220   | 0.1     |
| Acrylic acid                | $\text{C}_3\text{H}_4\text{O}_2$           | 72.063  | 12.5                 | 141                  | 1.0511 <sup>20</sup>    |                     |            |                | 2.022                              | 0.53   | 50        | 2.4-8%    | 438   | 2       |
| Acrylonitrile               | $\text{C}_3\text{H}_3\text{N}$             | 53.063  | -83.48               | 77.3                 | 0.8007 <sup>25</sup>    |                     | 33.0       | 3.87           | 2.05                               | 14.1   | 0         | 3-17%     | 481   | 2       |
| Allyl alcohol               | $\text{C}_3\text{H}_6\text{O}$             | 58.079  | -129                 | 97.0                 | 0.8540 <sup>20</sup>    | 1.218               | 19.7       | 1.60           | 2.392                              | 3.14   | 21        | 3-18%     | 378   | 0.5     |
| Allylamine                  | $\text{C}_3\text{H}_7\text{N}$             | 57.095  | -88.2                | 53.3                 | 0.758 <sup>20</sup>     |                     |            | 1.2            |                                    | 33.1   | -29       | 2-22%     | 374   |         |
| 2-Amino-2-methyl-1-propanol | $\text{C}_4\text{H}_{11}\text{NO}$         | 89.136  | 25.5                 | 165.5                | 0.934 <sup>20</sup>     |                     |            |                |                                    |        | 67        |           |       |         |
| 3-Amino-1-propanol          | $\text{C}_3\text{H}_7\text{NO}$            | 75.109  | 12.4                 | 187.5                | 0.9824 <sup>26</sup>    |                     |            |                |                                    |        | 80        |           |       |         |
| Aniline                     | $\text{C}_6\text{H}_7\text{N}$             | 93.127  | -6.02                | 184.17               | 1.0217 <sup>20</sup>    | 3.85                | 7.06       | 1.13           | 2.061                              | 0.090  | 70        | 1.3-11%   | 615   | 2       |
| Anisole                     | $\text{C}_7\text{H}_8\text{O}$             | 108.138 | -37.13               | 153.7                | 0.9940 <sup>20</sup>    | 1.056               | 4.30       | 1.38           | 1.840                              | 0.472  | 52        |           | 475   |         |
| Antimony(V) chloride        | $\text{Cl}_5\text{Sb}$                     | 299.024 | 4                    | 140 dec              | 2.34                    |                     | 3.222      |                |                                    |        |           |           |       |         |
| Antimony(V) fluoride        | $\text{F}_5\text{Sb}$                      | 216.752 | 8.3                  | 141                  | 3.10                    |                     |            |                |                                    |        |           |           |       |         |
| Arsenic(III) chloride       | $\text{AsCl}_3$                            | 181.280 | -16                  | 130                  | 2.150                   |                     |            | 1.59           |                                    | 5.38   |           |           |       |         |
| Benzaldehyde                | $\text{C}_7\text{H}_6\text{O}$             | 106.122 | -57.1                | 178.8                | 1.0401 <sup>25</sup>    |                     | 17.85      | 3.0            | 1.621                              | 0.169  | 63        |           | 192   |         |
| Benzene                     | $\text{C}_6\text{H}_6$                     | 78.112  | 5.49                 | 80.09                | 0.8765 <sup>20</sup>    | 0.604               | 2.2825     | 0              | 1.741                              | 12.7   | -11       | 1-8%      | 498   | 0.5     |
| Benzeneacetonitrile         | $\text{C}_9\text{H}_7\text{N}$             | 117.149 | -23.8                | 233.5                | 1.0205 <sup>15</sup>    |                     | 17.87      | 3.5            |                                    | 0.012  | 113       |           |       |         |
| Benzeneethanamine           | $\text{C}_8\text{H}_{11}\text{N}$          | 121.180 | <0                   | 195                  | 0.9640 <sup>25</sup>    |                     |            |                |                                    |        |           |           |       |         |
| Benzeneethanol              | $\text{C}_8\text{H}_{10}\text{O}$          | 122.164 | -27                  | 218.2                | 1.0202 <sup>20</sup>    |                     | 12.31      |                | 2.068                              | 0.01   | 96        |           |       |         |
| Benzenemethanethiol         | $\text{C}_7\text{H}_7\text{S}$             | 124.204 | -30                  | 194.5                | 1.058 <sup>20</sup>     |                     | 4.705      |                |                                    |        |           |           |       |         |
| Benzenesulfonyl chloride    | $\text{C}_6\text{H}_5\text{ClO}_2\text{S}$ | 176.621 | 14.5                 | 251 dec              | 1.3470 <sup>15</sup>    |                     | 28.90      |                |                                    | 0.008  |           |           |       |         |
| Benzenethiol                | $\text{C}_6\text{H}_6\text{S}$             | 110.177 | -14.93               | 169.1                | 1.0775 <sup>15</sup>    |                     | 4.26       | 1.23           | 1.572                              | 0.26   |           |           |       | 0.1     |
| Benzonitrile                | $\text{C}_7\text{H}_5\text{N}$             | 103.122 | -13.99               | 191.1                | 1.0093 <sup>15</sup>    | 1.267               | 25.9       | 4.18           | 1.602                              | 0.11   |           |           |       |         |
| Benzoyl chloride            | $\text{C}_7\text{H}_5\text{ClO}$           | 140.567 | -0.4                 | 197.2                | 1.2120 <sup>20</sup>    |                     | 23.0       |                |                                    | 0.084  | 72        |           |       | 0.5     |
| Benzyl acetate              | $\text{C}_9\text{H}_{10}\text{O}_2$        | 150.174 | -51.3                | 213                  | 1.0550 <sup>20</sup>    |                     | 5.34       | 1.22           | 0.989                              | 0.022  | 90        |           | 460   | 10      |
| Benzyl alcohol              | $\text{C}_7\text{H}_8\text{O}$             | 108.138 | -15.4                | 205.31               | 1.0419 <sup>24</sup>    | 5.47                | 11.916     | 1.71           | 2.015                              | 0.015  | 93        |           | 436   |         |
| Benzylamine                 | $\text{C}_7\text{H}_9\text{N}$             | 107.153 |                      | 185                  | 0.9813 <sup>20</sup>    | 1.624               | 5.18       |                |                                    | 0.096  |           |           |       |         |
| 2,2'-Bioxirane              | $\text{C}_4\text{H}_6\text{O}_2$           | 86.090  | 2.0                  | 144                  | 1.113 <sup>20</sup>     |                     |            |                |                                    |        |           |           |       |         |

| Name                                             | Mol. form.                                  | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | $\text{vp}/\text{kPa}$ | FP/<br>$^\circ\text{C}$ | Fl. lim.  | IT/ $^\circ\text{C}$ | TLV/ppm |
|--------------------------------------------------|---------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|------------------------|-------------------------|-----------|----------------------|---------|
| Bis(2-aminoethyl)amine                           | $\text{C}_4\text{H}_{13}\text{N}_3$         | 103.166 | -39                  | 207                  | 0.9569 <sup>20</sup>    |                     | 12.62      | 1.9            | 2.462                              | 0.03                   | 98                      | 2-7%      | 358                  | 1       |
| <i>N,N'</i> -Bis(2-aminoethyl)-1,2-ethanediamine | $\text{C}_6\text{H}_{18}\text{N}_4$         | 146.234 | 12                   | 266.5                |                         |                     | 10.76      |                |                                    |                        |                         |           |                      |         |
| Bis(2-chloroethyl) ether                         | $\text{C}_4\text{H}_8\text{Cl}_2\text{O}$   | 143.012 | -51.9                | 178.5                | 1.22 <sup>20</sup>      |                     | 21.20      | 2.6            | 1.545                              | 0.143                  | 55                      | 3%-       | 369                  | 5       |
| Bis(chloromethyl) ether                          | $\text{C}_2\text{H}_4\text{Cl}_2\text{O}$   | 114.958 | -41.5                | 106                  | 1.323 <sup>15</sup>     |                     | 3.51       |                |                                    |                        |                         |           |                      | 0.001   |
| Bis(2-ethylhexyl) phthalate                      | $\text{C}_{24}\text{H}_{38}\text{O}_4$      | 390.557 | -55                  | 384                  | 0.981 <sup>25</sup>     |                     | 5.3        | 2.84           | 1.804                              | 0.00000005             | 218                     |           |                      | 0.3     |
| Bis(2-hydroxyethyl) sulfide                      | $\text{C}_4\text{H}_{10}\text{O}_2\text{S}$ | 122.186 | -10.2                | 282                  | 1.1793 <sup>25</sup>    |                     | 28.61      |                |                                    | 0.08                   | 160                     |           | 298                  |         |
| Boron tribromide                                 | $\text{BBr}_3$                              | 250.523 | -45                  | 91                   | 2.6                     |                     |            | 0              |                                    |                        |                         |           |                      | 1       |
| Boron trichloride                                | $\text{BCl}_3$                              | 117.169 | -107                 | 12.65                |                         |                     |            | 0              | 0.911                              | 156                    |                         |           |                      |         |
| Bromine                                          | $\text{Br}_2$                               | 159.808 | -7.2                 | 58.8                 | 3.1028                  | 0.944               | 3.1484     | 0              | 0.474                              | 28.2                   |                         |           |                      | 0.1     |
| Bromobenzene                                     | $\text{C}_6\text{H}_5\text{Br}$             | 157.008 | -30.72               | 156.06               | 1.4950 <sup>20</sup>    | 1.074               | 5.45       | 1.70           | 0.983                              | 0.556                  | 51                      |           | 565                  |         |
| 1-Bromobutane                                    | $\text{C}_4\text{H}_9\text{Br}$             | 137.018 | -112.6               | 101.6                | 1.2750 <sup>20</sup>    | 0.606               | 7.315      | 2.08           | 0.798                              | 5.26                   | 18                      | 2.6-6.6%  | 265                  |         |
| 2-Bromobutane, ( $\pm$ )-                        | $\text{C}_4\text{H}_9\text{Br}$             | 137.018 | -112.65              | 91.3                 | 1.2585 <sup>20</sup>    |                     | 8.64       | 2.23           |                                    | 9.32                   | 21                      |           |                      |         |
| Bromochloromethane                               | $\text{CH}_2\text{BrCl}$                    | 129.384 | -87.9                | 68.0                 | 1.9344 <sup>20</sup>    |                     |            | 1.7            | 0.41                               | 19.5                   |                         |           |                      | 200     |
| Bromodichloromethane                             | $\text{CHBrCl}_2$                           | 163.829 | -57                  | 90                   | 1.980 <sup>20</sup>     |                     |            |                |                                    |                        |                         |           |                      |         |
| Bromoethane                                      | $\text{C}_2\text{H}_5\text{Br}$             | 108.965 | -118.6               | 38.5                 | 1.4604 <sup>20</sup>    | 0.374               | 9.01       | 2.03           | 0.925                              | 62.5                   |                         | 7-8%      | 511                  | 5       |
| Bromoethene                                      | $\text{C}_2\text{H}_3\text{Br}$             | 106.949 | -139.54              | 15.8                 | 1.4933 <sup>20</sup>    |                     | 5.63       | 1.42           | 1.007                              | 141                    |                         | 9-15%     | 530                  | 0.5     |
| 2-Bromo-2-methylpropane                          | $\text{C}_4\text{H}_9\text{Br}$             | 137.018 | -16.2                | 73.3                 | 1.4278 <sup>20</sup>    |                     | 10.98      | 2.17           | 1.102                              | 17.7                   |                         |           |                      |         |
| 1-Bromopentane                                   | $\text{C}_5\text{H}_{11}\text{Br}$          | 151.045 | -88.0                | 129.8                | 1.2182 <sup>20</sup>    |                     | 6.31       | 2.20           | 0.875                              | 1.68                   | 32                      |           |                      |         |
| 1-Bromopropane                                   | $\text{C}_3\text{H}_7\text{Br}$             | 122.992 | -110.3               | 71.1                 | 1.3537 <sup>20</sup>    | 0.489               | 8.09       | 2.18           | 0.702                              | 18.6                   |                         |           | 490                  |         |
| 2-Bromopropane                                   | $\text{C}_3\text{H}_7\text{Br}$             | 122.992 | -89.0                | 59.5                 | 1.3140 <sup>20</sup>    | 0.458               | 9.46       | 2.21           | 1.075                              | 28.9                   |                         |           |                      |         |
| 3-Bromopropene                                   | $\text{C}_3\text{H}_5\text{Br}$             | 120.976 | -119                 | 70.1                 | 1.398 <sup>20</sup>     | 0.471               | 7.0        | $\approx 1.9$  |                                    | 18.6                   | -1                      | 4.4-7.3%  | 295                  |         |
| 2-Bromotoluene                                   | $\text{C}_7\text{H}_7\text{Br}$             | 171.035 | -27.8                | 181.7                | 1.4232 <sup>20</sup>    |                     | 4.641      |                |                                    | 0.17                   | 79                      |           |                      |         |
| Bromotrichloromethane                            | $\text{CBrCl}_3$                            | 198.274 | -5.65                | 105                  | 2.012 <sup>25</sup>     |                     | 2.405      |                |                                    | 5.35                   |                         |           |                      |         |
| Butanal                                          | $\text{C}_4\text{H}_8\text{O}$              | 72.106  | -96.86               | 74.8                 | 0.8016 <sup>20</sup>    |                     | 13.45      | 2.72           | 2.270                              | 15.7                   | -22                     | 2-12.5%   | 218                  |         |
| 1,3-Butanediol                                   | $\text{C}_4\text{H}_{10}\text{O}_2$         | 90.121  | -77                  | 207.5                | 1.0053 <sup>20</sup>    |                     | 28.8       |                | 2.521                              | 0.008                  | 121                     |           | 395                  |         |
| 1,4-Butanediol                                   | $\text{C}_4\text{H}_{10}\text{O}_2$         | 90.121  | 20.4                 | 235                  | 1.0171 <sup>20</sup>    |                     | 31.9       | 2.58           | 2.220                              | 0.002                  | 121                     |           |                      |         |
| 2,3-Butanediol                                   | $\text{C}_4\text{H}_{10}\text{O}_2$         | 90.121  | 7.6                  | 182.5                | 1.0033 <sup>20</sup>    |                     |            |                | 2.363                              | 0.02                   |                         |           | 402                  |         |
| 2,3-Butanedione                                  | $\text{C}_4\text{H}_6\text{O}_2$            | 86.090  | -1.2                 | 88                   | 0.9808 <sup>18</sup>    |                     | 4.04       |                |                                    | 7.45                   | 27                      |           |                      |         |
| Butanenitrile                                    | $\text{C}_4\text{H}_7\text{N}$              | 69.106  | -111.9               | 117.6                | 0.7936 <sup>20</sup>    | 0.553               | 24.83      | 3.9            | 2.301                              | 2.55                   | 24                      | >1.6%     | 501                  |         |
| 1-Butanethiol                                    | $\text{C}_4\text{H}_{10}\text{S}$           | 90.187  | -115.7               | 98.5                 | 0.8416 <sup>20</sup>    |                     | 5.204      | 1.53           | 1.898                              | 6.07                   | 2                       |           |                      | 0.5     |
| 2-Butanethiol                                    | $\text{C}_4\text{H}_{10}\text{S}$           | 90.187  | -165                 | 85.0                 | 0.8295 <sup>20</sup>    |                     | 5.645      |                |                                    | 10.8                   | -23                     |           |                      |         |
| Butanoic acid                                    | $\text{C}_4\text{H}_8\text{O}_2$            | 88.106  | -5.1                 | 163.75               | 0.9529 <sup>25</sup>    | 1.426               | 2.98       | 1.65           | 2.027                              | 0.221                  | 72                      | 2-10%     | 443                  |         |
| Butanoic anhydride                               | $\text{C}_8\text{H}_{14}\text{O}_3$         | 158.195 | -75                  | 200                  | 0.9668 <sup>20</sup>    |                     | 12.8       |                | 1.793                              | 0.07                   | 54                      | 0.9-5.8%  | 279                  |         |
| 1-Butanol                                        | $\text{C}_4\text{H}_{10}\text{O}$           | 74.121  | -88.6                | 117.73               | 0.8095 <sup>20</sup>    | 2.54                | 17.84      | 1.66           | 2.391                              | 0.86                   | 37                      | 1-11%     | 343                  | 20      |
| 2-Butanol                                        | $\text{C}_4\text{H}_{10}\text{O}$           | 74.121  | -88.5                | 99.51                | 0.8063 <sup>20</sup>    | 3.10                | 17.26      | 1.8            | 2.656                              | 2.32                   | 24                      | 2-10%     | 405                  | 100     |
| 2-Butanone                                       | $\text{C}_4\text{H}_8\text{O}$              | 72.106  | -86.64               | 79.59                | 0.7999 <sup>25</sup>    | 0.405               | 18.56      | 2.78           | 2.201                              | 12.6                   | -9                      | 1-11%     | 404                  | 200     |
| <i>trans</i> -2-Butenal                          | $\text{C}_4\text{H}_6\text{O}$              | 70.090  | -76                  | 102.2                | 0.8516 <sup>20</sup>    |                     |            | 3.67           | 1.361                              | 4.92                   | 13                      | 2.1-15.5% | 232                  | 0.3     |
| <i>cis</i> -2-Butenoic acid                      | $\text{C}_4\text{H}_6\text{O}_2$            | 86.090  | 15                   | 169                  | 1.0267 <sup>20</sup>    |                     |            |                |                                    | 0.06                   |                         |           |                      |         |
| 2-Butoxyethanol                                  | $\text{C}_6\text{H}_{14}\text{O}_2$         | 118.174 | -74.8                | 168.4                | 0.9015 <sup>20</sup>    |                     | 9.30       | 2.1            | 2.378                              | 0.15                   | 69                      | 4-13%     | 238                  | 20      |
| Butyl acetate                                    | $\text{C}_6\text{H}_{12}\text{O}_2$         | 116.158 | -78                  | 126.1                | 0.8825 <sup>20</sup>    | 0.685               | 5.07       | 1.9            | 1.961                              | 1.66                   | 22                      | 2-8%      | 425                  | 150     |
| <i>sec</i> -Butyl acetate                        | $\text{C}_6\text{H}_{12}\text{O}_2$         | 116.158 | -98.9                | 112                  | 0.8748 <sup>20</sup>    |                     | 5.135      | 1.87           |                                    |                        | 31                      | 1.7-9.8%  |                      | 200     |
| Butyl acrylate                                   | $\text{C}_8\text{H}_{12}\text{O}_2$         | 128.169 | -64.6                | 145                  | 0.8898 <sup>20</sup>    |                     | 5.25       |                | 1.958                              | 0.731                  | 29                      | 1.7-9.9%  | 292                  | 2       |
| Butylamine                                       | $\text{C}_4\text{H}_{11}\text{N}$           | 73.137  | -49.1                | 77.00                | 0.7414 <sup>20</sup>    | 0.574               | 4.71       | 1.0            | 2.450                              | 12.2                   | -12                     | 2-10%     | 312                  | 5       |
| <i>sec</i> -Butylamine                           | $\text{C}_4\text{H}_{11}\text{N}$           | 73.137  | <-72                 | 62.73                | 0.7246 <sup>20</sup>    |                     |            | 1.28           |                                    |                        | -9                      |           |                      |         |
| <i>tert</i> -Butylamine                          | $\text{C}_4\text{H}_{11}\text{N}$           | 73.137  | -66.94               | 44.04                | 0.6958 <sup>20</sup>    |                     | 58.5       | 1.3            | 2.627                              | 48.4                   | -9                      | 2-9%      | 380                  |         |
| Butylbenzene                                     | $\text{C}_{10}\text{H}_{14}$                | 134.218 | -87.85               | 183.31               | 0.8601 <sup>20</sup>    | 0.950               | 2.359      | $\approx 0$    | 1.813                              | 0.150                  | 71                      | 0.8-5.8%  | 410                  |         |
| <i>tert</i> -Butylbenzene                        | $\text{C}_{10}\text{H}_{14}$                | 134.218 | -57.8                | 169.1                | 0.8665 <sup>20</sup>    |                     | 2.359      | $\approx 0.83$ | 1.773                              | 0.280                  | 60                      | 0.7-5.7%  | 450                  |         |
| Butyl benzoate                                   | $\text{C}_{11}\text{H}_{14}\text{O}_2$      | 178.228 | -22.4                | 250.3                | 1.000 <sup>20</sup>     |                     | 5.52       |                |                                    | 0.005                  | 107                     |           |                      |         |
| <i>tert</i> -Butyl ethyl ether                   | $\text{C}_6\text{H}_{14}\text{O}$           | 102.174 | -94                  | 72.6                 | 0.736 <sup>25</sup>     |                     |            |                | 2.13                               | 16.5                   |                         |           |                      | 5       |
| <i>tert</i> -Butyl hydroperoxide                 | $\text{C}_4\text{H}_{10}\text{O}_2$         | 90.121  | 6                    | 89 dec               | 0.8960 <sup>20</sup>    |                     |            |                |                                    |                        | 27                      |           |                      |         |
| 1- <i>tert</i> -Butyl-4-methylbenzene            | $\text{C}_{11}\text{H}_{16}$                | 148.245 | -52                  | 190                  | 0.8612 <sup>20</sup>    |                     |            | $\approx 0$    |                                    | 0.09                   | 68                      |           |                      | 1       |
| Butyl vinyl ether                                | $\text{C}_6\text{H}_{12}\text{O}$           | 100.158 | -92                  | 94                   | 0.7888 <sup>20</sup>    |                     |            | 1.25           | 2.316                              | 6.65                   | -9                      |           | 255                  |         |
| $\gamma$ -Butyrolactone                          | $\text{C}_4\text{H}_6\text{O}_2$            | 86.090  | -43.61               | 204                  | 1.1296 <sup>20</sup>    |                     | 39.0       | 4.27           | 1.642                              | 0.43                   | 98                      |           |                      |         |
| Carbon disulfide                                 | $\text{CS}_2$                               | 76.141  | -112.1               | 46                   | 1.2632 <sup>20</sup>    | 0.352               | 2.6320     | 0              | 1.003                              | 48.2                   | -30                     | 1-50%     | 90                   | 10      |
| Chloroacetaldehyde                               | $\text{C}_2\text{H}_3\text{ClO}$            | 78.497  | -16.3                | 85.5                 | 1.19                    |                     |            |                |                                    |                        |                         |           |                      | 1       |
| Chloroacetone                                    | $\text{C}_3\text{H}_5\text{ClO}$            | 92.524  | -44.5                | 119                  | 1.15 <sup>20</sup>      |                     |            |                |                                    | 2                      |                         |           |                      | 1       |
| Chloroacetyl chloride                            | $\text{C}_2\text{H}_2\text{Cl}_2\text{O}$   | 112.942 | -22                  | 106                  | 1.4202 <sup>20</sup>    |                     |            | 2.23           |                                    | 3.33                   |                         |           |                      | 0.05    |
| 2-Chloroaniline                                  | $\text{C}_6\text{H}_5\text{ClN}$            | 127.572 | -1.9                 | 208.8                |                         | 3.32                | 13.40      | 1.77           |                                    | 0.034                  |                         |           |                      |         |
| 3-Chloroaniline                                  | $\text{C}_6\text{H}_5\text{ClN}$            | 127.572 | -10.28               | 230.5                | 1.2161 <sup>20</sup>    |                     | 13.3       |                | 1.558                              | 0.0156                 |                         |           | 705                  |         |
| Chlorobenzene                                    | $\text{C}_6\text{H}_5\text{Cl}$             | 112.557 | -45.31               | 131.72               | 1.1058 <sup>20</sup>    | 0.753               | 5.6895     | 1.69           | 1.334                              | 1.6                    | 28                      | 1-10%     | 593                  | 10      |
| 2-Chloro-1,3-butadiene                           | $\text{C}_4\text{H}_5\text{Cl}$             | 88.536  | -130                 | 59.4                 | 0.956 <sup>20</sup>     |                     | 4.914      |                |                                    | 29.5                   | -20                     | 4-20%     |                      | 10      |
| 1-Chlorobutane                                   | $\text{C}_4\text{H}_9\text{Cl}$             | 92.567  | -123.1               | 78.4                 | 0.8857 <sup>20</sup>    | 0.422               | 7.276      | 2.05           | 1.891                              | 13.7                   | -12                     | 2-10%     | 240                  |         |
| 2-Chlorobutane                                   | $\text{C}_4\text{H}_9\text{Cl}$             | 92.567  | -131.3               | 68.2                 | 0.8732 <sup>20</sup>    |                     | 8.564      | 2.04           |                                    | 21.0                   | -10                     |           |                      |         |
| Chlorocyclohexane                                | $\text{C}_6\text{H}_{11}\text{Cl}$          | 118.604 | -43.81               | 142                  | 1.000 <sup>20</sup>     |                     | 7.9505     | 2.1            |                                    | 1.0                    | 32                      |           |                      |         |
| Chlorodibromomethane                             | $\text{CHBr}_2\text{Cl}$                    | 208.280 | -20                  | 120                  | 2.451 <sup>20</sup>     |                     |            |                |                                    |                        |                         |           |                      |         |
| Chloroethane                                     | $\text{C}_2\text{H}_5\text{Cl}$             | 64.514  | -138.4               | 12.3                 | 0.9239 <sup>0</sup>     |                     | 9.45       | 2.05           | 1.617                              | 160                    | -50                     | 4-15%     | 519                  | 100     |

| Name                                | Mol. form.                                        | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | $\text{vp}/\text{kPa}$ | FP/<br>$^\circ\text{C}$ | Fl. lim. | IT/ $^\circ\text{C}$ | TLV/ppm |
|-------------------------------------|---------------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|------------------------|-------------------------|----------|----------------------|---------|
| 2-Chloroethanol                     | $\text{C}_2\text{H}_5\text{ClO}$                  | 80.513  | -67.5                | 128.6                | 1.2019 <sup>20</sup>    |                     | 25.80      | 1.78           |                                    | 1.2                    | 60                      | 5-16%    | 425                  | 1       |
| 2-Chloroethyl vinyl ether           | $\text{C}_4\text{H}_7\text{ClO}$                  | 106.551 | -70                  | 108                  | 1.0495 <sup>20</sup>    |                     |            |                |                                    |                        | 27                      |          |                      |         |
| (Chloromethyl)benzene               | $\text{C}_7\text{H}_7\text{Cl}$                   | 126.584 | -45                  | 179                  | 1.1004 <sup>20</sup>    |                     | 6.854      | 1.8            | 1.44                               | 0.164                  | 67                      | 1%-      | 585                  | 1       |
| Chloromethyl methyl ether           | $\text{C}_2\text{H}_5\text{ClO}$                  | 80.513  | -103.5               | 59.5                 | 1.063 <sup>10</sup>     |                     |            |                |                                    | 24.9                   |                         |          |                      |         |
| 1-Chloro-2-methylpropane            | $\text{C}_4\text{H}_9\text{Cl}$                   | 92.567  | -130.3               | 68.5                 | 0.8773 <sup>20</sup>    |                     | 7.027      | 2.00           | 1.713                              | 19.9                   | -6                      | 2-8.7%   |                      |         |
| 2-Chloro-2-methylpropane            | $\text{C}_4\text{H}_9\text{Cl}$                   | 92.567  | -25.60               | 50.9                 | 0.8420 <sup>20</sup>    |                     | 9.663      | 2.13           | 1.867                              | 42.7                   | 0                       |          |                      |         |
| 1-Chloronaphthalene                 | $\text{C}_{10}\text{H}_7\text{Cl}$                | 162.616 | -2.5                 | 259                  | 1.1880 <sup>25</sup>    |                     | 5.04       | 1.57           | 1.307                              | 0.003                  | 121                     |          | >558                 |         |
| 1-Chlorooctane                      | $\text{C}_8\text{H}_{17}\text{Cl}$                | 148.674 | -57.8                | 183.5                | 0.8734 <sup>20</sup>    |                     | 5.05       | 2.00           | 1.335                              | 0.11                   | 70                      |          |                      |         |
| 1-Chloropentane                     | $\text{C}_5\text{H}_{11}\text{Cl}$                | 106.594 | -99.0                | 108.4                | 0.8820 <sup>20</sup>    |                     | 6.654      | 2.16           |                                    | 4.36                   | 13                      | 1.6-8.6% | 260                  |         |
| 2-Chlorophenol                      | $\text{C}_6\text{H}_5\text{ClO}$                  | 128.556 | 9.4                  | 174.9                | 1.2634 <sup>20</sup>    | 3.59                | 7.40       |                | 1.468                              | 0.308                  | 64                      |          |                      |         |
| 1-Chloropropane                     | $\text{C}_3\text{H}_7\text{Cl}$                   | 78.541  | -122.9               | 46.5                 | 0.8899 <sup>20</sup>    | 0.334               | 8.588      | 2.05           | 1.683                              | 45.8                   | <-18                    | 2.6-11%  | 520                  |         |
| 2-Chloropropane                     | $\text{C}_3\text{H}_7\text{Cl}$                   | 78.541  | -117.18              | 35.7                 | 0.8617 <sup>20</sup>    | 0.303               |            | 2.17           |                                    | 68.9                   | -32                     | 2.8-11%  | 593                  |         |
| 3-Chloro-1,2-propanediol            | $\text{C}_3\text{H}_7\text{ClO}_2$                | 110.540 |                      | 213 dec              | 1.325 <sup>18</sup>     |                     | 31.0       |                |                                    |                        |                         |          |                      |         |
| 3-Chloropropanenitrile              | $\text{C}_3\text{H}_4\text{ClN}$                  | 89.524  | -51                  | 175.5                | 1.1573 <sup>20</sup>    |                     |            |                |                                    |                        | 76                      |          |                      |         |
| 2-Chloropropene                     | $\text{C}_3\text{H}_5\text{Cl}$                   | 76.525  | -137.4               | 22.6                 | 0.9017 <sup>20</sup>    |                     | 8.92       | 1.647          |                                    | 110                    | -37                     | 4.5-16%  |                      |         |
| 3-Chloropropene                     | $\text{C}_3\text{H}_5\text{Cl}$                   | 76.525  | -134.5               | 45.1                 | 0.9376 <sup>20</sup>    | 0.314               | 8.2        | 1.94           | 1.635                              | 48.9                   | -32                     | 2.9-11%  | 485                  | 1       |
| Chlorosulfonic acid                 | $\text{ClHO}_3\text{S}$                           | 116.525 | -80                  | 152                  | 1.75                    |                     |            |                |                                    | 0.42                   |                         |          |                      |         |
| 2-Chlorotoluene                     | $\text{C}_7\text{H}_7\text{Cl}$                   | 126.584 | -35.8                | 159.0                | 1.0825 <sup>20</sup>    | 0.964               | 4.721      | 1.56           | 1.318                              | 0.482                  |                         |          |                      | 50      |
| 4-Chlorotoluene                     | $\text{C}_7\text{H}_7\text{Cl}$                   | 126.584 | 7.5                  | 162.4                | 1.0697 <sup>20</sup>    | 0.837               | 6.25       | 2.21           |                                    | 0.4                    |                         |          |                      |         |
| Chromyl chloride                    | $\text{CrO}_2\text{Cl}_2$                         | 154.900 | -96.5                | 117                  | 1.91                    |                     |            |                |                                    |                        |                         |          |                      | 0.025   |
| <i>trans</i> -Cinnamaldehyde        | $\text{C}_9\text{H}_8\text{O}$                    | 132.159 | -7.5                 | 246                  | 1.0497 <sup>20</sup>    |                     | 17.72      |                |                                    | 0.005                  |                         |          |                      |         |
| <i>o</i> -Cresol                    | $\text{C}_7\text{H}_8\text{O}$                    | 108.138 | 31.03                | 191.04               | 1.0327 <sup>35</sup>    |                     | 6.76       | 1.45           | 2.160                              | 0.041                  | 81                      | >1.4%    | 599                  | 5       |
| <i>m</i> -Cresol                    | $\text{C}_7\text{H}_8\text{O}$                    | 108.138 | 12.24                | 202.27               | 1.0339 <sup>20</sup>    | 12.91               | 12.44      | 1.48           | 2.080                              | 0.019                  | 86                      | >1.1%    | 558                  | 5       |
| <i>p</i> -Cresol                    | $\text{C}_7\text{H}_8\text{O}$                    | 108.138 | 34.77                | 201.98               | 1.0185 <sup>40</sup>    |                     | 13.05      | 1.48           | 2.044                              | 0.017                  | 86                      | >1.1%    | 558                  | 5       |
| Cyanogen chloride                   | $\text{CClN}$                                     | 61.471  | -6.5                 | 13                   | 1.186 <sup>60</sup>     |                     |            | 2.8331         |                                    |                        |                         |          |                      | 0.3     |
| Cyclobutane                         | $\text{C}_4\text{H}_8$                            | 56.107  | -90.7                | 12.6                 | 0.7038 <sup>0</sup>     |                     |            | 0              |                                    | 157                    | <10                     | >1.8%    |                      |         |
| Cyclohexane                         | $\text{C}_6\text{H}_{12}$                         | 84.159  | 6.59                 | 80.73                | 0.7739 <sup>25</sup>    | 0.894               | 2.0243     | $\approx 0$    | 1.841                              | 13.0                   | -20                     | 1-8%     | 245                  | 100     |
| Cyclohexanol                        | $\text{C}_6\text{H}_{12}\text{O}$                 | 100.158 | 25.93                | 160.84               | 0.9624 <sup>20</sup>    | 57.5                | 16.40      |                | 2.079                              | 0.10                   | 68                      | 1-9%     | 300                  | 50      |
| Cyclohexanone                       | $\text{C}_6\text{H}_{10}\text{O}$                 | 98.142  | -27.9                | 155.43               | 0.9478 <sup>20</sup>    | 2.02                | 16.1       | 2.87           | 1.856                              | 0.53                   | 44                      | 1-9%     | 420                  | 20      |
| Cyclohexene                         | $\text{C}_6\text{H}_{10}$                         | 82.143  | -103.5               | 82.98                | 0.8110 <sup>20</sup>    | 0.625               | 2.2176     | 0.33           | 1.805                              | 11.8                   | -12                     | >1.2%    | 310                  | 300     |
| Cyclohexylamine                     | $\text{C}_6\text{H}_{13}\text{N}$                 | 99.174  | -17.8                | 134                  | 0.8191 <sup>20</sup>    | 1.944               | 4.547      | 1.3            |                                    | 1.20                   | 31                      | 1-9%     | 293                  | 10      |
| 1,3-Cyclopentadiene                 | $\text{C}_5\text{H}_6$                            | 66.102  | -85                  | 41                   | 0.8021 <sup>20</sup>    |                     |            | 0.419          |                                    | 58.5                   |                         |          |                      | 75      |
| Cyclopentane                        | $\text{C}_5\text{H}_{10}$                         | 70.133  | -93.4                | 49.3                 | 0.7457 <sup>20</sup>    | 0.413               | 1.9687     | $\approx 0$    | 1.837                              | 42.3                   | -25                     | 2%-      | 361                  | 600     |
| Cyclopentanol                       | $\text{C}_5\text{H}_{10}\text{O}$                 | 86.132  | -17.5                | 140.42               | 0.9488 <sup>20</sup>    |                     | 18.5       |                | 2.119                              | 0.294                  | 51                      |          |                      |         |
| Cyclopentanone                      | $\text{C}_5\text{H}_8\text{O}$                    | 84.117  | -51.90               | 130.57               | 0.9487 <sup>20</sup>    |                     | 13.58      | 3.3            | 1.84                               | 1.55                   | 26                      |          |                      |         |
| <i>cis</i> -Decahydronaphthalene    | $\text{C}_{10}\text{H}_{18}$                      | 138.250 | -42.9                | 195.8                | 0.8965 <sup>20</sup>    | 3.04                | 2.219      | $\approx 0$    | 1.678                              | 0.10                   |                         |          |                      |         |
| <i>trans</i> -Decahydronaphthalene  | $\text{C}_{10}\text{H}_{18}$                      | 138.250 | -30.4                | 187.3                | 0.8659 <sup>25</sup>    | 1.948               | 2.184      | $\approx 0$    | 1.653                              | 0.164                  | 54                      | 1-5%     | 255                  |         |
| Decamethylcyclopenta-siloxane       | $\text{C}_{10}\text{H}_{30}\text{O}_5\text{Si}_5$ | 370.770 | -38                  | 210                  | 0.9593 <sup>20</sup>    |                     | 2.50       |                |                                    | 0.02                   |                         |          |                      |         |
| Decanal                             | $\text{C}_{10}\text{H}_{20}\text{O}$              | 156.265 | -4.0                 | 208.5                | 0.830 <sup>15</sup>     |                     |            |                |                                    | 0.02                   |                         |          |                      |         |
| Decane                              | $\text{C}_{10}\text{H}_{22}$                      | 142.282 | -29.6                | 174.15               | 0.7266 <sup>25</sup>    | 0.838               | 1.9853     | $\approx 0$    | 2.210                              | 0.170                  | 51                      | 0.8-5.4% | 210                  |         |
| Decanoic acid                       | $\text{C}_{10}\text{H}_{20}\text{O}_2$            | 172.265 | 31.4                 | 268.7                | 0.8858 <sup>40</sup>    |                     |            |                | 2.761                              |                        |                         |          |                      |         |
| 1-Decanol                           | $\text{C}_{10}\text{H}_{22}\text{O}$              | 158.281 | 6.9                  | 231.1                | 0.8297 <sup>20</sup>    | 10.91               | 7.93       |                | 2.341                              | 0.009                  | 82                      |          | 288                  |         |
| 1-Decene                            | $\text{C}_{10}\text{H}_{20}$                      | 140.266 | -66.3                | 170.5                | 0.7408 <sup>20</sup>    | 0.756               | 2.136      | $\approx 0$    | 2.144                              | 0.210                  | <55                     |          | 235                  |         |
| Diacetone alcohol                   | $\text{C}_6\text{H}_{12}\text{O}_2$               | 116.158 | -44                  | 167.9                | 0.9387 <sup>20</sup>    | 2.80                | 18.2       | 3.2            | 1.905                              | 0.224                  | 58                      | 2-7%     | 643                  | 50      |
| Dibenzyl ether                      | $\text{C}_{14}\text{H}_{14}\text{O}$              | 198.260 | 1.8                  | 298                  | 1.0428 <sup>20</sup>    |                     | 3.821      |                |                                    |                        | 135                     |          |                      |         |
| Dibromodifluoromethane              | $\text{CBr}_2\text{F}_2$                          | 209.816 | -110.1               | 22.76                |                         |                     |            | 0.66           |                                    | 110                    |                         |          |                      | 100     |
| 1,2-Dibromoethane                   | $\text{C}_2\text{H}_4\text{Br}_2$                 | 187.861 | 9.84                 | 131.6                | 2.1683 <sup>25</sup>    | 1.595               | 4.9612     | 1.2            | 0.724                              | 1.55                   |                         |          |                      |         |
| Dibromomethane                      | $\text{CH}_2\text{Br}_2$                          | 173.835 | -52.5                | 97                   | 2.4969 <sup>20</sup>    | 0.980               | 7.77       | 1.43           | 0.61                               | 6.12                   |                         |          |                      |         |
| 1,2-Dibromotetrafluoroethane        | $\text{C}_2\text{Br}_2\text{F}_4$                 | 259.823 | -110.32              | 47.35                | 2.149 <sup>25</sup>     |                     | 2.34       |                | 0.69                               | 43.4                   |                         |          |                      |         |
| Dibutylamine                        | $\text{C}_8\text{H}_{19}\text{N}$                 | 129.244 | -62                  | 159.6                | 0.7670 <sup>20</sup>    | 0.918               | 2.765      | 1.0            | 2.266                              | 0.34                   | 47                      | 1-6%     |                      |         |
| Dibutyl ether                       | $\text{C}_8\text{H}_{18}\text{O}$                 | 130.228 | -95.2                | 140.28               | 0.7684 <sup>20</sup>    | 0.637               | 3.0830     | 1.17           | 2.136                              | 0.898                  | 25                      | 1.5-7.6% | 194                  |         |
| Di- <i>tert</i> -butyl peroxide     | $\text{C}_8\text{H}_{18}\text{O}_2$               | 146.228 | -40                  | 111                  | 0.704 <sup>20</sup>     |                     |            |                |                                    | 3.43                   | 18                      |          |                      |         |
| Dibutyl phthalate                   | $\text{C}_{16}\text{H}_{22}\text{O}_4$            | 278.344 | -35                  | 340                  | 1.0465 <sup>20</sup>    | 16.63               | 6.58       | 2.82           | 1.789                              |                        | 157                     | >0.5%    | 402                  | 0.4     |
| Dibutyl sebacate                    | $\text{C}_{18}\text{H}_{34}\text{O}_4$            | 314.461 | -10                  | 344.5                | 0.9405 <sup>15</sup>    |                     | 4.54       | 2.48           | 1.968                              |                        | 178                     | >0.4%    | 365                  |         |
| Dibutyl sulfide                     | $\text{C}_8\text{H}_{18}\text{S}$                 | 146.294 | -79.7                | 185                  | 0.8386 <sup>20</sup>    |                     | 4.29       | 1.61           | 1.943                              | 0.09                   | 76                      |          |                      |         |
| Dichloroacetic acid                 | $\text{C}_2\text{H}_2\text{Cl}_2\text{O}_2$       | 128.942 | 10                   | 194                  | 1.5634 <sup>20</sup>    |                     | 8.33       |                |                                    | 0.03                   |                         |          |                      |         |
| <i>o</i> -Dichlorobenzene           | $\text{C}_6\text{H}_4\text{Cl}_2$                 | 147.002 | -17.0                | 180                  | 1.3059 <sup>20</sup>    | 1.324               | 10.12      | 2.50           | 1.105                              | 0.18                   | 66                      | 2-9%     | 648                  | 25      |
| <i>m</i> -Dichlorobenzene           | $\text{C}_6\text{H}_4\text{Cl}_2$                 | 147.002 | -24.8                | 173                  | 1.2884 <sup>20</sup>    | 1.044               | 5.02       | 1.72           | 1.163                              | 0.252                  | 72                      |          |                      |         |
| <i>trans</i> -1,4-Dichloro-2-butene | $\text{C}_4\text{H}_6\text{Cl}_2$                 | 124.997 | 1.0                  | 155.4                | 1.183 <sup>25</sup>     |                     |            |                |                                    |                        |                         |          |                      | 0.005   |
| Dichlorodimethylsilane              | $\text{C}_2\text{H}_6\text{Cl}_2\text{Si}$        | 129.061 | -16                  | 70.3                 | 1.064 <sup>25</sup>     |                     |            |                |                                    | 18.9                   | <21                     | 3.4-9.5% |                      |         |
| 1,1-Dichloroethane                  | $\text{C}_2\text{H}_4\text{Cl}_2$                 | 98.959  | -96.9                | 57.3                 | 1.1757 <sup>20</sup>    | 0.464               | 10.10      | 2.06           | 1.276                              | 30.5                   | -17                     | 5-11%    | 458                  | 100     |
| 1,2-Dichloroethane                  | $\text{C}_2\text{H}_4\text{Cl}_2$                 | 98.959  | -35.7                | 83.5                 | 1.2454 <sup>25</sup>    | 0.779               | 10.42      | 1.8            | 1.298                              | 10.6                   | 13                      | 6-16%    | 413                  | 10      |
| 1,1-Dichloroethene                  | $\text{C}_2\text{H}_2\text{Cl}_2$                 | 96.943  | -122.56              | 31.6                 | 1.213 <sup>20</sup>     |                     | 4.60       | 1.34           | 1.148                              | 80.0                   | -28                     | 7-16%    | 570                  | 5       |
| <i>cis</i> -1,2-Dichloroethene      | $\text{C}_2\text{H}_2\text{Cl}_2$                 | 96.943  | -80.0                | 60.1                 | 1.2837 <sup>20</sup>    | 0.445               | 9.20       | 1.90           | 1.201                              | 26.8                   | 6                       | 3-15%    | 460                  | 200     |
| <i>trans</i> -1,2-Dichloroethene    | $\text{C}_2\text{H}_2\text{Cl}_2$                 | 96.943  | -49.8                | 48.7                 | 1.2565 <sup>20</sup>    | 0.317               | 2.14       | 0              | 1.205                              | 44.2                   | 2                       | 6-13%    | 460                  | 200     |
| Dichloromethane                     | $\text{CH}_2\text{Cl}_2$                          | 84.933  | -97.2                | 40                   | 1.3266 <sup>20</sup>    | 0.413               | 8.93       | 1.60           | 1.192                              | 58.2                   |                         | 13-23%   | 556                  | 50      |

| Name                                      | Mol. form.                                  | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | $\text{vp/kPa}$ | FP/<br>$^\circ\text{C}$ | Fl. lim. | IT/ $^\circ\text{C}$ | TLV/ppm |
|-------------------------------------------|---------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|-----------------|-------------------------|----------|----------------------|---------|
| (Dichloromethyl)benzene                   | $\text{C}_6\text{H}_5\text{Cl}_2$           | 161.029 | -17                  | 205                  | 1.26 <sup>25</sup>      |                     | 6.9        | 2.1            |                                    | 0.06            |                         |          |                      |         |
| 1,1-Dichloropropane                       | $\text{C}_3\text{H}_5\text{Cl}_2$           | 112.986 |                      | 88.1                 | 1.1321 <sup>20</sup>    |                     |            |                |                                    | 9.09            |                         |          |                      |         |
| 1,2-Dichloropropane, ( $\pm$ )-           | $\text{C}_3\text{H}_5\text{Cl}_2$           | 112.986 | -100.53              | 96.4                 | 1.1560 <sup>20</sup>    |                     | 8.37       | 1.8            | 1.320                              | 6.62            | 21                      | 3-15%    | 557                  | 75      |
| 1,3-Dichloropropane                       | $\text{C}_3\text{H}_5\text{Cl}_2$           | 112.986 | -99.5                | 120.9                | 1.1785 <sup>25</sup>    |                     | 10.27      | 2.08           |                                    | 2.44            |                         |          |                      |         |
| 2,3-Dichloropropene                       | $\text{C}_3\text{H}_3\text{Cl}_2$           | 110.970 | 10                   | 94                   | 1.211 <sup>20</sup>     |                     |            |                |                                    |                 | 15                      | 2.6-7.8% |                      |         |
| 2,4-Dichlorotoluene                       | $\text{C}_7\text{H}_6\text{Cl}_2$           | 161.029 | -13.5                | 201                  | 1.2476 <sup>20</sup>    |                     | 5.68       | 1.70           |                                    | 0.055           |                         |          |                      |         |
| Dicyclohexylamine                         | $\text{C}_{12}\text{H}_{23}\text{N}$        | 181.318 | -0.1                 | 256 dec              | 0.9123 <sup>20</sup>    |                     |            |                |                                    | 0.003           | >99                     |          |                      |         |
| Diethanolamine                            | $\text{C}_4\text{H}_{11}\text{NO}_2$        | 105.136 | 28                   | 268.8                | 1.0966 <sup>20</sup>    |                     | 25.75      | 2.8            | 2.22                               | <0.01           | 172                     | 2-13%    | 662                  | 0.5     |
| 1,1-Diethoxyethane                        | $\text{C}_6\text{H}_{14}\text{O}_2$         | 118.174 | -100                 | 102.25               | 0.8254 <sup>20</sup>    |                     | 3.80       | 1.4            | 2.01                               | 3.68            | -21                     | 2-10%    | 230                  |         |
| 1,2-Diethoxyethane                        | $\text{C}_6\text{H}_{14}\text{O}_2$         | 118.174 | -74.0                | 121.2                | 0.8351 <sup>25</sup>    |                     | 3.90       |                | 2.195                              | 4.33            | 27                      |          | 205                  |         |
| Diethylamine                              | $\text{C}_4\text{H}_{11}\text{N}$           | 73.137  | -49.8                | 55.5                 | 0.7056 <sup>20</sup>    | 0.319               | 3.680      | 0.92           | 2.313                              | 30.1            | -23                     | 2-10%    | 312                  | 5       |
| <i>N,N</i> -Diethylaniline                | $\text{C}_{10}\text{H}_{15}\text{N}$        | 149.233 | -38.8                | 216.3                | 0.9307 <sup>20</sup>    |                     | 5.15       |                |                                    | 0.025           | 85                      |          | 630                  |         |
| <i>o</i> -Diethylbenzene                  | $\text{C}_{10}\text{H}_{14}$                | 134.218 | -31.2                | 184                  | 0.8800 <sup>20</sup>    |                     | 2.594      |                |                                    | 0.13            | 57                      |          | 395                  |         |
| <i>m</i> -Diethylbenzene                  | $\text{C}_{10}\text{H}_{14}$                | 134.218 | -83.9                | 181.1                | 0.8602 <sup>20</sup>    |                     | 2.369      |                |                                    | 0.14            | 56                      |          | 450                  |         |
| <i>p</i> -Diethylbenzene                  | $\text{C}_{10}\text{H}_{14}$                | 134.218 | -42.83               | 183.7                | 0.8620 <sup>20</sup>    |                     | 2.259      |                |                                    | 0.13            | 55                      | 0.7-6%   | 430                  |         |
| Diethyl carbonate                         | $\text{C}_6\text{H}_{10}\text{O}_3$         | 118.131 | -43                  | 126                  | 0.9692 <sup>25</sup>    |                     | 2.820      | 1.10           | 1.80                               | 1.63            | 25                      |          |                      |         |
| Diethylene glycol                         | $\text{C}_4\text{H}_{10}\text{O}_3$         | 106.120 | -10.4                | 245.8                | 1.1197 <sup>15</sup>    | 30.2                | 31.82      | 2.3            | 2.307                              | 0.001           | 124                     | 2-17%    | 224                  |         |
| Diethylene glycol diethyl ether           | $\text{C}_8\text{H}_{18}\text{O}_3$         | 162.227 | -45                  | 188                  | 0.9063 <sup>20</sup>    |                     | 5.70       |                | 2.104                              | 0.10            | 82                      |          |                      |         |
| Diethylene glycol dimethyl ether          | $\text{C}_6\text{H}_{14}\text{O}_3$         | 134.173 | -68                  | 162                  | 0.9434 <sup>20</sup>    | 0.989               | 7.23       | 2.0            | 2.043                              | 0.315           | 67                      |          |                      |         |
| Diethylene glycol monobutyl ether         | $\text{C}_8\text{H}_{18}\text{O}_3$         | 162.227 | -68                  | 231                  | 0.9553 <sup>20</sup>    |                     |            |                | 2.188                              | 0.0032          |                         |          |                      |         |
| Diethylene glycol monoethyl ether         | $\text{C}_6\text{H}_{14}\text{O}_3$         | 134.173 |                      | 196                  | 0.9885 <sup>20</sup>    |                     |            | 1.6            | 2.243                              | 0.017           | 96                      |          |                      |         |
| Diethylene glycol monoethyl ether acetate | $\text{C}_8\text{H}_{16}\text{O}_4$         | 176.211 | -25                  | 218.5                | 1.0096 <sup>20</sup>    |                     |            | 1.8            |                                    | 0.029           | 110                     |          | 425                  |         |
| Diethylene glycol monomethyl ether        | $\text{C}_5\text{H}_{12}\text{O}_3$         | 120.147 |                      | 193                  | 1.035 <sup>20</sup>     |                     |            | 1.6            | 2.256                              | 0.024           | 96                      | 1-23%    | 240                  |         |
| Diethyl ether                             | $\text{C}_4\text{H}_{10}\text{O}$           | 74.121  | -116.2               | 34.5                 | 0.7138 <sup>20</sup>    | 0.224               | 4.2666     | 1.15           | 2.369                              | 71.7            | -45                     | 2-36%    | 180                  | 400     |
| Diethyl maleate                           | $\text{C}_8\text{H}_{12}\text{O}_4$         | 172.179 | -8.8                 | 223                  | 1.0662 <sup>20</sup>    |                     | 7.560      |                |                                    | 0.015           | 121                     |          | 350                  |         |
| Diethyl malonate                          | $\text{C}_8\text{H}_{12}\text{O}_4$         | 160.168 | -50                  | 200                  | 1.0551 <sup>20</sup>    |                     | 7.550      | 2.54           | 1.779                              | 0.048           | 93                      |          |                      |         |
| Diethyl oxalate                           | $\text{C}_6\text{H}_{10}\text{O}_4$         | 146.141 | -40.6                | 185.7                | 1.0785 <sup>20</sup>    |                     | 8.266      | 2.49           | 1.784                              | 0.030           | 76                      |          |                      |         |
| Diethyl phthalate                         | $\text{C}_{12}\text{H}_{14}\text{O}_4$      | 222.237 | -40.5                | 295                  | 1.232 <sup>14</sup>     |                     | 7.86       |                | 1.647                              | 0.002           | 161                     | >0.7%    | 457                  | 0.6     |
| Diethyl succinate                         | $\text{C}_8\text{H}_{14}\text{O}_4$         | 174.195 | -21                  | 217.7                | 1.0402 <sup>20</sup>    |                     | 6.098      |                |                                    | 0.15            | 90                      |          |                      |         |
| Diethyl sulfate                           | $\text{C}_6\text{H}_{10}\text{O}_4\text{S}$ | 154.185 | -24                  | 208                  | 1.172 <sup>25</sup>     |                     | 29.2       |                |                                    | 0.05            | 104                     |          | 436                  |         |
| Diethyl sulfide                           | $\text{C}_4\text{H}_{10}\text{S}$           | 90.187  | -103.91              | 92.1                 | 0.8362 <sup>20</sup>    | 0.422               | 5.723      | 1.54           | 1.900                              | 7.78            |                         |          |                      |         |
| Diiodomethane                             | $\text{CH}_2\text{I}_2$                     | 267.836 | 6.1                  | 182                  | 3.3211 <sup>20</sup>    |                     | 5.32       | 1.08           | 0.500                              | 0.172           |                         |          |                      |         |
| Diiodosilane                              | $\text{H}_2\text{I}_2\text{Si}$             | 283.911 | -1                   | 150                  |                         |                     |            |                |                                    |                 |                         |          |                      |         |
| Diisobutylamine                           | $\text{C}_6\text{H}_{13}\text{N}$           | 129.244 | -73.5                | 139.6                |                         | 0.723               |            |                |                                    | 0.972           | 29                      |          |                      |         |
| Diisopentyl ether                         | $\text{C}_{10}\text{H}_{22}\text{O}$        | 158.281 |                      | 172.5                | 0.7777 <sup>20</sup>    |                     | 2.817      | 1.23           | 2.394                              | 0.210           |                         |          |                      |         |
| Diisopropylamine                          | $\text{C}_6\text{H}_{15}\text{N}$           | 101.190 | -61                  | 83.9                 | 0.7153 <sup>20</sup>    | 0.393               |            | 1.15           |                                    | 10.7            | -1                      | 1.1-7.1% | 316                  | 5       |
| Diisopropyl ether                         | $\text{C}_6\text{H}_{14}\text{O}$           | 102.174 | -85.4                | 68.4                 | 0.7192 <sup>25</sup>    | 0.379               | 3.805      | 1.13           | 2.122                              | 19.9            | -28                     | 1-8%     | 443                  | 250     |
| 1,2-Dimethoxyethane                       | $\text{C}_4\text{H}_{10}\text{O}_2$         | 90.121  | -69.20               | 84.5                 | 0.8637 <sup>25</sup>    | 0.455               | 7.30       |                | 2.145                              | 9.93            | -2                      |          | 202                  |         |
| Dimethoxymethane                          | $\text{C}_3\text{H}_8\text{O}_2$            | 76.095  | -105.1               | 42                   | 0.8593 <sup>20</sup>    |                     | 2.644      | 0.7            | 2.129                              | 53.1            | -32                     | 2-14%    | 237                  | 1000    |
| Dimethylacetal                            | $\text{C}_4\text{H}_{10}\text{O}_2$         | 90.121  | -113.2               | 64.5                 | 0.8501 <sup>20</sup>    |                     |            |                |                                    | 22.9            |                         |          |                      |         |
| <i>N,N</i> -Dimethylacetamide             | $\text{C}_4\text{H}_9\text{NO}$             | 87.120  | -18.59               | 165                  | 0.9372 <sup>25</sup>    | 1.927               | 38.85      | 3.7            | 2.016                              | 0.075           | 70                      | 2-12%    | 490                  | 10      |
| 2,3-Dimethylaniline                       | $\text{C}_8\text{H}_{11}\text{N}$           | 121.180 | <-15                 | 221.5                | 0.9931 <sup>20</sup>    |                     |            |                |                                    | 97              | >1%                     |          |                      |         |
| 2,6-Dimethylaniline                       | $\text{C}_8\text{H}_{11}\text{N}$           | 121.180 | 11.2                 | 215                  | 0.9842 <sup>20</sup>    |                     |            | 1.63           | 1.971                              | 0.45            | 96                      |          |                      |         |
| <i>N,N</i> -Dimethylaniline               | $\text{C}_8\text{H}_{11}\text{N}$           | 121.180 | 2.42                 | 194.15               | 0.9557 <sup>20</sup>    | 1.300               | 4.90       | 1.68           | 1.771                              | 0.107           | 63                      |          | 371                  | 5       |
| 2,2-Dimethylbutane                        | $\text{C}_6\text{H}_{14}$                   | 86.175  | -98.8                | 49.73                | 0.6444 <sup>25</sup>    | 0.351               | 1.869      | $\approx 0$    | 2.227                              | 42.5            | -48                     | 1.2-7%   | 405                  | 500     |
| 2,3-Dimethylbutane                        | $\text{C}_6\text{H}_{14}$                   | 86.175  | -128.10              | 57.93                | 0.6616 <sup>20</sup>    | 0.361               | 1.889      | $\approx 0$    | 2.201                              | 31.3            | -29                     | 1.2-7%   | 405                  | 500     |
| 3,3-Dimethyl-2-butanone                   | $\text{C}_6\text{H}_{12}\text{O}$           | 100.158 | -52.5                | 106.1                | 0.7229 <sup>25</sup>    |                     | 12.73      |                |                                    | 4.27            |                         |          |                      |         |
| Dimethylcarbamic chloride                 | $\text{C}_3\text{H}_6\text{ClNO}$           | 107.539 | -33                  | 167                  | 1.168 <sup>25</sup>     |                     |            |                |                                    |                 |                         |          |                      |         |
| Dimethyl disulfide                        | $\text{C}_2\text{H}_6\text{S}_2$            | 94.199  | -84.67               | 109.74               | 1.0625 <sup>20</sup>    |                     | 9.6        | 1.8            | 1.551                              | 3.82            | 24                      |          |                      |         |
| <i>N,N</i> -Dimethylethanolamine          | $\text{C}_4\text{H}_{11}\text{NO}$          | 89.136  | -59                  | 134                  | 0.8866 <sup>20</sup>    |                     |            |                |                                    | 0.9             |                         |          |                      |         |
| <i>N,N</i> -Dimethylformamide             | $\text{C}_3\text{H}_7\text{NO}$             | 73.094  | -60.48               | 153                  | 0.9445 <sup>25</sup>    | 0.794               | 38.25      | 3.82           | 2.060                              | 0.439           | 58                      | 2-15%    | 445                  | 10      |
| 2,6-Dimethyl-4-heptanone                  | $\text{C}_{10}\text{H}_{18}\text{O}$        | 142.238 | -41.5                | 169.4                | 0.8062 <sup>20</sup>    |                     | 9.91       | 2.7            | 2.090                              | 0.23            | 49                      | 1-7%     | 396                  | 25      |
| 1,1-Dimethylhydrazine                     | $\text{C}_2\text{H}_8\text{N}_2$            | 60.098  | -57.20               | 63.9                 | 0.791 <sup>22</sup>     |                     |            |                | 2.731                              | 20.9            | -15                     | 2-95%    | 249                  | 0.01    |
| Dimethyl phthalate                        | $\text{C}_{10}\text{H}_{10}\text{O}_4$      | 194.184 | 5.5                  | 283.7                | 1.1905 <sup>20</sup>    | 14.36               | 8.66       |                | 1.561                              | 0.001           | 146                     | >0.9%    | 490                  | 0.6     |
| 2,6-Dimethylpyridine                      | $\text{C}_8\text{H}_9\text{N}$              | 107.153 | -6.1                 | 144.01               | 0.9226 <sup>20</sup>    |                     | 7.33       | 1.7            | 1.728                              | 0.746           |                         |          |                      |         |
| Dimethyl sulfate                          | $\text{C}_2\text{H}_6\text{O}_4\text{S}$    | 126.132 | -31.7                | 188 dec              | 1.3322 <sup>20</sup>    |                     | 55.0       |                |                                    | 0.13            | 83                      |          | 188                  | 0.1     |
| Dimethyl sulfide                          | $\text{C}_2\text{H}_6\text{S}$              | 62.134  | -98.24               | 37.33                | 0.8483 <sup>20</sup>    | 0.284               | 6.70       | 1.554          | 1.901                              | 64.4            | -37                     | 2.2-20%  | 206                  | 10      |
| Dimethyl sulfoxide                        | $\text{C}_2\text{H}_6\text{OS}$             | 78.133  | 17.89                | 189                  | 1.1010 <sup>25</sup>    | 1.987               | 47.24      | 3.96           | 1.958                              | 0.084           | 95                      | 3-42%    | 215                  |         |
| 1,4-Dioxane                               | $\text{C}_4\text{H}_{10}\text{O}_2$         | 88.106  | 11.85                | 101.5                | 1.0333 <sup>20</sup>    | 1.177               | 2.2189     | 0              | 1.726                              | 4.95            | 12                      | 2-22%    | 180                  | 20      |
| 1,3-Dioxolane                             | $\text{C}_3\text{H}_6\text{O}_2$            | 74.079  | -97.22               | 78                   | 1.060 <sup>20</sup>     |                     |            | 1.19           | 1.593                              | 14.6            | 2                       |          |                      | 20      |
| Dipentyl ether                            | $\text{C}_{10}\text{H}_{22}\text{O}$        | 158.281 | -69                  | 190                  | 0.7833 <sup>20</sup>    |                     | 2.798      | 1.20           | 1.579                              | 0.13            | 57                      |          | 170                  |         |
| Dipropylamine                             | $\text{C}_6\text{H}_{15}\text{N}$           | 101.190 | -63                  | 109.3                | 0.7400 <sup>20</sup>    | 0.517               | 2.923      | 1.03           | 2.500                              | 3.21            | 17                      |          | 299                  |         |



| Name                                | Mol. form.                                   | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | $\text{vp/kPa}$ | FP/<br>$^\circ\text{C}$ | Fl. lim. | IT/ $^\circ\text{C}$ | TLV/ppm |
|-------------------------------------|----------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|-----------------|-------------------------|----------|----------------------|---------|
| Dipropylene glycol monomethyl ether | $\text{C}_7\text{H}_{16}\text{O}_3$          | 148.200 | -80                  | 188.3                | 0.95                    |                     |            |                |                                    |                 |                         |          |                      |         |
| Dipropyl ether                      | $\text{C}_6\text{H}_{14}\text{O}$            | 102.174 | -114.8               | 90.08                | 0.7466 <sup>20</sup>    | 0.396               | 3.38       | 1.21           | 2.169                              | 8.35            | 21                      | 1.3-7%   | 188                  |         |
| Dodecane                            | $\text{C}_{12}\text{H}_{26}$                 | 170.334 | -9.57                | 216.32               | 0.7495 <sup>20</sup>    | 1.383               | 2.0120     | $\approx 0$    | 2.206                              | 0.016           | 74                      | >0.6%    | 203                  |         |
| 1-Dodecanol                         | $\text{C}_{12}\text{H}_{26}\text{O}$         | 186.333 | 23.9                 | 260                  | 0.8309 <sup>24</sup>    |                     | 5.82       |                | 2.351                              | 0.000016        | 127                     |          | 275                  |         |
| 1-Dodecene                          | $\text{C}_{12}\text{H}_{24}$                 | 168.319 | -35.2                | 213.8                | 0.7584 <sup>20</sup>    | 1.20                | 2.152      | $\approx 0$    | 2.143                              | 0.019           | 79                      |          |                      |         |
| Epichlorohydrin                     | $\text{C}_3\text{H}_5\text{ClO}$             | 92.524  | -26                  | 118                  | 1.1812 <sup>20</sup>    | 1.073               | 22.6       | 1.8            | 1.422                              | 2.2             | 31                      | 4-21%    | 411                  | 0.5     |
| 1,2-Epoxybutane                     | $\text{C}_4\text{H}_8\text{O}$               | 72.106  | -150                 | 63.4                 | 0.8297 <sup>20</sup>    |                     |            | 1.891          | 2.039                              | 31.7            | -22                     | 1.7-19%  | 439                  |         |
| 1,2-Epoxy-4-(epoxyethyl)cyclohexane | $\text{C}_8\text{H}_{12}\text{O}_2$          | 140.180 | <-55                 | 227                  | 1.0966 <sup>20</sup>    |                     |            |                |                                    |                 |                         |          |                      | 0.1     |
| 1,2-Ethanediamine                   | $\text{C}_2\text{H}_8\text{N}_2$             | 60.098  | 11.14                | 117                  | 0.8979 <sup>20</sup>    |                     | 13.82      | 1.99           | 2.872                              | 1.62            | 40                      | 3-12%    | 385                  | 10      |
| 1,2-Ethenediol                      | $\text{C}_2\text{H}_6\text{O}_2$             | 62.068  | -12.69               | 197.3                | 1.1135 <sup>20</sup>    | 16.06               | 41.4       | 2.28           | 2.394                              | 0.01            | 111                     | 3-22%    | 398                  | 40      |
| 1,2-Ethanediol, diacetate           | $\text{C}_6\text{H}_{10}\text{O}_4$          | 146.141 | -31                  | 190                  | 1.1043 <sup>20</sup>    |                     | 7.7        | 2.34           | 2.121                              | 0.030           | 88                      | 1.6-8.4% | 482                  |         |
| 1,2-Ethanediol, dinitrate           | $\text{C}_2\text{H}_4\text{N}_2\text{O}_6$   | 152.062 | -22.3                | 198.5                | 1.4918 <sup>20</sup>    |                     | 28.26      |                |                                    | 0.009           |                         |          |                      | 0.05    |
| 1,2-Ethanedithiol                   | $\text{C}_2\text{H}_4\text{S}_2$             | 94.199  | -41.2                | 146.1                | 1.234 <sup>20</sup>     |                     | 7.26       | 2.03           |                                    |                 |                         |          |                      |         |
| Ethanethiol                         | $\text{C}_2\text{H}_4\text{S}$               | 62.134  | -147.88              | 35.0                 | 0.8315 <sup>25</sup>    | 0.287               | 6.667      | 1.60           | 1.898                              | 70.3            | -17                     | 2.8-18%  | 300                  | 0.5     |
| Ethanol                             | $\text{C}_2\text{H}_6\text{O}$               | 46.068  | -114.14              | 78.29                | 0.7893 <sup>20</sup>    | 1.074               | 25.3       | 1.69           | 2.438                              | 7.87            | 13                      | 3-19%    | 363                  | 1000    |
| Ethanolamine                        | $\text{C}_2\text{H}_7\text{NO}$              | 61.083  | 10.5                 | 171                  | 1.0180 <sup>20</sup>    | 21.1                | 31.94      | 2.3            | 3.201                              | 0.05            | 86                      | 3-24%    | 410                  | 3       |
| 4-Ethoxyaniline                     | $\text{C}_8\text{H}_9\text{NO}$              | 137.179 | 4.6                  | 254                  | 1.0652 <sup>16</sup>    |                     | 7.43       |                |                                    | 0.0007          | 116                     |          |                      |         |
| Ethoxybenzene                       | $\text{C}_8\text{H}_{10}\text{O}$            | 122.164 | -29.43               | 169.81               | 0.9651 <sup>20</sup>    | 1.197               | 4.216      | 1.45           | 1.870                              | 0.204           | 63                      |          |                      |         |
| 2-Ethoxyethanol                     | $\text{C}_4\text{H}_{10}\text{O}_2$          | 90.121  | -70                  | 135                  | 0.9253 <sup>25</sup>    |                     | 13.38      | 2.1            | 2.339                              | 0.71            | 43                      | 3-18%    | 235                  | 5       |
| 2-Ethoxyethyl acetate               | $\text{C}_8\text{H}_{16}\text{O}_3$          | 132.157 | -61.7                | 156.4                | 0.9740 <sup>20</sup>    |                     | 7.567      | 2.2            | 2.845                              | 0.24            | 56                      | 2-8%     | 379                  | 5       |
| Ethyl acetate                       | $\text{C}_4\text{H}_8\text{O}_2$             | 88.106  | -83.8                | 77.11                | 0.9003 <sup>20</sup>    | 0.423               | 6.0814     | 1.78           | 1.937                              | 12.6            | -4                      | 2-12%    | 426                  | 400     |
| Ethyl acetoacetate                  | $\text{C}_8\text{H}_{14}\text{O}_3$          | 130.141 | -45                  | 180.8                | 1.0368 <sup>10</sup>    |                     | 14.0       |                | 1.906                              | 0.095           | 57                      | 1-10%    | 295                  |         |
| Ethyl acrylate                      | $\text{C}_6\text{H}_{10}\text{O}_2$          | 100.117 | -71.2                | 99.4                 | 0.9234 <sup>20</sup>    |                     | 6.05       | 1.96           |                                    | 5.14            | 10                      | 1.4-14%  | 372                  | 5       |
| Ethylamine                          | $\text{C}_2\text{H}_7\text{N}$               | 45.084  | -80.5                | 16.5                 | 0.689 <sup>15</sup>     |                     | 8.7        | 1.22           | 2.884                              | 141             | -16                     | 4-14%    | 385                  | 5       |
| <i>N</i> -Ethylaniline              | $\text{C}_8\text{H}_9\text{N}$               | 121.180 | -63.5                | 203.0                | 0.9625 <sup>20</sup>    | 2.05                | 5.87       |                |                                    | 0.039           | 85                      |          |                      |         |
| Ethylbenzene                        | $\text{C}_8\text{H}_{10}$                    | 106.165 | -94.96               | 136.19               | 0.8626 <sup>25</sup>    | 0.631               | 2.4463     | 0.59           | 1.726                              | 1.28            | 21                      | 1-7%     | 432                  | 100     |
| Ethyl benzoate                      | $\text{C}_{10}\text{H}_{10}\text{O}_2$       | 150.174 | -34                  | 212                  | 1.0415 <sup>25</sup>    |                     | 6.20       | 2.00           | 1.638                              | 0.04            | 88                      |          | 490                  |         |
| Ethyl butanoate                     | $\text{C}_8\text{H}_{16}\text{O}_2$          | 116.158 | -98                  | 121.3                | 0.8735 <sup>25</sup>    | 0.639               | 5.18       | 1.74           | 1.963                              | 2.01            | 24                      |          | 463                  |         |
| 2-Ethyl-1-butanol                   | $\text{C}_8\text{H}_{18}\text{O}$            | 102.174 | <-15                 | 147                  | 0.8326 <sup>20</sup>    |                     | 6.19       |                |                                    | 0.206           | 57                      |          |                      |         |
| Ethyl chloroacetate                 | $\text{C}_4\text{H}_7\text{ClO}_2$           | 122.551 | -21                  | 144.3                | 1.1585 <sup>20</sup>    |                     |            |                |                                    | 0.640           | 64                      |          |                      |         |
| Ethyl chloroformate                 | $\text{C}_3\text{H}_5\text{ClO}_2$           | 108.524 | -80.6                | 95                   | 1.1352 <sup>20</sup>    |                     | 9.736      |                |                                    |                 | 16                      |          | 500                  |         |
| Ethyl cyanoacetate                  | $\text{C}_5\text{H}_9\text{NO}_2$            | 113.116 | -22.5                | 205                  | 1.0654 <sup>20</sup>    |                     | 31.62      | 2.17           | 1.947                              | 0.003           | 110                     |          |                      |         |
| Ethyleneimine                       | $\text{C}_2\text{H}_5\text{N}$               | 43.068  | -77.9                | 56                   | 0.832 <sup>25</sup>     |                     | 18.3       | 1.90           |                                    | 28.9            | -11                     | 3.3-55%  | 320                  | 0.5     |
| Ethyl formate                       | $\text{C}_3\text{H}_6\text{O}_2$             | 74.079  | -79.6                | 54.4                 | 0.9208 <sup>20</sup>    | 0.380               | 8.57       | 1.9            | 2.015                              | 32.3            | -20                     | 3-16%    | 455                  | 100     |
| 2-Ethylhexanal                      | $\text{C}_8\text{H}_{16}\text{O}$            | 128.212 | <-100                | 163                  | 0.8540 <sup>20</sup>    |                     |            |                |                                    |                 | 44                      | 0.9-7.2% | 190                  |         |
| 2-Ethyl-1,3-hexanediol              | $\text{C}_8\text{H}_{18}\text{O}_2$          | 146.228 | -40                  | 244                  | 0.9325 <sup>22</sup>    |                     | 18.73      |                |                                    |                 | 127                     |          | 360                  |         |
| 2-Ethyl-1-hexanol                   | $\text{C}_8\text{H}_{18}\text{O}$            | 130.228 | -70                  | 184.6                | 0.8319 <sup>25</sup>    | 6.27                | 7.58       | 1.74           | 2.438                              | 0.019           | 73                      | 0.8-9.7% | 231                  |         |
| 2-Ethylhexyl acetate                | $\text{C}_{10}\text{H}_{20}\text{O}_2$       | 172.265 | -80                  | 199                  | 0.8718 <sup>20</sup>    |                     |            | 1.8            |                                    | 0.09            | 71                      | 1-8%     | 268                  |         |
| Ethyl lactate                       | $\text{C}_5\text{H}_{10}\text{O}_3$          | 118.131 | -26                  | 154.5                | 1.0328 <sup>20</sup>    |                     | 15.4       | 2.4            | 2.150                              |                 | 46                      | >1.5%    | 400                  |         |
| Ethyl 3-methylbutanoate             | $\text{C}_8\text{H}_{16}\text{O}_2$          | 130.185 | -99.3                | 135.0                | 0.8656 <sup>20</sup>    |                     | 4.71       |                |                                    | 1.07            |                         |          |                      |         |
| Ethyl 2-methylpropanoate            | $\text{C}_6\text{H}_{12}\text{O}_2$          | 116.158 | -88.2                | 110.1                | 0.868 <sup>20</sup>     |                     |            |                |                                    | 3.25            | 13                      |          |                      |         |
| Ethyl nitrite                       | $\text{C}_2\text{H}_5\text{NO}_2$            | 75.067  |                      | 18                   | 0.899 <sup>15</sup>     |                     |            |                |                                    | 135             | -35                     | 4-50%    | 90                   |         |
| Ethyl propanoate                    | $\text{C}_6\text{H}_{12}\text{O}_2$          | 102.132 | -73.9                | 99.1                 | 0.8843 <sup>25</sup>    | 0.501               | 5.76       | 1.74           | 1.920                              | 4.97            | 12                      | 1.9-11%  | 440                  |         |
| Ethyl silicate                      | $\text{C}_8\text{H}_{20}\text{O}_4\text{Si}$ | 208.329 | -82.5                | 168.8                | 0.9320 <sup>20</sup>    |                     | 2.50       |                | 1.749                              | 1.17            | 52                      |          |                      | 10      |
| Eucalyptol                          | $\text{C}_{10}\text{H}_{18}\text{O}$         | 154.249 | 0.8                  | 176.4                | 0.9267 <sup>20</sup>    |                     | 4.57       |                |                                    | 0.260           | 48                      |          |                      |         |
| Fluorobenzene                       | $\text{C}_6\text{H}_5\text{F}$               | 96.102  | -42.18               | 84.73                | 1.0225 <sup>20</sup>    | 0.550               | 5.465      | 1.60           | 1.523                              | 10.4            | -15                     |          |                      |         |
| Fluorosulfonic acid                 | $\text{FHO}_3\text{S}$                       | 100.070 | -89                  | 163                  | 1.726                   |                     |            |                |                                    | 0.08            |                         |          |                      |         |
| Formamide                           | $\text{CH}_3\text{NO}$                       | 45.041  | 2.49                 | 220                  | 1.1334 <sup>20</sup>    | 3.34                | 111.0      | 3.73           | 2.389                              | 0.01            | 154                     |          |                      | 10      |
| Formic acid                         | $\text{CH}_2\text{O}_2$                      | 46.026  | 8.3                  | 101                  | 1.220 <sup>20</sup>     | 1.607               | 51.1       | 1.425          | 2.151                              | 5.75            | 50                      | 18-57%   | 434                  | 5       |
| Furan                               | $\text{C}_4\text{H}_4\text{O}$               | 68.074  | -85.61               | 31.5                 | 0.9514 <sup>20</sup>    | 0.361               | 2.94       | 0.66           | 1.686                              | 80.0            | -36                     | 2-14%    |                      |         |
| Furfural                            | $\text{C}_5\text{H}_4\text{O}_2$             | 96.085  | -38.1                | 161.7                | 1.1594 <sup>20</sup>    | 1.587               | 42.1       | 3.5            | 1.698                              | 0.29            | 60                      | 2-19%    | 316                  | 2       |
| Furfuryl alcohol                    | $\text{C}_5\text{H}_6\text{O}_2$             | 98.101  | -14.6                | 171                  | 1.1296 <sup>20</sup>    |                     | 16.85      | 1.9            | 2.079                              | 0.097           | 75                      | 2-16%    | 491                  | 10      |
| Germanium(IV) chloride              | $\text{Cl}_4\text{Ge}$                       | 214.42  | -51.50               | 86.55                | 1.88                    |                     |            | 0              |                                    |                 |                         |          |                      |         |
| Glycerol                            | $\text{C}_3\text{H}_8\text{O}_3$             | 92.094  | 18.1                 | 290                  | 1.2613 <sup>20</sup>    | 934                 | 46.53      | 2.6            | 2.377                              | <0.01           | 199                     | 3-19%    | 370                  | 2.7     |
| Glycerol triacetate                 | $\text{C}_9\text{H}_{14}\text{O}_6$          | 218.203 | -78                  | 259                  | 1.1583 <sup>20</sup>    |                     | 7.11       |                | 1.763                              | <0.01           | 138                     | 1%-      | 433                  |         |
| Glycerol trioleate                  | $\text{C}_{57}\text{H}_{104}\text{O}_6$      | 885.432 | -4                   |                      | 0.915 <sup>15</sup>     |                     | 3.109      |                |                                    |                 |                         |          |                      |         |
| Heptanal                            | $\text{C}_7\text{H}_{14}\text{O}$            | 114.185 | -43.4                | 152.8                | 0.8132 <sup>25</sup>    |                     | 9.07       |                | 2.015                              | 0.46            |                         |          |                      |         |
| Heptane                             | $\text{C}_7\text{H}_{16}$                    | 100.202 | -90.55               | 98.4                 | 0.6795 <sup>25</sup>    | 0.387               | 1.9209     | $\approx 0$    | 2.242                              | 6.09            | -4                      | 1-7%     | 204                  | 400     |
| Heptanoic acid                      | $\text{C}_7\text{H}_{14}\text{O}_2$          | 130.185 | -7.17                | 222.2                | 0.9124 <sup>25</sup>    | 3.84                | 3.04       |                | 2.039                              | 0.001           |                         |          | 275                  |         |
| 1-Heptanol                          | $\text{C}_7\text{H}_{16}\text{O}$            | 116.201 | -33.2                | 176.45               | 0.8219 <sup>20</sup>    | 5.81                | 11.75      |                | 2.342                              | 0.0044          |                         |          |                      |         |
| 2-Heptanone                         | $\text{C}_7\text{H}_{14}\text{O}$            | 114.185 | -35                  | 151.05               | 0.8111 <sup>20</sup>    | 0.714               | 11.95      | 2.6            | 2.037                              | 0.49            | 39                      | 1-8%     | 393                  | 50      |
| 3-Heptanone                         | $\text{C}_7\text{H}_{14}\text{O}$            | 114.185 | -39                  | 147                  | 0.8183 <sup>20</sup>    |                     | 12.7       | 2.78           |                                    | 0.5             | 46                      |          |                      | 50      |
| 4-Heptanone                         | $\text{C}_7\text{H}_{14}\text{O}$            | 114.185 | -33                  | 144                  | 0.8174 <sup>20</sup>    |                     | 12.60      |                |                                    | 0.164           | 49                      |          |                      | 50      |
| 1-Heptene                           | $\text{C}_7\text{H}_{14}$                    | 98.186  | -118.9               | 93.64                | 0.6970 <sup>20</sup>    | 0.340               | 2.092      | $\approx 0$    | 2.157                              | 7.52            | -1                      |          | 260                  |         |
| Hexachloro-1,3-butadiene            | $\text{C}_4\text{Cl}_6$                      | 260.761 | -21                  | 215                  | 1.556 <sup>25</sup>     |                     | 2.55       |                |                                    | 0.13            |                         |          | 610                  | 0.02    |

| Name                           | Mol. form.                                   | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | vp/kPa | FP/<br>$^\circ\text{C}$ | Fl. lim.  | IT/ $^\circ\text{C}$ | TLV/ppm |
|--------------------------------|----------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|--------|-------------------------|-----------|----------------------|---------|
| Hexachloro-1,3-cyclopentadiene | $\text{C}_5\text{Cl}_6$                      | 272.772 | -9                   | 239                  | 1.7019 <sup>25</sup>    |                     |            |                |                                    |        |                         |           |                      | 0.01    |
| Hexafluorobenzene              | $\text{C}_6\text{F}_6$                       | 186.054 | 5.03                 | 80.26                | 1.6184 <sup>20</sup>    | 2.79                | 2.029      | 0              | 1.191                              | 11.3   |                         |           |                      |         |
| Hexamethyldisiloxane           | $\text{C}_6\text{H}_{18}\text{OSi}_2$        | 162.377 | -66                  | 99                   | 0.7638 <sup>20</sup>    |                     | 2.179      |                | 1.918                              | 5.57   |                         |           |                      |         |
| Hexamethylphosphoric triamide  | $\text{C}_6\text{H}_{18}\text{N}_3\text{OP}$ | 179.200 | 7.2                  | 232.5                | 1.03 <sup>20</sup>      |                     | 31.3       | 5.5            | 1.791                              |        |                         |           |                      |         |
| Hexanal                        | $\text{C}_6\text{H}_{12}\text{O}$            | 100.158 | -56                  | 131                  | 0.8335 <sup>20</sup>    |                     |            |                | 2.101                              | 1.48   | 32                      |           |                      |         |
| Hexane                         | $\text{C}_6\text{H}_{14}$                    | 86.175  | -95.35               | 68.73                | 0.6606 <sup>25</sup>    | 0.300               | 1.8865     | $\approx 0$    | 2.270                              | 20.2   | -22                     | 1-8%      | 225                  | 50      |
| Hexanedinitrile                | $\text{C}_6\text{H}_8\text{N}_2$             | 108.141 | 1                    | 295                  | 0.9676 <sup>20</sup>    |                     |            |                | 1.190                              | <0.01  | 93                      | 2-5%      | 550                  | 2       |
| Hexanoic acid                  | $\text{C}_6\text{H}_{12}\text{O}_2$          | 116.158 | -3                   | 205.2                | 0.9212 <sup>25</sup>    |                     | 2.600      | 1.13           | 1.937                              | 0.005  | 102                     |           | 380                  |         |
| 1-Hexanol                      | $\text{C}_6\text{H}_{14}\text{O}$            | 102.174 | -47.4                | 157.6                | 0.8136 <sup>20</sup>    | 4.58                | 13.03      |                | 2.353                              | 0.11   | 63                      |           | 290                  |         |
| 2-Hexanone                     | $\text{C}_6\text{H}_{12}\text{O}$            | 100.158 | -55.5                | 127.6                | 0.8113 <sup>20</sup>    | 0.583               | 14.56      | 2.7            | 2.130                              | 1.54   | 25                      | 1-8%      | 423                  | 5       |
| 1-Hexene                       | $\text{C}_6\text{H}_{12}$                    | 84.159  | -139.76              | 63.48                | 0.6685 <sup>25</sup>    | 0.252               | 2.077      | $\approx 0$    | 2.178                              | 24.8   | -26                     | 1.2-6.9%  | 253                  | 50      |
| Hexyl acetate                  | $\text{C}_8\text{H}_{16}\text{O}_2$          | 144.212 | -80.9                | 171.5                | 0.8779 <sup>15</sup>    |                     | 4.42       |                | 1.961                              | 0.185  | 45                      |           |                      |         |
| Hydrazine                      | $\text{H}_2\text{N}_2$                       | 32.045  | 1.4                  | 113.55               | 1.0036                  | 0.876               | 51.7       | 1.75           | 3.086                              | 1.91   | 38                      | 5-100%    |                      | 0.01    |
| Hydrazoic acid                 | $\text{HN}_3$                                | 43.028  | -80                  | 35.7                 |                         |                     |            | 1.70           |                                    | 68.2   |                         |           |                      | 0.11    |
| Hydrogen cyanide               | $\text{HCN}$                                 | 27.026  | -13.29               | 26                   | 0.6876 <sup>20</sup>    | 0.183               | 114.9      | 2.985          | 2.612                              | 98.8   | -18                     | 6-40%     | 538                  | 4.7     |
| Hydrogen peroxide              | $\text{H}_2\text{O}_2$                       | 34.015  | -0.43                | 150.2                | 1.44                    |                     | 74.6       | 1.573          | 2.619                              | 0.26   |                         |           |                      | 1       |
| 3-Hydroxypropanenitrile        | $\text{C}_3\text{H}_5\text{NO}$              | 71.078  | -46                  | 221                  | 1.0404 <sup>25</sup>    |                     |            | 3.2            |                                    | 0.010  | 129                     |           |                      |         |
| Indan                          | $\text{C}_9\text{H}_{10}$                    | 118.175 | -51.38               | 177.97               | 0.9639 <sup>20</sup>    | 1.357               |            |                | 1.609                              | 0.2    |                         |           |                      |         |
| Indene                         | $\text{C}_9\text{H}_8$                       | 116.160 | -1.5                 | 182                  | 0.9960 <sup>25</sup>    |                     |            |                | 1.609                              | 0.220  |                         |           |                      | 10      |
| Iodine bromide                 | $\text{BrI}$                                 | 206.808 | 40                   | 116 dec              | 4.3                     |                     |            | 0.726          |                                    |        |                         |           |                      |         |
| Iodine chloride                | $\text{ClI}$                                 | 162.357 | 27.39                | 100 dec              | 3.24                    |                     |            | 1.24           |                                    | 3.59   |                         |           |                      |         |
| Iodobenzene                    | $\text{C}_6\text{H}_5\text{I}$               | 204.008 | -31.3                | 188.4                | 1.8308 <sup>20</sup>    | 1.554               | 4.59       | 1.70           | 0.778                              | 0.133  |                         |           |                      |         |
| 1-Iodobutane                   | $\text{C}_4\text{H}_9\text{I}$               | 184.018 | -103                 | 130.5                | 1.6154 <sup>20</sup>    |                     | 6.27       | 1.93           |                                    | 1.85   |                         |           |                      |         |
| Iodoethane                     | $\text{C}_2\text{H}_5\text{I}$               | 155.965 | -111.1               | 72.3                 | 1.9357 <sup>20</sup>    | 0.556               | 7.82       | 1.976          | 0.738                              | 18.2   |                         |           |                      |         |
| Iodomethane                    | $\text{CH}_3\text{I}$                        | 141.939 | -66.4                | 42.43                | 2.2789 <sup>20</sup>    | 0.469               | 6.97       | 1.62           | 0.888                              | 53.9   |                         |           |                      | 2       |
| 1-Iodopropane                  | $\text{C}_3\text{H}_7\text{I}$               | 169.992 | -101.3               | 102.5                | 1.7489 <sup>20</sup>    | 0.703               | 7.07       | 2.04           | 0.746                              | 5.75   |                         |           |                      |         |
| 2-Iodopropane                  | $\text{C}_3\text{H}_7\text{I}$               | 169.992 | -90                  | 89.5                 | 1.7042 <sup>20</sup>    | 0.653               | 8.19       | 1.95           | 0.535                              | 9.36   |                         |           |                      |         |
| Iron pentacarbonyl             | $\text{C}_5\text{FeO}_5$                     | 195.896 | -20                  | 103                  | 1.5 <sup>20</sup>       |                     | 2.602      |                | 1.228                              | 4      |                         |           |                      | 0.1     |
| Isobutanal                     | $\text{C}_4\text{H}_8\text{O}$               | 72.106  | -65.9                | 64.5                 | 0.7891 <sup>20</sup>    |                     |            | 2.75           |                                    | 23.0   | -18                     | 1.6-10.6% | 196                  |         |
| Isobutyl acetate               | $\text{C}_6\text{H}_{12}\text{O}_2$          | 116.158 | -98.8                | 116.5                | 0.8712 <sup>20</sup>    | 0.676               | 5.068      | 1.9            | 2.013                              | 2.39   | 18                      | 1-11%     | 421                  | 150     |
| Isobutyl acrylate              | $\text{C}_7\text{H}_{12}\text{O}_2$          | 128.169 | -61                  | 132                  | 0.8896 <sup>20</sup>    |                     |            |                |                                    | 30     |                         |           | 427                  |         |
| Isobutylamine                  | $\text{C}_4\text{H}_{11}\text{N}$            | 73.137  | -86.7                | 67.75                | 0.724 <sup>25</sup>     | 0.571               | 4.43       | 1.3            | 2.505                              | 19.0   | -9                      | 2-12%     | 378                  |         |
| Isobutylbenzene                | $\text{C}_{10}\text{H}_{14}$                 | 134.218 | -51.4                | 172.79               | 0.8532 <sup>20</sup>    |                     | 2.318      | $\approx 0$    | 1.793                              | 0.257  | 55                      | 0.8-6%    | 427                  |         |
| Isobutyl formate               | $\text{C}_6\text{H}_{10}\text{O}_2$          | 102.132 | -95.8                | 98.2                 | 0.8776 <sup>20</sup>    |                     | 6.41       | 1.88           |                                    | 5.34   | 5                       | 2-9%      | 320                  |         |
| Isobutyl isobutanoate          | $\text{C}_8\text{H}_{16}\text{O}_2$          | 144.212 | -80.7                | 148.6                | 0.8542 <sup>20</sup>    |                     |            | 1.9            |                                    | 0.552  | 38                      | 1-8%      | 432                  |         |
| Isopentane                     | $\text{C}_5\text{H}_{12}$                    | 72.149  | -159.77              | 27.88                | 0.6201 <sup>20</sup>    | 0.214               | 1.845      | 0.13           | 2.284                              | 91.7   | -51                     | 1.4-7.6%  | 420                  | 600     |
| Isopentyl acetate              | $\text{C}_7\text{H}_{14}\text{O}_2$          | 130.185 | -78.5                | 142.5                | 0.876 <sup>15</sup>     |                     | 4.72       | 1.9            | 1.909                              | 0.728  | 25                      | 1-8%      | 360                  | 50      |
| Isophorone                     | $\text{C}_9\text{H}_{18}\text{O}$            | 138.206 | -8.1                 | 215.2                | 0.9255 <sup>20</sup>    | 2.33                |            |                | 1.834                              | 0.06   | 84                      | 1-4%      | 460                  | 5       |
| Isopropenyl acetate            | $\text{C}_5\text{H}_8\text{O}_2$             | 100.117 | -92.9                | 94                   | 0.9090 <sup>20</sup>    |                     |            |                |                                    | 6.02   | 26                      |           | 432                  |         |
| Isopropenylbenzene             | $\text{C}_9\text{H}_{10}$                    | 118.175 | -23.2                | 165.4                | 0.9106 <sup>20</sup>    |                     | 2.28       |                | 1.711                              | 0.40   | 54                      | 1.9-6.1%  | 574                  | 50      |
| Isopropyl acetate              | $\text{C}_5\text{H}_{10}\text{O}_2$          | 102.132 | -73.4                | 88.6                 | 0.8718 <sup>20</sup>    |                     |            |                | 1.952                              | 7.88   | 2                       | 2-8%      | 460                  | 100     |
| Isopropylamine                 | $\text{C}_3\text{H}_7\text{N}$               | 59.110  | -95.13               | 31.76                | 0.6891 <sup>20</sup>    | 0.325               | 5.6268     | 1.19           | 2.771                              | 78.0   | -37                     |           | 402                  | 5       |
| Isopropylbenzene               | $\text{C}_9\text{H}_{12}$                    | 120.191 | -96.02               | 152.41               | 0.8640 <sup>25</sup>    | 0.737               | 2.381      | 0.79           | 1.753                              | 0.61   | 36                      | 1-7%      | 424                  | 50      |
| Isopropylbenzene hydroperoxide | $\text{C}_9\text{H}_{12}\text{O}_2$          | 152.190 |                      | 153                  | 1.03 <sup>20</sup>      |                     |            |                |                                    | 0.004  |                         |           |                      |         |
| 1-Isopropyl-2-methylbenzene    | $\text{C}_{10}\text{H}_{14}$                 | 134.218 | -71.5                | 178.1                | 0.8766 <sup>20</sup>    |                     |            |                |                                    | 0.2    |                         |           |                      |         |
| 1-Isopropyl-3-methylbenzene    | $\text{C}_{10}\text{H}_{14}$                 | 134.218 | -63.7                | 175.1                | 0.8610 <sup>20</sup>    |                     |            |                |                                    | 0.22   |                         |           |                      |         |
| 1-Isopropyl-4-methylbenzene    | $\text{C}_{10}\text{H}_{14}$                 | 134.218 | -67.94               | 177.1                | 0.8573 <sup>20</sup>    |                     | 2.2322     | $\approx 0$    | 1.761                              | 0.19   | 47                      | 1-6%      | 436                  |         |
| Isoquinoline                   | $\text{C}_8\text{H}_7\text{N}$               | 129.159 | 26.47                | 243.22               | 1.0910 <sup>30</sup>    |                     | 11.0       | 2.73           | 1.519                              | 0.007  |                         |           |                      |         |
| <i>d</i> -Limonene             | $\text{C}_{10}\text{H}_{16}$                 | 136.234 | -74.0                | 178                  | 0.8411 <sup>20</sup>    | 1.47                | 2.3746     |                | 1.828                              | 0.277  | 45                      | 0.7-6.1%  | 237                  |         |
| <i>l</i> -Limonene             | $\text{C}_{10}\text{H}_{16}$                 | 136.234 |                      | 178                  | 0.843 <sup>20</sup>     |                     | 2.3738     |                |                                    | 0.254  |                         |           |                      |         |
| Mesityl oxide                  | $\text{C}_8\text{H}_{10}\text{O}$            | 98.142  | -59                  | 130                  | 0.8653 <sup>20</sup>    | 0.602               | 15.6       | 2.8            | 2.165                              | 1.47   | 31                      | 1-7%      | 344                  | 15      |
| Methacrylic acid               | $\text{C}_4\text{H}_6\text{O}_2$             | 86.090  | 16                   | 162.5                | 1.0153 <sup>20</sup>    |                     |            | 1.65           | 1.871                              | 0.12   | 77                      | 1.6-8.8%  | 68                   | 20      |
| Methanol                       | $\text{CH}_3\text{O}$                        | 32.042  | -97.53               | 64.6                 | 0.7914 <sup>20</sup>    | 0.544               | 33.0       | 1.70           | 2.531                              | 16.9   | 11                      | 6-36%     | 464                  | 200     |
| 2-Methoxyaniline               | $\text{C}_7\text{H}_7\text{NO}$              | 123.152 | 6.2                  | 224                  | 1.0923 <sup>20</sup>    |                     | 5.230      |                |                                    | 0.013  | 118                     |           |                      | 0.1     |
| 4-Methoxybenzaldehyde          | $\text{C}_8\text{H}_8\text{O}_2$             | 136.149 | 0                    | 248                  | 1.119 <sup>15</sup>     |                     | 22.0       |                |                                    | 0.004  |                         |           |                      |         |
| 2-Methoxyethanol               | $\text{C}_3\text{H}_8\text{O}_2$             | 76.095  | -85.1                | 124.1                | 0.9647 <sup>20</sup>    |                     | 17.2       | 2.36           | 2.249                              | 1.31   | 39                      | 2-14%     | 285                  | 5       |
| 2-Methoxyethyl acetate         | $\text{C}_6\text{H}_{12}\text{O}_3$          | 118.131 | -70                  | 143                  | 1.0074 <sup>19</sup>    |                     | 8.25       | 2.1            | 2.624                              | 0.67   | 49                      | 2-12%     | 392                  | 5       |
| Methyl acetate                 | $\text{C}_3\text{H}_6\text{O}_2$             | 74.079  | -98.25               | 56.87                | 0.9342 <sup>20</sup>    | 0.364               | 7.07       | 1.72           | 1.916                              | 28.8   | -10                     | 3-16%     | 454                  | 200     |
| Methyl acrylate                | $\text{C}_4\text{H}_6\text{O}_2$             | 86.090  | <-75                 | 80.7                 | 0.9535 <sup>20</sup>    |                     | 7.03       | 1.77           | 1.845                              | 11.0   | -3                      | 2.8-25%   | 468                  | 2       |
| 2-Methylacrylonitrile          | $\text{C}_4\text{H}_5\text{N}$               | 67.090  | -35.8                | 90.3                 | 0.8001 <sup>20</sup>    |                     |            | 3.69           | 1.883                              | 8.26   | 1                       | 2-6.8%    |                      | 1       |
| 2-Methylaniline                | $\text{C}_7\text{H}_9\text{N}$               | 107.153 | -14.41               | 200.3                | 0.9984 <sup>20</sup>    | 3.82                | 6.138      | 1.6            | 1.96                               | 0.043  | 85                      |           | 482                  | 2       |
| 3-Methylaniline                | $\text{C}_7\text{H}_9\text{N}$               | 107.153 | -31.3                | 203.3                | 0.9889 <sup>20</sup>    | 3.31                | 5.816      | 1.45           | 2.118                              | 0.036  |                         |           |                      | 2       |
| <i>N</i> -Methylaniline        | $\text{C}_7\text{H}_9\text{N}$               | 107.153 | -57                  | 196.2                | 0.9891 <sup>20</sup>    | 2.04                | 5.96       |                | 1.933                              | 0.05   |                         |           |                      | 0.5     |
| Methyl benzoate                | $\text{C}_8\text{H}_8\text{O}_2$             | 136.149 | -12.4                | 199                  | 1.0837 <sup>25</sup>    | 1.857               | 6.642      | 1.9            | 1.625                              | 0.052  | 83                      |           |                      |         |

| Name                                      | Mol. form.                                  | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | $v_p/\text{kPa}$ | FP/<br>$^\circ\text{C}$ | Fl. lim.  | IT/ $^\circ\text{C}$ | TLV/ppm |
|-------------------------------------------|---------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|------------------|-------------------------|-----------|----------------------|---------|
| 2-Methyl-1,3-butadiene                    | $\text{C}_5\text{H}_8$                      | 68.118  | -145.9               | 34.0                 | 0.679 <sup>9</sup>      |                     | 2.098      | 0.25           | 2.240                              | 73.4             | -54                     | 1.5-8.9%  | 395                  |         |
| Methyl butanoate                          | $\text{C}_5\text{H}_{10}\text{O}_2$         | 102.132 | -85.8                | 102.8                | 0.8984 <sup>20</sup>    | 0.541               | 5.48       |                | 1.941                              | 4.30             | 14                      |           |                      |         |
| 3-Methylbutanoic acid                     | $\text{C}_5\text{H}_{10}\text{O}_2$         | 102.132 | -29.3                | 176.5                | 0.931 <sup>20</sup>     |                     |            | 0.63           | 1.930                              | 0.067            |                         |           | 416                  |         |
| 3-Methyl-1-butanol                        | $\text{C}_5\text{H}_{12}\text{O}$           | 88.148  | -117.2               | 131.1                | 0.8104 <sup>20</sup>    | 3.69                | 15.63      |                | 2.382                              | 0.315            | 43                      | 1.2-9%    | 350                  | 100     |
| 2-Methyl-2-butanol                        | $\text{C}_5\text{H}_{12}\text{O}$           | 88.148  | -9.1                 | 102.4                | 0.8096 <sup>20</sup>    | 3.55                | 5.78       | 1.82           | 2.803                              | 2.19             | 19                      | 1.2-9%    | 437                  |         |
| 3-Methyl-2-butanol, ( $\pm$ )-            | $\text{C}_5\text{H}_{12}\text{O}$           | 88.148  |                      | 112.9                | 0.8180 <sup>20</sup>    |                     | 12.1       |                |                                    | 1.20             | 38                      |           |                      |         |
| 3-Methyl-2-butanone                       | $\text{C}_5\text{H}_{10}\text{O}$           | 86.132  | -93.1                | 94.33                | 0.8051 <sup>20</sup>    |                     | 10.37      |                | 2.089                              | 6.99             |                         |           |                      | 200     |
| 2-Methyl-1-butene                         | $\text{C}_5\text{H}_{10}$                   | 70.133  | -137.53              | 31.2                 | 0.6504 <sup>20</sup>    |                     | 2.180      |                | 2.241                              | 81.4             | -20                     |           |                      |         |
| 2-Methyl-2-butene                         | $\text{C}_5\text{H}_{10}$                   | 70.133  | -133.72              | 38.56                | 0.6623 <sup>20</sup>    | 0.203               | 1.979      |                | 2.179                              | 62.1             | -20                     |           |                      |         |
| Methyl <i>tert</i> -butyl ether           | $\text{C}_5\text{H}_{12}\text{O}$           | 88.148  | -108.6               | 55.0                 | 0.7353 <sup>25</sup>    |                     |            |                | 2.127                              | 33.6             |                         |           |                      | 50      |
| Methyl chloroacetate                      | $\text{C}_3\text{H}_5\text{ClO}_2$          | 108.524 | -32.1                | 129.5                | 1.236 <sup>20</sup>     |                     | 12.0       |                |                                    | 1.0              | 57                      | 7.5-18.5% |                      |         |
| Methylcyclohexane                         | $\text{C}_7\text{H}_{14}$                   | 98.186  | -126.6               | 100.93               | 0.7694 <sup>20</sup>    | 0.679               | 2.024      | $\approx 0$    | 1.882                              | 6.18             | -4                      | 1-7%      | 250                  | 400     |
| Methylcyclopentane                        | $\text{C}_6\text{H}_{12}$                   | 84.159  | -142.42              | 71.8                 | 0.7486 <sup>20</sup>    | 0.479               | 1.9853     | $\approx 0$    | 1.886                              | 18.3             | -29                     | 1-8%      | 258                  |         |
| <i>N</i> -Methylformamide                 | $\text{C}_2\text{H}_5\text{NO}$             | 59.067  | -3.8                 | 199.51               | 1.011 <sup>19</sup>     | 1.678               | 189.0      | 3.83           | 2.096                              | 0.03             |                         |           |                      |         |
| Methyl formate                            | $\text{C}_2\text{H}_4\text{O}_2$            | 60.052  | -99                  | 31.7                 | 0.9713 <sup>20</sup>    | 0.325               | 9.20       | 1.77           | 1.983                              | 78.1             | -19                     | 5-23%     | 449                  | 100     |
| 5-Methyl-2-hexanone                       | $\text{C}_7\text{H}_{14}\text{O}$           | 114.185 |                      | 144                  | 0.888 <sup>20</sup>     |                     | 13.53      |                |                                    | 0.691            | 36                      | 1-8%      | 191                  | 50      |
| Methylhydrazine                           | $\text{CH}_6\text{N}_2$                     | 46.072  | -52.36               | 87.5                 |                         |                     |            |                | 2.928                              | 6.61             | -8                      | 2.5-92%   | 194                  | 0.01    |
| Methyl isocyanate                         | $\text{C}_2\text{H}_5\text{NO}$             | 57.051  | -45                  | 39.5                 | 0.9230 <sup>27</sup>    |                     | 21.75      | $\approx 2.8$  |                                    | 57.7             | -7                      | 5.3-26%   | 534                  | 0.02    |
| Methyl lactate, ( $\pm$ )-                | $\text{C}_4\text{H}_8\text{O}_3$            | 104.105 |                      | 144.8                | 1.0928 <sup>20</sup>    |                     |            |                |                                    | 0.62             | 49                      | >2.2%     | 385                  |         |
| Methyl methacrylate                       | $\text{C}_5\text{H}_8\text{O}_2$            | 100.117 | -47.55               | 100.5                | 0.9377 <sup>25</sup>    |                     | 6.32       | 1.67           | 1.910                              | 5.10             | 10                      | 1.7-8.2%  |                      | 50      |
| 1-Methylnaphthalene                       | $\text{C}_{11}\text{H}_{10}$                | 142.197 | -30.43               | 244.7                | 1.0202 <sup>20</sup>    |                     | 2.915      | $\approx 0$    | 1.578                              | 0.009            |                         |           | 529                  |         |
| Methyloxirane                             | $\text{C}_3\text{H}_6\text{O}$              | 58.079  | -111.9               | 35                   | 0.859 <sup>9</sup>      |                     |            | 2.01           | 2.073                              | 71.7             | -37                     | 3.1-27.5% | 449                  | 2       |
| 2-Methylpentane                           | $\text{C}_6\text{H}_{14}$                   | 86.175  | -153.6               | 60.26                | 0.650 <sup>25</sup>     | 0.286               | 1.886      | $\approx 0$    | 2.248                              | 28.2             | <-29                    | 1-7%      | 264                  | 500     |
| 3-Methylpentane                           | $\text{C}_6\text{H}_{14}$                   | 86.175  | -162.90              | 63.27                | 0.6598 <sup>25</sup>    | 0.306               | 1.886      | $\approx 0$    | 2.213                              | 25.3             | -7                      | 1.2-7%    | 278                  | 500     |
| 2-Methyl-2,4-pentanediol                  | $\text{C}_6\text{H}_{14}\text{O}_2$         | 118.174 | -50                  | 197.1                | 0.923 <sup>15</sup>     |                     | 23.4       | 2.9            | 2.843                              | <0.01            | 102                     | 1-9%      | 306                  | 25      |
| 2-Methyl-1-pentanol                       | $\text{C}_6\text{H}_{14}\text{O}$           | 102.174 |                      | 149                  | 0.8263 <sup>20</sup>    |                     |            |                | 2.427                              | 0.236            | 54                      | 1.1-9.65% | 310                  |         |
| 4-Methyl-2-pentanol                       | $\text{C}_6\text{H}_{14}\text{O}$           | 102.174 | -90                  | 131.6                | 0.8075 <sup>20</sup>    | 4.07                |            |                | 2.672                              | 0.698            | 41                      | 1-6%      |                      | 25      |
| 4-Methyl-2-pentanone                      | $\text{C}_6\text{H}_{12}\text{O}$           | 100.158 | -84                  | 116.5                | 0.7965 <sup>25</sup>    | 0.545               | 13.11      |                | 2.130                              | 2.64             | 18                      | 1-8%      | 448                  | 50      |
| 2-Methylpropanenitrile                    | $\text{C}_4\text{H}_7\text{N}$              | 69.106  | -71.5                | 103.9                | 0.7704 <sup>20</sup>    |                     | 24.42      | 4.29           |                                    |                  | 8                       |           | 482                  |         |
| 2-Methyl-2-propanethiol                   | $\text{C}_4\text{H}_{10}\text{S}$           | 90.187  | -0.5                 | 64.2                 | 0.7943 <sup>25</sup>    |                     | 5.475      | 1.66           |                                    | 24.2             | <-29                    |           |                      |         |
| Methyl propanoate                         | $\text{C}_4\text{H}_8\text{O}_2$            | 88.106  | -87.5                | 79.8                 | 0.9150 <sup>20</sup>    | 0.431               | 6.200      |                | 1.943                              | 11.5             | -2                      | 2.5-13%   | 469                  |         |
| 2-Methylpropanoic acid                    | $\text{C}_4\text{H}_8\text{O}_2$            | 88.106  | -46                  | 154.45               | 0.9681 <sup>20</sup>    | 1.226               | 2.58       | 1.08           | 1.964                              | 0.17             | 56                      | 2-9.2%    | 481                  |         |
| 2-Methyl-1-propanol                       | $\text{C}_4\text{H}_{10}\text{O}$           | 74.121  | -101.9               | 107.89               | 0.8018 <sup>20</sup>    | 3.33                | 17.93      | 1.64           | 2.449                              | 1.39             | 28                      | 2-11%     | 415                  | 50      |
| 2-Methyl-2-propanol                       | $\text{C}_4\text{H}_{10}\text{O}$           | 74.121  | 25.69                | 82.4                 | 0.7887 <sup>20</sup>    | 4.31                | 12.47      | 1.7            | 2.949                              | 5.52             | 11                      | 2-8%      | 478                  | 100     |
| 2-Methylpyridine                          | $\text{C}_6\text{H}_7\text{N}$              | 93.127  | -66.68               | 129.38               | 0.9443 <sup>20</sup>    |                     | 10.18      | 1.85           | 1.703                              | 1.5              | 39                      |           | 538                  |         |
| 3-Methylpyridine                          | $\text{C}_6\text{H}_7\text{N}$              | 93.127  | -18.14               | 144.14               | 0.9566 <sup>20</sup>    |                     | 11.10      | 2.40           | 1.704                              | 0.795            |                         |           |                      |         |
| 4-Methylpyridine                          | $\text{C}_6\text{H}_7\text{N}$              | 93.127  | 3.67                 | 145.36               | 0.9548 <sup>20</sup>    |                     | 12.2       | 2.70           | 1.707                              | 0.759            | 57                      |           |                      |         |
| <i>N</i> -Methyl-2-pyrrolidone            | $\text{C}_5\text{H}_9\text{NO}$             | 99.131  | -23.09               | 202                  | 1.0230 <sup>25</sup>    |                     | 32.55      | 4.1            | 3.105                              | 0.04             | 96                      | 1-10%     | 346                  |         |
| Methyl salicylate                         | $\text{C}_8\text{H}_8\text{O}_3$            | 152.148 | -8                   | 222.9                | 1.181 <sup>25</sup>     |                     | 8.80       | 2.47           | 1.637                              | 0.015            | 96                      |           | 454                  |         |
| 4-Methylstyrene                           | $\text{C}_9\text{H}_{10}$                   | 118.175 | -34.1                | 172.8                | 0.9173 <sup>25</sup>    |                     |            |                |                                    | 0.245            | 53                      | 0.8-11%   | 538                  | 50      |
| Morpholine                                | $\text{C}_4\text{H}_9\text{NO}$             | 87.120  | -4.8                 | 128                  | 1.0005 <sup>20</sup>    | 2.02                | 7.42       | 1.55           | 1.892                              | 1.34             | 37                      | 1-11%     | 290                  | 20      |
| $\beta$ -Myrcene                          | $\text{C}_{10}\text{H}_{16}$                | 136.234 |                      | 167                  | 0.8013 <sup>15</sup>    |                     | 2.3        |                |                                    | 0.280            |                         |           |                      |         |
| Nickel carbonyl                           | $\text{C}_5\text{NiO}_4$                    | 170.734 | -19.3                | 43 (exp 60)          | 1.31 <sup>25</sup>      |                     |            |                | 1.198                              |                  |                         |           |                      | 0.05    |
| <i>L</i> -Nicotine                        | $\text{C}_{10}\text{H}_{14}\text{N}_2$      | 162.231 | -79                  | 247                  | 1.0097 <sup>20</sup>    |                     | 8.937      |                |                                    |                  |                         |           |                      | 0.1     |
| Nitric acid                               | $\text{HNO}_3$                              | 63.013  | -41.6                | 83                   | 1.55                    |                     |            | 2.17           | 1.744                              | 8.34             |                         |           |                      | 2       |
| 2-Nitroanisole                            | $\text{C}_7\text{H}_9\text{NO}_3$           | 153.136 | 10.5                 | 272                  | 1.2540 <sup>20</sup>    |                     | 45.75      | 5.0            |                                    | 0.002            |                         |           |                      |         |
| Nitrobenzene                              | $\text{C}_6\text{H}_5\text{NO}_2$           | 123.110 | 5.7                  | 210.8                | 1.2037 <sup>20</sup>    | 1.863               | 35.6       | 4.22           | 1.509                              | 0.03             | 88                      | 2-9%      | 482                  | 1       |
| Nitroethane                               | $\text{C}_2\text{H}_5\text{NO}_2$           | 75.067  | -89.5                | 114.0                | 1.0448 <sup>25</sup>    | 0.688               | 29.11      | 3.23           | 1.790                              | 2.79             | 28                      | 3-17%     | 414                  | 100     |
| Nitromethane                              | $\text{CH}_3\text{NO}_2$                    | 61.041  | -28.38               | 101.19               | 1.1371 <sup>20</sup>    | 0.630               | 37.27      | 3.46           | 1.746                              | 4.79             | 35                      | 7-22%     | 418                  | 20      |
| 1-Nitropropane                            | $\text{C}_3\text{H}_7\text{NO}_2$           | 89.094  | -108                 | 131.1                | 0.9961 <sup>25</sup>    | 0.798               | 24.70      | 3.66           | 1.97                               | 1.36             | 36                      | 2%-       | 421                  | 25      |
| 2-Nitropropane                            | $\text{C}_3\text{H}_7\text{NO}_2$           | 89.094  | -91.3                | 120.2                | 0.9821 <sup>25</sup>    |                     | 26.74      | 3.73           | 1.911                              | 2.3              | 24                      | 3-11%     | 428                  | 10      |
| <i>N</i> -Nitrosodiethylamine             | $\text{C}_4\text{H}_{10}\text{N}_2\text{O}$ | 102.134 |                      | 176.9                | 0.9422 <sup>20</sup>    |                     |            |                |                                    |                  |                         |           |                      |         |
| <i>N</i> -Nitrosodimethylamine            | $\text{C}_2\text{H}_6\text{N}_2\text{O}$    | 74.081  |                      | 152                  | 1.0048 <sup>20</sup>    |                     |            |                |                                    | 0.73             |                         |           |                      |         |
| 2-Nitrotoluene                            | $\text{C}_7\text{H}_7\text{NO}_2$           | 137.137 | -10.4                | 222                  | 1.1611 <sup>19</sup>    |                     | 26.26      |                | 1.474                              | 0.0014           | 106                     |           |                      | 2       |
| 3-Nitrotoluene                            | $\text{C}_7\text{H}_7\text{NO}_2$           | 137.137 | 15.5                 | 232                  | 1.1581 <sup>20</sup>    |                     | 24.95      |                | 1.474                              | 0.03             | 106                     |           |                      | 2       |
| Nonane                                    | $\text{C}_9\text{H}_{20}$                   | 128.255 | -53.46               | 150.82               | 0.7192 <sup>20</sup>    | 0.665               | 1.9722     | $\approx 0$    | 2.217                              | 0.570            | 31                      | 0.8-2.9%  | 205                  | 200     |
| Nonanoic acid                             | $\text{C}_9\text{H}_{18}\text{O}_2$         | 158.238 | 12.4                 | 254.5                | 0.9052 <sup>20</sup>    | 7.01                | 2.475      | 0.79           | 2.290                              | 0.00005          |                         |           |                      |         |
| 1-Nonanol                                 | $\text{C}_9\text{H}_{20}\text{O}$           | 144.254 | -5                   | 213.37               | 0.8280 <sup>20</sup>    | 9.12                | 8.83       |                | 2.470                              | 0.00050          |                         |           | 260                  |         |
| 1-Nonene                                  | $\text{C}_9\text{H}_{18}$                   | 126.239 | -81.3                | 146.9                | 0.7253 <sup>25</sup>    | 0.586               | 2.180      | $\approx 0$    | 2.142                              | 0.714            | 26                      |           |                      |         |
| 4-Nonylphenol                             | $\text{C}_{15}\text{H}_{24}\text{O}$        | 220.351 | 42                   | $\approx 295$        | 0.950 <sup>20</sup>     |                     |            |                |                                    |                  |                         |           |                      |         |
| <i>cis,cis</i> -9,12-Octadecadienoic acid | $\text{C}_{18}\text{H}_{32}\text{O}_2$      | 280.446 | -7                   |                      | 0.9022 <sup>20</sup>    |                     | 2.754      |                |                                    |                  |                         |           |                      |         |
| <i>cis</i> -9-Octadecenoic acid           | $\text{C}_{18}\text{H}_{34}\text{O}_2$      | 282.462 | 13.4                 | 360                  | 0.8935 <sup>20</sup>    |                     | 2.336      | 1.18           | 2.043                              | 0.000001         | 189                     |           | 363                  |         |
| Octane                                    | $\text{C}_8\text{H}_{18}$                   | 114.229 | -56.82               | 125.67               | 0.6986 <sup>25</sup>    | 0.508               | 1.948      | $\approx 0$    | 2.229                              | 1.86             | 13                      | 1-7%      | 206                  | 300     |
| Octanoic acid                             | $\text{C}_8\text{H}_{16}\text{O}_2$         | 144.212 | 16.5                 | 239                  | 0.9073 <sup>25</sup>    | 5.02                | 2.85       | 1.15           | 2.066                              | 0.0002           |                         |           |                      |         |
| 1-Octanol                                 | $\text{C}_8\text{H}_{18}\text{O}$           | 130.228 | -14.8                | 195.16               | 0.8262 <sup>25</sup>    | 7.29                | 10.30      | 1.8            | 2.344                              | 0.01             | 81                      |           | 270                  |         |
| 2-Octanol                                 | $\text{C}_8\text{H}_{18}\text{O}$           | 130.228 | -31.6                | 179.3                | 0.8193 <sup>20</sup>    | 6.49                | 8.13       | 1.71           | 2.535                              |                  | 88                      |           | 265                  |         |

| Name                                  | Mol. form.                                       | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | $\text{vp/kPa}$ | FP/<br>$^\circ\text{C}$ | Fl. lim.  | IT/ $^\circ\text{C}$ | TLV/ppm |
|---------------------------------------|--------------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|-----------------|-------------------------|-----------|----------------------|---------|
| 2-Octanone                            | $\text{C}_8\text{H}_{16}\text{O}$                | 128.212 | -16                  | 172.5                | 0.820 <sup>20</sup>     |                     | 9.51       | 2.7            | 2.132                              | 0.12            | 52                      |           |                      |         |
| 1-Octene                              | $\text{C}_8\text{H}_{16}$                        | 112.213 | -101.7               | 121.29               | 0.7149 <sup>20</sup>    | 0.447               | 2.113      | $\approx 0$    | 2.148                              | 2.30            | 21                      |           | 230                  |         |
| Oxetane                               | $\text{C}_3\text{H}_6\text{O}$                   | 58.079  | -97                  | 47.6                 | 0.8930 <sup>25</sup>    |                     |            | 1.94           |                                    |                 |                         |           |                      |         |
| 2-Oxetanone                           | $\text{C}_3\text{H}_4\text{O}_2$                 | 72.063  | -33.4                | 162                  | 1.1460 <sup>20</sup>    |                     |            | 4.18           | 1.694                              | 0.3             | 74                      | >2.9%     |                      | 0.5     |
| Oxirane                               | $\text{C}_2\text{H}_4\text{O}$                   | 44.052  | -112.5               | 10.6                 | 0.8821 <sup>10</sup>    |                     | 12.42      | 1.89           | 1.998                              | 175             | -20                     | 3-100%    | 429                  | 1       |
| Oxiranemethanol, ( $\pm$ )-           | $\text{C}_3\text{H}_6\text{O}_2$                 | 74.079  | -45                  | 167 dec              | 1.1143 <sup>25</sup>    |                     |            |                |                                    |                 |                         |           |                      | 2       |
| Paraldehyde                           | $\text{C}_6\text{H}_{12}\text{O}_3$              | 132.157 | 12.6                 | 124.3                | 0.9943 <sup>20</sup>    | 1.079               |            | 1.43           |                                    | 1.6             | 36                      | >1.3%     | 238                  |         |
| Parathion                             | $\text{C}_{10}\text{H}_{14}\text{NO}_5\text{PS}$ | 291.261 | 6.1                  | 375                  | 1.2681 <sup>20</sup>    |                     |            |                |                                    |                 |                         |           |                      | 0.01    |
| Pentachloroethane                     | $\text{C}_2\text{Cl}_5$                          | 202.294 | -28.78               | 162.0                | 1.6796 <sup>20</sup>    | 2.25                | 3.716      | 0.92           | 0.859                              | 0.478           |                         |           |                      |         |
| cis-1,3-Pentadiene                    | $\text{C}_5\text{H}_8$                           | 68.118  | -140.8               | 44.1                 | 0.6910 <sup>20</sup>    |                     | 2.319      | 0.500          |                                    | 50.6            |                         |           |                      |         |
| trans-1,3-Pentadiene                  | $\text{C}_5\text{H}_8$                           | 68.118  | -87.4                | 42                   | 0.6710 <sup>25</sup>    |                     |            | 0.585          |                                    | 54.7            |                         |           |                      |         |
| Pentanal                              | $\text{C}_5\text{H}_{10}\text{O}$                | 86.132  | -91.5                | 103                  | 0.8095 <sup>20</sup>    |                     | 10.00      |                |                                    | 4.58            | 12                      |           | 222                  | 50      |
| Pentane                               | $\text{C}_5\text{H}_{12}$                        | 72.149  | -129.67              | 36.06                | 0.6262 <sup>20</sup>    | 0.224               | 1.8371     | $\approx 0$    | 2.317                              | 68.3            | -40                     | 2-8%      | 260                  | 600     |
| Pentanedial                           | $\text{C}_5\text{H}_8\text{O}_2$                 | 100.117 | -14                  | 188 dec              |                         |                     |            |                |                                    |                 |                         |           |                      | 0.05    |
| 1,5-Pentanediol                       | $\text{C}_5\text{H}_{12}\text{O}_2$              | 104.148 | -18                  | 239                  | 0.9914 <sup>20</sup>    |                     | 26.2       | 2.5            | 3.08                               | 0.001           | 129                     |           | 335                  |         |
| 2,4-Pentanedione                      | $\text{C}_5\text{H}_8\text{O}_2$                 | 100.117 | -23                  | 138                  | 0.9721 <sup>25</sup>    |                     | 26.524     | 2.8            | 2.08                               | 1.02            | 34                      |           | 340                  |         |
| 1-Pentanethiol                        | $\text{C}_5\text{H}_{12}\text{S}$                | 104.214 | -75.65               | 126.6                | 0.850 <sup>20</sup>     |                     | 4.847      |                |                                    | 1.83            | 18                      |           |                      |         |
| Pentanoic acid                        | $\text{C}_5\text{H}_{10}\text{O}_2$              | 102.132 | -33.6                | 186.1                | 0.9339 <sup>25</sup>    |                     | 2.661      | 1.61           | 2.059                              | 0.024           | 96                      |           | 400                  |         |
| 1-Pentanol                            | $\text{C}_5\text{H}_{12}\text{O}$                | 88.148  | -77.6                | 137.98               | 0.8144 <sup>20</sup>    | 3.62                | 15.13      | 1.7            | 2.361                              | 0.259           | 33                      | 1-10%     | 300                  |         |
| 2-Pentanol                            | $\text{C}_5\text{H}_{12}\text{O}$                | 88.148  | -73                  | 119.3                | 0.8094 <sup>20</sup>    | 3.47                | 13.71      | 1.66           | 2.716                              | 0.804           | 34                      | 1.2-9%    | 343                  |         |
| 3-Pentanol                            | $\text{C}_5\text{H}_{12}\text{O}$                | 88.148  | -69                  | 116.25               | 0.8203 <sup>20</sup>    | 4.15                | 13.35      | 1.64           | 2.719                              | 1.10            | 41                      | 1.2-9%    | 435                  |         |
| 2-Pentanone                           | $\text{C}_5\text{H}_{10}\text{O}$                | 86.132  | -76.8                | 102.26               | 0.809 <sup>20</sup>     | 0.470               | 15.45      | 2.7            | 2.137                              | 4.97            | 7                       | 2-8%      | 452                  | 200     |
| 3-Pentanone                           | $\text{C}_5\text{H}_{10}\text{O}$                | 86.132  | -39                  | 101.7                | 0.8098 <sup>25</sup>    | 0.444               | 17.00      | 2.82           | 2.216                              | 4.72            | 13                      | >1.6%     | 450                  | 200     |
| 1-Pentene                             | $\text{C}_5\text{H}_{10}$                        | 70.133  | -165.12              | 29.96                | 0.6405 <sup>20</sup>    | 0.195               | 2.011      | $\approx 0.5$  | 2.196                              | 85.0            | -18                     | 1.5-8.7%  | 275                  |         |
| cis-2-Pentene                         | $\text{C}_5\text{H}_{10}$                        | 70.133  | -151.36              | 36.93                | 0.6556 <sup>20</sup>    |                     |            | $\approx 0$    | 2.163                              | 66.0            | <-20                    |           |                      |         |
| trans-2-Pentene                       | $\text{C}_5\text{H}_{10}$                        | 70.133  | -140.21              | 36.34                | 0.6431 <sup>25</sup>    |                     |            | $\approx 0$    | 2.239                              | 67.4            | <-20                    |           |                      |         |
| Pentyl acetate                        | $\text{C}_7\text{H}_{14}\text{O}_2$              | 130.185 | -70.8                | 149.2                | 0.8756 <sup>20</sup>    |                     | 4.79       | 1.75           | 2.005                              | 0.60            | 16                      | 1-8%      | 360                  | 50      |
| Pentylamine                           | $\text{C}_5\text{H}_{13}\text{N}$                | 87.164  | -55                  | 104.3                | 0.7544 <sup>20</sup>    | 0.702               | 4.27       |                | 2.501                              | 4.00            | -1                      | 2.2-22%   |                      |         |
| Perchloric acid                       | $\text{ClHO}_4$                                  | 100.459 | -112                 | $\approx 90$ dec     | 1.77                    |                     |            |                |                                    |                 |                         |           |                      |         |
| Peroxyacetic acid                     | $\text{C}_2\text{H}_4\text{O}_3$                 | 76.051  | -0.2                 | 110                  | 1.226 <sup>15</sup>     |                     |            |                |                                    | 1.93            | 41                      |           |                      |         |
| Phenol                                | $\text{C}_6\text{H}_6\text{O}$                   | 94.111  | 40.89                | 181.87               | 1.0545 <sup>45</sup>    |                     | 12.40      | 1.224          | 2.123                              | 0.055           | 79                      | 1.8-8.6%  | 715                  | 5       |
| 2-Phenoxyethanol                      | $\text{C}_8\text{H}_{10}\text{O}_2$              | 138.164 | 14                   | 245                  | 1.102 <sup>22</sup>     |                     |            |                |                                    | 0.001           | 121                     |           |                      |         |
| Phenylhydrazine                       | $\text{C}_6\text{H}_8\text{N}_2$                 | 108.141 | 20.6                 | 243.5                | 1.0986 <sup>20</sup>    | 13.03               | 7.15       |                | 2.007                              | 0.003           | 88                      |           |                      | 0.1     |
| 1-Phenyl-2-propylamine,<br>( $\pm$ )- | $\text{C}_9\text{H}_{13}\text{N}$                | 135.206 |                      | 203                  | 0.9306 <sup>25</sup>    |                     |            |                |                                    | 0.06            | <100                    |           |                      |         |
| Phosphinic acid                       | $\text{H}_3\text{O}_2\text{P}$                   | 65.997  | 26.5                 | 130                  | 1.49                    |                     |            |                |                                    |                 |                         |           |                      |         |
| Phosphoric acid                       | $\text{H}_3\text{O}_4\text{P}$                   | 97.995  | 42.4                 | 407                  |                         |                     |            |                | 1.480                              |                 |                         |           |                      | 0.25    |
| Phosphorothioic trichloride           | $\text{Cl}_3\text{PS}$                           | 169.398 | -36.2                | 125                  | 1.635                   |                     | 4.94       |                |                                    |                 |                         |           |                      |         |
| Phosphorus(III) bromide               | $\text{Br}_3\text{P}$                            | 270.686 | -41.5                | 173.2                | 2.8                     |                     |            |                |                                    | 0.38            |                         |           |                      |         |
| Phosphorus(III) chloride              | $\text{Cl}_3\text{P}$                            | 137.332 | -93.6                | 76.1                 | 1.574                   | 0.529               | 3.498      | 0.56           |                                    | 16.1            |                         |           |                      | 0.2     |
| Phosphoryl chloride                   | $\text{Cl}_3\text{OP}$                           | 153.331 | 1.18                 | 105.5                | 1.645                   |                     | 14.1       | 2.54           | 0.905                              | 4.97            |                         |           |                      | 0.1     |
| $\alpha$ -Pinene                      | $\text{C}_{10}\text{H}_{16}$                     | 136.234 | -64                  | 156.2                | 0.8539 <sup>25</sup>    |                     | 2.1787     |                |                                    | 0.64            | 33                      |           | 255                  |         |
| $\beta$ -Pinene                       | $\text{C}_{10}\text{H}_{16}$                     | 136.234 | -61.5                | 166                  | 0.860 <sup>25</sup>     |                     | 2.4970     |                |                                    | 0.61            | 38                      |           | 275                  |         |
| Piperidine                            | $\text{C}_5\text{H}_{11}\text{N}$                | 85.148  | -11.02               | 106.22               | 0.8606 <sup>20</sup>    | 1.573               | 4.33       | 1.2            | 2.113                              | 4.28            | 16                      | 1-10%     |                      |         |
| Propanal                              | $\text{C}_3\text{H}_6\text{O}$                   | 58.079  | -80                  | 48                   | 0.8657 <sup>25</sup>    | 0.321               | 18.5       | 2.72           | 2.362                              | 42.2            | -30                     | 2.6-17%   | 207                  | 20      |
| 1,2-Propanediol                       | $\text{C}_3\text{H}_8\text{O}_2$                 | 76.095  | -60                  | 187.6                | 1.0361 <sup>20</sup>    | 40.4                | 27.5       | 2.2            | 2.507                              | 0.02            | 99                      | 3-13%     | 371                  |         |
| 1,3-Propanediol                       | $\text{C}_3\text{H}_8\text{O}_2$                 | 76.095  | -27.7                | 214.4                | 1.0538 <sup>20</sup>    |                     | 35.1       | 2.5            |                                    | 0.007           |                         |           | 400                  |         |
| Propanenitrile                        | $\text{C}_3\text{H}_5\text{N}$                   | 55.079  | -92.78               | 97.14                | 0.7818 <sup>20</sup>    | 0.294               | 29.7       | 4.05           | 2.166                              | 6.14            | 2                       | 3-14%     | 512                  |         |
| Propanoic acid                        | $\text{C}_3\text{H}_6\text{O}_2$                 | 74.079  | -20.5                | 141.15               | 0.9882 <sup>25</sup>    | 1.030               | 3.44       | 1.75           | 2.063                              | 0.553           | 52                      | 2.9-12.1% | 465                  | 10      |
| Propanoic anhydride                   | $\text{C}_6\text{H}_{10}\text{O}_3$              | 130.141 | -45                  | 170                  | 1.0110 <sup>20</sup>    |                     | 18.30      |                | 1.806                              | 0.45            | 63                      | 1.3-9.5%  | 285                  |         |
| 1-Propanol                            | $\text{C}_3\text{H}_8\text{O}$                   | 60.095  | -124.39              | 97.2                 | 0.7997 <sup>25</sup>    | 1.945               | 20.8       | 1.55           | 2.395                              | 2.76            | 23                      | 2-14%     | 412                  | 200     |
| 2-Propanol                            | $\text{C}_3\text{H}_8\text{O}$                   | 60.095  | -87.9                | 82.3                 | 0.7809 <sup>25</sup>    | 2.04                | 20.18      | 1.56           | 2.604                              | 6.02            | 12                      | 2-13%     | 399                  | 200     |
| Propargyl alcohol                     | $\text{C}_3\text{H}_4\text{O}$                   | 56.063  | -51.8                | 113.6                | 0.9478 <sup>20</sup>    |                     | 20.8       | 1.13           |                                    |                 | 36                      |           |                      | 1       |
| Propyl acetate                        | $\text{C}_5\text{H}_{10}\text{O}_2$              | 102.132 | -93                  | 101.54               | 0.8878 <sup>20</sup>    | 0.544               | 5.62       | 1.8            | 1.921                              | 4.49            | 13                      | 2-8%      | 450                  | 200     |
| Propylamine                           | $\text{C}_3\text{H}_7\text{N}$                   | 59.110  | -84.75               | 47.22                | 0.7173 <sup>20</sup>    | 0.376               | 5.08       | 1.17           | 2.776                              | 42.1            | -37                     | 2-10%     | 318                  |         |
| Propylbenzene                         | $\text{C}_9\text{H}_{12}$                        | 120.191 | -99.6                | 159.24               | 0.8593 <sup>25</sup>    |                     | 2.370      | $\approx 0$    | 1.786                              | 0.45            | 30                      | 1-6%      | 450                  |         |
| Propyl butanoate                      | $\text{C}_7\text{H}_{14}\text{O}_2$              | 130.185 | -95.2                | 143.0                | 0.8730 <sup>20</sup>    |                     | 4.3        |                |                                    | 0.618           | 37                      |           |                      |         |
| Propylene carbonate                   | $\text{C}_4\text{H}_6\text{O}_3$                 | 102.089 | -48.8                | 242                  | 1.2047 <sup>20</sup>    |                     | 66.14      | 4.9            | 2.141                              | 0.05            | 135                     |           |                      |         |
| Propyl formate                        | $\text{C}_4\text{H}_8\text{O}_2$                 | 88.106  | -92.9                | 80.9                 | 0.9073 <sup>20</sup>    | 0.485               | 6.92       | 1.89           | 1.945                              | 10.9            | -3                      |           | 455                  |         |
| Propyl propanoate                     | $\text{C}_8\text{H}_{16}\text{O}_2$              | 116.158 | -75.9                | 122.5                | 0.8809 <sup>20</sup>    |                     | 5.249      |                |                                    | 1.88            | 79                      |           |                      |         |
| Pyridine                              | $\text{C}_5\text{H}_5\text{N}$                   | 79.101  | -41.70               | 115.23               | 0.9819 <sup>20</sup>    | 0.879               | 13.260     | 2.21           | 1.678                              | 2.76            | 20                      | 2-12%     | 482                  | 1       |
| Pyrrole                               | $\text{C}_4\text{H}_5\text{N}$                   | 67.090  | -23.39               | 129.79               | 0.9698 <sup>20</sup>    | 1.225               | 8.00       | 1.74           | 1.903                              | 1.10            | 39                      |           |                      |         |
| Pyrrolidine                           | $\text{C}_4\text{H}_9\text{N}$                   | 71.121  | -57.79               | 86.56                | 0.8586 <sup>20</sup>    | 0.704               | 8.30       | 1.6            | 2.202                              | 8.40            | 3                       |           |                      |         |
| 2-Pyrrolidone                         | $\text{C}_4\text{H}_7\text{NO}$                  | 85.105  | 25                   | 251                  | 1.120 <sup>20</sup>     |                     | 28.18      | 3.5            | 1.99                               |                 | 129                     |           |                      |         |
| Quinoline                             | $\text{C}_8\text{H}_7\text{N}$                   | 129.159 | -14.78               | 237.16               | 1.0977 <sup>15</sup>    | 3.34                | 9.16       | 2.29           | 1.51                               | 0.011           |                         |           | 480                  |         |
| Safrole                               | $\text{C}_{10}\text{H}_{10}\text{O}_2$           | 162.185 | 11.2                 | 234.5                | 1.1000 <sup>20</sup>    |                     |            |                |                                    | 0.01            | 100                     |           |                      |         |
| Salicylaldehyde                       | $\text{C}_7\text{H}_6\text{O}_2$                 | 122.122 | -7                   | 197                  | 1.1674 <sup>20</sup>    |                     | 18.35      | 2.86           | 1.818                              | 0.075           | 78                      |           |                      |         |

| Name                                   | Mol. form.                                     | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | $\text{vp/kPa}$ | FP/<br>$^\circ\text{C}$ | Fl. lim.  | IT/ $^\circ\text{C}$ | TLV/ppm |
|----------------------------------------|------------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|-----------------|-------------------------|-----------|----------------------|---------|
| Selenium chloride                      | $\text{Cl}_2\text{Se}_2$                       | 228.83  | -85                  | 130 dec              | 2.774                   |                     |            |                |                                    |                 |                         |           |                      |         |
| Selenium oxychloride                   | $\text{Cl}_2\text{OSe}$                        | 165.86  | 8.5                  | 177                  | 2.44                    |                     | 46.2       |                |                                    | 0.02            |                         |           |                      |         |
| Selenium oxyfluoride                   | $\text{F}_2\text{OSe}$                         | 132.96  | 15                   | 125                  | 2.8                     |                     |            |                |                                    | 0.56            |                         |           |                      |         |
| Styrene                                | $\text{C}_6\text{H}_8$                         | 104.150 | -30.65               | 145                  | 0.9016 <sup>25</sup>    | 0.695               | 2.4737     | 0.123          | 1.747                              | 0.81            | 31                      | 1-7%      | 490                  | 20      |
| Sulfolane                              | $\text{C}_4\text{H}_8\text{O}_2\text{S}$       | 120.171 | 27.6                 | 287.3                | 1.2723 <sup>18</sup>    |                     | 43.26      | 4.8            | 1.498                              | <0.01           | 177                     |           |                      |         |
| Sulfur chloride                        | $\text{Cl}_2\text{S}_2$                        | 135.037 | -77                  | 137                  | 1.69                    |                     | 4.79       |                |                                    | 1.27            |                         |           |                      | 1       |
| Sulfur dichloride                      | $\text{Cl}_2\text{S}$                          | 102.971 | -122                 | 59.6                 | 1.62                    |                     | 2.915      | 0.36           |                                    | 17.9            |                         |           |                      |         |
| Sulfuric acid                          | $\text{H}_2\text{O}_4\text{S}$                 | 98.080  | 10.31                | 337                  | 1.8                     |                     |            |                | 1.416                              |                 |                         |           |                      | 0.05    |
| Sulfuryl chloride                      | $\text{Cl}_2\text{O}_2\text{S}$                | 134.970 | -51                  | 69.4                 | 1.680                   |                     | 9.1        | 1.81           | 0.993                              | 18.7            |                         |           |                      |         |
| $\alpha$ -Terpinene                    | $\text{C}_{10}\text{H}_{16}$                   | 136.234 |                      | 174                  | 0.8375 <sup>19</sup>    |                     | 2.4526     |                |                                    |                 |                         |           |                      |         |
| 1,1,2,2-Tetrabromoethane               | $\text{C}_2\text{H}_2\text{Br}_4$              | 345.653 | 0                    | 243.5                | 2.9655 <sup>20</sup>    |                     | 6.72       | 1.38           | 0.479                              | 0.003           |                         |           | 335                  | 1       |
| Tetrabromosilane                       | $\text{Br}_4\text{Si}$                         | 347.702 | 5.39                 | 154                  | 2.8                     |                     |            | 0              |                                    |                 |                         |           |                      |         |
| 1,1,2,2-Tetrachloro-1,2-difluoroethane | $\text{C}_2\text{Cl}_4\text{F}_2$              | 203.830 | 24.8                 | 92.8                 | 1.5951 <sup>50</sup>    |                     | 2.52       |                | 0.852                              | 7.51            |                         |           |                      | 500     |
| 1,1,1,2-Tetrachloroethane              | $\text{C}_2\text{H}_2\text{Cl}_4$              | 167.849 | -70.2                | 130.2                | 1.5406 <sup>20</sup>    | 1.437               |            |                | 0.92                               | 1.6             | 47                      | 5-12%     |                      |         |
| 1,1,2,2-Tetrachloroethane              | $\text{C}_2\text{H}_2\text{Cl}_4$              | 167.849 | -42.4                | 145.2                | 1.5953 <sup>20</sup>    |                     | 8.50       | 1.32           | 0.967                              | 0.622           | 62                      | 20-54%    |                      | 1       |
| Tetrachloroethene                      | $\text{C}_2\text{Cl}_4$                        | 165.833 | -22.3                | 121.3                | 1.6230 <sup>20</sup>    | 0.844               | 2.268      | 0              | 0.865                              | 2.42            | 45                      |           |                      | 25      |
| Tetrachloromethane                     | $\text{CCl}_4$                                 | 153.823 | -22.62               | 76.8                 | 1.5940 <sup>20</sup>    | 0.908               | 2.2379     | 0              | 0.850                              | 15.2            |                         |           |                      | 5       |
| Tetrachlorosilane                      | $\text{Cl}_4\text{Si}$                         | 169.897 | -68.74               | 57.65                | 1.5                     | 99.4                |            | 0              | 0.855                              | 31.3            |                         |           |                      |         |
| Tetradecane                            | $\text{C}_{14}\text{H}_{30}$                   | 198.388 | 5.82                 | 253.58               | 0.7596 <sup>20</sup>    | 2.13                | 2.0343     | $\approx 0$    |                                    | 0.002           | 112                     | >0.5%     | 200                  |         |
| Tetraethylene glycol                   | $\text{C}_8\text{H}_{18}\text{O}_5$            | 194.226 | -6.2                 | 328                  | 1.1285 <sup>15</sup>    |                     | 20.44      |                | 2.208                              | 0.000001        | 182                     |           |                      |         |
| Tetrafluoroboric acid                  | $\text{BF}_3\text{H}$                          | 87.813  |                      | 130 dec              | $\sim 1.8$              |                     |            |                |                                    |                 |                         |           |                      |         |
| Tetrahydrofuran                        | $\text{C}_4\text{H}_8\text{O}$                 | 72.106  | -108.44              | 65                   | 0.8833 <sup>25</sup>    | 0.456               | 7.52       | 1.75           | 1.720                              | 21.6            | -14                     | 2-12%     | 321                  | 200     |
| Tetrahydrofurfuryl alcohol             | $\text{C}_5\text{H}_{10}\text{O}_2$            | 102.132 | <-80                 | 178                  | 1.0524 <sup>20</sup>    |                     | 13.48      | 2.1            | 1.774                              | 0.100           | 75                      | 1.5-9.7%  | 282                  |         |
| 1,2,3,4-Tetrahydronaphthalene          | $\text{C}_{10}\text{H}_{12}$                   | 132.202 | -35.7                | 207.6                | 0.9645 <sup>25</sup>    | 2.14                | 2.771      | $\approx 0$    | 1.645                              | 0.05            | 71                      | 1-5%      | 385                  |         |
| Tetrahydropyran                        | $\text{C}_6\text{H}_{10}\text{O}$              | 86.132  | -49.1                | 88                   | 0.8814 <sup>20</sup>    |                     | 5.66       | 1.74           | 1.82                               | 9.54            | -20                     |           |                      |         |
| Tetrahydrothiophene                    | $\text{C}_4\text{H}_6\text{S}$                 | 88.172  | -96.2                | 121.1                | 0.9987 <sup>20</sup>    | 0.973               |            | 1.90           |                                    | 2.45            |                         |           |                      |         |
| Tetramethylsilane                      | $\text{C}_4\text{H}_{12}\text{Si}$             | 88.224  | -99.06               | 26.6                 | 0.648 <sup>19</sup>     |                     | 1.921      | 0              | 2.313                              | 94.2            |                         |           |                      |         |
| Tetramethylurea                        | $\text{C}_4\text{H}_{12}\text{N}_2\text{O}$    | 116.161 | -0.6                 | 176.5                | 0.9687 <sup>20</sup>    |                     | 23.10      | 3.5            |                                    | 0.138           | 77                      |           |                      |         |
| Tetranitromethane                      | $\text{CN}_4\text{O}_8$                        | 196.033 | 13.8                 | 126.1                | 1.6380 <sup>20</sup>    |                     | 2.317      | 0              |                                    | 1.13            |                         |           |                      | 0.005   |
| Thionyl bromide                        | $\text{Br}_2\text{OS}$                         | 207.873 | -50                  | 140                  |                         |                     | 9.06       |                |                                    | 0.84            |                         |           |                      |         |
| Thionyl chloride                       | $\text{Cl}_2\text{OS}$                         | 118.970 | -101                 | 75.6                 | 1.631                   |                     | 8.675      | 1.45           | 1.017                              | 16.0            |                         |           |                      | 1       |
| Thiophene                              | $\text{C}_4\text{H}_4\text{S}$                 | 84.140  | -38.21               | 84.0                 | 1.0649 <sup>20</sup>    |                     | 2.739      | 0.55           | 1.471                              | 10.6            | -1                      |           |                      |         |
| Tin(IV) chloride                       | $\text{Cl}_4\text{Sn}$                         | 260.521 | -34.07               | 114.15               | 2.234                   |                     |            | 0              | 0.634                              |                 |                         |           |                      |         |
| Titanium(IV) chloride                  | $\text{Cl}_4\text{Ti}$                         | 189.678 | -24.12               | 136.45               | 1.73                    |                     |            |                | 0.766                              |                 |                         |           |                      |         |
| Toluene                                | $\text{C}_7\text{H}_8$                         | 92.139  | -94.95               | 110.63               | 0.8668 <sup>20</sup>    | 0.560               | 2.379      | 0.37           | 1.707                              | 3.79            | 4                       | 1-7%      | 480                  | 50      |
| Toluene-2,4-diisocyanate               | $\text{C}_9\text{H}_8\text{N}_2\text{O}_2$     | 174.156 | 20.5                 | 251                  | 1.2244 <sup>20</sup>    |                     | 8.433      |                | 1.653                              | 0.003           | 127                     | 0.9-9.5%  |                      | 0.005   |
| Tribromomethane                        | $\text{CHBr}_3$                                | 252.731 | 8.69                 | 149.1                | 2.8788 <sup>25</sup>    | 1.857               | 4.404      | 0.99           | 0.517                              | 0.726           | 83                      |           |                      | 0.5     |
| Tributylamine                          | $\text{C}_{12}\text{H}_{27}\text{N}$           | 185.349 | -70                  | 216.5                | 0.7770 <sup>20</sup>    |                     | 2.340      | 0.8            |                                    | 0.01            | 63                      | 1-5%      |                      |         |
| Tributyl borate                        | $\text{C}_{12}\text{H}_{27}\text{BO}_3$        | 230.151 | <-70                 | 234                  | 0.8567 <sup>20</sup>    |                     | 2.23       | 0.77           |                                    |                 | 93                      |           |                      |         |
| Tributyrin                             | $\text{C}_{15}\text{H}_{26}\text{O}_6$         | 302.363 | -75                  | 307.5                | 1.0350 <sup>20</sup>    |                     | 5.72       |                | 1.837                              |                 | 180                     | >0.5%     | 407                  |         |
| Trichloroacetaldehyde                  | $\text{C}_2\text{HCl}_3\text{O}$               | 147.387 | -57.5                | 97.8                 | 1.512 <sup>20</sup>     |                     | 6.8        |                | 1.025                              | 6.66            |                         |           |                      |         |
| 1,2,4-Trichlorobenzene                 | $\text{C}_6\text{H}_3\text{Cl}_3$              | 181.447 | 16.92                | 213.5                | 1.459 <sup>25</sup>     |                     |            |                |                                    | 0.057           | 105                     | 2.5-6.6%  | 571                  | 5       |
| 1,1,1-Trichloroethane                  | $\text{C}_2\text{H}_2\text{Cl}_3$              | 133.404 | -30.01               | 74.09                | 1.3390 <sup>20</sup>    | 0.793               | 7.243      | 1.76           | 1.082                              | 16.5            | -1                      | 8-13%     | 500                  | 350     |
| 1,1,2-Trichloroethane                  | $\text{C}_2\text{H}_3\text{Cl}_3$              | 133.404 | -36.3                | 113.8                | 1.4397 <sup>20</sup>    |                     | 7.1937     | 1.4            | 1.131                              | 3.1             | 32                      | 6-28%     | 460                  | 10      |
| Trichloroethene                        | $\text{C}_2\text{HCl}_2$                       | 131.388 | -84.7                | 87.21                | 1.4642 <sup>20</sup>    | 0.545               | 3.390      | 0.8            | 0.947                              | 9.91            | 32                      | 8-11%     | 420                  | 50      |
| Trichloroethylsilane                   | $\text{C}_2\text{H}_3\text{Cl}_3\text{Si}$     | 163.506 | -105.6               | 100.5                | 1.2373 <sup>20</sup>    |                     |            | 2.04           |                                    | 6.29            | 22                      |           |                      |         |
| Trichlorofluoromethane                 | $\text{CCl}_3\text{F}$                         | 137.368 | -110.44              | 23.7                 | 1.4879 <sup>20</sup>    | 0.421               | 3.00       | 0.46           | 0.885                              | 106             |                         |           |                      | 1000    |
| Trichloromethane                       | $\text{CHCl}_3$                                | 119.378 | -63.41               | 61.17                | 1.4788 <sup>25</sup>    | 0.537               | 4.8069     | 1.04           | 0.957                              | 26.2            |                         |           |                      | 10      |
| (Trichloromethyl)benzene               | $\text{C}_7\text{H}_5\text{Cl}_3$              | 195.474 | -4.42                | 221                  | 1.3723 <sup>20</sup>    |                     | 6.9        | 2.03           |                                    | 0.35            | 127                     |           |                      | 0.1     |
| Trichloromethylsilane                  | $\text{CH}_3\text{Cl}_3\text{Si}$              | 149.480 | -90                  | 65.6                 | 1.273 <sup>20</sup>     |                     |            | 1.91           | 1.091                              | 22.5            | -9                      | 7.6->20%  | >404                 |         |
| Trichloronitromethane                  | $\text{CCl}_3\text{NO}_2$                      | 164.376 | -64                  | 112                  | 1.6558 <sup>20</sup>    |                     | 7.319      |                |                                    | 3.18            |                         |           |                      | 0.1     |
| 1,2,3-Trichloropropane                 | $\text{C}_3\text{H}_3\text{Cl}_3$              | 147.431 | -14.7                | 157                  | 1.3889 <sup>20</sup>    |                     | 7.5        |                | 1.245                              | 0.492           | 71                      | 3.2-12.6% |                      | 10      |
| Trichlorosilane                        | $\text{Cl}_3\text{HSi}$                        | 135.452 | -128.2               | 33                   | 1.331                   | 0.326               |            | 0.86           |                                    |                 | -50                     |           | 104                  |         |
| 1,1,2-Trichloro-1,2,2-trifluoroethane  | $\text{C}_2\text{Cl}_3\text{F}_3$              | 187.375 | -36.22               | 47.7                 | 1.5635 <sup>25</sup>    | 0.656               | 2.41       |                | 0.908                              | 44.8            |                         |           |                      | 1000    |
| Tri- <i>o</i> -cresyl phosphate        | $\text{C}_{21}\text{H}_{21}\text{O}_4\text{P}$ | 368.363 | 11                   | 410                  | 1.1955 <sup>20</sup>    |                     | 6.7        | 2.87           | 1.57                               | 0.0000002       | 225                     |           | 385                  | 0.01    |
| Tridecane                              | $\text{C}_{13}\text{H}_{28}$                   | 184.361 | -5.4                 | 235.47               | 0.7564 <sup>20</sup>    | 1.724               | 2.0213     | $\approx 0$    | 2.206                              | 0.005           | 79                      |           |                      |         |
| 1-Tridecene                            | $\text{C}_{13}\text{H}_{26}$                   | 182.345 | -13                  | 232.8                | 0.7658 <sup>20</sup>    | 1.50                | 2.139      | $\approx 0$    | 2.149                              | 0.0047          | 79                      |           |                      |         |
| Triethanolamine                        | $\text{C}_6\text{H}_{15}\text{NO}_3$           | 149.188 | 20.5                 | 335.4                | 1.1242 <sup>20</sup>    | 609                 | 29.36      | 3.6            | 2.61                               | <0.01           | 179                     | 1-10%     |                      | 0.8     |
| Triethylamine                          | $\text{C}_6\text{H}_{15}\text{N}$              | 101.190 | -114.7               | 89                   | 0.7275 <sup>20</sup>    | 0.347               | 2.418      | 0.66           | 2.173                              | 7.70            | -7                      | 1-8%      | 249                  | 1       |
| Triethylene glycol                     | $\text{C}_6\text{H}_{14}\text{O}_4$            | 150.173 | -7                   | 285                  | 1.1274 <sup>15</sup>    |                     | 23.69      |                | 2.18                               | 0.0002          | 177                     | 1-9%      | 371                  |         |
| Triethylene glycol dimethyl ether      | $\text{C}_8\text{H}_{18}\text{O}_4$            | 178.227 | -45                  | 216                  | 0.986 <sup>20</sup>     |                     | 7.62       |                |                                    |                 | 111                     |           |                      |         |
| Triethyl phosphate                     | $\text{C}_6\text{H}_{15}\text{O}_4\text{P}$    | 182.154 | -56.4                | 215.5                | 1.0695 <sup>20</sup>    |                     | 13.20      | 3.1            |                                    |                 | 115                     |           | 454                  |         |
| Trifluoroacetic acid                   | $\text{C}_2\text{HF}_3\text{O}_2$              | 114.023 | -15.2                | 73                   | 1.5351 <sup>25</sup>    | 0.808               | 8.42       | 2.28           |                                    | 15.1            |                         |           |                      |         |
| (Trifluoromethyl)benzene               | $\text{C}_7\text{H}_5\text{F}_3$               | 146.110 | -28.95               | 102.1                | 1.1884 <sup>20</sup>    |                     | 9.22       | 2.86           | 1.289                              | 5.14            | 12                      |           |                      |         |

| Name                    | Mol.<br>form.                              | $M_r$   | $t_m/^\circ\text{C}$ | $t_b/^\circ\text{C}$ | $\rho/\text{g mL}^{-1}$ | $\eta/\text{mPa s}$ | $\epsilon$ | $\mu/\text{D}$ | $c_p/\text{J g}^{-1}\text{K}^{-1}$ | $\text{vp}/\text{kPa}$ | FP/<br>$^\circ\text{C}$ | Fl. lim.  | IT/ $^\circ\text{C}$ | TLV/ppm |
|-------------------------|--------------------------------------------|---------|----------------------|----------------------|-------------------------|---------------------|------------|----------------|------------------------------------|------------------------|-------------------------|-----------|----------------------|---------|
| 1,2,3-Trimethylbenzene  | $\text{C}_9\text{H}_{12}$                  | 120.191 | -25.4                | 176.12               | 0.8944 <sup>20</sup>    |                     | 2.656      | $\approx 0$    | 1.800                              | 0.20                   | 44                      | 0.8-6.6%  | 470                  | 25      |
| 1,2,4-Trimethylbenzene  | $\text{C}_9\text{H}_{12}$                  | 120.191 | -43.77               | 169.38               | 0.8758 <sup>20</sup>    |                     | 2.377      | $\approx 0$    | 1.789                              | 0.30                   | 44                      | 1-6%      | 500                  | 25      |
| 1,3,5-Trimethylbenzene  | $\text{C}_9\text{H}_{12}$                  | 120.191 | -44.72               | 164.74               | 0.8615 <sup>25</sup>    |                     | 2.279      | 0              | 1.741                              | 0.33                   | 50                      | 1-5%      | 559                  | 25      |
| Trimethyl borate        | $\text{C}_3\text{H}_9\text{BO}_3$          | 103.912 | -29.3                | 67.5                 | 0.915 <sup>25</sup>     |                     | 2.2762     |                | 1.828                              | 17.2                   | -8                      |           |                      |         |
| Trimethylchlorosilane   | $\text{C}_3\text{H}_9\text{ClSi}$          | 108.642 | -40                  | 60                   | 0.856 <sup>25</sup>     |                     |            |                |                                    | 30.7                   | -28                     |           | 395                  |         |
| 2,2,4-Trimethylpentane  | $\text{C}_8\text{H}_{18}$                  | 114.229 | -107.3               | 99.22                | 0.6878 <sup>25</sup>    |                     | 1.943      | $\approx 0$    | 2.093                              | 6.50                   | -12                     |           | 418                  | 300     |
| 2,3,3-Trimethylpentane  | $\text{C}_8\text{H}_{18}$                  | 114.229 | -100.9               | 114.8                | 0.7262 <sup>20</sup>    |                     | 1.9780     | $\approx 0$    | 2.150                              | 3.60                   | <21                     |           | 425                  | 300     |
| Trimethyl phosphate     | $\text{C}_3\text{H}_9\text{O}_4\text{P}$   | 140.074 | -46                  | 197.2                | 1.2144 <sup>20</sup>    |                     | 20.6       | 3.2            |                                    | 0.11                   | 107                     |           |                      |         |
| 2,4,6-Trimethylpyridine | $\text{C}_8\text{H}_{11}\text{N}$          | 121.180 | -46                  | 170.6                | 0.9166 <sup>22</sup>    |                     | 7.807      | 2.05           |                                    | 4.1                    |                         |           |                      |         |
| Trinitroglycerol        | $\text{C}_3\text{H}_5\text{N}_3\text{O}_9$ | 227.087 | 13.5                 | exp 218              | 1.5931 <sup>20</sup>    |                     | 19.25      |                |                                    | 0.00005                |                         |           | 270                  | 0.05    |
| Undecane                | $\text{C}_{11}\text{H}_{24}$               | 156.309 | -25.5                | 195.9                | 0.7402 <sup>20</sup>    | 1.098               | 1.9972     | $\approx 0$    | 2.207                              | 0.05                   | 69                      |           |                      |         |
| Vanadium(IV) chloride   | $\text{Cl}_4\text{V}$                      | 192.753 | -25.7                | 148                  | 1.816                   |                     | 3.05       |                |                                    |                        |                         |           |                      |         |
| Vanadyl trichloride     | $\text{Cl}_3\text{OV}$                     | 173.299 | -79                  | 127                  | 1.829                   |                     | 3.4        |                |                                    |                        |                         |           |                      |         |
| Vinyl acetate           | $\text{C}_4\text{H}_6\text{O}_2$           | 86.090  | -93.2                | 72.8                 | 0.9256 <sup>25</sup>    |                     |            | 1.79           | 1.969                              | 15.4                   | -8                      | 2.6-13.4% | 402                  | 10      |
| 4-Vinylcyclohexene      | $\text{C}_8\text{H}_{12}$                  | 108.181 | -108.9               | 128                  | 0.8299 <sup>20</sup>    |                     |            |                |                                    | 1.87                   | 16                      |           | 269                  | 0.1     |
| Water                   | $\text{H}_2\text{O}$                       | 18.015  | 0.00                 | 100.0                | 0.9970                  | 0.890               | 80.100     | 1.8546         | 4.180                              | 3.17                   |                         |           |                      |         |
| <i>o</i> -Xylene        | $\text{C}_8\text{H}_{10}$                  | 106.165 | -25.2                | 144.5                | 0.8802 <sup>10</sup>    | 0.760               | 2.562      | 0.64           | 1.753                              | 0.88                   | 32                      | 1-7%      | 463                  | 100     |
| <i>m</i> -Xylene        | $\text{C}_8\text{H}_{10}$                  | 106.165 | -47.8                | 139.12               | 0.8596 <sup>25</sup>    | 0.581               | 2.359      | $\approx 0$    | 1.724                              | 1.13                   | 27                      | 1-7%      | 527                  | 100     |
| <i>p</i> -Xylene        | $\text{C}_8\text{H}_{10}$                  | 106.165 | 13.25                | 138.37               | 0.8566 <sup>25</sup>    | 0.603               | 2.2735     | 0              | 1.710                              | 1.19                   | 27                      | 1-7%      | 528                  | 100     |
| 2,4-Xylenol             | $\text{C}_8\text{H}_{10}\text{O}$          | 122.164 | 24.5                 | 210.98               | 0.9650 <sup>20</sup>    |                     | 5.060      | 1.4            |                                    | 0.022                  |                         |           |                      |         |

## DEPENDENCE OF BOILING POINT ON PRESSURE

The normal boiling point of a liquid is defined as the temperature at which the vapor pressure reaches standard atmospheric pressure, 101.325 kPa. The change in boiling point with pressure may be calculated from the representation of the vapor pressure by the Antoine Equation,

$$\ln p = A_1 - A_2/(T + A_3)$$

where  $p$  is the vapor pressure,  $T$  the absolute temperature, and  $A_1$ ,  $A_2$ , and  $A_3$  are constants. This table, which has been calculated using the Antoine constants in Reference 1, gives values of  $\Delta t/\Delta p$  for a number of liquids, in units of both °C/kPa and °C/mmHg. The correction to the boiling point is generally accurate to 0.1 to 0.2 °C as long as the pressure is within 10% of standard atmospheric pressure.

A slightly less accurate estimate of  $\Delta t/\Delta p$  may be obtained from the Clausius-Clapeyron equation, with the assumption that the

change in volume upon vaporization equals the ideal-gas volume of the vapor. This leads to the equation

$$\Delta t/\Delta p = RT_b^2/p_0 \Delta_{\text{vap}} H(T_b)$$

where  $R$  is the molar gas constant,  $p_0$  is 101.325 kPa,  $T_b$  is the normal boiling point temperature (absolute), and  $\Delta_{\text{vap}} H(T_b)$  is the molar enthalpy of vaporization at the normal boiling point. Values of the last quantity may be obtained from the table "Enthalpy of Vaporization" in Section 6.

## Reference

1. Lide, D. R., and Kehiaian, H. V., *CRC Handbook of Thermophysical and Thermochemical Data*, CRC Press, Boca Raton, FL, 1994, pp. 49-59.

| Compound           | $t_b$<br>°C | $\Delta t/\Delta p$ |         |
|--------------------|-------------|---------------------|---------|
|                    |             | °C/kPa              | °C/mmHg |
| Acetaldehyde       | 20.1        | 0.261               | 0.0348  |
| Acetic acid        | 117.9       | 0.324               | 0.0432  |
| Acetone            | 56.0        | 0.289               | 0.0385  |
| Acetonitrile       | 81.6        | 0.316               | 0.0421  |
| Ammonia            | -33.33      | 0.198               | 0.0264  |
| Aniline            | 184.1       | 0.378               | 0.0504  |
| Anisole            | 153.7       | 0.367               | 0.0489  |
| Benzaldehyde       | 179.0       | 0.392               | 0.0523  |
| Benzene            | 80.0        | 0.321               | 0.0428  |
| Bromine            | 58.8        | 0.300               | 0.0400  |
| Butane             | -0.5        | 0.267               | 0.0356  |
| 1-Butanol          | 117.7       | 0.278               | 0.0371  |
| Carbon disulfide   | 46.2        | 0.304               | 0.0405  |
| Chlorine           | -34.04      | 0.224               | 0.0299  |
| Chlorobenzene      | 131.7       | 0.365               | 0.0487  |
| 1-Chlorobutane     | 78.6        | 0.321               | 0.0428  |
| Chloroethane       | 12.3        | 0.262               | 0.0349  |
| Chloroethylene     | -13.3       | 0.241               | 0.0321  |
| Cyclohexane        | 80.7        | 0.328               | 0.0437  |
| Cyclohexanol       | 160.8       | 0.344               | 0.0459  |
| Cyclohexanone      | 155.4       | 0.382               | 0.0509  |
| Decane             | 174.1       | 0.388               | 0.0517  |
| Dibutyl ether      | 140.2       | 0.363               | 0.0484  |
| Dichloromethane    | 39.6        | 0.276               | 0.0368  |
| Diethyl ether      | 34.5        | 0.278               | 0.0371  |
| Dimethyl sulfoxide | 189.0       | 0.379               | 0.0505  |
| 1,4-Dioxane        | 101.5       | 0.321               | 0.0428  |
| Dipropyl ether     | 90.0        | 0.326               | 0.0435  |
| Ethanol            | 78.2        | 0.249               | 0.0332  |
| Ethyl acetate      | 77.1        | 0.300               | 0.0400  |
| Ethylene glycol    | 197.3       | 0.331               | 0.0441  |
| Heptane            | 98.5        | 0.336               | 0.0448  |
| Hexafluorobenzene  | 80.2        | 0.305               | 0.0407  |
| Hexane             | 68.7        | 0.314               | 0.0419  |

| Compound            | $t_b$<br>°C | $\Delta t/\Delta p$ |         |
|---------------------|-------------|---------------------|---------|
|                     |             | °C/kPa              | °C/mmHg |
| 1-Hexanol           | 157.6       | 0.318               | 0.0424  |
| Hydrogen fluoride   | 20.1        | 0.276               | 0.0368  |
| Iodomethane         | 42.5        | 0.291               | 0.0388  |
| Isobutane           | -11.7       | 0.254               | 0.0339  |
| Methanol            | 64.6        | 0.251               | 0.0335  |
| Methyl acetate      | 56.8        | 0.282               | 0.0376  |
| Methyl formate      | 31.7        | 0.582               | 0.0776  |
| N-Methylaniline     | 196.2       | 0.396               | 0.0528  |
| N-Methylformamide   | 199.5       | 0.371               | 0.0495  |
| Nitrobenzene        | 210.8       | 0.418               | 0.0557  |
| Nitromethane        | 101.1       | 0.320               | 0.0427  |
| 1-Octanol           | 195.1       | 0.360               | 0.0480  |
| Pentane             | 36.0        | 0.289               | 0.0385  |
| 1-Pentanol          | 137.9       | 0.296               | 0.0395  |
| Phenol              | 181.8       | 0.349               | 0.0465  |
| Propane             | -42.1       | 0.224               | 0.0299  |
| 1-Propanol          | 97.2        | 0.261               | 0.0348  |
| 2-Propanol          | 82.3        | 0.247               | 0.0329  |
| Pyridine            | 115.2       | 0.340               | 0.0453  |
| Pyrrole             | 129.7       | 0.330               | 0.0440  |
| Pyrrolidine         | 86.5        | 0.309               | 0.0412  |
| Styrene             | 145.1       | 0.369               | 0.0492  |
| Sulfur dioxide      | -10.05      | 0.221               | 0.0295  |
| Tetrachloroethylene | 121.3       | 0.354               | 0.0472  |
| Tetrachloromethane  | 76.8        | 0.325               | 0.0433  |
| Toluene             | 110.6       | 0.353               | 0.0471  |
| Trichloroethylene   | 87.2        | 0.330               | 0.0440  |
| Trichloromethane    | 61.1        | 0.302               | 0.0403  |
| Trimethylamine      | 2.8         | 0.248               | 0.0331  |
| Water               | 100.0       | 0.276               | 0.0368  |
| <i>o</i> -Xylene    | 144.5       | 0.373               | 0.0497  |
| <i>m</i> -Xylene    | 139.1       | 0.368               | 0.0491  |
| <i>p</i> -Xylene    | 138.3       | 0.369               | 0.0492  |

## EBULLIOSCOPIC CONSTANTS FOR CALCULATION OF BOILING POINT ELEVATION

The boiling point  $T_b$  of a dilute solution of a non-volatile, non-dissociating solute is elevated relative to that of the pure solvent. If the solution is ideal (i.e., follows Raoult's Law), the amount of elevation depends only on the number of particles of solute present. Hence the change in boiling point  $\Delta T_b$  can be expressed as

$$\Delta T_b = E_b m_2$$

where  $m_2$  is the molality (moles of solute per kilogram of solvent) and  $E_b$  is the Ebullioscopic Constant, a characteristic property of

the solvent. The Ebullioscopic Constant may be calculated from the relation

$$E_b = R T_b^2 M / \Delta_{\text{vap}} H$$

where  $R$  is the molar gas constant,  $T_b$  is the normal boiling point temperature (absolute) of the solvent,  $M$  the molar mass of the solvent, and  $\Delta_{\text{vap}} H$  the molar enthalpy (heat) of vaporization of the solvent at its normal boiling point.

This table lists  $E_b$  values for some common solvents, as calculated from data in the table "Enthalpy of Vaporization" in Section 6.

| Compound           | $E_b/\text{K kg mol}^{-1}$ |
|--------------------|----------------------------|
| Acetic acid        | 3.22                       |
| Acetone            | 1.80                       |
| Acetonitrile       | 1.44                       |
| Aniline            | 3.82                       |
| Anisole            | 4.20                       |
| Benzaldehyde       | 4.24                       |
| Benzene            | 2.64                       |
| 1-Butanol          | 2.17                       |
| Carbon disulfide   | 2.42                       |
| Chlorobenzene      | 4.36                       |
| 1-Chlorobutane     | 3.13                       |
| Cyclohexane        | 2.92                       |
| Cyclohexanol       | 3.5                        |
| Decane             | 6.10                       |
| Dichloromethane    | 2.42                       |
| Diethyl ether      | 2.20                       |
| Dimethyl sulfoxide | 3.22                       |
| 1,4-Dioxane        | 3.01                       |
| Ethanol            | 1.23                       |
| Ethyl acetate      | 2.82                       |
| Ethylene glycol    | 2.26                       |
| Heptane            | 3.62                       |

| Compound                  | $E_b/\text{K kg mol}^{-1}$ |
|---------------------------|----------------------------|
| Hexane                    | 2.90                       |
| Iodomethane               | 4.31                       |
| Methanol                  | 0.86                       |
| Methyl acetate            | 2.21                       |
| <i>N</i> -Methylaniline   | 4.3                        |
| <i>N</i> -Methylformamide | 2.2                        |
| Nitrobenzene              | 5.2                        |
| Nitromethane              | 2.09                       |
| 1-Octanol                 | 5.06                       |
| Phenol                    | 3.54                       |
| 1-Propanol                | 1.66                       |
| 2-Propanol                | 1.58                       |
| Pyridine                  | 2.83                       |
| Pyrrole                   | 2.33                       |
| Pyrrolidine               | 2.32                       |
| Tetrachloroethylene       | 6.18                       |
| Tetrachloromethane        | 5.26                       |
| Toluene                   | 3.40                       |
| Trichloroethylene         | 4.52                       |
| Trichloromethane          | 3.80                       |
| Water                     | 0.513                      |
| <i>o</i> -Xylene          | 4.25                       |



## CRYOSCOPIC CONSTANTS FOR CALCULATION OF FREEZING POINT DEPRESSION

The freezing point  $T_f$  of a dilute solution of a non-volatile, non-dissociating solute is depressed relative to that of the pure solvent. If the solution is ideal (i.e., follows Raoult's Law), this lowering is a function only of the number of particles of solute present. Thus the absolute value of the lowering of freezing point  $\Delta T_f$  can be expressed as

$$\Delta T_f = E_f m_2$$

where  $m_2$  is the molality (moles of solute per kilogram of solvent) and  $E_f$  is the Cryoscopic Constant, a characteristic property of the

solvent. The Cryoscopic Constant may be calculated from the relation

$$E_f = R T_f^2 M / \Delta_{\text{fus}} H$$

where  $R$  is the molar gas constant,  $T_b$  is the freezing point temperature (absolute) of the solvent,  $M$  the molar mass of the solvent, and  $\Delta_{\text{fus}} H$  the molar enthalpy (heat) of fusion of the solvent.

This table lists cryoscopic constants for selected substances, as calculated from data in the table "Enthalpy of Fusion" in Section 6.

| Compound                           | $E_f/\text{K kg mol}^{-1}$ | Compound                               | $E_f/\text{K kg mol}^{-1}$ |
|------------------------------------|----------------------------|----------------------------------------|----------------------------|
| Acetamide                          | 3.92                       | 1,4-Dioxane                            | 4.63                       |
| Acetic acid                        | 3.63                       | Diphenylamine                          | 8.38                       |
| Acetophenone                       | 5.16                       | Ethylene glycol                        | 3.11                       |
| Aniline                            | 5.23                       | Formamide                              | 4.25                       |
| Benzene                            | 5.07                       | Formic acid                            | 2.38                       |
| Benzonitrile                       | 5.35                       | Glycerol                               | 3.56                       |
| Benzophenone                       | 8.58                       | Methylcyclohexane                      | 2.60                       |
| (+)-Camphor                        | 37.8                       | Naphthalene                            | 7.45                       |
| 1-Chloronaphthalene                | 7.68                       | Nitrobenzene                           | 6.87                       |
| <i>o</i> -Cresol                   | 5.92                       | Phenol                                 | 6.84                       |
| <i>m</i> -Cresol                   | 7.76                       | Pyridine                               | 4.26                       |
| <i>p</i> -Cresol                   | 7.20                       | Quinoline                              | 6.73                       |
| Cyclohexane                        | 20.8                       | Succinonitrile                         | 19.3                       |
| Cyclohexanol                       | 42.2                       | 1,1,2,2-Tetrabromoethane               | 21.4                       |
| <i>cis</i> -Decahydronaphthalene   | 6.42                       | 1,1,2,2-Tetrachloro-1,2-difluoroethane | 41.0                       |
| <i>trans</i> -Decahydronaphthalene | 4.70                       | Toluene                                | 3.55                       |
| Dibenzyl ether                     | 6.17                       | <i>p</i> -Toluidine                    | 4.91                       |
| <i>p</i> -Dichlorobenzene          | 7.57                       | Tribromomethane                        | 15.0                       |
| Diethanolamine                     | 3.16                       | Water                                  | 1.86                       |
| Dimethyl sulfoxide                 | 3.85                       | <i>p</i> -Xylene                       | 4.31                       |

# FREEZING POINT LOWERING BY ELECTROLYTES IN AQUEOUS SOLUTION

## Reference

Forsythe, W. E., *Smithsonian Physical Tables, Ninth Edition*, Smithsonian Institution, Washington, 1956.

| Compound                       | Lowering of freezing point of water (in °C) as function of molality (mol/kg) |      |      |      |      |      |       |       |       |       |
|--------------------------------|------------------------------------------------------------------------------|------|------|------|------|------|-------|-------|-------|-------|
|                                | 0.05                                                                         | 0.10 | 0.25 | 0.50 | 0.75 | 1.00 | 1.50  | 2.00  | 2.50  | 3.00  |
| CaCl <sub>2</sub>              | 0.25                                                                         | 0.49 | 1.27 | 2.66 | 4.28 | 6.35 | 10.78 | 15.27 | 20.42 | 28.08 |
| CuSO <sub>4</sub>              | 0.13                                                                         | 0.23 | 0.47 | 0.96 |      |      |       |       |       |       |
| HCl                            | 0.18                                                                         | 0.36 | 0.90 | 1.86 | 2.90 | 4.02 | 6.63  | 9.94  |       |       |
| HNO <sub>3</sub>               | 0.18                                                                         | 0.35 | 0.88 | 1.80 | 2.78 | 3.80 | 5.98  | 8.34  | 10.95 | 13.92 |
| H <sub>2</sub> SO <sub>4</sub> | 0.20                                                                         | 0.39 | 0.96 | 1.95 | 3.04 | 4.28 | 7.35  | 11.35 | 16.32 |       |
| KBr                            | 0.18                                                                         | 0.36 | 0.92 | 1.78 |      |      |       |       |       |       |
| KCl                            | 0.17                                                                         | 0.35 | 0.86 | 1.68 | 2.49 | 3.29 | 4.88  | 6.50  | 8.14  | 9.77  |
| KNO <sub>3</sub>               | 0.17                                                                         | 0.33 | 0.78 | 1.47 | 2.11 | 2.66 |       |       |       |       |
| K <sub>2</sub> SO <sub>4</sub> | 0.23                                                                         | 0.43 | 1.01 | 1.87 |      |      |       |       |       |       |
| LiCl                           | 0.18                                                                         | 0.35 | 0.88 | 1.80 | 2.78 |      |       |       |       |       |
| MgSO <sub>4</sub>              | 0.13                                                                         | 0.24 | 0.55 | 1.01 | 1.50 | 2.08 | 3.41  |       |       |       |
| NH <sub>4</sub> Cl             | 0.17                                                                         | 0.34 | 0.85 | 1.70 | 2.55 |      |       |       |       |       |
| NaCl                           | 0.18                                                                         | 0.35 | 0.85 | 1.68 | 2.60 |      |       |       |       |       |
| NaNO <sub>3</sub>              | 0.18                                                                         | 0.36 | 0.80 | 1.62 | 2.63 | 3.10 |       |       |       |       |

## DETERMINATION OF RELATIVE HUMIDITY FROM DEW POINT

The relative humidity of a water vapor-air mixture is defined as 100 times the partial pressure of water divided by the saturation vapor pressure of water at the same temperature. The relative humidity may be determined from the dew point  $t_{\text{dew}}$ , which is the temperature at which liquid water first condenses when the

mixture is cooled from an initial temperature  $t$ . This table gives relative humidity as a function of the dew point depression  $t - t_{\text{dew}}$  for several values of the dew point. Values are calculated from the vapor pressure table in Section 6.

| $t - t_{\text{dew}}$ | $t_{\text{dew}}/^{\circ}\text{C}$ |     |     |     |     | $t - t_{\text{dew}}$ | $t_{\text{dew}}/^{\circ}\text{C}$ |    |    |    |    |
|----------------------|-----------------------------------|-----|-----|-----|-----|----------------------|-----------------------------------|----|----|----|----|
|                      | -10                               | 0   | 10  | 20  | 30  |                      | -10                               | 0  | 10 | 20 | 30 |
| 0.0                  | 100                               | 100 | 100 | 100 | 100 | 8.2                  | 54                                | 56 | 59 | 61 | 63 |
| 0.2                  | 99                                | 99  | 99  | 99  | 99  | 8.4                  | 53                                | 56 | 58 | 60 | 63 |
| 0.4                  | 97                                | 97  | 97  | 98  | 98  | 8.6                  | 52                                | 55 | 57 | 60 | 62 |
| 0.6                  | 95                                | 96  | 96  | 96  | 97  | 8.8                  | 51                                | 54 | 57 | 59 | 61 |
| 0.9                  | 94                                | 94  | 95  | 95  | 96  | 9.0                  | 51                                | 53 | 56 | 58 | 61 |
| 1.0                  | 92                                | 93  | 94  | 94  | 94  | 9.2                  | 50                                | 53 | 55 | 58 | 60 |
| 1.2                  | 91                                | 92  | 92  | 93  | 93  | 9.4                  | 49                                | 52 | 55 | 57 | 59 |
| 1.4                  | 90                                | 90  | 91  | 92  | 92  | 9.6                  | 48                                | 51 | 54 | 56 | 59 |
| 1.6                  | 88                                | 89  | 90  | 91  | 91  | 9.8                  | 48                                | 51 | 53 | 56 | 58 |
| 1.8                  | 87                                | 88  | 89  | 90  | 90  | 10.0                 | 47                                | 50 | 53 | 55 | 57 |
| 2.0                  | 86                                | 87  | 88  | 88  | 89  | 10.5                 | 45                                | 48 | 51 | 54 | 56 |
| 2.2                  | 84                                | 85  | 86  | 87  | 89  | 11.0                 | 44                                | 47 | 49 | 52 | 55 |
| 2.4                  | 83                                | 84  | 85  | 86  | 87  | 11.5                 | 42                                | 45 | 48 | 51 | 53 |
| 2.6                  | 82                                | 83  | 84  | 85  | 86  | 12.0                 | 41                                | 44 | 47 | 49 | 52 |
| 2.8                  | 80                                | 82  | 83  | 84  | 85  | 12.5                 | 39                                | 42 | 45 | 48 | 50 |
| 3.0                  | 79                                | 81  | 82  | 83  | 84  | 13.0                 | 38                                | 41 | 44 | 46 | 49 |
| 3.2                  | 78                                | 80  | 81  | 82  | 83  | 13.5                 | 37                                | 40 | 43 | 45 | 48 |
| 3.4                  | 77                                | 79  | 80  | 81  | 82  | 14.0                 | 35                                | 38 | 41 | 44 | 47 |
| 3.6                  | 76                                | 77  | 79  | 80  | 82  | 14.5                 | 34                                | 37 | 40 | 43 | 45 |
| 3.8                  | 75                                | 76  | 78  | 79  | 81  | 15.0                 | 33                                | 36 | 39 | 42 | 44 |
| 4.0                  | 73                                | 75  | 77  | 78  | 80  | 15.5                 | 32                                | 35 | 38 | 40 |    |
| 4.2                  | 72                                | 74  | 76  | 77  | 79  | 16.0                 | 31                                | 34 | 37 | 39 |    |
| 4.4                  | 71                                | 73  | 75  | 77  | 78  | 16.5                 | 30                                | 33 | 36 | 38 |    |
| 4.6                  | 70                                | 72  | 74  | 76  | 77  | 17.0                 | 29                                | 32 | 35 | 37 |    |
| 4.8                  | 69                                | 71  | 73  | 75  | 76  | 17.5                 | 28                                | 31 | 34 | 36 |    |
| 5.0                  | 69                                | 70  | 72  | 74  | 75  | 18.0                 | 27                                | 30 | 33 | 35 |    |
| 5.2                  | 67                                | 69  | 71  | 73  | 75  | 18.5                 | 26                                | 29 | 32 | 34 |    |
| 5.4                  | 66                                | 68  | 70  | 72  | 74  | 19.0                 | 25                                | 28 | 31 | 33 |    |
| 5.6                  | 65                                | 67  | 69  | 71  | 73  | 19.5                 | 24                                | 27 | 30 | 33 |    |
| 5.9                  | 64                                | 66  | 69  | 70  | 72  | 20.0                 | 24                                | 26 | 29 | 32 |    |
| 6.0                  | 63                                | 66  | 68  | 70  | 71  | 21.0                 | 22                                | 25 | 27 | 30 |    |
| 6.2                  | 62                                | 65  | 67  | 69  | 71  | 22.0                 | 21                                | 23 | 26 | 29 |    |
| 6.4                  | 61                                | 64  | 66  | 68  | 70  | 23.0                 | 19                                | 22 | 24 | 27 |    |
| 6.6                  | 60                                | 63  | 65  | 67  | 69  | 24.0                 | 18                                | 21 | 23 | 26 |    |
| 6.8                  | 60                                | 62  | 64  | 66  | 68  | 25.0                 | 17                                | 19 | 22 | 24 |    |
| 7.0                  | 59                                | 61  | 63  | 66  | 68  | 26.0                 | 16                                | 18 | 21 | 23 |    |
| 7.2                  | 58                                | 60  | 63  | 65  | 67  | 27.0                 | 15                                | 17 | 20 | 22 |    |
| 7.4                  | 57                                | 60  | 62  | 64  | 66  | 28.0                 | 14                                | 16 | 19 | 21 |    |
| 7.6                  | 56                                | 59  | 61  | 63  | 65  | 29.0                 | 13                                | 15 | 18 | 20 |    |
| 7.8                  | 55                                | 58  | 60  | 63  | 65  | 30.0                 | 12                                | 14 | 17 | 19 |    |
| 8.0                  | 54                                | 57  | 60  | 62  | 64  |                      |                                   |    |    |    |    |

# DETERMINATION OF RELATIVE HUMIDITY FROM WET AND DRY BULB TEMPERATURES

Relative humidity may be determined by comparing temperature readings of wet and dry bulb thermometers. The following table, extracted from more extensive U.S. National Weather Service tables, gives the relative humidity as a function of air temperature

$t_d$  (dry bulb) and the difference  $t_d - t_w$  between dry and wet bulb temperatures. The data assume a pressure near normal atmospheric pressure and an instrumental configuration with forced ventilation.

|                        | $(t_d - t_w)/^{\circ}\text{C}$ |     |     |     |     |     |     |     |     |     |     |     |
|------------------------|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| $t_d/^{\circ}\text{C}$ | 0.5                            | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 |
| -10                    | 83                             | 67  | 51  | 35  | 19  |     |     |     |     |     |     |     |
| -8                     | 86                             | 71  | 57  | 43  | 29  | 15  |     |     |     |     |     |     |
| -6                     | 88                             | 74  | 61  | 49  | 37  | 25  | 8   |     |     |     |     |     |
| -4                     | 89                             | 77  | 66  | 55  | 44  | 33  | 23  | 12  |     |     |     |     |
| -2                     | 90                             | 79  | 69  | 60  | 50  | 40  | 31  | 22  | 12  |     |     |     |
| 0                      | 91                             | 81  | 72  | 64  | 55  | 46  | 38  | 29  | 21  | 13  | 5   |     |
| 2                      | 91                             | 84  | 76  | 68  | 60  | 52  | 44  | 37  | 29  | 22  | 14  | 7   |
| 4                      | 92                             | 85  | 78  | 71  | 63  | 57  | 49  | 43  | 36  | 29  | 22  | 16  |
| 6                      | 93                             | 86  | 79  | 73  | 66  | 60  | 54  | 48  | 41  | 35  | 29  | 24  |
| 8                      | 93                             | 87  | 81  | 75  | 69  | 63  | 57  | 51  | 46  | 40  | 35  | 29  |
| 10                     | 94                             | 88  | 82  | 77  | 71  | 66  | 60  | 55  | 50  | 44  | 39  | 34  |
| 12                     | 94                             | 89  | 83  | 78  | 73  | 68  | 63  | 58  | 53  | 48  | 43  | 39  |
| 14                     | 95                             | 90  | 85  | 79  | 75  | 70  | 65  | 60  | 56  | 51  | 47  | 42  |
| 16                     | 95                             | 90  | 85  | 81  | 76  | 71  | 67  | 63  | 58  | 54  | 50  | 46  |
| 18                     | 95                             | 91  | 86  | 82  | 77  | 73  | 69  | 65  | 61  | 57  | 53  | 49  |
| 20                     | 96                             | 91  | 87  | 83  | 78  | 74  | 70  | 66  | 63  | 59  | 55  | 51  |
| 22                     | 96                             | 92  | 87  | 83  | 80  | 76  | 72  | 68  | 64  | 61  | 57  | 54  |
| 24                     | 96                             | 92  | 88  | 84  | 80  | 77  | 73  | 69  | 66  | 62  | 59  | 56  |
| 26                     | 96                             | 92  | 88  | 85  | 81  | 78  | 74  | 71  | 67  | 64  | 61  | 58  |
| 28                     | 96                             | 93  | 89  | 85  | 82  | 78  | 75  | 72  | 69  | 65  | 62  | 59  |
| 30                     | 96                             | 93  | 89  | 86  | 83  | 79  | 76  | 73  | 70  | 67  | 64  | 61  |
| 35                     | 97                             | 94  | 90  | 87  | 84  | 81  | 78  | 75  | 72  | 69  | 67  | 64  |
| 40                     | 97                             | 94  | 91  | 88  | 85  | 82  | 80  | 77  | 74  | 72  | 69  | 67  |

|                        | $(t_d - t_w)/^{\circ}\text{C}$ |     |     |     |     |     |      |      |      |      |      |      |
|------------------------|--------------------------------|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| $t_d/^{\circ}\text{C}$ | 6.5                            | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| 4                      | 9                              |     |     |     |     |     |      |      |      |      |      |      |
| 6                      | 17                             | 11  | 5   |     |     |     |      |      |      |      |      |      |
| 8                      | 24                             | 19  | 14  | 8   |     |     |      |      |      |      |      |      |
| 10                     | 29                             | 24  | 20  | 15  | 10  | 6   |      |      |      |      |      |      |
| 12                     | 34                             | 29  | 25  | 21  | 16  | 12  | 5    |      |      |      |      |      |
| 14                     | 38                             | 34  | 30  | 26  | 22  | 18  | 10   |      |      |      |      |      |
| 16                     | 42                             | 38  | 34  | 30  | 26  | 23  | 15   | 8    |      |      |      |      |
| 18                     | 45                             | 41  | 38  | 34  | 30  | 27  | 20   | 14   | 7    |      |      |      |
| 20                     | 48                             | 44  | 41  | 37  | 34  | 31  | 24   | 18   | 12   | 6    |      |      |
| 22                     | 50                             | 47  | 44  | 40  | 37  | 34  | 28   | 22   | 17   | 11   | 6    |      |
| 24                     | 53                             | 49  | 46  | 43  | 40  | 37  | 31   | 26   | 20   | 15   | 10   | 5    |
| 26                     | 54                             | 51  | 49  | 46  | 43  | 40  | 34   | 29   | 24   | 19   | 14   | 10   |
| 28                     | 56                             | 53  | 51  | 48  | 45  | 42  | 37   | 32   | 27   | 22   | 18   | 13   |
| 30                     | 58                             | 55  | 52  | 50  | 47  | 44  | 39   | 35   | 30   | 25   | 21   | 17   |
| 32                     | 60                             | 57  | 54  | 51  | 49  | 46  | 41   | 37   | 32   | 28   | 24   | 20   |
| 34                     | 61                             | 58  | 56  | 53  | 51  | 48  | 43   | 39   | 35   | 30   | 26   | 23   |
| 36                     | 62                             | 59  | 57  | 54  | 52  | 50  | 45   | 41   | 37   | 33   | 29   | 25   |
| 38                     | 63                             | 61  | 58  | 56  | 54  | 51  | 47   | 43   | 39   | 35   | 31   | 27   |
| 40                     | 64                             | 62  | 59  | 57  | 54  | 53  | 48   | 44   | 40   | 36   | 33   | 29   |

# CONSTANT HUMIDITY SOLUTIONS

Anthony Wexler

An excess of a water soluble salt in contact with its saturated solution and contained within an enclosed space produces a constant relative humidity and water vapor pressure according to

$$RH = A \exp(B/T)$$

where  $RH$  is the percent relative humidity (generally accurate to  $\pm 2\%$ ),  $T$  is the temperature in kelvin, and the constants  $A$  and  $B$  and the range of valid temperatures are given in the table below. The vapor pressure,  $p$ , can be calculated from

$$p = (RH/100) \times p_0$$

where  $p_0$  is the vapor pressure of pure water at temperature  $T$  as given in the table in Section 6 titled "Vapor Pressure of Water from 0 to 370°C".

## References

1. Wexler, A. S. and Seinfeld, J. H., *Atmospheric Environment*, 25A, 2731, 1991.
2. Greenspan, L., *J. Res. National Bureau of Standards*, 81A, 89, 1977.
3. Broul, et al., *Solubility of Inorganic Two-Component Systems*, Elsevier, New York, 1981.
4. Wagman, D. D. et al., *J. Phys. Chem. Ref. Data*, Vol. 11, Suppl. 2, 1982.

| Compound                                              | Temperature range (°C) | $RH$ (25°C) | $A$   | $B$  |
|-------------------------------------------------------|------------------------|-------------|-------|------|
| NaOH · H <sub>2</sub> O                               | 15—60                  | 6           | 5.48  | 27   |
| LiBr · 2H <sub>2</sub> O                              | 10—30                  | 6           | 0.23  | 996  |
| ZnBr <sub>2</sub> · 2H <sub>2</sub> O                 | 5—30                   | 8           | 1.69  | 455  |
| KOH · 2H <sub>2</sub> O                               | 5—30                   | 9           | 0.014 | 1924 |
| LiCl · H <sub>2</sub> O                               | 20—65                  | 11          | 14.53 | −75  |
| CaBr <sub>2</sub> · 6H <sub>2</sub> O                 | 11—22                  | 16          | 0.17  | 1360 |
| LiI · 3H <sub>2</sub> O                               | 15—65                  | 18          | 0.15  | 1424 |
| CaCl <sub>2</sub> · 6H <sub>2</sub> O                 | 15—25                  | 29          | 0.11  | 1653 |
| MgCl <sub>2</sub> · 6H <sub>2</sub> O                 | 5—45                   | 33          | 29.26 | 34   |
| NaI · 2H <sub>2</sub> O                               | 5—45                   | 38          | 3.62  | 702  |
| Ca(NO <sub>3</sub> ) <sub>2</sub> · 4H <sub>2</sub> O | 10—30                  | 51          | 1.89  | 981  |
| Mg(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O | 5—35                   | 53          | 25.28 | 220  |
| NaBr · 2H <sub>2</sub> O                              | 0—35                   | 58          | 20.49 | 308  |
| NH <sub>4</sub> NO <sub>3</sub>                       | 10—40                  | 62          | 3.54  | 853  |
| KI                                                    | 5—30                   | 69          | 29.35 | 254  |
| SrCl <sub>2</sub> · 6H <sub>2</sub> O                 | 5—30                   | 71          | 31.58 | 241  |
| NaNO <sub>3</sub>                                     | 10—40                  | 74          | 26.94 | 302  |
| NaCl                                                  | 10—40                  | 75          | 69.20 | 25   |
| NH <sub>4</sub> Cl                                    | 10—40                  | 79          | 35.67 | 235  |
| KBr                                                   | 5—25                   | 81          | 40.98 | 203  |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>       | 10—40                  | 81          | 62.06 | 79   |
| KCl                                                   | 5—25                   | 84          | 49.38 | 159  |
| Sr(NO <sub>3</sub> ) <sub>2</sub> · 4H <sub>2</sub> O | 5—25                   | 85          | 28.34 | 328  |
| BaCl <sub>2</sub> · 2H <sub>2</sub> O                 | 5—25                   | 90          | 69.99 | 75   |
| CsI                                                   | 5—25                   | 91          | 70.77 | 75   |
| KNO <sub>3</sub>                                      | 0—50                   | 92          | 43.22 | 225  |
| K <sub>2</sub> SO <sub>4</sub>                        | 10—50                  | 97          | 86.75 | 34   |

## STANDARD SALT SOLUTIONS FOR HUMIDITY CALIBRATION

Saturated aqueous solutions of inorganic salts are convenient secondary standards for calibration of instruments for measurement of relative humidity. The International Union of Pure and Applied Chemistry has recommended salt solutions for calibrations in the range of 10% to 90% relative humidity, and the American Society for Testing and Materials has published similar standards. The data in this table are taken from the IUPAC recommendations, except for  $K_2CO_3$  and  $K_2SO_4$ , which are ASTM recommendations.

Details on the preparation and use of these standards may be found in References 1 and 2. Data for other salts are given in Reference 3.

## References

1. Marsh, K. N., Editor, *Recommended Reference Materials for the Realization of Physicochemical Properties*, Blackwell Scientific Publications, Oxford, 1987, pp.157-162.
2. *Standard Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions*, ASTM Standard E 104-85, Reapproved 1991.
3. Greenspan, L., *J. Res. Nat. Bur. Stand.*, 81A, 89, 1977.

| $t/^{\circ}C$ | Relative Humidity in % |                   |                                |                                   |              |              |                                |
|---------------|------------------------|-------------------|--------------------------------|-----------------------------------|--------------|--------------|--------------------------------|
|               | LiCl                   | MgCl <sub>2</sub> | K <sub>2</sub> CO <sub>3</sub> | Mg(NO <sub>3</sub> ) <sub>2</sub> | NaCl         | KCl          | K <sub>2</sub> SO <sub>4</sub> |
| 0             |                        | 33.66 ± 0.33      | 43.1 ± 0.7                     | 60.35 ± 0.55                      | 75.51 ± 0.34 | 88.61 ± 0.53 | 98.8 ± 2.1                     |
| 5             |                        | 33.60 ± 0.28      | 43.1 ± 0.5                     | 58.86 ± 0.43                      | 75.65 ± 0.27 | 87.67 ± 0.45 | 98.5 ± 0.9                     |
| 10            |                        | 33.47 ± 0.24      | 43.1 ± 0.4                     | 57.36 ± 0.33                      | 75.67 ± 0.22 | 86.77 ± 0.39 | 98.2 ± 0.8                     |
| 15            |                        | 33.30 ± 0.21      | 43.2 ± 0.3                     | 55.87 ± 0.27                      | 75.61 ± 0.18 | 85.92 ± 0.33 | 97.9 ± 0.6                     |
| 20            | 11.31 ± 0.31           | 33.07 ± 0.18      | 43.2 ± 0.3                     | 54.38 ± 0.23                      | 75.47 ± 0.14 | 85.11 ± 0.29 | 97.6 ± 0.5                     |
| 25            | 11.30 ± 0.27           | 32.78 ± 0.16      | 43.2 ± 0.4                     | 52.89 ± 0.22                      | 75.29 ± 0.12 | 84.34 ± 0.26 | 97.3 ± 0.5                     |
| 30            | 11.28 ± 0.24           | 32.44 ± 0.14      | 43.2 ± 0.5                     | 51.40 ± 0.24                      | 75.09 ± 0.11 | 83.62 ± 0.25 | 97.0 ± 0.4                     |
| 35            | 11.25 ± 0.22           | 32.05 ± 0.13      |                                | 49.91 ± 0.29                      | 74.87 ± 0.12 | 82.95 ± 0.25 | 96.7 ± 0.4                     |
| 40            | 11.21 ± 0.21           | 31.60 ± 0.13      |                                | 48.42 ± 0.37                      |              | 82.32 ± 0.25 | 96.4 ± 0.4                     |
| 45            | 11.16 ± 0.21           | 31.10 ± 0.13      |                                | 46.93 ± 0.47                      |              | 81.74 ± 0.28 | 96.1 ± 0.4                     |
| 50            | 11.10 ± 0.22           | 30.54 ± 0.14      |                                | 45.44 ± 0.60                      |              | 81.20 ± 0.31 | 95.8 ± 0.5                     |
| 55            | 11.03 ± 0.23           | 29.93 ± 0.16      |                                |                                   |              | 80.70 ± 0.35 |                                |
| 60            | 10.95 ± 0.26           | 29.26 ± 0.18      |                                |                                   |              | 80.25 ± 0.41 |                                |
| 65            | 10.86 ± 0.29           | 28.54 ± 0.21      |                                |                                   |              | 79.85 ± 0.48 |                                |
| 70            | 10.75 ± 0.33           | 27.77 ± 0.25      |                                |                                   |              | 79.49 ± 0.57 |                                |
| 75            | 10.64 ± 0.38           | 26.94 ± 0.29      |                                |                                   |              | 79.17 ± 0.66 |                                |
| 80            | 10.51 ± 0.44           | 26.05 ± 0.34      |                                |                                   |              | 78.90 ± 0.77 |                                |

## LOW TEMPERATURE BATHS FOR MAINTAINING CONSTANT TEMPERATURE

A liquid-solid slurry is a convenient means of maintaining a constant temperature environment below room temperature. The following is a list of readily available organic liquids suitable for

this purpose, arranged in order of their melting (freezing) points  $t_m$ . The normal boiling points  $t_b$  are also given.

| Compound                                  | $t_m/^{\circ}\text{C}$ | $t_b/^{\circ}\text{C}$ |
|-------------------------------------------|------------------------|------------------------|
| Isopentane (2-Methylbutane)               | -159.9                 | 27.8                   |
| Methylcyclopentane                        | -142.5                 | 71.8                   |
| 3-Chloropropene (Allyl chloride)          | -134.5                 | 45.1                   |
| Pentane                                   | -129.7                 | 36.0                   |
| Allyl alcohol                             | -129                   | 97.0                   |
| Ethanol                                   | -114.1                 | 78.2                   |
| Carbon disulfide                          | -111.5                 | 46                     |
| Isobutyl alcohol                          | -108                   | 107.8                  |
| Toluene                                   | -94.9                  | 110.6                  |
| Acetone                                   | -94.8                  | 56.0                   |
| Ethyl acetate                             | -83.6                  | 77.1                   |
| Dry ice + acetone                         | -78                    |                        |
| <i>p</i> -Cymene                          | -68.9                  | 177.1                  |
| Trichloromethane (Chloroform)             | -63.6                  | 61.1                   |
| <i>N</i> -Methylaniline                   | -57                    | 196.2                  |
| Chlorobenzene                             | -45.2                  | 131.7                  |
| Anisole                                   | -37.5                  | 153.7                  |
| Bromobenzene                              | -30.6                  | 156.0                  |
| Tetrachloromethane (Carbon tetrachloride) | -23                    | 76.8                   |
| Benzonitrile                              | -12.7                  | 191.1                  |

## WIRE TABLES

The resistance per unit length of wires of various metals is tabulated here. Values were calculated from resistivity values in the tables “Electrical Resistivity of Pure Metals” and “Electrical Resistivity of Selected Alloys”, which appear in Section 12. In prac-

tice, resistance may vary because of differing heat treatments and metal composition. The values in the table refer to 20°C, but values at other temperatures may be calculated from the following resistivity data:

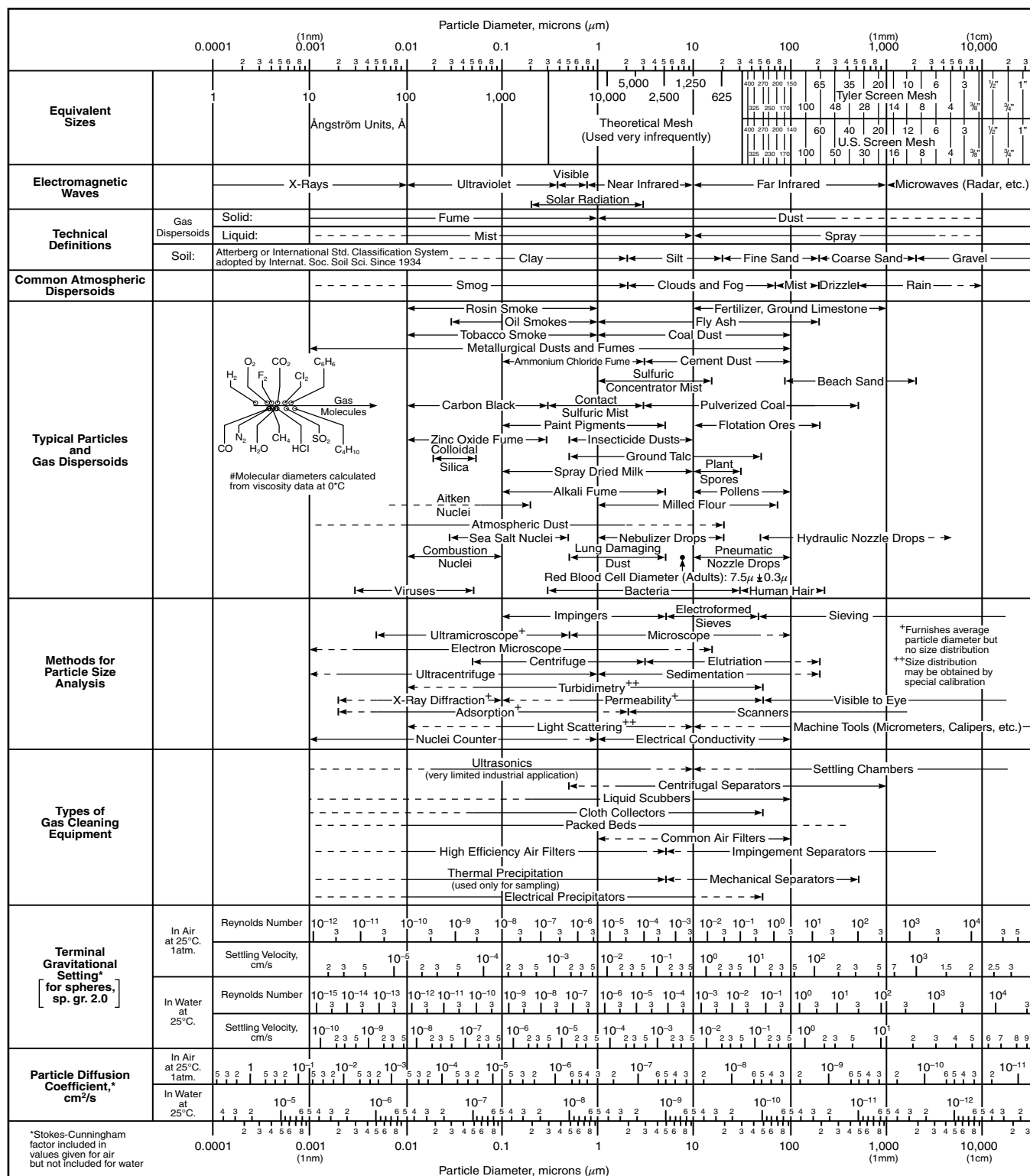
| Metal                       | Resistivity in $10^{-8} \Omega \cdot \text{m}$ at temperature |       |       |       |
|-----------------------------|---------------------------------------------------------------|-------|-------|-------|
|                             | 0°C                                                           | 20°C  | 25°C  | 100°C |
| Aluminum                    | 2.417                                                         | 2.650 | 2.709 | 3.56  |
| Brass (70% Cu, 30% Zn)      | 5.87                                                          | 6.08  | 6.13  | 6.91  |
| Constantan (60% Cu, 40% Ni) | 45.43                                                         | 45.38 | 45.35 | 45.11 |
| Copper                      | 1.543                                                         | 1.678 | 1.712 | 2.22  |
| Nichrome (79% Ni, 21% Cr)   | 107.3                                                         | 107.5 | 107.6 | 108.3 |
| Platinum                    | 9.6                                                           | 10.5  | 10.7  | 13.6  |
| Silver                      | 1.467                                                         | 1.587 | 1.617 | 2.07  |
| Tungsten                    | 4.82                                                          | 5.28  | 5.39  | 7.18  |

| Resistance per unit length at 20°C in $\Omega/\text{m}$ |               |          |         |            |          |          |          |          |          |
|---------------------------------------------------------|---------------|----------|---------|------------|----------|----------|----------|----------|----------|
| AWG Gauge <sup>a</sup>                                  | Diameter (mm) | Aluminum | Brass   | Constantan | Copper   | Nichrome | Platinum | Silver   | Tungsten |
| 0                                                       | 8.252         | 0.000495 | 0.00114 | 0.00848    | 0.000314 | 0.0201   | 0.00196  | 0.000297 | 0.00099  |
| 2                                                       | 6.543         | 0.000788 | 0.00181 | 0.0135     | 0.000499 | 0.0320   | 0.00312  | 0.000472 | 0.00157  |
| 4                                                       | 5.189         | 0.00125  | 0.00287 | 0.0214     | 0.000793 | 0.0508   | 0.00496  | 0.000750 | 0.00250  |
| 6                                                       | 4.115         | 0.00199  | 0.00457 | 0.0341     | 0.00126  | 0.0808   | 0.00789  | 0.00119  | 0.00397  |
| 8                                                       | 3.264         | 0.00317  | 0.00727 | 0.0542     | 0.00200  | 0.128    | 0.0125   | 0.00190  | 0.00631  |
| 10                                                      | 2.588         | 0.00504  | 0.0115  | 0.0863     | 0.00319  | 0.204    | 0.0200   | 0.00302  | 0.0100   |
| 12                                                      | 2.053         | 0.00800  | 0.0184  | 0.137      | 0.00507  | 0.325    | 0.0317   | 0.00479  | 0.0159   |
| 14                                                      | 1.628         | 0.0127   | 0.0292  | 0.218      | 0.00806  | 0.516    | 0.0504   | 0.00762  | 0.0254   |
| 16                                                      | 1.291         | 0.0202   | 0.0464  | 0.347      | 0.0128   | 0.821    | 0.0802   | 0.0121   | 0.0403   |
| 18                                                      | 1.024         | 0.0322   | 0.0738  | 0.551      | 0.0204   | 1.30     | 0.127    | 0.0193   | 0.0641   |
| 20                                                      | 0.8118        | 0.0512   | 0.117   | 0.877      | 0.0324   | 2.08     | 0.203    | 0.0307   | 0.102    |
| 22                                                      | 0.6439        | 0.0814   | 0.187   | 1.39       | 0.0515   | 3.30     | 0.322    | 0.0487   | 0.162    |
| 24                                                      | 0.5105        | 0.129    | 0.297   | 2.22       | 0.0820   | 5.25     | 0.513    | 0.0775   | 0.258    |
| 26                                                      | 0.4049        | 0.206    | 0.472   | 3.52       | 0.130    | 8.35     | 0.815    | 0.123    | 0.410    |
| 28                                                      | 0.3211        | 0.327    | 0.751   | 5.60       | 0.207    | 13.3     | 1.30     | 0.196    | 0.652    |
| 30                                                      | 0.2548        | 0.520    | 1.19    | 8.90       | 0.329    | 21.1     | 2.06     | 0.311    | 1.03     |
| 32                                                      | 0.2019        | 0.828    | 1.90    | 14.2       | 0.524    | 33.6     | 3.28     | 0.496    | 1.65     |
| 34                                                      | 0.1601        | 1.32     | 3.02    | 22.5       | 0.833    | 53.4     | 5.22     | 0.788    | 2.62     |
| 36                                                      | 0.1270        | 2.09     | 4.80    | 35.8       | 1.32     | 84.9     | 8.29     | 1.25     | 4.17     |
| 38                                                      | 0.1007        | 3.33     | 7.63    | 57.0       | 2.11     | 135      | 13.2     | 1.99     | 6.63     |
| 40                                                      | 0.07988       | 5.29     | 12.1    | 90.5       | 3.35     | 214      | 20.9     | 3.17     | 10.5     |

<sup>a</sup> Often called Brown & Sharpe Gauge.



## CHARACTERISTICS OF PARTICLES AND PARTICLE DISPERSIONS



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## DENSITY OF VARIOUS SOLIDS

This table gives the range of density for miscellaneous solid materials whose characteristics depend on the source or method of preparation.

### References

1. Forsythe, W. E., *Smithsonian Physical Tables, Ninth Edition*, Smithsonian Institution, Washington, D.C., 1956.

2. Kaye, G. W. C., and Laby, T. H., *Tables of Physical and Chemical Constants, 16th Edition*, Longman, London, 1995.
3. Brandrup, J., and Immergut, E. H., *Polymer Handbook, Third Edition*, John Wiley & Sons, New York, 1989.

| Material       | $\rho / \text{g cm}^{-3}$ | Material                  | $\rho / \text{g cm}^{-3}$ | Material         | $\rho / \text{g cm}^{-3}$ |
|----------------|---------------------------|---------------------------|---------------------------|------------------|---------------------------|
| Agate          | 2.5-2.7                   | Pyrex                     | 2.23                      | Solder           | 8.7-9.4                   |
| Alabaster,     |                           | Granite                   | 2.64-2.76                 | Starch           | 1.53                      |
| carbonate      | 2.69-2.78                 | Graphite                  | 2.30-2.72                 | Steel, stainless | 7.8                       |
| sulfate        | 2.26-2.32                 | Gum arabic                | 1.3-1.4                   | Sugar            | 1.59                      |
| Albite         | 2.62-2.65                 | Gypsum                    | 2.31-2.33                 | Talc             | 2.7-2.8                   |
| Amber          | 1.06-1.11                 | Hematite                  | 4.9-5.3                   | Tallow, beef     | 0.94                      |
| Amphiboles     | 2.9-3.2                   | Hornblende                | 3.0                       | Tar              | 1.02                      |
| Anorthite      | 2.74-2.76                 | Ice                       | 0.917                     | Topaz            | 3.5-3.6                   |
| Asbestos       | 2.0-2.8                   | Iron, cast                | 7.0-7.4                   | Tourmaline       | 3.0-3.2                   |
| Asbestos slate | 1.8                       | Ivory                     | 1.83-1.92                 | Tungsten carbide | 14.0-15.0                 |
| Asphalt        | 1.1-1.5                   | Kaolin                    | 2.6                       | Wax, sealing     | 1.8                       |
| Basalt         | 2.4-3.1                   | Leather, dry              | 0.86                      | Wood (seasoned)  |                           |
| Beeswax        | 0.96-0.97                 | Lime, slaked              | 1.3-1.4                   | alder            | 0.42-0.68                 |
| Beryl          | 2.69-2.70                 | Limestone                 | 2.68-2.76                 | apple            | 0.66-0.84                 |
| Biotite        | 2.7-3.1                   | Linoleum                  | 1.18                      | ash              | 0.65-0.85                 |
| Bone           | 1.7-2.0                   | Magnetite                 | 4.9-5.2                   | balsa            | 0.11-0.14                 |
| Brasses        | 8.44-8.75                 | Malachite                 | 3.7-4.1                   | bamboo           | 0.31-0.40                 |
| Brick          | 1.4-2.2                   | Marble                    | 2.6-2.84                  | basswood         | 0.32-0.59                 |
| Bronzes        | 8.74-8.89                 | Meerschaum                | 0.99-1.28                 | beech            | 0.70-0.90                 |
| Butter         | 0.86-0.87                 | Mica                      | 2.6-3.2                   | birch            | 0.51-0.77                 |
| Calamine       | 4.1-4.5                   | Muscovite                 | 2.76-3.00                 | blue gum         | 1.00                      |
| Calcspars      | 2.6-2.8                   | Ochre                     | 3.5                       | box              | 0.95-1.16                 |
| Camphor        | 0.99                      | Opal                      | 2.2                       | butternut        | 0.38                      |
| Cardboard      | 0.69                      | Paper                     | 0.7-1.15                  | cedar            | 0.49-0.57                 |
| Celluloid      | 1.4                       | Paraffin                  | 0.87-0.91                 | cherry           | 0.70-0.90                 |
| Cement, set    | 2.7-3.0                   | Peat blocks               | 0.84                      | dogwood          | 0.76                      |
| Chalk          | 1.9-2.8                   | Pitch                     | 1.07                      | ebony            | 1.11-1.33                 |
| Charcoal,      |                           | Polyamides                | 1.15-1.25                 | elm              | 0.54-0.60                 |
| oak            | 0.57                      | Polyethylene              | 0.92-0.97                 | hickory          | 0.60-0.93                 |
| pine           | 0.28-0.44                 | Poly(methyl methacrylate) | 1.19                      | holly            | 0.76                      |
| Cinnabar       | 8.12                      | Polypropylene             | 0.91-0.94                 | juniper          | 0.56                      |
| Clay           | 1.8-2.6                   | Polystyrene               | 1.06-1.12                 | larch            | 0.50-0.56                 |
| Coal,          |                           | Polytetrafluoroethylene   | 2.28-2.30                 | locust           | 0.67-0.71                 |
| anthracite     | 1.4-1.8                   | Poly(vinyl acetate)       | 1.19                      | logwood          | 0.91                      |
| bituminous     | 1.2-1.5                   | Poly(vinyl chloride)      | 1.39-1.42                 | mahogany         | 0.66-0.85                 |
| Coke           | 1.0-1.7                   | Porcelain                 | 2.3-2.5                   | maple            | 0.62-0.75                 |
| Copal          | 1.04-1.14                 | Porphyry                  | 2.6-2.9                   | oak              | 0.60-0.90                 |
| Cork           | 0.22-0.26                 | Pyrite                    | 4.95-5.10                 | pear             | 0.61-0.73                 |
| Corundum       | 3.9-4.0                   | Quartz ( $\alpha$ )       | 2.65                      | pine, pitch      | 0.83-0.85                 |
| Diamond        | 3.51                      | Resin                     | 1.07                      | white            | 0.35-0.50                 |
| Dolomite       | 2.84                      | Rock salt                 | 2.18                      | yellow           | 0.37-0.60                 |
| Ebonite        | 1.15                      | Rubber,                   |                           | plum             | 0.66-0.78                 |
| Emery          | 4.0                       | hard                      | 1.19                      | poplar           | 0.35-0.50                 |
| Epidote        | 3.25-3.50                 | soft                      | 1.1                       | satinwood        | 0.95                      |
| Feldspar       | 2.55-2.75                 | pure gum                  | 0.91-0.93                 | spruce           | 0.48-0.70                 |
| Flint          | 2.63                      | Neoprene                  | 1.23-1.25                 | sycamore         | 0.40-0.60                 |
| Fluorite       | 3.18                      | Sandstone                 | 2.14-2.36                 | teak, Indian     | 0.66-0.98                 |
| Galena         | 7.3-7.6                   | Serpentine                | 2.50-2.65                 | walnut           | 0.64-0.70                 |
| Garnet         | 3.15-4.3                  | Silica, fused,            | 2.21                      | water gum        | 1.00                      |
| Gelatin        | 1.27                      | Silicon carbide           | 3.16                      | willow           | 0.40-0.60                 |
| Glass,         |                           | Slag                      | 2.0-3.9                   | Wood's metal     | 9.70                      |
| common         | 2.4-2.8                   | Slate                     | 2.6-3.3                   |                  |                           |
| lead           | 3-4                       | Soapstone                 | 2.6-2.8                   |                  |                           |

# DIELECTRIC STRENGTH OF INSULATING MATERIALS

L. I. Berger

The loss of the dielectric properties by a sample of a gaseous, liquid, or solid insulator as a result of application to the sample of an electric field\* greater than a certain critical magnitude is called *dielectric breakdown*. The critical magnitude of electric field at which the breakdown of a material takes place is called the *dielectric strength* of the material (or *breakdown voltage*). The dielectric strength of a material depends on the specimen thickness (as a rule, thin films have greater dielectric strength than that of thicker samples of a material), the electrode shape\*\*, the rate of the applied voltage increase, the shape of the voltage vs. time curve, and the medium surrounding the sample, e.g., air or other gas (or a liquid — for solid materials only).

## Breakdown in Gases

The current carriers in gases are free electrons and ions generated by external radiation. The equilibrium concentration of these particles at normal pressure is about  $10^3 \text{ cm}^{-3}$ , and hence the electrical conductivity is very small, of the order of  $10^{-16} - 10^{-15} \text{ S/cm}$ . But in a strong electric field, these particles acquire kinetic energy along their free path, large enough to ionize the gas molecules. The new charged particles ionize more molecules; this avalanche-like process leads to formation between the electrodes of channels of conducting plasma (streamers), and the electrical resistance of the space between the electrodes decreases virtually to zero.

Because the dielectric strength (breakdown voltage) of gases strongly depends on the electrode geometry and surface condition and the gas pressure, it is generally accepted to present the data for a particular gas as a fraction of the dielectric strength of either nitrogen or sulfur hexafluoride measured at the same conditions. In Table 1, the data are presented in comparison with the dielectric strength of nitrogen, which is considered equal to 1.00. For convenience to the reader, a few average magnitudes of the dielectric strength of some gases are expressed in kilovolts per millimeter. The data in the table relate to the standard conditions, unless indicated otherwise.

## Breakdown in Liquids

If a liquid is pure, the breakdown mechanism in it is similar to that in gases. If a liquid contains liquid impurities in the form of small drops with greater dielectric constant than that of the main liquid, the breakdown is the result of formation of ellipsoids from these drops by the electric field. In a strong enough electric field, these ellipsoids merge and form a high-conductivity channel between the electrodes. The current increases the temperature in the channel, liquid boils, and the current along the steam canal leads to breakdown. Formation of a conductive channel (bridge) between

the electrodes is observed also in liquids with solid impurities. If a liquid contains gas impurities in the form of small bubbles, breakdown is the result of heating of the liquid in strong electric fields. In the locations with the highest current density, the liquid boils, the size of the gas bubbles increases, they merge and form gaseous channels between the electrodes, and the breakdown medium is again the gas plasma.

## Breakdown in Solids

It is known that the current in solid insulators does not obey Ohm's law in strong electric fields. The current density increases almost exponentially with the electric field, and at a certain field magnitude it jumps to very high magnitudes at which a specimen of a material is destroyed. The two known kinds of electric breakdown are thermal and electrical breakdowns. The former is the result of material heating by the electric current. Destruction of a sample of a material happens when, at a certain voltage, the amount of heat produced by the current exceeds the heat release through the sample surface; the breakdown voltage in this case is proportional to the square root of the ratio of the thermal conductivity and electrical conductivity of the material. A semi-empirical expression for dependence of the breakdown voltage,  $V_B$ , on the physical properties and geometry of a sample of a solid material for the one-dimensional case is

$$V_B = [A\rho\kappa / a\phi(d)]^{1/2}$$

where  $A$  is a numerical constant related to the system of units used,  $\rho$  and  $\kappa$  are the volume resistivity and thermal conductivity of the sample material,  $a$  is a constant related to the chemical bond nature and crystal structure of the sample material, and  $\phi(d)$  is a function of the sample geometry, first of all, thickness,  $d$  (see, e.g., Ref. R6). In the majority of materials,  $\phi(d)$  increases with  $d$ , hence, the magnitude of  $V_B$  is greater in the thinner samples of a particular material.

The electrical breakdown results from the tunneling of the charge carriers from electrodes or from the valence band or from the impurity levels into the conduction band, or by the impact ionization. The tunnel effect breakdown happens mainly in thin layers, e.g., in thin p-n junctions. Otherwise, the impact ionization mechanism dominates. For this mechanism, the dielectric strength of an insulator can be estimated using Boltzmann's kinetic equation for electrons in a crystal.

In the following tables, the dielectric strength values are for room temperature and normal atmospheric pressure, unless indicated otherwise.

\* The unit of electric field in the SI system is newton per coulomb or volt per meter.

\*\* For example, the U.S. standard ASTM D149 is based on use of symmetrical electrodes, while per U.K. standard BS2918 one electrode is a plane and the other is a rod with the axis normal to the plane.

TABLE 1. Dielectric Strength of Gases

| Material                                                 | Dielectric*<br>strength | Ref. | Material                                                                 | Dielectric*<br>strength | Ref. |
|----------------------------------------------------------|-------------------------|------|--------------------------------------------------------------------------|-------------------------|------|
| Nitrogen, N <sub>2</sub>                                 | 1.00                    |      | Trichlorofluoromethane, CCl <sub>3</sub> F                               | 3.50                    | 1    |
| Hydrogen, H <sub>2</sub>                                 | 0.50                    | 1,2  |                                                                          | 4.53                    | 2    |
| Helium, He                                               | 0.15                    | 1    | Trichloromethane, CHCl <sub>3</sub>                                      | 4.2                     | 1    |
| Oxygen, O <sub>2</sub>                                   | 0.92                    | 2    |                                                                          | 4.39                    | 2    |
| Air                                                      | 0.97                    | 6    | Methylamine, CH <sub>3</sub> NH <sub>2</sub>                             | 0.81                    | 1    |
| Air (flat electrodes), kV/mm                             | 3.0                     | 3    | Difluoromethane, CH <sub>2</sub> F <sub>2</sub>                          | 0.79                    | 2    |
| Air, kV/mm                                               | 0.4-0.7                 | 4    | Trifluoromethane, CHF <sub>3</sub>                                       | 0.71                    | 2    |
| Air, kV/mm                                               | 1.40                    | 5    | Bromochlorodifluoromethane, CF <sub>2</sub> ClBr                         | 3.84                    | 2    |
| Neon, Ne                                                 | 0.25                    | 1    | Chlorodifluoromethane, CHClF <sub>2</sub>                                | 1.40                    | 1    |
|                                                          | 0.16                    | 2    |                                                                          | 1.11                    | 2    |
| Argon, Ar                                                | 0.18                    | 2    | Dichlorofluoromethane, CHCl <sub>2</sub> F                               | 1.33                    | 1    |
| Chlorine, Cl <sub>2</sub>                                | 1.55                    | 1    |                                                                          | 2.61                    | 2    |
| Carbon monoxide, CO                                      | 1.02                    | 1    | Chlorofluoromethane, CH <sub>2</sub> ClF                                 | 1.03                    | 1    |
|                                                          | 1.05                    | 2    | Hexafluoroethane, C <sub>2</sub> F <sub>6</sub>                          | 1.82                    | 1    |
| Carbon dioxide, CO <sub>2</sub>                          | 0.88                    | 1    |                                                                          | 2.55                    | 2    |
|                                                          | 0.82                    | 2    | Ethyne (Acetylene), C <sub>2</sub> H <sub>2</sub>                        | 1.10                    | 1    |
|                                                          | 0.84                    | 6    |                                                                          | 1.11                    | 2    |
| Nitrous oxide, N <sub>2</sub> O                          | 1.24                    | 2    | Chloropentafluoroethane, C <sub>2</sub> ClF <sub>5</sub>                 | 2.3                     | 1    |
| Sulfur dioxide, SO <sub>2</sub>                          | 2.63                    | 2    |                                                                          | 3.0                     | 6    |
|                                                          | 2.68                    | 6    | Dichlorotetrafluoroethane, C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub> | 2.52                    | 1    |
| Sulfur monochloride, S <sub>2</sub> Cl <sub>2</sub>      | 1.02                    | 1    | Chlorotrifluoroethylene, C <sub>2</sub> ClF <sub>3</sub>                 | 1.82                    | 2    |
| (at 12.5 Torr)                                           |                         |      | 1,1,1-Trichloro-2,2,2-trifluoroethane                                    | 6.55                    | 2    |
| Thionyl fluoride, SOF <sub>2</sub>                       | 2.50                    | 1    | 1,1,2-Trichloro-1,2,2-trifluoroethane                                    | 6.05                    | 2    |
| Sulfur hexafluoride, SF <sub>6</sub>                     | 2.50                    | 1    | Chloroethane, C <sub>2</sub> H <sub>5</sub> Cl                           | 1.00                    | 1    |
|                                                          | 2.63                    | 2    | 1,1-Dichloroethane                                                       | 2.66                    | 2    |
| Sulfur hexafluoride, SF <sub>6</sub> , kV/mm             | 8.50                    | 7    | Trifluoroacetonitrile, CF <sub>3</sub> CN                                | 3.5                     | 1    |
|                                                          | 9.8                     | 8    | Acetonitrile, CH <sub>3</sub> CN                                         | 2.11                    | 2    |
| Perchloryl fluoride, ClO <sub>3</sub> F                  | 2.73                    | 1    | Dimethylamine, (CH <sub>3</sub> ) <sub>2</sub> NH                        | 1.04                    | 1    |
| Tetrachloromethane, CCl <sub>4</sub>                     | 6.33                    | 1    | Ethylamine, C <sub>2</sub> H <sub>5</sub> NH <sub>2</sub>                | 1.01                    | 1    |
|                                                          | 6.21                    | 2    | Ethylene oxide (oxirane), CH <sub>3</sub> CHO                            | 1.01                    | 1    |
| Tetrafluoromethane, CF <sub>4</sub>                      | 1.01                    | 1    | Perfluoropropene, C <sub>3</sub> F <sub>6</sub>                          | 2.55                    | 2    |
| Methane, CH <sub>4</sub>                                 | 1.00                    | 1    | Octafluoropropane, C <sub>3</sub> F <sub>8</sub>                         | 2.19                    | 1    |
|                                                          | 1.13                    | 2    |                                                                          | 2.47                    | 2    |
| Bromotrifluoromethane, CF <sub>3</sub> Br                | 1.35                    | 1    | 3,3,3-Trifluoro-1-propene, CH <sub>2</sub> CHCF <sub>3</sub>             | 2.11                    | 2    |
|                                                          | 1.97                    | 2    | Pentafluoroisocynoethane, C <sub>2</sub> F <sub>5</sub> NC               | 4.5                     | 1    |
| Bromomethane, CH <sub>3</sub> Br                         | 0.71                    | 2    | 1,1,1,4,4,4-Hexafluoro-2-butyne, CF <sub>3</sub> CCCCF <sub>3</sub>      | 5.84                    | 2    |
| Chloromethane, CH <sub>3</sub> Cl                        | 1.29                    | 2    | Octafluorocyclobutane, C <sub>4</sub> F <sub>8</sub>                     | 3.34                    | 2    |
| Iodomethane, CH <sub>3</sub> I                           | 3.02                    | 2    | 1,1,1,2,3,4,4,4-Octafluoro-2-butene                                      | 2.8                     | 1    |
| Iodomethane, CH <sub>3</sub> I, at 370 Torr              | 2.20                    | 7    | Decafluorobutane, C <sub>4</sub> F <sub>10</sub>                         | 3.08                    | 1    |
| Dichloromethane, CH <sub>2</sub> Cl <sub>2</sub>         | 1.92                    | 2    | Perfluorobutanenitrile, C <sub>3</sub> F <sub>7</sub> CN                 | 5.5                     | 1    |
| Dichlorodifluoromethane, CCl <sub>2</sub> F <sub>2</sub> | 2.42                    | 1    | Perfluoro-2-methyl-1,3-butadiene, C <sub>5</sub> F <sub>8</sub>          | 5.5                     | 1    |
|                                                          | 2.63                    | 2,6  | Hexafluorobenzene, C <sub>6</sub> F <sub>6</sub>                         | 2.11                    | 2    |
| Chlorotrifluoromethane, CClF <sub>3</sub>                | 1.43                    | 1    | Perfluorocyclohexane, C <sub>6</sub> F <sub>12</sub> , (saturated vapor) | 6.18                    | 2    |
|                                                          | 1.53                    | 2    |                                                                          |                         |      |

\* Relative to nitrogen, unless units of kV/mm are indicated.

TABLE 2. Dielectric Strength of Liquids

| Material                                                    | Dielectric strength<br>kV/mm | Ref.  | Material                                                                                                                                                            | Dielectric strength<br>kV/mm | Ref.  |
|-------------------------------------------------------------|------------------------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-------|
| Helium, He, liquid, 4.2 K                                   | 10                           | 9     |                                                                                                                                                                     | 20.4                         | 15    |
| Static                                                      | 10                           | 11    |                                                                                                                                                                     | 179                          | 17,18 |
| Dynamic                                                     | 5                            | 11    | Ethylbenzene, C <sub>8</sub> H <sub>10</sub>                                                                                                                        | 226                          | 17,18 |
|                                                             | 23                           | 12    | Propylbenzene, C <sub>9</sub> H <sub>12</sub>                                                                                                                       | 250                          | 17,18 |
| Nitrogen, N <sub>2</sub> , liquid, 77K                      |                              |       | Isopropylbenzene, C <sub>9</sub> H <sub>12</sub>                                                                                                                    | 238                          | 17,18 |
| Coaxial cylinder electrodes                                 | 20                           | 10    | Decane, C <sub>10</sub> H <sub>22</sub>                                                                                                                             | 192                          | 17,18 |
| Sphere to plane electrodes                                  | 60                           | 10    | Synthetic Paraffin Mixture                                                                                                                                          |                              |       |
| Water, H <sub>2</sub> O, distilled                          | 65-70                        | 13    | Synfluid 2cSt PAO                                                                                                                                                   | 29.5                         | 37    |
| Carbon tetrachloride, CCl <sub>4</sub>                      | 5.5                          | 14    | Butylbenzene, C <sub>10</sub> H <sub>14</sub>                                                                                                                       | 275                          | 17,18 |
|                                                             | 16.0                         | 15    | Isobutylbenzene, C <sub>10</sub> H <sub>14</sub>                                                                                                                    | 222                          | 17,18 |
| Hexane, C <sub>6</sub> H <sub>14</sub>                      | 42.0                         | 16    | Silicone oils—polydimethylsiloxanes,<br>(CH <sub>3</sub> ) <sub>3</sub> Si-O-[Si(CH <sub>3</sub> ) <sub>2</sub> ] <sub>x</sub> -O-Si(CH <sub>3</sub> ) <sub>3</sub> |                              |       |
| Two 2.54 cm diameter spherical<br>electrodes, 50.8 μm space | 156                          | 17,18 | Polydimethylsiloxane silicone fluid                                                                                                                                 | 15.4                         | 20    |
| Cyclohexane, C <sub>6</sub> H <sub>12</sub>                 | 42-48                        | 16    | Dimethyl silicone                                                                                                                                                   | 24.0                         | 21,22 |
| 2-Methylpentane, C <sub>6</sub> H <sub>14</sub>             | 149                          | 17,18 | Phenylmethyl silicone                                                                                                                                               | 23.2                         | 22    |
| 2,2-Dimethylbutane, C <sub>6</sub> H <sub>14</sub>          | 133                          | 17,18 | Silicone oil, Basilone M50                                                                                                                                          | 10-15                        | 23    |
| 2,3-Dimethylbutane, C <sub>6</sub> H <sub>14</sub>          | 138                          | 17,18 | Mineral insulating oils                                                                                                                                             | 11.8                         | 6     |
| Benzene, C <sub>6</sub> H <sub>6</sub>                      | 163                          | 17,18 | Polybutene oil for capacitors                                                                                                                                       | 13.8                         | 6     |
| Chlorobenzene, C <sub>6</sub> H <sub>5</sub> Cl             | 7.1                          | 14    | Transformer dielectric liquid                                                                                                                                       | 28-30                        | 6     |
|                                                             | 18.8                         | 15    | Isopropylbiphenyl capacitor oil                                                                                                                                     | 23.6                         | 6     |
| 2,2,4-Trimethylpentane, C <sub>8</sub> H <sub>18</sub>      | 140                          | 17,18 | Transformer oil                                                                                                                                                     | 110.7                        | 24    |
| Phenylxylethane                                             | 23.6                         | 19    | Transformer oil Agip ITE 360                                                                                                                                        | 9-12.6                       | 23    |
| Heptane, C <sub>7</sub> H <sub>16</sub>                     | 166                          | 17,18 | Perfluorinated hydrocarbons                                                                                                                                         |                              |       |
| 2,4-Dimethylpentane, C <sub>7</sub> H <sub>16</sub>         | 133                          | 17,18 | Fluorinert FC 6001                                                                                                                                                  | 8.0                          | 23    |
| Toluene, C <sub>6</sub> H <sub>5</sub> CH <sub>3</sub>      | 199                          | 17,18 | Fluorinert FC 77                                                                                                                                                    | 10.7                         | 23    |
|                                                             | 46                           | 16    | Perfluorinated polyethers                                                                                                                                           |                              |       |
|                                                             | 12.0                         | 14    | Galden XAD (Mol. wt. 800)                                                                                                                                           | 10.5                         | 23    |
|                                                             | 20.4                         | 15    | Galden D40 (Mol. wt. 2000)                                                                                                                                          | 10.2                         | 23    |
| Octane, C <sub>8</sub> H <sub>18</sub>                      | 16.6                         | 14    | Castor oil                                                                                                                                                          | 65                           | 25    |

TABLE 3. Dielectric Strength of Solids

| Material                                                                    | Dielectric strength<br>kV/mm | Ref   | Material                        | Dielectric strength<br>kV/mm | Ref |
|-----------------------------------------------------------------------------|------------------------------|-------|---------------------------------|------------------------------|-----|
| Sodium chloride, NaCl, crystalline                                          | 150                          | 26    | Phlogopite, amber, natural      | 118                          | 6   |
| Potassium bromide, KBr, crystalline                                         | 80                           | 26    | Fluorophlogopite, synthetic     | 118                          | 6   |
| Ceramics                                                                    |                              |       | Glass-bonded mica               | 14.0-15.7                    | 6   |
| Alumina (99.9% Al <sub>2</sub> O <sub>3</sub> )                             | 13.4                         | 6,27a | Thermoplastic Polymers          |                              |     |
| Aluminum silicate, Al <sub>2</sub> SiO <sub>5</sub>                         | 5.9                          | 6     | Polypropylene                   | 23.6                         | 6   |
| Berillia (99% BeO)                                                          | 13.8                         | 6,27b | Amide polymer nylon 6/6, dry    | 23.6                         | 6   |
| Boron nitride, BN                                                           | 37.4                         | 6     | Polyamide-imide copolymer       | 22.8                         | 6   |
| Cordierite, Mg <sub>2</sub> Al <sub>4</sub> Si <sub>5</sub> O <sub>18</sub> | 7.9                          | 6,27c | Modified polyphenylene oxide    | 21.7                         | 6   |
| Forsterite, Mg <sub>2</sub> SiO <sub>4</sub>                                | 9.8                          | 28    | Polystyrene                     | 19.7                         | 6   |
| Porcelain                                                                   | 35-160                       | 26    | Polymethyl methacrylate         | 19.7                         | 6   |
| Steatite, Mg <sub>3</sub> Si <sub>4</sub> O <sub>11</sub> •H <sub>2</sub> O | 9.1-15.4                     | 6     | Polyetherimide                  | 18.9                         | 6   |
| Titanates of Mg, Ca, Sr, Ba, and Pb                                         | 20-120                       | 3     | Amide polymer nylon 11(dry)     | 16.7                         | 6   |
| Barium titanate, glass bonded                                               | >30                          | 36    | Polysulfone                     | 16.7                         | 6   |
| Zirconia, ZrO <sub>2</sub>                                                  | 11.4                         | 29    | Styrene-acrylonitrile copolymer | 16.7                         | 6   |
| Glasses                                                                     |                              |       | Acrylonitrile-butadiene-styrene | 16.7                         | 6   |
| Fused silica, SiO <sub>2</sub>                                              | 470-670                      | 26    | Polyethersulfone                | 15.7                         | 6   |
| Alkali-silicate glass                                                       | 200                          | 26    | Polybutylene terephthalate      | 15.7                         | 6   |
| Standard window glass                                                       | 9.8-13.8                     | 28    | Polystyrene-butadiene copolymer | 15.7                         | 6   |
| Micas                                                                       |                              |       | Acetal homopolymer              | 15.0                         | 6   |
| Muscovite, ruby, natural                                                    | 118                          | 6     | Acetal copolymer                | 15.0                         | 6   |
|                                                                             |                              |       | Polyphenylene sulfide           | 15.0                         | 6   |

| Material                                                                 | Dielectric strength<br>kV/mm | Ref | Material                                                                                 | Dielectric strength<br>kV/mm | Ref |
|--------------------------------------------------------------------------|------------------------------|-----|------------------------------------------------------------------------------------------|------------------------------|-----|
| Polycarbonate                                                            | 15.0                         | 6   | Rigid, two-part                                                                          | 70.9                         | 6   |
| Acetal homopolymer resin (molding resin)                                 | 15.0                         | 6   | Semiflexible high-bond thixotropic                                                       | 78.7                         | 6   |
| Acetal copolymer resin                                                   | 15.0                         | 6   | Rigid high-bond high-flash<br>freon-resistant                                            | 68.9                         | 6   |
| Thermosetting Molding Compounds                                          |                              |     | Baking type epoxy varnish                                                                |                              |     |
| Glass-filled allyl<br>(Type GDI-30 per MIL-M-14G)                        | 15.7                         | 6   | Solventless, rigid, low viscosity,<br>one-part                                           | 90.6                         | 6   |
| Glass-filled epoxy, electrical grade                                     | 15.4                         | 6   | Solventless, semiflexible, one-part                                                      | 82.7                         | 6   |
| Glass-filled phenolic<br>(Type GPI-100 per MIL-M-14G)                    | 15.0                         | 6   | Solventless, semirigid, chemical<br>resistant, low dielectric constant                   | 106.3                        | 6   |
| Glass-filled alkyd/polyester<br>(Type MAI-60 per MIL-M-14G)              | 14.8                         | 6   | Solvable, for hermetic electric motors                                                   | 181.1                        | 6   |
| Glass-filled melamine<br>(Type MMI-30 per MIL-M-14G)                     | 13.4                         | 6   | Polyurethane coating                                                                     |                              |     |
| Extrusion Compounds for High-Temperature<br>Insulation                   |                              |     | Clear conformal, fast cure                                                               |                              |     |
| Polytetrafluoroethylene                                                  | 19.7                         | 6   | Standard conditions                                                                      | 78.7                         | 6   |
| Perfluoroalkoxy polymer                                                  | 21.7                         | 6   | Immersion conditions                                                                     | 47.2                         | 6   |
| Fluorinated ethylene-propylene copolymer                                 | 19.7                         | 6   | Insulating Films and Tapes                                                               |                              |     |
| Ethylene-tetrafluoroethylene copolymer                                   | 15.7                         | 6   | Low-density polyethylene film<br>(40 µm thick)                                           | 300                          | 31  |
| Polyvinylidene fluoride                                                  | 10.2                         | 6   | Poly- <i>p</i> -xylylene film                                                            | 410-590                      | 32  |
| Ethylene-chlorotrifluoroethylene<br>copolymer                            | 19.3                         | 6   | Aromatic polymer films                                                                   |                              |     |
| Polychlorotrifluoroethylene                                              | 19.7                         | 6   | Kapton H (Du Pont)                                                                       | 389-430                      | 33  |
| Extrusion Compounds for Low-Temperature<br>Insulation                    |                              |     | Ultem (GE Plastic and Roem AG)                                                           | 437-565                      | 33  |
| Polyvinyl chloride                                                       |                              |     | Hostaphan (Hoechst AG)                                                                   | 338-447                      | 33  |
| Flexible                                                                 | 11.8-15.7                    | 30  | Amorphous Stabar K2000<br>(ICI film)                                                     | 404-422                      | 33  |
| Rigid                                                                    | 13.8-19.7                    | 30  | Stabar S100 (ICI film)                                                                   | 353-452                      | 33  |
| Polyethylene                                                             | 18.9                         | 28  | Polyetherimide film (26 µm)                                                              | 486                          | 34  |
| Polyethylene, low-density                                                | 21.7                         | 6   | Parylene N/D (poly- <i>p</i> -xylylene/poly-<br>dichloro- <i>p</i> -xylylene) 25 µm film | 275                          | 6   |
|                                                                          | 300                          | 31  | Cellulose acetate film                                                                   | 157                          | 6   |
| Polyethylene, high-density                                               | 19.7                         | 6   | Cellulose triacetate film                                                                | 157                          | 6   |
| Polypropylene/polyethylene copolymer                                     | 23.6                         | 6   | Polytetrafluoroethylene film                                                             | 87-173                       | 6   |
| Embedding Compounds                                                      |                              |     | Perfluoroalkoxy film                                                                     | 157-197                      | 6   |
| Basic epoxy resin:                                                       | 19.7                         | 6   | Fluorinated ethylene-propylene<br>copolymer film                                         | 197                          | 6   |
| bisphenol-A/epichlorohydrin<br>polycondensate                            |                              |     | Ethylene-tetrafluoroethylene film                                                        | 197                          | 6   |
| Cycloaliphatic epoxy: alicyclic<br>diepoxy carboxylate                   | 19.7                         | 6   | Ethylene-chlorotrifluoroethylene<br>copolymer film                                       | 197                          | 6   |
| Polyetherketone                                                          | 18.9                         | 30  | Polychlorotrifluoroethylene film                                                         | 118-153.5                    | 6   |
| Polyurethanes                                                            |                              |     | High-voltage rubber insulating tape                                                      | 28                           | 6   |
| Two-component, polyol-cured                                              | 25.4                         | 6   | Composites                                                                               |                              |     |
| Two-part solventless,<br>polybutylene-based                              | 24.0                         | 6   | Isophthalic polyester (vinyl toluene<br>monomer) filled with                             |                              |     |
| Silicones                                                                |                              |     | Calcium carbonate, CaCO <sub>3</sub>                                                     | 15.0                         | 38  |
| Clear two-part heat curing electrical<br>grade silicone embedding resin  | 21.7                         | 6   | Gypsum, CaSO <sub>4</sub>                                                                | 14.4                         | 38  |
| Red insulating enamel (MIL-E-22118)                                      |                              |     | Alumina trihydrate                                                                       | 15.4                         | 38  |
| Dry                                                                      | 47.2                         | 6   | Clay                                                                                     | 14.4                         | 38  |
| Wet                                                                      | 11.8                         | 6   | BPA fumarate polyester (vinyl toluene<br>monomer) filled with                            |                              |     |
| Enamels                                                                  |                              |     | Calcium carbonate                                                                        | 6.1                          | 38  |
| Red enamel, fast cure                                                    |                              |     | Gypsum                                                                                   | 5.9                          | 38  |
| Standard conditions                                                      | 78.7                         | 6   | Alumina trihydrate                                                                       | 11.8                         | 38  |
| Immersion conditions                                                     | 47.2                         | 6   | Clay                                                                                     | 12.6                         | 38  |
| Black enamel                                                             |                              |     | Polysulfone resin—30% glass fiber                                                        | 16.5-18.7                    | 38  |
| Standard conditions                                                      | 70.9                         | 6   | Polyamid resin (Nylon 66)—<br>30% carbon fiber                                           | 13.0                         | 38  |
| Immersion conditions                                                     | 47.2                         | 6   | Polyimide thermoset resin,<br>glass reinforced                                           | 12.0                         | 39  |
| Varnishes                                                                |                              |     | Polyester resin (thermoplastic)—                                                         |                              |     |
| Vacuum-pressure impregnated baking<br>type solventless polyester varnish |                              |     |                                                                                          |                              |     |

| Material                                                           | Dielectric strength<br>kV/mm | Ref | Material                                       | Dielectric strength<br>kV/mm | Ref |
|--------------------------------------------------------------------|------------------------------|-----|------------------------------------------------|------------------------------|-----|
| 40% glass fiber                                                    | 20.0                         | 38  | Room-temperature vulcanized<br>silicone rubber | 9.2-10.9                     | 35  |
| Epoxy resin (diglycidyl ether of<br>bisphenol A), glass reinforced | 16.0                         | 40  | Ureas (from carbamide<br>to tetraphenylurea)   | 11.8-15.7                    | 28  |
| Various Insulators                                                 |                              |     | Dielectric papers                              |                              |     |
| Rubber, natural                                                    | 100-215                      | 26  | Aramid paper, calendered                       | 28.7                         | 6   |
| Butyl rubber                                                       | 23.6                         | 6   | Aramid paper, uncalendered                     | 12.2                         | 6   |
| Neoprene                                                           | 15.7-27.6                    | 6   | Aramid with Mica                               | 39.4                         | 6   |
| Silicone rubber                                                    | 26-36                        | 6   |                                                |                              |     |

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# ALLOCATION OF FREQUENCIES IN THE RADIO SPECTRUM

In the United States the National Telecommunications and Information Administration (NTIA) has responsibility for assigning each portion of the radio spectrum (9 kHz to 300 GHz) for different uses. These assignments must be compatible with the rules of the International Telecommunications Union (ITU), to which the United States is bound by treaty. The current assignments are given in a wall chart (Reference 1) and may also be found on the NTIA web site (Reference 2). The list below summarizes the broad features of the spectrum allocation, with particular attention to those sections of scientific interest. The references should be con-

sulted for details of the allocations in the frequency bands listed here, which in some cases are quite complex.

## References

1. *United States Frequency Allocations*, 1996 Spectrum Wall Chart, Stock No. 003-000-00652-2, U. S. Government Printing Office, P. O. Box 371954, Pittsburgh, PA 15250-7954.
2. <http://www.ntia.doc.gov/osmhome/allochrt.html>

| Frequency range     | Allocation                                                                         |
|---------------------|------------------------------------------------------------------------------------|
| 9 - 19.95 kHz       | Maritime communication, navigation                                                 |
| 19.95 - 20.05 kHz   | Standard frequency and time signal (also at 60 kHz and 2.5, 5, 10, 15, 20, 25 MHz) |
| 20.05 - 535 kHz     | Maritime and aeronautical communication, navigation                                |
| 535 - 1605 kHz      | AM radio broadcasting                                                              |
| 1605 - 3500 kHz     | Mobile communication and navigation, amateur radio (1800-1900 kHz)                 |
| 3.5 - 4.0 MHz       | Amateur radio                                                                      |
| 4.0 - 5.95 MHz      | Mobile communication                                                               |
| 5.95 - 13.36 MHz    | Mobile communication, amateur, short-wave broadcasting                             |
| 13.36 - 13.41 MHz   | Radioastronomy                                                                     |
| 13.41 - 25.55 MHz   | Mobile communication, amateur, short-wave broadcasting                             |
| 25.55 - 25.67 MHz   | Radioastronomy                                                                     |
| 25.67 - 37.5 MHz    | Mobile communication, amateur, short-wave broadcasting                             |
| 37.5 - 38.25 MHz    | Radioastronomy                                                                     |
| 38.25 - 50.0 MHz    | Mobile communication                                                               |
| 50.0 - 54.0 MHz     | Amateur                                                                            |
| 54.0 - 72.0 MHz     | TV channels 2-4                                                                    |
| 72.0 - 73.0 MHz     | Mobile communication                                                               |
| 73.0 - 74.6 MHz     | Radioastronomy                                                                     |
| 74.6 - 76.0 MHz     | Mobile communication                                                               |
| 76.0 - 88.0 MHz     | TV channels 5-6                                                                    |
| 88.0 - 108.0 MHz    | FM radio broadcasting                                                              |
| 108.0 - 118.0 MHz   | Aeronautical navigation                                                            |
| 118.0 - 174.0 MHz   | Mobile communication, space research, meteorological satellites                    |
| 174.0 - 216.0 MHz   | TV channels 7-13                                                                   |
| 216.0 - 400.05 MHz  | Mobile communication                                                               |
| 400.05 - 400.15 MHz | Standard frequency and time satellite (also 20 and 25 GHz)                         |
| 400.15 - 406.1 MHz  | Meteorological aids (radiosonde)                                                   |
| 406.1 - 410.0 MHz   | Radioastronomy                                                                     |
| 410.0 - 470.0 MHz   | Mobile communication, amateur                                                      |
| 470.0 - 512.0 MHz   | TV channels 14-20                                                                  |
| 512.0 - 608.0 MHz   | TV channels 21-36                                                                  |
| 608.0 - 614.0 MHz   | Radioastronomy                                                                     |
| 614.0 - 806.0 MHz   | TV channels 38-69                                                                  |
| 806 - 1400 MHz      | Mobile communication, navigation                                                   |
| 1400 - 1427 MHz     | Radioastronomy, space research                                                     |
| 1427 - 1660 MHz     | Various navigation and satellite applications                                      |
| 1660 - 1710 MHz     | Radioastronomy, space research, meteorology                                        |
| 1710 - 2655 MHz     | Various navigation and satellite applications                                      |
| 2655 - 2700 MHz     | Radioastronomy, space research                                                     |
| 2.7 - 4.99 GHz      | Various navigation and satellite applications                                      |
| 4.99 - 5.0 GHz      | Radioastronomy, space research                                                     |
| 5.0 - 10.6 GHz      | Various navigation and satellite applications                                      |
| 10.6 - 10.7 GHz     | Radioastronomy, space research                                                     |
| 10.7 - 15.35 GHz    | Various navigation and satellite applications                                      |
| 15.35 - 15.4 GHz    | Radioastronomy, space research                                                     |
| 15.4 - 22.21 GHz    | Various navigation and satellite applications                                      |



| Frequency range   | Allocation                                    |
|-------------------|-----------------------------------------------|
| 22.21 - 22.5 GHz  | Radioastronomy, space research                |
| 22.25 - 23.6 GHz  | Various navigation and satellite applications |
| 23.6 - 24.0 GHz   | Radioastronomy, space research                |
| 24.0 - 31.3 GHz   | Various navigation and satellite applications |
| 31.3 - 31.8 GHz   | Radioastronomy, space research                |
| 31.8 - 42.5 GHz   | Various navigation and satellite applications |
| 42.5 - 43.5 GHz   | Radioastronomy                                |
| 43.5 - 51.4 GHz   | Various navigation and satellite applications |
| 51.4 - 54.25 GHz  | Radioastronomy, space research                |
| 54.25 - 58.2 GHz  | Space research                                |
| 58.2 - 59.0 GHz   | Radioastronomy, space research                |
| 59.0 - 64.0 GHz   | Satellite applications                        |
| 64.0 - 65.0 GHz   | Radioastronomy, space research                |
| 65.0 - 72.77 GHz  | Various navigation and satellite applications |
| 72.77 - 72.91 GHz | Radioastronomy, space research                |
| 72.91 - 86.0 GHz  | Various navigation and satellite applications |
| 86.0 - 92.0 GHz   | Radioastronomy, space research                |
| 92.0 - 105.0 GHz  | Various navigation and satellite applications |
| 105.0 - 116.0 GHz | Radioastronomy, space research                |
| 116.0 - 164.0 GHz | Various navigation and satellite applications |
| 164.0 - 168.0 GHz | Radioastronomy, space research                |
| 168.0 - 182.0 GHz | Various navigation and satellite applications |
| 182.0 - 185.0 GHz | Radioastronomy, space research                |
| 185.0 - 217.0 GHz | Various navigation and satellite applications |
| 217.0 - 231.0 GHz | Radioastronomy, space research                |
| 231.0 - 265.0 GHz | Various navigation and satellite applications |
| 265.0 - 275.0 GHz | Radioastronomy                                |
| 275.0 - 300.0 GHz | Mobile communications                         |

## CORRECTION OF BAROMETER READINGS TO 0 °C TEMPERATURE

The following corrections are used to reduce the reading of a mercury barometer with a brass scale to 0 °C. The number in the table should be subtracted from the observed height of the mercury column to give the true pressure in mmHg (1mmHg = 133.322 Pa). The table is calculated from the formula

$$\Delta h = -0.0001634 \, h t / (1 + 0.0001818 \, t),$$

where  $h$  is the observed column height in mm and  $t$  the Celsius temperature. This relation is based on thermal expansion coefficients of  $181.8 \cdot 10^{-6} \, ^\circ\text{C}^{-1}$  for mercury and  $18.4 \cdot 10^{-6} \, ^\circ\text{C}^{-1}$  for brass.

| $t/^\circ\text{C}$ | Observed Height in mm |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|--------------------|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|                    | 620                   | 630  | 640  | 650  | 660  | 670  | 680  | 690  | 700  | 710  | 720  | 730  | 740  | 750  | 760  | 770  | 780  | 790  | 800  |
| 0                  | 0.00                  | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1                  | 0.10                  | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 |
| 2                  | 0.20                  | 0.21 | 0.21 | 0.21 | 0.22 | 0.22 | 0.22 | 0.23 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.25 | 0.25 | 0.25 | 0.25 | 0.26 | 0.26 |
| 3                  | 0.30                  | 0.31 | 0.31 | 0.32 | 0.32 | 0.33 | 0.33 | 0.34 | 0.34 | 0.35 | 0.35 | 0.36 | 0.36 | 0.37 | 0.37 | 0.38 | 0.38 | 0.39 | 0.39 |
| 4                  | 0.40                  | 0.41 | 0.42 | 0.42 | 0.43 | 0.44 | 0.44 | 0.45 | 0.46 | 0.46 | 0.47 | 0.48 | 0.48 | 0.49 | 0.50 | 0.50 | 0.51 | 0.52 | 0.52 |
| 5                  | 0.51                  | 0.51 | 0.52 | 0.53 | 0.54 | 0.55 | 0.56 | 0.56 | 0.57 | 0.58 | 0.59 | 0.60 | 0.60 | 0.61 | 0.62 | 0.63 | 0.64 | 0.64 | 0.65 |
| 6                  | 0.61                  | 0.62 | 0.63 | 0.64 | 0.65 | 0.66 | 0.67 | 0.68 | 0.69 | 0.70 | 0.71 | 0.71 | 0.72 | 0.73 | 0.74 | 0.75 | 0.76 | 0.77 | 0.78 |
| 7                  | 0.71                  | 0.72 | 0.73 | 0.74 | 0.75 | 0.77 | 0.78 | 0.79 | 0.80 | 0.81 | 0.82 | 0.83 | 0.85 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 | 0.91 |
| 8                  | 0.81                  | 0.82 | 0.84 | 0.85 | 0.86 | 0.87 | 0.89 | 0.90 | 0.91 | 0.93 | 0.94 | 0.95 | 0.97 | 0.98 | 0.99 | 1.01 | 1.02 | 1.03 | 1.04 |
| 9                  | 0.91                  | 0.92 | 0.94 | 0.95 | 0.97 | 0.98 | 1.00 | 1.01 | 1.03 | 1.04 | 1.06 | 1.07 | 1.09 | 1.10 | 1.12 | 1.13 | 1.15 | 1.16 | 1.17 |
| 10                 | 1.01                  | 1.03 | 1.04 | 1.06 | 1.08 | 1.09 | 1.11 | 1.13 | 1.14 | 1.16 | 1.17 | 1.19 | 1.21 | 1.22 | 1.24 | 1.26 | 1.27 | 1.29 | 1.30 |
| 11                 | 1.11                  | 1.13 | 1.15 | 1.17 | 1.18 | 1.20 | 1.22 | 1.24 | 1.26 | 1.27 | 1.29 | 1.31 | 1.33 | 1.35 | 1.36 | 1.38 | 1.40 | 1.42 | 1.44 |
| 12                 | 1.21                  | 1.23 | 1.25 | 1.27 | 1.29 | 1.31 | 1.33 | 1.35 | 1.37 | 1.39 | 1.41 | 1.43 | 1.45 | 1.47 | 1.49 | 1.51 | 1.53 | 1.55 | 1.57 |
| 13                 | 1.31                  | 1.34 | 1.36 | 1.38 | 1.40 | 1.42 | 1.44 | 1.46 | 1.48 | 1.50 | 1.53 | 1.55 | 1.57 | 1.59 | 1.61 | 1.63 | 1.65 | 1.67 | 1.70 |
| 14                 | 1.41                  | 1.44 | 1.46 | 1.48 | 1.51 | 1.53 | 1.55 | 1.57 | 1.60 | 1.62 | 1.64 | 1.67 | 1.69 | 1.71 | 1.73 | 1.76 | 1.78 | 1.80 | 1.83 |
| 15                 | 1.52                  | 1.54 | 1.56 | 1.59 | 1.61 | 1.64 | 1.66 | 1.69 | 1.71 | 1.74 | 1.76 | 1.78 | 1.81 | 1.83 | 1.86 | 1.88 | 1.91 | 1.93 | 1.96 |
| 16                 | 1.62                  | 1.64 | 1.67 | 1.69 | 1.72 | 1.75 | 1.77 | 1.80 | 1.82 | 1.85 | 1.88 | 1.90 | 1.93 | 1.96 | 1.98 | 2.01 | 2.03 | 2.06 | 2.09 |
| 17                 | 1.72                  | 1.74 | 1.77 | 1.80 | 1.83 | 1.86 | 1.88 | 1.91 | 1.94 | 1.97 | 1.99 | 2.02 | 2.05 | 2.08 | 2.10 | 2.13 | 2.16 | 2.19 | 2.22 |
| 18                 | 1.82                  | 1.85 | 1.88 | 1.91 | 1.93 | 1.96 | 1.99 | 2.02 | 2.05 | 2.08 | 2.11 | 2.14 | 2.17 | 2.20 | 2.23 | 2.26 | 2.29 | 2.32 | 2.35 |
| 19                 | 1.92                  | 1.95 | 1.98 | 2.01 | 2.04 | 2.07 | 2.10 | 2.13 | 2.17 | 2.20 | 2.23 | 2.26 | 2.29 | 2.32 | 2.35 | 2.38 | 2.41 | 2.44 | 2.48 |
| 20                 | 2.02                  | 2.05 | 2.08 | 2.12 | 2.15 | 2.18 | 2.21 | 2.25 | 2.28 | 2.31 | 2.34 | 2.38 | 2.41 | 2.44 | 2.47 | 2.51 | 2.54 | 2.57 | 2.60 |
| 21                 | 2.12                  | 2.15 | 2.19 | 2.22 | 2.26 | 2.29 | 2.32 | 2.36 | 2.39 | 2.43 | 2.46 | 2.50 | 2.53 | 2.56 | 2.60 | 2.63 | 2.67 | 2.70 | 2.73 |
| 22                 | 2.22                  | 2.26 | 2.29 | 2.33 | 2.36 | 2.40 | 2.43 | 2.47 | 2.51 | 2.54 | 2.58 | 2.61 | 2.65 | 2.69 | 2.72 | 2.76 | 2.79 | 2.83 | 2.86 |
| 23                 | 2.32                  | 2.36 | 2.40 | 2.43 | 2.47 | 2.51 | 2.54 | 2.58 | 2.62 | 2.66 | 2.69 | 2.73 | 2.77 | 2.81 | 2.84 | 2.88 | 2.92 | 2.96 | 2.99 |
| 24                 | 2.42                  | 2.46 | 2.50 | 2.54 | 2.58 | 2.62 | 2.66 | 2.69 | 2.73 | 2.77 | 2.81 | 2.85 | 2.89 | 2.93 | 2.97 | 3.01 | 3.05 | 3.08 | 3.12 |
| 25                 | 2.52                  | 2.56 | 2.60 | 2.64 | 2.68 | 2.72 | 2.77 | 2.81 | 2.85 | 2.89 | 2.93 | 2.97 | 3.01 | 3.05 | 3.09 | 3.13 | 3.17 | 3.21 | 3.25 |
| 26                 | 2.62                  | 2.66 | 2.71 | 2.75 | 2.79 | 2.83 | 2.88 | 2.92 | 2.96 | 3.00 | 3.04 | 3.09 | 3.13 | 3.17 | 3.21 | 3.26 | 3.30 | 3.34 | 3.38 |
| 27                 | 2.72                  | 2.77 | 2.81 | 2.85 | 2.90 | 2.94 | 2.99 | 3.03 | 3.07 | 3.12 | 3.16 | 3.20 | 3.25 | 3.29 | 3.34 | 3.38 | 3.42 | 3.47 | 3.51 |
| 28                 | 2.82                  | 2.87 | 2.91 | 2.96 | 3.00 | 3.05 | 3.10 | 3.14 | 3.19 | 3.23 | 3.28 | 3.32 | 3.37 | 3.41 | 3.46 | 3.51 | 3.55 | 3.60 | 3.64 |
| 29                 | 2.92                  | 2.97 | 3.02 | 3.06 | 3.11 | 3.16 | 3.21 | 3.25 | 3.30 | 3.35 | 3.39 | 3.44 | 3.49 | 3.54 | 3.58 | 3.63 | 3.68 | 3.72 | 3.77 |
| 30                 | 3.02                  | 3.07 | 3.12 | 3.17 | 3.22 | 3.27 | 3.32 | 3.36 | 3.41 | 3.46 | 3.51 | 3.56 | 3.61 | 3.66 | 3.71 | 3.75 | 3.80 | 3.85 | 3.90 |
| 31                 | 3.12                  | 3.17 | 3.22 | 3.27 | 3.32 | 3.37 | 3.43 | 3.48 | 3.53 | 3.58 | 3.63 | 3.68 | 3.73 | 3.78 | 3.83 | 3.88 | 3.93 | 3.98 | 4.03 |
| 32                 | 3.22                  | 3.28 | 3.33 | 3.38 | 3.43 | 3.48 | 3.54 | 3.59 | 3.64 | 3.69 | 3.74 | 3.79 | 3.85 | 3.90 | 3.95 | 4.00 | 4.05 | 4.11 | 4.16 |
| 33                 | 3.32                  | 3.38 | 3.43 | 3.48 | 3.54 | 3.59 | 3.64 | 3.70 | 3.75 | 3.81 | 3.86 | 3.91 | 3.97 | 4.02 | 4.07 | 4.13 | 4.18 | 4.23 | 4.29 |
| 34                 | 3.42                  | 3.48 | 3.53 | 3.59 | 3.64 | 3.70 | 3.75 | 3.81 | 3.87 | 3.92 | 3.98 | 4.03 | 4.09 | 4.14 | 4.20 | 4.25 | 4.31 | 4.36 | 4.42 |
| 35                 | 3.52                  | 3.58 | 3.64 | 3.69 | 3.75 | 3.81 | 3.86 | 3.92 | 3.98 | 4.03 | 4.09 | 4.15 | 4.21 | 4.26 | 4.32 | 4.38 | 4.43 | 4.49 | 4.55 |
| 36                 | 3.62                  | 3.68 | 3.74 | 3.80 | 3.86 | 3.92 | 3.97 | 4.03 | 4.09 | 4.15 | 4.21 | 4.27 | 4.32 | 4.38 | 4.44 | 4.50 | 4.56 | 4.62 | 4.68 |
| 37                 | 3.72                  | 3.78 | 3.84 | 3.90 | 3.96 | 4.02 | 4.08 | 4.14 | 4.20 | 4.26 | 4.32 | 4.38 | 4.44 | 4.50 | 4.56 | 4.62 | 4.68 | 4.74 | 4.80 |
| 38                 | 3.82                  | 3.88 | 3.95 | 4.01 | 4.07 | 4.13 | 4.19 | 4.25 | 4.32 | 4.38 | 4.44 | 4.50 | 4.56 | 4.62 | 4.69 | 4.75 | 4.81 | 4.87 | 4.93 |
| 39                 | 3.92                  | 3.99 | 4.05 | 4.11 | 4.18 | 4.24 | 4.30 | 4.37 | 4.43 | 4.49 | 4.56 | 4.62 | 4.68 | 4.75 | 4.81 | 4.87 | 4.94 | 5.00 | 5.06 |
| 40                 | 4.02                  | 4.09 | 4.15 | 4.22 | 4.28 | 4.35 | 4.41 | 4.48 | 4.54 | 4.61 | 4.67 | 4.74 | 4.80 | 4.87 | 4.93 | 5.00 | 5.06 | 5.13 | 5.19 |

# METALS AND ALLOYS WITH LOW MELTING TEMPERATURE

L. I. Berger

| Metal or alloy system | Composition, % *       |                         | Melting temperature (°C) | Comments     | Ref.   |
|-----------------------|------------------------|-------------------------|--------------------------|--------------|--------|
|                       | Weight                 | Atomic                  |                          |              |        |
| Hg                    | 100                    | 100                     | -38.84                   |              |        |
| Cs-K                  | 77.0-23.0              | 50.0-50.0               | -37.5                    | Eutectic (?) | 1      |
| Cs-Na                 | 94.5-5.5               | 75.0-25.0               | -30.0                    | Eutectic     | 2      |
| K-Na                  | 76.7-23.3              | 65.9-34.1               | -12.65                   | Eutectic     | 3      |
| Na-Rb                 | 8.0-92.0               | 24.4-75.6               | -5                       | Eutectic     | 4      |
| Ga-In-Sn              | 62.5-21.5-16.0         | 73.6-15.3-11.1          | 11                       | Eutectic     | 5      |
| Ga-Sn-Zn              | 82.0-12.0-6.0          | 86.0-7.3-6.7            | 17                       | Eutectic     | 5      |
| Cs                    | 100                    | 100                     | 28.44                    |              |        |
| Ga                    | 100                    | 100                     | 29.77                    |              |        |
| K-Rb                  | 32.0-68.0              | 50-50                   | 33                       | Eutectic     | 4      |
| Bi-Cd-In-Pb-Sn        | 44.7-5.3-19.1-22.6-8.3 | 35.1-8.2-27.3-17.9-11.5 | 46.7                     | Eutectic     | 6      |
| Bi-In-Pb-Sn           | 49.5-21.3-17.6-11.6    | 39.2-30.7-14.0-16.2     | 58.2                     | Eutectic     | 6      |
| Bi-In-Sn              | 32.5-51.0-16.5         | 21.1-60.1-18.8          | 60.5                     | Eutectic     | 7      |
| K                     | 100                    | 100                     | 63.38                    |              |        |
| Bi-Cd-Pb-Sn           | 50.0-12.5-25.0-12.5    | 41.5-19.3-21.0-18.2     | 70                       | Wood's alloy | 6      |
| Bi-In                 | 33.0-67.0              | 21.3-78.7               | 72                       | Eutectic     | 8      |
| Bi-Cd-Pb              | 51.6-8.2-40.2          | 48.1-14.2-37.7          | 91.5                     | Eutectic     | 6      |
| Bi-Pb-Sn              | 52.5-32.0-15.5         | 46.8-28.7-24.5          | 95                       | Eutectic     | 6      |
| Na                    | 100                    | 100                     | 97.8                     |              |        |
| Bi-Cd-Sn              | 54.0-20.0-26.0         | 39.4-27.2-33.4          | 102.5                    | Eutectic     | 6      |
| In-Sn                 | 51.8-48.2              | 52.6-47.4               | 119                      | Eutectic     | 9      |
| Cd-In                 | 25.3-74.7              | 25.7-74.3               | 120                      | Eutectic     | 10     |
| Bi-Pb                 | 55.5-44.5              | 55.3-44.7               | 124                      | Eutectic     | 11     |
| Bi-Sn-Zn              | 56.0-40.0-4.0          | 40.2-50.6-9.2           | 130                      | Eutectic     | 6, 7   |
| Bi-Sn                 | 70-30                  | 57.0-43.0               | 138.5                    | Eutectic     | 6, 12  |
| Bi-Cd                 | 60.3-39.7              | 45.0-55.0               | 145.5                    | Eutectic     | 13, 14 |
| In                    | 100                    | 100                     | 156.6                    |              |        |
| Li                    | 100                    | 100                     | 180.5                    |              |        |
| Pb-Sn                 | 38.1-61.9              | 26.1-73.9               | 183                      | Eutectic     | 6,15   |
| Bi-Tl                 | 48.0-52.0              | 47.5-52.5               | 185                      | Eutectic     | 13     |
| Sn-Zn                 | 91.0-9.0               | 85.0-15.0               | 198                      | Eutectic     | 14     |
| Sb-Sn                 | 8.0-92.0               | 7.8-92.2                | 199                      | White Metal  | 16     |
| Au-Pb                 | 14.6-85.4              | 15.2-84.8               | 212                      | Eutectic     | 17     |
| Ag-Sn                 | 3.5-96.5               | 3.8-96.2                | 221                      | Eutectic     | 13,18  |
| Bi-Pb-Sb-Sn           | 48.0-28.5-9.0-14.5     | 40.8-24.5-13.1-21.6     | 226                      | Matrix Alloy | 6      |
| Cu-Sn                 | 0.75-99.25             | 1.3-98.7                | 227                      | Eutectic     | 13, 19 |
| Sn                    | 100                    | 100                     | 231.9                    |              |        |

\* The useful expression for correlations between the atomic and weight concentrations of an alloy components are:

$$f(a, A_k) = \frac{f(w, A_k)}{M_k \sum_{i=1}^N \frac{f(w, A_i)}{M_i}} \quad \text{and} \quad f(w, A_k) = \frac{M_k \cdot f(a, A_k)}{\sum_{i=1}^N M_i \cdot f(a, A_i)} \quad (i = 1, \dots, k, \dots, N)$$

where  $f(a, A_i)$  and  $f(w, A_i)$  are the atomic and weight concentrations of component  $A_i$ , respectively, and  $M_i$  is the atomic weight of this component.

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## FLAME TEMPERATURES

This table gives the adiabatic flame temperature for stoichiometric mixtures of various fuels and oxidizers. The temperatures are calculated from thermodynamic and transport properties under ideal adiabatic conditions, using methods described in the reference.

### Reference

Fristrom, R. M., *Flame Structures and Processes*, Oxford University Press, New York, 1995.

Adiabatic Flame Temperature in K for Various Fuel-Oxidizer Combinations

| Fuel                             | Oxidizer |                |                |                 |                  |      |
|----------------------------------|----------|----------------|----------------|-----------------|------------------|------|
|                                  | Air      | O <sub>2</sub> | F <sub>2</sub> | Cl <sub>2</sub> | N <sub>2</sub> O | NO   |
| <i>Organic liquids and gases</i> |          |                |                |                 |                  |      |
| Acetaldehyde                     | 2288     |                |                |                 |                  |      |
| Acetone                          | 2253     |                |                |                 |                  |      |
| Acetylene                        | 2607     |                |                |                 |                  |      |
| Benzene                          | 2363     |                |                |                 |                  |      |
| Butane                           | 2248     |                |                |                 |                  |      |
| Carbon disulfide                 | 2257     |                |                |                 |                  |      |
| Cyanogen                         | 2596     | 4855           |                |                 |                  |      |
| Cyclohexane                      | 2250     |                |                |                 |                  |      |
| Cyclopropane                     | 2370     |                |                |                 |                  |      |
| Decane                           | 2286     |                |                |                 |                  |      |
| Ethane                           | 2244     |                |                |                 |                  |      |
| Ethanol                          | 2238     |                |                |                 |                  |      |
| Ethylene                         | 2375     |                |                |                 |                  |      |
| Hexane                           | 2238     |                |                |                 |                  |      |
| Methane                          | 2236     |                |                |                 |                  |      |
| Methanol                         | 2222     |                |                |                 |                  |      |
| Oxirane                          | 2177     |                |                |                 |                  |      |
| Pentane                          | 2250     |                |                |                 |                  |      |
| Propane                          | 2250     |                |                |                 |                  |      |
| Toluene                          | 2344     |                |                |                 |                  |      |
| <i>Solids</i>                    |          |                |                |                 |                  |      |
| Aluminum                         |          | 4005           |                |                 |                  |      |
| Lithium                          |          | 2711           |                |                 |                  |      |
| Phosphorus (white)               |          | 3242           |                |                 |                  |      |
| Zirconium                        |          | 4278           |                |                 |                  |      |
| <i>Other</i>                     |          |                |                |                 |                  |      |
| Ammonia                          |          | 2845           |                |                 |                  |      |
| Carbon monoxide                  | 1388     |                |                |                 |                  |      |
| Diborane                         |          | 3350           |                |                 |                  |      |
| Hydrazine                        |          | 3037           |                |                 |                  |      |
| Hydrogen                         | 2169     | 3000           | 4006           | 2493            | 2965             | 3127 |
| Hydrogen sulfide                 | 2091     | 3414           |                |                 |                  |      |
| Phosphine                        |          | 3139           |                |                 |                  |      |
| Silane                           |          | 3043           |                |                 |                  |      |

## DENSITY OF ETHANOL-WATER MIXTURES

This table gives the density of mixtures of ethanol and water as a function of composition and temperature. The composition is specified in weight percent of ethanol, i.e., mass of ethanol per 100 g of solution. Values from the reference have been converted to true densities.

### Reference

Washburn, E. W., Ed., *International Critical Tables of Numerical Data of Physics, Chemistry, and Technology*, Vol. 3, McGraw-Hill, New York, 1926–1932.

| Weight %<br>Ethanol | Density in g/cm <sup>3</sup> |         |         |         |         |         |         |
|---------------------|------------------------------|---------|---------|---------|---------|---------|---------|
|                     | 10 °C                        | 15 °C   | 20 °C   | 25 °C   | 30 °C   | 35 °C   | 40 °C   |
| 0                   | 0.99970                      | 0.99910 | 0.99820 | 0.99705 | 0.99565 | 0.99403 | 0.99222 |
| 5                   | 0.99095                      | 0.99029 | 0.98935 | 0.98814 | 0.98667 | 0.98498 | 0.98308 |
| 10                  | 0.98390                      | 0.98301 | 0.98184 | 0.98040 | 0.97872 | 0.97682 | 0.97472 |
| 15                  | 0.97797                      | 0.97666 | 0.97511 | 0.97331 | 0.97130 | 0.96908 | 0.96667 |
| 20                  | 0.97249                      | 0.97065 | 0.96861 | 0.96636 | 0.96392 | 0.96131 | 0.95853 |
| 25                  | 0.96662                      | 0.96421 | 0.96165 | 0.95892 | 0.95604 | 0.95303 | 0.94988 |
| 30                  | 0.95974                      | 0.95683 | 0.95379 | 0.95064 | 0.94738 | 0.94400 | 0.94052 |
| 35                  | 0.95159                      | 0.94829 | 0.94491 | 0.94143 | 0.93787 | 0.93422 | 0.93048 |
| 40                  | 0.94235                      | 0.93879 | 0.93515 | 0.93145 | 0.92767 | 0.92382 | 0.91989 |
| 45                  | 0.93223                      | 0.92849 | 0.92469 | 0.92082 | 0.91689 | 0.91288 | 0.90881 |
| 50                  | 0.92159                      | 0.91773 | 0.91381 | 0.90982 | 0.90577 | 0.90165 | 0.89747 |
| 55                  | 0.91052                      | 0.90656 | 0.90255 | 0.89847 | 0.89434 | 0.89013 | 0.88586 |
| 60                  | 0.89924                      | 0.89520 | 0.89110 | 0.88696 | 0.88275 | 0.87848 | 0.87414 |
| 65                  | 0.88771                      | 0.88361 | 0.87945 | 0.87524 | 0.87097 | 0.86664 | 0.86224 |
| 70                  | 0.87599                      | 0.87184 | 0.86763 | 0.86337 | 0.85905 | 0.85467 | 0.85022 |
| 75                  | 0.86405                      | 0.85985 | 0.85561 | 0.85131 | 0.84695 | 0.84254 | 0.83806 |
| 80                  | 0.85194                      | 0.84769 | 0.84341 | 0.83908 | 0.83470 | 0.83027 | 0.82576 |
| 85                  | 0.83948                      | 0.83522 | 0.83093 | 0.82658 | 0.82218 | 0.81772 | 0.81320 |
| 90                  | 0.82652                      | 0.82225 | 0.81795 | 0.81360 | 0.80920 | 0.80476 | 0.80026 |
| 95                  | 0.81276                      | 0.80850 | 0.80422 | 0.79989 | 0.79553 | 0.79112 | 0.78668 |
| 100                 | 0.79782                      | 0.79358 | 0.78932 | 0.78504 | 0.78073 | 0.77639 | 0.77201 |

## MISCIBILITY OF ORGANIC SOLVENTS

The chart below gives qualitative information on the miscibility of pairs of organic liquids. Two liquids are considered miscible (indicated by **M** in the chart) if mixing equal volumes produces a single liquid phase. If two phases separate, they are considered immiscible (**I**). An entry of **P** indicates two phases whose volumes dif-

fer appreciably, suggesting a partial miscibility of the components. The symbol **R** indicates a reaction between the components. All data refer to room temperature.

The codes for the columns are:

**A** Acetone  
**B** Benzaldehyde  
**C** Benzene  
**D** Butyl acetate  
**E** Butyl alcohol  
**F** Carbon tetrachloride  
**G** 2-Chloroethanol  
**H** Chloroform  
**I** *o*-Cresol

**J** Diethyl ether  
**K** *N,N*-Dimethylaniline  
**L** Dipentylamine  
**M** Ethyl alcohol  
**N** Ethylene glycol  
**O** Ethylene glycol monoethyl ether  
**P** Formamide  
**Q** Furfuryl alcohol  
**R** Glycerol

**S** Methyl isopropyl ketone  
**T** Nitromethane  
**U** 1-Octanol  
**V** 1,3-Propanediol  
**W** Pyridine  
**X** Triethylenetetramine  
**Y** Triethyl phosphate

## References

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|                                    | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y |
|------------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acetone                            | - | M | M | M | M | M | M | M |   | M | M | M | M | M | M | M | M | I | M | M | M | M | M | M | M |
| Adiponitrile                       | M |   | M |   | M | I |   |   |   | I | M |   | M | I |   | M | M | I |   |   |   | M | M |   |   |
| 2-Amino-2-methyl-1- propanol       | M | M | M | M | M | M |   |   |   | M | M |   | M | M |   | M | M | M |   | M | M | M | M |   |   |
| <i>p</i> -Anisaldehyde             |   |   |   |   |   |   | M |   |   |   |   |   |   |   | I | M |   | I |   |   |   | I |   |   | M |
| Benzaldehyde                       | M | - | M | M | M | M |   |   |   | M | M |   | M | P |   | M | M | P |   | M | M | M | M |   |   |
| Benzene                            | M | M | - | M | M | M | M | M |   | M | M | M | M | I | M | I | M | I | M | I | M | I | M | M | M |
| Benzonitrile                       | M |   | M |   | M | M |   |   |   | M | M |   | M | I |   | I | M | I |   |   |   | I | M |   |   |
| Benzothiazole                      | M |   | M |   | M | M |   |   |   | M | M |   | M | M |   | I | M | I |   |   |   | M | M |   |   |
| Benzyl alcohol                     | M | M | M | M | M | M |   |   |   | M | M |   | M | M |   | M | M | M |   | M | M | M | M |   |   |
| Benzyl mercaptan                   | M |   | M |   | M | M |   |   |   | M | M |   | M | I |   | I | M | I |   |   |   | I | M |   |   |
| 2-Bromoethyl acetate               | M |   | P |   |   |   |   | M |   |   |   | R | M |   |   |   |   |   | M |   |   |   |   | R |   |
| 1,3-Butanediol                     | M |   | I |   |   |   |   | M | M | P |   | M | M |   |   |   |   |   | M |   |   |   | M | M |   |
| 2,3-Butanediol                     | M |   | P |   |   |   |   | M | M | M |   | M | M |   |   |   |   |   | M |   |   |   | M | M |   |
| Butyl acetate                      | M | M | M | - | M | M |   |   |   | M | M |   | M | P |   | I | M | I |   | M | M | P | M |   |   |
| Butyl alcohol                      | M | M | M | M | - | M |   |   |   | M | M |   | M | M |   | M | M | M |   | M | M | M | M |   |   |
| Carbon tetrachloride               | M | M | M | M | M | - |   |   |   | M | M |   | M | I |   | I | M | I |   | M | M | I | M |   |   |
| 2-Chloroethanol                    | M |   | M |   |   |   | - |   | M | M |   | M |   |   |   |   |   |   | M |   |   |   | M | M | M |
| Chloroform                         | M |   | M |   |   |   | M | - |   | M |   | M | M | P | M |   |   | I | M |   |   | M |   | M | M |
| 3-Chloro-1,2-propanediol           | M |   | I |   |   |   |   | M | M | M |   | R | M |   |   |   |   |   | M |   |   |   | M | R |   |
| Cinnamaldehyde                     | M |   | M |   |   |   | M | M |   |   |   | M | M | I | M |   |   | I | M |   |   | I |   | R | M |
| <i>o</i> -Cresol                   |   |   |   |   |   |   | M |   | - |   |   |   |   | M | M |   |   | M |   |   |   | M |   |   | M |
| Diacetone alcohol                  | M | M | P | M | M | P |   |   |   | M | M |   | M | M |   | M | M | I |   | M | M | M | M |   |   |
| Dibenzyl ether                     | M |   | M |   |   |   | M | M |   |   |   | M |   | I | M |   |   | I | M |   |   |   |   | M | M |
| Dibutylamine                       |   |   |   |   |   |   | R |   |   |   |   |   |   | M | M |   |   | P |   |   |   |   |   |   | M |
| Dibutyl carbonate                  | M |   | M |   |   |   |   | M |   |   |   | M | M |   |   |   |   |   | M |   |   |   |   | I |   |
| Dibutyl ether                      | M | M | M | M | M | M |   |   |   | M | M |   | M | I |   | I | M | I |   | I | M | I | M |   |   |
| Diethanolamine                     | M | I | I | I | M | I |   |   |   | I | P |   | M | M |   | M | M | M |   | I | M | M | M |   |   |
| Diethylacetic acid                 | M |   | M |   |   |   | M | M |   |   |   | R | M | M | M |   |   | I | M |   |   | M |   | R | M |
| Diethylene glycol dibutyl ether    | M |   | M |   |   |   | M | M | M |   |   | R | M |   |   |   |   |   | M |   |   |   | M |   |   |
| Diethylene glycol diethyl ether    | M |   | M |   |   |   | M | M | M |   |   | M | M |   |   |   |   |   | M |   |   |   | M | M |   |
| Diethylene glycol monobutyl ether  | M |   | M |   |   |   | M | M | M |   |   | M | M |   |   |   |   |   | M |   |   |   | M | M |   |
| Diethylene glycol monoethyl ether  | M |   | M |   |   |   | M | M | M |   |   | M | M |   |   |   |   |   | M |   |   |   | M | M |   |
| Diethylene glycol monomethyl ether | M |   | M |   |   |   | M |   | M |   |   | M | M |   |   |   |   |   | M |   |   |   | M | M |   |
| Diethylenetriamine                 | M |   | M |   |   |   | R | M |   |   |   | I | M | M | M |   |   | M | R |   |   |   |   | M | M |
| Diethyl ether                      | M | M | M | M | M | M | M | M |   | - | M | M | M | I | M | I | M | I | M | M | M | I | M | M | M |
| Diethylformamide                   | M |   | M |   |   |   | M | M |   |   |   | R | M | M | M |   |   | M | M |   |   | M |   | R | M |
| Dihexyl ether                      | M |   | M |   |   |   | M | M |   |   |   | M | M | I | M |   |   | I | M |   |   | I |   | I |   |

|                                  | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y |
|----------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diisobutyl ketone                | M |   | M |   |   |   | M | M |   |   |   | M | M | I | M |   |   | I | M |   |   | I |   | M | M |
| Diisopropylamine                 | M |   | M |   |   |   | R | M |   |   |   | M | M | M | M |   |   | M | M |   |   | M |   | M | M |
| <i>N,N</i> -Dimethylaniline      | M | M | M | M | M | M |   |   |   | M | - |   | M | I |   | I | M | I |   | M | M | I | M |   |   |
| Dipentylamine                    | M |   | M |   |   |   |   | M |   | M |   | - | M | P | M |   |   | P | M |   |   | M |   | I | M |
| <i>N,N</i> -Dipropylaniline      | M |   | M |   | M | M | M | M |   | M | M | M | M | I | M | I | M | I | M |   |   | I | M | M | M |
| Dipropylene glycol               | M |   | M |   |   |   | M | M | M | M |   |   | M |   |   |   |   |   | M |   |   |   | M | M |   |
| Ethyl alcohol                    | M | M | M | M | M | M |   | M |   | M | M | M | - | M | M | M | M | M | M | M | M | M | M | M | M |
| Ethyl benzoate                   | M | M | M | M | M | M |   | M |   | M | M | M | M | I |   | I | M | I | M | M | M | P | M | M |   |
| Ethyl chloroacetate              | M |   | M |   |   |   | M | M |   |   |   | M | M | I | M |   |   | I | M |   |   | I |   | R | M |
| Ethyl cinnamate                  | M |   | M |   |   |   |   | M |   |   |   | M | M | I | M |   |   | I | M |   |   | I |   | M | M |
| Ethylene glycol                  | M | P | I | P | M | I |   | P | M | I | I | P | M | - |   | M | M | M | I | I | M | M | M | M |   |
| Ethylene glycol monobutyl ether  | M |   | M |   |   |   |   | M | M | M |   | M | M |   |   |   |   |   | M |   |   |   | M | M |   |
| Ethylene glycol monoethyl ether  | M |   | M |   |   |   |   | M | M | M |   | M | M |   | - |   |   |   | M |   |   |   | M | M |   |
| Ethylene glycol monomethyl ether | M |   | M |   |   |   |   |   | M | M |   | M | M |   |   |   |   |   |   |   |   |   | M | M |   |
| 2-Ethyl-1-hexanol                | M | M | M | M | M | M |   |   |   | M | M |   | M | M |   | I | M | I |   | I | M | M | M |   |   |
| Ethyl phenylacetate              | M |   | M |   |   |   | M | M |   |   |   | M |   | I | M |   |   | I | M |   |   | I |   | M | M |
| Ethyl thiocyanate                | M |   | M |   | M | M |   |   |   | M | M |   | M | I |   | I | M | I |   |   |   | I | M |   |   |
| Formamide                        | M | M | I | I | M | I |   |   |   | I | I |   | M | M |   | - | M | M |   | M | I | M | M |   |   |
| Furfuryl alcohol                 | M | M | M | M | M | M |   |   |   | M | M |   | M | M |   | M | - | M |   | M | M | M | M |   |   |
| Glycerol                         | I | P | I | I | M | I |   | I | M | I | I | P | M | M |   | M | M | - | I | I | I | M | M | M |   |
| 1-Heptadecanol                   | M |   | M |   |   |   |   | M |   |   |   | M | M |   |   |   |   |   | M |   |   |   |   | M |   |
| 3-Heptanol                       | M |   | M |   |   |   | M | M |   |   |   | M | M | M | M |   |   | I |   |   |   | M |   | M | M |
| Heptyl acetate                   | M |   | M |   |   |   | M | M |   |   |   | M |   | I | M |   |   | I | M |   |   | I |   | R | M |
| Hexanenitrile                    | M |   | M |   |   |   | M | M |   |   |   | M | M | I | M |   |   | I | M |   |   | I |   | M | M |
| Isobutyl mercaptan               | M |   | M |   | M | M |   |   |   | M | M |   | M | I |   | I | M | I |   |   |   | R | M |   |   |
| Isopentyl acetate                | M |   | M |   |   |   | M | M |   |   |   | M | M | I | M |   |   | I | M |   |   | I |   | M | M |
| Isopentyl alcohol                | M | M | M | M | M | M |   |   |   | M | M |   | M | M |   | M | M | I |   | M | M | M | M |   |   |
| Isopentyl sulfide                | M |   | M |   | M | M |   |   |   | M | M |   | M | I |   | I | I | I |   |   |   | I | M |   |   |
| Methyl disulfide                 | M |   | M |   | M | M |   |   |   | M | M |   | M | I |   | I | M | I |   |   |   | R | M |   |   |
| Methyl isobutyl ketone           | M | M | M | M | M | M |   |   |   | M | M |   | M | I |   | P | M | I |   | M | M | I | M |   |   |
| Methyl isopropyl ketone          | M |   | M |   |   |   | M | M |   | M |   | M | M | I | M |   |   | I | - |   |   | M |   | R | M |
| 4-Methylpentanoic acid           | M |   | M |   |   |   |   | M |   |   |   | M | M | M | M |   |   | I | M |   |   | M |   | R | M |
| Nitromethane                     | M | M | I | M | M | M |   |   |   | M | M |   | M | I |   | M | M | I |   | - | P | I | M |   |   |
| 1-Octanol                        | M | M | M | M | M | M |   |   |   | M | M |   | M | M |   | I | M | I |   | P | - | M | M |   |   |
| <i>o</i> -Phenetidine            | M |   | M |   |   |   | M | M |   |   |   | M | M | M | M |   |   |   | M |   |   | M |   | M |   |
| 1,2-Propanediol                  | M |   | I |   |   |   |   | M | M | P |   | M | M |   |   |   |   |   | M |   |   |   | M | M |   |
| 1,3-Propanediol                  | M | M | I | P | M | I |   | M | M | I | I | M | M | M |   | M | M | M | M | I | M | - | M | M |   |
| Pyridine                         | M | M | M | M | M | M | M |   |   | M | M |   | M | M | M | M | M | M |   | M | M | M | - |   | M |
| Tetradecanol                     | M |   | M |   |   |   | M | M |   |   |   | M | M | I | M |   |   | I | M |   |   | P |   | M | M |
| Tributyl phosphate               | M |   | M |   |   |   | M | M |   |   |   | M | M | P | M |   |   | I | M |   |   | M |   | M | M |
| Triethylene glycol               | M |   | P |   |   |   |   | M | M | I |   | P | M |   |   |   |   |   | M |   |   |   | M | M |   |
| Triethylenetetramine             | M |   | M |   |   |   | M | M |   | M |   | I | M | M | M |   |   | M | R |   |   | M |   | - | M |
| Triethyl phosphate               | M |   | M |   |   |   |   | M | M | M |   | M | M |   |   |   |   |   | M |   |   |   | M | M | - |
| 2,6,8-Trimethyl-4-nonanone       | M |   | M |   |   |   | M | M |   |   |   | M | M | I | M |   |   | I | M |   |   | I |   | I | M |

# DENSITY OF SOLVENTS AS A FUNCTION OF TEMPERATURE

The table below lists the density of several common solvents in the temperature range from 0°C to 100°C. The values have been calculated from the Rackett Equation using parameters in the reference. Density values refer to the liquid at its saturation vapor pressure; thus entries for temperatures above the normal boiling point are for pressures greater than atmospheric.

## Reference

Lide, D. R., and Kehiaian, H. V., *Handbook of Thermophysical and Thermochemical Data*, CRC Press, Boca Raton, FL, 1994.

| Solvent                     | Density in g/mL |        |        |        |        |        |        |        |        |        |        |
|-----------------------------|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                             | 0°C             | 10°C   | 20°C   | 30°C   | 40°C   | 50°C   | 60°C   | 70°C   | 80°C   | 90°C   | 100°C  |
| Acetic acid                 |                 |        | 1.051  | 1.038  | 1.025  | 1.012  | 0.9993 | 0.9861 | 0.9728 | 0.9592 | 0.9454 |
| Acetone                     | 0.8129          | 0.8016 | 0.7902 | 0.7785 | 0.7666 | 0.7545 | 0.7421 | 0.7293 | 0.7163 | 0.7029 | 0.6890 |
| Acetonitrile                |                 |        | 0.7825 | 0.7707 | 0.7591 | 0.7473 | 0.7353 | 0.7231 | 0.7106 | 0.6980 | 0.6851 |
| Aniline                     | 1.041           | 1.033  | 1.025  | 1.016  | 1.008  | 1.000  | 0.9909 | 0.9823 | 0.9735 | 0.9646 | 0.9557 |
| Benzene                     |                 | 0.8884 | 0.8786 | 0.8686 | 0.8584 | 0.8481 | 0.8376 | 0.8269 | 0.8160 | 0.8049 | 0.7935 |
| 1-Butanol                   | 0.8293          | 0.8200 | 0.8105 | 0.8009 | 0.7912 | 0.7812 | 0.7712 | 0.7609 | 0.7504 | 0.7398 | 0.7289 |
| Butylamine                  | 0.7606          | 0.7512 | 0.7417 | 0.7320 | 0.7221 | 0.7120 | 0.7017 | 0.6911 | 0.6803 | 0.6693 | 0.6579 |
| Carbon disulfide            | 1.290           | 1.277  | 1.263  | 1.248  | 1.234  |        |        |        |        |        |        |
| Chlorobenzene               | 1.127           | 1.116  | 1.106  | 1.096  | 1.085  | 1.074  | 1.064  | 1.053  | 1.042  | 1.030  | 1.019  |
| Cyclohexane                 |                 | 0.7872 | 0.7784 | 0.7694 | 0.7602 | 0.7509 | 0.7414 | 0.7317 | 0.7218 | 0.7117 | 0.7013 |
| Decane                      | 0.7447          | 0.7374 | 0.7301 | 0.7226 | 0.7151 | 0.7074 | 0.6997 | 0.6919 | 0.6839 | 0.6758 | 0.6676 |
| 1-Decanol                   |                 |        | 0.8294 | 0.8229 | 0.8162 | 0.8093 | 0.8024 | 0.7955 | 0.7884 | 0.7813 | 0.7740 |
| Dichloromethane             | 1.362           | 1.344  | 1.326  | 1.307  | 1.289  | 1.269  | 1.250  | 1.229  | 1.208  | 1.187  | 1.165  |
| Diethyl ether               | 0.7368          | 0.7254 | 0.7137 | 0.7018 | 0.6896 | 0.6770 | 0.6639 | 0.6505 | 0.6366 | 0.6220 | 0.6068 |
| <i>N,N</i> -Dimethylaniline |                 | 0.9638 | 0.9562 | 0.9483 | 0.9401 | 0.9318 | 0.9234 | 0.9150 | 0.9064 | 0.8978 | 0.8890 |
| Ethanol                     | 0.8121          | 0.8014 | 0.7905 | 0.7793 | 0.7680 | 0.7564 | 0.7446 | 0.7324 | 0.7200 | 0.7073 | 0.6942 |
| Ethyl acetate               | 0.9245          | 0.9126 | 0.9006 | 0.8884 | 0.8759 | 0.8632 | 0.8503 | 0.8370 | 0.8234 | 0.8095 | 0.7952 |
| Ethylbenzene                | 0.8836          | 0.8753 | 0.8668 | 0.8582 | 0.8495 | 0.8407 | 0.8318 | 0.8228 | 0.8136 | 0.8043 | 0.7948 |
| Ethyl formate               | 0.9472          | 0.9346 | 0.9218 | 0.9087 | 0.8954 | 0.8818 | 0.8678 | 0.8535 | 0.8389 | 0.8238 | 0.8082 |
| Ethyl propanoate            | 0.9113          | 0.9005 | 0.8895 | 0.8784 | 0.8671 | 0.8556 | 0.8439 | 0.8319 | 0.8197 | 0.8072 | 0.7944 |
| Heptane                     | 0.7004          | 0.6921 | 0.6837 | 0.6751 | 0.6664 | 0.6575 | 0.6485 | 0.6393 | 0.6298 | 0.6202 | 0.6102 |
| Hexane                      | 0.6774          | 0.6685 | 0.6594 | 0.6502 | 0.6407 | 0.6311 | 0.6212 | 0.6111 | 0.6006 | 0.5899 | 0.5789 |
| 1-Hexanol                   | 0.8359          | 0.8278 | 0.8195 | 0.8111 | 0.8027 | 0.7941 | 0.7854 | 0.7766 | 0.7676 | 0.7585 | 0.7492 |
| Isopropylbenzene            | 0.8769          | 0.8696 | 0.8615 | 0.8533 | 0.8450 | 0.8366 | 0.8280 | 0.8194 | 0.8106 | 0.8017 | 0.7927 |
| Methanol                    | 0.8157          | 0.8042 | 0.7925 | 0.7807 | 0.7685 | 0.7562 | 0.7435 | 0.7306 | 0.7174 | 0.7038 | 0.6898 |
| Methyl acetate              | 0.9606          | 0.9478 | 0.9346 | 0.9211 | 0.9074 | 0.8933 | 0.8790 | 0.8643 | 0.8491 | 0.8336 | 0.8176 |
| <i>N</i> -Methylaniline     | 1.0010          | 0.9933 | 0.9859 | 0.9785 | 0.9709 | 0.9633 | 0.9556 | 0.9478 | 0.9399 | 0.9319 | 0.9239 |
| Methylcyclohexane           | 0.7858          | 0.7776 | 0.7693 | 0.7608 | 0.7522 | 0.7435 | 0.7346 | 0.7255 | 0.7163 | 0.7069 | 0.6973 |
| Methyl formate              | 1.003           | 0.9887 | 0.9739 | 0.9588 | 0.9433 | 0.9275 | 0.9112 | 0.8945 | 0.8772 | 0.8594 | 0.8409 |
| Methyl propanoate           | 0.9383          | 0.9268 | 0.9150 | 0.9030 | 0.8907 | 0.8783 | 0.8656 | 0.8526 | 0.8393 | 0.8257 | 0.8117 |
| Nitromethane                |                 |        | 1.139  | 1.125  | 1.111  | 1.097  | 1.083  | 1.069  | 1.055  | 1.040  | 1.026  |
| Nonane                      | 0.7327          | 0.7252 | 0.7176 | 0.7099 | 0.7021 | 0.6941 | 0.6861 | 0.6779 | 0.6696 | 0.6611 | 0.6525 |
| Octane                      | 0.7185          | 0.7106 | 0.7027 | 0.6945 | 0.6863 | 0.6779 | 0.6694 | 0.6608 | 0.6520 | 0.6430 | 0.6338 |
| Pentanoic acid              | 0.9563          | 0.9476 | 0.9389 | 0.9301 | 0.9211 | 0.9121 | 0.9029 | 0.8937 | 0.8843 | 0.8748 | 0.8652 |
| 1-Propanol                  | 0.8252          | 0.8151 | 0.8048 | 0.7943 | 0.7837 | 0.7729 | 0.7619 | 0.7506 | 0.7391 | 0.7273 | 0.7152 |
| 2-Propanol                  | 0.8092          | 0.7982 | 0.7869 | 0.7755 | 0.7638 | 0.7519 | 0.7397 | 0.7272 | 0.7143 | 0.7011 | 0.6876 |
| Propyl acetate              | 0.9101          | 0.8994 | 0.8885 | 0.8775 | 0.8662 | 0.8548 | 0.8432 | 0.8313 | 0.8192 | 0.8069 | 0.7942 |
| Propylbenzene               | 0.8779          | 0.8700 | 0.8619 | 0.8538 | 0.8456 | 0.8373 | 0.8289 | 0.8204 | 0.8117 | 0.8030 | 0.7943 |
| Propyl formate              | 0.9275          | 0.9166 | 0.9053 | 0.8938 | 0.8821 | 0.8702 | 0.8581 | 0.8457 | 0.8330 | 0.8201 | 0.8068 |
| Tetrachloromethane          | 1.629           | 1.611  | 1.593  | 1.575  | 1.557  | 1.538  | 1.518  | 1.499  | 1.479  | 1.458  | 1.437  |
| Toluene                     | 0.8846          | 0.8757 | 0.8667 | 0.8576 | 0.8483 | 0.8389 | 0.8294 | 0.8197 | 0.8098 | 0.7998 | 0.7896 |
| Trichloromethane            | 1.524           | 1.507  | 1.489  | 1.471  | 1.452  | 1.433  | 1.414  | 1.394  |        |        |        |
| 2,2,4-Trimethylpentane      |                 |        | 0.6921 | 0.6836 | 0.6750 | 0.6663 | 0.6574 | 0.6484 | 0.6391 | 0.6296 | 0.6199 |
| <i>o</i> -Xylene            |                 |        | 0.8801 | 0.8717 | 0.8633 | 0.8547 | 0.8460 | 0.8372 | 0.8282 | 0.8191 | 0.8099 |
| <i>m</i> -Xylene            | 0.8813          | 0.8729 | 0.8644 | 0.8558 | 0.8470 | 0.8382 | 0.8292 | 0.8201 | 0.8109 | 0.8015 | 0.7920 |
| <i>p</i> -Xylene            |                 |        | 0.8609 | 0.8523 | 0.8436 | 0.8347 | 0.8258 | 0.8167 | 0.8075 | 0.7981 | 0.7886 |



## COEFFICIENT OF FRICTION

The coefficient of friction between two surfaces is the ratio of the force required to move one over the other to the force pressing the two together. Thus if  $F$  is the minimum force needed to move one surface over the other, and  $W$  is the force pressing the surfaces together, the coefficient of friction  $\mu$  is given by  $\mu = F/W$ . A greater force is generally needed to initiate movement from rest than to continue the motion once sliding has started. Thus the static coefficient of friction  $\mu(\text{static})$  is usually larger than the sliding or kinetic coefficient  $\mu(\text{sliding})$ .

This table gives characteristic values of both the static and sliding coefficients of friction for a number of material combinations. In each case Material 1 is moving over the surface of Material 2.

The type of lubrication or any other special condition is indicated in the third column. All values refer to room temperature unless otherwise indicated. It should be emphasized that the coefficient of friction is very sensitive to the condition of the surface, so that these values represent only a rough guide.

### References

1. Minshall, H., in *CRC Handbook of Chemistry and Physics, 73rd Edition*, Lide, D. R., Ed., CRC Press, Boca Raton, FL, 1992.
2. Fuller, D. D., in *American Institute of Physics Handbook, 3rd Edition*, Gray, D. E., Ed., McGraw-Hill, New York, 1972.

| Material 1       | Material 2      | Conditions        | $\mu(\text{static})$ | $\mu(\text{sliding})$ |
|------------------|-----------------|-------------------|----------------------|-----------------------|
| <b>Metals</b>    |                 |                   |                      |                       |
| Hard steel       | Hard steel      | Dry               | 0.78                 | 0.42                  |
|                  |                 | Castor oil        | 0.15                 | 0.081                 |
|                  |                 | Steric acid       | 0.005                | 0.029                 |
|                  |                 | Lard              | 0.11                 | 0.084                 |
|                  |                 | Light mineral oil | 0.23                 |                       |
|                  |                 | Graphite          |                      | 0.058                 |
| Hard steel       | Graphite        | Dry               | 0.21                 |                       |
| Mild steel       | Mild steel      | Dry               | 0.74                 | 0.57                  |
|                  |                 | Oleic acid        |                      | 0.09                  |
| Mild steel       | Phosphor bronze | Dry               |                      | 0.34                  |
| Mild steel       | Cast iron       | Dry               |                      | 0.23                  |
| Mild steel       | Lead            | Dry               | 0.95                 | 0.95                  |
|                  |                 | Mineral oil       | 0.5                  | 0.3                   |
| Mild steel       | Brass           | Dry               | 0.35                 |                       |
| Cast iron        | Cast iron       | Dry               | 1.10                 | 0.15                  |
| Aluminum         | Aluminum        | Dry               | 1.05                 | 1.4                   |
| Aluminum         | Mild steel      | Dry               | 0.61                 | 0.47                  |
| Brass            | Mild steel      | Dry               | 0.51                 | 0.44                  |
|                  |                 | Castor oil        | 0.11                 |                       |
| Brass            | Cast iron       | Dry               |                      | 0.30                  |
| Bronze           | Cast iron       | Dry               |                      | 0.22                  |
| Cadmium          | Mild steel      | Dry               |                      | 0.46                  |
| Copper           | Copper          | Dry               | 1.6                  |                       |
| Copper           | Mild steel      | Dry               | 0.53                 | 0.36                  |
|                  |                 | Oleic acid        |                      | 0.18                  |
|                  |                 |                   |                      |                       |
| Copper           | Cast iron       | Dry               | 1.05                 | 0.29                  |
| Copper           | Glass           | Dry               | 0.68                 | 0.53                  |
| Lead             | Cast iron       | Dry               |                      | 0.43                  |
| Magnesium        | Magnesium       | Dry               | 0.6                  |                       |
| Magnesium        | Mild steel      | Dry               |                      | 0.42                  |
| Magnesium        | Cast iron       | Dry               |                      | 0.25                  |
| Nickel           | Nickel          | Dry               | 1.10                 | 0.53                  |
| Nickel           | Mild steel      | Dry               |                      | 0.64                  |
| Tin              | Cast iron       | Dry               |                      | 0.32                  |
| Zinc             | Cast iron       | Dry               | 0.85                 | 0.21                  |
| <b>Nonmetals</b> |                 |                   |                      |                       |
| Diamond          | Diamond         | Dry               | 0.1                  |                       |
| Diamond          | Metals          | Dry               | 0.12                 |                       |
| Garnet           | Mild steel      | Dry               |                      | 0.39                  |
| Glass            | Glass           | Dry               | 0.94                 | 0.4                   |
| Glass            | Nickel          | Dry               | 0.78                 | 0.56                  |

| Material 1                               | Material 2       | Conditions             | μ(static) | μ(sliding) |
|------------------------------------------|------------------|------------------------|-----------|------------|
| Graphite                                 | Graphite         | Dry                    | 0.1       |            |
| Mica                                     | Mica             | Freshly cleaved        | 1.0       |            |
| Nylon                                    | Nylon            | Dry                    | 0.2       |            |
| Nylon                                    | Steel            | Dry                    | 0.40      |            |
| Polyethylene                             | Polyethylene     | Dry                    | 0.2       |            |
| Polyethylene                             | Steel            | Dry                    | 0.2       |            |
| Polystyrene                              | Polystyrene      | Dry                    | 0.5       |            |
| Polystyrene                              | Steel            | Dry                    | 0.3       |            |
| Sapphire                                 | Sapphire         | Dry                    | 0.2       |            |
| Teflon                                   | Teflon           | Dry                    | 0.04      | 0.04       |
| Teflon                                   | Steel            | Dry                    | 0.04      | 0.04       |
| Tungsten carbide                         | Tungsten carbide | Dry, room temp.        | 0.17      |            |
|                                          |                  | Dry, 1000°C            | 0.45      |            |
|                                          |                  | Dry, 1600°C            | 1.8       |            |
|                                          |                  | Oleic acid             | 0.12      |            |
| Tungsten carbide                         | Graphite         | Dry                    | 0.15      |            |
| Tungsten carbide                         | Steel            | Dry                    | 0.5       |            |
|                                          |                  | Oleic acid             | 0.08      |            |
| <i>Miscellaneous materials</i>           |                  |                        |           |            |
| Cotton                                   | Cotton           | Threads                | 0.3       |            |
| Leather                                  | Cast iron        | Dry                    | 0.6       | 0.56       |
| Leather                                  | Oak              | Parallel to grain      | 0.61      | 0.52       |
| Oak                                      | Oak              | Parallel to grain      | 0.62      | 0.48       |
|                                          |                  | Perpendicular to grain | 0.54      | 0.32       |
| Silk                                     | Silk             | Clean                  | 0.25      |            |
| Wood                                     | Wood             | Dry                    | 0.35      |            |
|                                          |                  | Wet                    | 0.2       |            |
| Wood                                     | Brick            | Dry                    | 0.6       |            |
| Wood                                     | Leather          | Dry                    | 0.35      |            |
| <i>Various materials on ice and snow</i> |                  |                        |           |            |
| Ice                                      | Ice              | Clean, 0°C             | 0.1       | 0.02       |
|                                          |                  | Clean, -12°C           | 0.3       | 0.035      |
|                                          |                  | Clean, -80°C           | 0.5       | 0.09       |
| Aluminum                                 | Snow             | Wet, 0°C               | 0.4       |            |
|                                          |                  | Dry, 0°C               | 0.35      |            |
| Brass                                    | Ice              | Clean, 0°C             |           | 0.02       |
|                                          |                  | Clean, -80°C           |           | 0.15       |
| Nylon                                    | Snow             | Wet, 0°C               | 0.4       |            |
|                                          |                  | Dry, -10°C             | 0.3       |            |
| Teflon                                   | Snow             | Wet, 0°C               | 0.05      |            |
|                                          |                  | Dry, 0°C               | 0.02      |            |
| Wax, ski                                 | Snow             | Wet, 0°C               | 0.1       |            |
|                                          |                  | Dry, 0°C               | 0.04      |            |
|                                          |                  | Dry, -10°C             | 0.2       |            |

## SECONDARY REFERENCE POINTS ON THE ITS-90 TEMPERATURE SCALE

The International Temperature Scale of 1990 is described in Section 1 of this *Handbook*, where the defining fixed points are listed. The Consultative Committee on Thermometry (CCT) of the International Committee on Weights and Measures (CIPM), which oversees the temperature scale, has recommended a number of secondary reference points whose values have been accurately determined with respect to the primary fixed points. The most accurate of these, referred to as “first quality points,” satisfy several criteria involving purity of the material, reproducibility, and documentation of the measurements. The CCT also lists “second quality points” that do not yet satisfy all the criteria but are still useful. Taken together,

these secondary reference points, help fill in the gaps between the primary fixed points.

The table below describes these secondary reference points. The best values resulting from the CCT evaluation are listed on both the Kelvin and Celsius scales, along with an estimate of uncertainty. Full details are given in the reference.

The entries within each quality group are listed in order of increasing temperature.

### Reference

Bedford, R. E., Bonnier, G., Maas, H., and Pavese, F., *Metrologia* 33, 133, 1996.

| Substance                    | Type of Transition                       | $T_{90}/\text{K}$ | $t_{90}/^{\circ}\text{C}$ | Uncert. |
|------------------------------|------------------------------------------|-------------------|---------------------------|---------|
| <i>First quality points</i>  |                                          |                   |                           |         |
| Zinc                         | Superconductive transition               | 0.8500            | -272.300                  | 0.0030  |
| Aluminum                     | Superconductive transition               | 1.1810            | -271.9690                 | 0.0025  |
| Helium ( $^4\text{He}$ )     | Superfluid transition                    | 2.1768            | -270.9732                 | 0.0001  |
| Indium                       | Superconductive transition               | 3.4145            | -269.7355                 | 0.0025  |
| Lead                         | Superconductive transition               | 7.1997            | -265.9503                 | 0.0025  |
| Niobium                      | Superconductive transition               | 9.2880            | -263.8620                 | 0.0025  |
| Deuterium ( $^2\text{H}_2$ ) | Triple point (equilibrium $\text{D}_2$ ) | 18.689            | -254.461                  | 0.001   |
| Deuterium ( $^2\text{H}_2$ ) | Triple point (normal $\text{D}_2$ )      | 18.724            | -254.426                  | 0.001   |
| Neon ( $^{20}\text{Ne}$ )    | Triple point                             | 24.541            | -248.609                  | 0.001   |
| Neon                         | Boiling point                            | 27.097            | -246.053                  | 0.001   |
| Nitrogen                     | Triple point                             | 63.151            | -209.999                  | 0.001   |
| Nitrogen                     | Boiling point                            | 77.352            | -195.798                  | 0.002   |
| Argon                        | Boiling point                            | 87.303            | -185.847                  | 0.001   |
| Oxygen                       | Condensation point                       | 90.197            | -182.953                  | 0.001   |
| Methane                      | Triple point                             | 90.694            | -182.456                  | 0.001   |
| Xenon                        | Triple point                             | 161.405           | -111.745                  | 0.001   |
| Carbon dioxide               | Triple point                             | 216.592           | -56.558                   | 0.001   |
| Mercury                      | Freezing point                           | 234.3210          | -38.8290                  | 0.0005  |
| Water                        | Ice point                                | 273.15            | 0                         |         |
| Gallium                      | Triple point                             | 302.9166          | 29.7666                   | 0.0001  |
| Water                        | Boiling point                            | 373.124           | 99.974                    | 0.001   |
| Indium                       | Triple point                             | 429.7436          | 156.5936                  | 0.0002  |
| Bismuth                      | Freezing point                           | 544.552           | 271.402                   | 0.001   |
| Cadmium                      | Freezing point                           | 594.219           | 321.069                   | 0.001   |
| Lead                         | Freezing point                           | 600.612           | 327.462                   | 0.001   |
| Antimony                     | Freezing point                           | 903.778           | 630.628                   | 0.001   |
| Copper/71.9% silver          | Eutectic melting point                   | 1052.78           | 779.63                    | 0.05    |
| Palladium                    | Freezing point                           | 1828.0            | 1554.8                    | 0.1     |
| Platinum                     | Freezing point                           | 2041.3            | 1768.2                    | 0.4     |
| Rhodium                      | Freezing point                           | 2236              | 1963                      | 3       |
| Iridium                      | Freezing point                           | 2719              | 2446                      | 6       |
| Molybdenum                   | Melting point                            | 2895              | 2622                      | 4       |
| Tungsten                     | Melting point                            | 3687              | 3414                      | 7       |
| <i>Second quality points</i> |                                          |                   |                           |         |
| Hydrogen                     | Triple point (normal $\text{H}_2$ )      | 13.952            | -259.198                  | 0.002   |
| Hydrogen                     | Boiling point (normal $\text{H}_2$ )     | 20.388            | -252.762                  | 0.002   |
| Oxygen                       | $\alpha$ - $\beta$ transition            | 23.868            | -249.282                  | 0.005   |
| Nitrogen                     | $\alpha$ - $\beta$ transition            | 35.614            | -237.536                  | 0.006   |
| Oxygen                       | $\beta$ - $\gamma$ transition            | 43.796            | -229.354                  | 0.001   |
| Krypton                      | Triple point                             | 115.775           | -157.375                  | 0.001   |
| Carbon dioxide               | Sublimation point                        | 194.686           | -78.464                   | 0.003   |

| Substance             | Type of Transition     | $T_{90}/\text{K}$ | $t_{90}/^{\circ}\text{C}$ | Uncert. |
|-----------------------|------------------------|-------------------|---------------------------|---------|
| Sulfur hexafluoride   | Triple point           | 223.554           | -49.596                   | 0.005   |
| Gallium/20% indium    | Eutectic melting point | 288.800           | 15.650                    | 0.001   |
| Gallium/8% tin        | Eutectic melting point | 293.626           | 20.476                    | 0.002   |
| Diphenyl ether        | Triple point           | 300.014           | 26.864                    | 0.001   |
| Ethylene carbonate    | Triple point           | 309.465           | 36.315                    | 0.001   |
| Succinonitrile        | Triple point           | 331.215           | 58.065                    | 0.002   |
| Sodium                | Freezing point         | 370.944           | 97.794                    | 0.005   |
| Benzoic acid          | Triple point           | 395.486           | 122.336                   | 0.002   |
| Benzoic acid          | Freezing point         | 395.502           | 122.352                   | 0.007   |
| Mercury               | Boiling point          | 629.769           | 356.619                   | 0.004   |
| Sulfur                | Boiling point          | 717.764           | 444.614                   | 0.002   |
| Copper/66.9% aluminum | Eutectic melting point | 840.957           | 567.807                   | 0.010   |
| Silver/30% aluminum   | Eutectic melting point | 840.957           | 567.807                   | 0.002   |
| Sodium chloride       | Freezing point         | 1075.168          | 802.018                   | 0.011   |
| Sodium                | Boiling point          | 1156.090          | 882.940                   | 0.005   |
| Nickel                | Freezing point         | 1728              | 1455                      | 1       |
| Cobalt                | Freezing point         | 1768              | 1495                      | 3       |
| Iron                  | Freezing point         | 1811              | 1538                      | 3       |
| Titanium              | Melting point          | 1943              | 1670                      | 2       |
| Zirconium             | Melting point          | 2127              | 1854                      | 8       |
| Aluminum oxide        | Melting point          | 2326              | 2053                      | 2       |
| Ruthenium             | Melting point          | 2606              | 2333                      | 10      |

## DENSITY OF SULFURIC ACID

This table gives the density of aqueous sulfuric acid solutions as a function of concentration (in mass percent of  $\text{H}_2\text{SO}_4$ ) and temperature.

| Mass % | Density in g/mL |        |        |        |        |        |        |        |        |        |        |
|--------|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|        | 0°C             | 10°C   | 15°C   | 20°C   | 25°C   | 30°C   | 40°C   | 50°C   | 60°C   | 80°C   | 100°C  |
| 1      | 1.0074          | 1.0068 | 1.0060 | 1.0051 | 1.0038 | 1.0022 | 0.9986 | 0.9944 | 0.9895 | 0.9779 | 0.9645 |
| 2      | 1.0147          | 1.0138 | 1.0129 | 1.0118 | 1.0104 | 1.0087 | 1.0050 | 1.0006 | 0.9956 | 0.9839 | 0.9705 |
| 3      | 1.0219          | 1.0206 | 1.0197 | 1.0184 | 1.0169 | 1.0152 | 1.0113 | 1.0067 | 1.0017 | 0.9900 | 0.9766 |
| 4      | 1.0291          | 1.0275 | 1.0264 | 1.0250 | 1.0234 | 1.0216 | 1.0176 | 1.0129 | 1.0078 | 0.9961 | 0.9827 |
| 5      | 1.0364          | 1.0344 | 1.0332 | 1.0317 | 1.0300 | 1.0281 | 1.0240 | 1.0192 | 1.0140 | 1.0022 | 0.9888 |
| 6      | 1.0437          | 1.0414 | 1.0400 | 1.0385 | 1.0367 | 1.0347 | 1.0305 | 1.0256 | 1.0203 | 1.0084 | 0.9950 |
| 7      | 1.0511          | 1.0485 | 1.0469 | 1.0453 | 1.0434 | 1.0414 | 1.0371 | 1.0321 | 1.0266 | 1.0146 | 1.0013 |
| 8      | 1.0585          | 1.0556 | 1.0539 | 1.0522 | 1.0502 | 1.0481 | 1.0437 | 1.0386 | 1.0330 | 1.0209 | 1.0076 |
| 9      | 1.0660          | 1.0628 | 1.0610 | 1.0591 | 1.0571 | 1.0549 | 1.0503 | 1.0451 | 1.0395 | 1.0273 | 1.0140 |
| 10     | 1.0735          | 1.0700 | 1.0681 | 1.0661 | 1.0640 | 1.0617 | 1.0570 | 1.0517 | 1.0460 | 1.0338 | 1.0204 |
| 12     | 1.0886          | 1.0846 | 1.0825 | 1.0802 | 1.0780 | 1.0756 | 1.0705 | 1.0651 | 1.0593 | 1.0469 | 1.0335 |
| 14     | 1.1039          | 1.0994 | 1.0971 | 1.0947 | 1.0922 | 1.0897 | 1.0844 | 1.0788 | 1.0729 | 1.0603 | 1.0469 |
| 16     | 1.1194          | 1.1145 | 1.1120 | 1.1094 | 1.1067 | 1.1040 | 1.0985 | 1.0927 | 1.0868 | 1.0740 | 1.0605 |
| 18     | 1.1351          | 1.1298 | 1.1271 | 1.1243 | 1.1215 | 1.1187 | 1.1129 | 1.1070 | 1.1009 | 1.0879 | 1.0744 |
| 20     | 1.1510          | 1.1453 | 1.1424 | 1.1394 | 1.1365 | 1.1335 | 1.1275 | 1.1215 | 1.1153 | 1.1021 | 1.0885 |
| 22     | 1.1670          | 1.1609 | 1.1579 | 1.1548 | 1.1517 | 1.1486 | 1.1424 | 1.1362 | 1.1299 | 1.1166 | 1.1029 |
| 24     | 1.1832          | 1.1768 | 1.1736 | 1.1704 | 1.1672 | 1.1640 | 1.1576 | 1.1512 | 1.1448 | 1.1313 | 1.1176 |
| 26     | 1.1996          | 1.1929 | 1.1896 | 1.1862 | 1.1829 | 1.1796 | 1.1730 | 1.1665 | 1.1599 | 1.1463 | 1.1325 |
| 28     | 1.2160          | 1.2091 | 1.2057 | 1.2023 | 1.1989 | 1.1955 | 1.1887 | 1.1820 | 1.1753 | 1.1616 | 1.1476 |
| 30     | 1.2326          | 1.2255 | 1.2220 | 1.2185 | 1.2150 | 1.2115 | 1.2046 | 1.1977 | 1.1909 | 1.1771 | 1.1630 |
| 32     | 1.2493          | 1.2421 | 1.2385 | 1.2349 | 1.2314 | 1.2278 | 1.2207 | 1.2137 | 1.2068 | 1.1928 | 1.1787 |
| 34     | 1.2661          | 1.2588 | 1.2552 | 1.2515 | 1.2479 | 1.2443 | 1.2371 | 1.2300 | 1.2229 | 1.2088 | 1.1946 |
| 36     | 1.2831          | 1.2757 | 1.2720 | 1.2684 | 1.2647 | 1.2610 | 1.2538 | 1.2466 | 1.2394 | 1.2251 | 1.2109 |
| 38     | 1.3004          | 1.2929 | 1.2891 | 1.2855 | 1.2818 | 1.2780 | 1.2707 | 1.2635 | 1.2561 | 1.2418 | 1.2276 |
| 40     | 1.3179          | 1.3103 | 1.3065 | 1.3028 | 1.2991 | 1.2953 | 1.2880 | 1.2806 | 1.2732 | 1.2589 | 1.2446 |
| 42     | 1.3357          | 1.3280 | 1.3242 | 1.3205 | 1.3167 | 1.3129 | 1.3055 | 1.2981 | 1.2907 | 1.2762 | 1.2619 |
| 44     | 1.3538          | 1.3461 | 1.3423 | 1.3384 | 1.3346 | 1.3308 | 1.3234 | 1.3160 | 1.3086 | 1.2939 | 1.2796 |
| 46     | 1.3724          | 1.3646 | 1.3608 | 1.3569 | 1.3530 | 1.3492 | 1.3417 | 1.3343 | 1.3269 | 1.3120 | 1.2976 |
| 48     | 1.3915          | 1.3835 | 1.3797 | 1.3758 | 1.3719 | 1.3680 | 1.3604 | 1.3528 | 1.3455 | 1.3305 | 1.3159 |
| 50     | 1.4110          | 1.4029 | 1.3990 | 1.3951 | 1.3911 | 1.3872 | 1.3795 | 1.3719 | 1.3644 | 1.3494 | 1.3348 |
| 52     | 1.4310          | 1.4228 | 1.4188 | 1.4148 | 1.4109 | 1.4069 | 1.3991 | 1.3914 | 1.3837 | 1.3687 | 1.3540 |
| 54     | 1.4515          | 1.4431 | 1.4391 | 1.4350 | 1.4310 | 1.4270 | 1.4191 | 1.4113 | 1.4036 | 1.3884 | 1.3735 |
| 56     | 1.4724          | 1.4640 | 1.4598 | 1.4557 | 1.4516 | 1.4475 | 1.4396 | 1.4317 | 1.4239 | 1.4085 | 1.3934 |
| 58     | 1.4937          | 1.4852 | 1.4809 | 1.4768 | 1.4726 | 1.4685 | 1.4604 | 1.4524 | 1.4446 | 1.4290 | 1.4137 |
| 60     | 1.5154          | 1.5067 | 1.5024 | 1.4983 | 1.4940 | 1.4898 | 1.4816 | 1.4735 | 1.4656 | 1.4497 | 1.4344 |
| 62     | 1.5375          | 1.5287 | 1.5243 | 1.5200 | 1.5157 | 1.5115 | 1.5031 | 1.4950 | 1.4869 | 1.4708 | 1.4554 |
| 64     | 1.5600          | 1.5510 | 1.5465 | 1.5421 | 1.5378 | 1.5335 | 1.5250 | 1.5167 | 1.5086 | 1.4923 | 1.4766 |
| 66     | 1.5828          | 1.5736 | 1.5691 | 1.5646 | 1.5602 | 1.5558 | 1.5472 | 1.5388 | 1.5305 | 1.5140 | 1.4981 |
| 68     | 1.6059          | 1.5965 | 1.5920 | 1.5874 | 1.5829 | 1.5785 | 1.5697 | 1.5611 | 1.5528 | 1.5359 | 1.5198 |
| 70     | 1.6293          | 1.6198 | 1.6151 | 1.6105 | 1.6059 | 1.6014 | 1.5925 | 1.5838 | 1.5753 | 1.5582 | 1.5417 |
| 72     | 1.6529          | 1.6433 | 1.6385 | 1.6338 | 1.6292 | 1.6246 | 1.6155 | 1.6067 | 1.5981 | 1.5806 | 1.5637 |
| 74     | 1.6768          | 1.6670 | 1.6622 | 1.6574 | 1.6526 | 1.6480 | 1.6387 | 1.6297 | 1.6209 | 1.6031 | 1.5857 |
| 76     | 1.7008          | 1.6908 | 1.6858 | 1.6810 | 1.6761 | 1.6713 | 1.6619 | 1.6526 | 1.6435 | 1.6252 | 1.6074 |
| 78     | 1.7247          | 1.7144 | 1.7093 | 1.7043 | 1.6994 | 1.6944 | 1.6847 | 1.6751 | 1.6657 | 1.6469 | 1.6286 |
| 80     | 1.7482          | 1.7376 | 1.7323 | 1.7272 | 1.7221 | 1.7170 | 1.7069 | 1.6971 | 1.6873 | 1.6680 | 1.6493 |
| 82     | 1.7709          | 1.7599 | 1.7544 | 1.7491 | 1.7437 | 1.7385 | 1.7281 | 1.7180 | 1.7080 | 1.6882 | 1.6692 |
| 84     | 1.7916          | 1.7804 | 1.7748 | 1.7693 | 1.7639 | 1.7585 | 1.7479 | 1.7375 | 1.7274 | 1.7072 | 1.6878 |
| 86     | 1.8095          | 1.7983 | 1.7927 | 1.7872 | 1.7818 | 1.7763 | 1.7657 | 1.7552 | 1.7449 | 1.7245 | 1.7050 |
| 88     | 1.8243          | 1.8132 | 1.8077 | 1.8022 | 1.7968 | 1.7914 | 1.7809 | 1.7705 | 1.7602 | 1.7397 | 1.7202 |
| 90     | 1.8361          | 1.8252 | 1.8198 | 1.8144 | 1.8091 | 1.8038 | 1.7933 | 1.7829 | 1.7729 | 1.7525 | 1.7331 |
| 91     | 1.8410          | 1.8302 | 1.8248 | 1.8195 | 1.8142 | 1.8090 | 1.7986 | 1.7883 | 1.7783 | 1.7581 | 1.7388 |
| 92     | 1.8453          | 1.8346 | 1.8293 | 1.8240 | 1.8188 | 1.8136 | 1.8033 | 1.7932 | 1.7832 | 1.7633 | 1.7439 |
| 93     | 1.8490          | 1.8384 | 1.8331 | 1.8279 | 1.8227 | 1.8176 | 1.8074 | 1.7974 | 1.7876 | 1.7681 | 1.7485 |
| 94     | 1.8520          | 1.8415 | 1.8363 | 1.8312 | 1.8260 | 1.8210 | 1.8109 | 1.8011 | 1.7914 |        |        |
| 95     | 1.8544          | 1.8439 | 1.8388 | 1.8337 | 1.8286 | 1.8236 | 1.8137 | 1.8040 | 1.7944 |        |        |
| 96     | 1.8560          | 1.8457 | 1.8406 | 1.8355 | 1.8305 | 1.8255 | 1.8157 | 1.8060 | 1.7965 |        |        |
| 97     | 1.8569          | 1.8466 | 1.8414 | 1.8364 | 1.8314 | 1.8264 | 1.8166 | 1.8071 | 1.7977 |        |        |
| 98     | 1.8567          | 1.8463 | 1.8411 | 1.8361 | 1.8310 | 1.8261 | 1.8163 | 1.8068 | 1.7976 |        |        |
| 99     | 1.8551          | 1.8445 | 1.8393 | 1.8342 | 1.8292 | 1.8242 | 1.8145 | 1.8050 | 1.7958 |        |        |
| 100    | 1.8517          | 1.8409 | 1.8357 | 1.8305 | 1.8255 | 1.8205 | 1.8107 | 1.8013 | 1.7922 |        |        |

# RELATIVE SENSITIVITY OF BAYARD-ALPERT IONIZATION GAUGES TO VARIOUS GASES

Paul Redhead

The ion current  $I_+$  in a hot-cathode ionization gauge is given by  $I_+ = KI_e P$ . The gauge constant is  $K = (I_+/I_e)(1/P)$ , where  $I_e$  is the electron current, and  $P$  the pressure. The sensitivity is given by  $S = KI_e = I_+/P$ . The constant  $K$  is independent of pressure below about  $10^{-3}$  Pa.

Relative sensitivities for different Bayard-Alpert ionization gauges may differ by as much as  $\pm 15\%$  as a result of differences in applied voltages, electron current, and electrode structure. The table below presents the average of the measurements of 12 experimenters on Bayard-Alpert ionization gauges in various gases. The sensitivity relative to nitrogen is tabulated.

| Gas                          |                                | Relative sensitivity<br>$S/S(N_2)$ |
|------------------------------|--------------------------------|------------------------------------|
| Helium                       | He                             | 0.18                               |
| Neon                         | Ne                             | 0.31                               |
| Argon                        | Ar                             | 1.4                                |
| Krypton                      | Kr                             | 1.9                                |
| Xenon                        | Xe                             | 2.7                                |
| Nitrogen                     | N <sub>2</sub>                 | 1.00                               |
| Hydrogen                     | H <sub>2</sub>                 | 0.43                               |
| Oxygen                       | O <sub>2</sub>                 | 0.96                               |
| Carbon monoxide              | CO                             | 1.0                                |
| Carbon dioxide               | CO <sub>2</sub>                | 1.4                                |
| Water                        | H <sub>2</sub> O               | 0.93                               |
| Sulfur hexafluoride          | SF <sub>6</sub>                | 2.3                                |
| Mercury                      | Hg                             | 3.5                                |
| Methane                      | CH <sub>4</sub>                | 1.6                                |
| Ethane                       | C <sub>2</sub> H <sub>6</sub>  | 2.6                                |
| Propane                      | C <sub>3</sub> H <sub>8</sub>  | 3.5                                |
| Butane                       | C <sub>4</sub> H <sub>10</sub> | 4.3                                |
| Ethene                       | C <sub>2</sub> H <sub>4</sub>  | 1.3                                |
| Propene                      | C <sub>3</sub> H <sub>6</sub>  | 1.8                                |
| Acetylene                    | C <sub>2</sub> H <sub>2</sub>  | 0.61                               |
| Allene                       | C <sub>3</sub> H <sub>4</sub>  | 1.3                                |
| 1-Propyne (Methyl acetylene) | C <sub>3</sub> H <sub>4</sub>  | 1.4                                |
| Benzene                      | C <sub>6</sub> H <sub>6</sub>  | 3.8                                |

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- Hollanda, R., *J. Vac. Sci. Technol.*, **10**, 1133, 1973.
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- Tilford, C. R., *J. Vac. Sci. Technol. A*, **1**, 152, 1983.
- Tilford, C. R., in *Physical Methods of Chemistry*, vol. 6, *Determination of Thermodynamic Properties*, B. W. Rossiter and R. C. Baetzold, Eds., pp. 101-173, John Wiley, New York, 1992.

# HANDLING AND DISPOSAL OF CHEMICALS IN LABORATORIES

## Robert Joyce and Blaine C. McKusick

The following material has been extracted from two books prepared under the auspices of the Committee on Hazardous Substances in the Laboratory of the National Academy of Sciences – National Research Council. Readers are referred to these books for full details:

*Prudent Practices for Handling Hazardous Chemicals in Laboratories*, National Academy Press, Washington, 1981.

*Prudent Practices for Disposal of Chemicals from Laboratories*, National Academy Press, Washington, 1983.

The permission of the National Academy Press to use these extracts is gratefully acknowledged.

### INCOMPATIBLE CHEMICALS

The term “incompatible chemicals” refers to chemicals that can react with each other

- Violently
- With evolution of substantial heat
- To produce flammable products
- To produce toxic products

Good laboratory safety practice requires that incompatible chemicals be stored, transported, and disposed of in ways that will prevent their coming together in the event of an accident. Tables 1 and 2 give some basic guidelines for the safe handling of acids, bases, reactive metals, and other chemicals. Neither of these tables is exhaustive, and additional information on incompatible chemicals can be found in the following references.

1. Urban, P. G., Ed., *Bretherick's Handbook of Reactive Chemical Hazards*, 5th ed., Butterworth-Heinemann, Oxford, 1995.
2. Luxon, S. G., Ed., *Hazards in the Chemical Laboratory*, 5th ed., Royal Society of Chemistry, Cambridge, 1992.
3. *Fire Protection Guide to Hazardous Materials*, 11th ed., National Fire Protection Association, Quincy, MA, 1994.

TABLE 1. General Classes of Incompatible Chemicals

| A                             | B                              |
|-------------------------------|--------------------------------|
| Acids                         | Bases, reactive metals         |
| Oxidizing agents <sup>a</sup> | Reducing agents <sup>a</sup>   |
| Chlorates                     | Ammonia, anhydrous and aqueous |
| Chromates                     | Carbon                         |
| Chromium trioxide             | Metals                         |
| Dichromates                   | Metal hydrides                 |
| Halogens                      | Nitrites                       |
| Halogenating agents           | Organic compounds              |
| Hydrogen peroxide             | Phosphorus                     |
| Nitric acid                   | Silicon                        |
| Nitrates                      | Sulfur                         |
| Perchlorates                  |                                |
| Peroxides                     |                                |
| Permanganates                 |                                |
| Persulfates                   |                                |

<sup>a</sup> The examples of oxidizing and reducing agents are illustrative of common laboratory chemicals; they are not intended to be exhaustive.

TABLE 2. Examples of Incompatible Chemicals

| Chemical                                                                                                       | Is incompatible with                                                                                                    |
|----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| Acetic acid                                                                                                    | Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates               |
| Acetylene                                                                                                      | Chlorine, bromine, copper, fluorine, silver, mercury                                                                    |
| Acetone                                                                                                        | Concentrated nitric and sulfuric acid mixtures                                                                          |
| Alkali and alkaline earth metals (such as powdered aluminum or magnesium, calcium, lithium, sodium, potassium) | Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens                                 |
| Ammonia (anhydrous)                                                                                            | Mercury (in manometers, for example), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)    |
| Ammonium nitrate                                                                                               | Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials |
| Aniline                                                                                                        | Nitric acid, hydrogen peroxide                                                                                          |
| Arsenical materials                                                                                            | Any reducing agent                                                                                                      |
| Azides                                                                                                         | Acids                                                                                                                   |

| Chemical                                        | Is incompatible with                                                                                                                                               |
|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bromine                                         | See Chlorine                                                                                                                                                       |
| Calcium oxide                                   | Water                                                                                                                                                              |
| Carbon (activated)                              | Calcium hypochlorite, all oxidizing agents                                                                                                                         |
| Carbon tetrachloride                            | Sodium                                                                                                                                                             |
| Chlorates                                       | Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials                                                                    |
| Chromic acid and chromium trioxide              | Acetic acid, naphthalene, camphor, glycerol, alcohol, flammable liquids in general                                                                                 |
| Chlorine                                        | Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine           |
| Chlorine dioxide                                | Ammonia, methane, phosphine, hydrogen sulfide                                                                                                                      |
| Copper                                          | Acetylene, hydrogen peroxide                                                                                                                                       |
| Cumene hydroperoxide                            | Acids (organic or inorganic)                                                                                                                                       |
| Cyanides                                        | Acids                                                                                                                                                              |
| Flammable liquids                               | Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens                                                                          |
| Fluorine                                        | Everything                                                                                                                                                         |
| Hydrocarbons (such as butane, propane, benzene) | Fluorine, chlorine, bromine, chromic acid, sodium peroxide                                                                                                         |
| Hydrocyanic acid                                | Nitric acid, alkali                                                                                                                                                |
| Hydrofluoric acid (anhydrous)                   | Ammonia (aqueous or anhydrous)                                                                                                                                     |
| Hydrogen peroxide                               | Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitro-methane, combustible materials                            |
| Hydrogen sulfide                                | Fuming nitric acid, oxidizing gases                                                                                                                                |
| Hypochlorites                                   | Acids, activated carbon                                                                                                                                            |
| Iodine                                          | Acetylene, ammonia (aqueous or anhydrous), hydrogen                                                                                                                |
| Mercury                                         | Acetylene, fulminic acid, ammonia                                                                                                                                  |
| Nitrates                                        | Sulfuric acid                                                                                                                                                      |
| Nitric acid (concentrated)                      | Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals                        |
| Nitrites                                        | Acids                                                                                                                                                              |
| Nitroparaffins                                  | Inorganic bases, amines                                                                                                                                            |
| Oxalic acid                                     | Silver, mercury                                                                                                                                                    |
| Oxygen                                          | Oils, grease, hydrogen, flammable liquids, solids, or gases                                                                                                        |
| Perchloric acid                                 | Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils                                                                                       |
| Peroxides, organic                              | Acids (organic or mineral), avoid friction, store cold                                                                                                             |
| Phosphorus (white)                              | Air, oxygen, alkalis, reducing agents                                                                                                                              |
| Potassium                                       | Carbon tetrachloride, carbon dioxide, water                                                                                                                        |
| Potassium chlorate                              | Sulfuric and other acids                                                                                                                                           |
| Potassium perchlorate (see also chlorates)      | Sulfuric and other acids                                                                                                                                           |
| Potassium permanganate                          | Glycerol, ethylene glycol, benzaldehyde, sulfuric acid                                                                                                             |
| Selenides                                       | Reducing agents                                                                                                                                                    |
| Silver                                          | Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid                                                                                           |
| Sodium                                          | Carbon tetrachloride, carbon dioxide, water                                                                                                                        |
| Sodium nitrite                                  | Ammonium nitrate and other ammonium salts                                                                                                                          |
| Sodium peroxide                                 | Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural |
| Sulfides                                        | Acids                                                                                                                                                              |
| Sulfuric acid                                   | Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metals, such as sodium, lithium)                                     |
| Tellurides                                      | Reducing agents                                                                                                                                                    |



## EXPLOSION HAZARDS

Table 3 lists some common classes of laboratory chemicals that have potential for producing a violent explosion when subjected to shock or friction. These chemicals should never be disposed of as such, but should be handled by procedures given in *Prudent Practices for Disposal of Chemicals from Laboratories*, National Academy Press, 1983, chapters 6 and 7. Additional information on these, as well as on some less common classes of explosives, can be found in L. Bretherick, *Handbook of Reactive Chemical Hazards*, 3rd ed., Butterworths, London–Boston, 1985.

Table 4 lists some illustrative combinations of common laboratory reagents that can produce explosions when they are brought together or that form reaction products that can explode without any apparent external initiating action. This list is not exhaustive, and additional information on potentially explosive reagent combinations can be found in *Manual of Hazardous Chemical Reactions, A Compilation of Chemical Reactions Reported to be Potentially Hazardous*, National Fire Protection Association, NFPA 491M, 1975, NFPA, 470 Atlantic Avenue, Boston, MA 02210.

## WATER-REACTIVE CHEMICALS

Table 5 lists some common laboratory chemicals that react violently with water and that should always be stored and handled so that they do not come into contact with liquid water or water vapor.

Procedures for decomposing laboratory quantities are given in *Prudent Practices for Disposal of Chemicals from Laboratories*, chapter 6; the pertinent section of that chapter is given in parentheses.

## PYROPHORIC CHEMICALS

Many members of the classes of readily oxidized, common laboratory chemicals listed in Table 6 ignite spontaneously in air. A more extensive list can be found in L. Bretherick, *Handbook of Reactive Chemical Hazards*, 3rd ed., Butterworths, London–Boston, 1985. Pyrophoric chemicals should be stored in tightly closed containers under an inert atmosphere (or, for some, an inert liquid),

and all transfers and manipulations of them must be carried out under an inert atmosphere or liquid. Suggested procedures for decomposing them are given in *Prudent Practices for Disposal of Chemicals from Laboratories*, chapter 6; the pertinent section of that chapter is given in parentheses.

TABLE 3. Shock-Sensitive Compounds

|                                                                                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Acetylenic compounds, especially polyacetylenes, haloacetylenes, and heavy metal salts of acetylenes (copper, silver, and mercury salts are particularly sensitive)                                                                                                          |
| Acyl nitrates                                                                                                                                                                                                                                                                |
| Alkyl nitrates, particularly polyol nitrates such as nitrocellulose and nitroglycerine                                                                                                                                                                                       |
| Alkyl and acyl nitrites                                                                                                                                                                                                                                                      |
| Alkyl perchlorates                                                                                                                                                                                                                                                           |
| Amminemetal oxosalts: metal compounds with coordinated ammonia, hydrazine, or similar nitrogenous donors and ionic perchlorate, nitrate, permanganate, or other oxidizing group                                                                                              |
| Azides, including metal, nonmetal, and organic azides                                                                                                                                                                                                                        |
| Chlorite salts of metals, such as $\text{AgClO}_2$ and $\text{Hg}(\text{ClO}_2)_2$                                                                                                                                                                                           |
| Diazo compounds such as $\text{CH}_2\text{N}_2$                                                                                                                                                                                                                              |
| Diazonium salts, when dry                                                                                                                                                                                                                                                    |
| Fulminates (silver fulminate, $\text{AgCNO}$ , can form in the reaction mixture from the Tollens' test for aldehydes if it is allowed to stand for some time; this can be prevented by adding dilute nitric acid to the test mixture as soon as the test has been completed) |
| Hydrogen peroxide becomes increasingly treacherous as the concentration rises above 30%, forming explosive mixtures with organic materials and decomposing violently in the presence of traces of transition metals                                                          |
| N-Halogen compounds such as difluoroamino compounds and halogen azides                                                                                                                                                                                                       |
| N-Nitro compounds such as N-nitromethylamine, nitrourea, nitroguanidine, and nitric amide                                                                                                                                                                                    |
| Oxo salts of nitrogenous bases: perchlorates, dichromates, nitrates, iodates, chlorites, chlorates, and permanganates of ammonia, amines, hydroxylamine, guanidine, etc.                                                                                                     |
| Perchlorate salts. Most metal, nonmetal, and amine perchlorates can be detonated and may undergo violent reaction in contact with combustible materials                                                                                                                      |
| Peroxides and hydroperoxides, organic (see Chapter 6, Section II.P)                                                                                                                                                                                                          |
| Peroxides (solid) that crystallize from or are left from evaporation of peroxidizable solvents (see Chapter 6 and Appendix I)                                                                                                                                                |
| Peroxides, transition-metal salts                                                                                                                                                                                                                                            |
| Picrates, especially salts of transition and heavy metals, such as Ni, Pb, Hg, Cu, and Zn; picric acid is explosive but is less sensitive to shock or friction than its metal salts and is relatively safe as a water-wet paste (see Chapter 7)                              |
| Polynitroalkyl compounds such as tetranitromethane and dinitroacetone                                                                                                                                                                                                        |
| Polynitroaromatic compounds, especially polynitro hydrocarbons, phenols, and amines                                                                                                                                                                                          |

**TABLE 4. Potentially Explosive Combinations of Some Common Reagents**

Acetone + chloroform in the presence of base  
 Acetylene + copper, silver, mercury, or their salts  
 Ammonia (including aqueous solutions) +  $\text{Cl}_2$ ,  $\text{Br}_2$ , or  $\text{I}_2$   
 Carbon disulfide + sodium azide  
 Chlorine + an alcohol  
 Chloroform or carbon tetrachloride + powdered Al or Mg  
 Decolorizing carbon + an oxidizing agent  
 Diethyl ether + chlorine (including a chlorine atmosphere)  
 Dimethyl sulfoxide + an acyl halide,  $\text{SOCl}_2$  or  $\text{POCl}_3$   
 Dimethyl sulfoxide +  $\text{CrO}_3$   
 Ethanol + calcium hypochlorite  
 Ethanol + silver nitrate  
 Nitric acid + acetic anhydride or acetic acid  
 Picric acid + a heavy-metal salt, such as of Pb, Hg, or Ag  
 Silver oxide + ammonia + ethanol  
 Sodium + a chlorinated hydrocarbon  
 Sodium hypochlorite + an amine

**TABLE 5. Water-Reactive Chemicals**

Alkali metals (III.D)  
 Alkali metal hydrides (III.C.2)  
 Alkali metal amides (III.C.7)  
 Metal alkyls, such as lithium alkyls and aluminum alkyls (IV.A)  
 Grignard reagents (IV.A)  
 Halides of nonmetals, such as  $\text{BCl}_3$ ,  $\text{BF}_3$ ,  $\text{PCl}_3$ ,  $\text{PCl}_5$ ,  $\text{SiCl}_4$ ,  $\text{S}_2\text{Cl}_2$  (III.F)  
 Inorganic acid halides, such as  $\text{POCl}_3$ ,  $\text{SOCl}_2$ ,  $\text{SO}_2\text{Cl}_2$  (III.F)  
 Anhydrous metal halides, such as  $\text{AlCl}_3$ ,  $\text{TiCl}_4$ ,  $\text{ZrCl}_4$ ,  $\text{SnCl}_4$  (III.E)  
 Phosphorus pentoxide (III.I)  
 Calcium carbide (IV.E)  
 Organic acid halides and anhydrides of low molecular weight (II.J)

**TABLE 6. Classes of Pyrophoric Chemicals**

Grignard reagents,  $\text{RMgX}$  (IV.A)  
 Metal alkyls and aryls, such as  $\text{RLi}$ ,  $\text{RNa}$ ,  $\text{R}_3\text{Al}$ ,  $\text{R}_2\text{Zn}$  (IV.A)  
 Metal carbonyls, such as  $\text{Ni}(\text{CO})_4$ ,  $\text{Fe}(\text{CO})_5$ ,  $\text{Co}_2(\text{CO})_8$  (IV.B)  
 Alkali metals such as Na, K (III.D.1)  
 Metal powders, such as Al, Co, Fe, Mg, Mn, Pd, Pt, Ti, Sn, Zn, Zr (III.D.2)  
 Metal hydrides, such as  $\text{NaH}$ ,  $\text{LiAlH}_4$  (IV.C.2)  
 Nonmetal hydrides, such as  $\text{B}_2\text{H}_6$  and other boranes,  $\text{PH}_3$ ,  $\text{AsH}_3$  (III.G)  
 Nonmetal alkyls, such as  $\text{R}_3\text{B}$ ,  $\text{R}_3\text{P}$ ,  $\text{R}_3\text{As}$  (IV.C)  
 Phosphorus (white) (III.H)

## HAZARDS FROM PEROXIDE FORMATION

Many common laboratory chemicals can form peroxides when allowed access to air over a period of time. A single opening of a container to remove some of the contents can introduce enough air for peroxide formation to occur. Some types of compounds form peroxides that are treacherously and violently explosive in concentrated solution or as solids. Accordingly, peroxide-containing liquids should never be evaporated near to or to dryness. Peroxide formation can also occur in many polymerizable unsaturated compounds, and these peroxides can initiate a runaway, sometimes explosive, polymerization reaction. Procedures for testing for peroxides and for removing small amounts from laboratory chemicals are given in *Prudent Practices for Disposal of Chemicals from Laboratories*, chapter 6, Section II.P.

Table 7 provides a list of structural characteristics in organic compounds that can peroxidize. These structures are listed in approximate order of decreasing hazard. Reports of serious incidents involving the last five structural types are extremely rare, but these structures are listed because laboratory workers should be aware that they can form peroxides that can influence the course of experiments in which they are used.

Table 8 gives examples of common laboratory chemicals that are prone to form peroxides on exposure to air. The lists are not exhaustive, and analogous organic compounds that have any of the structural features given in Table 7 should be tested for peroxides before being used as solvents or reagents, or before being distilled. The recommended retention times begin with the date of synthesis or of opening the original container.

## DISPOSAL OF TOXIC CHEMICALS

It is often desirable to precipitate toxic cations or hazardous anions from solution to facilitate recovery or disposal. Table 9 lists precipitants for many common cations, and Table 10 gives precipitants for some hazardous anions. Many cations can be precipitated as sulfides by adding sodium sulfide solution (preferable to the highly toxic hydrogen sulfide) to a neutral solution of the cation (Table 11). Control of pH is important because some sulfides will redissolve in excess sulfide ion. After precipitation, excess sulfide can be destroyed by addition of hypochlorite.

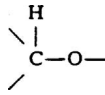
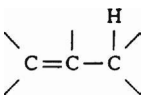
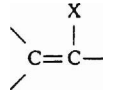
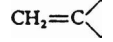
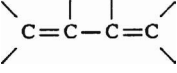
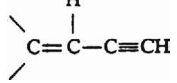
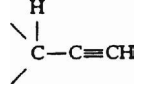
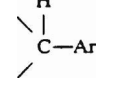
Most metal cations are precipitated as hydroxides or oxides at high pH. Since many of these precipitates will redissolve in excess

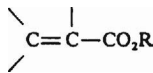
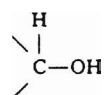
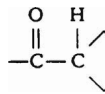
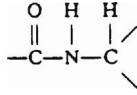
base, it is often necessary to control pH. Table 12 shows the recommended pH range for precipitating many cations in their most common oxidation state. The notation "1 N" in the right-hand column indicates that the precipitate will not dissolve in 1 N sodium hydroxide (pH 14).

The distinctions between high and low toxicity or hazard are based on toxicological and other data, and are relative. There is no implication of a sharp distinction between high and low, or that any cations or anions are totally without hazard.

TABLE 7. Types of Chemicals That Are Prone to Form Peroxides

## A. Organic structures (in approximate order of decreasing hazard)

|    |                                                                                     |                                                               |
|----|-------------------------------------------------------------------------------------|---------------------------------------------------------------|
| 1. |  | Ethers and acetals with $\alpha$ hydrogen atoms               |
| 2. |  | Olefins with allylic hydrogen atoms                           |
| 3. |  | Chloroolefins and fluoroolefins                               |
| 4. |  | Vinyl halides, esters, and ethers                             |
| 5. |  | Dienes                                                        |
| 6. |  | Vinylacetylenes with $\alpha$ hydrogen atoms                  |
| 7. |  | Alkylacetylenes with $\alpha$ hydrogen atoms                  |
| 8. |  | Alkylarenes that contain tertiary hydrogen atoms              |
| 9. |  | Alkanes and cycloalkanes that contain tertiary hydrogen atoms |

|     |                                                                                   |                                                                                            |
|-----|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| 10. |  | Acrylates and methacrylates                                                                |
| 11. |  | Secondary alcohols                                                                         |
| 12. |  | Ketones that contain $\alpha$ hydrogen atoms                                               |
| 13. |  | Aldehydes                                                                                  |
| 14. |  | Ureas, amides, and lactams that have a hydrogen atom on a carbon atom attached to nitrogen |

**B. Inorganic substances**

1. Alkali metals, especially potassium, rubidium, and cesium (see Chapter 6, Section III.D)
2. Metal amides (see Chapter 6, Section III.C.7)
3. Organometallic compounds with a metal atom bonded to carbon (see Chapter 6, Section IV)
4. Metal alkoxides

**TABLE 8. Common Peroxide-Forming Chemicals****LIST A****Severe Peroxide Hazard on Storage with Exposure to Air****Discard within 3 months**

- Diisopropyl ether (isopropyl ether)
- Divinylacetylene (DVA)<sup>a</sup>
- Potassium metal
- Potassium amide
- Sodium amide (sodamide)
- Vinylidene chloride (1,1-dichloroethylene)<sup>a</sup>

**LIST B****Peroxide Hazard on Concentration; Do Not Distill or Evaporate Without First Testing for the Presence of Peroxides****Discard or test for peroxides after 6 months**

- Acetaldehyde diethyl acetal (acetal)
- Cumene (isopropylbenzene)
- Cyclohexene
- Cyclopentene
- Decalin (decahydronaphthalene)
- Diacetylene
- Dicyclopentadiene
- Diethyl ether (ether)
- Diethylene glycol dimethyl ether (diglyme)
- Dioxane
- Ethylene glycol dimethyl ether (glyme)
- Ethylene glycol ether acetates
- Ethylene glycol monoethers (cellosolves)
- Furan
- Methylacetylene
- Methylcyclopentane
- Methyl isobutyl ketone
- Tetrahydrofuran (THF)
- Tetralin (tetrahydronaphthalene)
- Vinyl ethers<sup>a</sup>

**LIST C****Hazard of Rapid Polymerization Initiated by Internally Formed Peroxides<sup>a</sup>****a. Normal Liquids; discard or test for peroxides after 6 months<sup>b</sup>**

- Chloroprene (2-chloro-1,3-butadiene)<sup>c</sup>
- Styrene
- Vinyl acetate
- Vinylpyridine

**b. Normal Gases; discard after 12 months<sup>d</sup>**

- Butadiene<sup>c</sup>
- Tetrafluoroethylene (TFE)<sup>c</sup>
- Vinylacetylene (MVA)<sup>c</sup>
- Vinyl chloride

<sup>a</sup> Polymerizable monomers should be stored with a polymerization inhibitor from which the monomer can be separated by distillation just before use.<sup>b</sup> Although common acrylic monomers such as acrylonitrile, acrylic acid, ethyl acrylate, and methyl methacrylate can form peroxides, they have not been reported to develop hazardous levels in normal use and storage.<sup>c</sup> The hazard from peroxides in these compounds is substantially greater when they are stored in the liquid phase, and if so stored without an inhibitor they should be considered as in LIST A.<sup>d</sup> Although air will not enter a gas cylinder in which gases are stored under pressure, these gases are sometimes transferred from the original cylinder to another in the laboratory, and it is difficult to be sure that there is no residual air in the receiving cylinder. An inhibitor should be put into any such secondary cylinder before one of these gases is transferred into it; the supplier can suggest inhibitors to be used. The hazard posed by these gases is much greater if there is a liquid phase in such a secondary container, and even inhibited gases that have been put into a secondary container under conditions that create a liquid phase should be discarded within 12 months.

*Note:* Laboratory workers should label all containers of peroxidizable solvents or reagents with one of the following:

## [LIST A]

| Date | Peroxidizable compound         |        |
|------|--------------------------------|--------|
|      | Received                       | Opened |
|      | Discard 3 months after opening |        |

## [LISTS B AND C]

| Date | Peroxidizable compound                                  |        |
|------|---------------------------------------------------------|--------|
|      | Received                                                | Opened |
|      | Discard or test for peroxides<br>6 months after opening |        |

TABLE 9. Relative Toxicity of Cations

| High toxic hazard            | Precipitant <sup>a</sup>                                      | Low toxic hazard               | Precipitant <sup>a</sup>                                      |
|------------------------------|---------------------------------------------------------------|--------------------------------|---------------------------------------------------------------|
| Antimony                     | OH <sup>-</sup> , S <sup>2-</sup>                             | Aluminum                       | OH <sup>-</sup>                                               |
| Arsenic                      | S <sup>2-</sup>                                               | Bismuth                        | OH <sup>-</sup> , S <sup>2-</sup>                             |
| Barium                       | SO <sub>4</sub> <sup>2-</sup> , CO <sub>3</sub> <sup>2-</sup> | Calcium                        | SO <sub>4</sub> <sup>2-</sup> , CO <sub>3</sub> <sup>2-</sup> |
| Beryllium                    | OH <sup>-</sup>                                               | Cerium                         | OH <sup>-</sup>                                               |
| Cadmium                      | OH <sup>-</sup> , S <sup>2-</sup>                             | Cesium                         |                                                               |
| Chromium (III) <sup>b</sup>  | OH <sup>-</sup>                                               | Copper <sup>c</sup>            | OH <sup>-</sup> , S <sup>2-</sup>                             |
| Cobalt (II) <sup>b</sup>     | OH <sup>-</sup> , S <sup>2-</sup>                             | Gold                           | OH <sup>-</sup> , S <sup>2-</sup>                             |
| Gallium                      | OH <sup>-</sup>                                               | Iron <sup>c</sup>              | OH <sup>-</sup> , S <sup>2-</sup>                             |
| Germanium                    | OH <sup>-</sup> , S <sup>2-</sup>                             | Lanthanides                    | OH <sup>-</sup>                                               |
| Hafnium                      | OH <sup>-</sup>                                               | Lithium                        |                                                               |
| Indium                       | OH <sup>-</sup> , S <sup>2-</sup>                             | Magnesium                      | OH <sup>-</sup>                                               |
| Iridium                      | OH <sup>-</sup> , S <sup>2-</sup>                             | Molybdenum (VI) <sup>b,d</sup> |                                                               |
| Lead                         | OH <sup>-</sup> , S <sup>2-</sup>                             | Niobium (V)                    | OH <sup>-</sup>                                               |
| Manganese (II) <sup>b</sup>  | OH <sup>-</sup> , S <sup>2-</sup>                             | Palladium                      | OH <sup>-</sup> , S <sup>2-</sup>                             |
| Mercury                      | OH <sup>-</sup> , S <sup>2-</sup>                             | Potassium                      |                                                               |
| Nickel                       | OH <sup>-</sup> , S <sup>2-</sup>                             | Rubidium                       |                                                               |
| Osmium (IV) <sup>b,e</sup>   | OH <sup>-</sup> , S <sup>2-</sup>                             | Scandium                       | OH <sup>-</sup>                                               |
| Platinum (II) <sup>b</sup>   | OH <sup>-</sup> , S <sup>2-</sup>                             | Sodium                         |                                                               |
| Rhenium (VII) <sup>b</sup>   | S <sup>2-</sup>                                               | Strontium                      | SO <sub>4</sub> <sup>2-</sup> , CO <sub>3</sub> <sup>2-</sup> |
| Rhodium (III) <sup>b</sup>   | OH <sup>-</sup> , S <sup>2-</sup>                             | Tantalum                       | OH <sup>-</sup>                                               |
| Ruthenium (III) <sup>b</sup> | OH <sup>-</sup> , S <sup>2-</sup>                             | Tin                            | OH <sup>-</sup> , S <sup>2-</sup>                             |
| Selenium                     | S <sup>2-</sup>                                               | Titanium                       | OH <sup>-</sup>                                               |
| Silver                       | Cl <sup>-</sup> , OH <sup>-</sup> , S <sup>2-</sup>           | Yttrium                        | OH <sup>-</sup>                                               |
| Tellurium                    | S <sup>2-</sup>                                               | Zinc <sup>c</sup>              | OH <sup>-</sup> , S <sup>2-</sup>                             |
| Thallium                     | OH <sup>-</sup> , S <sup>2-</sup>                             | Zirconium                      | OH <sup>-</sup>                                               |
| Tungsten (VI) <sup>b,d</sup> |                                                               |                                |                                                               |
| Vanadium                     | OH <sup>-</sup> , S <sup>2-</sup>                             |                                |                                                               |

<sup>a</sup> Precipitants are listed in order of preference:

OH<sup>-</sup> = base (sodium hydroxide or sodium carbonate)

S<sup>2-</sup> = sulfide

Cl<sup>-</sup> = chloride

SO<sub>4</sub><sup>2-</sup> = sulfate

CO<sub>3</sub><sup>2-</sup> = carbonate

<sup>b</sup> The precipitant is for the indicated valence state.

<sup>c</sup> Maximum tolerance levels have been set for these low-toxicity ions by the U.S. Public Health Service, and large amounts should not be put into public sewer systems. The small amounts typically used in laboratories will not normally affect water supplies.

<sup>d</sup> These ions are best precipitated as calcium molybdate or calcium tungstate.

<sup>e</sup> CAUTION: OsO<sub>4</sub>, a volatile, extremely poisonous substance, is formed from almost any osmium compound under acid conditions in the presence of air.

TABLE 10. Relative Hazard of Anions

| High-hazard anions                                           |                          |                                     |                                                          |
|--------------------------------------------------------------|--------------------------|-------------------------------------|----------------------------------------------------------|
| Ion                                                          | Hazard type <sup>a</sup> | Precipitant                         | Low-hazard anions                                        |
| Aluminum hydride, $\text{AlH}_4^-$                           | F                        | —                                   | Bisulfite, $\text{HSO}_3^-$                              |
| Amide, $\text{NH}_2^-$                                       | F, E <sup>b</sup>        | —                                   | Borate, $\text{BO}_3^{3-}$ , $\text{B}_4\text{O}_7^{2-}$ |
| Arsenate, $\text{AsO}_3^-$ , $\text{AsO}_4^{3-}$             | T                        | $\text{Cu}^{2+}$ , $\text{Fe}^{2+}$ | Bromide, $\text{Br}^-$                                   |
| Arsenite, $\text{AsO}_2^-$ , $\text{AsO}_3^{3-}$             | T                        | $\text{Pb}^{2+}$                    | Carbonate, $\text{CO}_3^{2-}$                            |
| Azide, $\text{N}_3^-$                                        | E, T                     | —                                   | Chloride, $\text{Cl}^-$                                  |
| Borohydride, $\text{BH}_4^-$                                 | F                        | —                                   | Cyanate, $\text{OCN}^-$                                  |
| Bromate, $\text{BrO}_3^-$                                    | O, E                     | —                                   | Hydroxide, $\text{OH}^-$                                 |
| Chlorate, $\text{ClO}_3^-$                                   | O, E                     | —                                   | Iodide, $\text{I}^-$                                     |
| Chromate, $\text{CrO}_4^{2-}$ , $\text{Cr}_2\text{O}_7^{2-}$ | T, O                     | c                                   | Oxide, $\text{O}^{2-}$                                   |
| Cyanide, $\text{CN}^-$                                       | T                        | —                                   | Phosphate, $\text{PO}_4^{3-}$                            |
| Ferricyanide, $\text{Fe}(\text{CN})_6^{3-}$                  | T                        | $\text{Fe}^{2+}$                    | Sulfate, $\text{SO}_4^{2-}$                              |
| Ferrocyanide, $\text{Fe}(\text{CN})_6^{4-}$                  | T                        | $\text{Fe}^{3+}$                    | Sulfite, $\text{SO}_3^{2-}$                              |
| Fluoride, $\text{F}^-$                                       | T                        | $\text{Ca}^{2+}$                    | Thiocyanate, $\text{SCN}^-$                              |
| Hydride, $\text{H}^-$                                        | F                        | —                                   |                                                          |
| Hydroperoxide, $\text{O}_2\text{H}^-$                        | O, E                     | —                                   |                                                          |
| Hydrosulfide, $\text{SH}^-$                                  | T                        | —                                   |                                                          |
| Hypochlorite, $\text{OCl}^-$                                 | O                        | —                                   |                                                          |
| Iodate, $\text{IO}_3^-$                                      | O, E                     | —                                   |                                                          |
| Nitrate, $\text{NO}_3^-$                                     | O                        | —                                   |                                                          |
| Nitrite, $\text{NO}_2^-$                                     | T, O                     | —                                   |                                                          |
| Perchlorate, $\text{ClO}_4^-$                                | O, E                     | —                                   |                                                          |
| Permanganate, $\text{MnO}_4^-$                               | T, O                     | d                                   |                                                          |
| Peroxide, $\text{O}_2^{2-}$                                  | O, E                     | —                                   |                                                          |
| Persulfate, $\text{S}_2\text{O}_8^{2-}$                      | O                        | —                                   |                                                          |
| Selenate, $\text{SeO}_4^{2-}$                                | T                        | $\text{Pb}^{2+}$                    |                                                          |
| Selenide, $\text{Se}^{2-}$                                   | T                        | $\text{Cu}^{2+}$                    |                                                          |
| Sulfide, $\text{S}^{2-}$                                     | T                        | e                                   |                                                          |

<sup>a</sup> Toxic, T; oxidant, O; flammable, F; explosive, E.<sup>b</sup> Metal amides readily form explosive peroxides on exposure to air.<sup>c</sup> Reduce and precipitate as Cr(III); see Table 9.<sup>d</sup> Reduce and precipitate as Mn(II); see Table 9.<sup>e</sup> See Table 11.

TABLE 11. Precipitation of Sulfides

| Precipitated at pH 7          | Not precipitated at low pH | Forms a soluble complex at high pH |
|-------------------------------|----------------------------|------------------------------------|
| $\text{Ag}^+$                 |                            |                                    |
| $\text{As}^{3+}$ <sup>a</sup> |                            | X                                  |
| $\text{Au}^+$ <sup>a</sup>    |                            | X                                  |
| $\text{Bi}^{3+}$              |                            |                                    |
| $\text{Cd}^{2+}$              |                            |                                    |
| $\text{Co}^{2+}$              | X                          |                                    |
| $\text{Cr}^{3+}$ <sup>a</sup> |                            |                                    |
| $\text{Cu}^{2+}$              |                            |                                    |
| $\text{Fe}^{2+}$ <sup>a</sup> | X                          |                                    |
| $\text{Ge}^{2+}$              |                            | X                                  |
| $\text{Hg}^{2+}$              |                            | X                                  |
| $\text{In}^{3+}$              | X                          |                                    |
| $\text{Ir}^{4+}$              |                            | X                                  |
| $\text{Mn}^{2+}$ <sup>a</sup> | X                          |                                    |
| $\text{Mo}^{3+}$              |                            | X                                  |
| $\text{Ni}^{2+}$              | X                          |                                    |
| $\text{Os}^{4+}$              |                            |                                    |
| $\text{Pb}^{2+}$              |                            |                                    |
| $\text{Pd}^{2+}$ <sup>a</sup> |                            |                                    |
| $\text{Pt}^{2+}$ <sup>a</sup> |                            | X                                  |
| $\text{Re}^{4+}$              |                            |                                    |
| $\text{Rh}^{2+}$ <sup>a</sup> |                            |                                    |
| $\text{Ru}^{4+}$              |                            |                                    |

TABLE 11. Precipitation of Sulfides

| Precipitated at pH 7          | Not precipitated at low pH | Forms a soluble complex at high pH |
|-------------------------------|----------------------------|------------------------------------|
| $\text{Sb}^{3+}$ <sup>a</sup> |                            | X                                  |
| $\text{Se}^{2+}$              |                            | X                                  |
| $\text{Sn}^{2+}$              |                            | X                                  |
| $\text{Te}^{4+}$              |                            | X                                  |
| $\text{Tl}^{+}$ <sup>a</sup>  | X                          |                                    |
| $\text{V}^{4+}$ <sup>a</sup>  |                            |                                    |
| $\text{Zn}^{2+}$              | X                          |                                    |

<sup>a</sup> Higher oxidation states of this ion are reduced by sulfide ion and precipitated as this sulfide.

TABLE 12. pH Range for Precipitation of Metal Hydroxides and Oxides

|                  | 1                                         | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |       |  |
|------------------|-------------------------------------------|---|---|---|---|---|---|---|---|----|-------|--|
| Ag <sup>1+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1N    |  |
| Al <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| As <sup>3+</sup> | Not precipitated (precipitate as sulfide) |   |   |   |   |   |   |   |   |    |       |  |
| As <sup>5+</sup> | Not precipitated (precipitate as sulfide) |   |   |   |   |   |   |   |   |    |       |  |
| Au <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Be <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Bi <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Cd <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Co <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Cr <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Cu <sup>1+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Cu <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Fe <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Fe <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Ga <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Ge <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Hf <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Hg <sup>1+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Hg <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| In <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   | →  | pH 13 |  |
| Ir <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Mg <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Mn <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Mn <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Mo <sup>6+</sup> | Not precipitated (precipitate as Ca salt) |   |   |   |   |   |   |   |   |    |       |  |
| Nb <sup>5+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Ni <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Os <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Pb <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Pd <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Pd <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Pt <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Re <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   |    | 1 N   |  |
| Re <sup>7+</sup> | Not precipitated (precipitate as sulfide) |   |   |   |   |   |   |   |   |    |       |  |
| Rh <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Ru <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Sb <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Sb <sup>5+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Sc <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |
| Se <sup>4+</sup> | Not precipitated (precipitate as sulfide) |   |   |   |   |   |   |   |   |    |       |  |
| Se <sup>6+</sup> | Not precipitated (precipitate as sulfide) |   |   |   |   |   |   |   |   |    |       |  |
| Sn <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Sn <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Ta <sup>5+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Te <sup>4+</sup> | Not precipitated (precipitate as sulfide) |   |   |   |   |   |   |   |   |    |       |  |
| Te <sup>6+</sup> | Not precipitated (precipitate as sulfide) |   |   |   |   |   |   |   |   |    |       |  |
| Th <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   |    | 1 N   |  |
| Ti <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   |    |       |  |
| Ti <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   | →  | 1 N   |  |

TABLE 12. pH Range for Precipitation of Metal Hydroxides and Oxides

|                  | 1                                         | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 N |
|------------------|-------------------------------------------|---|---|---|---|---|---|---|---|----|-----|
| Tl <sup>3+</sup> |                                           |   |   |   |   |   |   |   |   |    |     |
| V <sup>4+</sup>  |                                           |   |   |   |   |   |   |   |   |    |     |
| V <sup>5+</sup>  |                                           |   |   |   |   |   |   |   |   |    |     |
| W <sup>6+</sup>  | Not precipitated (precipitate as Ca salt) |   |   |   |   |   |   |   |   |    |     |
| Zn <sup>2+</sup> |                                           |   |   |   |   |   |   |   |   |    |     |
| Zr <sup>4+</sup> |                                           |   |   |   |   |   |   |   |   |    |     |

### References

- L. Erdey, *Gravimetric Analysis*, Part II, Pergamon Press, New York, 1965.  
D. T. Burns, A. Towsend, and A. H. Carter, *Inorganic Reaction Chemistry*,  
Vol. 2, Ellis Horwood, New York, 1981.

## FIRE HAZARDS

Flammable solvents are a common source of laboratory fires. The relative ease with which some common laboratory solvents can be ignited is indicated by the following properties.

**Flash Point** — The lowest temperature, as determined by standard tests, at which a liquid emits vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid in a test vessel. Note that many of these common chemicals have flash points below room temperature.

**Ignition Temperature** — The minimum temperature required to initiate self-sustained combustion, regardless of the heat source.

**Flammable Limits** — The lower flammable limit is the minimum concentration (percent by volume) of a vapor in air below which a

flame is not propagated when an ignition source is present. Below this concentration the mixture is too lean to burn. The upper flammable limit is the maximum concentration (percent by volume) of the vapor in air above which a flame is not propagated. Above this concentration the mixture is too rich to burn. The flammable range comprises all concentrations between these two limits. This range becomes wider with increasing temperature and in oxygen-rich atmospheres. Table 13 lists these properties for a few common laboratory chemicals.

## GLOVE MATERIALS

It is good safety practice (and mandated in some laboratories) to wear rubber gloves while handling chemicals that can cause injury when in contact with, or absorbed through, the skin. The various

common rubbers are not equally resistant to all chemicals. Table 14 provides guidelines for selecting the best, and avoiding the poorest, glove material for handling a given chemical.

## RESPIRATORS

In the event of a laboratory accident or spill, it will be necessary for someone to enter the contaminated area for cleanup. If significant quantities of a chemical are spilled, or even minor quantities of a known toxic material, it is essential to wear the correct kind of respirator equipment when entering the area. If it is not known

whether the contamination is of a chemical “immediately dangerous to life or health,” the prudent course is to assume that it is, and to use the corresponding type of respirator. Guidelines are presented in Table 15.

TABLE 13. Flash Points, Boiling Points, Ignition Temperatures, and Flammable Limits of Some Common Laboratory Chemicals

| Chemical            | Flash point (°C) | Boiling point (°C) | Ignition temp. (°C) | Flammable limit<br>(percent by volume in air) |       |
|---------------------|------------------|--------------------|---------------------|-----------------------------------------------|-------|
|                     |                  |                    |                     | Lower                                         | Upper |
| Acetaldehyde        | -37.8            | 21.1               | 175.0               | 4.0                                           | 60.0  |
| Acetone             | -19.0            | 56.0               | 538.0               | 2.6                                           | 12.8  |
| Benzene             | -11.1            | 80.1               | 560.0               | 1.4                                           | 8.0   |
| Carbon disulfide    | -30.0            | 45.8               | 90.0                | 1.0                                           | 44.0  |
| Cyclohexane         | -18.0            | 80.7               | 260.0               | 1.3                                           | 8.0   |
| Diethyl ether       | -45.0            | 34.4               | 160.0               | 1.8                                           | 48.0  |
| Ethanol             | 12.0             | 78.3               | 363.0               | 3.3                                           | 19.0  |
| <i>n</i> -Heptane   | -3.9             | 98.4               | 204.0               | 1.0                                           | 6.7   |
| <i>n</i> -Hexane    | -21.7            | 68.7               | 223.0               | 1.2                                           | 7.5   |
| Isopropyl alcohol   | 11.7             | 82.2               | 398.9               | 2.0                                           | 12.0  |
| Methanol            | 11.1             | 64.5               | 385.0               | 6.0                                           | 36.5  |
| Methyl ethyl ketone | -6.1             | 79.6               | 515.6               | 1.9                                           | 11.0  |



**TABLE 13. Flash Points, Boiling Points, Ignition Temperatures, and Flammable Limits of Some Common Laboratory Chemicals**

| Chemical         | Flash point (°C) | Boiling point (°C) | Ignition temp. (°C) | Flammable limit<br>(percent by volume in air) |       |
|------------------|------------------|--------------------|---------------------|-----------------------------------------------|-------|
|                  |                  |                    |                     | Lower                                         | Upper |
| Pentane          | −40.0            | 36.1               | 260.0               | 1.4                                           | 7.8   |
| Styrene          | 31.0             | 145.0              | 490.0               | 1.1                                           | 6.1   |
| Toluene          | 4.4              | 110.6              | 530.0               | 1.3                                           | 7.0   |
| <i>p</i> -Xylene | 25.0             | 132.4              | 529.0               | 1.1                                           | 7.0   |

*Note:* For a more extensive listing, see the table "Properties of Common Solvents" in Section 15.

**TABLE 14. Resistance to Chemicals of Common Glove Materials (E = Excellent, G = Good, F = Fair, P = Poor)**

| Chemical                          | Natural rubber | Neoprene | Nitrile | Vinyl |
|-----------------------------------|----------------|----------|---------|-------|
| Acetaldehyde                      | G              | G        | E       | G     |
| Acetic acid                       | E              | E        | E       | E     |
| Acetone                           | G              | G        | G       | F     |
| Acrylonitrile                     | P              | G        | —       | F     |
| Ammonium hydroxide (sat)          | G              | E        | E       | E     |
| Aniline                           | F              | G        | E       | G     |
| Benzaldehyde                      | F              | F        | E       | G     |
| Benzene <sup>a</sup>              | P              | F        | G       | F     |
| Benzyl chloride <sup>a</sup>      | F              | P        | G       | P     |
| Bromine                           | G              | G        | —       | G     |
| Butane                            | P              | E        | —       | P     |
| Butyraldehyde                     | P              | G        | —       | G     |
| Calcium hypochlorite              | P              | G        | G       | G     |
| Carbon disulfide                  | P              | P        | G       | F     |
| Carbon tetrachloride <sup>a</sup> | P              | F        | G       | F     |
| Chlorine                          | G              | G        | —       | G     |
| Chloroacetone                     | F              | E        | —       | P     |
| Chloroform <sup>a</sup>           | P              | F        | G       | P     |
| Chromic acid                      | P              | F        | F       | E     |
| Cyclohexane                       | F              | E        | —       | P     |
| Dibenzyl ether                    | F              | G        | —       | P     |
| Dibutyl phthalate                 | F              | G        | —       | P     |
| Diethanolamine                    | F              | E        | —       | E     |
| Diethyl ether                     | F              | G        | E       | P     |
| Dimethyl sulfoxide <sup>b</sup>   | —              | —        | —       | —     |
| Ethyl acetate                     | F              | G        | G       | F     |
| Ethylene dichloride <sup>a</sup>  | P              | F        | G       |       |
| Ethylene glycol                   | G              | G        | E       | E     |
| Ethylene trichloride <sup>a</sup> | P              | P        | —       | P     |
| Fluorine                          | G              | G        | —       | G     |
| Formaldehyde                      | G              | E        | E       | E     |
| Formic acid                       | G              | E        | E       | E     |
| Glycerol                          | G              | G        | E       | E     |
| Hexane                            | P              | E        | —       | P     |
| Hydrobromic acid (40%)            | G              | E        | —       | E     |
| Hydrochloric acid (conc)          | G              | G        | G       | E     |
| Hydrofluoric acid (30%)           | G              | G        | G       | E     |
| Hydrogen peroxide                 | G              | G        | G       | E     |
| Iodine                            | G              | G        | —       | G     |
| Methylamine                       | G              | G        | E       | E     |
| Methyl cellosolve                 | F              | E        | —       | P     |
| Methyl chloride <sup>a</sup>      | P              | E        | —       | P     |
| Methyl ethyl ketone               | F              | G        | G       | P     |
| Methylene chloride <sup>a</sup>   | F              | F        | G       | F     |
| Monoethanolamine                  | F              | E        | —       | E     |
| Morpholine                        | F              | E        | —       | E     |
| Naphthalene <sup>a</sup>          | G              | G        | E       | G     |
| Nitric acid (conc)                | P              | P        | P       | G     |
| Perchloric acid                   | F              | G        | F       | E     |

**TABLE 14. Resistance to Chemicals of Common Glove Materials (E = Excellent, G = Good, F = Fair, P = Poor)**

| Chemical                          | Natural rubber | Neoprene | Nitrile | Vinyl |
|-----------------------------------|----------------|----------|---------|-------|
| Phenol                            | G              | E        | —       | E     |
| Phosphoric acid                   | G              | E        | —       | E     |
| Potassium hydroxide (sat)         | G              | G        | G       | E     |
| Propylene dichloride <sup>a</sup> | P              | F        | —       | P     |
| Sodium hydroxide                  | G              | G        | G       | E     |
| Sodium hypochlorite               | G              | P        | F       | G     |
| Sulfuric acid (conc)              | G              | G        | F       | G     |
| Toluene <sup>a</sup>              | P              | F        | G       | F     |
| Trichloroethylene <sup>a</sup>    | P              | F        | G       | F     |
| Tricresyl phosphate               | P              | F        | —       | F     |
| Triethanolamine                   | F              | E        | E       | E     |
| Trinitrotoluene                   | P              | E        | —       | P     |

<sup>a</sup> Aromatic and halogenated hydrocarbons will attack all types of natural and synthetic glove materials. Should swelling occur, the user should change to fresh gloves and allow the swollen gloves to dry and return to normal.

<sup>b</sup> No data on the resistance to dimethyl sulfoxide of natural rubber, neoprene, nitrile rubber, or vinyl materials are available; the manufacturer of the substance recommends the use of butyl rubber gloves.

**TABLE 15. Guide for Selection of Respirators**

| Type of hazard                                          | Type of respirator                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Oxygen deficiency                                       | Self-contained breathing apparatus<br>Hose mask with blower<br>Combination of air-line respirator and auxiliary self-contained air supply or air-storage receiver with alarm                                                                                                                                  |
| Gas and vapor contaminants                              | Self-contained breathing apparatus                                                                                                                                                                                                                                                                            |
| Immediately dangerous to life or health                 | Hose mask with blower<br>Air-purifying full-facepiece respirator with chemical canister (gas mask)<br>Self-rescue mouthpiece respirator (for escape only)<br>Combination of air-line respirator and auxiliary self-contained air supply or air-storage receiver with alarm                                    |
| Not immediately dangerous to life or health             | Air-line respirator<br>Hose mask with blower<br>Air-purifying half-mask or mouthpiece respirator with chemical cartridge                                                                                                                                                                                      |
| Particulate Contaminants                                | Self-contained breathing apparatus                                                                                                                                                                                                                                                                            |
| Immediately dangerous to life or health                 | Hose mask with blower<br>Air-purifying full-facepiece respirator with appropriate filter<br>Self-rescue mouthpiece respirator (for escape only)<br>Combination of air-line respirator and auxiliary self-contained air supply or air-storage receiver with alarm                                              |
| Not immediately dangerous to life or health             | Air-purifying half-mask or mouthpiece respirator with filter pad or cartridge<br>Air-line respirator<br>Air-line abrasive-blasting respirator<br>Hose mask with blower                                                                                                                                        |
| Combination of gas, vapor, and particulate contaminants | Self-contained breathing apparatus                                                                                                                                                                                                                                                                            |
| Immediately dangerous to life or health                 | Hose mask with blower<br>Air-purifying full-facepiece respirator with chemical canister and appropriate filter (gas mask with filter)<br>Self-rescue mouthpiece respirator (for escape only)<br>Combination of air-line respirator and auxiliary self-contained air supply or air-storage receiver with alarm |
| Not immediately dangerous to life or health             | Air-line respirator<br>Hose mask without blower<br>Air-purifying half-mask or mouthpiece respirator with chemical cartridge and appropriate filter                                                                                                                                                            |

Source: ANSI Standard Z88.2 (1969).

## FLAMMABILITY OF CHEMICAL SUBSTANCES

This table gives properties related to the flammability of about 900 chemical substances. The properties listed are:

- $t_b$ : Normal boiling point in °C (at 101.325 kPa pressure).
- FP: Flash point, which is the minimum temperature at which the vapor pressure of a liquid is sufficient to form an ignitable mixture with air near the surface of the liquid. Flash point is not an intrinsic physical property but depends on the conditions of measurement (see Reference 1).
- Fl. Limits: Flammable limits (often called explosive limits), which specify the range of concentration of the vapor in air (in percent by volume) for which a flame can propagate. Below the lower flammable limit, the gas mixture is too lean to burn; above the upper flammable limit, the mixture is too rich. Values refer to ambient temperature and pressure and are dependent on the precise test conditions. A ? indicates that one of the limits is not known.
- IT: Ignition temperature (sometimes called autoignition temperature), which is the minimum temperature required for self-sustained combustion in the absence of an external ignition source. As in the case of flash point, the value depends on specified test conditions.

Even in cases where very careful measurements of flash point have been replicated in several laboratories, observed values can differ by 3 to 6°C (Reference 4). For more typical measurements, larger uncertainties should be assumed in both flash points and autoignition temperatures. The absence of a flash point entry in this table does not mean that the substance is nonflammable, but only that no reliable value is available.

Compounds are listed by molecular formula following the Hill convention. Substances not containing carbon are listed first, followed by those that contain carbon. To locate an organic compound by name or CAS Registry Number when the molecular formula is not known, use the table "Physical Constants of Organic Compounds" in Section 3 and its indexes to determine the molecular formula.

### References

1. *Fire Protection Guide to Hazardous Materials, 11th Edition*, National Fire Protection Association, Quincy, MA, 1994.
2. Urben, P. G., Ed., *Bretherick's Handbook of Reactive Chemical Hazards, 5th Edition*, Butterworth-Heinemann, Oxford, 1995.
3. Daubert, T. E., Danner, R. P., Sibul, H. M., and Stebbins, C. C., *Physical and Thermodynamic Properties of Pure Compounds: Data Compilation*, extant 1994 (core with 4 supplements), Taylor & Francis, Bristol, PA.
4. *Report of Investigation: Flash Point Reference Materials*, National Institute of Standards and Technology, Standard Reference Materials Program, Gaithersburg, MD, 1995.

| Mol. form.                             | Name               | $t_b$ /°C | FP/°C | Fl. limits | IT/°C |
|----------------------------------------|--------------------|-----------|-------|------------|-------|
| <b>Compounds not containing carbon</b> |                    |           |       |            |       |
| B <sub>2</sub> H <sub>6</sub>          | Diborane           | -92.4     | -90   | 1-98%      | ≈40   |
| B <sub>5</sub> H <sub>9</sub>          | Pentaborane(9)     | 60        | 30    | 0.4-?      | 35    |
| BrH <sub>3</sub> Si                    | Bromosilane        | 1.9       | <0    |            | ≈20   |
| Br <sub>3</sub> HSi                    | Tribromosilane     | 109       |       |            | ≈20   |
| Cl <sub>2</sub> H <sub>2</sub> Si      | Dichlorosilane     | 8.3       |       | 4.1-99%    | 36    |
| Cl <sub>3</sub> HSi                    | Trichlorosilane    | 33        | -50   |            | 104   |
| GeH <sub>4</sub>                       | Germane            | -88.1     |       |            | ≈20   |
| Ge <sub>2</sub> H <sub>6</sub>         | Digermane          | 29        |       |            | ≈50   |
| H <sub>2</sub>                         | Hydrogen           | -252.8    |       | 4-74%      |       |
| H <sub>2</sub> S                       | Hydrogen sulfide   | -59.55    |       | 4-44%      | 260   |
| H <sub>2</sub> S <sub>2</sub>          | Hydrogen disulfide | 70.7      | <22   |            |       |
| H <sub>2</sub> Te                      | Hydrogen telluride | -2        |       |            | -50   |
| H <sub>3</sub> N                       | Ammonia            | -33.33    |       | 16-25%     |       |
| H <sub>3</sub> P                       | Phosphine          | -87.75    |       | 1.8-?      |       |
| H <sub>4</sub> N <sub>2</sub>          | Hydrazine          | 113.55    | 38    | 5-100%     |       |
| H <sub>4</sub> P <sub>2</sub>          | Diphosphine        | 63.5      |       |            | ≈20   |
| H <sub>4</sub> Si                      | Silane             | -111.9    | -112  | 1.4-?      | ≈20   |
| H <sub>6</sub> Si <sub>2</sub>         | Disilane           | -14.3     | -14   |            | ≈20   |
| H <sub>8</sub> Si <sub>3</sub>         | Trisilane          | 52.9      | <0    |            | ≈20   |
| P                                      | Phosphorus (white) | 280.5     |       |            | 38    |
| <b>Compounds containing carbon</b>     |                    |           |       |            |       |
| CHN                                    | Hydrogen cyanide   | 26        | -18   | 6-40%      | 538   |
| CH <sub>2</sub> Cl <sub>2</sub>        | Dichloromethane    | 40        |       | 13-23%     | 556   |
| CH <sub>2</sub> N <sub>2</sub>         | Cyanamide          |           | 141   |            |       |
| CH <sub>2</sub> O                      | Formaldehyde       | -19.1     | 85    | 7.0-73%    | 424   |
| (CH <sub>2</sub> O) <sub>x</sub>       | Paraformaldehyde   |           | 70    | 7.0-73%    | 300   |
| CH <sub>2</sub> O <sub>2</sub>         | Formic acid        | 101       | 50    | 18-57%     | 434   |
| CH <sub>3</sub> Br                     | Bromomethane       | 3.5       |       | 10-16%     | 537   |
| CH <sub>3</sub> Cl                     | Chloromethane      | -24.0     |       | 8.1-17.4%  | 632   |

| Mol. form.                                   | Name                               | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|----------------------------------------------|------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{CH}_3\text{Cl}_3\text{Si}$            | Methyltrichlorosilane              | 65.6                   | -9                     | 7.6-20%    | >404                   |
| $\text{CH}_3\text{NO}$                       | Formamide                          | 220                    | 154                    |            |                        |
| $\text{CH}_3\text{NO}_2$                     | Nitromethane                       | 101.1                  | 35                     | 7.3-?      | 418                    |
| $\text{CH}_4$                                | Methane                            | -161.5                 |                        | 5.0-15.0%  | 537                    |
| $\text{CH}_4\text{Cl}_2\text{Si}$            | Dichloromethylsilane               | 41                     | -9                     | 6.0-55%    | 316                    |
| $\text{CH}_4\text{O}$                        | Methanol                           | 64.6                   | 11                     | 6.0-36%    | 464                    |
| $\text{CH}_4\text{S}$                        | Methanethiol                       | 5.9                    | -18                    | 3.9-21.8%  |                        |
| $\text{CH}_5\text{N}$                        | Methylamine                        | -6.3                   | 0                      | 4.9-20.7%  | 430                    |
| $\text{CH}_6\text{N}_2$                      | Methylhydrazine                    | 87.5                   | -8                     | 2.5-92%    | 194                    |
| $\text{CO}$                                  | Carbon monoxide                    | -191.5                 |                        | 12.5-74%   | 609                    |
| $\text{COS}$                                 | Carbon oxysulfide                  | -50                    |                        | 12-29%     |                        |
| $\text{CS}_2$                                | Carbon disulfide                   | 46                     | -30                    | 1.3-50.0%  | 90                     |
| $\text{C}_2\text{ClF}_3$                     | Chlorotrifluoroethylene            | -27.8                  |                        | 8.4-16.0%  |                        |
| $\text{C}_2\text{F}_4$                       | Tetrafluoroethylene                | -75.9                  |                        | 10.0-50.0% | 200                    |
| $\text{C}_2\text{HCl}_3$                     | Trichloroethylene                  | 87.2                   |                        | 8-10.5%    | 420                    |
| $\text{C}_2\text{HCl}_3\text{O}$             | Dichloroacetyl chloride            | 108                    | 66                     |            |                        |
| $\text{C}_2\text{H}_2$                       | Acetylene                          | -84.7                  |                        | 2.5-100%   | 305                    |
| $\text{C}_2\text{H}_2\text{Cl}_2$            | 1,1-Dichloroethylene               | 31.6                   | -28                    | 6.5-15.5%  | 570                    |
| $\text{C}_2\text{H}_2\text{Cl}_2$            | <i>cis</i> -1,2-Dichloroethylene   | 60.1                   | 6                      | 3-15%      | 460                    |
| $\text{C}_2\text{H}_2\text{Cl}_2$            | <i>trans</i> -1,2-Dichloroethylene | 48.7                   | 2                      | 6-13%      | 460                    |
| $\text{C}_2\text{H}_2\text{F}_2$             | 1,1-Difluoroethylene               | -85.7                  |                        | 5.5-21.3%  |                        |
| $\text{C}_2\text{H}_3\text{Br}$              | Bromoethylene                      | 15.8                   |                        | 9-15%      | 530                    |
| $\text{C}_2\text{H}_3\text{Cl}$              | Chloroethylene                     | -13.3                  | -78                    | 3.6-33.0%  | 472                    |
| $\text{C}_2\text{H}_3\text{ClF}_2$           | 1-Chloro-1,1-difluoroethane        | -9.7                   |                        | 6-18%      | 632                    |
| $\text{C}_2\text{H}_3\text{ClO}$             | Acetyl chloride                    | 50.7                   | 4                      |            | 390                    |
| $\text{C}_2\text{H}_3\text{Cl}_2\text{NO}_2$ | 1,1-Dichloro-1-nitroethane         | 123.5                  | 76                     |            |                        |
| $\text{C}_2\text{H}_3\text{Cl}_3$            | 1,1,1-Trichloroethane              | 74.0                   |                        | 8-10.5%    | 500                    |
| $\text{C}_2\text{H}_3\text{Cl}_3$            | 1,1,2-Trichloroethane              | 113.8                  | 32                     | 6-28%      | 460                    |
| $\text{C}_2\text{H}_3\text{Cl}_3\text{Si}$   | Trichlorovinylsilane               | 91.5                   | 21                     |            |                        |
| $\text{C}_2\text{H}_3\text{F}$               | Fluoroethylene                     | -72                    |                        | 2.6-21.7%  |                        |
| $\text{C}_2\text{H}_3\text{N}$               | Acetonitrile                       | 81.6                   | 6                      | 3.0-16.0%  | 524                    |
| $\text{C}_2\text{H}_3\text{NO}$              | Methyl isocyanate                  | 39.5                   | -7                     | 5.3-26%    | 534                    |
| $\text{C}_2\text{H}_4$                       | Ethylene                           | -103.7                 |                        | 2.7-36%    | 450                    |
| $\text{C}_2\text{H}_4\text{ClNO}_2$          | 1-Chloro-1-nitroethane             | 124.5                  | 56                     |            |                        |
| $\text{C}_2\text{H}_4\text{Cl}_2$            | 1,1-Dichloroethane                 | 57.4                   | -17                    | 5.4-11.4%  | 458                    |
| $\text{C}_2\text{H}_4\text{Cl}_2$            | 1,2-Dichloroethane                 | 83.5                   | 13                     | 6.2-16%    | 413                    |
| $\text{C}_2\text{H}_4\text{O}$               | Acetaldehyde                       | 20.1                   | -39                    | 4.0-60%    | 175                    |
| $\text{C}_2\text{H}_4\text{O}$               | Ethylene oxide                     | 10.6                   | -20                    | 3.0-100%   | 429                    |
| $\text{C}_2\text{H}_4\text{O}_2$             | Acetic acid                        | 117.9                  | 39                     | 4.0-19.9%  | 463                    |
| $\text{C}_2\text{H}_4\text{O}_2$             | Methyl formate                     | 31.7                   | -19                    | 4.5-23%    | 449                    |
| $\text{C}_2\text{H}_4\text{O}_3$             | Ethaneperoxoic acid                | 110                    | 41                     |            |                        |
| $\text{C}_2\text{H}_5\text{Br}$              | Bromoethane                        | 38.5                   |                        | 6.8-8.0%   | 511                    |
| $\text{C}_2\text{H}_5\text{Cl}$              | Chloroethane                       | 12.3                   | -50                    | 3.8-15.4%  | 519                    |
| $\text{C}_2\text{H}_5\text{ClO}$             | Ethylene chlorohydrin              | 128.6                  | 60                     | 4.9-15.9%  | 425                    |
| $\text{C}_2\text{H}_5\text{Cl}_3\text{Si}$   | Trichloroethylsilane               | 100.5                  | 22                     |            |                        |
| $\text{C}_2\text{H}_5\text{N}$               | Ethyleneimine                      | 56                     | -11                    | 3.3-54.8%  | 320                    |
| $\text{C}_2\text{H}_5\text{NO}_2$            | Nitroethane                        | 114.0                  | 28                     | 3.4-17%    | 414                    |
| $\text{C}_2\text{H}_5\text{NO}_2$            | Ethyl nitrite                      | 18                     | -35                    | 4.0-50%    | 90                     |
| $\text{C}_2\text{H}_5\text{NO}_3$            | Ethyl nitrate                      | 87.2                   | 10                     | 4-?        |                        |
| $\text{C}_2\text{H}_6$                       | Ethane                             | -88.6                  |                        | 3.0-12.5%  | 472                    |
| $\text{C}_2\text{H}_6\text{Cl}_2\text{Si}$   | Dichlorodimethylsilane             | 70.3                   | <21                    | 3.4-9.5%   |                        |
| $\text{C}_2\text{H}_6\text{O}$               | Ethanol                            | 78.2                   | 13                     | 3.3-19%    | 363                    |
| $\text{C}_2\text{H}_6\text{O}$               | Dimethyl ether                     | -24.8                  | -41                    | 3.4-27.0%  | 350                    |
| $\text{C}_2\text{H}_6\text{OS}$              | 2-Mercaptoethanol                  | 158                    | 74                     |            |                        |
| $\text{C}_2\text{H}_6\text{OS}$              | Dimethyl sulfoxide                 | 189                    | 95                     | 2.6-42%    | 215                    |
| $\text{C}_2\text{H}_6\text{O}_2$             | Ethylene glycol                    | 197.3                  | 111                    | 3.2-22%    | 398                    |
| $\text{C}_2\text{H}_6\text{O}_4\text{S}$     | Dimethyl sulfate                   |                        | 83                     |            | 188                    |
| $\text{C}_2\text{H}_6\text{S}$               | Ethanethiol                        | 35.1                   | -17                    | 2.8-18.0%  | 300                    |
| $\text{C}_2\text{H}_6\text{S}$               | Dimethyl sulfide                   | 37.3                   | -37                    | 2.2-19.7%  | 206                    |
| $\text{C}_2\text{H}_6\text{S}_2$             | Dimethyl disulfide                 | 109.8                  | 24                     |            |                        |
| $\text{C}_2\text{H}_7\text{N}$               | Ethylamine                         | 16.5                   | -16                    | 3.5-14%    | 385                    |

| Mol. form.                                   | Name                          | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|----------------------------------------------|-------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_2\text{H}_7\text{N}$               | Dimethylamine                 | 6.8                    | 20                     | 2.8–14.4%  | 400                    |
| $\text{C}_2\text{H}_7\text{NO}$              | Ethanolamine                  | 171                    | 86                     | 3.0–23.5%  | 410                    |
| $\text{C}_2\text{H}_8\text{N}_2$             | 1,2-Ethanediamine             | 117                    | 40                     | 2.5–12.0%  | 385                    |
| $\text{C}_2\text{H}_8\text{N}_2$             | 1,1-Dimethylhydrazine         | 63.9                   | –15                    | 2–95%      | 249                    |
| $\text{C}_2\text{N}_2$                       | Cyanogen                      | –21.1                  |                        | 6.6–32%    |                        |
| $\text{C}_3\text{H}_3\text{Br}$              | 3-Bromo-1-propyne             | 89                     | 10                     | 3.0–?      | 324                    |
| $\text{C}_3\text{H}_3\text{N}$               | 2-Propenenitrile              | 77.3                   | 0                      | 3.0–17.0%  | 481                    |
| $\text{C}_3\text{H}_4$                       | Propyne                       | –23.2                  |                        | 2.1–12.5%  |                        |
| $\text{C}_3\text{H}_4\text{ClN}$             | 3-Chloropropanenitrile        | 175.5                  | 76                     |            |                        |
| $\text{C}_3\text{H}_4\text{Cl}_2$            | 2,3-Dichloropropene           | 94                     | 15                     | 2.6–7.8%   |                        |
| $\text{C}_3\text{H}_4\text{O}$               | Propargyl alcohol             | 113.6                  | 36                     |            |                        |
| $\text{C}_3\text{H}_4\text{O}$               | Acrolein                      | 52.6                   | –26                    | 2.8–31%    | 220                    |
| $\text{C}_3\text{H}_4\text{O}_2$             | Propenoic acid                | 141                    | 50                     | 2.4–8.0%   | 438                    |
| $\text{C}_3\text{H}_4\text{O}_2$             | 2-Oxetanone                   | 162                    | 74                     | 2.9–?      |                        |
| $\text{C}_3\text{H}_5\text{O}_3$             | Ethylene carbonate            | 248                    | 143                    |            |                        |
| $\text{C}_3\text{H}_5\text{Br}$              | 3-Bromopropene                | 70.1                   | –1                     | 4.4–7.3%   | 295                    |
| $\text{C}_3\text{H}_5\text{Cl}$              | 2-Chloropropene               | 22.6                   | –37                    | 4.5–16%    |                        |
| $\text{C}_3\text{H}_5\text{Cl}$              | 3-Chloropropene               | 45.1                   | –32                    | 2.9–11.1%  | 485                    |
| $\text{C}_3\text{H}_5\text{ClO}$             | Epichlorohydrin               | 118                    | 31                     | 3.8–21.0%  | 411                    |
| $\text{C}_3\text{H}_5\text{ClO}$             | Propanoyl chloride            | 80                     | 12                     |            |                        |
| $\text{C}_3\text{H}_5\text{ClO}_2$           | 2-Chloropropanoic acid        | 185                    | 107                    |            | 500                    |
| $\text{C}_3\text{H}_5\text{ClO}_2$           | Ethyl chloroformate           | 95                     | 16                     |            | 500                    |
| $\text{C}_3\text{H}_5\text{ClO}_2$           | Methyl chloroacetate          | 129.5                  | 57                     | 7.5–18.5%  |                        |
| $\text{C}_3\text{H}_5\text{Cl}_2\text{NO}_2$ | 1,1-Dichloro-1-nitropropane   | 145                    | 66                     |            |                        |
| $\text{C}_3\text{H}_5\text{Cl}_3$            | 1,2,3-Trichloropropane        | 157                    | 71                     | 3.2–12.6%  |                        |
| $\text{C}_3\text{H}_5\text{Cl}_3\text{Si}$   | Trichloro-2-propenylsilane    | 117.5                  | 35                     |            |                        |
| $\text{C}_3\text{H}_5\text{N}$               | Propanenitrile                | 97.1                   | 2                      | 3.1–14%    | 512                    |
| $\text{C}_3\text{H}_5\text{NO}$              | 3-Hydroxypropanenitrile       | 221                    | 129                    |            |                        |
| $\text{C}_3\text{H}_5\text{N}_3\text{O}_9$   | Trinitroglycerol              |                        |                        |            | 270                    |
| $\text{C}_3\text{H}_6$                       | Propene                       | –47.6                  |                        | 2.0–11.1%  | 455                    |
| $\text{C}_3\text{H}_6$                       | Cyclopropane                  | –32.8                  |                        | 2.4–10.4%  | 498                    |
| $\text{C}_3\text{H}_6\text{ClNO}_2$          | 1-Chloro-1-nitropropane       | 142                    | 62                     |            |                        |
| $\text{C}_3\text{H}_6\text{ClNO}_2$          | 2-Chloro-2-nitropropane       |                        | 57                     |            |                        |
| $\text{C}_3\text{H}_6\text{Cl}_2$            | 1,2-Dichloropropane           | 96.4                   | 21                     | 3.4–14.5%  | 557                    |
| $\text{C}_3\text{H}_6\text{Cl}_2\text{O}$    | 1,3-Dichloro-2-propanol       | 176                    | 74                     |            |                        |
| $\text{C}_3\text{H}_6\text{N}_2$             | Dimethylcyanamide             | 163.5                  | 71                     |            |                        |
| $\text{C}_3\text{H}_6\text{O}$               | Allyl alcohol                 | 97.0                   | 21                     | 2.5–18.0%  | 378                    |
| $\text{C}_3\text{H}_6\text{O}$               | Methyl vinyl ether            | 5.5                    |                        |            | 287                    |
| $\text{C}_3\text{H}_6\text{O}$               | Propanal                      | 48                     | –30                    | 2.6–17%    | 207                    |
| $\text{C}_3\text{H}_6\text{O}$               | Acetone                       | 56.0                   | –20                    | 2.5–12.8%  | 465                    |
| $\text{C}_3\text{H}_6\text{O}$               | Methyloxirane                 | 35                     | –37                    | 3.1–27.5%  | 449                    |
| $\text{C}_3\text{H}_6\text{O}_2$             | Propanoic acid                | 141.1                  | 52                     | 2.9–12.1%  | 465                    |
| $\text{C}_3\text{H}_6\text{O}_2$             | Ethyl formate                 | 54.4                   | –20                    | 2.8–16.0%  | 455                    |
| $\text{C}_3\text{H}_6\text{O}_2$             | Methyl acetate                | 56.8                   | –10                    | 3.1–16%    | 454                    |
| $\text{C}_3\text{H}_6\text{O}_2$             | 1,3-Dioxolane                 | 78                     | 2                      |            |                        |
| $\text{C}_3\text{H}_6\text{O}_3$             | Dimethyl carbonate            | 90.5                   | 19                     |            |                        |
| $\text{C}_3\text{H}_6\text{O}_3$             | 1,3,5-Trioxane                | 114.5                  | 45                     | 3.6–29%    | 414                    |
| $\text{C}_3\text{H}_7\text{Br}$              | 1-Bromopropane                | 71.1                   |                        |            | 490                    |
| $\text{C}_3\text{H}_7\text{Cl}$              | 1-Chloropropane               | 46.5                   | <–18                   | 2.6–11.1%  | 520                    |
| $\text{C}_3\text{H}_7\text{Cl}$              | 2-Chloropropane               | 35.7                   | –32                    | 2.8–10.7%  | 593                    |
| $\text{C}_3\text{H}_7\text{ClO}$             | 2-Chloro-1-propanol           | 133.5                  | 52                     |            |                        |
| $\text{C}_3\text{H}_7\text{ClO}$             | 1-Chloro-2-propanol           | 127                    | 52                     |            |                        |
| $\text{C}_3\text{H}_7\text{Cl}_3\text{Si}$   | Trichloropropylsilane         | 123.5                  | 37                     |            |                        |
| $\text{C}_3\text{H}_7\text{N}$               | Allylamine                    | 53.3                   | –29                    | 2.2–22%    | 374                    |
| $\text{C}_3\text{H}_7\text{NO}$              | <i>N,N</i> -Dimethylformamide | 153                    | 58                     | 2.2–15.2%  | 445                    |
| $\text{C}_3\text{H}_7\text{NO}_2$            | 1-Nitropropane                | 131.1                  | 36                     | 2.2–?      | 421                    |
| $\text{C}_3\text{H}_7\text{NO}_2$            | 2-Nitropropane                | 120.2                  | 24                     | 2.6–11.0%  | 428                    |
| $\text{C}_3\text{H}_7\text{NO}_3$            | Propyl nitrate                | 110                    | 20                     | 2–100%     | 175                    |
| $\text{C}_3\text{H}_8$                       | Propane                       | –42.1                  | –104                   | 2.1–9.5%   | 450                    |
| $\text{C}_3\text{H}_8\text{O}$               | 1-Propanol                    | 97.2                   | 23                     | 2.2–13.7%  | 412                    |
| $\text{C}_3\text{H}_8\text{O}$               | 2-Propanol                    | 82.3                   | 12                     | 2.0–12.7%  | 399                    |

| Mol. form.                                | Name                             | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|-------------------------------------------|----------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_3\text{H}_8\text{O}$            | Ethyl methyl ether               | 7.4                    | -37                    | 2.0–10.1%  | 190                    |
| $\text{C}_3\text{H}_8\text{O}_2$          | 1,2-Propylene glycol             | 187.6                  | 99                     | 2.6–12.5%  | 371                    |
| $\text{C}_3\text{H}_8\text{O}_2$          | 1,3-Propylene glycol             | 214.4                  |                        |            | 400                    |
| $\text{C}_3\text{H}_8\text{O}_2$          | Ethylene glycol monomethyl ether | 124.1                  | 39                     | 1.8–14%    | 285                    |
| $\text{C}_3\text{H}_8\text{O}_2$          | Dimethoxymethane                 | 42                     | -32                    | 2.2–13.8%  | 237                    |
| $\text{C}_3\text{H}_8\text{O}_3$          | Glycerol                         | 290                    | 199                    | 3–19%      | 370                    |
| $\text{C}_3\text{H}_9\text{BO}_3$         | Trimethyl borate                 | 67.5                   | -8                     |            |                        |
| $\text{C}_3\text{H}_9\text{ClSi}$         | Trimethylchlorosilane            | 60                     | -28                    |            | 395                    |
| $\text{C}_3\text{H}_9\text{N}$            | Propylamine                      | 47.2                   | -37                    | 2.0–10.4%  | 318                    |
| $\text{C}_3\text{H}_9\text{N}$            | Isopropylamine                   | 31.7                   | -37                    |            | 402                    |
| $\text{C}_3\text{H}_9\text{N}$            | Trimethylamine                   | 2.8                    | -5                     | 2.0–11.6%  | 190                    |
| $\text{C}_3\text{H}_9\text{NO}$           | 3-Amino-1-propanol               | 187.5                  | 80                     |            |                        |
| $\text{C}_3\text{H}_9\text{NO}$           | 1-Amino-2-propanol               | 159.4                  | 77                     |            | 374                    |
| $\text{C}_3\text{H}_9\text{NO}$           | N-Methyl-2-ethanolamine          | 158                    | 74                     |            |                        |
| $\text{C}_3\text{H}_9\text{O}_3\text{P}$  | Trimethyl phosphite              | 111.5                  | 54                     |            |                        |
| $\text{C}_3\text{H}_9\text{O}_4\text{P}$  | Trimethyl phosphate              | 197.2                  | 107                    |            |                        |
| $\text{C}_3\text{H}_{10}\text{N}_2$       | 1,3-Propanediamine               | 139.8                  | 24                     |            |                        |
| $\text{C}_4\text{Cl}_6$                   | Hexachloro-1,3-butadiene         | 215                    |                        |            | 610                    |
| $\text{C}_4\text{H}_2\text{O}_3$          | Maleic anhydride                 | 202                    | 102                    | 1.4–7.1%   | 477                    |
| $\text{C}_4\text{H}_4$                    | 1-Buten-3-yne                    | 5.1                    |                        | 21–100%    |                        |
| $\text{C}_4\text{H}_4\text{N}_2$          | Succinonitrile                   | 266                    | 132                    |            |                        |
| $\text{C}_4\text{H}_4\text{O}$            | Furan                            | 31.5                   | -36                    | 2.3–14.3%  |                        |
| $\text{C}_4\text{H}_4\text{O}_2$          | Diketene                         | 126.1                  | 34                     |            |                        |
| $\text{C}_4\text{H}_4\text{S}$            | Thiophene                        | 84.0                   | -1                     |            |                        |
| $\text{C}_4\text{H}_5\text{Cl}$           | 2-Chloro-1,3-butadiene           | 59.4                   | -20                    | 4.0–20.0%  |                        |
| $\text{C}_4\text{H}_5\text{N}$            | 2-Butenenitrile                  | 120.5                  | 16                     |            |                        |
| $\text{C}_4\text{H}_5\text{N}$            | Methylacrylonitrile              | 90.3                   | 1                      | 2–6.8%     |                        |
| $\text{C}_4\text{H}_5\text{N}$            | Pyrrole                          | 129.7                  | 39                     |            |                        |
| $\text{C}_4\text{H}_6$                    | 1,3-Butadiene                    | -4.4                   |                        | 2.0–12.0%  | 420                    |
| $\text{C}_4\text{H}_6$                    | 2-Butyne                         | 26.9                   | -31                    | 1.4–?      |                        |
| $\text{C}_4\text{H}_6\text{O}$            | Divinyl ether                    | 28.3                   | <-30                   | 1.7–27%    | 360                    |
| $\text{C}_4\text{H}_6\text{O}$            | Ethoxyacetylene                  | 50                     | <-7                    |            |                        |
| $\text{C}_4\text{H}_6\text{O}$            | trans-2-Butenal                  | 102.2                  | 13                     | 2.1–15.5%  | 232                    |
| $\text{C}_4\text{H}_6\text{O}$            | 3-Buten-2-one                    | 81.4                   | -7                     | 2.1–15.6%  | 491                    |
| $\text{C}_4\text{H}_6\text{O}$            | Vinylloxirane                    | 68                     | <-50                   |            |                        |
| $\text{C}_4\text{H}_6\text{O}_2$          | Methacrylic acid                 | 162.5                  | 77                     | 1.6–8.8%   | 68                     |
| $\text{C}_4\text{H}_6\text{O}_2$          | Vinyl acetate                    | 72.5                   | -8                     | 2.6–13.4%  | 402                    |
| $\text{C}_4\text{H}_6\text{O}_2$          | Methyl acrylate                  | 80.7                   | -3                     | 2.8–25%    | 468                    |
| $\text{C}_4\text{H}_6\text{O}_2$          | 2,3-Butanedione                  | 88                     | 27                     |            |                        |
| $\text{C}_4\text{H}_6\text{O}_2$          | $\gamma$ -Butyrolactone          | 204                    | 98                     |            |                        |
| $\text{C}_4\text{H}_6\text{O}_3$          | Acetic anhydride                 | 139.5                  | 49                     | 2.7–10.3%  | 316                    |
| $\text{C}_4\text{H}_6\text{O}_3$          | Propylene carbonate              | 242                    | 135                    |            |                        |
| $\text{C}_4\text{H}_6\text{O}_6$          | L-Tartaric acid                  |                        | 210                    |            | 425                    |
| $\text{C}_4\text{H}_7\text{Br}$           | 1-Bromo-2-butene                 | 104.5                  |                        | 4.6–12.0%  |                        |
| $\text{C}_4\text{H}_7\text{BrO}_2$        | Ethyl bromoacetate               | 168.5                  | 48                     |            |                        |
| $\text{C}_4\text{H}_7\text{Cl}$           | 2-Chloro-1-butene                | 58.5                   | -19                    | 2.3–9.3%   |                        |
| $\text{C}_4\text{H}_7\text{Cl}$           | 3-Chloro-2-methylpropene         | 71.5                   | -12                    | 3.2–8.1%   |                        |
| $\text{C}_4\text{H}_7\text{ClO}$          | 2-Chloroethyl vinyl ether        | 108                    | 27                     |            |                        |
| $\text{C}_4\text{H}_7\text{ClO}_2$        | Ethyl chloroacetate              | 144.3                  | 64                     |            |                        |
| $\text{C}_4\text{H}_7\text{N}$            | Butanenitrile                    | 117.6                  | 24                     | 1.6–?      | 501                    |
| $\text{C}_4\text{H}_7\text{N}$            | 2-Methylpropanenitrile           | 103.9                  | 8                      |            | 482                    |
| $\text{C}_4\text{H}_7\text{NO}$           | Acetone cyanohydrin              |                        | 74                     | 2.2–12.0%  | 688                    |
| $\text{C}_4\text{H}_7\text{NO}$           | 2-Pyrrolidone                    | 251                    | 129                    |            |                        |
| $\text{C}_4\text{H}_8$                    | 1-Butene                         | -6.2                   |                        | 1.6–10.0%  | 385                    |
| $\text{C}_4\text{H}_8$                    | cis-2-Butene                     | 3.7                    |                        | 1.7–9.0%   | 325                    |
| $\text{C}_4\text{H}_8$                    | trans-2-Butene                   | 0.8                    |                        | 1.8–9.7%   | 324                    |
| $\text{C}_4\text{H}_8$                    | Isobutene                        | -6.9                   |                        | 1.8–9.6%   | 465                    |
| $\text{C}_4\text{H}_8$                    | Cyclobutane                      | 12.6                   | <10                    | 1.8–?      |                        |
| $\text{C}_4\text{H}_8\text{Cl}_2$         | 1,2-Dichlorobutane               | 124.1                  |                        |            | 275                    |
| $\text{C}_4\text{H}_8\text{Cl}_2$         | 1,4-Dichlorobutane               | 161                    | 52                     |            |                        |
| $\text{C}_4\text{H}_8\text{Cl}_2\text{O}$ | Bis(2-chloroethyl) ether         | 178.5                  | 55                     | 2.7–?      | 369                    |

| Mol. form.                                  | Name                             | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|---------------------------------------------|----------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_4\text{H}_8\text{O}$              | 2-Buten-1-ol                     | 121.5                  | 27                     | 4.2–35.3%  | 349                    |
| $\text{C}_4\text{H}_8\text{O}$              | 2-Methyl-2-propenol              | 114.5                  | 33                     |            |                        |
| $\text{C}_4\text{H}_8\text{O}$              | Ethyl vinyl ether                | 35.5                   | <–46                   | 1.7–28%    | 202                    |
| $\text{C}_4\text{H}_8\text{O}$              | 1,2-Epoxybutane                  | 63.4                   | –22                    | 1.7–19%    | 439                    |
| $\text{C}_4\text{H}_8\text{O}$              | Butanal                          | 74.8                   | –22                    | 1.9–12.5%  | 218                    |
| $\text{C}_4\text{H}_8\text{O}$              | Isobutanal                       | 64.5                   | –18                    | 1.6–10.6%  | 196                    |
| $\text{C}_4\text{H}_8\text{O}$              | 2-Butanone                       | 79.5                   | –9                     | 1.4–11.4%  | 404                    |
| $\text{C}_4\text{H}_8\text{O}$              | Tetrahydrofuran                  | 65                     | –14                    | 2–11.8%    | 321                    |
| $\text{C}_4\text{H}_8\text{OS}$             | 1,4-Oxathiane                    | 147                    | 42                     |            |                        |
| $\text{C}_4\text{H}_8\text{O}_2$            | Butanoic acid                    | 163.7                  | 72                     | 2.0–10.0%  | 443                    |
| $\text{C}_4\text{H}_8\text{O}_2$            | 2-Methylpropanoic acid           | 154.4                  | 56                     | 2.0–9.2%   | 481                    |
| $\text{C}_4\text{H}_8\text{O}_2$            | Propyl formate                   | 80.9                   | –3                     |            | 455                    |
| $\text{C}_4\text{H}_8\text{O}_2$            | Isopropyl formate                | 68.2                   | –6                     |            | 485                    |
| $\text{C}_4\text{H}_8\text{O}_2$            | Ethyl acetate                    | 77.1                   | –4                     | 2.0–11.5%  | 426                    |
| $\text{C}_4\text{H}_8\text{O}_2$            | Methyl propanoate                | 79.8                   | –2                     | 2.5–13%    | 469                    |
| $\text{C}_4\text{H}_8\text{O}_2$            | 3-Hydroxybutanal                 |                        | 66                     |            | 250                    |
| $\text{C}_4\text{H}_8\text{O}_2$            | 1,4-Dioxane                      | 101.5                  | 12                     | 2.0–22%    | 180                    |
| $\text{C}_4\text{H}_8\text{O}_2\text{S}$    | Sulfolane                        | 287.3                  | 177                    |            |                        |
| $\text{C}_4\text{H}_8\text{O}_3$            | Methyl lactate                   | 144.8                  | 49                     | 2.2–?      | 385                    |
| $\text{C}_4\text{H}_8\text{O}_3$            | Ethylene glycol monoacetate      | 188                    | 102                    |            |                        |
| $\text{C}_4\text{H}_9\text{Br}$             | 1-Bromobutane                    | 101.6                  | 18                     | 2.6–6.6%   | 265                    |
| $\text{C}_4\text{H}_9\text{Br}$             | 2-Bromobutane                    | 91.2                   | 21                     |            |                        |
| $\text{C}_4\text{H}_9\text{Cl}$             | 1-Chlorobutane                   | 78.6                   | –12                    | 1.9–10.1%  | 240                    |
| $\text{C}_4\text{H}_9\text{Cl}$             | 2-Chlorobutane                   | 68.2                   | –10                    |            |                        |
| $\text{C}_4\text{H}_9\text{Cl}$             | 1-Chloro-2-methylpropane         | 68.5                   | –6                     | 2.0–8.7%   |                        |
| $\text{C}_4\text{H}_9\text{Cl}$             | 2-Chloro-2-methylpropane         | 50.9                   | 0                      |            |                        |
| $\text{C}_4\text{H}_9\text{Cl}_3\text{Si}$  | Butyltrichlorosilane             | 148.5                  | 54                     |            |                        |
| $\text{C}_4\text{H}_9\text{N}$              | Pyrrolidine                      | 86.5                   | 3                      |            |                        |
| $\text{C}_4\text{H}_9\text{NO}$             | <i>N</i> -Ethylacetamide         | 205                    | 110                    |            |                        |
| $\text{C}_4\text{H}_9\text{NO}$             | <i>N,N</i> -Dimethylacetamide    | 165                    | 70                     | 1.8–11.5%  | 490                    |
| $\text{C}_4\text{H}_9\text{NO}$             | Butanal oxime                    | 154                    | 58                     |            |                        |
| $\text{C}_4\text{H}_9\text{NO}$             | 2-Butanone oxime                 | 152.5                  | ≈70                    |            |                        |
| $\text{C}_4\text{H}_9\text{NO}$             | Morpholine                       | 128                    | 37                     | 1.4–11.2%  | 290                    |
| $\text{C}_4\text{H}_9\text{NO}_2$           | <i>N</i> -Acetyethanolamine      |                        | 179                    |            | 460                    |
| $\text{C}_4\text{H}_9\text{NO}_3$           | Butyl nitrate                    | 133                    | 36                     |            |                        |
| $\text{C}_4\text{H}_{10}$                   | Butane                           | –0.5                   | –60                    | 1.9–8.5%   | 287                    |
| $\text{C}_4\text{H}_{10}$                   | Isobutane                        | –11.7                  | –87                    | 1.8–8.4%   | 460                    |
| $\text{C}_4\text{H}_{10}\text{N}_2$         | Piperazine                       | 146                    | 81                     |            |                        |
| $\text{C}_4\text{H}_{10}\text{O}$           | 1-Butanol                        | 117.7                  | 37                     | 1.4–11.2%  | 343                    |
| $\text{C}_4\text{H}_{10}\text{O}$           | 2-Butanol                        | 99.5                   | 24                     | 1.7–9.8%   | 405                    |
| $\text{C}_4\text{H}_{10}\text{O}$           | 2-Methyl-1-propanol              | 107.8                  | 28                     | 1.7–10.6%  | 415                    |
| $\text{C}_4\text{H}_{10}\text{O}$           | 2-Methyl-2-propanol              | 82.4                   | 11                     | 2.4–8.0%   | 478                    |
| $\text{C}_4\text{H}_{10}\text{O}$           | Diethyl ether                    | 34.5                   | –45                    | 1.9–36.0%  | 180                    |
| $\text{C}_4\text{H}_{10}\text{O}$           | Methyl propyl ether              | 39.1                   | –20                    | 2.0–14.8%  |                        |
| $\text{C}_4\text{H}_{10}\text{O}_2$         | 1,2-Butanediol                   | 190.5                  | 40                     |            |                        |
| $\text{C}_4\text{H}_{10}\text{O}_2$         | 1,3-Butanediol                   | 207.5                  | 121                    |            | 395                    |
| $\text{C}_4\text{H}_{10}\text{O}_2$         | 1,4-Butanediol                   | 235                    | 121                    |            |                        |
| $\text{C}_4\text{H}_{10}\text{O}_2$         | 2,3-Butanediol                   | 182.5                  |                        |            | 402                    |
| $\text{C}_4\text{H}_{10}\text{O}_2$         | Ethylene glycol monoethyl ether  | 135                    | 43                     | 3–18%      | 235                    |
| $\text{C}_4\text{H}_{10}\text{O}_2$         | Ethylene glycol dimethyl ether   | 85                     | –2                     |            | 202                    |
| $\text{C}_4\text{H}_{10}\text{O}_2$         | <i>tert</i> -Butyl hydroperoxide |                        | 27                     |            |                        |
| $\text{C}_4\text{H}_{10}\text{O}_2\text{S}$ | 2,2'-Thiodiethanol               | 282                    | 160                    |            | 298                    |
| $\text{C}_4\text{H}_{10}\text{O}_3$         | Diethylene glycol                | 245.8                  | 124                    | 2–17%      | 224                    |
| $\text{C}_4\text{H}_{10}\text{O}_4\text{S}$ | Diethyl sulfate                  | 208                    | 104                    |            | 436                    |
| $\text{C}_4\text{H}_{10}\text{S}$           | 1-Butanethiol                    | 98.5                   | 2                      |            |                        |
| $\text{C}_4\text{H}_{10}\text{S}$           | 2-Butanethiol                    | 85                     | –23                    |            |                        |
| $\text{C}_4\text{H}_{10}\text{S}$           | 2-Methyl-1-propanethiol          | 88.5                   | 2                      |            |                        |
| $\text{C}_4\text{H}_{10}\text{S}$           | 2-Methyl-2-propanethiol          | 64.3                   | <–29                   |            |                        |
| $\text{C}_4\text{H}_{10}\text{Se}$          | Diethyl selenide                 | 108                    |                        | 2.5–?      |                        |
| $\text{C}_4\text{H}_{11}\text{N}$           | Butylamine                       | 77.0                   | –12                    | 1.7–9.8%   | 312                    |
| $\text{C}_4\text{H}_{11}\text{N}$           | <i>sec</i> -Butylamine           | 63.5                   | –9                     |            |                        |

| Mol. form.                           | Name                                     | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|--------------------------------------|------------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_4\text{H}_{11}\text{N}$    | <i>tert</i> -Butylamine                  | 44.0                   | −9                     | 1.7–8.9%   | 380                    |
| $\text{C}_4\text{H}_{11}\text{N}$    | Isobutylamine                            | 67.7                   | −9                     | 2–12%      | 378                    |
| $\text{C}_4\text{H}_{11}\text{N}$    | Diethylamine                             | 55.5                   | −23                    | 1.8–10.1%  | 312                    |
| $\text{C}_4\text{H}_{11}\text{NO}$   | 2-Amino-1-butanol                        | 178                    | 74                     |            |                        |
| $\text{C}_4\text{H}_{11}\text{NO}$   | 2-Amino-2-methyl-1-propanol              | 165.5                  | 67                     |            |                        |
| $\text{C}_4\text{H}_{11}\text{NO}_2$ | Diethanolamine                           | 268.8                  | 172                    | 2–13%      | 662                    |
| $\text{C}_4\text{H}_{12}\text{Sn}$   | Tetramethylstannane                      | 78                     | −12                    | 1.9–?      |                        |
| $\text{C}_4\text{H}_{13}\text{N}_3$  | Diethylenetriamine                       | 207                    | 98                     | 2–6.7%     | 358                    |
| $\text{C}_5\text{H}_4\text{O}_2$     | Furfural                                 | 161.7                  | 60                     | 2.1–19.3%  | 316                    |
| $\text{C}_5\text{H}_5\text{N}$       | Pyridine                                 | 115.2                  | 20                     | 1.8–12.4%  | 482                    |
| $\text{C}_5\text{H}_6$               | 2-Methyl-1-buten-3-yne                   | 32                     | <−7                    |            |                        |
| $\text{C}_5\text{H}_6\text{N}_2$     | 2-Methylpyrazine                         | 137                    | 50                     |            |                        |
| $\text{C}_5\text{H}_6\text{O}$       | 3-Methylfuran                            | 66                     | −30                    |            |                        |
| $\text{C}_5\text{H}_6\text{O}_2$     | Furfuryl alcohol                         | 171                    | 75                     | 1.8–16.3%  | 491                    |
| $\text{C}_5\text{H}_7\text{N}$       | 1-Methylpyrrole                          | 115                    | 16                     |            |                        |
| $\text{C}_5\text{H}_7\text{NO}$      | 2-Furanmethanamine                       | 145.5                  | 37                     |            |                        |
| $\text{C}_5\text{H}_7\text{NO}_2$    | Ethyl cyanoacetate                       | 205                    | 110                    |            |                        |
| $\text{C}_5\text{H}_8$               | 2-Methyl-1,3-butadiene                   | 34.0                   | −54                    | 1.5–8.9%   | 395                    |
| $\text{C}_5\text{H}_8$               | 1-Pentyne                                | 40.1                   | <−20                   |            |                        |
| $\text{C}_5\text{H}_8$               | Cyclopentene                             | 44.2                   | −29                    |            | 395                    |
| $\text{C}_5\text{H}_8\text{O}$       | 3-Methyl-3-buten-2-one                   | 98                     |                        | 1.8–9.0%   |                        |
| $\text{C}_5\text{H}_8\text{O}$       | Cyclopentanone                           | 130.5                  | 26                     |            |                        |
| $\text{C}_5\text{H}_8\text{O}$       | 3,4-Dihydro-2H-pyran                     | 86                     | −18                    |            |                        |
| $\text{C}_5\text{H}_8\text{O}_2$     | Allyl acetate                            | 103.5                  | 22                     |            | 374                    |
| $\text{C}_5\text{H}_8\text{O}_2$     | Isopropenyl acetate                      | 94                     | 26                     |            | 432                    |
| $\text{C}_5\text{H}_8\text{O}_2$     | Vinyl propanoate                         | 91.2                   | 1                      |            |                        |
| $\text{C}_5\text{H}_8\text{O}_2$     | Ethyl acrylate                           | 99.4                   | 10                     | 1.4–14%    | 372                    |
| $\text{C}_5\text{H}_8\text{O}_2$     | Methyl methacrylate                      | 100.5                  | 10                     | 1.7–8.2%   |                        |
| $\text{C}_5\text{H}_8\text{O}_2$     | 2,4-Pentanedione                         | 138                    | 34                     |            | 340                    |
| $\text{C}_5\text{H}_8\text{O}_3$     | Methyl acetoacetate                      | 171.7                  | 77                     |            | 280                    |
| $\text{C}_5\text{H}_9\text{NO}$      | <i>N</i> -Methyl-2-pyrrolidone           | 202                    | 96                     | 1–10%      | 346                    |
| $\text{C}_5\text{H}_{10}$            | 1-Pentene                                | 29.9                   | −18                    | 1.5–8.7%   | 275                    |
| $\text{C}_5\text{H}_{10}$            | <i>cis</i> -2-Pentene                    | 36.9                   | <−20                   |            |                        |
| $\text{C}_5\text{H}_{10}$            | <i>trans</i> -2-Pentene                  | 36.3                   | <−20                   |            |                        |
| $\text{C}_5\text{H}_{10}$            | 2-Methyl-1-butene                        | 31.2                   | −20                    |            |                        |
| $\text{C}_5\text{H}_{10}$            | 3-Methyl-1-butene                        | 20.1                   | −7                     | 1.5–9.1%   | 365                    |
| $\text{C}_5\text{H}_{10}$            | 2-Methyl-2-butene                        | 38.5                   | −20                    |            |                        |
| $\text{C}_5\text{H}_{10}$            | Cyclopentane                             | 49.3                   | −25                    | 1.5–?      | 361                    |
| $\text{C}_5\text{H}_{10}\text{Cl}_2$ | 1,5-Dichloropentane                      | 179                    | >27                    |            |                        |
| $\text{C}_5\text{H}_{10}\text{N}_2$  | 3-(Dimethylamino)propanenitrile          | 173                    | 65                     |            |                        |
| $\text{C}_5\text{H}_{10}\text{O}$    | Cyclopentanol                            | 140.4                  | 51                     |            |                        |
| $\text{C}_5\text{H}_{10}\text{O}$    | Pentanal                                 | 103                    | 12                     |            | 222                    |
| $\text{C}_5\text{H}_{10}\text{O}$    | 2-Pentanone                              | 102.2                  | 7                      | 1.5–8.2%   | 452                    |
| $\text{C}_5\text{H}_{10}\text{O}$    | 3-Pentanone                              | 101.9                  | 13                     | 1.6–?      | 450                    |
| $\text{C}_5\text{H}_{10}\text{O}$    | Tetrahydropyran                          | 88                     | −20                    |            |                        |
| $\text{C}_5\text{H}_{10}\text{O}$    | 2-Methyltetrahydrofuran                  | 78                     | −11                    |            |                        |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | Pentanoic acid                           | 186.1                  | 96                     |            | 400                    |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | 3-Methylbutanoic acid                    | 176.5                  |                        |            | 416                    |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | Butyl formate                            | 106.1                  | 18                     | 1.7–8.2%   | 322                    |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | Isobutyl formate                         | 98.2                   | 5                      | 2–9%       | 320                    |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | Propyl acetate                           | 101.5                  | 13                     | 1.7–8%     | 450                    |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | Isopropyl acetate                        | 88.6                   | 2                      | 1.8–8%     | 460                    |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | Ethyl propanoate                         | 99.1                   | 12                     | 1.9–11%    | 440                    |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | Methyl butanoate                         | 102.8                  | 14                     |            |                        |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | 3-Ethoxypropanal                         | 135.2                  | 38                     |            |                        |
| $\text{C}_5\text{H}_{10}\text{O}_2$  | Tetrahydrofurfuryl alcohol               | 178                    | 75                     | 1.5–9.7%   | 282                    |
| $\text{C}_5\text{H}_{10}\text{O}_3$  | Diethyl carbonate                        | 126                    | 25                     |            |                        |
| $\text{C}_5\text{H}_{10}\text{O}_3$  | Ethylene glycol monomethyl ether acetate | 143                    | 49                     | 1.5–12.3%  | 392                    |
| $\text{C}_5\text{H}_{10}\text{O}_3$  | Ethyl lactate                            | 154.5                  | 46                     | 1.5–?      | 400                    |
| $\text{C}_5\text{H}_{11}\text{Br}$   | 1-Bromopentane                           | 129.8                  | 32                     |            |                        |



| Mol. form.                                    | Name                               | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|-----------------------------------------------|------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_5\text{H}_{11}\text{Cl}$            | 1-Chloropentane                    | 107.8                  | 13                     | 1.6–8.6%   | 260                    |
| $\text{C}_5\text{H}_{11}\text{Cl}$            | 2-Chloro-2-methylbutane            | 85.6                   |                        | 1.5–7.4%   | 345                    |
| $\text{C}_5\text{H}_{11}\text{Cl}$            | 1-Chloro-3-methylbutane            | 98.9                   | <21                    | 1.5–7.4%   |                        |
| $\text{C}_5\text{H}_{11}\text{Cl}_3\text{Si}$ | Trichloropentylsilane              | 172                    | 63                     |            |                        |
| $\text{C}_5\text{H}_{11}\text{N}$             | Piperidine                         | 106.2                  | 16                     |            |                        |
| $\text{C}_5\text{H}_{11}\text{N}$             | <i>N</i> -Methylpyrrolidine        | 81                     | –14                    |            |                        |
| $\text{C}_5\text{H}_{11}\text{NO}$            | 4-Methylmorpholine                 | 116                    | 24                     |            |                        |
| $\text{C}_5\text{H}_{11}\text{NO}_2$          | Isopentyl nitrite                  | 99.2                   |                        |            | 210                    |
| $\text{C}_5\text{H}_{12}$                     | Pentane                            | 36.0                   | –40                    | 1.4–8.0%   | 260                    |
| $\text{C}_5\text{H}_{12}$                     | Isopentane                         | 27.8                   | –51                    | 1.4–7.6%   | 420                    |
| $\text{C}_5\text{H}_{12}$                     | Neopentane                         | 9.4                    | –65                    | 1.4–7.5%   | 450                    |
| $\text{C}_5\text{H}_{12}\text{N}_2$           | 1-Methylpiperazine                 | 138                    | 42                     |            |                        |
| $\text{C}_5\text{H}_{12}\text{N}_2\text{O}$   | Tetramethylurea                    | 176.5                  | 77                     |            |                        |
| $\text{C}_5\text{H}_{12}\text{O}$             | 1-Pentanol                         | 137.9                  | 33                     | 1.2–10.0%  | 300                    |
| $\text{C}_5\text{H}_{12}\text{O}$             | 2-Pentanol                         | 119.3                  | 34                     | 1.2–9.0%   | 343                    |
| $\text{C}_5\text{H}_{12}\text{O}$             | 3-Pentanol                         | 116.2                  | 41                     | 1.2–9.0%   | 435                    |
| $\text{C}_5\text{H}_{12}\text{O}$             | 2-Methyl-1-butanol                 | 128                    | 50                     |            | 385                    |
| $\text{C}_5\text{H}_{12}\text{O}$             | 3-Methyl-1-butanol                 | 131.1                  | 43                     | 1.2–9.0%   | 350                    |
| $\text{C}_5\text{H}_{12}\text{O}$             | 2-Methyl-2-butanol                 | 102.4                  | 19                     | 1.2–9.0%   | 437                    |
| $\text{C}_5\text{H}_{12}\text{O}$             | 3-Methyl-2-butanol                 | 112.9                  | 38                     |            |                        |
| $\text{C}_5\text{H}_{12}\text{O}$             | 2,2-Dimethyl-1-propanol            | 113.5                  | 37                     |            |                        |
| $\text{C}_5\text{H}_{12}\text{O}$             | Ethyl propyl ether                 | 63.2                   | <–20                   | 1.7–9.0%   |                        |
| $\text{C}_5\text{H}_{12}\text{O}_2$           | 1,5-Pentanediol                    | 239                    | 129                    |            | 335                    |
| $\text{C}_5\text{H}_{12}\text{O}_2$           | 2-Isopropoxyethanol                | 145                    | 33                     |            |                        |
| $\text{C}_5\text{H}_{12}\text{O}_2$           | 2,2-Dimethyl-1,3-propanediol       | 208                    | 129                    |            | 399                    |
| $\text{C}_5\text{H}_{12}\text{O}_3$           | Diethylene glycol monomethyl ether | 193                    | 96                     | 1.38–22.7% | 240                    |
| $\text{C}_5\text{H}_{12}\text{S}$             | 1-Pentanethiol                     | 126.6                  | 18                     |            |                        |
| $\text{C}_5\text{H}_{12}\text{S}$             | 3-Methyl-2-butanethiol             |                        | 3                      |            |                        |
| $\text{C}_5\text{H}_{13}\text{N}$             | Pentylamine                        | 104.3                  | –1                     | 2.2–22%    |                        |
| $\text{C}_5\text{H}_{13}\text{N}$             | Butylmethylamine                   | 91                     | 13                     |            |                        |
| $\text{C}_6\text{H}_2\text{Cl}_4$             | 1,2,4,5-Tetrachlorobenzene         | 244.5                  | 155                    |            |                        |
| $\text{C}_6\text{H}_3\text{ClN}_2\text{O}_4$  | 1-Chloro-2,4-dinitrobenzene        | 315                    | 194                    | 2.0–22%    |                        |
| $\text{C}_6\text{H}_3\text{Cl}_3$             | 1,2,4-Trichlorobenzene             | 213.5                  | 105                    | 2.5–6.6%   | 571                    |
| $\text{C}_6\text{H}_4\text{ClNO}_2$           | 1-Chloro-4-nitrobenzene            | 242                    | 127                    |            |                        |
| $\text{C}_6\text{H}_4\text{Cl}_2$             | <i>o</i> -Dichlorobenzene          | 180                    | 66                     | 2.2–9.2%   | 648                    |
| $\text{C}_6\text{H}_4\text{Cl}_2$             | <i>m</i> -Dichlorobenzene          | 173                    | 72                     |            |                        |
| $\text{C}_6\text{H}_4\text{Cl}_2$             | <i>p</i> -Dichlorobenzene          | 174                    | 66                     |            |                        |
| $\text{C}_6\text{H}_4\text{Cl}_2\text{O}$     | 2,4-Dichlorophenol                 | 210                    | 114                    |            |                        |
| $\text{C}_6\text{H}_5\text{Br}$               | Bromobenzene                       | 156.0                  | 51                     |            | 565                    |
| $\text{C}_6\text{H}_5\text{Cl}$               | Chlorobenzene                      | 131.7                  | 28                     | 1.3–9.6%   | 593                    |
| $\text{C}_6\text{H}_5\text{ClO}$              | <i>o</i> -Chlorophenol             | 174.9                  | 64                     |            |                        |
| $\text{C}_6\text{H}_5\text{ClO}$              | <i>p</i> -Chlorophenol             | 220                    | 121                    |            |                        |
| $\text{C}_6\text{H}_5\text{Cl}_2\text{N}$     | 3,4-Dichloroaniline                | 272                    | 166                    |            |                        |
| $\text{C}_6\text{H}_5\text{Cl}_3\text{Si}$    | Trichlorophenylsilane              | 201                    | 91                     |            |                        |
| $\text{C}_6\text{H}_5\text{F}$                | Fluorobenzene                      | 84.7                   | –15                    |            |                        |
| $\text{C}_6\text{H}_5\text{NO}_2$             | Nitrobenzene                       | 210.8                  | 88                     | 1.8–?      | 482                    |
| $\text{C}_6\text{H}_5\text{N}_3\text{O}_4$    | 2,4-Dinitroaniline                 |                        | 224                    |            |                        |
| $\text{C}_6\text{H}_6$                        | 1,5-Hexadien-3-yne                 | 85                     | <–20                   | 1.5–?      |                        |
| $\text{C}_6\text{H}_6$                        | Benzene                            | 80.0                   | –11                    | 1.2–7.8%   | 498                    |
| $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$    | <i>p</i> -Nitroaniline             | 332                    | 199                    |            |                        |
| $\text{C}_6\text{H}_6\text{O}$                | Phenol                             | 181.8                  | 79                     | 1.8–8.6%   | 715                    |
| $\text{C}_6\text{H}_6\text{O}_2$              | 1,2-Benzenediol                    | 245                    | 127                    |            |                        |
| $\text{C}_6\text{H}_6\text{O}_2$              | Resorcinol                         |                        | 127                    | 1.4–?      | 608                    |
| $\text{C}_6\text{H}_6\text{O}_2$              | <i>p</i> -Hydroquinone             | 287                    | 165                    |            | 516                    |
| $\text{C}_6\text{H}_7\text{N}$                | Aniline                            | 184.1                  | 70                     | 1.3–11%    | 615                    |
| $\text{C}_6\text{H}_7\text{N}$                | 2-Methylpyridine                   | 129.3                  | 39                     |            | 538                    |
| $\text{C}_6\text{H}_7\text{N}$                | 4-Methylpyridine                   | 145.3                  | 57                     |            |                        |
| $\text{C}_6\text{H}_8\text{ClN}$              | Aniline, hydrochloride             |                        | 193                    |            |                        |
| $\text{C}_6\text{H}_8\text{Cl}_2\text{O}_2$   | Hexanedioyl dichloride             |                        | 72                     |            |                        |
| $\text{C}_6\text{H}_8\text{N}_2$              | Adiponitrile                       | 295                    | 93                     | 1.0–?      | 550                    |
| $\text{C}_6\text{H}_8\text{N}_2$              | <i>o</i> -Phenylenediamine         | 257                    | 156                    | 1.5–?      |                        |

| Mol. form.                                     | Name                              | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|------------------------------------------------|-----------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_6\text{H}_8\text{N}_2$               | Phenylhydrazine                   | 243.5                  | 88                     |            |                        |
| $\text{C}_6\text{H}_8\text{N}_2$               | 2,5-Dimethylpyrazine              | 155                    | 64                     |            |                        |
| $\text{C}_6\text{H}_8\text{O}$                 | 2,5-Dimethylfuran                 | 93.5                   | 7                      |            |                        |
| $\text{C}_6\text{H}_8\text{O}_4$               | Dimethyl maleate                  | 202                    | 113                    |            |                        |
| $\text{C}_6\text{H}_{10}$                      | 1,4-Hexadiene                     | 65                     | -21                    | 2.0–6.1%   |                        |
| $\text{C}_6\text{H}_{10}$                      | 2-Methyl-1,3-pentadiene           | 75.8                   | -12                    |            |                        |
| $\text{C}_6\text{H}_{10}$                      | 4-Methyl-1,3-pentadiene           | 76.5                   | -34                    |            |                        |
| $\text{C}_6\text{H}_{10}$                      | 2-Hexyne                          | 84.5                   | -10                    |            |                        |
| $\text{C}_6\text{H}_{10}$                      | Cyclohexene                       | 82.9                   | -12                    | 1.2–?      | 310                    |
| $\text{C}_6\text{H}_{10}\text{O}$              | Diallyl ether                     | 94                     | -7                     |            |                        |
| $\text{C}_6\text{H}_{10}\text{O}$              | Cyclohexanone                     | 155.4                  | 44                     | 1.1–9.4%   | 420                    |
| $\text{C}_6\text{H}_{10}\text{O}$              | Mesityl oxide                     | 130                    | 31                     | 1.4–7.2%   | 344                    |
| $\text{C}_6\text{H}_{10}\text{O}_2$            | Vinyl butanoate                   | 116.7                  | 20                     | 1.4–8.8%   |                        |
| $\text{C}_6\text{H}_{10}\text{O}_2$            | Ethyl 2-butenolate                | 136.5                  | 2                      |            |                        |
| $\text{C}_6\text{H}_{10}\text{O}_2$            | Ethyl methacrylate                | 117                    | 20                     |            |                        |
| $\text{C}_6\text{H}_{10}\text{O}_2$            | 2,5-Hexanedione                   | 194                    | 79                     |            | 499                    |
| $\text{C}_6\text{H}_{10}\text{O}_3$            | Ethyl acetoacetate                | 180.8                  | 57                     | 1.4–9.5%   | 295                    |
| $\text{C}_6\text{H}_{10}\text{O}_3$            | Propanoic anhydride               | 170                    | 63                     | 1.3–9.5%   | 285                    |
| $\text{C}_6\text{H}_{10}\text{O}_4$            | Adipic acid                       | 337.5                  | 196                    |            | 420                    |
| $\text{C}_6\text{H}_{10}\text{O}_4$            | Diethyl oxalate                   | 185.7                  | 76                     |            |                        |
| $\text{C}_6\text{H}_{10}\text{O}_4$            | Ethylene glycol diacetate         | 190                    | 88                     | 1.6–8.4%   | 482                    |
| $\text{C}_6\text{H}_{11}\text{Cl}$             | Chlorocyclohexane                 | 142                    | 32                     |            |                        |
| $\text{C}_6\text{H}_{11}\text{NO}$             | Caprolactam                       | 270                    | 125                    |            |                        |
| $\text{C}_6\text{H}_{11}\text{NO}_2$           | Nitrocyclohexane                  | 205                    | 88                     |            |                        |
| $\text{C}_6\text{H}_{11}\text{NO}_2$           | 4-Acetylmorpholine                |                        | 113                    |            |                        |
| $\text{C}_6\text{H}_{12}$                      | 1-Hexene                          | 63.4                   | -26                    | 1.2–6.9%   | 253                    |
| $\text{C}_6\text{H}_{12}$                      | <i>cis</i> -2-Hexene              | 68.8                   | -21                    |            |                        |
| $\text{C}_6\text{H}_{12}$                      | 2-Methyl-1-pentene                | 62.1                   | -28                    |            | 300                    |
| $\text{C}_6\text{H}_{12}$                      | 4-Methyl-1-pentene                | 53.9                   | -7                     |            | 300                    |
| $\text{C}_6\text{H}_{12}$                      | 4-Methyl- <i>cis</i> -2-pentene   | 56.3                   | -32                    |            |                        |
| $\text{C}_6\text{H}_{12}$                      | 4-Methyl- <i>trans</i> -2-pentene | 58.6                   | -29                    |            |                        |
| $\text{C}_6\text{H}_{12}$                      | 2-Ethyl-1-butene                  | 64.7                   | <-20                   |            | 315                    |
| $\text{C}_6\text{H}_{12}$                      | 2,3-Dimethyl-1-butene             | 55.6                   | <-20                   |            | 360                    |
| $\text{C}_6\text{H}_{12}$                      | 2,3-Dimethyl-2-butene             | 73.3                   | <-20                   |            | 401                    |
| $\text{C}_6\text{H}_{12}$                      | Cyclohexane                       | 80.7                   | -20                    | 1.3–8%     | 245                    |
| $\text{C}_6\text{H}_{12}$                      | Methylcyclopentane                | 71.8                   | -29                    | 1.0–8.35%  | 258                    |
| $\text{C}_6\text{H}_{12}$                      | Ethylcyclobutane                  | 70.8                   | -15                    | 1.2–7.7%   | 210                    |
| $\text{C}_6\text{H}_{12}$                      | 2-Methyl-2-pentene                | 67.3                   | <-7                    |            |                        |
| $\text{C}_6\text{H}_{12}\text{Cl}_2\text{O}_2$ | 1,2-Bis(2-chloroethoxy)ethane     | 232                    | 121                    |            |                        |
| $\text{C}_6\text{H}_{12}\text{O}$              | <i>cis</i> -3-Hexen-1-ol          | 156.5                  | 54                     |            |                        |
| $\text{C}_6\text{H}_{12}\text{O}$              | Butyl vinyl ether                 | 94                     | -9                     |            | 255                    |
| $\text{C}_6\text{H}_{12}\text{O}$              | Isobutyl vinyl ether              | 83                     | -9                     |            |                        |
| $\text{C}_6\text{H}_{12}\text{O}$              | Hexanal                           | 131                    | 32                     |            |                        |
| $\text{C}_6\text{H}_{12}\text{O}$              | 2-Ethylbutanal                    |                        | 21                     | 1.2–7.7%   |                        |
| $\text{C}_6\text{H}_{12}\text{O}$              | 2-Methylpentanal                  | 117                    | 17                     |            | 199                    |
| $\text{C}_6\text{H}_{12}\text{O}$              | 2-Hexanone                        | 127.6                  | 25                     | 1–8%       | 423                    |
| $\text{C}_6\text{H}_{12}\text{O}$              | 3-Hexanone                        | 123.5                  | 35                     | 1–8%       |                        |
| $\text{C}_6\text{H}_{12}\text{O}$              | 4-Methyl-2-pentanone              | 116.5                  | 18                     | 1.2–8.0%   | 448                    |
| $\text{C}_6\text{H}_{12}\text{O}$              | Cyclohexanol                      | 160.8                  | 68                     | 1–9%       | 300                    |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Hexanoic acid                     | 205.2                  | 102                    |            | 380                    |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | 2-Methylpentanoic acid            | 195.6                  | 107                    |            | 378                    |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Diethylacetic acid                | 194                    | 99                     |            | 400                    |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Pentyl formate                    | 130.4                  | 26                     |            |                        |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Butyl acetate                     | 126.1                  | 22                     | 1.7–7.6%   | 425                    |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | <i>sec</i> -Butyl acetate         | 112                    | 31                     | 1.7–9.8%   |                        |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Isobutyl acetate                  | 116.5                  | 18                     | 1.3–10.5%  | 421                    |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Propyl propanoate                 | 122.5                  | 79                     |            |                        |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Ethyl butanoate                   | 121.5                  | 24                     |            | 463                    |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Ethyl 2-methylpropanoate          | 110.1                  | 13                     |            |                        |
| $\text{C}_6\text{H}_{12}\text{O}_2$            | Diacetone alcohol                 | 167.9                  | 58                     | 1.8–6.9%   | 643                    |

| Mol. form.                                    | Name                                        | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|-----------------------------------------------|---------------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_6\text{H}_{12}\text{O}_3$           | Ethylene glycol monoethyl ether acetate     | 156.4                  | 56                     | 2–8%       | 379                    |
| $\text{C}_6\text{H}_{12}\text{O}_3$           | Paraldehyde                                 | 124.3                  | 36                     | 1.3–?      | 238                    |
| $\text{C}_6\text{H}_{12}\text{S}$             | Cyclohexanethiol                            | 158.9                  | 43                     |            |                        |
| $\text{C}_6\text{H}_{13}\text{Cl}$            | 1-Chlorohexane                              | 135                    | 35                     |            |                        |
| $\text{C}_6\text{H}_{13}\text{N}$             | Cyclohexylamine                             | 134                    | 31                     | 1.9–9.4%   | 293                    |
| $\text{C}_6\text{H}_{13}\text{NO}$            | <i>N</i> -Butylacetamide                    | 229                    | 116                    |            |                        |
| $\text{C}_6\text{H}_{13}\text{NO}$            | 2,6-Dimethylmorpholine                      | 146.6                  | 44                     |            |                        |
| $\text{C}_6\text{H}_{13}\text{NO}$            | <i>N</i> -Ethylmorpholine                   | 138.5                  | 32                     |            |                        |
| $\text{C}_6\text{H}_{13}\text{NO}_2$          | 4-Morpholineethanol                         | 227                    | 99                     |            |                        |
| $\text{C}_6\text{H}_{14}$                     | Hexane                                      | 68.7                   | –22                    | 1.1–7.5%   | 225                    |
| $\text{C}_6\text{H}_{14}$                     | 2-Methylpentane                             | 60.2                   | <–29                   | 1.0–7.0%   | 264                    |
| $\text{C}_6\text{H}_{14}$                     | 3-Methylpentane                             | 63.2                   | –7                     | 1.2–7.0%   | 278                    |
| $\text{C}_6\text{H}_{14}$                     | 2,2-Dimethylbutane                          | 49.7                   | –48                    | 1.2–7.0%   | 405                    |
| $\text{C}_6\text{H}_{14}$                     | 2,3-Dimethylbutane                          | 57.9                   | –29                    | 1.2–7.0%   | 405                    |
| $\text{C}_6\text{H}_{14}\text{N}_2\text{O}$   | 1-Piperazineethanol                         | 246                    | 124                    |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}$             | 1-Hexanol                                   | 157.6                  | 63                     |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}$             | 2-Methyl-1-pentanol                         | 149                    | 54                     | 1.1–9.65%  | 310                    |
| $\text{C}_6\text{H}_{14}\text{O}$             | 4-Methyl-2-pentanol                         | 131.6                  | 41                     | 1.0–5.5%   |                        |
| $\text{C}_6\text{H}_{14}\text{O}$             | 2-Ethyl-1-butanol                           | 147                    | 57                     |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}$             | Dipropyl ether                              | 90.0                   | 21                     | 1.3–7.0%   | 188                    |
| $\text{C}_6\text{H}_{14}\text{O}$             | Diisopropyl ether                           | 68.5                   | –28                    | 1.4–7.9%   | 443                    |
| $\text{C}_6\text{H}_{14}\text{O}$             | Butyl ethyl ether                           | 92.3                   | 4                      |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}_2$           | 2,5-Hexanediol                              | 218                    | 110                    |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}_2$           | 2-Methyl-2,4-pentanediol                    | 197.1                  | 102                    | 1–9%       | 306                    |
| $\text{C}_6\text{H}_{14}\text{O}_2$           | Ethylene glycol monobutyl ether             | 168.4                  | 69                     | 4–13%      | 238                    |
| $\text{C}_6\text{H}_{14}\text{O}_2$           | 1,1-Diethoxyethane                          | 102.2                  | –21                    | 1.6–10.4%  | 230                    |
| $\text{C}_6\text{H}_{14}\text{O}_2$           | Ethylene glycol diethyl ether               | 119.4                  | 27                     |            | 205                    |
| $\text{C}_6\text{H}_{14}\text{O}_3$           | 1,2,6-Hexanetriol                           |                        | 191                    |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}_3$           | Diethylene glycol monoethyl ether           | 196                    | 96                     |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}_3$           | Diethylene glycol dimethyl ether            | 162                    | 67                     |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}_3$           | Trimethylolpropane                          |                        | 149                    |            |                        |
| $\text{C}_6\text{H}_{14}\text{O}_4$           | Triethylene glycol                          | 285                    | 177                    | 0.9–9.2%   | 371                    |
| $\text{C}_6\text{H}_{15}\text{N}$             | Hexylamine                                  | 132.8                  | 29                     |            |                        |
| $\text{C}_6\text{H}_{15}\text{N}$             | Butylethylamine                             | 107.5                  | 18                     |            |                        |
| $\text{C}_6\text{H}_{15}\text{N}$             | Dipropylamine                               | 109.3                  | 17                     |            | 299                    |
| $\text{C}_6\text{H}_{15}\text{N}$             | Diisopropylamine                            | 83.9                   | –1                     | 1.1–7.1%   | 316                    |
| $\text{C}_6\text{H}_{15}\text{N}$             | Triethylamine                               | 89                     | –7                     | 1.2–8.0%   | 249                    |
| $\text{C}_6\text{H}_{15}\text{NO}_2$          | Diisopropanolamine                          | 250                    | 127                    |            | 374                    |
| $\text{C}_6\text{H}_{15}\text{NO}_3$          | Triethanolamine                             | 335.4                  | 179                    | 1–10%      |                        |
| $\text{C}_6\text{H}_{15}\text{N}_3$           | 1-Piperazineethanamine                      | 220                    | 93                     |            |                        |
| $\text{C}_6\text{H}_{15}\text{O}_4\text{P}$   | Triethyl phosphate                          | 215.5                  | 115                    |            | 454                    |
| $\text{C}_6\text{H}_{16}\text{N}_2$           | <i>N,N</i> -Diethylethylenediamine          | 144                    | 46                     |            |                        |
| $\text{C}_7\text{H}_3\text{ClF}_3\text{NO}_2$ | 1-Chloro-4-nitro-2-(trifluoromethyl)benzene | 232                    | 135                    |            |                        |
| $\text{C}_7\text{H}_4\text{ClF}_3$            | 1-Chloro-2-(trifluoromethyl)benzene         | 152.2                  | 59                     |            |                        |
| $\text{C}_7\text{H}_4\text{F}_3\text{NO}_2$   | 1-Nitro-3-(trifluoromethyl)benzene          | 202.8                  | 103                    |            |                        |
| $\text{C}_7\text{H}_5\text{ClO}$              | Benzoyl chloride                            | 197.2                  | 72                     |            |                        |
| $\text{C}_7\text{H}_5\text{ClO}$              | 4-Chlorobenzaldehyde                        | 213.5                  | 88                     |            |                        |
| $\text{C}_7\text{H}_5\text{Cl}_3$             | (Trichloromethyl)benzene                    | 221                    | 127                    |            | 211                    |
| $\text{C}_7\text{H}_5\text{F}_3$              | (Trifluoromethyl)benzene                    | 102.1                  | 12                     |            |                        |
| $\text{C}_7\text{H}_6\text{N}_2\text{O}_4$    | 1-Methyl-2,4-dinitrobenzene                 |                        | 207                    |            |                        |
| $\text{C}_7\text{H}_6\text{O}$                | Benzaldehyde                                | 179.0                  | 63                     |            | 192                    |
| $\text{C}_7\text{H}_6\text{O}_2$              | Benzoic acid                                | 249.2                  | 121                    |            | 570                    |
| $\text{C}_7\text{H}_6\text{O}_2$              | Salicylaldehyde                             | 197                    | 78                     |            |                        |
| $\text{C}_7\text{H}_6\text{O}_3$              | Salicylic acid                              |                        | 157                    | 1.1–?      | 540                    |
| $\text{C}_7\text{H}_7\text{Br}$               | <i>o</i> -Bromotoluene                      | 181.7                  | 79                     |            |                        |
| $\text{C}_7\text{H}_7\text{Br}$               | <i>p</i> -Bromotoluene                      | 184.3                  | 85                     |            |                        |
| $\text{C}_7\text{H}_7\text{Cl}$               | (Chloromethyl)benzene                       | 179                    | 67                     | 1.1–?      | 585                    |
| $\text{C}_7\text{H}_7\text{NO}_2$             | <i>o</i> -Nitrotoluene                      | 222                    | 106                    |            |                        |
| $\text{C}_7\text{H}_7\text{NO}_2$             | <i>m</i> -Nitrotoluene                      | 232                    | 106                    |            |                        |
| $\text{C}_7\text{H}_7\text{NO}_2$             | <i>p</i> -Nitrotoluene                      | 238.3                  | 106                    |            |                        |

| Mol. form.                                  | Name                                   | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|---------------------------------------------|----------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_7\text{H}_8$                      | Toluene                                | 110.6                  | 4                      | 1.1–7.1%   | 480                    |
| $\text{C}_7\text{H}_8$                      | Bicyclo[2.2.1]hepta-2,5-diene          | 89.5                   | –21                    |            |                        |
| $\text{C}_7\text{H}_8\text{O}$              | <i>o</i> -Cresol                       | 191.0                  | 81                     | 1.4–?      | 599                    |
| $\text{C}_7\text{H}_8\text{O}$              | <i>m</i> -Cresol                       | 202.2                  | 86                     | 1.1–?      | 558                    |
| $\text{C}_7\text{H}_8\text{O}$              | <i>p</i> -Cresol                       | 201.9                  | 86                     | 1.1–?      | 558                    |
| $\text{C}_7\text{H}_8\text{O}$              | Benzyl alcohol                         | 205.3                  | 93                     |            | 436                    |
| $\text{C}_7\text{H}_8\text{O}$              | Anisole                                | 153.7                  | 52                     |            | 475                    |
| $\text{C}_7\text{H}_8\text{O}_2$            | 4-Methoxyphenol                        | 243                    | 132                    |            | 421                    |
| $\text{C}_7\text{H}_8\text{O}_3\text{S}$    | <i>p</i> -Toluenesulfonic acid         |                        | 184                    |            |                        |
| $\text{C}_7\text{H}_9\text{N}$              | <i>o</i> -Methylaniline                | 200.3                  | 85                     |            | 482                    |
| $\text{C}_7\text{H}_9\text{N}$              | <i>p</i> -Methylaniline                | 200.4                  | 87                     |            | 482                    |
| $\text{C}_7\text{H}_9\text{NO}$             | <i>o</i> -Anisidine                    | 224                    | 118                    |            |                        |
| $\text{C}_7\text{H}_{10}\text{O}$           | 3-Cyclohexene-1-carboxaldehyde         | 105                    | 57                     |            |                        |
| $\text{C}_7\text{H}_{10}\text{O}_4$         | 3,3-Diacetoxy-1-propene                | 180                    | 82                     |            |                        |
| $\text{C}_7\text{H}_{12}$                   | 4-Methylcyclohexene                    | 102.7                  | –1                     |            |                        |
| $\text{C}_7\text{H}_{12}\text{O}_2$         | Butyl acrylate                         | 145                    | 29                     | 1.7–9.9%   | 292                    |
| $\text{C}_7\text{H}_{12}\text{O}_2$         | Isobutyl acrylate                      | 132                    | 30                     |            | 427                    |
| $\text{C}_7\text{H}_{12}\text{O}_2$         | Cyclohexyl formate                     | 162                    | 51                     |            |                        |
| $\text{C}_7\text{H}_{12}\text{O}_4$         | Diethyl malonate                       | 200                    | 93                     |            |                        |
| $\text{C}_7\text{H}_{14}$                   | 1-Heptene                              | 93.6                   | –1                     |            | 260                    |
| $\text{C}_7\text{H}_{14}$                   | <i>trans</i> -2-Heptene                | 98                     | <0                     |            |                        |
| $\text{C}_7\text{H}_{14}$                   | Cycloheptane                           | 118.4                  | <21                    | 1.1–6.7%   |                        |
| $\text{C}_7\text{H}_{14}$                   | Methylcyclohexane                      | 100.9                  | –4                     | 1.2–6.7%   | 250                    |
| $\text{C}_7\text{H}_{14}$                   | Ethylcyclopentane                      | 103.5                  | <21                    | 1.1–6.7%   | 260                    |
| $\text{C}_7\text{H}_{14}\text{O}$           | 2-Heptanone                            | 151.0                  | 39                     | 1.1–7.9%   | 393                    |
| $\text{C}_7\text{H}_{14}\text{O}$           | 3-Heptanone                            | 147                    | 46                     |            |                        |
| $\text{C}_7\text{H}_{14}\text{O}$           | 4-Heptanone                            | 144                    | 49                     |            |                        |
| $\text{C}_7\text{H}_{14}\text{O}$           | 5-Methyl-2-hexanone                    | 144                    | 36                     | 1.0–8.2%   | 191                    |
| $\text{C}_7\text{H}_{14}\text{O}$           | <i>cis</i> -2-Methylcyclohexanol       | 165                    | 65                     |            | 296                    |
| $\text{C}_7\text{H}_{14}\text{O}$           | <i>trans</i> -2-Methylcyclohexanol     | 167.5                  | 65                     |            | 296                    |
| $\text{C}_7\text{H}_{14}\text{O}$           | <i>cis</i> -3-Methylcyclohexanol       | 174.5                  | 70                     |            | 295                    |
| $\text{C}_7\text{H}_{14}\text{O}$           | <i>trans</i> -3-Methylcyclohexanol     | 174.5                  | 70                     |            | 295                    |
| $\text{C}_7\text{H}_{14}\text{O}$           | <i>cis</i> -4-Methylcyclohexanol       | 173                    | 70                     |            | 295                    |
| $\text{C}_7\text{H}_{14}\text{O}$           | <i>trans</i> -4-Methylcyclohexanol     | 174                    | 70                     |            | 295                    |
| $\text{C}_7\text{H}_{14}\text{O}_2$         | Pentyl acetate                         | 149.2                  | 16                     | 1.1–7.5%   | 360                    |
| $\text{C}_7\text{H}_{14}\text{O}_2$         | Isopentyl acetate                      | 142.5                  | 25                     | 1.0–7.5%   | 360                    |
| $\text{C}_7\text{H}_{14}\text{O}_2$         | <i>sec</i> -Pentyl acetate             | 130.5                  | 32                     |            |                        |
| $\text{C}_7\text{H}_{14}\text{O}_2$         | Butyl propanoate                       | 146.8                  | 32                     |            | 426                    |
| $\text{C}_7\text{H}_{14}\text{O}_2$         | Propyl butanoate                       | 143.0                  | 37                     |            |                        |
| $\text{C}_7\text{H}_{15}\text{NO}_2$        | Ethyl <i>N</i> -butylcarbamate         | 202                    | 92                     |            |                        |
| $\text{C}_7\text{H}_{16}$                   | Heptane                                | 98.5                   | –4                     | 1.05–6.7%  | 204                    |
| $\text{C}_7\text{H}_{16}$                   | 2-Methylhexane                         | 90.0                   | –1                     | 1.0–6.0%   | 280                    |
| $\text{C}_7\text{H}_{16}$                   | 3-Methylhexane                         | 92                     | –4                     |            | 280                    |
| $\text{C}_7\text{H}_{16}$                   | 2,3-Dimethylpentane                    | 89.7                   | –56                    | 1.1–6.7%   | 335                    |
| $\text{C}_7\text{H}_{16}$                   | 2,4-Dimethylpentane                    | 80.4                   | –12                    |            |                        |
| $\text{C}_7\text{H}_{16}$                   | 2,2,3-Trimethylbutane                  | 80.8                   | <0                     |            | 412                    |
| $\text{C}_7\text{H}_{16}\text{N}_2\text{O}$ | 4-Morpholinepropanamine                | 220                    | 104                    |            |                        |
| $\text{C}_7\text{H}_{16}\text{O}$           | 2-Heptanol                             | 159                    | 71                     |            |                        |
| $\text{C}_7\text{H}_{16}\text{O}$           | 3-Heptanol                             | 157                    | 60                     |            |                        |
| $\text{C}_7\text{H}_{16}\text{O}$           | 2,4-Dimethyl-3-pentanol                | 138.7                  | 49                     |            |                        |
| $\text{C}_7\text{H}_{16}\text{O}$           | 2,3,3-Trimethyl-2-butanol              | 131                    | <0                     |            | 375                    |
| $\text{C}_7\text{H}_{17}\text{N}$           | Heptylamine                            | 156                    | 54                     |            |                        |
| $\text{C}_7\text{H}_{18}\text{N}_2$         | <i>N,N</i> -Diethyl-1,3-propanediamine | 168.5                  | 59                     |            |                        |
| $\text{C}_8\text{H}_4\text{O}_3$            | Phthalic anhydride                     | 295                    | 152                    | 1.7–10.5%  | 570                    |
| $\text{C}_8\text{H}_6\text{O}_4$            | Phthalic acid                          |                        | 168                    |            |                        |
| $\text{C}_8\text{H}_6\text{O}_4$            | Terephthalic acid                      |                        | 260                    |            | 496                    |
| $\text{C}_8\text{H}_7\text{ClO}$            | $\alpha$ -Chloroacetophenone           | 247                    | 118                    |            |                        |
| $\text{C}_8\text{H}_7\text{N}$              | Benzeneacetonitrile                    | 233.5                  | 113                    |            |                        |
| $\text{C}_8\text{H}_8$                      | Styrene                                | 145                    | 31                     | 0.9–6.8%   | 490                    |
| $\text{C}_8\text{H}_8\text{O}$              | Phenyloxirane                          | 194.1                  | 74                     |            | 498                    |
| $\text{C}_8\text{H}_8\text{O}$              | Benzeneacetaldehyde                    | 195                    | 71                     |            |                        |

| Mol. form.                          | Name                                  | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|-------------------------------------|---------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_8\text{H}_8\text{O}$      | Acetophenone                          | 202                    | 77                     |            | 570                    |
| $\text{C}_8\text{H}_8\text{O}_2$    | Benzeneacetic acid                    | 265.5                  | >100                   |            |                        |
| $\text{C}_8\text{H}_8\text{O}_2$    | Phenyl acetate                        | 196                    | 80                     |            |                        |
| $\text{C}_8\text{H}_8\text{O}_2$    | Methyl benzoate                       | 199                    | 83                     |            |                        |
| $\text{C}_8\text{H}_8\text{O}_2$    | 2-Methoxybenzaldehyde                 | 243.5                  | 118                    |            |                        |
| $\text{C}_8\text{H}_8\text{O}_3$    | Methyl salicylate                     | 222.9                  | 96                     |            | 454                    |
| $\text{C}_8\text{H}_9\text{Cl}$     | 1-Chloro-4-ethylbenzene               | 184.4                  | 64                     |            |                        |
| $\text{C}_8\text{H}_9\text{NO}$     | Acetanilide                           | 304                    | 169                    |            | 530                    |
| $\text{C}_8\text{H}_9\text{NO}_2$   | Methyl 2-aminobenzoate                | 256                    | >100                   |            |                        |
| $\text{C}_8\text{H}_{10}$           | Ethylbenzene                          | 136.1                  | 21                     | 0.8–6.7%   | 432                    |
| $\text{C}_8\text{H}_{10}$           | <i>o</i> -Xylene                      | 144.5                  | 32                     | 0.9–6.7%   | 463                    |
| $\text{C}_8\text{H}_{10}$           | <i>m</i> -Xylene                      | 139.1                  | 27                     | 1.1–7.0%   | 527                    |
| $\text{C}_8\text{H}_{10}$           | <i>p</i> -Xylene                      | 138.3                  | 27                     | 1.1–7.0%   | 528                    |
| $\text{C}_8\text{H}_{10}\text{O}$   | <i>p</i> -Ethylphenol                 | 217.9                  | 104                    |            |                        |
| $\text{C}_8\text{H}_{10}\text{O}$   | Benzeneethanol                        | 218.2                  | 96                     |            |                        |
| $\text{C}_8\text{H}_{10}\text{O}$   | $\alpha$ -Methylbenzyl alcohol        | 205                    | 93                     |            |                        |
| $\text{C}_8\text{H}_{10}\text{O}$   | Phenetole                             | 169.8                  | 63                     |            |                        |
| $\text{C}_8\text{H}_{10}\text{O}$   | Benzyl methyl ether                   | 170                    | 135                    |            |                        |
| $\text{C}_8\text{H}_{10}\text{O}$   | 4-Methylanisole                       | 175.5                  | 60                     |            |                        |
| $\text{C}_8\text{H}_{10}\text{O}_2$ | 2-Phenoxyethanol                      | 245                    | 121                    |            |                        |
| $\text{C}_8\text{H}_{11}\text{N}$   | <i>N</i> -Ethylaniline                | 203.0                  | 85                     |            |                        |
| $\text{C}_8\text{H}_{11}\text{N}$   | <i>N,N</i> -Dimethylaniline           | 194.1                  | 63                     |            | 371                    |
| $\text{C}_8\text{H}_{11}\text{N}$   | 2,3-Xylidine                          | 221.5                  | 97                     | 1.0–?      |                        |
| $\text{C}_8\text{H}_{11}\text{N}$   | 2,6-Xylidine                          | 215                    | 96                     |            |                        |
| $\text{C}_8\text{H}_{11}\text{N}$   | $\alpha$ -Methylbenzylamine           | 187                    | 79                     |            |                        |
| $\text{C}_8\text{H}_{11}\text{N}$   | 5-Ethyl-2-picoline                    | 178.3                  | 68                     | 1.1–6.6%   |                        |
| $\text{C}_8\text{H}_{11}\text{NO}$  | <i>N</i> -Phenylethanolamine          | 279.5                  | 152                    |            |                        |
| $\text{C}_8\text{H}_{11}\text{NO}$  | <i>o</i> -Phenetidine                 | 232.5                  | 115                    |            |                        |
| $\text{C}_8\text{H}_{11}\text{NO}$  | <i>p</i> -Phenetidine                 | 254                    | 116                    |            |                        |
| $\text{C}_8\text{H}_{12}$           | 1,5-Cyclooctadiene                    | 150.8                  | 35                     |            |                        |
| $\text{C}_8\text{H}_{12}$           | 4-Vinylcyclohexene                    | 128                    | 16                     |            | 269                    |
| $\text{C}_8\text{H}_{12}\text{O}_4$ | Diethyl maleate                       | 223                    | 121                    |            | 350                    |
| $\text{C}_8\text{H}_{12}\text{O}_4$ | Diethyl fumarate                      | 214                    | 104                    |            |                        |
| $\text{C}_8\text{H}_{14}\text{O}_2$ | Cyclohexyl acetate                    | 173                    | 58                     |            | 335                    |
| $\text{C}_8\text{H}_{14}\text{O}_2$ | Butyl methacrylate                    | 160                    | 52                     |            |                        |
| $\text{C}_8\text{H}_{14}\text{O}_3$ | Butanoic anhydride                    | 200                    | 54                     | 0.9–5.8%   | 279                    |
| $\text{C}_8\text{H}_{14}\text{O}_3$ | 2-Methylpropanoic anhydride           | 183                    | 59                     | 1.0–6.2%   | 329                    |
| $\text{C}_8\text{H}_{14}\text{O}_3$ | Butyl acetoacetate                    |                        | 85                     |            |                        |
| $\text{C}_8\text{H}_{14}\text{O}_4$ | Ethyl succinate                       | 217.7                  | 90                     |            |                        |
| $\text{C}_8\text{H}_{14}\text{O}_5$ | Diethylene glycol diacetate           | 200                    | 135                    |            |                        |
| $\text{C}_8\text{H}_{14}\text{O}_6$ | Diethyl tartrate                      | 281                    | 93                     |            |                        |
| $\text{C}_8\text{H}_{15}\text{ClO}$ | Octanoyl chloride                     | 195.6                  | 82                     |            |                        |
| $\text{C}_8\text{H}_{16}$           | 1-Octene                              | 121.2                  | 21                     |            | 230                    |
| $\text{C}_8\text{H}_{16}$           | 2,4,4-Trimethyl-1-pentene             | 101.4                  | –5                     | 0.8–4.8%   | 391                    |
| $\text{C}_8\text{H}_{16}$           | 2,4,4-Trimethyl-2-pentene             | 104.9                  | 2                      |            | 305                    |
| $\text{C}_8\text{H}_{16}$           | Ethylcyclohexane                      | 131.9                  | 35                     | 0.9–6.6%   | 238                    |
| $\text{C}_8\text{H}_{16}$           | <i>cis</i> -1,2-Dimethylcyclohexane   | 129.8                  | 16                     |            | 304                    |
| $\text{C}_8\text{H}_{16}$           | <i>trans</i> -1,2-Dimethylcyclohexane | 123.5                  | 11                     |            | 304                    |
| $\text{C}_8\text{H}_{16}$           | <i>cis</i> -1,4-Dimethylcyclohexane   | 124.4                  | 16                     |            |                        |
| $\text{C}_8\text{H}_{16}$           | Propylcyclopentane                    | 131                    |                        |            | 269                    |
| $\text{C}_8\text{H}_{16}\text{O}$   | Octanal                               | 171                    | 52                     |            |                        |
| $\text{C}_8\text{H}_{16}\text{O}$   | 2-Ethylhexanal                        | 163                    | 44                     | 0.85–7.2%  | 190                    |
| $\text{C}_8\text{H}_{16}\text{O}$   | 2-Octanone                            | 172.5                  | 52                     |            |                        |
| $\text{C}_8\text{H}_{16}\text{O}_2$ | Hexyl acetate                         | 171.5                  | 45                     |            |                        |
| $\text{C}_8\text{H}_{16}\text{O}_2$ | sec-Hexyl acetate                     | 147.5                  | 45                     |            |                        |
| $\text{C}_8\text{H}_{16}\text{O}_2$ | 2-Ethylbutyl acetate                  | 162.5                  | 54                     |            |                        |
| $\text{C}_8\text{H}_{16}\text{O}_2$ | Pentyl propanoate                     | 168.6                  | 41                     |            | 378                    |
| $\text{C}_8\text{H}_{16}\text{O}_2$ | Butyl butanoate                       | 166                    | 53                     |            |                        |
| $\text{C}_8\text{H}_{16}\text{O}_2$ | Isobutyl butanoate                    | 156.9                  | 50                     |            |                        |
| $\text{C}_8\text{H}_{16}\text{O}_2$ | Isobutyl isobutanoate                 | 148.6                  | 38                     | 0.96–7.59% | 432                    |
| $\text{C}_8\text{H}_{16}\text{O}_2$ | Ethyl hexanoate                       | 167                    | 49                     |            |                        |

| Mol. form.                                   | Name                                      | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|----------------------------------------------|-------------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_8\text{H}_{16}\text{O}_2$          | 1,4-Cyclohexanedimethanol                 | 283                    | 167                    |            | 316                    |
| $\text{C}_8\text{H}_{16}\text{O}_3$          | Pentyl lactate                            |                        | 79                     |            |                        |
| $\text{C}_8\text{H}_{16}\text{O}_4$          | Diethylene glycol monoethyl ether acetate | 218.5                  | 110                    |            | 425                    |
| $\text{C}_8\text{H}_{17}\text{Cl}$           | 1-Chlorooctane                            | 181.5                  | 70                     |            |                        |
| $\text{C}_8\text{H}_{17}\text{Cl}$           | 3-(Chloromethyl)heptane                   | 172                    | 60                     |            |                        |
| $\text{C}_8\text{H}_{18}$                    | Octane                                    | 125.6                  | 13                     | 1.0–6.5%   | 206                    |
| $\text{C}_8\text{H}_{18}$                    | 2,3-Dimethylhexane                        | 115.6                  | 7                      |            | 438                    |
| $\text{C}_8\text{H}_{18}$                    | 2,4-Dimethylhexane                        | 109.5                  | 10                     |            |                        |
| $\text{C}_8\text{H}_{18}$                    | 3-Ethyl-2-methylpentane                   | 115.6                  | <21                    |            | 460                    |
| $\text{C}_8\text{H}_{18}$                    | 2,2,3-Trimethylpentane                    | 110                    | <21                    |            | 346                    |
| $\text{C}_8\text{H}_{18}$                    | 2,2,4-Trimethylpentane                    | 99.2                   | –12                    |            | 418                    |
| $\text{C}_8\text{H}_{18}$                    | 2,3,3-Trimethylpentane                    | 114.8                  | <21                    |            | 425                    |
| $\text{C}_8\text{H}_{18}\text{O}$            | 1-Octanol                                 | 195.1                  | 81                     |            |                        |
| $\text{C}_8\text{H}_{18}\text{O}$            | 2-Octanol                                 | 180                    | 88                     |            |                        |
| $\text{C}_8\text{H}_{18}\text{O}$            | 2-Ethyl-1-hexanol                         | 184.6                  | 73                     | 0.88–9.7%  | 231                    |
| $\text{C}_8\text{H}_{18}\text{O}$            | Dibutyl ether                             | 140.2                  | 25                     | 1.5–7.6%   | 194                    |
| $\text{C}_8\text{H}_{18}\text{O}_2$          | 2-Ethyl-1,3-hexanediol                    | 244                    | 127                    |            | 360                    |
| $\text{C}_8\text{H}_{18}\text{O}_2$          | 2,2,4-Trimethyl-1,3-pentanediol           | 235                    | 113                    |            | 346                    |
| $\text{C}_8\text{H}_{18}\text{O}_2$          | Di- <i>tert</i> -butyl peroxide           | 111                    | 18                     |            |                        |
| $\text{C}_8\text{H}_{18}\text{O}_3$          | Diethylene glycol diethyl ether           | 188                    | 82                     |            |                        |
| $\text{C}_8\text{H}_{18}\text{O}_4$          | 2,5,8,11-Tetraoxadodecane                 | 216                    | 111                    |            |                        |
| $\text{C}_8\text{H}_{18}\text{O}_5$          | Tetraethylene glycol                      | 328                    | 182                    |            |                        |
| $\text{C}_8\text{H}_{18}\text{S}$            | 1-Octanethiol                             | 199.1                  | 69                     |            |                        |
| $\text{C}_8\text{H}_{18}\text{S}$            | Dibutyl sulfide                           | 185                    | 76                     |            |                        |
| $\text{C}_8\text{H}_{19}\text{N}$            | Octylamine                                | 179.6                  | 60                     |            |                        |
| $\text{C}_8\text{H}_{19}\text{N}$            | Dibutylamine                              | 159.6                  | 47                     | 1.1–6%     |                        |
| $\text{C}_8\text{H}_{19}\text{N}$            | Diisobutylamine                           | 139.6                  | 29                     |            |                        |
| $\text{C}_8\text{H}_{19}\text{N}$            | 2-Ethylhexylamine                         | 169.2                  | 60                     |            |                        |
| $\text{C}_8\text{H}_{20}\text{O}_4\text{Si}$ | Ethyl silicate                            | 168.8                  | 52                     |            |                        |
| $\text{C}_8\text{H}_{23}\text{N}_5$          | Tetraethylenepentamine                    | 341.5                  | 163                    |            | 321                    |
| $\text{C}_9\text{H}_6\text{N}_2\text{O}_2$   | Toluene-2,4-diisocyanate                  | 251                    | 127                    | 0.9–9.5%   |                        |
| $\text{C}_9\text{H}_7\text{N}$               | Quinoline                                 | 237.1                  |                        |            | 480                    |
| $\text{C}_9\text{H}_{10}$                    | <i>o</i> -Methylstyrene                   | 169.8                  | 53                     | 0.8–11.0%  | 538                    |
| $\text{C}_9\text{H}_{10}$                    | <i>m</i> -Methylstyrene                   | 164                    | 53                     | 0.8–11.0%  | 538                    |
| $\text{C}_9\text{H}_{10}$                    | <i>p</i> -Methylstyrene                   | 172.8                  | 53                     | 0.8–11.0%  | 538                    |
| $\text{C}_9\text{H}_{10}$                    | Isopropenylbenzene                        | 165.4                  | 54                     | 1.9–6.1%   | 574                    |
| $\text{C}_9\text{H}_{10}\text{O}$            | 1-Phenyl-1-propanone                      | 217.5                  | 99                     |            |                        |
| $\text{C}_9\text{H}_{10}\text{O}$            | 4-Methylacetophenone                      | 226                    | 96                     |            |                        |
| $\text{C}_9\text{H}_{10}\text{O}_2$          | Ethyl benzoate                            | 212                    | 88                     |            | 490                    |
| $\text{C}_9\text{H}_{10}\text{O}_2$          | Benzyl acetate                            | 213                    | 90                     |            | 460                    |
| $\text{C}_9\text{H}_{10}\text{O}_2$          | Methyl 2-phenylacetate                    | 216.5                  | 91                     |            |                        |
| $\text{C}_9\text{H}_{11}\text{NO}$           | 4-Methylacetanilide                       | 307                    | 168                    |            |                        |
| $\text{C}_9\text{H}_{12}$                    | Propylbenzene                             | 159.2                  | 30                     | 0.8–6.0%   | 450                    |
| $\text{C}_9\text{H}_{12}$                    | Isopropylbenzene                          | 152.4                  | 36                     | 0.9–6.5%   | 424                    |
| $\text{C}_9\text{H}_{12}$                    | <i>o</i> -Ethyltoluene                    | 165.2                  |                        |            | 440                    |
| $\text{C}_9\text{H}_{12}$                    | <i>m</i> -Ethyltoluene                    | 161.3                  |                        |            | 480                    |
| $\text{C}_9\text{H}_{12}$                    | <i>p</i> -Ethyltoluene                    | 162                    |                        |            | 475                    |
| $\text{C}_9\text{H}_{12}$                    | 1,2,3-Trimethylbenzene                    | 176.1                  | 44                     | 0.8–6.6%   | 470                    |
| $\text{C}_9\text{H}_{12}$                    | 1,2,4-Trimethylbenzene                    | 169.3                  | 44                     | 0.9–6.4%   | 500                    |
| $\text{C}_9\text{H}_{12}$                    | 1,3,5-Trimethylbenzene                    | 164.7                  | 50                     | 1–5%       | 559                    |
| $\text{C}_9\text{H}_{12}\text{O}$            | $\alpha$ -Ethylbenzyl alcohol             | 219                    | 100                    |            |                        |
| $\text{C}_9\text{H}_{12}\text{O}_2$          | Ethylene glycol monobenzyl ether          | 256                    | 129                    |            | 352                    |
| $\text{C}_9\text{H}_{12}\text{O}_3\text{S}$  | Ethyl <i>p</i> -toluenesulfonate          |                        | 158                    |            |                        |
| $\text{C}_9\text{H}_{13}\text{N}$            | Amphetamine                               | 203                    | <100                   |            |                        |
| $\text{C}_9\text{H}_{14}\text{O}$            | Phorone                                   | 197.5                  | 85                     |            |                        |
| $\text{C}_9\text{H}_{14}\text{O}$            | Isophorone                                | 215.2                  | 84                     | 0.8–3.8%   | 460                    |
| $\text{C}_9\text{H}_{14}\text{O}_6$          | Triacetin                                 | 259                    | 138                    | 1.0–?      | 433                    |
| $\text{C}_9\text{H}_{16}$                    | Octahydroindene                           | 167                    |                        |            | 296                    |
| $\text{C}_9\text{H}_{16}\text{O}_2$          | Allyl hexanoate                           | 186                    | 66                     |            |                        |
| $\text{C}_9\text{H}_{18}$                    | 1-Nonene                                  | 146.9                  | 26                     |            |                        |

| Mol. form.                              | Name                                | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|-----------------------------------------|-------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_9\text{H}_{18}$               | Propylcyclohexane                   | 156.7                  |                        |            | 248                    |
| $\text{C}_9\text{H}_{18}$               | Isopropylcyclohexane                | 154.8                  |                        |            | 283                    |
| $\text{C}_9\text{H}_{18}$               | Butylcyclopentane                   | 156.6                  |                        |            | 250                    |
| $\text{C}_9\text{H}_{18}\text{O}$       | 2-Nonanone                          | 195.3                  | 60                     | 0.9–5.9%   | 360                    |
| $\text{C}_9\text{H}_{18}\text{O}$       | Diisobutyl ketone                   | 169.4                  | 49                     | 0.8–7.1%   | 396                    |
| $\text{C}_9\text{H}_{18}\text{O}_2$     | Pentyl butanoate                    | 186.4                  | 57                     |            |                        |
| $\text{C}_9\text{H}_{18}\text{O}_2$     | Isopentyl butanoate                 | 179                    | 59                     |            |                        |
| $\text{C}_9\text{H}_{18}\text{O}_2$     | Butyl 3-methylbutanoate             |                        | 53                     |            |                        |
| $\text{C}_9\text{H}_{20}$               | Nonane                              | 150.8                  | 31                     | 0.8–2.9%   | 205                    |
| $\text{C}_9\text{H}_{20}$               | 3-Ethyl-4-methylhexane              | 140                    | 24                     |            |                        |
| $\text{C}_9\text{H}_{20}$               | 4-Ethyl-2-methylhexane              | 133.8                  | <21                    | 0.7–?      | 280                    |
| $\text{C}_9\text{H}_{20}$               | 2,2,5-Trimethylhexane               | 124.0                  | 13                     |            |                        |
| $\text{C}_9\text{H}_{20}$               | 3,3-Diethylpentane                  | 146.3                  |                        | 0.7–5.7%   | 290                    |
| $\text{C}_9\text{H}_{20}$               | 3-Ethyl-2,4-dimethylpentane         | 136.7                  | 390                    |            |                        |
| $\text{C}_9\text{H}_{20}$               | 2,2,3,3-Tetramethylpentane          | 140.2                  | <21                    | 0.8–4.9%   | 430                    |
| $\text{C}_9\text{H}_{20}$               | 2,2,3,4-Tetramethylpentane          | 133.0                  | <21                    |            |                        |
| $\text{C}_9\text{H}_{21}\text{BO}_3$    | Triisopropyl borate                 | 140                    | 28                     |            |                        |
| $\text{C}_9\text{H}_{21}\text{N}$       | Tripropylamine                      | 156                    | 41                     |            |                        |
| $\text{C}_9\text{H}_{21}\text{NO}_3$    | Triisopropanolamine                 |                        | 160                    |            | 320                    |
| $\text{C}_{10}\text{H}_7\text{Cl}$      | 1-Chloronaphthalene                 | 259                    | 121                    |            | >558                   |
| $\text{C}_{10}\text{H}_8$               | Naphthalene                         | 217.9                  | 79                     | 0.9–5.9%   | 526                    |
| $\text{C}_{10}\text{H}_8\text{O}$       | 2-Naphthol                          | 285                    | 153                    |            |                        |
| $\text{C}_{10}\text{H}_9\text{N}$       | 1-Naphthalenamine                   | 300.8                  | 157                    |            |                        |
| $\text{C}_{10}\text{H}_{10}\text{O}_2$  | Safrole                             | 234.5                  | 100                    |            |                        |
| $\text{C}_{10}\text{H}_{10}\text{O}_4$  | Dimethyl phthalate                  | 283.7                  | 146                    | 0.9–?      | 490                    |
| $\text{C}_{10}\text{H}_{10}\text{O}_4$  | Dimethyl isophthalate               | 282                    | 138                    |            |                        |
| $\text{C}_{10}\text{H}_{10}\text{O}_4$  | Dimethyl terephthalate              | 288                    | 153                    |            | 518                    |
| $\text{C}_{10}\text{H}_{11}\text{NO}_2$ | Acetoacetanilide                    |                        | 185                    |            |                        |
| $\text{C}_{10}\text{H}_{12}$            | 1,2,3,4-Tetrahydronaphthalene       | 207.6                  | 71                     | 0.8–5.0%   | 385                    |
| $\text{C}_{10}\text{H}_{12}\text{O}_2$  | Isopropyl benzoate                  | 216                    | 99                     |            |                        |
| $\text{C}_{10}\text{H}_{12}\text{O}_2$  | Ethyl phenylacetate                 | 227                    | 99                     |            |                        |
| $\text{C}_{10}\text{H}_{14}$            | Butylbenzene                        | 183.3                  | 71                     | 0.8–5.8%   | 410                    |
| $\text{C}_{10}\text{H}_{14}$            | sec-Butylbenzene                    | 173.3                  | 52                     | 0.8–6.9%   | 418                    |
| $\text{C}_{10}\text{H}_{14}$            | tert-Butylbenzene                   | 169.1                  | 60                     | 0.7–5.7%   | 450                    |
| $\text{C}_{10}\text{H}_{14}$            | Isobutylbenzene                     | 172.7                  | 55                     | 0.8–6.0%   | 427                    |
| $\text{C}_{10}\text{H}_{14}$            | p-Cymene                            | 177.1                  | 47                     | 0.7–5.6%   | 436                    |
| $\text{C}_{10}\text{H}_{14}$            | 1,2,3,4-Tetramethylbenzene          | 205                    | 74                     |            | 427                    |
| $\text{C}_{10}\text{H}_{14}$            | 1,2,3,5-Tetramethylbenzene          | 198                    | 71                     |            | 427                    |
| $\text{C}_{10}\text{H}_{14}$            | 1,2,4,5-Tetramethylbenzene          | 196.8                  | 54                     |            |                        |
| $\text{C}_{10}\text{H}_{14}$            | o-Diethylbenzene                    | 184                    | 57                     |            | 395                    |
| $\text{C}_{10}\text{H}_{14}$            | m-Diethylbenzene                    | 181.1                  | 56                     |            | 450                    |
| $\text{C}_{10}\text{H}_{14}$            | p-Diethylbenzene                    | 183.7                  | 55                     | 0.7–6.0%   | 430                    |
| $\text{C}_{10}\text{H}_{14}\text{O}$    | Butyl phenyl ether                  | 210                    | 82                     |            |                        |
| $\text{C}_{10}\text{H}_{14}\text{O}_2$  | 4-tert-Butyl-1,2-benzenediol        | 285                    | 130                    |            |                        |
| $\text{C}_{10}\text{H}_{15}\text{N}$    | N-Butylaniline                      | 243.5                  | 107                    |            |                        |
| $\text{C}_{10}\text{H}_{15}\text{N}$    | N,N-Diethylaniline                  | 216.3                  | 85                     |            | 630                    |
| $\text{C}_{10}\text{H}_{15}\text{NO}_2$ | N-Phenyl-N,N-diethanolamine         |                        | 196                    | 0.7–?      | 387                    |
| $\text{C}_{10}\text{H}_{16}$            | Dipentene                           | 178                    | 45                     |            | 237                    |
| $\text{C}_{10}\text{H}_{16}$            | d-Limonene                          | 178                    | 45                     | 0.7–6.1%   | 237                    |
| $\text{C}_{10}\text{H}_{16}$            | $\alpha$ -Pinene                    | 156.2                  | 33                     |            | 255                    |
| $\text{C}_{10}\text{H}_{16}$            | $\beta$ -Pinene                     | 166                    | 38                     |            | 275                    |
| $\text{C}_{10}\text{H}_{16}$            | $\beta$ -Phellandrene               | 171.5                  | 49                     |            |                        |
| $\text{C}_{10}\text{H}_{16}\text{O}$    | Camphor                             | 207.4                  | 66                     | 0.6–3.5%   | 466                    |
| $\text{C}_{10}\text{H}_{18}$            | trans-Decahydronaphthalene          | 187.3                  | 54                     | 0.7–5.4%   | 255                    |
| $\text{C}_{10}\text{H}_{18}\text{O}$    | Borneol                             |                        | 66                     |            |                        |
| $\text{C}_{10}\text{H}_{18}\text{O}$    | Linalol                             | 198                    | 71                     |            |                        |
| $\text{C}_{10}\text{H}_{18}\text{O}$    | $\alpha$ -Terpineol                 | 220                    | 90                     |            |                        |
| $\text{C}_{10}\text{H}_{18}\text{O}$    | Cineole                             | 176.4                  | 48                     |            |                        |
| $\text{C}_{10}\text{H}_{18}\text{O}$    | trans-Geraniol                      | 230                    | >100                   |            |                        |
| $\text{C}_{10}\text{H}_{18}\text{O}_4$  | Dibutyl oxalate                     | 241                    | 104                    |            |                        |
| $\text{C}_{10}\text{H}_{19}\text{NO}_2$ | N-tert-Butylaminoethyl methacrylate |                        | 96                     |            |                        |

| Mol. form.                                       | Name                                       | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|--------------------------------------------------|--------------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_{10}\text{H}_{20}$                     | 1-Decene                                   | 170.5                  | <55                    |            | 235                    |
| $\text{C}_{10}\text{H}_{20}$                     | Butylcyclohexane                           | 180.9                  |                        |            | 246                    |
| $\text{C}_{10}\text{H}_{20}$                     | Isobutylcyclohexane                        | 171.3                  |                        |            | 274                    |
| $\text{C}_{10}\text{H}_{20}$                     | <i>tert</i> -Butylcyclohexane              | 171.5                  |                        |            | 342                    |
| $\text{C}_{10}\text{H}_{20}\text{O}$             | Citronellol                                | 224                    | 96                     |            |                        |
| $\text{C}_{10}\text{H}_{20}\text{O}_2$           | 2-Ethylhexyl acetate                       | 199                    | 71                     | 0.76–8.14% | 268                    |
| $\text{C}_{10}\text{H}_{20}\text{O}_2$           | Ethyl octanoate                            | 208.5                  | 79                     |            |                        |
| $\text{C}_{10}\text{H}_{21}\text{N}$             | <i>N</i> -Butylcyclohexanamine             |                        | 93                     |            |                        |
| $\text{C}_{10}\text{H}_{22}$                     | Decane                                     | 174.1                  | 51                     | 0.8–5.4%   | 210                    |
| $\text{C}_{10}\text{H}_{22}$                     | 2-Methylnonane                             | 167.1                  |                        |            | 210                    |
| $\text{C}_{10}\text{H}_{22}$                     | 3-Ethyloctane                              | 166.5                  |                        |            | 230                    |
| $\text{C}_{10}\text{H}_{22}$                     | 4-Ethyloctane                              | 163.7                  |                        |            | 229                    |
| $\text{C}_{10}\text{H}_{22}\text{O}$             | 1-Decanol                                  | 231.1                  | 82                     |            | 288                    |
| $\text{C}_{10}\text{H}_{22}\text{O}$             | Dipentyl ether                             | 190                    | 57                     |            | 170                    |
| $\text{C}_{10}\text{H}_{22}\text{O}_2$           | Ethylene glycol dibutyl ether              | 203.3                  | 85                     |            |                        |
| $\text{C}_{10}\text{H}_{22}\text{O}_5$           | Tetraethylene glycol dimethyl ether        | 275.3                  | 141                    |            |                        |
| $\text{C}_{10}\text{H}_{22}\text{S}$             | Dipentyl sulfide                           |                        | 85                     |            |                        |
| $\text{C}_{10}\text{H}_{23}\text{N}$             | Decylamine                                 | 220.5                  | 99                     |            |                        |
| $\text{C}_{10}\text{H}_{23}\text{N}$             | Dipentylamine                              | 202.5                  | 51                     |            |                        |
| $\text{C}_{11}\text{H}_{10}$                     | 1-Methylnaphthalene                        | 244.7                  |                        |            | 529                    |
| $\text{C}_{11}\text{H}_{12}\text{O}_3$           | Ethyl benzoylacetate                       |                        | 141                    |            |                        |
| $\text{C}_{11}\text{H}_{14}\text{O}_2$           | Butyl benzoate                             | 250.3                  | 107                    |            |                        |
| $\text{C}_{11}\text{H}_{16}$                     | <i>p-tert</i> -Butyltoluene                | 190                    | 68                     |            |                        |
| $\text{C}_{11}\text{H}_{16}$                     | Pentylbenzene                              | 205.4                  | 66                     |            |                        |
| $\text{C}_{11}\text{H}_{16}$                     | 1,3-Diethyl-5-methylbenzene                | 205                    |                        |            | 455                    |
| $\text{C}_{11}\text{H}_{16}$                     | Pentamethylbenzene                         | 232                    | 93                     |            | 427                    |
| $\text{C}_{11}\text{H}_{16}\text{O}$             | 4- <i>tert</i> -Butyl-2-methylphenol       | 237                    | 118                    |            |                        |
| $\text{C}_{11}\text{H}_{17}\text{N}$             | <i>p-tert</i> -Pentylaniline               | 260.5                  | 102                    |            |                        |
| $\text{C}_{11}\text{H}_{20}\text{O}_2$           | 2-Ethylhexyl acrylate                      |                        | 82                     |            | 252                    |
| $\text{C}_{11}\text{H}_{22}$                     | Pentylcyclohexane                          | 203.7                  |                        |            | 239                    |
| $\text{C}_{11}\text{H}_{22}\text{O}$             | 2-Undecanone                               | 231.5                  | 89                     |            |                        |
| $\text{C}_{11}\text{H}_{22}\text{O}_2$           | Nonyl acetate                              | 210                    | 68                     |            |                        |
| $\text{C}_{11}\text{H}_{24}$                     | Undecane                                   | 195.9                  | 69                     |            |                        |
| $\text{C}_{11}\text{H}_{24}$                     | 2-Methyldecane                             | 189.3                  |                        |            | 225                    |
| $\text{C}_{11}\text{H}_{24}\text{O}$             | 2-Undecanol                                | 228                    | 113                    |            |                        |
| $\text{C}_{12}\text{H}_9\text{Br}$               | 4-Bromo-1,1'-biphenyl                      | 310                    | 144                    |            |                        |
| $\text{C}_{12}\text{H}_{10}$                     | Biphenyl                                   | 256.1                  | 113                    | 0.6–5.8%   | 540                    |
| $\text{C}_{12}\text{H}_{10}\text{Cl}_2\text{Si}$ | Dichlorodiphenylsilane                     | 305                    | 142                    |            |                        |
| $\text{C}_{12}\text{H}_{10}\text{O}$             | <i>o</i> -Phenylphenol                     | 286                    | 124                    |            | 530                    |
| $\text{C}_{12}\text{H}_{10}\text{O}$             | Diphenyl ether                             | 258.0                  | 112                    | 0.8–1.5%   | 618                    |
| $\text{C}_{12}\text{H}_{11}\text{N}$             | 2-Aminobiphenyl                            | 299                    |                        |            | 450                    |
| $\text{C}_{12}\text{H}_{11}\text{N}$             | Diphenylamine                              | 302                    | 153                    |            | 634                    |
| $\text{C}_{12}\text{H}_{12}$                     | 1-Ethyl-naphthalene                        | 258.6                  |                        |            | 480                    |
| $\text{C}_{12}\text{H}_{14}\text{O}_4$           | Diethyl phthalate                          | 295                    | 161                    | 0.7–?      | 457                    |
| $\text{C}_{12}\text{H}_{14}\text{O}_4$           | Diethyl terephthalate                      | 302                    | 117                    |            |                        |
| $\text{C}_{12}\text{H}_{16}$                     | Cyclohexylbenzene                          | 240.1                  | 99                     |            |                        |
| $\text{C}_{12}\text{H}_{16}\text{O}_3$           | Pentyl salicylate                          | 270                    | 132                    |            |                        |
| $\text{C}_{12}\text{H}_{17}\text{NO}$            | <i>N</i> -Butyl- <i>N</i> -phenylacetamide | 281                    | 141                    |            |                        |
| $\text{C}_{12}\text{H}_{18}$                     | 1,5,9-Cyclododecatriene                    | 240                    | 71                     |            |                        |
| $\text{C}_{12}\text{H}_{20}\text{O}_4$           | Dibutyl maleate                            | 280                    | 141                    |            |                        |
| $\text{C}_{12}\text{H}_{22}\text{O}_4$           | Dimethyl sebacate                          |                        | 145                    |            |                        |
| $\text{C}_{12}\text{H}_{22}\text{O}_6$           | Dibutyl tartrate                           | 320                    | 91                     |            | 284                    |
| $\text{C}_{12}\text{H}_{23}\text{N}$             | Dicyclohexylamine                          |                        | >99                    |            |                        |
| $\text{C}_{12}\text{H}_{24}$                     | 1-Dodecene                                 | 213.8                  | 79                     |            |                        |
| $\text{C}_{12}\text{H}_{24}\text{O}_2$           | Ethyl decanoate                            | 241.5                  | >100                   |            |                        |
| $\text{C}_{12}\text{H}_{25}\text{Br}$            | 1-Bromododecane                            | 276                    | 144                    |            |                        |
| $\text{C}_{12}\text{H}_{26}$                     | Dodecane                                   | 216.3                  | 74                     | 0.6–?      | 203                    |
| $\text{C}_{12}\text{H}_{26}\text{O}$             | 1-Dodecanol                                | 259                    | 127                    |            | 275                    |
| $\text{C}_{12}\text{H}_{26}\text{O}$             | 2-Butyl-1-octanol                          | 246.5                  | 110                    |            |                        |
| $\text{C}_{12}\text{H}_{26}\text{O}_3$           | Diethylene glycol dibutyl ether            | 256                    | 118                    |            | 310                    |
| $\text{C}_{12}\text{H}_{26}\text{S}$             | 1-Dodecanethiol                            | 277                    | 128                    |            |                        |



| Mol. form.                                       | Name                                      | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|--------------------------------------------------|-------------------------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_{12}\text{H}_{27}\text{BO}_3$          | Tributyl borate                           | 234                    | 93                     |            |                        |
| $\text{C}_{12}\text{H}_{27}\text{N}$             | Tributylamine                             | 216.5                  | 63                     |            |                        |
| $\text{C}_{12}\text{H}_{27}\text{O}_4\text{P}$   | Tributyl phosphate                        | 289                    | 146                    |            |                        |
| $\text{C}_{13}\text{H}_{12}$                     | 2-Methylbiphenyl                          | 255.5                  | 137                    |            | 502                    |
| $\text{C}_{13}\text{H}_{12}$                     | Diphenylmethane                           | 265.0                  | 130                    |            | 485                    |
| $\text{C}_{13}\text{H}_{14}\text{N}_2$           | <i>p,p'</i> -Diaminodiphenylmethane       | 398                    | 220                    |            |                        |
| $\text{C}_{13}\text{H}_{26}$                     | 1-Tridecene                               | 232.8                  | 79                     |            |                        |
| $\text{C}_{13}\text{H}_{26}\text{O}$             | 2-Tridecanone                             | 263                    | 107                    |            |                        |
| $\text{C}_{13}\text{H}_{28}$                     | Tridecane                                 | 235.4                  | 79                     |            |                        |
| $\text{C}_{13}\text{H}_{28}\text{O}$             | 1-Tridecanol                              |                        | 121                    |            |                        |
| $\text{C}_{14}\text{H}_8\text{O}_2$              | 9,10-Anthracenedione                      | 377                    | 185                    |            |                        |
| $\text{C}_{14}\text{H}_{10}$                     | Anthracene                                | 339.9                  | 121                    | 0.6–?      | 540                    |
| $\text{C}_{14}\text{H}_{10}$                     | Phenanthrene                              | 340                    | 171                    |            |                        |
| $\text{C}_{14}\text{H}_{12}\text{O}_2$           | Benzyl benzoate                           | 323.5                  | 148                    |            | 480                    |
| $\text{C}_{14}\text{H}_{12}\text{O}_3$           | Benzyl salicylate                         | 320                    | >100                   |            |                        |
| $\text{C}_{14}\text{H}_{14}$                     | 1,1-Diphenylethane                        | 272.6                  | >100                   |            | 440                    |
| $\text{C}_{14}\text{H}_{14}\text{O}$             | Dibenzyl ether                            | 298                    | 135                    |            |                        |
| $\text{C}_{14}\text{H}_{16}$                     | 1-Butylnaphthalene                        | 289.3                  | 360                    |            |                        |
| $\text{C}_{14}\text{H}_{16}\text{N}_2\text{O}_2$ | <i>o</i> -Dianisidine                     |                        | 206                    |            |                        |
| $\text{C}_{14}\text{H}_{23}\text{N}$             | <i>N,N</i> -Dibutylaniline                | 274.8                  | 110                    |            |                        |
| $\text{C}_{14}\text{H}_{28}$                     | 1-Tetradecene                             | 233                    | 110                    |            | 235                    |
| $\text{C}_{14}\text{H}_{30}$                     | Tetradecane                               | 253.5                  | 112                    | 0.5–?      | 200                    |
| $\text{C}_{14}\text{H}_{30}\text{O}$             | 1-Tetradecanol                            | 289                    | 141                    |            |                        |
| $\text{C}_{15}\text{H}_{18}$                     | 1-Pentylnaphthalene                       | 307                    | 124                    |            |                        |
| $\text{C}_{15}\text{H}_{24}$                     | Nonylbenzene                              | 280.5                  | 99                     |            |                        |
| $\text{C}_{15}\text{H}_{24}\text{O}$             | 2,6-Di- <i>tert</i> -butyl-4-methylphenol | 265                    | 127                    |            |                        |
| $\text{C}_{15}\text{H}_{26}\text{O}_6$           | Tributylin                                | 307.5                  | 180                    | 0.5–?      | 407                    |
| $\text{C}_{15}\text{H}_{33}\text{N}$             | Triptylamine                              | 242.5                  | 102                    |            |                        |
| $\text{C}_{16}\text{H}_{14}\text{O}$             | 1,3-Diphenyl-2-buten-1-one                | 342.5                  | 177                    |            |                        |
| $\text{C}_{16}\text{H}_{18}$                     | 2-Butyl-1,1'-biphenyl                     |                        | >100                   |            | 430                    |
| $\text{C}_{16}\text{H}_{22}\text{O}_4$           | Dibutyl phthalate                         | 340                    | 157                    | 0.5–?      | 402                    |
| $\text{C}_{16}\text{H}_{26}$                     | Decylbenzene                              | 298                    | 107                    |            |                        |
| $\text{C}_{16}\text{H}_{34}$                     | Hexadecane                                | 286.8                  | 136                    |            | 202                    |
| $\text{C}_{16}\text{H}_{34}\text{O}$             | Diocetyl ether                            | 283                    | >100                   |            | 205                    |
| $\text{C}_{16}\text{H}_{35}\text{N}$             | Bis(2-ethylhexyl)amine                    |                        | 132                    |            |                        |
| $\text{C}_{17}\text{H}_{20}\text{N}_2\text{O}$   | <i>N,N'</i> -Diethylcarbanilide           |                        | 150                    |            |                        |
| $\text{C}_{17}\text{H}_{34}\text{O}$             | 2-Heptadecanone                           | 320                    | 120                    |            |                        |
| $\text{C}_{17}\text{H}_{36}\text{O}$             | 1-Heptadecanol                            | 333                    | 154                    |            |                        |
| $\text{C}_{18}\text{H}_{14}$                     | <i>o</i> -Terphenyl                       | 332                    | 163                    |            |                        |
| $\text{C}_{18}\text{H}_{14}$                     | <i>m</i> -Terphenyl                       | 363                    | 191                    |            |                        |
| $\text{C}_{18}\text{H}_{15}\text{O}_3\text{P}$   | Triphenyl phosphite                       | 360                    | 218                    |            |                        |
| $\text{C}_{18}\text{H}_{15}\text{O}_4\text{P}$   | Triphenyl phosphate                       |                        | 220                    |            |                        |
| $\text{C}_{18}\text{H}_{15}\text{P}$             | Triphenylphosphine                        |                        | 180                    |            |                        |
| $\text{C}_{18}\text{H}_{30}$                     | Dodecylbenzene                            | 328                    | 140                    |            |                        |
| $\text{C}_{18}\text{H}_{32}\text{O}_7$           | Butyl citrate                             |                        | 157                    |            | 368                    |
| $\text{C}_{18}\text{H}_{34}\text{O}_2$           | Oleic acid                                | 360                    | 189                    |            | 363                    |
| $\text{C}_{18}\text{H}_{34}\text{O}_4$           | Dibutyl sebacate                          | 344.5                  | 178                    | 0.4–?      | 365                    |
| $\text{C}_{18}\text{H}_{36}\text{O}_2$           | Stearic acid                              |                        | 196                    |            | 395                    |
| $\text{C}_{18}\text{H}_{37}\text{Cl}_3\text{Si}$ | Trichlorooctadecylsilane                  |                        | 89                     |            |                        |
| $\text{C}_{18}\text{H}_{38}$                     | Octadecane                                | 316.3                  | >100                   |            | 227                    |
| $\text{C}_{18}\text{H}_{38}\text{O}$             | 1-Octadecanol                             |                        |                        |            | 450                    |
| $\text{C}_{19}\text{H}_{16}$                     | Triphenylmethane                          | 359                    | >100                   |            |                        |
| $\text{C}_{19}\text{H}_{38}\text{O}$             | 2-Nonadecanone                            |                        | 124                    |            |                        |
| $\text{C}_{19}\text{H}_{38}\text{O}_2$           | Methyl stearate                           | 443                    | 153                    |            |                        |
| $\text{C}_{19}\text{H}_{40}$                     | Nonadecane                                | 329.9                  | >100                   |            | 230                    |
| $\text{C}_{20}\text{H}_{14}\text{O}_4$           | Diphenyl phthalate                        |                        | 224                    |            |                        |
| $\text{C}_{20}\text{H}_{28}$                     | 1-Decylnaphthalene                        | 379                    | 177                    |            |                        |
| $\text{C}_{20}\text{H}_{42}$                     | Eicosane                                  | 343                    | >100                   |            | 232                    |
| $\text{C}_{21}\text{H}_{21}\text{O}_4\text{P}$   | Tri- <i>o</i> -cresyl phosphate           | 410                    | 225                    |            | 385                    |
| $\text{C}_{21}\text{H}_{26}\text{O}_3$           | 4-Octylphenyl salicylate                  |                        | 216                    |            | 416                    |
| $\text{C}_{21}\text{H}_{32}\text{O}_2$           | Methyl abietate                           |                        | 180                    |            |                        |

| Mol. form.                             | Name                        | $t_b/^{\circ}\text{C}$ | FP/ $^{\circ}\text{C}$ | Fl. limits | IT/ $^{\circ}\text{C}$ |
|----------------------------------------|-----------------------------|------------------------|------------------------|------------|------------------------|
| $\text{C}_{22}\text{H}_{42}\text{O}_2$ | Butyl oleate                |                        | 180                    |            |                        |
| $\text{C}_{22}\text{H}_{42}\text{O}_4$ | Bis(2-ethylhexyl) adipate   |                        | 206                    | 0.4–?      | 377                    |
| $\text{C}_{22}\text{H}_{44}\text{O}_2$ | Butyl stearate              | 343                    | 160                    |            | 355                    |
| $\text{C}_{23}\text{H}_{46}\text{O}_2$ | Pentyl stearate             |                        | 185                    |            |                        |
| $\text{C}_{24}\text{H}_{20}\text{Sn}$  | Tetraphenylstannane         | 420                    | 232                    |            |                        |
| $\text{C}_{24}\text{H}_{38}\text{O}_4$ | Bis(2-ethylhexyl) phthalate | 384                    | 218                    |            |                        |
| $\text{C}_{25}\text{H}_{48}\text{O}_4$ | Bis(2-ethylhexyl) azelate   |                        | 227                    | 0.3–?      | 374                    |

## THRESHOLD LIMITS FOR AIRBORNE CONTAMINANTS

Several organizations recommend limits of exposure to airborne contaminants in the workplace. These include the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the non-governmental organization, American Conference of Governmental Industrial Hygienists (ACGIH). The threshold limit value (TLV) for a substance is defined as the concentration level under which the majority of workers may be repeatedly exposed, day after day, without adverse effects. The TLV recommendations are given in two forms:

- Time-weighted average (TWA) concentration for a normal 8-hr workday and 40-hr workweek.
- Short-term exposure limit (STEL), which should not be exceeded for more than 15 min.

Both kinds of limits are specified for some substances.

The following table gives threshold limit values for a number of substances that may be encountered in the atmosphere of a chemical laboratory or industrial facility. All values refer to the concentration in air at 25 °C and normal atmospheric pressure. Data for gases are given in parts per million by volume (ppm). Values for liquids refer to mists or aerosols, and those for solids to dusts or fumes; both are stated in mass concentration (mg/m<sup>3</sup>). A “C” preceding a value indicates a ceiling limit, which should not be exceeded even for very brief periods because of acute toxic effects of

the substance. The notation “levels as low as possible” in the Notes column indicates such a high level of hazard that no safe limit can be recommended.

Substances are listed alphabetically by systematic name. The Notes column gives further information on the form of the substance and the basis to which the TLV is referred. This column also includes common synonyms and acronyms in brackets (e.g., [MTBE]). The Formula column gives the molecular formula in the Hill convention for organic compounds and the customary line formula for inorganic compounds. The TWA and STEL limits appear in the last two columns.

Proposed changes in the limits are given in the Notes column with the notation “NIC”, which stands for Notice of Intended Changes. These are considered trial values in 2008, which may be adopted permanently in subsequent years.

## References

1. *2008 TLV's and BEI's*, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-1634, 2008 ([www.acgih.org](http://www.acgih.org)).
2. *NIOSH Pocket Guide to Chemical Hazards*, U.S. Department of Health and Human Services, National Institute for Occupational Health and Safety, U.S. Government Printing Office, Washington, DC, 1994.
3. *Chemical Information Manual*, U.S. Department of Labor, Occupational Safety and Health Administration, Washington, DC, 1991.

| Substance                                         | Notes                                                                            | Formula                                                                      | CAS Reg. No. | Time-weighted average  | Short-term exposure limit |
|---------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------------------------------------|--------------|------------------------|---------------------------|
| Abate                                             | [Temephos]                                                                       | C <sub>16</sub> H <sub>20</sub> O <sub>6</sub> P <sub>2</sub> S <sub>3</sub> | 3383-96-8    | 10 mg/m <sup>3</sup>   |                           |
| Acetaldehyde                                      | [Ethanal]                                                                        | C <sub>2</sub> H <sub>4</sub> O                                              | 75-07-0      |                        | C 25 ppm                  |
| Acetic acid                                       | [Ethanoic acid]                                                                  | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                                 | 64-19-7      | 10 ppm                 | 15 ppm                    |
| Acetic anhydride                                  | [Acetyl acetate]                                                                 | C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                                 | 108-24-7     | 5 ppm                  |                           |
| Acetone                                           | [2-Propanone]                                                                    | C <sub>3</sub> H <sub>6</sub> O                                              | 67-64-1      | 500 ppm                | 750 ppm                   |
| Acetone cyanohydrin                               | as CN                                                                            | C <sub>4</sub> H <sub>7</sub> NO                                             | 75-86-5      |                        | C 5 mg/m <sup>3</sup>     |
| Acetonitrile                                      | [Methyl cyanide]                                                                 | C <sub>2</sub> H <sub>3</sub> N                                              | 75-05-8      | 20 ppm                 |                           |
| Acetophenone                                      | [Methyl phenyl ketone]                                                           | C <sub>8</sub> H <sub>8</sub> O                                              | 98-86-2      | 10 ppm                 |                           |
| 2-(Acetyloxy)benzoic acid                         | [Aspirin]                                                                        | C <sub>9</sub> H <sub>8</sub> O <sub>4</sub>                                 | 50-78-2      | 5 mg/m <sup>3</sup>    |                           |
| Acrolein                                          | [2-Propenal]                                                                     | C <sub>3</sub> H <sub>4</sub> O                                              | 107-02-8     |                        | C 0.1 ppm                 |
| Acrylamide                                        | [2-Propenamide]                                                                  | C <sub>3</sub> H <sub>5</sub> NO                                             | 79-06-1      | 0.03 mg/m <sup>3</sup> |                           |
| Acrylic acid                                      | [2-Propenoic acid]                                                               | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                                 | 79-10-7      | 2 ppm                  |                           |
| Acrylonitrile                                     | [Propenenitrile]                                                                 | C <sub>3</sub> H <sub>3</sub> N                                              | 107-13-1     | 2 ppm                  |                           |
| Alachlor                                          | [Acetamide, 2-chloro- <i>N</i> -(2,6-diethylphenyl)- <i>N</i> -(methoxymethyl)-] | C <sub>14</sub> H <sub>20</sub> ClNO <sub>2</sub>                            | 15972-60-8   | 1 mg/m <sup>3</sup>    |                           |
| Aldrin                                            |                                                                                  | C <sub>12</sub> H <sub>8</sub> Cl <sub>6</sub>                               | 309-00-2     | 0.05 mg/m <sup>3</sup> |                           |
| Allyl alcohol                                     | [2-Propen-1-ol]                                                                  | C <sub>3</sub> H <sub>6</sub> O                                              | 107-18-6     | 0.5 ppm                |                           |
| Allyl glycidyl ether                              | [AGE]                                                                            | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>                                | 106-92-3     | 1 ppm                  |                           |
| Allyl propyl disulfide                            |                                                                                  | C <sub>6</sub> H <sub>12</sub> S <sub>2</sub>                                | 2179-59-1    | 0.5 ppm                |                           |
| Aluminum                                          | metal dust and insoluble compounds                                               | Al                                                                           | 7429-90-5    | 1 mg/m <sup>3</sup>    |                           |
| 4-Aminobiphenyl                                   | [ <i>p</i> -Biphenylamine] levels as low as possible                             | C <sub>12</sub> H <sub>11</sub> N                                            | 92-67-1      |                        |                           |
| 4-Amino-3,5,6-trichloro-2-pyridinecarboxylic acid | [Picloram]                                                                       | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub> N <sub>2</sub> O <sub>2</sub>  | 1918-02-1    | 10 mg/m <sup>3</sup>   |                           |
| Ammonia                                           |                                                                                  | NH <sub>3</sub>                                                              | 7664-41-7    | 25 ppm                 | 35 ppm                    |
| Ammonium chloride                                 | fume                                                                             | NH <sub>4</sub> Cl                                                           | 12125-02-9   | 10 mg/m <sup>3</sup>   | 20 mg/m <sup>3</sup>      |
| Ammonium perfluorooctanoate                       |                                                                                  | C <sub>8</sub> H <sub>8</sub> F <sub>15</sub> NO <sub>2</sub>                | 3825-26-1    | 0.01 mg/m <sup>3</sup> |                           |
| Ammonium sulfamate                                |                                                                                  | NH <sub>4</sub> NH <sub>2</sub> SO <sub>3</sub>                              | 7773-06-0    | 10 mg/m <sup>3</sup>   |                           |

| Substance                              | Notes                                                                                                | Formula                                                                       | CAS Reg. No. | Time-weighted average     | Short-term exposure limit |
|----------------------------------------|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------|---------------------------|---------------------------|
| Aniline                                | [Benzenamine]                                                                                        | C <sub>6</sub> H <sub>7</sub> N                                               | 62-53-3      | 2 ppm                     |                           |
| Antimony                               | and compounds, as Sb                                                                                 | Sb                                                                            | 7440-36-0    | 0.5 mg/m <sup>3</sup>     |                           |
| Antimony trioxide                      | levels as low as possible                                                                            | Sb <sub>2</sub> O <sub>3</sub>                                                | 1309-64-4    |                           |                           |
| Arsenic                                | and inorganic compounds, as As                                                                       | As                                                                            | 7440-38-2    | 0.01 mg/m <sup>3</sup>    |                           |
| Arsine                                 | [Arsenic hydride]                                                                                    | AsH <sub>3</sub>                                                              | 7784-42-1    | 0.005 ppm                 |                           |
| Asbestos                               | all forms                                                                                            |                                                                               | 1332-21-4    | 0.1 fiber/cm <sup>3</sup> |                           |
| Asphalt                                | fume, as aerosol                                                                                     |                                                                               | 8052-42-4    | 0.5 mg/m <sup>3</sup>     |                           |
| Atrazine                               | [6-Chloro- <i>N</i> -ethyl- <i>N'</i> -(1-methylethyl)-1,3,5-triazine-2,4-diamine]                   | C <sub>8</sub> H <sub>14</sub> ClN <sub>5</sub>                               | 1912-24-9    | 5 mg/m <sup>3</sup>       |                           |
| Azinphos-methyl                        |                                                                                                      | C <sub>10</sub> H <sub>12</sub> N <sub>3</sub> O <sub>3</sub> PS <sub>2</sub> | 86-50-0      | 0.2 mg/m <sup>3</sup>     |                           |
| Barium                                 | and soluble compounds, as Ba                                                                         | Ba                                                                            | 7440-39-3    | 0.5 mg/m <sup>3</sup>     |                           |
| Barium sulfate                         | [Barite]                                                                                             | BaSO <sub>4</sub>                                                             | 7727-43-7    | 10 mg/m <sup>3</sup>      |                           |
| Benomyl                                |                                                                                                      | C <sub>14</sub> H <sub>18</sub> N <sub>4</sub> O <sub>3</sub>                 | 17804-35-2   | 1 mg/m <sup>3</sup>       |                           |
| Benz[a]anthracene                      | levels as low as possible                                                                            | C <sub>18</sub> H <sub>12</sub>                                               | 56-55-3      |                           |                           |
| Benzene                                |                                                                                                      | C <sub>6</sub> H <sub>6</sub>                                                 | 71-43-2      | 0.5 ppm                   | 2.5 ppm                   |
| 1,2-Benzenediamine                     | [ <i>o</i> -Phenylenediamine]                                                                        | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                  | 95-54-5      | 0.1 mg/m <sup>3</sup>     |                           |
| 1,3-Benzenediamine                     | [ <i>m</i> -Phenylenediamine]                                                                        | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                  | 108-45-2     | 0.1 mg/m <sup>3</sup>     |                           |
| 1,4-Benzenediamine                     | [ <i>p</i> -Phenylenediamine]                                                                        | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                  | 106-50-3     | 0.1 mg/m <sup>3</sup>     |                           |
| 1,3-Benzenedimethanamine               | [ <i>m</i> -Xylene diamine]                                                                          | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub>                                 | 1477-55-0    |                           | C 0.1 mg/m <sup>3</sup>   |
| Benzenethiol                           | [Phenyl mercaptan]                                                                                   | C <sub>6</sub> H <sub>6</sub> S                                               | 108-98-5     | 0.1 ppm                   |                           |
| <i>p</i> -Benzidine                    | levels as low as possible                                                                            | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                                | 92-87-5      |                           |                           |
| Benzo[b]fluoranthene                   | levels as low as possible                                                                            | C <sub>20</sub> H <sub>12</sub>                                               | 205-99-2     |                           |                           |
| Benzo[a]pyrene                         | levels as low as possible                                                                            | C <sub>20</sub> H <sub>12</sub>                                               | 50-32-8      |                           |                           |
| <i>p</i> -Benzoquinone                 | [Quinone]                                                                                            | C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>                                  | 106-51-4     | 0.1 ppm                   |                           |
| Benzoyl chloride                       | [Benzoic acid, chloride]                                                                             | C <sub>7</sub> H <sub>5</sub> ClO                                             | 98-88-4      |                           | C 0.5 ppm                 |
| Benzoyl peroxide                       |                                                                                                      | C <sub>14</sub> H <sub>10</sub> O <sub>4</sub>                                | 94-36-0      | 5 mg/m <sup>3</sup>       |                           |
| Benzyl acetate                         | [(Acetoxymethyl)benzene]                                                                             | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                                 | 140-11-4     | 10 ppm                    |                           |
| Beryllium                              | and compounds, as Be. NIC in 2008 to TWA 0.00005 mg/m <sup>3</sup> , STEL 0.0002 mg/m <sup>3</sup> . | Be                                                                            | 7440-41-7    | 0.002 mg/m <sup>3</sup>   | 0.01 mg/m <sup>3</sup>    |
| Biphenyl                               | [Diphenyl]                                                                                           | C <sub>12</sub> H <sub>10</sub>                                               | 92-52-4      | 0.2 ppm                   |                           |
| Bis(2-aminoethyl)amine                 | [Diethylenetriamine]                                                                                 | C <sub>4</sub> H <sub>13</sub> N <sub>3</sub>                                 | 111-40-0     | 1 ppm                     |                           |
| Bis(2-chloroethyl) ether               | [2,2'-Dichlorethyl ether]                                                                            | C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O                               | 111-44-4     | 5 ppm                     | 10 ppm                    |
| Bis(chloromethyl) ether                | [Chloromethyl ether]                                                                                 | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> O                               | 542-88-1     | 0.001 ppm                 |                           |
| Bis(2-dimethylaminoethyl) ether        | [DMAEE]                                                                                              | C <sub>8</sub> H <sub>20</sub> N <sub>2</sub> O                               | 3033-62-3    | 0.05 ppm                  | 0.15 ppm                  |
| Bis(2-ethylhexyl) phthalate            | [Di- <i>sec</i> -octyl phthalate; DEHP]                                                              | C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>                                | 117-81-7     | 5 mg/m <sup>3</sup>       |                           |
| Bismuth telluride                      | [Tetradymite]                                                                                        | Bi <sub>2</sub> Te <sub>3</sub>                                               | 1304-82-1    | 10 mg/m <sup>3</sup>      |                           |
| Boric acid                             | and inorganic borate compounds                                                                       | H <sub>3</sub> BO <sub>3</sub>                                                | 10043-35-3   | 2 mg/m <sup>3</sup>       | 6 mg/m <sup>3</sup>       |
| Boron oxide                            | [Boric oxide]                                                                                        | B <sub>2</sub> O <sub>3</sub>                                                 | 1303-86-2    | 10 mg/m <sup>3</sup>      |                           |
| Boron tribromide                       | [Tribromoborane]                                                                                     | BBr <sub>3</sub>                                                              | 10294-33-4   |                           | C 1 ppm                   |
| Boron trifluoride                      | [Trifluoroborane]                                                                                    | BF <sub>3</sub>                                                               | 7637-07-2    |                           | C 1 ppm                   |
| Bromacil                               | [5-Bromo-3- <i>sec</i> -butyl-6-methyluracil]                                                        | C <sub>9</sub> H <sub>13</sub> BrN <sub>2</sub> O <sub>2</sub>                | 314-40-9     | 10 mg/m <sup>3</sup>      |                           |
| Bromine                                |                                                                                                      | Br <sub>2</sub>                                                               | 7726-95-6    | 0.1 ppm                   | 0.2 ppm                   |
| Bromine pentafluoride                  |                                                                                                      | BrF <sub>5</sub>                                                              | 7789-30-2    | 0.1 ppm                   |                           |
| Bromochloromethane                     | [Halon 1011]                                                                                         | CH <sub>2</sub> BrCl                                                          | 74-97-5      | 200 ppm                   |                           |
| 2-Bromo-2-chloro-1,1,1-trifluoroethane | [Halothane]                                                                                          | C <sub>2</sub> HBrClF <sub>3</sub>                                            | 151-67-7     | 50 ppm                    |                           |
| Bromoethane                            | [Ethyl bromide]                                                                                      | C <sub>2</sub> H <sub>5</sub> Br                                              | 74-96-4      | 5 ppm                     |                           |
| Bromoethene                            | [Vinyl bromide]                                                                                      | C <sub>2</sub> H <sub>3</sub> Br                                              | 593-60-2     | 0.5 ppm                   |                           |
| Bromomethane                           | [Methyl bromide]                                                                                     | CH <sub>3</sub> Br                                                            | 74-83-9      | 1 ppm                     |                           |
| 1-Bromopropane                         | [Propyl bromide]                                                                                     | C <sub>3</sub> H <sub>7</sub> Br                                              | 106-94-5     | 10 ppm                    |                           |
| Bromotrifluoromethane                  | [Trifluorobromomethane]                                                                              | CBrF <sub>3</sub>                                                             | 75-63-8      | 1000 ppm                  |                           |
| 1,3-Butadiene                          | [Divinyl]                                                                                            | C <sub>4</sub> H <sub>6</sub>                                                 | 106-99-0     | 2 ppm                     |                           |
| Butane                                 |                                                                                                      | C <sub>4</sub> H <sub>10</sub>                                                | 106-97-8     | 1000 ppm                  |                           |
| 1-Butanethiol                          | [Butyl mercaptan]                                                                                    | C <sub>4</sub> H <sub>10</sub> S                                              | 109-79-5     | 0.5 ppm                   |                           |
| 1-Butanol                              | [Butyl alcohol]                                                                                      | C <sub>4</sub> H <sub>10</sub> O                                              | 71-36-3      | 20 ppm                    |                           |

| Substance                             | Notes                                                                               | Formula                                                          | CAS Reg. No. | Time-weighted average   | Short-term exposure limit |
|---------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------|--------------|-------------------------|---------------------------|
| 2-Butanol                             | [ <i>sec</i> -Butyl alcohol]                                                        | C <sub>4</sub> H <sub>10</sub> O                                 | 78-92-2      | 100 ppm                 |                           |
| 2-Butanone                            | [Methyl ethyl ketone; MEK]                                                          | C <sub>4</sub> H <sub>8</sub> O                                  | 78-93-3      | 200 ppm                 | 300 ppm                   |
| 2-Butanone peroxide                   | [Methyl ethyl ketone peroxide]                                                      | C <sub>8</sub> H <sub>16</sub> O <sub>4</sub>                    | 1338-23-4    |                         | C 0.2 ppm                 |
| <i>trans</i> -2-Butenal               | [Crotonaldehyde]                                                                    | C <sub>4</sub> H <sub>6</sub> O                                  | 4170-30-3    |                         | C 0.3 ppm                 |
| 1-Butene                              | [1-Butylene]                                                                        | C <sub>4</sub> H <sub>8</sub>                                    | 106-98-9     | 250 ppm                 |                           |
| <i>cis</i> -2-Butene                  |                                                                                     | C <sub>4</sub> H <sub>8</sub>                                    | 590-18-1     | 250 ppm                 |                           |
| <i>trans</i> -2-Butene                |                                                                                     | C <sub>4</sub> H <sub>8</sub>                                    | 624-64-6     | 250 ppm                 |                           |
| 3-Buten-2-one                         | [Methyl vinyl ketone]                                                               | C <sub>4</sub> H <sub>6</sub> O                                  | 78-94-4      |                         | C 0.2 ppm                 |
| 2-Butoxyethanol                       | [EGBE]                                                                              | C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>                    | 111-76-2     | 20 ppm                  |                           |
| 2-Butoxyethyl acetate                 | [EGBEA]                                                                             | C <sub>8</sub> H <sub>16</sub> O <sub>3</sub>                    | 112-07-2     | 20 ppm                  |                           |
| Butyl acetate                         |                                                                                     | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                    | 123-86-4     | 150 ppm                 | 200 ppm                   |
| <i>sec</i> -Butyl acetate             | [1-Methylpropyl acetate]                                                            | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                    | 105-46-4     | 200 ppm                 |                           |
| <i>tert</i> -Butyl acetate            |                                                                                     | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                    | 540-88-5     | 200 ppm                 |                           |
| Butyl acrylate                        | [Butyl 2-propenoate]                                                                | C <sub>7</sub> H <sub>12</sub> O <sub>2</sub>                    | 141-32-2     | 2 ppm                   |                           |
| Butylamine                            | [1-Butanamine]                                                                      | C <sub>4</sub> H <sub>11</sub> N                                 | 109-73-9     |                         | C 5 ppm                   |
| <i>tert</i> -Butyl chromate           | as CrO <sub>3</sub>                                                                 | C <sub>8</sub> H <sub>18</sub> CrO <sub>4</sub>                  | 1189-85-1    |                         | C 0.1 mg/m <sup>3</sup>   |
| <i>tert</i> -Butyl ethyl ether        | [ETBE]                                                                              | C <sub>6</sub> H <sub>14</sub> O                                 | 637-92-3     | 5 ppm                   |                           |
| Butyl glycidyl ether                  | [BGE]                                                                               | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                    | 2426-08-6    | 3 ppm                   |                           |
| Butyl lactate                         |                                                                                     | C <sub>7</sub> H <sub>14</sub> O <sub>3</sub>                    | 138-22-7     | 5 ppm                   |                           |
| 1- <i>tert</i> -Butyl-4-methylbenzene | [ <i>p-tert</i> -Butyltoluene]                                                      | C <sub>11</sub> H <sub>16</sub>                                  | 98-51-1      | 1 ppm                   |                           |
| 2- <i>sec</i> -Butylphenol            |                                                                                     | C <sub>10</sub> H <sub>14</sub> O                                | 89-72-5      | 5 ppm                   |                           |
| Cadmium                               | metal                                                                               | Cd                                                               | 7440-43-9    | 0.01 mg/m <sup>3</sup>  |                           |
| Cadmium                               | compounds, as Cd                                                                    | Cd                                                               | 7440-43-9    | 0.002 mg/m <sup>3</sup> |                           |
| Calcium chromate                      | as Cr                                                                               | CaCrO <sub>4</sub>                                               | 13765-19-0   | 0.001 mg/m <sup>3</sup> |                           |
| Calcium cyanamide                     | [Calcium carbimide]                                                                 | CaCN <sub>2</sub>                                                | 156-62-7     | 0.5 mg/m <sup>3</sup>   |                           |
| Calcium hydroxide                     | [Portlandite]                                                                       | Ca(OH) <sub>2</sub>                                              | 1305-62-0    | 5 mg/m <sup>3</sup>     |                           |
| Calcium metasilicate                  | synthetic, nonfibrous                                                               | CaSiO <sub>3</sub>                                               | 1344-95-2    | 10 mg/m <sup>3</sup>    |                           |
| Calcium oxide                         | [Lime]                                                                              | CaO                                                              | 1305-78-8    | 2 mg/m <sup>3</sup>     |                           |
| Calcium sulfate                       | [Anhydrite]                                                                         | CaSO <sub>4</sub>                                                | 7778-18-9    | 10 mg/m <sup>3</sup>    |                           |
| Camphor                               | [1,7,7-Trimethylbicyclo[2.2.1]heptan-2-one], synthetic                              | C <sub>10</sub> H <sub>16</sub> O                                | 76-22-2      | 2 ppm                   | 3 ppm                     |
| Caprolactam                           | [Hexahydro-2-azepinone]                                                             | C <sub>6</sub> H <sub>11</sub> NO                                | 105-60-2     | 5 mg/m <sup>3</sup>     |                           |
| Captafol                              |                                                                                     | C <sub>10</sub> H <sub>9</sub> Cl <sub>4</sub> NO <sub>2</sub> S | 2425-06-1    | 0.1 mg/m <sup>3</sup>   |                           |
| Captan                                |                                                                                     | C <sub>9</sub> H <sub>8</sub> Cl <sub>3</sub> NO <sub>2</sub> S  | 133-06-2     | 5 mg/m <sup>3</sup>     |                           |
| Carbaryl                              |                                                                                     | C <sub>12</sub> H <sub>11</sub> NO <sub>2</sub>                  | 63-25-2      | 0.5 mg/m <sup>3</sup>   |                           |
| Carbofuran                            | [7-Benzofuranol, 2,3-dihydro-2,2-dimethyl-, methylcarbamate]                        | C <sub>12</sub> H <sub>15</sub> NO <sub>3</sub>                  | 1563-66-2    | 0.1 mg/m <sup>3</sup>   |                           |
| Carbon black                          | [Carbon (amorphous)]                                                                | C                                                                | 1333-86-4    | 3.5 mg/m <sup>3</sup>   |                           |
| Carbon dioxide                        |                                                                                     | CO <sub>2</sub>                                                  | 124-38-9     | 5000 ppm                | 30,000 ppm                |
| Carbon disulfide                      | [Carbon bisulfide]                                                                  | CS <sub>2</sub>                                                  | 75-15-0      | 1 ppm                   |                           |
| Carbon monoxide                       |                                                                                     | CO                                                               | 630-08-0     | 25 ppm                  |                           |
| Carbonyl chloride                     | [Phosgene]                                                                          | CCl <sub>2</sub> O                                               | 75-44-5      | 0.1 ppm                 |                           |
| Carbonyl fluoride                     |                                                                                     | CF <sub>2</sub> O                                                | 353-50-4     | 2 ppm                   | 5 ppm                     |
| Cellulose                             |                                                                                     |                                                                  | 9004-34-6    | 10 mg/m <sup>3</sup>    |                           |
| Cesium hydroxide                      |                                                                                     | CsOH                                                             | 21351-79-1   | 2 mg/m <sup>3</sup>     |                           |
| Chlordane                             | [1,2,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1 <i>H</i> -indene] | C <sub>10</sub> H <sub>6</sub> Cl <sub>8</sub>                   | 57-74-9      | 0.5 mg/m <sup>3</sup>   |                           |
| <i>o</i> -Chlorinated diphenyl oxide  |                                                                                     |                                                                  | 31242-93-0   | 0.5 mg/m <sup>3</sup>   |                           |
| Chlorine                              |                                                                                     | Cl <sub>2</sub>                                                  | 7782-50-5    | 0.5 ppm                 | 1 ppm                     |
| Chlorine dioxide                      |                                                                                     | ClO <sub>2</sub>                                                 | 10049-04-4   | 0.1 ppm                 | 0.3 ppm                   |
| Chlorine trifluoride                  |                                                                                     | ClF <sub>3</sub>                                                 | 7790-91-2    |                         | C 0.1 ppm                 |
| Chloroacetaldehyde                    | [2-Chloro-1-ethanal]                                                                | C <sub>2</sub> H <sub>3</sub> ClO                                | 107-20-0     |                         | C 1 ppm                   |
| Chloroacetic acid                     |                                                                                     | C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>                   | 79-11-8      | 0.5 ppm                 |                           |
| Chloroacetone                         |                                                                                     | C <sub>3</sub> H <sub>5</sub> ClO                                | 78-95-5      |                         | C 1 ppm                   |
| $\alpha$ -Chloroacetophenone          | [ $\omega$ -Chloroacetophenone]                                                     | C <sub>8</sub> H <sub>7</sub> ClO                                | 532-27-4     | 0.05 ppm                |                           |

| Substance                                 | Notes                                                                                     | Formula               | CAS Reg. No. | Time-weighted average  | Short-term exposure limit |
|-------------------------------------------|-------------------------------------------------------------------------------------------|-----------------------|--------------|------------------------|---------------------------|
| Chloroacetyl chloride                     |                                                                                           | $C_2H_2Cl_2O$         | 79-04-9      | 0.05 ppm               | 0.15 ppm                  |
| Chlorobenzene                             | [Phenyl chloride]                                                                         | $C_6H_5Cl$            | 108-90-7     | 10 ppm                 |                           |
| <i>o</i> -Chlorobenzylidene malononitrile |                                                                                           | $C_{10}H_5ClN_2$      | 2698-41-1    |                        | C 0.05 ppm                |
| 2-Chloro-1,3-butadiene                    | [Chloroprene]                                                                             | $C_4H_5Cl$            | 126-99-8     | 10 ppm                 |                           |
| Chlorodifluoromethane                     | [HCFC-22]                                                                                 | $CHClF_2$             | 75-45-6      | 1000 ppm               |                           |
| Chloroethane                              | [Ethyl chloride]                                                                          | $C_2H_5Cl$            | 75-00-3      | 100 ppm                |                           |
| 2-Chloroethanol                           | [Ethylene chlorohydrin]                                                                   | $C_2H_5ClO$           | 107-07-3     |                        | C 1 ppm                   |
| Chloroethene                              | [Vinyl chloride]                                                                          | $C_2H_3Cl$            | 75-01-4      | 1 ppm                  |                           |
| Chloromethane                             | [Methyl chloride]                                                                         | $CH_3Cl$              | 74-87-3      | 50 ppm                 | 100 ppm                   |
| (Chloromethyl)benzene                     | [Benzyl chloride]                                                                         | $C_7H_7Cl$            | 100-44-7     | 1 ppm                  |                           |
| Chloromethyl methyl ether                 | levels as low as possible                                                                 | $C_2H_5ClO$           | 107-30-2     |                        |                           |
| 1-Chloro-4-nitrobenzene                   | [ <i>p</i> -Nitrochlorobenzene]                                                           | $C_6H_4ClNO_2$        | 100-00-5     | 0.1 ppm                |                           |
| 1-Chloro-1-nitropropane                   |                                                                                           | $C_3H_6ClNO_2$        | 600-25-9     | 2 ppm                  |                           |
| Chloropentafluoroethane                   | [CFC-115]                                                                                 | $C_2ClF_5$            | 76-15-3      | 1000 ppm               |                           |
| 2-Chloropropanoic acid                    | [2-Chloropropionic acid]                                                                  | $C_3H_5ClO_2$         | 598-78-7     | 0.1 ppm                |                           |
| 2-Chloro-1-propanol                       | [Propylene chlorohydrin]                                                                  | $C_3H_7ClO$           | 78-89-7      | 1 ppm                  |                           |
| 1-Chloro-2-propanol                       | [ <i>sec</i> -Propylene chlorohydrin]                                                     | $C_3H_7ClO$           | 127-00-4     | 1 ppm                  |                           |
| 3-Chloropropene                           | [Allyl chloride]                                                                          | $C_3H_5Cl$            | 107-05-1     | 1 ppm                  | 2 ppm                     |
| 2-Chlorostyrene                           |                                                                                           | $C_8H_7Cl$            | 2039-87-4    | 50 ppm                 | 75 ppm                    |
| 2-Chlorotoluene                           | [1-Chloro-2-methylbenzene]                                                                | $C_7H_7Cl$            | 95-49-8      | 50 ppm                 |                           |
| Chlorpyrifos                              | [Phosphorothioic acid, <i>O,O</i> -diethyl <i>O</i> -(3,5,6-trichloro-2-pyridinyl) ester] | $C_9H_{11}Cl_3NO_3PS$ | 2921-88-2    | 0.1 mg/m <sup>3</sup>  |                           |
| Chromium                                  | metal                                                                                     | Cr                    | 7440-47-3    | 0.5 mg/m <sup>3</sup>  |                           |
| Chromium                                  | Cr(III) compounds, as Cr                                                                  | Cr                    | 7440-47-3    | 0.5 mg/m <sup>3</sup>  |                           |
| Chromium                                  | soluble Cr(VI) compounds, as Cr                                                           | Cr                    | 7440-47-3    | 0.05 mg/m <sup>3</sup> |                           |
| Chromium                                  | insoluble Cr(VI) compounds, as Cr                                                         | Cr                    | 7440-47-3    | 0.01 mg/m <sup>3</sup> |                           |
| Chromium(VI) dichloride dioxide           | [Chromyl chloride]                                                                        | $CrO_2Cl_2$           | 14977-61-8   | 0.025 ppm              |                           |
| Chrysene                                  | levels as low as possible                                                                 | $C_{18}H_{12}$        | 218-01-9     |                        |                           |
| Clopidol                                  |                                                                                           | $C_7H_7Cl_2NO$        | 2971-90-6    | 10 mg/m <sup>3</sup>   |                           |
| Coal                                      | dust, anthracite                                                                          |                       |              | 0.4 mg/m <sup>3</sup>  |                           |
| Coal                                      | dust, bituminous                                                                          |                       |              | 0.9 mg/m <sup>3</sup>  |                           |
| Coal tar                                  | volatiles, as aerosol                                                                     |                       | 65966-93-2   | 0.2 mg/m <sup>3</sup>  |                           |
| Cobalt                                    | metal and inorganic compounds, as Co                                                      | Co                    | 7440-48-4    | 0.02 mg/m <sup>3</sup> |                           |
| Cobalt carbonyl                           | as Co                                                                                     | $Co_2(CO)_8$          | 10210-68-1   | 0.1 mg/m <sup>3</sup>  |                           |
| Cobalt hydrocarbonyl                      | as Co                                                                                     | $C_4HCoO_4$           | 16842-03-8   | 0.1 mg/m <sup>3</sup>  |                           |
| Copper                                    | fume                                                                                      | Cu                    | 7440-50-8    | 0.2 mg/m <sup>3</sup>  |                           |
| Copper                                    | dusts & mists, as Cu                                                                      | Cu                    | 7440-50-8    | 1 mg/m <sup>3</sup>    |                           |
| Coumaphos                                 |                                                                                           | $C_{14}H_{16}ClO_5PS$ | 56-72-4      | 0.05 mg/m <sup>3</sup> |                           |
| Cresol                                    | all isomers. NIC in 2008 to 20 mg/m <sup>3</sup>                                          | $C_7H_8O$             | 1319-77-3    | 5 ppm                  |                           |
| Crufomate                                 |                                                                                           | $C_{12}H_{19}ClNO_3P$ | 299-86-5     | 5 mg/m <sup>3</sup>    |                           |
| Cyanamide                                 | [Cyanogenamide]                                                                           | $CH_2N_2$             | 420-04-2     | 2 mg/m <sup>3</sup>    |                           |
| Cyanide ion                               | cyanide salts, as CN                                                                      | CN <sup>-</sup>       | 57-12-5      |                        | C 5 mg/m <sup>3</sup>     |
| Cyanogen                                  |                                                                                           | $C_2N_2$              | 460-19-5     | 10 ppm                 |                           |
| Cyanogen chloride                         | [Chlorine cyanide]                                                                        | CClN                  | 506-77-4     |                        | C 0.3 ppm                 |
| Cyclohexane                               | [Hexahydrobenzene]                                                                        | $C_6H_{12}$           | 110-82-7     | 100 ppm                |                           |
| Cyclohexanol                              | [Cyclohexyl alcohol]                                                                      | $C_6H_{12}O$          | 108-93-0     | 50 ppm                 |                           |
| Cyclohexanone                             | [Pimelic ketone]                                                                          | $C_6H_{10}O$          | 108-94-1     | 20 ppm                 | 50 ppm                    |
| Cyclohexene                               | [Tetrahydrobenzene]                                                                       | $C_6H_{10}$           | 110-83-8     | 300 ppm                |                           |
| Cyclohexylamine                           | [Cyclohexanamine]                                                                         | $C_6H_{13}N$          | 108-91-8     | 10 ppm                 |                           |
| Cyclonite                                 | [Hexahydro-1,3,5-trinitro-1,3,5-triazine]                                                 | $C_3H_6N_6O_6$        | 121-82-4     | 0.5 mg/m <sup>3</sup>  |                           |
| 1,3-Cyclopentadiene                       | [Pyropentylene]                                                                           | $C_5H_6$              | 542-92-7     | 75 ppm                 |                           |
| Cyclopentane                              | [Pentamethylene]                                                                          | $C_5H_{10}$           | 287-92-3     | 600 ppm                |                           |
| Cyhexatin                                 | [Tricyclohexylhydroxystannane]                                                            | $C_{18}H_{34}OSn$     | 13121-70-5   | 5 mg/m <sup>3</sup>    |                           |

| Substance                                 | Notes                                                              | Formula                                                                     | CAS Reg. No. | Time-weighted average  | Short-term exposure limit |
|-------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------|--------------|------------------------|---------------------------|
| Decaborane(14)                            |                                                                    | B <sub>10</sub> H <sub>14</sub>                                             | 17702-41-9   | 0.05 ppm               | 0.15 ppm                  |
| Demeton                                   | [Systox]                                                           | C <sub>8</sub> H <sub>19</sub> O <sub>3</sub> PS <sub>2</sub>               | 8065-48-3    | 0.05 mg/m <sup>3</sup> |                           |
| Demeton-S-methyl                          | [Phosphorothioic acid, S-[2-(ethylthio) ethyl] O,O-dimethyl ester] | C <sub>6</sub> H <sub>15</sub> O <sub>3</sub> PS <sub>2</sub>               | 919-86-8     | 0.05 mg/m <sup>3</sup> |                           |
| Diacetone alcohol                         | [4-Hydroxy-4-methyl-2-pentanone]                                   | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                               | 123-42-2     | 50 ppm                 |                           |
| 4,4'-Diaminodiphenylmethane               | [4,4-Methylene dianiline]                                          | C <sub>13</sub> H <sub>14</sub> N <sub>2</sub>                              | 101-77-9     | 0.1 ppm                |                           |
| Diazinon                                  |                                                                    | C <sub>12</sub> H <sub>21</sub> N <sub>2</sub> O <sub>3</sub> PS            | 333-41-5     | 0.01 mg/m <sup>3</sup> |                           |
| Diazomethane                              |                                                                    | CH <sub>2</sub> N <sub>2</sub>                                              | 334-88-3     | 0.2 ppm                |                           |
| Diborane                                  |                                                                    | B <sub>2</sub> H <sub>6</sub>                                               | 19287-45-7   | 0.1 ppm                |                           |
| Dibromodifluoromethane                    |                                                                    | CBr <sub>2</sub> F <sub>2</sub>                                             | 75-61-6      | 100 ppm                |                           |
| 2-Dibutylaminoethanol                     |                                                                    | C <sub>10</sub> H <sub>23</sub> NO                                          | 102-81-8     | 0.5 ppm                |                           |
| 2,6-Di- <i>tert</i> -butyl-4-methylphenol | [Butylated hydroxytoluene; BHT]                                    | C <sub>15</sub> H <sub>24</sub> O                                           | 128-37-0     | 2 mg/m <sup>3</sup>    |                           |
| Dibutylphenyl phosphate                   |                                                                    | C <sub>14</sub> H <sub>23</sub> O <sub>4</sub> P                            | 2528-36-1    | 0.3 ppm                |                           |
| Dibutyl phosphate                         | NIC in 2008 to TWA 5 mg/m <sup>3</sup>                             | C <sub>8</sub> H <sub>19</sub> O <sub>4</sub> P                             | 107-66-4     | 1 ppm                  | 2 ppm                     |
| Dibutyl phthalate                         | [Butyl phthalate]                                                  | C <sub>16</sub> H <sub>22</sub> O <sub>4</sub>                              | 84-74-2      | 5 mg/m <sup>3</sup>    |                           |
| Dichloroacetic acid                       |                                                                    | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>                | 79-43-6      | 0.5 ppm                |                           |
| Dichloroacetylene                         |                                                                    | C <sub>2</sub> Cl <sub>2</sub>                                              | 7572-29-4    |                        | C 0.1 ppm                 |
| <i>o</i> -Dichlorobenzene                 | [1,2-Dichlorobenzene]                                              | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 95-50-1      | 25 ppm                 | 50 ppm                    |
| <i>p</i> -Dichlorobenzene                 | [1,4-Dichlorobenzene]                                              | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 106-46-7     | 10 ppm                 |                           |
| 3,3'-Dichloro- <i>p</i> -benzidine        | levels as low as possible                                          | C <sub>12</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub>              | 91-94-1      |                        |                           |
| 1,4-Dichloro-2-butene                     | both isomers                                                       | C <sub>4</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 764-41-0     | 0.005 ppm              |                           |
| Dichlorodifluoromethane                   | [CFC-12]                                                           | CCl <sub>2</sub> F <sub>2</sub>                                             | 75-71-8      | 1000 ppm               |                           |
| 1,3-Dichloro-5,5-dimethyl hydantoin       |                                                                    | C <sub>5</sub> H <sub>6</sub> Cl <sub>2</sub> N <sub>2</sub> O <sub>2</sub> | 118-52-5     | 0.2 mg/m <sup>3</sup>  | 0.4 mg/m <sup>3</sup>     |
| Dichlorodiphenyltrichloroethane           | [DDT]                                                              | C <sub>14</sub> H <sub>9</sub> Cl <sub>5</sub>                              | 50-29-3      | 1 mg/m <sup>3</sup>    |                           |
| 1,1-Dichloroethane                        | [Ethylidene dichloride]                                            | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 75-34-3      | 100 ppm                |                           |
| 1,2-Dichloroethane                        | [Ethylene dichloride]                                              | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 107-06-2     | 10 ppm                 |                           |
| 1,1-Dichloroethene                        | [Vinylidene chloride]                                              | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                               | 75-35-4      | 5 ppm                  |                           |
| 1,2-Dichloroethylene                      | both isomers                                                       | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>                               | 540-59-0     | 200 ppm                |                           |
| Dichlorofluoromethane                     | [CFC 21]                                                           | CHCl <sub>2</sub> F                                                         | 75-43-4      | 10 ppm                 |                           |
| Dichloromethane                           | [Methylene chloride]                                               | CH <sub>2</sub> Cl <sub>2</sub>                                             | 75-09-2      | 50 ppm                 |                           |
| 1,1-Dichloro-1-nitroethane                | [Ethide]                                                           | C <sub>2</sub> H <sub>3</sub> Cl <sub>2</sub> NO <sub>2</sub>               | 594-72-9     | 2 ppm                  |                           |
| (2,4-Dichlorophenoxy)acetic acid          | [2,4-D]                                                            | C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>3</sub>                | 94-75-7      | 10 mg/m <sup>3</sup>   |                           |
| 1,2-Dichloropropane                       | [Propylene dichloride]                                             | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>                               | 78-87-5      | 10 ppm                 |                           |
| 2,2-Dichloropropanoic acid                | [2,2-Dichloropropionic acid]                                       | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub> O <sub>2</sub>                | 75-99-0      | 5 mg/m <sup>3</sup>    |                           |
| 1,3-Dichloropropene                       | both isomers                                                       | C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>                               | 542-75-6     | 1 ppm                  |                           |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane    | [CFC-114]                                                          | C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>                               | 76-14-2      | 1000 ppm               |                           |
| Dichlorvos                                | [Phosphoric acid, 2,2-dichloroethenyl dimethyl ester]              | C <sub>4</sub> H <sub>7</sub> Cl <sub>2</sub> O <sub>4</sub> P              | 62-73-7      | 0.1 mg/m <sup>3</sup>  |                           |
| Dicrotophos                               |                                                                    | C <sub>8</sub> H <sub>16</sub> NO <sub>5</sub> P                            | 141-66-2     | 0.05 mg/m <sup>3</sup> |                           |
| <i>m</i> -Dicyanobenzene                  | [ <i>m</i> -Phthalodinitrile]                                      | C <sub>8</sub> H <sub>4</sub> N <sub>2</sub>                                | 626-17-5     | 5 mg/m <sup>3</sup>    |                           |
| Dicyclopentadiene                         |                                                                    | C <sub>10</sub> H <sub>12</sub>                                             | 77-73-6      | 5 ppm                  |                           |
| Dieldrin                                  |                                                                    | C <sub>12</sub> H <sub>8</sub> Cl <sub>6</sub> O                            | 60-57-1      | 0.25 mg/m <sup>3</sup> |                           |
| Diesel fuel                               | as total hydrocarbons                                              |                                                                             | 68334-30-5   | 100 mg/m <sup>3</sup>  |                           |
| Diethanolamine                            | [Bis(2-hydroxyethyl)amine]. NIC in 2008 to 1 mg/m <sup>3</sup> .   | C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>                              | 111-42-2     | 2 mg/m <sup>3</sup>    |                           |
| Diethylamine                              | [ <i>N</i> -Ethylethanamine]                                       | C <sub>4</sub> H <sub>11</sub> N                                            | 109-89-7     | 5 ppm                  | 15 ppm                    |
| 2-Diethylaminoethanol                     |                                                                    | C <sub>6</sub> H <sub>15</sub> NO                                           | 100-37-8     | 2 ppm                  |                           |
| Diethyl ether                             | [Ethyl ether]                                                      | C <sub>4</sub> H <sub>10</sub> O                                            | 60-29-7      | 400 ppm                | 500 ppm                   |
| Diethyl phthalate                         |                                                                    | C <sub>12</sub> H <sub>14</sub> O <sub>4</sub>                              | 84-66-2      | 5 mg/m <sup>3</sup>    |                           |
| 1,1-Difluoroethene                        | [Vinylidene fluoride]                                              | C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>                                | 75-38-7      | 500 ppm                |                           |
| Diglycidyl ether                          | [DGE]                                                              | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                               | 2238-07-5    | 0.1 ppm                |                           |
| Diisopropylamine                          | [ <i>N</i> -Isopropyl-2-propanamine]                               | C <sub>6</sub> H <sub>15</sub> N                                            | 108-18-9     | 5 ppm                  |                           |
| Diisopropyl ether                         | [Isopropyl ether]                                                  | C <sub>6</sub> H <sub>14</sub> O                                            | 108-20-3     | 250 ppm                | 310 ppm                   |



| Substance                            | Notes                                                                               | Formula                                                                      | CAS Reg. No. | Time-weighted average   | Short-term exposure limit |
|--------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------|--------------|-------------------------|---------------------------|
| Dimethoxymethane                     | [Methylal]                                                                          | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                                 | 109-87-5     | 1000 ppm                |                           |
| <i>N,N</i> -Dimethylacetamide        | [ <i>N,N</i> -Dimethylethanamide]                                                   | C <sub>4</sub> H <sub>9</sub> NO                                             | 127-19-5     | 10 ppm                  |                           |
| Dimethylamine                        | [ <i>N</i> -Methylmethanamine]                                                      | C <sub>2</sub> H <sub>7</sub> N                                              | 124-40-3     | 5 ppm                   | 15 ppm                    |
| <i>N,N</i> -Dimethylaniline          |                                                                                     | C <sub>8</sub> H <sub>11</sub> N                                             | 121-69-7     | 5 ppm                   |                           |
| Dimethylaniline                      | other isomers                                                                       | C <sub>8</sub> H <sub>11</sub> N                                             | 1300-73-8    | 0.5 ppm                 |                           |
| 2,2-Dimethylbutane                   | [Neohexane]                                                                         | C <sub>6</sub> H <sub>14</sub>                                               | 75-83-2      | 500 ppm                 | 1000 ppm                  |
| 2,3-Dimethylbutane                   | [Diisopropyl]                                                                       | C <sub>6</sub> H <sub>14</sub>                                               | 79-29-8      | 500 ppm                 | 1000 ppm                  |
| Dimethylcarbamic chloride            | [Dimethyl carbamoyl chloride]                                                       | C <sub>3</sub> H <sub>6</sub> ClNO                                           | 79-44-7      | 0.005 mg/m <sup>3</sup> |                           |
| Dimethyl disulfide                   | [Methyl disulfide]                                                                  | C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>                                 | 624-92-0     | 0.5 mg/m <sup>3</sup>   |                           |
| <i>N,N</i> -Dimethylformamide        | [DMF]                                                                               | C <sub>3</sub> H <sub>7</sub> NO                                             | 68-12-2      | 10 ppm                  |                           |
| 2,6-Dimethyl-4-heptanone             | [Diisobutyl ketone]                                                                 | C <sub>9</sub> H <sub>18</sub> O                                             | 108-83-8     | 25 ppm                  |                           |
| 1,1-Dimethylhydrazine                | [UDMH]                                                                              | C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                                 | 57-14-7      | 0.01 ppm                |                           |
| Dimethyl mercury                     | [Mercury dimethyl]                                                                  | C <sub>2</sub> H <sub>6</sub> Hg                                             | 593-74-8     | 0.01 mg/m <sup>3</sup>  |                           |
| Dimethyl phthalate                   | [Methyl phthalate]                                                                  | C <sub>10</sub> H <sub>10</sub> O <sub>4</sub>                               | 131-11-3     | 5 mg/m <sup>3</sup>     |                           |
| 2,2-Dimethyl-1-propanol acetate      |                                                                                     | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                                | 926-41-0     | 50 ppm                  | 100 ppm                   |
| Dimethyl sulfate                     |                                                                                     | C <sub>2</sub> H <sub>6</sub> O <sub>4</sub> S                               | 77-78-1      | 0.1 ppm                 |                           |
| Dimethyl sulfide                     | [2-Thiapropane]                                                                     | C <sub>2</sub> H <sub>6</sub> S                                              | 75-18-3      | 10 ppm                  |                           |
| Dinitrobenzene                       | all isomers                                                                         | C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>                  | 25154-54-5   | 0.15 ppm                |                           |
| Dinitrotoluene                       | all isomers                                                                         | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>4</sub>                  | 25321-14-6   | 0.2 mg/m <sup>3</sup>   |                           |
| 1,4-Dioxane                          | [1,4-Dioxacyclohexane]                                                              | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                                 | 123-91-1     | 20 ppm                  |                           |
| Dioxathion                           |                                                                                     | C <sub>12</sub> H <sub>26</sub> O <sub>6</sub> P <sub>2</sub> S <sub>4</sub> | 78-34-2      | 0.1 mg/m <sup>3</sup>   |                           |
| 1,3-Dioxolane                        | [1,3-Dioxacyclopentane]                                                             | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                                 | 646-06-0     | 20 ppm                  |                           |
| Diphenylamine                        | [ <i>N</i> -Phenylbenzenamine]                                                      | C <sub>12</sub> H <sub>11</sub> N                                            | 122-39-4     | 10 mg/m <sup>3</sup>    |                           |
| Diphenyl ether                       | [Phenyl ether]                                                                      | C <sub>12</sub> H <sub>10</sub> O                                            | 101-84-8     | 1 ppm                   | 2 ppm                     |
| 4,4'-Diphenylmethane diisocyanate    | [Methylene diphenyl isocyanate; MDI]                                                | C <sub>15</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub>                | 101-68-8     | 0.005 ppm               |                           |
| Dipropylene glycol monomethyl ether  | [Bis(2-Methoxypropyl) ether; DPGME]                                                 | C <sub>7</sub> H <sub>16</sub> O <sub>3</sub>                                | 34590-94-8   | 100 ppm                 | 150 ppm                   |
| Diquat                               |                                                                                     | C <sub>12</sub> H <sub>12</sub> N <sub>2</sub>                               | 231-36-7     | 0.5 mg/m <sup>3</sup>   |                           |
| Disulfiram                           |                                                                                     | C <sub>10</sub> H <sub>20</sub> N <sub>2</sub> S <sub>4</sub>                | 97-77-8      | 2 mg/m <sup>3</sup>     |                           |
| Disulfoton                           | [Phosphorodithioic acid, <i>O,O</i> -diethyl <i>S</i> -[2-(ethylthio)ethyl] ester]  | C <sub>8</sub> H <sub>19</sub> O <sub>2</sub> PS <sub>3</sub>                | 298-04-4     | 0.05 mg/m <sup>3</sup>  |                           |
| Diuron                               |                                                                                     | C <sub>9</sub> H <sub>10</sub> Cl <sub>2</sub> N <sub>2</sub> O              | 330-54-1     | 10 mg/m <sup>3</sup>    |                           |
| Divinyl benzene                      | all isomers                                                                         | C <sub>10</sub> H <sub>10</sub>                                              | 1321-74-0    | 10 ppm                  |                           |
| 1-Dodecanethiol                      |                                                                                     | C <sub>12</sub> H <sub>26</sub> S                                            | 112-55-0     | 0.1 ppm                 |                           |
| Endosulfan                           |                                                                                     | C <sub>9</sub> H <sub>6</sub> Cl <sub>6</sub> O <sub>3</sub> S               | 115-29-7     | 0.1 mg/m <sup>3</sup>   |                           |
| Endrin                               |                                                                                     | C <sub>12</sub> H <sub>8</sub> Cl <sub>4</sub> O                             | 72-20-8      | 0.1 mg/m <sup>3</sup>   |                           |
| Enflurane                            |                                                                                     | C <sub>3</sub> H <sub>2</sub> ClF <sub>5</sub> O                             | 13838-16-9   | 75 ppm                  |                           |
| Epichlorohydrin                      | [(Chloromethyl)oxirane]                                                             | C <sub>3</sub> H <sub>5</sub> ClO                                            | 106-89-8     | 0.5 ppm                 |                           |
| 1,2-Epoxy-4-(epoxyethyl) cyclohexane | [Vinylcyclohexene dioxide]                                                          | C <sub>8</sub> H <sub>12</sub> O <sub>2</sub>                                | 106-87-6     | 0.1 ppm                 |                           |
| Ethane                               |                                                                                     | C <sub>2</sub> H <sub>6</sub>                                                | 74-84-0      | 1000 ppm                |                           |
| 1,2-Ethanediamine                    | [Ethylenediamine]                                                                   | C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>                                 | 107-15-3     | 10 ppm                  |                           |
| 1,2-Ethandiol                        | [Ethylene glycol]                                                                   | C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>                                 | 107-21-1     |                         | C 100 mg/m <sup>3</sup>   |
| 1,2-Ethandiol, dinitrate             | [Ethylene glycol dinitrate; EGDN]                                                   | C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>6</sub>                  | 628-96-6     | 0.05 ppm                |                           |
| Ethanethiol                          | [Ethyl mercaptan]                                                                   | C <sub>2</sub> H <sub>6</sub> S                                              | 75-08-1      | 0.5 ppm                 |                           |
| Ethanol                              | [Ethyl alcohol]                                                                     | C <sub>2</sub> H <sub>6</sub> O                                              | 64-17-5      | 1000 ppm                |                           |
| Ethanolamine                         | [2-Aminoethanol]                                                                    | C <sub>2</sub> H <sub>7</sub> NO                                             | 141-43-5     | 3 ppm                   | 6 ppm                     |
| Ethion                               | [Phosphorodithioic acid, <i>S,S'</i> -methylene <i>O,O,O',O'</i> -tetraethyl ester] | C <sub>9</sub> H <sub>22</sub> O <sub>4</sub> P <sub>2</sub> S <sub>4</sub>  | 563-12-2     | 0.05 mg/m <sup>3</sup>  |                           |
| Ethoxydimethylsilane                 | [Dimethylethoxysilane]                                                              | C <sub>4</sub> H <sub>12</sub> OSi                                           | 14857-34-2   | 0.5 ppm                 | 1.5 ppm                   |
| 2-Ethoxyethanol                      | [Ethylene glycol monoethyl ether; EGEE]                                             | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                                | 110-80-5     | 5 ppm                   |                           |
| 2-Ethoxyethyl acetate                | [Ethylene glycol monoethyl ether acetate; EGEEA]                                    | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>                                | 111-15-9     | 5 ppm                   |                           |
| Ethyl acetate                        |                                                                                     | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>                                 | 141-78-6     | 400 ppm                 |                           |
| Ethyl acrylate                       | [Ethyl propenoate]                                                                  | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                                 | 140-88-5     | 5 ppm                   | 15 ppm                    |



| Substance                                               | Notes                                                                        | Formula                                                        | CAS Reg. No. | Time-weighted average    | Short-term exposure limit |
|---------------------------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------|--------------|--------------------------|---------------------------|
| Ethylamine                                              | [Ethanamine]                                                                 | C <sub>2</sub> H <sub>7</sub> N                                | 75-04-7      | 5 ppm                    | 15 ppm                    |
| Ethylbenzene                                            | [Phenylethane]                                                               | C <sub>8</sub> H <sub>10</sub>                                 | 100-41-4     | 100 ppm                  | 125 ppm                   |
| Ethyl 2-cyanoacrylate                                   | [Ethyl 2-cyano-2-propenoate]                                                 | C <sub>6</sub> H <sub>7</sub> NO <sub>2</sub>                  | 7085-85-0    | 0.2 ppm                  |                           |
| Ethylene                                                | [Ethene]                                                                     | C <sub>2</sub> H <sub>4</sub>                                  | 74-85-1      | 200 ppm                  |                           |
| Ethyleneimine                                           | [Aziridine]                                                                  | C <sub>2</sub> H <sub>3</sub> N                                | 151-56-4     | 0.5 ppm                  |                           |
| Ethyl formate                                           |                                                                              | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                   | 109-94-4     | 100 ppm                  |                           |
| 2-Ethylhexanoic acid                                    |                                                                              | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                  | 149-57-5     | 5 mg/m <sup>3</sup>      |                           |
| 5-Ethylidene-2-norbornene                               | [5-Ethylidenebicyclo[2.2.1]hept-2-ene]                                       | C <sub>9</sub> H <sub>12</sub>                                 | 16219-75-3   |                          | C 5 ppm                   |
| N-Ethylmorpholine                                       |                                                                              | C <sub>6</sub> H <sub>13</sub> NO                              | 100-74-3     | 5 ppm                    |                           |
| O-Ethyl O- <i>p</i> -nitrophenyl benzenethiophosphonate | [EPN]                                                                        | C <sub>14</sub> H <sub>14</sub> NO <sub>4</sub> PS             | 2104-64-5    | 0.1 mg/m <sup>3</sup>    |                           |
| Ethyl silicate                                          |                                                                              | C <sub>8</sub> H <sub>20</sub> O <sub>4</sub> Si               | 78-10-4      | 10 ppm                   |                           |
| Fenamiphos                                              |                                                                              | C <sub>13</sub> H <sub>22</sub> NO <sub>3</sub> PS             | 22224-92-6   | 0.05 mg/m <sup>3</sup>   |                           |
| Fensulfthion                                            | [Phosphorothioic acid, O,O-diethyl O-[4-(methylsulfinyl)phenyl] ester]       | C <sub>11</sub> H <sub>17</sub> O <sub>4</sub> PS <sub>2</sub> | 115-90-2     | 0.01 mg/m <sup>3</sup>   |                           |
| Fenthion                                                | [Phosphorothioic acid, O,O-dimethyl O-[3-methyl-4-(methylthio)phenyl] ester] | C <sub>10</sub> H <sub>15</sub> O <sub>3</sub> PS <sub>2</sub> | 55-38-9      | 0.05 mg/m <sup>3</sup>   |                           |
| Ferbam                                                  | [Iron, tris(dimethylcarbamodithioato-S,S'), (OC-6-11)-]                      | C <sub>9</sub> H <sub>18</sub> FeN <sub>3</sub> S <sub>6</sub> | 14484-64-1   | 10 mg/m <sup>3</sup>     |                           |
| Ferrocene                                               | [Dicyclopentadienyl iron]                                                    | C <sub>10</sub> H <sub>10</sub> Fe                             | 102-54-5     | 10 mg/m <sup>3</sup>     |                           |
| Ferrovandium                                            | dust                                                                         |                                                                | 12604-58-9   | 1 mg/m <sup>3</sup>      | 3 mg/m <sup>3</sup>       |
| Flour                                                   | dust                                                                         |                                                                |              | 0.5 mg/m <sup>3</sup>    |                           |
| Fluoride ion                                            | fluoride salts, as F                                                         | F <sup>-</sup>                                                 | 16984-48-8   | 2.5 mg/m <sup>3</sup>    |                           |
| Fluorine                                                |                                                                              | F <sub>2</sub>                                                 | 7782-41-4    | 1 ppm                    | 2 ppm                     |
| Fluorine monoxide                                       | [Oxygen difluoride]                                                          | F <sub>2</sub> O                                               | 7783-41-7    |                          | C 0.05 ppm                |
| Fluoroethene                                            | [Vinyl fluoride]                                                             | C <sub>2</sub> H <sub>3</sub> F                                | 75-02-5      | 1 ppm                    |                           |
| Fonofos                                                 | [Phosphonodithioic acid, ethyl-, O-ethyl S-phenyl ester]                     | C <sub>10</sub> H <sub>15</sub> OPS <sub>2</sub>               | 944-22-9     | 0.01 mg/m <sup>3</sup>   |                           |
| Formaldehyde                                            | [Methanal]                                                                   | CH <sub>2</sub> O                                              | 50-00-0      |                          | C 0.3 ppm                 |
| Formamide                                               | [Methanamide]                                                                | CH <sub>3</sub> NO                                             | 75-12-7      | 10 ppm                   |                           |
| Formic acid                                             | [Methanoic acid]                                                             | CH <sub>2</sub> O <sub>2</sub>                                 | 64-18-6      | 5 ppm                    | 10 ppm                    |
| Furfural                                                | [2-Furaldehyde]                                                              | C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                   | 98-01-1      | 2 ppm                    |                           |
| Furfuryl alcohol                                        | [2-Furanmethanol]                                                            | C <sub>5</sub> H <sub>6</sub> O <sub>2</sub>                   | 98-00-0      | 10 ppm                   | 15 ppm                    |
| Gallium arsenide                                        |                                                                              | GaAs                                                           | 1303-00-0    | 0.0003 mg/m <sup>3</sup> |                           |
| Gasoline                                                |                                                                              |                                                                | 8006-61-9    | 300 ppm                  | 500 ppm                   |
| Germane                                                 | [Germanium tetrahydride]                                                     | GeH <sub>4</sub>                                               | 7782-65-2    | 0.2 ppm                  |                           |
| Glycerol                                                | [1,2,3-Propanetriol], mist                                                   | C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>                   | 56-81-5      | 10 mg/m <sup>3</sup>     |                           |
| Glyoxal                                                 |                                                                              | C <sub>2</sub> H <sub>2</sub> O <sub>2</sub>                   | 107-22-2     | 0.1 mg/m <sup>3</sup>    |                           |
| Grain                                                   | dust                                                                         |                                                                |              | 4 mg/m <sup>3</sup>      |                           |
| Graphite                                                | except fibers                                                                | C                                                              | 7440-44-0    | 2 mg/m <sup>3</sup>      |                           |
| Hafnium                                                 | metal and compounds, as Hf                                                   | Hf                                                             | 7440-58-6    | 0.5 mg/m <sup>3</sup>    |                           |
| Heptachlor                                              |                                                                              | C <sub>10</sub> H <sub>5</sub> Cl <sub>7</sub>                 | 76-44-8      | 0.05 mg/m <sup>3</sup>   |                           |
| Heptachlor epoxide                                      |                                                                              | C <sub>10</sub> H <sub>5</sub> Cl <sub>7</sub> O               | 1024-57-3    | 0.05 mg/m <sup>3</sup>   |                           |
| Heptane                                                 | all isomers                                                                  | C <sub>7</sub> H <sub>16</sub>                                 | 142-82-5     | 400 ppm                  | 500 ppm                   |
| 2-Heptanone                                             | [Methyl pentyl ketone]                                                       | C <sub>7</sub> H <sub>14</sub> O                               | 110-43-0     | 50 ppm                   |                           |
| 3-Heptanone                                             | [Ethyl butyl ketone]                                                         | C <sub>7</sub> H <sub>14</sub> O                               | 106-35-4     | 50 ppm                   | 75 ppm                    |
| 4-Heptanone                                             | [Dipropyl ketone]                                                            | C <sub>7</sub> H <sub>14</sub> O                               | 123-19-3     | 50 ppm                   |                           |
| Hexachlorobenzene                                       | [Perchlorobenzene]                                                           | C <sub>6</sub> Cl <sub>6</sub>                                 | 118-74-1     | 0.002 mg/m <sup>3</sup>  |                           |
| Hexachloro-1,3-butadiene                                | [Perchlorobutadiene]                                                         | C <sub>4</sub> Cl <sub>6</sub>                                 | 87-68-3      | 0.02 ppm                 |                           |
| 1,2,3,4,5,6-Hexachlorocyclohexane                       | [Lindane]                                                                    | C <sub>6</sub> H <sub>6</sub> Cl <sub>6</sub>                  | 58-89-9      | 0.5 mg/m <sup>3</sup>    |                           |
| Hexachloro-1,3-cyclopentadiene                          | [Perchlorocyclopentadiene]                                                   | C <sub>5</sub> Cl <sub>6</sub>                                 | 77-47-4      | 0.01 ppm                 |                           |
| Hexachloroethane                                        | [Perchloroethane]                                                            | C <sub>2</sub> Cl <sub>6</sub>                                 | 67-72-1      | 1 ppm                    |                           |
| Hexachloronaphthalene                                   | all isomers                                                                  | C <sub>10</sub> H <sub>2</sub> Cl <sub>6</sub>                 | 1335-87-1    | 0.2 mg/m <sup>3</sup>    |                           |

| Substance                        | Notes                                | Formula                                                        | CAS Reg. No. | Time-weighted average   | Short-term exposure limit |
|----------------------------------|--------------------------------------|----------------------------------------------------------------|--------------|-------------------------|---------------------------|
| Hexahydro-1,3-isobenzofurandione | [Hexahydrophthalic anhydride]        | C <sub>8</sub> H <sub>10</sub> O <sub>3</sub>                  | 85-42-7      |                         | C 0.005 mg/m <sup>3</sup> |
| Hexamethylene diisocyanate       |                                      | C <sub>8</sub> H <sub>12</sub> N <sub>2</sub> O <sub>2</sub>   | 822-06-0     | 0.005 ppm               |                           |
| Hexane                           |                                      | C <sub>6</sub> H <sub>14</sub>                                 | 110-54-3     | 50 ppm                  |                           |
| 1,6-Hexanediamine                | [Hexamethylenediamine]               | C <sub>6</sub> H <sub>16</sub> N <sub>2</sub>                  | 124-09-4     | 0.5 ppm                 |                           |
| Hexanedinitrile                  | [Adiponitrile]                       | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                   | 111-69-3     | 2 ppm                   |                           |
| 1,6-Hexanedioic acid             | [Adipic acid]                        | C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>                  | 124-04-9     | 5 mg/m <sup>3</sup>     |                           |
| 2-Hexanone                       | [Butyl methyl ketone]                | C <sub>6</sub> H <sub>12</sub> O                               | 591-78-6     | 5 ppm                   | 10 ppm                    |
| 1-Hexene                         |                                      | C <sub>6</sub> H <sub>12</sub>                                 | 592-41-6     | 50 ppm                  |                           |
| sec-Hexyl acetate                | [4-Methyl-2-pentyl acetate]          | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>                  | 108-84-9     | 50 ppm                  |                           |
| Hydrazine                        |                                      | N <sub>2</sub> H <sub>4</sub>                                  | 302-01-2     | 0.01 ppm                |                           |
| Hydrazoic acid                   | vapor                                | HN <sub>3</sub>                                                | 7782-79-8    |                         | C 0.11 ppm                |
| Hydrogen bromide                 | [Hydrobromic acid]                   | HBr                                                            | 10035-10-6   |                         | C 2 ppm                   |
| Hydrogen chloride                | [Hydrochloric acid]                  | HCl                                                            | 7647-01-0    |                         | C 2 ppm                   |
| Hydrogen cyanide                 | [Hydrocyanic acid]                   | HCN                                                            | 74-90-8      |                         | C 4.7 ppm                 |
| Hydrogen fluoride                | [Hydrofluoric acid]                  | HF                                                             | 7664-39-3    | 0.5 ppm                 | C 2 ppm                   |
| Hydrogen peroxide                |                                      | H <sub>2</sub> O <sub>2</sub>                                  | 7722-84-1    | 1 ppm                   |                           |
| Hydrogen selenide                |                                      | H <sub>2</sub> Se                                              | 7783-07-5    | 0.05 ppm                |                           |
| Hydrogen sulfide                 |                                      | H <sub>2</sub> S                                               | 7783-06-4    | 10 ppm                  | 15 ppm                    |
| p-Hydroquinone                   | [1,4-Benzenediol]                    | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                   | 123-31-9     | 1 mg/m <sup>3</sup>     |                           |
| 2-Hydroxypropyl acrylate         |                                      | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>                  | 999-61-1     | 0.5 ppm                 |                           |
| Indene                           | [Indonaphthene]                      | C <sub>9</sub> H <sub>8</sub>                                  | 95-13-6      | 5 ppm                   |                           |
| Indium                           | metal and compounds, as In           | In                                                             | 7440-74-6    | 0.1 mg/m <sup>3</sup>   |                           |
| Iodine                           | and volatile iodides                 | I <sub>2</sub>                                                 | 7553-56-2    | 0.01 ppm                | C 0.1 ppm                 |
| Iodomethane                      | [Methyl iodide]                      | CH <sub>3</sub> I                                              | 74-88-4      | 2 ppm                   |                           |
| Iron ion [Fe <sup>+2</sup> ]     | soluble ferrous salts, as Fe         | Fe <sup>+2</sup>                                               | 15438-31-0   | 1 mg/m <sup>3</sup>     |                           |
| Iron ion [Fe <sup>+3</sup> ]     | soluble ferric salts, as Fe          | Fe <sup>+3</sup>                                               | 20074-52-6   | 1 mg/m <sup>3</sup>     |                           |
| Iron(III) oxide                  | dust and fume, as Fe                 | Fe <sub>2</sub> O <sub>3</sub>                                 | 1309-37-1    | 5 mg/m <sup>3</sup>     |                           |
| Iron pentacarbonyl               | as Fe                                | C <sub>5</sub> FeO <sub>5</sub>                                | 13463-40-6   | 0.1 ppm                 | 0.2 ppm                   |
| Isobutane                        | [2-Methylpropane]                    | C <sub>4</sub> H <sub>10</sub>                                 | 75-28-5      | 1000 ppm                |                           |
| Isobutene                        | [2-Methyl-1-propene]                 | C <sub>4</sub> H <sub>8</sub>                                  | 115-11-7     | 250 ppm                 |                           |
| Isobutyl acetate                 | [2-Methylpropyl acetate]             | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                  | 110-19-0     | 150 ppm                 |                           |
| Isobutyl nitrite                 |                                      | C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>                  | 542-56-3     |                         | C 1 ppm                   |
| Isopentane                       | [2-Methylbutane]                     | C <sub>5</sub> H <sub>12</sub>                                 | 78-78-4      | 600 ppm                 |                           |
| Isopentyl acetate                | [Isoamyl acetate]                    | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 123-92-2     | 50 ppm                  | 100 ppm                   |
| Isophorone                       | [3,5,5-Trimethyl-2-cyclohexen-1-one] | C <sub>9</sub> H <sub>14</sub> O                               | 78-59-1      |                         | C 5 ppm                   |
| Isophorone diisocyanate          |                                      | C <sub>12</sub> H <sub>18</sub> N <sub>2</sub> O <sub>2</sub>  | 4098-71-9    | 0.005 ppm               |                           |
| Isopropenylbenzene               | [α-Methyl styrene]                   | C <sub>9</sub> H <sub>10</sub>                                 | 98-83-9      | 50 ppm                  | 100 ppm                   |
| 2-Isopropoxyethanol              |                                      | C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>                  | 109-59-1     | 25 ppm                  |                           |
| Isopropyl acetate                | [1-Methylethyl acetate]              | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                  | 108-21-4     | 100 ppm                 | 200 ppm                   |
| Isopropylamine                   | [2-Propanamine]                      | C <sub>3</sub> H <sub>9</sub> N                                | 75-31-0      | 5 ppm                   | 10 ppm                    |
| N-Isopropylaniline               |                                      | C <sub>9</sub> H <sub>13</sub> N                               | 768-52-5     | 2 ppm                   |                           |
| Isopropylbenzene                 | [Cumene]                             | C <sub>9</sub> H <sub>12</sub>                                 | 98-82-8      | 50 ppm                  |                           |
| Isopropyl glycidyl ether         | [IGE]                                | C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>                  | 4016-14-2    | 50 ppm                  | 75 ppm                    |
| Kaolin                           |                                      |                                                                | 1332-58-7    | 2 mg/m <sup>3</sup>     |                           |
| Kerosene                         |                                      |                                                                | 8008-20-6    | 200 mg/m <sup>3</sup>   |                           |
| Ketene                           |                                      | C <sub>2</sub> H <sub>2</sub> O                                | 463-51-4     | 0.5 ppm                 | 1.5 ppm                   |
| Lead                             | metal and inorganic compounds, as Pb | Pb                                                             | 7439-92-1    | 0.05 mg/m <sup>3</sup>  |                           |
| Lead(II) arsenate                |                                      | Pb <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub>               | 3687-31-8    | 0.15 mg/m <sup>3</sup>  |                           |
| Lead(II) chromate                | as Pb                                | PbCrO <sub>4</sub>                                             | 7758-97-6    | 0.05 mg/m <sup>3</sup>  |                           |
| Lithium hydride                  |                                      | LiH                                                            | 7580-67-8    | 0.025 mg/m <sup>3</sup> |                           |
| Magnesium oxide                  | [Magnesia]                           | MgO                                                            | 1309-48-4    | 10 mg/m <sup>3</sup>    |                           |
| Malathion                        |                                      | C <sub>10</sub> H <sub>19</sub> O <sub>6</sub> PS <sub>2</sub> | 121-75-5     | 1 mg/m <sup>3</sup>     |                           |
| Maleic anhydride                 |                                      | C <sub>4</sub> H <sub>2</sub> O <sub>3</sub>                   | 108-31-6     | 0.1 ppm                 |                           |

| Substance                                      | Notes                                                                  | Formula                                                        | CAS Reg. No. | Time-weighted average   | Short-term exposure limit |
|------------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------|--------------|-------------------------|---------------------------|
| Manganese                                      | metal and inorganic compounds, as Mn                                   | Mn                                                             | 7439-96-5    | 0.2 mg/m <sup>3</sup>   |                           |
| Manganese cyclopentadienyl tricarbonyl         | as Mn                                                                  | C <sub>8</sub> H <sub>5</sub> MnO <sub>3</sub>                 | 12079-65-1   | 0.1 mg/m <sup>3</sup>   |                           |
| Manganese 2-methylcyclopentadienyl tricarbonyl | as Mn                                                                  | C <sub>9</sub> H <sub>7</sub> MnO <sub>3</sub>                 | 12108-13-3   | 0.2 mg/m <sup>3</sup>   |                           |
| Mercury                                        | metal and inorganic compounds, as Hg                                   | Hg                                                             | 7439-97-6    | 0.025 mg/m <sup>3</sup> |                           |
| Mercury                                        | alkyl compounds, as Hg                                                 | Hg                                                             | 7439-97-6    | 0.01 mg/m <sup>3</sup>  | 0.03 mg/m <sup>3</sup>    |
| Mercury                                        | aryl compounds, as Hg                                                  | Hg                                                             | 7439-97-6    | 0.1 mg/m <sup>3</sup>   |                           |
| Mesityl oxide                                  | [Isobutenyl methyl ketone]                                             | C <sub>6</sub> H <sub>10</sub> O                               | 141-79-7     | 15 ppm                  | 25 ppm                    |
| Methacrylic acid                               | [2-Methylpropenoic acid]                                               | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                   | 79-41-4      | 20 ppm                  |                           |
| Methane                                        |                                                                        | CH <sub>4</sub>                                                | 74-82-8      | 1000 ppm                |                           |
| Methanethiol                                   | [Methyl mercaptan]                                                     | CH <sub>4</sub> S                                              | 74-93-1      | 0.5 ppm                 |                           |
| Methanol                                       | [Methyl alcohol]                                                       | CH <sub>4</sub> O                                              | 67-56-1      | 200 ppm                 | 250 ppm                   |
| Methomyl                                       | [Acetimidic acid, <i>N</i> -[(methylcarbamoyl)oxy]thio-, methyl ester] | C <sub>5</sub> H <sub>10</sub> N <sub>2</sub> O <sub>2</sub> S | 16752-77-5   | 2.5 mg/m <sup>3</sup>   |                           |
| 2-Methoxyaniline                               | [ <i>o</i> -Anisidine]                                                 | C <sub>7</sub> H <sub>9</sub> NO                               | 90-04-0      | 0.5 mg/m <sup>3</sup>   |                           |
| 4-Methoxyaniline                               | [ <i>p</i> -Anisidine]                                                 | C <sub>7</sub> H <sub>9</sub> NO                               | 104-94-9     | 0.5 mg/m <sup>3</sup>   |                           |
| Methoxychlor                                   |                                                                        | C <sub>16</sub> H <sub>15</sub> Cl <sub>3</sub> O <sub>2</sub> | 72-43-5      | 10 mg/m <sup>3</sup>    |                           |
| 2-Methoxyethanol                               | [Ethylene glycol monomethyl ether; EGME]                               | C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>                   | 109-86-4     | 0.1 ppm                 |                           |
| 2-Methoxyethyl acetate                         | [Ethylene glycol monomethyl ether acetate; EGMEA]                      | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>                  | 110-49-6     | 0.1 ppm                 |                           |
| 2-Methoxy-2-methylbutane                       | [Methyl <i>tert</i> -pentyl ether; TAME]                               | C <sub>6</sub> H <sub>14</sub> O                               | 994-05-8     | 20 ppm                  |                           |
| 4-Methoxyphenol                                |                                                                        | C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>                   | 150-76-5     | 5 mg/m <sup>3</sup>     |                           |
| 1-Methoxy-2-propanol                           | [1,2-Propylene glycol monomethyl ether; PGME]                          | C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>                  | 107-98-2     | 100 ppm                 | 150 ppm                   |
| Methyl acetate                                 |                                                                        | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                   | 79-20-9      | 200 ppm                 | 250 ppm                   |
| Methyl acrylate                                | [Methyl propenoate]                                                    | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>                   | 96-33-3      | 2 ppm                   |                           |
| 2-Methylacrylonitrile                          | [2-Methylpropenenitrile]                                               | C <sub>4</sub> H <sub>5</sub> N                                | 126-98-7     | 1 ppm                   |                           |
| Methylamine                                    | [Methanamine]                                                          | CH <sub>5</sub> N                                              | 74-89-5      | 5 ppm                   | 15 ppm                    |
| 2-Methylaniline                                | [ <i>o</i> -Toluidine]                                                 | C <sub>7</sub> H <sub>9</sub> N                                | 95-53-4      | 2 ppm                   |                           |
| 3-Methylaniline                                | [ <i>m</i> -Toluidine]                                                 | C <sub>7</sub> H <sub>9</sub> N                                | 108-44-1     | 2 ppm                   |                           |
| 4-Methylaniline                                | [ <i>p</i> -Toluidine]                                                 | C <sub>7</sub> H <sub>9</sub> N                                | 106-49-0     | 2 ppm                   |                           |
| <i>N</i> -Methylaniline                        | [ <i>N</i> -Methylbenzenamine]                                         | C <sub>7</sub> H <sub>9</sub> N                                | 100-61-8     | 0.5 ppm                 |                           |
| 3-Methyl-1-butanol                             | [Isoamyl alcohol]                                                      | C <sub>5</sub> H <sub>12</sub> O                               | 123-51-3     | 100 ppm                 | 125 ppm                   |
| 2-Methyl-1-butanol acetate                     |                                                                        | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 624-41-9     | 50 ppm                  | 100 ppm                   |
| 3-Methyl-2-butanol acetate                     |                                                                        | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                  | 5343-96-4    | 50 ppm                  | 100 ppm                   |
| 3-Methyl-2-butanone                            | [Methyl isopropyl ketone]                                              | C <sub>5</sub> H <sub>10</sub> O                               | 563-80-4     | 200 ppm                 |                           |
| Methyl <i>tert</i> -butyl ether                | [MTBE]                                                                 | C <sub>5</sub> H <sub>12</sub> O                               | 1634-04-4    | 50 ppm                  |                           |
| Methyl 2-cyanoacrylate                         | [Mecrylate]                                                            | C <sub>5</sub> H <sub>5</sub> NO <sub>2</sub>                  | 137-05-3     | 0.2 ppm                 |                           |
| Methylcyclohexane                              |                                                                        | C <sub>7</sub> H <sub>14</sub>                                 | 108-87-2     | 400 ppm                 |                           |
| Methylcyclohexanol                             | all isomers                                                            | C <sub>7</sub> H <sub>14</sub> O                               | 25639-42-3   | 50 ppm                  |                           |
| 2-Methylcyclohexanone                          |                                                                        | C <sub>7</sub> H <sub>12</sub> O                               | 583-60-8     | 50 ppm                  | 75 ppm                    |
| Methyl demeton                                 |                                                                        | C <sub>6</sub> H <sub>15</sub> O <sub>3</sub> PS <sub>2</sub>  | 8022-00-2    | 0.05 mg/m <sup>3</sup>  |                           |
| 2-Methyl-3,5-dinitrobenzamide                  | [3,5-Dinitro- <i>o</i> -toluamide; Dinitolmide]                        | C <sub>8</sub> H <sub>7</sub> N <sub>3</sub> O <sub>5</sub>    | 148-01-6     | 1 mg/m <sup>3</sup>     |                           |
| 2-Methyl-4,6-dinitrophenol                     | [Dinitro- <i>o</i> -cresol]                                            | C <sub>7</sub> H <sub>6</sub> N <sub>2</sub> O <sub>5</sub>    | 534-52-1     | 0.2 mg/m <sup>3</sup>   |                           |
| 4,4'-Methylenebis[2-chloroaniline]             | [MBOCA]                                                                | C <sub>13</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>2</sub> | 101-14-4     | 0.01 ppm                |                           |
| Methylenebis(4-cyclohexylisocyanate)           |                                                                        | C <sub>15</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>  | 5124-30-1    | 0.005 ppm               |                           |
| Methyl formate                                 |                                                                        | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                   | 107-31-3     | 100 ppm                 | 150 ppm                   |
| 6-Methyl-1-heptanol                            | [Isooctyl alcohol]                                                     | C <sub>8</sub> H <sub>18</sub> O                               | 26952-21-6   | 50 ppm                  |                           |
| 5-Methyl-3-heptanone                           | [Ethyl amyl ketone]                                                    | C <sub>8</sub> H <sub>16</sub> O                               | 541-85-5     | 10 ppm                  |                           |
| 5-Methyl-3-heptanone                           | [Ethyl 2-methylbutyl ketone]                                           | C <sub>8</sub> H <sub>16</sub> O                               | 541-85-5     | 10 ppm                  |                           |
| 5-Methyl-2-hexanone                            | [Methyl isopentyl ketone]                                              | C <sub>7</sub> H <sub>14</sub> O                               | 110-12-3     | 50 ppm                  |                           |
| Methylhydrazine                                |                                                                        | CH <sub>6</sub> N <sub>2</sub>                                 | 60-34-4      | 0.01 ppm                |                           |

| Substance                                           | Notes                                                                         | Formula              | CAS Reg. No. | Time-weighted average  | Short-term exposure limit |
|-----------------------------------------------------|-------------------------------------------------------------------------------|----------------------|--------------|------------------------|---------------------------|
| Methyl isocyanate                                   |                                                                               | $C_2H_3NO$           | 624-83-9     | 0.02 ppm               |                           |
| Methyl methacrylate                                 | [Methyl 2-methyl-2-propenoate]                                                | $C_5H_8O_2$          | 80-62-6      | 50 ppm                 | 100 ppm                   |
| 1-Methylnaphthalene                                 |                                                                               | $C_{11}H_{10}$       | 90-12-0      | 0.5 ppm                |                           |
| 2-Methylnaphthalene                                 |                                                                               | $C_{11}H_{10}$       | 91-57-6      | 0.5 ppm                |                           |
| 2-Methyl-5-nitroaniline                             |                                                                               | $C_7H_8N_2O_2$       | 99-55-8      | 1 mg/m <sup>3</sup>    |                           |
| Methyloxirane                                       | [1,2-Propylene oxide]                                                         | $C_3H_6O$            | 75-56-9      | 2 ppm                  |                           |
| Methyl parathion                                    |                                                                               | $C_8H_{10}NO_5PS$    | 298-00-0     | 0.2 mg/m <sup>3</sup>  |                           |
| 2-Methylpentane                                     | [Isohexane]                                                                   | $C_6H_{14}$          | 107-83-5     | 500 ppm                | 1000 ppm                  |
| 3-Methylpentane                                     |                                                                               | $C_6H_{14}$          | 96-14-0      | 500 ppm                | 1000 ppm                  |
| 2-Methyl-2,4-pentanediol                            | [Hexylene glycol]                                                             | $C_6H_{14}O_2$       | 107-41-5     |                        | C 25 ppm                  |
| 4-Methyl-2-pentanol                                 | [Methyl isobutyl carbinol]                                                    | $C_6H_{14}O$         | 108-11-2     | 25 ppm                 | 40 ppm                    |
| 4-Methyl-2-pentanone                                | [Isobutyl methyl ketone]                                                      | $C_6H_{12}O$         | 108-10-1     | 50 ppm                 | 75 ppm                    |
| 2-Methyl-1-propanol                                 | [Isobutyl alcohol]                                                            | $C_4H_{10}O$         | 78-83-1      | 50 ppm                 |                           |
| 2-Methyl-2-propanol                                 | [ <i>tert</i> -Butyl alcohol]                                                 | $C_4H_{10}O$         | 75-65-0      | 100 ppm                |                           |
| Methylstyrene                                       | all isomers                                                                   | $C_9H_{10}$          | 25013-15-4   | 50 ppm                 | 100 ppm                   |
| <i>N</i> -Methyl- <i>N</i> ,2,4,6-tetranitroaniline | [Tetryl]                                                                      | $C_7H_5N_5O_8$       | 479-45-8     | 1.5 mg/m <sup>3</sup>  |                           |
| Metribuzin                                          |                                                                               | $C_8H_{14}N_4OS$     | 21087-64-9   | 5 mg/m <sup>3</sup>    |                           |
| Mevinphos                                           |                                                                               | $C_7H_{13}O_6P$      | 7786-34-7    | 0.01 ppm               |                           |
| Mica                                                |                                                                               |                      | 12001-26-2   | 3 mg/m <sup>3</sup>    |                           |
| Mineral oil                                         | mist                                                                          |                      |              | 5 mg/m <sup>3</sup>    | 10 mg/m <sup>3</sup>      |
| Molybdenum                                          | metal and insoluble compounds, as Mo                                          | Mo                   | 7439-98-7    | 10 mg/m <sup>3</sup>   |                           |
| Molybdenum                                          | soluble compounds, as Mo                                                      | Mo                   | 7439-98-7    | 0.5 mg/m <sup>3</sup>  |                           |
| Monocrotophos                                       | [ <i>trans</i> -Dimethyl 1-methyl-3-(methylamino)-3-oxo-1-propenyl phosphate] | $C_7H_{14}NO_5P$     | 6923-22-4    | 0.05 mg/m <sup>3</sup> |                           |
| Morpholine                                          | [Tetrahydro-1,4-oxazine]                                                      | $C_4H_9NO$           | 110-91-8     | 20 ppm                 |                           |
| Naled                                               | [1,2-Dibromo-2,2-dichloroethylphosphoric acid, dimethyl ester]                | $C_4H_7Br_2Cl_2O_4P$ | 300-76-5     | 0.1 mg/m <sup>3</sup>  |                           |
| Naphtha                                             |                                                                               |                      | 8030-30-6    | 400 ppm                |                           |
| Naphthalene                                         |                                                                               | $C_{10}H_8$          | 91-20-3      | 10 ppm                 | 15 ppm                    |
| 1-Naphthalenylthiourea                              | [ANTU]                                                                        | $C_{11}H_{10}N_2S$   | 86-88-4      | 0.3 mg/m <sup>3</sup>  |                           |
| 2-Naphthylamine                                     | levels as low as possible                                                     | $C_{10}H_9N$         | 91-59-8      |                        |                           |
| Neopentane                                          | [2,2-Dimethylpropane]                                                         | $C_5H_{12}$          | 463-82-1     | 600 ppm                |                           |
| Nickel                                              | metal                                                                         | Ni                   | 7440-02-0    | 1.5 mg/m <sup>3</sup>  |                           |
| Nickel                                              | soluble compounds, as Ni                                                      | Ni                   | 7440-02-0    | 0.1 mg/m <sup>3</sup>  |                           |
| Nickel                                              | insoluble compounds, as Ni                                                    | Ni                   | 7440-02-0    | 0.2 mg/m <sup>3</sup>  |                           |
| Nickel carbonyl                                     | as Ni                                                                         | $C_4NiO_4$           | 13463-39-3   | 0.05 ppm               |                           |
| Nickel subsulfide                                   | as Ni                                                                         | $Ni_3S_2$            | 12035-72-2   | 0.1 mg/m <sup>3</sup>  |                           |
| Nicotine                                            | [3-(1-Methyl-2-pyrrolidinyl)pyridine, ( <i>S</i> )-]                          | $C_{10}H_{14}N_2$    | 54-11-5      | 0.5 mg/m <sup>3</sup>  |                           |
| Nitrapyrin                                          | [Pyridine, 2-chloro-6-(trichloromethyl)-]                                     | $C_6H_3Cl_4N$        | 1929-82-4    | 10 mg/m <sup>3</sup>   |                           |
| Nitric acid                                         |                                                                               | $HNO_3$              | 7697-37-2    | 2 ppm                  | 4 ppm                     |
| Nitric oxide                                        |                                                                               | NO                   | 10102-43-9   | 25 ppm                 |                           |
| 4-Nitroaniline                                      |                                                                               | $C_6H_6N_2O_2$       | 100-01-6     | 3 mg/m <sup>3</sup>    |                           |
| Nitrobenzene                                        |                                                                               | $C_6H_5NO_2$         | 98-95-3      | 1 ppm                  |                           |
| 4-Nitrobiphenyl                                     | levels as low as possible                                                     | $C_{12}H_9NO_2$      | 92-93-3      |                        |                           |
| Nitroethane                                         |                                                                               | $C_2H_5NO_2$         | 79-24-3      | 100 ppm                |                           |
| Nitrogen dioxide                                    |                                                                               | $NO_2$               | 10102-44-0   | 3 ppm                  | 5 ppm                     |
| Nitrogen trifluoride                                |                                                                               | $NF_3$               | 7783-54-2    | 10 ppm                 |                           |
| Nitromethane                                        | [Nitrocarbol]                                                                 | $CH_3NO_2$           | 75-52-5      | 20 ppm                 |                           |
| 1-Nitropropane                                      |                                                                               | $C_3H_7NO_2$         | 108-03-2     | 25 ppm                 |                           |
| 2-Nitropropane                                      | [Isonitropropane]                                                             | $C_3H_7NO_2$         | 79-46-9      | 10 ppm                 |                           |
| <i>N</i> -Nitrosodimethylamine                      | levels as low as possible                                                     | $C_2H_6N_2O$         | 62-75-9      |                        |                           |
| Nitrotoluene                                        | all isomers                                                                   | $C_7H_7NO_2$         | 1321-12-6    | 2 ppm                  |                           |

| Substance                                | Notes                                                             | Formula                                                                      | CAS Reg. No. | Time-weighted average   | Short-term exposure limit |
|------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------------------|--------------|-------------------------|---------------------------|
| Nitrous oxide                            |                                                                   | N <sub>2</sub> O                                                             | 10024-97-2   | 50 ppm                  |                           |
| 3,3,4,4,5,5,6,6,6-Nonafluoro-1-hexene    | [Perfluorobutylethene]                                            | C <sub>6</sub> H <sub>3</sub> F <sub>9</sub>                                 | 19430-93-4   | 100 ppm                 |                           |
| Nonane                                   | all isomers                                                       | C <sub>9</sub> H <sub>20</sub>                                               | 111-84-2     | 200 ppm                 |                           |
| Octachloronaphthalene                    | [Perchloronaphthalene]                                            | C <sub>10</sub> Cl <sub>8</sub>                                              | 2234-13-1    | 0.1 mg/m <sup>3</sup>   | 0.3 mg/m <sup>3</sup>     |
| Octane                                   | all isomers                                                       | C <sub>8</sub> H <sub>18</sub>                                               | 111-65-9     | 300 ppm                 | 375 ppm                   |
| Osmium(VIII) oxide                       | [Osmium tetroxide]                                                | OsO <sub>4</sub>                                                             | 20816-12-0   | 0.0002 ppm              | 0.0006 ppm                |
| Oxalic acid                              |                                                                   | C <sub>2</sub> H <sub>2</sub> O <sub>4</sub>                                 | 144-62-7     | 1 mg/m <sup>3</sup>     | 2 mg/m <sup>3</sup>       |
| 2-Oxetanone                              | [β-Propiolactone]                                                 | C <sub>3</sub> H <sub>4</sub> O <sub>2</sub>                                 | 57-57-8      | 0.5 ppm                 |                           |
| Oxirane                                  | [Ethylene oxide]                                                  | C <sub>2</sub> H <sub>4</sub> O                                              | 75-21-8      | 1 ppm                   |                           |
| Oxiranemethanol                          | [Glycidol]                                                        | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                                 | 556-52-5     | 2 ppm                   |                           |
| 4,4'-Oxybis(benzenesulfonylhydrazide)    |                                                                   | C <sub>12</sub> H <sub>14</sub> N <sub>4</sub> O <sub>5</sub> S <sub>2</sub> | 80-51-3      | 0.1 mg/m <sup>3</sup>   |                           |
| Ozone                                    | depends on workload                                               | O <sub>3</sub>                                                               | 10028-15-6   | 0.1 ppm                 |                           |
| Paraquat                                 |                                                                   | C <sub>12</sub> H <sub>14</sub> N <sub>2</sub>                               | 4685-14-7    | 0.5 mg/m <sup>3</sup>   |                           |
| Parathion                                |                                                                   | C <sub>10</sub> H <sub>14</sub> NO <sub>5</sub> PS                           | 56-38-2      | 0.05 mg/m <sup>3</sup>  |                           |
| Pentaborane(9)                           |                                                                   | B <sub>5</sub> H <sub>9</sub>                                                | 19624-22-7   | 0.005 ppm               | 0.015 ppm                 |
| Pentachloronaphthalene                   | all isomers                                                       | C <sub>10</sub> H <sub>3</sub> Cl <sub>5</sub>                               | 1321-64-8    | 0.5 mg/m <sup>3</sup>   |                           |
| Pentachloronitrobenzene                  | [Quintozene]                                                      | C <sub>6</sub> Cl <sub>5</sub> NO <sub>2</sub>                               | 82-68-8      | 0.5 mg/m <sup>3</sup>   |                           |
| Pentachlorophenol                        |                                                                   | C <sub>6</sub> HCl <sub>5</sub> O                                            | 87-86-5      | 0.5 mg/m <sup>3</sup>   |                           |
| Pentaerythritol                          |                                                                   | C <sub>5</sub> H <sub>12</sub> O <sub>4</sub>                                | 115-77-5     | 10 mg/m <sup>3</sup>    |                           |
| Pentanal                                 | [Valeraldehyde]                                                   | C <sub>5</sub> H <sub>10</sub> O                                             | 110-62-3     | 50 ppm                  |                           |
| Pentane                                  | all isomers                                                       | C <sub>5</sub> H <sub>12</sub>                                               | 109-66-0     | 600 ppm                 | 750 ppm                   |
| Pentanedial                              | [Glutaraldehyde]                                                  | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>                                 | 111-30-8     |                         | C 0.05 ppm                |
| 2-Pentanone                              | [Methyl propyl ketone]                                            | C <sub>5</sub> H <sub>10</sub> O                                             | 107-87-9     |                         | 150 ppm                   |
| 3-Pentanone                              | [Diethyl ketone]                                                  | C <sub>5</sub> H <sub>10</sub> O                                             | 96-22-0      | 200 ppm                 | 300 ppm                   |
| Pentyl acetate                           | [Amyl acetate]; all isomers                                       | C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>                                | 628-63-7     | 50 ppm                  | 100 ppm                   |
| Perchloryl fluoride                      | [Chlorine trioxide fluoride]                                      | ClO <sub>3</sub> F                                                           | 7616-94-6    | 3 ppm                   | 6 ppm                     |
| Perfluoroacetone                         | [Hexafluoroacetone]                                               | C <sub>3</sub> F <sub>6</sub> O                                              | 684-16-2     | 0.1 ppm                 |                           |
| Perfluoroisobutene                       | [Perfluoroisobutylene]                                            | C <sub>4</sub> F <sub>8</sub>                                                | 382-21-8     |                         | C 0.01 ppm                |
| Perfluoropropene                         | [Hexafluoropropene]                                               | C <sub>3</sub> F <sub>6</sub>                                                | 116-15-4     | 0.1 mg/m <sup>3</sup>   |                           |
| Phenol                                   | [Hydroxybenzene]                                                  | C <sub>6</sub> H <sub>6</sub> O                                              | 108-95-2     | 5 ppm                   |                           |
| 10H-Phenothiazine                        | [Thiodiphenylamine]                                               | C <sub>12</sub> H <sub>9</sub> NS                                            | 92-84-2      | 5 mg/m <sup>3</sup>     |                           |
| Phenyl glycidyl ether                    | [PGE]                                                             | C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>                                | 122-60-1     | 0.1 ppm                 |                           |
| Phenylhydrazine                          |                                                                   | C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>                                 | 100-63-0     | 0.1 ppm                 |                           |
| N-Phenyl-2-naphthalenamine               | levels as low as possible                                         | C <sub>16</sub> H <sub>13</sub> N                                            | 135-88-6     |                         |                           |
| Phenylphosphine                          | [Monophenylphosphine]                                             | C <sub>6</sub> H <sub>7</sub> P                                              | 638-21-1     |                         | C 0.05 ppm                |
| Phorate                                  | [Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester] | C <sub>7</sub> H <sub>17</sub> O <sub>2</sub> PS <sub>3</sub>                | 298-02-2     | 0.05 mg/m <sup>3</sup>  | 0.2 mg/m <sup>3</sup>     |
| Phosphine                                | [Phosphorus hydride]                                              | PH <sub>3</sub>                                                              | 7803-51-2    | 0.3 ppm                 | 1 ppm                     |
| Phosphoric acid                          | [Orthophosphoric acid]                                            | H <sub>3</sub> PO <sub>4</sub>                                               | 7664-38-2    | 1 mg/m <sup>3</sup>     | 3 mg/m <sup>3</sup>       |
| Phosphorus (yellow)                      | [White phosphorus]                                                | P                                                                            | 7723-14-0    | 0.1 mg/m <sup>3</sup>   |                           |
| Phosphorus(III) chloride                 | [Phosphorus trichloride]                                          | PCl <sub>3</sub>                                                             | 7719-12-2    | 0.2 ppm                 | 0.5 ppm                   |
| Phosphorus(V) chloride                   | [Phosphorus pentachloride]                                        | PCl <sub>5</sub>                                                             | 10026-13-8   | 0.1 ppm                 |                           |
| Phosphorus(V) sulfide                    | [Phosphorus pentasulfide]                                         | P <sub>2</sub> S <sub>5</sub>                                                | 1314-80-3    | 1 mg/m <sup>3</sup>     | 3 mg/m <sup>3</sup>       |
| Phosphoryl chloride                      | [Phosphorus(V) oxychloride]                                       | POCl <sub>3</sub>                                                            | 10025-87-3   | 0.1 ppm                 |                           |
| Phthalic anhydride                       |                                                                   | C <sub>8</sub> H <sub>4</sub> O <sub>3</sub>                                 | 85-44-9      | 1 ppm                   |                           |
| α-Pinene                                 | [2-Pinene]                                                        | C <sub>10</sub> H <sub>16</sub>                                              | 80-56-8      | 20 ppm                  |                           |
| β-Pinene                                 | [Nopinene]                                                        | C <sub>10</sub> H <sub>16</sub>                                              | 127-91-3     | 20 ppm                  |                           |
| Piperazine dihydrochloride               | [Diethylenediamine dihydrochloride]                               | C <sub>4</sub> H <sub>12</sub> Cl <sub>2</sub> N <sub>2</sub>                | 142-64-3     | 5 mg/m <sup>3</sup>     |                           |
| 2-Pivaloyl-1,3-indandione                | [Pindone]                                                         | C <sub>14</sub> H <sub>14</sub> O <sub>3</sub>                               | 83-26-1      | 0.1 mg/m <sup>3</sup>   |                           |
| Platinum                                 | metal dust                                                        | Pt                                                                           | 7440-06-4    | 1 mg/m <sup>3</sup>     |                           |
| Platinum                                 | soluble salts, as Pt                                              | Pt                                                                           | 7440-06-4    | 0.002 mg/m <sup>3</sup> |                           |
| Polychlorinated biphenyls (42% chlorine) | [PCBs]                                                            |                                                                              | 53469-21-9   | 1 mg/m <sup>3</sup>     |                           |

| Substance                                | Notes                                          | Formula                                                           | CAS Reg. No. | Time-weighted average    | Short-term exposure limit   |
|------------------------------------------|------------------------------------------------|-------------------------------------------------------------------|--------------|--------------------------|-----------------------------|
| Polychlorinated biphenyls (54% chlorine) | [PCBs]                                         |                                                                   | 11097-69-1   | 0.5 mg/m <sup>3</sup>    |                             |
| Poly(vinyl chloride)                     | [PVC]                                          |                                                                   | 9002-86-2    | 1 mg/m <sup>3</sup>      |                             |
| Portland cement                          |                                                |                                                                   | 65997-15-1   | 10 mg/m <sup>3</sup>     |                             |
| Potassium hydroxide                      |                                                | KOH                                                               | 1310-58-3    |                          | C 2 mg/m <sup>3</sup>       |
| Propanal                                 | [Propionaldehyde]                              | C <sub>3</sub> H <sub>6</sub> O                                   | 123-38-6     | 20 ppm                   |                             |
| Propane                                  | [LPG]                                          | C <sub>3</sub> H <sub>8</sub>                                     | 74-98-6      | 1000 ppm                 |                             |
| 1,3-Propane sultone                      | levels as low as possible                      | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub> S                    | 1120-71-4    |                          |                             |
| Propanoic acid                           | [Propionic acid]                               | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>                      | 79-09-4      | 10 ppm                   |                             |
| 1-Propanol                               | [Propyl alcohol]                               | C <sub>3</sub> H <sub>8</sub> O                                   | 71-23-8      | 100 ppm                  | 400 ppm                     |
| 2-Propanol                               | [Isopropyl alcohol]                            | C <sub>3</sub> H <sub>8</sub> O                                   | 67-63-0      | 200 ppm                  | 400 ppm                     |
| Propargyl alcohol                        | [2-Propyn-1-ol]                                | C <sub>3</sub> H <sub>4</sub> O                                   | 107-19-7     | 1 ppm                    |                             |
| Propene                                  | [Propylene]                                    | C <sub>3</sub> H <sub>6</sub>                                     | 115-07-1     | 500 ppm                  |                             |
| Propoxur                                 | [Phenol, 2-(1-methylethoxy)-, methylcarbamate] | C <sub>11</sub> H <sub>15</sub> NO <sub>3</sub>                   | 114-26-1     | 0.5 mg/m <sup>3</sup>    |                             |
| Propyl acetate                           |                                                | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>                     | 109-60-4     | 200 ppm                  | 250 ppm                     |
| 1,2-Propylene glycol dinitrate           |                                                | C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>6</sub>       | 6423-43-4    | 0.05 ppm                 |                             |
| Propyleneimine                           | [2-Methylaziridine]                            | C <sub>3</sub> H <sub>7</sub> N                                   | 75-55-8      | 2 ppm                    |                             |
| Propyl nitrate                           |                                                | C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>                     | 627-13-4     | 25 ppm                   | 40 ppm                      |
| Propyne                                  | [Methylacetylene]                              | C <sub>3</sub> H <sub>4</sub>                                     | 74-99-7      | 1000 ppm                 |                             |
| Pyrethrin I                              | [Pyrethrum]                                    | C <sub>21</sub> H <sub>28</sub> O <sub>3</sub>                    | 8003-34-7    | 5 mg/m <sup>3</sup>      |                             |
| 2-Pyridinamine                           | [2-Aminopyridine]                              | C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>                      | 504-29-0     | 0.5 ppm                  |                             |
| Pyridine                                 | [Azine]                                        | C <sub>5</sub> H <sub>5</sub> N                                   | 110-86-1     | 1 ppm                    |                             |
| Pyrocatechol                             | [Catechol]                                     | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                      | 120-80-9     | 5 ppm                    |                             |
| Resorcinol                               | [1,3-Benzenediol]                              | C <sub>6</sub> H <sub>6</sub> O <sub>2</sub>                      | 108-46-3     | 10 ppm                   | 20 ppm                      |
| Rhodium                                  | metal and insoluble compounds, as Rh           | Rh                                                                | 7440-16-6    | 1 mg/m <sup>3</sup>      |                             |
| Rhodium                                  | soluble compounds, as Rh                       | Rh                                                                | 7440-16-6    | 0.01 mg/m <sup>3</sup>   |                             |
| Ronnel                                   |                                                | C <sub>8</sub> H <sub>8</sub> Cl <sub>3</sub> O <sub>3</sub> PS   | 299-84-3     | 5 mg/m <sup>3</sup>      |                             |
| Rotenone                                 |                                                | C <sub>23</sub> H <sub>22</sub> O <sub>6</sub>                    | 83-79-4      | 5 mg/m <sup>3</sup>      |                             |
| Rubber                                   | natural latex, as inhalable proteins           |                                                                   |              | 0.0001 mg/m <sup>3</sup> |                             |
| Selenium                                 | element and compounds, as Se                   | Se                                                                | 7782-49-2    | 0.2 mg/m <sup>3</sup>    |                             |
| Selenium hexafluoride                    |                                                | SeF <sub>6</sub>                                                  | 7783-79-1    | 0.05 ppm                 |                             |
| Sesone                                   | [Sodium 2-(2,4-dichlorophenoxy)ethyl sulfate]  | C <sub>8</sub> H <sub>7</sub> Cl <sub>2</sub> NaO <sub>5</sub> S  | 136-78-7     | 10 mg/m <sup>3</sup>     |                             |
| Silane                                   | [Silicon tetrahydride]                         | SiH <sub>4</sub>                                                  | 7803-62-5    | 5 ppm                    |                             |
| Silicon carbide                          | lower limits for fibrous SiC                   | SiC                                                               | 409-21-2     | 10 mg/m <sup>3</sup>     |                             |
| Silicon dioxide (α-quartz)               | [Quartz]                                       | SiO <sub>2</sub>                                                  | 14808-60-7   | 0.025 mg/m <sup>3</sup>  |                             |
| Silicon dioxide (cristobalite)           | [Cristobalite]                                 | SiO <sub>2</sub>                                                  | 14464-46-1   | 0.025 mg/m <sup>3</sup>  |                             |
| Silver                                   | metal                                          | Ag                                                                | 7440-22-4    | 0.1 mg/m <sup>3</sup>    |                             |
| Silver                                   | soluble compounds, as Ag                       | Ag                                                                | 7440-22-4    | 0.01 mg/m <sup>3</sup>   |                             |
| Sodium azide                             | [Smite]                                        | NaN <sub>3</sub>                                                  | 26628-22-8   |                          | C 0.29 mg/m <sup>3</sup>    |
| Sodium fluoroacetate                     |                                                | C <sub>2</sub> H <sub>2</sub> FNao <sub>2</sub>                   | 62-74-8      | 0.05 mg/m <sup>3</sup>   |                             |
| Sodium hydrogen sulfite                  | [Sodium bisulfite]                             | NaHSO <sub>3</sub>                                                | 7631-90-5    | 5 mg/m <sup>3</sup>      |                             |
| Sodium hydroxide                         | [Caustic soda]                                 | NaOH                                                              | 1310-73-2    |                          | C 2 mg/m <sup>3</sup>       |
| Sodium metabisulfite                     | [Sodium pyrosulfite]                           | Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub>                     | 7681-57-4    | 5 mg/m <sup>3</sup>      |                             |
| Sodium tetraborate decahydrate           | [Borax]                                        | Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O | 1303-96-4    | 2 mg/m <sup>3</sup>      | 6 mg/m <sup>3</sup>         |
| Starch                                   |                                                |                                                                   | 9005-25-8    | 10 mg/m <sup>3</sup>     |                             |
| Stibine                                  | [Antimony hydride]                             | SbH <sub>3</sub>                                                  | 7803-52-3    | 0.1 ppm                  |                             |
| Stoddard solvent                         |                                                |                                                                   | 8052-41-3    | 100 ppm                  |                             |
| Strontium chromate                       | as Cr                                          | SrCrO <sub>4</sub>                                                | 7789-06-2    | 0.0005 mg/m <sup>3</sup> |                             |
| Strychnine                               |                                                | C <sub>21</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>     | 57-24-9      | 0.15 mg/m <sup>3</sup>   |                             |
| Styrene                                  | [Vinylbenzene]                                 | C <sub>8</sub> H <sub>8</sub>                                     | 100-42-5     | 20 ppm                   | 40 ppm                      |
| Subtilisins                              | as crystalline active enzyme                   |                                                                   | 9014-01-1    |                          | C 0.00006 mg/m <sup>3</sup> |



| Substance                                             | Notes                                                         | Formula                        | CAS Reg. No. | Time-weighted average   | Short-term exposure limit |
|-------------------------------------------------------|---------------------------------------------------------------|--------------------------------|--------------|-------------------------|---------------------------|
| Sucrose                                               |                                                               | $C_{12}H_{22}O_{11}$           | 57-50-1      | 10 mg/m <sup>3</sup>    |                           |
| Sulfometuron methyl                                   |                                                               | $C_{15}H_{16}N_4O_5S$          | 74222-97-2   | 5 mg/m <sup>3</sup>     |                           |
| Sulfotep                                              | [Tetraethyl thiodiphosphate; TEDP]                            | $C_8H_{20}O_5P_2S_2$           | 3689-24-5    | 0.2 mg/m <sup>3</sup>   |                           |
| Sulfur chloride                                       | [Disulfur dichloride]                                         | $S_2Cl_2$                      | 10025-67-9   |                         | C 1 ppm                   |
| Sulfur decafluoride                                   | [Sulfur pentafluoride]                                        | $S_2F_{10}$                    | 5714-22-7    |                         | C 0.01 ppm                |
| Sulfur dioxide                                        |                                                               | $SO_2$                         | 7446-09-5    | 2 ppm                   | 5 ppm                     |
| Sulfur hexafluoride                                   |                                                               | $SF_6$                         | 2551-62-4    | 1000 ppm                |                           |
| Sulfuric acid                                         | [Oil of vitriol]                                              | $H_2SO_4$                      | 7664-93-9    | 0.2 mg/m <sup>3</sup>   |                           |
| Sulfur tetrafluoride                                  |                                                               | $SF_4$                         | 7783-60-0    |                         | C 0.1 ppm                 |
| Sulfonyl fluoride                                     |                                                               | $SO_2F_2$                      | 2699-79-8    | 5 ppm                   | 10 ppm                    |
| Sulprofos                                             |                                                               | $C_{12}H_{19}O_2PS_3$          | 35400-43-2   | 1 mg/m <sup>3</sup>     |                           |
| Talc                                                  |                                                               | $3MgO \cdot 4SiO_2 \cdot H_2O$ | 14807-96-6   | 2 mg/m <sup>3</sup>     |                           |
| Tantalum                                              | dust                                                          | Ta                             | 7440-25-7    | 5 mg/m <sup>3</sup>     |                           |
| Tantalum(V) oxide                                     | dust, as Ta                                                   | $Ta_2O_5$                      | 1314-61-0    | 5 mg/m <sup>3</sup>     |                           |
| Tellurium                                             | and compounds, as Te (except H <sub>2</sub> Te)               | Te                             | 13494-80-9   | 0.1 mg/m <sup>3</sup>   |                           |
| Tellurium hexafluoride                                |                                                               | $TeF_6$                        | 7783-80-4    | 0.02 ppm                |                           |
| Terbufos                                              |                                                               | $C_9H_{21}O_2PS_3$             | 13071-79-9   | 0.01 mg/m <sup>3</sup>  |                           |
| Terephthalic acid                                     | [1,4-Benzenedicarboxylic acid]                                | $C_8H_6O_4$                    | 100-21-0     | 10 mg/m <sup>3</sup>    |                           |
| Terphenyl                                             | all isomers                                                   | $C_{18}H_{14}$                 | 26140-60-3   |                         | 5 mg/m <sup>3</sup>       |
| 1,1,2,2-Tetrabromoethane                              | [Acetylene tetrabromide]                                      | $C_2H_2Br_4$                   | 79-27-6      | 0.1 ppm                 |                           |
| Tetrabromomethane                                     | [Carbon tetrabromide]                                         | $CBr_4$                        | 558-13-4     | 0.1 ppm                 | 0.3 ppm                   |
| 1,1,1,2-Tetrachloro-2,2-difluoroethane                | [Tetrachloro-1,1-difluoroethane]                              | $C_2Cl_4F_2$                   | 76-11-9      | 100 ppm                 |                           |
| 1,1,2,2-Tetrachloro-1,2-difluoroethane                | [Tetrachloro-1,2-difluoroethane]                              | $C_2Cl_4F_2$                   | 76-12-0      | 50 ppm                  |                           |
| 1,1,2,2-Tetrachloroethane                             | [Acetylene tetrachloride]                                     | $C_2H_2Cl_4$                   | 79-34-5      | 1 ppm                   |                           |
| Tetrachloroethene                                     | [Perchloroethylene]                                           | $C_2Cl_4$                      | 127-18-4     | 25 ppm                  | 100 ppm                   |
| Tetrachloromethane                                    | [Carbon tetrachloride]                                        | $CCl_4$                        | 56-23-5      | 5 ppm                   | 10 ppm                    |
| Tetrachloronaphthalene                                | all isomers                                                   | $C_{10}H_4Cl_4$                | 1335-88-2    | 2 mg/m <sup>3</sup>     |                           |
| Tetraethyl lead                                       | as Pb                                                         | $C_8H_{20}Pb$                  | 78-00-2      | 0.1 mg/m <sup>3</sup>   |                           |
| Tetraethyl pyrophosphate                              | [TEPP]                                                        | $C_8H_{20}O_7P_2$              | 107-49-3     | 0.01 mg/m <sup>3</sup>  |                           |
| Tetrafluoroethene                                     | [Tetrafluoroethylene]                                         | $C_2F_4$                       | 116-14-3     | 2 ppm                   |                           |
| Tetrahydrofuran                                       | [Oxolane]                                                     | $C_4H_8O$                      | 109-99-9     | 50 ppm                  | 100 ppm                   |
| Tetramethyl lead                                      | as Pb                                                         | $C_4H_{12}Pb$                  | 75-74-1      | 0.15 mg/m <sup>3</sup>  |                           |
| Tetramethyl silicate                                  | [Methyl silicate]                                             | $C_4H_{12}O_4Si$               | 681-84-5     | 1 ppm                   |                           |
| Tetramethylsuccinonitrile                             | [Tetramethylbutanedinitrile]                                  | $C_8H_{12}N_2$                 | 3333-52-6    | 0.5 ppm                 |                           |
| Tetranitromethane                                     |                                                               | $CN_4O_8$                      | 509-14-8     | 0.005 ppm               |                           |
| Thallium                                              | and soluble compounds, as Tl                                  | Tl                             | 7440-28-0    | 0.1 mg/m <sup>3</sup>   |                           |
| 4,4'-Thiobis(6- <i>tert</i> -butyl- <i>m</i> -cresol) | [Bis(5- <i>tert</i> -butyl-4-hydroxy-2-methylphenyl) sulfide] | $C_{22}H_{30}O_2S$             | 96-69-5      | 10 mg/m <sup>3</sup>    |                           |
| Thioglycolic acid                                     |                                                               | $C_2H_3O_2S$                   | 68-11-1      | 1 ppm                   |                           |
| Thionyl chloride                                      | [Sulfinyl dichloride]                                         | $SOCl_2$                       | 7719-09-7    |                         | C 1 ppm                   |
| Thiram                                                |                                                               | $C_6H_{12}N_2S_4$              | 137-26-8     | 0.05 mg/m <sup>3</sup>  |                           |
| Tin                                                   | metal                                                         | Sn                             | 7440-31-5    | 2 mg/m <sup>3</sup>     |                           |
| Tin                                                   | inorganic compounds, as Sn                                    | Sn                             | 7440-31-5    | 2 mg/m <sup>3</sup>     |                           |
| Tin                                                   | organic compounds, as Sn                                      | Sn                             | 7440-31-5    | 0.1 mg/m <sup>3</sup>   |                           |
| Titanium(IV) oxide                                    | [Titanium dioxide]                                            | $TiO_2$                        | 13463-67-7   | 10 mg/m <sup>3</sup>    |                           |
| Toluene                                               | [Methylbenzene]                                               | $C_7H_8$                       | 108-88-3     | 20 ppm                  |                           |
| Toluene-2,4-diisocyanate                              |                                                               | $C_9H_6N_2O_2$                 | 584-84-9     | 0.005 ppm               | 0.02 ppm                  |
| Toluene-2,6-diisocyanate                              |                                                               | $C_9H_6N_2O_2$                 | 91-08-7      | 0.005 mg/m <sup>3</sup> | 0.02 ppm                  |
| Toxaphene                                             | [Polychlorocamphene]                                          | $C_{10}H_{10}Cl_8$             | 8001-35-2    | 0.5 mg/m <sup>3</sup>   |                           |
| 1 <i>H</i> -1,2,4-Triazol-3-amine                     | [Amitrole]                                                    | $C_2H_4N_4$                    | 61-82-5      | 0.2 mg/m <sup>3</sup>   |                           |
| Tribromomethane                                       | [Bromoform]                                                   | $CHBr_3$                       | 75-25-2      | 0.5 ppm                 |                           |
| Tributyl phosphate                                    | [Butyl phosphate]                                             | $C_{12}H_{27}O_4P$             | 126-73-8     | 0.2 ppm                 |                           |
| Trichlorfon                                           | [Trichlorphon]                                                | $C_4H_8Cl_3O_4P$               | 52-68-6      | 1 mg/m <sup>3</sup>     |                           |

| Substance                                   | Notes                                                                                         | Formula              | CAS Reg. No. | Time-weighted average    | Short-term exposure limit |
|---------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------|--------------|--------------------------|---------------------------|
| Trichloroacetic acid                        |                                                                                               | $C_2HCl_3O_2$        | 76-03-9      | 1 ppm                    |                           |
| 1,2,4-Trichlorobenzene                      |                                                                                               | $C_6H_3Cl_3$         | 120-82-1     |                          | C 5 ppm                   |
| 1,1,1-Trichloroethane                       | [Methyl chloroform]                                                                           | $C_2H_3Cl_3$         | 71-55-6      | 350 ppm                  | 450 ppm                   |
| 1,1,2-Trichloroethane                       | [Vinyl trichloride]                                                                           | $C_2H_3Cl_3$         | 79-00-5      | 10 ppm                   |                           |
| Trichloroethene                             | [Trichloroethylene]                                                                           | $C_2HCl_3$           | 79-01-6      | 10 ppm                   | 25 ppm                    |
| Trichlorofluoromethane                      | [CFC-11]                                                                                      | $CCl_3F$             | 75-69-4      |                          | C 1000 ppm                |
| Trichloromethane                            | [Chloroform]                                                                                  | $CHCl_3$             | 67-66-3      | 10 ppm                   |                           |
| Trichloromethanesulfonyl chloride           | [Perchloromethyl mercaptan]                                                                   | $CCl_4S$             | 594-42-3     | 0.1 ppm                  |                           |
| (Trichloromethyl)benzene                    | [Benzotrichloride]                                                                            | $C_7H_5Cl_3$         | 98-07-7      |                          | C 0.1 ppm                 |
| Trichloronaphthalene                        | all isomers                                                                                   | $C_{10}H_5Cl_3$      | 1321-65-9    | 5 mg/m <sup>3</sup>      |                           |
| Trichloronitromethane                       | [Chloropicrin]                                                                                | $CCl_3NO_2$          | 76-06-2      | 0.1 ppm                  |                           |
| 2,4,5-Trichlorophenoxyacetic acid           | [2,4,5-T]                                                                                     | $C_8H_5Cl_3O_3$      | 93-76-5      | 10 mg/m <sup>3</sup>     |                           |
| 1,2,3-Trichloropropane                      | [Allyl trichloride]                                                                           | $C_3H_5Cl_3$         | 96-18-4      | 10 ppm                   |                           |
| 1,1,2-Trichloro-1,2,2-trifluoroethane       | [CFC-113]                                                                                     | $C_2Cl_3F_3$         | 76-13-1      | 1000 ppm                 | 1250 ppm                  |
| Tri- <i>o</i> -cresyl phosphate             | [Tri- <i>o</i> -tolyl phosphate]                                                              | $C_{21}H_{21}O_4P$   | 78-30-8      | 0.1 mg/m <sup>3</sup>    |                           |
| Triethanolamine                             | [Tris(2-hydroxyethyl)amine]                                                                   | $C_6H_{15}NO_3$      | 102-71-6     | 5 mg/m <sup>3</sup>      |                           |
| Triethylamine                               | [ <i>N,N</i> -Diethylethanamine]                                                              | $C_6H_{15}N$         | 121-44-8     | 1 ppm                    | 3 ppm                     |
| 1,3,5-Triglycidyl- <i>s</i> -triazinetriene | [1,3,5-Tris(oxiranemethyl)-1,3,5-triazine-2,4,6-(1 <i>H</i> ,3 <i>H</i> ,5 <i>H</i> )-trione] | $C_{12}H_{15}N_3O_6$ | 2451-62-9    | 0.05 mg/m <sup>3</sup>   |                           |
| Triiodomethane                              | [Iodoform]                                                                                    | $CHI_3$              | 75-47-8      | 0.6 ppm                  |                           |
| Trimellitic anhydride                       | [1,2,4-Benzenetricarboxylic anhydride]                                                        | $C_9H_4O_5$          | 552-30-7     | 0.0005 mg/m <sup>3</sup> | C 0.002 mg/m <sup>3</sup> |
| Trimethylamine                              | [ <i>N,N</i> -Dimethylmethanamine]                                                            | $C_3H_9N$            | 75-50-3      | 5 ppm                    | 15 ppm                    |
| Trimethylbenzene                            | all isomers                                                                                   | $C_9H_{12}$          | 25551-13-7   | 25 ppm                   |                           |
| Trimethyl phosphite                         |                                                                                               | $C_3H_9O_3P$         | 121-45-9     | 2 ppm                    |                           |
| Trinitroglycerol                            | [Nitroglycerin; NG]                                                                           | $C_3H_5N_3O_9$       | 55-63-0      | 0.05 ppm                 |                           |
| 2,4,6-Trinitrophenol                        | [Picric acid]                                                                                 | $C_6H_3N_3O_7$       | 88-89-1      | 0.1 mg/m <sup>3</sup>    |                           |
| 2,4,6-Trinitrotoluene                       | [TNT]                                                                                         | $C_7H_5N_3O_6$       | 118-96-7     | 0.1 mg/m <sup>3</sup>    |                           |
| Triphenyl phosphate                         |                                                                                               | $C_{18}H_{15}O_4P$   | 115-86-6     | 3 mg/m <sup>3</sup>      |                           |
| Tungsten                                    | metal and insoluble compounds, as W                                                           | W                    | 7440-33-7    | 5 mg/m <sup>3</sup>      | 10 mg/m <sup>3</sup>      |
| Tungsten                                    | soluble compounds, as W                                                                       | W                    | 7440-33-7    | 1 mg/m <sup>3</sup>      | 3 mg/m <sup>3</sup>       |
| Turpentine                                  |                                                                                               |                      | 8006-64-2    | 20 ppm                   |                           |
| Uranium                                     | metal and compounds, as U                                                                     | U                    | 7440-61-1    | 0.2 mg/m <sup>3</sup>    | 0.6 mg/m <sup>3</sup>     |
| Vanadium(V) oxide                           | dust or fume; [Vanadium pentoxide]                                                            | $V_2O_5$             | 1314-62-1    | 0.05 mg/m <sup>3</sup>   |                           |
| Vinyl acetate                               |                                                                                               | $C_4H_6O_2$          | 108-05-4     | 10 ppm                   | 15 ppm                    |
| 4-Vinylcyclohexene                          |                                                                                               | $C_8H_{12}$          | 100-40-3     | 0.1 ppm                  |                           |
| 1-Vinyl-2-pyrrolidinone                     |                                                                                               | $C_6H_9NO$           | 88-12-0      | 0.05 ppm                 |                           |
| Warfarin                                    | [Coumadin]                                                                                    | $C_{19}H_{16}O_4$    | 81-81-2      | 0.1 mg/m <sup>3</sup>    |                           |
| Xylene                                      | [Dimethylbenzene], all isomers                                                                | $C_8H_{10}$          | 1330-20-7    | 100 ppm                  | 150 ppm                   |
| Xylidine                                    | [Dimethylaniline], all isomers                                                                | $C_8H_{11}N$         | 1300-73-8    | 0.5 ppm                  |                           |
| Yttrium                                     | metal and compounds, as Y                                                                     | Y                    | 7440-65-5    | 1 mg/m <sup>3</sup>      |                           |
| Zinc chloride                               | fume                                                                                          | $ZnCl_2$             | 7646-85-7    | 1 mg/m <sup>3</sup>      | 2 mg/m <sup>3</sup>       |
| Zinc chromate                               | as Cr                                                                                         | $ZnCrO_4$            | 13530-65-9   | 0.01 mg/m <sup>3</sup>   |                           |
| Zinc oxide                                  | [Zincite]                                                                                     | $ZnO$                | 1314-13-2    | 2 mg/m <sup>3</sup>      | 10 mg/m <sup>3</sup>      |
| Zirconium                                   | metal and compounds, as Zr                                                                    | Zr                   | 7440-67-7    | 5 mg/m <sup>3</sup>      | 10 mg/m <sup>3</sup>      |



# OCTANOL-WATER PARTITION COEFFICIENTS

The octanol-water partition coefficient,  $P$ , is a widely used parameter for correlating biological effects of organic substances. It is a property of the two-phase system in which water and 1-octanol are in equilibrium at a fixed temperature and the substance is distributed between the water-rich and octanol-rich phases.  $P$  is defined as the ratio of the equilibrium concentration of the substance in the octanol-rich phase to that in the water-rich phase, in the limit of zero concentration. In general,  $P$  tends to be large for compounds with extended non-polar structures (such as long chain or multi-ring hydrocarbons) and small for compounds with highly polar groups. Thus  $P$  (or, in its more common form of expression,  $\log P$ ) provides a measure of the lipophilic vs. hydrophilic nature of a compound, which is an important consideration in assessing the potential toxicity. A discussion of methods of measurement and accuracy considerations for  $\log P$  may be found in Reference 1.

This table gives selected values of  $\log P$  for about 450 organic compounds, including many of environmental importance. All values refer to a nominal temperature of 25°C. The source of each value is indicated in the last column. These references contain data on many more compounds than are included here.

Compounds are listed by molecular formula following the Hill convention. To locate a compound by name or CAS Registry Number when the molecular formula is not known, use the table "Physical Constants of Organic Compounds" in Section 3 and its indexes to determine the molecular formula.

## References

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| Mol. form.                                    | Name                           | $\log P$ | Ref. | Mol. form.                                     | Name                    | $\log P$ | Ref. |
|-----------------------------------------------|--------------------------------|----------|------|------------------------------------------------|-------------------------|----------|------|
| CCl <sub>2</sub> F <sub>2</sub>               | Dichlorodifluoromethane        | 2.16     | 2    | C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>   | Acetic acid             | -0.17    | 1    |
| CCl <sub>3</sub> F                            | Trichlorofluoromethane         | 2.53     | 2    | C <sub>2</sub> H <sub>5</sub> Br               | Bromoethane             | 1.6      | 2    |
| CCl <sub>4</sub>                              | Tetrachloromethane             | 2.64     | 2    | C <sub>2</sub> H <sub>5</sub> Cl               | Chloroethane            | 1.43     | 2    |
| CHBr <sub>3</sub>                             | Tribromomethane                | 2.38     | 2    | C <sub>2</sub> H <sub>5</sub> I                | Iodoethane              | 2        | 2    |
| CHCl <sub>3</sub>                             | Trichloromethane               | 1.97     | 2    | C <sub>2</sub> H <sub>5</sub> NO               | Acetamide               | -1.26    | 1    |
| CH <sub>2</sub> BrCl                          | Bromochloromethane             | 1.41     | 2    | C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>  | Nitroethane             | 0.18     | 1    |
| CH <sub>2</sub> Br <sub>2</sub>               | Dibromomethane                 | 2.3      | 2    | C <sub>2</sub> H <sub>6</sub> O                | Ethanol                 | -0.30    | 1    |
| CH <sub>2</sub> Cl <sub>2</sub>               | Dichloromethane                | 1.25     | 2    | C <sub>2</sub> H <sub>6</sub> O                | Dimethyl ether          | 0.10     | 1    |
| CH <sub>2</sub> F <sub>2</sub>                | Difluoromethane                | 0.20     | 1    | C <sub>2</sub> H <sub>6</sub> OS               | Dimethyl sulfoxide      | -1.35    | 1    |
| CH <sub>2</sub> I <sub>2</sub>                | Diiodomethane                  | 2.5      | 2    | C <sub>2</sub> H <sub>6</sub> O <sub>2</sub> S | Dimethyl sulfone        | -1.41    | 1    |
| CH <sub>2</sub> O                             | Formaldehyde                   | 0.35     | 1    | C <sub>2</sub> H <sub>7</sub> N                | Ethylamine              | -0.13    | 1    |
| CH <sub>2</sub> O <sub>2</sub>                | Formic acid                    | -0.54    | 1    | C <sub>2</sub> H <sub>7</sub> N                | Dimethylamine           | -0.38    | 1    |
| CH <sub>3</sub> Br                            | Bromomethane                   | 1.19     | 2    | C <sub>2</sub> H <sub>3</sub> N                | 2-Propenenitrile        | 0.25     | 1    |
| CH <sub>3</sub> Cl                            | Chloromethane                  | 0.91     | 2    | C <sub>3</sub> H <sub>2</sub> Cl <sub>2</sub>  | cis-1,3-Dichloropropene | 2.03     | 2    |
| CH <sub>3</sub> F                             | Fluoromethane                  | 0.51     | 1    | C <sub>3</sub> H <sub>3</sub> O                | Propargyl alcohol       | -0.38    | 1    |
| CH <sub>3</sub> I                             | Iodomethane                    | 1.5      | 2    | C <sub>3</sub> H <sub>4</sub> O                | Acrolein                | -0.01    | 1    |
| CH <sub>3</sub> NO                            | Formamide                      | -1.51    | 1    | C <sub>3</sub> H <sub>5</sub> Br               | 3-Bromopropene          | 1.79     | 1    |
| CH <sub>3</sub> NO <sub>2</sub>               | Nitromethane                   | -0.33    | 1    | C <sub>3</sub> H <sub>5</sub> ClO              | Epichlorohydrin         | 0.30     | 2    |
| CH <sub>4</sub> O                             | Methanol                       | -0.74    | 1    | C <sub>3</sub> H <sub>5</sub> Cl <sub>3</sub>  | 1,2,3-Trichloropropane  | 2.63     | 2    |
| CH <sub>5</sub> N                             | Methylamine                    | -0.57    | 1    | C <sub>3</sub> H <sub>5</sub> N                | Propanenitrile          | 0.16     | 1    |
| C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub> | 1,1,2-Trichlorotrifluoroethane | 3.16     | 2    | C <sub>3</sub> H <sub>5</sub> NO               | Acrylamide              | -0.78    | 1    |
| C <sub>2</sub> Cl <sub>4</sub>                | Tetrachloroethylene            | 2.88     | 2    | C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>  | 1,2-Dichloropropane     | 2.0      | 2    |
| C <sub>2</sub> Cl <sub>6</sub>                | Hexachloroethane               | 4.00     | 4    | C <sub>3</sub> H <sub>6</sub> O                | Allyl alcohol           | 0.17     | 1    |
| C <sub>2</sub> HCl <sub>3</sub>               | Trichloroethylene              | 2.53     | 2    | C <sub>3</sub> H <sub>6</sub> O                | Propanal                | 0.59     | 1    |
| C <sub>2</sub> HCl <sub>5</sub>               | Pentachloroethane              | 2.89     | 2    | C <sub>3</sub> H <sub>6</sub> O                | Acetone                 | -0.24    | 1    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> | 1,1-Dichloroethylene           | 2.13     | 2    | C <sub>3</sub> H <sub>6</sub> O                | Methyloxirane           | 0.03     | 1    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> | cis-1,2-Dichloroethylene       | 1.86     | 2    | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Propanoic acid          | 0.33     | 1    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> | trans-1,2-Dichloroethylene     | 1.93     | 2    | C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>   | Methyl acetate          | 0.18     | 1    |
| C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub> | 1,1,2,2-Tetrachloroethane      | 2.39     | 2    | C <sub>3</sub> H <sub>7</sub> Br               | 1-Bromopropane          | 2.1      | 2    |
| C <sub>2</sub> H <sub>3</sub> Cl              | Chloroethylene                 | 1.38     | 2    | C <sub>3</sub> H <sub>7</sub> Br               | 2-Bromopropane          | 1.9      | 2    |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> | 1,1,1-Trichloroethane          | 2.49     | 2    | C <sub>3</sub> H <sub>7</sub> Cl               | 1-Chloropropane         | 2.04     | 1    |
| C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub> | 1,1,2-Trichloroethane          | 2.38     | 2    | C <sub>3</sub> H <sub>7</sub> Cl               | 2-Chloropropane         | 1.90     | 1    |
| C <sub>2</sub> H <sub>3</sub> N               | Acetonitrile                   | -0.34    | 1    | C <sub>3</sub> H <sub>7</sub> I                | 1-Iodopropane           | 2.5      | 2    |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,1-Dichloroethane             | 1.79     | 2    | C <sub>3</sub> H <sub>7</sub> N                | Allylamine              | 0.03     | 1    |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> | 1,2-Dichloroethane             | 1.48     | 2    | C <sub>3</sub> H <sub>7</sub> NO               | N,N-Dimethylformamide   | -1.01    | 1    |
| C <sub>2</sub> H <sub>4</sub> O               | Acetaldehyde                   | 0.45     | 1    | C <sub>3</sub> H <sub>7</sub> NO               | N-Methylacetamide       | -1.05    | 1    |
| C <sub>2</sub> H <sub>4</sub> O               | Ethylene oxide                 | -0.30    | 1    | C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>  | 1-Nitropropane          | 0.87     | 1    |

| Mol. form.                                      | Name                          | log <i>P</i> | Ref. | Mol. form.                                      | Name                            | log <i>P</i> | Ref. |
|-------------------------------------------------|-------------------------------|--------------|------|-------------------------------------------------|---------------------------------|--------------|------|
| C <sub>3</sub> H <sub>8</sub> O                 | 1-Propanol                    | 0.25         | 1    | C <sub>5</sub> H <sub>10</sub> O                | 2-Methyltetrahydrofuran         | 1.85         | 2    |
| C <sub>3</sub> H <sub>8</sub> O                 | 2-Propanol                    | 0.05         | 1    | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Pentanoic acid                  | 1.39         | 1    |
| C <sub>3</sub> H <sub>8</sub> S                 | 1-Propanethiol                | 1.81         | 1    | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Propyl acetate                  | 1.24         | 1    |
| C <sub>3</sub> H <sub>9</sub> N                 | Propylamine                   | 0.48         | 1    | C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>   | Ethyl propanoate                | 1.21         | 1    |
| C <sub>3</sub> H <sub>9</sub> N                 | Isopropylamine                | 0.26         | 1    | C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>   | Diethyl carbonate               | 1.21         | 1    |
| C <sub>3</sub> H <sub>9</sub> N                 | Ethylmethylamine              | 0.15         | 1    | C <sub>5</sub> H <sub>11</sub> Br               | 1-Bromopentane                  | 3.37         | 1    |
| C <sub>3</sub> H <sub>9</sub> N                 | Trimethylamine                | 0.16         | 1    | C <sub>5</sub> H <sub>11</sub> F                | 1-Fluoropentane                 | 2.33         | 1    |
| C <sub>4</sub> H <sub>4</sub> O                 | Furan                         | 1.34         | 1    | C <sub>5</sub> H <sub>11</sub> N                | Piperidine                      | 0.84         | 1    |
| C <sub>4</sub> H <sub>4</sub> S                 | Thiophene                     | 1.81         | 1    | C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>  | 1-Nitropentane                  | 2.01         | 1    |
| C <sub>4</sub> H <sub>5</sub> N                 | Pyrrole                       | 0.75         | 1    | C <sub>5</sub> H <sub>12</sub>                  | Pentane                         | 3.45         | 1    |
| C <sub>4</sub> H <sub>6</sub>                   | 1,3-Butadiene                 | 1.99         | 1    | C <sub>5</sub> H <sub>12</sub>                  | Neopentane                      | 3.11         | 1    |
| C <sub>4</sub> H <sub>6</sub>                   | 2-Butyne                      | 1.46         | 1    | C <sub>5</sub> H <sub>12</sub> O                | 1-Pentanol                      | 1.51         | 1    |
| C <sub>4</sub> H <sub>6</sub> O                 | 2,5-Dihydrofuran              | 0.46         | 1    | C <sub>5</sub> H <sub>12</sub> O                | 2-Pentanol                      | 1.25         | 1    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>    | Methacrylic acid              | 0.93         | 1    | C <sub>5</sub> H <sub>12</sub> O                | 3-Pentanol                      | 1.21         | 1    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>    | Vinyl acetate                 | 0.73         | 1    | C <sub>5</sub> H <sub>12</sub> O                | 3-Methyl-1-butanol              | 1.28         | 1    |
| C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>    | Methyl acrylate               | 0.80         | 1    | C <sub>5</sub> H <sub>12</sub> O                | 2-Methyl-2-butanol              | 0.89         | 1    |
| C <sub>4</sub> H <sub>7</sub> N                 | Butanenitrile                 | 0.60         | 1    | C <sub>5</sub> H <sub>12</sub> O                | 3-Methyl-2-butanol              | 1.28         | 1    |
| C <sub>4</sub> H <sub>8</sub>                   | <i>cis</i> -2-Butene          | 2.33         | 1    | C <sub>5</sub> H <sub>12</sub> O                | 2,2-Dimethyl-1-propanol         | 1.31         | 1    |
| C <sub>4</sub> H <sub>8</sub>                   | <i>trans</i> -2-Butene        | 2.31         | 1    | C <sub>5</sub> H <sub>12</sub> O                | Methyl <i>tert</i> -butyl ether | 0.94         | 1    |
| C <sub>4</sub> H <sub>8</sub>                   | Isobutene                     | 2.35         | 1    | C <sub>5</sub> H <sub>13</sub> N                | Pentylamine                     | 1.49         | 1    |
| C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub> O | Bis(2-chloroethyl) ether      | 1.12         | 2    | C <sub>6</sub> Cl <sub>6</sub>                  | Hexachlorobenzene               | 5.47         | 5    |
| C <sub>4</sub> H <sub>8</sub> O                 | Ethyl vinyl ether             | 1.04         | 1    | C <sub>6</sub> HCl <sub>5</sub>                 | Pentachlorobenzene              | 5.03         | 5    |
| C <sub>4</sub> H <sub>8</sub> O                 | Butanal                       | 0.88         | 1    | C <sub>6</sub> HCl <sub>5</sub> O               | Pentachlorophenol               | 5.07         | 4    |
| C <sub>4</sub> H <sub>8</sub> O                 | 2-Butanone                    | 0.29         | 1    | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>   | 1,2,3,4-Tetrachlorobenzene      | 4.55         | 5    |
| C <sub>4</sub> H <sub>8</sub> O                 | Tetrahydrofuran               | 0.46         | 1    | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>   | 1,2,3,5-Tetrachlorobenzene      | 4.65         | 5    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>    | Butanoic acid                 | 0.79         | 1    | C <sub>6</sub> H <sub>2</sub> Cl <sub>4</sub>   | 1,2,4,5-Tetrachlorobenzene      | 4.51         | 5    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>    | Propyl formate                | 0.83         | 1    | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>   | 1,2,3-Trichlorobenzene          | 4.04         | 5    |
| C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>    | Ethyl acetate                 | 0.73         | 1    | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>   | 1,2,4-Trichlorobenzene          | 3.98         | 5    |
| C <sub>4</sub> H <sub>9</sub> Br                | 1-Bromobutane                 | 2.75         | 1    | C <sub>6</sub> H <sub>3</sub> Cl <sub>3</sub>   | 1,3,5-Trichlorobenzene          | 4.02         | 5    |
| C <sub>4</sub> H <sub>9</sub> Cl                | 1-Chlorobutane                | 2.64         | 2    | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>   | <i>o</i> -Dichlorobenzene       | 3.38         | 5    |
| C <sub>4</sub> H <sub>9</sub> F                 | 1-Fluorobutane                | 2.58         | 1    | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>   | <i>m</i> -Dichlorobenzene       | 3.48         | 5    |
| C <sub>4</sub> H <sub>9</sub> I                 | 1-Iodobutane                  | 3            | 2    | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>   | <i>p</i> -Dichlorobenzene       | 3.38         | 5    |
| C <sub>4</sub> H <sub>9</sub> N                 | Pyrrolidine                   | 0.46         | 1    | C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> O | 2,4-Dichlorophenol              | 3.23         | 4    |
| C <sub>4</sub> H <sub>9</sub> NO                | Butanamide                    | -0.21        | 1    | C <sub>6</sub> H <sub>5</sub> Br                | Bromobenzene                    | 2.99         | 2    |
| C <sub>4</sub> H <sub>9</sub> NO                | <i>N,N</i> -Dimethylacetamide | -0.77        | 1    | C <sub>6</sub> H <sub>5</sub> Cl                | Chlorobenzene                   | 2.84         | 1    |
| C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>   | 1-Nitrobutane                 | 1.47         | 1    | C <sub>6</sub> H <sub>5</sub> F                 | Fluorobenzene                   | 2.27         | 2    |
| C <sub>4</sub> H <sub>10</sub>                  | Isobutane                     | 2.8          | 2    | C <sub>6</sub> H <sub>5</sub> I                 | Iodobenzene                     | 3.28         | 2    |
| C <sub>4</sub> H <sub>10</sub> O                | 1-Butanol                     | 0.84         | 1    | C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>   | Nitrobenzene                    | 1.85         | 1    |
| C <sub>4</sub> H <sub>10</sub> O                | 2-Butanol                     | 0.65         | 1    | C <sub>6</sub> H <sub>6</sub>                   | Benzene                         | 2.13         | 1    |
| C <sub>4</sub> H <sub>10</sub> O                | 2-Methyl-1-propanol           | 0.76         | 1    | C <sub>6</sub> H <sub>6</sub> O                 | Phenol                          | 1.48         | 4    |
| C <sub>4</sub> H <sub>10</sub> O                | 2-Methyl-2-propanol           | 0.35         | 1    | C <sub>6</sub> H <sub>6</sub> S                 | Benzenethiol                    | 2.52         | 1    |
| C <sub>4</sub> H <sub>10</sub> O                | Diethyl ether                 | 0.89         | 1    | C <sub>6</sub> H <sub>7</sub> N                 | Aniline                         | 0.90         | 1    |
| C <sub>4</sub> H <sub>10</sub> S                | 1-Butanethiol                 | 2.28         | 1    | C <sub>6</sub> H <sub>7</sub> N                 | 2-Methylpyridine                | 1.11         | 1    |
| C <sub>4</sub> H <sub>10</sub> S                | Diethyl sulfide               | 1.95         | 1    | C <sub>6</sub> H <sub>7</sub> N                 | 3-Methylpyridine                | 1.20         | 1    |
| C <sub>4</sub> H <sub>11</sub> N                | Butylamine                    | 0.86         | 1    | C <sub>6</sub> H <sub>7</sub> N                 | 4-Methylpyridine                | 1.22         | 1    |
| C <sub>4</sub> H <sub>11</sub> N                | <i>tert</i> -Butylamine       | 0.40         | 1    | C <sub>6</sub> H <sub>8</sub>                   | 1,4-Cyclohexadiene              | 2.3          | 2    |
| C <sub>4</sub> H <sub>11</sub> N                | Diethylamine                  | 0.58         | 1    | C <sub>6</sub> H <sub>8</sub> O                 | 5-Hexyn-2-one                   | 0.58         | 1    |
| C <sub>5</sub> H <sub>5</sub> N                 | Pyridine                      | 0.65         | 1    | C <sub>6</sub> H <sub>8</sub> O                 | 2-Cyclohexen-1-one              | 0.61         | 1    |
| C <sub>5</sub> H <sub>6</sub> O                 | 2-Methylfuran                 | 1.85         | 1    | C <sub>6</sub> H <sub>8</sub> O                 | 2-Ethylfuran                    | 2.40         | 1    |
| C <sub>5</sub> H <sub>7</sub> N                 | 1-Methylpyrrole               | 1.21         | 1    | C <sub>6</sub> H <sub>10</sub>                  | 1,5-Hexadiene                   | 2.8          | 2    |
| C <sub>5</sub> H <sub>8</sub>                   | 1,4-Pentadiene                | 2.48         | 1    | C <sub>6</sub> H <sub>10</sub>                  | 1-Hexyne                        | 2.73         | 2    |
| C <sub>5</sub> H <sub>8</sub>                   | 1-Pentyne                     | 1.98         | 1    | C <sub>6</sub> H <sub>10</sub>                  | Cyclohexene                     | 2.86         | 1    |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>    | Methyl methacrylate           | 1.38         | 1    | C <sub>6</sub> H <sub>10</sub> O                | 5-Hexen-2-one                   | 1.02         | 1    |
| C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>    | Ethyl acrylate                | 1.32         | 1    | C <sub>6</sub> H <sub>10</sub> O                | Cyclohexanone                   | 0.81         | 1    |
| C <sub>5</sub> H <sub>9</sub> N                 | Pentanenitrile                | 0.94         | 1    | C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>   | Ethyl methacrylate              | 1.94         | 1    |
| C <sub>5</sub> H <sub>10</sub>                  | 1-Pentene                     | 2.2          | 2    | C <sub>6</sub> H <sub>11</sub> Br               | Bromocyclohexane                | 3.20         | 1    |
| C <sub>5</sub> H <sub>10</sub>                  | Cyclopentane                  | 3.00         | 1    | C <sub>6</sub> H <sub>11</sub> N                | Hexanenitrile                   | 1.66         | 1    |
| C <sub>5</sub> H <sub>10</sub> O                | 2-Pentanone                   | 0.84         | 1    | C <sub>6</sub> H <sub>12</sub>                  | 1-Hexene                        | 3.40         | 1    |
| C <sub>5</sub> H <sub>10</sub> O                | 3-Pentanone                   | 0.82         | 1    | C <sub>6</sub> H <sub>12</sub>                  | 4-Methyl-1-pentene              | 2.5          | 2    |
| C <sub>5</sub> H <sub>10</sub> O                | 3-Methyl-2-butanone           | 0.56         | 1    | C <sub>6</sub> H <sub>12</sub>                  | Cyclohexane                     | 3.44         | 1    |
| C <sub>5</sub> H <sub>10</sub> O                | Tetrahydropyran               | 0.82         | 1    | C <sub>6</sub> H <sub>12</sub>                  | Methylcyclopentane              | 3.37         | 2    |

| Mol. form.                                     | Name                    | log <i>P</i> | Ref. | Mol. form.                                    | Name                           | log <i>P</i> | Ref. |
|------------------------------------------------|-------------------------|--------------|------|-----------------------------------------------|--------------------------------|--------------|------|
| C <sub>6</sub> H <sub>12</sub> O               | Cyclohexanol            | 1.23         | 1    | C <sub>8</sub> H <sub>6</sub> O               | Benzofuran                     | 2.67         | 1    |
| C <sub>6</sub> H <sub>12</sub> O               | Hexanal                 | 1.78         | 1    | C <sub>8</sub> H <sub>6</sub> S               | Benzo[b]thiophene              | 3.12         | 1    |
| C <sub>6</sub> H <sub>12</sub> O               | 2-Hexanone              | 1.38         | 1    | C <sub>8</sub> H <sub>7</sub> N               | Benzeneacetonitrile            | 1.56         | 1    |
| C <sub>6</sub> H <sub>12</sub> O               | 4-Methyl-2-pentanone    | 1.31         | 1    | C <sub>8</sub> H <sub>7</sub> N               | Indole                         | 2.14         | 1    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | Hexanoic acid           | 1.92         | 1    | C <sub>8</sub> H <sub>8</sub>                 | Styrene                        | 3.05         | 1    |
| C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>  | Butyl acetate           | 1.82         | 1    | C <sub>8</sub> H <sub>8</sub> O               | Acetophenone                   | 1.63         | 1    |
| C <sub>6</sub> H <sub>13</sub> Br              | 1-Bromohexane           | 3.80         | 1    | C <sub>8</sub> H <sub>8</sub> O               | 2-Methylbenzaldehyde           | 2.26         | 1    |
| C <sub>6</sub> H <sub>13</sub> N               | Cyclohexylamine         | 1.49         | 1    | C <sub>8</sub> H <sub>8</sub> O               | Benzeneacetaldehyde            | 1.78         | 1    |
| C <sub>6</sub> H <sub>14</sub>                 | Hexane                  | 4.00         | 1    | C <sub>8</sub> H <sub>8</sub> O               | 2,3-Dihydrobenzofuran          | 2.14         | 1    |
| C <sub>6</sub> H <sub>14</sub>                 | 3-Methylpentane         | 3.60         | 2    | C <sub>8</sub> H <sub>8</sub> O               | Phenylloxirane                 | 1.61         | 1    |
| C <sub>6</sub> H <sub>14</sub>                 | 2,2-Dimethylbutane      | 3.82         | 1    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | <i>o</i> -Toluic acid          | 2.32         | 4    |
| C <sub>6</sub> H <sub>14</sub>                 | 2,3-Dimethylbutane      | 3.85         | 2    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | <i>m</i> -Toluic acid          | 2.37         | 1    |
| C <sub>6</sub> H <sub>14</sub> O               | 1-Hexanol               | 2.03         | 1    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | <i>p</i> -Toluic acid          | 2.34         | 1    |
| C <sub>6</sub> H <sub>14</sub> O               | 2-Hexanol               | 1.76         | 1    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | Benzeneacetic acid             | 1.41         | 1    |
| C <sub>6</sub> H <sub>14</sub> O               | 3-Hexanol               | 1.65         | 1    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | Phenyl acetate                 | 1.49         | 1    |
| C <sub>6</sub> H <sub>14</sub> O               | 3,3-Dimethyl-2-butanol  | 1.48         | 1    | C <sub>8</sub> H <sub>8</sub> O <sub>2</sub>  | Methyl benzoate                | 2.20         | 1    |
| C <sub>6</sub> H <sub>14</sub> O               | Dipropyl ether          | 2.03         | 1    | C <sub>8</sub> H <sub>10</sub>                | Ethylbenzene                   | 3.15         | 1    |
| C <sub>6</sub> H <sub>14</sub> O               | Diisopropyl ether       | 1.52         | 1    | C <sub>8</sub> H <sub>10</sub>                | <i>o</i> -Xylene               | 3.12         | 1    |
| C <sub>6</sub> H <sub>15</sub> N               | Hexylamine              | 2.06         | 1    | C <sub>8</sub> H <sub>10</sub>                | <i>m</i> -Xylene               | 3.20         | 1    |
| C <sub>6</sub> H <sub>15</sub> N               | Dipropylamine           | 1.67         | 1    | C <sub>8</sub> H <sub>10</sub>                | <i>p</i> -Xylene               | 3.15         | 1    |
| C <sub>6</sub> H <sub>15</sub> N               | Triethylamine           | 1.45         | 1    | C <sub>8</sub> H <sub>10</sub> O              | <i>o</i> -Ethylphenol          | 2.47         | 1    |
| C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub> | 2-Bromobenzoic acid     | 2.20         | 4    | C <sub>8</sub> H <sub>10</sub> O              | <i>m</i> -Ethylphenol          | 2.50         | 1    |
| C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub> | 3-Bromobenzoic acid     | 2.87         | 4    | C <sub>8</sub> H <sub>10</sub> O              | <i>p</i> -Ethylphenol          | 2.50         | 1    |
| C <sub>7</sub> H <sub>5</sub> BrO <sub>2</sub> | 4-Bromobenzoic acid     | 2.86         | 4    | C <sub>8</sub> H <sub>10</sub> O              | 2,4-Xylenol                    | 2.35         | 1    |
| C <sub>7</sub> H <sub>5</sub> N                | Benzonitrile            | 1.56         | 1    | C <sub>8</sub> H <sub>10</sub> O              | 2,5-Xylenol                    | 2.34         | 1    |
| C <sub>7</sub> H <sub>6</sub> O                | Benzaldehyde            | 1.48         | 1    | C <sub>8</sub> H <sub>10</sub> O              | 2,6-Xylenol                    | 2.36         | 1    |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>   | Benzoic acid            | 1.88         | 4    | C <sub>8</sub> H <sub>10</sub> O              | 3,4-Xylenol                    | 3.23         | 1    |
| C <sub>7</sub> H <sub>6</sub> O <sub>2</sub>   | Phenyl formate          | 1.26         | 1    | C <sub>8</sub> H <sub>10</sub> O              | 3,5-Xylenol                    | 2.35         | 1    |
| C <sub>7</sub> H <sub>6</sub> O <sub>3</sub>   | Salicylic acid          | 2.20         | 4    | C <sub>8</sub> H <sub>10</sub> O              | Benzeneethanol                 | 1.36         | 1    |
| C <sub>7</sub> H <sub>7</sub> Br               | (Bromomethyl)benzene    | 2.92         | 1    | C <sub>8</sub> H <sub>10</sub> O              | $\alpha$ -Methylbenzyl alcohol | 1.42         | 1    |
| C <sub>7</sub> H <sub>7</sub> Cl               | <i>o</i> -Chlorotoluene | 3.42         | 1    | C <sub>8</sub> H <sub>10</sub> O              | 3-Methylbenzenemethanol        | 1.60         | 1    |
| C <sub>7</sub> H <sub>7</sub> Cl               | <i>m</i> -Chlorotoluene | 3.28         | 1    | C <sub>8</sub> H <sub>10</sub> O              | 4-Methylbenzenemethanol        | 1.58         | 1    |
| C <sub>7</sub> H <sub>7</sub> Cl               | <i>p</i> -Chlorotoluene | 3.33         | 1    | C <sub>8</sub> H <sub>10</sub> O              | Phenetole                      | 2.51         | 1    |
| C <sub>7</sub> H <sub>7</sub> Cl               | (Chloromethyl)benzene   | 2.30         | 1    | C <sub>8</sub> H <sub>10</sub> O              | Benzyl methyl ether            | 1.35         | 1    |
| C <sub>7</sub> H <sub>7</sub> NO <sub>2</sub>  | <i>p</i> -Nitrotoluene  | 2.42         | 1    | C <sub>8</sub> H <sub>10</sub> O              | 2-Methylanisole                | 2.74         | 1    |
| C <sub>7</sub> H <sub>8</sub>                  | Toluene                 | 2.73         | 1    | C <sub>8</sub> H <sub>10</sub> O              | 3-Methylanisole                | 2.66         | 1    |
| C <sub>7</sub> H <sub>8</sub>                  | 1,3,5-Cycloheptatriene  | 2.63         | 2    | C <sub>8</sub> H <sub>10</sub> O              | 4-Methylanisole                | 2.81         | 1    |
| C <sub>7</sub> H <sub>8</sub> O                | <i>o</i> -Cresol        | 1.98         | 1    | C <sub>8</sub> H <sub>11</sub> N              | <i>p</i> -Ethylaniline         | 1.96         | 1    |
| C <sub>7</sub> H <sub>8</sub> O                | <i>m</i> -Cresol        | 1.98         | 1    | C <sub>8</sub> H <sub>11</sub> N              | <i>N,N</i> -Dimethylaniline    | 2.31         | 1    |
| C <sub>7</sub> H <sub>8</sub> O                | <i>p</i> -Cresol        | 1.97         | 1    | C <sub>8</sub> H <sub>11</sub> N              | Benzeneethanamine              | 1.41         | 1    |
| C <sub>7</sub> H <sub>8</sub> O                | Benzyl alcohol          | 1.05         | 1    | C <sub>8</sub> H <sub>14</sub> O <sub>2</sub> | Butyl methacrylate             | 2.88         | 1    |
| C <sub>7</sub> H <sub>8</sub> O                | Anisole                 | 2.11         | 1    | C <sub>8</sub> H <sub>15</sub> N              | Octanenitrile                  | 2.75         | 1    |
| C <sub>7</sub> H <sub>9</sub> N                | Benzylamine             | 1.09         | 1    | C <sub>8</sub> H <sub>16</sub>                | 1-Octene                       | 4.57         | 1    |
| C <sub>7</sub> H <sub>9</sub> N                | <i>o</i> -Methylaniline | 1.32         | 1    | C <sub>8</sub> H <sub>16</sub>                | Cyclooctane                    | 4.45         | 2    |
| C <sub>7</sub> H <sub>9</sub> N                | <i>m</i> -Methylaniline | 1.40         | 1    | C <sub>8</sub> H <sub>16</sub> O              | 2-Octanone                     | 2.37         | 1    |
| C <sub>7</sub> H <sub>9</sub> N                | <i>p</i> -Methylaniline | 1.39         | 1    | C <sub>8</sub> H <sub>16</sub> O <sub>2</sub> | Octanoic acid                  | 3.05         | 1    |
| C <sub>7</sub> H <sub>9</sub> N                | <i>N</i> -Methylaniline | 1.66         | 1    | C <sub>8</sub> H <sub>17</sub> Br             | 1-Bromooctane                  | 4.89         | 1    |
| C <sub>7</sub> H <sub>14</sub>                 | 1-Heptene               | 3.99         | 1    | C <sub>8</sub> H <sub>18</sub>                | Octane                         | 5.15         | 1    |
| C <sub>7</sub> H <sub>14</sub>                 | Methylcyclohexane       | 3.88         | 1    | C <sub>8</sub> H <sub>18</sub> O              | 1-Octanol                      | 3.07         | 1    |
| C <sub>7</sub> H <sub>14</sub> O               | 2-Heptanone             | 1.98         | 1    | C <sub>8</sub> H <sub>18</sub> O              | 2-Octanol                      | 2.90         | 1    |
| C <sub>7</sub> H <sub>14</sub> O               | 5-Methyl-2-hexanone     | 1.88         | 1    | C <sub>8</sub> H <sub>18</sub> O              | 4-Octanol                      | 2.68         | 1    |
| C <sub>7</sub> H <sub>15</sub> Br              | 1-Bromoheptane          | 4.36         | 1    | C <sub>8</sub> H <sub>18</sub> O              | Dibutyl ether                  | 3.21         | 1    |
| C <sub>7</sub> H <sub>15</sub> Cl              | 1-Chloroheptane         | 4.15         | 1    | C <sub>9</sub> H <sub>7</sub> N               | Quinoline                      | 2.03         | 1    |
| C <sub>7</sub> H <sub>15</sub> I               | 1-Iodoheptane           | 4.70         | 1    | C <sub>9</sub> H <sub>7</sub> N               | Isoquinoline                   | 2.08         | 1    |
| C <sub>7</sub> H <sub>16</sub>                 | Heptane                 | 4.50         | 1    | C <sub>9</sub> H <sub>8</sub>                 | Indene                         | 2.92         | 1    |
| C <sub>7</sub> H <sub>16</sub> O               | 1-Heptanol              | 2.62         | 1    | C <sub>9</sub> H <sub>8</sub> O <sub>2</sub>  | <i>trans</i> -Cinnamic acid    | 2.13         | 1    |
| C <sub>7</sub> H <sub>16</sub> O               | 2-Heptanol              | 2.31         | 1    | C <sub>9</sub> H <sub>7</sub> N               | Benzenepropanenitrile          | 1.72         | 1    |
| C <sub>7</sub> H <sub>16</sub> O               | 3-Heptanol              | 2.24         | 1    | C <sub>9</sub> H <sub>10</sub>                | Indan                          | 3.33         | 1    |
| C <sub>7</sub> H <sub>16</sub> O               | 4-Heptanol              | 2.22         | 1    | C <sub>9</sub> H <sub>10</sub> O              | 1-Phenyl-1-propanone           | 2.19         | 1    |
| C <sub>7</sub> H <sub>17</sub> N               | Heptylamine             | 2.57         | 1    | C <sub>9</sub> H <sub>10</sub> O              | 1-Phenyl-2-propanone           | 1.44         | 1    |
| C <sub>8</sub> H <sub>6</sub>                  | Phenylacetylene         | 2.40         | 1    | C <sub>9</sub> H <sub>10</sub> O              | 4-Methylacetophenone           | 2.19         | 1    |

| Mol. form.                                     | Name                                     | log <i>P</i> | Ref. | Mol. form.                                     | Name                          | log <i>P</i> | Ref. |
|------------------------------------------------|------------------------------------------|--------------|------|------------------------------------------------|-------------------------------|--------------|------|
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>  | 2-Phenylpropanoic acid                   | 1.80         | 1    | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub> | 2,3,4,5-Tetrachlorobiphenyl   | 5.72         | 3    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>  | Benzyl acetate                           | 1.96         | 1    | C <sub>12</sub> H <sub>6</sub> Cl <sub>4</sub> | 2,2',4',5-Tetrachlorobiphenyl | 5.73         | 7    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>  | 4-Methylphenyl acetate                   | 2.11         | 1    | C <sub>12</sub> H <sub>7</sub> Cl <sub>3</sub> | 2,4,5-Trichlorobiphenyl       | 5.60         | 3    |
| C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>  | Ethyl benzoate                           | 2.64         | 1    | C <sub>12</sub> H <sub>7</sub> Cl <sub>3</sub> | 2,4,6-Trichlorobiphenyl       | 5.47         | 3    |
| C <sub>9</sub> H <sub>12</sub>                 | Propylbenzene                            | 3.69         | 1    | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub> | 2,5-Dichlorobiphenyl          | 5.10         | 3    |
| C <sub>9</sub> H <sub>12</sub>                 | Isopropylbenzene                         | 3.66         | 1    | C <sub>12</sub> H <sub>8</sub> Cl <sub>2</sub> | 2,6-Dichlorobiphenyl          | 5.00         | 3    |
| C <sub>9</sub> H <sub>12</sub>                 | <i>o</i> -Ethyltoluene                   | 3.53         | 1    | C <sub>12</sub> H <sub>8</sub> O               | Dibenzofuran                  | 4.12         | 1    |
| C <sub>9</sub> H <sub>12</sub>                 | <i>p</i> -Ethyltoluene                   | 3.63         | 2    | C <sub>12</sub> H <sub>9</sub> Cl              | 2-Chlorobiphenyl              | 4.52         | 1    |
| C <sub>9</sub> H <sub>12</sub>                 | 1,2,3-Trimethylbenzene                   | 3.60         | 1    | C <sub>12</sub> H <sub>9</sub> Cl              | 3-Chlorobiphenyl              | 4.58         | 1    |
| C <sub>9</sub> H <sub>12</sub>                 | 1,2,4-Trimethylbenzene                   | 3.63         | 1    | C <sub>12</sub> H <sub>9</sub> Cl              | 4-Chlorobiphenyl              | 4.61         | 1    |
| C <sub>9</sub> H <sub>12</sub>                 | 1,3,5-Trimethylbenzene                   | 3.42         | 1    | C <sub>12</sub> H <sub>9</sub> N               | Carbazole                     | 3.72         | 1    |
| C <sub>9</sub> H <sub>12</sub> O               | 2-Propylphenol                           | 2.93         | 1    | C <sub>12</sub> H <sub>10</sub>                | Acenaphthene                  | 3.96         | 4    |
| C <sub>9</sub> H <sub>12</sub> O               | 4-Propylphenol                           | 3.20         | 1    | C <sub>12</sub> H <sub>10</sub>                | Biphenyl                      | 3.76         | 6    |
| C <sub>9</sub> H <sub>12</sub> O               | 2,3,6-Trimethylphenol                    | 2.67         | 1    | C <sub>12</sub> H <sub>10</sub> N <sub>2</sub> | Azobenzene                    | 3.82         | 1    |
| C <sub>9</sub> H <sub>12</sub> O               | 2,4,6-Trimethylphenol                    | 2.46         | 1    | C <sub>12</sub> H <sub>10</sub> O              | Diphenyl ether                | 4.21         | 1    |
| C <sub>9</sub> H <sub>12</sub> O               | Benzenepropanol                          | 1.88         | 1    | C <sub>12</sub> H <sub>10</sub> S              | Diphenyl sulfide              | 4.45         | 1    |
| C <sub>9</sub> H <sub>13</sub> N               | <i>N,N</i> -Dimethylbenzylamine          | 1.98         | 1    | C <sub>12</sub> H <sub>11</sub> N              | Diphenylamine                 | 3.44         | 4    |
| C <sub>9</sub> H <sub>13</sub> N               | Amphetamine                              | 1.76         | 1    | C <sub>12</sub> H <sub>12</sub>                | 1-Ethyl-naphthalene           | 4.40         | 1    |
| C <sub>9</sub> H <sub>18</sub>                 | 1-Nonene                                 | 5.15         | 1    | C <sub>12</sub> H <sub>12</sub>                | 1,2-Dimethylnaphthalene       | 4.31         | 1    |
| C <sub>9</sub> H <sub>18</sub> O               | 2-Nonanone                               | 3.16         | 1    | C <sub>12</sub> H <sub>12</sub>                | 1,4-Dimethylnaphthalene       | 4.37         | 1    |
| C <sub>9</sub> H <sub>18</sub> O               | 5-Methyl-2-octanone                      | 2.92         | 1    | C <sub>12</sub> H <sub>14</sub> O              | 4-Phenylcyclohexanone         | 2.45         | 1    |
| C <sub>9</sub> H <sub>20</sub>                 | Nonane                                   | 5.65         | 1    | C <sub>12</sub> H <sub>18</sub>                | Hexylbenzene                  | 5.52         | 1    |
| C <sub>9</sub> H <sub>20</sub> O               | 1-Nonanol                                | 4.02         | 1    | C <sub>12</sub> H <sub>18</sub>                | Hexamethylbenzene             | 4.69         | 4    |
| C <sub>9</sub> H <sub>21</sub> N               | Tripropylamine                           | 2.79         | 1    | C <sub>12</sub> H <sub>22</sub> O              | Cyclododecanone               | 4.10         | 1    |
| C <sub>10</sub> H <sub>7</sub> Cl              | 1-Chloronaphthalene                      | 3.90         | 1    | C <sub>12</sub> H <sub>24</sub> O <sub>2</sub> | Dodecanoic acid               | 4.6          | 1    |
| C <sub>10</sub> H <sub>7</sub> Cl              | 2-Chloronaphthalene                      | 3.98         | 1    | C <sub>12</sub> H <sub>26</sub> O              | 1-Dodecanol                   | 5.13         | 1    |
| C <sub>10</sub> H <sub>8</sub>                 | Naphthalene                              | 3.34         | 4    | C <sub>13</sub> H <sub>8</sub> O               | 9H-Fluoren-9-one              | 3.58         | 1    |
| C <sub>10</sub> H <sub>8</sub>                 | Azulene                                  | 3.22         | 1    | C <sub>13</sub> H <sub>9</sub> N               | Acridine                      | 3.40         | 1    |
| C <sub>10</sub> H <sub>8</sub> O               | 1-Naphthol                               | 2.84         | 1    | C <sub>13</sub> H <sub>10</sub>                | 9H-Fluorene                   | 4.20         | 4    |
| C <sub>10</sub> H <sub>8</sub> O               | 2-Naphthol                               | 2.70         | 1    | C <sub>13</sub> H <sub>10</sub> O              | Benzophenone                  | 3.18         | 1    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> | Isopropyl benzoate                       | 3.18         | 1    | C <sub>13</sub> H <sub>10</sub> O <sub>2</sub> | Phenyl benzoate               | 3.59         | 1    |
| C <sub>10</sub> H <sub>14</sub>                | Butylbenzene                             | 4.26         | 1    | C <sub>13</sub> H <sub>11</sub> NO             | <i>N</i> -Phenylbenzamide     | 2.62         | 1    |
| C <sub>10</sub> H <sub>14</sub>                | <i>tert</i> -Butylbenzene                | 4.11         | 1    | C <sub>13</sub> H <sub>12</sub>                | Diphenylmethane               | 4.14         | 1    |
| C <sub>10</sub> H <sub>14</sub>                | Isobutylbenzene                          | 4.01         | 2    | C <sub>13</sub> H <sub>12</sub>                | 4-Methylbiphenyl              | 4.63         | 1    |
| C <sub>10</sub> H <sub>14</sub>                | <i>p</i> -Cymene                         | 4.10         | 1    | C <sub>13</sub> H <sub>12</sub> O              | Diphenylmethanol              | 2.67         | 1    |
| C <sub>10</sub> H <sub>14</sub>                | 1,2,4,5-Tetramethylbenzene               | 4.10         | 2    | C <sub>13</sub> H <sub>12</sub> O              | Benzyl phenyl ether           | 3.79         | 1    |
| C <sub>10</sub> H <sub>14</sub>                | 1,2,3,4-Tetramethylbenzene               | 4.00         | 1    | C <sub>14</sub> H <sub>10</sub>                | Anthracene                    | 4.56         | 4    |
| C <sub>10</sub> H <sub>14</sub>                | 1,2,3,5-Tetramethylbenzene               | 4.10         | 1    | C <sub>14</sub> H <sub>10</sub>                | Phenanthrene                  | 4.52         | 4    |
| C <sub>10</sub> H <sub>14</sub> O              | 4-Butylphenol                            | 3.65         | 1    | C <sub>14</sub> H <sub>12</sub>                | <i>trans</i> -Stilbene        | 4.81         | 1    |
| C <sub>10</sub> H <sub>20</sub> O              | 2-Decanone                               | 3.77         | 1    | C <sub>14</sub> H <sub>12</sub>                | 1-Methylfluorene              | 4.97         | 1    |
| C <sub>10</sub> H <sub>20</sub> O <sub>2</sub> | Decanoic acid                            | 4.09         | 1    | C <sub>14</sub> H <sub>12</sub> O              | 2-Phenylacetophenone          | 3.18         | 1    |
| C <sub>10</sub> H <sub>22</sub>                | Decane                                   | 6.25         | 1    | C <sub>14</sub> H <sub>12</sub> O <sub>2</sub> | Benzyl benzoate               | 3.97         | 1    |
| C <sub>10</sub> H <sub>22</sub> O              | 1-Decanol                                | 4.57         | 1    | C <sub>14</sub> H <sub>14</sub>                | 1,2-Diphenylethane            | 4.70         | 1    |
| C <sub>11</sub> H <sub>9</sub> N               | 4-Phenylpyridine                         | 2.59         | 1    | C <sub>14</sub> H <sub>14</sub>                | 4,4'-Dimethylbiphenyl         | 5.09         | 1    |
| C <sub>11</sub> H <sub>10</sub>                | 1-Methylnaphthalene                      | 3.87         | 1    | C <sub>14</sub> H <sub>22</sub>                | Octylbenzene                  | 6.30         | 1    |
| C <sub>11</sub> H <sub>10</sub>                | 2-Methylnaphthalene                      | 4.00         | 1    | C <sub>14</sub> H <sub>28</sub> O <sub>2</sub> | Tetradecanoic acid            | 6.1          | 1    |
| C <sub>11</sub> H <sub>16</sub>                | Pentylbenzene                            | 4.90         | 1    | C <sub>15</sub> H <sub>12</sub>                | 2-Methylantracene             | 5.15         | 2    |
| C <sub>11</sub> H <sub>16</sub>                | Pentamethylbenzene                       | 4.56         | 1    | C <sub>15</sub> H <sub>12</sub>                | 9-Methylantracene             | 5.07         | 1    |
| C <sub>11</sub> H <sub>22</sub> O              | 2-Undecanone                             | 4.09         | 1    | C <sub>15</sub> H <sub>12</sub>                | 1-Methylphenanthrene          | 5.14         | 2    |
| C <sub>11</sub> H <sub>22</sub> O <sub>2</sub> | Methyl decanoate                         | 4.41         | 1    | C <sub>16</sub> H <sub>10</sub>                | Fluoranthene                  | 5.07         | 4    |
| C <sub>12</sub> Cl <sub>10</sub>               | Decachlorobiphenyl                       | 8.26         | 3    | C <sub>16</sub> H <sub>10</sub>                | Pyrene                        | 5.08         | 4    |
| C <sub>12</sub> HCl <sub>9</sub>               | 2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl | 8.16         | 3    | C <sub>16</sub> H <sub>14</sub>                | 9,10-Dimethylantracene        | 5.69         | 1    |
| C <sub>12</sub> H <sub>2</sub> Cl <sub>8</sub> | 2,2',3,3',5,5',6,6'-Octachlorobiphenyl   | 7.10         | 3    | C <sub>16</sub> H <sub>32</sub> O <sub>2</sub> | Hexadecanoic acid             | 7.17         | 1    |
| C <sub>12</sub> H <sub>3</sub> Cl <sub>7</sub> | 2,2',3,3',4,4',6-Heptachlorobiphenyl     | 6.70         | 3    | C <sub>17</sub> H <sub>12</sub>                | 11H-Benzo[a]fluorene          | 5.40         | 1    |
| C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub> | 2,2',3,3',4,4'-Hexachlorobiphenyl        | 7.00         | 3    | C <sub>17</sub> H <sub>12</sub>                | 11H-Benzo[b]fluorene          | 5.75         | 1    |
| C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub> | 2,2',4,4',6,6'-Hexachlorobiphenyl        | 7.00         | 3    | C <sub>18</sub> H <sub>12</sub>                | Benz[a]anthracene             | 5.91         | 1    |
| C <sub>12</sub> H <sub>4</sub> Cl <sub>6</sub> | 2,2',3,3',6,6'-Hexachlorobiphenyl        | 6.70         | 3    | C <sub>18</sub> H <sub>12</sub>                | Chrysene                      | 5.73         | 4    |
| C <sub>12</sub> H <sub>5</sub> Cl <sub>5</sub> | 2,3,4,5,6-Pentachlorobiphenyl            | 6.30         | 3    | C <sub>18</sub> H <sub>12</sub>                | Naphthacene                   | 5.76         | 1    |
| C <sub>12</sub> H <sub>5</sub> Cl <sub>5</sub> | 2,2',4,5,5'-Pentachlorobiphenyl          | 6.40         | 3    | C <sub>18</sub> H <sub>12</sub>                | Triphenylene                  | 5.49         | 4    |
|                                                |                                          |              |      | C <sub>18</sub> H <sub>15</sub> N              | Triphenylamine                | 5.74         | 1    |
|                                                |                                          |              |      | C <sub>18</sub> H <sub>30</sub> O <sub>2</sub> | Linolenic acid                | 6.46         | 1    |

| Mol. form.                                     | Name              | log <i>P</i> | Ref. | Mol. form.                                     | Name                                         | log <i>P</i> | Ref. |
|------------------------------------------------|-------------------|--------------|------|------------------------------------------------|----------------------------------------------|--------------|------|
| C <sub>18</sub> H <sub>32</sub> O <sub>2</sub> | Linoleic acid     | 7.05         | 1    | C <sub>20</sub> H <sub>40</sub> O <sub>2</sub> | Arachidic acid                               | 9.29         | 1    |
| C <sub>18</sub> H <sub>34</sub> O <sub>2</sub> | Oleic acid        | 7.64         | 1    | C <sub>21</sub> H <sub>16</sub>                | 1,2-Dihydro-3-methylbenz[j]<br>aceanthrylene | 6.75         | 1    |
| C <sub>18</sub> H <sub>36</sub> O <sub>2</sub> | Stearic acid      | 8.23         | 1    | C <sub>22</sub> H <sub>12</sub>                | Benzo[ghi]perylene                           | 6.90         | 1    |
| C <sub>19</sub> H <sub>16</sub> O              | Triphenylmethanol | 3.68         | 1    | C <sub>24</sub> H <sub>12</sub>                | Coronene                                     | 6.05         | 4    |
| C <sub>20</sub> H <sub>12</sub>                | Perylene          | 6.25         | 1    |                                                |                                              |              |      |
| C <sub>20</sub> H <sub>12</sub>                | Benzo[a]pyrene    | 6.20         | 4    |                                                |                                              |              |      |
| C <sub>20</sub> H <sub>32</sub> O <sub>2</sub> | Arachidonic acid  | 6.98         | 1    |                                                |                                              |              |      |

## PROTECTION AGAINST IONIZING RADIATION

The following data and rules of thumb are helpful in estimating the penetrating capability of and danger of exposure to various types of ionizing radiation. More precise data should be used for critical applications.

### Alpha Particles

Alpha particles of at least 7.5 MeV are required to penetrate the epidermis, the protective layer of skin, 0.07 mm thick.

### Electrons

Electrons of at least 70 keV are required to penetrate the epidermis, the protective layer of skin, 0.07 mm thick.

The range of electrons in  $\text{g/cm}^2$  is approximately equal to the maximum energy ( $E$ ) in MeV divided by 2.

The range of electrons in air is about 3.65 m per MeV; for example, a 3 MeV electron has a range of about 11 m in air.

A chamber wall thickness of 30  $\text{mg/cm}^2$  will transmit 70% of the initial fluence of 1 MeV electrons and 20% of that of 0.4 MeV electrons.

When electrons of 1 to 2 MeV pass through light materials such as water, aluminum, or glass, less than 1% of their energy is dissipated as bremsstrahlung.

The bremsstrahlung from 1 Ci of  $^{32}\text{P}$  aqueous solution in a glass bottle is about 1 mR/h at 1 meter distance.

When electrons from a 1 Ci source of  $^{90}\text{Sr} - ^{90}\text{Y}$  are absorbed, the bremsstrahlung hazard is approximately equal to that presented by the gamma radiation from 12 mg of radium. The average energy of the bremsstrahlung is about 300 keV.

### Gamma Rays

The air-scattered radiation (sky-shine) from a 100 Ci  $^{60}\text{Co}$  source placed 1 ft behind a 4 ft high shield is about 100 mrad/h at 6 ft from the outside of the shield.

Within  $\pm 20\%$  for point source gamma emitters with energies between 0.07 and 4 MeV, the exposure rate (R/h) at 1 ft is  $6C \cdot E \cdot n$  where  $C$  is the activity in curies,  $E$  is the energy in MeV, and  $n$  is the number of gammas per disintegration.

### Neutrons

An approximate HVL (thickness of absorber for which the neutron flux falls to half its initial value) for 1 MeV neutrons is 3.2 cm of paraffin; that for 5 MeV neutrons is 6.9 cm of paraffin.

### Miscellaneous

The activity of any radionuclide is reduced to less than 1% after 7 half-lives (i.e.,  $2^{-7} = 0.8\%$ ).

For nuclides with a half-life greater than 6 days, the change in activity in 24 hours will be less than 10%.

10 HVL (half-value layers) attenuates approximately by  $10^{-3}$ .

There is 0.64  $\text{mm}^3$  of radon gas at STP in transient equilibrium with 1 Ci of radium.

The natural background from all sources in most parts of the world leads to an equivalent dose rate of about 0.04 to 4 mSv per year for the average person. About 84% of this comes from terrestrial sources, the remainder from cosmic rays. The U. S. average is about 3.6 mSv/yr but can range up to 50 mSv/yr in some areas. A passenger in a plane flying at 12,000 meters receives 5  $\mu\text{Sv/hr}$  from cosmic rays (as compared to about 0.03  $\mu\text{Sv/hr}$  at sea level).

The ICRP recommended exposure limit to man-made sources of ionizing radiation (Reference 2) is 20 mSv/yr averaged over 5 years, with the dose in any one year not to exceed 50 mSv.

A whole-body dose of about 3 Gy over a short time interval will typically lead to 50% mortality in 30 days assuming no medical treatment.

### Units

The gray (Gy) is the SI unit of absorbed dose; it is a measure of the mean energy imparted to a sample of irradiated matter, divided by the mass of the sample. Gy is a special name for the SI unit J/kg.

The sievert (Sv) is the SI unit of equivalent dose, which is defined as the absorbed dose multiplied by a weighting factor that expresses the long-term biological risk from low-level chronic exposure to a specified type of radiation. The Sv is another special name for J/kg.

1 curie (Ci) =  $3.7 \cdot 10^{10}$  becquerel (Bq); i.e.,  $3.7 \cdot 10^{10}$  disintegrations per second.

1 roentgen (R) =  $2.58 \cdot 10^{-4}$  coulomb per kilogram (C/kg); a measure of the charge (positive or negative) liberated by x-ray or gamma radiation in air, divided by the mass of air.

1 rad = 0.01 Gy

1 rem = 0.01 Sv

## References

1. Padikal, T. N., and Fivozinsky, S. P., *Medical Physics Data Book, National Bureau of Standards Handbook 138*, U.S. Government Printing Office, Washington, D.C., 1981.
2. *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, *Annals of the ICRP*, Pergamon Press, Oxford, 1991.
3. *Radiation: Doses, Effects, Risks*, United Nations Sales No. E.86.III.D.4, 1985.
4. Eidelman, S., et al., *Physics Letters*, B592, 1, 2004.

# ANNUAL LIMITS ON INTAKES OF RADIONUCLIDES

K. F. Eckerman

The following table lists, for workers, the annual limits on oral and inhalation intakes (ALI) for selected radionuclides based on the occupational radiation protection guidance of the International Commission on Radiological Protection (References 1 and 2). An intake of one ALI corresponds to an annual whole body dose of 0.02 Sv (2 rem).

The ALI is expressed in the SI unit of activity, the becquerel (Bq), and in the conventional unit, the microcurie ( $\mu\text{Ci}$ );  $1 \mu\text{Ci} = 3.7 \cdot 10^4 \text{ Bq}$ . The chemical form of inhaled radionuclides is, in most instances, stated in terms of the rate of absorption to blood from the lungs and the fractional absorption from the small intestine. Type F, M, and S denote chemical forms which are absorbed from the lungs at rates characterized as fast, moderate, and slow, respectively. The time to absorb 90% of the deposited radionuclide, in the absence of radioactive decay, corresponds to about 10 minutes, 150 days, and 7000 days for Type F, M, and S compounds, respec-

tively. Type F compounds can be considered to be more soluble than M or S, S being the most insoluble. Chemical form consideration for ingestion is specified by the fractional absorption from the small intestine, denoted as  $f_1$ . The  $f_1$  values range from  $10^{-5}$  to 1. Higher fractional absorption is associated with greater solubility of the compound.

## References

1. *1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Annals of the ICRP 21, (1-3)*, Pergamon Press, Oxford, 1991.
2. *Dose Coefficients for Intakes of Radionuclides by Workers, ICRP Publication 68, Annals of the ICRP, 24(4)*, Pergamon Press, Oxford, 1995.

|                  | Physical<br>half-life | Inhalation intakes              |         |                | Oral intakes              |         |                |
|------------------|-----------------------|---------------------------------|---------|----------------|---------------------------|---------|----------------|
|                  |                       | Chemical<br>form<br>Type/ $f_1$ | ALI     |                | Chemical<br>form<br>$f_1$ | ALI     |                |
|                  |                       |                                 | Bq      | $\mu\text{Ci}$ |                           | Bq      | $\mu\text{Ci}$ |
| $^3\text{H}$     | 12.3 y                | HT gas                          | 1.1E+13 | 3.0E+08        | 1.000                     | 1.1E+13 | 3.0E+08        |
| $^{11}\text{C}$  | 0.340 h               | HTO vapor                       | 1.1E+09 | 3.0E+04        | 1.000                     | 8.3E+08 | 2.3E+04        |
|                  |                       | CO                              | 1.7E+10 | 4.5E+05        |                           |         |                |
|                  |                       | CO <sub>2</sub>                 | 9.1E+09 | 2.5E+05        |                           |         |                |
|                  |                       | Organic compounds               | 6.2E+09 | 1.7E+05        |                           |         |                |
| $^{14}\text{C}$  | 5730 y                | CO                              | 2.5E+10 | 6.8E+05        | 1.000                     | 3.4E+07 | 9.3E+02        |
|                  |                       | CO <sub>2</sub>                 | 3.1E+09 | 8.3E+04        |                           |         |                |
|                  |                       | Organic compounds               | 3.4E+07 | 9.3E+02        |                           |         |                |
|                  |                       |                                 |         |                |                           |         |                |
| $^{18}\text{F}$  | 1.83 h                | F 1.000                         | 3.7E+08 | 1.0E+04        | 1.000                     | 4.1E+08 | 1.1E+04        |
|                  |                       | M 1.000                         | 2.2E+08 | 6.1E+03        |                           |         |                |
|                  |                       | S 1.000                         | 2.2E+08 | 5.8E+03        |                           |         |                |
|                  |                       |                                 |         |                |                           |         |                |
| $^{22}\text{Na}$ | 2.60 y                | F 1.000                         | 1.0E+07 | 2.7E+02        | 1.000                     | 6.3E+06 | 1.7E+02        |
| $^{24}\text{Na}$ | 15.0 h                | F 1.000                         | 3.8E+07 | 1.0E+03        | 1.000                     | 4.7E+07 | 1.3E+03        |
| $^{32}\text{P}$  | 14.3 d                | F 0.800                         | 1.8E+07 | 4.9E+02        | 0.800                     | 8.3E+06 | 2.3E+02        |
|                  |                       | M 0.800                         | 6.9E+06 | 1.9E+02        |                           |         |                |
| $^{35}\text{S}$  | 87.4 d                | Inorganic compounds             |         |                | 0.800                     | 1.4E+08 | 3.9E+03        |
|                  |                       | F 0.800                         | 2.5E+08 | 6.8E+03        |                           |         |                |
|                  |                       | M 0.800                         | 1.8E+07 | 4.9E+02        |                           |         |                |
|                  |                       | Vapor                           | 1.7E+08 | 4.5E+03        |                           |         |                |
|                  |                       | Organic compounds               |         |                |                           |         |                |
|                  |                       |                                 |         |                |                           |         |                |
|                  |                       |                                 |         |                |                           |         |                |
| $^{42}\text{K}$  | 12.4 h                | F 1.000                         | 1.0E+08 | 2.7E+03        | 1.000                     | 2.6E+07 | 7.0E+02        |
| $^{43}\text{K}$  | 22.6 h                | F 1.000                         | 7.7E+07 | 2.1E+03        | 1.000                     | 8.0E+07 | 2.2E+03        |
| $^{45}\text{Ca}$ | 163 d                 | M 0.300                         | 8.7E+06 | 2.4E+02        | 0.300                     | 2.6E+07 | 7.1E+02        |
| $^{47}\text{Ca}$ | 4.53 d                | M 0.300                         | 9.5E+06 | 2.6E+02        | 0.300                     | 1.3E+07 | 3.4E+02        |
| $^{51}\text{Cr}$ | 27.7 d                | F 0.100                         | 6.7E+08 | 1.8E+04        | 0.100                     | 5.3E+08 | 1.4E+04        |
|                  |                       | M 0.100                         | 5.9E+08 | 1.6E+04        |                           |         |                |
|                  |                       | S 0.100                         | 5.6E+08 | 1.5E+04        |                           |         |                |
|                  |                       |                                 |         |                |                           |         |                |
| $^{54}\text{Mn}$ | 312 d                 | F 0.100                         | 1.8E+07 | 4.9E+02        | 0.100                     | 2.8E+07 | 7.6E+02        |
|                  |                       | M 0.100                         | 1.7E+07 | 4.5E+02        |                           |         |                |
| $^{52}\text{Fe}$ | 8.28 h                | F 0.100                         | 2.9E+07 | 7.8E+02        | 0.100                     | 1.4E+07 | 3.9E+02        |
|                  |                       | M 0.100                         | 2.1E+07 | 5.7E+02        |                           |         |                |
| $^{55}\text{Fe}$ | 2.70 y                | F 0.100                         | 2.2E+07 | 5.9E+02        | 0.100                     | 6.1E+07 | 1.6E+03        |
|                  |                       | M 0.100                         | 6.1E+07 | 1.6E+03        |                           |         |                |

|                           | Physical<br>half-life | Inhalation intakes |         |                | Oral intakes     |         |                |
|---------------------------|-----------------------|--------------------|---------|----------------|------------------|---------|----------------|
|                           |                       | Chemical<br>form   | ALI     |                | Chemical<br>form | ALI     |                |
|                           |                       | Type/ $f_1$        | Bq      | $\mu\text{Ci}$ | $f_1$            | Bq      | $\mu\text{Ci}$ |
| $^{59}\text{Fe}$          | 44.5 d                | F 0.100            | 6.7E+06 | 1.8E+02        | 0.100            | 1.1E+07 | 3.0E+02        |
|                           |                       | M 0.100            | 6.3E+06 | 1.7E+02        |                  |         |                |
| $^{57}\text{Co}$          | 271 d                 | M 0.100            | 5.1E+07 | 1.4E+03        | 0.100            | 9.5E+07 | 2.6E+03        |
|                           |                       | S 0.050            | 3.3E+07 | 9.0E+02        | 0.050            | 1.1E+08 | 2.8E+03        |
| $^{58}\text{Co}$          | 70.8 d                | M 0.100            | 1.4E+07 | 3.9E+02        | 0.100            | 2.7E+07 | 7.3E+02        |
|                           |                       | S 0.050            | 1.2E+07 | 3.2E+02        | 0.050            | 2.9E+07 | 7.7E+02        |
| $^{60}\text{Co}$          | 5.27 y                | M 0.100            | 2.8E+06 | 7.6E+01        | 0.100            | 5.9E+06 | 1.6E+02        |
|                           |                       | S 0.050            | 1.2E+06 | 3.2E+01        | 0.050            | 8.0E+06 | 2.2E+02        |
| $^{64}\text{Cu}$          | 12.7 h                | F 0.500            | 2.9E+08 | 7.9E+03        | 0.500            | 1.7E+08 | 4.5E+03        |
|                           |                       | M 0.500            | 1.3E+08 | 3.6E+03        |                  |         |                |
|                           |                       | S 0.500            | 1.3E+08 | 3.6E+03        |                  |         |                |
| $^{59}\text{Ni}$          | 75000 y               | F 0.050            | 9.1E+07 | 2.5E+03        | 0.050            | 3.2E+08 | 8.6E+03        |
|                           |                       | M 0.050            | 2.1E+08 | 5.8E+03        |                  |         |                |
|                           |                       | Vapor              | 2.4E+07 | 6.5E+02        |                  |         |                |
| $^{63}\text{Ni}$          | 96.0 y                | F 0.050            | 3.8E+07 | 1.0E+03        | 0.050            | 1.3E+08 | 3.6E+03        |
|                           |                       | M 0.050            | 6.5E+07 | 1.7E+03        |                  |         |                |
|                           |                       | Vapor              | 1.0E+07 | 2.7E+02        |                  |         |                |
| $^{65}\text{Zn}$          | 244 d                 | S 0.500            | 7.1E+06 | 1.9E+02        | 0.500            | 5.1E+06 | 1.4E+02        |
| $^{67}\text{Ga}$          | 3.26 d                | F 0.001            | 1.8E+08 | 4.9E+03        | 0.001            | 1.1E+08 | 2.8E+03        |
|                           |                       | M 0.001            | 7.1E+07 | 1.9E+03        |                  |         |                |
| $^{68}\text{Ga}$          | 1.13 h                | F 0.001            | 4.1E+08 | 1.1E+04        | 0.001            | 2.0E+08 | 5.4E+03        |
|                           |                       | M 0.001            | 2.5E+08 | 6.7E+03        |                  |         |                |
| $^{68}\text{Ge}$          | 288 d                 | F 1.000            | 2.4E+07 | 6.5E+02        | 1.000            | 1.5E+07 | 4.2E+02        |
|                           |                       | M 1.000            | 2.5E+06 | 6.8E+01        |                  |         |                |
| $^{75}\text{Se}$          | 120 d                 | F 0.800            | 1.4E+07 | 3.9E+02        | 0.800            | 7.7E+06 | 2.1E+02        |
|                           |                       | M 0.800            | 1.2E+07 | 3.2E+02        | 0.050            | 4.9E+07 | 1.3E+03        |
| $^{79}\text{Se}$          | 65000 y               | F 0.800            | 1.3E+07 | 3.4E+02        | 0.800            | 6.9E+06 | 1.9E+02        |
|                           |                       | M 0.800            | 6.5E+06 | 1.7E+02        | 0.050            | 5.1E+07 | 1.4E+03        |
| $^{86}\text{Rb}$          | 18.6 d                | F 1.000            | 1.5E+07 | 4.2E+02        | 1.000            | 7.1E+06 | 1.9E+02        |
| $^{85}\text{Sr}$          | 64.8 d                | F 0.300            | 3.6E+07 | 9.7E+02        | 0.300            | 3.6E+07 | 9.7E+02        |
|                           |                       | S 0.010            | 3.1E+07 | 8.4E+02        | 0.010            | 6.1E+07 | 1.6E+03        |
| $^{87\text{m}}\text{Sr}$  | 2.80 h                | F 0.300            | 9.1E+08 | 2.5E+04        | 0.300            | 6.7E+08 | 1.8E+04        |
|                           |                       | S 0.010            | 5.7E+08 | 1.5E+04        | 0.010            | 6.1E+08 | 1.6E+04        |
| $^{89}\text{Sr}$          | 50.5 d                | F 0.300            | 1.4E+07 | 3.9E+02        | 0.300            | 7.7E+06 | 2.1E+02        |
|                           |                       | S 0.010            | 3.6E+06 | 9.7E+01        | 0.010            | 8.7E+06 | 2.4E+02        |
| $^{90}\text{Sr}$          | 29.1 y                | F 0.300            | 6.7E+05 | 1.8E+01        | 0.300            | 7.1E+05 | 1.9E+01        |
|                           |                       | S 0.010            | 2.6E+05 | 7.0E+00        | 0.010            | 7.4E+06 | 2.0E+02        |
| $^{99}\text{Mo}$          | 2.75 d                | F 0.800            | 5.6E+07 | 1.5E+03        | 0.800            | 2.7E+07 | 7.3E+02        |
|                           |                       | S 0.050            | 1.8E+07 | 4.9E+02        | 0.050            | 1.7E+07 | 4.5E+02        |
| $^{99\text{m}}\text{Tc}$  | 6.02 h                | F 0.800            | 1.0E+09 | 2.7E+04        | 0.800            | 9.1E+08 | 2.5E+04        |
|                           |                       | M 0.800            | 6.9E+08 | 1.9E+04        |                  |         |                |
| $^{99}\text{Tc}$          | 213000 y              | F 0.800            | 5.0E+07 | 1.4E+03        | 0.800            | 2.6E+07 | 6.9E+02        |
|                           |                       | M 0.800            | 6.3E+06 | 1.7E+02        |                  |         |                |
| $^{106}\text{Ru}$         | 1.01 y                | F 0.050            | 2.0E+06 | 5.5E+01        | 0.050            | 2.9E+06 | 7.7E+01        |
|                           |                       | M 0.050            | 1.2E+06 | 3.2E+01        |                  |         |                |
|                           |                       | S 0.050            | 5.7E+05 | 1.5E+01        |                  |         |                |
| $^{111}\text{In}$         | 2.83 d                | F 0.020            | 9.1E+07 | 2.5E+03        | 0.020            | 6.9E+07 | 1.9E+03        |
|                           |                       | M 0.020            | 6.5E+07 | 1.7E+03        |                  |         |                |
| $^{113\text{m}}\text{In}$ | 1.66 h                | F 0.020            | 1.1E+09 | 2.8E+04        | 0.020            | 7.1E+08 | 1.9E+04        |
|                           |                       | M 0.020            | 6.3E+08 | 1.7E+04        |                  |         |                |
| $^{113}\text{Sn}$         | 115 d                 | F 0.020            | 2.5E+07 | 6.8E+02        | 0.020            | 2.7E+07 | 7.4E+02        |
|                           |                       | M 0.020            | 1.1E+07 | 2.8E+02        |                  |         |                |
| $^{123}\text{I}$          | 13.2 h                | F 1.000            | 1.8E+08 | 4.9E+03        | 1.000            | 9.5E+07 | 2.6E+03        |
|                           |                       | Vapor              | 9.5E+07 | 2.6E+03        |                  |         |                |
| $^{125}\text{I}$          | 60.1 d                | F 1.000            | 2.7E+06 | 7.4E+01        | 1.000            | 1.3E+06 | 3.6E+01        |
|                           |                       | Vapor              | 1.4E+06 | 3.9E+01        |                  |         |                |
| $^{129}\text{I}$          | $1.57 \cdot 10^7$ y   | F 1.000            | 3.9E+05 | 1.1E+01        | 1.000            | 1.8E+05 | 4.9E+00        |
|                           |                       | Vapor              | 2.1E+05 | 5.6E+00        |                  |         |                |



|                           |                         | Inhalation intakes  |         |                | Oral intakes  |         |                |
|---------------------------|-------------------------|---------------------|---------|----------------|---------------|---------|----------------|
|                           |                         | Chemical form       | ALI     |                | Chemical form | ALI     |                |
|                           | Physical half-life      | Type/ $f_1$         | Bq      | $\mu\text{Ci}$ | $f_1$         | Bq      | $\mu\text{Ci}$ |
| $^{131}\text{I}$          | 8.04 d                  | F 1.000             | 1.8E+06 | 4.9E+01        | 1.000         | 9.1E+05 | 2.5E+01        |
|                           |                         | Vapor               | 1.0E+06 | 2.7E+01        |               |         |                |
| $^{129}\text{Cs}$         | 1.34 d                  | F 1.000             | 2.5E+08 | 6.7E+03        | 1.000         | 3.3E+08 | 9.0E+03        |
| $^{134}\text{Cs}$         | 2.06 y                  | F 1.000             | 2.1E+06 | 5.6E+01        | 1.000         | 1.1E+06 | 2.8E+01        |
| $^{136}\text{Cs}$         | 13.1 d                  | F 1.000             | 1.1E+07 | 2.8E+02        | 1.000         | 6.7E+06 | 1.8E+02        |
| $^{137}\text{Cs}$         | 30.0 y                  | F 1.000             | 3.0E+06 | 8.1E+01        | 1.000         | 1.5E+06 | 4.2E+01        |
| $^{141}\text{Ce}$         | 32.5 d                  | M 5.0E-04           | 7.4E+06 | 2.0E+02        | 5.0E-04       | 2.8E+07 | 7.6E+02        |
|                           |                         | S 5.0E-04           | 6.5E+06 | 1.7E+02        |               |         |                |
| $^{144}\text{Ce}$         | 284 d                   | M 5.0E-04           | 8.7E+05 | 2.4E+01        | 5.0E-04       | 3.8E+06 | 1.0E+02        |
|                           |                         | S 5.0E-04           | 6.9E+05 | 1.9E+01        |               |         |                |
| $^{133}\text{Ba}$         | 10.7 y                  | F 0.100             | 1.1E+07 | 3.0E+02        | 0.100         | 2.0E+07 | 5.4E+02        |
| $^{140}\text{Ba}$         | 12.7 d                  | F 0.100             | 1.3E+07 | 3.4E+02        | 0.100         | 8.0E+06 | 2.2E+02        |
| $^{169}\text{Yb}$         | 32.0 d                  | M 5.0E-04           | 9.5E+06 | 2.6E+02        | 5.0E-04       | 2.8E+07 | 7.6E+02        |
|                           |                         | S 5.0E-04           | 8.3E+06 | 2.3E+02        |               |         |                |
| $^{198}\text{Au}$         | 2.69 d                  | F 0.100             | 5.1E+07 | 1.4E+03        | 0.100         | 2.0E+07 | 5.4E+02        |
|                           |                         | M 0.100             | 2.0E+07 | 5.5E+02        |               |         |                |
|                           |                         | S 0.100             | 1.8E+07 | 4.9E+02        |               |         |                |
| $^{198\text{m}}\text{Au}$ | 2.30 d                  | F 0.100             | 3.4E+07 | 9.2E+02        | 0.100         | 1.5E+07 | 4.2E+02        |
|                           |                         | M 0.100             | 1.0E+07 | 2.7E+02        |               |         |                |
|                           |                         | S 0.100             | 1.1E+07 | 2.8E+02        |               |         |                |
| $^{197}\text{Hg}$         | 2.67 d                  | Inorganic compounds |         |                |               |         |                |
|                           |                         | F 0.400             | 2.4E+08 | 6.4E+03        | 1.000         | 2.0E+08 | 5.5E+03        |
|                           |                         |                     |         |                | 0.400         | 1.2E+08 | 3.2E+03        |
|                           |                         | Vapor               | 4.5E+06 | 1.2E+02        |               |         |                |
|                           |                         | Organic compounds   |         |                |               |         |                |
|                           |                         | F 0.020             | 2.0E+08 | 5.4E+03        | 0.020         | 8.7E+07 | 2.4E+03        |
|                           |                         | M 0.020             | 7.1E+07 | 1.9E+03        |               |         |                |
| $^{203}\text{Hg}$         | 46.6 d                  | Inorganic compounds |         |                |               |         |                |
|                           |                         | F 0.400             | 2.7E+07 | 7.2E+02        | 1.000         | 1.1E+07 | 2.8E+02        |
|                           |                         |                     |         |                | 0.400         | 1.8E+07 | 4.9E+02        |
|                           |                         | Vapor               | 2.9E+06 | 7.7E+01        |               |         |                |
|                           |                         | Organic compounds   |         |                |               |         |                |
|                           |                         | F 0.020             | 3.4E+07 | 9.2E+02        | 0.020         | 3.7E+07 | 1.0E+03        |
|                           |                         | M 0.020             | 1.1E+07 | 2.8E+02        |               |         |                |
| $^{201}\text{Tl}$         | 3.04 d                  | F 1.000             | 2.6E+08 | 7.1E+03        | 1.000         | 2.1E+08 | 5.7E+03        |
| $^{210}\text{Pb}$         | 22.3 y                  | F 0.200             | 1.8E+04 | 4.9E-01        | 0.200         | 2.9E+04 | 7.9E-01        |
| $^{207}\text{Bi}$         | 38.0 y                  | F 0.050             | 2.4E+07 | 6.4E+02        | 0.050         | 1.5E+07 | 4.2E+02        |
|                           |                         | M 0.050             | 6.3E+06 | 1.7E+02        |               |         |                |
| $^{210}\text{Po}$         | 138 d                   | F 0.100             | 2.8E+04 | 7.6E-01        | 0.100         | 8.3E+04 | 2.3E+00        |
|                           |                         | M 0.100             | 9.1E+03 | 2.5E-01        |               |         |                |
| $^{224}\text{Ra}$         | 3.66 d                  | M 0.200             | 8.3E+03 | 2.3E-01        | 0.200         | 3.1E+05 | 8.3E+00        |
| $^{226}\text{Ra}$         | 1600 y                  | M 0.200             | 1.7E+03 | 4.5E-02        | 0.200         | 7.1E+04 | 1.9E+00        |
| $^{228}\text{Ra}$         | 5.75 y                  | M 0.200             | 1.2E+04 | 3.2E-01        | 0.200         | 3.0E+04 | 8.1E-01        |
| $^{228}\text{Th}$         | 1.91 y                  | M 5.0E-04           | 8.7E+02 | 2.4E-02        | 5.0E-04       | 2.9E+05 | 7.7E+00        |
|                           |                         | S 2.0E-04           | 6.3E+02 | 1.7E-02        | 2.0E-04       | 5.7E+05 | 1.5E+01        |
| $^{230}\text{Th}$         | 77000 y                 | M 5.0E-04           | 7.1E+02 | 1.9E-02        | 5.0E-04       | 9.5E+04 | 2.6E+00        |
|                           |                         | S 2.0E-04           | 2.8E+03 | 7.5E-02        | 2.0E-04       | 2.3E+05 | 6.2E+00        |
| $^{232}\text{Th}$         | 1.40·10 <sup>10</sup> y | M 5.0E-04           | 6.9E+02 | 1.9E-02        | 5.0E-04       | 9.1E+04 | 2.5E+00        |
|                           |                         | S 2.0E-04           | 1.7E+03 | 4.5E-02        | 2.0E-04       | 2.2E+05 | 5.9E+00        |
| $^{234}\text{U}$          | 2.44·10 <sup>5</sup> y  | F 0.020             | 3.1E+04 | 8.4E-01        | 0.020         | 4.1E+05 | 1.1E+01        |
|                           |                         | M 0.020             | 9.5E+03 | 2.6E-01        | 0.002         | 2.4E+06 | 6.5E+01        |
|                           |                         | S 0.002             | 2.9E+03 | 7.9E-02        |               |         |                |
| $^{235}\text{U}$          | 7.04·10 <sup>8</sup> y  | F 0.020             | 3.3E+04 | 9.0E-01        | 0.020         | 4.3E+05 | 1.2E+01        |
|                           |                         | M 0.020             | 1.1E+04 | 3.0E-01        | 0.002         | 2.4E+06 | 6.5E+01        |

|                   | Physical<br>half-life | Inhalation intakes |         |                | Oral intakes     |         |                |
|-------------------|-----------------------|--------------------|---------|----------------|------------------|---------|----------------|
|                   |                       | Chemical<br>form   | ALI     |                | Chemical<br>form | ALI     |                |
|                   |                       | Type/ $f_1$        | Bq      | $\mu\text{Ci}$ | $f_1$            | Bq      | $\mu\text{Ci}$ |
| $^{238}\text{U}$  | $4.47 \cdot 10^9$ y   | S 0.002            | 3.3E+03 | 8.9E-02        |                  |         |                |
|                   |                       | F 0.020            | 3.4E+04 | 9.3E-01        | 0.020            | 4.5E+05 | 1.2E+01        |
|                   |                       | M 0.020            | 1.3E+04 | 3.4E-01        | 0.002            | 2.6E+06 | 7.1E+01        |
|                   |                       | S 0.002            | 3.5E+03 | 9.5E-02        |                  |         |                |
| $^{237}\text{Np}$ | $2.14 \cdot 10^6$ y   | M 5.0E-04          | 1.3E+03 | 3.6E-02        | 5.0E-04          | 1.8E+05 | 4.9E+00        |
| $^{239}\text{Np}$ | 2.36 d                | M 5.0E-04          | 1.8E+07 | 4.9E+02        | 5.0E-04          | 2.5E+07 | 6.8E+02        |
| $^{238}\text{Pu}$ | 87.7 y                | M 5.0E-04          | 6.7E+02 | 1.8E-02        | 5.0E-04          | 8.7E+04 | 2.4E+00        |
|                   |                       | S 1.0E-05          | 1.8E+03 | 4.9E-02        | 1.0E-05          | 2.3E+06 | 6.1E+01        |
| $^{239}\text{Pu}$ | 24100 y               |                    |         |                | 1.0E-04          | 4.1E+05 | 1.1E+01        |
|                   |                       | M 5.0E-04          | 6.3E+02 | 1.7E-02        | 5.0E-04          | 8.0E+04 | 2.2E+00        |
|                   |                       | S 1.0E-05          | 2.4E+03 | 6.5E-02        | 1.0E-05          | 2.2E+06 | 6.0E+01        |
|                   |                       |                    |         |                | 1.0E-04          | 3.8E+05 | 1.0E+01        |
| $^{241}\text{Pu}$ | 14.4 y                | M 5.0E-04          | 3.4E+04 | 9.3E-01        | 5.0E-04          | 4.3E+06 | 1.2E+02        |
|                   |                       | S 1.0E-05          | 2.4E+05 | 6.4E+00        | 1.0E-05          | 1.8E+08 | 4.9E+03        |
|                   |                       |                    |         |                | 1.0E-04          | 2.1E+07 | 5.6E+02        |
| $^{241}\text{Am}$ | 432 y                 | M 5.0E-04          | 7.4E+02 | 2.0E-02        | 5.0E-04          | 1.0E+05 | 2.7E+00        |
| $^{244}\text{Cm}$ | 18.1 y                | M 5.0E-04          | 1.2E+03 | 3.2E-02        | 5.0E-04          | 1.7E+05 | 4.5E+00        |
| $^{252}\text{Cf}$ | 2.64 y                | M 5.0E-04          | 1.5E+03 | 4.2E-02        | 5.0E-04          | 2.2E+05 | 6.0E+00        |

## CHEMICAL CARCINOGENS

The following substances are listed in the 11th Report on Carcinogens 2004 released by the National Institute of Environmental Health Sciences (NIEHS) under the National Toxicology Program (NTP). Substances are grouped in two classes:

- **Known to be human carcinogens:** There is sufficient evidence of carcinogenicity from studies in humans which indicates a causal relationship between exposure to the substance and human cancer.
- **Reasonably anticipated to be human carcinogens:** There is limited evidence of carcinogenicity from studies in humans which indicates that causal interpretation is credible, but that alternative explanations, such as chance, bias, or confounding factors, could not be adequately excluded; or there is sufficient evidence of carcinogenicity from studies in experimental animals.

The NTP report also lists many poorly defined materials such as soots, tars, mineral oils, coke oven emissions, etc. These materials are not included here.

The table lists the name normally used in the *Handbook of Chemistry and Physics*, followed by additional names and acronyms by which the substance is known. In many cases the primary name given here is different from that used in the NTP report; however, names used in the NTP report appear in the Other Names column. The Chemical Abstracts Service Registry Number (CAS RN), given in the last column, is taken from the NTP report. Extensive details on each substance are given in the reference.

### Reference

Public Health Service, National Toxicology Program, 11th Report on Carcinogens, available on the Internet at <<http://ntp.niehs.nih.gov/>>.

| Substance                                                    | Other Names                                                                                                   | CAS RN     |
|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|------------|
| <i>Known to be Human Carcinogens</i>                         |                                                                                                               |            |
| Aflatoxins                                                   |                                                                                                               | 1402-68-2  |
| 4-Aminobiphenyl                                              | <i>p</i> -Biphenylamine                                                                                       | 92-67-1    |
| Arsenic compounds, inorganic                                 |                                                                                                               |            |
| Asbestos                                                     |                                                                                                               | 1332-21-4  |
| Azathioprine                                                 | 6-[(1-Methyl-4-nitro-1 <i>H</i> -imidazol-5-yl)thio]-1 <i>H</i> -purine                                       | 446-86-6   |
| Benzene                                                      |                                                                                                               | 71-43-2    |
| <i>p</i> -Benzidine (includes dyes metabolized to benzidine) | [1,1'-Biphenyl]-4,4'-diamine                                                                                  | 92-87-5    |
| Beryllium and beryllium compounds                            |                                                                                                               | 7440-41-7  |
| Bis(2-chloroethyl) sulfide                                   | Mustard gas                                                                                                   | 505-60-2   |
| Bis(chloromethyl) ether                                      |                                                                                                               | 542-88-1   |
| 1,3-Butadiene                                                |                                                                                                               | 106-99-0   |
| 1,4-Butanediol dimethylsulfonate                             | Myleran; Busulfan                                                                                             | 55-98-1    |
| Cadmium and cadmium compounds                                |                                                                                                               | 7440-43-9  |
| Chlorambucil                                                 |                                                                                                               | 305-03-3   |
| Chloroethene                                                 | Vinyl chloride; Chloroethylene                                                                                | 75-01-4    |
| 1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea       | MeCCNU                                                                                                        | 13909-09-6 |
| Chloromethyl methyl ether                                    |                                                                                                               | 107-30-2   |
| Chromium hexavalent compounds                                |                                                                                                               |            |
| Cyclophosphamide                                             | Cyclophosphane; 2 <i>H</i> -1,3,2-Oxazaphosphorin-2-amine, <i>N,N</i> -bis(2-chloroethyl)tetrahydro-, 2-oxide | 50-18-0    |
| Cyclosporin A                                                | Cyclosporine                                                                                                  | 59865-13-3 |
| Diethylstilbestrol                                           |                                                                                                               | 56-53-1    |
| Erionite                                                     |                                                                                                               | 66733-21-9 |
| Estrogens, steroidal                                         |                                                                                                               |            |
| <i>N</i> -(4-Ethoxyphenyl)acetamide                          | Phenacetin                                                                                                    | 62-44-2    |
| Melphalan                                                    | <i>L</i> -Phenylalanine, 4-[bis(2-chloroethyl)amino]-                                                         | 148-82-3   |
| Methoxsalen (with UV therapy)                                | PUVA; 9-Methoxy-7 <i>H</i> -furo[3,2- <i>g</i> ][1]benzopyran-7-one                                           | 298-81-7   |
| 2-Naphthylamine                                              | 2-Aminonaphthalene; $\beta$ -Naphthylamine                                                                    | 91-59-8    |
| Nickel compounds                                             |                                                                                                               |            |
| Oxirane                                                      | Ethylene oxide                                                                                                | 75-21-8    |

| Substance                                                     | Other Names                                                                                   | CAS RN      |
|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------|
| Radon                                                         |                                                                                               | 10043-92-2  |
| Silicon dioxide (respirable size)                             | Quartz; Silica                                                                                | 14808-60-7  |
| Silicon dioxide (respirable size)                             | Cristobalite; Silica                                                                          | 14464-46-1  |
| Silicon dioxide (respirable size)                             | Tridymite; Silica                                                                             | 15468-32-3  |
| Sulfuric acid (strong acid mists)                             | Oil of vitriol                                                                                | 7664-93-9   |
| Tamoxifen                                                     |                                                                                               | 10540-29-1  |
| 2,3,7,8-Tetrachlorodibenzo- <i>p</i> -dioxin                  | TCDD; Dioxin                                                                                  | 1746-01-6   |
| Thorium(IV) oxide                                             | Thorium dioxide                                                                               | 1314-20-1   |
| Triethylenethiophosphoramidate                                | Thiotepa; Tris(1-aziridinyl)phosphine, sulfide                                                | 52-24-4     |
| <b><i>Reasonably Anticipated to be Human Carcinogens</i></b>  |                                                                                               |             |
| Acetaldehyde                                                  | Ethanal                                                                                       | 75-07-0     |
| 2-(Acetylamino)fluorene                                       |                                                                                               | 53-96-3     |
| Acrylamide                                                    | 2-Propenamide                                                                                 | 79-06-1     |
| Acrylonitrile                                                 | Propenenitrile                                                                                | 107-13-1    |
| 4-Allyl-1,2-dimethoxybenzene                                  | Methyleugenol; 1,2-Dimethoxy-4-allylbenzene                                                   | 93-15-2     |
| 2-Amino-9,10-anthracenedione                                  | 2-Aminoanthraquinone                                                                          | 117-79-3    |
| 1-Amino-2,4-dibromo-9,10-anthracenedione                      | 1-Amino-2,4-dibromoanthraquinone                                                              | 81-49-2     |
| 2-Amino-3,4-dimethylimidazo[4,5- <i>f</i> ]quinoline          | MeIQ                                                                                          | 77094-11-2  |
| 2-Amino-3,8-dimethylimidazo[4,5- <i>f</i> ]quinoxaline        | MeIQx                                                                                         | 77500-04-0  |
| 1-Amino-2-methyl-9,10-anthracenedione                         | 1-Amino-2-methylanthraquinone                                                                 | 82-28-0     |
| 2-Amino-3-methyl-3 <i>H</i> -imidazo[4,5- <i>f</i> ]quinoline | IQ                                                                                            | 76180-96-6  |
| 2-Amino-1-methyl-6-phenylimidazo[4,5- <i>b</i> ]pyridine      | PhIP                                                                                          | 105650-23-5 |
| Azacitidine                                                   | 5-Azacytidine; 4-Amino-1- $\beta$ - <i>D</i> -ribofuranosyl-1,3,5-triazine-2(1 <i>H</i> )-one | 320-67-2    |
| Benz[a]anthracene                                             |                                                                                               | 56-55-3     |
| Benzo[b]fluoranthene                                          | Benzo[e]acephenanthrylene                                                                     | 205-99-2    |
| Benzo[j]fluoranthene                                          |                                                                                               | 205-82-3    |
| Benzo[k]fluoranthene                                          | 2,3,1',8'-Binaphthylene                                                                       | 207-08-9    |
| Benzo[a]pyrene                                                |                                                                                               | 50-32-8     |
| 2,2'-Bioxirane                                                | Diepoxybutane                                                                                 | 1464-53-5   |
| Bis(4-amino-3-chlorophenyl)methane                            | 4,4-Methylene-bis(2-chloraniline); MBOCA                                                      | 101-14-4    |
| 2,2-Bis(bromomethyl)-1,3-propanediol                          | BBMP; Pentaerythritol dibromide                                                               | 3296-90-0   |
| Bis(2-chloroethyl)methylamine                                 | Nitrogen mustard hydrochloride                                                                | 55-86-7     |
| <i>N,N'</i> -Bis(2-chloroethyl)- <i>N</i> -nitrosourea        | BCNU; Carmustine                                                                              | 154-93-8    |
| Bis[4-(dimethylamino)phenyl]methane                           | Michler's Base; 4,4-Methylenebis( <i>N,N</i> -dimethylbenzenamine)                            | 101-61-1    |
| 1,3-Bis(2,3-epoxypropoxy)benzene                              | Diglycidyl resorcinol ether                                                                   | 101-90-6    |
| Bis(2-ethylhexyl) phthalate                                   | DEHP; Di(2-ethylhexyl) phthalate                                                              | 117-81-7    |
| Bromodichloromethane                                          |                                                                                               | 75-27-4     |
| Bromoethene                                                   | Vinyl bromide                                                                                 | 593-60-2    |
| <i>tert</i> -Butyl-4-hydroxyanisole                           | BHA; Butylated hydroxyanisole                                                                 | 25013-16-5  |
| Chloramphenicol                                               |                                                                                               | 56-75-7     |
| Chlorendic acid                                               | 1,4,5,6,7,7-Hexachloro-5-norbornene-2,3-dicarboxylic acid                                     | 115-28-6    |
| Chlorinated paraffins (C <sub>12</sub> , 60% Cl)              |                                                                                               | 108171-26-2 |
| 4-Chloro-1,2-benzenediamine                                   | 4-Chloro- <i>o</i> -phenylenediamine                                                          | 95-83-0     |
| 2-Chloro-1,3-butadiene                                        | Chloroprene                                                                                   | 126-99-8    |
| 1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea                  | CCNU; Lomustine; Belustine                                                                    | 13010-47-4  |
| 4-Chloro-2-methylaniline                                      | <i>p</i> -Chloro- <i>o</i> -toluidine                                                         | 95-69-2     |
| 4-Chloro-2-methylaniline hydrochloride                        | <i>p</i> -Chloro- <i>o</i> -toluidine hydrochloride                                           | 3165-93-3   |

| Substance                                                                 | Other Names                                                                 | CAS RN     |
|---------------------------------------------------------------------------|-----------------------------------------------------------------------------|------------|
| 1-Chloro-2-methylpropene                                                  | Dimethylvinyl chloride                                                      | 513-37-1   |
| 3-Chloro-2-methylpropene                                                  |                                                                             | 563-47-3   |
| Chlorozotocin                                                             | 2-[[[(2-Chloroethyl)nitrosoamino]carbonyl]amino]-2-deoxy- <i>D</i> -glucose | 54749-90-5 |
| Fuchsin                                                                   | C.I. Basic Red 9, monohydrochloride                                         | 569-61-9   |
| Cobalt(II) sulfate                                                        | Cobaltous sulfate                                                           | 10124-43-3 |
| Cupferron                                                                 |                                                                             | 135-20-6   |
| Dacarbazine                                                               | 5-(3,3-Dimethyl-1-triazenyl)-1 <i>H</i> -imidazole-4-carboxamide            | 4342-03-4  |
| Decabromobiphenyl                                                         |                                                                             | 13654-09-6 |
| cis-Diaminedichloroplatinum                                               | Cisplatin                                                                   | 15663-27-1 |
| 2,4-Diaminoanisole sulfate                                                | 1,3-Benzenediamine, 4-methoxy, sulfate                                      | 39156-41-7 |
| 4,4'-Diaminodiphenyl ether                                                | 4,4-Oxydianiline                                                            | 101-80-4   |
| 4,4'-Diaminodiphenylmethane                                               | 4,4'-Methylenedianiline                                                     | 101-77-9   |
| 4,4'-Diaminodiphenylmethane dihydrochloride                               | 4,4'-Methylenedianiline dihydrochloride                                     | 13552-44-8 |
| 4,4'-Diaminodiphenyl sulfide                                              | 4,4'-Thiodianiline                                                          | 139-65-1   |
| Dibenz[a,h]acridine                                                       |                                                                             | 226-36-8   |
| Dibenz[a,j]acridine                                                       | 7-Azadibenz[a,j]anthracene                                                  | 224-42-0   |
| Dibenz[a,h]anthracene                                                     | 1,2:5,6-Dibenzanthracene                                                    | 53-70-3    |
| 7 <i>H</i> -Dibenzo[c,g]carbazole                                         |                                                                             | 194-59-2   |
| Dibenzo[a,e]pyrene                                                        | Naphtho[1,2,3,4- <i>def</i> ]chrysene                                       | 192-65-4   |
| Dibenzo[a,h]pyrene                                                        | Dibenzo[b,def]chrysene                                                      | 189-64-0   |
| Dibenzo[a,i]pyrene                                                        | Benzo[ <i>rst</i> ]pentaphene                                               | 189-55-9   |
| Dibenzo[a,l]pyrene                                                        | Dibenzo[def,p]chrysene                                                      | 191-30-0   |
| 1,2-Dibromo-3-chloropropane                                               |                                                                             | 96-12-8    |
| 1,2-Dibromoethane                                                         | Ethylene dibromide; EDB                                                     | 106-93-4   |
| 2,3-Dibromo-1-propanol                                                    | DBP                                                                         | 96-13-9    |
| 2,3-Dibromo-1-propanol, phosphate (3:1)                                   | Tris(2,3-dibromopropyl) phosphate                                           | 126-72-7   |
| <i>p</i> -Dichlorobenzene                                                 | 1,4-Dichlorobenzene                                                         | 106-46-7   |
| 3,3'-Dichloro- <i>p</i> -benzidine                                        | 3,3'-Dichloro[1,1'-biphenyl]-4,4'-diamine                                   | 91-94-1    |
| 3,3'-Dichloro- <i>p</i> -benzidine dihydrochloride                        | 3,3'-Dichloro-[1,1'-biphenyl]-4,4'-diamine dihydrochloride                  | 612-83-9   |
| 1,2-Dichloroethane                                                        | Ethylene dichloride                                                         | 107-06-2   |
| Dichloromethane                                                           | Methylene chloride                                                          | 75-09-2    |
| 1,3-Dichloropropene (unspecified isomer)                                  |                                                                             | 542-75-6   |
| Diethyl sulfate                                                           |                                                                             | 64-67-5    |
| 2,3-Dihydro-6-propyl-2-thioxo-4(1 <i>H</i> )-pyrimidinone                 | Propylthiouracil                                                            | 51-52-5    |
| 1,8-Dihydroxy-9,10-anthracenedione                                        | Danthron; 1,8-Dihydroxyanthraquinone                                        | 117-10-2   |
| 3,3'-Dimethoxybenzidine (and dyes metabolized to 3,3'-Dimethoxybenzidine) | Dianisidine                                                                 | 119-90-4   |
| <i>p</i> -(Dimethylamino)azobenzene                                       |                                                                             | 60-11-7    |
| 2',3-Dimethyl-4-aminoazobenzene                                           | <i>o</i> -Aminoazotoluene; 4- <i>o</i> -Tolylazo- <i>o</i> -toluidine       | 97-56-3    |
| Dimethylcarbamic chloride                                                 | Dimethylcarbamoyl chloride                                                  | 79-44-7    |
| 1,1-Dimethylhydrazine                                                     | UDMH                                                                        | 57-14-7    |
| Dimethyl sulfate                                                          |                                                                             | 77-78-1    |
| 1,6-Dinitropyrene                                                         |                                                                             | 42397-64-8 |
| 1,8-Dinitropyrene                                                         |                                                                             | 42397-65-9 |
| 1,4-Dioxane                                                               |                                                                             | 123-91-1   |
| 1,2-Diphenylhydrazine                                                     | Hydrazobenzene                                                              | 122-66-7   |
| 1,3-Diphenyl-1-triazene                                                   | Diazoaminobenzene                                                           | 136-35-6   |

| Substance                                                                                                  | Other Names                                                 | CAS RN     |
|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------|
| Disperse Blue No. 1                                                                                        | 1,4,5,8-Tetraamino-9,10-anthracenedione                     | 2475-45-8  |
| Doxorubicin hydrochloride                                                                                  | Adriamycin                                                  | 23214-92-8 |
| Epichlorohydrin                                                                                            | (Chloromethyl)oxirane                                       | 106-89-8   |
| 1,2-Epoxy-4-(epoxyethyl)cyclohexane                                                                        | 4-Vinyl-1-cyclohexene dioxide                               | 106-87-6   |
| Ethyl carbamate                                                                                            | Urethane                                                    | 51-79-6    |
| Ethyl methanesulfonate                                                                                     |                                                             | 62-50-0    |
| <i>N</i> -Ethyl- <i>N</i> -nitrosourea                                                                     | ENU; <i>N</i> -Nitroso- <i>N</i> -ethylurea                 | 759-73-9   |
| Fluoroethene                                                                                               | Vinyl fluoride                                              | 75-02-5    |
| Formaldehyde (gas)                                                                                         | Methanal                                                    | 50-00-0    |
| Furan                                                                                                      |                                                             | 110-00-9   |
| Hexabromobiphenyl isomers                                                                                  | Firemaster FF-1                                             | 67774-32-7 |
| Hexachlorobenzene                                                                                          | Perchlorobenzene                                            | 118-74-1   |
| Hexachlorocyclohexane isomers                                                                              |                                                             | 608-73-1   |
| 1,2,3,4,5,6-Hexachlorocyclohexane, (1 $\alpha$ ,2 $\alpha$ ,3 $\beta$ ,4 $\alpha$ ,5 $\beta$ ,6 $\beta$ )  | $\alpha$ -Hexachlorocyclohexane                             | 319-84-6   |
| 1,2,3,4,5,6-Hexachlorocyclohexane, (1 $\alpha$ ,2 $\beta$ ,3 $\alpha$ ,4 $\beta$ ,5 $\alpha$ ,6 $\beta$ )  | $\beta$ -Hexachlorocyclohexane                              | 319-85-7   |
| 1,2,3,4,5,6-Hexachlorocyclohexane, (1 $\alpha$ ,2 $\alpha$ ,3 $\beta$ ,4 $\alpha$ ,5 $\alpha$ ,6 $\beta$ ) | Lindane; $\gamma$ -Hexachlorocyclohexane                    | 58-89-9    |
| Hexachloroethane                                                                                           | Perchloroethane                                             | 67-72-1    |
| Hexamethylphosphoric triamide                                                                              | Hexamethylphosphoramide; Tris(dimethylamino)phosphine oxide | 680-31-9   |
| Hydrazine                                                                                                  |                                                             | 302-01-2   |
| Hydrazine sulfate                                                                                          |                                                             | 10034-93-2 |
| 2-Imidazolidinethione                                                                                      | Ethylene thiourea                                           | 96-45-7    |
| Indeno[1,2,3- <i>cd</i> ]pyrene                                                                            | 1,10-(1,2-Phenylene)pyrene                                  | 193-39-5   |
| Kepone                                                                                                     | Chlordecone                                                 | 143-50-0   |
| Lead and lead compounds                                                                                    | Includes all lead compounds                                 | 7439-92-1  |
| <i>o</i> -Methoxyaniline hydrochloride                                                                     | <i>o</i> -Anisidine hydrochloride                           | 134-29-2   |
| 2-Methoxy-5-methylaniline                                                                                  | <i>p</i> -Cresidine; 5-Methyl- <i>o</i> -anisidine          | 120-71-8   |
| <i>o</i> -Methylaniline                                                                                    | <i>o</i> -Toluidine                                         | 95-53-4    |
| <i>o</i> -Methylaniline hydrochloride                                                                      | <i>o</i> -Toluidine hydrochloride                           | 636-21-5   |
| 2-Methyl-1,3-butadiene                                                                                     | Isoprene                                                    | 78-79-5    |
| 5-Methylchrysene                                                                                           |                                                             | 3697-24-3  |
| 4,4'-Methylenedianiline dihydrochloride                                                                    | Benzenamine, 4,4'-methylenedi-, dihydrochloride             | 13552-44-8 |
| Methyl methanesulfonate                                                                                    |                                                             | 66-27-3    |
| <i>N</i> -Methyl- <i>N'</i> -nitro- <i>N</i> -nitrosoguanidine                                             |                                                             | 70-25-7    |
| <i>N</i> -Methyl- <i>N</i> -nitrosourea                                                                    | <i>N</i> -Nitroso- <i>N</i> -methylurea                     | 684-93-5   |
| Methyloxirane                                                                                              | 1,2-Propylene oxide                                         | 75-56-9    |
| Metronidazole                                                                                              | 2-Methyl-5-nitro-1 <i>H</i> -imidazole-1-ethanol            | 443-48-1   |
| Mirex                                                                                                      | Hexachloropentadiene dimer                                  | 2385-85-5  |
| Naphthalene                                                                                                |                                                             | 91-20-3    |
| Nickel (metallic)                                                                                          |                                                             | 7440-02-0  |
| Nitrilotriacetic acid                                                                                      | <i>N,N</i> -Bis(carboxymethyl)glycine                       | 139-13-9   |
| 2-Nitroanisole                                                                                             | 1-Methoxy-2-nitrobenzene                                    | 91-23-6    |
| Nitrobenzene                                                                                               |                                                             | 98-95-3    |
| 6-Nitrochrysene                                                                                            |                                                             | 7496-02-8  |
| Nitrofen                                                                                                   | 2,4-Dichloro-1-(4-nitrophenoxy)benzene                      | 1836-75-5  |
| Nitromethane                                                                                               |                                                             | 75-52-5    |
| 2-Nitropropane                                                                                             |                                                             | 79-46-9    |
| 1-Nitropyrene                                                                                              |                                                             | 5522-43-0  |

| Substance                                                  | Other Names                                                                    | CAS RN     |
|------------------------------------------------------------|--------------------------------------------------------------------------------|------------|
| 4-Nitropyrene                                              |                                                                                | 57835-92-4 |
| <i>N</i> -Nitrosodibutylamine                              | Dibutylnitrosamine                                                             | 924-16-3   |
| <i>N</i> -Nitrosodiethanolamine                            | 2,2'-(Nitrosoimino)ethanol                                                     | 1116-54-7  |
| <i>N</i> -Nitrosodiethylamine                              | DEN; Diethylnitrosamine                                                        | 55-18-5    |
| <i>N</i> -Nitrosodimethylamine                             | DMN; Dimethylnitrosamine                                                       | 62-75-9    |
| 4-( <i>N</i> -Nitrosomethylamino)-1-(3-pyridyl)-1-butanone | NNK; Ketone, 3-pyridyl-3-( <i>N</i> -methyl- <i>N</i> -nitrosamino)propyl      | 64091-91-4 |
| <i>N</i> -Nitroso- <i>N</i> -methylvinylamine              | <i>N</i> -Methyl- <i>N</i> -nitrosoethenamine                                  | 4549-40-0  |
| 4-Nitrosomorpholine                                        | <i>N</i> -Nitrosomorpholine                                                    | 59-89-2    |
| <i>N</i> -Nitrosornicotine                                 | <i>N</i> '-Nitroso-3-(2-pyrrolidinyl)pyridine                                  | 16543-55-8 |
| <i>N</i> -Nitrosopiperidine                                | 1-Nitrosopiperidine                                                            | 100-75-4   |
| <i>N</i> -Nitroso- <i>N</i> -propyl-1-propanamine          | <i>N</i> -Nitrosodipropylamine                                                 | 621-64-7   |
| <i>N</i> -Nitrosopyrrolidine                               |                                                                                | 930-55-2   |
| <i>N</i> -Nitrososarcosine                                 | <i>N</i> -Methyl- <i>N</i> -nitrosoglycine                                     | 13256-22-9 |
| Norethisterone                                             | 19-Norpregn-4-en-20-yn-3-one, 17-hydroxy-, (17 $\alpha$ )-                     | 68-22-4    |
| Ochratoxin A                                               |                                                                                | 303-47-9   |
| Octabromobiphenyl isomers                                  |                                                                                | 61288-13-9 |
| 2-Oxetanone                                                | $\beta$ -Propiolactone                                                         | 57-57-8    |
| Oxiranemethanol                                            | Glycidol                                                                       | 556-52-5   |
| Oxymetholone                                               | Androstan-3-one, 17-hydroxy-2-(hydroxymethylene)-17-methyl-                    | 434-07-1   |
| Phenazopyridine hydrochloride                              | 3-(Phenylazo)-2,6-pyridinediamine, monohydrochloride                           | 136-40-3   |
| Phenolphthalein                                            | 3,3-Bis(4-hydroxyphenyl)-1(3 <i>H</i> )-isobenzofuranone                       | 77-09-8    |
| Phenoxybenzamine hydrochloride                             |                                                                                | 63-92-3    |
| Phenyloxirane                                              | Styrene-7,8-oxide                                                              | 96-09-3    |
| Phenytoin                                                  | 5,5-Diphenyl-2,4-imidazolidinedione                                            | 57-41-0    |
| Polybrominated biphenyls                                   | PBBs                                                                           |            |
| Polychlorinated biphenyls                                  | PCBs                                                                           | 1336-36-3  |
| Procarbazine hydrochloride                                 |                                                                                | 366-70-1   |
| Progesterone                                               | Pregn-4-ene-3,20-dione                                                         | 57-83-0    |
| 1,3-Propane sultone                                        | 1,2-Oxathiolane, 2,2-dioxide                                                   | 1120-71-4  |
| Propyleneimine                                             | 2-Methylaziridine                                                              | 75-55-8    |
| Reserpine                                                  |                                                                                | 50-55-5    |
| Safrole                                                    | 5-(2-Propenyl)-1,3-benzodioxole                                                | 94-59-7    |
| Selenium sulfide                                           |                                                                                | 7446-34-6  |
| Streptozotocin                                             | <i>D</i> -Glucopyranose, 2-deoxy-2-[[[(methylnitrosoamino)carbon<br>yl]amino]- | 18883-66-4 |
| Sulfallate                                                 | <i>N,N</i> -Diethyldithiocarbamic acid, 2-chloroallyl ester                    | 95-06-7    |
| Tetrachloroethene                                          | Tetrachloroethylene; Perchloroethylene                                         | 127-18-4   |
| Tetrachloromethane                                         | Carbon tetrachloride                                                           | 56-23-5    |
| Tetrafluoroethene                                          | Tetrafluoroethylene                                                            | 116-14-3   |
| <i>N,N,N',N'</i> -Tetramethyl-4,4'-diaminobenzophenone     | Bis(dimethylamino)benzophenone; Michler's Ketone                               | 90-94-8    |
| Tetranitromethane                                          |                                                                                | 509-14-8   |
| Thioacetamide                                              | Ethanethioamide                                                                | 62-55-5    |
| Thiourea                                                   | Thiocarbamide                                                                  | 62-56-6    |
| <i>o</i> -Tolidine                                         | 3,3'-Dimethylbenzidine                                                         | 119-93-7   |
| Toluene-2,4-diamine                                        | 2,4-Diaminotoluene                                                             | 95-80-7    |
| Toluene diisocyanate (unspecified isomer)                  |                                                                                | 26471-62-5 |
| Toxaphene                                                  | Polychlorocamphene                                                             | 8001-35-2  |

| Substance                                     | Other Names                          | CAS RN  |
|-----------------------------------------------|--------------------------------------|---------|
| 1 <i>H</i> -1,2,4-Triazol-3-amine             | Amitrole                             | 61-82-5 |
| 1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane | DDT; Dichlorodiphenyltrichloroethane | 50-29-3 |
| Trichloroethene                               | Trichloroethylene                    | 79-01-6 |
| Trichloromethane                              | Chloroform                           | 67-66-3 |
| (Trichloromethyl)benzene                      | Benzotrichloride                     | 98-07-7 |
| 2,4,6-Trichlorophenol                         |                                      | 88-06-2 |
| 1,2,3-Trichloropropane                        |                                      | 96-18-4 |



## MISCELLANEOUS MATHEMATICAL CONSTANTS

### $\pi$ CONSTANTS

|                         |   |                                                               |
|-------------------------|---|---------------------------------------------------------------|
| $\pi$                   | = | 3.14159 26535 89793 23846 26433 83279 50288 41971 69399 37511 |
| $1/\pi$                 | = | 0.31830 98861 83790 67153 77675 26745 02872 40689 19291 48091 |
| $\pi^2$                 | = | 9.86960 44010 89358 61883 44909 99876 15113 53136 99407 24079 |
| $\log_e \pi$            | = | 1.14472 98858 49400 17414 34273 51353 05871 16472 94812 91531 |
| $\log_{10} \pi$         | = | 0.49714 98726 94133 85435 12682 88290 89887 36516 78324 38044 |
| $\log_{10} \sqrt{2\pi}$ | = | 0.39908 99341 79057 52478 25035 91507 69595 02099 34102 92128 |

### CONSTANTS INVOLVING $e$

|               |   |                                                                               |
|---------------|---|-------------------------------------------------------------------------------|
| $e$           | = | 2.71828 18284 59045 23536 02874 71352 66249 77572 47093 69996                 |
| $1/e$         | = | 0.36787 94411 71442 32159 55237 70161 46086 74458 11131 03177                 |
| $e^2$         | = | 7.38905 60989 30650 22723 04274 60575 00781 31803 15570 55185                 |
| $M$           | = | $\log_{10} e = 0.43429 44819 03251 82765 11289 18916 60508 22943 97005 80367$ |
| $1/M$         | = | $\log_e 10 = 2.30258 50929 94045 68401 79914 54684 36420 76011 01488 62877$   |
| $\log_{10} M$ | = | 9.63778 43113 00536 78912 29674 98645 – 10                                    |

### $\pi^e$ AND $e^\pi$ CONSTANTS

|             |   |                                                |
|-------------|---|------------------------------------------------|
| $\pi^e$     | = | 22.45915 77183 61045 47342 71522               |
| $e^\pi$     | = | 23.14069 26327 79269 00572 90864               |
| $e^{-\pi}$  | = | 0.04321 39182 63772 24977 44177                |
| $e^{\pi/2}$ | = | 4.81047 73809 65351 65547 30357                |
| $i^i$       | = | $e^{-\pi/2} = 0.20787 95763 50761 90854 69556$ |

### NUMERICAL CONSTANTS

|               |   |                                                               |
|---------------|---|---------------------------------------------------------------|
| $\sqrt{2}$    | = | 1.41421 35623 73095 04880 16887 24209 69807 85696 71875 37695 |
| $\sqrt[3]{2}$ | = | 1.25992 10498 94873 16476 72106 07278 22835 05702 51464 70151 |
| $\log_e 2$    | = | 0.69314 71805 59945 30941 72321 21458 17656 80755 00134 36026 |
| $\log_{10} 2$ | = | 0.30102 99956 63981 19521 37388 94724 49302 67881 89881 46211 |
| $\sqrt{3}$    | = | 1.73205 08075 68877 29352 74463 41505 87236 69428 05253 81039 |
| $\sqrt[3]{3}$ | = | 1.44224 95703 07408 38232 16383 10780 10958 83918 69253 49935 |
| $\log_e 3$    | = | 1.09861 22886 68109 69139 52452 36922 52570 46474 90557 82275 |
| $\log_{10} 3$ | = | 0.47712 12547 19662 43729 50279 03255 11530 92001 28864 19070 |

### OTHER CONSTANTS

|                           |   |                                                         |
|---------------------------|---|---------------------------------------------------------|
| Euler's Constant $\gamma$ | = | 0.57721 56649 01532 86061                               |
| $\log_e \gamma$           | = | –0.54953 93129 81644 82234                              |
| Golden Ratio $\phi$       | = | 1.61803 39887 49894 84820 45868 34365 63811 77203 09180 |

## DECIMAL EQUIVALENTS OF COMMON FRACTIONS

|      |       |       |          |       |       |       |          |
|------|-------|-------|----------|-------|-------|-------|----------|
|      |       | 1/64  | 0.015625 |       |       | 33/64 | 0.515625 |
|      | 1/32  | 2/64  | 0.03125  |       | 17/32 | 34/64 | 0.53125  |
|      |       | 3/64  | 0.046875 |       |       | 35/64 | 0.546875 |
| 1/16 | 2/32  | 4/64  | 0.0625   | 9/16  | 18/32 | 36/64 | 0.5625   |
|      |       | 5/64  | 0.078125 |       |       | 37/64 | 0.578125 |
|      | 3/32  | 6/64  | 0.09375  |       | 19/32 | 38/64 | 0.59375  |
|      |       | 7/64  | 0.109375 |       |       | 39/64 | 0.609375 |
| 1/8  | 4/32  | 8/64  | 0.125    | 5/8   | 20/32 | 40/64 | 0.625    |
|      |       | 9/64  | 0.140625 |       |       | 41/64 | 0.640625 |
|      | 5/32  | 10/64 | 0.15625  |       | 21/32 | 42/64 | 0.65625  |
|      |       | 11/64 | 0.171875 |       |       | 43/64 | 0.671875 |
| 3/16 | 6/32  | 12/64 | 0.1875   | 11/16 | 22/32 | 44/64 | 0.6875   |
|      |       | 13/64 | 0.203125 |       |       | 45/64 | 0.703125 |
|      | 7/32  | 14/64 | 0.21875  |       | 23/32 | 46/64 | 0.71875  |
|      |       | 15/64 | 0.234375 |       |       | 47/64 | 0.734375 |
| 1/4  | 8/32  | 16/64 | 0.25     | 3/4   | 24/32 | 48/64 | 0.75     |
|      |       | 17/64 | 0.265625 |       |       | 49/64 | 0.765625 |
|      | 9/32  | 18/64 | 0.28125  |       | 25/32 | 50/64 | 0.78125  |
|      |       | 19/64 | 0.296875 |       |       | 51/64 | 0.796875 |
| 5/16 | 10/32 | 20/64 | 0.3125   | 13/16 | 26/32 | 52/64 | 0.8125   |
|      |       | 21/64 | 0.328125 |       |       | 53/64 | 0.828125 |
|      | 11/32 | 22/64 | 0.34375  |       | 27/32 | 54/64 | 0.84375  |
|      |       | 23/64 | 0.359375 |       |       | 55/64 | 0.859375 |
| 3/8  | 12/32 | 24/64 | 0.375    | 7/8   | 28/32 | 56/64 | 0.875    |
|      |       | 25/64 | 0.390625 |       |       | 57/64 | 0.890625 |
|      | 13/32 | 26/64 | 0.40625  |       | 29/32 | 58/64 | 0.90625  |
|      |       | 27/64 | 0.421875 |       |       | 59/64 | 0.921875 |
| 7/16 | 14/32 | 28/64 | 0.4375   | 15/16 | 30/32 | 60/64 | 0.9375   |
|      |       | 29/64 | 0.453125 |       |       | 61/64 | 0.953125 |
|      | 15/32 | 30/64 | 0.46875  |       | 31/32 | 62/64 | 0.96875  |
|      |       | 31/64 | 0.484375 |       |       | 63/64 | 0.984375 |
| 1/2  | 16/32 | 32/64 | 0.5      | 1/1   | 32/32 | 64/64 | 1        |

## QUADRATIC FORMULA

The solutions of the equation  $ax^2 + bx + c = 0$ , where  $a \neq 0$ , are given by:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

# EXPONENTIAL AND HYPERBOLIC FUNCTIONS AND THEIR COMMON LOGARITHMS

| $x$  | $e^x$  |             | $e^{-x}$ | $\sinh x$ |             | $\cosh x$ |             | $\tanh x$<br>Value |
|------|--------|-------------|----------|-----------|-------------|-----------|-------------|--------------------|
|      | Value  | $\log_{10}$ |          | Value     | $\log_{10}$ | Value     | $\log_{10}$ |                    |
| 0.00 | 1.0000 | 0.00000     | 1.00000  | 0.0000    | $-\infty$   | 1.0000    | 0.00000     | 0.00000            |
| 0.01 | 1.0101 | .00434      | 0.99005  | .0100     | -2.00001    | 1.0001    | .00002      | .01000             |
| 0.02 | 1.0202 | .00869      | .98020   | .0200     | -2.30106    | 1.0002    | .00009      | .02000             |
| 0.03 | 1.0305 | .01303      | .97045   | .0300     | -2.47719    | 1.0005    | .00020      | .02999             |
| 0.04 | 1.0408 | .01737      | .96079   | .0400     | -2.60218    | 1.0008    | .00035      | .03998             |
| 0.05 | 1.0513 | .02171      | .95123   | .0500     | -2.69915    | 1.0013    | .00054      | .04996             |
| 0.06 | 1.0618 | .02606      | .94176   | .0600     | -2.77841    | 1.0018    | .00078      | .05993             |
| 0.07 | 1.0725 | .03040      | .93239   | .0701     | -2.84545    | 1.0025    | .00106      | .06989             |
| 0.08 | 1.0833 | .03474      | .92312   | .0801     | -2.90355    | 1.0032    | .00139      | .07983             |
| 0.09 | 1.0942 | .03909      | .91393   | .0901     | -2.95483    | 1.0041    | .00176      | .08976             |
| 0.10 | 1.1052 | .04343      | .90484   | .1002     | -1.00072    | 1.0050    | .00217      | .09967             |
| 0.11 | 1.1163 | .04777      | .89583   | .1102     | -1.04227    | 1.0061    | .00262      | .10956             |
| 0.12 | 1.1275 | .05212      | .88692   | .1203     | -1.08022    | 1.0072    | .00312      | .11943             |
| 0.13 | 1.1388 | .05646      | .87809   | .1304     | -1.11517    | 1.0085    | .00366      | .12927             |
| 0.14 | 1.1503 | .06080      | .86936   | .1405     | -1.14755    | 1.0098    | .00424      | .13909             |
| 0.15 | 1.1618 | .06514      | .86071   | .1506     | -1.17772    | 1.0113    | .00487      | .14889             |
| 0.16 | 1.1735 | .06949      | .85214   | .1607     | -1.20597    | 1.0128    | .00554      | .15865             |
| 0.17 | 1.1853 | .07383      | .84366   | .1708     | -1.23254    | 1.0145    | .00625      | .16838             |
| 0.18 | 1.1972 | .07817      | .83527   | .1810     | -1.25762    | 1.0162    | .00700      | .17808             |
| 0.19 | 1.2092 | .08252      | .82696   | .1911     | -1.28136    | 1.0181    | .00779      | .18775             |
| 0.20 | 1.2214 | .08686      | .81873   | .2013     | -1.30392    | 1.0201    | .00863      | .19738             |
| 0.21 | 1.2337 | .09120      | .81058   | .2115     | -1.32541    | 1.0221    | .00951      | .20697             |
| 0.22 | 1.2461 | .09554      | .80252   | .2218     | -1.34592    | 1.0243    | .01043      | .21652             |
| 0.23 | 1.2586 | .09989      | .79453   | .2320     | -1.36555    | 1.0266    | .01139      | .22603             |
| 0.24 | 1.2712 | .10423      | .78663   | .2423     | -1.38437    | 1.0289    | .01239      | .23550             |
| 0.25 | 1.2840 | .10857      | .77880   | .2526     | -1.40245    | 1.0314    | .01343      | .24492             |
| 0.26 | 1.2969 | .11292      | .77105   | .2629     | -1.41986    | 1.0340    | .01452      | .25430             |
| 0.27 | 1.3100 | .11726      | .76338   | .2733     | -1.43663    | 1.0367    | .01564      | .26362             |
| 0.28 | 1.3231 | .12160      | .75578   | .2837     | -1.45282    | 1.0395    | .01681      | .27291             |
| 0.29 | 1.3364 | .12595      | .74826   | .2941     | -1.46847    | 1.0423    | .01801      | .28213             |
| 0.30 | 1.3499 | .13029      | .74082   | .3045     | -1.48362    | 1.0453    | .01926      | .29131             |
| 0.31 | 1.3634 | .13463      | .73345   | .3150     | -1.49830    | 1.0484    | .02054      | .30044             |
| 0.32 | 1.3771 | .13897      | .72615   | .3255     | -1.51254    | 1.0516    | .02187      | .30951             |
| 0.33 | 1.3910 | .14332      | .71892   | .3360     | -1.52637    | 1.0549    | .02323      | .31852             |
| 0.34 | 1.4049 | .14766      | .71177   | .3466     | -1.53981    | 1.0584    | .02463      | .32748             |
| 0.35 | 1.4191 | .15200      | .70469   | .3572     | -1.55290    | 1.0619    | .02607      | .33638             |
| 0.36 | 1.4333 | .15635      | .69768   | .3678     | -1.56564    | 1.0655    | .02755      | .34521             |
| 0.37 | 1.4477 | .16069      | .69073   | .3785     | -1.57807    | 1.0692    | .02907      | .35399             |
| 0.38 | 1.4623 | .16503      | .68386   | .3892     | -1.59019    | 1.0731    | .03063      | .36271             |
| 0.39 | 1.4770 | .16937      | .67706   | .4000     | -1.60202    | 1.0770    | .03222      | .37136             |
| 0.40 | 1.4918 | .17372      | .67032   | .4108     | -1.61358    | 1.0811    | .03385      | .37995             |
| 0.41 | 1.5063 | .17806      | .66365   | .4216     | -1.62488    | 1.0852    | .03552      | .38847             |
| 0.42 | 1.5220 | .18240      | .65705   | .4325     | -1.63594    | 1.0895    | .03723      | .39693             |
| 0.43 | 1.5373 | .18675      | .65051   | .4434     | -1.64677    | 1.0939    | .03897      | .40532             |
| 0.44 | 1.5527 | .19109      | .64404   | .4543     | -1.65738    | 1.0984    | .04075      | .41364             |
| 0.45 | 1.5683 | .19543      | .63763   | .4653     | -1.66777    | 1.1030    | .04256      | .42190             |
| 0.46 | 1.5841 | .19978      | .63128   | .4764     | -1.67797    | 1.1077    | .04441      | .43008             |
| 0.47 | 1.6000 | .20412      | .62500   | .4875     | -1.68797    | 1.1125    | .04630      | .43820             |
| 0.48 | 1.6161 | .20846      | .61878   | .4986     | -1.69779    | 1.1174    | .04822      | .44624             |
| 0.49 | 1.6323 | .21280      | .61263   | .5098     | -1.70744    | 1.1225    | .05018      | .45422             |
| 0.50 | 1.6487 | .21715      | .60653   | .5211     | -1.71692    | 1.1276    | .05217      | .46212             |
| 0.51 | 1.6653 | .22149      | .60050   | .5324     | -1.72624    | 1.1329    | .05419      | .46995             |
| 0.52 | 1.6820 | .22583      | .59452   | .5438     | -1.73540    | 1.1383    | .05625      | .47770             |
| 0.53 | 1.6989 | .23018      | .58860   | .5552     | -1.74442    | 1.1438    | .05834      | .48538             |

| $x$  | $e^x$  |             | $e^{-x}$ | $\sinh x$ |             | $\cosh x$ |             | $\tanh x$ |
|------|--------|-------------|----------|-----------|-------------|-----------|-------------|-----------|
|      | Value  | $\log_{10}$ | Value    | Value     | $\log_{10}$ | Value     | $\log_{10}$ | Value     |
| 0.54 | 1.7160 | .23452      | .58275   | .5666     | −1.75330    | 1.1494    | .06046      | .49299    |
| 0.55 | 1.7333 | .23886      | .57695   | .5782     | −1.76204    | 1.1551    | .06262      | .50052    |
| 0.56 | 1.7507 | .24320      | .57121   | .5897     | −1.77065    | 1.1609    | .06481      | .50798    |
| 0.57 | 1.7683 | .24755      | .56553   | .6014     | −1.77914    | 1.1669    | .06703      | .51536    |
| 0.58 | 1.7860 | .25189      | .55990   | .6131     | −1.78751    | 1.1730    | .06929      | .52267    |
| 0.59 | 1.8040 | .25623      | .55433   | .6248     | −1.79576    | 1.1792    | .07157      | .52990    |
| 0.60 | 1.8221 | .26058      | .54881   | .6367     | −1.80390    | 1.1855    | .07389      | .53705    |
| 0.61 | 1.8404 | .26492      | .54335   | .6485     | −1.81194    | 1.1919    | .07624      | .54413    |
| 0.62 | 1.8589 | .26926      | .53794   | .6605     | −1.81987    | 1.1984    | .07861      | .55113    |
| 0.63 | 1.8776 | .27361      | .53259   | .6725     | −1.82770    | 1.2051    | .08102      | .55805    |
| 0.64 | 1.8965 | .27795      | .52729   | .6846     | −1.83543    | 1.2119    | .08346      | .56490    |
| 0.65 | 1.9155 | .28229      | .52205   | .6967     | −1.84308    | 1.2188    | .08593      | .57167    |
| 0.66 | 1.9348 | .28664      | .51685   | .7090     | −1.85063    | 1.2258    | .08843      | .57836    |
| 0.67 | 1.9542 | .29098      | .51171   | .7213     | −1.85809    | 1.2330    | .09095      | .58498    |
| 0.68 | 1.9739 | .29532      | .50662   | .7336     | −1.86548    | 1.2402    | .09351      | .59152    |
| 0.69 | 1.9937 | .29966      | .50158   | .7461     | −1.87278    | 1.2476    | .09609      | .59798    |
| 0.70 | 2.0138 | .30401      | .49659   | .7586     | −1.88000    | 1.2552    | .09870      | .60437    |
| 0.71 | 2.0340 | .30835      | .49164   | .7712     | −1.88715    | 1.2628    | .10134      | .61068    |
| 0.72 | 2.0544 | .31269      | .48675   | .7838     | −1.89423    | 1.2706    | .10401      | .61691    |
| 0.73 | 2.0751 | .31703      | .48191   | .7966     | −1.90123    | 1.2785    | .10670      | .62307    |
| 0.74 | 2.0959 | .32138      | .47711   | .8094     | −1.90817    | 1.2865    | .10942      | .62915    |
| 0.75 | 2.1170 | .32572      | .47237   | .8223     | −1.91504    | 1.2947    | .11216      | .63515    |
| 0.76 | 2.1383 | .33006      | .46767   | .8353     | −1.92185    | 1.3030    | .11493      | .64108    |
| 0.77 | 2.1598 | .33441      | .46301   | .8484     | −1.92859    | 1.3114    | .11773      | .64693    |
| 0.78 | 2.1815 | .33875      | .45841   | .8615     | −1.93527    | 1.3199    | .12055      | .65721    |
| 0.79 | 2.2034 | .34309      | .45384   | .8748     | −1.94190    | 1.3286    | .12340      | .65841    |
| 0.80 | 2.2255 | .34744      | .44933   | .8881     | −1.94846    | 1.3374    | .12627      | .66404    |
| 0.81 | 2.2479 | .35178      | .44486   | .9015     | −1.95498    | 1.3464    | .12917      | .66959    |
| 0.82 | 2.2705 | .35612      | .44043   | .9150     | −1.96144    | 1.3555    | .13209      | .67507    |
| 0.83 | 2.2933 | .36046      | .43605   | .9286     | −1.96784    | 1.3647    | .13503      | .68048    |
| 0.84 | 2.3164 | .36481      | .43171   | .9423     | −1.97420    | 1.3740    | .13800      | .68581    |
| 0.85 | 2.3396 | .36915      | .42741   | .9561     | −1.98051    | 1.3835    | .14099      | .69107    |
| 0.86 | 2.3632 | .37349      | .42316   | .9700     | −1.98677    | 1.3932    | .14400      | .69626    |
| 0.87 | 2.3869 | .37784      | .41895   | .9840     | −1.99299    | 1.4029    | .14704      | .70137    |
| 0.88 | 2.4100 | .38218      | .41478   | .9981     | −1.99916    | 1.4128    | .15009      | .70642    |
| 0.89 | 2.4351 | .38652      | .41066   | 1.0122    | 0.00528     | 1.4229    | .15317      | .71139    |
| 0.90 | 2.4596 | .39087      | .40657   | 1.0265    | .01137      | 1.4331    | .15627      | .71630    |
| 0.91 | 2.4843 | .39521      | .40242   | 1.0409    | .01741      | 1.4434    | .15939      | .72113    |
| 0.92 | 2.5093 | .39955      | .39852   | 1.0554    | .02341      | 1.4539    | .16254      | .72590    |
| 0.93 | 2.5345 | .40389      | .39455   | 1.0700    | .02937      | 1.4645    | .16570      | .73059    |
| 0.94 | 2.5600 | .40824      | .39063   | 1.0847    | .03530      | 1.4753    | .16888      | .73522    |
| 0.95 | 2.5857 | .41258      | .38674   | 1.0995    | .04119      | 1.4862    | .17208      | .73978    |
| 0.96 | 2.6117 | .41692      | .38289   | 1.1144    | .04704      | 1.4973    | .17531      | .74428    |
| 0.97 | 2.6379 | .42127      | .37908   | 1.1294    | .05286      | 1.5085    | .17855      | .74870    |
| 0.98 | 2.6645 | .42561      | .37531   | 1.1446    | .05864      | 1.5199    | .18181      | .75307    |
| 0.99 | 2.6912 | .42995      | .37158   | 1.1598    | .06439      | 1.5314    | .18509      | .75736    |
| 1.00 | 2.7183 | .43429      | .36788   | 1.1752    | .07011      | 1.5431    | .18839      | .76159    |
| 1.10 | 3.0042 | .47772      | .33287   | 1.3356    | .12569      | 1.6685    | .22233      | .80050    |
| 1.20 | 3.3201 | .52115      | .30119   | 1.5095    | .17882      | 1.8107    | .25784      | .83365    |
| 1.30 | 3.6693 | .56458      | .27253   | 1.6984    | .23004      | 1.9709    | .29467      | .86172    |
| 1.40 | 4.0552 | .60801      | .24660   | 1.9043    | .27974      | 2.1509    | .33262      | .88535    |
| 1.50 | 4.4817 | .65144      | .22313   | 2.1293    | .32823      | 2.3524    | .37151      | .90515    |
| 1.60 | 4.9530 | .69487      | .20190   | 2.3756    | .37577      | 2.5775    | .41119      | .92167    |
| 1.70 | 5.4739 | .73830      | .18268   | 2.6456    | .42253      | 2.8283    | .45153      | .93541    |
| 1.80 | 6.0496 | .78173      | .16530   | 2.9422    | .46867      | 3.1075    | .49241      | .94681    |
| 1.90 | 6.6859 | .82516      | .14957   | 3.2682    | .51430      | 3.4177    | .53374      | .95624    |
| 2.00 | 7.3891 | .86859      | .13534   | 3.6269    | .55953      | 3.7622    | .57544      | .96403    |

| $x$   | $e^x$  |             | $e^{-x}$ | $\sinh x$ |             | $\cosh x$ |             | $\tanh x$<br>Value |
|-------|--------|-------------|----------|-----------|-------------|-----------|-------------|--------------------|
|       | Value  | $\log_{10}$ |          | Value     | $\log_{10}$ | Value     | $\log_{10}$ |                    |
| 2.10  | 8.1662 | .91202      | .12246   | 4.0219    | .60443      | 4.1443    | .61745      | .97045             |
| 2.20  | 9.0250 | .95545      | .11080   | 4.4571    | .64905      | 4.5679    | .65972      | .97574             |
| 2.30  | 9.9742 | .99888      | .10026   | 4.9370    | .69346      | 5.0372    | .70219      | .98010             |
| 2.40  | 11.023 | 1.04231     | .09072   | 5.4662    | .73769      | 5.5569    | .74484      | .98367             |
| 2.50  | 12.182 | 1.08574     | .08208   | 6.0502    | .78177      | 6.1323    | .78762      | .98661             |
| 2.60  | 13.464 | 1.12917     | .07427   | 6.6947    | .82573      | 6.7690    | .83052      | .98903             |
| 2.70  | 14.880 | 1.17260     | .06721   | 7.4063    | .86960      | 7.4735    | .87352      | .99101             |
| 2.80  | 16.445 | 1.21602     | .06081   | 8.1919    | .91339      | 8.2527    | .91660      | .99263             |
| 2.90  | 18.174 | 1.25945     | .05502   | 9.0596    | .95711      | 9.1146    | .95974      | .99396             |
| 3.00  | 20.086 | 1.30288     | .04979   | 10.018    | 1.00078     | 10.068    | 1.00293     | 0.99505            |
| 3.50  | 33.115 | 1.52003     | .03020   | 16.543    | 1.21860     | 16.573    | 1.21940     | 0.99818            |
| 4.00  | 54.598 | 1.73718     | .01832   | 27.290    | 1.43600     | 27.308    | 1.43629     | 0.99933            |
| 4.50  | 90.017 | 1.95433     | .01111   | 45.003    | 1.65324     | 45.014    | 1.65335     | 0.99975            |
| 5.00  | 148.41 | 2.17147     | .00674   | 74.203    | 1.87042     | 74.210    | 1.87046     | 0.99991            |
| 5.50  | 244.69 | 2.38862     | .00409   | 122.34    | 2.08758     | 122.35    | 2.08760     | 0.99997            |
| 6.00  | 403.43 | 2.60577     | .00248   | 201.71    | 2.30473     | 201.72    | 2.30474     | 0.99999            |
| 6.50  | 665.14 | 2.82291     | .00150   | 332.57    | 2.52188     | 332.57    | 2.52189     | 1.00000            |
| 7.00  | 1096.6 | 3.04006     | .00091   | 548.32    | 2.73904     | 548.32    | 2.73903     | 1.00000            |
| 7.50  | 1808.0 | 3.25721     | .00055   | 904.02    | 2.95618     | 904.02    | 2.95618     | 1.00000            |
| 8.00  | 2981.0 | 3.47436     | .00034   | 1490.5    | 3.17333     | 1490.5    | 3.17333     | 1.00000            |
| 8.50  | 4914.8 | 3.69150     | .00020   | 2457.4    | 3.39047     | 2457.4    | 3.39047     | 1.00000            |
| 9.00  | 8103.1 | 3.90865     | .00012   | 4051.5    | 3.60762     | 4051.5    | 3.60762     | 1.00000            |
| 9.50  | 13360. | 4.12580     | .00007   | 6679.9    | 3.82477     | 6679.9    | 3.82477     | 1.00000            |
| 10.00 | 22026. | 4.34294     | .00005   | 11013.    | 4.04191     | 11013.    | 4.04191     | 1.00000            |

# NATURAL TRIGONOMETRIC FUNCTIONS TO FOUR PLACES

| $x$<br>radians | $x$<br>degrees | $\sin x$ | $\cos x$ | $\tan x$ | $\cot x$ | $\sec x$ | $\csc x$ |                |                |
|----------------|----------------|----------|----------|----------|----------|----------|----------|----------------|----------------|
| .0000          | 0° 00'         | .000     | 1.0000   | .0000    | —        | 1.000    | —        | 90° 00'        | 1.5708         |
| .0029          | 10             | .0029    | 1.0000   | .0029    | 343.8    | 1.000    | 343.8    | 50             | 1.5679         |
| .0058          | 20             | .0058    | 1.0000   | .0058    | 171.9    | 1.000    | 171.9    | 40             | 1.5650         |
| .0087          | 30             | .0087    | 1.0000   | .0087    | 114.6    | 1.000    | 114.6    | 30             | 1.5621         |
| .0116          | 40             | .0116    | .9999    | .0116    | 85.94    | 1.000    | 85.95    | 20             | 1.5592         |
| .0145          | 50             | .0145    | .9999    | .0145    | 68.75    | 1.000    | 68.76    | 10             | 1.5563         |
| .0175          | 1° 00'         | .0175    | .9998    | .0175    | 57.29    | 1.000    | 57.30    | 89° 00'        | 1.5533         |
| .0262          | 30             | .0262    | .9997    | .0262    | 38.19    | 1.000    | 38.20    | 30             | 1.5446         |
| .0349          | 2° 00'         | .0349    | .9994    | .0349    | 28.64    | 1.001    | 28.65    | 88° 00'        | 1.5359         |
| .0436          | 30             | .0436    | .9990    | .0437    | 22.90    | 1.001    | 22.93    | 30             | 1.5272         |
| .0524          | 3° 00'         | .0523    | .9986    | .0524    | 19.08    | 1.001    | 19.11    | 87° 00'        | 1.5184         |
| .0611          | 30             | .0610    | .9981    | .0612    | 16.35    | 1.002    | 16.38    | 30             | 1.5097         |
| .0698          | 4° 00'         | .0698    | .9976    | .0699    | 14.30    | 1.002    | 14.34    | 86° 00'        | 1.5010         |
| .0785          | 30             | .0785    | .9969    | .0787    | 12.71    | 1.003    | 12.75    | 30             | 1.4923         |
| .0873          | 5° 00'         | .0872    | .9962    | .0875    | 11.43    | 1.004    | 11.47    | 85° 00'        | 1.4835         |
| .0960          | 30             | .0958    | .9954    | .0963    | 10.39    | 1.005    | 10.43    | 30             | 1.4748         |
| .1047          | 6° 00'         | .1045    | .9945    | .1051    | 9.514    | 1.006    | 9.597    | 84° 00'        | 1.4661         |
| .1134          | 30             | .1132    | .9936    | .1139    | 8.777    | 1.006    | 8.834    | 30             | 1.4573         |
| .1222          | 7° 00'         | .1219    | .9925    | .1228    | 8.144    | 1.008    | 8.206    | 83° 00'        | 1.4486         |
| .1309          | 30             | .1305    | .9914    | .1317    | 7.596    | 1.009    | 7.661    | 30             | 1.4399         |
| .1396          | 8° 00'         | .1392    | .9903    | .1405    | 7.115    | 1.010    | 7.185    | 82° 00'        | 1.4312         |
| .1484          | 30             | .1478    | .9890    | .1495    | 6.691    | 1.011    | 6.765    | 30             | 1.4224         |
| .1571          | 9° 00'         | .1564    | .9877    | .1584    | 6.314    | 1.012    | 6.392    | 81° 00'        | 1.4137         |
| .1658          | 30             | .1650    | .9863    | .1673    | 5.976    | 1.014    | 6.059    | 30             | 1.4050         |
| .1745          | 10° 00'        | .1736    | .9848    | .1763    | 5.671    | 1.015    | 5.759    | 80° 00'        | 1.3963         |
| .1833          | 30             | .1822    | .9833    | .1853    | 5.396    | 1.017    | 5.487    | 30             | 1.3875         |
| .1920          | 11° 00'        | .1908    | .9816    | .1944    | 5.145    | 1.019    | 5.241    | 79° 00'        | 1.3788         |
| .2007          | 30             | .1994    | .9799    | .2035    | 4.915    | 1.020    | 5.016    | 30             | 1.3701         |
| .2094          | 12° 00'        | .2079    | .9781    | .2126    | 4.705    | 1.022    | 4.810    | 78° 00'        | 1.3614         |
| .2182          | 30             | .2164    | .9763    | .2217    | 4.511    | 1.025    | 4.620    | 30             | 1.3526         |
| .2269          | 13° 00'        | .2250    | .9744    | .2309    | 4.331    | 1.026    | 4.445    | 77° 00'        | 1.3439         |
| .2356          | 30             | .2334    | .9724    | .2401    | 4.165    | 1.028    | 4.284    | 30             | 1.3352         |
| .2443          | 14° 00'        | .2419    | .9703    | .2493    | 4.011    | 1.031    | 4.134    | 76° 00'        | 1.3265         |
| .2531          | 30             | .2404    | .9681    | .2586    | 3.867    | 1.033    | 3.994    | 30             | 1.3177         |
| .2618          | 15° 00'        | .2588    | .9659    | .2679    | 3.732    | 1.035    | 3.864    | 75° 00'        | 1.3090         |
| .2705          | 30             | .2672    | .9636    | .2773    | 3.606    | 1.038    | 3.742    | 30             | 1.3003         |
| .2793          | 16° 00'        | .2756    | .9613    | .2867    | 3.487    | 1.040    | 3.628    | 74° 00'        | 1.2915         |
| .2880          | 30             | .2840    | .9588    | .2962    | 3.376    | 1.043    | 3.521    | 30             | 1.2828         |
| .2967          | 17° 00'        | .2924    | .9563    | .3057    | 3.271    | 1.046    | 3.420    | 73° 00'        | 1.2741         |
| .3054          | 30             | .3007    | .9537    | .3153    | 3.172    | 1.049    | 3.326    | 30             | 1.2654         |
| .3142          | 18° 00'        | .3090    | .9511    | .3249    | 3.078    | 1.051    | 3.236    | 72° 00'        | 1.2566         |
| .3229          | 30             | .3173    | .9483    | .3346    | 2.989    | 1.054    | 3.152    | 30             | 1.2479         |
| .3316          | 19° 00'        | .3256    | .9455    | .3443    | 2.904    | 1.058    | 3.072    | 71° 00'        | 1.2392         |
| .3403          | 30             | .3338    | .9426    | .3541    | 2.824    | 1.061    | 2.996    | 30             | 1.2305         |
| .3491          | 20° 00'        | .3420    | .9397    | .3640    | 2.747    | 1.064    | 2.924    | 70° 00'        | 1.2217         |
| .3578          | 30             | .3502    | .9367    | .3739    | 2.675    | 1.068    | 2.855    | 30             | 1.2130         |
| .3665          | 21° 00'        | .3584    | .9336    | .3839    | 2.605    | 1.071    | 2.790    | 69° 00'        | 1.2043         |
| .3752          | 30             | .3665    | .9304    | .3939    | 2.539    | 1.075    | 2.729    | 30             | 1.1956         |
| .3840          | 22° 00'        | .3746    | .9272    | .4040    | 2.475    | 1.079    | 2.669    | 68° 00'        | 1.1868         |
| .3927          | 30             | .3827    | .9239    | .4142    | 2.414    | 1.082    | 2.613    | 30             | 1.1781         |
| .4014          | 23° 00'        | .3907    | .9205    | .4245    | 2.356    | 1.086    | 2.559    | 67° 00'        | 1.1694         |
| .4102          | 30             | .3987    | .9171    | .4348    | 2.300    | 1.090    | 2.508    | 30             | 1.1606         |
| .4189          | 24° 00'        | .4067    | .9135    | .4452    | 2.246    | 1.095    | 2.459    | 66° 00'        | 1.1519         |
|                |                | $\cos y$ | $\sin y$ | $\cot y$ | $\tan y$ | $\csc y$ | $\sec y$ | $y$<br>degrees | $y$<br>radians |

| $x$<br>radians | $x$<br>degrees | $\sin x$ | $\cos x$ | $\tan x$ | $\cot x$ | $\sec x$ | $\csc x$ |                |                |
|----------------|----------------|----------|----------|----------|----------|----------|----------|----------------|----------------|
| .4276          | 30             | .4147    | .9100    | .4557    | 2.194    | 1.099    | 2.411    | 30             | 1.1432         |
| .4363          | 25° 00'        | .4226    | .9063    | .4663    | 2.145    | 1.103    | 2.366    | 65° 00'        | 1.1345         |
| .4451          | 30             | .4305    | .9026    | .4770    | 2.097    | 1.108    | 2.323    | 30             | 1.1257         |
| .4538          | 26° 00'        | .4384    | .8988    | .4877    | 2.050    | 1.113    | 2.281    | 64° 00'        | 1.1170         |
| .4625          | 30             | .4462    | .8949    | .4986    | 2.006    | 1.117    | 2.241    | 30             | 1.1083         |
| .4712          | 27° 00'        | .4540    | .8910    | .5095    | 1.963    | 1.122    | 2.203    | 63° 00'        | 1.0996         |
| .4800          | 30             | .4617    | .8870    | .5206    | 1.921    | 1.127    | 2.166    | 30             | 1.0908         |
| .4887          | 28° 00'        | .4695    | .8829    | .5317    | 1.881    | 1.133    | 2.130    | 62° 00'        | 1.0821         |
| .4974          | 30             | .4772    | .8788    | .5430    | 1.842    | 1.138    | 2.096    | 30             | 1.0734         |
| .5061          | 29° 00'        | .4848    | .8746    | .5543    | 1.804    | 1.143    | 2.063    | 61° 00'        | 1.0647         |
| .5149          | 30             | .4924    | .8704    | .5658    | 1.767    | 1.149    | 2.031    | 30             | 1.0559         |
| .5236          | 30° 00'        | .5000    | .8660    | .5774    | 1.732    | 1.155    | 2.000    | 60° 00'        | 1.0472         |
| .5323          | 30             | .5075    | .8616    | .5890    | 1.698    | 1.161    | 1.970    | 30             | 1.0385         |
| .5411          | 31° 00'        | .5150    | .8572    | .6009    | 1.664    | 1.167    | 1.942    | 59° 00'        | 1.0297         |
| .5498          | 30             | .5225    | .8526    | .6128    | 1.632    | 1.173    | 1.914    | 30             | 1.0210         |
| .5585          | 32° 00'        | .5299    | .8480    | .6249    | 1.600    | 1.179    | 1.887    | 58° 00'        | 1.0123         |
| .5672          | 30             | .5373    | .8434    | .6371    | 1.570    | 1.186    | 1.861    | 30             | 1.0036         |
| .5760          | 33° 00'        | .5446    | .8397    | .6494    | 1.540    | 1.192    | 1.836    | 57° 00'        | .9948          |
| .5847          | 30             | .5519    | .8339    | .6619    | 1.511    | 1.199    | 1.812    | 30             | .9861          |
| .5934          | 34° 00'        | .5592    | .8290    | .6745    | 1.483    | 1.206    | 1.788    | 56° 00'        | .9774          |
| .6021          | 30             | .5664    | .8241    | .6873    | 1.455    | 1.213    | 1.766    | 30             | .9687          |
| .6109          | 35° 00'        | .5736    | .8192    | .7002    | 1.428    | 1.221    | 1.743    | 55° 00'        | .9599          |
| .6196          | 30             | .5807    | .8141    | .7133    | 1.402    | 1.228    | 1.722    | 30             | .9512          |
| .6283          | 36° 00'        | .5878    | .8090    | .7265    | 1.376    | 1.236    | 1.701    | 54° 00'        | .9425          |
| .6370          | 30             | .5948    | .8039    | .7400    | 1.351    | 1.244    | 1.681    | 30             | .9338          |
| .6458          | 37° 00'        | .6018    | .7986    | .7536    | 1.327    | 1.252    | 1.662    | 53° 00'        | .9250          |
| .6545          | 30             | .6088    | .7934    | .7673    | 1.303    | 1.260    | 1.643    | 30             | .9163          |
| .6632          | 38° 00'        | .6157    | .7880    | .7813    | 1.280    | 1.269    | 1.624    | 52° 00'        | .9076          |
| .6720          | 30             | .6225    | .7826    | .7954    | 1.257    | 1.278    | 1.606    | 30             | .8988          |
| .6807          | 39° 00'        | .6293    | .7771    | .8098    | 1.235    | 1.287    | 1.589    | 51° 00'        | .8901          |
| .6894          | 30             | .6361    | .7716    | .8243    | 1.213    | 1.296    | 1.572    | 30             | .8814          |
| .6981          | 40° 00'        | .6428    | .7660    | .8391    | 1.192    | 1.305    | 1.556    | 50° 00'        | .8727          |
| .7069          | 30             | .6494    | .7604    | .8541    | 1.171    | 1.315    | 1.540    | 30             | .8639          |
| .7156          | 41° 00'        | .6561    | .7547    | .8693    | 1.150    | 1.325    | 1.524    | 49° 00'        | .8552          |
| .7243          | 30             | .6626    | .7490    | .8847    | 1.130    | 1.335    | 1.509    | 30             | .8465          |
| .7330          | 42° 00'        | .6691    | .7431    | .9004    | 1.111    | 1.346    | 1.494    | 48° 00'        | .8378          |
| .7418          | 30             | .6756    | .7373    | .9163    | 1.091    | 1.356    | 1.480    | 30             | .8290          |
| .7505          | 43° 00'        | .6820    | .7314    | .9325    | 1.072    | 1.367    | 1.466    | 47° 00'        | .8203          |
| .7592          | 30             | .6884    | .7254    | .9490    | 1.054    | 1.379    | 1.453    | 30             | .8116          |
| .7679          | 44° 00'        | .6947    | .7193    | .9657    | 1.036    | 1.390    | 1.440    | 46° 00'        | .8029          |
| .7767          | 30             | .7009    | .7133    | .9827    | 1.018    | 1.402    | 1.427    | 30             | .7941          |
| .7854          | 45° 00'        | .7071    | .7071    | 1.0000   | 1.0000   | 1.414    | 1.414    | 45° 00'        | .7854          |
|                |                | $\cos y$ | $\sin y$ | $\cot y$ | $\tan y$ | $\csc y$ | $\sec y$ | $y$<br>degrees | $y$<br>radians |



## RELATION OF ANGULAR FUNCTIONS IN TERMS OF ONE ANOTHER

### Trigonometric Functions

| Function      | $\sin \alpha$                                   | $\cos \alpha$                                   | $\tan \alpha$                                   | $\cot \alpha$                                   | $\sec \alpha$                                     | $\csc \alpha$                                     |
|---------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|---------------------------------------------------|---------------------------------------------------|
| $\sin \alpha$ | $\sin \alpha$                                   | $\pm\sqrt{1-\cos^2 \alpha}$                     | $\frac{\tan \alpha}{\pm\sqrt{1+\tan^2 \alpha}}$ | $\frac{1}{\pm\sqrt{1+\cot^2 \alpha}}$           | $\frac{\pm\sqrt{\sec^2 \alpha - 1}}{\sec \alpha}$ | $\frac{1}{\csc \alpha}$                           |
| $\cos \alpha$ | $\pm\sqrt{1-\sin^2 \alpha}$                     | $\cos \alpha$                                   | $\frac{1}{\pm\sqrt{1+\tan^2 \alpha}}$           | $\frac{\cot \alpha}{\pm\sqrt{1+\cot^2 \alpha}}$ | $\frac{1}{\sec \alpha}$                           | $\frac{\pm\sqrt{\csc^2 \alpha - 1}}{\csc \alpha}$ |
| $\tan \alpha$ | $\frac{\sin \alpha}{\pm\sqrt{1-\sin^2 \alpha}}$ | $\frac{\pm\sqrt{1-\cos^2 \alpha}}{\cos \alpha}$ | $\tan \alpha$                                   | $\frac{1}{\cot \alpha}$                         | $\pm\sqrt{\sec^2 \alpha - 1}$                     | $\frac{1}{\pm\sqrt{\csc^2 \alpha - 1}}$           |
| $\cot \alpha$ | $\frac{\pm\sqrt{1-\sin^2 \alpha}}{\sin \alpha}$ | $\frac{\cos \alpha}{\pm\sqrt{1-\cos^2 \alpha}}$ | $\frac{1}{\tan \alpha}$                         | $\cot \alpha$                                   | $\frac{1}{\pm\sqrt{\sec^2 \alpha - 1}}$           | $\pm\sqrt{\csc^2 \alpha - 1}$                     |
| $\sec \alpha$ | $\frac{1}{\pm\sqrt{1-\sin^2 \alpha}}$           | $\frac{1}{\cos \alpha}$                         | $\pm\sqrt{1+\tan^2 \alpha}$                     | $\frac{\pm\sqrt{1+\cot^2 \alpha}}{\cot \alpha}$ | $\sec \alpha$                                     | $\frac{\csc \alpha}{\pm\sqrt{\csc^2 \alpha - 1}}$ |
| $\csc \alpha$ | $\frac{1}{\sin \alpha}$                         | $\frac{1}{\pm\sqrt{1-\cos^2 \alpha}}$           | $\frac{\pm\sqrt{1+\tan^2 \alpha}}{\tan \alpha}$ | $\pm\sqrt{1+\cot^2 \alpha}$                     | $\frac{\sec \alpha}{\pm\sqrt{\sec^2 \alpha - 1}}$ | $\csc \alpha$                                     |

*Note:* The choice of sign depends upon the quadrant in which the angle terminates.

### Hyperbolic Functions

| Function                    | $\sinh x$                            | $\cosh x$                                 | $\tanh x$                            |
|-----------------------------|--------------------------------------|-------------------------------------------|--------------------------------------|
| $\sinh x =$                 | $\sinh x$                            | $\pm\sqrt{\cosh^2 x - 1}$                 | $\frac{\tanh x}{\sqrt{1-\tanh^2 x}}$ |
| $\cosh x =$                 | $\sqrt{1+\sinh^2 x}$                 | $\cosh x$                                 | $\frac{1}{\sqrt{1-\tanh^2 x}}$       |
| $\tanh x =$                 | $\frac{\sinh x}{\sqrt{1+\sinh^2 x}}$ | $\pm\frac{\sqrt{\cosh^2 x - 1}}{\cosh x}$ | $\tanh x$                            |
| $\operatorname{cosech} x =$ | $\frac{1}{\sinh x}$                  | $\pm\frac{1}{\sqrt{\cosh^2 x - 1}}$       | $\frac{\sqrt{1-\tanh^2 x}}{\tanh x}$ |
| $\operatorname{sech} x =$   | $\frac{1}{\sqrt{1+\sinh^2 x}}$       | $\frac{1}{\cosh x}$                       | $\sqrt{1-\tanh^2 x}$                 |
| $\operatorname{coth} x =$   | $\frac{\sqrt{1+\sinh^2 x}}{\sinh x}$ | $\frac{\pm\cosh x}{\sqrt{\cosh^2 x - 1}}$ | $\frac{1}{\tanh x}$                  |

| Function                    | $\operatorname{cosech} x$                                                 | $\operatorname{sech} x$                                             | $\operatorname{coth} x$                                               |
|-----------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------|
| $\sinh x =$                 | $\frac{1}{\operatorname{cosech} x}$                                       | $\pm\frac{\sqrt{1-\operatorname{sech}^2 x}}{\operatorname{sech} x}$ | $\frac{\pm 1}{\sqrt{\operatorname{coth}^2 x - 1}}$                    |
| $\cosh x =$                 | $\pm\frac{\sqrt{\operatorname{cosech}^2 x + 1}}{\operatorname{cosech} x}$ | $\frac{1}{\operatorname{sech} x}$                                   | $\pm\frac{\operatorname{coth} x}{\sqrt{\operatorname{coth}^2 x - 1}}$ |
| $\tanh x =$                 | $\frac{1}{\sqrt{\operatorname{cosech}^2 x + 1}}$                          | $\pm\sqrt{1+\operatorname{sech}^2 x}$                               | $\frac{1}{\operatorname{coth} x}$                                     |
| $\operatorname{cosech} x =$ | $\operatorname{cosech} x$                                                 | $\pm\frac{\operatorname{sech} x}{\sqrt{1-\operatorname{sech}^2 x}}$ | $\pm\frac{\sqrt{\operatorname{coth}^2 x - 1}}{1}$                     |
| $\operatorname{sech} x =$   | $\pm\frac{\operatorname{cosech} x}{\sqrt{\operatorname{cosech}^2 x + 1}}$ | $\operatorname{sech} x$                                             | $\pm\frac{\sqrt{\operatorname{coth}^2 x - 1}}{\operatorname{coth} x}$ |
| $\operatorname{coth} x =$   | $\sqrt{\operatorname{cosech}^2 x + 1}$                                    | $\pm\frac{1}{\sqrt{1-\operatorname{sech}^2 x}}$                     | $\operatorname{coth} x$                                               |

Whenever two signs are shown, choose + sign if  $x$  is positive, – sign if  $x$  is negative.

## DERIVATIVES

In the following formulas  $u, v, w$  represent functions of  $x$ , while  $a, c, n$  represent fixed real numbers. All arguments in the trigonometric functions are measured in radians, and all inverse trigonometric and hyperbolic functions represent principal values. \*Let  $y = f(x)$  and  $\frac{dy}{dx} = \frac{d[f(x)]}{dx} = f'(x)$  define, respectively, a function and its derivative for any value  $x$  in their common domain. The differential for the function at such a value  $x$  is accordingly defined as

$$dy = d[f(x)] = \frac{dy}{dx} dx = \frac{d[f(x)]}{dx} dx = f'(x) dx$$

Each derivative formula has an associated differential formula. For example, formula 6 below has the differential formula

$$d(uvw) = uv \, dw + vw \, du + uw \, dv$$

1.  $\frac{d}{dx}(a) = 0$
  2.  $\frac{d}{dx}(x) = 1$
  3.  $\frac{d}{dx}(au) = a \frac{du}{dx}$
  4.  $\frac{d}{dx}(u + v - w) = \frac{du}{dx} + \frac{dv}{dx} - \frac{dw}{dx}$
  5.  $\frac{d}{dx}(uv) = u \frac{dv}{dx} + v \frac{du}{dx}$
  6.  $\frac{d}{dx}(uvw) = uv \frac{dw}{dx} + vw \frac{du}{dx} + uw \frac{dv}{dx}$
  7.  $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v \frac{du}{dx} - u \frac{dv}{dx}}{v^2} = \frac{1}{v} \frac{du}{dx} - \frac{u}{v^2} \frac{dv}{dx}$
  8.  $\frac{d}{dx}(u^n) = nu^{n-1} \frac{du}{dx}$
  9.  $\frac{d}{dx}(\sqrt{u}) = \frac{1}{2\sqrt{u}} \frac{du}{dx}$
  10.  $\frac{d}{dx}\left(\frac{1}{u}\right) = -\frac{1}{u^2} \frac{du}{dx}$
  11.  $\frac{d}{dx}\left(\frac{1}{u^n}\right) = -\frac{n}{u^{n+1}} \frac{du}{dx}$
  12.  $\frac{d}{dx}\left(\frac{u^n}{v^m}\right) = \frac{u^{n-1}}{v^{m+1}} \left(nv \frac{du}{dx} - mu \frac{dv}{dx}\right)$
  13.  $\frac{d}{dx}(u^n v^m) = u^{n-1} v^{m-1} \left(nv \frac{du}{dx} + mu \frac{dv}{dx}\right)$
  14.  $\frac{d}{dx}[f(u)] = \frac{d}{du}[f(u)] \cdot \frac{du}{dx}$
  15.  $\frac{d^2}{dx^2}[f(u)] = \frac{df(u)}{du} \cdot \frac{d^2 u}{dx^2} + \frac{d^2 f(u)}{du^2} \cdot \left(\frac{du}{dx}\right)^2$
  16.  $\frac{d^n}{dx^n}[uv] = \binom{n}{0} v \frac{d^n u}{dx^n} + \binom{n}{1} \frac{dv}{dx} \frac{d^{n-1} u}{dx^{n-1}} + \binom{n}{2} \frac{d^2 v}{dx^2} \frac{d^{n-2} u}{dx^{n-2}} + \cdots + \binom{n}{k} \frac{d^k v}{dx^k} \frac{d^{n-k} u}{dx^{n-k}} + \cdots + \binom{n}{n} u \frac{d^n v}{dx^n}$
- where  $\binom{n}{r} = \frac{n!}{r!(n-r)!}$  is the binomial coefficient,  $n$  non-negative integer, and  $\binom{n}{0} = 1$ .
17.  $\frac{du}{dx} = \frac{1}{\frac{dx}{du}}$  if  $\frac{dx}{du} \neq 0$
  18.  $\frac{d}{dx}(\log_a u) = (\log_a e) \frac{1}{u} \frac{du}{dx}$

19.  $\frac{d}{dx}(\log_e u) = \frac{1}{u} \frac{du}{dx}$
20.  $\frac{d}{dx}(a^u) = a^u(\log_e a) \frac{du}{dx}$
21.  $\frac{d}{dx}(e^u) = e^u \frac{du}{dx}$
22.  $\frac{d}{dx}(u^v) = v u^{v-1} \frac{du}{dx} + (\log_e u) u^v \frac{dv}{dx}$
23.  $\frac{d}{dx}(\sin u) = (\cos u) \frac{du}{dx}$
24.  $\frac{d}{dx}(\cos u) = -(\sin u) \frac{du}{dx}$
25.  $\frac{d}{dx}(\tan u) = (\sec^2 u) \frac{du}{dx}$
26.  $\frac{d}{dx}(\cot u) = -(\csc^2 u) \frac{du}{dx}$
27.  $\frac{d}{dx}(\sec u) = \sec u \cdot \tan u \frac{du}{dx}$
28.  $\frac{d}{dx}(\csc u) = -\csc u \cdot \cot u \frac{du}{dx}$
29.  $\frac{d}{dx}(\text{vers } u) = \sin u \frac{du}{dx}$
30.  $\frac{d}{dx}(\arcsin u) = \frac{1}{\sqrt{1-u^2}} \frac{du}{dx}, \quad \left(-\frac{\pi}{2} \leq \arcsin u \leq \frac{\pi}{2}\right)$
31.  $\frac{d}{dx}(\arccos u) = -\frac{1}{\sqrt{1-u^2}} \frac{du}{dx}, \quad (0 \leq \arccos u \leq \pi)$
32.  $\frac{d}{dx}(\arctan u) = \frac{1}{1+u^2} \frac{du}{dx}, \quad \left(-\frac{\pi}{2} < \arctan u < \frac{\pi}{2}\right)$
33.  $\frac{d}{dx}(\text{arc cot } u) = -\frac{1}{1+u^2} \frac{du}{dx}, \quad (0 \leq \text{arc cot } u \leq \pi)$
34.  $\frac{d}{dx}(\text{arc sec } u) = \frac{1}{u\sqrt{u^2-1}} \frac{du}{dx}, \quad \left(0 \leq \text{arc sec } u < \frac{\pi}{2}, -\pi \leq \text{arc sec } u < -\frac{\pi}{2}\right)$
35.  $\frac{d}{dx}(\text{arc csc } u) = -\frac{1}{u\sqrt{u^2-1}} \frac{du}{dx}, \quad \left(0 < \text{arc csc } u \leq \frac{\pi}{2}, -\pi < \text{arc csc } u \leq -\frac{\pi}{2}\right)$
36.  $\frac{d}{dx}(\text{arc vers } u) = \frac{1}{\sqrt{2u-u^2}} \frac{du}{dx}, \quad (0 \leq \text{arc vers } u \leq \pi)$
37.  $\frac{d}{dx}(\sinh u) = (\cosh u) \frac{du}{dx}$
38.  $\frac{d}{dx}(\cosh u) = (\sinh u) \frac{du}{dx}$
39.  $\frac{d}{dx}(\tanh u) = (\text{sech}^2 u) \frac{du}{dx}$
40.  $\frac{d}{dx}(\coth u) = -(\text{csch}^2 u) \frac{du}{dx}$
41.  $\frac{d}{dx}(\text{sech } u) = -(\text{sech } u \cdot \tanh u) \frac{du}{dx}$
42.  $\frac{d}{dx}(\text{csch } u) = -(\text{csch } u \cdot \coth u) \frac{du}{dx}$
43.  $\frac{d}{dx}(\sinh^{-1} u) = \frac{d}{dx}[\log(u + \sqrt{u^2 + 1})] = \frac{1}{\sqrt{u^2 + 1}} \frac{du}{dx}$
44.  $\frac{d}{dx}(\cosh^{-1} u) = \frac{d}{dx}[\log(u + \sqrt{u^2 - 1})] = \frac{1}{\sqrt{u^2 - 1}} \frac{du}{dx}, \quad (u > 1, \cosh^{-1} u > 0)$

45.  $\frac{d}{dx}(\tanh^{-1} u) = \frac{d}{dx} \left[ \frac{1}{2} \log \frac{1+u}{1-u} \right] = \frac{1}{1-u^2} \frac{du}{dx}, \quad (u^2 < 1)$
46.  $\frac{d}{dx}(\coth^{-1} u) = \frac{d}{dx} \left[ \frac{1}{2} \log \frac{u+1}{u-1} \right] = \frac{1}{1-u^2} \frac{du}{dx}, \quad (u^2 > 1)$
47.  $\frac{d}{dx}(\operatorname{sech}^{-1} u) = \frac{d}{dx} \left[ \log \frac{1+\sqrt{1-u^2}}{u} \right] = -\frac{1}{u\sqrt{1-u^2}} \frac{du}{dx}, \quad (0 < u < 1, \operatorname{sech}^{-1} u > 0)$
48.  $\frac{d}{dx}(\operatorname{csch}^{-1} u) = \frac{d}{dx} \left[ \log \frac{1+\sqrt{1+u^2}}{u} \right] = -\frac{1}{|u|\sqrt{1+u^2}} \frac{du}{dx}$
49.  $\frac{d}{dq} \int_p^q f(x) dx = f(q), \quad [p \text{ constant}]$
50.  $\frac{d}{dp} \int_p^q f(x) dx = -f(p), \quad [q \text{ constant}]$
51.  $\frac{d}{da} \int_p^q f(x, a) dx = \int_p^q \frac{\partial}{\partial a} [f(x, a)] dx + f(q, a) \frac{dq}{da} - f(p, a) \frac{dp}{da}$

## INTEGRATION

The following is a brief discussion of some integration techniques. A more complete discussion can be found in a number of good textbooks. However, the purpose of this introduction is simply to discuss a few of the important techniques which may be used, in conjunction with the integral table which follows, to integrate particular functions.

No matter how extensive the integral table, it is a fairly uncommon occurrence to find in the table the exact integral desired. Usually some form of transformation will have to be made. The simplest type of transformation, and yet the most general, is substitution. Simple forms of substitution, such as  $y = ax$ , are employed almost unconsciously by experienced users of integral tables. Other substitutions may require more thought. In some sections of the tables, appropriate substitutions are suggested for integrals that are similar to, but not exactly like, integrals in the table. Finding the right substitution is largely a matter of intuition and experience.

Several precautions must be observed when using substitutions:

1. Be sure to make the substitution in the  $dx$  term, as well as everywhere else in the integral.
2. Be sure that the function substituted is one-to-one and continuous. If this is not the case, the integral must be restricted in such a way as to make it true. See the example following.
3. With definite integrals, the limits should also be expressed in terms of the new dependent variable. With indefinite integrals, it is necessary to perform the reverse substitution to obtain the answer in terms of the original independent variable. This may also be done for definite integrals, but it is usually easier to change the limits.

**Example:**

$$\int \frac{x^4}{\sqrt{a^2 - x^2}} dx$$

Here we make the substitution  $x = |a| \sin \theta$ . Then  $dx = |a| \cos \theta d\theta$ , and

$$\sqrt{a^2 - x^2} = \sqrt{a^2 - a^2 \sin^2 \theta} = |a| \sqrt{1 - \sin^2 \theta} = |a| \cos \theta$$

Notice the absolute value signs. It is very important to keep in mind that a square root radical always denotes the positive square root, and to assure the sign is always kept positive. Thus  $\sqrt{x^2} = |x|$ . Failure to observe this is a common cause of errors in integration.

Notice also that the indicated substitution is not a one-to-one function; that is, it does not have a unique inverse. Thus we must restrict the range of  $\theta$  in such a way as to make the function one-to-one. Fortunately, this is easily done by solving for  $\theta$

$$\theta = \sin^{-1} \frac{x}{|a|}$$

and restricting the inverse sine to the principal values,  $-\frac{\pi}{2} \leq \theta \leq \frac{\pi}{2}$ .

Thus the integral becomes

$$\int \frac{a^4 \sin^4 \theta |a| \cos \theta d\theta}{|a| |\cos \theta|}$$

Now, however, in the range of values chosen for  $\theta$ ,  $\cos \theta$  is always positive. Thus we may remove the absolute value signs from  $\cos \theta$  in the denominator. (This is one of the reasons that the principal values of the inverse trigonometric functions are defined as they are.) Then the  $\cos \theta$  terms cancel, and the integral becomes

$$a^4 \int \sin^4 \theta d\theta$$

By application of integral formulas 299 and 296, we integrate this to

$$-a^4 \frac{\sin^3 \theta \cos \theta}{4} - \frac{3a^4}{8} \cos \theta \sin \theta + \frac{3a^4}{8} \theta + C$$

We now must perform the inverse substitution to get the result in terms of  $x$ . We have

$$\begin{aligned}\theta &= \sin^{-1} \frac{x}{|a|} \\ \sin \theta &= \frac{x}{|a|}\end{aligned}$$

Then

$$\cos \theta = \pm \sqrt{1 - \sin^2 \theta} = \pm \sqrt{1 - \frac{x^2}{a^2}} = \pm \frac{\sqrt{a^2 - x^2}}{|a|}.$$

Because of the previously mentioned fact that  $\cos \theta$  is positive, we may omit the  $\pm$  sign. The reverse substitution then produces the final answer

$$\int \frac{x^4}{\sqrt{a^2 - x^2}} dx = -\frac{1}{4}x^3 \sqrt{a^2 - x^2} - \frac{3}{8}a^2 x \sqrt{a^2 - x^2} + \frac{3}{8}a^4 \sin^{-1} \frac{x}{|a|} + C.$$

Any rational function of  $x$  may be integrated, if the denominator is factored into linear and irreducible quadratic factors. The function may then be broken into partial fractions, and the individual partial fractions integrated by use of the appropriate formula from the integral table. See the section on partial fractions for further information.

Many integrals may be reduced to rational functions by proper substitutions. For example,

$$z = \tan \frac{x}{2}$$

will reduce any rational function of the six trigonometric functions of  $x$  to a rational function of  $z$ . (Frequently there are other substitutions that are simpler to use, but this one will always work. See integral formula number 484.)

Any rational function of  $x$  and  $\sqrt{ax+b}$  may be reduced to a rational function of  $z$  by making the substitution

$$z = \sqrt{ax+b}.$$

Other likely substitutions will be suggested by looking at the form of the integrand.

The other main method of transforming integrals is integration by parts. This involves applying formula number 5 or 6 in the accompanying integral table. The critical factor in this method is the choice of the functions  $u$  and  $v$ . In order for the method to be successful,  $v = \int dv$  and  $\int v du$  must be easier to integrate than the original integral. Again, this choice is largely a matter of intuition and experience.

**Example:**

$$\int x \sin x dx$$

Two obvious choices are  $u = x$ ,  $dv = \sin x dx$ , or  $u = \sin x$ ,  $dv = x dx$ . Since a preliminary mental calculation indicates that  $\int v du$  in the second choice would be more, rather than less, complicated than the original integral (it would contain  $x^2$ ), we use the first choice.

$$\begin{aligned}u &= x & du &= dx \\ dv &= \sin x dx & v &= -\cos x \\ \int x \sin x dx &= \int u dv = uv - \int v du = -x \cos x + \int \cos x dx \\ &= \sin x - x \cos x\end{aligned}$$

Of course, this result could have been obtained directly from the integral table, but it provides a simple example of the method. In more complicated examples the choice of  $u$  and  $v$  may not be so obvious, and several different choices may have to be tried. Of course, there is no guarantee that any of them will work.

Integration by parts may be applied more than once, or combined with substitution. A fairly common case is illustrated by the following example.

**Example:**

$$\int e^x \sin x \, dx$$

Let

$$\begin{array}{ll} u = e^x & \text{Then } du = e^x \, dx \\ dv = \sin x \, dx & v = -\cos x \end{array}$$

$$\int e^x \sin x \, dx = \int u \, dv = uv - \int v \, du = -e^x \cos x + \int e^x \cos x \, dx$$

In this latter integral,

$$\begin{array}{ll} \text{Let } u = e^x & \text{Then } du = e^x \, dx \\ dv = \cos x \, dx & v = \sin x \end{array}$$

$$\begin{aligned} \int e^x \sin x \, dx &= -e^x \cos x + \int e^x \cos x \, dx = -e^x \cos x + \int u \, dv \\ &= -e^x \cos x + uv - \int v \, du \\ &= -e^x \cos x + e^x \sin x - \int e^x \sin x \, dx \end{aligned}$$

This looks as if a circular transformation has taken place, since we are back at the same integral we started from. However, the above equation can be solved algebraically for the required integral:

$$\int e^x \sin x \, dx = \frac{1}{2} e^x \sin x - \frac{1}{2} e^x \cos x$$

In the second integration by parts, if the parts had been chosen as  $u = \cos x$ ,  $dv = e^x \, dx$ , we would indeed have made a circular transformation, and returned to the starting place.

In general, when doing repeated integration by parts, one should never choose the function  $u$  at any stage to be the same as the function  $v$  at the previous stage, or a constant times the previous  $v$ .

The following rule is called the extended rule for integration by parts. It is the result of  $n+1$  successive applications of integration by parts. If

$$\begin{aligned} g_1(x) &= \int g(x) \, dx, & g_2(x) &= \int g_1(x) \, dx, \\ g_3(x) &= \int g_2(x) \, dx, \dots, & g_m(x) &= \int g_{m-1}(x) \, dx, \dots, \end{aligned}$$

then

$$\begin{aligned} \int f(x) \cdot g(x) \, dx &= f(x) \cdot g_1(x) - f'(x) \cdot g_2(x) + f''(x) \cdot g_3(x) - + \dots \\ &\quad + (-1)^n f^{(n)}(x) g_{n+1}(x) + (-1)^{n+1} \int f^{(n+1)}(x) g_{n+1}(x) \, dx. \end{aligned}$$

A useful special case of the above rule is when  $f(x)$  is a polynomial of degree  $n$ . Then  $f^{(n+1)}(x) = 0$ , and

$$\int f(x) \cdot g(x) \, dx = f(x) \cdot g_1(x) - f'(x) \cdot g_2(x) + f''(x) \cdot g_3(x) - + \dots + (-1)^n f^{(n)}(x) g_{n+1}(x) + C.$$

**Example:** If  $f(x) = x^2$ ,  $g(x) = \sin x$

$$\int x^2 \sin x \, dx = -x^2 \cos x + 2x \sin x + 2 \cos x + C.$$

Another application of this formula occurs if

$$f''(x) = af(x) \quad \text{and} \quad g''(x) = bg(x),$$

where  $a$  and  $b$  are unequal constants. In this case, by a process similar to that used in the above example for  $\int e^x \sin x \, dx$ , we get the formula

$$\int f(x)g(x) \, dx = \frac{f(x) \cdot g'(x) - f'(x) \cdot g(x)}{b - a} + C.$$

This formula could have been used in the example mentioned. Here is another example.

**Example:** If  $f(x) = e^{2x}$ ,  $g(x) = \sin 3x$ , then  $a = 4$ ,  $b = -9$ , and

$$\int e^{2x} \sin 3x \, dx = \frac{3e^{2x} \cos 3x - 2e^{2x} \sin 3x}{-9 - 4} + C = \frac{e^{2x}}{13} (2 \sin 3x - 3 \cos 3x) + C$$

The following additional points should be observed when using this table.

1. A constant of integration is to be supplied with the answers for indefinite integrals.
2. Logarithmic expressions are to base  $e = 2.71828 \dots$ , unless otherwise specified, and are to be evaluated for the absolute value of the arguments involved therein.
3. All angles are measured in radians, and inverse trigonometric and hyperbolic functions represent principal values, unless otherwise indicated.
4. If the application of a formula produces either a zero denominator or the square root of a negative number in the result, there is usually available another form of the answer which avoids this difficulty. In many of the results, the excluded values are specified, but when such are omitted it is presumed that one can tell what these should be, especially when difficulties of the type herein mentioned are obtained.
5. When inverse trigonometric functions occur in the integrals, be sure that any replacements made for them are strictly in accordance with the rules for such functions. This causes little difficulty when the argument of the inverse trigonometric function is positive, since then all angles involved are in the first quadrant. However, if the argument is negative, special care must be used. Thus if  $u > 0$ ,

$$\sin^{-1} u = \cos^{-1} \sqrt{1 - u^2} = \csc^{-1} \frac{1}{u}, \text{ etc.}$$

However, if  $u < 0$ ,

$$\sin^{-1} u = -\cos^{-1} \sqrt{1 - u^2} = -\pi - \csc^{-1} \frac{1}{u}, \text{ etc.}$$

See the section on inverse trigonometric functions for a full treatment of the allowable substitutions.

6. In integrals 340–345 and some others, the right side includes expressions of the form

$$A \tan^{-1} [B + C \tan f(x)].$$

In these formulas, the  $\tan^{-1}$  does not necessarily represent the principal value. Instead of always employing the principal branch of the inverse tangent function, one must instead use that branch of the inverse tangent function upon which  $f(x)$  lies for any particular choice of  $x$ . (This is not an issue when the antiderivative is continuous.)

**Example:**

$$\begin{aligned} \int_0^{4\pi} \frac{dx}{2 + \sin x} &= \frac{2}{\sqrt{3}} \tan^{-1} \frac{2 \tan(x/2 + 1)}{\sqrt{3}} \Big|_0^{4\pi} \\ &= \frac{2}{\sqrt{3}} \left[ \tan^{-1} \left( \frac{2 \tan 2\pi + 1}{\sqrt{3}} \right) - \tan^{-1} \left( \frac{2 \tan 0 + 1}{\sqrt{3}} \right) \right] \\ &= \frac{2}{\sqrt{3}} \left[ \frac{13\pi}{6} - \frac{\pi}{6} \right] = \frac{4\pi}{\sqrt{3}} = \frac{4\sqrt{3}\pi}{3} \end{aligned}$$



Here

$$\tan^{-1} \frac{2 \tan 2\pi + 1}{\sqrt{3}} = \tan^{-1} \frac{1}{\sqrt{3}} = \frac{13\pi}{6},$$

since  $f(x) = 2\pi$ ; and

$$\tan^{-1} \frac{2 \tan 0 + 1}{\sqrt{3}} = \tan^{-1} \frac{1}{\sqrt{3}} = \frac{\pi}{6},$$

since  $f(x) = 0$ .

7.  $B_n$  and  $E_n$  where used in integrals represents the Bernoulli and Euler numbers as defined in tables of Bernoulli and Euler polynomials contained in certain mathematics reference and handbooks.

# INTEGRALS

## ELEMENTARY FORMS

1.  $\int a \, dx = ax$
2.  $\int a \cdot f(x) \, dx = a \int f(x) \, dx$
3.  $\int \phi(y) \, dx = \int \frac{\phi(y)}{y'} \, dy$ , where  $y' = \frac{dy}{dx}$
4.  $\int (u + v) \, dx = \int u \, dx + \int v \, dx$ , where  $u$  and  $v$  are any functions of  $x$
5.  $\int u \, dv = u \int dv - \int v \, du = uv - \int v \, du$
6.  $\int u \frac{dv}{dx} \, dx = uv - \int v \frac{du}{dx} \, dx$
7.  $\int x^n \, dx = \frac{x^{n+1}}{n+1}$ , except  $n = -1$
8.  $\int \frac{f'(x) \, dx}{f(x)} = \log f(x)$ , ( $df(x) = f'(x) \, dx$ )
9.  $\int \frac{dx}{x} = \log x$
10.  $\int \frac{f'(x) \, dx}{2\sqrt{f(x)}} = \sqrt{f(x)}$ , ( $df(x) = f'(x) \, dx$ )
11.  $\int e^x \, dx = e^x$
12.  $\int e^{ax} \, dx = e^{ax} / a$
13.  $\int b^{ax} \, dx = \frac{b^{ax}}{a \log b}$ , ( $b > 0$ )
14.  $\int \log x \, dx = x \log x - x$
15.  $\int a^x \log a \, dx = a^x$ , ( $a > 0$ )
16.  $\int \frac{dx}{a^2 + x^2} = \frac{1}{a} \tan^{-1} \frac{x}{a}$
17.  $\int \frac{dx}{a^2 - x^2} = \begin{cases} \frac{1}{a} \tanh^{-1} \frac{x}{a} \\ \text{or} \\ \frac{1}{2a} \log \frac{a+x}{a-x}, & (a^2 > x^2) \end{cases}$
18.  $\int \frac{dx}{x^2 - a^2} = \begin{cases} -\frac{1}{a} \coth^{-1} \frac{x}{a} \\ \text{or} \\ \frac{1}{2a} \log \frac{x-a}{x+a}, & (x^2 > a^2) \end{cases}$

$$\begin{aligned}
19. \quad \int \frac{dx}{\sqrt{a^2 - x^2}} &= \begin{cases} \sin^{-1} \frac{x}{|a|} \\ \text{or} \\ -\cos^{-1} \frac{x}{|a|}, \end{cases} \quad (a^2 > x^2) \\
20. \quad \int \frac{dx}{\sqrt{x^2 \pm a^2}} &= \log(x + \sqrt{x^2 \pm a^2}) \\
21. \quad \int \frac{dx}{x\sqrt{x^2 - a^2}} &= \frac{1}{|a|} \sec^{-1} \frac{x}{a} \\
22. \quad \int \frac{dx}{x\sqrt{a^2 \pm x^2}} &= -\frac{1}{a} \log \left( \frac{a + \sqrt{a^2 \pm x^2}}{x} \right)
\end{aligned}$$

FORMS CONTAINING  $(a + bx)$ 

For forms containing  $a + bx$ , but not listed in the table, the substitution  $u = \frac{a+bx}{x}$  may prove helpful.

$$\begin{aligned}
23. \quad \int (a + bx)^n dx &= \frac{(a + bx)^{n+1}}{(n+1)b}, \quad (n \neq -1) \\
24. \quad \int x(a + bx)^n dx &= \frac{1}{b^2(n+2)}(a + bx)^{n+2} - \frac{a}{b^2(n+1)}(a + bx)^{n+1}, \quad (n \neq -1, -2) \\
25. \quad \int x^2(a + bx)^n dx &= \frac{1}{b^3} \left[ \frac{(a + bx)^{n+3}}{n+3} - 2a \frac{(a + bx)^{n+2}}{n+2} + a^2 \frac{(a + bx)^{n+1}}{n+1} \right] \\
26. \quad \int x^m(a + bx)^n dx &= \begin{cases} \frac{x^{m+1}(a+bx)^n}{m+n+1} + \frac{an}{m+n+1} \int x^m(a + bx)^{n-1} dx \\ \text{or} \\ \frac{1}{a(n+1)} \left[ -x^{m+1}(a + bx)^{n+1} + (m+n+2) \int x^m(a + bx)^{n+1} dx \right] \\ \text{or} \\ \frac{1}{b(m+n+1)} \left[ x^m(a + bx)^{n+1} - ma \int x^{m-1}(a + bx)^n dx \right] \end{cases} \\
27. \quad \int \frac{dx}{a + bx} &= \frac{1}{b} \log(a + bx) \\
28. \quad \int \frac{dx}{(a + bx)^2} &= -\frac{1}{b(a + bx)} \\
29. \quad \int \frac{dx}{(a + bx)^3} &= -\frac{1}{2b(a + bx)^2} \\
30. \quad \int \frac{x dx}{a + bx} &= \begin{cases} \frac{1}{b^2} [a + bx - a \log(a + bx)] \\ \text{or} \\ \frac{x}{b} - \frac{a}{b^2} \log(a + bx) \end{cases} \\
31. \quad \int \frac{x dx}{(a + bx)^2} &= \frac{1}{b^2} \left[ \log(a + bx) + \frac{a}{a + bx} \right] \\
32. \quad \int \frac{x dx}{(a + bx)^n} &= \frac{1}{b^2} \left[ \frac{-1}{(n-2)(a + bx)^{n-2}} + \frac{a}{(n-1)(a + bx)^{n-1}} \right], \quad n \neq 1, 2 \\
33. \quad \int \frac{x^2 dx}{a + bx} &= \frac{1}{b^3} \left[ \frac{1}{2}(a + bx)^2 - 2a(a + bx) + a^2 \log(a + bx) \right] \\
34. \quad \int \frac{x^2 dx}{(a + bx)^2} &= \frac{1}{b^3} \left[ a + bx - 2a \log(a + bx) - \frac{a^2}{a + bx} \right] \\
35. \quad \int \frac{x^2 dx}{(a + bx)^3} &= \frac{1}{b^3} \left[ \log(a + bx) + \frac{2a}{a + bx} - \frac{a^2}{2(a + bx)^2} \right] \\
36. \quad \int \frac{x^2 dx}{(a + bx)^n} &= \frac{1}{b^3} \left[ \frac{-1}{(n-3)(a + bx)^{n-3}} + \frac{2a}{(n-2)(a + bx)^{n-2}} - \frac{a^2}{(n-1)(a + bx)^{n-1}} \right], \quad n \neq 1, 2, 3 \\
37. \quad \int \frac{dx}{x(a + bx)} &= -\frac{1}{a} \log \frac{a + bx}{x} \\
38. \quad \int \frac{dx}{x(a + bx)^2} &= \frac{1}{a(a + bx)} - \frac{1}{a^2} \log \frac{a + bx}{x}
\end{aligned}$$

$$\begin{aligned}
39. \quad & \int \frac{dx}{x(a+bx)^3} = \frac{1}{a^3} \left[ \frac{1}{2} \left( \frac{2a+bx}{a+bx} \right)^2 + \log \frac{x}{a+bx} \right] \\
40. \quad & \int \frac{dx}{x^2(a+bx)} = -\frac{1}{ax} + \frac{b}{a^2} \log \frac{a+bx}{x} \\
41. \quad & \int \frac{dx}{x^3(a+bx)} = \frac{2bx-a}{2a^2x^2} + \frac{b^2}{a^3} \log \frac{x}{a+bx} \\
42. \quad & \int \frac{dx}{x^2(a+bx)^2} = -\frac{a+2bx}{a^2x(a+bx)} + \frac{2b}{a^3} \log \frac{a+bx}{x}
\end{aligned}$$

FORMS CONTAINING  $c^2 \pm x^2$  or  $x^2 - c^2$ 

$$\begin{aligned}
43. \quad & \int \frac{dx}{c^2+x^2} = \frac{1}{c} \tan^{-1} \frac{x}{c} \\
44. \quad & \int \frac{dx}{c^2-x^2} = \frac{1}{2c} \log \frac{c+x}{c-x}, \quad (c^2 > x^2) \\
45. \quad & \int \frac{dx}{x^2-c^2} = \frac{1}{2c} \log \frac{x-c}{x+c}, \quad (x^2 > c^2) \\
46. \quad & \int \frac{x dx}{c^2 \pm x^2} = \pm \frac{1}{2} \log (c^2 \pm x^2) \\
47. \quad & \int \frac{x dx}{(c^2 \pm x^2)^{n+1}} = \mp \frac{1}{2n(c^2 \pm x^2)^n} \\
48. \quad & \int \frac{dx}{(c^2 \pm x^2)^n} = \frac{1}{2c^2(n-1)} \left[ \frac{x}{(c^2 \pm x^2)^{n-1}} + (2n-3) \int \frac{dx}{(c^2 \pm x^2)^{n-1}} \right] \\
49. \quad & \int \frac{dx}{(x^2 - c^2)^n} = \frac{1}{2c^2(n-1)} \left[ -\frac{x}{(x^2 - c^2)^{n-1}} - (2n-3) \int \frac{dx}{(x^2 - c^2)^{n-1}} \right] \\
50. \quad & \int \frac{x dx}{x^2 - c^2} = \frac{1}{2} \log (x^2 - c^2) \\
51. \quad & \int \frac{x dx}{(x^2 - c^2)^{n+1}} = -\frac{1}{2n(x^2 - c^2)^n}
\end{aligned}$$

FORMS CONTAINING  $a+bx$  AND  $c+dx$ Define  $u = a+bx$ ,  $v = c+dx$ , and  $k = ad-bc$ . If  $k = 0$ , then  $v = \frac{c}{a}u$ .

$$\begin{aligned}
52. \quad & \int \frac{dx}{u \cdot v} = \frac{1}{k} \cdot \log \left( \frac{v}{u} \right) \\
53. \quad & \int \frac{x dx}{u \cdot v} = \frac{1}{k} \left[ \frac{a}{b} \log(u) - \frac{c}{d} \log(v) \right] \\
54. \quad & \int \frac{dx}{u^2 \cdot v} = \frac{1}{k} \left( \frac{1}{u} + \frac{d}{k} \log \frac{v}{u} \right) \\
55. \quad & \int \frac{x dx}{u^2 \cdot v} = \frac{-a}{bku} - \frac{c}{k^2} \log \frac{v}{u} \\
56. \quad & \int \frac{x^2 dx}{u^2 \cdot v} = \frac{a^2}{b^2ku} + \frac{1}{k^2} \left[ \frac{c^2}{d} \log(v) + \frac{a(k-bc)}{b^2} \log(u) \right] \\
57. \quad & \int \frac{dx}{u^n \cdot v^m} = \frac{1}{k(m-1)} \left[ \frac{-1}{u^{n-1} \cdot v^{m-1}} - (m+n-2)b \int \frac{dx}{u^n \cdot v^{m-1}} \right] \\
58. \quad & \int \frac{u}{v} dx = \frac{bx}{d} + \frac{k}{d^2} \log(v) \\
59. \quad & \int \frac{u^m dx}{v^n} = \begin{cases} \frac{-1}{k(n-1)} \left[ \frac{u^{m+1}}{v^{n-1}} + b(n-m-2) \int \frac{u^m}{v^{n-1}} dx \right] \\ \text{or} \\ \frac{-1}{d(n-m-1)} \left[ \frac{u^m}{v^{n-1}} + mk \int \frac{u^{m-1}}{v^n} dx \right] \\ \text{or} \\ \frac{-1}{d(n-1)} \left[ \frac{u^m}{v^{n-1}} - mb \int \frac{u^{m-1}}{v^{n-1}} dx \right] \end{cases}
\end{aligned}$$

FORMS CONTAINING  $(a + bx^n)$ 

60.  $\int \frac{dx}{a + bx^2} = \frac{1}{\sqrt{ab}} \tan^{-1} \frac{x\sqrt{ab}}{a}, \quad (ab > 0)$
61.  $\int \frac{dx}{a + bx^2} = \begin{cases} \frac{1}{2\sqrt{-ab}} \log \frac{a+x\sqrt{-ab}}{a-x\sqrt{-ab}}, & (ab < 0) \\ \text{or} \\ \frac{1}{\sqrt{-ab}} \tanh^{-1} \frac{x\sqrt{-ab}}{a}, & (ab < 0) \end{cases}$
62.  $\int \frac{dx}{a^2 + b^2x^2} = \frac{1}{ab} \tan^{-1} \frac{bx}{a}$
63.  $\int \frac{x dx}{a + bx^2} = \frac{1}{2b} \log(a + bx^2)$
64.  $\int \frac{x^2 dx}{a + bx^2} = \frac{x}{b} - \frac{a}{b} \int \frac{dx}{a + bx^2}$
65.  $\int \frac{dx}{(a + bx^2)^2} = \frac{x}{2a(a + bx^2)} + \frac{1}{2a} \int \frac{dx}{a + bx^2}$
66.  $\int \frac{dx}{a^2 - b^2x^2} = \frac{1}{2ab} \log \frac{a + bx}{a - bx}$
67.  $\int \frac{dx}{(a + bx^2)^{m+1}} = \begin{cases} \frac{1}{2ma} \frac{x}{(a + bx^2)^m} + \frac{2m-1}{2ma} \int \frac{dx}{(a + bx^2)^m} \\ \text{or} \\ \frac{(2m)!}{(m!)^2} \left[ \frac{x}{2a} \sum_{r=1}^m \frac{r!(r-1)!}{(4a)^{m-r}(2r)!(a + bx^2)^r} + \frac{1}{(4a)^m} \int \frac{dx}{a + bx^2} \right] \end{cases}$
68.  $\int \frac{x dx}{(a + bx^2)^{m+1}} = -\frac{1}{2bm(a + bx^2)^m}$
69.  $\int \frac{x^2 dx}{(a + bx^2)^{m+1}} = \frac{-x}{2mb(a + bx^2)^m} + \frac{1}{2mb} \int \frac{dx}{(a + bx^2)^m}$
70.  $\int \frac{dx}{x(a + bx^2)} = \frac{1}{2a} \log \frac{x^2}{a + bx^2}$
71.  $\int \frac{dx}{x^2(a + bx^2)} = -\frac{1}{ax} - \frac{b}{a} \int \frac{dx}{a + bx^2}$
72.  $\int \frac{dx}{x(a + bx^2)^{m+1}} = \begin{cases} \frac{1}{2am(a + bx^2)^m} + \frac{1}{a} \int \frac{dx}{x(a + bx^2)^m} \\ \text{or} \\ \frac{1}{2a^{m+1}} \left[ \sum_{r=1}^m \frac{a^r}{r(a + bx^2)^r} + \log \frac{x^2}{a + bx^2} \right] \end{cases}$
73.  $\int \frac{dx}{x^2(a + bx^2)^{m+1}} = \frac{1}{a} \int \frac{dx}{x^2(a + bx^2)^m} - \frac{b}{a} \int \frac{dx}{(a + bx^2)^{m+1}}$
74.  $\int \frac{dx}{a + bx^3} = \frac{k}{3a} \left[ \frac{1}{2} \log \frac{(k+x)^3}{a + bx^3} + \sqrt{3} \tan^{-1} \frac{2x-k}{k\sqrt{3}} \right], \quad \left( k = \sqrt[3]{\frac{a}{b}} \right)$
75.  $\int \frac{x dx}{a + bx^3} = \frac{1}{3bk} \left[ \frac{1}{2} \log \frac{a + bx^3}{(k+x)^3} + \sqrt{3} \tan^{-1} \frac{2x-k}{k\sqrt{3}} \right], \quad \left( k = \sqrt[3]{\frac{a}{b}} \right)$
76.  $\int \frac{x^2 dx}{a + bx^3} = \frac{1}{3b} \log(a + bx^3)$
77.  $\int \frac{dx}{a + bx^4} = \frac{k}{2a} \left[ \frac{1}{2} \log \frac{x^2 + 2kx + 2k^2}{x^2 - 2kx + 2k^2} + \tan^{-1} \frac{2kx}{2k^2 - x^2} \right], \quad \left( ab > 0, k = \sqrt[4]{\frac{a}{4b}} \right)$
78.  $\int \frac{dx}{a + bx^4} = \frac{k}{2a} \left[ \frac{1}{2} \log \frac{x+k}{x-k} + \tan^{-1} \frac{x}{k} \right], \quad \left( ab < 0, k = \sqrt[4]{-\frac{a}{b}} \right)$
79.  $\int \frac{x dx}{a + bx^4} = \frac{1}{2bk} \tan^{-1} \frac{x^2}{k}, \quad \left( ab > 0, k = \sqrt{\frac{a}{b}} \right)$
80.  $\int \frac{x dx}{a + bx^4} = \frac{1}{4bk} \log \frac{x^2 - k}{x^2 + k}, \quad \left( ab < 0, k = \sqrt{-\frac{a}{b}} \right)$
81.  $\int \frac{x^2 dx}{a + bx^4} = \frac{1}{4bk} \left[ \frac{1}{2} \log \frac{x^2 - 2kx + 2k^2}{x^2 + 2kx + 2k^2} + \tan^{-1} \frac{2kx}{2k^2 - x^2} \right], \quad \left( ab > 0, k = \sqrt[4]{\frac{a}{4b}} \right)$
82.  $\int \frac{x^2 dx}{a + bx^4} = \frac{1}{4bk} \left[ \log \frac{x-k}{x+k} + 2 \tan^{-1} \frac{x}{k} \right], \quad \left( ab < 0, k = \sqrt[4]{-\frac{a}{b}} \right)$
83.  $\int \frac{x^3 dx}{a + bx^4} = \frac{1}{4b} \log(a + bx^4)$
84.  $\int \frac{dx}{x(a + bx^n)} = \frac{1}{an} \log \frac{x^n}{a + bx^n}$

$$\begin{aligned}
85. \quad & \int \frac{dx}{(a+bx^n)^{m+1}} = \frac{1}{a} \int \frac{dx}{(a+bx^n)^m} - \frac{b}{a} \int \frac{x^n dx}{(a+bx^n)^{m+1}} \\
86. \quad & \int \frac{x^m dx}{(a+bx^n)^{p+1}} = \frac{1}{b} \int \frac{x^{m-n} dx}{(a+bx^n)^p} - \frac{a}{b} \int \frac{x^{m-n} dx}{(a+bx^n)^{p+1}} \\
87. \quad & \int \frac{dx}{x^m(a+bx^n)^{p+1}} = \frac{1}{a} \int \frac{dx}{x^m(a+bx^n)^p} - \frac{b}{a} \int \frac{dx}{x^{m-n}(a+bx^n)^{p+1}} \\
88. \quad & \int x^m(a+bx^n)^p dx = \begin{cases} \frac{1}{b(np+m+1)} [x^{m-n+1}(a+bx^n)^{p+1} - a(m-n+1) \int x^{m-n}(a+bx^n)^p dx] \\ \text{or} \\ \frac{1}{np+m+1} [x^{m+1}(a+bx^n)^p + anp \int x^m(a+bx^n)^{p-1} dx] \\ \text{or} \\ \frac{1}{a(m+1)} [x^{m+1}(a+bx^n)^{p+1} - (m+1+np+n)b \int x^{m+n}(a+bx^n)^p dx] \\ \text{or} \\ \frac{1}{an(p+1)} [-x^{m+1}(a+bx^n)^{p+1} + (m+1+np+n) \int x^m(a+bx^n)^{p+1} dx] \end{cases}
\end{aligned}$$

FORMS CONTAINING  $c^3 \pm x^3$ 

$$\begin{aligned}
89. \quad & \int \frac{dx}{c^3 \pm x^3} = \pm \frac{1}{6c^2} \log \frac{(c \pm x)^3}{c^3 \pm x^3} + \frac{1}{c^2\sqrt{3}} \tan^{-1} \frac{2x \mp c}{c\sqrt{3}} \\
90. \quad & \int \frac{dx}{(c^3 \pm x^3)^2} = \frac{x}{3c^3(c^3 \pm x^3)} + \frac{2}{3c^3} \int \frac{dx}{c^3 \pm x^3} \\
91. \quad & \int \frac{dx}{(c^3 \pm x^3)^{n+1}} = \frac{1}{3nc^3} \left[ \frac{x}{(c^3 \pm x^3)^n} + (3n-1) \int \frac{dx}{(c^3 \pm x^3)^n} \right] \\
92. \quad & \int \frac{x dx}{c^3 \pm x^3} = \frac{1}{6c} \log \frac{c^3 \pm x^3}{(c \pm x)^3} \pm \frac{1}{c\sqrt{3}} \tan^{-1} \frac{2x \mp c}{c\sqrt{3}} \\
93. \quad & \int \frac{x dx}{(c^3 \pm x^3)^2} = \frac{x^2}{3c^3(c^3 \pm x^3)} + \frac{1}{3c^3} \int \frac{x dx}{c^3 \pm x^3} \\
94. \quad & \int \frac{x dx}{(c^3 \pm x^3)^{n+1}} = \frac{1}{3nc^3} \left[ \frac{x^2}{(c^3 \pm x^3)^n} + (3n-2) \int \frac{x dx}{(c^3 \pm x^3)^n} \right] \\
95. \quad & \int \frac{x^2 dx}{c^3 \pm x^3} = \pm \frac{1}{3} \log(c^3 \pm x^3) \\
96. \quad & \int \frac{x^2 dx}{(c^3 \pm x^3)^{n+1}} = \mp \frac{1}{3n(c^3 \pm x^3)^n} \\
97. \quad & \int \frac{dx}{x(c^3 \pm x^3)} = \frac{1}{3c^3} \log \frac{x^3}{c^3 \pm x^3} \\
98. \quad & \int \frac{dx}{x(c^3 \pm x^3)^2} = \frac{1}{3c^3(c^3 \pm x^3)} + \frac{1}{3c^6} \log \frac{x^3}{c^3 \pm x^3} \\
99. \quad & \int \frac{dx}{x(c^3 \pm x^3)^{n+1}} = \frac{1}{3nc^3(c^3 \pm x^3)^n} + \frac{1}{c^3} \int \frac{dx}{x(c^3 \pm x^3)^n} \\
100. \quad & \int \frac{dx}{x^2(c^3 \pm x^3)} = -\frac{1}{c^3x} \mp \frac{1}{c^3} \int \frac{x dx}{c^3 \pm x^3} \\
101. \quad & \int \frac{dx}{x^2(c^3 \pm x^3)^{n+1}} = \frac{1}{c^3} \int \frac{dx}{x^2(c^3 \pm x^3)^n} \mp \frac{1}{c^3} \int \frac{x dx}{(c^3 \pm x^3)^{n+1}}
\end{aligned}$$

FORMS CONTAINING  $c^4 \pm x^4$ 

$$\begin{aligned}
102. \quad & \int \frac{dx}{c^4 + x^4} = \frac{1}{2c^3\sqrt{2}} \left[ \frac{1}{2} \log \frac{x^2 + cx\sqrt{2} + c^2}{x^2 - cx\sqrt{2} + c^2} + \tan^{-1} \frac{cx\sqrt{2}}{c^2 - x^2} \right] \\
103. \quad & \int \frac{dx}{c^4 - x^4} = \frac{1}{2c^3} \left[ \frac{1}{2} \log \frac{c+x}{c-x} + \tan^{-1} \frac{x}{c} \right] \\
104. \quad & \int \frac{x dx}{c^4 + x^4} = \frac{1}{2c^2} \tan^{-1} \frac{x^2}{c^2} \\
105. \quad & \int \frac{x dx}{c^4 - x^4} = \frac{1}{4c^2} \log \frac{c^2 + x^2}{c^2 - x^2} \\
106. \quad & \int \frac{x^2 dx}{c^4 + x^4} = \frac{1}{2c\sqrt{2}} \left[ \frac{1}{2} \log \frac{x^2 - cx\sqrt{2} + c^2}{x^2 + cx\sqrt{2} + c^2} + \tan^{-1} \frac{cx\sqrt{2}}{c^2 - x^2} \right]
\end{aligned}$$

$$107. \int \frac{x^2 dx}{c^4 - x^4} = \frac{1}{2c} \left[ \frac{1}{2} \log \frac{c+x}{c-x} - \tan^{-1} \frac{x}{c} \right]$$

$$108. \int \frac{x^3 dx}{c^4 \pm x^4} = \pm \frac{1}{4} \log (c^4 \pm x^4)$$

FORMS CONTAINING  $(a + bx + cx^2)$ 

Define  $X = a + bx + cx^2$  and  $q = 4ac - b^2$ . If  $q = 0$ , then  $X = c \left(x + \frac{b}{2c}\right)^2$ , and formulas starting with 23 should be used in place of these.

$$109. \int \frac{dx}{X} = \frac{2}{\sqrt{q}} \tan^{-1} \frac{2cx+b}{\sqrt{q}}, \quad (q > 0)$$

$$110. \int \frac{dx}{X} = \begin{cases} \frac{-2}{\sqrt{-q}} \tanh^{-1} \frac{2cx+b}{\sqrt{-q}} \\ \text{or} \\ \frac{1}{\sqrt{-q}} \log \frac{2cx+b-\sqrt{-q}}{2cx+b+\sqrt{-q}}, \end{cases} \quad (q < 0)$$

$$111. \int \frac{dx}{X^2} = \frac{2cx+b}{qX} + \frac{2c}{q} \int \frac{dx}{X}$$

$$112. \int \frac{dx}{X^3} = \frac{2cx+b}{q} \left( \frac{1}{2X^2} + \frac{3c}{qX} \right) + \frac{6c^2}{q^2} \int \frac{dx}{X}$$

$$113. \int \frac{dx}{X^{n+1}} = \begin{cases} \frac{2cx+b}{nqX^n} + \frac{2(2n-1)c}{qn} \int \frac{dx}{X^n} \\ \text{or} \\ \frac{(2n)!}{(n!)^2} \left( \frac{c}{q} \right)^n \left[ \frac{2cx+b}{q} \sum_{r=1}^n \left( \frac{q}{cX} \right)^r \left( \frac{(r-1)!r!}{(2r)!} \right) + \int \frac{dx}{X} \right] \end{cases}$$

$$114. \int \frac{x dx}{X} = \frac{1}{2c} \log X - \frac{b}{2c} \int \frac{dx}{X}$$

$$115. \int \frac{x dx}{X^2} = \frac{bx+2a}{qX} - \frac{b}{q} \int \frac{dx}{X}$$

$$116. \int \frac{x dx}{X^{n+1}} = -\frac{2a+bx}{nqX^n} - \frac{b(2n-1)}{nq} \int \frac{dx}{X^n}$$

$$117. \int \frac{x^2 dx}{X} = \frac{x}{c} - \frac{b}{2c^2} \log X + \frac{b^2-2ac}{2c^2} \int \frac{dx}{X}$$

$$118. \int \frac{x^2 dx}{X^2} = \frac{(b^2-2ac)x+ab}{cqX} + \frac{2a}{q} \int \frac{dx}{X}$$

$$119. \int \frac{x^m dx}{X^{n+1}} = -\frac{x^{m-1}}{(2n-m+1)cX^n} - \frac{n-m+1}{2n-m+1} \cdot \frac{b}{c} \int \frac{x^{m-1} dx}{X^{n+1}} + \frac{m-1}{2n-m+1} \cdot \frac{a}{c} \int \frac{x^{m-2} dx}{X^{n+1}}$$

$$120. \int \frac{dx}{xX} = \frac{1}{2a} \log \frac{x^2}{X} - \frac{b}{2a} \int \frac{dx}{X}$$

$$121. \int \frac{dx}{x^2 X} = \frac{b}{2a^2} \log \frac{X}{x^2} - \frac{1}{ax} + \left( \frac{b^2}{2a^2} - \frac{c}{a} \right) \int \frac{dx}{X}$$

$$122. \int \frac{dx}{xX^n} = \frac{1}{2a(n-1)X^{n-1}} - \frac{b}{2a} \int \frac{dx}{X^n} + \frac{1}{a} \int \frac{dx}{xX^{n-1}}$$

$$123. \int \frac{dx}{x^m X^{n+1}} = -\frac{1}{(m-1)ax^{m-1}X^n} - \frac{n+m-1}{m-1} \cdot \frac{b}{a} \int \frac{dx}{x^{m-1}X^{n+1}} - \frac{2n+m-1}{m-1} \cdot \frac{c}{a} \int \frac{dx}{x^{m-2}X^{n+1}}$$

FORMS CONTAINING  $\sqrt{a+bx}$ 

$$124. \int \sqrt{a+bx} dx = \frac{2}{3b} \sqrt{(a+bx)^3}$$

$$125. \int x\sqrt{a+bx} dx = -\frac{2(2a-3bx)\sqrt{(a+bx)^3}}{15b^2}$$

$$126. \int x^2\sqrt{a+bx} dx = \frac{2(8a^2-12abx+15b^2x^2)\sqrt{(a+bx)^3}}{105b^3}$$

$$127. \int x^m\sqrt{a+bx} dx = \begin{cases} \frac{2}{b(2m+3)} \left[ x^m \sqrt{(a+bx)^3} - ma \int x^{m-1} \sqrt{a+bx} dx \right] \\ \text{or} \\ \frac{2}{b^{m+1}} \sqrt{a+bx} \sum_{r=0}^m \frac{m!(-a)^{m-r}}{r!(m-r)!(2r+3)} (a+bx)^{r+1} \end{cases}$$

128.  $\int \frac{\sqrt{a+bx}}{x} dx = 2\sqrt{a+bx} + a \int \frac{dx}{x\sqrt{a+bx}}$
129.  $\int \frac{\sqrt{a+bx}}{x^2} dx = \frac{\sqrt{a+bx}}{x} + \frac{b}{2} \int \frac{dx}{x\sqrt{a+bx}}$
130.  $\int \frac{\sqrt{a+bx}}{x^m} dx = -\frac{1}{(m-1)a} \left[ \frac{\sqrt{(a+bx)^3}}{x^{m-1}} + \frac{(2m-5)b}{2} \int \frac{\sqrt{a+bx}}{x^{m-1}} dx \right]$
131.  $\int \frac{dx}{\sqrt{a+bx}} = \frac{2\sqrt{a+bx}}{b}$
132.  $\int \frac{x dx}{\sqrt{a+bx}} = -\frac{2(2a-bx)}{3b^2} \sqrt{a+bx}$
133.  $\int \frac{x^2 dx}{\sqrt{a+bx}} = \frac{2(8a^2 - 4abx - 3b^2x^2)}{15b^3} \sqrt{a+bx}$
134.  $\int \frac{x^m dx}{\sqrt{a+bx}} = \begin{cases} \frac{2}{(2m+1)b} \left[ x^m \sqrt{a+bx} - ma \int \frac{x^{m-1} dx}{\sqrt{a+bx}} \right] \\ \text{or} \\ \frac{2(-a)^m \sqrt{a+bx}}{b^{m+1}} \sum_{r=0}^m \frac{(-1)^r m!(a+bx)^r}{(2r+1)r!(m-r)!a^r} \end{cases}$
135.  $\int \frac{dx}{x\sqrt{a+bx}} = \frac{1}{\sqrt{a}} \log \left( \frac{\sqrt{a+bx} - \sqrt{a}}{\sqrt{a+bx} + \sqrt{a}} \right), \quad (a > 0)$
136.  $\int \frac{dx}{x\sqrt{a+bx}} = \frac{2}{\sqrt{-a}} \tan^{-1} \sqrt{\frac{a+bx}{-a}}, \quad (a < 0)$
137.  $\int \frac{dx}{x^2\sqrt{a+bx}} = -\frac{\sqrt{a+bx}}{ax} - \frac{b}{2a} \int \frac{dx}{x\sqrt{a+bx}}$
138.  $\int \frac{dx}{x^n \sqrt{a+bx}} = \begin{cases} -\frac{\sqrt{a+bx}}{(n-1)ax^{n-1}} - \frac{(2n-3)b}{(2n-2)a} \int \frac{dx}{x^{n-1}\sqrt{a+bx}} \\ \text{or} \\ \frac{(2n-2)!}{[(n-1)!]^2} \left[ -\frac{\sqrt{a+bx}}{a} \sum_{r=1}^{n-1} \frac{r!(r-1)!}{x^r 2(r)!} \left(-\frac{b}{4a}\right)^{n-r-1} + \left(-\frac{b}{4a}\right)^{n-1} \int \frac{dx}{x\sqrt{a+bx}} \right] \end{cases}$
139.  $\int (a+bx)^{\pm \frac{n}{2}} dx = \frac{2(a+bx)_2^{\pm n}}{b(2 \pm n)}$
140.  $\int x(a+bx)^{\pm \frac{n}{2}} dx = \frac{2}{b^2} \left[ \frac{(a+bx)_2^{4 \pm n}}{4 \pm n} - \frac{a(a+bx)_2^{2 \pm n}}{2 \pm n} \right]$
141.  $\int \frac{dx}{x(a+bx)^{\frac{m}{2}}} = \frac{1}{a} \int \frac{dx}{x(a+bx)^{\frac{m-2}{2}}} - \frac{b}{a} \int \frac{dx}{(a+bx)^{\frac{m}{2}}}$
142.  $\int \frac{(a+bx)^{n/2} dx}{x} = b \int (a+bx)^{(n-2)/2} dx + a \int \frac{(a+bx)^{(n-2)/2}}{x} dx$
143.  $\int f(x, \sqrt{a+bx}) dx = \frac{2}{b} \int f\left(\frac{z^2-a}{b}, z\right) z dz, \quad (z = \sqrt{a+bx})$

FORMS CONTAINING  $\sqrt{a+bx}$  and  $\sqrt{c+dx}$ 

Define  $u = a + bx$ ,  $v = c + dx$ , and  $k = ad - bc$ . If  $k = 0$ , then,  $v = (\frac{c}{a})u$ , and formulas starting with 124 should be used in place of these.

144.  $\int \frac{dx}{\sqrt{uv}} = \begin{cases} \frac{2}{\sqrt{bd}} \tanh^{-1} \frac{\sqrt{bd}uv}{bv}, & bd > 0, \quad k < 0 \\ \text{or} \\ \frac{2}{\sqrt{bd}} \tanh^{-1} \frac{\sqrt{bd}uv}{du}, & bd > 0, \quad k > 0 \\ \text{or} \\ \frac{1}{\sqrt{bd}} \log \frac{(bv + \sqrt{bd}uv)^2}{v}, & (bd > 0) \end{cases}$
145.  $\int \frac{dx}{\sqrt{uv}} = \begin{cases} \frac{2}{\sqrt{-bd}} \tan^{-1} \frac{\sqrt{-bd}uv}{bv} \\ \text{or} \\ -\frac{1}{\sqrt{-bd}} \sin^{-1} \left( \frac{2bdx+ad+bc}{|k|} \right), & (bd < 0) \end{cases}$



146.  $\int \sqrt{uv} \, dx = \frac{k+2bv}{4bd} \sqrt{uv} - \frac{k^2}{8bd} \int \frac{dx}{\sqrt{uv}}$
147.  $\int \frac{dx}{v\sqrt{u}} = \begin{cases} \frac{1}{\sqrt{kd}} \log \frac{d\sqrt{u}-\sqrt{kd}}{d\sqrt{u}+\sqrt{kd}} \\ \text{or} \\ \frac{1}{\sqrt{kd}} \log \frac{(d\sqrt{u}-\sqrt{kd})^2}{v}, \quad (kd > 0) \end{cases}$
148.  $\int \frac{dx}{v\sqrt{u}} = \frac{2}{\sqrt{-kd}} \tan^{-1} \frac{d\sqrt{u}}{\sqrt{-kd}}, \quad (kd < 0)$
149.  $\int \frac{x \, dx}{\sqrt{uv}} = \frac{\sqrt{uv}}{bd} - \frac{ad+bc}{2bd} \int \frac{dx}{\sqrt{uv}}$
150.  $\int \frac{dx}{v\sqrt{uv}} = \frac{-2\sqrt{uv}}{kv}$
151.  $\int \frac{v \, dx}{\sqrt{uv}} = \frac{\sqrt{uv}}{b} - \frac{k}{2b} \int \frac{dx}{\sqrt{uv}}$
152.  $\int \sqrt{\frac{v}{u}} \, dx = \frac{v}{|v|} \int \frac{v \, dx}{\sqrt{uv}}$
153.  $\int v^m \sqrt{u} \, dx = \frac{1}{(2m+3)d} \left( 2v^{m+1} \sqrt{u} + k \int \frac{v^m \, dx}{\sqrt{u}} \right)$
154.  $\int \frac{dx}{v^m \sqrt{u}} = -\frac{1}{(m-1)k} \left( \frac{\sqrt{u}}{v^{m-1}} + \left( m - \frac{3}{2} \right) b \int \frac{dx}{v^{m-1} \sqrt{u}} \right)$
155.  $\int \frac{v^m \, dx}{\sqrt{u}} = \begin{cases} \frac{2}{b(2m+1)} \left[ v^m \sqrt{u} - mk \int \frac{v^{m-1}}{\sqrt{u}} \, dx \right] \\ \text{or} \\ \frac{2(m!)^2 \sqrt{u}}{b(2m+1)!} \sum_{r=0}^m \left( -\frac{4k}{b} \right)^{m-r} \frac{(2r)!}{(r!)^2} v^r \end{cases}$

FORMS CONTAINING  $\sqrt{x^2 \pm a^2}$ 

156.  $\int \sqrt{x^2 \pm a^2} \, dx = \frac{1}{2} \left[ x \sqrt{x^2 \pm a^2} \pm a^2 \log(x + \sqrt{x^2 \pm a^2}) \right]$
157.  $\int \frac{dx}{\sqrt{x^2 \pm a^2}} = \log(x + \sqrt{x^2 \pm a^2})$
158.  $\int \frac{dx}{x\sqrt{x^2 - a^2}} = \frac{1}{|a|} \sec^{-1} \frac{x}{a}$
159.  $\int \frac{dx}{x\sqrt{x^2 + a^2}} = -\frac{1}{a} \log \left( \frac{a + \sqrt{x^2 + a^2}}{x} \right)$
160.  $\int \frac{\sqrt{x^2 + a^2}}{x} \, dx = \sqrt{x^2 + a^2} - a \log \left( \frac{a + \sqrt{x^2 + a^2}}{x} \right)$
161.  $\int \frac{\sqrt{x^2 - a^2}}{x} \, dx = \sqrt{x^2 - a^2} - |a| \sec^{-1} \frac{x}{a}$
162.  $\int \frac{x \, dx}{\sqrt{x^2 \pm a^2}} = \sqrt{x^2 \pm a^2}$
163.  $\int x \sqrt{x^2 \pm a^2} \, dx = \frac{1}{3} \sqrt{(x^2 \pm a^2)^3}$
164.  $\int \sqrt{(x^2 \pm a^2)^3} \, dx = \frac{1}{4} \left[ x \sqrt{(x^2 \pm a^2)^3} \pm \frac{3a^2 x}{2} \sqrt{x^2 \pm a^2} + \frac{3a^4}{2} \log(x + \sqrt{x^2 \pm a^2}) \right]$
165.  $\int \frac{dx}{\sqrt{(x^2 \pm a^2)^3}} = \frac{\pm x}{a^2 \sqrt{x^2 \pm a^2}}$
166.  $\int \frac{x \, dx}{\sqrt{(x^2 \pm a^2)^3}} = \frac{-1}{\sqrt{x^2 \pm a^2}}$
167.  $\int x \sqrt{(x^2 \pm a^2)^3} \, dx = \frac{1}{5} \sqrt{(x^2 \pm a^2)^5}$
168.  $\int x^2 \sqrt{x^2 \pm a^2} \, dx = \frac{x}{4} \sqrt{(x^2 \pm a^2)^3} \mp \frac{a^2}{8} x \sqrt{x^2 \pm a^2} - \frac{a^4}{8} \log(x + \sqrt{x^2 \pm a^2})$

169.  $\int x^3 \sqrt{x^2 + a^2} dx = \left(\frac{1}{5}x^2 - \frac{2}{15}a^2\right) \sqrt{(a^2 + x^2)^3}$
170.  $\int x^3 \sqrt{x^2 - a^2} dx = \frac{1}{5} \sqrt{(x^2 - a^2)^5} + \frac{a^2}{3} \sqrt{(x^2 - a^2)^3}$
171.  $\int \frac{x^2 dx}{\sqrt{x^2 \pm a^2}} = \frac{x}{2} \sqrt{x^2 \pm a^2} \mp \frac{a^2}{2} \log(x + \sqrt{x^2 \pm a^2})$
172.  $\int \frac{x^3 dx}{\sqrt{x^2 \pm a^2}} = \frac{1}{3} \sqrt{(x^2 \pm a^2)^3} \mp a^2 \sqrt{x^2 \pm a^2}$
173.  $\int \frac{dx}{x^2 \sqrt{x^2 \pm a^2}} = \mp \frac{\sqrt{x^2 \pm a^2}}{a^2 x}$
174.  $\int \frac{dx}{x^3 \sqrt{x^2 + a^2}} = \frac{\sqrt{x^2 + a^2}}{2a^2 x^2} + \frac{1}{2a^3} \log \frac{a + \sqrt{x^2 + a^2}}{x}$
175.  $\int \frac{dx}{x^3 \sqrt{x^2 - a^2}} = \frac{\sqrt{x^2 - a^2}}{2a^2 x^2} + \frac{1}{2|a^3|} \sec^{-1} \frac{x}{a}$
176.  $\int x^2 \sqrt{(x^2 \pm a^2)^3} dx = \frac{x}{6} \sqrt{(x^2 \pm a^2)^5} \mp \frac{a^2 x}{24} \sqrt{(x^2 \pm a^2)^3} - \frac{a^4 x}{16} \sqrt{x^2 \pm a^2} \mp \frac{a^6}{16} \log(x + \sqrt{x^2 \pm a^2})$
177.  $\int x^3 \sqrt{(x^2 \pm a^2)^3} dx = \frac{1}{7} \sqrt{(x^2 \pm a^2)^7} \mp \frac{a^2}{5} \sqrt{(x^2 \pm a^2)^5}$
178.  $\int \frac{\sqrt{x^2 \pm a^2} dx}{x^2} = -\frac{\sqrt{x^2 \pm a^2}}{x} + \log(x + \sqrt{x^2 \pm a^2})$
179.  $\int \frac{\sqrt{x^2 + a^2}}{x^3} dx = -\frac{\sqrt{x^2 + a^2}}{2x^2} - \frac{1}{2a} \log \frac{a + \sqrt{x^2 + a^2}}{x}$
180.  $\int \frac{\sqrt{x^2 - a^2}}{x^3} dx = -\frac{\sqrt{x^2 - a^2}}{2x^2} + \frac{1}{2|a|} \sec^{-1} \frac{x}{a}$
181.  $\int \frac{\sqrt{x^2 \pm a^2}}{x^4} dx = \mp \frac{\sqrt{(x^2 \pm a^2)^3}}{3a^2 x^3}$
182.  $\int \frac{x^2 dx}{\sqrt{(x^2 \pm a^2)^3}} = \frac{-x}{\sqrt{x^2 \pm a^2}} + \log(x + \sqrt{x^2 \pm a^2})$
183.  $\int \frac{x^3 dx}{\sqrt{(x^2 \pm a^2)^3}} = \sqrt{x^2 \pm a^2} \pm \frac{a^2}{\sqrt{x^2 \pm a^2}}$
184.  $\int \frac{dx}{x \sqrt{(x^2 + a^2)^3}} = \frac{1}{a^2 \sqrt{x^2 + a^2}} - \frac{1}{a^3} \log \frac{a + \sqrt{x^2 + a^2}}{x}$
185.  $\int \frac{dx}{x \sqrt{(x^2 - a^2)^3}} = -\frac{1}{a^2 \sqrt{x^2 - a^2}} - \frac{1}{|a^3|} \sec^{-1} \frac{x}{a}$
186.  $\int \frac{dx}{x^2 \sqrt{(x^2 \pm a^2)^3}} = -\frac{1}{a^4} \left[ \frac{\sqrt{x^2 \pm a^2}}{x} + \frac{x}{\sqrt{x^2 \pm a^2}} \right]$
187.  $\int \frac{dx}{x^3 \sqrt{(x^2 + a^2)^3}} = -\frac{1}{2a^2 x^2 \sqrt{x^2 + a^2}} - \frac{3}{2a^4 \sqrt{x^2 + a^2}} + \frac{3}{2a^5} \log \frac{a + \sqrt{x^2 + a^2}}{x}$
188.  $\int \frac{dx}{x^3 \sqrt{(x^2 - a^2)^3}} = \frac{1}{2a^2 x^2 \sqrt{x^2 - a^2}} - \frac{3}{2a^4 \sqrt{x^2 - a^2}} - \frac{3}{2|a^5|} \sec^{-1} \frac{x}{a}$
189.  $\int \frac{x^m}{\sqrt{x^2 \pm a^2}} dx = \frac{1}{m} x^{m-1} \sqrt{x^2 \pm a^2} \mp \frac{m-1}{m} a^2 \int \frac{x^{m-2}}{\sqrt{x^2 \pm a^2}} dx$
190.  $\int \frac{x^{2m}}{\sqrt{x^2 \pm a^2}} dx = \frac{(2m)!}{2^{2m}(m!)^2} \left[ \sqrt{x^2 \pm a^2} \sum_{r=1}^m \frac{r!(r-1)!}{(2r)!} (\mp a^2)^{m-r} (2x)^{2r-1} + (\mp a^2)^m \log(x + \sqrt{x^2 \pm a^2}) \right]$
191.  $\int \frac{x^{2m+1}}{\sqrt{x^2 \pm a^2}} dx = \sqrt{x^2 \pm a^2} \sum_{r=0}^m \frac{(2r)!(m!)^2}{(2m+1)!(r!)^2} (\mp 4a^2)^{m-r} x^{2r}$
192.  $\int \frac{dx}{x^m \sqrt{x^2 \pm a^2}} = \mp \frac{\sqrt{x^2 \pm a^2}}{(m-1)a^2 x^{m-1}} \mp \frac{(m-2)}{(m-1)a^2} \int \frac{dx}{x^{m-2} \sqrt{x^2 \pm a^2}}$

$$193. \int \frac{dx}{x^{2m}\sqrt{x^2 \pm a^2}} = \sqrt{x^2 \pm a^2} \sum_{r=0}^{m-1} \frac{(m-1)!m!(2r)!2^{2m-2r-1}}{(r!)^2(2m)!(\mp a^2)^{m-r}x^{2r+1}}$$

$$194. \int \frac{dx}{x^{2m+1}\sqrt{x^2+a^2}} = \frac{(2m)!}{(m!)^2} \left[ \frac{\sqrt{x^2+a^2}}{a^2} \sum_{r=1}^m (-1)^{m-r+1} \frac{r!(r-1)!}{2(2r)!(4a^2)^{m-r}x^{2r}} \right. \\ \left. + \frac{(-1)^{m+1}}{2^{2m}a^{2m+1}} \log \frac{\sqrt{x^2+a^2}+a}{x} \right]$$

$$195. \int \frac{dx}{x^{2m+1}\sqrt{x^2-a^2}} = \frac{(2m)!}{(m!)^2} \left[ \frac{\sqrt{x^2-a^2}}{a^2} \sum_{r=1}^m \frac{r!(r-1)!}{2(2r)!(4a^2)^{m-r}x^{2r}} + \frac{1}{2^{2m}|a|^{2m+1}} \sec^{-1} \frac{x}{a} \right]$$

$$196. \int \frac{dx}{(x-a)\sqrt{x^2-a^2}} = -\frac{\sqrt{x^2-a^2}}{a(x-a)}$$

$$197. \int \frac{dx}{(x+a)\sqrt{x^2-a^2}} = \frac{\sqrt{x^2-a^2}}{a(x+a)}$$

$$198. \int f(x, \sqrt{x^2+a^2}) dx = a \int f(a \tan u, a \sec u) \sec^2 u du, \quad (u = \tan^{-1} \frac{x}{a}, a > 0)$$

$$199. \int f(x, \sqrt{x^2-a^2}) dx = a \int f(a \sec u, a \tan u) \sec u \tan u du, \quad (u = \sec^{-1} \frac{x}{a}, a > 0)$$

#### FORMS CONTAINING $\sqrt{a^2-x^2}$

$$200. \int \sqrt{a^2-x^2} dx = \frac{1}{2} \left[ x\sqrt{a^2-x^2} + a^2 \sin^{-1} \frac{x}{|a|} \right]$$

$$201. \int \frac{dx}{\sqrt{a^2-x^2}} = \begin{cases} \sin^{-1} \frac{x}{|a|} \\ \text{or} \\ -\cos^{-1} \frac{x}{|a|} \end{cases}$$

$$202. \int \frac{dx}{x\sqrt{a^2-x^2}} = -\frac{1}{a} \log \left( \frac{a + \sqrt{a^2-x^2}}{x} \right)$$

$$203. \int \frac{\sqrt{a^2-x^2}}{x} dx = \sqrt{a^2-x^2} - a \log \left( \frac{a + \sqrt{a^2-x^2}}{x} \right)$$

$$204. \int \frac{x dx}{\sqrt{a^2-x^2}} = -\sqrt{a^2-x^2}$$

$$205. \int x\sqrt{a^2-x^2} dx = -\frac{1}{3} \sqrt{(a^2-x^2)^3}$$

$$206. \int \sqrt{(a^2-x^2)^3} dx = \frac{1}{4} \left[ x\sqrt{(a^2-x^2)^3} + \frac{3a^2x}{2} \sqrt{a^2-x^2} + \frac{3a^4}{2} \sin^{-1} \frac{x}{|a|} \right]$$

$$207. \int \frac{dx}{\sqrt{(a^2-x^2)^3}} = \frac{x}{a^2\sqrt{a^2-x^2}}$$

$$208. \int \frac{x dx}{\sqrt{(a^2-x^2)^3}} = \frac{1}{\sqrt{a^2-x^2}}$$

$$209. \int x\sqrt{(a^2-x^2)^3} dx = -\frac{1}{5} \sqrt{(a^2-x^2)^5}$$

$$210. \int x^2\sqrt{a^2-x^2} dx = -\frac{x}{4} \sqrt{(a^2-x^2)^3} + \frac{a^2}{8} \left( x\sqrt{a^2-x^2} + a^2 \sin^{-1} \frac{x}{|a|} \right)$$

$$211. \int x^3\sqrt{a^2-x^2} dx = \left( -\frac{1}{5}x^2 - \frac{2}{15}a^2 \right) \sqrt{(a^2-x^2)^3}$$

$$212. \int x^2\sqrt{(a^2-x^2)^3} dx = -\frac{1}{6}x\sqrt{(a^2-x^2)^5} + \frac{a^2x}{24} \sqrt{(a^2-x^2)^3} + \frac{a^4x}{16} \sqrt{a^2-x^2} + \frac{a^6}{16} \sin^{-1} \frac{x}{|a|}$$

$$213. \int x^3\sqrt{(a^2-x^2)^3} dx = \frac{1}{7} \sqrt{(a^2-x^2)^7} - \frac{a^2}{5} \sqrt{(a^2-x^2)^5}$$

$$214. \int \frac{x^2 dx}{\sqrt{a^2-x^2}} = -\frac{x}{2} \sqrt{a^2-x^2} + \frac{a^2}{2} \sin^{-1} \frac{x}{|a|}$$

$$215. \int \frac{dx}{x^2\sqrt{a^2-x^2}} = -\frac{\sqrt{a^2-x^2}}{a^2x}$$

$$216. \int \frac{\sqrt{a^2-x^2}}{x^2} dx = -\frac{\sqrt{a^2-x^2}}{x} - \sin^{-1} \frac{x}{|a|}$$

217.  $\int \frac{\sqrt{a^2 - x^2}}{x^3} dx = -\frac{\sqrt{a^2 - x^2}}{2x^2} + \frac{1}{2a} \log \frac{a + \sqrt{a^2 - x^2}}{x}$
218.  $\int \frac{\sqrt{a^2 - x^2}}{x^4} dx = -\frac{\sqrt{(a^2 - x^2)^3}}{3a^2 x^3}$
219.  $\int \frac{x^2 dx}{\sqrt{(a^2 - x^2)^3}} = \frac{x}{\sqrt{a^2 - x^2}} - \sin^{-1} \frac{x}{|a|}$
220.  $\int \frac{x^3 dx}{\sqrt{a^2 - x^2}} = -\frac{2}{3}(a^2 - x^2)^{3/2} - x^2(a^2 - x^2)^{1/2} = -\frac{1}{3}\sqrt{a^2 - x^2}(x^2 + 2a^2)$
221.  $\int \frac{x^3 dx}{\sqrt{(a^2 - x^2)^3}} = 2(a^2 - x^2)^{1/2} + \frac{x^2}{(a^2 - x^2)^{1/2}} = -\frac{a^2}{\sqrt{a^2 - x^2}} + \sqrt{a^2 - x^2}$
222.  $\int \frac{dx}{x^3 \sqrt{a^2 - x^2}} = -\frac{\sqrt{a^2 - x^2}}{2a^2 x^2} - \frac{1}{2a^3} \log \frac{a + \sqrt{a^2 - x^2}}{x}$
223.  $\int \frac{dx}{x \sqrt{(a^2 - x^2)^3}} = \frac{1}{a^2 \sqrt{a^2 - x^2}} - \frac{1}{a^3} \log \frac{a + \sqrt{a^2 - x^2}}{x}$
224.  $\int \frac{dx}{x^2 \sqrt{(a^2 - x^2)^3}} = \frac{1}{a^4} \left[ -\frac{\sqrt{a^2 - x^2}}{x} + \frac{x}{\sqrt{a^2 - x^2}} \right]$
225.  $\int \frac{dx}{x^3 \sqrt{(a^2 - x^2)^3}} = -\frac{1}{2a^2 x^2 \sqrt{a^2 - x^2}} + \frac{3}{2a^4 \sqrt{a^2 - x^2}} - \frac{3}{2a^5} \log \frac{a + \sqrt{a^2 - x^2}}{x}$
226.  $\int \frac{x^m}{\sqrt{a^2 - x^2}} dx = -\frac{x^{m-1} \sqrt{a^2 - x^2}}{m} + \frac{(m-1)a^2}{m} \int \frac{x^{m-2}}{\sqrt{a^2 - x^2}} dx$
227.  $\int \frac{x^{2m}}{\sqrt{a^2 - x^2}} dx = \frac{(2m)!}{(m!)^2} \left[ -\sqrt{a^2 - x^2} \sum_{r=1}^m \frac{r!(r-1)!}{2^{2m-2r+1}(2r)!} a^{2m-2r} x^{2r-1} + \frac{a^{2m}}{2^{2m}} \sin^{-1} \frac{x}{|a|} \right]$
228.  $\int \frac{x^{2m+1}}{\sqrt{a^2 - x^2}} dx = -\sqrt{a^2 - x^2} \sum_{r=0}^m \frac{(2r)!(m!)^2}{(2m+1)!(r!)^2} (4a^2)^{m-r} x^{2r}$
229.  $\int \frac{dx}{x^m \sqrt{a^2 - x^2}} = -\frac{\sqrt{a^2 - x^2}}{(m-1)a^2 x^{m-1}} + \frac{m-2}{(m-1)a^2} \int \frac{dx}{x^{m-2} \sqrt{a^2 - x^2}}$
230.  $\int \frac{ax}{x^{2m} \sqrt{a^2 - x^2}} = -\sqrt{a^2 - x^2} \sum_{r=0}^{m-1} \frac{(m-1)!m!(2r)!2^{2m-2r-1}}{(r!)^2(2m)!a^{2m-2r} x^{2r+1}}$
231.  $\int \frac{dx}{x^{2m+1} \sqrt{a^2 - x^2}} = \frac{(2m)!}{(m!)^2} \left[ -\frac{\sqrt{a^2 - x^2}}{a^2} \sum_{r=1}^m \frac{r!(r-1)!}{2(2r)!(4a^2)^{m-r} x^{2r}} + \frac{1}{2^{2m} a^{2m+1}} \log \frac{a - \sqrt{a^2 - x^2}}{x} \right]$
232.  $\int \frac{dx}{(b^2 - x^2) \sqrt{a^2 - x^2}} = \frac{1}{2b \sqrt{a^2 - b^2}} \log \frac{(b \sqrt{a^2 - x^2} + x \sqrt{a^2 - b^2})^2}{b^2 - x^2}, \quad (a^2 > b^2)$
233.  $\int \frac{dx}{(b^2 - x^2) \sqrt{a^2 - x^2}} = \frac{1}{b \sqrt{b^2 - a^2}} \tan^{-1} \frac{x \sqrt{b^2 - a^2}}{b \sqrt{a^2 - x^2}}, \quad (b^2 > a^2)$
234.  $\int \frac{dx}{(b^2 + x^2) \sqrt{a^2 - x^2}} = \frac{1}{b \sqrt{a^2 + b^2}} \tan^{-1} \frac{x \sqrt{a^2 + b^2}}{b \sqrt{a^2 - x^2}}$
235.  $\int \frac{\sqrt{a^2 - x^2}}{b^2 + x^2} dx = \frac{\sqrt{a^2 + b^2}}{|b|} \sin^{-1} \frac{x \sqrt{a^2 + b^2}}{|a| \sqrt{x^2 + b^2}} - \sin^{-1} \frac{x}{|a|}$
236.  $\int f(x, \sqrt{a^2 - x^2}) dx = a \int f(a \sin u, a \cos u) \cos u du, \quad \left( u = \sin^{-1} \frac{x}{a}, a > 0 \right)$

FORMS CONTAINING  $\sqrt{a + bx + cx^2}$ 

Define  $X = a + bx + cx^2$ ,  $q = 4ac - b^2$ , and  $k = \frac{4c}{q}$ . If  $q = 0$ , then  $\sqrt{X} = \sqrt{c} \left| x + \frac{b}{2c} \right|$ .

237.  $\int \frac{dx}{\sqrt{X}} = \begin{cases} \frac{1}{\sqrt{c}} \log(2\sqrt{cX} + 2cx + b) \\ \text{or} \\ \frac{1}{\sqrt{c}} \sinh^{-1} \frac{2cx+b}{\sqrt{q}}, \end{cases} \quad (c > 0)$
238.  $\int \frac{dx}{\sqrt{X}} = -\frac{1}{\sqrt{-c}} \sin^{-1} \frac{2cx+b}{\sqrt{-q}}, \quad (c < 0)$

- $$239. \int \frac{dx}{X\sqrt{x}} = \frac{2(2cx+b)}{q\sqrt{x}}$$
- $$240. \int \frac{dx}{X^2\sqrt{x}} = \frac{2(2cx+b)}{3q\sqrt{x}} \left( \frac{1}{X} + 2k \right)$$
- $$241. \int \frac{dx}{X^n\sqrt{x}} = \begin{cases} \frac{2(2cx+b)\sqrt{x}}{(2n-1)qX^n} + \frac{2k(n-1)}{2n-1} \int \frac{dx}{X^{n-1}\sqrt{x}} \\ \text{or} \\ \frac{(2cx+b)(n!)(n-1)!4^n k^{n-1}}{q!(2n)! \sqrt{x}} \sum_{r=0}^{n-1} \frac{(2r)!}{(4kX)^r (r!)^2} \end{cases}$$
- $$242. \int \sqrt{x} dx = \frac{(2cx+b)\sqrt{x}}{4c} + \frac{1}{2k} \int \frac{dx}{\sqrt{x}}$$
- $$243. \int X\sqrt{x} dx = \frac{(2cx+b)\sqrt{x}}{8c} \left( X + \frac{3}{2k} \right) + \frac{3}{8k^2} \int \frac{dx}{\sqrt{x}}$$
- $$244. \int X^2\sqrt{x} dx = \frac{(2cx+b)\sqrt{x}}{12c} \left( X^2 + \frac{5X}{4k} + \frac{15}{8k^2} \right) + \frac{5}{16k^3} \int \frac{dx}{\sqrt{x}}$$
- $$245. \int X^n\sqrt{x} dx = \begin{cases} \frac{(2cx+b)X^n\sqrt{x}}{4(n+1)c} + \frac{2n+1}{2(n+1)k} \int X^{n-1}\sqrt{x} dx \\ \text{or} \\ \frac{(2n+2)!}{[(n+1)!]^2(4k)^{n+1}} \frac{k(2cx+b)\sqrt{x}}{c} \sum_{r=0}^n \frac{r!(r+1)!(4kX)^r}{(2r+2)!} + \int \frac{dx}{\sqrt{x}} \end{cases}$$
- $$246. \int \frac{x dx}{\sqrt{x}} = \frac{\sqrt{x}}{c} - \frac{b}{2c} \int \frac{dx}{\sqrt{x}}$$
- $$247. \int \frac{x dx}{X\sqrt{x}} = -\frac{2(bx+2a)}{q\sqrt{x}}$$
- $$248. \int \frac{x dx}{X^n\sqrt{x}} = -\frac{\sqrt{x}}{(2n-1)cX^n} - \frac{b}{2c} \int \frac{dx}{X^n\sqrt{x}}$$
- $$249. \int \frac{x^2 dx}{\sqrt{x}} = \left( \frac{x}{2c} - \frac{3b}{4c^2} \right) \sqrt{x} + \frac{3b^2-4ac}{8c^2} \int \frac{dx}{\sqrt{x}}$$
- $$250. \int \frac{x^2 dx}{X\sqrt{x}} = \frac{(2b^2-4ac)x+2ab}{cq\sqrt{x}} + \frac{1}{c} \int \frac{dx}{\sqrt{x}}$$
- $$251. \int \frac{x^2 dx}{X^n\sqrt{x}} = \frac{(2b^2-4ac)x+2ab}{(2n-1)cqX^{n-1}\sqrt{x}} + \frac{4ac+(2n-3)b^2}{(2n-1)cq} \int \frac{dx}{X^{n-1}\sqrt{x}}$$
- $$252. \int \frac{x^3 dx}{\sqrt{x}} = \left( \frac{x^2}{3c} - \frac{5bx}{12c^2} + \frac{5b^2}{8c^3} - \frac{2a}{3c^2} \right) \sqrt{x} + \left( \frac{3ab}{4c^2} - \frac{5b^3}{16c^3} \right) \int \frac{dx}{\sqrt{x}}$$
- $$253. \int \frac{x^n dx}{\sqrt{x}} = \frac{1}{nc} x^{n-1} \sqrt{x} - \frac{(2n-1)b}{2nc} \int \frac{x^{n-1} dx}{\sqrt{x}} - \frac{(n-1)a}{nc} \int \frac{x^{n-2} dx}{\sqrt{x}}$$
- $$254. \int x\sqrt{x} dx = \frac{X\sqrt{x}}{3c} - \frac{b(2cx+b)}{8c^2} \sqrt{x} - \frac{b}{4ck} \int \frac{dx}{\sqrt{x}}$$
- $$255. \int xX\sqrt{x} dx = \frac{X^2\sqrt{x}}{5c} - \frac{b}{2c} \int X\sqrt{x} dx$$
- $$256. \int xX^n\sqrt{x} dx = \frac{X^{n+1}\sqrt{x}}{(2n+3)c} - \frac{b}{2c} \int X^n\sqrt{x} dx$$
- $$257. \int x^2\sqrt{x} dx = \left( x - \frac{5b}{6c} \right) \frac{X\sqrt{x}}{4c} + \frac{5b^2-4ac}{16c^2} \int \sqrt{x} dx$$
- $$258. \int \frac{dx}{x\sqrt{x}} = -\frac{1}{\sqrt{a}} \log \frac{2\sqrt{a}X+bx+2a}{x}, \quad (a > 0)$$
- $$259. \int \frac{dx}{x\sqrt{x}} = \frac{1}{\sqrt{-a}} \sin^{-1} \left( \frac{bx+2a}{|x|\sqrt{-q}} \right), \quad (a < 0)$$
- $$260. \int \frac{dx}{x\sqrt{x}} = -\frac{2\sqrt{x}}{bx}, \quad (a = 0)$$
- $$261. \int \frac{dx}{x^2\sqrt{x}} = -\frac{\sqrt{x}}{ax} - \frac{b}{2a} \int \frac{dx}{x\sqrt{x}}$$
- $$262. \int \frac{\sqrt{x} dx}{x} = \sqrt{x} + \frac{b}{2} \int \frac{dx}{\sqrt{x}} + a \int \frac{dx}{x\sqrt{x}}$$
- $$263. \int \frac{\sqrt{x} dx}{x^2} = -\frac{\sqrt{x}}{x} + \frac{b}{2} \int \frac{dx}{x\sqrt{x}} + c \int \frac{dx}{\sqrt{x}}$$

FORMS INVOLVING  $\sqrt{2ax - x^2}$ 

264.  $\int \sqrt{2ax - x^2} dx = \frac{1}{2} \left[ (x - a) \sqrt{2ax - x^2} + a^2 \sin^{-1} \frac{x - a}{|a|} \right]$
265.  $\int \frac{dx}{\sqrt{2ax - x^2}} = \begin{cases} \cos^{-1} \frac{a-x}{|a|} \\ \text{or} \\ \sin^{-1} \frac{x-a}{|a|} \end{cases}$
266.  $\int x^n \sqrt{2ax - x^2} dx = \begin{cases} -\frac{x^{n-1}(2ax-x^2)^{3/2}}{n+2} + \frac{(2n+1)a}{n+2} \int x^{n-1} \sqrt{2ax - x^2} dx \\ \text{or} \\ \sqrt{2ax - x^2} \left[ \frac{x^{n+1}}{n+2} - \sum_{r=0}^n \frac{(2n+1)!(r!)^2 a^{n-r+1}}{2^{n-r}(2r+1)!(n+2)!n!} x^r \right] \\ + \frac{(2n+1)!a^{n+2}}{2^n n!(n+2)!} \sin^{-1} \frac{x-a}{|a|} \end{cases}$
267.  $\int \frac{\sqrt{2ax - x^2}}{x^n} dx = \frac{(2ax - x^2)^{1/2}}{(3-2n)ax^n} + \frac{n-3}{(2n-3)a} \int \frac{\sqrt{2ax - x^2}}{x^{n-1}} dx$
268.  $\int \frac{x^n dx}{\sqrt{2ax - x^2}} = \begin{cases} \frac{-x^{n-1}\sqrt{2ax-x^2}}{n} + \frac{a(2n-1)}{n} \int \frac{x^{n-1}}{\sqrt{2ax-x^2}} dx \\ \text{or} \\ -\sqrt{2ax - x^2} \sum_{r=1}^n \frac{(2n)!r!(r-1)!a^{n-r}}{2^{n-r}(2r)!(n!)^2} x^{r-1} + \frac{(2n)!a^n}{2^n(n!)^2} \sin^{-1} \frac{x-a}{|a|} \end{cases}$
269.  $\int \frac{dx}{x^n \sqrt{2ax - x^2}} = \begin{cases} \frac{\sqrt{2ax - x^2}}{a(1-2n)x^n} + \frac{n-1}{(2n-1)a} \int \frac{dx}{x^{n-1} \sqrt{2ax - x^2}} \\ \text{or} \\ -\sqrt{2ax - x^2} \sum_{r=0}^{n-1} \frac{2^{n-r}(n-1)!n!(2r)!}{(2n)!(r!)^2 a^{n-r} x^{r+1}} \end{cases}$
270.  $\int \frac{dx}{(2ax - x^2)^{3/2}} = \frac{x - a}{a^2 \sqrt{2ax - x^2}}$
271.  $\int \frac{x dx}{(2ax - x^2)^{3/2}} = \frac{x}{a \sqrt{2ax - x^2}}$

## MISCELLANEOUS ALGEBRAIC FORMS

272.  $\int \frac{dx}{\sqrt{2ax + x^2}} = \log(x + a + \sqrt{2ax + x^2})$
273.  $\int \sqrt{ax^2 + c} dx = \frac{x}{2} \sqrt{ax^2 + c} + \frac{c}{2\sqrt{a}} \log(x\sqrt{a} + \sqrt{ax^2 + c}), \quad (a > 0)$
274.  $\int \sqrt{ax^2 + c} dx = \frac{x}{2} \sqrt{ax^2 + c} + \frac{c}{2\sqrt{-a}} \sin^{-1}\left(x\sqrt{-\frac{a}{c}}\right), \quad (a < 0)$
275.  $\int \sqrt{\frac{1+x}{1-x}} dx = \sin^{-1} x - \sqrt{1-x^2}$
276.  $\int \frac{dx}{x\sqrt{ax^n + c}} = \begin{cases} \frac{1}{n\sqrt{c}} \log \frac{\sqrt{ax^n+c}-\sqrt{c}}{\sqrt{ax^n+c}+\sqrt{c}} \\ \text{or} \\ \frac{2}{n\sqrt{c}} \log \frac{\sqrt{ax^n+c}-\sqrt{c}}{\sqrt{x^n}}, \quad (c > 0) \end{cases}$
277.  $\int \frac{dx}{x\sqrt{ax^n + c}} = \frac{2}{n\sqrt{-c}} \sec^{-1} \sqrt{-\frac{ax^n}{c}}, \quad (c < 0)$
278.  $\int \frac{dx}{\sqrt{ax^2 + c}} = \frac{1}{\sqrt{a}} \log(x\sqrt{a} + \sqrt{ax^2 + c}), \quad (a > 0)$
279.  $\int \frac{dx}{\sqrt{ax^2 + c}} = \frac{1}{\sqrt{-a}} \sin^{-1}\left(x\sqrt{-\frac{a}{c}}\right), \quad (a < 0)$
280.  $\int (ax^2 + c)^{m+1/2} dx = \begin{cases} \frac{x(ax^2+c)^{m+1/2}}{2(m+1)} + \frac{(2m+1)c}{2(m+1)} \int (ax^2 + c)^{m-1/2} dx \\ \text{or} \\ x\sqrt{ax^2 + c} \sum_{r=0}^m \frac{(2m+1)!(r!)^2 c^{m-r}}{2^{2m-2r+1} m!(m+1)!(2r+1)!} (ax^2 + c)^r \\ + \frac{(2m+1)!c^{m+1}}{2^{2m+1} m!(m+1)!} \int \frac{dx}{\sqrt{ax^2 + c}} \end{cases}$
281.  $\int x(ax^2 + c)^{m+1/2} dx = \frac{(ax^2 + c)^{m+3/2}}{(2m+3)a}$

$$\begin{aligned}
282. \quad \int \frac{(ax^2 + c)^{m+1/2}}{x} dx &= \begin{cases} \frac{(ax^2 + c)^{m+1/2}}{2m+1} + c \int \frac{(ax^2 + c)^{m-1/2}}{x} dx \\ \text{or} \\ \sqrt{ax^2 + c} \sum_{r=0}^m \frac{c^{m-r}(ax^2 + c)^r}{2r+1} + c^{m+1} \int \frac{dx}{x\sqrt{ax^2 + c}} \end{cases} \\
283. \quad \int \frac{dx}{(ax^2 + c)^{m+1/2}} &= \begin{cases} \frac{x}{(2m-1)c(ax^2 + c)^{m-1/2}} + \frac{2m-2}{(2m-1)c} \int \frac{dx}{(ax^2 + c)^{m-1/2}} \\ \text{or} \\ \frac{x}{\sqrt{ax^2 + c}} \sum_{r=0}^{m-1} \frac{2^{2m-2r-1}(m-1)!m!(2r)!}{(2m)!(r!)^2 c^{m-r}(ax^2 + c)^r} \end{cases} \\
284. \quad \int \frac{dx}{x^m \sqrt{ax^2 + c}} &= -\frac{\sqrt{ax^2 + c}}{(m-1)cx^{m-1}} - \frac{(m-2)a}{(m-1)c} \int \frac{dx}{x^{m-2} \sqrt{ax^2 + c}} \\
285. \quad \int \frac{1+x^2}{(1-x^2)\sqrt{1+x^4}} dx &= \frac{1}{\sqrt{2}} \log \frac{x\sqrt{2} + \sqrt{1+x^4}}{1-x^2} \\
286. \quad \int \frac{1-x^2}{(1+x^2)\sqrt{1+x^4}} dx &= \frac{1}{\sqrt{2}} \tan^{-1} \frac{x\sqrt{2}}{\sqrt{1+x^4}} \\
287. \quad \int \frac{dx}{x\sqrt{x^n + a^2}} &= -\frac{2}{na} \log \frac{a + \sqrt{x^n + a^2}}{\sqrt{x^n}} \\
288. \quad \int \frac{dx}{x\sqrt{x^n - a^2}} &= -\frac{2}{na} \sin^{-1} \frac{a}{\sqrt{x^n}} \\
289. \quad \int \sqrt{\frac{x}{a^3 - x^3}} dx &= \frac{2}{3} \sin^{-1} \left( \frac{x}{a} \right)^{3/2}
\end{aligned}$$

## FORMS INVOLVING TRIGONOMETRIC FUNCTIONS

$$\begin{aligned}
290. \quad \int (\sin ax) dx &= -\frac{1}{a} \cos ax \\
291. \quad \int (\cos ax) dx &= \frac{1}{a} \sin ax \\
292. \quad \int (\tan ax) dx &= -\frac{1}{a} \log \cos ax = \frac{1}{a} \log \sec ax \\
293. \quad \int (\cot ax) dx &= \frac{1}{a} \log \sin ax = -\frac{1}{a} \log \csc ax \\
294. \quad \int (\sec ax) dx &= \frac{1}{a} \log(\sec ax + \tan ax) = \frac{1}{a} \log \tan \left( \frac{\pi}{4} + \frac{ax}{2} \right) \\
295. \quad \int (\csc ax) dx &= \frac{1}{a} \log(\csc ax - \cot ax) = \frac{1}{a} \log \tan \frac{ax}{2} \\
296. \quad \int (\sin^2 ax) dx &= -\frac{1}{2a} \cos ax \sin ax + \frac{1}{2} x = \frac{1}{2} x - \frac{1}{4a} \sin 2ax \\
297. \quad \int (\sin^3 ax) dx &= -\frac{1}{3a} (\cos ax)(\sin^2 ax + 2) \\
298. \quad \int (\sin^4 ax) dx &= \frac{3x}{8} - \frac{\sin 2ax}{4a} + \frac{\sin 4ax}{32a} \\
299. \quad \int (\sin^n ax) dx &= -\frac{\sin^{n-1} ax \cos ax}{na} + \frac{n-1}{n} \int (\sin^{n-2} ax) dx \\
300. \quad \int (\sin^{2m} ax) dx &= -\frac{\cos ax}{a} \sum_{r=0}^{m-1} \frac{(2m)!(r!)^2}{2^{2m-2r}(2r+1)!(m!)^2} \sin^{2r+1} ax + \frac{(2m)!}{2^{2m}(m!)^2} x \\
301. \quad \int (\sin^{2m+1} ax) dx &= -\frac{\cos ax}{a} \sum_{r=0}^m \frac{2^{2m-2r}(m!)^2(2r)!}{(2m+1)!(r!)^2} \sin^{2r} ax \\
302. \quad \int (\cos^2 ax) dx &= \frac{1}{2a} \sin ax \cos ax + \frac{1}{2} x = \frac{1}{2} x + \frac{1}{4a} \sin 2ax \\
303. \quad \int (\cos^3 ax) dx &= \frac{1}{3a} (\sin ax)(\cos^2 ax + 2) \\
304. \quad \int (\cos^4 ax) dx &= \frac{3x}{8} + \frac{\sin 2ax}{4a} + \frac{\sin 4ax}{32a}
\end{aligned}$$

305.  $\int (\cos^n ax) dx = \frac{1}{na} \cos^{n-1} ax \sin ax + \frac{n-1}{n} \int (\cos^{n-2} ax) dx$
306.  $\int (\cos^{2m} ax) dx = \frac{\sin ax}{a} \sum_{r=0}^{m-1} \frac{(2m)!(r!)^2}{2^{2m-2r}(2r+1)!(m!)^2} \cos^{2r+1} ax + \frac{(2m)!}{2^{2m}(m!)^2} x$
307.  $\int (\cos^{2m+1} ax) dx = \frac{\sin ax}{a} \sum_{r=0}^m \frac{2^{2m-2r}(m!)^2(2r)!}{(2m+1)!(r!)^2} \cos^{2r} ax$
308.  $\int \frac{dx}{\sin^2 ax} = \int (\csc^2 ax) dx = -\frac{1}{a} \cot ax$
309.  $\int \frac{dx}{\sin^m ax} = \int (\csc^m ax) dx = -\frac{1}{(m-1)a} \cdot \frac{\cos ax}{\sin^{m-1} ax} + \frac{m-2}{m-1} \int \frac{dx}{\sin^{m-2} ax}$
310.  $\int \frac{dx}{\sin^{2m} ax} = \int (\csc^{2m} ax) dx = -\frac{1}{a} \cos ax \sum_{r=0}^{m-1} \frac{2^{2m-2r-1}(m-1)!m!(2r)!}{(2m)!(r!)^2 \sin^{2r+1} ax}$
311.  $\int \frac{dx}{\sin^{2m+1} ax} = \int (\csc^{2m+1} ax) dx = -\frac{1}{a} \cos ax \sum_{r=0}^{m-1} \frac{(2m)!(r!)^2}{2^{2m-2r}(m!)^2(2r+1)! \sin^{2r+2} ax} + \frac{1}{a} \cdot \frac{(2m)!}{2^{2m}(m!)^2} \log \tan \frac{ax}{2}$
312.  $\int \frac{dx}{\cos^2 ax} = \int (\sec^2 ax) dx = \frac{1}{a} \tan ax$
313.  $\int \frac{dx}{\cos^n ax} = \int (\sec^n ax) dx = \frac{1}{(n-1)a} \cdot \frac{\sin ax}{\cos^{n-1} ax} + \frac{n-2}{n-1} \int \frac{dx}{\cos^{n-2} ax}$
314.  $\int \frac{dx}{\cos^{2m} ax} = \int (\sec^{2m} ax) dx = \frac{1}{a} \sin ax \sum_{r=0}^{m-1} \frac{2^{2m-2r-1}(m-1)!m!(2r)!}{(2m)!(r!)^2 \cos^{2r+1} ax}$
315.  $\int \frac{dx}{\cos^{2m+1} ax} = \int (\sec^{2m+1} ax) dx = \frac{1}{a} \sin ax \sum_{r=0}^{m-1} \frac{(2m)!(r!)^2}{2^{2m-2r}(m!)^2(2r+1)! \cos^{2r+2} ax} + \frac{1}{a} \cdot \frac{(2m)!}{2^{2m}(m!)^2} \log(\sec ax + \tan ax)$
316.  $\int (\sin mx)(\sin nx) dx = \frac{\sin(m-n)x}{2(m-n)} - \frac{\sin(m+n)x}{2(m+n)}, \quad (m^2 \neq n^2)$
317.  $\int (\cos mx)(\cos nx) dx = \frac{\sin(m-n)x}{2(m-n)} + \frac{\sin(m+n)x}{2(m+n)}, \quad (m^2 \neq n^2)$
318.  $\int (\sin ax)(\cos ax) dx = \frac{1}{2a} \sin^2 ax$
319.  $\int (\sin mx)(\cos nx) dx = -\frac{\cos(m-n)x}{2(m-n)} - \frac{\cos(m+n)x}{2(m+n)}, \quad (m^2 \neq n^2)$
320.  $\int (\sin^2 ax)(\cos^2 ax) dx = -\frac{1}{32a} \sin 4ax + \frac{x}{8}$
321.  $\int (\sin ax)(\cos^m ax) dx = -\frac{\cos^{m+1} ax}{(m+1)a}$
322.  $\int (\sin^m ax)(\cos ax) dx = \frac{\sin^{m+1} ax}{(m+1)a}$
323.  $\int (\cos^m ax)(\sin^n ax) dx = \begin{cases} \frac{\cos^{m-1} ax \sin^{n+1} ax}{(m+n)a} + \frac{m-1}{m+n} \int (\cos^{m-2} ax)(\sin^n ax) dx \\ \text{or} \\ -\frac{\sin^{n-1} ax \cos^{m+1} ax}{(m+n)a} + \frac{n-1}{m+n} \int (\cos^m ax)(\sin^{n-2} ax) dx \end{cases}$
324.  $\int \frac{\cos^m ax}{\sin^n ax} dx = \begin{cases} -\frac{\cos^{m+1} ax}{(n-1)a \sin^{n-1} ax} - \frac{m-n+2}{n-1} \int \frac{\cos^m ax}{\sin^{n-2} ax} dx \\ \text{or} \\ \frac{\cos^{m-1} ax}{a(m-n) \sin^{n-1} ax} + \frac{m-1}{m-n} \int \frac{\cos^{m-2} ax}{\sin^n ax} dx \end{cases}$
325.  $\int \frac{\sin^m ax}{\cos^n ax} dx = \begin{cases} \frac{\sin^{m+1} ax}{a(n-1) \cos^{n-1} ax} - \frac{m-n+2}{n-1} \int \frac{\sin^m ax}{\cos^{n-2} ax} dx \\ \text{or} \\ -\frac{\sin^{m-1} ax}{a(m-n) \cos^{n-1} ax} + \frac{m-1}{m-n} \int \frac{\sin^{m-2} ax}{\cos^n ax} dx \end{cases}$
326.  $\int \frac{\sin ax}{\cos^2 ax} dx = \frac{1}{a \cos ax} = \frac{\sec ax}{a}$



327.  $\int \frac{\sin^2 ax}{\cos ax} dx = -\frac{1}{a} \sin ax + \frac{1}{a} \log \tan \left( \frac{\pi}{4} + \frac{ax}{2} \right)$
328.  $\int \frac{\cos ax}{\sin^2 ax} dx = -\frac{1}{a \sin ax} = -\frac{\csc ax}{a}$
329.  $\int \frac{dx}{(\sin ax)(\cos ax)} = \frac{1}{a} \log \tan ax$
330.  $\int \frac{dx}{(\sin ax)(\cos^2 ax)} = \frac{1}{a} \left( \sec ax + \log \tan \frac{ax}{2} \right)$
331.  $\int \frac{dx}{(\sin ax)(\cos^n ax)} = \frac{1}{a(n-1) \cos^{n-1} ax} + \int \frac{dx}{(\sin ax)(\cos^{n-2} ax)}$
332.  $\int \frac{dx}{(\sin^2 ax)(\cos ax)} = -\frac{1}{a} \csc ax + \frac{1}{a} \log \tan \left( \frac{\pi}{4} + \frac{ax}{2} \right)$
333.  $\int \frac{dx}{(\sin^2 ax)(\cos^2 ax)} = -\frac{2}{a} \cot 2ax$
334.  $\int \frac{dx}{\sin^m ax \cos^n ax} = \begin{cases} -\frac{1}{a(m-1)(\sin^{m-1} ax)(\cos^{n-1} ax)} \\ + \frac{m+n-2}{m-1} \int \frac{dx}{(\sin^{m-2} ax)(\cos^n ax)} \\ \text{or} \\ \frac{1}{a(n-1)\sin^{m-1} ax \cos^{n-1} ax} + \frac{m+n-2}{n-1} \int \frac{dx}{\sin^m ax \cos^{n-2} ax} \end{cases}$
335.  $\int \sin(a+bx) dx = -\frac{1}{b} \cos(a+bx)$
336.  $\int \cos(a+bx) dx = \frac{1}{b} \sin(a+bx)$
337.  $\int \frac{dx}{1 \pm \sin ax} = \mp \frac{1}{a} \tan \left( \frac{\pi}{4} \mp \frac{ax}{2} \right)$
338.  $\int \frac{dx}{1 + \cos ax} = \frac{1}{a} \tan \frac{ax}{2}$
339.  $\int \frac{dx}{1 - \cos ax} = -\frac{1}{a} \cot \frac{ax}{2}$
340.  $\int \frac{dx}{a + b \sin x} = \begin{cases} \frac{2}{\sqrt{a^2-b^2}} \tan^{-1} \frac{a \tan \frac{x}{2} + b}{\sqrt{a^2-b^2}} \\ \text{or} \\ \frac{1}{\sqrt{b^2-a^2}} \log \frac{a \tan \frac{x}{2} + b - \sqrt{b^2-a^2}}{a \tan \frac{x}{2} + b + \sqrt{b^2-a^2}} \end{cases}$
341.  $\int \frac{dx}{a + b \cos x} = \begin{cases} \frac{2}{\sqrt{a^2-b^2}} \tan^{-1} \frac{\sqrt{a^2-b^2} \tan \frac{x}{2}}{a+b} \\ \text{or} \\ \frac{1}{\sqrt{b^2-a^2}} \log \left( \frac{\sqrt{b^2-a^2} \tan \frac{x}{2} + a + b}{\sqrt{b^2-a^2} \tan \frac{x}{2} - a - b} \right) \end{cases}$
342.  $\int \frac{dx}{a + b \sin x + c \cos x} = \begin{cases} \frac{1}{\sqrt{b^2+c^2-a^2}} \log \left( \frac{b - \sqrt{b^2+c^2-a^2} + (a-c) \tan \frac{x}{2}}{b + \sqrt{b^2+c^2-a^2} + (a-c) \tan \frac{x}{2}} \right) & (\text{if } a^2 < b^2 + c^2, a \neq c), \\ \frac{2}{\sqrt{a^2-b^2-c^2}} \tan^{-1} \left( \frac{b+(a-c) \tan \frac{x}{2}}{\sqrt{a^2-b^2-c^2}} \right) & (\text{if } a^2 > b^2 + c^2), \\ \frac{1}{a} \left[ \frac{a-(b+c) \cos x - (b-c) \sin x}{a-(b-c) \cos x + (b+c) \sin x} \right] & (\text{if } a^2 = b^2 + c^2, a \neq c). \end{cases}$
343.  $\int \frac{\sin^2 x dx}{a + b \cos^2 x} = \frac{1}{b} \sqrt{\frac{a+b}{a}} \tan^{-1} \left( \sqrt{\frac{a}{a+b}} \tan x \right) - \frac{x}{b}, \quad (ab > 0, \text{ or } |a| > |b|)$
344.  $\int \frac{dx}{a^2 \cos^2 x + b^2 \sin^2 x} = \frac{1}{ab} \tan^{-1} \left( \frac{b \tan x}{a} \right)$
345.  $\int \frac{\cos^2 cx}{a^2 + b^2 \sin^2 cx} dx = \frac{\sqrt{a^2+b^2}}{ab^2c} \tan^{-1} \frac{\sqrt{a^2+b^2} \tan cx}{a} - \frac{x}{b^2}$
346.  $\int \frac{\sin cx \cos cx}{a \cos^2 cx + b \sin^2 cx} dx = \frac{1}{2c(b-a)} \log(a \cos^2 cx + b \sin^2 cx)$

$$347. \quad \int \frac{\cos cx}{a \cos cx + b \sin cx} dx = \int \frac{dx}{a + b \tan cx} = \frac{1}{c(a^2 + b^2)} [acx + b \log(a \cos cx + b \sin cx)]$$

$$348. \quad \int \frac{\sin cx}{a \sin cx + b \cos cx} dx = \int \frac{dx}{a + b \cot cx} = \frac{1}{c(a^2 + b^2)} [acx - b \log(a \sin cx + b \cos cx)]$$

$$349. \quad \int \frac{dx}{a \cos^2 x + 2b \cos x \sin x + c \sin^2 x} = \begin{cases} \frac{1}{2\sqrt{b^2 - ac}} \log \frac{c \tan x + b - \sqrt{b^2 - ac}}{c \tan x + b + \sqrt{b^2 - ac}}, & (b^2 > ac) \\ \text{or} \\ \frac{1}{\sqrt{ac - b^2}} \tan^{-1} \frac{c \tan x + b}{\sqrt{ac - b^2}}, & (b^2 < ac) \\ \text{or} \\ -\frac{1}{c \tan x + b}, & (b^2 = ac) \end{cases}$$

$$350. \quad \int \frac{\sin ax}{1 \pm \sin ax} dx = \pm x + \frac{1}{a} \tan \left( \frac{\pi}{4} \mp \frac{ax}{2} \right)$$

$$351. \quad \int \frac{dx}{(\sin ax)(1 \pm \sin ax)} = \frac{1}{a} \tan \left( \frac{\pi}{4} \mp \frac{ax}{2} \right) + \frac{1}{a} \log \tan \frac{ax}{2}$$

$$352. \quad \int \frac{dx}{(1 + \sin ax)^2} = -\frac{1}{2a} \tan \left( \frac{\pi}{4} - \frac{ax}{2} \right) - \frac{1}{6a} \tan^3 \left( \frac{\pi}{4} - \frac{ax}{2} \right)$$

$$353. \quad \int \frac{dx}{(1 - \sin ax)^2} = \frac{1}{2a} \cot \left( \frac{\pi}{4} - \frac{ax}{2} \right) + \frac{1}{6a} \cot^3 \left( \frac{\pi}{4} - \frac{ax}{2} \right)$$

$$354. \quad \int \frac{\sin ax}{(1 + \sin ax)^2} dx = -\frac{1}{2a} \tan \left( \frac{\pi}{4} - \frac{ax}{2} \right) + \frac{1}{6a} \tan^3 \left( \frac{\pi}{4} - \frac{ax}{2} \right)$$

$$355. \quad \int \frac{\sin ax}{(1 - \sin ax)^2} dx = -\frac{1}{2a} \cot \left( \frac{\pi}{4} - \frac{ax}{2} \right) + \frac{1}{6a} \cot^3 \left( \frac{\pi}{4} - \frac{ax}{2} \right)$$

$$356. \quad \int \frac{\sin x dx}{a + b \sin x} = \frac{x}{b} - \frac{a}{b} \int \frac{dx}{a + b \sin x}$$

$$357. \quad \int \frac{dx}{(\sin x)(a + b \sin x)} = \frac{1}{a} \log \tan \frac{x}{2} - \frac{b}{a} \int \frac{dx}{a + b \sin x}$$

$$358. \quad \int \frac{dx}{(a + b \sin x)^2} = \frac{b \cos x}{(a^2 - b^2)(a + b \sin x)} + \frac{a}{a^2 - b^2} \int \frac{dx}{a + b \sin x}$$

$$359. \quad \int \frac{\sin x dx}{(a + b \sin x)^2} = \frac{a \cos x}{(b^2 - a^2)(a + b \sin x)} + \frac{b}{b^2 - a^2} \int \frac{dx}{a + b \sin x}$$

$$360. \quad \int \frac{dx}{a^2 + b^2 \sin^2 cx} = \frac{1}{ac\sqrt{a^2 + b^2}} \tan^{-1} \frac{\sqrt{a^2 + b^2} \tan cx}{a}$$

$$361. \quad \int \frac{dx}{a^2 - b^2 \sin^2 cx} = \begin{cases} \frac{1}{ac\sqrt{a^2 - b^2}} \tan^{-1} \frac{\sqrt{a^2 - b^2} \tan cx}{a}, & (a^2 > b^2) \\ \text{or} \\ \frac{1}{2ac\sqrt{b^2 - a^2}} \log \frac{\sqrt{b^2 - a^2} \tan cx + a}{\sqrt{b^2 - a^2} \tan cx - a}, & (a^2 < b^2) \end{cases}$$

$$362. \quad \int \frac{\cos ax}{1 + \cos ax} dx = x - \frac{1}{a} \tan \frac{ax}{2}$$

$$363. \quad \int \frac{\cos ax}{1 - \cos ax} dx = -x - \frac{1}{a} \cot \frac{ax}{2}$$

$$364. \quad \int \frac{dx}{(\cos ax)(1 + \cos ax)} = \frac{1}{a} \log \tan \left( \frac{\pi}{4} + \frac{ax}{2} \right) - \frac{1}{a} \tan \frac{ax}{2}$$

$$365. \quad \int \frac{dx}{(\cos ax)(1 - \cos ax)} = \frac{1}{a} \log \tan \left( \frac{\pi}{4} + \frac{ax}{2} \right) - \frac{1}{a} \cot \frac{ax}{2}$$

$$366. \quad \int \frac{dx}{(1 + \cos ax)^2} = \frac{1}{2a} \tan \frac{ax}{2} + \frac{1}{6a} \tan^3 \frac{ax}{2}$$

$$367. \quad \int \frac{dx}{(1 - \cos ax)^2} = -\frac{1}{2a} \cot \frac{ax}{2} - \frac{1}{6a} \cot^3 \frac{ax}{2}$$

$$368. \quad \int \frac{\cos ax}{(1 + \cos ax)^2} dx = \frac{1}{2a} \tan \frac{ax}{2} - \frac{1}{6a} \tan^3 \frac{ax}{2}$$

$$369. \quad \int \frac{\cos ax}{(1 - \cos ax)^2} dx = \frac{1}{2a} \cot \frac{ax}{2} - \frac{1}{6a} \cot^3 \frac{ax}{2}$$

$$370. \quad \int \frac{\cos x dx}{a + b \cos x} = \frac{x}{b} - \frac{a}{b} \int \frac{dx}{a + b \cos x}$$

$$371. \quad \int \frac{dx}{(\cos x)(a + b \cos x)} = \frac{1}{a} \log \tan \left( \frac{x}{2} + \frac{\pi}{4} \right) - \frac{b}{a} \int \frac{dx}{a + b \cos x}$$

$$372. \quad \int \frac{dx}{(a + b \cos x)^2} = \frac{b \sin x}{(b^2 - a^2)(a + b \cos x)} - \frac{a}{b^2 - a^2} \int \frac{dx}{a + b \cos x}$$

$$373. \int \frac{\cos x}{(a + b \cos x)^2} dx = \frac{a \sin x}{(a^2 - b^2)(a + b \cos x)} - \frac{b}{a^2 - b^2} \int \frac{dx}{a + b \cos x}$$

$$374. \int \frac{dx}{a^2 + b^2 - 2ab \cos cx} = \frac{2}{c(a^2 - b^2)} \tan^{-1} \left( \frac{a + b}{a - b} \tan \frac{cx}{2} \right)$$

$$375. \int \frac{dx}{a^2 + b^2 \cos^2 cx} = \frac{1}{ac\sqrt{a^2 + b^2}} \tan^{-1} \frac{a \tan cx}{\sqrt{a^2 + b^2}}$$

$$376. \int \frac{dx}{a^2 - b^2 \cos^2 cx} = \begin{cases} \frac{1}{ac\sqrt{a^2 - b^2}} \tan^{-1} \frac{a \tan cx}{\sqrt{a^2 - b^2}}, & (a^2 > b^2) \\ \text{or} \\ \frac{1}{2ac\sqrt{b^2 - a^2}} \log \frac{a \tan cx - \sqrt{b^2 - a^2}}{a \tan cx + \sqrt{b^2 - a^2}}, & (b^2 > a^2) \end{cases}$$

$$377. \int \frac{\sin ax}{1 \pm \cos ax} dx = \mp \frac{1}{a} \log(1 \pm \cos ax)$$

$$378. \int \frac{\cos ax}{1 \pm \sin ax} dx = \pm \frac{1}{a} \log(1 \pm \sin ax)$$

$$379. \int \frac{dx}{(\sin ax)(1 \pm \cos ax)} = \pm \frac{1}{2a(1 \pm \cos ax)} + \frac{1}{2a} \log \tan \frac{ax}{2}$$

$$380. \int \frac{dx}{(\cos ax)(1 \pm \sin ax)} = \mp \frac{1}{2a(1 \pm \sin ax)} + \frac{1}{2a} \log \tan \left( \frac{\pi}{4} + \frac{ax}{2} \right)$$

$$381. \int \frac{\sin ax}{(\cos ax)(1 \pm \cos ax)} dx = \frac{1}{a} \log(\sec ax \pm 1)$$

$$382. \int \frac{\cos ax}{(\sin ax)(1 \pm \sin ax)} dx = -\frac{1}{a} \log(\csc ax \pm 1)$$

$$383. \int \frac{\sin ax}{(\cos ax)(1 \pm \sin ax)} dx = \frac{1}{2a(1 \pm \sin ax)} \pm \frac{1}{2a} \log \tan \left( \frac{\pi}{4} + \frac{ax}{2} \right)$$

$$384. \int \frac{\cos ax}{(\sin ax)(1 \pm \cos ax)} dx = -\frac{1}{2a(1 \pm \cos ax)} \pm \frac{1}{2a} \log \tan \frac{ax}{2}$$

$$385. \int \frac{dx}{\sin ax \pm \cos ax} = \frac{1}{a\sqrt{2}} \log \tan \left( \frac{ax}{2} \pm \frac{\pi}{8} \right)$$

$$386. \int \frac{dx}{(\sin ax \pm \cos ax)^2} = \frac{1}{2a} \tan \left( ax \mp \frac{\pi}{4} \right)$$

$$387. \int \frac{dx}{1 + \cos ax \pm \sin ax} = \pm \frac{1}{a} \log \left( 1 \pm \tan \frac{ax}{2} \right)$$

$$388. \int \frac{dx}{a^2 \cos^2 cx - b^2 \sin^2 cx} = \frac{1}{2abc} \log \frac{b \tan cx + a}{b \tan cx - a}$$

$$389. \int x(\sin ax) dx = \frac{1}{a^2} \sin ax - \frac{x}{a} \cos ax$$

$$390. \int x^2(\sin ax) dx = \frac{2x}{a^2} \sin ax - \frac{a^2 x^2 - 2}{a^3} \cos ax$$

$$391. \int x^3(\sin ax) dx = \frac{3a^2 x^2 - 6}{a^4} \sin ax - \frac{a^2 x^3 - 6x}{a^3} \cos ax$$

$$392. \int x^m \sin ax dx = \begin{cases} -\frac{1}{a} x^m \cos ax + \frac{m}{a} \int x^{m-1} \cos ax dx \\ \text{or} \\ \cos ax \sum_{r=0}^{\lfloor \frac{m}{2} \rfloor} (-1)^{r+1} \frac{m!}{(m-2r)!} \cdot \frac{x^{m-2r}}{a^{2r+1}} \\ + \sin ax \sum_{r=0}^{\lfloor \frac{m-1}{2} \rfloor} (-1)^r \frac{m!}{(m-2r-1)!} \cdot \frac{x^{m-2r-1}}{a^{2r+2}} \end{cases}$$

Note:  $[s]$  means greatest integer  $\leq s$ ; Thus  $[3.5]$  means 3;  $[5] = 5$ ,  $[\frac{1}{2}] = 0$ .

$$393. \int x(\cos ax) dx = \frac{1}{a^2} \cos ax + \frac{x}{a} \sin ax$$

$$394. \int x^2(\cos ax) dx = \frac{2x \cos ax}{a^2} + \frac{a^2 x^2 - 2}{a^3} \sin ax$$

$$395. \int x^3(\cos ax) dx = \frac{3a^2 x^2 - 6}{a^4} \cos ax + \frac{a^2 x^3 - 6x}{a^3} \sin ax$$

$$396. \int x^m(\cos ax) dx = \begin{cases} \frac{x^m \sin ax}{a} - \frac{m}{a} \int x^{m-1} \sin ax dx \\ \text{or} \\ \sin ax \sum_{r=0}^{\lfloor m/2 \rfloor} (-1)^r \frac{m!}{(m-2r)!} \cdot \frac{x^{m-2r}}{a^{2r+1}} \\ + \cos ax \sum_{r=0}^{\lfloor (m-1)/2 \rfloor} (-1)^r \frac{m!}{(m-2r-1)!} \cdot \frac{x^{m-2r-1}}{a^{2r+2}} \end{cases}$$

Note:  $[s]$  means greatest integer  $\leq s$ ; Thus  $[3.5]$  means 3;  $[5] = 5$ ,  $[\frac{1}{2}] = 0$ .

397.  $\int \frac{\sin ax}{x} dx = \sum_{n=0}^r (-1)^n \frac{(ax)^{2n+1}}{(2n+1)(2n+1)!}$
398.  $\int \frac{\cos ax}{x} dx = \log x + \sum_{n=1}^r (-1)^n \frac{(ax)^{2n}}{2n(2n)!}$
399.  $\int x(\sin^2 ax) dx = \frac{x^2}{4} - \frac{x \sin 2ax}{4a} - \frac{\cos 2ax}{8a^2}$
400.  $\int x^2(\sin^2 ax) dx = \frac{x^3}{6} - \left( \frac{x^2}{4a} - \frac{1}{8a^3} \right) \sin 2ax - \frac{x \cos 2ax}{4a^2}$
401.  $\int x(\sin^3 ax) dx = \frac{x \cos 3ax}{12a} - \frac{\sin 3ax}{36a^2} - \frac{3x \cos ax}{4a} + \frac{3 \sin ax}{4a^2}$
402.  $\int x(\cos^2 ax) dx = \frac{x^2}{4} + \frac{x \sin 2ax}{4a} + \frac{\cos 2ax}{8a^2}$
403.  $\int x^2(\cos^2 ax) dx = \frac{x^3}{6} + \left( \frac{x^2}{4a} - \frac{1}{8a^3} \right) \sin 2ax + \frac{x \cos 2ax}{4a^2}$
404.  $\int x(\cos^3 ax) dx = \frac{x \sin 3ax}{12a} + \frac{\cos 3ax}{36a^2} + \frac{3x \sin ax}{4a} + \frac{3 \cos ax}{4a^2}$
405.  $\int \frac{\sin ax}{x^m} dx = -\frac{\sin ax}{(m-1)x^{m-1}} + \frac{a}{m-1} \int \frac{\cos ax}{x^{m-1}} dx$
406.  $\int \frac{\cos ax}{x^m} dx = -\frac{\cos ax}{(m-1)x^{m-1}} - \frac{a}{m-1} \int \frac{\sin ax}{x^{m-1}} dx$
407.  $\int \frac{x}{1 \pm \sin ax} dx = \mp \frac{x \cos ax}{a(1 \pm \sin ax)} + \frac{1}{a^2} \log(1 \pm \sin ax)$
408.  $\int \frac{x}{1 + \cos ax} dx = \frac{x}{a} \tan \frac{ax}{2} + \frac{2}{a^2} \log \cos \frac{ax}{2}$
409.  $\int \frac{x}{1 - \cos ax} dx = -\frac{x}{a} \cot \frac{ax}{2} + \frac{2}{a^2} \log \sin \frac{ax}{2}$
410.  $\int \frac{x + \sin x}{1 + \cos x} dx = x \tan \frac{x}{2}$
411.  $\int \frac{x - \sin x}{1 - \cos x} dx = -x \cot \frac{x}{2}$
412.  $\int \sqrt{1 - \cos ax} dx = -\frac{2 \sin ax}{a\sqrt{1 - \cos ax}} = -\frac{2\sqrt{2}}{a} \cos\left(\frac{ax}{2}\right)$
413.  $\int \sqrt{1 + \cos ax} dx = \frac{2 \sin ax}{a\sqrt{1 + \cos ax}} = \frac{2\sqrt{2}}{a} \sin\left(\frac{ax}{2}\right)$
414.  $\int \sqrt{1 + \sin x} dx = \pm 2 \left( \sin \frac{x}{2} - \cos \frac{x}{2} \right),$   
[use + if  $(8k-1)\frac{\pi}{2} < x \leq (8k+3)\frac{\pi}{2}$ , otherwise -;  $k$  an integer]
415.  $\int \sqrt{1 - \sin x} dx = \pm 2 \left( \sin \frac{x}{2} + \cos \frac{x}{2} \right),$   
[use + if  $(8k-3)\frac{\pi}{2} < x \leq (8k+1)\frac{\pi}{2}$ , otherwise -;  $k$  an integer]
416.  $\int \frac{dx}{\sqrt{1 - \cos x}} = \pm \sqrt{2} \log \tan \frac{x}{4},$   
[use + if  $4k\pi < x < (4k+2)\pi$ , otherwise -;  $k$  an integer]
417.  $\int \frac{dx}{\sqrt{1 + \cos x}} = \pm \sqrt{2} \log \tan \left( \frac{x + \pi}{4} \right),$   
[use + if  $(4k-1)\pi < x < (4k+1)\pi$ , otherwise -;  $k$  an integer]
418.  $\int \frac{dx}{\sqrt{1 - \sin x}} = \pm \sqrt{2} \log \tan \left( \frac{x}{4} - \frac{\pi}{8} \right),$   
[use + if  $(8k+1)\frac{\pi}{2} < x < (8k+5)\frac{\pi}{2}$ , otherwise -;  $k$  an integer]
419.  $\int \frac{dx}{\sqrt{1 + \sin x}} = \pm \sqrt{2} \log \tan \left( \frac{x}{4} + \frac{\pi}{8} \right),$   
[use + if  $(8k-1)\frac{\pi}{2} < x < (8k+3)\frac{\pi}{2}$ , otherwise -;  $k$  an integer]
420.  $\int \tan^2(ax) dx = \frac{1}{a} \tan ax - x$
421.  $\int \tan^3(ax) dx = \frac{1}{2a} \tan^2 ax + \frac{1}{a} \log \cos ax$

422.  $\int \tan^4(ax) dx = \frac{\tan^3 ax}{3a} - \frac{1}{a} \tan ax + x$
423.  $\int \tan^n(ax) dx = \frac{\tan^{n-1} ax}{a(n-1)} - \int (\tan^{n-2} ax) dx$
424.  $\int \cot^2(ax) dx = -\frac{1}{a} \cot ax - x$
425.  $\int \cot^3(ax) dx = -\frac{1}{2a} \cot^2 ax - \frac{1}{a} \log \sin ax$
426.  $\int \cot^4(ax) dx = -\frac{1}{3a} \cot^3 ax + \frac{1}{a} \cot ax + x$
427.  $\int \cot^n(ax) dx = -\frac{\cot^{n-1} ax}{a(n-1)} - \int (\cot^{n-2} ax) dx$
428.  $\int \frac{x}{\sin^2 ax} dx = \int x(\csc^2 ax) dx = -\frac{x \cot ax}{a} + \frac{1}{a^2} \log \sin ax$
429.  $\int \frac{x}{\sin^n ax} dx = \int x(\csc^n ax) dx = -\frac{x \cos ax}{a(n-1) \sin^{n-1} ax} - \frac{1}{a^2(n-1)(n-2) \sin^{n-2} ax} + \frac{(n-2)}{(n-1)} \int \frac{x}{\sin^{n-2} ax} dx$
430.  $\int \frac{x}{\cos^2 ax} dx = \int x(\sec^2 ax) dx = \frac{1}{a} x \tan ax + \frac{1}{a^2} \log \cos ax$
431.  $\int \frac{x}{\cos^n(ax)} dx = \int x(\sec^n ax) dx = \frac{x \sin ax}{a(n-1) \cos^{n-1} ax} - \frac{1}{a^2(n-1)(n-2) \cos^{n-2} ax} + \frac{n-2}{n-1} \int \frac{x}{\cos^{n-2} ax} dx$
432.  $\int \frac{\sin ax}{\sqrt{1+b^2 \sin^2 ax}} dx = -\frac{1}{ab} \sin^{-1} \frac{b \cos ax}{\sqrt{1+b^2}}$
433.  $\int \frac{\sin ax}{\sqrt{1-b^2 \sin^2 ax}} dx = -\frac{1}{ab} \log(b \cos ax + \sqrt{1-b^2 \sin^2 ax})$
434.  $\int \sin(ax) \sqrt{1+b^2 \sin^2 ax} dx = -\frac{\cos ax}{2a} \sqrt{1+b^2 \sin^2 ax} - \frac{1+b^2}{2ab} \sin^{-1} \frac{b \cos ax}{\sqrt{1+b^2}}$
435.  $\int \sin(ax) \sqrt{1-b^2 \sin^2 ax} dx = -\frac{\cos ax}{2a} \sqrt{1-b^2 \sin^2 ax} - \frac{1-b^2}{2ab} \log(b \cos ax + \sqrt{1-b^2 \sin^2 ax})$
436.  $\int \frac{\cos ax}{\sqrt{1+b^2 \sin^2 ax}} dx = \frac{1}{ab} \log(b \sin ax + \sqrt{1+b^2 \sin^2 ax})$
437.  $\int \frac{\cos ax}{\sqrt{1-b^2 \sin^2 ax}} dx = \frac{1}{ab} \sin^{-1}(b \sin ax)$
438.  $\int \cos(ax) \sqrt{1+b^2 \sin^2 ax} dx = \frac{\sin ax}{2a} \sqrt{1+b^2 \sin^2 ax} + \frac{1}{2ab} \log(b \sin ax + \sqrt{1+b^2 \sin^2 ax})$
439.  $\int \cos(ax) \sqrt{1-b^2 \sin^2 ax} dx = \frac{\sin ax}{2a} \sqrt{1-b^2 \sin^2 ax} + \frac{1}{2ab} \sin^{-1}(b \sin ax)$
440.  $\int \frac{dx}{\sqrt{a+b \tan^2 cx}} = \frac{\pm 1}{c\sqrt{a-b}} \sin^{-1} \left( \sqrt{\frac{a-b}{a}} \sin cx \right), \quad (a > |b|)$   
 [use + if  $(2k-1)\frac{\pi}{2} < x \leq (2k+1)\frac{\pi}{2}$ , otherwise -;  $k$  an integer]

## FORMS INVOLVING INVERSE TRIGONOMETRIC FUNCTIONS

441.  $\int \sin^{-1}(ax) dx = x \sin^{-1} ax + \frac{\sqrt{1-a^2 x^2}}{a}$
442.  $\int \cos^{-1}(ax) dx = x \cos^{-1} ax - \frac{\sqrt{1-a^2 x^2}}{a}$
443.  $\int \tan^{-1}(ax) dx = x \tan^{-1} ax - \frac{1}{2a} \log(1+a^2 x^2)$
444.  $\int \cot^{-1}(ax) dx = x \cot^{-1} ax + \frac{1}{2a} \log(1+a^2 x^2)$

$$445. \int \sec^{-1}(ax) dx = x \sec^{-1} ax - \frac{1}{a} \log(ax + \sqrt{a^2 x^2 - 1})$$

$$446. \int \csc^{-1}(ax) dx = x \csc^{-1} ax + \frac{1}{a} \log(ax + \sqrt{a^2 x^2 - 1})$$

$$447. \int \sin^{-1} \frac{x}{a} dx = x \sin^{-1} \frac{x}{a} + \sqrt{a^2 - x^2}, \quad (a > 0)$$

$$448. \int \cos^{-1} \frac{x}{a} dx = x \cos^{-1} \frac{x}{a} - \sqrt{a^2 - x^2}, \quad (a > 0)$$

$$449. \int \tan^{-1} \frac{x}{a} dx = x \tan^{-1} \frac{x}{a} - \frac{a}{2} \log(a^2 + x^2)$$

$$450. \int \cot^{-1} \frac{x}{a} dx = x \cot^{-1} \frac{x}{a} + \frac{a}{2} \log(a^2 + x^2)$$

$$451. \int x \sin^{-1}(ax) dx = \frac{1}{4a^2} [(2a^2 x^2 - 1) \sin^{-1}(ax) + ax \sqrt{1 - a^2 x^2}]$$

$$452. \int x \cos^{-1}(ax) dx = \frac{1}{4a^2} [(2a^2 x^2 - 1) \cos^{-1}(ax) - ax \sqrt{1 - a^2 x^2}]$$

$$453. \int x^n \sin^{-1}(ax) dx = \frac{x^{n+1}}{n+1} \sin^{-1}(ax) - \frac{a}{n+1} \int \frac{x^{n+1} dx}{\sqrt{1 - a^2 x^2}}, \quad (n \neq -1)$$

$$454. \int x^n \cos^{-1}(ax) dx = \frac{x^{n+1}}{n+1} \cos^{-1}(ax) + \frac{a}{n+1} \int \frac{x^{n+1} dx}{\sqrt{1 - a^2 x^2}}, \quad (n \neq -1)$$

$$455. \int x \tan^{-1}(ax) dx = \frac{1 + a^2 x^2}{2a^2} \tan^{-1} ax - \frac{x}{2a}$$

$$456. \int x^n \tan^{-1}(ax) dx = \frac{x^{n+1}}{n+1} \tan^{-1} ax - \frac{a}{n+1} \int \frac{x^{n+1}}{1 + a^2 x^2} dx$$

$$457. \int x(\cot^{-1} ax) dx = \frac{1 + a^2 x^2}{2a^2} \cot^{-1} ax + \frac{x}{2a}$$

$$458. \int x^n \cot^{-1}(ax) dx = \frac{x^{n+1}}{n+1} \cot^{-1} ax + \frac{a}{n+1} \int \frac{x^{n+1}}{1 + a^2 x^2} dx$$

$$459. \int \frac{\sin^{-1}(ax)}{x^2} dx = a \log \left( \frac{1 - \sqrt{1 - a^2 x^2}}{x} \right) - \frac{\sin^{-1}(ax)}{x}$$

$$460. \int \frac{\cos^{-1}(ax) dx}{x^2} = -\frac{1}{x} \cos^{-1}(ax) + a \log \frac{1 + \sqrt{1 - a^2 x^2}}{x}$$

$$461. \int \frac{\tan^{-1}(ax) dx}{x^2} = -\frac{1}{x} \tan^{-1}(ax) - \frac{a}{2} \log \frac{1 + a^2 x^2}{x^2}$$

$$462. \int \frac{\cot^{-1}(ax) dx}{x^2} = -\frac{1}{x} \cot^{-1} ax - \frac{a}{2} \log \frac{x^2}{a^2 x^2 + 1}$$

$$463. \int \sin^{-1}(ax)^2 dx = x(\sin^{-1} ax)^2 - 2x + \frac{2\sqrt{1 - a^2 x^2}}{a} \sin^{-1} ax$$

$$464. \int \cos^{-1}(ax)^2 dx = x(\cos^{-1} ax)^2 - 2x - \frac{2\sqrt{1 - a^2 x^2}}{a} \cos^{-1} ax$$

$$465. \int (\sin^{-1} ax)^n dx = \begin{cases} x(\sin^{-1} ax)^n + \frac{n\sqrt{1 - a^2 x^2}}{a} (\sin^{-1} ax)^{n-1} - n(n-1) \int (\sin^{-1} ax)^{n-2} dx \\ \text{or} \\ \sum_{r=0}^{[n/2]} (-1)^r \frac{n!}{(n-2r)!} x(\sin^{-1} ax)^{n-2r} + \sum_{r=0}^{[n-1/2]} (-1)^r \frac{n! \sqrt{1 - a^2 x^2}}{(n-2r-1)!a} (\sin^{-1} ax)^{n-2r-1} \end{cases}$$

Note:  $[s]$  means greatest integer  $\leq s$ . Thus  $[3.5]$  means 3;  $[5] = 5$ ,  $[\frac{1}{2}] = 0$ .

$$466. \int (\cos^{-1} ax)^n dx = \begin{cases} x(\cos^{-1} ax)^n - \frac{n\sqrt{1 - a^2 x^2}}{a} (\cos^{-1} ax)^{n-1} - n(n-1) \int (\cos^{-1} ax)^{n-2} dx \\ \text{or} \\ \sum_{r=0}^{[n/2]} (-1)^r \frac{n!}{(n-2r)!} x(\cos^{-1} ax)^{n-2r} \times \sum_{r=0}^{[n-1/2]} (-1)^r \frac{n! \sqrt{1 - a^2 x^2}}{(n-2r-1)!a} (\cos^{-1} ax)^{n-2r-1} \end{cases}$$

$$467. \int \frac{1}{\sqrt{1 - a^2 x^2}} (\sin^{-1} ax) dx = \frac{1}{2a} (\sin^{-1} ax)^2$$

$$468. \int \frac{x^n}{\sqrt{1 - a^2 x^2}} (\sin^{-1} ax) dx = -\frac{x^{n-1}}{na^2} \sqrt{1 - a^2 x^2} \sin^{-1} ax + \frac{x^n}{n^2 a} + \frac{n-1}{na^2} \int \frac{x^{n-2}}{\sqrt{1 - a^2 x^2}} \sin^{-1} ax dx$$

469.  $\int \frac{1}{\sqrt{1-a^2x^2}} (\cos^{-1} ax) dx = -\frac{1}{2a} (\cos^{-1} ax)^2$
470.  $\int \frac{x^n}{\sqrt{1-a^2x^2}} (\cos^{-1} ax) dx = -\frac{x^{n+1}}{na^2} \sqrt{1-a^2x^2} \cos^{-1} ax - \frac{x^n}{n^2a} + \frac{n-1}{na^2} \int \frac{x^{n-2}}{\sqrt{1-a^2x^2}} \cos^{-1} ax dx$
471.  $\int \frac{\tan^{-1} ax}{a^2x^2+1} dx = \frac{1}{2a} (\tan^{-1} ax)^2$
472.  $\int \frac{\cot^{-1} ax}{a^2x^2+1} dx = -\frac{1}{2a} (\cot^{-1} ax)^2$
473.  $\int x \sec^{-1} ax dx = \frac{x^2}{2} \sec^{-1} ax - \frac{1}{2a^2} \sqrt{a^2x^2-1}$
474.  $\int x^n \sec^{-1} ax dx = \frac{x^{n+1}}{n+1} \sec^{-1} ax - \frac{1}{n+1} \int \frac{x^n dx}{\sqrt{a^2x^2-1}}$
475.  $\int \frac{\sec^{-1} ax}{x^2} dx = -\frac{\sec^{-1} ax}{x} + \frac{\sqrt{a^2x^2-1}}{x}$
476.  $\int x \csc^{-1} ax dx = \frac{x^2}{2} \csc^{-1} ax + \frac{1}{2a^2} \sqrt{a^2x^2-1}$
477.  $\int x^n \csc^{-1} ax dx = \frac{x^{n+1}}{n+1} \csc^{-1} ax + \frac{1}{n+1} \int \frac{x^n dx}{\sqrt{a^2x^2-1}}$
478.  $\int \frac{\csc^{-1} ax}{x^2} dx = -\frac{\csc^{-1} ax}{x} - \frac{\sqrt{a^2x^2-1}}{x}$

## FORMS INVOLVING TRIGONOMETRIC SUBSTITUTIONS

479.  $\int f(\sin x) dx = 2 \int f\left(\frac{2z}{1+z^2}\right) \frac{dz}{1+z^2}, \quad (z = \tan \frac{x}{2})$
480.  $\int f(\cos x) dx = 2 \int f\left(\frac{1-z^2}{1+z^2}\right) \frac{dz}{1+z^2}, \quad (z = \tan \frac{x}{2})$
481.  $\int f(\sin x) dx = \int f(u) \frac{du}{\sqrt{1-u^2}}, \quad (u = \sin x)$
482.  $\int f(\cos x) dx = - \int f(u) \frac{du}{\sqrt{1-u^2}}, \quad (u = \cos x)$
483.  $\int f(\sin x, \cos x) dx = \int f\left(u, \sqrt{1-u^2}\right) \frac{du}{\sqrt{1-u^2}}, \quad (u = \sin x)$
484.  $\int f(\sin x, \cos x) dx = 2 \int f\left(\frac{2z}{1+z^2}, \frac{1-z^2}{1+z^2}\right) \frac{dz}{1+z^2}, \quad (z = \tan \frac{x}{2})$

## LOGARITHMIC FORMS

485.  $\int (\log x) dx = x \log x - x$
486.  $\int x(\log x) dx = \frac{x^2}{2} \log x - \frac{x^2}{4}$
487.  $\int x^2(\log x) dx = \frac{x^3}{3} \log x - \frac{x^3}{9}$
488.  $\int x^n(\log ax) dx = \frac{x^{n+1}}{n+1} \log ax - \frac{x^{n+1}}{(n+1)^2}$
489.  $\int (\log x)^2 dx = x(\log x)^2 - 2x \log x + 2x$
490.  $\int (\log x)^n dx = \begin{cases} x(\log x)^n - n \int (\log x)^{n-1} dx, & (n \neq -1) \\ \text{or} \\ (-1)^n n! x \sum_{r=0}^n \frac{(-\log x)^r}{r!} \end{cases}$
491.  $\int \frac{(\log x)^n}{x} dx = \frac{1}{n+1} (\log x)^{n+1}$
492.  $\int \frac{dx}{\log x} = \log(\log x) + \log x + \frac{(\log x)^2}{2 \cdot 2!} + \frac{(\log x)^3}{3 \cdot 3!} + \dots$
493.  $\int \frac{dx}{x \log x} = \log(\log x)$

$$494. \int \frac{dx}{x(\log x)^n} = -\frac{1}{(n-1)(\log x)^{n-1}}$$

$$495. \int \frac{x^m dx}{(\log x)^n} = -\frac{x^{m+1}}{(n-1)(\log x)^{n-1}} + \frac{m+1}{n-1} \int \frac{x^m dx}{(\log x)^{n-1}}$$

$$496. \int x^m (\log x)^n dx = \begin{cases} \frac{x^{m+1} (\log x)^n}{m+1} - \frac{n}{m+1} \int x^m (\log x)^{n-1} dx \\ \text{or} \\ (-1)^n \frac{n!}{m+1} x^{m+1} \sum_{r=0}^n \frac{(-\log x)^r}{r!(m+1)^{n-r}} \end{cases}$$

$$497. \int x^p \cos(b \ln x) dx = \frac{x^{p+1}}{(p+1)^2 + b^2} [b \sin(b \ln x) + (p+1) \cos(b \ln x)] + c$$

$$498. \int x^p \sin(b \ln x) dx = \frac{x^{p+1}}{(p+1)^2 + b^2} [(p+1) \sin(b \ln x) - b \cos(b \ln x)] + c$$

$$499. \int [\log(ax+b)] dx = \frac{ax+b}{a} \log(ax+b) - x$$

$$500. \int \frac{\log(ax+b)}{x^2} dx = \frac{a}{b} \log x - \frac{ax+b}{bx} \log(ax+b)$$

$$501. \int x^m [\log(ax+b)] dx = \frac{1}{m+1} \left[ x^{m+1} - \left(-\frac{b}{a}\right)^{m+1} \right] \log(ax+b) - \frac{1}{m+1} \left(-\frac{b}{a}\right)^{m+1} \sum_{r=1}^{m+1} \frac{1}{r} \left(-\frac{ax}{b}\right)^r$$

$$502. \int \frac{\log(ax+b)}{x^m} dx = -\frac{1}{m-1} \frac{\log(ax+b)}{x^{m-1}} + \frac{1}{m-1} \left(-\frac{a}{b}\right)^{m-1} \log \frac{ax+b}{x} + \frac{1}{m-1} \left(-\frac{a}{b}\right)^{m-1} \sum_{r=1}^{m-2} \frac{1}{r} \left(-\frac{b}{ax}\right)^r, (m > 2)$$

$$503. \int \left[ \log \frac{x+a}{x-a} \right] dx = (x+a) \log(x+a) - (x-a) \log(x-a)$$

$$504. \int x^m \left[ \log \frac{x+a}{x-a} \right] dx = \frac{x^{m+1} - (-a)^{m+1}}{m+1} \log(x+a) - \frac{x^{m+1} - a^{m+1}}{m+1} \log(x-a) + \frac{2a^{m+1}}{m+1} \sum_{r=1}^{\left[\frac{m+1}{2}\right]} \frac{1}{m-2r+2} \left(\frac{x}{a}\right)^{m-2r+2}$$

Note:  $[s]$  means greatest integer  $\leq s$ ; Thus  $[3.5]$  means 3;  $[5] = 5$ ,  $\left[\frac{1}{2}\right] = 0$ .

$$505. \int \frac{1}{x^2} \left[ \log \frac{x+a}{x-a} \right] dx = \frac{1}{x} \log \frac{x-a}{x+a} - \frac{1}{a} \log \frac{x^2-a^2}{x^2}$$

$$506. \int (\log X) dx = \begin{cases} \left(x + \frac{b}{2c}\right) \log X - 2x + \frac{\sqrt{4ac-b^2}}{c} \tan^{-1} \frac{2cx+b}{\sqrt{4ac-b^2}}, & (b^2 - 4ac < 0) \\ \text{or} \\ \left(x + \frac{b}{2c}\right) \log X - 2x + \frac{\sqrt{b^2-4ac}}{c} \tanh^{-1} \frac{2cx+b}{\sqrt{b^2-4ac}}, & (b^2 - 4ac > 0) \end{cases}$$

where  
 $X = a + bx + cx^2$

$$507. \int x^n (\log(a + bx + cx^2)) dx = \frac{x^{n+1}}{n+1} \log X - \frac{2c}{n+1} \int \frac{x^{n+2}}{X} dx - \frac{b}{n+1} \int \frac{x^{n+1}}{X} dx$$

$$508. \int \log(x^2 + a^2) dx = x \log(x^2 + a^2) - 2x + 2a \tan^{-1} \frac{x}{a}$$

$$509. \int \log(x^2 - a^2) dx = x \log(x^2 - a^2) - 2x + a \log \frac{x+a}{x-a}$$

$$510. \int x \log(x^2 \pm a^2) dx = \frac{1}{2} (x^2 \pm a^2) \log(x^2 \pm a^2) - \frac{1}{2} x^2$$

$$511. \int \log(x + \sqrt{x^2 \pm a^2}) dx = x \log(x + \sqrt{x^2 \pm a^2}) - \sqrt{x^2 \pm a^2}$$

$$512. \int x \log(x + \sqrt{x^2 \pm a^2}) dx = \left(\frac{x^2}{2} \pm \frac{a^2}{4}\right) \log(x + \sqrt{x^2 \pm a^2}) - \frac{x\sqrt{x^2 \pm a^2}}{4}$$

$$513. \int x^m \log(x + \sqrt{x^2 \pm a^2}) dx = \frac{x^{m+1}}{m+1} \log(x + \sqrt{x^2 \pm a^2}) - \frac{1}{m+1} \int \frac{x^{m+1}}{\sqrt{x^2 \pm a^2}} dx$$

$$514. \int \frac{\log(x + \sqrt{x^2 + a^2})}{x^2} dx = -\frac{\log(x + \sqrt{x^2 + a^2})}{x} - \frac{1}{a} \log \frac{a + \sqrt{x^2 + a^2}}{x}$$

$$515. \int \frac{\log(x + \sqrt{x^2 - a^2})}{x^2} dx = -\frac{\log(x + \sqrt{x^2 - a^2})}{x} + \frac{1}{|a|} \sec^{-1} \frac{x}{a}$$

$$516. \int x^n \log(x^2 - a^2) dx = \frac{1}{n+1} \left[ x^{n+1} \log(x^2 - a^2) - a^{n+1} \log(x-a) - (-a)^{n+1} \log(x+a) - 2 \sum_{r=0}^{\left[\frac{n}{2}\right]} \frac{a^{2r} x^{n-2r+1}}{n-2r+1} \right]$$

Note:  $[s]$  means greatest integer  $\leq s$ ; Thus  $[3.5]$  means 3;  $[5] = 5$ ,  $\left[\frac{1}{2}\right] = 0$ .



## EXPONENTIAL FORMS

517.  $\int e^x dx = e^x$
518.  $\int e^{-x} dx = -e^{-x}$
519.  $\int e^{ax} dx = \frac{e^{ax}}{a}$
520.  $\int x e^{ax} dx = \frac{e^{ax}}{a^2}(ax - 1)$
521.  $\int x^m e^{ax} dx = \begin{cases} \frac{x^m e^{ax}}{a} - \frac{m}{a} \int x^{m-1} e^{ax} dx \\ \text{or} \\ e^{ax} \sum_{r=0}^m \frac{(-1)^r m! x^{m-r}}{(m-r)! a^{r+1}} \end{cases}$
522.  $\int \frac{e^{ax}}{x} dx = \log x + \frac{ax}{1!} + \frac{a^2 x^2}{2 \cdot 2!} + \frac{a^3 x^3}{3 \cdot 3!} + \dots$
523.  $\int \frac{e^{ax}}{x^m} dx = -\frac{1}{m-1} \frac{e^{ax}}{x^{m-1}} + \frac{a}{m-1} \int \frac{e^{ax}}{x^{m-1}} dx$
524.  $\int e^{ax} \log x dx = \frac{e^{ax} \log x}{a} - \frac{1}{a} \int \frac{e^{ax}}{x} dx$
525.  $\int \frac{dx}{1+e^x} = x - \log(1+e^x) = \log \frac{e^x}{1+e^x}$
526.  $\int \frac{dx}{a+be^{px}} = \frac{x}{a} - \frac{1}{ap} \log(a+be^{px})$
527.  $\int \frac{dx}{ae^{mx} + be^{-mx}} = \frac{1}{m\sqrt{ab}} \tan^{-1} \left( e^{mx} \sqrt{\frac{a}{b}} \right), \quad (a > 0, b > 0)$
528.  $\int \frac{dx}{ae^{mx} - be^{-mx}} = \begin{cases} \frac{1}{2m\sqrt{ab}} \log \frac{\sqrt{a} e^{mx} - \sqrt{b}}{\sqrt{a} e^{mx} + \sqrt{b}} \\ \text{or} \\ \frac{-1}{m\sqrt{ab}} \tanh^{-1} \left( \sqrt{\frac{a}{b}} e^{mx} \right), \quad (a > 0, b > 0) \end{cases}$
529.  $\int (a^x - a^{-x}) dx = \frac{a^x + a^{-x}}{\log a}$
530.  $\int \frac{e^{ax}}{b+ce^{ax}} dx = \frac{1}{ac} \log(b+ce^{ax})$
531.  $\int \frac{x e^{ax}}{(1+ax)^2} dx = \frac{e^{ax}}{a^2(1+ax)}$
532.  $\int x e^{-x^2} dx = -\frac{1}{2} e^{-x^2}$
533.  $\int e^{ax} \sin(bx) dx = \frac{e^{ax}[a \sin(bx) - b \cos(bx)]}{a^2 + b^2}$
534.  $\int e^{ax} \sin(bx) \sin(cx) dx = \frac{e^{ax}[(b-c) \sin(b-c)x + a \cos(b-c)x]}{2[a^2 + (b-c)^2]} - \frac{e^{ax}[(b+c) \sin(b+c)x + a \cos(b+c)x]}{2[a^2 + (b+c)^2]}$
535.  $\int e^{ax} \sin(bx) \cos(cx) dx = \begin{cases} \frac{e^{ax}[a \sin(b-c)x - (b-c) \cos(b-c)x]}{2[a^2 + (b-c)^2]} + \frac{e^{ax}[a \sin(b+c)x - (b+c) \cos(b+c)x]}{2[a^2 + (b+c)^2]} \\ \text{or} \\ \frac{e^{ax}}{\rho} [(a \sin bx - b \cos bx) \cos(cx - \alpha)] - c(\sin bx) \sin(cx - \alpha) \end{cases}$   
where  
 $\rho = \sqrt{(a^2 + b^2 - c^2)^2 + 4a^2 c^2},$   
 $\rho \cos \alpha = a^2 + b^2 - c^2, \quad \rho \sin \alpha = 2ac$
536.  $\int e^{ax} \sin(bx) \sin(bx+c) dx = \frac{e^{ax} \cos c}{2a} - \frac{e^{ax}[a \cos(2bx+c) + 2b \sin(2bx+c)]}{2(a^2 + 4b^2)}$
537.  $\int e^{ax} \sin(bx) \cos(bx+c) dx = -\frac{e^{ax} \sin c}{2a} + \frac{e^{ax}[a \sin(2bx+c) - 2b \cos(2bx+c)]}{2(a^2 + 4b^2)}$
538.  $\int e^{ax} \cos(bx) dx = \frac{e^{ax}}{a^2 + b^2} [a \cos(bx) + b \sin(bx)]$
539.  $\int e^{ax} \cos(bx) \cos(cx) dx = \frac{e^{ax}[(b-c) \sin(b-c)x + a \cos(b-c)x]}{2[a^2 + (b-c)^2]} + \frac{e^{ax}[(b+c) \sin(b+c)x + a \cos(b+c)x]}{2[a^2 + (b+c)^2]}$
540.  $\int e^{ax} \cos(bx) \cos(bx+c) dx = \frac{e^{ax} \cos c}{2a} + \frac{e^{ax}[a \cos(2bx+c) + 2b \sin(2bx+c)]}{2(a^2 + 4b^2)}$
541.  $\int e^{ax} \cos(bx) \sin(bx+c) dx = \frac{e^{ax} \sin c}{2a} + \frac{e^{ax}[a \sin(2bx+c) - 2b \cos(2bx+c)]}{2(a^2 + 4b^2)}$

$$542. \quad \int e^{ax} \sin^n(bx) dx = \frac{1}{a^2 + n^2 b^2} \left[ (a \sin bx - nb \cos bx) e^{ax} \sin^{n-1} bx + n(n-1)b^2 \int e^{ax} [\sin^{n-2} bx] dx \right]$$

$$543. \quad \int e^{ax} \cos^n(bx) dx = \frac{1}{a^2 + n^2 b^2} \left[ (a \cos bx + nb \sin bx) e^{ax} \cos^{n-1} bx + n(n-1)b^2 \int e^{ax} [\cos^{n-2} bx] dx \right]$$

$$544. \quad \int x^m e^x \sin x dx = \frac{1}{2} x^m e^x (\sin x - \cos x) - \frac{m}{2} \int x^{m-1} e^x \sin x dx + \frac{m}{2} \int x^{m-1} e^x \cos x dx$$

$$545. \quad \int x^m e^{ax} \sin(bx) dx = \begin{cases} x^m e^{ax} \frac{a \sin bx - b \cos bx}{a^2 + b^2} - \frac{m}{a^2 + b^2} \int x^{m-1} e^{ax} (a \sin bx - b \cos bx) dx \\ \text{or} \\ e^{ax} \sum_{r=0}^m \frac{(-1)^r m! x^{m-r}}{\rho^{r+1} (m-r)!} \sin[bx - (r+1)\alpha] \\ \text{where} \\ \rho = \sqrt{a^2 + b^2}, \quad \rho \cos \alpha = a, \quad \rho \sin \alpha = b \end{cases}$$

$$546. \quad \int x^m e^x \cos x dx = \frac{1}{2} x^m e^x (\sin x + \cos x) - \frac{m}{2} \int x^{m-1} e^x \sin x dx - \frac{m}{2} \int x^{m-1} e^x \cos x dx$$

$$547. \quad \int x^m e^{ax} \cos(bx) dx = \begin{cases} x^m e^{ax} \frac{a \cos bx + b \sin bx}{a^2 + b^2} - \frac{m}{a^2 + b^2} \int x^{m-1} e^{ax} (a \cos bx + b \sin bx) dx \\ \text{or} \\ e^{ax} \sum_{r=0}^m \frac{(-1)^r m! x^{m-r}}{\rho^{r+1} (m-r)!} \cos[bx - (r+1)\alpha] \\ \rho = \sqrt{a^2 + b^2}, \quad \rho \cos \alpha = a, \quad \rho \sin \alpha = b \end{cases}$$

$$548. \quad \int e^{ax} (\cos^m x) (\sin^n x) dx = \begin{cases} \frac{e^{ax} \cos^{m-1} x \sin^n x [a \cos x + (m+n) \sin x]}{(m+n)^2 + a^2} \\ - \frac{na}{(m+n)^2 + a^2} \int e^{ax} (\cos^{m-1} x) (\sin^{n-1} x) dx \\ + \frac{(m-1)(m+n)}{(m+n)^2 + a^2} \int e^{ax} (\cos^{m-2} x) (\sin^n x) dx \\ \text{or} \\ \frac{e^{ax} \cos^m x \sin^{n-1} x [a \sin x - (m+n) \cos x]}{(m+n)^2 + a^2} \\ + \frac{ma}{(m+n)^2 + a^2} \int e^{ax} (\cos^{m-1} x) (\sin^{n-1} x) dx \\ + \frac{(n-1)(m+n)}{(m+n)^2 + a^2} \int e^{ax} (\cos^m x) (\sin^{n-2} x) dx \\ \text{or} \\ \frac{e^{ax} (\cos^{m-1} x) (\sin^{n-1} x) (a \sin x \cos x + m \sin^2 x - n \cos^2 x)}{(m+n)^2 + a^2} \\ + \frac{m(m-1)}{(m+n)^2 + a^2} \int e^{ax} (\cos^{m-2} x) (\sin^n x) dx \\ + \frac{n(n-1)}{(m+n)^2 + a^2} \int e^{ax} (\cos^m x) (\sin^{n-2} x) dx \\ \text{or} \\ \frac{e^{ax} (\cos^{m-1} x) (\sin^{n-1} x) (a \cos x \sin x + m \sin^2 x - n \cos^2 x)}{(m+n)^2 + a^2} \\ + \frac{m(m-1)}{(m+n)^2 + a^2} \int e^{ax} (\cos^{m-2} x) (\sin^{n-2} x) dx \\ + \frac{(n-m)(n+m-1)}{(m+n)^2 + a^2} \int e^{ax} (\cos^m x) (\sin^{n-2} x) dx \end{cases}$$

$$549. \quad \int x e^{ax} \sin(bx) dx = \frac{x e^{ax}}{a^2 + b^2} (a \sin bx - b \cos bx) - \frac{e^{ax}}{(a^2 + b^2)^2} [(a^2 - b^2) \sin bx - 2ab \cos bx]$$

$$550. \quad \int x e^{ax} \cos(bx) dx = \frac{x e^{ax}}{a^2 + b^2} (a \cos bx + b \sin bx) - \frac{e^{ax}}{(a^2 + b^2)^2} [(a^2 - b^2) \cos bx + 2ab \sin bx]$$

$$551. \quad \int \frac{e^{ax}}{\sin^n x} dx = -\frac{e^{ax} [a \sin x + (n-2) \cos x]}{(n-1)(n-2) \sin^{n-1} x} + \frac{a^2 + (n-2)^2}{(n-1)(n-2)} \int \frac{e^{ax}}{\sin^{n-2} x} dx$$

$$552. \quad \int \frac{e^{ax}}{\cos^n x} dx = -\frac{e^{ax} [a \cos x - (n-2) \sin x]}{(n-1)(n-2) \cos^{n-1} x} + \frac{a^2 + (n-2)^2}{(n-1)(n-2)} \int \frac{e^{ax}}{\cos^{n-2} x} dx$$

$$553. \quad \int e^{ax} \tan^n x dx = e^{ax} \frac{\tan^{n-1} x}{n-1} - \frac{a}{n-1} \int e^{ax} \tan^{n-1} x dx - \int e^{ax} \tan^{n-2} x dx$$

## HYPERBOLIC FORMS

$$554. \quad \int \sinh x dx = \cosh x$$

$$555. \quad \int \cosh x dx = \sinh x$$

$$556. \quad \int \tanh x dx = \log \cosh x$$

557.  $\int \coth x \, dx = \log \sinh x$
558.  $\int \operatorname{sech} x \, dx = \tan^{-1}(\sinh x)$
559.  $\int \operatorname{csch} x \, dx = \log \tanh \left( \frac{x}{2} \right)$
560.  $\int x \sinh x \, dx = x \cosh x - \sinh x$
561.  $\int x^n \sinh x \, dx = x^n \cosh x - n \int x^{n-1} (\cosh x) \, dx$
562.  $\int x \cosh x \, dx = x \sinh x - \cosh x$
563.  $\int x^n \cosh x \, dx - x^n \sinh x - n \int x^{n-1} (\sinh x) \, dx$
564.  $\int \operatorname{sech} x \tanh x \, dx = -\operatorname{sech} x$
565.  $\int \operatorname{csch} x \coth x \, dx = -\operatorname{csch} x$
566.  $\int \sinh^2 x \, dx = \frac{\sinh 2x}{4} - \frac{x}{2}$
567.  $\int (\sinh^m x)(\cosh^n x) \, dx = \begin{cases} \frac{1}{m+n} (\sinh^{m+1} x)(\cosh^{n-1} x) + \frac{n-1}{m+n} \int (\sinh^m x)(\cosh^{n-2} x) \, dx \\ \text{or} \\ \frac{1}{m+n} \sinh^{m-1} x \cosh^{n+1} x - \frac{m-1}{m+n} \int (\sinh^{m-2} x)(\cosh^n x) \, dx, \quad (m+n \neq 0) \end{cases}$
568.  $\int \frac{dx}{(\sinh^m x)(\cosh^n x)} \begin{cases} -\frac{1}{(m-n)(\sinh^{m-1} x)(\cosh^{n-1} x)} - \frac{m+n-2}{m-1} \int \frac{dx}{(\sinh^{m-2} x)(\cosh^n x)}, \quad (m \neq 1) \\ \text{or} \\ \frac{1}{(n-1) \sinh^{m-1} x \cosh^{n-1} x} + \frac{m+n-2}{n-1} \int \frac{dx}{(\sinh^m x)(\cosh^{n-2} x)}, \quad (n \neq 1) \end{cases}$
569.  $\int \tanh^2 x \, dx = x - \tanh x$
570.  $\int \tanh^n x \, dx = -\frac{\tanh^{n-1} x}{n-1} + \int (\tanh^{n-2} x) \, dx, \quad (n \neq 1)$
571.  $\int \operatorname{sech}^2 x \, dx = \tanh x$
572.  $\int \cosh^2 x \, dx = \frac{\sinh 2x}{4} + \frac{x}{2}$
573.  $\int \coth^2 x \, dx = x - \coth x$
574.  $\int \coth^n x \, dx = -\frac{\coth^{n-1} x}{n-1} + \int \coth^{n-2} x \, dx, \quad (n \neq 1)$
575.  $\int \operatorname{csch}^2 x \, dx = -\operatorname{ctnh} x$
576.  $\int \sinh(mx) \sinh(nx) \, dx = \frac{\sinh(m+n)x}{2(m+n)} - \frac{\sinh(m-n)x}{2(m-n)}, \quad (m^2 \neq n^2)$
577.  $\int \cosh(mx) \cosh(nx) \, dx = \frac{\sinh(m+n)x}{2(m+n)} + \frac{\sinh(m-n)x}{2(m-n)}, \quad (m^2 \neq n^2)$
578.  $\int \sinh(mx) \cosh(nx) \, dx = \frac{\cosh(m+n)x}{2(m+n)} + \frac{\cosh(m-n)x}{2(m-n)}, \quad (m^2 \neq n^2)$
579.  $\int \sinh^{-1} \frac{x}{a} \, dx = x \sinh^{-1} \frac{x}{a} - \sqrt{x^2 + a^2}, \quad (a > 0)$
580.  $\int x \sinh^{-1} \frac{x}{a} \, dx = \left( \frac{x^2}{2} + \frac{a^2}{4} \right) \sinh^{-1} \frac{x}{a} - \frac{x}{4} \sqrt{x^2 + a^2}, \quad (a > 0)$
581.  $\int x^n \sinh^{-1} x \, dx = \left( \frac{x^{n+1}}{n+1} \right) \sinh^{-1} x - \frac{1}{n+1} \int \frac{x^{n+1}}{(1+x^2)^{\frac{1}{2}}} \, dx, \quad (n \neq -1)$
582.  $\int \cosh^{-1} \frac{x}{a} \, dx = \begin{cases} x \cosh^{-1} \frac{x}{a} - \sqrt{x^2 - a^2}, \quad \left( \cosh^{-1} \frac{x}{a} > 0 \right) \\ \text{or} \\ x \cosh^{-1} \frac{x}{a} + \sqrt{x^2 - a^2}, \quad \left( \cosh^{-1} \frac{x}{a} < 0 \right), \quad (a > 0) \end{cases}$

583.  $\int x \cosh^{-1} \frac{x}{a} dx = \frac{2x^2 - a^2}{4} \cosh^{-1} \frac{x}{a} - \frac{x}{4} (x^2 - a^2)^{\frac{1}{2}}$
584.  $\int x^n (\cosh^{-1} x) dx = \frac{x^{n+1}}{n+1} \cosh^{-1} x - \frac{1}{n+1} \int \frac{x^{n+1}}{(x^2 - 1)^{\frac{1}{2}}} dx, \quad (n \neq -1)$
585.  $\int \tanh^{-1} \frac{x}{a} dx = x \tanh^{-1} \frac{x}{a} + \frac{a}{2} \log(a^2 - x^2), \quad \left(\left|\frac{x}{a}\right| < 1\right)$
586.  $\int \coth^{-1} \frac{x}{a} dx = x \coth^{-1} \frac{x}{a} + \frac{a}{2} \log(x^2 - a^2), \quad \left(\left|\frac{x}{a}\right| > 1\right)$
587.  $\int x \tanh^{-1} \frac{x}{a} dx = \frac{x^2 - a^2}{2} \tanh^{-1} \frac{x}{a} + \frac{ax}{2}, \quad \left(\left|\frac{x}{a}\right| < 1\right)$
588.  $\int x^n \tanh^{-1} x dx = \frac{x^{n+1}}{n+1} \tanh^{-1} x - \frac{1}{n+1} \int \frac{x^{n+1}}{1 - x^2} dx, \quad (n \neq -1)$
589.  $\int x \coth^{-1} \frac{x}{a} dx = \frac{x^2 - a^2}{2} \coth^{-1} \frac{x}{a} + \frac{ax}{2}, \quad \left(\left|\frac{x}{a}\right| > 1\right)$
590.  $\int x^n \coth^{-1} x dx = \frac{x^{n+1}}{n+1} \coth^{-1} x + \frac{1}{n+1} \int \frac{x^{n+1}}{x^2 - 1} dx, \quad (n \neq -1)$
591.  $\int \operatorname{sech}^{-1} x dx = x \operatorname{sech}^{-1} x + \sin^{-1} x$
592.  $\int x \operatorname{sech}^{-1} x dx = \frac{x^2}{2} \operatorname{sech}^{-1} x - \frac{1}{2} \sqrt{1 - x^2}$
593.  $\int x^n \operatorname{sech}^{-1} x dx = \frac{x^{n+1}}{n+1} \operatorname{sech}^{-1} x + \frac{1}{n+1} \int \frac{x^n}{\sqrt{1 - x^2}} dx, \quad (n \neq -1)$
594.  $\int \operatorname{csch}^{-1} x dx = x \operatorname{csch}^{-1} x + \frac{x}{|x|} \sinh^{-1} x$
595.  $\int x \operatorname{csch}^{-1} x dx = \frac{x^2}{2} \operatorname{csch}^{-1} x + \frac{1}{2} \frac{x}{|x|} \sqrt{1 + x^2}$
596.  $\int x^n \operatorname{csch}^{-1} x dx = \frac{x^{n+1}}{n+1} \operatorname{csch}^{-1} x + \frac{1}{n+1} \frac{x}{|x|} \int \frac{x^n}{\sqrt{x^2 + 1}} dx, \quad (n \neq -1)$

## DEFINITE INTEGRALS

597.  $\int_0^\infty x^{n-1} e^{-x} dx = \int_0^1 \left(\log \frac{1}{x}\right)^{n-1} dx = \frac{1}{n} \prod_{m=1}^\infty \frac{\left(1 + \frac{1}{m}\right)^n}{1 + \frac{n}{m}} = \Gamma(n)$   
for  $n \neq 0, -1, -2, -3, \dots$  (This is the Gamma function)
598.  $\int_0^\infty t^n p^{-t} dt = \frac{n!}{(\log p)^{n+1}}, \quad (n = 0, 1, 2, 3, \dots \text{ and } p > 0)$
599.  $\int_0^\infty t^{n-1} e^{-(a+1)t} dt = \frac{\Gamma(n)}{(a+1)^n}, \quad (n > 0, a > -1)$
600.  $\int_0^1 x^m \left(\log \frac{1}{x}\right)^n dx = \frac{\Gamma(n+1)}{(m+1)^{n+1}}, \quad (m > -1, n > -1)$
601.  $\Gamma(n)$  is finite if  $n > 0$ ;  $\Gamma(n+1) = n\Gamma(n)$
602.  $\Gamma(n) \cdot \Gamma(1-n) = \frac{\pi}{\sin n\pi}$
603.  $\Gamma(n) = (n-1)!$  if  $n = \text{integer} > 0$
604.  $\Gamma\left(\frac{1}{2}\right) = 2 \int_0^\infty e^{-t^2} dt = \sqrt{\pi} = 1.7724538509 \dots = \left(-\frac{1}{2}\right)!$
605.  $\Gamma\left(n + \frac{1}{2}\right) = \frac{1 \cdot 3 \cdot 5 \dots (2n-1)}{2^n} \sqrt{\pi} \quad n = 1, 2, 3, \dots$
606.  $\Gamma\left(-n + \frac{1}{2}\right) = \frac{(-1)^n 2^n \sqrt{\pi}}{1 \cdot 3 \cdot 5 \dots (2n-1)} \quad n = 1, 2, 3, \dots$
607.  $\int_0^1 x^{m-1} (1-x)^{n-1} dx = \int_0^\infty \frac{x^{m-1}}{(1+x)^{m+n}} dx = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)} = B(m, n)$   
(This is the Beta function)
608.  $B(m, n) = B(n, m) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$ , where  $m$  and  $n$  are any positive real numbers.
609.  $\int_a^b (x-a)^m (b-x)^n dx = (b-a)^{m+n+1} \frac{\Gamma(m+1) \cdot \Gamma(n+1)}{\Gamma(m+n+2)}, \quad (m > -1, n > -1, b > a)$
610.  $\int_1^\infty \frac{dx}{x^m} = \frac{1}{m-1}, \quad [m > 1]$
611.  $\int_0^\infty \frac{dx}{(1+x)x^p} = \pi \csc p\pi, \quad [0 < p < 1]$

612.  $\int_0^\infty \frac{dx}{(1-x)x^p} = -\pi \cot p\pi, \quad [0 < p < 1]$
613.  $\int_0^\infty \frac{x^{p-1} dx}{(1+x)} = \frac{\pi}{\sin p\pi} = B(p, 1-p) = \Gamma(p)\Gamma(1-p), \quad [0 < p < 1]$
614.  $\int_0^\infty \frac{x^{m-1} dx}{1+x^n} = \frac{\pi}{n \sin \frac{m\pi}{n}}, \quad [0 < m < n]$
615.  $\int_0^\infty \frac{x^a dx}{(m+x^b)^c} = \frac{m^{\frac{a+1-bc}{b}}}{b} \left[ \frac{\Gamma(\frac{a+1}{b}) \Gamma(c - \frac{a+1}{b})}{\Gamma(c)} \right] \quad (a > -1, b > 0, m > 0, c > \frac{a+1}{b})$
616.  $\int_0^\infty \frac{dx}{(1+x)\sqrt{x}} = \pi$
617.  $\int_0^\infty \frac{a dx}{a^2 + x^2} = \begin{cases} \frac{\pi}{2} & (\text{if } a > 0), \\ 0 & (\text{if } a = 0), \\ -\frac{\pi}{2} & (\text{if } a < 0) \end{cases}$
618.  $\int_0^a (a^2 - x^2)^{n/2} dx = \frac{1}{2} \int_{-a}^a (a^2 - x^2)^{n/2} dx = \frac{1 \cdot 3 \cdot 5 \dots n}{2 \cdot 4 \cdot 6 \dots (n+1)} \cdot \frac{\pi}{2} \cdot a^{n+1} \quad (n \text{ odd}, a > 0)$
619.  $\int_0^a x^m (a^2 - x^2)^{n/2} dx = \begin{cases} \frac{1}{2} a^{m+n+1} B(\frac{m+1}{2}, \frac{n+2}{2}) & (a > 0, m > -1, n > -2) \\ \text{or} \\ \frac{1}{2} a^{m+n+1} \frac{\Gamma(\frac{m+1}{2}) \Gamma(\frac{n+2}{2})}{\Gamma(\frac{m+n+3}{2})} & (a > 0, m > -1, n > -2) \end{cases}$
620.  $\int_0^{\pi/2} \sin^n x dx = \begin{cases} \int_0^{\pi/2} (\cos^n x) dx \\ \frac{1 \cdot 3 \cdot 5 \dots (n-1)}{2 \cdot 4 \cdot 6 \dots (n)} \frac{\pi}{2}, & (n \text{ an even integer}, n \neq 0), \\ \frac{1 \cdot 3 \cdot 5 \dots (n-1)}{2 \cdot 4 \cdot 6 \dots (n)}, & (n \text{ an odd integer}, n \neq 0), \\ \frac{\sqrt{\pi}}{2} \frac{\Gamma(\frac{n+1}{2})}{\Gamma(\frac{n}{2}+1)} & (n > -1) \end{cases}$
621.  $\int_0^\infty \frac{\sin mx dx}{x} = \frac{\pi}{2}; \text{ if } m > 0; 0, \text{ if } m = 0; -\frac{\pi}{2}, \text{ if } m < 0$
622.  $\int_0^\infty \frac{\cos x dx}{x} = \infty$
623.  $\int_0^\infty \frac{\tan x dx}{x} = \frac{\pi}{2}$
624.  $\int_0^\pi \sin ax \cdot \sin bx dx = \int_0^\pi \cos ax \cdot \cos bx dx = 0, \quad (a \neq b; a, b \text{ integers})$
625.  $\int_0^{\pi/a} [\sin(ax)][\cos(ax)] dx = \int_0^\pi [\sin(ax)][\cos(ax)] dx = 0$
626.  $\int_0^\pi [\sin(ax)][\cos(bx)] dx = \frac{2a}{a^2 - b^2}, \text{ if } a - b \text{ is odd, or } 0 \text{ if } a - b \text{ is even}$
627.  $\int_0^\infty \frac{\sin x \cos mx dx}{x} = 0, \quad \text{if } m < -1 \text{ or } m > 1; \frac{\pi}{4}, \text{ if } m = \pm 1; \frac{\pi}{2}, \text{ if } m^2 < 1$
628.  $\int_0^\infty \frac{\sin ax \sin bx}{x^2} dx = \frac{\pi a}{2}, \quad (a \leq b)$
629.  $\int_0^\pi \sin^2 mx dx = \int_0^\pi \cos^2 mx dx = \frac{\pi}{2} \quad (m \text{ is a non-zero integer})$
630.  $\int_0^\infty \frac{\sin^2(px)}{x^2} dx = \frac{\pi|p|}{2}$
631.  $\int_0^\infty \frac{\sin x}{x^p} dx = \frac{\pi}{2\Gamma(p) \sin(p\pi/2)}, \quad 0 < p < 1$
632.  $\int_0^\infty \frac{\cos x}{x^p} dx = \frac{\pi}{2\Gamma(p) \cos(p\pi/2)}, \quad 0 < p < 1$
633.  $\int_0^\infty \frac{1 - \cos px}{x^2} dx = \frac{\pi|p|}{2}$
634.  $\int_0^\infty \frac{\sin px \cos qx}{x} dx = \begin{cases} 0, & q > p > 0; \\ \frac{\pi}{2}, & p > q > 0; \\ \frac{\pi}{4}, & p = q > 0 \end{cases}$
635.  $\int_0^\infty \frac{\cos(mx)}{x^2 + a^2} dx = \frac{\pi}{2|a|} e^{-|ma|}$

636.  $\int_0^\infty \cos(x^2) dx = \int_0^\infty \sin(x^2) dx = \frac{1}{2} \sqrt{\frac{\pi}{2}}$
637.  $\int_0^\infty \sin ax^n dx = \frac{1}{na^{1/n}} \Gamma(1/n) \sin \frac{\pi}{2n}, \quad \text{if } n > 1$
638.  $\int_0^\infty \cos ax^n dx = \frac{1}{na^{1/n}} \Gamma(1/n) \cos \frac{\pi}{2n}, \quad \text{if } n > 1$
639.  $\int_0^\infty \frac{\sin x}{\sqrt{x}} dx = \int_0^\infty \frac{\cos x}{\sqrt{x}} dx = \sqrt{\frac{\pi}{2}}$
640. (a)  $\int_0^\infty \frac{\sin^3 x}{x} dx = \frac{\pi}{4}$  (b)  $\int_0^\infty \frac{\sin^3 x}{x^2} dx = \frac{3}{4} \log 3$
641.  $\int_0^\infty \frac{\sin^3 x}{x^3} dx = \frac{3\pi}{8}$
642.  $\int_0^\infty \frac{\sin^4 x}{x^4} dx = \frac{\pi}{3}$
643.  $\int_0^{\pi/2} \frac{dx}{1+a \cos x} = \frac{\cos^{-1} a}{\sqrt{1-a^2}}, \quad (|a| < 1)$
644.  $\int_0^\pi \frac{dx}{a+b \cos x} = \frac{\pi}{\sqrt{a^2-b^2}}, \quad (a > b \geq 0)$
645.  $\int_0^{2\pi} \frac{dx}{1+a \cos x} = \frac{2\pi}{\sqrt{1-a^2}}, \quad (a^2 < 1)$
646.  $\int_0^\infty \frac{\cos ax - \cos bx}{x} dx = \log \left| \frac{b}{a} \right|$
647.  $\int_0^{\pi/2} \frac{dx}{a^2 \sin^2 x + b^2 \cos^2 x} = \frac{\pi}{2|ab|}$
648.  $\int_0^{\pi/2} \frac{dx}{(a^2 \sin^2 x + b^2 \cos^2 x)^2} = \frac{\pi(a^2+b^2)}{4a^3b^3}, \quad (a, b > 0)$
649.  $\int_0^{\pi/2} \sin^{n-1} x \cos^{m-1} x dx = \frac{1}{2} B\left(\frac{n}{2}, \frac{m}{2}\right), \quad (\text{if } m \text{ and } n \text{ are positive integers})$
650.  $\int_0^{\pi/2} (\sin^{2n+1} \theta) d\theta = \frac{2 \cdot 4 \cdot 6 \dots (2n)}{1 \cdot 3 \cdot 5 \dots (2n+1)}, \quad (n = 1, 2, 3, \dots)$
651.  $\int_0^{\pi/2} (\sin^{2n} \theta) d\theta = \frac{1 \cdot 3 \cdot 5 \dots (2n-1)}{2 \cdot 4 \dots (2n)} \left(\frac{\pi}{2}\right), \quad (n = 1, 2, 3, \dots)$
652.  $\int_0^{\pi/2} \frac{x}{\sin x} dx = 2 \left\{ \frac{1}{1^2} - \frac{1}{3^2} + \frac{1}{5^2} - \frac{1}{7^2} + \dots \right\}$
653.  $\int_0^{\pi/2} \frac{dx}{1+\tan^m x} = \frac{\pi}{4}$
654.  $\int_0^{\pi/2} \sqrt{\cos \theta} d\theta = \frac{(2\pi)^{\frac{3}{2}}}{[\Gamma(\frac{1}{4})]^2}$
655.  $\int_0^{\pi/2} (\tan^b \theta) d\theta = \frac{\pi}{2 \cos(\frac{b\pi}{2})}, \quad (0 < b < 1)$
656.  $\int_0^\infty \frac{\tan^{-1}(ax) - \tan^{-1}(bx)}{x} dx = \frac{\pi}{2} \log \frac{a}{b}, \quad (a, b > 0)$
657. The area enclosed by a curve defined through the equation  $x^{\frac{b}{c}} + y^{\frac{b}{c}} = a^{\frac{b}{c}}$  where  $a > 0$ ,  $c$  a positive odd integer and  $b$  a positive even integer is given by  $\frac{[\Gamma(\frac{c}{b})]^2}{\Gamma(\frac{2c}{b})} \left(\frac{2ca^2}{b}\right)$
658.  $I = \iiint_R x^{b-1} y^{m-1} z^{n-1} dv$ , where  $R$  denotes the region of space bounded by the co-ordinate planes and that portion of the surface  $\left(\frac{x}{a}\right)^p + \left(\frac{y}{b}\right)^q + \left(\frac{z}{c}\right)^k = 1$ , which lies in the first octant and where  $b, m, n, p, q, k, a, b, c$ , denote positive real numbers is given by
- $$\int_0^a x^{b-1} dx \int_0^b \left[1 - \left(\frac{x}{a}\right)^p\right]^{\frac{1}{p}} y^m dy \int_0^c \left[1 - \left(\frac{x}{a}\right)^p - \left(\frac{y}{b}\right)^q\right]^{\frac{1}{q}} z^{n-1} dz = \frac{a^b b^m c^n}{pqk} \frac{\Gamma\left(\frac{b}{p}\right) \Gamma\left(\frac{m}{q}\right) \Gamma\left(\frac{n}{k}\right)}{\Gamma\left(\frac{b}{p} + \frac{m}{q} + \frac{n}{k} + 1\right)}$$

659.  $\int_0^\infty e^{-ax} dx = \frac{1}{a}, \quad (a > 0)$
660.  $\int_0^\infty \frac{e^{-ax} - e^{-bx}}{x} dx = \log \frac{b}{a}, \quad (a, b > 0)$
661.  $\int_0^\infty x^n e^{-ax} dx = \begin{cases} \frac{\Gamma(n+1)}{a^{n+1}} & (\text{if } n > -1 \text{ and } a > 0) \\ \text{or} \\ \frac{n!}{a^{n+1}} & (\text{if } a > 0 \text{ and } n \text{ is a positive integer}) \end{cases}$
662.  $\int_0^\infty x^n \exp(-ax^p) dx = \frac{\Gamma(k)}{pa^k}, \quad \left(n > -1, p > 0, a > 0, k = \frac{n+1}{p}\right)$
663.  $\int_0^\infty e^{-a^2 x^2} dx = \frac{1}{2a} \sqrt{\pi} = \frac{1}{2a} \Gamma\left(\frac{1}{2}\right), \quad (a > 0)$
664.  $\int_0^\infty x e^{-x^2} dx = \frac{1}{2}$
665.  $\int_0^\infty x^2 e^{-x^2} dx = \frac{\sqrt{\pi}}{4}$
666.  $\int_0^\infty x^{2n} e^{-ax^2} dx = \frac{1 \cdot 3 \cdot 5 \cdots (2n-1)}{2^{n+1} a^n} \sqrt{\frac{\pi}{a}} \quad (a > 0, n > -\frac{1}{2})$
667.  $\int_0^\infty x^{2n+1} e^{-ax^2} dx = \frac{n!}{2a^{n+1}}, \quad (a > 0, n > -1)$
668.  $\int_0^1 x^m e^{-ax} dx = \frac{m!}{a^{m+1}} \left[1 - e^{-a} \sum_{r=0}^m \frac{a^r}{r!}\right]$
669.  $\int_0^\infty e^{\left(-x^2 - \frac{a^2}{x^2}\right)} dx = \frac{e^{-2a} \sqrt{\pi}}{2}, \quad (a \geq 0)$
670.  $\int_0^\infty e^{-nx} \sqrt{x} dx = \frac{1}{2n} \sqrt{\frac{\pi}{n}} \quad (n > 0)$
671.  $\int_0^\infty \frac{e^{-nx}}{\sqrt{x}} dx = \sqrt{\frac{\pi}{n}} \quad (n > 0)$
672.  $\int_0^\infty e^{-ax} (\cos mx) dx = \frac{a}{a^2 + m^2}, \quad (a > 0)$
673.  $\int_0^\infty e^{-ax} (\sin mx) dx = \frac{m}{a^2 + m^2}, \quad (a > 0)$
674.  $\int_0^\infty x e^{-ax} [\sin(bx)] dx = \frac{2ab}{(a^2 + b^2)^2}, \quad (a > 0)$
675.  $\int_0^\infty x e^{-ax} [\cos(bx)] dx = \frac{a^2 - b^2}{(a^2 + b^2)^2}, \quad (a > 0)$
676.  $\int_0^\infty x^n e^{-ax} [\sin(bx)] dx = \frac{n![(a+ib)^{n+1} - (a-ib)^{n+1}]}{2i(a^2 + b^2)^{n+1}}, \quad (i^2 = -1, a > 0)$
677.  $\int_0^\infty x^n e^{-ax} [\cos(bx)] dx = \frac{n![(a-ib)^{n+1} + (a+ib)^{n+1}]}{2(a^2 + b^2)^{n+1}}, \quad (i^2 = -1, a > 0, n > -1)$
678.  $\int_0^\infty \frac{e^{-ax} \sin x}{x} dx = \cot^{-1} a, \quad (a > 0)$
679.  $\int_0^\infty e^{-a^2 x^2} \cos bx dx = \frac{\sqrt{\pi}}{2|a|} \exp\left(-\frac{b^2}{4a^2}\right), \quad (ab \neq 0)$
680.  $\int_0^\infty e^{-t \cos \phi} t^{b-1} [\sin(t \sin \phi)] dt - [\Gamma(b)] \sin(b\phi), \quad \left(b > 0, -\frac{\pi}{2} < \phi < \frac{\pi}{2}\right)$
681.  $\int_0^\infty e^{-t \cos \phi} t^{b-1} [\cos(t \sin \phi)] dt - [\Gamma(b)] \cos(b\phi), \quad \left(b > 0, -\frac{\pi}{2} < \phi < \frac{\pi}{2}\right)$
682.  $\int_0^\infty t^{b-1} \cos t dt = [\Gamma(b)] \cos\left(\frac{b\pi}{2}\right), \quad (0 < b < 1)$
683.  $\int_0^\infty t^{b-1} (\sin t) dt = [\Gamma(b)] \sin\left(\frac{b\pi}{2}\right), \quad (0 < b < 1)$
684.  $\int_0^1 (\log x)^n dx = (-1)^n \cdot n! \quad (n > -1)$
685.  $\int_0^1 \left(\log \frac{1}{x}\right)^{\frac{1}{2}} dx = \frac{\sqrt{\pi}}{2}$
686.  $\int_0^1 \left(\log \frac{1}{x}\right)^{-\frac{1}{2}} dx = \sqrt{\pi}$

687.  $\int_0^1 \left( \log \frac{1}{x} \right)^n dx = n!$
688.  $\int_0^1 x \log(1-x) dx = -\frac{3}{4}$
689.  $\int_0^1 x \log(1+x) dx = \frac{1}{4}$
690.  $\int_0^1 x^m (\log x)^n dx = \frac{(-1)^n n!}{(m+1)^{n+1}}, \quad (m > -1, n = 0, 1, 2, \dots)$   
 If  $n \neq 0, 1, 2, \dots$  replace  $n!$  by  $\Gamma(n+1)$ .
691.  $\int_0^1 \frac{\log x}{1+x} dx = -\frac{\pi^2}{12}$
692.  $\int_0^1 \frac{\log x}{1-x} dx = -\frac{\pi^2}{6}$
693.  $\int_0^1 \frac{\log(1+x)}{x} dx = \frac{\pi^2}{12}$
694.  $\int_0^1 \frac{\log(1-x)}{x} dx = -\frac{\pi^2}{6}$
695.  $\int_0^1 \log(x) \log(1+x) dx = 2 - 2 \log 2 - \frac{\pi^2}{12}$
696.  $\int_0^1 \log(x) \log(1-x) dx = 2 - \frac{\pi^2}{6}$
697.  $\int_0^1 \frac{\log x}{1-x^2} dx = -\frac{\pi^2}{8}$
698.  $\int_0^1 \log \left( \frac{1+x}{1-x} \right) \cdot \frac{dx}{x} = \frac{\pi^2}{4}$
699.  $\int_0^1 \frac{\log x dx}{\sqrt{1-x^2}} = -\frac{\pi}{2} \log 2$
700.  $\int_0^1 x^m \left[ \log \left( \frac{1}{x} \right) \right]^n dx = \frac{\Gamma(n+1)}{(m+1)^{n+1}}, \quad (\text{if } m+1 > 0 \text{ and } n+1 > 0)$
701.  $\int_0^1 \frac{(x^p - x^q) dx}{\log x} = \log \left( \frac{p+1}{q+1} \right), \quad (p+1 > 0, q+1 > 0)$
702.  $\int_0^1 \frac{dx}{\sqrt{\log \left( \frac{1}{x} \right)}} = \sqrt{\pi}, \quad (\text{same as integral 686})$
703.  $\int_0^\infty \log \left( \frac{e^x + 1}{e^x - 1} \right) dx = \frac{\pi^2}{4}$
704.  $\int_0^{\pi/2} \log(\sin x) dx = \int_0^{\pi/2} \log \cos x dx = -\frac{\pi}{2} \log 2$
705.  $\int_0^{\pi/2} \log(\sec x) dx = \int_0^{\pi/2} \log \csc x dx = \frac{\pi}{2} \log 2$
706.  $\int_0^\pi x \log(\sin x) dx = -\frac{\pi^2}{2} \log 2$
707.  $\int_0^{\pi/2} \sin x \log(\sin x) dx = \log 2 - 1$
708.  $\int_0^{\pi/2} \log \tan x dx = 0$
709.  $\int_0^\pi \log(a \pm b \cos x) dx = \pi \log \left( \frac{a + \sqrt{a^2 - b^2}}{2} \right), \quad (a \geq b)$
710.  $\int_0^\pi \log(a^2 - 2ab \cos x + b^2) dx = \begin{cases} 2\pi \log a & a \geq b > 0 \\ 2\pi \log b & b \geq a > 0 \end{cases}$
711.  $\int_0^\infty \frac{\sin ax}{\sinh bx} dx = \frac{\pi}{2|b|} \tanh \frac{a\pi}{2b}$
712.  $\int_0^\infty \frac{\cos ax}{\cosh bx} dx = \frac{\pi}{2|b|} \operatorname{sech} \frac{a\pi}{2b}$
713.  $\int_0^\infty \frac{dx}{\cosh ax} = \frac{\pi}{2|a|}$



$$714. \int_0^{\infty} \frac{x dx}{\sinh ax} = \frac{\pi^2}{4a^2} \quad (a > 0)$$

$$715. \int_0^{\infty} e^{-ax} \cosh bx dx = \frac{a}{a^2 - b^2}, \quad (0 \leq |b| < a)$$

$$716. \int_0^{\infty} e^{-ax} \sinh bx dx = \frac{b}{a^2 - b^2}, \quad (0 \leq |b| < a)$$

$$717. \int_0^{\infty} \frac{\sinh ax}{e^{bx} + 1} dx = \frac{\pi}{2b} \csc \frac{a\pi}{b} - \frac{1}{2a} \quad (b > 0)$$

$$718. \int_0^{\infty} \frac{\sinh ax}{e^{bx} - 1} dx = \frac{1}{2a} - \frac{\pi}{2b} \cot \frac{a\pi}{b} \quad (b > 0)$$

$$719. \int_0^{\pi/2} \frac{dx}{\sqrt{1 - k^2 \sin^2 x}} = \frac{\pi}{2} \left[ 1 + \left( \frac{1}{2} \right)^2 k^2 + \left( \frac{1 \cdot 3}{2 \cdot 4} \right)^2 k^4 + \left( \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} \right)^2 k^6 + \dots \right], \quad \text{if } k^2 < 1$$

$$720. \int_0^{\pi/2} \sqrt{1 - k^2 \sin^2 x} dx = \frac{\pi}{2} \left[ 1 - \left( \frac{1}{2} \right)^2 k^2 - \left( \frac{1 \cdot 3}{2 \cdot 4} \right)^2 \frac{k^4}{3} - \left( \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} \right)^2 \frac{k^6}{5} - \dots \right], \quad \text{if } k^2 < 1$$

$$721. \int_0^{\infty} e^{-x} \log x dx = -\gamma = -0.5772157 \dots$$

$$722. \int_0^{\infty} e^{-x^2} \log x dx = -\frac{\sqrt{\pi}}{4} (\gamma + 2 \log 2)$$

$$723. \int_0^{\infty} \left( \frac{1}{1 - e^{-x}} - \frac{1}{x} \right) e^{-x} dx = \gamma = 0.5772157 \dots \quad [\text{Euler's Constant}]$$

$$724. \int_0^{\infty} \frac{1}{x} \left( \frac{1}{1+x} - e^{-x} \right) dx = \gamma = 0.5772157 \dots$$

For  $n$  even :

$$725. \int \cos^n x dx = \frac{1}{2^{n-1}} \sum_{k=0}^{n/2-1} \binom{n}{k} \frac{\sin(n-2k)x}{(n-2k)} + \frac{1}{2^n} \binom{n}{n/2} x$$

$$726. \int \sin^n x dx = \frac{1}{2^{n-1}} \sum_{k=0}^{n/2-1} \binom{n}{k} \frac{\sin[(n-2k)(\frac{\pi}{2}-x)]}{2k-n} + \frac{1}{2^n} \binom{n}{n/2} x$$

For  $n$  odd:

$$727. \int \cos^n x dx = \frac{1}{2^{n-1}} \sum_{k=0}^{(n-1)/2} \binom{n}{k} \frac{\sin(n-2k)x}{n-2k}$$

$$728. \int \sin^n x dx = \frac{1}{2^{n-1}} \sum_{k=0}^{(n-1)/2} \binom{n}{k} \frac{\sin[(n-2k)(\frac{\pi}{2}-x)]}{2k-n}$$

## DIFFERENTIAL EQUATIONS

Certain types of differential equations occur sufficiently often to justify the use of formulas for the corresponding particular solutions. The following set of Tables I to XIV covers all first, second, and  $n$ th order ordinary linear differential equations with constant coefficients for which the right members are of the form  $P(x)e^{rx} \sin sx$  or  $P(x)e^{rx} \cos sx$ , where  $r$  and  $s$  are constants and  $P(x)$  is a polynomial of degree  $n$ .

When the right member of a reducible linear partial differential equation with constant coefficients is not zero, particular solutions for certain types of right members are contained in Tables XV to XXI. In these tables both  $F$  and  $P$  are used to denote polynomials, and it is assumed that no denominator is zero. In any formula the roles of  $x$  and  $y$  may be reversed throughout, changing a formula in which  $x$  dominates to one in which  $y$  dominates. Tables XIX, XX, XXI are applicable whether the equations are reducible or not. The symbol  $\binom{m}{n}$  stands for  $\frac{m!}{(m-n)!n!}$  and is the  $(n+1)$ st coefficient in the expansion of  $(a+b)^m$ . Also  $0! = 1$  by definition.

The tables as herewith given are those contained in the text *Differential Equations* by Ginn and Company (1955) and are published with their kind permission and that of the author, Professor Frederick H. Steen.

### SOLUTION OF LINEAR DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS

Any linear differential equation with constant coefficients may be written in the form

$$p(D)y = R(x)$$

where

- $D$  is the differential operation:  $Dy = \frac{dy}{dx}$
- $p(D)$  is a polynomial in  $D$ ,
- $y$  is the dependent variable,
- $x$  is the independent variable,
- $R(x)$  is an arbitrary function of  $x$ .

A power of  $D$  represents repeated differentiation, that is

$$D^n y = \frac{d^n y}{dx^n}$$

For such an equation, the general solution may be written in the form

$$y = y_c + y_p$$

where  $y_p$  is any particular solution, and  $y_c$  is called the *complementary function*. This complementary function is defined as the general solution of the *homogeneous equation*, which is the original differential equation with the right side replaced by zero, i.e.,

$$p(D)y = 0$$

The complementary function  $y_c$  may be determined as follows:

1. Factor the polynomial  $p(D)$  into real and complex linear factors, just as if  $D$  were a variable instead of an operator.
2. For each nonrepeated linear factor of the form  $(D - a)$ , where  $a$  is real, write down a term of the form

$$ce^{ax}$$

where  $c$  is an arbitrary constant.

3. For each repeated real linear factor of the form  $(D - a)^n$ , write down  $n$  terms of the form

$$c_1 e^{ax} + c_2 x e^{ax} + c_3 x^2 e^{ax} + \cdots + c_n x^{n-1} e^{ax}$$

where the  $c_i$ 's are arbitrary constants.

4. For each non-repeated conjugate complex pair of factors of the form  $(D - a + ib)(D - a - ib)$ , write down two terms of the form

$$c_1 e^{ax} \cos bx + c_2 e^{ax} \sin bx$$

5. For each repeated conjugate complex pair of factors of the form  $(D - a + ib)^n (D - a - ib)^n$ , write down  $2n$  terms of the form

$$c_1 e^{ax} \cos bx + c_2 e^{ax} \sin bx + c_3 x e^{ax} \cos bx + c_4 x e^{ax} \sin bx \\ + \cdots + c_{2n-1} x^{n-1} e^{ax} \cos bx + c_{2n} x^{n-1} e^{ax} \sin bx$$

6. The sum of all the terms thus written down is the complementary function  $y_c$ .

To find the particular solution  $y_p$ , use the following tables, as shown in the examples. For cases not shown in the tables, there are various methods of finding  $y_p$ . The most general method is called *variation of parameters*. The following example illustrates the method:

**Example:** Find  $y_p$  for  $(D^2 - 4)y = e^x$ .

This example can be solved most easily by use of equation 63 in the tables following. However, it is given here as an example of the method of variation of parameters.

The complementary function is

$$y_c = c_1 e^{2x} + c_2 e^{-2x}$$

To find  $y_p$ , replace the constants in the complementary function with unknown functions,

$$y_p = u e^{2x} + v e^{-2x}$$

We now prepare to substitute this assumed solution into the original equation. We begin by taking all the necessary derivatives:

$$\begin{aligned}y_p &= ue^{2x} + ve^{-2x} \\y'_p &= 2ue^{2x} - 2ve^{-2x} + u'e^{2x} + v'e^{-2x}\end{aligned}$$

For each derivative of  $y_p$  except the highest, we set the sum of all the terms containing  $u'$  and  $v'$  to 0. Thus the above equation becomes

$$u'e^{2x} + v'e^{-2x} = 0 \quad \text{and} \quad y'_p = 2ue^{2x} - 2ve^{-2x}$$

Continuing to differentiate, we have

$$y''_p = 4ue^{2x} + 4ve^{-2x} + 2u'e^{2x} - 2v'e^{-2x}$$

When we substitute into the original equation, all the terms not containing  $u'$  or  $v'$  cancel out. This is a consequence of the method by which  $y_p$  was set up.

Thus all that is necessary is to write down the terms containing  $u'$  or  $v'$  in the highest order derivative of  $y_p$ , multiply by the constant coefficient of the highest power of  $D$  in  $p(D)$ , and set it equal to  $R(x)$ . Together with the previous terms in  $u'$  and  $v'$  which were set equal to 0, this gives us as many linear equations in the first derivatives of the unknown functions as there are unknown functions. The first derivatives may then be solved for by algebra, and the unknown functions found by integration. In the present example, this becomes

$$\begin{aligned}u'e^{2x} + v'e^{-2x} &= 0 \\2u'e^{2x} - 2v'e^{-2x} &= e^x\end{aligned}$$

We eliminate  $v'$  and  $u'$  separately, getting

$$\begin{aligned}4u'e^{2x} &= e^x \\4v'e^{-2x} &= -e^x\end{aligned}$$

Thus

$$\begin{aligned}u' &= \frac{1}{4}e^{-x} \\v' &= -\frac{1}{4}e^{3x}\end{aligned}$$

Therefore, by integrating

$$\begin{aligned}u &= -\frac{1}{4}e^{-x} \\v &= -\frac{1}{12}e^{3x}\end{aligned}$$

A constant of integration is not needed, since we need only one particular solution. Thus

$$\begin{aligned}y_p = ue^{2x} + ve^{-2x} &= -\frac{1}{4}e^{-x}e^{2x} - \frac{1}{12}e^{3x}e^{-2x} \\&= -\frac{1}{4}e^x - \frac{1}{12}e^x = -\frac{1}{3}e^x\end{aligned}$$

and the general solution is

$$y = y_c + y_p = c_1e^{2x} + c_2e^{-2x} - \frac{1}{3}e^x$$

The following samples illustrate the use of the tables.

**Example 1:** Solve  $(D^2 - 4)y = \sin 3x$ . Substitution of  $q = -4$ ,  $s = 3$  in formula 24 gives

$$y_p = \frac{\sin 3x}{-9 - 4}$$

wherefore the general solution is

$$y = c_1e^{2x} + c_2e^{-2x} - \frac{\sin 3x}{13}$$

**Example 2:** Obtain a particular solution of  $(D^2 - 4D + 5)y = x^2 e^{3x} \sin x$ .

Applying formula 40 with  $a = 2$ ,  $b = 1$ ,  $r = 3$ ,  $s = 1$ ,  $P(x) = x^2$ ,  $s + b = 2$ ,  $s - b = 0$ ,  $a - r = -1$ ,  $(a - r)^2 + (s + b)^2 = 5$ ,  $(a - r)^2 + (s - b)^2 = 1$ , we have

$$\begin{aligned} y_p &= \frac{e^{3x} \sin x}{2} \left[ \left( \frac{2}{5} - \frac{0}{1} \right) x^2 + \left( \frac{2(-1)2}{25} - \frac{2(-1)0}{1} \right) 2x + \left( \frac{3 \cdot 1 \cdot 2 - 2^3}{125} - \frac{3 \cdot 1 \cdot 0 - 0}{1} \right) 2 \right] \\ &\quad - \frac{e^{3x} \cos x}{2} \left[ \left( \frac{-1}{5} - \frac{-1}{1} \right) x^2 + \left( \frac{1-4}{25} - \frac{1-0}{1} \right) 2x + \left( \frac{-1-3(-1)4}{125} - \frac{-1-3(-1)0}{1} \right) 2 \right] \\ &= \left( \frac{1}{5} x^2 - \frac{4}{25} x - \frac{2}{125} \right) e^{3x} \sin x + \left( -\frac{2}{5} x^2 + \frac{28}{25} - \frac{136}{125} \right) e^{3x} \cos x \end{aligned}$$

The special formulas effect a very considerable saving of time in problems of this type.

**Example 3:** Obtain a particular solution of  $(D^2 - 4D + 5)y = x^2 e^{2x} \cos x$ . (Compare with Example 2.)

Formula 40 is not applicable here since for this equation  $r = a$ ,  $s = b$ , wherefore the denominator  $(a - r)^2 + (s - b)^2 = 0$ . We turn instead to formula 44. Substituting  $a = 2$ ,  $b = 1$ ,  $P(x) = x^2$  and replacing  $\sin$  by  $\cos$ ,  $\cos$  by  $-\sin$ , we obtain

$$\begin{aligned} y_p &= \frac{e^{2x} \cos x}{4} \left( x^2 - \frac{2}{4} \right) + \frac{e^{2x} \sin x}{2} \int \left( x^2 - \frac{1}{2} \right) dx \\ &= \left( \frac{x^2}{4} - \frac{1}{8} \right) e^{2x} \cos x + \left( \frac{x^3}{6} - \frac{x}{4} \right) e^{2x} \sin x \end{aligned}$$

which is the required solution.

**Example 4:** Find  $z_p$  for  $(D_x - 3D_y)z = \ln(y + 3x)$ . Referring to Table XV we note that formula 69 (not 68) is applicable. This gives

$$z_p = x \ln(y + 3x)$$

It is easily seen that  $-y/3 \ln(y + 3x)$  would serve equally well.

**Example 5:** Solve  $(D_x + 2D_y - 4)z = y \cos(y - 2x)$ .

Since  $R$  in formula 76 contains a polynomial in  $x$ , not  $y$ , we rewrite the given equation in the form  $(D_y + \frac{1}{2}D_x - 2)z = \frac{1}{2}y \cos(y - 2x)$ . Then

$$z_c = e^{2y} F \left( x - \frac{1}{2}y \right) = e^{2x} f(2x - y)$$

and by the formula

$$z_p = -\frac{1}{2} \cos(y - 2x) \cdot \left( \frac{y}{2} + \frac{1}{2} \right) = -\frac{1}{8} (2y + 1) \cos(y - 2x)$$

**Example 6:** Find  $z_p$  for  $(D_x + 4D_y)^3 z = (2x - y)^2$ .

Using formula 79, we obtain

$$z_p = \frac{\iiint u^2 du^3}{[2 + 4(-1)]^3} = \frac{u^5}{5 \cdot 4 \cdot 3 \cdot (-8)} = -\frac{(2x - y)^5}{480}$$

**Example 7:** Find  $z_p$  for  $(D_x^3 + 5D_x^2 D_y - 7D_x + 4)z = e^{2x+3y}$ . By formula 87

$$z_p = \frac{e^{2x+3y}}{2^3 + 5 \cdot 2^2 \cdot 3 - 7 \cdot 2 + 4} = \frac{e^{2x+3y}}{58}$$

**Example 8:** Find  $z_p$  for

$$(D_x^4 + 6D_x^3 D_y + D_x D_y + D_y^2 + 9)z = \sin(3x + 4y)$$

Since every term in the left number is of even degree in the two operators  $D_x$  and  $D_y$ , formula 90 is applicable. It gives

$$\begin{aligned} z_p &= \frac{\sin(3x + 4y)}{(-9)^2 + 6(-9)(-12) + (-12) + (-16) + 9} \\ &= \frac{\sin(3x + 4y)}{710} \end{aligned}$$

Table I:  $(D - a)y = R$ 

| R                          | $y_p$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. $e^{rx}$                | $\frac{e^{rx}}{r-a}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 2. $\sin sx$ *             | $-\frac{a \sin sx + s \cos sx}{a^2 + s^2} = \frac{1}{\sqrt{a^2 + s^2}} \sin \left( sx + \tan^{-1} \frac{s}{a} \right)$                                                                                                                                                                                                                                                                                                                                                                                       |
| 3. $P(x)$                  | $-\frac{1}{a} \left[ P(x) + \frac{P'(x)}{a} + \frac{P''(x)}{a^2} + \dots + \frac{P^{(n)}(x)}{a^n} \right]$                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4. $e^{rx} \sin sx$ *      | Replace $a$ by $a - r$ in formula 2 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 5. $P(x) e^{rx}$           | Replace $a$ by $a - r$ in formula 3 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 6. $P(x) \sin sx$ *        | $-\sin sx \left[ \frac{a}{a^2 + s^2} P(x) + \frac{a^2 - s^2}{(a^2 + s^2)^2} P'(x) + \frac{a^3 - 3as^2}{(a^2 + s^2)^3} P''(x) + \dots + \frac{a^k - \binom{k}{2} a^{k-2} s^2 + \binom{k}{4} a^{k-4} s^4 - \dots}{(a^2 + s^2)^k} P^{(k-1)}(x) + \dots \right]$ $-\cos sx \left[ \frac{s}{a^2 + s^2} P(x) + \frac{2as}{(a^2 + s^2)^2} P'(x) + \frac{3a^2 s - s^3}{(a^2 + s^2)^3} P''(x) + \dots + \frac{\binom{k}{1} a^{k-1} s - \binom{k}{3} a^{k-3} s^3 + \dots}{(a^2 + s^2)^k} P^{(k-1)}(x) + \dots \right]$ |
| 7. $P(x) e^{rx} \sin sx$ * | Replace $a$ by $a - r$ in formula 6 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 8. $e^{ax}$                | $x e^{ax}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 9. $e^{ax} \sin sx$ *      | $-\frac{e^{ax} \cos sx}{s}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 10. $P(x) e^{ax}$          | $e^{ax} \int P(x) dx$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 11. $P(x) e^{ax} \sin sx$  | $\frac{e^{ax} \sin sx}{s} \left[ \frac{P'(x)}{s^3} - \frac{P'''(x)}{s^5} + \frac{P^{(5)}(x)}{s^7} - \dots \right] - \frac{e^{ax} \cos sx}{s} \left[ P(x) - \frac{P''(x)}{s^2} + \frac{P^{(4)}(x)}{s^4} - \dots \right]$ <p>* For <math>\cos sx</math> in <math>R</math> replace “sin” by “cos” and “cos” by “-sin” in <math>y_p</math>.</p>                                                                                                                                                                  |

$$D^n = \frac{d^n}{dx^n} \quad \binom{m}{n} = \frac{m!}{(m-n)!n!} \quad 0! = 1$$

Table II:  $(D - a)^2 y = R$ 

| R                           | $y_p$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12. $e^{rx}$                | $\frac{e^{rx}}{(r-a)^2}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 13. $\sin sx$ *             | $\frac{1}{(a^2 + s^2)} [(a^2 - s^2) \sin sx + 2as \cos sx] = \frac{1}{a^2 + s^2} \sin \left( sx + \tan^{-1} \frac{2as}{a^2 - s^2} \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 14. $P(x)$                  | $\frac{1}{a^2} \left[ P(x) + \frac{2P'(x)}{a} + \frac{3P''(x)}{a^2} + \dots + \frac{(n+1)P^{(n)}(x)}{a^n} \right]$                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 15. $e^{rx} \sin sx$ *      | Replace $a$ by $a - r$ in formula 13 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 16. $P(x) e^{rx}$           | Replace $a$ by $a - r$ in formula 14 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 17. $P(x) \sin sx$ *        | $\sin sx \left[ \frac{a^2 - s^2}{(a^2 + s^2)^2} P(x) + 2 \frac{a^3 - 3as^2}{(a^2 + s^2)^3} P'(x) + 3 \frac{a^4 - 6a^2 s^2 + s^4}{(a^2 + s^2)^4} P''(x) + \dots \right]$ $+ (k-1) \frac{a^k - \binom{k}{2} a^{k-2} s^2 + \binom{k}{4} a^{k-4} s^4 - \dots}{(a^2 + s^2)^k} P^{(k-2)}(x) + \dots$ $+ \cos sx \left[ \frac{2as}{(a^2 + s^2)^2} P(x) + 2 \frac{3a^2 s - s^3}{(a^2 + s^2)^3} P'(x) + 3 \frac{4a^3 s - 4as^3}{(a^2 + s^2)^4} P''(x) + \dots \right]$ $+ (k-1) \frac{\binom{k}{1} a^{k-1} s - \binom{k}{3} a^{k-3} s^3 + \dots}{(a^2 + s^2)^k} P^{(k-2)}(x) + \dots$ |
| 18. $P(x) e^{rx} \sin sx$ * | Replace $a$ by $a - r$ in formula 17 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 19. $e^{ax}$                | $\frac{1}{2} x^2 e^{ax}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 20. $e^{ax} \sin sx$ *      | $-\frac{e^{ax} \sin sx}{s^2}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 21. $P(x) e^{ax}$           | $e^{ax} \int \int P(x) dx dx$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 22. $P(x) e^{ax} \sin sx$ * | $-\frac{e^{ax} \sin sx}{s^2} \left[ P(x) - \frac{3P''(x)}{s^2} + \frac{5P^{(4)}(x)}{s^4} - \frac{7P^{(6)}(x)}{s^6} + \dots \right]$ $-\frac{e^{ax} \cos sx}{s^2} \left[ \frac{2P'(x)}{s} + \frac{4P'''(x)}{s^3} - \frac{6P^{(5)}(x)}{s^5} + \dots \right]$ <p>* For <math>\cos sx</math> in <math>R</math> replace “sin” by “cos” and “cos” by “-sin” in <math>y_p</math>.</p>                                                                                                                                                                                               |

Table III:  $(D^2 + q)y = R$ 

| $R$                  | $y_p$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 23. $e^{rx}$         | $\frac{e^{rx}}{r^2 + q}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 24. $\sin sx$ *      | $\frac{\sin sx}{-s^2 + q}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 25. $P(x)$           | $\frac{1}{q} \left[ P(x) - \frac{P''(x)}{q} + \frac{P^{iv}(x)}{q^2} - \dots + (-1)^k \frac{P^{(2k)}(x)}{q^k} \dots \right]$                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 26. $e^{rx} \sin sx$ | $\frac{(r^2 - s^2 + q)e^{rx} \sin sx - 2rs e^{rx} \cos sx}{(r^2 - s^2 + q)^2 + (2rs)^2} = \frac{e^{rx}}{\sqrt{(r^2 - s^2 + q)^2 + (2rs)^2}} \sin \left[ sx - \tan^{-1} \frac{2rs}{r^2 - s^2 + q} \right]$                                                                                                                                                                                                                                                                                                                                                                                      |
| 27. $P(x)e^{rx}$     | $\frac{e^{rx}}{r^2 + q} \left[ P(x) - \frac{2r}{r^2 + q} P'(x) + \frac{3r^2 - q}{(r^2 + q)^2} P''(x) - \frac{4r^3 - 4qr}{(r^2 + q)^3} P'''(x) + \dots \right. \\ \left. + \dots + (-1)^{k-1} \frac{\binom{k}{1} r^{k-1} - \binom{k}{3} r^{k-3} q + \binom{k}{5} r^{k-5} q^2 - \dots}{(r^2 + q)^{k-1}} P^{(k-1)}(x) + \dots \right]$                                                                                                                                                                                                                                                            |
| 28. $P(x) \sin sx$ * | $\frac{\sin sx}{(-s^2 + q)} \left[ P(x) - \frac{3s^2 + q}{(-s^2 + q)^2} P''(x) + \frac{5s^4 + 10s^2 q + q^2}{(-s^2 + q)^4} P^{iv}(x) + \dots \right. \\ \left. + (-1)^k \frac{\binom{2k+1}{1} s^{2k+1} + \binom{2k+1}{3} s^{2k-2} q + \binom{2k+1}{5} s^{2k-4} q^2 + \dots}{(-s^2 + q)^{2k}} P^{(2k)}(x) + \dots \right] \\ - \frac{s \cos sx}{(-s^2 + q)} \left[ \frac{2P'(x)}{(-s^2 + q)} - \frac{4s^2 + 4q}{(-s^2 + q)^3} P'''(x) + \dots \right. \\ \left. + (-1)^{k+1} \frac{\binom{2k}{1} s^{2k-2} + \binom{2k}{3} s^{2k-4} q + \dots}{(-s^2 + q)^{2k-1}} P^{(2k-1)}(x) + \dots \right]$ |

Table IV:  $(D^2 + b^2)y = R$ 

|                      |                                                                                                                                                                                          |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 29. $\sin bx$ *      | $-\frac{x \cos bx}{2b}$                                                                                                                                                                  |
| 30. $P(x) \sin bx$ * | $\frac{\sin bx}{(2b)^2} \left[ P(x) - \frac{P''(x)}{(2b)^2} + \frac{P^{iv}(x)}{(2b)^4} - \dots \right] - \frac{\cos bx}{2b} \int \left[ P(x) - \frac{P''(x)}{(2b)^2} + \dots \right] dx$ |

\* For  $\cos sx$  in  $R$  replace “sin” by “cos” and “cos” by “-sin” in  $y_p$ .

Table V:  $(D^2 pD + q)y = R$ 

| $R$                    | $y_p$                                                                                                                                                                                                                          |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 31. $e^{rx}$           | $\frac{e^{rx}}{r^2 + pr + q}$                                                                                                                                                                                                  |
| 32. $\sin sx$ *        | $\frac{(q - s^2) \sin sx - ps \cos sx}{(q - s^2)^2 + (ps)^2} = \frac{1}{\sqrt{(q - s^2)^2 + (ps)^2}} \sin \left( sx - \tan^{-1} \frac{ps}{q - s^2} \right)$                                                                    |
| 33. $P(x)$             | $\frac{1}{q} \left[ P(x) - \frac{p}{q} P'(x) + \frac{p^2 - q}{q^2} P''(x) - \frac{p^3 - 2pq}{q^3} P'''(x) + \dots + (-1)^n \frac{p^n - \binom{n-1}{1} p^{n-2} q + \binom{n-2}{2} p^{n-4} q^2 - \dots}{q^n} P^{(n)}(x) \right]$ |
| 34. $e^{rx} \sin sx$ * | Replace $p$ by $p + 2r$ , $q$ by $q + pr + r^2$ in formula 32 and multiply by $e^{rx}$ .                                                                                                                                       |
| 35. $P(x)e^{rx}$       | Replace $p$ by $p + 2r$ , $q$ by $q + pr + r^2$ in formula 33 and multiply by $e^{rx}$ .                                                                                                                                       |

Table VI:  $(D - b)(D - a)y = R$ 

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 36. $P(x) \sin sx$ *       | $\frac{\sin sx}{b - a} \left[ \left( \frac{a}{a^2 + s^2} - \frac{b}{b^2 + s^2} \right) P(x) + \left( \frac{a^2 - s^2}{(a^2 + s^2)^2} - \frac{b^2 - s^2}{(b^2 + s^2)^2} \right) P'(x) \right. \\ \left. + \left( \frac{a^3 - 3as^2}{(a^2 + s^2)^3} - \frac{b^3 - 3bs^2}{(b^2 + s^2)^3} \right) P''(x) + \dots \right] \\ + \frac{\cos sx}{b - a} \left( \frac{s}{a^2 + s^2} - \frac{s}{b^2 + s^2} \right) P(x) + \left( \frac{2as}{(a^2 + s^2)^2} - \frac{2bs}{(b^2 + s^2)^2} \right) P'(x) \\ \left. + \left( \frac{3a^2 s - s^2}{(a^2 + s^2)^3} - \frac{3b^2 s - s^3}{(b^2 + s^2)^3} \right) P''(x) + \dots \right]^\dagger$ |
| 37. $P(x)e^{rx} \sin sx$ * | Replace $a$ by $a - r$ , $b$ by $b - r$ in formula 36 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 38. $P(x)e^{ax}$           | $\frac{e^{ax}}{a - b} \left[ \int P(x) dx + \frac{P(x)}{(b - a)} + \frac{P'(x)}{(b - a)^2} + \frac{P''(x)}{(b - a)^3} + \dots + \frac{P^{(n)}(x)}{(b - a)^{n+1}} \right]$                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

\* For  $\cos sx$  in  $R$  replace “sin” by “cos” and “cos” by “-sin” in  $y_p$ .  
 $\dagger$  For additional terms, compare with formula 6.

Table VII:  $(D^2 - 2aD + a^2 + b^2)y = R$ 

| R                          | $y_p$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 39. $P(x) \sin sx^*$       | $\frac{\sin sx}{2b} \left[ \left( \frac{s+b}{a^2+(s+b)^2} - \frac{s-b}{a^2+(s-b)^2} \right) P(x) + \left( \frac{2a(s+b)}{[a^2+(s+b)^2]^2} - \frac{2a(s-b)}{[a^2+(s-b)^2]^2} \right) P'(x) \right.$ $\left. + \left( \frac{3a^2(s+b)-(s+b)^3}{[a^2+(s+b)^2]^3} - \frac{3a^2(s-b)-(s-b)^3}{[a^2+(s-b)^2]^3} \right) P''(x) + \dots \right]$ $- \frac{\cos sx}{2b} \left[ \left( \frac{a}{a^2+(s+b)^2} - \frac{a}{a^2+(s-b)^2} \right) P(x) + \left( \frac{a^2-(s+b)^2}{[a^2+(s+b)^2]^2} - \frac{a^2-(s-b)^2}{[a^2+(s-b)^2]^2} \right) P'(x) \right.$ $\left. + \left( \frac{a^2-3a(s+b)^2}{[a^2+(s+b)^2]^3} - \frac{a^2-3a(s-b)^2}{[a^2+(s-b)^2]^3} \right) P''(x) + \dots \right]^\dagger$ |
| 40. $P(x)e^{rx} \sin sx^*$ | Replace $a$ by $a - r$ in formula 39 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 41. $P(x)e^{ax}$           | $\frac{e^{ax}}{b^2} \left[ P(x) - \frac{P''(x)}{b^2} + \frac{P^{iv}(x)}{b^4} - \dots \right]$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 42. $e^{ax} \sin sx^*$     | $\frac{e^{ax} \sin sx}{-s^2+b^2}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 43. $e^{ax} \sin bx^*$     | $-\frac{xe^{ax} \cos bx}{2b}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 44. $P(x)e^{ax} \sin bx^*$ | $\frac{e^{ax} \sin bx}{(2b)^2} \left[ P(x) - \frac{P''(x)}{(2b)^2} + \frac{P^{iv}(x)}{(2b)^4} - \dots \right]$ $- \frac{e^{ax} \cos bx}{2b} \int \left[ P(x) - \frac{P''(x)}{(2b)^2} + \frac{P^{iv}(x)}{(2b)^4} - \dots \right] dx$                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

\* For  $\cos sx$  in R replace “sin” by “cos” and “cos” by “- sin” in  $y_p$ .

† For additional terms, compare with formula 6.

Table VIII:  $f(D)y = [D^n + a_{n-1}D^{n-1} + \dots + a_1D + a_0]y = R$ 

| R               | $y_p$                                                                                                                                                               |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 45. $e^{rx}$    | $\frac{e^{rx}}{f(r)}$                                                                                                                                               |
| 46. $\sin sx^*$ | $\frac{[a_0 - a_2s^2 + a_4s^4 - \dots] \sin sx - [a_1s - a_3s^3 + a_5s^5 - \dots] \cos sx}{[a_0 - a_2s^2 + a_4s^4 - \dots]^2 + [a_1s - a_3s^3 + a_5s^5 - \dots]^2}$ |

Table IX:  $f(D^2)y = R$ 

|                 |                                                                             |
|-----------------|-----------------------------------------------------------------------------|
| 47. $\sin sx^*$ | $\frac{\sin sx}{f(-s^2)} = \frac{\sin sx}{a_0 - a_2s^2 + \dots \pm s^{2n}}$ |
|-----------------|-----------------------------------------------------------------------------|

Table X:  $(D - a)^ny = R$ 

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 48. $e^{rx}$               | $\frac{e^{rx}}{(r-a)^n}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 49. $\sin sx^*$            | $\frac{(-1)^n}{(a^2+s^2)^2} \{ [a^n - \binom{n}{2}a^{n-2}s^2 + \binom{n}{4}a^{n-4}s^4 - \dots] \sin sx$ $+ [ \binom{n}{1}a^{n-1}s - \binom{n}{3}a^{n-3}s^3 + \dots ] \cos sx \}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 50. $P(x)$                 | $\frac{(-1)^n}{a^n} \left[ P(x) + \binom{n}{1} \frac{P'(x)}{a} + \binom{n+1}{2} \frac{P''(x)}{a^2} + \binom{n+2}{3} \frac{P'''(x)}{a^3} + \dots \right]$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 51. $e^{rx} \sin sx^*$     | Replace $a$ by $a - r$ in formula 49 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 52. $e^{rx} P(x)$          | Replace $a$ by $a - r$ in formula 50 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 53. $P(x) \sin sx^*$       | $(-1)^n \sin sx [A_n P(x) + \binom{n}{1} A_{n+1} P'(x) + \binom{n+1}{2} A_{n+2} P''(x) + \binom{n+2}{3} A_{n+3} P'''(x) + \dots]$ $+ (-1)^n \cos sx [B_n P(x) + \binom{n}{1} B_{n+1} P'(x) + \binom{n+1}{2} B_{n+2} P''(x) + \binom{n+2}{3} B_{n+3} P'''(x) + \dots]$ $A_1 = \frac{a}{a^2 + s^2}, A_2 = \frac{a^2 - s^2}{(a^2 + s^2)^2}, \dots, A_k = \frac{a^k - \binom{k}{2}a^{k-2}s^2 + \binom{k}{4}a^{k-4}s^4 - \dots}{(a^2 + s^2)^k}$ $B_1 = \frac{a}{a^2 + s^2}, B_2 = \frac{2as}{(a^2 + s^2)^2}, \dots, B_k = \frac{\binom{k}{1}a^{k-1}s - \binom{k}{3}a^{k-3}s^3 + \dots}{(a^2 + s^2)^k}$                                                                                                                                                                                      |
| 54. $e^{rx} \sin sx^*$     | Replace $a$ by $a - r$ in formula 53 and multiply by $e^{rx}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 55. $e^{ax} P(x)$          | $e^{ax} \int \dots \int P(x) dx^n$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 56. $P(x)e^{ax} \sin sx^*$ | $\frac{(-1)^{\frac{n-1}{2}} e^{ax} \sin sx}{s^n} \left[ \binom{n}{n-1} \frac{P'(x)}{s} - \binom{n+2}{n-1} \frac{P'''(x)}{s^3} + \binom{n+4}{n-1} \frac{P^{v}(x)}{s^5} - \dots \right]$ $+ \frac{(-1)^{\frac{n+1}{2}} e^{ax} \cos sx}{s^n} \left[ \binom{n-1}{n-1} P(x) - \binom{n+1}{n-1} \frac{P''(x)}{s^2} + \binom{n+3}{n-1} \frac{P^{iv}(x)}{s^4} - \dots \right] \quad (n \text{ odd})$ $\frac{(-1)^{\frac{n}{2}} e^{ax} \sin sx}{s^n} \left[ \binom{n-1}{n-1} P(x) - \binom{n+1}{n-1} \frac{P''(x)}{s^2} + \binom{n+3}{n-1} \frac{P^{iv}(x)}{s^4} - \dots \right]$ $+ \frac{(-1)^{\frac{n}{2}} e^{ax} \cos sx}{s^n} \left[ \binom{n}{n-1} \frac{P'(x)}{s} - \binom{n+2}{n-1} \frac{P'''(x)}{s^3} + \binom{n+4}{n-1} \frac{P^{v}(x)}{s^5} - \dots \right] \quad (n \text{ even})$ |

\* For  $\cos sx$  in R replace “sin” by “cos” and “cos” by “- sin” in  $y_p$ .



Table XI:  $(D - a)^n f(D)y = R$ 

57.  $e^{ax}$   $\frac{x^n}{n!} \cdot \frac{e^{ax}}{f(a)}$   
 \* For  $\cos sx$  in  $R$  replace “sin” by “cos” and “cos” by “- sin” in  $y_p$ .

Table XII:  $(D^2 + q)^n y = R$ 

$R$   $y_p$   
 58.  $e^{rx}$   $e^{rx}/(r^2 + q)^n$   
 59.  $\sin sx$   $\sin sx/(q - s^2)^n$   
 60.  $P(x)$   $\frac{1}{q^n} \left[ P(x) - \binom{n}{1} \frac{P'(x)}{q^2} + \binom{n+1}{2} \frac{P''(x)}{q^2} - \binom{n+2}{3} \frac{P'''(x)}{q^3} + \dots \right]$   
 61.  $e^{rx} \sin sx$   $\frac{e^{rx}}{(A^2 + B^2)^n} \left\{ \left[ A^n - \binom{n}{2} A^{n-2} B^2 + \binom{n}{4} A^{n-4} B^4 - \dots \right] \sin sx \right.$   
 $\left. - \left[ \binom{n}{1} A^{n-1} B - \binom{n}{3} A^{n-3} B^3 + \dots \right] \cos sx \right\}$   
 $A = r^2 - s^2 + q, \quad B = 2rs$

Table XIII:  $(D^2 + b^2)^n y = R$ 

62.  $\sin bx$   $(-1)^{n+1/2} \frac{x^n \cos bx}{n!(2b)^n} \quad (n \text{ odd}), (-1)^{n/2} \frac{x^n \sin bx}{n!(2b)^n} \quad (n \text{ even})$

Table XIV:  $(D^n - q)y = R$ 

63.  $e^{rx}$   $e^{rx}/(r^n - q)$   
 64.  $P(x)$   $-\frac{1}{q} \left[ P(x) \frac{P^{(n)}(x)}{q} + \frac{P^{(2n)}(x)}{q^2} + \dots \right]$   
 65.  $\sin sx$   $-\frac{q \sin sx + (-1)^{\frac{n-1}{2}} s^n \cos sx}{q^2 + s^{2n}} \quad (n \text{ odd}), \quad \frac{\sin sx}{(-s^2)^{n/2} - q} \quad (n \text{ even})$   
 66.  $e^{rx} \sin sx$   $\frac{Ae^{rx} \sin sr - Be^{rx} \cos sx}{A^2 + B^2} = \frac{e^{rx}}{\sqrt{A^2 + B^2}} \sin \left( sx - \tan^{-1} \frac{B}{A} \right)$   
 $A = \left[ r^n - \binom{n}{2} r^{n-2} s^2 + \binom{n}{4} r^{n-4} s^4 - \dots \right] - q,$   
 $B = \left[ \binom{n}{1} r^{n-1} s - \binom{n}{3} r^{n-3} s^3 + \dots \right]$   
 \* For  $\cos sx$  in  $R$  replace “sin” by “cos” and cos by “- sin” in  $y_p$ .

Table XV:  $(D_x + mD_y)z = R$ 

$R$   $z_p$   
 67.  $e^{ax+by}$   $\frac{e^{ax+by}}{a+mb-k}$   
 68.  $f(ax+by)$   $\frac{\int f(u)du}{a+mb}, \quad u = ax+by$   
 69.  $f(y-mx)$   $x f(y-mx)$   
 70.  $\phi(x, y) f(y-mx)$   $f(y-mx) \int \phi(x, a+mx) dx \quad (a = y-mx \text{ after integration})$

Table XVI:  $(D_x + mD_y - k)z = R$ 

71.  $e^{ax+by}$   $\frac{e^{ax+by}}{a+mb-k}$   
 72.  $\sin(ax+by)$   $-\frac{(a+bm) \cos(ax+by) + k \sin(ax+by)}{(a+bm)^2 + k^2}$   
 73.  $e^{\alpha x + \beta y} \sin(ax+by)$   $\text{Replace } k \text{ in 72 by } k - \alpha - m\beta \text{ and multiply by } e^{\alpha x + \beta y}$   
 74.  $e^{kx} f(ax+by)$   $\frac{e^{kx} \int f(u)du}{a+mb}, \quad u = ax+by$   
 75.  $f(y-mx)$   $-\frac{f(y-mx)}{k}$   
 76.  $p(x) f(y-mx)$   $-\frac{1}{k} f(y-mx) \left[ p(x) + \frac{p'(x)}{k} + \frac{p''(x)}{k^2} + \dots + \frac{p^{(n)}(x)}{k^n} \right]$   
 77.  $e^{kx} f(y-mx)$   $x e^{kx} f(y-mx)$   
 \* For  $\cos(ax+by)$  replace “sin” by “cos” and “cos” by “- sin” in  $z_p$ .  
 $D_x = \frac{\partial}{\partial x}; \quad D_y = \frac{\partial}{\partial y}; \quad D_x^k D_y^r = \frac{\partial^{k+r}}{\partial x^k \partial y^r}$

Table XVII:  $(D_z + mD_y)^n z = R$ 

| $R$                      | $z_p$                                                                             |
|--------------------------|-----------------------------------------------------------------------------------|
| 78. $e^{ax+by}$          | $\frac{e^{ax+by}}{(a+mb)^n}$                                                      |
| 79. $f(ax+by)$           | $\frac{\int \dots \int f(u) du^n}{(a+mb)^n}, u = ax + by$                         |
| 80. $f(y-mx)$            | $\frac{x^n}{n!} f(y-mx)$                                                          |
| 81. $\phi(x, y) f(y+mx)$ | $f(y-mx) \int \dots \int \phi(x, a+mx) dx^n (a = y-mx \text{ after integration})$ |

Table XVIII:  $(D_x + mD_y - k)^n z = R$ 

|                       |                                                                                                                                                                  |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 82. $e^{ax+by}$       | $\frac{e^{ax+by}}{(a+mb-k)^n}$                                                                                                                                   |
| 83. $f(y-mx)$         | $\frac{(-1)^n f(y-mx)}{k^n}$                                                                                                                                     |
| 84. $P(x) f(y-mx)$    | $\frac{(-1)^n}{k^n} f(y-mx) \left[ p(x) + \binom{n}{1} \frac{p'(x)}{k} + \binom{n+1}{2} \frac{p''(x)}{k^2} + \binom{n+2}{3} \frac{p'''(x)}{k^3} + \dots \right]$ |
| 85. $e^{kx} f(ax+by)$ | $\frac{e^{kx} \int \dots \int f(u) du^n}{(a+mb)^n}, u = ax + by$                                                                                                 |
| 86. $e^{kx} f(y-mx)$  | $\frac{x^n}{n!} e^{kx} f(y-mx)$                                                                                                                                  |

Table XIX:  $[D_x^n + a_1 D_x^{n-1} D_y + a_2 D_x^{n-2} D_y^2 + \dots + a^n D_y^n] z = R$ 

|                 |                                                                                                            |
|-----------------|------------------------------------------------------------------------------------------------------------|
| 87. $e^{ax+by}$ | $\frac{e^{ax+by}}{a + a_1 a^{n-1} b + a_2 a^{n-2} b^2 + \dots + a_n b^n}$                                  |
| 88. $f(ax+by)$  | $\frac{\int \dots \int f(u) du^n}{a^n + a_1 a^{n-1} b + a_2 a^{n-2} b^2 + \dots + a_n b^n}, (u = ax + by)$ |

Table XX:  $F(D_x, D_y) z = R$ 

|                 |                             |
|-----------------|-----------------------------|
| 89. $e^{ax+by}$ | $\frac{e^{ax+by}}{F(a, b)}$ |
|-----------------|-----------------------------|

Table XXI:  $F(D_x^2, D_x D_y, D_y^2) z = R$ 

|                    |                                          |
|--------------------|------------------------------------------|
| 90. $\sin(ax+by)*$ | $\frac{\sin(ax+by)}{F(-a^2, -ab, -b^2)}$ |
|--------------------|------------------------------------------|

\* For  $\cos(ax+by)$  replace “sin” by “cos”, and “cos” by “-sin” in  $z_p$ .

| Differential equation                                                                                                                              | Method of solution                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $yF(xy) dx + xG(xy) dy = 0$                                                                                                                        | $\ln x = \int \frac{G(v) dv}{v\{G(v) - F(v)\}} + c$<br>where $v = xy$ . If $G(v) = F(v)$ ,<br>then the solution is $xy = c$ .                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Linear, homogeneous, second order equation</b><br>$\frac{d^2 y}{dx^2} + b \frac{dy}{dx} + cy = 0$<br>where $b$ and $c$ are real constants       | Let $m_1, m_2$ be the roots of $m^2 + bm + c = 0$ .<br>Then there are 3 cases:<br>Case 1. $m_1, m_2$ real and distinct:<br>$y = c_1 e^{m_1 x} + c_2 e^{m_2 x}$<br>Case 2. $m_1, m_2$ real and equal:<br>$y = c_1 e^{m_1 x} + c_2 x e^{m_1 x}$<br>Case 3. $m_1 = p + qi, m_2 = p - qi$ :<br>$y = e^{px}(c_1 \cos qx + c_2 \sin qx)$<br>where $p = -b/2, q = \sqrt{4c - b^2}/2$                                                                                                                                                                     |
| <b>Linear, nonhomogeneous, second order equation</b><br>$\frac{d^2 y}{dx^2} + b \frac{dy}{dx} + cy = R(x)$<br>where $b$ and $c$ are real constants | There are 3 cases corresponding to those above:<br>Case 1.<br>$y = c_1 e^{m_1 x} + c_2 e^{m_2 x}$<br>$+ \frac{e^{m_1 x}}{m_1 - m_2} \int e^{-m_1 x} R(x) dx$<br>$+ \frac{e^{m_2 x}}{m_2 - m_1} \int e^{-m_2 x} R(x) dx$<br>Case 2.<br>$y = c_1 e^{m_1 x} + c_2 x e^{m_1 x}$<br>$+ x e^{m_1 x} \int e^{-m_1 x} R(x) dx$<br>$- e^{m_1 x} \int x e^{-m_1 x} R(x) dx$<br>Case 3.<br>$y = e^{px}(c_1 \cos qx + c_2 \sin qx)$<br>$+ \frac{e^{px} \sin qx}{q} \int e^{-px} R(x) \cos qx dx$<br>$- \frac{e^{px} \cos qx}{q} \int e^{-px} R(x) \sin qx dx$ |

| Differential equation                                                                                                                       | Method of solution                                                                                                                                                                                                |
|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Euler or Cauchy equation</b><br>$x^2 \frac{d^2 y}{dx^2} + bx \frac{dy}{dx} + cy = S(x)$                                                  | Putting $x = e^t$ , the equation becomes<br>$\frac{d^2 y}{dt^2} + (b-1) \frac{dy}{dt} + cy = S(e^t)$<br>and can then be solved as a linear second order equation.                                                 |
| <b>Bessel's equation</b><br>$x^2 \frac{d^2 y}{dx^2} + x \frac{dy}{dx} + (\lambda^2 x^2 - n^2)y = 0$                                         | $y = c_1 J_n(\lambda x) + c_2 Y_n(\lambda x)$                                                                                                                                                                     |
| <b>Transformed Bessel's equation</b><br>$x^2 \frac{d^2 y}{dx^2} + (2p+1)x \frac{dy}{dx} + (\alpha^2 x^{2r} + \beta^2)y = 0$                 | $y = x^{-p} \left\{ c_1 J_{q/r} \left( \frac{\alpha}{r} x^r \right) + c_2 Y_{q/r} \left( \frac{\alpha}{r} x^r \right) \right\}$<br>where $q = \sqrt{p^2 - \beta^2}$ .                                             |
| <b>Legendre's equation</b><br>$(1-x^2) \frac{d^2 y}{dx^2} - 2x \frac{dy}{dx} + n(n+1)y = 0$                                                 | $y = c_1 P_n(x) + c_2 Q_n(x)$                                                                                                                                                                                     |
| <b>Separation of variables</b><br>$f_1(x)g_1(y) dx + f_2(x)g_2(y) dy = 0$                                                                   | $\int \frac{f_1(x)}{f_2(x)} dx + \int \frac{g_2(y)}{g_1(y)} dy = c$                                                                                                                                               |
| <b>Exact equation</b><br>$M(x, y) dx + N(x, y) dy = 0$<br>where $\partial M/\partial y = \partial N/\partial x$                             | $\int M \partial x + \int \left( n - \frac{\partial}{\partial y} \int M \partial x \right) dy = c$ where $\partial x$ indicates that the integration is to be performed with respect to $x$ keeping $y$ constant. |
| <b>Linear first order equation</b><br>$\frac{dy}{dx} + P(x)y = Q(x)$                                                                        | $ye^{\int P dx} = \int Qe^{\int P dx} dx + c$                                                                                                                                                                     |
| <b>Bernoulli's equation</b><br>$\frac{dy}{dx} + P(x)y = Q(x)y^n$                                                                            | $ve^{(1-n) \int P dx} = \int Qe^{(1-n) \int P dx} dx + c$<br>where $v = y^{1-n}$ .<br>If $n = 1$ , then the solution is $\ln y = \int (Q - P) dx + c$ .                                                           |
| <b>Homogeneous equation</b><br>$\frac{dy}{dx} = F\left(\frac{y}{x}\right)$                                                                  | $\ln x = \int \frac{dv}{F(v)-v} + c$ where $v = y/x$ .<br>If $F(v) = v$ , then the solution is $y = cx$ .                                                                                                         |
| <b>Reducible to homogeneous</b><br>$(a_1 x + b_1 y + c_1) dx + (a_2 x + b_2 y + c_2) dy = 0$<br>with $\frac{a_1}{a_2} \neq \frac{b_1}{b_2}$ | Set $u = a_1 x + b_1 y + c_1$ and $v = a_2 x + b_2 y + c_2$ . Then eliminate $x$ and $y$ and the equation becomes homogenous.                                                                                     |
| <b>Reducible to separable</b><br>$(a_1 x + b_1 y + c_1) dx + (a_2 x + b_2 y + c_2) dy = 0$<br>with $\frac{a_1}{a_2} = \frac{b_1}{b_2}$      | Set $u = a_1 x + b_1 y$ . Then eliminate $x$ or $y$ and the equation becomes separable.                                                                                                                           |

## FOURIER SERIES

1. If  $f(x)$  is a bounded periodic function of period  $2L$  (i.e.,  $f(x + 2L) = f(x)$ ), and satisfies the *Dirichlet conditions*:

- (a) In any period  $f(x)$  is continuous, except possibly for a finite number of jump discontinuities.
- (b) In any period  $f(x)$  has only a finite number of maxima and minima.

Then  $f(x)$  may be represented by the *Fourier series*

$$\frac{a_0}{2} + \sum_{n=1}^{\infty} \left( a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right)$$

where  $a_n$  and  $b_n$  are as determined below. This series will converge to  $f(x)$  at every point where  $f(x)$  is continuous, and to

$$\frac{f(x^+) + f(x^-)}{2}$$

(i.e., the average of the left-hand and right-hand limits) at every point where  $f(x)$  has a jump discontinuity.

$$\begin{aligned} a_n &= \frac{1}{L} \int_{-L}^L f(x) \cos \frac{n\pi x}{L} dx, \quad n = 0, 1, 2, 3, \dots, \\ b_n &= \frac{1}{L} \int_{-L}^L f(x) \sin \frac{n\pi x}{L} dx, \quad n = 1, 2, 3, \dots \end{aligned}$$

We may also write

$$a_n = \frac{1}{L} \int_{\alpha}^{\alpha+2L} f(x) \cos \frac{n\pi x}{L} dx \text{ and } b_n = \frac{1}{L} \int_{\alpha}^{\alpha+2L} f(x) \sin \frac{n\pi x}{L} dx$$

where  $\alpha$  is any real number. Thus if  $\alpha = 0$ ,

$$\begin{aligned} a_n &= \frac{1}{L} \int_0^{2L} f(x) \cos \frac{n\pi x}{L} dx, \quad n = 0, 1, 2, 3, \dots, \\ b_n &= \frac{1}{L} \int_0^{2L} f(x) \sin \frac{n\pi x}{L} dx, \quad n = 1, 2, 3, \dots \end{aligned}$$

2. If in addition to the restrictions in (1),  $f(x)$  is an even function (i.e.,  $f(-x) = f(x)$ ), then the Fourier series reduces to

$$\frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos \frac{n\pi x}{L}$$

That is,  $b_n = 0$ . In this case, a simpler formula for  $a_n$  is

$$a_n = \frac{2}{L} \int_0^L f(x) \cos \frac{n\pi x}{L} dx, \quad n = 0, 1, 2, 3, \dots$$

3. If in addition to the restrictions in (1),  $f(x)$  is an odd function (i.e.,  $f(-x) = -f(x)$ ), then the Fourier series reduces to

$$\sum_{n=1}^{\infty} b_n \sin \frac{n\pi x}{L}$$

That is,  $a_n = 0$ . In this case, a simpler formula for the  $b_n$  is

$$b_n = \frac{2}{L} \int_0^L f(x) \sin \frac{n\pi x}{L} dx, \quad n = 1, 2, 3, \dots$$

4. If in addition to the restrictions in (2) above,  $f(x) = -f(L - x)$ , then  $a_n$  will be 0 for all even values of  $n$ , including  $n = 0$ . Thus in this case, the expansion reduces to

$$\sum_{m=1}^{\infty} a_{2m-1} \cos \frac{(2m-1)\pi x}{L}$$

5. If in addition to the restrictions in (3) above,  $f(x) = f(L - x)$ , then  $b_n$  will be 0 for all even values of  $n$ . Thus in this case, the expansion reduces to

$$\sum_{m=1}^{\infty} b_{2m-1} \sin \frac{(2m-1)\pi x}{L}$$

(The series in (4) and (5) are known as *odd-harmonic series*, since only the odd harmonics appear. Similar rules may be stated for even-harmonic series, but when a series appears in the even-harmonic form, it means that  $2L$  has not been taken as the smallest period of  $f(x)$ . Since any integral multiple of a period is also a period, series obtained in this way will also work, but in general computation is simplified if  $2L$  is taken to be the smallest period.)

6. If we write the Euler definitions for  $\cos \theta$  and  $\sin \theta$ , we obtain the complex form of the Fourier series known either as the “Complex Fourier Series” or the “Exponential Fourier Series” of  $f(x)$ . It is represented as

$$f(x) = \frac{1}{2} \sum_{n=-\infty}^{n=+\infty} c_n e^{i\omega_n x}$$

where

$$c_n = \frac{1}{L} \int_{-L}^L f(x) e^{-i\omega_n x} dx, \quad n = 0, \pm 1, \pm 2, \pm 3, \dots$$

with  $\omega_n = \frac{n\pi}{L}$  for  $n = 0, \pm 1, \pm 2, \dots$ . The set of coefficients  $c_n$  is often referred to as the Fourier spectrum.

7. If both sine and cosine terms are present and if  $f(x)$  is of period  $2L$  and expandable by a Fourier series, it can be represented as

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} c_n \sin \left( \frac{n\pi x}{L} + \phi_n \right), \quad \text{where}$$

$$a_n = c_n \sin \phi_n, \quad b_n = c_n \cos \phi_n, \quad c_n = \sqrt{a_n^2 + b_n^2}, \quad \phi_n = \arctan \left( \frac{a_n}{b_n} \right)$$

It can also be represented as

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} c_n \cos \left( \frac{n\pi x}{L} + \phi_n \right), \quad \text{where}$$

$$a_n = c_n \cos \phi_n, \quad b_n = -c_n \sin \phi_n, \quad c_n = \sqrt{a_n^2 + b_n^2}, \quad \phi_n = \arctan \left( -\frac{b_n}{a_n} \right)$$

where  $\phi_n$  is chosen so as to make  $a_n$ ,  $b_n$ , and  $c_n$  hold.

8. The following table of trigonometric identities should be helpful for developing Fourier series.

|                         | $n$      | $n$ even     | $n$ odd                                   | $n/2$ odd        | $n/2$ even |
|-------------------------|----------|--------------|-------------------------------------------|------------------|------------|
| $\sin n\pi$             | 0        | 0            | 0                                         | 0                | 0          |
| $\cos n\pi$             | $(-1)^n$ | +1           | -1                                        | +1               | +1         |
| $* \sin \frac{n\pi}{2}$ |          | 0            | $(-1)^{(n-1)/2}$                          | 0                | 0          |
| $* \cos \frac{n\pi}{2}$ |          | $(-1)^{n/2}$ | 0                                         | -1               | +1         |
| $\sin \frac{n\pi}{4}$   |          |              | $\frac{\sqrt{2}}{2} (-1)^{(n^2+4n+11)/8}$ | $(-1)^{(n-2)/4}$ | 0          |

\*A useful formula for  $\sin \frac{n\pi}{2}$  and  $\cos \frac{n\pi}{2}$  is given by

$$\sin \frac{n\pi}{2} = \frac{(i)^{n+1}}{2} [(-1)^n - 1] \quad \text{and} \quad \cos \frac{n\pi}{2} = \frac{(i)^n}{2} [(-1)^n + 1], \quad \text{where } i^2 = -1.$$

### Auxiliary Formulas for Fourier Series

$$1 = \frac{4}{\pi} \left[ \sin \frac{\pi x}{k} + \frac{1}{3} \sin \frac{3\pi x}{k} + \frac{1}{5} \sin \frac{5\pi x}{k} + \dots \right] \quad [0 < x < k]$$

$$x = \frac{2k}{\pi} \left[ \sin \frac{\pi x}{k} - \frac{1}{2} \sin \frac{2\pi x}{k} + \frac{1}{3} \sin \frac{3\pi x}{k} - \dots \right] \quad [-k < x < k]$$

$$x = \frac{k}{2} - \frac{4k}{\pi^2} \left[ \cos \frac{\pi x}{k} + \frac{1}{3^2} \cos \frac{3\pi x}{k} + \frac{1}{5^2} \cos \frac{5\pi x}{k} + \dots \right] \quad [0 < x < k]$$

$$x^2 = \frac{2k^2}{\pi^3} \left[ \left( \frac{\pi^2}{1} - \frac{4}{1} \right) \sin \frac{\pi x}{k} - \frac{\pi^2}{2} \sin \frac{2\pi x}{k} + \left( \frac{\pi^2}{3} - \frac{4}{3^3} \right) \sin \frac{3\pi x}{k} \right. \\ \left. - \frac{\pi^2}{4} \sin \frac{4\pi x}{k} + \left( \frac{\pi^2}{5} - \frac{4}{5^3} \right) \sin \frac{5\pi x}{k} + \dots \right] \quad [0 < x < k]$$

$$x^2 = \frac{k^2}{3} - \frac{4k^2}{\pi^2} \left[ \cos \frac{\pi x}{k} - \frac{1}{2^2} \cos \frac{2\pi x}{k} + \frac{1}{3^2} \cos \frac{3\pi x}{k} - \frac{1}{4^2} \cos \frac{4\pi x}{k} + \dots \right] \\ [-k < x < k]$$

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots = \frac{\pi}{4}$$

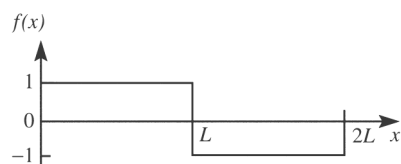
$$1 - \frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2} + \dots = \frac{\pi^2}{6}$$

$$1 - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \dots = \frac{\pi^2}{12}$$

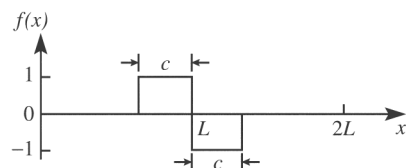
$$1 + \frac{1}{3^2} + \frac{1}{5^2} - \frac{1}{7^2} + \dots = \frac{\pi^2}{8}$$

$$\frac{1}{2^2} + \frac{1}{4^2} + \frac{1}{6^2} + \frac{1}{8^2} + \dots = \frac{\pi^2}{24}$$

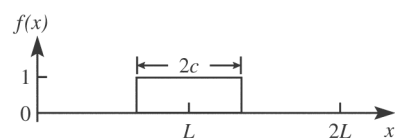
## FOURIER EXPANSIONS FOR BASIC PERIODIC FUNCTIONS



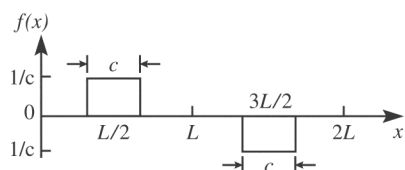
$$f(x) = \frac{4}{\pi} \sum_{n=1,3,5,\dots} \frac{1}{n} \sin \frac{n\pi x}{L}$$



$$f(x) = \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^n}{n} \left( \cos \frac{n\pi c}{L} - 1 \right) \sin \frac{n\pi x}{L}$$

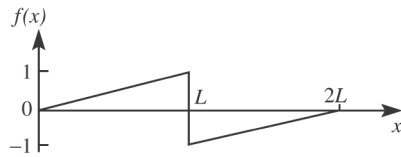


$$f(x) = \frac{c}{L} + \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^n}{n} \sin \frac{n\pi c}{L} \cos \frac{n\pi x}{L}$$

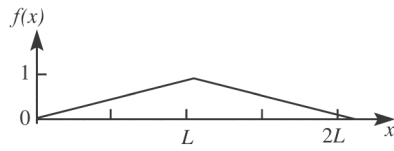


$$f(x) = \frac{2}{L} \sum_{n=1}^{\infty} \sin \frac{n\pi}{2} \frac{\sin(\frac{1}{2} n\pi c/L)}{\frac{1}{2} n\pi c/L} \sin \frac{n\pi x}{L}$$

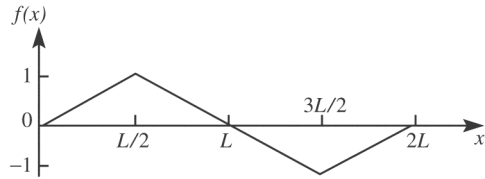




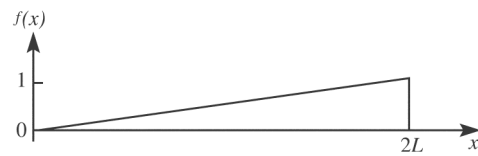
$$f(x) = \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n} \sin \frac{n\pi x}{L}$$



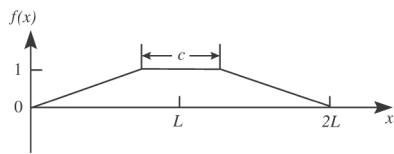
$$f(x) = \frac{1}{2} - \frac{4}{\pi^2} \sum_{n=1,3,5,\dots} \frac{1}{n^2} \cos \frac{n\pi x}{L}$$



$$f(x) = \frac{8}{\pi^2} \sum_{n=1,3,5,\dots} \frac{(-1)^{(n-1)/2}}{n^2} \sin \frac{n\pi x}{L}$$

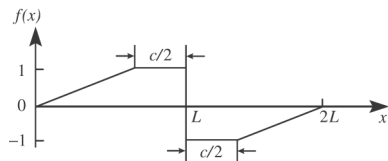


$$f(x) = \frac{1}{2} - \frac{1}{\pi} \sum_{n=1}^{\infty} \frac{1}{n} \sin \frac{n\pi x}{L}$$

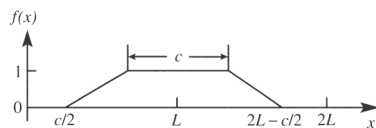


$$f(x) = \frac{1}{2}(1+a) + \frac{2}{\pi^2(1-a)} \sum_{n=1}^{\infty} \frac{1}{n^2} [(-1)^n \cos n\pi a - 1] \cos \frac{n\pi x}{L};$$

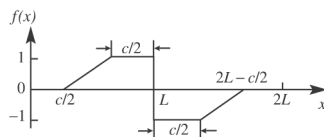
$$(a = \frac{c}{2L})$$



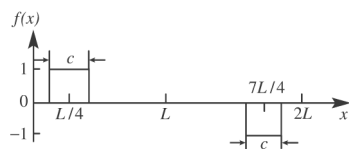
$$f(x) = \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{n} \left[ 1 + \frac{\sin n\pi a}{n\pi(1-a)} \right] \sin \frac{n\pi x}{L}; (a = \frac{c}{2L})$$



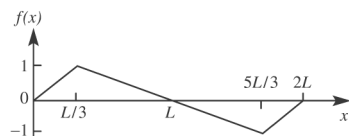
$$f(x) = \frac{1}{2} - \frac{4}{\pi^2(1-2a)} \sum_{n=1,3,5,\dots} \frac{1}{n^2} \cos n\pi a \cos \frac{n\pi x}{L}; (a = \frac{c}{2L})$$



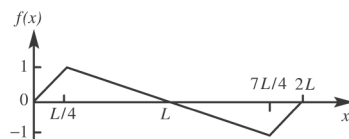
$$f(x) = \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^n}{n} \left[ 1 + \frac{1+(-1)^n}{n\pi(1-2a)} \sin n\pi a \right] \sin \frac{n\pi x}{L}; (a = \frac{c}{2L})$$



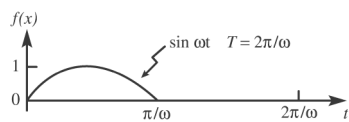
$$f(x) = \frac{4}{\pi} \sum_{n=1}^{\infty} \frac{1}{n} \sin \frac{n\pi}{4} \sin n\pi a \sin \frac{n\pi x}{L}; (a = \frac{c}{2L})$$



$$f(x) = \frac{9}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} \sin \frac{n\pi}{3} \sin \frac{n\pi x}{L}; \left(a = \frac{c}{2L}\right)$$



$$f(x) = \frac{32}{3\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} \sin \frac{n\pi}{4} \sin \frac{n\pi x}{L}; \left(a = \frac{c}{2L}\right)$$



$$f(x) = \frac{1}{\pi} + \frac{1}{2} \sin \omega t - \frac{2}{\pi} \sum_{n=2,4,6,\dots} \frac{1}{n^2-1} \cos n\omega t$$

Extracted from graphs and formulas, pages 372, 373, *Differential Equations in Engineering Problems*, Salvadori and Schwarz, published by Prentice-Hall, Inc., 1954.

## THE FOURIER TRANSFORMS

For a piecewise continuous function  $F(x)$  over a finite interval  $0 \leq x \leq \pi$ ; the *finite Fourier cosine transform* of  $F(x)$  is

$$f_c(n) = \int_0^\pi F(x) \cos nx \, dx \quad (n = 0, 1, 2, \dots)$$

If  $x$  ranges over the interval  $0 \leq x \leq L$ , the substitution  $x' = \pi x/L$  allows the use of this definition, also. The inverse transform is written.

$$\overline{F}(x) = \frac{1}{\pi} f_c(0) - \frac{2}{\pi} \sum_{n=1}^{\infty} f_c(n) \cos nx \quad (0 < x < \pi)$$

where  $F(x) = \frac{F(x+\epsilon) + F(x-\epsilon)}{2}$ . We observe that  $F(x+) = F(x-) = F(x)$  at points of continuity. The formula

$$\begin{aligned} f_c^{(2)}(n) &= \int_0^\pi F''(x) \cos nx \, dx \\ &= -n^2 f_c(n) - F'(0) + (-1)^n F'(\pi) \end{aligned} \tag{1}$$

makes the finite Fourier cosine transform useful in certain boundary value problems. Analogously, the *finite Fourier sine transform* of  $F(x)$  is

$$f_s(n) = \int_0^\pi F(x) \sin nx \, dx \quad (n = 1, 2, 3, \dots)$$

and

$$\overline{F}(x) = \frac{2}{\pi} \sum_{n=1}^{\infty} f_s(n) \sin nx \quad (0 < x < \pi)$$

Corresponding to (1) we have

$$\begin{aligned} f_s^{(2)}(n) &= \int_0^\pi F''(x) \sin nx \, dx \\ &= -n^2 f_s(n) - n F(0) - n(-1)^n F(\pi) \end{aligned} \tag{2}$$

If  $F(x)$  is defined for  $x \leq 0$  and is piecewise continuous over any finite interval, and if  $\int_0^x F(x) \, dx$  is absolutely convergent, then

$$f_c(\alpha) = \sqrt{\frac{2}{\pi}} \int_0^x F(x) \cos(\alpha x) \, dx$$

is the *Fourier cosine transform* of  $F(x)$ . Furthermore,

$$\bar{F}(x) = \sqrt{\frac{2}{\pi}} \int_0^x f_c(\alpha) \cos(\alpha x) d\alpha.$$

If  $\lim_{x \rightarrow \infty} d^n F/dx^n = 0$ , then an important property of the Fourier cosine transform is

$$f_c^{(2r)}(\alpha) = \sqrt{\frac{2}{\pi}} \int_0^x \left( \frac{d^{2r} F}{dx^{2r}} \right) \cos(\alpha x) dx = -\sqrt{\frac{2}{\pi}} \sum_{n=0}^{r-1} (-1)^n a_{2r-2n-1} \alpha^{2n} + (-1)^r \alpha^{2r} f_c(\alpha) \quad (3)$$

where  $\lim_{x \rightarrow \infty} d^r F/dx^r = a_r$ , makes it useful in the solution of many problems.

Under the same conditions,

$$f_s(\alpha) = \sqrt{\frac{2}{\pi}} \int_0^x F(x) \sin(\alpha x) dx$$

defines the *Fourier sine transform* of  $F(x)$ , and

$$\bar{F}(x) = \sqrt{\frac{2}{\pi}} \int_0^x f_s(\alpha) \sin(\alpha x) d\alpha$$

Corresponding to (3) we have

$$f_s^{(2r)}(\alpha) = \sqrt{\frac{2}{\pi}} \int_0^\infty \frac{d^{2r} F}{dx^{2r}} \sin(\alpha x) dx = -\sqrt{\frac{2}{\pi}} \sum_{n=1}^r (-1)^n \alpha^{2n-1} a_{2r-2n} + (-1)^{r-1} \alpha^{2r} f_s(\alpha)$$

Similarly, if  $F(x)$  is defined for  $-\infty < x < \infty$ , and if  $\int_{-\infty}^\infty F(x) dx$  is absolutely convergent, then

$$f(\alpha) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^\infty F(x) e^{i\alpha x} dx$$

is the *Fourier transform* of  $F(x)$ , and

$$\bar{F}(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^\infty f(\alpha) e^{-i\alpha x} d\alpha$$

Also, if

$$\lim_{|x| \rightarrow \infty} \left| \frac{d^n F}{dx^n} \right| = 0 \quad (n = 1, 2, \dots, r-1)$$

then

$$f^{(r)}(\alpha) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^\infty F^{(r)}(x) e^{i\alpha x} dx = (-i\alpha)^r f(\alpha)$$

## Finite Sine Transforms

| $f_s(n)$                                                         | $F(x)$                                                                                               |
|------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| 1. $f_s(n) = \int_0^\pi F(x) \sin nx \, dx \, (n = 1, 2, \dots)$ | $F(x)$                                                                                               |
| 2. $(-1)^{n+1} f_s(n)$                                           | $F(\pi - x)$                                                                                         |
| 3. $\frac{1}{n}$                                                 | $\frac{\pi - x}{\pi}$                                                                                |
| 4. $\frac{(-1)^{n+1}}{n}$                                        | $\frac{x}{\pi}$                                                                                      |
| 5. $\frac{1 - (-1)^n}{n}$                                        | 1                                                                                                    |
| 6. $\frac{2}{n^2} \sin \frac{n\pi}{2}$                           | $\begin{cases} x & \text{when } 0 < x < \pi/2 \\ \pi - x & \text{when } \pi/2 < x < \pi \end{cases}$ |
| 7. $\frac{(-1)^{n+1}}{n^3}$                                      | $\frac{x(\pi^2 - x^2)}{6\pi}$                                                                        |
| 8. $\frac{1 - (-1)^n}{n^3}$                                      | $\frac{x(\pi - x)}{2}$                                                                               |
| 9. $\frac{\pi^2(-1)^{n-1}}{n} - \frac{2[1 - (-1)^n]}{n^3}$       | $x^2$                                                                                                |
| 10. $\pi(-1)^n \left( \frac{6}{n^3} - \frac{\pi^2}{n} \right)$   | $x^3$                                                                                                |
| 11. $\frac{n}{n^2 + c^2} [1 - (-1)^n e^{c\pi}]$                  | $e^{cx}$                                                                                             |
| 12. $\frac{n}{n^2 + c^2}$                                        | $\frac{\sinh c(\pi - x)}{\sinh c\pi}$                                                                |

| $f_s(n)$                                                                                                                             | $F(x)$                                                                        |
|--------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| 13. $\frac{n}{n^2 - k^2} \, (k \neq 0, 1, 2, \dots)$                                                                                 | $\frac{\sin k(\pi - x)}{\sin k\pi}$                                           |
| 14. $\begin{cases} \frac{\pi}{2} & \text{when } n = m \\ 0 & \text{when } n \neq m \end{cases} \, (m = 1, 2, \dots)$                 | $\sin mx$                                                                     |
| 15. $\frac{n}{n^2 - k^2} [1 - (-1)^n \cos k\pi]$<br>$(k \neq 1, 2, \dots)$                                                           | $\cos kx$                                                                     |
| 16. $\begin{cases} \frac{n}{n^2 - m^2} [1 - (-1)^{n+m}] & \text{when } n \neq m = 1, 2, \dots \\ 0 & \text{when } n = m \end{cases}$ | $\cos mx$                                                                     |
| 17. $\frac{n}{(n^2 - k^2)^2} \, (k \neq 0, 1, 2, \dots)$                                                                             | $\frac{\pi \sin kx}{2k \sin^2 k\pi} - \frac{x \cos k(\pi - x)}{2k \sin k\pi}$ |
| 18. $\frac{b^n}{n} \, ( b  \leq 1)$                                                                                                  | $\frac{\pi}{2} \arctan \frac{b \sin x}{1 - b \cos x}$                         |
| 19. $\frac{1 - (-1)^n}{n} b^n \, ( b  \leq 1)$                                                                                       | $\frac{\pi}{2} \arctan \frac{2b \sin x}{1 - b^2}$                             |

## Finite Cosine Transforms

| $f_c(n)$                                                                                                       | $F(x)$                                                                                          |
|----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| 1. $f_c(n) = \int_0^\pi F(x) \cos nx \, dx \quad (n = 0, 1, 2, \dots)$                                         | $F(x)$                                                                                          |
| 2. $(-1)^n f_c(n)$                                                                                             | $F(\pi - x)$                                                                                    |
| 3. 0 when $n = 1, 2, \dots$ ; $f_c(0) = \pi$                                                                   | 1                                                                                               |
| 4. $\frac{2}{n} \sin \frac{n\pi}{2}$ ; $f_c(0) = 0$                                                            | $\begin{cases} 1 & \text{when } 0 < x < \pi/2 \\ -1 & \text{when } \pi/2 < x < \pi \end{cases}$ |
| 5. $-\frac{1-(-1)^n}{n^2}$ ; $f_c(0) = \frac{\pi^2}{2}$                                                        | $x$                                                                                             |
| 6. $\frac{(-1)^n}{n^2}$ ; $f_c(0) = \frac{\pi^2}{6}$                                                           | $\frac{x^2}{2\pi}$                                                                              |
| 7. $\frac{1}{n^2}$ ; $f_c(0) = 0$                                                                              | $\frac{(\pi-x)^2}{2\pi} - \frac{\pi}{6}$                                                        |
| 8. $3\pi^2 \frac{(-1)^n}{n^2} - 6 \frac{1-(-1)^n}{n^4}$ ; $f_c(0) = \frac{\pi^4}{4}$                           | $x^3$                                                                                           |
| 9. $\frac{(-1)^n e^{\pi n^2} - 1}{n^2 + c^2}$                                                                  | $\frac{1}{c} e^{cx}$                                                                            |
| 10. $\frac{1}{n^2 + c^2}$                                                                                      | $\frac{\cosh c(\pi-x)}{c \sinh c\pi}$                                                           |
| 11. $\frac{1}{n^2 - k^2} [(-1)^n \cos \pi k - 1]$<br>( $k \neq 0, 1, 2, \dots$ )                               | $\sin kx$                                                                                       |
| 12. $\frac{(-1)^{n+m} - 1}{n^2 - m^2}$ ; $f_c(m) = 0 \quad (m = 1, 2, \dots)$                                  | $\frac{1}{m} \sin mx$                                                                           |
| 13. $\frac{1}{n^2 - k^2} \quad (k \neq 0, 1, 2, \dots)$                                                        | $-\frac{\cos k(\pi-x)}{k \sin k\pi}$                                                            |
| 14. $\begin{cases} 0 & \text{for } n = 1, 2, \dots; n \neq m \\ \frac{\pi}{2} & \text{for } n = m \end{cases}$ | $\cos mx \quad \text{for } m = 1, 2, 3, \dots$                                                  |

## Fourier Sine Transforms

| $F(x)$                                                             | $f_s(\alpha)$                                                                                                                                         |
|--------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. $\begin{cases} 1 & (0 < x < a) \\ 0 & (x > a) \end{cases}$      | $\sqrt{\frac{2}{\pi}} \left[ \frac{1 - \cos \alpha}{\alpha} \right]$                                                                                  |
| 2. $x^{p-1} \quad (0 < p < 1)$                                     | $\sqrt{\frac{2}{\pi}} \frac{\Gamma(p)}{\alpha^p} \sin \frac{p\pi}{2}$                                                                                 |
| 3. $\begin{cases} \sin x & (0 < x < a) \\ 0 & (x > a) \end{cases}$ | $\frac{1}{\sqrt{2\pi}} \left[ \frac{\sin[a(1-\alpha)]}{1-\alpha} - \frac{\sin[a(1+\alpha)]}{1+\alpha} \right]$                                        |
| 4. $e^{-x}$                                                        | $\sqrt{\frac{2}{\pi}} \left[ \frac{\alpha}{1+\alpha^2} \right]$                                                                                       |
| 5. $xe^{-x^2/2}$                                                   | $\alpha e^{-\alpha^2/2}$                                                                                                                              |
| 6. $\cos \frac{x^2}{2}$                                            | $\sqrt{2} \left[ \sin \frac{\alpha^2}{2} C \left( \frac{\alpha^2}{2} \right) - \cos \frac{\alpha^2}{2} S \left( \frac{\alpha^2}{2} \right) \right]^*$ |
| 7. $\sin \frac{x^2}{2}$                                            | $\sqrt{2} \left[ \cos \frac{\alpha^2}{2} C \left( \frac{\alpha^2}{2} \right) + \sin \frac{\alpha^2}{2} S \left( \frac{\alpha^2}{2} \right) \right]^*$ |

Here  $C(y)$  and  $S(y)$  are the Fresnel integrals:

$$C(y) = \frac{1}{\sqrt{2\pi}} \int_0^y \frac{1}{\sqrt{t}} \cos t \, dt, \quad S(y) = \frac{1}{\sqrt{2\pi}} \int_0^y \frac{1}{\sqrt{t}} \sin t \, dt$$

\*More extensive tables of the Fourier sine and cosine transforms can be found in Fritz Oberhettinger, *Tabellen zur-Fourier Transformation*, Springer, 1957.

## Fourier Cosine Transforms

| $F(x)$                                                             | $f_c(\alpha)$                                                                                                  |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| 1. $\begin{cases} 1 & (0 < x < a) \\ 0 & (x > a) \end{cases}$      | $\sqrt{\frac{2}{\pi}} \frac{\sin a\alpha}{\alpha}$                                                             |
| 2. $x^{p-1} \quad (0 < p < 1)$                                     | $\sqrt{\frac{2}{\pi}} \frac{\Gamma(p)}{\alpha^p} \cos \frac{p\pi}{2}$                                          |
| 3. $\begin{cases} \cos x & (0 < x < a) \\ 0 & (x > a) \end{cases}$ | $\frac{1}{\sqrt{2\pi}} \left[ \frac{\sin[a(1-\alpha)]}{1-\alpha} + \frac{\sin[a(1+\alpha)]}{1+\alpha} \right]$ |
| 4. $e^{-x}$                                                        | $\sqrt{\frac{2}{\pi}} \left( \frac{1}{1+\alpha^2} \right)$                                                     |
| 5. $e^{-x^2/2}$                                                    | $e^{-\alpha^2/2}$                                                                                              |
| 6. $\cos \frac{x^2}{2}$                                            | $\cos \left( \frac{\alpha^2}{2} - \frac{\pi}{4} \right)$                                                       |
| 7. $\sin \frac{x^2}{2}$                                            | $\cos \left( \frac{\alpha^2}{2} + \frac{\pi}{4} \right)$                                                       |

# Fourier Transforms

| $F(x)$                                                                                                     | $f(\alpha)$                                                                                                       |
|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| 1. $\frac{\sin ax}{x}$                                                                                     | $\begin{cases} \sqrt{\frac{\pi}{2}} &  \alpha  < a \\ 0 &  \alpha  > a \end{cases}$                               |
| 2. $\begin{cases} e^{iwx} & (p < x < q) \\ 0 & (x < p, x > q) \end{cases}$                                 | $\frac{i}{\sqrt{2\pi}} \frac{e^{ip(w+\alpha)} - e^{iq(w+\alpha)}}{(w+\alpha)}$                                    |
| 3. $\begin{cases} e^{-cx+iwx} & (x > 0) \\ 0 & (x < 0) \end{cases} \quad (c > 0)$                          | $\frac{i}{\sqrt{2\pi}(w+\alpha+ic)}$                                                                              |
| 4. $e^{-px^2} R(p) > 0$                                                                                    | $\frac{1}{\sqrt{2p}} e^{-\alpha^2/4p}$                                                                            |
| 5. $\cos px^2$                                                                                             | $\frac{1}{\sqrt{2p}} \cos \left[ \frac{\alpha^2}{4p} - \frac{\pi}{4} \right]$                                     |
| 6. $\sin px^2$                                                                                             | $\frac{1}{\sqrt{2p}} \cos \left[ \frac{\alpha^2}{4p} + \frac{\pi}{4} \right]$                                     |
| 7. $ x ^{-p} \quad (0 < p < 1)$                                                                            | $\sqrt{\frac{2}{\pi}} \frac{\Gamma(1-p) \sin \frac{p\pi}{2}}{ \alpha ^{1-p}}$                                     |
| 8. $\frac{e^{-a x }}{\sqrt{ x }}$                                                                          | $\sqrt{\frac{a^2+\alpha^2}{a}}$                                                                                   |
| 9. $\frac{\cosh ax}{\cosh \pi x} \quad (-\pi < a < \pi)$                                                   | $\sqrt{\frac{2}{\pi}} \frac{\cos \frac{a}{2} \cosh \frac{\alpha}{2}}{\cosh \alpha + \cos a}$                      |
| 10. $\frac{\sinh ax}{\sinh \pi x} \quad (-\pi < a < \pi)$                                                  | $\frac{1}{\sqrt{2\pi}} \frac{\sin a}{\cosh \alpha + \cos a}$                                                      |
| 11. $\begin{cases} \frac{1}{\sqrt{a^2-x^2}} & ( x  < a) \\ 0 & ( x  > a) \end{cases}$                      | $\sqrt{\frac{\pi}{2}} J_0(a\alpha)$                                                                               |
| 12. $\frac{\sin[b\sqrt{a^2+x^2}]}{\sqrt{a^2+x^2}}$                                                         | $\begin{cases} 0 & ( \alpha  > b) \\ \sqrt{\frac{\pi}{2}} J_0(a\sqrt{b^2-\alpha^2}) & ( \alpha  < b) \end{cases}$ |
| 13. $\begin{cases} p_n(x) & ( x  < 1) \\ 0 & ( x  > 1) \end{cases}$                                        | $\frac{i^n}{\sqrt{\alpha}} J_{n+\frac{1}{2}}(\alpha)$                                                             |
| 14. $\begin{cases} \frac{\cos[b\sqrt{a^2-x^2}]}{\sqrt{a^2-x^2}} & ( x  < a) \\ 0 & ( x  > a) \end{cases}$  | $\sqrt{\frac{\pi}{2}} J_0(a\sqrt{a^2+b^2})$                                                                       |
| 15. $\begin{cases} \frac{\cosh[b\sqrt{a^2-x^2}]}{\sqrt{a^2-x^2}} & ( x  < a) \\ 0 & ( x  > a) \end{cases}$ | $\sqrt{\frac{\pi}{2}} J_0(a\sqrt{\alpha^2-b^2})$                                                                  |

\*More extensive tables of Fourier transforms can be found in W. Magnus and F. Oberhettinger, *Formulas and Theorems of the Special Functions of Mathematical Physics*. Chelsea, 1949, 116–120.

## SERIES EXPANSION

The expression in parentheses following certain of the series indicates the region of convergence. If not otherwise indicated it is to be understood that the series converges for all finite values of  $x$ .

### Binomial Series

$$\begin{aligned}
 (x + y)^n &= x^n + nx^{n-1}y + \frac{n(n-1)}{2!}x^{n-2}y^2 + \frac{n(n-1)(n-2)}{3!}x^{n-3}y^3 + \cdots (y^2 < x^2) \\
 (1 \pm x)^n &= 1 \pm nx + \frac{n(n-1)x^2}{2!} \pm \frac{n(n-1)(n-2)x^3}{3!} + \cdots (x^2 < 1) \\
 (1 \pm x)^{-n} &= 1 \mp nx + \frac{n(n+1)x^2}{2!} \mp \frac{n(n+1)(n+2)x^3}{3!} + \cdots (x^2 < 1) \\
 (1 \pm x)^{-1} &= 1 \mp x + x^2 \mp x^3 + x^4 \mp x^5 + \cdots (x^2 < 1) \\
 (1 \pm x)^{-2} &= 1 \mp 2x + 3x^2 \mp 4x^3 + 5x^4 \mp 6x^5 + \cdots (x^2 < 1)
 \end{aligned}$$

### Reversion of Series

Let a series be represented by

$$y = a_1x + a_2x^2 + a_3x^3 + a_4x^4 + a_5x^5 + a_6x^6 + \cdots$$

with  $a_1 \neq 0$ . The coefficients of the series

$$x = A_1y + A_2y^2 + A_3y^3 + A_4y^4 + \cdots$$



are

$$A_1 = \frac{1}{a_1} \quad A_2 = -\frac{a_2}{a_1^3} \quad A_3 = \frac{1}{a_1^5}(2a_2^2 - a_1a_3)$$

$$A_4 = \frac{1}{a_1^7}(5a_1a_2a_3 - a_1^2a_4 - 5a_2^3)$$

$$A_5 = \frac{1}{a_1^9}(6a_1^2a_2a_4 + 3a_1^2a_3^2 + 14a_2^4 - a_1^3a_5 - 21a_1a_2^2a_3)$$

$$A_6 = \frac{1}{a_1^{11}}(7a_1^3a_2a_5 + 7a_1^3a_3a_4 + 84a_1a_2^3a_3 - a_1^4a_6 - 28a_1^2a_2^2a_4 - 28a_1^2a_2a_3^2 - 42a_2^5)$$

$$A_7 = \frac{1}{a_1^{13}}(8a_1^4a_2a_6 + 8a_1^4a_3a_5 + 4a_1^4a_4^2 + 120a_1^2a_2^3a_4 + 180a_1^2a_2^2a_3^2 + 132a_2^6 - a_1^5a_7 - 36a_1^3a_2^2a_5 - 72a_1^3a_2a_3a_4 - 12a_1^3a_3^3 - 330a_1a_2^4a_3)$$

### Taylor Series

$$1. \quad f(x) = f(a) + (x-a)f'(a) + \frac{(x-a)^2}{2!}f''(a) + \frac{(x-a)^3}{3!}f'''(a) + \dots + \frac{(x-a)^n}{n!}f^{(n)}(a) + \dots \quad (\text{Taylor Series})$$

(Increment form)

$$2. \quad f(x+h) = f(x) + hf'(x) + \frac{h^2}{2!}f''(x) + \frac{h^3}{3!}f'''(x) + \dots$$

$$= f(h) + xf'(h) + \frac{x^2}{2!}f''(h) + \frac{x^3}{3!}f'''(h) + \dots$$

3. If  $f(x)$  is a function possessing derivatives of all orders throughout the interval  $a \leq x \leq b$ , then there is a value  $X$ , with  $a < X < b$ , such that

$$f(b) = f(a) + (b-a)f'(a) + \frac{(b-a)^2}{2!}f''(a) + \dots + \frac{(b-a)^{n-1}}{(n-1)!}f^{(n-1)}(a) + \frac{(b-a)^n}{n!}f^{(n)}(X)$$

$$f(a+h) = f(a) + hf'(a) + \frac{h^2}{2!}f''(a) + \dots + \frac{h^{n-1}}{(n-1)!}f^{(n-1)}(a) + \frac{h^n}{n!}f^{(n)}(a+\theta h)$$

where  $b = a+h$  and  $0 < \theta < 1$ . Or

$$f(x) = f(a) + (x-a)f'(a) + \frac{(x-a)^2}{2!}f''(a) + \dots + (x-a)^{n-1}\frac{f^{(n-1)}(a)}{(n-1)!} + R_n,$$

where

$$R_n = \frac{f^{(n)}[a + \theta \cdot (x-a)]}{n!}(x-a)^n, 0 < \theta < 1.$$

The above forms are known as Taylor series with the remainder term.

4. Taylor series for a function of two variables

$$\text{If } \left(h\frac{\partial}{\partial x} + k\frac{\partial}{\partial y}\right)f(x,y) = h\frac{\partial f(x,y)}{\partial x} + k\frac{\partial f(x,y)}{\partial y};$$

$$\left(h\frac{\partial}{\partial x} + k\frac{\partial}{\partial y}\right)^2 f(x,y) = h^2\frac{\partial^2 f(x,y)}{\partial x^2} + 2hk\frac{\partial^2 f(x,y)}{\partial x\partial y} + k^2\frac{\partial^2 f(x,y)}{\partial y^2}$$

etc., and if  $\left(h\frac{\partial}{\partial x} + k\frac{\partial}{\partial y}\right)^n f(x,y)\Big|_{x=a}^{y=b}$  where the bar and subscripts mean that after differentiation we are to replace  $x$  by  $a$  and  $y$  by  $b$ , then

$$f(a+h, b+k) = f(a,b) + \left(h\frac{\partial}{\partial x} + k\frac{\partial}{\partial y}\right)f(x,y)\Big|_{x=a}^{y=b} + \dots + \frac{1}{n!}\left(h\frac{\partial}{\partial x} + k\frac{\partial}{\partial y}\right)^n f(x,y)\Big|_{x=a}^{y=b} + \dots$$

**Maclaurin Series**

$$f(x) = f(0) + xf'(0) + \frac{x^2}{2!} f''(0) + \frac{x^3}{3!} f'''(0) + \cdots + x^{n-1} \frac{f^{(n-1)}(0)}{(n-1)!} + R_n,$$

where

$$R_n = \frac{x^n f^{(n)}(\theta x)}{n!}, \quad 0 < \theta < 1.$$

**Exponential Series**

$$e = 1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + \cdots$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \cdots$$

$$a^x = 1 + x \log_e a + \frac{(x \log_e a)^2}{2!} + \frac{(x \log_e a)^3}{3!} + \cdots$$

$$e^x = e^a \left[ 1 + (x-a) + \frac{(x-a)^2}{2!} + \frac{(x-a)^3}{3!} + \cdots \right]$$

**Logarithmic Series**

$$\log_e x = \frac{x-1}{x} + \frac{1}{2} \left( \frac{x-1}{x} \right)^2 + \frac{1}{3} \left( \frac{x-1}{x} \right)^3 + \cdots \quad (x > \frac{1}{2})$$

$$\log_e x = (x-1) - \frac{1}{2}(x-1)^2 + \frac{1}{3}(x-1)^3 - \cdots \quad (2 \geq x > 0)$$

$$\log_e x = 2 \left[ \frac{x-1}{x+1} + \frac{1}{3} \left( \frac{x-1}{x+1} \right)^3 + \frac{1}{5} \left( \frac{x-1}{x+1} \right)^5 + \cdots \right] \quad (x > 0)$$

$$\log_e(1+x) = x - \frac{1}{2}x^2 + \frac{1}{3}x^3 - \frac{1}{4}x^4 + \cdots \quad (-1 < x \leq 1)$$

$$\log_e(n+1) - \log_e(n-1) = 2 \left[ \frac{1}{n} + \frac{1}{3n^3} + \frac{1}{5n^5} + \cdots \right]$$

$$\log_e(a+x) = \log_e a + 2 \left[ \frac{x}{2a+x} + \frac{1}{3} \left( \frac{x}{2a+x} \right)^3 + \frac{1}{5} \left( \frac{x}{2a+x} \right)^5 + \cdots \right] \quad (a > 0, -a < x < +\infty)$$

$$\log_e \frac{1+x}{1-x} = 2 \left[ x + \frac{x^3}{3} + \frac{x^5}{5} + \cdots + \frac{x^{2n-1}}{2n-1} + \cdots \right] \quad -1 < x < 1$$

$$\log_e x = \log_e a + \frac{(x-a)}{a} - \frac{(x-a)^2}{2a^2} + \frac{(x-a)^3}{3a^3} - \cdots \quad 0 < x \leq 2a$$

**Trigonometric Series**

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \cdots \quad (\text{all real values of } x)$$

$$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \cdots \quad (\text{all real values of } x)$$

$$\tan x = x + \frac{x^3}{3} + \frac{2x^5}{15} + \frac{17x^7}{315} + \frac{62x^9}{2835} + \cdots + \frac{(-1)^{n-1} 2^{2n} (2^{2n}-1) B_{2n}}{(2n)!} x^{2n-1} + \cdots,$$

$\left[ x^2 < \frac{\pi^2}{4} \text{ and } B_n \text{ represents the } n^{\text{th}} \text{ Bernoulli number} \right]$

$$\cot x = \frac{1}{x} - \frac{x}{3} - \frac{x^3}{45} - \frac{2x^5}{945} - \frac{x^7}{4725} - \cdots - \frac{(-1)^{n+1} 2^{2n}}{(2n)!} B_{2n} x^{2n-1} - \cdots,$$

$\left[ x^2 < \pi^2 \text{ and } B_n \text{ represents the } n^{\text{th}} \text{ Bernoulli number} \right]$

$$\sec x = 1 + \frac{x^2}{2} + \frac{5}{24}x^4 + \frac{61}{720}x^6 + \frac{277}{8064}x^8 + \cdots + \frac{(-1)^n E_{2n}}{(2n)!} x^{2n} + \cdots,$$

$\left[ x^2 < \frac{\pi^2}{4} \text{ and } E_n \text{ represents the } n^{\text{th}} \text{ Euler number} \right]$

$$\csc x = \frac{1}{x} + \frac{x}{6} + \frac{7}{360}x^3 + \frac{31}{15,120}x^5 + \frac{127}{604,800}x^7 + \cdots + \frac{(-1)^{n+1} 2(2^{2n}-1)}{(2n)!} B_{2n} x^{2n-1} + \cdots,$$

$\left[ x^2 < \pi^2 \text{ and } B_n \text{ represents the } n^{\text{th}} \text{ Bernoulli number} \right]$

$$\sin x = x \left( 1 - \frac{x^2}{\pi^2} \right) \left( 1 - \frac{x^2}{2^2 \pi^2} \right) \left( 1 - \frac{x^2}{3^2 \pi^2} \right) \cdots \quad (x^2 < \infty)$$

$$[2pt] \cos x = \left( 1 - \frac{4x^2}{\pi^2} \right) \left( 1 - \frac{4x^2}{3^2 \pi^2} \right) \left( 1 - \frac{4x^2}{5^2 \pi^2} \right) \cdots \quad (x^2 < \infty)$$

$$[2pt] \sin^{-1} x = x + \frac{x^3}{2 \cdot 3} + \frac{1 \cdot 3}{2 \cdot 4 \cdot 5} x^5 + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 7} x^7 + \cdots \quad \left( x^2 < 1, -\frac{\pi}{2} < \sin^{-1} x < \frac{\pi}{2} \right)$$

$$[2pt] \cos^{-1} x = \frac{\pi}{2} - \left( x + \frac{x^3}{2 \cdot 3} + \frac{1 \cdot 3}{2 \cdot 4 \cdot 5} x^5 + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 7} x^7 + \cdots \right) \quad (x^2 < 1, 0 < \cos^{-1} x < \pi)$$

$$[2pt] \tan^{-1} x = x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} + \cdots \quad (x^2 < 1)$$

$$[2pt] \tan^{-1} x = \frac{\pi}{2} - \frac{1}{x} + \frac{1}{3x^3} - \frac{1}{5x^5} + \frac{1}{7x^7} - \cdots \quad (x > 1)$$

$$[2pt] \tan^{-1} x = -\frac{\pi}{2} - \frac{1}{x} + \frac{1}{3x^3} - \frac{1}{5x^5} + \frac{1}{7x^7} - \cdots \quad (x < -1)$$

$$[2pt] \cot^{-1} x = \frac{\pi}{2} - x + \frac{x^3}{3} - \frac{x^5}{5} + \frac{x^7}{7} - \cdots \quad (x^2 < 1)$$

$$\begin{aligned}
\log_e \sin x &= \log_e x - \frac{x^2}{6} - \frac{x^4}{180} - \frac{x^6}{2835} - \dots & (x^2 < \pi^2) \\
\log_e \cos x &= -\frac{x^2}{2} - \frac{x^4}{12} - \frac{x^6}{45} - \frac{17x^8}{2520} - \dots & \left(x^2 < \frac{\pi^2}{4}\right) \\
\log_e \tan x &= \log_e x + \frac{x^2}{3} + \frac{7x^4}{90} + \frac{62x^6}{2835} + \dots & \left(x^2 < \frac{\pi^2}{4}\right) \\
e^{\sin x} &= 1 + x + \frac{x^2}{2!} - \frac{3x^4}{4!} - \frac{8x^5}{5!} - \frac{3x^6}{6!} + \frac{56x^7}{7!} + \dots \\
e^{\cos x} &= e \left(1 - \frac{x^2}{2!} + \frac{4x^4}{4!} - \frac{31x^6}{6!} + \dots\right) \\
e^{\tan x} &= 1 + x + \frac{x^2}{2!} + \frac{3x^3}{3!} + \frac{9x^4}{4!} + \frac{37x^5}{5!} + \dots & \left(x^2 < \frac{\pi^2}{4}\right) \\
\sin x &= \sin a + (x-a) \cos a - \frac{(x-a)^2}{2!} \sin a \\
&\quad - \frac{(x-a)^3}{3!} \cos a + \frac{(x-a)^4}{4!} \sin a + \dots
\end{aligned}$$

# VECTOR ANALYSIS

## Definitions

Any quantity that is completely determined by its magnitude is called a *scalar*. Examples of such are mass, density, temperature, etc. Any quantity that is completely determined by its magnitude and direction is called a *vector*. Examples of such are velocity, acceleration, force, etc. A vector quantity is represented by a directed line segment, the length of which represents the magnitude of the vector. A vector quantity is usually represented by a boldfaced letter such as  $\mathbf{V}$ . Two vectors  $\mathbf{V}_1$  and  $\mathbf{V}_2$  are equal to one another if they have equal magnitudes and are acting in the same directions. A negative vector, written as  $-\mathbf{V}$ , is one that acts in the opposite direction to  $\mathbf{V}$ , but is of equal magnitude to it. If we represent the magnitude of  $\mathbf{V}$  by  $v$ , we write  $|\mathbf{V}| = v$ . A vector parallel to  $\mathbf{V}$ , but equal to the reciprocal of its magnitude is written as  $\mathbf{V}^{-1}$  or as  $1/\mathbf{V}$ .

The *unit vector*  $\mathbf{V}/v$  (when  $v \neq 0$ ) is that vector which has the same direction as  $\mathbf{V}$ , but has a magnitude of unity (sometimes represented as  $\mathbf{V}_0$  or  $\hat{\mathbf{v}}$ ).

## Vector Algebra

The vector sum of  $\mathbf{V}_1$  and  $\mathbf{V}_2$  is represented by  $\mathbf{V}_1 + \mathbf{V}_2$ . The vector sum of  $\mathbf{V}_1$  and  $-\mathbf{V}_2$ , or the difference of the vector  $\mathbf{V}_2$  from  $\mathbf{V}_1$  is represented by  $\mathbf{V}_1 - \mathbf{V}_2$ .

If  $r$  is a scalar, then  $r\mathbf{V} = \mathbf{V}r$ , and represents a vector  $r$  times the magnitude of  $\mathbf{V}$ , in the same direction as  $\mathbf{V}$  if  $r$  is positive, and in the opposite direction if  $r$  is negative. If  $r$  and  $s$  are scalars,  $\mathbf{V}_1, \mathbf{V}_2, \mathbf{V}_3$ , vectors, then the following rules of scalars and vectors hold:

$$\begin{aligned}\mathbf{V}_1 + \mathbf{V}_2 &= \mathbf{V}_2 + \mathbf{V}_1 \\ (r + s)\mathbf{V}_1 &= r\mathbf{V}_1 + s\mathbf{V}_1; \quad r(\mathbf{V}_1 + \mathbf{V}_2) = r\mathbf{V}_1 + r\mathbf{V}_2 \\ \mathbf{V}_1 + (\mathbf{V}_2 + \mathbf{V}_3) &= (\mathbf{V}_1 + \mathbf{V}_2) + \mathbf{V}_3 = \mathbf{V}_1 + \mathbf{V}_2 + \mathbf{V}_3\end{aligned}$$

## Vectors in Space

A plane is described by two distinct vectors  $\mathbf{V}_1$  and  $\mathbf{V}_2$ . Should these vectors not intersect each other, then one is displaced parallel to itself until they do (Figure 1). Any other vector  $\mathbf{V}$  lying in this plane is given by

$$\mathbf{V} = r\mathbf{V}_1 + s\mathbf{V}_2$$

A *position vector* specifies the position in space of a point relative to a fixed origin. If therefore  $\mathbf{V}_1$  and  $\mathbf{V}_2$  are the position vectors of the points  $A$  and  $B$ , relative to the origin  $O$ , then any point  $P$  on the line  $AB$  has a position vector  $\mathbf{V}$  given by

$$\mathbf{V} = r\mathbf{V}_1 + (1 - r)\mathbf{V}_2$$

The scalar “ $r$ ” can be taken as the metric representation of  $P$  since  $r = 0$  implies  $P = B$  and  $r = 1$  implies  $P = A$  (Figure 2). If  $P$  divides the line  $AB$  in the ratio  $r:s$  then

$$\mathbf{V} = \left( \frac{r}{r+s} \right) \mathbf{V}_1 + \left( \frac{s}{r+s} \right) \mathbf{V}_2$$

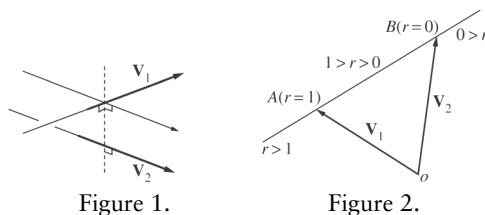


Figure 1.

Figure 2.

The vectors  $\mathbf{V}_1, \mathbf{V}_2, \mathbf{V}_3, \dots, \mathbf{V}_n$  are said to be *linearly dependent* if there exist scalars  $r_1, r_2, r_3, \dots, r_n$ , not all zero, such that

$$r_1\mathbf{V}_1 + r_2\mathbf{V}_2 + \dots + r_n\mathbf{V}_n = 0$$

A vector  $\mathbf{V}$  is linearly dependent upon the set of vectors  $\mathbf{V}_1, \mathbf{V}_2, \mathbf{V}_3, \dots, \mathbf{V}_n$  if

$$\mathbf{V} = r_1 \mathbf{V}_1 + r_2 \mathbf{V}_2 + r_3 \mathbf{V}_3 + \dots + r_n \mathbf{V}_n$$

Three vectors are linearly dependent if and only if they are co-planar.

All points in space can be uniquely determined by linear dependence upon three *base vectors*, i.e., three vectors any one of which is linearly independent of the other two. The simplest set of base vectors is the unit vectors along the coordinate  $Ox$ ,  $Oy$  and  $Oz$  axes. These are usually designated by  $\mathbf{i}$ ,  $\mathbf{j}$  and  $\mathbf{k}$ , respectively.

If  $\mathbf{V}$  is a vector in space, and  $a$ ,  $b$  and  $c$  are the respective magnitudes of the projections of the vector along the axes then

$$\mathbf{V} = a\mathbf{i} + b\mathbf{j} + c\mathbf{k}$$

and

$$v = \sqrt{a^2 + b^2 + c^2}$$

and the direction cosines of  $\mathbf{V}$  are

$$\cos \alpha = a/v, \quad \cos \beta = b/v, \quad \cos \gamma = c/v.$$

The law of addition yields

$$\mathbf{V}_1 + \mathbf{V}_2 = (a_1 + a_2)\mathbf{i} + (b_1 + b_2)\mathbf{j} + (c_1 + c_2)\mathbf{k}$$

### The Scalar, Dot, or Inner Product of Two Vectors

This product is represented as  $\mathbf{V}_1 \cdot \mathbf{V}_2$  and is defined to be equal to  $v_1 v_2 \cos \theta$ , where  $\theta$  is the angle from  $\mathbf{V}_1$  to  $\mathbf{V}_2$ , i.e.,

$$\mathbf{V}_1 \cdot \mathbf{V}_2 = v_1 v_2 \cos \theta$$

The following rules apply for this product:

$$\mathbf{V}_1 \cdot \mathbf{V}_2 = a_1 a_2 + b_1 b_2 + c_1 c_2 = \mathbf{V}_2 \cdot \mathbf{V}_1$$

It should be noted that this verifies that scalar multiplication is commutative.

$$\begin{aligned} (\mathbf{V}_1 + \mathbf{V}_2) \cdot \mathbf{V}_3 &= \mathbf{V}_1 \cdot \mathbf{V}_3 + \mathbf{V}_2 \cdot \mathbf{V}_3 \\ \mathbf{V}_1 \cdot (\mathbf{V}_2 + \mathbf{V}_3) &= \mathbf{V}_1 \cdot \mathbf{V}_2 + \mathbf{V}_1 \cdot \mathbf{V}_3 \end{aligned}$$

If  $\mathbf{V}_1$  is perpendicular to  $\mathbf{V}_2$  then  $\mathbf{V}_1 \cdot \mathbf{V}_2 = 0$ , and if  $\mathbf{V}_1$  is parallel to  $\mathbf{V}_2$ , then  $\mathbf{V}_1 \cdot \mathbf{V}_2 = v_1 v_2 = r w_1^2$ . In particular

$$\mathbf{i} \cdot \mathbf{i} = \mathbf{j} \cdot \mathbf{j} = \mathbf{k} \cdot \mathbf{k} = 1,$$

and

$$\mathbf{i} \cdot \mathbf{j} = \mathbf{j} \cdot \mathbf{k} = \mathbf{k} \cdot \mathbf{i} = 0$$

### The Vector or Cross Product of Two Vectors

This product is represented as  $\mathbf{V}_1 \times \mathbf{V}_2$  and is defined to be equal to  $v_1 v_2 (\sin \theta) \mathbf{1}$ , where  $\theta$  is the angle from  $\mathbf{V}_1$  to  $\mathbf{V}_2$  and  $\mathbf{1}$  is a unit vector perpendicular to the plane of  $\mathbf{V}_1$  and  $\mathbf{V}_2$  and so directed that a right-handed screw driven in the direction of  $\mathbf{1}$  would carry  $\mathbf{V}_1$  into  $\mathbf{V}_2$ , i.e.,

$$\mathbf{V}_1 \times \mathbf{V}_2 = v_1 v_2 (\sin \theta) \mathbf{1}$$

$$\text{and } \tan \theta = \frac{|\mathbf{V}_1 \times \mathbf{V}_2|}{\mathbf{V}_1 \cdot \mathbf{V}_2}$$

The following rules apply for vector products:

$$\begin{aligned} \mathbf{V}_1 \times \mathbf{V}_2 &= -\mathbf{V}_2 \times \mathbf{V}_1 \\ \mathbf{V}_1 \times (\mathbf{V}_2 + \mathbf{V}_3) &= \mathbf{V}_1 \times \mathbf{V}_2 + \mathbf{V}_1 \times \mathbf{V}_3 \\ (\mathbf{V}_1 + \mathbf{V}_2) \times \mathbf{V}_3 &= \mathbf{V}_1 \times \mathbf{V}_3 + \mathbf{V}_2 \times \mathbf{V}_3 \\ \mathbf{V}_1 \times (\mathbf{V}_2 \times \mathbf{V}_3) &= \mathbf{V}_2 (\mathbf{V}_3 \cdot \mathbf{V}_1) - \mathbf{V}_3 (\mathbf{V}_1 \cdot \mathbf{V}_2) \\ \mathbf{i} \times \mathbf{i} &= \mathbf{j} \times \mathbf{j} = \mathbf{k} \times \mathbf{k} = \mathbf{0} \quad (\text{the zero vector}) \\ \mathbf{i} \times \mathbf{j} &= \mathbf{k}, \quad \mathbf{j} \times \mathbf{k} = \mathbf{i}, \quad \mathbf{k} \times \mathbf{i} = \mathbf{j} \end{aligned}$$

If  $\mathbf{V}_1 = a_1 \mathbf{i} + b_1 \mathbf{j} + c_1 \mathbf{k}$ ,  $\mathbf{V}_2 = a_2 \mathbf{i} + b_2 \mathbf{j} + c_2 \mathbf{k}$ , and  $\mathbf{V}_3 = a_3 \mathbf{i} + b_3 \mathbf{j} + c_3 \mathbf{k}$ , then

$$\mathbf{V}_1 \times \mathbf{V}_2 = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix} = (b_1 c_2 - b_2 c_1) \mathbf{i} + (c_1 a_2 - c_2 a_1) \mathbf{j} + (a_1 b_2 - a_2 b_1) \mathbf{k}$$

It should be noted that, since  $\mathbf{V}_1 \times \mathbf{V}_2 = -\mathbf{V}_2 \times \mathbf{V}_1$ , the vector product is not commutative.

**Scalar Triple Product**

There is only one possible interpretation of the expression  $\mathbf{V}_1 \cdot \mathbf{V}_2 \times \mathbf{V}_3$  and that is  $\mathbf{V}_1 \cdot (\mathbf{V}_2 \times \mathbf{V}_3)$  which is obviously a scalar. Further

$$\begin{aligned}\mathbf{V}_1 \cdot (\mathbf{V}_2 \times \mathbf{V}_3) &= (\mathbf{V}_1 \times \mathbf{V}_2) \cdot \mathbf{V}_3 = \mathbf{V}_2 \cdot (\mathbf{V}_3 \times \mathbf{V}_1) \\ &= \begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} \\ &= r_1 r_2 r_3 \cos \phi \sin \theta,\end{aligned}$$

Where  $\theta$  is the angle between  $\mathbf{V}_2$  and  $\mathbf{V}_3$  and  $\phi$  is the angle between  $\mathbf{V}_1$  and the normal to the plane of  $\mathbf{V}_2$  and  $\mathbf{V}_3$ .

This product is called the *scalar triple product* and is written as  $[\mathbf{V}_1 \mathbf{V}_2 \mathbf{V}_3]$ .

The determinant indicates that it can be considered as the volume of the parallelepiped whose three determining edges are  $\mathbf{V}_1$ ,  $\mathbf{V}_2$  and  $\mathbf{V}_3$ .

It also follows that cyclic permutation of the subscripts does not change the value of the scalar triple product so that

$$\begin{aligned}[\mathbf{V}_1 \mathbf{V}_2 \mathbf{V}_3] &= [\mathbf{V}_2 \mathbf{V}_3 \mathbf{V}_1] = [\mathbf{V}_3 \mathbf{V}_1 \mathbf{V}_2] \\ \text{but } [\mathbf{V}_1 \mathbf{V}_2 \mathbf{V}_3] &= -[\mathbf{V}_2 \mathbf{V}_1 \mathbf{V}_3] \quad \text{etc.} \quad \text{and} \quad [\mathbf{V}_1 \mathbf{V}_1 \mathbf{V}_2] \equiv 0 \quad \text{etc.}\end{aligned}$$

Given three non-coplanar reference vectors  $\mathbf{V}_1$ ,  $\mathbf{V}_2$  and  $\mathbf{V}_3$ , the *reciprocal system* is given by  $\mathbf{V}_1^*$ ,  $\mathbf{V}_2^*$  and  $\mathbf{V}_3^*$ , where

$$\begin{aligned}1 &= v_1 v_1^* = v_2 v_2^* = v_3 v_3^* \\ 0 &= v_1 v_2^* = v_1 v_3^* = v_2 v_1^* \quad \text{etc.} \\ \mathbf{V}_1^* &= \frac{\mathbf{V}_2 \times \mathbf{V}_3}{[\mathbf{V}_1 \mathbf{V}_2 \mathbf{V}_3]}, \quad \mathbf{V}_2^* = \frac{\mathbf{V}_3 \times \mathbf{V}_1}{[\mathbf{V}_1 \mathbf{V}_2 \mathbf{V}_3]}, \quad \mathbf{V}_3^* = \frac{\mathbf{V}_1 \times \mathbf{V}_2}{[\mathbf{V}_1 \mathbf{V}_2 \mathbf{V}_3]}\end{aligned}$$

The system  $\mathbf{i}, \mathbf{j}, \mathbf{k}$  is its own reciprocal.

**Vector Triple Product**

The product  $\mathbf{V}_1 \times (\mathbf{V}_2 \times \mathbf{V}_3)$  defines the *vector triple product*. Obviously, in this case, the brackets are vital to the definition.

$$\begin{aligned}\mathbf{V}_1 \times (\mathbf{V}_2 \times \mathbf{V}_3) &= (\mathbf{V}_1 \cdot \mathbf{V}_3) \mathbf{V}_2 - (\mathbf{V}_1 \cdot \mathbf{V}_2) \mathbf{V}_3 \\ &= \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ a_1 & b_1 & c_1 \\ \begin{vmatrix} b_2 & c_2 \\ b_3 & c_3 \end{vmatrix} & \begin{vmatrix} c_2 & a_2 \\ c_3 & a_3 \end{vmatrix} & \begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix} \end{vmatrix}\end{aligned}$$

i.e., it is a vector, perpendicular to  $\mathbf{V}_1$ , lying in the plane of  $\mathbf{V}_2, \mathbf{V}_3$ . Similarly

$$\begin{aligned}(\mathbf{V}_1 \times \mathbf{V}_2) \times \mathbf{V}_3 &= \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ \begin{vmatrix} b_1 & c_1 \\ b_2 & c_2 \end{vmatrix} & \begin{vmatrix} c_1 & a_1 \\ c_2 & a_2 \end{vmatrix} & \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} \\ a_3 & b_3 & c_3 \end{vmatrix} \\ \mathbf{V}_1 \times (\mathbf{V}_2 \times \mathbf{V}_3) + \mathbf{V}_2 \times (\mathbf{V}_3 \times \mathbf{V}_1) + \mathbf{V}_3 \times (\mathbf{V}_1 \times \mathbf{V}_2) &\equiv 0\end{aligned}$$

If  $\mathbf{V}_1 \times (\mathbf{V}_2 \times \mathbf{V}_3) = (\mathbf{V}_1 \times \mathbf{V}_2) \times \mathbf{V}_3$ , then  $\mathbf{V}_1, \mathbf{V}_2, \mathbf{V}_3$  form an *orthogonal set*. Thus  $\mathbf{i}, \mathbf{j}, \mathbf{k}$  form an orthogonal set.

**Geometry of the Plane, Straight Line and Sphere**

The position vectors of the fixed points  $A, B, C, D$  relative to  $O$  are  $\mathbf{V}_1, \mathbf{V}_2, \mathbf{V}_3, \mathbf{V}_4$  and the position vector of the variable point  $P$  is  $\mathbf{V}$ .

The vector form of the equation of the straight line through  $A$  parallel to  $\mathbf{V}_2$  is

$$\begin{aligned}\mathbf{V} &= \mathbf{V}_1 + r \mathbf{V}_2 \\ \text{or } (\mathbf{V} - \mathbf{V}_1) &= r \mathbf{V}_2 \\ \text{or } (\mathbf{V} - \mathbf{V}_1) \times \mathbf{V}_2 &= 0\end{aligned}$$

while that of the plane through  $A$  perpendicular to  $\mathbf{V}_2$  is

$$(\mathbf{V} - \mathbf{V}_1) \cdot \mathbf{V}_2 = 0$$

The equation of the line  $AB$  is

$$\mathbf{V} = r \mathbf{V}_1 + (1 - r) \mathbf{V}_2$$

and those of the bisectors of the angles between  $\mathbf{V}_1$  and  $\mathbf{V}_2$  are

$$\begin{aligned}\mathbf{V} &= r \left( \frac{\mathbf{V}_1}{v_1} \pm \frac{\mathbf{V}_2}{v_2} \right) \quad \text{or} \\ \mathbf{V} &= r(\hat{\mathbf{v}}_1 \pm \hat{\mathbf{v}}_2)\end{aligned}$$

The perpendicular from  $C$  to the line through  $A$  parallel to  $\mathbf{V}_2$  has as its equation

$$\mathbf{V} = \mathbf{V}_1 - \mathbf{V}_3 - \hat{\mathbf{v}}_2 \cdot (\mathbf{V}_1 - \mathbf{V}_3) \hat{\mathbf{v}}_2.$$

The condition for the intersection of the two lines,  $\mathbf{V} = \mathbf{V}_1 + r\mathbf{V}_3$  and  $\mathbf{V} = \mathbf{V}_2 + s\mathbf{V}_4$ , is

$$[(\mathbf{V}_1 - \mathbf{V}_2)\mathbf{V}_3\mathbf{V}_4] = 0.$$

The common perpendicular to the above two lines is the line of intersection of the two planes

$$[(\mathbf{V} - \mathbf{V}_1)\mathbf{V}_3(\mathbf{V}_3 \times \mathbf{V}_4)] = 0 \quad \text{and} \quad [(\mathbf{V} - \mathbf{V}_2)\mathbf{V}_4(\mathbf{V}_3 \times \mathbf{V}_4)] = 0$$

and the length of this perpendicular is

$$\frac{[(\mathbf{V}_1 - \mathbf{V}_2)\mathbf{V}_3\mathbf{V}_4]}{|\mathbf{V}_3 \times \mathbf{V}_4|}.$$

The equation of the line perpendicular to the plane  $ABC$  is

$$\mathbf{V} = \mathbf{V}_1 \times \mathbf{V}_2 + \mathbf{V}_2 \times \mathbf{V}_3 + \mathbf{V}_3 \times \mathbf{V}_1$$

and the distance of the plane from the origin is

$$\frac{[\mathbf{V}_1\mathbf{V}_2\mathbf{V}_3]}{|(\mathbf{V}_2 - \mathbf{V}_1) \times (\mathbf{V}_3 - \mathbf{V}_1)|}.$$

In general the vector equation

$$\mathbf{V} \cdot \mathbf{V}_2 = r$$

defines the plane which is perpendicular to  $\mathbf{V}_2$ , and the perpendicular distance from  $A$  to this plane is

$$\frac{r - \mathbf{V}_1 \cdot \mathbf{V}_2}{v_2}$$

The distance from  $A$ , measured along a line parallel to  $\mathbf{V}_3$ , is

$$\frac{r - \mathbf{V}_1 \cdot \mathbf{V}_2}{\mathbf{V}_2 \cdot \hat{\mathbf{v}}_3} \quad \text{or} \quad \frac{r - \mathbf{V}_1 \cdot \mathbf{V}_2}{v_2 \cos \theta}$$

where  $\theta$  is the angle between  $\mathbf{V}_2$  and  $\mathbf{V}_3$ . (If this plane contains the point  $C$  then  $r = \mathbf{V}_3 \cdot \mathbf{V}_2$  and if it passes through the origin, then  $r = 0$ .) Given two planes

$$\begin{aligned} \mathbf{V} \cdot \mathbf{V}_1 &= r \\ \mathbf{V} \cdot \mathbf{V}_2 &= s \end{aligned}$$

then any plane through the line of intersection of these two planes is given by

$$\mathbf{V} \cdot (\mathbf{V}_1 + \lambda \mathbf{V}_2) = r + \lambda s$$

where  $\lambda$  is a scalar parameter. In particular  $\lambda = \pm v_1/v_2$  yields the equation of the two planes bisecting the angle between the given planes.

The plane through  $A$  parallel to the plane of  $\mathbf{V}_2, \mathbf{V}_3$  is

$$\begin{aligned} \mathbf{V} &= \mathbf{V}_1 + r\mathbf{V}_2 + s\mathbf{V}_3 \\ \text{or } (\mathbf{V} - \mathbf{V}_1) \cdot \mathbf{V}_2 \times \mathbf{V}_3 &= 0 \\ \text{or } [\mathbf{V}\mathbf{V}_2\mathbf{V}_3] - [\mathbf{V}_1\mathbf{V}_2\mathbf{V}_3] &= 0 \end{aligned}$$

so that the expansion in rectangular Cartesian coordinates yields (where  $\mathbf{V} \equiv x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$ ):

$$\begin{vmatrix} (x - a_1) & (y - b_1) & (z - c_1) \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = 0$$

which is obviously the usual linear equation in  $x, y$ , and  $z$ .

The plane through  $AB$  parallel to  $\mathbf{V}_3$  is given by

$$\begin{aligned} [(\mathbf{V} - \mathbf{V}_1)(\mathbf{V}_1 - \mathbf{V}_2)\mathbf{V}_3] &= 0 \\ \text{or } [\mathbf{V}\mathbf{V}_2\mathbf{V}_3] - [\mathbf{V}\mathbf{V}_1\mathbf{V}_3] - [\mathbf{V}_1\mathbf{V}_2\mathbf{V}_3] &= 0 \end{aligned}$$

The plane through the three points  $A, B$  and  $C$  is

$$\begin{aligned} \mathbf{V} &= \mathbf{V}_1 + s(\mathbf{V}_2 - \mathbf{V}_1) + t(\mathbf{V}_3 - \mathbf{V}_1) \\ \text{or } \mathbf{V} &= r\mathbf{V}_1 + s\mathbf{V}_2 + t\mathbf{V}_3 \quad (r + s + t \equiv 1) \\ \text{or } [(\mathbf{V} - \mathbf{V}_1)(\mathbf{V}_1 - \mathbf{V}_2)(\mathbf{V}_2 - \mathbf{V}_3)] &= 0 \\ \text{or } [\mathbf{V}\mathbf{V}_1\mathbf{V}_2] + [\mathbf{V}\mathbf{V}_2\mathbf{V}_3] + [\mathbf{V}\mathbf{V}_3\mathbf{V}_1] - [\mathbf{V}_1\mathbf{V}_2\mathbf{V}_3] &= 0 \end{aligned}$$

For four points  $A, B, C, D$  to be coplanar, then

$$r\mathbf{V}_1 + s\mathbf{V}_2 + t\mathbf{V}_3 + u\mathbf{V}_4 \equiv 0 \equiv r + s + t + u$$

The following formulas relate to a sphere when the vectors are taken to lie in three-dimensional space and to a circle when the space is two dimensional. For a circle in three dimensions, take the intersection of the sphere with a plane.

The equation of a sphere with center  $O$  and radius  $OA$  is

$$\begin{aligned} \mathbf{V} \cdot \mathbf{V} &= v_1^2 \quad (\text{not } \mathbf{V} = \mathbf{V}_1) \\ \text{or } (\mathbf{V} - \mathbf{V}_1) \cdot (\mathbf{V} + \mathbf{V}_1) &= 0 \end{aligned}$$

while that of a sphere with center  $B$  radius  $v_1$  is

$$\begin{aligned} (\mathbf{V} - \mathbf{V}_2) \cdot (\mathbf{V} - \mathbf{V}_2) &= v_1^2 \\ \text{or } \mathbf{V} \cdot (\mathbf{V} - 2\mathbf{V}_2) &= v_1^2 - v_2^2 \end{aligned}$$

If the above sphere passes through the origin, then

$$\mathbf{V} \cdot (\mathbf{V} - 2\mathbf{V}_2) = 0$$

Note that in two-dimensional polar coordinates this is simply

$$r = 2a \cdot \cos \theta$$

while in three-dimensional Cartesian coordinates it is

$$x^2 + y^2 + z^2 - 2(a_2x + b_2y + c_2z) = 0.$$

The equation of a sphere having the points  $A$  and  $B$  as the extremities of a diameter is

$$(\mathbf{V} - \mathbf{V}_1) \cdot (\mathbf{V} - \mathbf{V}_2) = 0.$$

The square of the length of the tangent from  $C$  to the sphere with center  $B$  and radius  $v_1$  is given by

$$(\mathbf{V}_3 - \mathbf{V}_2) \cdot (\mathbf{V}_3 - \mathbf{V}_2) = v_1^2$$

The condition that the plane  $\mathbf{V} \cdot \mathbf{V}_3 = s$  is tangential to the sphere  $(\mathbf{V} - \mathbf{V}_2) \cdot (\mathbf{V} - \mathbf{V}_2) = v_1^2$  is

$$(s - \mathbf{V}_3 \cdot \mathbf{V}_2) \cdot (s - \mathbf{V}_3 \cdot \mathbf{V}_2) = v_1^2 v_3^2.$$

The equation of the tangent plane at  $D$ , on the surface of sphere  $(\mathbf{V} - \mathbf{V}_2) \cdot (\mathbf{V} - \mathbf{V}_2) = v_1^2$ , is

$$\begin{aligned} (\mathbf{V} - \mathbf{V}_4) \cdot (\mathbf{V}_4 - \mathbf{V}_2) &= 0 \\ \text{or } \mathbf{V} \cdot \mathbf{V}_4 - \mathbf{V}_2 \cdot (\mathbf{V} + \mathbf{V}_4) &= v_1^2 - v_2^2 \end{aligned}$$

The condition that the two circles  $(\mathbf{V} - \mathbf{V}_2) \cdot (\mathbf{V} - \mathbf{V}_2) = v_1^2$  and  $(\mathbf{V} - \mathbf{V}_4) \cdot (\mathbf{V} - \mathbf{V}_4) = v_3^2$  intersect orthogonally is clearly

$$(\mathbf{V}_2 - \mathbf{V}_4) \cdot (\mathbf{V}_2 - \mathbf{V}_4) = v_1^2 + v_3^2$$

The polar plane of  $D$  with respect to the circle

$$\begin{aligned} (\mathbf{V} - \mathbf{V}_2) \cdot (\mathbf{V} - \mathbf{V}_2) &= v_1^2 \quad \text{is} \\ \mathbf{V} \cdot \mathbf{V}_4 - \mathbf{V}_2 \cdot (\mathbf{V} + \mathbf{V}_4) &= v_1^2 - v_2^2 \end{aligned}$$

Any sphere through the intersection of the two spheres  $(\mathbf{V} - \mathbf{V}_2) \cdot (\mathbf{V} - \mathbf{V}_2) = v_1^2$  and  $(\mathbf{V} - \mathbf{V}_4) \cdot (\mathbf{V} - \mathbf{V}_4) = v_3^2$  is given by

$$(\mathbf{V} - \mathbf{V}_2) \cdot (\mathbf{V} - \mathbf{V}_2) + \lambda(\mathbf{V} - \mathbf{V}_4) \cdot (\mathbf{V} - \mathbf{V}_4) = v_1^2 + \lambda v_3^2$$

while the radical plane of two such spheres is

$$\mathbf{V} \cdot (\mathbf{V}_2 - \mathbf{V}_4) = -\frac{1}{2}(v_1^2 - v_2^2 - v_3^2 + v_4^2)$$



## Differentiation of Vectors

If  $\mathbf{V}_1 = a_1\mathbf{i} + b_1\mathbf{j} + c_1\mathbf{k}$ , and  $\mathbf{V}_2 = a_2\mathbf{i} + b_2\mathbf{j} + c_2\mathbf{k}$ , and if  $\mathbf{V}_1$  and  $\mathbf{V}_2$  are functions of the scalar  $t$ , then

$$\begin{aligned}\frac{d}{dt}(\mathbf{V}_1 + \mathbf{V}_2 + \cdots) &= \frac{d\mathbf{V}_1}{dt} + \frac{d\mathbf{V}_2}{dt} + \cdots \\ \frac{d\mathbf{V}_1}{dt} &= \frac{da_1}{dt}\mathbf{i} + \frac{db_1}{dt}\mathbf{j} + \frac{dc_1}{dt}\mathbf{k}, \quad \text{etc} \\ \frac{d}{dt}(\mathbf{V}_1 \cdot \mathbf{V}_2) &= \frac{d\mathbf{V}_1}{dt} \cdot \mathbf{V}_2 + \mathbf{V}_1 \cdot \frac{d\mathbf{V}_2}{dt} \\ \frac{d}{dt}(\mathbf{V}_1 \times \mathbf{V}_2) &= \frac{d\mathbf{V}_1}{dt} \times \mathbf{V}_2 + \mathbf{V}_1 \times \frac{d\mathbf{V}_2}{dt} \\ \mathbf{V} \cdot \frac{d\mathbf{V}}{dt} &= v \cdot \frac{dv}{dt}\end{aligned}$$

In particular, if  $\mathbf{V}$  is a vector of constant length, then the right-hand side of the last equation is identically zero showing that  $\mathbf{V}$  is perpendicular to its derivative.

The derivatives of the triple products are

$$\begin{aligned}\frac{d}{dt}[\mathbf{V}_1 \mathbf{V}_2 \mathbf{V}_3] &= \left[ \left( \frac{d\mathbf{V}_1}{dt} \right) \mathbf{V}_2 \mathbf{V}_3 \right] + \left[ \mathbf{V}_1 \left( \frac{d\mathbf{V}_2}{dt} \right) \mathbf{V}_3 \right] + \left[ \mathbf{V}_1 \mathbf{V}_2 \left( \frac{d\mathbf{V}_3}{dt} \right) \right] \quad \text{and} \\ \frac{d}{dt}\{\mathbf{V}_1 \times (\mathbf{V}_2 \times \mathbf{V}_3)\} &= \left( \frac{d\mathbf{V}_1}{dt} \right) \times (\mathbf{V}_2 \times \mathbf{V}_3) + \mathbf{V}_1 \times \left( \left( \frac{d\mathbf{V}_2}{dt} \right) \times \mathbf{V}_3 \right) + \mathbf{V}_1 \times \left( \mathbf{V}_2 \times \left( \frac{d\mathbf{V}_3}{dt} \right) \right)\end{aligned}$$

## Geometry of Curves in Space

$s$  = the *length of arc*, measured from some fixed point on the curve (Figure 3).

$\mathbf{V}_1$  = the position vector of the point  $A$  on the curve.

$\mathbf{V}_1 + \delta\mathbf{V}_1$  = the position vector of the point  $P$  in the neighborhood of  $A$ .

$\hat{\mathbf{t}}$  = the *unit tangent* to the curve at the point  $A$ , measured in the direction of  $s$  increasing.

The *normal plane* is that plane which is perpendicular to the unit tangent. The principal normal is defined as the intersection of the normal plane with the plane defined by  $\mathbf{V}_1$  and  $\mathbf{V}_1 + \delta\mathbf{V}_1$  in the limit as  $\delta\mathbf{V}_1 \rightarrow 0$ .

$\hat{\mathbf{n}}$  = the *unit normal* (principal) at the point  $A$ . The plane defined by  $\hat{\mathbf{t}}$  and  $\hat{\mathbf{n}}$  is called the *osculating plane* (alternatively plane of curvature or local plane).

$\rho$  = the radius of curvature at  $A$ .

$\delta\theta$  = the angle subtended at the origin by  $\delta\mathbf{V}_1$ .

$$\kappa = \frac{d\theta}{ds} = \frac{1}{\rho}$$

$\hat{\mathbf{b}}$  = the *unit binormal* i.e., the unit vector which is parallel to  $\hat{\mathbf{t}} \times \hat{\mathbf{n}}$  at the point  $A$

$\lambda$  = the *torsion* of the curve at  $A$ .

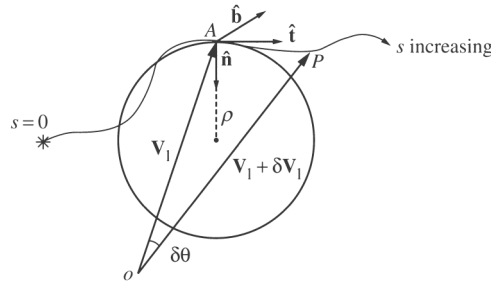


Figure 3.

*Frenet's Formulas:*

$$\begin{aligned}\frac{d\hat{\mathbf{t}}}{ds} &= \kappa \hat{\mathbf{n}} \\ \frac{d\hat{\mathbf{n}}}{ds} &= -\kappa \hat{\mathbf{t}} + \lambda \hat{\mathbf{b}} \\ \frac{d\hat{\mathbf{b}}}{ds} &= -\lambda \hat{\mathbf{n}}\end{aligned}$$

The following formulas are also applicable:

|                                  |                                                                                                                                                                                                          |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit tangent                     | $\hat{\mathbf{t}} = \frac{d\mathbf{V}_1}{ds}$                                                                                                                                                            |
| Equation of the tangent          | $(\mathbf{V} - \mathbf{V}_1) \times \hat{\mathbf{t}} = 0 \quad \text{or} \quad \mathbf{V} = \mathbf{V}_1 + q\hat{\mathbf{t}}$                                                                            |
| Unit normal                      | $\hat{\mathbf{n}} = \frac{1}{\kappa} \frac{d^2\mathbf{V}_1}{ds^2}$                                                                                                                                       |
| Equation of the normal plane     | $(\mathbf{V} - \mathbf{V}_1) \cdot \hat{\mathbf{t}} = 0$                                                                                                                                                 |
| Equation of the normal           | $(\mathbf{V} - \mathbf{V}_1) \times \hat{\mathbf{n}} = 0 \quad \text{or} \quad \mathbf{V} = \mathbf{V}_1 + r\hat{\mathbf{n}}$                                                                            |
| Unit binormal                    | $\hat{\mathbf{b}} = \hat{\mathbf{t}} \times \hat{\mathbf{n}}$                                                                                                                                            |
| Equation of the binormal         | $(\mathbf{V} - \mathbf{V}_1) \times \hat{\mathbf{b}} = 0$<br>or $\mathbf{V} = \mathbf{V}_1 + u\hat{\mathbf{b}}$                                                                                          |
|                                  | or $\mathbf{V} = \mathbf{V}_1 + w \frac{d\mathbf{V}_1}{ds} \times \frac{d^2\mathbf{V}_1}{ds^2}$                                                                                                          |
| Equation of the osculating plane | $[(\mathbf{V} - \mathbf{V}_1)\hat{\mathbf{t}}\hat{\mathbf{n}}] = 0$<br>or $\left[(\mathbf{V} - \mathbf{V}_1) \left(\frac{d\mathbf{V}_1}{ds}\right) \left(\frac{d^2\mathbf{V}_1}{ds^2}\right)\right] = 0$ |

#### Differential Operators—Rectangular Coordinates

$$dS = \frac{\partial S}{\partial x} \cdot dx + \frac{\partial S}{\partial y} \cdot dy + \frac{\partial S}{\partial z} \cdot dz$$

By definition

$$\nabla \equiv \text{del} \equiv \mathbf{i} \frac{\partial}{\partial x} + \mathbf{j} \frac{\partial}{\partial y} + \mathbf{k} \frac{\partial}{\partial z}$$

$$\nabla^2 \equiv \text{Laplacian} \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

If  $S$  is a scalar function, then  $\nabla S \equiv \text{grad } S \equiv \frac{\partial S}{\partial x} \mathbf{i} + \frac{\partial S}{\partial y} \mathbf{j} + \frac{\partial S}{\partial z} \mathbf{k}$ .

Grad  $S$  defines both the direction and magnitude of the maximum rate of increase of  $S$  at any point. Hence the name *gradient* and also its vectorial nature.  $\nabla S$  is independent of the choice of rectangular coordinates.

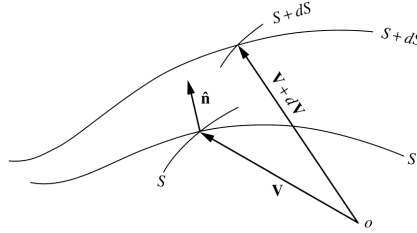


Figure 4.

$$\nabla S = \frac{\partial S}{\partial n} \hat{\mathbf{n}} \quad (4)$$

where  $\hat{\mathbf{n}}$  is the unit normal to the surface  $S = \text{constant}$ , in the direction of  $S$  increasing. The total derivative of  $S$  at a point having the position vector  $\mathbf{V}$  is given by (Figure 4)

$$dS = \frac{\partial S}{\partial n} \hat{\mathbf{n}} \cdot d\mathbf{V}$$

$$= d\mathbf{V} \cdot \nabla S$$

and the directional derivative of  $S$  in the direction of  $\mathbf{U}$  is

$$\mathbf{U} \cdot \nabla S = \mathbf{U} \cdot (\nabla S) = (\mathbf{U} \cdot \nabla) S$$

Similarly the directional derivative of the vector  $\mathbf{V}$  in the direction of  $\mathbf{U}$  is

$$(\mathbf{U} \cdot \nabla) \mathbf{V}$$

The *distributive* law holds for finding a gradient. Thus if  $S$  and  $T$  are scalar functions

$$\nabla(S + T) = \nabla S + \nabla T$$

The *associative* law becomes the rule for differentiating a product:

$$\nabla(ST) = S\nabla T + T\nabla S$$

If  $\mathbf{V}$  is a vector function with the magnitudes of the components parallel to the three coordinate axes  $V_x$ ,  $V_y$ ,  $V_z$ , then

$$\nabla \cdot \mathbf{V} \equiv \text{div } \mathbf{V} \equiv \frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}$$

The divergence obeys the distributive law. Thus, if  $\mathbf{V}$  and  $\mathbf{U}$  are vector functions, then

$$\begin{aligned}\nabla \cdot (\mathbf{V} + \mathbf{U}) &= \nabla \cdot \mathbf{V} + \nabla \cdot \mathbf{U} \\ \nabla \cdot (S\mathbf{V}) &= (\nabla S) \cdot \mathbf{V} + S(\nabla \cdot \mathbf{V}) \\ \nabla \cdot (\mathbf{U} \times \mathbf{V}) &= \mathbf{V} \cdot (\nabla \times \mathbf{U}) - \mathbf{U} \cdot (\nabla \times \mathbf{V})\end{aligned}$$

As with the gradient of a scalar, the divergence of a vector is invariant under a transformation from one set of rectangular coordinates to another.

$$\begin{aligned}\nabla \times \mathbf{V} &\equiv \text{curl } \mathbf{V} \quad (\text{sometimes } \nabla \wedge \mathbf{V} \text{ or } \text{rot } \mathbf{V}) \\ &\equiv \left( \frac{\partial V_x}{\partial y} - \frac{\partial V_y}{\partial x} \right) \mathbf{i} + \left( \frac{\partial V_x}{\partial z} - \frac{\partial V_z}{\partial x} \right) \mathbf{j} + \left( \frac{\partial V_y}{\partial z} - \frac{\partial V_z}{\partial y} \right) \mathbf{k} \\ &= \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ V_x & V_y & V_z \end{vmatrix}\end{aligned}$$

The *curl* (or *rotation*) of a vector is a vector that is invariant under a transformation from one set of rectangular coordinates to another.

$$\begin{aligned}\nabla \times (\mathbf{U} + \mathbf{V}) &= \nabla \times \mathbf{U} + \nabla \times \mathbf{V} \\ \nabla \times (S\mathbf{V}) &= (\nabla S) \times \mathbf{V} + S(\nabla \times \mathbf{V}) \\ \nabla \times (\mathbf{U} \times \mathbf{V}) &= (\mathbf{V} \cdot \nabla)\mathbf{U} - (\mathbf{U} \cdot \nabla)\mathbf{V} + \mathbf{U}(\nabla \cdot \mathbf{V}) - \mathbf{V}(\nabla \cdot \mathbf{U})\end{aligned}$$

If  $\mathbf{V} = V_x\mathbf{i} + V_y\mathbf{j} + V_z\mathbf{k}$ , then

$$\begin{aligned}\nabla \cdot \mathbf{V} &= \nabla V_x \cdot \mathbf{i} + \nabla V_y \cdot \mathbf{j} + \nabla V_z \cdot \mathbf{k} \\ \text{and } \nabla \times \mathbf{V} &= \nabla V_x \times \mathbf{i} + \nabla V_y \times \mathbf{j} + \nabla V_z \times \mathbf{k}\end{aligned}$$

The operator  $\nabla$  can be used more than once. The possibilities where  $\nabla$  is used twice are:

$$\begin{aligned}\nabla \cdot (\nabla \theta) &\equiv \text{div grad } \theta \\ \nabla \times (\nabla \theta) &\equiv \text{curl grad } \theta \\ \nabla(\nabla \cdot \mathbf{V}) &\equiv \text{grad div } \mathbf{V} \\ \nabla \cdot (\nabla \times \mathbf{V}) &\equiv \text{div curl } \mathbf{V} \\ \nabla \times (\nabla \times \mathbf{V}) &\equiv \text{curl curl } \mathbf{V}\end{aligned}$$

Thus, if  $S$  is a scalar and  $\mathbf{V}$  is a vector:

$$\begin{aligned}\text{div grad } S &\equiv \nabla \cdot (\nabla S) \equiv \text{Laplacian } S \equiv \nabla^2 S \equiv \frac{\partial^2 S}{\partial x^2} + \frac{\partial^2 S}{\partial y^2} + \frac{\partial^2 S}{\partial z^2} \\ \text{curl grad } S &\equiv 0 \\ \text{curl curl } \mathbf{V} &\equiv \text{grad div } \mathbf{V} - \nabla^2 \mathbf{V}; \\ \text{div curl } \mathbf{V} &\equiv 0\end{aligned}$$

Taylor expansion in three dimensions can be written

$$\begin{aligned}f(\mathbf{V} + \boldsymbol{\varepsilon}) &= e^{\boldsymbol{\varepsilon} \cdot \nabla} f(\mathbf{V}) \quad \text{where } \mathbf{V} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k} \\ \text{and } \boldsymbol{\varepsilon} &= h\mathbf{i} + l\mathbf{j} + m\mathbf{k}\end{aligned}$$

## ORTHOGONAL CURVILINEAR COORDINATES

If at a point  $P$  there exist three uniform point functions  $u$ ,  $v$  and  $w$  so that the surfaces  $u = \text{const.}$ ,  $v = \text{const.}$ , and  $w = \text{const.}$ , intersect in three distinct curves through  $P$ , then the surfaces are called the *coordinate surfaces* through  $P$ . The three lines of intersection are referred to as the *coordinate lines* and their tangents  $a$ ,  $b$ , and  $c$  as the *coordinate axes*. When the coordinate axes form an orthogonal set the system is said to define *orthogonal curvilinear coordinates* at  $P$ .

Consider an infinitesimal volume enclosed by the surfaces  $u, v, w, u + du, v + dv$ , and  $w + dw$  (Figure 5).

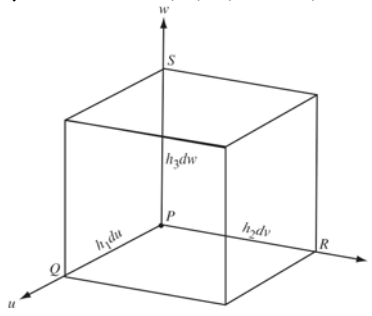


Figure 5.

The surface  $PRS \equiv u = \text{constant}$ , and the face of the curvilinear figure immediately opposite this is  $u + du = \text{constant}$ , etc. In terms of these surface constants

$$\begin{aligned} P &= P(u, v, w) \\ Q &= Q(u + du, v, w) \quad \text{and} \quad PQ = h_1 du \\ R &= R(u, v + dv, w) \quad \text{and} \quad PR = h_2 dv \\ S &= S(u, v, w + dw) \quad \text{and} \quad PS = h_3 dw \end{aligned}$$

where  $h_1, h_2$ , and  $h_3$  are functions of  $u, v$ , and  $w$ .

- In rectangular Cartesians  $\hat{i}, \hat{j}, \hat{k}$

$$\begin{aligned} h_1 &= 1, \quad h_2 = 1, \quad h_3 = 1. \\ \frac{\hat{\mathbf{a}}}{h_1} \frac{\partial}{\partial u} &= \hat{\mathbf{i}} \frac{\partial}{\partial x}, \quad \frac{\hat{\mathbf{b}}}{h_2} \frac{\partial}{\partial v} = \hat{\mathbf{j}} \frac{\partial}{\partial y}, \quad \frac{\hat{\mathbf{c}}}{h_3} \frac{\partial}{\partial w} = \hat{\mathbf{k}} \frac{\partial}{\partial z}. \end{aligned}$$

- In cylindrical Cartesians  $\hat{\mathbf{r}}, \hat{\boldsymbol{\theta}}, \hat{\mathbf{z}}$

$$\begin{aligned} h_1 &= 1, \quad h_2 = r, \quad h_3 = 1. \\ \frac{\hat{\mathbf{a}}}{h_1} \frac{\partial}{\partial u} &= \hat{\mathbf{r}} \frac{\partial}{\partial r}, \quad \frac{\hat{\mathbf{b}}}{h_2} \frac{\partial}{\partial v} = \frac{\hat{\boldsymbol{\theta}}}{r} \frac{\partial}{\partial \theta}, \quad \frac{\hat{\mathbf{c}}}{h_3} \frac{\partial}{\partial w} = \hat{\mathbf{z}} \frac{\partial}{\partial z}. \end{aligned}$$

- In spherical coordinates  $\hat{\mathbf{r}}, \hat{\boldsymbol{\theta}}, \hat{\boldsymbol{\psi}}$

$$\begin{aligned} h_1 &= 1, \quad h_2 = r, \quad h_3 = r \sin \theta \\ \frac{\hat{\mathbf{a}}}{h_1} \frac{\partial}{\partial u} &= \hat{\mathbf{r}} \frac{\partial}{\partial r}, \quad \frac{\hat{\mathbf{b}}}{h_2} \frac{\partial}{\partial v} = \frac{\hat{\boldsymbol{\theta}}}{r} \frac{\partial}{\partial \theta}, \quad \frac{\hat{\mathbf{c}}}{h_3} \frac{\partial}{\partial w} = \frac{\hat{\boldsymbol{\psi}}}{r \sin \theta} \frac{\partial}{\partial \psi} \end{aligned}$$

The general expressions for grad, div and curl together with those for  $\nabla^2$  and the directional derivative are, in orthogonal curvilinear coordinates, given by:

$$\begin{aligned} \nabla S &= \frac{\hat{\mathbf{a}}}{h_1} \frac{\partial S}{\partial u} + \frac{\hat{\mathbf{b}}}{h_2} \frac{\partial S}{\partial v} + \frac{\hat{\mathbf{c}}}{h_3} \frac{\partial S}{\partial w} \\ (\mathbf{V} \cdot \nabla) S &= \frac{V_1}{h_1} \frac{\partial S}{\partial u} + \frac{V_2}{h_2} \frac{\partial S}{\partial v} + \frac{V_3}{h_3} \frac{\partial S}{\partial w} \\ \nabla \cdot \mathbf{V} &= \frac{1}{h_1 h_2 h_3} \left\{ \frac{\partial}{\partial u} (h_2 h_3 V_1) + \frac{\partial}{\partial v} (h_3 h_1 V_2) + \frac{\partial}{\partial w} (h_1 h_2 V_3) \right\}. \\ \nabla \times \mathbf{V} &= \frac{\hat{\mathbf{a}}}{h_2 h_3} \left\{ \frac{\partial}{\partial v} (h_3 V_3) - \frac{\partial}{\partial w} (h_2 V_2) \right\} + \frac{\hat{\mathbf{b}}}{h_3 h_1} \left\{ \frac{\partial}{\partial w} (h_1 V_1) - \frac{\partial}{\partial u} (h_3 V_3) \right\} \\ &\quad + \frac{\hat{\mathbf{c}}}{h_1 h_2} \left\{ \frac{\partial}{\partial u} (h_2 V_2) - \frac{\partial}{\partial v} (h_1 V_1) \right\} \\ \nabla^2 S &= \frac{1}{h_1 h_2 h_3} \left\{ \frac{\partial}{\partial u} \left( \frac{h_2 h_3}{h_1} \frac{\partial S}{\partial u} \right) + \frac{\partial}{\partial v} \left( \frac{h_3 h_1}{h_2} \frac{\partial S}{\partial v} \right) + \frac{\partial}{\partial w} \left( \frac{h_1 h_2}{h_3} \frac{\partial S}{\partial w} \right) \right\} \end{aligned}$$

## Formulas of Vector Analysis

|                                       | Rectangular coordinates                                                                                                                                                                                       | Cylindrical coordinates                                                                                                                                                                                                                       | Spherical coordinates                                                                                                                                                                                                                                                                                                  |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Conversion to rectangular coordinates |                                                                                                                                                                                                               | $x = r \cos \varphi \quad y = r \sin \varphi \quad z = z$                                                                                                                                                                                     | $x = r \cos \varphi \sin \theta \quad y = r \sin \varphi \sin \theta$<br>$z = r \cos \theta$                                                                                                                                                                                                                           |
| Gradient...                           | $\nabla \phi = \frac{\partial \phi}{\partial x} \mathbf{i} + \frac{\partial \phi}{\partial y} \mathbf{j} + \frac{\partial \phi}{\partial z} \mathbf{k}$                                                       | $\nabla \phi = \frac{\partial \phi}{\partial r} \mathbf{r} + \frac{1}{r} \frac{\partial \phi}{\partial \varphi} \Phi + \frac{\partial \phi}{\partial z} \mathbf{k}$                                                                           | $\nabla \phi = \frac{\partial \phi}{\partial r} \mathbf{r} + \frac{1}{r} \frac{\partial \phi}{\partial \theta} \theta + \frac{1}{r \sin \theta} \frac{\partial \phi}{\partial \varphi} \Phi$                                                                                                                           |
| Divergence...                         | $\nabla \cdot \mathbf{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$                                                                               | $\nabla \cdot \mathbf{A} = \frac{1}{r} \frac{\partial(r A_r)}{\partial r} + \frac{1}{r} \frac{\partial A_\varphi}{\partial \varphi} + \frac{\partial A_z}{\partial z}$                                                                        | $\nabla \cdot \mathbf{A} = \frac{1}{r^2} \frac{\partial(r^2 A_r)}{\partial r} + \frac{1}{r \sin \theta} \frac{\partial(A_\theta \sin \theta)}{\partial \theta} + \frac{1}{r \sin \theta} \frac{\partial A_\varphi}{\partial \varphi}$                                                                                  |
| Curl...                               | $\nabla \times \mathbf{A} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ A_x & A_y & A_z \end{vmatrix}$ | $\nabla \times \mathbf{A} = \begin{vmatrix} \frac{1}{r} \mathbf{r} & \Phi & \frac{1}{r} \mathbf{k} \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \varphi} & \frac{\partial}{\partial z} \\ A_r & r A_\varphi & A_z \end{vmatrix}$ | $\nabla \times \mathbf{A} = \begin{vmatrix} \frac{r}{r^2} \sin \theta & \frac{\theta}{r \sin \theta} & \frac{\Phi}{r} \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \varphi} \\ A_r & r A_\theta & r A_\varphi \sin \theta \end{vmatrix}$                               |
| Laplacian...                          | $\nabla^2 \phi = \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} + \frac{\partial^2 \phi}{\partial z^2}$                                                                          | $\nabla^2 \phi = \frac{1}{r} \frac{\partial}{\partial r} \left( r \frac{\partial \phi}{\partial r} \right) + \frac{1}{r^2} \frac{\partial^2 \phi}{\partial \varphi^2} + \frac{\partial^2 \phi}{\partial z^2}$                                 | $\nabla^2 \phi = \frac{1}{r^2} \frac{\partial}{\partial r} \left( r^2 \frac{\partial \phi}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left( \sin \theta \frac{\partial \phi}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2 \phi}{\partial \varphi^2}$ |

## TRANSFORMATION OF INTEGRALS

If

1.  $s$  is the distance along a curve “ $C$ ” in space and is measured from some fixed point.
2.  $S$  is a surface area
3.  $V$  is a volume contained by a specified surface
4.  $\hat{\mathbf{t}}$  = the unit tangent to  $C$  at the point
5.  $\hat{\mathbf{n}}$  = the unit outward pointing normal
6.  $\mathbf{F}$  is some vector function
7.  $d\mathbf{s}$  is the vector element of curve ( $= \hat{\mathbf{t}} ds$ )
8.  $d\mathbf{S}$  is the vector element of surface ( $= \hat{\mathbf{n}} dS$ )

then

$$\int_{(c)} \mathbf{F} \cdot \hat{\mathbf{t}} ds = \int_{(c)} \mathbf{F}$$

and when  $\mathbf{F} = \nabla\phi$

$$\int_C (\nabla\phi) \cdot \hat{\mathbf{t}} ds = \int_C d\phi$$

*Gauss' Theorem*

When  $S$  defines a closed region having a volume  $V$ :

$$\iiint_V (\nabla \cdot \mathbf{F}) dV = \iint_S \mathbf{F} \cdot (\hat{\mathbf{n}}) dS = \iint_S \mathbf{F} \cdot d\mathbf{S}$$

also

$$\iiint_V (\nabla\phi) dV = \iint_S \phi \hat{\mathbf{n}} dS$$

and

$$\iiint_V (\nabla \times \mathbf{F}) dV = \iint_S (\hat{\mathbf{n}} \times \mathbf{F}) dS$$

*Stokes' Theorem*

When  $C$  is closed and bounds the open surface  $S$ :

$$\iint_S \hat{\mathbf{n}} \cdot (\nabla \times \mathbf{F}) dS = \int_C \mathbf{F} \cdot d\mathbf{s}$$

also

$$\iint_S (\hat{\mathbf{n}} \times \nabla\phi) dS = \int_{(c)} \phi d\mathbf{s}$$

*Green's Theorem*

$$\begin{aligned} \iint_S (\nabla\phi \cdot \nabla\theta) dS &= \iint_S \phi \hat{\mathbf{n}} \cdot (\nabla\theta) dS = \iiint_V \phi (\nabla^2\theta) dV \\ &= \iint_S \theta \cdot \hat{\mathbf{n}} (\nabla\phi) dS = \iiint_V \phi (\nabla^2\theta) dV \end{aligned}$$

## MOMENT OF INERTIA FOR VARIOUS BODIES OF MASS

The mass of the body is indicated by  $m$

| Body                                                              | Axis                                                                | Moment of inertia                                        |
|-------------------------------------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------|
| Uniform thin rod of length $l$                                    | Normal to the length, at one end                                    | $m\frac{1}{3}l^2$                                        |
| Uniform thin rod of length $l$                                    | Normal to the length, at the center                                 | $m\frac{1}{12}l^2$                                       |
| Thin rectangular sheet, sides $a$ and $b$                         | Through the center parallel to $b$                                  | $m\frac{1}{12}a^2$                                       |
| Thin rectangular sheet, sides $a$ and $b$                         | Through the center perpendicular to the sheet                       | $m\frac{1}{12}(a^2 + b^2)$                               |
| Thin circular sheet of radius $r$                                 | Normal to the plate through the center                              | $m\frac{1}{2}r^2$                                        |
| Thin circular sheet of radius $r$                                 | Along any diameter                                                  | $m\frac{1}{4}r^2$                                        |
| Thin circular ring. Radii $r_1$ and $r_2$                         | Through center normal to plane of ring                              | $m\frac{1}{2}(r_1^2 + r_2^2)$                            |
| Thin circular ring. Radii $r_1$ and $r_2$                         | Any diameter                                                        | $m\frac{1}{4}(r_1^2 + r_2^2)$                            |
| Rectangular parallelepiped, edges $a$ , $b$ , and $c$             | Through center perpendicular to face $ab$ , (parallel to edge $c$ ) | $m\frac{1}{12}(a^2 + b^2)$                               |
| Sphere, radius $r$                                                | Any diameter                                                        | $m\frac{2}{5}r^2$                                        |
| Spherical shell, external radius, $r_1$ , internal radius $r_2$   | Any diameter                                                        | $m\frac{2}{5}\frac{(r_1^5 - r_2^5)}{(r_1^3 - r_2^3)}$    |
| Spherical shell, very thin, mean radius, $r$                      | Any diameter                                                        | $m\frac{2}{3}r^2$                                        |
| Right circular cylinder of radius $r$ , length $l$                | The longitudinal axis of the solid                                  | $m\frac{1}{2}r^2$                                        |
| Right circular cylinder of radius $r$ , length $l$                | Transverse diameter                                                 | $m\left(\frac{r^2}{4} + \frac{l^2}{12}\right)$           |
| Hollow circular cylinder, length $l$ , radii $r_1$ and $r_2$      | The longitudinal axis of the figure                                 | $m\frac{1}{2}(r_1^2 + r_2^2)$                            |
| Thin cylindrical shell, length $l$ , mean radius, $r$             | The longitudinal axis of the figure                                 | $mr^2$                                                   |
| Hollow circular cylinder, length $l$ , radii $r_1$ and $r_2$      | Transverse diameter                                                 | $m\left(\frac{r_1^2 + r_2^2}{4} + \frac{l^2}{12}\right)$ |
| Hollow circular cylinder, length $l$ , very thin, mean radius $r$ | Transverse diameter                                                 | $m\left(\frac{r^2}{2} + \frac{l^2}{12}\right)$           |
| Elliptic cylinder, length $l$ , transverse semiaxes $a$ and $b$   | Longitudinal axis                                                   | $m\frac{1}{4}(a^2 + b^2)$                                |
| Right cone, altitude $h$ , radius of base $r$                     | Axis of the figure                                                  | $m\frac{3}{10}r^2$                                       |
| Spheroid of revolution, equatorial radius $r$                     | Polar axis                                                          | $m\frac{2}{5}r^2$                                        |
| Ellipsoid, axes $2a$ , $2b$ , $2c$                                | Axis $2a$                                                           | $m\frac{1}{5}(b^2 + c^2)$                                |



## BESSEL FUNCTIONS

1. Bessel's differential equation for a real variable  $x$  is

$$x^2 \frac{d^2 y}{dx^2} + x \frac{dy}{dx} + (x^2 - n^2)y = 0$$

2. When  $n$  is not an integer, two independent solutions of the equation are  $J_n(x)$  and  $J_{-n}(x)$  where

$$J_n(x) = \sum_{k=0}^{\infty} \frac{(-1)^k}{k! \Gamma(n+k+1)} \left(\frac{x}{2}\right)^{n+2k}$$

3. If  $n$  is an integer, then  $J_n(x) = (-1)^n J_{-n}(x)$ , where

$$J_n(x) = \frac{x^n}{2^n n!} \left\{ 1 - \frac{x^2}{2^2 \cdot 1!(n+1)} + \frac{x^4}{2^4 \cdot 2!(n+1)(n+2)} + \frac{x^6}{2^6 \cdot 3!(n+1)(n+2)(n+3)} + \dots \right\}$$

4. For  $n = 0$  and  $n = 1$ , this formula becomes

$$\begin{aligned} J_0(x) &= 1 - \frac{x^2}{2^2(1!)^2} + \frac{x^4}{2^4(2!)^2} - \frac{x^6}{2^6(3!)^2} + \frac{x^8}{2^8(4!)^2} - \dots \\ J_1(x) &= \frac{x}{2} - \frac{x^3}{2^3 \cdot 1!2!} + \frac{x^5}{2^5 \cdot 2!3!} - \frac{x^7}{2^7 \cdot 3!4!} + \frac{x^9}{2^9 \cdot 4!5!} - \dots \end{aligned}$$

5. When  $x$  is large and positive, the following asymptotic series may be used

$$\begin{aligned} J_0(x) &= \left(\frac{2}{\pi x}\right)^{\frac{1}{2}} \left\{ P_0(x) \cos\left(x - \frac{\pi}{4}\right) - Q_0(x) \sin\left(x - \frac{\pi}{4}\right) \right\} \\ J_1(x) &= \left(\frac{2}{\pi x}\right)^{\frac{1}{2}} \left\{ P_1(x) \cos\left(x - \frac{3\pi}{4}\right) - Q_1(x) \sin\left(x - \frac{3\pi}{4}\right) \right\} \end{aligned}$$

where

$$\begin{aligned} P_0(x) &\sim 1 - \frac{1^2 \cdot 3^2}{2!(8x)^2} + \frac{1^2 \cdot 3^2 \cdot 5^2 \cdot 7^2}{4!(8x)^4} - \frac{1^2 \cdot 3^2 \cdot 5^2 \cdot 7^2 \cdot 9^2 \cdot 11^2}{6!(8x)^6} + \dots \\ Q_0(x) &\sim -\frac{1^2}{1!8x} + \frac{1^2 \cdot 3^2 \cdot 5^2}{3!(8x)^3} - \frac{1^2 \cdot 3^2 \cdot 5^2 \cdot 7^2 \cdot 9^2}{5!(8x)^5} + \dots \\ P_1(x) &\sim 1 + \frac{1^2 \cdot 3 \cdot 5}{2!(8x)^2} - \frac{1^2 \cdot 3^2 \cdot 5^2 \cdot 7 \cdot 9}{4!(8x)^4} + \frac{1^2 \cdot 3^2 \cdot 5^2 \cdot 7^2 \cdot 9^2 \cdot 11 \cdot 13}{6!(8x)^6} - \dots \\ Q_1(x) &\sim \frac{1 \cdot 3}{1!8x} - \frac{1^2 \cdot 3^2 \cdot 5 \cdot 7}{3!(8x)^3} + \frac{1^2 \cdot 3^2 \cdot 5^2 \cdot 7^2 \cdot 9 \cdot 11}{5!(8x)^5} - \dots \end{aligned}$$

[In  $P_1(x)$  the signs alternate from  $+$  to  $-$  after the first term]

6. The zeros of  $J_0(x)$  and  $J_1(x)$ .

If  $j_{0s}$  and  $j_{1s}$  are the  $s$ th zeros of  $J_0(x)$  and  $J_1(x)$ , respectively, and if  $a = 4_s - 1$ ,  $b = 4_s + 1$

$$\begin{aligned} j_{0,s} &\sim \frac{1}{4} \pi a \left\{ 1 + \frac{2}{\pi^2 a^2} - \frac{62}{3\pi^4 a^4} + \frac{15,116}{15\pi^6 a^6} - \frac{12,554,474}{105\pi^8 a^8} + \frac{8,368,654,292}{315\pi^{10} a^{10}} - \dots \right\} \\ j_{1,s} &\sim \frac{1}{4} \pi b \left\{ 1 - \frac{6}{\pi^2 b^2} + \frac{6}{\pi^4 b^4} - \frac{4716}{5\pi^6 b^6} + \frac{3,902,418}{35\pi^8 b^8} - \frac{895,167,324}{35\pi^{10} b^{10}} + \dots \right\} \\ J_1(j_{0,s}) &\sim \frac{(-1)^{s+1} 2^{\frac{3}{2}}}{\pi a^{\frac{1}{2}}} \left\{ 1 - \frac{56}{3\pi^4 a^4} + \frac{9664}{5\pi^6 a^6} - \frac{7,381,280}{21\pi^8 a^8} + \dots \right\} \\ J_0(j_{1,s}) &\sim \frac{(-1)^s 2^{\frac{3}{2}}}{\pi b^{\frac{1}{2}}} \left\{ 1 + \frac{24}{\pi^4 b^4} - \frac{19,584}{10\pi^6 b^6} + \frac{2,466,720}{7\pi^8 b^8} - \dots \right\} \end{aligned}$$

7. Table of zeros for  $J_0(x)$  and  $J_1(x)$ 

Define  $\{\alpha_n, \beta_n\}$  by  $J_0(\alpha_n) = 0$  and  $J_1(\beta_n) = 0$ .

| Roots $\alpha_n$ | $J_1(\alpha_n)$ | Roots $\beta_n$ | $J_0(\beta_n)$ |
|------------------|-----------------|-----------------|----------------|
| 2.4048           | 0.5191          | 0.0000          | 1.0000         |
| 5.5201           | -0.3403         | 3.8317          | -0.4028        |
| 8.6537           | 0.2715          | 7.0156          | 0.3001         |
| 11.7915          | -0.2325         | 10.1735         | -0.2497        |
| 14.9309          | 0.2065          | 13.3237         | 0.2184         |
| 18.0711          | -0.1877         | 16.4706         | -0.1965        |
| 21.2116          | 0.1733          | 19.6159         | 0.1801         |

## 8. Recurrence formulas

$$\begin{aligned} J_{n-1}(x) + J_{n+1}(x) &= \frac{2n}{x} J_n(x) & nJ_n(x) + xJ'_n(x) &= xJ_{n-1}(x) \\ J_{n-1}(x) - J_{n+1}(x) &= 2J'_n(x) & nJ_n(x) - xJ'_n(x) &= xJ_{n+1}(x) \end{aligned}$$

9. If  $J_n$  is written for  $J_n(x)$  and  $J_n^{(k)}$  is written for  $\frac{d^k}{dx^k}\{J_n(x)\}$ , then the following derivative relationships are important

$$\begin{aligned} J_0^{(r)} &= -J_1^{(r-1)} \\ J_0^{(2)} &= -J_0 + \frac{1}{x}J_1 = \frac{1}{2}(J_2 - J_0) \\ J_0^{(3)} &= \frac{1}{x}J_0 + \left(1 - \frac{2}{x^2}\right)J_1 = \frac{1}{4}(-J_3 + 3J_1) \\ J_0^{(4)} &= \left(1 - \frac{3}{x^2}\right)J_0 - \left(\frac{2}{x} - \frac{6}{x^3}\right)J_1 = \frac{1}{8}(J_4 - 4J_2 + 3J_0), \text{ etc.} \end{aligned}$$

## 10. Half-order Bessel functions

$$\begin{aligned} J_{\frac{1}{2}}(x) &= \sqrt{\frac{2}{\pi x}} \sin x \\ J_{-\frac{1}{2}}(x) &= \sqrt{\frac{2}{\pi x}} \cos x \\ J_{n+\frac{3}{2}}(x) &= -x^{n+\frac{1}{2}} \frac{d}{dx} \{x^{-(n+\frac{1}{2})} J_{n+\frac{1}{2}}(x)\} \\ J_{n-\frac{1}{2}}(x) &= x^{-(n+\frac{1}{2})} \frac{d}{dx} \{x^{n+\frac{1}{2}} J_{n+\frac{1}{2}}(x)\} \end{aligned}$$

| n | $\left(\frac{\pi x}{2}\right)^{\frac{1}{2}} J_{n+\frac{1}{2}}(x)$                                   | $\left(\frac{\pi x}{2}\right)^{\frac{1}{2}} J_{-(n+\frac{1}{2})}(x)$                         |
|---|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| 0 | $\sin x$                                                                                            | $\cos x$                                                                                     |
| 1 | $\frac{\sin x}{x} - \cos x$                                                                         | $-\frac{\cos x}{x} - \sin x$                                                                 |
| 2 | $\left(\frac{3}{x^2} - 1\right) \sin x - \frac{3}{x} \cos x$                                        | $\left(\frac{3}{x^2} - 1\right) \cos x + \frac{3}{x} \sin x$                                 |
| 3 | $\left(\frac{15}{x^3} - \frac{6}{x}\right) \sin x - \left(\frac{15}{x^2} - 1\right) \cos x$<br>etc. | $-\left(\frac{15}{x^3} - \frac{6}{x}\right) \cos x - \left(\frac{15}{x^2} - 1\right) \sin x$ |

## 11. Additional solutions to Bessel's equation are

$$\begin{aligned} Y_n(x) &\text{ (also called Weber's function, and sometimes denoted by } N_n(x)) \\ H_n^{(1)}(x) &\text{ and } H_n^{(2)}(x) \text{ (also called Hankel functions)} \end{aligned}$$

These solutions are defined as follows

$$Y_n(x) = \begin{cases} \frac{J_n(x) \cos(n\pi) - J_{-n}(x)}{\sin(n\pi)} & n \text{ not an integer} \\ \lim_{\nu \rightarrow n} \frac{J_\nu(x) \cos(\nu\pi) - J_{-\nu}(x)}{\sin(\nu\pi)} & n \text{ an integer} \end{cases} \quad \begin{aligned} H_n^{(1)}(x) &= J_n(x) + iY_n(x) \\ H_n^{(2)}(x) &= J_n(x) - iY_n(x) \end{aligned}$$

The additional properties of these functions may all be derived from the above relations and the known properties of  $J_n(x)$ .

## 12. Complete solutions to Bessel's equation may be written as

$$c_1 J_n(x) + c_2 J_{-n}(x) \quad \text{if } n \text{ is not an integer}$$

or, for any value of  $n$ ,

$$c_1 J_n(x) + c_2 Y_n(x) \quad \text{or} \quad c_1 H_n^{(1)}(x) + c_2 H_n^{(2)}(x)$$

13. The modified (or hyperbolic) Bessel's differential equation is

$$x^2 \frac{d^2 y}{dx^2} + x \frac{dy}{dx} - (x^2 + n^2)y = 0$$

14. When  $n$  is not an integer, two independent solutions of the equation are  $I_n(x)$  and  $I_{-n}(x)$ , where

$$I_n(x) = \sum_{k=0}^{\infty} \frac{1}{k! \Gamma(n+k+1)} \left(\frac{x}{2}\right)^{n+2k}$$

15. If  $n$  is an integer,

$$I_n(x) = I_{-n}(x) = \frac{x^n}{2^n n!} \left\{ 1 + \frac{x^2}{2^2 \cdot 1!(n+1)} + \frac{x^4}{2^4 \cdot 2!(n+1)(n+2)} + \frac{x^6}{2^6 \cdot 3!(n+1)(n+2)(n+3)} + \cdots \right\}$$

16. For  $n = 0$  and  $n = 1$ , this formula becomes

$$I_0(x) = 1 + \frac{x^2}{2^2(1!)^2} + \frac{x^4}{2^4(2!)^2} + \frac{x^6}{2^6(3!)^2} + \frac{x^8}{2^8(4!)^2} + \cdots$$

$$I_1(x) = \frac{x}{2} + \frac{x^3}{2^3 \cdot 1!2!} + \frac{x^5}{2^5 \cdot 2!3!} + \frac{x^7}{2^7 \cdot 3!4!} + \frac{x^9}{2^9 \cdot 4!5!} + \cdots$$

17. Another solution to the modified Bessel's equation is

$$K_n(x) = \begin{cases} \frac{1}{2} \pi \frac{I_{-n}(x) - I_n(x)}{\sin(n\pi)} & n \text{ not an integer} \\ \lim_{\nu \rightarrow n} \frac{1}{2} \pi \frac{I_{-\nu}(x) - I_{\nu}(x)}{\sin(\nu\pi)} & n \text{ an integer} \end{cases}$$

This function is linearly independent of  $I_n(x)$  for all values of  $n$ . Thus the complete solution to the modified Bessel's equation may be written as

$$c_1 I_n(x) + c_2 I_{-n}(x) \quad n \text{ not an integer}$$

or

$$c_1 I_n(x) + c_2 K_n(x) \quad \text{any } n$$

18. The following relations hold among the various Bessel functions:

$$I_n(z) = i^{-n} J_n(iz)$$

$$Y_n(iz) = (i)^{n+1} I_n(z) - \frac{2}{\pi} i^{-n} K_n(z)$$

Most of the properties of the modified Bessel function may be deduced from the known properties of  $J_n(x)$  by use of these relations and those previously given.

19. Recurrence formulas

$$I_{n-1}(x) - I_{n+1}(x) = \frac{2n}{x} I_n(x) \quad I_{n-1}(x) + I_{n+1}(x) = 2I'_n(x)$$

$$I_{n-1}(x) - \frac{n}{x} I_n(x) = I'_n(x) \quad I'_n(x) = I_{n+1}(x) + \frac{n}{x} I_n(x)$$

## THE FACTORIAL FUNCTION

For non-negative integers  $n$ , the factorial of  $n$ , denoted  $n!$ , is the product of all positive integers less than or equal to  $n$ ;  $n! = n \cdot (n-1) \cdot (n-2) \cdots 2 \cdot 1$ . If  $n$  is a negative integer ( $n = -1, -2, \dots$ ), then  $n! = \pm\infty$ .

Approximations to  $n!$  for large  $n$  include Stirling's formula

$$n! \approx \sqrt{2\pi e} \left(\frac{n}{e}\right)^{n+\frac{1}{2}},$$

and Burnside's formula

$$n! \approx \sqrt{2\pi} \left(\frac{n+\frac{1}{2}}{e}\right)^{n+\frac{1}{2}}.$$

| $n$ | $n!$                      | $\log_{10} n!$ | $n$  | $n!$                      | $\log_{10} n!$ |
|-----|---------------------------|----------------|------|---------------------------|----------------|
| 0   | 1                         | 0.00000        | 1    | 1                         | 0.00000        |
| 2   | 2                         | 0.30103        | 3    | 6                         | 0.77815        |
| 4   | 24                        | 1.38021        | 5    | 120                       | 2.07918        |
| 6   | 720                       | 2.85733        | 7    | 5040                      | 3.70243        |
| 8   | 40320                     | 4.60552        | 9    | $3.6288 \times 10^5$      | 5.55976        |
| 10  | $3.6288 \times 10^6$      | 6.55976        | 11   | $3.9917 \times 10^7$      | 7.60116        |
| 12  | $4.7900 \times 10^8$      | 8.68034        | 13   | $6.2270 \times 10^9$      | 9.79428        |
| 14  | $8.7178 \times 10^{10}$   | 10.94041       | 15   | $1.3077 \times 10^{12}$   | 12.11650       |
| 16  | $2.0923 \times 10^{13}$   | 13.32062       | 17   | $3.5569 \times 10^{14}$   | 14.55107       |
| 18  | $6.4024 \times 10^{15}$   | 15.80634       | 19   | $1.2165 \times 10^{17}$   | 17.08509       |
| 20  | $2.4329 \times 10^{18}$   | 18.38612       | 25   | $1.5511 \times 10^{25}$   | 25.19065       |
| 30  | $2.6525 \times 10^{32}$   | 32.42366       | 40   | $8.1592 \times 10^{47}$   | 47.91165       |
| 50  | $3.0414 \times 10^{64}$   | 64.48307       | 60   | $8.3210 \times 10^{81}$   | 81.92017       |
| 70  | $1.1979 \times 10^{100}$  | 100.07841      | 80   | $7.1569 \times 10^{118}$  | 118.85473      |
| 90  | $1.4857 \times 10^{138}$  | 138.17194      | 100  | $9.3326 \times 10^{157}$  | 157.97000      |
| 110 | $1.5882 \times 10^{178}$  | 178.20092      | 120  | $6.6895 \times 10^{198}$  | 198.82539      |
| 130 | $6.4669 \times 10^{219}$  | 219.81069      | 150  | $5.7134 \times 10^{262}$  | 262.75689      |
| 500 | $1.2201 \times 10^{1134}$ | 1134.0864      | 1000 | $4.0239 \times 10^{2567}$ | 2567.6046      |

## THE GAMMA FUNCTION

*Definition:*  $\Gamma(n) = \int_0^{\infty} t^{n-1} e^{-t} dt \quad n > 0$

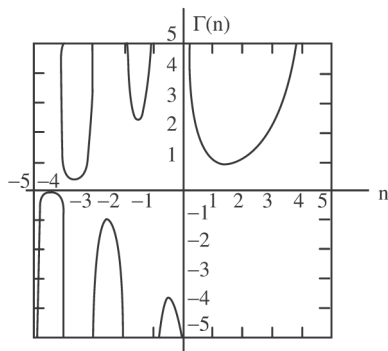
*Recursion Formula:*  $\Gamma(n+1) = n\Gamma(n)$

$\Gamma(n+1) = n!$  if  $n = 0, 1, 2, \dots$  where  $0! = 1$

For  $n < 0$  the gamma function can be defined by using

$$\Gamma(n) = \frac{\Gamma(n+1)}{n}$$

*Graph:*



*Special Values:*

$$\Gamma(1/2) = \sqrt{\pi}$$

$$\Gamma(m+1/2) = \frac{1 \cdot 3 \cdot 5 \cdots (2m-1)}{2^m} \sqrt{\pi} \quad m = 1, 2, 3, \dots$$

$$\Gamma(-m+1/2) = \frac{(-1)^m 2^m \sqrt{\pi}}{1 \cdot 3 \cdot 5 \cdots (2m-1)} \quad m = 1, 2, 3, \dots$$

*Definition:*

$$\Gamma(x+1) = \lim_{k \rightarrow \infty} \frac{1 \cdot 2 \cdot 3 \cdots k}{(x+1)(x+2) \cdots (x+k)} k^x$$

$$\frac{1}{\Gamma(x)} = x e^{\gamma x} \prod_{m=1}^{\infty} \left\{ \left(1 + \frac{x}{m}\right) e^{-x/m} \right\}$$

This is an infinite product representation for the gamma function where  $\gamma$  is Euler's constant.

Properties:

$$\begin{aligned}\Gamma'(1) &= \int_0^\infty e^{yx} \ln x \, dx = -\gamma \\ \frac{\Gamma'(x)}{\Gamma(x)} &= -\gamma + \left(\frac{1}{1} - \frac{1}{x}\right) + \left(\frac{1}{2} - \frac{1}{x+1}\right) + \cdots + \left(\frac{1}{n} - \frac{1}{x+n-1}\right) + \cdots \\ \Gamma(x+1) &= \sqrt{2\pi x} x^x e^{-x} \left\{1 + \frac{1}{12x} + \frac{1}{288x^2} - \frac{139}{51,840x^3} + \cdots\right\}\end{aligned}$$

This is called *Stirling's asymptotic series*.

$$\text{Values of } \Gamma(n) = \int_0^\infty e^{-x} x^{n-1} \, dx; \quad \Gamma(n+1) = n\Gamma(n)$$

| $n$  | $\Gamma(n)$ | $n$  | $\Gamma(n)$ | $n$  | $\Gamma(n)$ | $n$  | $\Gamma(n)$ |
|------|-------------|------|-------------|------|-------------|------|-------------|
| 1.00 | 1.00000     | 1.25 | .90640      | 1.50 | .88623      | 1.75 | .91906      |
| 1.01 | .99433      | 1.26 | .90440      | 1.51 | .88659      | 1.76 | .92137      |
| 1.02 | .98884      | 1.27 | .90250      | 1.52 | .88704      | 1.77 | .92376      |
| 1.03 | .98355      | 1.28 | .90072      | 1.53 | .88757      | 1.78 | .92623      |
| 1.04 | .97844      | 1.29 | .89904      | 1.54 | .88818      | 1.79 | .92877      |
| 1.05 | .97350      | 1.30 | .89747      | 1.55 | .88887      | 1.80 | .93138      |
| 1.06 | .96874      | 1.31 | .89600      | 1.56 | .88964      | 1.81 | .93408      |
| 1.07 | .96415      | 1.32 | .89464      | 1.57 | .89049      | 1.82 | .93685      |
| 1.08 | .95973      | 1.33 | .89338      | 1.58 | .89142      | 1.83 | .93969      |
| 1.09 | .95546      | 1.34 | .89222      | 1.59 | .89243      | 1.84 | .94261      |
| 1.10 | .95135      | 1.35 | .89115      | 1.60 | .89352      | 1.85 | .94561      |
| 1.11 | .94740      | 1.36 | .89018      | 1.61 | .89468      | 1.86 | .94869      |
| 1.12 | .94359      | 1.37 | .88931      | 1.62 | .89592      | 1.87 | .95184      |
| 1.13 | .93993      | 1.38 | .88854      | 1.63 | .89724      | 1.88 | .95507      |
| 1.14 | .93642      | 1.39 | .88785      | 1.64 | .89864      | 1.89 | .95838      |
| 1.15 | .93304      | 1.40 | .88726      | 1.65 | .90012      | 1.90 | .96177      |
| 1.16 | .92980      | 1.41 | .88676      | 1.66 | .90167      | 1.91 | .96523      |
| 1.17 | .92670      | 1.42 | .88636      | 1.67 | .90330      | 1.92 | .96877      |
| 1.18 | .92373      | 1.43 | .88604      | 1.68 | .90500      | 1.93 | .97240      |
| 1.19 | .92089      | 1.44 | .88581      | 1.69 | .90678      | 1.94 | .97610      |
| 1.20 | .91817      | 1.45 | .88566      | 1.70 | .90864      | 1.95 | .97988      |
| 1.21 | .91558      | 1.46 | .88560      | 1.71 | .91057      | 1.96 | .98374      |
| 1.22 | .91311      | 1.47 | .88563      | 1.72 | .91258      | 1.97 | .98768      |
| 1.23 | .91075      | 1.48 | .88575      | 1.73 | .91466      | 1.98 | .99171      |
| 1.24 | .90852      | 1.49 | .88595      | 1.74 | .91683      | 1.99 | .99581      |
|      |             |      |             |      |             | 2.00 | 1.00000     |

## THE BETA FUNCTION

*Definition:*  $B(m, n) = \int_0^1 t^{m-1} (1-t)^{n-1} dt \quad m > 0, n > 0$

*Relationship with Gamma function:*  $B(m, n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$

*Properties:*

$$B(m, n) = B(n, m)$$

$$B(m, n) = 2 \int_0^{\pi/2} \sin^{2m-1} \theta \cos^{2n-1} \theta d\theta$$

$$B(m, n) = \int_0^\infty \frac{t^{m-1}}{(1+t)^{m+n}} dt$$

$$B(m, n) = r^n (r+1)^m \int_0^1 \frac{t^{m-1} (1-t)^{n-1}}{(r+t)^{m+n}} dt$$



## THE ERROR FUNCTION

*Definition:*  $\operatorname{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$

*Series:*  $\operatorname{erf}(x) = \frac{2}{\sqrt{\pi}} \left( x - \frac{x^3}{3} + \frac{1}{2!} \frac{x^5}{5} - \frac{1}{3!} \frac{x^7}{7} + \cdots \right)$

*Property:*  $\operatorname{erf}(x) = -\operatorname{erf}(-x)$

*Relationship with Normal Probability Function*  $f(t) : \int_0^x f(t) dt = \frac{1}{2} \operatorname{erf} \left( \frac{x}{\sqrt{2}} \right)$  To evaluate  $\operatorname{erf}(2.3)$ , one proceeds as follows:

For  $\frac{x}{\sqrt{2}} = 2.3$ , one finds  $x = (2.3)(\sqrt{2}) = 3.25$ . In the normal probability function table (page A-104), one finds the entry 0.4994 opposite the value 3.25. Thus  $\operatorname{erf}(2.3) = 2(0.4994) = 0.9988$ .

$$\operatorname{erfc}(z) = 1 - \operatorname{erf}(z) = \frac{2}{\sqrt{\pi}} \int_z^\infty e^{-t^2} dt$$

is known as the complementary error function.

## ORTHOGONAL POLYNOMIALS

### I: Legendre

*Name:* Legendre      *Symbol:*  $P_n(x)$       *Interval:*  $[-1, 1]$   
*Differential Equation:*  $(1 - x^2)y'' - 2xy' + n(n+1)y = 0$   
*Explicit Expression:*  $P_n(x) = \frac{1}{2^n} \sum_{m=0}^{\lfloor n/2 \rfloor} (-1)^m \binom{n}{m} \binom{2n-2m}{n} x^{n-2m}$   
*Recurrence Relation:*  $(n+1)P_{n+1}(x) = (2n+1)xP_n(x) - nP_{n-1}(x)$   
*Weight:* 1  
*Standardization:*  $P_n(1) = 1$   
*Norm:*  $\int_{-1}^{+1} [P_n(x)]^2 dx = \frac{2}{2n+1}$   
*Rodrigues' Formula:*  $P_n(x) = \frac{(-1)^n}{2^n n!} \frac{d^n}{dx^n} \{(1-x^2)^n\}$   
*Generating Function:*  $R^{-1} = \sum_{n=0}^{\infty} P_n(x)z^n; -1 < x < 1, \quad |z| < 1,$   
 $R = \sqrt{1 - 2xz + z^2}$   
*Inequality:*  $|P_n(x)| \leq 1, -1 \leq x \leq 1.$

### II: Tschebysheff, First Kind

*Name:* Tschebysheff, First Kind      *Symbol:*  $T_n(x)$       *Interval:*  $[-1, 1]$   
*Differential Equation:*  $(1 - x^2)y - xy' + n^2y = 0$   
*Explicit Expression:*  $\frac{n}{2} \sum_{m=0}^{\lfloor n/2 \rfloor} (-1)^m \frac{(n-m-1)!}{m!(n-2m)!} (2x)^{n-2m} = \cos(n \arccos x) = T_n(x)$   
*Recurrence Relation:*  $T_{n+1}(x) = 2xT_n(x) - T_{n-1}(x)$   
*Weight:*  $(1 - x^2)^{-1/2}$   
*Standardization:*  $T_n(1) = 1$

$$\text{Norm: } \int_{-1}^{+1} (1-x^2)^{-1/2} [T_n(x)]^2 dx = \begin{cases} \pi/2, & n \neq 0 \\ \pi, & n = 0 \end{cases}$$

$$\text{Rodrigues' Formula: } \frac{(-1)^n (1-x^2)^{1/2} \sqrt{\pi}}{2^{n+1} \Gamma(n + \frac{1}{2})} \frac{d^n}{dx^n} \{(1-x^2)^{n-(1/2)}\} = T_n(x)$$

$$\text{Generating Function: } \frac{1-xz}{1-2xz-z^2} = \sum_{n=0}^{\infty} T_n(x) z^n, \quad -1 < x < 1, \quad |z| < 1$$

$$\text{Inequality: } |T_n(x)| \leq 1, \quad -1 \leq x \leq 1.$$

### III: Tschebysheff, Second Kind

$$\text{Name: Tschebysheff, Second Kind} \quad \text{Symbol } U_n(x) \quad \text{Interval: } [-1, 1]$$

$$\text{Differential Equation: } (1-x^2)y'' - 3xy' + n(n+2)y = 0$$

$$\text{Explicit Expression: } U_n(x) = \sum_{m=0}^{[n/2]} (-1)^m \frac{(m-n)!}{m!(n-2m)!} (2x)^{n-2m}$$

$$U_n(\cos \theta) = \frac{\sin[(n+1)\theta]}{\sin \theta}$$

$$\text{Recurrence Relation: } U_{n+1}(x) = 2xU_n(x) - U_{n-1}(x)$$

$$\text{Weight: } (1-x^2)^{1/2} \quad \text{Standardization: } U_n(1) = n+1$$

$$\text{Norm: } \int_{-1}^{+1} (1-x^2)^{1/2} [U_n(x)]^2 dx = \frac{\pi}{2}$$

$$\text{Rodrigues' Formula: } U_n(x) = \frac{(-1)^n (n+1) \sqrt{\pi}}{(1-x^2)^{1/2} 2^{n+1} \Gamma(n + \frac{3}{2})} \frac{d^n}{dx^n} \{(1-x^2)^{n+(1/2)}\}$$

$$\text{Generating Function: } \frac{1}{1-2xz+z^2} = \sum_{n=0}^{\infty} U_n(x) z^n, \quad -1 < x < 1, \quad |z| < 1$$

$$\text{Inequality: } |U_n(x)| \leq n+1, \quad -1 \leq x \leq 1.$$

### IV: Jacobi

$$\text{Name: Jacobi} \quad \text{Symbol: } P_n^{(\alpha, \beta)}(x) \quad \text{Interval: } [-1, 1]$$

$$\text{Differential Equation: } (1-x^2)y'' + [\beta - \alpha - (\alpha + \beta + 2)x]y' + n(n + \alpha + \beta + 1)y = 0$$

$$\text{Explicit Expression: } P_n^{(\alpha, \beta)}(x) = \frac{1}{2^n} \sum_{m=0}^n \binom{n+\alpha}{m} \binom{n+\beta}{n-m} (x-1)^{n-m} (x+1)^m$$

$$\text{Recurrence Relation:}$$

$$\begin{aligned} & 2(n+1)(n+\alpha+\beta+1)(2n+\alpha+\beta)P_{n+1}^{(\alpha, \beta)}(x) \\ &= (2n+\alpha+\beta+1)[(\alpha^2-\beta^2) + (2n+\alpha+\beta+2) \\ & \times (2n+\alpha+\beta)x]P_n^{(\alpha, \beta)}(x) \\ & - 2(n+\alpha)(n+\beta)(2n+\alpha+\beta+2)P_{n-1}^{(\alpha, \beta)}(x) \end{aligned}$$

$$\text{Weight: } (1-x)^\alpha (1+x)^\beta; \alpha, \beta > -1$$

$$\text{Standardization: } P_n^{(\alpha, \beta)}(x) = \binom{n+\alpha}{n}$$

$$\text{Norm: } \int_{-1}^{+1} (1-x)^\alpha (1+x)^\beta [P_n^{(\alpha, \beta)}(x)]^2 dx = \frac{2^{\alpha+\beta+1} \Gamma(n+\alpha+1) \Gamma(n+\beta+1)}{(2n+\alpha+\beta+1)n! \Gamma(n+\alpha+\beta+1)}$$

$$\text{Rodrigues' Formula: } P_n^{(\alpha, \beta)}(x) = \frac{(-1)^n}{2^n n! (1-x)^\alpha (1+x)^\beta} \frac{d^n}{dx^n} \{(1-x)^{n+\alpha} (1+x)^{n+\beta}\}$$

$$\text{Generating Function: } R^{-1}(1-z+R)^{-\alpha}(1+z+R)^{-\beta} = \sum_{n=0}^{\infty} 2^{-\alpha-\beta} P_n^{(\alpha, \beta)}(x) z^n,$$

$$R = \sqrt{1-2xz+z^2}, \quad |z| < 1$$

$$\text{Inequality: } \max_{-1 \leq x \leq 1} |P_n^{(\alpha, \beta)}(x)| = \begin{cases} \binom{n+q}{n} \sim n^q \text{ if } q = \max(\alpha, \beta) \geq -\frac{1}{2} \\ |P_n^{(\alpha, \beta)}(x')| \sim n^{-1/2} \text{ if } q < -\frac{1}{2} \\ x' \text{ is one of the two maximum points nearest } \frac{\beta - \alpha}{\alpha + \beta + 1} \end{cases}$$

## V: Generalized Laguerre

Name: Generalized Laguerre      Symbol:  $L_n^{(\alpha)}(x)$       Interval:  $[0, \infty]$

Differential Equation:  $xy'' + (\alpha + 1 - x)y' + ny = 0$

Explicit Expression:  $L_n^{(\alpha)}(x) = \sum_{m=0}^n (-1)^m \binom{n+\alpha}{n-m} \frac{1}{m!} x^m$

Recurrence Relation:  $(n+1)L_n^{(\alpha)} + 1(x) = [(2n+\alpha+1) - x]L_n^{(\alpha)}(x) - (n+\alpha)L_n^{(\alpha)} - 1(x)$

Weight:  $x^\alpha e^{-x}$ ,  $\alpha > -1$  Standardization:  $L_n^{(\alpha)}(x) = \frac{(-1)^n}{n!} x^n + \dots$

Norm:  $\int_0^\infty x^\alpha e^{-x} [L_n^{(\alpha)}(x)]^2 dx = \frac{\Gamma(n+\alpha+1)}{n!}$

Rodrigues' Formula:  $L_n^{(\alpha)}(x) = \frac{1}{n! x^\alpha e^{-x}} \frac{d^n}{dx^n} \{x^{n+\alpha} e^{-x}\}$

Generating Function:  $(1-z)^{-\alpha-1} \exp\left(\frac{xz}{z-1}\right) = \sum_{n=0}^\infty L_n^{(\alpha)}(x) z^n$

Inequality:  $|L_n^{(\alpha)}(x)| \leq \frac{\Gamma(n+\alpha+1)}{n! \Gamma(\alpha+1)} e^{x/2}; \quad \begin{matrix} x \geq 0 \\ \alpha > 0 \end{matrix}$   
 $|L_n^{(\alpha)}(x)| \leq \left[2 - \frac{\Gamma(\alpha+n+1)}{n! \Gamma(\alpha+1)}\right] e^{x/2}; \quad \begin{matrix} x \geq 0 \\ -1 < \alpha < 0 \end{matrix}$

## VI: Hermite

Name: Hermite      Symbol:  $H_n(x)$       Interval:  $[-\infty, \infty]$

Differential Equation:  $y'' - 2xy' + 2ny = 0$

Explicit Expression:  $H_n(x) = \sum_{m=0}^{\lfloor n/2 \rfloor} \frac{(-1)^m n! (2x)^{n-2m}}{m! (n-2m)!}$

Recurrence Relation:  $H_{n+1}(x) = 2xH_n(x) - 2nH_{n-1}(x)$

Weight:  $e^{-x^2}$  Standardization:  $H_n(1) = 2^n x^n + \dots$

Norm:  $\int_{-\infty}^\infty e^{-x^2} [H_n(x)]^2 dx = 2^n n! \sqrt{\pi}$

Rodrigues' Formula:  $H_n(x) = (-1)^n e^{x^2} \frac{d^n}{dx^n} (e^{-x^2})$

Generating Function:  $e^{-x^2+2zx} = \sum_{n=0}^\infty H_n(x) \frac{z^n}{n!}$

Inequality:  $|H_n(x)| e^{x^2/2} k 2^{n/2} \sqrt{n!} k \approx 1.086435$

# TABLES OF ORTHOGONAL POLYNOMIALS

|                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $H_0 = 1$<br>$H_1 = 2x$<br>$H_2 = 4x^2 - 2$<br>$H_3 = 8x^3 - 12x$<br>$H_4 = 16x^4 - 48x^2 + 12$<br>$H_5 = 32x^5 - 160x^3 + 120x$<br>$H_6 = 64x^6 - 480x^4 + 720x^2 - 120$<br>$H_7 = 128x^7 - 1344x^5 + 3360x^3 - 1680x$<br>$H_8 = 256x^8 - 3584x^6 + 13440x^4 - 13440x^2 + 1680$<br>$H_9 = 512x^9 - 9216x^7 + 48384x^5 - 80640x^3 + 30240x$<br>$H_{10} = 1024x^{10} - 23040x^8 + 161280x^6 - 403200x^4 + 302400x^2 - 30240$ | $x^{10} = (30240H_0 + 75600H_2 + 25200H_4 + 2520H_6 + 90H_8 + H_{10})/1024$<br>$x^9 = (15120H_1 + 10080H_3 + 1512H_5 + 72H_7 + H_9)/512$<br>$x^8 = (1680H_0 + 3360H_2 + 840H_4 + 56H_6 + H_8)/256$<br>$x^7 = (840H_1 + 420H_3 + 42H_5 + H_7)/128$<br>$x^6 = (120H_0 + 180H_2 + 30H_4 + H_6)/64$<br>$x^5 = (60H_1 + 20H_3 + H_5)/32$<br>$x^4 = (12H_0 + 12H_2 + H_4)/16$<br>$x^3 = (6H_1 + H_3)/8$<br>$x^2 = (2H_0 + H_2)/4$<br>$x = (H_1)/2$<br>$1 = H_0$ |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $L_0 = 1$<br>$L_1 = -x + 1$<br>$L_2 = (x^2 - 4x + 2)/2$<br>$L_3 = (-x^3 + 9x^2 - 18x + 6)/6$<br>$L_4 = (x^4 - 16x^3 + 72x^2 - 96x + 24)/24$<br>$L_5 = (-x^5 + 25x^4 - 200x^3 + 600x^2 - 600x + 120)/120$<br>$L_6 = (x^6 - 36x^5 + 450x^4 - 2400x^3 + 5400x^2 - 4320x + 720)/720$ | $x^6 = 720L_0 - 4320L_1 + 10800L_2 - 14400L_3 + 10800L_4 - 4320L_5 + 720L_6$<br>$x^5 = 120L_0 - 600L_1 + 1200L_2 - 1200L_3 + 600L_4 - 120L_5$<br>$x^4 = 24L_0 - 96L_1 + 144L_2 - 96L_3 + 24L_4$<br>$x^3 = 6L_0 - 18L_1 + 18L_2 - 6L_3$<br>$x^2 = 2L_0 - 4L_1 + 2L_2$<br>$x = L_0 - L_1$<br>$1 = L_0$ |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $P_0 = 1$<br>$P_1 = x$<br>$P_2 = (3x^2 - 1)/2$<br>$P_3 = (5x^3 - 3x)/2$<br>$P_4 = (35x^4 - 30x^2 + 3)/8$<br>$P_5 = (63x^5 - 70x^3 + 15x)/8$<br>$P_6 = (231x^6 - 315x^4 + 105x^2 - 5)/16$<br>$P_7 = (429x^7 - 693x^5 + 315x^3 - 35x)/16$<br>$P_8 = (6435x^8 - 12012x^6 + 6930x^4 - 1260x^2 + 35)/128$<br>$P_9 = (12155x^9 - 25740x^7 + 18018x^5 - 4620x^3 + 315x)/128$<br>$P_{10} = (46189x^{10} - 109395x^8 + 90090x^6 - 30030x^4 + 3465x^2 - 63)/256$ | $x^{10} = (4199P_0 + 16150P_2 + 15504P_4 + 7904P_6 + 2176P_8 + 256P_{10})/46189$<br>$x^9 = (3315P_1 + 4760P_3 + 2992P_5 + 960P_7 + 128P_9)/12155$<br>$x^8 = (715P_0 + 2600P_2 + 2160P_4 + 832P_6 + 128P_8)/6435$<br>$x^7 = (143P_1 + 182P_3 + 88P_5 + 16P_7)/429$<br>$x^6 = (33P_0 + 110P_2 + 72P_4 + 16P_6)/231$<br>$x^5 = (27P_1 + 28P_3 + 8P_5)/63$<br>$x^4 = (7P_0 + 20P_2 + 8P_4)/35$<br>$x^3 = (3P_1 + 2P_3)/5$<br>$x^2 = (P_0 + 2P_2)/3$<br>$x = P_1$<br>$1 = P_0$ |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $T_0 = 1$<br>$T_1 = x$<br>$T_2 = 2x^2 - 1$<br>$T_3 = 4x^3 - 3x$<br>$T_4 = 8x^4 - 8x^2 + 1$<br>$T_5 = 16x^5 - 20x^3 + 5x$<br>$T_6 = 32x^6 - 48x^4 + 18x^2 - 1$<br>$T_7 = 64x^7 - 112x^5 + 56x^3 - 7x$<br>$T_8 = 128x^8 - 256x^6 + 160x^4 - 32x^2 + 1$<br>$T_9 = 256x^9 - 576x^7 + 432x^5 - 120x^3 + 9x$<br>$T_{10} = 512x^{10} - 1280x^8 + 1120x^6 - 400x^4 + 50x^2 - 1$ | $x^{10} = (126T_0 + 210T_2 + 120T_4 + 45T_6 + 10T_8 + T_{10})/512$<br>$x^9 = (126T_1 + 84T_3 + 36T_5 + 9T_7 + T_9)/256$<br>$x^8 = (35T_0 + 56T_2 + 28T_4 + 8T_6 + T_8)/128$<br>$x^7 = (35T_1 + 21T_3 + 7T_5 + T_7)/64$<br>$x^6 = (10T_0 + 15T_2 + 6T_4 + T_6)/32$<br>$x^5 = (10T_1 + 5T_3 + T_5)/16$<br>$x^4 = (3T_0 + 4T_2 + T_4)/8$<br>$x^3 = (3T_1 + T_3)/4$<br>$x^2 = (T_0 + T_2)/2$<br>$x = T_1$<br>$1 = T_0$ |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $U_0 = 1$<br>$U_1 = 2x$<br>$U_2 = 4x^2 - 1$<br>$U_3 = 8x^3 - 4x$<br>$U_4 = 16x^4 - 12x^2 + 1$<br>$U_5 = 32x^5 - 32x^3 + 6x$<br>$U_6 = 64x^6 - 80x^4 + 24x^2 - 1$<br>$U_7 = 128x^7 - 192x^5 + 80x^3 - 8x$<br>$U_8 = 256x^8 - 448x^6 + 240x^4 - 40x^2 + 1$<br>$U_9 = 512x^9 - 1024x^7 + 672x^5 - 160x^3 + 10x$<br>$U_{10} = 1024x^{10} - 2304x^8 + 1792x^6 - 560x^4 + 60x^2 - 1$ | $x^{10} = (42U_0 + 90U_2 + 75U_4 + 35U_6 + 9U_8 + U_{10})/1024$<br>$x^9 = (42U_1 + 48U_3 + 27U_5 + 8U_7 + U_9)/512$<br>$x^8 = (14U_0 + 28U_2 + 20U_4 + 7U_6 + U_8)/256$<br>$x^7 = (14U_1 + 14U_3 + 6U_5 + U_7)/128$<br>$x^6 = (5U_0 + 9U_2 + 5U_4 + U_6)/64$<br>$x^5 = (5U_1 + 4U_3 + U_5)/32$<br>$x^4 = (2U_0 + 3U_2 + U_4)/16$<br>$x^3 = (2U_1 + U_3)/8$<br>$x^2 = (U_0 + U_2)/4$<br>$x = (U_1)/2$<br>$1 = U_0$ |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## CLEBSCH-GORDAN COEFFICIENTS

$$\begin{aligned} \left( \begin{array}{cc|c} j_1 & j_2 & j \\ m_1 & m_2 & m \end{array} \right) &= \delta_{m, m_1+m_2} \sqrt{\frac{(j_1+j_2-j)!(j+j_1-j_2)!(j+j_2-j_1)!(2j+1)}{(j+j_1+j_2+1)!}} \\ &\times \sum_k \frac{(-1)^k \sqrt{(j_1+m_1)!(j_1-m_1)!(j_2+m_2)!(j_2-m_2)!(j+m)!(j-m)!}}{k!(j_1+j_2-j-k)!(j_1-m_1-k)!(j_2+m_2-k)!(j-j_2+m_1+k)!(j-j_1-m_2+k)!}. \end{aligned}$$

1. Conditions:

- (a) Each of  $\{j_1, j_2, j, m_1, m_2, m\}$  may be an integer, or half an integer. Additionally:  $j > 0$ ,  $j_1 > 0$ ,  $j_2 > 0$  and  $j + j_1 + j_2$  is an integer.
- (b)  $j_1 + j_2 - j \geq 0$ .
- (c)  $j_1 - j_2 + j \geq 0$ .
- (d)  $-j_1 + j_2 + j \geq 0$ .
- (e)  $|m_1| \leq j_1$ ,  $|m_2| \leq j_2$ ,  $|m| \leq j$ .

2. Special values:

- (a)  $\left( \begin{array}{cc|c} j_1 & j_2 & j \\ m_1 & m_2 & m \end{array} \right) = 0$  if  $m_1 + m_2 \neq m$ .
- (b)  $\left( \begin{array}{cc|c} j_1 & 0 & j \\ m_1 & 0 & m \end{array} \right) = \delta_{j_1, j} \delta_{m_1, m}$ .
- (c)  $\left( \begin{array}{cc|c} j_1 & j_2 & j \\ 0 & 0 & 0 \end{array} \right) = 0$  when  $j_1 + j_2 + j$  is an odd integer.
- (d)  $\left( \begin{array}{cc|c} j_1 & j_1 & j \\ m_1 & m_1 & m \end{array} \right) = 0$  when  $2j_1 + j$  is an odd integer.

3. Symmetry relations: all of the following are equal to  $\left( \begin{array}{cc|c} j_1 & j_2 & j \\ m_1 & m_2 & m \end{array} \right)$ :

- (a)  $\left( \begin{array}{cc|c} j_2 & j_1 & j \\ -m_2 & -m_1 & -m \end{array} \right),$
- (b)  $(-1)^{j_1+j_2-j} \left( \begin{array}{cc|c} j_2 & j_1 & j \\ m_1 & m_2 & m \end{array} \right),$
- (c)  $(-1)^{j_1+j_2-j} \left( \begin{array}{cc|c} j_1 & j_2 & j \\ -m_1 & -m_2 & -m \end{array} \right),$
- (d)  $\sqrt{\frac{2j+1}{2j_1+1}} (-1)^{j_2+m_2} \left( \begin{array}{cc|c} j & j_2 & j_1 \\ -m & m_2 & -m_1 \end{array} \right),$
- (e)  $\sqrt{\frac{2j+1}{2j_1+1}} (-1)^{j_1-m_1+j-m} \left( \begin{array}{cc|c} j & j_2 & j_1 \\ m & -m_2 & m_1 \end{array} \right),$
- (f)  $\sqrt{\frac{2j+1}{2j_1+1}} (-1)^{j-m+j_1-m_1} \left( \begin{array}{cc|c} j_2 & j & j_1 \\ m_2 & -m & -m_1 \end{array} \right),$
- (g)  $\sqrt{\frac{2j+1}{2j_2+1}} (-1)^{j_1-m_1} \left( \begin{array}{cc|c} j_1 & j & j_2 \\ m_1 & -m & -m_2 \end{array} \right),$
- (h)  $\sqrt{\frac{2j+1}{2j_2+1}} (-1)^{j_1-m_1} \left( \begin{array}{cc|c} j & j_1 & j_2 \\ m & -m_1 & m_2 \end{array} \right).$

By use of the symmetry relations, Clebsch–Gordan coefficients may be put in the standard form  $j_1 \leq j_2 \leq j$  and  $m \geq 0$ .

| $m_2$          | $m$           | $j_1$         | $j$           | $\left( \begin{array}{cc c} j_1 & \frac{1}{2} & j \\ m_1 & m_2 & m \end{array} \right)$ |
|----------------|---------------|---------------|---------------|-----------------------------------------------------------------------------------------|
| $-\frac{1}{2}$ | 0             | $\frac{1}{2}$ | 1             | $\frac{\sqrt{2}}{2} \approx 0.707107$                                                   |
| 0              | $\frac{1}{2}$ | $\frac{1}{2}$ | 1             | $\frac{\sqrt{3}}{2} \approx 0.866025$                                                   |
| $\frac{1}{2}$  | 0             | $\frac{1}{2}$ | 1             | $\frac{\sqrt{2}}{2} \approx 0.707107$                                                   |
| $\frac{1}{2}$  | $\frac{1}{2}$ | $\frac{1}{2}$ | 1             | $\frac{\sqrt{3}}{2} \approx 0.866025$                                                   |
| $\frac{1}{2}$  | 1             | $\frac{1}{2}$ | 1             | 1 $\approx 1.000000$                                                                    |
| $m_2$          | $m$           | $j_1$         | $j$           | $\left( \begin{array}{cc c} j_1 & 1 & j \\ m_1 & m_2 & m \end{array} \right)$           |
| -1             | 0             | 1             | 1             | $\frac{\sqrt{2}}{2} \approx 0.707107$                                                   |
| -1             | 0             | 1             | 2             | $\frac{\sqrt{6}}{6} \approx 0.408248$                                                   |
| $-\frac{1}{2}$ | 0             | $\frac{1}{2}$ | $\frac{3}{2}$ | $\frac{\sqrt{2}}{2} \approx 0.707107$                                                   |
| $-\frac{1}{2}$ | $\frac{1}{2}$ | 1             | 1             | $\frac{3}{4} \approx 0.750000$                                                          |
| $-\frac{1}{2}$ | $\frac{1}{2}$ | 1             | 2             | $\frac{\sqrt{5}}{4} \approx 0.559017$                                                   |
| 0              | 0             | 1             | 2             | $\frac{\sqrt{6}}{3} \approx 0.816496$                                                   |
| 0              | 0             | $\frac{1}{2}$ | $\frac{3}{2}$ | $\frac{\sqrt{3}}{2} \approx 0.866025$                                                   |
| 0              | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{3}{2}$ | $\frac{\sqrt{6}}{3} \approx 0.8164967$                                                  |
| 0              | $\frac{1}{2}$ | 1             | 1             | $\frac{\sqrt{2}}{4} \approx 0.353553$                                                   |
| 0              | $\frac{1}{2}$ | 1             | 2             | $\frac{\sqrt{10}}{4} \approx 0.790569$                                                  |
| 0              | 1             | 1             | 1             | $\frac{\sqrt{2}}{2} \approx 0.707107$                                                   |

| $m_2$         | $m$           | $j_1$         | $j$           | $\left( \begin{array}{cc c} j_1 & 1 & j \\ m_1 & m_2 & m \end{array} \right)$ |
|---------------|---------------|---------------|---------------|-------------------------------------------------------------------------------|
| 0             | 1             | 1             | 2             | $\frac{\sqrt{2}}{2} \approx 0.707107$                                         |
| $\frac{1}{2}$ | 0             | $\frac{1}{2}$ | $\frac{3}{2}$ | $\frac{\sqrt{2}}{2} \approx 0.707107$                                         |
| $\frac{1}{2}$ | $\frac{1}{2}$ | 1             | 1             | $-\frac{\sqrt{2}}{4} \approx -0.353553$                                       |
| $\frac{1}{2}$ | $\frac{1}{2}$ | 1             | 2             | $\frac{\sqrt{10}}{4} \approx 0.790569$                                        |
| $\frac{1}{2}$ | 1             | $\frac{1}{2}$ | $\frac{3}{2}$ | $\frac{\sqrt{30}}{6} \approx 0.912871$                                        |
| $\frac{1}{2}$ | $\frac{3}{2}$ | 1             | 2             | $\frac{\sqrt{105}}{12} \approx 0.853913$                                      |
| 1             | 0             | 1             | 1             | $-\frac{\sqrt{2}}{2} \approx -0.707107$                                       |
| 1             | 0             | 1             | 2             | $\frac{\sqrt{6}}{6} \approx 0.408248$                                         |
| 1             | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{3}{2}$ | $\frac{\sqrt{3}}{3} \approx 0.577350$                                         |
| 1             | $\frac{1}{2}$ | 1             | 1             | $-\frac{3}{4} \approx -0.750000$                                              |
| 1             | $\frac{1}{2}$ | 1             | 2             | $\frac{\sqrt{5}}{4} \approx 0.559017$                                         |
| 1             | 1             | $\frac{1}{2}$ | $\frac{3}{2}$ | $\frac{\sqrt{10}}{4} \approx 0.790569$                                        |
| 1             | 1             | 1             | 1             | $-\frac{\sqrt{2}}{2} \approx -0.707107$                                       |
| 1             | 1             | 1             | 2             | $\frac{\sqrt{2}}{2} \approx 0.707107$                                         |
| 1             | $\frac{3}{2}$ | $\frac{1}{2}$ | $\frac{3}{2}$ | 1 $\approx 1.000000$                                                          |
| 1             | $\frac{3}{2}$ | 1             | 2             | $\frac{\sqrt{105}}{12} \approx 0.853913$                                      |
| 1             | 2             | 1             | 2             | 1 $\approx 1.000000$                                                          |

## NORMAL PROBABILITY FUNCTION

**Table of the Normal Distribution**

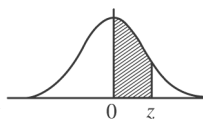
For a standard normal random variable ( $\Phi(z)$  is the area under the Standard Normal Curve from  $-\infty$  to  $z$ ).

| Limits                |                       | Proportion of<br>the total area | Remaining<br>area |
|-----------------------|-----------------------|---------------------------------|-------------------|
| $\mu - \lambda\sigma$ | $\mu + \lambda\sigma$ | (%)                             | (%)               |
| $\mu - \sigma$        | $\mu + \sigma$        | 68.27                           | 31.73             |
| $\mu - 1.65\sigma$    | $\mu + 1.65\sigma$    | 90                              | 10                |
| $\mu - 1.96\sigma$    | $\mu + 1.96\sigma$    | 95                              | 5                 |
| $\mu - 2\sigma$       | $\mu + 2\sigma$       | 95.45                           | 4.55              |
| $\mu - 2.58\sigma$    | $\mu + 2.58\sigma$    | 99.0                            | 0.99              |
| $\mu - 3\sigma$       | $\mu + 3\sigma$       | 99.73                           | 0.27              |
| $\mu - 3.09\sigma$    | $\mu + 3.09\sigma$    | 99.8                            | 0.2               |
| $\mu - 3.29\sigma$    | $\mu + 3.29\sigma$    | 99.9                            | 0.1               |

| $x$              | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 |
|------------------|-------|-------|-------|-------|-------|-------|
| $\Phi(x)$        | 0.90  | 0.95  | 0.975 | 0.99  | 0.995 | 0.999 |
| $2[1 - \Phi(x)]$ | 0.20  | 0.10  | 0.05  | 0.02  | 0.01  | 0.002 |

| $x$           | 3.09      | 3.72      | 4.26      | 4.75      | 5.20      | 5.61      | 6.00      | 6.36       |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| $1 - \Phi(x)$ | $10^{-3}$ | $10^{-4}$ | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ | $10^{-8}$ | $10^{-9}$ | $10^{-10}$ |





Areas under the Standard Normal Curve from 0 to z

| z   | 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0.0 | .0000 | .0040 | .0080 | .0120 | .0160 | .0199 | .0239 | .0279 | .0319 | .0359 |
| 0.1 | .0398 | .0438 | .0478 | .0517 | .0557 | .0596 | .0636 | .0675 | .0714 | .0754 |
| 0.2 | .0793 | .0832 | .0871 | .0910 | .0948 | .0987 | .1026 | .1064 | .1103 | .1141 |
| 0.3 | .1179 | .1217 | .1255 | .1293 | .1331 | .1368 | .1406 | .1443 | .1480 | .1517 |
| 0.4 | .1554 | .1591 | .1628 | .1664 | .1700 | .1736 | .1772 | .1808 | .1844 | .1879 |
| 0.5 | .1915 | .1950 | .1985 | .2019 | .2054 | .2088 | .2123 | .2157 | .2190 | .2224 |
| 0.6 | .2258 | .2291 | .2324 | .2357 | .2389 | .2422 | .2454 | .2486 | .2518 | .2549 |
| 0.7 | .2580 | .2612 | .2652 | .2673 | .2704 | .2734 | .2764 | .2794 | .2823 | .2852 |
| 0.8 | .2881 | .2910 | .2939 | .2967 | .2996 | .3023 | .3051 | .3078 | .3106 | .3133 |
| 0.9 | .3159 | .3186 | .3212 | .3238 | .3264 | .3289 | .3315 | .3340 | .3365 | .3389 |
| 1.0 | .3413 | .3438 | .3461 | .3485 | .3508 | .3531 | .3554 | .3577 | .3599 | .3621 |
| 1.1 | .3643 | .3665 | .3686 | .3708 | .3729 | .3749 | .3770 | .3790 | .3810 | .3830 |
| 1.2 | .3849 | .3869 | .3888 | .3907 | .3925 | .3944 | .3962 | .3980 | .3997 | .4015 |
| 1.3 | .4032 | .4049 | .4066 | .4082 | .4099 | .4115 | .4131 | .4147 | .4162 | .4177 |
| 1.4 | .4192 | .4207 | .4222 | .4236 | .4251 | .4265 | .4279 | .4292 | .4306 | .4319 |
| 1.5 | .4332 | .4345 | .4357 | .4370 | .4382 | .4394 | .4406 | .4418 | .4429 | .4441 |
| 1.6 | .4452 | .4463 | .4474 | .4484 | .4495 | .4505 | .4515 | .4525 | .4535 | .4545 |
| 1.7 | .4554 | .4564 | .4573 | .4582 | .4591 | .4599 | .4608 | .4616 | .4625 | .4633 |
| 1.8 | .4641 | .4649 | .4656 | .4664 | .4671 | .4678 | .4686 | .4693 | .4699 | .4706 |
| 1.9 | .4713 | .4719 | .4726 | .4732 | .4738 | .4744 | .4750 | .4756 | .4761 | .4767 |
| 2.0 | .4772 | .4778 | .4783 | .4788 | .4793 | .4798 | .4803 | .4808 | .4812 | .4817 |
| 2.1 | .4821 | .4826 | .4830 | .4834 | .4838 | .4842 | .4846 | .4850 | .4854 | .4857 |
| 2.2 | .4861 | .4864 | .4868 | .4871 | .4875 | .4878 | .4881 | .4884 | .4887 | .4890 |
| 2.3 | .4893 | .4896 | .4898 | .4901 | .4904 | .4906 | .4909 | .4911 | .4913 | .4916 |
| 2.4 | .4918 | .4920 | .4922 | .4925 | .4927 | .4929 | .4931 | .4932 | .4934 | .4936 |
| 2.5 | .4938 | .4940 | .4941 | .4943 | .4945 | .4946 | .4948 | .4949 | .4951 | .4952 |
| 2.6 | .4953 | .4955 | .4956 | .4957 | .4959 | .4960 | .4961 | .4962 | .4963 | .4964 |
| 2.7 | .4965 | .4966 | .4967 | .4968 | .4969 | .4970 | .4971 | .4972 | .4973 | .4974 |
| 2.8 | .4974 | .4975 | .4976 | .4977 | .4977 | .4978 | .4979 | .4979 | .4980 | .4981 |
| 2.9 | .4981 | .4982 | .4982 | .4983 | .4984 | .4984 | .4985 | .4985 | .4986 | .4986 |
| 3.0 | .4987 | .4987 | .4987 | .4988 | .4988 | .4989 | .4989 | .4989 | .4990 | .4990 |
| 3.1 | .4990 | .4991 | .4991 | .4991 | .4992 | .4992 | .4992 | .4992 | .4993 | .4993 |
| 3.2 | .4993 | .4993 | .4994 | .4994 | .4994 | .4994 | .4994 | .4995 | .4995 | .4995 |
| 3.3 | .4995 | .4995 | .4995 | .4996 | .4996 | .4996 | .4996 | .4996 | .4996 | .4997 |
| 3.4 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4997 | .4998 |
| 3.5 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 | .4998 |
| 3.6 | .4998 | .4998 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 |
| 3.7 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 |
| 3.8 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 | .4999 |
| 3.9 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 | .5000 |

## Common sample size calculations

| Parameter       | Estimate                | Sample size                                                          |
|-----------------|-------------------------|----------------------------------------------------------------------|
| $\mu$           | $\bar{x}$               | $n = \left( \frac{z_{\alpha/2} \cdot \sigma}{E} \right)^2$           |
| $p$             | $\hat{p}$               | $n = \frac{(z_{\alpha/2})^2 \cdot pq}{E^2}$                          |
| $\mu_1 - \mu_2$ | $\bar{x}_1 - \bar{x}_2$ | $n_1 = n_2 = \frac{(z_{\alpha/2})^2 (\sigma_1^2 + \sigma_2^2)}{E^2}$ |
| $p_1 - p_2$     | $\hat{p}_1 - \hat{p}_2$ | $n_1 = n_2 = \frac{(z_{\alpha/2})^2 (p_1 q_1 + p_2 q_2)}{E^2}$       |

## Common one-sample confidence intervals

| Parameter  | Assumptions                                                 | 100(1 - $\alpha$ )% Confidence interval                                                             |
|------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| $\mu$      | $n$ large, $\sigma^2$ known, or normality, $\sigma^2$ known | $\bar{x} \pm z_{\alpha/2} \cdot \frac{\sigma}{\sqrt{n}}$                                            |
| $\mu$      | normality, $\sigma^2$ unknown                               | $\bar{x} \pm t_{\alpha/2, n-1} \cdot \frac{s}{\sqrt{n}}$                                            |
| $\sigma^2$ | normality                                                   | $\left( \frac{(n-1)s^2}{\chi_{\alpha/2, n-1}^2}, \frac{(n-1)s^2}{\chi_{1-\alpha/2, n-1}^2} \right)$ |
| $p$        | binomial experiment, $n$ large                              | $\hat{p} \pm z_{\alpha/2} \cdot \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$                                |

## Common two-sample confidence intervals

| Parameter       | Assumptions                                                                                                               | 100(1 - $\alpha$ )% Confidence interval                                                                                                                                                                                                  |
|-----------------|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\mu_1 - \mu_2$ | normality, independence, $\sigma_1^2, \sigma_2^2$ known or $n_1, n_2$ large, independence, $\sigma_1^2, \sigma_2^2$ known | $(\bar{x}_1 - \bar{x}_2) \pm z_{\alpha/2} \cdot \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$                                                                                                                                  |
| $\mu_1 - \mu_2$ | normality, independence, $\sigma_1^2 = \sigma_2^2$ unknown                                                                | $(\bar{x}_1 - \bar{x}_2) \pm t_{\alpha/2, n_1+n_2-2} \cdot s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$<br>$s_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}$                                                                          |
| $\mu_1 - \mu_2$ | normality, independence, $\sigma_1^2 \neq \sigma_2^2$ unknown                                                             | $(\bar{x}_1 - \bar{x}_2) \pm t_{\alpha/2, v} \cdot \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$<br>$v \approx \frac{\left( \frac{s_1^2}{n_1} + \frac{s_2^2}{n_2} \right)^2}{\frac{(s_1^2/n_1)^2}{n_1-1} + \frac{(s_2^2/n_2)^2}{n_2-1}}$ |
| $\mu_1 - \mu_2$ | normality, $n$ pairs, dependence                                                                                          | $\bar{d} \pm t_{\alpha/2, n-1} \cdot \frac{s_d}{\sqrt{n}}$                                                                                                                                                                               |
| $p_1 - p_2$     | binomial experiments, $n_1, n_2$ large, independence                                                                      | $(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2} \cdot \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$                                                                                                          |

## PERCENTAGE POINTS, STUDENT'S $T$ -DISTRIBUTION

This table gives values of  $t$  such that

$$F(t) = \int_{-\infty}^t \frac{\Gamma\left(\frac{n+1}{2}\right)}{\sqrt{n\pi}\Gamma\left(\frac{n}{2}\right)} \left(1 + \frac{x^2}{n}\right)^{-\frac{n+1}{2}} dx$$

for  $n$ , the number of degrees of freedom, equal to 1, 2, ..., 30, 40, 60, 120,  $\infty$ ; and for  $F(t) = 0.60, 0.75, 0.90, 0.95, 0.975, 0.99, 0.995$ , and  $0.9995$ . The  $t$ -distribution is symmetrical, so that  $F(-t) = 1 - F(t)$

| $n/F$    | .60  | .75   | .90   | .95   | .975   | .99    | .995   | .9995   |
|----------|------|-------|-------|-------|--------|--------|--------|---------|
| 1        | .325 | 1.000 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 | 636.619 |
| 2        | .289 | .816  | 1.886 | 2.920 | 4.303  | 6.965  | 9.925  | 31.598  |
| 3        | .277 | .765  | 1.638 | 2.353 | 3.182  | 4.541  | 5.841  | 12.924  |
| 4        | .271 | .741  | 1.533 | 2.132 | 2.776  | 3.747  | 4.604  | 8.610   |
| 5        | .267 | .727  | 1.476 | 2.015 | 2.571  | 3.365  | 4.032  | 6.869   |
| 6        | .265 | .718  | 1.440 | 1.943 | 2.447  | 3.143  | 3.707  | 5.959   |
| 7        | .263 | .711  | 1.415 | 1.895 | 2.365  | 2.998  | 3.499  | 5.408   |
| 8        | .262 | .706  | 1.397 | 1.860 | 2.306  | 2.896  | 3.355  | 5.041   |
| 9        | .261 | .703  | 1.383 | 1.833 | 2.262  | 2.821  | 3.250  | 4.781   |
| 10       | .260 | .700  | 1.372 | 1.812 | 2.228  | 2.764  | 3.169  | 4.587   |
| 11       | .260 | .697  | 1.363 | 1.796 | 2.201  | 2.718  | 3.106  | 4.437   |
| 12       | .259 | .695  | 1.356 | 1.782 | 2.179  | 2.681  | 3.055  | 4.318   |
| 13       | .259 | .694  | 1.350 | 1.771 | 2.160  | 2.650  | 3.012  | 4.221   |
| 14       | .258 | .692  | 1.345 | 1.761 | 2.145  | 2.624  | 2.977  | 4.140   |
| 15       | .258 | .691  | 1.341 | 1.753 | 2.131  | 2.602  | 2.947  | 4.073   |
| 16       | .258 | .690  | 1.337 | 1.746 | 2.120  | 2.583  | 2.921  | 4.015   |
| 17       | .257 | .689  | 1.333 | 1.740 | 2.110  | 2.567  | 2.898  | 3.965   |
| 18       | .257 | .688  | 1.330 | 1.734 | 2.101  | 2.552  | 2.878  | 3.922   |
| 19       | .257 | .688  | 1.328 | 1.729 | 2.093  | 2.539  | 2.861  | 3.883   |
| 20       | .257 | .687  | 1.325 | 1.725 | 2.086  | 2.528  | 2.845  | 3.850   |
| 21       | .257 | .686  | 1.323 | 1.721 | 2.080  | 2.518  | 2.831  | 3.819   |
| 22       | .256 | .686  | 1.321 | 1.717 | 2.074  | 2.508  | 2.819  | 3.792   |
| 23       | .256 | .685  | 1.319 | 1.714 | 2.069  | 2.500  | 2.807  | 3.767   |
| 24       | .256 | .685  | 1.318 | 1.711 | 2.064  | 2.492  | 2.797  | 3.745   |
| 25       | .256 | .684  | 1.316 | 1.708 | 2.060  | 2.485  | 2.787  | 3.725   |
| 26       | .256 | .684  | 1.315 | 1.706 | 2.056  | 2.479  | 2.779  | 3.707   |
| 27       | .256 | .684  | 1.314 | 1.703 | 2.052  | 2.473  | 2.771  | 3.690   |
| 28       | .256 | .683  | 1.313 | 1.701 | 2.048  | 2.467  | 2.763  | 3.674   |
| 29       | .256 | .683  | 1.311 | 1.699 | 2.045  | 2.462  | 2.756  | 3.659   |
| 30       | .256 | .683  | 1.310 | 1.697 | 2.042  | 2.457  | 2.750  | 3.646   |
| 40       | .255 | .681  | 1.303 | 1.684 | 2.021  | 2.423  | 2.704  | 3.551   |
| 60       | .254 | .679  | 1.296 | 1.671 | 2.000  | 2.390  | 2.660  | 3.460   |
| 120      | .254 | .677  | 1.289 | 1.658 | 1.980  | 2.358  | 2.617  | 3.373   |
| $\infty$ | .253 | .674  | 1.282 | 1.645 | 1.960  | 2.326  | 2.576  | 3.291   |

\*This table is abridged from the *Statistical Tables* by R. A. Fisher and Frank Yates published by Oliver & Boyd, Ltd., Edinburgh and London, 1938. It is published here with the kind permission of the authors and their publishers.

## PERCENTAGE POINTS, CHI-SQUARE DISTRIBUTION

This table gives values of  $\chi^2$  such that

$$F(\chi)^2 = \int_0^{\chi^2} \frac{1}{2^{n/2} \Gamma(\frac{n}{2})} x^{(n-2)/2} e^{-x/2} dx$$

for  $n$ , the number of degrees of freedom, equal to 1, 2, ..., 30. For  $n > 30$ , a normal approximation is quite accurate. The expression  $\sqrt{2x^2} - \sqrt{2n-1}$  is approximately normally distributed as the standard normal distribution. Thus  $\chi_\alpha^2$ , the  $\alpha$ -point of the distribution, may be computed by the formula

$$\chi_\alpha^2 = \frac{1}{2} [x_\alpha + \sqrt{2n-1}]^2,$$

where  $x_\alpha$  is the  $\alpha$ -point of the cumulative normal distribution. For even values of  $n$ ,  $F(\chi^2)$  can be written as

$$1 - F(\chi^2) = \sum_{x=0}^{x'-1} \frac{e^{-\lambda} \lambda^x}{x!}$$

with  $\lambda = \frac{1}{2}\chi^2$  and  $x' = \frac{1}{2}n$ . Thus the cumulative chi-square distribution is related to the cumulative Poisson distribution.

Another approximate formula for large  $n$

$$\chi_\alpha^2 = n \left( 1 - \frac{2}{9n} + z_\alpha \sqrt{\frac{2}{9n}} \right)^3$$

$n$  = degrees of freedom

$z_\alpha$  = the normal deviate (the value of  $x$  for which  $F(x)$  = the desired percentile).

|        |       |       |       |       |       |       |
|--------|-------|-------|-------|-------|-------|-------|
| $x$    | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 |
| $F(x)$ | .90   | .95   | .975  | .99   | .995  | .999  |

$\chi_{.99}^2 = 60[1 - 0.00370 + 2.326(0.06086)]^3 = 88.4$  is the 99th percentile for 60 degrees of freedom.

$$F(\chi^2) = \int_0^{\chi^2} \frac{1}{2^{n/2} \Gamma(\frac{n}{2})} x^{n-2/2} e^{-x/2} dx$$

| $n \backslash F$ | .005     | .010    | .025    | .050   | .100  | .250 | .500 | .750 | .900 | .950 | .975 | .990 | .995 |
|------------------|----------|---------|---------|--------|-------|------|------|------|------|------|------|------|------|
| 1                | .0000393 | .000157 | .000982 | .00393 | .0158 | .102 | .455 | 1.32 | 2.71 | 3.84 | 5.02 | 6.63 | 7.88 |
| 2                | .0100    | .0201   | .0506   | .103   | .211  | .575 | 1.39 | 2.77 | 4.61 | 5.99 | 7.38 | 9.21 | 10.6 |
| 3                | .0717    | .115    | .216    | .352   | .584  | 1.21 | 2.37 | 4.11 | 6.25 | 7.81 | 9.35 | 11.3 | 12.8 |
| 4                | .207     | .297    | .484    | .711   | 1.06  | 1.92 | 3.36 | 5.39 | 7.78 | 9.49 | 11.1 | 13.3 | 14.9 |
| 5                | .412     | .554    | .831    | 1.15   | 1.61  | 2.67 | 4.35 | 6.63 | 9.24 | 11.1 | 12.8 | 15.1 | 16.7 |
| 6                | .676     | .872    | 1.24    | 1.64   | 2.20  | 3.45 | 5.35 | 7.84 | 10.6 | 12.6 | 14.4 | 16.8 | 18.5 |
| 7                | .989     | 1.24    | 1.69    | 2.17   | 2.83  | 4.25 | 6.35 | 9.04 | 12.0 | 14.1 | 16.0 | 18.5 | 20.3 |
| 8                | 1.34     | 1.65    | 2.18    | 2.73   | 3.49  | 5.07 | 7.34 | 10.2 | 13.4 | 15.5 | 17.5 | 20.1 | 22.0 |
| 9                | 1.73     | 2.09    | 2.70    | 3.33   | 4.17  | 5.90 | 8.34 | 11.4 | 14.7 | 16.9 | 19.0 | 21.7 | 23.6 |
| 10               | 2.16     | 2.56    | 3.25    | 3.94   | 4.87  | 6.74 | 9.34 | 12.5 | 16.0 | 18.3 | 20.5 | 23.2 | 25.2 |
| 11               | 2.60     | 3.05    | 3.82    | 4.57   | 5.58  | 7.58 | 10.3 | 13.7 | 17.3 | 19.7 | 21.9 | 24.7 | 26.8 |
| 12               | 3.07     | 3.57    | 4.40    | 5.23   | 6.30  | 8.44 | 11.3 | 14.8 | 18.5 | 21.0 | 23.3 | 26.2 | 28.3 |
| 13               | 3.57     | 4.11    | 5.01    | 5.89   | 7.04  | 9.30 | 12.3 | 16.0 | 19.8 | 22.4 | 24.7 | 27.7 | 29.8 |
| 14               | 4.07     | 4.66    | 5.63    | 6.57   | 7.79  | 10.2 | 13.3 | 17.1 | 21.1 | 23.7 | 26.1 | 29.1 | 31.3 |
| 15               | 4.60     | 5.23    | 6.26    | 7.26   | 8.55  | 11.0 | 14.3 | 18.2 | 22.3 | 25.0 | 27.5 | 30.6 | 32.8 |
| 16               | 5.14     | 5.81    | 6.91    | 7.96   | 9.31  | 11.9 | 15.3 | 19.4 | 23.5 | 26.3 | 28.8 | 32.0 | 34.3 |
| 17               | 5.70     | 6.41    | 7.56    | 8.67   | 10.1  | 12.8 | 16.3 | 20.5 | 24.8 | 27.6 | 30.2 | 33.4 | 35.7 |
| 18               | 6.26     | 7.01    | 8.23    | 9.39   | 10.9  | 13.7 | 17.3 | 21.6 | 26.0 | 28.9 | 31.5 | 34.8 | 37.2 |
| 19               | 6.84     | 7.63    | 8.91    | 10.1   | 11.7  | 14.6 | 18.3 | 22.7 | 27.2 | 30.1 | 32.9 | 36.2 | 38.6 |
| 20               | 7.43     | 8.26    | 9.59    | 10.9   | 12.4  | 15.5 | 19.3 | 23.8 | 28.4 | 31.4 | 34.2 | 37.6 | 40.0 |
| 21               | 8.03     | 8.90    | 10.3    | 11.6   | 13.2  | 16.3 | 20.3 | 24.9 | 29.6 | 32.7 | 35.5 | 38.9 | 41.4 |
| 22               | 8.64     | 9.54    | 11.0    | 12.3   | 14.0  | 17.2 | 21.3 | 26.0 | 30.8 | 33.9 | 36.8 | 40.3 | 42.8 |
| 23               | 9.26     | 10.2    | 11.7    | 13.1   | 14.8  | 18.1 | 22.3 | 27.1 | 32.0 | 35.2 | 38.1 | 41.6 | 44.2 |
| 24               | 9.89     | 10.9    | 12.4    | 13.8   | 15.7  | 19.0 | 23.3 | 28.2 | 33.2 | 36.4 | 39.4 | 43.0 | 45.6 |
| 25               | 10.5     | 11.5    | 13.1    | 14.6   | 16.5  | 19.9 | 24.3 | 29.3 | 34.4 | 37.7 | 40.6 | 44.3 | 46.9 |
| 26               | 11.2     | 12.2    | 13.8    | 15.4   | 17.3  | 20.8 | 25.3 | 30.4 | 35.6 | 38.9 | 41.9 | 45.6 | 48.3 |
| 27               | 11.8     | 12.9    | 14.6    | 16.2   | 18.1  | 21.7 | 26.3 | 31.5 | 36.7 | 40.1 | 43.2 | 47.0 | 49.6 |
| 28               | 12.5     | 12.6    | 15.3    | 16.9   | 18.9  | 22.7 | 27.3 | 32.6 | 37.9 | 41.3 | 44.5 | 48.3 | 51.0 |
| 29               | 13.1     | 14.3    | 16.0    | 17.7   | 19.8  | 23.6 | 28.3 | 33.7 | 39.1 | 42.6 | 45.7 | 49.6 | 52.3 |
| 30               | 13.8     | 15.0    | 16.8    | 18.5   | 20.6  | 24.5 | 29.3 | 34.8 | 40.3 | 43.8 | 47.0 | 50.9 | 53.7 |

## PERCENTAGE POINTS, $F$ -DISTRIBUTION

This table gives values of  $F$  such that

$$F(F) = \int_0^F \frac{\Gamma\left(\frac{m+n}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{n}{2}\right)} m^{m/2} n^{n/2} x^{m-2/2} (n+mx)^{-(m+n)/2} dx$$

for selected values of  $m$ , the number of degrees of freedom of the numerator of  $F$ ; and for selected values of  $n$ , the number of degrees of freedom of the denominator of  $F$ . The table also provides values corresponding to  $F(F) = .10, .05, .025, .01, .005, .001$  since  $F_{1-\alpha}$  for  $m$  and  $n$  degrees of freedom is the reciprocal of  $F_\alpha$  for  $n$  and  $m$  degrees of freedom. Thus

$$F_{.05}(4, 7) = \frac{1}{F_{.95}(7, 4)} = \frac{1}{6.09} = .164$$

$$F(F) = \int_0^F \frac{\Gamma\left(\frac{m+n}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{n}{2}\right)} m^{m/2} n^{n/2} x^{(m/2)-1} (n+mx)^{-(m+n)/2} dx = .90$$

| $n \backslash m$ | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 12    | 15    | 20    | 24    | 30    | 40    | 60    | 120   | $\infty$ |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
| 1                | 39.86 | 49.50 | 53.59 | 55.83 | 57.24 | 58.20 | 58.91 | 59.44 | 59.86 | 60.19 | 60.71 | 61.22 | 61.74 | 62.00 | 62.26 | 62.53 | 62.79 | 63.06 | 63.33    |
| 2                | 8.53  | 9.00  | 9.16  | 9.24  | 9.29  | 9.33  | 9.35  | 9.37  | 9.38  | 9.39  | 9.41  | 9.42  | 9.44  | 9.45  | 9.46  | 9.47  | 9.47  | 9.48  | 9.49     |
| 3                | 5.54  | 5.46  | 5.39  | 5.34  | 5.31  | 5.28  | 5.27  | 5.25  | 5.24  | 5.23  | 5.22  | 5.20  | 5.18  | 5.18  | 5.17  | 5.16  | 5.15  | 5.14  | 5.13     |
| 4                | 4.54  | 4.32  | 4.19  | 4.11  | 4.05  | 4.01  | 3.98  | 3.95  | 3.94  | 3.92  | 3.90  | 3.87  | 3.84  | 3.83  | 3.82  | 3.80  | 3.79  | 3.78  | 3.76     |
| 5                | 4.06  | 3.78  | 3.62  | 3.52  | 3.45  | 3.40  | 3.37  | 3.34  | 3.32  | 3.30  | 3.27  | 3.24  | 3.21  | 3.19  | 3.17  | 3.16  | 3.14  | 3.12  | 3.10     |
| 6                | 3.78  | 3.46  | 3.29  | 3.18  | 3.11  | 3.05  | 3.01  | 2.98  | 2.96  | 2.94  | 2.90  | 2.87  | 2.84  | 2.82  | 2.80  | 2.78  | 2.76  | 2.74  | 2.72     |
| 7                | 3.59  | 3.26  | 3.07  | 2.96  | 2.88  | 2.83  | 2.78  | 2.75  | 2.72  | 2.70  | 2.67  | 2.63  | 2.59  | 2.58  | 2.56  | 2.54  | 2.51  | 2.49  | 2.47     |
| 8                | 3.46  | 3.11  | 2.92  | 2.81  | 2.73  | 2.67  | 2.62  | 2.59  | 2.56  | 2.54  | 2.50  | 2.46  | 2.42  | 2.40  | 2.38  | 2.36  | 2.34  | 2.32  | 2.29     |
| 9                | 3.36  | 3.01  | 2.81  | 2.69  | 2.61  | 2.55  | 2.51  | 2.47  | 2.44  | 2.42  | 2.38  | 2.34  | 2.30  | 2.28  | 2.25  | 2.23  | 2.21  | 2.18  | 2.16     |
| 10               | 3.29  | 2.92  | 2.73  | 2.61  | 2.52  | 2.46  | 2.41  | 2.38  | 2.35  | 2.32  | 2.28  | 2.24  | 2.20  | 2.18  | 2.16  | 2.13  | 2.11  | 2.08  | 2.06     |
| 11               | 3.23  | 2.86  | 2.66  | 2.54  | 2.45  | 2.39  | 2.34  | 2.30  | 2.27  | 2.25  | 2.21  | 2.17  | 2.12  | 2.10  | 2.08  | 2.05  | 2.03  | 2.00  | 1.97     |
| 12               | 3.18  | 2.81  | 2.61  | 2.48  | 2.39  | 2.33  | 2.28  | 2.24  | 2.21  | 2.19  | 2.15  | 2.10  | 2.06  | 2.04  | 2.01  | 1.99  | 1.96  | 1.93  | 1.90     |
| 13               | 3.14  | 2.76  | 2.56  | 2.43  | 2.35  | 2.28  | 2.23  | 2.20  | 2.16  | 2.14  | 2.10  | 2.05  | 2.01  | 1.98  | 1.96  | 1.93  | 1.90  | 1.88  | 1.85     |
| 14               | 3.10  | 2.73  | 2.52  | 2.39  | 2.31  | 2.24  | 2.19  | 2.15  | 2.12  | 2.10  | 2.05  | 2.01  | 1.96  | 1.94  | 1.91  | 1.89  | 1.86  | 1.83  | 1.80     |
| 15               | 3.07  | 2.70  | 2.49  | 2.36  | 2.27  | 2.21  | 2.16  | 2.12  | 2.09  | 2.06  | 2.02  | 1.97  | 1.92  | 1.90  | 1.87  | 1.85  | 1.82  | 1.79  | 1.76     |
| 16               | 3.05  | 2.67  | 2.46  | 2.33  | 2.24  | 2.18  | 2.13  | 2.09  | 2.06  | 2.03  | 1.99  | 1.94  | 1.89  | 1.87  | 1.84  | 1.81  | 1.78  | 1.75  | 1.72     |
| 17               | 3.03  | 2.64  | 2.44  | 2.31  | 2.22  | 2.15  | 2.10  | 2.06  | 2.03  | 2.00  | 1.96  | 1.91  | 1.86  | 1.84  | 1.81  | 1.78  | 1.75  | 1.72  | 1.69     |
| 18               | 3.01  | 2.62  | 2.42  | 2.29  | 2.20  | 2.13  | 2.08  | 2.04  | 2.00  | 1.98  | 1.93  | 1.89  | 1.84  | 1.81  | 1.78  | 1.75  | 1.72  | 1.69  | 1.66     |
| 19               | 2.99  | 2.61  | 2.40  | 2.27  | 2.18  | 2.11  | 2.06  | 2.02  | 1.98  | 1.96  | 1.91  | 1.86  | 1.81  | 1.79  | 1.76  | 1.73  | 1.70  | 1.67  | 1.63     |
| 20               | 2.97  | 2.59  | 2.38  | 2.25  | 2.16  | 2.09  | 2.04  | 2.00  | 1.96  | 1.94  | 1.89  | 1.84  | 1.79  | 1.77  | 1.74  | 1.71  | 1.68  | 1.64  | 1.61     |
| 21               | 2.96  | 2.57  | 2.36  | 2.23  | 2.14  | 2.08  | 2.02  | 1.98  | 1.95  | 1.92  | 1.87  | 1.83  | 1.78  | 1.75  | 1.72  | 1.69  | 1.66  | 1.62  | 1.59     |
| 22               | 2.95  | 2.56  | 2.35  | 2.22  | 2.13  | 2.06  | 2.01  | 1.97  | 1.93  | 1.90  | 1.86  | 1.81  | 1.76  | 1.73  | 1.70  | 1.67  | 1.64  | 1.60  | 1.57     |
| 23               | 2.94  | 2.55  | 2.34  | 2.21  | 2.11  | 2.05  | 1.99  | 1.95  | 1.92  | 1.89  | 1.84  | 1.80  | 1.74  | 1.72  | 1.69  | 1.66  | 1.62  | 1.59  | 1.55     |
| 24               | 2.93  | 2.54  | 2.33  | 2.19  | 2.10  | 2.04  | 1.98  | 1.94  | 1.91  | 1.88  | 1.83  | 1.78  | 1.73  | 1.70  | 1.67  | 1.64  | 1.61  | 1.57  | 1.53     |
| 25               | 2.92  | 2.53  | 2.32  | 2.18  | 2.09  | 2.02  | 1.97  | 1.93  | 1.89  | 1.87  | 1.82  | 1.77  | 1.72  | 1.69  | 1.66  | 1.63  | 1.59  | 1.56  | 1.52     |
| 26               | 2.91  | 2.52  | 2.31  | 2.17  | 2.08  | 2.01  | 1.96  | 1.92  | 1.88  | 1.86  | 1.81  | 1.76  | 1.71  | 1.68  | 1.65  | 1.61  | 1.58  | 1.54  | 1.50     |
| 27               | 2.90  | 2.51  | 2.30  | 2.17  | 2.07  | 2.00  | 1.95  | 1.91  | 1.87  | 1.85  | 1.80  | 1.75  | 1.70  | 1.67  | 1.64  | 1.60  | 1.57  | 1.53  | 1.49     |
| 28               | 2.89  | 2.50  | 2.29  | 2.16  | 2.06  | 2.00  | 1.94  | 1.90  | 1.87  | 1.84  | 1.79  | 1.74  | 1.69  | 1.66  | 1.63  | 1.59  | 1.56  | 1.52  | 1.48     |
| 29               | 2.89  | 2.50  | 2.28  | 2.15  | 2.06  | 1.99  | 1.93  | 1.89  | 1.86  | 1.83  | 1.78  | 1.73  | 1.68  | 1.65  | 1.62  | 1.58  | 1.55  | 1.51  | 1.47     |
| 30               | 2.88  | 2.49  | 2.28  | 2.14  | 2.05  | 1.98  | 1.93  | 1.88  | 1.85  | 1.82  | 1.77  | 1.72  | 1.67  | 1.64  | 1.61  | 1.57  | 1.54  | 1.50  | 1.46     |
| 40               | 2.84  | 2.44  | 2.23  | 2.09  | 2.00  | 1.93  | 1.87  | 1.83  | 1.79  | 1.76  | 1.71  | 1.66  | 1.61  | 1.57  | 1.54  | 1.51  | 1.47  | 1.42  | 1.38     |
| 60               | 2.79  | 2.39  | 2.18  | 2.04  | 1.95  | 1.87  | 1.82  | 1.77  | 1.74  | 1.71  | 1.66  | 1.60  | 1.54  | 1.51  | 1.48  | 1.44  | 1.40  | 1.35  | 1.29     |
| 120              | 2.75  | 2.35  | 2.13  | 1.99  | 1.90  | 1.82  | 1.77  | 1.72  | 1.68  | 1.65  | 1.60  | 1.55  | 1.48  | 1.45  | 1.41  | 1.37  | 1.32  | 1.26  | 1.19     |
| $\infty$         | 2.71  | 2.30  | 2.08  | 1.94  | 1.85  | 1.77  | 1.72  | 1.67  | 1.63  | 1.60  | 1.55  | 1.49  | 1.42  | 1.38  | 1.34  | 1.30  | 1.24  | 1.17  | 1.00     |

$F = \frac{s_1^2}{s_2^2} = \frac{S_1/m}{S_2/n}$ , where  $s_1^2 = S_1/m$  and  $s_2^2 = S_2/n$  are independent mean squares estimating a common variance  $\sigma^2$  and based on  $m$  and  $n$  degrees of freedom, respectively.

$$F(F) = \int_0^F \frac{\Gamma\left(\frac{m+n}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{n}{2}\right)} m^{m/2} n^{n/2} x^{(m/2)-1} (n+mx)^{-(m+n)/2} dx = .95$$

| $n \backslash m$ | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 12    | 15    | 20    | 24    | 30    | 40    | 60    | 120   | $\infty$ |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
| 1                | 161.4 | 199.5 | 215.7 | 224.6 | 230.2 | 234.0 | 236.8 | 238.9 | 240.5 | 241.9 | 243.9 | 245.9 | 248.0 | 249.1 | 250.1 | 251.1 | 252.2 | 253.3 | 254.3    |
| 2                | 18.51 | 19.00 | 19.16 | 19.25 | 19.30 | 19.33 | 19.35 | 19.37 | 19.38 | 19.40 | 19.41 | 19.43 | 19.45 | 19.45 | 19.46 | 19.47 | 19.48 | 19.49 | 19.50    |
| 3                | 10.13 | 9.55  | 9.28  | 9.12  | 9.01  | 8.94  | 8.89  | 8.85  | 8.81  | 8.79  | 8.74  | 8.70  | 8.66  | 8.64  | 8.62  | 8.59  | 8.57  | 8.55  | 8.53     |
| 4                | 7.71  | 6.94  | 6.59  | 6.39  | 6.26  | 6.16  | 6.09  | 6.04  | 6.00  | 5.96  | 5.91  | 5.86  | 5.80  | 5.77  | 5.75  | 5.72  | 5.69  | 5.66  | 5.63     |
| 5                | 6.61  | 5.79  | 5.41  | 5.19  | 5.05  | 4.95  | 4.88  | 4.82  | 4.77  | 4.74  | 4.68  | 4.62  | 4.56  | 4.53  | 4.50  | 4.46  | 4.43  | 4.40  | 4.36     |
| 6                | 5.99  | 5.14  | 4.76  | 4.53  | 4.39  | 4.28  | 4.21  | 4.15  | 4.10  | 4.06  | 4.00  | 3.94  | 3.87  | 3.84  | 3.81  | 3.77  | 3.74  | 3.70  | 3.67     |
| 7                | 5.59  | 4.74  | 4.35  | 4.12  | 3.97  | 3.87  | 3.79  | 3.73  | 3.68  | 3.64  | 3.57  | 3.51  | 3.44  | 3.41  | 3.38  | 3.34  | 3.30  | 3.27  | 3.23     |
| 8                | 5.32  | 4.46  | 4.07  | 3.84  | 3.69  | 3.58  | 3.50  | 3.44  | 3.39  | 3.35  | 3.28  | 3.22  | 3.15  | 3.12  | 3.08  | 3.04  | 3.01  | 2.97  | 2.93     |
| 9                | 5.12  | 4.26  | 3.86  | 3.63  | 3.48  | 3.37  | 3.29  | 3.23  | 3.18  | 3.14  | 3.07  | 3.01  | 2.94  | 2.90  | 2.86  | 2.83  | 2.79  | 2.75  | 2.71     |
| 10               | 4.96  | 4.10  | 3.71  | 3.48  | 3.33  | 3.22  | 3.14  | 3.07  | 3.02  | 2.98  | 2.91  | 2.85  | 2.77  | 2.74  | 2.70  | 2.66  | 2.62  | 2.58  | 2.54     |
| 11               | 4.84  | 3.98  | 3.59  | 3.36  | 3.20  | 3.09  | 3.01  | 2.95  | 2.90  | 2.85  | 2.79  | 2.72  | 2.65  | 2.61  | 2.57  | 2.53  | 2.49  | 2.45  | 2.40     |
| 12               | 4.75  | 3.89  | 3.49  | 3.26  | 3.11  | 3.00  | 2.91  | 2.85  | 2.80  | 2.75  | 2.69  | 2.62  | 2.54  | 2.51  | 2.47  | 2.43  | 2.38  | 2.34  | 2.30     |
| 13               | 4.67  | 3.81  | 3.41  | 3.18  | 3.03  | 2.92  | 2.83  | 2.77  | 2.71  | 2.67  | 2.60  | 2.53  | 2.46  | 2.42  | 2.38  | 2.34  | 2.30  | 2.25  | 2.21     |
| 14               | 4.60  | 3.74  | 3.34  | 3.11  | 2.96  | 2.85  | 2.76  | 2.70  | 2.65  | 2.60  | 2.53  | 2.46  | 2.39  | 2.35  | 2.31  | 2.27  | 2.22  | 2.18  | 2.13     |
| 15               | 4.54  | 3.68  | 3.29  | 3.06  | 2.90  | 2.79  | 2.71  | 2.64  | 2.59  | 2.54  | 2.48  | 2.40  | 2.33  | 2.29  | 2.25  | 2.20  | 2.16  | 2.11  | 2.07     |
| 16               | 4.49  | 3.63  | 3.24  | 3.01  | 2.85  | 2.74  | 2.66  | 2.59  | 2.54  | 2.49  | 2.42  | 2.35  | 2.28  | 2.24  | 2.19  | 2.15  | 2.11  | 2.06  | 2.01     |
| 17               | 4.45  | 3.59  | 3.20  | 2.96  | 2.81  | 2.70  | 2.61  | 2.55  | 2.49  | 2.45  | 2.38  | 2.31  | 2.23  | 2.19  | 2.15  | 2.10  | 2.06  | 2.01  | 1.96     |
| 18               | 4.41  | 3.55  | 3.16  | 2.93  | 2.77  | 2.66  | 2.58  | 2.51  | 2.46  | 2.41  | 2.34  | 2.27  | 2.19  | 2.15  | 2.11  | 2.06  | 2.02  | 1.97  | 1.92     |
| 19               | 4.38  | 3.52  | 3.13  | 2.90  | 2.74  | 2.63  | 2.54  | 2.48  | 2.42  | 2.38  | 2.31  | 2.23  | 2.16  | 2.11  | 2.07  | 2.03  | 1.98  | 1.93  | 1.88     |
| 20               | 4.35  | 3.49  | 3.10  | 2.87  | 2.71  | 2.60  | 2.51  | 2.45  | 2.39  | 2.35  | 2.28  | 2.20  | 2.12  | 2.08  | 2.04  | 1.99  | 1.95  | 1.90  | 1.84     |
| 21               | 4.32  | 3.47  | 3.07  | 2.84  | 2.68  | 2.57  | 2.49  | 2.42  | 2.37  | 2.32  | 2.25  | 2.18  | 2.10  | 2.05  | 2.01  | 1.96  | 1.92  | 1.87  | 1.81     |
| 22               | 4.30  | 3.44  | 3.05  | 2.82  | 2.66  | 2.55  | 2.46  | 2.40  | 2.34  | 2.30  | 2.23  | 2.15  | 2.07  | 2.03  | 1.98  | 1.94  | 1.89  | 1.84  | 1.78     |
| 23               | 4.28  | 3.42  | 3.03  | 2.80  | 2.64  | 2.53  | 2.44  | 2.37  | 2.32  | 2.27  | 2.20  | 2.13  | 2.05  | 2.01  | 1.96  | 1.91  | 1.86  | 1.81  | 1.76     |
| 24               | 4.26  | 3.40  | 3.01  | 2.78  | 2.62  | 2.51  | 2.42  | 2.36  | 2.30  | 2.25  | 2.18  | 2.11  | 2.03  | 1.98  | 1.94  | 1.89  | 1.84  | 1.79  | 1.73     |
| 25               | 4.24  | 3.39  | 2.99  | 2.76  | 2.60  | 2.49  | 2.40  | 2.34  | 2.28  | 2.24  | 2.16  | 2.09  | 2.01  | 1.96  | 1.92  | 1.87  | 1.82  | 1.77  | 1.71     |
| 26               | 4.23  | 3.37  | 2.98  | 2.74  | 2.59  | 2.47  | 2.39  | 2.32  | 2.27  | 2.22  | 2.15  | 2.07  | 1.99  | 1.95  | 1.90  | 1.85  | 1.80  | 1.75  | 1.69     |
| 27               | 4.21  | 3.35  | 2.96  | 2.73  | 2.57  | 2.46  | 2.37  | 2.31  | 2.25  | 2.20  | 2.13  | 2.06  | 1.97  | 1.93  | 1.88  | 1.84  | 1.79  | 1.73  | 1.67     |
| 28               | 4.20  | 3.34  | 2.95  | 2.71  | 2.56  | 2.45  | 2.36  | 2.29  | 2.24  | 2.19  | 2.12  | 2.04  | 1.96  | 1.91  | 1.87  | 1.82  | 1.77  | 1.71  | 1.65     |
| 29               | 4.18  | 3.33  | 2.93  | 2.70  | 2.55  | 2.43  | 2.35  | 2.28  | 2.22  | 2.18  | 2.10  | 2.03  | 1.94  | 1.90  | 1.85  | 1.81  | 1.75  | 1.70  | 1.64     |
| 30               | 4.17  | 3.32  | 2.92  | 2.69  | 2.53  | 2.42  | 2.33  | 2.27  | 2.21  | 2.16  | 2.09  | 2.01  | 1.93  | 1.89  | 1.84  | 1.79  | 1.74  | 1.68  | 1.62     |
| 40               | 4.08  | 3.23  | 2.84  | 2.61  | 2.45  | 2.34  | 2.25  | 2.18  | 2.12  | 2.08  | 2.00  | 1.92  | 1.84  | 1.79  | 1.74  | 1.69  | 1.64  | 1.58  | 1.51     |
| 60               | 4.00  | 3.15  | 2.76  | 2.53  | 2.37  | 2.25  | 2.17  | 2.10  | 2.04  | 1.99  | 1.92  | 1.84  | 1.75  | 1.70  | 1.65  | 1.59  | 1.53  | 1.47  | 1.39     |
| 120              | 3.92  | 3.07  | 2.68  | 2.45  | 2.29  | 2.17  | 2.09  | 2.02  | 1.96  | 1.91  | 1.83  | 1.75  | 1.66  | 1.61  | 1.55  | 1.50  | 1.43  | 1.35  | 1.25     |
| $\infty$         | 3.84  | 3.00  | 2.60  | 2.37  | 2.21  | 2.10  | 2.01  | 1.94  | 1.88  | 1.83  | 1.75  | 1.67  | 1.57  | 1.52  | 1.46  | 1.39  | 1.32  | 1.22  | 1.00     |

$F = \frac{s_1^2}{s_2^2} = \frac{S_1/m}{S_2/n}$ , where  $s_1^2 = S_1/m$  and  $s_2^2 = S_2/n$  are independent mean squares estimating a common variance  $\sigma^2$  and based on  $m$  and  $n$  degrees of freedom, respectively.

$$F(F) = \int_0^F \frac{\Gamma\left(\frac{m+n}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{n}{2}\right)} m^{m/2} n^{n/2} x^{(m/2)-1} (n+mx)^{-(m+n)/2} dx = .975$$

| $n \backslash m$ | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 12    | 15    | 20    | 24    | 30    | 40    | 60    | 120   | $\infty$ |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
| 1                | 647.8 | 799.5 | 864.2 | 899.6 | 921.8 | 937.1 | 948.2 | 956.7 | 963.3 | 968.6 | 976.7 | 984.9 | 993.1 | 997.2 | 1001  | 1006  | 1010  | 1014  | 1018     |
| 2                | 38.51 | 39.00 | 39.17 | 39.25 | 39.30 | 39.33 | 39.36 | 39.37 | 39.39 | 39.40 | 39.41 | 39.43 | 39.45 | 39.46 | 39.46 | 39.47 | 39.48 | 39.49 | 39.50    |
| 3                | 17.44 | 16.04 | 15.44 | 15.10 | 14.88 | 14.73 | 14.62 | 14.54 | 14.47 | 14.42 | 14.34 | 14.25 | 14.17 | 14.12 | 14.08 | 14.04 | 13.99 | 13.95 | 13.90    |
| 4                | 12.22 | 10.65 | 9.98  | 9.60  | 9.36  | 9.20  | 9.07  | 8.98  | 8.90  | 8.84  | 8.75  | 8.66  | 8.56  | 8.51  | 8.46  | 8.41  | 8.36  | 8.31  | 8.26     |
| 5                | 10.01 | 8.43  | 7.76  | 7.39  | 7.15  | 6.98  | 6.85  | 6.76  | 6.68  | 6.62  | 6.52  | 6.43  | 6.33  | 6.28  | 6.23  | 6.18  | 6.12  | 6.07  | 6.02     |
| 6                | 8.81  | 7.26  | 6.60  | 6.23  | 5.99  | 5.82  | 5.70  | 5.60  | 5.52  | 5.46  | 5.37  | 5.27  | 5.17  | 5.12  | 5.07  | 5.01  | 4.96  | 4.90  | 4.85     |
| 7                | 8.07  | 6.54  | 5.89  | 5.52  | 5.29  | 5.12  | 4.99  | 4.90  | 4.82  | 4.76  | 4.67  | 4.57  | 4.47  | 4.42  | 4.36  | 4.31  | 4.25  | 4.20  | 4.14     |
| 8                | 7.57  | 6.06  | 5.42  | 5.05  | 4.82  | 4.65  | 4.53  | 4.43  | 4.36  | 4.30  | 4.20  | 4.10  | 4.00  | 3.95  | 3.89  | 3.84  | 3.78  | 3.73  | 3.67     |
| 9                | 7.21  | 5.71  | 5.08  | 4.72  | 4.48  | 4.32  | 4.20  | 4.10  | 4.03  | 3.96  | 3.87  | 3.77  | 3.67  | 3.61  | 3.56  | 3.51  | 3.45  | 3.39  | 3.33     |
| 10               | 6.94  | 5.46  | 4.83  | 4.47  | 4.24  | 4.07  | 3.95  | 3.85  | 3.78  | 3.72  | 3.62  | 3.52  | 3.42  | 3.37  | 3.31  | 3.26  | 3.20  | 3.14  | 3.08     |
| 11               | 6.72  | 5.26  | 4.63  | 4.28  | 4.04  | 3.88  | 3.76  | 3.66  | 3.59  | 3.53  | 3.43  | 3.33  | 3.23  | 3.17  | 3.12  | 3.06  | 3.00  | 2.94  | 2.88     |
| 12               | 6.55  | 5.10  | 4.47  | 4.12  | 3.89  | 3.73  | 3.61  | 3.51  | 3.44  | 3.37  | 3.28  | 3.18  | 3.07  | 3.02  | 2.96  | 2.91  | 2.85  | 2.79  | 2.72     |
| 13               | 6.41  | 4.97  | 4.35  | 4.00  | 3.77  | 3.60  | 3.48  | 3.39  | 3.31  | 3.25  | 3.15  | 3.05  | 2.95  | 2.89  | 2.84  | 2.78  | 2.72  | 2.66  | 2.60     |
| 14               | 6.30  | 4.86  | 4.24  | 3.89  | 3.66  | 3.50  | 3.38  | 3.29  | 3.21  | 3.15  | 3.05  | 2.95  | 2.84  | 2.79  | 2.73  | 2.67  | 2.61  | 2.55  | 2.49     |
| 15               | 6.20  | 4.77  | 4.15  | 3.80  | 3.58  | 3.41  | 3.29  | 3.20  | 3.12  | 3.06  | 2.96  | 2.86  | 2.76  | 2.70  | 2.64  | 2.59  | 2.52  | 2.46  | 2.40     |
| 16               | 6.12  | 4.69  | 4.08  | 3.73  | 3.50  | 3.34  | 3.22  | 3.12  | 3.05  | 2.99  | 2.89  | 2.79  | 2.68  | 2.63  | 2.57  | 2.51  | 2.45  | 2.38  | 2.32     |
| 17               | 6.04  | 4.62  | 4.01  | 3.66  | 3.44  | 3.28  | 3.16  | 3.06  | 2.98  | 2.92  | 2.82  | 2.72  | 2.62  | 2.56  | 2.50  | 2.44  | 2.38  | 2.32  | 2.25     |
| 18               | 5.98  | 4.56  | 3.95  | 3.61  | 3.38  | 3.22  | 3.10  | 3.01  | 2.93  | 2.87  | 2.77  | 2.67  | 2.56  | 2.50  | 2.44  | 2.38  | 2.32  | 2.26  | 2.19     |
| 19               | 5.92  | 4.51  | 3.90  | 3.56  | 3.33  | 3.17  | 3.05  | 2.96  | 2.88  | 2.82  | 2.72  | 2.62  | 2.51  | 2.45  | 2.39  | 2.33  | 2.27  | 2.20  | 2.13     |
| 20               | 5.87  | 4.46  | 3.86  | 3.51  | 3.29  | 3.13  | 3.01  | 2.91  | 2.84  | 2.77  | 2.68  | 2.57  | 2.46  | 2.41  | 2.35  | 2.29  | 2.22  | 2.16  | 2.09     |
| 21               | 5.83  | 4.42  | 3.82  | 3.48  | 3.25  | 3.09  | 2.97  | 2.87  | 2.80  | 2.73  | 2.64  | 2.53  | 2.42  | 2.37  | 2.31  | 2.25  | 2.18  | 2.11  | 2.04     |
| 22               | 5.79  | 4.38  | 3.78  | 3.44  | 3.22  | 3.05  | 2.93  | 2.84  | 2.76  | 2.70  | 2.60  | 2.50  | 2.39  | 2.33  | 2.27  | 2.21  | 2.14  | 2.08  | 2.00     |
| 23               | 5.75  | 4.35  | 3.75  | 3.41  | 3.18  | 3.02  | 2.90  | 2.81  | 2.73  | 2.67  | 2.57  | 2.47  | 2.36  | 2.30  | 2.24  | 2.18  | 2.11  | 2.04  | 1.97     |
| 24               | 5.72  | 4.32  | 3.72  | 3.38  | 3.15  | 2.99  | 2.87  | 2.78  | 2.70  | 2.64  | 2.54  | 2.44  | 2.33  | 2.27  | 2.21  | 2.15  | 2.08  | 2.01  | 1.94     |
| 25               | 5.69  | 4.29  | 3.69  | 3.35  | 3.13  | 2.97  | 2.85  | 2.75  | 2.68  | 2.61  | 2.51  | 2.41  | 2.30  | 2.24  | 2.18  | 2.12  | 2.05  | 1.98  | 1.91     |
| 26               | 5.66  | 4.27  | 3.67  | 3.33  | 3.10  | 2.94  | 2.82  | 2.73  | 2.65  | 2.59  | 2.49  | 2.39  | 2.28  | 2.22  | 2.16  | 2.09  | 2.03  | 1.95  | 1.88     |
| 27               | 5.63  | 4.24  | 3.65  | 3.31  | 3.08  | 2.92  | 2.80  | 2.71  | 2.63  | 2.57  | 2.47  | 2.36  | 2.25  | 2.19  | 2.13  | 2.03  | 2.00  | 1.93  | 1.85     |
| 28               | 5.61  | 4.22  | 3.63  | 3.29  | 3.06  | 2.90  | 2.78  | 2.69  | 2.61  | 2.55  | 2.45  | 2.34  | 2.23  | 2.17  | 2.11  | 2.05  | 1.98  | 1.91  | 1.83     |
| 29               | 5.59  | 4.20  | 3.61  | 3.27  | 3.04  | 2.88  | 2.76  | 2.67  | 2.59  | 2.53  | 2.43  | 2.32  | 2.21  | 2.15  | 2.09  | 2.03  | 1.96  | 1.89  | 1.81     |
| 30               | 5.57  | 4.18  | 3.59  | 3.25  | 3.03  | 2.87  | 2.75  | 2.65  | 2.57  | 2.51  | 2.41  | 2.31  | 2.20  | 2.14  | 2.07  | 2.01  | 1.94  | 1.87  | 1.79     |
| 40               | 5.42  | 4.05  | 3.46  | 3.13  | 2.90  | 2.74  | 2.62  | 2.53  | 2.45  | 2.39  | 2.29  | 2.18  | 2.07  | 2.01  | 1.94  | 1.88  | 1.80  | 1.72  | 1.64     |
| 60               | 5.29  | 3.93  | 3.34  | 3.01  | 2.79  | 2.63  | 2.51  | 2.41  | 2.33  | 2.27  | 2.17  | 2.06  | 1.94  | 1.88  | 1.82  | 1.74  | 1.67  | 1.58  | 1.48     |
| 120              | 5.15  | 3.80  | 3.23  | 2.89  | 2.67  | 2.52  | 2.39  | 2.30  | 2.22  | 2.16  | 2.05  | 1.94  | 1.82  | 1.76  | 1.69  | 1.61  | 1.53  | 1.43  | 1.31     |
| $\infty$         | 5.02  | 3.69  | 3.12  | 2.79  | 2.57  | 2.41  | 2.29  | 2.19  | 2.11  | 2.05  | 1.94  | 1.83  | 1.71  | 1.64  | 1.57  | 1.48  | 1.39  | 1.27  | 1.00     |

$F = \frac{s_1^2}{s_2^2} = \frac{S_1/m}{S_2/n}$ , where  $s_1^2 = S_1/m$  and  $s_2^2 = S_2/n$  are independent mean squares estimating a common variance  $\sigma^2$  and based on  $m$  and  $n$  degrees of freedom, respectively.



$$F(F) = \int_0^F \frac{\Gamma\left(\frac{m+n}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{n}{2}\right)} m^{m/2} n^{n/2} x^{(m/2)-1} (n+mx)^{-(m+n)/2} dx = .99$$

| $n \backslash m$ | 1     | 2      | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 12    | 15    | 20    | 24    | 30    | 40    | 60    | 120   | $\infty$ |
|------------------|-------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
| 1                | 4052  | 4999.5 | 5403  | 5625  | 5764  | 5859  | 5928  | 5982  | 6022  | 6056  | 6106  | 6157  | 6209  | 6235  | 6261  | 6287  | 6313  | 6339  | 6366     |
| 2                | 98.50 | 99.00  | 99.17 | 99.25 | 99.30 | 99.33 | 99.36 | 99.37 | 99.39 | 99.40 | 99.42 | 99.43 | 99.45 | 99.46 | 99.47 | 99.47 | 99.48 | 99.49 | 99.50    |
| 3                | 34.12 | 30.82  | 29.46 | 28.71 | 28.24 | 27.91 | 27.67 | 27.49 | 27.35 | 27.23 | 27.05 | 26.87 | 26.69 | 26.60 | 26.50 | 26.41 | 26.32 | 26.22 | 26.13    |
| 4                | 21.20 | 18.00  | 16.69 | 15.98 | 15.52 | 15.21 | 14.98 | 14.80 | 14.66 | 14.55 | 14.37 | 14.20 | 14.02 | 13.93 | 13.84 | 13.75 | 13.65 | 13.56 | 13.46    |
| 5                | 16.26 | 13.27  | 12.06 | 11.39 | 10.97 | 10.67 | 10.46 | 10.29 | 10.16 | 10.05 | 9.89  | 9.72  | 9.55  | 9.47  | 9.38  | 9.29  | 9.20  | 9.11  | 9.02     |
| 6                | 13.75 | 10.92  | 9.78  | 9.15  | 8.75  | 8.47  | 8.26  | 8.10  | 7.98  | 7.87  | 7.72  | 7.56  | 7.40  | 7.31  | 7.23  | 7.14  | 7.06  | 6.97  | 6.88     |
| 7                | 12.25 | 9.55   | 8.45  | 7.85  | 7.46  | 7.19  | 6.99  | 6.84  | 6.72  | 6.62  | 6.47  | 6.31  | 6.16  | 6.07  | 5.99  | 5.91  | 5.82  | 5.74  | 5.65     |
| 8                | 11.26 | 8.65   | 7.59  | 7.01  | 6.63  | 6.37  | 6.18  | 6.03  | 5.91  | 5.81  | 5.67  | 5.52  | 5.36  | 5.28  | 5.20  | 5.12  | 5.03  | 4.95  | 4.86     |
| 9                | 10.56 | 8.02   | 6.99  | 6.42  | 6.06  | 5.80  | 5.61  | 5.47  | 5.35  | 5.26  | 5.11  | 4.96  | 4.81  | 4.73  | 4.65  | 4.57  | 4.48  | 4.40  | 4.31     |
| 10               | 10.04 | 7.56   | 6.55  | 5.99  | 5.64  | 5.39  | 5.20  | 5.06  | 4.94  | 4.85  | 4.71  | 4.56  | 4.41  | 4.33  | 4.25  | 4.17  | 4.08  | 4.00  | 3.91     |
| 11               | 9.65  | 7.21   | 6.22  | 5.67  | 5.32  | 5.07  | 4.89  | 4.74  | 4.63  | 4.54  | 4.40  | 4.25  | 4.10  | 4.02  | 3.94  | 3.86  | 3.78  | 3.69  | 3.60     |
| 12               | 9.33  | 6.93   | 5.95  | 5.41  | 5.06  | 4.82  | 4.64  | 4.50  | 4.39  | 4.30  | 4.16  | 4.01  | 3.86  | 3.78  | 3.70  | 3.62  | 3.54  | 3.45  | 3.36     |
| 13               | 9.07  | 6.70   | 5.74  | 5.21  | 4.86  | 4.62  | 4.44  | 4.30  | 4.19  | 4.10  | 3.96  | 3.82  | 3.66  | 3.59  | 3.51  | 3.43  | 3.34  | 3.25  | 3.17     |
| 14               | 8.86  | 6.51   | 5.56  | 5.04  | 4.69  | 4.46  | 4.28  | 4.14  | 4.03  | 3.94  | 3.80  | 3.66  | 3.51  | 3.43  | 3.35  | 3.27  | 3.18  | 3.09  | 3.00     |
| 15               | 8.68  | 6.36   | 5.42  | 4.89  | 4.56  | 4.32  | 4.14  | 4.00  | 3.89  | 3.80  | 3.67  | 3.52  | 3.37  | 3.29  | 3.21  | 3.13  | 3.05  | 2.96  | 2.87     |
| 16               | 8.53  | 6.23   | 5.29  | 4.77  | 4.44  | 4.20  | 4.03  | 3.89  | 3.78  | 3.69  | 3.55  | 3.41  | 3.26  | 3.18  | 3.10  | 3.02  | 2.93  | 2.84  | 2.75     |
| 17               | 8.40  | 6.11   | 5.18  | 4.67  | 4.34  | 4.10  | 3.93  | 3.79  | 3.68  | 3.59  | 3.46  | 3.31  | 3.16  | 3.08  | 3.00  | 2.92  | 2.83  | 2.75  | 2.65     |
| 18               | 8.29  | 6.01   | 5.09  | 4.58  | 4.25  | 4.01  | 3.84  | 3.71  | 3.60  | 3.51  | 3.37  | 3.23  | 3.08  | 3.00  | 2.92  | 2.84  | 2.75  | 2.66  | 2.57     |
| 19               | 8.18  | 5.93   | 5.01  | 4.50  | 4.17  | 3.94  | 3.77  | 3.63  | 3.52  | 3.43  | 3.30  | 3.15  | 3.00  | 2.92  | 2.84  | 2.76  | 2.67  | 2.58  | 2.49     |
| 20               | 8.10  | 5.85   | 4.94  | 4.43  | 4.10  | 3.87  | 3.70  | 3.56  | 3.46  | 3.37  | 3.23  | 3.09  | 2.94  | 2.86  | 2.78  | 2.69  | 2.61  | 2.52  | 2.42     |
| 21               | 8.02  | 5.78   | 4.87  | 4.37  | 4.04  | 3.81  | 3.64  | 3.51  | 3.40  | 3.31  | 3.17  | 3.03  | 2.88  | 2.80  | 2.72  | 2.64  | 2.55  | 2.46  | 2.36     |
| 22               | 7.95  | 5.72   | 4.82  | 4.31  | 3.99  | 3.76  | 3.59  | 3.45  | 3.35  | 3.26  | 3.12  | 2.98  | 2.83  | 2.75  | 2.67  | 2.58  | 2.50  | 2.40  | 2.31     |
| 23               | 7.88  | 5.66   | 4.76  | 4.26  | 3.94  | 3.71  | 3.54  | 3.41  | 3.30  | 3.21  | 3.07  | 2.93  | 2.78  | 2.70  | 2.62  | 2.54  | 2.45  | 2.35  | 2.26     |
| 24               | 7.82  | 5.61   | 4.72  | 4.22  | 3.90  | 3.67  | 3.50  | 3.36  | 3.26  | 3.17  | 3.03  | 2.89  | 2.74  | 2.66  | 2.58  | 2.49  | 2.40  | 2.31  | 2.21     |
| 25               | 7.77  | 5.57   | 4.68  | 4.18  | 3.85  | 3.63  | 3.46  | 3.32  | 3.22  | 3.13  | 2.99  | 2.85  | 2.70  | 2.62  | 2.54  | 2.45  | 2.36  | 2.27  | 2.17     |
| 26               | 7.72  | 5.53   | 4.64  | 4.14  | 3.82  | 3.59  | 3.42  | 3.29  | 3.18  | 3.09  | 2.96  | 2.81  | 2.66  | 2.58  | 2.50  | 2.42  | 2.33  | 2.23  | 2.13     |
| 27               | 7.68  | 5.49   | 4.60  | 4.11  | 3.78  | 3.56  | 3.39  | 3.26  | 3.15  | 3.06  | 2.93  | 2.78  | 2.63  | 2.55  | 2.47  | 2.38  | 2.29  | 2.20  | 2.10     |
| 28               | 7.64  | 5.45   | 4.57  | 4.07  | 3.75  | 3.53  | 3.36  | 3.23  | 3.12  | 3.03  | 2.90  | 2.75  | 2.60  | 2.52  | 2.44  | 2.35  | 2.26  | 2.17  | 2.06     |
| 29               | 7.60  | 5.42   | 4.54  | 4.04  | 3.73  | 3.50  | 3.33  | 3.20  | 3.09  | 3.00  | 2.87  | 2.73  | 2.57  | 2.49  | 2.41  | 2.33  | 2.23  | 2.14  | 2.03     |
| 30               | 7.56  | 5.39   | 4.51  | 4.02  | 3.70  | 3.47  | 3.30  | 3.17  | 3.07  | 2.98  | 2.84  | 2.70  | 2.55  | 2.47  | 2.39  | 2.30  | 2.21  | 2.11  | 2.01     |
| 40               | 7.31  | 5.18   | 4.31  | 3.83  | 3.51  | 3.29  | 3.12  | 2.99  | 2.89  | 2.80  | 2.66  | 2.52  | 2.37  | 2.29  | 2.20  | 2.11  | 2.02  | 1.92  | 1.80     |
| 60               | 7.08  | 4.98   | 4.13  | 3.65  | 3.34  | 3.12  | 2.95  | 2.82  | 2.72  | 2.63  | 2.50  | 2.35  | 2.20  | 2.12  | 2.03  | 1.94  | 1.84  | 1.73  | 1.60     |
| 120              | 6.85  | 4.79   | 3.95  | 3.48  | 3.17  | 2.96  | 2.79  | 2.66  | 2.56  | 2.47  | 2.34  | 2.19  | 2.03  | 1.95  | 1.86  | 1.76  | 1.66  | 1.53  | 1.38     |
| $\infty$         | 6.63  | 4.61   | 3.78  | 3.32  | 3.02  | 2.80  | 2.64  | 2.51  | 2.41  | 2.32  | 2.18  | 2.04  | 1.88  | 1.79  | 1.70  | 1.59  | 1.47  | 1.32  | 1.00     |

$F = \frac{s_1^2}{s_2^2} = \frac{S_1/m}{S_2/n}$ , where  $s_1^2 = S_1/m$  and  $s_2^2 = S_2/n$  are independent mean squares estimating a common variance  $\sigma^2$  and based on  $m$  and  $n$  degrees of freedom, respectively.

## SOURCES OF PHYSICAL AND CHEMICAL DATA

In addition to the primary research journals, there are many useful sources of property data of the type contained in the *CRC Handbook of Chemistry and Physics*. A selected list of these is presented here, with emphasis on print and electronic sources whose contents have been subject to a reasonable level of quality control.

### A. Data Journals

1. **Journal of Physical and Chemical Reference Data** — Published jointly by the National Institute of Standards and Technology and the American Institute of Physics, this quarterly journal contains compilations of evaluated data in chemistry, physics, and materials science. It is available in print and on the Internet. [ojps.aip.org/jpcrd/]
2. **Journal of Chemical and Engineering Data** — This bimonthly journal of the American Chemical Society publishes articles reporting original experimental measurements carried out under carefully controlled conditions. The main emphasis is on thermochemical and thermophysical properties. Review articles with evaluated data from the literature are also published. [pubs.acs.org/journals/jceaax/index.html]
3. **Journal of Chemical Thermodynamics** — This journal publishes original research papers that include highly accurate measurements of thermodynamic and thermophysical properties. [www.sciencedirect.com/science/journal/00219614]
4. **Atomic Data and Nuclear Data Tables** — This is a bimonthly journal containing compilations of data in atomic physics, nuclear physics, and related fields. [www.science-direct.com/science/journal/0092640X]
5. **Journal of Phase Equilibria and Diffusion** — This journal presents critically evaluated phase diagrams and related data on alloy systems. It is published by ASM International and is the successor to the previous ASM periodical *Bulletin of Alloy Phase Diagrams*. [www.asm-intl.org]

### B. Data Centers

This section lists selected organizations that perform a continuing function of compiling and critically evaluating data in specific fields of science.

1. **National Institute of Standards and Technology** — Under its Standard Reference Data program, NIST supports a number of data centers in chemistry, physics, and materials science. Topics covered include thermodynamics, fluid properties, chemical kinetics, mass spectroscopy, atomic spectroscopy, fundamental physical constants, ceramics, and crystallography. Address: Office of Standard Reference Data, National Institute of Standards and Technology, Gaithersburg, MD 20899 [www.nist.gov/srd/].
2. **Thermodynamics Research Center** — Now located at the National Institute of Standards and Technology, TRC maintains an extensive archive of data covering thermodynamic, thermochemical, and transport properties of organic compounds and mixtures. Data are distributed in both print and electronic form. Address: Mail code 838.00, 325 Broadway, Boulder, CO 80305-3328 [www.trc.nist.gov].
3. **Design Institute for Physical Property Data** — Under the auspices of the American Institute of Chemical Engineers [www.aiche.org/dippr/], DIPPR offers evaluated data on industrially important chemical compounds. The largest project deals with physical, thermodynamic, and transport properties of pure compounds. Address: Brigham Young University, Provo, UT 84602 [dippr.byu.edu].
4. **Dortmund Data Bank** — Maintains extensive databases on thermodynamic and transport properties of pure compounds and mixtures of industrial interest. The data are distributed through DECHEMA, FIZ CHEMIE, and other outlets. An abbreviated database system is also available for educational use. Address: DDBST GmbH, Industriestr. 1, 26121 Oldenburg, Germany [www.ddbst.de].
5. **Cambridge Crystallographic Data Centre** — Maintains the Cambridge Structural Database of over 430,000 organic compounds. The data files and manipulation software are distributed in several ways. Address: 12 Union Rd., Cambridge CB2 1EZ, U.K. [www.ccdc.cam.ac.uk].
6. **FIZ Karlsruhe** — In addition to many bibliographic databases, FIZ Karlsruhe maintains the Inorganic Crystal Structure Database in collaboration with the National Institute of Standards and Technology. The ICSD contains the atomic coordinates and related data on over 50,000 inorganic crystals. Address: Fachinformationszentrum (FIZ) Karlsruhe, Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany [www.fiz-karlsruhe.de].
7. **International Centre for Diffraction Data** — Maintains and distributes the Powder Diffraction File (PDF), a file of over 500,000 X-ray powder diffraction patterns used for identification of crystalline materials. The ICDD also distributes the NIST Crystal Data file, which contains lattice parameters for over 235,000 inorganic, organic, metal, and mineral crystalline materials. Address: 12 Campus Blvd., Newton Square, PA 19073-3273 [www.icdd.com].
8. **Research Collaboratory for Structural Bioinformatics** — Maintains the Protein Data Bank (PDB), a file of 3-dimensional structures of proteins and other biological macromolecules. Address: Department of Chemistry and Chemical Biology, Rutgers University, 610 Taylor Road, Piscataway, NJ 08854-8087 [www.rcsb.org].
9. **Toth Information Systems** — Maintains the Metals Crystallographic Data File (CRYSTMET). Address: 2045 Quincy Ave., Gloucester, ON, Canada K1J 6B2 [www.tothcanada.com].
10. **Atomic Mass Data Center** — Collects and evaluates high-precision data on masses of individual isotopes and maintains a comprehensive database. Address: C.S.N.S.M (IN2P3-CNRS), Batiment 108, F-91405 Orsay Campus, France [www.nndc.bnl.gov/amdc].
11. **Particle Data Group** — International center for data of high-energy physics; maintains a database of properties of fundamental particles that is published in both print and electronic form. Address: MS 50-308, Lawrence Berkeley National Laboratory, Berkeley, CA 94720 [pdg.lbl.gov].
12. **National Nuclear Data Center** — Maintains databases on nuclear structure and reactions, including neutron cross sections. The NNDC is the U.S. node in an international network of nuclear data centers. Address: Brookhaven National Laboratory, Upton, NY 11973-5000 [www.nndc.bnl.gov].

13. **International Union of Pure and Applied Chemistry** — Address: PO Box 13757, Research Triangle Park, NC 27709-3757 [www.iupac.org]. IUPAC supports a number of long-term data projects, including these examples:
  - a. **Solubility Data Project** — Carries out evaluation of all types of solubility data. The results are published in the Solubility Data Series, whose current outlet is the *Journal of Physical and Chemical Reference Data*. [www.iupac.org/divisions/V/cp5.html]
  - b. **Kinetic Data for Atmospheric Chemistry** — Maintains a comprehensive database on the kinetics of reactions important in the chemistry of the atmosphere. [www.iupac-kinetic.ch.cam.ac.uk/]
  - c. **International Thermodynamic Tables for the Fluid State** — Prepares definitive tables of the thermodynamic properties of industrially important fluids. Thirteen volumes have been published by IUPAC. [www.iupac.org/publications/books/seriestitles/]
  - d. **Stability Constants Database** — Collection of metal-ligand stability constants and associated software. [www.acadsoft.co.uk]

### C. Major Multi-Volume Handbook Series

1. **Chapman & Hall/CRC Chemical Dictionaries** — These originally appeared in print form as the *Dictionary of Organic Compounds*, *Dictionary of Natural Products*, etc. They are now published in electronic form and are available in DVD format [www.crcpress.com] and on the Internet [www.chemnetbase.com]. The consolidated version, called the *Combined Chemical Dictionary*, has data on more than 550,000 compounds spanning all branches of chemistry. The coverage includes physical properties, biological sources, hazard information, uses, and literature references.
2. **Properties of Organic Compounds** — Originally published in three editions as the *Handbook of Data on Organic Compounds*, it is now in electronic form as *Properties of Organic Compounds*. The database includes about 30,000 compounds; physical properties and spectral data (mass, infrared, Raman, ultraviolet, and NMR) are covered. It is offered as CDROM [www.crcpress.com] and by Web access [www.chemnetbase.com].
3. **Beilstein Handbook of Organic Chemistry** — The classic source of data on organic compounds, dating from the 19th century, *Beilstein* was converted to electronic form in the last decade of the 20th century. Over 8 million compounds and 10 million chemical reactions are now covered, with a broad range of physical properties as well as synthetic methods and ecological data. The database is accessed by the CrossFire software [www.beilstein.com].
4. **Gmelin Handbook of Inorganic and Organometallic Chemistry** — A subset of the information in the print series has been converted to electronic form and is now distributed in the same manner as *Beilstein*. In addition to the standard physical properties, the coverage includes a wide range of optical, magnetic, spectroscopic, thermal, and transport properties for about 1.4 million compounds [www.mdli.com].
5. **DECHEMA Chemical Data Series** — DECHEMA distributes the DETHERM database, which emphasizes data used in process design in the chemical industry, including thermodynamic and transport properties of about 20,000 pure compounds and 90,000 mixtures. Access is available

through in-house databases and via the Internet [www.dechema.de].

6. **Landolt-Börnstein Numerical Data and Functional Relationships in Science and Technology** — *Landolt-Börnstein* covers a very broad range of data in physics, chemistry, crystallography, materials science, biophysics, astronomy, and geophysics. Hard-copy volumes in the New Series (started in 1961) are still being published, and the entire New Series is now accessible on the Internet [www.landolt-boernstein.com].

### D. Selected Single-Volume Handbooks

The following handbooks offer broad coverage of high-quality data in a single volume. This list is only representative; an extensive listing of handbooks in all fields of science may be found in *Handbooks and Tables in Science and Technology, Third Edition* (Russell H. Powell, ed., Oryx Press, Westport, CT, 1994).

1. **American Institute of Physics Handbook** — Although an old book, it contains much data that are still useful, especially in acoustics, mechanics, optics, and solid state physics. (Dwight E. Gray, ed., McGraw-Hill, New York, 1972)
2. **Constants of Inorganic Substances** — This book presents physical constants, thermodynamic data, solubility, reactivity, and other information on over 3000 inorganic compounds. Since it draws heavily on Russian literature, it contains a great deal of data that do not make their way into most U.S. handbooks. (R. A. Lidin, L. L. Andreeva, and V. A. Molochko, Begell House, New York, 1995)
3. **Handbook of Chemistry and Physics** — Now in the 90th Edition, the *CRC Handbook* covers data from most branches of chemistry and physics. The annual revisions permit regular updating of the information. Also available on CDROM [www.crcpress.com] and the Web [hbcnetbase.com]. (David R. Lide, ed., CRC Press, Boca Raton, FL, 2009)
4. **Handbook of Inorganic Compounds** — This book covers physical constants and solubility for about 3300 inorganic compounds. Also available on CDROM [www.crcpress.com]. (Dale L. Perry and Sidney L. Phillips, eds., CRC Press, Boca Raton, FL, 1995)
5. **Handbook of Physical Properties of Liquids and Gases** — This is a valuable source of data on all types of fluids, ranging from liquid and gaseous hydrocarbons to molten metals and ionized gases. Detailed tables of physical, thermodynamic, and transport properties are given for temperatures from the cryogenic region to 6000 K. Western and Russian literature is covered. (N. B. Vargaftik, Y. K. Vinogradov, and V. S. Yargin, Begell House, New York, 1996)
6. **Handbook of Physical Quantities** — The range of coverage is somewhat similar to the *CRC Handbook of Chemistry and Physics*, but with a stronger emphasis on physics than on chemistry. Solid state physics, lasers, nuclear physics, geophysics, and astronomy receive considerable attention. (Igor S. Grigoriev and Evgenii Z. Meilikhov, eds., CRC Press, Boca Raton, FL, 1997)
7. **Kaye & Laby Tables of Physical and Chemical Constants** — *Kaye & Laby* dates from 1911, and the 16th Edition was prepared in 1995 by a committee of experts. The coverage extends to almost every field of physics and chemistry; data on a limited number of representative substances or materials are given for each topic. (Longman Group Limited, Harlow, Essex, U.K., 1995)

8. **Lange's Handbook of Chemistry** — Provides broad coverage of chemical data; last updated in 2005. Also available on the Web [www.knovel.com]. (James G. Speight, ed., McGraw-Hill, New York, 2005)
9. **Recommended Reference Materials for the Realization of Physicochemical Properties** — This IUPAC book emphasizes highly accurate data on substances and materials that can be used as calibration standards. It covers physical, thermal, optical, and electrical properties. (K. N. Marsh, ed., Blackwell Scientific Publications, Oxford, 1987)
10. **The Merck Index** — Now in its 14th Edition (published in 2006), *The Merck Index* is a widely used source of data on over 10,000 compounds, chosen particularly for their importance in biology, medicine, and ecology. A short mono-

graph on each compound gives information on the synthesis and uses as well as physical and toxicological properties. A CD-ROM accompanies the book. (Maryadele J. O'Neil, ed., John Wiley & Sons, Indianapolis, IN, 2006)

### E. Summary of Useful Web Sites for Physical and Chemical Properties

Most of the Web sites in the following list provide direct access to factual data on physical and chemical properties. However, the list also includes portals that link to different property databases or describe the procedure for gaining access to electronic sources of property data. There are also a few chemical directory sites that are useful for obtaining formulas, synonyms, and registry numbers for substances of interest.

| Web Site                                                   | Address                                                                           | Comments                                                                                                                              |
|------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| ACD/Labs Spectral Data                                     | www.acdlabs.com/products/spec_lab/exp_spectra/spec_libraries/                     | Infrared, Raman and NMR spectra collections from Coblenz Society and other sources                                                    |
| Acronyms and Symbols                                       | www3.interscience.wiley.com/stasa/                                                | Free service; useful for identifying acronyms for chemicals                                                                           |
| Advanced Chemistry Development                             | www.acdlabs.com                                                                   | Chemical directory, with programs for estimating physical and spectral properties                                                     |
| Alloy Center                                               | products.asminternational.org/alloycenter/                                        | Physical, electrical, thermal, and mechanical properties of alloys                                                                    |
| American Mineralogist Crystal Structure Database           | www.geo.arizona.edu/AMS/amcsd.php                                                 | Lattice constants of minerals                                                                                                         |
| Atomic Mass Data Center                                    | www.nndc.bnl.gov/amdc                                                             | See B.10                                                                                                                              |
| Beilstein                                                  | www.mdl.com/products/knowledge/crossfire_beilstein.com                            | See C.3                                                                                                                               |
| Biocatalysis/Biodegradation Database                       | umbdd.ahc.umn.edu/                                                                | Biocatalytic reactions, biodegradation of chemical compounds                                                                          |
| BioCyc                                                     | biocyc.org/                                                                       | Metabolic pathways of microorganisms                                                                                                  |
| BioInfo Bank                                               | gibk26.bse.kyutech.ac.jp/jouhou/jouhoubank.html                                   | Portal to ProTherm (protein thermodynamics), ProNit (protein–nucleic acid interactions), biomolecule structures                       |
| Biological Macromolecule Crystallization Database          | xpdb.nist.gov:8060/BMCD4/index.faces                                              | Crystal data and crystallization conditions for proteins, nucleic acids, and complexes                                                |
| BRENDA                                                     | www.brenda-enzymes.info/                                                          | Enzyme nomenclature and properties                                                                                                    |
| Cambridge Structural Database                              | www.ccdc.cam.ac.uk                                                                | See B.5                                                                                                                               |
| Carbon Dioxide Information Center                          | cdiac.esd.ornl.gov/                                                               | Data on atmospheric carbon dioxide                                                                                                    |
| Ceramic Properties Databases                               | www.ceramics.org/publications_ceramic_properties_databases.aspx                   | Mechanical, thermal, and other properties of ceramic materials                                                                        |
| ChemExper                                                  | www.chemexper.com/                                                                | Consolidated chemical catalogs from various suppliers; provides physical properties and safety data; links to molfiles and MSDS       |
| Chemfinder                                                 | www.chemfinder.com                                                                | Chemical directory, with links to several property databases                                                                          |
| Chemical Acronyms Database                                 | www.oscar.chem.indiana.edu/cfdocs/libchem/acronyms/acronymsearch.html             | Useful for associating chemical names and acronyms                                                                                    |
| Chemical Entities of Biological Interest (ChEBI)           | www.ebi.ac.uk/chebi/                                                              | Dictionary of molecules and fragments, with identifiers and structures                                                                |
| Chemical Information Sources—Physical Property Information | cheminfo.informatics.indiana.edu/cicc/cis/index.php/Physical_Property_Information | Extensive listing of print and electronic sources of chemical data                                                                    |
| ChemIDplus                                                 | chem.sis.nlm.nih.gov/chemidplus/                                                  | Chemical directory                                                                                                                    |
| ChemIndustry                                               | www.chemindustry.com/chemicals/                                                   | Chemical directory                                                                                                                    |
| CHEMnetBASE                                                | www.chemnetbase.com                                                               | Portal to <i>CRC Chemical Dictionaries</i> , <i>Handbook of Chemistry and Physics</i> , <i>Properties of Organic Compounds</i> , etc. |
| ChemSynthesis Chemical Database                            | www.chemsynthesis.com                                                             | References to synthesis; limited property data                                                                                        |
| ChemWeb Databases                                          | www.chemweb.com/content/databases                                                 | Portal to databases from John Wiley and others                                                                                        |
| CODATA Databases                                           | www.codata.org/resources/databases/index.html                                     | Thermodynamic key values and fundamental constants                                                                                    |

| Web Site                                          | Address                                             | Comments                                                                                                                   |
|---------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Comparative Toxicogenomics Database (CTD)         | ctd.mdibl.org/                                      | Chemical – gene/protein interactions                                                                                       |
| CRC Combined Chemical Dictionary                  | www.chemnetbase.com/scripts/ccdweb.exe              | See C.1                                                                                                                    |
| Crystallography Open Database (COD)               | www.crystallography.net                             | Crystal data on 52,000 compounds                                                                                           |
| DECHEMA (DETERM)                                  | www.dechema.de/en/isystems.html                     | See C.5                                                                                                                    |
| DIPPR Pure Compound Database                      | dippr.byu.edu                                       | See B.3                                                                                                                    |
| Dortmund Data Bank                                | www.ddbst.de                                        | See B.4                                                                                                                    |
| Enzyme Nomenclature Database                      | www.expasy.ch/enzyme/                               | IUBMB nomenclature for enzymes                                                                                             |
| Enzyme Structures Database                        | www.ebi.ac.uk/thornton-srv/databases/enzymes/       | Structures of enzymes in Protein Data Bank                                                                                 |
| European Bioinformatics Institute                 | www.ebi.ac.uk/Databases/                            | Nucleotide and protein sequences, protein structures, enzyme nomenclature and reactions                                    |
| FDM Reference Spectra Databases                   | www.fdmspectra.com/                                 | Infrared, Raman, and mass spectra                                                                                          |
| FIZ Chemie Berlin                                 | www.fiz-chemie.de                                   | Portal to DETERM (C.5), Dortmund Data Bank (B.4), Infotherm, Acronyms                                                      |
| FIZ Karlsruhe — ICSD                              | www.fiz-karlsruhe.de                                | See B.6                                                                                                                    |
| Fundamental Physical Constants                    | physics.nist.gov/constants                          | CODATA fundamental constants                                                                                               |
| Gmelin                                            | www.mdli.com/products/knowledge/crossfire_gmelin/   | See C.4                                                                                                                    |
| <i>Handbook of Chemistry and Physics</i>          | hbcnetbase.com                                      | Web version of <i>CRC Handbook</i>                                                                                         |
| Hazardous Substances Data Bank                    | toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB         | Physical and toxicological properties of chemicals of health or environmental importance                                   |
| HITRAN Database                                   | cfa-www.harvard.edu/hitran/                         | High resolution spectroscopic data for constituents of the atmosphere; parameters for calculating atmospheric transmission |
| Human Metabolome Database                         | hmdb.ca                                             | Chemical and biological data on small molecule metabolites in humans                                                       |
| Infotherm                                         | www.fiz-chemie.de/infotherm/servlet/infothermsearch | Physical and thermal properties of pure compounds and mixtures                                                             |
| International Centre for Diffraction Data         | www.icdd.com                                        | See B.7                                                                                                                    |
| International Spectroscopic Data Bank             | www.is-db.org                                       | All types of spectra, deposited by users. Access is free                                                                   |
| Ionic Liquids Database (ILThermo)                 | ilthermo.boulder.nist.gov/                          | Thermodynamic and thermophysical properties of ionic liquids and mixtures                                                  |
| Ionic Liquids Catalogue                           | ildb.merck.de/ionicliquids/en/startpage.htm         | Miscibility and other properties of organic liquids                                                                        |
| IUBMB                                             | www.chem.qmw.ac.uk/iubmb/                           | Enzyme and nucleic acid nomenclature                                                                                       |
| IUCr Data Activities                              | www.iucr.org/iucr-top/data/index.html#database3     | Portal to crystallographic databases                                                                                       |
| IUPAC Home Page                                   | www.iupac.org                                       | See B.13                                                                                                                   |
| IUPAC Kinetics Data                               | www.iupac-kinetic.ch.cam.ac.uk/                     | See B.13.b                                                                                                                 |
| IUPAC Nomenclature Rules                          | www.chem.qmul.ac.uk/iupac/                          | Useful site for organic and biochemical nomenclature                                                                       |
| IUPAC-NIST Solubility Database                    | srdata.nist.gov/solubility/                         | See B.13.a                                                                                                                 |
| Klotho Biochemical Compounds Declarative Database | www.biocheminfo.org/klotho/                         | Structure diagrams of biochemical molecules                                                                                |
| Knovel.com                                        | www.knovel.com                                      | Portal to <i>Lange's Handbook</i> , <i>Perry's Chemical Engineers' Handbook</i> , etc.                                     |
| Kyoto Encyclopedia of Genes and Genomes (KEGG)    | www.genome.ad.jp/kegg/                              | Includes data on drugs and other biochemical compounds                                                                     |
| <i>Landolt-Börnstein Online</i>                   | www.landolt-boernstein.com                          | See C.6                                                                                                                    |
| Lipidat                                           | www.lipidat.ul.ie/                                  | Structures and thermodynamic properties of lipids; crystal polymorphic transitions                                         |
| MatWeb                                            | www.matweb.com                                      | Thermal, electrical, and mechanical properties of engineering materials                                                    |
| Metals Crystallographic Data File                 | www.tothcanada.com                                  | See B.9                                                                                                                    |
| NASA Chemical Kinetics Data                       | jpldataeval.jpl.nasa.gov                            | Kinetic and photochemical data for stratospheric modeling                                                                  |
| National Center for Biotechnology Information     | www.ncbi.nlm.nih.gov                                | Portal to GenBank and other sequence databases                                                                             |
| National Nuclear Data Center                      | www.nndc.bnl.gov                                    | See B.12                                                                                                                   |
| National Toxicology Program                       | ntp-server.niehs.nih.gov                            | Chemical health and safety data                                                                                            |
| NIST Atomic Spectra Database                      | physics.nist.gov/PhysRefData/contents-atomic.html   | Energy levels, wavelengths, and transition probabilities of atoms and atomic ions                                          |
| NIST Ceramics Webbook                             | www.ceramics.nist.gov/                              | See B.1                                                                                                                    |
| NIST Chemistry Webbook                            | webbook.nist.gov                                    | Broad range of physical, thermal, and spectral properties                                                                  |



| Web Site                                     | Address                                                                           | Comments                                                                                                                                                                                                   |
|----------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NIST Data Gateway                            | srdata.nist.gov/gateway/                                                          | Portal to all NIST data systems; see B.1                                                                                                                                                                   |
| NIST Physical Reference Data                 | physics.nist.gov/PhysRefData/                                                     | Atomic and molecular spectra, cross sections, X-ray attenuation, and dosimetry data                                                                                                                        |
| NLM Gateway                                  | gateway.nlm.nih.gov/gw/                                                           | Portal to all National Library of Medicine databases                                                                                                                                                       |
| NMR Shift DB                                 | www.nmrshiftdb.org                                                                | NMR data submitted by users                                                                                                                                                                                |
| Nucleic Acid Database                        | ndbserver.rutgers.edu/                                                            | Crystal structures of nucleic acids                                                                                                                                                                        |
| Particle Data Group                          | pdg.lbl.gov                                                                       | See B.11                                                                                                                                                                                                   |
| Physical Property Information                | cheminfo.informatics.indiana.edu/cicc/cis/index.php/Physical_Property_Information | Useful list of data sources from Indiana University                                                                                                                                                        |
| Polymers — A Property Database               | www.polymersdatabase.com/                                                         | Properties of commercial polymers                                                                                                                                                                          |
| Powder Diffraction File                      | www.icdd.com                                                                      | See B.7                                                                                                                                                                                                    |
| Properties of Organic Compounds              | www.chemnetbase.com/scripts/pocweb.exe                                            | See C.2                                                                                                                                                                                                    |
| Protein Data Bank                            | www.rcsb.org                                                                      | See B.8                                                                                                                                                                                                    |
| PubChem                                      | pubchem.ncbi.nlm.nih.gov/                                                         | Chemical directory with links to biological information                                                                                                                                                    |
| SABIO-Reaction Kinetics Database             | sabio.villa-bosch.de/SABIORK/                                                     | Data on kinetics of biochemical reactions                                                                                                                                                                  |
| Sigma-Aldrich                                | www.sigmaaldrich.com/                                                             | Chemical catalogs; includes some physical property data                                                                                                                                                    |
| Spectral Database for Organic Compounds      | riodb01.ibase.aist.go.jp/sdbs/cgi-bin/cre_index.cgi?lang=eng                      | MS, NMR, IR, Raman, and ESR spectra; 32,000 compounds measured at AIST, Japan                                                                                                                              |
| SpecInfo                                     | www3.interscience.wiley.com/cgi-bin/mrwhome/109609148/HOME                        | IR, NMR, and mass spectra                                                                                                                                                                                  |
| Spectra Online                               | www.ftirsearch.com/                                                               | FTIR and Raman spectra                                                                                                                                                                                     |
| SPRESI-web                                   | www.spresi.de/                                                                    | Structures, reactions, and some physical properties                                                                                                                                                        |
| STN Easy                                     | stneasy.cas.org                                                                   | Chemical directory (and access to Chemical Abstracts databases)                                                                                                                                            |
| STN Easy-Europe                              | stneasy.fiz-karlsruhe.de                                                          | European node of STN Easy                                                                                                                                                                                  |
| STN Easy-Japan                               | stneasy-japan.cas.org                                                             | Japanese node of STN Easy                                                                                                                                                                                  |
| Swissprot                                    | bo.expasy.org/enzyme/                                                             | Enzyme nomenclature and related information                                                                                                                                                                |
| Syracuse Research Corporation                | www.syrres.com/esc/databases.htm                                                  | Properties of environmental interest                                                                                                                                                                       |
| Table of Isotopes                            | ie.lbl.gov/education/isotopes.htm                                                 | Nuclear energy levels, moments, and other properties                                                                                                                                                       |
| Thermodynamics of Enzyme-Catalyzed Reactions | xpdb.nist.gov/enzyme_thermodynamics/                                              | Equilibrium constants of biochemical reactions                                                                                                                                                             |
| Thermodynamics Research Center               | www.trc.nist.gov                                                                  | See B.2                                                                                                                                                                                                    |
| TOXNET                                       | toxnet.nlm.nih.gov                                                                | Portal to HSDB and other databases on hazardous chemicals                                                                                                                                                  |
| Wiley Interscience                           | www3.interscience.wiley.com/reference.html                                        | Portal to <i>Kirk-Othmer Encyclopedia of Chemical Technology</i> , <i>Ullmann's Encyclopedia of Industrial Chemistry</i> , <i>Encyclopedia of Reagents for Organic Synthesis</i> , SpecInfo Database, etc. |

## Tables Relocated or Removed from CRC Handbook of Chemistry and Physics, 71st through 89th Editions

The following tables appeared in previous editions of the *CRC Handbook of Chemistry and Physics* but have been removed, retitled, or rearranged in subsequent editions. In most cases, some or all of the information contained in the original table has been incorporated, in updated form, in a different table (or tables). In such cases the appropriate page references to the 90th Edition (2009-2010) are given in the last column, and the older table should be considered obsolete. The last edition in which the older table appeared is indicated.

| Table Title                                                              | Last Ed. | Comments                                                                                                                    |
|--------------------------------------------------------------------------|----------|-----------------------------------------------------------------------------------------------------------------------------|
| Abbreviations Used in Polymerization Processes                           | 75 Ed.   | Removed; general abbreviations in 90 Ed., p. 2-29                                                                           |
| Absorption and Velocity of Sound in Still Air                            | 76 Ed.   | Updated; see 90 Ed., p. 14-50, 14-51                                                                                        |
| Allowable Carrying Capacities of Conductors                              | 75 Ed.   | Removed                                                                                                                     |
| Aluminum Wire Table                                                      | 75 Ed.   | Data included in 90 Ed., p. 15-37                                                                                           |
| Biochemical Symbols and Abbreviations                                    | 77 Ed.   | See 90 Ed., p. 2-29                                                                                                         |
| Boiling Point of Water at Various Pressures                              | 89 Ed.   | Removed; can be calculated from vapor pressure table in 90 Ed., p. 6-5                                                      |
| Boiling Point Index of Organic Compounds                                 | 83 Ed.   | Searching available in Internet and CDROM versions                                                                          |
| Brazing Filler Metals (Solders)                                          | 75 Ed.   | Removed                                                                                                                     |
| Chemical Composition of Rocks                                            | 73 Ed.   | Removed                                                                                                                     |
| Classification of Comparative Life Hazards of Gases and Vapors           | 76 Ed.   | Removed                                                                                                                     |
| Constants for Satellite Geodesy                                          | 74 Ed.   | Removed                                                                                                                     |
| Cross-Section and Mass of Wires                                          | 75 Ed.   | Data included in 90 Ed., p. 15-37                                                                                           |
| Density and Composition of Fuming Sulfuric Acid                          | 75 Ed.   | Removed                                                                                                                     |
| Density of D <sub>2</sub> O                                              | 89 Ed.   | See 90 Ed., p. 6-10                                                                                                         |
| Diamagnetic Susceptibility Data on Organosilicon Compounds               | 74 Ed.   | Removed                                                                                                                     |
| Diffusivities of Metallic Solutes in Molten Metals                       | 76 Ed.   | Removed                                                                                                                     |
| Diffusivities of Metallic Tracers in Mercury                             | 75 Ed.   | Removed                                                                                                                     |
| Dissociation Constants of Acids in Water at Various Temperatures         | 74 Ed.   | Removed                                                                                                                     |
| Dissociation Constants of Aqueous Ammonia from 0 to 50° C                | 74 Ed.   | Removed                                                                                                                     |
| Dissociation Constants of Inorganic Acids in Aqueous Solution            | 74 Ed.   | See 90 Ed., p. 8-40 (acids and bases combined)                                                                              |
| Dissociation Constants of Inorganic Bases in Aqueous Solution at 298 K   | 74 Ed.   | See 90 Ed., p. 8-40 (acids and bases combined)                                                                              |
| Dissociation Constants of Organic Acids in Aqueous Solution              | 74 Ed.   | See 90 Ed., p. 8-42 (acids and bases combined)                                                                              |
| Dissociation Constants of Organic Bases in Aqueous Solution              | 74 Ed.   | See 90 Ed., p. 8-42 (acids and bases combined)                                                                              |
| Efficacies and Other Characteristics of Illuminants                      | 76 Ed.   | Removed                                                                                                                     |
| Efficiency of Drying Agents                                              | 76 Ed.   | Removed                                                                                                                     |
| Emergent Stem Corrections for Liquid-in-Glass Thermometers               | 75 Ed.   | Removed                                                                                                                     |
| Emissivity of Total Radiation for Various Materials                      | 77 Ed.   | Removed                                                                                                                     |
| Emissivity of Tungsten                                                   | 77 Ed.   | Removed                                                                                                                     |
| Enthalpy of Vaporization of Water                                        | 89 Ed.   | See 90 Ed., p. 6-5                                                                                                          |
| Fats and Oils                                                            | 76 Ed.   | See 90 Ed., p. 7-9                                                                                                          |
| Gibbs Energy of Formation of Metal Oxides                                | 77 Ed.   | Included in comprehensive table of thermodynamic properties; see 90 Ed., p. 5-4                                             |
| Heat Capacity of Liquids and Gases at 25° C                              | 76 Ed.   | Included in comprehensive table of thermodynamic properties; see 90 Ed., p. 5-4                                             |
| Heat Capacity of Mercury                                                 | 73 Ed.   | Included with other thermal properties of mercury; see 90 Ed., p. 6-158                                                     |
| Index of Refraction of Fused Quartz                                      | 76 Ed.   | See 90 Ed., p. 10-250                                                                                                       |
| Index of Refraction of Rock Salt, Sylvine, Calcite, Fluorite, and Quartz | 76 Ed.   | See 90 Ed., p. 4-149                                                                                                        |
| Introduction to X-Ray Cross Sections                                     | 74 Ed.   | Removed                                                                                                                     |
| Ion Exchange Resins                                                      | 77 Ed.   | Removed                                                                                                                     |
| Isothermal Compressibility of Liquids                                    | 76 Ed.   | Data included in 90 Ed., p. 6-140                                                                                           |
| Kinetic and Photochemical Data for Atmospheric Chemistry                 | 79 Ed.   | See 90 Ed., p. 5-90 (emphasis on stratospheric chemistry)                                                                   |
| Kinetic Data for Combustion Modelling                                    | 79 Ed.   | Removed from book; still present in electronic versions                                                                     |
| Lattice Constants for Cubic Crystals                                     | 76 Ed.   | Removed; some data included in 90 Ed., p. 4-156                                                                             |
| Lattice Spacing of Common Analyzing Crystals                             | 76 Ed.   | Removed                                                                                                                     |
| Lowering of Vapor Pressure by Salts in Aqueous Solution                  | 77 Ed.   | Removed; related data in 90 Ed., p. 6-110                                                                                   |
| Magnetic Rotatory Power                                                  | 74 Ed.   | Removed                                                                                                                     |
| Melting Point Index of Organic Compounds                                 | 83 Ed.   | Searching available in Internet and CDROM versions                                                                          |
| Minerals Arranged in Order of Increasing Vickers Hardness Numbers        | 75 Ed.   | See 90 Ed., p. 12-222, for hardness of minerals and ceramics (Mohs and Knoop scales); can be sorted in electronic versions. |
| Molecular Depression of the Freezing Point                               | 75 Ed.   | See 90 Ed., p. 15-28                                                                                                        |
| Molecular Elevation of the Boiling Point                                 | 75 Ed.   | See 90 Ed., p. 15-27                                                                                                        |
| Nomenclature of Inorganic Chemistry                                      | 74 Ed.   | See 90 Ed., p. 2-15 (references only), 2-16                                                                                 |
| Nomenclature of Organic Compounds                                        | 74 Ed.   | See 90 Ed., p. 2-15 (references only), 2-23                                                                                 |
| Nomograph and Table for Doppler Linewidths                               | 76 Ed.   | Removed                                                                                                                     |
| Optical Properties of Metals                                             | 73 Ed.   | See 90 Ed., p. 12-123                                                                                                       |
| Organic Compounds Listed in Order of Index of Refraction                 | 74 Ed.   | Removed; electronic versions permit sorting in this order.                                                                  |
| Oxygen Solubility in Aqueous Electrolyte Solutions                       | 76 Ed.   | Removed                                                                                                                     |

|                                                                                       |                                                                                                       |
|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Permittivity (Dielectric Constant) of Water as a Function of Temperature and Pressure | 89 Ed. See 90 Ed., p. <b>6-1</b>                                                                      |
| Physical and Photometric Data for Planets and Satellites                              | 74 Ed. Related data included in 90 Ed., p. <b>14-2, 14-4</b>                                          |
| Physical Constants of Clear Fused Quartz                                              | 76 Ed. Removed                                                                                        |
| Physical Constants of Minerals                                                        | 75 Ed. See 90 Ed., p. <b>4-149</b> , for physical & optical properties                                |
| Platinum Wire                                                                         | 73 Ed. Data included in 90 Ed., p. <b>15-37</b>                                                       |
| Properties of Carbohydrates                                                           | 77 Ed. Removed as separate table; data included in 90 Ed., p. <b>3-1 to 3-523</b>                     |
| Properties of Large Production and Priority Organic Pollutants                        | 77 Ed. See 90 Ed., p. <b>6-72, 8-85, 16-43</b> for the data in this table                             |
| Properties of Sulfuric Acid                                                           | 75 Ed. Removed; for density, see 90 Ed., p. <b>15-40</b>                                              |
| Properties of Tungsten                                                                | 76 Ed. Removed                                                                                        |
| Properties of Water in the Range 0-100 °C                                             | 89 Ed. See 90 Ed., pp. <b>6-1, 6-5</b>                                                                |
| Radiative Transition Probabilities for X-Ray Lines                                    | 77 Ed. Removed                                                                                        |
| Radioactive Tracer Diffusion Data for Pure Metals                                     | 75 Ed. Removed                                                                                        |
| Recommended Daily Dietary Allowances                                                  | 77 Ed. Removed                                                                                        |
| Reduction of Barometer to Sea Level                                                   | 75 Ed. Removed                                                                                        |
| Refractory Materials                                                                  | 76 Ed. Some data included in 90 Ed., p. <b>12-211</b>                                                 |
| Resistance of Wires                                                                   | 75 Ed. See 90 Ed., p. <b>15-37</b>                                                                    |
| Resistivity of Semiconducting Minerals                                                | 73 Ed. Data included in 90 Ed., pp. <b>12-80</b>                                                      |
| Solvents for Liquid Chromatography                                                    | 78 Ed. Removed; data included in other tables on solvents                                             |
| Spark-Gap Voltages                                                                    | 73 Ed. Removed                                                                                        |
| Specific Heat and Enthalpy of Some Solids at Low Temperature                          | 73 Ed. Removed                                                                                        |
| Spectral Emissivity                                                                   | 76 Ed. Removed                                                                                        |
| Spectral Emissivity of Oxides                                                         | 76 Ed. Removed                                                                                        |
| Standard Test Sieves and Mesh Size Conversion                                         | 75 Ed. Removed                                                                                        |
| Standard Types of Stainless and Heat Resisting Steels                                 | 74 Ed. Removed                                                                                        |
| Steam Tables                                                                          | 79 Ed. Replaced by 90 Ed., p. <b>6-1</b>                                                              |
| Steroid Hormones and Other Steroidal Synthetics                                       | 76 Ed. Removed as separate table; data included in 90 Ed., p. <b>3-1 to 3-523</b>                     |
| Sublimation Pressure for Organic Compounds                                            | 73 Ed. See 90 Ed., p. <b>6-70</b>                                                                     |
| Surface Tension of Liquid Elements                                                    | 73 Ed. Removed                                                                                        |
| Temperature Correction for Barometer Readings                                         | 75 Ed. See 90 Ed., p. <b>15-30</b>                                                                    |
| Temperature Correction for Glass Volumetric Apparatus                                 | 75 Ed. Removed                                                                                        |
| Temperature Correction for Volumetric Solutions                                       | 75 Ed. Removed                                                                                        |
| Temperature Correction, Glass Scale                                                   | 73 Ed. Removed                                                                                        |
| Temperature Dependence of the Permittivity (Dielectric Constant) of Liquids           | 78 Ed. See 90 Ed., p. <b>6-166</b> (Temperature dependence included in general table of permittivity) |
| The Earth: Its Mass, Dimensions, and Other Related Quantities                         | 74 Ed. Updated table in 90 Ed., p. <b>14-10</b>                                                       |
| The Limits of Superheat of Pure Liquids                                               | 76 Ed. Removed                                                                                        |
| The pH of Natural Media and its Relation to Precipitation of Hydroxides               | 73 Ed. See 90 Ed., p. <b>8-37</b>                                                                     |
| Thermal Conductivity of Certain Metals                                                | 73 Ed. See 90 Ed., p. <b>12-203, 12-205, 12-206, 12-208</b>                                           |
| Thermal Conductivity of Rocks                                                         | 73 Ed. Removed; certain data included in 90 Ed., p. <b>12-211</b>                                     |
| Thermal Conductivity of Saturated H <sub>2</sub> O and D <sub>2</sub> O               | 89 Ed. See 90 Ed., pp. <b>6-1, 6-10</b>                                                               |
| Thermal Conductivity of the Elements                                                  | 73 Ed. See 90 Ed., p. <b>12-203 &amp; 12-206</b> for solid elements; <b>6-218</b> for gases.          |
| Total Monthly Solar Radiation in a Cloudless Sky                                      | 76 Ed. Removed; related data in 90 Ed., p. <b>14-26</b>                                               |
| Transmission of Corning Colored Filters                                               | 74 Ed. Removed                                                                                        |
| Transmission of Light by Common Optical Materials                                     | 76 Ed. See 90 Ed., p. <b>10-250</b>                                                                   |
| Transmission of Wratten Filters                                                       | 74 Ed. Removed                                                                                        |
| Ultraviolet Spectra of Common Liquids                                                 | 77 Ed. Removed                                                                                        |
| Units, Symbols, and Equations for Radiometric and Photometric Quantities              | 77 Ed. Removed (this information is contained in 90 Ed., p. <b>2-1</b> and <b>2-29</b> )              |
| Values for the Langevin Function                                                      | 77 Ed. Removed                                                                                        |
| Vapor Pressure at Elevated Temperatures                                               | 77 Ed. See 90 Ed., p. <b>6-72</b>                                                                     |
| Vapor Pressure in the Range -25 °C to 150 °C                                          | 77 Ed. See 90 Ed., p. <b>6-72</b>                                                                     |
| Velocity of Sound in Dry Air                                                          | 76 Ed. See 90 Ed., p. <b>14-51</b>                                                                    |
| Velocity of Sound in Various Media                                                    | 77 Ed. See 90 Ed., p. <b>14-48</b>                                                                    |
| Viscosity of Aqueous Solutions                                                        | 78 Ed. See 90 Ed., p. <b>8-52</b>                                                                     |
| Weight of One Gallon of Water                                                         | 75 Ed. See 90 Ed., p. <b>8-139</b> for related data                                                   |
| Wire Table:Standard Annealed Copper                                                   | 75 Ed. See 90 Ed., p. <b>15-37</b>                                                                    |
| Wire Tables:Comparison of Wire Gauges                                                 | 75 Ed. See 90 Ed., p. <b>15-37</b>                                                                    |
| X-Ray Crystallographic Data on Inorganic Substances and Minerals                      | 76 Ed. See 90 Ed., p. <b>4-156</b>                                                                    |
| X-Ray Wavelengths                                                                     | 76 Ed. Removed                                                                                        |



## ALLOWABLE CARRYING CAPACITIES OF CONDUCTORS

(National Electrical Code)

The ratings in the following tabulation are those permitted by the National Electrical Code for flexible cords and for interior wiring of houses, hotels, office buildings, industrial plants, and other buildings.

The values are for copper wire. For aluminum wire the allowable carrying capacities shall be taken as 84% of those given in the table for the respective sizes of copper wire with the same kind of covering.

| Size<br>A.W.G. | Area<br>Circular<br>Mils | Diameter<br>of Solid<br>Wires Mils | Rubber<br>Insulation<br>Amperes | Varnished<br>Cambric<br>Insulation<br>Amperes | Other<br>Insulations<br>and Bare<br>Conductors<br>Amperes | Size<br>A.W.G. | Area<br>Circular<br>Mils | Diameter<br>of Solid<br>Wires Mils | Rubber<br>Insulation<br>Amperes | Varnished<br>Cambric<br>Insulation<br>Amperes | Other<br>Insulations<br>and Bare<br>Conductors<br>Amperes |
|----------------|--------------------------|------------------------------------|---------------------------------|-----------------------------------------------|-----------------------------------------------------------|----------------|--------------------------|------------------------------------|---------------------------------|-----------------------------------------------|-----------------------------------------------------------|
| 18             | 1,624.                   | 40.3                               | 3*                              |                                               | 6†                                                        | 4              | 41,740.                  | 204.3                              | 70                              | 85                                            | 90                                                        |
| 16             | 2,583.                   | 50.8                               | 6*                              |                                               | 10†                                                       | 3              | 52,630.                  | 229.4                              | 80                              | 95                                            | 100                                                       |
| 14             | 4,107.                   | 64.1                               | 15                              | 18                                            | 20                                                        | 2              | 66,370.                  | 257.6                              | 90                              | 110                                           | 125                                                       |
| 12             | 6,530.                   | 80.8                               | 20                              | 25                                            | 30                                                        | 1              | 83,690.                  | 289.3                              | 100                             | 120                                           | 150                                                       |
| 10             | 10,380.                  | 101.9                              | 25                              | 30                                            | 35                                                        | 0              | 105,500.                 | 325.0                              | 125                             | 150                                           | 200                                                       |
| 8              | 16,510.                  | 128.5                              | 35                              | 40                                            | 50                                                        | 00             | 135,100.                 | 364.8                              | 150                             | 180                                           | 225                                                       |
| 6              | 26,250.                  | 162.0                              | 50                              | 60                                            | 70                                                        | 000            | 167,800.                 | 409.6                              | 175                             | 210                                           | 275                                                       |
| 5              | 33,100.                  | 181.9                              | 55                              | 65                                            | 80                                                        | 0000           | 211,600.                 | 460                                | 225                             | 270                                           | 325                                                       |

\* The allowable carrying capacities of No. 18 and 16 are 5 and 7 amperes respectively, when in flexible cords.

† The allowable carrying capacities of No. 18 and 16 are 10 and 15 amperes respectively, when in cords for portable heaters. Types AFS, AFSJ, HC, HPD, and HSJ.

# ALUMINUM WIRE TABLE

Hard-Drawn Aluminum Wire at 20°C (or, 68°F) American Wire Gauge (B. & S.) English Units

| Gauge No. | Diameter in mils | Cross section |               | Ohms per 1000 ft | Pounds per 1000 ft | Pounds per ohm | Feet per ohm | Gauge No. | Diameter in mm | Cross section in mm² | Ohms per kilometer | Kilograms per kilometer | Grams per ohm | Meters per ohm |
|-----------|------------------|---------------|---------------|------------------|--------------------|----------------|--------------|-----------|----------------|----------------------|--------------------|-------------------------|---------------|----------------|
|           |                  | Circular mils | Square inches |                  |                    |                |              |           |                |                      |                    |                         |               |                |
| 0000      | 460              | 212000        | 0.166         | 0.0804           | 195                | 2420           | 12400        | 0000      | 11.7           | 107                  | .0264              | 289                     | 1100000       | 3790           |
| 000       | 410              | 168000        | .132          | .101             | 154                | 1520           | 9860         | 000       | 10.4           | 85.0                 | .333               | 230                     | 690000        | 3010           |
| 00        | 365              | 133000        | .105          | .128             | 122                | 957            | 7820         | 00        | 9.3            | 67.4                 | .419               | 182                     | 434000        | 2380           |
| 0         | 325              | 106000        | .0829         | .161             | 97.0               | 602            | 6200         | 0         | 8.3            | 53.5                 | .529               | 144                     | 273000        | 1890           |
| 1         | 289              | 83700         | .0657         | .203             | 76.9               | 379            | 4920         | 1         | 7.3            | 42.4                 | .667               | 114.                    | 172000        | 1500           |
| 2         | 258              | 66400         | .0521         | .256             | 61.0               | 238            | 3900         | 2         | 6.5            | 33.6                 | .841               | 90.8                    | 108000        | 1190           |
| 3         | 229              | 52600         | .0413         | .323             | 48.4               | 150            | 3090         | 3         | 5.8            | 26.7                 | 1.06               | 72.0                    | 67900         | 943            |
| 4         | 204              | 41700         | .0328         | .408             | 38.4               | 94.2           | 2450         | 4         | 5.2            | 21.2                 | 1.34               | 57.1                    | 42700         | 748            |
| 5         | 182              | 33100         | .0260         | .514             | 30.4               | 59.2           | 1950         | 5         | 4.6            | 16.8                 | 1.69               | 45.3                    | 26900         | 593            |
| 6         | 162              | 26300         | .0206         | .648             | 24.1               | 37.2           | 1540         | 6         | 4.1            | 13.3                 | 2.13               | 35.9                    | 16900         | 470            |
| 7         | 144              | 20800         | .0164         | .817             | 19.1               | 23.4           | 1220         | 7         | 3.7            | 10.5                 | 2.68               | 28.5                    | 10600         | 373            |
| 8         | 128              | 16500         | .0130         | 1.03             | 15.2               | 14.7           | 970          | 8         | 3.3            | 8.37                 | 3.38               | 22.6                    | 6680          | 296            |
| 9         | 114              | 13100         | .0103         | 1.30             | 12.0               | 9.26           | 770          | 9         | 2.91           | 6.63                 | 4.26               | 17.9                    | 4200          | 235            |
| 10        | 102              | 10400         | .00815        | 1.64             | 9.55               | 5.83           | 610          | 10        | 2.59           | 5.26                 | 5.38               | 14.2                    | 2640          | 186            |
| 11        | 91               | 8230          | .00647        | 2.07             | 7.57               | 3.66           | 484          | 11        | 2.30           | 4.17                 | 6.78               | 11.3                    | 1660          | 148            |
| 12        | 81               | 6530          | .00513        | 2.61             | 6.00               | 2.30           | 384          | 12        | 2.05           | 3.31                 | 8.55               | 8.93                    | 1050          | 117            |
| 13        | 72               | 5180          | .00407        | 3.29             | 4.76               | 1.45           | 304          | 13        | 1.83           | 2.62                 | 10.8               | 7.08                    | 657           | 92.8           |
| 14        | 64               | 4110          | .00323        | 4.14             | 3.78               | 0.911          | 241          | 14        | 1.63           | 2.08                 | 13.6               | 5.62                    | 413           | 73.6           |
| 15        | 57               | 3260          | .00256        | 5.22             | 2.99               | .573           | 191          | 15        | 1.45           | 1.65                 | 17.1               | 4.46                    | 260           | 58.4           |
| 16        | 51               | 2580          | .00203        | 6.59             | 2.37               | .360           | 152          | 16        | 1.29           | 1.31                 | 21.6               | 3.53                    | 164           | 46.3           |
| 17        | 45               | 2050          | .00161        | 8.31             | 1.88               | .227           | 120          | 17        | 1.15           | 1.04                 | 27.3               | 2.80                    | 103           | 36.7           |
| 18        | 40               | 1620          | .00128        | 10.5             | 1.49               | .143           | 95.5         | 18        | 1.02           | 0.823                | 34.4               | 2.22                    | 64.7          | 29.1           |
| 19        | 36               | 1290          | .00101        | 13.2             | 1.18               | .0897          | 75.7         | 19        | 0.91           | .653                 | 43.3               | 1.76                    | 40.7          | 23.1           |
| 20        | 32               | 1020          | .000802       | 16.7             | 0.939              | .0564          | 60.0         | 20        | .81            | .518                 | 54.6               | 1.40                    | 25.6          | 18.3           |
| 21        | 28.5             | 810           | .000636       | 21.0             | .745               | .0355          | 47.6         | 21        | .72            | .411                 | 68.9               | 1.11                    | 16.1          | 14.5           |
| 22        | 25.3             | 642           | .000505       | 26.5             | .591               | .0223          | 37.8         | 22        | .64            | .326                 | 86.9               | 0.879                   | 10.1          | 11.5           |
| 23        | 22.6             | 509           | .000400       | 33.4             | .468               | .0140          | 29.9         | 23        | .57            | .258                 | 110                | .697                    | 6.36          | 9.13           |
| 24        | 20.1             | 404           | .000317       | 42.1             | .371               | .00882         | 23.7         | 24        | .51            | .205                 | 138                | .553                    | 4.00          | 7.24           |
| 25        | 17.9             | 320           | .000252       | 53.1             | .295               | .00555         | 18.8         | 25        | .45            | .162                 | 174                | .438                    | 2.52          | 5.74           |
| 26        | 15.9             | 254           | .000200       | 67.0             | .234               | .00349         | 14.9         | 26        | .40            | .129                 | 220                | .348                    | 1.58          | 4.55           |
| 27        | 14.2             | 202           | .000158       | 84.4             | .185               | .00219         | 11.8         | 27        | .36            | .102                 | 277                | .276                    | 0.995         | 3.61           |
| 28        | 12.6             | 160           | .000126       | 106.             | .147               | .00138         | 9.39         | 28        | .32            | .0810                | 349                | .219                    | .626          | 2.86           |
| 29        | 11.3             | 127           | .0000995      | 134.             | .117               | .000868        | 7.45         | 29        | .29            | .0642                | 440                | .173                    | .394          | 2.27           |
| 30        | 10.0             | 101           | .0000789      | 169.             | .0924              | .000546        | 5.91         | 30        | .25            | .0509                | 555                | .138                    | .248          | 1.80           |
| 31        | 8.9              | 79.7          | .0000626      | 213.             | .0733              | .000343        | 4.68         | 31        | .227           | .0404                | 700                | .109                    | .156          | 1.43           |
| 32        | 8.0              | 63.2          | .0000496      | 269.             | .0581              | .000216        | 3.72         | 32        | .202           | .0320                | 883                | .0865                   | .0979         | 1.13           |
| 33        | 7.1              | 50.1          | .0000394      | 339.             | .0461              | .000136        | 2.95         | 33        | .180           | .0254                | 1110               | .0686                   | .0616         | 0.899          |
| 34        | 6.3              | 39.8          | .0000312      | 428.             | .0365              | .0000854       | 2.34         | 34        | .160           | .0201                | 1400               | .0544                   | .0387         | .712           |
| 35        | 5.6              | 31.5          | .0000248      | 540.             | .0290              | .0000537       | 1.85         | 35        | .143           | .0160                | 1770               | .0431                   | .0244         | .565           |
| 36        | 5.0              | 25.0          | .0000196      | 681.             | .0230              | .0000338       | 1.47         | 36        | .127           | .0127                | 2230               | .0342                   | .0153         | .448           |
| 37        | 4.5              | 19.8          | .0000156      | 858.             | .0182              | .0000212       | 1.17         | 37        | .113           | .0100                | 2820               | .0271                   | .00963        | .355           |
| 38        | 4.0              | 15.7          | .0000123      | 1080.            | .0145              | .0000134       | 0.924        | 38        | .101           | .0080                | 3550               | .0215                   | .00606        | .282           |
| 39        | 3.5              | 12.5          | .00000979     | 1360.            | .0115              | .00000840      | .733         | 39        | .090           | .0063                | 4480               | .0171                   | .00381        | .223           |
| 40        | 3.1              | 9.9           | .0000077      | 1720.            | .0091              | .00000528      | .581         | 40        | .080           | .0050                | 5640               | .0135                   | .00240        | .177           |

## BRAZING FILLER METALS (SOLDERS)

| AWS-ASTM<br>Classification | Solidus, °F | Liquidus, °F | Brazing Temperature<br>Range, °F | Ag          | Al    | As | Au       | B | Be            | Bi | C | Cd    | Cr      | Cu         | Fe       | Li | Mg   | Mn        | Ni      | P     | Pb        | Sb        | Si        | Sn       | Ti        | Zn                | Other             |                    | AWS-ASTM<br>Classification |
|----------------------------|-------------|--------------|----------------------------------|-------------|-------|----|----------|---|---------------|----|---|-------|---------|------------|----------|----|------|-----------|---------|-------|-----------|-----------|-----------|----------|-----------|-------------------|-------------------|--------------------|----------------------------|
|                            |             |              |                                  |             |       |    |          |   |               |    |   |       |         |            |          |    |      |           |         |       |           |           |           |          |           |                   | Each              | Total              |                            |
|                            |             |              |                                  |             |       |    |          |   |               |    |   |       |         |            |          |    |      |           |         |       |           |           |           |          |           |                   |                   |                    |                            |
| ALUMINUM-SILICON           |             |              |                                  |             |       |    |          |   |               |    |   |       |         |            |          |    |      |           |         |       |           |           |           |          |           |                   |                   |                    |                            |
| BAISI-2                    | 1070        | 1135         | 1110-1150                        |             | Bal.  |    |          |   |               |    |   |       |         | 0.25       | 0.8      |    |      | 0.10      |         |       |           |           | 6.8-8.2   |          |           | 0.20              | 0.05              | 0.15               | BAISI-2                    |
| BAISI-3                    | 970         | 1085         | 1060-1120                        |             | Bal.  |    |          |   |               |    |   | 0.15  | 3.3-4.7 | 0.30       | 0.8      |    | 0.15 | 0.15      |         |       |           |           | 9.3-10.7  |          |           | 0.20              | 0.05              | 0.15               | BAISI-3                    |
| BAISI-4                    | 1070        | 1080         | 1080-1120                        |             | Bal.  |    |          |   |               |    |   |       |         | 0.30       | 0.8      |    | 0.10 | 0.15      |         |       |           |           | 11.0-13.0 |          |           | 0.20              | 0.05              | 0.15               | BAISI-4                    |
| BAISI-5                    | 1070        | 1095         | 1090-1120                        |             | Bal.  |    |          |   |               |    |   |       |         | 0.30       | 0.8      |    | 0.05 | 0.05      |         |       |           |           | 9.0-11.0  | 0.20     | 0.10      | 0.05              | 0.15              | BAISI-5            |                            |
| COPPER-PHOSPHORUS          |             |              |                                  |             |       |    |          |   |               |    |   |       |         |            |          |    |      |           |         |       |           |           |           |          |           |                   |                   |                    |                            |
| BCuP-1                     | 1310        | 1650         | 1450-1700                        |             |       |    |          |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       | 4.75-5.25 |           |           |          |           |                   |                   | 0.15               | BCuP-1                     |
| BCuP-2                     | 1310        | 1460         | 1350-1550                        |             |       |    |          |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       | 7.00-7.25 |           |           |          |           |                   |                   | 0.15               | BCuP-2                     |
| BCuP-3                     | 1190        | 1485         | 1300-1500                        | 4.75-5.25   |       |    |          |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       | 5.75-6.25 |           |           |          |           |                   |                   | 0.15               | BCuP-3                     |
| BCuP-4                     | 1190        | 1335         | 1300-1450                        | 5.75-6.25   |       |    |          |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       | 7.00-7.50 |           |           |          |           |                   |                   | 0.15               | BCuP-4                     |
| BCuP-5                     | 1190        | 1475         | 1300-1500                        | 14.50-15.50 |       |    |          |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       | 4.75-5.25 |           |           |          |           |                   |                   | 0.15               | BCuP-5                     |
| SILVER                     |             |              |                                  |             |       |    |          |   |               |    |   |       |         |            |          |    |      |           |         |       |           |           |           |          |           |                   |                   |                    |                            |
| BAG-1                      | 1125        | 1145         | 1145-1400                        | 44-46       |       |    |          |   |               |    |   | 23-25 |         | 14-16      |          |    |      |           |         |       |           |           |           |          | 14-18     |                   | 0.15              | BAG-1              |                            |
| BAG-1a                     | 1160        | 1175         | 1175-1400                        | 49-51       |       |    |          |   |               |    |   | 17-19 |         | 14.5-16.5  |          |    |      |           |         |       |           |           |           |          | 14.5-18.5 |                   | 0.15              | BAG-1a             |                            |
| BAG-2                      | 1125        | 1295         | 1295-1550                        | 34-36       |       |    |          |   |               |    |   | 17-19 |         | 25-27      |          |    |      |           |         |       |           |           |           |          | 19-23     |                   | 0.15              | BAG-2              |                            |
| BAG-3                      | 1170        | 1270         | 1270-1500                        | 49-51       |       |    |          |   |               |    |   | 15-17 |         | 14.5-16.5  |          |    |      |           | 2.5-3.5 |       |           |           |           |          | 13.5-17.5 |                   | 0.15              | BAG-3              |                            |
| BAG-4                      | 1240        | 1435         | 1435-1650                        | 39-41       |       |    |          |   |               |    |   |       |         | 29-31      |          |    |      |           | 1.5-2.5 |       |           |           |           |          | 26-30     |                   | 0.15              | BAG-4              |                            |
| BAG-5                      | 1250        | 1370         | 1370-1550                        | 44-46       |       |    |          |   |               |    |   |       |         | 29-31      |          |    |      |           |         |       |           |           |           |          | 23-27     |                   | 0.15              | BAG-5              |                            |
| BAG-6                      | 1270        | 1425         | 1425-1600                        | 49-51       |       |    |          |   |               |    |   |       |         | 33-35      |          |    |      |           |         |       |           |           |           |          | 14-18     |                   | 0.15              | BAG-6              |                            |
| BAG-7                      | 1145        | 1205         | 1205-1400                        | 55-57       |       |    |          |   |               |    |   |       |         | 21-23      |          |    |      |           |         |       |           |           | 4.5-5.5   |          | 15-19     |                   | 0.15              | BAG-7              |                            |
| BAG-8                      | 1435        | 1435         | 1435-1650                        | 71-73       |       |    |          |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       |           |           |           |          |           |                   | 0.15              | BAG-8              |                            |
| BAG-8a                     | 1410        | 1410         | 1410-1600                        | 71-73       |       |    |          |   |               |    |   |       |         | Bal.       | 0.15-0.3 |    |      |           |         |       |           |           |           |          |           |                   | 0.15              | BAG-8a             |                            |
| BAG-13                     | 1325        | 1575         | 1575-1775                        | 53-55       |       |    |          |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       |           |           |           |          | 4.0-6.0   |                   | 0.15              | BAG-13             |                            |
| BAG-18                     | 1115        | 1125         | 1325-1550                        | 59-61       |       |    |          |   |               |    |   |       |         | Bal.       |          |    |      |           |         | 0.025 |           |           |           | 9.5-10.5 |           |                   | 0.15              | BAG-18             |                            |
| BAG-19                     | 1435        | 1635         | 1610-1800                        | 92-93       |       |    |          |   |               |    |   |       |         | Bal.       | 0.15-0.3 |    |      |           |         |       |           |           |           |          |           |                   | 0.15              | BAG-19             |                            |
| PRECIOUS METALS            |             |              |                                  |             |       |    |          |   |               |    |   |       |         |            |          |    |      |           |         |       |           |           |           |          |           |                   |                   |                    |                            |
| BAu-1                      | 1815        | 1860         | 1860-2000                        |             |       |    | 37.0+1-0 |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       |           |           |           |          |           |                   | 0.15              | BAu-1              |                            |
| BAu-2                      | 1635        | 1635         | 1635-1850                        |             |       |    | 79.5+1-0 |   |               |    |   |       |         | Bal.       |          |    |      |           |         |       |           |           |           |          |           |                   | 0.15              | BAu-2              |                            |
| BAu-3                      | 1785        | 1885         | 1885-1995                        |             |       |    | 34.5+1-0 |   |               |    |   |       |         | Bal.       |          |    |      |           | 2.5-3.5 |       |           |           |           |          |           |                   | 0.15              | BAu-3              |                            |
| BAu-4                      | 1740        | 1740         | 1740-1840                        |             |       |    | 81.5+1-0 |   |               |    |   |       |         |            |          |    |      |           | Bal.    |       |           |           |           |          |           |                   | 0.15              | BAu-4              |                            |
| COPPER AND COPPER-ZINC     |             |              |                                  |             |       |    |          |   |               |    |   |       |         |            |          |    |      |           |         |       |           |           |           |          |           |                   |                   |                    |                            |
| BCu-1                      | 1980        | 1980         | 2000-2100                        |             | 0.01  |    |          |   |               |    |   |       |         | 99.90 min. |          |    |      |           |         | 0.075 | 0.02      |           |           |          |           |                   | 0.10              | BCu-1              |                            |
| BCu-1a                     | 1980        | 1980         | 2000-2100                        |             |       |    |          |   |               |    |   |       |         | 99.0 min.  |          |    |      |           |         |       |           |           |           |          |           |                   | 0.30              | BCu-1a             |                            |
| BCu-2                      | 1980        | 1980         | 2000-2100                        |             |       |    |          |   |               |    |   |       |         | 86.5 min.  |          |    |      |           |         |       |           |           |           |          |           |                   | 0.50              | BCu-2 <sup>b</sup> |                            |
| RBCuZn-A                   | 1630        | 1650         | 1670-1750                        |             | 0.01* |    |          |   |               |    |   |       |         | 57-61      | *        |    | *    |           |         | 0.05* |           | *         | 0.25-1.00 |          | Bal.      |                   | 0.50 <sup>d</sup> | RBCuZn-A*          |                            |
| RBCuZn-D                   | 1690        | 1715         | 1720-1800                        |             | 0.01* |    |          |   |               |    |   |       |         | 46-50      |          |    |      | 9.0-11.0  | 0.25    | 0.05* |           | 0.04-0.25 |           | Bal.     |           | 0.50 <sup>d</sup> | RBCuZn-D*         |                    |                            |
| MAGNESIUM                  |             |              |                                  |             |       |    |          |   |               |    |   |       |         |            |          |    |      |           |         |       |           |           |           |          |           |                   |                   |                    |                            |
| BMg-1                      | 830         | 1110         | 1120-1160                        | 8.3-9.7     |       |    |          |   | 0.0002-0.0008 |    |   |       |         | 0.05       | 0.005    |    | Bal. | 0.15 min. | 0.005   |       |           |           | 0.05      |          |           | 1.7-2.3           | 0.30              | BMg-1              |                            |
| BMg-2                      | 770         | 1050         | 1080-1130                        | 11.0-13.0   |       |    |          |   |               |    |   |       |         |            |          |    | Bal. |           |         |       |           |           |           |          | 4.5-5.5   | 0.30              | BMg-2             |                    |                            |
| BMg-2a                     | 770         | 1050         | 1080-1130                        | 11.0-13.0   |       |    |          |   | 0.0002-0.0008 |    |   |       |         |            |          |    | Bal. |           |         |       |           |           |           |          | 4.5-5.5   | 0.30              | BMg-2a            |                    |                            |

\* Total other elements requirement pertains only to the metallic elements for this filler metal.

<sup>b</sup> These chemical requirements pertain only to the copper oxide and do not include requirements for the organic vehicle in which the copper oxide is suspended.

<sup>c</sup> Total other elements requirement pertains only to metallic elements for this filler metal. The following limitations are placed on the nonmetallic elements:

|                              |                |
|------------------------------|----------------|
| Constituent                  | per cent (max) |
| Chlorides .....              | 0.4            |
| Sulfates .....               | 0.1            |
| Oxygen .....                 | remainder      |
| Nitric acid insoluble .....  | 0.3            |
| Acetone soluble matter ..... | 0.5            |

<sup>d</sup> Total other elements, including the elements marked with an asterisk (\*), shall not exceed the value specified.

\* This AWS-ASTM classification is intended to be identical with the same classification that appears in the Specification for Copper and Copper-Alloy Welding Rods (AWS Designation A5.7; ASTM Designation B 259).<sup>3</sup>



**BRAZING FILLER METALS (SOLDERS) (Continued)**

| AWS-ASTM<br>Classification                      | Solidus, °F | Liquidus, °F | Brazing Temperature<br>Range, °F | Ag    | Al    | As   | Au | B         | Be | Bi   | C       | Cd | Cr        | Cu   | Fe      | Li | Mg | Mn | Ni | P    | Pb        | Sb      | Si        | Sn    | Ti | Zn | Other |       | AWS-ASTM<br>Classification |  |  |
|-------------------------------------------------|-------------|--------------|----------------------------------|-------|-------|------|----|-----------|----|------|---------|----|-----------|------|---------|----|----|----|----|------|-----------|---------|-----------|-------|----|----|-------|-------|----------------------------|--|--|
|                                                 |             |              |                                  |       |       |      |    |           |    |      |         |    |           |      |         |    |    |    |    |      |           |         |           |       |    |    | Each  | Total |                            |  |  |
|                                                 |             |              |                                  |       |       |      |    |           |    |      |         |    |           |      |         |    |    |    |    |      |           |         |           |       |    |    |       |       |                            |  |  |
| NICKEL                                          |             |              |                                  |       |       |      |    |           |    |      |         |    |           |      |         |    |    |    |    |      |           |         |           |       |    |    |       |       |                            |  |  |
| BNi-1                                           | 1790        | 1900         | 1950-2200                        |       |       |      |    | 2.75-4.00 |    |      | 0.6-0.9 |    | 13.0-15.0 |      | 4.0-5.0 |    |    |    |    | Bal. |           |         | 3.0-5.0   |       |    |    |       | 0.50  | BNi-1                      |  |  |
| BNi-2                                           | 1780        | 1830         | 1850-2150                        |       |       |      |    | 2.75-3.5  |    |      | 0.15    |    | 6.0-8.0   |      | 2.0-4.0 |    |    |    |    | Bal. |           |         | 4.0-5.0   |       |    |    |       | 0.50  | BNi-2                      |  |  |
| BNi-3                                           | 1800        | 1900         | 1850-2150                        |       |       |      |    | 2.75-3.5  |    |      | 0.06    |    |           |      | 1.5     |    |    |    |    | Bal. |           |         | 4.0-5.0   |       |    |    |       | 0.50  | BNi-3                      |  |  |
| BNi-4                                           | 1800        | 1950         | 1850-2150                        |       |       |      |    | 1.0-2.2   |    |      | 0.06    |    |           |      | 1.5     |    |    |    |    | Bal. |           |         | 3.0-4.0   |       |    |    |       | 0.50  | BNi-4                      |  |  |
| BNi-5                                           | 1975        | 2075         | 2100-2200                        |       |       |      |    |           |    |      | 0.15    |    | 18.0-20.0 |      |         |    |    |    |    | Bal. |           |         | 9.75-10.5 |       |    |    |       | 0.50  | BNi-5                      |  |  |
| BNi-6                                           | 1610        | 1610         | 1700-1875                        |       |       |      |    |           |    |      | 0.15    |    |           |      |         |    |    |    |    | Bal. | 10.0-12.0 |         |           |       |    |    |       | 0.50  | BNi-6                      |  |  |
| BNi-7                                           | 1630        | 1630         | 1700-1900                        |       |       |      |    |           |    |      |         |    | 11.0-15.0 |      |         |    |    |    |    | Bal. | 9.0-11.0  |         |           |       |    |    |       | 0.50  | BNi-7                      |  |  |
| SOLDERS—ASTM DESIGNATION B-32-60T, REVISED 1966 |             |              |                                  |       |       |      |    |           |    |      |         |    |           |      |         |    |    |    |    |      |           |         |           |       |    |    |       |       |                            |  |  |
| 70A                                             | 361         | 378          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 30        |         |           | 70    |    |    | 0.005 |       | 70A                        |  |  |
| 70B                                             |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 30        | 0.2-0.5 |           | 70    |    |    | max   |       | 70B                        |  |  |
| 63A                                             | 361         | 361          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 37        | 0.12    |           | 63    |    |    | max   |       | 63A                        |  |  |
| 63B                                             |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 37        | max     |           | 63    |    |    | max   |       | 63B                        |  |  |
| 60A                                             | 361         | 374          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 40        | 0.12    |           | 60    |    |    | max   |       | 60A                        |  |  |
| 60B                                             |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 40        | max     |           | 60    |    |    | max   |       | 60B                        |  |  |
| 50A                                             | 361         | 421          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 50        | 0.12    |           | 50    |    |    | max   |       | 50A                        |  |  |
| 50B                                             | 360         | 420          |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 50        | 0.2-0.5 |           | 50    |    |    | max   |       | 50B                        |  |  |
| 45A                                             | 361         | 441          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 55        | 0.12    |           | 45    |    |    | max   |       | 45A                        |  |  |
| 45B                                             |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 55        | max     |           | 45    |    |    | max   |       | 45B                        |  |  |
| 40A                                             | 361         | 460          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 60        | 0.12    |           | 40    |    |    | max   |       | 40A                        |  |  |
| 40B                                             | 360         | 460          |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 60        | 0.2-0.5 |           | 40    |    |    | max   |       | 40B                        |  |  |
| 40C                                             | 365         | 448          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 58        | 1.8-2.4 |           | 40    |    |    | max   |       | 40C                        |  |  |
| 35A                                             | 361         | 477          |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 65        | 0.25    |           | 35    |    |    | max   |       | 35A                        |  |  |
| 35B                                             |             |              |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 65        | max     |           | 35    |    |    | max   |       | 35B                        |  |  |
| 35C                                             | 365         | 470          |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 63.2      | 0.2-2.0 |           | 35    |    |    | max   |       | 35C                        |  |  |
| 30A                                             | 361         | 491          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 70        | 0.25    |           | 30    |    |    | max   |       | 30A                        |  |  |
| 30B                                             |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 70        | max     |           | 30    |    |    | max   |       | 30B                        |  |  |
| 30C                                             | 364         | 482          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 68.4      | 0.5     |           | 30    |    |    | max   |       | 30C                        |  |  |
| 25A                                             | 361         | 511          |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 75        | 1.8     |           | 25    |    |    | max   |       | 25A                        |  |  |
| 25B                                             | 360         | 510          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 75        | max     |           | 25    |    |    | max   |       | 25B                        |  |  |
| 25C                                             |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 73.7      | 0.5     |           | 25    |    |    | max   |       | 25C                        |  |  |
| 20B                                             | 361         | 531          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 80        | 1.5     |           | 20    |    |    | max   |       | 20B                        |  |  |
| 20C                                             | 363         | 517          |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 79        | 0.2-0.5 |           | 20    |    |    | max   |       | 20C                        |  |  |
| 15B                                             | 440         | 550          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 85        | 1.2     |           | 15    |    |    | max   |       | 15B                        |  |  |
| 10B                                             |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 90        | 0.5     |           | 10    |    |    | max   |       | 10B                        |  |  |
| 5A                                              | 518         | 594          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 95        | 0.2-0.5 |           | 5*    |    |    | max   |       | 5A                         |  |  |
| 5B                                              |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 95        | max     |           | 5*    |    |    | max   |       | 5B                         |  |  |
| 2A                                              |             |              |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | 0.08 | 0.02    |    |    |    |    |      | 98        | 0.5     |           | 2**   |    |    | max   |       | 2A                         |  |  |
| 2B                                              |             |              |                                  |       | max   | max  |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 98        | max     |           | 2**   |    |    | max   |       | 2B                         |  |  |
| 2.5S                                            | 579         | 579          |                                  |       | 0.005 | 0.03 |    |           |    | 0.25 |         |    |           | max  | max     |    |    |    |    |      | 97.5      | 0.2-0.5 |           | 0***  |    |    | max   |       | 2.5S                       |  |  |
| 1.5S                                            | 588         | 588          | 2.3-2.7                          | 0.005 | 0.03  |      |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 97.5      | max     |           | 1**** |    |    | max   |       | 1.5S                       |  |  |
| 95TA                                            | 452         | 464          | 1.3-1.7                          | 0.005 | 0.03  |      |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 0.2       | 4.5-5.5 |           | 95    |    |    | max   |       | 95TA                       |  |  |
| 96.5TS                                          |             |              | 3.3-3.7                          | 0.005 | 0.03  |      |    |           |    | max  |         |    |           | max  | max     |    |    |    |    |      | 0.2       | 0.2-0.5 |           | 96.5  |    |    | max   |       | 96.5TS                     |  |  |

\* Permissible tin range, 4.5-5.5%.

\*\* Permissible tin range, 1.5-2.5%.

\*\*\* Tin maximum, 0.25%.

\*\*\*\* Permissible tin range, 0.75-1.25%.

### CHEMICAL COMPOSITION OF ROCKS

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| Element                        | Average<br>igneous rock | Average<br>shale | Average<br>sandstone | Average<br>limestone | Average<br>sediment |
|--------------------------------|-------------------------|------------------|----------------------|----------------------|---------------------|
| SiO <sub>2</sub>               | 59.14                   | 58.10            | 78.33                | 5.19                 | 57.95               |
| TiO <sub>2</sub>               | 1.05                    | 0.65             | 0.25                 | 0.06                 | 0.57                |
| Al <sub>2</sub> O <sub>3</sub> | 15.34                   | 15.40            | 4.77                 | 0.81                 | 13.39               |
| Fe <sub>2</sub> O <sub>3</sub> | 3.08                    | 4.02             | 1.07                 | 0.54                 | 3.47                |
| FeO                            | 3.80                    | 2.45             | 0.30                 |                      | 2.08                |
| MgO                            | 3.49                    | 2.44             | 1.16                 | 7.89                 | 2.65                |
| CaO                            | 5.08                    | 3.11             | 5.50                 | 42.57                | 5.89                |
| Na <sub>2</sub> O              | 3.84                    | 1.30             | 0.45                 | 0.05                 | 1.13                |
| K <sub>2</sub> O               | 3.13                    | 3.24             | 1.31                 | 0.33                 | 2.86                |
| H <sub>2</sub> O               | 1.15                    | 5.00             | 1.63                 | 0.77                 | 3.23                |
| P <sub>2</sub> O <sub>5</sub>  | 0.30                    | 0.17             | 0.08                 | 0.04                 | 0.13                |
| CO <sub>2</sub>                | 0.10                    | 2.63             | 5.03                 | 41.54                | 5.38                |
| SO <sub>3</sub>                |                         | 0.64             | 0.07                 | 0.05                 | 0.54                |
| BaO                            | 0.06                    | 0.05             | 0.05                 |                      |                     |
| C                              |                         | 0.80             |                      |                      | 0.66                |
|                                | 99.56                   | 100.00           | 100.00               | 99.84                | 99.93               |

**UNDERWRITERS' LABORATORIES' CLASSIFICATION OF COMPARATIVE  
LIFEHAZARD OF GASES AND VAPORS**  
(Group number definition)

| Group           | Definition                                                                                                                                                                | Examples                                                                                                                                                                                                                               |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1               | Gases or vapors which in concentrations of the order of $\frac{1}{2}$ to 1% for durations of exposure of the order of 5 min are lethal or produce serious injury.         | Sulfur dioxide                                                                                                                                                                                                                         |
| 2               | Gases or vapors which in concentrations of the order of $\frac{1}{2}$ to 1% for duration of exposure of the order of $\frac{1}{2}$ h are lethal or produce serious injury | Ammonia, methyl bromide                                                                                                                                                                                                                |
| 3               | Gases or vapors which in concentrations of the order of 2 to $2\frac{1}{2}$ % for durations of exposure of the order of 1 hr are lethal or produce serious injury.        | Bromochloromethane carbon tetrachloride, chloroform, methyl formate                                                                                                                                                                    |
| 4               | Gases or vapors which in concentrations of the order of 2 to $2\frac{1}{2}$ % for durations of exposure of the order of 2 h are lethal or produce serious injury          | Dichloroethylene methyl chloride, ethylbromide                                                                                                                                                                                         |
| Between 4 and 5 | Appear to classify as somewhat less toxic than Group 4.                                                                                                                   | Methylene chloride, ethyl chloride.                                                                                                                                                                                                    |
|                 | Much less toxic than group 4 but somewhat more toxic than Group 5.                                                                                                        | Refrigerant 112 <sup>a</sup><br>Refrigerant 113<br>Refrigerant 21                                                                                                                                                                      |
| 5a              | Gases or vapors much less toxic than Group 4 but more toxic than Group 6.                                                                                                 | Refrigerant 11<br>Refrigerant 22<br>Refrigerant 114B2<br>Refrigerant 502<br>Carbon dioxide                                                                                                                                             |
| 5b              | Gases or vapors which available data indicate would classify as either Group 5a or Group 6.                                                                               | Ethane, propane, butane                                                                                                                                                                                                                |
| 6               | Gases or vapors which in concentrations up to at least about 20% by volume for duration of exposure of the order of 2 h do not appear to produce injury.                  | Refrigerant 13B1<br>Refrigerant 12<br>Refrigerant 114<br>Refrigerant 115<br>Refrigerant 13 <sup>a</sup><br>Refrigerant 14 <sup>a</sup><br>Refrigerant 23 <sup>a</sup><br>Refrigerant 116 <sup>a</sup><br>Refrigerant C318 <sup>a</sup> |

<sup>a</sup> Not tested by U.L. but estimated to belong in group indicated.

## CONSTANTS FOR SATELLITE GEODESY

### Defining Constants

1. Number of ephemeris seconds in 1 tropical year (1900) .....  $s$  = 31 556 925.9747
2. Gaussian gravitational constant, defining the a. u. ....  $k$  = 0.017 202 09895

### Primary Constants

3. Velocity of light in meters per second (in vacuum) .....  $c$  =  $2.99792458(1.2) \times 10^8$
4. Dynamical form-factor for Earth .....  $J_2$  = 0.001 082 7
5. Sidereal mean motion of Moon in radians per second (1900) .....  $n_{\text{L}}^*$  =  $2.661\,699\,489 \times 10^{-6}$
6. General precession in longitude per tropical century (1900) .....  $p$  = 5025".64
7. Constant of nutation (1900) .....  $N$  = 9".210

### Auxiliary Constants and Factors

- $k/86400$ , for use when the unit of time is 1 second .....  $k'$  =  $1.990\,983\,675 \times 10^{-7}$
- Number of seconds of arc in 1 radian ..... = 206 264.806
- Factor for constant of aberration (note 10) .....  $F_1$  = 1.000 142
- Factor for mean distance of Moon (note 12) .....  $F_2$  = 0.999 093 142
- Factor for parallactic inequality (note 15) .....  $F_3$  = 49853".2

### Derived Constants

8. Solar parallax .....  $\arcsin(\alpha_e/A) = \pi$  = 8".79405 (8".794)
9. Light-time for unit distance .....  $A/c' = \tau_A$  = 499.012  
= 1<sup>s</sup>/0.002 003 96
10. Constant of aberration .....  $F_1 k' \tau_A = \kappa$  = 20".4958 (20".496)
11. Ratio of masses of Sun to (Earth + Moon) .....  $S/E(1 + \mu) = 328\,912$
12. Perturbed mean distance of Moon, in meters .....  $F_2(GE(1 + \mu)/n_{\text{L}}^{*2})^{\frac{1}{3}} = \alpha_{\text{L}}$  =  $384\,400 \times 10^3$
13. Constant of sine parallax for Moon .....  $\alpha_e/\alpha_{\text{L}} = \sin \pi_{\text{L}}$  = 3422".451
14. Constant of lunar inequality .....  $\frac{\mu}{1 + \mu} \frac{\alpha_{\text{L}}}{A} = L$  = 6".43987 (6".440)
15. Constant of parallactic inequality .....  $F_3 \frac{1 - \mu}{1 + \mu} \frac{\alpha_{\text{L}}}{A} = P_{\text{L}}$  = 124".986

## CROSS-SECTION AND MASS OF WIRES

### U. S. Measure

Diameters are given in mils (1 mil = .001 in.), and area in square mils (1 sq. mil = .000001 sq. in.). For sections and masses for one-tenth the diameters given, divide by 100 and for sections and masses for ten times the diameter multiply by 100.

| Pounds per foot  |                           |                            |                          |                           |                              | Pounds per foot  |                           |                            |                          |                           |                              |
|------------------|---------------------------|----------------------------|--------------------------|---------------------------|------------------------------|------------------|---------------------------|----------------------------|--------------------------|---------------------------|------------------------------|
| Diam. in<br>mils | Cross-sec.<br>in sq. mils | Copper,<br>density<br>8.90 | Iron,<br>density<br>7.80 | Brass,<br>density<br>8.56 | Aluminum,<br>density<br>2.67 | Diam. in<br>mils | Cross-sec.<br>in sq. mils | Copper,<br>density<br>8.90 | Iron,<br>density<br>7.80 | Brass,<br>density<br>8.56 | Aluminum,<br>density<br>2.67 |
| 10               | 78.54                     | 0.000303                   | 0.0002656                | 0.0002915                 | 0.0000909                    | 40               | 1256.64                   | 0.004849                   | 0.004249                 | 0.004664                  | 0.001455                     |
| 11               | 95.03                     | 0367                       | 03214                    | 03527                     | 01100                        | 41               | 1320.25                   | 5094                       | 4465                     | 4900                      | 1528                         |
| 12               | 113.10                    | 0436                       | 03825                    | 04197                     | 01309                        | 42               | 1385.44                   | 5346                       | 4685                     | 5141                      | 1604                         |
| 13               | 132.73                    | 0512                       | 04488                    | 04926                     | 01536                        | 43               | 1452.20                   | 5603                       | 4911                     | 5389                      | 1681                         |
| 14               | 153.94                    | 0594                       | 05206                    | 05713                     | 01782                        | 44               | 1520.53                   | 5867                       | 5142                     | 5643                      | 1760                         |
| 15               | 176.71                    | 0682                       | 05976                    | 06558                     | 02045                        | 45               | 1590.43                   | 6137                       | 5378                     | 5902                      | 1841                         |
| 16               | 201.06                    | 0776                       | 06799                    | 07461                     | 02327                        | 46               | 1661.90                   | 6412                       | 5620                     | 6167                      | 1924                         |
| 17               | 226.98                    | 0876                       | 07675                    | 08423                     | 02627                        | 47               | 1734.94                   | 6694                       | 5867                     | 6438                      | 2008                         |
| 18               | 254.47                    | 0982                       | 08605                    | 09443                     | 02946                        | 48               | 1809.56                   | 6982                       | 6119                     | 6715                      | 2095                         |
| 19               | 283.53                    | 1094                       | 09588                    | 10522                     | 03282                        | 49               | 1885.74                   | 7276                       | 6377                     | 6998                      | 2183                         |
| 20               | 314.16                    | 1212                       | 1062                     | 1166                      | 03636                        | 50               | 1963.50                   | 7576                       | 6640                     | 7287                      | 2273                         |
| 21               | 346.36                    | 1336                       | 1171                     | 1285                      | 04009                        | 51               | 2042.82                   | 7882                       | 6908                     | 7581                      | 2365                         |
| 22               | 380.13                    | 1467                       | 1286                     | 1411                      | 04400                        | 52               | 2123.72                   | 8194                       | 7181                     | 7881                      | 2458                         |
| 23               | 415.48                    | 1603                       | 1405                     | 1542                      | 04809                        | 53               | 2206.18                   | 8512                       | 7460                     | 8187                      | 2554                         |
| 24               | 452.39                    | 1746                       | 1530                     | 1679                      | 05237                        | 54               | 2290.22                   | 8837                       | 7744                     | 8499                      | 2651                         |
| 25               | 490.87                    | 1894                       | 1660                     | 1822                      | 05682                        | 55               | 2375.83                   | 9167                       | 8034                     | 8817                      | 2750                         |
| 26               | 530.93                    | 2046                       | 1795                     | 1970                      | 061647                       | 56               | 2463.01                   | 9504                       | 8329                     | 9140                      | 2851                         |
| 27               | 572.56                    | 2209                       | 1936                     | 2125                      | 06628                        | 57               | 2551.76                   | 9846                       | 8629                     | 9470                      | 2954                         |
| 28               | 615.75                    | 2376                       | 2082                     | 2285                      | 07127                        | 58               | 2642.08                   | 10195                      | 8934                     | 9805                      | 3058                         |
| 29               | 660.52                    | 2549                       | 2234                     | 2451                      | 07646                        | 59               | 2733.97                   | 10549                      | 9245                     | 10146                     | 3165                         |
| 30               | 706.86                    | 2727                       | 2390                     | 2623                      | 08182                        | 60               | 2827.43                   | 1091                       | 956                      | 1049                      | 3273                         |
| 31               | 754.77                    | 2912                       | 2552                     | 2801                      | 08737                        | 61               | 2922.47                   | 1128                       | 988                      | 1085                      | 3383                         |
| 32               | 804.25                    | 3103                       | 2720                     | 2985                      | 09309                        | 62               | 3019.07                   | 1165                       | 1021                     | 1120                      | 3495                         |
| 33               | 855.30                    | 3300                       | 2892                     | 3174                      | 09900                        | 63               | 3117.25                   | 1203                       | 1054                     | 1157                      | 3608                         |
| 34               | 907.92                    | 3503                       | 3070                     | 3369                      | 10509                        | 64               | 3216.99                   | 1241                       | 1088                     | 1194                      | 3724                         |
| 35               | 962.11                    | 3712                       | 3253                     | 3570                      | 1114                         | 65               | 3318.31                   | 1280                       | 1122                     | 1231                      | 3841                         |
| 36               | 1017.88                   | 3927                       | 3442                     | 3777                      | 1178                         | 66               | 3421.19                   | 1320                       | 1157                     | 1270                      | 3960                         |
| 37               | 1075.21                   | 4149                       | 3636                     | 3990                      | 1245                         | 67               | 3525.65                   | 1360                       | 1192                     | 1308                      | 4081                         |
| 38               | 1134.11                   | 4376                       | 3844                     | 4218                      | 1316                         | 68               | 3631.68                   | 1401                       | 1228                     | 1348                      | 4204                         |
| 39               | 1194.59                   | 4609                       | 4040                     | 4433                      | 1383                         | 69               | 3739.28                   | 1443                       | 1264                     | 1388                      | 4328                         |



# CROSS-SECTION AND MASS OF WIRES (continued)

## U. S. Measure

| Pounds per foot  |                           |                            |                          |                           |                              | Pounds per foot  |                           |                            |                          |                           |                              |
|------------------|---------------------------|----------------------------|--------------------------|---------------------------|------------------------------|------------------|---------------------------|----------------------------|--------------------------|---------------------------|------------------------------|
| Diam. in<br>mils | Cross-sec.<br>in sq. mils | Copper,<br>density<br>8.90 | Iron,<br>density<br>7.80 | Brass,<br>density<br>8.56 | Aluminum,<br>density<br>2.67 | Diam. in<br>mils | Cross-sec.<br>in sq. mils | Copper,<br>density<br>8.90 | Iron,<br>density<br>7.80 | Brass,<br>density<br>8.56 | Aluminum,<br>density<br>2.67 |
| 70               | 3848.45                   | 0.01485                    | 0.01302                  | 0.01429                   | 0.004456                     | 86               | 5808.80                   | 0.02241                    | 0.01964                  | 0.02156                   | 0.006724                     |
| 71               | 3959.19                   | 1528                       | 1339                     | 1469                      | 4583                         | 87               | 5944.68                   | 2294                       | 2010                     | 2206                      | 6881                         |
| 72               | 4071.50                   | 1571                       | 1377                     | 1511                      | 4713                         | 88               | 6082.12                   | 2347                       | 2057                     | 2257                      | 7040                         |
| 73               | 4185.39                   | 1615                       | 1415                     | 1553                      | 4845                         | 89               | 6221.14                   | 2400                       | 2104                     | 2309                      | 7201                         |
| 74               | 4300.84                   | 1660                       | 1454                     | 1596                      | 4978                         | 90               | 6361.73                   | 2455                       | 2151                     | 2360                      | 7364                         |
| 75               | 4417.86                   | 1705                       | 1494                     | 1639                      | 5114                         | 91               | 6503.88                   | 2509                       | 2199                     | 2414                      | 7528                         |
| 76               | 4536.46                   | 1751                       | 1534                     | 1684                      | 5251                         | 92               | 6647.61                   | 2565                       | 2248                     | 2467                      | 7695                         |
| 77               | 4656.63                   | 1797                       | 1575                     | 1728                      | 5390                         | 93               | 6792.91                   | 2621                       | 2297                     | 2521                      | 7863                         |
| 78               | 4778.36                   | 1844                       | 1616                     | 1773                      | 5531                         | 94               | 6939.78                   | 2678                       | 2347                     | 2575                      | 8033                         |
| 79               | 4901.67                   | 1892                       | 1658                     | 1819                      | 5674                         | 95               | 7088.22                   | 2735                       | 2397                     | 2630                      | 8205                         |
| 80               | 5026.55                   | 1939                       | 1700                     | 1865                      | 5818                         | 96               | 7238.23                   | 2793                       | 2448                     | 2686                      | 8378                         |
| 81               | 5153.00                   | 1988                       | 1743                     | 1912                      | 5965                         | 97               | 7389.81                   | 2851                       | 2499                     | 2742                      | 8554                         |
| 82               | 5281.02                   | 2038                       | 1786                     | 1960                      | 6113                         | 98               | 7542.96                   | 2910                       | 2551                     | 2799                      | 8731                         |
| 83               | 5410.61                   | 2088                       | 1830                     | 2008                      | 6263                         | 99               | 7697.69                   | 2970                       | 2603                     | 2857                      | 8910                         |
| 84               | 5541.77                   | 2138                       | 1874                     | 2057                      | 6415                         | 100              | 7853.98                   | 3030                       | 2656                     | 2915                      | 9091                         |
| 85               | 5674.50                   | 2189                       | 1919                     | 2106                      | 6568                         |                  |                           |                            |                          |                           |                              |

## Metric Measure

Diameters are given in thousandths of a centimeter and area of section in square thousandths of a centimeter. 1 (cm/1000)<sup>2</sup> = .000001 sq cm. For sections and masses for diameters 1/10 or 10 times those of the table, divide or multiply by 100.

| Grams per meter                    |                                                      |                            |                          |                           |                              | Grams per meter                    |                                                      |                            |                          |                           |                              |
|------------------------------------|------------------------------------------------------|----------------------------|--------------------------|---------------------------|------------------------------|------------------------------------|------------------------------------------------------|----------------------------|--------------------------|---------------------------|------------------------------|
| Diam. in<br>thousandths<br>of a cm | Cross-section<br>in square<br>thousandths<br>of a cm | Copper,<br>density<br>8.90 | Iron,<br>density<br>7.80 | Brass,<br>density<br>8.56 | Aluminum,<br>density<br>2.67 | Diam. in<br>thousandths<br>of a cm | Cross-section<br>in square<br>thousandths<br>of a cm | Copper,<br>density<br>8.90 | Iron,<br>density<br>7.80 | Brass,<br>density<br>8.56 | Aluminum,<br>density<br>2.67 |
| 10                                 | 78.54                                                | 0.06990                    | 0.06126                  | 0.06723                   | 0.02097                      | 55                                 | 235.83                                               | 2.114                      | 1.853                    | 2.034                     | 0.6343                       |
| 11                                 | 95.03                                                | .08458                     | .07412                   | .08135                    | .02537                       | 56                                 | 2463.01                                              | .192                       | .921                     | .108                      | .6576                        |
| 12                                 | 113.10                                               | .10065                     | .08822                   | .09681                    | .03020                       | 57                                 | 2551.76                                              | .271                       | .990                     | .184                      | .6813                        |
| 13                                 | 132.73                                               | .11813                     | .10353                   | .11362                    | .03544                       | 58                                 | 2642.08                                              | .351                       | 2.061                    | .262                      | .7054                        |
| 14                                 | 153.94                                               | .13701                     | .12008                   | .13177                    | .04110                       | 59                                 | 2733.97                                              | .433                       | .132                     | .340                      | .7300                        |
| 15                                 | 176.71                                               | .1573                      | .1378                    | .1513                     | .04718                       | 60                                 | 2827.43                                              | 2.516                      | 2.205                    | 2.420                     | .7549                        |
| 16                                 | 201.06                                               | .1789                      | .1568                    | .1721                     | .05368                       | 61                                 | 2922.47                                              | .601                       | .280                     | .502                      | .7803                        |
| 17                                 | 226.98                                               | .2020                      | .1770                    | .1943                     | .06060                       | 62                                 | 3019.07                                              | .687                       | .355                     | .584                      | .8061                        |
| 18                                 | 254.47                                               | .2265                      | .1985                    | .2178                     | .06794                       | 63                                 | 3117.25                                              | .774                       | .431                     | .668                      | .8323                        |
| 19                                 | 283.53                                               | .2523                      | .2212                    | .2427                     | .07570                       | 64                                 | 3216.99                                              | .863                       | .509                     | .760                      | .8589                        |
| 20                                 | 314.16                                               | .2796                      | .2450                    | .2689                     | .08388                       | 65                                 | 3318.31                                              | 2.953                      | 2.588                    | 2.840                     | .8860                        |
| 21                                 | 346.36                                               | .3083                      | .2702                    | .2965                     | .09248                       | 66                                 | 3421.19                                              | 3.045                      | .669                     | .929                      | .9135                        |
| 22                                 | 380.13                                               | .3383                      | .2965                    | .3254                     | .10149                       | 67                                 | 3525.65                                              | .138                       | .750                     | 3.018                     | .9413                        |
| 23                                 | 415.48                                               | .3698                      | .3241                    | .3557                     | .11093                       | 68                                 | 3631.68                                              | .232                       | .833                     | .109                      | .9697                        |
| 24                                 | 452.39                                               | .4026                      | .3529                    | .3872                     | .12079                       | 69                                 | 3739.28                                              | .328                       | .917                     | .201                      | .9984                        |
| 25                                 | 490.87                                               | .4369                      | .3829                    | .4202                     | .1311                        | 70                                 | 3848.45                                              | 3.426                      | 3.003                    | 3.295                     | 1.028                        |
| 26                                 | 530.93                                               | .4725                      | .4141                    | .4545                     | .1418                        | 71                                 | 3959.19                                              | .524                       | .088                     | .389                      | .057                         |
| 27                                 | 572.56                                               | .5096                      | .4466                    | .4901                     | .1529                        | 72                                 | 4071.50                                              | .624                       | .176                     | .485                      | .087                         |
| 28                                 | 615.75                                               | .5480                      | .4803                    | .5271                     | .1644                        | 73                                 | 4185.39                                              | .725                       | .265                     | .583                      | .117                         |
| 29                                 | 660.52                                               | .5879                      | .5152                    | .5654                     | .1764                        | 74                                 | 4300.84                                              | .828                       | .355                     | .682                      | .148                         |
| 30                                 | 706.86                                               | .6291                      | .5514                    | .6051                     | .1887                        | 75                                 | 4417.86                                              | 3.932                      | 3.446                    | 3.782                     | 1.180                        |
| 31                                 | 754.77                                               | .6717                      | .5887                    | .6461                     | .2015                        | 76                                 | 4536.46                                              | 4.037                      | .538                     | .883                      | .211                         |
| 32                                 | 804.25                                               | .7158                      | .6273                    | .6884                     | .2147                        | 77                                 | 4656.63                                              | .144                       | .632                     | .986                      | .243                         |
| 33                                 | 855.30                                               | .7612                      | .6671                    | .7321                     | .2284                        | 78                                 | 4778.36                                              | .253                       | .727                     | 4.090                     | .276                         |
| 34                                 | 907.92                                               | .8081                      | .7082                    | .7772                     | .2424                        | 79                                 | 4901.67                                              | .362                       | .823                     | .177                      | .309                         |
| 35                                 | 962.11                                               | .856                       | .7504                    | .8236                     | .2569                        | 80                                 | 5026.55                                              | 4.474                      | 3.921                    | 4.303                     | 1.342                        |
| 36                                 | 1017.88                                              | .906                       | .7939                    | .8713                     | .2718                        | 81                                 | 5153.00                                              | .586                       | 4.019                    | .411                      | .376                         |
| 37                                 | 1075.21                                              | .957                       | .8387                    | .9204                     | .2871                        | 82                                 | 5281.02                                              | .700                       | .119                     | .521                      | .410                         |
| 38                                 | 1134.11                                              | 1.012                      | .8866                    | .9730                     | .3035                        | 83                                 | 5410.61                                              | .815                       | .220                     | .631                      | .445                         |
| 39                                 | 1194.59                                              | .063                       | .9318                    | 1.0230                    | .3190                        | 84                                 | 5541.77                                              | .932                       | .323                     | .744                      | .480                         |
| 40                                 | 1256.64                                              | 1.118                      | .980                     | 1.076                     | .3355                        | 85                                 | 5674.50                                              | 5.050                      | 4.426                    | 4.857                     | 1.515                        |
| 41                                 | 1320.25                                              | .175                       | 1.030                    | .130                      | .3525                        | 86                                 | 5808.80                                              | .170                       | .531                     | .972                      | .551                         |
| 42                                 | 1385.44                                              | .233                       | .081                     | .186                      | .3699                        | 87                                 | 5944.68                                              | .291                       | .637                     | 5.089                     | .587                         |
| 43                                 | 1452.20                                              | .292                       | .133                     | .243                      | .3877                        | 88                                 | 6082.12                                              | .413                       | .744                     | .206                      | .624                         |
| 44                                 | 1520.53                                              | .353                       | .186                     | .302                      | .4060                        | 89                                 | 6221.14                                              | .537                       | .852                     | .325                      | .661                         |
| 45                                 | 1590.43                                              | 1.415                      | 1.241                    | 1.361                     | .4246                        | 90                                 | 6361.73                                              | 5.662                      | 4.962                    | 5.446                     | 1.699                        |
| 46                                 | 1661.90                                              | .479                       | .296                     | .423                      | .4437                        | 91                                 | 6503.88                                              | .788                       | 5.073                    | .567                      | .737                         |
| 47                                 | 1734.94                                              | .544                       | .353                     | .485                      | .4632                        | 92                                 | 6647.61                                              | .916                       | .185                     | .690                      | .775                         |
| 48                                 | 1809.56                                              | .611                       | .411                     | .549                      | .4832                        | 93                                 | 6792.91                                              | 6.046                      | .298                     | .815                      | .814                         |
| 49                                 | 1885.74                                              | .678                       | .471                     | .614                      | .5035                        | 94                                 | 6939.78                                              | .176                       | .413                     | .940                      | .853                         |
| 50                                 | 1963.50                                              | 1.748                      | 1.532                    | 1.681                     | .5243                        | 95                                 | 7088.22                                              | 6.309                      | 5.529                    | 6.068                     | 1.893                        |
| 51                                 | 2042.82                                              | .818                       | .593                     | .753                      | .5454                        | 96                                 | 7238.23                                              | .442                       | .646                     | .196                      | .933                         |
| 52                                 | 2123.72                                              | .890                       | .657                     | .818                      | .5670                        | 97                                 | 7389.81                                              | .577                       | .764                     | .326                      | .973                         |
| 53                                 | 2206.18                                              | .964                       | .721                     | .888                      | .5891                        | 98                                 | 7542.96                                              | .713                       | .884                     | .457                      | 2.014                        |
| 54                                 | 2290.22                                              | 2.038                      | .786                     | .960                      | .6115                        | 99                                 | 7697.69                                              | .851                       | 6.004                    | .589                      | .055                         |
|                                    |                                                      |                            |                          |                           |                              | 100                                | 7853.98                                              | 6.990                      | 6.126                    | 6.723                     | 2.097                        |

# **DENSITY AND COMPOSITION OF FUMING SULFURIC ACID**

| Actual<br>H <sub>2</sub> SO <sub>4</sub> ,<br>% | Spe-<br>cific<br>grav-<br>ity | Equiv.<br>H <sub>2</sub> SO <sub>4</sub> ,<br>% | Weight,<br>lb /cu<br>ft | Weight,<br>lb per<br>U.S. gal | Comb.<br>H <sub>2</sub> O,<br>% | Free<br>SO <sub>3</sub> ,<br>% | Total<br>SO <sub>3</sub> ,<br>% | SO <sub>3</sub> ,<br>lb /cu<br>ft |
|-------------------------------------------------|-------------------------------|-------------------------------------------------|-------------------------|-------------------------------|---------------------------------|--------------------------------|---------------------------------|-----------------------------------|
| 100                                             | 1.839                         | 100.00                                          | 114.70                  | 15.33                         | 18.37                           | 0                              | 81.63                           | 93.63                             |
| 99                                              | 1.845                         | 100.22                                          | 115.07                  | 15.38                         | 18.19                           | 1                              | 81.81                           | 94.14                             |
| 98                                              | 1.851                         | 100.45                                          | 115.33                  | 15.41                         | 18.00                           | 2                              | 82.00                           | 94.57                             |
| 97                                              | 1.855                         | 100.67                                          | 115.70                  | 15.46                         | 17.82                           | 3                              | 82.18                           | 95.08                             |
| 96                                              | 1.858                         | 100.89                                          | 115.88                  | 15.49                         | 17.64                           | 4                              | 82.36                           | 95.44                             |
| 95                                              | 1.862                         | 101.13                                          | 116.13                  | 15.52                         | 17.45                           | 5                              | 82.55                           | 95.87                             |
| 94                                              | 1.865                         | 101.35                                          | 116.32                  | 15.55                         | 17.27                           | 6                              | 82.73                           | 96.23                             |
| 93                                              | 1.869                         | 101.58                                          | 116.57                  | 15.58                         | 17.08                           | 7                              | 82.92                           | 96.66                             |
| 92                                              | 1.873                         | 101.80                                          | 116.82                  | 15.61                         | 16.90                           | 8                              | 83.10                           | 97.12                             |
| 91                                              | 1.877                         | 102.02                                          | 117.07                  | 15.64                         | 16.72                           | 9                              | 83.28                           | 97.50                             |
| 90                                              | 1.880                         | 102.25                                          | 117.26                  | 15.67                         | 16.57                           | 10                             | 83.47                           | 97.88                             |
| 89                                              | 1.884                         | 102.47                                          | 117.51                  | 15.70                         | 16.35                           | 11                             | 83.65                           | 98.30                             |
| 88                                              | 1.887                         | 102.71                                          | 117.69                  | 15.73                         | 16.17                           | 12                             | 83.83                           | 98.66                             |
| 87                                              | 1.891                         | 102.92                                          | 117.94                  | 15.76                         | 15.98                           | 13                             | 84.02                           | 99.09                             |
| 86                                              | 1.895                         | 103.15                                          | 118.19                  | 15.79                         | 15.80                           | 14                             | 84.20                           | 99.52                             |
| 85                                              | 1.899                         | 103.38                                          | 118.44                  | 15.82                         | 15.61                           | 15                             | 84.39                           | 99.95                             |
| 84                                              | 1.902                         | 103.60                                          | 118.63                  | 15.86                         | 15.43                           | 16                             | 84.57                           | 100.33                            |
| 83                                              | 1.905                         | 103.82                                          | 118.81                  | 15.89                         | 15.25                           | 17                             | 84.75                           | 100.69                            |
| 82                                              | 1.909                         | 104.05                                          | 119.06                  | 15.92                         | 15.06                           | 18                             | 84.94                           | 101.13                            |
| 81                                              | 1.911                         | 104.28                                          | 119.28                  | 15.95                         | 14.88                           | 19                             | 85.12                           | 101.45                            |
| 80                                              | 1.915                         | 104.50                                          | 119.50                  | 15.98                         | 14.70                           | 20                             | 85.30                           | 101.93                            |
| 79                                              | 1.920                         | 104.73                                          | 119.75                  | 16.01                         | 14.51                           | 21                             | 85.49                           | 102.37                            |
| 78                                              | 1.923                         | 104.95                                          | 119.94                  | 16.04                         | 14.33                           | 22                             | 85.67                           | 102.75                            |
| 77                                              | 1.927                         | 105.18                                          | 120.19                  | 16.07                         | 14.14                           | 23                             | 85.86                           | 103.20                            |
| 76                                              | 1.931                         | 105.40                                          | 120.44                  | 16.10                         | 13.96                           | 24                             | 86.04                           | 103.63                            |
| 75                                              | 1.934                         | 105.62                                          | 120.62                  | 16.12                         | 13.78                           | 25                             | 86.22                           | 104.00                            |
| 74                                              | 1.939                         | 105.85                                          | 120.94                  | 16.16                         | 13.59                           | 26                             | 86.41                           | 104.50                            |
| 73                                              | 1.943                         | 106.08                                          | 121.18                  | 16.19                         | 13.41                           | 27                             | 86.59                           | 104.93                            |
| 72                                              | 1.946                         | 106.29                                          | 121.37                  | 16.22                         | 13.28                           | 28                             | 86.72                           | 105.31                            |
| 71                                              | 1.949                         | 106.53                                          | 121.56                  | 16.25                         | 13.04                           | 29                             | 86.96                           | 105.71                            |
| 70                                              | 1.952                         | 106.75                                          | 121.75                  | 16.28                         | 12.86                           | 30                             | 87.14                           | 106.09                            |
| 69                                              | 1.955                         | 106.97                                          | 121.93                  | 16.30                         | 12.68                           | 31                             | 87.32                           | 106.47                            |
| 68                                              | 1.958                         | 107.20                                          | 122.12                  | 16.33                         | 12.49                           | 32                             | 87.51                           | 106.87                            |
| 67                                              | 1.961                         | 107.42                                          | 122.31                  | 16.35                         | 12.31                           | 33                             | 87.69                           | 107.25                            |
| 66                                              | 1.965                         | 107.65                                          | 122.56                  | 16.38                         | 12.12                           | 34                             | 87.88                           | 107.71                            |
| 65                                              | 1.968                         | 107.87                                          | 122.74                  | 16.40                         | 11.94                           | 35                             | 88.06                           | 108.08                            |
| 64                                              | 1.972                         | 108.10                                          | 122.99                  | 16.43                         | 11.76                           | 36                             | 88.24                           | 108.53                            |
| 63                                              | 1.976                         | 108.33                                          | 123.24                  | 16.46                         | 11.57                           | 37                             | 88.43                           | 108.98                            |
| 62                                              | 1.979                         | 108.55                                          | 123.43                  | 16.50                         | 11.39                           | 38                             | 88.61                           | 109.37                            |
| 61                                              | 1.981                         | 108.77                                          | 123.55                  | 16.52                         | 11.21                           | 39                             | 88.79                           | 109.70                            |
| 60                                              | 1.983                         | 109.00                                          | 123.74                  | 16.54                         | 11.02                           | 40                             | 88.98                           | 110.10                            |
| 59                                              | 1.985                         | 109.22                                          | 123.80                  | 16.55                         | 10.84                           | 41                             | 89.16                           | 110.38                            |
| 58                                              | 1.987                         | 109.45                                          | 123.93                  | 16.56                         | 10.65                           | 42                             | 89.35                           | 110.83                            |
| 57                                              | 1.989                         | 109.68                                          | 124.05                  | 16.58                         | 10.47                           | 43                             | 89.53                           | 111.06                            |
| 56                                              | 1.991                         | 109.90                                          | 124.18                  | 16.60                         | 10.29                           | 44                             | 89.71                           | 111.40                            |
| 55                                              | 1.993                         | 110.13                                          | 124.30                  | 16.62                         | 10.10                           | 45                             | 89.90                           | 111.75                            |
| 50                                              | 2.001                         | 111.25                                          | 124.80                  | 16.68                         | 9.18                            | 50                             | 90.72                           | 113.34                            |
| 40                                              | 2.102                         | 113.50                                          | 131.10                  | 17.53                         | 7.35                            | 60                             | 92.65                           | 121.46                            |
| 30                                              | 1.982                         | 115.75                                          | 123.62                  | 16.50                         | 5.51                            | 70                             | 94.49                           | 116.81                            |
| 20                                              | 1.949                         | 118.00                                          | 121.56                  | 16.25                         | 3.67                            | 80                             | 96.33                           | 117.10                            |
| 10                                              | 1.911                         | 120.25                                          | 119.19                  | 15.92                         | 1.84                            | 90                             | 98.16                           | 117.00                            |
| 0                                               | 1.857                         | 122.50                                          | 115.83                  | 15.50                         | 0.00                            | 100                            | 100.00                          | 115.83                            |

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## DIAMAGNETIC SUSCEPTIBILITY DATA ON ORGANOSILICON COMPOUNDS

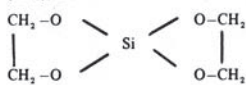
R. R. Gupta

The molar susceptibility is represented by  $\chi_M$  and expressed in c.g.s. units. For some of the compounds volume or specific susceptibility is available in the literature and in such cases  $\chi_M$  has been calculated by the relation

$$\chi_M = M\chi = M(\kappa/\rho)$$

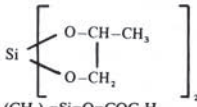
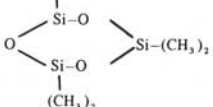
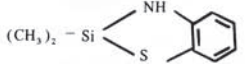
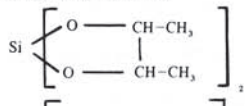
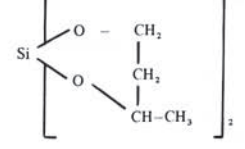
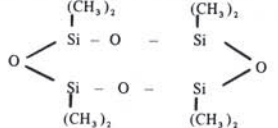
where  $M$  is the molar mass of the substance,  $\chi$  is the specific or mass susceptibility,  $\kappa$  is the volume susceptibility, and  $\rho$  is the density of the substance.

The compounds are arranged in the increasing order of C, H, Si, O, Cl, Br, I, S, and N.

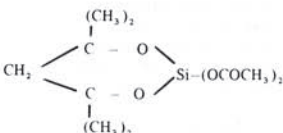
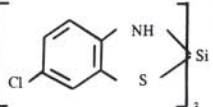
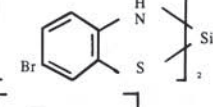
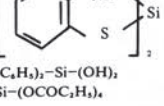
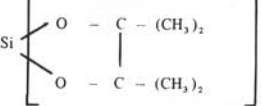
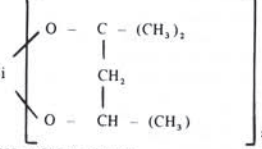
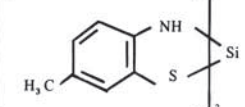
| Compound                                         | Molecular formula                      | Structural formula                                                                  | $-\chi_M \cdot 10^6$   | Ref.      |
|--------------------------------------------------|----------------------------------------|-------------------------------------------------------------------------------------|------------------------|-----------|
| Methyl trichlorosilane                           | $\text{CH}_3\text{SiCl}_3$             | $\text{CH}_3-\text{Si}-\text{Cl}_3$                                                 | 85.40, 87.45           | 2, 8      |
| Methyl tribromosilane                            | $\text{CH}_3\text{SiBr}_3$             | $\text{CH}_3-\text{Si}-\text{Br}_3$                                                 | 126.00, 128.00, 155.50 | 10, 11, 4 |
| Methyl dichlorosilane                            | $\text{CH}_3\text{SiCl}_2$             | $\text{CH}_3-\text{SiH}-\text{Cl}_2$                                                | 66.90                  | 4         |
| Ethyl trichlorosilane                            | $\text{C}_2\text{H}_5\text{SiCl}_3$    | $\text{C}_2\text{H}_5-\text{Si}-\text{Cl}_3$                                        | 98.00, 98.84, 96.40    | 2, 9, 7   |
| Ethyl tribromosilane                             | $\text{C}_2\text{H}_5\text{SiBr}_3$    | $\text{C}_2\text{H}_5-\text{Si}-\text{Br}_3$                                        | 147.50                 | 4         |
| Ethyl triiodosilane                              | $\text{C}_2\text{H}_5\text{SiI}_3$     | $\text{C}_2\text{H}_5-\text{Si}-\text{I}_3$                                         | 171.50                 | 4         |
| Ethyl dichlorosilane                             | $\text{C}_2\text{H}_5\text{SiCl}_2$    | $\text{C}_2\text{H}_5-\text{SiH}-\text{Cl}_2$                                       | 78.90                  | 4         |
| Dimethyl dichlorosilane                          | $\text{C}_2\text{H}_6\text{SiCl}_2$    | $(\text{CH}_3)_2-\text{Si}-\text{Cl}_2$                                             | 81.30, 82.45           | 4, 8      |
| Dimethyl diiodosilane                            | $\text{C}_2\text{H}_6\text{SiI}_2$     | $(\text{CH}_3)_2-\text{Si}-\text{I}_2$                                              | 131.80                 | 4         |
| Dimethyl silanediol                              | $\text{C}_2\text{H}_6\text{SiO}_2$     | $(\text{CH}_3)_2-\text{Si}-(\text{OH})_2$                                           | 58.40                  | 17, 18    |
| <i>n</i> -Propyl trichlorosilane                 | $\text{C}_3\text{H}_7\text{SiCl}_3$    | $\text{CH}_3-(\text{CH}_2)_2-\text{Si}-\text{Cl}_3$                                 | 108.00, 110.20         | 4, 8      |
| Trimethyl chlorosilane                           | $\text{C}_3\text{H}_9\text{SiCl}$      | $(\text{CH}_3)_3-\text{SiCl}$                                                       | 79.00, 73.76           | 4, 8      |
| Trimethyl bromosilane                            | $\text{C}_3\text{H}_9\text{SiBr}$      | $(\text{CH}_3)_3-\text{Si}-\text{Br}$                                               | 91.30                  | 4         |
| Trimethyl iododisilane                           | $\text{C}_3\text{H}_9\text{SiI}$       | $(\text{CH}_3)_3-\text{Si}-\text{I}$                                                | 104.10                 | 4         |
| 1, 4, 6, 9 - Tetraoxa - 5 - silaspiro[4,4]nonane | $\text{C}_4\text{H}_8\text{SiO}_4$     |  | 80.94                  | 5         |
| Diethyl dichlorosilane                           | $\text{C}_4\text{H}_{10}\text{SiCl}_2$ | $(\text{C}_2\text{H}_5)_2-\text{SiCl}_2$                                            | 105.80                 | 8         |
| Tetramethylsilane                                | $\text{C}_4\text{H}_{12}\text{Si}$     | $\text{Si}-(\text{CH}_3)_4$                                                         | 74.80                  | 1         |
| Trimethyl methoxysilane                          | $\text{C}_4\text{H}_{12}\text{SiO}$    | $(\text{CH}_3)_3-\text{Si}-\text{OCH}_3$                                            | 78.80                  | 1         |
| Dimethyl dimethoxysilane                         | $\text{C}_4\text{H}_{12}\text{SiO}_2$  | $(\text{CH}_3)_2-\text{Si}-(\text{OCH}_3)_2$                                        | 81.70, 81.60, 81.95    | 1, 17, 5  |
| Diethyl silanediol                               | $\text{C}_4\text{H}_{12}\text{SiO}_2$  | $(\text{C}_2\text{H}_5)_2-\text{Si}-(\text{OH})_2$                                  | 81.00                  | 17, 18    |



# DIAMAGNETIC SUSCEPTIBILITY DATA ON ORGANOSILICON COMPOUNDS (continued)

| Compound                                                    | Molecular formula      | Structural formula                                                                  | $-\chi_M \cdot 10^6$         | Ref.        |
|-------------------------------------------------------------|------------------------|-------------------------------------------------------------------------------------|------------------------------|-------------|
| Methyl trimethoxysilane                                     | $C_4H_{10}SiO_3$       | $CH_3-Si-(OCH_3)_3$                                                                 | 85.6                         | 17          |
| Tetramethoxysilane                                          | $C_4H_{10}SiO_4$       | $Si-(OCH_3)_4$                                                                      | 83.68                        | 5           |
| Trimethylacetoxysilane                                      | $C_6H_{14}SiO_2$       | $(CH_3)_3-Si-OCOCH_3$                                                               | 85.00, 86.09                 | 16, 5       |
| Trimethylsilylchloromethylamidoxime                         | $C_4H_{13}SiOCIN_2$    | $NH_2-C-(CH_2Cl)=N-O-Si-(CH_3)_3$                                                   | 109.60                       | 15          |
| Trimethylethylsilane                                        | $C_6H_{14}Si$          | $C_2H_5-Si-(CH_3)_3$                                                                | 86.00                        | 2           |
| Trimethylethoxysilane                                       | $C_6H_{14}SiO$         | $(CH_3)_3-Si-OC_2H_5$                                                               | 89.50                        | 1, 17       |
| Phenyl trichlorosilane                                      | $C_6H_5SiCl_3$         | $C_6H_5-Si-Cl_3$                                                                    | 120.4                        | 8           |
| Dimethyl diacetoxysilane                                    | $C_8H_{18}SiO_4$       | $(CH_3)_2-Si-(OCOCH_3)_2$                                                           | 98.3, 101.18                 | 16, 5       |
| 1,4,6,9-Tetraoxa-2,7-dimethyl-5-silaspiro[4,4]nonane        | $C_8H_{18}SiO_4$       |    | 104.34                       | 5           |
| Trimethylpropionoxysilane                                   | $C_8H_{18}SiO_2$       | $(CH_3)_3-Si-O-COC_2H_5$                                                            | 99.09                        | 5           |
| Dimethyldiethylsilane                                       | $C_8H_{18}Si$          | $(C_2H_5)_2-Si-(CH_3)_2$                                                            | 97.90                        | 1           |
| Triethylsilane                                              | $C_6H_{14}Si$          | $(C_2H_5)_3-Si-H$                                                                   | 95.00                        | 3           |
| Trimethylpropoxysilane                                      | $C_8H_{18}SiO$         | $(CH_3)_3-Si-O-(CH_2)_3-CH_3$                                                       | 101.1                        | 1           |
| Trimethylsilylethylamidoxime                                | $C_8H_{18}SiON_2$      | $(NH_2)-C(C_2H_5)=N-O-Si(CH_3)_3$                                                   | 101.00                       | 15          |
| Dimethyldiethoxysilane                                      | $C_8H_{18}SiO_2$       | $(CH_3)_2-Si-(OC_2H_5)_2$                                                           | 103.60, 104.70, 104.1, 104.6 | 1, 18, 5, 8 |
| Trimethylthio-n-propylsilane                                | $C_8H_{18}SiS$         | $(CH_3)_3-Si-S-(CH_2)_3-CH_3$                                                       | 114.09                       | 12          |
| Trimethylthio-isopropylsilane                               | $C_8H_{18}SiS$         | $(CH_3)_3-Si-S-(CH_3)_2-CH_2$                                                       | 115.11                       | 12          |
| Hexamethyldisiloxane                                        | $C_6H_{14}Si_2O$       | $(CH_3)_3-Si-O-Si-(CH_3)_3$                                                         | 118.9                        | 8           |
| Hexamethylcyclotrisiloxane                                  | $C_6H_{14}Si_3O_3$     |    | 140.5                        | 8           |
| Methyltriacetoxysilane                                      | $C_8H_{18}SiO_4$       | $(CH_3)_3-Si-(OCOCH_3)_3$                                                           | 112.50                       | 5           |
| Triethylmethylsilane                                        | $C_8H_{18}Si$          | $(C_2H_5)_3-Si-CH_3$                                                                | 109.30                       | 2           |
| Trimethylbutylsilane                                        | $C_8H_{18}Si$          | $(CH_3)_3-Si-(CH_2)_4-CH_3$                                                         | 109.00                       | 2           |
| Trimethylbutoxysilane                                       | $C_8H_{18}SiO$         | $(CH_3)_3-Si-O-(CH_2)_4-CH_3$                                                       | 114.2                        | 5           |
| Trimethylsilyl-n-propylamidoxime                            | $C_8H_{18}SiON_2$      | $NH_2-C-(CH_2)_3-CH_3=N-O-Si-(CH_3)_3$                                              | 123.8                        | 15          |
| Methyltriethoxysilane                                       | $C_8H_{18}SiO_3$       | $CH_3-Si-(OC_2H_5)_3$                                                               | 120.3                        | 17          |
| Trimethylthio-n-butylsilane                                 | $C_9H_{20}SiS$         | $(CH_3)_3-Si-S-(CH_2)_4-CH_3$                                                       | 125.73                       | 12          |
| Trimethylthio-tert-butylsilane                              | $C_9H_{20}SiS$         | $(CH_3)_3-Si-S-C(CH_3)_3$                                                           | 126.55                       | 12          |
| Trimethyl-N-dimethylsilane                                  | $C_8H_{18}SiN$         | $(CH_3)_3-Si-N-(CH_3)_2$                                                            | 91.3                         | 1           |
| 2,2-Dimethyl-2-sila-2,3-dihydrobenzothiazole                | $C_8H_{11}SiN$         |  | 144.44                       | 12          |
| Tetraacetoxysilane                                          | $C_8H_{18}SiO_4$       | $Si-(OCOCH_3)_4$                                                                    | 129.26                       | 5           |
| Dimethyldipropionoxysilane                                  | $C_8H_{18}SiO_2$       | $(CH_3)_2-Si-(OCOC_2H_5)_2$                                                         | 122.0, 123.97                | 16, 5       |
| 1,4,6,9-Tetraoxa-2,3,7,8-tetramethyl-5-silaspiro[4,4]nonane | $C_{12}H_{26}SiO_4$    |  | 127.12                       | 5           |
| 1,5,7,11-Tetraoxa-2,8-dimethyl-6-silaspiro[5,5]undecane     | $C_{14}H_{30}SiO_4$    |  | 126.34                       | 5           |
| Dimethyldi-n-propylsilane                                   | $C_{10}H_{22}Si$       | $(CH_3)_2-Si-[(CH_2)_3-CH_3]_2$                                                     | 121.70                       | 1           |
| Tetraethylsilane                                            | $C_{10}H_{22}Si$       | $Si-(C_2H_5)_4$                                                                     | 120.30, 120.40, 117.00       | 1, 4, 5     |
| Dimethyl-di-n-propoxysilane                                 | $C_{10}H_{22}SiO_2$    | $(CH_3)_2-Si-[O(CH_2)_3-CH_3]_2$                                                    | 125.70, 126.90               | 1, 5        |
| Tetraethoxysilane                                           | $C_{10}H_{22}SiO_4$    | $Si-(OC_2H_5)_4$                                                                    | 83.68, 134.50                | 5, 17       |
| Bis(trimethylsilyl)-methylamidoxime                         | $C_{10}H_{22}SiO_2N_2$ | $(CH_3)_3-Si-NH-C(CH_3)=N-O-Si-(CH_3)_3$                                            | 156.60                       | 15          |
| Octamethyltrisiloxane                                       | $C_{14}H_{30}Si_3O_2$  | $(CH_3)_3-Si-O-Si-(CH_3)_2(CH_3)_2$                                                 | 165.00                       | 16          |
| Octamethyltetraacyclosiloxane                               | $C_{14}H_{30}Si_4O_4$  |  | 188.00                       | 5           |
| Tri-n-propylsilane                                          | $C_{12}H_{26}Si$       | $CH_3-(CH_2)_3-Si-H$                                                                | 130.00                       | 3           |
| Trimethyl-N-(n-propyl)silane                                | $C_{12}H_{26}SiN$      | $(CH_3)_3-Si-N-[(CH_2)_3-CH_3]$                                                     | 113.4                        | 1           |
| Bis(trimethyl)-ethylamidoxime                               | $C_{12}H_{26}SiON_2$   | $(CH_3)_3-Si-NH-C(C_2H_5)=N-O-Si(CH_3)_3$                                           | 168.00                       | 15          |
| Bis(trimethyl)-phenylamidoxime                              | $C_{18}H_{18}SiON_2$   | $NH_2-C(C_6H_5)=N-O-Si(CH_3)_3$                                                     | 141.7                        | 15          |

# DIAMAGNETIC SUSCEPTIBILITY DATA ON ORGANOSILICON COMPOUNDS (continued)

| Compound                                                         | Molecular formula          | Structural formula                                                                  | $-\chi_M \cdot 10^6$ | Ref.   |
|------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|----------------------|--------|
| 2,2-Diacetoxy-4,4,6,6-tetramethyl-1,3-dioxo-2-sila-cyclohexane   | $C_{10}H_{20}SiO_4$        |    | 150.65               | 5      |
| Dimethyl di- <i>n</i> -butylsilane                               | $C_{10}H_{24}Si$           | $(CH_3)_2-Si-[(CH_2)_3-CH_3]_2$                                                     | 145.80               | 1      |
| Methyl tri- <i>n</i> -butylsilane                                | $C_{10}H_{24}Si$           | $CH_3-Si-[(CH_2)_3-CH_3]_3$                                                         | 143.90               | 1      |
| Dimethyl di- <i>n</i> -butoxysilane                              | $C_{10}H_{24}SiO_2$        | $(CH_3)_2-Si-[O(CH_2)_3CH_3]_2$                                                     | 147.40, 149.40       | 1, 5   |
| Dimethyl di-iso-butoxysilane                                     | $C_{10}H_{24}SiO_2$        | $(CH_3)_2-Si-[O-CH_2-CH-(CH_3)_2]_2$                                                | 150.73               | 5      |
| Dimethyl di-(1-methylpropoxy)silane                              | $C_{10}H_{24}SiO_2$        | $(CH_3)_2-Si-[O-CH(CH_3)-C_2H_5]_2$                                                 | 150.83               | 5      |
| Di- <i>n</i> -propyldiethoxysilane                               | $C_{10}H_{24}SiO_2$        | $[CH_3-(CH_2)_2]_2-Si-(OC_2H_5)_2$                                                  | 150.80               | 17, 18 |
| Bis(trimethylsilyl)- <i>n</i> -propylamidoxime                   | $C_{10}H_{24}SiON_2$       | $(CH_3)_3-Si-NH-C(CH_3)_2-CH_2=N-O-Si-(CH_3)_3$                                     | 179.00               | 15     |
| Trimethyl- <i>n</i> -octylsilane                                 | $C_{11}H_{26}Si$           | $(CH_3)_3-Si-(CH_2)_7-CH_3$                                                         | 156.00               | 2      |
| Trimethyl- <i>n</i> -octoxysilane                                | $C_{11}H_{26}SiO$          | $(CH_3)_3-Si-O(CH_2)_7-CH_3$                                                        | 149.00               | 1      |
| Trimethyl- <i>N</i> -(di- <i>N</i> -butyl)silane                 | $C_{11}H_{27}SiN$          | $(CH_3)_3-Si-N-[(CH_2)_3-CH_3]_2$                                                   | 158.5                | 1      |
| 2,2'-Spirobis(6-chloro-2,3-dihydrobenzothiazole)silane           | $C_{12}H_{10}SiCl_2S_2N_2$ |    | 183.29               | 12     |
| 2,2'-Spirobis(6-bromo-2,3-dihydrobenzothiazole)silane            | $C_{12}H_{10}SiBr_2S_2N_2$ |    | 199.37               | 12     |
| 2,2'-Spirobis(2,3-dihydrobenzothiazole)silane                    | $C_{12}H_{10}SiS_2N_2$     |   | 153.71               | 12     |
| Diphenylsilanediol                                               | $C_{12}H_{12}SiO_2$        | $(C_6H_5)_2-Si-(OH)_2$                                                              | 131.60               | 8      |
| Tetrapropionoxysilane                                            | $C_{12}H_{26}SiO_4$        | $Si-(OCOC_2H_5)_4$                                                                  | 129.26               | 5      |
| 1,4,6,9-Tetraoxo-2,3,7,8-octamethyl-1-5-silaspiro[4,4]nonane     | $C_{12}H_{24}SiO_4$        |  | 127.45               | 5      |
| 1,5,7,11-Tetraoxa-2,4,8,10-hexamethyl-1-6-silaspiro[5,5]undecane | $C_{12}H_{24}SiO_4$        |  | 172.48               | 5      |
| Dodecyltrichlorosilane                                           | $C_{13}H_{28}SiCl_3$       | $CH_3-(CH_2)_{11}-Si-Cl_3$                                                          | 210.40, 209.20       | 2, 8   |
| Dimethyl di- <i>n</i> -pentylsilane                              | $C_{13}H_{30}Si$           | $(CH_3)_2-Si-[(CH_2)_4-CH_3]_2$                                                     | 167.60               | 1      |
| Tetra- <i>n</i> -propylsilane                                    | $C_{13}H_{30}Si$           | $Si-[(CH_2)_2-CH_3]_4$                                                              | 165.80               | 1      |
| Tri- <i>n</i> -butylsilane                                       | $C_{13}H_{30}Si$           | $H-Si-[(CH_2)_3-CH_3]_3$                                                            | 172.00               | 3      |
| Dimethyl di- <i>n</i> -pentoxysilane                             | $C_{13}H_{30}SiO_2$        | $(CH_3)_2-Si-[O-(CH_2)_4-CH_3]_2$                                                   | 172.37               | 5      |
| Hexaethoxydisiloxane                                             | $C_{13}H_{30}Si_2O_6$      | $(H_3C)_2O-Si-O-Si-(OC_2H_5)_3$                                                     | 217.00               | 13     |
| Bis(trimethylsilyl)-phenylamidoxime                              | $C_{13}H_{24}SiON_2$       | $(CH_3)_3-Si-NH-C(C_6H_5)=N-O-Si-(CH_3)_3$                                          | 199.50               | 15     |
| Methyltri- <i>n</i> -butylsilane                                 | $C_{13}H_{30}Si$           | $CH_3-Si-[(CH_2)_3-CH_3]_3$                                                         | 178.50               | 1      |
| 2,2'-Spirobis(6-methyl-2,3-dihydrobenzothiazole)silane           | $C_{14}H_{14}S_2N_2Si$     |  | 170.06               | 12     |
| Diphenyldimethoxysilane                                          | $C_{14}H_{18}SiO_2$        | $(C_6H_5)_2-Si-(OCH_3)_2$                                                           | 156.80               | 19     |
| Trimethyldodecylsilane                                           | $C_{14}H_{30}Si$           | $(CH_3)_3-Si-(CH_2)_{11}-CH_3$                                                      | 192.00               | 2      |
| Trimethyl- <i>n</i> -dodeconoxysilane                            | $C_{14}H_{30}SiO$          | $(CH_3)_3-Si-O-(CH_2)_{11}-CH_3$                                                    | 205.6                | 1      |
| Diphenyl diethoxysilane                                          | $C_{14}H_{20}SiO_2$        | $(C_6H_5)_2-Si-(OC_2H_5)_2$                                                         | 179.25               | 19     |
| Hexadodecyltrichlorosilane                                       | $C_{14}H_{30}SiCl_3$       | $C_{14}H_{30}-Si-Cl_3$                                                              | 259.00, 252.40       | 2, 8   |
| Tetra- <i>n</i> -butylsilane                                     | $C_{14}H_{30}Si$           | $Si-[(CH_2)_3-CH_3]_4$                                                              | 202.50               | 3      |
| Hexa-dodecamethylheptasiloxane                                   | $C_{16}H_{38}O_6Si_7$      | $(CH_3)_3-Si-(O-Si)_5-O-Si-(CH_3)_3$                                                | 351.3                | 8      |
| Triphenylhydroxysilane                                           | $C_{18}H_{18}SiO$          | $(C_6H_5)_3-Si-OH$                                                                  | 176.0                | 8      |
| Dephenyl di- <i>n</i> -propoxysilane                             | $C_{18}H_{34}SiO_2$        | $(C_6H_5)_2-Si-[O(CH_2)_2-CH_3]_2$                                                  | 201.58               | 19     |

## DIAMAGNETIC SUSCEPTIBILITY DATA ON ORGANOSILICON COMPOUNDS (continued)

| Compound                                | Molecular formula               | Structural formula                     | $-\chi_M \cdot 10^6$ | Ref.      |
|-----------------------------------------|---------------------------------|----------------------------------------|----------------------|-----------|
| Diphenyl di-isopropoxysilane            | $C_{18}H_{24}SiO_2$             | $(C_6H_5)_2-Si-[OCH-(CH_3)]_2$         | 202.46               | 19        |
| <i>n</i> -Octadecyltrichlorosilane      | $C_{18}H_{37}SiCl_3$            | $CH_3-(CH_2)_{17}-Si-Cl_3$             | 278.00, 273.7        | 2, 8      |
| Diphenyl di- <i>n</i> -butoxysilane     | $C_{26}H_{38}SiO_2$             | $(C_6H_5)_2-Si-[O-(CH_2)_4-CH_3]_2$    | 223.62               | 19        |
| Diphenyl di-iso-butoxy silane           | $C_{26}H_{38}SiO_2$             | $(C_6H_5)_2-Si-[O-CH_2-CH(CH_3)]_2$    | 224.46               | 19        |
| Trimethyl- <i>n</i> -octadeconyl silane | $C_{21}H_{44}Si$                | $CH_3-(CH_2)_{17}-Si-(CH_3)_3$         | 278.00               | 2         |
| Tetraphenylsilane                       | $C_{24}H_{18}Si$                | $Si-(C_6H_5)_4$                        | 212.20               | 7         |
| Tetrabenzylsilane                       | $C_{28}H_{26}Si$                | $Si-(CH_2-C_6H_5)_4$                   | 266.20               | 6         |
| Tetra- <i>p</i> -tolylsilane            | $C_{28}H_{26}Si$                | $Si-(C_6H_4-CH_3)_4$                   | 276.40               | 6         |
| Other silicon compounds                 |                                 |                                        |                      |           |
| Carborundum (silicon carbide)           | CSi                             | C-Si                                   | 12.80                | 20        |
| Silane                                  | SiH <sub>4</sub>                | Si-H <sub>4</sub>                      | 20.4                 | 13        |
| Silicon dioxide                         | SiO <sub>2</sub>                | O=Si=O                                 | 29.6                 | 11        |
| Tetrachlorosilane                       | SiCl <sub>4</sub>               | Si-Cl <sub>4</sub>                     | 87.40, 84.60, 88.30  | 4, 11, 10 |
| Tetrabromosilane                        | SiBr <sub>4</sub>               | Si-Br <sub>4</sub>                     | 123.30               | 4         |
| Tetraiodosilane                         | SiI <sub>4</sub>                | Si-I <sub>4</sub>                      | 186.20               | 4         |
| Trichlorosilane                         | HSiCl <sub>3</sub>              | H-Si-Cl <sub>3</sub>                   | 70.50, 71.30, 70.60  | 2, 7, 4   |
| Silicic acid                            | H <sub>2</sub> SiO <sub>3</sub> | O=S-(OH) <sub>2</sub>                  | 33.30                | 11        |
| Ortho silicic acid                      | H <sub>4</sub> SiO <sub>4</sub> | Si-(OH) <sub>4</sub>                   | 42.60                | 21        |
| Disilane                                | Si <sub>2</sub> H <sub>6</sub>  | H <sub>3</sub> -Si-Si-H <sub>3</sub>   | 37.3                 | 4         |
| Hexachlorosilane                        | Si <sub>2</sub> Cl <sub>6</sub> | Cl <sub>3</sub> -Si-Si-Cl <sub>3</sub> | 138.00               | 7         |

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# DIFFUSIVITIES OF METALLIC SOLUTES IN MOLTEN METALS

A. K. Roy and R. P. Chhabra

| Solute | Solvent | Temperature (K) | Diffusivity × 10 <sup>5</sup><br>cm <sup>2</sup> /s | Solute | Solvent | Temperature (K) | Diffusivity × 10 <sup>5</sup><br>cm <sup>2</sup> /s |      |       |
|--------|---------|-----------------|-----------------------------------------------------|--------|---------|-----------------|-----------------------------------------------------|------|-------|
| Au     | Ag      | 1253            | 2.46                                                | Te     |         | 980             | 2.94                                                |      |       |
|        |         | 1300            | 2.80                                                |        |         | 1030            | 4.00                                                |      |       |
|        |         | 1350            | 3.19                                                |        |         | 1080            | 5.30                                                |      |       |
|        |         | 1400            | 3.59                                                |        |         | 1130            | 6.83                                                |      |       |
|        |         | 1450            | 4.00                                                |        |         | 1180            | 8.62                                                |      |       |
|        |         | 1500            | 4.44                                                |        |         | 1230            | 10.68                                               |      |       |
|        |         | 1533            | 4.73                                                |        |         | 1280            | 13.01                                               |      |       |
| In     |         | 1253            | 3.81                                                | Zn     |         | 1320            | 15.07                                               |      |       |
|        |         | 1300            | 4.20                                                |        |         | 970             | 6.20                                                |      |       |
|        |         | 1350            | 4.63                                                |        |         | 1073            | 14.00                                               |      |       |
|        |         | 1400            | 5.06                                                |        |         | Ag              | Bi                                                  | 573  | 2.24  |
|        |         | 1450            | 5.50                                                |        |         |                 |                                                     | 673  | 5.17  |
|        |         | 1500            | 5.95                                                |        |         |                 |                                                     | 773  | 9.61  |
|        |         | 1533            | 6.25                                                |        |         |                 |                                                     | 873  | 16.00 |
| Sb     |         | 1253            | 4.11                                                | 973    | 22.63   |                 |                                                     |      |       |
|        |         | 1300            | 4.47                                                | Au     |         | 773             | 5.22                                                |      |       |
|        |         | 1350            | 4.85                                                |        |         | 773             | 4.90                                                |      |       |
|        |         | 1400            | 5.23                                                |        |         | 773             | 6.50                                                |      |       |
|        |         | 1450            | 5.62                                                |        |         | 873             | 5.50                                                |      |       |
|        |         | 1500            | 6.00                                                |        |         | 873             | 8.20                                                |      |       |
|        |         | 1533            | 6.25                                                | Ag     | Cu      | 1373            | 2.33                                                |      |       |
| Sn     |         | 1248            | 3.87                                                |        |         | 1473            | 2.82                                                |      |       |
|        |         | 1298            | 4.25                                                |        |         | 1573            | 3.32                                                |      |       |
|        |         | 1348            | 4.63                                                | Au     |         | 1373            | 2.42                                                |      |       |
|        |         | 1398            | 5.02                                                |        |         | 1473            | 2.79                                                |      |       |
|        |         | 1448            | 5.41                                                |        |         | 1573            | 3.17                                                |      |       |
|        |         | 1498            | 5.80                                                | Co     |         | 1373            | 3.61                                                |      |       |
|        |         | 1548            | 6.20                                                |        |         | 1423            | 4.18                                                |      |       |
| 1623   | 6.78    | 1473            | 4.80                                                |        |         |                 |                                                     |      |       |
| Ag     | Al      | 1183            | 11.00                                               |        |         | 1523            | 5.45                                                |      |       |
|        |         | 1183            | 20.00                                               |        |         | 1573            | 6.14                                                |      |       |
|        |         | Co              |                                                     | 980    | 2.82    | Ga              |                                                     | 1373 | 4.63  |
| 1080   | 3.85    |                 |                                                     | 1423   | 5.13    |                 |                                                     |      |       |
| 1180   | 4.98    |                 |                                                     | 1473   | 5.65    |                 |                                                     |      |       |
| 1280   | 6.20    |                 |                                                     | 1523   | 6.18    |                 |                                                     |      |       |
| 1320   | 6.70    |                 |                                                     | 1573   | 6.72    |                 |                                                     |      |       |
| Cu     |         | 973             | 7.20                                                | In     |         | 1373            | 2.56                                                |      |       |
|        |         | 1000            | 6.00                                                |        |         | 1473            | 3.28                                                |      |       |
|        |         | 1050            | 6.87                                                |        |         | 1573            | 4.08                                                |      |       |
|        |         | 1100            | 7.78                                                | Ni     |         | 1373            | 3.62                                                |      |       |
|        |         | 1150            | 8.71                                                |        |         | 1423            | 4.15                                                |      |       |
|        |         | 1200            | 9.67                                                |        |         | 1473            | 4.70                                                |      |       |
|        |         | 1250            | 10.63                                               |        |         | 1523            | 5.29                                                |      |       |
|        |         | 1273            | 15.00                                               |        |         | 1573            | 5.90                                                |      |       |
|        |         | 1300            | 11.61                                               |        |         | Sb              |                                                     | 1373 | 2.25  |
|        |         | 973             | 1.40                                                |        |         |                 |                                                     | 1473 | 3.07  |
| 1273   | 20.00   | 1573            | 4.03                                                |        |         |                 |                                                     |      |       |
| Ga     |         | 1000            | 7.70                                                | In     | Ga      | 473             | 3.67                                                |      |       |
|        |         | 1050            | 8.67                                                |        |         | 523             | 4.33                                                |      |       |
|        |         | 1100            | 9.64                                                |        |         | 573             | 4.97                                                |      |       |
|        |         | 1150            | 10.63                                               |        |         | 623             | 5.58                                                |      |       |
|        |         | 1200            | 11.62                                               |        |         | 673             | 6.16                                                |      |       |
| 1250   | 12.62   | 723             | 6.70                                                |        |         |                 |                                                     |      |       |
| 1300   | 13.61   | Ga              | In                                                  |        |         | 473             | 3.08                                                |      |       |
| Mg     |         |                 |                                                     |        |         | 973             | 2.70                                                | 523  | 3.75  |
|        |         |                 |                                                     |        |         | 973             | 7.54                                                | 573  | 4.41  |
|        |         |                 |                                                     |        |         | 1073            | 6.40                                                | 623  | 5.05  |
| Ni     |         |                 |                                                     | 980    | 3.86    | 673             | 5.67                                                |      |       |
|        |         | 1080            | 5.22                                                | Ag     | Pb      | 623             | 1.74                                                |      |       |
|        |         | 1180            | 6.70                                                |        |         | 673             | 1.96                                                |      |       |
|        |         | 1280            | 8.27                                                |        |         | 723             | 2.16                                                |      |       |
|        |         | 1320            | 8.92                                                |        |         | 773             | 2.36                                                |      |       |



DIFFUSIVITIES OF METALLIC SOLUTES IN MOLTEN METALS (continued)

| Solute | Solvent | Temperature (K) | Diffusivity $\times 10^5$<br>cm <sup>2</sup> /s | Solute | Solvent | Temperature (K) | Diffusivity $\times 10^5$<br>cm <sup>2</sup> /s |
|--------|---------|-----------------|-------------------------------------------------|--------|---------|-----------------|-------------------------------------------------|
| Au     |         | 773             | 3.70                                            |        |         | 800             | 6.52                                            |
| Bi     |         | 773             | 4.93                                            |        |         | 900             | 8.29                                            |
|        |         | 773             | 5.60                                            |        |         | 1000            | 10.06                                           |
|        |         | 823             | 6.23                                            |        |         | 1100            | 11.83                                           |
|        |         | 873             | 8.30                                            |        |         | 1300            | 15.37                                           |
| Cd     |         | 723             | 3.90                                            |        |         | 1500            | 18.91                                           |
|        |         | 773             | 5.00                                            |        |         | 1683            | 22.10                                           |
|        |         | 823             | 6.00                                            |        |         | 1853            | 26.10                                           |
|        |         | 873             | 6.80                                            | Bi     |         | 723             | 3.60                                            |
| Cu     |         | 723             | 3.43                                            |        |         | 773             | 4.60                                            |
|        |         | 773             | 3.92                                            |        |         | 823             | 5.80                                            |
|        |         | 823             | 4.41                                            |        |         | 873             | 6.60                                            |
|        |         | 873             | 4.89                                            | Co     |         | 623             | 2.70                                            |
|        |         | 923             | 5.37                                            | Cu     |         | 560             | 4.13                                            |
|        |         | 973             | 5.83                                            |        |         | 600             | 5.31                                            |
|        |         | 1040            | 6.44                                            |        |         | 650             | 6.97                                            |
| Na     |         | 625             | 2.75                                            |        |         | 700             | 8.79                                            |
|        |         | 673             | 1.21                                            |        |         | 750             | 10.75                                           |
|        |         | 773             | 1.42                                            | Na     |         | 550             | 1.24                                            |
|        |         | 853             | 5.25                                            |        |         | 600             | 1.67                                            |
|        |         | 873             | 1.79                                            |        |         | 625             | 1.90                                            |
|        |         | 903             | 5.91                                            |        |         | 700             | 2.66                                            |
| Sb     |         | 723             | 3.10                                            |        |         | 853             | 6.39                                            |
|        |         | 773             | 4.10                                            |        |         | 903             | 6.98                                            |
|        |         | 823             | 5.50                                            | Ni     |         | 560             | 3.92                                            |
|        |         | 873             | 6.40                                            |        |         | 600             | 5.15                                            |
| Sn     |         | 723             | 2.60                                            |        |         | 650             | 6.89                                            |
|        |         | 773             | 3.52                                            |        |         | 700             | 8.86                                            |
|        |         | 783             | 1.75                                            |        |         | 750             | 11.00                                           |
|        |         | 823             | 4.30                                            | Pb     |         | 773             | 3.68                                            |
|        |         | 873             | 5.50                                            |        |         | 823             | 3.68                                            |
| Ag     | Sn      | 560             | 3.02                                            | Sb     |         | 600             | 3.15                                            |
|        |         | 600             | 3.71                                            |        |         | 700             | 4.14                                            |
|        |         | 650             | 4.57                                            |        |         | 800             | 5.36                                            |
|        |         | 700             | 5.43                                            |        |         | 900             | 6.42                                            |
|        |         | 750             | 6.29                                            |        |         | 1000            | 7.48                                            |
|        |         | 773             | 4.80                                            |        |         | 1100            | 8.54                                            |
|        |         | 943             | 10.20                                           |        |         | 1300            | 10.66                                           |
|        |         | 1108            | 11.80                                           |        |         | 1500            | 12.78                                           |
| Al     |         | 560             | 1.76                                            | Zn     |         | 560             | 7.72                                            |
|        |         | 600             | 2.41                                            |        |         | 600             | 10.34                                           |
|        |         | 650             | 3.37                                            |        |         | 650             | 14.20                                           |
|        |         | 700             | 4.50                                            |        |         | 700             | 18.56                                           |
|        |         | 750             | 5.77                                            |        |         | 750             | 23.46                                           |
| Au     |         | 600             | 2.98                                            | Mn     | Zn      | 973             | 3.28                                            |
|        |         | 700             | 4.75                                            |        |         | 1023            | 3.75                                            |
|        |         | 773             | 5.37                                            |        |         | 1073            | 4.22                                            |



# DIFFUSIVITIES OF METALLIC TRACERS IN MERCURY

R. P. Chhabra

There are several sources for these data in the literature. Different investigators have obtained different results. That is the reason there are different diffusivity values listed for the same temperature.

| Tracer | Temp. (K) | Diffusivity $\times 10^5$<br>cm <sup>2</sup> /s | Tracer | Temp. (K) | Diffusivity $\times 10^5$<br>cm <sup>2</sup> /s |
|--------|-----------|-------------------------------------------------|--------|-----------|-------------------------------------------------|
| Ag     | 273       | 0.7                                             | Li     | 281.3     | 0.77                                            |
|        | 298       | 1.30                                            |        | 298       | 0.92                                            |
|        | 298       | 1.05                                            |        | 298       | 1.20                                            |
|        | 393       | 2.67                                            |        | 293       | 0.94                                            |
| Al     | 293       | 1.54                                            | Mn     | 293       | 1.84                                            |
|        | 303       | 1.90                                            |        | 298       | 0.81                                            |
|        | 323       | 2.36                                            |        | 298       | 0.98                                            |
| Au     | 293       | 0.61                                            |        | 282.7     | 0.74                                            |
|        | 298       | 0.73                                            | Na     | 293       | 0.76                                            |
|        | 298       | 0.96                                            |        | 293       | 0.97                                            |
| Ba     | 280.9     | 0.62                                            |        | 924       | 0.80                                            |
|        | 293       | 0.49                                            |        | 298       | 0.84                                            |
|        | 293       | 1.04                                            |        | 298       | 0.97                                            |
| Bi     | 333       | 1.44                                            | Ni     | 333       | 1.78                                            |
|        | 293       | 1.33                                            |        | 293       | 0.64                                            |
|        | 293       | 1.44                                            |        | 298       | 0.54                                            |
|        | 298       | 0.99                                            |        | 298       | 0.65                                            |
| Cd     | 298       | 1.62                                            | Pb     | 273       | 0.97                                            |
|        | 281.9     | 1.68                                            |        | 282.5     | 1.74                                            |
|        | 283       | 1.52                                            |        | 288.7     | 1.58                                            |
|        | 288       | 1.81                                            |        | 293       | 1.25                                            |
|        | 293       | 0.92                                            | Rb     | 295       | 1.41                                            |
|        | 2.93      | 3.06                                            |        | 298       | 1.15                                            |
|        | 298       | 2.00                                            |        | 298       | 1.39                                            |
|        | 313       | 1.80                                            |        | 372.3     | 2.21                                            |
|        | 333       | 2.01                                            | Sb     | 280.4     | 0.53                                            |
| Cs     | 372.2     | 3.42                                            |        | 293       | 0.75                                            |
|        | 421       | 3.05                                            |        | 293       | 1.30                                            |
|        | 280.3     | 0.52                                            |        | 293       | 1.47                                            |
| Cu     | 293       | 0.54                                            | Sn     | 298       | 1.64                                            |
|        | 298       | 0.63                                            |        | 298       | 1.64                                            |
|        | 293       | 0.88                                            |        | 343       | 1.37                                            |
|        | 293       | 1.19                                            |        | 363       | 2.42                                            |
| Ga     | 298       | 0.83                                            | Tl     | 282.7     | 1.80                                            |
|        | 298       | 1.06                                            |        | 283.8     | 1.77                                            |
|        | 363       | 1.01                                            |        | 293       | 1.43                                            |
|        | 293       | 1.64                                            |        | 295       | 1.53                                            |
| In     | 293       | 1.72                                            | Zn     | 298       | 1.30                                            |
|        | 298       | 1.57                                            |        | 298       | 1.68                                            |
|        | 298       | 1.74                                            |        | 284.6     | 1.00                                            |
|        | 293       | 1.36                                            |        | 293       | 0.91                                            |
| K      | 293       | 1.42                                            |        | 293       | 1.05                                            |
|        | 294       | 1.47                                            |        | 298       | 1.00                                            |
|        | 295       | 1.57                                            |        | 298       | 1.60                                            |
|        | 298       | 1.31                                            |        | 273       | 1.51                                            |
|        | 298       | 1.39                                            |        | 284.6     | 2.52                                            |
|        | 283.6     | 0.61                                            |        | 288       | 2.42                                            |
|        | 293       | 0.66                                            |        | 293       | 1.46                                            |
|        | 293       | 0.85                                            |        | 293       | 1.89                                            |
|        | 298       | 0.71                                            |        | 298       | 1.57                                            |
|        | 550       | 3.10                                            |        | 298       | 2.40                                            |
|        | 550       | 3.68                                            |        | 303       | 1.20                                            |
|        | 550       | 3.50                                            |        | 303       | 1.80                                            |
|        | 550       | 5.32                                            |        | 323       | 2.06                                            |
|        | 650       | 5.23                                            |        | 372.4     | 3.35                                            |
|        | 650       | 6.11                                            |        |           |                                                 |
|        |           |                                                 |        |           |                                                 |

### DISSOCIATION CONSTANTS OF ACIDS IN WATER AT VARIOUS TEMPERATURES

| Acids             |                        | 0°    | 5°    | 10°   | 15°   | 20°   | 25°   | 30°   | 35°   | 40°   | 45°   | 50°   |
|-------------------|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Formic            | $K_a \cdot 10^4$       | 1.638 | 1.691 | 1.728 | 1.749 | 1.765 | 1.772 | 1.768 | 1.747 | 1.716 | 1.685 | 1.650 |
| Acetic            | $K_a \cdot 10^5$       | 1.657 | 1.700 | 1.729 | 1.745 | 1.753 | 1.754 | 1.750 | 1.728 | 1.703 | 1.670 | 1.633 |
| Propionic         | $K_a \cdot 10^5$       | 1.274 | 1.305 | 1.326 | 1.336 | 1.338 | 1.336 | 1.326 | 1.310 | 1.280 | 1.257 | 1.229 |
| <i>n</i> -Butyric | $K_a \cdot 10^5$       | 1.563 | 1.574 | 1.576 | 1.569 | 1.542 | 1.515 | 1.484 | 1.439 | 1.395 | 1.347 | 1.302 |
| Chloracetic       | $K_a \cdot 10^3$       | 1.528 | —     | 1.488 | —     | —     | 1.379 | —     | —     | 1.230 | —     | —     |
| Lactic            | $K_a \cdot 10^4$       | 1.287 | —     | —     | —     | —     | 1.374 | —     | —     | —     | —     | 1.270 |
| Glycollic         | $K_a \cdot 10^4$       | 1.334 | —     | —     | —     | —     | 1.475 | —     | —     | —     | —     | 1.415 |
| Oxalic            | $K_{2a} \cdot 10^5$    | 5.91  | 5.82  | 5.70  | 5.55  | 5.40  | 5.18  | 4.92  | 4.67  | 4.41  | 4.09  | 3.83  |
| Malonic           | $K_{2a} \cdot 10^3$    | 2.140 | 2.165 | 2.152 | 2.124 | 2.076 | 2.014 | 1.948 | 1.863 | 1.768 | 1.670 | 1.575 |
| Phosphoric        | $K_a \cdot 10^3$       | 8.968 | —     | —     | —     | —     | 7.516 | —     | —     | —     | —     | 5.495 |
| Phosphoric        | $K_{2a} \cdot 10^8$    | 4.85  | 5.24  | 5.57  | 5.89  | 6.12  | 6.34  | 6.46  | 6.53  | 6.58  | 6.59  | 6.55  |
| Boric             | $K_a \cdot 10^{10}$    | —     | 3.63  | 4.17  | 4.72  | 5.26  | 5.79  | 6.34  | 6.86  | 7.38  | —     | 8.32  |
| Carbonic          | $K_{1a} \cdot 10^7$    | 2.64  | 3.04  | 3.44  | 3.81  | 4.16  | 4.45  | 4.71  | 4.90  | 5.04  | 5.13  | 5.19  |
| Phenol-sulfonic   | $K_{2a} \cdot 10^{10}$ | 4.45  | 5.20  | 6.03  | 6.92  | 7.85  | 8.85  | 9.89  | 10.94 | 12.00 | 13.09 | 14.16 |
| Glycine           | $K_{1a} \cdot 10^7$    | —     | 3.82  | 3.99  | 4.17  | 4.32  | 4.46  | 4.57  | 4.66  | 4.73  | 4.77  | 4.79  |
| Citric            | $K_{1a} \cdot 10^4$    | 6.03  | 6.31  | 6.69  | 6.92  | 7.21  | 7.45  | 7.66  | 7.78  | 7.96  | 7.99  | 8.04  |
|                   | $K_{2a} \cdot 10^5$    | 1.45  | 1.54  | 1.60  | 1.65  | 1.70  | 1.73  | 1.76  | 1.77  | 1.78  | 1.76  | 1.75  |
|                   | $K_{3a} \cdot 10^7$    | 4.05  | 4.11  | 4.14  | 4.13  | 4.09  | 4.02  | 3.99  | 3.78  | 3.69  | 3.45  | 3.28  |

Reproducibility between various workers is about  $\pm (0.01\text{--}0.02) \cdot 10^5$ .

### DISSOCIATION CONSTANTS ( $K_b$ ) OF AQUEOUS AMMONIA FROM 0 TO 50°C

| Temperature (°C) | $pK_b$ | $K_b$                  |
|------------------|--------|------------------------|
| 0                | 4.862  | $1.374 \times 10^{-5}$ |
| 5                | 4.830  | $1.479 \times 10^{-5}$ |
| 10               | 4.804  | $1.570 \times 10^{-5}$ |
| 15               | 4.782  | $1.652 \times 10^{-5}$ |
| 20               | 4.767  | $1.710 \times 10^{-5}$ |
| 25               | 4.751  | $1.774 \times 10^{-5}$ |
| 30               | 4.740  | $1.820 \times 10^{-5}$ |
| 35               | 4.733  | $1.849 \times 10^{-5}$ |
| 40               | 4.730  | $1.862 \times 10^{-5}$ |
| 45               | 4.726  | $1.879 \times 10^{-5}$ |
| 50               | 4.723  | $1.892 \times 10^{-5}$ |

Values of  $K_b$  accurate to  $\pm 0.005$ ; determined by e.m.f. method by: Bates, R. G. and Pinching, G. D., *J. Am. Chem. Soc.*, 72, 1393, 1950.

# EFFICACIES AND OTHER CHARACTERISTICS OF ILLUMINANTS

Gordon D. Rowe

## A. Incandescent Lamps (120 volt; Inside Frost)

| Nominal lamp watts | Bulb        | Base         | Approximate rated life (hr) | Approximate initial lumens | Approximate initial efficacy | Chromaticity (°K)                                                                                                                                                           |
|--------------------|-------------|--------------|-----------------------------|----------------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 25                 | A-19        | Medium       | 2500                        | 235                        | 9.4                          | Note: The chromaticity of incandescent lamps is generally in the order of 2900—3000 K; the color rendering index, 99+. These factors will vary with changes in the voltage. |
| 40                 | A-19        | Medium       | 1000                        | 480                        | 12.0                         |                                                                                                                                                                             |
| 60                 | A-19        | Medium       | 1000                        | 870                        | 14.5                         |                                                                                                                                                                             |
| 75                 | A-19        | Medium       | 750                         | 1,190                      | 15.9                         |                                                                                                                                                                             |
| 100                | A-19        | Medium       | 750                         | 1,750                      | 17.5                         |                                                                                                                                                                             |
| 150                | A-21        | Medium       | 750                         | 2,850                      | 19.0                         |                                                                                                                                                                             |
| 200                | A-23        | Medium       | 750                         | 4,010                      | 20.0                         |                                                                                                                                                                             |
| 500                | PS-35       | Mogul        | 1000                        | 10,850                     | 21.7                         |                                                                                                                                                                             |
| 750                | PS-52       | Mogul        | 1000                        | 17,040                     | 22.7                         |                                                                                                                                                                             |
| 1000               | PS-52       | Mogul        | 1000                        | 23,740                     | 23.7                         |                                                                                                                                                                             |
| 1500               | Clear PS-52 | Mogul        | 1000                        | 34,400                     | 22.9                         |                                                                                                                                                                             |
| 5000               | Clear G-64  | Mogul bipost | 150                         | 145,000                    | 29.0                         |                                                                                                                                                                             |
| 10000              | Clear G-96  | Mogul bipost | 75                          | 335,000                    | 33.6                         |                                                                                                                                                                             |

## B. Fluorescent Lamp (F40T12)

|                                 | Nominal lamp watts | Approximate rated life (h)* | Approximate initial lumens | Approximate initial efficacy (lm/lamp W) | Chromaticity (K) | Chromaticity coordinates |       | Color-rendering index |
|---------------------------------|--------------------|-----------------------------|----------------------------|------------------------------------------|------------------|--------------------------|-------|-----------------------|
|                                 |                    |                             |                            |                                          |                  | X                        | Y     |                       |
| Cool white                      | 40                 | 20,000 +                    | 3150                       | 78.75                                    | 4150             | 0.377                    | 0.385 | 62                    |
| Deluxe cool white               | 40                 | 20,000 +                    | 2250                       | 56.25                                    | 4175             | 0.372                    | 0.371 | 89                    |
| Warm white                      | 40                 | 20,000 +                    | 3200                       | 80.00                                    | 3000             | 0.443                    | 0.411 | 52                    |
| Deluxe warm white               | 40                 | 20,000 +                    | 2200                       | 55.00                                    | 3025             | 0.435                    | 0.404 | 77                    |
| Daylight                        | 40                 | 20,000 +                    | 2600                       | 65.00                                    | 6250             | 0.316                    | 0.341 | 75                    |
| White                           | 40                 | 20,000 +                    | 3150                       | 78.75                                    | 3450             | 0.410                    | 0.400 | 60                    |
| Sign white                      | 40                 | 20,000 +                    | 2400                       | 60.00                                    | 5200             | 0.340                    | 0.354 | 82                    |
| Natural                         | 40                 | 20,000 +                    | 2100                       | 52.50                                    | 3700             | 0.389                    | 0.368 | 90                    |
| Chroma 50                       | 40                 | 20,000 +                    | 2210                       | 55.25                                    | 5000             | 0.346                    | 0.362 | 90                    |
| Chroma 75                       | 40                 | 20,000 +                    | 2000                       | 50.00                                    | 7500             | 0.303                    | 0.319 | 92                    |
| Regal white®                    | 40                 | 20,000 +                    | 2850                       | 71.25                                    | 3000             | 0.434                    | 0.403 | 81                    |
| Lite white                      | 40                 | 15,000 <sup>b</sup>         | 3450                       | 86.25                                    | 4200             | 0.377                    | 0.393 | 49                    |
| SP30                            | 40                 | 15,000                      | 3325                       | 83.10                                    | 3000             | 0.438                    | 0.403 | 70                    |
| SP35                            | 40                 | 15,000 <sup>b</sup>         | 3325                       | 83.10                                    | 3500             | 0.413                    | 0.401 | 73                    |
| SP41                            | 40                 | 15,000                      | 3265                       | 81.60                                    | 4100             | 0.376                    | 0.390 | 70                    |
| Green                           | 40                 | 20,000 +                    | 4350                       | 108.75                                   | 6975             | 0.244                    | 0.628 | —                     |
| Cool green                      | 40                 | 20,000 +                    | 2850                       | 71.25                                    | 6450             | 0.307                    | 0.376 | 68                    |
| Blue                            | 40                 | 20,000 +                    | 1200                       | 30.00                                    | —                | 0.191                    | 0.202 | —                     |
| Gold                            | 40                 | 20,000 +                    | 2400                       | 60.00                                    | 2500             | 0.516                    | 0.476 | 38                    |
| Pink                            | 40                 | 20,000 +                    | 1100                       | 27.50                                    | —                | 0.538                    | 0.343 | —                     |
| Red                             | 40                 | 20,000 +                    | 200                        | 5.00                                     | —                | 0.691                    | 0.303 | —                     |
| Plant light                     | 40                 | 20,000 +                    | 850                        | 21.25                                    | 6750             | 0.323                    | 0.240 | - 2                   |
| Plant light (wide spectrum)     | 40                 | 20,000 +                    | 1950                       | 48.75                                    | 3050             | 0.412                    | 0.360 | 90                    |
| Cool white (Watt-Miser® Plus)   | 32                 | 15,000 +                    | 2750                       | 86.00                                    | 4150             | 0.377                    | 0.385 | 62                    |
| Warm white (Watt-Miser® Plus)   | 32                 | 15,000 +                    | 2800                       | 87.50                                    | 3000             | 0.443                    | 0.411 | 52                    |
| SP30 (Watt-Miser® Plus)         | 32                 | 15,000 +                    | 2900                       | 90.60                                    | 3000             | 0.438                    | 0.403 | 70                    |
| SP35 (Watt-Miser® Plus)         | 32                 | 15,000 +                    | 2900                       | 90.60                                    | 3500             | 0.413                    | 0.401 | 73                    |
| SP41 (Watt-Miser® Plus)         | 32                 | 15,000 +                    | 2850                       | 89.00                                    | 4100             | 0.376                    | 0.390 | 70                    |
| Lite white (Watt-Miser® Plus)   | 32                 | 15,000 +                    | 2925                       | 91.40                                    | 4200             | 0.377                    | 0.393 | 49                    |
| Cool white (Watt-Miser®)        | 34                 | 20,000                      | 2750                       | 80.90                                    | 4150             | 0.377                    | 0.385 | 62                    |
| Deluxe cool white (Watt-Miser®) | 32                 | 20,000                      | 1925                       | 56.60                                    | 4175             | 0.372                    | 0.371 | 89                    |
| Warm white (Watt-Miser®)        | 32                 | 20,000                      | 2800                       | 82.35                                    | 3000             | 0.443                    | 0.411 | 52                    |
| Deluxe warm white (Watt-Miser®) | 32                 | 20,000                      | 1925                       | 56.60                                    | 3025             | 0.435                    | 0.404 | 77                    |
| Daylight (Watt-Miser®)          | 32                 | 20,000                      | 2300                       | 67.65                                    | 6250             | 0.316                    | 0.341 | 75                    |
| White (Watt-Miser®)             | 32                 | 20,000                      | 2800                       | 82.35                                    | 3450             | 0.410                    | 0.400 | 60                    |

|                                                     | Nominal<br>lamp<br>watts | Approximate<br>rated life<br>(h) <sup>a</sup> | Approximate<br>initial<br>lumens | Approximate<br>initial<br>efficacy<br>(lm/lamp W) | Chromaticity<br>(K) | Chromaticity<br>coordinates |       | Color-<br>rendering<br>index |
|-----------------------------------------------------|--------------------------|-----------------------------------------------|----------------------------------|---------------------------------------------------|---------------------|-----------------------------|-------|------------------------------|
|                                                     |                          |                                               |                                  |                                                   |                     | X                           | Y     |                              |
| Regal White <sup>b</sup> (Watt-Miser <sup>b</sup> ) | 32                       | 20,000                                        | 2450                             | 72.00                                             | 3000                | 0.434                       | 0.403 | 81                           |
| SP30 (Watt-Miser <sup>b</sup> )                     | 32                       | 20,000                                        | 2900                             | 85.30                                             | 3000                | 0.438                       | 0.403 | 70                           |
| SP35 (Watt-Miser <sup>b</sup> )                     | 32                       | 20,000                                        | 2900                             | 85.30                                             | 3500                | 0.413                       | 0.401 | 73                           |
| SP41 (Watt-Miser <sup>b</sup> )                     | 32                       | 20,000                                        | 2850                             | 83.80                                             | 4100                | 0.376                       | 0.390 | 70                           |
| Lite white (Watt-Miser <sup>b</sup> II)             | 32                       | 20,000                                        | 2925                             | 86.00                                             | 4200                | 0.377                       | 0.393 | 49                           |
| Cool white                                          | 75                       | 12,000 <sup>c</sup>                           | 6300                             | 84.00                                             |                     |                             |       |                              |
| Deluxe cool white                                   | 75                       | 12,000 <sup>c</sup>                           | 4500                             | 60.00                                             |                     |                             |       |                              |
| Warm white                                          | 75                       | 12,000 <sup>c</sup>                           | 6500                             | 86.65                                             |                     |                             |       |                              |
| Deluxe warm white                                   | 75                       | 12,000 <sup>c</sup>                           | 4350                             | 58.00                                             |                     |                             |       |                              |
| Daylight                                            | 75                       | 12,000 <sup>c</sup>                           | 5450                             | 72.65                                             |                     |                             |       |                              |
| White                                               | 75                       | 12,000 <sup>c</sup>                           | 6400                             | 85.30                                             |                     |                             |       |                              |
| Cool white (Watt-Miser <sup>b</sup> )               | 60                       | 12,000 <sup>c</sup>                           | 5600                             | 93.30                                             |                     |                             |       |                              |
| Deluxe cool white (Watt-Miser <sup>b</sup> )        | 60                       | 12,000 <sup>c</sup>                           | 4000                             | 66.65                                             |                     |                             |       |                              |
| Warm white (Watt-Miser <sup>b</sup> )               | 60                       | 12,000 <sup>c</sup>                           | 5800                             | 96.65                                             |                     |                             |       |                              |
| Daylight (Watt-Miser <sup>b</sup> )                 | 60                       | 12,000 <sup>c</sup>                           | 4840                             | 80.65                                             |                     |                             |       |                              |
| White (Watt-Miser <sup>b</sup> )                    | 60                       | 12,000 <sup>c</sup>                           | 5600                             | 93.30                                             |                     |                             |       |                              |
| Lite white (Watt-Miser <sup>b</sup> II)             | 60                       | 12,000 <sup>c</sup>                           | 6000                             | 100.00                                            |                     |                             |       |                              |
| High-output (F96T12, 800ma)                         |                          |                                               |                                  |                                                   |                     |                             |       |                              |
| Cool white                                          | 110                      | 12,000 <sup>c</sup>                           | 9200                             | 83.60                                             |                     |                             |       |                              |
| Deluxe cool white                                   | 110                      | 12,000                                        | 6600                             | 60.00                                             |                     |                             |       |                              |
| Warm white                                          | 110                      | 12,000 <sup>c</sup>                           | 9200                             | 83.60                                             |                     |                             |       |                              |
| Deluxe warm white                                   | 110                      | 12,000 <sup>c</sup>                           | 6550                             | 59.50                                             |                     |                             |       |                              |
| Daylight                                            | 110                      | 12,000 <sup>c</sup>                           | 7800                             | 71.00                                             |                     |                             |       |                              |
| White                                               | 110                      | 12,000 <sup>c</sup>                           | 9200                             | 83.60                                             |                     |                             |       |                              |
| Cool white (Watt-Miser <sup>b</sup> )               | 95                       | 12,000 <sup>c</sup>                           | 8300                             | 87.35                                             |                     |                             |       |                              |
| Deluxe cool white (Watt-Miser <sup>b</sup> )        | 95                       | 12,000 <sup>c</sup>                           | 6100                             | 64.20                                             |                     |                             |       |                              |
| Warm white (Watt-Miser <sup>b</sup> )               | 95                       | 12,000 <sup>c</sup>                           | 8500                             | 89.50                                             |                     |                             |       |                              |
| White (Watt-Miser <sup>b</sup> )                    | 95                       | 12,000 <sup>c</sup>                           | 8300                             | 87.35                                             |                     |                             |       |                              |
| Lite white (Watt-Miser <sup>b</sup> II)             | 95                       | 12,000 <sup>c</sup>                           | 8800                             | 92.60                                             |                     |                             |       |                              |
| Cool white                                          | 215                      | 12,000 <sup>c</sup>                           | 16,000                           | 74.40                                             |                     |                             |       |                              |
| Deluxe cool white                                   | 215                      | 12,000 <sup>c</sup>                           | 11,000                           | 51.15                                             |                     |                             |       |                              |
| Warm white                                          | 215                      | 12,000 <sup>c</sup>                           | 15,000                           | 69.75                                             |                     |                             |       |                              |
| Daylight                                            | 215                      | 12,000 <sup>c</sup>                           | 13,300                           | 61.85                                             |                     |                             |       |                              |
| Cool white (Watt-Miser <sup>b</sup> )               | 185                      | 12,000 <sup>c</sup>                           | 14,000                           | 75.65                                             |                     |                             |       |                              |
| Lite white (Watt-Miser <sup>b</sup> II)             | 185                      | 12,000 <sup>c</sup>                           | 14,900                           | 80.50                                             |                     |                             |       |                              |

*Note:* Chromaticity, Chromaticity Index, and Color Rendering Index (CRI) are the same as for the equivalent colors of the 40-W lamps listed in the F40T12 section of this table.

### C. High-Intensity Discharge (HID)

|                                              | Bulb                             | ANSI Code       | Nominal<br>lamp<br>watts | Approximate<br>rated life<br>(h) <sup>a</sup> | Approximate<br>initial lumens <sup>d</sup> | Approximate<br>initial efficacy<br>(lm/lamp W) <sup>d</sup> |
|----------------------------------------------|----------------------------------|-----------------|--------------------------|-----------------------------------------------|--------------------------------------------|-------------------------------------------------------------|
| Mercury-vapor                                |                                  |                 |                          |                                               |                                            |                                                             |
| Clear                                        | E-37                             | H33CD-R400      | 400                      | 24,000 +                                      | 21,000                                     | 52.50                                                       |
| Deluxe white                                 | E-37                             | H33GL-R400/DX   | 400                      | 24,000 +                                      | 22,500                                     | 56.25                                                       |
| Warm deluxe white                            | E-37                             | H33GL-R400/WDX  | 400                      | 24,000 +                                      | 19,500                                     | 48.75                                                       |
| Clear                                        | BT-56                            | H36GV-R1000     | 1000                     | 24,000 +                                      | 57,000                                     | 57.00                                                       |
| Deluxe white                                 | BT-56                            | H36GW-R1000/DX  | 1000                     | 24,000 +                                      | 63,000                                     | 63.00                                                       |
| Warm deluxe white                            | BT-56                            | H36GW-R1000/WDX | 1000                     | 24,000 +                                      | 58,000                                     | 58.00                                                       |
| Metal halide (Multi-Vapor <sup>®</sup> )     |                                  |                 |                          |                                               |                                            |                                                             |
| Clear; vertical, base up                     | E-23 <sup>1</sup> / <sub>2</sub> | M57PE-R175/XBU  | 175                      | 10,000                                        | 16,600                                     | 94.85                                                       |
| Diffuse; vertical, base up                   | E-23 <sup>1</sup> / <sub>2</sub> | M57PF-R175/XBU  | 175                      | 10,000                                        | 15,750                                     | 90.00                                                       |
| Clear; vertical, base down                   | E-23 <sup>1</sup> / <sub>2</sub> | M57PE-R175/XBD  | 175                      | 10,000                                        | 16,600                                     | 94.85                                                       |
| Diffuse; vertical, base down                 | E-23 <sup>1</sup> / <sub>2</sub> | M57PF-R175/XBD  | 175                      | 10,000                                        | 15,750                                     | 90.00                                                       |
| Clear; "any position"                        | E-28                             | M57PE-R175/U    | 175                      | 10,000                                        | 14,000                                     | 80.00                                                       |
| Phosphor-coated; "any position"              | E-28                             | M57PF-R175/U    | 175                      | 10,000                                        | 14,000                                     | 80.00                                                       |
| Clear; "any position"                        | E-28                             | M58PG-R250/U    | 250                      | 10,000                                        | 20,500                                     | 82.00                                                       |
| Phosphor-coated; "any position"              | E-28                             | M58PH-R250/U    | 250                      | 10,000                                        | 20,500                                     | 82.00                                                       |
| Clear; "any position"                        | E-37                             | M59PJ-R400/U    | 400                      | 20,000                                        | 36,000                                     | 90.00                                                       |
| Phosphor-coated; "any position"              | E-37                             | M59PK-R400/U    | 400                      | 20,000                                        | 36,000                                     | 90.00                                                       |
| Clear; "any position"                        | BT-56                            | M47PA-R1000/U   | 1000                     | 12,000                                        | 110,000                                    | 111.00                                                      |
| Phosphor-coated; "any position"              | BT-56                            | M47PB-R1000/U   | 1000                     | 12,000                                        | 105,000                                    | 105.00                                                      |
| High-pressure sodium (Lucalox <sup>®</sup> ) |                                  |                 |                          |                                               |                                            |                                                             |
| Clear; medium base                           | E-17                             | S76HA-35        | 35                       | 16,000                                        | 2,250                                      | 64.80                                                       |
| Diffuse; medium base                         | E-17                             | S76HB-35        | 35                       | 16,000                                        | 2,150                                      | 61.40                                                       |
| Clear; mogul base                            | E-23 <sup>1</sup> / <sub>2</sub> | S68MS-50        | 50                       | 24,000 +                                      | 4,000                                      | 80.00                                                       |
| Diffuse; mogul base                          | E-23 <sup>1</sup> / <sub>2</sub> | S68MY-50        | 50                       | 24,000 +                                      | 3,800                                      | 76.00                                                       |
| Clear; medium base                           | E-17                             | S68XX-50        | 50                       | 24,000 +                                      | 4,000                                      | 80.00                                                       |
| Diffuse; medium base                         | E-17                             | S68YY-50        | 50                       | 24,000 +                                      | 3,800                                      | 76.00                                                       |
| Clear; mogul base                            | E-23 <sup>1</sup> / <sub>2</sub> | S62-ME70        | 70                       | 24,000 +                                      | 5,800                                      | 82.85                                                       |
| Diffuse; mogul base                          | E-23 <sup>1</sup> / <sub>2</sub> | S62-MF70        | 70                       | 24,000 +                                      | 5,400                                      | 77.00                                                       |
| Clear; medium base                           | E-17                             | S62-LG70        | 70                       | 24,000 +                                      | 5,800                                      | 82.85                                                       |
| Diffuse; medium base                         | E-17                             | S62LH-70        | 70                       | 24,000 +                                      | 5,400                                      | 77.00                                                       |
| Clear; mogul base                            | E-23 <sup>1</sup> / <sub>2</sub> | S54SB-100       | 100                      | 24,000 +                                      | 9,500                                      | 95.00                                                       |
| Diffuse; mogul base                          | E-23 <sup>1</sup> / <sub>2</sub> | S54MC-100       | 100                      | 24,000 +                                      | 8,800                                      | 88.00                                                       |
| Clear; medium base                           | E-17                             | S54SG-100       | 100                      | 24,000 +                                      | 9,500                                      | 95.00                                                       |
| Diffuse; medium base                         | E-17                             | S54SH-100       | 100                      | 24,000 +                                      | 8,800                                      | 88.00                                                       |
| Clear; mogul base                            | E-23 <sup>1</sup> / <sub>2</sub> | S55SC-150       | 150                      | 24,000 +                                      | 16,000                                     | 106.65                                                      |
| Diffuse; mogul base                          | E-23 <sup>1</sup> / <sub>2</sub> | S55MD-150       | 150                      | 24,000 +                                      | 15,000                                     | 100.00                                                      |
| Clear; mogul base                            | E-28                             | S56SD-150       | 150                      | 24,000 +                                      | 15,000                                     | 100.00                                                      |
| Clear; mogul base                            | E-18                             | S66MN-200       | 200                      | 24,000 +                                      | 22,000                                     | 110.00                                                      |
| Clear; mogul base                            | E-18                             | S50VA-250       | 250                      | 24,000 +                                      | 27,500                                     | 110.00                                                      |
| Clear; mogul base                            | E-18                             | S50VA-250/S     | 250                      | 24,000 +                                      | 30,000                                     | 120.00                                                      |
| Diffuse; mogul base                          | E-28                             | S50VC-250       | 250                      | 24,000 +                                      | 26,000                                     | 104.00                                                      |

|                                  | Bulb | ANSI Code    | Nominal lamp watts | Approximate rated life (hr.) | Approximate initial lumens <sup>d</sup> | Approximate initial efficacy (lm/lamp W) <sup>d</sup> |
|----------------------------------|------|--------------|--------------------|------------------------------|-----------------------------------------|-------------------------------------------------------|
| Clear; mogul base (deluxe color) | E-18 | S50VA-250/DX | 250                | 10,000                       | 22,500                                  | 90.00                                                 |
| Clear; mogul base                | E-18 | S67MR-310    | 310                | 24,000 +                     | 37,000                                  | 119.35                                                |
| Clear; mogul base                | E-18 | S51WA-400    | 400                | 24,000 +                     | 50,000                                  | 125.00                                                |
| Diffuse; mogul base              | E-37 | S51WB-400    | 400                | 24,000 +                     | 47,500                                  | 118.75                                                |
| Clear; mogul base                | E-25 | S52XB-1000   | 1000               | 24,000 +                     | 140,000                                 | 140.00                                                |

Note: \* = Registered trademark of the General Electric Company.

<sup>a</sup> Life rating at 3 or more hours per start on rapid-start circuits, 15,000 hr.

<sup>b</sup> Life with rapid-start circuits; on preheat circuits, 12,000 hr.

<sup>c</sup> Rated average life at 3 hr/start; at 12 hr/start, 18,000 hr.

<sup>d</sup> Initial lumen rating as measured when lamp is operated in vertical position.

## APPROXIMATE LUMINANCE OF VARIOUS LIGHT SOURCES

Compiled by C.J. Allen and G.D. Rowe

Luminance of source is given in candelas per square centimeter

| Source                                  |                                              | Approx. avg. luminance* (cd cm <sup>-2</sup> ) | Source                                    |           | Approx. avg. luminance* (cd cm <sup>-2</sup> ) |
|-----------------------------------------|----------------------------------------------|------------------------------------------------|-------------------------------------------|-----------|------------------------------------------------|
| Natural sources                         |                                              |                                                | High-output (96T12)                       | 800 mA    | 1.13                                           |
| Clear sky                               | Average luminance                            | 0.8                                            | Grooved bulb (96T17)                      | 1500 mA   | 1.50                                           |
| Sun (as observed from earth's surface)  | At meridian                                  | 160000                                         | Fluorescent lamps (other than cool white) |           |                                                |
| Sun (as observed from earth's surface)  | Near horizon                                 | 600                                            | Daylight (40wT12)                         | 430 mA    | 0.62                                           |
| Moon (as observed from earth's surface) | Bright spot                                  | 0.25                                           | Blue (40wT12)                             | 430 mA    | 0.30                                           |
| Combustion sources                      |                                              |                                                | Green (40wT12)                            | 430 mA    | 1.17                                           |
| Candle flame (sperm)                    | Bright spot                                  | 1.0                                            | Red (40wT12)                              | 430 mA    | 0.05                                           |
| Welsbach mantle                         | Bright spot                                  | 6.2                                            | High-intensity discharge (HID)            |           |                                                |
| Acetylene flame                         | Mees burner                                  | 10.5                                           | Mercury-vapor (E-37)                      |           |                                                |
| Photoflash lamps                        |                                              | 16000-40000 peak                               | Clear                                     | 400 watt  | 970                                            |
| Incandescent electric lamps             |                                              |                                                | Color-improved                            | 400 watt  | 11.0                                           |
| Carbon filament                         | 3 Lumens per watt                            | 52                                             | Deluxe-white                              | 400 watt  | 12.1                                           |
| Tungsten filament                       | Vacuum lamp--10 lumens per watt              | 200                                            | Mercury-vapor (BT-56)                     |           |                                                |
| Tungsten filament                       | Gas-filled lamp--20 lumens per watt          | 1200                                           | Clear                                     | 1000 watt | 980                                            |
| Tungsten filament                       | 750-watt projection lamp--26 lumens per watt | 7500                                           | Color-improved                            | 1000 watt | 15.0                                           |
| Fluorescent lamps (cool white)          |                                              |                                                | Deluxe white                              | 1000 watt | 17.2                                           |
| Rapid start (40wT12)                    | 430 mA                                       | 0.82                                           | Metal halide (E-37)                       |           |                                                |
|                                         |                                              |                                                | Clear                                     | 400 watt  | 810                                            |
|                                         |                                              |                                                | Color-improved                            | 1000 watt | 930                                            |
|                                         |                                              |                                                | Deluxe white                              | 1500 watt | 1620                                           |
|                                         |                                              |                                                | High pressure sodium (Lucalox®)           |           |                                                |
|                                         |                                              |                                                | 250 watt                                  | 520       |                                                |
|                                         |                                              |                                                | 400 watt                                  | 780       |                                                |
|                                         |                                              |                                                | 1000 watt                                 | 810       |                                                |

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\*Luminance values perpendicular to lamp axis



## EFFICIENCY OF DRYING AGENTS

Compiled by John H. Yoe

### A. Drying agents depending upon chemical action (absorption) for their efficiency:\*

| Substance                                 | Residual water, mg per liter<br>of dry air** | Reference                                                       |
|-------------------------------------------|----------------------------------------------|-----------------------------------------------------------------|
| P <sub>2</sub> O <sub>5</sub>             | <1 mg in 40,000 liters                       | Morley, Am. J. Sci., 34, 199 (1887); J.A.C.S., 26, 1171 (1904). |
| Mg(ClO <sub>4</sub> ) <sub>2</sub> anhyd. | "Unweighable" in 210 liters                  | Willard and Smith, J.A.C.S., 44, 2255 (1922).                   |
| BaO                                       | 0.00065                                      | Bower, Bur. Std. J. Res., 12, 241 (1934).                       |
| KOH fused                                 | 0.002                                        | Baxter and Starkweather, J.A.C.S., 38, 2038 (1916).             |
| CaO                                       | 0.003                                        | Bower, loc. cit.                                                |
| H <sub>2</sub> SO <sub>4</sub>            | 0.003                                        | Baxter and Starkweather, loc. cit.                              |
| CaSO <sub>4</sub> anhyd.                  | 0.005                                        | Bower loc. cit.                                                 |
| Al <sub>2</sub> O <sub>3</sub>            | 0.005                                        | Ibid.                                                           |
| KOH sticks                                | 0.014                                        | Ibid.                                                           |
| NaOH fused                                | 0.16                                         | Baxter and Starkweather, loc. cit.                              |
| CaBr <sub>2</sub>                         | 0.18                                         | Baxter and Warren, J.A.C.S., 33, 340 (1911).                    |
| CaCl <sub>2</sub> fused                   | 0.34                                         | Baxter and Starkweather, loc. cit.                              |
| NaOH sticks                               | 0.80                                         | Bower loc. cit.                                                 |
| Ba(ClO <sub>4</sub> ) <sub>2</sub>        | 0.82                                         | Ibid.                                                           |
| ZnCl <sub>2</sub>                         | 0.85                                         | Baxter and Warren, loc. cit.                                    |
| ZnBr <sub>2</sub>                         | 1.16                                         | Ibid.                                                           |
| CaCl <sub>2</sub> granular                | 1.5                                          | Bower, loc. cit.                                                |
| CuSO <sub>4</sub> anhyd.                  | 2.8                                          | Ibid.                                                           |

### B. Drying agents depending upon physical action (adsorption) for their efficiency:\* Alumina (low temperature fired), asbestos, charcoal, clay and porcelain (low temperature fired), glass wool, kieselguhr, silica gel, refrigeration.

\* It should be noted that the efficiency of some drying agents (e.g. Al<sub>2</sub>O<sub>3</sub> and anhydrous CaCl<sub>2</sub>, and probably also BaO, anhydrous Mg(ClO<sub>4</sub>)<sub>2</sub>, Mg(ClO<sub>4</sub>)<sub>2</sub>·3H<sub>2</sub>O, anhydrous Ba(ClO<sub>4</sub>)<sub>2</sub>, and CaSO<sub>4</sub>) depends upon both adsorption and absorption.

\*\* 30°C. for Bower's values; others 25°C. or room temp.

## EMERGENT STEM CORRECTION FOR LIQUID-IN-GLASS THERMOMETERS

Accurate thermometers are calibrated with the entire stem immersed in the bath which determines the temperature of the thermometer bulb. However, for reasons of convenience it is common practice when using a thermometer to permit its stem to extend out of the apparatus. Under these conditions both the stem and the mercury in the exposed stem are at a temperature different from that of the bulb. This introduces an error into the observed temperature. Since the coefficient of thermal expansion of glass is less than that of mercury, the observed temperature will be less than the true temperature if the bulb is hotter than the stem and greater than the true temperature, providing the thermal gradient is reversed. For exact work the magnitude of this error can only be determined by experiment. However, for most purposes it is sufficiently accurate to apply the following equation which takes into account the difference of the thermal expansion of glass and mercury:

$$T_c = T_o + F \times L(T_o - T_m)$$

Where

$T_c$  = corrected temperature

$T_o$  = observed temperature

$T_m$  = mean temperature of exposed stem. The mean temperature of the exposed stem may be determined by fastening the bulb of a second thermometer against the midpoint of the exposed liquid column.

$L$  = the length of the exposed column in degrees above the surface of the substance whose temperature is being determined.

$F$  = correction factor. For approximate work and when the liquid in the thermometer is mercury a value for  $F$  of 0.00016 is generally used. For more accurate work with mercury filled thermometers values as given in the following table are used. For thermometers filled with organic liquids it is customary to use 0.001 for the value of  $F$ .

Values of  $F$  for various glasses

| $T_m$ °C. | Corning<br>0041 | Corning<br>8800 | Corning<br>8810 | Jena<br>16 III | Jena<br>59 III |
|-----------|-----------------|-----------------|-----------------|----------------|----------------|
| 50        | 0.000157        | 0.000166        | 0.000156        | 0.000158       | 0.000164       |
| 150       | 0.000159        | 0.000167        | 0.000157        | 0.000158       | 0.000165       |
| 250       | 0.000163        | 0.000168        | 0.000161        | 0.000161       | 0.000170       |
| 350       | 0.000168        | 0.000173        | 0.000166        | —              | 0.000177       |



# EMISSION OF TOTAL RADIATION FOR VARIOUS MATERIALS

| Material                       | Temperature<br>(°C) | $\epsilon_{\text{tot}}$ | Material                               | Temperature<br>(°C) | $\epsilon_{\text{tot}}$ |
|--------------------------------|---------------------|-------------------------|----------------------------------------|---------------------|-------------------------|
| <b>Alloys</b>                  |                     |                         | <b>Lamp black</b>                      | 25                  | 0.94                    |
| Nickel-Chromium                |                     |                         | <b>Lead</b>                            | 20—400              | 0.96                    |
| 20 Ni—25 Cr—55 Fe, oxidized    | 200                 | 0.90                    | Oxidized                               | 200                 | 0.05                    |
|                                | 500                 | 0.97                    | Unoxidized                             | 200                 | 0.63                    |
| 60 Ni—12 Cr—28 Fe, oxidized    | 270                 | 0.89                    | Mercury                                |                     |                         |
|                                | 560                 | 0.82                    | Unoxidized                             | 25                  | 0.10                    |
| 80 Ni—20 Cr                    | 100                 | 0.87                    |                                        | 100                 | 0.12                    |
|                                | 600                 | 0.87                    | <b>Molybdenum</b>                      | 600—1000            | 0.08—0.13               |
|                                | 1300                | 0.89                    |                                        | 1500—2200           | 0.19—0.26               |
| <b>Aluminum</b>                |                     |                         | <b>Monel metal</b>                     |                     |                         |
| Polished                       | 50—500              | 0.04—0.06               | Oxidized                               | 200                 | 0.43                    |
| Rough surface                  | 20—50               | 0.06—0.07               | Nichrome                               | 600                 | 0.43                    |
| Strongly oxidized              | 55—500              | 0.2—0.3                 | Wire                                   |                     |                         |
|                                | 25                  | 0.022                   | Clean                                  | 50                  | 0.65                    |
|                                | 100                 | 0.028                   | Oxidized                               | 500—1000            | 0.71—0.79               |
|                                | 500                 | 0.060                   |                                        | 50—500              | 0.95—0.98               |
| Oxidized                       | 200                 | 0.11                    | <b>Nickel</b>                          |                     |                         |
|                                | 600                 | 0.19                    | Industrial, polished                   | 200—400             | 0.07—0.09               |
| <b>Asbestos board</b>          | 20                  | 0.96                    | Oxidized                               | 200                 | 0.37                    |
| <b>Bismuth</b>                 |                     |                         | Oxidized at 600°C                      | 200—600             | 0.37—0.48               |
| Unoxidized                     | 25                  | 0.048                   | Unoxidized                             | 25                  | 0.045                   |
| <b>Brass</b>                   |                     |                         |                                        | 100                 | 0.06                    |
| Dull tarnished                 | 200                 | 0.61                    |                                        | 500                 | 0.12                    |
| Oxidized at 600° C             | 200                 | 0.61                    |                                        | 1000                | 0.19                    |
|                                | 600                 | 0.59                    | <b>Platinum</b>                        |                     |                         |
| Unoxidized                     | 25                  | 0.035                   | Clean, polished                        | 200—600             | 0.05—0.1                |
|                                | 100                 | 0.035                   | Unoxidized                             | 25                  | 0.037                   |
| Polished                       | 200                 | 0.03                    |                                        | 100                 | 0.047                   |
| Rolled sheet                   | 20                  | 0.06                    |                                        | 500                 | 0.096                   |
| <b>Bronze</b>                  |                     |                         |                                        | 1000                | 0.152                   |
| Polished                       | 50                  | 0.1                     |                                        | 1500                | 0.191                   |
| <b>Carbon</b>                  |                     |                         | <b>Wire</b>                            |                     |                         |
| Filament                       | 1000—1400           | 0.53                    |                                        | 50—200              | 0.06—0.07               |
| Graphite                       | 0—3600              | 0.7—0.8                 |                                        | 500—1000            | 0.1—0.16                |
| Lamp black                     | 20—400              | 0.96                    |                                        | 1400                | 0.18                    |
| Soot applied to solid          | 50—1000             | 0.96                    | <b>Porcelain</b>                       |                     |                         |
| Soot with water glass          | 20—200              | 0.96                    | Glazed                                 | 20                  | 0.92                    |
| Unoxidized                     | 100                 | 0.81                    | <b>Rubber</b>                          |                     |                         |
| <b>Chromium</b>                |                     |                         | Hard                                   | 20                  | 0.95                    |
| Polished                       | 50                  | 0.1                     | Soft, gray, rough                      | 20                  | 0.86                    |
|                                | 500—1000            | 0.28—0.38               | <b>Silica brick</b>                    | 1000                | 0.80                    |
| <b>Colbalt</b>                 |                     |                         |                                        | 1100                | 0.85                    |
| Unoxidized                     | 500                 | 0.13                    | <b>Silver</b>                          |                     |                         |
|                                | 1000                | 0.23                    | Clean, polished                        | 200—600             | 0.02—0.03               |
| <b>Columbium</b>               |                     |                         | Unoxidized                             | 100                 | 0.02                    |
| Unoxidized                     | 1500                | 0.19                    |                                        | 500                 | 0.035                   |
| <b>Copper</b>                  |                     |                         | <b>Soot applied to a solid surface</b> | 50—1000             | 0.94—0.91               |
| Calorized                      | 100                 | 0.26                    | <b>Soot with water glass</b>           | 20—200              | 0.96                    |
| Calorized, oxidized            | 200                 | 0.18                    | <b>Steel</b>                           |                     |                         |
|                                | 600                 | 0.19                    | Alloyed (8% Ni, 18% Cr)                | 500                 | 0.35                    |
| Commercial, scoured to a shine | 20                  | 0.07                    | Aluminized                             | 50—500              | 0.79                    |
| Oxidized                       | 50                  | 0.6—0.7                 | Dull nickel plated                     | 20                  | 0.11                    |
|                                | 500                 | 0.88                    | Flat, rough surface                    | 50                  | 0.95—0.98               |
| Polished                       | 50—100              | 0.02                    | Cast, polished                         | 750—1050            | 0.52—0.56               |
| Unoxidized                     | 100                 | 0.02                    | Sheet, ground                          | 50                  | 0.56                    |
| Unoxidized, liquid             | —                   | 0.15                    |                                        | 950—1100            | 0.55—0.61               |
| <b>Fire brick</b>              | 1000                | 0.75                    | Oxidized                               | 200—600             | 0.8                     |
| <b>Glass</b>                   |                     |                         | Calorized, oxidized                    | 200                 | 0.52                    |
|                                | 20—100              | 0.94—0.91               |                                        | 600                 | 0.57                    |
|                                | 250—1000            | 0.87—0.72               | Sheet with shiny layer of oxide        | 20                  | 0.82                    |
|                                | 1100—1500           | 0.7—0.67                | Strongly oxidized                      | 50                  | 0.88                    |
| <b>Gold</b>                    |                     |                         |                                        | 500                 | 0.98                    |
| Carefully polished             | 200—600             | 0.02—0.03               | Unoxidized                             | 100                 | 0.08                    |
| Unoxidized                     | 100                 | 0.02                    | Unoxidized, liquid                     | —                   | 0.28                    |
| Enamel                         | 100                 | 0.37                    | <b>Tantalum</b>                        |                     |                         |
| <b>Graphite</b>                | 0—3600              | 0.7—0.8                 | Unoxidized                             | 1500                | 0.21                    |
| <b>Gypsum</b>                  | 20                  | 0.93                    |                                        | 2000                | 0.26                    |
| <b>Iron</b>                    |                     |                         | <b>Tungsten</b>                        |                     |                         |
| Cast                           |                     |                         | Unoxidized                             | 25                  | 0.024                   |
| Oxidized                       | 200                 | 0.64                    |                                        | 100                 | 0.032                   |
|                                | 600                 | 0.78                    |                                        | 500                 | 0.071                   |
| Strongly oxidized              | 40                  | 0.95                    |                                        | 1000                | 0.15                    |
|                                | 250                 | 0.95                    |                                        | 1500                | 0.23                    |
| Unoxidized                     | 100                 | 0.21                    |                                        | 2000                | 0.28                    |
| Unoxidized, liquid             | —                   | 0.29                    | <b>Varnish</b>                         |                     |                         |
| Oxidized                       | 100                 | 0.74                    | Dull black                             | 40—100              | 0.8—0.95                |
|                                | 500                 | 0.84                    | Glossy black sprayed on iron           | 40—100              | 0.96—0.98               |
|                                | 1200                | 0.89                    | <b>Zinc</b>                            | 20                  | 0.87                    |
| Rusted                         | 25                  | 0.65                    | Polished                               | 200—300             | 0.04—0.05               |
| <b>Wrought, dull</b>           | 100                 | 0.05                    | Unoxidized                             | 300                 | 0.05                    |

# **EMISSION OF TUNGSTEN** Wavelengths in $\mu\text{m}$

| Temperature<br>K | 0.25  | 0.30  | 0.35 | 0.40 | 0.50 | 0.60  | 0.70  | Temperature<br>K | 0.80  | 0.90  | 1.0   | 1.1   | 1.2   | 1.3   | 1.4   |
|------------------|-------|-------|------|------|------|-------|-------|------------------|-------|-------|-------|-------|-------|-------|-------|
| 1600             | .448* | .482  | .478 | .481 | .469 | .455  | .444  | 2400             | .408  | .391  | .372  | .355  | .340  | .324  | .309  |
| 1800             | .442* | .478* | .476 | .477 | .465 | .452  | .44   | 2600             | .404  | .386  | .369  | .352  | .338  | .325  | .310  |
| 2000             | .436* | .474  | .473 | .474 | .462 | .448  | .436  | 2800             | .400  | .383  | .367  | .352  | .337  | .325  | .313  |
| 2200             | .429* | .470  | .470 | .471 | .458 | .445  | .431  |                  |       |       |       |       |       |       |       |
| 2400             | .422  | .465  | .466 | .468 | .455 | .441  | .427  | Temperature<br>K | 1.5   | 1.6   | 1.8   | 2.0   | 2.2   | 2.4   | 2.6   |
| 2600             | .418  | .461  | .464 | .464 | .451 | .437  | .423  | 1600             | .279* | .263* | .234* | .210* | .19*  | .175* | .164* |
| 2800             | .411  | .456  | .461 | .461 | .448 | .434  | .419  | 1800             | .282  | .267* | .241* | .218* | .20*  | .182* | .174* |
| Temperature<br>K | 0.80  | 0.90  | 1.0  | 1.1  | 1.2  | 1.3   | 1.4   | 2000             | .288  | .273  | .247  | .227  | .209* | .197  | .175  |
| 1600             | .431  | .413  | .39  | .366 | .345 | .322* | .300* | 2200             | .291  | .278  | .254  | .235  | .218  | .205  | .194  |
| 1800             | .425  | .407  | .385 | .364 | .344 | .323* | .302* | 2400             | .296  | .283  | .262  | .244  | .228  | .215  | .205  |
| 2000             | .419  | .401  | .381 | .361 | .343 | .323  | .305  | 2600             | .299  | .288  | .269  | .251  | .236  | .224  | .214  |
| 2200             | .415  | .396  | .378 | .359 | .342 | .324  | .306  | 2800             | .302  | .292  | .274  | .259  | .245  | .233  | .224  |

\* Values by extrapolation.

## FATS AND OILS

These data for fats and oils were compiled originally for the *Biology Data Book* by H. J. Harwood, and R. P. Geyer, 1964. Data are reproduced here by permission of the copyright owners of the above publication, the Federation of American Societies for Experimental Biology, Washington, D.C. pp. 380—82.

Values are typical rather than average, and frequently were derived from specific analyses for particular samples (especially the constituent fatty acids). Extreme variations may occur, depending on a number of variables such as source, treatment, and age of a fat or oil. **Specific Gravity** (column D) was calculated at the specified temperature (degrees centigrade) and referred to water at the same temperature, unless otherwise specified. **Density**, shown in parentheses (column D), was measured at the specified temperature (degrees centigrade). **Refractive Index** (column E) was measured at 50°C, unless otherwise specified.

|                    |                                   | Constants                                                   |                                               |                                                 |                        |                                          | Constituent fatty acids (g/100 g total fatty acids) |                   |                    |                    |                   |                                                         |             |                   |                   |                    |                                                                                                                                                          |
|--------------------|-----------------------------------|-------------------------------------------------------------|-----------------------------------------------|-------------------------------------------------|------------------------|------------------------------------------|-----------------------------------------------------|-------------------|--------------------|--------------------|-------------------|---------------------------------------------------------|-------------|-------------------|-------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
|                    |                                   | Melting<br>(or solid-<br>ification)<br>Point<br>(°C)<br>(C) | Specific<br>gravity<br>(or<br>density)<br>(D) | Refractive<br>index<br>( $n_{50}^{50}$ )<br>(E) | Iodine<br>value<br>(F) | Sapon-<br>ifica-<br>tion<br>value<br>(G) | Saturated                                           |                   |                    |                    |                   |                                                         | Unsaturated |                   |                   |                    |                                                                                                                                                          |
|                    |                                   |                                                             |                                               |                                                 |                        |                                          | Lauric                                              | Myristic          | Palmitic           | Stearic            | Arachidic         | Other                                                   | Palmitoleic | Oleic             | Linoleic          | Linolonic          | Other                                                                                                                                                    |
| Fat or oil<br>(A)  | Source<br>(B)                     | (C)                                                         | (D)                                           | (E)                                             | (F)                    | (G)                                      | (H)                                                 | (I)               | (J)                | (K)                | (L)               | (M)                                                     | (N)         | (O)               | (P)               | (Q)                | (R)                                                                                                                                                      |
| Land animals       |                                   |                                                             |                                               |                                                 |                        |                                          |                                                     |                   |                    |                    |                   |                                                         |             |                   |                   |                    |                                                                                                                                                          |
| Butterfat          | <i>Bos taurus</i>                 | 32.2                                                        | 0.911 <sup>40/15°</sup>                       | 1.4548                                          | 36.1                   | 227                                      | 2.5                                                 | 11.1              | 29.0               | 9.2                | 2.4               | 2.0; <sup>a</sup> 0.5; <sup>b</sup><br>2.3 <sup>c</sup> | 4.6         | 26.7              | 3.6               | —                  | 3.6; <sup>d</sup> 0.1; <sup>e</sup><br>0.1; <sup>f</sup> 0.9; <sup>g</sup><br>1.4; <sup>h</sup> 1.0; <sup>i</sup><br>1.0; <sup>j</sup> 0.4; <sup>k</sup> |
| Depot fat          | <i>Homo sapiens</i>               | (15)                                                        | 0.918 <sup>15°</sup>                          | 1.4602                                          | 67.6                   | 196.2                                    | —                                                   | 2.7               | 24.0               | 8.4                | —                 | —                                                       | 5           | 46.9              | 10.2              | —                  | 2.5 <sup>h</sup>                                                                                                                                         |
| Lard oil           | <i>Sus scrofa</i>                 | (30.5)                                                      | 0.919 <sup>15°</sup>                          | 1.4615                                          | 58.6                   | 194.6                                    | —                                                   | 1.3               | 28.3               | 11.9               | —                 | —                                                       | 2.7         | 47.5              | 6                 | —                  | 0.2; <sup>l</sup> 2.1 <sup>m</sup>                                                                                                                       |
| Neat's-foot oil    | <i>B. taurus</i>                  | —                                                           | 0.910 <sup>25°</sup>                          | 1.464 <sup>25°</sup>                            | 69—76                  | 190—199                                  | —                                                   | —                 | 17—18              | 2—3                | —                 | —                                                       | —           | 74—76             | —                 | —                  | —                                                                                                                                                        |
| Tallow, beef       | <i>B. taurus</i>                  | —                                                           | —                                             | —                                               | 49.5                   | 197                                      | —                                                   | 6.3               | 27.4               | 14.1               | —                 | —                                                       | —           | 49.6              | 2.5               | —                  | —                                                                                                                                                        |
| Tallow, mutton     | <i>Ovis aries</i>                 | (42.0)                                                      | 0.945 <sup>15°</sup>                          | 1.4565                                          | 40                     | 194                                      | —                                                   | 4.6               | 24.6               | 30.5               | —                 | —                                                       | —           | 36.0              | 4.3               | —                  | —                                                                                                                                                        |
| Marine animals     |                                   |                                                             |                                               |                                                 |                        |                                          |                                                     |                   |                    |                    |                   |                                                         |             |                   |                   |                    |                                                                                                                                                          |
| Cod-liver oil      | <i>Gadus morhua</i>               | —                                                           | 0.925 <sup>25°</sup>                          | 1.481 <sup>25°</sup>                            | 165                    | 186                                      | —                                                   | 5.8               | 8.4                | 0.6                | —                 | —                                                       | 20.0        | ←29.1→            | —                 | —                  | 25.4; <sup>1</sup> 9.6 <sup>m</sup>                                                                                                                      |
| Herring oil        | <i>Clupea harengus</i>            | —                                                           | 0.900 <sup>60°</sup>                          | 1.4610 <sup>60°</sup>                           | 140                    | 192                                      | —                                                   | 7.3               | 13.0               | Trace              | —                 | —                                                       | 4.9         | —                 | —                 | 20.7               | 30.1; <sup>1</sup> 23.2 <sup>m</sup>                                                                                                                     |
| Menhaden oil       | <i>Brevoortia tyrannus</i>        | —                                                           | 0.903 <sup>60°</sup>                          | 1.4645 <sup>60°</sup>                           | 170                    | 191                                      | —                                                   | 5.9               | 16.3               | 0.6                | 0.6               | —                                                       | 15.5        | —                 | —                 | 29.6               | 19.0; <sup>1</sup> 11.7 <sup>m</sup><br>0.8 <sup>n</sup>                                                                                                 |
| Sardine oil        | <i>Sardinops caerulea</i>         | —                                                           | 0.905 <sup>60°</sup>                          | 1.4660 <sup>60°</sup>                           | 185                    | 191                                      | —                                                   | 5.1               | 14.6               | 3.2                | —                 | —                                                       | 11.8        | ←17.8→            | —                 | —                  | 18.1; <sup>1</sup><br>14.0; <sup>m</sup><br>trace; <sup>2</sup><br>15.4 <sup>o</sup>                                                                     |
| Sperm oil(body)    | <i>Physeter<br/>macrocephalus</i> | —                                                           | —                                             | —                                               | 76—88                  | 122—130                                  | 1                                                   | 5                 | 6.5                | —                  | —                 | —                                                       | 26.5        | 37                | 19                | —                  | 1; <sup>m</sup> 4; <sup>8</sup> 19 <sup>p</sup>                                                                                                          |
| Sperm oil(head)    | <i>P. macrocephalus</i>           | —                                                           | —                                             | —                                               | 70                     | 140—144                                  | 16                                                  | 14                | 8                  | 2                  | —                 | 3.5 <sup>c</sup>                                        | 15          | 17                | 6.5               | —                  | 4; <sup>1</sup> 14; <sup>8</sup> 6.5 <sup>p</sup>                                                                                                        |
| Whale oil          | <i>Balaena mysticetus</i>         | —                                                           | 0.892 <sup>60°</sup>                          | 1.460 <sup>60°</sup>                            | 120                    | 195                                      | 0.2                                                 | 9.3               | 15.6               | 2.8                | —                 | —                                                       | 14.4        | 35.2              | —                 | —                  | 13.6; <sup>1</sup> 5.9; <sup>m</sup><br>2.5; <sup>8</sup> 0.2 <sup>q</sup>                                                                               |
| Plants             |                                   |                                                             |                                               |                                                 |                        |                                          |                                                     |                   |                    |                    |                   |                                                         |             |                   |                   |                    |                                                                                                                                                          |
| Babassu oil        | <i>Attalea funifera</i>           | 22—26                                                       | (0.893 <sup>60°</sup> )                       | 1.443 <sup>60°</sup>                            | 15.5                   | 247                                      | 44.1                                                | 15.4              | 8.5                | 2.7                | 0.2               | 0.2; <sup>a</sup> 4.8; <sup>b</sup><br>6.6 <sup>c</sup> | —           | 16.1              | 1.4               | —                  | —                                                                                                                                                        |
| Castor oil         | <i>Ricinus communis</i>           | (— 18.0)                                                    | 0.961 <sup>15°</sup>                          | 1.4770                                          | 85.5                   | 180.3                                    | ←2.4→                                               | —                 | —                  | —                  | —                 | —                                                       | —           | 7.4               | 3.1               | —                  | 87 <sup>r</sup>                                                                                                                                          |
| Cocoa butter       | <i>Theobroma cacao</i>            | 34.1                                                        | 0.964 <sup>15°</sup>                          | 1.4568                                          | 36.5                   | 193.8                                    | —                                                   | —                 | 24.4               | 35.4               | —                 | —                                                       | —           | 38.1              | 2.1               | —                  | —                                                                                                                                                        |
| Coconut oil        | <i>Cocos nucifera</i>             | 25.1                                                        | 0.924 <sup>15°</sup>                          | 1.4493                                          | 10.4                   | 268                                      | 45.4                                                | 18.0              | 10.5               | 2.3                | 0.4 <sup>19</sup> | 0.8; <sup>a</sup> 5.4; <sup>b</sup><br>8.4 <sup>c</sup> | 0.4         | 7.5               | Trace             | —                  | —                                                                                                                                                        |
| Corn oil           | <i>Zea mays</i>                   | (— 20.0)                                                    | 0.922 <sup>15°</sup>                          | 1.4734                                          | 122.6                  | 192.0                                    | —                                                   | 1.4               | 10.2               | 3.0                | —                 | —                                                       | 1.5         | 49.6              | 34.3              | —                  | —                                                                                                                                                        |
| Cotton seed oil    | <i>Gossypium hirsutum</i>         | (— 1.0)                                                     | 0.917 <sup>25°</sup>                          | 1.4735                                          | 105.7                  | 194.3                                    | —                                                   | 1.4               | 23.4               | 1.1                | 1.3               | —                                                       | 2.0         | 22.9              | 47.8              | —                  | —                                                                                                                                                        |
| Linseed oil        | <i>Linum usitatissimum</i>        | (— 24.0)                                                    | 0.938 <sup>15°</sup>                          | 1.4782 <sup>25°</sup>                           | 178.7                  | 190.3                                    | —                                                   | —                 | 6.3                | 2.5                | 0.5               | —                                                       | —           | 19.0              | 24.1              | 47.4               | 0.2 <sup>n</sup>                                                                                                                                         |
| Mustard oil        | <i>Brassica hirta</i>             | —                                                           | 0.9145 <sup>15°</sup>                         | 1.475                                           | 102                    | 174                                      | —                                                   | 1.3 <sup>20</sup> | —                  | —                  | —                 | —                                                       | —           | 27.2 <sup>1</sup> | 16.6 <sup>1</sup> | 401.8 <sup>1</sup> | 1.1; <sup>18</sup> 1.0; <sup>19</sup><br>51.0 <sup>r</sup>                                                                                               |
| Neem oil           | <i>Melia azadirachta</i>          | — 3                                                         | 0.017 <sup>15°</sup>                          | 1.4615                                          | 71                     | 194.5                                    | —                                                   | 2.6 <sup>20</sup> | 14.1 <sup>20</sup> | 24.0 <sup>20</sup> | 0.8 <sup>20</sup> | —                                                       | —           | 58.5 <sup>1</sup> | —                 | —                  | —                                                                                                                                                        |
| Niger-seed oil     | <i>Guizotia abyssinica</i>        | —                                                           | 0.925 <sup>15°</sup>                          | 1.471                                           | 128.5                  | 190                                      | —                                                   | 3.3 <sup>20</sup> | 8.2 <sup>20</sup>  | 4.8 <sup>20</sup>  | 0.5 <sup>20</sup> | —                                                       | —           | 30.3 <sup>1</sup> | 57.3 <sup>1</sup> | —                  | —                                                                                                                                                        |
| Oiticica oil       | <i>Licania rigida</i>             | —                                                           | 0.974 <sup>25°</sup>                          | —                                               | 140—180                | —                                        | ←11.3 <sup>23</sup> →                               | —                 | —                  | —                  | —                 | —                                                       | —           | 6.2               | —                 | —                  | 82.5 <sup>18</sup>                                                                                                                                       |
| Olive oil          | <i>Olea europaea<br/>sativa</i>   | (— 6.0)                                                     | 0.918 <sup>15°</sup>                          | 1.4679                                          | 81.1                   | 189.7                                    | —                                                   | Trace             | 6.9                | 2.3                | 0.1               | —                                                       | —           | 84.4              | 4.6               | —                  | —                                                                                                                                                        |
| Palm oil           | <i>Elaeis guineensis</i>          | 35.0                                                        | 0.915 <sup>15°</sup>                          | 1.4578                                          | 54.2                   | 199.1                                    | —                                                   | 1.4               | 40.1               | 5.5                | —                 | —                                                       | —           | 42.7              | 10.3              | —                  | —                                                                                                                                                        |
| Palm-kernel oil    | <i>E. guineensis</i>              | 24.1                                                        | 0.923 <sup>15°</sup>                          | 1.4569                                          | 37.0                   | 219.9                                    | 46.9                                                | 14.1              | 8.8                | 1.3                | —                 | 2.7; <sup>b</sup> 7.0 <sup>c</sup>                      | —           | 18.5              | 0.7               | —                  | —                                                                                                                                                        |
| Peanut oil         | <i>Arachis hypogaea</i>           | (3.0)                                                       | 0.914 <sup>15°</sup>                          | 1.4691                                          | 93.4                   | 192.1                                    | —                                                   | —                 | 8.3                | 3.1                | 2.4               | —                                                       | —           | 56.0              | 26.0              | —                  | 3.1; <sup>18</sup> 1.1 <sup>19</sup>                                                                                                                     |
| Perilla oil        | <i>Perilla frutescens</i>         | —                                                           | (0.935 <sup>15°</sup> )                       | 1.481 <sup>25°</sup>                            | 195                    | 192                                      | ←9.6 <sup>23</sup> →                                | —                 | —                  | —                  | —                 | —                                                       | —           | 17.8              | —                 | 17.5               | —                                                                                                                                                        |
| Poppy-seed oil     | <i>Papaver somniferum</i>         | (— 15)                                                      | 0.925 <sup>15°</sup>                          | 1.4685                                          | 135                    | 194                                      | —                                                   | —                 | 4.8 <sup>20</sup>  | 2.9 <sup>20</sup>  | —                 | —                                                       | —           | 30.1 <sup>1</sup> | 62.2 <sup>1</sup> | —                  | —                                                                                                                                                        |
| Rapeseed oil       | <i>Brassica campestris</i>        | (— 10)                                                      | 0.915 <sup>15°</sup>                          | 1.4706                                          | 98.6                   | 174.7                                    | —                                                   | —                 | 1                  | —                  | —                 | —                                                       | —           | 32                | 15                | 1                  | 50 <sup>r</sup>                                                                                                                                          |
| Safflower oil      | <i>Carthamus<br/>tinctorius</i>   | —                                                           | (0.900 <sup>60°</sup> )                       | 1.462 <sup>60°</sup>                            | 145                    | 192                                      | ←6.8 <sup>23</sup> →                                | —                 | —                  | —                  | —                 | —                                                       | —           | 18.6              | 70.1              | 3.4                | —                                                                                                                                                        |
| Sesame oil         | <i>Sesamum indicum</i>            | (— 6.0)                                                     | 0.919 <sup>25°</sup>                          | 1.4646                                          | 106.6                  | 187.9                                    | —                                                   | —                 | 9.1                | 4.3                | 0.8               | —                                                       | —           | 45.4              | 40.4              | —                  | —                                                                                                                                                        |
| Soybean oil        | <i>Glycine soja</i>               | (— 16.0)                                                    | 0.927 <sup>15°</sup>                          | 1.4729                                          | 130.0                  | 190.6                                    | 0.2                                                 | 0.1               | 9.8                | 2.4                | 0.9               | —                                                       | 0.4         | 28.9              | 50.7              | 6.5                | 0.1 <sup>18</sup>                                                                                                                                        |
| Sunflower-seed oil | <i>Helianthus annuus</i>          | (— 17.0)                                                    | 0.923 <sup>15°</sup>                          | 1.4694                                          | 125.5                  | 188.7                                    | —                                                   | —                 | 5.6                | 2.2                | 0.9               | —                                                       | —           | 25.1              | 66.2              | —                  | —                                                                                                                                                        |
| Tung oil           | <i>Aleurites fordii</i>           | (— 2.5)                                                     | 0.934 <sup>15°</sup>                          | 1.5174 <sup>25°</sup>                           | 168.2                  | 193.1                                    | ←4.6 <sup>23</sup> →                                | —                 | —                  | —                  | —                 | —                                                       | —           | 4.1               | 0.6               | —                  | 90.7 <sup>r</sup>                                                                                                                                        |
| Wheat-germ oil     | <i>Triticum aestivum</i>          | —                                                           | —                                             | —                                               | 125                    | —                                        | ←16.0 <sup>23</sup> →                               | —                 | —                  | —                  | —                 | —                                                       | —           | 28.1              | 52.3              | 3.6                | —                                                                                                                                                        |

- <sup>a</sup> Caproic  
<sup>b</sup> Caprylic  
<sup>c</sup> Capric  
<sup>d</sup> Butyric  
<sup>e</sup> Decenoic  
<sup>f</sup> C<sub>12</sub> monoethenoic  
<sup>g</sup> C<sub>14</sub> monoethenoic  
<sup>h</sup> Gadoleic plus erucic  
<sup>i</sup> C<sub>12</sub> n-pentadecanoic.  
<sup>j</sup> C<sub>17</sub> margaric  
<sup>k</sup> 12-Methyl tetradecanoic  
<sup>l</sup> C<sub>20</sub> polyethenoic  
<sup>m</sup> C<sub>22</sub> polyethenoic  
<sup>n</sup> Behenic  
<sup>o</sup> C<sub>14</sub> polyethenoic  
<sup>p</sup> Gadoleic  
<sup>q</sup> C<sub>24</sub> polyethenoic  
<sup>r</sup> Ricinoleic  
<sup>s</sup> Includes behenic and lignoceric  
<sup>t</sup> Percent by weight  
<sup>u</sup> Lignoceric  
<sup>v</sup> Erucic  
<sup>w</sup> Includes behenic  
<sup>x</sup> Licanic.  
<sup>y</sup> Eleostearic

# INTRODUCTION TO X-RAY CROSS SECTIONS

Alex F. Burr

These tables are part of an extensive report published by W. H. McMaster, et al. as UCRL 50174 and available from the National Technical Information Service, Springfield, Va. 22151. Section I of UCRL 50174 describes the data base and the treatment given it. Section II contains the total cross sections between 1 and 1000 keV for all the elements. Section III contains results used in producing Section II, and Section IV contains total cross sections for selected energies and is reproduced in part here. To obtain these values existing experimental x-ray total cross section data and theoretical cross section calculations were surveyed. The coherent (Rayleigh) scattering cross sections and the incoherent (Compton) scattering cross sections were computed. The photo-electric cross sections were obtained by least squares fitting of experimental data, theory, and interpolation of experiment and theory. The following table contains cross sections interpolated from the basic compilation at those wavelengths of most use to x-ray crystallographers. The wavelengths chosen were selected to correspond to those given in the International Tables for X-Ray Crystallography. The energy-to-wavelength conversion is given below.

Table I. Energy-to-wavelength conversion

| Target radiation | $\lambda$ | keV    | Target radiation | $\lambda$ | keV   |
|------------------|-----------|--------|------------------|-----------|-------|
| Ag K $\alpha$    | 0.5608    | 22.105 | Ni K $\alpha$    | 1.6591    | 7.472 |
| K $\beta_1$      | 0.4970    | 24.942 | K $\beta_1$      | 1.5001    | 8.265 |
| Pd K $\alpha$    | 0.5869    | 21.125 | Co K $\alpha$    | 1.7902    | 6.925 |
| K $\beta_1$      | 0.5205    | 23.819 | K $\beta_1$      | 1.6208    | 7.649 |
| Rh K $\alpha$    | 0.6147    | 20.169 | Fe K $\alpha$    | 1.9373    | 6.400 |
| K $\beta_1$      | 0.5456    | 22.724 | K $\beta_1$      | 1.7565    | 7.058 |
| Mo K $\alpha$    | 0.7107    | 17.444 | Mn K $\alpha$    | 2.1031    | 5.895 |
| K $\beta_1$      | 0.6323    | 19.608 | K $\beta_1$      | 1.9102    | 6.490 |
| Zn K $\alpha$    | 1.4364    | 8.631  | Cr K $\alpha$    | 2.2909    | 5.412 |
| K $\beta_1$      | 1.2952    | 9.572  | K $\beta_1$      | 2.0848    | 5.947 |
| Cu K $\alpha$    | 1.5418    | 8.041  | Ti K $\alpha$    | 2.7496    | 4.509 |
| K $\beta_1$      | 1.3922    | 8.905  | K $\beta_1$      | 2.5138    | 4.932 |

Table II. Total Cross Section in cm<sup>2</sup>/g

| Z     | 1   | 2   | 3   | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   | 18   | 19   | 20   |
|-------|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| keV   | H   | He  | Li  | Be   | B    | C    | N    | O    | F    | Ne   | Na   | Mg   | Al   | Si   | P    | S    | Cl   | Ar   | K    | Ca   |
| 4.51  | 432 | 661 | 210 | 5.63 | 12.9 | 25.6 | 43.0 | 64.8 | 91.8 | 125  | 168  | 220  | 264  | 336  | 386  | 464  | 518  | 577  | 679  | 805  |
| 4.93  | 421 | 550 | 162 | 4.25 | 9.69 | 19.4 | 32.6 | 49.4 | 70.3 | 95.9 | 129  | 171  | 206  | 263  | 304  | 364  | 411  | 456  | 542  | 638  |
| 5.41  | 412 | 465 | 124 | 3.18 | 7.23 | 14.5 | 24.4 | 37.2 | 53.1 | 72.7 | 98.5 | 131  | 158  | 203  | 236  | 282  | 322  | 356  | 427  | 500  |
| 5.90  | 405 | 405 | 966 | 2.45 | 5.53 | 11.1 | 18.7 | 28.6 | 41.1 | 56.4 | 76.6 | 102  | 124  | 160  | 186  | 223  | 256  | 282  | 342  | 398  |
| 5.95  | 405 | 400 | 964 | 2.39 | 5.39 | 10.8 | 18.2 | 27.9 | 40.0 | 54.9 | 74.7 | 99.6 | 121  | 156  | 182  | 217  | 250  | 276  | 334  | 389  |
| 6.40  | 400 | 362 | 798 | 1.92 | 4.28 | 8.55 | 14.5 | 22.2 | 32.0 | 44.0 | 59.9 | 80.2 | 97.5 | 126  | 148  | 177  | 205  | 225  | 275  | 319  |
| 6.49  | 400 | 355 | 770 | 1.84 | 4.10 | 8.18 | 13.9 | 21.3 | 30.6 | 42.2 | 57.5 | 77   | 93.7 | 121  | 142  | 170  | 197  | 217  | 264  | 307  |
| 6.93  | 397 | 329 | 659 | 1.52 | 3.36 | 6.68 | 11.3 | 17.4 | 25.1 | 34.7 | 47.3 | 63.5 | 77.5 | 100  | 118  | 141  | 165  | 181  | 222  | 257  |
| 7.06  | 396 | 322 | 631 | 1.44 | 3.17 | 6.30 | 10.7 | 16.5 | 23.7 | 32.8 | 44.7 | 60.1 | 73.4 | 95.1 | 112  | 134  | 156  | 172  | 211  | 244  |
| 7.47  | 394 | 303 | 555 | 1.23 | 2.67 | 5.28 | 8.96 | 13.8 | 19.9 | 27.6 | 37.7 | 50.8 | 62.2 | 80.7 | 95.2 | 114  | 134  | 147  | 181  | 209  |
| 7.65  | 393 | 297 | 528 | 1.15 | 2.49 | 4.92 | 8.33 | 12.9 | 18.6 | 25.7 | 35.2 | 47.4 | 58.1 | 75.4 | 89.1 | 107  | 125  | 137  | 170  | 196  |
| 8.04  | 391 | 284 | 477 | 1.01 | 2.14 | 4.22 | 7.14 | 11.0 | 16.0 | 22.1 | 30.3 | 40.9 | 50.2 | 65.3 | 77.3 | 92.5 | 109  | 120  | 148  | 171  |
| 8.27  | 390 | 277 | 452 | 936  | 1.98 | 3.88 | 6.56 | 10.1 | 14.7 | 20.4 | 27.9 | 37.6 | 46.3 | 60.2 | 71.3 | 85.5 | 101  | 111  | 138  | 159  |
| 8.63  | 389 | 268 | 417 | 837  | 1.74 | 3.40 | 5.74 | 8.87 | 12.8 | 17.9 | 24.4 | 33.0 | 40.7 | 53.0 | 62.9 | 75.4 | 89.4 | 97.7 | 122  | 141  |
| 8.91  | 388 | 262 | 394 | 774  | 1.59 | 3.09 | 5.22 | 8.06 | 11.7 | 16.2 | 22.2 | 30.1 | 37.1 | 48.4 | 57.4 | 68.9 | 81.8 | 89.3 | 112  | 129  |
| 9.57  | 386 | 250 | 349 | 651  | 1.30 | 2.49 | 4.19 | 6.47 | 9.36 | 13.1 | 17.9 | 24.2 | 30.0 | 39.1 | 46.6 | 55.9 | 66.7 | 72.7 | 91.4 | 106  |
| 17.44 | 373 | 202 | 197 | 245  | 345  | 535  | 790  | 115  | 158  | 221  | 294  | 398  | 504  | 653  | 787  | 963  | 116  | 126  | 162  | 19   |
| 19.61 | 370 | 197 | 187 | 222  | 293  | 429  | 605  | 855  | 115  | 160  | 210  | 283  | 359  | 462  | 557  | 684  | 826  | 895  | 115  | 13.6 |
| 20.17 | 369 | 196 | 185 | 217  | 283  | 408  | 570  | 799  | 107  | 148  | 194  | 260  | 330  | 426  | 513  | 630  | 761  | 824  | 10.6 | 12.5 |
| 21.13 | 368 | 195 | 182 | 210  | 268  | 379  | 519  | 717  | 952  | 131  | 170  | 228  | 289  | 371  | 447  | 550  | 663  | 718  | 9.24 | 10.9 |
| 22.11 | 366 | 193 | 179 | 205  | 256  | 354  | 476  | 648  | 851  | 116  | 150  | 200  | 254  | 325  | 391  | 482  | 580  | 628  | 8.08 | 9.57 |
| 22.72 | 366 | 192 | 177 | 201  | 249  | 340  | 452  | 610  | 795  | 108  | 139  | 186  | 235  | 300  | 361  | 445  | 535  | 579  | 7.45 | 8.84 |
| 23.82 | 364 | 191 | 175 | 196  | 239  | 319  | 416  | 553  | 711  | 963  | 123  | 163  | 206  | 262  | 315  | 388  | 466  | 504  | 6.49 | 7.71 |
| 24.94 | 363 | 189 | 173 | 192  | 229  | 301  | 385  | 504  | 640  | 861  | 109  | 144  | 181  | 230  | 276  | 340  | 408  | 441  | 5.67 | 6.75 |



**X-RAY CROSS SECTIONS (Continued)**  
**Table II. Total Cross Section in cm<sup>2</sup>/g (Continued)**

| Z     | 21   | 22   | 23   | 24   | 25   | 26   | 27   | 28   | 29   | 30   | 31   | 32   | 33   | 34   | 35   | 36   | 37   | 38   | 39   | 40   |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| keV   | Sc   | Ti   | V    | Cr   | Mn   | Fe   | Co   | Ni   | Cu   | Zn   | Ga   | Ge   | As   | Se   | Br   | Kr   | Rb   | Sr   | Y    | Zr   |
| 4.51  | 819  | 111  | 125  | 143  | 160  | 188  | 206  | 240  | 257  | 280  | 309  | 329  | 368  | 403  | 435  | 464  | 508  | 552  | 599  | 648  |
| 4.93  | 658  | 86.8 | 97.3 | 111  | 125  | 147  | 161  | 188  | 201  | 220  | 242  | 258  | 288  | 317  | 342  | 366  | 400  | 436  | 473  | 511  |
| 5.41  | 521  | 571  | 75.1 | 85.7 | 96.1 | 113  | 125  | 146  | 155  | 172  | 187  | 200  | 224  | 246  | 266  | 285  | 312  | 339  | 369  | 399  |
| 5.90  | 420  | 449  | 51.3 | 67.4 | 75.6 | 88.9 | 98.4 | 113  | 123  | 137  | 148  | 158  | 178  | 195  | 211  | 226  | 248  | 270  | 294  | 317  |
| 5.95  | 411  | 459  | 501  | 65.8 | 73.8 | 86.8 | 96.1 | 113  | 120  | 134  | 144  | 155  | 173  | 190  | 206  | 221  | 242  | 263  | 287  | 310  |
| 6.40  | 339  | 370  | 411  | 462  | 519  | 70.4 | 78.3 | 91.8 | 97.4 | 110  | 117  | 126  | 142  | 156  | 169  | 181  | 198  | 215  | 235  | 254  |
| 6.49  | 327  | 357  | 396  | 445  | 506  | 67.7 | 75.3 | 88.3 | 93.6 | 106  | 113  | 122  | 136  | 150  | 162  | 174  | 191  | 207  | 227  | 244  |
| 6.93  | 276  | 301  | 333  | 375  | 405  | 56.3 | 62.9 | 73.8 | 78.1 | 88.7 | 94.2 | 102  | 114  | 125  | 136  | 146  | 160  | 174  | 190  | 205  |
| 7.06  | 262  | 286  | 316  | 357  | 385  | 53.3 | 59.6 | 70.0 | 74.1 | 84.3 | 89.3 | 96.8 | 108  | 119  | 129  | 138  | 152  | 165  | 181  | 195  |
| 7.47  | 226  | 246  | 271  | 307  | 331  | 367  | 50.9 | 59.8 | 63.2 | 72.4 | 76.2 | 82.9 | 92.5 | 101  | 110  | 119  | 136  | 141  | 155  | 167  |
| 7.65  | 212  | 231  | 255  | 288  | 311  | 346  | 47.7 | 56.1 | 59.2 | 68.0 | 71.4 | 77.8 | 86.8 | 95.1 | 104  | 111  | 122  | 132  | 145  | 157  |
| 8.04  | 186  | 202  | 223  | 252  | 273  | 304  | 339  | 48.8 | 51.5 | 59.5 | 62.1 | 67.9 | 75.7 | 82.9 | 90.3 | 97   | 106  | 115  | 127  | 137  |
| 8.27  | 173  | 188  | 206  | 234  | 253  | 283  | 315  | 45.2 | 47.7 | 55.3 | 57.5 | 63.0 | 70.1 | 77.8 | 83.7 | 89.9 | 98.5 | 107  | 118  | 127  |
| 8.63  | 153  | 167  | 183  | 208  | 225  | 253  | 281  | 306  | 42.3 | 49.2 | 50.9 | 56.0 | 62.2 | 68.0 | 74.2 | 79.8 | 87.4 | 94.7 | 105  | 113  |
| 8.91  | 141  | 153  | 168  | 191  | 207  | 234  | 259  | 283  | 38.7 | 45.3 | 46.7 | 51.4 | 57.0 | 62.3 | 68.1 | 73.2 | 80.2 | 86.8 | 96.2 | 103  |
| 9.57  | 116  | 126  | 138  | 157  | 170  | 194  | 214  | 236  | 245  | 37.4 | 38.1 | 42.3 | 46.7 | 51.0 | 55.8 | 60.0 | 65.7 | 71.0 | 79.0 | 84.8 |
| 17.44 | 21.0 | 23.3 | 25.2 | 29.3 | 31.9 | 37.7 | 41.0 | 47.2 | 49.3 | 55.5 | 56.9 | 60.5 | 66.0 | 68.8 | 74.7 | 79.1 | 83.0 | 88.0 | 97.6 | 161  |
| 19.61 | 15.0 | 16.7 | 18.1 | 21.0 | 22.9 | 27.2 | 29.5 | 34.2 | 35.8 | 40.3 | 41.7 | 44.3 | 48.6 | 51.2 | 55.6 | 58.6 | 62.1 | 65.6 | 72.6 | 75.2 |
| 20.17 | 13.8 | 15.4 | 16.7 | 19.4 | 21.1 | 25.1 | 27.2 | 31.6 | 33.1 | 37.2 | 38.6 | 41.0 | 45.1 | 47.6 | 51.7 | 54.5 | 57.8 | 61.0 | 67.5 | 70.1 |
| 21.13 | 12.1 | 13.4 | 14.6 | 17.0 | 18.5 | 22.0 | 23.8 | 27.7 | 29.0 | 32.7 | 34.0 | 36.1 | 39.7 | 42.1 | 45.6 | 48.1 | 51.1 | 54.0 | 59.7 | 62.1 |
| 22.11 | 10.5 | 11.8 | 12.8 | 14.9 | 16.2 | 19.3 | 20.9 | 24.3 | 25.5 | 28.7 | 29.9 | 31.8 | 35.0 | 37.2 | 40.4 | 42.5 | 45.3 | 47.9 | 53.0 | 55.2 |
| 22.72 | 9.72 | 10.9 | 11.8 | 13.7 | 15.0 | 17.8 | 19.3 | 22.5 | 23.6 | 26.6 | 27.7 | 29.4 | 32.4 | 34.6 | 37.5 | 39.5 | 42.1 | 44.5 | 49.2 | 51.4 |
| 23.82 | 8.47 | 9.48 | 10.3 | 12.0 | 13.1 | 15.6 | 16.9 | 19.7 | 20.7 | 23.3 | 24.3 | 25.8 | 28.5 | 30.5 | 33.1 | 34.8 | 37.2 | 39.3 | 43.5 | 45.5 |
| 24.94 | 7.40 | 8.30 | 9.02 | 10.5 | 11.5 | 13.7 | 14.8 | 17.3 | 18.2 | 20.4 | 21.4 | 22.7 | 25.1 | 26.9 | 29.2 | 30.7 | 32.9 | 34.8 | 38.5 | 40.4 |

| Z     | 41   | 42   | 43   | 44   | 45   | 46   | 47   | 48   | 49   | 50   | 51   | 52   | 53   | 54   | 55   | 56   | 57   | 58   | 59   | 60   |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| keV   | Nb   | Mo   | Tc   | Ru   | Rh   | Pd   | Ag   | Cd   | In   | Sn   | Sb   | Te   | I    | Xe   | Cs   | Ba   | La   | Ce   | Pr   | Nd   |
| 4.51  | 697  | 738  | 786  | 832  | 892  | 928  | 987  | 1064 | 1151 | 1128 | 997  | 753  | 293  | 300  | 324  | 334  | 355  | 383  | 414  | 433  |
| 4.93  | 552  | 585  | 621  | 660  | 708  | 739  | 785  | 842  | 906  | 899  | 926  | 843  | 921  | 683  | 259  | 266  | 282  | 304  | 330  | 344  |
| 5.41  | 432  | 457  | 486  | 518  | 555  | 581  | 617  | 659  | 706  | 709  | 733  | 769  | 835  | 755  | 803  | 587  | 223  | 240  | 261  | 271  |
| 5.90  | 344  | 365  | 387  | 414  | 444  | 466  | 495  | 526  | 561  | 569  | 592  | 617  | 666  | 701  | 742  | 660  | 677  | 521  | 210  | 218  |
| 5.95  | 336  | 357  | 378  | 404  | 434  | 455  | 484  | 514  | 548  | 557  | 579  | 603  | 651  | 685  | 725  | 645  | 662  | 509  | 205  | 213  |
| 6.40  | 276  | 293  | 310  | 333  | 357  | 375  | 398  | 422  | 449  | 460  | 479  | 497  | 535  | 565  | 597  | 615  | 636  | 592  | 450  | 464  |
| 6.49  | 266  | 282  | 299  | 320  | 344  | 361  | 384  | 407  | 433  | 443  | 462  | 479  | 516  | 545  | 575  | 593  | 613  | 571  | 410  | 447  |
| 6.93  | 223  | 237  | 251  | 269  | 289  | 304  | 324  | 342  | 363  | 374  | 391  | 404  | 434  | 459  | 484  | 499  | 519  | 559  | 596  | 532  |
| 7.06  | 212  | 225  | 238  | 256  | 275  | 289  | 308  | 325  | 345  | 356  | 373  | 385  | 413  | 437  | 460  | 475  | 494  | 532  | 567  | 506  |
| 7.47  | 182  | 193  | 204  | 220  | 236  | 249  | 265  | 279  | 295  | 307  | 322  | 331  | 355  | 376  | 395  | 408  | 427  | 459  | 488  | 506  |
| 7.65  | 170  | 181  | 192  | 207  | 222  | 234  | 249  | 262  | 277  | 289  | 303  | 312  | 333  | 353  | 372  | 384  | 402  | 432  | 459  | 476  |
| 8.04  | 149  | 158  | 168  | 181  | 194  | 205  | 218  | 229  | 242  | 253  | 267  | 273  | 292  | 310  | 325  | 336  | 354  | 379  | 402  | 418  |
| 8.27  | 138  | 147  | 156  | 168  | 180  | 190  | 203  | 213  | 225  | 236  | 248  | 254  | 271  | 288  | 302  | 312  | 329  | 352  | 374  | 389  |
| 8.63  | 122  | 130  | 138  | 149  | 160  | 169  | 180  | 189  | 200  | 210  | 221  | 226  | 241  | 256  | 269  | 278  | 294  | 314  | 333  | 347  |
| 8.91  | 112  | 120  | 127  | 137  | 147  | 156  | 166  | 174  | 183  | 193  | 204  | 208  | 222  | 236  | 248  | 256  | 271  | 290  | 307  | 320  |
| 9.57  | 92.0 | 98.2 | 104  | 113  | 121  | 128  | 137  | 143  | 151  | 159  | 168  | 172  | 183  | 195  | 204  | 211  | 224  | 240  | 253  | 265  |
| 17.44 | 17.0 | 18.4 | 19.8 | 21.3 | 23.1 | 24.4 | 26.4 | 27.7 | 29.1 | 31.2 | 33.0 | 33.9 | 36.3 | 38.3 | 40.4 | 42.4 | 45.3 | 48.6 | 50.8 | 53.3 |
| 19.61 | 81.2 | 13.3 | 14.3 | 15.4 | 16.7 | 17.6 | 19.1 | 20.1 | 21.2 | 22.6 | 23.9 | 24.7 | 26.5 | 27.9 | 29.5 | 31.0 | 33.1 | 35.5 | 37.1 | 38.9 |
| 20.17 | 75.6 | 79.3 | 13.2 | 14.2 | 15.4 | 16.3 | 17.7 | 18.6 | 19.6 | 20.9 | 22.1 | 22.8 | 24.6 | 25.8 | 27.3 | 28.7 | 30.7 | 33.0 | 34.4 | 36.0 |
| 21.13 | 67.1 | 70.3 | 73.0 | 12.5 | 13.5 | 14.3 | 15.5 | 16.4 | 17.3 | 18.4 | 19.4 | 20.1 | 22.7 | 22.7 | 24.1 | 25.4 | 27.9 | 29.1 | 30.3 | 31.7 |
| 22.11 | 59.6 | 62.5 | 65.0 | 11.0 | 11.9 | 12.6 | 13.7 | 14.5 | 15.3 | 16.2 | 17.1 | 17.7 | 19.2 | 20.0 | 21.3 | 22.5 | 23.9 | 25.7 | 26.8 | 28.0 |
| 22.72 | 55.5 | 58.2 | 60.6 | 63.8 | 11.0 | 11.6 | 12.7 | 13.4 | 14.1 | 15.0 | 15.8 | 16.4 | 17.8 | 18.6 | 19.8 | 20.9 | 22.1 | 23.9 | 24.9 | 26.0 |
| 23.82 | 49.1 | 51.5 | 53.7 | 56.6 | 58.3 | 10.2 | 11.1 | 11.8 | 12.4 | 13.2 | 13.8 | 14.4 | 15.7 | 16.3 | 17.4 | 18.4 | 19.5 | 21.0 | 21.9 | 22.9 |
| 24.94 | 43.6 | 45.7 | 47.7 | 50.3 | 52.0 | 57.0 | 97.8 | 10.4 | 11.0 | 11.6 | 12.1 | 12.7 | 13.9 | 14.4 | 15.4 | 16.3 | 17.2 | 18.6 | 19.3 | 20.2 |

**X-RAY CROSS SECTIONS (Continued)**  
**Table II. Total Cross Section in cm<sup>2</sup>/g (Continued)**

| Z<br>keV | 61<br>Pm | 62<br>Sm | 63<br>Eu | 64<br>Gd | 65<br>Tb | 66<br>Dy | 67<br>Ho | 68<br>Er | 69<br>Tm | 70<br>Yb | 71<br>Lu | 72<br>Hf | 73<br>Ta | 74<br>W | 75<br>Re | 76<br>Os | 77<br>Ir | 78<br>Pt | 79<br>Au | 80<br>Hg |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|----------|----------|----------|----------|----------|
| 4.51     | 455      | 473      | 503      | 510      | 546      | 568      | 589      | 615      | 644      | 664      | 696      | 720      | 736      | 753     | 796      | 824      | 871      | 934      | 906      | 938      |
| 4.93     | 361      | 375      | 398      | 405      | 432      | 449      | 465      | 485      | 508      | 524      | 549      | 568      | 581      | 598     | 631      | 653      | 688      | 734      | 720      | 760      |
| 5.41     | 285      | 295      | 313      | 319      | 339      | 352      | 363      | 380      | 397      | 410      | 430      | 445      | 455      | 470     | 496      | 512      | 540      | 572      | 568      | 598      |
| 5.90     | 229      | 237      | 251      | 256      | 271      | 281      | 290      | 303      | 317      | 327      | 343      | 355      | 363      | 378     | 397      | 410      | 431      | 455      | 457      | 480      |
| 5.95     | 224      | 232      | 245      | 250      | 265      | 275      | 283      | 296      | 310      | 319      | 335      | 347      | 355      | 369     | 388      | 401      | 422      | 444      | 447      | 469      |
| 6.40     | 186      | 192      | 203      | 207      | 219      | 227      | 234      | 244      | 255      | 263      | 276      | 286      | 293      | 306     | 321      | 332      | 348      | 365      | 371      | 388      |
| 6.49     | 185      | 195      | 200      | 200      | 211      | 219      | 225      | 235      | 246      | 254      | 266      | 276      | 282      | 295     | 310      | 320      | 336      | 351      | 358      | 375      |
| 6.93     | 401      | 412      | 412      | 412      | 412      | 412      | 412      | 412      | 412      | 412      | 412      | 412      | 412      | 412     | 412      | 412      | 412      | 412      | 412      | 412      |
| 7.06     | 536      | 536      | 536      | 536      | 536      | 536      | 536      | 536      | 536      | 536      | 536      | 536      | 536      | 536     | 536      | 536      | 536      | 536      | 536      | 536      |
| 7.47     | 535      | 475      | 361      | 369      | 147      | 152      | 156      | 163      | 170      | 175      | 184      | 191      | 195      | 206     | 215      | 222      | 233      | 241      | 250      | 261      |
| 7.65     | 503      | 446      | 477      | 347      | 367      | 143      | 146      | 153      | 160      | 165      | 173      | 180      | 184      | 194     | 203      | 209      | 219      | 226      | 236      | 246      |
| 8.04     | 441      | 454      | 418      | 427      | 322      | 337      | 128      | 134      | 140      | 145      | 152      | 158      | 162      | 171     | 178      | 184      | 192      | 198      | 208      | 216      |
| 8.27     | 410      | 422      | 450      | 397      | 420      | 313      | 333      | 125      | 131      | 135      | 142      | 147      | 150      | 159     | 166      | 171      | 179      | 184      | 194      | 202      |
| 8.63     | 366      | 376      | 401      | 410      | 375      | 392      | 296      | 318      | 117      | 120      | 126      | 131      | 134      | 142     | 149      | 153      | 160      | 164      | 174      | 180      |
| 8.91     | 336      | 347      | 369      | 377      | 400      | 360      | 272      | 292      | 289      | 111      | 117      | 121      | 124      | 132     | 137      | 141      | 148      | 151      | 161      | 167      |
| 9.57     | 278      | 287      | 305      | 312      | 330      | 344      | 364      | 336      | 239      | 232      | 247      | 256      | 103      | 110     | 114      | 118      | 123      | 125      | 134      | 139      |
| 17.44    | 55.5     | 58.0     | 61.2     | 62.8     | 66.8     | 68.9     | 72.1     | 75.6     | 79.0     | 80.2     | 84.2     | 86.3     | 89.5     | 93.8    | 98.7     | 100      | 103      | 109      | 111      | 115      |
| 19.61    | 40.5     | 42.4     | 44.7     | 46.0     | 48.9     | 50.4     | 52.8     | 55.1     | 57.9     | 59.2     | 62.0     | 64.2     | 66.1     | 70.6    | 72.5     | 74.1     | 77.2     | 80.2     | 82.3     | 85.3     |
| 20.17    | 37.6     | 39.3     | 41.5     | 42.6     | 45.3     | 46.7     | 48.9     | 51.0     | 53.8     | 55.0     | 57.6     | 59.7     | 61.4     | 65.5    | 67.3     | 68.9     | 71.9     | 74.6     | 76.5     | 79.4     |
| 21.13    | 33.1     | 34.7     | 36.6     | 37.6     | 40.0     | 41.2     | 43.2     | 45.0     | 47.5     | 48.7     | 51.0     | 52.9     | 54.4     | 58.0    | 59.5     | 61.1     | 63.8     | 66.0     | 67.8     | 70.4     |
| 22.11    | 29.3     | 30.7     | 32.4     | 33.3     | 35.4     | 36.5     | 38.3     | 39.8     | 42.1     | 43.2     | 45.3     | 46.9     | 48.3     | 51.4    | 52.8     | 54.2     | 56.8     | 58.6     | 60.2     | 62.6     |
| 22.72    | 27.1     | 28.5     | 30.1     | 30.9     | 32.9     | 33.9     | 35.6     | 37.0     | 39.1     | 40.2     | 42.1     | 43.7     | 44.9     | 47.8    | 49.1     | 50.5     | 52.9     | 54.5     | 56.0     | 58.3     |
| 23.82    | 23.9     | 25.1     | 26.5     | 27.3     | 29.0     | 29.9     | 31.4     | 32.6     | 34.5     | 35.5     | 37.2     | 38.6     | 39.7     | 42.2    | 43.3     | 44.6     | 46.8     | 48.2     | 49.5     | 51.7     |
| 24.94    | 21.1     | 22.2     | 23.4     | 24.1     | 25.6     | 26.4     | 27.8     | 28.8     | 30.6     | 31.5     | 33.0     | 34.2     | 35.2     | 37.4    | 38.4     | 39.6     | 41.6     | 42.7     | 43.9     | 45.9     |

| Z<br>keV | 81<br>Tl | 82<br>Pb | 83<br>Bi | 86<br>Rn | 90<br>Th | 92<br>U | 95<br>Pu |
|----------|----------|----------|----------|----------|----------|---------|----------|
| 4.51     | 991      | 1035     | 1066     | 1174     | 1098     | 1084    | 960      |
| 4.93     | 785      | 820      | 847      | 930      | 993      | 862     | 1023     |
| 5.41     | 617      | 645      | 667      | 731      | 844      | 774     | 803      |
| 5.90     | 494      | 517      | 536      | 586      | 678      | 672     | 731      |
| 5.95     | 483      | 505      | 524      | 573      | 663      | 657     | 772      |
| 6.40     | 400      | 418      | 435      | 474      | 549      | 545     | 638      |
| 6.49     | 386      | 403      | 419      | 458      | 530      | 526     | 615      |
| 6.93     | 326      | 341      | 355      | 387      | 449      | 446     | 520      |
| 7.06     | 311      | 325      | 338      | 369      | 428      | 425     | 495      |
| 7.47     | 268      | 280      | 293      | 318      | 370      | 368     | 427      |
| 7.65     | 253      | 264      | 276      | 300      | 348      | 347     | 402      |
| 8.04     | 222      | 232      | 243      | 264      | 307      | 306     | 353      |
| 8.27     | 207      | 216      | 227      | 246      | 286      | 285     | 329      |
| 8.63     | 185      | 194      | 203      | 220      | 256      | 256     | 294      |
| 8.91     | 171      | 179      | 188      | 203      | 237      | 236     | 271      |
| 9.57     | 142      | 149      | 156      | 169      | 197      | 197     | 225      |
| 17.44    | 119      | 123      | 126      | 117      | 99.5     | 96.7    | 48.8     |
| 19.61    | 88.3     | 90.6     | 93.5     | 101      | 73.3     | 72.6    | 79.0     |
| 20.17    | 82.0     | 84.1     | 87.0     | 93.8     | 95.0     | 67.8    | 73.7     |
| 21.13    | 72.7     | 74.5     | 77.2     | 83.3     | 97.2     | 84.2    | 65.7     |
| 22.11    | 64.6     | 66.1     | 68.7     | 74.1     | 86.3     | 86.9    | 58.8     |
| 22.72    | 60.1     | 61.5     | 64.0     | 69.1     | 80.3     | 81.1    | 76.4     |
| 23.82    | 53.2     | 54.4     | 56.7     | 61.2     | 71.0     | 72.1    | 78.3     |
| 24.94    | 47.2     | 48.2     | 50.4     | 54.4     | 62.9     | 64.2    | 69.8     |

# ION EXCHANGE RESINS

## ANION EXCHANGE RESINS

The following table is divided into two parts; the first lists properties of some anionic resins and the second, properties of some cationic resins.

| Character<br>S=strong<br>W=weak | Trade<br>name   | Manu-<br>facturer* | Active<br>group                              | Matrix              | Effective<br>pH | Selectivity            | Order<br>of<br>selectivity                           | Total<br>exchange<br>capacity:<br>meq/ml | Total<br>exchange<br>capacity:<br>meq/gm | Maximum<br>thermal<br>stability:<br>°C    | Physical<br>form:<br>s = sphere<br>b = beads | Standard<br>mesh<br>range | Ionic<br>form as<br>shipped | Shipping<br>density:<br>lb./cu. ft. |
|---------------------------------|-----------------|--------------------|----------------------------------------------|---------------------|-----------------|------------------------|------------------------------------------------------|------------------------------------------|------------------------------------------|-------------------------------------------|----------------------------------------------|---------------------------|-----------------------------|-------------------------------------|
| S                               | Dowex 1         | 1                  | Trimethyl<br>benzyl<br>ammonium              | Polystyrene         | 0-14            | Cl/H<br>approx.<br>25  | I, NO <sub>3</sub> ,<br>Br, Cl,<br>Acetate,<br>OH, F | 1.33                                     | 3.5                                      | OH <sup>-</sup> 50<br>Cl <sup>-</sup> 150 | s                                            | 20-50<br>(wet)            | Cl <sup>-</sup>             | 44                                  |
| S                               | Dowex 21 K      | 1                  | Trimethyl<br>benzyl<br>ammonium              | Polystyrene         | 0-14            | Cl/H<br>approx.<br>15  | I, NO <sub>3</sub> ,<br>Br, Cl,<br>Acetate,<br>OH, F | 1.25                                     | 4.5                                      | OH <sup>-</sup> 50<br>Cl <sup>-</sup> 150 | s                                            | 20-50<br>(wet)            | Cl <sup>-</sup>             | 43                                  |
| S                               | Duolite A-101 D | 2                  | Quaternary<br>ammonium                       | Polystyrene         | 0-14            | --                     | --                                                   | 1.4                                      | 4.2                                      | OH <sup>-</sup> 60<br>Cl <sup>-</sup> 100 | b                                            | 16-50                     | Cl <sup>-</sup>             | --                                  |
| S                               | Ionac A-540     | 3                  | Quaternary<br>ammonium                       | Polystyrene         | 0-14            | --                     | --                                                   | 1.0                                      | 3.6                                      | salt 100<br>OH <sup>-</sup> 60            | b                                            | 16-50                     | salt                        | 43-66                               |
| S                               | Dowex 2         | 1                  | Dimethyl<br>ethanol<br>benzyl<br>ammonium    | Polystyrene         | 0-14            | Cl/H<br>approx.<br>1.5 | I, NO <sub>3</sub> ,<br>Br, Cl,<br>Acetate,<br>OH, F | 1.33                                     | 3.5                                      | OH <sup>-</sup> 30<br>Cl <sup>-</sup> 150 | s                                            | 20-50<br>(wet)            | Cl <sup>-</sup>             | 44                                  |
| S                               | Duolite A-102 D | 2                  | Quaternary<br>ammonium                       | Polystyrene         | 0-14            | --                     | --                                                   | 1.4                                      | 4.2                                      | OH <sup>-</sup> 40<br>Cl <sup>-</sup> 100 | b                                            | 16-50                     | Cl <sup>-</sup>             | --                                  |
| S                               | Ionac A-550     | 3                  | Dimethyl<br>ethanol<br>benzyl<br>ammonium    | Polystyrene         | 0-14            | --                     | --                                                   | 1.3                                      | 3.5                                      | salt 100<br>OH <sup>-</sup> 40            | b                                            | 16-50                     | salt                        | 43-46                               |
| W                               | Duolite A-30 B  | 2                  | Tertiary<br>amine;<br>Quaternary<br>ammonium | Epoxy<br>polyamines | 0-9             | --                     | --                                                   | 2.6                                      | 8.7                                      | 80                                        | b                                            | 16-50                     | salt                        | --                                  |
| W                               | Ionac A-300     | 3                  | Tertiary<br>amine;<br>Quaternary<br>ammonium | Epoxy amine         | 0-12            | --                     | --                                                   | 1.8                                      | 5.5                                      | 40                                        | g                                            | 16-50                     | salt                        | 19-21                               |
| W                               | Duolite A-6     | 2                  | Tertiary<br>amine                            | Phenolic            | 0-5             | --                     | --                                                   | 2.4                                      | 7.6                                      | 60                                        | g                                            | 16-50                     | salt                        | --                                  |
| W                               | Duolite A-7     | 2                  | Secondary<br>amine                           | Phenolic            | 0-4             | --                     | --                                                   | 2.4                                      | 9.1                                      | 40                                        | g                                            | 16-50                     | salt                        | --                                  |

## CATION EXCHANGE RESINS

| Character<br>S=strong<br>W=weak | Trade<br>name | Manu-<br>facturer* | Active<br>group          | Matrix      | Effective<br>pH | Selectivity            | Order<br>of<br>selectivity                                                       | Total<br>exchange<br>capacity:<br>meq/ml  | Total<br>exchange<br>capacity:<br>meq/gm  | Maximum<br>thermal<br>stability:<br>°C          | Physical<br>form:<br>s = sphere<br>b = beads | Standard<br>mesh<br>range | Ionic<br>form as<br>shipped          | Shipping<br>density:<br>lb./cu. ft.     |
|---------------------------------|---------------|--------------------|--------------------------|-------------|-----------------|------------------------|----------------------------------------------------------------------------------|-------------------------------------------|-------------------------------------------|-------------------------------------------------|----------------------------------------------|---------------------------|--------------------------------------|-----------------------------------------|
| S                               | Dowex 50      | 1                  | Nuclear<br>sulfonic acid | Polystyrene | 0-14            | Na/H<br>approx.<br>1.2 | Ag, Cs,<br>Rb, K,<br>NH <sub>4</sub> ,<br>Na, H,<br>Li, Ba,<br>Sr, Ca,<br>Mg, Be | Na <sup>+</sup> 1.9<br>H <sup>+</sup> 1.7 | Na <sup>+</sup> 4.8<br>H <sup>+</sup> 5.0 | 150                                             | s                                            | 20-50<br>(wet)            | H <sup>+</sup> or<br>Na <sup>+</sup> | H <sup>+</sup> 50<br>Na <sup>+</sup> 53 |
| S                               | Dowex MPC-1   | 4                  | Nuclear<br>sulfonic acid | Polystyrene | 0-14            | --                     | --                                                                               | 1.6-1.8<br>H <sup>+</sup> form            | 4.5-4.9<br>H <sup>+</sup> form            | 150                                             | b                                            | 20-40<br>(wet)            | Na <sup>+</sup>                      | 50                                      |
| S                               | Duolite C-20  | 2                  | Nuclear<br>sulfonic acid | Polystyrene | 0-14            | --                     | --                                                                               | 2.2                                       | 5.1                                       | 150                                             | b                                            | 16-50                     | Na <sup>+</sup>                      | --                                      |
| S                               | Ionac 240     | 3                  | Nuclear<br>sulfonic acid | Polystyrene | 0-14            | --                     | --                                                                               | 1.9                                       | 4.6                                       | 140 (Na <sup>+</sup> )<br>130 (H <sup>+</sup> ) | b                                            | 16-50                     | Na <sup>+</sup>                      | 50-55                                   |
| S                               | Duolite C-3   | 2                  | Methylene<br>sulfonic    | Phenolic    | 0-9             | --                     | --                                                                               | 1.1                                       | 2.9                                       | 60                                              | g                                            | 16-50                     | H <sup>+</sup>                       | --                                      |
| W                               | Dowex CCR-1   | 4                  | Carboxylic               | Phenolic    | 0-9             | --                     | --                                                                               | --                                        | --                                        | 38                                              | g                                            | 20-50<br>(wet)            | H <sup>+</sup> (dry)                 | 21                                      |
| W                               | Duolite ES-63 | 2                  | Phosphonic               | Polystyrene | 4-14            | --                     | --                                                                               | 3.3                                       | 6.5                                       | 100                                             | b                                            | 16-50                     | H <sup>+</sup>                       | --                                      |
| W                               | Duolite ES-80 | 2                  | Aliphatic                | Acrylic     | 6-14            | --                     | --                                                                               | 3.5                                       | 10.2                                      | 100                                             | b                                            | 16-50                     | H <sup>+</sup>                       | --                                      |

- \* 1. Dow
- 2. Diamond Shamrock
- 3. Ionac
- 4. Nalco

# LATTICE CONSTANTS FOR CUBIC CRYSTALS

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| $a/\text{\AA}$ |     | Substance                                                                               | $a/\text{\AA}$ |                  | Substance                           |
|----------------|-----|-----------------------------------------------------------------------------------------|----------------|------------------|-------------------------------------|
| 3.56           | A 4 | C (diamond)                                                                             | 4.44           |                  | ScN                                 |
| 5.42           |     | Si                                                                                      | 4.446          |                  | TaC                                 |
| 5.62           |     | Ge                                                                                      | 4.458          |                  | HfC                                 |
| 6.46           |     | $\alpha$ -Sn                                                                            | 4.615          |                  | NaF                                 |
|                | A 1 |                                                                                         | 4.62           |                  | ZrN                                 |
| 3.517          |     | Ni                                                                                      | 4.69           |                  | CdO                                 |
| 3.554          |     | $\alpha$ -Co                                                                            | 4.69           |                  | ZrC                                 |
| 3.60           |     | Taenite (57.7% Fe, 40.8% Ni, 0.5% P)                                                    | 4.80           |                  | CaO                                 |
| 3.608          |     | Cu                                                                                      | 4.82           |                  | (Na <sub>2</sub> CeO <sub>3</sub> ) |
| 3.63           |     | $\gamma$ -Fe (1370 K.)                                                                  | 4.84           |                  | (Na <sub>2</sub> PrO <sub>3</sub> ) |
| 3.797          |     | Rh                                                                                      | 4.88           |                  | NaH                                 |
| 3.831          |     | Ir                                                                                      | 4.92           |                  | AgF                                 |
| 3.880          |     | Pd                                                                                      | 5.006          |                  | CaNH                                |
| 3.88—4.04      |     | Pd-H                                                                                    | 5.13           |                  | SrO                                 |
| 3.912          |     | Pt                                                                                      | 5.14           |                  | LiCl                                |
| 4.041          |     | Al                                                                                      | 5.14           |                  | NdN                                 |
| 4.070          |     | Au                                                                                      | 5.19           |                  | MgS                                 |
| 4.077          |     | Ag                                                                                      | 5.192          |                  | MnS (130 K.)                        |
| 4.30           |     | Co-N                                                                                    | 5.210          |                  | MnS (299 K.)                        |
| 4.40—4.46      |     | Ti-H                                                                                    | 5.33           |                  | KF                                  |
| 4.52           |     | Ne (4 K.)                                                                               | 5.45           |                  | MgSe                                |
| 4.66           |     | Zr-H                                                                                    | 5.45           |                  | MnSe                                |
| 4.84           |     | $\beta$ -Ti                                                                             | 5.45           |                  | SrNH                                |
| 4.939          |     | Pb                                                                                      | 5.49           |                  | LiBr                                |
| 5.08           |     | Th                                                                                      | 5.52           |                  | BaO                                 |
| 5.14           |     | $\alpha$ -Ce                                                                            | 5.545          |                  | AgCl                                |
| 5.296          |     | $\beta$ -La                                                                             | 5.55—5.76      |                  | AgCl-AgBr                           |
| 5.43           |     | A (4 K.)                                                                                | 5.627          |                  | NaCl                                |
| 5.56           |     | Ca                                                                                      | 5.63           |                  | RbF                                 |
| 5.59           |     | Kr (20 K.)                                                                              | 5.68           |                  | CaS                                 |
| 5.70           |     | Kr (92 K.)                                                                              | 5.69           |                  | SnAs                                |
| 6.05           |     | Sr                                                                                      | 5.70           |                  | KH                                  |
| 6.20           |     | X (88 K.)                                                                               | 5.755          |                  | AgBr                                |
|                | A 2 |                                                                                         | 5.76—5.92      |                  | AgBr-AgI                            |
| 2.861          |     | $\alpha$ -Fe                                                                            | 5.83           |                  | NdP                                 |
| 2.875          |     | $\alpha$ -Cr                                                                            | 5.83           |                  | NaCN                                |
| 2.90           |     | $\beta$ -Fe (1070 K.)                                                                   | 5.84           |                  | BaNH                                |
| 2.93           |     | $\delta$ -Fe (1700 K.)                                                                  | 5.87           |                  | SrS                                 |
| 3.03           |     | V                                                                                       | 5.91           |                  | CaSe                                |
| 3.03—3.41      |     | V-C                                                                                     | 5.94           |                  | PbS                                 |
| 3.140          |     | Mo                                                                                      | 5.95           |                  | NaBr                                |
| 3.157          |     | W                                                                                       | 5.957          |                  | EuS                                 |
| 3.295          |     | Cb                                                                                      | 5.96           |                  | NdAs                                |
| 3.30           |     | Ta                                                                                      | 6.00           |                  | PrAs                                |
| 3.32           |     | $\beta$ -Ti (1200 K.)                                                                   | 6.00           |                  | LiI                                 |
| 3.46           |     | Li (~80 K.)                                                                             | 6.01           |                  | CsF                                 |
| 3.50           |     | Li                                                                                      | 6.04           |                  | RbH                                 |
| 3.61           |     | $\beta$ -Zr (1120 K.)                                                                   | 6.05           |                  | $\beta$ -NaSH (>360 K.)             |
| 4.24           |     | Na (~80 K.)                                                                             | 6.06           |                  | CeAs                                |
| 4.29           |     | Na                                                                                      | 6.13           |                  | LaAs                                |
| 5.02           |     | Ba                                                                                      | 6.14           |                  | PbSe                                |
| 5.20           |     | K (120 K.)                                                                              | 6.23           |                  | SrSe                                |
| 5.33           |     | K                                                                                       | 6.278          |                  | KCl                                 |
| 5.62           |     | Rb (~80 K.)                                                                             | 6.285          |                  | SnTe                                |
| 6.05           |     | Cs (~80 K.)                                                                             | 6.31           |                  | NdSb                                |
|                | B 1 |                                                                                         | 6.345          |                  | CaTe                                |
| 4.018          |     | LiF                                                                                     | 6.35           |                  | PrSb                                |
| 4.065          |     | LiD                                                                                     | 6.36           |                  | BaS                                 |
| 4.08           |     | VO                                                                                      | 6.38           |                  | CsH                                 |
| 4.09           |     | LiH                                                                                     | 6.40           |                  | CeSb                                |
| 4.12           |     | (Li <sub>2</sub> TiO <sub>3</sub> )                                                     | 6.44           |                  | PbTe                                |
| 4.12—4.20      |     | (Li <sub>2</sub> TiO <sub>3</sub> -MgO)                                                 | 6.462          |                  | NaI                                 |
| 4.13           |     | VN                                                                                      | 6.45           |                  | PrBi                                |
| 4.14           |     | CrN                                                                                     | 6.48           |                  | LaSb                                |
| 4.14           |     | VC                                                                                      | 6.49           |                  | CeBi                                |
| 4.142          |     | (63Li <sub>2</sub> Fe <sub>2</sub> O <sub>4</sub> ·37Li <sub>2</sub> TiO <sub>3</sub> ) | 6.53           |                  | KCN                                 |
| 4.173          |     | NiO                                                                                     | 6.53           |                  | NH <sub>4</sub> Cl (>457 K.)        |
| 4.207          |     | MgO                                                                                     | 6.56           |                  | RbCl                                |
| 4.282          |     | MgO (1570 K.)                                                                           | 6.57           |                  | LaBi                                |
| 4.225          |     | TiN                                                                                     | 6.58           |                  | KBr                                 |
| 4.235          |     | TiO                                                                                     | 6.59           |                  | BaSe                                |
| 4.24           |     | 80 TiN-20 TiC                                                                           | 6.60           |                  | $\beta$ -KSH (>440 K.)              |
| 4.27           |     | CoO                                                                                     | 6.65           |                  | SrTe                                |
| 4.28           |     | V-N                                                                                     | 6.82           |                  | RbCN                                |
| 4.283          |     | FeO (160 K.)                                                                            | 6.86           |                  | RbBr                                |
| 4.290          |     | FeO (299 K.)                                                                            | 6.90           |                  | NH <sub>4</sub> Br (>411 K.)        |
| 4.30           |     | VC ( $\epsilon$ -phase)                                                                 | 6.93           |                  | $\beta$ -RbSH (470 K.)              |
| 4.315          |     | TiC                                                                                     | 6.99           |                  | BaTe                                |
| 4.40           |     | CbC                                                                                     | 7.052          |                  | KI                                  |
| 4.41           |     | CbN                                                                                     | 7.10           |                  | $\beta$ -CsCl (>730 K.)             |
| 4.426          |     | MnO (117 K.)                                                                            | 7.24           |                  | NH <sub>4</sub> I (>255 K.)         |
| 4.436          |     | MnO (299 K.)                                                                            | 7.325          |                  | RbI                                 |
|                |     |                                                                                         | 6.96 ± 0.04    | H 0 <sub>s</sub> | AgClO <sub>4</sub> (453 ± 20 K.)    |



# LATTICE CONSTANTS FOR CUBIC CRYSTALS (continued)

| $a/\text{\AA}$ | Substance                                                         | $a/\text{\AA}$ | Substance                                 |
|----------------|-------------------------------------------------------------------|----------------|-------------------------------------------|
| 7.16 ± 0.10    | NaClO <sub>4</sub> (618 ± 35 K.)                                  | 3.86           | CeCd                                      |
| 7.49 ± 0.02    | KClO <sub>4</sub> (598 ± 15 K.)                                   | 3.88           | MgPr                                      |
| 7.65 ± 0.05    | TlClO <sub>4</sub> (553 K.)                                       | 3.90           | LaCd                                      |
| 7.65 ± 0.02    | NH <sub>4</sub> ClO <sub>4</sub> (528 ± 15 K.)                    | 3.97           | TlBr                                      |
| 7.68 ± 0.03    | RbClO <sub>4</sub> (583 ± 10 K.)                                  | 3.98           | TlBi                                      |
| 7.97 ± 0.01    | CsClO <sub>4</sub> (513 ± 10 K.)                                  | 4.024          | SrTi                                      |
|                |                                                                   | 4.05           | NH <sub>4</sub> Br (<411 K.)              |
| 4.255          | B 3 CuF                                                           | 4.112          | CsCl                                      |
| 4.36           | CSi IV                                                            | 4.20           | TlI                                       |
| 4.855          | BeS                                                               | 4.20           | CsCl (<720 K.)                            |
| 5.10           | BeSe                                                              | 4.25           | CsCN                                      |
| 5.304          | (Cu, Fe, Mo, Sn) <sub>4</sub> (S, As, Te) <sub>2</sub> , coussite | 4.287          | CsBr                                      |
| 5.41           | CuCl                                                              | 4.29           | CsSH                                      |
| 5.425          | β-ZnS                                                             | 4.37           | NH <sub>4</sub> I (290 K.)                |
| 5.43           | AlP                                                               | 4.56           | CsI                                       |
| 5.44           | GaP                                                               |                |                                           |
| 5.58           | BeTe                                                              | 4.07           | D 2, YB <sub>6</sub>                      |
| 5.60           | MnS (red)                                                         | 4.07           | ErB <sub>6</sub>                          |
| 5.63           | AlAs                                                              | 4.10           | NdB <sub>6</sub>                          |
| 5.635          | GaAs                                                              | 4.12           | GdB <sub>6</sub>                          |
| 5.655          | ZnSe                                                              | 4.12           | PrB <sub>6</sub>                          |
| 5.68           | CuBr                                                              | 4.13           | CeB <sub>6</sub>                          |
| 5.82           | β-CdS                                                             | 4.13           | YbB <sub>6</sub>                          |
| 5.84           | HgS                                                               | 4.14           | CaB <sub>6</sub>                          |
| 5.86           | InP                                                               | 4.15           | LaB <sub>6</sub>                          |
| 6.04           | CdSe                                                              | 4.15           | ThB <sub>6</sub>                          |
| 6.04           | InAs                                                              | 4.19           | SrB <sub>6</sub>                          |
| 6.05           | CuI                                                               | 4.33           | BaB <sub>6</sub>                          |
| 6.07           | HgSe                                                              |                |                                           |
| 6.08           | ZnTe                                                              |                |                                           |
| 6.103          | α-Cu <sub>2</sub> HgI <sub>4</sub>                                | 4.33           | C 1 Be <sub>2</sub> C                     |
| 6.12           | AlSb                                                              | 4.619          | Li <sub>2</sub> O                         |
| 6.12           | GaSb                                                              | 5.06           | (3ZrO <sub>2</sub> ·MgO)                  |
| 6.13           | SnSb                                                              | 5.07           | ZrO <sub>2</sub>                          |
| 6.383          | α-Ag <sub>2</sub> HgI <sub>4</sub>                                | 5.08           | (95ZrO <sub>2</sub> ·5CeO <sub>2</sub> )  |
| 6.40           | HgTe                                                              | 5.13           | (95HfO <sub>2</sub> ·5CeO <sub>2</sub> )  |
| 6.43           | CdTe                                                              | 5.38           | PrO <sub>2</sub>                          |
| 6.45           | InSb                                                              | 5.40           | CeO <sub>2</sub>                          |
| 6.48           | AgI                                                               | 5.40           | CdF <sub>2</sub>                          |
|                |                                                                   | 5.406          | CuF <sub>2</sub>                          |
| 6.195          | B 32 LiGa                                                         | 5.45           | CaF <sub>2</sub>                          |
| 6.209          | LiZn                                                              | 5.47           | UO <sub>2</sub>                           |
| 6.36           | LiAl                                                              | 5.526          | (66CaF <sub>2</sub> ·33YF <sub>3</sub> )  |
| 6.687          | LiCd                                                              | 5.53           | (91CaF <sub>2</sub> ·9ThF <sub>4</sub> )  |
| 6.786          | LiIn                                                              | 5.54           | HgF <sub>2</sub>                          |
| 7.297          | NaIn                                                              | 5.55           | Na <sub>2</sub> O                         |
| 7.373          | (CeMg <sub>3</sub> )                                              | 5.58           | ThO <sub>2</sub>                          |
| 7.373          | (PrMg <sub>3</sub> )                                              | 5.59           | Cu <sub>2</sub> S                         |
| 7.473          | NaTi                                                              | 5.704          | Li <sub>2</sub> S                         |
|                |                                                                   | 5.749          | Cu <sub>2</sub> Se                        |
| 4.437          | B 20 NiSi                                                         | 5.782          | SrF <sub>2</sub>                          |
| 4.438          | FeSi                                                              | 5.796          | EuF <sub>2</sub>                          |
| 4.438          | CoSi                                                              | 5.838          | (66SrF <sub>2</sub> ·33LaF <sub>3</sub> ) |
| 4.548          | MnSi                                                              | 5.91           | PtAl <sub>3</sub>                         |
| 4.620          | CrSi                                                              | 5.91           | PtGa <sub>2</sub>                         |
|                |                                                                   | 5.935          | β-PbF <sub>2</sub> (520 K.)               |
| 2.603          | NiBe                                                              | 5.99           | Al <sub>2</sub> Au                        |
| 2.606          | CoBe                                                              | 6.005          | Li <sub>2</sub> Se                        |
| 2.69           | CuBe                                                              | 6.06           | AuGa <sub>2</sub>                         |
| 2.813          | PdBe                                                              | 6.19           | BaF <sub>2</sub>                          |
| 2.82           | AlNi                                                              | 6.34           | Mg <sub>2</sub> Si                        |
| 2.945          | CuZn                                                              | 6.35           | PtIn <sub>2</sub>                         |
| 2.989          | CuPd                                                              | 6.368          | RaF <sub>2</sub>                          |
| 3.146          | AuZn                                                              | 6.379          | Mg <sub>2</sub> Ge                        |
| 3.156          | AgZn                                                              | 6.436          | K <sub>2</sub> O                          |
| 3.168          | AgLi                                                              | 6.50           | Li <sub>2</sub> Te                        |
| 3.259          | AuMg                                                              | 6.50           | AuIn <sub>2</sub>                         |
| 3.275          | AgMg                                                              | 6.526          | Na <sub>2</sub> S                         |
| 3.287          | HgLi                                                              | 6.763          | Mg <sub>2</sub> Sn                        |
| 3.325          | AgCd                                                              | 6.809          | Na <sub>2</sub> Se                        |
| 3.34           | AuCd (670 K.)                                                     | 6.81           | Mg <sub>2</sub> Pb                        |
| 3.424          | LiTi                                                              | 6.98           | SrCl <sub>2</sub>                         |
| 3.442          | HgMg                                                              | 7.314          | Na <sub>2</sub> Te                        |
| 3.628          | MgTi                                                              | 7.38           | K <sub>2</sub> S                          |
| 3.67           | PrZn                                                              | 7.65           | RbS <sub>2</sub>                          |
| 3.70           | CeZn                                                              | 7.676          | K <sub>2</sub> Se                         |
| 3.73           | AlNd                                                              | 8.152          | K <sub>2</sub> Te                         |
| 3.74           | α-RbCl (83 K.)                                                    |                |                                           |
| 3.75           | LaZn                                                              | 5.94           | C 15 Be <sub>2</sub> Cu                   |
| 3.82           | TiCn                                                              | 6.287          | Be <sub>2</sub> Ag                        |
| 3.82           | PrCd                                                              | 6.435          | Be <sub>2</sub> Ti                        |
| 3.84           | TiSb                                                              | 6.96           | MgNiZn                                    |
| 3.835          | TiCl                                                              | 7.03           | Cu <sub>2</sub> Mg                        |
| 3.847          | CaTi                                                              | 7.61           | W <sub>2</sub> Zr                         |
| 3.86           | NH <sub>4</sub> Cl (<457 K.)                                      | 7.79           | Au <sub>2</sub> Na                        |

# LATTICE CONSTANTS FOR CUBIC CRYSTALS (continued)

| $a/\text{\AA}$ |                  | Substance                                                                              | $a/\text{\AA}$ |                  | Substance                                      |
|----------------|------------------|----------------------------------------------------------------------------------------|----------------|------------------|------------------------------------------------|
| 7.91           |                  | Au <sub>2</sub> Pb                                                                     | 3.83           |                  | NaWO <sub>3</sub>                              |
| 7.94           |                  | Au <sub>2</sub> Bi                                                                     | 3.85           |                  | (Na, Ce, Ca)(Ti, Cb)O <sub>3</sub> Loparite    |
| 8.02           |                  | Al <sub>2</sub> Ca                                                                     | 3.88           |                  | NaTaO <sub>3</sub>                             |
| 8.04           |                  | Al <sub>2</sub> Ce                                                                     | 3.89           |                  | LaGaO <sub>3</sub>                             |
| 8.16           |                  | Al <sub>2</sub> La                                                                     | 3.89           |                  | NaCbO <sub>3</sub>                             |
| 9.50           |                  | Bi <sub>2</sub> K                                                                      | 3.91           |                  | SrTiO <sub>3</sub>                             |
|                | C 2              |                                                                                        | 3.92           |                  | CaSnO <sub>3</sub>                             |
| 5.41           |                  | FeS <sub>2</sub>                                                                       | 3.97           |                  | BaTiO <sub>3</sub>                             |
| 5.42           |                  | (Fe, Ni)S <sub>2</sub> (6.5% Ni)                                                       | 3.98           |                  | KTaO <sub>3</sub>                              |
| 5.57           |                  | RbS <sub>2</sub>                                                                       | 3.99           |                  | CaZrO <sub>3</sub>                             |
| 5.57           |                  | RuS <sub>2</sub>                                                                       | 4.00           |                  | KMgF <sub>3</sub>                              |
| 5.57           |                  | Bravoite (53.8% NiS <sub>2</sub> , 39.1% FeS <sub>2</sub> ,<br>7.1% CoS <sub>2</sub> ) | 4.005          |                  | KNiF <sub>3</sub>                              |
| 5.62           |                  | OsS <sub>2</sub>                                                                       | 4.01           |                  | KCbO <sub>3</sub>                              |
| 5.64           |                  | CoS <sub>2</sub>                                                                       | 4.03           |                  | SrSnO <sub>3</sub>                             |
| 5.65           |                  | (Cu, Ni, Co, Fe)(S, Se) <sub>2</sub>                                                   | 4.05           |                  | KZnF <sub>3</sub>                              |
| 5.68           |                  | PtP <sub>2</sub>                                                                       | 4.07           |                  | KCoF <sub>3</sub>                              |
| 5.74           |                  | NiS <sub>2</sub>                                                                       | 4.07           |                  | SrHfO <sub>3</sub>                             |
| 5.85           |                  | CoSe <sub>2</sub>                                                                      | 4.09           |                  | SrZrO <sub>3</sub>                             |
| 5.92           |                  | RuSe <sub>2</sub>                                                                      | 4.18           |                  | BaZrO <sub>3</sub>                             |
| 5.93           |                  | OsSe <sub>2</sub>                                                                      | 4.35           |                  | BaPrO <sub>3</sub>                             |
| 5.94           |                  | PtAs <sub>2</sub>                                                                      | 4.38           |                  | BaCeO <sub>3</sub>                             |
| 5.97           |                  | PdAs <sub>2</sub>                                                                      | 4.46           |                  | KIO <sub>3</sub>                               |
| 6.02           |                  | NiSe <sub>2</sub>                                                                      | 4.48           |                  | BaThO <sub>3</sub>                             |
| 6.096          |                  | MnS <sub>2</sub>                                                                       | 4.5            |                  | NH <sub>4</sub> IO <sub>3</sub>                |
| 6.36           |                  | RuTe <sub>2</sub>                                                                      | 4.52           |                  | RbIO <sub>3</sub>                              |
| 6.37           |                  | OsTe <sub>2</sub>                                                                      | 4.66           |                  | CsIO <sub>3</sub>                              |
| 6.43           |                  | PtSb <sub>2</sub>                                                                      | 5.12           |                  | MgZrO <sub>3</sub>                             |
| 6.44           |                  | PdSb <sub>2</sub>                                                                      | 5.20           |                  | CsCdCl <sub>3</sub>                            |
| 6.64           |                  | AuSb <sub>2</sub>                                                                      | 5.33           |                  | CsCdBr <sub>3</sub>                            |
| 6.94           |                  | MnTe <sub>2</sub>                                                                      | 5.44           |                  | CsHgCl <sub>3</sub>                            |
|                | C 3              |                                                                                        | 5.77           |                  | CsHgBr <sub>3</sub>                            |
| 4.25           |                  | Cu <sub>2</sub> O                                                                      | 6.57           | G 0 <sub>3</sub> | NaClO <sub>3</sub>                             |
| 4.73           |                  | Ag <sub>2</sub> O                                                                      | 6.71           |                  | NaBrO <sub>3</sub>                             |
|                | F 1              |                                                                                        |                | G 2 <sub>1</sub> |                                                |
| 5.55           |                  | CoAsS                                                                                  | 7.60           |                  | Ca(NO <sub>3</sub> ) <sub>2</sub>              |
| 5.68           |                  | NiAsS                                                                                  | 7.81           |                  | Sr(NO <sub>3</sub> ) <sub>2</sub>              |
| 5.90           |                  | NiSbS                                                                                  | 7.84           |                  | Pb(NO <sub>3</sub> ) <sub>2</sub>              |
|                |                  | (Ni, Fe)AsS, plessite                                                                  | 8.11           |                  | Ba(NO <sub>3</sub> ) <sub>2</sub>              |
|                |                  | Ni(As, Sb)S, corynite                                                                  |                | H 1 <sub>1</sub> |                                                |
|                |                  | Ni(Sb, Bi)S, kalliite                                                                  | 8.045          |                  | NiAl <sub>2</sub> O <sub>4</sub>               |
|                |                  | (Co, Ni)SbS, willyamite                                                                | 8.07           |                  | CuAl <sub>2</sub> O <sub>4</sub>               |
|                | D 5 <sub>1</sub> |                                                                                        | 8.07           |                  | CoCo <sub>2</sub> O <sub>4</sub>               |
| 8.13           |                  | Be <sub>2</sub> N <sub>2</sub>                                                         | 8.07           |                  | MgAl <sub>2</sub> O <sub>4</sub>               |
| 9.37           |                  | (Mn, Fe) <sub>2</sub> O <sub>3</sub>                                                   | 8.08           |                  | CoAl <sub>2</sub> O <sub>4</sub>               |
| 9.42           |                  | Mn <sub>2</sub> O <sub>3</sub>                                                         | 8.08           |                  | ZnAl <sub>2</sub> O <sub>4</sub>               |
| 9.74           |                  | Zn <sub>2</sub> N <sub>2</sub>                                                         | 8.10           |                  | FeAl <sub>2</sub> O <sub>4</sub>               |
| 9.79           |                  | Sc <sub>2</sub> O <sub>3</sub>                                                         | 8.11           |                  | (Ni, Co)(Co, Ni) <sub>2</sub> O <sub>4</sub>   |
| 9.94           |                  | Mg <sub>2</sub> N <sub>2</sub>                                                         | 8.11           |                  | (Zn, Co)Co <sub>2</sub> O <sub>4</sub>         |
| 10.12          |                  | In <sub>2</sub> O <sub>3</sub>                                                         | 8.11           |                  | MgCo <sub>2</sub> O <sub>4</sub>               |
| 10.15          |                  | Be <sub>2</sub> P <sub>2</sub>                                                         | 8.27           |                  | MnAl <sub>2</sub> O <sub>4</sub>               |
| 10.37          |                  | Lu <sub>2</sub> O <sub>3</sub>                                                         | 8.27           |                  | (Mn, Co)(Co, Mn) <sub>2</sub> O <sub>4</sub>   |
| 10.39          |                  | Yb <sub>2</sub> O <sub>3</sub>                                                         |                | H 1 <sub>1</sub> |                                                |
| 10.52          |                  | Tm <sub>2</sub> O <sub>3</sub>                                                         | 8.28           |                  | MgGa <sub>2</sub> O <sub>4</sub>               |
| 10.54          |                  | Er <sub>2</sub> O <sub>3</sub>                                                         | 8.30           |                  | NiCr <sub>2</sub> O <sub>4</sub>               |
| 10.57          |                  | Tl <sub>2</sub> O <sub>3</sub>                                                         | 8.30           |                  | MgCr <sub>2</sub> O <sub>4</sub>               |
| 10.58          |                  | Ho <sub>2</sub> O <sub>3</sub>                                                         | 8.31           |                  | ZnCr <sub>2</sub> O <sub>4</sub>               |
| 10.60          |                  | Y <sub>2</sub> O <sub>3</sub>                                                          | 8.32           |                  | CoCr <sub>2</sub> O <sub>4</sub>               |
| 10.63          |                  | Dy <sub>2</sub> O <sub>3</sub>                                                         | 8.32           |                  | ZnGa <sub>2</sub> O <sub>4</sub>               |
| 10.70          |                  | Tb <sub>2</sub> O <sub>3</sub>                                                         | 8.35           |                  | NiFe <sub>2</sub> O <sub>4</sub>               |
| 10.79          |                  | Gd <sub>2</sub> O <sub>3</sub>                                                         | 8.35           |                  | Cu <sub>2</sub> Cr <sub>2</sub> O <sub>4</sub> |
| 10.79          |                  | Cd <sub>2</sub> N <sub>2</sub>                                                         | 8.35           |                  | FeCr <sub>2</sub> O <sub>4</sub>               |
| 10.84          |                  | Eu <sub>2</sub> O <sub>3</sub>                                                         | 8.36           |                  | MgFe <sub>2</sub> O <sub>4</sub>               |
| 10.85          |                  | Sm <sub>2</sub> O <sub>3</sub>                                                         | 8.38           |                  | CoFe <sub>2</sub> O <sub>4</sub>               |
| 11.05          |                  | Nd <sub>2</sub> O <sub>3</sub>                                                         | 8.38           |                  | NiMn <sub>2</sub> O <sub>4</sub>               |
| 11.40          |                  | $\alpha$ -Ca <sub>2</sub> N <sub>2</sub>                                               | 8.40           |                  | ZnFe <sub>2</sub> O <sub>4</sub>               |
| 12.02          |                  | Mg <sub>3</sub> P <sub>2</sub>                                                         | 8.40           |                  | FeFe <sub>2</sub> O <sub>4</sub>               |
| 12.33          |                  | Mg <sub>3</sub> As <sub>2</sub>                                                        | 8.42           |                  | (Mn, Mg)Fe <sub>2</sub> O <sub>4</sub>         |
|                | D 6 <sub>1</sub> |                                                                                        | 8.42           |                  | TiCo <sub>2</sub> O <sub>4</sub>               |
| 11.05          |                  | As <sub>4</sub> O <sub>6</sub>                                                         | 8.43           |                  | MnCr <sub>2</sub> O <sub>4</sub>               |
| 11.14          |                  | Sb <sub>4</sub> O <sub>6</sub>                                                         | 8.43           |                  | TiMg <sub>2</sub> O <sub>4</sub>               |
|                | D 1 <sub>1</sub> |                                                                                        | 8.43           |                  | TiZn <sub>2</sub> O <sub>4</sub>               |
| 10.32          |                  | ZrCl <sub>4</sub>                                                                      | 8.44           |                  | CuFe <sub>2</sub> O <sub>4</sub>               |
| 11.25          |                  | TiBr <sub>4</sub>                                                                      | 8.47           |                  | FeV <sub>2</sub> O <sub>4</sub>                |
| (11.34)        |                  | (CBr <sub>4</sub> ) (>320 K.)                                                          | 8.49           |                  | MnCr <sub>2</sub> O <sub>4</sub>               |
| (11.62)        |                  | (Cl <sub>4</sub> )                                                                     | 8.50           |                  | TiFe <sub>2</sub> O <sub>4</sub>               |
| 11.89          |                  | GeI <sub>4</sub>                                                                       | 8.54           |                  | MnFe <sub>2</sub> O <sub>4</sub>               |
| 11.99          |                  | SiI <sub>4</sub>                                                                       | 8.58           |                  | CdCr <sub>2</sub> O <sub>4</sub>               |
| 12.00          |                  | TiI <sub>4</sub>                                                                       | 8.58           |                  | SnMg <sub>2</sub> O <sub>4</sub>               |
| 12.23          |                  | SnI <sub>4</sub>                                                                       | 8.61           |                  | SnCo <sub>2</sub> O <sub>4</sub>               |
|                | E 2 <sub>1</sub> |                                                                                        | 8.63           |                  | SnZn <sub>2</sub> O <sub>4</sub>               |
| 3.67           |                  | YAlO <sub>3</sub>                                                                      | 8.67           |                  | CdFe <sub>2</sub> O <sub>4</sub>               |
| 3.75           |                  | CdTiO <sub>3</sub>                                                                     | 8.67           |                  | TiMn <sub>2</sub> O <sub>4</sub>               |
| 3.78           |                  | LaAlO <sub>3</sub>                                                                     | 8.81           |                  | MgIn <sub>2</sub> O <sub>4</sub>               |
| 3.80           |                  | CaTiO <sub>3</sub>                                                                     | 9.26           |                  | Ag <sub>2</sub> MoO <sub>4</sub>               |

# LATTICE CONSTANTS FOR CUBIC CRYSTALS (continued)

| $a/\text{\AA}$ | Substance                                                                                              | $a/\text{\AA}$ | Substance                                                                          |
|----------------|--------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------|
| 9.4            | $\text{CoCo}_2\text{S}_4$                                                                              | 10.47          | $\text{Mg}(\text{NH}_3)_6\text{Br}_2$                                              |
| 9.45           | $(\text{Co}, \text{Ni})_3\text{S}_4$                                                                   | 10.48          | $\text{K}_2\text{SnBr}_6$                                                          |
| 9.46           | $\text{CuCo}_2\text{O}_4$                                                                              | 10.51          | $\text{Co}(\text{NH}_3)_6\text{SO}_4\text{Br}$                                     |
| 9.5            | $\text{NiN}_2\text{S}_4$                                                                               | 10.52          | $\text{Mn}(\text{NH}_3)_6\text{Br}_2$                                              |
| 9.92           | $\text{ZnCr}_2\text{S}_4$                                                                              | 10.54          | $\text{Sr}_2\text{Ni}(\text{NO}_2)_6$                                              |
| 10.05          | $\text{MnCr}_2\text{S}_4$                                                                              | 10.55          | $\text{Pb}_2\text{Ni}(\text{NO}_2)_6$                                              |
| 10.19          | $\text{CdCr}_2\text{S}_4$                                                                              | 10.57          | $(\text{NH}_4)_2\text{SnBr}_6$                                                     |
| 12.54          | $\text{K}_2\text{Zn}(\text{CN})_4$                                                                     | 10.58          | $\text{Rb}_2\text{SnBr}_6$                                                         |
| 12.76          | $\text{K}_2\text{Hg}(\text{CN})_4$                                                                     | 10.62          | $\text{Co}(\text{NH}_3)_5\text{H}_2\text{OSO}_4\text{I}$                           |
| 12.84          | $\text{K}_2\text{Cd}(\text{CN})_4$                                                                     | 10.63          | $\text{Co}(\text{NH}_3)_6\text{SeO}_4\text{Br}$                                    |
|                | H 5 <sub>h</sub>                                                                                       | 10.67          | $\text{Ba}_2\text{Ni}(\text{NO}_2)_6$                                              |
| 10.08          | $2\text{Na}_2\text{SO}_4 \cdot \text{NaCl} \cdot \text{NaF}$                                           | 10.71          | $\text{Ca}(\text{NH}_3)_6\text{Br}_2$                                              |
|                | H 4 <sub>13</sub>                                                                                      | 10.71          | $\text{Co}(\text{NH}_3)_6\text{SO}_4\text{I}$                                      |
| 12.11          | $\text{KCr}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$                                                 | 10.77          | $\text{Cs}_2\text{SnBr}_6$                                                         |
| 12.12          | $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$                                                 | 10.79          | $\text{Co}(\text{NH}_3)_6\text{SeO}_4\text{I}$                                     |
| 12.15          | $\text{NH}_4\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$                                       | 10.9           | $\text{Ni}(\text{NH}_3)_6\text{I}_2$                                               |
| 12.20          | $\text{RbAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$                                                | 10.91          | $\text{Co}(\text{NH}_3)_6\text{I}_2$                                               |
| 12.21          | $\text{TiAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$                                                | 10.96          | $\text{Zn}(\text{NH}_3)_6\text{I}_2$                                               |
| 12.31          | $\text{CsAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$                                                | 10.97          | $\text{Fe}(\text{NH}_3)_6\text{I}_2$                                               |
| 12.44          | $\text{NH}_3 \cdot \text{CH}_3\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O} (\beta\text{-alum})$ | 10.98          | $\text{Mg}(\text{NH}_3)_6\text{I}_2$                                               |
|                | Langbeinite                                                                                            | 11.04          | $\text{Mn}(\text{NH}_3)_6\text{I}_2$                                               |
| 9.93           | $\text{K}_2\text{Mg}(\text{SO}_4)_2$                                                                   | 11.04          | $\text{Cd}(\text{NH}_3)_6\text{I}_2$                                               |
| 10.2           | $\text{K}_2(\text{Ca}_2\text{Mg})\text{SO}_4$                                                          | 11.24          | $\text{Ca}(\text{NH}_3)_6\text{I}_2$                                               |
|                | H 2 <sub>1</sub>                                                                                       | 11.27          | $\text{Ni}(\text{NH}_3)_6(\text{BF}_4)_2$                                          |
| 6.00           | $\text{Ag}_3\text{PO}_4$                                                                               | 11.3           | $\text{Co}(\text{NH}_3)_6(\text{BF}_4)_2$                                          |
| 6.120          | $\text{Ag}_3\text{AsO}_4 (90 \text{ K})$                                                               | (11.3)         | $\text{Zn}(\text{NH}_3)_6(\text{ClO}_4)_2$                                         |
| 6.130          | $\text{Ag}_3\text{AsO}_4 (380 \text{ K})$                                                              | 11.34          | $\text{Mg}(\text{NH}_3)_6(\text{BF}_4)_2$                                          |
|                | H 2 <sub>4</sub>                                                                                       | 11.34          | $\text{Fe}(\text{NH}_3)_6(\text{BF}_4)_2$                                          |
| 5.37           | $\text{Cu}_3\text{VS}_4$                                                                               | 11.37          | $\text{Mn}(\text{NH}_3)_6(\text{BF}_4)_2$                                          |
|                | J 1 <sub>1</sub>                                                                                       | 11.38          | $\text{Cd}(\text{NH}_3)_6(\text{BF}_4)_2$                                          |
| 8.17           | $\text{K}_2\text{SiF}_6$                                                                               | 11.41          | $\text{Ni}(\text{NH}_3)_6(\text{ClO}_4)_2$                                         |
| 8.35           | $(\text{NH}_4)_2\text{SiF}_6$                                                                          | 11.43          | $\text{Co}(\text{NH}_3)_6(\text{ClO}_4)_2$                                         |
| 8.38           | $\text{Rb}_2\text{CrF}_6 \cdot \text{H}_2\text{O}$                                                     | 11.46          | $\text{Ni}(\text{NH}_3)_6(\text{SO}_4\text{F})_2$                                  |
| 8.41           | $\text{Ti}_2\text{CrF}_6 \cdot \text{H}_2\text{O}$                                                     | 11.49          | $\text{Co}(\text{NH}_3)_6(\text{SO}_4\text{F})_2$                                  |
| 8.42           | $(\text{NH}_4)_2\text{VF}_6 \cdot \text{H}_2\text{O}$                                                  | 11.52          | $\text{Fe}(\text{NH}_3)_6(\text{ClO}_4)_2$                                         |
| 8.42           | $\text{Rb}_2\text{VF}_6 \cdot \text{H}_2\text{O}$                                                      | 11.53          | $\text{Mg}(\text{NH}_3)_6(\text{ClO}_4)_2$                                         |
| 8.45           | $\text{Ti}_2\text{VF}_6 \cdot \text{H}_2\text{O}$                                                      | 11.54          | $\text{Cd}(\text{NH}_3)_6\text{Br}_2$                                              |
| 8.45           | $\text{Rb}_2\text{SiF}_6$                                                                              | 11.54          | $\text{Fe}(\text{NH}_3)_6(\text{SO}_4\text{F})_2$                                  |
| 8.58           | $\text{Ti}_2\text{SiF}_6$                                                                              | 11.58          | $\text{Mn}(\text{NH}_3)_6(\text{ClO}_4)_2$                                         |
| 8.87           | $\text{Cs}_2\text{SiF}_6$                                                                              | 11.59          | $\text{Cd}(\text{NH}_3)_6(\text{ClO}_4)_2$                                         |
| 8.99           | $\text{Cs}_2\text{GeF}_6$                                                                              | 11.59          | $\text{Mn}(\text{NH}_3)_6(\text{SO}_4\text{F})_2$                                  |
| 9.73           | $\text{K}_2\text{PtCl}_6$                                                                              | 11.62          | $\text{Cd}(\text{NH}_3)_6(\text{SO}_4\text{F})_2$                                  |
| 9.73           | $\text{K}_2\text{OsCl}_6$                                                                              | 11.91          | $\text{Ni}(\text{NH}_3)_6(\text{PF}_6)_2$                                          |
| 9.76           | $\text{Ti}_2\text{PtCl}_6$                                                                             | 11.94          | $\text{Co}(\text{NH}_3)_6(\text{PF}_6)_2$                                          |
| 9.84           | $(\text{NH}_4)_2\text{PtCl}_6$                                                                         | 12.03          | $\text{Ni}(\text{NH}_3 \cdot \text{CH}_3)_6\text{I}_2$                             |
| 9.86           | $\text{K}_2\text{ReCl}_6$                                                                              | 12.05          | $\text{Co}(\text{NH}_3 \cdot \text{CH}_3)_6\text{I}_2$                             |
| 9.88           | $\text{Rb}_2\text{PtCl}_6$                                                                             | 12.19          | $\{\text{NH}(\text{CH}_3)_2\}_2\text{SnCl}_6$                                      |
| 9.92           | $\text{Rb}_2\text{TiCl}_6$                                                                             | 12.41          | $\{\text{S}(\text{CH}_3)_2\}_2\text{SnCl}_6$                                       |
| 9.94           | $(\text{NH}_4)_2\text{SeCl}_6$                                                                         | 12.65          | $\{\text{N}(\text{CH}_3)_2\}_2\text{PtCl}_6$                                       |
| 9.97           | $\text{K}_2\text{SnCl}_6$                                                                              | 12.80          | $\{\text{S}(\text{CH}_3)_2\}_2\text{C}_2\text{H}_5\text{SnCl}_6$                   |
| 9.97           | $\text{Ti}_2\text{SnCl}_6$                                                                             | 12.87          | $\{\text{N}(\text{CH}_3)_2\}_2\text{SnCl}_6$                                       |
| 9.98           | $\text{Rb}_2\text{SeCl}_6$                                                                             | 13.17          | $\{\text{N}(\text{CH}_3)_2\}_2\text{CH}_3\text{SnCl}_6$                            |
| 10.02          | $\text{Rb}_2\text{PdBr}_6$                                                                             | 13.51          | $\{\text{N}(\text{CH}_3)(\text{C}_2\text{H}_5)_2\}_2\text{SnCl}_6$                 |
| 10.04          | $(\text{NH}_4)_2\text{SnCl}_6$                                                                         | 13.93          | $\{\text{P}(\text{CH}_3)(\text{C}_2\text{H}_5)_2\}_2\text{SnCl}_6$                 |
| 10.08          | $\text{Ni}(\text{NH}_3)_6\text{Cl}_2$                                                                  |                | J 2 <sub>1</sub> and Related Structures                                            |
| 10.10          | $\text{Rb}_2\text{SnCl}_6$                                                                             | 8.88           | $\text{Li}_2\text{FeF}_6$                                                          |
| 10.10          | $\text{Co}(\text{NH}_3)_6\text{Cl}_2$                                                                  | 8.90           | $(\text{NH}_4)_2\text{AlF}_6$                                                      |
| 10.11          | $\text{Ti}_2\text{TeCl}_6$                                                                             | 9.01           | $(\text{NH}_4)_2\text{CrF}_6$                                                      |
| 10.14          | $(\text{NH}_4)_2\text{PbCl}_6$                                                                         | 9.04           | $(\text{NH}_4)_2\text{VF}_6$                                                       |
| 10.14          | $\text{K}_2\text{TeCl}_6$                                                                              | 9.10           | $(\text{NH}_4)_2\text{FeF}_6$                                                      |
| 10.15          | $\text{Fe}(\text{NH}_3)_6\text{Cl}_2$                                                                  | 9.10           | $(\text{NH}_4)_2\text{MoO}_4\text{F}_2$                                            |
| 10.16          | $\text{Mg}(\text{NH}_3)_6\text{Cl}_2$                                                                  | 9.26           | $\text{Na}_2\text{FeF}_6$                                                          |
| 10.17          | $\text{Cs}_2\text{PtCl}_6$                                                                             | 9.93           | $\text{K}_2\text{FeF}_6$                                                           |
|                | J 1 <sub>1</sub>                                                                                       | 9.96           | $\text{CuLi}_2\text{Fe}(\text{CN})_6$                                              |
| 10.18          | $\text{Rb}_2\text{ZrCl}_6$                                                                             | 10.0           | $\text{CuR}_2\text{Fe}(\text{CN})_6 \text{ R} = \text{Na, K, Rb, NH}_4, \text{Ti}$ |
| 10.18          | $(\text{NH}_4)_2\text{TeCl}_6$                                                                         | 10.15          | $\text{K}_2\text{CdFe}(\text{NO}_2)_6$                                             |
| 10.20          | $\text{Mn}(\text{NH}_3)_6\text{Cl}_2$                                                                  | 10.17          | $\text{K}_2\text{CaCo}(\text{NO}_2)_6$                                             |
| 10.20          | $\text{Rb}_2\text{PbCl}_6$                                                                             | 10.19          | $\text{K}_2\text{CaFe}(\text{NO}_2)_6$                                             |
| 10.22          | $\text{Cs}_2\text{TiCl}_6$                                                                             | 10.2           | $\text{Fe}^{III}\text{RFe}^{II}(\text{CN})_6 \text{ R} = \text{Na, K, Rb, NH}_4$   |
| 10.23          | $\text{Rb}_2\text{TeCl}_6$                                                                             | 10.22          | $\text{K}_2\text{HgFe}(\text{NO}_2)_6$                                             |
| 10.25          | $\text{Zn}(\text{NH}_3)_6(\text{ClH}_4)_2$                                                             | 10.23          | $\text{K}_2\text{SrCo}(\text{NO}_2)_6$                                             |
| 10.26          | $\text{Cs}_2\text{SeCl}_6$                                                                             | 10.25          | $(\text{NH}_4)_2\text{CaFe}(\text{NO}_2)_6$                                        |
| 10.30          | $\text{K}_2\text{OSBr}_6$                                                                              | 10.25          | $\text{NaTi}_2\text{Co}(\text{NO}_2)_6$                                            |
| 10.35          | $\text{Cs}_2\text{SnCl}_6$                                                                             | 10.28          | $\text{K}_2\text{CdNi}(\text{NO}_2)_6$                                             |
| 10.36          | $\text{K}_2\text{SeBr}_6$                                                                              | 10.28          | $(\text{NH}_4)_2\text{CdFe}(\text{NO}_2)_6$                                        |
| 10.36          | $\text{K}_2\text{PtBr}_6$                                                                              | 10.29          | $\text{K}_2\text{HgNi}(\text{NO}_2)_6$                                             |
| 10.39          | $\text{Co}(\text{NH}_3)_6\text{Br}_2$                                                                  | 10.30          | $\text{K}_2\text{SrFe}(\text{NO}_2)_6$                                             |
| 10.4           | $\text{Ni}(\text{NH}_3)_6\text{Br}_2$                                                                  | 10.30          | $\text{Ti}_2\text{CaFe}(\text{NO}_2)_6$                                            |
| 10.41          | $\text{Cs}_2\text{ZrCl}_6$                                                                             | 10.31          | $\text{K}_2\text{PbFe}(\text{NO}_2)_6$                                             |
| 10.42          | $\text{Cs}_2\text{PbCl}_6$                                                                             | 10.32          | $\text{K}_2\text{CaNi}(\text{NO}_2)_6$                                             |
| 10.45          | $\text{Cs}_2\text{TeCl}_6$                                                                             | 10.34          | $(\text{NH}_4)_2\text{SrFe}(\text{NO}_2)_6$                                        |
| 10.45          | $\text{Co}(\text{NH}_3)_5\text{H}_2\text{OSO}_4\text{Br}$                                              | 10.37          | $(\text{NH}_4)_2\text{PbFe}(\text{NO}_2)_6$                                        |
| 10.46          | $(\text{NH}_4)_2\text{SeBr}_6$                                                                         | 10.37          | $\text{Ti}_2\text{CdNi}(\text{NO}_2)_6$                                            |
| 10.46          | $\text{Zn}(\text{NH}_3)_6\text{Br}_2$                                                                  | 10.39          | $\text{Ti}_2\text{PbFe}(\text{NO}_2)_6$                                            |
| 10.47          | $\text{Fe}(\text{NH}_3)_6\text{Br}_2$                                                                  |                |                                                                                    |

# LATTICE CONSTANTS FOR CUBIC CRYSTALS (continued)

| $a/\text{\AA}$ | Substance                                                                               |
|----------------|-----------------------------------------------------------------------------------------|
| 10.39          | NaRb <sub>2</sub> Co(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.40          | Tl <sub>2</sub> SrFe(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.4           | K <sub>2</sub> PbCo(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.41          | (NH <sub>4</sub> ) <sub>2</sub> CdNi(NO <sub>2</sub> ) <sub>6</sub>                     |
| 10.42          | Tl <sub>2</sub> HgNi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.43          | K <sub>2</sub> BaFe(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.45          | K <sub>2</sub> BaCo(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.45          | K <sub>2</sub> Co(NO <sub>2</sub> ) <sub>6</sub>                                        |
| 10.46          | (NH <sub>4</sub> ) <sub>2</sub> HgNi(NO <sub>2</sub> ) <sub>6</sub>                     |
| 10.47          | Rb <sub>2</sub> HgNi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.49          | K <sub>2</sub> SrNi(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.49          | K <sub>4</sub> Ni(NO <sub>2</sub> ) <sub>6</sub>                                        |
| 10.50          | (NH <sub>4</sub> ) <sub>2</sub> BaFe(NO <sub>2</sub> ) <sub>6</sub>                     |
| 10.54          | K <sub>2</sub> LiBi(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.55          | K <sub>2</sub> PbNi(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.55          | Tl <sub>2</sub> BaFe(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.58          | Rb <sub>2</sub> CdNi, Cd(NO <sub>2</sub> ) <sub>6</sub>                                 |
| 10.58          | K <sub>2</sub> Ir(NO <sub>2</sub> ) <sub>6</sub>                                        |
| 10.59          | Rb <sub>2</sub> LiBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.6           | K <sub>2</sub> PbCu(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.63          | K <sub>2</sub> Rh(NO <sub>2</sub> ) <sub>6</sub>                                        |
| 10.63          | (NH <sub>4</sub> ) <sub>2</sub> LiBi(NO <sub>2</sub> ) <sub>6</sub>                     |
| 10.64          | Tl <sub>2</sub> LiBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.67          | K <sub>2</sub> BaNi(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.70          | NaCs <sub>2</sub> Co(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.70          | Ba <sub>2</sub> {Rh(NO <sub>2</sub> ) <sub>6</sub> } <sub>2</sub>                       |
| 10.72          | Tl <sub>2</sub> Co(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 10.73          | Rb <sub>2</sub> Co(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 10.73          | (NH <sub>4</sub> ) <sub>2</sub> Ir(NO <sub>2</sub> ) <sub>6</sub>                       |
| 10.73          | Tl <sub>2</sub> Ir(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 10.77          | Rb <sub>2</sub> Ir(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 10.8           | (NH <sub>4</sub> ) <sub>2</sub> Co(NO <sub>2</sub> ) <sub>6</sub>                       |
| 10.81          | Cs <sub>2</sub> Cd{Ni, Cd(NO <sub>2</sub> ) <sub>6</sub> }                              |
| 10.82          | Co(NH <sub>3</sub> ) <sub>6</sub> H <sub>2</sub> OI <sub>3</sub>                        |
| 10.83          | Rb <sub>2</sub> Rh(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 10.88          | K <sub>2</sub> NaBi(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.89          | Co(NH <sub>3</sub> ) <sub>6</sub> I <sub>3</sub>                                        |
| 10.91          | Tl <sub>2</sub> Rh(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 10.91          | (NH <sub>4</sub> ) <sub>2</sub> Rh(NO <sub>2</sub> ) <sub>6</sub>                       |
| 10.94          | Cs <sub>2</sub> LiBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.95          | K <sub>2</sub> AgBi(NO <sub>2</sub> ) <sub>6</sub>                                      |
| 10.98          | Rb <sub>2</sub> NaBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 10.99          | (NH <sub>4</sub> ) <sub>2</sub> NaBi(NO <sub>2</sub> ) <sub>6</sub>                     |
| 11.01          | Tl <sub>2</sub> NaBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 11.05          | Rb <sub>2</sub> AgBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 11.06          | Tl <sub>2</sub> AgBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 11.10          | (NH <sub>4</sub> ) <sub>2</sub> AgBi(NO <sub>2</sub> ) <sub>6</sub>                     |
| 11.15          | Cs <sub>2</sub> NaBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 11.15          | Cs <sub>2</sub> Co(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 11.17          | Cs <sub>2</sub> Ir(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 11.19          | Cs <sub>2</sub> Bi(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 11.19          | Cs <sub>2</sub> AgBi(NO <sub>2</sub> ) <sub>6</sub>                                     |
| 11.21          | Co(NH <sub>3</sub> ) <sub>6</sub> (BF <sub>4</sub> ) <sub>3</sub>                       |
| 11.30          | Cs <sub>2</sub> Rh(NO <sub>2</sub> ) <sub>6</sub>                                       |
| 11.32          | {Co(NH <sub>3</sub> ) <sub>6</sub> · H <sub>2</sub> O}(ClO <sub>4</sub> ) <sub>3</sub>  |
| 11.39          | Co(NH <sub>3</sub> ) <sub>6</sub> (ClO <sub>4</sub> ) <sub>3</sub>                      |
| 11.67          | Co(NH <sub>3</sub> ) <sub>6</sub> (PF <sub>6</sub> )                                    |
|                | K 6 <sub>1</sub>                                                                        |
| 7.46           | SiP <sub>2</sub> O <sub>7</sub>                                                         |
| 7.80           | TiP <sub>2</sub> O <sub>7</sub>                                                         |
| 7.98           | SnP <sub>2</sub> O <sub>7</sub>                                                         |
| 8.18           | HfP <sub>2</sub> O <sub>7</sub>                                                         |
| 8.20           | ZrP <sub>2</sub> O <sub>7</sub>                                                         |
| 8.61           | UP <sub>2</sub> O <sub>7</sub>                                                          |
|                | S 1 <sub>4</sub>                                                                        |
| 11.51          | Al <sub>2</sub> (Mg, Fe) <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> , pyrope         |
| 11.51          | Al <sub>2</sub> Fe <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> , almandite            |
| 11.60          | Al <sub>2</sub> Mn <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> , spessartite          |
| 11.87          | Al <sub>2</sub> Ca <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> , grossularite         |
| 11.89          | (Al, Fe) <sub>2</sub> Ca <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> , hessonite      |
| 11.95          | Cr <sub>2</sub> Ca <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> , uvarovite            |
| 12.03          | Fe <sub>2</sub> Ca <sub>3</sub> (SiO <sub>4</sub> ) <sub>3</sub> , andradite            |
| 12.10          | (Na, Li) <sub>3</sub> AlF <sub>6</sub> , cryolithionite                                 |
| 12.35—12.46    | (Mg, Mn) <sub>2</sub> (Ca, Na) <sub>3</sub> AsO <sub>4</sub> ) <sub>3</sub> , berzelite |
|                | S 6 <sub>1</sub>                                                                        |
| 13.68          | NaAlSi <sub>2</sub> O <sub>6</sub> H <sub>2</sub> O                                     |
|                | S 0 <sub>6</sub>                                                                        |
| 13.82          | Al <sub>12</sub> Si <sub>5</sub> O <sub>20</sub> (OH, F) <sub>18</sub> Cl, zunyite      |
|                | S 6 <sub>2</sub>                                                                        |
| 8.87           | Na <sub>4</sub> (AlSiO <sub>4</sub> ) <sub>3</sub> Cl, sodalite                         |
|                | Tetrahedrite                                                                            |
| 10.19          | (Cu, Fe) <sub>12</sub> As <sub>4</sub> S <sub>13</sub> , binnite                        |
| 10.2—10.6      | (Cu, Ag) <sub>10</sub> (Zn, Fe) <sub>2</sub> (Sb, As) <sub>4</sub> S <sub>13</sub>      |

### LATTICE SPACING OF COMMON ANALYZING CRYSTALS

| Crystal           | Reflection plane | <i>d</i> Spacing (Å) | Crystal          | Reflection plane | <i>d</i> Spacing (Å) |
|-------------------|------------------|----------------------|------------------|------------------|----------------------|
| ADP <sup>a</sup>  | 101              | 5.31                 | Lead stearate    |                  | 51                   |
| ADP <sup>a</sup>  | 110              | 5.325                | LiF              | 200              | 2.014                |
| ADP <sup>a</sup>  | 200              | 3.75                 | LiF              | 220              | 1.424                |
| Beryl             | 10 $\bar{1}$ 0   | 7.98                 | Mica             | 002              | 9.96                 |
| Calcite           | 100              | 3.036                | NaCl             | 200              | 2.820                |
| EDDT <sup>b</sup> | 020              | 4.404                | Oxalic acid      | 001              | 5.85                 |
| Germanium         | 111              | 3.265                | PET <sup>d</sup> | 002              | 4.371                |
| Graphite          | 001              | 6.69                 | Quartz           | 10 $\bar{1}$ 0   | 4.225                |
| Gypsum            | 010              | 7.600                | Quartz           | 10 $\bar{1}$ 1   | 3.343                |
| KAP <sup>c</sup>  | 001              | 13.32                | Quartz           | 11 $\bar{2}$ 0   | 2.456                |
| KBr               | 200              | 3.29                 | Silicon          | 111              | 3.13                 |
| KCl               | 200              | 3.14                 | Topaz            | 303              | 1.356                |

While several of the above spacings have been measured to more than four significant figures, no more than four figures are given here because complications introduced by the index of refraction, anomalous dispersion, temperature coefficient of expansion, and crystal impurities must be considered before the additional figures are useful.

<sup>a</sup> Ammonium dihydrogen phosphate.

<sup>b</sup> Ethylenediamine *d*-tartrate.

<sup>c</sup> Potassium acid phthalate.

<sup>d</sup> Pentaerythritol.



## LOWERING OF VAPOR PRESSURE BY SALTS IN AQUEOUS SOLUTIONS

The table gives the reduction of the vapor pressure in mmHg due to the presence of the number of moles of salt per liter of water given at the head of the columns, at the temperature 100° C, at which temperature the vapor pressure of pure water is 760 mmHg.

(From Smithsonian Tables.)

| Substance                                             | 0.5  | 1.0  | 2.0   | 3.0   | 4.0   | 5.0   | 6.0   | 8.0   | 10.0  | Substance                                              | 0.5  | 1.0  | 2.0   | 3.0   | 4.0   | 5.0   | 6.0   | 8.0   | 10.0  |
|-------------------------------------------------------|------|------|-------|-------|-------|-------|-------|-------|-------|--------------------------------------------------------|------|------|-------|-------|-------|-------|-------|-------|-------|
| Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ..... | 12.8 | 36.5 |       |       |       |       |       |       |       | LiOH.....                                              | 15.9 | 37.4 | 78.1  |       |       |       |       |       |       |
| AlCl <sub>3</sub> .....                               | 22.5 | 61.0 | 179.0 | 318.0 |       |       |       |       |       | Li <sub>2</sub> CrO <sub>4</sub> .....                 | 16.4 | 32.6 | 74.0  | 120.0 | 171.0 |       |       |       |       |
| Ba <sub>3</sub> O <sub>4</sub> .....                  | 6.6  | 15.4 | 34.4  |       |       |       |       |       |       | MgSO <sub>4</sub> .....                                | 6.5  | 12.0 | 24.5  | 47.5  |       |       |       |       |       |
| Ba(OH) <sub>2</sub> .....                             | 12.3 | 22.5 | 39.0  |       |       |       |       |       |       | MgCl <sub>2</sub> .....                                | 16.8 | 39.0 | 100.5 | 183.3 | 277.0 | 377.0 |       |       |       |
| Ba(NO <sub>3</sub> ) <sub>2</sub> .....               | 13.5 | 27.0 |       |       |       |       |       |       |       | Mg(NO <sub>3</sub> ) <sub>2</sub> .....                | 17.6 | 42.0 | 101.0 | 174.8 |       |       |       |       |       |
| Ba(ClO <sub>3</sub> ) <sub>2</sub> .....              | 15.8 | 33.3 | 70.5  | 108.2 |       |       |       |       |       | MgBr <sub>2</sub> .....                                | 17.9 | 44.0 | 115.8 | 205.3 | 298.5 |       |       |       |       |
| BaCl <sub>2</sub> .....                               | 16.4 | 36.7 | 77.6  |       |       |       |       |       |       | MgH <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ..... | 18.3 | 46.0 | 116.0 |       |       |       |       |       |       |
| BaBr <sub>2</sub> .....                               | 16.8 | 38.8 | 91.4  | 150.0 | 204.7 |       |       |       |       | MnSO <sub>4</sub> .....                                | 6.0  | 10.5 | 21.0  |       |       |       |       |       |       |
| Ca <sub>3</sub> O <sub>3</sub> .....                  | 9.9  | 23.0 | 56.0  | 106.0 |       |       |       |       |       | MnCl <sub>2</sub> .....                                | 15.0 | 34.0 | 76.0  | 122.3 | 167.0 | 209.0 |       |       |       |
| Ca(NO <sub>3</sub> ) <sub>2</sub> .....               | 16.4 | 34.8 | 74.6  | 139.3 | 161.7 | 205.4 |       |       |       | NaH <sub>2</sub> PO <sub>4</sub> .....                 | 10.5 | 20.0 | 36.5  | 51.7  | 66.8  | 82.0  | 96.5  | 126.7 | 157.1 |
| CaCl <sub>2</sub> .....                               | 17.0 | 39.8 | 95.3  | 166.6 | 241.5 | 319.5 |       |       |       | NaHSO <sub>4</sub> .....                               | 10.9 | 22.1 | 47.3  | 75.0  | 100.2 | 126.1 | 148.5 | 189.7 | 231.4 |
| CaBr <sub>2</sub> .....                               | 17.7 | 44.2 | 105.8 | 191.0 | 283.3 | 368.5 |       |       |       | NaNO <sub>3</sub> .....                                | 10.6 | 22.5 | 46.2  | 68.1  | 90.3  | 111.5 | 131.7 | 167.8 | 198.8 |
| CdSO <sub>4</sub> .....                               | 4.1  | 8.9  | 18.1  |       |       |       |       |       |       | NaClO <sub>3</sub> .....                               | 10.5 | 23.0 | 48.4  | 73.5  | 98.5  | 123.3 | 147.5 | 196.5 | 223.5 |
| CdI <sub>2</sub> .....                                | 7.6  | 14.8 | 33.5  | 52.7  |       |       |       |       |       | (NaPO <sub>3</sub> ) <sub>6</sub> .....                | 11.6 |      |       |       |       |       |       |       |       |
| CdBr <sub>2</sub> .....                               | 8.6  | 17.8 | 36.7  | 55.7  | 80.0  |       |       |       |       | NaOH.....                                              | 11.8 | 22.8 | 48.2  | 77.3  | 107.5 | 139.1 | 172.5 | 243.3 | 314.0 |
| CdCl <sub>2</sub> .....                               | 9.6  | 18.8 | 36.7  | 57.0  | 77.3  | 99.0  |       |       |       | NaNO <sub>2</sub> .....                                | 11.6 | 24.4 | 50.0  | 75.0  | 98.2  | 122.5 | 146.5 | 189.0 | 226.2 |
| Cd(NO <sub>3</sub> ) <sub>2</sub> .....               | 15.9 | 36.1 | 78.0  | 122.2 |       |       |       |       |       | Na <sub>2</sub> HPO <sub>4</sub> .....                 | 12.1 | 23.5 | 43.0  | 60.0  | 78.7  | 99.8  | 122.1 |       |       |
| Cd(ClO <sub>3</sub> ) <sub>2</sub> .....              | 17.5 |      |       |       |       |       |       |       |       | NaHCO <sub>3</sub> .....                               | 12.9 | 24.1 | 48.2  | 77.6  | 102.2 | 127.8 | 152.0 | 198.0 | 239.4 |
| CoSO <sub>4</sub> .....                               | 5.5  | 10.7 | 22.9  | 45.5  |       |       |       |       |       | Na <sub>2</sub> SO <sub>4</sub> .....                  | 12.6 | 25.0 | 48.9  | 74.2  |       |       |       |       |       |
| CoCl <sub>2</sub> .....                               | 15.0 | 34.8 | 83.0  | 136.0 | 186.4 |       |       |       |       | NaCl.....                                              | 12.3 | 25.2 | 52.1  | 80.0  | 111.0 | 143.0 | 176.5 |       |       |
| Co(NO <sub>3</sub> ) <sub>2</sub> .....               | 17.3 | 39.2 | 89.0  | 152.0 | 218.7 | 282.0 | 332.0 |       |       | NaBrO <sub>3</sub> .....                               | 12.1 | 25.0 | 54.1  | 81.3  | 108.8 | 136.0 |       |       |       |
| FeSO <sub>4</sub> .....                               | 5.8  | 10.7 | 24.0  | 42.4  |       |       |       |       |       | NaBr.....                                              | 12.6 | 25.9 | 57.0  | 89.2  | 124.2 | 159.5 | 197.5 | 268.0 |       |
| H <sub>3</sub> BO <sub>3</sub> .....                  | 6.0  | 12.3 | 25.1  | 38.0  | 51.0  |       |       |       |       | NaI.....                                               | 12.1 | 25.6 | 60.2  | 99.5  | 136.7 | 177.5 | 221.0 | 301.5 | 370.0 |
| H <sub>3</sub> PO <sub>4</sub> .....                  | 6.6  | 14.0 | 28.6  | 45.2  | 62.0  | 81.5  | 103.0 | 146.9 | 189.5 | Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub> .....    | 13.2 | 22.0 |       |       |       |       |       |       |       |
| H <sub>3</sub> AsO <sub>4</sub> .....                 | 7.3  | 15.0 | 30.2  | 46.4  | 64.9  |       |       |       |       | Na <sub>2</sub> CO <sub>3</sub> .....                  | 14.3 | 27.3 | 53.5  | 80.2  | 111.0 |       |       |       |       |
| H <sub>2</sub> SO <sub>4</sub> .....                  | 12.9 | 26.5 | 62.8  | 104.0 | 148.0 | 198.4 | 247.0 | 343.2 |       | Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> .....    | 14.5 | 30.0 | 65.8  | 105.8 | 146.0 |       |       |       |       |
| KH <sub>2</sub> PO <sub>4</sub> .....                 | 10.2 | 19.5 | 33.3  | 47.8  | 60.5  | 73.1  | 85.2  |       |       | Na <sub>2</sub> WO <sub>4</sub> .....                  | 14.8 | 33.6 | 71.6  | 115.7 | 162.6 |       |       |       |       |
| KNO <sub>3</sub> .....                                | 10.3 | 21.1 | 40.1  | 57.6  | 74.5  | 88.2  | 102.1 | 126.3 | 148.0 | Na <sub>3</sub> PO <sub>4</sub> .....                  | 16.5 | 30.0 | 52.5  |       |       |       |       |       |       |
| KClO <sub>3</sub> .....                               | 10.6 | 21.6 | 42.8  | 62.1  | 80.0  |       |       |       |       | (NaPO <sub>3</sub> ) <sub>3</sub> .....                | 17.1 | 36.5 |       |       |       |       |       |       |       |
| KBrO <sub>3</sub> .....                               | 10.9 | 22.4 | 45.0  |       |       |       |       |       |       | NH <sub>4</sub> NO <sub>3</sub> .....                  | 12.8 | 22.0 | 42.1  | 62.7  | 82.9  | 103.8 | 121.0 | 152.2 | 180.0 |
| KHSO <sub>4</sub> .....                               | 10.9 | 21.9 | 43.3  | 65.3  | 85.5  | 107.8 | 129.9 | 170.0 |       | (NH <sub>4</sub> ) <sub>2</sub> SiF <sub>6</sub> ..... | 11.5 | 25.0 | 44.5  |       |       |       |       |       |       |
| KNO <sub>2</sub> .....                                | 11.1 | 22.8 | 44.8  | 67.0  | 90.0  | 110.5 | 130.7 | 167.0 | 198.8 | NH <sub>4</sub> Cl.....                                | 12.0 | 23.7 | 45.1  | 69.3  | 94.2  | 118.5 | 138.2 | 179.0 | 213.8 |
| KClO <sub>4</sub> .....                               | 11.5 | 22.3 |       |       |       |       |       |       |       | NH <sub>4</sub> HSO <sub>4</sub> .....                 | 11.5 | 22.0 | 46.8  | 71.0  | 94.5  | 118.  | 139.0 | 181.2 | 218.0 |
| KCl.....                                              | 12.2 | 24.4 | 48.8  | 74.1  | 100.9 | 128.5 | 152.2 |       |       | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> .....  | 11.0 | 24.0 | 46.5  | 69.5  | 93.0  | 117.0 | 141.8 |       |       |
| KHCO <sub>3</sub> .....                               | 11.6 | 23.6 | 59.0  | 77.6  | 104.2 | 132.0 | 160.0 | 210.0 | 255.0 |                                                        | 11.9 | 23.9 | 48.8  | 74.1  | 99.4  | 121.5 | 145.5 | 190.2 | 228.5 |
| KI.....                                               | 12.5 | 25.3 | 52.2  | 82.6  | 112.2 | 141.5 | 171.8 | 225.5 | 278.5 | NH <sub>4</sub> Br.....                                | 12.9 | 25.1 | 49.8  | 78.5  | 104.5 | 132.3 | 156.0 | 200.0 | 243.5 |
| K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> .....    | 13.9 | 28.3 | 59.8  | 94.2  | 131.0 |       |       |       |       | NiSO <sub>4</sub> .....                                | 5.0  | 10.2 | 21.5  |       |       |       |       |       |       |
| K <sub>2</sub> WO <sub>4</sub> .....                  | 13.9 | 33.0 | 75.0  | 123.8 | 175.4 | 226.4 |       |       |       | NiCl <sub>2</sub> .....                                | 16.1 | 37.0 | 86.7  | 147.0 | 212.8 |       |       |       |       |
| K <sub>2</sub> CO <sub>3</sub> .....                  | 14.4 | 31.0 | 68.3  | 105.5 | 152.0 | 209.0 | 258.5 | 350.0 |       | Ni(NO <sub>3</sub> ) <sub>2</sub> .....                | 16.1 | 37.3 | 91.3  | 156.2 | 235.0 |       |       |       |       |
| KOH.....                                              | 15.0 | 29.5 | 64.0  | 99.2  | 140.0 | 181.8 | 223.0 | 309.5 | 387.8 | Pb(NO <sub>3</sub> ) <sub>2</sub> .....                | 12.3 | 23.5 | 45.0  | 63.0  |       |       |       |       |       |
| K <sub>2</sub> CrO <sub>4</sub> .....                 | 16.2 | 29.5 | 60.0  |       |       |       |       |       |       | Sr(SO <sub>3</sub> ) <sub>2</sub> .....                | 7.2  | 20.3 | 47.0  |       |       |       |       |       |       |
| LiNO <sub>3</sub> .....                               | 12.2 | 25.9 | 55.7  | 88.9  | 122.2 | 155.1 | 188.0 | 253.4 | 309.2 | Sr(NO <sub>3</sub> ) <sub>2</sub> .....                | 15.8 | 31.0 | 64.0  | 97.4  | 131.4 |       |       |       |       |
| LiCl.....                                             | 12.1 | 25.5 | 57.1  | 95.0  | 132.5 | 175.5 | 219.5 | 311.5 | 393.5 | SrCl <sub>2</sub> .....                                | 16.8 | 38.8 | 91.4  | 156.8 | 223.3 | 281.5 |       |       |       |
| LiBr.....                                             | 12.2 | 26.2 | 60.0  | 97.0  | 140.0 | 186.3 | 241.5 | 341.5 | 438.0 | SrBr <sub>2</sub> .....                                | 17.8 | 42.0 | 101.1 | 179.0 | 267.0 |       |       |       |       |
| Li <sub>2</sub> SO <sub>4</sub> .....                 | 13.3 | 28.1 | 56.8  | 89.0  |       |       |       |       |       | ZnSO <sub>4</sub> .....                                | 4.9  | 10.4 | 21.5  | 42.1  | 66.2  |       |       |       |       |
| LiHSO <sub>4</sub> .....                              | 12.8 | 27.0 | 57.0  | 93.0  | 130.0 | 168.0 |       |       |       | ZnCl <sub>2</sub> .....                                | 9.2  | 18.7 | 46.2  | 75.0  | 107.0 | 153.0 | 195.0 |       |       |
| LiI.....                                              | 13.6 | 28.6 | 64.7  | 105.2 | 154.5 | 206.0 | 264.0 | 357.0 | 445.0 | Zn(NO <sub>3</sub> ) <sub>2</sub> .....                | 16.6 | 39.0 | 93.5  | 157.5 | 223.8 |       |       |       |       |
| LiSiF <sub>6</sub> .....                              | 15.4 | 34.0 | 70.0  | 106.0 |       |       |       |       |       |                                                        |      |      |       |       |       |       |       |       |       |

## MAGNETIC ROTATORY POWER

The rotation of the plane of polarization of light by transparent substances subjected to a magnetic field may be applied to problems of molecular structure. This rotary effect is known as the Faraday effect. Investigations of this effect by E. Verdet showed the angle of rotation ( $\alpha$ ) to depend on the nature of the substance and to be proportional to the length ( $l$ ) of the column of the substance which the light traverses and to the strength ( $H$ ) of the magnetic field. Thus

$$\alpha = \Lambda/H$$

where  $\Lambda$  is the Verdet constant for the experimental material.

Other symbols in the table have the following significance:

$\lambda$  = Wavelength in  $\mu\text{m}$

$t$  = Temperature in  $^{\circ}\text{C}$

$\rho_m$  = Molecular magnetic rotation of the substance under consideration compared to that of water determined in the same apparatus in the same magnetic field.

Thus

$$\rho_M = M \alpha \rho / M' \alpha' \rho'$$

where  $M$  is the molecular weight,  $\alpha$  the angle of rotation and  $\rho$  the density of the given substance, and  $M'$ ,  $\alpha'$ , and  $\rho'$  are the same quantities of water.

$[\Lambda]_M^{\lambda, t}$  = Molecular rotatory value of the substance at the given temperature and at the wavelength  $\lambda$ . Values are in (radians)(gauss $^{-1}$ )(cm $^{-1}$ ).

Values in this table are reproduced by permission from Volume 3, Tables de Constantes et Donnees Numeriques, "Pouvoir Rotatoire Magnetique, Effet Magneto-Optique de Kerr."

A much greater listing of values for both organic and inorganic compounds is in the above publication.

| Formula                                                          | Name                                                      | $\lambda$ | $t$  | $\rho_m$ | $10^4[\Lambda]_M^{\lambda, t}$ | $10^4\Lambda^{\lambda, t}$<br>Verdet |
|------------------------------------------------------------------|-----------------------------------------------------------|-----------|------|----------|--------------------------------|--------------------------------------|
| CH <sub>4</sub>                                                  | Methane                                                   | 578       | 0    | —        | —                              | *17.4                                |
| CCl <sub>4</sub>                                                 | Tetrachloromethane                                        | 589       | 25.1 | 6.58     | 45.3                           | 1.60                                 |
| CHCl <sub>3</sub>                                                | Trichloromethane                                          | 589       | 20.0 | 5.535    | 37.98                          | 1.60                                 |
| CHBr <sub>3</sub>                                                | Tribromomethane                                           | 589       | 17.9 | 11.63    | 80.00                          | 3.13                                 |
| CH <sub>2</sub> O <sub>2</sub>                                   | Formic acid                                               | 589       | 20.8 | 1.671    | 11.50                          | 1.046                                |
| CH <sub>2</sub> Cl <sub>2</sub>                                  | Dichloromethane                                           | 589       | 11.9 | 4.31     | 29.7                           | 1.60                                 |
| CH <sub>2</sub> Br <sub>2</sub>                                  | Dibromomethane                                            | 589       | 15.9 | 8.11     | 55.8                           | 2.74                                 |
| CH <sub>2</sub> I <sub>2</sub>                                   | Diiodomethane                                             | 589       | 15.0 | 10.83    | 129.5                          | 1.51                                 |
| CH <sub>3</sub> Cl                                               | Monochloromethane                                         | 589       | 23.0 | 2.99     | 20.5                           | 1.37                                 |
| CH <sub>3</sub> Br                                               | Monobromomethane                                          | 589       | 1.5  | 4.64     | 31.9                           | 2.04                                 |
| CH <sub>3</sub> I                                                | Monoiodomethane                                           | 589       | 19.5 | 9.01     | 63.2                           | 3.35                                 |
| CH <sub>3</sub> N                                                | Methylalcohol                                             | 589       | 18.7 | 1.640    | 11.28                          | 0.958                                |
| CH <sub>3</sub> Cl <sub>2</sub>                                  | Methylamine                                               | 578       | —    | —        | —                              | *22.7                                |
| CH <sub>3</sub> Cl <sub>2</sub>                                  | Diffuorodichloromethane (Freon)                           | —         | —    | —        | —                              | *32.7                                |
| CH <sub>3</sub> O <sub>2</sub> N                                 | Mononitromethane                                          | 589       | 9.9  | 1.86     | 12.8                           | 0.826                                |
| CH <sub>3</sub> ON <sub>2</sub>                                  | Urea (carbamide) 40% aqueous solution                     | 578       | 20.0 | 2.38     | 22.7                           | —                                    |
| C <sub>2</sub> H <sub>2</sub>                                    | Ethyne (ethyne)                                           | 578       | —    | —        | —                              | *33.0                                |
| C <sub>2</sub> H <sub>4</sub>                                    | Ethylene (ethene)                                         | 578       | —    | —        | —                              | *34.5                                |
| C <sub>2</sub> H <sub>6</sub>                                    | Ethane                                                    | 578       | —    | —        | —                              | *23.5                                |
| C <sub>2</sub> N <sub>2</sub>                                    | Cyanogen                                                  | —         | —    | —        | —                              | —                                    |
| C <sub>2</sub> H <sub>2</sub> O <sub>4</sub>                     | Oxalic acid (aqueous sol. 8.3%)                           | 578       | 20   | 2.88     | 20.6                           | —                                    |
| C <sub>2</sub> H <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O | Oxalic acid (alcohol sol. 16.5%)                          | 578       | 24   | 2.82     | 20.2                           | —                                    |
| C <sub>2</sub> H <sub>3</sub> Br                                 | Vinylbromide                                              | 589       | 7.8  | 6.22     | 42.8                           | 2.10                                 |
| C <sub>2</sub> H <sub>3</sub> N                                  | Acetonitrile (ethanonitrile)                              | 589       | 25.0 | 2.32     | 16.0                           | *21.0                                |
| C <sub>2</sub> H <sub>4</sub> O                                  | Ethyleneoxide (1,2-epoxyethane)                           | 589       | 8.0  | 1.935    | 13.3                           | 0.92                                 |
| C <sub>2</sub> H <sub>4</sub> O                                  | Acetaldehyde (ethanal)                                    | 589       | 16.3 | 2.38     | 16.4                           | 1.00                                 |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>                     | Acetic acid                                               | 589       | 21.0 | 2.525    | 17.37                          | 1.044                                |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | Formic acid methylester (methylformate)                   | 589       | 16.5 | 2.49     | 17.1                           | 0.96                                 |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                    | Ethylidenechloride (1,1-dichloroethane)                   | 589       | 14.4 | 5.33     | 36.7                           | 1.51                                 |
| C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>                    | Ethylenechloride (1,2-dichloroethane)                     | 589       | 14.4 | 5.49     | 37.7                           | 1.65                                 |
| C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>                    | Ethylenebromide (1,2-dibromoethane)                       | 589       | 15.2 | 9.70     | 66.7                           | 2.66                                 |
| C <sub>2</sub> H <sub>4</sub> Cl                                 | Monochloroethane                                          | 589       | 5.0  | 4.04     | 27.8                           | 1.36                                 |
| C <sub>2</sub> H <sub>4</sub> Br                                 | Monobromoethane                                           | 589       | 19.7 | 5.85     | 40.2                           | 1.82                                 |
| C <sub>2</sub> H <sub>4</sub> I                                  | Monoiodoethane                                            | 589       | 18.1 | 10.07    | 69.3                           | 2.95                                 |
| C <sub>2</sub> H <sub>5</sub> O                                  | Ethylalcohol (ethanol)                                    | 589       | 16.8 | 2.780    | 19.13                          | 1.131                                |
| C <sub>2</sub> H <sub>5</sub> O <sub>2</sub>                     | Glycol (1,2-ethanediol)                                   | 589       | 15.1 | 2.94     | 20.2                           | 1.25                                 |
| C <sub>2</sub> H <sub>5</sub> S                                  | Ethylmercaptan                                            | 578       | 16.0 | 5.52     | 39.5                           | 1.85                                 |
| C <sub>2</sub> H <sub>5</sub> N                                  | Ethylamine (aminoethane)                                  | 589       | 5.8  | 3.61     | 24.8                           | *34.5                                |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> Cl <sub>2</sub>     | Dichloroacetic acid (dichloroethanoic acid)               | 589       | 13.5 | 5.30     | 3.65                           | 1.52                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> Cl                  | Chloroacetic acid (chloroethanoic acid)                   | 589       | 64.5 | 3.89     | 26.7                           | 1.33                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> Cl <sub>3</sub>     | Chloralhydrate (2-2-2-trichloro-1,1-ethanediol)           | 589       | 54.6 | 7.10     | 48.8                           | 1.65                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> N                   | Mononitroethane                                           | 589       | 10.2 | 2.84     | 19.5                           | 0.946                                |
| C <sub>2</sub> H <sub>3</sub>                                    | Propene                                                   | 578       | —    | —        | —                              | *34.0                                |
| C <sub>2</sub> H <sub>3</sub> O                                  | Acrolein (propenal)                                       | 578       | 20.0 | 4.74     | 34.0                           | 1.76                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | Pyruvic acid (2-oxopropanoic acid)                        | 589       | 14.5 | 3.56     | 24.2                           | 1.21                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | Malonic acid (propanedioic acid) 2 <i>n</i> -aqueous sol. | 589       | 23.0 | 3.47     | —                              | —                                    |
| C <sub>2</sub> H <sub>3</sub> O                                  | Allyl alcohol                                             | 589       | 18.3 | 4.68     | 32.2                           | 1.60                                 |
| C <sub>2</sub> H <sub>3</sub> O                                  | Propyl alcohol (1-propanol)                               | 589       | 13.6 | 3.33     | 22.9                           | 1.09                                 |
| C <sub>2</sub> H <sub>3</sub> O                                  | Acetone (2-propanone)                                     | 589       | 20.0 | 3.472    | 23.89                          | 1.1136                               |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | Propionic acid (propanoic acid)                           | 589       | 20.3 | 3.462    | 23.82                          | 1.10                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | Formic acid ethylester (ethylmethanoate)                  | 589       | 18.8 | 3.56     | 24.5                           | 1.05                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | Acetic acid methylester (methylacetate)                   | 589       | 20.0 | 3.42     | 23.5                           | 1.03                                 |
| C <sub>2</sub> H <sub>3</sub> Cl                                 | Propylchloride (1-chloropropane)                          | 589       | 16.1 | 5.04     | 34.7                           | 1.34                                 |
| C <sub>2</sub> H <sub>3</sub> Cl                                 | Isopropylchloride (2-chloropropane)                       | 589       | 17.2 | 5.16     | 35.5                           | 1.34                                 |
| C <sub>2</sub> H <sub>3</sub> Br                                 | Propylbromide (1-bromopropane)                            | 589       | 19.2 | 6.88     | 47.8                           | 1.79                                 |
| C <sub>2</sub> H <sub>3</sub> Br                                 | Isopropylbromide (2-bromopropane)                         | 589       | 17.1 | 7.00     | 48.2                           | 1.77                                 |
| C <sub>2</sub> H <sub>3</sub> I                                  | Propyliodide (1-iodopropane)                              | 589       | 18.1 | 11.08    | 76.2                           | 2.69                                 |
| C <sub>2</sub> H <sub>3</sub> I                                  | Isopropyliodide (2-iodopropane)                           | 589       | 26.3 | 11.18    | 76.9                           | 2.63                                 |
| C <sub>2</sub> H <sub>3</sub> O                                  | <i>n</i> -Propyl alcohol (1-propanol)                     | 589       | 15.6 | 3.77     | 25.9                           | 1.20                                 |
| C <sub>2</sub> H <sub>3</sub> O                                  | Isopropyl alcohol (2-propanol)                            | 589       | 20.0 | 3.90     | 26.8                           | 1.23                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>                     | Glycerine (1,2,3-propanetriol)                            | 589       | 16.0 | 4.11     | 28.3                           | 1.33                                 |
| C <sub>2</sub> H <sub>3</sub> N                                  | <i>n</i> -Propylamine                                     | 589       | 9.6  | 4.56     | 31.4                           | 1.33                                 |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> N <sub>2</sub>      | Nitroglycerine                                            | 589       | 13.5 | 5.405    | 37.2                           | 0.900                                |
| C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> N                   | 1-Nitropropane                                            | 589       | 18.9 | 3.82     | 26.3                           | 1.018                                |
| C <sub>2</sub> H <sub>4</sub>                                    | 1,3-Butadiene (erythrene)                                 | 589       | 15.0 | 7.94     | 54.6                           | 2.16                                 |
| C <sub>2</sub> H <sub>4</sub>                                    | 1-Butene ( $\alpha$ -butylene)                            | 589       | 15.0 | 5.53     | 38.0                           | 1.39                                 |
| C <sub>2</sub> H <sub>4</sub>                                    | cis-2-Butene ( $\beta$ -butylene)                         | 589       | 15.0 | 5.27     | 36.3                           | 1.38                                 |
| C <sub>2</sub> H <sub>4</sub>                                    | trans-2-Butene                                            | 589       | 15.0 | 5.07     | 34.9                           | 1.29                                 |
| C <sub>2</sub> H <sub>6</sub>                                    | Butane                                                    | 589       | 15.0 | 4.59     | 31.6                           | 1.09                                 |
| C <sub>2</sub> H <sub>6</sub>                                    | Isobutane (2-methylpropane)                               | 589       | 15.0 | 4.87     | 33.5                           | 1.11                                 |
| C <sub>2</sub> H <sub>2</sub> O <sub>3</sub>                     | Maleic anhydride (cis-butenedioic anhydride)              | 589       | 25.0 | 4.5      | 31.0                           | —                                    |

\* Verdet constant factor =  $10^4$ .



# MAGNETIC ROTATORY POWER (Continued)

| Formula                                                     | Name                                                             | $\lambda$ | $t$   | $Q_M$ | $10^3[A]_D^{25}$ | $10^3 A^{25}$<br>Verdet |
|-------------------------------------------------------------|------------------------------------------------------------------|-----------|-------|-------|------------------|-------------------------|
| C <sub>4</sub> H <sub>4</sub> O                             | Furan (furfuran)                                                 | 589       | 20.0  | 5.48  | 37.7             | 1.78                    |
| C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>                | Maleic acid (cis-butenedioic acid) 2 <i>n</i> aqueous solution   | 589       | 25.0  | 5.63  | 38.7             | —                       |
| C <sub>4</sub> H <sub>4</sub> S                             | Thiophene (thiofuran)                                            | 589       | 20.0  | 9.40  | 64.7             | 2.83                    |
| C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>                | Acetic anhydride (ethanoic anhydride)                            | 589       | 20.0  | 4.28  | 29.5             | 1.115                   |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | Succinic acid (butanedioic acid) 5.9% aqueous sol.               | 578       | 20.0  | 4.68  | 33.5             | —                       |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | Tartaric acid (4,8% aqueous sol.)                                | 578       | 20.0  | 4.79  | 34.3             | —                       |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | <i>n</i> -Butyric acid (butanoic acid)                           | 589       | 18.8  | 4.47  | 30.8             | 1.15                    |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | Ethylacetate (ethyl ethanoate)                                   | 589       | 20.0  | 4.47  | 30.8             | 1.08                    |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | Propionic acid methyl ester (methylpropanoate)                   | 589       | 20.0  | 4.37  | 30.1             | 1.07                    |
| C <sub>4</sub> H <sub>6</sub> O <sub>4</sub>                | Lactic acid methyl ester (methyl 2-hydroxypropanoate)            | 589       | —     | 4.66  | 32.1             | —                       |
| C <sub>4</sub> H <sub>10</sub> O                            | Ethyl ether (ethoxyethane)                                       | 589       | 20.0  | 4.78  | 32.9             | 1.09                    |
| C <sub>4</sub> H <sub>10</sub> O                            | <i>n</i> -Butyl alcohol (1-butanol)                              | 589       | 20.0  | 4.60  | 31.6             | 1.23                    |
| C <sub>4</sub> H <sub>10</sub> O                            | Isobutyl alcohol (2-methyl-1-propanol)                           | 589       | 17.7  | 4.94  | 34.0             | 1.27                    |
| C <sub>4</sub> H <sub>10</sub> O                            | sec-Butyl alcohol (methyl ethylcarbinol)                         | 589       | 20.0  | 4.91  | 33.8             | 1.27                    |
| C <sub>5</sub> H <sub>6</sub>                               | Cyclopentadiene                                                  | 589       | 15.0  | 7.03  | 48.8             | 2.02                    |
| C <sub>5</sub> H <sub>8</sub>                               | 1,3-Pentadiene                                                   | 589       | 15.0  | 8.80  | 60.5             | 2.08                    |
| C <sub>5</sub> H <sub>8</sub>                               | Isoprene (2-methyl-1,3-butadiene)                                | 589       | 15.0  | 8.80  | 60.5             | 2.08                    |
| C <sub>5</sub> H <sub>8</sub>                               | Cyclopentene                                                     | 589       | 15.0  | 5.69  | 39.1             | 1.52                    |
| C <sub>5</sub> H <sub>10</sub>                              | 1-Pentene                                                        | 589       | 15.0  | 6.45  | 44.4             | 1.39                    |
| C <sub>5</sub> H <sub>10</sub>                              | Isopentane (2-methyl-1-butane)                                   | 589       | 15.0  | 6.36  | 43.8             | 1.39                    |
| C <sub>5</sub> H <sub>10</sub>                              | Cyclopentane                                                     | 589       | 20.0  | 4.89  | 33.6             | 1.23                    |
| C <sub>5</sub> H <sub>12</sub>                              | Pentane                                                          | 589       | 15.0  | 5.60  | 38.5             | 1.15                    |
| C <sub>5</sub> H <sub>12</sub>                              | Isopentane (2-methylbutane)                                      | 589       | 15.0  | 5.75  | 39.6             | 1.17                    |
| C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>                | Furfural (2-furancarbal)                                         | 578       | 20.0  | 7.01  | 50.2             | 2.06                    |
| C <sub>5</sub> H <sub>7</sub> N                             | Pyridine                                                         | 589       | 11.9  | 8.76  | 60.3             | 2.58                    |
| C <sub>5</sub> H <sub>8</sub> O <sub>4</sub>                | Glutaric acid (pentanedioic acid) 2 <i>N</i> aqueous sol.        | 589       | 16.0  | 5.48  | 37.7             | —                       |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>               | Propionic acid ethyl ester                                       | 589       | 20.0  | 5.46  | 37.6             | 1.13                    |
| C <sub>5</sub> H <sub>10</sub> O <sub>2</sub>               | Acetic acid propyl ester                                         | 589       | 15.7  | 5.45  | 37.5             | 1.13                    |
| C <sub>5</sub> H <sub>14</sub> N <sub>2</sub>               | Cadaverine (1,5-pentanediamine)                                  | 589       | 14.7  | 7.49  | 51.6             | 1.53                    |
| C <sub>6</sub> H <sub>6</sub>                               | Benzene                                                          | 589       | 15.0  | 11.27 | 77.5             | 3.00                    |
| C <sub>6</sub> H <sub>12</sub>                              | Cyclohexane                                                      | 589       | 20.0  | 5.66  | 39.0             | 1.24                    |
| C <sub>6</sub> H <sub>14</sub>                              | Hexane                                                           | 589       | 15.0  | 6.62  | 45.5             | 1.20                    |
| C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>               | 1,4-Dichlorobenzene ( <i>p</i> -dichlorobenzene)                 | 589       | 64.5  | 13.55 | 93.2             | 2.69                    |
| C <sub>6</sub> H <sub>5</sub> F                             | Fluorobenzene (phenylfluoride)                                   | 589       | 19.0  | 9.96  | 68.5             | 2.51                    |
| C <sub>6</sub> H <sub>5</sub> Cl                            | Chlorobenzene (phenylchloride)                                   | 589       | 15.0  | 12.51 | 86.1             | 2.92                    |
| C <sub>6</sub> H <sub>5</sub> Br                            | Bromobenzene (phenylbromide)                                     | 589       | 15.0  | 14.51 | 99.8             | 3.26                    |
| C <sub>6</sub> H <sub>5</sub> I                             | Iodobenzene (phenyliodide)                                       | 589       | 15.0  | 19.11 | 131.4            | 4.06                    |
| C <sub>6</sub> H <sub>5</sub> O                             | Phenol (hydroxybenzene)                                          | 589       | 39.0  | 12.07 | 83.5             | 3.21                    |
| C <sub>6</sub> H <sub>5</sub> N                             | Aniline (aminobenzene)                                           | 589       | 15.0  | 16.08 | 110.6            | 4.18                    |
| C <sub>6</sub> H <sub>11</sub> Cl                           | Chlorocyclohexane (cyclohexylchloride)                           | 589       | 13.0  | 7.50  | 51.6             | 1.46                    |
| C <sub>6</sub> H <sub>10</sub> O <sub>2</sub>               | Paraldehyde (paraacetaldehyde)                                   | 589       | 17.3  | 6.66  | 45.8             | 1.19                    |
| C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>               | Glucose 11H <sub>2</sub> O (dextrose) (1 <i>M</i> aqueous sol.)  | 589       | 15.0  | 6.72  | 46.2             | —                       |
| C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>               | Galactose 10H <sub>2</sub> O (1 <i>M</i> aqueous sol.)           | 589       | 15.0  | 6.89  | 47.4             | —                       |
| C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>               | Fructose 10H <sub>2</sub> O (levulose) (1 <i>M</i> aqueous sol.) | 589       | 15.0  | 6.73  | 46.3             | —                       |
| C <sub>6</sub> H <sub>14</sub> O                            | 2-Hexanol (butylmethylcarbinol)                                  | 589       | 20.0  | 6.89  | 47.4             | 1.31                    |
| C <sub>6</sub> H <sub>14</sub> O                            | 3-Hexanol (ethylpropylcarbinol)                                  | 589       | 20.0  | 6.85  | 47.1             | 1.30                    |
| C <sub>6</sub> H <sub>14</sub> O                            | 2-Methyl-3-Pentanol (ethylisopropylcarbinol)                     | 589       | 20.0  | 6.90  | 47.5             | 1.32                    |
| C <sub>6</sub> H <sub>4</sub> O <sub>2</sub> N <sub>2</sub> | 1,3-Dinitrobenzene ( <i>m</i> -Dinitrobenzene)                   | 589       | 17.1  | 9.65  | 66.4             | 2.17                    |
| C <sub>6</sub> H <sub>5</sub> O <sub>2</sub> N              | Nitrobenzene                                                     | 589       | 15.0  | 9.36  | 64.4             | 2.17                    |
| C <sub>6</sub> H <sub>5</sub>                               | Toluene (methylbenzene)                                          | 589       | 15.0  | 12.16 | 83.7             | 2.71                    |
| C <sub>6</sub> H <sub>14</sub>                              | 1-Heptene ( $\alpha$ -heptylene)                                 | 589       | 18.0  | 8.48  | 58.3             | 1.43                    |
| C <sub>6</sub> H <sub>16</sub>                              | Heptane                                                          | 589       | 15.0  | 7.61  | 52.7             | 1.23                    |
| C <sub>6</sub> H <sub>5</sub> N                             | Benzonitrile (benzenecarbonitrile)                               | 589       | 15.7  | 11.85 | 81.5             | 2.74                    |
| C <sub>6</sub> H <sub>5</sub> O <sub>2</sub>                | Benzoic acid (20% alcohol sol.)                                  | 578       | 20.0  | 11.8  | 84.7             | —                       |
| C <sub>6</sub> H <sub>5</sub> Cl                            | <i>o</i> -Chlorotoluene (2-chloro-1-methylbenzene)               | 589       | 15.4  | 13.72 | 94.3             | 2.95                    |
| C <sub>6</sub> H <sub>5</sub> Cl                            | <i>p</i> -Chlorotoluene (4-chloro-1-methylbenzene)               | 589       | 15.2  | 13.25 | 90.8             | 2.65                    |
| C <sub>6</sub> H <sub>5</sub> Br                            | <i>o</i> -Bromotoluene (2-bromo-1-methylbenzene)                 | 589       | 16.7  | 15.67 | 107.3            | 3.08                    |
| C <sub>6</sub> H <sub>5</sub> Br                            | <i>p</i> -Bromotoluene (4-bromo-1-methylbenzene)                 | 589       | 39.0  | 15.09 | 103.6            | 2.88                    |
| C <sub>6</sub> H <sub>5</sub> O                             | <i>o</i> -Cresol ( <i>o</i> -methylphenol)                       | 589       | 16.0  | 13.38 | 92.1             | 3.07                    |
| C <sub>6</sub> H <sub>5</sub> O                             | <i>m</i> -Cresol ( <i>m</i> -methylphenol)                       | 589       | 17.9  | 12.77 | 87.6             | 2.89                    |
| C <sub>6</sub> H <sub>5</sub> O                             | <i>p</i> -Cresol ( <i>p</i> -methylphenol)                       | 589       | 17.0  | 12.86 | 88.5             | 2.91                    |
| C <sub>6</sub> H <sub>5</sub> N                             | <i>o</i> -Toluidine ( <i>o</i> -methylaniline)                   | 589       | 17.3  | 17.18 | 118.2            | 3.79                    |
| C <sub>6</sub> H <sub>5</sub> N                             | <i>m</i> -Toluidine ( <i>m</i> -methylaniline)                   | 589       | 15.0  | 16.21 | 111.5            | 3.56                    |
| C <sub>6</sub> H <sub>5</sub> N                             | <i>p</i> -Toluidine ( <i>p</i> -methylaniline)                   | 589       | 50.0  | 15.92 | 109.5            | 3.37                    |
| C <sub>6</sub> H <sub>10</sub> O                            | Enanthaldehyde (heptanal)                                        | 589       | 16.2  | 7.42  | 51.1             | 1.26                    |
| C <sub>6</sub> H <sub>10</sub> O                            | 1-Heptanol ( <i>n</i> -heptyl alcohol)                           | 589       | 12.6  | 7.85  | 54.0             | 1.33                    |
| C <sub>6</sub> H <sub>10</sub> O                            | 2-Heptanol (amylmethylcarbinol)                                  | 589       | 20.0  | 7.94  | 54.6             | 1.32                    |
| C <sub>6</sub> H <sub>10</sub> O                            | 3-Heptanol (butylethylcarbinol)                                  | 589       | 20.0  | 7.86  | 54.1             | 1.37                    |
| C <sub>6</sub> H <sub>5</sub> O <sub>2</sub> N              | <i>o</i> -Nitrotoluene                                           | 589       | 18.0  | 10.80 | 74.3             | 2.16                    |
| C <sub>6</sub> H <sub>5</sub> O <sub>2</sub> N              | <i>p</i> -Nitrotoluene                                           | 589       | 54.3  | 10.20 | 70.2             | 1.97                    |
| C <sub>6</sub> H <sub>10</sub>                              | Ethylbenzene (phenylethane)                                      | 589       | 15.0  | 13.41 | 92.3             | 2.80                    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>o</i> -Xylene (1,2-dimethylbenzene)                           | 589       | 15.0  | 13.36 | 91.9             | 2.62                    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>m</i> -Xylene (1,3-dimethylbenzene)                           | 589       | 15.0  | 12.82 | 88.2             | 2.47                    |
| C <sub>6</sub> H <sub>10</sub>                              | <i>p</i> -Xylene (1,4-dimethylbenzene)                           | 589       | 15.0  | 12.80 | 88.1             | 2.46                    |
| C <sub>6</sub> H <sub>14</sub>                              | 1-Octene ( $\alpha$ -octylene)                                   | 589       | 15.0  | 9.00  | 65.5             | 1.44                    |
| C <sub>6</sub> H <sub>16</sub>                              | 2-Octene ( $\beta$ -octylene)                                    | 589       | 15.0  | 9.33  | 64.2             | 1.43                    |
| C <sub>6</sub> H <sub>18</sub>                              | Octane                                                           | 589       | 15.0  | 8.65  | 59.5             | 1.26                    |
| C <sub>6</sub> H <sub>14</sub> O                            | 1-Octanol ( <i>n</i> -octyl alcohol)                             | 589       | 20.0  | 8.88  | 61.1             | 1.33                    |
| C <sub>6</sub> H <sub>14</sub> O                            | 2-Octanol (methylhexylcarbinol)                                  | 589       | 20.0  | 9.00  | 61.8             | 1.34                    |
| C <sub>6</sub> H <sub>14</sub> O                            | 3-Octanol (ethylamylcarbinol)                                    | 589       | 20.0  | 8.90  | 61.2             | 1.33                    |
| C <sub>6</sub> H <sub>12</sub>                              | <i>o</i> -Ethyltoluene (1-ethyl-2-ethylbenzene)                  | 589       | 15.0  | 14.56 | 100.2            | 2.32                    |
| C <sub>6</sub> H <sub>12</sub>                              | <i>m</i> -Ethyltoluene (1-ethyl-3-ethylbenzene)                  | 589       | 15.0  | 14.18 | 97.6             | 2.91                    |
| C <sub>6</sub> H <sub>12</sub>                              | <i>p</i> -Ethyltoluene (1-ethyl-4-ethylbenzene)                  | 589       | 15.0  | 13.98 | 96.2             | 2.37                    |
| C <sub>6</sub> H <sub>12</sub>                              | Mesitylene (1-3-5-trimethylbenzene)                              | 589       | 15.0  | 13.36 | 91.9             | 2.28                    |
| C <sub>6</sub> H <sub>10</sub>                              | Nonane                                                           | 589       | 15.0  | 9.70  | 66.7             | 1.28                    |
| C <sub>10</sub> H <sub>8</sub>                              | Naphthalene                                                      | 589       | 89.5  | 24.98 | 171.8            | 4.47                    |
| C <sub>10</sub> H <sub>16</sub>                             | 1-Decene ( <i>n</i> -decylene)                                   | 589       | 21.0  | 11.65 | 80.1             | 1.45                    |
| C <sub>10</sub> H <sub>18</sub>                             | Decane                                                           | 589       | 15.0  | 10.70 | 73.6             | 1.30                    |
| C <sub>10</sub> H <sub>7</sub> Cl                           | 1-Chloronaphthalene ( $\alpha$ -chloronaphthalene)               | 578       | 18.0  | 28.15 | 201.5            | 4.91                    |
| C <sub>10</sub> H <sub>7</sub> Br                           | 1-Bromonaphthalene ( $\alpha$ -bromonaphthalene)                 | 578       | 20.0  | 31.05 | 222.0            | 5.19                    |
| C <sub>10</sub> H <sub>6</sub> O                            | $\beta$ -Naphthol (2-hydroxynaphthalene)                         | 578       | 136.0 | 27.1  | 194.0            | 4.80                    |
| C <sub>10</sub> H <sub>12</sub> N <sub>2</sub>              | 1-Naphthylamine ( $\alpha$ -naphthylamine)                       | 589       | 32.6  | 37.23 | 256.1            | 6.84                    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | Isoeugenol (4-propenylguaiaicol)                                 | 589       | 19.3  | 21.44 | 147.5            | 3.55                    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | Eugenol (4-allylguaiacol)                                        | 589       | 15.4  | 18.72 | 128.8            | 2.88                    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | Benzoic acid propyl ester ( <i>n</i> -propylbenzoate)            | 589       | 15.4  | 14.87 | 102.3            | 2.20                    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | <i>o</i> -Toluic acid ethyl ester                                | 589       | 15.2  | 15.06 | 103.6            | 2.25                    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | <i>p</i> -Toluic acid ethyl ester                                | 589       | 15.0  | 14.74 | 101.4            | 2.18                    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | $\alpha$ -Toluic acid ethyl ester (ethylphenylacetate)           | 589       | 14.0  | 14.09 | 103.1            | 2.25                    |
| C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>              | Methylsalicylic acid ethyl ester                                 | 589       | 18.6  | 17.14 | 117.9            | 2.50                    |
| C <sub>10</sub> H <sub>13</sub> N                           | N,N-Diethylaniline (N-phenyldiethylamine)                        | 589       | 15.3  | 25.16 | 173.1            | 3.74                    |



# MAGNETIC ROTATORY POWER (Continued)

| Formula                                         | Name                                             | $\lambda$ | $t$   | $Q_M$ | $10^6[\Lambda]_D^{L,T}$ | $10^6\Lambda^{L,T}$<br>Verdet |
|-------------------------------------------------|--------------------------------------------------|-----------|-------|-------|-------------------------|-------------------------------|
| C <sub>10</sub> H <sub>16</sub> O               | Camphor                                          | 589       | 14.0  | 9.26  | 63.7                    | —                             |
| C <sub>10</sub> H <sub>16</sub> O               | $\alpha$ -Terpineol                              | 589       | 16.0  | 10.84 | 76.6                    | 1.56                          |
| C <sub>10</sub> H <sub>16</sub> O               | Citronellal                                      | 589       | 14.5  | 11.48 | 79.0                    | 1.51                          |
| C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>  | Dipropylsuccinate                                | 589       | 11.4  | 10.36 | 71.3                    | 1.22                          |
| C <sub>10</sub> H <sub>16</sub> O <sub>6</sub>  | Tartaric acid dipropylester (propyltartrate)     | 589       | 15.4  | 10.83 | 74.5                    | 1.24                          |
| C <sub>10</sub> H <sub>18</sub> O               | Menthol                                          | 589       | 45.2  | 10.51 | 72.3                    | 1.40                          |
| C <sub>11</sub> H <sub>24</sub>                 | Undecane                                         | 589       | 20.5  | 11.65 | 80.1                    | 1.31                          |
| C <sub>12</sub> H <sub>26</sub>                 | Dodecane                                         | 589       | 21.5  | 12.71 | 87.4                    | 1.32                          |
| C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> | Saccharose 19H <sub>2</sub> O (1 M aqueous sol.) | 589       | 15.0  | 12.59 | 86.6                    | —                             |
| C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> | Maltose 20H <sub>2</sub> O (1 M aqueous sol.)    | 589       | 15.0  | 12.69 | 87.3                    | —                             |
| C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> | Lactose 41H <sub>2</sub> O (1 M aqueous sol.)    | 589       | 18.3  | 12.71 | 87.5                    | —                             |
| C <sub>14</sub> H <sub>10</sub>                 | Phenanthrene                                     | 578       | 100.0 | 39.7  | 284.0                   | 5.84                          |
| C <sub>16</sub> H <sub>34</sub>                 | Hexadecane                                       | 589       | 15.0  | 16.8  | 115.6                   | 1.35                          |
| C <sub>16</sub> H <sub>14</sub>                 | 1,2-Diphenylbenzene                              | 589       | 15.0  | 40.2  | 276.3                   | 4.70                          |
| C <sub>16</sub> H <sub>14</sub>                 | 1,3-Diphenylbenzene (m-phenyldiphenyl)           | 589       | 15.0  | 41.0  | 282.4                   | —                             |
| C <sub>16</sub> H <sub>22</sub>                 | 1,6-Diphenylhexane                               | 589       | 20.0  | —     | —                       | 2.75                          |

# NOMOGRAPH AND TABLE FOR DOPPLER LINEWIDTHS

Sidney O. Kastner

The Doppler width of a spectral line is given by the well-known relation  $\Delta\lambda = (7.162 \times 10^{-7}) \lambda T^{1/2} M^{-1/2}$ , where wavelength units are in Angstroms, temperature is in degrees Kelvin and M is the atomic mass. This relation between four variables is amenable to representation by a nomograph, which does not appear to have been constructed but which would seem to be of practical value. Therefore such a nomograph is presented here. Its construction is briefly described so that the reader who has not made a plot of this type may follow the steps.

The Doppler relation is first rewritten as

$$\ln \Delta\lambda = \ln k\lambda + \frac{1}{2} \ln T - \frac{1}{2} \ln M$$

or equivalently  $u_4 = u_1 + u_2 + u_3$ , with  $k = 7.162 \times 10^{-7}$ . Putting  $\xi = u_1 + u_2$ , first, one has a linear relation  $\xi - u_1 - u_2 = 0$  between three variables which can be represented (Menzel\*) by the determinantal equation

$$\begin{vmatrix} \xi/2 & 1/2 & 1 \\ u_1 & 1 & 1 \\ u_2 & 0 & 1 \end{vmatrix} = 0$$

so that in the Cartesian (x,y) plane the function  $u_2$  lies along the x axis, the function  $u_1$  along the line  $y = 1$  and the function  $\xi/2$  along the line  $y = 1/2$ . These lines form three parallel scales with which to obtain a value of  $\xi$ , given the pair  $(u_1, u_2)$ .

The original equation  $u_4 = \xi + u_3$  provides a second linear relation  $u_4 - \xi - u_3 = 0$ , so that a second set of scales similarly results with  $u_3$  along the x axis,  $\xi$  along the line  $y = 1$  and  $u_4/2$  along the line  $y = 1/2$ . The function  $u_4 \equiv \log \Delta\lambda$  can then be obtained from the known pair  $(\xi, u_3)$ .

In practice, for the nomograph scales to represent useful ranges of the physical variables, some shifting and magnification of the individual scales will be found to be necessary, after completion of the first diagram. The nomograph arrived at here is shown in Figure 1. The x axis runs horizontally through the values  $x = 0$ ,  $T = 10^5$ , and the ordinates of the six scales from left to right are given by:

$$\begin{aligned} y_1 &= 5 \ln(10^{5/2} k\lambda) & y_2 &= 10 \ln(k\lambda T^{1/2}) \\ y_3 &= \frac{5}{2} \ln(k\lambda T^{1/2}) & y_4 &= 5 \ln \Delta\lambda + \frac{5}{2} \ln 10 \\ y_5 &= 5 \ln(T^{1/2} / 10^{5/2}) & y_6 &= 5 \ln(10/M) \end{aligned}$$

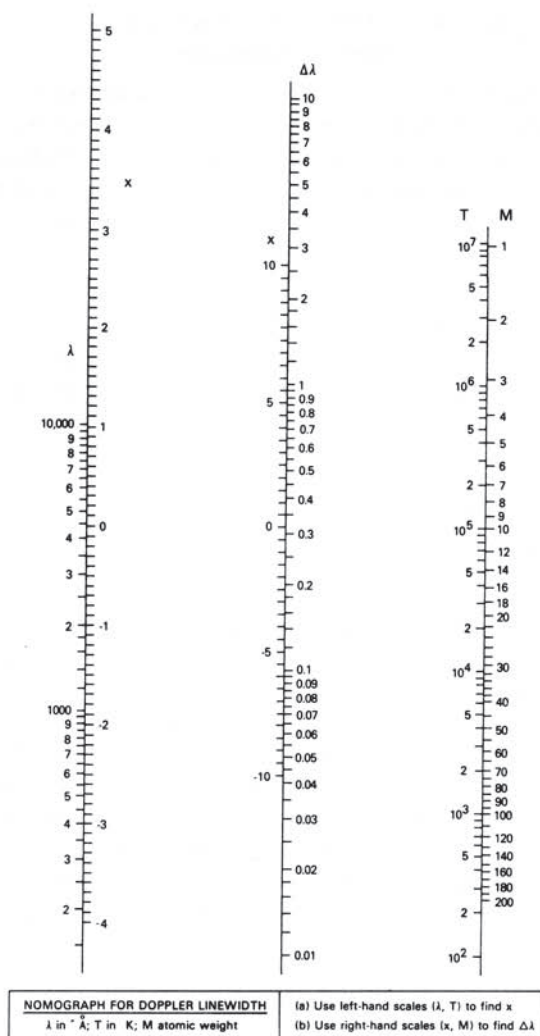
The approximate range of temperatures covered by the figure is a slowly varying function of wavelength, being  $1000^\circ\text{K}$ - $10^6$  K for  $\lambda = 10,000\text{\AA}$ ;  $4000$  K- $5 \times 10^6$  K for  $\lambda = 5000\text{\AA}$ ;  $80,000$  K- $10^7$  K for  $\lambda = 1000\text{\AA}$ ; and  $300,000$  K- $10^7$  K for  $\lambda = 500\text{\AA}$ .

In use, the left-hand sides of the three lines are used to find the value of the intermediate variable  $x$  corresponding to given  $\lambda$  and  $T$ . The right-hand sides then give the Doppler width  $\Delta\lambda$  in  $\text{\AA}$ , for this value of  $x$  and the given  $M$ .

For example, suppose one wishes to find the Doppler width of the solar coronal forbidden line of Fe XIV (atomic mass  $M = 56$ ) at  $5303\text{\AA}$ , emitted at a temperature of about  $T = 2 \times 10^6$  K. A straight line drawn between  $\lambda = 5300\text{\AA}$  and  $T = 2 \times 10^6$  intersects the  $x$  scale at about 4.2. A second line then drawn between  $x = 4.2$  and  $M = 56$  intersects the middle line at  $\Delta\lambda \approx 0.73\text{\AA}$ .

To use the nomograph, one must know the appropriate atomic weight  $M$  for a given element of interest. An alternative and more accurate procedure, if a calculator is available, for obtaining any required Doppler width is to use Table I, which gives the value of the constant  $k_z \equiv 7.162 M_z^{-1/2}$  for any given atomic number  $Z$ , in the equivalent Doppler relation  $\Delta\lambda = k_z(\lambda T^{1/2}) \times 10^{-7}$ . This table thereby avoids the necessity of looking up the atomic weight  $M$ . For the forbidden line example above, where  $Z = 26$ , the Doppler width obtained from the table is  $\Delta\lambda = (0.9584)(5303)(2,000,000)^{1/2}(10^{-7}) = 0.719\text{\AA}$ .

\* D. H. Menzel, *Fundamental Formulas of Physics*, Dover Publications, New York, 1960, ch. 3.



**TABLE 1**  
**Values of  $k_z$  (Z Atomic Number) for Use in**  
**Doppler Linewidth Formula**

$$\Delta\lambda = k_z(\lambda T^{1/2}) \times 10^{-7}$$

| Z  | $k_z$  | Z  | $k_z$  | Z  | $k_z$  | Z  | $k_z$  |
|----|--------|----|--------|----|--------|----|--------|
| 1  | 7.1335 | 21 | 1.0682 | 41 | 0.7430 | 61 | 0.5927 |
| 2  | 3.5798 | 22 | 1.0348 | 42 | 0.7312 | 62 | 0.5840 |
| 3  | 2.7185 | 23 | 1.0035 | 43 | 0.7202 | 63 | 0.5810 |
| 4  | 2.3857 | 24 | 0.9932 | 44 | 0.7124 | 64 | 0.5711 |
| 5  | 2.1782 | 25 | 0.9663 | 45 | 0.7060 | 65 | 0.5681 |
| 6  | 2.0665 | 26 | 0.9584 | 46 | 0.6943 | 66 | 0.5618 |
| 7  | 1.9137 | 27 | 0.9329 | 47 | 0.6896 | 67 | 0.5577 |
| 8  | 1.7905 | 28 | 0.9347 | 48 | 0.6755 | 68 | 0.5538 |
| 9  | 1.6431 | 29 | 0.8984 | 49 | 0.6684 | 69 | 0.5510 |
| 10 | 1.5944 | 30 | 0.8858 | 50 | 0.6574 | 70 | 0.5492 |
| 11 | 1.4937 | 31 | 0.8577 | 51 | 0.6491 | 71 | 0.5414 |
| 12 | 1.4527 | 32 | 0.8406 | 52 | 0.6340 | 72 | 0.5361 |
| 13 | 1.3788 | 33 | 0.8274 | 53 | 0.6358 | 73 | 0.5324 |
| 14 | 1.3514 | 34 | 0.8060 | 54 | 0.6250 | 74 | 0.5282 |
| 15 | 1.2869 | 35 | 0.8012 | 55 | 0.6212 | 75 | 0.5249 |
| 16 | 1.2649 | 36 | 0.7824 | 56 | 0.6111 | 76 | 0.5193 |
| 17 | 1.2028 | 37 | 0.7747 | 57 | 0.6077 | 77 | 0.5166 |
| 18 | 1.1331 | 38 | 0.7651 | 58 | 0.6050 | 78 | 0.5128 |
| 19 | 1.1453 | 39 | 0.7596 | 59 | 0.6033 | 79 | 0.5103 |
| 20 | 1.1313 | 40 | 0.7499 | 60 | 0.5963 | 80 | 0.5057 |

## OXYGEN SOLUBILITY IN AQUEOUS ELECTROLYTE SOLUTIONS

The Bunsen coefficients,  $\alpha$ , and the standard deviation among a number of tests performed under identical conditions are presented. The Bunsen coefficient is defined as the gas volume at STP (0.101 325 MPa and 273.15 K) absorbed per unit volume of pure liquid at the temperature of the measurement. All data refer to a temperature of 310.2 K and a pressure of 0.101 325 MPa.

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| Electrolyte       | Concn of solution<br>(mol/dm <sup>3</sup> ) | 10 <sup>4</sup> $\alpha$ | Electrolyte        | Concn of solution<br>(mol/dm <sup>3</sup> ) | 10 <sup>4</sup> $\alpha$ | Electrolyte                       | Concn of solution<br>(mol/dm <sup>3</sup> ) | 10 <sup>4</sup> $\alpha$ |
|-------------------|---------------------------------------------|--------------------------|--------------------|---------------------------------------------|--------------------------|-----------------------------------|---------------------------------------------|--------------------------|
| HCl               | 2.005                                       | 211 $\pm$ 4              | CuCl <sub>2</sub>  | 6.122                                       | 60 $\pm$ 2               | HNO <sub>3</sub>                  | 1.017                                       | 164 $\pm$ 4              |
|                   | 3.050                                       | 198 $\pm$ 7              |                    | 0.497                                       | 192 $\pm$ 2              |                                   | 1.069                                       | 158 $\pm$ 3              |
|                   | 3.910                                       | 191 $\pm$ 4              |                    | 0.519                                       | 189 $\pm$ 1              |                                   | 1.250                                       | 154 $\pm$ 1              |
|                   | 4.000                                       | 185 $\pm$ 2              |                    | 0.763                                       | 169 $\pm$ 1              |                                   | 1.460                                       | 149 $\pm$ 1              |
| AlCl <sub>3</sub> | 0.501                                       | 173 $\pm$ 1              | FeCl <sub>3</sub>  | 0.994                                       | 155 $\pm$ 1              | Al(NO <sub>3</sub> ) <sub>3</sub> | 1.939                                       | 132 $\pm$ 3              |
|                   | 0.745                                       | 144 $\pm$ 3              |                    | 1.002                                       | 156 $\pm$ 1              |                                   | 2.005                                       | 132 $\pm$ 2              |
|                   | 1.006                                       | 119 $\pm$ 2              |                    | 1.499                                       | 122 $\pm$ 1              |                                   | 2.959                                       | 108 $\pm$ 2              |
|                   | 1.081                                       | 113 $\pm$ 3              |                    | 1.517                                       | 124 $\pm$ 1              |                                   | 1.000                                       | 236 $\pm$ 4              |
| BaCl <sub>2</sub> | 2.009                                       | 63 $\pm$ 3               | KCl                | 0.500                                       | 186 $\pm$ 3              | Ba(NO <sub>3</sub> ) <sub>2</sub> | 2.000                                       | 230 $\pm$ 2              |
|                   | 2.503                                       | 41 $\pm$ 2               |                    | 1.016                                       | 148 $\pm$ 2              |                                   | 4.000                                       | 221 $\pm$ 4              |
|                   | 0.507                                       | 178 $\pm$ 3              |                    | 2.064                                       | 84 $\pm$ 7               |                                   | 0.308                                       | 202 $\pm$ 5              |
|                   | 0.997                                       | 131 $\pm$ 2              |                    | 0.503                                       | 208 $\pm$ 1              |                                   | 0.602                                       | 171 $\pm$ 3              |
| CaCl <sub>2</sub> | 1.509                                       | 96 $\pm$ 2               | LaCl <sub>3</sub>  | 1.002                                       | 178 $\pm$ 2              | Ca(NO <sub>3</sub> ) <sub>2</sub> | 1.095                                       | 127 $\pm$ 7              |
|                   | 0.494                                       | 184 $\pm$ 2              |                    | 1.502                                       | 158 $\pm$ 5              |                                   | 0.158                                       | 222 $\pm$ 3              |
|                   | 0.747                                       | 162 $\pm$ 2              |                    | 1.992                                       | 134 $\pm$ 3              |                                   | 0.298                                       | 207 $\pm$ 4              |
|                   | 0.987                                       | 144 $\pm$ 1              |                    | 2.976                                       | 105 $\pm$ 1              |                                   | 0.497                                       | 195 $\pm$ 4              |
| CdCl <sub>2</sub> | 1.021                                       | 141 $\pm$ 1              | LiCl               | 0.514                                       | 162 $\pm$ 2              | Ce(NO <sub>3</sub> ) <sub>3</sub> | 0.990                                       | 155 $\pm$ 6              |
|                   | 1.421                                       | 110 $\pm$ 2              |                    | 0.992                                       | 112 $\pm$ 1              |                                   | 1.961                                       | 101 $\pm$ 3              |
|                   | 1.490                                       | 107 $\pm$ 1              |                    | 1.993                                       | 50 $\pm$ 1               |                                   | 0.551                                       | 194 $\pm$ 5              |
|                   | 2.985                                       | 51 $\pm$ 2               |                    | 2.478                                       | 37 $\pm$ 2               |                                   | 0.740                                       | 181 $\pm$ 3              |
| CdCl <sub>2</sub> | 3.557                                       | 37 $\pm$ 1               | MgCl <sub>2</sub>  | 0.985                                       | 194 $\pm$ 4              | Co(NO <sub>3</sub> ) <sub>2</sub> | 1.548                                       | 133 $\pm$ 2              |
|                   | 3.894                                       | 34 $\pm$ 1               |                    | 1.069                                       | 189 $\pm$ 8              |                                   | 2.046                                       | 110 $\pm$ 3              |
|                   | 4.477                                       | 23 $\pm$ 1               |                    | 1.482                                       | 174 $\pm$ 6              |                                   | 0.997                                       | 137 $\pm$ 3              |
|                   | 0.260                                       | 213 $\pm$ 4              |                    | 1.993                                       | 159 $\pm$ 7              |                                   | 1.862                                       | 85 $\pm$ 2               |
| CeCl <sub>3</sub> | 0.479                                       | 196 $\pm$ 1              | MnCl <sub>2</sub>  | 2.336                                       | 150 $\pm$ 3              | CsNO <sub>3</sub>                 | 2.952                                       | 50 $\pm$ 3               |
|                   | 0.505                                       | 194 $\pm$ 3              |                    | 3.978                                       | 109 $\pm$ 3              |                                   | 0.502                                       | 194 $\pm$ 4              |
|                   | 0.523                                       | 193 $\pm$ 3              |                    | 0.503                                       | 190 $\pm$ 3              |                                   | 0.753                                       | 177 $\pm$ 4              |
|                   | 0.747                                       | 179 $\pm$ 3              |                    | 0.523                                       | 187 $\pm$ 4              |                                   | 1.002                                       | 157 $\pm$ 2              |
| CoCl <sub>2</sub> | 0.760                                       | 178 $\pm$ 2              | NaCl               | 0.982                                       | 153 $\pm$ 1              | Cu(NO <sub>3</sub> ) <sub>2</sub> | 1.487                                       | 126 $\pm$ 2              |
|                   | 0.966                                       | 164 $\pm$ 1              |                    | 0.998                                       | 149 $\pm$ 3              |                                   | 0.314                                       | 226 $\pm$ 2              |
|                   | 0.997                                       | 163 $\pm$ 2              |                    | 1.463                                       | 120 $\pm$ 2              |                                   | 0.325                                       | 228 $\pm$ 2              |
|                   | 1.025                                       | 161 $\pm$ 3              |                    | 1.592                                       | 113 $\pm$ 2              |                                   | 0.615                                       | 215 $\pm$ 2              |
| CsCl              | 1.046                                       | 164 $\pm$ 3              | NiCl <sub>2</sub>  | 1.745                                       | 106 $\pm$ 3              | Fe(NO <sub>3</sub> ) <sub>3</sub> | 0.624                                       | 209 $\pm$ 1              |
|                   | 1.264                                       | 149 $\pm$ 3              |                    | 2.126                                       | 91 $\pm$ 1               |                                   | 0.930                                       | 198 $\pm$ 2              |
|                   | 1.457                                       | 141 $\pm$ 3              |                    | 2.879                                       | 64 $\pm$ 2               |                                   | 0.298                                       | 213 $\pm$ 5              |
|                   | 1.491                                       | 141 $\pm$ 3              |                    | 0.840                                       | 159 $\pm$ 2              |                                   | 0.497                                       | 198 $\pm$ 1              |
| CeCl <sub>3</sub> | 1.503                                       | 138 $\pm$ 3              | RbCl               | 1.230                                       | 134 $\pm$ 3              | KNO <sub>3</sub>                  | 0.613                                       | 188 $\pm$ 3              |
|                   | 1.922                                       | 120 $\pm$ 1              |                    | 1.756                                       | 106 $\pm$ 2              |                                   | 0.987                                       | 160 $\pm$ 1              |
|                   | 1.996                                       | 116 $\pm$ 2              |                    | 2.127                                       | 88 $\pm$ 1               |                                   | 1.267                                       | 144 $\pm$ 1              |
|                   | 2.041                                       | 116 $\pm$ 2              |                    | 1.001                                       | 177 $\pm$ 4              |                                   | 0.498                                       | 189 $\pm$ 5              |
| CoCl <sub>2</sub> | 2.029                                       | 115 $\pm$ 1              | NH <sub>4</sub> Cl | 1.265                                       | 164 $\pm$ 8              | La(NO <sub>3</sub> ) <sub>3</sub> | 0.739                                       | 169 $\pm$ 1              |
|                   | 0.498                                       | 159 $\pm$ 7              |                    | 1.503                                       | 152 $\pm$ 2              |                                   | 0.999                                       | 147 $\pm$ 3              |
|                   | 0.979                                       | 111 $\pm$ 2              |                    | 2.016                                       | 130 $\pm$ 3              |                                   | 1.037                                       | 147 $\pm$ 1              |
|                   | 1.974                                       | 51 $\pm$ 1               |                    | 2.989                                       | 100 $\pm$ 2              |                                   | 0.746                                       | 201 $\pm$ 1              |
| CsCl              | 2.462                                       | 33 $\pm$ 4               | ZnCl <sub>2</sub>  | 3.030                                       | 98 $\pm$ 3               | LiNO <sub>3</sub>                 | 1.013                                       | 191 $\pm$ 3              |
|                   | 0.501                                       | 184 $\pm$ 2              |                    | 4.017                                       | 71 $\pm$ 2               |                                   | 1.510                                       | 169 $\pm$ 2              |
|                   | 0.749                                       | 162 $\pm$ 2              |                    | 1.002                                       | 200 $\pm$ 3              |                                   | 1.852                                       | 161 $\pm$ 6              |
|                   | 0.993                                       | 144 $\pm$ 3              |                    | 2.008                                       | 172 $\pm$ 1              |                                   | 0.493                                       | 184 $\pm$ 2              |
| CsCl              | 1.494                                       | 114 $\pm$ 2              | RbCl               | 2.215                                       | 160 $\pm$ 1              | Mg(NO <sub>3</sub> ) <sub>2</sub> | 0.966                                       | 141 $\pm$ 2              |
|                   | 0.515                                       | 212 $\pm$ 5              |                    | 3.001                                       | 144 $\pm$ 2              |                                   | 2.227                                       | 69 $\pm$ 2               |
|                   | 1.001                                       | 192 $\pm$ 2              |                    | 0.744                                       | 167 $\pm$ 2              |                                   | 0.955                                       | 201 $\pm$ 4              |
|                   | 1.028                                       | 187 $\pm$ 4              |                    | 0.991                                       | 145 $\pm$ 1              |                                   | 1.916                                       | 169 $\pm$ 4              |
| CsCl              | 1.505                                       | 170 $\pm$ 3              | ZnCl <sub>2</sub>  | 1.490                                       | 117 $\pm$ 2              | Mn(NO <sub>3</sub> ) <sub>2</sub> | 2.070                                       | 164 $\pm$ 3              |
|                   | 1.993                                       | 152 $\pm$ 3              |                    | 0.990                                       | 187 $\pm$ 3              |                                   | 2.869                                       | 140 $\pm$ 3              |
|                   | 2.203                                       | 138 $\pm$ 2              |                    | 1.014                                       | 184 $\pm$ 7              |                                   | 0.861                                       | 175 $\pm$ 6              |
|                   | 2.517                                       | 132 $\pm$ 3              |                    | 1.359                                       | 166 $\pm$ 2              |                                   | 0.992                                       | 162 $\pm$ 2              |
| CsCl              | 3.002                                       | 119 $\pm$ 2              | ZnCl <sub>2</sub>  | 1.984                                       | 143 $\pm$ 1              | Mn(NO <sub>3</sub> ) <sub>2</sub> | 1.663                                       | 124 $\pm$ 2              |
|                   | 3.382                                       | 105 $\pm$ 1              |                    | 2.957                                       | 112 $\pm$ 2              |                                   | 2.238                                       | 99 $\pm$ 3               |
|                   | 4.003                                       | 97 $\pm$ 1               |                    | 0.250                                       | 213 $\pm$ 7              |                                   | 0.506                                       | 198 $\pm$ 2              |
|                   | 4.028                                       | 98 $\pm$ 1               |                    | 0.493                                       | 190 $\pm$ 3              |                                   | 1.011                                       | 161 $\pm$ 3              |
| CsCl              | 5.003                                       | 78 $\pm$ 2               | ZnCl <sub>2</sub>  | 0.762                                       | 176 $\pm$ 3              | Mn(NO <sub>3</sub> ) <sub>2</sub> | 1.482                                       | 132 $\pm$ 5              |
|                   | 6.003                                       | 64 $\pm$ 2               |                    | 0.816                                       | 174 $\pm$ 2              |                                   | 1.936                                       | 112 $\pm$ 1              |



# **OXYGEN SOLUBILITY IN AQUEOUS ELECTROLYTE SOLUTIONS (continued)**

| Electrolyte                                     | Concn of solution<br>(mol/dm <sup>3</sup> ) | 10 <sup>4</sup> α | Electrolyte                                     | Concn of solution<br>(mol/dm <sup>3</sup> ) | 10 <sup>4</sup> α | Electrolyte                      | Concn of solution<br>(mol/dm <sup>3</sup> ) | 10 <sup>4</sup> α |
|-------------------------------------------------|---------------------------------------------|-------------------|-------------------------------------------------|---------------------------------------------|-------------------|----------------------------------|---------------------------------------------|-------------------|
| NaNO <sub>3</sub>                               | 0.762                                       | 200 ± 3           |                                                 | 0.741                                       | 155 ± 3           |                                  | 1.499                                       | 95 ± 3            |
|                                                 | 1.017                                       | 189 ± 4           |                                                 | 0.959                                       | 139 ± 1           |                                  | 1.783                                       | 82 ± 1            |
|                                                 | 1.533                                       | 166 ± 3           |                                                 | 1.000                                       | 133 ± 1           |                                  | 2.151                                       | 66 ± 1            |
|                                                 | 2.078                                       | 151 ± 4           | Fe <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> | 0.487                                       | 148 ± 2           | KHSO <sub>4</sub>                | 0.565                                       | 192 ± 2           |
| NH <sub>4</sub> NO <sub>3</sub>                 | 0.998                                       | 210 ± 4           |                                                 | 0.723                                       | 115 ± 2           |                                  | 0.771                                       | 176 ± 1           |
|                                                 | 1.991                                       | 185 ± 4           |                                                 | 0.940                                       | 94 ± 2            |                                  | 1.011                                       | 162 ± 3           |
|                                                 | 2.050                                       | 181 ± 4           | K <sub>2</sub> SO <sub>4</sub>                  | 0.247                                       | 200 ± 3           |                                  | 1.484                                       | 141 ± 2           |
|                                                 | 3.120                                       | 158 ± 2           |                                                 | 0.297                                       | 190 ± 2           |                                  | 1.522                                       | 137 ± 3           |
| Ni(NO <sub>3</sub> ) <sub>2</sub>               | 0.752                                       | 173 ± 1           |                                                 | 0.397                                       | 177 ± 2           |                                  | 1.638                                       | 133 ± 2           |
|                                                 | 0.852                                       | 167 ± 2           |                                                 | 0.405                                       | 174 ± 3           |                                  | 1.798                                       | 128 ± 3           |
|                                                 | 1.385                                       | 135 ± 1           |                                                 | 0.500                                       | 166 ± 3           |                                  | 1.805                                       | 127 ± 2           |
|                                                 | 2.062                                       | 99 ± 1            |                                                 | 0.582                                       | 157 ± 2           |                                  | 2.017                                       | 115 ± 2           |
| RbNO <sub>3</sub>                               | 0.487                                       | 219 ± 3           | Li <sub>2</sub> SO <sub>4</sub>                 | 0.510                                       | 177 ± 2           | NaHSO <sub>4</sub>               | 0.489                                       | 194 ± 2           |
|                                                 | 0.522                                       | 216 ± 5           |                                                 | 1.007                                       | 127 ± 2           |                                  | 0.519                                       | 193 ± 1           |
|                                                 | 0.958                                       | 193 ± 3           |                                                 | 1.903                                       | 71 ± 1            |                                  | 0.776                                       | 175 ± 3           |
|                                                 | 1.006                                       | 192 ± 3           | MgSO <sub>4</sub>                               | 0.497                                       | 174 ± 3           |                                  | 0.995                                       | 159 ± 2           |
|                                                 | 1.058                                       | 192 ± 5           |                                                 | 0.750                                       | 148 ± 4           |                                  | 1.018                                       | 159 ± 2           |
|                                                 | 1.360                                       | 177 ± 4           |                                                 | 0.996                                       | 128 ± 1           |                                  | 1.503                                       | 135 ± 1           |
|                                                 | 1.989                                       | 158 ± 1           |                                                 | 1.196                                       | 112 ± 2           |                                  | 1.574                                       | 132 ± 2           |
|                                                 | 2.017                                       | 155 ± 7           |                                                 | 1.202                                       | 113 ± 2           |                                  | 1.939                                       | 118 ± 3           |
| Th(NO <sub>3</sub> ) <sub>4</sub>               | 0.488                                       | 174 ± 1           |                                                 | 1.500                                       | 89 ± 2            |                                  | 2.628                                       | 92 ± 2            |
|                                                 | 0.741                                       | 145 ± 2           |                                                 | 2.003                                       | 66 ± 3            | NH <sub>4</sub> HSO <sub>4</sub> | 1.031                                       | 176 ± 3           |
|                                                 | 0.974                                       | 121 ± 3           |                                                 | 2.013                                       | 66 ± 2            |                                  | 1.503                                       | 153 ± 2           |
|                                                 | 1.385                                       | 92 ± 1            | MnSO <sub>4</sub>                               | 0.503                                       | 179 ± 2           |                                  | 1.982                                       | 135 ± 2           |
| Zn(NO <sub>3</sub> ) <sub>2</sub>               | 0.499                                       | 196 ± 3           |                                                 | 0.691                                       | 161 ± 4           |                                  | 2.643                                       | 116 ± 1           |
|                                                 | 0.756                                       | 178 ± 3           |                                                 | 0.998                                       | 132 ± 3           |                                  | 3.010                                       | 108 ± 2           |
|                                                 | 0.995                                       | 159 ± 5           |                                                 | 1.386                                       | 108 ± 2           | CsOH                             | 0.890                                       | 174 ± 1           |
|                                                 | 1.239                                       | 146 ± 3           |                                                 | 1.407                                       | 108 ± 1           |                                  | 2.142                                       | 108 ± 3           |
|                                                 | 1.506                                       | 128 ± 4           |                                                 | 1.740                                       | 88 ± 1            |                                  | 2.325                                       | 100 ± 1           |
|                                                 | 1.651                                       | 119 ± 1           | Na <sub>2</sub> SO <sub>4</sub>                 | 0.498                                       | 163 ± 2           | KOH                              | 0.938                                       | 169 ± 1           |
| H <sub>2</sub> SO <sub>4</sub>                  | 1.000                                       | 209 ± 7           |                                                 | 0.748                                       | 136 ± 2           |                                  | 1.030                                       | 164 ± 2           |
|                                                 | 1.500                                       | 189 ± 5           |                                                 | 0.883                                       | 120 ± 2           |                                  | 1.844                                       | 122 ± 1           |
|                                                 | 1.600                                       | 190 ± 1           |                                                 | 0.993                                       | 113 ± 2           |                                  | 2.135                                       | 108 ± 2           |
|                                                 | 2.000                                       | 177 ± 5           |                                                 | 1.325                                       | 87 ± 1            |                                  | 2.311                                       | 102 ± 1           |
|                                                 | 2.500                                       | 163 ± 4           |                                                 | 1.487                                       | 76 ± 2            |                                  | 2.329                                       | 100 ± 1           |
| Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> | 0.197                                       | 175 ± 2           |                                                 | 1.762                                       | 63 ± 1            |                                  | 3.077                                       | 79 ± 1            |
|                                                 | 0.298                                       | 151 ± 3           | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | 1.016                                       | 140 ± 2           |                                  | 3.502                                       | 67 ± 1            |
|                                                 | 0.396                                       | 129 ± 2           |                                                 | 1.047                                       | 137 ± 2           |                                  | 4.848                                       | 42 ± 1            |
| CdSO <sub>4</sub>                               | 1.012                                       | 132 ± 2           |                                                 | 1.988                                       | 86 ± 2            |                                  | 4.871                                       | 37 ± 1            |
|                                                 | 1.583                                       | 96 ± 3            |                                                 | 2.007                                       | 82 ± 2            | LiOH                             | 1.015                                       | 175 ± 1           |
|                                                 | 1.989                                       | 70 ± 2            |                                                 | 2.498                                       | 66 ± 2            |                                  | 1.856                                       | 135 ± 1           |
|                                                 | 2.510                                       | 50 ± 2            |                                                 | 2.984                                       | 51 ± 1            |                                  | 3.075                                       | 95 ± 2            |
|                                                 | 2.735                                       | 45 ± 1            |                                                 | 3.499                                       | 44 ± 1            |                                  | 4.059                                       | 65 ± 4            |
|                                                 | 3.026                                       | 36 ± 1            | NiSO <sub>4</sub>                               | 0.499                                       | 176 ± 2           | NaOH                             | 1.000                                       | 164 ± 1           |
| CoSO <sub>4</sub>                               | 0.497                                       | 174 ± 2           |                                                 | 0.749                                       | 150 ± 1           |                                  | 1.139                                       | 155 ± 2           |
|                                                 | 0.767                                       | 150 ± 1           |                                                 | 1.181                                       | 116 ± 3           |                                  | 2.000                                       | 114 ± 1           |
|                                                 | 1.001                                       | 128 ± 2           |                                                 | 1.489                                       | 95 ± 3            |                                  | 2.105                                       | 104 ± 1           |
|                                                 | 1.494                                       | 96 ± 1            | Rb <sub>2</sub> SO <sub>4</sub>                 | 0.401                                       | 181 ± 1           |                                  | 2.122                                       | 106 ± 1           |
| Cs <sub>2</sub> SO <sub>4</sub>                 | 0.500                                       | 171 ± 1           |                                                 | 0.803                                       | 138 ± 2           |                                  | 3.035                                       | 74 ± 1            |
|                                                 | 1.015                                       | 120 ± 1           |                                                 | 1.199                                       | 104 ± 1           |                                  | 4.071                                       | 49 ± 1            |
|                                                 | 1.525                                       | 86 ± 1            | ZnSO <sub>4</sub>                               | 0.501                                       | 170 ± 2           | RbOH                             | 1.112                                       | 157 ± 2           |
|                                                 | 1.909                                       | 66 ± 1            |                                                 | 0.719                                       | 148 ± 5           |                                  | 2.070                                       | 109 ± 3           |
| CuSO <sub>4</sub>                               | 0.496                                       | 177 ± 1           |                                                 | 1.006                                       | 122 ± 4           |                                  | 3.187                                       | 76 ± 3            |
|                                                 | 0.591                                       | 168 ± 4           |                                                 | 1.481                                       | 98 ± 2            |                                  |                                             |                   |

**PHYSICAL CONSTANTS OF CLEAR FUSED QUARTZ**  
**Based on information contained in Fused Quartz Catalogue Q-7A**  
**General Electric Company**

| Property                               | Clear fused quartz                                                                                                                                   |
|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Density                                | 2.2 g cm <sup>-3</sup>                                                                                                                               |
| Hardness                               | 4.9 (Mohs')                                                                                                                                          |
| Tensile strength                       | 7000 psi                                                                                                                                             |
| Compressive strength                   | >160,000 psi                                                                                                                                         |
| Bulk modulus                           | (approx.) $5.3 \times 10^6$ psi                                                                                                                      |
| Rigidity modulus                       | $4.5 \times 10^6$ psi                                                                                                                                |
| Young's modulus                        | $10.4 \times 10^6$ psi                                                                                                                               |
| Poisson's ratio                        | 0.16                                                                                                                                                 |
| Coefficient of thermal expansion       | (av.) $5.5 \times 10^{-7}$ cm cm <sup>-1</sup> °C <sup>-1</sup> $\left\{ \begin{array}{l} 20^\circ\text{C} \\ 320^\circ\text{C} \end{array} \right.$ |
| Thermal conductivity                   | 0.0033 cal cm <sup>-1</sup> s <sup>-1</sup> °C <sup>-1</sup> cm <sup>-1</sup>                                                                        |
| Specific heat                          | 0.18 cal g <sup>-1</sup>                                                                                                                             |
| Softening point                        | (approx.) 1665°C                                                                                                                                     |
| Annealing point                        | (approx.) 1140°C                                                                                                                                     |
| Strain point                           | 1070°C                                                                                                                                               |
| Electrical resistance                  | $9.5 \log_{10} R$ for cm <sup>3</sup> at 350°C                                                                                                       |
| Dielectric constant                    | 3.75 at 20°C. 1 MHz                                                                                                                                  |
| Dielectric loss factor                 | less than 0.0004 at 20°C. 1 MHz                                                                                                                      |
| Dissipation factor                     | less than 0.0001 at 20°C. 1 MHz                                                                                                                      |
| Index of refraction                    | 1.4585                                                                                                                                               |
| Velocity of sound — shear wave         | $3.75 \times 10^5$ cm s <sup>-1</sup>                                                                                                                |
| Velocity of sound — compressional wave | $5.90 \times 10^5$ cm s <sup>-1</sup>                                                                                                                |
| Sonic attenuation                      | less than 0.033 dB ft <sup>-1</sup> MHz <sup>-1</sup>                                                                                                |

## PLATINUM WIRE

Mass in Grams per Foot

| B. & S.<br>Gauge | Diameter,<br>inches | Mass,<br>g per ft | B. & S.<br>Gauge | Diameter,<br>inches | Mass,<br>g per ft |
|------------------|---------------------|-------------------|------------------|---------------------|-------------------|
| 10               | .1019               | 37.5              | 23               | .02257              | 1.8               |
| 11               | .09074              | 28.0              | 24               | .02010              | 1.4               |
| 12               | .08081              | 22.0              | 25               | .01790              | 1.1               |
| 13               | .07196              | 17.5              | 26               | .01594              | 0.9               |
| 14               | .06408              | 14.0              | 27               | .01420              | 0.7               |
| 15               | .05707              | 11.0              | 28               | .01264              | 0.6               |
| 16               | .05082              | 9.0               | 29               | .01126              | 0.45              |
| 17               | .04526              | 7.0               | 30               | .01003              | 0.35              |
| 18               | .04030              | 5.7               | 31               | .008928             | 0.28              |
| 19               | .03589              | 4.4               | 32               | .007950             | 0.22              |
| 20               | .03196              | 3.4               | 33               | .007080             | 0.17              |
| 21               | .02846              | 2.9               | 34               | .006305             | 0.15              |
| 22               | .02535              | 2.3               | 35               | .005615             | 0.11              |

## PROPERTIES OF CARBOHYDRATES

These data for carbohydrates were compiled originally for the Biology Data Book by M. L. Wolfram, G. G. Maher and R. G. Pagnucco (1964). Data are reproduced here by permission of the copyright owners of the above publication, the Federation of American Societies for Experimental Biology, Washington, D.C. pp. 351-359.

All data are for crystalline substances, unless otherwise specified. Selection of substances was restricted to natural carbohydrates found free (or in chemical combination and released on hydrolysis) and to biological oxidation products of the natural carbohydrates. The nomenclature conforms with that of the British-American report as published in the *Journal of Organic Chemistry*, 28:281 (1963). Substances have been arranged alphabetically under the name of the parent sugar within groups formulated according to increasing carbon content (excluding carbon in substituents), with synonymous common names in parentheses. **Melting Point:** b.p. = boiling point; d. = decomposes; s. = sinters. **Specific Rotation** was determined in water at concentrations of 1-5 g per 100 ml. of solution and at 20°-25°C, unless otherwise specified; other temperatures or wavelengths are shown in brackets; c = grams solute per 100 ml of solution.

### Part I. NATURAL MONOSACCHARIDES: ALDOSES AND KETOSES

| Substance (Synonym)                                                                                     | Chemical Formula                                | Melting Point °C                    | Specific Rotation $[\alpha]_D$                |
|---------------------------------------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------|-----------------------------------------------|
| (A)                                                                                                     | (B)                                             | (C)                                 | (D)                                           |
| Aldoses                                                                                                 |                                                 |                                     |                                               |
| 1 D-Glyceraldehyde                                                                                      | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>    | .....                               | +13.5 ± 0.5 (syrup)                           |
| 2 D-Glyceraldehyde, 3-deoxy-3,3-C-bis-(hydroxymethyl)- (Cordycepose)                                    | C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>   | .....                               | -26 (c 0.6, C <sub>2</sub> H <sub>5</sub> OH) |
| 3 D-Glyceraldehyde, 3,3-bis(C'-hydroxymethyl)- (Apiose)                                                 | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | .....                               | +5.6 (c 10) [15°] syrup                       |
| 4 β-D-Arabinose                                                                                         | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | 155                                 | -175 → -103                                   |
| 5 D-Arabinose, 2-O-methyl-                                                                              | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | Syrup                               | -102                                          |
| 6 α-L-Arabinose                                                                                         | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | 158 amorphous                       | +55.4 → +105                                  |
| 7 β-L-Arabinose                                                                                         | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | 160                                 | +190.6 → +104.5                               |
| 8 DL-Arabinose                                                                                          | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | 163.5-164.5                         | None                                          |
| 9 α-L-Lyxose                                                                                            | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | 105                                 | +5.8 → +13.5                                  |
| 10 L-Lyxose, 5-deoxy-3-C'-formyl- (Streptose)                                                           | C <sub>6</sub> H <sub>10</sub> O <sub>5</sub>   | .....                               | .....                                         |
| 11 L-Lyxose, 3-C'-formyl- (Hydroxystreptose)                                                            | C <sub>6</sub> H <sub>10</sub> O <sub>6</sub>   | .....                               | .....                                         |
| 12 Pentose, 4,5-anhydro-5-deoxy-D-erythro-                                                              | C <sub>5</sub> H <sub>8</sub> O <sub>3</sub>    | .....                               | .....                                         |
| 13 Pentose, 2-deoxy-D-erythro-                                                                          | C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>   | 96-98                               | -91 → -58                                     |
| 14 D-Ribose                                                                                             | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | 87                                  | -23.1 → -23.7                                 |
| 15 D-Ribose, 2-C'-hydroxymethyl- (Hamamelose)                                                           | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | .....                               | -7.1 [λ578]                                   |
| 16 α-D-Xylose                                                                                           | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | 145                                 | +93.6 → +18.8                                 |
| 17 D-Xylose, 5-deoxy-                                                                                   | C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>   | .....                               | +16                                           |
| 18 β-D-Xylose, 2-O-methyl-                                                                              | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 137-138                             | -21 → +34                                     |
| 19 α-D-Xylose, 3-O-methyl-                                                                              | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 95                                  | +45 → +19                                     |
| 20 D-Allose, 6-deoxy-                                                                                   | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 140-143                             | +1.6 [18°] (c 0.6)                            |
|                                                                                                         |                                                 | 146-148                             | -4.7 → 0                                      |
| 21 D-Allose, 6-deoxy-2,3-di-O-methyl- (Mycinoose)                                                       | C <sub>6</sub> H <sub>14</sub> O <sub>5</sub>   | 102-106                             | -46 → -29                                     |
| 22 Amicitose (a trideoxy hexose)                                                                        | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>   | Oil, b.p. 65-70                     | +28.6 (CHCl <sub>3</sub> )                    |
| 23 Antiarose                                                                                            | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | .....                               | Levo                                          |
| 24 α-D-Galactose                                                                                        | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | 167                                 | +150.7 → +80.2                                |
| 25 β-D-Galactose                                                                                        | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | 143-145                             | +52.8 → +80.2                                 |
| 26 D-Galactose, 3,6-anhydro-                                                                            | C <sub>6</sub> H <sub>10</sub> O <sub>5</sub>   | .....                               | +21.3 [10°]                                   |
| 27 α-D-Galactose, 6-deoxy- (D-Fucose; Rhodeose)                                                         | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 140-145                             | +127 → +76.3 (c 10)                           |
| 28 D-Galactose, 6-deoxy-3-O-methyl- (Digitalose)                                                        | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 106 <sup>1</sup> , 119 <sup>2</sup> | +106                                          |
| 29 D-Galactose, 6-deoxy-4-O-methyl-                                                                     | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 131-132                             | +82                                           |
| 30 D-Galactose, 6-deoxy-2,3-di-O-methyl-                                                                | C <sub>8</sub> H <sub>16</sub> O <sub>6</sub>   | .....                               | +73                                           |
| 31 α-D-Galactose, 3-O-methyl-                                                                           | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 144-147                             | +150.6 → +108.6                               |
| 32 α-D-Galactose, 6-O-methyl-                                                                           | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 122-123                             | +117 → +77.3                                  |
| 33 L-Galactose                                                                                          | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | .....                               | See D-Galactose                               |
| 34 α-L-Galactose, 3,6-anhydro-                                                                          | C <sub>6</sub> H <sub>10</sub> O <sub>5</sub>   | .....                               | -39.4 → -25.2                                 |
| 35 α-L-Galactose, 6-deoxy- (L-Fucose)                                                                   | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 145                                 | -124.1 → -76.4                                |
| 36 L-Galactose, 6-deoxy-2-O-methyl-                                                                     | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 149-150                             | -75 ± 4 (c 0.5)                               |
| 37 L-Galactose, 6-sulfate                                                                               | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> S | .....                               | -47 (c 0.2) (Na salt)                         |
| 38 DL-Galactose                                                                                         | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | 143-144, 163                        | None (racemic)                                |
| 39 α-D-Glucose                                                                                          | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | 146, 83 (H <sub>2</sub> O)          | +112 → +52.7                                  |
| 40 β-D-Glucose                                                                                          | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | 148-150                             | +18.7 → +52.7                                 |
| 41 D-Glucose, 6-acetate                                                                                 | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>   | 135                                 | +48                                           |
| 42 D-Glucose, 2,3-di-O-methyl-                                                                          | C <sub>8</sub> H <sub>16</sub> O <sub>6</sub>   | 85-86, 121                          | +50                                           |
| 43 D-Glucose, 6-O-benzoyl- (Vaccinin)                                                                   | C <sub>12</sub> H <sub>16</sub> O <sub>7</sub>  | Amorphous                           | +48 (C <sub>2</sub> H <sub>5</sub> OH)        |
| 44 α-D-Glucose, 6-deoxy- (Chinovose; Epirhamnose; Glucomethyllose; Isorhamnose; Isorhodeose; Quinovose) | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 139-140                             | +73.3 → +29.7 (c 8)                           |
| 45 α-D-Glucose, 6-deoxy-3-O-methyl- (D-Thevetose)                                                       | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 116                                 | +84 → +33                                     |



# PROPERTIES OF CARBOHYDRATES (continued)

Part I. NATURAL MONOSACCHARIDES: ALDOSES AND KETOSES (Continued)

| Substance (Synonym)                                                                     | Chemical Formula                                | Melting Point °C               | Specific Rotation $[\alpha]_D$                         |
|-----------------------------------------------------------------------------------------|-------------------------------------------------|--------------------------------|--------------------------------------------------------|
| (A)                                                                                     | (B)                                             | (C)                            | (D)                                                    |
| Aldoses (Con't)                                                                         |                                                 |                                |                                                        |
| 46 D-Glucose, 6-sulfonic acid, 6-deoxy- (6-Sulfoquinovose)                              | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> S | 173-174                        | +87 <sup>a</sup>                                       |
| 47 D-Glucose, 3-O-methyl-                                                               | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 162-167                        | +98 → +59.5                                            |
| 48 α-L-Glucose                                                                          | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | 141-143                        | -95.5 → -51.4                                          |
| 49 L-Glucose, 6-deoxy-3-O-methyl- (L-Thevetose)                                         | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 126-129                        | -36.9 ± 2                                              |
| 50 D-Gulose, 6-deoxy-                                                                   | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | .....                          | .....                                                  |
| 51 Hexose, 2-deoxy-D-arabino- <sup>a</sup>                                              | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 148                            | +46.6 [18°]                                            |
| 52 Hexose, 2,6-dideoxy-3-O-methyl-D-arabino- (D-Oleandrose)                             | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | .....                          | -11                                                    |
| 53 Hexose, 3,6-dideoxy-D-arabino- (Tyvelose)                                            | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | .....                          | +24 ± 2                                                |
| 54 Hexose, 2,6-dideoxy-3-O-methyl-L-arabino- (L-Oleandrose)                             | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 62-63                          | +11.9 ± 2.5                                            |
| 55 Hexose, 3,6-dideoxy-L-arabino- (Ascarylose)                                          | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | .....                          | -24 ± 2                                                |
| 56 Hexose, 2,6-dideoxy-3-O-methyl-D-lyxo- (Diginose)                                    | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 90-92                          | +56 ± 4                                                |
| 57 Hexose, 2,6-dideoxy-L-lyxo- (L-Fucose, 2-deoxy-)                                     | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | 103-106                        | -61.6                                                  |
| 58 Hexose, 2,6-dideoxy-3-O-methyl-L-lyxo-                                               | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 78-85                          | -65                                                    |
| 59 Hexose, 2,6-dideoxy-D-ribo- (Digi-<br>toxose; D-Altrose, 2,6-dideoxy-)               | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | 110                            | +46.4                                                  |
| 60 Hexose, 2,6-dideoxy-3-O-methyl-D-ribo- (Cymarose)                                    | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 93                             | +52                                                    |
| 61 Hexose, 3,6-dideoxy-D-ribo- (Paratose)                                               | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | .....                          | +10 ± 2 (c 0.9)                                        |
| 62 Hexose, 4,6-dideoxy-3-O-methyl-D-ribo- (D-Gulose, 4,6-dideoxy-3-O-methyl-; Chalcose) | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 96-99                          | +120 → +76                                             |
| 63 Hexose, 2,6-dideoxy-D-xylo- (Boivinose)                                              | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | 96-98                          | -3.9 → +3.9                                            |
| 64 Hexose, 2,6-dideoxy-3-O-methyl-D-xylo- (Sarmentose)                                  | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 78-79                          | +12 → +15.8                                            |
| 65 Hexose, 3,6-dideoxy-D-xylo- (Abe-<br>quose)                                          | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | .....                          | -3.2 ± 0.6                                             |
| 66 Hexose, 2,6-dideoxy-3-C-methyl-L-xylo- (Mycarose)                                    | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>   | 129-129                        | -31.1                                                  |
| 67 Hexose, 2,6-dideoxy-3-C-methyl-3-O-methyl-L-xylo- (Cladinose)                        | C <sub>8</sub> H <sub>16</sub> O <sub>6</sub>   | oil, b.p. 120-132<br>(0.25 mm) | -23.1                                                  |
| 68 Hexose, 3,6-dideoxy-L-xylo- (Colitose)                                               | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | .....                          | +4 (H <sub>2</sub> O); -51 ± 2<br>(CH <sub>2</sub> OH) |
| 69 D-Idose <sup>b</sup>                                                                 | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | .....                          | .....                                                  |
| 70 L-Idose, 1,6-anhydro-                                                                | C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>   | .....                          | .....                                                  |
| 71 α-D-Mannose                                                                          | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 133                            | +29.3 → +14.5                                          |
| 72 β-D-Mannose                                                                          | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>   | 132                            | -16.3 → +14.5                                          |
| 73 D-Mannose, 6-deoxy- (D-Rhamnose)                                                     | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>   | 86-90                          | -7.0                                                   |
| 74 α-L-Mannose, 6-deoxy-monohydrate (L-Rhamnose)                                        | C <sub>6</sub> H <sub>14</sub> O <sub>4</sub>   | 93-94                          | -8.6 → +8.2                                            |
| 75 β-L-Mannose, 6-deoxy-                                                                | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>   | 123-125                        | +38.4 → +8.9                                           |
| 76 L-Mannose, 6-deoxy-2-O-methyl-                                                       | C <sub>7</sub> H <sub>14</sub> O <sub>5</sub>   | .....                          | .....                                                  |
| 77 L-Mannose, 6-deoxy-3-O-methyl- (L-Acofriose)                                         | C <sub>7</sub> H <sub>14</sub> O <sub>5</sub>   | 114-115                        | +30 [18°]                                              |
| 78 L-Mannose, 6-deoxy-2,4-di-O-methyl-                                                  | C <sub>8</sub> H <sub>16</sub> O <sub>5</sub>   | 82                             | -19 [16°]                                              |
| 79 L-Mannose, 6-deoxy-5-C-methyl-4-O-methyl- (Noviose)                                  | C <sub>8</sub> H <sub>16</sub> O <sub>5</sub>   | 128-130                        | +19.9 (50% C <sub>2</sub> H <sub>5</sub> OH)           |
| 80 Rhodiose (a 2,3,6-trideoxyhexose)                                                    | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>   | .....                          | -11 ± 1.6                                              |
| 81 D-Talose                                                                             | C <sub>6</sub> H <sub>12</sub> O <sub>4</sub>   | 128-132                        | +16.9                                                  |
| 82 D-Talose, 6-deoxy- (D-Talomethylose)                                                 | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>   | 129-131                        | +20.6                                                  |
| 83 L-Talose, 6-deoxy- (L-Talomethylose)                                                 | C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>   | 116-118                        | -19.5 ± 2 [18°]                                        |
| 84 L-Talose, 6-deoxy-2-O-methyl- (L-Acovenose)                                          | C <sub>7</sub> H <sub>14</sub> O <sub>5</sub>   | .....                          | -19.4                                                  |
| 85 Heptose, D-glycero-D-galacto-                                                        | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>   | 139-140                        | +47 → +64 (c 0.5)                                      |
| 86 Heptose, D-glycero-D-manno-                                                          | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>   | .....                          | .....                                                  |
| 87 Heptose, D-glycero-L-manno-                                                          | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>   | .....                          | .....                                                  |
| Ketoses                                                                                 |                                                 |                                |                                                        |
| 88 Dihydroxyacetone                                                                     | C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>    | 80 (dimer)                     | None                                                   |
| 89 Tetrulose, L-glycero- <sup>a</sup> (L-Erythrulose; Ketoerythritol; L-Threulose)      | C <sub>4</sub> H <sub>8</sub> O <sub>4</sub>    | Syrup                          | +12                                                    |
| 90 Pentulose, D-erythro- (Adonose; D-Ribulose)                                          | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | Syrup                          | +16.6 [27°]                                            |
| 91 Pentulose, L-erythro- (L-Ribulose)                                                   | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>   | .....                          | -16.6                                                  |

# PROPERTIES OF CARBOHYDRATES (continued)

## Part I. NATURAL MONOSACCHARIDES: ALDOSES AND KETOSES (Continued)

| Substance (Synonym)                                                               | Chemical Formula                                                   | Melting Point °C     | Specific Rotation [α] <sub>D</sub> |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------|----------------------|------------------------------------|
| (A)                                                                               | (B)                                                                | (C)                  | (D)                                |
| Ketoses (Con't)                                                                   |                                                                    |                      |                                    |
| 92 Pentulose, <i>D-threo-</i> ( <i>D</i> -Xylulose)                               | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                      | .....                | −33                                |
| 93 Pentulose, 5-deoxy- <i>D-threo-</i>                                            | C <sub>5</sub> H <sub>10</sub> O <sub>4</sub>                      | .....                | −5 ± 1 (CH <sub>3</sub> OH)        |
| 94 Pentulose, <i>L-threo-</i> ( <i>L</i> -Xylulose; <i>L</i> -Lyxulose; Xylulose) | C <sub>5</sub> H <sub>10</sub> O <sub>5</sub>                      | Syrup                | +33.1                              |
| 95 Hexulose, β- <i>D-arabino-</i> (β- <i>D</i> -Fructose; Levulose)               | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                      | 102–104 <sup>1</sup> | −133.5 → −92                       |
| 96 Hexulose, 6-deoxy- <i>D-arabino-</i> ( <i>D</i> -Rhamnulose)                   | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                      | .....                | −13 ± 2                            |
| 97 Hexulose, <i>D-lyxo-</i> ( <i>D</i> -Tagatose)                                 | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                      | 131–132              | +2.7 → −4, −5                      |
| 98 5-Hexulose, <i>D-lyxo</i>                                                      | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                      | 158                  | −86.6                              |
| 99 Hexulose, 6-deoxy- <i>L-lyxo-</i> ( <i>L</i> -Fuculose)                        | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                      | .....                | .....                              |
| 100 Hexulose, <i>D-ribo-</i> ( <i>D</i> -Psicose)                                 | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                      | Amorphous            | +4.7                               |
| 101 Hexulose, <i>L-xyl-</i> ( <i>L</i> -Sorbse)                                   | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                      | 159–161              | −43.1                              |
| 102 Hexulose, 6-deoxy- <i>L-xyl-</i>                                              | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                      | 88                   | −25 ± 2 ( <i>c</i> 0.7)            |
| 103 Heptulose, <i>D-altro-</i> (Sedoheptulose; Sedoheptose)                       | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>                      | Amorphous            | +2.5 ( <i>c</i> 10)                |
| 104 Heptulose-hemihydrate, <i>L-galacto-</i> (Perseulose)                         | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub> · ½ H <sub>2</sub> O | 110–115              | −90 → −80                          |
| 105 Heptulose, <i>L-gulo-</i>                                                     | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>                      | .....                | −28                                |
| 106 Heptulose, <i>D-ido-</i>                                                      | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>                      | 172                  | −34 ± 8 ( <i>c</i> 0.3)            |
| 107 Heptulose, <i>D-manno-</i> (Mannoketose; <i>D</i> -Mannotagatoheptose)        | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>                      | 152                  | +29.4                              |
| 108 Heptulose, <i>D-talo-</i>                                                     | C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>                      | .....                | .....                              |
| 109 Octulose, <i>D-glycero-L-galacto-</i>                                         | C <sub>8</sub> H <sub>16</sub> O <sub>8</sub>                      | .....                | −57, −43.4 → −13.4                 |
| 110 Octulose, <i>D-glycero-D-manno-</i>                                           | C <sub>8</sub> H <sub>16</sub> O <sub>8</sub>                      | .....                | +20 (CH <sub>3</sub> OH)           |

<sup>1</sup> Original melting point. <sup>2</sup> Melting point after four-months' storage. <sup>3</sup> As a methyl glycoside cyclohexylamine salt. <sup>4</sup> Included because of speculations concerning it in biological processes. <sup>5</sup> Either *D*-idose or *L*-altrose is in the polysaccharide varianose. <sup>6</sup> Early literature refers to this as *D*-erythrose. <sup>7</sup> The ·½ H<sub>2</sub>O and ·2H<sub>2</sub>O forms also exist.

## Part II. NATURAL MONOSACCHARIDES: AMINO SUGARS

| Substance (Synonym)                                                              | Chemical Formula                                             | Melting Point °C | Specific Rotation [α] <sub>D</sub>    |
|----------------------------------------------------------------------------------|--------------------------------------------------------------|------------------|---------------------------------------|
| (A)                                                                              | (B)                                                          | (C)              | (D)                                   |
| Aldosamines                                                                      |                                                              |                  |                                       |
| 1 <i>D</i> -Ribose, 3-amino-3-deoxy-                                             | C <sub>5</sub> H <sub>11</sub> NO <sub>4</sub>               | 158–158.5 d.     | −24.6 (hydrochloride)                 |
| 2 <i>D</i> -Galactose, 2-amino-2-deoxy- (Galactosamine; Chondrosamine)           | C <sub>6</sub> H <sub>13</sub> NO <sub>5</sub>               | 185              | +121 → +80 (hydrochloride)            |
| 3 α- <i>L</i> -Galactose, 2-amino-2,6-dideoxy- ( <i>L</i> -Fucosamine)           | C <sub>6</sub> H <sub>13</sub> NO <sub>4</sub>               | 192–193 d.       | −119 → −92 [27°] (hydrochloride)      |
| 4 α- <i>D</i> -Glucose, 2-amino-2-deoxy- (Glucosamine; Chitosamine)              | C <sub>6</sub> H <sub>13</sub> NO <sub>5</sub>               | 88               | +100 → +47.5                          |
| 5 β- <i>D</i> -Glucose, 2-amino-2-deoxy-                                         | C <sub>6</sub> H <sub>13</sub> NO <sub>5</sub>               | 110–111          | +28 → +47.5                           |
| 6 <i>D</i> -Glucose, 3-amino-3-deoxy- (Kanosamine)                               | C <sub>6</sub> H <sub>13</sub> NO <sub>5</sub>               | 128 d.           | +19 [14°]                             |
| 7 <i>D</i> -Glucose, 6-amino-6-deoxy-                                            | C <sub>6</sub> H <sub>13</sub> NO <sub>5</sub>               | 161–162 d.       | +23 → +50.1 (hydrochloride)           |
| 8 <i>D</i> -Glucose, 2,6-diamino-2,6-dideoxy- (Neosamine C)                      | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>4</sub> | > 230            | +61.5 (dihydrochloride)               |
| 9 <i>D</i> -Glucose, 3,6-dideoxy-3-dimethylamino- (Mycaminose)                   | C <sub>8</sub> H <sub>17</sub> NO <sub>4</sub>               | 115–116          | +31 (hydrochloride)                   |
| 10 <i>D</i> -Glucose, 4,6-dideoxy-4-dimethylamino-                               | C <sub>8</sub> H <sub>17</sub> NO <sub>4</sub>               | 192–193          | +45.5 (hydrochloride)                 |
| 11 <i>L</i> -Glucose, 2-deoxy-2-methylamino-                                     | C <sub>7</sub> H <sub>15</sub> NO <sub>5</sub>               | 130–132          | −64                                   |
| 12 <i>D</i> -Gulose, 2-amino-1,6-anhydro-2-deoxy-                                | C <sub>6</sub> H <sub>13</sub> NO <sub>4</sub>               | 250–260 d.       | +41 ± 2 (hydrochloride)               |
| 13 <i>D</i> -Gulose, 2-amino-2-deoxy-                                            | C <sub>6</sub> H <sub>13</sub> NO <sub>5</sub>               | 152–162 d.       | +5.6 → −18.7 (hydrochloride)          |
| 14 Hexose, 3,4,6-trideoxy-3-dimethylamino- <i>D-xyl-</i> (Desosamine; Picrocine) | C <sub>8</sub> H <sub>17</sub> NO <sub>3</sub>               | 189–191 d.       | +49.5 ( <i>c</i> 10) (hydrochloride)  |
| 15 Hexose, a 4-acetamido-2-amino-2,4,6-trideoxy-                                 | C <sub>8</sub> H <sub>16</sub> N <sub>2</sub> O <sub>4</sub> | 216–219          | +115 → +94 [26°] ( <i>c</i> 0.05)     |
| 16 Hexose, an amino-deoxy-3- <i>O</i> -carboxyethyl-                             | C <sub>9</sub> H <sub>17</sub> NO <sub>7</sub>               | .....            | .....                                 |
| 17 Hexose, a 2,6-diamino-2,6-dideoxy- (Neosamine B; Paramose)                    | C <sub>6</sub> H <sub>14</sub> N <sub>2</sub> O <sub>4</sub> | 135–150 d.       | +17.5 ( <i>c</i> 0.9) (hydrochloride) |

## PROPERTIES OF CARBOHYDRATES (continued)

### Part II. NATURAL MONOSACCHARIDES: AMINO SUGARS (Continued)

| Substance (Synonym)                                                     | Chemical Formula   | Melting Point °C | Specific Rotation $[\alpha]_D$      |
|-------------------------------------------------------------------------|--------------------|------------------|-------------------------------------|
| (A)                                                                     | (B)                | (C)              | (D)                                 |
| Aldosamines (Con't)                                                     |                    |                  |                                     |
| 18 Hexose, a 3-dimethylamino-2,3,6-trideoxy- (Rhodosamine)              | $C_6H_{17}NO_3$    | .....            | .....                               |
| 19 D-Mannose, 2-amino-2-deoxy- (Mannosamine)                            | $C_6H_{13}NO_5$    | 142 d.           | −4.3 (c 9) (hydrochloride)          |
| 20 D-Mannose, 3-amino-3,6-dideoxy- (Mycosamine)                         | $C_6H_{13}NO_4$    | 162              | −11.5 (hydrochloride)               |
| 21 D-Talose, 2-amino-2-deoxy- (Talosanamine)                            | $C_6H_{13}NO_5$    | 151–153          | +3.4 → −5.7 (c 0.9) (hydrochloride) |
| 22 L-Talose, 2-amino-2,6-dideoxy- (Pneumosamine)                        | $C_6H_{13}NO_4$    | 162–163          | +6.9 → +10.4 (hydrochloride)        |
| Ketosamines                                                             |                    |                  |                                     |
| 23 Pentulose, 1-( <i>o</i> -carboxyanilino)-1-deoxy-D- <i>erythro</i> - | $C_{12}H_{14}NO_8$ | .....            | .....                               |
| 24 Hexulose, 1-( <i>o</i> -carboxyanilino)-1-deoxy-D- <i>arabino</i> -  | $C_{13}H_{16}NO_7$ | .....            | .....                               |
| 25 Hexulose, 5-amino-5-deoxy-L- <i>xyl</i> o-                           | $C_6H_{13}NO_5$    | 174–176          | −62                                 |
| 26 Hexulose, 6-deoxy-6-( <i>N</i> -methylacetamido)-L- <i>xyl</i> o-    | $C_9H_{17}NO_6$    | .....            | .....                               |

### Part III. NATURAL ALDITOLS AND INOSITOLS (with Inososes and Inosamines)

| Substance (Synonym)                                                                                               | Chemical Formula        | Melting Point °C  | Specific Rotation $[\alpha]_D$ |
|-------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------|--------------------------------|
| (A)                                                                                                               | (B)                     | (C)               | (D)                            |
| Alditols                                                                                                          |                         |                   |                                |
| 1 Glycerol                                                                                                        | $C_3H_8O_3$             | 20                | None                           |
| 2 Glycerol, 1-deoxy- (1,2-Propane-diol) <sup>1</sup>                                                              | $C_3H_6O_2$             | Oil, b.p. 188–189 | None (racemic)                 |
| 3 Erythritol                                                                                                      | $C_4H_{10}O_4$          | 118–120           | None (meso)                    |
| 4 Erythritol, 1,4-dideoxy- (2,3-Butylene-glycol)                                                                  | $C_4H_{10}O_2$          | 25, 34            | None (meso)                    |
| 5 D-Threitol, 1,4-dideoxy-                                                                                        | $C_4H_{10}O_2$          | 19                | −13.0                          |
| 6 L-Threitol, 1,4-dideoxy-                                                                                        | $C_4H_{10}O_2$          | .....             | +10.2                          |
| 7 DL-Threitol, 1,4-dideoxy-                                                                                       | $C_4H_{10}O_2$          | 7.6               | None (racemic)                 |
| 8 D-Arabinitol                                                                                                    | $C_5H_{12}O_5$          | 103               | +7.82 (c 8, borax solution)    |
| 9 L-Arabinitol                                                                                                    | $C_5H_{12}O_5$          | 101–102           | −32 (c 0.4, 5% molybdate)      |
| 10 Ribitol (Adomitol)                                                                                             | $C_5H_{12}O_5$          | 102               | None (meso)                    |
| 11 Galactitol (Dulcitol)                                                                                          | $C_6H_{14}O_6$          | 186–188           | None (meso)                    |
| 12 D-Glucitol (Sorbitol)                                                                                          | $C_6H_{14}O_6$          | 112               | −1.8 [15°]                     |
| 13 D-Glucitol, 1,5-anhydro- (Polygalitol)                                                                         | $C_6H_{12}O_5$          | 140–141           | +42.4                          |
| 14 L-Iditol                                                                                                       | $C_6H_{14}O_6$          | 73.5              | −3.5 (c 10)                    |
| 15 D-Mannitol                                                                                                     | $C_6H_{14}O_6$          | 166               | −0.21                          |
| 16 D-Mannitol, 1,5-anhydro- (Styracitol)                                                                          | $C_6H_{12}O_5$          | 157               | −49.9                          |
| 17 Heptitol, D- <i>glycero</i> -D- <i>galacto</i> - (Heptitol, L- <i>glycero</i> -D- <i>manno</i> -; Perseitol)   | $C_7H_{16}O_7$          | 183–185, 188      | −1.1                           |
| 18 Heptitol, D- <i>glycero</i> -D- <i>gluco</i> - (Heptitol, L- <i>glycero</i> -D- <i>tal</i> o-; β-Sedoheptitol) | $C_7H_{16}O_7$          | 131–132           | +46 (5% $NH_4$ molybdate)      |
| 19 Heptitol, D- <i>glycero</i> -D- <i>manno</i> - (Heptitol, D- <i>glycero</i> -D- <i>tal</i> o-; Volemitol)      | $C_7H_{16}O_7$          | 153               | +2.65                          |
| 20 Octitol, D- <i>erythro</i> -D- <i>galacto</i> -                                                                | $C_8H_{18}O_8$ , $H_2O$ | 169–170           | −11 (5% $NH_4$ molybdate)      |
| Inositols                                                                                                         |                         |                   |                                |
| 21 Betitol (a dideoxy inositol)                                                                                   | $C_6H_{12}O_4$          | 224               | .....                          |
| 22 Bioinosose ( <i>scyllo</i> -Inosose; <i>myo</i> -Inosose-2; a deoxy keto inositol)                             | $C_6H_{10}O_4$          | 198–200           | None (meso)                    |
| 23 <i>h</i> -Bornesitol (a <i>myo</i> -inositol mono-methyl ether)                                                | $C_7H_{14}O_4$          | 200               | +31.6                          |
| 24 <i>l</i> -Bornesitol (a <i>myo</i> -inositol mono-methyl ether)                                                | $C_7H_{14}O_4$          | 205–206           | −32.1                          |
| 25 Conduritol (a 2,3-dehydro-2,3-dideoxyinositol)                                                                 | $C_6H_{10}O_4$          | 142–143           | None (meso)                    |
| 26 Cordycepic acid (a tetrahydroxycyclohexanecarboxylic acid) <sup>2</sup>                                        | $C_7H_{12}O_6$          | .....             | .....                          |
| 27 Dambonitol (a <i>myo</i> -inositol dimethyl ether)                                                             | $C_8H_{16}O_6$          | 206               | None (meso)                    |
| 28 DL-Inositol                                                                                                    | $C_6H_{12}O_6$          | 253               | None (racemic)                 |



## PROPERTIES OF CARBOHYDRATES (continued)

### Part III. NATURAL ALDITOLS AND INOSITOLS (with Inososes and Inosamines) (Continued)

| Substance (Synonym)                                                   | Chemical Formula                                             | Melting Point °C | Specific Rotation [α] <sub>D</sub> |
|-----------------------------------------------------------------------|--------------------------------------------------------------|------------------|------------------------------------|
| (A)                                                                   | (B)                                                          | (C)              | (D)                                |
| Inositols (Con't)                                                     |                                                              |                  |                                    |
| 29 <i>d</i> -Inositol                                                 | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | .....            | +60                                |
| 30 <i>l</i> -Inositol                                                 | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | 240              | −65                                |
| 31 Laminitol (a <i>C</i> -methyl <i>myo</i> -inositol)                | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                | 266–269          | −3                                 |
| 32 Liriodendritol (a <i>myo</i> -inositol dimethyl ether)             | C <sub>8</sub> H <sub>18</sub> O <sub>6</sub>                | 224              | −25                                |
| 33 <i>muco</i> -Inositol monomethyl ether                             | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                | 322–325          | .....                              |
| 34 <i>myo</i> -Inositol ( <i>meso</i> -Inositol)                      | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | 217–218          | None ( <i>meso</i> )               |
| 35 <i>d</i> - <i>myo</i> -Inosose-1 (a deoxy keto inositol)           | C <sub>6</sub> H <sub>10</sub> O <sub>6</sub>                | 138–139          | +19.6                              |
| 36 Mytilitol (a <i>C</i> -methyl <i>scyllo</i> -inositol)             | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                | 259              | None ( <i>meso</i> )               |
| 37 <i>neo</i> -Inosamine-2 (a deoxy amino inositol)                   | C <sub>6</sub> H <sub>13</sub> O <sub>5</sub> N              | 239–241 d.       | None ( <i>meso</i> )               |
| 38 <i>d</i> -Ononitol (a <i>myo</i> -inositol monomethyl ether)       | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                | 172              | +6.6                               |
| 39 <i>h</i> -Pinitol (a <i>dextro</i> -inositol monomethyl ether)     | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                | 186              | +65.5                              |
| 40 <i>l</i> -Pinitol (a <i>levo</i> -inositol monomethyl ether)       | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                | 186              | −65                                |
| 41 <i>l</i> -Quebrachitol (a <i>levo</i> -inositol monomethyl ether)  | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                | 190–191          | −80.2 [28°]                        |
| 42 <i>d</i> -Quercitol (a deoxy <i>dextro</i> -inositol)              | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                | 235              | +24.2                              |
| 43 <i>d</i> -Quinic acid (a trideoxy carboxy <i>dextro</i> -inositol) | C <sub>7</sub> H <sub>12</sub> O <sub>6</sub>                | 164              | +44 (c 10)                         |
| 44 <i>l</i> -Quinic acid (a trideoxy carboxy <i>levo</i> -inositol)   | C <sub>7</sub> H <sub>12</sub> O <sub>6</sub>                | 162              | −42.1                              |
| 45 Quinic acid, 5-dehydro-                                            | C <sub>7</sub> H <sub>10</sub> O <sub>6</sub>                | 140–142 (138 s.) | −82.4 [28°]                        |
| 46 Scyllitol ( <i>scyllo</i> -Inositol; Cocositol)                    | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>                | 352–353          | None ( <i>meso</i> )               |
| 47 Sequoyitol (a <i>myo</i> -inositol monomethyl ether)               | C <sub>7</sub> H <sub>14</sub> O <sub>6</sub>                | 234–235          | None ( <i>meso</i> )               |
| 48 Shikimic acid (a 3,4-anhydro-quinic acid)                          | C <sub>7</sub> H <sub>10</sub> O <sub>5</sub>                | 183–184          | −200 [16°]                         |
| 49 Shikimic acid, 5-dehydro-                                          | C <sub>7</sub> H <sub>8</sub> O <sub>5</sub>                 | 150–152          | −57.5 [28°] (EtOH)                 |
| 50 Streptamine (2,4-diaminodideoxy-scylitol)                          | C <sub>6</sub> H <sub>14</sub> O <sub>4</sub> N <sub>2</sub> | 88, 210–250 d.   | None ( <i>meso</i> )               |
| 51 Streptamine, 2-deoxy-                                              | C <sub>6</sub> H <sub>14</sub> O <sub>3</sub> N <sub>2</sub> | .....            | None ( <i>meso</i> )               |
| 52 Streptadine (1,3-Dideoxy-1,3-diguani-dino-scylitol)                | C <sub>6</sub> H <sub>13</sub> N <sub>6</sub> O <sub>4</sub> | .....            | None ( <i>meso</i> )               |
| 53 Viburnitol (a deoxy <i>levo</i> -inositol) <sup>3</sup>            | C <sub>6</sub> H <sub>12</sub> O <sub>5</sub>                | 174              | −73.9                              |

<sup>1</sup> The 1-phosphate ester of this diol is said to occur in brain tissue and sea-urchin eggs. <sup>2</sup> Strong evidence that cordycepic acid is really *D*-mannitol. <sup>3</sup> Not an enantiomorph of *d*-quercitol; other isomeric relationship is involved.

### Part IV. NATURAL ALDONIC, URONIC, AND ALDARIC ACIDS

| Substance (Synonym)                                                                              | Chemical Formula                                | Melting Point °C     | Specific Rotation [α] <sub>D</sub>                    |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------|----------------------|-------------------------------------------------------|
| (A)                                                                                              | (B)                                             | (C)                  | (D)                                                   |
| Aldonic Acids                                                                                    |                                                 |                      |                                                       |
| 1 <i>D</i> -Glyceric acid                                                                        | C <sub>3</sub> H <sub>6</sub> O <sub>4</sub>    | Gum                  | Dextro                                                |
| 2 <i>L</i> -Glyceric acid                                                                        | C <sub>3</sub> H <sub>6</sub> O <sub>4</sub>    | Gum                  | Levo                                                  |
| 3 <i>D</i> -Arabinonic acid                                                                      | C <sub>5</sub> H <sub>10</sub> O <sub>6</sub>   | 114–116              | +10.5 (c 6)                                           |
| 4 <i>L</i> -Arabinonic acid                                                                      | C <sub>5</sub> H <sub>10</sub> O <sub>6</sub>   | 118–119              | −9.6 → −41.7 <sup>1</sup>                             |
| 5 <i>L</i> -Arabinonic-1,4-lactone                                                               | C <sub>5</sub> H <sub>8</sub> O <sub>5</sub>    | 97–99                | −72                                                   |
| 6 <i>D</i> -Ribonic acid                                                                         | C <sub>5</sub> H <sub>10</sub> O <sub>6</sub>   | 112–113              | −17.0                                                 |
| 7 <i>D</i> -Xylonic acid                                                                         | C <sub>5</sub> H <sub>10</sub> O <sub>6</sub>   | .....                | −2.9 → +20.1 <sup>1</sup>                             |
| 8 <i>L</i> -Xylonic acid                                                                         | C <sub>5</sub> H <sub>10</sub> O <sub>6</sub>   | .....                | −91.8 <sup>1</sup>                                    |
| 9 <i>D</i> -Altronic acid                                                                        | C <sub>6</sub> H <sub>12</sub> O <sub>7</sub>   | .....                | +11.5 → +24.8 <sup>1</sup><br>(Ca salt, <i>N</i> HCl) |
| 10 <i>D</i> -Galactonic acid                                                                     | C <sub>6</sub> H <sub>12</sub> O <sub>7</sub>   | 122                  | −11.2 → +57.6 <sup>1</sup>                            |
| 11 <i>D</i> -Glucuronic acid                                                                     | C <sub>6</sub> H <sub>12</sub> O <sub>7</sub>   | 130–132 (110–112 s.) | −6.7 → +11.9 <sup>1</sup>                             |
| 12 <i>L</i> -Gulonic acid                                                                        | C <sub>6</sub> H <sub>12</sub> O <sub>7</sub>   | Exists only in soln. | [ca. 0°]                                              |
| 13 Hexosonic acid, 2-deoxy- <i>D</i> -arabino-                                                   | C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>   | 93–95                | +68 (lactone)                                         |
| 14 2-Hexulosonic acid, <i>D</i> -arabino-                                                        | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | .....                | −81.7 (Na salt)                                       |
| 15 2-Hexulosonic acid, 3-deoxy- <i>D</i> -erythro-                                               | C <sub>6</sub> H <sub>10</sub> O <sub>6</sub>   | .....                | −29.2 (c 6, Ca salt)                                  |
| 16 2-Hexulosonic acid, <i>D</i> -lyxo-                                                           | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | 169                  | −5                                                    |
| 17 5-Hexulosonic acid, <i>D</i> -arabino-                                                        | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | 108–109              | .....                                                 |
| 18 5-Hexulosonic acid, <i>D</i> -xylo-                                                           | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | .....                | −14.5                                                 |
| 19 <i>D</i> -Mannonic acid                                                                       | C <sub>6</sub> H <sub>12</sub> O <sub>7</sub>   | .....                | −15.6                                                 |
| 20 <i>D</i> -Gluconic acid, <i>O</i> -β- <i>D</i> -galactopyranosyl- (1 → 4)- (Lactobionic acid) | C <sub>12</sub> H <sub>22</sub> O <sub>12</sub> | .....                | +25.1 (Ca salt)                                       |

## PROPERTIES OF CARBOHYDRATES (continued)

### Part IV. NATURAL ALDONIC, URONIC, AND ALDARIC ACIDS (Continued)

| Substance (Synonym)                      | Chemical Formula                                | Melting Point °C     | Specific Rotation $[\alpha]_D$ |
|------------------------------------------|-------------------------------------------------|----------------------|--------------------------------|
| (A)                                      | (B)                                             | (C)                  | (D)                            |
| Uronic Acids                             |                                                 |                      |                                |
| 21 L-Lyxuronic acid                      | C <sub>5</sub> H <sub>8</sub> O <sub>6</sub>    | .....                | .....                          |
| 22 β-D-Galacturonic acid                 | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | 160                  | +27 → +55.6                    |
| 23 α-D-Galacturonic acid-monohydrate     | C <sub>6</sub> H <sub>12</sub> O <sub>8</sub>   | 159–160 (110–115 s.) | +97.9 → +50.9                  |
| 24 D-Galacturonic acid, 2-amino-2-deoxy- | C <sub>6</sub> H <sub>11</sub> O <sub>6</sub> N | 160 d.               | +84.5 (pH 2 HCl)               |
| 25 β-D-Glucuronic acid                   | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | 156                  | +11.7 → +36.3                  |
| 26 D-Glucuronic acid, 2-amino-2-deoxy-   | C <sub>6</sub> H <sub>11</sub> O <sub>6</sub> N | 120–172 d.           | +55                            |
| 27 D-Glucuronic acid, 3-O-methyl-        | C <sub>7</sub> H <sub>12</sub> O <sub>7</sub>   | Syrup                | +6                             |
| 28 L-Guluronic acid                      | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | .....                | .....                          |
| 29 L-Iduronic acid                       | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | .....                | +30                            |
| 30 β-D-Mannuronic acid                   | C <sub>6</sub> H <sub>10</sub> O <sub>7</sub>   | 165–167              | –47.9 → –23.9                  |
| 31 α-D-Mannuronic acid-monohydrate       | C <sub>6</sub> H <sub>12</sub> O <sub>8</sub>   | 110 s., 120–130 d.   | +16 → –6.1 (c 6.8)             |
| Aldaric Acids                            |                                                 |                      |                                |
| 32 D-Tartaric acid                       | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>    | 170                  | –15                            |
| 33 L-Tartaric acid                       | C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>    | 170                  | +15 [15°]                      |
| 34 L-Malic acid                          | C <sub>4</sub> H <sub>6</sub> O <sub>5</sub>    | 100                  | –2.3 (c 8.4)                   |

<sup>1</sup> Equilibrates with the lactone.

**PROPERTIES OF SULFURIC ACID**  
**Values at 20°C; specific gravity is referred to water at 4°C**

| Bé   | Sp gr  | Percent<br>H <sub>2</sub> SO <sub>4</sub> | g per<br>liter | Lbs per<br>cu ft | Lbs per<br>gal | Bé   | Sp gr  | Percent<br>H <sub>2</sub> SO <sub>4</sub> | g per<br>liter | Lbs per<br>cu ft | Lbs per<br>gal |
|------|--------|-------------------------------------------|----------------|------------------|----------------|------|--------|-------------------------------------------|----------------|------------------|----------------|
| 0.7  | 1.0051 | 1                                         | 10.05          | 0.6275           | 0.0839         | 41.8 | 1.4049 | 51                                        | 716.5          | 44.73            | 5.979          |
| 1.7  | 1.0118 | 2                                         | 20.24          | 1.263            | 0.1689         | 42.5 | 1.4148 | 52                                        | 735.7          | 45.93            | 6.140          |
| 2.6  | 1.0184 | 3                                         | 30.55          | 1.907            | 0.2550         | 43.2 | 1.4248 | 53                                        | 755.1          | 47.14            | 6.302          |
| 3.5  | 1.0250 | 4                                         | 41.00          | 2.560            | 0.3422         | 44.0 | 1.4350 | 54                                        | 774.9          | 48.37            | 6.467          |
| 4.5  | 1.0317 | 5                                         | 51.59          | 3.220            | 0.4305         | 44.7 | 1.4453 | 55                                        | 794.9          | 49.62            | 6.634          |
| 5.4  | 1.0385 | 6                                         | 62.31          | 3.890            | 0.5200         | 45.4 | 1.4557 | 56                                        | 815.2          | 50.89            | 6.803          |
| 6.3  | 1.0453 | 7                                         | 73.17          | 4.568            | 0.6106         | 46.1 | 1.4662 | 57                                        | 835.7          | 52.17            | 6.974          |
| 7.2  | 1.0522 | 8                                         | 84.18          | 5.255            | 0.7025         | 46.8 | 1.4768 | 58                                        | 856.5          | 53.47            | 7.148          |
| 8.1  | 1.0591 | 9                                         | 95.32          | 5.950            | 0.7955         | 47.5 | 1.4875 | 59                                        | 877.6          | 54.79            | 7.324          |
| 9.0  | 1.0661 | 10                                        | 106.6          | 6.655            | 0.8897         | 48.2 | 1.4983 | 60                                        | 899.0          | 56.12            | 7.502          |
| 9.9  | 1.0731 | 11                                        | 118.0          | 7.369            | 0.9851         | 48.9 | 1.5091 | 61                                        | 920.6          | 57.47            | 7.682          |
| 10.8 | 1.0802 | 12                                        | 129.6          | 8.092            | 1.082          | 49.6 | 1.5200 | 62                                        | 942.4          | 58.83            | 7.865          |
| 11.7 | 1.0874 | 13                                        | 141.4          | 8.825            | 1.180          | 50.3 | 1.5310 | 63                                        | 964.5          | 60.21            | 8.049          |
| 12.5 | 1.0947 | 14                                        | 153.3          | 9.567            | 1.279          | 51.0 | 1.5421 | 64                                        | 986.9          | 61.61            | 8.236          |
| 13.4 | 1.1020 | 15                                        | 165.3          | 10.32            | 1.379          | 51.7 | 1.5533 | 65                                        | 1010           | 63.03            | 8.426          |
| 14.3 | 1.1094 | 16                                        | 177.5          | 11.08            | 1.481          | 52.3 | 1.5646 | 66                                        | 1033           | 64.46            | 8.618          |
| 15.2 | 1.1168 | 17                                        | 189.9          | 11.85            | 1.584          | 53.0 | 1.5760 | 67                                        | 1056           | 65.92            | 8.812          |
| 16.0 | 1.1243 | 18                                        | 202.4          | 12.63            | 1.689          | 53.7 | 1.5874 | 68                                        | 1079           | 67.39            | 9.008          |
| 16.9 | 1.1318 | 19                                        | 215.0          | 13.42            | 1.795          | 54.3 | 1.5989 | 69                                        | 1103           | 68.87            | 9.207          |
| 17.7 | 1.1394 | 20                                        | 227.9          | 14.23            | 1.902          | 55.0 | 1.6105 | 70                                        | 1127           | 70.38            | 9.408          |
| 18.6 | 1.1471 | 21                                        | 240.9          | 15.04            | 2.010          | 55.6 | 1.6221 | 71                                        | 1152           | 71.90            | 9.611          |
| 19.4 | 1.1548 | 22                                        | 254.1          | 15.86            | 2.120          | 56.3 | 1.6338 | 72                                        | 1176           | 73.44            | 9.817          |
| 20.3 | 1.1626 | 23                                        | 267.4          | 16.69            | 2.231          | 56.9 | 1.6456 | 73                                        | 1201           | 74.99            | 10.02          |
| 21.1 | 1.1704 | 24                                        | 280.9          | 17.54            | 2.344          | 57.5 | 1.6574 | 74                                        | 1226           | 76.57            | 10.24          |
| 21.9 | 1.1783 | 25                                        | 294.6          | 18.39            | 2.458          | 58.1 | 1.6692 | 75                                        | 1252           | 78.15            | 10.45          |
| 22.8 | 1.1862 | 26                                        | 308.4          | 19.25            | 2.574          | 58.7 | 1.6810 | 76                                        | 1278           | 79.75            | 10.66          |
| 23.6 | 1.1942 | 27                                        | 322.4          | 20.13            | 2.691          | 59.3 | 1.6927 | 77                                        | 1303           | 81.37            | 10.88          |
| 24.4 | 1.2023 | 28                                        | 336.6          | 21.02            | 2.809          | 59.9 | 1.7043 | 78                                        | 1329           | 82.99            | 11.09          |
| 25.2 | 1.2104 | 29                                        | 351.0          | 21.91            | 2.929          | 60.5 | 1.7158 | 79                                        | 1355           | 84.62            | 11.31          |
| 26.0 | 1.2185 | 30                                        | 365.6          | 22.82            | 3.051          | 61.1 | 1.7272 | 80                                        | 1382           | 86.26            | 11.53          |
| 26.8 | 1.2267 | 31                                        | 380.3          | 23.74            | 3.173          | 61.6 | 1.7383 | 81                                        | 1408           | 87.90            | 11.75          |
| 27.6 | 1.2349 | 32                                        | 395.2          | 24.67            | 3.298          | 62.1 | 1.7491 | 82                                        | 1434           | 89.54            | 11.97          |
| 28.4 | 1.2432 | 33                                        | 410.3          | 25.61            | 3.424          | 62.6 | 1.7594 | 83                                        | 1460           | 91.16            | 12.19          |
| 29.1 | 1.2515 | 34                                        | 425.5          | 26.56            | 3.551          | 63.0 | 1.7693 | 84                                        | 1486           | 92.78            | 12.40          |
| 29.9 | 1.2599 | 35                                        | 441.0          | 27.53            | 3.680          | 63.5 | 1.7786 | 85                                        | 1512           | 94.38            | 12.62          |
| 30.7 | 1.2684 | 36                                        | 456.6          | 28.51            | 3.811          | 63.9 | 1.7872 | 86                                        | 1537           | 95.95            | 12.83          |
| 31.4 | 1.2769 | 37                                        | 472.5          | 29.49            | 3.943          | 64.2 | 1.7951 | 87                                        | 1562           | 97.49            | 13.03          |
| 32.2 | 1.2855 | 38                                        | 488.5          | 30.49            | 4.077          | 64.5 | 1.8022 | 88                                        | 1586           | 99.01            | 13.23          |
| 33.0 | 1.2941 | 39                                        | 504.7          | 31.51            | 4.212          | 64.8 | 1.8087 | 89                                        | 1610           | 100.5            | 13.42          |
| 33.7 | 1.3028 | 40                                        | 521.1          | 32.53            | 4.349          | 65.1 | 1.8144 | 90                                        | 1633           | 101.9            | 13.63          |
| 34.5 | 1.3116 | 41                                        | 537.8          | 33.57            | 4.488          | 65.3 | 1.8195 | 91                                        | 1656           | 103.4            | 13.82          |
| 35.2 | 1.3205 | 42                                        | 554.6          | 34.62            | 4.628          | 65.5 | 1.8240 | 92                                        | 1678           | 104.8            | 14.00          |
| 35.9 | 1.3294 | 43                                        | 571.6          | 35.69            | 4.770          | 65.7 | 1.8279 | 93                                        | 1700           | 106.1            | 14.19          |
| 36.7 | 1.3384 | 44                                        | 588.9          | 36.76            | 4.914          | 65.8 | 1.8312 | 94                                        | 1721           | 107.5            | 14.36          |
| 37.4 | 1.3476 | 45                                        | 606.4          | 37.86            | 5.061          | 65.9 | 1.8337 | 95                                        | 1742           | 108.7            | 14.54          |
| 38.1 | 1.3569 | 46                                        | 624.2          | 38.97            | 5.209          | 66.0 | 1.8355 | 96                                        | 1762           | 110.0            | 14.70          |
| 38.9 | 1.3663 | 47                                        | 642.2          | 40.09            | 5.359          | 66.0 | 1.8364 | 97                                        | 1781           | 111.2            | 14.87          |
| 39.6 | 1.3758 | 48                                        | 660.4          | 41.23            | 5.511          | 66.0 | 1.8361 | 98                                        | 1799           | 112.3            | 15.02          |
| 40.3 | 1.3854 | 49                                        | 678.8          | 42.38            | 5.665          | 65.9 | 1.8342 | 99                                        | 1816           | 113.4            | 15.15          |
| 41.1 | 1.3951 | 50                                        | 697.6          | 43.55            | 5.821          | 65.8 | 1.8305 | 100                                       | 1831           | 114.3            | 15.28          |

# PROPERTIES OF TUNGSTEN

Jones and Langmuir, General Electric Review

| Temp.<br>K | Resis-<br>tivity<br>mi-<br>crohm<br>cm | Electron<br>emission<br>amp./cm <sup>2</sup> | Evaporation<br>g/cm <sup>2</sup> -s | Vapor<br>pressure<br>dynes/cm <sup>2</sup> | Thermal<br>expan-<br>sion per<br>cent $t_0$ at<br>293° | Atomic<br>heat<br>cal/g<br>atom/<br>°C |
|------------|----------------------------------------|----------------------------------------------|-------------------------------------|--------------------------------------------|--------------------------------------------------------|----------------------------------------|
| 300        | 5.65                                   | —                                            | —                                   | —                                          | .003                                                   | 6.0                                    |
| 400        | 8.06                                   | —                                            | —                                   | —                                          | .044                                                   | 6.0                                    |
| 500        | 10.56                                  | —                                            | —                                   | —                                          | .086                                                   | 6.1                                    |
| 600        | 13.23                                  | —                                            | —                                   | —                                          | .130                                                   | 6.1                                    |
| 700        | 16.09                                  | —                                            | —                                   | —                                          | .175                                                   | 6.2                                    |
| 800        | 19.00                                  | —                                            | —                                   | —                                          | .222                                                   | 6.2                                    |
| 900        | 21.94                                  | —                                            | —                                   | —                                          | .270                                                   | 6.3                                    |
| 1000       | 24.93                                  | $1.07 \times 10^{-15}$                       | $5.32 \times 10^{-34}$              | $1.98 \times 10^{-29}$                     | .320                                                   | 6.4                                    |
| 1100       | 27.94                                  | $1.52 \times 10^{-13}$                       | $2.17 \times 10^{-30}$              | $1.22 \times 10^{-25}$                     | .371                                                   | 6.4                                    |
| 1200       | 30.98                                  | $9.73 \times 10^{-12}$                       | $3.21 \times 10^{-27}$              | $1.87 \times 10^{-22}$                     | .424                                                   | 6.5                                    |
| 1300       | 34.08                                  | $3.21 \times 10^{-10}$                       | $1.35 \times 10^{-24}$              | $8.18 \times 10^{-20}$                     | .479                                                   | 6.7                                    |
| 1400       | 37.19                                  | $6.62 \times 10^{-9}$                        | $2.51 \times 10^{-22}$              | $1.62 \times 10^{-17}$                     | .535                                                   | 6.8                                    |
| 1500       | 40.36                                  | $9.14 \times 10^{-8}$                        | $2.37 \times 10^{-20}$              | $1.54 \times 10^{-15}$                     | .593                                                   | 7.0                                    |
| 1600       | 43.55                                  | $9.27 \times 10^{-7}$                        | $1.25 \times 10^{-18}$              | $8.43 \times 10^{-14}$                     | .652                                                   | 7.1                                    |
| 1700       | 46.78                                  | $7.08 \times 10^{-6}$                        | $4.17 \times 10^{-17}$              | $2.82 \times 10^{-12}$                     | .713                                                   | 7.2                                    |
| 1800       | 50.05                                  | $4.47 \times 10^{-5}$                        | $8.81 \times 10^{-16}$              | $6.31 \times 10^{-11}$                     | .775                                                   | 7.4                                    |
| 1900       | 53.35                                  | $2.28 \times 10^{-4}$                        | $1.41 \times 10^{-14}$              | $1.01 \times 10^{-9}$                      | .839                                                   | 7.6                                    |
| 2000       | 56.67                                  | $1.00 \times 10^{-3}$                        | $1.76 \times 10^{-13}$              | $1.33 \times 10^{-8}$                      | .904                                                   | 7.7                                    |
| 2100       | 60.06                                  | $3.93 \times 10^{-3}$                        | $1.66 \times 10^{-12}$              | $1.28 \times 10^{-7}$                      | .971                                                   | 7.8                                    |
| 2200       | 63.48                                  | $1.33 \times 10^{-2}$                        | $1.25 \times 10^{-11}$              | $9.88 \times 10^{-7}$                      | 1.039                                                  | 8.0                                    |
| 2300       | 66.91                                  | $4.07 \times 10^{-2}$                        | $8.00 \times 10^{-11}$              | $6.47 \times 10^{-6}$                      | 1.109                                                  | 8.2                                    |
| 2400       | 70.39                                  | $1.16 \times 10^{-1}$                        | $4.26 \times 10^{-10}$              | $3.52 \times 10^{-5}$                      | 1.180                                                  | 8.3                                    |
| 2500       | 73.91                                  | $2.98 \times 10^{-1}$                        | $2.03 \times 10^{-9}$               | $1.71 \times 10^{-4}$                      | 1.253                                                  | 8.4                                    |
| 2600       | 77.49                                  | $7.16 \times 10^{-1}$                        | $8.41 \times 10^{-9}$               | $7.24 \times 10^{-4}$                      | 1.328                                                  | 8.6                                    |
| 2700       | 81.04                                  | 1.63                                         | $3.19 \times 10^{-8}$               | $2.86 \times 10^{-3}$                      | 1.404                                                  | 8.7                                    |
| 2800       | 84.70                                  | 3.54                                         | $1.10 \times 10^{-7}$               | $9.84 \times 10^{-3}$                      | 1.479                                                  | 8.9                                    |
| 2900       | 88.33                                  | 7.31                                         | $3.30 \times 10^{-7}$               | $3.00 \times 10^{-2}$                      | 1.561                                                  | 9.0                                    |
| 3000       | 92.04                                  | $1.42 \times 10$                             | $9.95 \times 10^{-7}$               | $9.20 \times 10^{-2}$                      | 1.642                                                  | 9.2                                    |
| 3100       | 95.76                                  | $2.64 \times 10$                             | $2.60 \times 10^{-6}$               | $2.50 \times 10^{-1}$                      | 1.724                                                  | 9.4                                    |
| 3200       | 99.54                                  | $4.78 \times 10$                             | $6.38 \times 10^{-6}$               | $6.13 \times 10^{-1}$                      | 1.808                                                  | 9.5                                    |
| 3300       | 103.3                                  | $8.44 \times 10$                             | $1.56 \times 10^{-5}$               | 1.51                                       | 1.893                                                  | 9.6                                    |
| 3400       | 107.2                                  | $1.42 \times 10^2$                           | $3.47 \times 10^{-5}$               | 3.41                                       | 1.980                                                  | 9.8                                    |
| 3500       | 111.1                                  | $2.33 \times 10^2$                           | $7.54 \times 10^{-5}$               | 7.52                                       | 2.068                                                  | 9.9                                    |
| 3600       | 115.0                                  | $3.73 \times 10^2$                           | $1.51 \times 10^{-4}$               | $1.53 \times 10$                           | 2.158                                                  | 10.1                                   |
| 3655       | 117.1                                  | $4.79 \times 10^2$                           | $2.28 \times 10^{-4}$               | $2.33 \times 10$                           | 2.209                                                  | 10.2                                   |

Roeser and Wensel, National Bureau of Standards

| Temp.<br>K | Normal<br>brightness<br>new can-<br>dles per<br>cm <sup>2</sup> | Spectral<br>emissivity |         | Color<br>emis-<br>sivity | Total<br>emis-<br>sivity | Bright-<br>ness<br>temp.<br>0.65μm | Color<br>temp |
|------------|-----------------------------------------------------------------|------------------------|---------|--------------------------|--------------------------|------------------------------------|---------------|
|            |                                                                 | 0.65μm                 | 0.467μm |                          |                          |                                    |               |
| 300        | —                                                               | 0.472                  | 0.505   | —                        | 0.032                    | —                                  | —             |
| 400        | —                                                               | —                      | —       | —                        | .042                     | —                                  | —             |
| 500        | —                                                               | —                      | —       | —                        | .053                     | —                                  | —             |
| 600        | —                                                               | —                      | —       | —                        | .064                     | —                                  | —             |
| 700        | —                                                               | —                      | —       | —                        | .076                     | —                                  | —             |
| 800        | —                                                               | —                      | —       | —                        | .088                     | —                                  | —             |
| 900        | —                                                               | —                      | —       | —                        | .101                     | —                                  | —             |
| 1000       | 0.0001                                                          | .458                   | .486    | .395                     | .114                     | 966                                | 1007          |
| 1100       | 0.001                                                           | .456                   | .484    | .392                     | .128                     | 1059                               | 1108          |
| 1200       | 0.006                                                           | .454                   | .482    | .390                     | .143                     | 1151                               | 1210          |
| 1300       | 0.029                                                           | .452                   | .480    | .387                     | .158                     | 1242                               | 1312          |
| 1400       | 0.11                                                            | .450                   | .478    | .385                     | .175                     | 1332                               | 1414          |
| 1500       | 0.33                                                            | .448                   | .476    | .382                     | .192                     | 1422                               | 1516          |
| 1600       | 0.92                                                            | .446                   | .475    | .380                     | .207                     | 1511                               | 1619          |
| 1700       | 2.3                                                             | .444                   | .473    | .377                     | .222                     | 1599                               | 1722          |
| 1800       | 5.1                                                             | .442                   | .472    | .374                     | .236                     | 1687                               | 1825          |
| 1900       | 10.4                                                            | .440                   | .470    | .371                     | .249                     | 1774                               | 1928          |
| 2000       | 20.0                                                            | .438                   | .469    | .368                     | .260                     | 1861                               | 2032          |
| 2100       | 36                                                              | .436                   | .467    | .365                     | .270                     | 1946                               | 2136          |
| 2200       | 61                                                              | .434                   | .466    | .362                     | .279                     | 2031                               | 2241          |
| 2300       | 101                                                             | .432                   | .464    | .359                     | .288                     | 2115                               | 2345          |
| 2400       | 157                                                             | .430                   | .463    | .356                     | .296                     | 2198                               | 2451          |
| 2500       | 240                                                             | .428                   | .462    | .353                     | .303                     | 2280                               | 2556          |
| 2600       | 350                                                             | .426                   | .460    | .349                     | .311                     | 2362                               | 2662          |
| 2700       | 500                                                             | .424                   | .459    | .346                     | .318                     | 2443                               | 2769          |
| 2800       | 690                                                             | .422                   | .458    | .343                     | .323                     | 2523                               | 2876          |
| 2900       | 950                                                             | .420                   | .456    | .340                     | .329                     | 2602                               | 2984          |
| 3000       | 1260                                                            | .418                   | .455    | .336                     | .334                     | 2681                               | 3092          |
| 3100       | 1650                                                            | .416                   | .454    | .333                     | .337                     | 2759                               | 3200          |
| 3200       | 2100                                                            | .414                   | .452    | .330                     | .341                     | 2837                               | 3310          |
| 3300       | 2700                                                            | .412                   | .451    | .326                     | .344                     | 2913                               | 3420          |
| 3400       | 3400                                                            | .410                   | .450    | .323                     | .348                     | 2989                               | 3530          |
| 3500       | 4200                                                            | .408                   | .449    | .320                     | .351                     | 3063                               | 3642          |
| 3600       | 5200                                                            | .406                   | .447    | .317                     | .354                     | 3137                               | 3754          |



# RADIATIVE TRANSITION PROBABILITIES FOR X-RAY LINES

## Ratios of Transition Probabilities for K X-Ray Lines

| Element           | $K\alpha_2/K\alpha_1$ | $K\alpha_3/K\alpha_1$ | $K\beta_1/K\alpha_1$ | $K\beta'_2/K\alpha_1$ | $K\beta_4/K\alpha_1$  | $K\beta_5/K\alpha_1$  | $K\beta_3/K\beta_1$ | $K\beta/K\alpha$ |
|-------------------|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|-----------------------|---------------------|------------------|
| <sup>12</sup> Mg  |                       |                       |                      |                       |                       |                       |                     | 0.013            |
| <sup>14</sup> Si  |                       |                       |                      |                       |                       |                       |                     | 0.027            |
| <sup>16</sup> S   |                       |                       |                      |                       |                       |                       |                     | 0.059            |
| <sup>18</sup> Ar  |                       |                       |                      |                       |                       |                       |                     | 0.105            |
| <sup>20</sup> Ca  | 0.502                 |                       |                      |                       |                       |                       |                     | 0.128            |
| <sup>22</sup> Ti  | 0.503                 |                       |                      |                       |                       |                       |                     | 0.133            |
| <sup>24</sup> Cr  | 0.504                 |                       |                      |                       |                       |                       |                     | 0.133            |
| <sup>26</sup> Fe  | 0.506                 |                       |                      |                       |                       |                       |                     | 0.134            |
| <sup>28</sup> Ni  | 0.508                 |                       |                      |                       |                       |                       |                     | 0.135            |
| <sup>30</sup> Zn  | 0.510                 |                       |                      |                       |                       |                       |                     | 0.136            |
| <sup>32</sup> Ge  | 0.513                 |                       |                      |                       |                       |                       |                     | 0.147            |
| <sup>34</sup> Se  | 0.515                 |                       |                      |                       |                       |                       |                     | 0.157            |
| <sup>36</sup> Kr  | 0.517                 |                       |                      | 0.019                 |                       |                       |                     | 0.172            |
| <sup>38</sup> Sr  | 0.520                 |                       |                      | 0.030                 |                       |                       |                     | 0.180            |
| <sup>40</sup> Ze  | 0.523                 |                       |                      | 0.037                 |                       |                       |                     | 0.190            |
| <sup>42</sup> Mo  | 0.525                 |                       |                      | 0.041                 |                       |                       |                     | 0.197            |
| <sup>44</sup> Ru  | 0.527                 |                       |                      | 0.045                 |                       |                       | 0.513               | 0.204            |
| <sup>46</sup> Pd  | 0.529                 |                       |                      | 0.048                 |                       |                       | 0.513               | 0.210            |
| <sup>48</sup> Cd  | 0.532                 |                       |                      | 0.053                 |                       |                       | 0.514               | 0.213            |
| <sup>50</sup> Sn  | 0.534                 |                       |                      | 0.055                 |                       |                       | 0.514               | 0.220            |
| <sup>52</sup> Te  | 0.537                 |                       | 0.187                | 0.058                 |                       |                       | 0.514               | 0.225            |
| <sup>54</sup> Xe  | 0.539                 |                       | 0.188                | 0.064                 |                       |                       | 0.516               | 0.232            |
| <sup>56</sup> Ba  | 0.543                 |                       | 0.189                | 0.070                 |                       |                       | 0.516               | 0.237            |
| <sup>58</sup> Ce  | 0.546                 |                       | 0.190                | 0.076                 |                       |                       | 0.516               | 0.242            |
| <sup>60</sup> Nd  | 0.549                 | $0.11 \times 10^{-3}$ | 0.191                | 0.083                 |                       |                       | 0.516               | 0.247            |
| <sup>62</sup> Sm  | 0.552                 | $0.14 \times 10^{-3}$ | 0.192                | 0.086                 |                       |                       | 0.516               | 0.250            |
| <sup>64</sup> Gd  | 0.556                 | $0.17 \times 10^{-3}$ | 0.194                | 0.089                 | $0.85 \times 10^{-3}$ | $3.02 \times 10^{-3}$ | 0.517               | 0.255            |
| <sup>66</sup> Dy  | 0.560                 | $0.21 \times 10^{-3}$ | 0.198                | 0.089                 | $0.92 \times 10^{-3}$ | $3.43 \times 10^{-3}$ | 0.517               | 0.257            |
| <sup>68</sup> Er  | 0.564                 | $0.26 \times 10^{-3}$ | 0.202                | 0.088                 | $0.96 \times 10^{-3}$ | $3.85 \times 10^{-3}$ | 0.518               | 0.260            |
| <sup>70</sup> Yb  | 0.567                 | $0.30 \times 10^{-3}$ | 0.207                | 0.087                 | $1.04 \times 10^{-3}$ | $4.23 \times 10^{-3}$ | 0.518               | 0.264            |
| <sup>72</sup> Hf  | 0.572                 | $0.36 \times 10^{-3}$ | 0.212                | 0.085                 | $1.16 \times 10^{-3}$ | $4.62 \times 10^{-3}$ | 0.518               | 0.267            |
| <sup>74</sup> W   | 0.576                 | $0.43 \times 10^{-3}$ | 0.216                | 0.086                 | $1.28 \times 10^{-3}$ | $5.04 \times 10^{-3}$ | 0.518               | 0.269            |
| <sup>76</sup> Os  | 0.580                 | $0.51 \times 10^{-3}$ | 0.222                | 0.087                 | $1.43 \times 10^{-3}$ | $5.44 \times 10^{-3}$ | 0.519               | 0.273            |
| <sup>78</sup> Pt  | 0.583                 | $0.63 \times 10^{-3}$ | 0.226                | 0.091                 | $1.61 \times 10^{-3}$ | $5.84 \times 10^{-3}$ | 0.520               | 0.275            |
| <sup>80</sup> Hg  | 0.588                 | $0.76 \times 10^{-3}$ | 0.228                | 0.096                 | $1.80 \times 10^{-3}$ | $6.24 \times 10^{-3}$ | 0.520               | 0.278            |
| <sup>82</sup> Pb  | 0.593                 | $0.91 \times 10^{-3}$ | 0.228                | 0.102                 | $2.02 \times 10^{-3}$ | $6.64 \times 10^{-3}$ | 0.521               | 0.280            |
| <sup>84</sup> Po  | 0.597                 | $1.12 \times 10^{-3}$ | 0.228                | 0.108                 | $2.26 \times 10^{-3}$ | $7.05 \times 10^{-3}$ | 0.522               | 0.283            |
| <sup>86</sup> Rn  | 0.602                 | $1.32 \times 10^{-3}$ | 0.228                | 0.113                 | $2.52 \times 10^{-3}$ | $7.48 \times 10^{-3}$ | 0.523               | 0.286            |
| <sup>88</sup> Ra  | 0.608                 | $1.58 \times 10^{-3}$ | 0.230                | 0.117                 | $2.80 \times 10^{-3}$ | $7.80 \times 10^{-3}$ | 0.524               | 0.287            |
| <sup>90</sup> Th  | 0.613                 | $1.85 \times 10^{-3}$ | 0.232                | 0.120                 | $3.13 \times 10^{-3}$ | $8.25 \times 10^{-3}$ | 0.525               | 0.288            |
| <sup>92</sup> U   | 0.619                 | $2.15 \times 10^{-3}$ | 0.234                | 0.123                 | $3.47 \times 10^{-3}$ | $8.65 \times 10^{-3}$ | 0.527               | 0.289            |
| <sup>94</sup> Pu  | 0.625                 |                       | 0.234                | 0.125                 |                       |                       | 0.528               | 0.291            |
| <sup>96</sup> Cm  | 0.632                 |                       | 0.234                | 0.128                 |                       |                       | 0.529               | 0.293            |
| <sup>98</sup> Cf  | 0.642                 |                       | 0.238                | 0.132                 |                       |                       | 0.531               | 0.295            |
| <sup>100</sup> Fm | 0.648                 |                       | 0.240                | 0.135                 |                       |                       | 0.533               | 0.297            |



# **RADIATIVE TRANSITION PROBABILITIES FOR X-RAY LINES (continued)**

## **$L_1$ X-Ray Lines Normalized to $L\beta_3 = 100$**

| Element          | $L\beta_3$ | $L\beta_4$ | $L\gamma_2$ | $L\gamma_3$ | Element          | $L\beta_3$ | $L\beta_4$ | $L\gamma_2$ | $L\gamma_3$ |
|------------------|------------|------------|-------------|-------------|------------------|------------|------------|-------------|-------------|
| <sup>32</sup> Ge | 100        |            |             | 17.3        | <sup>66</sup> Dy | 100        | 61.8       | 19.5        | 28.0        |
| <sup>34</sup> Se | 100        |            |             | 18.0        | <sup>68</sup> Er | 100        | 63.5       | 19.8        | 29.0        |
| <sup>36</sup> Kr | 100        |            |             | 18.2        | <sup>70</sup> Yb | 100        | 65.5       | 20.7        | 29.8        |
| <sup>38</sup> Sr | 100        |            |             | 18.8        | <sup>72</sup> Hf | 100        | 67.8       | 21.2        | 30.7        |
| <sup>40</sup> Zr | 100        |            |             | 19.0        | <sup>74</sup> W  | 100        | 70.5       | 21.8        | 31.8        |
| <sup>42</sup> Mo | 100        | 70.6       |             | 19.6        | <sup>76</sup> Os | 100        | 73.2       | 23.0        | 32.8        |
| <sup>44</sup> Ru | 100        | 67.8       |             | 20.2        | <sup>78</sup> Pt | 100        | 76.5       | 24.5        | 33.8        |
| <sup>46</sup> Pd | 100        | 65.5       |             | 20.6        | <sup>80</sup> Hg | 100        | 80.3       | 26.3        | 35.0        |
| <sup>48</sup> Cd | 100        | 63.5       |             | 21.3        | <sup>82</sup> Pb | 100        | 84.2       | 28.6        | 36.0        |
| <sup>50</sup> Sn | 100        | 62.1       |             | 22.0        | <sup>84</sup> Po | 100        | 88.5       | 31.3        | 37.2        |
| <sup>52</sup> Te | 100        | 60.7       |             | 22.6        | <sup>86</sup> Rn | 100        | 93.4       | 34.2        | 38.2        |
| <sup>54</sup> Xe | 100        | 59.8       |             | 23.3        | <sup>88</sup> Ra | 100        | 98.9       | 37.5        | 39.6        |
| <sup>56</sup> Ba | 100        | 59.5       |             | 24.0        | <sup>90</sup> Th | 100        | 104.5      | 41.2        | 41.0        |
| <sup>58</sup> Ce | 100        | 59.2       |             | 24.6        | <sup>92</sup> U  | 100        | 110.2      | 45.0        | 42.6        |
| <sup>60</sup> Nd | 100        | 59.4       |             | 25.4        | <sup>94</sup> Pu | 100        | 116.2      | 49.5        | 44.0        |
| <sup>62</sup> Sm | 100        | 60.0       |             | 26.3        | <sup>96</sup> Cm | 100        | 123.0      | 55.7        | 45.7        |
| <sup>64</sup> Gd | 100        | 60.8       | 19.2        | 27.0        |                  |            |            |             |             |

## **$L_2$ X-Ray Lines Normalized to $L\beta_1 = 100$**

| Element          | $L\beta_1$ | $L\eta$ | $L\gamma_1$ | $L\gamma_6$ | Element          | $L\beta_1$ | $L\eta$ | $L\gamma_1$ | $L\gamma_6$ |
|------------------|------------|---------|-------------|-------------|------------------|------------|---------|-------------|-------------|
| <sup>28</sup> Ni | 100        | 7.60    |             |             | <sup>64</sup> Gd | 100        | 2.35    | 17.00       |             |
| <sup>30</sup> Zn | 100        | 6.80    |             |             | <sup>66</sup> Dy | 100        | 2.25    | 17.40       |             |
| <sup>32</sup> Ge | 100        | 6.28    |             |             | <sup>68</sup> Er | 100        | 2.16    | 17.80       |             |
| <sup>34</sup> Se | 100        | 5.80    |             |             | <sup>70</sup> Yb | 100        | 2.10    | 18.17       |             |
| <sup>36</sup> Kr | 100        | 5.35    |             |             | <sup>72</sup> Hf | 100        | 2.08    | 18.43       |             |
| <sup>38</sup> Sr | 100        | 4.93    |             |             | <sup>74</sup> W  | 100        | 2.10    | 18.80       | 0.72        |
| <sup>40</sup> Zr | 100        | 4.60    | 3.30        |             | <sup>76</sup> Os | 100        | 2.12    | 19.34       | 1.65        |
| <sup>42</sup> Mo | 100        | 4.30    | 5.50        |             | <sup>78</sup> Pt | 100        | 2.18    | 19.73       | 2.40        |
| <sup>44</sup> Ru | 100        | 4.00    | 7.33        |             | <sup>80</sup> Hg | 100        | 2.25    | 20.35       | 3.10        |
| <sup>46</sup> Pd | 100        | 3.75    | 10.67       |             | <sup>82</sup> Pb | 100        | 2.30    | 20.93       | 3.65        |
| <sup>48</sup> Cd | 100        | 3.55    | 10.60       |             | <sup>84</sup> Po | 100        | 2.40    | 21.54       | 4.15        |
| <sup>50</sup> Sn | 100        | 3.35    | 11.80       |             | <sup>86</sup> Rn | 100        | 2.46    | 22.20       | 4.55        |
| <sup>52</sup> Te | 100        | 3.20    | 12.70       |             | <sup>88</sup> Ra | 100        | 2.50    | 22.87       | 4.87        |
| <sup>54</sup> Xe | 100        | 3.00    | 14.00       |             | <sup>90</sup> Th | 100        | 2.60    | 23.43       | 5.02        |
| <sup>56</sup> Ba | 100        | 2.85    | 14.50       |             | <sup>92</sup> U  | 100        | 2.65    | 24.10       | 5.12        |
| <sup>58</sup> Ce | 100        | 2.70    | 15.30       |             | <sup>94</sup> Pu | 100        | 2.70    | 24.40       | 5.16        |
| <sup>60</sup> Nd | 100        | 2.60    | 16.00       |             | <sup>96</sup> Cm | 100        | 2.75    | 25.07       | 5.20        |
| <sup>62</sup> Sn | 100        | 2.45    | 16.50       |             |                  |            |         |             |             |

# **RADIATIVE TRANSITION PROBABILITIES FOR X-RAY LINES (continued)**

## **$L_3$ X-Ray Lines Normalized to $L\alpha_1 = 100$**

| Element          | $L\alpha_1$ | $L\beta_{2,15}$ | $L\alpha_2$ | $L\beta_5$ | $L\beta_6$ | $L_t$ |
|------------------|-------------|-----------------|-------------|------------|------------|-------|
| <sup>26</sup> Fe | 100         |                 |             |            |            | 12.22 |
| <sup>28</sup> Ni | 100         |                 |             |            |            | 8.95  |
| <sup>30</sup> Zn | 100         |                 |             |            |            | 7.34  |
| <sup>32</sup> Ge | 100         |                 |             |            |            | 6.45  |
| <sup>34</sup> Se | 100         |                 |             |            |            | 7.76  |
| <sup>36</sup> Kr | 100         |                 |             |            |            | 5.28  |
| <sup>38</sup> Sr | 100         |                 |             |            |            | 4.92  |
| <sup>40</sup> Zr | 100         | 0.70            | 11.10       |            |            | 4.67  |
| <sup>42</sup> Mo | 100         | 5.17            | 11.10       |            |            | 4.45  |
| <sup>44</sup> Ru | 100         | 9.30            | 11.12       |            |            | 4.28  |
| <sup>46</sup> Pd | 100         | 11.80           | 11.12       |            |            | 4.11  |
| <sup>48</sup> Cd | 100         | 14.33           | 11.12       |            |            | 4.07  |
| <sup>50</sup> Sn | 100         | 16.00           | 11.13       |            |            | 4.00  |
| <sup>52</sup> Te | 100         | 18.00           | 11.13       |            |            | 4.00  |
| <sup>54</sup> Xe | 100         | 19.40           | 11.13       |            |            | 4.00  |
| <sup>56</sup> Ba | 100         | 20.67           | 11.13       |            |            | 4.02  |
| <sup>58</sup> Ce | 100         | 21.00           | 11.14       |            |            | 4.09  |
| <sup>60</sup> Nd | 100         | 21.33           | 11.14       |            | 0.875      | 4.13  |
| <sup>62</sup> Sm | 100         | 21.07           | 11.14       |            | 0.925      | 4.16  |
| <sup>64</sup> Gd | 100         | 20.83           | 11.14       |            | 0.99       | 4.20  |
| <sup>66</sup> Dy | 100         | 20.50           | 11.14       |            | 1.05       | 4.26  |
| <sup>68</sup> Er | 100         | 20.04           | 11.15       |            | 1.12       | 4.33  |
| <sup>70</sup> Yb | 100         | 19.40           | 11.15       |            | 1.17       | 4.47  |
| <sup>72</sup> Hf | 100         | 21.33           | 11.15       | 0.30       | 1.21       | 4.59  |
| <sup>74</sup> W  | 100         | 22.74           | 11.16       | 0.50       | 1.25       | 4.76  |
| <sup>76</sup> Os | 100         | 23.40           | 11.16       | 1.32       | 1.37       | 4.95  |
| <sup>78</sup> Pt | 100         | 24.00           | 11.16       | 1.98       | 1.43       | 5.14  |
| <sup>80</sup> Hg | 100         | 24.50           | 11.17       | 2.62       | 1.50       | 5.37  |
| <sup>82</sup> Pb | 100         | 24.83           | 11.17       | 3.21       | 1.56       | 5.58  |
| <sup>84</sup> Po | 100         | 25.13           | 11.17       | 3.73       | 1.62       | 5.80  |
| <sup>86</sup> Rn | 100         | 25.60           | 11.18       | 4.25       | 1.68       | 6.00  |
| <sup>88</sup> Ra | 100         | 25.92           | 11.18       | 4.73       | 1.76       | 6.26  |
| <sup>90</sup> Th | 100         | 26.17           | 11.18       | 5.18       | 1.82       | 6.54  |
| <sup>92</sup> U  | 100         | 26.40           | 11.18       | 5.58       | 1.89       | 6.79  |
| <sup>94</sup> Pu | 100         | 26.67           | 11.18       | 5.92       | 1.95       | 7.02  |
| <sup>96</sup> Cm | 100         | 26.93           | 11.18       | 6.26       | 2.01       | 7.34  |

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# RADIOACTIVE TRACER DIFFUSION DATA FOR PURE METALS

John Askill

The data in these tables are the most reliable set of radioactive tracer diffusion data for pure metals published in the literature from 1938 through December, 1970. For a complete listing of all published data on this subject up to December 1968 see "Tracer Diffusion Data for Metals, Alloys and Simple Oxides" by John Askill, published by Plenum Press, New York, 1970.

The diffusion coefficient  $D_T$  at a temperature  $T(^{\circ}\text{K})$  is given by the following relation:

$$D_T = D_0 e^{-Q/RT}$$

Abbreviations used in the tables are:

A.R.G. = Autoradiography  
R.A. = Residual Activity  
S.D. = Surface Decrease  
S.S. = Serial Sectioning  
P. = Polycrystalline  
S. = Single Crystal  
⊥c. = Perpendicular to c Direction  
||c. = Parallel to c Direction  
99.95 = 99.95%

| Solute (tracer)   | Material (metal, crystalline form and purity) | Temperature range, $^{\circ}\text{C}$ | Form of analysis | Activation energy, $Q$ , Kcal/mole | Frequency factor, $D_0$ , $\text{cm}^2/\text{sec}$ | Reference |
|-------------------|-----------------------------------------------|---------------------------------------|------------------|------------------------------------|----------------------------------------------------|-----------|
| <b>Aluminum</b>   |                                               |                                       |                  |                                    |                                                    |           |
| Ag <sup>110</sup> | S 99.999                                      | 371-655                               | S.S.             | 27.83                              | 0.118                                              | 1         |
| Al <sup>27</sup>  | S                                             | 450-650                               | S.S.             | 34.0                               | 1.71                                               | 2         |
| Au <sup>198</sup> | S 99.999                                      | 423-609                               | S.S.             | 27.0                               | 0.077                                              | 3         |
| Cd <sup>113</sup> | S 99.999                                      | 441-631                               | S.S.             | 29.7                               | 1.04                                               | 3         |
| Ce <sup>141</sup> | P 99.995                                      | 450-630                               | R.A.             | 26.60                              | $1.9 \times 10^{-6}$                               | 5         |
| Co <sup>60</sup>  | S 99.999                                      | 369-655                               | S.S.             | 27.79                              | 0.131                                              | 1         |
| Cr <sup>51</sup>  | S 99.999                                      | 422-654                               | S.S.             | 41.74                              | 464                                                | 1         |
| Cu <sup>64</sup>  | S 99.999                                      | 433-652                               | S.S.             | 32.27                              | 0.647                                              | 1         |
| Fe <sup>59</sup>  | S 99.99                                       | 550-636                               | S.S.             | 46.0                               | 135                                                | 3         |
| Ga <sup>67</sup>  | S 99.999                                      | 406-652                               | S.S.             | 29.24                              | 0.49                                               | 1         |
| Ge <sup>76</sup>  | S 99.999                                      | 401-653                               | S.S.             | 28.98                              | 0.481                                              | 1         |
| In <sup>114</sup> | P 99.99                                       | 400-600                               | S.S., R.A.       | 27.6                               | 0.123                                              | 4         |
| La <sup>140</sup> | P 99.995                                      | 500-630                               | R.A.             | 27.0                               | $1.4 \times 10^{-6}$                               | 5         |
| Mn <sup>54</sup>  | P 99.99                                       | 450-650                               | S.S.             | 28.8                               | 0.22                                               | 2         |
| Mo <sup>99</sup>  | P 99.995                                      | 400-630                               | R.A.             | 13.1                               | $1.04 \times 10^{-9}$                              | 6         |
| Nb <sup>95</sup>  | P 99.95                                       | 350-480                               | R.A.             | 19.65                              | $1.66 \times 10^{-7}$                              | 7         |
| Nd <sup>147</sup> | P 99.995                                      | 450-630                               | R.A.             | 25.0                               | $4.8 \times 10^{-7}$                               | 5         |
| Ni <sup>63</sup>  | P 99.99                                       | 360-630                               | R.A.             | 15.7                               | $2.9 \times 10^{-8}$                               | 8         |
| Pd <sup>103</sup> | P 99.995                                      | 400-630                               | R.A.             | 20.2                               | $1.92 \times 10^{-7}$                              | 9         |
| Pr <sup>142</sup> | P 99.995                                      | 520-630                               | R.A.             | 23.87                              | $3.58 \times 10^{-7}$                              | 5         |
| Sb <sup>124</sup> | P                                             | 448-620                               | R.A.             | 29.1                               | 0.09                                               | 10        |
| Sm <sup>153</sup> | P 99.995                                      | 450-630                               | R.A.             | 22.88                              | $3.45 \times 10^{-7}$                              | 5         |
| Sn <sup>113</sup> | P                                             | 400-600                               | S.S., R.A.       | 28.5                               | 0.245                                              | 4         |
| V <sup>48</sup>   | P 99.995                                      | 400-630                               | R.A.             | 19.6                               | $6.05 \times 10^{-8}$                              | 11        |
| Zn <sup>65</sup>  | S 99.999                                      | 357-653                               | S.S.             | 28.86                              | 0.259                                              | 1         |
| <b>Beryllium</b>  |                                               |                                       |                  |                                    |                                                    |           |
| Ag <sup>110</sup> | S ⊥c 99.75                                    | 650-900                               | R.A.             | 43.2                               | 1.76                                               | 12        |
| Ag <sup>110</sup> | S ⊥c 99.75                                    | 650-900                               | R.A.             | 39.3                               | 0.43                                               | 12        |
| Be <sup>7</sup>   | S ⊥c 99.75                                    | 565-1065                              | R.A.             | 37.6                               | 0.52                                               | 13        |
| Be <sup>7</sup>   | S ⊥c 99.75                                    | 565-1065                              | R.A.             | 39.4                               | 0.62                                               | 13        |
| Fe <sup>59</sup>  | S 99.75                                       | 700-1076                              | R.A.             | 51.6                               | 0.67                                               | 12        |
| Ni <sup>63</sup>  | P                                             | 800-1250                              | R.A.             | 58.0                               | 0.2                                                | 14        |
| <b>Cadmium</b>    |                                               |                                       |                  |                                    |                                                    |           |
| Ag <sup>110</sup> | S 99.99                                       | 180-300                               |                  | 25.4                               | 2.21                                               | 15        |
| Cd <sup>113</sup> | S 99.95                                       | 110-283                               | R.A.             | 19.3                               | 0.14                                               | 16        |
| Zn <sup>65</sup>  | S 99.99                                       | 180-300                               |                  | 19.0                               | 0.0016                                             | 15        |
| <b>Calcium</b>    |                                               |                                       |                  |                                    |                                                    |           |
| C <sup>14</sup>   | 99.95                                         | 550-800                               | R.A.             | 29.8                               | $3.2 \times 10^{-5}$                               | 17        |
| Ca <sup>45</sup>  | 99.95                                         | 500-800                               | R.A.             | 38.5                               | 8.3                                                | 17        |
| Fe <sup>59</sup>  | 99.95                                         | 500-800                               | R.A.             | 23.3                               | $2.7 \times 10^{-3}$                               | 17        |
| Ni <sup>63</sup>  | 99.95                                         | 550-800                               |                  | 28.9                               | $1.0 \times 10^{-5}$                               | 17        |
| U <sup>235</sup>  | 99.95                                         | 500-700                               | R.A.             | 34.8                               | $1.1 \times 10^{-5}$                               | 17        |
| <b>Carbon</b>     |                                               |                                       |                  |                                    |                                                    |           |
| Ag <sup>110</sup> | ⊥c                                            | 750-1050                              | R.A.             | 64.3                               | 9280                                               | 18        |
| C <sup>14</sup>   |                                               | 2000-2200                             |                  | 163                                | 5                                                  | 19        |
| Ni <sup>63</sup>  | ⊥c                                            | 540-920                               | R.A.             | 47.2                               | 102                                                | 18        |
| Ni <sup>63</sup>  | ⊥c                                            | 750-1060                              | R.A.             | 53.3                               | 2.2                                                | 18        |
| Th <sup>228</sup> | ⊥c                                            | 1400-2200                             | R.A.             | 145.4                              | $1.33 \times 10^{-5}$                              | 18        |
| Th <sup>228</sup> | ⊥c                                            | 1800-2200                             | R.A.             | 114.7                              | 2.48                                               | 18        |
| U <sup>232</sup>  | ⊥c                                            | 1400-2200                             | R.A.             | 115.0                              | 6760                                               | 18        |
| U <sup>232</sup>  | ⊥c                                            | 1400-1820                             | R.A.             | 129.5                              | 385                                                | 18        |
| <b>Chromium</b>   |                                               |                                       |                  |                                    |                                                    |           |
| C <sup>14</sup>   | P                                             | 1200-1500                             | R.A.             | 26.5                               | $9.0 \times 10^{-3}$                               | 20        |
| Cr <sup>51</sup>  | P 99.98                                       | 1030-1545                             | S.S.             | 73.7                               | 0.2                                                | 21        |
| Fe <sup>59</sup>  | P 99.8                                        | 980-1420                              | R.A.             | 79.3                               | 0.47                                               | 22        |
| Mo <sup>99</sup>  | P                                             | 1100-1420                             | R.A.             | 58.0                               | $2.7 \times 10^{-3}$                               | 20        |
| <b>Cobalt</b>     |                                               |                                       |                  |                                    |                                                    |           |
| C <sup>14</sup>   | P 99.82                                       | 600-1400                              | R.A.             | 34.0                               | 0.21                                               | 23        |
| Co <sup>60</sup>  | P 99.9                                        | 1100-1405                             | S.S.             | 67.7                               | 0.83                                               | 24        |
| Fe <sup>59</sup>  | P 99.9                                        | 1104-1303                             | S.S.             | 62.7                               | 0.21                                               | 24        |
| Ni <sup>63</sup>  | P                                             | 1192-1297                             | R.A.             | 60.2                               | 0.10                                               | 25        |
| S <sup>35</sup>   | P 99.99                                       | 1150-1250                             | R.A.             | 5.4                                | 1.3                                                | 26        |
| <b>Copper</b>     |                                               |                                       |                  |                                    |                                                    |           |
| Ag <sup>110</sup> | S, P                                          | 580-980                               | R.A.             | 46.5                               | 0.61                                               | 27        |
| As <sup>76</sup>  | P                                             | 810-1075                              | R.A.             | 42.13                              | 0.20                                               | 28        |
| Au <sup>198</sup> | S, P                                          | 400-1050                              | S.S.             | 42.6                               | 0.03                                               | 29        |
| Cd <sup>113</sup> | S 99.98                                       | 725-950                               | S.S.             | 45.7                               | 0.935                                              | 30        |

## RADIOACTIVE TRACER DIFFUSION DATA FOR PURE METALS (Continued)

| Solute (tracer)   | Material (metal, crystalline form and purity) | Temperature range, °C | Form of analysis | Activation energy, $Q$ , Kcal/mole | Frequency factor, $D_0$ , cm <sup>2</sup> /s | Reference |
|-------------------|-----------------------------------------------|-----------------------|------------------|------------------------------------|----------------------------------------------|-----------|
| Ce <sup>141</sup> | P 99.999                                      | 766-947               | R.A.             | 27.6                               | $2.17 \times 10^{-8}$                        | 31        |
| Cr <sup>51</sup>  | S, P                                          | 800-1070              | R.A.             | 53.5                               | 1.02                                         | 32        |
| Co <sup>60</sup>  | S 99.998                                      | 701-1077              | S.S.             | 54.1                               | 1.93                                         | 33        |
| Cu <sup>67</sup>  | S 99.999                                      | 698-1061              | S.S.             | 50.5                               | 0.78                                         | 34        |
| Eu <sup>152</sup> | P 99.999                                      | 750-970               | S.S., R.A.       | 26.85                              | $1.17 \times 10^{-7}$                        | 31        |
| Fe <sup>59</sup>  | S, P                                          | 460-1070              | R.A.             | 52.0                               | 1.36                                         | 32        |
| Ga <sup>72</sup>  | —                                             | —                     | —                | 45.90                              | 0.55                                         | 35        |
| Ge <sup>68</sup>  | S 99.998                                      | 653-1015              | S.S.             | 44.76                              | 0.397                                        | 36        |
| Hg <sup>203</sup> | P                                             | —                     | —                | 44.0                               | 0.35                                         | 35        |
| Lu <sup>177</sup> | P 99.999                                      | 857-1010              | R.A.             | 26.15                              | $4.3 \times 10^{-9}$                         | 31        |
| Mn <sup>54</sup>  | S 99.99                                       | 754-950               | S.S.             | 91.4                               | 10 <sup>7</sup>                              | 37        |
| Nb <sup>95</sup>  | P 99.999                                      | 807-906               | R.A.             | 60.06                              | 2.04                                         | 38        |
| Ni <sup>63</sup>  | P                                             | 620-1080              | R.A.             | 53.8                               | 1.1                                          | 39        |
| Pd <sup>102</sup> | S 99.999                                      | 807-1056              | S.S.             | 54.37                              | 1.71                                         | 40        |
| Pm <sup>147</sup> | P 99.999                                      | 720-955               | R.A.             | 27.5                               | $3.62 \times 10^{-8}$                        | 31        |
| Pt <sup>195</sup> | P                                             | 843-997               | S.S.             | 37.5                               | $4.8 \times 10^{-4}$                         | 41        |
| S <sup>35</sup>   | S 99.999                                      | 800-1000              | R.A.             | 49.2                               | 23                                           | 42        |
| Sb <sup>124</sup> | S 99.999                                      | 600-1000              | S.S.             | 42.0                               | 0.34                                         | 43        |
| Sn <sup>113</sup> | P                                             | 680-910               | —                | 45.0                               | 0.11                                         | 44        |
| Tb <sup>160</sup> | P 99.999                                      | 770-980               | R.A.             | 27.45                              | $8.96 \times 10^{-9}$                        | 31        |
| Tl <sup>204</sup> | S 99.999                                      | 785-996               | S.S.             | 43.3                               | 0.71                                         | 45        |
| Tm <sup>170</sup> | P 99.999                                      | 705-950               | R.A.             | 24.15                              | $7.28 \times 10^{-9}$                        | 31        |
| Zn <sup>65</sup>  | P 99.999                                      | 890-1000              | S.S.             | 47.50                              | 0.73                                         | 46        |
| <b>Germanium</b>  |                                               |                       |                  |                                    |                                              |           |
| Cd <sup>115</sup> | S                                             | 750-950               | R.A.             | 102.0                              | $1.75 \times 10^9$                           | 47        |
| Fe <sup>59</sup>  | S                                             | 775-930               | R.A.             | 24.8                               | 0.13                                         | 48        |
| Ge <sup>71</sup>  | S                                             | 766-928               | S.S.             | 68.5                               | 7.8                                          | 49        |
| In <sup>114</sup> | S                                             | 600-920               | —                | 39.9                               | $2.9 \times 10^{-4}$                         | 50        |
| Sb <sup>124</sup> | S                                             | 720-900               | —                | 50.2                               | 0.22                                         | 51        |
| Te <sup>125</sup> | S                                             | 770-900               | S.S.             | 56.0                               | 2.0                                          | 52        |
| Tl <sup>204</sup> | S                                             | 800-930               | S.S.             | 78.4                               | 1700                                         | 53        |
| <b>Gold</b>       |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup> | S 99.99                                       | 699-1007              | S.S.             | 40.2                               | 0.072                                        | 54        |
| Au <sup>198</sup> | S 99.97                                       | 850-1050              | S.S.             | 42.26                              | 0.107                                        | 224       |
| Co <sup>60</sup>  | P 99.93                                       | 702-948               | R.A.             | 41.6                               | 0.068                                        | 55        |
| Fe <sup>59</sup>  | P 99.93                                       | 701-948               | R.A.             | 41.6                               | 0.082                                        | 55        |
| Hg <sup>203</sup> | S 99.994                                      | 600-1027              | —                | 37.38                              | 0.116                                        | 56        |
| Ni <sup>63</sup>  | P 99.96                                       | 880-940               | S.S.             | 46.0                               | 0.30                                         | 57        |
| Pt <sup>195</sup> | P, S 99.98                                    | 800-1060              | S.S.             | 60.9                               | 7.6                                          | 58        |
| <b>β-Hafnium</b>  |                                               |                       |                  |                                    |                                              |           |
| Hf <sup>181</sup> | P 97.9                                        | 1795-1995             | S.S.             | 38.7                               | $1.2 \times 10^{-3}$                         | 59        |
| <b>Indium</b>     |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup> | S, Lc 99.99                                   | 25-140                | S.S.             | 12.8                               | 0.52                                         | 60        |
| Ag <sup>110</sup> | S, Lc 99.99                                   | 25-140                | S.S.             | 11.5                               | 0.11                                         | 60        |
| Au <sup>198</sup> | S 99.99                                       | 25-140                | S.S.             | 6.7                                | $9 \times 10^{-3}$                           | 60        |
| In <sup>114</sup> | S, Lc 99.99                                   | 44-144                | S.S.             | 18.7                               | 3.7                                          | 61        |
| In <sup>114</sup> | S, Lc 99.99                                   | 44-144                | S.S.             | 18.7                               | 2.7                                          | 61        |
| Tl <sup>204</sup> | S 99.99                                       | 49-157                | S.S.             | 15.5                               | 0.049                                        | 62        |
| <b>α-Iron</b>     |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup> | P                                             | 748-888               | S.S.             | 69.0                               | 1950                                         | 63        |
| Au <sup>198</sup> | P 99.999                                      | 800-900               | R.A.             | 62.4                               | 31                                           | 64        |
| C <sup>14</sup>   | P 99.98                                       | 616-844               | R.A.             | 29.3                               | 2.2                                          | 65        |
| Co <sup>60</sup>  | P 99.995                                      | 638-768               | R.A.             | 62.2                               | 7.19                                         | 62        |
| Cr <sup>51</sup>  | P 99.95                                       | 775-875               | R.A.             | 57.5                               | 2.53                                         | 66        |
| Cu <sup>64</sup>  | P 99.9                                        | 800-1050              | R.A.             | 57.0                               | 0.57                                         | 67        |
| Fe <sup>55</sup>  | P 99.92                                       | 809-889               | —                | 60.3                               | 5.4                                          | 68        |
| K <sup>42</sup>   | P 99.92                                       | 500-800               | R.A.             | 42.3                               | 0.036                                        | 69        |
| Mn <sup>54</sup>  | P 99.97                                       | 800-900               | R.A.             | 52.5                               | 0.35                                         | 70        |
| Mo <sup>99</sup>  | P                                             | 750-875               | R.A.             | 73.0                               | 7800                                         | 71        |
| Ni <sup>63</sup>  | P 99.97                                       | 680-800               | R.A.             | 56.0                               | 1.3                                          | 72        |
| P <sup>32</sup>   | P                                             | 860-900               | R.A.             | 55.0                               | 2.9                                          | 73        |
| Sb <sup>124</sup> | P                                             | 800-900               | R.A.             | 66.6                               | 1100                                         | 74        |
| V <sup>48</sup>   | P                                             | 755-875               | R.A.             | 55.4                               | 1.43                                         | 75        |
| W <sup>185</sup>  | P                                             | 755-875               | R.A.             | 55.1                               | 0.29                                         | 75        |
| <b>γ-Iron</b>     |                                               |                       |                  |                                    |                                              |           |
| Be <sup>7</sup>   | P 99.9                                        | 1100-1350             | R.A.             | 57.6                               | 0.1                                          | 76        |
| C <sup>14</sup>   | P 99.34                                       | 800-1400              | —                | 34.0                               | 0.15                                         | 23        |
| Co <sup>60</sup>  | P 99.98                                       | 1138-1340             | S.S.             | 72.9                               | 1.25                                         | 77        |
| Cr <sup>51</sup>  | P 99.99                                       | 950-1400              | R.A.             | 69.7                               | 10.8                                         | 78        |
| Fe <sup>59</sup>  | P 99.98                                       | 1171-1361             | S.S.             | 67.86                              | 0.49                                         | 79        |
| Hf <sup>181</sup> | P 99.99                                       | 1110-1360             | R.A.             | 97.3                               | 3600                                         | 78        |
| Mn <sup>54</sup>  | P 99.97                                       | 920-1280              | R.A.             | 62.5                               | 0.16                                         | 70        |
| Ni <sup>63</sup>  | P 99.97                                       | 930-2050              | R.A.             | 67.0                               | 0.77                                         | 72        |
| P <sup>32</sup>   | P 99.99                                       | 950-1200              | R.A.             | 43.7                               | 0.01                                         | 80        |
| S <sup>35</sup>   | P                                             | 900-1250              | R.A.             | 53.0                               | 1.7                                          | 81        |
| V <sup>48</sup>   | P 99.99                                       | 1120-1380             | R.A.             | 69.3                               | 0.28                                         | 78        |
| W <sup>185</sup>  | P 99.5                                        | 1050-1250             | R.A.             | 90.0                               | 1000                                         | 82        |
| <b>δ-Iron</b>     |                                               |                       |                  |                                    |                                              |           |
| Co <sup>60</sup>  | P 99.995                                      | 1428-1521             | R.A.             | 61.4                               | 6.38                                         | 83        |
| Fe <sup>59</sup>  | P 99.95                                       | 1428-1492             | S.S.             | 57.5                               | 2.01                                         | 83        |
| P <sup>32</sup>   | P 99.99                                       | 1370-1460             | R.A.             | 55.0                               | 2.9                                          | 73        |
| <b>Lanthanum</b>  |                                               |                       |                  |                                    |                                              |           |
| Au <sup>198</sup> | P 99.97                                       | 600-800               | S.S.             | 45.1                               | 1.5                                          | 84        |
| La <sup>140</sup> | P 99.97                                       | 690-850               | S.S.             | 18.1                               | $2.2 \times 10^{-2}$                         | 84        |
| <b>Lead</b>       |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup> | P 99.9                                        | 200-310               | R.A.             | 14.4                               | 0.064                                        | 85        |
| Au <sup>198</sup> | S 99.999                                      | 190-320               | S.S.             | 10.0                               | $8.7 \times 10^{-3}$                         | 86        |



## RADIOACTIVE TRACER DIFFUSION DATA FOR PURE METALS (Continued)

| Solute (tracer)   | Material (metal, crystalline form and purity) | Temperature range, °C | Form of analysis | Activation energy, $Q$ , Kcal/mole | Frequency factor, $D_0$ , cm <sup>2</sup> /s | Reference |
|-------------------|-----------------------------------------------|-----------------------|------------------|------------------------------------|----------------------------------------------|-----------|
| Cd <sup>115</sup> | S 99.999                                      | 150–320               | S.S.             | 21.23                              | 0.409                                        | 87        |
| Cu <sup>64</sup>  | S                                             | 150–320               | S.S.             | 14.44                              | 0.046                                        | 88        |
| Pb <sup>204</sup> | S 99.999                                      | 150–320               | S.S.             | 25.52                              | 0.887                                        | 87        |
| Ti <sup>205</sup> | P 99.999                                      | 207–322               | S.S.             | 24.33                              | 0.511                                        | 89        |
| <b>Lithium</b>    |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup> | P 92.5                                        | 65–161                | S.S.             | 12.83                              | 0.37                                         | 90        |
| Au <sup>195</sup> | P 92.5                                        | 47–153                | S.S.             | 10.49                              | 0.21                                         | 90        |
| Bi                | P 99.95                                       | 141–177               | S.S.             | 47.3                               | $5.3 \times 10^{13}$                         | 91        |
| Cd <sup>115</sup> | P 92.5                                        | 80–174                | S.S.             | 16.05                              | 2.35                                         | 90        |
| Cu <sup>64</sup>  | P 99.98                                       | 51–120                | S.S.             | 9.22                               | 0.47                                         | 93        |
| Ga <sup>72</sup>  | P 99.98                                       | 58–173                | S.S.             | 12.9                               | 0.21                                         | 93        |
| Hg <sup>203</sup> | P 99.98                                       | 58–173                | S.S.             | 14.18                              | 1.04                                         | 93        |
| In <sup>114</sup> | P 92.5                                        | 80–175                | S.S.             | 15.87                              | 0.39                                         | 90        |
| Li <sup>6</sup>   | P 99.98                                       | 35–178                | S.S.             | 12.60                              | 0.14                                         | 94        |
| Na <sup>22</sup>  | P 92.5                                        | 52–176                | S.S.             | 12.61                              | 0.41                                         | 90        |
| Pb <sup>204</sup> | P 99.95                                       | 129–169               | S.S.             | 25.2                               | 160                                          | 91        |
| Sb <sup>124</sup> | P 99.95                                       | 141–176               | S.S.             | 41.5                               | $1.6 \times 10^{10}$                         | 91        |
| Sn <sup>113</sup> | P 99.95                                       | 108–174               | S.S.             | 15.0                               | 0.62                                         | 91        |
| Zn <sup>65</sup>  | P 92.5                                        | 60–175                | S.S.             | 12.98                              | 0.57                                         | 92        |
| <b>Magnesium</b>  |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup> | P 99.9                                        | 476–621               | S.S.             | 28.50                              | 0.34                                         | 95        |
| Fe <sup>59</sup>  | P 99.95                                       | 400–600               | R.A.             | 21.2                               | $4 \times 10^{-6}$                           | 96        |
| In <sup>114</sup> | P 99.9                                        | 472–610               | S.S.             | 28.4                               | $5.2 \times 10^{-2}$                         | 95        |
| Mg <sup>28</sup>  | S.L.c                                         | 467–635               | S.S.             | 32.5                               | 1.5                                          | 97        |
| Mg <sup>28</sup>  | S.J.c                                         | 467–635               | S.S.             | 32.2                               | 1.0                                          | 97        |
| Ni <sup>63</sup>  | P 99.95                                       | 400–600               | R.A.             | 22.9                               | $1.2 \times 10^{-5}$                         | 96        |
| U <sup>235</sup>  | P 99.95                                       | 500–620               | R.A.             | 27.4                               | $1.6 \times 10^{-5}$                         | 96        |
| Zn <sup>65</sup>  | P 99.9                                        | 467–620               | S.S.             | 28.6                               | 0.41                                         | 95        |
| <b>Molybdenum</b> |                                               |                       |                  |                                    |                                              |           |
| C <sup>14</sup>   | P 99.98                                       | 1200–1600             | R.A.             | 41.0                               | $2.04 \times 10^{-2}$                        | 99        |
| Co <sup>60</sup>  | P 99.98                                       | 1850–2350             | S.S.             | 106.7                              | 18                                           | 100       |
| Cr <sup>51</sup>  | P                                             | 1000–1500             | R.A.             | 54.0                               | $2.5 \times 10^{-4}$                         | 20        |
| Cs <sup>134</sup> | S 99.99                                       | 1000–1470             | R.A., A.R.G.     | 28.0                               | $8.7 \times 10^{-11}$                        | 101       |
| K <sup>42</sup>   | S                                             | 800–1100              | R.A.             | 25.04                              | $5.5 \times 10^{-9}$                         | 102       |
| Mo <sup>99</sup>  | P                                             | 1850–2350             | S.S.             | 96.9                               | 0.5                                          | 103       |
| Na <sup>24</sup>  | S                                             | 800–1100              | R.A.             | 21.25                              | $2.95 \times 10^{-9}$                        | 102       |
| Nb <sup>95</sup>  | P 99.98                                       | 1850–2350             | S.S.             | 108.1                              | 14                                           | 100       |
| P <sup>32</sup>   | P 99.97                                       | 2000–2200             | S.S.             | 80.5                               | 0.19                                         | 104       |
| Re <sup>186</sup> | P                                             | 1700–2100             | A.R.G.           | 94.7                               | 0.097                                        | 105       |
| S <sup>35</sup>   | S 99.97                                       | 2220–2470             | S.S.             | 101.0                              | 320                                          | 106       |
| Ta <sup>182</sup> | P                                             | 1700–2150             | R.A.             | 83.0                               | $3.5 \times 10^{-4}$                         | 20        |
| U <sup>235</sup>  | P 99.98                                       | 1500–2000             | R.A.             | 76.4                               | $7.6 \times 10^{-3}$                         | 107       |
| W <sup>185</sup>  | P 99.98                                       | 1700–2260             | S.S.             | 110                                | 1.7                                          | 108       |
| <b>Nickel</b>     |                                               |                       |                  |                                    |                                              |           |
| Au <sup>198</sup> | S, P 99.999                                   | 700–1075              | S.S.             | 55.0                               | 0.02                                         | 109       |
| Be <sup>7</sup>   | P 99.9                                        | 1020–1400             | R.A.             | 46.2                               | 0.019                                        | 76        |
| C <sup>14</sup>   | P 99.86                                       | 600–1400              | —                | 34.0                               | 0.012                                        | 23        |
| Co <sup>60</sup>  | P 99.97                                       | 1149–1390             | R.A.             | 65.9                               | 1.39                                         | 110       |
| Cr <sup>51</sup>  | P 99.95                                       | 1100–1270             | S.S.             | 65.1                               | 1.1                                          | 111       |
| Cu <sup>64</sup>  | P 99.95                                       | 1050–1360             | S.S.             | 61.7                               | 0.57                                         | 111       |
| Fe <sup>59</sup>  | P                                             | 1020–1263             | S.S.             | 58.6                               | 0.074                                        | 112       |
| Mo <sup>99</sup>  | P                                             | 900–1200              | R.A.             | 51.0                               | $1.6 \times 10^{-3}$                         | 20        |
| Ni <sup>63</sup>  | P 99.95                                       | 1042–1404             | S.S.             | 68.0                               | 1.9                                          | 111       |
| Pu <sup>238</sup> | P                                             | 1025–1125             | A.R.G.           | 51.0                               | 0.5                                          | 113       |
| Sb <sup>124</sup> | P 99.97                                       | 1020–1220             | —                | 27.0                               | $1.8 \times 10^{-5}$                         | 114       |
| Sn <sup>113</sup> | P 99.8                                        | 700–1350              | A.R.G.           | 58.0                               | 0.83                                         | 115       |
| V <sup>48</sup>   | P 99.99                                       | 800–1300              | R.A.             | 66.5                               | 0.87                                         | 11        |
| W <sup>185</sup>  | P 99.95                                       | 1100–1300             | S.S.             | 71.5                               | 2.0                                          | 116       |
| <b>Niobium</b>    |                                               |                       |                  |                                    |                                              |           |
| C <sup>14</sup>   | P                                             | 800–1250              | R.A.             | 32.0                               | $1.09 \times 10^{-5}$                        | 117       |
| Co <sup>60</sup>  | P 99.85                                       | 1500–2100             | A.R.G.           | 70.5                               | 0.74                                         | 118       |
| Cr <sup>51</sup>  | S                                             | 943–1435              | S.S.             | 83.5                               | 0.30                                         | 119       |
| Fe <sup>55</sup>  | P 99.85                                       | 1400–2100             | A.R.G.           | 77.7                               | 1.5                                          | 118       |
| K <sup>42</sup>   | S                                             | 900–1100              | R.A.             | 22.10                              | $2.38 \times 10^{-7}$                        | 102       |
| Nb <sup>95</sup>  | P, S 99.99                                    | 878–2395              | S.S.             | 96.0                               | 1.1                                          | 120       |
| P <sup>32</sup>   | P 99.0                                        | 1300–1800             | S.S.             | 51.5                               | $5.1 \times 10^{-2}$                         | 104       |
| S <sup>35</sup>   | S 99.9                                        | 1100–1500             | R.A.             | 73.1                               | 2600                                         | 121       |
| Sn <sup>113</sup> | P 99.85                                       | 1850–2400             | S.S.             | 78.9                               | 0.14                                         | 122       |
| Ta <sup>182</sup> | P, S 99.997                                   | 878–2395              | S.S.             | 99.3                               | 1.0                                          | 120       |
| Ti <sup>44</sup>  | S                                             | 994–1492              | S.S.             | 86.9                               | 0.099                                        | 123       |
| U <sup>235</sup>  | P 99.55                                       | 1500–2000             | R.A.             | 76.8                               | $8.9 \times 10^{-3}$                         | 107       |
| V <sup>48</sup>   | S 99.99                                       | 1000–1400             | R.A.             | 85.0                               | 2.21                                         | 124       |
| W <sup>185</sup>  | P 99.8                                        | 1800–2200             | R.A.             | 91.7                               | $5 \times 10^{-4}$                           | 125       |
| <b>Palladium</b>  |                                               |                       |                  |                                    |                                              |           |
| Pd <sup>103</sup> | S 99.999                                      | 1060–1500             | S.S.             | 63.6                               | 0.205                                        | 126       |
| <b>Phosphorus</b> |                                               |                       |                  |                                    |                                              |           |
| P <sup>32</sup>   | P                                             | 0–44                  | S.S.             | 9.4                                | $1.07 \times 10^{-3}$                        | 127       |
| <b>Platinum</b>   |                                               |                       |                  |                                    |                                              |           |
| Co <sup>60</sup>  | P 99.99                                       | 900–1050              | —                | 74.2                               | 19.6                                         | 129       |
| Cu <sup>64</sup>  | P                                             | 1098–1375             | S.S.             | 59.5                               | 0.074                                        | 41        |
| Pt <sup>195</sup> | P 99.99                                       | 1325–1600             | S.S.             | 68.2                               | 0.33                                         | 130       |
| <b>Potassium</b>  |                                               |                       |                  |                                    |                                              |           |
| Au <sup>198</sup> | P 99.95                                       | 5.6–52.5              | S.S.             | 3.23                               | $1.29 \times 10^{-3}$                        | 131       |
| K <sup>42</sup>   | S 99.7                                        | –52–61                | S.S.             | 9.36                               | 0.16                                         | 132       |
| Na <sup>22</sup>  | P 99.7                                        | 0–62                  | S.S.             | 7.45                               | 0.058                                        | 133       |
| Rb <sup>86</sup>  | P 99.95                                       | 0.1–59.9              | S.S.             | 8.78                               | 0.090                                        | 134       |

## RADIOACTIVE TRACER DIFFUSION DATA FOR PURE METALS (Continued)

| Solute (tracer)                         | Material (metal, crystalline form and purity) | Temperature range, °C | Form of analysis | Activation energy, $Q$ , Kcal/mole | Frequency factor, $D_0$ , cm <sup>2</sup> /s | Reference |
|-----------------------------------------|-----------------------------------------------|-----------------------|------------------|------------------------------------|----------------------------------------------|-----------|
| <b><math>\gamma</math>-Plutonium</b>    |                                               |                       |                  |                                    |                                              |           |
| Pu <sup>238</sup>                       | P                                             | 190–310               | S.S.             | 16.7                               | $2.1 \times 10^{-5}$                         | 135       |
| <b><math>\delta</math>-Plutonium</b>    |                                               |                       |                  |                                    |                                              |           |
| Pu <sup>238</sup>                       | P                                             | 350–440               | S.S.             | 23.8                               | $4.5 \times 10^{-3}$                         | 136       |
| <b><math>\epsilon</math>-Plutonium</b>  |                                               |                       |                  |                                    |                                              |           |
| Pu <sup>238</sup>                       | P                                             | 500–612               | R.A.             | 18.5                               | $2.0 \times 10^{-2}$                         | 137       |
| <b><math>\alpha</math>-Praseodymium</b> |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup>                       | P 99.93                                       | 610–730               | S.S.             | 25.4                               | 0.14                                         | 138       |
| Au <sup>195</sup>                       | P 99.93                                       | 650–780               | S.S.             | 19.7                               | $4.3 \times 10^{-2}$                         | 138       |
| Co <sup>60</sup>                        | P 99.93                                       | 660–780               | S.S.             | 16.4                               | $4.7 \times 10^{-2}$                         | 138       |
| Zn <sup>65</sup>                        | P 99.96                                       | 766–603               | S.S.             | 24.8                               | 0.18                                         | 139       |
| <b><math>\beta</math>-Praseodymium</b>  |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup>                       | P 99.93                                       | 800–900               | S.S.             | 21.5                               | $3.2 \times 10^{-2}$                         | 138       |
| Au <sup>195</sup>                       | P 99.93                                       | 800–910               | S.S.             | 20.1                               | $3.3 \times 10^{-2}$                         | 138       |
| Ho <sup>166</sup>                       | P 99.96                                       | 800–930               | S.S.             | 26.3                               | 9.5                                          | 140       |
| In <sup>114</sup>                       | P 99.96                                       | 800–930               | S.S.             | 28.9                               | 9.6                                          | 140       |
| La <sup>140</sup>                       | P 99.96                                       | 800–930               | S.S.             | 25.7                               | 1.8                                          | 140       |
| Pr <sup>142</sup>                       | P 99.93                                       | 800–900               | S.S.             | 29.4                               | 8.7                                          | 140       |
| Zn <sup>65</sup>                        | P 99.96                                       | 822–921               | S.S.             | 27.0                               | 0.63                                         | 139       |
| <b>Selenium</b>                         |                                               |                       |                  |                                    |                                              |           |
| Fe <sup>59</sup>                        | P                                             | 40–100                | R.A.             | 8.88                               | —                                            | 141       |
| Hg <sup>203</sup>                       | P 99.996                                      | 25–100                | R.A.             | 1.2                                | —                                            | 141       |
| S <sup>35</sup>                         | S.l.c                                         | 60–90                 | S.D.             | 29.9                               | 1700                                         | 142       |
| S <sup>35</sup>                         | S.l.c                                         | 60–90                 | S.D.             | 15.6                               | 1100                                         | 142       |
| Se <sup>75</sup>                        | P                                             | 35–140                | —                | 11.7                               | $1.4 \times 10^{-4}$                         | 143       |
| <b>Silicon</b>                          |                                               |                       |                  |                                    |                                              |           |
| Au <sup>198</sup>                       | S                                             | 700–1300              | S.S.             | 47.0                               | $2.75 \times 10^{-3}$                        | 145       |
| C <sup>14</sup>                         | P                                             | 1070–1400             | R.A.             | 67.2                               | 0.33                                         | 146       |
| Cu <sup>64</sup>                        | P                                             | 800–1100              | R.A.             | 23.0                               | $4 \times 10^{-2}$                           | 147       |
| Fe <sup>59</sup>                        | S                                             | 1000–1200             | R.A.             | 20.0                               | $6.2 \times 10^{-3}$                         | 148       |
| Ni <sup>63</sup>                        | P                                             | 450–800               | —                | 97.5                               | 1000                                         | 149       |
| P <sup>32</sup>                         | S                                             | 1100–1250             | R.A.             | 41.5                               | —                                            | 150       |
| Sb <sup>124</sup>                       | S                                             | 1190–1398             | R.A.             | 91.7                               | 12.9                                         | 151       |
| Si <sup>31</sup>                        | S 99.99999                                    | 1225–1400             | S.S.             | 110.0                              | 1800                                         | 146       |
| <b>Silver</b>                           |                                               |                       |                  |                                    |                                              |           |
| Au <sup>198</sup>                       | P 99.99                                       | 718–942               | S.S.             | 48.28                              | 0.85                                         | 54        |
| Ag <sup>110</sup>                       | S 99.999                                      | 640–955               | S.S.             | 45.2                               | 0.67                                         | 152       |
| Cd <sup>115</sup>                       | S 99.99                                       | 592–937               | S.S.             | 41.69                              | 0.44                                         | 153       |
| Co <sup>60</sup>                        | S 99.999                                      | 700–940               | —                | 48.75                              | 1.9                                          | 154       |
| Cu <sup>64</sup>                        | P 99.99                                       | 717–945               | S.S.             | 46.1                               | 1.23                                         | 155       |
| Fe <sup>59</sup>                        | S 99.99                                       | 720–930               | S.S.             | 49.04                              | 2.42                                         | 156       |
| Ge <sup>77</sup>                        | P                                             | 640–870               | S.S.             | 36.5                               | 0.084                                        | 157       |
| Hg <sup>203</sup>                       | P 99.99                                       | 653–948               | S.S.             | 38.1                               | 0.079                                        | 155       |
| In <sup>114</sup>                       | S 99.99                                       | 592–937               | S.S.             | 40.80                              | 0.41                                         | 153       |
| Ni <sup>63</sup>                        | S 99.99                                       | 749–950               | S.S.             | 54.8                               | 21.9                                         | 158       |
| Pb <sup>210</sup>                       | P                                             | 700–865               | S.S.             | 38.1                               | 0.22                                         | 159       |
| Pd <sup>102</sup>                       | S 99.999                                      | 736–939               | S.S.             | 56.75                              | 9.56                                         | 140       |
| Ru <sup>103</sup>                       | S 99.99                                       | 793–945               | S.S.             | 65.8                               | 180                                          | 160       |
| S <sup>35</sup>                         | S 99.999                                      | 600–900               | R.A.             | 40.0                               | 1.65                                         | 161       |
| Sb <sup>124</sup>                       | P 99.999                                      | 780–950               | S.S., R.A.       | 39.07                              | 0.234                                        | 162       |
| Sn <sup>113</sup>                       | S 99.99                                       | 592–937               | S.S.             | 39.30                              | 0.255                                        | 153       |
| Te <sup>125</sup>                       | P                                             | 770–940               | R.A.             | 38.90                              | 0.47                                         | 163       |
| Tl <sup>204</sup>                       | P                                             | 640–870               | S.S.             | 37.9                               | 0.15                                         | 157       |
| Zn <sup>65</sup>                        | S 99.99                                       | 640–925               | S.S.             | 41.7                               | 0.54                                         | 164       |
| <b>Sodium</b>                           |                                               |                       |                  |                                    |                                              |           |
| Au <sup>198</sup>                       | P 99.99                                       | 1.0–77                | S.S.             | 2.21                               | $3.34 \times 10^{-4}$                        | 165       |
| K <sup>42</sup>                         | P 99.99                                       | 0–91                  | S.S.             | 8.43                               | 0.08                                         | 133       |
| Na <sup>22</sup>                        | P 99.99                                       | 0–98                  | S.S.             | 10.09                              | 0.145                                        | 166       |
| Rb <sup>86</sup>                        | P 99.99                                       | 0–85                  | S.S.             | 8.49                               | 0.15                                         | 133       |
| <b>Tantalum</b>                         |                                               |                       |                  |                                    |                                              |           |
| C <sup>14</sup>                         | P                                             | 1450–2200             | S.S.             | 40.3                               | $1.2 \times 10^{-2}$                         | 167       |
| Fe <sup>59</sup>                        | P                                             | 930–1240              | —                | 71.4                               | 0.505                                        | 168       |
| Mo <sup>99</sup>                        | P                                             | 1750–2220             | R.A.             | 81.0                               | $1.8 \times 10^{-3}$                         | 20        |
| Nb <sup>95</sup>                        | P, S 99.996                                   | 921–2484              | S.S.             | 98.7                               | 0.23                                         | 169       |
| S <sup>35</sup>                         | P 99.0                                        | 1970–2110             | R.A.             | 70.0                               | 100                                          | 170       |
| Ta <sup>182</sup>                       | P, S 99.996                                   | 1250–2200             | S.S.             | 98.7                               | 1.24                                         | 226       |
| <b>Tellurium</b>                        |                                               |                       |                  |                                    |                                              |           |
| Hg <sup>203</sup>                       | P                                             | 270–440               | —                | 18.7                               | $3.14 \times 10^{-5}$                        | 171       |
| Se <sup>75</sup>                        | P                                             | 320–440               | —                | 28.6                               | $2.6 \times 10^{-2}$                         | 171       |
| Tl <sup>204</sup>                       | P                                             | 360–430               | —                | 41.0                               | 320                                          | 172       |
| Te <sup>127</sup>                       | S.l.c 99.9999                                 | 300–400               | S.S.             | 46.7                               | $3.91 \times 10^4$                           | 173       |
| Te <sup>127</sup>                       | S.l.c 99.9999                                 | 300–400               | S.S.             | 35.5                               | 130                                          | 173       |
| <b><math>\alpha</math>-Thallium</b>     |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup>                       | P.l.c 99.999                                  | 80–250                | S.S.             | 11.8                               | $3.8 \times 10^{-2}$                         | 174       |
| Ag <sup>110</sup>                       | P.l.c 99.999                                  | 80–250                | S.S.             | 11.2                               | $2.7 \times 10^{-2}$                         | 174       |
| Au <sup>198</sup>                       | P.l.c 99.999                                  | 110–260               | S.S.             | 2.8                                | $2.0 \times 10^{-5}$                         | 174       |
| Au <sup>198</sup>                       | P.l.c 99.999                                  | 110–260               | S.S.             | 5.2                                | $5.3 \times 10^{-4}$                         | 174       |
| Tl <sup>204</sup>                       | S.l.c 99.9                                    | 135–230               | S.S.             | 22.6                               | 0.4                                          | 175       |
| Tl <sup>204</sup>                       | S.l.c 99.9                                    | 135–230               | S.S.             | 22.9                               | 0.4                                          | 175       |
| <b><math>\beta</math>-Thallium</b>      |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup>                       | P 99.999                                      | 230–310               | S.S.             | 11.9                               | $4.2 \times 10^{-2}$                         | 174       |
| Au <sup>198</sup>                       | P 99.999                                      | 230–310               | S.S.             | 6.0                                | $5.2 \times 10^{-4}$                         | 174       |
| Tl <sup>204</sup>                       | S 99.9                                        | 230–280               | S.S.             | 20.7                               | 0.7                                          | 175       |

## RADIOACTIVE TRACER DIFFUSION DATA FOR PURE METALS (Continued)

| Solute (tracer)                     | Material (metal, crystalline form and purity) | Temperature range, °C | Form of analysis | Activation energy, $Q$ , Kcal/mole | Frequency factor, $D_0$ , cm <sup>2</sup> /s | Reference |
|-------------------------------------|-----------------------------------------------|-----------------------|------------------|------------------------------------|----------------------------------------------|-----------|
| <b><math>\alpha</math>-Thorium</b>  |                                               |                       |                  |                                    |                                              |           |
| Pa <sup>231</sup>                   | P 99.85                                       | 770-910               | —                | 74.7                               | 126                                          | 176       |
| Th <sup>228</sup>                   | P 99.85                                       | 720-880               | —                | 71.6                               | 395                                          | 176       |
| U <sup>233</sup>                    | P 99.85                                       | 700-880               | —                | 79.3                               | 2210                                         | 176       |
| <b>Tin</b>                          |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup>                   | S.L.c                                         | 135-225               | S.S.             | 18.4                               | 0.18                                         | 177       |
| Ag <sup>110</sup>                   | S c                                           | 135-225               | S.S.             | 12.3                               | $7.1 \times 10^{-3}$                         | 177       |
| Au <sup>198</sup>                   | S.L.c                                         | 135-225               | S.S.             | 17.7                               | 0.16                                         | 177       |
| Au <sup>198</sup>                   | S c                                           | 135-225               | S.S.             | 11.0                               | $5.8 \times 10^{-3}$                         | 177       |
| Co <sup>60</sup>                    | S, P                                          | 140-217               | R.A.             | 22.0                               | 5.5                                          | 178       |
| In <sup>114</sup>                   | S.L.c 99.998                                  | 181-221               | S.S.             | 25.8                               | 34.1                                         | 179       |
| In <sup>114</sup>                   | S c 99.998                                    | 181-221               | S.S.             | 25.6                               | 12.2                                         | 179       |
| Sn <sup>113</sup>                   | S.L.c 99.999                                  | 160-226               | S.S.             | 25.1                               | 10.7                                         | 180       |
| Sn <sup>113</sup>                   | S c 99.999                                    | 160-226               | S.S.             | 25.6                               | 7.7                                          | 180       |
| Tl <sup>204</sup>                   | P 99.999                                      | 137-216               | S.S.             | 14.7                               | $1.2 \times 10^{-3}$                         | 181       |
| <b><math>\alpha</math>-Titanium</b> |                                               |                       |                  |                                    |                                              |           |
| Ti <sup>44</sup>                    | P 99.99                                       | 700-850               | R.A.             | 35.9                               | $8.6 \times 10^{-6}$                         | 182       |
| <b><math>\beta</math>-Titanium</b>  |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup>                   | P 99.95                                       | 940-1570              | S.S.             | 43.2                               | $3 \times 10^{-3}$                           | 183       |
| Be <sup>7</sup>                     | P 99.96                                       | 915-1300              | R.A.             | 40.2                               | 0.8                                          | 184       |
| C <sup>14</sup>                     | P 99.62                                       | 1100-1600             | R.A.             | 20.0                               | $3.02 \times 10^{-3}$                        | 185       |
| Cr <sup>51</sup>                    | P 99.7                                        | 950-1600              | A.R.G.           | 35.1                               | $5 \times 10^{-3}$                           | 186       |
|                                     |                                               |                       |                  | 61.0                               | 4.9                                          |           |
| Co <sup>60</sup>                    | P 99.7                                        | 900-1600              | S.S.             | 30.6                               | $1.2 \times 10^{-2}$                         | 186       |
|                                     |                                               |                       |                  | 52.5                               | 2.0                                          |           |
| Fe <sup>59</sup>                    | P 99.7                                        | 900-1600              | A.R.G.           | 31.6                               | $7.8 \times 10^{-3}$                         | 186       |
|                                     |                                               |                       |                  | 55.0                               | 2.7                                          |           |
| Mo <sup>99</sup>                    | P 99.7                                        | 900-1600              | S.S.             | 43.0                               | $8.0 \times 10^{-3}$                         | 186       |
|                                     |                                               |                       |                  | 73.0                               | 20                                           |           |
| Mn <sup>54</sup>                    | P 99.7                                        | 900-1600              | S.S.             | 33.7                               | $6.1 \times 10^{-3}$                         | 186       |
|                                     |                                               |                       |                  | 58.0                               | 20                                           |           |
| Nb <sup>95</sup>                    | P 99.7                                        | 1000-1600             | A.R.G.           | 39.3                               | $5.0 \times 10^{-3}$                         | 186       |
|                                     |                                               |                       |                  | 73.0                               | 20                                           |           |
| Ni <sup>63</sup>                    | P 99.7                                        | 925-1600              | A.R.G.           | 29.6                               | $9.2 \times 10^{-3}$                         | 186       |
|                                     |                                               |                       |                  | 52.5                               | 2.0                                          |           |
| P <sup>32</sup>                     | P 99.7                                        | 950-1600              | S.S.             | 24.1                               | $3.62 \times 10^{-3}$                        | 187       |
|                                     |                                               |                       |                  | 56.5                               | 5                                            |           |
| Sc <sup>46</sup>                    | P 99.95                                       | 940-1590              | S.S.             | 32.4                               | $4.0 \times 10^{-3}$                         | 183       |
| Sn <sup>113</sup>                   | P 99.7                                        | 950-1600              | S.S.             | 31.6                               | $3.8 \times 10^{-4}$                         | 187       |
|                                     |                                               |                       |                  | 69.2                               | 10                                           |           |
| Ti <sup>44</sup>                    | P 99.95                                       | 900-1540              | S.S.             | 31.2                               | $3.58 \times 10^{-4}$                        | 188       |
|                                     |                                               |                       |                  | 60.0                               | 1.09                                         |           |
| U <sup>235</sup>                    | P 99.9                                        | 900-1400              | R.A.             | 29.3                               | $5.1 \times 10^{-4}$                         | 189       |
| V <sup>48</sup>                     | P 99.95                                       | 900-1545              | S.S.             | 32.2                               | $3.1 \times 10^{-4}$                         | 190       |
|                                     |                                               |                       |                  | 57.2                               | 1.4                                          |           |
| W <sup>185</sup>                    | P 99.94                                       | 900-1250              | R.A.             | 43.9                               | $3.6 \times 10^{-3}$                         | 191       |
| Zr <sup>95</sup>                    | P 98.94                                       | 920-1500              | R.A.             | 35.4                               | $4.7 \times 10^{-3}$                         | 191       |
| <b>Tungsten</b>                     |                                               |                       |                  |                                    |                                              |           |
| C <sup>14</sup>                     | P 99.51                                       | 1200-1600             | R.A.             | 53.5                               | $8.91 \times 10^{-3}$                        | 99        |
| Fe <sup>59</sup>                    | P                                             | 940-1240              | —                | 66.0                               | $1.4 \times 10^{-2}$                         | 168       |
| Mo <sup>99</sup>                    | P                                             | 1700-2100             | R.A.             | 101.0                              | 0.3                                          | 20        |
| Nb <sup>95</sup>                    | P 99.99                                       | 1305-2367             | S.S.             | 137.6                              | 3.01                                         | 192       |
| Re <sup>186</sup>                   | S                                             | 2100-2400             | R.A.             | 141.0                              | 19.5                                         | 193       |
| Ta <sup>182</sup>                   | P 99.99                                       | 1305-2375             | S.S.             | 139.9                              | 3.05                                         | 192       |
| W <sup>185</sup>                    | P 99.99                                       | 1800-2403             | S.S.             | 140.3                              | 1.88                                         | 192       |
| <b><math>\alpha</math>-Uranium</b>  |                                               |                       |                  |                                    |                                              |           |
| U <sup>234</sup>                    | P                                             | 580-650               | —                | 40.0                               | $2 \times 10^{-3}$                           | 194       |
| <b><math>\beta</math>-Uranium</b>   |                                               |                       |                  |                                    |                                              |           |
| Co <sup>60</sup>                    | P 99.999                                      | 692-763               | S.S.             | 27.45                              | $1.5 \times 10^{-2}$                         | 195       |
| U <sup>235</sup>                    | P                                             | 690-750               | R.A.             | 44.2                               | $2.8 \times 10^{-3}$                         | 196       |
| <b><math>\gamma</math>-Uranium</b>  |                                               |                       |                  |                                    |                                              |           |
| Au <sup>195</sup>                   | P 99.99                                       | 785-1007              | S.S.             | 30.4                               | $4.86 \times 10^{-3}$                        | 197       |
| Co <sup>60</sup>                    | P 99.99                                       | 783-989               | S.S.             | 12.57                              | $3.51 \times 10^{-4}$                        | 198       |
| Cr <sup>51</sup>                    | P 99.99                                       | 797-1037              | S.S.             | 24.46                              | $5.37 \times 10^{-3}$                        | 198       |
| Cu <sup>64</sup>                    | P 99.99                                       | 787-1039              | S.S.             | 24.06                              | $1.96 \times 10^{-3}$                        | 198       |
| Fe <sup>55</sup>                    | P 99.99                                       | 787-990               | S.S.             | 12.0                               | $2.69 \times 10^{-4}$                        | 198       |
| Mn <sup>54</sup>                    | P 99.99                                       | 787-939               | S.S.             | 13.88                              | $1.81 \times 10^{-4}$                        | 198       |
| Nb <sup>95</sup>                    | P 99.99                                       | 791-1102              | S.S.             | 39.65                              | $4.87 \times 10^{-2}$                        | 198       |
| Ni <sup>63</sup>                    | P 99.99                                       | 787-1039              | S.S.             | 15.66                              | $5.36 \times 10^{-4}$                        | 198       |
| U <sup>233</sup>                    | P 99.99                                       | 800-1070              | S.S.             | 28.5                               | $2.33 \times 10^{-3}$                        | 227       |
| Zr <sup>95</sup>                    | P                                             | 800-1000              | R.A.             | 16.5                               | $3.9 \times 10^{-4}$                         | 228       |
| <b>Vanadium</b>                     |                                               |                       |                  |                                    |                                              |           |
| C <sup>14</sup>                     | P 99.7                                        | 845-1130              | S.S.             | 27.3                               | $4.9 \times 10^{-3}$                         | 199       |
| Cr <sup>51</sup>                    | P 99.8                                        | 960-1200              | R.A.             | 64.6                               | $9.54 \times 10^{-3}$                        | 200       |
| Fe <sup>59</sup>                    | P                                             | 960-1350              | S.S.             | 71.0                               | 0.373                                        | 201       |
| P <sup>32</sup>                     | P 99.8                                        | 1200-1450             | R.A.             | 49.8                               | $2.45 \times 10^{-2}$                        | 202       |
| S <sup>35</sup>                     | P 99.8                                        | 1320-1520             | R.A.             | 34.0                               | $3.1 \times 10^{-2}$                         | 184       |
| V <sup>48</sup>                     | S, P 99.99                                    | 880-1360              | S.S.             | 73.65                              | 0.36                                         | 203       |
| V <sup>48</sup>                     | S, P 99.99                                    | 1360-1830             | S.S.             | 94.14                              | 214.0                                        | 203       |
| <b>Yttrium</b>                      |                                               |                       |                  |                                    |                                              |           |
| Y <sup>90</sup>                     | S.L.c                                         | 900-1300              | R.A.             | 67.1                               | 5.2                                          | 204       |
| Y <sup>90</sup>                     | S c                                           | 900-1300              | R.A.             | 60.3                               | 0.82                                         | 204       |
| <b>Zinc</b>                         |                                               |                       |                  |                                    |                                              |           |
| Ag <sup>110</sup>                   | S.L.c 99.999                                  | 271-413               | S.S.             | 27.6                               | 0.45                                         | 205       |
| Ag <sup>110</sup>                   | S c 99.999                                    | 271-413               | S.S.             | 26.0                               | 0.32                                         | 205       |



# RADIOACTIVE TRACER DIFFUSION DATA FOR PURE METALS (Continued)

| Solute (tracer)                      | Material (metal, crystalline form and purity) | Temperature range, °C | Form of analysis | Activation energy, $Q$ , Kcal/mole | Frequency factor, $D_0$ , cm <sup>2</sup> /s | Reference |
|--------------------------------------|-----------------------------------------------|-----------------------|------------------|------------------------------------|----------------------------------------------|-----------|
| Au <sup>198</sup>                    | S.L.c. 99.999                                 | 315-415               | S.S.             | 29.72                              | 0.29                                         | 206       |
| Au <sup>198</sup>                    | S.L.c. 99.999                                 | 315-415               | S.S.             | 29.73                              | 0.97                                         | 206       |
| Cd <sup>115</sup>                    | S.L.c. 99.999                                 | 225-416               | S.S.             | 20.12                              | 0.117                                        | 206       |
| Cd <sup>115</sup>                    | S.L.c. 99.999                                 | 225-416               | S.S.             | 20.54                              | 0.114                                        | 206       |
| Cu <sup>64</sup>                     | S.L.c. 99.999                                 | 338-415               | S.S.             | 29.92                              | 2.0                                          | 206       |
| Cu <sup>64</sup>                     | S.L.c. 99.999                                 | 338-415               | S.S.             | 29.53                              | 2.22                                         | 207       |
| Ga <sup>72</sup>                     | S.L.c.                                        | 240-403               | S.S.             | 18.15                              | 0.018                                        | 207       |
| Ga <sup>72</sup>                     | S.L.c.                                        | 240-403               | S.S.             | 18.4                               | 0.016                                        | 207       |
| Hg <sup>203</sup>                    | S.L.c.                                        | 260-413               | S.S.             | 20.18                              | 0.073                                        | 208       |
| Hg <sup>203</sup>                    | S.L.c.                                        | 260-413               | S.S.             | 19.70                              | 0.056                                        | 208       |
| In <sup>114</sup>                    | S.L.c.                                        | 271-413               | S.S.             | 19.60                              | 0.14                                         | 205       |
| In <sup>114</sup>                    | S.L.c.                                        | 271-413               | S.S.             | 19.10                              | 0.062                                        | 205       |
| Sn <sup>113</sup>                    | S.L.c.                                        | 298-400               | S.S.             | 18.4                               | 0.13                                         | 209       |
| Sn <sup>113</sup>                    | S.L.c.                                        | 298-400               | S.S.             | 19.4                               | 0.15                                         | 209       |
| Zn <sup>65</sup>                     | S.L.c. 99.999                                 | 240-418               | S.S.             | 23.0                               | 0.18                                         | 210       |
| Zn <sup>65</sup>                     | S.L.c. 99.999                                 | 240-418               | S.S.             | 21.9                               | 0.13                                         | 210       |
| <b><math>\alpha</math>-Zirconium</b> |                                               |                       |                  |                                    |                                              |           |
| Cr <sup>51</sup>                     | P 99.9                                        | 700-850               | R.A.             | 18.0                               | $1.19 \times 10^{-8}$                        | 211       |
| Fe <sup>55</sup>                     | P                                             | 750-840               | —                | 48.0                               | $2.5 \times 10^{-2}$                         | 212       |
| Mo <sup>99</sup>                     | P                                             | 600-850               | R.A.             | 24.76                              | $6.22 \times 10^{-8}$                        | 213       |
| Nb <sup>95</sup>                     | P 99.99                                       | 740-857               | R.A.             | 31.5                               | $6.6 \times 10^{-6}$                         | 182       |
| Sn <sup>113</sup>                    | P                                             | 300-700               | A.R.G.           | 22.0                               | $1.0 \times 10^{-8}$                         | 214       |
| Ta <sup>182</sup>                    | P 99.6                                        | 700-800               | R.A.             | 70.0                               | 100                                          | 215       |
| V <sup>48</sup>                      | P 99.99                                       | 600-850               | R.A.             | 22.9                               | $1.12 \times 10^{-8}$                        | 124       |
| Zr <sup>95</sup>                     | P 99.95                                       | 750-850               | S.S.             | 45.5                               | $5.6 \times 10^{-4}$                         | 216       |
| <b><math>\beta</math>-Zirconium</b>  |                                               |                       |                  |                                    |                                              |           |
| Be <sup>7</sup>                      | P 99.7                                        | 915-1300              | R.A.             | 31.1                               | $8.33 \times 10^{-2}$                        | 184       |
| C <sup>14</sup>                      | P 96.6                                        | 1100-1600             | R.A.             | 34.2                               | $3.57 \times 10^{-2}$                        | 217       |
| Ce <sup>141</sup>                    | P                                             | 880-1600              | R.A.             | 41.4                               | 3.16                                         | 218       |
|                                      |                                               |                       |                  | 74.1                               | 42.17                                        |           |
| Co <sup>60</sup>                     | P 99.99                                       | 920-1600              | S.S.             | 21.82                              | $3.26 \times 10^{-3}$                        | 219       |
| Cr <sup>51</sup>                     | P 99.9                                        | 700-850               | R.A.             | 18.0                               | $1.19 \times 10^{-8}$                        | 211       |
| Fe <sup>55</sup>                     | P                                             | 750-840               | —                | 48.0                               | $2.5 \times 10^{-2}$                         | 212       |
| Mo <sup>99</sup>                     | P                                             | 900-1635              | R.A.             | 35.2                               | $1.99 \times 10^{-6}$                        | 218       |
|                                      |                                               |                       |                  | 68.55                              | 2.63                                         |           |
| Nb <sup>95</sup>                     | P                                             | 1230-1635             | R.A.             | 36.6                               | $7.8 \times 10^{-4}$                         | 220       |
| P <sup>32</sup>                      | P 99.94                                       | 950-1200              | R.A.             | 33.3                               | 0.33                                         | 221       |
| Sn <sup>113</sup>                    | P                                             | 300-700               | A.R.G.           | 22.0                               | $1 \times 10^{-8}$                           | 214       |
| Ta <sup>182</sup>                    | P 99.6                                        | 900-1200              | R.A.             | 27.0                               | $5.5 \times 10^{-5}$                         | 215       |
| U <sup>235</sup>                     | P                                             | 900-1065              | S.S.             | 30.5                               | $5.7 \times 10^{-4}$                         | 222       |
| V <sup>48</sup>                      | P 99.99                                       | 870-1200              | R.A.             | 45.8                               | $7.59 \times 10^{-3}$                        | 223       |
| V <sup>48</sup>                      | P 99.99                                       | 1200-1400             | R.A.             | 57.7                               | 0.32                                         | 223       |
| W <sup>185</sup>                     | P 99.7                                        | 900-1250              | R.A.             | 55.8                               | 0.41                                         | 223       |
| Zr <sup>95</sup>                     | P                                             | 1100-1500             | S.S.             | 30.1                               | $2.4 \times 10^{-4}$                         | 225       |

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**RECOMMENDED DAILY DIETARY ALLOWANCES**  
**Designed for the Maintenance of Good Nutrition of Practically all Healthy People in the United States<sup>a</sup>**  
**1989 Recommendations of the Food and Nutrition Board, National Academy of Sciences**

| Category              | Age (years)<br>or Condition | Fat-Soluble Vitamins              |                                |                                     |                   | Water-Soluble Vitamins |                 |                    |                                |                                |                | Minerals                        |                 |                    |                   | Selenium<br>(µg) |              |              |                |     |    |    |     |    |
|-----------------------|-----------------------------|-----------------------------------|--------------------------------|-------------------------------------|-------------------|------------------------|-----------------|--------------------|--------------------------------|--------------------------------|----------------|---------------------------------|-----------------|--------------------|-------------------|------------------|--------------|--------------|----------------|-----|----|----|-----|----|
|                       |                             | Vitamin A<br>(µg RE) <sup>c</sup> | Vitamin D <sup>d</sup><br>(µg) | Vitamin E<br>(mg α-TE) <sup>e</sup> | Vitamin K<br>(µg) | Vitamin C<br>(mg)      | Thiamin<br>(mg) | Riboflavin<br>(mg) | Niacin<br>(mg NE) <sup>f</sup> | Vitamin B <sub>6</sub><br>(mg) | Folate<br>(µg) | Vitamin B <sub>12</sub><br>(µg) | Calcium<br>(mg) | Phosphorus<br>(mg) | Magnesium<br>(mg) |                  | Iron<br>(mg) | Zinc<br>(mg) | Iodine<br>(µg) |     |    |    |     |    |
| Infants               | 0.0-0.5                     | 6                                 | 13                             | 60                                  | 24                | 13                     | 375             | 7.5                | 3                              | 5                              | 30             | 0.3                             | 0.4             | 5                  | 0.3               | 25               | 0.3          | 400          | 300            | 40  | 6  | 5  | 40  | 10 |
|                       | 0.5-1.0                     | 9                                 | 20                             | 71                                  | 28                | 14                     | 375             | 10                 | 4                              | 10                             | 35             | 0.4                             | 0.5             | 6                  | 0.6               | 35               | 0.5          | 600          | 500            | 60  | 10 | 5  | 50  | 15 |
| Children              | 1-3                         | 13                                | 29                             | 90                                  | 35                | 16                     | 400             | 10                 | 6                              | 15                             | 40             | 0.7                             | 0.8             | 9                  | 1.0               | 50               | 0.7          | 800          | 800            | 80  | 10 | 70 | 20  | 20 |
|                       | 4-6                         | 20                                | 44                             | 112                                 | 44                | 24                     | 500             | 10                 | 7                              | 20                             | 45             | 0.9                             | 1.1             | 12                 | 1.1               | 75               | 1.0          | 800          | 800            | 120 | 10 | 10 | 90  | 20 |
| Males                 | 7-10                        | 28                                | 62                             | 132                                 | 52                | 28                     | 700             | 10                 | 7                              | 30                             | 45             | 1.0                             | 1.2             | 13                 | 1.4               | 100              | 1.4          | 800          | 800            | 170 | 10 | 10 | 120 | 30 |
|                       | 11-14                       | 45                                | 99                             | 157                                 | 62                | 45                     | 1,000           | 10                 | 10                             | 45                             | 50             | 1.3                             | 1.5             | 17                 | 1.7               | 150              | 2.0          | 1,200        | 1,200          | 270 | 12 | 15 | 150 | 40 |
|                       | 15-18                       | 66                                | 145                            | 176                                 | 69                | 59                     | 1,000           | 10                 | 10                             | 65                             | 60             | 1.5                             | 1.8             | 20                 | 2.0               | 200              | 2.0          | 1,200        | 1,200          | 400 | 12 | 15 | 150 | 50 |
|                       | 19-24                       | 72                                | 160                            | 177                                 | 70                | 58                     | 1,000           | 10                 | 10                             | 70                             | 60             | 1.5                             | 1.7             | 19                 | 2.0               | 200              | 2.0          | 1,200        | 1,200          | 350 | 10 | 15 | 150 | 70 |
|                       | 25-50                       | 79                                | 174                            | 176                                 | 70                | 63                     | 1,000           | 5                  | 10                             | 80                             | 60             | 1.5                             | 1.7             | 19                 | 2.0               | 200              | 2.0          | 800          | 800            | 350 | 10 | 15 | 150 | 70 |
|                       | 51+                         | 77                                | 170                            | 173                                 | 68                | 63                     | 1,000           | 5                  | 10                             | 80                             | 60             | 1.2                             | 1.4             | 15                 | 2.0               | 200              | 2.0          | 800          | 800            | 350 | 10 | 15 | 150 | 70 |
| Females               | 11-14                       | 46                                | 101                            | 157                                 | 62                | 46                     | 800             | 10                 | 8                              | 45                             | 50             | 1.1                             | 1.3             | 15                 | 1.4               | 150              | 2.0          | 1,200        | 1,200          | 280 | 15 | 12 | 150 | 45 |
|                       | 15-18                       | 55                                | 120                            | 163                                 | 64                | 44                     | 800             | 10                 | 8                              | 55                             | 60             | 1.1                             | 1.3             | 15                 | 1.5               | 180              | 2.0          | 1,200        | 1,200          | 300 | 15 | 12 | 150 | 50 |
|                       | 19-24                       | 58                                | 128                            | 164                                 | 65                | 46                     | 800             | 10                 | 8                              | 60                             | 60             | 1.1                             | 1.3             | 15                 | 1.6               | 180              | 2.0          | 1,200        | 1,200          | 280 | 15 | 12 | 150 | 55 |
|                       | 25-50                       | 63                                | 138                            | 163                                 | 64                | 50                     | 800             | 5                  | 8                              | 65                             | 60             | 1.1                             | 1.3             | 15                 | 1.6               | 180              | 2.0          | 800          | 800            | 280 | 15 | 12 | 150 | 55 |
| Pregnant<br>Lactating | 51+                         | 65                                | 143                            | 160                                 | 63                | 60                     | 800             | 5                  | 8                              | 65                             | 60             | 1.0                             | 1.2             | 13                 | 1.6               | 180              | 2.0          | 800          | 800            | 280 | 10 | 12 | 150 | 55 |
|                       | 1st 6 months                |                                   |                                |                                     |                   | 60                     | 800             | 10                 | 10                             | 65                             | 70             | 1.5                             | 1.6             | 17                 | 2.2               | 400              | 2.2          | 1,200        | 1,200          | 320 | 30 | 15 | 175 | 65 |
|                       | 2nd 6 months                |                                   |                                |                                     |                   | 62                     | 1,300           | 10                 | 12                             | 65                             | 95             | 1.6                             | 1.8             | 20                 | 2.1               | 280              | 2.6          | 1,200        | 1,200          | 355 | 15 | 19 | 200 | 75 |
|                       |                             |                                   |                                |                                     |                   | 62                     | 1,200           | 10                 | 11                             | 65                             | 90             | 1.6                             | 1.7             | 20                 | 2.1               | 260              | 2.6          | 1,200        | 1,200          | 340 | 15 | 16 | 200 | 75 |

<sup>a</sup> The allowances, expressed as average daily intakes over time, are intended to provide for individual variations among most normal persons as they live in the United States under usual environmental stresses. Diets should be based on a variety of common foods in order to provide other nutrients for which human requirements have been less well defined.

<sup>b</sup> Weights and heights of Reference Adults are actual medians for the U.S. population of the designated age. The use of these figures does not imply that the height-to-weight ratios are ideal.

<sup>c</sup> Retinol equivalents. 1 retinol equivalent = 1 µg retinol or 6 µg β-carotene.

<sup>d</sup> As cholecalciferol. 10 µg cholecalciferol = 400 IU of vitamin D.

<sup>e</sup> α-Tocopherol equivalents. 1 mg d-α-tocopherol = 1 α-TE.

<sup>f</sup> 1 NE (niacin equivalent) is equal to 1 mg of niacin or 60 mg of dietary tryptophan.

## RECOMMENDED DAILY DIETARY ALLOWANCES (continued)

### Estimated Safe and Adequate Daily Dietary Intakes of Selected Vitamins and Minerals<sup>a</sup>

| Category                    | Age<br>(years) | Vitamins       |                          |
|-----------------------------|----------------|----------------|--------------------------|
|                             |                | Biotin<br>(μg) | Pantothenic<br>Acid (mg) |
| Infants                     | 0–0.5          | 10             | 2                        |
|                             | 0.5–1          | 15             | 3                        |
| Children and<br>adolescents | 1–3            | 20             | 3                        |
|                             | 4–6            | 25             | 3–4                      |
|                             | 7–10           | 30             | 4–5                      |
|                             | 11+            | 30–100         | 4–7                      |
| Adults                      |                | 30–100         | 4–7                      |

| Trace Elements <sup>b</sup> |                |                |                        |                  |                  |                    |
|-----------------------------|----------------|----------------|------------------------|------------------|------------------|--------------------|
| Category                    | Age<br>(years) | Copper<br>(mg) | Man-<br>ganese<br>(mg) | Fluoride<br>(mg) | Chromium<br>(μg) | Molybdenum<br>(μg) |
| Infants                     | 0–0.5          | 0.4–0.6        | 0.3–0.6                | 0.1–0.5          | 10–40            | 15–30              |
|                             | 0.5–1          | 0.6–0.7        | 0.6–1.0                | 0.2–1.0          | 20–60            | 20–40              |
| Children and<br>adolescents | 1–3            | 0.7–1.0        | 1.0–1.5                | 0.5–1.5          | 20–80            | 25–50              |
|                             | 4–6            | 1.0–1.5        | 1.5–2.0                | 1.0–2.5          | 30–120           | 30–75              |
|                             | 7–10           | 1.0–2.0        | 2.0–3.0                | 1.5–2.5          | 50–200           | 50–150             |
|                             | 11+            | 1.5–2.5        | 2.0–5.0                | 1.5–2.5          | 50–200           | 75–250             |
| Adults                      |                | 1.5–3.0        | 2.0–5.0                | 1.5–4.0          | 50–200           | 75–250             |

<sup>a</sup> Because there is less information on which to base allowances, these figures are not given in the main table of RDA and are provided here in the form of ranges of recommended intakes.

<sup>b</sup> Since the toxic levels for many trace elements may be only several times usual intakes, the upper levels for the trace elements given in this table should not be habitually exceeded.



## REDUCTION OF BAROMETER TO SEA LEVEL

The correction to be added to reduce barometric readings to "sea level" values depends principally on three factors: The temperature of the air column (assumed) from the station to sea level, the altitude of the station, and the value of the reading itself. Two tables are provided. Table I is entered with the altitude and assumed temperature and is a factor "2000 m" taken out. Table II is entered with the above factor and the approximate barometer reading and the final correction taken out.

The correction is to be added. If  $B_0$  is the corrected or sea level value; B the barometer reading at the station; C the correction,—

$$C = B_0 - B = B(10^n - 1)$$

The actual barometer reading at the station should be corrected for temperature of the mercury column by the usual methods before entering the tables or applying the sea level correction.

A complete explanation of the theory of the corrections and a more extended set of tables will be found in the Smithsonian Meteorological Tables.

### Latitude Factor

The influence of the latitude on the value of the correction is usually negligible, being overshadowed by uncertainties in the assumed temperature of the air column. For cases where this correction is desirable the table below is provided. The value of the temperature-altitude factor "2000 m" obtained in Table I is corrected for latitude by subtracting for latitudes 0-45° and adding for latitudes from 45-90° the values found. With this corrected value of "2000 m" Table II is entered for the value of the correction.

## LATITUDE FACTOR

To be used in connection with Tables I and II, either English or metric units, to obtain latitude corrections to temperature-altitude factor. For latitudes 0-45° subtract the correction. For latitudes 45-90° add the correction.

| Temp.-Alt.<br>from<br>Table I | Latitude |     |     |     |
|-------------------------------|----------|-----|-----|-----|
|                               | 0°       | 15° | 30° | 45° |
| 100                           | 0.3      | 0.2 | 0.1 | 0.0 |
| 200                           | 0.5      | 0.5 | 0.3 | 0.0 |
| 300                           | 0.8      | 0.7 | 0.4 | 0.0 |
|                               | 90°      | 75° | 60° | 45° |

## METRIC UNITS—TABLE I

Values of the temperature-altitude factor (2000 m ) for entering table II.

| Altitude<br>in<br>meters | Assumed temperature of air column °C |       |       |       |       |       |       |       |       |       | Altitude<br>in<br>meters | Assumed temperature of air column °C |       |       |       |       |       |       |       |       |       |
|--------------------------|--------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------------------------|--------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                          | -16°                                 | -8°   | 0°    | +4°   | +8°   | +12°  | +16°  | +20°  | +24°  | +28°  |                          | -16°                                 | -8°   | 0°    | +4°   | +8°   | +12°  | +16°  | +20°  | +24°  | +28°  |
| 10                       | 1.2                                  | 1.1   | 1.1   | 1.1   | 1.0   | 1.0   | 1.0   | 1.0   | 1.0   | 1.0   | 1500                     | 172.6                                | 167.3 | 162.3 | 159.8 | 157.3 | 154.9 | 152.5 | 150.3 | 148.0 | 145.9 |
| 50                       | 5.8                                  | 5.6   | 5.4   | 5.3   | 5.2   | 5.2   | 5.1   | 5.0   | 4.9   | 4.9   | 1550                     | 178.3                                | 172.9 | 167.7 | 165.1 | 162.6 | 160.1 | 157.6 | 155.3 | 153.0 | 150.7 |
| 100                      | 11.5                                 | 11.2  | 10.8  | 10.7  | 10.5  | 10.3  | 10.2  | 10.0  | 9.9   | 9.7   | 1600                     | 184.1                                | 178.5 | 173.1 | 170.4 | 167.8 | 165.2 | 162.7 | 160.3 | 157.9 | 155.6 |
| 150                      | 17.3                                 | 16.7  | 16.2  | 16.0  | 15.7  | 15.5  | 15.3  | 15.0  | 14.8  | 14.6  | 1650                     | 189.8                                | 184.0 | 178.5 | 175.7 | 173.0 | 170.4 | 167.8 | 165.3 | 162.8 | 160.5 |
| 200                      | 23.0                                 | 22.3  | 21.6  | 21.3  | 21.0  | 20.7  | 20.3  | 20.0  | 19.7  | 19.5  | 1700                     | 195.6                                | 189.6 | 183.9 | 181.1 | 178.3 | 175.6 | 172.9 | 170.3 | 167.8 | 165.3 |
| 250                      | 28.8                                 | 27.9  | 27.0  | 26.6  | 26.2  | 25.8  | 25.4  | 25.0  | 24.7  | 24.3  | 1750                     | 201.4                                | 195.2 | 189.3 | 186.4 | 183.5 | 180.7 | 178.0 | 175.3 | 172.7 | 170.2 |
| 300                      | 34.5                                 | 33.5  | 32.5  | 32.0  | 31.5  | 31.0  | 30.5  | 30.1  | 29.6  | 29.2  | 1800                     | 207.1                                | 200.8 | 194.7 | 191.7 | 188.8 | 185.9 | 183.1 | 180.3 | 177.6 | 175.0 |
| 350                      | 40.3                                 | 39.0  | 37.9  | 37.3  | 36.7  | 36.2  | 35.6  | 35.1  | 34.6  | 34.0  | 1850                     | 212.9                                | 206.3 | 200.1 | 197.0 | 194.0 | 191.0 | 188.1 | 185.3 | 182.6 | 179.9 |
| 400                      | 46.0                                 | 44.6  | 43.3  | 42.6  | 42.0  | 41.3  | 40.7  | 40.1  | 39.5  | 38.9  | 1900                     | 218.6                                | 211.9 | 205.5 | 202.4 | 199.3 | 196.2 | 193.2 | 190.3 | 187.5 | 184.8 |
| 450                      | 51.8                                 | 50.2  | 48.7  | 47.9  | 47.2  | 46.5  | 45.8  | 45.1  | 44.4  | 43.8  | 1950                     | 224.4                                | 217.5 | 210.9 | 207.7 | 204.5 | 201.4 | 198.3 | 195.3 | 192.4 | 189.6 |
| 500                      | 57.5                                 | 55.8  | 54.1  | 53.3  | 52.4  | 51.6  | 50.9  | 50.1  | 49.4  | 48.6  | 2000                     | 230.1                                | 223.0 | 216.3 | 213.0 | 209.7 | 206.5 | 203.4 | 200.3 | 197.4 | 194.5 |
| 550                      | 63.3                                 | 61.4  | 59.5  | 58.6  | 57.7  | 56.8  | 55.9  | 55.1  | 54.3  | 53.5  | 2050                     | 235.9                                | 228.6 | 221.7 | 218.3 | 215.0 | 211.7 | 208.5 | 205.3 | 202.3 | 199.3 |
| 600                      | 69.0                                 | 66.9  | 64.9  | 63.9  | 62.9  | 62.0  | 61.0  | 60.1  | 59.2  | 58.3  | 2100                     | 241.6                                | 234.2 | 227.1 | 223.7 | 220.2 | 216.8 | 213.5 | 210.4 | 207.2 | 204.2 |
| 650                      | 74.8                                 | 72.5  | 70.3  | 69.2  | 68.2  | 67.1  | 66.1  | 65.1  | 64.2  | 63.2  | 2150                     | 247.4                                | 239.8 | 232.5 | 229.0 | 225.5 | 222.0 | 218.6 | 215.4 | 212.2 | 209.1 |
| 700                      | 80.6                                 | 78.1  | 75.7  | 74.6  | 73.4  | 72.3  | 71.2  | 70.1  | 69.1  | 68.1  | 2200                     | 253.1                                | 245.4 | 237.9 | 234.3 | 230.7 | 227.2 | 223.7 | 220.4 | 217.1 | 213.9 |
| 750                      | 86.3                                 | 83.7  | 81.1  | 79.9  | 78.7  | 77.5  | 76.3  | 75.1  | 74.0  | 72.9  | 2250                     | 258.9                                | 250.9 | 243.4 | 239.6 | 235.9 | 232.3 | 228.8 | 225.4 | 222.0 | 218.8 |
| 800                      | 92.1                                 | 89.2  | 86.5  | 85.2  | 83.9  | 82.6  | 81.4  | 80.1  | 79.0  | 77.8  | 2300                     | 264.6                                | 256.5 | 248.8 | 245.0 | 241.2 | 237.5 | 233.9 | 230.4 | 227.0 | 223.6 |
| 850                      | 97.8                                 | 94.8  | 92.0  | 90.5  | 89.2  | 87.8  | 86.4  | 85.2  | 83.9  | 82.7  | 2350                     | 270.4                                | 262.1 | 254.2 | 250.3 | 246.4 | 242.7 | 239.0 | 235.4 | 231.9 | 228.5 |
| 900                      | 103.6                                | 100.4 | 97.4  | 95.9  | 94.4  | 93.0  | 91.5  | 90.2  | 88.8  | 87.5  | 2400                     | 276.1                                | 267.7 | 259.6 | 255.6 | 251.7 | 247.8 | 244.0 | 240.4 | 236.8 | 233.4 |
| 950                      | 109.3                                | 106.0 | 102.8 | 101.2 | 99.6  | 98.1  | 96.6  | 95.2  | 93.8  | 92.4  | 2450                     | 281.9                                | 273.2 | 265.0 | 260.9 | 256.9 | 253.0 | 249.1 | 245.4 | 241.8 | 238.2 |
| 1000                     | 115.1                                | 111.5 | 108.2 | 106.5 | 104.9 | 103.3 | 101.7 | 100.2 | 98.7  | 97.3  | 2500                     | 287.6                                | 278.8 | 270.4 | 266.2 | 262.2 | 258.1 | 254.2 | 250.4 | 246.7 | 243.1 |
| 1050                     | 120.8                                | 117.1 | 113.6 | 111.8 | 110.1 | 108.4 | 106.8 | 105.2 | 103.6 | 102.1 | 2550                     | 293.4                                | 284.4 | 275.8 | 271.6 | 267.4 | 263.3 | 259.3 | 255.4 | 251.6 | 247.9 |
| 1100                     | 126.6                                | 122.7 | 119.0 | 117.2 | 115.4 | 113.6 | 111.9 | 110.2 | 108.6 | 107.0 | 2600                     | 299.1                                | 290.0 | 281.2 | 276.9 | 272.6 | 268.5 | 264.4 | 260.4 | 256.6 | 252.8 |
| 1150                     | 132.3                                | 128.3 | 124.4 | 122.5 | 120.6 | 118.8 | 117.0 | 115.2 | 113.5 | 111.8 | 2650                     | 304.9                                | 295.5 | 286.6 | 282.2 | 277.9 | 273.6 | 269.5 | 265.4 | 261.5 | 257.7 |
| 1200                     | 138.1                                | 133.8 | 129.8 | 127.8 | 125.9 | 123.9 | 122.0 | 120.2 | 118.4 | 116.7 | 2700                     | 310.6                                | 301.1 | 292.0 | 287.5 | 283.1 | 278.8 | 274.5 | 270.4 | 266.4 | 262.5 |
| 1250                     | 143.8                                | 139.4 | 135.2 | 133.1 | 131.1 | 129.1 | 127.1 | 125.2 | 123.4 | 121.6 | 2750                     | 316.4                                | 306.7 | 297.4 | 292.9 | 288.4 | 283.9 | 279.6 | 275.4 | 271.4 | 267.4 |
| 1300                     | 149.6                                | 145.0 | 140.6 | 138.5 | 136.3 | 134.3 | 132.2 | 130.2 | 128.3 | 126.4 | 2800                     | 322.1                                | 312.3 | 302.8 | 298.2 | 293.6 | 289.1 | 284.7 | 280.4 | 276.3 | 272.2 |
| 1350                     | 155.3                                | 150.6 | 146.0 | 143.8 | 141.6 | 139.4 | 137.3 | 135.2 | 133.2 | 131.3 | 2850                     | 327.9                                | 317.8 | 308.2 | 303.5 | 298.8 | 294.3 | 289.8 | 285.4 | 281.2 | 277.1 |
| 1400                     | 161.1                                | 156.2 | 151.4 | 149.1 | 146.8 | 144.6 | 142.4 | 140.2 | 138.2 | 136.2 | 2900                     | 333.6                                | 323.4 | 313.6 | 308.8 | 304.1 | 299.4 | 294.9 | 290.4 | 286.2 | 282.0 |
| 1450                     | 166.8                                | 161.7 | 156.8 | 154.5 | 152.1 | 149.7 | 147.5 | 145.3 | 143.1 | 141.0 | 2950                     | 339.4                                | 329.0 | 319.0 | 314.2 | 309.3 | 304.6 | 299.9 | 295.5 | 291.1 | 286.8 |
|                          |                                      |       |       |       |       |       |       |       |       |       | 3000                     | 345.1                                | 334.5 | 324.4 | 319.5 | 314.6 | 309.7 | 305.0 | 300.5 | 296.0 | 291.7 |

## METRIC UNITS — TABLE II

### Values of Correction to be Added

| Temp.-<br>alt.-<br>factor | Barometer reading (mmHg) |       |       |       |       | Temp.-<br>alt.-<br>factor | Barometer reading (mmHg) |       |       |       |       |       |
|---------------------------|--------------------------|-------|-------|-------|-------|---------------------------|--------------------------|-------|-------|-------|-------|-------|
|                           | 780                      | 760   | 740   | 720   | 700   |                           | 640                      | 620   | 600   | 580   | 560   |       |
| 1                         | 0.9                      | 0.9   | 0.9   | 0.8   | 0.8   | 170                       | 138.4                    | 134.0 | 129.7 | 125.4 | 121.1 |       |
| 5                         | 4.5                      | 4.4   | 4.3   | 4.2   | 4.0   | 175                       | 142.9                    | 138.4 | 133.9 | 129.5 | 125.0 |       |
| 10                        | 9.0                      | 8.8   | 8.6   | 8.3   | 8.1   | 180                       | 147.4                    | 142.8 | 138.2 | 133.6 | 129.0 |       |
| 15                        | 13.6                     | 13.2  | 12.9  | 12.5  | 12.2  | 185                       | 151.9                    | 147.2 | 142.4 | 137.7 | 132.9 |       |
| 20                        | 18.2                     | 17.7  | 17.2  | 16.8  | 16.3  | 190                       | 156.5                    | 151.6 | 146.7 | 141.8 | 136.9 |       |
| 25                        | 22.8                     | 22.2  | 21.6  | 21.0  | 20.4  | 195                       | 161.1                    | 156.1 | 151.0 | 146.0 | 141.0 |       |
| 30                        | 27.4                     | 26.7  | 26.0  | 25.3  | 24.6  | 200                       | 165.7                    | 160.5 | 155.4 | 150.2 | 145.0 |       |
| 35                        | —                        | 31.2  | 30.4  | 29.6  | 28.8  | 205                       | 170.4                    | 165.0 | 159.7 | 154.4 | 149.1 |       |
|                           |                          |       |       |       |       | 210                       | —                        | 169.6 | 164.1 | 158.6 | 153.2 |       |
|                           | 760                      | 740   | 720   | 700   | 680   | 660                       | 215                      | —     | 174.1 | 168.5 | 162.9 | 157.3 |
| 40                        | 35.8                     | 34.9  | 33.9  | 33.0  | 32.0  | 31.1                      | 620                      | 600   | 580   | 560   | 540   |       |
| 45                        | 40.4                     | 39.3  | 38.3  | 37.2  | 36.2  | 35.1                      |                          |       |       |       |       |       |
| 50                        | 45.0                     | 43.8  | 42.7  | 41.5  | 40.3  | 39.1                      | 215                      | 174.1 | 168.5 | 162.9 | 157.3 | 151.7 |
| 55                        | 49.7                     | 48.4  | 47.1  | 45.8  | 44.5  | 43.1                      | 220                      | 178.7 | 172.9 | 167.2 | 161.4 | 155.7 |
| 60                        | —                        | 52.9  | 51.5  | 50.1  | 48.6  | 47.2                      | 225                      | 183.3 | 177.4 | 171.5 | 165.6 | 159.7 |
| 65                        | —                        | 57.5  | 55.9  | 54.4  | 52.8  | 51.3                      | 230                      | 188.0 | 181.9 | 175.8 | 169.8 | 163.7 |
| 70                        | —                        | 62.1  | 60.4  | 58.7  | 57.1  | 55.4                      | 235                      | 192.6 | 186.4 | 180.2 | 174.0 | 167.8 |
| 75                        | —                        | 66.7  | 64.9  | 63.1  | 61.3  | 59.5                      | 240                      | —     | 191.0 | 184.6 | 178.2 | 171.9 |
|                           |                          |       |       |       |       |                           | 245                      | —     | 195.5 | 189.0 | 182.5 | 176.0 |
|                           | 720                      | 700   | 680   | 660   | 640   |                           | 250                      | —     | 200.1 | 193.4 | 186.8 | 180.1 |
| 80                        | 69.5                     | 67.5  | 65.6  | 63.7  | 61.7  |                           | 255                      | —     | 204.7 | 197.9 | 191.1 | 184.3 |
| 85                        | 74.0                     | 72.0  | 69.9  | 67.9  | 65.8  |                           | 260                      | —     | 209.4 | 202.4 | 195.4 | 188.4 |
| 90                        | 78.6                     | 76.4  | 74.2  | 72.1  | 69.9  |                           |                          | 580   | 560   | 540   | 520   |       |
| 95                        | 83.2                     | 80.9  | 78.6  | 76.3  | 74.0  |                           | 260                      | 202.4 | 195.4 | 188.4 | 181.5 |       |
| 100                       | 87.9                     | 85.4  | 83.0  | 80.5  | 78.1  |                           | 265                      | 206.9 | 199.8 | 192.6 | 185.5 |       |
| 105                       | —                        | 89.9  | 87.4  | 84.8  | 82.2  |                           | 270                      | 211.5 | 204.2 | 196.9 | 189.6 |       |
| 110                       | —                        | 94.5  | 91.8  | 89.1  | 86.4  |                           | 275                      | 216.0 | 208.6 | 201.1 | 193.7 |       |
| 115                       | —                        | 99.1  | 96.3  | 93.4  | 90.6  |                           | 280                      | 220.6 | 213.0 | 205.4 | 197.8 |       |
| 120                       | —                        | 103.7 | 100.7 | 97.8  | 94.8  |                           | 285                      | 225.2 | 217.5 | 209.7 | 201.9 |       |
| 125                       | —                        | 108.3 | 105.3 | 102.2 | 99.1  |                           | 290                      | 229.9 | 222.0 | 214.0 | 206.1 |       |
|                           | 680                      | 660   | 640   | 620   | 600   |                           | 295                      | —     | 226.5 | 218.4 | 210.3 |       |
| 125                       | 105.3                    | 102.2 | 99.1  | 96.0  | 92.9  |                           | 300                      | —     | 231.0 | 222.8 | 214.5 |       |
| 130                       | 109.8                    | 106.6 | 103.3 | 100.1 | 96.9  |                           |                          | 560   | 540   | 520   | 500   | 480   |
| 135                       | 114.3                    | 111.0 | 107.6 | 104.3 | 100.9 |                           | 305                      | 235.6 | 227.2 | 218.8 | 210.3 | 201.9 |
| 140                       | 118.9                    | 115.4 | 111.9 | 108.4 | 104.9 |                           | 310                      | 240.2 | 231.6 | 223.0 | 214.4 | 205.9 |
| 145                       | 123.5                    | 119.9 | 116.3 | 112.6 | 109.0 |                           | 315                      | 244.8 | 236.0 | 227.3 | 218.6 | 209.8 |
| 150                       | 128.2                    | 124.4 | 120.6 | 116.9 | 113.1 |                           | 320                      | 249.4 | 240.5 | 231.6 | 222.7 | 213.8 |
| 155                       | —                        | 128.9 | 125.0 | 121.1 | 117.2 |                           | 325                      | 254.1 | 245.0 | 236.0 | 226.9 | 217.8 |
| 160                       | —                        | 133.5 | 129.4 | 125.4 | 121.4 |                           | 330                      | —     | 249.6 | 240.3 | 231.1 | 221.8 |
| 165                       | —                        | 138.1 | 133.9 | 129.7 | 125.5 |                           | 335                      | —     | 254.1 | 244.7 | 235.3 | 225.9 |
| 170                       | —                        | 142.7 | 138.4 | 134.0 | 129.7 |                           | 340                      | —     | 258.7 | 249.1 | 239.6 | 230.0 |
|                           |                          |       |       |       |       |                           | 345                      | —     | 263.3 | 253.6 | 243.8 | 234.1 |

## ENGLISH UNITS — TABLE I

Values of the temperature-altitude factor (2000 m) for entering table II

| Altitude<br>feet | Assumed temperature of air column, °F |       |       |       |       |       |       |       |       |       | Altitude<br>feet | Assumed temperature of air column, °F |       |       |       |       |       |       |       |       |       |
|------------------|---------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------------------|---------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                  | -20                                   | 0     | +10   | +20   | +30   | +40   | +50   | +60   | +70   | +80   |                  | -20                                   | 0     | +10   | +20   | +30   | +40   | +50   | +60   | +70   | +80   |
| 200              | 7.4                                   | 7.1   | 6.9   | 6.8   | 6.6   | 6.5   | 6.3   | 6.2   | 6.1   | 6.0   | 4800             | 177.3                                 | 169.5 | 165.9 | 162.3 | 158.9 | 155.6 | 152.2 | 149.0 | 145.9 | 143.0 |
| 400              | 14.8                                  | 14.1  | 13.8  | 13.5  | 13.2  | 13.0  | 12.7  | 12.4  | 12.2  | 11.9  | 5000             | 184.7                                 | 176.6 | 172.8 | 169.1 | 165.6 | 162.0 | 158.6 | 155.2 | 152.0 | 148.9 |
| 600              | 22.2                                  | 21.2  | 20.7  | 20.3  | 19.9  | 19.5  | 19.0  | 18.6  | 18.2  | 17.9  | 5200             | 192.1                                 | 183.7 | 179.7 | 175.9 | 172.2 | 168.5 | 164.9 | 161.5 | 158.1 | 154.9 |
| 800              | 29.6                                  | 28.3  | 27.7  | 27.1  | 26.5  | 25.9  | 25.4  | 24.8  | 24.3  | 23.8  | 5400             | 199.5                                 | 190.7 | 186.6 | 182.6 | 178.8 | 175.0 | 171.3 | 167.7 | 164.2 | 160.8 |
| 1000             | 37.0                                  | 35.3  | 34.6  | 33.8  | 33.1  | 32.4  | 31.7  | 31.1  | 30.4  | 29.8  | 5600             | 206.9                                 | 197.8 | 193.5 | 189.4 | 185.4 | 181.5 | 177.6 | 173.9 | 170.3 | 166.8 |
| 1200             | 44.3                                  | 42.4  | 41.5  | 40.6  | 39.7  | 38.9  | 38.1  | 37.3  | 36.5  | 35.8  | 5800             | 214.3                                 | 204.8 | 200.4 | 196.2 | 192.0 | 188.0 | 184.0 | 180.1 | 176.3 | 172.8 |
| 1400             | 51.7                                  | 49.5  | 48.4  | 47.4  | 46.4  | 45.4  | 44.4  | 43.5  | 42.6  | 41.7  | 6000             | 221.7                                 | 211.9 | 207.3 | 202.9 | 198.7 | 194.4 | 190.3 | 186.3 | 182.4 | 178.7 |
| 1600             | 59.1                                  | 56.5  | 55.3  | 54.1  | 53.0  | 51.9  | 50.8  | 49.7  | 48.7  | 47.7  | 6200             | 229.1                                 | 219.0 | 214.2 | 209.7 | 205.3 | 200.9 | 196.6 | 192.5 | 188.5 | 184.7 |
| 1800             | 66.5                                  | 63.6  | 62.2  | 60.9  | 59.6  | 58.4  | 57.1  | 55.9  | 54.7  | 53.6  | 6400             | 236.4                                 | 226.0 | 221.1 | 216.4 | 211.9 | 207.4 | 203.0 | 198.7 | 194.6 | 190.6 |
| 2000             | 73.9                                  | 70.6  | 69.1  | 67.7  | 66.2  | 64.8  | 63.4  | 62.1  | 60.8  | 59.6  | 6600             | 243.8                                 | 233.1 | 228.0 | 223.2 | 218.5 | 213.0 | 209.3 | 204.9 | 200.7 | 196.6 |
| 2200             | 81.3                                  | 77.7  | 76.0  | 74.4  | 72.9  | 71.3  | 69.8  | 68.3  | 66.9  | 65.5  | 6800             | 251.2                                 | 240.1 | 235.0 | 230.0 | 225.1 | 220.4 | 215.7 | 211.1 | 206.7 | 202.5 |
| 2400             | 88.7                                  | 84.8  | 82.9  | 81.2  | 79.5  | 77.8  | 76.1  | 74.5  | 73.0  | 71.5  | 7000             | 258.6                                 | 247.2 | 241.9 | 236.7 | 231.8 | 226.8 | 222.0 | 217.3 | 212.8 | 208.5 |
| 2600             | 96.1                                  | 91.8  | 89.9  | 87.9  | 86.1  | 84.3  | 82.5  | 80.7  | 79.1  | 77.5  | 7200             | 266.0                                 | 254.3 | 248.8 | 243.5 | 238.4 | 233.3 | 228.4 | 223.5 | 218.9 | 214.4 |
| 2800             | 103.5                                 | 98.9  | 96.8  | 94.7  | 92.7  | 90.8  | 88.8  | 87.0  | 85.1  | 83.4  | 7400             | 273.4                                 | 261.3 | 255.7 | 250.2 | 245.0 | 239.8 | 234.7 | 229.7 | 225.0 | 220.4 |
| 3000             | 110.9                                 | 106.0 | 103.7 | 101.5 | 99.3  | 97.2  | 95.2  | 93.2  | 91.2  | 89.4  | 7600             | 280.8                                 | 268.4 | 262.6 | 257.0 | 251.6 | 246.3 | 241.0 | 235.9 | 231.1 | 226.4 |
| 3200             | 118.2                                 | 113.0 | 110.6 | 108.2 | 106.0 | 103.7 | 101.5 | 99.4  | 97.3  | 95.3  | 7800             | 288.1                                 | 275.4 | 269.5 | 263.8 | 258.2 | 252.8 | 247.4 | 242.2 | 237.1 | 232.3 |
| 3400             | 125.6                                 | 120.1 | 117.5 | 115.0 | 112.6 | 110.2 | 107.9 | 105.6 | 103.4 | 101.3 | 8000             | 295.5                                 | 282.5 | 276.4 | 270.5 | 264.8 | 259.2 | 253.7 | 248.4 | 243.2 | 238.3 |
| 3600             | 133.0                                 | 127.2 | 124.4 | 121.8 | 119.2 | 116.7 | 114.2 | 111.8 | 109.5 | 107.2 | 8200             | 302.9                                 | 289.6 | 283.3 | 277.3 | 271.5 | 265.7 | 260.1 | 254.6 | 249.3 | 244.2 |
| 3800             | 140.4                                 | 134.2 | 131.3 | 128.5 | 125.8 | 123.2 | 120.5 | 118.0 | 115.5 | 113.2 | 8400             | 310.3                                 | 296.6 | 290.2 | 284.0 | 278.1 | 272.2 | 266.4 | 260.8 | 255.4 | 250.2 |
| 4000             | 147.8                                 | 141.3 | 138.2 | 135.3 | 132.4 | 129.6 | 126.9 | 124.2 | 121.6 | 119.2 | 8600             | 317.7                                 | 303.7 | 297.1 | 290.8 | 284.7 | 278.7 | 272.7 | 267.0 | 261.4 | 256.1 |
| 4200             | 155.2                                 | 148.3 | 145.1 | 142.1 | 139.1 | 136.1 | 133.2 | 130.4 | 127.7 | 125.1 | 8800             | 325.1                                 | 310.7 | 304.0 | 297.6 | 291.3 | 285.2 | 279.1 | 273.2 | 267.5 | 262.1 |
| 4400             | 162.6                                 | 155.4 | 152.0 | 148.8 | 145.7 | 142.6 | 139.6 | 136.6 | 133.8 | 131.1 | 9000             | 332.5                                 | 317.8 | 310.9 | 304.3 | 297.9 | 291.6 | 285.4 | 279.4 | 273.6 | 268.0 |
| 4600             | 170.0                                 | 162.5 | 159.0 | 155.5 | 152.3 | 149.1 | 145.9 | 142.8 | 139.9 | 137.0 |                  |                                       |       |       |       |       |       |       |       |       |       |



# ENGLISH UNITS — TABLE II

Value of Correction to be Added.

| Temp.<br>alt.<br>factor | Barometer reading |      |      |      |      | Temp.<br>alt.<br>factor | Barometer reading |      |      |      |      | Temp.<br>alt.<br>factor | Barometer reading |      |      |      |      | Temp.<br>alt.<br>factor | Barometer reading |      |      |      |
|-------------------------|-------------------|------|------|------|------|-------------------------|-------------------|------|------|------|------|-------------------------|-------------------|------|------|------|------|-------------------------|-------------------|------|------|------|
|                         | 31                | 30   | 29   | 28   | 27   |                         | 26                | 25   | 24   | 23   | 22   |                         | 28                | 27   | 26   | 25   | 24   |                         | 23                | 22   | 21   | 20   |
| 1                       | in.               | in.  | in.  | in.  | in.  | 165                     | in.               | in.  | in.  | in.  | in.  | 75                      | in.               | in.  | in.  | in.  | in.  | 250                     | in.               | in.  | in.  | in.  |
| 5                       | 0.04              | 0.03 | 0.03 | —    | —    | 170                     | 5.44              | 5.23 | 5.02 | —    | —    | 80                      | 2.53              | 2.43 | 2.34 | —    | —    | 255                     | 7.67              | 7.34 | —    | —    |
| 10                      | 0.18              | 0.17 | 0.17 | —    | —    | 175                     | 5.62              | 5.40 | 5.19 | —    | —    | 85                      | 2.70              | 2.60 | 2.51 | —    | —    | 260                     | 7.85              | 7.51 | —    | —    |
| 15                      | 0.36              | 0.35 | 0.34 | 0.32 | —    | 180                     | —                 | 5.58 | 5.36 | —    | —    | 90                      | 2.88              | 2.78 | 2.67 | —    | —    | 265                     | 8.03              | 7.68 | 7.33 | —    |
| 20                      | 0.54              | 0.52 | 0.51 | 0.49 | —    | 185                     | —                 | 5.76 | 5.53 | 5.30 | —    | 95                      | 3.06              | 2.95 | 2.84 | —    | —    | 270                     | 8.21              | 7.85 | 7.49 | —    |
| 25                      | 0.72              | 0.70 | 0.68 | 0.65 | —    | 190                     | —                 | 5.93 | 5.70 | 5.46 | —    | 100                     | 3.24              | 3.12 | 3.01 | —    | —    | 275                     | 8.39              | 8.02 | 7.66 | —    |
| 30                      | —                 | 0.88 | 0.85 | 0.82 | —    | 195                     | —                 | 6.11 | 5.87 | 5.62 | —    | 105                     | 3.42              | 3.29 | 3.17 | —    | —    | 280                     | 8.57              | 8.19 | 7.82 | —    |
| 35                      | —                 | 1.05 | 1.02 | 0.98 | —    | 200                     | —                 | 6.29 | 6.04 | 5.79 | —    | 110                     | 3.60              | 3.47 | 3.34 | 3.21 | —    | 285                     | —                 | 8.37 | 7.99 | —    |
| 40                      | —                 | 1.23 | 1.19 | 1.15 | —    | 205                     | —                 | —    | 6.21 | 5.96 | —    | 115                     | —                 | 3.85 | 3.51 | 3.38 | —    | 290                     | —                 | 8.54 | 8.16 | —    |
| 45                      | —                 | 1.41 | 1.37 | 1.32 | 1.27 | 210                     | —                 | —    | 6.39 | 6.12 | —    | 120                     | —                 | 3.82 | 3.68 | 3.54 | —    | 295                     | —                 | 8.72 | 8.32 | —    |
| 50                      | —                 | 1.60 | 1.54 | 1.49 | 1.44 | 215                     | —                 | —    | 6.56 | 6.29 | —    | 125                     | —                 | 4.00 | 3.85 | 3.70 | —    | 300                     | —                 | 8.90 | 8.49 | 8.09 |
| 55                      | —                 | —    | 1.72 | 1.66 | 1.60 | 220                     | —                 | —    | 6.74 | 6.46 | —    | 130                     | —                 | 4.18 | 4.02 | 3.87 | —    | 305                     | —                 | 9.08 | 8.66 | 8.25 |
| 60                      | —                 | —    | 1.90 | 1.83 | 1.76 | 225                     | —                 | —    | 6.92 | 6.63 | 6.34 | 135                     | —                 | 4.36 | 4.20 | 4.04 | —    | 310                     | —                 | 9.26 | 8.83 | 8.41 |
| 65                      | —                 | —    | 2.07 | 2.00 | 1.93 | 230                     | —                 | —    | 7.10 | 6.80 | 6.51 | 140                     | —                 | 4.54 | 4.37 | 4.20 | —    | 315                     | —                 | 9.44 | 9.01 | 8.58 |
| 70                      | —                 | —    | 2.25 | 2.18 | 2.10 | 235                     | —                 | —    | 7.28 | 6.97 | 6.67 | 145                     | —                 | —    | 4.55 | 4.37 | 4.20 | 320                     | —                 | 9.62 | 9.18 | 8.74 |
| 75                      | —                 | —    | 2.43 | 2.35 | 2.27 | 240                     | —                 | —    | 7.46 | 7.15 | 6.84 | 150                     | —                 | —    | 4.72 | 4.54 | 4.36 | 325                     | —                 | 9.80 | 9.35 | 8.91 |
| 80                      | —                 | —    | —    | 2.53 | 2.43 | 245                     | —                 | —    | —    | 7.32 | 7.00 | 155                     | —                 | —    | 4.90 | 4.71 | 4.52 | 330                     | —                 | —    | 9.53 | 9.08 |
|                         | —                 | —    | —    | 2.70 | 2.60 | 245                     | —                 | —    | —    | 7.49 | 7.17 | 160                     | —                 | —    | 5.08 | 4.88 | 4.69 | —                       | —                 | —    | 9.71 | 9.24 |
|                         |                   |      |      |      |      |                         |                   |      |      |      |      |                         |                   |      | 5.26 | 5.06 | 4.85 | —                       | —                 | —    |      |      |

## REDUCTION OF BAROMETER TO GRAVITY AT SEA LEVEL

Metric Units

Correction to be subtracted given in millimeters  
(From Smithsonian Physical Tables)

| Height above<br>sea level in<br>meters | Observed Height of Barometer in Millimeters |     |     |     |     |     |     | Height above<br>sea level in<br>meters | Observed Height of Barometer in Millimeters |      |      |      |      |      |      |
|----------------------------------------|---------------------------------------------|-----|-----|-----|-----|-----|-----|----------------------------------------|---------------------------------------------|------|------|------|------|------|------|
|                                        | 500                                         | 550 | 600 | 650 | 700 | 750 | 800 |                                        | 500                                         | 550  | 600  | 650  | 700  | 750  | 800  |
| 100                                    | —                                           | —   | —   | —   | .02 | .02 | .02 | 2400                                   | .38                                         | .42  | .45  | —    | —    | —    | —    |
| 200                                    | —                                           | —   | —   | —   | .04 | .05 | .05 | 2500                                   | .39                                         | .43  | .47  | —    | —    | —    | —    |
| 300                                    | —                                           | —   | —   | —   | .07 | .07 | .07 | English Units                          |                                             |      |      |      |      |      |      |
| 400                                    | —                                           | —   | —   | —   | .09 | .10 | .10 | Height above<br>sea level in<br>feet   | Observed Height in Inches                   |      |      |      |      |      |      |
| 500                                    | —                                           | —   | —   | —   | .11 | .12 | .13 |                                        | 18                                          | 20   | 22   | 24   | 26   | 28   | 30   |
| 600                                    | —                                           | —   | —   | .12 | .13 | .14 | —   |                                        |                                             |      |      |      |      |      |      |
| 700                                    | —                                           | —   | —   | .14 | .15 | .16 | —   |                                        |                                             |      |      |      |      |      |      |
| 800                                    | —                                           | —   | —   | .16 | .18 | .19 | —   |                                        |                                             |      |      |      |      |      |      |
| 900                                    | —                                           | —   | —   | .18 | .20 | .22 | —   | 1000                                   | —                                           | —    | —    | —    | .003 | .003 | .003 |
| 1000                                   | —                                           | .18 | .19 | .20 | .22 | .24 | —   | 2000                                   | —                                           | —    | —    | .004 | .005 | .005 | .006 |
| 1100                                   | —                                           | .19 | .21 | .22 | .24 | —   | —   | 3000                                   | —                                           | —    | .007 | .007 | .008 | .008 | —    |
| 1200                                   | —                                           | .21 | .23 | .24 | .26 | —   | —   | 4000                                   | —                                           | —    | .009 | .009 | .010 | —    | —    |
| 1300                                   | —                                           | .22 | .24 | .26 | .29 | —   | —   | 4500                                   | —                                           | —    | 0.10 | 0.10 | 0.11 | —    | —    |
| 1400                                   | —                                           | .24 | .26 | .28 | .31 | —   | —   | 5000                                   | —                                           | 0.10 | 0.11 | 0.11 | 0.12 | —    | —    |
| 1500                                   | .24                                         | .26 | .28 | .30 | .33 | —   | —   | 5500                                   | —                                           | 0.11 | 0.12 | 0.13 | —    | —    | —    |
| 1600                                   | .25                                         | .28 | .30 | .32 | —   | —   | —   | 6000                                   | —                                           | 0.11 | 0.13 | 0.14 | —    | —    | —    |
| 1700                                   | .27                                         | .30 | .32 | .34 | —   | —   | —   | 6500                                   | 0.11                                        | 0.12 | 0.14 | 0.15 | —    | —    | —    |
| 1800                                   | .28                                         | .31 | .34 | .36 | —   | —   | —   | 7000                                   | 0.12                                        | 0.13 | 0.15 | 0.16 | —    | —    | —    |
| 1900                                   | .30                                         | .33 | .36 | .39 | —   | —   | —   | 7500                                   | 0.13                                        | 0.14 | 0.16 | 0.17 | —    | —    | —    |
| 2000                                   | .31                                         | .34 | .38 | .41 | —   | —   | —   | 8000                                   | 0.14                                        | 0.15 | 0.17 | —    | —    | —    | —    |
| 2100                                   | .33                                         | .36 | .40 | —   | —   | —   | —   | 8500                                   | 0.15                                        | 0.16 | 0.18 | —    | —    | —    | —    |
| 2200                                   | .35                                         | .38 | .41 | —   | —   | —   | —   | 9000                                   | 0.16                                        | 0.17 | 0.19 | —    | —    | —    | —    |
| 2300                                   | .36                                         | .40 | .43 | —   | —   | —   | —   | 9500                                   | 0.16                                        | 0.18 | 0.20 | —    | —    | —    | —    |

## REDUCTION OF BAROMETER TO LATITUDE 45°

Metric Scale

For latitudes below 45°, subtract the correction; for latitudes greater than 45° it is to be added. Corrections in cm.  
(From Smithsonian Meteorological Tables.)

| Latitude | Observed Height of Barometer in Centimeters |       |       |       |       |       | Latitude | Observed Height in Inches |       |       |       |       |       |
|----------|---------------------------------------------|-------|-------|-------|-------|-------|----------|---------------------------|-------|-------|-------|-------|-------|
|          | 68                                          | 70    | 72    | 74    | 76    | 78    |          | 25                        | 26    | 27    | 28    | 29    | 30    |
| 25° 65°  | 0.116                                       | 0.120 | 0.123 | 0.127 | 0.130 | 0.133 | 25° 65°  | 0.043                     | 0.044 | 0.046 | 0.048 | 0.050 | 0.051 |
| 26 64    | .111                                        | .115  | .118  | .121  | .125  | .128  | 26 64    | .041                      | .043  | .044  | .046  | .048  | .049  |
| 27 63    | .106                                        | .110  | .113  | .116  | .119  | .122  | 27 63    | .039                      | .041  | .042  | .044  | .045  | .047  |
| 28 62    | .101                                        | .104  | .107  | .110  | .113  | .116  | 28 62    | .037                      | .039  | .040  | .042  | .043  | .045  |
| 29 61    | .096                                        | .099  | .102  | .104  | .107  | .110  | 29 61    | .035                      | .037  | .038  | .039  | .041  | .042  |
| 30 60    | .091                                        | .094  | .096  | .098  | .101  | .104  | 30 60    | .033                      | .035  | .036  | .037  | .039  | .040  |
| 31 59    | .085                                        | .087  | .090  | .092  | .095  | .097  | 31 59    | .031                      | .032  | .034  | .035  | .036  | .037  |
| 32 58    | .079                                        | .082  | .084  | .086  | .089  | .091  | 32 58    | .029                      | .030  | .032  | .033  | .034  | .035  |
| 33 57    | .074                                        | .076  | .078  | .080  | .082  | .084  | 33 57    | .027                      | .028  | .029  | .030  | .031  | .032  |
| 34 56    | .068                                        | .070  | .072  | .074  | .076  | .078  | 34 56    | .025                      | .026  | .027  | .028  | .029  | .030  |
| 35 55    | .062                                        | .064  | .066  | .067  | .069  | .071  | 35 55    | .023                      | .024  | .025  | .025  | .026  | .027  |
| 36 54    | .056                                        | .058  | .059  | .061  | .063  | .064  | 36 54    | .021                      | .021  | .022  | .023  | .024  | .025  |
| 37 53    | .050                                        | .051  | .053  | .054  | .056  | .057  | 37 53    | .018                      | .019  | .020  | .021  | .021  | .022  |
| 38 52    | .044                                        | .045  | .046  | .048  | .049  | .050  | 38 52    | .016                      | .017  | .017  | .018  | .019  | .019  |
| 39 51    | .038                                        | .039  | .040  | .041  | .042  | .043  | 39 51    | .014                      | .014  | .015  | .015  | .016  | .017  |
| 40 50    | .031                                        | .032  | .033  | .034  | .035  | .036  | 40 50    | .012                      | .012  | .012  | .013  | .013  | .014  |
| 41 49    | .025                                        | .026  | .027  | .027  | .028  | .029  | 41 49    | .009                      | .010  | .010  | .010  | .011  | .011  |
| 42 48    | .019                                        | .019  | .020  | .021  | .021  | .022  | 42 48    | .007                      | .007  | .008  | .008  | .008  | .008  |
| 43 47    | .013                                        | .013  | .013  | .14   | .014  | .014  | 43 47    | .005                      | .005  | .005  | .005  | .005  | .006  |
| 44 46    | .006                                        | .007  | .007  | .007  | .007  | .007  | 44 46    | .002                      | .002  | .003  | .003  | .003  | .003  |

# REFRACTORY MATERIALS

## Borides

| Name              | Formula            | Molecular weight | Melting point, °C                                               | Crystalline form                                | Lattice parameter, Å                                | X-ray density, g/cm <sup>3</sup> |
|-------------------|--------------------|------------------|-----------------------------------------------------------------|-------------------------------------------------|-----------------------------------------------------|----------------------------------|
| Chromium boride   | CrB <sub>2</sub>   | 73.65            | 1,850 <sup>(29)</sup> a                                         | Hexagonal AlB <sub>2</sub> type [C 32]          | a = 2.969<br>c = 3.066 <sup>(39)</sup>              | 5.16                             |
| Hafnium boride    | HfB <sub>2</sub>   | 200.14           | 3,100 <sup>(31)</sup>                                           | Hexagonal AlB <sub>2</sub> type [C 32]          | a = 3.14 <sup>(6)</sup><br>c = 3.47                 | 10.5                             |
| Molybdenum boride | MoB                | 106.77           | 2,180 <sup>(40)</sup>                                           | Tetragonal                                      | a = 3.110 <sup>(41)</sup><br>c = 16.95              | 8.77                             |
|                   | MoB <sub>2</sub>   | 117.59           | 2,100 <sup>(40)</sup>                                           | Hexagonal AlB <sub>2</sub> type [C 32]          | a = 3.05<br>c = 3.113 <sup>(42)</sup>               | 7.78                             |
|                   | Mo <sub>2</sub> B  | 202.72           | 2,000 <sup>(40)</sup><br>(decomposes)<br>>0.2000 <sup>(3)</sup> | Tetragonal CuAl <sub>2</sub> type [C 16]        | a = 5.543 <sup>(41)</sup><br>c = 4.735              | 9.31                             |
| Niobium boride    | NbB                | 103.73           | >0.2000 <sup>(3)</sup>                                          | Orthorhombic                                    | a = 3.298<br>b = 8.724<br>c = 3.137 <sup>(35)</sup> |                                  |
|                   | NbB <sub>2</sub>   | 114.55           | 2,900 <sup>(36)</sup><br>(decomposes)<br>>0.2000 <sup>(3)</sup> | Hexagonal AlB <sub>2</sub> type [C 32]          | a = 3.086 <sup>(28)</sup><br>c = 3.306              | 7.21                             |
| Tantalum boride   | TaB                | 191.77           | >0.2000 <sup>(3)</sup>                                          | Orthorhombic                                    | a = 3.276<br>b = 8.669<br>c = 3.157 <sup>(37)</sup> | 14.29                            |
|                   | TaB <sub>2</sub>   | 202.59           | 3,000 <sup>(6)</sup>                                            | Hexagonal AlB <sub>2</sub> type [C 32]          | a = 3.088 <sup>(28)</sup><br>c = 3.241              | 12.60                            |
| Thorium boride    | ThB <sub>4</sub>   | 275.53           | >0.2500 <sup>(6)</sup>                                          | Tetragonal D <sub>4h</sub> <sup>+</sup> -P4/mbm | a = 7.256 <sup>(43)</sup><br>c = 4.113              | 8.45                             |
| Titanium boride   | TiB <sub>2</sub>   | 69.54            | 2,980 <sup>(6)</sup>                                            | Hexagonal AlB <sub>2</sub> type [C 32]          | a = 3.028 <sup>(28)</sup><br>c = 3.228              | 4.52                             |
| Tungsten boride   | WB                 | 194.68           | 2,860 <sup>(29)</sup>                                           | Tetragonal                                      | a = 3.115 <sup>(6)</sup><br>c = 16.92               | 16.0                             |
|                   | W <sub>2</sub> B   | 378.54           | 2,770 <sup>(29)</sup>                                           | Tetragonal CuAl <sub>2</sub> type [C 16]        | a = 5.564 <sup>(41)</sup><br>c = 4.740              | 16.72                            |
| Uranium boride    | UB <sub>1.2</sub>  | 367.91           | >0.1500 <sup>(6)</sup><br>(decomposes)                          | Face-centered cubic                             | a = 7.473 <sup>(44)</sup>                           | 5.82                             |
| Vanadium boride   | VB <sub>2</sub>    | 72.59            | 2,100 <sup>(29)</sup>                                           | Hexagonal AlB <sub>2</sub> type [C 32]          | a = 2.998 <sup>(28)</sup><br>c = 3.057              | 5.10                             |
| Zirconium boride  | ZrB <sub>2</sub>   | 112.86           | 3,040 ± 50 <sup>(30)</sup>                                      | Hexagonal AlB <sub>2</sub> type [C 32]          | a = 3.169 <sup>(28)</sup><br>c = 3.530              | 6.09                             |
|                   | ZrB <sub>1.2</sub> | 221.06           | 2,680 <sup>(30)</sup>                                           | Face-centered cubic                             | a = 7.408 <sup>(33)</sup>                           |                                  |

| Name              | Thermal conductivity, cal-sec <sup>-1</sup> ·cm <sup>-2</sup> ·cm <sup>-2</sup> ·C <sup>-1</sup> | Electrical resistivity, microhm-cm                                                                                                                                                                                                                                                                                                                                | Ductility relative scale <sup>b</sup> | Resistance to oxidation <sup>c</sup> | Hardness <sup>d</sup>                                                                                                |
|-------------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Chromium boride   |                                                                                                  | 21 at room temperature <sup>(38)</sup>                                                                                                                                                                                                                                                                                                                            |                                       |                                      | 1,800 kg/mm <sup>2</sup> (29)                                                                                        |
| Hafnium boride    |                                                                                                  | 10 <sup>(31)</sup>                                                                                                                                                                                                                                                                                                                                                | 3 <sup>(3)</sup>                      |                                      |                                                                                                                      |
| Molybdenum boride |                                                                                                  | α-MoB = 45 at room temperature <sup>(40)</sup><br>β-MoB = 25 at room temperature <sup>(40)</sup><br>45 at room temperature <sup>(40)</sup><br>40 at room temperature <sup>(40)</sup><br>6.45 at room temperature <sup>(36)</sup><br>32.0 at room temperature <sup>(36)</sup><br>100 at room temperature <sup>(38)</sup><br>68 at room temperature <sup>(38)</sup> | 3 <sup>(3)</sup>                      | 3 <sup>(3)</sup>                     | 8 Mohs <sup>(20)</sup><br>1,570 kg/mm <sup>2</sup> (29)<br>1,280 kg/mm <sup>2</sup> (29)<br>8–9 Mohs <sup>(20)</sup> |
| Niobium boride    | 0.040 at 20°C <sup>(36)</sup>                                                                    |                                                                                                                                                                                                                                                                                                                                                                   |                                       |                                      | >0.8 Mohs <sup>(36)</sup>                                                                                            |
| Tantalum boride   | 0.026 at 20°C <sup>(6)</sup>                                                                     |                                                                                                                                                                                                                                                                                                                                                                   | 3 <sup>(3)</sup>                      | 3 <sup>(3)</sup>                     |                                                                                                                      |
| Thorium boride    |                                                                                                  | 28.4 <sup>(28)</sup>                                                                                                                                                                                                                                                                                                                                              | 3 <sup>(3)</sup>                      | 2–3 <sup>(3)</sup>                   | 3,400 kg/mm <sup>2</sup> (29)                                                                                        |
| Titanium boride   | 0.0624 at 200°C <sup>(28)</sup><br>(15% porosity)                                                |                                                                                                                                                                                                                                                                                                                                                                   | 3 <sup>(3)</sup>                      | 3 <sup>(3)</sup>                     | 9 Mohs <sup>(6)</sup>                                                                                                |
| Tungsten boride   |                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                   | 3 <sup>(3)</sup>                      | 3 <sup>(3)</sup>                     |                                                                                                                      |
| Uranium boride    | 16 at 20°C <sup>(34)</sup>                                                                       |                                                                                                                                                                                                                                                                                                                                                                   |                                       |                                      | 8–9 Mohs <sup>(6)</sup>                                                                                              |
| Vanadium boride   |                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                   |                                       |                                      |                                                                                                                      |
| Zirconium boride  | 0.0550 at 200°C <sup>(28)</sup><br>0.029 at room temperature <sup>(33)</sup>                     | 9.2 at 20°C <sup>(31)</sup><br>60–80 at room temperature <sup>(30)</sup>                                                                                                                                                                                                                                                                                          | 2 <sup>(3)</sup>                      | 2–3 <sup>(3)</sup>                   | 8 Mohs <sup>(32)</sup>                                                                                               |

## Carbides

| Name             | Formula                         | Molecular weight | Melting point, °C          | Crystalline form                           | Lattice parameter, Å                                                                           | X-ray density, g/cm <sup>3</sup> |
|------------------|---------------------------------|------------------|----------------------------|--------------------------------------------|------------------------------------------------------------------------------------------------|----------------------------------|
| Boron carbide    | B <sub>4</sub> C                | 55.29            | 2,450                      | Hexagonal                                  | a <sub>0</sub> = 5.60 <sup>(6)</sup><br>c <sub>0</sub> = 12.12                                 | 2.52                             |
| Chromium carbide | Cr <sub>3</sub> C <sub>2</sub>  | 180.05           | 1,895 <sup>(15)</sup>      | Orthorhombic (DS <sub>10</sub> )           | a = 2.82<br>b = 5.53<br>c = 11.47 <sup>(16)</sup>                                              | 6.7                              |
|                  | Cr <sub>7</sub> Cr <sub>3</sub> | 400.01           | 1,780 <sup>(15)</sup>      | Hexagonal [C <sub>3</sub> v <sup>4</sup> ] | a = 14.01<br>c = 4.532 <sup>(17)</sup>                                                         | 6.92                             |
| Graphite         | C                               | 12.01            | 3,700 ± 100 <sup>(3)</sup> | Hexagonal                                  | Orthohexagonal axes<br>a <sub>0</sub> = 2.46<br>b <sub>0</sub> = 4.28<br>c <sub>0</sub> = 6.71 | 2.25                             |
| Hafnium carbide  | HfC                             | 190.51           | 3,890 <sup>(9)</sup>       | Cubic NaCl type (B1)                       | a = 4.46 <sup>(10)</sup>                                                                       | 12.7                             |



**REFRACTORY MATERIALS (Continued)**  
Carbides (Continued)

| Carbides (Continued) |                                                                                    |                  |                                                   |                                                    |                                                                  |                                            |                               |
|----------------------|------------------------------------------------------------------------------------|------------------|---------------------------------------------------|----------------------------------------------------|------------------------------------------------------------------|--------------------------------------------|-------------------------------|
| Name                 | Formula                                                                            | Molecular weight | Melting point, °C                                 | Crystalline form                                   | Lattice parameter, Å                                             | X-ray density, g/cm <sup>3</sup>           |                               |
| Molybdenum carbide   | MoC                                                                                | 107.96           | 2,695 <sup>(9)</sup>                              | Face-centered cubic                                | a = 4.28 <sup>(19)</sup>                                         | 9.2                                        |                               |
|                      | Mo <sub>2</sub> C                                                                  | 203.91           | 2,690 <sup>(6)</sup>                              | Hexagonal (L'3)                                    | a = 3.002<br>c = 4.724 <sup>(18)</sup>                           |                                            |                               |
| Niobium carbide      | NbC                                                                                | 104.92           | 3,500 <sup>(9)</sup>                              | Cubic NaCl type (B1)                               | a = 4.461                                                        | 7.85                                       |                               |
| Silicon carbide β    | SiC                                                                                | 40.07            | Trans. to α at 2,100                              | Face-centered cubic                                | a <sub>0</sub> = 4.3590 <sup>(6)</sup>                           | 3.22                                       |                               |
| α                    | SiC                                                                                |                  | 2,700 <sup>(6)</sup>                              | Hexagonal (Wurtzite)                               | a <sub>0</sub> = 3.081 <sup>(6)</sup><br>c <sub>0</sub> = 5.0394 |                                            |                               |
| Tantalum carbide     | TaC                                                                                | 192.96           | 3,880 <sup>(9)</sup> , 4,730 <sup>(4)</sup>       | Cubic NaCl type (B1)                               | a = 4.455 <sup>(14)</sup>                                        | 14.5                                       |                               |
| Thorium carbide      | ThC                                                                                | 244.06           | 2,625 <sup>(23)</sup>                             | Cubic NaCl type (B1)                               | a = 5.34 <sup>(9)</sup>                                          | 10.67                                      |                               |
|                      | ThC <sub>2</sub>                                                                   | 256.07           | 2,655 <sup>(29)</sup>                             | Monoclinic [C 2/e]                                 | a = 6.53 <sup>(24)</sup><br>b = 4.24                             | 9.6                                        |                               |
| Titanium carbide     | TiC                                                                                | 59.91            | 3,160 <sup>(4)</sup>                              | Cubic NaCl type (B1)                               | a = 4.32 <sup>(6)</sup>                                          | 4.938                                      |                               |
| Tungsten carbide     | W <sub>2</sub> C                                                                   | 379.73           | 2,730 <sup>(21)</sup>                             | Hexagonal (L'3)                                    | a = 2.98 <sup>(6)</sup><br>c = 4.71                              | 17.34                                      |                               |
|                      | WC                                                                                 | 195.87           | 2,630 <sup>(21)</sup><br>(decomposes)             | Hexagonal (L'3)                                    | a = 2.900 <sup>(22)</sup><br>c = 2.831                           | 15.77                                      |                               |
| Uranium carbide      | UC                                                                                 | 250.08           | 2,450–2,500 <sup>(25)</sup>                       | Cubic NaCl type (B1)                               | a = 4.955 <sup>(26)</sup>                                        | 13.6                                       |                               |
|                      | UC <sub>2</sub>                                                                    | 262.09           | 2,350–2,400 <sup>(25)</sup>                       | Body-centered tetragonal<br>CaCl <sub>2</sub> type | a = 3.517 <sup>(27)</sup><br>c = 5.987                           | 11.68                                      |                               |
| Vanadium carbide     | VC                                                                                 | 62.96            | 2,830 <sup>(1)</sup>                              | Cubic NaCl type (B1)                               | a = 4.16 <sup>(6)</sup>                                          | 5.8                                        |                               |
| Zirconium carbide    | ZrC                                                                                | 103.23           | 3,030 <sup>(4)</sup>                              | Cubic NaCl type (B1)                               | a = 4.689 <sup>(5)</sup>                                         | 6.44                                       |                               |
| Name                 | Thermal conductivity,<br>cal-sec <sup>-1</sup> -cm <sup>-2</sup> -°C <sup>-1</sup> |                  | Electrical resistivity,<br>microhm-cm             |                                                    | Ductility<br>relative<br>scale <sup>b</sup>                      | Resistance<br>to<br>oxidation <sup>c</sup> | Hardness <sup>d</sup>         |
| Boron carbide        | 0.05 at 20–425°C <sup>(1)</sup>                                                    |                  | 0.30–0.80 <sup>(1)</sup>                          |                                                    | 3 <sup>(3)</sup>                                                 | 3 <sup>(3)</sup>                           | 9.3 Mohs                      |
| Chromium carbide     |                                                                                    |                  |                                                   |                                                    | 3 <sup>(3)</sup>                                                 | 3 <sup>(3)</sup>                           | 1,300 kg/mm <sup>2</sup> (8)  |
| Graphite             | 0.268–0.451 at room temperature                                                    |                  | 65 at room temperature <sup>(71)</sup>            |                                                    | 3 <sup>(3)</sup>                                                 | 3 <sup>(3)</sup>                           |                               |
| Hafnium carbide      |                                                                                    |                  | 109 at room temperature <sup>(1)</sup>            |                                                    | 3 <sup>(3)</sup>                                                 | 3 <sup>(3)</sup>                           |                               |
| Molybdenum carbide   |                                                                                    |                  | 97 <sup>(6)</sup>                                 |                                                    | 3 <sup>(3)</sup>                                                 | 3 <sup>(3)</sup>                           | 1,800 kg/mm <sup>2</sup> (6)  |
|                      |                                                                                    |                  |                                                   |                                                    | 3 <sup>(3)</sup>                                                 | 5 <sup>(3)</sup>                           | >0.7 Mohs <sup>(20)</sup>     |
| Niobium carbide      | 0.034 at room temperature <sup>(7)</sup>                                           |                  | 74 <sup>(6)</sup>                                 |                                                    | 2–3 <sup>(3)</sup>                                               | 3 <sup>(3)</sup>                           | 2,470 kg/mm <sup>2</sup> (13) |
| Silicon carbide β    | 0.10 at 20–425°C <sup>(1)</sup>                                                    |                  | 107–200 ohm cm <sup>(1)</sup> at room temperature |                                                    | 3 <sup>(3)</sup>                                                 | 2 <sup>(3)</sup>                           | 9.2 Mohs                      |
| Tantalum carbide     | 0.053 at room temperature <sup>(6)</sup>                                           |                  | 30 <sup>(6)</sup>                                 |                                                    | 2–3 <sup>(3)</sup>                                               | 3 <sup>(3)</sup>                           | 1,800 kg/mm <sup>2</sup> (8)  |
| Thorium carbide      |                                                                                    |                  |                                                   |                                                    | 3 <sup>(3)</sup>                                                 | 3 <sup>(3)</sup>                           |                               |
| Titanium carbide     | 0.049 at room temperature <sup>(6)</sup>                                           |                  | 180–250 <sup>(4)</sup>                            |                                                    | 3 <sup>(3)</sup>                                                 | 3 <sup>(4)</sup>                           | 3,200 kg/mm <sup>2</sup> (8)  |
| Tungsten carbide     |                                                                                    |                  | 80 <sup>(6)</sup>                                 |                                                    | 3 <sup>(3)</sup>                                                 | 5 <sup>(3)</sup>                           | 3,000 kg/mm <sup>2</sup> (6)  |
|                      |                                                                                    |                  | 53 <sup>(6)</sup>                                 |                                                    | 3 <sup>(3)</sup>                                                 | 5 <sup>(3)</sup>                           | 2,400 kg/mm <sup>2</sup> (6)  |
| Uranium carbide      |                                                                                    |                  |                                                   |                                                    | 3 <sup>(3)</sup>                                                 | 5 <sup>(3)</sup>                           |                               |
| Vanadium carbide     |                                                                                    |                  | 150 <sup>(6)</sup>                                |                                                    | 3 <sup>(3)</sup>                                                 |                                            | 2,800 kg/mm <sup>2</sup> (11) |
| Zirconium carbide    | 0.049 at room temperature <sup>(6)</sup>                                           |                  | 70 at room temperature <sup>(4)</sup>             |                                                    | 3 <sup>(3)</sup>                                                 | 3 <sup>(3)</sup>                           | 2,100 kg/mm <sup>2</sup> (12) |
|                      |                                                                                    |                  |                                                   |                                                    |                                                                  |                                            | 2,600 kg/mm <sup>2</sup> (6)  |

Nitrides

| Name              | Formula           | Molecular weight | Melting point, °C                                               | Crystalline form     | Lattice parameter, Å                                      | X-ray density, g/cm <sup>3</sup> |
|-------------------|-------------------|------------------|-----------------------------------------------------------------|----------------------|-----------------------------------------------------------|----------------------------------|
| Boron nitride     | BN                | 24.83            | 2,730 <sup>(6)</sup>                                            | Hexagonal (B 12)     | a = 2.51 ± .02<br>c = 6.70 ± .04 <sup>(52)</sup>          | 2.25                             |
| Chromium nitride  | CrN               | 66.02            | 1,500<br>(decomposes)                                           | Cubic NaCl type (B1) | a = 4.140 <sup>(6)</sup>                                  | 6.14                             |
| Hafnium nitride   | HfN               | 192.60           | 3,310 <sup>(6)</sup>                                            | Cubic NaCl type (B1) | a = 4.41–4.375 <sup>(6)</sup><br>a = 3.05 <sup>(48)</sup> | 7.28                             |
| Niobium nitride   | NbN               | 106.92           | 2,050 <sup>(46)</sup>                                           |                      |                                                           |                                  |
| Tantalum nitride  | Ta <sub>2</sub> N | 375.77           | 3,090 <sup>(46)</sup>                                           | Hexagonal            | c = 4.95 <sup>(53)</sup><br>a = 5.2 <sup>(48)</sup>       | 14.1                             |
| Thorium nitride   | ThN               | 246.13           | 2,630 <sup>(48)</sup>                                           | Cubic NaCl type (B1) |                                                           |                                  |
| Titanium nitride  | TiN               | 61.91            | 2,930 N <sub>2</sub><br>liberated on<br>melting <sup>(46)</sup> | Cubic NaCl type (B1) | a = 4.23 <sup>(53)</sup>                                  | 5.43                             |
| Uranium nitride   | UN                |                  | 2,650                                                           | Cubic NaCl type (B1) | a = 4.880 <sup>(58)</sup>                                 | 14.32                            |
| Vanadium nitride  | VN                | 64.96            | 2,050 <sup>(46)</sup>                                           | Cubic NaCl type (B1) | a = 4.129 <sup>(6)</sup>                                  | 6.102                            |
| Zirconium nitride | ZrN               | 105.22           | 2,980 <sup>(47)</sup>                                           | Cubic NaCl type (B1) | a = 4.567 <sup>(53)</sup>                                 | 7.349                            |

# REFRACTORY MATERIALS (Continued)

## Nitrides (Continued)

| Name              | Thermal conductivity,<br>cal-sec <sup>-1</sup> -cm <sup>-2</sup> -cm <sup>2</sup> -°C <sup>-1</sup> | Electrical resistivity,<br>microhm-cm    | Ductility<br>relative<br>scale <sup>b</sup> | Resistance<br>to<br>oxidation <sup>c</sup> | Hardness <sup>d</sup>                 |
|-------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------|---------------------------------------------|--------------------------------------------|---------------------------------------|
| Boron nitride     |                                                                                                     | 1,900 at 2,000°C <sup>(1)</sup>          | 3 <sup>(3)</sup>                            | 2 <sup>(3)</sup>                           | 2.0 Mohs                              |
| Chromium nitride  |                                                                                                     |                                          |                                             |                                            |                                       |
| Hafnium nitride   |                                                                                                     |                                          |                                             |                                            |                                       |
| Niobium nitride   |                                                                                                     | 200 at room temperature <sup>(46)</sup>  | 5 <sup>(3)</sup>                            | 3 <sup>(3)</sup>                           | +8 Mohs <sup>(46)</sup>               |
| Tantalum nitride  |                                                                                                     | 135 at room temperature <sup>(47)</sup>  | 3 <sup>(3)</sup>                            | 5 <sup>(3)</sup>                           | +8                                    |
| Thorium nitride   |                                                                                                     |                                          |                                             |                                            |                                       |
| Titanium nitride  |                                                                                                     | 21.7 at room temperature                 | 3 <sup>(3)</sup>                            | 3 <sup>(3)</sup>                           | Between 9 and 10 Mohs <sup>(46)</sup> |
| Uranium nitride   |                                                                                                     |                                          |                                             |                                            |                                       |
| Vanadium nitride  |                                                                                                     | 200 at room temperature <sup>(46)</sup>  | 3 <sup>(3)</sup>                            |                                            |                                       |
| Zirconium nitride |                                                                                                     | 13.6 at room temperature <sup>(46)</sup> | 3 <sup>(3)</sup>                            | 3 <sup>(3)</sup>                           | +8 Mohs <sup>(6)</sup>                |

## Oxides

| Name            | Formula                        | Molecular<br>weight | Melting point,<br>°C | Crystalline form    | Lattice parameter,<br>Å           | X-ray<br>density,<br>g/cm <sup>3</sup> |
|-----------------|--------------------------------|---------------------|----------------------|---------------------|-----------------------------------|----------------------------------------|
| Aluminum oxide  | Al <sub>2</sub> O <sub>3</sub> | 101.92              | 2,015 <sup>(1)</sup> | Rhombohedral        | a = 5.13<br>axial angle = 55° 6'  | 3.965                                  |
| Beryllium oxide | BeO                            | 25.02               | 2,550 <sup>(1)</sup> | Hexagonal           | a = 2.70<br>c = 4.39              | 3.03                                   |
| Cerium oxide    | CeO <sub>2</sub>               | 172.3               | 2,600 <sup>(1)</sup> | Face-centered cubic | a = 5.41                          | 7.13                                   |
| Chromic oxide   | Cr <sub>2</sub> O <sub>3</sub> | 152.02              | 2,265 <sup>(1)</sup> | Rhombohedral        | a = 5.38<br>axial angle = 54° 50' | 5.21                                   |
| Hafnium oxide   | HfO <sub>2</sub>               | 210.6               | 2,777 <sup>(1)</sup> | Face-centered cubic | a = 5.11                          | 9.68                                   |
| Magnesium oxide | MgO                            | 40.32               | 2,800 <sup>(1)</sup> | Face-centered cubic | a = 4.20                          | 3.58                                   |
| Silicon oxide   | SiO <sub>2</sub>               | 60.06               | 1,728 <sup>(1)</sup> | Hexagonal           | a = 4.90<br>c = 5.39              | 2.32 (low<br>cristobalite)             |
| Thorium oxide   | ThO <sub>2</sub>               | 264.12              | 3,300 <sup>(1)</sup> | Face-centered cubic | a = 5.59                          | 9.69                                   |
| Titanium oxide  | TiO <sub>2</sub>               | 79.90               | 1,840 <sup>(1)</sup> | Tetragonal          | a = 4.58<br>c = 2.98              | 4.24                                   |
| Uranium oxide   | UO <sub>2</sub>                | 270.07              | 2,280 <sup>(1)</sup> | Face-centered cubic | a = 5.47                          | 10.96                                  |
| Zirconium oxide | ZrO <sub>2</sub>               | 123.22              | 2,677 <sup>(1)</sup> | Monoclinic          | a = 5.21<br>c = 5.37              | 5.56                                   |

| Name            | Thermal conductivity,<br>cal-sec <sup>-1</sup> -cm <sup>-2</sup> -cm <sup>2</sup> -°C <sup>-1</sup> | Electrical resistivity,<br>microhm-cm                                                                                                                                                                                                                                                                 | Ductility<br>relative<br>scale <sup>b</sup> | Resistance<br>to<br>oxidation <sup>c</sup> | Hardness <sup>d</sup>                     |
|-----------------|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|--------------------------------------------|-------------------------------------------|
| Aluminum oxide  | 0.0723 at 100°C <sup>(2)</sup>                                                                      | 1 × 10 <sup>12</sup> at 14°C <sup>(1)</sup><br>3 × 10 <sup>13</sup> at 300°C <sup>(1)</sup><br>3.5 × 10 <sup>14</sup> at 800°C <sup>(1)</sup>                                                                                                                                                         | 3 <sup>(3)</sup>                            | 1 <sup>(3)</sup>                           | 9 Mohs <sup>(1)</sup>                     |
| Beryllium oxide | 0.525 at 100°C <sup>(2)</sup>                                                                       | 4 × 10 <sup>14</sup> at 600°C <sup>(1)</sup><br>5 × 10 <sup>12</sup> at 1,100°C <sup>(1)</sup><br>8 × 10 <sup>8</sup> at 2,100°C <sup>(1)</sup>                                                                                                                                                       |                                             |                                            | 9 Mohs <sup>(1)</sup>                     |
| Cerium oxide    |                                                                                                     | 6.5 × 10 <sup>10</sup> at 800°C <sup>(1)</sup><br>3.4 × 10 <sup>8</sup> at 1,200°C <sup>(1)</sup>                                                                                                                                                                                                     |                                             |                                            | 6 Mohs <sup>(1)</sup>                     |
| Chromium oxide  |                                                                                                     | 1.3 × 10 <sup>9</sup> at 350°C <sup>(1)</sup><br>2.3 × 10 <sup>7</sup> at 1,200°C <sup>(1)</sup><br>6.8 × 10 <sup>3</sup> at 600°C <sup>(1)</sup><br>4.5 × 10 <sup>3</sup> at 1,100°C <sup>(1)</sup><br>5 × 10 <sup>15</sup> at 400°C <sup>(1)</sup><br>1 × 10 <sup>2</sup> at 1,500°C <sup>(1)</sup> | 3 <sup>(3)</sup>                            | 1 <sup>(3)</sup>                           |                                           |
| Hafnium oxide   |                                                                                                     |                                                                                                                                                                                                                                                                                                       |                                             |                                            |                                           |
| Magnesium oxide | 0.0860 at 100°C <sup>(2)</sup>                                                                      | 2 × 10 <sup>14</sup> at 850°C <sup>(1)</sup><br>3 × 10 <sup>13</sup> at 980°C <sup>(1)</sup><br>4.5 × 10 <sup>8</sup> at 2,100°C <sup>(1)</sup>                                                                                                                                                       |                                             |                                            | 6 Mohs <sup>(1)</sup>                     |
| Silicon oxide   |                                                                                                     | 1 × 10 <sup>11</sup> at 20°C <sup>(1)</sup><br>7 × 10 <sup>12</sup> at 600°C <sup>(1)</sup><br>4 × 10 <sup>9</sup> at 1,300°C <sup>(1)</sup> (vitreous)                                                                                                                                               | 3 <sup>(4)</sup><br>(vitreous)              | 1 <sup>(4)</sup><br>(vitreous)             | 6–7 Mohs <sup>(1)</sup><br>(cristobalite) |
| Thorium oxide   | 0.0245 at 100°C <sup>(2)</sup>                                                                      | 2.6 × 10 <sup>13</sup> at 550°C <sup>(1)</sup><br>8 × 10 <sup>11</sup> at 800°C <sup>(1)</sup><br>1.5 × 10 <sup>10</sup> at 1,200°C <sup>(1)</sup>                                                                                                                                                    |                                             |                                            | 6.5 Mohs <sup>(1)</sup>                   |
| Titanium oxide  | 0.0156 at 100°C <sup>(2)</sup>                                                                      | 1.2 × 10 <sup>10</sup> at 800°C <sup>(1)</sup><br>8.5 × 10 <sup>6</sup> at 1,200°C <sup>(1)</sup>                                                                                                                                                                                                     |                                             |                                            | 5.5–6.0 Mohs <sup>(1)</sup>               |
| Uranium oxide   | 0.0234 at 100°C <sup>(2)</sup>                                                                      | 3.8 × 10 <sup>10</sup> at 20°C <sup>(1)</sup><br>5 × 10 <sup>8</sup> at 500°C <sup>(1)</sup>                                                                                                                                                                                                          |                                             |                                            |                                           |
| Zirconium oxide | 0.00466 at 100°C <sup>(2)</sup>                                                                     | 1 × 10 <sup>12</sup> at 385°C <sup>(1)</sup><br>2.2 × 10 <sup>10</sup> at 700°C <sup>(1)</sup><br>3.6 × 10 <sup>8</sup> at 1,200°C <sup>(1)</sup>                                                                                                                                                     | 3 <sup>(3)</sup>                            | 1 <sup>(3)</sup>                           | 6.5 Mohs <sup>(1)</sup>                   |

# REFRACTORY MATERIALS (Continued)

| Silicides           |                                 |                  |                                        |                                                   |                                                  |                                 |
|---------------------|---------------------------------|------------------|----------------------------------------|---------------------------------------------------|--------------------------------------------------|---------------------------------|
| Name                | Formula                         | Molecular weight | Melting point, °C                      | Crystalline form                                  | Lattice parameter, Å                             | X-ray density g/cm <sup>3</sup> |
| Chromium silicide   | CrSi <sub>2</sub>               | 108.13           | 1,570 <sup>(51)</sup>                  | Hexagonal                                         | a = 4.42<br>c = 6.35 <sup>(51)</sup>             |                                 |
|                     | CrSi                            | 80.07            | 1,870<br>(decomposes in presence of C) | Tetragonal (C 11b)                                | a = 3.20<br>c = 7.86 <sup>(6)</sup>              |                                 |
| Molybdenum silicide | MoSi <sub>2</sub>               | 152.07           | 1,870<br>(decomposes in presence of C) | Tetragonal (C 11b)                                | a = 3.20<br>c = 7.86 <sup>(64)(51)</sup>         | 6.24                            |
| Niobium silicide    | NbSi <sub>2</sub>               |                  | 1,950 <sup>(50)</sup>                  | Hexagonal<br>CrSi <sub>2</sub> type               | a = 4.785<br>c = 6.576 <sup>(51)</sup>           | 5.29                            |
| Tantalum silicide   | TaSi <sub>2</sub>               | 237.00           | 2,400 <sup>(50)</sup>                  | Hexagonal<br>CrSi <sub>2</sub> type               | a = 4.773<br>c = 6.552 <sup>(51)</sup>           | 8.83                            |
| Titanium silicide   | TiSi <sub>2</sub>               | 104.02           | 1,540 <sup>(49)</sup>                  | Orthorhombic                                      | a = 8.24<br>b = 4.79<br>c = 8.52 <sup>(59)</sup> | 4.13                            |
|                     | Ti <sub>3</sub> Si <sub>3</sub> | 323.68           | 2,120 <sup>(49)</sup>                  | Hexagonal                                         | a = 7.465<br>c = 5.162 <sup>(60)</sup>           | 4.32                            |
| Tungsten silicide   | WSi <sub>2</sub>                | 240.04           | 2,050 <sup>(50)</sup>                  | Tetragonal<br>MoSi <sub>2</sub> Structure (C 11b) | a = 3.21<br>c = 7.83 <sup>(66)</sup>             | 9.3                             |
| Uranium silicide    | βUSi <sub>2</sub>               | 294.19           | 1,700 <sup>(6)</sup>                   | Hexagonal                                         | a = 3.85 <sup>(6)</sup><br>c = 4.06              | 9.25                            |
|                     | U <sub>3</sub> Si <sub>2</sub>  | 770.33           | 1,665 <sup>(6)</sup>                   | Tetragonal                                        | a = 7.3151 <sup>(6)</sup><br>c = 3.8925          | 12.20                           |
| Vanadium silicide   | VSi <sub>2</sub>                | 107.07           | 1,750 <sup>(50)</sup>                  | Hexagonal<br>CrSi <sub>2</sub> type               | a = 4.562<br>c = 6.359 <sup>(51)</sup>           | 4.71                            |

| Name                | Thermal conductivity, cal-sec <sup>-1</sup> -cm <sup>-2</sup> -cm <sup>-2</sup> -C <sup>-1</sup> | Electrical resistivity, microhm-cm                                               | Ductility relative scale <sup>b</sup> | Resistance to oxidation <sup>c</sup> | Hardness <sup>d</sup>                                          |
|---------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|---------------------------------------|--------------------------------------|----------------------------------------------------------------|
| Chromium silicide   |                                                                                                  |                                                                                  |                                       |                                      | 1,150 kg/mm <sup>2</sup> (50)                                  |
| Molybdenum silicide | 0.075 at room temperature to 200°C <sup>(6)</sup>                                                | 21.5 at room temperature<br>18.9 at -80°C <sup>(69)</sup><br>6.3 <sup>(68)</sup> | 2 <sup>(3)</sup>                      | 1 <sup>(3)</sup>                     | 1,290 kg/mm <sup>2</sup> (50)                                  |
| Niobium silicide    |                                                                                                  |                                                                                  | 2 <sup>(3)</sup>                      | 4 <sup>(3)</sup>                     | 1,050 kg/mm <sup>2</sup> (50)                                  |
| Tantalum silicide   |                                                                                                  | 8.5 <sup>(68)</sup>                                                              | 2 <sup>(3)</sup>                      | 3 <sup>(3)</sup>                     | 1,560 kg/mm <sup>2</sup> (50)                                  |
| Titanium silicide   |                                                                                                  | 123 (hot pressed) <sup>(1)</sup>                                                 | 3 <sup>(3)</sup>                      | 4 <sup>(3)</sup>                     | 870 kg/mm <sup>2</sup> (70)                                    |
|                     |                                                                                                  |                                                                                  | 3 <sup>(3)</sup>                      | 4 <sup>(3)</sup>                     | 986 kg/mm <sup>2</sup> (49)                                    |
| Tungsten silicide   |                                                                                                  | 33.4 <sup>(68)</sup>                                                             |                                       | 1-2 <sup>(3)</sup>                   | 1,310 kg/mm <sup>2</sup> (68)<br>1,090 kg/mm <sup>2</sup> (68) |
| Uranium silicide    |                                                                                                  |                                                                                  |                                       |                                      |                                                                |
| Vanadium silicide   |                                                                                                  | 9.5 <sup>(68)</sup>                                                              |                                       |                                      | 1,090 kg/mm <sup>2</sup> (50)                                  |

<sup>a</sup>Numbers in parentheses refer to references at end of table.

<sup>b</sup>Ductility - 1: capable of being severely drawn, rolled, or otherwise worked without failure; 2: capable of withstanding slight deformation, or consisting of individually ductile crystals fragilely bound together; 3: incapable of being worked, of glasslike brittleness.

<sup>c</sup>Resistance to oxidation - classed according to the temperature range in which the rate of attack by air would cause severe erosion or failure of the coated specimen within a few hours. 1: above 1,700°C; 2: 1,400 to 1,700°C; 1,100 to 1,400°C; 4: 800 to 1,000°C; 5: 500 to 800°C.

<sup>d</sup>Microhardness values taken with 100-g load.

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# SOLVENTS FOR LIQUID CHROMATOGRAPHY

| Solvent                                | Viscosity<br>(mPa·s;<br>20 °C) | UV<br>cutoff<br>(nm) | Refractive<br>index<br>(20 °C) | Normal<br>boiling<br>point<br>(°C) | Dielectric<br>constant<br>(20 °C) |
|----------------------------------------|--------------------------------|----------------------|--------------------------------|------------------------------------|-----------------------------------|
| Acetic acid                            | 1.31(15)                       |                      | 1.372                          | 117.9                              | 6.15                              |
| Acetone                                | 0.30(25)                       | 330                  | 1.359                          | 56.1                               | 20.7(25)                          |
| Acetonitrile                           | 0.34(25)                       | 190                  | 1.344                          | 81.6                               | 37.5                              |
| Benzene                                | 0.65                           | 278                  | 1.501                          | 80.1                               | 2.284                             |
| 1-Butanol                              | 2.95                           | 215                  | 1.399                          | 117.7                              | 17.8                              |
| 2-Butanol                              | 4.21                           | 260                  | 1.397                          | 99.5                               | 15.8(25)                          |
| <i>n</i> -Butyl acetate                | 0.73                           | 254                  | 1.394                          | 126.1                              |                                   |
| <i>n</i> -Butyl chloride               | 0.47(15)                       | 220                  | 1.402                          | 78.4                               |                                   |
| Carbon tetrachloride                   | 0.97                           | 263                  | 1.460                          | 76.8                               | 2.238                             |
| Chlorobenzene                          | 0.80                           | 287                  | 1.525                          | 131.7                              | 2.708                             |
| Chloroform                             | 0.58                           | 245                  | 1.446                          | 61.2                               | 4.806                             |
| Cyclohexane                            | 0.98                           | 200                  | 1.426                          | 80.7                               | 2.023                             |
| Cyclopentane                           | 0.44                           | 200                  | 1.406                          | 49.3                               | 1.965                             |
| <i>o</i> -Dichlorobenzene              | 1.32(25)                       | 295                  | 1.551                          | 180.0                              | 9.93(25)                          |
| <i>N,N</i> -Dimethylacetamide          | 2.14                           | 268                  | 1.438                          | 166.0                              | 37.8                              |
| Dimethylformamide                      | 0.92                           | 268                  | 1.430                          | 153.0                              | 36.7                              |
| Dimethyl sulfoxide                     | 2.20                           | 286                  | 1.478                          | 189.0                              | 4.7                               |
| Dioxane                                | 1.44(15)                       | 215                  | 1.422                          | 101.4                              | 2.209(25)                         |
| 2-Ethoxyethanol                        | 2.05                           | 210                  | 1.408                          | 135.0                              |                                   |
| Ethyl acetate                          | 0.46                           | 256                  | 1.372                          | 77.1                               | 6.02(25)                          |
| Ethyl ether                            | 0.24                           | 218                  | 1.352                          | 34.4                               | 4.335                             |
| Glyme (ethylene glycol dimethyl ether) | 0.46(25)                       | 220                  | 1.380                          | 93.0                               |                                   |
| Heptane                                | 0.42                           | 200                  | 1.388                          | 98.4                               | 1.92                              |
| Hexadecane                             | 3.34                           | 200                  | 1.434                          | 286.9                              |                                   |
| Hexane                                 | 0.31                           | 200                  | 1.375                          | 68.7                               | 1.890                             |
| Isobutyl alcohol                       | 4.70(15)                       | 200                  | 1.396                          | 107.9                              | 15.8(25)                          |
| Methanol                               | 0.55                           | 205                  | 1.328                          | 64.6                               | 32.63(25)                         |
| 2-Methoxyethanol                       | 1.72                           | 210                  | 1.402                          | 124.1                              | 16.9                              |
| 2-Methoxyethyl acetate                 |                                | 254                  | 1.402                          | 143.0                              |                                   |
| Methylene chloride                     | 0.45(15)                       | 233                  | 1.424                          | 39.8                               | 9.08                              |
| Methylethylketone                      | 0.42(15)                       | 329                  | 1.379                          | 79.6                               | 18.5                              |
| Methylisoamylketone                    |                                | 330                  | 1.406                          | 144.0                              |                                   |
| Methylisobutylketone                   | 0.54(25)                       | 334                  | 1.396                          | 116.5                              |                                   |
| <i>N</i> -Methyl-2-pyrrolidone         | 1.67(25)                       | 285                  | 1.488                          | 202.0                              | 32.0                              |
| Nonane                                 | 0.72                           | 200                  | 1.405                          | 150.8                              | 1.972                             |
| Pentane                                | 0.24                           | 200                  | 1.357                          | 36.1                               | 1.84                              |
| Petroleum ether                        | 0.30                           | 226                  |                                | 30—60                              |                                   |
| $\beta$ -Phenethylamine                |                                | 285                  | 1.529(25)                      | 197—198                            |                                   |
| 1-Propanol                             | 2.26                           | 210                  | 1.386                          | 97.2                               | 20.1(25)                          |
| 2-Propanol                             | 2.86(15)                       | 205                  | 1.377                          | 82.2                               | 18.3(25)                          |
| Propylene carbonate                    |                                |                      | 1.419                          | 240.0                              |                                   |
| Pyridine                               | 0.95                           | 330                  | 1.510                          | 115.3                              | 12.3(25)                          |
| Tetrachloroethylene                    | 0.93(15)                       | 295                  | 1.506                          | 121.2                              |                                   |
| Tetrahydrofuran                        | 0.55                           | 212                  | 1.407                          | 64.8                               | 7.6                               |
| Tetramethyl urea                       |                                | 265                  | 1.449(25)                      | 175.2                              | 23.0                              |
| Toluene                                | 0.59                           | 284                  | 1.497                          | 110.6                              | 2.379(25)                         |
| Trichloroethylene                      | 0.57                           | 273                  | 1.477                          | 87.2                               | 3.4(16)                           |
| 1,2,2-Trichloro-1,2,2-trifluoroethane  | 0.71                           | 231                  | 1.356(25)                      | 47.6                               |                                   |
| 2,2,4-Trimethylpentane                 | 0.50                           | 215                  | 1.391                          | 99.2                               | 1.94                              |
| Water                                  | 1.00                           | <190                 | 1.333                          | 100.0                              | 78.54                             |
| <i>o</i> -Xylene                       | 0.81                           | 288                  | 1.505                          | 144.4                              | 2.568                             |
| <i>p</i> -Xylene                       |                                | 290                  | 1.496                          | 138.4                              | 2.270                             |

## SPARK-GAP VOLTAGES

Based on results of the American Institute of Electric Engineers Air at 760 mmHg, 25°C.

| Peak voltage, kilovolts | Diameter of spherical electrodes, cm |      |      |      | Needle points | Peak voltage, kilovolts | Diameter of spherical electrodes, cm |      |      |      | Needle points |
|-------------------------|--------------------------------------|------|------|------|---------------|-------------------------|--------------------------------------|------|------|------|---------------|
|                         | 2.5                                  | 5    | 10   | 25   |               |                         | 2.5                                  | 5    | 10   | 25   |               |
| Length of spark gap, cm |                                      |      |      |      |               | Length of spark gap, cm |                                      |      |      |      |               |
| 5                       | 0.13                                 | 0.15 | 0.15 | 0.16 | 0.42          | 110                     | —                                    | 5.79 | 4.25 | 3.88 | 17.7          |
| 10                      | 0.27                                 | 0.29 | 0.30 | 0.32 | 0.85          | 120                     | —                                    | 7.07 | 4.78 | 4.28 | 19.8          |
| 15                      | 0.42                                 | 0.44 | 0.46 | 0.48 | 1.30          | 130                     | —                                    | —    | 5.35 | 4.69 | 22.0          |
| 20                      | 0.58                                 | 0.60 | 0.62 | 0.64 | 1.75          | 140                     | —                                    | —    | 5.97 | 5.10 | 24.1          |
| 25                      | 0.76                                 | 0.77 | 0.78 | 0.81 | 2.20          | 150                     | —                                    | —    | 6.64 | 5.52 | 26.1          |
| 30                      | 0.95                                 | 0.94 | 0.95 | 0.98 | 2.69          | 160                     | —                                    | —    | 7.37 | 5.95 | 28.1          |
| 35                      | 1.17                                 | 1.12 | 1.12 | 1.15 | 2.69          | 170                     | —                                    | —    | 8.16 | 6.39 | 30.1          |
| 40                      | 1.41                                 | 1.30 | 1.29 | 1.32 | 3.81          | 180                     | —                                    | —    | 9.03 | 6.84 | 32.0          |
| 45                      | 1.68                                 | 1.50 | 1.47 | 1.49 | 4.49          | 190                     | —                                    | —    | 10.0 | 7.30 | 33.9          |
| 50                      | 2.00                                 | 1.71 | 1.65 | 1.66 | 5.20          | 200                     | —                                    | —    | 11.1 | 7.76 | 35.7          |
| 60                      | 2.82                                 | 2.17 | 2.02 | 2.01 | 6.81          | 210                     | —                                    | —    | 12.3 | 8.24 | 37.6          |
| 70                      | 4.05                                 | 2.68 | 2.42 | 2.37 | 8.81          | 220                     | —                                    | —    | 13.7 | 8.73 | 39.5          |
| 80                      | —                                    | 3.26 | 2.84 | 2.74 | 11.1          | 230                     | —                                    | —    | 15.3 | 9.24 | 41.4          |
| 90                      | —                                    | 3.94 | 3.28 | 3.11 | 13.3          | 240                     | —                                    | —    | —    | 9.76 | 43.4          |
| 100                     | —                                    | 4.77 | 3.75 | 3.49 | 15.5          | 250                     | —                                    | —    | —    | 10.3 | 45.2          |
|                         |                                      |      |      |      |               | 300                     | —                                    | —    | —    | 13.3 | 54.7          |

## SPECIFIC HEAT AND ENTHALPY OF SOME SOLIDS AT LOW TEMPERATURES

R. J. Corruccini and J. J. Gniewek

For a more extensive listing of data one is referred to N.B.S. Monograph 21 (1960)

| Metals            |                               |                                 |                               |                                 |                               |                                 |                               |                                 |
|-------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|
| Aluminum          |                               |                                 | Beryllium                     |                                 | Bismuth                       |                                 | Cadmium                       |                                 |
| <i>T</i><br>K     | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g |
| 1                 | 0.00010 <sup>a</sup>          | —                               | —                             | —                               | —                             | —                               | —                             | —                               |
| 1                 | 0.000051                      | 0.000025                        | 0.000025                      | 0.000013                        | 0.00000598                    | 0.00000158                      | 0.000008                      | 0.000003                        |
| 2                 | 0.000108                      | 0.000105                        | 0.000051                      | 0.000051                        | 0.0000461                     | 0.0000233                       | 0.000033                      | 0.000022                        |
| 3                 | 0.000176                      | 0.000246                        | 0.000079                      | 0.000116                        | 0.000170                      | 0.000123                        | 0.000090                      | 0.000082                        |
| 4                 | 0.000261                      | 0.000463                        | 0.000109                      | 0.000209                        | 0.000493                      | 0.000432                        | 0.00021                       | 0.00022                         |
| 6                 | 0.00050                       | 0.00121                         | 0.000180                      | 0.000496                        | 0.00214                       | 0.00288                         | 0.00130                       | 0.0015                          |
| 8                 | 0.00088                       | 0.0026                          | 0.000271                      | 0.000944                        | 0.00547                       | 0.0102                          | 0.0043                        | 0.0070                          |
| 10                | 0.0014                        | 0.0049                          | 0.000389                      | 0.00160                         | 0.0104                        | 0.0259                          | 0.0080                        | 0.109                           |
| 15                | 0.0040                        | 0.018                           | 0.000842                      | 0.00457                         | 0.0238                        | 0.111                           | 0.025                         | 0.102                           |
| 20                | 0.0089                        | 0.048                           | 0.00161                       | 0.0105                          | 0.0363                        | 0.262                           | 0.046                         | 0.28                            |
| 25                | 0.0175                        | 0.112                           | 0.00279                       | 0.0212                          | 0.0477                        | 0.472                           | 0.066                         | 0.56                            |
| 30                | 0.0315                        | 0.232                           | 0.00450                       | 0.0392                          | 0.0572                        | 0.734                           | 0.086                         | 0.94                            |
| 35                | 0.0515                        | 0.436                           | —                             | —                               | —                             | —                               | —                             | —                               |
| 40                | 0.0775                        | 0.755                           | 0.00996                       | 0.109                           | 0.0727                        | 1.38                            | 0.117                         | 1.96                            |
| 50                | 0.142                         | 1.85                            | 0.0192                        | 0.253                           | 0.0846                        | 2.17                            | 0.141                         | 3.26                            |
| 60                | 0.214                         | 3.64                            | 0.0341                        | 0.523                           | 0.0935                        | 3.06                            | 0.159                         | 4.76                            |
| 70                | 0.287                         | 6.15                            | 0.0562                        | 0.971                           | 0.100                         | 4.03                            | 0.172                         | 6.43                            |
| 80                | 0.357                         | 9.37                            | 0.0906                        | 1.69                            | 0.105                         | 5.05                            | 0.182                         | 8.20                            |
| 90                | 0.422                         | 13.25                           | 0.139                         | 2.82                            | 0.108                         | 6.12                            | 0.190                         | 10.1                            |
| 100               | 0.481                         | 17.76                           | 0.199                         | 4.51                            | 0.111                         | 7.21                            | 0.196                         | 12.0                            |
|                   |                               |                                 |                               |                                 |                               |                                 |                               |                                 |
| Chromium          |                               |                                 | Copper                        |                                 | Germanium <sup>b</sup>        |                                 | Gold                          |                                 |
| <i>T</i><br>K     | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g |
| 1                 | 0.0000285                     | 0.0000142                       | 0.000012                      | 0.000006                        | 0.000000528                   | 0.000000132                     | 0.000006                      | 0.000002                        |
| 2                 | 0.000058                      | 0.0000573                       | 0.000028                      | 0.000025                        | 0.00000423                    | 0.00000211                      | 0.000025                      | 0.000016                        |
| 3                 | 0.000089                      | 0.000131                        | 0.000053                      | 0.000064                        | 0.0000144                     | 0.0000107                       | 0.000070                      | 0.000061                        |
| 4                 | 0.00014                       | 0.000237                        | 0.000091                      | 0.00013                         | 0.0000344                     | 0.0000343                       | 0.00016                       | 0.00017                         |
| 6                 | 0.000206                      | 0.000567                        | 0.00023                       | 0.00044                         | 0.000125                      | 0.000179                        | 0.00050                       | 0.00078                         |
| 6                 | 0.000206                      | 0.000567                        | 0.00023                       | 0.00044                         | 0.000125                      | 0.000179                        | 0.00050                       | 0.00078                         |
| 8                 | 0.000312                      | 0.00107                         | 0.00047                       | 0.00112                         | 0.000335                      | 0.000612                        | 0.0012                        | 0.0024                          |
| 10                | 0.000451                      | 0.00182                         | 0.00086                       | 0.0024                          | 0.000813                      | 0.00169                         | 0.0022                        | 0.0056                          |
| 15                | 0.00102                       | 0.00528                         | 0.0027                        | 0.0107                          | 0.00445                       | 0.0136                          | 0.0074                        | 0.028                           |
| 20                | 0.00210                       | 0.0128                          | 0.0077                        | 0.034                           | 0.0125                        | 0.0540                          | 0.0159                        | 0.086                           |
| 25                | 0.00392                       | 0.0274                          | 0.016                         | 0.090                           | 0.0240                        | 0.145                           | 0.0263                        | 0.191                           |
| 30                | 0.00683                       | 0.0532                          | 0.027                         | 0.195                           | 0.0366                        | 0.296                           | 0.0371                        | 0.349                           |
| 40                | 0.0171                        | 0.163                           | 0.060                         | 0.61                            | 0.0617                        | 0.786                           | 0.0572                        | 0.821                           |
| 50                | 0.0358                        | 0.421                           | 0.099                         | 1.40                            | 0.0858                        | 1.52                            | 0.0726                        | 1.47                            |
| 60                | 0.0621                        | 0.904                           | 0.137                         | 2.58                            | 0.108                         | 2.50                            | 0.0842                        | 2.25                            |
| 70                | 0.093                         | 1.68                            | 0.173                         | 4.13                            | 0.131                         | 3.70                            | 0.0928                        | 3.14                            |
| 80                | 0.127                         | 2.77                            | 0.205                         | 6.02                            | 0.153                         | 5.12                            | 0.0992                        | 4.10                            |
| 90                | 0.161                         | 4.21                            | 0.232                         | 8.22                            | 0.173                         | 6.74                            | 0.1043                        | 5.12                            |
| 100               | 0.193                         | 5.98                            | 0.254                         | 10.6                            | 0.191                         | 8.55                            | 0.1083                        | 6.18                            |
|                   |                               |                                 |                               |                                 |                               |                                 |                               |                                 |
| Indium            |                               |                                 | α-Iron <sup>c</sup>           |                                 | γ-Iron <sup>d</sup>           |                                 | Lead                          |                                 |
| <i>T</i><br>K     | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g |
| 1                 | 0.000029                      | 0.000011                        | 0.000090                      | 0.000045                        | —                             | —                               | 0.000026                      | 0.000010                        |
| 1                 | 0.000019 <sup>a</sup>         | 0.000006 <sup>a</sup>           | —                             | —                               | —                             | —                               | 0.000012 <sup>a</sup>         | 0.000003 <sup>a</sup>           |
| 2                 | 0.000138                      | 0.000085                        | 0.000183                      | 0.000181                        | —                             | —                               | 0.00012                       | 0.00007                         |
| 2                 | 0.000141 <sup>a</sup>         | 0.000073 <sup>a</sup>           | —                             | —                               | —                             | —                               | 0.00009 <sup>a</sup>          | 0.00005 <sup>a</sup>            |
| 3                 | 0.000410                      | 0.000341                        | 0.000279                      | 0.000412                        | —                             | —                               | 0.00033                       | 0.00023 <sup>a</sup>            |
| 3                 | 0.000464 <sup>a</sup>         | 0.000357 <sup>a</sup>           | —                             | —                               | —                             | —                               | 0.00031 <sup>a</sup>          | —                               |
| 3.40 <sup>e</sup> | 0.000584                      | 0.000537                        | —                             | —                               | —                             | —                               | —                             | —                               |
| 3.40              | 0.000669 <sup>a</sup>         | 0.000581 <sup>a</sup>           | —                             | —                               | —                             | —                               | —                             | —                               |
| 4                 | 0.00095                       | 0.00099                         | 0.000382                      | 0.000742                        | —                             | —                               | 0.0007                        | 0.0008                          |
| 4                 | —                             | —                               | —                             | —                               | —                             | —                               | 0.0007 <sup>a</sup>           | 0.0007 <sup>a</sup>             |
| 5                 | —                             | —                               | —                             | —                               | —                             | —                               | 0.0015                        | 0.0018                          |
| 5                 | —                             | —                               | —                             | —                               | —                             | —                               | 0.0015 <sup>a</sup>           | 0.0018 <sup>a</sup>             |
| 6                 | 0.00359                       | 0.00520                         | 0.000615                      | 0.00173                         | —                             | —                               | 0.0029                        | 0.0039                          |
| 6                 | —                             | —                               | —                             | —                               | —                             | —                               | 0.0030 <sup>a</sup>           | 0.0040 <sup>a</sup>             |
| 7                 | —                             | —                               | —                             | —                               | —                             | —                               | 0.0048                        | 0.008                           |

# SPECIFIC HEAT AND ENTHALPY OF SOME SOLIDS AT LOW TEMPERATURES (continued)

| Chromium      |                               |                                 | Copper                        |                                 | Germanium <sup>b</sup>        |                                 | Gold                          |                                 |
|---------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|
| <i>T</i><br>K | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g |
| 7             | —                             | —                               | —                             | —                               | —                             | —                               | 0.0050 <sup>a</sup>           | 0.008 <sup>a</sup>              |
| 8             | 0.00855                       | 0.0170                          | 0.00090                       | 0.003233                        | —                             | —                               | 0.0073                        | 0.014                           |
| 10            | 0.0155                        | 0.0408                          | 0.00124                       | 0.00537                         | —                             | —                               | 0.0137                        | 0.034                           |
| 15            | 0.036                         | 0.170                           | 0.00249                       | 0.0145                          | —                             | —                               | 0.0335                        | 0.150                           |
| 20            | 0.0608                        | 0.413                           | 0.0045                        | 0.0316                          | 0.007                         | 0                               | 0.0531                        | 0.368                           |
| 25            | 0.0857                        | 0.778                           | 0.0075                        | 0.061                           | —                             | —                               | 0.0681                        | 0.672                           |
| 30            | 0.108                         | 1.265                           | 0.0124                        | 0.110                           | 0.016                         | 0.11                            | 0.0796                        | 1.042                           |
| 40            | 0.141                         | 2.52                            | 0.029                         | 0.31                            | 0.041                         | 0.39                            | 0.0944                        | 1.920                           |
| 50            | 0.162                         | 4.04                            | 0.055                         | 0.73                            | 0.090                         | 1.0 <sup>2</sup>                | 0.103                         | 2.91                            |
| 60            | 0.176                         | 5.73                            | 0.087                         | 1.43                            | 0.13 <sup>7</sup>             | 2.1 <sup>6</sup>                | 0.108                         | 3.97                            |
| 70            | 0.186                         | 7.53                            | 0.121                         | 2.46                            | 0.18 <sup>0</sup>             | 3.7 <sup>5</sup>                | 0.112                         | 5.07                            |
| 80            | 0.193                         | 9.42                            | 0.154                         | 3.84                            | 0.21 <sup>8</sup>             | 5.74 <sup>4</sup>               | 0.114                         | 6.20                            |
| 90            | 0.198                         | 11.38                           | 0.186                         | 5.55                            | 0.25 <sup>5</sup>             | 8.1 <sup>1</sup>                | 0.116                         | 7.35                            |
| 100           | 0.203                         | 13.39                           | 0.216                         | 7.56                            | 0.28 <sup>8</sup>             | 10 <sup>8</sup>                 | 0.118                         | 853                             |

| Molybdenum    |                               |                                 | Nickel                        |                                 | Palladium                     |                                 |
|---------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|
| <i>T</i><br>K | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g |
| 1             | 0.0000229                     | 0.0000105                       | 0.000120                      | 0.000060                        | 0.000099                      | 0.0000493                       |
| 2             | 0.0000472                     | 0.0000445                       | 0.000242                      | 0.000241                        | 0.000203                      | 0.000200                        |
| 2             | —                             | —                               | —                             | —                               | —                             | —                               |
| 3             | 0.0000745                     | 0.000105                        | 0.000369                      | 0.000546                        | 0.000318                      | 0.000459                        |
| 3             | —                             | —                               | —                             | —                               | —                             | —                               |
| 4             | 0.000106                      | 0.000194                        | 0.000503                      | 0.00098                         | 0.000447                      | 0.000840                        |
| 4             | —                             | —                               | —                             | —                               | —                             | —                               |
| 5             | —                             | —                               | —                             | —                               | —                             | —                               |
| 5             | —                             | —                               | —                             | —                               | —                             | —                               |
| 6             | 0.000191                      | 0.000484                        | 0.00082                       | 0.00228                         | 0.000891                      | 0.00231                         |
| 6             | —                             | —                               | —                             | —                               | —                             | —                               |
| 7             | —                             | —                               | —                             | —                               | —                             | —                               |
| 7             | —                             | —                               | —                             | —                               | —                             | —                               |
| 8             | 0.000317                      | 0.000981                        | 0.00119                       | 0.00428                         | 0.00141                       | 0.00460                         |
| 8             | —                             | —                               | —                             | —                               | —                             | —                               |
| 9             | —                             | —                               | —                             | —                               | —                             | —                               |
| 9             | —                             | —                               | —                             | —                               | —                             | —                               |
| 10            | 0.000498                      | 0.00178                         | 0.00162                       | 0.0071                          | 0.00210                       | 0.00807                         |
| 15            | 0.00131                       | 0.00610                         | 0.0031                        | 0.0185                          | 0.00471                       | 0.0245                          |
| 20            | 0.00287                       | 0.0161                          | 0.0058                        | 0.041                           | 0.00922                       | 0.0586                          |
| 25            | 0.00577                       | 0.0374                          | 0.0101                        | 0.079                           | 0.0160                        | 0.120                           |
| 30            | 0.00960                       | 0.0729                          | 0.0167                        | 0.145                           | 0.0258                        | 0.223                           |
| 40            | 0.0236                        | 0.232                           | 0.0381                        | 0.413                           | 0.0507                        | 0.600                           |
| 50            | 0.0410                        | 0.554                           | 0.0682                        | 0.937                           | 0.0777                        | 1.24                            |
| 60            | 0.0619                        | 1.07                            | 0.103                         | 1.79                            | 0.101                         | 2.14                            |
| 70            | 0.0838                        | 1.80                            | 0.139                         | 3.00                            | 0.122                         | 3.26                            |
| 80            | 0.104                         | 2.74                            | 0.173                         | 4.56                            | 0.139                         | 4.56                            |
| 90            | 0.123                         | 3.88                            | 0.204                         | 6.45                            | 0.154                         | 6.03                            |
| 100           | 0.139                         | 5.20                            | 0.232                         | 8.63                            | 0.167                         | 7.63                            |

| Platinum      |                               |                                 | Rhodium                       |                                 | Silicon <sup>1</sup>          |                                 | Silver                        |                                 |
|---------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|
| <i>T</i><br>K | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g |
| 1             | 0.000035                      | 0.0000175                       | 0.000048                      | 0.000024                        | 0.000000263                   | 0.0000000658                    | 0.0000072                     | 0.0000032                       |
| 2             | 0.000074                      | 0.000071                        | 0.000097                      | 0.000096                        | 0.00000210                    | 0.00000105                      | 0.0000239                     | 0.0000176                       |
| 3             | 0.000122                      | 0.000168                        | 0.000147                      | 0.000218                        | 0.00000709                    | 0.00000532                      | 0.0000595                     | 0.0000574                       |
| 4             | 0.000186                      | 0.000320                        | 0.000201                      | 0.000392                        | 0.0000168                     | 0.0000168                       | 0.000124                      | 0.000146                        |
| 6             | 0.00037                       | 0.00085                         | 0.00032                       | 0.00091                         | 0.0000596                     | 0.0000853                       | 0.00039                       | 0.00062                         |
| 8             | 0.00067                       | 0.00188                         | 0.00047                       | 0.00170                         | 0.000140                      | 0.000279                        | 0.00091                       | 0.00187                         |
| 10            | 0.00112                       | 0.00365                         | 0.00065                       | 0.00281                         | 0.000275                      | 0.000679                        | 0.0018                        | 0.00452                         |
| 15            | 0.0033                        | 0.0135                          | 0.00135                       | 0.00765                         | 0.00109                       | 0.00374                         | 0.0064                        | 0.0233                          |
| 20            | 0.0074                        | 0.0395                          | 0.00271                       | 0.0174                          | 0.00337                       | 0.0138                          | 0.0155                        | 0.076                           |
| 25            | 0.0137                        | 0.092                           | 0.00561                       | 0.0373                          | 0.00849                       | 0.0423                          | 0.0287                        | 0.185                           |
| 30            | 0.0212                        | 0.182                           | 0.0106                        | 0.0071                          | 0.0171                        | 0.105                           | 0.0442                        | 0.368                           |
| 40            | 0.038                         | 0.048                           | 0.266                         | 0.256                           | 0.0440                        | 0.400                           | 0.078                         | 0.979                           |
| 50            | 0.055                         | 0.95                            | 0.0489                        | 0.633                           | 0.0785                        | 1.00                            | 0.108                         | 1.91                            |
| 60            | 0.068                         | 1.56                            | 0.9724                        | 1.238                           | 0.115                         | 1.97                            | 0.133                         | 3.12                            |
| 70            | 0.079                         | 2.29                            | 0.094                         | 2.07                            | 0.152                         | 3.31                            | 0.151                         | 4.54                            |
| 80            | 0.088                         | 3.12                            | 0.114                         | 3.11                            | 0.188                         | 5.01                            | 0.166                         | 6.13                            |
| 90            | 0.094                         | 4.02                            | 0.132                         | 4.34                            | 0.224                         | 7.06                            | 0.177                         | 7.85                            |
| 100           | 0.100                         | 5.01                            | 0.147                         | 5.74                            | 0.259                         | 9.47                            | 0.187                         | 9.67                            |



# SPECIFIC HEAT AND ENTHALPY OF SOME SOLIDS AT LOW TEMPERATURES (continued)

| Sodium <sup>m</sup> |                               |                                 | Tantalum                      |                                 | Tin (white)                   |                                 | Titanium                      |                                 |
|---------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|
| <i>T</i><br>K       | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g |
| 1                   | 0.000081                      | 0.000035                        | 0.000032                      | 0.000016                        | 0.0000170                     | 0.0000079                       | 0.000071                      | 0.000035                        |
| 1                   | —                             | —                               | 0.0000063 <sup>a</sup>        | 0.0000021 <sup>a</sup>          | 0.0000041 <sup>a</sup>        | 0.0000009 <sup>a</sup>          | —                             | —                               |
| 2                   | 0.000289                      | 0.000204                        | 0.000068                      | 0.000065                        | 0.000047                      | 0.0000383                       | 0.000146                      | 0.000143                        |
| 2                   | —                             | —                               | 0.000054 <sup>a</sup>         | 0.000026 <sup>a</sup>           | 0.000048 <sup>a</sup>         | 0.0000228 <sup>a</sup>          | —                             | —                               |
| 3                   | 0.00076                       | 0.00070                         | 0.000112                      | 0.000155                        | 0.000109                      | 0.000113                        | 0.000226                      | 0.000329                        |
| 3                   | —                             | —                               | 0.000178 <sup>a</sup>         | 0.000138 <sup>a</sup>           | 0.000151 <sup>a</sup>         | 0.000116 <sup>a</sup>           | —                             | —                               |
| 3.72 <sup>n</sup>   | —                             | —                               | —                             | —                               | 0.000198                      | 0.000221                        | —                             | —                               |
| 3.72                | —                             | —                               | —                             | —                               | 0.000285 <sup>a</sup>         | 0.000270 <sup>a</sup>           | —                             | —                               |
| 4                   | 0.00160                       | 0.00184                         | 0.000171                      | 0.000295                        | 0.000245                      | 0.000283                        | 0.000317                      | 0.000599                        |
| 4                   | —                             | —                               | 0.000352 <sup>a</sup>         | 0.000400 <sup>a</sup>           | —                             | —                               | —                             | —                               |
| 4.39 <sup>o</sup>   | —                             | —                               | 0.000201                      | 0.000368                        | —                             | —                               | —                             | —                               |
| 4.39                | —                             | —                               | 0.000433 <sup>a</sup>         | 0.000553 <sup>a</sup>           | —                             | —                               | —                             | —                               |
| 5                   | 0.00298                       | 0.00408                         | —                             | —                               | 0.00054                       | 0.00065                         | —                             | —                               |
| 6                   | 0.0051                        | 0.0081                          | 0.000333                      | 0.000776                        | 0.00127                       | 0.00151                         | 0.00054                       | 0.00145                         |
| 8                   | 0.0122                        | 0.0247                          | 0.000648                      | 0.00173                         | 0.0042                        | 0.0068                          | 0.00084                       | 0.00281                         |
| 10                  | 0.0238                        | 0.0602                          | 0.00117                       | 0.00352                         | 0.0081                        | 0.0190                          | 0.00126                       | 0.00489                         |
| 12                  | 0.0397                        | 0.123                           | —                             | —                               | —                             | —                               | —                             | —                               |
| 14                  | 0.063                         | 0.225                           | —                             | —                               | —                             | —                               | —                             | —                               |
| 15                  | —                             | —                               | 0.00360                       | 0.0145                          | 0.226                         | 0.093                           | 0.0033                        | 0.0156                          |
| 16                  | 0.093                         | 0.380                           | —                             | —                               | —                             | —                               | —                             | —                               |
| 18                  | 0.124                         | 0.597                           | —                             | —                               | —                             | —                               | —                             | —                               |
| 20                  | 0.155                         | 0.875                           | 0.00823                       | 0.0432                          | 0.040                         | 0.251                           | 0.0070                        | 0.040                           |
| 25                  | 0.259                         | 1.90                            | 0.0153                        | 0.102                           | 0.058                         | 0.498                           | 0.0134                        | 0.090                           |
| 30                  | 0.364                         | 3.45                            | 0.0240                        | 0.202                           | 0.076                         | 0.834                           | 0.0245                        | 0.182                           |
| 40                  | 0.544                         | 8.03                            | 0.0430                        | 0.540                           | 0.106                         | 1.75                            | 0.0571                        | 0.581                           |
| 50                  | 0.695                         | 14.2                            | 0.0604                        | 1.06                            | 0.130                         | 2.93                            | 0.0992                        | 1.358                           |
| 60                  | 0.793                         | 21.7                            | 0.0754                        | 1.74                            | 0.148                         | 4.33                            | 0.1467                        | 2.592                           |
| 70                  | 0.86                          | 30.0                            | 0.0819                        | 4.27                            | 0.162                         | 5.88                            | 0.189                         | 4.27                            |
| 80                  | 0.91                          | 38.9                            | 0.0976                        | 3.49                            | 0.173                         | 7.55                            | 0.230                         | 6.37                            |
| 90                  | 0.95                          | 48.2                            | 0.105                         | 4.50                            | 0.182                         | 9.33                            | 0.267                         | 8.86                            |
| 100                 | 0.98                          | 57.9                            | 0.111                         | 5.58                            | 0.189                         | 11.18                           | 0.300                         | 11.69                           |

| Tungsten      |                               |                                 | Zinc                          |                                 |
|---------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|
| <i>T</i><br>K | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g | <i>C<sub>p</sub></i><br>J/g K | <i>H — H<sub>o</sub></i><br>J/g |
| 1             | 0.0000074                     | 0.0000037                       | 0.000011                      | 0.000005                        |
| 2             | 0.0000158                     | 0.0000152                       | 0.000028                      | 0.000023                        |
| 3             | 0.0000262                     | 0.0000360                       | 0.000058                      | 0.000065                        |
| 4             | 0.0000393                     | 0.0000685                       | 0.00011                       | 0.00014                         |
| 6             | 0.0000783                     | 0.000182                        | 0.00029                       | 0.00053                         |
| 8             | 0.000141                      | 0.000396                        | 0.00096                       | 0.0016                          |
| 10            | 0.000234                      | 0.000765                        | 0.0025                        | 0.0050                          |
| 15            | 0.000725                      | 0.00297                         | 0.011                         | 0.034                           |
| 20            | 0.00189                       | 0.00927                         | 0.026                         | 0.125                           |
| 25            | 0.00421                       | 0.0237                          | 0.049                         | 0.31                            |
| 30            | 0.00783                       | 0.0534                          | 0.076                         | 0.62                            |
| 40            | 0.0184                        | 0.181                           | 0.125                         | 1.62                            |
| 50            | 0.0332                        | 0.436                           | 0.171                         | 3.11                            |
| 60            | 0.0483                        | 0.843                           | 0.208                         | 5.01                            |
| 70            | 0.0605                        | 1.39                            | 0.236                         | 7.23                            |
| 80            | 0.0715                        | 2.05                            | 0.258                         | 9.70                            |
| 90            | 0.0810                        | 2.81                            | 0.277                         | 12.38                           |
| 100           | 0.0888                        | 3.66                            | 0.293                         | 15.24                           |

- <sup>m</sup> Superconducting.
- <sup>n</sup> In germanium the electronic specific heat is markedly dependent on impurities. The values given are for pure germanium (negligible electronic specific heat).
- <sup>o</sup> α-Iron is the form that is thermodynamically stable at low temperatures. It has the body-centered cubic lattice which is the basis of the ferritic steels.
- <sup>p</sup> γ-Iron is stable between 910 and 1400°C. It has the face-centered cubic structure which is the basis of the austenitic steels. Since pure γ-iron is not stable at low temperatures the above values were calculated by application of the Kopp-Neumann rule to experimental data on two austenitic Fe-Mn alloys and of uncertain accuracy.
- <sup>q</sup> Superconducting transition temperature.
- <sup>r</sup> Superconducting transition temperature of mercury.
- <sup>s</sup> Melting temperature of mercury.
- <sup>t</sup> In silicon the electronic specific heat,  $\gamma T$ , is markedly dependent on impurities. Values of the coefficient,  $\gamma$ , from zero to  $2.4 \times 10^{-6}$  J/g K<sup>2</sup> have been reported. The values in the above table are for pure silicon ( $\gamma = 0$ ).
- <sup>u</sup> It has been shown (Barrett 1956, Hull & Rosenberg 1959) that sodium partially transforms at low temperatures from the normal body-centered cubic structure to close-packed hexagonal. The transformation is of the martensitic type and is promoted by cold-working at the low temperatures. Inasmuch as none of the calorimetric measurements on sodium were accompanied by crystallographic analysis, the tabulated data below 100 K are to some degree ambiguous.
- <sup>v</sup> Superconducting transition temperature of tin.
- <sup>w</sup> Superconducting transition temperature of tantalum.

## SPECTRAL EMISSIVITY

Prepared by Roeser and Wensel, National Bureau of Standards  
Spectral Emissivity of Materials, Surface Unoxidized for  $0.65\mu\text{m}$

| Element    | Solid     | Liquid | Element                        | Solid | Liquid |
|------------|-----------|--------|--------------------------------|-------|--------|
| Beryllium  | 0.61      | 0.61   | Thorium                        | 0.36  | 0.40   |
| Carbon     | 0.80—0.93 | —      | Titanium                       | 0.63  | 0.65   |
| Chromium   | 0.34      | 0.39   | Tungsten                       | 0.43  | —      |
| Cobalt     | 0.36      | 0.37   | Uranium                        | 0.54  | 0.34   |
| Columbium  | 0.37      | 0.40   | Vanadium                       | 0.35  | 0.32   |
| Copper     | 0.10      | 0.15   | Yttrium                        | 0.35  | 0.35   |
| Erbium     | 0.55      | 0.38   | Zirconium                      | 0.32  | 0.30   |
| Gold       | 0.14      | 0.22   | Steel                          | 0.35  | 0.37   |
| Iridium    | 0.30      | —      | Cast Iron                      | 0.37  | 0.40   |
| Iron       | 0.35      | 0.37   | Constantan                     | 0.35  | —      |
| Manganese  | 0.59      | 0.59   | Monel                          | 0.37  | —      |
| Molybdenum | 0.37      | 0.40   | Chromel P (90Ni-10Cr)          | 0.35  | —      |
| Nickel     | 0.36      | 0.37   | 80Ni-20Cr                      | 0.35  | —      |
| Palladium  | 0.33      | 0.37   | 60Ni-24Fe-16Cr                 | 0.36  | —      |
| Platinum   | 0.30      | 0.38   | Alumel (95Ni; Bal. Al, Mn, Si) | 0.37  | —      |
| Rhodium    | 0.24      | 0.30   | 90Pt-10Rh                      | 0.27  | —      |
| Silver     | 0.07      | 0.07   |                                |       |        |
| Tantalum   | 0.49      | —      |                                |       |        |

## SPECTRAL EMISSIVITY OF OXIDES

The emissivity of oxides and oxidized metals depends to a large extent upon the roughness of the surface. In general, higher values of emissivity are obtained on the rougher surfaces.

| Material               | Range of<br>observed values | Probable value for oxide<br>formed on smooth metal |
|------------------------|-----------------------------|----------------------------------------------------|
| <b>Oxide</b>           |                             |                                                    |
| Aluminum               | 0.22—0.40                   | 0.30                                               |
| Beryllium              | 0.07—0.37                   | 0.35                                               |
| Cerium                 | 0.58—0.80                   | —                                                  |
| Chromium               | 0.60—0.80                   | 0.70                                               |
| Cobalt                 | —                           | 0.75                                               |
| Columbium              | 0.55—0.71                   | 0.70                                               |
| Copper                 | 0.60—0.80                   | 0.70                                               |
| Iron                   | 0.63—0.98                   | 0.70                                               |
| Magnesium              | 0.10—0.43                   | 0.20                                               |
| Nickel                 | 0.85—0.96                   | 0.90                                               |
| Thorium                | 0.20—0.57                   | 0.50                                               |
| Tin                    | 0.32—0.60                   | —                                                  |
| Titanium               | —                           | 0.50                                               |
| Uranium                | —                           | 0.30                                               |
| Vanadium               | —                           | 0.70                                               |
| Yttrium                | —                           | 0.60                                               |
| Zirconium              | 0.18—0.43                   | 0.40                                               |
| <b>Oxidized</b>        |                             |                                                    |
| Alumel                 | —                           | 0.87                                               |
| Cast Iron              | —                           | 0.70                                               |
| Chromel P (90Ni-10Cr)  | —                           | 0.87                                               |
| 80Ni-20Cr              | —                           | 0.90                                               |
| 60Ni-24Fe-16Cr         | —                           | 0.83                                               |
| 55Fe-37.5Cr-7.5Al      | —                           | 0.78                                               |
| 70Fe-23Cr-5Al-2Co      | —                           | 0.75                                               |
| Constantan (55Cu-45Ni) | —                           | 0.84                                               |
| Carbon Steel           | —                           | 0.80                                               |
| Stainless Steel (18-8) | —                           | 0.85                                               |
| Porcelain              | 0.25—0.50                   | —                                                  |

STANDARD TEST SIEVES (WIRE CLOTH)

PARTICLE SIZE CONVERSION TABLE

| Sieve Designation |             | Nominal<br>Sieve<br>Opening<br>in | Permissible Vari-<br>ation of Average<br>Opening from the<br>Standard Sieve<br>Designation | Maximum Open-<br>ing Size for Not<br>More than 5<br>percent of<br>Openings | Maximum<br>Individual<br>Opening | Nominal<br>Wire<br>Diameter,<br>mm* | Mesh size | Approximate<br>micrometer<br>size | Approximate<br>millimeter<br>size | Approximate<br>inch size |
|-------------------|-------------|-----------------------------------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------|-------------------------------------|-----------|-----------------------------------|-----------------------------------|--------------------------|
| Standard          | Alternative |                                   |                                                                                            |                                                                            |                                  |                                     |           |                                   |                                   |                          |
| (1)               | (2)         | (3)                               | (4)                                                                                        | (5)                                                                        | (6)                              | (7)                                 |           |                                   |                                   |                          |
| 125 mm            | 5 in.       | 5                                 | ± 3.7 mm                                                                                   | 130.0 mm                                                                   | 130.9 mm                         | 8.0                                 | 4         | 4760                              | 4.76                              | 0.185                    |
| 106 mm            | 4.24 in.    | 4                                 | ± 3.2 mm                                                                                   | 110.2 mm                                                                   | 111.1 mm                         | 6.40                                | 6         | 3360                              | 3.36                              | 0.131                    |
| 100 mm            | 4 in.       | 4                                 | ± 3.0 mm                                                                                   | 104.0 mm                                                                   | 104.8 mm                         | 6.30                                | 8         | 2380                              | 2.38                              | 0.093                    |
| 90 mm             | 3½ in.      | 3.5                               | ± 2.7 mm                                                                                   | 93.6 mm                                                                    | 94.4 mm                          | 6.08                                | 12        | 1680                              | 1.68                              | 0.065                    |
| 75 mm             | 3 in.       | 3                                 | ± 2.2 mm                                                                                   | 78.1 mm                                                                    | 78.7 mm                          | 5.80                                | 16        | 1190                              | 1.19                              | 0.046                    |
| 63 mm             | 2½ in.      | 2.5                               | ± 1.9 mm                                                                                   | 65.6 mm                                                                    | 66.2 mm                          | 5.50                                | 20        | 840                               | 0.84                              | 0.0328                   |
| 53 mm             | 2½ in.      | 2.5                               | ± 1.6 mm                                                                                   | 55.2 mm                                                                    | 55.7 mm                          | 5.15                                | 30        | 590                               | 0.59                              | 0.0232                   |
| 45 mm             | 2 in.       | 2                                 | ± 1.5 mm                                                                                   | 52.1 mm                                                                    | 52.6 mm                          | 5.05                                | 40        | 420                               | 0.42                              | 0.0164                   |
| 40 mm             | 1½ in.      | 1.5                               | ± 1.4 mm                                                                                   | 46.9 mm                                                                    | 47.4 mm                          | 4.85                                | 50        | 297                               | 0.29                              | 0.0116                   |
| 37.5 mm           | 1½ in.      | 1.5                               | ± 1.1 mm                                                                                   | 39.1 mm                                                                    | 39.5 mm                          | 4.59                                | 60        | 250                               | 0.25                              | 0.0097                   |
| 31.5 mm           | 1¼ in.      | 1.25                              | ± 1.0 mm                                                                                   | 32.9 mm                                                                    | 33.2 mm                          | 4.23                                | 70        | 210                               | 0.21                              | 0.0082                   |
| 26.5 mm           | 1 in.       | 1.06                              | ± 0.8 mm                                                                                   | 27.7 mm                                                                    | 28.0 mm                          | 3.90                                | 80        | 177                               | 0.17                              | 0.0069                   |
| 25.0 mm           | 1 in.       | 1                                 | ± 0.8 mm                                                                                   | 26.1 mm                                                                    | 26.4 mm                          | 3.80                                | 100       | 149                               | 0.14                              | 0.0058                   |
| 22.4 mm           | ¾ in.       | 0.875                             | ± 0.7 mm                                                                                   | 23.4 mm                                                                    | 23.7 mm                          | 3.50                                | 140       | 105                               | 0.10                              | 0.0041                   |
| 19.0 mm           | ¾ in.       | 0.750                             | ± 0.6 mm                                                                                   | 19.9 mm                                                                    | 20.1 mm                          | 3.30                                | 200       | 74                                | 0.07                              | 0.0029                   |
| 16.0 mm           | 5/8 in.     | 0.625                             | ± 0.5 mm                                                                                   | 16.7 mm                                                                    | 17.0 mm                          | 3.00                                | 230       | 62                                | 0.06                              | 0.0024                   |
| 13.2 mm           | ½ in.       | 0.530                             | ± 0.41 mm                                                                                  | 13.83 mm                                                                   | 14.05 mm                         | 2.75                                | 270       | 53                                | 0.05                              | 0.0021                   |
| 12.5 mm           | ½ in.       | 0.500                             | ± 0.39 mm                                                                                  | 13.10 mm                                                                   | 13.31 mm                         | 2.67                                | 325       | 44                                | 0.04                              | 0.0017                   |
| 11.2 mm           | 7/16 in.    | 0.438                             | ± 0.35 mm                                                                                  | 11.75 mm                                                                   | 11.94 mm                         | 2.45                                | 400       | 37                                | 0.03                              | 0.0015                   |
| 9.5 mm            | 3/8 in.     | 0.375                             | ± 0.30 mm                                                                                  | 9.97 mm                                                                    | 10.16 mm                         | 2.27                                | 625       | 20                                | 0.02                              | 0.0008                   |
| 8.0 mm            | 5/16 in.    | 0.312                             | ± 0.25 mm                                                                                  | 8.41 mm                                                                    | 8.58 mm                          | 2.07                                | 1250      | 10                                | 0.01                              | 0.0004                   |
| 6.7 mm            | 1/8 in.     | 0.265                             | ± 0.21 mm                                                                                  | 7.05 mm                                                                    | 7.20 mm                          | 1.87                                | 2500      | 5                                 | 0.005                             | 0.0002                   |
| 6.3 mm            | 1/8 in.     | 0.250                             | ± 0.20 mm                                                                                  | 6.64 mm                                                                    | 6.78 mm                          | 1.82                                |           |                                   |                                   |                          |
| 5.6 mm            | No. 3½      | 0.223                             | ± 0.18 mm                                                                                  | 5.90 mm                                                                    | 6.04 mm                          | 1.68                                |           |                                   |                                   |                          |
| 4.75 mm           | No. 4       | 0.187                             | ± 0.15 mm                                                                                  | 5.02 mm                                                                    | 5.14 mm                          | 1.54                                |           |                                   |                                   |                          |
| 4.00 mm           | No. 5       | 0.157                             | ± 0.13 mm                                                                                  | 4.23 mm                                                                    | 4.35 mm                          | 1.37                                |           |                                   |                                   |                          |
| 3.35 mm           | No. 6       | 0.132                             | ± 0.11 mm                                                                                  | 3.55 mm                                                                    | 3.66 mm                          | 1.23                                |           |                                   |                                   |                          |
| 2.80 mm           | No. 7       | 0.111                             | ± 0.095 mm                                                                                 | 2.975 mm                                                                   | 3.070 mm                         | 1.10                                |           |                                   |                                   |                          |
| 2.36 mm           | No. 8       | 0.0937                            | ± 0.080 mm                                                                                 | 2.515 mm                                                                   | 2.600 mm                         | 1.00                                |           |                                   |                                   |                          |
| 2.00 mm           | No. 10      | 0.0787                            | ± 0.070 mm                                                                                 | 2.135 mm                                                                   | 2.215 mm                         | 0.900                               |           |                                   |                                   |                          |
| 1.70 mm           | No. 12      | 0.0661                            | ± 0.060 mm                                                                                 | 1.820 mm                                                                   | 1.890 mm                         | 0.810                               |           |                                   |                                   |                          |
| 1.40 mm           | No. 14      | 0.0555                            | ± 0.050 mm                                                                                 | 1.505 mm                                                                   | 1.565 mm                         | 0.725                               |           |                                   |                                   |                          |
| 1.18 mm           | No. 16      | 0.0469                            | ± 0.045 mm                                                                                 | 1.270 mm                                                                   | 1.330 mm                         | 0.650                               |           |                                   |                                   |                          |
| 1.00 mm           | No. 18      | 0.0394                            | ± 0.040 mm                                                                                 | 1.080 mm                                                                   | 1.135 mm                         | 0.580                               |           |                                   |                                   |                          |
| 850 µm            | No. 20      | 0.0331                            | ± 35 µm                                                                                    | 925 µm                                                                     | 970 µm                           | 0.510                               |           |                                   |                                   |                          |
| 710 µm            | No. 25      | 0.0278                            | ± 30 µm                                                                                    | 775 µm                                                                     | 815 µm                           | 0.450                               |           |                                   |                                   |                          |
| 600 µm            | No. 30      | 0.0234                            | ± 25 µm                                                                                    | 660 µm                                                                     | 695 µm                           | 0.390                               |           |                                   |                                   |                          |
| 500 µm            | No. 35      | 0.0197                            | ± 20 µm                                                                                    | 550 µm                                                                     | 585 µm                           | 0.340                               |           |                                   |                                   |                          |
| 425 µm            | No. 40      | 0.0165                            | ± 19 µm                                                                                    | 471 µm                                                                     | 502 µm                           | 0.290                               |           |                                   |                                   |                          |
| 355 µm            | No. 45      | 0.0139                            | ± 16 µm                                                                                    | 396 µm                                                                     | 425 µm                           | 0.247                               |           |                                   |                                   |                          |
| 300 µm            | No. 50      | 0.0117                            | ± 14 µm                                                                                    | 337 µm                                                                     | 363 µm                           | 0.215                               |           |                                   |                                   |                          |
| 250 µm            | No. 60      | 0.0098                            | ± 12 µm                                                                                    | 283 µm                                                                     | 306 µm                           | 0.180                               |           |                                   |                                   |                          |
| 212 µm            | No. 70      | 0.0083                            | ± 10 µm                                                                                    | 242 µm                                                                     | 263 µm                           | 0.152                               |           |                                   |                                   |                          |
| 180 µm            | No. 80      | 0.0070                            | ± 9 µm                                                                                     | 207 µm                                                                     | 227 µm                           | 0.131                               |           |                                   |                                   |                          |
| 150 µm            | No. 100     | 0.0059                            | ± 8 µm                                                                                     | 174 µm                                                                     | 192 µm                           | 0.110                               |           |                                   |                                   |                          |
| 125 µm            | No. 120     | 0.0049                            | ± 7 µm                                                                                     | 147 µm                                                                     | 163 µm                           | 0.091                               |           |                                   |                                   |                          |
| 106 µm            | No. 140     | 0.0041                            | ± 6 µm                                                                                     | 126 µm                                                                     | 141 µm                           | 0.076                               |           |                                   |                                   |                          |
| 90 µm             | No. 170     | 0.0035                            | ± 5 µm                                                                                     | 108 µm                                                                     | 122 µm                           | 0.064                               |           |                                   |                                   |                          |
| 75 µm             | No. 200     | 0.0029                            | ± 5 µm                                                                                     | 91 µm                                                                      | 103 µm                           | 0.053                               |           |                                   |                                   |                          |
| 63 µm             | No. 230     | 0.0025                            | ± 4 µm                                                                                     | 77 µm                                                                      | 89 µm                            | 0.044                               |           |                                   |                                   |                          |
| 53 µm             | No. 270     | 0.0021                            | ± 4 µm                                                                                     | 66 µm                                                                      | 76 µm                            | 0.037                               |           |                                   |                                   |                          |
| 45 µm             | No. 325     | 0.0017                            | ± 3 µm                                                                                     | 57 µm                                                                      | 66 µm                            | 0.030                               |           |                                   |                                   |                          |
| 38 µm             | No. 400     | 0.0015                            | ± 3 µm                                                                                     | 48 µm                                                                      | 57 µm                            | 0.025                               |           |                                   |                                   |                          |

\* The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any sieve shall not deviate from the nominal values by more than the following:

|                            |            |
|----------------------------|------------|
| Sieves coarser than 600 µm | 5 percent  |
| Sieves 600 to 125 µm       | 7½ percent |
| Sieves finer than 125 µm   | 10 percent |

# STANDARD TYPES OF STAINLESS AND HEAT RESISTING STEELS

Chemical Ranges and Limits  
Subject to Tolerances for Check Analyses  
By permission of American Iron and Steel Institute

| Type number          | Chemical composition (%) |                |       |              |               |                 |                 |                           |                           |              |                          |    |               |              |
|----------------------|--------------------------|----------------|-------|--------------|---------------|-----------------|-----------------|---------------------------|---------------------------|--------------|--------------------------|----|---------------|--------------|
|                      | C                        | Mn Max.        | P Max | S Max.       | Si Max.       | Cr              | Ni              | Mo                        | Zr                        | Se           | Cb-Ta                    | Ta | Al            | N            |
| 201 <sup>c</sup>     | 0.15<br>Max.             | 5.50/<br>7.50  | 0.060 | 0.030        | 1.00          | 16.00/<br>18.00 | 3.50/<br>5.50   |                           |                           |              |                          |    |               | 0.25<br>Max. |
| 202 <sup>c</sup>     | 0.15<br>Max.             | 7.50/<br>10.00 | 0.060 | 0.030        | 1.00          | 17.00/<br>19.00 | 4.00/<br>6.00   |                           |                           |              |                          |    |               | 0.25<br>Max. |
| 301 <sup>c</sup>     | 0.15<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 16.00/<br>18.00 | 6.00/<br>8.00   |                           |                           |              |                          |    |               |              |
| 302 <sup>c</sup>     | 0.15<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 17.00/<br>19.00 | 8.00/<br>10.00  |                           |                           |              |                          |    |               |              |
| 302B <sup>c</sup>    | 0.15<br>Max.             | 2.00           | 0.045 | 0.030        | 2.00/<br>3.00 | 17.00/<br>19.00 | 8.00/<br>10.00  |                           |                           |              |                          |    |               |              |
| 303 <sup>c</sup>     | 0.15<br>Max.             | 2.00           | 0.20  | 0.15<br>Min. | 1.00          | 17.00/<br>19.00 | 8.00/<br>10.00  | 0.60<br>Max. <sup>a</sup> | 0.60<br>Max. <sup>a</sup> |              |                          |    |               |              |
| 303 Se <sup>c</sup>  | 0.15<br>Max.             | 2.00           | 0.20  | 0.06         | 1.00          | 17.00/<br>19.00 | 8.00/<br>10.00  |                           |                           | 0.15<br>Min. |                          |    |               |              |
| 304 <sup>c</sup>     | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 18.00/<br>20.00 | 8.00/<br>12.00  |                           |                           |              |                          |    |               |              |
| 304L <sup>c</sup>    | 0.03<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 18.00/<br>20.00 | 8.00/<br>12.00  |                           |                           |              |                          |    |               |              |
| 305 <sup>c</sup>     | 0.12<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 17.00/<br>19.00 | 10.00/<br>13.00 |                           |                           |              |                          |    |               |              |
| 308 <sup>c</sup>     | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 19.00/<br>21.00 | 10.00/<br>12.00 |                           |                           |              |                          |    |               |              |
| 309 <sup>c</sup>     | 0.20<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 22.00/<br>24.00 | 12.00/<br>15.00 |                           |                           |              |                          |    |               |              |
| 309S <sup>c</sup>    | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 22.00/<br>24.00 | 12.00/<br>15.00 |                           |                           |              |                          |    |               |              |
| 310 <sup>c</sup>     | 0.25<br>Max.             | 2.00           | 0.045 | 0.030        | 1.50          | 24.00/<br>26.00 | 19.00/<br>22.00 |                           |                           |              |                          |    |               |              |
| 310S <sup>c</sup>    | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.50          | 24.00/<br>26.00 | 19.00/<br>22.00 |                           |                           |              |                          |    |               |              |
| 314 <sup>c</sup>     | 0.25<br>Max.             | 2.00           | 0.045 | 0.030        | 1.50/<br>3.00 | 23.00/<br>26.00 | 19.00/<br>22.00 |                           |                           |              |                          |    |               |              |
| 316 <sup>c</sup>     | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 16.00/<br>18.00 | 10.00/<br>14.00 | 2.00/<br>3.00             |                           |              |                          |    |               |              |
| 316L <sup>c</sup>    | 0.03<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 16.00/<br>18.00 | 10.00/<br>14.00 | 2.00/<br>3.00             |                           |              |                          |    |               |              |
| 317 <sup>c</sup>     | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 18.00/<br>20.00 | 11.00/<br>15.00 | 3.00/<br>4.00             |                           |              |                          |    |               |              |
| 321 <sup>c</sup>     | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 17.00/<br>19.00 | 9.00/<br>12.00  |                           |                           |              | 5 × C Min.               |    |               |              |
| 347 <sup>c</sup>     | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 17.00/<br>19.00 | 9.00/<br>13.00  |                           |                           |              | 10 × C Min.              |    |               |              |
| 348 <sup>c</sup>     | 0.08<br>Max.             | 2.00           | 0.045 | 0.030        | 1.00          | 17.00/<br>19.00 | 9.00/<br>13.00  |                           |                           |              | 10 × C Min. 0.10<br>Max. |    |               |              |
| 403 <sup>b</sup>     | 0.15<br>Max.             | 1.00           | 0.040 | 0.030        | 0.50          | 11.50/<br>13.00 |                 |                           |                           |              |                          |    |               |              |
| 405 <sup>d</sup>     | 0.08<br>Max.             | 1.00           | 0.040 | 0.030        | 1.00          | 11.50/<br>14.50 |                 |                           |                           |              |                          |    | 0.10/<br>0.30 |              |
| 410 <sup>b</sup>     | 0.15<br>Max.             | 1.00           | 0.040 | 0.030        | 1.00          | 11.50/<br>13.50 |                 |                           |                           |              |                          |    |               |              |
| 414 <sup>b</sup>     | 0.15<br>Max.             | 1.00           | 0.040 | 0.030        | 1.00          | 11.50/<br>13.50 | 1.25/<br>2.50   |                           |                           |              |                          |    |               |              |
| 416 <sup>b</sup>     | 0.15<br>Max.             | 1.25           | 0.06  | 0.15<br>Min. | 1.00          | 12.00/<br>14.00 |                 | 0.60<br>Max. <sup>a</sup> | 0.60<br>Max. <sup>a</sup> |              |                          |    |               |              |
| 416 Se <sup>b</sup>  | 0.15<br>Max.             | 1.25           | 0.06  | 0.06         | 1.00          | 12.00/<br>14.00 |                 |                           |                           | 0.15<br>Min. |                          |    |               |              |
| 420 <sup>b</sup>     | Over<br>0.15             | 1.00           | 0.040 | 0.030        | 1.00          | 12.00/<br>14.00 |                 |                           |                           |              |                          |    |               |              |
| 430 <sup>a</sup>     | 0.12<br>Max.             | 1.00           | 0.040 | 0.030        | 1.00          | 14.00/<br>18.00 |                 |                           |                           |              |                          |    |               |              |
| 430F <sup>d</sup>    | 0.12<br>Max.             | 1.25           | 0.06  | 0.15<br>Min. | 1.00          | 14.00/<br>18.00 |                 | 0.60<br>Max.              | 0.60<br>Max. <sup>a</sup> |              |                          |    |               |              |
| 430F Se <sup>d</sup> | 0.12<br>Max.             | 1.25           | 0.06  | 0.06         | 1.00          | 14.00/<br>18.00 |                 |                           |                           | 0.15<br>Min. |                          |    |               |              |
| 431 <sup>b</sup>     | 0.20<br>Max.             | 1.00           | 0.040 | 0.030        | 1.00          | 15.00/<br>17.00 | 1.25/<br>2.50   |                           |                           |              |                          |    |               |              |
| 440A <sup>b</sup>    | 0.60/<br>0.75            | 1.00           | 0.040 | 0.030        | 1.00          | 16.00/<br>18.00 |                 | 0.75<br>Max.              |                           |              |                          |    |               |              |

# STANDARD TYPES OF STAINLESS AND HEAT RESISTING STEELS (continued)

## Chemical composition (%)

| Type number       | C             | Mn Max. | P Max | S Max. | Si Max. | Cr              | Ni | Mo            | Zr | Se | Cb-Ta | Ta | Al | N            |
|-------------------|---------------|---------|-------|--------|---------|-----------------|----|---------------|----|----|-------|----|----|--------------|
| 400B <sup>b</sup> | 0.75/<br>0.95 | 1.00    | 0.040 | 0.030  | 1.00    | 16.00/<br>18.00 |    | 0.75<br>Max.  |    |    |       |    |    |              |
| 440C <sup>b</sup> | 0.95/<br>1.20 | 1.00    | 0.040 | 0.030  | 1.00    | 16.00/<br>18.00 |    | 0.75<br>Max.  |    |    |       |    |    |              |
| 446 <sup>d</sup>  | 0.20<br>Max.  | 1.50    | 0.040 | 0.030  | 1.00    | 23.00/<br>27.00 |    |               |    |    |       |    |    | 0.25<br>Max. |
| 501 <sup>b</sup>  | Over<br>0.10  | 1.00    | 0.040 | 0.030  | 1.00    | 4.00/<br>6.00   |    | 0.40/<br>0.65 |    |    |       |    |    |              |
| 502 <sup>b</sup>  | 0.10<br>Max.  | 1.00    | 0.040 | 0.030  | 1.00    | 4.00/<br>6.00   |    | 0.40/<br>0.65 |    |    |       |    |    |              |

<sup>a</sup> At producer's option; reported only when intentionally added.

<sup>b</sup> Heat treatable

<sup>c</sup> Not heat treatable.

<sup>d</sup> Essentially not heat treatable.



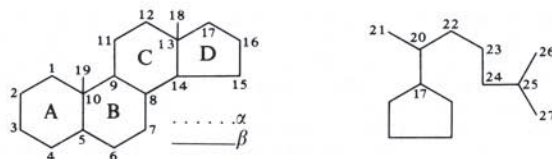
## STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS

Erwin DiCyan

The field of steroids has expanded considerably and rapidly in degree and in kind, because synthetic steroids have been synthesized which though resembling the hormones in the body have no natural counterpart, but exert an effect comparable to those of the natural hormones.

In fact, the term *steroid hormone* thus becomes a misnomer when applied to the newer synthetically prepared steroids which do not have a counterpart in the body of man or other animals—as prednisone. (A hormone, by definition, is a material with certain functions and characteristics, *secreted by the ductless glands*. That part of the definition cannot be met by prednisone or by similar steroids as these are not secreted by the ductless, or endocrine glands.)

All the hormones as well as the synthetic analogues have in common the cyclopentanophenanthrene nucleus. Although chemically very similar, a comparatively slight structural change is in many instances productive of substances which have physiologically dissimilar effects, often acting upon different physiologic systems. But in many cases a small change in structure will result merely in an accentuation of certain effects.



The Cyclopentanophenanthrene Nucleus

**Classification.** Classification becomes a bizarre problem by reason of the (a) overlapping uses to which these substances are put, and (b) the multiple purposes for which the hormones or synthetic substances are used. Indeed, the steroids may be classified by structure; that however would be uninformative to the student as to their use. Classification by origin, as adrenal, would also be unsuitable because, for example, a number of the adrenal corticosteroids are not found in the adrenal cortex at all, but merely resemble the natural hormones found in the adrenal cortex.

For those reasons the hormonal or hormonelike entries in the tables are classified by-and-large, by their predominant pharmacologic effects. Even that classification has its disparities as for example, the use of male sex hormones, i.e. the androgens, is neither limited to men, nor to uses which entail their effect upon male sex characteristics.

**Uses.** Originally, the use of steroid hormones was largely based upon one or more of the following predicates:

- To supplement the progressively declining secretion of a specific hormone due to natural biologic aging of the organism; in the menopause as an example of such declining secretion, a female sex hormone is used for such supplementation;
- To make available to the body a specific hormone, the natural secretion of which is inhibited because of a congenital or developmental anomaly; the underdevelopment of male secondary sex characteristics is an example of such an inhibited secretion, in which a male sex hormone is used—and correspondingly, female sex hormones in underdevelopment in females;
- To cause a reversal of hormonal balance in the treatment of diseases peculiar to a sex; for example, in the case of cancer of the female breast, a male sex hormone is administered, and in cancer of the prostate, a female sex hormone is used;
- To mimic a natural function, as menstruation, by the administration of estrogens—on withdrawal of which bleeding occurs; or by the alternate use of estrogenic and progestational—both female sex hormones.
- To delay a function, as ovulation, as in oral contraceptives, or *birth control pills*.

Since the finding that cortisone ameliorates the symptoms of rheumatoid arthritis (1949) the adrenal corticosteroid hormones and especially the synthetically prepared steroid analogues which have no natural counterpart in the body, have been successfully employed in the treatment of diseases not related to sex or sex function.

**Androgens and Anabolic Agents.** The agents listed in the tables under this classification have the effect of male sex hormones (androgens) i.e., to stimulate sexual maturation, in the "male climacteric," etc. But all androgens have in greater or lesser degree the ability to stimulate muscle development, i.e., an anabolic effect. Among the synthetically prepared agents which have no counterpart in the body (Methandrostenolone or Oxymetholone) are those which have a lessened androgenic, but a heightened anabolic effect. These qualities are determined by biological tests on animals but principally confirmed by clinical use in man. The anabolic effect includes remineralization of bone, which may be partially demineralized (osteoporosis) by age, or by certain drugs, as the adrenal corticosteroids (q.v.).

Anabolic agents are used for muscle and bone nutrition in men as well as women. The reason for the high interest in synthetic steroidal substances for anabolic use, is based on the need for materials, which within a given effective dose have a greater anabolic-to-androgenic ratio than such androgens as methyl testosterone. Otherwise, the administration of androgens to women produces manifestations of virilism, such as growth of hair on the face, a deepening of the voice, etc. Androgens are also used in the female in the suppression of excessive bleeding and in the treatment of cancer of the breast and cervix. (For other androgen-like agents, see also Progestogens and Progestins.)

**Estrogens.** Estrogenic agents hasten sexual maturation in the female. Therefore, they are used in underdevelopment in the female. The widest use of estrogens is in the treatment of the menopause, in which they supplement from without, the secretion of natural estrogens by the ovary, which begins to decline at about the 40th year. The menopause is usually a slow process, and the declining secretion gives rise to various symptoms during the time that the secretion declines, until adjustment to the new status takes place. The menopause, a period of physical and psychological stress, is made less precipitous by estrogens.

Frequently, a menopause must be quickly induced, as in cancer of the ovary or in uterine hemorrhage. This is done by radiation or by the removal of the uterus. Severe vasomotor symptoms occur when the menopause is thus suddenly induced. Estrogens—among other drugs—are used in the amelioration of these symptoms.

Estrogens (especially diethylstilbestrol which though not a hormone has an estrogenic effect) are also used in the control of cancer of the prostate in the male. Note the inverse correspondence to the use of male sex hormones in cancer of the breast in the female.

**Progestogens and Progestins (Including 19-Norsteroid Compounds).** The agents under that listing include progesterone, a female sex hormone, as well as progestins, i.e., synthetic progesterone-like compounds which have no natural counterpart in the body. Their use includes a variety of conditions: functional uterine bleeding, absence of menstruation (amenorrhea) used at times with estrogens, painful menstruation (dysmenorrhea), infertility, habitual abortion in order to maintain pregnancy, and in fact, to suppress ovulation hence their use as antifertility drugs. Certain progestins—as norethindrone combined with



## STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

an estrogen, are the principal components of birth control pills—suppressing ovulation, there is no egg to fertilize, hence conception does not take place.

**Adrenal Corticosteroids, Including Antiinflammatory, Antiallergic and Antirheumatic Agents.** The adrenal cortex secretes a large number of hormones. They usually differ from each other in the accentuation of some phases of their properties. Virtually all of the cortical hormones are catabolic, thus having an effect in this respect, diametrically opposed to the androgens which are anabolic. Nearly all the cortical hormones—differing in degree from each other—cause retention of sodium and water by the body and hasten the excretion of potassium. These effects are utilized in the treatment of adrenal insufficiency or Addison's disease, in which conversely, there is an undue excretion of sodium and a strong retention of potassium. Desoxycorticosterone is used in Addison's disease because it has a particularly strong sodium retaining and potassium excreting effect.

Since the finding in 1949 of the usefulness of cortisone in profoundly reducing the symptoms of rheumatoid arthritis, the adrenal corticosteroids, including hydrocortisone, a natural hormone secreted by the adrenal cortex, and particularly the synthetic analogues not found in the body, as prednisone, have been used in the treatment of a wide variety of inflammatory diseases—especially diseases of collagen tissue. The same antiinflammatory effect is also brought into use in the reduction of inflammations associated with diseases of the skin, allergy, asthma, and in such systematic diseases as disseminated lupus erythematosus, also a collagen disease.

The drawbacks of cortisone, also shared in lesser measure by hydrocortisone, gave the impetus to the synthesis of steroidal substances not native to the body but differing somewhat from cortisone and hydrocortisone, in order to reduce the drawbacks attendant to the use of the latter. The sideeffects—especially those of cortisone—are retention of water and sodium, excretion of potassium, loss of mineral from bone leading to osteoporosis and fractures, hypertension, at times diabetes, personality changes or gastric ulcer. Prednisone and prednisolone among others (see tables) are two such steroidal synthetics which have the effects of cortisone, but fewer or less severe sideeffects. Whereas the synthetic steroidal substances are superior to cortisone with respect to lessened sideeffects, it cannot be said that the sideeffects are absent—they vary in degree from substance to substance.

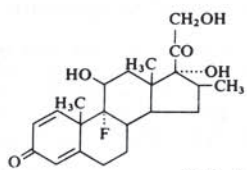
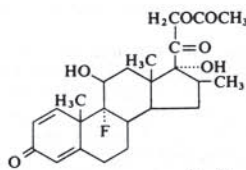
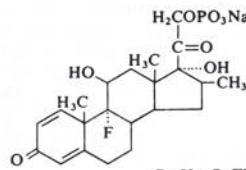
**Diuretic, Antidiuretic and Local Anesthetic Agents.** Aldosterone, a natural hormone of the adrenal cortex promotes retention in the body of sodium and water, and facilitates excretion of potassium. Hence its effect is almost diametrically opposed to diuretics—especially the thiazide diuretics. Aldosterone is much more active in this respect than desoxycorticosterone, and is used in the treatment of Addison's disease, a hypofunction of the adrenal glands.

Spironolactone is an antagonist to aldosterone—the latter when elaborated in the body in excessive amounts gives rise to a syndrome called aldosteronism. Spironolactone, a synthetically produced steroid does not have a natural counterpart in the body, is diuretic when mercurial or thiazide diuretics are ineffective; it prevents sodium retention and potassium excretion—effects opposite to aldosterone. Hence spironolactone is used in aldosteronism, against edema, in the treatment of congestive heart failure and in other conditions in which an accumulation of water, and water-retaining salt, is to be corrected.

**Doses.** The amount of substance which comprises a dose of steroid hormones, or of the steroidal synthetics varies from substance to substance—from 0.1 mg for an estradiol ester, to 50 mg for a 19-norsteroid compound. The dose is conditioned upon the order of activity of the substance, the purpose for which it is administered, as well as the patient's response. However, as additional steroids for hormonal use are synthesized—especially those with adrenocortical activity, their average dose is usually smaller than the previously available steroid. The smaller effective dose of the more recent steroid is cited as an advantage over the previously available steroid.

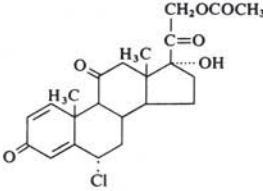
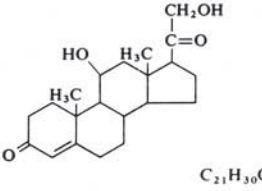
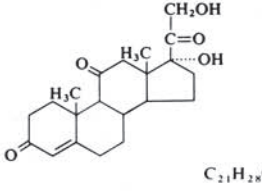
However, a smaller dose cannot be claimed as an inherent advantage of a new steroid in comparison with an existing one, unless the lower dosage exhibits either greater or more prolonged activity or lesser sideeffects. One cannot meaningfully compare a dose, milligram for milligram, without taking into consideration if a heightened effect of the smaller dose produces fewer sideeffects. For example, it does not make any difference if a given effect and the same accompanying sideeffects are produced by a 50 mg dose or a 5 mg dose.

### ADRENAL CORTICOSTEROIDS, INCLUDING ANTIINFLAMMATORY, ANTIALLERGIC AND ANTIRHEUMATIC AGENTS

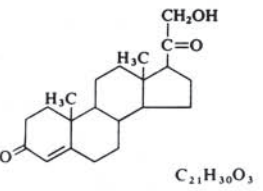
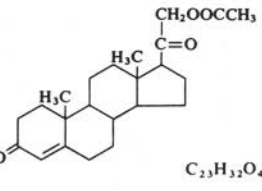
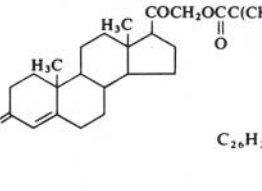
| Names & synonyms:  | BETAMETHASONE;<br>9 $\alpha$ -fluoro-16 $\beta$ -methylprednisolone;<br>16 $\beta$ -methyl-11 $\beta$ ,17 $\alpha$ ,21-trihydroxy-9 $\alpha$ -fluoro-1,4-pregnadiene-3,20-dione. | BETAMETHASONE ACETATE;<br>9 $\alpha$ -fluoro-16 $\beta$ -methylprednisolone-21-acetate.                                                 | BETAMETHASONE DISODIUM PHOSPHATE;<br>9 $\alpha$ -fluoro-16 $\beta$ -methylprednisolone-21-disodium phosphate.                                             |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Formulae:          | <br>C <sub>22</sub> H <sub>29</sub> O <sub>5</sub> F                                          | <br>C <sub>24</sub> H <sub>31</sub> O <sub>6</sub> F | <br>C <sub>22</sub> H <sub>28</sub> O <sub>8</sub> FN <sub>2</sub> P |
| Molecular weight   | 392.5                                                                                                                                                                            | 434.5                                                                                                                                   | 516.4                                                                                                                                                     |
| Melting point (°C) | 240 (dec.)                                                                                                                                                                       | 200 to 220 (dec.)                                                                                                                       | decomposes                                                                                                                                                |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D}$ +112 to +120 (100 mg. in 10 ml. dioxane)                                                                                                             | ( $\alpha$ ) $\frac{25}{D}$ +120 to +128 (100 mg. in 10 ml. dioxane)                                                                    | ( $\alpha$ ) $\frac{25}{D}$ +99 to +105 (100 mg. in 10 ml. water)                                                                                         |
| Absorption max.    | 239 m $\mu$ , E(1 %, 1 cm) 390, methanol                                                                                                                                         | 239 m $\mu$ , methanol                                                                                                                  | 241 m $\mu$ , water                                                                                                                                       |



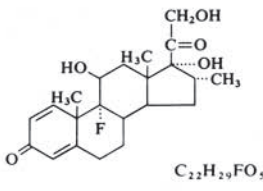
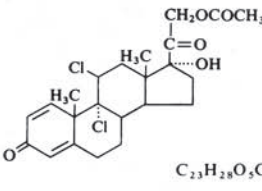
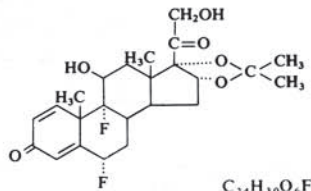
### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

|                               |                                                                                                                                                                       |                                                                                                                                                                                                           |                                                                                                                                                                                                                          |
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| Names & synonyms:             | CHLOROPREDNISONE<br>ACETATE;<br>6 $\alpha$ -chloroprednisone acetate;<br>6 $\alpha$ -chloro- $\Delta^1$ -,4-pregnadien-17 $\beta$ ,21-diol-3,11,20-trione 21-acetate. | CORTICOSTERONE;<br>11,21-dihydroxyprogesterone;<br>$\Delta^4$ -pregnene-11 $\beta$ ,21-diol-3,20-dione;<br>11 $\beta$ ,21-dihydroxy-4-pregnene-3,20-dione;<br>Kendall compound B; Reichstein substance H. | CORTISONE;<br>17-hydroxy-11-dehydrocorticosterone;<br>17 $\alpha$ ,21-dihydroxy-4-pregnene-3,11,20-trione;<br>$\Delta^4$ -pregnene-17 $\alpha$ ,21-diol-3,11,20-trione;<br>Kendall compound E; Wintersteiner compound F. |
| Formulae:                     | <br><chem>CC(=O)OCC12CC[C@H]3[C@@H]([C@@H]1CC[C@@H]2C(=O)C=C[C@H]3Cl)C(=O)O</chem>   | <br><chem>OC[C@]12CC[C@H]3[C@H]([C@@H]1CC[C@@H]2C(=O)C=C[C@H]3O)CO</chem><br>$C_{21}H_{30}O_4$                           | <br><chem>OC[C@]12CC[C@H]3[C@H]([C@@H]1CC[C@@H]2C(=O)C=C[C@H]3O)CO</chem><br>$C_{21}H_{28}O_5$                                        |
| Molecular weight              | 436.6                                                                                                                                                                 | 346.40                                                                                                                                                                                                    | 360.4                                                                                                                                                                                                                    |
| Melting point ( $^{\circ}C$ ) | 207–213                                                                                                                                                               | 180–182                                                                                                                                                                                                   | 220–224                                                                                                                                                                                                                  |
| Specific rotation             | $(\alpha) \frac{25}{D} + 137$ to $+142$ (100 mg. in 10 ml. chloroform)                                                                                                | $(\alpha) \frac{15}{D} + 222$ (110 mg. in 10 ml. alcohol)                                                                                                                                                 | $(\alpha) \frac{25}{D} + 209$ (120 mg. in 10 ml. alcohol)                                                                                                                                                                |
| Absorption max.               |                                                                                                                                                                       | 240 $m\mu$                                                                                                                                                                                                | 237 $m\mu$                                                                                                                                                                                                               |

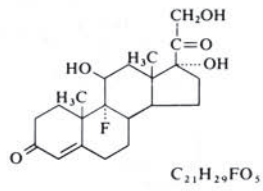
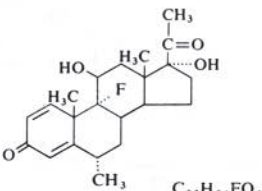
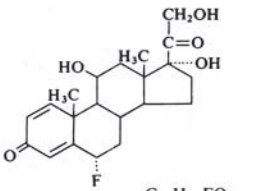
  

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| Names & synonyms:             | DESOXYCORTICOSTERONE;<br>deoxycorticosterone;<br>11-desoxycorticosterone;<br>21-hydroxyprogesterone;<br>4-pregnen-21-ol-3,20-dione;<br>Kendall desoxy compound B;<br>Reichstein substance Q. | DESOXYCORTICOSTERONE<br>ACETATE;<br>DCA;<br>11-desoxycorticosterone acetate.                                                                                                              | DESOXYCORTICOSTERONE<br>PIVALATE;<br>desoxycorticosterone trimethylacetate;<br>21-hydroxy-4-pregnene-3,20-dione pivalate.                                                                          |
| Formulae:                     | <br><chem>OC[C@]12CC[C@H]3[C@H]([C@@H]1CC[C@@H]2C(=O)C=C[C@H]3O)CO</chem><br>$C_{21}H_{30}O_3$            | <br><chem>CC(=O)OCC12CC[C@H]3[C@@H]([C@@H]1CC[C@@H]2C(=O)C=C[C@H]3O)C(=O)O</chem><br>$C_{23}H_{32}O_4$ | <br><chem>CC(C)(C)C(=O)OCC12CC[C@H]3[C@@H]([C@@H]1CC[C@@H]2C(=O)C=C[C@H]3O)C(=O)O</chem><br>$C_{26}H_{38}O_4$ |
| Molecular weight              | 330.2                                                                                                                                                                                        | 372.4                                                                                                                                                                                     | 414.6                                                                                                                                                                                              |
| Melting point ( $^{\circ}C$ ) | 140–142                                                                                                                                                                                      | 154–160                                                                                                                                                                                   | 198–204                                                                                                                                                                                            |
| Specific rotation             | $(\alpha) \frac{22}{D} + 176$ – $+178$ (100 mg. in 10 ml. alcohol)                                                                                                                           | $(\alpha) \frac{20}{D} + 168$ – $+178$ (100 mg. in 10 ml. dioxane)                                                                                                                        | $(\alpha) \frac{25}{D} + 157 \pm 4$ (1 % in dioxane)                                                                                                                                               |
| Absorption max.               | 240 $m\mu$                                                                                                                                                                                   |                                                                                                                                                                                           | 240 $m\mu$ (in ethanol)                                                                                                                                                                            |

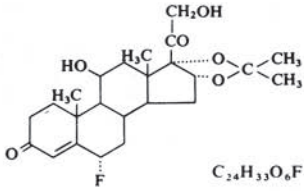
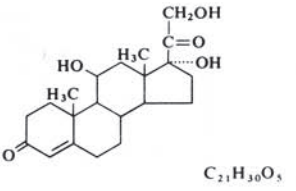
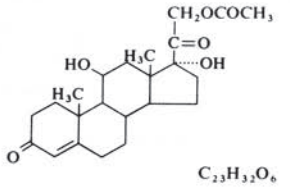
# STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

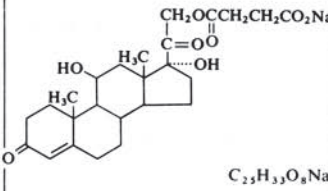
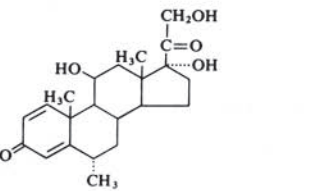
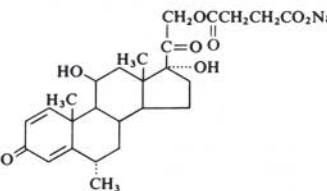
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| Names & synonyms:  | DEXAMETHASONE;<br>hexadecadrol;<br>9 $\alpha$ -fluoro-16 $\alpha$ -methyl prednisolone;<br>9 $\alpha$ -fluoro-11 $\beta$ ,17 $\alpha$ -21-trihydroxy-16 $\alpha$ -methyl-1,4-pregnadiene-3,20-dione;<br>16 $\alpha$ -methyl-9 $\alpha$ -fluoro-1,4-pregnadiene-11 $\beta$ ,17 $\alpha$ -21-triol-3,20-dione;<br>16 $\alpha$ -methyl-9 $\alpha$ -fluoro- $\Delta^1$ -hydrocortisone;<br>1-dehydro-16 $\alpha$ -methyl-9 $\alpha$ -fluorohydrocortisone. | DICHLORISONE ACETATE;<br>9 $\alpha$ -11 $\beta$ -dichloro-1,4-pregnadiene-17 $\alpha$ ,21-diol-3,20-dione-21-acetate                                | FLUOCINOLONE ACETONIDE;<br>6 $\alpha$ ,9 $\alpha$ -difluoro-16 $\alpha$ hydroxyprednisolone-16,17-acetonide;<br>6 $\alpha$ ,9 $\alpha$ -difluoro-16 $\alpha$ ,17 $\alpha$ -isopropylidenedioxy-1,4-pregnadiene-3,20-dione. |
| Formulae:          | <br>C <sub>22</sub> H <sub>29</sub> FO <sub>5</sub>                                                                                                                                                                                                                                                                                                                   | <br>C <sub>23</sub> H <sub>28</sub> O <sub>5</sub> Cl <sub>2</sub> | <br>C <sub>24</sub> H <sub>30</sub> O <sub>6</sub> F <sub>2</sub>                                                                       |
| Molecular weight   | 392.4                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 455.3                                                                                                                                               | 452.50                                                                                                                                                                                                                     |
| Melting point (°C) | 262–264                                                                                                                                                                                                                                                                                                                                                                                                                                                | 235 (dec.)                                                                                                                                          | 255–266                                                                                                                                                                                                                    |
| Specific rotation  | ( $\alpha$ ) <sub>D</sub> <sup>25</sup> +78 (100 mg. in 10 ml. dioxane)                                                                                                                                                                                                                                                                                                                                                                                | ( $\alpha$ ) <sub>D</sub> <sup>25</sup> +160 – 168 (100 mg. in 10 ml. dioxane)                                                                      | not less than +95° and not more than +105°C at 25°C.                                                                                                                                                                       |
| Absorption max.    |                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 237 m $\mu$ – 316 – 337 ( $\epsilon$ )                                                                                                              | 237 m $\mu$ $\pm$ 1 m $\mu$                                                                                                                                                                                                |

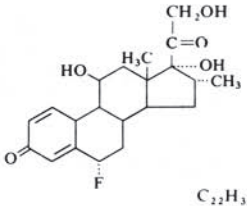
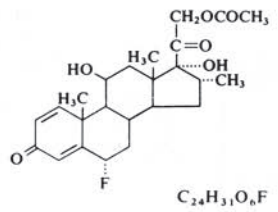
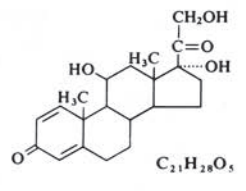
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| Names & synonyms:  | FLUOROHYDROCORTISONE;<br>fludrocortisone;<br>9 $\alpha$ -fluorohydrocortisone;<br>9 $\alpha$ -fluorocortisol;<br>fluohydroisone;<br>9 $\alpha$ -fluoro-11 $\beta$ ,17 $\alpha$ ,21-trihydroxy-4-pregnene-3,20-dione;<br>9 $\alpha$ -fluoro-17-hydroxycorticosterone. | FLUOROMETHOLONE;<br>9 $\alpha$ -fluoro-11 $\beta$ ,17 $\alpha$ -dihydroxy-6 $\alpha$ -methyl-1,4-pregnadiene-3,20-dione;<br>21-desoxy-9 $\alpha$ -fluoro-6 $\alpha$ -methylprednisolone. | FLUPREDNISOLONE;<br>6 $\alpha$ -fluoroprednisolone;<br>6 $\alpha$ -fluoro-1-dehydrohydrocortisone;<br>6 $\alpha$ -fluoro-11 $\beta$ ,17 $\alpha$ ,21-trihydroxy-1,4-pregnadiene-3,20-dione. |
| Formulae:          | <br>C <sub>21</sub> H <sub>29</sub> FO <sub>5</sub>                                                                                                                               | <br>C <sub>22</sub> H <sub>24</sub> FO <sub>4</sub>                                                   | <br>C <sub>21</sub> H <sub>27</sub> FO <sub>5</sub>                                                    |
| Molecular weight   | 380.4                                                                                                                                                                                                                                                                | 376.4                                                                                                                                                                                    | 378.4                                                                                                                                                                                       |
| Melting point (°C) | 260–262 (dec.)                                                                                                                                                                                                                                                       | 290 (dec.)                                                                                                                                                                               | 205–210                                                                                                                                                                                     |
| Specific rotation  | ( $\alpha$ ) <sub>D</sub> <sup>23</sup> +139 (55 mg. in 10 ml. alcohol)                                                                                                                                                                                              | ( $\alpha$ ) <sub>D</sub> <sup>25</sup> +56 (pyridine)                                                                                                                                   | ( $\alpha$ ) <sub>D</sub> +88 (dioxane)                                                                                                                                                     |
| Absorption max.    |                                                                                                                                                                                                                                                                      | 239 m $\mu$ ( $a_M$ = 15,050) methanol                                                                                                                                                   | $\lambda_{max}$ 241.5 m $\mu$ ( $\epsilon$ 16,000)                                                                                                                                          |

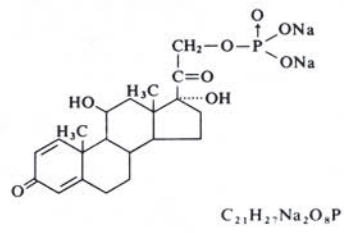
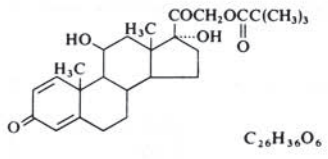
# STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

|                    |                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                       |                                                                                                                                       |
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| Names & synonyms:  | FLURANDRENOLONE;<br>6-fluoro-16 $\alpha$ -hydroxyhydrocortisone-16,17-acetonide;<br>6 $\alpha$ -fluoro-11 $\beta$ ,21-dehydroxy-16 $\alpha$ ,17 $\alpha$ -isopropylidenedioxy-pregna-4-ene-3,20-dione. | HYDROCORTISONE;<br>cortisol;<br>17-hydroxycorticosterone;<br>hydrocortisone free alcohol;<br>11 $\beta$ ,17 $\alpha$ ,21-trihydroxy-4-pregnene-3,20-dione;<br>4-pregnene-11 $\beta$ ,17 $\alpha$ ,21-triol-3,20-dione;<br>Kendall compound F; Reichstein substance M. | HYDROCORTISONE ACETATE;<br>cortisol acetate;<br>hydrocortisone-21-acetate;<br>17-hydroxycorticosterone-21-acetate.                    |
| Formulae:          | <br>C <sub>24</sub> H <sub>33</sub> O <sub>6</sub> F                                                                  | <br>C <sub>21</sub> H <sub>30</sub> O <sub>5</sub>                                                                                                                                  | <br>C <sub>23</sub> H <sub>32</sub> O <sub>6</sub> |
| Molecular weight   | 436.5                                                                                                                                                                                                  | 362.5                                                                                                                                                                                                                                                                 | 404.5                                                                                                                                 |
| Melting point (°C) | 240–250                                                                                                                                                                                                | 215–220 (dec.)                                                                                                                                                                                                                                                        | 223 (dec.)                                                                                                                            |
| Specific rotation  | ( $\alpha$ ) <sub>D</sub> <sup>25</sup> = +145 (1% in CHCl <sub>3</sub> )                                                                                                                              | ( $\alpha$ ) <sub>D</sub> <sup>25</sup> +150 – +156 (100 mg. in 10 ml. dioxane)                                                                                                                                                                                       | ( $\alpha$ ) <sub>D</sub> <sup>25</sup> +158 – +165 (100 mg. in 10 ml. dioxane)                                                       |
| Absorption max.    | 236 m $\mu$ (methanol)                                                                                                                                                                                 | 242 m $\mu$                                                                                                                                                                                                                                                           | 242 m $\mu$ (methanol)                                                                                                                |

|                    |                                                                                                                                                                                                |                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                               |
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| Names & synonyms:  | HYDROCORTISONE SODIUM SUCCINATE;<br>11 $\beta$ , 17 $\alpha$ , 21-trihydroxy-4-pregnene-3,20-dione, 21 hydrogen succinate, sodium salt;<br>hydrocortisone, 21 hydrogen succinate, sodium salt. | METHYLPREDNISOLONE;<br>6 $\alpha$ -methylprednisolone;<br>$\Delta^1$ -6 $\alpha$ -methylhydrocortisone;<br>1-dehydro-6 $\alpha$ -methylhydrocortisone;<br>11 $\beta$ , 17 $\alpha$ ,21-trihydroxy-6 $\alpha$ -methyl-1,4-pregnadiene-3,20-dione. | METHYLPREDNISOLONE SODIUM SUCCINATE;<br>1-dehydro-6 $\alpha$ -methylhydrocortisone, 21-hydrogen succinate, sodium salt;<br>6 $\alpha$ -methylprednisolone 21-hydrogen succinate, sodium salt;<br>11 $\beta$ , 17 $\alpha$ , 21-trihydroxy-6 $\alpha$ -methyl-1,4-pregnadiene-3, 20-dione, 21-hydrogen succinate, sodium salt. |
| Formulae:          | <br>C <sub>23</sub> H <sub>33</sub> O <sub>8</sub> Na                                                       | <br>C <sub>22</sub> H <sub>30</sub> O <sub>5</sub>                                                                                                           | <br>C <sub>26</sub> H <sub>33</sub> O <sub>8</sub> Na                                                                                                                                                                                    |
| Molecular weight   | 484.5                                                                                                                                                                                          | 374.5                                                                                                                                                                                                                                            | 496.5                                                                                                                                                                                                                                                                                                                         |
| Melting point (°C) | decomposes                                                                                                                                                                                     | 230–240 (dec.)                                                                                                                                                                                                                                   | decomposes                                                                                                                                                                                                                                                                                                                    |
| Specific rotation  | ( $\alpha$ ) <sub>D</sub> +140 $\pm$ 5 (alcohol)                                                                                                                                               | ( $\alpha$ ) <sub>D</sub> <sup>25</sup> +85 (dioxane)                                                                                                                                                                                            | ( $\alpha$ ) <sub>D</sub> +100 $\pm$ 4 (alcohol)                                                                                                                                                                                                                                                                              |
| Absorption max.    | $\lambda$ 242 m $\mu$ ( $\epsilon$ 15,700)                                                                                                                                                     | 243 m $\mu$                                                                                                                                                                                                                                      | $\lambda$ max 242 m $\mu$ ( $\epsilon$ 14,500)                                                                                                                                                                                                                                                                                |

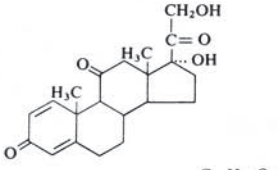
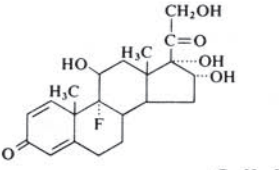
# **STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)**

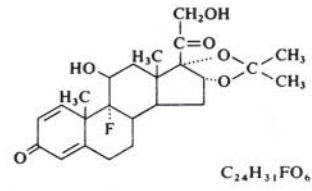
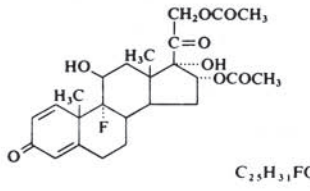
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| Names & synonyms:  | PARAMETHASONE;<br>6 $\alpha$ -fluoro-16 $\alpha$ -methylprednisolone;<br>6 $\alpha$ -fluoro-11 $\beta$ -17 $\alpha$ ,21-trihydroxy-16 $\alpha$ -methyl-1,4-pregnadiene-3,20-dione. | PARAMETHASONE ACETATE;<br>6 $\alpha$ -fluoro-16 $\alpha$ -methylprednisolone-21-acetate;<br>6 $\alpha$ -fluoro-16 $\alpha$ -methylpregna-1,4-diene-11 $\beta$ ,21-diol-3,20-dione-21-acetate;<br>6 $\alpha$ -fluoro-17 $\beta$ ,17 $\alpha$ ,21-trihydroxy-16 $\alpha$ -methyl-1,4-pregnadiene-3,20-dione-21-acetate. | PREDNISOLONE;<br>metacortandralone;<br>$\Delta^1$ -dehydrocortisol;<br>delta F;<br>$\Delta^1$ -hydrocortisone;<br>$\Delta^1$ -dehydrohydrocortisone;<br>1,4-pregnadiene-3,20-dione-11 $\beta$ ,17 $\alpha$ ,21-triol;<br>11 $\beta$ ,17 $\alpha$ ,21-trihydroxy-1,4-pregnadiene-3,20-dione. |
| Formulae:          | <br>$C_{22}H_{30}O_5$                                                                             | <br>$C_{24}H_{32}O_6F$                                                                                                                                                                                                               | <br>$C_{21}H_{28}O_5$                                                                                                                                                                                    |
| Molecular weight   | 392.45                                                                                                                                                                             | 434.5                                                                                                                                                                                                                                                                                                                 | 360.4                                                                                                                                                                                                                                                                                       |
| Melting point (°C) | 228–241                                                                                                                                                                            | 233–246                                                                                                                                                                                                                                                                                                               | 240 (dec.)                                                                                                                                                                                                                                                                                  |
| Specific rotation  | +59 to +69 at 25°C                                                                                                                                                                 | ( $\alpha$ ) $\frac{25}{D} + 72$ (1% in $CHCl_3$ )                                                                                                                                                                                                                                                                    | ( $\alpha$ ) $\frac{25}{D} + 97 - +103$ (100 mg. in 10 ml. dioxane)                                                                                                                                                                                                                         |
| Absorption max.    | 242 $m\mu$                                                                                                                                                                         | 242 $m\mu$ (methanol)                                                                                                                                                                                                                                                                                                 | 242 $m\mu$ ( $\epsilon = 15,000$ ) methanol                                                                                                                                                                                                                                                 |

|                    |                                                                                                               |                                                                                                                                            |
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| Names & synonyms:  | PREDNISOLONE PHOSPHATE SODIUM;<br>disodium prednisolone 21-phosphate.                                         | PREDNISOLONE PIVALATE;<br>prednisolone trimethylacetate;<br>11 $\beta$ ,17 $\alpha$ ,21-trihydroxy-1,4-pregnadiene-3,20-dione 21-pivalate. |
| Formulae:          | <br>$C_{21}H_{27}Na_2O_8P$ | <br>$C_{26}H_{36}O_6$                                  |
| Molecular weight   | 484.4                                                                                                         | 444.6                                                                                                                                      |
| Melting point (°C) |                                                                                                               | 229                                                                                                                                        |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} + 102.5$ (100 mg. in 10 ml. $H_2O$ )                                               | +108 $\pm$ 4 (1% in dioxane)                                                                                                               |
| Absorption max.    | 243 $m\mu$                                                                                                    | 240 and 263 $m\mu$ (in absolute ethanol)                                                                                                   |



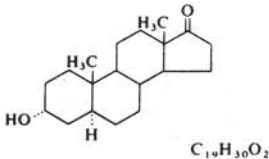
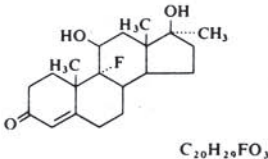
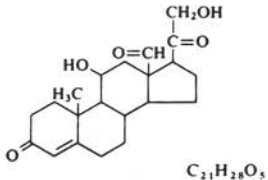
### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

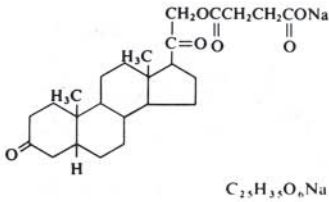
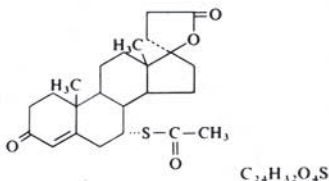
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| Names & synonyms:  | <b>PREDNISONE:</b><br>metacortandricin;<br>$\Delta^1$ -dehydrocortisone;<br>delta E;<br>$\Delta^1$ -cortisone;<br>1,4-pregnadiene-17 $\alpha$ ,21-diol-3,11,20-trione;<br>17 $\alpha$ ,21-dihydroxy-1,4-pregnadiene-3,11,20-trione. | <b>TRIAMCINOLONE:</b><br>9 $\alpha$ -fluoro-16 $\alpha$ -hydroxyprednisolone;<br>9 $\alpha$ -fluoro-11 $\beta$ ,16 $\alpha$ ,17 $\alpha$ ,21-tetrahydroxy-1,4-pregnadiene-3,20-dione. |
| Formulae:          | <br>$C_{21}H_{26}O_5$                                                                                                                              | <br>$C_{21}H_{26}FO_6$                                                                              |
| Molecular weight   | 358.4                                                                                                                                                                                                                               | 394.4                                                                                                                                                                                 |
| Melting point (°C) | 225 (dec.)                                                                                                                                                                                                                          | 260–262.5 (dec.)                                                                                                                                                                      |
| Specific rotation  | $(\alpha) \frac{25}{D} + 167 - +175$ (100 mg. in 10 ml. dioxane)                                                                                                                                                                    | $(\alpha) \frac{25}{D} + 75$ (200 mg. in 100 ml. acetone)                                                                                                                             |
| Absorption max.    | 239 $m\mu$ ( $\epsilon = 15,500$ ) methanol                                                                                                                                                                                         | 238 $m\mu$ ( $\epsilon = 15,800$ )                                                                                                                                                    |

|                    |                                                                                                                                                                                                                                   |                                                                                                                                                                                                                        |
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| Names & synonyms:  | <b>TRIAMCINOLONE ACETONIDE:</b><br>9 $\alpha$ -fluoro-11 $\beta$ ,21-dihydroxy-16 $\alpha$ ,17 $\alpha$ -isopropylidene-dioxy-1,4-pregnadiene-3,20-dione;<br>9 $\alpha$ -fluoro-16 $\alpha$ -hydroxyprednisolone 16,17-acetonide. | <b>TRIAMCINOLONE DIACETATE:</b><br>16 $\alpha$ ,21-diacetoxy-9 $\alpha$ -fluoro-11 $\beta$ ,17 $\alpha$ -dihydroxy-1,4-pregnadiene-3,20-dione;<br>9 $\alpha$ -fluoro-16 $\alpha$ -hydroxyprednisolone 16,21-diacetate. |
| Formulae:          | <br>$C_{24}H_{31}FO_6$                                                                                                                         | <br>$C_{25}H_{31}FO_8$                                                                                                             |
| Molecular weight   | 434.4                                                                                                                                                                                                                             | 478.49                                                                                                                                                                                                                 |
| Melting point (°C) | 274–278 (dec.); 292–294                                                                                                                                                                                                           | variable: 158–235                                                                                                                                                                                                      |
| Specific rotation  | $(\alpha) \frac{25}{D} + 109 - +112$ (53.7 mg. in 10 ml. chloroform)                                                                                                                                                              | $(\alpha) \frac{25}{D} + 22$ (78.8 mg. in 10 ml. chloroform)                                                                                                                                                           |
| Absorption max.    | 238–239 $m\mu$ ( $\epsilon = 14,600$ )                                                                                                                                                                                            | 239 $m\mu$ ( $\epsilon = 15,200$ )                                                                                                                                                                                     |

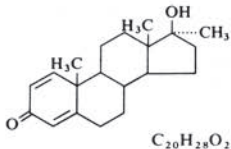
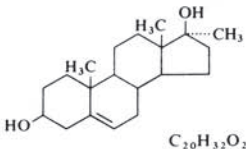
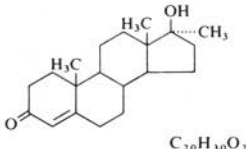
# **STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)**

## **ANDROGENS AND ANABOLIC AGENTS**

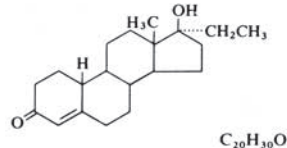
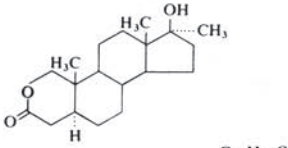
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| Names & synonyms:  | <b>ANDROSTERONE:</b><br>cis-androsterone;<br>3 $\alpha$ -hydroxy-17-androstanone;<br>androstane-3 $\alpha$ -ol-17-one. | <b>FLUOXYMESTERONE:</b><br>9 $\alpha$ -fluoro-11 $\beta$ -hydroxy-17 $\alpha$ -methyltestosterone<br>9 $\alpha$ -fluoro-11 $\beta$ ,17 $\beta$ -dihydroxy-17 $\alpha$ -methyl-4-androsten-3-one. | <b>ALDOSTERONE:</b><br>electrocortin;<br>18-oxocorticosterone;<br>18-formyl-11 $\beta$ ,21-dihydroxy-4-pregnene-3,20-dione. |
| Formulae:          | <br><chem>C19H30O2</chem>             | <br><chem>C20H28FO3</chem>                                                                                      | <br><chem>C21H28O5</chem>                |
| Molecular weight   | 290.4                                                                                                                  | 336.4                                                                                                                                                                                            | 360.4                                                                                                                       |
| Melting point (°C) | 185–185.5                                                                                                              | 270 (dec.)                                                                                                                                                                                       | 108–112 (hydrate); 164 (anhydrous)                                                                                          |
| Specific rotation  | ( $\alpha$ ) $\frac{15}{D} + 85 - +90$ (150 mg. in 10 ml. dioxane)                                                     | ( $\alpha$ ) $\frac{25}{D} + 107 - +109$ (alcohol)                                                                                                                                               | ( $\alpha$ ) $\frac{25}{D} + 161$ (10 mg. in 10 ml. chloroform)                                                             |
| Absorption max.    |                                                                                                                        | 240 m $\mu$ ( $\epsilon$ = 16,700) alcohol                                                                                                                                                       | 240 m $\mu$ (log $\epsilon$ = 4.20 monohydr.; $\epsilon$ mol. 15,000 anhydr.)                                               |

|                    |                                                                                                                |                                                                                                                                      |
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| Names & synonyms:  | <b>HYDROXYDIONE SODIUM:</b><br>21-hydroxypregnane-3,20-dione-21-sodium hemisuccinate.                          | <b>SPIRONOLACTONE:</b><br>3-(3-oxo-7 $\alpha$ -acetylthio-17 $\beta$ -hydroxy-4-androsten-17 $\alpha$ -yl)-propionic acid ; lactone. |
| Formulae:          | <br><chem>C25H35O6Na</chem> | <br><chem>C24H32O4S</chem>                       |
| Molecular weight   | 454.5                                                                                                          | 416.5                                                                                                                                |
| Melting point (°C) | 193–203 (dec.)                                                                                                 | 135 (preliminary)–202 (dec.)                                                                                                         |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} + 95$ (chloroform) for free acid.                                                   | ( $\alpha$ ) $\frac{25}{D} - 34$ (chloroform)                                                                                        |
| Absorption max.    | 280 m $\mu$ ( $\epsilon$ = 93.2)                                                                               | $\epsilon^{238} = 20,200$                                                                                                            |

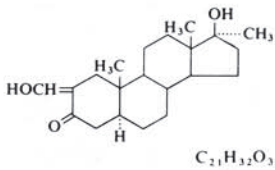
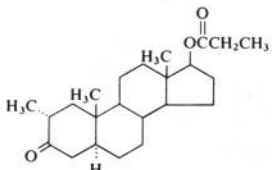
### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

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| Names & synonyms:  | METHANDROSTENOLONE:<br>17 $\alpha$ -methyl-17 $\beta$ -hydroxy-1,4-androstadien-3-one.                                              | METHYLANDROSTENEDIOL:<br>MAD;<br>methandriol;<br>17 $\alpha$ -methyl-5-androsten-3 $\beta$ ,17 $\beta$ -diol.                       | METHYL TESTOSTERONE:<br>17-methyl testosterone;<br>17 $\alpha$ -methyl- $\Delta^4$ -androsten-17- $\beta$ -ol-3-one;<br>17( $\beta$ )-hydroxy-17( $\alpha$ -methyl-4-androsten-3-one. |
| Formulae:          | <br>C <sub>20</sub> H <sub>28</sub> O <sub>2</sub> | <br>C <sub>20</sub> H <sub>32</sub> O <sub>2</sub> | <br>C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>                                                 |
| Molecular weight   | 300.4                                                                                                                               | 304.4                                                                                                                               | 302.4                                                                                                                                                                                 |
| Melting point (°C) | 166–167                                                                                                                             | 205–207                                                                                                                             | 161–166                                                                                                                                                                               |
| Specific rotation  | ( $\alpha$ ) $\frac{20}{D} + 9 - + 17$ (100 mg. in 10 ml. alcohol)                                                                  | ( $\alpha$ ) $\frac{20}{D} - 73$ (100 mg. in 10 ml. alcohol)                                                                        | ( $\alpha$ ) $\frac{25}{D} + 69 - + 75$ (100 mg. in 10 ml. dioxane)                                                                                                                   |
| Absorption max.    |                                                                                                                                     |                                                                                                                                     |                                                                                                                                                                                       |

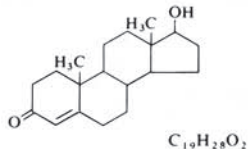
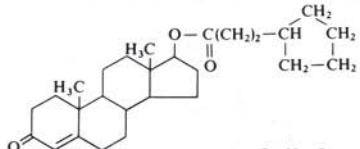
  

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| Names & synonyms:  | NORETHANDROLONE:<br>17 $\alpha$ -ethyl-19-nortestosterone;<br>17 $\alpha$ -ethyl-17-hydroxy-4-norandrosten-3-one;<br>17 $\alpha$ -ethyl-17-hydroxy-19-norandrost-4-en-3-one. | OXANDROLONE:<br>17 $\beta$ -hydroxy-17 $\alpha$ -methyl-2-oxa-5 $\alpha$ -androstane-3-one.                                            |
| Formulae:          | <br>C <sub>20</sub> H <sub>30</sub> O <sub>2</sub>                                        | <br>C <sub>18</sub> H <sub>30</sub> O <sub>3</sub> |
| Molecular weight   | 302.4                                                                                                                                                                        | 306.4                                                                                                                                  |
| Melting point (°C) | 130–136                                                                                                                                                                      | 230–233                                                                                                                                |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} + 21$ (dioxane)                                                                                                                                   | ( $\alpha$ ) $\frac{25}{D} - 21$ (1% in chloroform)                                                                                    |
| Absorption max.    | 240 m $\mu$ ( $\epsilon$ = 16,500)                                                                                                                                           | None                                                                                                                                   |

### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

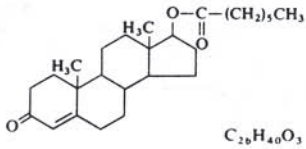
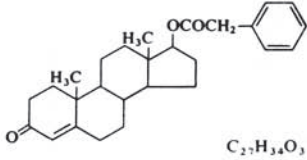
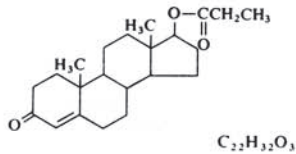
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| Names & synonyms:  | OXYMETHOLONE:<br>17 $\beta$ -hydroxy-2-hydroxymethylene-17 $\alpha$ -methyl-3-androstanone;<br>2-hydroxymethylene-17- $\alpha$ -methyl dihydrotestosterone.                      | PROMETHOLONE:<br>2 $\alpha$ -methyl-dihydro-testosterone propionate;<br>2 $\alpha$ -methyl-5 $\alpha$ -androstane-17 $\beta$ -ol-3-one-propionate.                  |
| Formulae:          | <br><chem>C[C@]12CC[C@@H]3[C@H]([C@@H]1CC[C@@H]2O)C(=O)C=C[C@]3(O)C</chem><br>$C_{21}H_{32}O_3$ | <br><chem>CCOC(=O)[C@]12CC[C@@H]3[C@H]([C@@H]1CC[C@@H]2O)C(=O)C=C[C@]3(C)C</chem> |
| Molecular weight   | 332.4                                                                                                                                                                            | 360.5                                                                                                                                                               |
| Melting point (°C) | 182                                                                                                                                                                              | 124–130                                                                                                                                                             |
| Specific rotation  | $(\alpha)_{\text{D}}^{25} = +36$ (200 mg. in 10 ml. dioxane)                                                                                                                     | $(\alpha)_{\text{D}}^{25} +22 - +29$ (200 mg. in 10 ml. chloroform)                                                                                                 |
| Absorption max.    | $E_1^1 = 547$ at 315 $m\mu$ (in alkaline methanol made 0.01 N with NaOH)                                                                                                         | without significant absorption from 220–300 $m\mu$ (methanol)                                                                                                       |

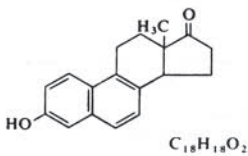
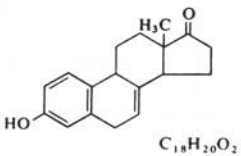
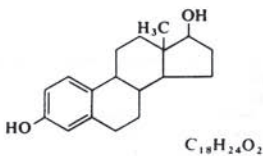
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| Names & synonyms:  | TESTOSTERONE:<br>trans-testosterone;<br>$\Delta^4$ -androst-17- $\beta$ -ol-3-one;<br>17 $\beta$ -hydroxy-4-androsten-3-one.                                                       | TESTOSTERONE CYPIONATE:<br>testosterone cyclopentylpropionate;<br>17 $\beta$ -hydroxy-4-androsten-3-one, cyclopentanepropionate.                                                                     |
| Formulae:          | <br><chem>C[C@]12CC[C@@H]3[C@H]([C@@H]1CC[C@@H]2O)C(=O)C=C[C@]3(C)C</chem><br>$C_{19}H_{28}O_2$ | <br><chem>CC1CCC(CC1)CC(=O)O[C@]23CC[C@@H]4[C@H]([C@@H]2CC[C@@H]3O)C(=O)C=C[C@]4(C)C</chem><br>$C_{27}H_{40}O_3$ |
| Molecular weight   | 288.4                                                                                                                                                                              | 412.6                                                                                                                                                                                                |
| Melting point (°C) | 151–156                                                                                                                                                                            | 100–102                                                                                                                                                                                              |
| Specific rotation  | $(\alpha)_{\text{D}}^{24} +109$ (400 mg. in 10 ml. alcohol)                                                                                                                        | $(\alpha)_D +88.5 \pm 3.5$ ( $\text{CHCl}_3$ )                                                                                                                                                       |
| Absorption max.    | 238 $m\mu$                                                                                                                                                                         | $\lambda_{\text{max}}$ 241 $m\mu$ ( $\epsilon$ 16,125)                                                                                                                                               |



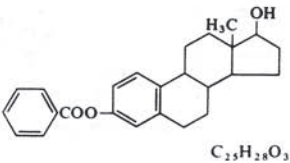
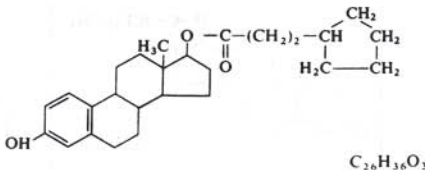
### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

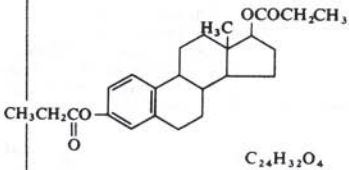
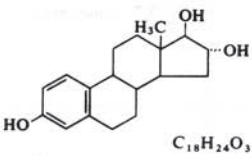
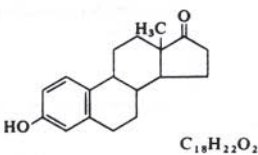
| Names & synonyms:  | TESTOSTERONE ENANTHATE;<br>testosterone heptanoate;<br>17 $\beta$ -hydroxyandrost-4-en-3-one-17-enanthate. | TESTOSTERONE PHENYLACETATE;<br>17 $\beta$ -hydroxy-4-androsten-3-one phenylacetate;<br>testosterone $\alpha$ -toluate. | TESTOSTERONE PROPIONATE;<br>$\Delta^4$ -androstene-17- $\beta$ -propionate-3-one.                        |
|--------------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Formulae:          | <br>$C_{26}H_{40}O_3$     | <br>$C_{27}H_{34}O_3$                | <br>$C_{22}H_{32}O_3$ |
| Molecular weight   | 400.6                                                                                                      | 406.5                                                                                                                  | 344.4                                                                                                    |
| Melting point (°C) | 34–39                                                                                                      | 129–131                                                                                                                | 118–122                                                                                                  |
| Specific rotation  | $(\alpha)_{\text{D}}^{25} + 77 - + 82$ (2 % in dioxane)                                                    | $(\alpha)_{\text{D}}^{25} + 101 \pm 3$ (1 % in chloroform)                                                             | $(\alpha)_{\text{D}}^{25} + 83 - + 90$ (100 mg. in 10 ml. dioxane)                                       |
| Absorption max.    | 241 m $\mu$ (in ethanol)                                                                                   | 241 m $\mu$ (in ethanol)                                                                                               |                                                                                                          |

### ESTROGENS

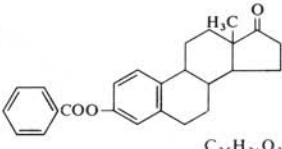
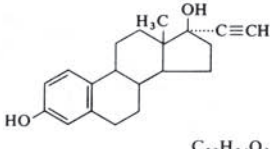
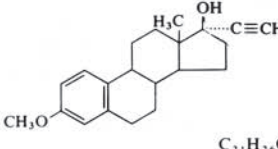
| Names & synonyms:  | EQUILENIN;<br>3-hydroxy-17-keto- $\Delta^{1,3,5-10,6,8}$ estrapentaene;<br>1,3,5-10,6,8-estrapentaen-3-ol-17-one. | EQUILIN;<br>3-hydroxy-17-keto- $\Delta^{1,3,5-10,7}$ estratetraene;<br>1,3,5,7-estratetraen-3-ol-17-one. | ESTRADIOL (formerly called $\alpha$ -estradiol);<br>$\beta$ -estradiol;<br>dihydrofolliculin;<br>dihydroxyestrin;<br>1,3,5-estratriene-3,17 $\beta$ -diol;<br>3,17-dihydroxy- $\Delta^{1,3,5-10}$ -estratriene;<br>3,17-epidihydroxyestratriene. |
|--------------------|-------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Formulae:          | <br>$C_{18}H_{18}O_2$          | <br>$C_{18}H_{20}O_2$ | <br>$C_{18}H_{24}O_2$                                                                                                                                       |
| Molecular weight   | 266.3                                                                                                             | 268.3                                                                                                    | 272.3                                                                                                                                                                                                                                            |
| Melting point (°C) | 258–259                                                                                                           | 236–240                                                                                                  | 173–179                                                                                                                                                                                                                                          |
| Specific rotation  | $(\alpha)_{\text{D}}^{25} + 89$ (dioxane)                                                                         | $(\alpha)_{\text{D}}^{25} + 308$ (200 mg. in 10 ml. dioxane);<br>$+ 325$ (200 mg. in 10 ml. alcohol).    | $(\alpha)_{\text{D}}^{25} + 76 - + 83$ (100 mg. in 10 ml. dioxane)                                                                                                                                                                               |
| Absorption max.    | 231, 270, 282, 292, 325, 340 m $\mu$                                                                              | 283–285 m $\mu$                                                                                          | 225, 280 m $\mu$                                                                                                                                                                                                                                 |

### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

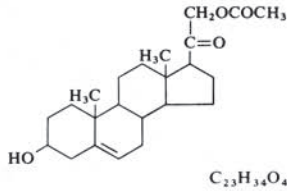
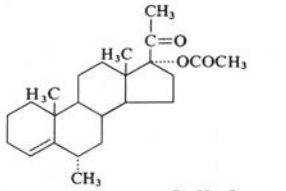
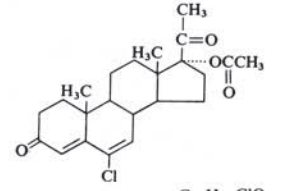
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| Names & synonyms:  | ESTRADIOL BENZOATE;<br>$\beta$ -estradiol-3-benzoate;<br>estradiol monobenzoate.                       | ESTRADIOL CYPIONATE;<br>estradiol cyclopentylpropionate;<br>$\beta$ -estradiol 17-cyclopentanepropionate;<br>1,3,5(10)-estratriene-3,17 $\beta$ -diol,17-cyclopentanepropionate. |
| Formulae:          | <br>$C_{25}H_{28}O_3$ | <br>$C_{26}H_{36}O_3$                                                                          |
| Molecular weight   | 376.4                                                                                                  | 396.6                                                                                                                                                                            |
| Melting point (°C) | 191–196                                                                                                | 151–154                                                                                                                                                                          |
| Specific rotation  | $(\alpha)_{\text{D}}^{25} + 58 - + 63$ (200 mg. in 10 ml. dioxane)                                     | $(\alpha)_{\text{D}} + 41.5 \pm 3.5$ (dioxane)                                                                                                                                   |
| Absorption max.    |                                                                                                        | 223 m $\mu$                                                                                                                                                                      |

|                    |                                                                                                          |                                                                                                                                                  |                                                                                                            |
|--------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| Names & synonyms:  | ESTRADIOL DIPROPIONATE;<br>$\alpha$ -estradiol dipropionate;<br>17 $\beta$ -estradiol dipropionate.      | ESTRIOL;<br>trihydroxyestrin;<br>$\Delta^{1,3,5-10}$ -estratriene-3-16-cis-17-trans-diol;<br>1,3,5-estratriene-3,16 $\alpha$ ,17 $\beta$ -triol. | ESTRONE;<br>folliculin;<br>keto-hydroxyestrin;<br>1,3,5-estratrien-3-ol-17-one.                            |
| Formulae:          | <br>$C_{24}H_{32}O_4$ | <br>$C_{18}H_{24}O_3$                                         | <br>$C_{18}H_{22}O_2$ |
| Molecular weight   | 384.5                                                                                                    | 288.3                                                                                                                                            | 270.3                                                                                                      |
| Melting point (°C) | 104–109                                                                                                  | 282                                                                                                                                              | 258–262                                                                                                    |
| Specific rotation  | $(\alpha)_{\text{D}}^{25} + 39 \pm 2$ (1 % in dioxane)                                                   | $(\alpha)_{\text{D}}^{25} + 53 - + 63$ (40 mg. in 1 ml. dioxane)                                                                                 | $(\alpha)_{\text{D}}^{25} + 158 - + 168$ (100 mg. in 10 ml. dioxane)                                       |
| Absorption max.    | 268 m $\mu$                                                                                              | 280 m $\mu$                                                                                                                                      | 283–285 m $\mu$                                                                                            |

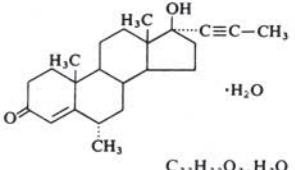
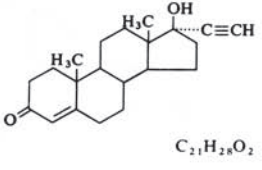
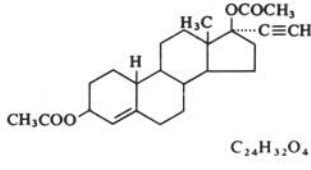
### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

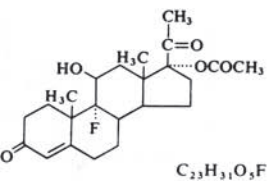
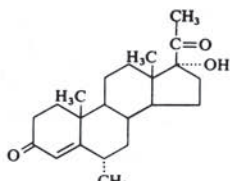
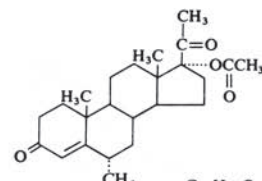
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|--------------------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Names & synonyms:  | ESTRONE BENZOATE                                                                                                                    | ETHYNYL ESTRADIOL;<br>17-ethinyl estradiol;<br>17 $\alpha$ -ethinyl-1,3,5-estratriene-3,17 $\beta$ -diol.                           | MESTRANOL;<br>ethynylestradiol 3-methyl ether;<br>3-methoxy-17 $\alpha$ -ethinyl-1,3,5(10)-<br>estratriene-17 $\beta$ -ol;<br>17 $\alpha$ -ethinyl-estradiol-3-methyl ether;<br>3-methoxy-19-nor-17 $\alpha$ -pregna-1,3,5,10-<br>trien-20-yn-17-ol. |
| Formulae:          | <br>C <sub>25</sub> H <sub>26</sub> O <sub>3</sub> | <br>C <sub>20</sub> H <sub>24</sub> O <sub>2</sub> | <br>C <sub>21</sub> H <sub>26</sub> O <sub>2</sub>                                                                                                                |
| Molecular weight   | 374.4                                                                                                                               | 296.4                                                                                                                               | 310.4                                                                                                                                                                                                                                                |
| Melting point (°C) | 220                                                                                                                                 | 141–146                                                                                                                             | 148–154                                                                                                                                                                                                                                              |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} + 120$ (dioxane)                                                                                         | ( $\alpha$ ) $\frac{25}{D} + 1 - + 10$ (100 mg. in 10 ml. dioxane)                                                                  | ( $\alpha$ ) $\frac{25}{D} + 2$ to $+ 8$ (200 mg. in 10 ml. dioxane)                                                                                                                                                                                 |
| Absorption max.    |                                                                                                                                     | 248 m $\mu$                                                                                                                         | 278 to 287 m $\mu$ (methanol)                                                                                                                                                                                                                        |

### PROGESTOGENS AND PROGESTINS (INCLUDING 19-NORSTEROID COMPOUNDS)

|                    |                                                                                                                                                                                                                           |                                                                                                                                                                                                               |                                                                                                                                                                   |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Names & synonyms:  | ACETOXYPREGNEOLONE;<br>21-acetoxypregnenolone;<br>prebediolone acetate;<br>$\Delta^5$ -pregnene-3 $\beta$ ,21-diol-20-one-21-monoacetate;<br>21-acetoxy-5-pregnone-3-ol-20-one;<br>3-hydroxy-21-acetoxy-5-pregnen-20-one. | ANAGESTONE ACETATE;<br>6 $\alpha$ -methyl-4-pregnen-17 $\alpha$ -ol-20-one acetate;<br>17 $\alpha$ -acetoxy-6 $\alpha$ -methylpregn-4-en-20-one;<br>17 $\alpha$ -acetoxy-6 $\alpha$ -methyl-4-pregnen-20-one. | CHLORMADINONE ACETATE;<br>6-chloro- $\Delta^6$ -dehydro-17 $\alpha$ -acetoxyprogesterone;<br>6-chloro- $\Delta^4$ -pregnadiene-17 $\alpha$ -ol-3,20-dioneacetate. |
| Formulae:          | <br>C <sub>23</sub> H <sub>34</sub> O <sub>4</sub>                                                                                     | <br>C <sub>24</sub> H <sub>36</sub> O <sub>3</sub>                                                                         | <br>C <sub>23</sub> H <sub>29</sub> ClO <sub>4</sub>                         |
| Molecular weight   | 374.5                                                                                                                                                                                                                     | 372.6                                                                                                                                                                                                         | 404.9                                                                                                                                                             |
| Melting point (°C) | 184–185                                                                                                                                                                                                                   | 172–178                                                                                                                                                                                                       | 204–212                                                                                                                                                           |
| Specific rotation  | ( $\alpha$ ) $\frac{20}{D} + 37 - + 43$ (dioxane)                                                                                                                                                                         | ( $\alpha$ ) $\frac{25}{D} + 40$ to $+ 45$ (10 mg. in 10 ml. chloroform)                                                                                                                                      | ( $\alpha$ ) $\frac{25}{D}$ 0 to $- 6$ (200 mg. in 10 ml. chloroform)                                                                                             |
| Absorption max.    |                                                                                                                                                                                                                           |                                                                                                                                                                                                               | 284 m $\mu$ (methanol)<br>Log $\epsilon$ = 4.34 $\pm$ 0.02                                                                                                        |

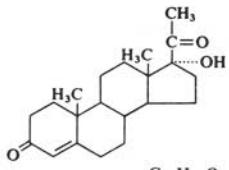
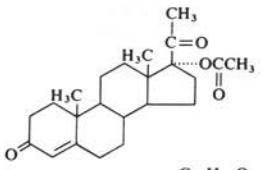
# STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

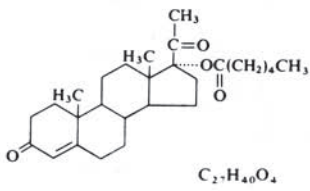
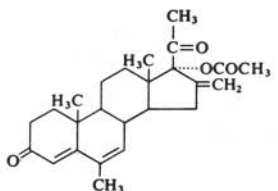
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| Names & synonyms:  | DIMETHISTERONE;<br>6 $\alpha$ ,21-dimethylethisterone;<br>6 $\alpha$ ,21-dimethyl-17 $\beta$ -hydroxy-17 $\alpha$ -pregn-4-en-20-yn-3-one;<br>6 $\alpha$ -methyl-17 $\alpha$ -propynylandrost-4-en-17 $\beta$ -ol-3-one;<br>17 $\beta$ -hydroxy-6 $\alpha$ -methyl-17 $\alpha$ -(prop-1-ynyl)-androst-4-ene-3-one. | ETHISTERONE;<br>anhydrohydroxyprogesterone;<br>ethinyl testosterone;<br>pregneninolone;<br>17 $\alpha$ ethynyl testosterone;<br>17 $\alpha$ -ethynyl-17 $\beta$ -hydroxy-4-androsten-3-one. | ETHYNODIOL DIACETATE;<br>17 $\alpha$ -ethynyl-4-estrene-3 $\beta$ ,17 $\beta$ -diol-17-diacetate;<br>19-nor-17 $\alpha$ -pregn-4-en-20-yne-3 $\beta$ ,17-diol diacetate. |
| Formulae:          | <br>$C_{23}H_{32}O_2 \cdot H_2O$                                                                                                                                                                                                  | <br>$C_{21}H_{28}O_2$                                                                                      | <br>$C_{24}H_{32}O_4$                                                                 |
| Molecular weight   | 358.5                                                                                                                                                                                                                                                                                                              | 312.4                                                                                                                                                                                       | 384.5                                                                                                                                                                    |
| Melting point (°C) | App. 100 (dec.)                                                                                                                                                                                                                                                                                                    | 266–273                                                                                                                                                                                     | 126–132                                                                                                                                                                  |
| Specific rotation  | ( $\alpha$ ) $\frac{20}{D} + 16.5$ to $+18.5$ (2 % solution in chloroform) (calculated to the anhydrous basis)                                                                                                                                                                                                     | ( $\alpha$ ) $\frac{25}{D} - 32^\circ$ (100 mg. in 10 ml. pyridine)                                                                                                                         | ( $\alpha$ ) $\frac{25}{D} - 74$ (1 % in chloroform)                                                                                                                     |
| Absorption max.    | App. 240 m $\mu$ (anhydrous ethanol)<br>$E_1^{1\%} = 443$                                                                                                                                                                                                                                                          | 241 m $\mu$ (methanol)                                                                                                                                                                      | None                                                                                                                                                                     |

|                    |                                                                                                             |                                                                                                                                                                              |                                                                                                                                                                                                              |
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| Names & synonyms:  | FLUROGESTONE ACETATE;<br>17 $\alpha$ -acetoxy-9 $\alpha$ -fluoro-11 $\beta$ -hydroxy-4-pregnene-3,20-dione. | HYDROXYMETHYLPROGESTERONE;<br>medroxyprogesterone;<br>17 $\alpha$ -hydroxy-6 $\alpha$ -methylprogesterone;<br>17 $\alpha$ -hydroxy-6 $\alpha$ -methyl-4-pregnene-3,20-dione. | HYDROXYMETHYLPROGESTERONE ACETATE;<br>medroxyprogesterone acetate;<br>17 $\alpha$ -hydroxy-6 $\alpha$ -methylprogesterone acetate;<br>17 $\alpha$ -hydroxy-6 $\alpha$ -methyl-4-pregnene-3,20-dione acetate. |
| Formulae:          | <br>$C_{23}H_{31}O_5F$   | <br>$C_{22}H_{32}O_3$                                                                     | <br>$C_{24}H_{34}O_4$                                                                                                   |
| Molecular weight   | 406.5                                                                                                       | 344.5                                                                                                                                                                        | 386.5                                                                                                                                                                                                        |
| Melting point (°C) | 250–251                                                                                                     | 220–223.5                                                                                                                                                                    | 202–207                                                                                                                                                                                                      |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} + 78$                                                                            | ( $\alpha$ ) $\frac{25}{D} + 75$                                                                                                                                             | ( $\alpha$ ) $\frac{25}{D} + 51$ (dioxane)                                                                                                                                                                   |
| Absorption max.    | 238 m $\mu$ ( $\epsilon = 17,100$ )                                                                         | 241 m $\mu$ ( $\epsilon = 16,150$ )                                                                                                                                          | 241 m $\mu$ ( $\alpha_M = 16,500$ ) ethanol                                                                                                                                                                  |

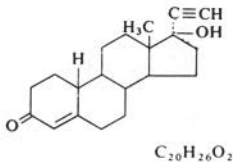
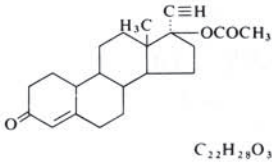


# STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

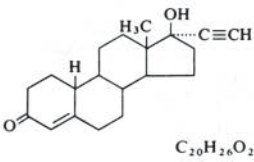
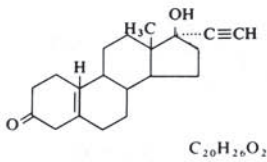
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| Names & synonyms:  | HYDROXYPROGESTERONE;<br>17 $\alpha$ -hydroxyprogesterone;<br>17 $\alpha$ -hydroxy-4-pregene-3,20 dione;<br>4-pregnen-17 $\alpha$ -ol-3,20-dione.  | HYDROXYPROGESTERONE ACETATE;<br>17 $\alpha$ -acetoxyprogesterone;<br>17 $\alpha$ -hydroxyprogesterone acetate;<br>17 $\alpha$ -hydroxy-4-pregnene-3,20 dione acetate. |
| Formulae:          |  <p style="text-align: center;"><math>C_{21}H_{30}O_3</math></p> |  <p style="text-align: center;"><math>C_{23}H_{32}O_4</math></p>                    |
| Molecular weight   | 330.4                                                                                                                                             | 372.5                                                                                                                                                                 |
| Melting point (°C) | 276                                                                                                                                               | 249–250                                                                                                                                                               |
| Specific rotation  | ( $\alpha$ ) $\frac{17}{D} + 105$ (104 mg. in 10 ml. chloroform)                                                                                  | ( $\alpha$ ) $\frac{25}{D} + 72$ (chloroform)                                                                                                                         |
| Absorption max.    |                                                                                                                                                   | 240 m $\mu$ ( $a_M = 16,875$ ) ethanol                                                                                                                                |

|                    |                                                                                                                                                     |                                                                                                                                                                                  |
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| Names & synonyms:  | HYDROXYPROGESTERONE CAPROATE;<br>17 $\alpha$ -hydroxyprogesterone caproate;<br>17 $\alpha$ -hydroxy-4-pregnene-3,20-dione caproate.                 | MELENGESTROL ACETATE: MGA;<br>17 $\alpha$ -hydroxy-6-methyl-16-methylene-4,6-pregnadiene-3,20-dione acetate;<br>6-dehydro-17-hydroxy-6-methyl-16-methylene-progesterone acetate. |
| Formulae:          |  <p style="text-align: center;"><math>C_{27}H_{40}O_4</math></p> |  <p style="text-align: center;"><math>C_{25}H_{32}O_4</math></p>                             |
| Molecular weight   | 428.6                                                                                                                                               | 396.51                                                                                                                                                                           |
| Melting point (°C) | 121–123                                                                                                                                             | 215–227                                                                                                                                                                          |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} + 57$ (chloroform)                                                                                                       | ( $\alpha$ ) <sub>D</sub> – 127 to – 135 (in $CHCl_3$ )                                                                                                                          |
| Absorption max.    |                                                                                                                                                     | 288 m $\mu$ ( $\epsilon_1^1 = 24,000$ ) (ethanol)                                                                                                                                |

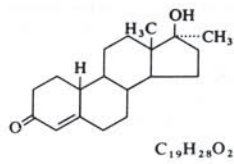
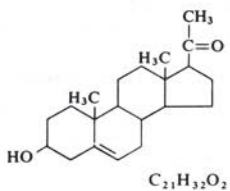
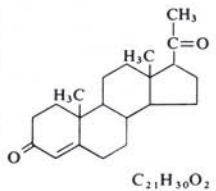
### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

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| Names & synonyms:  | <b>NORETHINDRONE;</b><br>Norethisterone;<br>17 $\alpha$ -ethynyl-19-nortestosterone;<br>17 $\alpha$ -ethynyl-17-hydroxy-19-nor-17 $\alpha$ -4-en-20-yn-3-one. | <b>NORETHINDRONE ACETATE;</b><br>17 $\alpha$ -ethynyl-19-nortestosterone acetate.                       |
| Formulae:          | <br>$C_{20}H_{26}O_2$                                                        | <br>$C_{22}H_{28}O_3$ |
| Molecular weight   | 298.4                                                                                                                                                         | 340.4                                                                                                   |
| Melting point (°C) | 202 and 208                                                                                                                                                   | 157–163                                                                                                 |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} - 30 - -35$ (200 mg. in 10 ml. dioxane)                                                                                            | ( $\alpha$ ) $\frac{25}{D} - 32 - -35$ (200 mg. in 10 ml. dioxane)                                      |
| Absorption max.    | $\alpha$ (1 %, 1 cm.) $\lambda$ 240 = 535 $\pm$ 15                                                                                                            | $\alpha$ (1 %, 1 cm.) $\lambda$ 240 = 490 to 520 (505 $\pm$ 15) (ethanol)                               |

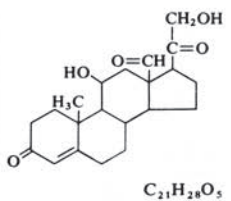
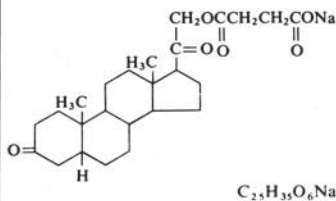
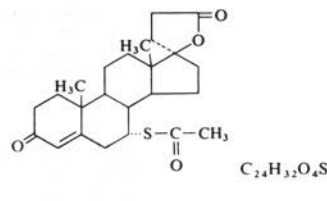
  

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| Names & synonyms:  | <b>NORETHISTERONE;</b><br>norethindrone;<br>19-norethisterone;<br>17 $\alpha$ -ethynyl-19-nor- $\Delta^4$ -androstan-17 $\beta$ -ol-3-one;<br>17 $\alpha$ -ethynyl-19-nor-testosterone;<br>17-hydroxy-3-oxo-19-nor-17 $\alpha$ -pregn-4-ene-20-yne;<br>17-hydroxy-19-nor-17 $\alpha$ -pregn-4-en-20-yn-3-one. | <b>NORETHYNODREL;</b><br>17 $\alpha$ -ethynyl-17 $\beta$ -hydroxy-5(10)-estren-3-one.                     |
| Formulae:          | <br>$C_{20}H_{26}O_2$                                                                                                                                                                                                      | <br>$C_{20}H_{26}O_2$ |
| Molecular weight   | 298.4                                                                                                                                                                                                                                                                                                         | 298.4                                                                                                     |
| Melting point (°C) | 200–207                                                                                                                                                                                                                                                                                                       | 174–184                                                                                                   |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} - 30 - -38$ (200 mg. in 10 ml. dioxane)                                                                                                                                                                                                                                            | ( $\alpha$ ) $\frac{25}{D} + 125$ (dioxane)                                                               |
| Absorption max.    | 240 m $\mu$ ( $\epsilon_1^1 = 576$ )                                                                                                                                                                                                                                                                          |                                                                                                           |

### STEROID HORMONES AND OTHER STEROIDAL SYNTHETICS (Continued)

|                    |                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                   |                                                                                                          |
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| Names & synonyms:  | <b>NORMETHISTERONE:</b><br>19-normethisterone;<br>normethandrolone; metalutin;<br>normetandrone;<br>17 $\alpha$ -methyl-19-nor- $\Delta^4$ -androstene-17 $\beta$ -ol-3-one;<br>17 $\alpha$ -methyl-19-nor-testosterone;<br>17 $\beta$ -hydroxy-3-oxo-17 $\alpha$ -methyl-estra-4-ene;<br>17 $\beta$ -hydroxy-17-methyl-estr-4-en-3-one. | <b>PREGNENOLONE:</b><br>$\Delta^5$ -pregnenolone;<br>$\Delta^5$ -pregnen-3 $\beta$ -ol-20-one;<br>17 $\beta$ (1-ketoethyl)- $\Delta^5$ -androstene-3 $\beta$ -ol. | <b>PROGESTERONE:</b><br>progestin;<br>progestone;<br>pregnendione;<br>$\Delta^4$ -pregnene-3,20-dione.   |
| Formulae:          | <br>$C_{19}H_{28}O_2$                                                                                                                                                                                                                                   | <br>$C_{21}H_{32}O_2$                                                            | <br>$C_{21}H_{30}O_2$ |
| Molecular weight   | 288.4                                                                                                                                                                                                                                                                                                                                    | 308.4                                                                                                                                                             | 314.4                                                                                                    |
| Melting point (°C) | 153–158                                                                                                                                                                                                                                                                                                                                  | 193                                                                                                                                                               | ( $\beta$ ) isomer 121; ( $\alpha$ ) isomer 127–131                                                      |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} + 25$ to $+29$ (200 mg. in 10 ml. chloroform)                                                                                                                                                                                                                                                                 | ( $\alpha$ ) $\frac{20}{D} + 28$ – $+30$ (alcohol)                                                                                                                | ( $\alpha$ ) $\frac{20}{D} + 172$ – $+182$ (200 mg. in 10 ml. dioxane)                                   |
| Absorption max.    | 241 m $\mu$ – 565 $\pm$ 15                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                   | 240 m $\mu$                                                                                              |

### DIURETIC, ANTIDIURETIC AND LOCAL ANESTHETIC AGENTS

|                    |                                                                                                                             |                                                                                                             |                                                                                                                                             |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Names & synonyms:  | <b>ALDOSTERONE:</b><br>electrocortin;<br>18-oxocorticosterone;<br>18-formyl-11 $\beta$ ,21-dihydroxy-4-pregnene-3,20-dione. | <b>HYDROXYDIONE SODIUM:</b><br>21-hydroxypregnane-3,20-dione-21-sodium hemisuccinate.                       | <b>SPIRONOLACTONE:</b><br>3-(3-oxo-7 $\alpha$ -acetylthio-17 $\beta$ -hydroxy-4-androsten-17 $\alpha$ -yl)-propionic acid $\gamma$ lactone. |
| Formulae:          | <br>$C_{21}H_{28}O_5$                    | <br>$C_{25}H_{35}O_6Na$ | <br>$C_{24}H_{32}O_4S$                                 |
| Molecular weight   | 360.4                                                                                                                       | 454.5                                                                                                       | 416.5                                                                                                                                       |
| Melting point (°C) | 108–112 (hydrate); 164 (anhydrous)                                                                                          | 193–203 (dec.)                                                                                              | 135; 202 (dec.)                                                                                                                             |
| Specific rotation  | ( $\alpha$ ) $\frac{25}{D} + 161$ (10 mg. in 10 ml. chloroform)                                                             | ( $\alpha$ ) $\frac{25}{D} + 95$ (chloroform) for free acid.                                                | ( $\alpha$ ) $\frac{25}{D} - 34$ (chloroform)                                                                                               |
| Absorption max.    | 240 m $\mu$ (log $\epsilon$ = 4.20 monohydr.; $\epsilon$ mol. 15,000 anhydr.)                                               | 280 m $\mu$ ( $\epsilon$ = 93.2)                                                                            | $\epsilon^{238} = 20,200$                                                                                                                   |

# SURFACE TENSION OF LIQUID ELEMENTS

Gernot Lang

The following data were collected from many sources. As a result their accuracy varies. Users of data in this table are advised that:

1. As a rule, results from the "sessile drop" and "maximum bubble pressure" as well as from the "pendant drop" methods are preferable to results obtained from other methods for metals with very high melting points.
2. Values of single measurements are usually not as well supported by experiments as those of serial measurements at various temperatures.
3. Values in parentheses can be considered improbable.

The units of  $\sigma$  are mN/m.

| Values of $\sigma$ at various temperatures |                   |                      |                     |                                                                                          |               |                                                              |              |                          |          |                          |      |         |
|--------------------------------------------|-------------------|----------------------|---------------------|------------------------------------------------------------------------------------------|---------------|--------------------------------------------------------------|--------------|--------------------------|----------|--------------------------|------|---------|
| Element                                    | Purity<br>(wt. %) | $\sigma_{mp}$ (mN/m) | Atm.                | $t/^{\circ}\text{C}$                                                                     | $\sigma$      | $t/^{\circ}\text{C}$                                         | $\sigma$     | $t/^{\circ}\text{C}$     | $\sigma$ | Method                   | Year | Ref.    |
| Ag                                         | 99.99             |                      | H <sub>2</sub>      | 1000                                                                                     | 916           |                                                              |              |                          |          | Bubble pressure          | 1959 | 134     |
|                                            | —                 | (785)                | vac.                |                                                                                          |               |                                                              |              |                          |          | Pendant drop             | 1959 | 182     |
|                                            | 99.96             |                      | H <sub>2</sub>      | 1000                                                                                     | 893           | 1150                                                         | 862          | 1250                     | 849      | Bubble pressure          | 1961 | 127     |
|                                            | —                 |                      | vac.                | 1000                                                                                     | 908           |                                                              |              |                          |          | Sessile drop             | 1963 | 51      |
|                                            | 99.995            |                      | H <sub>2</sub>      | 1000                                                                                     | 907           | 1100                                                         | 894          | 1200                     | 876      | Bubble pressure          | 1964 | 128     |
|                                            | 99.999            | (828)                | vac.                |                                                                                          |               |                                                              |              |                          |          | Pendant drop             | 1965 | 65      |
|                                            | 99.99             |                      | Ar, H <sub>2</sub>  | 1000                                                                                     | 890           |                                                              |              |                          |          | Bubble pressure          | 1966 | 169     |
|                                            | Spect. pure       | 921                  | —                   | $\sigma_t = 1136 - 0.174 \cdot T$ (K) (1300—2200 K)                                      |               |                                                              |              |                          |          | Bubble pressure          | 1968 | 26      |
|                                            |                   | 918                  | —                   | $\sigma_t = 918 - 0.149 (t - t_{mp})$ ( $^{\circ}\text{C}$ )                             |               |                                                              |              |                          |          | Bubble pressure          | 1969 | 204     |
|                                            | 99.999            |                      | Ar                  | 980                                                                                      | $905 \pm 10$  | 1108                                                         | $890 \pm 10$ |                          |          | Sessile drop             | 1971 | 212     |
|                                            | 99.999            | 926                  | vac.                | $\sigma_t = 926 - 0.15 (t - t_{mp})$                                                     |               |                                                              |              |                          |          | Sessile drop             | 1972 | 224     |
|                                            | —                 | —                    | vac.                | $d\sigma/dt = -0.11$                                                                     |               |                                                              |              |                          |          | Sessile drop             | 1961 | 262     |
|                                            | 99.999            | 964                  | H <sub>2</sub> , Ar | $\sigma_t = 964 - 0.185 (t - t_{mp})$ ( $^{\circ}\text{C}$ ) (—1450 $^{\circ}\text{C}$ ) |               |                                                              |              |                          |          | Sessile drop             | 1976 | 276     |
|                                            | 99.999            | 957                  | vac.                | $\sigma_t = 957 - 0.14 (t - t_{mp})$ ( $^{\circ}\text{C}$ ) (—1100 $^{\circ}\text{C}$ )  |               |                                                              |              |                          |          | Sessile drop             | 1970 | 282     |
|                                            | 99.999            | 918                  | Ar                  | $\sigma_t = 918 - 0.16 (t - t_{mp})$ ( $^{\circ}\text{C}$ ) 985—1240 $^{\circ}\text{C}$  |               |                                                              |              |                          |          | Bubble pressure          | 1970 | 289     |
| Al                                         | —                 | (385)                | air                 |                                                                                          |               |                                                              |              |                          |          | Pendant drop             | 1897 | 168     |
|                                            | —                 | (520)                | CO <sub>2</sub>     | 700—820                                                                                  | (520)         |                                                              |              |                          |          | Capillary method         | 1914 | 183     |
|                                            | —                 | (300)                | Ar                  |                                                                                          |               |                                                              |              |                          |          | Bubble pressure          | 1936 | 161     |
|                                            | —                 |                      | Ar                  | 706                                                                                      | (494)         | 935                                                          | (463)        |                          |          | Bubble pressure          | 1937 | 208     |
|                                            | —                 | (502)                | air                 |                                                                                          |               |                                                              |              |                          |          | Ring removal             | 1937 | 96      |
|                                            | 99.5              | (915)                | N <sub>2</sub>      | 720                                                                                      | (890)         | 800                                                          | (865)        |                          |          | Bubble pressure          | 1948 | 149     |
|                                            | 99.99             | $860 \pm 20$         | Ar                  |                                                                                          |               |                                                              |              |                          |          | Bubble pressure          | 1956 | 102     |
|                                            | 99.72             |                      | vac.                | 950                                                                                      | 840           |                                                              |              |                          |          | Bubble pressure          | 1958 | 46      |
|                                            | 99.7              | $863 \pm 25$         | Ar                  | $\sigma_t = (863 \pm 25) - 0.33 (t - t_{mp})$ ( $^{\circ}\text{C}$ )                     |               |                                                              |              |                          |          | Bubble pressure          | 1959 | 113     |
|                                            | 99.99             | 865                  | vac.                | $\sigma_t = 865 - 0.14 (t - t_{mp})$ ( $^{\circ}\text{C}$ )                              |               |                                                              |              |                          |          | Sessile drop             | 1961 | 56, 137 |
|                                            | 99.99             | (825)                | Ar                  | $(\sigma_t = 825 - 0.05 (T - 993))$ (T K)                                                |               |                                                              |              |                          |          | Bubble pressure          | 1964 | 38      |
|                                            | 99.996            | 866                  | He                  | $\sigma_t = 866 - 0.15 (t - t_{mp})$ ( $^{\circ}\text{C}$ )                              |               |                                                              |              |                          |          | Sessile drop             | 1968 | 10      |
|                                            | 99.999            | 873                  | He                  | 1600                                                                                     | 725           | $(\sigma_t = 873 - 0.15 (t - t_{mp})$ ( $^{\circ}\text{C}$ ) |              |                          |          | Sessile drop             | 1969 | 199     |
|                                            | 99.99             | (760)                | vac.                | $(\sigma_t = 948 - 0.202T)$ (T K, 980—1090 K)                                            |               |                                                              |              |                          |          | Sessile drop             | 1970 | 213     |
|                                            | 99.998            | (915)                | Ar                  | $(\sigma_t = 915 - 0.51 (t - t_{mp})$ ( $^{\circ}\text{C}$ )                             |               |                                                              |              |                          |          | Sessile drop             | 1971 | 219     |
|                                            | 99.996            | $855 \pm 6$          | Ar                  | $(660 - 800^{\circ}\text{C})$                                                            |               |                                                              |              |                          |          | Bubble pressure          | 1972 | 222     |
|                                            |                   |                      |                     | $\sigma_t = 855 - 0.104 (t - t_{mp})$ ( $^{\circ}\text{C}$ )                             |               |                                                              |              |                          |          |                          |      |         |
|                                            |                   |                      |                     | $(660 - 911^{\circ}\text{C})$                                                            |               |                                                              |              |                          |          |                          |      |         |
|                                            | 99.99             | 860                  | vac.                | $\sigma_t = 860 - 0.19 (t - t_{mp})$                                                     |               |                                                              |              |                          |          | Sessile drop             | 1972 | 225     |
|                                            | 99.99             |                      | He                  | 1650                                                                                     | 718           |                                                              |              |                          |          | Sessile drop             | 1972 | 228     |
|                                            | 99.99             | 870                  | vac., He            | $\sigma_t = 870 - 0.195 (T - T_{mp})$ (T K)                                              |               |                                                              |              |                          |          | Sessile drop             | 1973 | 225     |
|                                            | 99.999            | 865                  | vac.                | $\sigma_t = 865 - 0.16 (T - 933)$ (T K)                                                  |               |                                                              |              |                          |          | Sessile drop             | 1971 | 236     |
|                                            | 99.996            | 868                  | Ar                  | $\sigma_t = 868 - 0.152 (t - t_{mp})$ ( $\pm 2$ ) ( $^{\circ}\text{C}$ )                 |               |                                                              |              |                          |          | Bubble pressure          | 1974 | 245     |
|                                            | 99.99             | 870                  | vac.                | $\sigma_t = 870 - 0.195 (t - t_{mp})$ ( $^{\circ}\text{C}$ )                             |               |                                                              |              |                          |          | Sessile drop             | 1974 | 247     |
|                                            | 99.997            | (788)                | vac.                | $(\sigma_t = 788 - 0.286 (t - t_{mp})$ ( $^{\circ}\text{C}$ ))                           |               |                                                              |              |                          |          | Sessile drop             | 1974 | 259     |
|                                            | 99.996            | 865                  | vac.                | $\sigma_t = 865 - 0.15 (t - t_{mp}) - 915^{\circ}\text{C}$                               |               |                                                              |              |                          |          | Sessile drop             | 1976 | 267     |
|                                            | 99.99             | 865                  | vac.                | $\sigma_t = 865 - 0.16 (T - T_{mp}) - 1473$ K                                            |               |                                                              |              |                          |          | Sessile drop             | 1974 | 273     |
|                                            | 99.999            | 865                  | vac.                | $\sigma_t = 865 - 0.12 (T - T_{mp})$                                                     |               |                                                              |              | —1173 K                  |          | Sessile drop             | 1979 | 288     |
| Ar                                         | 99.999            | —                    | Ar                  | $700 \pm 10$                                                                             | $860 \pm 10$  |                                                              |              |                          |          | Bubble pressure          | 1979 | 288     |
|                                            | 99.93             | 13.12                | Ar                  | 90 K                                                                                     | 11.86         | 125 K                                                        | 3.94         | 145 K                    | 0.57     | Bubble pressure          | 1965 | 308     |
| Au                                         |                   |                      | H <sub>2</sub>      | 1070                                                                                     | (983)         |                                                              |              |                          |          | Pendant drop             | 1868 | 165     |
|                                            |                   | 1134                 | H <sub>2</sub> , Ar | 1120                                                                                     | 1128          | 1200                                                         | 1120         | 1310                     | 1109     | Bubble pressure          | 1929 | 111     |
|                                            |                   | (754)                | vac.                |                                                                                          |               |                                                              |              |                          |          | Pendant drop             | 1959 | 182     |
|                                            | 99.999            | 1130                 | He                  | 1200                                                                                     | 1070          | 1300                                                         | 1020         |                          |          | Sessile drop             | 1965 | 86      |
|                                            | 99.999            | (731)                | vac.                |                                                                                          |               |                                                              |              |                          |          | Pendant drop             | 1965 | 65      |
|                                            | 99.999            |                      | Ar                  | 1108                                                                                     | $1130 \pm 10$ |                                                              |              |                          |          | Sessile drop             | 1971 | 212     |
|                                            | 99.999            |                      | He                  | 1100                                                                                     | $1130 \pm 10$ |                                                              |              |                          |          | Sessile drop             | 1972 | 225     |
|                                            | 99.99             | 1185                 | H <sub>2</sub> , Ar | $\sigma_t = 1185 - 0.251 (t - t_{mp})$ ( $^{\circ}\text{C}$ )                            |               |                                                              |              | —1450 $^{\circ}\text{C}$ |          | Sessile drop             | 1976 | 276     |
| B                                          | 99.8              | $1060 \pm 50$        | vac.                |                                                                                          |               |                                                              |              |                          |          | Sessile and pendant drop | 1963 | 187     |
| Ba                                         | —                 |                      | Ar                  | 720                                                                                      | 224           |                                                              |              |                          |          | Bubble pressure          | 1963 | 3       |
|                                            | 99.5              | 276                  |                     | $\sigma = 351 - 0.075 \cdot T$ K (1410—1880 K)                                           |               |                                                              |              |                          |          | Bubble pressure          | 1968 | 25      |
|                                            | 99.9              | 267.6                | He                  | $\sigma_t = 267.6 (\pm 1.48) - 0.0690 (T \text{ K}) (T - T_{mp})$ (—1800 K)              |               |                                                              |              |                          |          | Bubble pressure          | 1977 | 286     |
| Be                                         | 99.98             |                      | vac.                | 1500                                                                                     | 1100          |                                                              |              |                          |          | Sessile drop             | 1960 | 58      |
| Bi                                         |                   | 378                  | H <sub>2</sub>      | 320                                                                                      | 375           | 472                                                          | 365          |                          |          | Drop pressure            | 1921 | 78      |



# SURFACE TENSION OF LIQUID ELEMENTS (continued)

| Values of $\sigma$ at various temperatures |                   |                      |                                                 |                                                                        |           |                      |                    |                       |          |                       |      |      |
|--------------------------------------------|-------------------|----------------------|-------------------------------------------------|------------------------------------------------------------------------|-----------|----------------------|--------------------|-----------------------|----------|-----------------------|------|------|
| Element                                    | Purity<br>(wt. %) | $\sigma_{mp}$ (mN/m) | Atm.                                            | $t/^{\circ}\text{C}$                                                   | $\sigma$  | $t/^{\circ}\text{C}$ | $\sigma$           | $t/^{\circ}\text{C}$  | $\sigma$ | Method                | Year | Ref. |
| Br                                         |                   | 390                  | H <sub>2</sub>                                  | 300                                                                    | 388       | 400                  | 380                | 962                   | 340      | Bubble pressure       | 1926 | 19   |
|                                            |                   | 374                  | H <sub>2</sub>                                  | 583                                                                    | 353.9     | 770                  | 342                |                       |          | Bubble pressure       | 1926 | 173  |
|                                            |                   | 393.4                | vac.                                            | 400                                                                    | 373.8     | 500                  | 353.2              |                       |          | Drop weight           | 1927 | 131  |
|                                            |                   | 393                  | air                                             | 280                                                                    | 392       | 340                  | 384                |                       |          | Ring removal          | 1949 | 98   |
|                                            |                   | 370                  | vac.                                            | 450                                                                    | 358       |                      |                    |                       |          | Drop pressure         | 1952 | 163  |
|                                            |                   |                      | —                                               | 400                                                                    | (310)     |                      |                    |                       |          | Bubble pressure       | 1953 | 13   |
|                                            |                   | 376                  | vac.                                            | $\sigma = 376 - 0.075(t - t_{mp})$                                     |           |                      |                    |                       |          | Drop pressure         | 1954 | 112  |
|                                            | 99.99             | 376                  | vac.                                            |                                                                        |           |                      |                    |                       |          | Drop pressure         | 1956 | 156  |
|                                            | 99.90             | 386                  | H <sub>2</sub>                                  | 800                                                                    | 343       | 1000                 | 328                |                       |          | Bubble pressure       | 1956 | 134  |
|                                            |                   |                      | vac.                                            | 450                                                                    | 382       |                      |                    |                       |          | Electro-capillarity   | 1959 | 118  |
|                                            | 99.9              | 380 ± 10             | Ar                                              |                                                                        |           |                      |                    |                       |          | Bubble pressure       | 1960 | 103  |
|                                            |                   |                      | —                                               | 350                                                                    | 362       |                      |                    |                       |          | Drop pressure         | 1960 | 76   |
|                                            |                   |                      | vac.                                            | 700                                                                    | 350       |                      |                    |                       |          | Sessile drop          | 1961 | 29   |
|                                            | 99.98             | 380 ± 10             | Ar                                              |                                                                        |           |                      |                    |                       |          | Bubble pressure       | 1961 | 105  |
|                                            |                   |                      | vac.                                            | 450                                                                    | 380       |                      |                    |                       |          | Drop pressure         | 1962 | 120  |
|                                            |                   |                      | vac.                                            | 300                                                                    | 379       |                      |                    |                       |          | Sessile drop          | 1964 | 64   |
|                                            |                   | 378                  | vac., Ar,<br>H <sub>2</sub>                     |                                                                        |           |                      |                    |                       |          | Drop weight           | 1966 | 4    |
|                                            | 99.99995          | 375                  |                                                 | $\sigma = 423 - 0.088 \cdot T$ (T K) (1352—1555 K)                     |           |                      |                    |                       |          | Bubble pressure       | 1968 | 26   |
|                                            | 99.999            | 380 ± 3              | Ar                                              | $\sigma_t = 380 - 0.142(t - t_{mp})$ (t <sup>o</sup> C)                |           |                      |                    |                       |          | Bubble pressure       | 1972 | 223  |
|                                            | 99.999            | 376                  | Ar                                              | $\sigma_t = 376 - 0.070(t - t_{mp}) - 565^{\circ}\text{C}$             |           |                      |                    |                       |          | Bubble pressure       | 1976 | 267  |
|                                            | 99.999            | 372                  | Ar                                              | $\sigma_t = 372 - 0.089(t - t_{mp}) - 719^{\circ}\text{C}$             |           |                      |                    |                       |          | Sessile drop          | 1976 | 267  |
|                                            | chem. pure        | 386                  | Ar                                              | $\sigma_t = 386 - 0.07(t - t_{mp}) - 680^{\circ}\text{C}$              |           |                      |                    |                       |          | Bubble pressure       | 1977 | 274  |
|                                            | 99.99999          | 373                  | vac.                                            | $\sigma_t = 373 - 0.07(t - t_{mp}) - 500^{\circ}\text{C}$              |           |                      |                    |                       |          | levitated drop        | 1964 | 280  |
|                                            | 99.98             | 46.8                 | Air                                             | $\sigma = 45.5 - 0.182 \cdot t$ (t <sup>o</sup> C) 0—50 <sup>o</sup> C |           |                      |                    |                       |          | Capillary rise        | 1964 | 306  |
|                                            | —                 |                      | Ar                                              | 850                                                                    | 337       |                      |                    |                       |          | Bubble pressure       | 1963 | 3    |
|                                            | p.a.              | 360                  |                                                 | $\sigma = 472 - 0.100 \cdot T$ (T K) (144—1655 K)                      |           |                      |                    |                       |          | Bubble pressure       | 1968 | 25   |
| Cd                                         |                   | (693)                | H <sub>2</sub>                                  |                                                                        |           |                      |                    |                       |          | Drop weight           | 1868 | 166  |
|                                            |                   |                      | H <sub>2</sub>                                  | 339                                                                    | 606       | 421                  | 622                | 544                   | 616      | Drop pressure         | 1921 | 78   |
|                                            |                   |                      | H <sub>2</sub>                                  | 330                                                                    | 570       | 400                  | 597                | 600                   | 585      | Bubble pressure       | 1927 | 20   |
|                                            |                   |                      |                                                 |                                                                        |           |                      | (nonlinear)        |                       |          |                       |      |      |
|                                            |                   | (666.1)              | vac.                                            | 589                                                                    | (590.6)   |                      |                    |                       |          | Drop weight           | 1927 | 131  |
|                                            |                   |                      | air                                             | 420                                                                    | 622       |                      |                    |                       |          | Ring removal          | 1937 | 96   |
|                                            |                   | 630                  | —                                               |                                                                        |           |                      |                    |                       |          | —                     | 1940 | 12   |
|                                            | 99.97             |                      | H <sub>2</sub> , N <sub>2</sub>                 | 330                                                                    | 564       | 410                  | 600                | 500                   | 600      | Bubble pressure       | 1947 | 71   |
|                                            |                   |                      |                                                 |                                                                        |           |                      | (nonlinear)        |                       |          |                       |      |      |
|                                            |                   |                      | —                                               | 450                                                                    | 600       |                      |                    |                       |          | Drop pressure         | 1953 | 118  |
|                                            |                   |                      | —                                               | 400                                                                    | 600       |                      |                    |                       |          | Bubble pressure       | 1953 | 13   |
|                                            |                   |                      | —                                               | 350                                                                    | 586       |                      |                    |                       |          | Drop pressure         | 1959 | 69   |
|                                            | 99.9              | 550 ± 10             | Ar                                              |                                                                        |           |                      |                    |                       |          | Bubble pressure       | 1960 | 103  |
|                                            |                   |                      |                                                 | 390                                                                    | 604       |                      |                    |                       |          | Bubble pressure       | 1970 | 1    |
| Ce                                         |                   | 525 ± 30             | H <sub>2</sub>                                  |                                                                        |           |                      |                    |                       |          | Solid state curvature | 1955 | 217  |
|                                            | 99.9999           | 59 ± 5               | —                                               |                                                                        |           |                      | (nonlinear)        |                       |          | Sessile drop          | 1972 | 221  |
|                                            | —                 | 570                  | —                                               |                                                                        |           |                      |                    |                       |          | —                     | 1962 | 122  |
|                                            | 99.999            |                      | H <sub>2</sub>                                  | 427                                                                    | 609       |                      | (nonlinear)        |                       |          | Bubble pressure       | 1977 | 287  |
|                                            | 99.9995           | 640                  |                                                 | $\sigma = 640 - 0.13(T - 598 \text{ K})$ (325—800 K)                   |           |                      |                    |                       |          |                       | 1977 | 298  |
|                                            | —                 | 740                  | vac.                                            | $\sigma_t = 740 - 0.33(t - t_{mp})$                                    |           |                      |                    |                       |          | Sessile drop          | 1955 | 260  |
| Co                                         |                   |                      | Ar                                              | 1550                                                                   | 1836      |                      |                    |                       |          | Sessile drop          | 1957 | 108  |
|                                            | 99.99             |                      | vac. Al <sub>2</sub> O <sub>3</sub>             | 1520                                                                   | 1800      |                      |                    |                       |          | Sessile drop          | 1958 | 46   |
|                                            | 99.99             |                      | He, Al <sub>2</sub> O <sub>3</sub>              | 1520                                                                   | (1630)    |                      |                    |                       |          | Sessile drop          | 1958 | 46   |
|                                            | 99.99             |                      | He, BeO                                         | 1520                                                                   | (1640)    |                      |                    |                       |          | Sessile drop          | 1958 | 46   |
|                                            | 99.99             |                      | He, MgO                                         | 1520                                                                   | (1560)    |                      |                    |                       |          | Sessile drop          | 1958 | 46   |
|                                            | 99.99             |                      | H <sub>2</sub> , Al <sub>2</sub> O <sub>3</sub> | 1520                                                                   | 1780      |                      |                    |                       |          | Sessile drop          | 1958 | 46   |
|                                            | 99.99             |                      | He                                              | 1520                                                                   | (1620)    |                      |                    |                       |          | Bubble pressure       | 1958 | 46   |
|                                            | 99.99             |                      | H <sub>2</sub>                                  | 1520                                                                   | (1590)    |                      |                    |                       |          | Bubble pressure       | 1958 | 46   |
|                                            |                   |                      | vac.                                            | 1500                                                                   | 1870      |                      |                    |                       |          | Sessile drop          | 1959 | 7    |
|                                            |                   |                      |                                                 | 1600                                                                   | (1640)    |                      |                    |                       |          | Sessile drop          | 1960 | 135  |
|                                            |                   |                      |                                                 | 1600                                                                   | (1600)    |                      |                    |                       |          | Sessile drop          | 1960 | 135  |
|                                            |                   |                      | vac.                                            | 1600                                                                   | 1815      |                      |                    |                       |          | Sessile drop          | 1960 | 53   |
|                                            | 99.99             |                      | vac., Al <sub>2</sub> O <sub>3</sub>            | 1600                                                                   | 1812      |                      |                    |                       |          | Sessile drop          | 1961 | 54   |
|                                            |                   | (1520)               | H <sub>2</sub> , He                             |                                                                        |           |                      |                    |                       |          | Bubble pressure       | 1961 | 61   |
|                                            | 99.99             |                      | H <sub>2</sub> , He                             | 1550                                                                   | 1845      |                      |                    |                       |          | Bubble pressure       | 1962 | 63   |
| Cr                                         | 99.9983           | 1880                 | vac.                                            |                                                                        |           |                      |                    |                       |          | Pendant drop          | 1963 | 5    |
|                                            | 99.99             |                      |                                                 | 1550                                                                   | 1780      |                      |                    |                       |          | Bubble pressure       | 1965 | 59   |
|                                            | —                 |                      | He                                              | 1527                                                                   | 1852      |                      |                    |                       |          | Sessile drop          | 1971 | 233  |
|                                            | 99.8              |                      | vac.                                            | 1500                                                                   | 1880      |                      |                    |                       |          | Sessile drop          | 1962 | 248  |
|                                            | —                 |                      | vac.                                            | 1530                                                                   | 1864      |                      |                    |                       |          | Sessile drop          | 1976 | 283  |
|                                            | 99.95             | 846                  | He                                              | $\sigma_t = 1846 - 0.41(t - t_{mp})$                                   |           |                      | (t <sup>o</sup> C) | — 2200 <sup>o</sup> C |          | Sessile drop          | 1978 | 291  |
|                                            | —                 | —                    | —                                               | 1550                                                                   | 1807      |                      |                    |                       |          | Sessile drop          | 1972 | 296  |
|                                            | —                 | —                    | vac.                                            | 1950                                                                   | 1590 ± 50 |                      |                    |                       |          | Sessile drop          | 1959 | 47   |
|                                            | 99.9997           | 1700 ± 50            | Ar                                              |                                                                        |           |                      |                    |                       |          | Dynam. drop weight    | 1964 | 6    |
|                                            | —                 | —                    | Ar, He                                          | 1800                                                                   | 1520      |                      |                    |                       |          | Sessile drop          | 1979 | 293  |

# SURFACE TENSION OF LIQUID ELEMENTS (continued)

| Values of $\sigma$ at various temperatures |                   |                      |                                                                                  |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     |                                   |      |     |
|--------------------------------------------|-------------------|----------------------|----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|----------------------|----------|-------------------------|---------------------------------|-------------------------------------|-----------------------------------|------|-----|
| Element                                    | Purity<br>(wt. %) | $\sigma_{mp}$ (mN/m) | Atm.                                                                             | $t/^{\circ}\text{C}$                                                                                                                                                         | $\sigma$                            | $t/^{\circ}\text{C}$ | $\sigma$ | $t/^{\circ}\text{C}$    | $\sigma$                        | Method                              | Year                              | Ref. |     |
| Cs                                         |                   | 67.0                 | Ar                                                                               | 62                                                                                                                                                                           |                                     |                      |          |                         |                                 | $-280^{\circ}$                      | Pendant drop                      | 1962 | 195 |
|                                            |                   |                      | Ar                                                                               | 62                                                                                                                                                                           | 67.5                                | 146                  | 62.9     |                         |                                 |                                     | Bubble pressure                   | 1962 | 193 |
|                                            | 99.95             | 70.0                 | Ar                                                                               | 39                                                                                                                                                                           | 69.5                                | 494                  | 42.8     | 642                     | 34.6                            |                                     | Bubble pressure                   | 1967 | 24  |
|                                            | 99.99             | 73.74                | Ar                                                                               | $\sigma = 73.74 - 1.791 \cdot 10^{-2}(t-t_{mp}) - 9610 \cdot 10^{-5}(t-t_{mp})^2 + 6.629 \cdot 10^{-8}(t-t_{mp})^3$<br>( $t^{\circ}\text{C}$ ) (71—1011 $^{\circ}\text{C}$ ) |                                     |                      |          |                         |                                 | Bubble pressure                     | 1968                              | 172  |     |
| Cu                                         | 99.995            | 68.6                 | He                                                                               | $= 68.6 - 0.047 (t-t_{mp}) (t^{\circ}\text{C}) (52-1100^{\circ}\text{C})$                                                                                                    |                                     |                      |          |                         |                                 | Bubble pressure                     | 1970                              | 121  |     |
|                                            |                   |                      | H <sub>2</sub> ,Ar                                                               | 1140                                                                                                                                                                         | (1120)                              | 1300                 | (1226)   |                         |                                 |                                     | Bubble pressure                   | 1929 | 111 |
|                                            |                   |                      | Ar                                                                               | 1150                                                                                                                                                                         | (1034)                              | 1350                 | (1068)   | 1450                    | (1061)                          |                                     | Sessile drop                      | 1949 | 14  |
|                                            |                   |                      | Ar                                                                               | 1120                                                                                                                                                                         | 1269 $\pm$ 20                       |                      |          |                         |                                 |                                     | Sessile drop                      | 1953 | 11  |
|                                            | —                 | (1150)               | vac.                                                                             |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Pendant drop                      | 1957 | 35  |
|                                            |                   |                      | Ar                                                                               | 1120                                                                                                                                                                         | 1285 $\pm$ 10                       |                      |          |                         |                                 |                                     | Sessile drop                      | 1957 | 108 |
|                                            | 99.98             |                      | H <sub>2</sub>                                                                   | 1100                                                                                                                                                                         | 1301                                | 1165                 | 1295     | 1255                    | 1287                            |                                     | Bubble pressure                   | 1959 | 134 |
|                                            |                   | 1270                 | H <sub>2</sub> ,vac.                                                             |                                                                                                                                                                              | $\sigma = 1270 - 0.31(t-t_{mp})$    |                      |          |                         |                                 |                                     | Sessile drop                      | 1959 | 7   |
|                                            |                   |                      | vac.                                                                             | 1120                                                                                                                                                                         | 1285                                |                      |          |                         |                                 |                                     | Sessile drop                      | 1959 | 198 |
|                                            |                   |                      |                                                                                  | 1440                                                                                                                                                                         | 1298                                |                      |          |                         |                                 |                                     | Bubble pressure                   | 1959 | 129 |
|                                            |                   | (1085)               | vac.                                                                             |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Pendant drop                      | 1959 | 182 |
|                                            | 99.99             |                      | He                                                                               | 1250                                                                                                                                                                         | 1290                                |                      |          |                         |                                 |                                     | Bubble pressure                   | 1960 | 62  |
|                                            | 99.99             |                      | H <sub>2</sub>                                                                   | 1250                                                                                                                                                                         | 1300                                |                      |          |                         |                                 |                                     | Bubble pressure                   | 1960 | 62  |
|                                            | 99.9              | 1180 $\pm$ 40        | Ar                                                                               |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Bubble pressure                   | 1960 | 103 |
|                                            | —                 |                      | H <sub>2</sub>                                                                   | 1100                                                                                                                                                                         | 1220                                |                      |          |                         |                                 |                                     | Sessile drop                      | 1960 | 136 |
|                                            | —                 |                      |                                                                                  | 1183                                                                                                                                                                         | (1130)                              |                      |          |                         |                                 |                                     | Sessile drop                      | 1960 | 200 |
|                                            | —                 |                      | vac.                                                                             | 1150                                                                                                                                                                         | 1370                                |                      |          |                         |                                 |                                     | Sessile drop                      | 1960 | 52  |
|                                            | 99.997            | 1355                 | He,H <sub>2</sub>                                                                |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Sessile drop +<br>bubble pressure | 1961 | 138 |
|                                            | 99.997            | 1352                 | vac.                                                                             |                                                                                                                                                                              | $\sigma_t = 1352 - 0.17 (t-t_{mp})$ |                      |          |                         |                                 | ( $t^{\circ}\text{C}$ )             | Sessile drop                      | 1961 | 137 |
|                                            | 99.997            | 1358                 | Ar                                                                               |                                                                                                                                                                              | $\sigma_t = 1358 - 0.20 (t-t_{mp})$ |                      |          |                         |                                 | ( $t^{\circ}\text{C}$ )             | Bubble pressure                   | 1961 | 137 |
|                                            | —                 |                      | Ar,He                                                                            | 1120                                                                                                                                                                         | 1285 $\pm$ 10                       |                      |          |                         |                                 |                                     | Sessile drop                      | 1961 | 110 |
|                                            | 99.99             |                      | H <sub>2</sub> ,he                                                               | 1550                                                                                                                                                                         | 1265                                |                      |          |                         |                                 |                                     | Bubble pressure                   | 1962 | 63  |
|                                            | 99.99999          | 1300                 | vac.                                                                             |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Pendant drop                      | 1963 | 5   |
|                                            |                   |                      | vac.                                                                             | 1130                                                                                                                                                                         | 1268 $\pm$ 60                       |                      |          |                         |                                 |                                     | Sessile drop                      | 1963 | 15  |
|                                            | 99.98             |                      | Ar                                                                               | 1600                                                                                                                                                                         | 1230                                |                      |          |                         |                                 |                                     | Bubble pressure                   | 1964 | 205 |
|                                            | 99.999            |                      | N <sub>2</sub>                                                                   | 1100                                                                                                                                                                         | 1341                                | 1150                 | 1338     | 1200                    | 1335                            |                                     | Bubble pressure                   | 1964 | 128 |
|                                            | 99.9              | (1127)               | vac.                                                                             |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Pendant drop                      | 1965 | 65  |
|                                            | 99.99             |                      | Ar,H <sub>2</sub>                                                                | 1100                                                                                                                                                                         | 1320                                |                      |          |                         |                                 |                                     | Bubble pressure                   | 1966 | 169 |
|                                            | 99.999            | 1282                 | vac.                                                                             | $\sigma_t = 1282 - 0.16 (t-t_{mp})$                                                                                                                                          |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1972 | 224 |
|                                            | —                 | 1319                 | He                                                                               | $\sigma_t = 1319 - 0.27 (t-t_{mp})$                                                                                                                                          |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1971 | 234 |
|                                            | 99.999            | 1275 $\pm$ 10        | vac.                                                                             |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Pendant drop                      | 1963 | 186 |
|                                            | 99.994            | 1275                 | Ar                                                                               | $\sigma_t = 1275 - 0.279 (t-t_{mp})$                                                                                                                                         |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1963 | 66  |
|                                            | —                 |                      | Ar                                                                               | 1550                                                                                                                                                                         | 1265                                |                      |          |                         |                                 |                                     | Bubble pressure                   | 1963 | 255 |
|                                            | —                 | 1212                 | —                                                                                |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Drop weight                       | 1968 | 257 |
|                                            | 99.999            | 1207                 | He                                                                               | $\sigma_t = 1207 - 34.1 \cdot 10^{-3}(t-t_{mp})$                                                                                                                             |                                     |                      |          |                         | (1100—1400 $^{\circ}\text{C}$ ) |                                     | Bubble pressure                   | 1971 | 258 |
|                                            | —                 | —                    | vac.                                                                             | $d\sigma/dt = -0.23$                                                                                                                                                         |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1961 | 262 |
| —                                          | 1285              | Ar                   | $\sigma_t = 1285 - 0.2 (t-t_{mp})$                                               |                                                                                                                                                                              |                                     |                      |          |                         |                                 | Sessile drop                        | 1971                              | 263  |     |
| 99.9                                       | (1384)            | Ar                   | $\sigma_t = 1384 - 0.41 (t-t_{mp})$                                              |                                                                                                                                                                              |                                     |                      |          | $-1300^{\circ}\text{C}$ |                                 | Sess. dr., max., bubble<br>pressure | 1973                              | 266  |     |
| 99.99                                      | 1282              | Ar,N <sub>2</sub>    | $\sigma_t = 1282 - 0.15 (t-t_{mp})$                                              |                                                                                                                                                                              |                                     |                      |          | $-1364^{\circ}\text{C}$ |                                 | Sess.Drop                           | 1976                              | 267  |     |
| 99.99                                      | 1290              | Ar                   | $\sigma_t = 1290 - 0.16 (t-t_{mp})$                                              |                                                                                                                                                                              |                                     |                      |          | $-1270^{\circ}\text{C}$ |                                 | Bubble pressure                     | 1976                              | 267  |     |
| 99.99                                      |                   | N <sub>2</sub>       | 1200                                                                             | 1300                                                                                                                                                                         |                                     |                      |          |                         |                                 | Bubble pressure                     | 1972                              | 265  |     |
| 99.99                                      | 1360              | vac.                 | $\sigma_t = 1360 - 0.239 (T-T_{mp}) - 1473 \text{ K}$                            |                                                                                                                                                                              |                                     |                      |          |                         |                                 | Sessile drop                        | 1974                              | 273  |     |
| 99.999                                     | 1313              |                      | $\sigma_t = 1313(\pm 35) - 0.176 (T-T_{mp})(\pm 0.023)$                          |                                                                                                                                                                              |                                     |                      |          | 1373—1861 K             |                                 | Sessile drop                        | 1977                              | 275  |     |
| 99.999                                     | 1303              | H <sub>2</sub> ,Ar   | $\sigma_t = 1303 - 0.233 (t-t_{mp}) (t^{\circ}\text{C}) - 1450^{\circ}\text{C}$  |                                                                                                                                                                              |                                     |                      |          |                         |                                 | Sessile drop                        | 1976                              | 276  |     |
| 99.999                                     | (1170)            | vac.                 | $(\sigma_t = 1170 - 0.27 (t-t_{mp})) (t^{\circ}\text{C}) - 1200^{\circ}\text{C}$ |                                                                                                                                                                              |                                     |                      |          |                         |                                 | Sessile drop                        | 1970                              | 282  |     |
| 99.999                                     | (1390)            | H <sub>2</sub>       | $(\sigma_t = 1390 - 0.43 (t-t_{mp})(t^{\circ}\text{C})) - 1300^{\circ}\text{C}$  |                                                                                                                                                                              |                                     |                      |          |                         |                                 | Levitated droplets                  | 1977                              | 285  |     |
| 99.999                                     | 1313              | Ar                   | $\sigma_t = 1313(\pm 35) - 0.176(\pm 0.023)(T-T_{mp})$                           |                                                                                                                                                                              |                                     |                      |          | $-1861 \text{ K}$       |                                 | Sessile drop                        | 1977                              | 287  |     |
| Fe                                         |                   | (1373)               | Ar                                                                               | 1600                                                                                                                                                                         | (1360)                              | 1700                 | (1371)   |                         | (nonlinear)                     |                                     | Sessile drop                      | 1949 | 14  |
|                                            | —                 |                      |                                                                                  | 1550                                                                                                                                                                         | (1450)                              |                      |          |                         |                                 |                                     | Sessile drop                      | 1954 | 92  |
|                                            | —                 |                      |                                                                                  | 1570                                                                                                                                                                         | 1731                                |                      |          |                         |                                 |                                     | Sessile drop                      | 1954 | 95  |
|                                            | —                 |                      |                                                                                  | 1550                                                                                                                                                                         | 1860                                |                      |          |                         |                                 |                                     | Sessile drop                      | 1955 | 74  |
|                                            |                   | 1720                 | He                                                                               |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1955 | 74  |
|                                            |                   |                      |                                                                                  | 1580—1760                                                                                                                                                                    | (880)                               |                      |          |                         |                                 |                                     | Bubble pressure                   | 1956 | 100 |
|                                            |                   |                      |                                                                                  | 1570                                                                                                                                                                         | (1632)                              |                      |          |                         |                                 |                                     | Sessile drop                      | 1958 | 93  |
|                                            | 99.99             |                      | He                                                                               | 1650                                                                                                                                                                         | (1610)                              |                      |          |                         |                                 |                                     | Sessile drop                      | 1958 | 46  |
|                                            | 99.99             |                      | He                                                                               | 1650                                                                                                                                                                         | 1430                                |                      |          |                         |                                 |                                     | Sessile drop                      | 1958 | 46  |
|                                            | 99.99             |                      | H <sub>2</sub>                                                                   | 1650                                                                                                                                                                         | (1400)                              |                      |          |                         |                                 |                                     | Sessile drop                      | 1958 | 46  |
|                                            | —                 | (1384)               | vac.                                                                             |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Pendant drop                      | 1959 | 182 |
|                                            |                   | 1700                 | vac.                                                                             |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1959 | 7   |
|                                            |                   |                      | vac.,He                                                                          | 1550                                                                                                                                                                         | 1865                                |                      |          |                         |                                 |                                     | Sessile drop                      | 1960 | 209 |
|                                            | 99.99             |                      | He                                                                               | 1650                                                                                                                                                                         | (1430)                              |                      |          |                         |                                 |                                     | Bubble pressure                   | 1960 | 62  |
|                                            | 99.99             |                      | H <sub>2</sub>                                                                   | 1650                                                                                                                                                                         | (1400)                              |                      |          |                         |                                 |                                     | Bubble pressure                   | 1960 | 62  |
|                                            |                   | (1650)               | He,H <sub>2</sub>                                                                |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1960 | 136 |
|                                            | 99.985            |                      | Ar                                                                               | 1550                                                                                                                                                                         | 1788                                |                      |          |                         |                                 |                                     | Bubble pressure                   | 1961 | 61  |
|                                            | —                 | (1560)               |                                                                                  |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1961 | 110 |
|                                            |                   |                      |                                                                                  |                                                                                                                                                                              |                                     |                      |          |                         |                                 |                                     | Sessile drop                      | 1961 | 68  |

# SURFACE TENSION OF LIQUID ELEMENTS (continued)

| Values of $\sigma$ at various temperatures |                   |                         |                                                 |                                                                                                           |               |                      |               |                      |          |                       |           |
|--------------------------------------------|-------------------|-------------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------|---------------|----------------------|---------------|----------------------|----------|-----------------------|-----------|
| Element                                    | Purity<br>(wt. %) | $\sigma_{mp}$ (mN/m)    | Atm.                                            | $t/^{\circ}\text{C}$                                                                                      | $\sigma$      | $t/^{\circ}\text{C}$ | $\sigma$      | $t/^{\circ}\text{C}$ | $\sigma$ | Method                | Year Ref. |
| Ir                                         | 99.94             |                         | vac.                                            | 1560                                                                                                      | 1710          |                      |               |                      |          | Sessile drop          | 1962 207  |
|                                            |                   |                         | Al <sub>2</sub> O <sub>3</sub>                  |                                                                                                           |               |                      |               |                      |          |                       |           |
|                                            | 99.9998           | 1880                    | vac.                                            |                                                                                                           |               |                      |               |                      |          | Pendant drop          | 1963 5    |
|                                            | 99.93             | 1860 $\pm$ 40<br>(1510) | He                                              |                                                                                                           |               |                      |               |                      |          | Sessile drop          | 1963 116  |
|                                            |                   |                         | vac.                                            |                                                                                                           |               |                      |               |                      |          | Drop weight           | 1963 139  |
|                                            | 99.97             |                         | vac., BeO                                       | 1550                                                                                                      | 1830 $\pm$ 6  |                      |               |                      |          | Sessile drop          | 1963 45   |
|                                            | Armco             |                         | Ar, N <sub>2</sub>                              | 1550                                                                                                      | 1795          |                      |               |                      |          | Bubble pressure       | 1963 164  |
|                                            |                   |                         | vac.                                            | 1550                                                                                                      | 1754          |                      |               |                      |          | Sessile drop          | 1963 42   |
|                                            | 99.987            |                         | vac.                                            | 1550                                                                                                      | 1730          |                      |               |                      |          | Sessile drop          | 1964 159  |
|                                            | 99.85             | (1619)                  | vac.                                            |                                                                                                           |               |                      |               |                      |          | Pendant drop          | 1965 65   |
|                                            | 99.69             |                         | He, Al <sub>2</sub> O <sub>3</sub>              | 1550                                                                                                      | 1727          |                      |               |                      |          | Sessile drop          | 1965 158  |
|                                            | 99.69             |                         | H <sub>2</sub> , Al <sub>2</sub> O <sub>3</sub> | 1550                                                                                                      | 1734          |                      |               |                      |          | Sessile drop          | 1965 158  |
|                                            | —                 | 1760 $\pm$ 20           | He, H <sub>2</sub>                              | $\sigma_t = 1760 - 0.35 (t - t_{mp}) (^{\circ}\text{C})$                                                  |               |                      |               |                      |          | Sessile drop          | 1969 157  |
|                                            | 99.9992           | 1773                    | He, H <sub>2</sub>                              | $\sigma_t = 773 + 0.65 \cdot t (^{\circ}\text{C}) (1550-1780^{\circ}\text{C})$                            |               |                      |               |                      |          | Oscillating drop      | 1971 211  |
|                                            | —                 |                         | —                                               | 1550                                                                                                      | 1780          |                      |               |                      |          | Sessile drop          | 1971 220  |
|                                            | —                 | (1958)                  |                                                 | $(\sigma_t = 1836 + 0.079t (^{\circ}\text{C}) (1555-1705))$                                               |               |                      |               |                      |          | Levitated droplets    | 1971 227  |
|                                            | 99.988            |                         | He                                              | 1650                                                                                                      | 1832          |                      |               |                      |          | Sessile drop          | 1972 228  |
|                                            | 99.996            |                         | Ar, H <sub>2</sub>                              | 1550                                                                                                      | 1850 $\pm$ 80 | 1600                 | 1835 $\pm$ 80 |                      |          | Sessile drop          | 1970 231  |
|                                            | —                 |                         | He                                              | 1527                                                                                                      | 1820          |                      |               |                      |          | Sessile drop          | 1971 233  |
|                                            | 99.997            |                         | He                                              | 1550                                                                                                      | 1760          | 1850                 | 1655          |                      |          | Sessile drop          | 1971 235  |
|                                            | 99.89             |                         | He                                              | 1550                                                                                                      | 1860          |                      |               |                      |          | Sessile drop          | 1963 241  |
|                                            | 99.97             |                         | H <sub>2</sub>                                  | 1600                                                                                                      | 1710 $\pm$ 30 |                      |               |                      |          | Sessile drop          | 1973 242  |
|                                            | 99.5              |                         | H <sub>2</sub> , Ar                             | 1550                                                                                                      | 1735          |                      |               |                      |          | Sessile drop          | 1974 243  |
|                                            | 99.95             | —                       | Ar                                              | 1570—1620                                                                                                 | (1650—1680)   |                      |               |                      |          | Bubble pressure       | 1962 254  |
|                                            | —                 | —                       | Ar                                              | 1550                                                                                                      | 1835          |                      |               |                      |          | Sessile drop          | 1957 108  |
|                                            | —                 | —                       | Ar                                              | 1550                                                                                                      | (1450)        |                      |               |                      |          | Sessile drop          | 1975 269  |
|                                            | 99.9              | 1806                    | He                                              | $\sigma_t = 1806 - 0.295 (t - t_{mp}) (^{\circ}\text{C}) - 2200^{\circ}\text{C}$                          |               |                      |               |                      |          | Sessile drop          | 1978 191  |
|                                            | —                 | —                       | —                                               | 1550                                                                                                      | 1850          |                      |               |                      |          | Sessile drop          | 1968 295  |
|                                            | —                 | —                       | —                                               | 100                                                                                                       | 58.4          |                      |               |                      |          | Calculated            | 1969 145  |
|                                            | Ir                |                         |                                                 |                                                                                                           |               |                      |               |                      |          | Sessile drop          | 1921 170  |
|                                            | Ga                | (358.2)                 | CO <sub>2</sub> , C                             | 30.5                                                                                                      | 735 $\pm$ 20  |                      |               |                      |          | Sessile drop          | 1941 130  |
|                                            | —                 |                         | H <sub>2</sub> , CO <sub>2</sub>                | $\sigma = 707 - 0.05 (t - t_{mp}) (t_{mp} = 505^{\circ}\text{C})$                                         |               |                      |               |                      |          | Bubble pressure       | 1960 197  |
|                                            | 99.9              | 707                     | Ar, He                                          |                                                                                                           |               |                      |               |                      |          | Bubble pressure       | 1960 104  |
|                                            | —                 | 725 $\pm$ 10            | Ar                                              |                                                                                                           |               |                      |               |                      |          | Sessile drop          | 1964 64   |
|                                            | —                 |                         | vac.                                            | 350                                                                                                       | 718           |                      |               |                      |          | Sessile drop          | 1966 57   |
|                                            | —                 |                         | He, Al <sub>2</sub> O <sub>3</sub>              | 1500                                                                                                      | 559           |                      |               |                      |          | Sessile drop          | 1967 85   |
|                                            | 99.9998           | 718                     | vac., Al <sub>2</sub> O <sub>3</sub>            | $\sigma = 718 - 0.101 (t - t_{mp}) (^{\circ}\text{C})$                                                    |               |                      |               |                      |          | Sessile drop          | 1971 236  |
|                                            | 99.999            | 712                     | vac.                                            | $\sigma_t = 712 - 0.0606 (T - 303) (\text{K})$                                                            |               |                      |               |                      |          | Sessile drop          | 1965 249  |
|                                            | —                 | 708                     | He                                              | $\sigma_t = 708 - 31 \cdot 10^{-4} (T - T_{mp}) - 0.67 \cdot 10^{-4} (T - T_m)^2$                         |               |                      |               |                      |          | Drop pressure         | 1974 264  |
|                                            | 99.999            | 708                     | vac.                                            | $\sigma_t = 708 - 37 \cdot 10^{-4} (t - t_{mp}) (30-450^{\circ}\text{C})$                                 |               |                      |               |                      |          | Pendant drop          | 1975 270  |
|                                            | —                 | 723.9                   | N <sub>2</sub>                                  | $\sigma_t = 723.9 - 0.068 (t - t_{mp})$                                                                   |               |                      |               |                      |          | Sessile drop          | 1974 273  |
|                                            | 99.99             | 712                     | vac.                                            | $\sigma_t = 712 - 0.0606 (T - T_{mp}) - 1473 \text{ K}$                                                   |               |                      |               |                      |          | Drop pressure         | 1960 281  |
|                                            | —                 | 706.6                   | vac.                                            | $\sigma_t = 706.6 - 6.47 \cdot 10^{-4} (t - t_{mp}) - 0.965 \cdot 10^{-4} (t - t_{mp})^2$                 |               |                      |               |                      |          | Bubble pressure       | 1970 289  |
|                                            | 99.9999           | (784)                   | Ar                                              | $\sigma_t = 784 - 0.11 (t - t_{mp}) (^{\circ}\text{C}) (30-505^{\circ}\text{C}) 900-1100^{\circ}\text{C}$ |               |                      |               |                      |          | Sessile drop          | 1983 299  |
|                                            | 99.9999           | 680                     | H <sub>2</sub>                                  | $\sigma_t = 680 - 0.091 (t - t_{mp}) - 1150 \text{ K} (T \text{ K})$                                      |               |                      |               |                      |          | Floating zone         | 1965 238  |
|                                            | 99.999            | 810                     | Ar                                              |                                                                                                           |               |                      |               |                      |          | Pendant drop          | 1953 87   |
| Ge                                         |                   |                         | He                                              | 959                                                                                                       | 600           |                      |               |                      |          | Drop weight           | 1960 126  |
|                                            |                   | 621.4                   | vac.                                            | 1200                                                                                                      | 530           |                      |               |                      |          | Sessile drop          | 1960 99   |
|                                            |                   | 650                     | vac.                                            | 1000                                                                                                      | 650           |                      |               |                      |          | Sessile drop          | 1971 214  |
|                                            |                   | 632 $\pm$ 5             | N <sub>2</sub> , He                             |                                                                                                           |               |                      |               |                      |          | Solid state curvature | 1955 217  |
|                                            | —                 | 599                     | He                                              | $\sigma_t = 599 - 0.099 (t - t_{mp})$                                                                     |               |                      |               |                      |          | Sessile drop          | 1971 234  |
|                                            | —                 | 580                     | vac.                                            | $\sigma_t = 580 - 0.119 (t - t_{mp}) (\text{mp} - 1240^{\circ}\text{C})$                                  |               |                      |               |                      |          | Sessile drop          | 1973 225  |
|                                            | 99.999            | 581                     | He                                              | $\sigma_t = 581 - 0.12 (t - t_{mp}) (\text{mp} - 1600^{\circ}\text{C})$                                   |               |                      |               |                      |          | Sessile drop          | 1969 268  |
|                                            | 99.999            | 589                     | vac.                                            | $\sigma_t = 589 - 0.105 (T - T_{mp}) (\text{mp} - 1423 \text{ K})$                                        |               |                      |               |                      |          | Sessile drop          | 1977 277  |
|                                            | —                 | —                       | vac.                                            | 1530                                                                                                      | 510           |                      |               |                      |          | Sessile drop          | 1976 283  |
|                                            | He                | 0.27                    | Air                                             | $\sigma = 0.3745 - 0.0096 \cdot T^2 (\text{K})$                                                           |               |                      |               |                      |          | Capillary rise        | 1965 304  |
|                                            | Hf                | 1460                    | vac.                                            |                                                                                                           |               |                      |               |                      |          | Pendant drop          | 1958 151  |
|                                            | 97.5 + 2.5        | 1630                    | vac.                                            |                                                                                                           |               |                      |               |                      |          | Pendant drop          | 1963 5    |
|                                            | Zr                |                         |                                                 |                                                                                                           |               |                      |               |                      |          |                       |           |
|                                            | —                 | 1490 $\pm$ 10           | vac.                                            |                                                                                                           |               |                      |               |                      |          | Pendant drop          | 1972 229  |
| Hg                                         |                   |                         | H <sub>2</sub>                                  | 20                                                                                                        | (542)         |                      |               |                      |          | Pendant drop          | 1868 165  |
|                                            |                   |                         | air                                             | 16                                                                                                        | (410)         |                      |               |                      |          | Sessile drop          | 1897 181  |
|                                            |                   |                         | air                                             | 20                                                                                                        | (435.5)       |                      |               |                      |          | Oscillating jet       | 1912 175  |
|                                            |                   |                         | vac.                                            | 20                                                                                                        | 472           |                      |               |                      |          | Oscillating jet       | 1914 73   |
|                                            |                   |                         | vac.                                            | 20                                                                                                        | (402)         |                      |               |                      |          | Drop pressure         | 1920 146  |
|                                            |                   |                         |                                                 | 25                                                                                                        | 476           |                      |               |                      |          | Drop weight           | 1920 75   |
|                                            |                   |                         | vac.                                            | 20                                                                                                        | (436)         |                      |               |                      |          | Sessile drop          | 1921 160  |
|                                            |                   |                         | vac.                                            | 20                                                                                                        | (432)         |                      |               |                      |          | Sessile drop          | 1921 170  |
|                                            |                   |                         | H <sub>2</sub>                                  | 25                                                                                                        | 476           |                      |               |                      |          | Drop pressure         | 1921 78   |
|                                            |                   |                         |                                                 | 25                                                                                                        | 472           |                      |               |                      |          | Drop weight           | 1923 81   |
|                                            |                   |                         |                                                 | 25                                                                                                        | (464)         |                      |               |                      |          | Sessile drop          | 1924 82   |



# SURFACE TENSION OF LIQUID ELEMENTS (continued)

| Element | Purity<br>(wt. %) | $\sigma_{mp}$ (mN/m) | Atm.                                                                               | Values of $\sigma$ at various temperatures                                                                                                                                 |                                                                                        |                                              |                  |                      |                 | Method          | Year                         | Ref. |     |
|---------|-------------------|----------------------|------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------|------------------|----------------------|-----------------|-----------------|------------------------------|------|-----|
|         |                   |                      |                                                                                    | $t/^{\circ}\text{C}$                                                                                                                                                       | $\sigma$                                                                               | $t/^{\circ}\text{C}$                         | $\sigma$         | $t/^{\circ}\text{C}$ | $\sigma$        |                 |                              |      |     |
| I<br>In | 99.9              | 491                  | H <sub>2</sub>                                                                     | 19                                                                                                                                                                         | 473                                                                                    |                                              |                  |                      |                 |                 | Bubble pressure              | 1926 | 173 |
|         |                   |                      |                                                                                    | 20                                                                                                                                                                         | (437)                                                                                  |                                              |                  |                      |                 |                 | Capillary depression         | 1928 | 144 |
|         |                   |                      | vac.                                                                               | 20                                                                                                                                                                         | 480                                                                                    |                                              |                  |                      |                 |                 | Drop weight                  | 1928 | 21  |
|         |                   |                      |                                                                                    | 25                                                                                                                                                                         | (516)                                                                                  |                                              |                  |                      |                 |                 | Sessile drop                 | 1929 | 37  |
|         |                   |                      |                                                                                    | 25                                                                                                                                                                         | (435)                                                                                  |                                              |                  |                      |                 |                 | Sessile drop                 | 1931 | 90  |
|         |                   |                      | vac.                                                                               | 25                                                                                                                                                                         | 473                                                                                    |                                              |                  |                      |                 |                 | Drop weight                  | 1932 | 31  |
|         |                   |                      |                                                                                    | 25                                                                                                                                                                         | 488                                                                                    |                                              |                  |                      |                 |                 | Sessile drop                 | 1932 | 32  |
|         |                   |                      |                                                                                    | 25                                                                                                                                                                         | (498)                                                                                  |                                              |                  |                      |                 |                 | Sessile drop                 | 1934 | 30  |
|         |                   |                      | vac.                                                                               | 20                                                                                                                                                                         | (420)                                                                                  |                                              |                  |                      |                 |                 | Sessile drop                 | 1935 | 17  |
|         |                   |                      |                                                                                    | 25                                                                                                                                                                         | 476                                                                                    |                                              |                  |                      |                 |                 | Sessile drop                 | 1936 | 91  |
|         |                   |                      | vac.                                                                               | 20                                                                                                                                                                         | (410)                                                                                  |                                              |                  |                      |                 |                 | Drop pressure                | 1937 | 178 |
|         |                   |                      | vac.                                                                               | 20                                                                                                                                                                         | (455)                                                                                  |                                              |                  |                      |                 |                 | Drop pressure                | 1941 | 39  |
|         |                   |                      |                                                                                    | 25                                                                                                                                                                         | 484 $\pm$ 1.5                                                                          |                                              |                  |                      |                 |                 | Sessile drop                 | 1946 | 89  |
|         |                   |                      | vac.                                                                               | 22                                                                                                                                                                         | (468)                                                                                  |                                              |                  |                      |                 |                 | Drop pressure                | 1951 | 162 |
|         |                   |                      | vac.                                                                               | 20                                                                                                                                                                         | (465.2)                                                                                | 103                                          | 449.7            | 350                  | 387.1           | Drop pressure   | 1951                         | 162  |     |
|         |                   |                      |                                                                                    | 25                                                                                                                                                                         | 484.9 $\pm$ 1.8                                                                        |                                              |                  |                      |                 | Sessile drop    | 1953                         | 216  |     |
|         |                   |                      | vac.                                                                               | 20                                                                                                                                                                         | 485.5 $\pm$ 1.0                                                                        | $\sigma_t = 489.5 - 0.20t(^{\circ}\text{C})$ |                  |                      |                 | Drop pressure   | 1953                         | 17   |     |
|         |                   |                      | Ar                                                                                 | 20                                                                                                                                                                         | (454.7)                                                                                |                                              |                  |                      |                 | Bubble pressure | 1954                         | 188  |     |
|         |                   |                      |                                                                                    | 21                                                                                                                                                                         | (505.5)                                                                                |                                              |                  |                      |                 | Bubble pressure | 1960                         | 23   |     |
|         |                   |                      | Ar                                                                                 | 20                                                                                                                                                                         | (500 $\pm$ 15)                                                                         |                                              |                  |                      |                 | Bubble pressure | 1959                         | 103  |     |
|         |                   |                      | vac.                                                                               | -10                                                                                                                                                                        | 487                                                                                    |                                              |                  |                      |                 | Drop pressure   | 1960                         | 69   |     |
|         |                   |                      | vac.                                                                               | 25                                                                                                                                                                         | 483.5 $\pm$ 1.0                                                                        |                                              |                  |                      |                 | Sessile drop    | 1961                         | 140  |     |
|         |                   |                      |                                                                                    | 22                                                                                                                                                                         | (465)                                                                                  |                                              |                  |                      |                 | Bubble pressure | 1962                         | 194  |     |
|         |                   |                      |                                                                                    | 25                                                                                                                                                                         | 485.1                                                                                  |                                              |                  |                      |                 | Sessile drop    | 1963                         | 142  |     |
|         |                   |                      |                                                                                    | 16.5                                                                                                                                                                       | 487.3                                                                                  | 25                                           | 485.4            |                      |                 | Pendant drop    | 1964                         | 171  |     |
|         |                   |                      |                                                                                    |                                                                                                                                                                            |                                                                                        |                                              | $\pm 1.2$        |                      |                 |                 |                              |      |     |
|         |                   |                      |                                                                                    | 23—25                                                                                                                                                                      | 482.8 $\pm$ 9.7                                                                        |                                              |                  |                      |                 | Contact angle   | 1966                         | 18   |     |
|         |                   |                      |                                                                                    |                                                                                                                                                                            | $(\sigma_t = 468.7 - 1.61 \cdot 10^{-1}t - 1.815 \cdot 10^{-4}t^2 (^{\circ}\text{C}))$ |                                              |                  |                      |                 |                 | —                            | 1968 | 206 |
|         |                   |                      | vac.                                                                               | 20                                                                                                                                                                         | 484.6 $\pm$ 1.3                                                                        |                                              |                  |                      |                 | Pendant drop    | 1968                         | 132  |     |
|         |                   |                      | Ar                                                                                 | 25                                                                                                                                                                         | 480                                                                                    |                                              |                  |                      |                 | Bubble pressure | 1968                         | 172  |     |
|         |                   |                      | vac.                                                                               | 20                                                                                                                                                                         | 482.5 $\pm$ 3.0                                                                        |                                              |                  |                      |                 | Bubble pressure | 1968                         | 172  |     |
|         |                   |                      |                                                                                    |                                                                                                                                                                            | $\sigma_t = 485.5 - 0.149t - 2.84 \cdot 10^{-4}t^2 (^{\circ}\text{C})$                 |                                              |                  |                      |                 |                 | Bubble pressure              | 1970 | 177 |
|         |                   |                      | Ar                                                                                 | 21.5                                                                                                                                                                       | 484.9 $\pm$ 0.3                                                                        |                                              |                  |                      |                 | Bubble pressure | 1972                         | 223  |     |
|         |                   |                      |                                                                                    | 20                                                                                                                                                                         | 471 $\pm$ 3                                                                            |                                              |                  |                      |                 | Drop weight     | 1973                         | 239  |     |
|         |                   |                      | vac.                                                                               |                                                                                                                                                                            | $\sigma_t = 480.0 - 0.26t (^{\circ}\text{C}) (50—250^{\circ}\text{C})$                 |                                              |                  |                      |                 |                 | Drop pressure/capillary rise | 1977 | 278 |
|         | 99.99             | 487                  | vac.                                                                               | $\sigma_t = 487 - 0.281 (t - t_{mp}) - 450^{\circ}\text{C}$                                                                                                                |                                                                                        |                                              |                  |                      |                 | Drop pressure   | 1976                         | 290  |     |
|         | —                 | 37.92                | Ar                                                                                 | $\sigma = 37.92 - 0.0956 (T - T_{mp}) 398—428 \text{ K}$                                                                                                                   |                                                                                        |                                              |                  |                      |                 | Capillary rise  | 1965                         | 303  |     |
| 99.95   | 559               | H <sub>2</sub>       | 600                                                                                | 515                                                                                                                                                                        |                                                                                        |                                              | Capillary method | 1957                 | 133             |                 |                              |      |     |
|         |                   |                      | 623                                                                                | 540                                                                                                                                                                        |                                                                                        |                                              | Capillary method | 1957                 | 77              |                 |                              |      |     |
| 99.995  | 556.0             | Ar, He               |                                                                                    |                                                                                                                                                                            |                                                                                        |                                              | Bubble pressure  | 1959                 | 196             |                 |                              |      |     |
|         |                   | vac.                 | 185                                                                                | 592                                                                                                                                                                        |                                                                                        |                                              | Drop pressure    | 1959                 | 69              |                 |                              |      |     |
|         |                   | H <sub>2</sub>       | 600                                                                                | 514                                                                                                                                                                        |                                                                                        |                                              | —                | 1962                 | 16              |                 |                              |      |     |
|         |                   |                      | 300                                                                                | 541                                                                                                                                                                        |                                                                                        |                                              | Sessile drop     | 1962                 | 83              |                 |                              |      |     |
| 99.999  | 558               | Ar                   | 200                                                                                | 556                                                                                                                                                                        | 400                                                                                    | 535                                          | 550              | 527.8                | Bubble pressure | 1964            | 123                          |      |     |
|         |                   |                      |                                                                                    | $\sigma = 558 - 0.08(t - t_{mp})$                                                                                                                                          |                                                                                        |                                              |                  |                      |                 |                 |                              |      |     |
| 99.9994 |                   | vac.                 | 350                                                                                | 539                                                                                                                                                                        |                                                                                        |                                              |                  |                      | Drop pressure   | 1968            | 106                          |      |     |
| 99.9999 | 560 $\pm$ 5       | —                    | $\sigma = 568.0 - 0.04t - 7.08 \cdot 10^{-5}t^2 (^{\circ}\text{C})$                |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Sessile drop    | 1972            | 221                          |      |     |
| 99.999  | 565.0             | vac.                 | $\sigma_t = 565.0 - 0.09 (T - 428) (\text{T K})$                                   |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Sessile drop    | 1971            | 236                          |      |     |
| 99.99   | 553               | Ar                   | $\sigma_t = 553 - 0.13 (t - t_{mp}) - 450^{\circ}\text{C}$                         |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Bubble pressure | 1976            | 267                          |      |     |
| 99.99   | 558               | vac.                 | $\sigma_t = 558 - 0.11 (t - t_{mp}) - 586^{\circ}\text{C}$                         |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Sessile drop    | 1976            | 267                          |      |     |
| 99.99   | 565               | vac.                 | $\sigma_t = 565 - 0.09 (T - T_{mp}) - 1473 \text{ K}$                              |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Sessile drop    | 1974            | 273                          |      |     |
| 99.9995 | (585)             | Ar                   | $(\sigma_t = 585 - 0.10 (t - t_{mp}) (^{\circ}\text{C}) 620—1020^{\circ}\text{C})$ |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Bubble pressure | 1970            | 289                          |      |     |
| 99.9999 | 560               | H <sub>2</sub>       | $\sigma_t 560 - 0.10 (t - t_{mp}) - 1150 \text{ K (T K)}$                          |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Sessile drop    | 1983            | 299                          |      |     |
| Ir      | 99.9980           | 2250                 | vac.                                                                               |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Pendant drop    | 1963            | 5                            |      |     |
| —       | —                 | He                   | 2450 $^{\circ}\text{C}$                                                            | 2264                                                                                                                                                                       |                                                                                        |                                              |                  |                      | Sessile drop    | 1982            | 300                          |      |     |
| K       | 99.895            | (411)                | CO <sub>2</sub>                                                                    |                                                                                                                                                                            |                                                                                        |                                              |                  |                      |                 | Drop weight     | 1868                         | 166  |     |
|         |                   |                      | Ar                                                                                 | 79                                                                                                                                                                         | (400.5)                                                                                | 228                                          | (391.5)          |                      |                 | Bubble pressure | 1937                         | 208  |     |
|         |                   |                      | Ar                                                                                 |                                                                                                                                                                            |                                                                                        |                                              |                  |                      |                 | Bubble pressure | 1955                         | 189  |     |
|         |                   | 110.3 $\pm$ 1        | —                                                                                  |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | —               | 1965            | 84                           |      |     |
|         | 93.0              | 117                  | vac.                                                                               | $\sigma = 117 - 0.066 (t - 64) (65—800^{\circ}\text{C})$                                                                                                                   |                                                                                        |                                              |                  | Drop weight          | 1966            | 185             |                              |      |     |
|         | —                 | 113                  | Ar                                                                                 | 87                                                                                                                                                                         | 112                                                                                    | 457                                          | 80               | 677                  | 64.8            | Bubble pressure | 1967                         | 24   |     |
|         | 99.986            | 116.95               | Ar                                                                                 | $\sigma = 116.95 - 6.742 \cdot 10^{-2} (t - t_{mp}) - 3.836 \cdot 10^{-5} (t - t_{mp})^2 + 3.707 \cdot 10^{-8} (t - t_{mp})^3 (^{\circ}\text{C}) (77—983^{\circ}\text{C})$ |                                                                                        |                                              |                  |                      |                 | Bubble pressure | 1968                         | 172  |     |
|         |                   |                      |                                                                                    | $\sigma = 76.8 - 70.2 \cdot 10^{-4} (t - 400) (^{\circ}\text{C}) (600—1126^{\circ}\text{C})$                                                                               |                                                                                        |                                              |                  |                      |                 |                 |                              |      |     |
|         | 99.936            | 79.2                 | He                                                                                 |                                                                                                                                                                            |                                                                                        |                                              |                  |                      |                 | Bubble pressure | 1970                         | 121  |     |
|         |                   | 95 $\pm$ 9.5         | —                                                                                  |                                                                                                                                                                            |                                                                                        |                                              |                  |                      |                 | Drop weight     | 1954                         | 218  |     |
| 99.97   | 111.35 $\pm$ 0.64 | He                   | $\sigma = 115.51 - 0.0653t (^{\circ}\text{C}) (70—713^{\circ}\text{C})$            |                                                                                                                                                                            |                                                                                        |                                              |                  |                      | Bubble pressure | 1964            | 219                          |      |     |
| Kr      | —                 | 16.34                | vac.                                                                               | $\sigma = 16.344 - 0.2089 (T - 116) 115—123 \text{ K}$                                                                                                                     |                                                                                        |                                              |                  |                      |                 | Bubble pressure | 1965                         | 307  |     |
| La      | —                 | 720                  | vac.                                                                               | $\sigma_t = 720 - 0.32 (t - t_{mp})$                                                                                                                                       |                                                                                        |                                              |                  |                      |                 | Sessile drop    | 1955                         | 260  |     |
| Li      | 99.95             | 408                  | Ar                                                                                 | 180                                                                                                                                                                        | 397.5                                                                                  | 300                                          | 380              | 500                  | 351.5           | Bubble pressure | 1955                         | 189  |     |
|         | 99.98             | 416                  | Ar                                                                                 | 287                                                                                                                                                                        | 386                                                                                    | 922                                          | 275              | 1077                 | 253             | Bubble pressure | 1967                         | 24   |     |
| Mg      |                   |                      | air                                                                                | 700                                                                                                                                                                        | (987)                                                                                  |                                              |                  |                      |                 | Ring removal    | 1937                         | 96   |     |

# SURFACE TENSION OF LIQUID ELEMENTS (continued)

| Element  | Purity<br>(wt. %) | Values of $\sigma$ at various temperatures |                                                     |                                                                                                                                                    |          |      |          |       |          | Method             | Year | Ref. |
|----------|-------------------|--------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|----------|------|----------|-------|----------|--------------------|------|------|
|          |                   | $\sigma_{mp}$ (mN/m)                       | Atm.                                                | t/°C                                                                                                                                               | $\sigma$ | t/°C | $\sigma$ | t/°C  | $\sigma$ |                    |      |      |
| Mn       |                   | 571                                        | Ar                                                  | 681                                                                                                                                                | 563      | 789  | 532      | 894   | 502      | Bubble pressure    | 1937 | 208  |
|          | 99.8              | 559                                        | N <sub>2</sub>                                      | 670                                                                                                                                                | 552      | 700  | 542      | 740   | 528      | Bubble pressure    | 1948 | 149  |
|          | 99.9              |                                            | Ar                                                  | 700                                                                                                                                                | 550 ± 15 |      |          |       |          | Bubble pressure    | 1959 | 114  |
|          | 99.91             | 525 ± 10                                   | Ar                                                  |                                                                                                                                                    |          |      |          |       |          | Bubble pressure    | 1961 | 105  |
|          | 99.5              | 583                                        |                                                     | $\sigma = 721 - 0.149 \cdot T$ (T K) (1125—1326 K)                                                                                                 |          |      |          |       |          | Bubble pressure    | 1968 | 25   |
|          | 99.9              | —                                          | vac.                                                | 800                                                                                                                                                | 543      | —    | —        | —     | —        | Sessile drop       | 1977 | 279  |
|          | 99.9985           | 1100 ± 50                                  | Ar                                                  |                                                                                                                                                    |          |      |          |       |          | Dynam. drop weight | 1964 | 6    |
|          | 99.94             |                                            | vac.                                                | 1550                                                                                                                                               | 1030     |      |          |       |          | Sessile drop       | 1964 | 159  |
|          | —                 |                                            | —                                                   | 1550                                                                                                                                               | 1010     |      |          |       |          | Sessile drop       | 1971 | 220  |
|          | 99.7              | 1915                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1963 | 148  |
| Mo       |                   | 2080                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Drop weight        | 1963 | 139  |
|          | 99.9996           | 2250                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1963 | 5    |
|          | 99.98             | 2049                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | pendant drop       | 1965 | 65   |
|          | —                 | 2130                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1970 | 210  |
|          | 99.9              | 11.77                                      | N                                                   | 75 K                                                                                                                                               | 9.41     | 95 K | 5.06     | 115 K | 1.39     | Capillary rise     | 1965 | 308  |
| Na       |                   | (293.6)                                    | CO <sub>2</sub>                                     |                                                                                                                                                    |          |      |          |       |          | Drop weight        | 1868 | 166  |
|          |                   | 222                                        | vac.                                                | 100                                                                                                                                                | 222      | 250  | 211      |       |          | Sessile drop       | 1926 | 152  |
|          |                   | 206                                        | Ar                                                  | 110                                                                                                                                                | 205.7    | 263  | 198.2    |       |          | Bubble pressure    | 1937 | 208  |
|          | 99.995            | 191                                        | Ar                                                  |                                                                                                                                                    |          |      |          |       |          | Bubble pressure    | 1954 | 188  |
|          |                   | 196                                        | vac.                                                | 123                                                                                                                                                | 198      | 129  | 198.5    |       |          | Drop volume        | 1955 | 2    |
|          |                   |                                            |                                                     | 140                                                                                                                                                | 190      |      |          |       |          | Sessile drop       | 1961 | 28   |
|          |                   | 200.2 ± 0.6                                |                                                     |                                                                                                                                                    |          |      |          |       |          | —                  | 1965 | 84   |
|          | 99.8              | 202                                        | vac.                                                | $\sigma = 202 - 0.092 (t-98) (100-1000^\circ\text{C})$                                                                                             |          |      |          |       |          | Drop weight        | 1966 | 185  |
|          | p.a.              | 195                                        | Ar                                                  | 617                                                                                                                                                | 144      | 764  | 130      | 855   | 120.4    | Bubble pressure    | 1967 | 24   |
|          | 99.96             | 210.12                                     | Ar                                                  | $\sigma = 210.105 \cdot 10^{-2} (t-t_{mp}) - 8.064 \cdot 10^{-5} (t-t_{mp})^2 + 3.380 \cdot 10^{-8} (t-t_{mp})^3 (t^\circ\text{C})$<br>(141—992°C) |          |      |          |       |          | Bubble pressure    | 1968 | 172  |
| Nb       | 99.982            | 187.4                                      | He                                                  | $\sigma = 144 - 0.108 (t-500) (t^\circ\text{C}) (400-1125^\circ\text{C})$                                                                          |          |      |          |       |          | Bubble pressure    | 1970 | 121  |
|          | spec. pure        | 222.46                                     | vac., Ar                                            | $\sigma = 222.46 - 0.12846 (t-t_{mp}) (633-1319^\circ\text{C})$                                                                                    |          |      |          |       |          | Bubble pressure    | 1979 | 301  |
|          | 99.9986           | 1900                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1963 | 5    |
|          | 99.99             | 1827                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1965 | 65   |
|          | —                 | 2020                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1970 | 220  |
| Nd       |                   | 688                                        | Ar                                                  | 1186                                                                                                                                               | 674      |      |          |       |          | Bubble pressure    | 1962 | 124  |
| Ni       | 99.7              |                                            | He                                                  | 1470                                                                                                                                               | (1615)   |      |          |       |          | Sessile drop       | 1953 | 94   |
|          | 99.7              |                                            | H <sub>2</sub>                                      | 1470                                                                                                                                               | (1570)   |      |          |       |          | Sessile drop       | 1953 | 94   |
|          | 99.7              |                                            | vac.                                                | 1470                                                                                                                                               | 1735     |      |          |       |          | Sessile drop       | 1953 | 94   |
|          |                   | 1725                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Sessile drop       | 1955 | 141  |
|          |                   |                                            | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Sessile drop       | 1956 | 115  |
|          | —                 |                                            | Ar                                                  | 1550                                                                                                                                               | (1934)   |      |          |       |          | Sessile drop       | 1957 | 108  |
|          | 99.99             |                                            | vac., Al <sub>2</sub> O <sub>3</sub>                | 1520                                                                                                                                               | 1740     |      |          |       |          | Sessile drop       | 1958 | 46   |
|          | 99.99             |                                            | He, Ar, Al <sub>2</sub> O <sub>3</sub>              | 1520                                                                                                                                               | 1770     |      |          |       |          | Sessile drop       | 1958 | 46   |
|          | 99.99             |                                            | H <sub>2</sub> , Al <sub>2</sub> O <sub>3</sub>     | 1520                                                                                                                                               | (1600)   |      |          |       |          | Sessile drop       | 1958 | 46   |
|          | 99.99             |                                            | He, MgO                                             | 1470                                                                                                                                               | (1530)   |      |          |       |          | Sessile drop       | 1958 | 46   |
|          | 99.99             |                                            | He, BeO                                             | 1470                                                                                                                                               | (1500)   |      |          |       |          | Sessile drop       | 1958 | 46   |
|          | 99.99             |                                            | H <sub>2</sub>                                      | 1530                                                                                                                                               | (1650)   |      |          |       |          | Bubble pressure    | 1958 | 46   |
|          | 99.99             |                                            | H <sub>2</sub>                                      | 1470                                                                                                                                               | (1530)   |      |          |       |          | Bubble pressure    | 1958 | 46   |
|          | 99.99             |                                            | He                                                  | 1470                                                                                                                                               | (1490)   |      |          |       |          | Bubble pressure    | 1958 | 46   |
|          |                   | 1725                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Sessile drop       | 1959 | 7    |
|          | 99.99             |                                            |                                                     | 1600                                                                                                                                               | (1600)   |      |          |       |          | Sessile drop       | 1960 | 136  |
|          | 99.99             |                                            | vac.                                                | 1500                                                                                                                                               | 1720     |      |          |       |          | Sessile drop       | 1960 | 50   |
|          | 99.99             |                                            | vac., Al <sub>2</sub> O <sub>3</sub>                | 1550                                                                                                                                               | 1780     |      |          |       |          | Sessile drop       | 1961 | 54   |
|          |                   |                                            |                                                     | 1550                                                                                                                                               | 1735     |      |          |       |          | Bubble pressure    | 1961 | 60   |
|          |                   |                                            | H <sub>2</sub> , He                                 | 1470                                                                                                                                               | 1700     |      |          |       |          | Bubble pressure    | 1961 | 61   |
|          | 99.99             |                                            | vac.                                                | 1640                                                                                                                                               | 1705     |      |          |       |          | Sessile drop       | 1961 | 56   |
|          | —                 |                                            | vac., Al <sub>2</sub> O <sub>3</sub>                | 1560                                                                                                                                               | 1810     |      |          |       |          | Sessile drop       | 1962 | 207  |
|          | 99.9991           | 1770 ± 13                                  | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Drop weight        | 1963 | 5    |
|          | 99.9991           | 1728 ± 10                                  | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Drop weight        | 1963 | 5    |
|          | 99.9991           | 1822 ± 8                                   | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1963 | 5    |
|          |                   | (1670)                                     | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Drop weight        | 1963 | 139  |
|          |                   | 1760                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Sessile drop       | 1964 | 55   |
|          |                   | (1687)                                     | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1965 | 65   |
|          | 99.99             |                                            | vac.                                                | 1500                                                                                                                                               | 1745     |      |          |       |          | Sessile drop       | 1966 | 57   |
|          | —                 | 1809 ± 20                                  | H <sub>2</sub> , He, Al <sub>2</sub> O <sub>3</sub> | $\sigma_t = 1770 - 0.39 (t-1550) (t^\circ\text{C})$                                                                                                |          |      |          |       |          | Sessile drop       | 1969 | 157  |
|          | 99.99975          | (1977)                                     | He                                                  | $\sigma_t = 1665 + 0.215 (t^\circ\text{C}) (1475-1650^\circ\text{C})$                                                                              |          |      |          |       |          | Oscillating drop   | 1971 | 211  |
|          | 99.998            |                                            | He                                                  | 1550                                                                                                                                               | 1735     | 1850 | 1620     |       |          | Sessile drop       | 1971 | 235  |
|          | —                 |                                            | Ar                                                  | 1550                                                                                                                                               | (1530)   |      |          |       |          | Sessile drop       | 1975 | 269  |
|          | 99.99             | 1758                                       | He                                                  | $\sigma_t = 1758 - 0.333 (t-t_{mp}) (t^\circ\text{C}) - 2200^\circ\text{C}$                                                                        |          |      |          |       |          | Sessile drop       | 1978 | 291  |
|          | —                 |                                            | —                                                   | 1550                                                                                                                                               | 1797     |      |          |       |          | Sessile drop       | 1972 | 296  |
| Os       | 99.9998           | 2500                                       | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1963 | 5    |
| P(white) |                   | 71.2                                       |                                                     | 50                                                                                                                                                 | 69.7     | 68.7 | 64.95    |       |          | Bubble pressure    | 1943 | 80   |
| Pb       |                   | 448                                        | H <sub>2</sub>                                      |                                                                                                                                                    |          |      |          |       |          | Pendant drop       | 1868 | 165  |
|          |                   | (394.2)                                    | vac.                                                |                                                                                                                                                    |          |      |          |       |          | Oscillating jet    | 1914 | 73   |
|          |                   | 445                                        | H <sub>2</sub>                                      | 366                                                                                                                                                | 442      | 444  | 433      | 522   | 429      | Drop pressure      | 1921 | 78   |
|          |                   | 444                                        | H <sub>2</sub>                                      | 350                                                                                                                                                | 441      | 600  | 426      | 800   | 409      | Bubble pressure    | 1926 | 19   |

# SURFACE TENSION OF LIQUID ELEMENTS (continued)

| Element | Purity<br>(wt. %) | $\sigma_{mp}$ (mN/m) | Atm.                           | Values of $\sigma$ at various temperatures                                                                                                    |                                                                  |                                             |          | Method | Year                          | Ref.             |                       |          |     |
|---------|-------------------|----------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|---------------------------------------------|----------|--------|-------------------------------|------------------|-----------------------|----------|-----|
|         |                   |                      |                                | $t/^{\circ}\text{C}$                                                                                                                          | $\sigma$                                                         | $t/^{\circ}\text{C}$                        | $\sigma$ |        |                               |                  | $t/^{\circ}\text{C}$  | $\sigma$ |     |
| Au      | 99.98             | 454                  | H <sub>2</sub>                 | 350                                                                                                                                           | 453                                                              | 600                                         | 436      | 982    | 414                           | Pendant drop     | 1927                  | 20       |     |
|         |                   | 469.9                | vac.                           | 507                                                                                                                                           | 440.5                                                            | 657                                         | 415.9    |        |                               | Drop weight      | 1927                  | 131      |     |
|         |                   | 460                  | H <sub>2</sub>                 | 750                                                                                                                                           | 423                                                              | 900                                         | 407      | 1000   | 401                           | Bubble pressure  | 1927                  | 40       |     |
|         |                   | 449                  | H <sub>2</sub> ,N <sub>2</sub> | 340                                                                                                                                           | 448                                                              | 390                                         | 442      | 440    | 439                           | Bubble pressure  | 1947                  | 71       |     |
|         |                   |                      | air                            | 360                                                                                                                                           | 452                                                              |                                             |          |        |                               | Ring removal     | 1948                  | 97       |     |
|         |                   |                      | vac.                           | 425                                                                                                                                           | 440                                                              |                                             |          |        |                               | Drop pressure    | 1950                  | 101      |     |
|         |                   | 451                  | He                             |                                                                                                                                               |                                                                  |                                             |          |        |                               | Pendant drop     | 1953                  | 87       |     |
|         |                   |                      |                                | 350—450                                                                                                                                       | 450                                                              |                                             |          |        |                               | Ring removal     | 1953                  | 13       |     |
|         |                   | 99.998               | 480                            | H <sub>2</sub>                                                                                                                                |                                                                  |                                             |          |        |                               | Capillary method | 1957                  | 133      |     |
|         |                   |                      |                                | vac.                                                                                                                                          | 623                                                              | 474                                         |          |        |                               | Capillary method | 1957                  | 77       |     |
|         | Ag                | 99.9                 |                                |                                                                                                                                               | 362                                                              | 455                                         |          |        |                               |                  | Drop pressure         | 1959     | 69  |
|         |                   |                      |                                |                                                                                                                                               | 700                                                              | 428                                         |          |        |                               |                  | Sessile drop          | 1959     | 27  |
|         |                   |                      | 99.9                           | (410 ± 5)                                                                                                                                     | H <sub>2</sub>                                                   | 1000                                        | 388      |        |                               |                  | Bubble pressure       | 1959     | 134 |
|         |                   |                      | 99.9                           |                                                                                                                                               | Ar                                                               |                                             |          |        |                               |                  | Bubble pressure       | 1960     | 104 |
|         |                   |                      |                                |                                                                                                                                               | 350                                                              | 445                                         |          |        |                               |                  | Drop pressure         | 1962     | 153 |
|         |                   | 99.98                | 443                            | vac.                                                                                                                                          | 340                                                              | 442                                         | 400      | 435    |                               | Drop pressure    | 1963                  | 70       |     |
|         |                   | 99.9995              | 470                            |                                                                                                                                               | $\sigma = 538 - 0.114T$ (T K) (1440—1970 K)                      |                                             |          |        |                               | Bubble pressure  | 1968                  | 26       |     |
|         |                   | 99.9994              |                                | vac.                                                                                                                                          | 450                                                              | 438                                         |          |        |                               | Drop pressure    | 1968                  | 107      |     |
|         |                   | 99.999               |                                | He                                                                                                                                            | 1600                                                             | 310                                         |          |        |                               | Sessile drop     | 1969                  | 199      |     |
|         |                   |                      |                                |                                                                                                                                               | 390                                                              | 456                                         |          |        |                               | Bubble pressure  | 1970                  | 1        |     |
|         | Cu                | 99.999               | (424 ± 10)                     | air                                                                                                                                           |                                                                  |                                             |          |        |                               |                  | Solid state curvature | 1955     | 217 |
|         |                   |                      | 470                            | Ar                                                                                                                                            | $\sigma_t = 470 - 0.164(t - t_{mp})$ (MP-535°C) (t°C)            |                                             |          |        |                               |                  | Bubble pressure       | 1972     | 223 |
|         |                   |                      | 99.9999                        | 462                                                                                                                                           | vac.                                                             | $\sigma_t = 462 - 0.11(t - t_{mp})$         |          |        |                               |                  | Sessile drop          | 1972     | 224 |
|         |                   |                      | 99.9999                        | 444.5                                                                                                                                         | H <sub>2</sub> ,He                                               | $\sigma_t = 472.7 - 0.085t$ (± 5) (t°C)     |          |        |                               |                  | Sessile drop          | 1971     | 226 |
|         |                   |                      | 99.95                          | 472                                                                                                                                           | Ar                                                               | $\sigma_t = 548 - 0.233t$ (t°C) (650—800°C) |          |        |                               |                  | Bubble pressure       | 1971     | 230 |
|         |                   | 99.999               | 468.5                          | Ar                                                                                                                                            | $\sigma = 512 - 0.133t$ (t°C) ( $t_{mp} - 750^{\circ}\text{C}$ ) |                                             |          |        |                               | Bubble pressure  | 1961                  | 237      |     |
|         |                   | —                    | 468.6                          | H <sub>2</sub>                                                                                                                                | $\sigma = 497 - 0.087t$ (t°C) (350—500°C)                        |                                             |          |        |                               | Capillary rise   | 1973                  | 240      |     |
|         |                   | Chem.pure            | 456                            | Ar                                                                                                                                            | 360                                                              | 449                                         | 500      | 436    |                               | Bubble pressure  | 1947                  | 252      |     |
|         |                   | 99.999               | 458                            | H <sub>2</sub> ,Ar                                                                                                                            | $\sigma_t = 456 - 0.14(t - t_{mp})$ (360—650°C)                  |                                             |          |        |                               | Bubble pressure  | 1977                  | 274      |     |
|         |                   | 99.999               | 462                            | vac.                                                                                                                                          | $\sigma_t = 458 - 0.128(t - t_{mp})$ (t°C) — 1100°C              |                                             |          |        |                               | Sessile drop     | 1976                  | 276      |     |
| Pd      | 99.999            | 469                  | vac.                           | $\sigma_t = 62 - 0.11(T - T_{mp}) - 1173$ K                                                                                                   |                                                                  |                                             |          |        | Sessile drop                  | 1979             | 288                   |          |     |
|         |                   | —                    | 469                            | vac.                                                                                                                                          | $\sigma_t = 469 - 0.086(t - t_{mp}) - 450^{\circ}\text{C}$       |                                             |          |        |                               | Drop pressure    | 1976                  | 289      |     |
|         |                   | 99.99                | 444.5                          | H <sub>2</sub>                                                                                                                                | $\sigma_t = 444.5 - 0.100(t - t_{mp}) - 550^{\circ}\text{C}$     |                                             |          |        |                               | Sessile drop     | 1978                  | 292      |     |
|         |                   |                      | 1470                           | vac.                                                                                                                                          |                                                                  |                                             |          |        |                               | Sessile drop     | 1961                  | 49       |     |
|         |                   | 99.998               | 1500                           | vac.                                                                                                                                          |                                                                  |                                             |          |        |                               | Pendant drop     | 1963                  | 5        |     |
|         | 99.998            | 1460                 | He                             |                                                                                                                                               |                                                                  |                                             |          |        | Sessile drop                  | 1969             | 199                   |          |     |
|         | Pt                |                      |                                |                                                                                                                                               | 1780                                                             | 1673                                        |          |        |                               | Capillary method | 1868                  | 165      |     |
|         |                   |                      | 1869                           | CO <sub>2</sub>                                                                                                                               |                                                                  |                                             |          |        |                               | Drop weight      | 1869                  | 167      |     |
|         |                   | 99.84                | 1740 ± 20                      | vac.                                                                                                                                          |                                                                  |                                             |          |        |                               | Drop volume      | 1959                  | 48       |     |
|         |                   | 99.999               |                                | Ar                                                                                                                                            | 1800                                                             | 1699 ± 20                                   |          |        |                               | Sessile drop     | 1961                  | 109      |     |
| 99.9980 |                   | 1865                 | vac.                           |                                                                                                                                               |                                                                  |                                             |          |        | Pendant drop                  | 1963             | 5                     |          |     |
| 99.99   |                   | 1746                 | vac.                           | $\sigma_t = 1746 - 0.307(t - 1774)$ (t°C)                                                                                                     |                                                                  |                                             |          |        | Sessile drop                  | 1975             | 271                   |          |     |
| 99.999  |                   | 550 ± 55             | vac.                           |                                                                                                                                               |                                                                  |                                             |          |        | Pendant drop                  | 1963             | 186                   |          |     |
| Rb      |                   | 77 ± 5               | vac.                           |                                                                                                                                               |                                                                  |                                             |          |        | Drop diffusion in quartz tube | 1956             | 201                   |          |     |
| 99.8    |                   | 84.6                 | Ar                             | 52                                                                                                                                            | 84                                                               | 477                                         | 55       | 632    | 46.8                          | Bubble pressure  | 1967                  | 24       |     |
| 99.92   |                   | 91.17                | Ar                             | $\sigma = 91.17 - 9.189 \cdot 10^{-2}(t - t_{mp}) + 7.228 \cdot 10^{-5}(t - t_{mp})^2 - 3.830 \cdot 10^{-8}(t - t_{mp})^3$ (t°C) (104—1006°C) |                                                                  |                                             |          |        | Bubble pressure               | 1968             | 172                   |          |     |
| Re      | 99.997            | 85.7                 | He                             | $\sigma = 85.7 - 0.054(t - t_{mp})$ (t°C) (53—1115°C)                                                                                         |                                                                  |                                             |          |        | Bubble pressure               | 1970             | 121                   |          |     |
|         | 99.4              | 2610                 | vac.                           |                                                                                                                                               |                                                                  |                                             |          |        | Pendant drop                  | 1963             | 148                   |          |     |
|         | 99.9999           | 2700                 | vac.                           |                                                                                                                                               |                                                                  |                                             |          |        | Pendant drop                  | 1963             | 5                     |          |     |
| Rh      |                   | 1940                 | vac.                           |                                                                                                                                               |                                                                  |                                             |          |        | Sessile drop                  | 1961             | 49                    |          |     |
|         | 99.9975           | 2000                 | vac.                           |                                                                                                                                               |                                                                  |                                             |          |        | Pendant drop                  | 1963             | 5                     |          |     |
|         | 99.99             | 1915                 | He                             | $\sigma_t = 1915 - 0.664(t - t_{mp})$ (t°C) — 2200°C                                                                                          |                                                                  |                                             |          |        | Sessile drop                  | 1975             | 27                    |          |     |
| Ru      | 99.9980           | 2250                 | vac.                           |                                                                                                                                               |                                                                  |                                             |          |        | Pendant drop                  | 1963             | 5                     |          |     |
| S       | —                 | 60.9                 | vac.                           | 250                                                                                                                                           | 51.1                                                             |                                             |          |        | Pendant drop                  | 1957             | 143                   |          |     |
| Sb      |                   | 350                  | H <sub>2</sub>                 | 640                                                                                                                                           | 349                                                              | 700                                         | 349      | 974    | 342                           | Drop weight      | 1927                  | 20       |     |
|         |                   | 375                  | H <sub>2</sub>                 | 750                                                                                                                                           | 368                                                              | 900                                         | 361      | 1100   | 348                           | Bubble pressure  | 1927                  | 40       |     |
|         |                   | 368                  | vac.                           | 640                                                                                                                                           | 367.9                                                            | 762                                         | 364.9    |        |                               | Drop weight      | 1927                  | 131      |     |
|         | 99.5              | 383                  | H <sub>2</sub> ,N <sub>2</sub> | 675                                                                                                                                           | 384                                                              | 800                                         | 380      |        |                               | Bubble pressure  | 1947                  | 71       |     |
|         | 99.99             | 395 ± 20             | Ar                             |                                                                                                                                               |                                                                  |                                             |          |        |                               | Bubble pressure  | 1960                  | 104      |     |
|         | 99.15             | 395 ± 20             | Ar                             |                                                                                                                                               |                                                                  |                                             |          |        |                               | Bubble pressure  | 1961                  | 105      |     |
|         | 99.999            | 367                  | N <sub>2</sub>                 | 800                                                                                                                                           | 359                                                              | 1000                                        | 351      | 1100   | 345                           | Bubble pressure  | 1964                  | 128      |     |
|         | 99.995            | 350                  | Ar                             | 650                                                                                                                                           | 350.2                                                            | 700                                         | 347.6    | 800    | 345.0                         | Bubble pressure  | 1964                  | 123      |     |
|         | 99.999            |                      | He                             | 1600                                                                                                                                          | 320                                                              |                                             |          |        |                               | Sessile drop     | 1969                  | 199      |     |
|         | 99.9999           | 372                  | Ar                             | $\sigma_t = 372 - 0.05(t - t_{mp})$ 670—1010°C                                                                                                |                                                                  |                                             |          |        | Bubble pressure               | 1970             | 289                   |          |     |
| Se      |                   | 70.4                 | —                              |                                                                                                                                               |                                                                  |                                             |          |        |                               | Drop weight      | 1868                  | 166      |     |
|         | 99.95             | 105.4                | —                              | 260                                                                                                                                           | 98.5                                                             | 300                                         | 95.7     |        |                               | Drop weight      | 1946                  | 8        |     |
|         | —                 |                      | Ar                             | 230—250                                                                                                                                       | 88.0 ± 5                                                         |                                             |          |        |                               | Bubble pressure  | 1961                  | 105      |     |
|         | —                 | 96.7                 | —                              | $\log \sigma = 1.8202 + 35.8711/t$ (t°C)                                                                                                      |                                                                  |                                             |          |        | Bubble pressure               | 1970             | 251                   |          |     |
|         | —                 |                      | vac.                           | 220                                                                                                                                           | 95                                                               |                                             |          |        |                               | Sessile drop     | 1978                  | 284      |     |
|         | 99.995            |                      | Ar                             | $\sigma_t = 90 - 0.075(t - 310)$ 310—650°C                                                                                                    |                                                                  |                                             |          |        | Bubble pressure               | 1970             | 289                   |          |     |
|         | 99.995            | 94                   | Ar                             | $\sigma_t = 94 - 0.02(t - t_{mp})$ von 220—310°C                                                                                              |                                                                  |                                             |          |        | Bubble pressure               | 1970             | 289                   |          |     |
|         |                   |                      |                                |                                                                                                                                               |                                                                  |                                             |          |        |                               |                  |                       |          |     |
|         |                   |                      |                                |                                                                                                                                               |                                                                  |                                             |          |        |                               |                  |                       |          |     |
|         |                   |                      |                                |                                                                                                                                               |                                                                  |                                             |          |        |                               |                  |                       |          |     |



# SURFACE TENSION OF LIQUID ELEMENTS (continued)

| Element | Purity<br>(wt. %) | $\sigma_{mp}$ (mN/m) | Atm.               | Values of $\sigma$ at various temperatures                                                    |          |                      |          | Method           | Year  | Ref.                             |      |     |
|---------|-------------------|----------------------|--------------------|-----------------------------------------------------------------------------------------------|----------|----------------------|----------|------------------|-------|----------------------------------|------|-----|
|         |                   |                      |                    | $t/^{\circ}\text{C}$                                                                          | $\sigma$ | $t/^{\circ}\text{C}$ | $\sigma$ |                  |       |                                  |      |     |
| Si      | 99.995            | 106                  | Ar                 | $\sigma_t = 102 - 0.09(t-310) \text{ 310--650}^{\circ}\text{C}$                               |          |                      |          | Bubble pressure  | 1970  | 289                              |      |     |
|         | 99.995            |                      | Ar                 | $\sigma_t = 106 - 0.02(t-t_{mp}) \text{ 220--310}^{\circ}\text{C}$                            |          |                      |          | Bubble pressure  | 1970  | 289                              |      |     |
|         |                   |                      | He                 | 1450                                                                                          | 725      |                      |          | Pendant drop     | 1953  | 87                               |      |     |
|         |                   |                      | vac.               | 1550                                                                                          | 720      |                      |          | Sessile drop     | 1961  | 68                               |      |     |
|         | 99.99             |                      | vac.               | 1550                                                                                          | 750      |                      |          | Sessile drop     | 1964  | 41                               |      |     |
|         | 99.999            |                      | Ar                 | 1500                                                                                          | 825      |                      |          | Pendant drop     | 1970  | 43                               |      |     |
|         | 99.999            |                      | He                 | $\sigma_t = 720 - 0.073(t-t_{mp}) \text{ (} t_{mp} \text{--1500}^{\circ}\text{C)}$            |          |                      |          | Bubble pressure  | 1972  | 232                              |      |     |
|         | 99.999            | 727                  | He                 | $\sigma_t = 727 - 0.01044(t-t_{mp}) \text{ (} t_{mp} \text{--1700}^{\circ}\text{C)}$          |          |                      |          | Sessile drop     | 1979  | 294                              |      |     |
|         | 99.999            | —                    | —                  | $d\sigma/dT = -0.1290 - 1700^{\circ}\text{C}$                                                 |          |                      |          | Sessile drop     | 1979  | 302                              |      |     |
| Sn      |                   | 587                  | H <sub>2</sub>     |                                                                                               |          |                      |          | Pendant drop     | 1868  | 165                              |      |     |
|         |                   | (681.2)              | air                |                                                                                               |          |                      |          | Drop weight      | 1868  | 165                              |      |     |
|         |                   | 593                  |                    |                                                                                               |          |                      |          | Capillary method | 1868  | 166                              |      |     |
|         |                   | 612                  |                    |                                                                                               |          |                      |          | Capillary method | 1897  | 181                              |      |     |
|         |                   | (352)                | air                |                                                                                               |          |                      |          | Capillary waves  | 1900  | 72                               |      |     |
|         |                   | (480)                |                    |                                                                                               |          |                      |          | Capillary method | 1914  | 183                              |      |     |
|         |                   |                      | vac.               | 247                                                                                           | 540      |                      |          | Oscillating jet  | 1914  | 73                               |      |     |
|         |                   | 531                  | H <sub>2</sub>     |                                                                                               |          |                      |          | Drop pressure    | 1921  | 78                               |      |     |
|         |                   | 528                  | H <sub>2</sub>     | 253                                                                                           | 526      | 600                  | 525      | 964              | 514   | Drop weight                      | 1926 | 19  |
|         |                   | 565                  | H <sub>2</sub>     | 878                                                                                           | 508      |                      |          |                  |       | Bubble pressure                  | 1926 | 173 |
|         |                   | 566                  | H <sub>2</sub> ,Ar | 878                                                                                           | 508      | 900                  | 506      | 1000             | 497   | Bubble pressure                  | 1927 | 40  |
|         |                   | 524                  | N <sub>2</sub>     |                                                                                               |          |                      |          |                  |       | Drop weight                      | 1927 | 36  |
|         |                   | (662.2)              | air                | 347                                                                                           | (627.8)  | 418                  | (617.1)  |                  |       | Drop weight                      | 1927 | 131 |
|         |                   | 578.8                | vac.               | 400                                                                                           | 545.4    | 600                  | 506.2    |                  |       | Drop weight                      | 1927 | 131 |
|         |                   | 518                  | vac.               |                                                                                               |          |                      |          |                  |       | Sessile drop                     | 1935 | 174 |
|         | —                 | 619                  | N <sub>2</sub>     | 275                                                                                           | 612      | 500                  | 572      | 800              | 520   | Bubble pressure                  | 1948 | 149 |
|         |                   | 525                  | air                | 280                                                                                           | 523      | 340                  | 520      |                  |       | Ring removal                     | 1948 | 97  |
|         | 99.99             | 537                  | vac.               | 500                                                                                           | 524      | 600                  | 508      |                  |       | Drop pressure                    | 1949 | 154 |
|         |                   | 530                  | He                 |                                                                                               |          |                      |          |                  |       | Pendant drop                     | 1953 | 87  |
|         |                   | 594                  | H <sub>2</sub>     | 489                                                                                           | 543      | 572                  | 528      | 692              | 503   | Conical capillaries              | 1953 | 9   |
|         |                   |                      | —                  | 250                                                                                           | 536      |                      |          |                  |       | Drop pressure                    | 1953 | 179 |
|         |                   |                      | vac.               | 450                                                                                           | 530      |                      |          |                  |       | Drop pressure                    | 1953 | 119 |
|         |                   |                      | —                  | 250                                                                                           | 545      |                      |          |                  |       | Drop pressure                    | 1954 | 112 |
|         | 99.93             | 550                  | vac.               | 250                                                                                           | 549      | 400                  | 539      | 600              | 526   | Drop pressure                    | 1956 | 156 |
|         | 99.998            | 566                  | H <sub>2</sub>     | $\sigma = 566 - 0.07(t-t_{mp})$                                                               |          |                      |          |                  |       | Capillary method                 | 1957 | 133 |
|         |                   |                      | —                  | 623                                                                                           | 559      |                      |          |                  |       | Capillary method                 | 1957 | 77  |
|         |                   | 610                  | vac.               |                                                                                               |          |                      |          |                  |       | Pendant drop                     | 1959 | 182 |
|         |                   |                      | H <sub>2</sub>     | 800                                                                                           | 500      |                      |          |                  |       | Sessile drop                     | 1959 | 7   |
|         |                   |                      | —                  | 300                                                                                           | 538      |                      |          |                  |       | Drop pressure                    | 1960 | 190 |
|         |                   |                      | —                  | 300                                                                                           | 527      |                      |          |                  |       | Drop pressure                    | 1960 | 76  |
|         |                   |                      | —                  | 290                                                                                           | 546      |                      |          |                  |       | Sessile drop                     | 1960 | 190 |
|         | 99.99             |                      | H <sub>2</sub> ,He | 600                                                                                           | 530      |                      |          |                  |       | Bubble pressure                  | 1960 | 62  |
|         | 99.9              | 526 ± 10             | Ar                 |                                                                                               |          |                      |          |                  |       | Bubble pressure                  | 1960 | 104 |
|         | —                 |                      | vac.               | 290                                                                                           | 600      |                      |          |                  |       | Sessile drop                     | 1961 | 147 |
|         | 99.965            | 546                  | H <sub>2</sub>     | 740                                                                                           | 508      | 950                  | 489.5    | 1115             | 479.5 | Bubble pressure                  | 1961 | 127 |
|         | 99.89             | 543.7                | Ar                 | $\sigma = 543.7 - 0.07(t-t_{mp})$                                                             |          |                      |          |                  |       | Bubble pressure                  | 1964 | 33  |
|         |                   | 562                  | vac.               |                                                                                               |          |                      |          |                  |       | Sessile drop                     | 1964 | 55  |
|         |                   |                      | vac.               | 300                                                                                           | 554      |                      |          |                  |       | Sessile drop                     | 1964 | 64  |
|         | 99.999            | 590                  | vac.               |                                                                                               |          |                      |          |                  |       | Sessile drop                     | 1965 | 86  |
|         |                   |                      | H <sub>2</sub>     | 290                                                                                           | 520      | 290                  | 524      | (vac.)           |       | Sessile drop                     | 1966 | 67  |
|         | 99.9999           |                      | H <sub>2</sub>     | 246                                                                                           | 552.7    |                      |          |                  |       | Sessile drop                     | 1968 | 203 |
|         | 99.9994           |                      | vac.               | 350                                                                                           | 537      |                      |          |                  |       | Drop pressure                    | 1968 | 106 |
|         | 99.999            | 555.8 ± 1.9          |                    | $\sigma = 566.84 - 4.76 \cdot 10^{-2}t \text{ (}^{\circ}\text{C)}$                            |          |                      |          |                  |       | Bubble pressure                  | 1970 | 176 |
|         | 99.96             | 552                  | vac.               | 1000                                                                                          | 470      |                      |          |                  |       | Sessile drop                     | 1971 | 5   |
|         | 99.96             | 552                  | Ar                 | $\sigma_t = 552 - 0.167(t-t_{mp}) \text{ (MP--500}^{\circ}\text{C) (}^{\circ}\text{C)}$       |          |                      |          |                  |       | Bubble pressure                  | 1972 | 223 |
|         | 99.9999           | 550.5                | H <sub>2</sub> ,He | $\sigma_t = 569.0 - 0.080t \text{ (} \pm 5) \text{ (}^{\circ}\text{C)}$                       |          |                      |          |                  |       | Sessile drop                     | 1971 | 226 |
|         | 99.95             | 574                  | Ar                 | $\sigma_t = 626 - 0.222t \text{ (}^{\circ}\text{C) (608--800}^{\circ}\text{C)}$               |          |                      |          |                  |       | Bubble pressure                  | 1971 | 230 |
|         | 99.999            | 540                  | vac.               | $\sigma_t = 540 - 0.064(T-505) \text{ (T K)}$                                                 |          |                      |          |                  |       | Sessile drop                     | 1971 | 236 |
|         | —                 | 574.5                | H <sub>2</sub>     | $\sigma_t = 587.5 - 0.056t \text{ (}^{\circ}\text{C) (250--500}^{\circ}\text{C)}$             |          |                      |          |                  |       | Capillary rise                   | 1973 | 240 |
|         | —                 | 533                  | Ar                 | $\sigma_t = 524 - 0.073(t-360) \text{ (}^{\circ}\text{C)}$                                    |          |                      |          |                  |       | Bubble pressure                  | 1975 | 244 |
|         | 99.9              | (624)                | Ar                 | $(\sigma_t = 624 - 0.21(t-t_{mp}) - 1300^{\circ}\text{C)}$                                    |          |                      |          |                  |       | Sessile drop and bubble pressure | 1973 | 266 |
|         | 99.96             | 561                  | Ar                 | $\sigma_t = 561 - 0.13(t-t_{mp}) - 702^{\circ}\text{C}$                                       |          |                      |          |                  |       | Sessile drop                     | 1976 | 267 |
|         | 99.96             | 551                  | Ar                 | $\sigma_t = 551 - 0.17(t-t_{mp}) - 546^{\circ}\text{C}$                                       |          |                      |          |                  |       | Bubble pressure                  | 1976 | 267 |
|         | 99.99             | 540                  | vac.               | $\sigma_t = 540 - 0.064(T-T_{mp}) - 1473 \text{ K}$                                           |          |                      |          |                  |       | Sessile drop                     | 1974 | 273 |
|         | 99.999            | 560                  | H <sub>2</sub> ,Ar | $\sigma_t = 560 - 0.091t \text{ (} t_{mp} \text{) (}^{\circ}\text{C) - 1450}^{\circ}\text{C}$ |          |                      |          |                  |       | Sessile drop                     | 1976 | 276 |
|         | 99.999            | —                    | vac.               | 800                                                                                           | 501      | —                    | —        | —                | —     | Sessile drop                     | 1977 | 279 |
|         | 99.9998           | 540                  | vac.               | $\sigma_t = 540 - 0.04(t-t_{mp}) - 500^{\circ}\text{C}$                                       |          |                      |          |                  |       | levitated drop                   | 1964 | 280 |
|         | 99.99             | 551.4                | H <sub>2</sub>     | $\sigma_t = 551.4 - 0.089(t-t_{mp}) - 500^{\circ}\text{C}$                                    |          |                      |          |                  |       | Bubble pressure                  | 1977 | 287 |
|         | 99.999            | 561                  | vac.               | $\sigma_t = 561 - 0.13(T-T_{mp}) - 1173 \text{ K}$                                            |          |                      |          |                  |       | Sessile drop                     | 1979 | 288 |
|         | 99.85             | 559.8                | H <sub>2</sub>     | $\sigma_t = 559.8 - 0.095(t-t_{mp}) - 550^{\circ}\text{C}$                                    |          |                      |          |                  |       | Sessile drop                     | 1978 | 292 |
| Sr      |                   | 287                  | Ar                 | 775                                                                                           | 288      | 830                  | 282      | 893              | 282   | Bubble pressure                  | 1963 | 125 |

# SURFACE TENSION OF LIQUID ELEMENTS (continued)

| Element | Purity<br>(wt. %) | $\sigma_{mp}$ (mN/m) | Atm.                | Values of $\sigma$ at various temperatures                         |                                                                       |                      |          | Method              | Year | Ref.    |
|---------|-------------------|----------------------|---------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------|----------------------|----------|---------------------|------|---------|
|         |                   |                      |                     | $t/^{\circ}\text{C}$                                               | $\sigma$                                                              | $t/^{\circ}\text{C}$ | $\sigma$ |                     |      |         |
| Ta      | 99.5              | 303                  |                     | $\sigma = 393 = 392 - 0.085T$ ( $T^{\circ}\text{K}$ ) (115—1602°K) |                                                                       |                      |          | Bubble pressure     | 1968 | 25      |
|         |                   | 2360                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1959 | 88      |
|         |                   | 2030                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1959 | 88      |
|         |                   | 1910                 | vac.                |                                                                    |                                                                       |                      |          | Drop weight         | 1963 | 139     |
|         | 99.9983           | 2150                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1963 | 5       |
| Te      | 99.9              | (1884)               | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1965 | 65      |
|         | 99.4              | 186 ± 2              | Ar                  |                                                                    |                                                                       |                      |          | Bubble pressure     | 1961 | 105     |
|         |                   |                      | vac.                | 460                                                                | 178 ± 1.5                                                             |                      |          | Capillary method    | 1962 | 184     |
|         | —                 |                      | vac.                | 475                                                                | 162                                                                   |                      |          | Electro-capillarity | 1963 | 117     |
|         |                   | 178                  |                     |                                                                    | $\sigma = 178 - 0.024(t - t_{mp})$ ( $t^{\circ}\text{C}$ )            |                      |          | Bubble pressure     | 1969 | 204     |
| Th      |                   | 178.8                | vac.                |                                                                    | $\sigma_t = 178.8 - 0.07(t - t_{mp})$ ( $t^{\circ}\text{C}$ )         |                      |          | Sessile drop        | 1975 | 272     |
|         | —                 | —                    | vac.                | 500                                                                | 170                                                                   |                      |          | Drop pressure       | 1978 | 284     |
|         | 99.999            | 190                  | Ar                  |                                                                    | $\sigma_t = 190 - 0.035(t - 600)$ ( $t^{\circ}\text{C}$ ) 480—760°K   |                      |          | Bubble pressure     | 1970 | 289     |
|         | 99.999            |                      | Ar                  |                                                                    | $\sigma_t = 174 + 0.14(t - 450^{\circ}\text{C})$ 450—560°K            |                      |          | Bubble pressure     | 1970 | 289     |
|         | 99.99999          | 192                  | Ar                  |                                                                    | $\sigma_t = 192 - 0.03(t - 600^{\circ}\text{C})$ 470—900°K            |                      |          | Bubble pressure     | 1970 | 289     |
|         | 99.99999          |                      | Ar                  |                                                                    | $\sigma_t = 179 + 0.095(t - 450^{\circ}\text{C})$ 450—560°K           |                      |          | Bubble pressure     | 1970 | 289     |
|         | —                 | 978                  | vac.                |                                                                    |                                                                       |                      |          | Drop weight         | 1965 | 261     |
|         | 98.7              | 1510                 | vac.                |                                                                    |                                                                       |                      |          | Capillary method    | 1956 | 44      |
|         | 99.92             | 1390                 | Ar                  |                                                                    |                                                                       |                      |          | Pendant drop        | 1958 | 151     |
|         |                   | 1460                 | vac.                |                                                                    |                                                                       |                      |          | Drop weight         | 1963 | 139     |
| Ti      | 99.9991           | 1650                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1963 | 5       |
|         | 99.0              |                      | vac.                | 1680                                                               | 1576                                                                  |                      |          | Drop weight         | 1963 | 191     |
|         | 99.99999          |                      | vac.                | 1680                                                               | 1588                                                                  |                      |          | Drop weight         | 1963 | 191     |
|         | 99.85             | (1880)               | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1965 | 65      |
|         | 99.69             | 1402                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1965 | 65      |
|         | —                 | 1410 ± 10            | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1972 | 229     |
|         |                   |                      | H <sub>2</sub>      | 318                                                                | 436—444                                                               |                      |          | Bubble pressure     | 1929 | 11, 174 |
|         |                   | 464.5                | Ar                  |                                                                    |                                                                       |                      |          | Bubble pressure     | 1961 | 192     |
|         |                   |                      | vac.                | 450                                                                | 452                                                                   |                      |          | Drop pressure       | 1962 | 119     |
|         | —                 |                      | vac.                | 450                                                                | 450                                                                   |                      |          | Electro-capillarity | 1963 | 117     |
| U       | 99.999            | 467                  |                     |                                                                    | $\sigma = 536 - 0.119T$ ( $T^{\circ}\text{K}$ ) (1270—1695 K)         |                      |          | Bubble pressure     | 1968 | 26      |
|         | 99.999            |                      | vac.                | 450                                                                | 450                                                                   |                      |          | Drop pressure       | 1968 | 107     |
|         | 99.999            | 451                  | vac.                |                                                                    | $\sigma_t = 451 - 0.106(t - t_{mp}) - 750^{\circ}\text{C}$            |                      |          | Sessile drop        | 1978 | 284     |
|         | 99.999            | (513)                | Ar                  |                                                                    | $(\sigma_t = 513 - 0.11(t - t_{mp}))$ 500—900°K                       |                      |          | Bubble pressure     | 1979 | 289     |
|         | 99.999            | 1500 ± 75            | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1963 | 186     |
|         |                   | 1550                 | Ar                  |                                                                    |                                                                       |                      |          | Bubble pressure     | 1965 | 34      |
|         | 99.94             | (1294)               | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1965 | 65      |
|         | 99.993            |                      | Ar                  | 1190—1600                                                          | 1450                                                                  |                      |          | Sessile drop        | 1971 | 256     |
|         | 99.997            | 1950                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1963 | 5       |
|         | —                 | (1760)               | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1970 | 210     |
| W       | —                 | 2310                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1957 | 35      |
|         | 99.9999           | 2500                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1963 | 5       |
|         | 99.8              | 2220                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1963 | 148     |
|         | 99.9              | (2000)               | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1965 | 65      |
|         | 99.98             | 18.7                 | air                 | 162°K                                                              | 18.7                                                                  |                      |          | Capillary rise      | 1965 | 305     |
| Xe      |                   | 757                  | vac.                | 459                                                                | 754                                                                   | 500                  | 747      | Oscillating jet     | 1914 | 73      |
|         |                   |                      | air                 | 580—630                                                            | (708)                                                                 |                      |          | Capillary method    | 1914 | 183     |
|         |                   | 758                  | H <sub>2</sub>      | 477                                                                | 753                                                                   | 543                  | 747      | Drop pressure       | 1921 | 78      |
|         |                   | 830                  | H <sub>2</sub>      | 600                                                                | 787                                                                   | 700                  | 763      | Bubble pressure     | 1927 | 20      |
|         |                   | 784.4                | vac.                | 545                                                                | 749.5                                                                 | 635                  | 728.9    | Drop weight         | 1927 | 131     |
|         |                   | 802                  | H <sub>2</sub> , Ar | 510                                                                | 785                                                                   | 600                  | 768      | Bubble pressure     | 1929 | 111     |
|         |                   |                      | air, vac.           | 462                                                                | 782                                                                   |                      |          | Ring removal        | 1937 | 96      |
|         |                   |                      | N <sub>2</sub>      | 440                                                                | (816)                                                                 | 500                  | (798)    | Bubble pressure     | 1948 | 149     |
|         | 99.99             | 750 ± 20             | ar                  |                                                                    |                                                                       |                      |          | Bubble pressure     | 1960 | 104     |
|         | 99.99             | 757.0 ± 5            | vac.                |                                                                    |                                                                       |                      |          | Sessile drop        | 1966 | 202     |
| Zr      | 99.999            | 761.0                | vac.                |                                                                    |                                                                       |                      |          | Sessile drop        | 1966 | 202     |
|         | 99.9999           | 767.5                | vac.                |                                                                    |                                                                       |                      |          | Sessile drop        | 1966 | 202     |
|         | 99.99             | —                    | vac.                | 450                                                                | 770                                                                   |                      |          | Sessile drop        | 1972 | 250     |
|         | 99.999            | 780                  | vac.                |                                                                    | $\sigma_t = 780 - 0.17(t - t_{mp})$ (430—495°K)                       |                      |          | Drop pressure       | 1962 | 253     |
|         | 99.999            | —                    | Ar                  | 490 ± 10                                                           | 780 ± 10                                                              |                      |          | Bubble pressure     | 1979 | 288     |
|         | 99.997            | 806                  | vac.                |                                                                    | $\sigma_t = 806 - 0.25(t - t_{mp})$ ( $t^{\circ}\text{C}$ ) 420—800°K |                      |          | Sessile drop        | 1979 | 297     |
|         |                   | 1400                 | Ar                  |                                                                    |                                                                       |                      |          | Drop weight         | 1958 | 151     |
|         | 99.5              | 1411 ± 70            | vac.                |                                                                    |                                                                       |                      |          | Drop weight         | 1962 | 180     |
|         | 99.9998           | 1480                 | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1963 | 5       |
|         | 99.7              | (1533)               | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1965 | 65      |
|         | —                 | 1430 ± 10            | vac.                |                                                                    |                                                                       |                      |          | Pendant drop        | 1972 | 229     |



# SURFACE TENSION OF LIQUID ELEMENTS (continued)

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## TEMPERATURE CORRECTION FOR GLASS VOLUMETRIC APPARATUS

This table gives the correction to be added to actual capacity (determined at certain temperatures) to give the capacity at the standard temperature, 20°C. Conversely, by subtracting the corrections from the indicated capacity of an instrument standard at 20°C, the corresponding capacity at other temperatures is obtained. The table assumes for the cubical coefficient of expansion of glass 0.000025 per degree centigrade. The coefficients of expansion of glasses used for volumetric instruments vary from 0.000023 to 0.000028.

| Temperature<br>in degrees C. | 2,000 ml | 1,000 ml | 500 ml | 400 ml | 300 ml | 250 ml  | Temperature<br>in degrees C. | 2,000 ml | 1,000 ml | 500 ml | 400 ml | 300 ml | 250 ml |
|------------------------------|----------|----------|--------|--------|--------|---------|------------------------------|----------|----------|--------|--------|--------|--------|
| 15                           | + 0.25   | + 1.12   | + 0.06 | + 0.05 | + 0.04 | + 0.031 | 23                           | - .15    | - .08    | - .04  | - .03  | - .02  | - .019 |
| 16                           | + .20    | + .10    | + .05  | + 0.04 | + .03  | + .025  | 24                           | - .20    | - .10    | - .05  | - .04  | - .03  | - .025 |
| 17                           | + .15    | + .08    | + .04  | + .03  | + .02  | + .019  | 25                           | - .25    | - .12    | - .06  | - .05  | - .04  | - .031 |
| 18                           | + .10    | + .05    | + .02  | + .02  | + .02  | + .012  | 26                           | - .30    | - .15    | - .08  | - .06  | - .04  | - .038 |
| 19                           | + .05    | + .02    | + .01  | + .01  | + .01  | + .006  | 27                           | - .35    | - .18    | - .09  | - .07  | - .05  | - .044 |
| 21                           | - .05    | - .02    | - .01  | - .01  | - .01  | - .006  | 28                           | - .40    | - .20    | - .10  | - .08  | - .06  | - .050 |
| 22                           | - .10    | - .05    | - .02  | - .02  | - .02  | - .012  | 29                           | - .45    | - .22    | - .11  | - .09  | - .07  | - .056 |
|                              |          |          |        |        |        |         | 30                           | - .50    | - .25    | - .12  | - .10  | - .08  | - .062 |

### TEMPERATURE CORRECTION FOR VOLUMETRIC SOLUTIONS

This table gives the correction to various observed volumes of water, measured at the designated temperatures to give the volume at the standard temperature, 20°C. Conversely, by subtracting the corrections from the volume desired at 20°C., the volume that must be measured out at the designated temperatures in order to give the desired volume at 20°C., will be obtained. It is assumed that the volumes are measured in glass apparatus having a coefficient of cubical expansion of 0.000025 per degree centigrade. The table is applicable to dilute aqueous solutions having the same coefficient of expansion as water.

| Temperature of measurement, °C. | Capacity of apparatus in milliliters at 20°C.              |       |       |       |       |       |       | Temperature of measurement, °C. | Capacity of apparatus in milliliters at 20°C.              |       |       |      |      |      |      |
|---------------------------------|------------------------------------------------------------|-------|-------|-------|-------|-------|-------|---------------------------------|------------------------------------------------------------|-------|-------|------|------|------|------|
|                                 | 2,000                                                      | 1,000 | 500   | 400   | 300   | 250   | 150   |                                 | 2,000                                                      | 1,000 | 500   | 400  | 300  | 250  | 150  |
|                                 | Correction in milliliters to give volume of water at 20°C. |       |       |       |       |       |       |                                 | Correction in milliliters to give volume of water at 20°C. |       |       |      |      |      |      |
| 15                              | +1.54                                                      | +0.77 | +0.38 | +0.31 | +0.23 | +0.19 | +0.12 | 24                              | -1.61                                                      | -.81  | -.40  | -.32 | -.24 | -.20 | -.12 |
| 16                              | +1.28                                                      | +.64  | +.32  | +.26  | +.19  | +.16  | +.10  | 25                              | -2.07                                                      | -1.03 | -.52  | -.41 | -.31 | -.26 | -.15 |
| 17                              | +.99                                                       | +.50  | +.25  | +.20  | +.15  | +.12  | +.07  | 26                              | -2.54                                                      | -1.27 | -.64  | -.51 | -.38 | -.32 | -.19 |
| 18                              | +.68                                                       | +.34  | +.17  | +.14  | +.10  | +.08  | +.05  | 27                              | -3.03                                                      | -1.52 | -.76  | -.61 | -.46 | -.38 | -.23 |
| 19                              | +.35                                                       | +.18  | +.09  | +.07  | +.05  | +.04  | +.03  | 28                              | -3.55                                                      | -1.77 | -.89  | -.71 | -.53 | -.44 | -.27 |
| 21                              | -.37                                                       | -.18  | -.09  | -.07  | -.06  | -.05  | -.03  | 29                              | -4.08                                                      | -2.04 | -1.02 | -.82 | -.61 | -.51 | -.31 |
| 22                              | -.77                                                       | -.38  | -.19  | -.15  | -.12  | -.10  | -.06  | 30                              | -4.62                                                      | -2.31 | -1.16 | -.92 | -.69 | -.58 | -.35 |
| 23                              | -1.18                                                      | -.59  | -.30  | -.24  | -.18  | -.15  | -.09  |                                 |                                                            |       |       |      |      |      |      |

In using the above table to correct the volume of certain standard solutions to 20°C. more accurate results will be obtained if the numerical values of the corrections are increased by the percentages given below:

| Solution                       | Normality |     |      |
|--------------------------------|-----------|-----|------|
|                                | N         | N/2 | N/10 |
| HNO <sub>3</sub>               | 50        | 25  | 6    |
| H <sub>2</sub> SO <sub>4</sub> | 45        | 25  | 5    |
| NaOH                           | 40        | 25  | 5    |
| KOH                            | 40        | 20  | 4    |

## TEMPERATURE CORRECTION, GLASS SCALE

Metric

To reduce readings of a mercurial barometer with a glass scale to 0°C. subtract the appropriate quantity as found in table.

| Temp<br>°C | Observed height in centimeters. |       |       |       |       |       |       |       |       |       | Temp.<br>°C | Observed height in centimeters. |       |       |       |       |       |       |       |  |  |
|------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|--|--|
|            | 70 cm                           | 71 cm | 72 cm | 73 cm | 74 cm | 75 cm | 76 cm | 77 cm | 78 cm | 70 cm |             | 71 cm                           | 72 cm | 73 cm | 74 cm | 75 cm | 76 cm | 77 cm | 78 cm |  |  |
| 0          | 0.000                           | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 15    | 0.181       | 0.184                           | 0.186 | 0.189 | 0.191 | 0.193 | 0.196 | 0.198 | 0.201 |  |  |
| 1          | .012                            | .012  | .013  | .013  | .013  | .013  | .013  | .013  | .014  | 16    | .194        | .196                            | .199  | .201  | .204  | .207  | .209  | .212  | .214  |  |  |
| 2          | .025                            | .025  | .025  | .026  | .026  | .026  | .026  | .027  | .027  | 17    | .205        | .208                            | .210  | .213  | .216  | .219  | .221  | .224  | .227  |  |  |
| 3          | .036                            | .036  | .037  | .037  | .038  | .038  | .039  | .039  | .040  | 18    | .217        | .220                            | .223  | .226  | .229  | .232  | .235  | .238  | .241  |  |  |
| 4          | .048                            | .049  | .049  | .050  | .051  | .051  | .052  | .053  | .053  | 19    | .230        | .233                            | .236  | .239  | .242  | .245  | .248  | .251  | .254  |  |  |
| 5          | .060                            | .061  | .062  | .063  | .064  | .064  | .065  | .066  | .067  | 20    | .242        | .245                            | .248  | .252  | .255  | .258  | .261  | .264  | .268  |  |  |
| 6          | .073                            | .074  | .074  | .076  | .077  | .077  | .078  | .079  | .080  | 21    | .254        | .258                            | .261  | .264  | .268  | .271  | .275  | .278  | .281  |  |  |
| 7          | .085                            | .086  | .087  | .088  | .089  | .091  | .092  | .093  | .094  | 22    | .266        | .269                            | .273  | .276  | .280  | .283  | .287  | .290  | .294  |  |  |
| 8          | .096                            | .098  | .099  | .100  | .101  | .103  | .104  | .105  | .107  | 23    | .278        | .282                            | .285  | .289  | .293  | .296  | .300  | .304  | .308  |  |  |
| 9          | .109                            | .110  | .111  | .113  | .114  | .116  | .117  | .119  | .120  | 24    | .290        | .294                            | .298  | .302  | .306  | .310  | .313  | .317  | .321  |  |  |
| 10         | .121                            | .122  | .124  | .126  | .127  | .129  | .130  | .132  | .134  | 25    | .303        | .307                            | .311  | .315  | .319  | .323  | .327  | .331  | .335  |  |  |
| 11         | .133                            | .135  | .137  | .138  | .140  | .142  | .144  | .146  | .147  | 26    | .315        | .319                            | .323  | .327  | .332  | .336  | .340  | .344  | .348  |  |  |
| 12         | .144                            | .146  | .148  | .150  | .152  | .154  | .156  | .158  | .160  | 27    | .326        | .331                            | .335  | .339  | .344  | .348  | .352  | .357  | .361  |  |  |
| 13         | .157                            | .159  | .161  | .163  | .165  | .167  | .169  | .171  | .174  | 28    | .339        | .343                            | .348  | .352  | .357  | .361  | .366  | .370  | .375  |  |  |
| 14         | .169                            | .171  | .174  | .176  | .178  | .180  | .183  | .185  | .187  | 29    | .351        | .356                            | .360  | .365  | .370  | .374  | .379  | .384  | .388  |  |  |
|            |                                 |       |       |       |       |       |       |       |       | 30    | .363        | .368                            | .373  | .378  | .383  | .387  | .392  | .397  | .402  |  |  |



# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS

C. T. Avedisian

The limit of superheat of a liquid, also known as the homogenous nucleation limit, represents the deepest possible penetration of a liquid into the domain of metastable states. At constant pressure ( $P$ ) it is the highest temperature ( $T$ ) below the critical point that a liquid can sustain without undergoing a phase transition; at constant temperature, it is the lowest pressure. The importance of this limit resides in the consequences of the phase transition that eventually occurs when the limit is reached. The phase transition may be explosive or nonexplosive as it relates to such processes as contact vapor explosions in postulated nuclear reactor accidents, spills of liquid natural gas during transport, and burning of fuel droplets.

The perspective upon which the concept of a superheat limit emerges is based on random molecular density fluctuations within the bulk of a liquid producing hole-like regions of molecular dimensions that act as bubbles. A phase transition occurs when a bubble, formed by these molecular processes, grows to a size such that it is in unstable equilibrium (i.e., a "critical size nucleus") with the surrounding liquid. The "nucleation rate",  $J$ , refers to the mean rate of forming such vapor nuclei in units of nuclei/(volume•time).

According to classical homogeneous nucleation theory, the nucleation rate depends exponentially on the energy ( $\Phi$ ) of forming a critical size nucleus as follows:

$$J = \Gamma k_n N_o \exp[-\Phi/(kT)] \quad (1)$$

where

$$\Phi = 16 \pi \sigma^3 / [3(P_b - P)^2] \quad (2)$$

and  $k$  is the Boltzmann constant,  $k_n$  is the molecular evaporation rate for a nucleus containing  $n$  molecules,  $N_o$  is the number density of liquid molecules,  $P$  is the ambient pressure,  $P_b$  is the gas pressure within the critical size nucleus,  $\sigma$  is surface tension, and  $\Gamma$  is a kinetic pre-factor which accounts for the possibility that nuclei larger than the critical size may decay; if every critical size nucleus continues to grow, then  $\Gamma = 1$ . From Equations (1) and (2), it is evident that 1) a unique superheat limit does not exist because to each nucleation rate corresponds its own superheat limit at a given ambient pressure, 2) if  $J$  increases so should  $T$  at constant pressure, and 3)  $J$  depends very strongly on  $T$  because of the variation of physical properties (surface tension, vapor pressure, and density) with temperature. This strong dependence implies the existence of a threshold temperature above which  $J$  will be large and below which it will be negligibly small. The limit of superheat is defined as the mean temperature in this range of large change of  $J$ .

The limits of superheat given below are organized as follows. All substances are listed in alphabetical order by chemical formula. Inorganic substances are listed first, followed by organic compounds in the order of increasing carbon number. The second and third columns list the nucleation pressures and temperatures at the corresponding nucleation rate. The nucleation rates listed are characteristic of the various experimental methods used to perform the measurements.

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| Substance      | $P$<br>[MPa] | $T$<br>[K] | $J$<br>[nuclei/(cm <sup>3</sup> •s)] |
|----------------|--------------|------------|--------------------------------------|
| Ar             | -1.220       | 85.0       | 10 <sup>2</sup>                      |
| Argon          | 0.101        | 130.8      | 10 <sup>2</sup>                      |
|                | 0.190        | 131.2      | 10 <sup>2</sup>                      |
|                | 0.260        | 131.5      | 10 <sup>5</sup>                      |
|                | 0.360        | 131.8      | 10                                   |
|                | 0.410        | 131.9      | 10 <sup>5</sup>                      |
|                | 0.600        | 132.8      | 10 <sup>5</sup>                      |
|                | 0.810        | 133.5      | 10 <sup>3</sup>                      |
|                | 1.100        | 134.3      | 10                                   |
|                | 1.150        | 135.1      | 10 <sup>5</sup>                      |
|                | 1.400        | 135.3      | 10                                   |
|                | 1.420        | 136.0      | 10 <sup>5</sup>                      |
|                | 1.720        | 137.1      | 10 <sup>5</sup>                      |
|                | 2.140        | 138.6      | 10 <sup>5</sup>                      |
|                | 2.450        | 139.5      | 10 <sup>5</sup>                      |
|                | 2.710        | 141.3      | 10 <sup>5</sup>                      |
| H <sub>2</sub> | 0.076        | 27.8       | 10 <sup>-2</sup>                     |
| Hydrogen       | 0.149        | 27.9       | 10 <sup>-2</sup>                     |
|                | 0.381        | 29.4       | 10 <sup>-2</sup>                     |
|                | 0.751        | 30.6       | 10 <sup>-2</sup>                     |
|                | 0.834        | 30.8       | 10 <sup>-2</sup>                     |



# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance | <i>T</i><br>[MPa] | <i>J</i><br>[K] | [nuclei/(cm <sup>3</sup> ·s)] |
|-----------------------|-------------------|-----------------|-------------------------------|
| H <sub>2</sub> O      | −27.700           | 283.2           | 10 <sup>3</sup>               |
| Water                 | 0.101             | 553.0           | 10 <sup>6</sup>               |
|                       | 0.101             | 575.2           | 10 <sup>15</sup>              |
|                       | 1.293             | 580.4           | 10 <sup>21</sup>              |
|                       | 2.519             | 584.9           | 10 <sup>21</sup>              |
|                       | 2.710             | 588.3           | 10 <sup>21</sup>              |
|                       | 5.000             | 593.6           | 10 <sup>21</sup>              |
|                       | 6.808             | 600.4           | 10 <sup>21</sup>              |
|                       | 8.500             | 606.5           | 10 <sup>21</sup>              |
|                       | 9.731             | 607.2           | 10 <sup>21</sup>              |
|                       | 10.746            | 610.3           | 10 <sup>21</sup>              |
|                       | 11.978            | 615.6           | 10 <sup>21</sup>              |
|                       | 12.873            | 616.7           | 10 <sup>21</sup>              |
|                       | 13.731            | 620.2           | 10 <sup>21</sup>              |
|                       | 15.789            | 627.0           | 10 <sup>21</sup>              |
|                       | 17.556            | 632.3           | 10 <sup>21</sup>              |
|                       | 20.113            | 642.2           | 10 <sup>21</sup>              |
| He I                  | 0.012             | 4.05            | 10 <sup>7</sup>               |
| Helium I              | 0.017             | 4.12            | 10 <sup>7</sup>               |
|                       | 0.037             | 4.22            | 10 <sup>7</sup>               |
|                       | 0.054             | 4.31            | 10 <sup>7</sup>               |
|                       | 0.066             | 4.37            | 10 <sup>7</sup>               |
|                       | 0.081             | 4.45            | 10 <sup>7</sup>               |
|                       | 0.100             | 4.55            | 10 <sup>7</sup>               |
|                       | 0.112             | 4.62            | 10 <sup>7</sup>               |
|                       | 0.129             | 4.70            | 10 <sup>7</sup>               |
|                       | 0.143             | 4.76            | 10 <sup>7</sup>               |
| He II                 | −0.06             | 2.09            | 10 <sup>5</sup>               |
| Helium II             |                   |                 |                               |
| Kr                    | 0.400             | 182.5           | 10 <sup>5</sup>               |
| Krypton               | 0.820             | 184.3           | 10 <sup>5</sup>               |
|                       | 1.200             | 187.0           | 10 <sup>5</sup>               |
|                       | 1.410             | 187.6           | 10 <sup>5</sup>               |
|                       | 1.630             | 189.1           | 10 <sup>5</sup>               |
|                       | 1.900             | 189.9           | 10 <sup>5</sup>               |
|                       | 2.200             | 192.1           | 10 <sup>5</sup>               |
|                       | 2.430             | 192.9           | 10 <sup>5</sup>               |
|                       | 2.800             | 194.8           | 10 <sup>5</sup>               |
|                       | 3.140             | 196.6           | 10 <sup>5</sup>               |
|                       | 3.460             | 198.0           | 10 <sup>5</sup>               |
|                       | 3.800             | 199.4           | 10 <sup>5</sup>               |
| N <sub>2</sub>        | −1.010            | 75.0            | 10 <sup>2</sup>               |
| Nitrogen              | 0.101             | 110.0           | 1.0                           |
|                       | 0.410             | 111.4           | 10 <sup>5</sup>               |
|                       | 0.520             | 112.0           | 10 <sup>5</sup>               |
|                       | 0.610             | 112.1           | 10 <sup>5</sup>               |
|                       | 0.700             | 112.7           | 10 <sup>5</sup>               |
|                       | 0.820             | 113.2           | 10 <sup>5</sup>               |
|                       | 0.940             | 113.8           | 10 <sup>5</sup>               |
|                       | 1.060             | 114.2           | 10 <sup>5</sup>               |
|                       | 1.210             | 114.8           | 10 <sup>5</sup>               |
|                       | 1.240             | 115.2           | 10 <sup>5</sup>               |
|                       | 1.330             | 115.5           | 10 <sup>5</sup>               |

# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance         | <i>T</i><br>[MPa] | <i>J</i><br>[K] | [nuclei/(cm <sup>3</sup> .s)] |
|-------------------------------|-------------------|-----------------|-------------------------------|
|                               | 1.360             | 115.6           | 10 <sup>5</sup>               |
|                               | 1.460             | 116.2           | 10 <sup>5</sup>               |
|                               | 1.590             | 116.8           | 10 <sup>5</sup>               |
|                               | 1.620             | 117.0           | 10 <sup>5</sup>               |
|                               | 1.730             | 117.6           | 10 <sup>5</sup>               |
|                               | 1.770             | 117.7           | 10 <sup>5</sup>               |
|                               | 1.870             | 118.3           | 10 <sup>5</sup>               |
|                               | 1.920             | 118.4           | 10 <sup>5</sup>               |
|                               | 2.070             | 119.1           | 10 <sup>5</sup>               |
| N <sub>2</sub> O <sub>4</sub> | 0.154             | 395.6           | 10 <sup>2</sup>               |
| Nitrogen tetroxide            | 0.554             | 396.2           | 10 <sup>2</sup>               |
|                               | 0.980             | 398.2           | 10                            |
|                               | 2.000             | 401.5           | 10                            |
|                               | 3.040             | 405.2           | 10                            |
|                               | 3.920             | 408.1           | 10                            |
|                               | 4.500             | 410.2           | 10                            |
|                               | 5.000             | 412.5           | 10                            |
|                               | 5.500             | 414.5           | 10                            |
|                               | 6.000             | 416.4           | 10                            |
| O <sub>2</sub>                | -1.520            | 75.0            | 10 <sup>2</sup>               |
| Oxygen                        | 0.101             | 134.1           | 1.0                           |
|                               | 0.400             | 135.4           | 10 <sup>5</sup>               |
|                               | 0.500             | 136.2           | 10 <sup>5</sup>               |
|                               | 0.680             | 136.5           | 10 <sup>5</sup>               |
|                               | 0.920             | 137.4           | 10 <sup>5</sup>               |
|                               | 1.060             | 137.5           | 10 <sup>5</sup>               |
|                               | 1.180             | 138.3           | 10 <sup>5</sup>               |
|                               | 1.350             | 138.9           | 10 <sup>5</sup>               |
|                               | 1.480             | 139.3           | 10 <sup>5</sup>               |
|                               | 1.740             | 140.7           | 10 <sup>5</sup>               |
|                               | 2.030             | 141.9           | 10 <sup>5</sup>               |
|                               | 2.260             | 142.8           | 10 <sup>5</sup>               |
|                               | 2.500             | 143.6           | 10 <sup>5</sup>               |
|                               | 2.700             | 144.5           | 10 <sup>5</sup>               |
|                               | 2.970             | 145.9           | 10 <sup>5</sup>               |
| SO <sub>2</sub>               | 0.101             | 323.2           | 10 <sup>2</sup>               |
| Sulfur dioxide                |                   |                 |                               |
| Xe                            | 0.500             | 254.1           | 10 <sup>5</sup>               |
| Xenon                         | 0.830             | 256.3           | 10 <sup>5</sup>               |
|                               | 1.070             | 257.2           | 10 <sup>5</sup>               |
|                               | 1.260             | 258.2           | 10 <sup>5</sup>               |
|                               | 1.470             | 259.6           | 10 <sup>5</sup>               |
|                               | 1.550             | 260.3           | 10 <sup>5</sup>               |
|                               | 1.680             | 261.0           | 10 <sup>5</sup>               |
|                               | 1.750             | 261.6           | 10 <sup>5</sup>               |
|                               | 1.860             | 261.9           | 10 <sup>5</sup>               |
|                               | 1.970             | 262.8           | 10 <sup>5</sup>               |
|                               | 2.070             | 263.4           | 10 <sup>5</sup>               |
|                               | 2.170             | 263.8           | 10 <sup>5</sup>               |
|                               | 2.370             | 265.2           | 10 <sup>5</sup>               |
|                               | 2.480             | 266.1           | 10 <sup>5</sup>               |
|                               | 2.630             | 266.9           | 10 <sup>5</sup>               |
|                               | 2.750             | 267.5           | 10 <sup>5</sup>               |

# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance           | <i>T</i><br>[MPa] | <i>J</i><br>[K] | [nuclei/(cm <sup>3</sup> ·s)] |
|---------------------------------|-------------------|-----------------|-------------------------------|
|                                 | 2.850             | 267.8           | 10 <sup>5</sup>               |
|                                 | 2.970             | 269.1           | 10 <sup>5</sup>               |
|                                 | 3.050             | 269.7           | 10 <sup>5</sup>               |
|                                 | 3.130             | 270.0           | 10 <sup>5</sup>               |
|                                 | 3.450             | 272.0           | 10 <sup>5</sup>               |
|                                 | 3.630             | 273.0           | 10 <sup>5</sup>               |
| CCl <sub>2</sub> F <sub>2</sub> | 0.221             | 342.5           | 10 <sup>6</sup>               |
| Dichlorodifluoromethane         | 0.427             | 344.3           | 10 <sup>6</sup>               |
|                                 | 0.462             | 344.7           | 10 <sup>6</sup>               |
|                                 | 0.655             | 346.6           | 10 <sup>6</sup>               |
|                                 | 0.896             | 348.8           | 10 <sup>6</sup>               |
|                                 | 0.931             | 349.0           | 10 <sup>6</sup>               |
|                                 | 1.227             | 351.7           | 10 <sup>6</sup>               |
|                                 | 1.489             | 354.4           | 10 <sup>6</sup>               |
|                                 | 1.917             | 358.8           | 10 <sup>6</sup>               |
|                                 | 2.399             | 363.7           | 10 <sup>6</sup>               |
|                                 | 2.910             | 369.0           | 10 <sup>6</sup>               |
|                                 | 3.289             | 373.0           | 10 <sup>6</sup>               |
|                                 | 3.323             | 373.4           | 10 <sup>6</sup>               |
|                                 | 3.585             | 376.2           | 10 <sup>6</sup>               |
|                                 | 3.634             | 376.9           | 10 <sup>6</sup>               |
| CCl <sub>4</sub>                | −27.600           | 268.2           | 10 <sup>3</sup>               |
| Carbon tetrachloride            |                   |                 |                               |
| CHClF <sub>2</sub>              | 0.101             | 327.8           | 10 <sup>4</sup>               |
| Chlorodifluoromethane           | 0.236             | 328.2           | 10 <sup>4</sup>               |
|                                 | 0.280             | 329.4           | 10 <sup>4</sup>               |
|                                 | 0.510             | 330.8           | 10 <sup>4</sup>               |
|                                 | 0.560             | 331.5           | 10 <sup>4</sup>               |
|                                 | 0.710             | 332.4           | 10 <sup>4</sup>               |
|                                 | 0.810             | 332.9           | 10 <sup>4</sup>               |
|                                 | 0.910             | 334.2           | 10 <sup>4</sup>               |
| CHCl <sub>3</sub>               | −31.700           | 258.2           | 10 <sup>3</sup>               |
| Trichloromethane                | 0.101             | 466.2           | 10 <sup>2</sup>               |
| CH <sub>2</sub> Cl <sub>2</sub> | 0.101             | 394.8           | 10                            |
| Dichloromethane                 |                   |                 |                               |
| CH <sub>3</sub> Cl              | 0.101             | 366.2           | 10 <sup>5</sup>               |
| Chloromethane                   |                   |                 |                               |
| CH <sub>4</sub>                 | 0.400             | 167.6           | 10 <sup>5</sup>               |
| Methane                         | 0.620             | 168.3           | 10 <sup>5</sup>               |
|                                 | 0.820             | 169.3           | 10 <sup>5</sup>               |
|                                 | 1.030             | 170.5           | 10 <sup>5</sup>               |
|                                 | 1.230             | 171.4           | 10 <sup>5</sup>               |
|                                 | 1.430             | 172.1           | 10 <sup>5</sup>               |
|                                 | 1.630             | 173.1           | 10 <sup>5</sup>               |
|                                 | 1.830             | 174.0           | 10 <sup>5</sup>               |
|                                 | 2.030             | 175.2           | 10 <sup>5</sup>               |
|                                 | 2.220             | 176.4           | 10 <sup>5</sup>               |
|                                 | 2.430             | 177.6           | 10 <sup>5</sup>               |
|                                 | 2.630             | 178.6           | 10 <sup>5</sup>               |
|                                 | 2.820             | 180.0           | 10 <sup>5</sup>               |

# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance                                              | <i>T</i><br>[MPa]                                                                               | <i>J</i><br>[K]                                                                                 | [nuclei/(cm <sup>3</sup> ·s)]                                                                                                                                                                            |
|--------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CH <sub>3</sub> O                                                  | 0.101                                                                                           | 458.4                                                                                           | 10                                                                                                                                                                                                       |
| Methanol                                                           | 0.101                                                                                           | 461.2                                                                                           | 10 <sup>5</sup>                                                                                                                                                                                          |
|                                                                    | 0.101                                                                                           | 466.2                                                                                           | 10 <sup>18</sup>                                                                                                                                                                                         |
|                                                                    | 0.600                                                                                           | 469.2                                                                                           | 10 <sup>19</sup>                                                                                                                                                                                         |
|                                                                    | 1.050                                                                                           | 471.2                                                                                           | 10 <sup>20</sup>                                                                                                                                                                                         |
|                                                                    | 2.030                                                                                           | 476.7                                                                                           | 10 <sup>16</sup>                                                                                                                                                                                         |
|                                                                    | 2.030                                                                                           | 478.2                                                                                           | 10 <sup>20</sup>                                                                                                                                                                                         |
|                                                                    | 3.000                                                                                           | 482.2                                                                                           | 10 <sup>21</sup>                                                                                                                                                                                         |
|                                                                    | 4.000                                                                                           | 488.7                                                                                           | 10 <sup>22</sup>                                                                                                                                                                                         |
|                                                                    | 4.980                                                                                           | 494.7                                                                                           | 10 <sup>22</sup>                                                                                                                                                                                         |
|                                                                    | 5.970                                                                                           | 501.2                                                                                           | 10 <sup>23</sup>                                                                                                                                                                                         |
|                                                                    | 6.960                                                                                           | 507.7                                                                                           | 10 <sup>23</sup>                                                                                                                                                                                         |
| C <sub>2</sub> H <sub>3</sub> Cl<br>Chloroethane                   | 0.101                                                                                           | 374.1                                                                                           | 10 <sup>5</sup>                                                                                                                                                                                          |
| C <sub>2</sub> H <sub>3</sub> F<br>Fluoroethene                    | 0.101                                                                                           | 290.1                                                                                           | 10 <sup>5</sup>                                                                                                                                                                                          |
| C <sub>2</sub> H <sub>3</sub> N<br>Acetonitrile                    | 0.101                                                                                           | 497.0                                                                                           | 10 <sup>6</sup>                                                                                                                                                                                          |
| C <sub>2</sub> H <sub>4</sub> F <sub>2</sub><br>1,1-Difluoroethane | 0.101                                                                                           | 343.6                                                                                           | 10 <sup>5</sup>                                                                                                                                                                                          |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub><br>Acetic acid        | -28.800<br>0.101                                                                                | 292.7<br>526.2                                                                                  | 10 <sup>3</sup><br>10 <sup>6</sup>                                                                                                                                                                       |
| C <sub>2</sub> H <sub>4</sub> O <sub>2</sub><br>Methyl formate     | 0.101                                                                                           | 423.2                                                                                           | 10                                                                                                                                                                                                       |
| C <sub>2</sub> H <sub>5</sub> Br<br>Ethyl bromide                  | 0.101                                                                                           | 422.2                                                                                           | 10                                                                                                                                                                                                       |
| C <sub>2</sub> H <sub>5</sub> Cl<br>Ethyl chloride                 | 0.101                                                                                           | 399.2                                                                                           | 10                                                                                                                                                                                                       |
| C <sub>2</sub> H <sub>6</sub><br>Ethane                            | 0.101                                                                                           | 269.2                                                                                           | 10 <sup>5</sup>                                                                                                                                                                                          |
| C <sub>2</sub> H <sub>6</sub> O<br>Ethanol                         | 0.101<br>0.101<br>0.101<br>0.580<br>0.980<br>1.070<br>1.540<br>2.030<br>2.520<br>3.010<br>3.500 | 464.1<br>466.0<br>471.5<br>474.2<br>471.0<br>477.2<br>481.7<br>484.2<br>486.7<br>490.2<br>494.2 | 10<br>10 <sup>4</sup><br>10 <sup>17</sup><br>10 <sup>19</sup><br>10 <sup>2</sup><br>10 <sup>20</sup><br>10 <sup>20</sup><br>10 <sup>21</sup><br>10 <sup>21</sup><br>10 <sup>21</sup><br>10 <sup>22</sup> |
| C <sub>3</sub> H <sub>3</sub> N<br>Acrylonitrile                   | 0.101                                                                                           | 489.0                                                                                           | 10 <sup>5</sup>                                                                                                                                                                                          |
| C <sub>3</sub> H <sub>4</sub><br>Propadiene                        | 0.101                                                                                           | 346.2                                                                                           | 10 <sup>5</sup>                                                                                                                                                                                          |

# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance                                          | <i>T</i><br>[MPa] | <i>J</i><br>[K] | [nuclei/(cm <sup>3</sup> ·s)] |
|----------------------------------------------------------------|-------------------|-----------------|-------------------------------|
| C <sub>3</sub> H <sub>4</sub><br>Propyne                       | 0.101             | 356.8           | 10 <sup>5</sup>               |
| C <sub>3</sub> H <sub>6</sub><br>Cyclopropane                  | 0.101             | 350.7           | 10 <sup>5</sup>               |
| C <sub>3</sub> H <sub>6</sub><br>Propene                       | 0.101             | 325.6           | 10 <sup>5</sup>               |
| C <sub>3</sub> H <sub>6</sub> O<br>Acetone                     | 0.101             | 454.5           | 10                            |
|                                                                | 0.101             | 456.4           | 10 <sup>2</sup>               |
|                                                                | 0.101             | 458.7           | 10 <sup>13</sup>              |
|                                                                | 0.101             | 462.7           | 10 <sup>18</sup>              |
|                                                                | 0.980             | 462.6           | 10                            |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub><br>Ethyl formate  | 0.101             | 428.5           | 10                            |
| C <sub>3</sub> H <sub>6</sub> O <sub>2</sub><br>Methyl acetate | 0.101             | 416.6           | 10                            |
| C <sub>3</sub> H <sub>8</sub><br>Propane                       | 0.101             | 326.4           | 10 <sup>6</sup>               |
|                                                                | 0.302             | 332.8           | 10 <sup>4</sup>               |
|                                                                | 0.491             | 336.8           | 10 <sup>4</sup>               |
|                                                                | 0.715             | 339.1           | 10 <sup>4</sup>               |
|                                                                | 0.907             | 343.2           | 10 <sup>4</sup>               |
| C <sub>3</sub> H <sub>8</sub> O<br>1-Propanol                  | 0.101             | 487.4           | 10 <sup>4</sup>               |
|                                                                | 0.101             | 493.0           | 10 <sup>15</sup>              |
|                                                                | 0.101             | 495.7           | 10 <sup>18</sup>              |
| C <sub>3</sub> H <sub>8</sub> O<br>Isopropanol                 | 0.101             | 473.0           | 10 <sup>6</sup>               |
| C <sub>4</sub> H <sub>6</sub><br>1,3-Butadiene                 | 0.101             | 377.3           | 10 <sup>5</sup>               |
| C <sub>4</sub> H <sub>8</sub><br>1-Butene                      | 0.101             | 371.0           | 10 <sup>5</sup>               |
| C <sub>4</sub> H <sub>8</sub><br><i>cis</i> -2-Butene          | 0.101             | 385.4           | 10 <sup>5</sup>               |
| C <sub>4</sub> H <sub>8</sub><br><i>trans</i> -2-Butene        | 0.101             | 379.7           | 10 <sup>5</sup>               |
| C <sub>4</sub> H <sub>8</sub><br>2-Methylpropene               | 0.101             | 369.6           | 10 <sup>5</sup>               |
| C <sub>4</sub> H <sub>10</sub><br>Butane                       | 0.101             | 377.6           | 10 <sup>5</sup>               |
| C <sub>4</sub> H <sub>10</sub><br>2-Methylpropane              | 0.101             | 361.0           | 10 <sup>5</sup>               |
| C <sub>4</sub> H <sub>10</sub> O<br>1-Butanol                  | 0.101             | 509.6           | 10 <sup>2</sup>               |
|                                                                | 0.101             | 511.9           | 10 <sup>4</sup>               |

# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance            | <i>T</i><br>[MPa] | <i>J</i><br>[K] | [nuclei/(cm <sup>3</sup> ·s)] |
|----------------------------------|-------------------|-----------------|-------------------------------|
|                                  | 0.101             | 513.2           | 10 <sup>13</sup>              |
|                                  | 0.101             | 516.2           | 10 <sup>16</sup>              |
|                                  | 0.101             | 518.2           | 10 <sup>18</sup>              |
|                                  | 0.908             | 519.4           | 10 <sup>2</sup>               |
| C <sub>4</sub> H <sub>10</sub> O | -1.75             | 293.            | 10 <sup>2</sup>               |
| Diethyl ether                    | -1.520            | 402.7           | 10 <sup>4</sup>               |
|                                  | -1.220            | 407.6           | 10 <sup>4</sup>               |
|                                  | -1.120            | 409.2           | 10 <sup>4</sup>               |
|                                  | -1.000            | 410.2           | 10 <sup>4</sup>               |
|                                  | -0.740            | 413.4           | 10 <sup>4</sup>               |
|                                  | 0.101             | 417.5           | 10 <sup>2</sup>               |
|                                  | 0.101             | 425.7           | 10 <sup>19</sup>              |
|                                  | 0.211             | 419.4           | 10                            |
|                                  | 0.415             | 420.3           | 10                            |
|                                  | 0.480             | 427.7           | 10 <sup>18</sup>              |
|                                  | 0.500             | 421.1           | 10 <sup>2</sup>               |
|                                  | 0.641             | 424.3           | 10 <sup>2</sup>               |
|                                  | 0.777             | 426.3           | 10                            |
|                                  | 0.880             | 432.7           | 10 <sup>18</sup>              |
|                                  | 1.000             | 428.4           | 10                            |
|                                  | 1.280             | 436.7           | 10                            |
|                                  | 1.366             | 433.6           | 10                            |
|                                  | 1.442             | 435.1           | 10 <sup>2</sup>               |
|                                  | 1.575             | 437.2           | 10                            |
|                                  | 1.660             | 440.7           | 10 <sup>19</sup>              |
|                                  | 1.865             | 441.2           | 10                            |
|                                  | 2.089             | 443.3           | 10                            |
|                                  | 2.450             | 450.7           | 10 <sup>21</sup>              |
|                                  | 2.850             | 455.7           | 10 <sup>20</sup>              |
| C <sub>4</sub> H <sub>10</sub> O | 0.101             | 437.2           | 10                            |
| Isobutanol                       |                   |                 |                               |
| C <sub>4</sub> H <sub>11</sub> N | 0.101             | 408.5           | 10                            |
| Diethylamine                     |                   |                 |                               |
| C <sub>5</sub> F <sub>12</sub>   | 0.101             | 381.5           | 10 <sup>6</sup>               |
| Perfluoropentane                 | 0.300             | 385.4           | 10 <sup>6</sup>               |
|                                  | 0.500             | 388.7           | 10 <sup>6</sup>               |
|                                  | 0.700             | 392.2           | 10 <sup>6</sup>               |
|                                  | 0.890             | 396.4           | 10 <sup>6</sup>               |
|                                  | 1.090             | 399.0           | 10 <sup>6</sup>               |
|                                  | 1.280             | 403.1           | 10 <sup>6</sup>               |
|                                  | 1.480             | 407.4           | 10 <sup>6</sup>               |
| C <sub>5</sub> H <sub>8</sub>    | 0.101             | 451.4           | 10 <sup>6</sup>               |
| Cyclopentene                     |                   |                 |                               |
| C <sub>5</sub> H <sub>10</sub>   | 0.101             | 455.1           | 10 <sup>6</sup>               |
| Cyclopentane                     |                   |                 |                               |
| C <sub>5</sub> H <sub>10</sub>   | 0.101             | 417.2           | 10 <sup>6</sup>               |
| 1-Pentene                        |                   |                 |                               |
| C <sub>5</sub> H <sub>12</sub>   | 0.101             | 386.1           | 10 <sup>6</sup>               |
| 2,2-Dimethylpropane              |                   |                 |                               |

# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance            | <i>T</i><br>[MPa] | <i>J</i><br>[K] | [nuclei/(cm <sup>3</sup> ·s)] |
|----------------------------------|-------------------|-----------------|-------------------------------|
| C <sub>5</sub> H <sub>12</sub>   | 0.101             | 409.2           | 10                            |
| Isopentane                       | 0.101             | 411.7           | 10 <sup>7</sup>               |
| C <sub>5</sub> H <sub>12</sub>   | 0.101             | 418.8           | 10 <sup>4</sup>               |
| Pentane                          | 0.101             | 426.2           | 10 <sup>18</sup>              |
|                                  | 0.490             | 423.7           | 10 <sup>2</sup>               |
|                                  | 0.880             | 429.1           | 10 <sup>2</sup>               |
|                                  | 1.280             | 435.3           | 10 <sup>2</sup>               |
|                                  | 2.600             | 451.2           | 10 <sup>6</sup>               |
| C <sub>5</sub> H <sub>12</sub> O | 0.101             | 551.7           | 10 <sup>4</sup>               |
| 1-Pentanol                       |                   |                 |                               |
| C <sub>6</sub> F <sub>6</sub>    | 0.101             | 464.8           | 10                            |
| Hexafluorobenzene                | 0.101             | 467.9           | 10 <sup>6</sup>               |
|                                  | 0.500             | 469.9           | 10 <sup>2</sup>               |
|                                  | 0.570             | 474.1           | 10 <sup>6</sup>               |
|                                  | 1.000             | 477.1           | 10 <sup>2</sup>               |
|                                  | 1.050             | 480.4           | 10 <sup>6</sup>               |
|                                  | 1.540             | 486.0           | 10 <sup>6</sup>               |
|                                  | 2.030             | 494.2           | 10 <sup>6</sup>               |
| C <sub>6</sub> F <sub>14</sub>   | 0.101             | 409.8           | 10 <sup>6</sup>               |
| Perfluorohexane                  | 0.300             | 414.4           | 10 <sup>6</sup>               |
|                                  | 0.500             | 418.5           | 10 <sup>6</sup>               |
|                                  | 0.700             | 422.3           | 10 <sup>6</sup>               |
|                                  | 0.880             | 425.6           | 10 <sup>6</sup>               |
|                                  | 1.050             | 430.3           | 10 <sup>6</sup>               |
|                                  | 1.240             | 434.6           | 10 <sup>6</sup>               |
| C <sub>6</sub> H <sub>5</sub> Br | 0.101             | 534.2           | 10 <sup>2</sup>               |
| Bromobenzene                     |                   |                 |                               |
| C <sub>6</sub> H <sub>5</sub> Cl | 0.101             | 523.2           | 10 <sup>2</sup>               |
| Chlorobenzene                    |                   |                 |                               |
| C <sub>6</sub> H <sub>6</sub>    | -15.000           | 291.2           | 10 <sup>3</sup>               |
| Benzene                          | 0.101             | 498.9           | 10 <sup>2</sup>               |
|                                  | 0.101             | 510.2           | 10 <sup>18</sup>              |
|                                  | 0.490             | 502.2           | 10 <sup>2</sup>               |
|                                  | 0.580             | 514.2           | 10 <sup>19</sup>              |
|                                  | 0.980             | 509.2           | 10 <sup>2</sup>               |
|                                  | 1.070             | 516.7           | 10 <sup>18</sup>              |
|                                  | 1.470             | 513.8           | 10 <sup>2</sup>               |
|                                  | 1.540             | 520.7           | 10 <sup>19</sup>              |
|                                  | 2.030             | 525.7           | 10 <sup>19</sup>              |
|                                  | 2.520             | 532.2           | 10 <sup>20</sup>              |
|                                  | 3.010             | 537.7           | 10 <sup>17</sup>              |
|                                  | 3.500             | 544.7           | 10 <sup>18</sup>              |
| C <sub>6</sub> H <sub>7</sub> N  | -30.000           | 272.2           | 10 <sup>3</sup>               |
| Aniline                          | 0.101             | 535.2           | 10 <sup>2</sup>               |
| C <sub>6</sub> H <sub>10</sub>   | 0.101             | 465.2           | 10 <sup>6</sup>               |
| 1-Hexyne                         |                   |                 |                               |

# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance                                | <i>T</i><br>[MPa] | <i>J</i><br>[K] | [nuclei/(cm <sup>3</sup> ·s)] |
|------------------------------------------------------|-------------------|-----------------|-------------------------------|
| C <sub>6</sub> H <sub>12</sub><br>Cyclohexane        | 0.101             | 490.8           | 10 <sup>6</sup>               |
|                                                      | 0.300             | 493.1           | 10 <sup>2</sup>               |
|                                                      | 0.420             | 495.2           | 10 <sup>6</sup>               |
|                                                      | 0.720             | 499.7           | 10 <sup>6</sup>               |
|                                                      | 0.950             | 501.7           | 10 <sup>6</sup>               |
|                                                      | 0.980             | 502.1           | 10 <sup>2</sup>               |
|                                                      | 1.110             | 504.2           | 10 <sup>6</sup>               |
|                                                      | 1.350             | 506.2           | 10 <sup>6</sup>               |
|                                                      | 1.700             | 512.2           | 10 <sup>6</sup>               |
|                                                      | 2.160             | 518.2           | 10 <sup>6</sup>               |
| C <sub>6</sub> H <sub>12</sub><br>Methylcyclopentane | 0.101             | 476.1           | 10 <sup>6</sup>               |
|                                                      | 0.101             | 446.4           | 10 <sup>6</sup>               |
|                                                      | 0.101             | 446.4           | 10 <sup>6</sup>               |
|                                                      | 0.101             | 453.5           | 10 <sup>2</sup>               |
|                                                      | 0.101             | 454.9           | 10 <sup>5</sup>               |
|                                                      | 0.101             | 459.2           | 10 <sup>13</sup>              |
|                                                      | 0.101             | 463.7           | 10 <sup>20</sup>              |
|                                                      | 0.290             | 465.2           | 10 <sup>15</sup>              |
|                                                      | 0.420             | 461.7           | 10 <sup>6</sup>               |
|                                                      | 0.490             | 459.3           | 10 <sup>2</sup>               |
| C <sub>6</sub> H <sub>14</sub><br>Hexane             | 0.490             | 468.2           | 10 <sup>22</sup>              |
|                                                      | 0.760             | 466.7           | 10 <sup>6</sup>               |
|                                                      | 0.980             | 467.0           | 10 <sup>2</sup>               |
|                                                      | 0.980             | 475.2           | 10 <sup>23</sup>              |
|                                                      | 1.080             | 471.7           | 10 <sup>6</sup>               |
|                                                      | 1.120             | 478.2           | 10 <sup>15</sup>              |
|                                                      | 1.280             | 474.7           | 10 <sup>6</sup>               |
|                                                      | 1.420             | 475.7           | 10 <sup>6</sup>               |
|                                                      | 1.590             | 479.7           | 10 <sup>6</sup>               |
|                                                      | 1.600             | 486.2           | 10 <sup>16</sup>              |
| C <sub>6</sub> H <sub>14</sub> O<br>1-Hexanol        | 1.720             | 481.7           | 10 <sup>6</sup>               |
|                                                      | 1.960             | 487.7           | 10 <sup>17</sup>              |
|                                                      | 2.060             | 493.2           | 10 <sup>16</sup>              |
|                                                      | 2.390             | 496.7           | 10 <sup>6</sup>               |
|                                                      | 2.570             | 501.2           | 10 <sup>16</sup>              |
|                                                      | 0.101             | 551.7           | 10 <sup>4</sup>               |
|                                                      | 0.101             | 485.3           | 10                            |
|                                                      | 0.490             | 489.7           | 10                            |
|                                                      | 0.980             | 499.8           | 10                            |
|                                                      | 0.101             | 434.8           | 10 <sup>6</sup>               |
| C <sub>7</sub> F <sub>16</sub><br>Perfluoroheptane   | 0.230             | 436.9           | 10 <sup>6</sup>               |
|                                                      | 0.400             | 440.5           | 10 <sup>6</sup>               |
|                                                      | 0.570             | 444.4           | 10 <sup>6</sup>               |
|                                                      | 0.770             | 448.3           | 10 <sup>6</sup>               |
|                                                      | 0.920             | 452.7           | 10 <sup>6</sup>               |



# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance                                    | <i>T</i><br>[MPa] | <i>J</i><br>[K] | [nuclei/(cm <sup>3</sup> ·s)] |
|----------------------------------------------------------|-------------------|-----------------|-------------------------------|
|                                                          | 1.070             | 456.1           | 10 <sup>6</sup>               |
|                                                          | 1.150             | 459.0           | 10 <sup>6</sup>               |
|                                                          | 1.280             | 461.3           | 10 <sup>6</sup>               |
| C <sub>7</sub> H <sub>8</sub><br>Toluene                 | 0.101             | 526.7           | 10 <sup>2</sup>               |
| C <sub>7</sub> H <sub>14</sub><br>Methylcyclohexane      | 0.101             | 510.4           | 10 <sup>6</sup>               |
| C <sub>7</sub> H <sub>16</sub><br>Heptane                | 0.101             | 486.9           | 10 <sup>6</sup>               |
|                                                          | 0.101             | 493.7           | 10 <sup>18</sup>              |
|                                                          | 0.294             | 489.2           | 10 <sup>6</sup>               |
|                                                          | 0.392             | 490.7           | 10 <sup>6</sup>               |
|                                                          | 0.490             | 493.7           | 10 <sup>6</sup>               |
|                                                          | 0.589             | 494.2           | 10 <sup>6</sup>               |
|                                                          | 0.736             | 498.7           | 10 <sup>6</sup>               |
|                                                          | 0.952             | 500.7           | 10 <sup>6</sup>               |
|                                                          | 1.275             | 505.2           | 10 <sup>6</sup>               |
|                                                          | 1.373             | 509.7           | 10 <sup>6</sup>               |
|                                                          | 1.570             | 512.7           | 10 <sup>6</sup>               |
|                                                          | 1.736             | 515.2           | 10 <sup>6</sup>               |
|                                                          | 1.805             | 516.7           | 10 <sup>6</sup>               |
|                                                          | 2.001             | 519.7           | 10 <sup>6</sup>               |
| C <sub>7</sub> H <sub>16</sub> O<br>1-Heptanol           | 0.101             | 566.3           | 10 <sup>4</sup>               |
| C <sub>8</sub> F <sub>18</sub><br>Perfluorooctane        | 0.101             | 457.0           | 10 <sup>6</sup>               |
|                                                          | 0.300             | 461.1           | 10 <sup>6</sup>               |
|                                                          | 0.500             | 467.1           | 10 <sup>6</sup>               |
|                                                          | 0.700             | 471.2           | 10 <sup>6</sup>               |
|                                                          | 0.890             | 476.9           | 10 <sup>6</sup>               |
|                                                          | 1.090             | 482.8           | 10 <sup>6</sup>               |
|                                                          | 1.190             | 484.1           | 10 <sup>6</sup>               |
| C <sub>8</sub> H <sub>10</sub><br>Cyclooctane            | 0.101             | 560.7           | 10 <sup>6</sup>               |
| C <sub>8</sub> H <sub>10</sub><br>2,3-dimethylbenzene    | 0.101             | 508.2           | 10 <sup>2</sup>               |
| C <sub>8</sub> H <sub>16</sub><br>1-Octene               | 0.101             | 510.3           | 10 <sup>6</sup>               |
| C <sub>8</sub> H <sub>18</sub><br>Octane                 | 0.101             | 513.8           | 10 <sup>6</sup>               |
|                                                          | 0.377             | 519.3           | 10 <sup>4</sup>               |
|                                                          | 0.653             | 525.2           | 10 <sup>4</sup>               |
|                                                          | 0.929             | 528.6           | 10 <sup>4</sup>               |
|                                                          | 1.204             | 532.4           | 10 <sup>4</sup>               |
| C <sub>8</sub> H <sub>18</sub><br>2,2,4-Trimethylpentane | 0.101             | 488.5           | 10 <sup>6</sup>               |
| C <sub>8</sub> H <sub>18</sub> O<br>1-Octanol            | 0.101             | 586.0           | 10 <sup>4</sup>               |

# THE LIMITS OF SUPERHEAT OF PURE LIQUIDS (CONTINUED)

| <i>P</i><br>Substance                              | <i>T</i><br>[MPa] | <i>J</i><br>[K] | <i>J</i><br>[nuclei/(cm <sup>3</sup> .s)] |
|----------------------------------------------------|-------------------|-----------------|-------------------------------------------|
| C <sub>9</sub> F <sub>20</sub><br>Perfluorononane  | 0.101             | 478.5           | 10 <sup>6</sup>                           |
|                                                    | 0.300             | 484.4           | 10 <sup>6</sup>                           |
|                                                    | 0.500             | 489.3           | 10 <sup>6</sup>                           |
|                                                    | 0.700             | 493.3           | 10 <sup>6</sup>                           |
|                                                    | 0.890             | 499.7           | 10 <sup>6</sup>                           |
|                                                    | 1.090             | 505.7           | 10 <sup>6</sup>                           |
| C <sub>9</sub> H <sub>20</sub><br>Nonane           | 0.101             | 538.5           | 10 <sup>6</sup>                           |
|                                                    |                   |                 |                                           |
| C <sub>10</sub> F <sub>22</sub><br>Perfluorodecane | 0.101             | 497.1           | 10 <sup>6</sup>                           |
|                                                    | 0.300             | 503.2           | 10 <sup>6</sup>                           |
|                                                    | 0.500             | 508.6           | 10 <sup>6</sup>                           |
|                                                    | 0.700             | 515.6           | 10 <sup>6</sup>                           |
|                                                    | 0.890             | 521.2           | 10 <sup>6</sup>                           |
|                                                    | 1.090             | 527.7           | 10 <sup>6</sup>                           |
| C <sub>10</sub> H <sub>22</sub><br>Decane          | 0.101             | 558.3           | 10 <sup>6</sup>                           |
|                                                    |                   |                 |                                           |
| C <sub>12</sub> H <sub>10</sub> O<br>Diphenylether | 0.101             | 703.2           | 10 <sup>17</sup>                          |
|                                                    | 0.101             | 708.7           | 10 <sup>19</sup>                          |

# THERMAL CONDUCTIVITY OF ROCKS

| Rock                      | Temperature,<br>°C | Conductivity<br>Kcal·m·m <sup>-2</sup> ·h <sup>-1</sup> ·°C <sup>-1</sup> | Heat Capacity,<br>cal·g <sup>-1</sup> ·°C <sup>-1</sup> |
|---------------------------|--------------------|---------------------------------------------------------------------------|---------------------------------------------------------|
| Granite                   | 0                  | 3.02                                                                      | 0.192                                                   |
|                           | 50                 | 2.81                                                                      | —                                                       |
|                           | 100                | 2.59                                                                      | —                                                       |
|                           | 200                | 2.34                                                                      | 0.228                                                   |
|                           | 300                | 2.12                                                                      | —                                                       |
|                           | 400                | —                                                                         | 0.258                                                   |
| Marble                    | 118                | 1.44                                                                      | 0.21                                                    |
|                           | 196                | 1.29                                                                      | 0.24                                                    |
|                           | 245                | 1.19                                                                      | —                                                       |
|                           | 360                | 0.95                                                                      | 0.271                                                   |
| Dolomitic<br>limestone    | 130                | 1.41                                                                      | —                                                       |
|                           | 181                | 1.37                                                                      | —                                                       |
|                           | 268                | 1.29                                                                      | —                                                       |
|                           | 377                | 1.15                                                                      | —                                                       |
| Shale                     | 0                  | 1.65                                                                      | 0.17                                                    |
|                           | 100                | 1.51                                                                      | —                                                       |
|                           | 120                | 1.33                                                                      | —                                                       |
|                           | 188                | 1.41                                                                      | 0.24                                                    |
|                           | 304                | 1.26                                                                      | 0.245                                                   |
| Sandstone<br>(quartzitic) | 0                  | 4.9                                                                       | —                                                       |
|                           | 100                | 3.82                                                                      | 0.26                                                    |
|                           | 200                | 3.24                                                                      | —                                                       |

# TOTAL MONTHLY SOLAR RADIATION IN A CLOUDLESS SKY

Total radiation is the sum of the direct and scattered radiation that strikes the earth's surface. It is influenced by the degree of cloudiness, atmospheric transparency, duration of sunshine, and height of elevation at which the measurements are taken. Deviations from values in this table are bound to occur; however, it is believed that the deviations do not exceed  $\pm 10\%$  for the summer months and  $\pm 15\%$  for the winter months. The radiation units in this table are kcal/cm<sup>2</sup>.

| $\varphi^\circ$ | January | February | March | April | May  | June | July | August | September | October | November | December |
|-----------------|---------|----------|-------|-------|------|------|------|--------|-----------|---------|----------|----------|
| 90 N            | 0       | 0        | 0.1   | 10.0  | 21.9 | 26.0 | 23.8 | 12.9   | 2.4       | 0       | 0        | 0        |
| 85              | 0       | 0        | 0.7   | 10.2  | 21.8 | 25.8 | 23.4 | 13.1   | 3.0       | 0       | 0        | 0        |
| 80              | 0       | 0        | 2.4   | 10.8  | 21.4 | 25.2 | 23.0 | 13.4   | 4.3       | 0.5     | 0        | 0        |
| 75              | 0       | 0.5      | 4.0   | 11.7  | 21.0 | 24.5 | 22.2 | 13.8   | 5.8       | 1.3     | 0        | 0        |
| 70              | 0       | 1.6      | 6.0   | 13.1  | 20.5 | 23.6 | 21.2 | 14.6   | 7.5       | 2.7     | 0.5      | 0        |
| 65              | 0.7     | 2.8      | 8.0   | 14.5  | 20.1 | 22.8 | 21.0 | 15.6   | 9.5       | 4.3     | 1.4      | 0.2      |
| 60              | 1.8     | 4.3      | 9.9   | 16.0  | 20.8 | 22.9 | 21.4 | 16.7   | 11.3      | 6.1     | 2.6      | 1.1      |
| 55              | 3.1     | 6.2      | 11.7  | 17.3  | 21.4 | 23.4 | 21.9 | 17.9   | 12.9      | 7.8     | 4.0      | 2.3      |
| 50              | 4.8     | 8.2      | 13.3  | 18.5  | 22.2 | 23.7 | 22.6 | 19.1   | 14.4      | 9.7     | 5.8      | 3.9      |
| 45              | 6.7     | 10.3     | 14.8  | 19.5  | 22.6 | 23.9 | 23.2 | 20.1   | 15.8      | 11.5    | 7.8      | 5.9      |
| 40              | 8.8     | 12.2     | 16.4  | 20.3  | 23.0 | 24.0 | 23.4 | 20.9   | 17.0      | 13.2    | 9.7      | 7.7      |
| 35              | 10.7    | 14.0     | 17.6  | 21.0  | 23.0 | 24.0 | 23.6 | 21.6   | 18.1      | 14.7    | 11.4     | 9.7      |
| 30              | 12.5    | 15.5     | 18.6  | 21.4  | 23.0 | 23.8 | 23.4 | 21.8   | 19.1      | 16.1    | 13.1     | 11.5     |
| 25              | 14.1    | 16.8     | 19.5  | 21.6  | 23.0 | 23.4 | 23.1 | 21.8   | 19.8      | 17.4    | 14.6     | 13.1     |
| 20              | 15.5    | 17.9     | 20.2  | 21.6  | 22.5 | 22.8 | 22.6 | 21.6   | 20.4      | 18.5    | 16.1     | 14.7     |
| 15              | 16.9    | 19.0     | 20.8  | 21.4  | 21.9 | 22.0 | 21.9 | 21.2   | 20.9      | 19.3    | 17.4     | 16.1     |
| 10              | 18.1    | 19.8     | 21.1  | 21.2  | 21.2 | 21.0 | 21.1 | 20.6   | 21.2      | 20.1    | 18.5     | 17.5     |
| 5               | 19.3    | 20.4     | 21.4  | 21.0  | 20.2 | 19.9 | 20.0 | 20.0   | 21.3      | 20.6    | 19.5     | 18.8     |
| 0               | 20.2    | 20.9     | 21.5  | 20.4  | 19.3 | 18.8 | 19.1 | 19.3   | 21.2      | 21.2    | 20.4     | 19.2     |
| 5S              | 20.1    | 21.4     | 21.4  | 19.9  | 18.3 | 17.6 | 17.9 | 18.3   | 20.8      | 21.4    | 21.8     | 21.0     |
| 10              | 22.0    | 21.8     | 21.1  | 19.2  | 17.7 | 16.3 | 16.3 | 17.3   | 20.4      | 21.4    | 21.8     | 22.0     |
| 15              | 22.6    | 22.0     | 20.6  | 18.3  | 16.0 | 14.9 | 15.4 | 16.1   | 19.7      | 21.3    | 22.4     | 22.9     |
| 20              | 23.2    | 22.0     | 20.0  | 17.2  | 14.7 | 13.4 | 13.8 | 14.9   | 18.9      | 21.0    | 22.6     | 23.6     |
| 25              | 23.6    | 22.0     | 19.4  | 16.0  | 13.0 | 12.0 | 12.6 | 13.6   | 18.0      | 20.6    | 23.0     | 24.1     |
| 30              | 23.9    | 21.8     | 18.6  | 14.9  | 11.9 | 10.6 | 11.1 | 12.1   | 17.0      | 20.1    | 23.0     | 24.6     |
| 35              | 24.0    | 21.3     | 17.6  | 13.6  | 10.4 | 9.0  | 9.6  | 10.6   | 15.9      | 19.5    | 23.0     | 25.0     |
| 40              | 24.0    | 20.6     | 16.4  | 12.2  | 8.7  | 7.3  | 8.1  | 9.0    | 14.3      | 18.7    | 22.8     | 25.2     |
| 45              | 24.0    | 19.9     | 15.2  | 10.7  | 7.1  | 5.5  | 6.3  | 7.3    | 13.4      | 17.7    | 22.4     | 25.2     |
| 50              | 23.6    | 18.9     | 13.8  | 9.2   | 5.4  | 3.8  | 4.6  | 5.5    | 12.0      | 16.6    | 21.8     | 25.0     |
| 55              | 23.2    | 17.8     | 12.3  | 7.5   | 3.8  | 2.3  | 3.0  | 3.8    | 10.3      | 15.4    | 21.2     | 24.6     |
| 60              | 22.6    | 16.6     | 10.8  | 5.6   | 2.4  | 1.0  | 1.6  | 2.3    | 8.5       | 14.1    | 21.0     | 24.4     |
| 65              | 22.4    | 15.3     | 9.1   | 3.9   | 1.1  | 0.1  | 0.4  | 1.0    | 6.7       | 12.6    | 20.8     | 24.5     |
| 70              | 22.6    | 14.2     | 7.3   | 2.2   | 0.1  | 0    | 0    | 0      | 5.0       | 11.4    | 21.0     | 24.9     |
| 75              | 23.2    | 13.4     | 5.7   | 0.9   | 0    | 0    | 0    | 0      | 3.5       | 10.4    | 21.2     | 25.4     |
| 80              | 24.0    | 12.8     | 4.3   | 0     | 0    | 0    | 0    | 0      | 2.1       | 9.7     | 21.9     | 26.0     |
| 85              | 24.6    | 12.4     | 2.9   | 0     | 0    | 0    | 0    | 0      | 0.9       | 9.2     | 22.4     | 26.6     |
| 90              | 24.9    | 12.3     | 1.7   | 0     | 0    | 0    | 0    | 0      | 0         | 9.0     | 22.6     | 27.0     |

## TRANSMISSION OF CORNING COLORED FILTERS

Supplied by R. G. Saxton

If  $I_0$  is the intensity of radiation entering a layer of some medium and  $I$  the intensity reaching the opposite surface, the ratio  $I/I_0$  is called the transmittance. In practice the ratio of intensity of radiation passing through a glass sample to that incident on its surface is often measured and plotted as transmission. The transmission is the result of two factors, the transmittance of the glass and the losses by reflection. These losses amount to about 4 % for each glass-air surface; the transmission of a sample is about 92 % of its transmittance. Since the reflection losses differ slightly with different samples, the correction is often determined and applied when the transmission is measured. Values in this table have been corrected for reflection losses.

The identifying glass number, CS number, color and properties, and nominal thickness for the Corning glasses in this table are:

| Glass No. | CS    | Color and properties                               | Nominal thickness |
|-----------|-------|----------------------------------------------------|-------------------|
| 0160      | 0-54  | Clear; Ultraviolet transmitting                    | 2.0               |
| 2030      | 2-64  | Red; Sharp cut                                     | 3.0               |
| 2403      | 2-58  | Red; Sharp cut                                     | 3.0               |
| 2404      | 2-59  | Red; Sharp cut                                     | 3.0               |
| 2408      | 2-60  | Red; Sharp cut                                     | 3.0               |
| 2412      | 2-61  | Red; Sharp cut                                     | 3.0               |
| 2418      | 2-62  | Red; Sharp cut                                     | 3.0               |
| 2424      | 2-63  | Red; Sharp cut                                     | 3.0               |
| 2434      | 2-73  | Red; Sharp cut                                     | 3.0               |
| 2540      | 7-56  | Black; IR transmitting; Visible absorbing          | 2.5               |
| 2550      | 7-57  | Black; IR transmitting; Visible absorbing          | 2.0               |
| 2600      | 7-69  | Black; IR transmitting; Visible absorbing          | 3.0               |
| 3060      | 3-75  | Straw                                              | 2.0               |
| 3304      | 3-76  | Dark amber                                         | 3.0               |
| 3307      | 3-77  | Dark amber                                         | 3.0               |
| 3384      | 3-70  | Yellow                                             | 3.0               |
| 3385      | 3-71  | Yellow                                             | 3.0               |
| 3387      | 3-72  | Straw                                              | 3.0               |
| 3389      | 3-73  | Straw                                              | 3.0               |
| 3391      | 3-74  | Straw                                              | 3.0               |
| 3480      | 3-66  | Yellow; Sharp cut                                  | 3.0               |
| 3482      | 3-67  | Yellow; Sharp cut                                  | 3.0               |
| 3484      | 3-68  | Yellow; Sharp cut                                  | 3.0               |
| 3486      | 3-69  | Yellow; Sharp cut                                  | 3.0               |
| 3718      | 3-94  | Yellow                                             | 3.0               |
| 3750      | 3-79  | Yellow; Yellow green fluorescing                   | 5.0               |
| 3780      | 3-80  | Yellow                                             | 2.0               |
| 3850      | 0-51  | Clear; UV transmitting                             | 4.0               |
| 3961      | 1-56  | Bluish; IR absorbing; Visible transmitting         | 2.5               |
| 3962      | 1-57  | Bluish; IR absorbing; Visible transmitting         | 2.5               |
| 3965      | 1-58  | Bluish; IR absorbing; Visible transmitting         | 2.5               |
| 3966      | 1-59  | Bluish; IR absorbing; Visible transmitting         | 2.5               |
| 4010      | 4-64  | Green                                              | 4.0               |
| 4015      | 4-65  | Yellow green                                       | 3.0               |
| 4060      | 4-67  | Green                                              | 2.0               |
| 4084      | 4-68  | Green                                              | 4.5               |
| 4303      | 4-72  | Blue green                                         | 4.0               |
| 4305      | 4-71  | Blue green                                         | 4.0               |
| 4308      | 4-70  | Blue green                                         | 4.0               |
| 4309      | 4-69  | Blue green                                         | 4.0               |
| 4445      | 4-74  | Green                                              | 2.5               |
| 4602      | 1-75  | Bluish; IR absorbing; Visible transmitting         | 3.0               |
| 4784      | 4-94  | Blue green                                         | 5.0               |
| 5030      | 5-57  | Blue                                               | 5.0               |
| 5031      | 5-56  | Blue                                               | 4.5               |
| 5070      | 7-62  | Amethyst                                           | 3.9               |
| 5071      | 7-63  | Amethyst                                           | 3.9               |
| 5073      | 7-64  | Amethyst                                           | 3.9               |
| 5113      | 5-58  | Blue                                               | 4.0               |
| 5120      | 1-60  | Smoky violet; Absorbs yellow                       | 5.2               |
| 5300      | 4-106 | Green                                              | 3.9               |
| 5330      | 1-64  | Blue                                               | 4.5               |
| 5433      | 5-59  | Blue                                               | 5.0               |
| 5543      | 5-60  | Blue                                               | 5.0               |
| 5562      | 5-61  | Blue                                               | 5.0               |
| 5572      | 1-61  | Blue                                               | 5.0               |
| 5840      | 7-60  | Black; UV transmitting; Visible absorbing          | 4.5               |
| 5850      | 7-59  | Purple; UV transmitting; Visible absorbing         | 4.0               |
| 5860      | 7-37  | Black; UV transmitting; Visible absorbing          | 5.0               |
| 5874      | 7-39  | Black; UV transmitting; Visible absorbing          | 5.0               |
| 5900      | 1-62  | Blue                                               | 5.5               |
| 5970      | 7-51  | Black; UV transmitting; Visible absorbing          | 5.0               |
| 7380      | 0-52  | Clear; UV transmitting                             | 2.0               |
| 7740      | 0-53  | Clear; UV transmitting                             | 2.0               |
| 7905      | 9-30  | Clear; UV transmitting; Long Range IR transmitting | 2.0               |
| 7910      | 9-54  | Clear; UV transmitting                             | 2.0               |
| 8364      | 7-98  | Gray                                               | 2.0               |
| 9780      | 4-76  | Blue green                                         | 5.0               |
| 9782      | 4-96  | Blue green                                         | 5.0               |
| 9788      | 4-97  | Blue green                                         | 5.0               |
| 9830      | 4-77  | Green                                              | 3.4               |
| 9863      | 7-54  | Black; UV transmitting; Visible absorbing          | 3.0               |

### TRANSMISSION OF CORNING COLORED FILTERS (Continued)

| Transmittance |                      |      |      |      |      |      |      |      |      |      |      |      |
|---------------|----------------------|------|------|------|------|------|------|------|------|------|------|------|
|               | Corning Glass Number |      |      |      |      |      |      |      |      |      |      |      |
| λ(nm)         | 0160                 | 2030 | 2403 | 2404 | 2408 | 2412 | 2418 | 2424 | 2434 | 2540 | 2550 | 2600 |
| .22           | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .24           | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .26           | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .28           | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .30           | .005                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .32           | .642                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .34           | .850                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .36           | .882                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .38           | .890                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .40           | .892                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .41           | .893                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .42           | .896                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .43           | .896                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .44           | .898                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .45           | .899                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .46           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .47           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .48           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .49           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .50           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .51           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .52           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .53           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .54           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .55           | .900                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .56           | .901                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .57           | .904                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .005 | .000 | .000 | .000 |
| .58           | .904                 | .000 | .000 | .000 | .000 | .000 | .000 | .005 | .200 | .000 | .000 | .000 |
| .59           | .908                 | .000 | .000 | .000 | .000 | .000 | .008 | .170 | .615 | .000 | .000 | .000 |
| .60           | .910                 | .000 | .000 | .000 | .000 | .006 | .250 | .575 | .808 | .000 | .000 | .000 |
| .61           | .910                 | .000 | .000 | .000 | .018 | .190 | .660 | .790 | .856 | .000 | .000 | .000 |
| .62           | .910                 | .000 | .000 | .015 | .265 | .625 | .822 | .848 | .872 | .000 | .000 | .000 |
| .63           | .910                 | .000 | .018 | .295 | .670 | .828 | .862 | .870 | .881 | .000 | .000 | .000 |
| .64           | .910                 | .006 | .260 | .660 | .828 | .868 | .874 | .880 | .887 | .000 | .001 | .000 |
| .65           | .910                 | .028 | .675 | .796 | .866 | .881 | .881 | .887 | .892 | .000 | .003 | .000 |
| .66           | .910                 | .110 | .838 | .828 | .877 | .885 | .885 | .893 | .895 | .000 | .005 | .000 |
| .67           | .910                 | .305 | .871 | .842 | .883 | .887 | .887 | .897 | .897 | .000 | .006 | .000 |
| .68           | .910                 | .550 | .880 | .847 | .886 | .889 | .889 | .900 | .899 | .000 | .009 | .000 |
| .69           | .910                 | .735 | .885 | .851 | .888 | .900 | .900 | .901 | .900 | .000 | .012 | .000 |
| .70           | .910                 | .820 | .886 | .852 | .888 | .900 | .900 | .903 | .900 | .000 | .017 | .000 |
| .71           | .910                 | .853 | .888 | .854 | .888 | .889 | .889 | .903 | .900 | .000 | .023 | .000 |
| .72           | .910                 | .864 | .889 | .853 | .888 | .888 | .888 | .903 | .899 | .000 | .031 | .040 |
| .73           | .910                 | .867 | .900 | .851 | .887 | .887 | .887 | .903 | .897 | .000 | .041 | .175 |
| .74           | .910                 | .867 | .900 | .850 | .885 | .886 | .886 | .903 | .896 | .000 | .055 | .372 |
| .75           | .910                 | .866 | .900 | .849 | .884 | .885 | .885 | .902 | .895 | .000 | .069 | .547 |
| .80           | .910                 | .839 | .875 | .827 | .870 | .858 | .857 | .881 | .866 | .005 | .225 | .770 |
| 1.00          | .912                 | .801 | .840 | .772 | .840 | .828 | .822 | .857 | .842 | .562 | .780 | .350 |
| 1.20          | .908                 | .799 | .845 | .786 | .845 | .837 | .827 | .859 | .849 | .790 | .870 | .000 |
| 1.40          | .909                 | .811 | .854 | .809 | .854 | .848 | .840 | .862 | .857 | .850 | .895 | .000 |
| 1.60          | .913                 | .839 | .873 | .837 | .873 | .869 | .858 | .880 | .879 | .872 | .904 | .000 |
| 1.80          | .909                 | .844 | .870 | .829 | .870 | .864 | .854 | .877 | .872 | .880 | .900 | .000 |
| 2.00          | .904                 | .841 | .868 | .827 | .868 | .861 | .851 | .874 | .871 | .880 | .897 | .000 |
| 2.20          | .888                 | .833 | .820 | .773 | .825 | .820 | .810 | .837 | .835 | .860 | .875 | .005 |
| 2.40          | .875                 | .832 | .803 | .757 | .809 | .803 | .792 | .818 | .812 | .868 | .870 | .049 |
| 2.60          | .868                 | .822 | .750 | .695 | .754 | .750 | .723 | .772 | .767 | .858 | .850 | .058 |
| 2.80          | .690                 | .600 | .100 | .100 | .100 | .100 | .050 | .050 | .260 | .450 | .480 | .030 |
| 3.00          | .630                 | .470 | .070 | .020 | .070 | .070 | .072 | .122 | .400 | .465 | .383 | .022 |
| 3.20          | .500                 | .340 | .140 | .074 | .150 | .140 | .142 | .180 | .470 | .390 | .330 | .020 |
| 3.40          | .379                 | .260 | .140 | .078 | .140 | .140 | .120 | .150 | .350 | .310 | .245 | .018 |
| 3.60          | .320                 | .247 | .000 | .000 | .000 | .000 | .000 | .006 | .015 | .280 | .220 | .021 |
| 3.80          | .310                 | .257 | .000 | .000 | .000 | .000 | .000 | .000 | .020 | .285 | .250 | .035 |
| 4.00          | .311                 | .274 | .000 | .000 | .000 | .000 | .000 | .000 | .015 | .285 | .275 | .068 |
| 4.20          | .251                 | .200 | .000 | .000 | .000 | .000 | .000 | .000 | .017 | .190 | .190 | .065 |
| 4.40          | .110                 | .060 | .000 | .000 | .000 | .000 | .000 | .000 | .002 | .050 | .100 | .020 |
| 4.60          | .012                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 4.80          | .004                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 5.00          | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |



## TRANSMISSION OF CORNING COLORED FILTERS (Continued)

| λ(nm) | Transmittance        |      |      |      |      |      |      |      |      |      |      |      |
|-------|----------------------|------|------|------|------|------|------|------|------|------|------|------|
|       | Corning Glass Number |      |      |      |      |      |      |      |      |      |      |      |
|       | 3060                 | 3304 | 3307 | 3384 | 3385 | 3387 | 3389 | 3391 | 3480 | 3482 | 3484 | 3486 |
| .22   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .24   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .26   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .28   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .30   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .32   | .000                 | .000 | .000 | .000 | .000 | .000 | .005 | .000 | .000 | .000 | .000 | .000 |
| .34   | .000                 | .000 | .038 | .000 | .000 | .000 | .010 | .000 | .000 | .000 | .000 | .000 |
| .36   | .000                 | .000 | .050 | .000 | .005 | .000 | .015 | .000 | .000 | .000 | .000 | .000 |
| .38   | .060                 | .000 | .027 | .005 | .010 | .010 | .020 | .000 | .000 | .000 | .000 | .000 |
| .40   | .410                 | .000 | .016 | .011 | .016 | .020 | .026 | .075 | .000 | .000 | .000 | .005 |
| .41   | .517                 | .000 | .014 | .011 | .016 | .020 | .025 | .425 | .000 | .000 | .000 | .005 |
| .42   | .604                 | .000 | .014 | .010 | .015 | .019 | .105 | .655 | .000 | .000 | .000 | .005 |
| .43   | .665                 | .000 | .016 | .009 | .013 | .017 | .437 | .747 | .000 | .000 | .000 | .005 |
| .44   | .710                 | .000 | .022 | .005 | .011 | .050 | .620 | .801 | .000 | .000 | .000 | .005 |
| .45   | .748                 | .000 | .033 | .003 | .010 | .325 | .714 | .838 | .000 | .000 | .000 | .005 |
| .46   | .778                 | .000 | .049 | .002 | .008 | .565 | .780 | .860 | .000 | .000 | .000 | .004 |
| .47   | .800                 | .000 | .070 | .001 | .060 | .690 | .820 | .874 | .000 | .000 | .000 | .003 |
| .48   | .819                 | .000 | .101 | .005 | .410 | .763 | .848 | .884 | .000 | .000 | .000 | .003 |
| .49   | .836                 | .003 | .143 | .088 | .640 | .803 | .866 | .890 | .000 | .000 | .000 | .002 |
| .50   | .850                 | .009 | .193 | .350 | .727 | .834 | .878 | .895 | .000 | .000 | .000 | .001 |
| .51   | .860                 | .019 | .250 | .595 | .780 | .854 | .886 | .898 | .000 | .000 | .000 | .045 |
| .52   | .870                 | .037 | .315 | .725 | .817 | .868 | .890 | .900 | .000 | .000 | .003 | .425 |
| .53   | .875                 | .063 | .379 | .789 | .840 | .876 | .892 | .901 | .000 | .000 | .175 | .710 |
| .54   | .881                 | .102 | .447 | .825 | .856 | .883 | .894 | .902 | .000 | .015 | .600 | .792 |
| .55   | .884                 | .146 | .504 | .846 | .866 | .887 | .895 | .903 | .000 | .230 | .774 | .823 |
| .56   | .886                 | .200 | .560 | .860 | .873 | .889 | .894 | .902 | .020 | .675 | .818 | .844 |
| .57   | .885                 | .255 | .607 | .869 | .876 | .890 | .893 | .901 | .325 | .850 | .839 | .859 |
| .58   | .883                 | .310 | .648 | .873 | .878 | .889 | .892 | .900 | .710 | .885 | .854 | .868 |
| .59   | .882                 | .360 | .680 | .876 | .877 | .887 | .890 | .898 | .829 | .894 | .865 | .876 |
| .60   | .882                 | .404 | .705 | .877 | .877 | .884 | .886 | .896 | .858 | .900 | .873 | .882 |
| .61   | .882                 | .438 | .722 | .877 | .877 | .881 | .884 | .893 | .869 | .903 | .880 | .886 |
| .62   | .882                 | .466 | .735 | .875 | .876 | .875 | .880 | .890 | .876 | .905 | .885 | .888 |
| .63   | .882                 | .488 | .744 | .871 | .874 | .871 | .876 | .886 | .881 | .906 | .888 | .889 |
| .64   | .883                 | .505 | .748 | .865 | .872 | .866 | .872 | .884 | .884 | .907 | .890 | .890 |
| .65   | .885                 | .519 | .750 | .860 | .867 | .860 | .868 | .881 | .885 | .908 | .892 | .890 |
| .66   | .886                 | .531 | .750 | .856 | .863 | .856 | .865 | .876 | .886 | .908 | .893 | .890 |
| .67   | .888                 | .543 | .749 | .850 | .858 | .851 | .860 | .873 | .886 | .908 | .894 | .890 |
| .68   | .890                 | .552 | .745 | .844 | .853 | .846 | .856 | .869 | .886 | .908 | .893 | .889 |
| .69   | .891                 | .561 | .740 | .837 | .847 | .839 | .852 | .865 | .885 | .907 | .892 | .887 |
| .70   | .892                 | .569 | .734 | .831 | .842 | .834 | .847 | .860 | .884 | .907 | .891 | .885 |
| .71   | .893                 | .574 | .727 | .825 | .837 | .827 | .842 | .856 | .882 | .906 | .890 | .883 |
| .72   | .893                 | .575 | .720 | .819 | .831 | .822 | .837 | .852 | .880 | .905 | .888 | .880 |
| .73   | .892                 | .576 | .712 | .813 | .825 | .816 | .831 | .848 | .877 | .905 | .886 | .877 |
| .74   | .891                 | .574 | .702 | .807 | .820 | .810 | .826 | .844 | .874 | .904 | .885 | .875 |
| .75   | .890                 | .570 | .694 | .800 | .814 | .805 | .820 | .840 | .870 | .903 | .882 | .873 |
| .80   | .871                 | .526 | .642 | .770 | .865 | .780 | .775 | .815 | .837 | .878 | .846 | .829 |
| 1.00  | .830                 | .435 | .516 | .715 | .830 | .725 | .716 | .772 | .801 | .857 | .811 | .781 |
| 1.20  | .860                 | .429 | .500 | .718 | .858 | .735 | .730 | .782 | .807 | .859 | .819 | .793 |
| 1.40  | .901                 | .475 | .540 | .750 | .900 | .768 | .768 | .810 | .828 | .870 | .837 | .817 |
| 1.60  | .917                 | .580 | .635 | .795 | .918 | .812 | .812 | .843 | .852 | .884 | .856 | .841 |
| 1.80  | .916                 | .627 | .675 | .808 | .915 | .818 | .820 | .849 | .847 | .882 | .852 | .834 |
| 2.00  | .908                 | .620 | .668 | .800 | .909 | .822 | .817 | .846 | .847 | .884 | .852 | .835 |
| 2.20  | .900                 | .630 | .675 | .802 | .900 | .823 | .810 | .840 | .805 | .865 | .829 | .798 |
| 2.40  | .885                 | .651 | .690 | .800 | .885 | .825 | .811 | .842 | .787 | .853 | .817 | .777 |
| 2.60  | .860                 | .650 | .690 | .785 | .858 | .815 | .800 | .840 | .725 | .818 | .757 | .718 |
| 2.80  | .550                 | .345 | .390 | .325 | .670 | .360 | .340 | .440 | .050 | .060 | .110 | .060 |
| 3.00  | .379                 | .320 | .360 | .318 | .348 | .348 | .322 | .423 | .080 | .088 | .190 | .088 |
| 3.20  | .315                 | .240 | .290 | .268 | .332 | .324 | .290 | .395 | .150 | .158 | .270 | .145 |
| 3.40  | .250                 | .151 | .190 | .218 | .289 | .288 | .255 | .353 | .120 | .132 | .140 | .090 |
| 3.60  | .231                 | .130 | .150 | .217 | .266 | .280 | .249 | .351 | .000 | .000 | .000 | .000 |
| 3.80  | .258                 | .140 | .160 | .228 | .270 | .298 | .267 | .376 | .000 | .000 | .000 | .000 |
| 4.00  | .283                 | .140 | .175 | .220 | .280 | .290 | .260 | .365 | .000 | .000 | .000 | .000 |
| 4.20  | .200                 | .090 | .125 | .143 | .210 | .210 | .178 | .288 | .000 | .000 | .000 | .000 |
| 4.40  | .100                 | .020 | .030 | .025 | .080 | .070 | .040 | .115 | .000 | .000 | .000 | .000 |
| 4.60  | .008                 | .008 | .010 | .007 | .002 | .003 | .000 | .009 | .000 | .000 | .000 | .000 |
| 4.80  | .000                 | .005 | .009 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 5.00  | .000                 | .001 | .008 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |

## TRANSMISSION OF CORNING COLORED FILTERS (Continued)

| λ(nm) | Transmittance        |      |      |      |      |      |      |      |      |      |      |      |
|-------|----------------------|------|------|------|------|------|------|------|------|------|------|------|
|       | Corning Glass Number |      |      |      |      |      |      |      |      |      |      |      |
|       | 3718                 | 3750 | 3780 | 3850 | 3961 | 3962 | 3965 | 3966 | 4010 | 4015 | 4060 | 4084 |
| .22   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .24   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .26   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .28   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .30   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .32   | .004                 | .000 | .000 | .000 | .000 | .000 | .018 | .055 | .000 | .000 | .000 | .000 |
| .34   | .030                 | .000 | .000 | .000 | .000 | .018 | .192 | .375 | .000 | .000 | .001 | .018 |
| .36   | .550                 | .215 | .000 | .005 | .020 | .125 | .430 | .630 | .000 | .000 | .021 | .128 |
| .38   | .665                 | .327 | .000 | .350 | .085 | .270 | .558 | .710 | .000 | .000 | .080 | .248 |
| .40   | .480                 | .113 | .000 | .675 | .185 | .395 | .636 | .781 | .000 | .000 | .178 | .216 |
| .41   | .443                 | .088 | .000 | .749 | .218 | .426 | .651 | .788 | .000 | .000 | .228 | .180 |
| .42   | .465                 | .088 | .000 | .788 | .248 | .453 | .666 | .795 | .000 | .000 | .281 | .151 |
| .43   | .560                 | .135 | .000 | .812 | .269 | .474 | .678 | .800 | .000 | .000 | .335 | .136 |
| .44   | .675                 | .255 | .006 | .828 | .290 | .494 | .693 | .806 | .000 | .000 | .388 | .140 |
| .45   | .748                 | .410 | .028 | .841 | .313 | .519 | .709 | .816 | .000 | .005 | .434 | .163 |
| .46   | .780                 | .472 | .058 | .850 | .331 | .538 | .724 | .824 | .006 | .025 | .473 | .200 |
| .47   | .803                 | .570 | .092 | .858 | .346 | .556 | .737 | .831 | .021 | .073 | .506 | .247 |
| .48   | .800                 | .555 | .088 | .865 | .361 | .570 | .748 | .836 | .050 | .145 | .527 | .303 |
| .49   | .802                 | .550 | .095 | .870 | .370 | .582 | .756 | .840 | .100 | .245 | .535 | .370 |
| .50   | .824                 | .597 | .152 | .874 | .376 | .590 | .762 | .842 | .160 | .350 | .528 | .430 |
| .51   | .862                 | .720 | .325 | .878 | .377 | .594 | .765 | .843 | .220 | .455 | .503 | .465 |
| .52   | .894                 | .825 | .595 | .881 | .373 | .593 | .765 | .841 | .252 | .537 | .460 | .467 |
| .53   | .904                 | .853 | .717 | .883 | .364 | .588 | .761 | .838 | .247 | .582 | .400 | .438 |
| .54   | .905                 | .860 | .763 | .884 | .354 | .579 | .764 | .833 | .207 | .594 | .325 | .376 |
| .55   | .906                 | .864 | .783 | .884 | .342 | .569 | .746 | .827 | .153 | .572 | .252 | .303 |
| .56   | .907                 | .867 | .795 | .883 | .331 | .559 | .736 | .821 | .096 | .525 | .183 | .225 |
| .57   | .907                 | .869 | .799 | .882 | .317 | .547 | .724 | .813 | .054 | .457 | .125 | .157 |
| .58   | .907                 | .870 | .804 | .880 | .298 | .529 | .706 | .802 | .026 | .385 | .083 | .107 |
| .59   | .907                 | .870 | .811 | .877 | .276 | .508 | .685 | .790 | .011 | .311 | .053 | .073 |
| .60   | .908                 | .876 | .826 | .876 | .251 | .481 | .662 | .775 | .004 | .245 | .033 | .048 |
| .61   | .908                 | .880 | .835 | .875 | .225 | .452 | .636 | .757 | .000 | .190 | .020 | .034 |
| .62   | .909                 | .881 | .842 | .874 | .299 | .423 | .610 | .739 | .000 | .145 | .012 | .024 |
| .63   | .909                 | .884 | .848 | .875 | .217 | .392 | .577 | .719 | .000 | .115 | .007 | .018 |
| .64   | .910                 | .885 | .854 | .876 | .147 | .359 | .546 | .698 | .000 | .098 | .004 | .015 |
| .65   | .910                 | .887 | .859 | .877 | .125 | .326 | .515 | .675 | .000 | .084 | .001 | .012 |
| .66   | .911                 | .891 | .864 | .880 | .104 | .297 | .482 | .652 | .000 | .075 | .000 | .010 |
| .67   | .913                 | .896 | .869 | .883 | .086 | .265 | .450 | .630 | .000 | .075 | .000 | .009 |
| .68   | .914                 | .900 | .873 | .885 | .063 | .235 | .418 | .603 | .000 | .071 | .000 | .008 |
| .69   | .915                 | .901 | .877 | .887 | .055 | .206 | .385 | .576 | .000 | .065 | .000 | .007 |
| .70   | .915                 | .904 | .880 | .888 | .042 | .279 | .352 | .550 | .000 | .067 | .000 | .007 |
| .71   | .915                 | .905 | .883 | .888 | .032 | .155 | .322 | .524 | .000 | .070 | .000 | .007 |
| .72   | .915                 | .906 | .885 | .889 | .025 | .133 | .294 | .496 | .000 | .075 | .000 | .007 |
| .73   | .915                 | .907 | .885 | .888 | .018 | .114 | .266 | .472 | .000 | .080 | .000 | .007 |
| .74   | .915                 | .907 | .882 | .887 | .014 | .097 | .242 | .448 | .000 | .084 | .000 | .008 |
| .75   | .914                 | .906 | .882 | .886 | .010 | .084 | .220 | .424 | .000 | .086 | .000 | .008 |
| .80   | .902                 | .875 | .855 | .863 | .000 | .033 | .120 | .310 | .000 | .109 | .000 | .013 |
| 1.00  | .899                 | .860 | .882 | .820 | .000 | .002 | .038 | .158 | .000 | .215 | .018 | .100 |
| 1.20  | .898                 | .882 | .898 | .850 | .000 | .002 | .040 | .161 | .007 | .393 | .158 | .303 |
| 1.40  | .880                 | .810 | .855 | .894 | .002 | .018 | .100 | .270 | .058 | .549 | .404 | .548 |
| 1.60  | .882                 | .805 | .855 | .905 | .007 | .050 | .190 | .390 | .162 | .663 | .612 | .710 |
| 1.80  | .900                 | .844 | .907 | .904 | .008 | .057 | .201 | .408 | .299 | .740 | .740 | .791 |
| 2.00  | .897                 | .819 | .909 | .895 | .011 | .070 | .228 | .435 | .422 | .783 | .817 | .830 |
| 2.20  | .888                 | .720 | .900 | .870 | .021 | .105 | .277 | .475 | .518 | .803 | .840 | .792 |
| 2.40  | .865                 | .668 | .890 | .850 | .037 | .140 | .320 | .512 | .597 | .817 | .862 | .808 |
| 2.60  | .840                 | .570 | .860 | .800 | .050 | .005 | .339 | .515 | .634 | .813 | .870 | .740 |
| 2.80  | .460                 | .075 | .620 | .200 | .022 | .092 | .135 | .085 | .270 | .460 | .520 | .010 |
| 3.00  | .282                 | .028 | .465 | .165 | .033 | .133 | .200 | .230 | .260 | .418 | .620 | .033 |
| 3.20  | .252                 | .016 | .420 | .120 | .054 | .150 | .247 | .294 | .204 | .345 | .642 | .128 |
| 3.40  | .175                 | .007 | .370 | .070 | .048 | .112 | .165 | .200 | .131 | .235 | .631 | .130 |
| 3.60  | .150                 | .003 | .351 | .045 | .003 | .008 | .016 | .018 | .121 | .192 | .634 | .006 |
| 3.80  | .168                 | .000 | .368 | .067 | .007 | .015 | .035 | .048 | .125 | .200 | .600 | .016 |
| 4.00  | .182                 | .000 | .370 | .080 | .006 | .010 | .020 | .022 | .123 | .200 | .557 | .006 |
| 4.20  | .120                 | .000 | .300 | .040 | .005 | .013 | .022 | .021 | .070 | .130 | .422 | .001 |
| 4.40  | .020                 | .000 | .140 | .005 | .001 | .001 | .000 | .001 | .002 | .015 | .135 | .000 |
| 4.60  | .002                 | .000 | .010 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .012 | .000 |
| 4.80  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .002 | .000 |
| 5.00  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |



## TRANSMISSION OF CORNING COLORED FILTERS (Continued)

| λ(nm) | Transmittance        |      |      |      |      |      |      |      |      |      |      |      |
|-------|----------------------|------|------|------|------|------|------|------|------|------|------|------|
|       | Corning Glass Number |      |      |      |      |      |      |      |      |      |      |      |
|       | 4303                 | 4305 | 4308 | 4309 | 4445 | 4602 | 4784 | 5030 | 5031 | 5070 | 5071 | 5073 |
| .22   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .24   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .26   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .28   | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .30   | .000                 | .000 | .000 | .000 | .000 | .001 | .000 | .000 | .016 | .000 | .000 | .000 |
| .32   | .000                 | .000 | .000 | .022 | .001 | .106 | .000 | .000 | .145 | .012 | .045 | .090 |
| .34   | .011                 | .060 | .190 | .394 | .018 | .505 | .009 | .038 | .420 | .310 | .330 | .540 |
| .36   | .188                 | .380 | .580 | .740 | .114 | .755 | .200 | .285 | .685 | .628 | .340 | .757 |
| .38   | .390                 | .590 | .740 | .831 | .248 | .827 | .450 | .595 | .820 | .745 | .420 | .810 |
| .40   | .545                 | .723 | .826 | .884 | .400 | .835 | .596 | .770 | .884 | .712 | .665 | .830 |
| .41   | .588                 | .750 | .840 | .887 | .454 | .845 | .627 | .799 | .894 | .600 | .712 | .786 |
| .42   | .624                 | .770 | .850 | .890 | .505 | .846 | .648 | .808 | .895 | .430 | .716 | .705 |
| .43   | .654                 | .786 | .857 | .892 | .550 | .851 | .666 | .797 | .890 | .290 | .694 | .620 |
| .44   | .680                 | .798 | .862 | .894 | .593 | .856 | .680 | .767 | .872 | .170 | .655 | .525 |
| .45   | .698                 | .809 | .867 | .897 | .631 | .857 | .697 | .738 | .865 | .097 | .612 | .436 |
| .46   | .712                 | .815 | .869 | .898 | .659 | .856 | .717 | .702 | .864 | .055 | .568 | .365 |
| .47   | .715                 | .814 | .866 | .897 | .678 | .861 | .735 | .628 | .845 | .035 | .531 | .313 |
| .48   | .705                 | .802 | .856 | .894 | .689 | .866 | .750 | .522 | .805 | .023 | .501 | .275 |
| .49   | .678                 | .780 | .838 | .885 | .687 | .869 | .763 | .406 | .750 | .017 | .482 | .252 |
| .50   | .636                 | .740 | .810 | .872 | .673 | .870 | .768 | .288 | .684 | .015 | .469 | .237 |
| .51   | .570                 | .685 | .770 | .850 | .641 | .869 | .767 | .186 | .601 | .013 | .463 | .231 |
| .52   | .480                 | .610 | .714 | .817 | .586 | .866 | .753 | .105 | .495 | .013 | .461 | .230 |
| .53   | .387                 | .525 | .650 | .781 | .520 | .863 | .725 | .053 | .388 | .014 | .464 | .235 |
| .54   | .288                 | .430 | .576 | .736 | .437 | .865 | .676 | .022 | .295 | .016 | .473 | .245 |
| .55   | .205                 | .340 | .502 | .683 | .355 | .869 | .615 | .007 | .198 | .018 | .486 | .260 |
| .56   | .132                 | .255 | .422 | .627 | .275 | .868 | .525 | .000 | .113 | .023 | .502 | .278 |
| .57   | .082                 | .184 | .345 | .565 | .202 | .863 | .427 | .000 | .057 | .030 | .522 | .300 |
| .58   | .047                 | .127 | .277 | .505 | .144 | .856 | .328 | .000 | .025 | .038 | .540 | .324 |
| .59   | .026                 | .087 | .218 | .447 | .102 | .848 | .235 | .000 | .008 | .048 | .555 | .348 |
| .60   | .013                 | .057 | .170 | .393 | .068 | .838 | .157 | .000 | .000 | .058 | .571 | .373 |
| .61   | .006                 | .036 | .131 | .341 | .046 | .824 | .102 | .000 | .000 | .070 | .587 | .395 |
| .62   | .001                 | .022 | .100 | .296 | .031 | .806 | .058 | .000 | .000 | .083 | .600 | .415 |
| .63   | .000                 | .013 | .074 | .256 | .020 | .787 | .032 | .000 | .000 | .096 | .612 | .435 |
| .64   | .000                 | .007 | .056 | .221 | .013 | .767 | .017 | .000 | .000 | .108 | .622 | .450 |
| .65   | .000                 | .004 | .042 | .191 | .008 | .745 | .007 | .000 | .000 | .120 | .633 | .466 |
| .66   | .000                 | .002 | .033 | .167 | .006 | .722 | .002 | .000 | .000 | .135 | .644 | .482 |
| .67   | .000                 | .001 | .025 | .146 | .003 | .695 | .000 | .000 | .000 | .148 | .658 | .498 |
| .68   | .000                 | .000 | .020 | .128 | .001 | .665 | .000 | .000 | .000 | .165 | .674 | .515 |
| .69   | .000                 | .000 | .016 | .116 | .000 | .634 | .000 | .000 | .000 | .182 | .686 | .531 |
| .70   | .000                 | .000 | .013 | .104 | .000 | .600 | .000 | .000 | .000 | .200 | .700 | .548 |
| .71   | .000                 | .000 | .010 | .096 | .000 | .565 | .000 | .000 | .000 | .220 | .712 | .566 |
| .72   | .000                 | .000 | .009 | .088 | .000 | .531 | .000 | .004 | .024 | .245 | .725 | .586 |
| .73   | .000                 | .000 | .007 | .083 | .000 | .496 | .000 | .047 | .119 | .268 | .736 | .606 |
| .74   | .000                 | .000 | .006 | .079 | .000 | .463 | .000 | .190 | .330 | .295 | .749 | .675 |
| .75   | .000                 | .000 | .005 | .075 | .000 | .430 | .000 | .440 | .580 | .323 | .759 | .642 |
| .80   | .000                 | .000 | .008 | .080 | .003 | .258 | .000 | .890 | .917 | .505 | .815 | .750 |
| 1.00  | .000                 | .005 | .045 | .188 | .056 | .019 | .000 | .753 | .868 | .860 | .885 | .872 |
| 1.20  | .013                 | .060 | .166 | .375 | .269 | .009 | .000 | .455 | .720 | .890 | .897 | .890 |
| 1.40  | .080                 | .180 | .342 | .542 | .527 | .016 | .003 | .100 | .285 | .892 | .902 | .892 |
| 1.60  | .210                 | .342 | .500 | .658 | .701 | .035 | .038 | .056 | .162 | .890 | .902 | .892 |
| 1.80  | .350                 | .482 | .617 | .732 | .792 | .059 | .142 | .052 | .140 | .878 | .890 | .877 |
| 2.00  | .475                 | .590 | .690 | .772 | .839 | .048 | .275 | .075 | .175 | .860 | .865 | .860 |
| 2.20  | .560                 | .653 | .720 | .778 | .850 | .038 | .345 | .172 | .295 | .840 | .830 | .840 |
| 2.40  | .635                 | .704 | .752 | .791 | .870 | .045 | .404 | .330 | .483 | .812 | .795 | .805 |
| 2.60  | .663                 | .710 | .748 | .770 | .861 | .066 | .340 | .382 | .530 | .804 | .752 | .775 |
| 2.80  | .260                 | .370 | .370 | .250 | .280 | .018 | .045 | .030 | .030 | .550 | .500 | .500 |
| 3.00  | .249                 | .250 | .203 | .212 | .395 | .000 | .000 | .010 | .001 | .390 | .308 | .340 |
| 3.20  | .202                 | .212 | .145 | .168 | .451 | .000 | .000 | .065 | .026 | .222 | .145 | .180 |
| 3.40  | .135                 | .136 | .084 | .107 | .449 | .000 | .000 | .002 | .006 | .120 | .070 | .090 |
| 3.60  | .124                 | .120 | .078 | .077 | .470 | .000 | .000 | .000 | .000 | .078 | .032 | .063 |
| 3.80  | .132                 | .125 | .082 | .083 | .470 | .000 | .000 | .000 | .000 | .078 | .029 | .060 |
| 4.00  | .132                 | .131 | .094 | .090 | .448 | .000 | .000 | .000 | .000 | .093 | .037 | .075 |
| 4.20  | .078                 | .073 | .050 | .042 | .320 | .000 | .000 | .000 | .000 | .079 | .020 | .048 |
| 4.40  | .008                 | .009 | .008 | .002 | .100 | .000 | .000 | .000 | .000 | .020 | .004 | .014 |
| 4.60  | .000                 | .000 | .000 | .000 | .007 | .000 | .000 | .000 | .000 | .002 | .000 | .000 |
| 4.80  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 5.00  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |

### TRANSMISSION OF CORNING COLORED FILTERS (Continued)

| Transmittance        |                      |      |      |      |      |      |      |      |      |      |      |      |
|----------------------|----------------------|------|------|------|------|------|------|------|------|------|------|------|
|                      | Corning Glass Number |      |      |      |      |      |      |      |      |      |      |      |
| $\lambda(\text{nm})$ | 5113                 | 5120 | 5300 | 5330 | 5433 | 5543 | 5562 | 5572 | 5840 | 5850 | 5860 | 5874 |
| .22                  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .24                  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .26                  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .28                  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| .30                  | .000                 | .000 | .000 | .002 | .000 | .000 | .000 | .000 | .001 | .039 | .000 | .000 |
| .32                  | .000                 | .000 | .000 | .250 | .000 | .000 | .000 | .045 | .242 | .490 | .008 | .031 |
| .34                  | .000                 | .000 | .000 | .622 | .000 | .000 | .012 | .325 | .600 | .790 | .179 | .228 |
| .36                  | .035                 | .018 | .000 | .796 | .100 | .120 | .205 | .660 | .682 | .858 | .340 | .447 |
| .38                  | .200                 | .540 | .000 | .835 | .350 | .380 | .495 | .805 | .392 | .850 | .085 | .378 |
| .40                  | .371                 | .670 | .000 | .865 | .585 | .600 | .717 | .874 | .000 | .788 | .000 | .032 |
| .41                  | .371                 | .790 | .000 | .850 | .636 | .635 | .748 | .873 | .000 | .720 | .000 | .004 |
| .42                  | .337                 | .805 | .000 | .823 | .665 | .646 | .761 | .865 | .000 | .630 | .000 | .000 |
| .43                  | .272                 | .560 | .000 | .783 | .674 | .635 | .759 | .857 | .000 | .522 | .000 | .000 |
| .44                  | .198                 | .386 | .000 | .725 | .665 | .602 | .742 | .845 | .000 | .410 | .000 | .000 |
| .45                  | .118                 | .485 | .000 | .650 | .635 | .550 | .713 | .832 | .000 | .290 | .000 | .000 |
| .46                  | .055                 | .475 | .000 | .555 | .577 | .465 | .662 | .808 | .000 | .175 | .000 | .000 |
| .47                  | .013                 | .370 | .008 | .455 | .467 | .335 | .565 | .765 | .000 | .125 | .000 | .000 |
| .48                  | .000                 | .385 | .026 | .355 | .327 | .190 | .435 | .693 | .000 | .022 | .000 | .000 |
| .49                  | .000                 | .685 | .085 | .270 | .205 | .090 | .300 | .605 | .000 | .005 | .000 | .000 |
| .50                  | .000                 | .660 | .125 | .197 | .120 | .040 | .197 | .523 | .000 | .000 | .000 | .000 |
| .51                  | .000                 | .390 | .106 | .145 | .060 | .013 | .110 | .430 | .000 | .000 | .000 | .000 |
| .52                  | .000                 | .305 | .094 | .110 | .024 | .002 | .051 | .328 | .000 | .000 | .000 | .000 |
| .53                  | .000                 | .175 | .064 | .085 | .008 | .000 | .022 | .247 | .000 | .000 | .000 | .000 |
| .54                  | .000                 | .610 | .149 | .068 | .005 | .000 | .012 | .216 | .000 | .000 | .000 | .000 |
| .55                  | .000                 | .817 | .147 | .055 | .006 | .000 | .015 | .246 | .000 | .000 | .000 | .000 |
| .56                  | .000                 | .230 | .087 | .043 | .007 | .000 | .018 | .285 | .000 | .000 | .000 | .000 |
| .57                  | .000                 | .125 | .013 | .032 | .000 | .000 | .011 | .258 | .000 | .000 | .000 | .000 |
| .58                  | .000                 | .000 | .000 | .022 | .000 | .000 | .002 | .175 | .000 | .000 | .000 | .000 |
| .59                  | .000                 | .006 | .000 | .016 | .000 | .000 | .000 | .116 | .000 | .000 | .000 | .000 |
| .60                  | .000                 | .180 | .000 | .012 | .000 | .000 | .000 | .113 | .000 | .000 | .000 | .000 |
| .61                  | .000                 | .545 | .000 | .009 | .000 | .000 | .000 | .123 | .000 | .000 | .000 | .000 |
| .62                  | .000                 | .825 | .000 | .010 | .000 | .000 | .000 | .126 | .000 | .000 | .000 | .000 |
| .63                  | .000                 | .838 | .000 | .013 | .000 | .000 | .000 | .120 | .000 | .000 | .000 | .000 |
| .64                  | .000                 | .878 | .000 | .015 | .000 | .000 | .000 | .111 | .000 | .000 | .000 | .000 |
| .65                  | .000                 | .893 | .000 | .015 | .000 | .000 | .000 | .120 | .000 | .000 | .000 | .000 |
| .66                  | .000                 | .883 | .000 | .014 | .000 | .000 | .000 | .165 | .000 | .000 | .000 | .000 |
| .67                  | .000                 | .820 | .000 | .013 | .000 | .000 | .000 | .265 | .000 | .000 | .000 | .000 |
| .68                  | .000                 | .705 | .000 | .015 | .000 | .000 | .000 | .425 | .000 | .000 | .000 | .000 |
| .69                  | .000                 | .743 | .000 | .022 | .000 | .000 | .001 | .615 | .000 | .029 | .000 | .000 |
| .70                  | .000                 | .860 | .000 | .041 | .000 | .000 | .004 | .756 | .007 | .160 | .000 | .017 |
| .71                  | .000                 | .876 | .000 | .085 | .000 | .001 | .004 | .837 | .020 | .385 | .000 | .075 |
| .72                  | .000                 | .815 | .000 | .165 | .000 | .002 | .004 | .874 | .037 | .615 | .000 | .168 |
| .73                  | .000                 | .435 | .000 | .285 | .000 | .002 | .002 | .889 | .060 | .760 | .000 | .257 |
| .74                  | .000                 | .045 | .000 | .460 | .000 | .002 | .002 | .895 | .086 | .843 | .000 | .320 |
| .75                  | .000                 | .055 | .000 | .645 | .000 | .001 | .001 | .898 | .080 | .878 | .000 | .335 |
| .80                  | .000                 | .030 | .000 | .900 | .005 | .002 | .003 | .895 | .009 | .890 | .000 | .218 |
| 1.00                 | .000                 | .860 | .003 | .800 | .010 | .015 | .020 | .880 | .000 | .716 | .000 | .050 |
| 1.20                 | .000                 | .770 | .026 | .570 | .030 | .020 | .047 | .690 | .000 | .169 | .000 | .011 |
| 1.40                 | .000                 | .550 | .072 | .410 | .060 | .040 | .095 | .640 | .004 | .042 | .004 | .012 |
| 1.60                 | .000                 | .620 | .200 | .405 | .116 | .060 | .154 | .625 | .002 | .036 | .002 | .010 |
| 1.80                 | .000                 | .580 | .265 | .425 | .172 | .090 | .223 | .635 | .000 | .048 | .000 | .010 |
| 2.00                 | .010                 | .580 | .374 | .476 | .343 | .247 | .410 | .750 | .000 | .168 | .000 | .018 |
| 2.20                 | .071                 | .747 | .533 | .535 | .475 | .400 | .528 | .780 | .000 | .338 | .000 | .036 |
| 2.40                 | .190                 | .400 | .370 | .552 | .575 | .520 | .600 | .780 | .000 | .492 | .000 | .074 |
| 2.60                 | .203                 | .530 | .523 | .540 | .580 | .532 | .603 | .745 | .000 | .510 | .000 | .088 |
| 2.80                 | .100                 | .250 | .265 | .007 | .162 | .132 | .360 | .470 | .000 | .170 | .000 | .003 |
| 3.00                 | .080                 | .080 | .202 | .012 | .195 | .151 | .280 | .315 | .000 | .128 | .000 | .020 |
| 3.20                 | .068                 | .072 | .180 | .082 | .131 | .105 | .172 | .200 | .000 | .084 | .000 | .053 |
| 3.40                 | .030                 | .029 | .131 | .003 | .079 | .065 | .100 | .100 | .000 | .065 | .000 | .050 |
| 3.60                 | .021                 | .017 | .103 | .000 | .061 | .030 | .053 | .049 | .002 | .070 | .000 | .000 |
| 3.80                 | .023                 | .021 | .093 | .000 | .068 | .032 | .040 | .037 | .001 | .082 | .000 | .000 |
| 4.00                 | .040                 | .025 | .112 | .000 | .071 | .039 | .050 | .042 | .005 | .090 | .000 | .000 |
| 4.20                 | .019                 | .010 | .069 | .000 | .020 | .015 | .017 | .020 | .002 | .055 | .000 | .000 |
| 4.40                 | .001                 | .001 | .007 | .000 | .000 | .000 | .000 | .002 | .000 | .002 | .000 | .000 |
| 4.60                 | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 4.80                 | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 5.00                 | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |



## TRANSMISSION OF CORNING COLORED FILTERS (Continued)

| λ(nm) | Transmittance        |      |      |      |      |      |      |      |      |      |      |      |
|-------|----------------------|------|------|------|------|------|------|------|------|------|------|------|
|       | Corning Glass Number |      |      |      |      |      |      |      |      |      |      |      |
|       | 5900                 | 5970 | 7380 | 7740 | 7905 | 7910 | 8364 | 9780 | 9782 | 9788 | 9830 | 9863 |
| .22   | .000                 | .000 | .000 | .000 | .000 | .012 | .000 | .000 | .000 | .000 | .000 | .000 |
| .24   | .000                 | .000 | .000 | .000 | .360 | .505 | .000 | .000 | .000 | .000 | .000 | .054 |
| .26   | .000                 | .000 | .000 | .000 | .495 | .780 | .000 | .000 | .000 | .000 | .000 | .482 |
| .28   | .000                 | .000 | .000 | .004 | .590 | .855 | .000 | .000 | .000 | .000 | .000 | .731 |
| .30   | .000                 | .000 | .000 | .321 | .720 | .877 | .000 | .000 | .000 | .000 | .000 | .831 |
| .32   | .000                 | .138 | .000 | .722 | .825 | .900 | .000 | .000 | .000 | .000 | .000 | .862 |
| .34   | .008                 | .600 | .000 | .851 | .880 | .903 | .002 | .015 | .000 | .060 | .001 | .854 |
| .36   | .150                 | .799 | .440 | .889 | .910 | .905 | .083 | .290 | .060 | .470 | .059 | .816 |
| .38   | .445                 | .742 | .795 | .900 | .915 | .906 | .136 | .590 | .445 | .770 | .160 | .620 |
| .40   | .678                 | .190 | .892 | .916 | .920 | .920 | .296 | .725 | .747 | .885 | .130 | .090 |
| .41   | .688                 | .029 | .904 | .915 | .920 | .920 | .273 | .705 | .790 | .895 | .044 | .018 |
| .42   | .635                 | .000 | .910 | .915 | .920 | .921 | .232 | .770 | .818 | .902 | .004 | .003 |
| .43   | .586                 | .000 | .913 | .914 | .920 | .923 | .191 | .778 | .836 | .905 | .000 | .000 |
| .44   | .522                 | .000 | .915 | .913 | .920 | .924 | .157 | .801 | .847 | .906 | .000 | .000 |
| .45   | .458                 | .000 | .916 | .913 | .922 | .925 | .144 | .814 | .855 | .906 | .000 | .000 |
| .46   | .400                 | .000 | .917 | .914 | .922 | .925 | .140 | .823 | .860 | .906 | .000 | .000 |
| .47   | .350                 | .000 | .917 | .915 | .922 | .925 | .141 | .832 | .863 | .906 | .000 | .000 |
| .48   | .306                 | .000 | .917 | .915 | .923 | .925 | .146 | .839 | .863 | .905 | .000 | .000 |
| .49   | .275                 | .000 | .918 | .915 | .930 | .926 | .152 | .843 | .859 | .904 | .000 | .000 |
| .50   | .246                 | .000 | .918 | .915 | .925 | .926 | .166 | .843 | .848 | .900 | .014 | .000 |
| .51   | .223                 | .000 | .919 | .915 | .925 | .927 | .178 | .838 | .825 | .893 | .180 | .000 |
| .52   | .196                 | .000 | .919 | .916 | .925 | .928 | .190 | .824 | .784 | .880 | .175 | .000 |
| .53   | .172                 | .000 | .919 | .916 | .923 | .928 | .196 | .798 | .720 | .862 | .018 | .000 |
| .54   | .154                 | .000 | .919 | .916 | .926 | .929 | .198 | .756 | .627 | .831 | .000 | .000 |
| .55   | .148                 | .000 | .920 | .917 | .923 | .929 | .197 | .697 | .515 | .787 | .050 | .000 |
| .56   | .151                 | .000 | .920 | .917 | .925 | .930 | .199 | .615 | .380 | .728 | .265 | .000 |
| .57   | .146                 | .000 | .919 | .918 | .925 | .930 | .206 | .518 | .255 | .655 | .165 | .000 |
| .58   | .125                 | .000 | .918 | .919 | .925 | .930 | .217 | .414 | .150 | .570 | .035 | .000 |
| .59   | .102                 | .000 | .918 | .920 | .925 | .930 | .222 | .302 | .075 | .475 | .004 | .000 |
| .60   | .093                 | .000 | .920 | .920 | .925 | .930 | .215 | .215 | .032 | .380 | .000 | .000 |
| .61   | .087                 | .000 | .920 | .920 | .925 | .930 | .196 | .135 | .010 | .290 | .000 | .000 |
| .62   | .081                 | .000 | .920 | .920 | .925 | .930 | .175 | .080 | .002 | .210 | .000 | .000 |
| .63   | .070                 | .000 | .920 | .919 | .926 | .930 | .161 | .042 | .000 | .145 | .000 | .000 |
| .64   | .061                 | .000 | .920 | .919 | .927 | .931 | .156 | .021 | .000 | .094 | .000 | .000 |
| .65   | .055                 | .000 | .920 | .918 | .927 | .931 | .162 | .008 | .000 | .059 | .000 | .000 |
| .66   | .055                 | .000 | .920 | .917 | .927 | .932 | .176 | .003 | .000 | .035 | .000 | .000 |
| .67   | .059                 | .000 | .920 | .916 | .928 | .932 | .200 | .000 | .000 | .020 | .000 | .000 |
| .68   | .065                 | .000 | .920 | .916 | .927 | .932 | .228 | .000 | .000 | .010 | .075 | .022 |
| .69   | .068                 | .007 | .921 | .915 | .927 | .932 | .248 | .000 | .000 | .005 | .380 | .106 |
| .70   | .068                 | .036 | .921 | .915 | .928 | .932 | .251 | .000 | .000 | .001 | .642 | .234 |
| .71   | .066                 | .085 | .922 | .914 | .926 | .933 | .237 | .000 | .000 | .000 | .694 | .332 |
| .72   | .064                 | .145 | .922 | .912 | .926 | .933 | .223 | .000 | .000 | .000 | .666 | .383 |
| .73   | .060                 | .222 | .922 | .910 | .926 | .933 | .210 | .000 | .000 | .000 | .607 | .384 |
| .74   | .057                 | .323 | .921 | .909 | .927 | .934 | .197 | .000 | .000 | .000 | .531 | .358 |
| .75   | .055                 | .385 | .921 | .907 | .928 | .934 | .180 | .000 | .000 | .000 | .445 | .322 |
| .80   | .050                 | .287 | .918 | .890 | .930 | .932 | .110 | .000 | .000 | .000 | .045 | .175 |
| 1.00  | .085                 | .032 | .910 | .860 | .930 | .928 | .032 | .000 | .000 | .000 | .000 | .119 |
| 1.20  | .180                 | .021 | .910 | .860 | .925 | .928 | .032 | .000 | .000 | .005 | .007 | .016 |
| 1.40  | .295                 | .109 | .906 | .870 | .925 | .930 | .062 | .018 | .000 | .080 | .000 | .005 |
| 1.60  | .405                 | .088 | .910 | .892 | .931 | .930 | .137 | .131 | .011 | .266 | .000 | .007 |
| 1.80  | .495                 | .040 | .903 | .896 | .931 | .930 | .182 | .317 | .085 | .430 | .157 | .011 |
| 2.00  | .590                 | .008 | .900 | .897 | .934 | .929 | .171 | .440 | .216 | .512 | .041 | .029 |
| 2.20  | .628                 | .002 | .898 | .875 | .934 | .835 | .184 | .440 | .278 | .455 | .000 | .048 |
| 2.40  | .640                 | .009 | .890 | .850 | .930 | .890 | .225 | .440 | .325 | .433 | .000 | .060 |
| 2.60  | .630                 | .018 | .860 | .820 | .920 | .780 | .258 | .280 | .212 | .252 | .057 | .051 |
| 2.80  | .470                 | .030 | .375 | .140 | .908 | .180 | .145 | .060 | .040 | .060 | .020 | .000 |
| 3.00  | .248                 | .030 | .425 | .360 | .880 | .695 | .130 | .000 | .000 | .000 | .000 | .000 |
| 3.20  | .121                 | .030 | .380 | .490 | .861 | .760 | .125 | .000 | .000 | .000 | .000 | .000 |
| 3.40  | .032                 | .020 | .310 | .270 | .670 | .620 | .099 | .000 | .000 | .000 | .000 | .000 |
| 3.60  | .010                 | .015 | .270 | .010 | .111 | .080 | .115 | .000 | .000 | .000 | .000 | .000 |
| 3.80  | .010                 | .020 | .275 | .040 | .270 | .240 | .142 | .000 | .000 | .000 | .000 | .000 |
| 4.00  | .010                 | .030 | .260 | .013 | .170 | .150 | .172 | .000 | .000 | .000 | .000 | .000 |
| 4.20  | .006                 | .017 | .180 | .026 | .250 | .230 | .158 | .000 | .000 | .000 | .000 | .000 |
| 4.40  | .001                 | .002 | .040 | .004 | .085 | .080 | .078 | .000 | .000 | .000 | .000 | .000 |
| 4.60  | .000                 | .000 | .000 | .000 | .050 | .020 | .010 | .000 | .000 | .000 | .000 | .000 |
| 4.80  | .000                 | .000 | .000 | .000 | .000 | .000 | .003 | .000 | .000 | .000 | .000 | .000 |
| 5.00  | .000                 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |

# TRANSMISSION OF WRATTEN FILTERS

Compiled by Allie C. Peed, Jr. for The Eastman Kodak Company

Data condensed from Kodak Wratten Filters for Scientific and Technical Use published by the Eastman Kodak Company, manufacturers of the filters.

The following pages give (1) percentage luminous transmittance at wave lengths from 400 to 700 $\mu$  at intervals of 10 $\mu$  for the standard illuminant "C" adopted by the International Commission of Illumination, (2) dominant wavelength in millimicrons, and (3) percentage of excitation purity. Values of wave length followed by "c" indicate the complementary wave lengths of purple filters which do not have a dominant wave length.

All colorimetric specifications are based on the 1931 standard ICI colorimetric and luminosity data.

The transmittance data are given as representing standard samples of the filters. They are intended only for the information of users in choosing filters which will meet their requirements. Values taken from the tables of data should not be used by research workers as representing precisely the absorption characteristics of a particular filter. If such precise data are needed, they should be determined for the particular filter being used.

Where the spectra extend into the ultraviolet this fact is indicated by an asterisk (\*) in the transmission tables immediately beneath the filter number, and quantitative data are not given. The manufacturer should be consulted for this information. Transmission in the ultraviolet of wave lengths less than 330 $\mu$  will be eliminated in the case of cemented filters, as glass absorbs ultraviolet radiation of wave lengths shorter than about 330 $\mu$ .

Stability ratings are given as three letter combinations following the filter description in the table below. In establishing the stability classifications each filter is exposed to a selected light source for a specific time interval. The following grading system is used to describe the result:

Class A — stable  
Class B — relatively stable  
Class C — somewhat unstable  
Class D — unstable

The classification letters, for example, AAA, describe the stability to the following three exposure tests in this order:

1. Two weeks' exposure to daylight in a south window
2. Twenty-four hours' exposure to a "Fade-Ometer"
3. Two weeks' exposure at two feet from a 1000-watt tungsten lamp.

Filters are supplied in two forms: as lacquered gelatin film, or as a gelatin film cemented between pieces of optical glass. Filters in glass are cemented between sheets of plane-parallel glass, which is surfaced in quantities and is of sufficient accuracy for general photographic work, and for most scientific purposes.

Most Wratten Gelatin Filters are stocked in 2- or 3-inch squares. Stocks of 2- or 3-inch square filters cemented in glass are maintained only in filters usually used for general photographic work.

The booklet "Kodak Filters and Lens Attachments" gives more valuable information on this subject.

## FILTER DATA

| No. | Description, use, and stability                                                                                                                                                                                                 | No. | Description, use, and stability                                                                                                                                                               |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|     | <b>Colorless</b>                                                                                                                                                                                                                |     |                                                                                                                                                                                               |
| 0   | For compensating thickness of other gelatin filters in optical systems, AAA.                                                                                                                                                    | 25  | A — Tricolor red for direct color separation. Contrast effects in commercial photography and in outdoor scenes. Two-color general viewing. Aerial infrared photography and haze cutting, AAA. |
| 1   | Absorbs ultraviolet below 360 m $\mu$ , DDD.                                                                                                                                                                                    | 26  | Stereo red, AAA.                                                                                                                                                                              |
| 1A  | Kodak Skylight Filter — Reduces excess bluishness in outdoor color photographs in open shade under a clear, blue sky, ACA.                                                                                                      | 29  | Red color separation from transparencies and for the Kodak Fluorescence Process. Strong contrast effects. Copying blueprints. Tungsten tricolor projection, AAA.                              |
|     | <b>Yellow</b>                                                                                                                                                                                                                   |     |                                                                                                                                                                                               |
| 2B  | Absorbs ultraviolet below 410 m $\mu$ , ACA.                                                                                                                                                                                    |     | <b>Magentas and Violets</b>                                                                                                                                                                   |
| 3   | Light yellow, CCD.                                                                                                                                                                                                              | 30  | Green absorption, BBC.                                                                                                                                                                        |
| 3N5 | No. 3 plus 0.5 neutral density, AAA.                                                                                                                                                                                            | 31  | Green absorption, CCA.                                                                                                                                                                        |
| 4   | Light yellow — Approximate correction on panchromatic materials for outdoor scenes, including sky, CCC.                                                                                                                         | 32  | Minus green, CCD.                                                                                                                                                                             |
| 6   | K1 — Light yellow — Partial correction outdoors, BBA.                                                                                                                                                                           | 33  | Strong green absorption, CCB.                                                                                                                                                                 |
| 8   | K2 — Yellow — Full correction outdoors on Type B panchromatic materials. Widely used for proper sky, cloud, and foliage rendering. Green separation for Fluorescence Process, AAA.                                              | 34  | Violet, CDD.                                                                                                                                                                                  |
| 8N5 | No. 8 plus 0.5 neutral density, AAA.                                                                                                                                                                                            | 34A | Blue separation — Kodak Fluorescence Process, DCC.                                                                                                                                            |
| 9   | K3 — Deep yellow. Moderate contrast in outdoor photography (with black-and-white films), AAA.                                                                                                                                   | 35  | Contrast in microscopy, CDD.                                                                                                                                                                  |
| 11  | X1 — Greenish yellow. Correction for tungsten light on Type B panchromatic materials; also for daylight correction with Type C panchromatic materials in making outdoor portraits, darkening skies, or lightening foliage, AAA. | 36  | Dark violet, CCC.                                                                                                                                                                             |
| 12  | Minus blue. Haze cutting in aerial photography, AAA.                                                                                                                                                                            |     | <b>Blues and Blue-greens</b>                                                                                                                                                                  |
| 13  | X2 — Yellow green. Correction for Type C panchromatic materials in tungsten light, ABA.                                                                                                                                         | 38  | Red absorption, BCA.                                                                                                                                                                          |
| 15  | G — Deep yellow. Overcorrection in landscape photography. Contrast control in copying and in aerial infrared photography, AAA.                                                                                                  | 38A | Red absorption. Increasing contrast in visual microscopy, BBB.                                                                                                                                |
| 16  | Blue absorption, AAB.                                                                                                                                                                                                           | 39  | Contrast control in printing motion-picture duplicates (glass) AAA.                                                                                                                           |
| 18A | Transmits ultraviolet and infrared only (glass), AAA.                                                                                                                                                                           | 40  | Green for two-color photography (tungsten), CBC.                                                                                                                                              |
|     | <b>Oranges and Reds</b>                                                                                                                                                                                                         | 44  | Minus red — Two-color general viewing, DDD.                                                                                                                                                   |
| 21  | Blue and blue-green absorption, CBB.                                                                                                                                                                                            | 44A | Minus red, DDD.                                                                                                                                                                               |
| 22  | Yellow-orange. For increasing contrast in blue preparations in microscopy. Mercury yellow, BAC.                                                                                                                                 | 45  | Contrast in microscopy, DDD.                                                                                                                                                                  |
| 23A | Light red. Two-color projection — contrast effects, BAB.                                                                                                                                                                        | 45A | Highest resolving power in visual microscopy, CDC.                                                                                                                                            |
| 24  | Red for two-color photography (daylight or tungsten). White-flame-arc tricolor projection, AAB.                                                                                                                                 | 46  | Blue projection (experimental), DDD.                                                                                                                                                          |
|     |                                                                                                                                                                                                                                 | 47  | Tricolor blue for direct color separation and from Kodak Ektacolor Film for Dye Transfer. Contrast effects in commercial photography. Tungsten and white-flame-arc tricolor projection, BBC.  |
|     |                                                                                                                                                                                                                                 | 47B | Tricolor blue for color separation from transparencies and from Kodak Ektacolor Film for Graphic Arts, BBB.                                                                                   |
|     |                                                                                                                                                                                                                                 | 48  | Green and red absorption, CBC.                                                                                                                                                                |
|     |                                                                                                                                                                                                                                 | 48A | Green and red absorption, AAB.                                                                                                                                                                |
|     |                                                                                                                                                                                                                                 | 49  | Dark blue, BCB.                                                                                                                                                                               |
|     |                                                                                                                                                                                                                                 | 49B | Very dark blue, BBB.                                                                                                                                                                          |
|     |                                                                                                                                                                                                                                 | 50  | Very dark blue. Mercury violet, CCC.                                                                                                                                                          |
|     |                                                                                                                                                                                                                                 |     | <b>Greens</b>                                                                                                                                                                                 |
|     |                                                                                                                                                                                                                                 | 52  | Light green, AAB.                                                                                                                                                                             |



# TRANSMISSION OF WRATTEN FILTERS (Continued)

## FILTER DATA

| No.  | Description, use, and stability                                                                             | No.                    | Description, use, and stability                                              |
|------|-------------------------------------------------------------------------------------------------------------|------------------------|------------------------------------------------------------------------------|
| 53   | Medium green, CCB.                                                                                          | †86B                   | Yellowish. Photometric filter (visual), BCA.                                 |
|      | Very dark green, AAA.                                                                                       | †86C                   | Yellowish. Photometric filter (visual), AAA.                                 |
| 55   | Stereo green, BBC.                                                                                          | <b>Light Balancing</b> |                                                                              |
| 56   | Very light green, CBC.                                                                                      | 80A                    | For Kodachrome Film, Daylight Type, and photographic flood lamps, ABA.       |
| 57   | Green for two-color photography (daylight), CBC.                                                            | 81                     | Yellowish. For warmer color rendering.                                       |
| 57A  | Light green, BBC.                                                                                           | 81A                    | Yellowish. For Kodak Ektachrome Film, Type B, with photographic flood lamps. |
| 58   | Tricolor green for direct color separation. Contrast effects in commercial photography and microscopy, BBC. | 81B                    | Yellowish. For warmer color rendering.                                       |
| 59   | Green for tricolor projection (white-flame-arc), BBB.                                                       | 81C                    | Yellowish. For Kodachrome Film, Type A, with flash lamps.                    |
| 59A  | Very light green, BBB.                                                                                      | 81D                    | Yellowish. For Kodachrome Film, Type A, with flash lamps.                    |
| 60   | Green for two-color photography (tungsten), BDC.                                                            | 81EF                   | Yellowish. For Kodak Ektachrome Film, Type B, with flash lamps.              |
| 61   | Green color separation from transparencies and Kodak Ektacolor Film. Tricolor projection (tungsten), ABC.   | 82                     | Bluish. For cooler color rendering.                                          |
| 64   | Red absorption (light), CDB.                                                                                | 82A                    | Bluish. For Kodachrome Film, Type A, with 3200 K lamps.                      |
| 65   | Red absorption, ADB.                                                                                        | 82B                    | Bluish. For cooler color rendering.                                          |
| 65A  | Red absorption, CCD.                                                                                        | 82C                    | Bluish. For cooler color rendering.                                          |
| 66   | Contrast effects in microscopy and medical photography, DDC.                                                | 83                     | Yellowish. For 16 mm Commercial Kodachrome Film and daylight exposure, BBB.  |
| 67A  | Red absorption (light). Two-color projection, CDC.                                                          | 85                     | Orange. For Type A Kodak color films and daylight exposure, BAA.             |
|      | <b>Narrow-band</b>                                                                                          | 85B                    | Orange. For Kodak Ektachrome Film, Type B, and daylight exposure, BAB.       |
| 70   | Dark red. Infrared photography. Color separation for Kodak Ektacolor Film (with tungsten), ABC.             | <b>Miscellaneous</b>   |                                                                              |
| 72B  | Dark orange-yellow, CCC.                                                                                    | 79                     | Photographic sensitometry. Corrects 2360 K to 5500 K, AAA.                   |
| 73   | Dark yellow-green, ABB.                                                                                     | 87                     | For infrared photography. Absorbs visual.                                    |
| 74   | Dark green. Mercury green, BBC.                                                                             | 87C                    | Absorbs visual, transmits infrared.                                          |
| 75   | Dark blue-green, ACC.                                                                                       | 88A                    | For infrared photography. Absorbs visual.                                    |
| 76   | Dark violet (compound filter), DDD.                                                                         | 89B                    | For infrared photography, AAA.                                               |
| 77   | Transmits 546 mμ mercury line (glass plus gelatin), AAA.                                                    | 90                     | Narrow-band viewing filter for judging brightness scale of scenes, CCD.      |
| 77A  | Transmits 546 mμ mercury line (glass plus gelatin), AAA.                                                    | 96                     | Neutral filters for controlling luminance, AAB.                              |
|      | <b>Photometrics</b>                                                                                         | 97                     | Dichroic absorption, AAA.                                                    |
| 78   | Bluish. Photometric filter (visual), BAB.                                                                   | 102                    | Correction filter for Barrier-layer photocell, ABA.                          |
| 78AA | Bluish. Photometric filter (visual), BAA.                                                                   | 106                    | Correction filter for S-4 type photocell, AAA.                               |
| 78A  | Bluish. Photometric filter (visual), AAA.                                                                   |                        |                                                                              |
| 78B  | Bluish. Photometric filter (visual), AAA.                                                                   |                        |                                                                              |
| 78C  | Bluish. Photometric filter (visual), BAA.                                                                   |                        |                                                                              |
| 86   | Yellowish. Photometric filter (visual), BBA.                                                                |                        |                                                                              |
| 86A  | Yellowish. Photometric filter (visual), AAA.                                                                |                        |                                                                              |

| Percent transmittance |       |       |        |        |       |         |       |       |       |         |       |        |        |
|-----------------------|-------|-------|--------|--------|-------|---------|-------|-------|-------|---------|-------|--------|--------|
| Wave length           | No. 0 | No. 1 | No. 1A | No. 2B | No. 3 | No. 3N5 | No. 4 | No. 6 | No. 8 | No. 8N5 | No. 9 | No. 11 | No. 12 |
| 400                   | 88.0  | 85.0  | 59.0   | 19.0   | —     | —       | —     | 7.40  | —     | —       | —     | —      | —      |
| 10                    | 88.5  | 85.5  | 76.0   | 48.0   | —     | —       | —     | 8.32  | —     | —       | —     | —      | —      |
| 20                    | 88.9  | 86.0  | 82.0   | 67.0   | —     | —       | —     | 10.4  | —     | —       | —     | 0.16   | —      |
| 30                    | 89.3  | 86.5  | 84.6   | 75.3   | 0.36  | —       | —     | 13.5  | —     | —       | —     | 0.29   | —      |
| 40                    | 89.6  | 87.0  | 86.0   | 80.0   | 1.78  | —       | —     | 18.9  | —     | —       | —     | 0.56   | —      |
| 50                    | 89.8  | 87.4  | 86.8   | 83.0   | 11.5  | 1.59    | —     | 27.6  | —     | —       | —     | 1.32   | —      |
| 60                    | 89.9  | 87.8  | 87.2   | 85.2   | 38.0  | 9.40    | 6.9   | 39.0  | 0.25  | 0.16    | —     | 4.00   | —      |
| 70                    | 90.1  | 88.2  | 87.5   | 86.7   | 68.0  | 18.5    | 42.0  | 52.3  | 5.50  | 2.0     | 1.78  | 12.0   | —      |
| 80                    | 90.3  | 88.5  | 87.3   | 88.1   | 80.8  | 23.5    | 74.0  | 65.8  | 19.0  | 6.3     | 8.31  | 26.0   | —      |
| 90                    | 90.4  | 88.7  | 86.8   | 88.8   | 85.2  | 25.5    | 84.7  | 76.8  | 41.0  | 13.2    | 20.7  | 43.7   | —      |
| 500                   | 90.5  | 88.9  | 86.3   | 89.5   | 86.9  | 26.3    | 87.5  | 83.5  | 63.5  | 20.0    | 34.5  | 55.0   | 1.50   |
| 10                    | 90.6  | 89.1  | 85.5   | 89.9   | 87.8  | 26.7    | 88.5  | 87.0  | 78.0  | 24.3    | 48.8  | 60.0   | 17.3   |
| 20                    | 90.7  | 89.3  | 84.8   | 90.3   | 88.4  | 27.0    | 89.1  | 88.4  | 84.1  | 26.7    | 62.0  | 60.2   | 55.0   |
| 30                    | 90.7  | 89.5  | 84.3   | 90.5   | 89.0  | 27.2    | 89.4  | 89.0  | 86.5  | 28.0    | 76.0  | 57.8   | 77.8   |
| 40                    | 90.8  | 89.7  | 84.0   | 90.6   | 89.5  | 27.5    | 89.6  | 89.4  | 87.7  | 28.6    | 83.8  | 54.2   | 86.0   |
| 50                    | 90.8  | 89.9  | 83.9   | 90.7   | 89.8  | 27.8    | 89.8  | 89.7  | 88.4  | 29.0    | 87.0  | 50.0   | 88.4   |
| 60                    | 90.9  | 90.1  | 84.1   | 90.8   | 90.1  | 27.9    | 90.0  | 89.9  | 88.8  | 29.3    | 88.3  | 44.8   | 89.4   |
| 70                    | 90.9  | 90.2  | 84.8   | 90.9   | 90.4  | 28.0    | 90.2  | 90.1  | 89.2  | 29.5    | 88.8  | 38.9   | 89.7   |
| 80                    | 90.9  | 90.3  | 86.0   | 90.9   | 90.6  | 28.4    | 90.4  | 90.3  | 89.5  | 29.6    | 89.1  | 33.1   | 90.1   |
| 90                    | 91.0  | 90.4  | 87.4   | 91.0   | 90.7  | 29.0    | 90.6  | 90.5  | 89.8  | 29.8    | 89.3  | 27.6   | 90.3   |
| 600                   | 91.0  | 90.5  | 88.5   | 91.1   | 90.8  | 29.5    | 90.8  | 90.6  | 90.1  | 29.9    | 89.5  | 22.7   | 90.4   |
| 10                    | 91.0  | 90.5  | 89.5   | 91.2   | 90.9  | 29.5    | 90.9  | 90.7  | 90.3  | 29.6    | 89.7  | 19.0   | 90.5   |
| 20                    | 91.0  | 90.6  | 90.2   | 91.3   | 91.0  | 29.3    | 91.0  | 90.8  | 90.5  | 29.4    | 89.8  | 14.9   | 90.7   |
| 30                    | 91.0  | 90.6  | 90.6   | 91.3   | 91.0  | 29.1    | 91.1  | 90.9  | 90.7  | 29.1    | 89.9  | 11.4   | 90.9   |
| 40                    | 91.1  | 90.7  | 90.8   | 91.4   | 91.1  | 29.0    | 91.2  | 91.0  | 90.9  | 28.8    | 90.0  | 9.10   | 91.0   |
| 50                    | 91.1  | 90.7  | 91.0   | 91.4   | 91.2  | 20.4    | 91.3  | 91.1  | 91.0  | 28.9    | 90.1  | 8.05   | 91.1   |
| 60                    | 91.1  | 90.8  | 91.1   | 91.5   | 91.3  | 29.6    | 91.4  | 91.2  | 91.1  | 29.2    | 90.1  | 7.50   | 91.2   |
| 70                    | 91.1  | 90.8  | 91.1   | 91.5   | 91.4  | 29.8    | 91.5  | 91.2  | 91.2  | 29.4    | 90.2  | 7.05   | 91.2   |
| 80                    | 91.1  | 90.9  | 91.1   | 91.6   | 91.5  | 30.0    | 91.5  | 91.3  | 91.3  | 29.5    | 90.2  | 6.50   | 91.2   |
| 90                    | 91.1  | 90.9  | 91.1   | 91.7   | 91.6  | 30.2    | 91.6  | 91.4  | 91.4  | 29.7    | 90.3  | 6.10   | 91.2   |
| 700                   | 91.1  | 91.0  | 91.1   | 91.8   | 91.7  | 31.0    | 91.6  | 91.3  | 91.5  | 30.2    | 90.3  | 6.20   | 91.3   |
| Luminous transmit.    | 90.8  | 89.9  | 85.9   | 90.5   | 88.3  | 27.4    | 87.8  | 87.5  | 82.7  | 27.0    | 76.6  | 40.2   | 73.8   |
| Dominant wave lgth.   | 571.0 | 575.0 | 498.0  | 570.0  | 569.5 | 570.5   | 569.5 | 570.3 | 571.8 | 572.0   | 574.4 | 550.3  | 576.1  |
| Excitation purity.    | 0.8   | 1.5   | 1.2    | 5.7    | 50.0  | 56.3    | 64.0  | 44.7  | 85.2  | 84.0    | 91.4  | 60.7   | 97.8   |

\* Some transmission below 400 mμ. Consult the manufacturer.

# TRANSMISSION OF WRATTEN FILTERS (Continued)

| Wave length         | Percent transmittance |        |        |         |        |        |         |        |        |        |        |        |        |
|---------------------|-----------------------|--------|--------|---------|--------|--------|---------|--------|--------|--------|--------|--------|--------|
|                     | No. 13                | No. 15 | No. 16 | No. 18A | No. 21 | No. 22 | No. 23A | No. 24 | No. 25 | No. 26 | No. 29 | No. 30 | No. 31 |
| 400                 | —                     | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 48.6   | 13.8   |
| 10                  | —                     | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 47.4   | 14.5   |
| 20                  | —                     | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 48.5   | 16.4   |
| 30                  | 0.18                  | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 50.1   | 25.5   |
| 40                  | 0.50                  | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 49.4   | 42.7   |
| 50                  | 1.35                  | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 43.0   | 50.2   |
| 60                  | 4.08                  | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 26.5   | 40.4   |
| 70                  | 11.0                  | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 13.8   | 22.6   |
| 80                  | 23.5                  | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 5.00   | 8.20   |
| 90                  | 39.0                  | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | 0.63   | 1.85   |
| 500                 | 50.8                  | —      | —      | —       | —      | —      | —       | —      | —      | —      | —      | —      | 0.12   |
| 10                  | 55.2                  | 1.00   | —      | —       | —      | —      | —       | —      | —      | —      | —      | —      | —      |
| 20                  | 56.5                  | 16.0   | 3.00   | —       | —      | —      | —       | —      | —      | —      | —      | —      | —      |
| 30                  | 55.0                  | 52.1   | 22.0   | —       | —      | —      | —       | —      | —      | —      | —      | —      | —      |
| 40                  | 51.0                  | 70.7   | 48.0   | —       | 2.50   | —      | —       | —      | —      | —      | —      | —      | —      |
| 50                  | 46.0                  | 84.3   | 69.5   | —       | 29.0   | 0.25   | —       | —      | —      | —      | —      | —      | —      |
| 60                  | 39.2                  | 87.5   | 79.5   | —       | 65.0   | 19.0   | —       | —      | —      | —      | —      | —      | —      |
| 70                  | 32.0                  | 88.7   | 84.0   | —       | 80.6   | 60.0   | 11.0    | —      | —      | —      | —      | 0.10   | —      |
| 80                  | 25.1                  | 89.3   | 86.3   | —       | 85.4   | 81.0   | 47.0    | 4.55   | —      | —      | —      | 45.0   | —      |
| 90                  | 18.2                  | 89.7   | 87.8   | —       | 87.3   | 87.0   | 69.6    | 37.3   | 12.6   | 2.90   | —      | 76.0   | 0.63   |
| 600                 | 13.5                  | 90.0   | 89.0   | —       | 88.1   | 88.5   | 82.7    | 72.3   | 50.0   | 30.0   | —      | 87.4   | 26.0   |
| 10                  | 9.60                  | 90.1   | 89.6   | —       | 88.7   | 89.0   | 85.8    | 82.9   | 75.0   | —      | 10.0   | 89.5   | 67.2   |
| 20                  | 6.40                  | 90.2   | 90.0   | —       | 89.0   | 89.5   | 87.2    | 86.4   | 82.6   | 78.9   | 45.3   | 90.2   | 84.0   |
| 30                  | 3.66                  | 90.3   | 90.2   | —       | 89.5   | 89.8   | 87.9    | 87.8   | 85.5   | 84.0   | 71.4   | 90.5   | 88.1   |
| 40                  | 2.20                  | 90.4   | 90.3   | —       | 89.9   | 90.0   | 88.5    | 88.5   | 86.7   | 86.1   | 82.7   | 90.7   | 89.8   |
| 50                  | 1.58                  | 90.5   | 90.4   | —       | 90.2   | 90.1   | 89.0    | 89.0   | 87.6   | 87.2   | 86.6   | 90.8   | 90.2   |
| 60                  | 1.74                  | 90.6   | 90.5   | —       | 90.4   | 90.2   | 89.4    | 89.3   | 88.2   | 88.1   | 88.4   | 90.9   | 90.4   |
| 70                  | 2.62                  | 90.6   | 90.6   | —       | 90.5   | 90.3   | 89.6    | 89.7   | 88.5   | 88.5   | 89.4   | 91.0   | 90.5   |
| 80                  | 3.55                  | 90.7   | 90.7   | —       | 90.5   | 90.4   | 89.8    | 89.9   | 89.0   | 88.9   | 90.0   | 91.1   | 90.7   |
| 90                  | 4.48                  | 90.7   | 90.8   | 0.25    | 90.6   | 90.5   | 90.0    | 90.2   | 89.3   | 89.2   | 90.3   | 91.1   | 90.8   |
| 700                 | 5.25                  | 90.8   | 90.8   | 1.20    | 90.6   | 90.6   | 90.2    | 90.3   | 89.5   | 89.5   | 90.4   | 91.1   | 91.0   |
| Luminous transmit.  | 34.5                  | 66.2   | 57.7   | 0.0014  | 45.6   | 35.8   | 25.0    | 17.8   | 14.0   | 11.7   | 6.3    | 26.6   | 12.9   |
| Dominant wave lgth. | 542.0                 | 579.3  | 582.7  | 700.0   | 588.9  | 595.1  | 602.7   | 610.6  | 615.1  | 619.0  | 631.6  | 498.6  | 513.1  |
| Excitation purity.  | 57.5                  | 99.0   | 99.3   | 100.0   | 99.9   | 99.9   | 100.0   | 100.0  | 100.0  | 100.0  | 100.0  | 62.4   | 81.9   |

| Wave length         | Percent transmittance |        |        |         |        |        |        |         |        |        |        |         |        |
|---------------------|-----------------------|--------|--------|---------|--------|--------|--------|---------|--------|--------|--------|---------|--------|
|                     | No. 32                | No. 33 | No. 34 | No. 34A | No. 35 | No. 36 | No. 38 | No. 38A | No. 39 | No. 40 | No. 44 | No. 44A | No. 45 |
| 400                 | 38.0                  | 0.85   | 64.0   | —       | 48.0   | 36.5   | 60.5   | 33.4    | 85.2   | —      | 0.44   | 2.52    | —      |
| 10                  | 37.9                  | 0.71   | 70.1   | 0.1     | 57.0   | 45.5   | 66.5   | 41.2    | 78.2   | —      | 0.36   | 3.39    | —      |
| 20                  | 40.0                  | 1.17   | 72.0   | 40.0    | 57.6   | 45.5   | 72.5   | 53.0    | 70.5   | —      | 0.63   | 6.30    | —      |
| 30                  | 43.0                  | 1.69   | 68.4   | 69.7    | 47.5   | 32.7   | 75.3   | 58.0    | 63.3   | —      | 3.63   | 17.4    | —      |
| 40                  | 55.5                  | 5.36   | 58.2   | 68.7    | 29.5   | 15.2   | 76.2   | 58.8    | 53.6   | —      | 13.1   | 32.7    | 5.00   |
| 50                  | 66.0                  | 14.3   | 42.3   | 56.2    | 12.3   | 3.7    | 75.9   | 57.6    | 42.5   | —      | 25.4   | 41.8    | 19.0   |
| 60                  | 66.0                  | 12.4   | 25.2   | 40.5    | 3.5    | 0.35   | 74.8   | 55.2    | 28.5   | 3.16   | 36.5   | 48.1    | 29.5   |
| 70                  | 57.0                  | 5.00   | 12.1   | 23.8    | 0.25   | —      | 73.4   | 51.9    | 17.3   | 21.6   | 46.5   | 51.7    | 34.4   |
| 80                  | 40.0                  | 0.50   | 2.7    | 9.2     | —      | —      | 71.6   | 48.5    | 10.2   | 44.7   | 53.6   | 52.9    | 35.7   |
| 90                  | 21.0                  | —      | 0.2    | 2.3     | —      | —      | 69.5   | 44.6    | 4.00   | 61.4   | 56.8   | 52.2    | 34.5   |
| 500                 | 9.56                  | —      | —      | 0.33    | —      | —      | 66.7   | 40.2    | 1.33   | 70.2   | 55.8   | 49.8    | 29.7   |
| 10                  | 2.51                  | —      | —      | —       | —      | —      | 63.9   | 35.8    | 0.35   | 72.4   | 50.9   | 44.8    | 21.5   |
| 20                  | 0.13                  | —      | —      | —       | —      | —      | 60.8   | 31.7    | —      | 70.5   | 42.1   | 36.8    | 11.5   |
| 30                  | —                     | —      | —      | —       | —      | —      | 57.0   | 27.2    | —      | 64.8   | 30.5   | 26.8    | 3.80   |
| 40                  | —                     | —      | —      | —       | —      | —      | 52.6   | 22.3    | —      | 55.5   | 18.6   | 16.8    | 0.85   |
| 50                  | —                     | —      | —      | —       | —      | —      | 48.0   | 17.6    | —      | 44.2   | 8.99   | 8.20    | —      |
| 60                  | —                     | —      | —      | —       | —      | —      | 42.8   | 12.9    | —      | 32.5   | 3.59   | 2.95    | —      |
| 70                  | —                     | —      | —      | —       | —      | —      | 37.0   | 8.78    | —      | 20.3   | 0.80   | 0.91    | —      |
| 80                  | —                     | —      | —      | —       | —      | —      | 30.6   | 5.65    | —      | 9.56   | —      | 0.10    | —      |
| 90                  | —                     | —      | —      | —       | —      | —      | 25.5   | 3.48    | —      | 3.20   | —      | —       | —      |
| 600                 | 6.04                  | —      | —      | —       | —      | —      | 20.9   | 2.09    | —      | 1.10   | —      | —       | —      |
| 10                  | 41.0                  | 0.80   | —      | 0.13    | —      | —      | 16.8   | 1.15    | —      | 0.32   | —      | —       | —      |
| 20                  | 75.0                  | 24.9   | —      | 1.0     | —      | —      | 12.9   | 0.59    | —      | —      | —      | —       | —      |
| 30                  | 86.1                  | 60.8   | —      | 6.3     | —      | —      | 10.0   | 0.28    | —      | —      | —      | —       | —      |
| 40                  | 89.0                  | 78.0   | 0.4    | 22.0    | —      | —      | 7.79   | 0.13    | —      | —      | —      | —       | —      |
| 50                  | 90.0                  | 85.0   | 4.0    | 45.0    | 0.1    | —      | 6.68   | —       | —      | —      | —      | —       | —      |
| 60                  | 90.6                  | 87.5   | 20.7   | 65.0    | 3.0    | 0.21   | 6.20   | —       | —      | —      | —      | —       | —      |
| 70                  | 90.7                  | 88.7   | 45.2   | 77.3    | 19.0   | 7.5    | 5.91   | —       | —      | —      | —      | —       | —      |
| 80                  | 90.8                  | 89.4   | 66.5   | 85.0    | 43.5   | 29.0   | 5.41   | —       | 0.50   | 0.80   | —      | —       | —      |
| 90                  | 90.9                  | 89.8   | 78.8   | 88.2    | 66.0   | 55.0   | 4.90   | —       | 4.06   | 6.99   | 0.18   | —       | —      |
| 700                 | 91.0                  | 90.0   | 85.0   | 89.8    | 77.7   | 71.3   | 5.00   | —       | 17.8   | 23.5   | 1.60   | —       | 1.00   |
| Luminous transmit.  | 12.5                  | 5.2    | 1.3    | 2.9     | 0.45   | 0.25   | 42.5   | 17.3    | 1.2    | 33.6   | 15.6   | 14.4    | 5.2    |
| Dominant wave lgth. | 551.7                 | 498.0  | 424.0  | 564.8   | 566.8  | 566.4  | 483.5  | 478.9   | 450.6  | 516.2  | 589.1  | 483.4   | 481.5  |
| Excitation purity.  | 79.6                  | 88.3   | 94.4   | 91.4    | 96.3   | 97.8   | 41.8   | 69.8    | 98.9   | 48.5   | 72.9   | 77.2    | 88.4   |

\* Some transmission below 400 mμ. Consult the manufacturer.



# TRANSMISSION OF WRATTEN FILTERS (Continued)

| Wave length         | Percent transmittance |        |        |         |        |         |        |         |        |        |        |        |        |
|---------------------|-----------------------|--------|--------|---------|--------|---------|--------|---------|--------|--------|--------|--------|--------|
|                     | No. 45A               | No. 46 | No. 47 | No. 47B | No. 48 | No. 48A | No. 49 | No. 49B | No. 50 | No. 52 | No. 53 | No. 54 | No. 55 |
| 400                 | —                     | 1.20   | 7.80   | 16.0    | 0.96   | 5.65    | 3.30   | 1.70    | 0.45   | 2.18   | —      | —      | —      |
| 10                  | —                     | 0.60   | 17.4   | 29.5    | 3.16   | 10.0    | 4.28   | 2.00    | 0.39   | 1.51   | —      | —      | —      |
| 20                  | —                     | 0.80   | 34.0   | 43.6    | 8.25   | 16.0    | 6.93   | 3.55    | 0.59   | 0.80   | —      | —      | —      |
| 30                  | 1.00                  | 5.98   | 47.0   | 50.0    | 15.0   | 21.0    | 11.2   | 7.00    | 2.63   | 0.44   | —      | —      | —      |
| 40                  | 8.81                  | 19.0   | 50.3   | 47.2    | 22.6   | 25.0    | 18.9   | 13.0    | 8.90   | 0.41   | —      | —      | —      |
| 50                  | 17.4                  | 30.1   | 48.3   | 36.0    | 30.3   | 26.2    | 25.6   | 17.4    | 14.0   | 0.69   | —      | —      | —      |
| 60                  | 20.9                  | 33.8   | 43.4   | 25.0    | 33.2   | 22.9    | 24.0   | 14.8    | 12.3   | 1.45   | —      | —      | 0.20   |
| 70                  | 21.6                  | 32.1   | 36.2   | 13.2    | 29.6   | 16.5    | 15.7   | 7.60    | 5.36   | 2.70   | 0.10   | —      | 2.90   |
| 80                  | 20.5                  | 27.0   | 28.5   | 4.5     | 22.4   | 9.55    | 6.93   | 2.76    | 1.55   | 4.90   | 0.7    | —      | 13.1   |
| 90                  | 18.0                  | 20.2   | 19.6   | 1.3     | 14.1   | 4.27    | 2.14   | 0.40    | 0.10   | 8.50   | 2.14   | —      | 34.2   |
| 500                 | 14.4                  | 11.1   | 0.36   | 0.17    | 7.30   | 1.58    | 0.46   | —       | —      | 13.3   | 4.47   | —      | 53.4   |
| 10                  | 10.1                  | 4.39   | —      | —       | 2.64   | 0.48    | —      | —       | —      | 18.2   | 7.24   | 0.10   | 67.0   |
| 20                  | 5.60                  | 1.66   | —      | —       | 0.50   | —       | —      | —       | —      | 23.7   | 10.7   | 0.31   | 69.3   |
| 30                  | 2.52                  | 0.35   | —      | —       | —      | —       | —      | —       | —      | 28.5   | 14.0   | 0.64   | 65.1   |
| 40                  | 0.4                   | —      | —      | —       | —      | —       | —      | —       | —      | 32.1   | 16.6   | 0.89   | 56.7   |
| 50                  | 0.10                  | —      | —      | —       | —      | —       | —      | —       | —      | 33.1   | 17.3   | 0.93   | 45.0   |
| 60                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 31.0   | 15.4   | 0.62   | 33.1   |
| 70                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 25.6   | 11.4   | 0.21   | 20.7   |
| 80                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 19.1   | 6.90   | —      | 9.00   |
| 90                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 12.6   | 3.60   | —      | 2.70   |
| 600                 | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 7.78   | 1.41   | —      | 0.40   |
| 10                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 4.17   | 0.40   | —      | —      |
| 20                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 2.34   | 0.15   | —      | —      |
| 30                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 1.38   | —      | —      | —      |
| 40                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 0.80   | —      | —      | —      |
| 50                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 0.54   | —      | —      | —      |
| 60                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 0.36   | —      | —      | —      |
| 70                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 0.27   | —      | —      | —      |
| 80                  | —                     | —      | —      | —       | —      | —       | —      | —       | —      | 0.23   | —      | —      | 0.66   |
| 90                  | 0.20                  | 0.25   | —      | —       | —      | —       | —      | —       | —      | 0.19   | —      | —      | 6.90   |
| 700                 | 2.24                  | 0.85   | —      | —       | —      | —       | —      | —       | —      | 0.17   | —      | —      | 27.8   |
| Luminous transmit.  | 2.8                   | 2.4    | 2.8    | 0.78    | 1.86   | 0.88    | 0.69   | 0.36    | 0.26   | 20.1   | 9.0    | 0.032  | 31.4   |
| Dominant wave lgth. | 477.6                 | 470.4  | 463.7  | 479.8   | 466.5  | 458.0   | 457.9  | 455.5   | 455.9  | 553.3  | 551.1  | 546.1  | 530.2  |
| Excitation purity.  | 89.7                  | 94.9   | 95.8   | 69.1    | 96.1   | 98.3    | 98.9   | 99.3    | 99.4   | 77.3   | 89.7   | 97.0   | 68.4   |

| Wave length         | Percent transmittance |        |         |        |        |         |        |        |        |        |         |        |         |
|---------------------|-----------------------|--------|---------|--------|--------|---------|--------|--------|--------|--------|---------|--------|---------|
|                     | No. 56                | No. 57 | No. 57A | No. 58 | No. 59 | No. 59A | No. 60 | No. 61 | No. 64 | No. 65 | No. 65A | No. 66 | No. 67A |
| 400                 | —                     | —      | —       | —      | —      | —       | —      | —      | 9.00   | —      | —       | 12.3   | 1.10    |
| 10                  | —                     | —      | —       | —      | —      | —       | —      | —      | 9.20   | —      | —       | 13.0   | 0.93    |
| 20                  | —                     | —      | —       | —      | —      | —       | —      | —      | 8.75   | 0.23   | —       | 15.0   | 1.28    |
| 30                  | —                     | —      | —       | —      | —      | 0.16    | —      | —      | 9.20   | 0.61   | 0.16    | 18.4   | 3.16    |
| 40                  | —                     | —      | 0.19    | —      | —      | 0.37    | —      | —      | 11.3   | 1.58   | 1.32    | 23.2   | 6.40    |
| 50                  | —                     | —      | 0.87    | —      | 0.40   | 1.26    | 0.19   | —      | 15.5   | 4.10   | 5.50    | 31.2   | 10.5    |
| 60                  | 0.16                  | 0.44   | 2.56    | —      | 1.90   | 4.57    | 1.38   | —      | 23.3   | 9.00   | 13.0    | 42.2   | 17.7    |
| 70                  | 3.12                  | 3.10   | 7.80    | 0.23   | 7.70   | 13.2    | 5.38   | —      | 34.4   | 16.8   | 24.9    | 55.5   | 28.5    |
| 80                  | 13.0                  | 13.1   | 21.6    | 1.38   | 21.0   | 30.0    | 15.0   | 0.33   | 46.8   | 24.9   | 36.6    | 68.4   | 41.4    |
| 90                  | 34.5                  | 31.9   | 41.7    | 4.90   | 41.5   | 50.8    | 32.0   | 4.00   | 56.6   | 31.3   | 45.1    | 77.6   | 52.1    |
| 500                 | 59.0                  | 50.5   | 58.8    | 17.7   | 59.0   | 66.0    | 48.4   | 16.6   | 62.1   | 33.7   | 45.8    | 82.7   | 57.9    |
| 10                  | 73.0                  | 60.6   | 67.9    | 38.8   | 67.7   | 73.0    | 57.2   | 32.3   | 62.9   | 32.4   | 39.7    | 84.6   | 58.8    |
| 20                  | 79.0                  | 63.3   | 70.1    | 52.2   | 69.8   | 75.1    | 59.2   | 40.0   | 59.1   | 27.5   | 29.7    | 84.0   | 55.4    |
| 30                  | 79.9                  | 61.0   | 67.6    | 53.6   | 67.2   | 73.2    | 55.5   | 39.6   | 51.6   | 20.7   | 17.8    | 82.6   | 47.5    |
| 40                  | 77.5                  | 55.0   | 61.8    | 47.6   | 61.5   | 68.5    | 47.5   | 34.5   | 41.3   | 13.7   | 7.90    | 79.1   | 36.6    |
| 50                  | 72.6                  | 47.1   | 53.5    | 38.4   | 54.0   | 62.0    | 36.8   | 26.3   | 28.0   | 6.50   | 2.40    | 73.7   | 25.0    |
| 60                  | 66.1                  | 37.3   | 43.3    | 27.8   | 45.0   | 54.4    | 25.2   | 17.3   | 16.2   | 1.66   | 0.32    | 67.1   | 14.2    |
| 70                  | 58.0                  | 26.5   | 31.6    | 17.4   | 35.0   | 44.5    | 14.4   | 9.70   | 7.95   | 0.40   | —       | 58.8   | 5.50    |
| 80                  | 46.1                  | 16.6   | 19.4    | 9.0    | 24.0   | 33.0    | 6.3    | 4.40   | 3.10   | —      | —       | 47.2   | 1.40    |
| 90                  | 33.8                  | 8.69   | 9.70    | 3.50   | 14.0   | 22.0    | 1.82   | 1.66   | 0.80   | —      | —       | 34.5   | 0.28    |
| 600                 | 24.0                  | 3.70   | 4.50    | 1.50   | 7.95   | 14.6    | 0.48   | 0.38   | —      | —      | —       | 24.4   | —       |
| 10                  | 18.7                  | 1.60   | 2.00    | 0.41   | 4.90   | 10.5    | 0.10   | —      | —      | —      | —       | 18.5   | —       |
| 20                  | 13.2                  | 0.49   | 0.87    | —      | 2.70   | 6.92    | —      | —      | —      | —      | —       | 13.7   | —       |
| 30                  | 7.22                  | —      | 0.22    | —      | 1.00   | 3.16    | —      | —      | —      | —      | —       | 7.70   | —       |
| 40                  | 3.02                  | —      | —       | —      | 0.17   | 1.07    | —      | —      | —      | —      | —       | 3.00   | —       |
| 50                  | 1.48                  | —      | —       | —      | —      | 0.50    | —      | —      | —      | —      | —       | 1.46   | —       |
| 60                  | 1.91                  | —      | —       | —      | —      | 0.91    | —      | —      | —      | —      | —       | 1.91   | —       |
| 70                  | 7.95                  | —      | —       | —      | 0.63   | 3.00    | —      | —      | —      | —      | —       | 6.17   | —       |
| 80                  | 23.0                  | —      | 0.16    | —      | 4.00   | 10.0    | —      | —      | —      | —      | —       | 19.9   | —       |
| 90                  | 44.1                  | —      | 1.15    | —      | 12.0   | 20.0    | 2.10   | —      | 0.10   | —      | 0.20    | 42.6   | —       |
| 700                 | 64.8                  | —      | 3.17    | 0.53   | 22.6   | 30.0    | 8.70   | —      | 4.50   | —      | 2.18    | 63.1   | 0.40    |
| Luminous transmit.  | 52.8                  | 32.5   | 37.2    | 23.7   | 38.7   | 45.8    | 26.1   | 16.8   | 25.0   | 9.6    | 9.8     | 58.3   | 22.4    |
| Dominant wave lgth. | 552.3                 | 536.4  | 534.0   | 540.2  | 538.3  | 541.4   | 525.7  | 536.8  | 497.3  | 496.6  | 492.7   | 512.3  | 499.8   |
| Excitation purity.  | 78.2                  | 69.2   | 62.1    | 88.1   | 66.0   | 59.3    | 62.2   | 85.4   | 55.0   | 67.8   | 77.4    | 21.5   | 55.8    |

\* Some transmission below 400 mμ. Consult the manufacturer.

# TRANSMISSION OF WRATTEN FILTERS (Continued)

| Wave length         | Percent transmittance |         |        |        |        |        |        |         |        |          |         |         |
|---------------------|-----------------------|---------|--------|--------|--------|--------|--------|---------|--------|----------|---------|---------|
|                     | No. 70                | No. 72B | No. 73 | No. 74 | No. 75 | No. 76 | No. 77 | No. 77A | No. 78 | No. 78AA | No. 78A | No. 78B |
| 400                 | —                     | —       | —      | —      | —      | 0.22   | —      | —       | 37.2   | 43.0     | 56.0    | 64.1    |
| 10                  | —                     | —       | —      | —      | —      | 0.18   | —      | —       | 41.7   | 46.0     | 58.6    | 66.5    |
| 20                  | —                     | —       | —      | —      | —      | 0.29   | —      | —       | 44.2   | 48.7     | 61.0    | 68.4    |
| 30                  | —                     | —       | —      | —      | —      | 1.38   | —      | —       | 44.6   | 49.8     | 61.8    | 69.5    |
| 40                  | —                     | —       | —      | —      | —      | 3.50   | —      | —       | 44.2   | 49.7     | 61.8    | 70.0    |
| 50                  | —                     | —       | —      | —      | —      | 3.50   | —      | —       | 41.7   | 48.0     | 61.0    | 69.4    |
| 60                  | —                     | —       | —      | —      | 1.97   | 1.92   | —      | —       | 38.0   | 44.9     | 58.7    | 67.5    |
| 70                  | —                     | —       | —      | —      | 10.0   | 0.51   | —      | —       | 33.8   | 40.3     | 55.0    | 65.4    |
| 80                  | —                     | —       | —      | —      | 17.4   | —      | —      | —       | 27.5   | 35.6     | 51.0    | 62.9    |
| 90                  | —                     | —       | —      | —      | 18.0   | —      | —      | —       | 23.5   | 30.9     | 47.1    | 59.8    |
| 500                 | —                     | —       | —      | —      | 13.0   | —      | —      | —       | 19.5   | 26.5     | 43.5    | 57.0    |
| 10                  | —                     | —       | —      | 0.96   | 7.35   | —      | 0.30   | 0.10    | 15.8   | 23.4     | 40.0    | 54.2    |
| 20                  | —                     | —       | —      | 7.95   | 3.20   | —      | 9.10   | 5.35    | 13.8   | 20.3     | 36.9    | 51.4    |
| 30                  | —                     | —       | —      | 14.6   | 0.83   | —      | 13.5   | 1.90    | 11.8   | 17.8     | 34.4    | 49.3    |
| 40                  | —                     | —       | —      | 12.9   | 0.14   | —      | 46.1   | 35.0    | 10.5   | 16.6     | 32.7    | 48.1    |
| 50                  | —                     | —       | —      | 7.60   | —      | —      | 78.0   | 71.8    | 9.56   | 14.9     | 31.2    | 46.7    |
| 60                  | —                     | —       | 2.24   | 3.06   | —      | —      | 75.8   | 63.1    | 8.53   | 13.2     | 29.4    | 45.0    |
| 70                  | —                     | —       | 5.97   | 0.83   | —      | —      | 8.00   | —       | 7.77   | 12.1     | 28.0    | 43.6    |
| 80                  | —                     | —       | 4.56   | 0.12   | —      | —      | 1.00   | —       | 7.41   | 11.6     | 27.5    | 43.1    |
| 90                  | —                     | 1.26    | 2.00   | —      | —      | —      | 0.32   | —       | 6.93   | 11.1     | 27.0    | 42.9    |
| 600                 | —                     | 5.89    | 0.56   | —      | —      | —      | 16.2   | 1.60    | 6.45   | 10.40    | 26.0    | 41.8    |
| 10                  | —                     | 5.25    | 0.10   | —      | —      | —      | 52.1   | 32.1    | 5.50   | 9.20     | 24.1    | 40.0    |
| 20                  | —                     | 2.88    | —      | —      | —      | —      | 83.0   | 78.0    | 4.80   | 7.70     | 21.8    | 37.6    |
| 30                  | —                     | 1.26    | —      | —      | —      | —      | 84.9   | 79.5    | 3.94   | 6.50     | 19.7    | 35.5    |
| 40                  | —                     | 0.48    | —      | —      | —      | —      | 88.1   | 86.5    | 3.46   | 5.60     | 18.6    | 34.2    |
| 50                  | 0.63                  | 0.14    | —      | —      | —      | —      | 89.8   | 89.2    | 3.24   | 5.50     | 18.4    | 33.6    |
| 60                  | 10.5                  | —       | —      | —      | —      | —      | 89.8   | 89.0    | 3.16   | 5.60     | 18.5    | 34.0    |
| 70                  | 35.0                  | —       | —      | —      | —      | —      | 85.5   | 79.5    | 3.39   | 5.80     | 18.7    | 34.1    |
| 80                  | 55.2                  | —       | —      | —      | —      | —      | 76.1   | 62.5    | 3.45   | 6.10     | 19.0    | 34.5    |
| 90                  | 70.0                  | —       | —      | —      | —      | 0.13   | 75.0   | 62.4    | 3.51   | 6.10     | 19.3    | 34.8    |
| 700                 | 79.0                  | —       | —      | —      | 0.14   | 1.24   | 86.5   | 83.0    | 3.90   | 6.50     | 20.2    | 36.0    |
| Luminous transmitt. | 0.31                  | 0.74    | 1.3    | 4.0    | 1.9    | 0.046  | 32.3   | 25.5    | 10.7   | 15.8     | 31.6    | 46.7    |
| Dominant wave lgth. | 675.6                 | 604.9   | 574.9  | 538.6  | 487.7  | 449.2  | 579.9  | 581.5   | 471.1  | 473.4    | 475.7   | 477.2   |
| Excitation purity.  | 100.0                 | 100.0   | 100.0  | 96.7   | 90.4   | 99.7   | 99.0   | 99.1    | 63.0   | 54.5     | 33.7    | 20.7    |

| Wave length         | Percent transmittance |        |         |        |         |         |         |         |          |        |         |         |
|---------------------|-----------------------|--------|---------|--------|---------|---------|---------|---------|----------|--------|---------|---------|
|                     | No. 78C               | No. 79 | No. 80A | No. 81 | No. 81A | No. 81B | No. 81C | No. 81D | No. 81EF | No. 82 | No. 82A | No. 82B |
| 400                 | 74.9                  | 24.0   | 67.6    | 77.7   | 65.1    | 55.1    | 46.1    | 38.2    | 30.7     | 83.0   | 80.1    | 76.7    |
| 10                  | 76.6                  | 26.0   | 73.1    | 78.1   | 65.9    | 55.8    | 46.6    | 38.4    | 31.5     | 83.7   | 80.8    | 78.0    |
| 20                  | 77.9                  | 29.0   | 76.8    | 79.0   | 67.6    | 57.7    | 49.0    | 41.0    | 34.3     | 84.6   | 81.6    | 79.2    |
| 30                  | 78.9                  | 31.0   | 7.77    | 80.5   | 70.2    | 61.0    | 52.5    | 45.5    | 38.6     | 85.1   | 82.2    | 79.7    |
| 40                  | 79.4                  | 32.2   | 76.5    | 81.9   | 72.8    | 64.5    | 57.2    | 50.0    | 43.2     | 85.4   | 82.4    | 79.7    |
| 50                  | 79.5                  | 32.7   | 73.0    | 83.0   | 74.8    | 67.2    | 60.5    | 53.9    | 47.4     | 85.4   | 82.4    | 79.2    |
| 60                  | 79.3                  | 31.4   | 69.0    | 83.7   | 76.0    | 69.1    | 63.0    | 56.5    | 50.2     | 85.0   | 81.7    | 78.0    |
| 70                  | 78.6                  | 28.8   | 63.6    | 84.3   | 77.1    | 70.6    | 64.2    | 58.1    | 52.0     | 84.6   | 80.7    | 76.3    |
| 80                  | 77.8                  | 25.6   | 57.6    | 84.6   | 77.8    | 71.3    | 65.0    | 59.0    | 53.0     | 84.0   | 79.3    | 74.4    |
| 90                  | 76.7                  | 22.2   | 51.3    | 84.9   | 78.3    | 71.8    | 65.7    | 60.0    | 54.0     | 83.3   | 78.0    | 72.1    |
| 500                 | 75.5                  | 19.3   | 45.2    | 85.3   | 78.6    | 72.6    | 66.4    | 60.8    | 55.4     | 82.6   | 76.6    | 70.2    |
| 10                  | 74.2                  | 16.8   | 39.4    | 85.4   | 79.0    | 72.9    | 66.5    | 61.1    | 56.2     | 82.0   | 75.3    | 68.3    |
| 20                  | 73.0                  | 14.2   | 34.2    | 85.5   | 79.5    | 73.2    | 67.0    | 61.6    | 57.0     | 81.4   | 74.0    | 66.5    |
| 30                  | 72.1                  | 12.7   | 30.0    | 86.0   | 80.4    | 74.5    | 68.8    | 62.5    | 59.5     | 81.0   | 73.1    | 65.5    |
| 40                  | 71.5                  | 11.8   | 27.1    | 86.5   | 81.5    | 76.0    | 71.0    | 66.1    | 62.7     | 80.8   | 72.7    | 65.0    |
| 50                  | 70.7                  | 11.0   | 24.8    | 86.8   | 82.3    | 77.0    | 72.0    | 67.3    | 64.5     | 80.6   | 72.4    | 64.5    |
| 60                  | 69.8                  | 9.76   | 23.5    | 87.0   | 82.6    | 77.6    | 72.5    | 68.0    | 65.3     | 80.4   | 71.8    | 63.8    |
| 70                  | 69.0                  | 8.81   | 22.6    | 87.1   | 82.7    | 77.8    | 72.7    | 68.3    | 65.8     | 80.2   | 71.5    | 63.2    |
| 80                  | 68.8                  | 8.50   | 22.6    | 87.1   | 82.8    | 78.0    | 73.0    | 68.5    | 66.0     | 80.2   | 71.5    | 63.2    |
| 90                  | 68.6                  | 8.29   | 23.2    | 87.4   | 83.1    | 78.2    | 74.0    | 69.5    | 66.5     | 80.3   | 71.7    | 63.4    |
| 600                 | 68.0                  | 7.56   | 23.7    | 87.6   | 84.0    | 79.1    | 75.6    | 72.0    | 68.1     | 80.2   | 71.5    | 63.0    |
| 10                  | 66.7                  | 6.45   | 23.2    | 88.1   | 85.0    | 81.0    | 78.5    | 75.0    | 71.6     | 79.3   | 70.3    | 61.5    |
| 20                  | 65.0                  | 5.13   | 21.0    | 88.8   | 86.1    | 83.1    | 80.8    | 78.0    | 74.7     | 78.4   | 68.5    | 59.0    |
| 30                  | 63.8                  | 4.17   | 18.2    | 89.2   | 87.0    | 84.2    | 82.1    | 79.8    | 77.0     | 77.5   | 66.9    | 56.9    |
| 40                  | 63.0                  | 3.47   | 15.8    | 89.4   | 87.4    | 85.1    | 83.0    | 80.8    | 78.4     | 76.8   | 65.5    | 55.0    |
| 50                  | 62.7                  | 3.16   | 14.5    | 89.5   | 87.7    | 85.6    | 83.5    | 81.5    | 79.2     | 76.5   | 64.8    | 54.1    |
| 60                  | 63.0                  | 3.09   | 13.8    | 89.8   | 88.0    | 86.0    | 84.1    | 82.1    | 80.1     | 76.2   | 64.6    | 53.7    |
| 70                  | 63.3                  | 3.16   | 13.4    | 90.0   | 88.2    | 86.5    | 84.8    | 83.0    | 80.9     | 76.1   | 64.5    | 53.7    |
| 80                  | 63.4                  | 3.16   | 12.7    | 90.1   | 88.5    | 87.0    | 85.5    | 83.7    | 81.8     | 76.1   | 64.4    | 53.5    |
| 90                  | 63.6                  | 3.16   | 11.7    | 90.3   | 89.0    | 87.5    | 86.1    | 84.6    | 82.9     | 76.2   | 64.2    | 53.4    |
| 700                 | 65.0                  | 3.31   | 11.5    | 90.5   | 89.2    | 88.0    | 86.8    | 85.5    | 84.0     | 77.1   | 64.6    | 54.1    |
| Luminous transmitt. | 70.4                  | 11.3   | 28.4    | 86.8   | 82.0    | 76.9    | 72.0    | 67.4    | 64.0     | 80.7   | 72.5    | 64.6    |
| Dominant wave lgth. | 479.8                 | 474.8  | 471.7   | 576.7  | 577.5   | 577.8   | 577.4   | 579.5   | 579.0    | 477.5  | 476.6   | 475.6   |
| Excitation purity.  | 6.8                   | 52.8   | 45.9    | 2.9    | 6.0     | 8.7     | 10.7    | 14.7    | 19.0     | 3.0    | 6.3     | 10.2    |

\* Some transmission below 400 mμ. Consult the manufacturer.



# TRANSMISSION OF WRATTEN FILTERS (Continued)

| Wave length         | Percent transmittance |        |        |         |        |         |         |         |         |        |        |        |         |
|---------------------|-----------------------|--------|--------|---------|--------|---------|---------|---------|---------|--------|--------|--------|---------|
|                     | No. 82C               | No. 83 | No. 85 | No. 85B | No. 86 | No. 86A | No. 86B | No. 86C | No. 89B | No. 90 | No. 96 | No. 97 | No. 102 |
| 400                 | 73.4                  | 13.5   | 6.0    | 1.59    | 0.50   | 8.00    | 20.0    | 44.0    | —       | —      | 4.28   | —      | 1.12    |
| 10                  | 75.0                  | 13.1   | 18.0   | 9.32    | 0.81   | 12.2    | 26.1    | 55.0    | —       | —      | 4.91   | —      | 0.96    |
| 20                  | 76.4                  | 13.5   | 28.4   | 15.5    | 1.55   | 16.7    | 31.6    | 62.0    | —       | —      | 5.50   | —      | 0.89    |
| 30                  | 77.2                  | 14.1   | 33.4   | 19.0    | 2.88   | 21.5    | 37.5    | 66.6    | —       | —      | 6.17   | —      | 0.96    |
| 40                  | 77.2                  | 15.6   | 36.2   | 20.8    | 5.50   | 27.8    | 44.0    | 70.8    | —       | —      | 6.92   | —      | 1.23    |
| 50                  | 76.6                  | 17.8   | 38.1   | 22.1    | 9.10   | 34.2    | 50.1    | 74.3    | —       | —      | 7.50   | —      | 1.86    |
| 60                  | 75.2                  | 21.0   | 40.4   | 24.3    | 13.5   | 40.4    | 55.4    | 76.8    | —       | —      | 7.81   | —      | 3.23    |
| 70                  | 73.2                  | 25.5   | 43.0   | 27.5    | 17.8   | 45.0    | 59.5    | 78.7    | —       | —      | 8.15   | 0.22   | 6.45    |
| 80                  | 70.7                  | 30.2   | 45.3   | 30.9    | 21.3   | 48.7    | 62.5    | 80.2    | —       | —      | 8.47   | 0.43   | 14.0    |
| 90                  | 68.1                  | 35.8   | 47.2   | 34.3    | 24.5   | 51.2    | 64.6    | 81.2    | —       | —      | 8.60   | 0.39   | 21.6    |
| 500                 | 65.7                  | 43.5   | 48.9   | 38.3    | 26.8   | 52.8    | 66.0    | 81.7    | —       | —      | 8.73   | 0.15   | 30.7    |
| 10                  | 63.5                  | 46.3   | 49.2   | 40.7    | 27.9   | 53.4    | 66.4    | 81.9    | —       | —      | 8.85   | —      | 41.4    |
| 20                  | 61.5                  | 47.2   | 48.2   | 40.6    | 28.6   | 53.7    | 66.6    | 82.0    | —       | —      | 8.90   | —      | 51.3    |
| 30                  | 59.9                  | 48.3   | 48.3   | 40.7    | 30.4   | 55.0    | 67.6    | 82.4    | —       | —      | 9.01   | —      | 59.4    |
| 40                  | 59.1                  | 49.6   | 49.2   | 41.6    | 32.5   | 56.5    | 69.0    | 83.0    | —       | —      | 9.07   | —      | 64.2    |
| 50                  | 58.3                  | 51.8   | 51.0   | 43.2    | 35.0   | 58.5    | 70.2    | 83.5    | —       | —      | 9.20   | —      | 66.7    |
| 60                  | 57.2                  | 56.5   | 55.8   | 47.1    | 41.2   | 63.0    | 73.0    | 84.6    | —       | 9.00   | 9.30   | —      | 66.3    |
| 70                  | 56.2                  | 65.0   | 64.5   | 56.0    | 53.0   | 70.9    | 78.1    | 86.8    | —       | 30.5   | 9.20   | —      | 63.0    |
| 80                  | 56.1                  | 75.5   | 75.0   | 68.1    | 67.5   | 79.0    | 84.0    | 88.9    | —       | 34.3   | 9.19   | —      | 58.0    |
| 90                  | 56.0                  | 83.0   | 83.0   | 78.1    | 76.5   | 85.2    | 87.5    | 89.9    | —       | 25.2   | 9.54   | —      | 51.9    |
| 600                 | 55.0                  | 87.3   | 87.2   | 85.0    | 88.1   | 89.3    | 90.6    | —       | —       | 16.1   | 9.64   | —      | 45.2    |
| 10                  | 53.0                  | 89.3   | 88.9   | 88.0    | 88.1   | 89.8    | 90.3    | 91.0    | —       | 11.3   | 9.73   | —      | 37.8    |
| 20                  | 50.2                  | 90.4   | 90.0   | 89.6    | 89.6   | 90.5    | 90.7    | 91.1    | —       | 7.40   | 9.56   | —      | 30.5    |
| 30                  | 47.4                  | 90.8   | 90.5   | 90.3    | 90.4   | 90.8    | 90.9    | 91.2    | —       | 2.91   | 9.27   | —      | 25.0    |
| 40                  | 45.2                  | 91.0   | 90.7   | 90.7    | 90.7   | 91.1    | 91.3    | 91.3    | —       | 0.76   | 9.10   | —      | 20.6    |
| 50                  | 44.1                  | 91.1   | 90.9   | 90.9    | 91.0   | 91.2    | 91.2    | 91.4    | —       | 0.29   | 9.07   | —      | 17.5    |
| 60                  | 43.6                  | 91.3   | 91.0   | 91.0    | 91.1   | 91.3    | 91.3    | 91.5    | —       | 0.41   | 9.00   | —      | 15.2    |
| 70                  | 43.5                  | 91.5   | 91.0   | 91.2    | 91.2   | 91.4    | 91.4    | 91.6    | —       | 2.30   | 9.13   | —      | 13.7    |
| 80                  | 43.1                  | 91.5   | 91.0   | 91.3    | 91.3   | 91.4    | 91.5    | 91.6    | 0.10    | 9.52   | 9.08   | 0.44   | 12.8    |
| 90                  | 42.8                  | 91.5   | 91.0   | 91.3    | 91.3   | 91.5    | 91.6    | 91.6    | 1.58    | 28.5   | 9.21   | 5.02   | 12.1    |
| 700                 | 43.5                  | 91.5   | 91.0   | 91.3    | 91.3   | 91.5    | 91.6    | 91.6    | 11.2    | 51.9   | 9.52   | 18.7   | 12.0    |
| Luminous transmit.  | 58.1                  | 61.4   | 62.5   | 55.5    | 49.7   | 67.1    | 75.5    | 85.4    | 0.017   | 9.8    | 9.1    | 0.041  | 50.8    |
| Dominant wave lgth. | 477.2                 | 581.5  | 587.7  | 585.7   | 585.7  | 581.7   | 579.6   | 577.6   | 700     | 583.1  | 572.4  | 555.0  | 564.9   |
| Excitation purity.  | 14.5                  | 55.4   | 30.3   | 48.0    | 69.7   | 37.1    | 24.1    | 9.0     | 100     | 100.0  | 12.1   | 48.0   | 80.0    |

| Wave length         | Percent transmittance |        |        |        |        |        |        |        |        |        |        |        |        |
|---------------------|-----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                     | No. 106               | CC-05R | CC-10R | CC-20R | CC-30R | CC-40R | CC-50R | CC-05B | CC-10B | CC-20B | CC-30B | CC-40B | CC-50B |
| 400                 | —                     | 81.0   | 73.0   | 61.5   | 51.6   | 42.5   | 36.4   | 87.0   | 85.5   | 82.2   | 80.2   | 77.0   | 74.1   |
| 10                  | —                     | 81.0   | 72.4   | 60.0   | 50.0   | 40.0   | 33.9   | 87.5   | 86.4   | 84.0   | 82.5   | 80.3   | 78.4   |
| 20                  | 0.10                  | 81.0   | 72.0   | 58.6   | 48.2   | 38.2   | 31.9   | 87.7   | 87.2   | 85.0   | 84.0   | 82.2   | 80.7   |
| 30                  | 0.20                  | 81.1   | 71.6   | 57.7   | 47.0   | 36.8   | 30.5   | 88.0   | 87.5   | 85.3   | 84.3   | 82.5   | 81.1   |
| 40                  | 0.35                  | 81.2   | 71.5   | 57.2   | 46.4   | 36.0   | 29.7   | 88.1   | 87.5   | 85.0   | 83.5   | 81.3   | 79.8   |
| 50                  | 0.58                  | 81.4   | 71.6   | 57.2   | 46.4   | 36.1   | 29.6   | 88.1   | 87.2   | 83.9   | 81.9   | 78.7   | 76.6   |
| 60                  | 0.98                  | 81.7   | 72.4   | 58.5   | 47.5   | 37.5   | 31.0   | 87.9   | 86.4   | 82.5   | 79.5   | 75.9   | 72.9   |
| 70                  | 1.5                   | 82.3   | 73.7   | 60.6   | 49.9   | 40.0   | 33.6   | 87.5   | 85.3   | 80.3   | 76.2   | 72.0   | 67.9   |
| 80                  | 2.3                   | 82.8   | 74.9   | 62.0   | 52.0   | 42.5   | 35.9   | 87.0   | 84.0   | 77.8   | 72.5   | 67.5   | 62.7   |
| 90                  | 3.5                   | 83.2   | 75.8   | 63.5   | 53.9   | 44.8   | 37.9   | 86.2   | 82.4   | 74.2   | 68.3   | 62.3   | 56.6   |
| 500                 | 5.2                   | 83.3   | 76.6   | 64.6   | 55.2   | 46.1   | 39.4   | 85.2   | 80.5   | 71.2   | 63.8   | 56.7   | 50.1   |
| 10                  | 7.7                   | 83.0   | 76.1   | 64.0   | 54.5   | 46.0   | 38.5   | 84.4   | 78.6   | 67.7   | 58.7   | 51.0   | 44.5   |
| 20                  | 10.7                  | 82.4   | 74.9   | 61.5   | 51.6   | 42.5   | 35.0   | 83.5   | 77.0   | 64.0   | 54.4   | 46.0   | 38.6   |
| 30                  | 15.1                  | 81.6   | 73.5   | 59.4   | 48.5   | 38.5   | 31.5   | 82.6   | 75.2   | 61.5   | 50.7   | 41.6   | 34.1   |
| 40                  | 20.2                  | 81.2   | 72.5   | 57.8   | 46.5   | 36.6   | 29.4   | 82.1   | 73.9   | 59.5   | 48.3   | 39.0   | 31.3   |
| 50                  | 25.7                  | 81.1   | 72.4   | 57.1   | 45.6   | 35.6   | 28.7   | 81.5   | 73.0   | 58.0   | 46.6   | 36.9   | 29.5   |
| 60                  | 31.0                  | 81.4   | 72.8   | 58.0   | 46.9   | 36.4   | 29.7   | 81.4   | 72.7   | 57.5   | 45.9   | 35.9   | 28.6   |
| 70                  | 35.6                  | 82.5   | 74.5   | 60.6   | 49.2   | 39.2   | 32.7   | 81.4   | 73.0   | 57.9   | 46.3   | 36.1   | 28.7   |
| 80                  | 43.2                  | 83.9   | 77.3   | 65.0   | 54.6   | 45.0   | 38.6   | 81.9   | 73.9   | 59.3   | 47.9   | 37.8   | 30.5   |
| 90                  | 53.8                  | 85.7   | 80.7   | 71.0   | 61.8   | 53.5   | 47.6   | 82.7   | 75.1   | 61.6   | 50.3   | 40.8   | 33.4   |
| 600                 | 65.6                  | 87.6   | 84.0   | 77.0   | 70.5   | 64.0   | 58.7   | 83.4   | 76.3   | 63.5   | 53.0   | 43.5   | 36.0   |
| 10                  | 77.0                  | 89.0   | 86.5   | 82.0   | 77.8   | 73.0   | 69.8   | 83.6   | 76.7   | 64.5   | 54.6   | 44.7   | 37.8   |
| 20                  | 82.8                  | 90.0   | 88.9   | 86.2   | 83.5   | 80.8   | 78.3   | 83.5   | 76.5   | 64.3   | 54.4   | 44.3   | 37.5   |
| 30                  | 86.0                  | 90.6   | 89.9   | 88.1   | 87.2   | 85.1   | 84.2   | 83.2   | 76.6   | 63.1   | 53.2   | 42.5   | 35.6   |
| 40                  | 87.6                  | 91.1   | 90.5   | 89.8   | 89.2   | 88.0   | 87.5   | 82.8   | 74.5   | 61.6   | 51.5   | 40.2   | 33.7   |
| 50                  | 88.7                  | 91.2   | 90.8   | 90.5   | 90.3   | 89.5   | 89.2   | 82.5   | 74.0   | 60.6   | 50.3   | 39.0   | 32.4   |
| 60                  | 89.5                  | 91.3   | 91.1   | 90.8   | 90.6   | 90.4   | 90.1   | 82.5   | 73.8   | 60.1   | 49.5   | 38.4   | 31.8   |
| 70                  | 90.0                  | 91.4   | 91.3   | 91.0   | 90.9   | 90.8   | 90.7   | 82.3   | 73.3   | 59.6   | 49.0   | 37.7   | 31.0   |
| 80                  | 90.5                  | 91.6   | 91.5   | 91.2   | 91.1   | 91.0   | 91.1   | 82.0   | 72.8   | 58.6   | 48.2   | 36.5   | 30.0   |
| 90                  | 90.8                  | 91.7   | 91.7   | 91.4   | 91.4   | 91.3   | 91.1   | 81.9   | 72.5   | 58.1   | 47.2   | 35.4   | 29.0   |
| 700                 | 91.0                  | 91.9   | 91.9   | 91.5   | 91.5   | 91.4   | 91.2   | 82.2   | 73.0   | 58.5   | 47.5   | 35.6   | 29.0   |
| Luminous transmit.  | 34.6                  | 83.7   | 77.0   | 65.3   | 55.9   | 47.3   | 41.3   | 82.8   | 75.5   | 62.3   | 52.0   | 42.8   | 35.7   |
| Dominant wave lgth. | 589.4                 | 605.0  | 597.8  | 604.2  | 605.8  | 605.5  | 608.5  | 459.0  | 462.0  | 460.0  | 461.0  | 463.2  | 462.5  |
| Excitation purity.  | 95.2                  | 2.0    | 4.7    | 8.5    | 12.3   | 17.3   | 21.4   | 2.8    | 6.3    | 13.2   | 20.2   | 27.7   | 34.2   |

\* Some transmission below 400 mμ. Consult the manufacturer.

# TRANSMISSION OF WRATTEN FILTERS (Continued)

| Wave length         | Percent transmittance |        |        |        |        |        |        |        |        |        |        |        |
|---------------------|-----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                     | CC-05G                | CC-10G | CC-20G | CC-30G | CC-40G | CC-50G | CC-05Y | CC-10Y | CC-20Y | CC-30Y | CC-40Y | CC-50Y |
| 400                 | 80.0                  | 73.1   | 58.8   | 48.0   | 39.7   | 32.0   | 81.0   | 74.5   | 61.3   | 50.5   | 43.0   | 34.5   |
| 10                  | 80.7                  | 72.9   | 57.8   | 46.5   | 38.1   | 30.3   | 80.6   | 73.2   | 59.0   | 47.4   | 39.5   | 30.5   |
| 20                  | 81.0                  | 72.8   | 57.3   | 45.8   | 37.3   | 29.5   | 80.4   | 72.6   | 57.8   | 46.0   | 37.5   | 29.0   |
| 30                  | 81.4                  | 72.7   | 57.0   | 45.5   | 36.5   | 29.0   | 80.4   | 72.5   | 57.5   | 45.6   | 36.5   | 28.7   |
| 40                  | 81.6                  | 73.0   | 57.3   | 45.8   | 36.6   | 29.1   | 80.6   | 72.8   | 57.8   | 46.5   | 36.8   | 29.5   |
| 50                  | 82.1                  | 73.9   | 58.4   | 46.9   | 38.1   | 30.6   | 81.2   | 74.0   | 59.5   | 48.5   | 38.5   | 31.5   |
| 60                  | 83.0                  | 75.5   | 61.4   | 50.3   | 41.5   | 34.3   | 82.5   | 76.0   | 63.0   | 52.5   | 42.5   | 36.2   |
| 70                  | 84.4                  | 78.0   | 65.4   | 55.8   | 47.0   | 40.5   | 83.9   | 78.5   | 67.5   | 48.2   | 48.8   | 43.5   |
| 80                  | 85.6                  | 80.4   | 70.0   | 61.8   | 53.5   | 47.8   | 85.3   | 81.2   | 72.3   | 64.9   | 56.2   | 54.0   |
| 90                  | 86.8                  | 83.0   | 75.2   | 68.9   | 61.3   | 57.0   | 87.0   | 84.4   | 78.0   | 72.4   | 66.0   | 64.0   |
| 500                 | 87.9                  | 85.9   | 80.3   | 76.4   | 70.7   | 68.0   | 88.4   | 87.2   | 84.0   | 81.0   | 77.0   | 75.5   |
| 10                  | 88.7                  | 87.5   | 83.8   | 80.9   | 77.8   | 75.3   | 89.5   | 89.0   | 88.0   | 86.6   | 85.5   | 84.2   |
| 20                  | 89.0                  | 88.1   | 84.9   | 82.3   | 79.5   | 77.5   | 90.0   | 90.0   | 89.6   | 89.1   | 89.0   | 88.5   |
| 30                  | 89.0                  | 88.0   | 84.6   | 81.7   | 79.4   | 77.0   | 90.4   | 90.4   | 90.0   | 89.7   | 89.9   | 89.6   |
| 40                  | 89.0                  | 87.6   | 83.7   | 80.5   | 77.8   | 74.8   | 90.7   | 90.7   | 90.6   | 90.4   | 90.2   | 90.0   |
| 50                  | 88.6                  | 87.1   | 82.4   | 78.6   | 75.8   | 72.2   | 90.9   | 90.9   | 90.8   | 90.6   | 90.4   | 90.3   |
| 60                  | 88.1                  | 86.3   | 80.9   | 76.2   | 72.9   | 68.8   | 91.0   | 91.0   | 90.9   | 90.8   | 90.7   | 90.6   |
| 70                  | 87.5                  | 85.3   | 79.0   | 73.5   | 69.3   | 64.8   | 91.3   | 91.3   | 91.0   | 90.9   | 90.8   | 90.7   |
| 80                  | 87.0                  | 84.1   | 77.0   | 70.4   | 65.3   | 60.3   | 91.4   | 91.4   | 91.1   | 91.0   | 90.8   | 90.7   |
| 90                  | 86.4                  | 82.8   | 74.5   | 67.2   | 61.9   | 55.9   | 91.4   | 91.4   | 91.2   | 91.1   | 90.9   | 90.8   |
| 600                 | 85.7                  | 81.5   | 72.0   | 64.1   | 57.7   | 51.7   | 91.4   | 91.4   | 91.3   | 91.2   | 90.9   | 90.8   |
| 10                  | 85.0                  | 80.0   | 69.5   | 60.7   | 53.7   | 47.3   | 91.4   | 91.4   | 91.3   | 91.2   | 90.9   | 90.9   |
| 20                  | 84.0                  | 78.5   | 66.5   | 57.2   | 49.8   | 42.5   | 91.4   | 91.4   | 91.3   | 91.2   | 91.0   | 90.9   |
| 30                  | 83.0                  | 76.9   | 63.8   | 53.7   | 45.5   | 38.0   | 91.5   | 91.5   | 91.4   | 91.3   | 91.0   | 91.0   |
| 40                  | 82.2                  | 75.6   | 61.5   | 50.8   | 42.0   | 34.6   | 91.5   | 91.5   | 91.4   | 91.3   | 91.0   | 91.0   |
| 50                  | 81.9                  | 74.9   | 60.1   | 49.1   | 40.2   | 32.5   | 91.5   | 91.5   | 91.4   | 91.3   | 91.1   | 91.1   |
| 60                  | 81.5                  | 74.4   | 59.4   | 48.1   | 39.5   | 31.5   | 91.5   | 91.5   | 91.4   | 91.3   | 91.1   | 91.1   |
| 70                  | 81.4                  | 74.0   | 58.8   | 47.5   | 38.5   | 31.0   | 91.5   | 91.5   | 91.4   | 91.4   | 91.2   | 91.2   |
| 80                  | 81.1                  | 73.5   | 58.1   | 46.6   | 37.6   | 29.9   | 91.5   | 91.5   | 91.4   | 91.4   | 91.2   | 91.2   |
| 90                  | 81.1                  | 73.2   | 57.6   | 46.0   | 36.6   | 28.9   | 91.5   | 91.5   | 91.4   | 91.4   | 91.3   | 91.3   |
| 700                 | 81.5                  | 73.5   | 58.0   | 46.4   | 36.5   | 28.7   | 91.5   | 91.5   | 91.4   | 91.4   | 91.3   | 91.3   |
| Luminous transmit.  | 87.2                  | 84.5   | 77.8   | 72.2   | 67.7   | 63.3   | 90.4   | 90.1   | 89.1   | 88.2   | 87.4   | 86.9   |
| Dominant wave lgth. | 553.0                 | 555.5  | 555.0  | 554.0  | 554.3  | 553.4  | 572.0  | 571.3  | 571.4  | 571.3  | 571.3  | 571.2  |
| Excitation purity.  | 2.3                   | 5.2    | 10.9   | 15.8   | 21.1   | 25.9   | 5.3    | 9.6    | 18.8   | 28.3   | 35.7   | 42.0   |

| Wave length         | Percent transmittance |        |        |        |        |        |        |        |        |        |        |        |
|---------------------|-----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                     | CC-05M                | CC-10M | CC-20M | CC-30M | CC-40M | CC-50M | CC-05C | CC-10C | CC-20C | CC-30C | CC-40C | CC-50C |
| 400                 | 87.6                  | 86.6   | 85.6   | 84.2   | 82.3   | 80.9   | 87.3   | 86.0   | 83.9   | 82.3   | 80.4   | 78.8   |
| 10                  | 88.2                  | 87.7   | 86.6   | 85.7   | 84.6   | 83.6   | 88.2   | 87.5   | 85.2   | 84.5   | 83.4   | 82.7   |
| 20                  | 88.6                  | 88.0   | 87.0   | 85.9   | 85.2   | 84.4   | 88.7   | 88.1   | 86.5   | 86.0   | 85.3   | 84.8   |
| 30                  | 88.7                  | 88.0   | 86.9   | 85.6   | 84.4   | 83.6   | 89.0   | 88.6   | 87.5   | 87.0   | 86.3   | 85.9   |
| 40                  | 88.7                  | 87.9   | 86.0   | 84.7   | 82.5   | 81.4   | 89.3   | 89.0   | 87.7   | 87.3   | 86.6   | 86.1   |
| 50                  | 88.6                  | 87.5   | 84.9   | 82.8   | 80.0   | 78.1   | 89.5   | 89.1   | 87.8   | 87.5   | 86.6   | 86.0   |
| 60                  | 88.4                  | 86.5   | 83.1   | 80.0   | 76.1   | 73.7   | 89.6   | 89.1   | 87.7   | 87.3   | 86.4   | 85.7   |
| 70                  | 87.8                  | 85.2   | 80.8   | 76.4   | 71.3   | 68.0   | 89.7   | 89.0   | 87.5   | 87.0   | 85.8   | 85.2   |
| 80                  | 87.0                  | 83.6   | 77.9   | 72.1   | 65.8   | 61.7   | 89.7   | 89.0   | 87.2   | 86.5   | 85.3   | 84.3   |
| 90                  | 86.0                  | 81.8   | 74.4   | 67.0   | 60.0   | 55.0   | 89.7   | 89.0   | 87.0   | 86.0   | 84.4   | 83.4   |
| 500                 | 85.0                  | 79.7   | 70.5   | 61.7   | 53.7   | 48.1   | 89.6   | 89.0   | 86.5   | 85.2   | 83.5   | 82.3   |
| 10                  | 83.8                  | 77.5   | 66.7   | 56.5   | 47.7   | 41.6   | 89.6   | 88.7   | 86.0   | 84.4   | 82.4   | 80.8   |
| 20                  | 82.7                  | 75.3   | 63.4   | 52.0   | 42.8   | 36.3   | 89.5   | 88.5   | 85.2   | 83.5   | 81.1   | 79.2   |
| 30                  | 81.8                  | 73.7   | 60.5   | 48.6   | 39.0   | 31.9   | 89.4   | 88.0   | 84.3   | 82.4   | 79.6   | 77.3   |
| 40                  | 81.3                  | 72.5   | 58.6   | 46.6   | 36.7   | 29.8   | 89.2   | 87.5   | 83.4   | 81.0   | 77.7   | 75.0   |
| 50                  | 81.2                  | 72.2   | 58.0   | 46.0   | 36.0   | 29.1   | 88.9   | 87.0   | 82.3   | 79.0   | 75.3   | 72.2   |
| 60                  | 81.5                  | 72.8   | 58.3   | 46.5   | 36.7   | 29.7   | 88.5   | 86.1   | 80.5   | 76.7   | 72.7   | 69.0   |
| 70                  | 82.5                  | 74.6   | 60.5   | 49.8   | 40.2   | 32.3   | 88.0   | 85.0   | 78.5   | 74.0   | 69.3   | 65.0   |
| 80                  | 84.0                  | 77.3   | 64.9   | 55.6   | 46.2   | 39.0   | 87.5   | 83.8   | 76.1   | 70.9   | 65.4   | 60.5   |
| 90                  | 85.8                  | 80.8   | 70.6   | 63.3   | 54.9   | 48.7   | 87.0   | 82.5   | 73.9   | 67.5   | 61.6   | 55.8   |
| 600                 | 88.0                  | 84.5   | 77.1   | 71.6   | 64.9   | 59.9   | 86.4   | 81.0   | 71.2   | 64.1   | 57.6   | 51.3   |
| 10                  | 89.3                  | 87.0   | 82.2   | 79.2   | 74.9   | 70.7   | 85.5   | 79.5   | 68.5   | 60.4   | 53.4   | 46.2   |
| 20                  | 90.2                  | 88.9   | 86.1   | 84.1   | 81.4   | 79.2   | 84.5   | 77.9   | 65.5   | 56.7   | 49.2   | 42.3   |
| 30                  | 90.6                  | 90.0   | 88.7   | 87.4   | 86.0   | 84.5   | 83.8   | 76.3   | 62.7   | 53.1   | 45.0   | 38.0   |
| 40                  | 90.8                  | 90.5   | 90.0   | 89.3   | 88.7   | 87.6   | 83.3   | 75.1   | 60.8   | 50.4   | 42.0   | 34.9   |
| 50                  | 91.0                  | 90.7   | 90.5   | 90.2   | 90.0   | 89.7   | 82.8   | 74.4   | 59.5   | 48.8   | 40.2   | 32.9   |
| 60                  | 91.1                  | 91.0   | 90.8   | 90.8   | 90.4   | 90.4   | 82.5   | 74.0   | 58.5   | 48.0   | 39.4   | 32.0   |
| 70                  | 91.2                  | 91.2   | 91.0   | 91.0   | 90.7   | 90.7   | 82.4   | 73.6   | 57.9   | 47.2   | 38.6   | 31.0   |
| 80                  | 91.3                  | 91.3   | 91.2   | 91.1   | 91.0   | 91.0   | 82.0   | 73.0   | 57.5   | 46.0   | 37.5   | 29.9   |
| 90                  | 91.4                  | 91.4   | 91.4   | 91.3   | 91.3   | 91.3   | 82.0   | 72.8   | 57.4   | 45.5   | 36.7   | 29.1   |
| 700                 | 91.5                  | 91.5   | 91.5   | 91.5   | 91.5   | 91.5   | 82.5   | 74.0   | 58.5   | 46.4   | 37.3   | 29.8   |
| Luminous transmit.  | 84.2                  | 77.9   | 67.1   | 58.1   | 50.0   | 44.0   | 88.0   | 85.1   | 78.9   | 74.8   | 70.5   | 66.7   |
| Dominant wave lgth. | 541.0                 | 547.5  | 551.2  | 550.0  | 550.3  | 551.2  | 489.2  | 487.5  | 486.5  | 486.2  | 486.1  | 485.5  |
| Excitation purity.  | 3.5                   | 7.4    | 14.4   | 21.5   | 28.3   | 34.0   | 1.6    | 4.1    | 8.9    | 12.8   | 17.5   | 20.2   |

\* Some transmission below 400 mμ. Consult the manufacturer.

### TRANSMISSION OF WRATTEN FILTERS (Continued)

| Wave<br>length | Percent transmittance |         |         |         | Wave<br>length | Percent transmittance |         |         |         |
|----------------|-----------------------|---------|---------|---------|----------------|-----------------------|---------|---------|---------|
|                | No. 87                | No. 87C | No. 88A | No. 89B |                | No. 87                | No. 87C | No. 88A | No. 89B |
| 700            | —                     | —       | —       | 11.2    | 30             | 74.1                  | 17.8    | 84.7    | 88.8    |
| 10             | —                     | —       | —       | 32.4    | 40             | 77.7                  | 28.2    | 85.5    | 89.0    |
| 20             | —                     | —       | —       | 57.6    | 50             | 81.4                  | 41.0    | 86.1    | 89.2    |
| 30             | —                     | —       | 7.4     | 69.1    | 60             | 84.0                  | 53.8    | 86.6    | 89.4    |
| 40             | 0.10                  | —       | 32.8    | 77.6    | 70             | 85.4                  | 61.6    | 87.2    | 89.6    |
| 50             | 2.19                  | —       | 56.3    | 83.1    | 80             | 86.8                  | 69.2    | 87.5    | 89.8    |
| 60             | 7.95                  | —       | 69.2    | 85.0    | 90             | 87.8                  | 74.1    | 87.8    | 89.9    |
| 70             | 17.4                  | —       | 74.2    | 86.1    | 900            | 88.4                  | 78.5    | 88.0    | 90.0    |
| 80             | 31.6                  | —       | 77.6    | 87.0    | 10             | 88.8                  | 81.5    | 88.2    | 90.1    |
| 90             | 43.7                  | —       | 79.7    | 87.7    | 20             | 89.1                  | 83.6    | 88.4    | 90.2    |
| 800            | 53.8                  | 0.32    | 81.4    | 88.1    | 30             | 89.1                  | 85.1    | 88.6    | 90.3    |
| 10             | 61.7                  | 3.20    | 82.6    | 88.4    | 40             | 89.1                  | 86.0    | 88.8    | 90.4    |
| 20             | 69.2                  | 8.90    | 83.7    | 88.6    | 50             | 89.1                  | 87.0    | 89.0    | 90.5    |

\* Some transmission below 400 mμ. Consult the manufacturer.

## ULTRAVIOLET SPECTRA OF COMMON LIQUIDS

The following tables present the UV spectra of some common solvents and other liquids. The data were obtained, using a 1.00-cm path-length cell, against a water reference.

### REFERENCES

1. Krieger, P. A., *High Purity Solvent Guide*, Burdick and Jackson, McGaw Park, IL, 1984.

#### ACETONE

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 330                | 1.000             |
| 340                | 0.060             |
| 350                | 0.010             |
| 375                | 0.005             |
| 400                | 0.005             |

#### BENZENE

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 278                | 1.000             |
| 300                | 0.020             |
| 325                | 0.010             |
| 350                | 0.005             |
| 400                | 0.005             |

#### ACETONITRILE

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 190                | 1.000             |
| 200                | 0.050             |
| 225                | 0.010             |
| 250                | 0.005             |
| 350                | 0.005             |

#### 1-BUTANOL

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 215                | 1.000             |
| 225                | 0.500             |
| 250                | 0.040             |
| 275                | 0.010             |
| 300                | 0.005             |

#### 2-BUTANOL

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 260                | 1.000             |
| 275                | 0.300             |
| 300                | 0.010             |
| 350                | 0.005             |
| 400                | 0.005             |

#### CARBON TETRACHLORIDE

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 263                | 1.000             |
| 275                | 0.100             |
| 300                | 0.005             |
| 350                | 0.005             |
| 400                | 0.005             |

#### *n*-BUTYL ACETATE

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 254                | 1.000             |
| 275                | 0.050             |
| 300                | 0.010             |
| 350                | 0.005             |
| 400                | 0.005             |

#### CHLOROBENZENE

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 287                | 1.000             |
| 300                | 0.050             |
| 325                | 0.040             |
| 350                | 0.020             |
| 400                | 0.005             |

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***n*-BUTYL CHLORIDE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 220                | 1.000             |
| 225                | 0.300             |
| 250                | 0.010             |
| 300                | 0.005             |
| 400                | 0.005             |

**CHLOROFORM**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 245                | 1.000             |
| 250                | 0.300             |
| 275                | 0.005             |
| 300                | 0.005             |
| 400                | 0.005             |

**CYCLOHEXANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 200                | 1.000             |
| 225                | 0.170             |
| 250                | 0.020             |
| 300                | 0.005             |
| 400                | 0.005             |

***o*-DICHLOROBENZENE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 295                | 1.000             |
| 300                | 0.300             |
| 325                | 0.100             |
| 350                | 0.050             |
| 400                | 0.005             |

**CYCLOPENTANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 200                | 1.000             |
| 215                | 0.300             |
| 225                | 0.020             |
| 300                | 0.005             |
| 400                | 0.005             |

**DIETHYL CARBONATE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 256                | 1.000             |
| 265                | 0.150             |
| 275                | 0.050             |
| 300                | 0.040             |
| 400                | 0.010             |

**DECAHYDRONAPHTHALENE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 200                | 1.000             |
| 225                | 0.500             |
| 250                | 0.050             |
| 300                | 0.005             |
| 400                | 0.005             |

**DIMETHYL ACETAMIDE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 268                | 1.000             |
| 275                | 0.300             |
| 300                | 0.080             |
| 350                | 0.005             |
| 400                | 0.005             |

**DIMETHYL FORMAMIDE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 268                | 1.000             |
| 275                | 0.300             |
| 300                | 0.050             |
| 350                | 0.005             |
| 400                | 0.005             |

**2-ETHOXYETHANOL**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 210                | 1.000             |
| 225                | 0.500             |
| 250                | 0.200             |
| 300                | 0.005             |
| 400                | 0.005             |

**DIMETHYL SULFOXIDE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 268                | 1.000             |
| 275                | 0.500             |
| 300                | 0.200             |
| 350                | 0.020             |
| 400                | 0.005             |

**ETHYL ACETATE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 256                | 1.000             |
| 275                | 0.050             |
| 300                | 0.030             |
| 325                | 0.005             |
| 350                | 0.005             |

**1,4-DIOXANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 215                | 1.000             |
| 250                | 0.300             |
| 300                | 0.020             |
| 350                | 0.005             |
| 400                | 0.005             |

**DIETHYL ETHER**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 215                | 1.000             |
| 250                | 0.080             |
| 275                | 0.010             |
| 300                | 0.005             |
| 400                | 0.005             |

**ETHYLENE DICHLORIDE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 228                | 1.000             |
| 240                | 0.300             |
| 250                | 0.100             |
| 300                | 0.005             |
| 400                | 0.005             |

**HEXADECANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 190                | 1.000             |
| 200                | 0.500             |
| 250                | 0.020             |
| 300                | 0.005             |
| 400                | 0.005             |

**ETHYLENE GLYCOL DIMETHYL  
ETHER (GLYME)**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 220                | 1.000             |
| 250                | 0.250             |
| 300                | 0.050             |
| 350                | 0.010             |
| 400                | 0.005             |

**HEXANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 195                | 1.000             |
| 225                | 0.050             |
| 250                | 0.010             |
| 275                | 0.005             |
| 300                | 0.005             |

**HEPTANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 200                | 1.000             |
| 225                | 0.100             |
| 250                | 0.010             |
| 300                | 0.005             |
| 400                | 0.005             |

**ISOBUTANOL**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 220                | 1.000             |
| 250                | 0.050             |
| 275                | 0.030             |
| 300                | 0.020             |
| 400                | 0.010             |

**METHANOL**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 205                | 1.000             |
| 225                | 0.160             |
| 250                | 0.020             |
| 300                | 0.005             |
| 400                | 0.005             |

**METHYL *t*-BUTYL ETHER**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 210                | 1.000             |
| 225                | 0.500             |
| 250                | 0.100             |
| 300                | 0.005             |
| 400                | 0.005             |

**2-METHOXYETHANOL**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 210                | 1.000             |
| 250                | 0.130             |
| 275                | 0.030             |
| 300                | 0.005             |
| 400                | 0.005             |

**METHYLENE CHLORIDE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 233                | 1.000             |
| 240                | 0.100             |
| 250                | 0.010             |
| 300                | 0.005             |
| 400                | 0.005             |

**2-METHOXYETHYL ACETATE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 254                | 1.000             |
| 275                | 0.150             |
| 300                | 0.050             |
| 350                | 0.005             |
| 400                | 0.005             |

**METHYL ETHYL KETONE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 329                | 1.000             |
| 340                | 0.100             |
| 350                | 0.020             |
| 375                | 0.010             |
| 400                | 0.005             |

**METHYL ISOAMYL KETONE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 330                | 1.000             |
| 340                | 0.100             |
| 350                | 0.050             |
| 375                | 0.010             |
| 400                | 0.005             |

***n*-METHYLPYRROLIDONE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 285                | 1.000             |
| 300                | 0.500             |
| 325                | 0.100             |
| 350                | 0.030             |
| 400                | 0.010             |

**METHYL ISOBUTYL KETONE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 334                | 1.000             |
| 340                | 0.500             |
| 350                | 0.250             |
| 375                | 0.050             |
| 400                | 0.005             |

**PENTANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 190                | 1.000             |
| 200                | 0.600             |
| 250                | 0.010             |
| 300                | 0.005             |
| 400                | 0.005             |

**METHYL *n*-PROPYL KETONE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 331                | 1.000             |
| 340                | 0.150             |
| 350                | 0.020             |
| 375                | 0.005             |
| 400                | 0.005             |

**β-PHENETHYLAMINE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 285                | 1.000             |
| 300                | 0.300             |
| 325                | 0.100             |
| 350                | 0.050             |
| 400                | 0.005             |

**1-PROPANOL**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 210                | 1.000             |
| 225                | 0.500             |
| 250                | 0.050             |
| 300                | 0.005             |
| 400                | 0.005             |

**PYRIDINE**

| avelength<br>(nm) | Max<br>absorbance |
|-------------------|-------------------|
| 330               | 1.000             |
| 340               | 0.100             |
| 350               | 0.010             |
| 375               | 0.010             |
| 400               | 0.005             |

**2-PROPANOL**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 205                | 1.000             |
| 225                | 0.160             |
| 250                | 0.020             |
| 300                | 0.005             |
| 400                | 0.010             |

**TETRAHYDROFURAN**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 212                | 1.000             |
| 250                | 0.180             |
| 300                | 0.020             |
| 350                | 0.005             |
| 400                | 0.005             |

**PROPYLENE CARBONATE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 280                | 1.000             |
| 300                | 0.500             |
| 350                | 0.050             |
| 375                | 0.030             |
| 400                | 0.020             |

**TOLUENE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 284                | 1.000             |
| 300                | 0.120             |
| 325                | 0.020             |
| 350                | 0.050             |
| 400                | 0.005             |

**1,2,4-TRICHLOROBENZENE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 308                | 1.000             |
| 310                | 0.500             |
| 350                | 0.050             |
| 375                | 0.010             |
| 400                | 0.005             |

**2,2,4-TRIMETHYLPENTANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 215                | 1.000             |
| 225                | 0.100             |
| 250                | 0.020             |
| 300                | 0.005             |
| 400                | 0.005             |



**TRICHLOROETHYLENE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 273                | 1.000             |
| 300                | 0.100             |
| 325                | 0.080             |
| 350                | 0.060             |
| 400                | 0.060             |

**WATER**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 190                | 0.010             |
| 200                | 0.010             |
| 250                | 0.005             |
| 300                | 0.005             |
| 400                | 0.005             |

**1,1,2-TRICHLOROTRIFLUOROETHANE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 231                | 1.000             |
| 250                | 0.050             |
| 300                | 0.005             |
| 350                | 0.005             |
| 400                | 0.005             |

***o*-XYLENE**

| Wavelength<br>(nm) | Max<br>absorbance |
|--------------------|-------------------|
| 288                | 1.000             |
| 300                | 0.200             |
| 325                | 0.050             |
| 350                | 0.010             |
| 400                | 0.005             |

# UNITS, SYMBOLS, AND EQUATIONS FOR RADIOMETRIC AND PHOTOMETRIC QUANTITIES

Submitted by Abraham Abramowitz  
from Z-7.1-1967

## Radiometric Quantities (See Note at bottom of page)

| Quantity*                         | Symbol*          | Defining Equation**                                                                                                                                                                                               | Commonly Used Units                                                                     | Symbol                                                |
|-----------------------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------------------------|
| Radiant energy                    | $Q, (Q_e)$       |                                                                                                                                                                                                                   | erg<br>‡ joule<br>kilowatt-hour                                                         | J<br>kWh                                              |
| Radiant density                   | $w, (w_e)$       | $w = dQ/dV$                                                                                                                                                                                                       | ‡ joule per cubic meter<br>erg per cubic centimeter                                     | $J/m^3$<br>$erg/cm^3$                                 |
| Radiant flux                      | $\Phi, (\Phi_e)$ | $\Phi = dQ/dt$                                                                                                                                                                                                    | erg per second<br>† watt                                                                | $erg/s$<br>W                                          |
| Radiant flux density at a surface |                  |                                                                                                                                                                                                                   |                                                                                         |                                                       |
| Radiant exitance                  | $M, (M_e)$       | $M = d\Phi/dA$                                                                                                                                                                                                    | watt per square centimeter                                                              | $W/cm^2$                                              |
| (Radiant emittance)†              |                  |                                                                                                                                                                                                                   |                                                                                         |                                                       |
| Irradiance                        | $E, (E_e)$       | $E = d\Phi/dA$                                                                                                                                                                                                    | ‡ watt per square meter,<br>etc.                                                        | $W/m^2$                                               |
| Radiant intensity                 | $I, (I_e)$       | $I = d\Phi/d\omega$<br>( $\omega$ = solid angle through<br>which flux from point<br>source is radiated)                                                                                                           | ‡ watt per steradian                                                                    | $W/sr$                                                |
| Radiance                          | $L, (L_e)$       | $L = d^2\Phi/d\omega(dA \cos\theta)$<br>$= dI/(dA \cos\theta)$<br>( $\theta$ = angle between line of<br>sight and normal to sur-<br>face considered)                                                              | watt per steradian and<br>square centimeter<br>‡ watt per steradian and<br>square meter | $W \cdot sr^{-1} cm^{-2}$<br>$W \cdot sr^{-1} m^{-2}$ |
| Emissivity                        | $\epsilon$       | $\epsilon = M/M_{blackbody}$<br>( $M$ and $M_{blackbody}$ are re-<br>spectively the radiant exi-<br>tance of the measured<br>specimen and that of a<br>blackbody at the same<br>temperature as the speci-<br>men) | one (numeric)                                                                           | —                                                     |

Note: The symbols for photometric quantities (see following table) are the same as those for the corresponding radiometric quantities (see above). When it is necessary to differentiate them the subscripts  $v$  and  $e$  respectively should be used, e.g.,  $Q_v$  and  $Q_e$ .

\*Quantities may be restricted to a narrow wavelength band by adding the word spectral and indicating the wavelength. The corresponding symbols are changed by adding a subscript  $\lambda$ , e.g.,  $Q_\lambda$  for a spectral concentration or a  $\lambda$  in parentheses, e.g.,  $K(\lambda)$ , for a function of wavelength.

\*\*The equations in this column are given merely for identification.

\*\*\* $\Phi_i$  = incident flux  
 $\Phi_a$  = absorbed flux  
 $\Phi_r$  = reflected flux  
 $\Phi_t$  = transmitted flux

†to be deprecated.

‡International System (SI) unit.

# **UNITS, SYMBOLS, AND EQUATIONS FOR RADIOMETRIC AND PHOTOMETRIC QUANTITIES** (continued)

| <i>Photometric Quantities</i>              |                                |                                                                                                                                               |                                                                                                                                                                                             |                                                         |
|--------------------------------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| Quantity*                                  | Symbol*                        | Defining Equation**                                                                                                                           | Commonly Used Units                                                                                                                                                                         | Symbol                                                  |
| Absorptance                                | $\alpha, (\alpha_v, \alpha_e)$ | $\alpha = \Phi_d/\Phi_i^{***}$                                                                                                                | one (numeric)                                                                                                                                                                               | —                                                       |
| Reflectance                                | $\rho, (\rho_v, \rho_e)$       | $\rho = \Phi_r/\Phi_i^{***}$                                                                                                                  | one (numeric)                                                                                                                                                                               | —                                                       |
| Transmittance                              | $\tau, (\tau_v, \tau_e)$       | $\tau = \Phi_t/\Phi_i^{***}$                                                                                                                  | one (numeric)                                                                                                                                                                               | —                                                       |
| Luminous energy<br>(quantity of light)     | $Q, (Q_v)$                     | $Q_v = \int_{380}^{760} K(\lambda) Q_e \lambda d\lambda$                                                                                      | lumen-hour<br>‡lumen-second (talbot)                                                                                                                                                        | lm · h<br>lm · s                                        |
| Luminous density                           | $w, (w_v)$                     | $w = dQ/dV$                                                                                                                                   | ‡lumen-second per cubic meter                                                                                                                                                               | lm · s · m <sup>-3</sup>                                |
| Luminous flux                              | $\Phi, (\Phi_v)$               | $\Phi = dQ/dt$                                                                                                                                | ‡lumen                                                                                                                                                                                      | lm                                                      |
| Luminous flux density at a surface         |                                |                                                                                                                                               |                                                                                                                                                                                             |                                                         |
| Luminous exitance<br>(Luminous emittance)† | $M, (M_v)$                     | $M = d\Phi/dA$                                                                                                                                | lumen per square foot                                                                                                                                                                       | lm/ft <sup>2</sup>                                      |
| Illumination<br>(illuminance)              | $E, (E_v)$                     | $E = d\Phi/dA$                                                                                                                                | footcandle (lumen per square foot)<br>‡lux (lm/m <sup>2</sup> )<br>phot (lm/cm <sup>2</sup> )                                                                                               | fc<br>lx<br>ph                                          |
| Luminous intensity<br>(candlepower)        | $I, (I_v)$                     | $I = d\Phi/d\omega$<br>( $\omega$ = solid angle through which flux from point source is radiated)                                             | ‡candela (lumen per steradian)                                                                                                                                                              | cd                                                      |
| Luminance<br>(photometric brightness)      | $L, (L_v)$                     | $L = d^2\Phi/d\omega (dA \cos\theta)$<br>$= dI/(dA \cos\theta)$<br>( $\theta$ = angle between line of sight and normal to surface considered) | candela per unit area<br>stilb (cd/cm <sup>2</sup> )<br>nit (‡cd/m <sup>2</sup> )<br>footlambert (cd/πft <sup>2</sup> )<br>lambert (cd/πcm <sup>2</sup> )<br>apostilb (cd/πm <sup>2</sup> ) | cd/in <sup>2</sup> , etc.<br>sb<br>nt<br>fL<br>L<br>asb |
| Luminous efficacy                          | $K$                            | $K = \Phi_v/\Phi_e$                                                                                                                           | ‡lumen per watt                                                                                                                                                                             | lm/W                                                    |
| Luminous efficiency                        | $V$                            | $V = K/K_{\text{maximum}}$<br>( $K_{\text{maximum}}$ = maximum value of $K(\lambda)$ function)                                                | one (numeric)                                                                                                                                                                               | —                                                       |

## **ILLUMINATION CONVERSION FACTORS**

|                                        |                                                |
|----------------------------------------|------------------------------------------------|
| 1 lumen = 1/680 lightwatt              | 1 watt-second = 1 joule = 10 <sup>7</sup> ergs |
| 1 lumen-hour = 60 lumen-minutes        | 1 phot = 1 lumen/cm <sup>2</sup>               |
| 1 footcandle = 1 lumen/ft <sup>2</sup> | 1 lux = 1 lumen/m <sup>2</sup>                 |

|                               |             |        |        |            |
|-------------------------------|-------------|--------|--------|------------|
| Number of →<br>Multiplied by↘ |             |        |        |            |
| Equals Number of<br>↓         | Footcandles | *Lux   | Phots  | Milliphots |
| Footcandles                   | 1           | 0.0929 | 929    | 0.929      |
| *Lux                          | 10.76       | 1      | 10,000 | 10         |
| Phot                          | 0.00108     | 0.0001 | 1      | 0.001      |
| Milliphot                     | 1.076       | 0.1    | 1,000  | 1          |

\*The International System (SI) unit.

# VALUES FOR THE LANGEVIN FUNCTION $\mathcal{L}(u)$ Compiled by Allen L. King

Because of random thermal rotations a dipole or dipole-like element ordinarily has an average dipole moment of zero. If it is placed in an orienting field  $F$  however it tends to align itself with the field so that the average component of the dipole moment parallel to the field equals  $p$ . Classically, if the system is in thermal equilibrium,

$$\bar{p} = p_o(\coth u - 1/u) = p_o\mathcal{L}(u)$$

Here  $p_o$  is the permanent moment (electric or magnetic) of the dipole, and  $\mathcal{L}(u)$  is the Langevin function of the argument  $u$  which equals  $Fp_o/kT$ . The following table gives values of  $\mathcal{L}(u)$ . Note that for  $u \ll 1$ ,  $\mathcal{L}(u) \approx u/3$ ; for  $u \gg 1$ ,  $\mathcal{L}(u) \approx (u - 1)/u$ .

| (u) | 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | Diff. |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0.0 | .0000 | .0033 | .0066 | .0100 | .0133 | .0166 | .0200 | .0233 | .0267 | .0300 | .0333 | 33    |
| 0.1 | .0333 | .0366 | .0400 | .0433 | .0466 | .0499 | .0532 | .0566 | .0599 | .0632 | .0665 | 33    |
| 0.2 | .0665 | .0698 | .0731 | .0764 | .0797 | .0830 | .0863 | .0896 | .0928 | .0961 | .0994 | 33    |
| 0.3 | .0994 | .1027 | .1059 | .1092 | .1125 | .1157 | .1190 | .1222 | .1255 | .1287 | .1319 | 32.5  |
| 0.4 | .1319 | .1352 | .1384 | .1416 | .1448 | .1480 | .1512 | .1544 | .1576 | .1608 | .1640 | 32    |
| 0.5 | .1640 | .1671 | .1703 | .1734 | .1766 | .1797 | .1829 | .1860 | .1891 | .1922 | .1954 | 31    |
| 0.6 | .1954 | .1985 | .2016 | .2046 | .2077 | .2108 | .2139 | .2169 | .2200 | .2230 | .2261 | 31    |
| 0.7 | .2261 | .2291 | .2321 | .2351 | .2381 | .2411 | .2441 | .2471 | .2500 | .2530 | .2559 | 30    |
| 0.8 | .2559 | .2589 | .2618 | .2647 | .2677 | .2706 | .2735 | .2763 | .2792 | .2821 | .2850 | 29    |
| 0.9 | .2850 | .2878 | .2906 | .2935 | .2963 | .2991 | .3019 | .3047 | .3075 | .3103 | .3130 | 28    |
| 1.0 | .3130 | .3158 | .3185 | .3213 | .3240 | .3267 | .3294 | .3321 | .3348 | .3375 | .3401 | 27    |
| 1.1 | .3401 | .3428 | .3454 | .3481 | .3507 | .3533 | .3559 | .3585 | .3611 | .3636 | .3662 | 26    |
| 1.2 | .3662 | .3688 | .3713 | .3738 | .3763 | .3789 | .3813 | .3838 | .3863 | .3888 | .3912 | 25    |
| 1.3 | .3912 | .3937 | .3961 | .3985 | .4010 | .4034 | .4057 | .4081 | .4105 | .4129 | .4152 | 24    |
| 1.4 | .4152 | .4175 | .4199 | .4222 | .4245 | .4268 | .4291 | .4314 | .4336 | .4359 | .4381 | 23    |
| 1.5 | .4381 | .4404 | .4426 | .4448 | .4470 | .4492 | .4514 | .4535 | .4557 | .4578 | .4600 | 22    |
| 1.6 | .4600 | .4621 | .4642 | .4663 | .4684 | .4705 | .4726 | .4747 | .4767 | .4788 | .4808 | 21    |
| 1.7 | .4808 | .4828 | .4849 | .4869 | .4889 | .4908 | .4928 | .4948 | .4967 | .4987 | .5006 | 20    |
| 1.8 | .5006 | .5026 | .5045 | .5064 | .5083 | .5102 | .5120 | .5139 | .5158 | .5176 | .5194 | 19    |
| 1.9 | .5194 | .5213 | .5231 | .5249 | .5267 | .5285 | .5303 | .5321 | .5338 | .5356 | .5373 | 18    |
| 2.0 | .5373 | .5390 | .5408 | .5425 | .5442 | .5459 | .5476 | .5493 | .5509 | .5526 | .5543 | 17    |
| 2.1 | .5543 | .5559 | .5575 | .5592 | .5608 | .5624 | .5640 | .5656 | .5672 | .5687 | .5703 | 16    |
| 2.2 | .5703 | .5719 | .5734 | .5750 | .5765 | .5780 | .5795 | .5810 | .5825 | .5840 | .5855 | 15    |
| 2.3 | .5855 | .5870 | .5885 | .5899 | .5914 | .5928 | .5943 | .5957 | .5971 | .5985 | .5999 | 14.5  |
| 2.4 | .5999 | .6013 | .6027 | .6041 | .6055 | .6068 | .6082 | .6096 | .6109 | .6122 | .6136 | 14    |
| 2.5 | .6136 | .6149 | .6162 | .6175 | .6188 | .6201 | .6214 | .6227 | .6240 | .6252 | .6265 | 13    |
| 2.6 | .6265 | .6277 | .6290 | .6302 | .6314 | .6327 | .6339 | .6351 | .6363 | .6375 | .6387 | 12    |
| 2.7 | .6387 | .6399 | .6411 | .6422 | .6434 | .6446 | .6457 | .6469 | .6480 | .6492 | .6503 | 12    |
| 2.8 | .6503 | .6514 | .6525 | .6536 | .6547 | .6558 | .6569 | .6580 | .6591 | .6602 | .6612 | 11    |
| 2.9 | .6612 | .6623 | .6634 | .6644 | .6655 | .6665 | .6675 | .6686 | .6696 | .6706 | .6716 | 10.5  |
| 3.0 | .6716 | .6726 | .6736 | .6746 | .6756 | .6766 | .6776 | .6786 | .6796 | .6805 | .6815 | 10    |
| 3.1 | .6815 | .6824 | .6834 | .6843 | .6853 | .6862 | .6872 | .6881 | .6890 | .6899 | .6908 | 9     |
| 3.2 | .6908 | .6917 | .6926 | .6935 | .6944 | .6953 | .6962 | .6971 | .6980 | .6988 | .6997 | 9     |
| 3.3 | .6997 | .7006 | .7014 | .7023 | .7031 | .7040 | .7048 | .7056 | .7065 | .7073 | .7081 | 8.5   |
| 3.4 | .7081 | .7089 | .7097 | .7106 | .7114 | .7122 | .7130 | .7138 | .7145 | .7153 | .7161 | 8     |
| 3.5 | .7161 | .7169 | .7177 | .7184 | .7192 | .7200 | .7207 | .7215 | .7222 | .7230 | .7237 | 8     |
| 3.6 | .7237 | .7245 | .7252 | .7259 | .7267 | .7274 | .7281 | .7288 | .7295 | .7302 | .7310 | 7     |
| 3.7 | .7310 | .7317 | .7324 | .7331 | .7337 | .7344 | .7351 | .7358 | .7365 | .7372 | .7378 | 7     |
| 3.8 | .7378 | .7385 | .7392 | .7398 | .7405 | .7412 | .7418 | .7425 | .7431 | .7438 | .7444 | 7     |
| 3.9 | .7444 | .7450 | .7457 | .7463 | .7469 | .7476 | .7482 | .7488 | .7494 | .7501 | .7507 | 6     |



## X-RAY WAVELENGTHS

J. A. Bearden

These tables were originally published as the final report to the U.S. Atomic Energy Commission as Report NYO-10586 in partial fulfillment of Contract AT(30-1)-2543. The tables were later reproduced in *Review of Modern Physics*. The data may also be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402 in the publication NSRDS-NBS 14. Persons seeking discussion of the experimental work, conventions, secondary standards, etc. will find these in *Review of Modern Physics*, Vol. 39, No. 1, 78-124, January 1967.

### THE W $K\alpha_1$ WAVELENGTH STANDARD

A wavelength standard should possess characteristics which permit its ready redetermination in other laboratories by different techniques. Considering all of the factors involved in the selection of a wavelength standard, the W  $K\alpha_1$  line is superior to any other x-ray or  $\gamma$ -ray wavelength. Its advantages as the x-ray wavelength standard are discussed in *Review of Modern Physics* Vol. 39, page 82 (1967).

$$\lambda W K\alpha_1 = 0.2090100 \text{ \AA} \pm 5 \text{ ppm.}$$

This numerical value of the wavelength of the W  $K\alpha_1$  line is used to define the *x-ray wavelength standard* by the relation

$$\lambda(W K\alpha_1) = 0.2090100 \text{ \AA}^*.$$

This is a new unit of length which may differ from the angstrom by  $\pm 5$  ppm (probable error), *but as a wavelength standard it has no error*. In order to clearly indicate that this unit is not exactly an angstrom, it has been designated  $\text{\AA}^*$ .

Wavelengths tabulated normally refer to the pure element in its solid form. However, there are many instances in which such data are not available. For example, rare gases are of necessity almost always used in the gaseous form, while the rare-earth elements were customarily used in the form of salts.

In high precision work there is some ambiguity as to exactly what feature of a line profile should be taken to be the "true wavelength." In double-crystal work the line peak is usually employed. In crystallography the centroid is widely used; in photographic work with visual observation of the plates, there is involved some subjective criterion of the observer which it is difficult to define precisely. In this survey the peak of the line profile has been adopted as the standard criterion.

In the study of the X-ray literature, the wavelengths of a number of lines were noted which appeared inconsistent with the remaining data. A Moseley-type diagram was constructed, and if the value was clearly outside estimated probable error, it was assumed that an experimental or typographical error had occurred, and the interpolated value was listed in the table. Such cases are marked with a dagger ( $\dagger$ ) as a superscript to the wavelength. For elements of atomic number 85 through 89 and 91, there are no measured lines of the  $K$  series and very few of other series except for 88 radium and 91 protactinium. Likewise there are very few measurements for 43 technetium and 54 xenon. In these cases, interpolated values are listed for the more prominent lines and marked with a dagger ( $\dagger$ ).

# X-RAY WAVELENGTHS

X-ray wavelengths in Å\* units and in keV. The probable error (p.e.) is the error in the last digit of wavelength. Designation indicates both conventional Siegbahn notation (if applicable) and transition, e.g.,  $\beta_1 L_{II}M_{IV}$  denotes a transition between the  $L_{II}$  and  $M_{IV}$  levels, which is the  $L\beta_1$  line in Siegbahn notation.

| Designation                | Å*      | p.e. | keV     | Å*      | p.e. | keV          | Designation                    | Å*                             | p.e.     | keV     | Å*          | p.e.                           | keV     |         |        |         |   |        |
|----------------------------|---------|------|---------|---------|------|--------------|--------------------------------|--------------------------------|----------|---------|-------------|--------------------------------|---------|---------|--------|---------|---|--------|
| 3 Lithium                  |         |      |         |         |      | 4 Beryllium  |                                | 19 Potassium (Cont.)           |          |         |             | 20 Calcium (Cont.)             |         |         |        |         |   |        |
| $\alpha KL$                | 228.    | 1    | 0.0543  | 114.    | 1    | 0.1085       | $\eta L_{II}M_I$               | 47.24                          | 2        | 0.2625  | 40.46       | 2                              | 0.3064  |         |        |         |   |        |
| 5 Boron                    |         |      |         |         |      | 6 Carbon     |                                | $\beta_1 L_{III}M_I$           | 47.74    | 1       | 0.25971     | 35.94                          | 2       | 0.3449  |        |         |   |        |
| $\alpha KL$                | 67.6    | 3    | 0.1833  | 44.7    | 3    | 0.277        | $\alpha_{1,2} L_{III}M_{IV,V}$ |                                |          |         | 40.96       | 2                              | 0.3027  |         |        |         |   |        |
| 7 Nitrogen                 |         |      |         |         |      | 8 Oxygen     |                                | $M_{II,III}N_I$                | 692      | 9       | 0.0179      | 36.33                          | 2       | 0.3413  |        |         |   |        |
| $\alpha KL$                | 31.6    | 4    | 0.3924  | 23.62   | 3    | 0.5249       | 21 Scandium                    |                                |          |         | 22 Titanium |                                | 525.    | 9       | 0.0236 |         |   |        |
| 9 Fluorine                 |         |      |         |         |      | 10 Neon      |                                |                                |          |         |             |                                |         |         |        |         |   |        |
| $\alpha_{1,2} KL_{II,III}$ | 18.32   | 2    | 0.6768  | 14.610  | 3    | 0.8486       | $\alpha_2 KL_{II}$             | 3.0342                         | 1        | 4.0861  | 2.75216     | 2                              | 4.50486 |         |        |         |   |        |
| $\beta KM$                 |         |      |         | 14.452  | 5    | 0.8579       | $\alpha_1 KL_{III}$            | 3.0309†                        | 1        | 4.0906  | 2.74851     | 2                              | 4.51084 |         |        |         |   |        |
| 11 Sodium                  |         |      |         |         |      | 12 Magnesium |                                | $\beta_{1,2} KM_{II,III}$      | 2.7796   | 2       | 4.4605      | 2.51391                        | 2       | 4.93181 |        |         |   |        |
| $\alpha_{1,2} KL_{II,III}$ | 11.9101 | 9    | 1.0410  | 9.8900  | 2    | 1.25360      | $\beta_2 KM_{IV,V}$            | 2.7634                         | 3        | 4.4865  | 2.4985      | 2                              | 4.9623  |         |        |         |   |        |
| $\beta KM$                 | 11.575  | 2    | 1.0711  | 9.521   | 2    | 1.3022       | $\eta L_{II}M_I$               | 35.13                          | 2        | 0.3529  | 30.89       | 3                              | 0.4013  |         |        |         |   |        |
| $L_{II,III}M$              | 407.1   | 5    | 0.03045 | 251.5   | 5    | 0.0493       | $\beta_1 L_{II}M_{IV}$         | 31.02                          | 2        | 0.3996  | 27.05       | 2                              | 0.4584  |         |        |         |   |        |
| $L_1L_{II,III}$            | 376     | 1    | 0.0330  | 317     | 1    | 0.0392       | $l L_{III}M_I$                 | 35.59                          | 3        | 0.3483  | 31.36       | 2                              | 0.3953  |         |        |         |   |        |
| 13 Aluminum                |         |      |         |         |      | 14 Silicon   |                                | $\alpha_{1,2} L_{III}M_{IV,V}$ | 31.35    | 3       | 0.3954      | 27.42                          | 2       | 0.4522  |        |         |   |        |
| $\alpha_2 KL_{II}$         | 8.34173 | 9    | 1.48627 | 7.12791 | 9    | 1.73938      | 23 Vanadium                    |                                |          |         | 24 Chromium |                                |         |         |        |         |   |        |
| $\alpha_1 KL_{III}$        | 8.33934 | 9    | 1.48670 | 7.12542 | 9    | 1.73998      | $\alpha_2 KL_{II}$             | 2.50738                        | 2        | 4.94464 | 2.293606    | 3                              | 5.40551 |         |        |         |   |        |
| $\beta KM$                 | 7.960   | 2    | 1.5574  | 6.753   | 1    | 1.8359       | $\alpha_1 KL_{III}$            | 2.50356                        | 2        | 4.95220 | 2.28970     | 2                              | 5.41472 |         |        |         |   |        |
| $L_{II,III}$               | 171.4   | 5    | 0.0724  | 135.5   | 4    | 0.0915       | $\beta_{1,2} KM_{II,III}$      | 2.28440                        | 2        | 5.42729 | 2.08487     | 2                              | 5.94671 |         |        |         |   |        |
| $L_1L_{II,III}$            | 290.    | 1    | 0.0428  |         |      |              | $\beta_2 KM_{IV,V}$            | 2.26951                        | 6        | 5.4629  | 2.07087     | 6                              | 5.9869  |         |        |         |   |        |
| 15 Phosphorus              |         |      |         |         |      | 16 Sulfur    |                                | $\beta_{2,4} L_1M_{II,III}$    | 21.19†   | 9       | 0.585       | 18.96                          | 2       | 0.654   |        |         |   |        |
| $\alpha_2 KL_{II}$         | 6.160†  | 1    | 2.0127  | 5.37496 | 8    | 2.30664      | $\eta L_{II}M_I$               | 27.34                          | 3        | 0.4535  | 24.30       | 3                              | 0.5102  |         |        |         |   |        |
| $\alpha_1 KL_{III}$        | 6.157†  | 1    | 2.0137  | 5.37216 | 7    | 2.30784      | $\beta_1 L_{II}M_{IV}$         | 23.88                          | 4        | 0.5192  | 21.27       | 1                              | 0.5828  |         |        |         |   |        |
| $\beta KM$                 | 5.796   | 2    | 2.1390  |         |      |              | $l L_{III}M_I$                 | 27.77                          | 1        | 0.4465  | 24.78       | 1                              | 0.5003  |         |        |         |   |        |
| $\beta_1 KM$               |         |      |         | 5.0316  | 2    | 2.4640       | $\alpha_{1,2} L_{III}M_{IV,V}$ | 24.25                          | 3        | 0.5113  | 21.64       | 3                              | 0.5728  |         |        |         |   |        |
| $\beta_2 KM$               |         |      |         | 5.0233  | 3    | 2.4681       | $M_{II,III}M_{IV,V}$           | 337.                           | 9        | 0.037   | 309.        | 9                              | 0.040   |         |        |         |   |        |
| $L_{II,III}M$              | 103.8   | 4    | 0.1194  |         |      |              | 25 Manganese                   |                                |          |         |             |                                | 26 Iron |         |        |         |   |        |
| $l, \eta L_{II,III}M_I$    |         |      |         | 83.4    | 3    | 0.1487       | $\alpha_2 KL_{II}$             | 2.10578                        | 2        | 5.88765 | 1.939980    | 9                              | 6.39084 |         |        |         |   |        |
| 17 Chlorine                |         |      |         |         |      | 18 Argon     |                                | $\alpha_1 KL_{III}$            | 2.101820 | 9       | 5.89875     | 1.936042                       | 9       | 6.40384 |        |         |   |        |
| $\alpha_2 KL_{II}$         | 4.7307  | 1    | 2.62078 | 4.19474 | 5    | 2.95563      | $\beta_{1,2} KM_{II,III}$      | 1.91021                        | 2        | 6.49045 | 1.75661     | 2                              | 7.05798 |         |        |         |   |        |
| $\alpha_1 KL_{III}$        | 4.7278  | 1    | 2.62239 | 4.19180 | 5    | 2.95770      | $\beta_2 KM_{IV,V}$            | 1.8971                         | 1        | 6.5352  | 1.7442      | 1                              | 7.1081  |         |        |         |   |        |
| $\beta KM$                 | 4.4034  | 3    | 2.8156  |         |      |              | $\beta_{2,4} L_1M_{II,III}$    | 17.19                          | 2        | 0.721   | 15.65       | 2                              | 0.792   |         |        |         |   |        |
| $\beta_{1,2} KM_{II,III}$  |         |      |         | 3.8860  | 2    | 3.1905       | $\eta L_{II}M_I$               | 21.85                          | 2        | 0.5675  | 19.75       | 4                              | 0.628   |         |        |         |   |        |
| $\eta L_{II}M_I$           | 67.33   | 9    | 0.1841  | 55.9†   | 1    | 0.2217       | $\beta_1 L_{II}M_{IV}$         | 19.11                          | 2        | 0.6488  | 17.26       | 1                              | 0.7185  |         |        |         |   |        |
| $l L_{III}M_I$             | 67.90   | 9    | 0.1826  | 56.3†   | 1    | 0.2201       | $l L_{III}M_I$                 | 22.29                          | 1        | 0.5563  | 20.15       | 1                              | 0.6152  |         |        |         |   |        |
| 19 Potassium               |         |      |         |         |      | 20 Calcium   |                                | $\alpha_{1,2} L_{III}M_{IV,V}$ | 19.45    | 1       | 0.6374      | 17.59                          | 2       | 0.7050  |        |         |   |        |
| $\alpha_2 KL_{II}$         | 3.7445  | 2    | 3.3111  | 3.36166 | 3    | 3.68809      | $M_{II,III}M_{IV,V}$           | 273.                           | 6        | 0.045   | 243.        | 5                              | 0.051   |         |        |         |   |        |
| $\alpha_1 KL_{III}$        | 3.7414  | 2    | 3.3138  | 3.35839 | 3    | 3.69168      | 27 Cobalt                      |                                |          |         | 28 Nickel   |                                |         |         |        |         |   |        |
| $\beta KM$                 | 4.4034  | 3    | 2.8156  | 3.0897  | 2    | 4.0127       | $\alpha_2 KL_{II}$             | 1.792850                       | 9        | 6.91530 | 1.661747    | 8                              | 7.46089 |         |        |         |   |        |
| $\beta_{1,2} KM_{II,III}$  |         |      |         | 3.0746  | 3    | 4.0325       | $\alpha_1 KL_{III}$            | 1.788965                       | 9        | 6.93032 | 1.657910    | 8                              | 7.47815 |         |        |         |   |        |
| $\beta_2 KM_{IV,V}$        | 3.4413  | 4    | 3.6027  |         |      |              | $\beta_{1,2} KM_{II,III}$      | 1.62079                        | 2        | 7.64943 | 1.500135    | 8                              | 8.26466 |         |        |         |   |        |
|                            |         |      |         |         |      |              |                                |                                |          |         |             | $\beta_2 KM_{IV,V}$            | 1.60891 | 3       | 7.7059 | 1.48862 | 4 | 8.3286 |
|                            |         |      |         |         |      |              |                                |                                |          |         |             | $\beta_{2,4} L_1M_{II,III}$    | 14.31   | 3       | 0.870  | 13.18   | 1 | 0.941  |
|                            |         |      |         |         |      |              |                                |                                |          |         |             | $\eta L_{II}M_I$               | 17.87   | 3       | 0.694  | 16.27   | 3 | 0.762  |
|                            |         |      |         |         |      |              |                                |                                |          |         |             | $\beta_1 L_{II}M_{IV}$         | 15.666  | 8       | 0.7914 | 14.271  | 6 | 0.8688 |
|                            |         |      |         |         |      |              |                                |                                |          |         |             | $l L_{III}M_I$                 | 18.292  | 8       | 0.6778 | 16.693  | 9 | 0.7427 |
|                            |         |      |         |         |      |              |                                |                                |          |         |             | $\alpha_{1,2} L_{III}M_{IV,V}$ | 15.972  | 6       | 0.7762 | 14.561  | 3 | 0.8515 |
|                            |         |      |         |         |      |              |                                |                                |          |         |             | $M_{II,III}M_{IV,V}$           | 214.    | 6       | 0.058  | 190.    | 2 | 0.0651 |



X-Ray Wavelengths  
TABLE A (Continued)

| Designation                    | Å*       | p.e.  | keV      | Å*           | p.e. | keV     | Designation                     | Å*       | p.e. | keV     | Å*                 | p.e. | keV     |
|--------------------------------|----------|-------|----------|--------------|------|---------|---------------------------------|----------|------|---------|--------------------|------|---------|
| 29 Copper                      |          |       |          | 30 Zinc      |      |         | 35 Bromine (Cont.)              |          |      |         | 36 Krypton (Cont.) |      |         |
| $\alpha_2 KL_{II}$             | 1.544390 | 2     | 8.02783  | 1.439000     | 8    | 8.61578 | $\beta_{2,4} L_{II}M_{II,III}$  | 7.767†   | 9    | 1.596   |                    |      |         |
| $\alpha_1 KL_{III}$            | 1.540562 | 2     | 8.04778  | 1.435155     | 7    | 8.63886 | $\eta L_{II}M_I$                | 9.255    | 1    | 1.3396  |                    |      |         |
| $\beta_3 KM_{II}$              | 1.3926   | 1     | 8.9029   |              |      |         | $\beta_1 L_{II}M_{IV}$          | 8.1251   | 5    | 1.52590 | 7.576†             | 3    | 1.6366  |
| $\beta_{1,3} KM_{II,III}$      | 1.392218 | 9     | 8.90529  | 1.29525      | 2    | 9.5720  | $\gamma_4$                      |          |      |         | 7.279              | 5    | 1.703   |
| $\beta_2 KN_{II,III}$          |          |       |          | 1.28372      | 2    | 9.6580  | $\delta L_{II}M_I$              | 9.585    | 1    | 1.2935  |                    |      |         |
| $\beta_3 KM_{IV,V}$            | 1.38109  | 3     | 8.9770   | 1.2848       | 1    | 9.6501  | $\alpha_{1,2} L_{III}M_{IV,V}$  | 8.3746   | 5    | 1.48043 | 7.817†             | 3    | 1.5860  |
| $\beta_{2,4} L_{II}M_{II,III}$ | 12.122   | 8     | 1.0228   | 11.200       | 7    | 1.1070  | $\beta_6$                       |          |      |         | 7.510              | 4    | 1.6510  |
| $\eta L_{II}M_I$               | 14.90    | 2     | 0.832    | 13.68        | 2    | 0.906   | $L_{II}N_{III}$                 |          |      |         | 7.250              | 5    | 1.710   |
| $\beta_1 L_{II}M_{IV}$         | 13.053   | 3     | 0.9498   | 11.983       | 3    | 1.0347  | $M_I M_{II}$                    | 184.6    | 3    | 0.0672  |                    |      |         |
| $\delta L_{III}M_I$            | 15.286   | 9     | 0.8111   | 14.02        | 2    | 0.884   | $M_I M_{III}$                   | 164.7    | 3    | 0.0753  |                    |      |         |
| $\alpha_{1,2} L_{III}M_{IV,V}$ | 13.336   | 3     | 0.9297   | 12.254       | 3    | 1.0117  | $M_{II}M_{IV}$                  | 109.4    | 3    | 0.1133  |                    |      |         |
| $M_{II,III}M_{V,V}173.$        | 3        | 0.072 |          | 157.         | 3    | 0.079   | $M_{II}N_I$                     | 76.9     | 2    | 0.1613  |                    |      |         |
|                                |          |       |          |              |      |         | $M_{III}M_{IV,V}$               | 113.8    | 3    | 0.1089  |                    |      |         |
|                                |          |       |          |              |      |         |                                 | 79.8     | 3    | 0.1554  |                    |      |         |
|                                |          |       |          |              |      |         | $\zeta_2 M_{IV}N_{II}$          | 191.1    | 2    | 0.06488 |                    |      |         |
|                                |          |       |          |              |      |         | $M_{IV}N_{III}$                 | 189.5    | 3    | 0.0654  |                    |      |         |
|                                |          |       |          |              |      |         | $\zeta_1 M_{V}N_{III}$          | 192.6    | 2    | 0.06437 |                    |      |         |
| 31 Gallium                     |          |       |          | 32 Germanium |      |         | 37 Rubidium                     |          |      |         | 38 Strontium       |      |         |
| $\alpha_2 KL_{II}$             | 1.34399  | 1     | 9.22482  | 1.258011     | 9    | 9.85532 | $\alpha_2 KL_{II}$              | 0.92969  | 1    | 13.3358 | 0.87943            | 1    | 14.0979 |
| $\alpha_1 KL_{III}$            | 1.340083 | 9     | 9.25174  | 1.254054     | 9    | 9.88642 | $\alpha_1 KL_{III}$             | 0.925553 | 9    | 13.3953 | 0.87526            | 1    | 14.1650 |
| $\beta_3 KM_{II}$              | 1.20835  | 5     | 10.2603  | 1.12936      | 9    | 10.9780 | $\beta_3 KM_{II}$               | 0.82921  | 3    | 14.9517 | 0.78345            | 3    | 15.8249 |
| $\beta_1 KM_{III}$             | 1.20789  | 2     | 10.2642  | 1.12894      | 2    | 10.9821 | $\beta_1 KM_{III}$              | 0.82868  | 2    | 14.9613 | 0.78292            | 2    | 15.8357 |
| $\beta_2 KN_{II,III}$          | 1.19600  | 2     | 10.3663  | 1.11686      | 2    | 11.1008 | $\beta_2 KN_{II,III}$           | 0.81645  | 3    | 15.1854 | 0.77081            | 3    | 16.0846 |
| $\beta_3 KM_{IV,V}$            | 1.1981   | 2     | 10.348   | 1.1195       | 1    | 11.0745 | $\beta_3 KM_{IV,V}$             | 0.8219   | 1    | 15.085  | 0.7764             | 1    | 15.969  |
| $\beta_4 L_{II}M_{II}$         |          |       |          | 9.640        | 2    | 1.2861  | $\beta_1 KN_{IV,V}$             | 0.8154   | 2    | 15.205  | 0.76989            | 5    | 16.104  |
| $\beta_1 L_{II}M_{III}$        |          |       |          | 9.581        | 2    | 1.2941  | $\beta_4 L_{II}M_{II}$          | 6.8207   | 3    | 1.81771 | 6.4026             | 3    | 1.93643 |
| $\beta_{2,4} L_{II}M_{II,III}$ | 10.359†  | 8     | 1.197    |              |      |         | $\beta_3 L_{II}M_{III}$         | 6.7876   | 3    | 1.82659 | 6.3672             | 3    | 1.94719 |
| $\eta L_{II}M_I$               | 12.597   | 2     | 0.9842   | 11.609       | 2    | 1.0680  | $\gamma_{2,3} L_{II}N_{II,III}$ | 6.0458   | 3    | 2.0507  | 5.6445             | 3    | 2.1965  |
| $\beta_1 L_{II}M_{IV}$         | 11.023   | 2     | 1.1248   | 10.175       | 1    | 1.2185  | $\eta L_{II}M_I$                | 8.0415   | 4    | 1.54177 | 7.5171             | 3    | 1.64933 |
| $\delta L_{III}M_I$            | 12.953   | 2     | 0.9572   | 11.965       | 4    | 1.0362  | $\beta_1 L_{II}M_{IV}$          | 7.0759   | 3    | 1.75217 | 6.6239             | 3    | 1.87172 |
| $\alpha_{1,2} L_{III}M_{IV,V}$ | 11.292   | 1     | 1.09792  | 10.4361      | 8    | 1.18800 | $\gamma_4 L_{II}N_{IV}$         | 6.7553   | 3    | 1.83532 | 6.2961             | 3    | 1.96916 |
|                                |          |       |          |              |      |         | $\delta L_{III}M_I$             | 8.3636   | 4    | 1.48238 | 7.8362             | 3    | 1.58215 |
|                                |          |       |          |              |      |         | $\alpha_2 L_{III}M_{IV}$        | 7.3251   | 3    | 1.69256 | 6.8697             | 3    | 1.80474 |
|                                |          |       |          |              |      |         | $\alpha_1 L_{III}M_V$           | 7.3183   | 2    | 1.69413 | 6.8628             | 2    | 1.80656 |
|                                |          |       |          |              |      |         | $\beta_4 L_{III}N_I$            | 6.9842   | 3    | 1.77517 | 6.5191             | 3    | 1.90181 |
|                                |          |       |          |              |      |         | $M_I M_{III}$                   | 144.4    | 3    | 0.0859  |                    |      |         |
|                                |          |       |          |              |      |         | $M_{II}M_{IV}$                  | 91.5     | 2    | 0.1355  | 85.7               | 2    | 0.1447  |
|                                |          |       |          |              |      |         | $M_{II}N_I$                     | 57.0     | 2    | 0.2174  | 51.3               | 1    | 0.2416  |
|                                |          |       |          |              |      |         | $M_{III}M_{IV,V}$               | 96.7     | 2    | 0.1282  | 91.4               | 2    | 0.1357  |
|                                |          |       |          |              |      |         | $M_{III}N_I$                    | 59.5     | 2    | 0.2083  | 53.6               | 1    | 0.2313  |
|                                |          |       |          |              |      |         | $\zeta_1 M_{IV}N_{II}$          | 127.8    | 2    | 0.0970  |                    |      |         |
|                                |          |       |          |              |      |         | $M_{IV}N_{III}$                 | 126.8    | 2    | 0.0978  |                    |      |         |
|                                |          |       |          |              |      |         | $\zeta_2 M_{IV}N_{II,III}$      |          |      |         | 108.0              | 2    | 0.1148  |
|                                |          |       |          |              |      |         | $\zeta_1 M_{V}N_{III}$          | 128.7    | 2    | 0.0964  | 108.7              | 1    | 0.1140  |
| 33 Arsenic                     |          |       |          | 34 Selenium  |      |         | 39 Yttrium                      |          |      |         | 40 Zirconium       |      |         |
| $\alpha_2 KL_{II}$             | 1.17987  | 1     | 10.50799 | 1.10882      | 2    | 11.1814 | $\alpha_2 KL_{II}$              | 0.83305  | 1    | 14.8829 | 0.79015            | 1    | 15.6909 |
| $\alpha_1 KL_{III}$            | 1.17588  | 1     | 10.54372 | 1.10477      | 2    | 11.2224 | $\alpha_1 KL_{III}$             | 0.82884  | 1    | 14.9584 | 0.78593            | 1    | 15.7751 |
| $\beta_3 KM_{II}$              | 1.05783  | 5     | 11.7203  | 0.99268      | 5    | 12.4896 | $\beta_3 KM_{II}$               | 0.74126  | 3    | 16.7258 | 0.70228            | 4    | 17.654  |
| $\beta_1 KM_{III}$             | 1.05730  | 2     | 11.7262  | 0.99218      | 3    | 12.4959 | $\beta_1 KM_{III}$              | 0.74072  | 2    | 16.7378 | 0.70173            | 3    | 17.6678 |
| $\beta_2 KN_{II,III}$          | 1.04500  | 3     | 11.8642  | 0.97992      | 5    | 12.6522 | $\beta_2 KN_{II,III}$           | 0.72864  | 4    | 17.0154 | 0.68993            | 4    | 17.970  |
| $\beta_3 KM_{IV,V}$            | 1.0488   | 1     | 11.822   | 0.9843       | 1    | 12.595  | $\beta_3 KM_{IV,V}$             | 0.7345   | 1    | 16.879  | 0.6959             | 1    | 17.815  |
| $\beta_{2,4} L_{II}M_{II,III}$ | 8.929    | 1     | 1.3884   | 8.321†       | 9    | 1.490   |                                 |          |      |         |                    |      |         |
| $\eta L_{II}M_I$               | 10.734   | 1     | 1.1550   | 9.962        | 1    | 1.2446  |                                 |          |      |         |                    |      |         |
| $\beta_1 L_{II}M_{IV}$         | 9.4141   | 8     | 1.3170   | 8.7358       | 5    | 1.41923 |                                 |          |      |         |                    |      |         |
| $\delta L_{III}M_I$            | 11.072   | 1     | 1.1198   | 10.294       | 1    | 1.2044  |                                 |          |      |         |                    |      |         |
| $\alpha_{1,2} L_{III}M_{IV,V}$ | 9.6709   | 8     | 1.2820   | 8.9900       | 5    | 1.37910 |                                 |          |      |         |                    |      |         |
| $M_V N_{III}$                  |          |       |          | 230.         | 2    | 0.0538  |                                 |          |      |         |                    |      |         |
| 35 Bromine                     |          |       |          | 36 Krypton   |      |         |                                 |          |      |         |                    |      |         |
| $\alpha_2 KL_{II}$             | 1.04382  | 2     | 11.8776  | 0.9841       | 1    | 12.598  |                                 |          |      |         |                    |      |         |
| $\alpha_1 KL_{III}$            | 1.03974  | 2     | 11.9242  | 0.9801       | 1    | 12.649  |                                 |          |      |         |                    |      |         |
| $\beta_3 KM_{II}$              | 0.93327  | 5     | 13.2845  | 0.8790       | 1    | 14.104  |                                 |          |      |         |                    |      |         |
| $\beta_1 KM_{III}$             | 0.93279  | 2     | 13.2914  | 0.8785       | 1    | 14.112  |                                 |          |      |         |                    |      |         |
| $\beta_2 KN_{II,III}$          | 0.92046  | 2     | 13.4695  | 0.8661       | 1    | 14.315  |                                 |          |      |         |                    |      |         |
| $\beta_3 KM_{IV,V}$            | 0.9255   | 1     | 13.396   | 0.8708       | 2    | 14.238  |                                 |          |      |         |                    |      |         |
| $\beta_4 KN_{IV,V}$            |          |       |          | 0.8653       | 2    | 14.328  |                                 |          |      |         |                    |      |         |
| $\beta_4 L_{II}M_{II}$         |          |       |          | 7.304        | 5    | 1.697   |                                 |          |      |         |                    |      |         |
| $\beta_3 L_{II}M_{III}$        |          |       |          | 7.264        | 5    | 1.707   |                                 |          |      |         |                    |      |         |

X-Ray Wavelengths  
TABLE A (Continued)

| Designation                     | Å*      | p.e. | keV     | Å*       | p.e. | keV                  | Designation                     | Å*                   | p.e. | keV     | Å*       | p.e.         | keV     |  |  |
|---------------------------------|---------|------|---------|----------|------|----------------------|---------------------------------|----------------------|------|---------|----------|--------------|---------|--|--|
| 39 Yttrium (Cont.)              |         |      |         |          |      | 40 Zirconium (Cont.) |                                 | 43 Technetium        |      |         |          | 44 Ruthenium |         |  |  |
| $\beta_4 KN_{IV,V}$             | 0.72776 | 5    | 17.036  | 0.68901  | 5    | 17.994               | $\alpha_2 KL_{II}$              | 0.67932 <sup>†</sup> | 3    | 18.2508 | 0.647408 | 5            | 19.1504 |  |  |
| $\beta_4 L_{II}M_{II}$          | 6.0186  | 3    | 2.0600  | 5.6681   | 3    | 2.1873               | $\alpha_1 KL_{III}$             | 0.67502 <sup>†</sup> | 3    | 18.3671 | 0.643083 | 4            | 19.2792 |  |  |
| $\beta_3 L_{II}M_{III}$         | 5.9832  | 3    | 2.0722  | 5.6330   | 3    | 2.2010               | $\beta_3 KM_{II}$               | 0.60188 <sup>†</sup> | 4    | 20.599  | 0.573067 | 4            | 21.6346 |  |  |
| $\gamma_{2,3} L_{II}N_{II,III}$ | 5.2830  | 3    | 2.3468  | 4.9536   | 3    | 2.5029               | $\beta_1 KM_{III}$              | 0.60130 <sup>†</sup> | 4    | 20.619  | 0.572482 | 4            | 21.6568 |  |  |
| $\eta L_{II}M_I$                | 7.0406  | 3    | 1.76095 | 6.6069   | 3    | 1.87654              | $\beta_3 KN_{II,III}$           | 0.59024 <sup>†</sup> | 5    | 21.005  | 0.56166  | 3            | 22.074  |  |  |
| $\beta_1 L_{III}M_{IV}$         | 6.2120  | 3    | 1.99584 | 5.8360   | 3    | 2.1244               | $\beta_6^{II} KM_{IV}$          |                      |      |         | 0.5680   | 2            | 21.829  |  |  |
| $\gamma_4 L_{II}N_I$            | 5.8754  | 3    | 2.1102  | 5.4977   | 3    | 2.2551               | $\beta_6^I KM_V$                |                      |      |         | 0.56785  | 9            | 21.834  |  |  |
| $\gamma_1 L_{II}N_{IV}$         |         |      |         | 5.3843   | 3    | 2.3027               | $\beta_4$                       |                      |      |         | 0.56089  | 9            | 22.104  |  |  |
| $l L_{III}M_I$                  | 7.3563  | 3    | 1.68536 | 6.9185   | 3    | 1.79201              | $\beta_4 L_{II}M_{IV}$          |                      |      |         | 4.5230   | 2            | 2.7411  |  |  |
| $\alpha_2 L_{III}M_{IV}$        | 6.4558  | 3    | 1.92047 | 6.0778   | 3    | 2.0399               | $\beta_3 L_{II}M_{III}$         |                      |      |         | 4.4866   | 3            | 2.7634  |  |  |
| $\alpha_1 L_{III}M_V$           | 6.4488  | 2    | 1.92256 | 6.0705   | 2    | 2.04236              | $\gamma_{2,3} L_{II}N_{II,III}$ |                      |      |         | 3.8977   | 2            | 3.1809  |  |  |
| $\beta_4 L_{III}N_I$            | 6.0942  | 3    | 2.0344  | 5.7101   | 3    | 2.1712               | $\eta L_{II}M_I$                |                      |      |         | 5.2050   | 2            | 2.38197 |  |  |
| $\beta_{2,16}$                  |         |      |         | 5.5863   | 3    | 2.2194               | $\beta_1 L_{II}M_{IV}$          | 4.8873 <sup>†</sup>  | 8    | 2.5368  | 4.62058  | 3            | 2.68323 |  |  |
| $M_{II}M_{IV}$                  | 81.5    | 2    | 0.1522  | 76.7     | 2    | 0.1617               | $\gamma_4 L_{II}N_I$            |                      |      |         | 4.2873   | 2            | 2.8918  |  |  |
| $M_{II}N_I$                     | 46.48   | 9    | 0.267   |          |      |                      | $\gamma_1 L_{II}N_{IV}$         |                      |      |         | 4.1822   | 2            | 2.9645  |  |  |
| $M_{III}M_V$                    |         |      |         | 80.9     | 3    | 0.1533               | $l L_{III}M_I$                  |                      |      |         | 5.5035   | 3            | 2.2528  |  |  |
| $M_{III}N_I$                    | 48.5    | 2    | 0.256   |          |      |                      | $\alpha_2 L_{III}M_{IV}$        |                      |      |         | 4.85381  | 7            | 2.55431 |  |  |
| $M_{III}M_{IV,V}$               | 86.5    | 2    | 0.1434  |          |      |                      | $\alpha_1 L_{III}M_V$           | 5.1148 <sup>†</sup>  | 3    | 2.4240  | 4.84575  | 5            | 2.55855 |  |  |
| $\zeta M_{IV,V}N_{II,III}$      | 93.4    | 2    | 0.1328  | 82.1     | 2    | 0.1511               | $\beta_6 L_{III}N_I$            |                      |      |         | 4.4866   | 3            | 2.7634  |  |  |
| $M_{IV,V}O_{II,III}$            |         |      |         | 70.0     | 4    | 0.177                | $\beta_{2,16} L_{III}N_{IV,V}$  |                      |      |         | 4.3718   | 2            | 2.8360  |  |  |
| 41 Niobium                      |         |      |         |          |      | 42 Molybdenum        |                                 | 45 Rhodium           |      |         |          | 46 Palladium |         |  |  |
| $\alpha_2 KL_{II}$              | 0.75044 | 1    | 16.5210 | 0.713590 | 6    | 17.3743              | $M_{II}M_{IV}$                  |                      |      |         | 62.2     | 1            | 0.1992  |  |  |
| $\alpha_1 KL_{III}$             | 0.74620 | 1    | 16.6151 | 0.709300 | 1    | 17.47934             | $M_{II}N_I$                     |                      |      |         | 32.3     | 2            | 0.384   |  |  |
| $\beta_3 KM_{II}$               | 0.66634 | 3    | 18.6063 | 0.632872 | 9    | 19.5903              | $M_{II}N_{IV}$                  |                      |      |         | 25.50    | 9            | 0.486   |  |  |
| $\beta_1 KM_{III}$              | 0.66576 | 2    | 18.6225 | 0.632288 | 9    | 19.6083              | $M_{III}M_V$                    |                      |      |         | 68.3     | 1            | 0.1814  |  |  |
| $\beta_2^{II}$                  |         |      |         | 0.62107  | 5    | 19.963               | $\gamma M_{III}N_{IV,V}$        |                      |      |         | 26.9     | 1            | 0.462   |  |  |
| $\beta_2 KN_{II,III}$           | 0.65416 | 4    | 18.953  | 0.62099  | 2    | 19.9652              | $\zeta M_{IV,V}N_{II,III}$      |                      |      |         | 52.34    | 7            | 0.2369  |  |  |
| $\beta_4 KN_{IV,V}$             | 0.65318 | 5    | 18.981  |          |      |                      | $M_{IV,V}O_{II,III}$            |                      |      |         | 44.8     | 1            | 0.2768  |  |  |
| $\beta_6^{II} KM_{IV}$          |         |      |         | 0.62708  | 5    | 19.771               |                                 |                      |      |         |          |              |         |  |  |
| $\beta_6^I KM_V$                |         |      |         | 0.62692  | 5    | 19.776               |                                 |                      |      |         |          |              |         |  |  |
| $\beta_4 KN_{IV,V}$             |         |      |         | 0.62001  | 9    | 19.996               |                                 |                      |      |         |          |              |         |  |  |
| $\beta_4 L_{II}M_{II}$          | 5.3455  | 3    | 2.3194  | 5.0488   | 3    | 2.4557               |                                 |                      |      |         |          |              |         |  |  |
| $\beta_3 L_{II}M_{III}$         | 5.3102  | 3    | 2.3348  | 5.0133   | 3    | 2.4730               |                                 |                      |      |         |          |              |         |  |  |
| $\gamma_{2,3} L_{II}N_{II,III}$ | 4.6542  | 2    | 2.6638  | 4.3800   | 2    | 2.8306               |                                 |                      |      |         |          |              |         |  |  |
| $\eta L_{II}M_I$                | 6.2109  | 3    | 1.99620 | 5.8475   | 3    | 2.1202               |                                 |                      |      |         |          |              |         |  |  |
| $\beta_1 L_{II}M_{IV}$          | 5.4923  | 3    | 2.2574  | 5.17708  | 8    | 2.39481              |                                 |                      |      |         |          |              |         |  |  |
| $\gamma_4 L_{II}N_I$            | 5.1517  | 3    | 2.4066  | 4.8369   | 2    | 2.5632               |                                 |                      |      |         |          |              |         |  |  |
| $\gamma_1 L_{II}N_{IV}$         | 5.0361  | 3    | 2.4618  | 4.7258   | 2    | 2.6235               |                                 |                      |      |         |          |              |         |  |  |
| $l L_{III}M_I$                  | 6.5176  | 3    | 1.90225 | 6.1508   | 3    | 2.01568              |                                 |                      |      |         |          |              |         |  |  |
| $\alpha_2 L_{III}M_{IV}$        | 5.7319  | 3    | 2.1630  | 5.41437  | 8    | 2.28985              |                                 |                      |      |         |          |              |         |  |  |
| $\alpha_1 L_{III}M_V$           | 5.7243  | 2    | 2.16589 | 5.40655  | 8    | 2.29316              |                                 |                      |      |         |          |              |         |  |  |
| $\beta_6 L_{III}N_I$            | 5.3613  | 3    | 2.3125  | 5.0488   | 5    | 2.4557               |                                 |                      |      |         |          |              |         |  |  |
| $\beta_{2,16} L_{III}N_{IV,V}$  | 5.2379  | 3    | 2.3670  | 4.9232   | 2    | 2.5183               |                                 |                      |      |         |          |              |         |  |  |
| $M_{II}M_{IV}$                  | 72.1    | 3    | 0.1718  | 68.9     | 2    | 0.1798               |                                 |                      |      |         |          |              |         |  |  |
| $M_{II}N_I$                     | 38.4    | 3    | 0.323   | 35.3     | 3    | 0.351                |                                 |                      |      |         |          |              |         |  |  |
| $M_{II}N_{IV}$                  | 33.1    | 2    | 0.375   |          |      |                      |                                 |                      |      |         |          |              |         |  |  |
| $M_{III}M_V$                    | 78.4    | 2    | 0.1582  | 74.9     | 1    | 0.1656               |                                 |                      |      |         |          |              |         |  |  |
| $M_{III}N_I$                    | 40.7    | 2    | 0.305   | 37.5     | 2    | 0.331                |                                 |                      |      |         |          |              |         |  |  |
| $\gamma M_{III}N_{IV,V}$        | 34.9    | 2    | 0.356   |          |      |                      |                                 |                      |      |         |          |              |         |  |  |
| $\zeta M_{IV,V}N_{II,III}$      | 72.19   | 9    | 0.1717  | 64.38    | 7    | 0.1926               |                                 |                      |      |         |          |              |         |  |  |
| $M_{IV,V}O_{II,III}$            | 61.9    | 2    | 0.2002  | 54.8     | 2    | 0.2262               |                                 |                      |      |         |          |              |         |  |  |



X-Ray Wavelengths  
TABLE A (Continued)

| Designation                     | Å*        | p.e. | keV      | Å*                   | p.e. | keV     | Designation                     | Å*       | p.e. | keV     | Å*             | p.e. | keV     |
|---------------------------------|-----------|------|----------|----------------------|------|---------|---------------------------------|----------|------|---------|----------------|------|---------|
| 45 Rhodium (Cont.)              |           |      |          | 46 Palladium (Cont.) |      |         | 49 Indium (Cont.)               |          |      |         | 50 Tin (Cont.) |      |         |
| $\beta_1 L_I M_V$               |           |      |          | 3.7920               | 2    | 3.2696  | $\beta_1 K M_{III}$             | 0.454545 | 4    | 27.2759 | 0.435236       | 5    | 28.4860 |
| $M_{II} N_{II,III}$             |           |      |          | 20.1                 | 2    | 0.616   | $\beta_2 K N_{II,III}$          | 0.44500  | 1    | 27.8608 | 0.425915       | 8    | 29.1093 |
| $M_{II} M_{IV}$                 | 59.3      | 1    | 0.2090   | 56.5                 | 1    | 0.2194  | $K O_{II,III}$                  | 0.44374  | 3    | 27.940  | 0.42467        | 3    | 29.195  |
| $M_{II} N_I$                    | 28.1      | 2    | 0.442    | 26.2                 | 2    | 0.474   | $\beta_1^{II} K M_{IV}$         | 0.45098  | 2    | 27.491  | 0.43184        | 3    | 28.710  |
| $M_{II} N_{IV}$                 |           |      |          | 22.1                 | 1    | 0.560   | $\beta_2^{II} K M_V$            | 0.45086  | 2    | 27.499  | 0.43175        | 3    | 28.716  |
| $M_{II} M_V$                    | 65.5      | 1    | 0.1892   | 62.9                 | 1    | 0.1970  | $\beta_4 K N_{IV,V}$            | 0.44393  | 4    | 27.928  | 0.42495        | 3    | 29.175  |
| $M_{II}^{II} N_I$               | 29.8      | 1    | 0.417    | 27.9                 | 1    | 0.445   | $\beta_4 L_I M_{II}$            | 3.50697  | 9    | 3.5353  | 3.34335        | 9    | 3.7083  |
| $\gamma M_{III} N_{IV,V}$       | 25.01     | 9    | 0.496    | 23.3 <sup>†</sup>    | 1    | 0.531   | $\beta_3 L_I M_{III}$           | 3.46984  | 9    | 3.5731  | 3.30585        | 3    | 3.7500  |
| $\zeta M_{IV,V} N_{II,III}$     | 47.67     | 9    | 0.2601   | 43.6                 | 1    | 0.2844  | $\gamma_{2,3} L_I N_{II,III}$   | 2.9800   | 2    | 4.1605  | 2.8327         | 2    | 4.3768  |
| $M_{IV,V} O_{II,III}$           | 40.9      | 2    | 0.303    | 37.4                 | 2    | 0.332   | $\gamma_4 L_I O_{II,III}$       | 2.9264   | 2    | 4.2367  | 2.7775         | 2    | 4.4638  |
|                                 |           |      |          |                      |      |         | $\eta L_{II} M_I$               | 3.98327  | 9    | 3.11254 | 3.78876        | 9    | 3.27234 |
| 47 Silver                       |           |      |          | 48 Cadmium           |      |         | $\beta_1 L_{II} M_{IV}$         | 3.55531  | 4    | 3.48721 | 3.38487        | 3    | 3.66280 |
| $\alpha_2 K L_{II}$             | 0.563798  | 4    | 21.9903  | 0.539422             | 3    | 22.9841 | $\gamma_8 L_{II} N_I$           | 3.24907  | 9    | 3.8159  | 3.08475        | 9    | 4.0192  |
| $\alpha_1 K L_{III}$            | 0.5594075 | 6    | 22.16292 | 0.535010             | 3    | 23.1736 | $\gamma_1 L_{II} N_{IV}$        | 3.16213  | 4    | 3.92081 | 3.00115        | 3    | 4.13112 |
| $\beta_2 K M_{II}$              | 0.497685  | 4    | 24.9115  | 0.475730             | 5    | 26.0612 | $\beta_1 L_{III} M_I$           | 4.26873  | 9    | 2.90440 | 4.07165        | 9    | 3.04499 |
| $\beta_1 K M_{III}$             | 0.497069  | 4    | 24.9424  | 0.475105             | 6    | 26.0955 | $\alpha_2 L_{III} M_{IV}$       | 3.78073  | 6    | 3.27929 | 3.60891        | 4    | 3.43542 |
| $\beta_2 K N_{II,III}$          | 0.487032  | 4    | 25.4564  | 0.465328             | 7    | 26.6438 | $\alpha_1 L_{III} M_V$          | 3.77192  | 4    | 3.28694 | 3.59994        | 3    | 3.44398 |
| $\beta_3 K M_{IV,V}$            | 0.49306   | 2    | 25.145   |                      |      |         | $\beta_4 L_{III} N_I$           | 3.43606  | 9    | 3.60823 | 3.26901        | 9    | 3.7926  |
| $\beta_4 K N_{IV,V}$            | 0.48598   | 3    | 25.512   |                      |      |         | $\beta_{2,18} L_{III} N_{IV,V}$ | 3.33838  | 3    | 3.71381 | 3.17505        | 3    | 3.90486 |
| $\beta_4 L_I M_{II}$            | 3.87023   | 5    | 3.20346  | 3.68203              | 9    | 3.36719 | $\beta_3 L_{III} O_I$           | 3.324    | 4    | 3.730   | 3.1564         | 3    | 3.9279  |
| $\beta_3 L_I M_{III}$           | 3.83313   | 9    | 3.23446  | 3.64495              | 9    | 3.40145 | $\beta_{10} L_I M_{IV}$         | 3.27404  | 9    | 3.7868  | 3.12170        | 9    | 3.9716  |
| $\gamma_2 L_I N_{II}$           | 3.31216   | 9    | 3.7432   | 3.1377               | 2    | 3.9513  | $\beta_8 L_I M_V$               | 3.26763  | 9    | 3.7942  | 3.11513        | 9    | 3.9800  |
| $\gamma_8 L_I N_{III}$          | 3.30635   | 9    | 3.7498   |                      |      |         | $M_{II} M_{IV}$                 |          |      |         | 47.3           | 1    | 0.2621  |
| $\eta L_{II} M_I$               | 4.4183    | 2    | 2.8061   | 4.19315              | 9    | 2.95675 | $M_{II} N_I$                    |          |      |         | 20.0           | 1    | 0.619   |
| $\beta_1 L_{II} M_{IV}$         | 3.93473   | 3    | 3.15094  | 3.73823              | 4    | 3.31657 | $M_{II} N_{IV}$                 |          |      |         | 16.93          | 5    | 0.733   |
| $\gamma_8 L_{II} N_I$           | 3.61638   | 9    | 3.42832  | 3.42551              | 9    | 3.61935 | $M_{III} M_V$                   |          |      |         | 54.2           | 1    | 0.2287  |
| $\gamma_1 L_{III} N_{IV}$       | 3.52260   | 4    | 3.51959  | 3.33564              | 6    | 3.71686 | $M_{III} N_I$                   |          |      |         | 21.5           | 1    | 0.575   |
| $\beta_1 L_{III} M_I$           | 4.7076    | 2    | 2.6337   | 4.48014              | 9    | 2.76735 | $\gamma M_{III} N_{IV,V}$       |          |      |         | 17.94          | 5    | 0.691   |
| $\alpha_2 L_{III} M_{IV}$       | 4.16294   | 5    | 2.97821  | 3.96496              | 6    | 3.12691 | $M_{IV} O_{II,III}$             |          |      |         | 25.3           | 1    | 0.491   |
| $\alpha_1 L_{III} M_V$          | 4.15443   | 3    | 2.98431  | 3.95635              | 4    | 3.13373 | $\zeta M_{IV,V} N_{II,III}$     |          |      |         | 31.24          | 9    | 0.397   |
| $\beta_4 L_{III} N_I$           | 3.80774   | 9    | 3.25603  | 3.61467              | 9    | 3.42994 | $M_V O_{III}$                   |          |      |         | 25.7           | 1    | 0.483   |
| $\beta_{2,18} L_{III} N_{IV,V}$ | 3.70335   | 3    | 3.34781  | 3.51408              | 4    | 3.52812 |                                 |          |      |         |                |      |         |
| $\beta_{10} L_I M_{IV}$         | 3.61158   | 9    | 3.43287  | 3.4367               | 2    | 3.6075  | 51 Antimony                     |          |      |         | 52 Tellurium   |      |         |
| $\beta_3 L_I M_V$               | 3.60497   | 9    | 3.43917  | 3.43015              | 9    | 3.61445 | $\alpha_2 K L_{II}$             | 0.474827 | 3    | 26.1108 | 0.455784       | 3    | 27.2017 |
| $M_{II} N_{II,III}$             | 18.8      | 2    | 0.658    |                      |      |         | $\alpha_1 K L_{III}$            | 0.470354 | 3    | 26.3591 | 0.451295       | 3    | 27.4723 |
| $M_{II} M_{IV}$                 | 54.0      | 1    | 0.2295   | 52.0                 | 2    | 0.2384  | $\beta_3 K M_{II}$              | 0.417737 | 4    | 29.6792 | 0.400659       | 4    | 30.9443 |
| $M_{II} N_I$                    |           |      |          | 22.9                 | 2    | 0.540   | $\beta_1 K M_{III}$             | 0.417085 | 3    | 29.7256 | 0.399995       | 5    | 30.9957 |
| $M_{II} N_{IV}$                 | 20.66     | 7    | 0.600    | 19.40                | 7    | 0.639   | $\beta_2 K N_{II,III}$          | 0.407973 | 5    | 30.3895 | 0.391102       | 6    | 31.7004 |
| $M_{III} M_V$                   | 60.5      | 1    | 0.2048   | 58.7                 | 2    | 0.2111  | $K O_{II,III}$                  | 0.40666  | 1    | 30.4875 | 0.38974        | 1    | 31.8114 |
| $M_{III} N_I$                   | 26.0      | 1    | 0.478    | 24.5                 | 1    | 0.507   | $\beta_1^{II} K M_{IV}$         | 0.41388  | 1    | 29.9560 |                |      |         |
| $\gamma M_{III} N_{IV,V}$       | 21.82     | 7    | 0.568    | 20.47                | 7    | 0.606   | $\beta_2^{II} K M_V$            | 0.41378  | 1    | 29.9632 |                |      |         |
| $M_{IV} O_{II,III}$             |           |      |          | 30.4                 | 1    | 0.408   | $\beta_4 K N_{IV,V}$            | 0.40702  | 1    | 30.4604 |                |      |         |
| $\zeta M_{IV,V} N_{II,III}$     | 39.77     | 7    | 0.3117   | 36.8                 | 1    | 0.3371  | $\beta_4 L_I M_{II}$            | 3.19014  | 9    | 3.8864  | 3.04661        | 9    | 4.0695  |
| $M_V N_I$                       | 24.4      | 2    | 0.509    |                      |      |         | $\beta_3 L_I M_{III}$           | 3.15258  | 9    | 3.9327  | 3.00893        | 9    | 4.1204  |
| $M_V O_{III}$                   |           |      |          | 30.8                 | 1    | 0.403   | $\gamma_{2,3} L_I N_{II,III}$   | 2.6953   | 2    | 4.5999  | 2.5674         | 2    | 4.8290  |
| $M_{IV,V} O_{II,III}$           | 33.5      | 3    | 0.370    |                      |      |         | $\gamma_4 L_I O_{II,III}$       | 2.6398   | 2    | 4.6967  | 2.5113         | 2    | 4.9369  |
|                                 |           |      |          |                      |      |         | $\eta L_{II} M_I$               | 3.60765  | 9    | 3.43661 | 3.43832        | 9    | 3.60586 |
| 49 Indium                       |           |      |          | 50 Tin               |      |         | $\beta_1 L_{II} M_{IV}$         | 3.22567  | 4    | 3.84357 | 3.07677        | 6    | 4.02958 |
| $\alpha_2 K L_{II}$             | 0.516544  | 3    | 24.0020  | 0.495053             | 3    | 25.0440 | $\gamma_8 L_{II} N_I$           | 2.93187  | 9    | 4.2287  | 2.79007        | 9    | 4.4437  |
| $\alpha_1 K L_{III}$            | 0.512113  | 3    | 24.2097  | 0.490599             | 3    | 25.2713 | $\gamma_1 L_{II} N_{IV}$        | 2.85159  | 3    | 4.34779 | 2.71241        | 6    | 4.5709  |
| $\beta_3 K M_{II}$              | 0.455181  | 4    | 27.2377  | 0.435877             | 5    | 28.4440 | $\beta_1 L_{III} M_I$           | 3.88826  | 9    | 3.18860 | 3.71696        | 9    | 3.33555 |
|                                 |           |      |          |                      |      |         | $\alpha_2 L_{III} M_{IV}$       | 3.44840  | 6    | 3.59532 | 3.29846        | 9    | 3.7588  |

TABLE A (Continued)

| Designation                     | $\lambda^*$          | p.e. | keV     | $\lambda^*$          | p.e. | keV                  | Designation                    | $\lambda^*$       | p.e. | keV     | $\lambda^*$       | p.e. | keV       |  |
|---------------------------------|----------------------|------|---------|----------------------|------|----------------------|--------------------------------|-------------------|------|---------|-------------------|------|-----------|--|
| 51 Antimony (Cont.)             |                      |      |         |                      |      | 52 Tellurium (Cont.) |                                | 55 Cesium (Cont.) |      |         | 56 Barium (Cont.) |      |           |  |
| $\alpha_1 L_{III}M_V$           | 3.43941              | 4    | 3.60472 | 3.28920              | 6    | 3.76933              | $\gamma_4 I_{II}O_{II,III}$    | 2.1741            | 2    | 5.7026  | 2.0756            | 3    | 5.9733    |  |
| $\beta_8 L_{III}N_I$            | 3.11513              | 9    | 3.9800  | 2.97088              | 9    | 4.1732               | $\eta L_{II}M_I$               | 2.9932            | 2    | 4.1421  | 2.8627            | 3    | 4.3309    |  |
| $\beta_{2,18} L_{III}N_{IV,V}$  | 3.02335              | 3    | 4.10078 | 2.88217              | 8    | 4.3017               | $\beta_1 L_{II}M_{IV}$         | 2.6837            | 2    | 4.6198  | 2.56821           | 5    | 4.82753   |  |
| $\beta_7 L_{III}O_I$            | 3.0052               | 3    | 4.1255  | 2.8634               | 3    | 4.3298               | $\gamma_5 L_{II}N_I$           | 2.4174            | 2    | 5.1287  | 2.3085            | 3    | 5.3707    |  |
| $\beta_{10} L_{II}M_{IV}$       | 2.97917              | 9    | 4.1616  | 2.84679              | 9    | 4.3551               | $\gamma_1 L_{II}N_{IV}$        | 2.3480            | 2    | 5.2804  | 2.2415            | 2    | 5.5311    |  |
| $\beta_9 L_{II}M_V$             | 2.97261              | 9    | 4.1708  | 2.83897              | 9    | 4.3671               | $l L_{III}M_I$                 | 3.2670            | 2    | 3.7950  | 3.1355            | 2    | 3.9541    |  |
| $M_{II}M_{IV}$                  | 45.2                 | 1    | 0.2743  |                      |      |                      | $\alpha_2 L_{III}M_{IV}$       | 2.9020            | 2    | 4.2722  | 2.78553           | 5    | 4.45090   |  |
| $M_{II}N_I$                     | 18.8                 | 1    | 0.658   | 17.6                 | 1    | 0.703                | $\alpha_1 L_{III}M_V$          | 2.8924            | 2    | 4.2865  | 2.77595           | 5    | 4.46626   |  |
| $M_{II}N_{IV}$                  | 15.98                | 5    | 0.776   |                      |      |                      | $\beta_6 L_{III}N_I$           | 2.5932            | 2    | 4.7811  | 2.4826            | 2    | 4.9939    |  |
| $M_{III}M_V$                    | 52.2                 | 1    | 0.2375  | 50.3                 | 1    | 0.2465               | $\beta_{2,18} L_{III}N_{IV,V}$ | 2.5118            | 2    | 4.9359  | 2.40435           | 6    | 5.1565    |  |
| $M_{III}N_I$                    | 20.2                 | 1    | 0.612   | 19.1                 | 1    | 0.648                | $\beta_7 L_{III}O_I$           | 2.4849            | 2    | 4.9893  | 2.3806            | 2    | 5.2079    |  |
| $\gamma M_{III}N_{IV,V}$        | 16.92                | 4    | 0.733   | 15.93                | 4    | 0.778                | $\beta_{10} L_{II}M_{IV}$      | 2.4920            | 2    | 4.9752  | 2.3869            | 2    | 5.1941    |  |
| $M_{IV}O_{II,III}$              |                      |      |         | 21.34                | 5    | 0.581                | $\beta_9 L_{II}M_V$            | 2.4783            | 2    | 5.0026  | 2.3764            | 2    | 5.2171    |  |
| $\zeta M_{IV,V}N_{II,III}$      | 28.88                | 8    | 0.429   | 26.72                | 9    | 0.464                | $\gamma M_{III}N_{IV,V}$       |                   |      |         | 12.75             | 3    | 0.973     |  |
| $M_VO_{III}$                    |                      |      |         | 21.78                | 5    | 0.569                | $M_{IV}O_{II}$                 |                   |      |         | 15.91             | 5    | 0.779     |  |
| 53 Iodine                       |                      |      |         |                      |      | 54 Xenon             |                                | 57 Lanthanum      |      |         | 58 Cerium         |      |           |  |
| $\alpha_2 K L_{II}$             | 0.437829             | 7    | 28.3172 | 0.42087 <sup>†</sup> | 2    | 29.458               | $M_VO_{III}$                   |                   |      |         | 16.20             | 5    | 0.765     |  |
| $\alpha_1 K L_{III}$            | 0.433318             | 5    | 28.6120 | 0.41634 <sup>†</sup> | 2    | 29.779               | $N_{IV}O_{II}$                 | 188.6             | 1    | 0.06574 | 163.3             | 2    | 0.07590   |  |
| $\beta_3 K M_{II}$              | 0.384564             | 4    | 32.2394 | 0.36941 <sup>†</sup> | 2    | 33.562               | $N_{IV}O_{III}$                | 183.8             | 1    | 0.06746 | 159.0             | 2    | 0.07796   |  |
| $\beta_1 K M_{III}$             | 0.383905             | 4    | 32.2947 | 0.36872 <sup>†</sup> | 2    | 33.624               | $N_VO_{III}$                   | 190.3             | 1    | 0.06515 | 164.6             | 2    | 0.07530   |  |
| $\beta_2 K N_{II,III}$          | 0.37523 <sup>†</sup> | 2    | 33.042  | 0.36026 <sup>†</sup> | 3    | 34.415               | 57 Lanthanum                   |                   |      |         |                   |      | 58 Cerium |  |
| $\beta_4 L_{II}M_{II}$          | 2.91207              | 9    | 4.2575  |                      |      |                      | $\alpha_2 K L_{II}$            | 0.375313          | 2    | 33.0341 | 0.361683          | 2    | 34.2789   |  |
| $\beta_5 L_{II}M_{III}$         | 2.87429              | 9    | 4.3134  |                      |      |                      | $\alpha_1 K L_{III}$           | 0.370737          | 2    | 33.4418 | 0.357092          | 2    | 34.7197   |  |
| $\gamma_{2,8} L_{II}N_{II,III}$ | 2.4475               | 2    | 5.0657  |                      |      |                      | $\beta_3 K M_{II}$             | 0.328686          | 4    | 37.7202 | 0.316520          | 4    | 39.1701   |  |
| $\gamma_4 L_{II}O_{II,III}$     | 2.3913               | 2    | 5.1848  |                      |      |                      | $\beta_1 K M_{III}$            | 0.327983          | 3    | 37.8010 | 0.315816          | 2    | 39.2573   |  |
| $\eta L_{II}M_I$                | 3.27979              | 9    | 3.7801  |                      |      |                      | $\beta_2 K N_{II,III}$         | 0.320117          | 7    | 38.7299 | 0.30816           | 1    | 40.233    |  |
| $\beta_1 L_{II}M_{IV}$          | 2.93744              | 6    | 4.22072 |                      |      |                      | $K O_{II,III}$                 | 0.31864           | 2    | 38.909  | 0.30668           | 2    | 40.427    |  |
| $\gamma_6 L_{II}N_I$            | 2.65710              | 9    | 4.6660  |                      |      |                      | $\beta_5^{II} K M_{IV}$        | 0.32563           | 2    | 38.074  | 0.31357           | 2    | 39.539    |  |
| $\gamma_1 L_{II}N_{IV}$         | 2.58244              | 8    | 4.8009  |                      |      |                      | $\beta_6^I K M_V$              | 0.32546           | 2    | 38.094  | 0.31342           | 2    | 39.558    |  |
| $l L_{III}M_I$                  | 3.55754              | 9    | 3.48502 |                      |      |                      | $\beta_4 K N_{IV,V}$           | 0.31931           | 2    | 38.828  | 0.30737           | 2    | 40.337    |  |
| $\alpha_2 L_{III}M_{IV}$        | 3.15791              | 6    | 3.92604 | 3.0166 <sup>†</sup>  | 2    | 4.1099               | $\beta_4 L_{II}M_{II}$         | 2.4493            | 3    | 5.0620  | 2.3497            | 4    | 5.2765    |  |
| $\alpha_1 L_{III}M_V$           | 3.14860              | 6    | 3.93765 |                      |      |                      | $\beta_3 L_{II}M_{III}$        | 2.4105            | 3    | 5.1434  | 2.3109            | 3    | 5.3651    |  |
| $\beta_6 L_{III}N_I$            | 2.83672              | 9    | 4.3706  |                      |      |                      | $\gamma_2 L_{II}N_{II}$        | 2.0460            | 4    | 6.060   | 1.9602            | 3    | 6.3250    |  |
| $\beta_{2,18} L_{III}N_{IV,V}$  | 2.75053              | 8    | 4.5075  |                      |      |                      | $\gamma_3 L_{II}N_{III}$       | 2.0410            | 4    | 6.074   | 1.9553            | 3    | 6.3409    |  |
| $\beta_7 L_{III}O_I$            | 2.7288               | 3    | 4.5435  |                      |      |                      | $\gamma_4 I_{II}O_{II,III}$    | 1.9830            | 4    | 6.252   | 1.8991            | 4    | 6.528     |  |
| $\beta_{10} L_{II}M_{IV}$       | 2.72104              | 9    | 4.5564  |                      |      |                      | $\eta L_{II}M_I$               | 2.740             | 3    | 4.525   | 2.6203            | 4    | 4.7315    |  |
| $\beta_9 L_{II}M_V$             | 2.71352              | 9    | 4.5690  |                      |      |                      | $\beta_1 L_{II}M_{IV}$         | 2.45891           | 5    | 5.0421  | 2.3561            | 3    | 5.2622    |  |
| 55 Cesium                       |                      |      |         |                      |      | 56 Barium            |                                | 57 Lanthanum      |      |         | 58 Cerium         |      |           |  |
| $\alpha_2 K L_{II}$             | 0.404835             | 4    | 30.6251 | 0.389668             | 5    | 31.8171              | $\gamma_6 L_{II}N_I$           | 2.2056            | 4    | 5.621   | 2.1103            | 3    | 5.8751    |  |
| $\alpha_1 K L_{III}$            | 0.400290             | 4    | 30.9728 | 0.385111             | 4    | 32.1936              | $\gamma_1 L_{II}N_{IV}$        | 2.1418            | 3    | 5.7885  | 2.0487            | 4    | 6.052     |  |
| $\beta_3 K M_{II}$              | 0.355050             | 4    | 34.9194 | 0.341507             | 4    | 36.3040              | $\gamma_8 L_{II}O_I$           |                   |      |         | 2.0237            | 4    | 6.126     |  |
| $\beta_1 K M_{III}$             | 0.354364             | 7    | 34.9869 | 0.340811             | 3    | 36.3782              | $l L_{III}M_I$                 | 3.006             | 3    | 4.124   | 2.8917            | 4    | 4.2875    |  |
| $\beta_2 K N_{II,III}$          | 0.34611              | 2    | 35.822  | 0.33277              | 1    | 37.257               | $\alpha_2 L_{III}M_{IV}$       | 2.67533           | 5    | 4.63423 | 2.5706            | 3    | 4.8230    |  |
| $K O_{II,III}$                  |                      |      |         | 0.33127              | 2    | 37.426               | $\alpha_1 L_{III}M_V$          | 2.66570           | 5    | 4.65097 | 2.5615            | 2    | 4.8402    |  |
| $\beta_5^{II} K M_{IV}$         |                      |      |         | 0.33835              | 2    | 36.643               | $\beta_5 L_{III}N_I$           | 2.3790            | 4    | 5.2114  | 2.2818            | 3    | 5.4334    |  |
| $\beta_5^I K M_V$               |                      |      |         | 0.33814              | 2    | 36.666               | $\beta_{2,18} L_{III}N_{IV,V}$ | 2.3030            | 3    | 5.3835  | 2.2087            | 2    | 5.6134    |  |
| $\beta_4 K N_{IV,V}$            |                      |      |         | 0.33229              | 2    | 37.311               | $\beta_7 L_{III}O_I$           | 2.275             | 3    | 5.450   | 2.1701            | 2    | 5.7132    |  |
| $\beta_4 L_{II}M_{II}$          | 2.6666               | 2    | 4.6494  | 2.5553               | 2    | 4.8519               | $\beta_{10} L_{II}M_{IV}$      | 2.290             | 3    | 5.415   | 2.1958            | 5    | 5.646     |  |
| $\beta_3 L_{II}M_{III}$         | 2.6285               | 2    | 4.7167  | 2.5164               | 2    | 4.9269               | $\beta_9 L_{II}M_V$            | 2.282             | 3    | 5.434   | 2.1885            | 3    | 5.6650    |  |
| $\gamma_2 L_{II}N_{II}$         | 2.2371               | 2    | 5.5420  | 2.1387               | 2    | 5.7969               | $\gamma M_{III}N_{IV,V}$       | 12.08             | 4    | 1.027   | 11.53             | 1    | 1.0749    |  |
| $\gamma_3 L_{II}N_{III}$        | 2.2328               | 2    | 5.5527  | 2.1342               | 2    | 5.8092               | $\beta M_{IV}N_{VI}$           | 14.51             | 5    | 0.854   | 13.75             | 4    | 0.902     |  |
|                                 |                      |      |         |                      |      |                      | $\zeta M_V N_{III}$            | 19.44             | 5    | 0.638   | 18.35             | 4    | 0.676     |  |
|                                 |                      |      |         |                      |      |                      | $\alpha M_V N_{VI, VII}$       | 14.88             | 5    | 0.833   | 14.04             | 2    | 0.883     |  |



X-Ray Wavelengths  
TABLE A (Continued)

| Designation                                  | Å*                   | p.e. | keV     | Å*                  | p.e. | keV               | Designation                                  | Å*                                    | p.e.   | keV     | Å*            | p.e.                | keV     |       |
|----------------------------------------------|----------------------|------|---------|---------------------|------|-------------------|----------------------------------------------|---------------------------------------|--------|---------|---------------|---------------------|---------|-------|
| 57 Lanthanum (Cont.)                         |                      |      |         |                     |      | 58 Cerium (Cont.) |                                              | 61 Promethium (Cont.)                 |        |         |               | 62 Samarium (Cont.) |         |       |
| $M_{\text{V}}O_{\text{II,III}}$              |                      |      |         | 14.39               | 5    | 0.862             | $\alpha_2 L_{\text{III}}M_{\text{IV}}$       | 2.2926                                | 4      | 5.4078  | 2.21062       | 3                   | 5.6084  |       |
| $N_{\text{IV,V}}O_{\text{II,III}}$           | 152.6                | 6    | 0.0812  | 144.4               | 6    | 0.0859            | $\alpha_1 L_{\text{III}}M_{\text{V}}$        | 2.2822                                | 3      | 5.4325  | 2.1998        | 2                   | 5.6361  |       |
| 59 Praseodymium                              |                      |      |         |                     |      | 60 Neodymium      |                                              | $\beta_6 L_{\text{III}}N_{\text{I}}$  |        |         | 1.94643       | 3                   | 6.3697  |       |
| $\alpha_2 KL_{\text{II}}$                    | 0.348749             | 2    | 35.5502 | 0.336472            | 2    | 36.8474           | $\beta_{2,16} L_{\text{III}}N_{\text{IV,V}}$ | 1.9559                                | 6      | 6.339   | 1.88221       | 3                   | 6.5870  |       |
| $\alpha_1 KL_{\text{III}}$                   | 0.344140             | 2    | 36.0263 | 0.331846            | 2    | 37.3610           | $\beta_7 L_{\text{III}}O_{\text{I}}$         |                                       |        | 1.85626 | 3             | 6.6791              |         |       |
| $\beta_3 KM_{\text{II}}$                     | 0.304975             | 5    | 40.6529 | 0.294027            | 3    | 42.1665           | $\beta_5 L_{\text{III}}O_{\text{IV,V}}$      |                                       |        | 1.84700 | 9             | 6.7126              |         |       |
| $\beta_1 KM_{\text{III}}$                    | 0.304261             | 4    | 40.7482 | 0.293299            | 2    | 42.2713           | $\beta_{10} L_{\text{I}}M_{\text{IV}}$       |                                       |        | 1.86990 | 3             | 6.6304              |         |       |
| $\beta_2 KN_{\text{II,III}}$                 | 0.29679              | 2    | 41.773  | 0.2861 <sup>†</sup> | 1    | 43.33             | $\beta_9 L_{\text{I}}M_{\text{V}}$           |                                       |        | 1.86166 | 3             | 6.6597              |         |       |
| $\beta_4 L_{\text{I}}M_{\text{II}}$          | 2.2550               | 4    | 5.4981  | 2.1669              | 3    | 5.7216            | $\gamma M_{\text{III}}N_{\text{IV,V}}$       |                                       |        | 9.600   | 9             | 1.291               |         |       |
| $\beta_3 L_{\text{I}}M_{\text{III}}$         | 2.2172               | 3    | 5.5918  | 2.1268              | 2    | 5.8294            | $\beta M_{\text{IV}}N_{\text{VI}}$           |                                       |        | 11.27   | 1             | 1.0998              |         |       |
| $\gamma_2 L_{\text{I}}N_{\text{II}}$         | 1.8791               | 4    | 6.598   | 1.8013              | 4    | 6.883             | $\zeta M_{\text{V}}N_{\text{III}}$           |                                       |        | 14.91   | 4             | 0.831               |         |       |
| $\gamma_3 L_{\text{I}}N_{\text{III}}$        | 1.8740               | 4    | 6.616   | 1.7964              | 4    | 6.902             | $\alpha M_{\text{V}}N_{\text{VI,VII}}$       |                                       |        | 11.47   | 3             | 1.081               |         |       |
| $\gamma_4 L_{\text{I}}O_{\text{II,III}}$     | 1.8193               | 4    | 6.815   | 1.7445              | 4    | 7.107             | $N_{\text{IV,V}}N_{\text{VI,VII}}$           |                                       |        | 98.     | 1             | 0.126               |         |       |
| $\eta L_{\text{II}}M_{\text{I}}$             | 2.512                | 3    | 4.935   | 2.4094              | 4    | 5.1457            | $N_{\text{IV,V}}O_{\text{II,III}}$           |                                       |        | 117.4   | 4             | 0.1056              |         |       |
| $\beta_1 L_{\text{II}}M_{\text{IV}}$         | 2.2588               | 3    | 5.4889  | 2.1669              | 2    | 5.7216            | 63 Europium                                  |                                       |        |         | 64 Gadolinium |                     |         |       |
| $\gamma_6 L_{\text{II}}N_{\text{I}}$         | 2.0205               | 4    | 6.136   | 1.9355              | 4    | 6.406             | $\alpha_2 KL_{\text{II}}$                    | 0.303118                              | 2      | 40.9019 | 0.293038      | 2                   | 42.3089 |       |
| $\gamma_1 L_{\text{II}}N_{\text{IV}}$        | 1.9611               | 3    | 6.3221  | 1.8779              | 2    | 6.6021            | $\alpha_1 KL_{\text{III}}$                   | 0.298446                              | 2      | 41.5422 | 0.288353      | 2                   | 42.9962 |       |
| $\gamma_8 L_{\text{II}}O_{\text{I}}$         | 1.9362               | 4    | 6.403   | 1.8552              | 5    | 6.683             | $\beta_3 KM_{\text{II}}$                     | 0.264332                              | 5      | 46.9036 | 0.25534       | 2                   | 48.555  |       |
| $l L_{\text{III}}M_{\text{I}}$               | 2.7841               | 4    | 4.4532  | 2.6760              | 4    | 4.6330            | $\beta_1 KM_{\text{III}}$                    | 0.263577                              | 5      | 47.0379 | 0.25460       | 2                   | 48.697  |       |
| $\alpha_2 L_{\text{III}}M_{\text{IV}}$       | 2.4729               | 3    | 5.0135  | 2.3807              | 3    | 5.2077            | $\beta_2 KN_{\text{II,III}}$                 | 0.256923                              | 8      | 48.256  | 0.24816       | 3                   | 49.959  |       |
| $\alpha_1 L_{\text{III}}M_{\text{V}}$        | 2.4630               | 2    | 5.0337  | 2.3704              | 2    | 5.2304            | $KO_{\text{II,III}}$                         | 0.255645                              | 7      | 48.497  | 0.24687       | 3                   | 50.221  |       |
| $\beta_6 L_{\text{III}}N_{\text{I}}$         | 2.1906               | 4    | 5.660   | 2.1039              | 3    | 5.8930            | $\beta_6 KM_{\text{IV,V}}$                   |                                       |        | 0.25275 | 3             | 49.052              |         |       |
| $\beta_{2,16} L_{\text{III}}N_{\text{IV,V}}$ | 2.1194               | 4    | 5.850   | 2.0360              | 3    | 6.0894            | $\beta_4 L_{\text{I}}M_{\text{II}}$          | 1.9255                                | 2      | 6.4389  | 1.8540        | 2                   | 6.6871  |       |
| $\beta_7 L_{\text{III}}O_{\text{I}}$         | 2.0919               | 4    | 5.927   | 2.0092              | 3    | 6.1708            | $\beta_3 L_{\text{I}}M_{\text{III}}$         | 1.8867                                | 2      | 6.5713  | 1.8150        | 2                   | 6.8311  |       |
| $\beta_{10} L_{\text{I}}M_{\text{IV}}$       | 2.1071               | 4    | 5.884   | 2.0237              | 3    | 6.1265            | $\gamma_2 L_{\text{I}}N_{\text{II}}$         | 1.5961                                | 2      | 7.7677  | 1.5331        | 2                   | 8.087   |       |
| $\beta_9 L_{\text{I}}M_{\text{V}}$           | 2.1004               | 4    | 5.903   | 2.0165              | 3    | 6.1484            | $\gamma_3 L_{\text{I}}N_{\text{III}}$        | 1.5903                                | 2      | 7.7961  | 1.5297        | 2                   | 8.105   |       |
| $\gamma M_{\text{III}}N_{\text{IV,V}}$       | 10.998               | 9    | 1.1273  | 10.505              | 9    | 1.180             | $\gamma_4 L_{\text{I}}O_{\text{II,III}}$     | 1.5439                                | 1      | 8.0304  | 1.4839        | 2                   | 8.355   |       |
| $\beta M_{\text{IV}}N_{\text{VI}}$           | 13.06                | 2    | 0.950   | 12.44               | 2    | 0.997             | $\eta L_{\text{II}}M_{\text{I}}$             | 2.1315                                | 2      | 5.8166  | 2.0494        | 1                   | 6.0495  |       |
| $\zeta M_{\text{V}}N_{\text{III}}$           | 17.38                | 4    | 0.714   | 16.46               | 4    | 0.753             | $\beta_1 L_{\text{II}}M_{\text{IV}}$         | 1.9203                                | 2      | 6.4564  | 1.8468        | 2                   | 6.7132  |       |
| $\alpha M_{\text{V}}N_{\text{VI,VII}}$       | 13.343               | 5    | 0.9292  | 12.68               | 2    | 0.978             | $\gamma_6 L_{\text{II}}N_{\text{I}}$         | 1.7085                                | 2      | 7.2566  | 1.6412        | 2                   | 7.5543  |       |
| $N_{\text{IV,V}}N_{\text{VI,VII}}$           | 113.                 | 1    | 0.1095  | 107.                | 1    | 0.116             | $\gamma_1 L_{\text{II}}N_{\text{IV}}$        | 1.6574                                | 2      | 7.4803  | 1.5924        | 2                   | 7.7858  |       |
| $N_{\text{IV,V}}O_{\text{II,III}}$           | 136.5                | 4    | 0.0908  | 128.9               | 7    | 0.0962            | $\gamma_8 L_{\text{II}}O_{\text{I}}$         | 1.6346                                | 2      | 7.5849  | 1.5707        | 2                   | 7.894   |       |
| 61 Promethium                                |                      |      |         |                     |      | 62 Samarium       |                                              | $\gamma_6 L_{\text{II}}O_{\text{IV}}$ | 1.6282 | 2       | 7.6147        | 1.5644              | 2       | 7.925 |
| $\alpha_2 KL_{\text{II}}$                    | 0.324803             | 4    | 38.1712 | 0.313698            | 2    | 39.5224           | $l L_{\text{III}}M_{\text{I}}$               | 2.3948                                | 2      | 5.1772  | 2.3122        | 2                   | 5.3621  |       |
| $\alpha_1 KL_{\text{III}}$                   | 0.320160             | 4    | 38.7247 | 0.309040            | 2    | 40.1181           | $\alpha_2 L_{\text{III}}M_{\text{IV}}$       | 2.1315                                | 2      | 5.8166  | 2.0578        | 2                   | 6.0250  |       |
| $\beta_3 KM_{\text{II}}$                     | 0.28363 <sup>†</sup> | 4    | 43.713  | 0.27376             | 2    | 45.289            | $\alpha_1 L_{\text{III}}M_{\text{V}}$        | 2.1209                                | 2      | 5.8457  | 2.0468        | 2                   | 6.0572  |       |
| $\beta_1 KM_{\text{III}}$                    | 0.28290 <sup>†</sup> | 3    | 43.826  | 0.27301             | 2    | 45.413            | $\beta_6 L_{\text{III}}N_{\text{I}}$         | 1.8737                                | 2      | 6.6170  | 1.8054        | 2                   | 6.8671  |       |
| $\beta_2 KN_{\text{II,III}}$                 | 0.2759 <sup>†</sup>  | 1    | 44.94   | 0.2662              | 1    | 46.58             | $\beta_{2,16} L_{\text{III}}N_{\text{IV,V}}$ | 1.8118                                | 2      | 6.8432  | 1.7455        | 2                   | 7.1028  |       |
| $KO_{\text{II,III}}$                         |                      |      |         | 0.26491             | 3    | 46.801            | $\beta_7 L_{\text{III}}O_{\text{I}}$         | 1.7851                                | 2      | 6.9453  | 1.7203        | 2                   | 7.2071  |       |
| $\beta_6 KM_{\text{IV,V}}$                   |                      |      |         | 0.27111             | 3    | 45.731            | $\beta_5 L_{\text{III}}O_{\text{IV,V}}$      | 1.7772                                | 2      | 6.9763  | 1.7130        | 2                   | 7.2374  |       |
| $\beta_4 L_{\text{I}}M_{\text{II}}$          |                      |      |         | 2.00095             | 6    | 6.1963            | $\beta_{10} L_{\text{I}}M_{\text{IV}}$       | 1.7993                                | 3      | 6.890   | 1.7315        | 3                   | 7.160   |       |
| $\beta_3 L_{\text{I}}M_{\text{III}}$         | 2.0421               | 4    | 6.071   | 1.96241             | 3    | 6.3180            | $\beta_9 L_{\text{I}}M_{\text{V}}$           | 1.7916                                | 3      | 6.920   | 1.7240        | 3                   | 7.192   |       |
| $\gamma_2 L_{\text{I}}N_{\text{II}}$         |                      |      |         | 1.66044             | 6    | 7.4668            | $L_{\text{I}}O_{\text{IV,V}}$                |                                       |        | 1.4807  | 3             | 8.373               |         |       |
| $\gamma_3 L_{\text{I}}N_{\text{III}}$        |                      |      |         | 1.65601             | 3    | 7.4867            | $\gamma M_{\text{III}}N_{\text{IV,V}}$       | 9.211                                 | 9      | 1.346   | 8.844         | 9                   | 1.402   |       |
| $\gamma_4 L_{\text{I}}O_{\text{II,III}}$     |                      |      |         | 1.60728             | 3    | 7.7137            | $\beta M_{\text{IV}}N_{\text{VI}}$           | 10.750                                | 7      | 1.1533  | 10.254        | 6                   | 1.2091  |       |
| $\eta L_{\text{II}}M_{\text{I}}$             |                      |      |         | 2.21824             | 3    | 5.5892            | $\zeta M_{\text{V}}N_{\text{III}}$           | 14.22                                 | 2      | 0.872   | 13.57         | 2                   | 0.914   |       |
| $\beta_1 L_{\text{II}}M_{\text{IV}}$         | 2.0797               | 4    | 5.961   | 1.99806             | 3    | 6.2051            | $\alpha M_{\text{V}}N_{\text{VI,VII}}$       | 10.96                                 | 3      | 1.131   | 10.46         | 3                   | 1.185   |       |
| $\gamma_6 L_{\text{II}}N_{\text{I}}$         |                      |      |         | 1.77934*            | 3    | 6.9678            | $N_{\text{IV,V}}O_{\text{II,III}}$           | 112.0                                 | 6      | 0.1107  |               |                     |         |       |
| $\gamma_1 L_{\text{II}}N_{\text{IV}}$        | 1.7989               | 9    | 6.892   | 1.72724             | 3    | 7.1780            | 65 Terbium                                   |                                       |        |         | 66 Dysprosium |                     |         |       |
| $\gamma_8 L_{\text{II}}O_{\text{IV}}$        |                      |      |         | 1.6966              | 9    | 7.3076            | $\alpha_2 KL_{\text{II}}$                    | 0.283423                              | 2      | 43.7441 | 0.274247      | 2                   | 45.2078 |       |
| $l L_{\text{III}}M_{\text{I}}$               |                      |      |         | 2.4823              | 4    | 4.9945            | $\alpha_1 KL_{\text{III}}$                   | 0.278724                              | 2      | 44.4816 | 0.269533      | 2                   | 45.9984 |       |
|                                              |                      |      |         |                     |      |                   | $\beta KM_{\text{II}}$                       | 0.24683                               | 2      | 50.229  | 0.23862       | 2                   | 51.957  |       |

X-Ray Wavelengths  
TABLE A (Continued)

| Designation                    | Å*                  | p.e. | keV     | Å*                  | p.e. | keV                   | Designation                    | Å*                   | p.e. | keV     | Å*                   | p.e.               | keV          |  |  |  |  |                   |  |  |  |  |  |
|--------------------------------|---------------------|------|---------|---------------------|------|-----------------------|--------------------------------|----------------------|------|---------|----------------------|--------------------|--------------|--|--|--|--|-------------------|--|--|--|--|--|
| 65 Terbium (Cont.)             |                     |      |         |                     |      | 66 Dysprosium (Cont.) |                                |                      |      |         |                      | 67 Holmium (Cont.) |              |  |  |  |  | 68 Erbium (Cont.) |  |  |  |  |  |
| $\beta_1 KM_{III}$             | 0.24608             | 2    | 50.382  | 0.23788             | 2    | 52.119                | $\beta_{10} L_{IV}M_{IV}$      | 1.5486               | 3    | 8.006   | 1.4941               | 3                  | 8.298        |  |  |  |  |                   |  |  |  |  |  |
| $\beta_2 KN_{II,III}$          | 0.2397 <sup>†</sup> | 2    | 51.72   | 0.2317 <sup>†</sup> | 2    | 53.51                 | $L_{IV}O_{IV,V}$               | 1.3208               | 3    | 9.387   |                      |                    |              |  |  |  |  |                   |  |  |  |  |  |
| $KO_{II,III}$                  | 0.23858             | 3    | 51.965  | 0.23056             | 3    | 53.774                | $\beta_9 L_{IV}M_V$            |                      |      |         | 1.4855               | 5                  | 8.346        |  |  |  |  |                   |  |  |  |  |  |
| $\beta_8 KM_{IV,V}$            |                     |      |         | 0.23618             | 3    | 52.494                | $M_{II}N_{IV}$                 |                      |      |         | 7.60                 | 1                  | 1.632        |  |  |  |  |                   |  |  |  |  |  |
| $\beta_4 L_{IV}M_{II}$         | 1.7864              | 2    | 6.9403  | 1.72103             | 7    | 7.2039                | $\gamma M_{III}N_{IV,V}$       | 7.865                | 9    | 1.576   |                      |                    |              |  |  |  |  |                   |  |  |  |  |  |
| $\beta_3 L_{IV}M_{III}$        | 1.7472              | 2    | 7.0959  | 1.6822              | 2    | 7.3702                | $\gamma M_{III} v$             |                      |      |         | 7.546                | 8                  | 1.643        |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_2 L_{IV}N_{II}$        | 1.4764              | 2    | 8.398   | 1.42278             | 7    | 8.7140                | $\beta M_{IV}N_{VI}$           | 8.965                | 4    | 1.3830  | 8.592                | 3                  | 1.4430       |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{IV}N_{III}$       | 1.4718              | 2    | 8.423   | 1.41640             | 7    | 8.7532                | $\zeta M_VN_{III}$             | 11.86                | 1    | 1.0450  | 11.37                | 1                  | 1.0901       |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{IV}O_{II,III}$    | 1.4276              | 2    | 8.685   | 1.37459             | 7    | 9.0195                | $\alpha M_VN_{VI,VII}$         | 9.20                 | 2    | 1.348   | 8.82                 | 1                  | 1.406        |  |  |  |  |                   |  |  |  |  |  |
| $\eta L_{II}M_I$               | 1.9730              | 2    | 6.2839  | 1.89743             | 7    | 6.5342                | $N_{IV}N_{VI}$                 |                      |      |         | 72.7                 | 9                  | 0.171        |  |  |  |  |                   |  |  |  |  |  |
| $\beta_1 L_{II}M_{IV}$         | 1.7768              | 3    | 6.978   | 1.71062             | 7    | 7.2477                | $N_VN_{VI,VII}$                |                      |      |         | 76.3                 | 7                  | 0.163        |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{II}N_I$           | 1.5787              | 2    | 7.8535  | 1.51824             | 7    | 8.1661                |                                |                      |      |         |                      |                    |              |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_1 L_{II}N_{IV}$        | 1.5303              | 2    | 8.102   | 1.47266             | 7    | 8.4188                | 69 Thulium                     |                      |      |         |                      |                    | 70 Ytterbium |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{II}O_I$           | 1.5097              | 2    | 8.212   |                     |      |                       | $\alpha_2 KL_{II}$             | 0.249095             | 2    | 49.7726 | 0.241424             | 2                  | 51.3540      |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{II}O_{IV}$        | 1.5035              | 2    | 8.246   | 1.44579             | 7    | 8.5753                | $\alpha_1 KL_{III}$            | 0.244338             | 2    | 50.7416 | 0.236655             | 2                  | 52.3889      |  |  |  |  |                   |  |  |  |  |  |
| $l L_{III}M_I$                 | 2.2352              | 2    | 5.5467  | 2.15877             | 7    | 5.7431                | $\beta_4 KM_{II}$              | 0.21636              | 2    | 57.304  | 0.2096 <sup>†</sup>  | 1                  | 59.14        |  |  |  |  |                   |  |  |  |  |  |
| $\alpha_2 L_{III}M_{IV}$       | 1.9875              | 2    | 6.2380  | 1.91991             | 3    | 6.4577                | $\beta_1 KM_{III}$             | 0.21556              | 2    | 57.517  | 0.20884              | 8                  | 59.37        |  |  |  |  |                   |  |  |  |  |  |
| $\alpha_1 L_{III}M_V$          | 1.9765              | 2    | 6.2728  | 1.90881             | 3    | 6.4952                | $\beta_2 KN_{II,III}$          | 0.2098 <sup>†</sup>  | 2    | 59.09   | 0.2033 <sup>†</sup>  | 2                  | 60.98        |  |  |  |  |                   |  |  |  |  |  |
| $\beta_8 L_{III}N_I$           | 1.7422              | 2    | 7.1163  | 1.68213             | 7    | 7.3705                | $KO_{II,III}$                  | 0.20891              | 2    | 59.346  | 0.20226              | 2                  | 61.298       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_{2,10} L_{III}N_{IV,V}$ | 1.6830              | 2    | 7.3667  | 1.62369             | 7    | 7.6357                | $\beta_8 KM_{IV,V}$            | 0.21404              | 2    | 57.923  | 0.20739              | 2                  | 59.782       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_1 L_{III}O_I$           | 1.6585              | 2    | 7.4753  | 1.60447             | 7    | 7.7272                | $\beta_4 L_{IV}M_{II}$         | 1.5448               | 2    | 8.026   | 1.49138              | 3                  | 8.3132       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_3 L_{III}O_{IV,V}$      | 1.6510              | 2    | 7.5094  | 1.58837             | 7    | 7.8055                | $\beta_3 L_{IV}M_{III}$        | 1.5063               | 2    | 8.231   | 1.45233              | 5                  | 8.5367       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_{10} L_{IV}M_{IV}$      | 1.6673              | 3    | 7.436   | 1.60743             | 9    | 7.7130                | $\gamma_2 L_{IV}N_{II}$        | 1.2742               | 2    | 9.730   | 1.22879              | 7                  | 10.0897      |  |  |  |  |                   |  |  |  |  |  |
| $\beta_9 L_{IV}M_V$            |                     |      |         | 1.59973             | 9    | 7.7501                | $\gamma_4 L_{IV}N_{III}$       | 1.2678               | 2    | 9.779   | 1.22232              | 5                  | 10.1431      |  |  |  |  |                   |  |  |  |  |  |
| $L_{IV}O_{IV,V}$               | 1.4228              | 3    | 8.714   |                     |      |                       | $\gamma_4 L_{IV}O_{II,III}$    | 1.2294               | 2    | 10.084  | 1.1853               | 1                  | 10.4603      |  |  |  |  |                   |  |  |  |  |  |
| $\gamma M_{III}N_{IV,V}$       | 8.486               | 9    | 1.461   | 8.144               | 9    | 1.522                 | $\eta L_{II}M_I$               | 1.6963               | 2    | 7.3088  | 1.63560              | 5                  | 7.5802       |  |  |  |  |                   |  |  |  |  |  |
| $\beta M_{IV}N_{VI}$           | 9.792               | 6    | 1.2661  | 9.357               | 6    | 1.3250                | $\beta_1 L_{II}M_{IV}$         | 1.5304               | 2    | 8.101   | 1.47565              | 5                  | 8.4018       |  |  |  |  |                   |  |  |  |  |  |
| $\zeta M_VN_{III}$             | 12.98               | 2    | 0.955   | 12.43               | 2    | 0.998                 | $\gamma_4 L_{II}N_I$           | 1.3558               | 2    | 9.144   | 1.3063               | 1                  | 9.4910       |  |  |  |  |                   |  |  |  |  |  |
| $\alpha M_VN_{VI,VII}$         | 10.00               | 2    | 1.240   | 9.59                | 2    | 1.293                 | $\gamma_1 L_{II}N_{IV}$        | 1.3153               | 2    | 9.426   | 1.26769              | 5                  | 9.8701       |  |  |  |  |                   |  |  |  |  |  |
| $N_{IV,V}N_{VI,VII}$           | 86.                 | 1    | 0.144   | 83.                 | 1    | 0.149                 | $\gamma_4 L_{II}O_I$           |                      |      |         | 1.24923              | 5                  | 9.9246       |  |  |  |  |                   |  |  |  |  |  |
| $N_{IV,V}O_{II,III}$           | 102.2               | 4    | 0.1213  | 97.2                | 8    | 0.128                 | $\gamma_4 L_{II}O_{IV}$        | 1.2905               | 2    | 9.607   | 1.24271              | 3                  | 9.9766       |  |  |  |  |                   |  |  |  |  |  |
| 67 Holmium                     |                     |      |         |                     |      | 68 Erbium             |                                |                      |      |         |                      |                    |              |  |  |  |  |                   |  |  |  |  |  |
| $\alpha_2 KL_{II}$             | 0.265486            | 2    | 46.6997 | 0.257110            | 2    | 48.2211               | $l L_{III}M_I$                 | 1.9550               | 2    | 6.3419  | 1.89415              | 5                  | 6.5455       |  |  |  |  |                   |  |  |  |  |  |
| $\alpha_1 KL_{III}$            | 0.260756            | 2    | 47.5467 | 0.252365            | 2    | 49.1277               | $\alpha_2 L_{III}M_{IV}$       | 1.7381               | 2    | 7.1331  | 1.68285              | 5                  | 7.3673       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_4 KM_{II}$              | 0.23083             | 2    | 53.711  | 0.22341             | 2    | 55.494                | $\alpha_1 L_{III}M_V$          | 1.7268 <sup>†</sup>  | 2    | 7.1799  | 1.67189              | 4                  | 7.4156       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_1 KM_{III}$             | 0.23012             | 2    | 53.877  | 0.22266             | 2    | 55.681                | $\beta_8 L_{III}N_I$           | 1.5162               | 2    | 8.177   | 1.4661               | 1                  | 8.4563       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_2 KN_{II,III}$          | 0.2241 <sup>†</sup> | 2    | 55.32   | 0.2167 <sup>†</sup> | 2    | 57.21                 | $\beta_{2,10} L_{III}N_{IV,V}$ | 1.4640               | 2    | 8.468   | 1.41550              | 5                  | 8.7588       |  |  |  |  |                   |  |  |  |  |  |
| $KO_{II,III}$                  | 0.22305             | 3    | 55.584  | 0.21581             | 3    | 57.450                | $\beta_1 L_{III}O_I$           |                      |      |         | 1.3948               | 1                  | 8.8889       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_8 KM_{IV,V}$            | 0.22855             | 3    | 54.246  | 0.22124             | 3    | 56.040                | $\beta_3 L_{III}O_{IV,V}$      | 1.4349               | 2    | 8.641   | 1.38696              | 7                  | 8.9390       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_4 L_{IV}M_{II}$         | 1.6595              | 2    | 7.4708  | 1.6007              | 1    | 7.7453                | $\beta_{10} L_{IV}M_{IV}$      | 1.4410               | 3    | 8.604   | 1.3915               | 1                  | 8.9100       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_3 L_{IV}M_{III}$        | 1.6203              | 2    | 7.6519  | 1.5616              | 1    | 7.9392                | $\beta_3 L_{IV}M_V$            | 1.4336               | 3    | 8.648   | 1.3838               | 1                  | 8.9597       |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_2 L_{IV}N_{II}$        | 1.3698              | 2    | 9.051   | 1.3210              | 2    | 9.385                 | $L_{IV}O_I$                    |                      |      |         | 1.1886               | 1                  | 10.4312      |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{IV}N_{III}$       | 1.3643              | 2    | 9.087   | 1.3146              | 1    | 9.4309                | $L_{IV}O_{IV,V}$               | 1.2263               | 3    | 10.110  | 1.1827               | 1                  | 10.4833      |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{IV}O_{II,III}$    | 1.3225              | 2    | 9.374   | 1.2752              | 2    | 9.722                 | $L_{II}M_{II}$                 |                      |      |         | 1.58844              | 9                  | 7.8052       |  |  |  |  |                   |  |  |  |  |  |
| $\eta L_{II}M_I$               | 1.8264              | 2    | 6.7883  | 1.7566              | 1    | 7.0579                | $L_{II}O_{II,III}$             |                      |      |         | 1.2453               | 1                  | 9.9561       |  |  |  |  |                   |  |  |  |  |  |
| $\beta_1 L_{II}M_{IV}$         | 1.6475              | 2    | 7.5253  | 1.5873              | 1    | 7.8109                | $l L_{III}M_{II}$              |                      |      |         | 1.83091              | 9                  | 6.7715       |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{II}N_I$           | 1.4618              | 2    | 8.481   | 1.4067              | 3    | 8.814                 | $L_{III}O_{II,III}$            |                      |      |         | 1.3898               | 1                  | 8.9209       |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_1 L_{II}N_{IV}$        | 1.4174              | 2    | 8.747   | 1.3641              | 2    | 9.089                 | $M_{III}N_I$                   |                      |      |         | 8.470                | 9                  | 1.464        |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{II}O_I$           | 1.3983              | 2    | 8.867   |                     |      |                       | $\gamma M_{III}N_V$            |                      |      |         | 7.024                | 8                  | 1.765        |  |  |  |  |                   |  |  |  |  |  |
| $\gamma_4 L_{II}O_{IV}$        | 1.3923              | 2    | 8.905   | 1.3397              | 3    | 9.255                 | $\beta M_{IV}N_{VI}$           | 8.249                | 7    | 1.503   | 7.909                | 2                  | 1.5675       |  |  |  |  |                   |  |  |  |  |  |
| $l L_{III}M_I$                 | 2.0860              | 2    | 5.9434  | 2.015               | 1    | 6.152                 | $\zeta M_VN_{III}$             |                      |      |         | 10.48                | 1                  | 1.183        |  |  |  |  |                   |  |  |  |  |  |
| $\alpha_2 L_{III}M_{IV}$       | 1.8561              | 2    | 6.6795  | 1.7955              | 2    | 6.9050                | $\alpha M_VN_{VI,VII}$         | 8.48                 | 1    | 1.462   | 8.149                | 5                  | 1.5214       |  |  |  |  |                   |  |  |  |  |  |
| $\alpha_1 L_{III}M_V$          | 1.8450              | 2    | 6.7198  | 1.78425             | 9    | 6.9487                | $N_{IV}N_{VI}$                 |                      |      |         | 65.1                 | 7                  | 0.190        |  |  |  |  |                   |  |  |  |  |  |
| $\beta_8 L_{III}N_I$           | 1.6237              | 2    | 7.6359  | 1.5675              | 2    | 7.909                 | $N_VN_{VI,VII}$                |                      |      |         | 69.3                 | 5                  | 0.179        |  |  |  |  |                   |  |  |  |  |  |
| $\beta_{2,10} L_{III}N_{IV,V}$ | 1.5671              | 2    | 7.911   | 1.51399             | 9    | 8.1890                | 71 Lutetium                    |                      |      |         |                      |                    | 72 Hafnium   |  |  |  |  |                   |  |  |  |  |  |
| $\beta_1 L_{III}O_I$           |                     |      |         | 1.4941              | 3    | 8.298                 | $\alpha_2 KL_{II}$             | 0.234081             | 2    | 52.9650 | 0.227024             | 3                  | 54.6114      |  |  |  |  |                   |  |  |  |  |  |
| $\beta_4 L_{III}O_{IV,V}$      | 1.5378              | 2    | 8.062   | 1.4848              | 3    | 8.350                 | $\alpha_1 KL_{III}$            | 0.229298             | 2    | 54.0698 | 0.222227             | 3                  | 55.7902      |  |  |  |  |                   |  |  |  |  |  |
|                                |                     |      |         |                     |      |                       | $\beta_4 KM_{II}$              | 0.20309 <sup>†</sup> | 4    | 61.05   | 0.19686 <sup>†</sup> | 4                  | 62.98        |  |  |  |  |                   |  |  |  |  |  |



*X-Ray Wavelengths*  
TABLE A (Continued)

| Designation                | $\lambda^*$          | p.e. | keV     | $\lambda^*$          | p.e.   | keV                | Designation                | $\lambda^*$ | p.e. | keV     | $\lambda^*$ | p.e.                | keV     |  |  |  |  |                     |  |  |  |  |  |
|----------------------------|----------------------|------|---------|----------------------|--------|--------------------|----------------------------|-------------|------|---------|-------------|---------------------|---------|--|--|--|--|---------------------|--|--|--|--|--|
| 71 Lutetium (Cont.)        |                      |      |         |                      |        | 72 Hafnium (Cont.) |                            |             |      |         |             | 73 Tantalum (Cont.) |         |  |  |  |  | 74 Tungsten (Cont.) |  |  |  |  |  |
| $\beta_1 KM_{III}$         | 0.20231 <sup>†</sup> | 3    | 61.283  | 0.19607 <sup>†</sup> | 3      | 63.234             | $KO_{II,III}$              | 0.184031    | 7    | 67.370  | 0.178444    | 5                   | 69.479  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_2 KN_{II,III}$      | 0.1969 <sup>†</sup>  | 2    | 62.97   | 0.1908 <sup>†</sup>  | 2      | 64.98              | $KL_I$                     |             |      |         | 0.21592     | 4                   | 57.42   |  |  |  |  |                     |  |  |  |  |  |
| $KO_{II,III}$              | 0.19589              | 2    | 63.293  |                      |        |                    | $\beta_2^{II} KM_{IV}$     | 0.188920    | 6    | 65.626  | 0.183264    | 5                   | 67.652  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_3 KM_{IV,V}$        | 0.20084              | 2    | 61.732  |                      |        |                    | $\beta_3^{II} KM_V$        | 0.188757    | 6    | 65.683  | 0.183092    | 7                   | 67.715  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_4 L_1M_{II}$        | 1.44056              | 5    | 8.6064  | 1.39220              | 5      | 8.9054             | $\beta_3 KN_{IV,V}$        | 0.18451     | 1    | 67.194  | 0.17892     | 2                   | 69.294  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_5 L_1M_{III}$       | 1.40140              | 5    | 8.8469  | 1.35300              | 5      | 9.1634             | $\beta_4 L_1M_{II}$        | 1.34581     | 3    | 9.2124  | 1.30162     | 5                   | 9.5255  |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_2 L_1N_{II}$       | 1.1853               | 2    | 10.460  | 1.14442              | 5      | 10.8335            | $\beta_5 L_1M_{III}$       | 1.30678     | 3    | 9.4875  | 1.26269     | 5                   | 9.8188  |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_3 L_1N_{III}$      | 1.17953              | 4    | 10.5110 | 1.13841              | 5      | 10.8907            | $\gamma_2 L_1N_{II}$       | 1.1053      | 1    | 11.217  | 1.06806     | 3                   | 11.6080 |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_4 L_1O_{II}$       |                      |      |         | 1.10376              | 5      | 11.2326            | $\gamma_3 L_1N_{III}$      | 1.09936     | 4    | 11.2776 | 1.06200     | 6                   | 11.6743 |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_5 L_1O_{II,III}$   | 1.1435               | 1    | 10.8425 | 1.10303              | 5      | 11.2401            | $\gamma_4 L_1O_{II}$       | 1.06544     | 3    | 11.6366 | 1.02863     | 3                   | 12.0530 |  |  |  |  |                     |  |  |  |  |  |
| $\eta L_{II}M_I$           | 1.5779               | 1    | 7.8575  | 1.52325              | 5      | 8.1393             | $\gamma_5 L_1O_{III}$      | 1.06467     | 3    | 11.6451 | 1.02775     | 3                   | 12.0634 |  |  |  |  |                     |  |  |  |  |  |
| $\beta_1 L_{III}M_{IV}$    | 1.42359              | 3    | 8.7090  | 1.37410              | 5      | 9.0227             | $\eta L_{II}M_I$           | 1.47106     | 5    | 8.4280  | 1.42110     | 3                   | 8.7243  |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_5 L_{II}N_I$       | 1.2596               | 1    | 9.8428  | 1.21537              | 5      | 10.2011            | $\beta_1 L_{III}M_{IV}$    | 1.32698     | 3    | 9.3431  | 1.281809    | 9                   | 9.67235 |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_1 L_{III}N_{IV}$   | 1.22228              | 4    | 10.1434 | 1.17900              | 5      | 10.5158            | $\gamma_5 L_{II}N_I$       | 1.1729      | 1    | 10.5702 | 1.13235     | 3                   | 10.9490 |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_8 L_{II}O_I$       | 1.2047               | 1    | 10.2915 | 1.16138              | 5      | 10.6754            | $\gamma_1 L_{III}N_{IV}$   | 1.13794     | 3    | 10.8952 | 1.09855     | 3                   | 11.2859 |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_5 L_{III}O_{IV}$   | 1.1987               | 1    | 10.3431 | 1.15519              | 5      | 10.7325            | $\gamma_8 L_{II}O_I$       | 1.1205      | 1    | 11.0646 | 1.08113     | 4                   | 11.4677 |  |  |  |  |                     |  |  |  |  |  |
| $l L_{III}M_I$             | 1.8360               | 1    | 6.7528  | 1.78145              | 5      | 6.9596             | $\gamma_5 L_{III}O_{IV}$   | 1.11388     | 3    | 11.1306 | 1.07448     | 5                   | 11.5387 |  |  |  |  |                     |  |  |  |  |  |
| $\alpha_2 L_{III}M_{IV}$   | 1.63029              | 5    | 7.6049  | 1.58046              | 5      | 7.8446             | $l L_{III}M_I$             | 1.72841     | 5    | 7.1731  | 1.6782      | 1                   | 7.3878  |  |  |  |  |                     |  |  |  |  |  |
| $\alpha_1 L_{III}M_{IV}$   | 1.61951              | 3    | 7.6555  | 1.56958              | 5      | 7.8990             | $\alpha_2 L_{III}M_{IV}$   | 1.53293     | 2    | 8.0879  | 1.48743     | 2                   | 8.3352  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_5 L_{III}N_I$       | 1.4189               | 1    | 8.7376  | 1.37410              | 5      | 9.0227             | $\alpha_1 L_{III}M_{IV}$   | 1.52197     | 2    | 8.1461  | 1.47639     | 2                   | 8.3976  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_{15} L_{III}N_{IV}$ | 1.3715               | 1    | 9.0395  | 1.32783              | 5      | 9.3371             | $\beta_5 L_{III}N_I$       | 1.33094     | 8    | 9.3153  | 1.28989     | 7                   | 9.6117  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_3 L_{III}N_V$       | 1.37012              | 3    | 9.0489  | 1.32639              | 5      | 9.3473             | $\beta_{15} L_{III}N_{IV}$ | 1.28619     | 5    | 9.6394  | 1.24631     | 3                   | 9.9478  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_1 L_{III}O_I$       | 1.34949              | 5    | 9.1873  | 1.30564              | 5      | 9.4958             | $\beta_3 L_{III}N_V$       | 1.28454     | 2    | 9.6518  | 1.24460     | 3                   | 9.9615  |  |  |  |  |                     |  |  |  |  |  |
| $\beta_5 L_{III}O_{IV,V}$  | 1.34183              | 7    | 9.2397  | 1.29761              | 5      | 9.5546             | $\beta_1 L_{III}O_I$       | 1.26385     | 5    | 9.8098  | 1.22400     | 4                   | 10.1292 |  |  |  |  |                     |  |  |  |  |  |
| $L_1M_I$                   |                      |      |         | 1.43025              | 9      | 8.6685             | $\beta_5 L_{III}O_{IV,V}$  | 1.2555      | 1    | 9.8750  | 1.21545     | 3                   | 10.2004 |  |  |  |  |                     |  |  |  |  |  |
| $\beta_{10} L_1M_{IV}$     | 1.3430               | 2    | 9.232   | 1.29819              | 9      | 9.5503             | $L_1M_I$                   |             |      |         | 1.3365      | 3                   | 9.277   |  |  |  |  |                     |  |  |  |  |  |
| $\beta_5 L_1M_V$           | 1.3358               | 1    | 9.2816  | 1.29025              | 9      | 9.6090             | $\beta_{10} L_1M_{IV}$     | 1.2537      | 2    | 9.889   | 1.21218     | 3                   | 10.2279 |  |  |  |  |                     |  |  |  |  |  |
| $L_1N_{IV}$                | 1.16227              | 9    | 10.6672 | 1.12250              | 9      | 11.0451            | $\beta_5 L_1M_V$           | 1.2466      | 2    | 9.946   | 1.20479     | 7                   | 10.2907 |  |  |  |  |                     |  |  |  |  |  |
| $\gamma_{11} L_1N_V$       | 1.16107              | 9    | 10.6782 | 1.12146              | 9      | 11.0553            | $L_1N_I$                   | 1.11521     | 9    | 11.1173 |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
| $L_1O_I$                   |                      |      |         | 1.10664              | 9      | 11.2034            | $L_1N_{IV}$                | 1.08377     | 7    | 11.4398 | 1.0468      | 2                   | 11.844  |  |  |  |  |                     |  |  |  |  |  |
| $L_1O_{IV}$                |                      |      |         | 1.10086              | 9      | 11.2622            | $\gamma_{11} L_1N_V$       | 1.08205     | 7    | 11.4580 | 1.0458      | 1                   | 11.856  |  |  |  |  |                     |  |  |  |  |  |
| $L_{II}M_{II}$             | 1.53333              | 9    | 8.0858  | 1.48064              | 9      | 8.3735             | $L_{II}N_{VI,VII}$         | 1.06357     | 9    | 11.6570 |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
| $\beta_{17} L_{II}M_{III}$ |                      |      |         | 1.43643              | 9      | 8.6312             | $L_1O_I$                   | 1.06771     | 9    | 11.6118 | 1.0317      | 3                   | 12.017  |  |  |  |  |                     |  |  |  |  |  |
| $L_{II}N_V$                |                      |      |         | 1.17788              | 9      | 10.5258            | $L_1O_{IV,V}$              | 1.06192     | 9    | 11.6752 | 1.0250      | 2                   | 12.095  |  |  |  |  |                     |  |  |  |  |  |
| $v L_{II}N_{VI}$           |                      |      |         | 1.15830              | 9      | 10.7037            | $L_{II}M_{II}$             | 1.43048     | 9    | 8.6671  |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
| $L_{II}O_{II,III}$         |                      |      |         |                      |        |                    | $\beta_{17} L_{II}M_{III}$ | 1.3864      | 1    | 8.9428  | 1.3387      | 2                   | 9.261   |  |  |  |  |                     |  |  |  |  |  |
| $t L_{II}M_{II}$           | 1.2014               | 1    | 10.3198 | 1.72305              | 9      | 7.1954             | $L_{II}M_{IV}$             | 1.31897     | 9    | 9.3998  | 1.2728      | 2                   | 9.741   |  |  |  |  |                     |  |  |  |  |  |
| $s L_{II}M_{III}$          | 1.7760               | 1    | 6.9810  | 1.66346              | 9      | 7.4532             | $L_{II}N_{II}$             | 1.1600      | 2    | 10.688  | 1.1218      | 3                   | 11.052  |  |  |  |  |                     |  |  |  |  |  |
| $L_{III}N_{II}$            |                      |      |         | 1.35887              | 9      | 9.1239             | $L_{II}N_{III}$            | 1.1553      | 1    | 10.7316 | 1.1149      | 2                   | 11.120  |  |  |  |  |                     |  |  |  |  |  |
| $L_{III}N_{III}$           |                      |      |         | 1.35053              | 9      | 9.1802             | $L_{II}N_V$                | 1.13687     | 9    | 10.9055 |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
| $u L_{III}N_{VI,VII}$      |                      |      |         | 1.30165              | 9      | 9.5249             | $v L_{II}N_{VI}$           | 1.1158      | 1    | 11.1113 | 1.0771      | 1                   | 11.510  |  |  |  |  |                     |  |  |  |  |  |
| $L_{III}O_{II,III}$        | 1.34524              | 9    | 9.2163  |                      |        |                    | $L_{II}O_{II}$             | 1.11789     | 9    | 11.0907 |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
| $M_{III}N_I$               |                      |      |         | 7.887                | 9      | 1.572              | $L_{II}O_{III}$            | 1.11693     | 9    | 11.1001 | 1.0792      | 2                   | 11.488  |  |  |  |  |                     |  |  |  |  |  |
| $\gamma M_{III}N_V$        | 6.768                | 6    | 1.832   | 6.544                | 4      | 1.895              | $t L_{III}M_{II}$          | 1.67265     | 9    | 7.4123  | 1.6244      | 3                   | 7.632   |  |  |  |  |                     |  |  |  |  |  |
| $\xi_3$                    |                      |      |         | 9.686                | 7      | 1.2800             | $s L_{III}M_{III}$         | 1.61264     | 9    | 7.6881  | 1.5642      | 3                   | 7.926   |  |  |  |  |                     |  |  |  |  |  |
| $\beta M_{IV,N_{VI}}$      | 7.601                | 2    | 1.6312  | 7.303                | 1      | 1.6976             | $L_{III}N_{II}$            | 1.3167      | 1    | 9.4158  | 1.2765      | 2                   | 9.712   |  |  |  |  |                     |  |  |  |  |  |
| $\xi_1$                    |                      |      |         | 9.686                | 7      | 1.2800             | $L_{III}N_{III}$           | 1.3086      | 1    | 9.4742  | 1.2672      | 2                   | 9.784   |  |  |  |  |                     |  |  |  |  |  |
| $\alpha M_V,N_{VI,VII}$    | 7.840                | 2    | 1.5813  | 7.539                | 1      | 1.6446             | $u L_{III}N_{VI,VII}$      | 1.25778     | 4    | 9.8572  | 1.21868     | 5                   | 10.1733 |  |  |  |  |                     |  |  |  |  |  |
| $N_{IV}N_{VI}$             | 63.0                 | 5    | 0.197   |                      |        |                    | $L_{III}O_{II,III}$        | 1.2601      | 3    | 9.839   | 1.2211      | 2                   | 10.153  |  |  |  |  |                     |  |  |  |  |  |
| $N_VN_{VI,VII}$            | 65.7                 | 2    | 0.1886  |                      |        |                    | $M_I N_{III}$              | 5.40        | 2    | 2.295   | 5.172       | 9                   | 2.397   |  |  |  |  |                     |  |  |  |  |  |
| 73 Tantalum                |                      |      |         |                      |        | 74 Tungsten        |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
| $\alpha_2 KL_{II}$         | 0.220305             | 8    | 56.277  | 0.213828             | 2      | 57.9817            | $M_I O_{II,III}$           |             |      |         | 4.44        | 2                   | 2.79    |  |  |  |  |                     |  |  |  |  |  |
| $\alpha_1 KL_{III}$        | 0.215497             | 4    | 57.532  | 0.2090100            | Std 59 | 31824              | $M_{II}N_I$                | 5.570       | 4    | 2.226   | 6.28        | 2                   | 1.973   |  |  |  |  |                     |  |  |  |  |  |
| $\beta_3 KM_{II}$          | 0.190890             | 2    | 64.9488 | 0.185181             | 2      | 66.9514            | $M_{II}N_{IV}$             | 7.612       | 9    | 1.629   | 5.357       | 4                   | 2.314   |  |  |  |  |                     |  |  |  |  |  |
| $\beta_1 KM_{III}$         | 0.190089             | 4    | 65.223  | 0.184374             | 2      | 67.2443            | $M_{III}N_I$               | 6.353       | 5    | 1.951   | 7.360       | 8                   | 1.684   |  |  |  |  |                     |  |  |  |  |  |
| $\beta_2^{II} KN_{II}$     | 0.185188             | 9    | 66.949  | 0.17960              | 1      | 69.031             | $M_{III}N_{IV}$            | 6.312       | 4    | 1.964   | 6.134       | 4                   | 2.021   |  |  |  |  |                     |  |  |  |  |  |
| $\beta_2^{II} KN_{III}$    | 0.185011             | 8    | 67.013  | 0.179421             | 7      | 69.101             | $\gamma M_{III}N_V$        | 5.83        | 2    | 2.126   | 6.092       | 3                   | 2.035   |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |
|                            |                      |      |         |                      |        |                    |                            |             |      |         |             |                     |         |  |  |  |  |                     |  |  |  |  |  |



*X-Ray Wavelengths*  
TABLE A (Continued)

| Designation                 | Å*       | p.e. | keV     | Å*        | p.e. | keV                 | Designation                 | Å*                 | p.e.  | keV     | Å*          | p.e.              | keV     |       |
|-----------------------------|----------|------|---------|-----------|------|---------------------|-----------------------------|--------------------|-------|---------|-------------|-------------------|---------|-------|
| 73 Tantalum (Cont.)         |          |      |         |           |      | 74 Tungsten (Cont.) |                             | 75 Rhenium (Cont.) |       |         |             | 76 Osmium (Cont.) |         |       |
| $\zeta_2 M_{IV}N_{II}$      | 9.330    | 5    | 1.3288  | 8.993     | 5    | 1.3787              | $L_{II}M_V$                 | 1.2305             | 1     | 10.0753 | 1.18977     | 7                 | 10.4205 |       |
| $M_{IV}N_{III}$             | 8.90     | 2    | 1.393   | 8.573     | 8    | 1.446               | $L_{II}N_{II}$              | 1.0839             | 1     | 11.438  |             |                   |         |       |
| $\beta M_{IV}N_{VI}$        | 7.023    | 1    | 1.7655  | 6.757     | 1    | 1.8349              | $L_{II}N_{III}$             | 1.0767             | 1     | 11.515  | 1.03973     | 5                 | 11.9243 |       |
| $M_{IV}O_{II}$              | 7.09     | 2    | 1.748   | 6.806     | 9    | 1.822               | $v L_{II}N_{VI}$            | 1.0404             | 1     | 11.917  | 1.0050      | 2                 | 12.337  |       |
| $\zeta_1 M_VN_{III}$        | 9.316    | 4    | 1.3308  | 8.962     | 4    | 1.3835              | $L_{II}O_{III}$             | 1.0397             | 1     | 11.925  | 1.0047      | 2                 | 12.340  |       |
| $\alpha M_VN_{VI,VII}$      | 7.252    | 1    | 1.7096  |           |      |                     | $i L_{III}M_{II}$           | 1.5789             | 1     | 7.8525  | 1.5347      | 2                 | 8.079   |       |
| $\alpha_2 M_VN_{VI}$        |          |      |         | 6.992     | 2    | 1.7731              | $s L_{III}M_{III}$          | 1.5178             | 1     | 8.1682  | 1.4735      | 2                 | 8.414   |       |
| $\alpha_1 M_VN_{VII}$       |          |      |         | 6.983     | 1    | 1.7754              | $L_{III}N_I$                |                    |       |         | 1.20086     | 7                 | 10.3244 |       |
| $M_VO_{III}$                | 7.30     | 2    | 1.700   | 7.005     | 9    | 1.770               | $L_{III}N_{III}$            | 1.2283             | 1     | 10.0933 |             |                   |         |       |
| $N_{II}N_{IV}$              |          |      |         | 54.0      | 2    | 0.2295              | $u L_{III}N_{VI,VII}$       | 1.1815             | 1     | 10.4931 | 1.14537     | 7                 | 10.8245 |       |
| $N_{IV}N_{VI}$              | 58.2     | 1    | 0.2130  | 55.8      | 1    | 0.2221              | $M_I N_{III}$               |                    |       |         | 4.79        | 2                 | 2.59    |       |
| $N_VN_{VI,VII}$             | 61.1     | 2    | 0.2028  |           |      |                     | $M_{II}N_I$                 |                    |       |         | 5.81        | 2                 | 2.133   |       |
| $N_VN_{VI}$                 |          |      |         | 59.5      | 3    | 0.208               | $M_{II}N_{IV}$              |                    |       |         | 4.955       | 4                 | 2.502   |       |
| $N_VN_{VII}$                |          |      |         | 58.4      | 1    | 0.2122              | $M_{III}N_I$                |                    |       |         | 6.89        | 2                 | 1.798   |       |
| 75 Rhenium                  |          |      |         | 76 Osmium |      |                     |                             | $M_{III}N_{IV}$    | 5.931 | 5       | 2.090       | 5.724             | 5       | 2.166 |
| $\alpha_2 K L_{II}$         | 0.207611 | 1    | 59.7179 | 0.201639  | 2    | 61.4867             | $\gamma M_{III}N_V$         | 5.885              | 2     | 2.1067  | 5.682       | 4                 | 2.182   |       |
| $\alpha_1 K L_{III}$        | 0.202781 | 2    | 61.1403 | 0.196794  | 2    | 63.0005             | $\zeta_2 M_{IV}N_{II}$      | 8.664              | 5     | 1.4310  | 8.359       | 5                 | 1.4831  |       |
| $\beta_2 K M_{II}$          | 0.179697 | 3    | 68.994  | 0.174431  | 3    | 71.077              | $M_{IV}N_{III}$             | 8.239              | 8     | 1.505   |             |                   |         |       |
| $\beta_1 K M_{III}$         | 0.178880 | 3    | 69.310  | 0.173611  | 3    | 71.413              | $\beta M_{IV}N_{VI}$        | 6.504              | 1     | 1.9061  | 6.267       | 1                 | 1.9783  |       |
| $\beta_2^{II} K N_{II}$     | 0.17425  | 1    | 71.151  | 0.16910   | 1    | 73.318              | $\zeta_1 M_VN_{III}$        | 8.629              | 4     | 1.4368  | 8.310       | 4                 | 1.4919  |       |
| $\beta_2^I K N_{III}$       | 0.174054 | 6    | 71.232  | 0.168906  | 6    | 73.402              | $\alpha M_VN_{VI,VII}$      | 6.729              | 1     | 1.8425  | 6.490       | 1                 | 1.9102  |       |
| $K O_{II,III}$              | 0.17308  | 1    | 71.633  | 0.16798   | 1    | 73.808              | $N_{IV}N_{VI}$              |                    |       |         | 51.9        | 1                 | 0.2388  |       |
| $\beta_2^{II} K M_{IV}$     | 0.17783  | 1    | 69.719  | 0.17262   | 1    | 71.824              | $N_VN_{VI,VII}$             |                    |       |         | 54.7        | 2                 | 0.2266  |       |
| $\beta_2^I K M_V$           | 0.17766  | 1    | 69.786  | 0.17245   | 1    | 71.895              | 77 Iridium                  |                    |       |         | 78 Platinum |                   |         |       |
| $\beta_1 K N_{IV,V}$        | 0.17362  | 2    | 71.410  | 0.16842   | 2    | 73.615              | $\alpha_2 K L_{II}$         | 0.195904           | 2     | 63.2867 | 0.190381    | 4                 | 65.122  |       |
| $\beta_4 L_I M_{II}$        | 1.25917  | 5    | 9.8463  | 1.21844   | 5    | 10.1754             | $\alpha_1 K L_{III}$        | 0.191047           | 2     | 64.8956 | 0.185511    | 4                 | 66.832  |       |
| $\beta_3 L_I M_{III}$       | 1.22031  | 5    | 10.1598 | 1.17955   | 7    | 10.5108             | $\beta_2 K M_{II}$          | 0.169367           | 2     | 73.2027 | 0.164501    | 3                 | 75.368  |       |
| $\gamma_2 L_I N_{II}$       | 1.03233  | 5    | 12.0098 | 0.99805   | 5    | 12.4224             | $\beta_1 K M_{III}$         | 0.168542           | 2     | 73.5608 | 0.163675    | 3                 | 75.748  |       |
| $\gamma_2 L_I N_{III}$      | 1.02613  | 7    | 12.0824 | 0.99186   | 5    | 12.4998             | $\beta_2^{II} K N_{II}$     | 0.16415            | 1     | 75.529  | 0.15939     | 1                 | 77.785  |       |
| $\gamma_4 L_I O_{II}$       | 0.99334  | 5    | 12.4813 | 0.96033   | 8    | 12.910              | $\beta_2^I K N_{III}$       | 0.163956           | 7     | 75.619  | 0.15920     | 1                 | 77.878  |       |
| $\gamma_4 L_I O_{III}$      | 0.99249  | 5    | 12.4920 | 0.95938   | 8    | 12.923              | $K O_{II,III}$              | 0.163019           | 5     | 76.053  | 0.15826     | 1                 | 78.341  |       |
| $\eta L_{II} M_I$           | 1.37342  | 5    | 9.0272  | 1.32785   | 7    | 9.3370              | $\beta_2^{II} K M_{IV}$     | 0.16759            | 2     | 73.980  | 0.16271     | 2                 | 76.199  |       |
| $\beta_1 L_{II} M_{IV}$     | 1.23858  | 2    | 10.0100 | 1.19727   | 7    | 10.3553             | $\beta_2^I K M_V$           | 0.167373           | 9     | 74.075  | 0.16255     | 3                 | 76.27   |       |
| $\gamma_2 L_{II} N_I$       | 1.09388  | 5    | 11.3341 | 1.05693   | 5    | 11.7303             | $\beta_1 K N_{IV,V}$        | 0.16352            | 2     | 75.821  | 0.15881     | 2                 | 78.069  |       |
| $\gamma_1 L_{II} N_{IV}$    | 1.06099  | 5    | 11.6854 | 1.02503   | 5    | 12.0953             | $\beta_4 L_I M_{II}$        | 1.17958            | 3     | 10.5106 | 1.14223     | 5                 | 10.8543 |       |
| $\gamma_2 L_{II} O_I$       | 1.04398  | 5    | 11.8758 | 1.00788   | 5    | 12.3012             | $\beta_3 L_I M_{III}$       | 1.14085            | 3     | 10.8674 | 1.10394     | 5                 | 11.2308 |       |
| $\gamma_2 L_{II} O_{IV}$    | 1.03699  | 9    | 11.956  | 1.00107   | 5    | 12.3848             | $\gamma_2 L_I N_{II}$       | 0.96545            | 3     | 12.8418 | 0.93427     | 5                 | 13.2704 |       |
| $i L_{III} M_I$             | 1.63056  | 5    | 7.6036  | 1.58498   | 7    | 7.8222              | $\gamma_2 L_I N_{III}$      | 0.95931            | 5     | 12.9240 | 0.92791     | 5                 | 13.3613 |       |
| $\alpha_2 L_{III} M_{IV}$   | 1.44396  | 5    | 8.5862  | 1.40234   | 5    | 8.8410              | $\gamma_4 L_I O_{II}$       | 0.92831            | 3     | 13.3555 | 0.89747     | 4                 | 13.8145 |       |
| $\alpha_1 L_{III} M_V$      | 1.43290  | 4    | 8.6525  | 1.39121   | 5    | 8.9117              | $\gamma_4 L_I O_{III}$      | 0.92744            | 3     | 13.3681 | 0.89659     | 4                 | 13.8281 |       |
| $\beta_2 L_{III} N_I$       | 1.25100  | 5    | 9.9105  | 1.21349   | 5    | 10.2169             | $\eta L_{II} M_I$           | 1.28448            | 3     | 9.6522  | 1.2429      | 2                 | 9.975   |       |
| $\beta_{18} L_{III} N_{IV}$ | 1.20819  | 5    | 10.2617 | 1.17167   | 5    | 10.5816             | $\beta_1 L_{II} M_{IV}$     | 1.15781            | 3     | 10.7083 | 1.11990     | 2                 | 11.0707 |       |
| $\beta_2 L_{III} N_V$       | 1.20660  | 4    | 10.2752 | 1.16979   | 8    | 10.5985             | $\gamma_2 L_{II} N_I$       | 1.02175            | 5     | 12.1342 | 0.9877      | 2                 | 12.552  |       |
| $\beta_7 L_{III} O_I$       | 1.18610  | 5    | 10.4529 | 1.14933   | 8    | 10.7872             | $\gamma_1 L_{II} N_{IV}$    | 0.99085            | 3     | 12.5126 | 0.95797     | 3                 | 12.9420 |       |
| $\beta_2 L_{III} O_{IV,V}$  | 1.17721  | 5    | 10.5318 | 1.1405    | 1    | 10.8711             | $\gamma_2 L_{II} O_I$       | 0.97409            | 3     | 12.7279 | 0.9411      | 1                 | 13.173  |       |
| $\beta_{10} L_I M_{IV}$     | 1.17218  | 5    | 10.5770 | 1.13353   | 5    | 10.9376             | $\gamma_2 L_{II} O_{IV}$    | 0.96708            | 4     | 12.8201 | 0.9342      | 2                 | 13.271  |       |
| $\beta_9 L_I M_V$           | 1.16487  | 4    | 10.6433 | 1.12637   | 6    | 11.0071             | $i L_{III} M_I$             | 1.54094            | 3     | 8.0458  | 1.4995      | 2                 | 8.268   |       |
| $L_I N_I$                   | 1.0420   | 1    | 11.899  |           |      |                     | $\alpha_2 L_{III} M_{IV}$   | 1.36250            | 5     | 9.0995  | 1.32432     | 2                 | 9.3618  |       |
| $L_I N_{IV}$                | 1.0119   | 1    | 12.252  | 0.9772    | 3    | 12.687              | $\alpha_1 L_{III} M_V$      | 1.35128            | 3     | 9.1751  | 1.31304     | 3                 | 9.4423  |       |
| $\gamma_{11} L_I N_V$       | 1.0108   | 1    | 12.266  | 0.9765    | 3    | 12.696              | $\beta_2 L_{III} N_I$       | 1.17796            | 3     | 10.5251 | 1.14355     | 5                 | 10.8418 |       |
| $L_I O_I$                   | 0.9965   | 1    | 12.442  | 0.96318   | 7    | 12.8721             | $\beta_{18} L_{III} N_{IV}$ | 1.13707            | 3     | 10.9036 |             |                   |         |       |
| $L_I O_{IV,V}$              | 0.9900   | 1    | 12.524  | 0.95603   | 5    | 12.9683             | $\beta_2 L_{III} N_V$       | 1.13532            | 3     | 10.9203 | 1.10200     | 3                 | 11.2505 |       |
| $L_{II} M_{II}$             | 1.3366   | 1    | 9.2761  | 1.2934    | 2    | 9.586               | $\beta_7 L_{III} O_I$       | 1.11489            | 3     | 11.1205 | 1.08168     | 3                 | 11.4619 |       |
| $\beta_{17} L_{II} M_{III}$ | 1.2927   | 1    | 9.5910  | 1.2480    | 2    | 9.934               |                             |                    |       |         |             |                   |         |       |

*X-Ray Wavelengths*  
TABLE A (Continued)

| Designation                | Å*                 | p.e. | keV     | Å*       | p.e. | keV                 | Designation                | Å*                  | p.e.   | keV     | Å*                  | p.e.               | keV     |  |
|----------------------------|--------------------|------|---------|----------|------|---------------------|----------------------------|---------------------|--------|---------|---------------------|--------------------|---------|--|
| 77 Iridium (Cont.)         |                    |      |         |          |      | 78 Platinum (Cont.) |                            | 79 Gold (Cont.)     |        |         |                     | 80 Mercury (Cont.) |         |  |
| $\beta_8 L_{III}O_{IV,V}$  | 1.10585            | 3    | 11.2114 | 1.0724   | 2    | 11.561              | $\gamma_8 L_{II}N_{II}$    | 0.90434             | 3      | 13.7095 | 0.87544             | 7                  | 14.162  |  |
| $L_{II}M_I$                | 1.2102             | 2    | 10.245  | 1.16962  | 9    | 10.6001             | $\gamma_8 L_{II}N_{III}$   | 0.89783             | 5      | 13.8090 | 0.86915             | 7                  | 14.265  |  |
| $\beta_{10} L_{II}M_{IV}$  | 1.09702            | 4    | 11.3016 | 1.06183  | 7    | 11.6762             | $\gamma_8 L_{II}O_{II}$    | 0.86816             | 4      | 14.2809 | 0.84013             | 7                  | 14.757  |  |
| $\beta_8 L_{II}M_V$        | 1.08975            | 5    | 11.3770 | 1.05446  | 5    | 11.7577             | $\gamma_8 L_{II}O_{III}$   | 0.86703             | 4      | 14.2996 | 0.83894             | 7                  | 14.778  |  |
| $L_{II}N_I$                | 0.9766             | 2    | 12.695  | 0.9455   | 2    | 13.113              | $\eta L_{II}M_I$           | 1.20273             | 3      | 10.3083 | 1.1640              | 1                  | 10.6512 |  |
| $L_{II}N_{IV}$             | 0.9459             | 2    | 13.108  |          |      |                     | $\beta_1 L_{II}M_{IV}$     | 1.08353             | 3      | 11.4423 | 1.04868             | 5                  | 11.8226 |  |
| $\gamma_{II} L_{II}N_V$    | 0.9446             | 2    | 13.126  | 0.9143   | 2    | 13.560              | $\gamma_8 L_{II}N_I$       | 0.95559             | 3      | 12.9743 | 0.92453             | 7                  | 13.410  |  |
| $L_{II}O_{IV,V}$           | 0.9243             | 3    | 13.413  |          |      |                     | $\gamma_1 L_{II}N_{IV}$    | 0.92650             | 3      | 13.3817 | 0.89646             | 5                  | 13.8301 |  |
| $L_{II}O_I$                |                    |      |         | 0.8995   | 2    | 13.784              | $\gamma_8 L_{II}O_I$       | 0.90989             | 5      | 13.6260 | 0.87995             | 7                  | 14.090  |  |
| $L_{II}O_{IV}$             |                    |      |         | 0.8943   | 1    | 13.864              | $\gamma_8 L_{II}O_{IV}$    | 0.90297             | 3      | 13.7304 | 0.87319             | 7                  | 14.199  |  |
| $L_{II}O_V$                |                    |      |         | 0.8934   | 1    | 13.878              | $\beta_1 L_{II}M_I$        | 1.45964             | 9      | 8.4939  | 1.4216              | 1                  | 8.7210  |  |
| $L_{II}M_{II}$             | 1.2502             | 3    | 9.917   | 1.213    | 1    | 10.225              | $\alpha_1 L_{II}M_{IV}$    | 1.28772             | 3      | 9.6280  | 1.25264             | 7                  | 9.8976  |  |
| $\beta_{11} L_{II}M_{III}$ | 1.2069             | 2    | 10.273  | 1.1667   | 1    | 10.6265             | $\alpha_1 L_{II}M_V$       | 1.27640             | 3      | 9.7133  | 1.24120             | 5                  | 9.9888  |  |
| $L_{II}M_V$                | 1.1489             | 2    | 10.791  | 1.1129   | 2    | 11.140              | $\beta_8 L_{II}N_I$        | 1.11092             | 3      | 11.1602 | 1.07975             | 7                  | 11.4824 |  |
| $L_{II}N_{II}$             | 1.0120             | 2    | 12.251  | 0.9792   | 2    | 12.661              | $\beta_{18} L_{II}N_{IV}$  | 1.07188             | 5      | 11.5667 | 1.04151             | 7                  | 11.9040 |  |
| $L_{II}N_{III}$            | 1.0054             | 3    | 12.332  | 0.97173  | 4    | 12.7588             | $\beta_8 L_{II}N_V$        | 1.07022             | 3      | 11.5847 | 1.03975             | 7                  | 11.9241 |  |
| $\nu L_{II}N_{VI}$         | 0.97161            | 6    | 12.7603 | 0.93931  | 5    | 13.1992             | $\beta_1 L_{II}O_I$        | 1.04974             | 8      | 11.8106 | 1.01937             | 7                  | 12.1625 |  |
| $L_{II}O_{III}$            | 0.96979            | 5    | 12.7843 |          |      |                     | $\beta_8 L_{III}O_{IV,V}$  | 1.04044             | 3      | 11.9163 | 1.00987             | 7                  | 12.2769 |  |
| $\beta L_{II}M_{II}$       | 1.4930             | 3    | 8.304   | 1.4530   | 2    | 8.533               | $L_{II}M_I$                | 1.13525             | 5      | 10.9210 | 1.0999              | 2                  | 11.272  |  |
| $\beta L_{II}M_{III}$      | 1.4318             | 2    | 8.659   | 1.3895   | 2    | 8.923               | $\beta_{10} L_{II}M_{IV}$  | 1.02789             | 7      | 12.0617 | 0.9962              | 2                  | 12.446  |  |
| $L_{II}N_{II}$             | 1.16545            | 5    | 10.6380 | 1.1310   | 2    | 10.962              | $\beta_8 L_{II}M_V$        | 1.02063             | 7      | 12.1474 | 0.9871              | 2                  | 12.560  |  |
| $L_{II}N_{III}$            | 1.1560             | 3    | 10.725  | 1.1226   | 2    | 11.044              | $L_{II}N_I$                | 0.9131              | 1      | 13.578  | 0.8827              | 2                  | 14.045  |  |
| $\mu L_{II}N_{VI,VII}$     | 1.11145            | 4    | 11.1549 | 1.07896  | 5    | 11.4908             | $L_{II}N_{IV}$             | 0.88563             | 7      | 13.999  |                     |                    |         |  |
| $L_{III}O_{II,III}$        | 1.10923            | 6    | 11.1772 | 1.0761   | 3    | 11.521              | $\gamma_{II} L_{II}N_V$    | 0.88433             | 7      | 14.020  | 0.85657             | 7                  | 14.474  |  |
| $M_{II}N_{III}$            | 4.631 <sup>†</sup> | 9    | 2.677   | 4.460    | 9    | 2.780               | $L_{II}O_I$                | 0.87074             | 5      | 14.2385 | 0.8452              | 2                  | 14.670  |  |
| $M_{II}N_{IV}$             | 4.780              | 4    | 2.594   | 4.601    | 4    | 2.695               | $L_{II}O_{IV,V}$           | 0.86400             | 5      | 14.3497 | 0.8350              | 2                  | 14.847  |  |
| $M_{III}N_I$               | 6.669              | 9    | 1.859   | 6.455    | 9    | 1.921               | $L_{II}M_{II}$             | 1.1708              | 1      | 10.5892 | 1.1387              | 5                  | 10.888  |  |
| $M_{III}N_{IV}$            | 5.540              | 5    | 2.238   | 5.357    | 5    | 2.314               | $\beta_{11} L_{II}M_{III}$ | 1.12798             | 5      | 10.9915 | 1.0916              | 5                  | 11.358  |  |
| $\gamma M_{II}N_V$         | 5.500              | 4    | 2.254   | 5.319    | 4    | 2.331               | $L_{II}M_V$                | 1.0756              | 2      | 11.526  |                     |                    |         |  |
| $M_{III}O_I$               |                    |      |         | 4.876    | 9    | 2.543               | $L_{II}N_{III}$            | 0.9402              | 2      | 13.186  | 0.90894             | 7                  | 13.640  |  |
| $M_{III}O_{IV,V}$          | 4.869              | 9    | 2.546   | 4.694    | 8    | 2.641               | $\nu L_{II}N_{VI}$         | 0.90837             | 5      | 13.6487 | 0.87885             | 7                  | 14.107  |  |
| $\zeta_2 M_{IV}N_{II}$     | 8.065              | 5    | 1.5373  | 7.790    | 5    | 1.592               | $L_{II}O_{II}$             | 0.90746             | 7      | 13.662  | 0.8784              | 1                  | 14.114  |  |
| $M_{IV}N_{III}$            | 7.645              | 8    | 1.622   | 7.371    | 8    | 1.682               | $L_{II}O_{III}$            | 0.90638             | 7      | 13.679  | 0.8758              | 1                  | 14.156  |  |
| $\beta M_{IV}N_{VI}$       | 6.038              | 1    | 2.0535  | 5.828    | 1    | 2.1273              | $\beta L_{II}M_{II}$       | 1.41366             | 7      | 8.7702  | 1.3746              | 2                  | 9.019   |  |
| $\zeta_1 M_{V}N_{III}$     | 8.021              | 4    | 1.5458  | 7.738    | 4    | 1.6022              | $\beta L_{II}M_{III}$      | 1.35131             | 7      | 9.1749  | 1.3112              | 2                  | 9.455   |  |
| $\alpha_2 M_{V}N_{VI}$     | 6.275              | 3    | 1.9758  | 6.058    | 3    | 2.047               | $L_{III}N_{II}$            | 1.09968             | 7      | 11.2743 | 1.0649              | 2                  | 11.642  |  |
| $\alpha_1 M_{V}N_{VII}$    | 6.262              | 1    | 1.9799  | 6.047    | 1    | 2.0505              | $L_{III}N_{III}$           | 1.09026             | 7      | 11.3717 | 1.0585              | 1                  | 11.713  |  |
| $M_{VO_{III}}$             |                    |      |         | 5.987    | 9    | 2.071               | $\mu L_{III}N_{VI,VII}$    | 1.04752             | 5      | 11.8357 |                     |                    |         |  |
| $N_{IV}N_{VI}$             | 50.2               | 1    | 0.2470  | 48.1     | 2    | 0.258               | $\mu' L_{III}N_{VI}$       |                     |        |         | 1.01769             | 7                  | 12.1826 |  |
| $N_VN_{VI,VII}$            | 52.8               | 1    | 0.2348  | 50.9     | 1    | 0.2436              | $\mu L_{III}N_{VII}$       |                     |        |         | 1.01674             | 7                  | 12.1940 |  |
| 79 Gold                    |                    |      |         |          |      | 80 Mercury          |                            | $L_{III}O_{II,III}$ | 1.0450 | 2       | 11.865              |                    |         |  |
| $\alpha_2 K L_{II}$        | 0.185075           | 2    | 66.9895 | 0.179958 | 3    | 68.895              | $L_{III}O_{II}$            |                     |        |         | 1.01558             | 7                  | 12.2079 |  |
| $\alpha_1 K L_{III}$       | 0.180195           | 2    | 68.8037 | 0.175068 | 3    | 70.819              | $L_{III}O_{III}$           |                     |        |         | 1.01404             | 7                  | 12.2264 |  |
| $\beta_2 K M_{II}$         | 0.159810           | 2    | 77.580  | 0.155321 | 3    | 79.822              | $L_{III}P_{II,III}$        | 1.03876             | 7      | 11.9355 |                     |                    |         |  |
| $\beta_1 K M_{III}$        | 0.158982           | 3    | 77.984  | 0.154487 | 3    | 80.253              | $M_{II}N_{III}$            | 4.300               | 9      | 2.883   |                     |                    |         |  |
| $\beta_2^{II} K N_{II}$    | 0.15483            | 2    | 80.08   | 0.15040  | 2    | 82.43               | $M_{II}N_{IV}$             | 4.432               | 4      | 2.797   |                     |                    |         |  |
| $\beta_2^I K N_{III}$      | 0.154618           | 9    | 80.185  | 0.15020  | 2    | 82.54               | $M_{III}N_I$               | 6.259               | 9      | 1.981   | 6.09                | 2                  | 2.036   |  |
| $K O_{II,III}$             | 0.153694           | 7    | 80.667  | 0.14931  | 2    | 83.04               | $M_{III}N_{IV}$            | 5.186               | 5      | 2.391   |                     |                    |         |  |
| $K L_I$                    | 0.18672            | 4    | 66.40   |          |      |                     | $\gamma M_{III}N_V$        | 5.145               | 4      | 2.410   | 4.984 <sup>†</sup>  | 2                  | 2.4875  |  |
| $\beta_5^{II} K M_{IV}$    | 0.158062           | 7    | 78.438  |          |      |                     | $M_{III}O_I$               | 4.703               | 9      | 2.636   |                     |                    |         |  |
| $\beta_5^I K M_V$          | 0.157880           | 5    | 78.529  |          |      |                     | $M_{III}O_{IV,V}$          | 4.522               | 6      | 2.742   |                     |                    |         |  |
| $\beta_8 K M_{IV,V}$       |                    |      |         | 0.15353  | 2    | 80.75               | $\zeta_1 M_{IV}N_{II}$     | 7.523               | 5      | 1.648   |                     |                    |         |  |
| $\beta_4 K N_{IV,V}$       | 0.154224           | 5    | 80.391  | 0.14978  | 2    | 82.78               | $M_{IV}N_{III}$            | 7.101               | 8      | 1.746   | 6.87                | 2                  | 1.805   |  |
| $\beta_4 L_{II}M_{II}$     | 1.10651            | 3    | 11.2047 | 1.07222  | 7    | 11.5630             | $\beta M_{IV}N_{VI}$       | 5.624               | 1      | 2.2046  | 5.4318 <sup>†</sup> | 9                  | 2.2825  |  |
| $\beta_8 L_{II}M_{III}$    | 1.06785            | 9    | 11.6103 | 1.03358  | 7    | 11.9953             | $\zeta_1 M_{V}N_{III}$     | 7.466               | 4      | 1.6605  |                     |                    |         |  |
|                            |                    |      |         |          |      |                     | $\alpha_2 M_{V}N_{VI}$     | 5.854               | 3      | 2.118   |                     |                    |         |  |



*X-Ray Wavelengths*  
TABLE A (Continued)

| Designation                 | Å*       | p.e. | keV     | Å*                  | p.e. | keV                | Designation                   | Å*                  | p.e. | keV     | Å*                   | p.e.            | keV     |  |  |
|-----------------------------|----------|------|---------|---------------------|------|--------------------|-------------------------------|---------------------|------|---------|----------------------|-----------------|---------|--|--|
| 79 Gold (Cont.)             |          |      |         |                     |      | 80 Mercury (Cont.) |                               | 81 Thallium (Cont.) |      |         |                      | 82 Lead (Cont.) |         |  |  |
| $\alpha_1 M_V N_{VII}$      | 5.840    | 1    | 2.1229  | 5.6476 <sup>†</sup> | 9    | 2.1953             | $L_{II} N_{III}$              | 0.87996             | 5    | 14.0893 | 0.85192              | 7               | 14.553  |  |  |
| $M_V O_{III}$               | 5.767    | 9    | 2.150   |                     |      |                    | $L_{II} N_V$                  |                     |      |         | 0.8382               | 2               | 14.791  |  |  |
| $N_{IV} N_{VI}$             | 46.8     | 2    | 0.265   | 45.2 <sup>†</sup>   | 3    | 0.274              | $v L_{II} N_{VI}$             | 0.85048             | 5    | 14.5777 | 0.82327              | 7               | 15.060  |  |  |
| $N_V N_{VI, VII}$           | 49.4     | 1    | 0.2510  | 47.9 <sup>†</sup>   | 3    | 0.259              | $L_{II} O_{II}$               | 0.8490              | 1    | 14.604  |                      |                 |         |  |  |
|                             |          |      |         |                     |      |                    | $L_{II} O_{III}$              |                     |      |         | 0.8200               | 1               | 15.120  |  |  |
|                             |          |      |         |                     |      |                    | $i L_{III} M_{II}$            | 1.34154             | 5    | 9.2417  | 1.30767              | 7               | 9.4811  |  |  |
|                             |          |      |         |                     |      |                    | $s L_{III} M_{III}$           | 1.27807             | 5    | 9.7007  | 1.24385              | 7               | 9.9675  |  |  |
|                             |          |      |         |                     |      |                    | $L_{III} N_{II}$              |                     |      |         | 1.01040              | 7               | 12.2705 |  |  |
|                             |          |      |         |                     |      |                    | $L_{III} N_{III}$             | 1.0286              | 1    | 12.053  | 1.0005               | 1               | 12.392  |  |  |
| $\alpha_2 K L_{II}$         | 0.175036 | 2    | 70.8319 | 0.170294            | 2    | 72.8042            | $u L_{III} N_{VI, VII}$       | 0.9888              | 1    | 12.538  | 0.96133              | 7               | 12.8968 |  |  |
| $\alpha_1 K L_{III}$        | 0.170136 | 2    | 72.8715 | 0.165376            | 2    | 74.9694            | $L_{III} O_{II}$              | 0.98738             | 5    | 12.5566 | 0.9586               | 1               | 12.934  |  |  |
| $\beta_8 K M_{II}$          | 0.150980 | 6    | 82.118  | 0.146810            | 4    | 84.450             | $L_{III} O_{III}$             | 0.98538             | 5    | 12.5820 | 0.9578               | 1               | 12.945  |  |  |
| $\beta_1 K M_{III}$         | 0.150142 | 5    | 82.576  | 0.145970            | 6    | 84.936             | $L_{III} P_{II, III}$         | 0.97926             | 5    | 12.6607 | 0.95118              | 7               | 13.0344 |  |  |
| $\beta_2^{II} K N_{II}$     | 0.14614  | 1    | 84.836  | 0.14212             | 2    | 87.23              | $M_I N_{III}$                 | 4.013               | 9    | 3.089   | 3.872                | 9               | 3.202   |  |  |
| $\beta_2^I K N_{III}$       | 0.14595  | 1    | 84.946  | 0.14191             | 1    | 87.364             | $M_{II} N_I$                  |                     |      |         | 4.655                | 8               | 2.664   |  |  |
| $K O_{II, III}$             | 0.14509  | 1    | 85.451  | 0.141012            | 8    | 87.922             | $M_{II} N_{IV}$               | 4.116               | 4    | 3.013   | 3.968                | 5               | 3.124   |  |  |
| $K P$                       |          |      |         | 0.1408              | 1    | 88.06              | $M_{III} N_I$                 | 5.884               | 8    | 2.107   | 5.704                | 8               | 2.174   |  |  |
| $\beta_8 K M_{IV, V}$       | 0.14917  | 1    | 83.114  |                     |      |                    | $M_{III} N_{IV}$              | 4.865               | 5    | 2.548   | 4.715                | 3               | 2.630   |  |  |
| $\beta_2^{II} K M_{IV}$     |          |      |         | 0.14512             | 2    | 85.43              | $\gamma M_{III} N_V$          | 4.823               | 4    | 2.571   | 4.674                | 1               | 2.6527  |  |  |
| $\beta_2^I K M_V$           |          |      |         | 0.14495             | 3    | 85.53              | $M_{III} O_I$                 |                     |      |         | 4.244                | 9               | 2.921   |  |  |
| $\beta_4 K N_{IV, V}$       | 0.14553  | 2    | 85.19   | 0.14155             | 3    | 87.59              | $M_{II} O_{IV, V}$            | 4.216               | 6    | 2.941   | 4.069                | 6               | 3.047   |  |  |
| $\beta_4 L_I M_{II}$        | 1.03918  | 3    | 11.9306 | 1.0075              | 1    | 12.306             | $\zeta_1 M_{IV} N_{II}$       | 7.032               | 5    | 1.763   | 6.802                | 5               | 1.823   |  |  |
| $\beta_1 L_I M_{III}$       | 1.00062  | 3    | 12.3904 | 0.96911             | 7    | 12.7933            | $M_{IV} N_{III}$              |                     |      |         | 6.384                | 7               | 1.942   |  |  |
| $\gamma_2 L_I N_{II}$       | 0.84773  | 5    | 14.6251 | 0.8210              | 2    | 15.101             | $\beta M_{IV} N_{VI}$         | 5.249               | 1    | 2.3621  | 5.076                | 1               | 2.4427  |  |  |
| $\gamma_1 L_I N_{III}$      | 0.84130  | 4    | 14.7368 | 0.8147              | 1    | 15.218             | $M_{IV} O_{II}$               | 5.196               | 9    | 2.386   | 5.004                | 9               | 2.477   |  |  |
| $\gamma'_4 L_I O_{II}$      | 0.81308  | 5    | 15.2482 | 0.78706             | 7    | 15.752             | $\zeta_1 M_V N_{III}$         | 6.974               | 4    | 1.778   | 6.740                | 3               | 1.8395  |  |  |
| $\gamma_4 L_I O_{III}$      | 0.81184  | 5    | 15.2716 | 0.7858              | 1    | 15.777             | $\alpha_2 M_V N_{VI}$         | 5.472               | 2    | 2.2656  | 5.299                | 2               | 2.3397  |  |  |
| $\eta L_{II} M_I$           | 1.12769  | 3    | 10.9943 | 1.09241             | 7    | 11.3493            | $\alpha_1 M_V N_{VII}$        | 5.460               | 1    | 2.2706  | 5.286                | 1               | 2.3455  |  |  |
| $\beta_1 L_{II} M_{IV}$     | 1.01513  | 4    | 12.2133 | 0.98291             | 3    | 12.6137            | $M_V O_{III}$                 |                     |      |         | 5.168                | 9               | 2.399   |  |  |
| $\gamma_8 L_{II} N_I$       | 0.89500  | 4    | 13.8526 | 0.86655             | 5    | 14.3075            | $N_{IV} N_{VI}$               |                     |      |         | 42.3                 | 2               | 0.293   |  |  |
| $\gamma_1 L_{II} N_{IV}$    | 0.86752  | 3    | 14.2915 | 0.83973             | 3    | 14.7644            | $N_V N_{VI, VII}$             | 46.5                | 2    | 0.267   | 45.0                 | 1               | 0.2756  |  |  |
| $\gamma_8 L_{II} O_I$       | 0.8513   | 2    | 14.564  | 0.82365             | 5    | 15.0527            | $N_{VI} O_{IV}$               | 115.3               | 2    | 0.1075  | 102.4                | 1               | 0.1211  |  |  |
| $\gamma_6 L_{II} O_{IV}$    | 0.8442   | 2    | 14.685  | 0.81683             | 5    | 15.1783            | $N_{VII} O_V$                 | 113.0               | 1    | 0.10968 | 100.2                | 2               | 0.1237  |  |  |
| $L_{II} P_I$                |          |      |         | 0.81583             | 5    | 15.1969            | $N_{VII} O_V$                 | 117.7               | 1    | 0.10530 | 104.3                | 1               | 0.1189  |  |  |
| $i L_{III} M_I$             | 1.38477  | 3    | 8.9532  | 1.34990             | 7    | 9.1845             |                               |                     |      |         |                      |                 |         |  |  |
| $\alpha_2 L_{III} M_{IV}$   | 1.21875  | 3    | 10.1728 | 1.18648             | 5    | 10.4495            |                               |                     |      |         |                      |                 |         |  |  |
| $\alpha_1 L_{III} M_V$      | 1.20739  | 4    | 10.2685 | 1.17501             | 2    | 10.5515            |                               |                     |      |         |                      |                 |         |  |  |
| $\beta_1 L_{III} N_I$       | 1.04963  | 5    | 11.8118 | 1.0210              | 1    | 12.143             | $\alpha_2 K L_{II}$           | 0.165717            | 2    | 74.8148 | 0.16130 <sup>†</sup> | 1               | 76.862  |  |  |
| $\beta_{18} L_{III} N_{IV}$ | 1.01201  | 3    | 12.2510 | 0.98389             | 7    | 12.6011            | $\alpha_1 K L_{III}$          | 0.160789            | 2    | 77.1079 | 0.15636 <sup>†</sup> | 1               | 79.290  |  |  |
| $\beta_1 L_{III} N_V$       | 1.01031  | 3    | 12.2715 | 0.98221             | 7    | 12.6226            | $\beta_1 K M_{II}$            | 0.142779            | 7    | 86.834  | 0.13892 <sup>†</sup> | 2               | 89.25   |  |  |
| $\beta_7 L_{III} O_I$       | 0.99017  | 5    | 12.5212 | 0.9620              | 1    | 12.888             | $\beta_1 K M_{III}$           | 0.141948            | 3    | 87.343  | 0.13807 <sup>†</sup> | 2               | 89.80   |  |  |
| $\beta_8 L_{III} O_{IV, V}$ | 0.98058  | 3    | 12.6436 | 0.9526              | 1    | 13.015             | $\beta_2^{II} K N_{II}$       | 0.13817             | 1    | 89.733  | 0.13438 <sup>†</sup> | 2               | 92.26   |  |  |
| $L_I M_I$                   | 1.0644   | 2    | 11.648  | 1.0323              | 2    | 12.010             | $\beta_2^I K N_{III}$         | 0.13797             | 1    | 89.864  | 0.13418 <sup>†</sup> | 2               | 92.40   |  |  |
| $\beta_{10} L_I M_{IV}$     | 0.96389  | 7    | 12.8626 | 0.9339              | 2    | 13.275             | $K O_{II, III}$               | 0.13709             | 1    | 90.435  |                      |                 |         |  |  |
| $\beta_9 L_I M_V$           | 0.95675  | 7    | 12.9585 | 0.9268              | 1    | 13.377             | $\beta_8 K M_{IV, V}$         | 0.14111             | 1    | 87.860  |                      |                 |         |  |  |
| $L_I N_I$                   | 0.8549   | 1    | 14.503  | 0.82859             | 7    | 14.963             | $\beta_4 K N_{IV, V}$         | 0.13759             | 2    | 90.11   |                      |                 |         |  |  |
| $L_I N_{IV}$                | 0.83001  | 7    | 14.937  | 0.80364             | 7    | 15.427             | $\beta_4 L_I M_{II}$          | 0.97690             | 4    | 12.6912 | 0.9475               | 3               | 13.086  |  |  |
| $\gamma_{11} L_I N_V$       | 0.82879  | 5    | 14.9593 | 0.80233             | 9    | 15.453             | $\beta_4 L_I M_{III}$         | 0.93855             | 3    | 13.2098 | 0.9091               | 3               | 13.638  |  |  |
| $L_I N_{VI, VII}$           |          |      |         | 0.7884              | 1    | 15.725             | $\gamma_2 L_I N_{II}$         | 0.79565             | 3    | 15.5824 | 0.772                | 1               | 16.07   |  |  |
| $L_I O_I$                   | 0.8158   | 1    | 15.198  | 0.7897              | 1    | 15.699             | $\gamma_8 L_I N_{III}$        | 0.78917             | 5    | 15.7102 |                      |                 |         |  |  |
| $L_I O_{IV, V}$             | 0.80861  | 5    | 15.3327 | 0.78257             | 7    | 15.843             | $\gamma'_4 L_I O_{II}$        | 0.76198             | 3    | 16.2709 |                      |                 |         |  |  |
| $L_{II} M_{II}$             | 1.0997   | 1    | 11.274  | 1.0644              | 2    | 11.648             | $\gamma_4 L_I O_{III}$        | 0.76087             | 3    | 16.2947 |                      |                 |         |  |  |
| $\beta_{17} L_{II} M_{III}$ | 1.05609  | 7    | 11.7397 | 1.0223              | 1    | 12.127             | $\gamma_{18} L_I P_{II, III}$ | 0.75690             | 3    | 16.3802 |                      |                 |         |  |  |
| $L_{II} M_V$                | 1.00722  | 5    | 12.3093 | 0.9747              | 1    | 12.720             | $\eta L_{II} M_I$             | 1.05856             | 3    | 11.7122 |                      |                 |         |  |  |
| $L_{II} N_{II}$             | 0.882    | 2    | 14.057  | 0.8585              | 3    | 14.442             | $\beta_1 L_{II} M_{IV}$       | 0.951978            | 9    | 13.0235 | 0.9220               | 2               | 13.447  |  |  |
|                             |          |      |         |                     |      |                    | $\gamma_8 L_{II} N_I$         | 0.83923             | 5    | 14.7732 |                      |                 |         |  |  |



TABLE A (Continued)

| Designation                | $\lambda^*$ | p.e. | keV      | $\lambda^*$          | p.e. | keV                 | Designation                | $\lambda^*$          | p.e. | keV     | $\lambda^*$          | p.e.      | keV      |  |
|----------------------------|-------------|------|----------|----------------------|------|---------------------|----------------------------|----------------------|------|---------|----------------------|-----------|----------|--|
| 83 Bismuth (Cont.)         |             |      |          |                      |      | 84 Polonium (Cont.) |                            | 85 Astatine          |      |         |                      |           | 86 Radon |  |
| $\gamma_1 L_{II}N_{IV}$    | 0.81311     | 2    | 15.2477  | 0.78748              | 9    | 15.744              | $\alpha_2 K L_{II}$        | 0.15705 <sup>†</sup> | 2    | 78.95   | 0.15294 <sup>†</sup> | 3         | 81.07    |  |
| $\gamma_8 L_{II}O_I$       | 0.7973      | 1    | 15.551   |                      |      |                     | $\alpha_1 K L_{III}$       | 0.15210 <sup>†</sup> | 2    | 81.52   | 0.14798 <sup>†</sup> | 3         | 83.78    |  |
| $\gamma_6 L_{II}O_{IV}$    | 0.79043     | 3    | 15.6853  | 0.7645               | 2    | 16.218              | $\beta_3 K M_{II}$         | 0.13517 <sup>†</sup> | 4    | 91.72   | 0.13155 <sup>†</sup> | 5         | 94.24    |  |
| $l L_{III}M_I$             | 1.31610     | 7    | 9.4204   | 1.2829               | 5    | 9.664               | $\beta_1 K M_{III}$        | 0.13432 <sup>†</sup> | 4    | 92.30   | 0.13069 <sup>†</sup> | 5         | 94.87    |  |
| $\alpha_2 L_{III}M_{IV}$   | 1.15536     | 1    | 10.73091 | 1.12548 <sup>†</sup> | 5    | 11.0158             | $\beta_2^{II} K N_{II}$    | 0.13072 <sup>†</sup> | 4    | 94.84   | 0.12719 <sup>†</sup> | 5         | 97.47    |  |
| $\alpha_1 L_{III}M_V$      | 1.14386     | 2    | 10.8388  | 1.11386              | 4    | 11.1308             | $\beta_2^I K N_{III}$      | 0.13052 <sup>†</sup> | 4    | 94.99   | 0.12698 <sup>†</sup> | 5         | 97.64    |  |
| $\beta_8 L_{III}N_I$       | 0.99331     | 3    | 12.4816  | 0.9672               | 2    | 12.819              | $\beta_3 L_1 M_{III}$      | 0.88135 <sup>†</sup> | 9    | 14.067  | 0.85436 <sup>†</sup> | 9         | 14.512   |  |
| $\beta_5 L_{III}N_{IV}$    | 0.95702     | 5    | 12.9549  | 0.9312               | 2    | 13.314              | $\beta_1 L_1 M_{IV}$       | 0.89349 <sup>†</sup> | 9    | 13.876  | 0.86605 <sup>†</sup> | 9         | 14.316   |  |
| $\beta_2 L_{III}N_V$       | 0.95518     | 4    | 12.9799  | 0.92937              | 5    | 13.3404             | $\gamma_1 L_{II}N_{IV}$    | 0.76289 <sup>†</sup> | 9    | 16.251  | 0.73928 <sup>†</sup> | 9         | 16.770   |  |
| $\beta_7 L_{III}O_I$       | 0.93505     | 5    | 13.2593  |                      |      |                     | $\alpha_2 L_{III}M_{IV}$   | 1.09671 <sup>†</sup> | 5    | 11.3048 | 1.06899 <sup>†</sup> | 5         | 11.5979  |  |
| $\beta_4 L_{III}O_{IV,V}$  | 0.92556     | 3    | 13.3953  | 0.8996               | 2    | 13.782              | $\alpha_1 L_{III}M_V$      | 1.08500 <sup>†</sup> | 5    | 11.4268 | 1.05723 <sup>†</sup> | 5         | 11.7270  |  |
| $L_{II}M_I$                | 1.0005      | 9    | 12.39    |                      |      |                     | 87 Francium                |                      |      |         |                      | 88 Radium |          |  |
| $\beta_{10} L_1 M_{IV}$    | 0.90495     | 4    | 13.7002  |                      |      |                     | $\alpha_2 K L_{II}$        | 0.14896 <sup>†</sup> | 3    | 83.23   | 0.14512 <sup>†</sup> | 2         | 85.43    |  |
| $\beta_9 L_1 M_V$          | 0.89791     | 3    | 13.8077  |                      |      |                     | $\alpha_1 K L_{III}$       | 0.14399 <sup>†</sup> | 3    | 86.10   | 0.14014 <sup>†</sup> | 2         | 88.47    |  |
| $L_1 N_I$                  | 0.8022      | 1    | 15.456   |                      |      |                     | $\beta_3 K M_{II}$         | 0.12807 <sup>†</sup> | 5    | 96.81   | 0.12469 <sup>†</sup> | 3         | 99.43    |  |
| $L_1 N_{IV}$               | 0.7795      | 5    | 15.904   |                      |      |                     | $\beta_1 K M_{III}$        | 0.12719 <sup>†</sup> | 5    | 97.47   | 0.12382 <sup>†</sup> | 3         | 100.13   |  |
| $\gamma_{11} L_1 N_V$      | 0.77728     | 5    | 15.951   |                      |      |                     | $\beta_2^{II} K N_{II}$    | 0.12379 <sup>†</sup> | 5    | 100.16  | 0.12050 <sup>†</sup> | 3         | 102.89   |  |
| $L_1 N_{VI,VII}$           | 0.7641      | 5    | 16.23    |                      |      |                     | $\beta_2^I K N_{III}$      | 0.12358 <sup>†</sup> | 5    | 100.33  | 0.12029 <sup>†</sup> | 3         | 103.07   |  |
| $L_1 O_{IV,V}$             | 0.75791     | 5    | 16.358   |                      |      |                     | $\beta_4 L_1 M_{II}$       |                      |      |         | 0.84071              | 5         | 14.7472  |  |
| $L_{II}M_{II}$             | 1.0346      | 9    | 11.98    |                      |      |                     | $\beta_3 L_1 M_{III}$      | 0.82789 <sup>†</sup> | 9    | 14.976  | 0.80273              | 5         | 15.4449  |  |
| $\beta_{17} L_{II}M_{III}$ | 0.98913     | 5    | 12.5344  |                      |      |                     | $\gamma_2 L_1 N_{II}$      |                      |      |         | 0.68199              | 5         | 18.179   |  |
| $L_{II}M_V$                | 0.94419     | 5    | 13.1310  |                      |      |                     | $\gamma_3 L_1 N_{III}$     |                      |      |         | 0.67538              | 5         | 18.357   |  |
| $L_{II}N_{II}$             | 0.8344      | 9    | 14.86    |                      |      |                     | $\gamma_4 L_1 O_{II}$      |                      |      |         | 0.65131              | 5         | 19.036   |  |
| $L_{II}N_{III}$            | 0.8248      | 1    | 15.031   |                      |      |                     | $\gamma_4 L_1 O_{III}$     |                      |      |         | 0.64965              | 5         | 19.084   |  |
| $v L_{II}N_{VI}$           | 0.79721     | 9    | 15.552   |                      |      |                     | $\gamma_3 L_1 P_{II,III}$  |                      |      |         | 0.64513              | 5         | 19.218   |  |
| $L_{II}O_{III}$            | 0.79384     | 5    | 15.6178  |                      |      |                     | $\eta L_{II}M_I$           |                      |      |         | 0.90742              | 5         | 13.6630  |  |
| $l L_{III}M_{II}$          | 1.2748      | 1    | 9.7252   |                      |      |                     | $\beta_1 L_{II}M_{IV}$     | 0.83940 <sup>†</sup> | 9    | 14.770  | 0.81375              | 5         | 15.2358  |  |
| $s L_{III}M_{III}$         | 1.2105      | 1    | 10.2421  |                      |      |                     | $\gamma_6 L_{II}N_I$       |                      |      |         | 0.71774              | 5         | 17.274   |  |
| $L_{III}N_{II}$            | 0.98280     | 5    | 12.6151  |                      |      |                     | $\gamma_1 L_{II}N_{IV}$    | 0.71652 <sup>†</sup> | 9    | 17.303  | 0.69463              | 5         | 17.849   |  |
| $L_{III}N_{III}$           | 0.97321     | 5    | 12.7394  |                      |      |                     | $\gamma_8$                 |                      |      |         | 0.6801               | 1         | 18.230   |  |
| $u L_{III}N_{VI,VII}$      | 0.93505     | 5    | 13.2593  |                      |      |                     | $\gamma_6 L_{II}O_{IV}$    |                      |      |         | 0.67328              | 5         | 18.414   |  |
| $L_{III}O_{II}$            | 0.9323      | 2    | 13.298   |                      |      |                     | $L_{II}P_I$                |                      |      |         | 0.6724               | 1         | 18.439   |  |
| $L_{III}O_{III}$           | 0.9302      | 2    | 13.328   |                      |      |                     | $l L_{III}M_I$             |                      |      |         | 1.16719              | 5         | 10.6222  |  |
| $L_{III}P_{II,III}$        | 0.92413     | 4    | 13.4159  |                      |      |                     | $\alpha_2 L_{III}M_{IV}$   | 1.04230              | 5    | 11.8950 | 1.01656              | 5         | 12.1962  |  |
| $M_I N_{II}$               | 3.892       | 9    | 3.185    |                      |      |                     | $\alpha_1 L_{III}M_V$      | 1.03049              | 5    | 12.0313 | 1.00473              | 5         | 12.3397  |  |
| $M_I N_{III}$              | 3.740       | 9    | 3.315    |                      |      |                     | $\beta_6 L_{III}N_I$       |                      |      |         | 0.87088              | 5         | 14.2362  |  |
| $M_{II} N_{IV}$            | 3.834       | 4    | 3.234    |                      |      |                     | $\beta_{18} L_{III}N_{IV}$ |                      |      |         | 0.83722              | 5         | 14.8086  |  |
| $M_{III} N_I$              | 5.537       | 8    | 2.239    |                      |      |                     | $\beta_2 L_{III}N_V$       | 0.858                | 2    | 14.45   | 0.83537              | 5         | 14.8414  |  |
| $M_{III} N_{IV}$           | 4.571       | 5    | 2.712    |                      |      |                     | $\beta_7 L_{III}O_I$       |                      |      |         | 0.8162               | 1         | 15.190   |  |
| $\gamma M_{III} N_V$       | 4.532       | 2    | 2.735    |                      |      |                     | $\beta_5 L_{III}O_{IV,V}$  |                      |      |         | 0.80627              | 5         | 15.3771  |  |
| $M_{III} O_I$              | 4.105       | 9    | 3.021    |                      |      |                     | $L_{III}P_I$               |                      |      |         | 0.8050               | 1         | 15.402   |  |
| $M_{III} O_{IV,V}$         | 3.932       | 6    | 3.153    |                      |      |                     | $\beta_{10} L_1 M_{IV}$    |                      |      |         | 0.77546              | 5         | 15.988   |  |
| $\zeta_2 M_{IV} N_{II}$    | 6.585       | 5    | 1.883    |                      |      |                     | $\beta_9 L_1 M_V$          |                      |      |         | 0.76857              | 5         | 16.131   |  |
| $M_{IV} N_{III}$           | 6.162       | 8    | 2.012    |                      |      |                     | $L_1 N_I$                  |                      |      |         | 0.6874               | 1         | 18.036   |  |
| $\beta M_{IV} N_{VI}$      | 4.909       | 1    | 2.5255   |                      |      |                     | $L_1 N_{IV}$               |                      |      |         | 0.6666               | 1         | 18.600   |  |
| $M_{IV} O_{II}$            | 4.823       | 3    | 2.571    |                      |      |                     | $\gamma_{11} L_1 N_V$      |                      |      |         | 0.6654               | 1         | 18.633   |  |
| $M_{IV} P_{II,III}$        | 4.59        | 2    | 2.70     |                      |      |                     | $L_1 O_{IV,V}$             |                      |      |         | 0.6468               | 1         | 19.167   |  |
| $\zeta_1 M_V N_{III}$      | 6.521       | 4    | 1.901    |                      |      |                     | $\beta_{17} L_{II}M_{III}$ |                      |      |         | 0.8438               | 1         | 14.692   |  |
| $\alpha_2 M_V N_{VI}$      | 5.130       | 2    | 2.4170   |                      |      |                     | $L_{II}N_{III}$            |                      |      |         | 0.7043               | 1         | 17.604   |  |
| $\alpha_1 M_V N_{VII}$     | 5.118       | 1    | 2.4226   |                      |      |                     | $L_{II}N_V$                |                      |      |         | 0.6932               | 1         | 17.884   |  |
| $N_I P_{II,III}$           | 13.30       | 6    | 0.932    |                      |      |                     | $L_{II}O_{II}$             |                      |      |         | 0.6780               | 1         | 18.286   |  |
| $N_{VI} O_{IV}$            | 91.6        | 1    | 0.1354   |                      |      |                     |                            |                      |      |         |                      |           |          |  |
| $N_{VII} O_V$              | 93.2        | 1    | 0.1330   |                      |      |                     |                            |                      |      |         |                      |           |          |  |

TABLE A (Continued)

| Designation                  | Å*                    | p.e. | keV     | Å*                | p.e. | keV     | Designation             | Å*                    | p.e. | keV     | Å*         | p.e.               | keV     |  |  |
|------------------------------|-----------------------|------|---------|-------------------|------|---------|-------------------------|-----------------------|------|---------|------------|--------------------|---------|--|--|
| 87 Francium (Cont.)          |                       |      |         | 88 Radium (Cont.) |      |         |                         | 89 Actinium (Cont.)   |      |         |            | 90 Thorium (Cont.) |         |  |  |
| $L_{II}O_{III}$              |                       |      |         | 0.6764            | 1    | 18.330  | $9 L_{II}N_{VI}$        |                       |      |         | 0.64064    | 9                  | 19.353  |  |  |
| $L_{II}P_{II,III}$           |                       |      |         | 0.6714            | 1    | 18.466  | $L_{II}O_{II}$          |                       |      |         | 0.6369     | 1                  | 19.466  |  |  |
| $L_{III}N_{II}$              |                       |      |         | 0.8618            | 1    | 14.387  | $L_{II}O_{III}$         |                       |      |         | 0.6356     | 1                  | 19.506  |  |  |
| $L_{III}N_{III}$             |                       |      |         | 0.8512            | 1    | 14.566  | $L_{II}P_{II,III}$      |                       |      |         | 0.6312     | 1                  | 19.642  |  |  |
| $u L_{III}N_{VI,VII}$        |                       |      |         | 0.8186            | 1    | 15.146  | $l L_{III}M_I$          |                       |      |         | 1.08009    | 9                  | 11.4788 |  |  |
| $L_{III}P_{II,III}$          |                       |      |         | 0.8038            | 1    | 15.425  | $s L_{III}M_{II}$       |                       |      |         | 1.0112     | 1                  | 12.261  |  |  |
| 89 Actinium                  |                       |      |         | 90 Thorium        |      |         |                         | $L_{III}N_{II}$       |      |         | 0.8190     | 2                  | 15.138  |  |  |
| $\alpha_2 K L_{II}$          | 0.14141 <sup>†</sup>  | 2    | 87.67   | 0.137829          | 2    | 89.953  | $L_{III}N_{III}$        |                       |      |         | 0.8082     | 1                  | 15.341  |  |  |
| $\alpha_1 K L_{III}$         | 0.136417 <sup>†</sup> | 8    | 90.884  | 0.132813          | 2    | 93.350  | $u L_{III}N_{VI,VII}$   |                       |      |         | 0.77661    | 5                  | 15.964  |  |  |
| $\beta_3 K M_{II}$           | 0.12143 <sup>†</sup>  | 2    | 102.10  | 0.118268          | 3    | 104.831 | $L_{III}O_{II}$         |                       |      |         | 0.7713     | 1                  | 16.074  |  |  |
| $\beta_1 K M_{III}$          | 0.12055 <sup>†</sup>  | 2    | 102.85  | 0.117396          | 9    | 105.609 | $L_{III}O_{III}$        |                       |      |         | 0.7690     | 1                  | 16.123  |  |  |
| $\beta_2^{II} K N_{II}$      | 0.11732 <sup>†</sup>  | 2    | 105.67  | 0.11426           | 1    | 108.511 | $L_{III}P_{II,III}$     |                       |      |         | 0.7625     | 2                  | 16.260  |  |  |
| $\beta_2^I K N_{III}$        | 0.11711 <sup>†</sup>  | 2    | 105.86  | 0.114040          | 9    | 108.717 | $M_I N_{III}$           |                       |      |         | 2.934      | 8                  | 4.23    |  |  |
| $K O_{II,III}$               |                       |      |         | 0.11322           | 1    | 109.500 | $M_I O_{III}$           |                       |      |         | 2.442      | 9                  | 5.08    |  |  |
| $\beta_6 K M_{IV,V}$         |                       |      |         | 0.116667          | 9    | 106.269 | $M_{II} N_I$            |                       |      |         | 3.537      | 9                  | 3.505   |  |  |
| $\beta_4 K N_{IV,V}$         |                       |      |         | 0.11366           | 2    | 109.08  | $M_{II} N_{IV}$         |                       |      |         | 3.011      | 2                  | 4.117   |  |  |
| $\beta_4 L_1 M_{II}$         |                       |      |         | 0.79257           | 4    | 15.6429 | $M_{II} O_{IV}$         |                       |      |         | 2.618      | 5                  | 4.735   |  |  |
| $\beta_3 L_1 M_{III}$        | 0.77822 <sup>†</sup>  | 9    | 15.931  | 0.75479           | 3    | 16.4258 | $M_{III} N_I$           |                       |      |         | 4.568      | 5                  | 2.714   |  |  |
| $\gamma_2 L_{II} N_{II}$     |                       |      |         | 0.64221           | 4    | 19.305  | $M_{III} N_{IV}$        |                       |      |         | 3.718      | 3                  | 3.335   |  |  |
| $\gamma_3 L_1 N_{III}$       |                       |      |         | 0.63559           | 4    | 19.507  | $\gamma M_{II} N_V$     |                       |      |         | 3.679      | 2                  | 3.370   |  |  |
| $\gamma'_4 L_1 O_{II}$       |                       |      |         | 0.61251           | 4    | 20.242  | $M_{III} O_I$           |                       |      |         | 3.283      | 9                  | 3.78    |  |  |
| $\gamma_4 L_1 O_{III}$       |                       |      |         | 0.61098           | 4    | 20.292  | $M_{III} O_{IV,V}$      |                       |      |         | 3.131      | 3                  | 3.959   |  |  |
| $\gamma_{18} L_1 P_{II,III}$ |                       |      |         | 0.60705           | 8    | 20.424  | $\xi_2 M_V N_{II}$      |                       |      |         | 5.340      | 5                  | 2.322   |  |  |
| $\eta L_{II} M_I$            |                       |      |         | 0.85446           | 4    | 14.5099 | $M_{IV} N_{III}$        |                       |      |         | 4.911      | 5                  | 2.524   |  |  |
| $\beta_1 L_{II} M_{IV}$      | 0.78903 <sup>†</sup>  | 9    | 15.713  | 0.765210          | 9    | 16.2022 | $\beta M_{IV} N_{VI}$   |                       |      |         | 3.941      | 1                  | 3.1458  |  |  |
| $\beta_5 L_{II} N_I$         |                       |      |         | 0.67491           | 4    | 18.370  | $M_{IV} O_{II}$         |                       |      |         | 3.808      | 4                  | 3.256   |  |  |
| $\gamma_1 L_{II} N_{IV}$     | 0.67351 <sup>†</sup>  | 9    | 18.408  | 0.65313           | 3    | 18.9825 | $\xi_1 M_V N_{III}$     |                       |      |         | 5.245      | 5                  | 2.364   |  |  |
| $\gamma_8 L_{II} O_I$        |                       |      |         | 0.63898           | 5    | 19.403  | $\alpha_2 M_V N_{VI}$   |                       |      |         | 4.151      | 2                  | 2.987   |  |  |
| $\gamma_6 L_{II} O_{IV}$     |                       |      |         | 0.63258           | 4    | 19.599  | $\alpha_1 M_V N_{VII}$  |                       |      |         | 4.1381     | 9                  | 2.9961  |  |  |
| $L_{II} P_I$                 |                       |      |         | 0.6316            | 1    | 19.629  | $M_V P_{III}$           |                       |      |         | 3.760      | 9                  | 3.298   |  |  |
| $L_{II} P_{IV}$              |                       |      |         | 0.62991           | 9    | 19.682  | $N P_{II}$              |                       |      |         | 9.44       | 7                  | 1.313   |  |  |
| $l L_{III} M_I$              |                       |      |         | 1.11508           | 4    | 11.1186 | $N P_{III}$             |                       |      |         | 9.40       | 7                  | 1.1319  |  |  |
| $\alpha_2 L_{III} M_{IV}$    | 0.99178 <sup>†</sup>  | 5    | 12.5008 | 0.96788           | 2    | 12.8096 | $N_{II} O_{IV}$         |                       |      |         | 11.56      | 5                  | 1.072   |  |  |
| $\alpha_1 L_{III} M_V$       | 0.97993 <sup>†</sup>  | 5    | 12.6520 | 0.95600           | 3    | 12.9687 | $N_I P_I$               |                       |      |         | 11.07      | 7                  | 1.120   |  |  |
| $\beta_6 L_{III} N_I$        |                       |      |         | 0.82790           | 8    | 14.975  | $N_{III} O_V$           |                       |      |         | 13.8       | 1                  | 0.897   |  |  |
| $\beta_{16} L_{III} N_{IV}$  |                       |      |         | 0.79539           | 5    | 15.5875 | $N_{IV} N_{VI}$         |                       |      |         | 33.57      | 9                  | 0.3693  |  |  |
| $\beta_2 L_{III} N_V$        |                       |      |         | 0.79354           | 3    | 15.6237 | $N_V N_{VI,VII}$        |                       |      |         | 36.32      | 9                  | 0.3414  |  |  |
| $\beta_7 L_{III} O_I$        |                       |      |         | 0.77437           | 4    | 16.0105 | $N_{VI} O_{IV}$         |                       |      |         | 49.5       | 1                  | 0.2505  |  |  |
| $\beta_6 L_{III} O_{IV,V}$   |                       |      |         | 0.76468           | 5    | 16.213  | $N_{VI} O_V$            |                       |      |         | 48.2       | 1                  | 0.2572  |  |  |
| $L_{III} P_I$                |                       |      |         | 0.76338           | 5    | 16.241  | $N_{VII} O_V$           |                       |      |         | 50.0       | 1                  | 0.2479  |  |  |
| $L_{III} P_{IV,V}$           |                       |      |         | 0.76087           | 9    | 16.295  | $O_{III} P_{IV,V}$      |                       |      |         | 68.2       | 3                  | 0.1817  |  |  |
| $\beta_{10} L_1 M_{IV}$      |                       |      |         | 0.7301            | 1    | 16.981  | $O_{IV,V} Q_{II,III}$   |                       |      |         | 181.       | 5                  | 0.068   |  |  |
| $\beta_9 L_1 M_V$            |                       |      |         | 0.7234            | 1    | 17.139  | 91 Protactinium         |                       |      |         | 92 Uranium |                    |         |  |  |
| $L_1 N_I$                    |                       |      |         | 0.64755           | 5    | 19.146  | $\alpha_2 K L_{II}$     | 0.134343 <sup>†</sup> | 9    | 92.287  | 0.130968   | 4                  | 94.665  |  |  |
| $L_1 N_{IV}$                 |                       |      |         | 0.6276            | 1    | 19.755  | $\alpha_1 K L_{III}$    | 0.129325 <sup>†</sup> | 3    | 95.868  | 0.125947   | 3                  | 98.439  |  |  |
| $\gamma_{11} L_1 N_V$        |                       |      |         | 0.62636           | 9    | 19.794  | $\beta_3 K M_{II}$      | 0.11523 <sup>†</sup>  | 2    | 107.60  | 0.112296   | 4                  | 110.406 |  |  |
| $L_1 N_{VI,VII}$             |                       |      |         | 0.6160            | 1    | 20.128  | $\beta_1 K M_{III}$     | 0.114345 <sup>†</sup> | 8    | 108.427 | 0.111394   | 5                  | 111.300 |  |  |
| $L_1 O_I$                    |                       |      |         | 0.6146            | 1    | 20.174  | $\beta_2^{II} K N_{II}$ | 0.11129 <sup>†</sup>  | 2    | 111.40  | 0.10837    | 1                  | 114.40  |  |  |
| $L_1 O_{IV,V}$               |                       |      |         | 0.6083            | 1    | 20.383  | $\beta_2^I K N_{III}$   | 0.11107 <sup>†</sup>  | 2    | 111.62  | 0.10818    | 1                  | 114.60  |  |  |
| $L_{II} M_{II}$              |                       |      |         | 0.8338            | 1    | 14.869  | $K O_{II,III}$          |                       |      |         | 0.10744    | 1                  | 115.39  |  |  |
| $\beta_{17} L_{II} M_{III}$  |                       |      |         | 0.79257           | 4    | 15.6429 | $\beta_6 K M_{IV,V}$    |                       |      |         | 0.11069    | 1                  | 112.01  |  |  |
| $L_{II} M_V$                 |                       |      |         | 0.7579            | 1    | 16.359  | $\beta_4 K N_{IV,V}$    |                       |      |         | 0.10780    | 2                  | 115.01  |  |  |
| $L_{II} N_{III}$             |                       |      |         | 0.6620            | 1    | 18.729  | $\beta_4 L_1 M_I$       | 0.7699                | 1    | 16.104  | 0.747985   | 9                  | 16.5753 |  |  |
| $L_{II} N_V$                 |                       |      |         | 0.6521            | 1    | 19.014  | $\beta_3 L_1 M_{III}$   | 0.73230               | 5    | 16.930  | 0.71029    | 2                  | 17.4550 |  |  |



*X-Ray Wavelengths*  
TABLE A (Continued)

| Designation                 | Å*                   | p.e. | keV     | Å*       | p.e. | keV                | Designation                  | Å*                   | p.e. | keV     | Å*       | p.e.                    | keV          |  |  |  |  |                    |  |  |  |  |  |
|-----------------------------|----------------------|------|---------|----------|------|--------------------|------------------------------|----------------------|------|---------|----------|-------------------------|--------------|--|--|--|--|--------------------|--|--|--|--|--|
| 91 Protactinium (Cont.)     |                      |      |         |          |      | 92 Uranium (Cont.) |                              |                      |      |         |          | 91 Protactinium (Cont.) |              |  |  |  |  | 92 Uranium (Cont.) |  |  |  |  |  |
| $\gamma_2 L_{II}N_{II}$     | 0.6239               | 1    | 19.872  | 0.605237 | 9    | 20.4847            | $M_{IV}O_{II}$               | 3.691                | 2    | 3.359   | 3.576    | 1                       | 3.4666       |  |  |  |  |                    |  |  |  |  |  |
| $\gamma_3 L_{II}N_{III}$    | 0.6169               | 1    | 20.098  | 0.598574 | 9    | 20.7127            | $\zeta_1 M_{VI}N_{III}$      | 5.092                | 2    | 2.4350  | 4.946    | 2                       | 2.507        |  |  |  |  |                    |  |  |  |  |  |
| $\gamma'_4 L_{II}O_{II}$    |                      |      |         | 0.576700 | 9    | 21.4984            | $\alpha_2 M_{VI}N_{VI}$      | 4.035                | 3    | 3.072   | 3.924    | 1                       | 3.1595       |  |  |  |  |                    |  |  |  |  |  |
| $\gamma_4 L_{II}O_{II,III}$ | 0.5937               | 1    | 20.882  | 0.57499  | 9    | 21.562             | $\alpha_1 M_{VI}N_{VII}$     | 4.022                | 1    | 3.0823  | 3.910    | 1                       | 3.1708       |  |  |  |  |                    |  |  |  |  |  |
| $\gamma_5$                  |                      |      |         | 0.5706   | 1    | 21.729             | $N_{II}O_{III}$              |                      |      |         | 10.09    | 7                       | 1.229        |  |  |  |  |                    |  |  |  |  |  |
| $\eta L_{II}M_I$            | 0.8295               | 1    | 14.946  | 0.80509  | 2    | 15.3997            | $N_{II}P_{II}$               |                      |      |         | 8.81     | 7                       | 1.41         |  |  |  |  |                    |  |  |  |  |  |
| $\beta_1 L_{II}M_{IV}$      | 0.74232              | 5    | 16.702  | 0.719984 | 8    | 17.2200            | $N_{II}P_{III}$              |                      |      |         | 8.76     | 7                       | 1.42         |  |  |  |  |                    |  |  |  |  |  |
| $\gamma_5 L_{II}N_I$        | 0.6550               | 1    | 18.930  | 0.63557  | 2    | 19.5072            | $N_{II}P_I$                  |                      |      |         | 10.40    | 7                       | 1.192        |  |  |  |  |                    |  |  |  |  |  |
| $\gamma_1 L_{II}N_{IV}$     | 0.63358 <sup>†</sup> | 9    | 19.568  | 0.614770 | 9    | 20.1671            | $N_{III}O_V$                 |                      |      |         | 12.90    | 9                       | 0.961        |  |  |  |  |                    |  |  |  |  |  |
| $\gamma_5 L_{II}O_I$        |                      |      |         | 0.60125  | 5    | 20.621             | $N_{IV}N_{VI}$               |                      |      |         | 31.8     | 1                       | 0.390        |  |  |  |  |                    |  |  |  |  |  |
| $\gamma_5 L_{II}O_{IV}$     | 0.6133               | 1    | 20.216  | 0.594845 | 9    | 20.8426            | $N_{VI}N_{VI, VII}$          |                      |      |         | 34.8     | 1                       | 0.357        |  |  |  |  |                    |  |  |  |  |  |
| $L_{II}P_{IV}$              |                      |      |         | 0.59203  | 5    | 20.942             | $N_{IV}O_{IV}$               |                      |      |         | 43.3     | 2                       | 0.286        |  |  |  |  |                    |  |  |  |  |  |
| $l L_{III}M_I$              | 1.0908               | 1    | 11.366  | 1.06712  | 2    | 11.6183            | $N_{VI}O_V$                  |                      |      |         | 42.1     | 2                       | 0.295        |  |  |  |  |                    |  |  |  |  |  |
| $\alpha_2 L_{III}M_{IV}$    | 0.94482 <sup>†</sup> | 5    | 13.1222 | 0.922558 | 9    | 13.4388            | $N_{I}P_{IV, V}$             |                      |      |         | 8.60     | 7                       | 1.44         |  |  |  |  |                    |  |  |  |  |  |
| $\alpha_1 L_{III}M_V$       | 0.93284              | 5    | 13.2907 | 0.910639 | 9    | 13.6147            |                              |                      |      |         |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $\beta_5 L_{III}N_I$        | 0.8079               | 1    | 15.347  | 0.78838  | 2    | 15.7260            | 93 Neptunium                 |                      |      |         |          |                         | 94 Plutonium |  |  |  |  |                    |  |  |  |  |  |
| $\beta_{15} L_{III}N_{IV}$  |                      |      |         | 0.756642 | 9    | 16.3857            | $\beta_4 L_{II}M_{II}$       | 0.72671              | 2    | 17.0607 | 0.70620  | 2                       | 17.5560      |  |  |  |  |                    |  |  |  |  |  |
| $\beta_2 L_{III}N_V$        | 0.7737               | 1    | 16.024  | 0.754681 | 9    | 16.4283            | $\beta_5 L_{II}M_{III}$      | 0.68920 <sup>†</sup> | 9    | 17.989  | 0.66871  | 2                       | 18.5405      |  |  |  |  |                    |  |  |  |  |  |
| $\beta_7 L_{III}O_I$        | 0.7546               | 2    | 16.431  | 0.73602  | 6    | 16.845             | $\gamma_2 L_{II}N_{II}$      | 0.5873               | 5    | 21.11   | 0.57068  | 2                       | 21.7251      |  |  |  |  |                    |  |  |  |  |  |
| $\beta_5 L_{III}O_{IV, V}$  | 0.7452               | 2    | 16.636  | 0.726305 | 9    | 17.0701            | $\gamma_3 L_{II}N_{III}$     | 0.5810               | 5    | 21.34   | 0.564001 | 9                       | 21.9824      |  |  |  |  |                    |  |  |  |  |  |
| $L_{III}P_I$                |                      |      |         | 0.72521  | 5    | 17.096             | $\gamma'_4 L_{II}O_{II}$     |                      |      |         | 0.5432   | 1                       | 22.823       |  |  |  |  |                    |  |  |  |  |  |
| $L_{III}P_{IV, V}$          |                      |      |         | 0.72240  | 5    | 17.162             | $\gamma_4 L_{II}O_{II, III}$ | 0.5585               | 5    | 22.20   | 0.5416   | 1                       | 22.891       |  |  |  |  |                    |  |  |  |  |  |
| $\beta_{10} L_{II}M_V$      | 0.7088               | 2    | 17.492  | 0.68760  | 5    | 18.031             | $\eta L_{II}M_I$             | 0.7809               | 2    | 15.876  | 0.7591   | 1                       | 16.333       |  |  |  |  |                    |  |  |  |  |  |
| $\beta_9 L_{II}M_V$         | 0.7018               | 1    | 17.667  | 0.681014 | 8    | 18.2054            | $\beta_1 L_{II}M_{IV}$       | 0.698478             | 9    | 17.7502 | 0.67772  | 2                       | 18.2937      |  |  |  |  |                    |  |  |  |  |  |
| $L_{II}N_{IV}$              |                      |      |         | 0.59096  | 5    | 20.979             | $\gamma_5 L_{II}N_I$         | 0.616                | 1    | 20.12   | 0.5988   | 1                       | 20.704       |  |  |  |  |                    |  |  |  |  |  |
| $\gamma_{11} L_{II}N_V$     |                      |      |         | 0.58986  | 5    | 21.019             | $\gamma_1 L_{II}N_{IV}$      | 0.596498             | 9    | 20.7848 | 0.578882 | 9                       | 21.4173      |  |  |  |  |                    |  |  |  |  |  |
| $L_{II}O_{IV, V}$           |                      |      |         | 0.5725   | 1    | 21.657             | $\gamma_5$                   |                      |      |         | 0.5658   | 1                       | 21.914       |  |  |  |  |                    |  |  |  |  |  |
| $\beta_{17} L_{II}M_{III}$  |                      |      |         | 0.74503  | 5    | 16.641             | $\gamma_5 L_{II}O_{IV}$      | 0.57699              | 5    | 21.488  | 0.55973  | 2                       | 22.1502      |  |  |  |  |                    |  |  |  |  |  |
| $L_{II}N_{III}$             |                      |      |         | 0.6228   | 1    | 19.907             | $l L_{III}M_I$               | 1.0428               | 6    | 11.890  | 1.0226   | 1                       | 12.124       |  |  |  |  |                    |  |  |  |  |  |
| $v L_{II}N_{VI}$            |                      |      |         | 0.6031   | 1    | 20.556             | $\alpha_2 L_{III}M_{IV}$     | 0.901045             | 9    | 13.7597 | 0.88028  | 2                       | 14.0842      |  |  |  |  |                    |  |  |  |  |  |
| $L_{III}O_{III}$            |                      |      |         | 0.59728  | 5    | 20.758             | $\alpha_1 L_{III}M_V$        | 0.889128             | 9    | 13.9441 | 0.86830  | 2                       | 14.2786      |  |  |  |  |                    |  |  |  |  |  |
| $L_{II}P_{II, III}$         |                      |      |         | 0.5930   | 2    | 20.906             | $\beta_5 L_{III}N_I$         | 0.769                | 1    | 16.13   | 0.75148  | 2                       | 16.4983      |  |  |  |  |                    |  |  |  |  |  |
| $l L_{III}M_{II}$           |                      |      |         | 1.0347   | 1    | 11.982             | $\beta_{15} L_{III}N_{IV}$   |                      |      |         | 0.7205   | 1                       | 17.208       |  |  |  |  |                    |  |  |  |  |  |
| $s L_{III}M_{III}$          |                      |      |         | 0.9636   | 1    | 12.866             | $\beta_2 L_{III}N_V$         | 0.736230             | 9    | 16.8400 | 0.71851  | 2                       | 17.2553      |  |  |  |  |                    |  |  |  |  |  |
| $L_{III}N_{II}$             |                      |      |         | 0.78017  | 9    | 15.892             | $\beta_7 L_{III}O_I$         |                      |      |         | 0.7003   | 1                       | 17.705       |  |  |  |  |                    |  |  |  |  |  |
| $L_{III}N_{III}$            |                      |      |         | 0.7691   | 1    | 16.120             | $\beta_5 L_{III}O_{IV, V}$   | 0.70814              | 2    | 17.5081 | 0.69068  | 2                       | 17.9506      |  |  |  |  |                    |  |  |  |  |  |
| $u L_{III}N_{VI, VII}$      |                      |      |         | 0.738603 | 9    | 16.7859            | $\beta_{10} L_{II}M_{IV}$    |                      |      |         | 0.6482   | 1                       | 19.126       |  |  |  |  |                    |  |  |  |  |  |
| $L_{III}O_{II}$             |                      |      |         | 0.7333   | 1    | 16.907             | $\beta_5 L_{II}M_V$          |                      |      |         | 0.6416   | 1                       | 19.323       |  |  |  |  |                    |  |  |  |  |  |
| $L_{III}O_{III}$            |                      |      |         | 0.7309   | 1    | 16.962             | $u L_{III}N_{VI, VII}$       |                      |      |         | 0.7031   | 1                       | 17.635       |  |  |  |  |                    |  |  |  |  |  |
| $L_{III}P_{II, III}$        |                      |      |         | 0.72426  | 5    | 17.118             |                              |                      |      |         |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{II}N_{II}$              |                      |      |         | 2.92     | 2    | 4.25               | 95 Americium                 |                      |      |         |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{II}N_{III}$             |                      |      |         | 2.753    | 8    | 4.50               | $\beta_4 L_{II}M_{II}$       | 0.68639              | 2    | 18.0627 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{II}O_{III}$             |                      |      |         | 2.304    | 7    | 5.38               | $\beta_5 L_{II}M_{III}$      | 0.64891              | 2    | 19.1059 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{II}P_{III}$             |                      |      |         | 2.253    | 6    | 5.50               | $\gamma_2 L_{II}N_{II}$      | 0.5544               | 2    | 22.361  |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{II}N_I$                 | 3.441                | 5    | 3.603   | 3.329    | 4    | 3.724              | $\beta_1 L_{II}M_{IV}$       | 0.657655             | 9    | 18.8520 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{II}N_{IV}$              | 2.910                | 2    | 4.260   | 2.817    | 2    | 4.401              | $\gamma_1 L_{II}N_{IV}$      | 0.561886             | 9    | 22.0652 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{II}O_{IV}$              | 2.527                | 4    | 4.906   | 2.443    | 4    | 5.075              | $\gamma_5 L_{II}O_{IV}$      | 0.54311              | 2    | 22.8282 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{III}N_I$                | 4.450                | 4    | 2.786   | 4.330    | 2    | 2.863              | $l L_{III}M_I$               | 1.0012               | 6    | 12.384  |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{III}N_{IV}$             | 3.614                | 2    | 3.430   | 3.521    | 2    | 3.521              | $\alpha_2 L_{III}M_{IV}$     | 0.860266             | 9    | 14.4119 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $\gamma M_{III}N_V$         | 3.577                | 1    | 3.4657  | 3.479    | 1    | 3.563              | $\alpha_1 L_{III}M_V$        | 0.848187             | 9    | 14.6172 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{III}O_I$                | 3.245                | 9    | 3.82    | 3.115    | 7    | 3.980              | $\beta_5 L_{III}N_I$         | 0.73418              | 2    | 16.8870 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{III}O_{IV, V}$          | 3.038                | 2    | 4.081   | 2.948    | 2    | 4.205              | $\beta_{15} L_{III}N_{IV}$   | 0.70341              | 2    | 17.6258 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $\zeta_2 M_{IV}N_{II}$      | 5.193                | 2    | 2.3876  | 5.050    | 2    | 2.4548             | $\beta_2 L_{III}N_V$         | 0.701390             | 9    | 17.6765 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $M_{IV}N_{III}$             |                      |      |         | 4.625    | 5    | 2.681              | $\beta_5 L_{III}O_{IV, V}$   | 0.67383              | 2    | 18.3996 |          |                         |              |  |  |  |  |                    |  |  |  |  |  |
| $\beta M_{IV}N_{VI}$        | 3.827                | 1    | 3.2397  | 3.716    | 1    | 3.3367             |                              |                      |      |         |          |                         |              |  |  |  |  |                    |  |  |  |  |  |

TABLE B. Wavelengths in numerical order of the emission lines and absorption edges.

| Wavelength |      |         |                                    |                            | Wavelength |          |         |             |                                    |                            |         |
|------------|------|---------|------------------------------------|----------------------------|------------|----------|---------|-------------|------------------------------------|----------------------------|---------|
| Å*         | p.e. | Element | Designation                        | keV                        | Å*         | p.e.     | Element | Designation | keV                                |                            |         |
| 0.10723    | 1    | 92 U    | <i>K</i>                           | Abs. Edge                  | 115.62     | 0.1408   | 1       | 82 Pb       | <i>KP</i>                          | 88.06                      |         |
| 0.10744    | 1    | 92 U    |                                    | <i>KO<sub>II,III</sub></i> | 115.39     | 0.140880 | 5       | 82 Pb       | <i>K</i>                           | Abs. Edge                  | 88.005  |
| 0.10780    | 2    | 92 U    | <i>Kβ<sub>4</sub></i>              | <i>KN<sub>IV,V</sub></i>   | 115.01     | 0.141012 | 8       | 82 Pb       |                                    | <i>KO<sub>II,III</sub></i> | 87.922  |
| 0.10818    | 1    | 92 U    | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 114.60     | 0.14111  | 1       | 83 Bi       | <i>Kβ<sub>5</sub></i>              | <i>KM<sub>IV,V</sub></i>   | 87.860  |
| 0.10837    | 1    | 92 U    | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 114.40     | 0.14141  | 2       | 89 Ac       | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 87.67   |
| 0.11069    | 1    | 92 U    | <i>Kβ<sub>5</sub></i>              | <i>KM<sub>IV,V</sub></i>   | 112.01     | 0.14155  | 3       | 82 Pb       | <i>Kβ<sub>4</sub></i>              | <i>KN<sub>IV,V</sub></i>   | 87.59   |
| 0.11107    | 2    | 91 Pa   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 111.62     | 0.14191  | 1       | 82 Pb       | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 87.364  |
| 0.11129    | 2    | 91 Pa   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 111.40     | 0.141948 | 3       | 83 Bi       | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 87.343  |
| 0.111394   | 5    | 92 U    | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 111.300    | 0.14212  | 2       | 82 Pb       | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 87.23   |
| 0.112296   | 4    | 92 U    | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 110.406    | 0.142779 | 7       | 83 Bi       | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 86.834  |
| 0.11307    | 1    | 90 Th   | <i>K</i>                           | Abs. Edge                  | 109.646    | 0.14399  | 3       | 87 Fr       | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 86.10   |
| 0.11322    | 1    | 90 Th   |                                    | <i>KO<sub>II,III</sub></i> | 109.500    | 0.14495  | 1       | 81 Tl       | <i>K</i>                           | Abs. Edge                  | 85.533  |
| 0.11366    | 2    | 90 Th   | <i>Kβ<sub>4</sub></i>              | <i>KN<sub>IV,V</sub></i>   | 109.08     | 0.14495  | 3       | 82 Pb       | <i>Kβ<sub>5</sub><sup>I</sup></i>  | <i>KM<sub>V</sub></i>      | 85.53   |
| 0.114040   | 9    | 90 Th   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 108.717    | 0.14509  | 1       | 81 Tl       |                                    | <i>KO<sub>II,III</sub></i> | 85.451  |
| 0.11426    | 1    | 90 Th   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 108.511    | 0.14512  | 2       | 82 Pb       | <i>Kβ<sub>5</sub><sup>II</sup></i> | <i>KM<sub>IV</sub></i>     | 85.43   |
| 0.114345   | 8    | 91 Pa   | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 108.427    | 0.14512  | 2       | 88 Ra       | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 85.43   |
| 0.11523    | 2    | 91 Pa   | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 107.60     | 0.14553  | 2       | 81 Tl       | <i>Kβ<sub>4</sub></i>              | <i>KN<sub>IV,V</sub></i>   | 85.19   |
| 0.116667   | 9    | 90 Th   | <i>Kβ<sub>5</sub></i>              | <i>KM<sub>IV,V</sub></i>   | 106.269    | 0.14595  | 1       | 81 Tl       | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 84.946  |
| 0.11711    | 2    | 89 Ac   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 105.86     | 0.145970 | 6       | 82 Pb       | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 84.936  |
| 0.11732    | 2    | 89 Ac   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 105.67     | 0.14614  | 1       | 81 Tl       | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 84.836  |
| 0.117396   | 9    | 90 Th   | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 105.609    | 0.146810 | 4       | 82 Pb       | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 84.450  |
| 0.118268   | 3    | 90 Th   | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 104.831    | 0.14798  | 3       | 86 Rn       | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 83.78   |
| 0.12029    | 3    | 88 Ra   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 103.07     | 0.14896  | 3       | 87 Fr       | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 83.23   |
| 0.12050    | 3    | 88 Ra   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 102.89     | 0.14917  | 1       | 81 Tl       | <i>Kβ<sub>5</sub></i>              | <i>KM<sub>IV,V</sub></i>   | 83.114  |
| 0.12055    | 2    | 89 Ac   | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 102.85     | 0.14918  | 1       | 80 Hg       | <i>K</i>                           | Abs. Edge                  | 83.109  |
| 0.12143    | 2    | 89 Ac   | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 102.10     | 0.14931  | 2       | 80 Hg       |                                    | <i>KO<sub>II,III</sub></i> | 83.04   |
| 0.12358    | 5    | 87 Fr   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 100.33     | 0.14978  | 2       | 80 Hg       | <i>Kβ<sub>4</sub></i>              | <i>KN<sub>IV,V</sub></i>   | 82.78   |
| 0.12379    | 5    | 87 Fr   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 100.16     | 0.150142 | 5       | 81 Tl       | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 82.576  |
| 0.12382    | 3    | 88 Ra   | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 100.13     | 0.15020  | 2       | 80 Hg       | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 82.54   |
| 0.12469    | 3    | 88 Ra   | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 99.43      | 0.15040  | 2       | 80 Hg       | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 82.43   |
| 0.125947   | 3    | 92 U    | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 98.439     | 0.150980 | 6       | 81 Tl       | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 82.118  |
| 0.12698    | 5    | 86 Rn   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 97.64      | 0.15210  | 2       | 85 At       | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 81.52   |
| 0.12719    | 5    | 86 Rn   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 97.47      | 0.15294  | 3       | 86 Rn       | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 81.07   |
| 0.12719    | 5    | 87 Fr   | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 97.47      | 0.15353  | 2       | 80 Hg       | <i>Kβ<sub>5</sub></i>              | <i>KM<sub>IV,V</sub></i>   | 80.75   |
| 0.12807    | 5    | 87 Fr   | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 96.81      | 0.153593 | 5       | 79 Au       | <i>K</i>                           | Abs. Edge                  | 80.720  |
| 0.129325   | 3    | 91 Pa   | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 95.868     | 0.153694 | 7       | 79 Au       |                                    | <i>KO<sub>II,III</sub></i> | 80.667  |
| 0.13052    | 4    | 85 At   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 94.99      | 0.154224 | 5       | 79 Au       | <i>Kβ<sub>4</sub></i>              | <i>KN<sub>IV,V</sub></i>   | 80.391  |
| 0.13069    | 5    | 86 Rn   | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 94.87      | 0.154487 | 3       | 80 Hg       | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 80.253  |
| 0.13072    | 4    | 85 At   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 94.84      | 0.154618 | 9       | 79 Au       | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 80.185  |
| 0.130968   | 4    | 92 U    | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 94.665     | 0.15483  | 2       | 79 Au       | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 80.08   |
| 0.13155    | 5    | 86 Rn   | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 94.24      | 0.155321 | 3       | 80 Hg       | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 79.822  |
| 0.132813   | 2    | 90 Th   | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 93.350     | 0.15636  | 1       | 84 Po       | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 79.290  |
| 0.13418    | 2    | 84 Po   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 92.40      | 0.15705  | 2       | 85 At       | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 78.95   |
| 0.13432    | 4    | 85 At   | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 92.30      | 0.157880 | 5       | 79 Au       | <i>Kβ<sub>5</sub><sup>I</sup></i>  | <i>KM<sub>V</sub></i>      | 78.529  |
| 0.134343   | 9    | 91 Pa   | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 92.287     | 0.158062 | 7       | 79 Au       | <i>Kβ<sub>5</sub><sup>II</sup></i> | <i>KM<sub>IV</sub></i>     | 78.438  |
| 0.13438    | 2    | 84 Po   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 92.26      | 0.15818  | 1       | 78 Pt       | <i>K</i>                           | Abs. Edge                  | 78.381  |
| 0.13517    | 4    | 85 At   | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 91.72      | 0.15826  | 1       | 78 Pt       |                                    | <i>KO<sub>II,III</sub></i> | 78.341  |
| 0.136417   | 8    | 89 Ac   | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 90.884     | 0.15881  | 2       | 78 Pt       | <i>Kβ<sub>4</sub></i>              | <i>KN<sub>IV,V</sub></i>   | 78.069  |
| 0.13694    | 1    | 83 Bi   | <i>K</i>                           | Abs. Edge                  | 90.534     | 0.158982 | 3       | 79 Au       | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 77.984  |
| 0.13709    | 1    | 83 Bi   |                                    | <i>KO<sub>II,III</sub></i> | 90.435     | 0.15920  | 1       | 78 Pt       | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 77.878  |
| 0.13759    | 2    | 83 Bi   | <i>Kβ<sub>4</sub></i>              | <i>KN<sub>IV,V</sub></i>   | 90.11      | 0.15939  | 1       | 78 Pt       | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 77.785  |
| 0.137829   | 2    | 90 Th   | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 89.953     | 0.159810 | 2       | 79 Au       | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 77.580  |
| 0.13797    | 1    | 83 Bi   | <i>Kβ<sub>2</sub><sup>I</sup></i>  | <i>KN<sub>III</sub></i>    | 89.864     | 0.160789 | 2       | 83 Bi       | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 77.1079 |
| 0.13807    | 2    | 84 Po   | <i>Kβ<sub>1</sub></i>              | <i>KM<sub>III</sub></i>    | 89.80      | 0.16130  | 1       | 84 Po       | <i>Kα<sub>2</sub></i>              | <i>KL<sub>II</sub></i>     | 76.862  |
| 0.13817    | 1    | 83 Bi   | <i>Kβ<sub>2</sub><sup>II</sup></i> | <i>KN<sub>II</sub></i>     | 89.733     | 0.16255  | 3       | 78 Pt       | <i>Kβ<sub>5</sub><sup>I</sup></i>  | <i>KM<sub>V</sub></i>      | 76.27   |
| 0.13892    | 2    | 84 Po   | <i>Kβ<sub>3</sub></i>              | <i>KM<sub>II</sub></i>     | 89.25      | 0.16271  | 2       | 78 Pt       | <i>Kβ<sub>5</sub><sup>II</sup></i> | <i>KM<sub>IV</sub></i>     | 76.199  |
| 0.14014    | 2    | 88 Ra   | <i>Kα<sub>1</sub></i>              | <i>KL<sub>III</sub></i>    | 88.47      | 0.16292  | 1       | 77 Ir       | <i>K</i>                           | Abs. Edge                  | 76.101  |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation     | keV     | Wavelength<br>Å* | p.e. Element | Designation   | keV      |
|------------------|--------------|-----------------|---------|------------------|--------------|---------------|----------|
| 0.163019         | 5 77 Ir      | $KO_{II,III}$   | 76.053  | 0.190381         | 4 78 Pt      | $K\alpha_2$   | 65.122   |
| 0.16352          | 2 77 Ir      | $K\beta_4$      | 75.821  | 0.1908           | 2 72 Hf      | $K\beta_2$    | 64.98    |
| 0.163675         | 3 78 Pt      | $K\beta_1$      | 75.748  | 0.190890         | 2 73 Ta      | $K\beta_3$    | 64.9488  |
| 0.163956         | 7 77 Ir      | $K\beta_2^I$    | 75.619  | 0.191047         | 2 77 Ir      | $K\alpha_1$   | 64.8956  |
| 0.16415          | 1 77 Ir      | $K\beta_2^{II}$ | 75.529  | 0.19585          | 5 71 Lu      | $K$           | 63.31    |
| 0.164501         | 3 78 Pt      | $K\beta_3$      | 75.368  | 0.19589          | 2 71 Lu      | $KO_{II,III}$ | 63.293   |
| 0.165376         | 2 82 Pb      | $K\alpha_1$     | 74.9694 | 0.195904         | 2 77 Ir      | $K\alpha_2$   | 63.2867  |
| 0.165717         | 2 83 Bi      | $K\alpha_2$     | 74.8148 | 0.19607          | 3 72 Hf      | $K\beta_1$    | 63.234   |
| 0.167373         | 9 77 Ir      | $K\beta_3^I$    | 74.075  | 0.196794         | 2 76 Os      | $K\alpha_1$   | 63.0005  |
| 0.16759          | 2 77 Ir      | $K\beta_3^{II}$ | 73.980  | 0.19686          | 4 72 Hf      | $K\beta_3$    | 62.98    |
| 0.16787          | 1 76 Os      | $K$             | 73.856  | 0.1969           | 2 71 Lu      | $K\beta_2$    | 62.97    |
| 0.16798          | 1 76 Os      | $KO_{II,III}$   | 73.808  | 0.20084          | 2 71 Lu      | $K\beta_5$    | 61.732   |
| 0.16842          | 2 76 Os      | $K\beta_4$      | 73.615  | 0.201639         | 2 76 Os      | $K\alpha_2$   | 61.4867  |
| 0.168542         | 2 77 Ir      | $K\beta_1$      | 73.5608 | 0.20224          | 5 70 Yb      | $K$           | 61.30    |
| 0.168906         | 6 76 Os      | $K\beta_2^I$    | 73.402  | 0.20226          | 2 70 Yb      | $KO_{II,III}$ | 61.298   |
| 0.16910          | 1 76 Os      | $K\beta_2^{II}$ | 73.318  | 0.20231          | 3 71 Lu      | $K\beta_1$    | 61.283   |
| 0.169367         | 2 77 Ir      | $K\beta_3$      | 73.2027 | 0.202781         | 2 75 Re      | $K\alpha_1$   | 61.1403  |
| 0.170136         | 2 81 Tl      | $K\alpha_1$     | 72.8715 | 0.20309          | 4 71 Lu      | $K\beta_3$    | 61.05    |
| 0.170294         | 2 82 Pb      | $K\alpha_2$     | 72.8042 | 0.2033           | 2 70 Yb      | $K\beta_2$    | 60.89    |
| 0.17245          | 1 76 Os      | $K\beta_5^I$    | 71.895  | 0.20739          | 2 70 Yb      | $K\beta_5$    | 59.782   |
| 0.17262          | 1 76 Os      | $K\beta_5^{II}$ | 71.824  | 0.207611         | 1 75 Re      | $K\alpha_2$   | 59.7179  |
| 0.17302          | 1 75 Re      | $K$             | 71.658  | 0.20880          | 5 69 Tm      | $K$           | 59.38    |
| 0.17308          | 1 75 Re      | $KO_{II,III}$   | 71.633  | 0.20884          | 8 70 Yb      | $K\beta_1$    | 59.37    |
| 0.173611         | 3 76 Os      | $K\beta_1$      | 71.413  | 0.20891          | 2 69 Tm      | $KO_{II,III}$ | 59.346   |
| 0.17362          | 2 75 Re      | $K\beta_4$      | 71.410  | 0.2090100        | Std. 74 W    | $K\alpha_1$   | 59.31824 |
| 0.174054         | 6 75 Re      | $K\beta_2^I$    | 71.232  | 0.2096           | 1 70 Yb      | $K\beta_3$    | 59.14    |
| 0.17425          | 1 75 Re      | $K\beta_2^{II}$ | 71.151  | 0.2098           | 2 69 Tm      | $K\beta_2$    | 59.09    |
| 0.174431         | 3 76 Os      | $K\beta_3$      | 71.077  | 0.213828         | 2 74 W       | $K\alpha_2$   | 57.9817  |
| 0.175036         | 2 81 Tl      | $K\alpha_2$     | 70.8319 | 0.21404          | 2 69 Tm      | $K\beta_5$    | 57.923   |
| 0.175068         | 3 80 Hg      | $K\alpha_1$     | 70.819  | 0.215497         | 4 73 Ta      | $K\alpha_1$   | 57.532   |
| 0.17766          | 1 75 Re      | $K\beta_5^I$    | 69.786  | 0.21556          | 2 69 Tm      | $K\beta_1$    | 57.517   |
| 0.17783          | 1 75 Re      | $K\beta_5^{II}$ | 69.719  | 0.21567          | 1 68 Er      | $K$           | 57.487   |
| 0.17837          | 1 74 W       | $K$             | 69.508  | 0.21581          | 3 68 Er      | $KO_{II,III}$ | 57.450   |
| 0.178444         | 5 74 W       | $KO_{II,III}$   | 69.479  | 0.21592          | 4 74 W       | $KL_I$        | 57.42    |
| 0.178880         | 3 75 Re      | $K\beta_1$      | 69.310  | 0.21636          | 2 69 Tm      | $K\beta_4$    | 57.304   |
| 0.17892          | 2 74 W       | $K\beta_4$      | 69.294  | 0.2167           | 2 68 Er      | $K\beta_2$    | 57.21    |
| 0.179421         | 7 74 W       | $K\beta_2^I$    | 69.101  | 0.220305         | 8 73 Ta      | $K\alpha_2$   | 56.277   |
| 0.17960          | 1 74 W       | $K\beta_2^{II}$ | 69.031  | 0.22124          | 3 68 Er      | $K\beta_5$    | 56.040   |
| 0.179697         | 3 75 Re      | $K\beta_3$      | 68.994  | 0.222227         | 3 72 Hf      | $K\alpha_1$   | 55.7902  |
| 0.179958         | 3 80 Hg      | $K\alpha_2$     | 68.895  | 0.22266          | 2 68 Er      | $K\beta_1$    | 55.681   |
| 0.180195         | 2 79 Au      | $K\alpha_1$     | 68.8037 | 0.22291          | 1 67 Ho      | $K$           | 55.619   |
| 0.183092         | 7 74 W       | $K\beta_3^I$    | 67.715  | 0.22305          | 3 67 Ho      | $KO_{II,III}$ | 55.584   |
| 0.183264         | 5 74 W       | $K\beta_3^{II}$ | 67.652  | 0.22341          | 2 68 Er      | $K\beta_3$    | 55.494   |
| 0.18394          | 1 73 Ta      | $K$             | 67.403  | 0.2241           | 2 67 Ho      | $K\beta_2$    | 55.32    |
| 0.184031         | 7 73 Ta      | $KO_{II,III}$   | 67.370  | 0.227024         | 3 72 Hf      | $K\alpha_2$   | 54.6114  |
| 0.184374         | 2 74 W       | $K\beta_1$      | 67.2443 | 0.22855          | 3 67 Ho      | $K\beta_5$    | 54.246   |
| 0.18451          | 1 73 Ta      | $K\beta_4$      | 67.194  | 0.229298         | 2 71 Lu      | $K\alpha_1$   | 54.0698  |
| 0.185011         | 8 73 Ta      | $K\beta_2^I$    | 67.013  | 0.23012          | 2 67 Ho      | $K\beta_1$    | 53.877   |
| 0.185075         | 2 79 Au      | $K\alpha_2$     | 66.9895 | 0.23048          | 1 66 Dy      | $K$           | 53.793   |
| 0.185181         | 2 74 W       | $K\beta_3$      | 66.9514 | 0.23056          | 3 66 Dy      | $KO_{II,III}$ | 53.774   |
| 0.185188         | 9 73 Ta      | $K\beta_3^{II}$ | 66.949  | 0.23083          | 2 67 Ho      | $K\beta_3$    | 53.711   |
| 0.185511         | 4 78 Pt      | $K\alpha_1$     | 66.832  | 0.2317           | 2 66 Dy      | $K\beta_2$    | 53.47    |
| 0.18672          | 4 79 Au      | $KL_I$          | 66.40   | 0.234081         | 2 71 Lu      | $K\alpha_2$   | 52.9650  |
| 0.188757         | 6 73 Ta      | $K\beta_5^I$    | 65.683  | 0.23618          | 3 66 Dy      | $K\beta_5$    | 52.494   |
| 0.188920         | 6 73 Ta      | $K\beta_5^{II}$ | 65.626  | 0.236655         | 2 70 Yb      | $K\alpha_1$   | 52.3889  |
| 0.18982          | 5 72 Hf      | $K$             | 65.31   | 0.23788          | 2 66 Dy      | $K\beta_1$    | 52.119   |
| 0.190089         | 4 73 Ta      | $K\beta_1$      | 65.223  | 0.23841          | 1 65 Tb      | $K$           | 52.002   |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation     | keV     | Wavelength<br>Å* | p.e. Element | Designation     | keV     |
|------------------|--------------|-----------------|---------|------------------|--------------|-----------------|---------|
| 0.23858          | 3 65 Tb      | $KO_{II,III}$   | 51.965  | 0.315816         | 2 58 Ce      | $K\beta_1$      | 39.2573 |
| 0.23862          | 2 66 Dy      | $K\beta_3$      | 51.957  | 0.316520         | 4 58 Ce      | $K\beta_3$      | 39.1701 |
| 0.2397           | 2 65 Tb      | $K\beta_2$      | 51.68   | 0.31844          | 5 57 La      | $K$             | 38.934  |
| 0.241424         | 2 70 Yb      | $K\alpha_2$     | 51.3540 | 0.31864          | 2 57 La      | $KO_{II,III}$   | 38.909  |
| 0.244338         | 2 69 Tm      | $K\alpha_1$     | 50.7416 | 0.31931          | 2 57 La      | $K\beta_4^I$    | 38.828  |
| 0.24608          | 2 65 Tb      | $K\beta_1$      | 50.382  | 0.320117         | 7 57 La      | $K\beta_2$      | 38.7299 |
| 0.24681          | 1 64 Gd      | $K$             | 50.233  | 0.320160         | 4 61 Pm      | $K\alpha_1$     | 38.7247 |
| 0.24683          | 2 65 Tb      | $K\beta_3$      | 50.229  | 0.324803         | 4 61 Pm      | $K\alpha_2$     | 38.1712 |
| 0.24687          | 3 64 Gd      | $KO_{II,III}$   | 50.221  | 0.32546          | 2 57 La      | $K\beta_5^I$    | 38.094  |
| 0.24816          | 3 64 Gd      | $K\beta_2$      | 49.959  | 0.32563          | 2 57 La      | $K\beta_6^{II}$ | 38.074  |
| 0.249095         | 2 69 Tm      | $K\alpha_2$     | 49.7726 | 0.327983         | 3 57 La      | $K\beta_1$      | 37.8010 |
| 0.252365         | 2 68 Er      | $K\alpha_1$     | 49.1277 | 0.328686         | 4 57 La      | $K\beta_3$      | 37.7202 |
| 0.25275          | 3 64 Gd      | $K\beta_5$      | 49.052  | 0.33104          | 1 56 Ba      | $K$             | 37.452  |
| 0.25460          | 2 64 Gd      | $K\beta_1$      | 48.697  | 0.33127          | 2 56 Ba      | $KO_{II,III}$   | 37.426  |
| 0.25534          | 2 64 Gd      | $K\beta_3$      | 48.555  | 0.331846         | 2 60 Nd      | $K\alpha_1$     | 37.3610 |
| 0.25553          | 1 63 Eu      | $K$             | 48.519  | 0.33229          | 2 56 Ba      | $K\beta_4^{II}$ | 37.311  |
| 0.255645         | 7 63 Eu      | $KO_{II,III}$   | 48.497  | 0.33277          | 1 56 Ba      | $K\beta_2$      | 37.257  |
| 0.256923         | 8 63 Eu      | $K\beta_2^I$    | 48.256  | 0.336472         | 2 60 Nd      | $K\alpha_2$     | 36.8474 |
| 0.257110         | 2 68 Er      | $K\alpha_2$     | 48.2211 | 0.33814          | 2 56 Ba      | $K\beta_5^I$    | 36.666  |
| 0.260756         | 2 67 Ho      | $K\alpha_1$     | 47.5467 | 0.33835          | 2 56 Ba      | $K\beta_6^{II}$ | 36.643  |
| 0.263577         | 5 63 Eu      | $K\beta_1$      | 47.0379 | 0.340811         | 3 56 Ba      | $K\beta_1$      | 36.3782 |
| 0.264332         | 5 63 Eu      | $K\beta_3$      | 46.9036 | 0.341507         | 4 56 Ba      | $K\beta_3$      | 36.3040 |
| 0.26464          | 5 62 Sm      | $K$             | 46.849  | 0.344140         | 2 59 Pr      | $K\alpha_1$     | 36.0263 |
| 0.26491          | 3 62 Sm      | $KO_{II,III}$   | 46.801  | 0.34451          | 1 55 Cs      | $K$             | 35.987  |
| 0.265486         | 2 67 Ho      | $K\alpha_2$     | 46.6997 | 0.34611          | 2 55 Cs      | $K\beta_2$      | 35.822  |
| 0.2662           | 1 62 Sm      | $K\beta_2$      | 46.57   | 0.348749         | 2 59 Pr      | $K\alpha_2$     | 35.5502 |
| 0.269533         | 2 66 Dy      | $K\alpha_1$     | 45.9984 | 0.354364         | 7 55 Cs      | $K\beta_1$      | 34.9869 |
| 0.27111          | 3 62 Sm      | $K\beta_5$      | 45.731  | 0.355050         | 4 55 Cs      | $K\beta_3$      | 34.9194 |
| 0.27301          | 2 62 Sm      | $K\beta_1$      | 45.413  | 0.357092         | 2 58 Ce      | $K\alpha_1$     | 34.7197 |
| 0.27376          | 2 62 Sm      | $K\beta_3$      | 45.289  | 0.3584           | 5 54 Xe      | $K$             | 34.59   |
| 0.274247         | 2 66 Dy      | $K\alpha_2$     | 45.2078 | 0.36026          | 3 54 Xe      | $K\beta_2$      | 34.415  |
| 0.27431          | 5 61 Pm      | $K$             | 45.198  | 0.361683         | 2 58 Ce      | $K\alpha_2$     | 34.2789 |
| 0.2759           | 1 61 Pm      | $K\beta_2$      | 44.93   | 0.36872          | 2 54 Xe      | $K\beta_1$      | 33.624  |
| 0.278724         | 2 65 Tb      | $K\alpha_1$     | 44.4816 | 0.36941          | 2 54 Xe      | $K\beta_3$      | 33.562  |
| 0.28290          | 3 61 Pm      | $K\beta_1$      | 43.826  | 0.370737         | 2 57 La      | $K\alpha_1$     | 33.4418 |
| 0.283423         | 2 65 Tb      | $K\alpha_2$     | 43.7441 | 0.37381          | 1 53 I       | $K$             | 33.1665 |
| 0.28363          | 4 61 Pm      | $K\beta_3$      | 43.713  | 0.37523          | 2 53 I       | $K\beta_2$      | 33.042  |
| 0.28453          | 5 60 Nd      | $K$             | 43.574  | 0.375313         | 2 57 La      | $K\alpha_2$     | 33.0341 |
| 0.2861           | 1 60 Nd      | $K\beta_2$      | 43.32   | 0.383905         | 4 53 I       | $K\beta_1$      | 32.2947 |
| 0.288353         | 2 64 Gd      | $K\alpha_1$     | 42.9962 | 0.384564         | 4 53 I       | $K\beta_3$      | 32.2394 |
| 0.293038         | 2 64 Gd      | $K\alpha_2$     | 42.3089 | 0.385111         | 4 56 Ba      | $K\alpha_1$     | 32.1936 |
| 0.293299         | 2 60 Nd      | $K\beta_1$      | 42.2713 | 0.389668         | 5 56 Ba      | $K\alpha_2$     | 31.8171 |
| 0.294027         | 3 60 Nd      | $K\beta_3$      | 42.1665 | 0.38974          | 1 52 Te      | $KO_{II,III}$   | 31.8114 |
| 0.29518          | 5 59 Pr      | $K$             | 42.002  | 0.38974          | 1 52 Te      | $K$             | 31.8114 |
| 0.29679          | 2 59 Pr      | $K\beta_2$      | 41.773  | 0.391102         | 6 52 Te      | $K\beta_2$      | 31.7004 |
| 0.298446         | 2 63 Eu      | $K\alpha_1$     | 41.5422 | 0.399995         | 5 52 Te      | $K\beta_1$      | 30.9957 |
| 0.303118         | 2 63 Eu      | $K\alpha_2$     | 40.9019 | 0.400290         | 4 55 Cs      | $K\alpha_1$     | 30.9728 |
| 0.304261         | 4 59 Pr      | $K\beta_1$      | 40.7482 | 0.400659         | 4 52 Te      | $K\beta_3$      | 30.9443 |
| 0.304975         | 5 59 Pr      | $K\beta_3$      | 40.6529 | 0.404835         | 4 55 Cs      | $K\alpha_2$     | 30.6251 |
| 0.30648          | 5 58 Ce      | $K$             | 40.453  | 0.40666          | 1 51 Sb      | $KO_{II,III}$   | 30.4875 |
| 0.30668          | 2 58 Ce      | $KO_{II,III}$   | 40.427  | 0.40668          | 1 51 Sb      | $K$             | 30.4860 |
| 0.30737          | 2 58 Ce      | $K\beta_4^I$    | 40.337  | 0.40702          | 1 51 Sb      | $K\beta_4^I$    | 30.4604 |
| 0.30816          | 1 58 Ce      | $K\beta_2$      | 40.233  | 0.407973         | 5 51 Sb      | $K\beta_2$      | 30.3895 |
| 0.309040         | 2 62 Sm      | $K\alpha_1$     | 40.1181 | 0.41378          | 1 51 Sb      | $K\beta_5^I$    | 29.9632 |
| 0.31342          | 2 58 Ce      | $K\beta_5^I$    | 39.558  | 0.41388          | 1 51 Sb      | $K\beta_6^{II}$ | 29.9560 |
| 0.31357          | 2 58 Ce      | $K\beta_6^{II}$ | 39.539  | 0.41634          | 2 54 Xe      | $K\alpha_1$     | 29.779  |
| 0.313698         | 2 62 Sm      | $K\alpha_2$     | 39.5224 | 0.417085         | 3 51 Sb      | $K\beta_1$      | 29.7256 |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation     | keV       | Wavelength<br>Å* | p.e. Element | Designation        | keV       |
|------------------|--------------|-----------------|-----------|------------------|--------------|--------------------|-----------|
| 0.417737         | 4 51 Sb      | $K\beta_3$      | 29.6792   | 0.546200         | 4 45 Rh      | $K\beta_3$         | 22.6989   |
| 0.42087          | 2 54 Xe      | $K\alpha_2$     | 29.458    | 0.5544           | 2 95 Am      | $L_{\gamma_2}$     | 22.361    |
| 0.42467          | 3 50 Sn      | $KO_{II,III}$   | 29.195    | 0.5572           | 1 94 Pu      | $L_{II}$           | Abs. Edge |
| 0.42467          | 1 50 Sn      | $K$             | Abs. Edge | 0.5585           | 5 93 Np      | $L_{\gamma_4}$     | 22.20     |
| 0.42495          | 3 50 Sn      | $K\beta_4^I$    | 29.175    | 0.5594075        | 6 47 Ag      | $K\alpha_1$        | 22.16292  |
| 0.425915         | 8 50 Sn      | $K\beta_2$      | 29.1093   | 0.55973          | 2 94 Pu      | $L_{\gamma_6}$     | 22.1502   |
| 0.43175          | 3 50 Sn      | $K\beta_3^I$    | 28.716    | 0.56051          | 1 44 Ru      | $K$                | Abs. Edge |
| 0.43184          | 3 50 Sn      | $K\beta_3^{II}$ | 28.710    | 0.56089          | 9 44 Ru      | $K\beta_4$         | 22.1193   |
| 0.433318         | 5 53 I       | $K\alpha_1$     | 28.6120   | 0.56166          | 3 44 Ru      | $K\beta_2$         | 22.104    |
| 0.435236         | 5 50 Sn      | $K\beta_1$      | 28.4860   | 0.561886         | 9 95 Am      | $L_{\gamma_1}$     | 22.074    |
| 0.435877         | 5 50 Sn      | $K\beta_3$      | 28.4440   | 0.563798         | 4 47 Ag      | $K\alpha_2$        | 22.0652   |
| 0.437829         | 7 53 I       | $K\alpha_2$     | 28.3172   | 0.564001         | 9 94 Pu      | $L_{\gamma_3}$     | 21.9903   |
| 0.44371          | 1 49 In      | $K$             | Abs. Edge | 0.5658           | 1 94 Pu      | $L_{\gamma_8}$     | 21.9824   |
| 0.44374          | 3 49 In      | $KO_{II,III}$   | 27.940    | 0.5658           | 1 94 Pu      | $L_{II}O_I$        | 21.914    |
| 0.44393          | 4 49 In      | $K\beta_4^I$    | 27.928    | 0.56785          | 9 44 Ru      | $K\beta_3^I$       | 21.834    |
| 0.44500          | 1 49 In      | $K\beta_2$      | 27.8608   | 0.5680           | 2 44 Ru      | $K\beta_3^{II}$    | 21.829    |
| 0.45086          | 2 49 In      | $K\beta_3^I$    | 27.499    | 0.5695           | 1 92 U       | $L_I$              | Abs. Edge |
| 0.45098          | 2 49 In      | $K\beta_3^{II}$ | 27.491    | 0.5706           | 1 92 U       | $L_{\gamma_{11}}$  | 21.771    |
| 0.451295         | 3 52 Te      | $K\alpha_1$     | 27.4723   | 0.57068          | 2 94 Pu      | $L_{\gamma_2}$     | 21.729    |
| 0.454545         | 4 49 In      | $K\beta_1$      | 27.2759   | 0.572482         | 4 44 Ru      | $K\beta_1$         | 21.1251   |
| 0.455181         | 4 49 In      | $K\beta_3$      | 27.2377   | 0.5725           | 1 92 U       | $L_{IO_{IV,V}}$    | 21.657    |
| 0.455784         | 3 52 Te      | $K\alpha_2$     | 27.2017   | 0.573067         | 4 44 Ru      | $K\beta_3$         | 21.6346   |
| 0.46407          | 1 48 Cd      | $K$             | Abs. Edge | 0.57499          | 9 92 U       | $L_{\gamma_4}$     | 21.562    |
| 0.465328         | 7 48 Cd      | $K\beta_2$      | 26.6438   | 0.576700         | 9 92 U       | $L_{\gamma_4}'$    | 21.4984   |
| 0.470354         | 3 51 Sb      | $K\alpha_1$     | 26.3591   | 0.57699          | 5 93 Np      | $L_{\gamma_6}$     | 21.488    |
| 0.474827         | 3 51 Sb      | $K\alpha_2$     | 26.1108   | 0.578882         | 9 94 Pu      | $L_{\gamma_1}$     | 21.4173   |
| 0.475105         | 6 48 Cd      | $K\beta_1$      | 26.0955   | 0.5810           | 5 93 Np      | $L_{\gamma_3}$     | 21.34     |
| 0.475730         | 5 48 Cd      | $K\beta_3$      | 26.0612   | 0.585448         | 3 46 Pd      | $K\alpha_1$        | 21.1771   |
| 0.48589          | 1 47 Ag      | $K$             | Abs. Edge | 0.5873           | 5 93 Np      | $L_{\gamma_2}$     | 21.11     |
| 0.4859           | 9 47 Ag      | $K\beta_4$      | 25.512    | 0.58906          | 1 43 Te      | $K$                | Abs. Edge |
| 0.487032         | 4 47 Ag      | $K\beta_2$      | 25.4564   | 0.589821         | 3 46 Pd      | $K\alpha_2$        | 21.0473   |
| 0.490599         | 3 50 Sn      | $K\alpha_1$     | 25.2713   | 0.58986          | 5 92 U       | $L_{\gamma_{11}}$  | 21.0201   |
| 0.49306          | 2 47 Ag      | $K\beta_6$      | 25.145    | 0.58986          | 5 92 U       | $L_{IN_V}$         | 21.019    |
| 0.495053         | 3 50 Sn      | $K\alpha_2$     | 25.0440   | 0.59024          | 5 43 Tc      | $K\beta_2$         | 21.005    |
| 0.497069         | 4 47 Ag      | $K\beta_1$      | 24.9424   | 0.59096          | 5 92 U       | $L_{IN_{IV}}$      | 20.979    |
| 0.497685         | 4 47 Ag      | $K\beta_3$      | 24.9115   | 0.5919           | 1 92 U       | $L_{II}$           | Abs. Edge |
| 0.5092           | 1 46 Pd      | $K$             | Abs. Edge | 0.59203          | 5 92 U       | $L_{II}P_{IV}$     | 20.945    |
| 0.5093           | 2 46 Pd      | $K\beta_4$      | 24.348    | 0.5930           | 2 92 U       | $L_{II}P_{II,III}$ | 20.942    |
| 0.510228         | 4 46 Pd      | $K\beta_2$      | 24.2991   | 0.5930           | 2 92 U       | $L_{II}P_{II,III}$ | 20.906    |
| 0.512113         | 3 49 In      | $K\alpha_1$     | 24.2097   | 0.5937           | 1 91 Pa      | $L_{\gamma_4}$     | 20.882    |
| 0.516544         | 3 49 In      | $K\alpha_2$     | 24.0020   | 0.594845         | 9 92 U       | $L_{\gamma_6}$     | 20.826    |
| 0.51670          | 9 46 Pd      | $K\beta_5$      | 23.995    | 0.596498         | 9 93 Np      | $L_{\gamma_1}$     | 20.7848   |
| 0.520520         | 4 46 Pd      | $K\beta_1$      | 23.8187   | 0.59728          | 5 92 U       | $L_{II}O_{III}$    | 20.758    |
| 0.521123         | 4 46 Pd      | $K\beta_3$      | 23.7911   | 0.598574         | 9 92 U       | $L_{\gamma_3}$     | 20.7127   |
| 0.53395          | 1 45 Rh      | $K$             | Abs. Edge | 0.5988           | 1 94 Pu      | $L_{\gamma_8}$     | 20.704    |
| 0.53401          | 9 45 Rh      | $K\beta_4^I$    | 23.217    | 0.60125          | 5 92 U       | $L_{\gamma_8}$     | 20.621    |
| 0.535010         | 3 48 Cd      | $K\alpha_1$     | 23.1736   | 0.60130          | 4 43 Tc      | $K\beta_1$         | 20.619    |
| 0.53503          | 2 45 Rh      | $K\beta_2$      | 23.1728   | 0.60188          | 4 43 Tc      | $K\beta_3$         | 20.599    |
| 0.53513          | 5 45 Rh      | $K\beta_3^{II}$ | 23.168    | 0.6031           | 1 92 U       | $L_v$              | 20.556    |
| 0.5365           | 1 94 Pu      | $L_I$           | Abs. Edge | 0.605237         | 9 92 U       | $L_{\gamma_2}$     | 20.4847   |
| 0.539422         | 3 48 Cd      | $K\alpha_2$     | 22.9841   | 0.6059           | 1 90 Th      | $L_I$              | Abs. Edge |
| 0.54101          | 9 45 Rh      | $K\beta_3^I$    | 22.917    | 0.60705          | 8 90 Th      | $L_{\gamma_{11}}$  | 20.464    |
| 0.54118          | 9 45 Rh      | $K\beta_3^{II}$ | 22.909    | 0.6083           | 1 90 Th      | $L_{IO_{IV,V}}$    | 20.424    |
| 0.5416           | 1 94 Pu      | $L_{\gamma_4}$  | 22.891    | 0.61098          | 4 90 Th      | $L_{\gamma_4}$     | 20.383    |
| 0.54311          | 2 95 Am      | $L_{\gamma_8}$  | 22.8282   | 0.61251          | 4 90 Th      | $L_{\gamma_4}'$    | 20.292    |
| 0.5432           | 1 94 Pu      | $L_{\gamma_4}'$ | 22.823    | 0.6133           | 1 91 Pa      | $L_{\gamma_6}$     | 20.242    |
| 0.545605         | 4 45 Rh      | $K\beta_1$      | 22.7236   | 0.613279         | 4 45 Rh      | $K\alpha_1$        | 20.216    |
|                  |              |                 |           | 0.6146           | 1 90 Th      | $L_{IO_I}$         | 20.2161   |
|                  |              |                 |           | 0.614770         | 9 92 U       | $L_{\gamma_1}$     | 20.174    |
|                  |              |                 |           | 0.6160           | 1 90 Th      | $L_{IN_{IV}}$      | 20.1671   |
|                  |              |                 |           |                  |              | $L_{IN_{VI,VII}}$  | 20.128    |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation       | keV                | Wavelength<br>Å* | p.e. Element | Designation | keV            |                     |          |
|------------------|--------------|-------------------|--------------------|------------------|--------------|-------------|----------------|---------------------|----------|
| 0.616            | 1 93 Np      | $L_{\gamma_5}$    | $L_{II}N_I$        | 20.12            | 0.67383      | 2 95 Am     | $L\beta_5$     | $L_{III}O_{IV,V}$   | 18.3996  |
| 0.6169           | 1 91 Pa      | $L_{\gamma_3}$    | $L_{II}N_{III}$    | 20.098           | 0.67491      | 4 90 Th     | $L_{\gamma_5}$ | $L_{II}N_I$         | 18.370   |
| 0.617630         | 4 45 Rh      | $K\alpha_2$       | $KL_{II}$          | 20.0737          | 0.67502      | 3 43 Tc     | $K\alpha_1$    | $KL_{III}$          | 18.3671  |
| 0.61978          | 1 42 Mo      | $K$               | Abs. Edge          | 20.0039          | 0.67538      | 5 88 Ra     | $L_{\gamma_3}$ | $L_{II}N_{III}$     | 18.357   |
| 0.62001          | 9 42 Mo      | $K\beta_4^I$      | $KN_{IV,V}$        | 19.996           | 0.6764       | 1 88 Ra     |                | $L_{II}O_{III}$     | 18.330   |
| 0.62099          | 2 42 Mo      | $K\beta_2$        | $KN_{II,III}$      | 19.9652          | 0.67772      | 2 94 Pu     | $L\beta_1$     | $L_{II}M_{IV}$      | 18.2937  |
| 0.62107          | 5 42 Mo      | $K\beta_2^{II}$   | $KN_{II}$          | 19.963           | 0.6780       | 1 88 Ra     |                | $L_{II}O_{II}$      | 18.286   |
| 0.6228           | 1 92 U       |                   | $L_{II}N_{III}$    | 19.907           | 0.67932      | 3 43 Tc     | $K\alpha_2$    | $KL_{II}$           | 18.2508  |
| 0.6239           | 1 91 Pa      | $L_{\gamma_2}$    | $L_{II}N_{II}$     | 19.872           | 0.6801       | 1 88 Ra     | $L_{\gamma_8}$ | $L_{II}O_I$         | 18.230   |
| 0.62636          | 9 90 Th      | $L_{\gamma_{11}}$ | $L_{II}N_V$        | 19.794           | 0.681014     | 8 92 U      | $L\beta_9$     | $L_{II}M_V$         | 18.2054  |
| 0.62692          | 5 42 No      | $K\beta_5^I$      | $KM_V$             | 19.776           | 0.68199      | 5 88 Ra     | $L_{\gamma_2}$ | $L_{II}N_{II}$      | 18.179   |
| 0.62708          | 5 42 Mo      | $K\beta_5^{II}$   | $KM_{IV}$          | 19.771           | 0.68639      | 2 95 Am     | $L\beta_4$     | $L_{II}M_{II}$      | 18.0627  |
| 0.6276           | 1 90 Th      |                   | $L_{II}N_{IV}$     | 19.755           | 0.6867       | 1 94 Pu     | $L_{III}$      | Abs. Edge           | 18.054   |
| 0.6299           | 1 90 Th      | $L_{II}$          | Abs. Edge          | 19.683           | 0.6874       | 1 88 Ra     |                | $L_{II}N_I$         | 18.036   |
| 0.62991          | 9 90 Th      |                   | $L_{II}P_{IV}$     | 19.682           | 0.68760      | 5 92 U      | $L\beta_{10}$  | $L_{II}M_{IV}$      | 18.031   |
| 0.6312           | 1 90 Th      |                   | $L_{II}P_{II,III}$ | 19.642           | 0.68883      | 1 40 Zr     | $K$            | Abs. Edge           | 17.9989  |
| 0.6316           | 1 90 Th      |                   | $L_{II}P_I$        | 19.629           | 0.68901      | 5 40 Zr     | $K\beta_4$     | $KN_{IV,V}$         | 17.994   |
| 0.632288         | 9 42 Mo      | $K\beta_1$        | $KM_{III}$         | 19.6083          | 0.68920      | 9 93 Np     | $L\beta_3$     | $L_{II}M_{III}$     | 17.989   |
| 0.63258          | 4 90 Th      | $L_{\gamma_6}$    | $L_{II}O_{IV}$     | 19.599           | 0.68993      | 4 40 Zr     | $K\beta_2$     | $KN_{II,III}$       | 17.970   |
| 0.632872         | 2 42 Mo      | $K\beta_3$        | $KM_{II}$          | 19.5903          | 0.69068      | 2 94 Pu     | $L\beta_5$     | $L_{III}O_{IV,V}$   | 17.9506  |
| 0.63358          | 9 91 Pa      | $L_{\gamma_1}$    | $L_{II}N_{IV}$     | 19.568           | 0.6932       | 1 88 Ra     |                | $L_{II}N_V$         | 17.884   |
| 0.63557          | 2 92 U       | $L_{\gamma_5}$    | $L_{II}N_I$        | 19.5072          | 0.69463      | 5 88 Ra     | $L_{\gamma_1}$ | $L_{II}N_{IV}$      | 17.849   |
| 0.63559          | 4 90 Th      | $L_{\gamma_3}$    | $L_{II}N_{III}$    | 19.507           | 0.6959       | 1 40 Zr     | $K\beta_5$     | $KM_{IV,V}$         | 17.815   |
| 0.6356           | 1 90 Th      |                   | $L_{II}O_{III}$    | 19.506           | 0.698478     | 9 93 Np     | $L\beta_1$     | $L_{II}M_{IV}$      | 17.7502  |
| 0.6369           | 1 90 Th      |                   | $L_{II}O_{II}$     | 19.466           | 0.7003       | 1 94 Pu     | $L\beta_7$     | $L_{III}O_I$        | 17.705   |
| 0.63898          | 5 90 Th      | $L_{\gamma_8}$    | $L_{II}O_I$        | 19.403           | 0.701390     | 9 95 Am     | $L\beta_2$     | $L_{III}N_V$        | 17.6765  |
| 0.64064          | 9 90 Th      | $L_V$             | $L_{II}N_{VI}$     | 19.353           | 0.70173      | 3 40 Zr     | $K\beta_1$     | $KM_{III}$          | 17.6678  |
| 0.6416           | 1 94 Pu      | $L\beta_9$        | $L_{II}M_V$        | 19.323           | 0.7018       | 1 91 Pa     | $L\beta_9$     | $L_{II}M_V$         | 17.667   |
| 0.64221          | 4 90 Th      | $L_{\gamma_2}$    | $L_{II}N_{II}$     | 19.305           | 0.70228      | 4 40 Zr     | $K\beta_3$     | $KM_{II}$           | 17.654   |
| 0.643083         | 4 44 Ru      | $K\alpha_1$       | $KL_{III}$         | 19.2792          | 0.7031       | 1 94 Pu     | $L_{II}$       | $L_{III}N_{VI,VII}$ | 17.635   |
| 0.6445           | 1 88 Ra      | $L_I$             | Abs. Edge          | 19.236           | 0.70341      | 2 95 Am     | $L\beta_{15}$  | $L_{III}N_{IV}$     | 17.6258  |
| 0.64513          | 5 88 Ra      | $L_{\gamma_{13}}$ | $L_{II}P_{II,III}$ | 19.218           | 0.7043       | 1 88 Ra     |                | $L_{II}N_{III}$     | 17.604   |
| 0.6468           | 1 88 Ra      |                   | $L_{II}O_{IV,V}$   | 19.167           | 0.70620      | 2 94 Pu     | $L\beta_4$     | $L_{II}M_{II}$      | 17.5560  |
| 0.647408         | 5 44 Ru      | $K\alpha_2$       | $KL_{II}$          | 19.1504          | 0.70814      | 2 93 Np     | $L\beta_5$     | $L_{III}O_{IV,V}$   | 17.5081  |
| 0.64755          | 5 90 Th      |                   | $L_{II}N_I$        | 19.146           | 0.7088       | 2 91 Pa     | $L\beta_{10}$  | $L_{II}M_{IV}$      | 17.492   |
| 0.6482           | 1 94 Pu      | $L\beta_{10}$     | $L_{II}M_{IV}$     | 19.126           | 0.709300     | 1 42 Mo     | $K\alpha_1$    | $KL_{III}$          | 17.47934 |
| 0.64891          | 2 95 Am      | $L\beta_3$        | $L_{II}M_{III}$    | 19.1059          | 0.71029      | 2 92 U      | $L\beta_3$     | $L_{II}M_{III}$     | 17.4550  |
| 0.64965          | 5 88 Ra      | $L_{\gamma_4}$    | $L_{II}O_{III}$    | 19.084           | 0.713590     | 6 42 Mo     | $K\alpha_2$    | $KL_{II}$           | 17.3743  |
| 0.65131          | 5 88 Ra      | $L_{\gamma_4'}$   | $L_{II}O_{II}$     | 19.036           | 0.71652      | 9 87 Fr     | $L_{\gamma_1}$ | $L_{II}N_{IV}$      | 17.303   |
| 0.6521           | 1 90 Th      |                   | $L_{II}N_V$        | 19.014           | 0.71774      | 5 88 Ra     | $L_{\gamma_5}$ | $L_{II}N_I$         | 17.274   |
| 0.65298          | 1 41 Nb      | $K$               | Abs. Edge          | 18.9869          | 0.71851      | 2 94 Pu     | $L\beta_2$     | $L_{III}N_V$        | 17.2553  |
| 0.65313          | 3 90 Th      | $L_{\gamma_1}$    | $L_{II}N_{IV}$     | 18.9825          | 0.719984     | 8 92 U      | $L\beta_1$     | $L_{II}M_{IV}$      | 17.2200  |
| 0.65318          | 5 41 Nb      | $K\beta_4$        | $KN_{IV,V}$        | 18.981           | 0.7205       | 1 94 Pu     | $L\beta_{16}$  | $L_{III}N_{IV}$     | 17.208   |
| 0.65416          | 4 41 Nb      | $K\beta_2$        | $KN_{II,III}$      | 18.953           | 0.7223       | 1 92 U      | $L_{III}$      | Abs. Edge           | 17.165   |
| 0.6550           | 1 91 Pa      | $L_{\gamma_5}$    | $L_{II}N_I$        | 18.930           | 0.72240      | 5 92 U      |                | $L_{III}P_{IV,V}$   | 17.162   |
| 0.657655         | 9 95 Am      | $L\beta_1$        | $L_{II}M_{IV}$     | 18.8520          | 0.7234       | 1 90 Th     | $L\beta_9$     | $L_{II}M_V$         | 17.139   |
| 0.6620           | 1 90 Th      |                   | $L_{II}N_{III}$    | 18.729           | 0.72426      | 5 92 U      |                | $L_{III}P_{II,III}$ | 17.118   |
| 0.6654           | 1 88 Ra      | $L_{\gamma_{11}}$ | $L_{II}N_V$        | 18.633           | 0.72521      | 5 92 U      |                | $L_{III}P_I$        | 17.096   |
| 0.66576          | 2 41 Nb      | $K\beta_1$        | $KM_{III}$         | 18.6225          | 0.726305     | 9 92 U      | $L\beta_5$     | $L_{III}O_{IV,V}$   | 17.0701  |
| 0.66634          | 3 41 Nb      | $K\beta_3$        | $KM_{II}$          | 18.6063          | 0.72671      | 2 93 Np     | $L\beta_4$     | $L_{II}M_{II}$      | 17.0607  |
| 0.6666           | 1 88 Ra      |                   | $L_{II}N_{IV}$     | 18.600           | 0.72766      | 5 39 Y      | $K$            | Abs. Edge           | 17.038   |
| 0.66871          | 2 94 Pu      | $L\beta_3$        | $L_{II}M_{III}$    | 18.5405          | 0.72776      | 5 39 Y      | $K\beta_4$     | $KN_{IV,V}$         | 17.036   |
| 0.6707           | 1 88 Ra      | $L_{II}$          | Abs. Edge          | 18.486           | 0.72864      | 4 39 Y      | $K\beta_2$     | $KN_{II,III}$       | 17.0154  |
| 0.6714           | 1 88 Ra      |                   | $L_{II}P_{II,III}$ | 18.466           | 0.7301       | 1 90 Th     | $L\beta_{10}$  | $L_{II}M_{IV}$      | 16.981   |
| 0.6724           | 1 88 Ra      |                   | $L_{II}P_I$        | 18.439           | 0.7309       | 1 92 U      |                | $L_{III}O_{III}$    | 16.962   |
| 0.67328          | 5 88 Ra      | $L_{\gamma_6}$    | $L_{II}O_{IV}$     | 18.414           | 0.73230      | 5 91 Pa     | $L\beta_3$     | $L_{II}M_{III}$     | 16.930   |
| 0.67351          | 9 89 Ac      | $L_{\gamma_1}$    | $L_{II}N_{IV}$     | 18.408           | 0.7333       | 1 92 U      |                | $L_{III}O_{II}$     | 16.907   |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation    | keV                 | Wavelength<br>Å* | p.e. Element | Designation | keV            |                     |         |
|------------------|--------------|----------------|---------------------|------------------|--------------|-------------|----------------|---------------------|---------|
| 0.73418          | 2 95 Am      | $L\beta_6$     | $L_{III}N_I$        | 16.8870          | 0.78292      | 2 38 Sr     | $K\beta_1$     | $KM_{III}$          | 15.8357 |
| 0.7345           | 1 39 Y       | $K\beta_6$     | $KM_{IV,V}$         | 16.879           | 0.78345      | 3 38 Sr     | $K\beta_2$     | $KM_{II}$           | 15.8249 |
| 0.73602          | 6 92 U       | $L\beta_7$     | $L_{III}O_I$        | 16.845           | 0.7858       | 1 82 Pb     | $L\gamma_4$    | $L_I O_{III}$       | 15.777  |
| 0.736230         | 9 93 Np      | $L\beta_2$     | $L_{III}N_V$        | 16.8400          | 0.78593      | 1 40 Zr     | $K\alpha_1$    | $KL_{III}$          | 15.7751 |
| 0.738603         | 9 92 U       | $L\alpha$      | $L_{III}N_{VI,VII}$ | 16.7859          | 0.78706      | 7 82 Pb     | $L\gamma_4'$   | $L_I O_{II}$        | 15.752  |
| 0.73928          | 9 86 Rn      | $L\gamma_1$    | $L_{II}N_{IV}$      | 16.770           | 0.78748      | 9 84 Po     | $L\gamma_1$    | $L_{II}N_{IV}$      | 15.744  |
| 0.74072          | 2 39 Y       | $K\beta_1$     | $KM_{III}$          | 16.7378          | 0.78838      | 2 92 U      | $L\beta_6$     | $L_{III}N_I$        | 15.7260 |
| 0.74126          | 3 39 Y       | $K\beta_3$     | $KM_{II}$           | 16.7258          | 0.7884       | 1 82 Pb     |                | $L_I N_{VI,VII}$    | 15.725  |
| 0.74232          | 5 91 Pa      | $L\beta_1$     | $L_{II}M_{IV}$      | 16.702           | 0.7887       | 1 83 Bi     | $L_{II}$       | Abs. Edge           | 15.719  |
| 0.74503          | 5 92 U       | $L\beta_{17}$  | $L_{II}M_{III}$     | 16.641           | 0.78903      | 9 89 Ac     | $L\beta_1$     | $L_{II}M_{IV}$      | 15.713  |
| 0.7452           | 2 91 Pa      | $L\beta_5$     | $L_{III}O_{IV,V}$   | 16.636           | 0.78917      | 5 83 Bi     | $L\gamma_2$    | $L_I N_{III}$       | 15.7102 |
| 0.74620          | 1 41 Nb      | $K\alpha_1$    | $KL_{III}$          | 16.6151          | 0.7897       | 1 82 Pb     |                | $L_I O_I$           | 15.699  |
| 0.747985         | 9 92 U       | $L\beta_4$     | $L_I M_{II}$        | 16.5753          | 0.79015      | 1 40 Zr     | $K\alpha_2$    | $KL_{II}$           | 15.6909 |
| 0.75044          | 1 41 Nb      | $K\alpha_2$    | $KL_{II}$           | 16.5210          | 0.79043      | 3 83 Bi     | $L\gamma_6$    | $L_{II}O_{IV}$      | 15.6853 |
| 0.75148          | 2 94 Pu      | $L\beta_5$     | $L_{III}N_I$        | 16.4983          | 0.79257      | 4 90 Th     | $L\beta_4$     | $L_I M_{II}$        | 15.6429 |
| 0.7546           | 2 91 Pa      | $L\beta_7$     | $L_{III}O_I$        | 16.431           | 0.79257      | 4 90 Th     | $L\beta_{17}$  | $L_{II}M_{III}$     | 15.6429 |
| 0.754681         | 9 92 U       | $L\beta_2$     | $L_{III}N_V$        | 16.4283          | 0.79354      | 3 90 Th     | $L\beta_2$     | $L_{III}M_V$        | 15.6237 |
| 0.75479          | 3 90 Th      | $L\beta_3$     | $L_I M_{III}$       | 16.4258          | 0.79384      | 5 83 Bi     |                | $L_{II}O_{III}$     | 15.6178 |
| 0.756642         | 9 92 U       | $L\beta_{16}$  | $L_{III}N_{IV}$     | 16.3857          | 0.79539      | 5 90 Th     | $L\beta_{16}$  | $L_{III}N_{IV}$     | 15.5875 |
| 0.75690          | 3 83 Bi      | $L\gamma_{13}$ | $L_I P_{II,III}$    | 16.3802          | 0.79565      | 3 83 Bi     | $L\gamma_2$    | $L_I N_{II}$        | 15.5824 |
| 0.7571           | 1 83 Bi      | $L_I$          | Abs. Edge           | 16.376           | 0.79721      | 9 83 Bi     | $L\gamma$      | $L_{II}N_{VI}$      | 15.552  |
| 0.7579           | 1 90 Th      |                | $L_{II}M_V$         | 16.359           | 0.7973       | 1 83 Bi     | $L\gamma_8$    | $L_{II}O_I$         | 15.551  |
| 0.75791          | 5 83 Bi      |                | $L_I O_{IV,V}$      | 16.358           | 0.8022       | 1 83 Bi     |                | $L_I N_I$           | 15.456  |
| 0.7591           | 1 94 Pu      | $L\eta$        | $L_{II}M_I$         | 16.333           | 0.80233      | 9 82 Pb     | $L\gamma_{11}$ | $L_I N_V$           | 15.453  |
| 0.7607           | 1 90 Th      | $L_{III}$      | Abs. Edge           | 16.299           | 0.80273      | 5 88 Ra     | $L\beta_8$     | $L_I M_{III}$       | 15.4449 |
| 0.76087          | 9 90 Th      |                | $L_{III}P_{IV,V}$   | 16.295           | 0.8028       | 1 88 Ra     | $L_{III}$      | Abs. Edge           | 15.444  |
| 0.76087          | 3 83 Bi      | $L\gamma_4$    | $L_I O_{III}$       | 16.2947          | 0.80364      | 7 82 Pb     |                | $L_I N_{IV}$        | 15.427  |
| 0.76198          | 3 83 Bi      | $L\gamma_4'$   | $L_I O_{II}$        | 16.2709          | 0.8038       | 1 88 Ra     |                | $L_{III}P_{II,III}$ | 15.425  |
| 0.7625           | 2 90 Th      |                | $L_{III}P_{II,III}$ | 16.260           | 0.8050       | 1 88 Ra     |                | $L_{III}P_I$        | 15.402  |
| 0.76289          | 9 85 At      | $L\gamma_1$    | $L_{II}N_{IV}$      | 16.251           | 0.80509      | 2 92 U      | $L\eta$        | $L_{II}M_I$         | 15.3997 |
| 0.76338          | 5 90 Th      |                | $L_{III}P_I$        | 16.241           | 0.80627      | 5 88 Ra     | $L\beta_5$     | $L_{III}O_{IV,V}$   | 15.3771 |
| 0.7641           | 5 83 Bi      |                | $L_I N_{VI,VII}$    | 16.23            | 0.8079       | 1 91 Pa     | $L\beta_6$     | $L_{III}N_I$        | 15.347  |
| 0.7645           | 2 84 Po      | $L\gamma_6$    | $L_{II}O_{IV}$      | 16.218           | 0.8081       | 1 81 Tl     | $L_I$          | Abs. Edge           | 15.343  |
| 0.76468          | 5 90 Th      | $L\beta_5$     | $L_{III}O_{IV,V}$   | 16.213           | 0.8082       | 1 90 Th     |                | $L_{III}N_{III}$    | 15.341  |
| 0.765210         | 9 90 Th      | $L\beta_1$     | $L_{II}M_{IV}$      | 16.2022          | 0.80861      | 5 81 Tl     |                | $L_I O_{IV,V}$      | 15.3327 |
| 0.76857          | 5 88 Ra      | $L\beta_9$     | $L_I M_V$           | 16.131           | 0.81163      | 9 90 Th     |                | $L_I M_I$           | 15.276  |
| 0.769            | 1 93 Np      | $L\beta_6$     | $L_{III}N_I$        | 16.13            | 0.81184      | 5 81 Tl     | $L\gamma_4$    | $L_I O_{III}$       | 15.2716 |
| 0.7690           | 1 90 Th      |                | $L_{III}O_{III}$    | 16.123           | 0.81308      | 5 81 Tl     | $L\gamma_4'$   | $L_I O_{II}$        | 15.2482 |
| 0.7691           | 1 92 U       |                | $L_{III}N_{III}$    | 16.120           | 0.81311      | 2 83 Bi     | $L\gamma_1$    | $L_{II}N_{IV}$      | 15.2477 |
| 0.76973          | 5 38 Sr      | $K$            | Abs. Edge           | 16.107           | 0.81375      | 5 88 Ra     | $L\beta_1$     | $L_{II}M_{IV}$      | 15.2358 |
| 0.7699           | 1 91 Pa      | $L\beta_4$     | $L_I M_{II}$        | 16.104           | 0.8147       | 1 82 Pb     | $L\gamma_3$    | $L_I N_{III}$       | 15.218  |
| 0.76989          | 5 38 Sr      | $K\beta_4$     | $KN_{IV,V}$         | 16.104           | 0.81538      | 5 82 Pb     | $L_{II}$       | Abs. Edge           | 15.2053 |
| 0.77081          | 3 38 Sr      | $K\beta_2$     | $KN_{II,III}$       | 16.0846          | 0.8154       | 2 37 Rb     | $K\beta_4$     | $KN_{IV,V}$         | 15.205  |
| 0.7713           | 1 90 Th      |                | $L_{III}O_{II}$     | 16.074           | 0.81554      | 5 37 Rb     | $K$            | Abs. Edge           | 15.2023 |
| 0.772            | 1 84 Po      | $L\gamma_2$    | $L_I N_{II}$        | 16.07            | 0.8158       | 1 81 Tl     |                | $L_I O_I$           | 15.198  |
| 0.7737           | 1 91 Pa      | $L\beta_2$     | $L_{III}N_V$        | 16.024           | 0.81583      | 5 82 Pb     |                | $L_{II}P_I$         | 15.1969 |
| 0.77437          | 4 90 Th      | $L\beta_7$     | $L_{III}O_I$        | 16.0105          | 0.8162       | 1 88 Ra     | $L\beta_7$     | $L_{III}O_I$        | 15.190  |
| 0.77546          | 5 88 Ra      | $L\beta_{10}$  | $L_I M_{IV}$        | 15.988           | 0.81645      | 3 37 Rb     | $K\beta_2$     | $KN_{II,III}$       | 15.1854 |
| 0.7764           | 1 38 Sr      | $K\beta_5$     | $KM_{IV,V}$         | 15.969           | 0.81683      | 5 82 Pb     | $L\gamma_6$    | $L_{II}O_{IV}$      | 15.1783 |
| 0.77661          | 5 90 Th      | $L\alpha$      | $L_{III}N_{VI,VII}$ | 15.964           | 0.8186       | 1 88 Ra     | $L\alpha$      | $L_{III}N_{VI,VII}$ | 15.146  |
| 0.77728          | 5 83 Bi      | $L\gamma_{11}$ | $L_I N_V$           | 15.951           | 0.8190       | 2 90 Th     |                | $L_{III}N_{II}$     | 15.138  |
| 0.77822          | 9 89 Ac      | $L\beta_8$     | $L_I M_{III}$       | 15.931           | 0.8200       | 1 82 Pb     |                | $L_{II}O_{III}$     | 15.120  |
| 0.77954          | 5 83 Bi      |                | $L_I N_{IV}$        | 15.904           | 0.8210       | 2 82 Pb     | $L\gamma_2$    | $L_I N_{II}$        | 15.101  |
| 0.78017          | 9 92 U       |                | $L_{III}N_{II}$     | 15.892           | 0.8219       | 1 37 Rb     | $K\beta_5$     | $KM_{IV,V}$         | 15.085  |
| 0.7809           | 2 93 Np      | $L\eta$        | $L_{II}M_I$         | 15.876           | 0.82327      | 7 82 Pb     | $L\gamma$      | $L_{II}N_{VI}$      | 15.060  |
| 0.78196          | 5 82 Pb      | $L_I$          | Abs. Edge           | 15.855           | 0.82365      | 5 82 Pb     | $L\gamma_8$    | $L_{II}O_I$         | 15.0527 |
| 0.78257          | 7 82 Pb      |                | $L_I O_{IV,V}$      | 15.843           | 0.8248       | 1 83 Bi     |                | $L_{II}N_{III}$     | 15.031  |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength |              |                   |                  |         | Wavelength |              |                   |                     |         |
|------------|--------------|-------------------|------------------|---------|------------|--------------|-------------------|---------------------|---------|
| Å*         | p.e. Element | Designation       |                  | keV     | Å*         | p.e. Element | Designation       |                     | keV     |
| 0.82789    | 9 87 Fr      | $L\beta_3$        | $L_{III}M_{III}$ | 14.976  | 0.87088    | 5 88 Ra      | $L\beta_6$        | $L_{III}N_I$        | 14.2362 |
| 0.82790    | 8 90 Th      | $L\beta_6$        | $L_{III}N_I$     | 14.975  | 0.8722     | 1 80 Hg      | $L_{II}$          | Abs. Edge           | 14.215  |
| 0.82859    | 7 82 Pb      |                   | $L_I N_I$        | 14.963  | 0.87319    | 7 80 Hg      | $L_{\gamma_6}$    | $L_{II}O_{IV}$      | 14.199  |
| 0.82868    | 2 37 Rb      | $K\beta_1$        | $KM_{III}$       | 14.9613 | 0.87526    | 1 38 Sr      | $K\alpha_1$       | $KL_{III}$          | 14.1650 |
| 0.82879    | 5 81 Tl      | $L_{\gamma_{II}}$ | $L_I N_V$        | 14.9593 | 0.87544    | 7 80 Hg      | $L_{\gamma_2}$    | $L_I N_{II}$        | 14.162  |
| 0.82884    | 1 39 Y       | $K\alpha_1$       | $KL_{III}$       | 14.9584 | 0.8758     | 1 80 Hg      |                   | $L_{II}O_{III}$     | 14.156  |
| 0.82921    | 3 37 Rb      | $K\beta_3$        | $KM_{II}$        | 14.9517 | 0.8784     | 1 80 Hg      |                   | $L_{II}O_{II}$      | 14.114  |
| 0.8295     | 1 91 Pa      | $L\eta$           | $L_{II}M_I$      | 14.946  | 0.8785     | 1 36 Kr      | $K\beta_1$        | $KM_{III}$          | 14.112  |
| 0.83001    | 7 81 Tl      |                   | $L_I N_{IV}$     | 14.937  | 0.87885    | 7 80 Hg      | $L\nu$            | $L_{II}N_{VI}$      | 14.107  |
| 0.83305    | 1 39 Y       | $K\alpha_2$       | $KL_{II}$        | 14.8829 | 0.8790     | 1 36 Kr      | $K\beta_3$        | $KM_{II}$           | 14.104  |
| 0.8338     | 1 90 Th      |                   | $L_{II}M_{II}$   | 14.869  | 0.87943    | 1 38 Sr      | $K\alpha_2$       | $KL_{II}$           | 14.0979 |
| 0.8344     | 9 83 Bi      |                   | $L_{II}N_{II}$   | 14.86   | 0.87995    | 7 80 Hg      | $L_{\gamma_8}$    | $L_{II}O_I$         | 14.090  |
| 0.8350     | 2 80 Hg      |                   | $L_I O_{IV,V}$   | 14.847  | 0.87996    | 5 81 Tl      |                   | $L_{II}N_{III}$     | 14.0893 |
| 0.8353     | 1 80 Hg      | $L_I$             | Abs. Edge        | 14.842  | 0.88028    | 2 94 Pu      | $L\alpha_2$       | $L_{III}M_{IV}$     | 14.0842 |
| 0.83537    | 5 88 Ra      | $L\beta_2$        | $L_{III}N_V$     | 14.8414 | 0.88135    | 9 85 At      | $L\beta_3$        | $L_I M_{III}$       | 14.067  |
| 0.83722    | 5 88 Ra      | $L\beta_{15}$     | $L_{III}N_{IV}$  | 14.8086 | 0.8827     | 2 80 Hg      |                   | $L_I N_I$           | 14.045  |
| 0.8382     | 2 82 Pb      |                   | $L_{II}N_V$      | 14.791  | 0.88433    | 7 79 Au      | $L_{\gamma_{II}}$ | $L_I N_V$           | 14.020  |
| 0.83894    | 7 80 Hg      | $L_{\gamma_4}$    | $L_I O_{III}$    | 14.778  | 0.88563    | 7 79 Au      |                   | $L_I N_{IV}$        | 13.999  |
| 0.83923    | 5 83 Bi      | $L_{\gamma_6}$    | $L_{II}N_I$      | 14.7732 | 0.8882     | 2 81 Tl      |                   | $L_{II}M_{II}$      | 13.959  |
| 0.83940    | 9 87 Fr      | $L\beta_1$        | $L_{II}M_{IV}$   | 14.770  | 0.889128   | 9 93 Np      | $L\alpha_1$       | $L_{III}M_V$        | 13.9441 |
| 0.83973    | 3 82 Pb      | $L_{\gamma_1}$    | $L_{II}N_{IV}$   | 14.7644 | 0.8931     | 1 78 Pt      | $L_I$             | Abs. Edge           | 13.883  |
| 0.84013    | 7 80 Hg      | $L_{\gamma_4}'$   | $L_I O_{II}$     | 14.757  | 0.8934     | 1 78 Pt      |                   | $L_I O_V$           | 13.878  |
| 0.84071    | 5 88 Ra      | $L\beta_4$        | $L_I M_{II}$     | 14.7472 | 0.89349    | 9 85 At      | $L\beta_1$        | $L_{II}M_{IV}$      | 13.876  |
| 0.84130    | 4 81 Tl      | $L_{\gamma_3}$    | $L_I N_{III}$    | 14.7368 | 0.8943     | 1 78 Pt      |                   | $L_I O_{IV}$        | 13.864  |
| 0.8434     | 1 81 Tl      | $L_{II}$          | Abs. Edge        | 14.699  | 0.89500    | 4 81 Tl      | $L_{\gamma_5}$    | $L_{II}N_I$         | 13.8526 |
| 0.8438     | 1 88 Ra      | $L\beta_{17}$     | $L_{II}M_{III}$  | 14.692  | 0.89646    | 5 80 Hg      | $L_{\gamma_1}$    | $L_{II}N_{IV}$      | 13.8301 |
| 0.8442     | 2 81 Tl      | $L_{\gamma_6}$    | $L_{II}O_{IV}$   | 14.685  | 0.89659    | 4 78 Pt      | $L_{\gamma_4}$    | $L_I O_{III}$       | 13.8281 |
| 0.8452     | 2 80 Hg      |                   | $L_I O_I$        | 14.670  | 0.89747    | 4 78 Pt      | $L_{\gamma_4}'$   | $L_I O_{II}$        | 13.8145 |
| 0.84773    | 5 81 Tl      | $L_{\gamma_2}$    | $L_I N_{II}$     | 14.6251 | 0.89783    | 5 79 Au      | $L_{\gamma_3}$    | $L_I N_{III}$       | 13.8090 |
| 0.848187   | 9 95 Am      | $L\alpha_1$       | $L_{III}M_V$     | 14.6172 | 0.89791    | 3 83 Bi      | $L\beta_9$        | $L_I M_V$           | 13.8077 |
| 0.8490     | 1 81 Tl      |                   | $L_{II}O_{II}$   | 14.604  | 0.8995     | 2 78 Pt      |                   | $L_I O_I$           | 13.784  |
| 0.85048    | 5 81 Tl      | $L\nu$            | $L_{II}N_{VI}$   | 14.5777 | 0.8996     | 2 84 Po      | $L\beta_5$        | $L_{III}O_{IV,V}$   | 13.782  |
| 0.8512     | 1 88 Ra      |                   | $L_{III}N_{III}$ | 14.566  | 0.901045   | 9 93 Np      | $L\alpha_2$       | $L_{III}M_{IV}$     | 13.7597 |
| 0.8513     | 2 81 Tl      | $L_{\gamma_8}$    | $L_{II}O_I$      | 14.564  | 0.90259    | 5 79 Au      | $L_{II}$          | Abs. Edge           | 13.7361 |
| 0.85192    | 7 82 Pb      |                   | $L_{II}N_{III}$  | 14.553  | 0.90297    | 3 79 Au      | $L_{\gamma_6}$    | $L_{II}O_{IV}$      | 13.7304 |
| 0.85436    | 9 86 Rn      | $L\beta_3$        | $L_I M_{III}$    | 14.512  | 0.90434    | 3 79 Au      | $L_{\gamma_2}$    | $L_I N_{II}$        | 13.7095 |
| 0.85446    | 4 90 Th      | $L\eta$           | $L_{II}M_I$      | 14.5099 | 0.90495    | 4 83 Bi      | $L\beta_{10}$     | $L_I M_{IV}$        | 13.7002 |
| 0.8549     | 1 81 Tl      |                   | $L_I N_I$        | 14.503  | 0.90638    | 7 79 Au      |                   | $L_{II}O_{III}$     | 13.679  |
| 0.85657    | 7 80 Hg      | $L_{\gamma_{II}}$ | $L_I N_V$        | 14.474  | 0.90742    | 5 88 Ra      | $L\eta$           | $L_{II}M_I$         | 13.6630 |
| 0.858      | 2 87 Fr      | $L\beta_2$        | $L_{III}N_V$     | 14.45   | 0.90746    | 7 79 Au      |                   | $L_{II}O_{II}$      | 13.662  |
| 0.8585     | 3 82 Pb      |                   | $L_{II}N_{II}$   | 14.442  | 0.90837    | 5 79 Au      | $L\nu$            | $L_{II}N_{VI}$      | 13.6487 |
| 0.860266   | 9 95 Am      | $L\alpha_2$       | $L_{III}M_{IV}$  | 14.4119 | 0.90894    | 7 80 Hg      |                   | $L_{II}N_{III}$     | 13.640  |
| 0.8618     | 1 88 Ra      |                   | $L_{III}N_{II}$  | 14.387  | 0.9091     | 3 84 Po      | $L\beta_3$        | $L_I M_{III}$       | 13.638  |
| 0.86376    | 5 79 Au      | $L_I$             | Abs. Edge        | 14.3537 | 0.90989    | 5 79 Au      | $L_{\gamma_8}$    | $L_{II}O_I$         | 13.6260 |
| 0.86400    | 5 79 Au      |                   | $L_I O_{IV,V}$   | 14.3497 | 0.910639   | 9 92 U       | $L\alpha_1$       | $L_{III}M_V$        | 13.6147 |
| 0.8653     | 2 36 Kr      | $K\beta_4$        | $KN_{IV,V}$      | 14.328  | 0.9131     | 1 79 Au      |                   | $L_I N_I$           | 13.578  |
| 0.86552    | 1 36 Kr      | $K$               | Abs. Edge        | 14.3244 | 0.9143     | 2 78 Pt      | $L_{\gamma_{II}}$ | $L_I N_V$           | 13.560  |
| 0.86605    | 9 86 Rn      | $L\beta_1$        | $L_{II}M_{IV}$   | 14.316  | 0.9204     | 1 35 Br      | $K$               | Abs. Edge           | 13.470  |
| 0.8661     | 1 36 Kr      | $K\beta_2$        | $KN_{II,III}$    | 14.315  | 0.92046    | 2 35 Br      | $K\beta_2$        | $KN_{II,III}$       | 13.4695 |
| 0.86655    | 5 82 Pb      | $L_{\gamma_6}$    | $L_{II}N_I$      | 14.3075 | 0.9220     | 2 84 Po      | $L\beta_1$        | $L_{II}M_{IV}$      | 13.447  |
| 0.86703    | 4 79 Au      | $L_{\gamma_4}$    | $L_I O_{III}$    | 14.2996 | 0.922558   | 9 92 U       | $L\alpha_2$       | $L_{III}M_{IV}$     | 13.4388 |
| 0.86752    | 3 81 Tl      | $L_{\gamma_1}$    | $L_{II}N_{IV}$   | 14.2915 | 0.9234     | 1 83 Bi      | $L_{III}$         | Abs. Edge           | 13.426  |
| 0.86816    | 4 79 Au      | $L_{\gamma_4}'$   | $L_I O_{II}$     | 14.2809 | 0.9236     | 1 77 Ir      | $L_I$             | Abs. Edge           | 13.423  |
| 0.86830    | 2 94 Pu      | $L\alpha_1$       | $L_{III}M_V$     | 14.2786 | 0.92413    | 4 83 Bi      |                   | $L_{III}P_{II,III}$ | 13.4159 |
| 0.86915    | 7 80 Hg      | $L_{\gamma_3}$    | $L_I N_{III}$    | 14.265  | 0.9243     | 3 77 Ir      |                   | $L_I O_{IV,V}$      | 13.413  |
| 0.87074    | 5 79 Au      |                   | $L_I O_I$        | 14.2385 | 0.92453    | 7 80 Hg      | $L_{\gamma_5}$    | $L_{II}N_I$         | 13.410  |
| 0.8708     | 2 36 Kr      | $K\beta_5$        | $KM_{IV,V}$      | 14.238  | 0.9255     | 1 35 Br      | $K\beta_5$        | $KM_{IV,V}$         | 13.396  |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation    | keV     | Wavelength<br>Å* | p.e. Element | Designation    | keV     |
|------------------|--------------|----------------|---------|------------------|--------------|----------------|---------|
| 0.925553         | 9 37 Rb      | $K\alpha_1$    | 13.3953 | 0.96788          | 2 90 Th      | $L\alpha_2$    | 12.8096 |
| 0.92556          | 3 83 Bi      | $L\beta_8$     | 13.3953 | 0.96911          | 7 82 Pb      | $L\beta_2$     | 12.7933 |
| 0.92650          | 3 79 Au      | $L\gamma_1$    | 13.3817 | 0.96979          | 5 77 Ir      |                | 12.7843 |
| 0.9268           | 1 82 Pb      | $L\beta_9$     | 13.377  | 0.97161          | 6 77 Ir      | $L\gamma$      | 12.7603 |
| 0.92744          | 3 77 Ir      | $L\gamma_4$    | 13.3681 | 0.97173          | 4 78 Pt      |                | 12.7588 |
| 0.92791          | 5 78 Pt      | $L\gamma_3$    | 13.3613 | 0.97321          | 5 83 Bi      |                | 12.7394 |
| 0.92831          | 3 77 Ir      | $L\gamma_4'$   | 13.3555 | 0.97409          | 3 77 Ir      | $L\gamma_8$    | 12.7279 |
| 0.92937          | 5 84 Po      | $L\beta_2$     | 13.3404 | 0.9747           | 1 82 Pb      |                | 12.720  |
| 0.92969          | 1 37 Rb      | $K\alpha_2$    | 13.3358 | 0.9765           | 3 76 Os      | $L\gamma_{11}$ | 12.696  |
| 0.9302           | 2 83 Bi      |                | 13.328  | 0.9766           | 2 77 Ir      |                | 12.695  |
| 0.9312           | 2 84 Po      | $L\beta_{15}$  | 13.314  | 0.97690          | 4 83 Bi      | $L\beta_4$     | 12.6912 |
| 0.9323           | 2 83 Bi      |                | 13.298  | 0.9772           | 3 76 Os      |                | 12.687  |
| 0.93279          | 2 35 Br      | $K\beta_1$     | 13.2914 | 0.9792           | 2 78 Pt      |                | 12.661  |
| 0.93284          | 5 91 Pa      | $L\alpha_1$    | 13.2907 | 0.97926          | 5 81 Tl      |                | 12.6607 |
| 0.93327          | 5 35 Br      | $K\beta_2$     | 13.2845 | 0.9793           | 1 81 Tl      | $L_{III}$      | 12.660  |
| 0.9339           | 2 82 Pb      | $L\beta_{10}$  | 13.275  | 0.97974          | 1 34 Se      | $K$            | 12.6545 |
| 0.93414          | 5 78 Pt      | $L_{II}$       | 13.2723 | 0.97992          | 5 34 Se      | $K\beta_2$     | 12.6522 |
| 0.9342           | 2 78 Pt      | $L\gamma_6$    | 13.271  | 0.97993          | 5 89 Ac      | $L\alpha_1$    | 12.6520 |
| 0.93427          | 5 78 Pt      | $L\gamma_2$    | 13.2704 | 0.9801           | 1 36 Kr      | $K\alpha_1$    | 12.649  |
| 0.93505          | 5 83 Bi      | $L\beta_7$     | 13.2593 | 0.98058          | 3 81 Tl      | $L\beta_5$     | 12.6436 |
| 0.93505          | 5 83 Bi      | $L\alpha$      | 13.2593 | 0.98221          | 7 82 Pb      | $L\beta_2$     | 12.6226 |
| 0.93855          | 3 83 Bi      | $L\beta_3$     | 13.2098 | 0.98280          | 5 83 Bi      |                | 12.6151 |
| 0.93931          | 5 78 Pt      | $L\gamma$      | 13.1992 | 0.98291          | 3 82 Pb      | $L\beta_1$     | 12.6137 |
| 0.9402           | 2 79 Au      |                | 13.186  | 0.98389          | 7 82 Pb      | $L\beta_{15}$  | 12.6011 |
| 0.9411           | 1 78 Pt      | $L\gamma_8$    | 13.173  | 0.9841           | 1 36 Kr      | $K\alpha_2$    | 12.598  |
| 0.94419          | 5 83 Bi      |                | 13.1310 | 0.9843           | 1 34 Se      | $K\beta_6$     | 12.595  |
| 0.9446           | 2 77 Ir      | $L\gamma_{11}$ | 13.126  | 0.98538          | 5 81 Tl      |                | 12.5820 |
| 0.94482          | 5 91 Pa      | $L\alpha_2$    | 13.1222 | 0.9871           | 2 80 Hg      | $L\beta_9$     | 12.560  |
| 0.9455           | 2 78 Pt      |                | 13.113  | 0.98738          | 5 81 Tl      |                | 12.5566 |
| 0.9459           | 2 77 Ir      |                | 13.108  | 0.9877           | 2 78 Pt      | $L\gamma_8$    | 12.552  |
| 0.9475           | 3 84 Po      | $L\beta_4$     | 13.086  | 0.9888           | 1 81 Tl      | $L\alpha$      | 12.538  |
| 0.95073          | 5 82 Pb      | $L_{III}$      | 13.0406 | 0.98913          | 5 83 Bi      | $L\beta_{17}$  | 12.5344 |
| 0.95118          | 7 82 Pb      |                | 13.0344 | 0.9894           | 1 75 Re      | $L_1$          | 12.530  |
| 0.951978         | 9 83 Bi      | $L\beta_1$     | 13.0235 | 0.9900           | 1 75 Re      |                | 12.524  |
| 0.9526           | 1 82 Pb      | $L\beta_5$     | 13.015  | 0.99017          | 5 81 Tl      | $L\beta_7$     | 12.5212 |
| 0.95518          | 4 83 Bi      | $L\beta_2$     | 12.9799 | 0.99085          | 3 77 Ir      | $L\gamma_1$    | 12.5126 |
| 0.95559          | 3 79 Au      | $L\gamma_5$    | 12.9743 | 0.99178          | 5 89 Ac      | $L\alpha_2$    | 12.5008 |
| 0.9558           | 1 76 Os      | $L_1$          | 12.972  | 0.99186          | 5 76 Os      | $L\gamma_3$    | 12.4998 |
| 0.95600          | 3 90 Th      | $L\alpha_1$    | 12.9687 | 0.99218          | 3 34 Se      | $K\beta_1$     | 12.4959 |
| 0.95603          | 5 76 Os      |                | 12.9683 | 0.99249          | 5 75 Re      | $L\gamma_4$    | 12.4920 |
| 0.95675          | 7 81 Tl      | $L\beta_9$     | 12.9585 | 0.99268          | 5 34 Se      | $K\beta_3$     | 12.4896 |
| 0.95702          | 5 83 Bi      | $L\beta_{15}$  | 12.9549 | 0.99331          | 3 83 Bi      | $L\beta_6$     | 12.4816 |
| 0.9578           | 1 82 Pb      |                | 12.945  | 0.99334          | 5 75 Re      | $L\gamma_4'$   | 12.4813 |
| 0.95797          | 3 78 Pt      | $L\gamma_1$    | 12.9420 | 0.9962           | 2 80 Hg      | $L\beta_{10}$  | 12.446  |
| 0.9586           | 1 82 Pb      |                | 12.934  | 0.9965           | 1 75 Re      |                | 12.442  |
| 0.95931          | 5 77 Ir      | $L\gamma_3$    | 12.9240 | 0.99805          | 5 76 Os      | $L\gamma_2$    | 12.4224 |
| 0.95938          | 8 76 Os      | $L\gamma_4$    | 12.923  | 1.0005           | 1 82 Pb      |                | 12.392  |
| 0.96033          | 8 76 Os      | $L\gamma_4'$   | 12.910  | 1.0005           | 9 83 Bi      |                | 12.39   |
| 0.96133          | 7 82 Pb      | $L\alpha$      | 12.8968 | 1.00062          | 3 81 Tl      | $L\beta_3$     | 12.3904 |
| 0.9620           | 1 82 Pb      | $L\beta_7$     | 12.888  | 1.00107          | 5 76 Os      | $L\gamma_6$    | 12.3848 |
| 0.96318          | 7 76 Os      |                | 12.8721 | 1.0012           | 6 95 Am      | $Ll$           | 12.384  |
| 0.9636           | 1 92 U       | $L_5$          | 12.866  | 1.0014           | 1 76 Os      | $L_{II}$       | 12.381  |
| 0.96389          | 7 81 Tl      | $L\beta_{10}$  | 12.8626 | 1.0047           | 2 76 Os      |                | 12.340  |
| 0.96545          | 3 77 Ir      | $L\gamma_2$    | 12.8418 | 1.00473          | 5 88 Ra      | $L\alpha_1$    | 12.3397 |
| 0.96708          | 4 77 Ir      | $L\gamma_6$    | 12.8201 | 1.0050           | 2 76 Os      | $L\gamma$      | 12.337  |
| 0.9671           | 1 77 Ir      | $L_{II}$       | 12.820  | 1.0054           | 3 77 Ir      |                | 12.332  |
| 0.9672           | 2 84 Po      | $L\beta_6$     | 12.819  | 1.00722          | 5 81 Tl      |                | 12.3093 |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation         | keV     | Wavelength<br>Å* | p.e. Element | Designation    | keV     |
|------------------|--------------|---------------------|---------|------------------|--------------|----------------|---------|
| 1.0075           | 1 82 Pb      | $L\beta_4$          | 12.306  | 1.04500          | 3 33 As      | $K\beta_2$     | 11.8642 |
| 1.00788          | 5 76 Os      | $L\gamma_8$         | 12.3012 | 1.0458           | 1 74 W       | $L\gamma_{11}$ | 11.856  |
| 1.0091           | 1 80 Hg      | $L_{III}$           | 12.286  | 1.0468           | 2 74 W       |                | 11.844  |
| 1.00987          | 7 80 Hg      | $L\beta_6$          | 12.2769 | 1.04752          | 5 79 Au      | $L\alpha$      | 11.8357 |
| 1.01031          | 3 81 Tl      | $L\beta_2$          | 12.2715 | 1.04868          | 5 80 Hg      | $L\beta_1$     | 11.8226 |
| 1.01040          | 7 82 Pb      |                     | 12.2705 | 1.0488           | 1 33 As      | $K\beta_6$     | 11.822  |
| 1.0108           | 1 75 Re      | $L\gamma_{11}$      | 12.266  | 1.04963          | 5 81 Tl      | $L\beta_6$     | 11.8118 |
| 1.0112           | 1 90 Th      | $Ls$                | 12.261  | 1.04974          | 8 79 Au      | $L\beta_7$     | 11.8106 |
| 1.0119           | 1 75 Re      |                     | 12.252  | 1.05446          | 5 78 Pt      | $L\beta_9$     | 11.7577 |
| 1.0120           | 2 77 Ir      |                     | 12.251  | 1.05609          | 7 81 Tl      | $L\beta_{17}$  | 11.7397 |
| 1.01201          | 3 81 Tl      | $L\beta_{16}$       | 12.2510 | 1.05693          | 5 76 Os      | $L\gamma_6$    | 11.7303 |
| 1.01404          | 7 80 Hg      | $L_{III}O_{III}$    | 12.2264 | 1.05723          | 5 86 Rn      | $L\alpha_1$    | 11.7270 |
| 1.01513          | 4 81 Tl      | $L\beta_1$          | 12.2133 | 1.05730          | 2 33 As      | $K\beta_1$     | 11.7262 |
| 1.01558          | 7 80 Hg      |                     | 12.2079 | 1.05783          | 5 33 As      | $K\beta_2$     | 11.7203 |
| 1.01656          | 5 88 Ra      | $L\alpha_2$         | 12.1962 | 1.0585           | 1 80 Hg      |                | 11.713  |
| 1.01674          | 7 80 Hg      | $L\alpha$           | 12.1940 | 1.05856          | 3 83 Bi      | $L\eta$        | 11.7122 |
| 1.01769          | 7 80 Hg      | $L\alpha'$          | 12.1826 | 1.06099          | 5 75 Re      | $L\gamma_1$    | 11.6854 |
| 1.01937          | 7 80 Hg      | $L\beta_7$          | 12.1625 | 1.0613           | 1 73 Ta      | $L_I$          | 11.682  |
| 1.02063          | 7 79 Au      | $L\beta_9$          | 12.1474 | 1.06183          | 7 78 Pt      | $L\beta_{10}$  | 11.6762 |
| 1.0210           | 1 82 Pb      | $L\beta_5$          | 12.143  | 1.06192          | 9 73 Ta      |                | 11.6752 |
| 1.02175          | 5 77 Ir      | $L\gamma_6$         | 12.1342 | 1.06200          | 6 74 W       | $L\gamma_2$    | 11.6743 |
| 1.0223           | 1 82 Pb      | $L\beta_{17}$       | 12.127  | 1.06357          | 9 73 Ta      |                | 11.6570 |
| 1.0226           | 1 94 Pu      | $Ll$                | 12.124  | 1.0644           | 2 82 Pb      |                | 11.648  |
| 1.02467          | 5 74 W       | $L_I$               | 12.0996 | 1.0644           | 2 81 Tl      |                | 11.648  |
| 1.0250           | 2 74 W       |                     | 12.095  | 1.06467          | 3 73 Ta      | $L\gamma_4$    | 11.6451 |
| 1.02503          | 5 76 Os      | $L\gamma_1$         | 12.0953 | 1.0649           | 2 80 Hg      |                | 11.642  |
| 1.02613          | 7 75 Re      | $L\gamma_3$         | 12.0824 | 1.06544          | 3 73 Ta      | $L\gamma_4'$   | 11.6366 |
| 1.02775          | 3 74 W       | $L\gamma_4$         | 12.0634 | 1.06712          | 2 92 U       | $Ll$           | 11.6183 |
| 1.02789          | 7 79 Au      | $L\beta_{10}$       | 12.0617 | 1.06771          | 9 73 Ta      |                | 11.6118 |
| 1.0286           | 1 81 Tl      |                     | 12.053  | 1.06785          | 9 79 Au      | $L\beta_3$     | 11.6103 |
| 1.02863          | 3 74 W       | $L\gamma_4'$        | 12.0530 | 1.06806          | 3 74 W       | $L\gamma_2$    | 11.6080 |
| 1.03049          | 5 87 Fr      | $L\alpha_1$         | 12.0313 | 1.06899          | 5 86 Rn      | $L\alpha_2$    | 11.5979 |
| 1.0317           | 3 74 W       |                     | 12.017  | 1.07022          | 3 79 Au      | $L\beta_2$     | 11.5847 |
| 1.03233          | 5 75 Re      | $L\gamma_2$         | 12.0098 | 1.07188          | 5 79 Au      | $L\beta_{15}$  | 11.5667 |
| 1.0323           | 2 82 Pb      |                     | 12.010  | 1.07222          | 7 80 Hg      | $L\beta_4$     | 11.5630 |
| 1.03358          | 7 80 Hg      | $L\beta_3$          | 11.9953 | 1.0723           | 1 78 Pt      | $L_{III}$      | 11.562  |
| 1.0346           | 9 83 Bi      |                     | 11.98   | 1.0724           | 2 78 Pt      | $L\beta_6$     | 11.561  |
| 1.0347           | 1 92 U       | $Lt$                | 11.982  | 1.07448          | 5 74 W       | $L\gamma_6$    | 11.5387 |
| 1.03699          | 9 75 Re      | $L\gamma_6$         | 11.956  | 1.0745           | 1 74 W       | $L_{II}$       | 11.538  |
| 1.0371           | 1 75 Re      | $L_{II}$            | 11.954  | 1.0756           | 2 79 Au      |                | 11.526  |
| 1.03876          | 7 79 Au      | $L_{III}P_{II,III}$ | 11.9355 | 1.0761           | 3 78 Pt      |                | 11.521  |
| 1.03918          | 3 81 Tl      | $L\beta_4$          | 11.9306 | 1.0767           | 1 75 Re      |                | 11.515  |
| 1.0397           | 1 75 Re      |                     | 11.925  | 1.0771           | 1 74 W       | $Lv$           | 11.510  |
| 1.03973          | 5 76 Os      |                     | 11.9243 | 1.07896          | 5 78 Pt      | $L\alpha$      | 11.4908 |
| 1.03974          | 2 35 Br      | $KL_{III}$          | 11.9242 | 1.0792           | 2 74 W       |                | 11.488  |
| 1.03975          | 7 80 Hg      | $L\beta_2$          | 11.9241 | 1.07975          | 7 80 Hg      | $L\beta_6$     | 11.4824 |
| 1.04000          | 5 79 Au      | $L_{III}$           | 11.9212 | 1.08009          | 9 90 Th      | $Lt$           | 11.4788 |
| 1.0404           | 1 75 Re      | $Lv$                | 11.917  | 1.08113          | 4 74 W       | $L\gamma_8$    | 11.4677 |
| 1.04044          | 3 79 Au      | $L\beta_6$          | 11.9163 | 1.08168          | 3 78 Pt      | $L\beta_7$     | 11.4619 |
| 1.04151          | 7 80 Hg      | $L\beta_{15}$       | 11.9040 | 1.08205          | 7 73 Ta      | $L\gamma_{11}$ | 11.4580 |
| 1.0420           | 1 75 Re      |                     | 11.899  | 1.08353          | 3 79 Au      | $L\beta_1$     | 11.4423 |
| 1.04230          | 5 87 Fr      | $L\alpha_2$         | 11.8950 | 1.08377          | 7 73 Ta      |                | 11.4398 |
| 1.0428           | 6 93 Np      | $Ll$                | 11.890  | 1.0839           | 1 75 Re      |                | 11.438  |
| 1.04382          | 2 35 Br      | $K\alpha_2$         | 11.8776 | 1.08500          | 5 85 At      | $L\alpha_1$    | 11.4268 |
| 1.04398          | 5 75 Re      | $L\gamma_8$         | 11.8758 | 1.08975          | 5 77 Ir      | $L\beta_3$     | 11.3770 |
| 1.0450           | 2 79 Au      |                     | 11.865  | 1.09026          | 7 79 Au      |                | 11.3717 |
| 1.0450           | 1 33 As      | $K$                 | 11.865  | 1.0908           | 1 91 Pa      | $Ll$           | 11.366  |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength |      |         |                |                     | Wavelength |         |         |             |                |                     |          |
|------------|------|---------|----------------|---------------------|------------|---------|---------|-------------|----------------|---------------------|----------|
| Å*         | p.e. | Element | Designation    | keV                 | Å*         | p.e.    | Element | Designation | keV            |                     |          |
| 1.0916     | 5    | 80 Hg   | $L\beta_{17}$  | $L_{II}M_{III}$     | 11.358     | 1.13687 | 9       | 73 Ta       | $L_{II}N_V$    | 10.9055             |          |
| 1.09241    | 7    | 82 Pb   | $L\eta$        | $L_{II}M_I$         | 11.3493    | 1.13707 | 3       | 77 Ir       | $L\beta_{16}$  | 10.9036             |          |
| 1.09388    | 5    | 75 Re   | $L\gamma_5$    | $L_{II}N_I$         | 11.3341    | 1.13794 | 3       | 73 Ta       | $L\gamma_1$    | 10.8952             |          |
| 1.09671    | 5    | 85 At   | $L\alpha_2$    | $L_{III}M_{IV}$     | 11.3048    | 1.13841 | 5       | 72 Hf       | $L\gamma_3$    | 10.8907             |          |
| 1.09702    | 4    | 77 Ir   | $L\beta_{10}$  | $L_I M_{IV}$        | 11.3016    | 1.1387  | 5       | 80 Hg       | $L_{II}M_{II}$ | 10.888              |          |
| 1.09855    | 3    | 74 W    | $L\gamma_1$    | $L_{II}N_{IV}$      | 11.2859    | 1.1402  | 1       | 71 Lu       | $L_I$          | Abs. Edge           | 10.8740  |
| 1.09936    | 4    | 73 Ta   | $L\gamma_3$    | $L_I N_{III}$       | 11.2776    | 1.1405  | 1       | 76 Os       | $L\beta_5$     | $L_{III}O_{IV,V}$   | 10.8711  |
| 1.0997     | 1    | 81 Tl   |                | $L_{II}M_{II}$      | 11.274     | 1.1408  | 1       | 76 Os       | $L_{III}$      | Abs. Edge           | 10.8683  |
| 1.0997     | 1    | 72 Hf   | $L_I$          | Abs. Edge           | 11.274     | 1.14085 | 3       | 77 Ir       | $L\beta_2$     | $L_I M_{III}$       | 10.8674  |
| 1.09968    | 7    | 79 Au   |                | $L_{III}N_{II}$     | 11.2743    | 1.14223 | 5       | 78 Pt       | $L\beta_4$     | $L_I M_{II}$        | 10.8543  |
| 1.0999     | 2    | 80 Hg   |                | $L_I M_I$           | 11.272     | 1.1435  | 1       | 71 Lu       | $L\gamma_4$    | $L_I O_{II,III}$    | 10.8425  |
| 1.10086    | 9    | 72 Hf   |                | $L_I O_{IV}$        | 11.2622    | 1.14355 | 5       | 78 Pt       | $L\beta_6$     | $L_{III}N_I$        | 10.8418  |
| 1.10200    | 3    | 78 Pt   | $L\beta_2$     | $L_{III}N_V$        | 11.2505    | 1.14386 | 2       | 83 Bi       | $L\alpha_1$    | $L_{III}M_V$        | 10.8388  |
| 1.10303    | 5    | 72 Hf   | $L\gamma_4$    | $L_I O_{III}$       | 11.2401    | 1.14442 | 5       | 72 Hf       | $L\gamma_2$    | $L_I N_{II}$        | 10.8335  |
| 1.10376    | 5    | 72 Hf   | $L\gamma_4'$   | $L_I O_{II}$        | 11.2326    | 1.14537 | 7       | 76 Os       | $L\mu$         | $L_{III}N_{VI,VII}$ | 10.8245  |
| 1.10394    | 5    | 78 Pt   | $L\beta_3$     | $L_I M_{III}$       | 11.2308    | 1.1489  | 2       | 77 Ir       |                | $L_{II}M_V$         | 10.791   |
| 1.10477    | 2    | 34 Se   | $K\alpha_1$    | $K L_{III}$         | 11.2224    | 1.14933 | 8       | 76 Os       | $L\beta_7$     | $L_{III}O_I$        | 10.7872  |
| 1.1053     | 1    | 73 Ta   | $L\gamma_2$    | $L_I N_{II}$        | 11.217     | 1.1548  | 1       | 72 Hf       | $L_{II}$       | Abs. Edge           | 10.7362  |
| 1.1058     | 1    | 77 Ir   | $L_{III}$      | Abs. Edge           | 11.212     | 1.15519 | 5       | 72 Hf       | $L\gamma_6$    | $L_{II}O_{IV}$      | 10.7325  |
| 1.10585    | 3    | 77 Ir   | $L\beta_5$     | $L_{III}O_{IV,V}$   | 11.2114    | 1.1553  | 1       | 73 Ta       |                | $L_{II}N_{III}$     | 10.7316  |
| 1.10651    | 3    | 79 Au   | $L\beta_4$     | $L_I M_{II}$        | 11.2047    | 1.15536 | 1       | 83 Bi       | $L\alpha_2$    | $L_{III}M_{IV}$     | 10.73091 |
| 1.10664    | 9    | 72 Hf   |                | $L_I O_I$           | 11.2034    | 1.1560  | 3       | 77 Ir       |                | $L_{III}N_{III}$    | 10.725   |
| 1.10882    | 2    | 34 Se   | $K\alpha_2$    | $K L_{II}$          | 11.1814    | 1.15781 | 3       | 77 Ir       | $L\beta_1$     | $L_{II}M_{IV}$      | 10.7083  |
| 1.10923    | 6    | 77 Ir   |                | $L_{III}O_{II,III}$ | 11.1772    | 1.15830 | 9       | 72 Hf       | $L_V$          | $L_{II}N_{VI}$      | 10.7037  |
| 1.11092    | 3    | 79 Au   | $L\beta_6$     | $L_{III}N_I$        | 11.1602    | 1.1600  | 2       | 73 Ta       |                | $L_{II}N_{II}$      | 10.688   |
| 1.11145    | 4    | 77 Ir   | $L\mu$         | $L_{III}N_{VI,VII}$ | 11.1549    | 1.16107 | 9       | 71 Lu       | $L\gamma_{11}$ | $L_I N_V$           | 10.6782  |
| 1.1129     | 2    | 78 Pt   |                | $L_{II}M_V$         | 11.140     | 1.16138 | 5       | 72 Hf       | $L\gamma_8$    | $L_{II}O_I$         | 10.6754  |
| 1.1137     | 1    | 73 Ta   | $L_{II}$       | Abs. Edge           | 11.132     | 1.16227 | 9       | 71 Lu       |                | $L_I N_{IV}$        | 10.6672  |
| 1.11386    | 4    | 84 Po   | $L\alpha_1$    | $L_{III}M_V$        | 11.1308    | 1.1640  | 1       | 80 Hg       | $L\eta$        | $L_{II}M_I$         | 10.6512  |
| 1.11388    | 3    | 73 Ta   | $L\gamma_6$    | $L_{II}O_{IV}$      | 11.1306    | 1.16487 | 4       | 75 Re       | $L\beta_9$     | $L_I M_V$           | 10.6433  |
| 1.11489    | 3    | 77 Ir   | $L\beta_7$     | $L_{III}O_I$        | 11.1205    | 1.16545 | 5       | 77 Ir       |                | $L_{III}N_{II}$     | 10.6380  |
| 1.1149     | 2    | 74 W    |                | $L_{II}N_{III}$     | 11.120     | 1.1667  | 1       | 78 Pt       | $L\beta_{17}$  | $L_{II}M_{III}$     | 10.6265  |
| 1.11508    | 4    | 90 Th   | $L_I$          | $L_{III}M_I$        | 11.1186    | 1.16719 | 5       | 88 Ra       | $L_I$          | $L_{III}M_I$        | 10.6222  |
| 1.11521    | 9    | 73 Ta   |                | $L_I N_I$           | 11.1173    | 1.16962 | 9       | 78 Pt       |                | $L_I M_I$           | 10.6001  |
| 1.1158     | 1    | 73 Ta   | $L_V$          | $L_{II}N_{VI}$      | 11.1113    | 1.16979 | 8       | 76 Os       | $L\beta_2$     | $L_{III}N_V$        | 10.5985  |
| 1.11658    | 5    | 32 Ge   | $K$            | Abs. Edge           | 11.1036    | 1.1708  | 1       | 79 Au       |                | $L_{II}M_{II}$      | 10.5892  |
| 1.11686    | 2    | 32 Ge   | $K\beta_2$     | $KN_{II,III}$       | 11.1008    | 1.17167 | 5       | 76 Os       | $L\beta_{15}$  | $L_{III}N_{IV}$     | 10.5816  |
| 1.11693    | 9    | 73 Ta   |                | $L_{II}O_{III}$     | 11.1001    | 1.17218 | 5       | 75 Re       | $L\beta_{10}$  | $L_I M_{IV}$        | 10.5770  |
| 1.11789    | 9    | 73 Ta   |                | $L_{II}O_{II}$      | 11.0907    | 1.1729  | 1       | 73 Ta       | $L\gamma_5$    | $L_{II}N_I$         | 10.5702  |
| 1.1195     | 1    | 32 Ge   | $K\beta_5$     | $KM_{IV,V}$         | 11.0745    | 1.17501 | 2       | 82 Pb       | $L\alpha_1$    | $L_{III}M_V$        | 10.5515  |
| 1.11990    | 2    | 78 Pt   | $L\beta_1$     | $L_{II}M_{IV}$      | 11.0707    | 1.17588 | 1       | 33 As       | $K\alpha_1$    | $K L_{III}$         | 10.54372 |
| 1.1205     | 1    | 73 Ta   | $L\gamma_8$    | $L_{II}O_I$         | 11.0646    | 1.17721 | 5       | 75 Re       | $L\beta_6$     | $L_{III}O_{IV,V}$   | 10.5318  |
| 1.12146    | 9    | 72 Hf   | $L\gamma_{11}$ | $L_I N_V$           | 11.0553    | 1.1773  | 1       | 75 Re       | $L_{III}$      | Abs. Edge           | 10.5306  |
| 1.1218     | 3    | 74 W    |                | $L_{II}N_{II}$      | 11.052     | 1.17788 | 9       | 72 Hf       |                | $L_{II}N_V$         | 10.5258  |
| 1.12250    | 9    | 72 Hf   |                | $L_I N_{IV}$        | 11.0451    | 1.17796 | 3       | 77 Ir       | $L\beta_6$     | $L_{III}N_I$        | 10.5251  |
| 1.1226     | 2    | 78 Pt   |                | $L_{III}N_{III}$    | 11.044     | 1.17900 | 5       | 72 Hf       | $L\gamma_1$    | $L_{II}N_{IV}$      | 10.5158  |
| 1.12548    | 5    | 84 Po   | $L\alpha_2$    | $L_{III}M_{IV}$     | 11.0158    | 1.17953 | 4       | 71 Lu       | $L\gamma_3$    | $L_I N_{III}$       | 10.5110  |
| 1.12637    | 6    | 76 Os   | $L\beta_9$     | $L_I M_V$           | 11.0071    | 1.17955 | 7       | 76 Os       | $L\beta_3$     | $L_I M_{III}$       | 10.5108  |
| 1.12769    | 3    | 81 Tl   | $L\eta$        | $L_{II}M_I$         | 10.9943    | 1.17958 | 3       | 77 Ir       | $L\beta_4$     | $L_I M_{II}$        | 10.5106  |
| 1.12798    | 5    | 79 Au   | $L\beta_{17}$  | $L_{II}M_{III}$     | 10.9915    | 1.17987 | 1       | 33 As       | $K\alpha_2$    | $K L_{II}$          | 10.50799 |
| 1.12894    | 2    | 32 Ge   | $K\beta_1$     | $KM_{III}$          | 10.9821    | 1.1815  | 1       | 75 Re       | $L\mu$         | $L_{III}N_{VI,VII}$ | 10.4931  |
| 1.12936    | 9    | 32 Ge   | $K\beta_3$     | $KM_{II}$           | 10.9780    | 1.1818  | 1       | 70 Yb       | $L_I$          | Abs. Edge           | 10.4904  |
| 1.1310     | 2    | 78 Pt   |                | $L_{III}N_{II}$     | 10.962     | 1.1827  | 1       | 70 Yb       |                | $L_I O_{IV,V}$      | 10.4833  |
| 1.13235    | 3    | 74 W    | $L\gamma_6$    | $L_{II}N_I$         | 10.9490    | 1.1853  | 1       | 70 Yb       | $L\gamma_4$    | $L_I O_{II,III}$    | 10.4603  |
| 1.13353    | 5    | 76 Os   | $L\beta_{10}$  | $L_I M_{IV}$        | 10.9376    | 1.1853  | 2       | 71 Lu       | $L\gamma_2$    | $L_I N_{II}$        | 10.460   |
| 1.13525    | 5    | 79 Au   |                | $L_I M_I$           | 10.9210    | 1.18610 | 5       | 75 Re       | $L\beta_7$     | $L_{III}O_I$        | 10.4529  |
| 1.13532    | 3    | 77 Ir   | $L\beta_2$     | $L_{III}N_V$        | 10.9203    | 1.18648 | 5       | 82 Pb       | $L\alpha_2$    | $L_{III}M_{IV}$     | 10.4495  |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation                    | keV     | Wavelength<br>Å* | p.e. Element | Designation                    | keV     |
|------------------|--------------|--------------------------------|---------|------------------|--------------|--------------------------------|---------|
| 1.1886           | 1 70 Yb      | $L_I O_I$                      | 10.4312 | 1.254054         | 9 32 Ge      | $K\alpha_1$ $KL_{III}$         | 9.88642 |
| 1.18977          | 7 76 Os      | $L_{II} M_V$                   | 10.4205 | 1.2553           | 1 73 Ta      | $L_{III}$ Abs. Edge            | 9.8766  |
| 1.1958           | 1 31 Ga      | $K$ Abs. Edge                  | 10.3682 | 1.2555           | 1 73 Ta      | $L\beta_5$ $L_{III} O_{IV,V}$  | 9.8750  |
| 1.19600          | 2 31 Ga      | $K\beta_2$ $KN_{II,III}$       | 10.3663 | 1.25778          | 4 73 Ta      | $L_{II}$ $L_{III} N_{VI,VII}$  | 9.8572  |
| 1.19727          | 7 76 Os      | $L\beta_1$ $L_{II} M_{IV}$     | 10.3553 | 1.258011         | 9 32 Ge      | $K\alpha_2$ $KL_{II}$          | 9.85532 |
| 1.1981           | 2 31 Ga      | $K\beta_3$ $KM_{IV,V}$         | 10.348  | 1.25917          | 5 75 Re      | $L\beta_4$ $L_I M_{II}$        | 9.8463  |
| 1.1985           | 1 71 Lu      | $L_{II}$ Abs. Edge             | 10.3448 | 1.2596           | 1 71 Lu      | $L\gamma_3$ $L_{II} N_I$       | 9.8428  |
| 1.1987           | 1 71 Lu      | $L\gamma_6$ $L_{II} O_{IV}$    | 10.3431 | 1.2601           | 3 73 Ta      | $L_{III} O_{II,III}$           | 9.839   |
| 1.20086          | 7 76 Os      | $L_{III} N_{II}$               | 10.3244 | 1.26269          | 5 74 W       | $L\beta_3$ $L_I M_{III}$       | 9.8188  |
| 1.2014           | 1 71 Lu      | $L_{II} O_{II,III}$            | 10.3198 | 1.26385          | 5 73 Ta      | $L\beta_7$ $L_{III} O_I$       | 9.8098  |
| 1.20273          | 3 79 Au      | $L\eta$ $L_{II} M_I$           | 10.3083 | 1.2672           | 2 74 W       | $L_{III} N_{III}$              | 9.784   |
| 1.2047           | 1 71 Lu      | $L\gamma_8$ $L_{II} O_I$       | 10.2915 | 1.26769          | 5 70 Yb      | $L\gamma_1$ $L_{II} N_{IV}$    | 9.7801  |
| 1.20479          | 7 74 W       | $L\beta_9$ $L_I M_V$           | 10.2907 | 1.2678           | 2 69 Tm      | $L\gamma_3$ $L_I N_{III}$      | 9.779   |
| 1.20660          | 4 75 Re      | $L\beta_2$ $L_{III} N_V$       | 10.2752 | 1.2706           | 1 68 Er      | $L_I$ Abs. Edge                | 9.7574  |
| 1.2069           | 2 77 Ir      | $L\beta_{17}$ $L_{II} M_{III}$ | 10.273  | 1.2728           | 2 74 W       | $L_{II} M_V$                   | 9.741   |
| 1.20739          | 4 81 Tl      | $L\alpha_1$ $L_{III} M_V$      | 10.2685 | 1.2742           | 2 69 Tm      | $L\gamma_2$ $L_I N_{II}$       | 9.730   |
| 1.20789          | 2 31 Ga      | $K\beta_1$ $KM_{III}$          | 10.2642 | 1.2748           | 1 83 Bi      | $L_I$ $L_{III} M_{II}$         | 9.7252  |
| 1.20819          | 5 75 Re      | $L\beta_{15}$ $L_{III} N_{IV}$ | 10.2617 | 1.2752           | 2 68 Er      | $L\gamma_4$ $L_I O_{II,III}$   | 9.722   |
| 1.20835          | 5 31 Ga      | $K\beta_3$ $KM_{II}$           | 10.2603 | 1.27640          | 3 79 Au      | $L\alpha_1$ $L_{III} M_V$      | 9.7133  |
| 1.2102           | 2 77 Ir      | $L_I M_I$                      | 10.245  | 1.2765           | 2 74 W       | $L_{III} N_{II}$               | 9.712   |
| 1.2105           | 1 83 Bi      | $L_S$ $L_{III} M_{III}$        | 10.2421 | 1.27807          | 5 81 Tl      | $L_S$ $L_{III} M_{III}$        | 9.7007  |
| 1.21218          | 3 74 W       | $L\beta_{10}$ $L_I M_{IV}$     | 10.2279 | 1.281809         | 9 74 W       | $L\beta_1$ $L_{II} M_{IV}$     | 9.67235 |
| 1.213            | 1 78 Pt      | $L_{II} M_{II}$                | 10.225  | 1.2829           | 5 84 Po      | $L_I$ $L_{III} M_I$            | 9.664   |
| 1.21349          | 5 76 Os      | $L\beta_6$ $L_{III} N_I$       | 10.2169 | 1.2834           | 1 30 Zn      | $K$ Abs. Edge                  | 9.6607  |
| 1.21537          | 5 72 Hf      | $L\gamma_5$ $L_{II} N_I$       | 10.2011 | 1.28372          | 2 30 Zn      | $K\beta_2$ $KN_{II,III}$       | 9.6580  |
| 1.21545          | 3 74 W       | $L\beta_5$ $L_{III} O_{IV,V}$  | 10.2004 | 1.28448          | 3 77 Ir      | $L\eta$ $L_{II} M_I$           | 9.6522  |
| 1.2155           | 1 74 W       | $L_{III}$ Abs. Edge            | 10.1999 | 1.28454          | 2 73 Ta      | $L\beta_2$ $L_{III} N_V$       | 9.6518  |
| 1.21844          | 5 76 Os      | $L\beta_4$ $L_I M_{II}$        | 10.1754 | 1.2848           | 1 30 Zn      | $K\beta_3$ $KM_{IV,V}$         | 9.6501  |
| 1.21868          | 5 74 W       | $L_{II}$ $L_{III} N_{VI,VII}$  | 10.1733 | 1.28619          | 5 73 Ta      | $L\beta_{16}$ $L_{III} N_{IV}$ | 9.6394  |
| 1.21875          | 3 81 Tl      | $L\alpha_2$ $L_{III} M_{IV}$   | 10.1728 | 1.28772          | 3 79 Au      | $L\alpha_2$ $L_{III} M_{IV}$   | 9.6280  |
| 1.22031          | 5 75 Re      | $L\beta_3$ $L_I M_{III}$       | 10.1598 | 1.2892           | 1 69 Tm      | $L_{II}$ Abs. Edge             | 9.6171  |
| 1.2211           | 2 74 W       | $L_{III} O_{II,III}$           | 10.153  | 1.28989          | 7 74 W       | $L\beta_8$ $L_{III} N_I$       | 9.6117  |
| 1.22228          | 4 71 Lu      | $L\gamma_1$ $L_{II} N_{IV}$    | 10.1434 | 1.29025          | 9 72 Hf      | $L\beta_9$ $L_I M_V$           | 9.6090  |
| 1.22232          | 5 70 Yb      | $L\gamma_3$ $L_I N_{III}$      | 10.1431 | 1.2905           | 2 69 Tm      | $L\gamma_6$ $L_{II} O_{IV}$    | 9.607   |
| 1.22400          | 4 74 W       | $L\beta_7$ $L_{III} O_I$       | 10.1292 | 1.2927           | 1 75 Re      | $L\beta_{17}$ $L_{II} M_{II}$  | 9.5910  |
| 1.2250           | 1 69 Tm      | $L_I$ Abs. Edge                | 10.1206 | 1.2934           | 2 76 Os      | $L_{II} M_{II}$                | 9.586   |
| 1.2263           | 3 69 Tm      | $L_I O_{IV,V}$                 | 10.110  | 1.29525          | 2 30 Zn      | $K\beta_{1,3}$ $KM_{II,III}$   | 9.5720  |
| 1.2283           | 1 75 Re      | $L_{III} N_{III}$              | 10.0933 | 1.2972           | 1 72 Hf      | $L_{III}$ Abs. Edge            | 9.5577  |
| 1.22879          | 7 70 Yb      | $L\gamma_2$ $L_I N_{II}$       | 10.0897 | 1.29761          | 5 72 Hf      | $L\beta_5$ $L_{III} O_{IV,V}$  | 9.5546  |
| 1.2294           | 2 69 Tm      | $L\gamma_4$ $L_I O_{II,III}$   | 10.084  | 1.29819          | 9 72 Hf      | $L\beta_{10}$ $L_I M_{IV}$     | 9.5503  |
| 1.2305           | 1 75 Re      | $L_{II} M_V$                   | 10.0753 | 1.30162          | 5 74 W       | $L\beta_4$ $L_I M_{II}$        | 9.5252  |
| 1.23858          | 2 75 Re      | $L\beta_1$ $L_{II} M_{IV}$     | 10.0100 | 1.30165          | 9 72 Hf      | $L_{II}$ $L_{III} N_{VI,VII}$  | 9.5249  |
| 1.24120          | 5 80 Hg      | $L\alpha_1$ $L_{III} M_V$      | 9.9888  | 1.30564          | 5 72 Hf      | $L\beta_7$ $L_{III} O_I$       | 9.4958  |
| 1.24271          | 3 70 Yb      | $L\gamma_6$ $L_{II} O_{IV}$    | 9.9766  | 1.3063           | 1 70 Yb      | $L\gamma_5$ $L_{II} N_I$       | 9.4910  |
| 1.2428           | 1 70 Yb      | $L_{II}$ Abs. Edge             | 9.9761  | 1.30678          | 3 73 Ta      | $L\beta_3$ $L_I M_{III}$       | 9.4875  |
| 1.2429           | 2 78 Pt      | $L\eta$ $L_{II} M_I$           | 9.975   | 1.30767          | 7 82 Pb      | $L_I$ $L_{III} M_{II}$         | 9.4811  |
| 1.24385          | 7 82 Pb      | $L_S$ $L_{III} M_{III}$        | 9.9675  | 1.3086           | 1 73 Ta      | $L_{III} N_{III}$              | 9.4742  |
| 1.24460          | 3 74 W       | $L\beta_2$ $L_{III} N_V$       | 9.9615  | 1.3112           | 2 80 Hg      | $L_S$ $L_{III} M_{III}$        | 9.455   |
| 1.2453           | 1 70 Yb      | $L_{II} O_{II,III}$            | 9.9561  | 1.31304          | 3 78 Pt      | $L\alpha_1$ $L_{III} M_V$      | 9.4423  |
| 1.24631          | 3 74 W       | $L\beta_{16}$ $L_{III} N_{IV}$ | 9.9478  | 1.3146           | 1 68 Er      | $L\gamma_3$ $L_I N_{III}$      | 9.4309  |
| 1.2466           | 2 73 Ta      | $L\beta_9$ $L_I M_V$           | 9.946   | 1.3153           | 2 69 Tm      | $L\gamma_1$ $L_{II} N_{IV}$    | 9.426   |
| 1.2480           | 2 76 Os      | $L\beta_{17}$ $L_{II} M_{III}$ | 9.934   | 1.31610          | 7 83 Bi      | $L_I$ $L_{III} M_I$            | 9.4204  |
| 1.24923          | 5 70 Yb      | $L\gamma_8$ $L_{II} O_I$       | 9.9246  | 1.3167           | 1 73 Ta      | $L_{III} N_{II}$               | 9.4158  |
| 1.2502           | 3 77 Ir      | $L_{II} M_{II}$                | 9.917   | 1.31897          | 9 73 Ta      | $L_{II} M_V$                   | 9.3998  |
| 1.25100          | 5 75 Re      | $L\beta_6$ $L_{III} N_I$       | 9.9105  | 1.3190           | 1 67 Ho      | $L_I$ Abs. Edge                | 9.3994  |
| 1.25264          | 7 80 Hg      | $L\alpha_2$ $L_{III} M_{IV}$   | 9.8976  | 1.3208           | 3 67 Ho      | $L_I O_{IV,V}$                 | 9.387   |
| 1.2537           | 2 73 Ta      | $L\beta_{10}$ $L_I M_{IV}$     | 9.889   | 1.3210           | 2 68 Er      | $L\gamma_2$ $L_I N_{II}$       | 9.385   |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation          | keV     | Wavelength<br>Å* | p.e. Element | Designation         | keV     |
|------------------|--------------|----------------------|---------|------------------|--------------|---------------------|---------|
| 1.3225           | 2 67 Ho      | $L\gamma_4$          | 9.374   | 1.3948           | 1 70 Yb      | $L\beta_7$          | 8.8889  |
| 1.32432          | 2 78 Pt      | $L\alpha_2$          | 9.3618  | 1.3983           | 2 67 Ho      | $L\gamma_8$         | 8.867   |
| 1.32639          | 5 72 Hf      | $L\beta_2$           | 9.3473  | 1.40140          | 5 71 Lu      | $L\beta_8$          | 8.8469  |
| 1.32698          | 3 73 Ta      | $L\beta_1$           | 9.3431  | 1.40234          | 5 76 Os      | $L\alpha_2$         | 8.8410  |
| 1.32783          | 5 72 Hf      | $L\beta_{15}$        | 9.3371  | 1.4067           | 3 68 Er      | $L\gamma_5$         | 8.814   |
| 1.32785          | 7 76 Os      | $L\eta$              | 9.3370  | 1.41366          | 7 79 Au      | $Lt$                | 8.7702  |
| 1.33094          | 8 73 Ta      | $L\beta_6$           | 9.3153  | 1.41550          | 5 70 Yb      | $L\beta_{2,18}$     | 8.7588  |
| 1.3358           | 1 71 Lu      | $L\beta_9$           | 9.2816  | 1.41640          | 7 66 Dy      | $L\gamma_3$         | 8.7532  |
| 1.3365           | 3 74 W       | $L_I M_I$            | 9.277   | 1.4174           | 2 67 Ho      | $L\gamma_1$         | 8.747   |
| 1.3366           | 1 75 Re      | $L_{II} M_{II}$      | 9.2761  | 1.4189           | 1 71 Lu      | $L\beta_8$          | 8.7376  |
| 1.3386           | 1 68 Er      | $L_{II}$ Abs. Edge   | 9.2622  | 1.42110          | 3 74 W       | $L\eta$             | 8.7243  |
| 1.3387           | 2 74 W       | $L\beta_{17}$        | 9.261   | 1.4216           | 1 80 Hg      | $Ll$                | 8.7210  |
| 1.3397           | 3 68 Er      | $L\gamma_6$          | 9.255   | 1.4223           | 1 65 Tb      | $L_I$ Abs. Edge     | 8.7167  |
| 1.340083         | 9 31 Ga      | $K\alpha_1$          | 9.25174 | 1.42278          | 7 66 Dy      | $L\gamma_2$         | 8.7140  |
| 1.3405           | 1 71 Lu      | $L_{III}$ Abs. Edge  | 9.2490  | 1.4228           | 3 65 Tb      | $L_I O_{IV,v}$      | 8.714   |
| 1.34154          | 5 81 Tl      | $Lt$                 | 9.2417  | 1.42359          | 3 71 Lu      | $L\beta_1$          | 8.7090  |
| 1.34183          | 7 71 Lu      | $L\beta_5$           | 9.2397  | 1.4276           | 2 65 Tb      | $L\gamma_4$         | 8.685   |
| 1.3430           | 2 71 Lu      | $L\beta_{10}$        | 9.232   | 1.43025          | 9 72 Hf      | $L_I M_I$           | 8.6685  |
| 1.34399          | 1 31 Ga      | $K\alpha_2$          | 9.22482 | 1.43048          | 9 73 Ta      | $L_{II} M_{II}$     | 8.6671  |
| 1.34524          | 9 71 Lu      | $L_{III} O_{II,III}$ | 9.2163  | 1.4318           | 2 77 Ir      | $Ls$                | 8.659   |
| 1.34581          | 3 73 Ta      | $L\beta_4$           | 9.2124  | 1.43290          | 4 75 Re      | $L\alpha_1$         | 8.6525  |
| 1.34949          | 5 71 Lu      | $L\beta_7$           | 9.1873  | 1.4334           | 1 69 Tm      | $L_{III}$ Abs. Edge | 8.6496  |
| 1.34990          | 7 82 Pb      | $Ll$                 | 9.1845  | 1.4336           | 3 69 Tm      | $L\beta_9$          | 8.648   |
| 1.35053          | 9 72 Hf      | $L_{III} N_{III}$    | 9.1802  | 1.4349           | 2 69 Tm      | $L\beta_8$          | 8.641   |
| 1.35128          | 3 77 Ir      | $L\alpha_1$          | 9.1751  | 1.435155         | 7 30 Zn      | $K\alpha_1$         | 8.63886 |
| 1.35131          | 7 79 Au      | $Ls$                 | 9.1749  | 1.43643          | 9 72 Hf      | $L\beta_{17}$       | 8.6312  |
| 1.35300          | 5 72 Hf      | $L\beta_3$           | 9.1634  | 1.439000         | 8 30 Zn      | $K\alpha_2$         | 8.61578 |
| 1.3558           | 2 69 Tm      | $L\gamma_5$          | 9.144   | 1.44056          | 5 71 Lu      | $L\beta_4$          | 8.6064  |
| 1.35887          | 9 72 Hf      | $L_{III} N_{II}$     | 9.1239  | 1.4410           | 3 69 Tm      | $L\beta_{10}$       | 8.604   |
| 1.36250          | 5 77 Ir      | $L\alpha_2$          | 9.0995  | 1.44396          | 5 75 Re      | $L\alpha_2$         | 8.5862  |
| 1.3641           | 2 68 Er      | $L\gamma_1$          | 9.089   | 1.4445           | 1 66 Dy      | $L_{II}$ Abs. Edge  | 8.5830  |
| 1.3643           | 2 67 Ho      | $L\gamma_3$          | 9.087   | 1.44579          | 7 66 Dy      | $L\gamma_6$         | 8.5753  |
| 1.3692           | 1 66 Dy      | $L_I$ Abs. Edge      | 9.0548  | 1.45233          | 5 70 Yb      | $L\beta_3$          | 8.5367  |
| 1.3698           | 2 67 Ho      | $L\gamma_2$          | 9.051   | 1.4530           | 2 78 Pt      | $Lt$                | 8.533   |
| 1.37012          | 3 71 Lu      | $L\beta_2$           | 9.0489  | 1.45964          | 9 79 Au      | $Ll$                | 8.4939  |
| 1.3715           | 1 71 Lu      | $L\beta_{16}$        | 9.0395  | 1.4618           | 2 67 Ho      | $L\gamma_8$         | 8.481   |
| 1.37342          | 5 75 Re      | $L\eta$              | 9.0272  | 1.4640           | 2 69 Tm      | $L\beta_{2,18}$     | 8.468   |
| 1.37410          | 5 72 Hf      | $L\beta_1$           | 9.0227  | 1.4661           | 1 70 Yb      | $L\beta_8$          | 8.4563  |
| 1.37410          | 5 72 Hf      | $L\beta_6$           | 9.0227  | 1.47106          | 5 73 Ta      | $L\eta$             | 8.4280  |
| 1.37459          | 7 66 Dy      | $L\gamma_4$          | 9.0195  | 1.4718           | 2 65 Tb      | $L\gamma_3$         | 8.423   |
| 1.3746           | 2 80 Hg      | $Lt$                 | 9.019   | 1.47266          | 7 66 Dy      | $L\gamma_1$         | 8.4188  |
| 1.38059          | 5 29 Cu      | $K$ Abs. Edge        | 8.9803  | 1.4735           | 2 76 Os      | $Ls$                | 8.414   |
| 1.38109          | 3 29 Cu      | $K\beta_2$           | 8.9770  | 1.47565          | 5 70 Yb      | $L\beta_1$          | 8.4018  |
| 1.3838           | 1 70 Yb      | $L\beta_9$           | 8.9597  | 1.4764           | 2 65 Tb      | $L\gamma_2$         | 8.398   |
| 1.38477          | 3 81 Tl      | $Ll$                 | 8.9532  | 1.47639          | 2 74 W       | $L\alpha_1$         | 8.3976  |
| 1.3862           | 1 70 Yb      | $L_{III}$ Abs. Edge  | 8.9441  | 1.4784           | 1 64 Gd      | $L_I$ Abs. Edge     | 8.3864  |
| 1.3864           | 1 73 Ta      | $L\beta_{17}$        | 8.9428  | 1.48064          | 9 72 Hf      | $L_{II} M_{II}$     | 8.3735  |
| 1.38696          | 7 70 Yb      | $L\beta_5$           | 8.9390  | 1.4807           | 3 64 Gd      | $L_I O_{IV,v}$      | 8.373   |
| 1.3895           | 2 78 Pt      | $Ls$                 | 8.923   | 1.4835           | 1 68 Er      | $L_{III}$ Abs. Edge | 8.3575  |
| 1.3898           | 1 70 Yb      | $L_{III} O_{II,III}$ | 8.9209  | 1.4839           | 2 64 Gd      | $L\gamma_4$         | 8.355   |
| 1.3905           | 1 67 Ho      | $L_{II}$ Abs. Edge   | 8.9164  | 1.4848           | 3 68 Er      | $L\beta_5$          | 8.350   |
| 1.39121          | 5 76 Os      | $L\alpha_1$          | 8.9117  | 1.4855           | 5 68 Er      | $L\beta_9$          | 8.346   |
| 1.3915           | 1 70 Yb      | $L\beta_{10}$        | 8.9100  | 1.48743          | 2 74 W       | $L\alpha_2$         | 8.3352  |
| 1.39220          | 5 72 Hf      | $L\beta_4$           | 8.9054  | 1.48807          | 1 28 Ni      | $K$ Abs. Edge       | 8.33165 |
| 1.392218         | 9 29 Cu      | $K\beta_{1,3}$       | 8.90529 | 1.48862          | 4 28 Ni      | $K\beta_5$          | 8.3286  |
| 1.3923           | 2 67 Ho      | $L\gamma_8$          | 8.905   | 1.49138          | 3 70 Yb      | $L\beta_4$          | 8.3132  |
| 1.3926           | 1 29 Cu      | $K\beta_2$           | 8.9029  | 1.4930           | 3 77 Ir      | $Lt$                | 8.304   |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation     | keV               | Wavelength<br>Å* | p.e. Element | Designation | keV             |                   |         |
|------------------|--------------|-----------------|-------------------|------------------|--------------|-------------|-----------------|-------------------|---------|
| 1.4941           | 3 68 Er      | $L\beta_7$      | $L_{III}O_I$      | 8.298            | 1.60891      | 3 27 Co     | $K\beta_8$      | $KM_{IV,v}$       | 7.7059  |
| 1.4941           | 3 68 Er      | $L\beta_{10}$   | $L_{II}M_{IV}$    | 8.298            | 1.61264      | 9 73 Ta     | $L_s$           | $L_{III}M_{III}$  | 7.6881  |
| 1.4995           | 2 78 Pt      | $L_I$           | $L_{III}M_I$      | 8.268            | 1.61951      | 3 71 Lu     | $L\alpha_1$     | $L_{III}M_V$      | 7.6555  |
| 1.500135         | 8 28 Ni      | $K\beta_{1,3}$  | $KM_{II,III}$     | 8.26466          | 1.6203       | 2 67 Ho     | $L\beta_3$      | $L_I M_{III}$     | 7.6519  |
| 1.5023           | 1 65 Tb      | $L_{II}$        | Abs. Edge         | 8.2527           | 1.62079      | 2 27 Co     | $K\beta_{1,3}$  | $KM_{II,III}$     | 7.64943 |
| 1.5035           | 2 65 Tb      | $L_{\gamma_6}$  | $L_{II}O_{IV}$    | 8.246            | 1.6237       | 2 67 Ho     | $L\beta_5$      | $L_{III}N_I$      | 7.6359  |
| 1.5063           | 2 69 Tm      | $L\beta_8$      | $L_I M_{III}$     | 8.231            | 1.62369      | 7 66 Dy     | $L\beta_{2,15}$ | $L_{III}N_{IV,v}$ | 7.6357  |
| 1.5097           | 2 65 Tb      | $L_{\gamma_8}$  | $L_{II}O_I$       | 8.212            | 1.6244       | 3 74 W      | $L_I$           | $L_{III}M_{II}$   | 7.6324  |
| 1.51399          | 9 68 Er      | $L\beta_{2,15}$ | $L_{III}N_{IV,v}$ | 8.1890           | 1.6271       | 1 63 Eu     | $L_{II}$        | Abs. Edge         | 7.6199  |
| 1.5162           | 2 69 Tm      | $L\beta_6$      | $L_{III}N_I$      | 8.177            | 1.6282       | 2 63 Eu     | $L_{\gamma_6}$  | $L_{II}O_{IV}$    | 7.6147  |
| 1.5178           | 1 75 Re      | $L_s$           | $L_{III}M_{III}$  | 8.1682           | 1.63029      | 5 71 Lu     | $L\alpha_2$     | $L_{III}M_{IV}$   | 7.6049  |
| 1.51824          | 7 66 Dy      | $L_{\gamma_5}$  | $L_{II}N_I$       | 8.1661           | 1.63056      | 5 75 Re     | $L_I$           | $L_{III}M_I$      | 7.6036  |
| 1.52197          | 2 73 Ta      | $L\alpha_1$     | $L_{III}M_V$      | 8.1461           | 1.6346       | 2 63 Eu     | $L_{\gamma_8}$  | $L_{II}O_I$       | 7.5849  |
| 1.52325          | 5 72 Hf      | $L_{\eta}$      | $L_{II}M_I$       | 8.1393           | 1.63560      | 5 70 Yb     | $L_{\eta}$      | $L_{II}M_I$       | 7.5802  |
| 1.5297           | 2 64 Gd      | $L_{\gamma_8}$  | $L_I N_{III}$     | 8.105            | 1.6412       | 2 64 Gd     | $L_{\gamma_6}$  | $L_{II}N_I$       | 7.5543  |
| 1.5303           | 2 65 Tb      | $L_{\gamma_1}$  | $L_{II}N_{IV}$    | 8.102            | 1.6475       | 2 67 Ho     | $L\beta_1$      | $L_{II}M_{IV}$    | 7.5253  |
| 1.5304           | 2 69 Tm      | $L\beta_1$      | $L_{II}M_{IV}$    | 8.101            | 1.6497       | 1 65 Tb     | $L_{III}$       | Abs. Edge         | 7.5153  |
| 1.53293          | 2 73 Ta      | $L\alpha_2$     | $L_{III}M_{IV}$   | 8.0879           | 1.6510       | 2 65 Tb     | $L\beta_5$      | $L_{III}O_{IV,v}$ | 7.5094  |
| 1.5331           | 2 64 Gd      | $L_{\gamma_2}$  | $L_I N_{II}$      | 8.087            | 1.65601      | 3 62 Sm     | $L_{\gamma_3}$  | $L_I N_{III}$     | 7.487   |
| 1.53333          | 9 71 Lu      | $L_{II}$        | $L_{II}M_{II}$    | 8.0858           | 1.6574       | 2 63 Eu     | $L_{\gamma_1}$  | $L_{II}N_{IV}$    | 7.4803  |
| 1.5347           | 2 76 Os      | $L_I$           | $L_{III}M_{II}$   | 8.079            | 1.657910     | 8 28 Ni     | $K\alpha_1$     | $K L_{III}$       | 7.47815 |
| 1.5368           | 1 67 Ho      | $L_{III}$       | Abs. Edge         | 8.0676           | 1.6585       | 2 65 Tb     | $L\beta_7$      | $L_{III}O_I$      | 7.4753  |
| 1.5378           | 2 67 Ho      | $L\beta_5$      | $L_{III}O_{IV,v}$ | 8.062            | 1.6595       | 2 67 Ho     | $L\beta_4$      | $L_I M_{II}$      | 7.4708  |
| 1.5381           | 1 63 Eu      | $L_I$           | Abs. Edge         | 8.0607           | 1.66044      | 6 62 Sm     | $L_{\gamma_2}$  | $L_I N_{II}$      | 7.467   |
| 1.540562         | 2 29 Cu      | $K\alpha_1$     | $K L_{III}$       | 8.04778          | 1.661747     | 8 28 Ni     | $K\alpha_2$     | $K L_{II}$        | 7.46089 |
| 1.54094          | 3 77 Ir      | $L_I$           | $L_{III}M_I$      | 8.0458           | 1.66346      | 9 72 Hf     | $L_s$           | $L_{III}M_{III}$  | 7.4532  |
| 1.5439           | 1 63 Eu      | $L_{\gamma_4}$  | $L_I O_{II,III}$  | 8.0304           | 1.6673       | 3 65 Tb     | $L\beta_{10}$   | $L_I M_{IV}$      | 7.436   |
| 1.544390         | 9 29 Cu      | $K\alpha_2$     | $K L_{II}$        | 8.02783          | 1.6674       | 5 61 Pm     | $L_I$           | Abs. Edge         | 7.436   |
| 1.5448           | 2 69 Tm      | $L\beta_4$      | $L_I M_{II}$      | 8.026            | 1.67189      | 4 70 Yb     | $L\alpha_1$     | $L_{III}M_V$      | 7.4156  |
| 1.5486           | 3 67 Ho      | $L\beta_{10}$   | $L_I M_{IV}$      | 8.006            | 1.67265      | 9 73 Ta     | $L_I$           | $L_{III}M_{II}$   | 7.4123  |
| 1.5616           | 1 68 Er      | $L\beta_3$      | $L_I M_{III}$     | 7.9392           | 1.6782       | 1 74 W      | $L_I$           | $L_{III}M_I$      | 7.3878  |
| 1.5632           | 1 64 Gd      | $L_{II}$        | Abs. Edge         | 7.9310           | 1.68213      | 7 66 Dy     | $L\beta_5$      | $L_{III}N_I$      | 7.3705  |
| 1.5642           | 3 74 W       | $L_s$           | $L_{III}M_{III}$  | 7.926            | 1.6822       | 2 66 Dy     | $L\beta_3$      | $L_I M_{III}$     | 7.3702  |
| 1.5644           | 2 64 Gd      | $L_{\gamma_6}$  | $L_{II}O_{IV}$    | 7.925            | 1.68285      | 5 70 Yb     | $L\alpha_2$     | $L_{III}M_{IV}$   | 7.3673  |
| 1.5671           | 2 67 Ho      | $L\beta_{2,15}$ | $L_{III}N_{IV,v}$ | 7.911            | 1.6830       | 2 65 Tb     | $L\beta_{2,15}$ | $L_{III}N_{I,v}$  | 7.3667  |
| 1.5675           | 2 68 Er      | $L\beta_6$      | $L_{III}N_I$      | 7.909            | 1.6953       | 1 62 Sm     | $L_{II}$        | Abs. Edge         | 7.3132  |
| 1.56958          | 5 72 Hf      | $L\alpha_1$     | $L_{III}M_V$      | 7.8990           | 1.6963       | 2 69 Tm     | $L_{\eta}$      | $L_{II}M_I$       | 7.3088  |
| 1.5707           | 2 64 Gd      | $L_{\gamma_8}$  | $L_{II}O_I$       | 7.894            | 1.6966       | 9 62 Sm     | $L_{\gamma_6}$  | $L_{II}O_{IV}$    | 7.308   |
| 1.5779           | 1 71 Lu      | $L_{\eta}$      | $L_{II}M_I$       | 7.8575           | 1.7085       | 2 63 Eu     | $L_{\gamma_5}$  | $L_{II}N_I$       | 7.2566  |
| 1.5787           | 2 65 Tb      | $L_{\gamma_5}$  | $L_{II}N_I$       | 7.8535           | 1.71062      | 7 66 Dy     | $L\beta_1$      | $L_{II}M_{IV}$    | 7.2477  |
| 1.5789           | 1 75 Re      | $L_I$           | $L_{III}M_{II}$   | 7.8525           | 1.7117       | 1 64 Gd     | $L_{III}$       | Abs. Edge         | 7.2430  |
| 1.58046          | 5 72 Hf      | $L\alpha_2$     | $L_{III}M_{IV}$   | 7.8446           | 1.7130       | 2 64 Gd     | $L\beta_5$      | $L_{III}O_{IV,v}$ | 7.2374  |
| 1.58498          | 7 76 Os      | $L_I$           | $L_{III}M_I$      | 7.8222           | 1.7203       | 2 64 Gd     | $L\beta_7$      | $L_{III}O_I$      | 7.2071  |
| 1.5873           | 1 68 Er      | $L\beta_1$      | $L_{II}M_{IV}$    | 7.8109           | 1.72103      | 7 66 Dy     | $L\beta_4$      | $L_I M_{II}$      | 7.2039  |
| 1.58837          | 7 66 Dy      | $L\beta_5$      | $L_{III}O_{IV,v}$ | 7.8055           | 1.72305      | 9 72 Hf     | $L_I$           | $L_{III}M_{II}$   | 7.1954  |
| 1.58844          | 9 70 Yb      | $L_{II}$        | $L_{II}M_{II}$    | 7.8052           | 1.7240       | 3 64 Gd     | $L\beta_9$      | $L_I M_V$         | 7.192   |
| 1.5903           | 2 63 Eu      | $L_{\gamma_3}$  | $L_I N_{III}$     | 7.7961           | 1.72724      | 3 62 Sm     | $L_{\gamma_1}$  | $L_{II}N_{IV}$    | 7.178   |
| 1.5916           | 1 66 Dy      | $L_{III}$       | Abs. Edge         | 7.7897           | 1.7268       | 2 69 Tm     | $L\alpha_1$     | $L_{III}M_V$      | 7.1799  |
| 1.5924           | 2 64 Gd      | $L_{\gamma_1}$  | $L_{II}N_{IV}$    | 7.7858           | 1.72841      | 5 73 Ta     | $L_I$           | $L_{III}M_I$      | 7.1731  |
| 1.5961           | 2 63 Eu      | $L_{\gamma_2}$  | $L_I N_{II}$      | 7.7677           | 1.7315       | 3 64 Gd     | $L\beta_{10}$   | $L_I M_{IV}$      | 7.160   |
| 1.59973          | 9 66 Dy      | $L\beta_9$      | $L_I M_V$         | 7.7501           | 1.7381       | 2 69 Tm     | $L\alpha_2$     | $L_{III}M_{IV}$   | 7.1331  |
| 1.6002           | 1 62 Sm      | $L_I$           | Abs. Edge         | 7.7478           | 1.7390       | 1 60 Nd     | $L_I$           | Abs. Edge         | 7.1294  |
| 1.6007           | 1 68 Er      | $L\beta_4$      | $L_I M_{II}$      | 7.7453           | 1.7422       | 2 65 Tb     | $L\beta_5$      | $L_{III}N_I$      | 7.1163  |
| 1.60447          | 7 66 Dy      | $L\beta_7$      | $L_{III}O_I$      | 7.7272           | 1.74346      | 1 26 Fe     | $K$             | Abs. Edge         | 7.11120 |
| 1.60728          | 3 62 Sm      | $L_{\gamma_4}$  | $L_I O_{II,III}$  | 7.714            | 1.7442       | 1 26 Fe     | $K\beta_5$      | $KM_{IV,v}$       | 7.1081  |
| 1.60743          | 9 66 Dy      | $L\beta_{10}$   | $L_I M_{IV}$      | 7.7130           | 1.7445       | 4 60 Nd     | $L_{\gamma_4}$  | $L_I O_{II,III}$  | 7.107   |
| 1.60815          | 1 27 Co      | $K$             | Abs. Edge         | 7.70954          | 1.7455       | 2 64 Gd     | $L\beta_{2,15}$ | $L_{III}N_{IV,v}$ | 7.1028  |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength |              |                 |                    |         | Wavelength   |             |                 |                    |         |
|------------|--------------|-----------------|--------------------|---------|--------------|-------------|-----------------|--------------------|---------|
| Å*         | p.e. Element | Designation     | keV                | Å*      | p.e. Element | Designation | keV             |                    |         |
| 1.7472     | 2 65 Tb      | $L\beta_3$      | $L_I M_{III}$      | 7.0959  | 1.9255       | 2 63 Eu     | $L\beta_4$      | $L_I M_{II}$       | 6.4389  |
| 1.75661    | 2 26 Fe      | $K\beta_{1,2}$  | $K M_{II,III}$     | 7.05798 | 1.9255       | 5 59 Pr     | $L_{II}$        | Abs. Edge          | 6.439   |
| 1.7566     | 1 68 Er      | $L\eta$         | $L_{II} M_I$       | 7.0579  | 1.9355       | 4 60 Nd     | $L\gamma_5$     | $L_{II} N_I$       | 6.406   |
| 1.7676     | 5 61 Pm      | $L_{II}$        | Abs. Edge          | 7.014   | 1.936042     | 9 26 Fe     | $K\alpha_1$     | $K L_{III}$        | 6.40384 |
| 1.7760     | 1 71 Lu      | $L\epsilon$     | $L_{III} M_{II}$   | 6.9810  | 1.9362       | 4 59 Pr     | $L\gamma_8$     | $L_{II} O_I$       | 6.403   |
| 1.7761     | 1 63 Eu      | $L_{III}$       | Abs. Edge          | 6.9806  | 1.939980     | 9 26 Fe     | $K\alpha_2$     | $K L_{II}$         | 6.39084 |
| 1.7768     | 3 65 Tb      | $L\beta_1$      | $L_{II} M_{IV}$    | 6.978   | 1.94643      | 3 62 Sm     | $L\beta_6$      | $L_{III} N_I$      | 6.3693  |
| 1.7772     | 2 63 Eu      | $L\beta_5$      | $L_{III} O_{IV,V}$ | 6.9763  | 1.9550       | 2 69 Tm     | $L\epsilon$     | $L_{III} M_I$      | 6.3419  |
| 1.77934    | 3 62 Sm      | $L\gamma_6$     | $L_{II} N_I$       | 6.968   | 1.9553       | 3 58 Ce     | $L\gamma_3$     | $L_I N_{III}$      | 6.3409  |
| 1.78145    | 5 72 Hf      | $L\epsilon$     | $L_{III} M_I$      | 6.9596  | 1.9559       | 6 61 Pm     | $L\beta_{2,15}$ | $L_{III} N_{IV,V}$ | 6.339   |
| 1.78425    | 9 68 Er      | $L\alpha_1$     | $L_{III} M_V$      | 6.9487  | 1.9602       | 3 58 Ce     | $L\gamma_2$     | $L_I N_{II}$       | 6.3250  |
| 1.7851     | 2 63 Eu      | $L\beta_7$      | $L_{III} O_I$      | 6.9453  | 1.9611       | 3 59 Pr     | $L\gamma_1$     | $L_{II} N_{IV}$    | 6.3221  |
| 1.7864     | 2 65 Tb      | $L\beta_4$      | $L_I M_{II}$       | 6.9403  | 1.96241      | 3 62 Sm     | $L\beta_3$      | $L_I M_{III}$      | 6.318   |
| 1.788965   | 9 27 Co      | $K\alpha_1$     | $K L_{III}$        | 6.93032 | 1.9730       | 2 65 Tb     | $L\eta$         | $L_{II} M_I$       | 6.2839  |
| 1.7916     | 3 63 Eu      | $L\beta_9$      | $L_I M_V$          | 6.920   | 1.9765       | 2 65 Tb     | $L\alpha_1$     | $L_{III} M_V$      | 6.2728  |
| 1.792850   | 9 27 Co      | $K\alpha_2$     | $K L_{II}$         | 6.91530 | 1.9780       | 5 57 La     | $L_I$           | Abs. Edge          | 6.268   |
| 1.7955     | 2 68 Er      | $L\alpha_2$     | $L_{III} M_{IV}$   | 6.9050  | 1.9830       | 4 57 La     | $L\gamma_4$     | $L_I O_{II,III}$   | 6.252   |
| 1.7964     | 4 60 Nd      | $L\gamma_3$     | $L_I N_{III}$      | 6.902   | 1.9875       | 2 65 Tb     | $L\alpha_2$     | $L_{III} M_{IV}$   | 6.2380  |
| 1.7989     | 9 61 Pm      | $L\gamma_1$     | $L_{II} N_{IV}$    | 6.892   | 1.9967       | 1 60 Nd     | $L_{III}$       | Abs. Edge          | 6.2092  |
| 1.7993     | 3 63 Eu      | $L\beta_{10}$   | $L_I M_{IV}$       | 6.890   | 1.99806      | 3 62 Sm     | $L\beta_1$      | $L_{II} M_{IV}$    | 6.2051  |
| 1.8013     | 4 60 Nd      | $L\gamma_2$     | $L_I N_{II}$       | 6.883   | 2.00095      | 6 62 Sm     | $L\beta_4$      | $L_I M_{II}$       | 6.196   |
| 1.8054     | 2 64 Gd      | $L\beta_6$      | $L_{III} N_I$      | 6.8671  | 2.0092       | 3 60 Nd     | $L\beta_7$      | $L_{III} O_I$      | 6.1708  |
| 1.8118     | 2 63 Eu      | $L\beta_{2,15}$ | $L_{III} N_{IV,V}$ | 6.8432  | 2.0124       | 5 58 Ce     | $L_{II}$        | Abs. Edge          | 6.161   |
| 1.8141     | 5 59 Pr      | $L_I$           | Abs. Edge          | 6.834   | 2.015        | 1 68 Er     | $L\epsilon$     | $L_{III} M_I$      | 6.152   |
| 1.8150     | 2 64 Gd      | $L\beta_3$      | $L_I M_{III}$      | 6.8311  | 2.0165       | 3 60 Nd     | $L\beta_9$      | $L_I M_V$          | 6.1484  |
| 1.8193     | 4 59 Pr      | $L\gamma_4$     | $L_I O_{II,III}$   | 6.815   | 2.0205       | 4 59 Pr     | $L\gamma_5$     | $L_{II} N_I$       | 6.136   |
| 1.8264     | 2 67 Ho      | $L\eta$         | $L_{II} M_I$       | 6.7883  | 2.0237       | 4 58 Ce     | $L\gamma_8$     | $L_{II} O_I$       | 6.126   |
| 1.83091    | 9 70 Yb      | $L\epsilon$     | $L_{III} M_{II}$   | 6.7715  | 2.0237       | 3 60 Nd     | $L\beta_{10}$   | $L_I M_{IV}$       | 6.1265  |
| 1.8360     | 1 71 Lu      | $L\epsilon$     | $L_{III} M_I$      | 6.7528  | 2.0360       | 3 60 Nd     | $L\beta_{2,15}$ | $L_{III} N_{IV,V}$ | 6.0894  |
| 1.8440     | 1 60 Nd      | $L_{II}$        | Abs. Edge          | 6.7234  | 2.0410       | 4 57 La     | $L\gamma_3$     | $L_I N_{III}$      | 6.074   |
| 1.8450     | 2 67 Ho      | $L\alpha_1$     | $L_{III} M_V$      | 6.7198  | 2.0421       | 4 61 Pm     | $L\beta_3$      | $L_I M_{III}$      | 6.071   |
| 1.8457     | 1 62 Sm      | $L_{III}$       | Abs. Edge          | 6.7172  | 2.0460       | 4 57 La     | $L\gamma_2$     | $L_I N_{II}$       | 6.060   |
| 1.8468     | 2 64 Gd      | $L\beta_1$      | $L_{II} M_{IV}$    | 6.7132  | 2.0468       | 2 64 Gd     | $L\alpha_1$     | $L_{III} M_V$      | 6.0572  |
| 1.84700    | 9 62 Sm      | $L\beta_6$      | $L_{III} O_{IV,V}$ | 6.7126  | 2.0487       | 4 58 Ce     | $L\gamma_1$     | $L_{II} N_{IV}$    | 6.052   |
| 1.8540     | 2 64 Gd      | $L\beta_4$      | $L_I M_{II}$       | 6.6871  | 2.0494       | 1 64 Gd     | $L\eta$         | $L_{II} M_I$       | 6.0495  |
| 1.8552     | 5 60 Nd      | $L\gamma_8$     | $L_{II} O_I$       | 6.683   | 2.0578       | 2 64 Gd     | $L\alpha_2$     | $L_{III} M_{IV}$   | 6.0250  |
| 1.8561     | 2 67 Ho      | $L\alpha_2$     | $L_{III} M_{IV}$   | 6.6795  | 2.0678       | 5 56 Ba     | $L_I$           | Abs. Edge          | 5.996   |
| 1.85626    | 3 62 Sm      | $L\beta_7$      | $L_{III} O_I$      | 6.679   | 2.07020      | 5 24 Cr     | $K$             | Abs. Edge          | 5.9888  |
| 1.86166    | 3 62 Sm      | $L\beta_9$      | $L_I M_V$          | 6.660   | 2.07087      | 6 24 Cr     | $K\beta_5$      | $K M_{IV,V}$       | 5.9869  |
| 1.86990    | 3 62 Sm      | $L\beta_{10}$   | $L_I M_{IV}$       | 6.634   | 2.0756       | 3 56 Ba     | $L\gamma_4$     | $L_I O_{II,III}$   | 5.9733  |
| 1.8737     | 2 63 Eu      | $L\beta_6$      | $L_{III} N_I$      | 6.6170  | 2.0791       | 5 59 Pr     | $L_{III}$       | Abs. Edge          | 5.963   |
| 1.8740     | 4 59 Pr      | $L\gamma_3$     | $L_I N_{III}$      | 6.616   | 2.0797       | 4 61 Pm     | $L\beta_1$      | $L_{II} M_{IV}$    | 5.961   |
| 1.8779     | 2 60 Nd      | $L\gamma_1$     | $L_{II} N_{IV}$    | 6.6021  | 2.08487      | 2 24 Cr     | $K\beta_{1,3}$  | $K M_{II,III}$     | 5.94671 |
| 1.8791     | 4 59 Pr      | $L\gamma_2$     | $L_I N_{II}$       | 6.598   | 2.0860       | 2 67 Ho     | $L\epsilon$     | $L_{III} M_I$      | 5.9434  |
| 1.8821     | 3 62 Sm      | $L\beta_{2,15}$ | $L_{III} N_{IV,V}$ | 6.586   | 2.0919       | 4 59 Pr     | $L\beta_7$      | $L_{III} O_I$      | 5.927   |
| 1.8867     | 2 63 Eu      | $L\beta_3$      | $L_I M_{III}$      | 6.5713  | 2.1004       | 4 59 Pr     | $L\beta_9$      | $L_I M_V$          | 5.903   |
| 1.8934     | 5 58 Ce      | $L_I$           | Abs. Edge          | 6.548   | 2.101820     | 9 25 Mn     | $K\alpha_1$     | $K L_{III}$        | 5.89875 |
| 1.89415    | 5 70 Yb      | $L\epsilon$     | $L_{III} M_I$      | 6.5455  | 2.1039       | 3 60 Nd     | $L\beta_6$      | $L_{III} N_I$      | 5.8930  |
| 1.89643    | 5 25 Mn      | $K$             | Abs. Edge          | 6.5376  | 2.1053       | 5 57 La     | $L_{II}$        | Abs. Edge          | 5.889   |
| 1.8971     | 1 25 Mn      | $K\beta_5$      | $K M_{IV,V}$       | 6.5352  | 2.10578      | 2 25 Mn     | $K\alpha_2$     | $K L_{II}$         | 5.88765 |
| 1.89743    | 7 66 Dy      | $L\eta$         | $L_{II} M_I$       | 6.5342  | 2.1071       | 4 59 Pr     | $L\beta_{10}$   | $L_I M_{IV}$       | 5.884   |
| 1.8991     | 4 58 Ce      | $L\gamma_4$     | $L_I O_{II,III}$   | 6.528   | 2.1103       | 3 58 Ce     | $L\gamma_5$     | $L_{II} N_I$       | 5.8751  |
| 1.90881    | 3 66 Dy      | $L\alpha_1$     | $L_{III} M_V$      | 6.4952  | 2.1194       | 4 59 Pr     | $L\beta_{2,15}$ | $L_{III} N_{IV,V}$ | 5.850   |
| 1.91021    | 2 25 Mn      | $K\beta_{1,3}$  | $K M_{II,III}$     | 6.49045 | 2.1209       | 2 63 Eu     | $L\alpha_1$     | $L_{III} M_V$      | 5.8457  |
| 1.9191     | 1 61 Pm      | $L_{III}$       | Abs. Edge          | 6.4605  | 2.1268       | 2 60 Nd     | $L\beta_3$      | $L_I M_{III}$      | 5.8294  |
| 1.91991    | 3 66 Dy      | $L\alpha_2$     | $L_{III} M_{IV}$   | 6.4577  | 2.1315       | 2 63 Eu     | $L\eta$         | $L_{II} M_I$       | 5.8166  |
| 1.9203     | 2 63 Eu      | $L\beta_1$      | $L_{II} M_{IV}$    | 6.4564  | 2.1315       | 2 63 Eu     | $L\alpha_2$     | $L_{III} M_{IV}$   | 5.8166  |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation     | keV               | Wavelength<br>Å* | p.e. Element | Designation | keV             |                   |         |
|------------------|--------------|-----------------|-------------------|------------------|--------------|-------------|-----------------|-------------------|---------|
| 2.1342           | 2 56 Ba      | $L\gamma_3$     | $L_{II}N_{III}$   | 5.8092           | 2.3913       | 2 53 I      | $L\gamma_4$     | $L_{IO_{II,III}}$ | 5.1848  |
| 2.1387           | 2 56 Ba      | $L\gamma_2$     | $L_{II}N_{II}$    | 5.7969           | 2.3948       | 2 63 Eu     | $L_I$           | $L_{III}M_I$      | 5.1772  |
| 2.1418           | 3 57 La      | $L\gamma_1$     | $L_{II}N_{IV}$    | 5.7885           | 2.40435      | 6 56 Ba     | $L\beta_{2,15}$ | $L_{III}N_{IV,V}$ | 5.1565  |
| 2.15877          | 7 66 Dy      | $L_I$           | $L_{III}M_I$      | 5.7431           | 2.4094       | 4 60 Nd     | $L\eta$         | $L_{II}M_I$       | 5.1457  |
| 2.166            | 1 58 Ce      | $L_{III}$       | Abs. Edge         | 5.723            | 2.4105       | 3 57 La     | $L\beta_3$      | $L_{IM_{III}}$    | 5.1434  |
| 2.1669           | 3 60 Nd      | $L\beta_4$      | $L_{IM_{II}}$     | 5.7216           | 2.4174       | 2 55 Cs     | $L\gamma_5$     | $L_{II}N_I$       | 5.1287  |
| 2.1669           | 2 60 Nd      | $L\beta_1$      | $L_{II}M_{IV}$    | 5.7216           | 2.4292       | 1 54 Xe     | $L_{II}$        | Abs. Edge         | 5.1037  |
| 2.1673           | 5 55 Cs      | $L_I$           | Abs. Edge         | 5.721            | 2.442        | 9 90 Th     |                 | $M_{IO_{III}}$    | 5.08    |
| 2.1701           | 2 58 Ce      | $L\beta_7$      | $L_{III}O_I$      | 5.7132           | 2.443        | 4 92 U      |                 | $M_{II}O_{IV}$    | 5.075   |
| 2.1741           | 2 55 Cs      | $L\gamma_4$     | $L_{IO_{II,III}}$ | 5.7026           | 2.4475       | 2 53 I      | $L\gamma_{2,3}$ | $L_{IN_{II,III}}$ | 5.0657  |
| 2.1885           | 3 58 Ce      | $L\beta_9$      | $L_{IM_V}$        | 5.6650           | 2.4493       | 3 57 La     | $L\beta_4$      | $L_{IM_{II}}$     | 5.0620  |
| 2.1906           | 4 59 Pr      | $L\beta_5$      | $L_{III}N_I$      | 5.660            | 2.45891      | 5 57 La     | $L\beta_1$      | $L_{II}M_{IV}$    | 5.0421  |
| 2.1958           | 5 58 Ce      | $L\beta_{10}$   | $L_{IM_{IV}}$     | 5.646            | 2.4630       | 2 59 Pr     | $L\alpha_1$     | $L_{III}M_V$      | 5.0337  |
| 2.1998           | 2 62 Sm      | $L\alpha_1$     | $L_{III}M_V$      | 5.6361           | 2.4729       | 3 59 Pr     | $L\alpha_2$     | $L_{III}M_{IV}$   | 5.0135  |
| 2.2048           | 1 56 Ba      | $L_{II}$        | Abs. Edge         | 5.6233           | 2.4740       | 1 55 Cs     | $L_{III}$       | Abs. Edge         | 5.0113  |
| 2.2056           | 4 57 La      | $L\gamma_5$     | $L_{II}N_I$       | 5.621            | 2.4783       | 2 55 Cs     | $L\beta_9$      | $L_{IM_V}$        | 5.0026  |
| 2.2087           | 2 58 Ce      | $L\beta_{2,15}$ | $L_{III}N_{IV,V}$ | 5.6134           | 2.4823       | 4 62 Sm     | $L_I$           | $L_{III}M_I$      | 4.9945  |
| 2.21062          | 3 62 Sm      | $L\alpha_2$     | $L_{III}M_{IV}$   | 5.6090           | 2.4826       | 2 56 Ba     | $L\beta_6$      | $L_{III}N_I$      | 4.9939  |
| 2.2172           | 3 59 Pr      | $L\beta_3$      | $L_{IM_{III}}$    | 5.5918           | 2.4849       | 2 55 Cs     | $L\beta_7$      | $L_{III}O_I$      | 4.9893  |
| 2.21824          | 3 62 Sm      | $L\eta$         | $L_{II}M_I$       | 5.589            | 2.4920       | 2 55 Cs     | $L\beta_{10}$   | $L_{IM_{IV}}$     | 4.9752  |
| 2.2328           | 2 55 Cs      | $L\gamma_3$     | $L_{IN_{III}}$    | 5.5527           | 2.49734      | 5 22 Ti     | $K$             | Abs. Edge         | 4.96452 |
| 2.2352           | 2 65 Tb      | $L_I$           | $L_{III}M_I$      | 5.5467           | 2.4985       | 2 22 Ti     | $K\beta_5$      | $KM_{IV,V}$       | 4.9623  |
| 2.2371           | 2 55 Cs      | $L\gamma_2$     | $L_{IN_{II}}$     | 5.5420           | 2.50356      | 2 23 V      | $K\alpha_1$     | $KL_{III}$        | 4.95220 |
| 2.2415           | 2 56 Ba      | $L\gamma_1$     | $L_{IN_{IV}}$     | 5.5311           | 2.50738      | 2 23 V      | $K\alpha_2$     | $KL_{II}$         | 4.94464 |
| 2.253            | 6 92 U       |                 | $M_{IP_{III}}$    | 5.50             | 2.5099       | 1 52 Te     | $L_I$           | Abs. Edge         | 4.9397  |
| 2.2550           | 4 59 Pr      | $L\beta_4$      | $L_{IM_{II}}$     | 5.4981           | 2.5113       | 2 52 Te     | $L\gamma_4$     | $L_{IO_{II,III}}$ | 4.9369  |
| 2.2588           | 3 59 Pr      | $L\beta_1$      | $L_{II}M_{IV}$    | 5.4889           | 2.5118       | 2 55 Cs     | $L\beta_{2,15}$ | $L_{III}N_{IV,V}$ | 4.9359  |
| 2.261            | 1 57 La      | $L_{III}$       | Abs. Edge         | 5.484            | 2.512        | 3 59 Pr     | $L\eta$         | $L_{II}M_I$       | 4.935   |
| 2.2691           | 1 23 V       | $K$             | Abs. Edge         | 5.4639           | 2.51391      | 2 22 Ti     | $K\beta_{1,3}$  | $KM_{II,III}$     | 4.93181 |
| 2.26951          | 6 23 V       | $K\beta_5$      | $KM_{IV,V}$       | 5.4629           | 2.5164       | 2 56 Ba     | $L\beta_3$      | $L_{IM_{III}}$    | 4.9269  |
| 2.2737           | 1 54 Xe      | $L_I$           | Abs. Edge         | 5.4528           | 2.527        | 4 91 Pa     |                 | $M_{II}O_{IV}$    | 4.906   |
| 2.275            | 3 57 La      | $L\beta_7$      | $L_{III}O_I$      | 5.450            | 2.5542       | 5 53 I      | $L_{II}$        | Abs. Edge         | 4.8540  |
| 2.282            | 3 57 La      | $L\beta_9$      | $L_{IM_V}$        | 5.434            | 2.5553       | 2 56 Ba     | $L\beta_4$      | $L_{IM_{II}}$     | 4.8519  |
| 2.2818           | 3 58 Ce      | $L\beta_5$      | $L_{III}N_I$      | 5.4334           | 2.5615       | 2 58 Ce     | $L\alpha_1$     | $L_{III}M_V$      | 4.8402  |
| 2.2822           | 3 61 Pm      | $L\alpha_1$     | $L_{III}M_V$      | 5.4325           | 2.5674       | 2 52 Te     | $L\gamma_{2,3}$ | $L_{IN_{II,III}}$ | 4.8290  |
| 2.28440          | 2 23 V       | $K\beta_{1,3}$  | $KM_{II,III}$     | 5.42729          | 2.56821      | 5 56 Ba     | $L\beta_1$      | $L_{II}M_{IV}$    | 4.82753 |
| 2.28970          | 2 24 Cr      | $K\alpha_1$     | $KL_{III}$        | 5.41472          | 2.5706       | 3 58 Ce     | $L\alpha_2$     | $L_{III}M_{IV}$   | 4.8230  |
| 2.290            | 3 57 La      | $L\beta_{10}$   | $L_{IM_{IV}}$     | 5.415            | 2.58244      | 8 53 I      | $L\gamma_1$     | $L_{II}N_{IV}$    | 4.8009  |
| 2.2926           | 4 61 Pm      | $L\alpha_2$     | $L_{III}M_{IV}$   | 5.4078           | 2.5926       | 1 54 Xe     | $L_{III}$       | Abs. Edge         | 4.7822  |
| 2.293606         | 3 24 Cr      | $K\alpha_2$     | $KL_{II}$         | 5.405509         | 2.5932       | 2 55 Cs     | $L\beta_5$      | $L_{III}N_I$      | 4.7811  |
| 2.3030           | 3 57 La      | $L\beta_{2,15}$ | $L_{III}N_{IV,V}$ | 5.3835           | 2.618        | 5 90 Th     |                 | $M_{II}O_{IV}$    | 4.735   |
| 2.304            | 7 92 U       |                 | $M_{IO_{III}}$    | 5.38             | 2.6203       | 4 58 Ce     | $L\eta$         | $L_{II}M_I$       | 4.7315  |
| 2.3085           | 3 56 Ba      | $L\gamma_5$     | $L_{II}N_I$       | 5.3707           | 2.6285       | 2 55 Cs     | $L\beta_3$      | $L_{IM_{III}}$    | 4.7167  |
| 2.3109           | 3 58 Ce      | $L\beta_3$      | $L_{IM_{III}}$    | 5.3651           | 2.6388       | 1 51 Sb     | $L_I$           | Abs. Edge         | 4.6984  |
| 2.3122           | 2 64 Gd      | $L_I$           | $L_{III}M_I$      | 5.3621           | 2.6398       | 2 51 Sb     | $L\gamma_4$     | $L_{IO_{II,III}}$ | 4.6967  |
| 2.3139           | 1 55 Cs      | $L_{II}$        | Abs. Edge         | 5.3581           | 2.65710      | 9 53 I      | $L\gamma_5$     | $L_{II}N_I$       | 4.6660  |
| 2.3480           | 2 55 Cs      | $L\gamma_1$     | $L_{II}N_{IV}$    | 5.2804           | 2.66570      | 5 57 La     | $L\alpha_1$     | $L_{III}M_V$      | 4.65097 |
| 2.3497           | 4 58 Ce      | $L\beta_4$      | $L_{IM_{II}}$     | 5.2765           | 2.6666       | 2 55 Cs     | $L\beta_4$      | $L_{IM_{II}}$     | 4.6494  |
| 2.3561           | 3 58 Ce      | $L\beta_1$      | $L_{II}M_{IV}$    | 5.2622           | 2.67533      | 5 57 La     | $L\alpha_2$     | $L_{III}M_{IV}$   | 4.63423 |
| 2.3629           | 1 56 Ba      | $L_{III}$       | Abs. Edge         | 5.2470           | 2.6760       | 4 60 Nd     | $L_I$           | $L_{III}M_I$      | 4.6330  |
| 2.3704           | 2 60 Nd      | $L\alpha_1$     | $L_{III}M_V$      | 5.2304           | 2.6837       | 2 55 Cs     | $L\beta_1$      | $L_{II}M_{IV}$    | 4.6198  |
| 2.3764           | 2 56 Ba      | $L\beta_9$      | $L_{IM_V}$        | 5.2171           | 2.6879       | 1 52 Te     | $L_{II}$        | Abs. Edge         | 4.6126  |
| 2.3790           | 4 57 La      | $L\beta_5$      | $L_{III}N_I$      | 5.2114           | 2.6953       | 2 51 Sb     | $L\gamma_{2,3}$ | $L_{IN_{II,III}}$ | 4.5999  |
| 2.3806           | 2 56 Ba      | $L\beta_7$      | $L_{III}O_I$      | 5.2079           | 2.71241      | 6 52 Te     | $L\gamma_1$     | $L_{II}N_{IV}$    | 4.5709  |
| 2.3807           | 3 60 Nd      | $L\alpha_2$     | $L_{III}M_{IV}$   | 5.2077           | 2.71352      | 9 53 I      | $L\beta_9$      | $L_{IM_V}$        | 4.5690  |
| 2.3869           | 2 56 Ba      | $L\beta_{10}$   | $L_{IM_{IV}}$     | 5.1941           | 2.7196       | 5 53 I      | $L_{III}$       | Abs. Edge         | 4.5587  |
| 2.3880           | 5 53 I       | $L_I$           | Abs. Edge         | 5.192            | 2.72104      | 9 53 I      | $L\beta_{10}$   | $L_{IM_{IV}}$     | 4.5564  |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation     | keV       | Wavelength<br>Å* | p.e. Element | Designation     | keV               |
|------------------|--------------|-----------------|-----------|------------------|--------------|-----------------|-------------------|
| 2.7288           | 3 53 I       | $L\beta_7$      | 4.5435    | 3.04661          | 9 52 Te      | $L\beta_4$      | 4.0695            |
| 2.740            | 3 57 La      | $L\eta$         | 4.525     | 3.068            | 5 90 Th      | $M_{III}$       | Abs. Edge         |
| 2.74851          | 2 22 Ti      | $K\alpha_1$     | 4.51084   | 3.0703           | 1 20 Ca      | $K$             | Abs. Edge         |
| 2.75053          | 8 53 I       | $L\beta_{2,15}$ | 4.5075    | 3.0746           | 3 20 Ca      | $K\beta_5$      | $KM_{IV,v}$       |
| 2.75216          | 2 22 Ti      | $K\alpha_2$     | 4.50486   | 3.07677          | 6 52 Te      | $L\beta_1$      | $L_{II}M_{IV}$    |
| 2.753            | 8 92 U       |                 | 4.50      | 3.08475          | 9 50 Sn      | $L\gamma_5$     | $L_{II}N_I$       |
| 2.762            | 1 21 Sc      | $K$             | Abs. Edge | 3.0849           | 1 48 Cd      | $L_I$           | Abs. Edge         |
| 2.7634           | 3 21 Sc      | $K\beta_5$      | 4.4865    | 3.0897           | 2 20 Ca      | $K\beta_{1,3}$  | $KM_{II,III}$     |
| 2.77595          | 5 56 Ba      | $L\alpha_1$     | 4.46626   | 3.094            | 5 83 Bi      | $M_I$           | Abs. Edge         |
| 2.7769           | 1 50 Sn      | $L_I$           | Abs. Edge | 3.11513          | 9 50 Sn      | $L\beta_9$      | $L_I M_V$         |
| 2.7775           | 2 50 Sn      | $L\gamma_4$     | 4.4638    | 3.11513          | 9 51 Sb      | $L\beta_5$      | $L_{III}N_I$      |
| 2.7796           | 2 21 Sc      | $K\beta_{1,3}$  | 4.4605    | 3.115            | 7 92 U       |                 | $M_{III}O_I$      |
| 2.7841           | 4 59 Pr      | $L_I$           | 4.4532    | 3.12170          | 9 50 Sn      | $L\beta_{10}$   | $L_I M_{IV}$      |
| 2.78553          | 5 56 Ba      | $L\alpha_2$     | 4.45090   | 3.131            | 3 90 Th      |                 | $M_{III}O_{IV,v}$ |
| 2.79007          | 9 52 Te      | $L\gamma_5$     | 4.4437    | 3.1355           | 2 56 Ba      | $L_I$           | $L_{III}M_I$      |
| 2.817            | 2 92 U       |                 | 4.401     | 3.1377           | 2 48 Cd      | $L\gamma_2$     | $L_I N_{II}$      |
| 2.8294           | 5 51 Sb      | $L_{II}$        | Abs. Edge | 3.1473           | 1 49 In      | $L_{II}$        | Abs. Edge         |
| 2.8327           | 2 50 Sn      | $L\gamma_{2,3}$ | 4.3768    | 3.14860          | 6 53 I       | $L\alpha_1$     | $L_{III}M_V$      |
| 2.83672          | 9 53 I       | $L\beta_5$      | 4.3706    | 3.15258          | 9 51 Sb      | $L\beta_3$      | $L_I M_{III}$     |
| 2.83897          | 9 52 Te      | $L\beta_9$      | 4.3671    | 3.1557           | 1 50 Sn      | $L_{III}$       | Abs. Edge         |
| 2.84679          | 9 52 Te      | $L\beta_{10}$   | 4.3551    | 3.1564           | 3 50 Sn      | $L\beta_7$      | $L_{III}O_I$      |
| 2.85159          | 3 51 Sb      | $L\gamma_1$     | 4.34779   | 3.15791          | 6 53 I       | $L\alpha_2$     | $L_{III}M_{IV}$   |
| 2.8555           | 1 52 Te      | $L_{III}$       | Abs. Edge | 3.16213          | 4 49 In      | $L\gamma_1$     | $L_{II}N_{IV}$    |
| 2.8627           | 3 56 Ba      | $L\eta$         | 4.3309    | 3.17505          | 3 50 Sn      | $L\beta_{2,15}$ | $L_{III}N_{IV,v}$ |
| 2.8634           | 3 52 Te      | $L\beta_7$      | 4.3298    | 3.19014          | 9 51 Sb      | $L\beta_4$      | $L_I M_{II}$      |
| 2.87429          | 9 53 I       | $L\beta_3$      | 4.3134    | 3.217            | 5 82 Pb      | $M_I$           | Abs. Edge         |
| 2.88217          | 8 52 Te      | $L\beta_{2,15}$ | 4.3017    | 3.22567          | 4 51 Sb      | $L\beta_1$      | $L_{II}M_{IV}$    |
| 2.884            | 5 92 U       | $M_{III}$       | Abs. Edge | 3.245            | 9 91 Pa      |                 | $M_{III}O_I$      |
| 2.8917           | 4 58 Ce      | $L_I$           | 4.2875    | 3.24907          | 9 49 In      | $L\gamma_5$     | $L_{II}N_I$       |
| 2.8924           | 2 55 Cs      | $L\alpha_1$     | 4.2865    | 3.2564           | 1 47 Ag      | $L_I$           | Abs. Edge         |
| 2.9020           | 2 55 Cs      | $L\alpha_2$     | 4.2722    | 3.2670           | 2 55 Cs      | $L_I$           | $L_{III}M_I$      |
| 2.910            | 2 91 Pa      |                 | 4.260     | 3.26763          | 9 49 In      | $L\beta_9$      | $L_I M_V$         |
| 2.91207          | 9 53 I       | $L\beta_4$      | 4.2575    | 3.26901          | 9 50 Sn      | $L\beta_5$      | $L_{III}N_I$      |
| 2.92             | 2 92 U       |                 | 4.25      | 3.27404          | 9 49 In      | $L\beta_{10}$   | $L_I M_{IV}$      |
| 2.9260           | 1 49 In      | $L_I$           | Abs. Edge | 3.27979          | 9 53 I       | $L\eta$         | $L_{II}M_I$       |
| 2.9264           | 2 49 In      | $L\gamma_4$     | 4.2367    | 3.283            | 9 90 Th      |                 | $M_{III}O_I$      |
| 2.93187          | 9 51 Sb      | $L\gamma_5$     | 4.2287    | 3.28920          | 6 52 Te      | $L\alpha_1$     | $L_{III}M_V$      |
| 2.934            | 8 90 Th      |                 | 4.23      | 3.29846          | 9 52 Te      | $L\alpha_2$     | $L_{III}M_{IV}$   |
| 2.93744          | 6 53 I       | $L\beta_1$      | 4.22072   | 3.30585          | 3 50 Sn      | $L\beta_3$      | $L_I M_{III}$     |
| 2.948            | 2 92 U       |                 | 4.205     | 3.30635          | 9 47 Ag      | $L\gamma_3$     | $L_I N_{III}$     |
| 2.97088          | 9 52 Te      | $L\beta_5$      | 4.1732    | 3.31216          | 9 47 Ag      | $L\gamma_2$     | $L_I N_{II}$      |
| 2.97261          | 9 51 Sb      | $L\beta_9$      | 4.1708    | 3.3237           | 1 49 In      | $L_{III}$       | Abs. Edge         |
| 2.97917          | 9 51 Sb      | $L\beta_{10}$   | 4.1616    | 3.324            | 4 49 In      | $L\beta_7$      | $L_{III}O_I$      |
| 2.9800           | 2 49 In      | $L\gamma_{2,3}$ | 4.1605    | 3.3257           | 1 48 Cd      | $L_{II}$        | Abs. Edge         |
| 2.9823           | 1 50 Sn      | $L_{II}$        | Abs. Edge | 3.329            | 4 92 U       |                 | $M_{II}N_I$       |
| 2.9932           | 2 55 Cs      | $L\eta$         | 4.1421    | 3.333            | 5 92 U       | $M_{IV}$        | Abs. Edge         |
| 3.0003           | 1 51 Sb      | $L_{III}$       | Abs. Edge | 3.33564          | 6 48 Cd      | $L\gamma_1$     | $L_{II}N_{IV}$    |
| 3.00115          | 3 50 Sn      | $L\gamma_1$     | 4.13112   | 3.33838          | 3 49 In      | $L\beta_{2,15}$ | $L_{III}N_{IV,v}$ |
| 3.0052           | 3 51 Sb      | $L\beta_7$      | 4.1255    | 3.34335          | 9 50 Sn      | $L\beta_4$      | $L_I M_{II}$      |
| 3.006            | 3 57 La      | $L_I$           | 4.124     | 3.346            | 5 81 Tl      | $M_I$           | Abs. Edge         |
| 3.00893          | 9 52 Te      | $L\beta_3$      | 4.1204    | 3.35839          | 3 20 Ca      | $K\alpha_1$     | $KL_{III}$        |
| 3.011            | 2 90 Th      |                 | 4.117     | 3.359            | 5 83 Bi      | $M_{II}$        | Abs. Edge         |
| 3.0166           | 2 54 Xe      | $L\alpha_1$     | 4.1099    | 3.36166          | 3 20 Ca      | $K\alpha_2$     | $KL_{II}$         |
| 3.02335          | 3 51 Sb      | $L\beta_{2,15}$ | 4.10078   | 3.38487          | 3 50 Sn      | $L\beta_1$      | $L_{II}M_{IV}$    |
| 3.0309           | 1 21 Sc      | $K\alpha_1$     | 4.0906    | 3.42551          | 9 48 Cd      | $L\gamma_5$     | $L_{II}N_I$       |
| 3.0342           | 1 21 Sc      | $K\alpha_2$     | 4.0861    | 3.43015          | 9 48 Cd      | $L\beta_9$      | $L_I M_V$         |
| 3.038            | 2 91 Pa      |                 | 4.081     | 3.43606          | 9 49 In      | $L\beta_5$      | $L_{III}N_I$      |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. | Element | Designation               | keV                                              | Wavelength<br>Å* | p.e.    | Element | Designation             | keV                                            |                                                  |         |
|------------------|------|---------|---------------------------|--------------------------------------------------|------------------|---------|---------|-------------------------|------------------------------------------------|--------------------------------------------------|---------|
| 3.4365           | 1    | 19 K    | <i>K</i>                  | Abs. Edge                                        | 3.6078           | 4       | 49 In   | <i>L</i> <sub>α1</sub>  | <i>L</i> <sub>III</sub> <i>M</i> <sub>V</sub>  | 3.28694                                          |         |
| 3.4367           | 2    | 48 Cd   | <i>L</i> <sub>β10</sub>   | <i>L</i> <sub>I</sub> <i>M</i> <sub>IV</sub>     | 3.6075           | 6       | 49 In   | <i>L</i> <sub>α2</sub>  | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV</sub> | 3.27929                                          |         |
| 3.437            | 1    | 46 Pd   | <i>L</i> <sub>I</sub>     | Abs. Edge                                        | 3.607            | 5       | 80 Hg   | <i>M</i> <sub>II</sub>  | Abs. Edge                                      | 3.277                                            |         |
| 3.43832          | 9    | 52 Te   | <i>L</i> <sub>γ</sub>     | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>     | 3.60586          | 9       | 50 Sn   | <i>L</i> <sub>γ</sub>   | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>   | 3.27234                                          |         |
| 3.43941          | 4    | 51 Sb   | <i>L</i> <sub>α1</sub>    | <i>L</i> <sub>III</sub> <i>M</i> <sub>V</sub>    | 3.60472          | 2       | 46 Pd   | <i>L</i> <sub>β9</sub>  | <i>L</i> <sub>I</sub> <i>M</i> <sub>V</sub>    | 3.2696                                           |         |
| 3.441            | 5    | 91 Pa   |                           | <i>M</i> <sub>II</sub> <i>N</i> <sub>I</sub>     | 3.603            | 2       | 46 Pd   | <i>L</i> <sub>β10</sub> | <i>L</i> <sub>I</sub> <i>M</i> <sub>IV</sub>   | 3.2637                                           |         |
| 3.4413           | 4    | 19 K    | <i>K</i> <sub>β5</sub>    | <i>K</i> <i>M</i> <sub>IV,V</sub>                | 3.6027           | 9       | 47 Ag   | <i>L</i> <sub>β5</sub>  | <i>L</i> <sub>III</sub> <i>N</i> <sub>I</sub>  | 3.25603                                          |         |
| 3.44840          | 6    | 51 Sb   | <i>L</i> <sub>α2</sub>    | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV</sub>   | 3.59532          | 4       | 90 Th   |                         | <i>M</i> <sub>IV</sub> <i>O</i> <sub>II</sub>  | 3.256                                            |         |
| 3.4539           | 2    | 19 K    | <i>K</i> <sub>β1,3</sub>  | <i>K</i> <i>M</i> <sub>II,III</sub>              | 3.5896           | 3.808   | 2       | 46 Pd                   | <i>L</i> <sub>γ5</sub>                         | <i>L</i> <sub>II</sub> <i>N</i> <sub>I</sub>     | 3.2437  |
| 3.46984          | 9    | 49 In   | <i>L</i> <sub>β2</sub>    | <i>L</i> <sub>I</sub> <i>M</i> <sub>III</sub>    | 3.57311          | 3.827   | 1       | 91 Pa                   | <i>M</i> <sub>β</sub>                          | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 3.2397  |
| 3.478            | 5    | 80 Hg   | <i>M</i> <sub>I</sub>     | Abs. Edge                                        | 3.565            | 3.83313 | 9       | 47 Ag                   | <i>L</i> <sub>β2</sub>                         | <i>L</i> <sub>I</sub> <i>M</i> <sub>III</sub>    | 3.23446 |
| 3.479            | 1    | 92 U    | <i>M</i> <sub>γ</sub>     | <i>M</i> <sub>III</sub> <i>N</i> <sub>V</sub>    | 3.563            | 3.834   | 4       | 83 Bi                   |                                                | <i>M</i> <sub>II</sub> <i>N</i> <sub>IV</sub>    | 3.234   |
| 3.4892           | 2    | 46 Pd   | <i>L</i> <sub>γ2,3</sub>  | <i>L</i> <sub>I</sub> <i>N</i> <sub>II,III</sub> | 3.5533           | 3.835   | 5       | 44 Ru                   | <i>L</i> <sub>I</sub>                          | Abs. Edge                                        | 3.233   |
| 3.492            | 5    | 82 Pb   | <i>M</i> <sub>II</sub>    | Abs. Edge                                        | 3.550            | 3.87023 | 5       | 47 Ag                   | <i>L</i> <sub>β4</sub>                         | <i>L</i> <sub>I</sub> <i>M</i> <sub>II</sub>     | 3.20346 |
| 3.497            | 5    | 92 U    | <i>M</i> <sub>V</sub>     | Abs. Edge                                        | 3.545            | 3.87090 | 5       | 18 A                    | <i>K</i>                                       | Abs. Edge                                        | 3.20290 |
| 3.5047           | 1    | 48 Cd   | <i>L</i> <sub>III</sub>   | Abs. Edge                                        | 3.5376           | 3.872   | 9       | 82 Pb                   |                                                | <i>M</i> <sub>I</sub> <i>N</i> <sub>III</sub>    | 3.202   |
| 3.50697          | 9    | 49 In   | <i>L</i> <sub>β4</sub>    | <i>L</i> <sub>I</sub> <i>M</i> <sub>II</sub>     | 3.53528          | 3.8860  | 2       | 18 A                    | <i>K</i> <sub>β1,3</sub>                       | <i>K</i> <i>M</i> <sub>II,III</sub>              | 3.1905  |
| 3.51408          | 4    | 48 Cd   | <i>L</i> <sub>β2,15</sub> | <i>L</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 3.52812          | 3.88826 | 9       | 51 Sb                   | <i>L</i> <sub>I</sub>                          | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 3.18860 |
| 3.5164           | 1    | 47 Ag   | <i>L</i> <sub>II</sub>    | Abs. Edge                                        | 3.5258           | 3.892   | 9       | 83 Bi                   |                                                | <i>M</i> <sub>I</sub> <i>N</i> <sub>II</sub>     | 3.185   |
| 3.521            | 2    | 92 U    |                           | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV</sub>   | 3.521            | 3.8977  | 2       | 44 Ru                   | <i>L</i> <sub>γ2,3</sub>                       | <i>L</i> <sub>I</sub> <i>N</i> <sub>II,III</sub> | 3.1809  |
| 3.52260          | 4    | 47 Ag   | <i>L</i> <sub>γ1</sub>    | <i>L</i> <sub>II</sub> <i>N</i> <sub>IV</sub>    | 3.51959          | 3.904   | 5       | 83 Bi                   | <i>M</i> <sub>III</sub>                        | Abs. Edge                                        | 3.176   |
| 3.537            | 9    | 90 Th   |                           | <i>M</i> <sub>II</sub> <i>N</i> <sub>I</sub>     | 3.505            | 3.9074  | 1       | 46 Pd                   | <i>L</i> <sub>III</sub>                        | Abs. Edge                                        | 3.17298 |
| 3.55531          | 4    | 49 In   | <i>L</i> <sub>β1</sub>    | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 3.48721          | 3.90887 | 4       | 46 Pd                   | <i>L</i> <sub>β2,15</sub>                      | <i>L</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 3.17179 |
| 3.557            | 5    | 90 Th   | <i>M</i> <sub>IV</sub>    | Abs. Edge                                        | 3.485            | 3.910   | 1       | 92 U                    | <i>M</i> <sub>α1</sub>                         | <i>M</i> <sub>V</sub> <i>N</i> <sub>VII</sub>    | 3.1708  |
| 3.55754          | 9    | 53 I    | <i>L</i> <sub>I</sub>     | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 3.48502          | 3.915   | 5       | 77 Ir                   | <i>M</i> <sub>I</sub>                          | Abs. Edge                                        | 3.167   |
| 3.576            | 1    | 92 U    |                           | <i>M</i> <sub>IV</sub> <i>O</i> <sub>II</sub>    | 3.4666           | 3.924   | 1       | 92 U                    | <i>M</i> <sub>α2</sub>                         | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI</sub>     | 3.1595  |
| 3.577            | 1    | 91 Pa   | <i>M</i> <sub>γ</sub>     | <i>M</i> <sub>III</sub> <i>N</i> <sub>V</sub>    | 3.4657           | 3.932   | 6       | 83 Bi                   |                                                | <i>M</i> <sub>III</sub> <i>O</i> <sub>IV,V</sub> | 3.153   |
| 3.59994          | 3    | 50 Sn   | <i>L</i> <sub>α1</sub>    | <i>L</i> <sub>III</sub> <i>M</i> <sub>V</sub>    | 3.44398          | 3.93473 | 3       | 47 Ag                   | <i>L</i> <sub>β1</sub>                         | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 3.15094 |
| 3.60497          | 9    | 47 Ag   | <i>L</i> <sub>β9</sub>    | <i>L</i> <sub>I</sub> <i>M</i> <sub>V</sub>      | 3.43917          | 3.936   | 5       | 79 Au                   | <i>M</i> <sub>II</sub>                         | Abs. Edge                                        | 3.150   |
| 3.60765          | 9    | 51 Sb   | <i>L</i> <sub>γ</sub>     | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>     | 3.43661          | 3.941   | 1       | 90 Th                   | <i>M</i> <sub>β</sub>                          | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 3.1458  |
| 3.60891          | 4    | 50 Sn   | <i>L</i> <sub>α2</sub>    | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV</sub>   | 3.43542          | 3.9425  | 5       | 45 Rh                   | <i>L</i> <sub>II</sub>                         | Abs. Edge                                        | 3.1448  |
| 3.61158          | 9    | 47 Ag   | <i>L</i> <sub>β10</sub>   | <i>L</i> <sub>I</sub> <i>M</i> <sub>IV</sub>     | 3.43287          | 3.9437  | 2       | 45 Rh                   | <i>L</i> <sub>γ1</sub>                         | <i>L</i> <sub>II</sub> <i>N</i> <sub>IV</sub>    | 3.1438  |
| 3.614            | 2    | 91 Pa   |                           | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV</sub>   | 3.430            | 3.95635 | 4       | 48 Cd                   | <i>L</i> <sub>α1</sub>                         | <i>L</i> <sub>III</sub> <i>M</i> <sub>V</sub>    | 3.13373 |
| 3.61467          | 9    | 48 Cd   | <i>L</i> <sub>β5</sub>    | <i>L</i> <sub>III</sub> <i>N</i> <sub>I</sub>    | 3.42994          | 3.96496 | 6       | 48 Cd                   | <i>L</i> <sub>α2</sub>                         | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV</sub>   | 3.12691 |
| 3.61638          | 9    | 47 Ag   | <i>L</i> <sub>γ5</sub>    | <i>L</i> <sub>II</sub> <i>N</i> <sub>I</sub>     | 3.42832          | 3.968   | 5       | 82 Pb                   |                                                | <i>M</i> <sub>II</sub> <i>N</i> <sub>IV</sub>    | 3.124   |
| 3.616            | 5    | 79 Au   | <i>M</i> <sub>I</sub>     | Abs. Edge                                        | 3.428            | 3.98327 | 9       | 49 In                   | <i>L</i> <sub>γ</sub>                          | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>     | 3.11254 |
| 3.629            | 5    | 45 Rh   | <i>L</i> <sub>I</sub>     | Abs. Edge                                        | 3.417            | 4.013   | 9       | 81 Tl                   |                                                | <i>M</i> <sub>I</sub> <i>N</i> <sub>III</sub>    | 3.089   |
| 3.634            | 5    | 81 Tl   | <i>M</i> <sub>II</sub>    | Abs. Edge                                        | 3.412            | 4.0162  | 2       | 46 Pd                   | <i>L</i> <sub>β5</sub>                         | <i>L</i> <sub>III</sub> <i>N</i> <sub>I</sub>    | 3.0870  |
| 3.64495          | 9    | 48 Cd   | <i>L</i> <sub>β2</sub>    | <i>L</i> <sub>I</sub> <i>M</i> <sub>III</sub>    | 3.40145          | 4.022   | 1       | 91 Pa                   | <i>M</i> <sub>α1</sub>                         | <i>M</i> <sub>V</sub> <i>N</i> <sub>VII</sub>    | 3.0823  |
| 3.679            | 2    | 90 Th   | <i>M</i> <sub>γ</sub>     | <i>M</i> <sub>III</sub> <i>N</i> <sub>V</sub>    | 3.370            | 4.0346  | 2       | 46 Pd                   | <i>L</i> <sub>β2</sub>                         | <i>L</i> <sub>I</sub> <i>M</i> <sub>III</sub>    | 3.0730  |
| 3.68203          | 9    | 48 Cd   | <i>L</i> <sub>β4</sub>    | <i>L</i> <sub>I</sub> <i>M</i> <sub>II</sub>     | 3.36719          | 4.035   | 3       | 91 Pa                   | <i>M</i> <sub>α2</sub>                         | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI</sub>     | 3.072   |
| 3.6855           | 2    | 45 Rh   | <i>L</i> <sub>γ2,3</sub>  | <i>L</i> <sub>I</sub> <i>N</i> <sub>II,III</sub> | 3.3640           | 4.0451  | 2       | 45 Rh                   | <i>L</i> <sub>γ5</sub>                         | <i>L</i> <sub>II</sub> <i>N</i> <sub>I</sub>     | 3.0650  |
| 3.691            | 2    | 91 Pa   |                           | <i>M</i> <sub>IV</sub> <i>O</i> <sub>II</sub>    | 3.359            | 4.047   | 1       | 82 Pb                   | <i>M</i> <sub>III</sub>                        | Abs. Edge                                        | 3.0632  |
| 3.6999           | 1    | 47 Ag   | <i>L</i> <sub>III</sub>   | Abs. Edge                                        | 3.35096          | 4.058   | 5       | 43 Te                   | <i>L</i> <sub>I</sub>                          | Abs. Edge                                        | 3.055   |
| 3.70335          | 3    | 47 Ag   | <i>L</i> <sub>β2,15</sub> | <i>L</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 3.34781          | 4.069   | 6       | 82 Pb                   |                                                | <i>M</i> <sub>III</sub> <i>O</i> <sub>IV,V</sub> | 3.047   |
| 3.716            | 1    | 92 U    | <i>M</i> <sub>β</sub>     | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 3.3367           | 4.0711  | 2       | 46 Pd                   | <i>L</i> <sub>β4</sub>                         | <i>L</i> <sub>I</sub> <i>M</i> <sub>II</sub>     | 3.0454  |
| 3.71696          | 9    | 52 Te   | <i>L</i> <sub>I</sub>     | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 3.33555          | 4.071   | 5       | 76 Os                   | <i>M</i> <sub>I</sub>                          | Abs. Edge                                        | 3.045   |
| 3.718            | 3    | 90 Th   |                           | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV</sub>   | 3.335            | 4.07165 | 9       | 50 Sn                   | <i>L</i> <sub>I</sub>                          | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 3.04499 |
| 3.7228           | 1    | 46 Pd   | <i>L</i> <sub>II</sub>    | Abs. Edge                                        | 3.33031          | 4.093   | 5       | 78 Pt                   | <i>M</i> <sub>II</sub>                         | Abs. Edge                                        | 3.029   |
| 3.7246           | 2    | 46 Pd   | <i>L</i> <sub>γ1</sub>    | <i>L</i> <sub>II</sub> <i>N</i> <sub>IV</sub>    | 3.3287           | 4.105   | 9       | 83 Bi                   |                                                | <i>M</i> <sub>III</sub> <i>O</i> <sub>I</sub>    | 3.021   |
| 3.729            | 5    | 90 Th   | <i>M</i> <sub>V</sub>     | Abs. Edge                                        | 3.325            | 4.116   | 4       | 81 Tl                   |                                                | <i>M</i> <sub>II</sub> <i>N</i> <sub>IV</sub>    | 3.013   |
| 3.73823          | 4    | 48 Cd   | <i>L</i> <sub>β1</sub>    | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 3.31657          | 4.1299  | 5       | 45 Rh                   | <i>L</i> <sub>III</sub>                        | Abs. Edge                                        | 3.0021  |
| 3.740            | 9    | 83 Bi   |                           | <i>M</i> <sub>I</sub> <i>N</i> <sub>III</sub>    | 3.315            | 4.1310  | 2       | 45 Rh                   | <i>L</i> <sub>β2,15</sub>                      | <i>L</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 3.0013  |
| 3.7414           | 2    | 19 K    | <i>K</i> <sub>α1</sub>    | <i>K</i> <i>L</i> <sub>III</sub>                 | 3.3138           | 4.1381  | 9       | 90 Th                   | <i>M</i> <sub>α1</sub>                         | <i>M</i> <sub>V</sub> <i>N</i> <sub>VII</sub>    | 2.9961  |
| 3.7445           | 2    | 19 K    | <i>K</i> <sub>α2</sub>    | <i>K</i> <i>L</i> <sub>II</sub>                  | 3.3111           | 4.14622 | 5       | 46 Pd                   | <i>L</i> <sub>β1</sub>                         | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 2.99022 |
| 3.760            | 9    | 90 Th   |                           | <i>M</i> <sub>V</sub> <i>P</i> <sub>III</sub>    | 3.298            | 4.151   | 2       | 90 Th                   | <i>M</i> <sub>α2</sub>                         | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI</sub>     | 2.987   |
| 3.762            | 5    | 78 Pt   | <i>M</i> <sub>I</sub>     | Abs. Edge                                        | 3.296            | 4.15443 | 3       | 47 Ag                   | <i>L</i> <sub>α1</sub>                         | <i>L</i> <sub>III</sub> <i>M</i> <sub>V</sub>    | 2.98431 |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation        | keV     | Wavelength<br>Å* | p.e. Element | Designation       | keV     |
|------------------|--------------|--------------------|---------|------------------|--------------|-------------------|---------|
| 4.16294          | 5 47 Ag      | $L\alpha_2$        | 2.97821 | 4.6542           | 2 41 Nb      | $L\gamma_{2,3}$   | 2.6638  |
| 4.180            | 1 44 Ru      | $L_{II}$           | 2.9663  | 4.655            | 8 82 Pb      | $M_{II}N_I$       | 2.664   |
| 4.1822           | 2 44 Ru      | $L\gamma_1$        | 2.9645  | 4.6605           | 2 46 Pd      | $L\eta$           | 2.6603  |
| 4.19180          | 5 18 A       | $K\alpha_1$        | 2.95770 | 4.674            | 1 82 Pb      | $M\gamma$         | 2.6527  |
| 4.19315          | 9 48 Cd      | $L\eta$            | 2.95675 | 4.686            | 1 78 Pt      | $M_{III}$         | 2.6459  |
| 4.19474          | 5 18 A       | $K\alpha_2$        | 2.95563 | 4.694            | 8 78 Pt      | $M_{III}O_{IV,v}$ | 2.641   |
| 4.198            | 1 81 Tl      | $M_{III}$          | 2.9535  | 4.703            | 9 79 Au      | $M_{III}O_I$      | 2.636   |
| 4.216            | 6 81 Tl      | $M_{III}O_{IV,v}$  | 2.941   | 4.7076           | 2 47 Ag      | $L_I$             | 2.6337  |
| 4.236            | 5 75 Re      | $M_I$              | 2.927   | 4.715            | 3 82 Pb      | $M_{III}N_{IV}$   | 2.630   |
| 4.2417           | 2 45 Rh      | $L\beta_6$         | 2.9229  | 4.719            | 1 42 Mo      | $L_{II}$          | 2.6274  |
| 4.244            | 9 82 Pb      | $M_{III}O_I$       | 2.921   | 4.7258           | 2 42 Mo      | $L\gamma_1$       | 2.6235  |
| 4.2522           | 2 45 Rh      | $L\beta_5$         | 2.9157  | 4.7278           | 1 17 Cl      | $K\alpha_1$       | 2.62239 |
| 4.260            | 5 77 Ir      | $M_{II}$           | 2.910   | 4.7307           | 1 17 Cl      | $K\alpha_2$       | 2.62078 |
| 4.26873          | 9 49 In      | $L_I$              | 2.90440 | 4.757            | 5 82 Pb      | $M_{IV}$          | 2.606   |
| 4.2873           | 2 44 Ru      | $L\gamma_5$        | 2.8918  | 4.764            | 5 83 Bi      | $M_V$             | 2.603   |
| 4.2888           | 2 45 Rh      | $L\beta_4$         | 2.8908  | 4.780            | 4 77 Ir      | $M_{II}N_{IV}$    | 2.594   |
| 4.300            | 9 79 Au      | $M_I N_{III}$      | 2.883   | 4.79             | 2 76 Os      | $M_I N_{III}$     | 2.59    |
| 4.304            | 5 42 Mo      | $L_I$              | 2.881   | 4.815            | 5 74 W       | $M_{II}$          | 2.575   |
| 4.330            | 2 92 U       | $M_{III}N_I$       | 2.863   | 4.823            | 3 83 Bi      | $M_{IV}O_{II}$    | 2.571   |
| 4.355            | 1 80 Hg      | $M_{III}$          | 2.8469  | 4.823            | 4 81 Tl      | $M\gamma$         | 2.571   |
| 4.36767          | 5 46 Pd      | $L\alpha_1$        | 2.83861 | 4.8369           | 2 42 Mo      | $L\gamma_5$       | 2.5632  |
| 4.369            | 1 44 Ru      | $L_{III}$          | 2.8377  | 4.84575          | 5 44 Ru      | $L\alpha_1$       | 2.55855 |
| 4.3718           | 2 44 Ru      | $L\beta_{2,15}$    | 2.8360  | 4.85381          | 7 44 Ru      | $L\alpha_2$       | 2.55431 |
| 4.37414          | 4 45 Rh      | $L\beta_1$         | 2.83441 | 4.861            | 1 77 Ir      | $M_{III}$         | 2.5505  |
| 4.37588          | 7 46 Pd      | $L\alpha_2$        | 2.83329 | 4.865            | 5 81 Tl      | $M_{III}N_{IV}$   | 2.548   |
| 4.3800           | 2 42 Mo      | $L\gamma_{2,3}$    | 2.8306  | 4.869            | 9 77 Ir      | $M_{III}O_{IV,v}$ | 2.546   |
| 4.3971           | 1 17 Cl      | $K$                | 2.81960 | 4.876            | 9 78 Pt      | $M_{III}O_I$      | 2.543   |
| 4.4034           | 3 17 Cl      | $K\beta$           | 2.8156  | 4.879            | 5 40 Zr      | $L_I$             | 2.541   |
| 4.407            | 5 74 W       | $M_I$              | 2.813   | 4.8873           | 8 43 Tc      | $L\beta_1$        | 2.5368  |
| 4.4183           | 2 47 Ag      | $L\eta$            | 2.8061  | 4.909            | 1 83 Bi      | $M\beta$          | 2.5255  |
| 4.432            | 4 79 Au      | $M_{II}N_{IV}$     | 2.797   | 4.911            | 5 90 Th      | $M_{IV}N_{III}$   | 2.524   |
| 4.433            | 5 76 Os      | $M_{II}$           | 2.797   | 4.913            | 1 42 Mo      | $L_{III}$         | 2.5234  |
| 4.436            | 1 43 Te      | $L_{II}$           | 2.7948  | 4.9217           | 2 45 Rh      | $L\eta$           | 2.5191  |
| 4.44             | 2 74 W       | $M_I O_{II,III}$   | 2.79    | 4.9232           | 2 42 Mo      | $L\beta_{2,15}$   | 2.5183  |
| 4.450            | 4 91 Pa      | $M_{III}N_I$       | 2.786   | 4.946            | 2 92 U       | $M\zeta_1$        | 2.507   |
| 4.460            | 9 78 Pt      | $M_I N_{III}$      | 2.780   | 4.952            | 5 81 Tl      | $M_{IV}$          | 2.504   |
| 4.48014          | 9 48 Cd      | $L_I$              | 2.76735 | 4.9525           | 3 46 Pd      | $L_I$             | 2.5034  |
| 4.4866           | 3 44 Ru      | $L\beta_5$         | 2.7634  | 4.9536           | 3 40 Zr      | $L\gamma_{2,3}$   | 2.5029  |
| 4.4866           | 3 44 Ru      | $L\beta_6$         | 2.7634  | 4.955            | 4 76 Os      | $M_{II}N_{IV}$    | 2.502   |
| 4.518            | 1 79 Au      | $M_{III}$          | 2.7439  | 4.955            | 5 82 Pb      | $M_V$             | 2.502   |
| 4.522            | 6 79 Au      | $M_{III}O_{IV,v}$  | 2.742   | 4.984            | 2 80 Hg      | $M\gamma$         | 2.4875  |
| 4.5230           | 2 44 Ru      | $L\beta_4$         | 2.7411  | 5.004            | 9 82 Pb      | $M_{IV}O_{II}$    | 2.477   |
| 4.532            | 2 83 Bi      | $M\gamma$          | 2.735   | 5.0133           | 3 42 Mo      | $L\beta_3$        | 2.4730  |
| 4.568            | 5 90 Th      | $M_{III}N_I$       | 2.714   | 5.0185           | 1 16 S       | $K$               | 2.47048 |
| 4.571            | 5 83 Bi      | $M_{III}N_{IV}$    | 2.712   | 5.020            | 5 73 Ta      | $M_{II}$          | 2.470   |
| 4.572            | 5 83 Bi      | $M_{IV}$           | 2.711   | 5.0233           | 3 16 S       | $K\beta_x$        | 2.4681  |
| 4.575            | 5 41 Nb      | $L_I$              | 2.710   | 5.031            | 1 41 Nb      | $L_{II}$          | 2.4641  |
| 4.585            | 5 73 Ta      | $M_I$              | 2.704   | 5.0316           | 2 16 S       | $K\beta_1$        | 2.46404 |
| 4.59             | 2 83 Bi      | $M_{IV}P_{II,III}$ | 2.70    | 5.0361           | 3 41 Nb      | $L\gamma_1$       | 2.4618  |
| 4.59743          | 9 45 Rh      | $L\alpha_1$        | 2.69674 | 5.043            | 5 76 Os      | $M_{III}$         | 2.458   |
| 4.601            | 4 78 Pt      | $M_{II}N_{IV}$     | 2.695   | 5.0488           | 3 42 Mo      | $L\beta_4$        | 2.4557  |
| 4.60545          | 9 45 Rh      | $L\alpha_2$        | 2.69205 | 5.0488           | 5 42 Mo      | $L\beta_6$        | 2.4557  |
| 4.620            | 5 75 Re      | $M_{II}$           | 2.684   | 5.050            | 2 92 U       | $M\zeta_2$        | 2.4548  |
| 4.62058          | 3 44 Ru      | $L\beta_1$         | 2.68323 | 5.076            | 1 82 Pb      | $M\beta$          | 2.4427  |
| 4.625            | 5 92 U       | $M_{IV}N_{III}$    | 2.681   | 5.092            | 2 91 Pa      | $M\zeta_1$        | 2.4350  |
| 4.630            | 1 43 Tc      | $L_{III}$          | 2.6780  | 5.1148           | 3 43 Tc      | $L\alpha_1$       | 2.4240  |
| 4.631            | 9 77 Ir      | $M_I N_{III}$      | 2.677   | 5.118            | 1 83 Bi      | $M\alpha_1$       | 2.4226  |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength |      |         |                  |                   | Wavelength |        |         |             |                  |                   |         |
|------------|------|---------|------------------|-------------------|------------|--------|---------|-------------|------------------|-------------------|---------|
| Å*         | p.e. | Element | Designation      | keV               | Å*         | p.e.   | Element | Designation | keV              |                   |         |
| 5.130      | 2    | 83 Bi   | $M\alpha_2$      | $M_VN_{VI}$       | 2.4170     | 5.6445 | 3       | 38 Sr       | $L_{\gamma_2,3}$ | $L_I N_{II,III}$  | 2.1965  |
| 5.145      | 4    | 79 Au   | $M\gamma$        | $M_{III}N_V$      | 2.410      | 5.6476 | 9       | 80 Hg       | $M\alpha_1$      | $M_VN_{VII}$      | 2.1953  |
| 5.1517     | 3    | 41 Nb   | $L_{\gamma_5}$   | $L_{II}N_I$       | 2.4066     | 5.650  | 5       | 73 Ta       | $M_{III}$        | Abs. Edge         | 2.194   |
| 5.153      | 5    | 81 Tl   | $M_V$            | Abs. Edge         | 2.406      | 5.6681 | 3       | 40 Zr       | $L\beta_4$       | $L_I M_{II}$      | 2.1873  |
| 5.157      | 5    | 80 Hg   | $M_{IV}$         | Abs. Edge         | 2.404      | 5.67   | 3       | 73 Ta       |                  | $M_{III}O_{IV,V}$ | 2.19    |
| 5.168      | 9    | 82 Pb   |                  | $M_VO_{III}$      | 2.399      | 5.682  | 4       | 76 Os       | $M\gamma$        | $M_{III}N_V$      | 2.182   |
| 5.172      | 9    | 74 W    |                  | $M_I N_{III}$     | 2.397      | 5.704  | 8       | 82 Pb       |                  | $M_{III}N_I$      | 2.174   |
| 5.17708    | 8    | 42 Mo   | $L\beta_1$       | $L_{II}M_{IV}$    | 2.39481    | 5.7101 | 3       | 40 Zr       | $L\beta_6$       | $L_{III}N_I$      | 2.1712  |
| 5.186      | 5    | 79 Au   |                  | $M_{III}N_{IV}$   | 2.391      | 5.724  | 5       | 76 Os       |                  | $M_{III}N_{IV}$   | 2.166   |
| 5.193      | 2    | 91 Pa   | $M\zeta_2$       | $M_{IV}N_{II}$    | 2.3876     | 5.7243 | 2       | 41 Nb       | $L\alpha_1$      | $L_{III}M_V$      | 2.16589 |
| 5.196      | 9    | 81 Tl   |                  | $M_{IV}O_{II}$    | 2.386      | 5.7319 | 3       | 41 Nb       | $L\alpha_2$      | $L_{III}M_{IV}$   | 2.1630  |
| 5.2050     | 2    | 44 Ru   | $L\eta$          | $L_{II}M_I$       | 2.38197    | 5.756  | 1       | 39 Y        | $L_{II}$         | Abs. Edge         | 2.1540  |
| 5.217      | 5    | 39 Y    | $L_I$            | Abs. Edge         | 2.377      | 5.767  | 9       | 79 Au       |                  | $M_VO_{III}$      | 2.150   |
| 5.2169     | 3    | 45 Rh   | $L_I$            | $L_{III}M_I$      | 2.3765     | 5.784  | 1       | 15 P        | $K$              | Abs. Edge         | 2.1435  |
| 5.230      | 1    | 41 Nb   | $L_{III}$        | Abs. Edge         | 2.3706     | 5.796  | 2       | 15 P        | $K\beta$         | $KM$              | 2.1391  |
| 5.234      | 5    | 75 Re   | $M_{III}$        | Abs. Edge         | 2.369      | 5.81   | 2       | 76 Os       |                  | $M_{II}N_I$       | 2.133   |
| 5.2379     | 3    | 41 Nb   | $L\beta_{2,15}$  | $L_{III}N_{IV,V}$ | 2.3670     | 5.81   | 1       | 78 Pt       | $M_V$            | Abs. Edge         | 2.133   |
| 5.245      | 5    | 90 Th   | $M\zeta_1$       | $M_VN_{III}$      | 2.364      | 5.828  | 1       | 78 Pt       | $M\beta$         | $M_{IV}N_{VI}$    | 2.1273  |
| 5.249      | 1    | 81 Tl   | $M\beta$         | $M_{IV}N_{VI}$    | 2.3621     | 5.83   | 2       | 73 Ta       |                  | $M_{III}O_I$      | 2.126   |
| 5.2830     | 3    | 39 Y    | $L_{\gamma_2,3}$ | $L_I N_{II,III}$  | 2.3468     | 5.83   | 1       | 77 Ir       | $M_{IV}$         | Abs. Edge         | 2.126   |
| 5.286      | 1    | 82 Pb   | $M\alpha_1$      | $M_VN_{VII}$      | 2.3455     | 5.8360 | 3       | 40 Zr       | $L\beta_1$       | $L_{II}M_{IV}$    | 2.1244  |
| 5.299      | 2    | 82 Pb   | $M\alpha_2$      | $M_VN_{VI}$       | 2.3397     | 5.840  | 1       | 79 Au       | $M\alpha_1$      | $M_VN_{VII}$      | 2.1229  |
| 5.3102     | 3    | 41 Nb   | $L\beta_3$       | $L_I M_{III}$     | 2.3348     | 5.8475 | 3       | 42 Mo       | $L\eta$          | $L_{II}M_I$       | 2.1202  |
| 5.319      | 4    | 78 Pt   | $M\gamma$        | $M_{III}N_V$      | 2.331      | 5.854  | 3       | 79 Au       | $M\alpha_2$      | $M_VN_{VI}$       | 2.118   |
| 5.340      | 5    | 90 Th   | $M\zeta_2$       | $M_{IV}N_{II}$    | 2.322      | 5.8754 | 3       | 39 Y        | $L_{\gamma_5}$   | $L_{II}N_I$       | 2.1102  |
| 5.3455     | 3    | 41 Nb   | $L\beta_4$       | $L_I M_{II}$      | 2.3194     | 5.884  | 8       | 81 Tl       |                  | $M_{III}N_I$      | 2.107   |
| 5.357      | 4    | 74 W    |                  | $M_{II}N_{IV}$    | 2.314      | 5.885  | 2       | 75 Re       | $M\gamma$        | $M_{III}N_V$      | 2.1067  |
| 5.357      | 5    | 78 Pt   |                  | $M_{III}N_{IV}$   | 2.314      | 5.931  | 5       | 75 Re       |                  | $M_{III}N_{IV}$   | 2.090   |
| 5.36       | 1    | 80 Hg   | $M_V$            | Abs. Edge         | 2.313      | 5.962  | 1       | 39 Y        | $L_{III}$        | Abs. Edge         | 2.0794  |
| 5.3613     | 3    | 41 Nb   | $L\beta_6$       | $L_{III}N_I$      | 2.3125     | 5.9832 | 3       | 39 Y        | $L\beta_3$       | $L_I M_{III}$     | 2.0722  |
| 5.37216    | 7    | 16 S    | $K\alpha_1$      | $KL_{III}$        | 2.30784    | 5.987  | 9       | 78 Pt       |                  | $M_VO_{III}$      | 2.071   |
| 5.374      | 5    | 79 Au   | $M_{IV}$         | Abs. Edge         | 2.307      | 6.008  | 5       | 37 Rb       | $L_I$            | Abs. Edge         | 2.063   |
| 5.37496    | 8    | 16 S    | $K\alpha_2$      | $KL_{II}$         | 2.30664    | 6.0186 | 3       | 39 Y        | $L\beta_4$       | $L_I M_{II}$      | 2.0600  |
| 5.378      | 1    | 40 Zr   | $L_{II}$         | Abs. Edge         | 2.3053     | 6.038  | 1       | 77 Ir       | $M\beta$         | $M_{IV}N_{VI}$    | 2.0535  |
| 5.3843     | 3    | 40 Zr   | $L_{\gamma_1}$   | $L_{II}N_{IV}$    | 2.3027     | 6.0458 | 3       | 37 Rb       | $L_{\gamma_2,3}$ | $L_I N_{II,III}$  | 2.0507  |
| 5.40       | 2    | 73 Ta   |                  | $M_I N_{III}$     | 2.295      | 6.047  | 1       | 78 Pt       | $M\alpha_1$      | $M_VN_{VII}$      | 2.0505  |
| 5.40655    | 8    | 42 Mo   | $L\alpha_1$      | $L_{III}M_V$      | 2.29316    | 6.05   | 1       | 77 Ir       | $M_V$            | Abs. Edge         | 2.048   |
| 5.41437    | 8    | 42 Mo   | $L\alpha_2$      | $L_{III}M_{IV}$   | 2.28985    | 6.058  | 3       | 78 Pt       | $M\alpha_2$      | $M_VN_{VI}$       | 2.047   |
| 5.4318     | 9    | 80 Hg   | $M\beta$         | $M_{IV}N_{VI}$    | 2.2825     | 6.0705 | 2       | 40 Zr       | $L\alpha_1$      | $L_{III}M_V$      | 2.04236 |
| 5.435      | 1    | 74 W    | $M_{III}$        | Abs. Edge         | 2.2811     | 6.073  | 5       | 76 Os       | $M_{IV}$         | Abs. Edge         | 2.042   |
| 5.460      | 1    | 81 Tl   | $M\alpha_1$      | $M_VN_{VII}$      | 2.2706     | 6.0778 | 3       | 40 Zr       | $L\alpha_2$      | $L_{III}M_{IV}$   | 2.0399  |
| 5.472      | 2    | 81 Tl   | $M\alpha_2$      | $M_VN_{VI}$       | 2.2656     | 6.09   | 2       | 80 Hg       |                  | $M_{III}N_I$      | 2.036   |
| 5.4923     | 3    | 41 Nb   | $L\beta_1$       | $L_{II}M_{IV}$    | 2.2574     | 6.092  | 3       | 74 W        | $M\gamma$        | $M_{III}N_V$      | 2.035   |
| 5.4977     | 3    | 40 Zr   | $L_{\gamma_6}$   | $L_{II}N_I$       | 2.2551     | 6.0942 | 3       | 39 Y        | $L\beta_6$       | $L_{III}N_I$      | 2.0344  |
| 5.500      | 4    | 77 Ir   | $M\gamma$        | $M_{III}N_V$      | 2.254      | 6.134  | 4       | 74 W        |                  | $M_{III}N_{IV}$   | 2.021   |
| 5.5035     | 3    | 44 Ru   | $L_I$            | $L_{III}M_I$      | 2.2528     | 6.1508 | 3       | 42 Mo       | $L_I$            | $L_{III}M_I$      | 2.01568 |
| 5.537      | 8    | 83 Bi   |                  | $M_{III}N_I$      | 2.239      | 6.157  | 1       | 15 P        | $K\alpha_1$      | $KL_{III}$        | 2.0137  |
| 5.540      | 5    | 77 Ir   |                  | $M_{III}N_{IV}$   | 2.238      | 6.160  | 1       | 15 P        | $K\alpha_2$      | $KL_{II}$         | 2.0127  |
| 5.570      | 4    | 73 Ta   |                  | $M_{II}N_{IV}$    | 2.226      | 6.162  | 8       | 83 Bi       |                  | $M_{IV}N_{III}$   | 2.012   |
| 5.579      | 1    | 40 Zr   | $L_{III}$        | Abs. Edge         | 2.2225     | 6.173  | 1       | 38 Sr       | $L_{II}$         | Abs. Edge         | 2.0085  |
| 5.584      | 5    | 79 Au   | $M_V$            | Abs. Edge         | 2.220      | 6.2109 | 3       | 41 Nb       | $L\eta$          | $L_{II}M_I$       | 1.99620 |
| 5.5863     | 3    | 40 Zr   | $L\beta_{2,15}$  | $L_{III}N_{IV,V}$ | 2.2194     | 6.2120 | 3       | 39 Y        | $L\beta_1$       | $L_{II}M_{IV}$    | 1.99584 |
| 5.59       | 1    | 78 Pt   | $M_{IV}$         | Abs. Edge         | 2.217      | 6.259  | 9       | 79 Au       |                  | $M_{III}N_I$      | 1.981   |
| 5.592      | 5    | 38 Sr   | $L_I$            | Abs. Edge         | 2.217      | 6.262  | 1       | 77 Ir       | $M\alpha_1$      | $M_VN_{VII}$      | 1.9799  |
| 5.624      | 1    | 79 Au   | $M\beta$         | $M_{IV}N_{VI}$    | 2.2046     | 6.267  | 1       | 76 Os       | $M\beta$         | $M_{IV}N_{VI}$    | 1.9783  |
| 5.628      | 8    | 74 W    |                  | $M_{III}O_I$      | 2.203      | 6.275  | 3       | 77 Ir       | $M\alpha_2$      | $M_VN_{VI}$       | 1.9758  |
| 5.6330     | 3    | 40 Zr   | $L\beta_3$       | $L_I M_{III}$     | 2.2010     | 6.28   | 2       | 74 W        |                  | $M_{II}N_I$       | 1.973   |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation | keV     | Wavelength<br>Å* | p.e. Element | Designation     | keV     |
|------------------|--------------|-------------|---------|------------------|--------------|-----------------|---------|
| 6.2961           | 3 38 Sr      | $L\gamma_8$ | 1.96916 | 7.101            | 8 79 Au      | $M_{IV}N_{III}$ | 1.746   |
| 6.30             | 1 76 Os      | $M_V$       | 1.967   | 7.11             | 1 73 Ta      | $M_V$           | 1.743   |
| 6.312            | 4 73 Ta      | $M_\gamma$  | 1.964   | 7.12542          | 9 14 Si      | $K\alpha_1$     | 1.73998 |
| 6.33             | 1 75 Re      | $M_{IV}$    | 1.958   | 7.12791          | 9 14 Si      | $K\alpha_2$     | 1.73938 |
| 6.353            | 5 73 Ta      |             | 1.951   | 7.168            | 1 36 Kr      | $L_{II}$        | 1.7297  |
| 6.3672           | 3 38 Sr      | $L\beta_3$  | 1.94719 | 7.250            | 5 36 Kr      |                 | 1.710   |
| 6.384            | 7 82 Pb      |             | 1.942   | 7.252            | 1 73 Ta      | $M\alpha$       | 1.7096  |
| 6.387            | 1 38 Sr      | $L_{III}$   | 1.9411  | 7.264            | 5 36 Kr      | $L\beta_3$      | 1.707   |
| 6.4026           | 3 38 Sr      | $L\beta_4$  | 1.93643 | 7.279            | 5 36 Kr      | $L\gamma_8$     | 1.703   |
| 6.4488           | 2 39 Y       | $L\alpha_1$ | 1.92256 | 7.30             | 2 73 Ta      |                 | 1.700   |
| 6.455            | 9 78 Pt      |             | 1.921   | 7.303            | 1 72 Hf      | $M\beta$        | 1.6976  |
| 6.4558           | 3 39 Y       | $L\alpha_2$ | 1.92047 | 7.304            | 5 36 Kr      | $L\beta_4$      | 1.697   |
| 6.47             | 1 36 Kr      | $L_I$       | 1.915   | 7.3183           | 2 37 Rb      | $L\alpha_1$     | 1.69413 |
| 6.490            | 1 76 Os      | $M\alpha$   | 1.9102  | 7.3251           | 3 37 Rb      | $L\alpha_2$     | 1.69256 |
| 6.504            | 1 75 Re      | $M\beta$    | 1.9061  | 7.3563           | 3 39 Y       | $L_I$           | 1.68536 |
| 6.5176           | 3 41 Nb      | $L_I$       | 1.90225 | 7.360            | 8 74 W       |                 | 1.684   |
| 6.5191           | 3 38 Sr      | $L\beta_5$  | 1.90181 | 7.371            | 8 78 Pt      |                 | 1.682   |
| 6.521            | 4 83 Bi      | $M\zeta_1$  | 1.901   | 7.392            | 1 36 Kr      | $L_{III}$       | 1.6772  |
| 6.544            | 4 72 Hf      | $M_\gamma$  | 1.895   | 7.466            | 4 79 Au      | $M\zeta_1$      | 1.6605  |
| 6.560            | 5 75 Re      | $M_V$       | 1.890   | 7.503            | 1 34 Se      | $L_I$           | 1.6525  |
| 6.585            | 5 83 Bi      | $M\zeta_2$  | 1.883   | 7.510            | 4 36 Kr      | $L\beta_5$      | 1.6510  |
| 6.59             | 1 74 W       | $M_{IV}$    | 1.880   | 7.5171           | 3 38 Sr      | $L\eta$         | 1.64933 |
| 6.6069           | 3 40 Zr      | $L\eta$     | 1.87654 | 7.523            | 5 79 Au      | $M\zeta_2$      | 1.648   |
| 6.6239           | 3 38 Sr      | $L\beta_1$  | 1.87172 | 7.539            | 1 72 Hf      | $M\alpha$       | 1.6446  |
| 6.644            | 1 37 Rb      | $L_{II}$    | 1.8661  | 7.546            | 8 68 Er      | $M_\gamma$      | 1.643   |
| 6.669            | 9 77 Ir      |             | 1.859   | 7.576            | 3 36 Kr      | $L\beta_1$      | 1.6366  |
| 6.729            | 1 75 Re      | $M\alpha$   | 1.8425  | 7.60             | 1 68 Er      |                 | 1.632   |
| 6.738            | 1 14 Si      | $K$         | 1.8400  | 7.601            | 2 71 Lu      | $M\beta$        | 1.6312  |
| 6.740            | 3 82 Pb      | $M\zeta_1$  | 1.8395  | 7.612            | 9 73 Ta      |                 | 1.629   |
| 6.7530           | 1 14 Si      | $K\beta$    | 1.83594 | 7.645            | 8 77 Ir      |                 | 1.622   |
| 6.755            | 3 37 Rb      | $L\gamma_8$ | 1.83532 | 7.738            | 4 78 Pt      | $M\zeta_1$      | 1.6022  |
| 6.757            | 1 74 W       | $M\beta$    | 1.8349  | 7.753            | 5 35 Br      | $L_{II}$        | 1.599   |
| 6.768            | 6 71 Lu      | $M_\gamma$  | 1.832   | 7.767            | 9 35 Br      | $L\beta_{3,4}$  | 1.596   |
| 6.7876           | 3 37 Rb      | $L\beta_3$  | 1.82659 | 7.790            | 5 78 Pt      | $M\zeta_2$      | 1.592   |
| 6.802            | 5 82 Pb      | $M\zeta_2$  | 1.823   | 7.817            | 3 36 Kr      | $L\alpha_{1,2}$ | 1.5860  |
| 6.806            | 9 74 W       |             | 1.822   | 7.8362           | 3 38 Sr      | $L_I$           | 1.58215 |
| 6.8207           | 3 37 Rb      | $L\beta_4$  | 1.81771 | 7.840            | 2 71 Lu      | $M\alpha$       | 1.5813  |
| 6.83             | 1 74 W       | $M_V$       | 1.814   | 7.865            | 9 67 Ho      | $M_\gamma$      | 1.576   |
| 6.862            | 1 37 Rb      | $L_{III}$   | 1.8067  | 7.887            | 9 72 Hf      |                 | 1.572   |
| 6.8628           | 2 38 Sr      | $L\alpha_1$ | 1.80656 | 7.909            | 2 70 Yb      | $M\beta$        | 1.5675  |
| 6.8697           | 3 38 Sr      | $L\alpha_2$ | 1.80474 | 7.94813          | 5 13 Al      | $K$             | 1.55988 |
| 6.87             | 1 73 Ta      | $M_{IV}$    | 1.804   | 7.960            | 2 13 Al      | $K\beta$        | 1.55745 |
| 6.87             | 2 80 Hg      | $\delta$    | 1.805   | 7.984            | 5 35 Br      | $L_{III}$       | 1.5530  |
| 6.89             | 2 76 Os      |             | 1.798   | 8.021            | 4 77 Ir      | $M\zeta_1$      | 1.5458  |
| 6.9185           | 3 40 Zr      | $L_I$       | 1.79201 | 8.0415           | 4 37 Rb      | $L\eta$         | 1.54177 |
| 6.959            | 5 35 Br      | $L_I$       | 1.781   | 8.065            | 5 77 Ir      | $M\zeta_2$      | 1.5373  |
| 6.974            | 4 81 Tl      | $M\zeta_1$  | 1.778   | 8.107            | 1 33 As      | $L_I$           | 1.5293  |
| 6.983            | 1 74 W       | $M\alpha_1$ | 1.7754  | 8.1251           | 5 35 Br      | $L\beta_1$      | 1.52590 |
| 6.9842           | 3 37 Rb      | $L\beta_5$  | 1.77517 | 8.144            | 9 66 Dy      | $M_\gamma$      | 1.522   |
| 6.992            | 2 74 W       | $M\alpha_2$ | 1.7731  | 8.149            | 5 70 Yb      | $M\alpha$       | 1.5214  |
| 7.005            | 9 74 W       |             | 1.770   | 8.239            | 8 75 Re      |                 | 1.505   |
| 7.023            | 1 73 Ta      | $M\beta$    | 1.7655  | 8.249            | 7 69 Tm      | $M\beta$        | 1.503   |
| 7.024            | 8 70 Yb      | $M_\gamma$  | 1.765   | 8.310            | 4 76 Os      | $M\zeta_1$      | 1.4919  |
| 7.032            | 5 81 Tl      | $M\zeta_2$  | 1.763   | 8.321            | 9 34 Se      | $L\beta_{3,4}$  | 1.490   |
| 7.0406           | 3 39 Y       | $L\eta$     | 1.76095 | 8.33934          | 9 13 Al      | $K\alpha_1$     | 1.48670 |
| 7.0759           | 3 37 Rb      | $L\beta_1$  | 1.75217 | 8.34173          | 9 13 Al      | $K\alpha_2$     | 1.48627 |
| 7.09             | 2 73 Ta      |             | 1.748   | 8.359            | 5 76 Os      | $M\zeta_2$      | 1.4831  |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation               | keV                                              | Wavelength<br>Å* | p.e. Element | Designation | keV                       |                                                  |         |
|------------------|--------------|---------------------------|--------------------------------------------------|------------------|--------------|-------------|---------------------------|--------------------------------------------------|---------|
| 8.3636           | 4 37 Rb      | <i>L</i> <sub>I</sub>     | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 1.48238          | 10.254       | 6 64 Gd     | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 1.2091  |
| 8.3746           | 5 35 Br      | <i>L</i> α <sub>1,2</sub> | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV,V</sub> | 1.48043          | 10.294       | 1 34 Se     | <i>L</i> <sub>I</sub>     | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 1.2044  |
| 8.407            | 1 34 Se      | <i>L</i> <sub>II</sub>    | Abs. Edge                                        | 1.4747           | 10.359       | 9 31 Ga     | <i>L</i> β <sub>3,4</sub> | <i>L</i> <sub>I</sub> <i>M</i> <sub>II,III</sub> | 1.197   |
| 8.470            | 9 70 Yb      |                           | <i>M</i> <sub>III</sub> <i>N</i> <sub>I</sub>    | 1.464            | 10.40        | 7 92 U      |                           | <i>N</i> <sub>II</sub> <i>P</i> <sub>I</sub>     | 1.192   |
| 8.48             | 1 69 Tm      | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 1.462            | 10.4361      | 8 32 Ge     | <i>L</i> α <sub>1,2</sub> | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV,V</sub> | 1.18800 |
| 8.486            | 9 65 Tb      | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 1.461            | 10.46        | 3 64 Gd     | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 1.185   |
| 8.487            | 5 69 Tm      | <i>M</i> ν                | Abs. Edge                                        | 1.4609           | 10.48        | 1 70 Yb     | <i>M</i> ζ                | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 1.183   |
| 8.573            | 8 74 W       |                           | <i>M</i> <sub>IV</sub> <i>N</i> <sub>III</sub>   | 1.446            | 10.505       | 9 60 Nd     | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 1.180   |
| 8.592            | 3 68 Er      | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 1.4430           | 10.711       | 5 63 Eu     | <i>M</i> <sub>IV</sub>    | Abs. Edge                                        | 1.1575  |
| 8.60             | 7 92 U       |                           | <i>N</i> <sub>I</sub> <i>P</i> <sub>IV,V</sub>   | 1.44             | 10.734       | 1 33 As     | <i>L</i> η                | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>     | 1.1550  |
| 8.601            | 5 68 Er      | <i>M</i> <sub>IV</sub>    | Abs. Edge                                        | 1.4415           | 10.750       | 7 63 Eu     | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 1.1533  |
| 8.629            | 4 75 Re      | <i>M</i> ζ <sub>1</sub>   | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 1.4368           | 10.828       | 5 31 Ga     | <i>L</i> <sub>II</sub>    | Abs. Edge                                        | 1.1450  |
| 8.646            | 1 34 Se      | <i>L</i> <sub>III</sub>   | Abs. Edge                                        | 1.4340           | 10.96        | 3 63 Eu     | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 1.131   |
| 8.664            | 5 75 Re      | <i>M</i> ζ <sub>2</sub>   | <i>M</i> <sub>IV</sub> <i>N</i> <sub>II</sub>    | 1.4310           | 10.998       | 9 59 Pr     | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 1.1273  |
| 8.7358           | 5 34 Se      | <i>L</i> β <sub>1</sub>   | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 1.41923          | 11.013       | 5 63 Eu     | <i>M</i> ν                | Abs. Edge                                        | 1.1258  |
| 8.76             | 7 92 U       |                           | <i>N</i> <sub>I</sub> <i>P</i> <sub>III</sub>    | 1.42             | 11.023       | 2 31 Ga     | <i>L</i> β <sub>1</sub>   | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 1.1248  |
| 8.773            | 1 32 Ge      | <i>L</i> <sub>I</sub>     | Abs. Edge                                        | 1.4132           | 11.072       | 1 33 As     | <i>L</i> <sub>I</sub>     | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 1.1198  |
| 8.81             | 7 92 U       |                           | <i>N</i> <sub>I</sub> <i>P</i> <sub>II</sub>     | 1.41             | 11.07        | 7 90 Th     |                           | <i>N</i> <sub>II</sub> <i>P</i> <sub>I</sub>     | 1.120   |
| 8.82             | 1 68 Er      | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 1.406            | 11.100       | 1 31 Ga     | <i>L</i> <sub>III</sub>   | Abs. Edge                                        | 1.1169  |
| 8.844            | 9 64 Gd      | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 1.402            | 11.200       | 7 30 Zn     | <i>L</i> β <sub>3,4</sub> | <i>L</i> <sub>I</sub> <i>M</i> <sub>II,III</sub> | 1.1070  |
| 8.847            | 5 68 Er      | <i>M</i> ν                | Abs. Edge                                        | 1.4013           | 11.27        | 1 62 Sm     | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 1.0998  |
| 8.90             | 2 73 Ta      |                           | <i>M</i> <sub>IV</sub> <i>N</i> <sub>III</sub>   | 1.393            | 11.288       | 5 62 Sm     | <i>M</i> <sub>IV</sub>    | Abs. Edge                                        | 1.0983  |
| 8.929            | 1 33 As      | <i>L</i> β <sub>3,4</sub> | <i>L</i> <sub>I</sub> <i>M</i> <sub>II,III</sub> | 1.3884           | 11.292       | 1 31 Ga     | <i>L</i> α <sub>1,2</sub> | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV,V</sub> | 1.09792 |
| 8.962            | 4 74 W       | <i>M</i> ζ <sub>1</sub>   | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 1.3835           | 11.37        | 1 68 Er     | <i>M</i> ζ                | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 1.0901  |
| 8.965            | 4 67 Ho      | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 1.3830           | 11.47        | 3 62 Sm     | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 1.081   |
| 8.9900           | 5 34 Se      | <i>L</i> α <sub>1,2</sub> | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV,V</sub> | 1.37910          | 11.53        | 1 58 Ce     | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 1.0749  |
| 8.993            | 5 74 W       | <i>M</i> ζ <sub>2</sub>   | <i>M</i> <sub>IV</sub> <i>N</i> <sub>II</sub>    | 1.3787           | 11.552       | 5 62 Sm     | <i>M</i> ν                | Abs. Edge                                        | 1.0732  |
| 9.125            | 1 33 As      | <i>L</i> <sub>II</sub>    | Abs. Edge                                        | 1.3587           | 11.56        | 5 90 Th     |                           | <i>N</i> <sub>II</sub> <i>O</i> <sub>IV</sub>    | 1.072   |
| 9.20             | 2 67 Ho      | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 1.348            | 11.569       | 1 11 Na     | <i>K</i>                  | Abs. Edge                                        | 1.07167 |
| 9.211            | 9 63 Eu      | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 1.346            | 11.575       | 2 11 Na     | <i>K</i> β                | <i>K</i> <i>M</i>                                | 1.0711  |
| 9.255            | 1 35 Br      | <i>L</i> η                | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>     | 1.3396           | 11.609       | 2 32 Ge     | <i>L</i> η                | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>     | 1.0680  |
| 9.316            | 4 73 Ta      | <i>M</i> ζ <sub>1</sub>   | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 1.3308           | 11.862       | 1 30 Zn     | <i>L</i> <sub>II</sub>    | Abs. Edge                                        | 1.04523 |
| 9.330            | 5 73 Ta      | <i>M</i> ζ <sub>2</sub>   | <i>M</i> <sub>IV</sub> <i>N</i> <sub>II</sub>    | 1.3288           | 11.86        | 1 67 Ho     | <i>M</i> ζ                | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 1.0450  |
| 9.357            | 6 66 Dy      | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 1.3250           | 11.9101      | 9 11 Na     | <i>K</i> α <sub>1,2</sub> | <i>K</i> <i>L</i> <sub>II,III</sub>              | 1.04098 |
| 9.367            | 1 33 As      | <i>L</i> <sub>III</sub>   | Abs. Edge                                        | 1.3235           | 11.965       | 2 32 Ge     | <i>L</i> <sub>I</sub>     | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 1.0362  |
| 9.40             | 7 90 Th      |                           | <i>N</i> <sub>I</sub> <i>P</i> <sub>III</sub>    | 1.319            | 11.983       | 3 30 Zn     | <i>L</i> β <sub>1</sub>   | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 1.0347  |
| 9.4141           | 8 33 As      | <i>L</i> β <sub>1</sub>   | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 1.3170           | 12.08        | 4 57 La     | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 1.027   |
| 9.44             | 7 90 Th      |                           | <i>N</i> <sub>I</sub> <i>P</i> <sub>II</sub>     | 1.313            | 12.122       | 3 29 Cu     | <i>L</i> β <sub>3,4</sub> | <i>L</i> <sub>I</sub> <i>M</i> <sub>II,III</sub> | 1.0228  |
| 9.5122           | 1 12 Mg      | <i>K</i>                  | Abs. Edge                                        | 1.30339          | 12.131       | 1 30 Zn     | <i>L</i> <sub>III</sub>   | Abs. Edge                                        | 1.02201 |
| 9.517            | 5 31 Ga      | <i>L</i> <sub>I</sub>     | Abs. Edge                                        | 1.3028           | 12.254       | 3 30 Zn     | <i>L</i> α <sub>1,2</sub> | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV,V</sub> | 1.0117  |
| 9.521            | 2 12 Mg      | <i>K</i> β                | <i>K</i> <i>M</i>                                | 1.3022           | 12.43        | 2 66 Dy     | <i>M</i> ζ                | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 0.998   |
| 9.581            | 2 32 Ge      | <i>L</i> β <sub>3</sub>   | <i>L</i> <sub>I</sub> <i>M</i> <sub>III</sub>    | 1.2941           | 12.44        | 2 60 Nd     | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 0.997   |
| 9.585            | 1 35 Br      | <i>L</i> <sub>I</sub>     | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 1.2935           | 12.459       | 5 60 Nd     | <i>M</i> <sub>IV</sub>    | Abs. Edge                                        | 0.9951  |
| 9.59             | 2 66 Dy      | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 1.293            | 12.597       | 2 31 Ga     | <i>L</i> η                | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>     | 0.9842  |
| 9.600            | 9 62 Sm      | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 1.291            | 12.68        | 2 60 Nd     | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 0.978   |
| 9.640            | 2 32 Ge      | <i>L</i> β <sub>4</sub>   | <i>L</i> <sub>I</sub> <i>M</i> <sub>II</sub>     | 1.2861           | 12.737       | 5 60 Nd     | <i>M</i> ν                | Abs. Edge                                        | 0.9734  |
| 9.6709           | 8 33 As      | <i>L</i> α <sub>1,2</sub> | <i>L</i> <sub>III</sub> <i>M</i> <sub>IV,V</sub> | 1.2820           | 12.75        | 3 56 Ba     | <i>M</i> γ                | <i>M</i> <sub>III</sub> <i>N</i> <sub>IV,V</sub> | 0.973   |
| 9.686            | 7 72 Hf      | <i>M</i> ζ <sub>2</sub>   | <i>M</i> <sub>IV</sub> <i>N</i> <sub>II</sub>    | 1.2800           | 12.90        | 9 92 U      |                           | <i>N</i> <sub>III</sub> <i>O</i> <sub>V</sub>    | 0.961   |
| 9.686            | 7 72 Hf      | <i>M</i> ζ <sub>1</sub>   | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 1.2800           | 12.953       | 2 31 Ga     | <i>L</i> <sub>I</sub>     | <i>L</i> <sub>III</sub> <i>M</i> <sub>I</sub>    | 0.9572  |
| 9.792            | 6 65 Tb      | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 1.2661           | 12.98        | 2 65 Tb     | <i>M</i> ζ                | <i>M</i> <sub>V</sub> <i>N</i> <sub>III</sub>    | 0.955   |
| 9.8900           | 2 12 Mg      | <i>K</i> α <sub>1,2</sub> | <i>K</i> <i>L</i> <sub>II,III</sub>              | 1.25360          | 13.014       | 1 29 Cu     | <i>L</i> <sub>II</sub>    | Abs. Edge                                        | 0.95268 |
| 9.924            | 1 32 Ge      | <i>L</i> <sub>II</sub>    | Abs. Edge                                        | 1.2494           | 13.053       | 3 29 Cu     | <i>L</i> β <sub>1</sub>   | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 0.9498  |
| 9.962            | 1 34 Se      | <i>L</i> η                | <i>L</i> <sub>II</sub> <i>M</i> <sub>I</sub>     | 1.2446           | 13.06        | 2 59 Pr     | <i>M</i> β                | <i>M</i> <sub>IV</sub> <i>N</i> <sub>VI</sub>    | 0.950   |
| 10.00            | 2 65 Tb      | <i>M</i> α                | <i>M</i> <sub>V</sub> <i>N</i> <sub>VI,VII</sub> | 1.240            | 13.06        | 1 30 Zn     | <i>L</i> <sub>I</sub>     | Abs. Edge                                        | 0.9495  |
| 10.09            | 7 92 U       |                           | <i>N</i> <sub>I</sub> <i>O</i> <sub>III</sub>    | 1.229            | 13.122       | 5 59 Pr     | <i>M</i> <sub>IV</sub>    | Abs. Edge                                        | 0.9448  |
| 10.175           | 1 32 Ge      | <i>L</i> β <sub>1</sub>   | <i>L</i> <sub>II</sub> <i>M</i> <sub>IV</sub>    | 1.2185           | 13.18        | 2 28 Ni     | <i>L</i> β <sub>3,4</sub> | <i>L</i> <sub>I</sub> <i>M</i> <sub>II,III</sub> | 0.941   |
| 10.187           | 1 32 Ge      | <i>L</i> <sub>III</sub>   | Abs. Edge                                        | 1.2170           | 13.288       | 1 29 Cu     | <i>L</i> <sub>III</sub>   | Abs. Edge                                        | 0.93306 |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation      | keV       | Wavelength<br>Å* | p.e. Element | Designation      | keV       |
|------------------|--------------|------------------|-----------|------------------|--------------|------------------|-----------|
| 13.30            | 6 83 Bi      | $N_{II,III}$     | 0.932     | 18.8             | 2 47 Ag      | $M_{II,III}$     | 0.658     |
| 13.336           | 3 29 Cu      | $L_{\alpha 1,2}$ | 0.9297    | 18.96            | 4 24 Cr      | $L_{\beta 3,4}$  | 0.654     |
| 13.343           | 5 59 Pr      | $M_{\alpha}$     | 0.9292    | 19.11            | 2 25 Mn      | $L_{\beta 1}$    | 0.6488    |
| 13.394           | 5 59 Pr      | $M_{\gamma}$     | Abs. Edge | 19.1             | 1 52 Te      |                  | 0.648     |
| 13.57            | 2 64 Gd      | $M_{\zeta}$      | 0.914     | 19.40            | 7 48 Cd      |                  | 0.639     |
| 13.68            | 2 30 Zn      | $L_{\eta}$       | 0.906     | 19.44            | 5 57 La      | $M_{\zeta}$      | 0.638     |
| 13.75            | 4 58 Ce      | $M_{\beta}$      | 0.902     | 19.45            | 1 25 Mn      | $L_{\alpha 1,2}$ | 0.6374    |
| 13.8             | 1 90 Th      |                  | 0.897     | 19.66            | 5 53 I       | $M_{IV,v}$       | 0.631     |
| 14.02            | 2 30 Zn      | $L_I$            | 0.884     | 19.75            | 4 26 Fe      | $L_{\eta}$       | 0.628     |
| 14.04            | 2 58 Ce      | $M_{\alpha}$     | 0.883     | 20.0             | 1 50 Sn      |                  | 0.619     |
| 14.22            | 2 63 Eu      | $M_{\zeta}$      | 0.872     | 20.1             | 2 46 Pd      |                  | 0.616     |
| 14.242           | 5 28 Ni      | $L_{II}$         | Abs. Edge | 20.15            | 1 26 Fe      | $L_I$            | 0.6152    |
| 14.271           | 6 28 Ni      | $L_{\beta 1}$    | 0.8688    | 20.2             | 1 51 Sb      |                  | 0.612     |
| 14.3018          | 1 10 Ne      | $K$              | 0.866889  | 20.47            | 7 48 Cd      | $M_{\gamma}$     | 0.606     |
| 14.31            | 3 27 Co      | $L_{\beta 3,4}$  | 0.870     | 20.64            | 4 56 Ba      | $M_{\zeta}$      | 0.601     |
| 14.39            | 5 58 Ce      |                  | 0.862     | 20.66            | 7 47 Ag      |                  | 0.600     |
| 14.452           | 5 10 Ne      | $K_{\beta}$      | 0.8579    | 20.7             | 1 24 Cr      | $L_{III}$        | Abs. Edge |
| 14.51            | 5 57 La      | $M_{\beta}$      | 0.854     | 21.19            | 5 23 Va      | $L_{\beta 3,4}$  | 0.585     |
| 14.525           | 5 28 Ni      | $L_{III}$        | Abs. Edge | 21.27            | 1 24 Cr      | $L_{\beta 1}$    | 0.5828    |
| 14.561           | 3 28 Ni      | $L_{\alpha 1,2}$ | 0.8515    | 21.34            | 5 52 Te      |                  | 0.581     |
| 14.610           | 3 10 Ne      | $K_{\alpha 1,2}$ | 0.8486    | 21.5             | 1 50 Sn      |                  | 0.575     |
| 14.88            | 5 57 La      | $M_{\alpha}$     | 0.833     | 21.64            | 3 24 Cr      | $L_{\alpha 1,2}$ | 0.5728    |
| 14.90            | 2 29 Cu      | $L_{\eta}$       | 0.832     | 21.78            | 5 52 Te      |                  | 0.569     |
| 14.91            | 4 62 Sm      | $M_{\zeta}$      | 0.831     | 21.82            | 7 47 Ag      | $M_{\gamma}$     | 0.568     |
| 15.286           | 9 29 Cu      | $L_I$            | 0.8111    | 21.85            | 2 25 Mn      | $L_{\eta}$       | 0.5675    |
| 15.56            | 1 56 Ba      | $M_{IV}$         | Abs. Edge | 22.1             | 1 46 Pd      |                  | 0.560     |
| 15.618           | 5 27 Co      | $L_{II}$         | Abs. Edge | 22.29            | 1 25 Mn      | $L_I$            | 0.5563    |
| 15.65            | 4 26 Fe      | $L_{\beta 3,4}$  | 0.792     | 22.9             | 2 48 Cd      |                  | 0.540     |
| 15.666           | 8 27 Co      | $L_{\beta 1}$    | 0.7914    | 23.32            | 1 8 O        | $K$              | Abs. Edge |
| 15.72            | 9 56 Ba      |                  | 0.789     | 23.3             | 1 46 Pd      | $M_{\gamma}$     | 0.531     |
| 15.89            | 1 56 Ba      | $M_{\gamma}$     | Abs. Edge | 23.62            | 3 8 O        | $K_{\alpha}$     | 0.5249    |
| 15.91            | 5 56 Ba      | $M_{IV,III}$     | 0.779     | 23.88            | 4 23 Va      | $L_{\beta 1}$    | 0.5192    |
| 15.915           | 5 27 Co      | $L_{III}$        | Abs. Edge | 24.25            | 3 23 Va      | $L_{\alpha 1,2}$ | 0.5113    |
| 15.93            | 4 52 Te      | $M_{\gamma}$     | 0.778     | 24.28            | 5 50 Sn      | $M_{IV,v}$       | Abs. Edge |
| 15.972           | 6 27 Co      | $L_{\alpha 1,2}$ | 0.7762    | 24.30            | 3 24 Cr      | $L_{\eta}$       | 0.5102    |
| 15.98            | 5 51 Sb      |                  | 0.776     | 24.4             | 2 47 Ag      |                  | 0.509     |
| 16.20            | 5 56 Ba      |                  | 0.765     | 24.5             | 1 48 Cd      |                  | 0.507     |
| 16.27            | 3 28 Ni      | $L_{\eta}$       | 0.762     | 24.78            | 1 24 Cr      | $L_I$            | 0.5003    |
| 16.46            | 4 60 Nd      | $M_{\zeta}$      | 0.753     | 25.01            | 9 45 Rh      | $M_{\gamma}$     | 0.496     |
| 16.693           | 9 28 Ni      | $L_I$            | 0.7427    | 25.3             | 1 50 Sn      |                  | 0.491     |
| 16.7             | 1 24 Cr      | $L_I$            | Abs. Edge | 25.50            | 9 44 Ru      |                  | 0.486     |
| 16.92            | 4 51 Sb      | $M_{\gamma}$     | 0.733     | 25.7             | 1 50 Sn      |                  | 0.483     |
| 16.93            | 5 50 Sn      |                  | 0.733     | 26.0             | 1 47 Ag      |                  | 0.478     |
| 17.19            | 4 25 Mn      | $L_{\beta 3,4}$  | 0.721     | 26.2             | 2 46 Pd      |                  | 0.474     |
| 17.202           | 5 26 Fe      | $L_{II}$         | Abs. Edge | 26.72            | 9 52 Te      | $M_{\zeta}$      | 0.464     |
| 17.26            | 1 26 Fe      | $L_{\beta 1}$    | 0.7185    | 26.9             | 1 44 Ru      | $M_{\gamma}$     | 0.462     |
| 17.38            | 4 59 Pr      | $M_{\zeta}$      | 0.714     | 27.05            | 2 22 Ti      | $L_{\beta 1}$    | 0.4584    |
| 17.525           | 5 26 Fe      | $L_{III}$        | Abs. Edge | 27.29            | 1 22 Ti      | $L_{II,III}$     | Abs. Edge |
| 17.59            | 2 26 Fe      | $L_{\alpha 1,2}$ | 0.7050    | 27.34            | 3 23 Va      | $L_{\eta}$       | 0.4535    |
| 17.6             | 1 52 Te      |                  | 0.703     | 27.42            | 2 22 Ti      | $L_{\alpha 1,2}$ | 0.4522    |
| 17.87            | 3 27 Co      | $L_{\eta}$       | 0.694     | 27.77            | 1 23 Va      | $L_I$            | 0.4465    |
| 17.94            | 5 50 Sn      | $M_{\gamma}$     | 0.691     | 27.9             | 1 46 Pd      |                  | 0.445     |
| 17.9             | 1 24 Cr      | $L_{II}$         | Abs. Edge | 28.1             | 2 45 Rh      |                  | 0.442     |
| 18.292           | 8 27 Co      | $L_I$            | 0.6778    | 28.13            | 5 48 Cd      | $M_{IV,v}$       | Abs. Edge |
| 18.32            | 2 9 F        | $K_{\alpha}$     | 0.6768    | 28.88            | 8 51 Sb      | $M_{\zeta}$      | 0.429     |
| 18.35            | 4 58 Ce      | $M_{\zeta}$      | 0.676     | 29.8             | 1 45 Rh      |                  | 0.417     |
| 18.8             | 1 51 Sb      |                  | 0.658     | 30.4             | 1 48 Cd      |                  | 0.408     |

*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation                                                  | keV     | Wavelength<br>Å* | p.e. Element | Designation                        | keV    |
|------------------|--------------|--------------------------------------------------------------|---------|------------------|--------------|------------------------------------|--------|
| 30.8             | 1 48 Cd      | $M_{\text{V}}O_{\text{III}}$                                 | 0.403   | 49.4             | 1 79 Au      | $N_{\text{V}}N_{\text{VI,VII}}$    | 0.2510 |
| 30.82            | 5 47 Ag      | $M_{\text{IV}}$ Abs. Edge                                    | 0.4022  | 49.5             | 1 90 Th      | $N_{\text{VI}}O_{\text{IV}}$       | 0.2505 |
| 30.89            | 3 22 Ti      | $L_{\text{II}}M_{\text{I}}$                                  | 0.4013  | 50.0             | 1 90 Th      | $N_{\text{VII}}O_{\text{V}}$       | 0.2479 |
| 30.99            | 1 7 N        | $K$ Abs. Edge                                                | 0.4000  | 50.2             | 1 77 Ir      | $N_{\text{IV}}N_{\text{VI}}$       | 0.2470 |
| 31.02            | 2 21 Sc      | $L_{\text{II}}M_{\text{IV}}$                                 | 0.3996  | 50.3             | 1 52 Te      | $M_{\text{III}}M_{\text{V}}$       | 0.2465 |
| 31.14            | 5 47 Ag      | $M_{\text{V}}$ Abs. Edge                                     | 0.3981  | 50.9             | 1 78 Pt      | $N_{\text{V}}N_{\text{VI,VII}}$    | 0.2436 |
| 31.24            | 9 50 Sn      | $M_{\text{I}}^{\text{Z}}$ $M_{\text{IV,V}}N_{\text{II,III}}$ | 0.397   | 51.3             | 1 38 Sr      | $M_{\text{II}}N_{\text{I}}$        | 0.2416 |
| 31.35            | 3 21 Sc      | $L_{\text{III}}M_{\text{IV,V}}$                              | 0.3954  | 51.9             | 1 76 Os      | $N_{\text{IV}}N_{\text{VI}}$       | 0.2388 |
| 31.36            | 2 22 Ti      | $L_{\text{II}}M_{\text{I}}$                                  | 0.3953  | 52.0             | 2 48 Cd      | $M_{\text{II}}M_{\text{IV}}$       | 0.2384 |
| 31.60            | 4 7 N        | $K\alpha$ $KL$                                               | 0.3924  | 52.2             | 1 51 Sb      | $M_{\text{III}}M_{\text{V}}$       | 0.2375 |
| 31.8             | 1 92 U       | $N_{\text{IV}}N_{\text{VI}}$                                 | 0.390   | 52.34            | 7 44 Ru      | $M_{\text{IV,V}}N_{\text{II,III}}$ | 0.2369 |
| 32.3             | 2 44 Ru      | $M_{\text{II}}N_{\text{I}}$                                  | 0.384   | 52.8             | 1 77 Ir      | $N_{\text{V}}N_{\text{VI,VII}}$    | 0.2348 |
| 33.1             | 2 41 Nb      | $M_{\text{II}}N_{\text{IV}}$                                 | 0.375   | 53.6             | 1 38 Sr      | $M_{\text{III}}N_{\text{I}}$       | 0.2313 |
| 33.5             | 3 47 Ag      | $M_{\text{IV,V}}O_{\text{II,III}}$                           | 0.370   | 54.0             | 2 74 W       | $N_{\text{II}}N_{\text{IV}}$       | 0.2295 |
| 33.57            | 9 90 Th      | $N_{\text{IV}}N_{\text{VI}}$                                 | 0.3693  | 54.0             | 1 47 Ag      | $M_{\text{II}}M_{\text{IV}}$       | 0.2295 |
| 34.8             | 1 92 U       | $N_{\text{V}}N_{\text{VI,VII}}$                              | 0.357   | 54.2             | 1 50 Sn      | $M_{\text{III}}M_{\text{V}}$       | 0.2287 |
| 34.9             | 2 41 Nb      | $M_{\text{III}}N_{\text{IV,V}}$                              | 0.356   | 54.7             | 2 76 Os      | $N_{\text{V}}N_{\text{VI,VII}}$    | 0.2266 |
| 35.13            | 2 21 Sc      | $L_{\text{II}}M_{\text{I}}$                                  | 0.3529  | 54.8             | 2 42 Mo      | $M_{\text{IV,V}}O_{\text{II,III}}$ | 0.2262 |
| 35.13            | 1 20 Ca      | $L_{\text{II}}$ Abs. Edge                                    | 0.3529  | 55.8             | 1 74 W       | $N_{\text{IV}}N_{\text{VI}}$       | 0.2221 |
| 35.3             | 3 42 Mo      | $M_{\text{II}}N_{\text{I}}$                                  | 0.351   | 55.9             | 1 18 A       | $L_{\text{II}}M_{\text{I}}$        | 0.2217 |
| 35.49            | 1 20 Ca      | $L_{\text{III}}$ Abs. Edge                                   | 0.34931 | 56.3             | 1 18 A       | $L_{\text{III}}M_{\text{I}}$       | 0.2201 |
| 35.59            | 3 21 Sc      | $L_{\text{II}}M_{\text{I}}$                                  | 0.3483  | 56.5             | 1 46 Pd      | $M_{\text{II}}M_{\text{IV}}$       | 0.2194 |
| 35.63            | 1 20 Ca      | $L_{\text{II,III}}$ Abs. Edge                                | 0.34793 | 57.0             | 2 37 Rb      | $M_{\text{II}}N_{\text{I}}$        | 0.2174 |
| 35.94            | 2 20 Ca      | $L_{\text{II}}M_{\text{IV}}$                                 | 0.3449  | 58.2             | 1 73 Ta      | $N_{\text{IV}}N_{\text{VI}}$       | 0.2130 |
| 36.32            | 9 90 Th      | $N_{\text{V}}N_{\text{VI,VII}}$                              | 0.3414  | 58.4             | 1 74 W       | $N_{\text{V}}N_{\text{VII}}$       | 0.2122 |
| 36.33            | 2 20 Ca      | $L_{\text{III}}M_{\text{IV,V}}$                              | 0.3413  | 58.7             | 2 48 Cd      | $M_{\text{III}}M_{\text{V}}$       | 0.2111 |
| 36.8             | 1 48 Cd      | $M_{\text{I}}^{\text{Z}}$ $M_{\text{IV,V}}N_{\text{II,III}}$ | 0.3371  | 59.3             | 1 45 Rh      | $M_{\text{II}}M_{\text{IV}}$       | 0.2090 |
| 37.4             | 2 46 Pd      | $M_{\text{IV,V}}O_{\text{II,III}}$                           | 0.332   | 59.5             | 3 74 W       | $N_{\text{V}}N_{\text{VI}}$        | 0.208  |
| 37.5             | 2 42 Mo      | $M_{\text{III}}N_{\text{I}}$                                 | 0.331   | 59.5             | 2 37 Rb      | $M_{\text{III}}N_{\text{I}}$       | 0.2083 |
| 38.4             | 3 41 Nb      | $M_{\text{II}}N_{\text{I}}$                                  | 0.323   | 60.5             | 1 47 Ag      | $M_{\text{III}}M_{\text{V}}$       | 0.2048 |
| 39.77            | 7 47 Ag      | $M_{\text{I}}^{\text{Z}}$ $M_{\text{IV,V}}N_{\text{II,III}}$ | 0.3117  | 61.1             | 2 73 Ta      | $N_{\text{V}}N_{\text{VI,VII}}$    | 0.2028 |
| 40.46            | 2 20 Ca      | $L_{\text{II}}M_{\text{I}}$                                  | 0.3064  | 61.9             | 2 41 Nb      | $M_{\text{IV,V}}O_{\text{II,III}}$ | 0.2002 |
| 40.7             | 2 41 Nb      | $M_{\text{III}}N_{\text{I}}$                                 | 0.305   | 62.2             | 1 44 Ru      | $M_{\text{II}}M_{\text{IV}}$       | 0.1992 |
| 40.9             | 2 45 Rh      | $M_{\text{IV,V}}O_{\text{II,III}}$                           | 0.303   | 62.9             | 1 46 Pd      | $M_{\text{III}}M_{\text{V}}$       | 0.1970 |
| 40.96            | 2 20 Ca      | $L_{\text{II}}M_{\text{I}}$                                  | 0.3027  | 63.0             | 5 71 Lu      | $N_{\text{IV}}N_{\text{VI}}$       | 0.197  |
| 42.1             | 2 92 U       | $N_{\text{VI}}O_{\text{V}}$                                  | 0.295   | 64.38            | 7 42 Mo      | $M_{\text{IV,V}}N_{\text{II,III}}$ | 0.1926 |
| 42.1             | 1 19 K       | $L_{\text{II,III}}$ Abs. Edge                                | 0.2946  | 65.1             | 7 70 Yb      | $N_{\text{IV}}N_{\text{VI}}$       | 0.190  |
| 42.3             | 2 82 Pb      | $N_{\text{IV}}N_{\text{VI}}$                                 | 0.293   | 65.5             | 1 45 Rh      | $M_{\text{III}}M_{\text{V}}$       | 0.1892 |
| 43.3             | 2 92 U       | $N_{\text{VI}}O_{\text{IV}}$                                 | 0.286   | 65.7             | 2 71 Lu      | $N_{\text{V}}N_{\text{VI,VII}}$    | 0.1886 |
| 43.6             | 1 46 Pd      | $M_{\text{I}}^{\text{Z}}$ $M_{\text{IV,V}}N_{\text{II,III}}$ | 0.2844  | 67.33            | 9 17 Cl      | $L_{\text{II}}M_{\text{I}}$        | 0.1841 |
| 43.68            | 1 6 C        | $K$ Abs. Edge                                                | 0.28384 | 67.6             | 3 5 B        | $KL$                               | 0.1833 |
| 44.7             | 3 6 C        | $K\alpha$ $KL$                                               | 0.277   | 67.90            | 9 17 Cl      | $L_{\text{III}}M_{\text{I}}$       | 0.1826 |
| 44.8             | 1 44 Ru      | $M_{\text{IV,V}}O_{\text{II,III}}$                           | 0.2768  | 68.2             | 3 90 Th      | $O_{\text{III}}P_{\text{IV,V}}$    | 0.1817 |
| 45.0             | 1 82 Pb      | $N_{\text{V}}N_{\text{VI,VII}}$                              | 0.2756  | 68.3             | 1 44 Ru      | $M_{\text{III}}M_{\text{V}}$       | 0.1814 |
| 45.2             | 3 80 Hg      | $N_{\text{IV}}N_{\text{VI}}$                                 | 0.274   | 68.9             | 2 42 Mo      | $M_{\text{II}}M_{\text{IV}}$       | 0.1798 |
| 45.2             | 1 51 Sb      | $M_{\text{II}}M_{\text{IV}}$                                 | 0.2743  | 69.3             | 5 70 Yb      | $N_{\text{V}}N_{\text{VI,VII}}$    | 0.179  |
| 46.48            | 9 39 Y       | $M_{\text{II}}N_{\text{I}}$                                  | 0.267   | 70.0             | 4 40 Zr      | $M_{\text{IV,V}}O_{\text{II,III}}$ | 0.177  |
| 46.5             | 2 81 Tl      | $N_{\text{V}}N_{\text{VI,VII}}$                              | 0.267   | 72.1             | 3 41 Nb      | $M_{\text{II}}M_{\text{IV}}$       | 0.1718 |
| 46.8             | 2 79 Au      | $N_{\text{IV}}N_{\text{VI}}$                                 | 0.265   | 72.19            | 9 41 Nb      | $M_{\text{IV,V}}N_{\text{II,III}}$ | 0.1717 |
| 47.24            | 2 19 K       | $L_{\text{II}}M_{\text{I}}$                                  | 0.2625  | 72.7             | 9 68 Er      | $N_{\text{IV}}N_{\text{VI}}$       | 0.171  |
| 47.3             | 1 50 Sn      | $M_{\text{II}}M_{\text{IV}}$                                 | 0.2621  | 74.9             | 1 42 Mo      | $M_{\text{III}}M_{\text{V}}$       | 0.1656 |
| 47.67            | 9 45 Rh      | $M_{\text{IV,V}}N_{\text{II,III}}$                           | 0.2601  | 76.3             | 7 68 Er      | $N_{\text{V}}N_{\text{VI,VII}}$    | 0.163  |
| 47.74            | 1 19 K       | $L_{\text{III}}M_{\text{I}}$                                 | 0.25971 | 76.7             | 2 40 Zr      | $M_{\text{II}}M_{\text{IV}}$       | 0.1617 |
| 47.9             | 3 80 Hg      | $N_{\text{V}}N_{\text{VI,VII}}$                              | 0.259   | 76.9             | 2 35 Br      | $M_{\text{II}}N_{\text{I}}$        | 0.1613 |
| 48.1             | 2 78 Pt      | $N_{\text{IV}}N_{\text{VI}}$                                 | 0.258   | 78.4             | 2 41 Nb      | $M_{\text{III}}M_{\text{V}}$       | 0.1582 |
| 48.2             | 1 90 Th      | $N_{\text{VI}}O_{\text{V}}$                                  | 0.2572  | 79.8             | 3 35 Br      | $M_{\text{III}}N_{\text{I}}$       | 0.1554 |
| 48.5             | 2 39 Y       | $M_{\text{III}}N_{\text{I}}$                                 | 0.256   | 80.9             | 3 40 Zr      | $M_{\text{III}}M_{\text{V}}$       | 0.1533 |



*X-Ray Wavelengths*  
TABLE B (Continued)

| Wavelength<br>Å* | p.e. Element | Designation          | keV     | Wavelength<br>Å* | p.e. Element | Designation            | keV     |
|------------------|--------------|----------------------|---------|------------------|--------------|------------------------|---------|
| 81.5             | 2 39 Y       | $M_{II}M_{IV}$       | 0.1522  | 157.             | 3 30 Zn      | $M_{II,III}M_{IV,V}$   | 0.079   |
| 82.1             | 2 40 Zr      | $M_{IV,V}N_{II,III}$ | 0.1511  | 159.0            | 2 56 Ba      | $N_{IV}O_{III}$        | 0.07796 |
| 83.              | 1 66 Dy      | $N_{IV,V}N_{VI,VII}$ | 0.149   | 159.5            | 5 29 Cu      | $M_{II}$ Abs. Edge     | 0.0777  |
| 83.4             | 3 16 S       | $L_{II,III}M_I$      | 0.1487  | 163.3            | 2 56 Ba      | $N_{IV}O_{II}$         | 0.07590 |
| 85.7             | 2 38 Sr      | $M_{II}M_{IV}$       | 0.1447  | 164.6            | 2 56 Ba      | $N_VO_{III}$           | 0.07530 |
| 86.              | 1 65 Tb      | $N_{IV,V}N_{VI,VII}$ | 0.144   | 164.7            | 3 35 Br      | $M_I M_{III}$          | 0.0753  |
| 86.5             | 2 39 Y       | $M_{III}M_{IV,V}$    | 0.1434  | 166.0            | 5 29 Cu      | $M_{III}$ Abs. Edge    | 0.0747  |
| 91.4             | 2 38 Sr      | $M_{III}M_{IV,V}$    | 0.1357  | 170.4            | 1 13 Al      | $L_{II,III}$ Abs. Edge | 0.07278 |
| 91.5             | 2 37 Rb      | $M_{II}M_{IV}$       | 0.1355  | 171.4            | 5 13 Al      | $L_{II,III}M$          | 0.0724  |
| 91.6             | 1 83 Bi      | $N_{VI}O_{IV}$       | 0.1354  | 173.             | 3 29 Cu      | $M_{II,III}M_{IV,V}$   | 0.072   |
| 93.2             | 1 83 Bi      | $N_{VII}O_V$         | 0.1330  | 181.             | 5 90 Th      | $O_{IV,V}O_{II,III}$   | 0.068   |
| 93.4             | 2 39 Y       | $M_{IV,V}N_{II,III}$ | 0.1328  | 183.8            | 1 55 Cs      | $N_{IV}O_{III}$        | 0.06746 |
| 94.              | 1 15 P       | Abs. Edge            | 0.132   | 184.6            | 3 35 Br      | $M_I M_{II}$           | 0.0672  |
| 96.7             | 2 37 Rb      | $M_{III}M_{IV,V}$    | 0.1282  | 188.4            | 1 28 Ni      | Abs. Edge              | 0.06581 |
| 97.2             | 8 66 Dy      | $N_{IV,V}O_{II,III}$ | 0.128   | 188.6            | 1 55 Cs      | $N_{IV}O_{II}$         | 0.06574 |
| 98.              | 1 62 Sm      | $N_{IV,V}N_{VI,VII}$ | 0.126   | 189.5            | 3 35 Br      | $M_{IV}N_{III}$        | 0.0654  |
| 100.2            | 2 82 Pb      | $N_{VI}O_V$          | 0.1237  | 190.3            | 1 55 Cs      | $N_VO_{III}$           | 0.06515 |
| 102.2            | 4 65 Tb      | $N_{IV,V}O_{II,III}$ | 0.1213  | 190.             | 2 28 Ni      | $M_{II,III}M_{IV,V}$   | 0.0651  |
| 102.4            | 1 82 Pb      | $N_{VI}O_{IV}$       | 0.1211  | 191.1            | 2 35 Br      | $M_{IV}N_{II}$         | 0.06488 |
| 103.8            | 4 15 P       | $L_{II,III}M$        | 0.1194  | 192.6            | 2 35 Br      | $M_{VI}$               | 0.06437 |
| 104.3            | 1 82 Pb      | $N_{VII}O_V$         | 0.1189  | 197.3            | 1 12 Mg      | $L_I$ Abs. Edge        | 0.06284 |
| 107.             | 1 60 Nd      | $N_{IV,V}N_{VI,VII}$ | 0.116   | 202.             | 5 27 Co      | Abs. Edge              | 0.061   |
| 108.0            | 2 38 Sr      | $M_{IV}N_{II,III}$   | 0.1148  | 203.             | 1 16 S       | $L_I L_{II,III}$       | 0.061   |
| 108.7            | 1 38 Sr      | $M_V N_{III}$        | 0.1140  | 214.             | 6 27 Co      | $M_{II,III}M_{IV,V}$   | 0.058   |
| 109.4            | 3 35 Br      | $M_{II}M_{IV}$       | 0.1133  | 224.             | 1 53 I       | $N_{IV,V}$ Abs. Edge   | 0.0552  |
| 110.6            | 5 29 Cu      | Abs. Edge            | 0.1121  | 226.5            | 1 3 Li       | $K$ Abs. Edge          | 0.05475 |
| 111.             | 1 4 Be       | Abs. Edge            | 0.111   | 227.8            | 1 34 Se      | $M_V$ Abs. Edge        | 0.05443 |
| 112.0            | 6 63 Eu      | $N_{IV,V}O_{II,III}$ | 0.1107  | 228.             | 1 3 Li       | $K\alpha$ $KL$         | 0.0543  |
| 113.0            | 1 81 Tl      | $N_{VI}O_V$          | 0.10968 | 230.             | 2 34 Se      | $M_V N_{III}$          | 0.0538  |
| 113.             | 1 59 Pr      | $N_{IV,V}N_{VI,VII}$ | 0.1095  | 230.             | 1 26 Fe      | $M_{II,III}$ Abs. Edge | 0.0538  |
| 113.8            | 3 35 Br      | $M_{III}M_{IV,V}$    | 0.1089  | 243.             | 5 26 Fe      | $M_{II,III}M_{IV,V}$   | 0.051   |
| 114.             | 1 4 Be       | $KL$                 | 0.1085  | 249.3            | 1 12 Mg      | $L_{II}$ Abs. Edge     | 0.04973 |
| 115.3            | 2 81 Tl      | $N_{VI}O_{IV}$       | 0.1075  | 250.7            | 1 12 Mg      | $L_{III}$ Abs. Edge    | 0.04945 |
| 117.4            | 4 62 Sm      | $N_{IV,V}O_{II,III}$ | 0.1056  | 251.5            | 5 12 Mg      | $L_{II,III}M$          | 0.04929 |
| 117.7            | 1 81 Tl      | $N_{VII}O_V$         | 0.10530 | 273.             | 6 25 Mn      | $M_{II,III}M_{IV,V}$   | 0.045   |
| 123.             | 1 14 Si      | Abs. Edge            | 0.1006  | 290.             | 1 13 Al      | $L_I L_{II,III}$       | 0.0428  |
| 126.8            | 2 37 Rb      | $M_{IV}N_{III}$      | 0.0978  | 309.             | 9 24 Cr      | $M_{II,III}M_{IV,V}$   | 0.040   |
| 127.8            | 2 37 Rb      | $M_{IV}N_{II}$       | 0.0970  | 317.             | 1 12 Mg      | $L_I L_{II,III}$       | 0.0392  |
| 128.7            | 2 37 Rb      | $M_V N_{III}$        | 0.0964  | 337.             | 9 23 V       | $M_{II,III}M_{IV,V}$   | 0.0368  |
| 128.9            | 7 60 Nd      | $N_{IV,V}O_{II,III}$ | 0.0962  | 376.             | 1 11 Na      | $L_I L_{II,III}$       | 0.03299 |
| 135.5            | 4 14 Si      | $L_{II,III}M$        | 0.0915  | 399.             | 5 35 Br      | $N_I$ Abs. Edge        | 0.0311  |
| 136.5            | 4 59 Pr      | $N_{IV,V}O_{II,III}$ | 0.0908  | 405.             | 5 11 Na      | $L_{II,III}$ Abs. Edge | 0.0306  |
| 137.0            | 5 30 Zn      | Abs. Edge            | 0.0905  | 407.1            | 5 11 Na      | $L_{II,III}M$          | 0.03045 |
| 142.5            | 1 13 Al      | Abs. Edge            | 0.08701 | 417.             | 5 17 Cl      | $M_I$ Abs. Edge        | 0.0297  |
| 143.9            | 5 30 Zn      | Abs. Edge            | 0.0862  | 444.             | 5 53 I       | $O_I$ Abs. Edge        | 0.0279  |
| 144.4            | 6 58 Ce      | $N_{IV,V}O_{II,III}$ | 0.0859  | 525.             | 9 20 Ca      | $M_{II,III}N_I$        | 0.0236  |
| 144.4            | 3 37 Rb      | $M_I M_{III}$        | 0.0859  | 692.             | 9 19 K       | $M_{II,III}N_I$        | 0.0179  |
| 152.6            | 6 57 La      | $N_{IV,V}O_{II,III}$ | 0.0812  |                  |              |                        |         |

# Index

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The most efficient way to use this index is to look for the pertinent *property* (e.g., vapor pressure, entropy), *process* (e.g., disposal of chemicals, calibration), or *general concept* (e.g., units, radiation). Most primary entries are subdivided into several secondary entries, e.g., under heat capacity there are 17 secondary entries such as air, metals, water, etc. Primary entries will be found for certain *classes of substances*, such as alloys, elements, organic compounds, refrigerants, semiconductors, etc. Primary entries are also given for the individual chemical elements and for a few compounds such as water and carbon dioxide. However, only the most important tables are listed under these substances. Therefore, the user will find in most cases that it is best to look first for the property of interest, then examine the table or tables that are referenced.

Entries in boldface type are the titles of tables as they appear in the Table of Contents.

The reference given for each index term is the inclusive pages of the pertinent table (e.g., **8-45** to 55). The introduction to each table describes the method of ordering the substances within that table.

The editor would be grateful for comments and suggestions on this index.

# INDEX

## A

AAS, definition, **12-1 to 4**

Abbreviations  
 amino acids, **7-3 to 4**  
 physical quantities, **2-1 to 12**  
 scientific terms, **2-29 to 41**  
 units, **1-23 to 26**

Absorption  
 infrared, by earth's atmosphere, **14-33**  
 light, by elemental solids, **12-123 to 147**  
 light, by other solids, **12-148 to 166**  
 microwave power, by water, **6-14**  
 sound, by air, **14-50**

**Abundance of Elements in the Earth's Crust and in the Sea, 14-18**

Abundance, isotopic, **1-14 to 17, 11-56 to 253**

**Acceleration Due to Gravity, 14-13**

Acceleration due to gravity  
 at poles and equator, **14-10 to 11**  
 at various latitudes, **14-13**  
 on the sun, moon, and planets, **14-2 to 3**  
 standard value, **1-1 to 11**

**Acid-Base Indicators, 8-15 to 17**

Acid dissociation constant  
 amino acids, **7-1 to 2**  
 biological buffers, **7-26**  
 indicators, **8-15 to 17**  
 inorganic acids and bases, **8-40 to 41**  
 organic acids and bases, **8-42 to 51**  
 purine and pyrimidine bases, **7-5**

Acid rain, pH measurement, **8-37 to 38**

Acids  
 activity coefficients, **5-78 to 79, 5-80 to 83**  
 decinormal solutions, **8-5 to 6**  
 electrical conductivity, **5-71**  
 enthalpy of dilution, **5-84**  
 fatty, **7-7 to 8**  
 indicators, **8-15 to 17**  
 inorganic, dissociation constant, **8-40 to 41**  
 organic, dissociation constant, **8-42 to 51**

Acoustics  
 human hearing, **14-53 to 54**  
 musical scales, **14-52**  
 noise levels, **14-53 to 54**  
 sound velocity, **14-48 to 49, 14-50, 14-51**  
 sound velocity in air, **6-15 to 20**  
 sound velocity in fluids, **6-21 to 37**  
 sound velocity in water and steam, **6-1 to 4**

Acronyms, definitions, **2-29 to 41**

Actinium: *see also* Elements  
 electron configuration, **1-18 to 19**  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1 to 42**  
 ionization energy, **10-203 to 205**  
 isotopes and their properties, **11-56 to 253**  
 physical properties, **4-133 to 134**  
 thermal properties, **12-203 to 204**

Activation energy  
 atmospheric reactions, **5-90 to 101**  
 diffusion in semiconductors, **12-99 to 106**

Activity coefficients, **5-78 to 79, 5-80 to 83**

**Activity Coefficients of Acids, Bases, and Salts, 5-78 to 79**

AES, definition, **12-1 to 4**

AFM, definition, **12-1 to 4**

Air  
 absorption of sound, **14-50**  
 cryogenic properties, **6-143**  
 density, **6-15 to 20**  
 diffusion of gases in, **6-225 to 226**  
 enthalpy, **6-15 to 20**  
 entropy, **6-15 to 20**  
 heat capacity, **6-15 to 20**  
 index of refraction, **10-253**  
 mean free path, **6-48**  
 permittivity (dielectric constant), **6-188**  
 speed of sound, as function of humidity and frequency, **14-50**  
 speed of sound, as function of temperature, **6-15 to 20, 14-51**  
 thermal conductivity, **6-15 to 20, 6-218 to 219**  
 thermodynamic properties, **6-15 to 20**  
 U.S. Standard Atmosphere, **14-20 to 25**  
 vapor pressure, **6-15 to 20**  
 viscosity, **6-15 to 20, 6-208**

Airborne contaminants, threshold limits, **16-29 to 42**

Albedo  
 planets, **14-2 to 3**  
 satellites of the planets, **14-4 to 6**

ALI for radionuclides, **16-49 to 52**

Alkali halides, secondary electron emission, **12-122**

Alkali hydroxide solutions, viscosity and density, **6-215**

Alkali metals: *see* entries for Lithium, Sodium, etc.

**Allocation of Frequencies in the Radio Spectrum, 15-50 to 51**

Alloys  
 composition, **12-107 to 115**  
 electrical resistivity, **12-43 to 45**  
 eutectic temperatures, **15-36**  
 magnetic properties, **12-107 to 115**  
 phase diagrams, **12-184 to 201**  
 superconducting properties, **12-59 to 74**  
 thermal conductivity, **12-208**

Alloys, commercial  
 electrical resistivity, **12-221**  
 mechanical and thermal properties, **12-221**  
 stainless steel, **12-205**  
 thermal conductivity, **12-208**

Alphabets: Greek, Russian, Hebrew, **2-42**

Aluminum: *see also* Elements  
 electrical resistivity, **12-41 to 42**  
 electron configuration, **1-18 to 19**  
 heat capacity, **4-135, 12-202**  
 history, occurrence, uses, **4-1 to 42**  
 ionization energy, **10-203 to 205**  
 isotopes and their properties, **11-56 to 253**  
 magnetic susceptibility, **4-142 to 147**  
 molten, density, **4-139 to 141**  
 physical properties, **4-133 to 134**  
 resistance of wires, **15-37**  
 thermal conductivity, **12-206 to 207**  
 thermal properties, **12-203 to 204**  
 thermodynamic properties, **5-1 to 3**  
 vapor pressure, **6-72 to 101**  
 vapor pressure, high temperature, **4-136 to 137**

wire tables, **15-37**

Americium: *see also* Elements  
 electron configuration, **1-18 to 19**  
 history, occurrence, uses, **4-1 to 42**  
 ionization energy, **10-203 to 205**  
 isotopes and their properties, **11-56 to 253**  
 vapor pressure, high temperature, **4-136 to 137**

Amino acids  
 abbreviations and symbols, **7-3 to 4**  
 in blood, **7-45 to 47**  
 dissociation constants, **7-1 to 2**  
 physical properties, **7-1 to 2**  
 solubility, **7-1 to 2**  
 structure, **7-3 to 4**

Ampere  
 definition, **1-23 to 26**  
 maintained value, **1-1 to 11**

Analytical procedures  
 flame and bead tests, **8-13 to 14**  
 organic reagents, **8-8 to 12**  
 preparation of reagents, **8-1 to 4**  
 reduction of weighings, **8-138**  
 solids and surfaces, **12-1 to 4**  
 volumetric calibrations, **8-139**

Ångström, definition, **1-23 to 26**

**Annual Limits on Intakes of Radionuclides, 16-49 to 52**

Antiferroelectric crystals, Curie temperature, **12-57**

Antiferromagnetic elements and compounds, **12-107 to 115**

Antiferromagnetic materials, Faraday rotation, **12-167 to 180**

Antimony: *see also* Elements  
 electrical resistivity, **12-41 to 42**  
 electron configuration, **1-18 to 19**  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1 to 42**  
 ionization energy, **10-203 to 205**  
 isotopes and their properties, **11-56 to 253**  
 magnetic susceptibility, **4-142 to 147**  
 molten, density, **4-139 to 141**  
 physical properties, **4-133 to 134**  
 thermal properties, **12-203 to 204**  
 vapor pressure, **6-72 to 101**

**Apparent Equilibrium Constants for Enzyme-Catalyzed Reactions, 7-19 to 22**

Appearance potential, molecules, **10-206 to 223**

APS, definition, **12-1 to 4**

**Aqueous Solubility and Henry's Law Constants of Organic Compounds, 8-85 to 120**

**Aqueous Solubility of Inorganic Compounds at Various Temperatures, 8-121 to 126**

Aqueous solutions  
 activity coefficients, **5-78 to 79, 5-80 to 83**  
 concentrative properties, **8-52 to 77**  
 density, **8-52 to 77**  
 diffusion of ions, **5-75 to 77**  
 diffusion of non-electrolytes, **6-228 to 229**  
 electrical conductivity, **5-74, 5-75 to 77**  
 enthalpy, **5-85**  
 freezing point depression, **8-52 to 77**

- heat capacity, 5-66 to 67  
hydrohalogen acids, conductivity, 5-73  
index of refraction, 8-52 to 77  
sodium chloride, volumetric properties, 6-142  
solubility product constant, 8-127 to 129  
surface tension, 6-165  
thermodynamic properties, 5-66 to 67  
vapor pressure, 6-110  
viscosity, 8-52 to 77
- Argon: *see also* Elements  
critical constants, 6-50 to 69  
cryogenic properties, 6-143  
electron configuration, 1-18 to 19  
entropy, 5-1 to 3  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
mean free path, 6-48  
permittivity (dielectric constant), 6-166 to 187, 6-188  
physical properties, 4-133 to 134  
solubility in water, 8-80 to 83  
thermal conductivity, 6-21 to 37, 6-218 to 219  
thermodynamic properties at high temperature, 5-43 to 65  
thermophysical properties, 6-21 to 37  
van der Waals constants, 6-47  
vapor pressure, 6-72 to 101, 6-102 to 109  
viscosity, 6-21 to 37, 6-208
- Arsenic: *see also* Elements  
critical constants, 6-50 to 69  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
vapor pressure, 6-72 to 101
- Astatine: *see also* Elements  
electron configuration, 1-18 to 19  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
vapor pressure, 6-72 to 101
- Astronomical Constants, 14-1**  
Astronomical unit, 14-1  
Atmosphere  
carbon dioxide concentration, 14-34 to 35  
cosmic ray background, 11-267 to 270  
electrical conductance, 14-41 to 47  
infrared absorption, 14-33  
ion mobility, 14-41 to 47  
kinetic and photochemical data, 5-90 to 101  
mass, 14-10 to 11  
planetary, composition, 14-2 to 3  
potential, electrical, 14-41 to 47  
standard (unit), 1-23 to 26  
U.S. Standard, various properties, 14-20 to 25
- Atmospheric Concentration of Carbon Dioxide, 1958-2004, 14-34 to 35**  
**Atmospheric Electricity, 14-41 to 47**  
**Atomic and Molecular Polarizabilities, 10-193 to 202**  
Atomic mass unit (amu), 1-1 to 11, 1-23 to 26  
Atomic masses, 1-14 to 17, 11-56 to 253  
**Atomic Masses and Abundances, 1-14 to 17**  
**Atomic Radii of the Elements, 9-49**  
Atomic radius, rare earth elements, 4-127 to 132  
Atomic spectra  
elements, line spectra, 10-1 to 92  
ionization energies, 10-203 to 205  
transition probabilities, 10-93 to 155  
wavelengths, 10-1 to 92  
Atomic transition probability, 10-93 to 155  
Atomic weights, 1-12 to 13  
Atoms  
electron affinity, 10-156 to 173  
electron binding energy, 10-228 to 233  
electron configuration, 1-18 to 19  
ionization energies, 10-203 to 205  
masses, 1-14 to 17  
photon cross sections, 10-235 to 239  
polarizability, 10-193 to 202  
spectra, 10-1 to 92  
x-ray energy levels, 10-224 to 227  
ATR, definition, 12-1 to 4  
**Attenuation and Speed of Sound in Air as a Function of Humidity and Frequency, 14-50**  
Autoignition temperature, 16-13 to 28  
Avogadro constant, 1-1 to 11  
Azeotropes, 6-189 to 207  
**Azeotropic Data for Binary Mixtures, 6-189 to 207**
- ## B
- Bands, electromagnetic (classification), 10-240 to 241  
Barium: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137  
Barn, definition, 1-23 to 26  
Barometer corrections, 15-30  
Barriers to internal rotation, 9-59 to 63  
Baryons, summary of properties, 11-1 to 55  
Bases  
activity coefficients, 5-78 to 79, 5-80 to 83  
decinormal solutions, 8-5 to 6  
electrical conductivity, 5-71  
indicators, 8-15 to 17  
inorganic, dissociation constant, 8-40 to 41  
organic, dissociation constant, 8-42 to 51  
purine and pyrimidine, 7-5  
Becquerel, definition, 1-23 to 26  
Berkelium: *see also* Elements  
electron configuration, 1-18 to 19  
history, occurrence, uses, 4-1 to 42  
isotopes and their properties, 11-56 to 253  
Beryllium: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137  
Bessel functions, A-78 to 80  
Bessel's equation, A-46 to 56  
BET, definition, 12-1 to 4  
Beta function, A-82  
Billion, billiard (definition), 1-38  
Binding energy  
electrons in atoms, 10-228 to 233  
in molecules, 9-64 to 97  
Binomial series, A-65 to 68  
Biochemical nomenclature, references, 2-15  
Biochemical reactions, redox potentials, 7-16 to 18  
**Biological Buffers, 7-23 to 25, 7-26**  
Biological materials and tissues  
effect of cosmic rays, 11-267 to 270  
pH, 7-27  
Biosphere, mass of, 14-10 to 11  
Bismuth: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
**Black Body Radiation, 10-243 to 244**  
Blood  
chemical composition, 7-45 to 47  
pH, 7-27, 7-45 to 47  
Bohr magneton, 1-1 to 11  
Bohr radius, 1-1 to 11  
Bohrium (element 107), 4-1 to 42, 11-56 to 253  
Boiling point  
correction to standard pressure, 15-26  
cryogenic fluids, 6-143  
D<sub>2</sub>O, 6-9  
elements, 4-133 to 134  
elevation of, 15-27  
halocarbons, 6-145 to 147  
inorganic compounds, 4-43 to 101, 6-50 to 69, 6-112 to 129  
metals, 12-203 to 204  
organic compounds, 3-1 to 523, 6-50 to 69, 6-112 to 129  
pressure dependence, 15-26  
rare earth elements, 4-127 to 132  
solvents, 15-13 to 22  
Boltzmann constant, 1-1 to 11  
**Bond Dissociation Energies, 9-64 to 97**  
Bond energy, 9-64 to 97  
Bond lengths  
characteristic, 9-48  
diatomic molecules, 9-102 to 107  
gas-phase molecules, 9-19 to 47  
organic crystals, 9-1 to 16  
organometallic compounds, 9-17 to 18



## Bond Lengths and Angles in Gas-Phase Molecules, 9-19 to 47

## Bond Lengths in Crystalline Organic Compounds, 9-1 to 16

## Bond Lengths in Organometallic Compounds, 9-17 to 18

### Bonds, chemical

- disruption energy, 9-64 to 97
- dissociation energy (enthalpy), 9-64 to 97
- lengths and angles, 9-1 to 16, 9-17 to 18, 9-19 to 47
- strength, 9-64 to 97
- stretching force constants, 9-99

### Born-Haber cycle, 12-21 to 33

### Boron: *see also* Elements

- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- thermodynamic properties, 5-1 to 3
- vapor pressure, 6-72 to 101

### Bosons, summary of properties, 11-1 to 55

### Brass

- phase diagram, 12-184 to 201
- resistance of wires, 15-37
- thermal conductivity, 12-208
- wire tables, 15-37

### Bravais lattices, 12-5 to 10

### Breakdown voltage, 15-42 to 46

### Bromine: *see also* Elements

- critical constants, 6-50 to 69
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- physical properties, 4-133 to 134
- thermodynamic properties, 5-1 to 3
- thermodynamic properties at high temperature, 5-43 to 65
- vapor pressure, 6-72 to 101, 6-102 to 109

## Buffer Solutions Giving Round Values of pH at 25 °C, 8-39

### Buffers

- biological, 7-23 to 25, 7-26
- for round values of pH, 8-39
- for seawater measurements, 8-37 to 38
- standard solutions, 8-32 to 36, 8-37 to 38

### Burnside's formula, A-80 to 81

## C

## <sup>13</sup>C Chemical Shifts of Useful NMR Solvents, 8-142

## <sup>13</sup>C NMR Absorptions of Major Functional Groups, 9-117

### Cadmium: *see also* Elements

- electrical resistivity, 12-41 to 42
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- thermal properties, 12-203 to 204

### thermodynamic properties, 5-1 to 3

### vapor pressure, 6-72 to 101

### vapor pressure, high temperature, 4-136 to 137

### Calcium: *see also* Elements

- electrical resistivity, 12-41 to 42
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- thermal properties, 12-203 to 204
- thermodynamic properties, 5-1 to 3
- vapor pressure, 6-72 to 101
- vapor pressure, high temperature, 4-136 to 137

### Calibration

- barometers, 15-30
- boiling points, to standard pressure, 15-26
- conductivity cells, 5-72
- index of refraction, 10-252
- infrared and far infrared frequencies, 10-268 to 272
- infrared frequencies, 10-261 to 267
- pH, 8-32 to 36
- relative humidity, 15-34
- temperature scale, 1-20, 15-10 to 11
- thermocouples, 15-1 to 9
- vapor pressure, 6-111
- volumetric, 8-139
- weighings in air, 8-138

### Californium: *see also* Elements

- electron configuration, 1-18 to 19
- history, occurrence, uses, 4-1 to 42
- isotopes and their properties, 11-56 to 253

### Calorie, value of, 1-28 to 37

### Candela, definition, 1-23 to 26

## Carbohydrate Names and Symbols, 7-14 to 15

### Carbon: *see also* Elements

- dielectric constant, 12-47 to 55
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- physical properties, 4-133 to 134
- thermodynamic properties, 5-1 to 3
- vapor pressure, 6-72 to 101

### Carbon dioxide

- atmospheric concentration (historical), 14-34 to 35
- critical constants, 6-50 to 69
- global warming potential, 14-39 to 40
- infrared laser frequencies, 10-261 to 267
- mean free path, 6-48
- permittivity (dielectric constant), 6-166 to 187, 6-188
- release by combustion of fuels, 5-69
- solubility in water, 8-80 to 83
- solubility in water at various pressures, 8-84
- speed of sound, 14-48 to 49
- standard thermodynamic properties, 5-4 to 42
- sublimation pressure, 6-70 to 71
- thermal conductivity, 6-218 to 219, 6-21 to 37

### thermodynamic properties at high temperature, 5-43 to 65

- thermophysical properties, 6-21 to 37
- van der Waals constants, 6-47
- vapor pressure, 6-102 to 109, 6-111
- viscosity, 6-208, 6-21 to 37, 6-214

### Carcinogenic chemicals, list, 16-53 to 58

### Carrier gas properties, for chromatography, 8-140

### CARS, definition, 12-1 to 4

## CAS Registry Number Index of Inorganic Compounds, 4-115 to 126

## CAS Registry Number Index of Organic Compounds, 3-634 to 671

### CAS Registry Numbers

- inorganic compounds, 4-43 to 101
- organic compounds, 3-1 to 523
- organic compounds, index, 3-634 to 671

### Cauchy equation, A-46 to 56

### Celsius temperature

- conversion to other scales, 1-38
- definition, 1-23 to 26

### Ceramics

- breakdown voltage, 15-42 to 46
- permittivity (dielectric constant), 12-47 to 55
- phase diagrams, 12-184 to 201
- thermal conductivity, 12-211 to 212

### Cerenkov light, in cosmic ray showers, 11-267 to 270

### Ceres, orbital data and dimensions, 14-2 to 3

### Cerium: *see also* Elements

- electrical resistivity, 12-41 to 42
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- thermal properties, 12-203 to 204
- vapor pressure, 6-72 to 101
- vapor pressure, high temperature, 4-136 to 137

### Cesium: *see also* Elements

- electrical resistivity, 12-41 to 42
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- thermal properties, 12-203 to 204
- thermodynamic properties, 5-1 to 3
- vapor pressure, 6-72 to 101
- vapor pressure, high temperature, 4-136 to 137

### CFC's, global warming potential, 14-39 to 40

### CFC's, various properties, 6-145 to 147

## Characteristic Bond Lengths in Free Molecules, 9-48

## Characteristics of Human Hearing, 14-53 to 54

## Characteristics of Infrared Detectors, 10-245

## Characteristics of Laser Sources, 10-255 to 260

## Characteristics of Particles and Particle Dispersoids, 15-38

- Characterization of materials, 12-1 to 4
- Charge  
  electron, 1-1 to 11  
  fundamental particles, 11-1 to 55
- Chemical Abstracts Service nomenclature, 2-15
- Chemical Abstracts Service Registry Numbers:  
  *see* CAS Registry Numbers
- Chemical Carcinogens**, 16-53 to 58
- Chemical Composition of the Human Body**, 7-48
- Chemical Constituents of Human Blood**, 7-45 to 47
- Chemical Kinetic Data for Stratospheric Modeling**, 5-90 to 101
- Chemical kinetics  
  atmospheric reactions, 5-90 to 101  
  conversion factors, 1-43
- Chemical nomenclature, 2-15
- Chemical shifts, NMR  
  for  $^{13}\text{C}$ , 9-117  
  for protons, 9-116  
  of solvents for NMR, 8-142
- Chemical structure representation, 2-27 to 28
- Chemicals, safe handling and disposal, 16-1 to 12
- Chi-square distribution, A-91 to 92
- Chlorine: *see also* Elements  
  critical constants, 6-50 to 69  
  electron configuration, 1-18 to 19  
  heat capacity, 4-135  
  history, occurrence, uses, 4-1 to 42  
  ionization energy, 10-203 to 205  
  isotopes and their properties, 11-56 to 253  
  physical properties, 4-133 to 134  
  thermodynamic properties, 5-1 to 3  
  thermodynamic properties at high temperature, 5-43 to 65  
  vapor pressure, 6-72 to 101, 6-102 to 109
- Chlorofluorocarbon refrigerants, 6-145 to 147
- Chromatography, carrier gas properties, 8-140
- Chromium: *see also* Elements  
  electrical resistivity, 12-41 to 42  
  electron configuration, 1-18 to 19  
  heat capacity, 4-135  
  history, occurrence, uses, 4-1 to 42  
  ionization energy, 10-203 to 205  
  isotopes and their properties, 11-56 to 253  
  magnetic susceptibility, 4-142 to 147  
  molten, density, 4-139 to 141  
  physical properties, 4-133 to 134  
  thermal properties, 12-203 to 204  
  vapor pressure, 6-72 to 101  
  vapor pressure, high temperature, 4-136 to 137
- Classification of Electromagnetic Radiation**, 10-240 to 241
- Clathrate hydrates, 6-148 to 152
- Clausius-Mosotti equation, 12-13 to 14
- Clebsch-Gordan coefficients, A-87 to 88
- Cobalt: *see also* Elements  
  electrical resistivity, 12-41 to 42  
  electron configuration, 1-18 to 19  
  heat capacity, 4-135  
  history, occurrence, uses, 4-1 to 42  
  ionization energy, 10-203 to 205  
  isotopes and their properties, 11-56 to 253  
  magnetic susceptibility, 4-142 to 147  
  molten, density, 4-139 to 141  
  physical properties, 4-133 to 134  
  thermal properties, 12-203 to 204  
  vapor pressure, 6-72 to 101
- vapor pressure, high temperature, 4-136 to 137
- CODATA fundamental constants, 1-1 to 11
- CODATA Key Values for Thermodynamics**, 5-1 to 3
- Coefficient of Friction**, 15-47 to 48
- Coercivity, magnetic materials, 12-107 to 115
- Collision diameter of gases, 6-48
- Collision frequency, common gases, 6-48
- Combustion, heat of  
  fuels, 5-69  
  various compounds, 5-68
- Composition  
  atmosphere, 14-2 to 3  
  earth's crust, 14-18  
  glasses, 12-213 to 216  
  human body, 7-48  
  magnetic materials, 12-107 to 115  
  planetary atmospheres, 14-2 to 3  
  sea water, 14-18  
  U.S. Standard Atmosphere, 14-20 to 25
- Composition and Properties of Common Oils and Fats**, 7-9 to 13
- Compressibility  
  ice, 6-12  
  liquids, 6-140 to 141  
  semiconductors, 12-80 to 92  
  sodium chloride solutions, 6-142
- Compton wavelength (electron, proton, neutron), 1-1 to 11
- Concentrative Properties of Aqueous Solutions: Density, Refractive Index, Freezing Point Depression, and Viscosity**, 8-52 to 77
- Conductance: *see* Conductivity, electrical
- Conductivity, electrical  
  aqueous solutions of acids, bases, salts, 5-71  
  calibration standards, 5-72  
  earth's atmosphere, 14-41 to 47  
  electrolyte solutions, 5-74  
  hydrohalogen acids, 5-73  
  ions, at infinite dilution, 5-75 to 77  
  potassium chloride solutions, 5-72  
  seawater, 14-16 to 17  
  standard solutions, 5-72  
  water, 5-70
- Conductivity, thermal: *see* Thermal conductivity
- Confidence intervals, A-88 to 90
- Constant Humidity Solutions**, 15-33
- Constantan  
  thermal conductivity, 12-208  
  wire tables, 15-37
- Construction materials  
  density, 15-39  
  thermal conductivity, 12-211 to 212
- Conversion Factors**, 1-28 to 37
- Conversion Factors for Chemical Kinetics**, 1-43
- Conversion Factors for Electrical Resistivity Units**, 1-42
- Conversion Factors for Energy Units**, 1-39
- Conversion Factors for Ionizing Radiation**, 1-44 to 45
- Conversion Factors for Pressure Units**, 1-40
- Conversion Factors for Thermal Conductivity Units**, 1-41
- Conversion Formulas for Concentration of Solutions**, 8-19
- Conversion of Temperatures**, 1-38
- Conversion of Temperatures from the 1948 and 1968 Scales to ITS-90**, 1-21 to 22
- Coordinate systems, A-75 to 77
- Copper: *see also* Elements  
  electrical resistivity, 12-41 to 42  
  electron configuration, 1-18 to 19  
  heat capacity, 4-135, 12-202  
  history, occurrence, uses, 4-1 to 42  
  ionization energy, 10-203 to 205  
  isotopes and their properties, 11-56 to 253  
  magnetic susceptibility, 4-142 to 147  
  molten, density, 4-139 to 141  
  physical properties, 4-133 to 134  
  resistance of wires, 15-37  
  thermal conductivity, 12-206 to 207  
  thermal properties, 12-203 to 204  
  thermodynamic properties, 5-1 to 3  
  vapor pressure, 6-72 to 101  
  vapor pressure, high temperature, 4-136 to 137  
  wire tables, 15-37
- Copper-constantan thermocouple tables, 15-1 to 9
- Correction of Barometer Readings to 0 °C Temperature**, 15-30
- Correlation charts for infrared spectra, 9-108 to 112
- Cosecant function, A-6 to 7
- Cosine function, A-6 to 7
- Cosmic Radiation**, 11-267 to 270
- Cosmic rays, 11-267 to 270
- Cotangent function, A-6 to 7
- Coulomb, definition, 1-23 to 26
- Critical Constants**, 6-50 to 69
- Critical constants  
  cryogenic fluids, 6-143  
  elements, 4-133 to 134, 6-50 to 69  
   $\text{H}_2\text{O}$  and  $\text{D}_2\text{O}$ , 6-9  
  halocarbons, 6-145 to 147  
  inorganic compounds, 6-50 to 69  
  organic compounds, 6-50 to 69
- Critical solution temperatures, polymers, 13-19 to 36
- Cross product, A-68 to 75
- Cross section, x-ray and gamma-ray, 10-235 to 239
- Crust  
  composition, 14-18  
  density, pressure, gravity, 14-14
- Cryogenic fluids  
  liquid helium properties, 6-144  
  thermophysical properties, 6-21 to 37  
  vapor pressure, 6-102 to 109  
  various properties, 6-143
- Cryoscopic Constants for Calculation of Freezing Point Depression**, 15-28
- Crystal elastic constants, 12-35 to 40
- Crystal ionic radii, 12-11 to 12
- Crystal lattice energy, 12-21 to 33, 12-34
- Crystal optical properties  
  elements, 12-123 to 147  
  inorganic compounds, 10-246 to 249  
  minerals, 4-149 to 155  
  various materials, 12-148 to 166
- Crystal structure  
  elements, 4-156 to 163, 12-15 to 18  
  elements, phase transitions, 12-19 to 20  
  gas clathrate hydrates, 6-148 to 152



inorganic compounds, 4-43 to 101, 4-156 to 163  
magnetic materials, 12-107 to 115  
minerals, 4-149 to 155, 4-156 to 163  
rare earth elements, 4-127 to 132  
semiconductors, 12-80 to 92  
superconductors, 12-59 to 74, 12-75 to 76  
**Crystal Structures and Lattice Parameters of Allotropes of the Elements, 12-15 to 18**  
Crystal symmetry, 12-5 to 10  
**Crystallographic Data on Minerals, 4-156 to 163**  
Curie temperature  
  antiferroelectric crystals, 12-57  
  ferroelectric crystals, 12-56  
  magnetic materials, 12-107 to 115  
  rare earth elements, 4-127 to 132  
**Curie Temperature of Selected Ferroelectric Crystals, 12-56**  
Curie, definition, 16-48  
Curium: *see also* Elements  
  electron configuration, 1-18 to 19  
  history, occurrence, uses, 4-1 to 42  
  isotopes and their properties, 11-56 to 253  
  vapor pressure, high temperature, 4-136 to 137  
Curl, definition, A-68 to 75

**D**

D<sub>2</sub>O  
  boiling point, 6-9  
  critical constants, 6-9  
  density, 6-10 to 11  
  dissociation constant, 8-79  
  fixed point properties, 6-9  
  heat capacity, 6-10 to 11  
  ion product, 8-79  
  surface tension, 6-10 to 11  
  thermal conductivity, 6-10 to 11, 6-218 to 219  
  triple point constants, 6-9  
  vapor pressure, 6-10 to 11  
  viscosity, 6-10 to 11, 6-208  
Dalton, definition, 1-23 to 26  
Darmstadtium (element 110), 4-1 to 42, 11-56 to 253  
Data sources, B-1 to 5  
Debye equation, 6-14  
Debye temperature  
  rare earth elements, 4-127 to 132  
  semiconductors, 12-80 to 92  
Decay mode  
  fundamental particles, 11-1 to 55  
  nuclides, 11-56 to 253  
Decimal equivalents of common fractions, A-2  
Decinormal solutions  
  oxidation and reduction reagents, 8-7  
  salts, acids, and bases, 8-5 to 6  
Definitions  
  abbreviations and acronyms, 2-29 to 41  
  scientific terms, 2-43 to 67  
  SI base units, 1-23 to 26  
  thermodynamic functions, 2-68  
**Definitions of Scientific Terms, 2-43 to 67**  
Density  
  air, 6-15 to 20  
  aqueous solutions, 8-52 to 77  
  atmosphere, as function of altitude, 14-20 to 25

  carrier gases for chromatography, 8-140  
  commercial metals and alloys, 12-221  
  common fluids, as function of temperature and pressure, 6-21 to 37  
  construction materials, 15-39  
  cryogenic fluids, 6-21 to 37, 6-143  
  D<sub>2</sub>O, 6-9  
  earth, 14-10 to 11  
  earth, as function of depth, 14-14  
  elements, 4-139 to 141  
  ethanol-water mixtures, 15-41  
  hydroxide solutions, 6-215  
  ice, 6-12  
  inorganic compounds, 4-43 to 101  
  liquid elements and salts, 4-139 to 141  
  liquids, pressure and temperature dependence, 6-140 to 141  
  mercury, 6-157  
  metallic elements, 12-203 to 204  
  minerals, 4-149 to 155  
  miscellaneous materials, 15-39  
  molten salts, 4-139 to 141  
  oils and fats, 7-9 to 13  
  organic compounds, 3-1 to 523  
  planets, 14-2 to 3  
  polymer melts, 13-14 to 18  
  rare earth elements, 4-127 to 132  
  rocks, 15-39  
  satellites, 14-4 to 6  
  seawater, 14-16 to 17  
  semiconductors, 12-80 to 92  
  sodium chloride solutions, 6-142  
  solvents, 15-13 to 22  
  solvents, as function of temperature, 15-25  
  stainless steel, 12-205  
  steam, 6-1 to 4  
  sulfuric acid, 15-40  
  water, 6-1 to 4, 6-7 to 8  
  water, supercooled, 6-12  
  wood, 15-39  
**Density and Specific Volume of Mercury, 6-157**  
**Density of Ethanol-Water Mixtures, 15-41**  
**Density of Molten Elements and Representative Salts, 4-139 to 141**  
**Density of Solvents as a Function of Temperature, 15-25**  
**Density of Sulfuric Acid, 15-40**  
**Density of Various Solids, 15-39**  
**Density, Pressure, and Gravity as a Function of Depth within the Earth, 14-14**  
**Dependence of Boiling Point on Pressure, 15-26**  
Depression of the freezing point, 8-52 to 77, 15-28, 15-29  
Derivatives, A-9 to 11  
Detectors, infrared, 10-245  
**Determination of Relative Humidity from Dew Point, 15-31**  
**Determination of Relative Humidity from Wet and Dry Bulb Temperatures, 15-32**  
Deuterium  
  solubility in water, 8-80 to 83  
  viscosity, 6-208  
Dew point and relative humidity, 15-31  
Diamagnetic susceptibility  
  elements, 4-142 to 147  
  inorganic compounds, 4-142 to 147

  organic compounds, 3-672 to 676  
**Diamagnetic Susceptibility of Selected Organic Compounds, 3-672 to 676**  
Diamond  
  dielectric constant, 12-47 to 55  
  optical properties, 12-123 to 147  
  phase diagram, 12-184 to 201  
  thermal conductivity, 12-206 to 207  
Diatomic molecules  
  bond lengths, 9-102 to 107  
  bond strengths, 9-64 to 97  
  electron affinity, 10-156 to 173  
  force constants, 9-99  
  polarizability, 10-193 to 202  
  spectroscopic constants, 9-102 to 107  
  vibrational frequencies, 9-102 to 107  
Dielectric constant  
  common fluids, as function of temperature and pressure, 6-21 to 37  
  cryogenic fluids, 6-21 to 37  
  crystals, 12-47 to 55  
  gases, 6-188  
  glass, 12-58  
  ice, 6-12  
  liquids, 6-166 to 187  
  plastics, 13-13  
  quartz, 12-58  
  rubbers, 13-13  
  semiconductors, 12-80 to 92  
  solids, 12-47 to 55  
  solvents, 8-141, 15-13 to 22  
  vacuum, 1-1 to 11  
  water and steam, temperature and pressure dependence, 6-1 to 4  
  water, frequency dependence, 6-14  
**Dielectric Constant of Selected Polymers, 13-13**  
**Dielectric Constants of Glasses, 12-58**  
**Dielectric Strength of Insulating Materials, 15-42 to 46**  
Differential equations, A-46 to 56  
Diffusion  
  in air, 6-225 to 226  
  gases, 6-225 to 226  
  gases in water, 6-227  
  ions in solution, 5-75 to 77  
  liquids, 6-228 to 229  
  semiconductors, 12-99 to 106  
**Diffusion Coefficients in Liquids at Infinite Dilution, 6-228 to 229**  
**Diffusion Data for Semiconductors, 12-99 to 106**  
**Diffusion in Gases, 6-225 to 226**  
**Diffusion of Gases in Water, 6-227**  
Dipole moment  
  electric, of molecules, 9-50 to 58  
  magnetic, of nuclides, 11-56 to 253  
  solvents, 15-13 to 22  
**Dipole Moments, 9-50 to 58**  
Discharges, electrical, in the atmosphere, 14-41 to 47  
Disposal of laboratory chemicals, 16-1 to 12  
Dissociation constant  
  acid-base indicators, 8-15 to 17  
  amino acids, 7-1 to 2  
  biological buffers, 7-23 to 25, 7-26  
  D<sub>2</sub>O, 8-79  
  inorganic acids and bases, 8-40 to 41  
  inorganic salts in water, 8-127 to 129  
  organic acids and bases, 8-42 to 51

purine and pyrimidine bases, 7-5  
 water, 8-78, 8-79

**Dissociation Constants of Inorganic Acids and Bases**, 8-40 to 41

**Dissociation Constants of Organic Acids and Bases**, 8-42 to 51

Dissociation energy of chemical bonds, 9-64 to 97

Distillation, azeotropes, 6-189 to 207

Divergence, definition, A-68 to 75

Drugs, structure and applications, 7-28 to 44

DSC, definition, 12-1 to 4

DTA, definition, 12-1 to 4

Dubnium (element 105), 4-1 to 42, 11-56 to 253

Dysprosium: *see also* Elements  
 electrical resistivity, 12-41 to 42  
 electron configuration, 1-18 to 19  
 heat capacity, 4-135  
 history, occurrence, uses, 4-1 to 42  
 ionization energy, 10-203 to 205  
 isotopes and their properties, 11-56 to 253  
 magnetic susceptibility, 4-142 to 147  
 molten, density, 4-139 to 141  
 physical properties, 4-133 to 134  
 thermal properties, 12-203 to 204  
 vapor pressure, 6-72 to 101  
 vapor pressure, high temperature, 4-136 to 137

## E

Earth  
 age, 14-10 to 11  
 area of land and oceans, 14-10 to 11  
 atmospheric composition, 14-2 to 3  
 composition of crust, 14-18  
 density as function of depth, 14-14  
 dimensions, 14-1, 14-10 to 11  
 gravity in interior, 14-14  
 mass and density, 14-10 to 11  
 orbital and rotational parameters, 14-2 to 3, 14-10 to 11  
 pressure in interior, 14-14

Earthquakes, historical data, 14-27 to 30

**Ebullioscopic Constants for Calculation of Boiling Point Elevation**, 15-27

ECR, definition, 12-1 to 4

EELS, definition, 12-1 to 4

Einsteinium: *see also* Elements  
 electron configuration, 1-18 to 19  
 history, occurrence, uses, 4-1 to 42  
 isotopes and their properties, 11-56 to 253

**Elastic Constants of Single Crystals**, 12-35 to 40

Elastic modulus  
 commercial metals and alloys, 12-221  
 rare earth elements, 4-127 to 132

**Elasto-optic, Electro-optic, and Magneto-optic Constants**, 12-167 to 180

Electrical conductance: *see* Conductivity, electrical

**Electrical Conductivity of Aqueous Solutions**, 5-71

**Electrical Conductivity of Water**, 5-70

**Electrical Resistivity of Graphite Materials**, 12-46

**Electrical Resistivity of Pure Metals**, 12-41 to 42

**Electrical Resistivity of Selected Alloys**, 12-43 to 45

Electrical resistivity: *see* Resistivity

Electro-optic constants, 12-167 to 180

**Electrochemical Series**, 8-20 to 29

Electrode potential  
 general table, 8-20 to 29  
 ion radicals, 8-30 to 31

Electrolytes  
 activity coefficients, 5-78 to 79, 5-80 to 83  
 diffusion of ions, 5-75 to 77  
 electrical conductivity, 5-74, 5-75 to 77  
 enthalpy of solution, 5-85  
 freezing point lowering, 8-52 to 77, 15-29

Electromagnetic radiation, classification of bands, 10-240 to 241

Electron  
 charge, 1-1 to 11  
 in cosmic ray showers, 11-267 to 270  
 magnetic moment, 1-1 to 11, 11-1 to 55  
 mean free path in solids, 12-119 to 120  
 range in various materials, 16-48

**Electron Affinities**, 10-156 to 173

**Electron Binding Energies of the Elements**, 10-228 to 233

Electron configuration  
 neutral atoms, 1-18 to 19  
 rare earth elements, 4-127 to 132

**Electron Configuration and Ionization Energy of Neutral Atoms in the Ground State**, 1-18 to 19

**Electron Inelastic Mean Free Paths**, 12-119 to 120

Electron volt, 1-1 to 11, 1-23 to 26

**Electron Work Function of the Elements**, 12-121

Electrons, secondary, emission by metals, 12-122

**Electronegativity**, 9-98

Elementary charge, 1-1 to 11

Elements  
 abundance of isotopes, 1-14 to 17, 11-56 to 253  
 atomic mass, 1-14 to 17, 11-56 to 253  
 atomic radii, 9-49  
 atomic spectrum, 10-1 to 92  
 atomic transition probability, 10-93 to 155  
 atomic weight, 1-12 to 13  
 boiling point, 4-133 to 134  
 chemical analysis, 8-13 to 14  
 critical temperature, 4-133 to 134  
 crystal ionic radii, 12-11 to 12  
 crystal phase transitions, 12-19 to 20  
 crystal structure, 4-156 to 163, 12-15 to 18  
 density, 4-139 to 141  
 in the earth's crust, 14-18  
 electrical resistivity, 12-41 to 42  
 electron affinity, 10-156 to 173  
 electron binding energy, 10-228 to 233  
 electron configuration, 1-18 to 19  
 electronegativity, 9-98  
 enthalpy of fusion, 6-130 to 139  
 enthalpy of vaporization, 6-112 to 129  
 gamma-ray cross sections, 10-235 to 239  
 gamma-ray emission, 11-56 to 253  
 general information, 4-1 to 42  
 heat capacity, 4-135  
 historical information, 4-1 to 42  
 in human blood, 7-45 to 47  
 in the human body, 7-48  
 line spectrum, 10-1 to 92  
 magnetic susceptibility, 4-142 to 147  
 melting point, 4-133 to 134  
 periodic table, Inside front cover

photon attenuation coefficients, 10-235 to 239

polarizability, 10-193 to 202

radii of ions, 12-11 to 12

reference states, 5-4 to 42

in seawater, 14-18

semiconducting properties, 12-80 to 92

superconducting properties, 12-59 to 74

thermal conductivity, 6-218 to 219, 12-203 to 204, 12-206 to 207

thermal properties, 12-203 to 204

thermodynamic properties, 5-4 to 42

transition probabilities, 10-93 to 155

triple point, 4-133 to 134

van der Waals radii, 9-49

vapor pressure, 6-72 to 101

vapor pressure at high temperature, 4-136 to 137, 4-138

work function, 12-121

x-ray atomic energy levels, 10-224 to 227

x-ray cross sections, 10-235 to 239

Elevation of the boiling point, 15-27

Emission, secondary electrons, 12-122

Emissivity, rare earth metals, 4-127 to 132

ENDOR, definition, 12-1 to 4

Energy  
 conversion factors, 1-39  
 crystal lattice, 12-21 to 33, 12-34  
 Fermi, 12-219 to 220  
 spectrum of cosmic rays, 11-267 to 270

Energy, activation  
 chemical reactions, 5-90 to 101  
 diffusion in semiconductors, 12-99 to 106

**Energy Content of Fuels**, 5-69

Energy gap  
 semiconductor solid solutions, 12-93 to 94  
 semiconductors, 12-80 to 92, 12-95 to 98  
 superconductors, 12-75 to 76

Energy levels, x-ray, 10-224 to 227

Energy states of solids, 12-1 to 4

Enthalpy  
 air, 6-15 to 20  
 common fluids, as function of temperature and pressure, 6-21 to 37  
 crystal lattices, 12-21 to 33  
 polymer solutions, 13-42 to 69  
 steam, 6-1 to 4  
 water, 6-1 to 4

Enthalpy of combustion, 5-68, 5-69

**Enthalpy of Dilution of Acids**, 5-84

Enthalpy of formation  
 aqueous ions, 5-66 to 67  
 CODATA Key Values, 5-1 to 3  
 free radicals, 9-64 to 97  
 gaseous atoms, 9-64 to 97  
 high temperature, 5-43 to 65  
 inorganic compounds, 5-4 to 42  
 ions, 10-206 to 223  
 organic compounds, 5-4 to 42  
 semiconductors, 12-80 to 92  
 standard state values, 5-4 to 42

**Enthalpy of Fusion**, 6-130 to 139

Enthalpy of fusion  
 cryogenic fluids, 6-143  
 elements, 6-130 to 139  
 ice, 6-12  
 inorganic compounds, 6-130 to 139  
 metals, 12-203 to 204  
 organic compounds, 6-130 to 139  
 rare earth elements, 4-127 to 132

**Enthalpy of Hydration of Gases**, 5-86 to 89

- Enthalpy of Solution of Electrolytes**, 5-85  
 Enthalpy of solvation of gases, 5-86 to 89  
**Enthalpy of Vaporization**, 6-112 to 129  
 Enthalpy of vaporization  
   cryogenic fluids, 6-143  
   elements, 6-112 to 129  
   ice, 6-12  
   inorganic compounds, 6-112 to 129  
   organic compounds, 6-112 to 129  
   rare earth elements, 4-127 to 132  
   water, 6-5 to 6  
 Entropy  
   air, 6-15 to 20  
   aqueous ions, 5-66 to 67  
   CODATA Key Values, 5-1 to 3  
   common fluids, as function of temperature and pressure, 6-21 to 37  
   high temperature, 5-43 to 65  
   rare earth elements, 4-127 to 132  
   standard state values, 5-4 to 42  
   steam, 6-1 to 4  
   water, 6-1 to 4  
 Enzyme-catalyzed reactions, equilibrium constants, 7-19 to 22  
 EPMA, definition, 12-1 to 4  
 EPR, definition, 12-1 to 4  
 Equation of state  
   Tait (for polymer melts), 13-14 to 18  
   van der Waals, 6-47  
   virial, 6-38 to 46  
 Equilibrium constant of formation, 5-43 to 65  
 Equilibrium constant, biochemical reactions, 7-16 to 18, 7-19 to 22  
 Equivalent conductance: *see* Conductivity, electrical  
**Equivalent Conductivity of Electrolytes in Aqueous Solution**, 5-74  
 Erbium: *see also* Elements  
   electrical resistivity, 12-41 to 42  
   electron configuration, 1-18 to 19  
   heat capacity, 4-135  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   magnetic susceptibility, 4-142 to 147  
   molten, density, 4-139 to 141  
   physical properties, 4-133 to 134  
   thermal properties, 12-203 to 204  
   vapor pressure, 6-72 to 101  
   vapor pressure, high temperature, 4-136 to 137  
 Eris, orbital data and dimensions, 14-2 to 3  
 Error function, A-83  
 Errors in measurement, 2-13 to 14  
 ESCA, definition, 12-1 to 4  
 ESD, definition, 12-1 to 4  
 Euler equation, A-46 to 56  
 Euler's constant, value of, A-1  
 Europium: *see also* Elements  
   electrical resistivity, 12-41 to 42  
   electron configuration, 1-18 to 19  
   heat capacity, 4-135  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   magnetic susceptibility, 4-142 to 147  
   molten, density, 4-139 to 141  
   physical properties, 4-133 to 134  
   thermal properties, 12-203 to 204  
   vapor pressure, 6-72 to 101  
   vapor pressure, high temperature, 4-136 to 137  
 Eutectic temperatures, low-melting alloys, 15-36  
 EXAFS, definition, 12-1 to 4  
 EXELFS, definition, 12-1 to 4  
 Expansion coefficient  
   commercial metals and alloys, 12-221  
   liquid helium, 6-144  
   metals, 12-203 to 204  
   rare earth elements, 4-127 to 132  
   semiconductors, 12-80 to 92  
   sodium chloride solutions, 6-142  
 Explosion hazards of laboratory chemicals, 16-1 to 12  
 Explosive limits, 16-13 to 28  
 Exponential functions, table, A-3 to 5  
 Exponential series, A-65 to 68  
 Exposure limits  
   airborne contaminants, 16-29 to 42  
   ionizing radiation, 16-48  
   radionuclides, 16-49 to 52  
**Expression of Uncertainty in Measurement**, 2-13 to 14  
 Extinction coefficient, in solids, 12-123 to 147, 12-148 to 166
- ## F
- F*-distribution, A-93 to 96  
 Factorial function, A-80 to 81  
 Fahrenheit temperature, conversion to other scales, 1-38  
 Farad, definition, 1-23 to 26  
 Faraday constant, 1-1 to 11  
 Faraday effect, 12-167 to 180  
 Fats, composition and properties, 7-9 to 13  
 Fatty acids and methyl esters, physical properties, 7-7 to 8  
 Fehling's solution, preparation, 8-1 to 4  
 FEM, definition, 12-1 to 4  
**Fermi Energy and Related Properties of Metals**, 12-219 to 220  
 Fermium: *see also* Elements  
   electron configuration, 1-18 to 19  
   history, occurrence, uses, 4-1 to 42  
   isotopes and their properties, 11-56 to 253  
 Ferrimagnetic materials  
   Faraday rotation, 12-167 to 180  
   organic, 12-116 to 118  
 Ferrites, magnetic properties, 12-107 to 115  
 Ferroelectric crystals  
   Curie temperature, 12-56  
   Kerr constants, 12-167 to 180  
 Ferromagnetic materials  
   Faraday rotation, 12-167 to 180  
   organic, 12-116 to 118  
   various properties, 12-107 to 115  
 Ferromagnetic moment, rare earth elements, 4-127 to 132  
 FIM, definition, 12-1 to 4  
 Fine structure constant, 1-1 to 11  
 First radiation constant, 1-1 to 11  
 Fixed point properties  
   cryogenic fluids, 6-143  
   water and heavy water, 6-9  
**Fixed Point Properties of H<sub>2</sub>O and D<sub>2</sub>O**, 6-9  
**Flame and Bead Tests**, 8-13 to 14  
**Flame Temperatures**, 15-49  
 Flammability  
   chemical substances, general, 16-13 to 28  
   laboratory chemicals, 16-1 to 12  
   organic solvents, 15-13 to 22  
**Flammability of Chemical Substances**, 16-13 to 28  
 Flash point: *see* Flammability  
 Flattening factor for the earth, 14-1  
**Fluorescent Indicators**, 8-18 to 19  
 Fluorine: *see also* Elements  
   critical constants, 6-50 to 69  
   electron configuration, 1-18 to 19  
   heat capacity, 4-135  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   physical properties, 4-133 to 134  
   thermodynamic properties, 5-1 to 3  
   thermodynamic properties at high temperature, 5-43 to 65  
   vapor pressure, 6-72 to 101, 6-102 to 109  
 Fluorocarbon refrigerants, 6-145 to 147  
 Foods  
   nutrient values, 7-49 to 60  
   pH, 7-27  
**Force Constants for Bond Stretching**, 9-99  
 Formation, heat of: *see* Enthalpy of formation  
 Formula index  
   inorganic compounds, 4-102 to 114  
   organic compounds, 3-634 to 671  
 Fossils, age of, 14-10 to 11  
 Fourier expansions for basic periodic functions, A-59 to 61  
 Fourier series, A-57 to 59  
 Fourier transforms, A-61 to 65  
 Fractions, decimal equivalents, A-2  
 Francium: *see also* Elements  
   electron configuration, 1-18 to 19  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   vapor pressure, 6-72 to 101  
 Free energy: *see* Thermodynamic properties  
 Free radicals  
   dipole moment, 9-50 to 58  
   enthalpy of formation, 9-64 to 97  
   ionization energy, 10-206 to 223  
   reaction rates, 5-90 to 101  
   vibrational frequencies, 9-100 to 102  
 Freezing point: *see also* Melting point  
   depression of, 8-52 to 77, 15-28  
   pressure dependence, 6-49  
   seawater, 14-16 to 17  
 Freezing point depression  
   aqueous solutions, 8-52 to 77  
   cryoscopic constants for various liquids, 15-28  
   electrolytes, 15-29  
**Freezing Point Lowering by Electrolytes in Aqueous Solution**, 15-29  
 Frequency  
   electromagnetic radiation bands, 10-240 to 241  
   human hearing range, 14-53 to 54  
   musical scales, 14-52  
   NMR resonances, 9-113 to 115  
   radio spectrum allocations, 15-50 to 51  
   standards, infrared, 10-261 to 267, 10-268 to 272  
 Friction, coefficient of, 15-47 to 48  
 FTIR, definition, 12-1 to 4  
 Fundamental constants, 1-1 to 11  
 Fundamental particles, 11-1 to 55



**Fundamental Physical Constants, 1-1 to 11**

**Fundamental Physical Constants -**

**Frequently Used Constants,**  
Inside back cover

**Fundamental Vibrational Frequencies of**

**Small Molecules, 9-100 to 102**

Fusion: *see* Enthalpy of fusion

## G

g-Factor of the electron, 1-1 to 11

Gadolinium: *see also* Elements

electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137

Gallium: *see also* Elements

electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137

Gamma function, A-81 to 82

Gamma rays

in cosmic ray showers, 11-267 to 270  
cross sections, for the elements, 10-235 to 239  
energy, of nuclides, 11-56 to 253  
photon attenuation coefficients, 10-235 to 239  
protection against, 16-48

Gas chromatography, carrier gas properties, 8-140

Gas clathrate hydrates, 6-148 to 152

Gas constant, 1-1 to 11, 1-46

Gas phase basicity, 10-174 to 192

Gases

average velocity, 6-48  
breakdown voltage, 15-42 to 46  
collision diameter, 6-48  
dielectric constant, 6-188  
diffusion, 6-225 to 226  
diffusion in water, 6-227  
dipole moment, 9-50 to 58  
enthalpy of solvation, 5-86 to 89  
mean free path, 6-48  
permittivity, 6-188  
refractive index, 10-254  
solubility in water, 8-80 to 83  
speed of sound in, 14-48 to 49  
thermal conductivity, 6-218 to 219  
threshold limits, 16-29 to 42  
van der Waals constants, 6-47  
Verdet constants, 12-167 to 180

virial coefficients, 6-38 to 46

viscosity, 6-208

Gauges, of wires, 15-37

Gauss' Theorem, A-77

Gaussian gravitational constant, 14-1

GDMS, definition, 12-1 to 4

Genetic code, 7-6

**Geographical and Seasonal Variation in  
Solar Radiation, 14-26**

**Geological Time Scale, 14-12**

Geophysical constants, 14-10 to 11

Germanium: *see also* Elements

dielectric constant, 12-47 to 55  
electron configuration, 1-18 to 19  
heat capacity, 4-135, 12-202  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
optical properties, 12-123 to 147  
physical properties, 4-133 to 134  
semiconducting properties, 12-80 to 92  
thermal conductivity, 12-206 to 207  
thermodynamic properties, 5-1 to 3  
vapor pressure, 6-72 to 101

Gibbs energy of formation

aqueous ions, 5-66 to 67  
biochemical species, 7-16 to 18  
high temperature, 5-43 to 65  
standard state values, 5-4 to 42

**Glass Transition Temperature for Selected  
Polymers, 13-6 to 12**

Glasses

composition, 12-213 to 216  
density, 15-39  
dielectric constant, 12-58  
index of refraction, 10-250  
loss factor, 12-58  
resistivity, 12-58  
speed of sound in, 14-48 to 49  
thermal conductivity, 12-209 to 210, 12-213 to 216  
transmittance, 10-250  
Verdet constants, 12-167 to 180

**Global Temperature Trend, 1856-2004, 14-38**

Global warming

atmospheric carbon dioxide concentration, 14-34 to 35  
mean temperatures, global, 14-38  
mean temperatures, U. S., 14-36 to 37

**Global Warming Potential of Greenhouse  
Gases, 14-39 to 40**

Gloves, resistance to chemicals, 16-1 to 12

Glucose, aqueous solution properties, 8-52 to 77

Gold: *see also* Elements

electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135, 12-202  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal conductivity, 12-206 to 207  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137

Golden ratio, A-1

Googol, googolplex, 1-38

Gradient, definition, A-68 to 75

Graphite

electrical resistivity, 12-46  
heat capacity, 12-202  
heat of combustion, 5-68  
phase diagram, 12-184 to 201  
sublimation pressure, 6-72 to 101  
thermal conductivity, 12-206 to 207

Gravitational constant, 1-1 to 11, 14-1

Gravitational potential, 14-2 to 3

Gravity, acceleration of

in interior of earth, 14-14  
at poles and equator, 14-10 to 11  
standard value, 1-1 to 11  
at various latitudes, 14-13

Gray, definition, 1-23 to 26, 16-48

**Greek, Russian, and Hebrew Alphabets, 2-42**

Green's Theorem, A-77

Greenhouse gases

carbon dioxide concentration, 14-34 to 35  
carbon dioxide, from fuel combustion, 5-69  
global warming potential, 14-39 to 40  
infrared absorption, 14-33  
radiative efficiency and lifetime, 14-39 to 40

## H

Hafnium: *see also* Elements

electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137

Hall coefficient, rare earth elements, 4-127 to 132

Hall density, superconductors, 12-75 to 76

Hall resistance, quantized, 1-1 to 11

Halocarbon refrigerants, 6-145 to 147

**Handling and Disposal of Chemicals in  
Laboratories, 16-1 to 12**

Hardness

ceramics, 12-222  
minerals, 4-149 to 155, 12-222  
scales, comparison, 12-222  
semiconductors, 12-80 to 92  
various materials, 12-222

**Hardness of Minerals and Ceramics, 12-222**

Hartree energy, 1-1 to 11

Hassium (element 108), 4-1 to 42, 11-56 to 253  
Hazardous chemicals, handling and disposal, 16-1 to 12

Hearing, characteristics, 14-53 to 54

Heat capacity

air, 6-15 to 20  
aqueous ions, 5-66 to 67  
carrier gases for chromatography, 8-140  
common fluids, as function of temperature and pressure, 6-21 to 37  
cryogenic fluids, 6-143  
elements, 4-135  
high temperature, 5-43 to 65

- ice, 6-12
  - liquid helium, 6-144
  - mercury, 6-158
  - metals, 12-202, 12-203 to 204
  - rare earth elements, 4-127 to 132
  - seawater, 14-16 to 17
  - semiconductors, 12-80 to 92
  - solids, 12-202
  - solvents, 15-13 to 22
  - stainless steel, 12-205
  - standard state values, 5-4 to 42
  - steam, 6-1 to 4
  - water, 6-1 to 4
  - Heat Capacity of Selected Solids, 12-202**
  - Heat Capacity of the Elements at 25 °C, 4-135**
  - Heat conductivity: *see* Thermal conductivity
  - Heat of Combustion, 5-68**
  - Heat of dilution: *see* Enthalpy of dilution
  - Heat of formation: *see* Enthalpy of formation
  - Heat of fusion: *see* Enthalpy of fusion
  - Heat of solution: *see* Enthalpy of solution
  - Heat of vaporization: *see* Enthalpy of vaporization
  - Hebrew alphabet, 2-42
  - Helium: *see also* Elements
    - critical constants, 6-50 to 69
    - cryogenic properties, 6-143, 6-144
    - density, 6-144
    - electron configuration, 1-18 to 19
    - enthalpy of vaporization, 6-144
    - entropy, 5-1 to 3
    - expansion coefficient, 6-144
    - heat capacity, 6-144
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - liquid properties, 6-144
    - magnetic susceptibility, 4-142 to 147
    - mean free path, 6-48
    - permittivity (dielectric constant), 6-144, 6-166 to 187, 6-188
    - physical properties, 4-133 to 134
    - solubility in water, 8-80 to 83
    - surface tension, 6-144
    - thermal conductivity, 6-21 to 37
    - thermal conductivity (gas), 6-218 to 219
    - thermal conductivity (liquid), 6-144
    - thermophysical properties, 6-21 to 37
    - van der Waals constants, 6-47
    - vapor pressure, 6-72 to 101, 6-102 to 109, 6-144
    - viscosity, 6-21 to 37
    - viscosity (gas), 6-208
    - viscosity (liquid), 6-144
  - Henry, definition, 1-23 to 26
  - Henry's Law constant, 8-85 to 120
  - Hermite polynomials, A-83 to 85
  - Hertz, definition, 1-23 to 26
  - High Temperature Superconductors, 12-75 to 76**
  - Hindered Internal Rotation, 9-59 to 63**
  - HITRAN Molecular Spectroscopy Database, 14-33
  - Holmium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - thermal properties, 12-203 to 204
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
  - Human body
    - chemical composition, 7-48
    - pH of fluids, 7-27
    - sensitivity of eye to light, 10-242
  - Humidity, relative
    - from wet and dry bulb temperatures, 15-32
    - relation to dew point, 15-31
    - solutions for calibration, 15-34
    - solutions for constant humidity, 15-33
  - Hurricane and other wind scales, 14-31 to 32
  - Hydrocarbons
    - flame temperature, 15-49
    - heat of combustion, 5-68
    - solubility in seawater, 8-131 to 132
    - thermophysical properties, 6-21 to 37
  - Hydrogen: *see also* Elements
    - critical constants, 6-50 to 69
    - cryogenic properties, 6-143
    - electron configuration, 1-18 to 19
    - enthalpy of fusion, 6-130 to 139
    - enthalpy of vaporization, 6-112 to 129
    - flame temperature, 15-49
    - heat of combustion, 5-68
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - mean free path, 6-48
    - permittivity (dielectric constant), 6-166 to 187, 6-188
    - physical properties, 4-133 to 134
    - solubility in water, 8-80 to 83
    - thermal conductivity, 6-218 to 219, 6-21 to 37
    - thermodynamic properties, 5-1 to 3
    - thermodynamic properties at high temperature, 5-43 to 65
    - thermophysical properties, 6-21 to 37
    - van der Waals constants, 6-47
    - vapor pressure, 6-72 to 101, 6-102 to 109
    - viscosity, 6-208, 6-21 to 37
  - Hydrosphere, mass of, 14-10 to 11
  - Hyperbolic functions
    - relations, A-8
    - table, A-3 to 5
  - Hysteresis, in magnetic materials, 12-107 to 115
- ## I
- Ice
    - compressibility, 6-12
    - crystal structure, 4-156 to 163
    - density, 6-12
    - dielectric constant, 6-12, 12-47 to 55
    - heat capacity, 6-12
    - melting point, pressure dependence, 6-13, 6-49
    - phase diagram, 12-184 to 201
    - phase transitions, 6-12, 6-13
    - thermal conductivity, 6-12, 12-209 to 210
    - thermal expansion coefficient, 6-12
    - vapor pressure, 6-13
  - ICPMS, definition, 12-1 to 4
  - Ignition temperature
    - chemical substances, general, 16-13 to 28
  - laboratory chemicals, 16-1 to 12
  - solvents, 15-13 to 22
  - InChI representation of chemical structures, 2-27 to 28
  - Index of refraction
    - air, 10-253
    - aqueous solutions, 8-52 to 77
    - gases, 10-254
    - glass, 10-250
    - inorganic crystals, 10-246 to 249
    - inorganic liquids, 4-148
    - liquids, for calibration, 10-252
    - metals, 12-123 to 147
    - minerals, 4-149 to 155
    - oils and fats, 7-9 to 13
    - organic compounds, 3-1 to 523
    - semiconductors, 12-80 to 92, 12-123 to 147, 12-148 to 166
    - solids, as function of wavelength, 10-246 to 249, 12-123 to 147, 12-148 to 166
    - water, 10-251
  - Index of Refraction of Air, 10-253**
  - Index of Refraction of Gases, 10-254**
  - Index of Refraction of Inorganic Crystals, 10-246 to 249**
  - Index of Refraction of Inorganic Liquids, 4-148**
  - Index of Refraction of Liquids for Calibration Purposes, 10-252**
  - Index of Refraction of Water, 10-251**
  - Indicators
    - acid-base, 8-15 to 17
    - fluorescent, 8-18 to 19
    - pH, 8-15 to 17, 8-18 to 19
    - pK, 8-15 to 17
    - preparation, 8-1 to 4, 8-15 to 17
  - Indium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - vapor pressure, 6-72 to 101
    - vapor pressure, high temperature, 4-136 to 137
  - Influence of Pressure on Freezing Points, 6-49**
  - Infrared Absorption by the Earth's Atmosphere, 14-33**
  - Infrared and Far-Infrared Absorption Frequency Standards, 10-268 to 272**
  - Infrared Correlation Charts, 9-108 to 112**
  - Infrared detectors, 10-245
  - Infrared Laser Frequencies, 10-261 to 267**
  - Infrared spectrum
    - carbon dioxide laser, 10-261 to 267
    - characteristic group frequencies, 9-108 to 112
    - correlation charts, 9-108 to 112
    - earth's atmosphere, 14-33
    - frequency standards, 10-268 to 272
    - HITRAN Database, 14-33
    - vibrational frequencies of molecules, 9-100 to 102

## Inorganic compounds

- activity coefficients, 5-78 to 79, 5-80 to 83
  - bond lengths and angles, 9-19 to 47
  - characteristic infrared frequencies, 9-108 to 112
  - crystal lattice energy, 12-21 to 33
  - crystal structure, 4-43 to 101, 4-156 to 163
  - dielectric constant, 12-47 to 55
  - dipole moment, 9-50 to 58
  - dissociation constant in water, 8-127 to 129
  - electrical conductivity, 5-74
  - enthalpy of formation, 5-4 to 42
  - enthalpy of fusion, 6-130 to 139
  - enthalpy of solution, 5-85
  - enthalpy of vaporization, 6-112 to 129
  - entropy, 5-4 to 42
  - Gibbs energy of formation, 5-4 to 42
  - heat capacity, 5-4 to 42
  - index of refraction, 4-148
  - magnetic susceptibility, 4-142 to 147
  - nomenclature, 2-16 to 22
  - permittivity, 12-47 to 55
  - physical properties, 4-43 to 101
  - polarizability, 10-193 to 202
  - reagents for determination, 8-8 to 12
  - solubility as a function of temperature, 8-121 to 126
  - solubility product constant, 8-127 to 129
  - solubility, qualitative rules, 8-136 to 137
  - standard thermodynamic properties, 5-4 to 42
  - surface tension, 6-161 to 164
- INS, definition, 12-1 to 4
- Insulation, thermal conductivity of, 12-211 to 212
- Insulators, breakdown voltage, 15-42 to 46
- Integral tables, A-46
- Integration, methods and techniques, A-11 to 15
- Interatomic distances
- diatomic molecules, 9-102 to 107
  - gas-phase molecules, 9-19 to 47
  - organic crystals, 9-1 to 16
  - organometallic compounds, 9-17 to 18
- Internal rotation in molecules, 9-59 to 63
- International System of Units (SI)**, 1-23 to 26
- International Temperature Scale (ITS-90)
- conversion from IPTS-68 and IPTS-48, 1-21 to 22
  - definition and fixed points, 1-20
  - secondary reference points, 15-10 to 11
- International Temperature Scale of 1990 (ITS-90)**, 1-20
- International Union of Pure and Applied Chemistry: *see* IUPAC
- Interstellar Molecules**, 14-7 to 9
- Iodine: *see also* Elements
- critical constants, 6-50 to 69
  - dielectric constant, 12-47 to 55
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - physical properties, 4-133 to 134
  - thermodynamic properties, 5-1 to 3
  - thermodynamic properties at high temperature, 5-43 to 65
  - vapor pressure, 6-72 to 101
- Iodine value, oils and fats, 7-9 to 13

## Ion product

- D<sub>2</sub>O, 8-79
  - water, 8-78, 8-79
- Ion Product of Water Substance**, 8-78
- Ionic Conductivity and Diffusion at Infinite Dilution**, 5-75 to 77
- Ionic Liquids**, 6-153 to 156
- Ionic radii
- in crystals, 12-11 to 12
  - rare earth elements, 4-127 to 132
- Ionic Radii in Crystals**, 12-11 to 12
- Ionization constant
- biological buffers, 7-23 to 25
  - D<sub>2</sub>O, 8-79
  - inorganic acids and bases, 8-40 to 41
  - inorganic compounds in water, 8-127 to 129
  - organic acids and bases, 8-42 to 51
  - water, 8-78, 8-79
- Ionization Constant of Normal and Heavy Water**, 8-79
- Ionization Energies of Atoms and Atomic Ions**, 10-203 to 205
- Ionization Energies of Gas-Phase Molecules**, 10-206 to 223
- Ionization energy
- atoms and ions, 10-203 to 205
  - molecules, 10-206 to 223
  - neutral atoms, 1-18 to 19
  - rare earth elements, 4-127 to 132
- Ionization gauges, sensitivity, 15-12
- Ionization potential: *see* Ionization energy
- Ions
- aerosol, 14-41 to 47
  - in the atmosphere, 14-41 to 47
  - diffusion in aqueous solutions, 5-75 to 77
  - electrical conductivity in aqueous solutions, 5-75 to 77
  - enthalpy of formation, 10-206 to 223
  - heat capacity, aqueous solutions, 5-66 to 67
  - magnetic properties, 12-107 to 115
  - nomenclature, 2-16 to 22
  - polarizability, 12-13 to 14
  - radii, in crystals, 12-11 to 12
  - thermodynamic properties, aqueous solutions, 5-66 to 67
- Iridium: *see also* Elements
- electrical resistivity, 12-41 to 42
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - thermal properties, 12-203 to 204
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
- Iron: *see also* Elements
- electrical resistivity, 12-41 to 42
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135, 12-202
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - thermal conductivity, 12-206 to 207
  - thermal properties, 12-203 to 204

## vapor pressure, 6-72 to 101

- vapor pressure, high temperature, 4-136 to 137
- Iron-constantan thermocouple tables, 15-1 to 9
- Irradiance of the sun, 14-19
- Isoelectric point, amino acids, 7-1 to 2
- Isotopes, summary of properties, 11-56 to 253
- Isotopic abundance, 1-14 to 17, 11-56 to 253
- ITS-90
- conversion from IPTS-68 and IPTS-48, 1-21 to 22
  - definition and fixed points, 1-20
  - secondary reference points, 15-10 to 11
- IUPAC
- atomic weights, 1-12 to 13
  - chemical structure representation (InChI), 2-27 to 28
  - nomenclature for carbohydrates, 7-14 to 15
  - nomenclature for inorganic ions and ligands, 2-16 to 22
  - nomenclature for organic substituent groups, 2-23 to 26
  - nomenclature for polymers, 13-1 to 4
  - pH scale, 8-32 to 36
  - symbols for physical quantities, 2-1 to 12
  - vapor pressure calibration data, 6-111
- IUPAC Recommended Data for Vapor Pressure Calibration**, 6-111

## J

- Jacobi polynomials, A-83 to 85
- Josephson ratio, 1-1 to 11
- Joule, definition, 1-23 to 26
- Jupiter, orbital data and dimensions, 14-2 to 3

## K

- Katal, definition, 1-23 to 26
- Kelvin, definition, 1-23 to 26
- Kerr constants, 12-167 to 180
- Kilogram, definition, 1-23 to 26
- Kinetics

  - atmospheric reactions, 5-90 to 101
  - conversion factors, 1-43

- Krypton: *see also* Elements

  - critical constants, 6-50 to 69
  - cryogenic properties, 6-143
  - electron configuration, 1-18 to 19
  - entropy, 5-1 to 3
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - mean free path, 6-48
  - permittivity (dielectric constant), 6-166 to 187, 6-188
  - physical properties, 4-133 to 134
  - solubility in water, 8-80 to 83
  - thermal conductivity, 6-218 to 219
  - van der Waals constants, 6-47
  - vapor pressure, 6-72 to 101, 6-102 to 109
  - viscosity, 6-208

## L

- Laboratory reagents, preparation of, 8-1 to 4
- Laboratory Solvents and other Liquid Reagents**, 15-13 to 22



- Laguerre polynomials, **A-83** to 85
- Lanthanum: *see also* Elements  
 electrical resistivity, **12-41** to 42  
 electron configuration, **1-18** to 19  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1** to 42  
 ionization energy, **10-203** to 205  
 isotopes and their properties, **11-56** to 253  
 magnetic susceptibility, **4-142** to 147  
 molten, density, **4-139** to 141  
 physical properties, **4-133** to 134  
 thermal properties, **12-203** to 204  
 vapor pressure, **6-72** to 101  
 vapor pressure, high temperature, **4-136** to 137
- Laplacian, definition, **A-68** to 75
- Lasers  
 characteristics of various types, **10-255** to 260  
 infrared, frequencies, **10-261** to 267
- Lattice constants  
 elements, **4-156** to 163, **12-15** to 18  
 inorganic compounds, **4-156** to 163  
 minerals, **4-156** to 163  
 rare earth elements, **4-127** to 132  
 semiconductors, **12-80** to 92
- Lattice Energies**, **12-21** to 33
- Lattice energy, **12-21** to 33, **12-34**
- Lawrencium: *see also* Elements  
 electron configuration, **1-18** to 19  
 history, occurrence, uses, **4-1** to 42  
 isotopes and their properties, **11-56** to 253
- Lead: *see also* Elements  
 electrical resistivity, **12-41** to 42  
 electron configuration, **1-18** to 19  
 heat capacity, **4-135**, **12-202**  
 history, occurrence, uses, **4-1** to 42  
 ionization energy, **10-203** to 205  
 isotopes and their properties, **11-56** to 253  
 magnetic susceptibility, **4-142** to 147  
 molten, density, **4-139** to 141  
 physical properties, **4-133** to 134  
 thermal conductivity, **12-206** to 207  
 thermal properties, **12-203** to 204  
 thermodynamic properties, **5-1** to 3  
 vapor pressure, **6-72** to 101  
 vapor pressure, high temperature, **4-136** to 137
- LEED, definition, **12-1** to 4
- Legendre polynomials, **A-83** to 85
- Legendre's equation, **A-46** to 56
- Leptons, summary of properties, **11-1** to 55
- Lifetime  
 fundamental particles, **11-1** to 55  
 in laser systems, **10-255** to 260  
 nuclides, **11-56** to 253
- Light, speed of, **1-1** to 11
- Lightning, **14-41** to 47
- LIMS, definition, **12-1** to 4
- Line Spectra of the Elements**, **10-1** to 92
- Line strengths in atomic spectra, **10-93** to 155
- Line width, x-ray lines, **10-234**
- Liquid air, thermodynamic properties, **6-15** to 20
- Liquid helium properties, **6-144**
- Liquid metals  
 density, **4-139** to 141  
 viscosity, **6-216** to 217
- Liquids  
 breakdown voltage, **15-42** to 46  
 dielectric constant, **6-166** to 187  
 diffusion, **6-228** to 229  
 flammability, **15-13** to 22  
 index of refraction, **4-148**, **10-252**  
 Kerr constants, **12-167** to 180  
 permittivity, **6-166** to 187  
 speed of sound in, **14-48** to 49  
 surface tension, **6-161** to 164  
 thermal conductivity, **6-220** to 224  
 Verdet constants, **12-167** to 180  
 viscosity, **6-209** to 213
- Liter, definition, **1-23** to 26
- Lithium: *see also* Elements  
 electrical resistivity, **12-41** to 42  
 electron configuration, **1-18** to 19  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1** to 42  
 ionization energy, **10-203** to 205  
 isotopes and their properties, **11-56** to 253  
 magnetic susceptibility, **4-142** to 147  
 molten, density, **4-139** to 141  
 physical properties, **4-133** to 134  
 thermal properties, **12-203** to 204  
 thermodynamic properties, **5-1** to 3  
 vapor pressure, **6-72** to 101  
 vapor pressure, high temperature, **4-136** to 137
- Lithosphere, mass of, **14-10** to 11
- Logarithmic series, **A-65** to 68
- Log *P*, **16-43** to 47
- Loss factor, glasses, **12-58**
- Loss tangent, **6-14**
- Loudness level, definition, **14-53** to 54
- Low Temperature Baths for Maintaining Constant Temperature**, **15-35**
- Lumen, definition, **1-23** to 26
- Lutetium: *see also* Elements  
 electrical resistivity, **12-41** to 42  
 electron configuration, **1-18** to 19  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1** to 42  
 ionization energy, **10-203** to 205  
 isotopes and their properties, **11-56** to 253  
 magnetic susceptibility, **4-142** to 147  
 molten, density, **4-139** to 141  
 physical properties, **4-133** to 134  
 thermal properties, **12-203** to 204  
 vapor pressure, **6-72** to 101  
 vapor pressure, high temperature, **4-136** to 137
- Lux, definition, **1-23** to 26
- ## M
- Maclaurin series, **A-65** to 68
- Madelung constant, **12-34**
- Magnesium: *see also* Elements  
 electrical resistivity, **12-41** to 42  
 electron configuration, **1-18** to 19  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1** to 42  
 ionization energy, **10-203** to 205  
 isotopes and their properties, **11-56** to 253  
 magnetic susceptibility, **4-142** to 147  
 molten, density, **4-139** to 141  
 thermal conductivity, **12-206** to 207  
 thermal properties, **12-203** to 204  
 thermodynamic properties, **5-1** to 3  
 vapor pressure, **6-72** to 101  
 vapor pressure, high temperature, **4-136** to 137
- Magnetic materials, composition and properties, **12-107** to 115
- Magnetic moment  
 electron, **1-1** to 11, **11-1** to 55  
 fundamental particles, **11-1** to 55  
 NMR, for important nuclei, **9-113** to 115  
 nuclides, **11-56** to 253  
 proton, **1-1** to 11  
 rare earth elements, **4-127** to 132
- Magnetic phase transitions, **12-19** to 20
- Magnetic properties  
 alloys, **12-107** to 115  
 organic magnets, **12-116** to 118  
 rare earth elements, **4-127** to 132  
 superconductors, **12-59** to 74, **12-75** to 76
- Magnetic susceptibility  
 elements, **4-142** to 147  
 inorganic compounds, **4-142** to 147  
 organic compounds, **3-672** to 676  
 rare earth elements, **4-127** to 132  
 semiconductors, **12-80** to 92  
 various materials, **12-107** to 115
- Magnetic Susceptibility of the Elements and Inorganic Compounds**, **4-142** to 147
- Magnetism, symbols and units, **1-27**, **12-107** to 115
- Magneton (nuclear, Bohr), **1-1** to 11
- Magneto-optic constants, **12-167** to 180
- Magnetostriction, **12-107** to 115
- Major World Earthquakes**, **14-27** to 30
- Makemake, orbital data and dimensions, **14-2** to 3
- Manganese: *see also* Elements  
 electrical resistivity, **12-41** to 42  
 electron configuration, **1-18** to 19  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1** to 42  
 ionization energy, **10-203** to 205  
 isotopes and their properties, **11-56** to 253  
 magnetic susceptibility, **4-142** to 147  
 molten, density, **4-139** to 141  
 physical properties, **4-133** to 134  
 thermal properties, **12-203** to 204  
 vapor pressure, **6-72** to 101  
 vapor pressure, high temperature, **4-136** to 137
- Mars, orbital data and dimensions, **14-2** to 3
- Mass  
 atmosphere, oceans, and crust, **14-10** to 11  
 atomic mass unit, **1-1** to 11  
 atomic, of nuclides, **11-56** to 253  
 earth, moon, and sun, **14-1**  
 electron, proton, neutron, **1-1** to 11  
 fundamental particles, **11-1** to 55  
 planets, **14-2** to 3  
 planets, relative to sun, **14-1**  
 satellites, **14-4** to 6  
 sun, **14-2** to 3
- Mass Spectral Peaks of Common Organic Solvents**, **8-143** to 149
- Mass, Dimensions, and other Parameters of the Earth**, **14-10** to 11
- Materials characterization, techniques, **12-1** to 4
- Mathematical constants, **A-1**
- Mean Activity Coefficients of Electrolytes as a Function of Concentration**, **5-80** to 83
- Mean free path  
 common gases, **6-48**

electrons in solids, 12-119 to 120  
 molecules in the atmosphere, 14-20 to 25

**Mean Free Path and Related Properties of Gases**, 6-48

**Mean Temperatures in the United States, 1900-1992**, 14-36 to 37

Mechanical properties  
 commercial metals and alloys, 12-221  
 gas clathrate hydrates, 6-148 to 152  
 rare earth elements, 4-127 to 132

Meitnerium (element 109), 4-1 to 42, 11-56 to 253

**Melting Curve of Mercury**, 6-159

Melting point  
 alloys (eutectics), 15-36  
 amino acids, 7-1 to 2  
 commercial metals and alloys, 12-221  
 cryogenic fluids, 6-143  
 $D_2O$ , 6-9  
 depression of, 15-28  
 elements, 4-133 to 134  
 fatty acids, 7-7 to 8  
 halocarbons, 6-145 to 147  
 ice, as function of pressure, 6-13  
 inorganic compounds, 4-43 to 101, 6-130 to 139  
 ionic liquids, 6-153 to 156  
 mercury, as function of pressure, 6-159  
 metals, 12-203 to 204  
 oils and fats, 7-9 to 13  
 organic compounds, 3-1 to 523, 6-130 to 139  
 pressure dependence, 6-49  
 rare earth elements, 4-127 to 132  
 semiconductors, 12-80 to 92  
 solvents, 15-13 to 22

**Melting Point of Ice as a Function of Pressure**, 6-13

**Melting, Boiling, Triple, and Critical Point Temperatures of the Elements**, 4-133 to 134

Mendelevium: *see also* Elements  
 electron configuration, 1-18 to 19  
 history, occurrence, uses, 4-1 to 42  
 isotopes and their properties, 11-56 to 253

Mercury: *see also* Elements  
 compressibility, 6-158  
 critical constants, 6-50 to 69  
 density, 6-157  
 electrical resistivity, 12-41 to 42  
 electron configuration, 1-18 to 19  
 heat capacity, 4-135, 6-158  
 history, occurrence, uses, 4-1 to 42  
 ionization energy, 10-203 to 205  
 isotopes and their properties, 11-56 to 253  
 magnetic susceptibility, 4-142 to 147  
 melting curve, 6-159  
 physical properties, 4-133 to 134  
 specific volume, 6-157  
 speed of sound in, 6-158  
 thermal conductivity, 6-220 to 224  
 thermal expansion, 6-158  
 thermal properties, 12-203 to 204  
 thermodynamic properties, 5-1 to 3  
 vapor pressure, 6-111, 6-160  
 vapor pressure, high temperature, 4-136 to 137

Mercury (planet), orbital data and dimensions, 14-2 to 3

Mesons, summary of properties, 11-1 to 55

Metal oxides, secondary electron emission, 12-122

Metals  
 coefficient of friction, 15-47 to 48  
 commercial, mechanical and thermal properties, 12-221  
 crystal phase transitions, 12-19 to 20  
 crystal structure, 12-15 to 18  
 elastic constants, 12-35 to 40  
 electrical resistivity, 12-41 to 42  
 electron inelastic mean free path, 12-119 to 120  
 extinction coefficient, 12-123 to 147  
 Fermi energy, 12-219 to 220  
 heat capacity, 12-202  
 index of refraction, 12-123 to 147  
 optical properties, 12-123 to 147  
 reflection coefficient, 12-123 to 147  
 secondary electron emission, 12-122  
 speed of sound in, 14-48 to 49  
 sublimation pressure, 6-72 to 101  
 superconducting properties, 12-59 to 74  
 thermal conductivity, 12-206 to 207  
 thermal properties, 12-203 to 204  
 thermoelectric properties, 12-217 to 218

**Metals and Alloys with Low Melting Temperature**, 15-36

Meter, definition, 1-23 to 26

Microwave bands, classification, 10-240 to 241

Million, milliard (definition), 1-38

Minerals  
 chemical formulas, 4-149 to 155, 4-156 to 163  
 crystal structure, 4-156 to 163  
 elastic constants, 12-35 to 40  
 hardness, 12-222  
 index of refraction, 4-149 to 155  
 physical constants, 4-149 to 155  
 semiconducting properties, 12-80 to 92  
 solubility as a function of temperature, 8-121 to 126  
 thermal conductivity, 12-211 to 212

**Miscibility of Organic Solvents**, 15-23 to 24

Mobility  
 of atmospheric ions, 14-41 to 47  
 in semiconductors, 12-80 to 92, 12-95 to 98

**Molar Conductivity of Aqueous HF, HCl, HBr, and HI**, 5-73

Mole, definition, 1-23 to 26

**Molecular Formula Index of Organic Compounds**, 3-634 to 671

Molecular weight  
 amino acids, 7-1 to 2  
 inorganic compounds, 4-43 to 101  
 organic compounds, 3-1 to 523

Molecules  
 appearance potential, 10-206 to 223  
 barriers to internal rotation, 9-59 to 63  
 bond lengths, 9-1 to 16, 9-17 to 18, 9-48  
 bond lengths and angles, 9-19 to 47  
 bond strengths, 9-64 to 97  
 electron affinity, 10-156 to 173  
 force constants, 9-99  
 fundamental vibrational frequencies, 9-100 to 102  
 ionization energy, 10-206 to 223  
 polarizability, 10-193 to 202  
 proton affinity, 10-174 to 192

Molybdenum: *see also* Elements  
 electrical resistivity, 12-41 to 42  
 electron configuration, 1-18 to 19

heat capacity, 4-135  
 history, occurrence, uses, 4-1 to 42  
 ionization energy, 10-203 to 205  
 isotopes and their properties, 11-56 to 253  
 magnetic susceptibility, 4-142 to 147  
 molten, density, 4-139 to 141  
 physical properties, 4-133 to 134  
 thermal properties, 12-203 to 204  
 vapor pressure, 6-72 to 101  
 vapor pressure, high temperature, 4-136 to 137

Moment of inertia, formulas for, A-97

Moon  
 orbital constants and other parameters, 14-2 to 3, 14-4 to 6  
 ratio of mass to earth's mass, 14-1

Muon  
 in cosmic ray showers, 11-267 to 270  
 summary of properties, 11-1 to 55

**Musical Scales**, 14-52

## N

NAA, definition, 12-1 to 4

Natural trigonometric functions to four places, A-6 to 7

**Natural Width of X-Ray Lines**, 10-234

Néel temperature  
 magnetic materials, 12-107 to 115  
 rare earth elements, 4-127 to 132

Neodymium: *see also* Elements  
 electrical resistivity, 12-41 to 42  
 electron configuration, 1-18 to 19  
 heat capacity, 4-135  
 history, occurrence, uses, 4-1 to 42  
 ionization energy, 10-203 to 205  
 isotopes and their properties, 11-56 to 253  
 magnetic susceptibility, 4-142 to 147  
 molten, density, 4-139 to 141  
 physical properties, 4-133 to 134  
 thermal properties, 12-203 to 204  
 vapor pressure, 6-72 to 101  
 vapor pressure, high temperature, 4-136 to 137

Neon: *see also* Elements  
 critical constants, 6-50 to 69  
 cryogenic properties, 6-143  
 electron configuration, 1-18 to 19  
 entropy, 5-1 to 3  
 history, occurrence, uses, 4-1 to 42  
 ionization energy, 10-203 to 205  
 isotopes and their properties, 11-56 to 253  
 magnetic susceptibility, 4-142 to 147  
 mean free path, 6-48  
 permittivity (dielectric constant), 6-166 to 187, 6-188  
 physical properties, 4-133 to 134  
 solubility in water, 8-80 to 83  
 thermal conductivity, 6-218 to 219  
 van der Waals constants, 6-47  
 vapor pressure, 6-72 to 101, 6-102 to 109  
 viscosity, 6-208

Neptune, orbital data and dimensions, 14-2 to 3

Neptunium: *see also* Elements  
 electron configuration, 1-18 to 19  
 history, occurrence, uses, 4-1 to 42  
 ionization energy, 10-203 to 205  
 isotopes and their properties, 11-56 to 253  
 magnetic susceptibility, 4-142 to 147  
 physical properties, 4-133 to 134



- vapor pressure, high temperature, 4-136 to 137
- Neutrino, summary of properties, 11-1 to 55
- Neutron
- mass, 1-1 to 11
  - range in paraffin, 16-48
  - scattering and absorption, 11-254 to 266
  - summary of properties, 11-1 to 55
- Neutron cross sections, 11-254 to 266
- Neutron resonance integrals, 11-254 to 266
- Neutron Scattering and Absorption Properties**, 11-254 to 266
- Newton, definition, 1-23 to 26
- Nichrome, wire tables, 15-37
- Nickel: *see also* Elements
- electrical resistivity, 12-41 to 42
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - thermal properties, 12-203 to 204
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
- Niobium: *see also* Elements
- electrical resistivity, 12-41 to 42
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - physical properties, 4-133 to 134
  - thermal properties, 12-203 to 204
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
- NIST Atomic Transition Probability Tables**, 10-93 to 155
- Nitrogen: *see also* Elements
- critical constants, 6-50 to 69
  - cryogenic properties, 6-143
  - electron configuration, 1-18 to 19
  - enthalpy of vaporization, 6-112 to 129
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - mean free path, 6-48
  - permittivity (dielectric constant), 6-166 to 187, 6-188
  - physical properties, 4-133 to 134
  - solubility in water, 8-80 to 83
  - thermal conductivity, 6-21 to 37, 6-218 to 219
  - thermodynamic properties, 5-1 to 3
  - thermodynamic properties at high temperature, 5-43 to 65
  - thermophysical properties, 6-21 to 37
  - van der Waals constants, 6-47
  - vapor pressure, 6-72 to 101, 6-102 to 109
  - viscosity, 6-21 to 37, 6-208
- NMR spectrum
- characteristic  $^{13}\text{C}$  chemical shifts, 9-117
  - characteristic shifts for protons, 9-116
  - nuclear moments and resonance frequencies, 9-113 to 115
  - solvents,  $^{13}\text{C}$  shifts, 8-142
  - solvents, proton shifts, 8-150 to 156
- Nobel Laureates in Chemistry and Physics**, 2-69 to 70
- Nobelium: *see also* Elements
- electron configuration, 1-18 to 19
  - history, occurrence, uses, 4-1 to 42
  - isotopes and their properties, 11-56 to 253
- Noise thresholds, 14-53 to 54
- Nomenclature
- carbohydrates, 7-14 to 15
  - chemical, references, 2-15
  - inorganic ions and ligands, 2-16 to 22
  - minerals, 4-149 to 155
  - organic substituent groups and ring systems, 2-23 to 26
  - physical quantities, 2-1 to 12
  - polymers, 13-1 to 4
- Nomenclature for Inorganic Ions and Ligands**, 2-16 to 22
- Nomenclature for Organic Polymers**, 13-1 to 4
- Nomenclature of Chemical Compounds**, 2-15
- Nonlinear Optical Constants**, 12-181 to 183
- Normal probability function, A-88 to 90
- NQR, definition, 12-1 to 4
- NRA, definition, 12-1 to 4
- Nuclear magnetic resonance: *see* NMR
- Nuclear magneton, 1-1 to 11
- Nuclear spins and moments
- for all nuclides, 11-56 to 253
  - for important nuclei in NMR, 9-113 to 115
- Nuclear Spins, Moments, and Other Data Related to NMR Spectroscopy**, 9-113 to 115
- Nucleic acids
- genetic code, 7-6
  - purine and pyrimidine bases, 7-5
- Nuclides, summary of properties, 11-56 to 253
- Nutrient Values of Foods**, 7-49 to 60
- ## O
- Ocean Pressure as a Function of Depth and Latitude**, 14-15
- Oceans
- abundance of chemical elements, 14-18
  - pressure as a function of depth and latitude, 14-15
- Octanol-Water Partition Coefficients**, 16-43 to 47
- Ohm
- definition, 1-23 to 26
  - maintained value, 1-1 to 11
- Oils, composition and properties, 7-9 to 13
- Optical materials
- elasto-, electro-, and magneto-optic constants, 12-167 to 180
  - harmonic generation, 12-181 to 183
  - index of refraction, 10-250
  - nonlinear constants, 12-181 to 183
- Optical properties
- glass, 10-250
  - human eye, 10-242
  - inorganic crystals, 10-246 to 249
  - metals, 12-123 to 147
  - polytetrafluoroethylene, 12-148 to 166
  - semiconductors, 12-123 to 147, 12-148 to 166, 12-181 to 183
  - solids, as function of wavelength, 10-246 to 249, 12-148 to 166
- various materials, 12-167 to 180, 12-181 to 183
- Optical Properties of Selected Elements**, 12-123 to 147
- Optical Properties of Selected Inorganic and Organic Solids**, 12-148 to 166
- Orbital data for planets and satellites, 14-2 to 3, 14-4 to 6
- Organic Analytical Reagents for the Determination of Inorganic Substances**, 8-8 to 12
- Organic compounds
- bond lengths (in crystals), 9-1 to 16
  - bond lengths and angles (in gas phase), 9-19 to 47
  - bond strengths, 9-64 to 97
  - characteristic  $^{13}\text{C}$  chemical shifts, 9-117
  - characteristic proton chemical shifts, 9-116
  - classes, definitions, 2-43 to 67
  - dipole moment, 9-50 to 58
  - enthalpy of fusion, 6-130 to 139
  - enthalpy of vaporization, 6-112 to 129
  - heat of combustion, 5-68
  - infrared correlation charts, 9-108 to 112
  - magnetic susceptibility, 3-672 to 676
  - mass spectral peaks, 8-143 to 149
  - NMR shifts, 8-150 to 156
  - nomenclature, 2-23 to 26
  - physical properties, 3-1 to 523
  - polarizability, 10-193 to 202
  - solubility, aqueous, 8-85 to 120
  - solubility, aqueous at high temperature, 8-133 to 135
  - sublimation pressure, 6-70 to 71
  - superconducting properties, 12-77 to 79
  - surface tension, 6-161 to 164
  - thermal conductivity, 6-220 to 224
  - thermodynamic properties, 5-4 to 42
- Organic Magnets**, 12-116 to 118
- Organic Semiconductors**, 12-95 to 98
- Organic Substituent Groups and Ring Systems**, 2-23 to 26
- Organic Superconductors**, 12-77 to 79
- Organometallic compounds, bond lengths, 9-17 to 18
- Orthogonal curvilinear coordinates, A-75 to 77
- Orthogonal polynomials
- formulas and relations, A-83 to 85
  - tables, A-86
- Oscillator strengths in atomic spectra, 10-93 to 155
- Osmium: *see also* Elements
- electrical resistivity, 12-41 to 42
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - thermal properties, 12-203 to 204
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
- Oxidation and reduction reagents, decinormal solutions, 8-7
- Oxidation-reduction potentials
- biochemical species, 7-16 to 18
  - general table, 8-20 to 29
  - ion radicals, 8-30 to 31

Oxygen: *see also* Elements  
 critical constants, 6-50 to 69  
 cryogenic properties, 6-143  
 electron configuration, 1-18 to 19  
 enthalpy of fusion, 6-130 to 139  
 enthalpy of vaporization, 6-112 to 129  
 history, occurrence, uses, 4-1 to 2  
 ionization energy, 10-203 to 205  
 isotopes and their properties, 11-56 to 253  
 magnetic susceptibility, 4-142 to 147  
 mean free path, 6-48  
 permittivity (dielectric constant), 6-166 to 187, 6-188  
 physical properties, 4-133 to 134  
 solubility in water, 8-80 to 83  
 thermal conductivity, 6-21 to 37, 6-218 to 219  
 thermodynamic properties, 5-1 to 3  
 thermophysical properties, 6-21 to 37  
 van der Waals constants, 6-47  
 vapor pressure, 6-72 to 101, 6-102 to 109  
 viscosity, 6-21 to 37, 6-208

## P

Palladium: *see also* Elements  
 electrical resistivity, 12-41 to 42  
 electron configuration, 1-18 to 19  
 heat capacity, 4-135  
 history, occurrence, uses, 4-1 to 2  
 ionization energy, 10-203 to 205  
 isotopes and their properties, 11-56 to 253  
 magnetic susceptibility, 4-142 to 147  
 molten, density, 4-139 to 141  
 physical properties, 4-133 to 134  
 thermal properties, 12-203 to 204  
 vapor pressure, 6-72 to 101  
 vapor pressure, high temperature, 4-136 to 137  
 Paramagnetic moment, rare earth elements, 4-127 to 132  
 Paramagnetic susceptibility, elements and inorganic compounds, 4-142 to 147  
 Partial molar volume, amino acids, 7-1 to 2  
 Particle size, 15-38  
 Particles, fundamental, summary of properties, 11-1 to 55  
 Pascal, definition, 1-23 to 26  
 Pauling electronegativity scale, 9-98  
 Pearson symbols, 12-5 to 10, 12-15 to 18  
 Peltier effect, 12-217 to 218  
 Percentage points, chi-square distribution, A-91 to 92  
 Percentage points, *F*-distribution, A-93 to 96  
 Percentage points, Student's *t*-distribution, A-91  
 Periodic functions, Fourier expansions, A-59 to 61  
 Periodic table of the elements, Inside front cover  
 Permeability, magnetic alloys, 12-107 to 115  
 Permeability of vacuum, 1-1 to 11  
 Permittivity (dielectric constant)  
   cryogenic fluids, temperature and pressure dependence, 6-21 to 37  
   crystals, 12-47 to 55  
   gases, 6-188  
   glass, 12-58  
   ice, 6-12  
   liquid helium, 6-144

liquids, 6-166 to 187  
 plastics, 13-13  
 quartz, 12-58  
 rubbers, 13-13  
 semiconductors, 12-80 to 92  
 solids, 12-47 to 55  
 solvents, 8-141  
 vacuum, 1-1 to 11  
 water and steam, temperature and pressure dependence, 6-1 to 4  
 water, frequency dependence, 6-14  
**Permittivity (Dielectric Constant) of Gases**, 6-188  
**Permittivity (Dielectric Constant) of Inorganic Solids**, 12-47 to 55  
**Permittivity (Dielectric Constant) of Liquids**, 6-166 to 187  
**Permittivity (Dielectric Constant) of Water at Various Frequencies**, 6-14  
 Peroxide formation by laboratory chemicals, 16-1 to 12  
 pH  
   acid-base indicators, 8-15 to 17  
   biological buffers, 7-26  
   biological materials and tissues, 7-27  
   blood, 7-27  
   definition of pH scale, 8-32 to 36  
   fluorescent indicators, 8-18 to 19  
   foods, 7-27  
   measurement in natural waters, 8-37 to 38  
   seawater, 8-37 to 38  
   solutions giving round values, 8-39  
   standards, 8-32 to 36  
**pH Scale for Aqueous Solutions**, 8-32 to 36  
**Phase Diagrams**, 12-184 to 201  
 Phase transitions  
   enthalpy of fusion, 6-130 to 139  
   enthalpy of vaporization, 6-112 to 129  
   ice, 6-12, 6-13  
   polymers, glass to crystal, 13-6 to 12  
   rare earth elements, 4-127 to 132  
   solid elements, 12-19 to 20  
**Phase Transitions in the Solid Elements at Atmospheric Pressure**, 12-19 to 20  
 Phon, definition, 14-53 to 54  
 Phonon-electron coupling, rare earth elements, 4-127 to 132  
 Phosphorus: *see also* Elements  
   critical constants, 6-50 to 69  
   dielectric constant, 12-47 to 55  
   electron configuration, 1-18 to 19  
   heat capacity, 4-135  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   magnetic susceptibility, 4-142 to 147  
   physical properties, 4-133 to 134  
   thermodynamic properties, 5-1 to 3  
   vapor pressure, 6-72 to 101  
 Photochemical data, 5-90 to 101  
 Photoelastic constants, 12-167 to 180  
**Photon Attenuation Coefficients**, 10-235 to 239  
 Photopic spectral luminous efficiency function, 10-242  
**Physical and Optical Properties of Minerals**, 4-149 to 155  
**Physical Constants of Inorganic Compounds**, 4-43 to 101

**Physical Constants of Organic Compounds**, 3-1 to 523  
 Physical constants, fundamental, 1-1 to 11  
 Physical properties  
   amino acids, 7-1 to 2  
   gas clathrate hydrates, 6-148 to 152  
   inorganic compounds, 4-43 to 101  
   minerals, 4-149 to 155  
   oils and fats, 7-9 to 13  
   organic compounds, 3-1 to 523  
   semiconductors, 12-80 to 92  
   solvents, 15-13 to 22  
**Physical Properties of the Rare Earth Metals**, 4-127 to 132  
 Physical quantities  
   definitions, 2-43 to 67  
   terminology and symbols, 2-1 to 12  
 Pi, value of, A-1  
 Pion, summary of properties, 11-1 to 55  
 Pitch, in musical scales, 14-52  
 PIXE, definition, 12-1 to 4  
 pK  
   acid-base indicators, 8-15 to 17  
   amino acids, 7-1 to 2  
   biological buffers, 7-23 to 25, 7-26  
   inorganic acids and bases, 8-40 to 41  
   organic acids and bases, 8-42 to 51  
   purine and pyrimidine bases, 7-5  
 Planck constant, 1-1 to 11  
 Planets  
   atmospheric composition, 14-2 to 3  
   general properties, 14-2 to 3  
   orbital parameters, 14-2 to 3  
   satellites, 14-4 to 6  
 Plastics  
   breakdown voltage, 15-42 to 46  
   density, 15-39  
   dielectric constant, 13-13  
   speed of sound in, 14-48 to 49  
   thermal conductivity, 12-211 to 212  
 Platinum: *see also* Elements  
   electrical resistivity, 12-41 to 42  
   electron configuration, 1-18 to 19  
   heat capacity, 4-135  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   magnetic susceptibility, 4-142 to 147  
   molten, density, 4-139 to 141  
   physical properties, 4-133 to 134  
   resistance of wires, 15-37  
   thermal conductivity, 12-206 to 207  
   thermal properties, 12-203 to 204  
   vapor pressure, 6-72 to 101  
   vapor pressure, high temperature, 4-136 to 137  
   wire tables, 15-37  
 Platinum-rhodium thermocouple tables, 15-1 to 9  
 Pluto, orbital data and dimensions, 14-2 to 3  
 Plutonium: *see also* Elements  
   electron configuration, 1-18 to 19  
   heat capacity, 4-135  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   magnetic susceptibility, 4-142 to 147  
   molten, density, 4-139 to 141  
   physical properties, 4-133 to 134  
   thermal properties, 12-203 to 204  
   vapor pressure, 6-72 to 101

- vapor pressure, high temperature, 4-136 to 137
  - Point groups of small molecules, 9-100 to 102
  - Polarizability
    - atoms and ions in solids, 12-13 to 14
    - free atoms and molecules, 10-193 to 202
  - Polarizability of Atoms and Ions in Solids**, 12-13 to 14
  - Pollutants
    - airborne, limits in the workplace, 16-29 to 42
    - Henry's Law constants, 8-85 to 120
    - octanol-water partition coefficients, 16-43 to 47
    - solubility, 8-85 to 120
  - Polonium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - vapor pressure, 6-72 to 101
  - Polymers
    - breakdown voltage, 15-42 to 46
    - cohesive energy density, 13-70 to 71
    - critical solution temperatures, 13-19 to 36
    - density of melts, 13-14 to 18
    - dielectric constant, 13-13
    - electron inelastic mean free path, 12-119 to 120
    - enthalpy of solution, 13-42 to 69
    - glass transition temperature, 13-6 to 12
    - molar volume, 13-14 to 18
    - nomenclature, 13-1 to 4
    - solubility parameters, 13-70 to 71
    - solutions, enthalpy of mixing, 13-42 to 69
    - solvent activities, 13-37 to 41
    - solvents for, 13-5
    - vapor pressure of solutions, 13-37 to 41
  - Polynomials, orthogonal, A-83 to 85
  - Potassium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - thermodynamic properties, 5-1 to 3
    - thermodynamic properties at high temperature, 5-43 to 65
    - vapor pressure, 6-72 to 101
    - vapor pressure, high temperature, 4-136 to 137
  - Potential
    - electrical, in the atmosphere, 14-41 to 47
    - oxidation-reduction, 8-20 to 29
    - oxidation-reduction, of ion radicals, 8-30 to 31
  - Practical pH Measurements on Natural Waters**, 8-37 to 38
  - Praseodymium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - thermal properties, 12-203 to 204
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
  - Precipitation of metal ions, 16-1 to 12
  - Preparation of Special Analytical Reagents**, 8-1 to 4
  - Pressure
    - atmosphere, as function of altitude, 14-20 to 25
    - conversion factors, 1-40
    - earth, as function of depth, 14-14
    - effect on boiling point, 15-26
    - effect on freezing point, 6-49
    - ocean, as function of depth, 14-15
    - planetary atmospheres, 14-2 to 3
    - sensitivity of ionization gauges, 15-12
  - Pressure and Temperature Dependence of Liquid Density**, 6-140 to 141
  - Pressure-Volume-Temperature Relationship for Polymer Melts**, 13-14 to 18
  - Probability function, A-88 to 90
  - Promethium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
  - Properties of Amino Acids**, 7-1 to 2
  - Properties of Antiferroelectric Crystals**, 12-57
  - Properties of Carrier Gases for Gas Chromatography**, 8-140
  - Properties of Commercial Metals and Alloys**, 12-221
  - Properties of Cryogenic Fluids**, 6-143
  - Properties of Fatty Acids and their Methyl Esters**, 7-7 to 8
  - Properties of Gas Clathrate Hydrates**, 6-148 to 152
  - Properties of Ice and Supercooled Water**, 6-12
  - Properties of Liquid Helium**, 6-144
  - Properties of Magnetic Materials**, 12-107 to 115
  - Properties of Organic Semiconductors**, 12-95 to 98
  - Properties of Purine and Pyrimidine Bases**, 7-5
  - Properties of Refrigerants**, 6-145 to 147
  - Properties of Saturated Liquid D<sub>2</sub>O**, 6-10 to 11
  - Properties of Seawater**, 14-16 to 17
  - Properties of Semiconductors**, 12-80 to 92
  - Properties of Superconductors**, 12-59 to 74
  - Properties of the Solar System**, 14-2 to 3
  - Protactinium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - physical properties, 4-133 to 134
  - thermal properties, 12-203 to 204
  - vapor pressure, high temperature, 4-136 to 137
  - Protection Against Ionizing Radiation**, 16-48
  - Proton
    - in cosmic ray showers, 11-267 to 270
    - magnetic moment, 1-1 to 11
    - mass, 1-1 to 11
    - summary of properties, 11-1 to 55
  - Proton Affinities**, 10-174 to 192
  - Proton NMR Chemical Shifts for Characteristic Organic Structures**, 9-116
  - Proton NMR Shifts of Common Organic Solvents**, 8-150 to 156
  - PSD, definition, 12-1 to 4
  - psia and psig, definition, 1-40
  - Purine bases, properties of, 7-5
  - Pyrimidine bases, properties of, 7-5
  - Pyrophoric chemicals, safe handling, 16-1 to 12
- ## Q
- Quadratic equation formula, A-2
  - Quadrupole moments
    - all nuclides, 11-56 to 253
    - important nuclei for NMR, 9-113 to 115
  - Quartz
    - crystallographic data, 4-156 to 163
    - dielectric constant, 12-58
    - loss factor, 12-58
    - optical properties, 4-149 to 155
    - phase diagram, 12-184 to 201
    - thermal conductivity, 12-209 to 210
- ## R
- Rad, definition, 16-48
  - Radiation
    - black body, 10-243 to 244
    - electromagnetic, classification, 10-240 to 241
    - microwave, classification of bands, 10-240 to 241
  - Radiation, ionizing
    - conversion factors, 1-44 to 45
    - from nuclear decay, 11-56 to 253
    - permissible intake of radionuclides, 16-49 to 52
    - protection against, 16-48
  - Radiation, solar
    - by month and latitude, 14-26
    - by wavelength, 14-19
    - flux, solar constant, 14-2 to 3
  - Radiative transition probability, 10-93 to 155
  - Radicals, free: *see* Free radicals
  - Radicals, nomenclature, 2-16 to 22, 2-23 to 26
  - Radio spectrum, 15-50 to 51
  - Radioastronomy, 14-7 to 9
  - Radionuclides, permissible intake, 16-49 to 52
  - Radium: *see also* Elements
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - physical properties, 4-133 to 134



- thermal properties, 12-203 to 204
  - vapor pressure, 6-72 to 101
  - Radius of ions in crystals, 12-11 to 12
  - Radon: *see also* Elements
    - critical constants, 6-50 to 69
    - electron configuration, 1-18 to 19
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - physical properties, 4-133 to 134
    - solubility in water, 8-80 to 83
    - vapor pressure, 6-72 to 101, 6-102 to 109
  - Rankine temperature, conversion to other scales, 1-38
  - Rare earth crystals, Verdet constants, 12-167 to 180
  - Rare earth metals, general properties, 4-127 to 132
  - Rate constants
    - atmospheric reactions, 5-90 to 101
    - conversion factors, 1-43
  - RBS, definition, 12-1 to 4
  - Reagents
    - decinormal solutions, 8-5 to 6, 8-7
    - disposal of, 16-1 to 12
    - formulas for concentration, 8-19
    - organic, for analysis, 8-8 to 12
    - preparation, 8-1 to 4
  - Reduction and Oxidation Potentials for Certain Ion Radicals, 8-30 to 31**
  - Reduction of Weighings in Air to Vacuo, 8-138**
  - Reduction potentials
    - biochemical species, 7-16 to 18
    - general table, 8-20 to 29
    - ion radicals, 8-30 to 31
  - Reference states of elements, 5-4 to 42
  - Reflection coefficient of solids, 12-123 to 147, 12-148 to 166
  - Refractive Index and Transmittance of Representative Glasses, 10-250**
  - Refractive index: *see* Index of refraction
  - Refractory materials
    - hardness, 12-222
    - thermal conductivity, 12-211 to 212
  - Refrigerants, various properties, 6-145 to 147
  - Relation of angular functions in terms of one another, A-8
  - Relative humidity
    - from wet and dry bulb temperatures, 15-32
    - relation to dew point, 15-31
    - solutions for calibration, 15-34
    - solutions for constant humidity, 15-33
  - Relative Sensitivity of Bayard-Alpert Ionization Gauges to Various Gases, 15-12**
  - Relaxation time, in water, 6-14
  - Rem, definition, 16-48
  - Remanence, magnetic materials, 12-107 to 115
  - Representation of Chemical Structures with the IUPAC International Chemical Identifier (InChI), 2-27 to 28**
  - Resistance of wires, 15-37
  - Resistivity, electrical
    - alloys, 12-43 to 45
    - commercial metals and alloys, 12-221
    - conversion factors, 1-42
    - elements, 12-41 to 42
    - glasses, 12-58
    - graphite and related materials, 12-46
    - pure metals, 12-41 to 42
    - quartz, 12-58
    - rare earth elements, 4-127 to 132
    - semiconducting minerals, 12-80 to 92
    - semiconductors, 12-80 to 92, 12-95 to 98
    - superconductors, 12-75 to 76
  - Respirators, for laboratory use, 16-1 to 12
  - RHEED, definition, 12-1 to 4
  - Rhenium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - vapor pressure, 6-72 to 101
    - vapor pressure, high temperature, 4-136 to 137
  - Rhodium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - vapor pressure, 6-72 to 101
    - vapor pressure, high temperature, 4-136 to 137
  - Rhodium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - vapor pressure, 6-72 to 101
    - vapor pressure, high temperature, 4-136 to 137
  - Ring systems, nomenclature, 2-23 to 26
  - Rochelle salts, 12-56
  - Rocks
    - age, 14-10 to 11
    - density, 15-39
    - thermal conductivity, 12-211 to 212
  - Roentgen, definition, 16-48
  - Roentgenium (element 111), 4-1 to 42, 11-56 to 253
  - Rotational constants, diatomic molecules, 9-102 to 107
  - Rounding of numbers, 1-28 to 37
  - Rubbers
    - breakdown voltage, 15-42 to 46
    - density, 15-39
    - dielectric constant, 13-13
    - speed of sound in, 14-48 to 49
    - thermal conductivity, 12-211 to 212
  - Rubidium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - thermodynamic properties, 5-1 to 3
    - vapor pressure, 6-72 to 101
    - vapor pressure, high temperature, 4-136 to 137
  - Russian alphabet, 2-42
  - Ruthenium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - vapor pressure, 6-72 to 101
    - vapor pressure, high temperature, 4-136 to 137
  - Rutherfordium (element 104)
    - electron configuration, 1-18 to 19
    - history, occurrence, uses, 4-1 to 42
    - isotopes and their properties, 11-56 to 253
  - Rydberg constant, 1-1 to 11
- S**
- Sackur-Tetrode constant, 1-1 to 11
  - Safety
    - chemical carcinogens, 16-53 to 58
    - flammability of chemicals, 16-13 to 28
    - laboratory practices, 16-1 to 12
    - radiation, 16-48, 16-49 to 52
  - SALI, definition, 12-1 to 4
  - Salinity scale for seawater, 14-16 to 17
  - Salts
    - activity coefficients, 5-78 to 79, 5-80 to 83
    - decinormal solutions, 8-5 to 6
    - electrical conductivity, 5-71, 5-74
    - enthalpy of solution, 5-85
    - molten, density of, 4-139 to 141
    - solubility as a function of temperature, 8-121 to 126, 8-130
    - vapor pressure of aqueous solutions, 6-110
  - Samarium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - vapor pressure, 6-72 to 101
    - vapor pressure, high temperature, 4-136 to 137
  - Sample size calculations, A-88 to 90
  - SANS, definition, 12-1 to 4
  - Saponification value, oils and fats, 7-9 to 13
  - Satellites of the Planets, 14-4 to 6**
  - Saturn, orbital data and dimensions, 14-2 to 3
  - Scalar product, A-68 to 75
  - Scandium: *see also* Elements
    - electrical resistivity, 12-41 to 42
    - electron configuration, 1-18 to 19
    - heat capacity, 4-135
    - history, occurrence, uses, 4-1 to 42
    - ionization energy, 10-203 to 205
    - isotopes and their properties, 11-56 to 253
    - magnetic susceptibility, 4-142 to 147
    - molten, density, 4-139 to 141
    - physical properties, 4-133 to 134
    - thermal properties, 12-203 to 204
    - vapor pressure, 6-72 to 101

- vapor pressure, high temperature, 4-136 to 137
- Scientific Abbreviations and Symbols**, 2-29 to 41
- Seaborgium (element 106), 4-1 to 42, 11-56 to 253
- Seawater
- composition (elemental), 14-18
  - composition (ions), 14-16 to 17
  - density, 14-16 to 17
  - electrical conductivity, 14-16 to 17
  - freezing point, 14-16 to 17
  - pH measurement, 8-37 to 38
  - pressure as a function of depth, 14-15
  - salinity scale, 14-16 to 17
  - solubility of hydrocarbons in, 8-131 to 132
  - specific heat, 14-16 to 17
  - speed of sound in, 14-48 to 49
  - viscosity, 14-16 to 17
- Secant function, A-6 to 7
- Second, definition, 1-23 to 26
- Second radiation constant, 1-1 to 11
- Secondary Electron Emission**, 12-122
- Secondary Reference Points on the ITS-90 Temperature Scale**, 15-10 to 11
- Seebeck effect, 12-217 to 218
- Selected Properties of Semiconductor Solid Solutions**, 12-93 to 94
- Selenium: *see also* Elements
- critical constants, 6-50 to 69
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - vapor pressure, 6-72 to 101
- SEM, definition, 12-1 to 4
- Semiconductors
- crystal structure, 12-15 to 18, 12-80 to 92
  - diffusion in, 12-99 to 106
  - effective mass, 12-80 to 92
  - elastic constants, 12-35 to 40
  - electrical properties, 12-80 to 92, 12-95 to 98
  - extinction coefficient, 12-123 to 147, 12-148 to 166
  - index of refraction, 12-123 to 147, 12-148 to 166
  - minerals, resistivity of, 12-80 to 92
  - optical properties, 12-123 to 147, 12-148 to 166, 12-167 to 180
  - organic, 12-95 to 98
  - physical properties, 12-80 to 92
  - reflection coefficient, 12-123 to 147, 12-148 to 166
  - solid solutions, 12-93 to 94
  - thermal conductivity, 12-80 to 92, 12-206 to 207
  - thermoelectric properties, 12-217 to 218
- Sensitivity of the Human Eye to Light of Different Wavelengths**, 10-242
- Series expansions, A-65 to 68
- Shielding, from radiation, 10-235 to 239, 16-48
- SI units
- conversion factors to, 1-28 to 37
  - definitions and symbols, 1-23 to 26
  - prefixes, 1-23 to 26
- Siemens, definition, 1-23 to 26
- Sievert, definition, 1-23 to 26, 16-48
- Silicon: *see also* Elements
- dielectric constant, 12-47 to 55
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135, 12-202
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - optical properties, 12-123 to 147
  - physical properties, 4-133 to 134
  - semiconducting properties, 12-80 to 92
  - thermal conductivity, 12-206 to 207
  - thermodynamic properties, 5-1 to 3
  - thermodynamic properties at high temperature, 5-43 to 65
  - vapor pressure, 6-72 to 101
- Silver: *see also* Elements
- electrical resistivity, 12-41 to 42
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135, 12-202
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - resistance of wires, 15-37
  - thermal conductivity, 12-206 to 207
  - thermal properties, 12-203 to 204
  - thermodynamic properties, 5-1 to 3
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
  - wire tables, 15-37
- SIMS, definition, 12-1 to 4
- Sine function, A-6 to 7
- SLAM, definition, 12-1 to 4
- SMOW (standard mean ocean water), density, 6-7 to 8
- SNMS, definition, 12-1 to 4
- Sodium: *see also* Elements
- electrical resistivity, 12-41 to 42
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135, 12-202
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - thermal properties, 12-203 to 204
  - thermodynamic properties, 5-1 to 3
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
- Sodium chloride
- activity coefficients, 5-78 to 79, 5-80 to 83
  - aqueous solutions, concentrative properties, 8-52 to 77
  - aqueous solutions, relative humidity, 15-34
  - aqueous solutions, volumetric properties, 6-142
  - density of aqueous solutions, 6-142
  - enthalpy of solution, 5-85
  - standard thermodynamic properties, 5-4 to 42
- Solar constant, 14-2 to 3
- Solar radiation
- by month and latitude, 14-26
  - by wavelength, 14-19
- Solar Spectral Irradiance**, 14-19
- Solar system, 14-2 to 3
- Solder
- phase diagram, 12-184 to 201
  - thermal conductivity, 12-208
- Solids, characterization and analysis, 12-1 to 4
- Solubility
- amino acids, 7-1 to 2
  - carbon dioxide in water, 8-84
  - gases in water, 8-80 to 83
  - hydrocarbons in seawater, 8-131 to 132
  - inorganic compounds, 4-43 to 101
  - inorganic compounds, as function of temperature, 8-121 to 126, 8-130
  - inorganic compounds, qualitative rules, 8-136 to 137
  - inorganic compounds, sparingly soluble, 8-127 to 129
  - octanol-water partition coefficients, 16-43 to 47
  - organic compounds, 3-1 to 523
  - organic compounds in water, 8-85 to 120
  - organic compounds in water at high temperature, 8-133 to 135
  - polymers, 13-70 to 71
  - purine and pyrimidine bases, 7-5
  - salts in water, 8-130
- Solubility Chart**, 8-136 to 137
- Solubility of Carbon Dioxide in Water at Various Temperatures and Pressures**, 8-84
- Solubility of Common Salts at Ambient Temperatures**, 8-130
- Solubility of Hydrocarbons in Seawater**, 8-131 to 132
- Solubility of Organic Compounds in Pressurized Hot Water**, 8-133 to 135
- Solubility of Selected Gases in Water**, 8-80 to 83
- Solubility Parameters of Selected Polymers**, 13-70 to 71
- Solubility Product Constants**, 8-127 to 129
- Solutions
- aqueous, concentrative properties, 8-52 to 77
  - decinormal, oxidation reagents, 8-7
  - decinormal, salts, 8-5 to 6
  - density, 8-52 to 77
  - diffusion of ions, 5-75 to 77
  - enthalpy, for common electrolytes, 5-85
  - formulas for concentration, 8-19
  - freezing point depression, 8-52 to 77
  - index of refraction, 8-52 to 77
  - ionic conductivity, 5-75 to 77
  - polymers, 13-42 to 69
  - for round values of pH, 8-39
  - viscosity, 8-52 to 77
- Solvents
- azeotropic data, 6-189 to 207
  - density, as function of temperature, 15-25
  - dielectric constant, 8-141, 15-13 to 22
  - dipole moment, 15-13 to 22
  - flammability, 15-13 to 22
  - heat capacity, 15-13 to 22
  - ionic liquids, 6-153 to 156
  - mass spectral peaks, 8-143 to 149
  - miscibility, 15-23 to 24
  - NMR shifts, <sup>13</sup>C, 8-142
  - NMR shifts, proton, 8-150 to 156

- physical properties, 15-13 to 22
- for polymers, 13-5
- polymers, critical solution temperatures, 13-19 to 36
- threshold limit in air, 15-13 to 22
- for ultraviolet spectrophotometry, 8-141
- vapor pressure, 15-13 to 22
- viscosity, 15-13 to 22
- wavelength cutoff (UV), 8-141
- Solvents for Common Polymers, 13-5**
- Solvents for Ultraviolet Spectrophotometry, 8-141**
- Sound level, in human hearing, 14-53 to 54
- Sound velocity
  - air, as function of humidity and frequency, 14-50
  - air, as function of temperature, 14-51
  - air, as function of temperature and pressure, 6-15 to 20
  - atmosphere, as function of altitude, 14-20 to 25
  - fluids, 6-21 to 37
  - mercury, 6-158
  - seawater, 14-16 to 17
  - various solids, liquids, and gases, 14-48 to 49
  - water and seawater, 14-48 to 49
  - water and steam, 6-1 to 4
- Sources of Physical and Chemical Data, B-1 to 5**
- Space group
  - elements, 12-15 to 18
  - notation, 12-5 to 10
- Specific Enthalpies of Solution of Polymers and Copolymers, 13-42 to 69**
- Specific gravity: *see* Density
- Specific heat: *see* Heat capacity
- Specific volume: *see also* Density
  - mercury, 6-157
  - sodium chloride solutions, 6-142
  - water, 8-139
- Spectroscopic Constants of Diatomic Molecules, 9-102 to 107**
- Spectrum, infrared
  - calibration frequencies, 10-261 to 267, 10-268 to 272
  - correlation charts, 9-108 to 112
  - fundamental vibrational frequencies, 9-100 to 102
- Spectrum, line, of the elements, 10-1 to 92
- Speed of light, 1-1 to 11
- Speed of sound
  - air, as function of frequency, 14-50
  - air, as function of humidity, 14-50
  - air, as function of temperature, 14-51
  - air, as function of temperature and pressure, 6-15 to 20
  - atmosphere, as function of altitude, 14-20 to 25
  - fluids, 6-21 to 37
  - various solids, liquids, and gases, 14-48 to 49
  - water and seawater, 14-48 to 49
  - water and steam, 6-1 to 4
- Speed of Sound in Dry Air, 14-51**
- Speed of Sound in Various Media, 14-48 to 49**
- Spin
  - fundamental particles, 11-1 to 55
  - nuclides, 11-56 to 253
  - nuclides of NMR interest, 9-113 to 115
- ordering in magnetic materials, 12-116 to 118
- SPM, definition, 12-1 to 4
- SSMS, definition, 12-1 to 4
- Standard Atmosphere (U.S.), 14-20 to 25
- Standard Atomic Weights (by atomic number), Inside back cover**
- Standard Atomic Weights (alphabetical), 1-12 to 13**
- Standard Density of Water, 6-7 to 8**
- Standard ITS-90 Thermocouple Tables, 15-1 to 9**
- Standard KCl Solutions for Calibrating Conductivity Cells, 5-72**
- Standard Salt Solutions for Humidity Calibration, 15-34**
- Standard Solutions of Acids, Bases, and Salts, 8-5 to 6**
- Standard Solutions of Oxidation and Reduction Reagents, 8-7**
- Standard solutions, for pH measurement, 8-32 to 36, 8-37 to 38
- Standard Thermodynamic Properties of Chemical Substances, 5-4 to 42**
- Standard Transformed Gibbs Energies of Formation for Important Biochemical Reactants, 7-16 to 18**
- Standards
  - CODATA thermodynamic values, 5-1 to 3
  - index of refraction, 10-252
  - infrared absorption frequencies, 10-268 to 272
  - infrared laser frequencies, 10-261 to 267
  - temperature, 1-20
  - vapor pressure, 6-111
  - weather-related scales, 14-31 to 32
- Steam, thermophysical properties, 6-1 to 4
- Steel
  - mechanical properties, 12-221
  - thermal conductivity, 12-208
  - thermophysical properties, 12-205
- Stefan-Boltzmann constant, 1-1 to 11
- STEM, definition, 12-1 to 4
- STM, definition, 12-1 to 4
- Stokes' Theorem, A-77
- Stratosphere
  - chemical reactions, 5-90 to 101
  - properties, 14-20 to 25
- Strontium: *see also* Elements
  - electrical resistivity, 12-41 to 42
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - thermal properties, 12-203 to 204
  - vapor pressure, 6-72 to 101
  - vapor pressure, high temperature, 4-136 to 137
- Structure
  - amino acids, 7-3 to 4
  - bond lengths in organic crystals, 9-1 to 16
  - bond lengths in organometallic compounds, 9-17 to 18
  - characteristic  $^{13}\text{C}$  chemical shifts, 9-117
  - characteristic infrared frequencies, 9-108 to 112
  - characteristic proton chemical shifts, 9-116
- crystal, of elements, 12-15 to 18
- crystal, of superconductors, 12-59 to 74, 12-75 to 76
- drugs, 7-28 to 44
- force constants, 9-99
- formulas for organic compounds, 3-1 to 523
- fundamental vibrational frequencies, 9-100 to 102
- gas-phase molecules, 9-19 to 47
- geometry of small molecules, 9-100 to 102
- InChI identifier, 2-27 to 28
- solids, characterization techniques, 12-1 to 4
- Structure and Functions of Some Common Drugs, 7-28 to 44**
- Structures of Common Amino Acids, 7-3 to 4**
- Student's *t*-distribution, A-91
- Sublimation Pressure of Solids, 6-70 to 71**
- Sugars
  - aqueous solution properties, 8-52 to 77
  - nomenclature, 7-14 to 15
- Sulfur: *see also* Elements
  - critical constants, 6-50 to 69
  - dielectric constant, 12-47 to 55
  - electron configuration, 1-18 to 19
  - heat capacity, 4-135
  - history, occurrence, uses, 4-1 to 42
  - ionization energy, 10-203 to 205
  - isotopes and their properties, 11-56 to 253
  - magnetic susceptibility, 4-142 to 147
  - molten, density, 4-139 to 141
  - physical properties, 4-133 to 134
  - thermodynamic properties, 5-1 to 3
  - thermodynamic properties at high temperature, 5-43 to 65
  - vapor pressure, 6-72 to 101
- Sulfuric acid
  - activity coefficients, 5-78 to 79, 5-80 to 83
  - concentrative properties, 8-52 to 77
  - constant humidity solutions, 15-33
  - density, 15-40
  - electrical conductivity, 5-71
  - vapor pressure, 6-72 to 101
- Summary Tables of Particle Properties, 11-1 to 55**
- Sun
  - mass, dimensions, and other properties, 14-2 to 3
  - radiative properties, 14-2 to 3
  - spectral irradiance, 14-19
- Superconductors
  - electrical and magnetic properties, 12-59 to 74, 12-75 to 76
  - organic, 12-77 to 79
  - rare earth elements, 4-127 to 132
  - transition temperature, 12-59 to 74, 12-75 to 76, 12-77 to 79
- Superconductors, high temperature
  - general properties, 12-75 to 76
  - phase diagram, 12-184 to 201
- Supercooled water, 6-12
- Surface characterization and analysis, 12-1 to 4
- Surface tension
  - aqueous mixtures, 6-165
  - liquid helium, 6-144
  - liquid rare earth metals, 4-127 to 132
  - various liquids, 6-161 to 164
  - water, 6-5 to 6
- Surface Tension of Aqueous Mixtures, 6-165**
- Surface Tension of Common Liquids, 6-161 to 164**



Susceptibility: *see* Magnetic susceptibility

## Symbols

- amino acids, 7-3 to 4
- carbohydrates, 7-14 to 15
- magnetism, 12-107 to 115
- physical quantities, 2-1 to 12, 2-29 to 41
- SI units, 1-23 to 26
- units, 2-29 to 41

## Symbols and Terminology for Physical and Chemical Quantities, 2-1 to 12

## Symmetry of Crystals, 12-5 to 10

## Synonym Index of Organic Compounds, 3-549 to 633

# T

## Table of the Isotopes, 11-56 to 253

Tangent function, A-6 to 7

Tantalum: *see also* Elements

- electrical resistivity, 12-41 to 42
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- thermal properties, 12-203 to 204
- vapor pressure, 6-72 to 101
- vapor pressure, high temperature, 4-136 to 137

Taylor series, A-65 to 68

Technetium: *see also* Elements

- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- physical properties, 4-133 to 134
- thermal properties, 12-203 to 204
- vapor pressure, 6-72 to 101

## Techniques for Materials Characterization, 12-1 to 4

Tellurium: *see also* Elements

- dielectric constant, 12-47 to 55
- electron configuration, 1-18 to 19
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- vapor pressure, 6-72 to 101

## Temperature

- atmosphere, as function of altitude, 14-20 to 25
- baths for temperature control, 15-35, 15-36
- calibration, ITS-90, 1-20, 15-10 to 11
- Celsius and absolute, definitions, 1-23 to 26
- conversion between scales, 1-38
- conversion to ITS-90, 1-21 to 22
- flames, 15-49
- glass transition, in polymers, 13-6 to 12
- International Temperature Scale (ITS-90), 1-20
- mean global, 14-38
- mean United States, 14-36 to 37
- planetary atmospheres, 14-2 to 3
- superconducting transition, 12-59 to 74

thermocouple tables, 15-1 to 9

## Tensile strength

- commercial metals and alloys, 12-221
- rare earth elements, 4-127 to 132

Terbium: *see also* Elements

- electrical resistivity, 12-41 to 42
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- thermal properties, 12-203 to 204
- vapor pressure, 6-72 to 101
- vapor pressure, high temperature, 4-136 to 137

## Terminology

- inorganic ions and ligands, 2-16 to 22
- organic substituent groups and ring systems, 2-23 to 26
- physical quantities, 2-1 to 12
- polymers, 13-1 to 4
- scientific terms, definitions, 2-43 to 67

Tesla, definition, 1-23 to 26

TGA, definition, 12-1 to 4

Thallium: *see also* Elements

- electrical resistivity, 12-41 to 42
- electron configuration, 1-18 to 19
- heat capacity, 4-135
- history, occurrence, uses, 4-1 to 42
- ionization energy, 10-203 to 205
- isotopes and their properties, 11-56 to 253
- magnetic susceptibility, 4-142 to 147
- molten, density, 4-139 to 141
- physical properties, 4-133 to 134
- thermal properties, 12-203 to 204
- vapor pressure, 6-72 to 101
- vapor pressure, high temperature, 4-136 to 137

## The Elements, 4-1 to 42

## The Genetic Code, 7-6

## The Madelung Constant and Crystal Lattice Energy, 12-34

## Thermal and Physical Properties of Pure Metals, 12-203 to 204

## Thermal conductivity

- air, 6-15 to 20
- alloys, 12-208
- argon, liquid and gas, 6-21 to 37
- atmosphere, as function of altitude, 14-20 to 25
- Carbon dioxide, 6-21 to 37
- carrier gases for chromatography, 8-140
- ceramics, 12-211 to 212
- commercial metals, 12-208
- commercial metals and alloys, 12-221
- common fluids, as function of temperature and pressure, 6-21 to 37
- construction materials, 12-211 to 212
- conversion factors, 1-41
- cryogenic solids, 12-209 to 210
- crystalline solids, 12-209 to 210
- dielectric crystals, 12-209 to 210
- gases, at atmospheric pressure, 6-218 to 219
- glasses, 12-213 to 216
- helium, liquid, 6-144
- helium, liquid and gas, 6-21 to 37
- ice, 6-12, 12-209 to 210
- insulation, 12-211 to 212

liquids, 6-220 to 224

mercury, 6-220 to 224

metals, 12-203 to 204, 12-206 to 207

minerals, 12-211 to 212

nitrogen, liquid and gas, 6-21 to 37

organic compounds, 6-220 to 224

oxygen, liquid and gas, 6-21 to 37

plastics, 12-211 to 212

quartz, 12-209 to 210

rare earth elements, 4-127 to 132

refractory materials, 12-211 to 212

rocks, 12-211 to 212

rubber, 12-211 to 212

semiconductors, 12-80 to 92, 12-206 to 207

stainless steel, 12-205

superconductors, 12-75 to 76

water, 6-220 to 224

water and steam, 6-1 to 4

wood, 12-211 to 212

## Thermal Conductivity of Alloys as a Function of Temperature, 12-208

## Thermal Conductivity of Ceramics and Other Insulating Materials, 12-211 to 212

## Thermal Conductivity of Crystalline Dielectrics, 12-209 to 210

## Thermal Conductivity of Gases, 6-218 to 219

## Thermal Conductivity of Glasses, 12-213 to 216

## Thermal Conductivity of Liquids, 6-220 to 224

## Thermal Conductivity of Metals and Semiconductors as a Function of Temperature, 12-206 to 207

## Thermal expansion coefficient

- commercial metals and alloys, 12-221
- ice, 6-12
- liquids, 6-140 to 141
- metals, 12-203 to 204
- rare earth elements, 4-127 to 132
- semiconductors, 12-80 to 92
- sodium chloride solutions, 6-142

Thermal neutron cross sections, 11-254 to 266

## Thermal Properties of Mercury, 6-158

Thermocouple calibration tables, 15-1 to 9

## Thermodynamic Functions and Relations, 2-68

Thermodynamic properties (*see also* Enthalpy, Heat capacity, etc.)

- air, 6-15 to 20
- aqueous ions, 5-66 to 67
- argon, 6-21 to 37
- biochemical species, 7-16 to 18, 7-19 to 22, 7-23 to 25
- CODATA Key Values, 5-1 to 3
- common fluids, as function of temperature and pressure, 6-21 to 37
- gas clathrate hydrates, 6-148 to 152
- helium, 6-21 to 37
- high temperature, 5-43 to 65
- hydrogen, 6-21 to 37
- inorganic compounds, 5-4 to 42
- nitrogen, 6-21 to 37
- organic compounds, 5-4 to 42
- oxygen, 6-21 to 37
- rare earth elements, 4-127 to 132
- standard state values, 5-4 to 42
- temperature dependence, 5-43 to 65
- water and steam, 6-1 to 4

## Thermodynamic Properties as a Function of Temperature, 5-43 to 65

- Thermodynamic Properties of Aqueous Ions**, 5-66 to 67
- Thermodynamic Quantities for the Ionization Reactions of Buffers in Water**, 7-23 to 25
- Thermodynamic relations, 2-68
- Thermoelectric power (thermal emf), 12-217 to 218
- Thermoelectric Properties of Metals and Semiconductors**, 12-217 to 218
- Thermometers, wet and dry bulb, 15-32
- Thermophysical Properties of Air**, 6-15 to 20
- Thermophysical Properties of Fluids**, 6-21 to 37
- Thermophysical Properties of Stainless Steel**, 12-205
- Thermophysical Properties of Water and Steam**, 6-1 to 4
- Thomson effect, 12-217 to 218
- Thorium: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
thermodynamic properties, 5-1 to 3  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137
- Threshold limits  
airborne contaminants, 16-29 to 42  
halocarbon refrigerants, 6-145 to 147  
solvents, 15-13 to 22
- Threshold Limits for Airborne Contaminants**, 16-29 to 42
- Thulium: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137
- Thunderstorm electricity, 14-41 to 47
- Time  
astronomical units, 14-1  
geological scale, 14-12
- Tin: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal conductivity, 12-206 to 207  
thermal properties, 12-203 to 204  
thermodynamic properties, 5-1 to 3  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137
- Titanium: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135, 12-202  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
thermodynamic properties, 5-1 to 3  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137
- Toxicity of anions and cations, 16-1 to 12
- Transformation of integrals, A-77
- Transition probability, atomic, 10-93 to 155
- Transition temperature  
glass, in polymers, 13-6 to 12  
superconductors, 12-59 to 74, 12-75 to 76, 12-77 to 79
- Transport properties: *see* Thermal conductivity, Viscosity, Diffusion
- Trigonometric functions  
relations, A-8  
table, A-6 to 7
- Trigonometric series, A-65 to 68
- Trillion, definition, 1-38
- Triple point constants  
carbon dioxide, 6-70 to 71  
cryogenic fluids, 6-143  
D<sub>2</sub>O, 6-9  
elements, 4-133 to 134  
various compounds, 6-70 to 71  
water, 6-9
- Tschebysheff polynomials, A-83 to 85
- Tungsten: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135, 12-202  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
resistance of wires, 15-37  
thermal conductivity, 12-206 to 207  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137  
wire tables, 15-37
- Typical pH Values of Biological Materials and Foods**, 7-27
- U**
- U.S. Standard Atmosphere (1976)**, 14-20 to 25
- Ultraviolet spectrophotometry, solvents for, 8-141
- Uncertainty, means of expression, 2-13 to 14
- Units  
conversion factors, 1-28 to 37  
definitions, 2-43 to 67  
ionizing radiation, 1-44 to 45, 16-48  
magnetic quantities, 1-27, 12-107 to 115  
pH, 8-32 to 36  
SI, definitions and symbols, 1-23 to 26
- Units for Magnetic Properties**, 1-27
- Upper Critical (UCST) and Lower Critical (LCST) Solution Temperatures of Binary Polymer Solutions**, 13-19 to 36
- UPS, definition, 12-1 to 4
- Uranium: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
thermodynamic properties, 5-1 to 3  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137
- Uranus, orbital data and dimensions, 14-2 to 3
- V**
- Values of the Gas Constant in Different Unit Systems**, 1-46
- Van der Waals Constants for Gases**, 6-47
- Van der Waals radii of the elements, 9-49
- Vanadium: *see also* Elements  
electrical resistivity, 12-41 to 42  
electron configuration, 1-18 to 19  
heat capacity, 4-135  
history, occurrence, uses, 4-1 to 42  
ionization energy, 10-203 to 205  
isotopes and their properties, 11-56 to 253  
magnetic susceptibility, 4-142 to 147  
molten, density, 4-139 to 141  
physical properties, 4-133 to 134  
thermal properties, 12-203 to 204  
vapor pressure, 6-72 to 101  
vapor pressure, high temperature, 4-136 to 137
- Vapor Pressure**, 6-72 to 101
- Vapor pressure  
air, 6-15 to 20  
aqueous salt solutions, 15-34  
at temperatures below 300 K, 6-102 to 109  
calibration data, 6-111  
carbon dioxide, 6-70 to 71, 6-102 to 109, 6-111  
cryogenic fluids, 6-102 to 109  
elements, 6-72 to 101  
elements, high temperature, 4-136 to 137, 4-138  
general table, 6-72 to 101  
helium, 1-20, 6-102 to 109, 6-144  
ice, 6-13, 6-111  
inorganic compounds, 6-72 to 101  
IUPAC recommended data, 6-111  
mercury, 6-160  
metals, at high temperatures, 4-136 to 137, 4-138  
organic compounds, 6-72 to 101  
polymer solutions, 13-37 to 41  
rare earth elements, 4-127 to 132  
rare gases, 6-102 to 109  
salt solutions, 6-110  
solids, 6-70 to 71



solvents, 15-13 to 22  
 water, 6-1 to 4, 6-5 to 6, 6-111  
 water, over salt solutions, 6-110, 15-33, 15-34

**Vapor Pressure and Other Saturation Properties of Water, 6-5 to 6**

**Vapor Pressure of Fluids at Temperatures below 300 K, 6-102 to 109**

**Vapor Pressure of Ice, 6-13**

**Vapor Pressure of Mercury, 6-160**

**Vapor Pressure of Saturated Salt Solutions, 6-110**

**Vapor Pressure of the Metallic Elements - Data, 4-138**

**Vapor Pressure of the Metallic Elements - Equations, 4-136 to 137**

**Vapor Pressures (Solvent Activities) for Binary Polymer Solutions, 13-37 to 41**

Vaporization: *see* Enthalpy of vaporization

Vector analysis, A-68 to 75

Velocity of light, 1-1 to 11

Velocity of sound  
   air, as function of frequency, 14-50  
   air, as function of humidity, 14-50  
   air, as function of temperature, 14-51  
   atmosphere, as function of altitude, 14-20 to 25  
   fluids, 6-21 to 37  
   various solids, liquids, and gases, 14-48 to 49

Velocity, mean, in gases, 6-48

Venus, orbital data and dimensions, 14-2 to 3

Verdet constants, 12-167 to 180

Vibrational force constants, 9-99

Vibrational frequencies of molecules, 9-100 to 102, 9-102 to 107

Vibrational-rotational spectra, for frequency calibration, 10-268 to 272

**Virial Coefficients of Selected Gases, 6-38 to 46**

Viscosity  
   air, 6-15 to 20  
   aqueous solutions, 8-52 to 77  
   argon, liquid and gas, 6-21 to 37  
   atmosphere, as function of altitude, 14-20 to 25  
   carbon dioxide, on saturation line, 6-214  
   carrier gases for chromatography, 8-140  
   common fluids, as function of temperature and pressure, 6-21 to 37  
   gases, at atmospheric pressure, 6-208  
   helium, liquid, 6-144  
   helium, liquid and gas, 6-21 to 37  
   hydroxide solutions, 6-215  
   ionic liquids, 6-153 to 156  
   liquid metals, 6-216 to 217  
   liquids, 6-209 to 213  
   methane, liquid and gas, 6-21 to 37  
   nitrogen, liquid and gas, 6-21 to 37  
   oxygen, liquid and gas, 6-21 to 37  
   seawater, 14-16 to 17  
   solvents, 15-13 to 22  
   water and steam, 6-1 to 4

**Viscosity and Density of Aqueous Hydroxide Solutions, 6-215**

**Viscosity of Carbon Dioxide along the Saturation Line, 6-214**

**Viscosity of Gases, 6-208**

**Viscosity of Liquid Metals, 6-216 to 217**

**Viscosity of Liquids, 6-209 to 213**

Volt  
   definition, 1-23 to 26  
   maintained value, 1-1 to 11

**Volume of One Gram of Water, 8-139**

**Volumetric Properties of Aqueous Sodium Chloride Solutions, 6-142**

## W

Water  
   azeotropic mixtures, 6-189 to 207  
   compressibility, 6-140 to 141  
   critical constants, 6-9  
   density, as function of pressure and temperature, 6-1 to 4  
   density, 6-7 to 8  
   density (supercooled), 6-12  
   dielectric constant, as function of frequency, 6-14  
   dielectric constant, as function of temperature and pressure, 6-1 to 4  
   dielectric constant, vapor, 6-188  
   diffusion of gases, 6-227  
   dissociation constant, 8-78, 8-79  
   electrical conductivity, 5-70  
   enthalpy of fusion, 6-130 to 139  
   enthalpy of vaporization, 6-5 to 6  
   fixed point properties, 6-9  
   freezing point, pressure dependence, 6-49  
   index of refraction, 10-251  
   ion product, 8-78, 8-79  
   octanol-water partition coefficients, 16-43 to 47  
   permittivity, as function of frequency, 6-14  
   permittivity, as function of temperature and pressure, 6-1 to 4  
   pH measurement, 8-37 to 38  
   speed of sound, 6-1 to 4, 14-48 to 49  
   surface tension, 6-5 to 6  
   thermal conductivity, 6-218 to 219  
   thermal expansion coefficient, 6-140 to 141  
   thermodynamic properties at high temperature, 5-43 to 65  
   thermophysical properties, 6-1 to 4  
   triple point constants, 6-9  
   van der Waals constants, 6-47  
   vapor pressure, 6-5 to 6  
   vapor pressure over salt solutions, 15-33  
   viscosity, 6-208  
   volume of one gram, 8-139

Water(D<sub>2</sub>O)  
   boiling point, 6-9  
   critical constants, 6-9  
   density, 6-10 to 11  
   dissociation constant, 8-79  
   fixed point properties, 6-9  
   heat capacity, 6-10 to 11  
   ion product, 8-79  
   surface tension, 6-10 to 11  
   thermal conductivity, liquid, 6-10 to 11  
   thermal conductivity, vapor, 6-218 to 219  
   triple point constants, 6-9  
   vapor pressure, 6-10 to 11  
   viscosity, liquid, 6-10 to 11  
   viscosity, vapor, 6-208

Watt, definition, 1-23 to 26

Wavelengths  
   atomic spectra, 10-1 to 92  
   correction to vacuum, 10-253

electromagnetic radiation bands, 10-240 to 241  
 laser sources, 10-255 to 260  
 sensitivity of eye, 10-242

**Weather-Related Scales, 14-31 to 32**

Weber, definition, 1-23 to 26

Weighings, reduction from air to vacuum, 8-138

Width, x-ray lines, 10-234

Wien displacement law constant, 1-1 to 11

Wind chill factors, 14-31 to 32

Wind scales, 14-31 to 32

**Wire Tables, 15-37**

Wood  
   density, 15-39  
   speed of sound in, 14-48 to 49  
   thermal conductivity, 12-211 to 212

Work function, of the elements, 12-121

## X

Xenon: *see also* Elements  
   critical constants, 6-50 to 69  
   cryogenic properties, 6-143  
   electron configuration, 1-18 to 19  
   entropy, 5-1 to 3  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   magnetic susceptibility, 4-142 to 147  
   mean free path, 6-48  
   permittivity (dielectric constant), 6-166 to 187, 6-188  
   physical properties, 4-133 to 134  
   solubility in water, 8-80 to 83  
   thermal conductivity, 6-218 to 219  
   van der Waals constants, 6-47  
   vapor pressure, 6-72 to 101, 6-102 to 109  
   viscosity, 6-208

**X-Ray Atomic Energy Levels, 10-224 to 227**

X-rays  
   atomic energy levels, 10-224 to 227  
   attenuation coefficients, 10-235 to 239  
   cross sections, for the elements, 10-235 to 239  
   natural line width, 10-234

## Y

Young's modulus, rare earth elements, 4-127 to 132

Ytterbium: *see also* Elements  
   electrical resistivity, 12-41 to 42  
   electron configuration, 1-18 to 19  
   heat capacity, 4-135  
   history, occurrence, uses, 4-1 to 42  
   ionization energy, 10-203 to 205  
   isotopes and their properties, 11-56 to 253  
   magnetic susceptibility, 4-142 to 147  
   molten, density, 4-139 to 141  
   physical properties, 4-133 to 134  
   thermal properties, 12-203 to 204  
   vapor pressure, 6-72 to 101  
   vapor pressure, high temperature, 4-136 to 137

Yttrium: *see also* Elements  
   electrical resistivity, 12-41 to 42  
   electron configuration, 1-18 to 19  
   heat capacity, 4-135  
   history, occurrence, uses, 4-1 to 42

ionization energy, **10-203** to **205**  
 isotopes and their properties, **11-56** to **253**  
 magnetic susceptibility, **4-142** to **147**  
 molten, density, **4-139** to **141**  
 physical properties, **4-133** to **134**  
 thermal properties, **12-203** to **204**  
 vapor pressure, **6-72** to **101**  
 vapor pressure, high temperature, **4-136** to  
**137**

## Z

Zeotropes, **6-189** to **207**  
 Zinc: *see also* Elements  
     electrical resistivity, **12-41** to **42**

electron configuration, **1-18** to **19**  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1** to **42**  
 ionization energy, **10-203** to **205**  
 isotopes and their properties, **11-56** to **253**  
 magnetic susceptibility, **4-142** to **147**  
 molten, density, **4-139** to **141**  
 physical properties, **4-133** to **134**  
 thermal properties, **12-203** to **204**  
 thermodynamic properties, **5-1** to **3**  
 vapor pressure, **6-72** to **101**  
 vapor pressure, high temperature, **4-136** to  
**137**  
 Zirconium: *see also* Elements  
     electrical resistivity, **12-41** to **42**

electron configuration, **1-18** to **19**  
 heat capacity, **4-135**  
 history, occurrence, uses, **4-1** to **42**  
 ionization energy, **10-203** to **205**  
 isotopes and their properties, **11-56** to **253**  
 magnetic susceptibility, **4-142** to **147**  
 molten, density, **4-139** to **141**  
 physical properties, **4-133** to **134**  
 thermal properties, **12-203** to **204**  
 vapor pressure, **6-72** to **101**  
 vapor pressure, high temperature, **4-136** to  
**137**